CATALOGUE
OF
HIGH ENERGY ACCELERATORS
XIVth International Conference on High Energy Accelerators

CATALOGUE OF HIGH ENERGY ACCELERATORS
(Revised Version)

Complied by:
Shin-ichi Kurokawa

Tsukuba, Japan
October 1989
Foreword

Nine years have passed since the last catalogue of high energy accelerators was distributed at the 11th International Conference on High Energy Accelerators in 1980, held at CERN. Since many new accelerators have been completed during these years and some new ones are under construction or in planning at present, the Organizing Committee of the 14th International Conference on High Energy Accelerators has decided to compile a new catalogue with up-to-date information.

This catalogue contains the parameters and status of high energy accelerators and storage rings with the energy higher than 1 GeV or 1 GeV/n together with their injectors. An exception has been made for the accelerators for meson factories and ISIS at Rutherford Appleton Laboratory. One difference between the previous catalogue and the present one is that we include storage rings used as synchrotron radiation sources. The other change from the last catalogue is that we have created a new heading "Heavy Ion Accelerators" and "Linear Collider".

We would like to express our thanks to all those who took time to complete data-sheets. We also acknowledge with thanks Professor H. Nakayama for his careful proof reading, Ms. C. Tanaka for her assistance in organizing this catalogue and Ms. S. Shimazaki for her typing the manuscripts.

Shin-ichi Kurokawa  
Compiler of the Catalogue  
August, 1989

After the workshop we received some data-sheets the contents of which were not included in the catalogue distributed at the Conference; therefore, we have decided to revise the catalogue. Some small corrections were made at the same time.

Shin-ichi Kurokawa  
October, 1989
LIST OF HIGH ENERGY ACCELERATORS

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NAME OF SYNCHROTRON: KAOAN FACTORY DRIVER SYNCHROTRON

INSTITUTION: TRIUMF

LOCATION: 4004 Wesbrook Mall, Vancouver, B.C., Canada V6T 2A3

PERSON IN CHARGE: A. Astbury

DATE: July 1989

DATA SUPPLIED BY: M.K. Craddock

HISTORY AND STATUS

CONSTRUCTION STARTED (date) --
FIRST BEAM OBTAINED, OR GOAL (date) 1995
TOTAL COST OF FACILITY 2620 M (Gdb)
TOTAL ACCELERATOR STAFF (now) --
ANN. OPERAT. BUDGET (without salaries) 5900 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES Proton
ENERGY 30 GeV
RING DIAM. 245 x 399 m, TUNNEL SECT. (W x H) 7.2 x 5.6 m

Injector
TYPE Booster Synchrotron (50 Hz)
OUTPUT (max) 0.1 m Arc
EMITTANCE* 60 x 60 nm-mrad
INJECTION PERIOD 3 μs or 1 turns
INJECTOR TYPE Kicker

Magnet System
FOCUSING TYPE AG FIELD INDEX n = 0.91
FOCUSING ORDER 2000
BETATRON FREQU. 13.27 μs
LEN T (ev) 14.18 μs
NO. MAGNETS (dipole) 96 LENGTH (ev) 5 m
BENDING FIELD STING 0.176 T; at max 1.35 T
NO. QUADS 128 LENGTH (ev) 1.6 m
GRAD. at inf. 1.46 μs; at max 1.8 μs
NO. SHORT. STRAIGHT SECT 10 LENGTH ≤ 0 m
NO. LONG. STRAIGHT SECT 2 LENGTH 1.54 m
RISE TIME 75 μs; FLAT-TOP TIME 5 μs
POWER INPUT PEAK 7625 kW; MEAN 15 MW

Acceleration System
NO. CAVITIES 20 LENGTH (ev) 2.1 m
HARMONIC NUMBER 225
RF RANGE 60.8 to 62.6 MHz
ENERGY GAIN 2560 KEV/turn
RADIATION LOSS - KEV/turn
RF POWER INPUT PEAK 7625 kW; MEAN 3622 kW

Vacuum System
MATERIAL OF VAC. CHAMBER 316 L N S.S./96% Alumina
APERTURE OF VAC. CHAMBER 100 x 150 mm
AVERAGE PRESSURE 3 x 10⁻⁸ torr

Extraction System
TYPE I) Fast kicker, e.g. 6 magnetic septa
II) Slow extraction from booster (i.e. stretcher) ring
LENGTH OF SPILL I) 3 μs
II) 100,000 μs
III) 3 μs

ACCELERATOR PERFORMANCE

ENERGY (GeV) Normal Maximum Achieved
0.4 - 0.55 GeV/c 1 1
0.5 - 0.55 GeV/c 1 1
0.5 - 0.8 1 1
1.2 - 1.5 1 1
2.0 - 6.0 1 1
2.0 - 9.0 1 1
6 x 10⁻³ 1 1
EMITTANCE* AT PEAK E 90 x 90 nm-mrad

SECONDARY BEAMS

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<td>1</td>
<td>1 Elect. Separator</td>
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<td>K</td>
<td>0.5 - 0.8</td>
<td>1</td>
<td>1 Elect. Separator</td>
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<tr>
<td>e⁻</td>
<td>1.2 - 1.5</td>
<td>1</td>
<td>1 Elect. Separator</td>
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<tr>
<td>e⁺</td>
<td>2.0 - 6.0</td>
<td>1</td>
<td>1 Elect. Separator</td>
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<td>e⁻</td>
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<td>1</td>
<td>1 Elect. Separator</td>
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<tr>
<td>e⁻</td>
<td>6 x 10⁻³</td>
<td>1</td>
<td>1 Elect. Separator</td>
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 EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS 8000 m²
NO. INTERNAL TARGETS 6
NO. SEPARATED BEAMS 6
NO. BEAMS SERVED AT SAME TIME 6
TOTAL POWER USED (AVERAGE) FOR RESEARCH 20 MW
NO. USER GROUPS, IN house outside 1
TOTAL RESEARCH STAFF, IN house outside 1
ANN. RESEARCH BUDGET, IN house outside [without sal] 1
ANNUAL RESEARCH TIME 5000 h

Other Relevant Parameters, Recent Improvements, etc.

The KAOAN Factory will consist of a chain of 6 accelerators and storage rings: 6 cyclotrons: 452 MeV/cv (can separate entry) Accumulator: stores beam of 20 ns periods Booster: 50 Hz synchrotron (452-3000 MeV) Collector: delivers 5 pulses and inflates to Driver: 10 Hz synchrotron (3-10 GeV) Extender: Stretcher with bunched/debunched slow extraction

*Emittance = Area x br at 90% of current (for p-machines)
NAME OF SYRINGEON: Super Proton Synchrotron (SPS)

INSTITUTION: CERN

LOCATION: Frérevens (France)

PERSON IN CHARGE: H. de Raad

DATE: 5.7.89

DATA SUPPLIED BY: G. Brianti

HISTORY AND STATUS

CONSTRUCTION STARTED (DATE): February 1970
FIRST BEAM OBTAINED, OR GOAL (DATE): May 1976
TOTAL COST OF FACILITY: 424 MWF (to 1970 GBP)
TOTAL ACCELERATOR STAFF (now): 90
ANNUAL OPERATING BUDGET: 1.3 MCHF (without salaries)
ANNUAL OPERATING TIME: 3300 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES: Protons
ENERGY: 450 GeV
RING DIAM.: 2200 m; TUNNEL SECT. (W x H): 4 x 3 m

Injector
TYPE: Proton Synchrotron
OUTPUT (max): 14000 mA at 14000 MeV
EMITTANCE*: 10 x 10^-11 m-mrad
INJECTION PERIOD: 2 x 11.5 μs or 2 x 1/2 turn
INFLECTOR TYPE: Fast kicker

Magnet System
FOCUSING TYPE: Separation Function
FIELD INDEX n =

FOCUSING ORDER: 9000
BETA FREQ. Vθ: 26.6 m
NO. OF MAGNETS: 744
LENGTH (m): 6.26 m
BENDING FIELD AT M: 0.04 T; at max 2.02 T
NO. OF QUADS: 216
LENGTH (m): 3.05 m
GRAD. AT M: 0.07 T/m; at max 22.5 T/m
NO. OF LONG STRAIGHT SECT: 6
LENGTH (m): 126 m
RISE TIME: 3 s; FLAT-TOP TIME: 2.8 s
POWER INPUT PEAK: 210 MW; MEAN: 57 MW

Acceleration System
NO. OF CAVITIES: 4
LENGTH (m): 20 m
HARMONIC NUMBER: 4620
RF RANGE: 199.2 to 200.4 MHz
ENERGY GAIN: 7200 keV/turn
RADIATION LOSS: keV/turn
RF POWER INPUT PEAK: (each) 750 kW; MEAN 500 kW

Vacuum System
MATERIAL OF VAC. CHAMBER: Stainless steel
APERTURE OF VAC. CHAMBER: 150 x 50 mm
AVERAGE PRESSURE: 10^-11 torr

Extraction System
TYPE: i) Fast
ii) Fast resonant
iii) Slow 173 Hz resonant
LENGTH OF SPILL: i) 2 to 21 J
ii) 1000 to 5000 J
iii) 0.5 to 2 msec

ACCELERATOR PERFORMANCE

ENERGY (GeV): Normal Maximum
(3) 6650 < p < 225 GeV 710.5
450

RESOLUTION (ΔE/E (%)): ±0.05

REPEET RATE (pulses/s): 2

PULSE WIDTH AT PEAK E: 2 x 10^-13

INTERNAL BEAM
(particles/pulse): 3 x 10^-13

EMITTANCE* AT PEAK E: 50 x mm-mrad

SECONDARY BEAMS (1989)

Particle Momentum range: No. of beams Other inform.

- e^+ e^- < 500 GeV/c 4 H1, H2, H3, H8
- ν e < 280 GeV 1 T1 Hyperon Beam
- Protons 650 GeV 2 P0, P1 Micro-particle beam
- Hadrons e^- < 400 GeV 4 H1, H2, H3, H8
- η < 250 GeV 1 H6
- Tertiary γ e^- < 100 GeV/q 4 A1, A2, A3, A4

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS: 6 ~ 32000 m²
TOTAL INTERNAL TARGETS: 0
TOTAL EXTERNAL TARGETS: 10
NO. OF SEPARATED BEAMS, a, μ, v, γ: beams are pure
NO. OF BEAMS SERVED AT SAME TIME: 12
TOTAL POWER USED (AVERAGE) FOR RESEARCH: 21 MW
NO. OF USER GROUPS: 35
IN HOUSE: 110
TOTAL RESEARCH STAFF: 800
ANNUAL RESEARCH BUDGET: 3.7 MCHF
(Without salaries)
ANNUAL RESEARCH TIME: ~ 3000

OTHER RELEVANT PARAMETERS, RECENT IMPROVEMENTS, ETC.

*Emittance = Area x J at 90% of current (for p-machines)
ACCELERATOR PARAMETERS

General

ACCELERATED PARTICLES Protons (antiprotons/light ions/ e+ e-)
ENERGY 26 GeV/c nuc/beam (3.6 a·g^-1)
RING DIAMETER 200 m; TUNNEL SECT. (W x H) 6 x 6 m

Injector

TYPE Booster (protons)
OUTPUT (max) 1280 mA at 1200 MWe
EMITTANCE * e+ e- turn
INJECTOR PERIOD 2.5 μs, or 1 turn
INJECTOR TYPE magnetic septum and pulsed kicker

Magnet System

FOCUSING TYPE AG FIELD INDEX n = 288
FOCUSING ORDER f = 550 μm
BETAVATION FREQUENCY 6.25 Hz
NO. MAGNETS 100 LENGTH (mm) 2.26 m
BENDING FIELD 0.0147 T; at max 1.4 T
NO. QUADS LENGTH (mm) 5.2 m
GRAD. AT 2 (T) 0.0147 T; at max 1.4 T
NO. SHORT STRAIGHT SECTION 90 LENGTH 1.6 m
NO. LONG STRAIGHT SECTION 20 LENGTH 3.0 m
RISE TIME 0.7 s; FLAT-TOP TIME 0.5 - 0.7 s
POWER INPUT PEAK 41 kW; MEAN 2.8 MW

Acceleration System

NO. CAVITIES 11 LENGTH (mm) 40 m
HARMONIC NUMBER 20 (6/10/12/14/16/18)
RF FREQUENCY 2.6 - 9.95 MHz
ENERGY GAIN 220 KEV/Turn
RADIATION LOSS 200 kHz, MEAN 50 kHz
RF POWER INPUT PEAK 100 kW, MEAN 50 kW

Vacuum System

MATERIAL OF VAC. CHAMBER Austenitic Steel
APERTURE OF VAC. CHAMBER 146 x 70 (178 x 67) mm
AVERAGE PRESSURE 1 x 10^-6 torr

Extraction System

TYPE i) Fast extractions (FE)
ii) Slow extraction (ST)
iii) Radial shaping on 3 turns
LENGTH OF SPILL 0.1 m to 2.1 μs
i) 200 μs ii) 10 μs

- Booster - PS injection was raised from 0.8 to 1 GeV
- PS RF accelerating system is able to cope with new increased beam loading and complex harmonic number gymnastics. 200 and 114 MHz are used in addition to the original 9.5 MHz system.
- PS vacuum chamber and poleface windings are new, leading to improved vacuum and high energy magnetic conditions.

ACCELERATOR PERFORMANCE

ENERGY (GeV) Normal Maximum achieved
26 28
RESOLUTION A/E (%) 0.05 1
REPET. RATE (pulses) 0.5 1
PULSE WIDTH AT PEAK E 2 x 10^11 2.3 x 10^11
INTERNAL BEAM (part/pulse) 2 x 10^11
EMITTANCE * AT PEAK E 1.2 x 10^11

SECONDARY BEAMS

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<th>MOMENTUM RANGE</th>
<th>NO. OF BEAMS</th>
<th>OTHER INFORM</th>
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<tr>
<td>p</td>
<td>0.1 - 2 GeV/c</td>
<td>7 experimental beams in South America</td>
<td></td>
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</tbody>
</table>

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS 2000 (East) + 2000 (South) m²
NO. INTERNAL TARGETS 1
NO. SEPARATED BEAMS 4
NO. BEAMS SERVED AT SAME TIME 2
TOTAL POWER USED (AVERAGE) FOR RESEARCH 7 MW
NO. USER GROUPS, IN HOUSE 2 outside
TOTAL RESEARCH STAFF, IN HOUSE 15 outside
ANN. RESEARCH BUDGET, IN HOUSE (without salaries) 300 K

*Emission = area x py at 50% of current (for p-machines)

Other Relevant Parameters, Recent Improvements, etc.

The PS machine is gaining injection/extraction points with their complete related septum/kicker/bumpers pulsed systems. Using different injectors, it can deliver (an example) a pulse to pulse basis in normal operation:

- 2.2 x 10^13 ppp at 14 GeV/c to SPS
- 1.5 x 10^13 ppp in 5 bunches at 26 GeV/c for production
- 5 x 10^11 ppp at 24 GeV/c 430 ms spill length
- twice 1 bunch of 2 x 10^10 e^+ e^- at 10 μs
rate at 3.5 GeV/c for SPS-LEP filling
- 3 x 10^10 p/p h decelerated down to 0.6 GeV/c to LEAR.

During SPS collider run, up to 10^12 p/p h can be delivered.

4 batches of 3 x 10^7 sulfur ions pp at 10 GeV/c/nucleon were provided to SPS (repetition rate 1.2 s) in 1987.
NAME OF SYNCHROTRON
CERN Proton Synchrotron Booster (PSB, four rings stacked vertically)

LOCATION FOR
CERN PS

PERSON IN CHARGE
R. BILLINGE, K. SCHINDL

DATA SUPPLIED BY
K. Schindl, H. Schmeiser

HISTORY AND STATUS

CONSTRUCTION STARTED (date) January 1968
FIRST BEAM OBTAINED or GOAL (Gate) May 1972
TOTAL CAPITAL FUND (Swiss Francs) 60 NSF
TOTAL ACCELERATOR STAFF (now) 46 man-years
ANNUAL OPERATING BUDGET 1025 KFr (Without salaries)
ANNUAL OPERATING TIME 8300 h
(STAFF and budget including overheads)

ACCELERATOR PARAMETERS

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<td>Injector</td>
<td>Type</td>
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<td>Output</td>
<td>Energy</td>
<td>140 (0.07) mAt 50 (1-2/amu) MeV</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emittance</td>
<td>x (3.5) y (2.2)</td>
<td>mm.m/mrad</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injection Period</td>
<td>Up to 100 μs or 3 x 15 (8) turns</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Injector Type</td>
<td>Magnétique</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Magnet System
FOCUSING TYPE | A.6. Sep. Fun. FIELD INDEX | n = 1
FOCUSING ORDER | L7/2, G-L2, L7, L3, L, L7, L3, L2, L2 |
BETATRON FREQUENCIES | v5, v17, v29, v41 |
No. Magnets | 32 |
BENDING FIELD | 0.125 T. at max. 0.026 T |
No. QUADS | 32F, 160 |
LENGTH (mm) | 0.50, 8.80 |
GRAD. at max. | 0.01 Tm |
No. SHORT STRAIGHT | 15 |
LENGTH | 3.77, 6.5 |
No. LONG STRAIGHT | 16 |
LENGTH | 2.68, 2.68 |
RISE TIME | 0.45 s. FLAT TOP TIME | 0.035 s |
POWER INPUT PEAK | 5.6 MW. MEAN | 2.1 kW |

Acceleration System
No. Cavities | 2 per ring |
LENGTH (mm) | 2.23, 1.40 |
HARMONIC NUMBER | 5710 |
RF RANGE | 2.95, 5.90 |
ENERGY GAIN | 1-3, 6 |
RADIATION LOSS | KeV/turn |
RF POWER INPUT PEAK | 7.5, 2.5 | kW. MEAN | 4.7, 1.5 kW |

Vacuum System
MATERIAL OF VAC.CHAMBER | Indonel 750, 316L |
APERTURE OF VAC.CHAMBER | 132 x 61 (bending) mm |
AVERAGE PRESSURE | 10^-9 torr |

Extraction System
TYPE | Fast vertical recombination of the beams |
LENGTH OF SPILL | From the four rings |

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>ENERGY (GeV)</th>
<th>0.8 (0.28/amu)</th>
<th>1.0 (0.32/amu)</th>
</tr>
</thead>
<tbody>
<tr>
<td>REJECTION (%)</td>
<td>0.73</td>
<td>0.12</td>
</tr>
<tr>
<td>REPET. RATE (pulses)</td>
<td>0.83</td>
<td>1.25</td>
</tr>
<tr>
<td>PULSE WIDTH AT PEAK</td>
<td>4 x 10^{-6}</td>
<td>3 x 10^{-6}</td>
</tr>
<tr>
<td>INTERNAL BEAM (pulses)</td>
<td>3 x 10^{-6} (2.5 x 10^{-6})</td>
<td></td>
</tr>
<tr>
<td>BEAM EMITTANCE x</td>
<td>3.2 x 10^{-13}</td>
<td>3.2 x 10^{-13}</td>
</tr>
<tr>
<td>BEAM LINES</td>
<td>0.20 (25) x 0.20 (10)</td>
<td></td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent Improvements, etc.
Bending magnets and quadrupoles are 4-gaps stacked units fed by a static power converter. At 1 GeV, the four beams are ejected in sequence and combined by vertical septum and kicker magnets. Alternatively, the twenty bunches may be recombined into ten by simultaneous ejection of rings 3+2 and 4+1, and vertical bunching by a magnetic dipole, giving higher line density for antiproton production.

Recent Improvements
1) Tunes varying with time, necessitating compensation of $\delta Q_{11}$ and $\delta Q_{19}$ (structural stop-band).
2) Implementation of a second acceleration station per ring working at $h=10$, twice the fundamental, to flatten the bunch shape and thus raise the space-charge limit.
3) Increase of ejection energy to 1 GeV to ease space-charge effects in the CPS.
4) Acceleration of 0^+ and 1^+ ions to 326 MeV/amu with Linac 1 as injector.

Published articles describing machine
 Dubna 1976, Vol. 2 p. 271
 Stanford 1974 p. 195
 Geneva 1980 p. 299
 Washington 1981 p. 2803
 Washington 1987 p. 126 (ions)
 Chicago 1989 R. Cappi et al., Upgrading of the CERN PS Booster to 1 GeV for improved anti-proton production

*Emittance = Area x b at 90% of current (for p-machines)
HISTORY AND STATUS

CONSTRUCTION STARTED (date) 1956
FIRST BEAM OBTAINED, or GOAL (date) 1959
TOTAL COST OF FACILITY
TOTAL ACCELERATOR STAFF (now) ~ 44 man-years
ANN. OPERAT. BUDGET $500,000
(Without salaries)
ANN. OPERATING TIME 2000 h
(staff and budget including overheads)

ACCELERATOR PARAMETERS

Physical Dimensions
TOTAL LENGTH 29 m; No. TANKS 3
TANK DIAM. ~ 1 m; No. DRIFT TUBES 113
DRIFT TUBE LENGTHS ~ 39.6 - 320.8
DRIFT-TUBE DIAMETERS ~ 61.6 - 172.8
GAP CELL LENGTH ~ 0.25 - 0.305
APERTURE DIAM. ~ 16 mm to 33 mm

Ion Source
TYPE Duoplasmatron (ECR 15 GHz)
OUTPUT 80 (0.1) mA at 50 (5.6/amu) KeV
EMITTANCE* 2 (≤ 1) mm-mrad

Injector
TYPE RFQ (RFQ)
OUTPUT 75 (0.1) mA at 516 (193/amu) KeV
EMITTANCE* 2 (≤ 1) mm-mrad

Bunchers
TYPE 2 re-buncher systems
MODULATION 0.111 Hz, DRIFT 1 - mm at 202.5 MHz
181.11 Hz, DRIFT 2 - mm at 3 MHz
KeV, DRIFT 1 - mm at 7 MHz

Acceleration System
RF FREQUENCY 202.57 MHz
FIELD MODE Φ 10 rad
EQUIL PHASE ~ 30°
ACCEL RATE ~ 1.7 MeV/m
REPEITION RATE up to 1 Hz
DUTY FACTOR up to 0.03 % (RF); 0.02 to 0.011 % (Beam)
PULSE LENGTH ~ 0.05 μs (RF); ~ 0.11 μs (Beam)
EFFECTIVE SHUNT IMPEDANCE ~ 30 MΩ/m
FILLING TIME ~ 170 μs
RF POWER INPUT PEAK 5 (8) MW; MEAN 0.002 MW

Focusing System
No. QUADS 112 TYPE 70 DC ORDER 0
GRADIENTS 75 (100) to - 4 (5) T/m

Vacuum System
MATERIAL CHAMBER Steel
AVERAGE PRESSURE ~ 1.10-6 torr

*Emittance = Area x β at 90% current
NAME OF LINAC: CERN 50 MeV Proton Linac 2
INJECTOR FOR: 1 GeV PS Booster
LOCATION: CERN Geneva, Switzerland
PERSON IN CHARGE: R. BILLING, K. SCHINDL
DATA SUPPLIED BY: D. WARMER, C.E. HILL

HISTORY AND STATUS

CONSTRUCTION STARTED (date): November 1973
FIRST BEAM OBTAINED, or GOAL (date): September 1979
TOTAL COST OF FACILITY: 23 MSF
TOTAL ACCELERATOR STAFF (now) at 18 man-years/y
ANN. OPERAT. BUDGET: 650 KSF (without salaries)
ANN. OPERATING TIME: 7000 h (staff and budget including overheads)

ACCELERATOR PARAMETERS

Physical Dimensions
TOTAL LENGTH: 33.6 m, No. TANKS: 3
TANK DIAM. SE (7") in. No. DRIFT TUBES: 125 + 6 (1/2)
DRIFT TUBE LENGTHS: 40 mm to 316 mm
DRIFT TUBE Diameters: 100 mm (Tank 1), 160 mm (rest)
GAPCELLE LENGTH: 0.26-0.31, 0.70-0.29, 0.26-0.32
APERTURE DIAM: 20 mm to 30 mm

Ion Source
TYPE: Duoplasmatron (with expansion cup)
OUTPUT: 400 mA at 0 KeV
EMITTANCE*: 0 mrad

Injector
TYPE: High gradient column with Cockcroft-Walton
OUTPUT: 750 mA at 15 KeV
EMITTANCE*: 2 mrad

Buncher
TYPE: Three buncher system
MODULATION: 37 KeV, Drift 500 mm at 202.56 MHz
35 KeV, Drift 1600 mm at 405.12 MHz

Acceleration System
RF FREQ: 202.56 MHz
FIELD MODE: 1000 (see 2) 0 00000
EQUIL PHASE: 300 (see 2) ACCEL RATE: 1.40 MeV/m
REPETITION RATE: 2 PPS (Normal); 1 PPS (Max.)
DUTY FACTOR: 0.05 % (RF); 0.04 % (Beam)
PULSE LENGTH: 300 µsec (RF); 110 µsec (Beam)
EFFECTIVE SHUNT IMPEDANCE: 36 MQ/m
FILLING TIME: - µsec
RF POWER INPUT/Peak: 10 MW; MEAN 0.002 MW

Focusing System
No. QUADS: 131 TYPE: Pulsed ORDER: 1, 2, 3
GRADIENTS: 100 T/m
OTHER: pulse flat top w 220 A

Vacuum System
MATERIAL: Chamber: copper clad steel accelerating tanks
AVERAGE PRESSURE: 2 x 10^-7 torr

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>OUTPUT ENERGY (MeV)</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>50</td>
<td>150</td>
</tr>
<tr>
<td>ENERGY SPREAD Δ/ΔE (%)</td>
<td>± 0.25</td>
<td></td>
</tr>
<tr>
<td>CURRENT (mA)</td>
<td>140</td>
<td>150</td>
</tr>
<tr>
<td>EMITTANCE*</td>
<td>5 mm-mrad</td>
<td></td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent Improvements, etc.

1) 3 accelerating tanks 0.75-10.4-30.5-50.0 MeV of diameter 0.94, 0.90, 0.86 m resp.
2) Post coupled Alvarez Accelerating System Equilibrium phase -360 to 2σ (Tank 1), 2σ (rest)
RF parameters quoted are total or mean for 150 mA accelerated current at 1pps.
3) Performance is quoted after debunching.
4) Also accelerated deuterons (20 mA) to 11.6 MeV/amu

Published articles describing machine


*Emittance = Area x β at 90% current*
NAME OF SYNCHROTRON: AA Antiproton Accumulator
INJECTOR FOR: SPS, LEAR, PS
LOCATION: CERN, Meyrin, CH-1211 Geneva 23, SWITZERLAND
PERSON IN CHARGE: R. BILLINGE, F. PEDESEN
DATA SUPPLIED BY: F. PEDESEN, S. MAURY

DATE: 21.06.1989

HISTORY AND STATUS

CONSTRUCTION STARTED: July 1978
FIRST BEAM OBTAINED: July 1980
TOTAL COST OF FACILITY: 130 MFF (AC-MAA)
TOTAL ACCELERATOR STAFF (now): 11.5, 2.5 (MAA, MAA-AC)
ANN. OPERAT. BUDGET: 2,330 kSF (AC-MAA) (without salaries)
ANN. OPERATING TIME: 6,200 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES: Antiproton
ENERGY: 2.69 GeV
RING DIAMETER: 50 m; TUNNEL SECT. (W x H): 5 x 3 m

Injector
TYPE: AC (Antiproton Collector)
OUTPUT (max): 0.032 mAAt, 2760 MeV
EMITTA-N*: 95.05 m-mrad
INJECTION PERIOD: 0.5 µs, or 1 turn
INFLECTOR TYPE

Magnet System
FOODO: FIELD INDEX n =
FOCUSING TYPE
BETATRON FREQ. vₜ: 2.268
LENGTH (ea): 2.255 m
No. MAGNETS: 6, 4
BENDING FIELD (ea): 1.871, 6 T, at max
No. QUADS: 24
GRAD. at max: F = 0.18 Tm; at max
No. SHORT STRAIGHT SECT.: 8
LENGTH: 6 m
No. LONG STRAIGHT SECT.: 12
LENGTH: 2.6 m
RISE TIME: 6; FLAT-TOP TIME: 2 s
POWER INPUT PEAK: 3.2 MW; MEAN: 3.2 MW

Acceleration System
No. CAVITIES:
HARMONIC NUMBER: 1
RF RANGE: 1.840 to 1.86 MHz
ENERGY GAIN: 14 KeV/turn
RADIATION LOSS: KeV/turn
RF POWER INPUT PEAK: kW; MEAN: kW

Vacuum System
MATERIAL OF VAC.CHAMBER: Stainless steel
APERTURE OF VAC. CHAMBER: up to 1100 mm
AVERAGE PRESSURE: 7 x 10⁻¹¹ torr

Extraction System
TYPE: Fast kickers + septum magnets
LENGTH OF SPLICE: to µs

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>2.69</td>
</tr>
<tr>
<td>RESOLUTION ΔE/ΔE (%)</td>
<td>&lt; ΔE/ΔE = 1.6 x 10⁻⁴</td>
</tr>
<tr>
<td>REPET. RATE (pulse/s)</td>
<td>4 x 10⁸</td>
</tr>
<tr>
<td>PULSE WIDTH AT PEAK E</td>
<td>5 x 10⁻¹⁰</td>
</tr>
<tr>
<td>INTERNAL BEAM (particels/parsec)</td>
<td>1 x 10¹²</td>
</tr>
<tr>
<td>BEAM EMITTANCE *</td>
<td>&lt; 7.7 x 7.7 nm-mrad</td>
</tr>
<tr>
<td>BEAM LINES TO</td>
<td>1.15 x 10¹²</td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent improvements, etc.

*Emittance = Area x p, at 95% of current (for p-machines)
NAME OF SYNCHROTRON: ANTIPROTON COLLECTOR: AC
INJECTOR FOR: AA
LOCATION: CERN, Meyrin, CH-1211 Geneva 23, SWITZERLAND
PERSON IN CHARGE: R. BILLINGE, F. PEDERSEN
DATA SUPPLIED BY: F. PEDERSEN, S. MAURY

DATE: 21.06.1989

-- 8 --

HISTORY AND STATUS
CONSTRUCTION STARTED (date): July 1986
FIRST BEAM OBTAINED, OR GOAL (date): JUNE 1987
TOTAL COST OF FACILITY: 1.25 M$ (CHF+AA)
TOTAL ACCELERATOR STAFF (now): (includes, in AA) (without salaries)
ANNUAL OPERATING TIME: 5200 h

ACCELERATOR PARAMETERS
General
ACCELERATED PARTICLES: Antiprotons
ENERGY: 2.76 GeV
RING DIAM: 54 m; TUNNEL SECT. (W x H): 5 x 3 m

Injector
TYPE: Target
OUTPUT (max): 0.042 mA at 2750 MeV
EMITTANCE*: 752 x 762 nm µrad or 1 mµ rad
INJECTION PERIOD: 0.5 µs; or 1 turn
INJECTOR TYPE: Septum magnet and fast kickers

Magnet System
FOCUSING TYPE: FOC0
FOCUSING ORDER:
BETATRON FREQ. ωh: 5.46
BETATRON INDEX υ: 5.41
No. MAGNETS: 24
LENGTH (ea): 2.20 m
BENDING FIELD AT INJ.: 1.2 T; AT MAX T
No. QUADS: 56
LENGTH (ea): 0.80 m
GRAD. AT INJ.: 6/6.8 T/m; AT MAX T/m
No. S. STRAIGHT SECT.: 24
LENGTH: 2.50 m
RISE TIME: 5 FLAT TOP TIME
POWER INPUT PEAK: 3.5 MW; MEAN: 3.5 MW

ACCELERATION SYSTEM (Bunch rotation + debunching cavities)
No. CAVITIES: 2
LENGTH (ea): 2.40 m
HARMONIC NUMBER: 6
RF RANGE: 9.53686E5 to MHz
ENERGY GAIN: 1500 (on both cavities) KeV/turn
RADIATION LOSS:
RF POWER INPUT PEAK: KW; MEAN: KW

Vacuum System
MATERIAL OF VAC. CHAMBER: Stainless steel
APERTURE OF VAC. CHAMBER: up to 500 mm
AVERAGE PRESSURE: < 10^-5 torr

Extraction System
TYPE: Fast kickers + septum magnets
LENGTH OF SPILL: to 0.25 µs

ACCELERATOR PERFORMANCE
ENERGY (GeV) Normal (or Goal) Maximum achieved
2.76
0.417 0.208
REPET. RATE (pulse/s): x10^-9 7.6x10^-9
PULSE WIDTH AT PEAK E:
INTERNAL BEAM (part/pulse) (µm/µrad):
BEAM EMITTANCE*: 95x95 69x69
BEAM LINES TO:

*Emittance = Area x p at 95% of current (for p-machines)
**NAME OF SYNCHROTRON**
LEAR (Low Energy Antiproton Ring)

**INSTITUTION**
CERN PS

**LOCATION**
PS: South Hall

**PERSON IN CHARGE**
R. BILLINGE, F. PEDERSEN

**DATA SUPPLIED BY**
R. CHANEL, D. MOHL

**DATE:**
21.06.1989

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**HISTORY AND STATUS**

**CONSTRUCTION STARTED (date):**
1981

**FIRST BEAM OBTAINED, OR GOAL (date):**
End 1982

**TOTAL COST OF FACILITY**
≈ 10 MSF @ 5 NPS (consolidation)

**TOTAL ACCELERATOR STAFF (now):**
21 men/year/shift

**ANN. OPERATING BUDGET (now):**
650 KFS (without salaries)

**ANN. OPERATING TIME:**
5200 h

---

**ACCELERATOR PARAMETERS**

**General**

**ACCELERATED PARTICLES:**
Antiprotons, protons, H

**ENERGY:**
5 – 1200 MeV

**RING DIAM.:**
25 m; TUNNEL SECT. (W x H) = 1/2 m

**Injector**

**TYPE:**
Antiproton Accumulator via PS

**OUTPUT (max):** 2.10^11 1/hour m^2

**EMITTANCe: Vert. = 10^{-2} mrad, Hor. = 20 mrad

**INJECTION PERIOD:**
0.48 μs, or 1.5 turn

**INJECTOR TYPE:**
Magnetic septum + full aperture kicker

**Magnet System**

**FOCUSING TYPE & FIELD INDEX n:**
FOCUSING ORDER μ, δ

**BETATRON FREQU.:**
μ = 2.30, δ = 2.73

**No. MAGNETS:**
4

**LENGTH (ea):**
0.86 m

**BENDING FIELD:**
μ = 1.6 T, δ = 1.6 T

**GRAD. at min.:**
δ = 9.4 T/m

**NO. SHORT STRAIGHT SECT:**
4

**LENGTH:**
0.15 m

**RISSE TIME:**
10 μs

**FLAT TOP TIME:**
1000 μs

**POWER INPUT PEAK:**
1 MW; MEAN: 0.5 MW

**ACCELERATION SYSTEM**

**No. CAVITIES:**
2

**HARMONIC NUMBER:**
1/2/4/8

**RF RANGE:**
0.38 to 3.5 MeV/k

**ENERGY GAIN:**
< 10 MeV/k

**RF POWER INPUT PEAK:**
KWM, MEAN KWM

**Vacuum System**

**MATERIAL OF VAC. CHAMBER:**
Stainless steel bakeable

**APERTURE OF VAC. CHAMBER:**
155x90 to 170x54 mm

**AVERAGE PRESSURE:**
2.5 x 10^{-12} torr

**Extraction System**

**TYPE:**
Superslow stochastic extraction

**LENGTH OF SCRIP:**
0 μs to 2.10^10 μs

**Options:**
- Internal target (installation in progress)
- Co-rotating beam of H and p for protonium formation in flight
- p-p colliding beams.

**Improvments:**
Lower momenta (61.2 MeV/c ± 1 MeV), electron cooling, beam stability for high beam density.

---

**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th>Energy (GeV)</th>
<th>Normal</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.05 - 1.250</td>
<td>1.200</td>
<td></td>
</tr>
</tbody>
</table>

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**SECONDARY BEAMS**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other inform.</th>
</tr>
</thead>
<tbody>
<tr>
<td>p, n</td>
<td>0 – 2 GeV/c</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

---

**EXPERIMENTAL FACILITY**

<table>
<thead>
<tr>
<th>TOTAL EXPERIMENTAL AREAS</th>
<th>≈ 2000 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. INTERNAL TARGETS</td>
<td>No. EXT. TARGETS</td>
</tr>
<tr>
<td>No. SEPARATED BEAMS</td>
<td>3</td>
</tr>
<tr>
<td>No. BEAMS SERVED AT SAME TIME</td>
<td>7</td>
</tr>
<tr>
<td>TOTAL POWER USED (AVERAGE) FOR RESEARCH</td>
<td>4500 MW</td>
</tr>
<tr>
<td>No. USER GROUPS, inhouse</td>
<td>outside</td>
</tr>
<tr>
<td>TOTAL RESEARCH STAFF, inhouse</td>
<td>outside</td>
</tr>
<tr>
<td>ANN. RESEARCH BUDGET, inhouse</td>
<td>(without sal.)</td>
</tr>
<tr>
<td>ANNUAL RESEARCH TIME</td>
<td>≈ 4500 h</td>
</tr>
</tbody>
</table>
NAME OF SYNCHROTRON  SATURNE

INSTITUTION  SATURNE NATIONAL LABORATORY - J. ARVIEUX - Director
LOCATION  C.E.N. SACLAY 91191 GIF-SUR-YVETTE CEDRIX
PERSON IN CHARGE  PA. CHAMOUD - Operation Service
DATA SUPPLIED BY  W. OLIVIER - A. YAKSHINNO - PA. CHAMOUD

HISTORY AND STATUS

CONSTRUCTION STARTED (date)  1974
FIRST BEAM OBTAINED, OR GOAL (date)  1978
TOTAL COST OF FACILITY
ACCELERATOR STAFF(now)  (without salaries)
ANN. OPERAT. BUDGET  h
ANN. OPERATING TIME 5000

ACCELERATOR PARAMETERS

1) General
ACCELERATED PARTICLES  p, d, and HI : p, d
ENERGY 30 GeV
RING DIAM. 33.8 m; TUNNEL SEC. (W x H) m

2) Injector
TYPE LINAC (p-d) - Synch. KIMAS (others)
OUTPUT [(max) mA] MeV
EMITTANCE* mm-mrad
INJECTION PERIOD μs or turns
INJECTOR TYPE Electrostatic

Magnet System
FOCUSING TYPE STRONG FIELD INDEX n = 0
FOCUSING ORDER FOODO - SEP. FUNCTIONS
BETATRON FREQ. vu 3.64 vu 3.61
NO. MAGNETS 16 LENGTH(ef) 2.49 m
LENDBING FIELD (m) 0.1 T; at max 1.8 T
NO. QUADRUPoles 24 LENGTH(q) 0.45 + 0.47 m
GRAD. at ing 1/m; at max 1/m

3) No. SHORT STRAIGHT 32 LENGTH 0.73 m
No. LONG STRAIGHT 8 LENGTH 3.94 m
RECEIVED 0.5 T; FLAT TOP TIME See spill s
POWER INPUT PEAK 16 MW; MEAN kW

AcCELERATION System
No. CAVITIES 2 LENGTH(ef) 3.94 m
HARMONIC NUMBER 3
RF RANGE P: 1.7 to 8.8 MHz
ENERGY GAIN 2.8 keV/turn
RADIATION LOSS 7 keV/μA
RF POWER INPUT PEAK 56 each kW; MEAN kW

Vacuum System
MATERIAL OF VAC. CHAMBER Stainless steel
APERTURE OF VAC. CHAMBER 240 x 120 mm
AVERAGE PRESSURE 4 x 10^-9 torr

Extraction System
TYPE 1) Third Int. Res. Extraction

LENTH OF SPILL 1) 30 ms to 1000 ms μs
2) 30 to μs
3) 30 to μs

ACCELERATOR PERFORMANCE / P

ENERGY (GeV) Normal (or Goal) Maximum achieved
(Or Goal) 3 4
REPET. RATE (pulse/s) 0.33 0.33
PULSE WIDTH AT PEAK E 2.10 12
INTERNAL BEAM (par/pulse) 1.510 12
(particle) 3.150 12
EMITANCE* AT PEAK E 2.10 4
H 16 μm mrad
V 49 μm mrad
polarization > 90% d
SECONDARY BEAMS > 80% p

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS 6000 m²
No. INTERNAL TARGETS / No. EXT. TARGETS 9
No. SEPARATED BEAMS 9
Beams SERVED AT SAME TIME 2
TOTAL POWER USED (AVERAGE FOR RESEARCH 7 MW
No user GROUPS, in house outside
TOTAL RESEARCH STAFF, in house 120 outside 120
ANN. RESEARCH BUDGET, in house (without sel.)

Other Relevant Parameters, Recent Improvements, etc.
1) See also HI Synchrotrons
2) See Linacs and Synchrotron KIMAS
3) A long straight section is 2 SD of 3.94 m each.

*Emittance = Area x β at 90% of current (for p-machines)
HISTORY AND STATUS

CONSTRUCTION STARTED (date) 1983
FIRST BEAM OBTAINED, OR GOAL (date) 1987
TOTAL COST OF FACILITY
TOTAL ACCELERATOR STAFF (now) 300
ANN. OPERATING BUDGET (without salaries)
ANN. OPERATING TIME 4500 h

ACCELERATOR PARAMETERS

General
ACCELERATING PARTICLES \( \overrightarrow{f_n} \overrightarrow{d_n} \) H.I.
ENERGY 47 MeV p, 12 MeV/amu HI
RING DIAM 11.7 m; TUNNEL SECT. (WxH) m
Injector
TYPE RFQ and 400 KV C.W.
OUTPUT (max) mA
EMITTANCE* \( 3.10^{-6} \) mrad
INJECTION PERIOD 1000 \( \mu \)s or 130 turns
INFLECTOR TYPE Electrostatic

Magnet System
FOCUSING TYPE STRONG
FIELD INDEX \( n = 0 \)
FOCUSING ORDER 8000
BETATRON FREQ. \( v_b \) 2.22
No. MAGNETS 8
LENGTH (ea) 0.842 m
BENDING FIELD at in. 0.08 T; at max 0.97 T
No. QUADS 16
LENGTH (ea) 0.4 m
GRAD. at in. 0.04 Tm; at max 1.85 Tm
No. SHORT STRAIGHT SECT. 16
LENGTH 0.45 m
No. LONG STRAIGHT SECT. 8
LENGTH 2.034 m
RISE TIME 0.18
FLAT-TOP TIME 40 ms
POWER INPUT PEAK 10 MW; MEAN .5 MW

Acceleration System
No. CAVITIES 2
LENGTH (ea) 1.4 m
HARMONIC NUMBER 1
RF RANGE 0.16 to 2.48 MHz
ENERGY GAIN 0.2 Kev/turn
RADIATION LOSS / Kev/turn
RF POWER INPUT PEAK 4 each kW; MEAN kW

Vacuum System
MATERIAL OF VAC. CHAMBER Stainless steel
APERTURE OF VAC. CHAMBER 150 x 280 mm
AVERAGE PRESSURE 3.10^-11 torr

Extraction System
TYPE FAST/KICKERS
LENGTH OF SPILL 0.2 to 1. \( \mu \)s

ACCELERATOR PERFORMANCE /p

<table>
<thead>
<tr>
<th>ENERGY (GeV)</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent Improvements, etc.

1) HI: from Carbon to Krypton (1989)

2) 47 MeV p

Other Relevant Parameters, Recent Improvements, etc.

3) \( \beta \)

Other Relevant Parameters, Recent Improvements, etc.

4) \( \beta \)

Other Relevant Parameters, Recent Improvements, etc.

5) \( \beta \)

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x \( \beta \) at 90% of current (for p-machines)
**NAME OF LINAC**
20 MeV LINAC

**INJECTOR FOR**
SATURNE

**LOCATION**
LABORATOIRE NATIONAL SATURNE - J. ARVIEUX - Director

**PERSON IN CHARGE**
JL. LEMAIRE

**DATE**
20/06/89

---

**HISTORY AND STATUS**

<table>
<thead>
<tr>
<th>CONSTRUCTION STARTED (date)</th>
<th>1966</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST BEAM OBTAINED, or GOAL (date)</td>
<td>1969</td>
</tr>
<tr>
<td>TOTAL COST OF FACILITY</td>
<td></td>
</tr>
<tr>
<td>TOTAL ACCELERATOR STAFF (now)</td>
<td></td>
</tr>
<tr>
<td>ANNUAL OPERATING BUDGET (without salaries)</td>
<td>500 h</td>
</tr>
</tbody>
</table>

---

**ACCELERATOR PARAMETERS**

**Physical Dimensions**

| TOTAL LENGTH | 10.47 m |
| TANK DIAM | 3.5 m |
| DRIFT TUBE LENGTH | 4.53 to 10.23 cm |
| DRIFT TUBE DIAMETERS | 18 to 18 cm |
| GAP CELL LENGTH | 0.26 to 0.32 |
| APERTURE DIAM | 0.79 cm to 1.25 cm |

**Ion Source**

| TYPE | Du plasmotron - Von Ardenne |
| OUTPUT | mA at |
| EMITTANCE* | mmm-mrad |

**Injector**

| TYPE | Pressurized Cockerill Walton |
| OUTPUT | mA at |
| EMITTANCE | mmm-mrad |

**Bunchers**

| TYPE | |
| OUTPUT | mA at |
| EMITTANCE | mmm-mrad |

**Acceleration System**

| RF FREQ | 200 MHz |
| FIELD MODE | TM010 |
| ACCEL RATE | 1.61 MeV/m |
| REPETITION RATE | 1.1 Hz |
| DUTY FACTOR | 0.1 |
| PULSE LENGTH | 500 µs |
| EFFECTIVE SHUNT IMPEDANCE | 60 Ω |
| FILLING TIME | 30 µs |
| RF POWER INPUT PEAK | 2.3 MW |
| MEAN | 0.3 MW |

**Focusing System**

| NO. QUADS | 58 |
| GRADIENTS | 10 |
| ORDER | 6.4 |

**Vacuum System**

| MATERIAL CHAMBER | Ionics pumpa |
| AVERAGE PRESSURE | 1.1 x 10^-7 torr |

---

**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th>OUTPUT ENERGY (MeV)</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>20</td>
<td>0.8</td>
<td>20</td>
</tr>
<tr>
<td>23</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>2.8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Other Relevant Parameters, Recent Improvements, etc.**

- **a)** used in 2 π mode for particles injected at 187.5 KEV/amu and accelerated to 5 MeV/amu
  - 2π, He, 7 He
  - d, He, 3 He, 4

- **b)** used for multturn injector in Saturne
  - t = 450 µs ; 260 turns.
NAME OF SYNCHROTRON: 12 GeV Proton Synchrotron (KEK-PS)
INSTITUTION: KEK, National Laboratory for High Energy Physics
LOCATION: Tsukuba, Ibaraki, 305, Japan
PERSON IN CHARGE: M. Kihara
DATA SUPPLIED BY: M. Kihara

HISTORY AND STATUS
CONSTRUCTION STARTED (date): April 1971
FIRST BEAM OBTAINED, or GOAL (date): March 1976 (3 GeV)
TOTAL COST OF FACILITY: 5 x 10^11 Y
TOTAL ACCELERATOR STAFF (now): 55
ANN. OPERAT. BUDGET: 4000 h (without salaries)
ANN. OPERATING TIME: 4000 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES: 6.5 x 10^17 pp
ENERGY: 12 GeV
RING DIAM: 108 m, TUNNEL SECT. (W x M): 4 x 6 m

Injector
TYPE: 40 MeV Linac + 500 MeV Booster Synchrotron
OUTPUT(MAX): 1 x 10^11 pp, Max MAX 500 MeV
EMITTANCE*: 5 x 10^-7 m x mrad
INJECTION PERIOD: 5 x 10^-3 s, or 9 pulses
INJECTOR TYPE: magnetic septum + Fast kickers

Magnet System
FOCUSING TYPE AG, separated FIELD INDEX n =
FOCUSING ORDER: FODO
BETATRON FREQUENCY: 7.12
V_y: 7.22
No. MAGNETS: 48
LENGTH(ea): 1.72 m
BENDING FIELD: at i 0.15 T, at max 1.75 T
No. QUADS: 56
LENGTH(ea): 0.6 m
GRAD. AT i: 1.5 T/m, at max 18.1 T/m
No. SHORT STRAIGHT SECT: 46
LENGTH: 1.84 m
No. LONG STRAIGHT SECT: 8
LENGTH: 5.45 m
RISE TIME: 0.63 s, FLAT-TOP TIME: 0.65 s
POWER INPUT PEAK: 27 MW, MEAN: 2.3 MW

Acceleration System
No. CAVITIES: 4
HARMONIC NUMBER: 9
RF RANGE: 0.03 to 7.93 MHz
ENERGY GAIN: 20 Kev/turn
RADIATION LOSS: Kev/turn
RF POWER INPUT: 160 kW, MEAN: 80 kW

Vacuum System
MATERIAL OF VAC.CHAMBER: stainless steel (316L)
APERTURE OF VAC. CHAMBER: 15 x 50 mm
AVERAGE PRESSURE: 1 x 10^-7 torr

Extraction System
TYPE: Slow extraction (half-integer)

*Emittance = Area x ', at 90% of current (for p-machines)

ACCELERATOR PERFORMANCE
ENERGY (GeV): Normal (or Goal): Maximum achieved
12
12

RESOLUTION ΔE/E (%): 0.1
ΔE/E: 0.03
REP. RATE (pulses): 0.3
PULSE WIDTH AT PEAK E: 0.3 sec
INTERNAL BEAM (part/pulse): 4 x 10^-2
(part): 5 x 10^-2
EMITTANCE* AT PEAK E: 1.6 x 10^-1
mm-mrad

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other inform.</th>
</tr>
</thead>
<tbody>
<tr>
<td>e^-/e^+</td>
<td>0.5 - 2 GeV/c</td>
<td>2 x 10^10/pp (p^+)</td>
<td>K3</td>
</tr>
<tr>
<td>P^-/P^+</td>
<td>0.5 - 1 GeV/c</td>
<td>5 x 10^9/pp (p^+)</td>
<td>K2</td>
</tr>
<tr>
<td>K^-/K^+</td>
<td>0.1 - 5 GeV/c</td>
<td>5 x 10^10/pp (p^-)</td>
<td>K0</td>
</tr>
<tr>
<td>π^-/π^+</td>
<td>1 - 4 GeV/c</td>
<td>2 x 10^10/pp (π^-)</td>
<td>T2</td>
</tr>
<tr>
<td>K^-/π^+</td>
<td>0.5 - 2.5 GeV/c</td>
<td>5 x 10^9/pp (π^-)</td>
<td>T1</td>
</tr>
<tr>
<td>π^-/π^+</td>
<td>0.5 - 6 GeV/c</td>
<td>1 x 10^10/pp (π^-)</td>
<td>T2</td>
</tr>
</tbody>
</table>

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS: 5000 m^2
No. INTERNAL TARGETS: 1
No. EXT. TARGETS: 5
No. SEPARATED BEAMS: 2
No. BEAMS SERVED AT SAME TIME: 30
TOTAL POWER USED (AVERAGE) FOR RESEARCH: 6 MW
No. USER GROUPS, in house: 8
TOTAL RESEARCH STAFF, in house: 30
ANNUAL RESEARCH BUDGET, in house: 1.2 x 10^5 yen (without tax)
ANNUAL RESEARCH TIME: 4000 h

Other Relevant Parameters, Recent Improvements, etc.

Improvement programs underway:
(1) Duty-factor improvement (Present 0.5 ms to 2 ms)
will finish in October, 1990.
(2) A new experimental hall will be available late 1989.
NAME OF SYNCHROTRON
Booster Synchrotron for KEK-PE

INJECTOR FOR
12 GeV Proton Synchrotron

LOCATION
Tochigi, Ibaraki, 305, Japan

PERSON IN CHARGE
M. Kihara

DATA SUPPLIED BY
M. Kihara

DATE:
July 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date) April 1971
FIRST BEAM OBTAINED, OR GOAL (date) December 1974
TOTAL COST OF FACILITY
TOTAL ACCELERATOR STAFF (now) (without salaries)
ANN. OPERAT. BUDGET
ANN. OPERATING TIME

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES \(2.2 \times 10^{12}\) ppp
ENERGY 0.5 GeV
RING DIAM 12 m; TUNNEL SECT. (W x H) m

Injector
TYPE Linac (H)
OUTPUT (max) 10 mA at 40 MeV
EMITTANCE* 3 \(\mu m\)-radian
INJECTION PERIOD 80 \(\mu s\), or \(\mu s\) turns
INJECTOR TYPE magnetic

Magnet System
FOCUSING TYPE AC, Combined FIELD INDEX n = 12.1
FOCUSING ORDER FDUO
BEATRON FREQ. \(f_b\) 2.17 \(\nu_b\) m
No. MAGNETS 8 LENGTH(zz) 2.6 m
BENDING FIELD (at in. 0.26 T, at max 1.1 T
No. QUADS LENGTH (zz) m
GRAD. at in. \(T/m\), at max \(T/m\)
No. SHORT STRAIGHT SECT. 8 LENGTH 2.0 m
No. LONG STRAIGHT SECT. LENGTH m
RISE TIME 20 \(\mu s\), flat-top time \(\mu s\)
POWER INPUT PEAK MW; MEAN 0.5 MW

Acceleration System
No. CAVITIES 2 LENGTH(zz) 1.6 m
HARMONIC NUMBER 1
RF RANGE 2.25 to 6.03 MHz
ENERGY GAIN 5.4 Kev/turn
RADIATION LOSS KeV/turn
RF POWER INPUT PEAK 100 kW; MEAN 30 kW

Vacuum System
MATERIAL OF VAC.CHAMBER stainless steel (316L) (corrugated)
APERTURE OF VAC. CHAMBER 140 x 60 mm
AVERAGE PRESSURE 1.3 x 10^{-4} torr

Extraction System
TYPE one-turn extraction by kickers
LENGTH OF SPILL \(\mu s\)

ACCELERATOR PERFORMANCE

ENERGY (GeV) Normal Maximum
(or Goal) achieved
0.5 0.5

RESOLUTION \(\Delta E/E (\%)\) 
\(\pm 0.5\) \(\pm 0.5\)

REPET. RATE (pulse/s) 20 20

PULSE WIDTH AT PEAK \(E\) \(80 \text{ ns}\) \(80 \text{ ns}\)

INTERNAL BEAM \(\text{(particle/pulse)}\)
\(2.2 \times 10^{12}\) \(2.2 \times 10^{12}\)
\(4.4 \times 10^{13}\) \(4.4 \times 10^{13}\)

BEAM EMITTANCE* \(35 (H), 45 (V) + (99 \%) \text{ nm-radian}\)

BEAM LINES TO KEK-PE and BSF**

Other Relevant Parameters, Recent Improvements, etc.

* At a beam intensity of \(1.8 \times 10^{12}\) ppp.
** BSF: Booster Synchrotron Utilization Facility.
It consists of pulsed spallation neutron source (KENS), Masen Science Laboratory (DOOM) and Particle Radiation Medical Science Center (PARMS).

* Emittance = Area x p at 90% of current (for p-machines)
**NAME OF LINAC**
40 MeV Injector for KEK-PS

**INJECTOR FOR**
12 GeV Proton Synchrotron

**LOCATION**
Tochigi, Ibaraki, 305, Japan

**PERSON IN CHARGE**
M. Kihara

**DATA SUPPLIED BY**
M. Kihara

**DATE:** July 1989

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**HISTORY AND STATUS**

| CONSTRUCTION STARTED (date) | April 1971 |
| FIRST BEAM OBTAINED, or GOAL (date) | August 1974 |
| TOTAL COST OF FACILITY |  |
| TOTAL ACCELERATOR STAFF (now) | (Without salaries) |
| ANNUAL OPERATING BUDGET | 4000 |

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**ACCELERATOR PARAMETERS**

**Physical Dimensions**

| TOTAL LENGTH | 5.5/12.9 m; NO. TANKS | 2 |
| TANK DIAM | 0.94/0.9 m; NO. DRIFT TUBES | 90/35 |
| DRIFT TUBE LENGTH | 2.329 ~ 28.79 cm |
| DRIFT TUBE DIAMETERS | 18/15 cm |
| GAPCELL LENGTH | 0.21 ~ 0.317 |
| APERTURE DIAM. | 20 ~ 20 (1st tank) mm to 30 (2nd tank) mm |

**Ion Source**

| TYPE | Cusp H- Ion Source |
| OUTPUT | 25 mA at 750 KeV |
| EMITTANCE* | 1.4 mm-mrad |

**Injector**

| TYPE | Cockcroft-Walton |
| OUTPUT | 25 mA at 750 KeV |
| EMITTANCE* | 1.4 mm-mrad |

**Bunchers**

| TYPE | Coaxial, two gaps |
| MODULATION | 16 KeV, DRIFT # 94.2 mm at 20.1 MHz |
| KeV, DRIFT # | mm at MHz |

**Acceleration System**

| RF FREQ | 201.0669 MHz |
| FIELD MODE | TM11a |
| EQUIL PHASE | 35° |
| ACCEL RATE | 1.23/1.57 Mev/m |
| REPETITION RATE | 20 Hz |
| DUTY FACTOR | 0.55 |
| PULSE LENGTH | 275 μs (RF), 80 μs (Beam) |
| EFFECTIVE SHUNT IMPEDANCE | 53/46 MΩ/m |
| FILLING TIME | % 60 |
| RF POWER INPUT PEAK | 1.3 MW; MEAN 0.006 MW |

**Focusing System**

| NO. QUADS | 90/35 |
| TYPE | Magnet | ORDER | PERM. MAGNET FOR 2nd TANK |
| GRADIENTS | 110 | 22 |
| OTHER | |

**Vacuum System**

| MATERIAL CHAMBER | Copper, plating steel |
| AVERAGE PRESSURE | 1 x 10^-5 |

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**ACCELERATOR PERFORMANCE**

| OUTPUT ENERGY (MeV) | Normal (or Goal) | Maximum achieved |
| ENERGY SPREAD ΔE/E (%) | 0.3 | 0.8 |
| CURRENT (mA) | 10 | |
| EMITTANCE* | 2.4 | 3 mm-mrad |

**Other Relevant Parameters, Recent Improvements, etc.**

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*Emittance = Area x p at 90% current*
NAME OF SYNCHROTRON: ISIS
INSTITUTION: Rutherford Appleton Laboratory
LOCATION: Chilton, Didcot, Oxon., UK
PERSON IN CHARGE: D.A. Grey
DATE: 1/8/89
DATA SUPPLIED BY: M.R. Harold

HISTORY AND STATUS
CONSTRUCTION STARTED (DATE): 1977
FIRST BEAM OBTAINED, OR GOAL (DATE): 1986
TOTAL COST OF FACILITY £60M new + £60M old (incl. staff costs)
TOTAL ACCELERATOR STAFF (now): 102
ABB. OPERAT. BUDGET: £3400 K (without salaries)
ABB. OPERATING TIME: ~ 5000 h

ACCELERATOR PARAMETERS

<table>
<thead>
<tr>
<th>General</th>
<th>Protons</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY</td>
<td>0.8 GeV</td>
</tr>
<tr>
<td>RING DIAM.</td>
<td>52 m, TUNNEL SECT (W x H) m</td>
</tr>
</tbody>
</table>

Injextor
TYPE: Alvarez Linac
OUTPUT (max) | 20 mA, 70.4 MeV
EMITTANCE* | 0.9 mm-mrad
INJECTION PERIOD | 470 μs, or 100 turns
INJECTOR TYPE | H' Stripping foil

Magnet System
FOCUSING TYPE | AC |
FIELD INDEX n | 3.3 |
FOCUSING ORDER | 50 |
BIOTRON FREQ. | 60, 00, 02, 04 |
NO. MAGNETS | 10 |
LENGTH (ea) | 4.6 m |
BENDING FIELD at inj. | 0.176 T, at max 0.607 T |
NO. QUADS | 30 |
LENGTH (ea) | 0.76, 0.4 m |
GRAD. at inj. | 1.1 μrad |
LENGTH (ea) | 10 |
NO. SHORT STRAIGHT SECT | 10 |
LENGTH | 3.05 m |
NO. LONG STRAIGHT SECT | 10 |
LENGTH | 5.32 m |
RSE TIME | 0.91 μs, FLAT TOP TIME | s |
POWER INPUT PEAK | 175 MW |

ACCELERATION SYSTEM
NO. CAVITIES | 6 |
LENGTH (ea) | 1.14 m |
RF RANGE | 1.34 to 3.06 MHz |
ENERGY GAIN | 65 Kev/turn |
RADIATION LOSS | Kev/turn |
RF POWER INPUT PEAK | 910 MW, MEAN 530 kW |

Vacuum System
MATERIAL OF VAC CHAMBER | Alumina |
APERTURE OF VAC. CHAMBER | 160 mm |
AVERAGE PRESSURE | < 3.10^-7 torr |

Extraction System
TYPE | Single turn |

LENGTH OF SPILL | 0.45 μs, to ~ μs |

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>0.8</td>
</tr>
<tr>
<td>RESOLUTION δE/E (%)</td>
<td>0.4</td>
</tr>
<tr>
<td>REPET. RATE (pulses)</td>
<td>50</td>
</tr>
<tr>
<td>PULSE WIDTH AT PEAK E</td>
<td>2.5 × 10^-4 s, 1.6 × 10^-2 s</td>
</tr>
<tr>
<td>INTERNAL BEAM (part/pulse)</td>
<td>2.5 × 10^-4 s, 1.6 × 10^-2 s</td>
</tr>
<tr>
<td>EMITTANCE* AT PEAK E</td>
<td>1.20 × 125 mm-mrad</td>
</tr>
</tbody>
</table>

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other inform.</th>
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<tbody>
<tr>
<td>Neutron</td>
<td>14</td>
<td>18 available</td>
<td></td>
</tr>
<tr>
<td>Neutrons</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Muons</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Protons</td>
<td>1</td>
<td>Test beam</td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS | 3050 m² |
No. INTERNAL TARGETS | 1 |
No. EXT. TARGETS | 2 |
No. SEPARATED BEAMS | |
NO. BEAMS SERVED AT SAME TIME | |
TOTAL POWER USED (AVERAGE) FOR RESEARCH | MW |
No. USER GROUPS, in house | 6 |
outside | > 50 |
TOTAL RESEARCH STAFF, in house | 22 |
outside | 100 |
ANNUAL RESEARCH BUDGET, in house | 700k (without sal.) |
ANNUAL RESEARCH TIME | 9700 h |

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x p at 90% of current (for p-machines)
HISTORY AND STATUS

CONSTRUCTION STARTED (date) 1977 - Conversion to H^+
FIRST BEAM OBTAINED, or GOAL (date) Jan. 1983
TOTAL COST OF FACILITY See note below
TOTAL ACCELERATOR STAFF (now) See ISIS Synchrotron
ANN. OPERAT. BUDGET " (without salaries)
ANN. OPERATING TIME "

ACCELERATOR PARAMETERS

Physical Dimensions
TOTAL LENGTH 64 m; No. TANKS 4
TANK DIAM., mm 381; No. DRIFT TUBES 148
DRIFT TUBE LENGTHS 45.4 - 240.7 mm
DRIFT TUBE DIAMETERS 180.0, 272.8, 272.8, 160 mm
GAP/CYL LENGTH 0.21 - 0.37
APERTURE DIAM. 20 - 30 mm (Tanks 243 - 31.3 mm)

Ion Source
TYPE H Penning
OUTPUT max 30 mA
EMITTANCE* 18 KeV

Injector
TYPE Cockcroft-Walton
OUTPUT max 30 mA; 665 KeV
EMITTANCE* 1.7 x 3.5 mm-mrad

Bunchers
TYPE Coaxial resonator-double gap
MODULATION 3323 KeV, DRIFT TIME 6080 μs at 202.5 MHz KeV, DRIFT TIME 6080 μs at 202.5 MHz

Acceleration System
RF FREQ. 202.5 MHz
FIELD MODE E(010) 0, 40, 60, 60, 60 kHz
EQUIL PHASE - 30° ACCEL RATE 0.86 - 1.77 MeV/m
REPEITION RATE 50 Hz
DUTY FACTOR Design 3.5 % (RF); Design 2.5 % (Beam)
PULSE LENGTH 700 μs (RF); 500 μs (Beam)
EFFECTIVE SHUNT IMPEDANCE 125 MΩ
RF POWER INPUT PEAK 7.0 MW; MEAN 0.24 MW

Focusing System
GRADIENTS 152 TYPE Pulsed 4th de ORDER FM
OTHER 125 μs

Vacuum System
MATERIAL CHAMBER Steel
AVERAGE PRESSURE 1 x 10^-6 torr

*Emittance = Area x β at 90% current

OTHER RELEVANT PARAMETERS, RECENT IMPROVEMENTS, ETC.

Originally built as a low duty cycle proton linac, 1973-76, at construction cost (capital) of £1.8M. Converted to high duty cycle, H^+ linac at cost (capital) of £0.9M. Tanks 243 originally formed part of an earlier 50 MeV proton linac which operated 1960-69.
NAME OF SYNCYROTRON: Alternating Gradient Synchrotron

INSTITUTION: Brookhaven National Laboratory

LOCATION: Upton, New York 11973

PERSON IN CHARGE: D.I. Lowenstein/Th. Sloyters

DATA SUPPLIED BY: L.A. Ahrense/Y.Y. Lee

HISTORY AND STATUS

CONSTRUCTION STARTED (date): 1953
FIRST BEAM OBTAINED, or GOAL (date): July 20, 1960
TOTAL COST OF FACILITY: $30,655
TOTAL ACCELERATOR STAFF (now): 325
ANNUAL OPERATING BUDGET: $18,911 (without salaries)
ANNUAL OPERATING TIME: 4,480 h

ACCELERATOR PARAMETERS

**General**
- **ACCELERATED PARTICLES**: Proton
- **ENERGY**: 30 GeV
- **RING DIAM.**: 256.9 m, TUNNEL SECT. (W x H): 5.4 x 5.4 m

**Injector**
- **TYPE**: Alvarez Linear Accelerator
- **OUTPUT (max)**: 30 mA at 200 kV, 1 MHz
- **EMITTANCE**: 10 nmm-rad
- **INJECTION PERIOD**: < 400 µs, or < 300 turns
- **INJECTOR TYPE**: H- injection

**Magnet System**
- **FOCUSING TYPE SC, Comb. Funct., FIELD INDEX n**: 365
- **BETATRON FREQU.**: 8.75 Hz
- **NO. MAGNETS**: 250
- **LENGTH (m)**: 2.28 or 1.90 m
- **BENDING FIELD at min.**: 0.025 T, at max. 1.91 T
- **NO. QUADS**: 250
- **LENGTH (m)**: 2.28 or 1.90 m
- **GRAD. at min.**: 0.103 T/m, at max. 3.3 T/m
- **NO. SHORT STRAIGHT**: 22
- **LENGTH (m)**: 1.61 m
- **NO. LONG STRAIGHT**: 24
- **LENGTH (m)**: 3.75 m
- **RISE TIME**: 0.6 s, FLAT-TOP TIME: 1-2 s
- **POWER INPUT PEAK**: 60 MW, MEAN 6 MW

**Acceleration System**
- **NO. CAVITIES**: 10, 4 gaps ea., LENGTH (m): 2 m
- **HARMONIC NUMBER**: 12
- **RF RANGE**: 2.5 to 4.46 MHz
- **ENERGY GAIN**: 192 MeV
- **RADIATION LOSS**: 10 KeV/turn
- **RF POWER INPUT PEAK**: 1,000 kW, MEAN 800 kW

**Vacuum System**
- **MATERIAL OF VAC. CHAMBER**: Inconel - 750
- **APERTURE OF VAC. CHAMBER**: 175 x 77.8 mm
- **AVERAGE PRESSURE**: 1 x 10^-7 Torr

**Extraction System**
- **TYPE**: 1) Fast Extraction, 2) Slow Extraction, 3) Single bunch Extraction
- **LENGTH OF SPILL**: 1) 3.0 m, 10 to 30 µs, 2) 0.5 m, 2.5 µs, 3) 2 µs

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>ENERGY (GeV)</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>24/28.5</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>0.2</td>
<td>0.4</td>
<td>0.8</td>
</tr>
<tr>
<td>0.2</td>
<td>0.2</td>
<td>1.7 x 10^13</td>
</tr>
<tr>
<td>1 x 10^13</td>
<td>2 x 10^13</td>
<td></td>
</tr>
</tbody>
</table>

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>PARTICLE</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other info.</th>
</tr>
</thead>
<tbody>
<tr>
<td>e^-</td>
<td>0.2-24 GeV/c</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>e^-</td>
<td>0.5-22 GeV/c</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>e^-</td>
<td>0.5-2.2 GeV/c</td>
<td>4 x 2 Branches Separated</td>
<td></td>
</tr>
<tr>
<td>e^-</td>
<td>0.5-6 GeV/c</td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>e^-</td>
<td>0.5-2.2 GeV/c</td>
<td>4 x 2 Branches Separated</td>
<td></td>
</tr>
<tr>
<td>e^-</td>
<td>0.5-18 GeV/c</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>e^-</td>
<td>0.02-20 GeV/c</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>e^-</td>
<td>0.5-18 GeV/c</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL FACILITY

<table>
<thead>
<tr>
<th>TOTAL EXPERIMENTAL AREAS</th>
<th>7 total of 15,000 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>NO. INTERNAL TARGETS</td>
<td>0</td>
</tr>
<tr>
<td>NO. EXT. TARGETS</td>
<td>6</td>
</tr>
<tr>
<td>NO. SEPARATED BEAMS</td>
<td>3</td>
</tr>
<tr>
<td>NO. BEAMS SERVED AT SAME TIME</td>
<td>14</td>
</tr>
<tr>
<td>TOTAL POWER USED (AVERAGE) FOR RESEARCH</td>
<td>25 MW</td>
</tr>
<tr>
<td>NO. USER GROUPS, in house</td>
<td>4 outside 30</td>
</tr>
<tr>
<td>TOTAL RESEARCH STAFF, in house</td>
<td>45 outside 300</td>
</tr>
<tr>
<td>ANNUAL RESEARCH BUDGET, in house</td>
<td>3.5 M (with 20% from INL)</td>
</tr>
<tr>
<td>ANNUAL RESEARCH TIME</td>
<td>3,000 h</td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent Improvements, etc.

- Longitudinal phase space dilution cavity (1989).
- Gamma-transition jump to be commissioned in 1990.

*Emittance = Area x Pret 90% of current (for p-machines)
HISTORY AND STATUS

CONSTRUCTION STARTED (date)  
FIRST BEAM OBTAINED, OR GOAL (date)  
TOTAL COST OF FACILITY  
TOTAL ACCELERATOR STAFF (now)  
ANN. OPERAT. BUDGET (now)  
ANN. OPERATING TIME  

ACCELERATOR PARAMETERS

General

ACCELERATED PARTICLES  
ENERGY  
RING DIAMETER  
TUNNEL SECT. (W x H)  

Injector

TYPE  
OUTPUT(max)  
EMITTANCE*  
INJECTION PERIOD  
INFLECTOR TYPE  
RING DIPOL  
INJECTION

Magnet System

FOCUSING TYPE  
ACCELERATOR FIELD INDEX  
FOCUSING ORDER  
BETATRON FREQ.  
NO. MAGNETS  
LENGTH[mm]  
MAXIMUM INCLINATION  
NO. QUADS  
LENGTH[mm]  
GRADIENT AT INJ  
NO. SHORT STRAIGHT SECT.  
LENGTH  
NO. LONG STRAIGHT SECT.  
LENGTH  
RISE TIME  
FLAT-TOP TIME

Power Supply Peak  
Power Supply Mean

Accumulation System

NO. CAVITIES  
HARMONIC NUMBER  
RF RANGE  
ENERGY GAIN  
RADIATION LOSS  
RF POWER INPUT PEAK

Vacuum System

MATERIAL OF VAC CHAMBER  
APERTURE OF VAC CHAMBER  
AVERAGE PRESSURE

Extraction System

TYPE  
LENGTH OF SPILL  
TRANSFER TO AGS

ACCELERATOR PERFORMANCE

ENERGY (GeV)  
ENERGY (or Goal)  
Maximum achieved  

RESOLUTION ΔE/E (%)  
REPEAT RATE (pulses)  
PULSE WIDTH AT PEAK E  
INTERNAL BEAM (part/pulse)  
BEAM EMITTANCE*  
BEAM LINES TO  
mm-mrad

Other Relevant Parameters, Recent Improvements, etc.

In addition to accelerating regular protons, the Booster also accelerates polarized proton and heavy ions from oxygen to gold.

*Emittance = Area x β at 90% of current (for p-machines)
NAME OF LINAC: Brookhaven 200 MeV Linac
INJECTOR FOR: Brookhaven Alternating Gradient Synchrotron
LOCATION: Brookhaven National Laboratory
PERSON IN CHARGE: D.I. Lovenstein/Th. Sluyters
DATE: 6/19/89
DATA SUPPLIED BY: J.G. Alessi

HISTORY AND STATUS
CONSTRUCTION STARTED (date): April 11, 1967
FIRST BEAM OBTAINED, or GOAL (date): November, 1970
TOTAL COST OF FACILITY: $22,491
TOTAL ACCELERATOR STAFF (now): 12
ANNUAL OPERATING BUDGET: Inc. in ADS budget (without salaries): 15,000
ANNUAL OPERATING TIME: 8,000 h

ACCELERATOR PARAMETERS
Physical Dimensions
TOTAL LENGTH: 144.8 m; No. TANKS: 9
PARCELER LENGTH: 0.20 - 0.47 m
APERTURE DIAM: 20 mm to 40 mm

List of parameters and values:

- **Ion Source**
  - TYPE: H⁻ Magnetron
  - OUTPUT: 70-100 mA; KEV: 35
  - EMITTANCE: 1.1 x 1.5 mm mrad

- **Injector**
  - TYPE: REL
  - OUTPUT: 50-55 mA; KEV: 750
  - EMITTANCE: 1.2 x 2.0 mm mrad

- **Bunchers**
  - TYPE: Double Drift-Edge
  - MODULATION: 27 Kev, DRIFT # 1 mm at 201.25 MHz
  - 12 Kev, DRIFT # 2 mm at 201.25 MHz
  - 25 Kev, DRIFT # 3 mm at 201.25 MHz

- **Acceleration System**
  - RF FREQ.: 261.25 MHz
  - FIELD MOD.: 10.0, 0.0, 0.0, 0.0
  - Eq. PHASE: 32°
  - ACCELERATING RATES: 1.0 - 2.6 Mev/m
  - REPEITION RATES: 24 pulses/sec
  - DUTY FACTOR: 0.35
  - PULSE LENGTH: 750 µs (RF); 500 µs (Beam)
  - EFFECTIVE SHUNT IMPEDANCE: 50 - 15 MΩ
  - FILLING TIME: 50 µs
  - RF POWER INPUT PEAK: 27 MW, MEAN: 0.045 MW

- **Focusing System**
  - No. OASIS: 277
  - TYPE: Electromagnet, ORDER: + +
  - GRADIENTS: 0.92 mm to 0.10 mm
  - OTHER:

- **Vacuum System**
  - MATERIAL: Chamber, Copper-clad steel
  - AVERAGE PRESSURE: < 10⁻⁸ torr

Other Relevant Parameters, Recent Improvements, etc.
Recent upgrade from Cockcroft-Walton to an RFQ preinjector (1/89).
80-85% transmission from Linac entrance to 200 MeV.

*Emittance = Area x p at 90% current
**History and Status**

**Construction Started (Date):** 1979  
**First Beam Obtained, or Goal (Date):** August 1983

**Total Cost of Facility:** $130M  
**Total Accelerator Staff (now):** 10 physicists  
**Ann. Operating Budget:** $4.0M (without salaries)  
**Ann. Operating Time:** 4000 h

### Accelerator Parameters

<table>
<thead>
<tr>
<th>General</th>
<th>Accelerated Particles</th>
<th>Protons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy</td>
<td>800-1000 GeV</td>
<td>150 MeV</td>
</tr>
<tr>
<td>Ring Dia.</td>
<td>2000 m; Tunnel Sect. (W×H) 3×2.4 m</td>
<td></td>
</tr>
</tbody>
</table>

**Injector**

<table>
<thead>
<tr>
<th>Type</th>
<th>Alternating Gradient Synchrotron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output (max)</td>
<td>2.20 ps, 6.6 A</td>
</tr>
<tr>
<td>Emission*</td>
<td>15 mm-mrad</td>
</tr>
</tbody>
</table>

**Injector Period**

| Time | 22 ps, or 1 turn |

**Inflector Type**

- Magnetic septum & kicker magnet

**Magnet System**

**Focusing Type**

- Gradient  
- Field Index n = 0

**Focusing Order**

- 1940

<table>
<thead>
<tr>
<th>No. Magnets</th>
<th>7/4</th>
<th>Length (m)</th>
<th>6.12</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Quads</td>
<td>21/6</td>
<td>Length (m)</td>
<td>1.68</td>
</tr>
<tr>
<td>Grad. at min</td>
<td>11/4</td>
<td>Yaw, at max</td>
<td>76.0</td>
</tr>
<tr>
<td>No. Short Straight Sect</td>
<td>6</td>
<td>Length</td>
<td>12 m</td>
</tr>
<tr>
<td>No. Long Straight Sect</td>
<td>6</td>
<td>Length</td>
<td>50 m</td>
</tr>
<tr>
<td>Rise Time</td>
<td>15 s; Flat-Top Time</td>
<td>28 (1988) s</td>
<td></td>
</tr>
</tbody>
</table>

**Acceleration System**

| No. CAVITIES | 8 | Length (m) | 2.5 |
| Harmonic Number | 1113 |
| RF Range | 35.0-104686 MHz |
| Energy Gain | 1000 kV per turn |
| Radiation Loss | 1 eV per turn at 900 GeV |
| RF Power Input Peak | 1600 kW; Mean | 715 kW |

**Vacuum System**

- Material of Vac Chamber: Stainless 304
- Aperture of Vac Chamber: 75 mm
- Average Pressure: 10^-10 Torr

**Extraction System**

<table>
<thead>
<tr>
<th>Type</th>
<th>Slow respondent</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Acceleration</td>
<td>10</td>
</tr>
<tr>
<td>No. Fast</td>
<td></td>
</tr>
</tbody>
</table>

| Length of Spill | 25 sec, 10 N/A, 2 msec, 10 N/A, 200 N/A |

**Emitter* at Peak E**

- 18 mm-mrad

**Accelerator Performance**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (GeV)</td>
<td>1000</td>
<td>800</td>
</tr>
<tr>
<td>Resolution (fwhm)</td>
<td>0.8%</td>
<td>0.8%</td>
</tr>
<tr>
<td>Repet. Rate (pulses/s)</td>
<td>1/minute</td>
<td>1/minute</td>
</tr>
<tr>
<td>Pulse Width at Peak E</td>
<td>4 nsec per bunch</td>
<td></td>
</tr>
<tr>
<td>Internal Beam (part/pulse)</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td>Emittance* at Peak E</td>
<td>18 mm-mrad</td>
<td></td>
</tr>
</tbody>
</table>

**Secondary Beams**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other Info.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron</td>
<td>250-600 GeV</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>K-0*</td>
<td>400-600 GeV</td>
<td>1</td>
<td>Hyperons</td>
</tr>
<tr>
<td>Photon</td>
<td>150 GeV</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Antiproton</td>
<td>500 GeV</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Proton</td>
<td>200 GeV</td>
<td>1</td>
<td>Polarized</td>
</tr>
<tr>
<td>X-ray</td>
<td>125 GeV</td>
<td>1</td>
<td>Average E</td>
</tr>
</tbody>
</table>

**Experimental Facility**

<table>
<thead>
<tr>
<th>Total Experimental Area</th>
<th>m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Internal Targets</td>
<td>0</td>
</tr>
<tr>
<td>No. External Targets</td>
<td>16</td>
</tr>
<tr>
<td>No. Separated Beams</td>
<td>16</td>
</tr>
<tr>
<td>No. Beams Served at Same Time</td>
<td>12</td>
</tr>
<tr>
<td>Total Power Used (Average) for Research</td>
<td>15 MW</td>
</tr>
<tr>
<td>No. User Groups, in house</td>
<td>Outside</td>
</tr>
<tr>
<td>Total Research Staff, in house</td>
<td>80</td>
</tr>
<tr>
<td>Ann. Research Budget, in house</td>
<td>(without Sal)</td>
</tr>
<tr>
<td>Annual Research Time</td>
<td>1000 h</td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x mm at 90% of current (for p-machines)*
NAME OF SYRCHOTRON  Fermilab Main Ring
INJECTOR FOR  Tevatron
LOCATION  Fermilab, Batavia, IL 60510
PERSON IN CHARGE  Phil Martin  DATE: 6/27/89
DATA SUPPLIED BY  Stan Pruss

HISTORY AND STATUS
CONSTRUCTION STARTED (date)  1957
FIRST BEAM OBTAINED, OR GOAL (date)  1972
TOTAL COST OF FACILITY  $243,500
TOTAL ACCELERATOR STAFF (now)  4 physicists
ANNUAL OPERATING BUDGET  $1,600,000 (without salaries)
ANNUAL OPERATING TIME  4,000 h

ACCELERATOR PARAMETERS
General
ACCELERATED PARTICLES  protons and antiprotons
ENERGY  150 GeV
RING DIAMETER  2000 m; TUNNEL SEC. (W x H) 322.4 m

Injector
TYPE  Rapid cycling alternating gradient synchrotron
OUTPUT (max)  220 mA at 8000 MeV
EMITTANCE*  8-16 mm-mrad
INJECTION PERIOD  .867 to 8.82 sec or \t
INJECTOR TYPE  Kicker magnet

Magnet System
FOCUSING TYPE  Alternating gradient
FIELD INDEX n = 0
FOCUSING ORDER  1000
BETA / K ALPHA  19.42 % 19.38
No. MAGNETS  774
LENGTH (ea)  6 m
BENDING FIELD at inj  .04 T; at max  .675 T
No. QUADS  192/48
LENGTH (ea)  2.1/1.2 m
GRAD. at inj  .54
T/m; at max  .91
T/m
No. SHORT STRAIGHT SEC.  6
LENGTH  12 m
No. LONG STRAIGHT SEC.  6
LENGTH  52 m
RISE TIME  1.9 s; FLAT-TOP TIME  5.5 s
POWER INPUT PEAK  20 MW; MEAN  4 MW

Acceleration System
No. CAVITIES  18
LENGTH (ea)  1.7 m
HARMONIC NUMBER  1113
RF RANGE  52.4 MHz
ENERGY GAIN  2553 KeV/turn
RADIATION LOSS  KeV/turn
RF POWER INPUT PEAK  3500 kW; MEAN 1500 kW

Vacuum System
MATERIAL OF VAC. CHAMBER  Stainless steel
APERTURE OF VAC. CHAMBER  125 x 50 mm
AVERAGE PRESSURE  1 x 10^-7 torr

 Extraction System
TYPE  Single turn kicker
LENGTH OF SPILL  1.6 to 18 ns

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>120-150</td>
<td></td>
</tr>
<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td>0.1%</td>
<td></td>
</tr>
<tr>
<td>REPEAT RATE (pulse/s)</td>
<td>1/2 sec</td>
<td>1/2.4 sec</td>
</tr>
<tr>
<td>PULSE WIDTH AT PEAK (μs)</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>INTERNAL BEAM (p/pulse) (part%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BEAM EMITTANCE*</td>
<td>8-24 mm-mrad</td>
<td></td>
</tr>
<tr>
<td>BEAM LINES TO</td>
<td>Tevatron, pbar production target</td>
<td></td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x 1/2 at 90% of current (for p-machines)
NAME OF SYNCHROTRON: Fermilab Booster
INJECTOR FOR: Fermilab Main Ring, Antiproton Source (Test Beams)
LOCATION: Batavia, Illinois
PERSON IN CHARGE: Vinod K. Bharadwaj
DATE: 6/27/83
DATA SUPPLIED BY: Booster Group

HISTORY AND STATUS

CONSTRUCTION STARTED (date) 1969
FIRST BEAM OBTAINED, OR GOAL (date) 1971
TOTAL COST OF FACILITY $132M
TOTAL ACCELERATOR STAFF (now) 13
ANNUAL OPERAT. BUDGET $400K (without salaries)
ANNUAL OPERATING TIME 7503 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES: Protons
ENERGY: 8 GeV (kinetic) GeV
RING DIAMETER: 150.94 m; TUNNEL SECT. (W x H) 3x2.5 m

Injector
TYPE: Linac
OUTPUT (max): 35 mA (at 200 MeV)
EMITTANCE*: 71 mm-mrad
INJECTION PERIOD: 2.0 n, or 1-10 turns
INJECTION TYPE: Multi-turn H, with stripping foil

Magnet System
FOCUSING TYPE: Alt. gradient FIELD INDEX = n
FOCUSING ORDER: POPOODO, combined function
BETATRON FREQU. YH 6.7 YH 6.8
No. MAGNETS: 96 LENGTH(m): 3.048 m
BENDING FIELD RING: .650 T; at max 0.7 T
No. QUADS: 96 LENGTH(m): combined function
GRAD. at ring: 1.75 /m; at max 1.75 /m
No. SHORT STRAIGHT SECT.: 24 LENGTH: 3.7 m
No. LONG STRAIGHT SECT.: 24 LENGTH: 3 m
RISE TIME: 0.033 s; FLAT-TOP TIME: 19 Hz sinusoidal /s
POWER INPUT PEAK: 4 MW; MEAN: 1 MW

Acceleration System
No. CAVITIES: 18 LENGTH(m): 2.4 m
HARMONIC NUMBER: 64
RF RANGE: 30.3 to 52.8 MHz
ENERGY GAIN: --- Kev/turn
RADIATION LOSS: --- Kev/turn
RF POWER INPUT PEAK: 1800 kW; MEAN: kW

Vacuum System
MATERIAL OF VAC. CHAMBER: Stainless steel
APERTURE OF VAC. CHAMBER: 57 (minimum) mm
AVG. PRESSURE: 5x10^-7 torr

Extraction System
TYPE: Single turn, fast kicker and septum magnet
LENGTH OF SPILL: 0 to 1.6 µs

ACCELERATOR PERFORMANCE

ENERGY (GeV) Normal Maximum
(or Goal) achieved
0 10
RESOLUTION (DE/RE (%)) 0.1
REPET. RATE (pulses/e) 15
PULSE WIDTH AT PEAK E (parts) 3.6 µs
INTERNAL BEAM (part/pulse) 2.5x10^12 3.5x10^12
BEAM EMITTANCE * 15 mm-mrad
BEAM LINES: Main Ring, Antiproton Source

Other Relevant Parameters, Recent Improvements, etc.

1. Combined function magnets.
2. Fast cycling resonant power supply system. Current is a 15 Hz biased sine wave excitation.
3. H^- injection with carbon foil stripping for multi-turn operation.
4. Upgrade for 400 MeV injection in progress.

*Emittance = Area x p at 90% of current (for p-machines)
**NAME OF SYNCHROTRON**
Accumulator

**INJECTOR FOR**
Main Ring (collider mode)

**LOCATION**
Fermilab

**PERSON IN CHARGE**
John Marriner

**DATA SUPPLIED BY**
John Marriner

**DATE:** 6/13/89

### HISTORY AND STATUS

- **CONSTRUCTION STARTED (date):** 1982
- **FIRST BEAM OBTAINED, or GOAL (date):** 1985
- **TOTAL COST OF FACILITY (M):** 30 M
- **TOTAL ACCELERATOR STAFF (now):** 10
- **ANNUAL OPERATING BUDGET (now):** 700,000 K (without salaries)
- **ANNUAL OPERATING TIME:** 7,000 h

### ACCELERATOR PARAMETERS

#### General
- **ACCELERATED PARTICLES:** Anti-protons
- **ENERGY (GeV):** 0
- **RING DIAM (m):** 627 m
- **TUNNEL SEC (W x H):** 6 x 2.4 m

#### Injector
- **TYPE:** Storage Ring
- **OUTPUT (max):** 0.002 mA at 8000 MeV
- **EMITTANCE (transverse):** 5 mm-mrad
- **INJECTION PERIOD:** 1 µs, or 1 turn
- **INFLUENTYPE:** Septum kicker

#### Magnet System
- **FOCUSING TYPE:** Triplet-triole-triole
- **BETATRON FREQUENCY:** 0.610 V
- **LENGTH (m):** 8.602 m
- **BENDING FIELD (T):** 1.7 T
- **NUMBER OF QUADS:** 84
- **NUMBER OF STRAIGHT SECTIONS:** 15
- **RISE TIME:** 5 sec
- **POWER INPUT PEAK:** 2 MW, MEAN: 2 MW

#### Acceleration System
- **NO. OF CAVITIES:** 2
- **HARMONIC NUMBER:** 84
- **RF RANGE:** 52.812 to 32.822 MHz
- **ENERGY GAIN (in):** 1 Kev/turn
- **RADIATION LOSS:** 0 Kev/turn
- **RF POWER INPUT PEAK:** 200 kW, MEAN: 20 kW

#### Vacuum System
- **MATERIAL OF VACUUM CHAMBER:** Stainless Steel
- **APERTURE OF VAC. CHAMBER (mm):** 35
- **AVERAGE PRESSURE:** 3x10^-10 torr

#### Extraction System
- **TYPE:** Kicker/Lambertson
- **LENGTH OF SPILL:** 10 µs

### ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>RESOLUTION σ/E (%)</td>
<td>0.02</td>
<td>0.02</td>
</tr>
<tr>
<td>REPET. RATE (pulses)</td>
<td>2.4</td>
<td>1.5</td>
</tr>
<tr>
<td>PULSE WIDTH AT PEAK E</td>
<td>1.5x10^-1</td>
<td>1.5x10^-1</td>
</tr>
<tr>
<td>INTERNAL BEAM (part/pulse)</td>
<td>(part/turn)</td>
<td>(part/turn)</td>
</tr>
<tr>
<td>BEAM EMITTANCE*</td>
<td>1 mm-mrad</td>
<td>1 mm-mrad</td>
</tr>
</tbody>
</table>

**BEAM LINES TO:**
- **Main Ring**

*Emittance = Area × p at 90% of current (for p-machines)*
**NAME OF SYNCHROTRON:** Debnacher  
**INJECTOR FOR:** Accumulator  
**LOCATION:** Fermilab  
**PERSON IN CHARGE:** John Marriner  
**DATE:** 6/13/89  
**DATA SUPPLIED BY:** John Marriner

### HISTORY AND STATUS

<table>
<thead>
<tr>
<th>Construction Started (date)</th>
<th>1983</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Beam Obtained, or Goal (date)</td>
<td>1985</td>
</tr>
<tr>
<td>Total Cost of Facility</td>
<td>30 MB</td>
</tr>
<tr>
<td>Total Accelerator Staff (now)</td>
<td>10</td>
</tr>
<tr>
<td>Ann. Operat. Budget</td>
<td>700 K $ (without salaries)</td>
</tr>
<tr>
<td>Ann. Operating Time</td>
<td>7000 h</td>
</tr>
</tbody>
</table>

### ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (GeV)</td>
<td>8</td>
<td>8</td>
</tr>
<tr>
<td>Resolution ΔE/E (%)</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>Repet. Rate (pulses)</td>
<td>2.4</td>
<td>3.2</td>
</tr>
<tr>
<td>Pulse Width at Peak E</td>
<td>2 x 10⁻⁸</td>
<td>2 x 10⁻⁸</td>
</tr>
<tr>
<td>Internal Beam (part/pulse) (partial)</td>
<td>6 x 10⁻⁸</td>
<td>10⁻⁸</td>
</tr>
<tr>
<td>Beam Emittance *</td>
<td>5 nmm-mrad</td>
<td></td>
</tr>
<tr>
<td>Beam Lines to</td>
<td>Accumulator</td>
<td></td>
</tr>
</tbody>
</table>

*Other Relevant Parameters, Recent Improvements, etc.*

### ACCELERATOR PARAMETERS

#### General

<table>
<thead>
<tr>
<th>Accelerated Particles</th>
<th>Antiprotons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (GeV)</td>
<td>8</td>
</tr>
<tr>
<td>Ring Diameter</td>
<td>505 m; Tunnel Sect. (W x H) 6 x 2.4 m</td>
</tr>
</tbody>
</table>

#### Injector

<table>
<thead>
<tr>
<th>Type</th>
<th>Target</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output (max)</td>
<td>0.001 mA at 8000 MeV</td>
</tr>
<tr>
<td>Injection Period</td>
<td>20 μs, or 3 turns</td>
</tr>
<tr>
<td>Injector Type</td>
<td>Septum/Kicker</td>
</tr>
</tbody>
</table>

#### Magnet System

<table>
<thead>
<tr>
<th>Focusing Type</th>
<th>Strong</th>
</tr>
</thead>
<tbody>
<tr>
<td>Focusing Order</td>
<td>P000</td>
</tr>
<tr>
<td>Beta Freq. ν₀</td>
<td>9.77 ν₀ 9.76</td>
</tr>
<tr>
<td>No. Quadrupoles</td>
<td>114</td>
</tr>
<tr>
<td>Grad. at min.</td>
<td>10 Tm; at max 10 Tm</td>
</tr>
<tr>
<td>No. Straight Sect.</td>
<td>16</td>
</tr>
<tr>
<td>Rise Time</td>
<td>2 s; Flat-Top Time</td>
</tr>
</tbody>
</table>

#### Acceleration System

| No. CAVITIES | 6 |
| Harmonic Number | 90 |
| RF Range | 53.1 Mhz to 53.1 Mhz |
| Energy Gain | 0 KeV/turn |
| Radiation Loss | 0 KeV/turn |
| RF Power Input Peak | 5000 kW; Mean 0.1 kW |

#### Vacuum System

| Material of Vac. Chamber | Stainless Steel |
| Aperture of Vac. Chamber | 45 mm |
| Average Pressure | 10⁻⁶ torr |

#### Extraction System

<table>
<thead>
<tr>
<th>Type</th>
<th>Septum/Kicker</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of Spill</td>
<td>3.5 μs</td>
</tr>
</tbody>
</table>

*Emittance = Area x β₀ at 90% of current (for p-machines)*
### NAME OF LINAC
Fermilab 200-MeV Proton Linac

### INFECTOR FOR
8 GeV Booster Synchrotron

### LOCATION
Batavia, Illinois

### PERSON IN CHARGE
D. E. Young

### DATE
30 June 1989

### DATA SUPPLIED BY
D. E. Young

---

### HISTORY AND STATUS

<table>
<thead>
<tr>
<th>Construction Started (data)</th>
<th>December 1968</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Beam Obtained, or Goal (data)</td>
<td>November 30, 1970</td>
</tr>
<tr>
<td>Total Cost of Facility</td>
<td>$32.7M</td>
</tr>
<tr>
<td>Total Accelerator Staff (now)</td>
<td>8 (part of Accel. Div.)</td>
</tr>
<tr>
<td>Ann. Operat. Budget</td>
<td>$600K (without salaries)</td>
</tr>
<tr>
<td>Ann. Operating Time</td>
<td>8000 h</td>
</tr>
</tbody>
</table>

### ACCELERATOR PARAMETERS

**Physical Dimensions**
- Total Length: 1448 m
- No. Tanks: 9
- Tank Diameter: 24
- No. Drift Tubes: 286
- Drift Tube Lengths: 47-146
- Drift Tube Diameters: 180-120
- Gap Cell Length: 0.21-0.47
- Aperture Diameter: 20 mm to 40 mm

**Ion Source**
- Type: Magnetron $^3$He source
- Output: 60 mA at 38 KeV
- Emittance: 45 x $10^{-3}$ mm-rad

**Injector**
- Type: Cockcroft-Walton
- Output: 65 mA at 750 KeV
- Emittance: 45 x $10^{-3}$ mm-rad

**Bunchers**
- Type: Single-gap re-entrant cavity
- Modulation: 25 KeV, Drift # 750 mm at 20.1 MHz
- Emittance: 45 x $10^{-3}$ mm-rad

**Acceleration System**
- RF Frequency: 201.25 MHz
- Field Mode: TM 010
- Equil. Phase: 0.1
- Accel. Rate: 1.4 MeV/m
- Repetition Rate: 15 Hz
- Duty Factor: 0.2
- % (RF); 0.1 % (beam)
- Pulse Length: 150 μs (RF); 60 μs (Beam)
- Effective Shunt Impedance: 27-15 MHz
- Filling Time: 120 (70-160) μs
- RF Power Input Peak: 55 MW; Mean: 0.075 MW

**Focusing System**
- No. Quads: 205
- Type: Pulsed Mag, Order 70
- Gradients: 70/10/7

**Other**
- Vacuum Chamber: Copper Clad Steel
- Average Pressure: 3 x 10^-8 Torr

---

### ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Output Energy (MeV)</th>
<th>Normal (or Goal)</th>
<th>Maximum Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>201</td>
<td></td>
</tr>
<tr>
<td>Energy Spread ΔE/E (%)</td>
<td>0.35</td>
<td></td>
</tr>
<tr>
<td>Current (mA)</td>
<td>35</td>
<td>46</td>
</tr>
<tr>
<td>Emittance*</td>
<td>4 (855 μm)</td>
<td></td>
</tr>
</tbody>
</table>

**Other Relevant Parameters, Recent Improvements, etc.**

"Energy spread adjustable to optimize the performance of a 3-cell debuncher which reduces the energy spread at the input of the booster synchrotron.

The linac delivers only $^3$He beam which is time shared between injection into the booster for the fixed target, high energy physics program, the colliding beam physics program, the production of antiprotons for the anti-proton source, accelerator physics experiments, and neutron cancer therapy.

In the period from 1975 to 1978, high current diploplasmatron sources were used to provide short linac beam pulses of 150 to 300 mA for single-turn injection into the booster.

Recent Improvements or Modifications to Machine. The major modification in the last two years involved the switch over in March 1978 to a negative ion source for routine operation to provide multi-turn injection into the booster via a carbon stripping foil.

Published articles describing machine.
### History and Status

**Construction Started (date):** 1961  
**First Beam Obtained, or Goal (date):** 1967  
**Total Cost of Facility:**  
**Total Accelerator Staff (now):** 500  
**Annual Operating Budget:** (without salaries)  
**Annual Operating Time:** 4500 hours

### Accelerator Parameters

**General**  
**Accelerated Particles:** protons  
**Energy:** 70 GeV  
**Ring Dia.:** 236.3 m; Tunnel Sect. (W x H): 6 x 8 m

**Injector**  
**Type:** Fast Cyclotron Booster (200 Hz)  
**Output (max):** 9.1 x 10^12 DPP mA at 1500 MeV  
**Emitance:** 15 nm-mrad  
**Injection Period:** 0.1 μs or 1/30 turns  
**Inflector Type:** Kicker Magnet

**Magnet System**  
**Focusing Order:** P/O/O  
**BetaFron Freq.:** 9.85  
**No. Magnets:** 120  
**Bending Field at inj.:** 0.036 T; at max: 1.2 T  
**Grad. at inj.:** T/m; at max: T/m  
**No. Short Straight Sect:** 26  
**Length:** 2.62 m  
**Rise Time:** 2.5 μs; Flat Top Time: 2 μs  
**Power Input Peak:** 80 MW; Mean: 45 MW

### Acceleration System

**No. Cavities:** 40  
**Harmonic Number:** 30  
**RF Range:** 5.5 to 6.1 MHz  
**Energy Gain:** 200 keV/turn  
**Radiation Loss:** 175 keV/turn  
**RF Power Input Peak:** 1000 kW; Mean: 1000 kW

### Vacuum System

**Material of Vac. Chamber:** Stainless Steel  
**Aperture of Vac. Chamber:** 170 x 115 mm  
**Average Pressure:** 2 x 10^-7 torr

### Extraction System

**Type:**  
1) Fast  
2) Slow  
3) Internal Target  
**Length of Spill:**  
1) 10 μs  
2) 1.5 μs  
3) 1.8 μs

*Emitance = Area × π / at 90% of current (for p-machines)*

### Accelerator Performance

<table>
<thead>
<tr>
<th>Normal</th>
<th>Achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>70</td>
<td>76</td>
</tr>
</tbody>
</table>

### Secondary Beams

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum Range</th>
<th>No. of Beams</th>
<th>Other Information</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>pp</strong></td>
<td>20–70 GeV/c</td>
<td>6</td>
<td>Internal Target</td>
</tr>
<tr>
<td><strong>e</strong></td>
<td>5–70</td>
<td>2</td>
<td>Ext. Target</td>
</tr>
<tr>
<td><strong>o</strong></td>
<td>2–10³ ppm</td>
<td>2</td>
<td>Ext. Target</td>
</tr>
<tr>
<td><strong>n</strong></td>
<td>10² ppm</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Experimental Facility

<table>
<thead>
<tr>
<th>Total Experimental Areas</th>
<th>17500 m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. Internal Targets</td>
<td>4</td>
</tr>
<tr>
<td>No. Ext. Targets</td>
<td>2</td>
</tr>
<tr>
<td>No. Separated Beams</td>
<td></td>
</tr>
<tr>
<td>No. Beams SERVED AT SAME TIME</td>
<td>5 – 6</td>
</tr>
<tr>
<td>Total Power Used (Average) for Research</td>
<td>30 MW</td>
</tr>
<tr>
<td>No. USER GROUPS, in house</td>
<td>20</td>
</tr>
<tr>
<td>No. outside</td>
<td>20</td>
</tr>
<tr>
<td>Total Research Staff, in house</td>
<td>150</td>
</tr>
<tr>
<td>Annual Research Time</td>
<td>3500 h</td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent Improvements, etc.

- 1985: New Injection System
- 1989: High Intensity Slow Extraction System
**NAME OF SYNCHROTRON**

1.5 GeV Fast Cycling Booster Synchrotron

**INSTITUTION**

Institute for High Energy Physics

**LOCATION**

Serpukhov, Moscow Region

**PERSON IN CHARGE**

E. A. Myas

**DATE:**

01.07.89

**DATA SUPPLIED BY**

E. A. Myas

---

**HISTORY AND STATUS**

<table>
<thead>
<tr>
<th>CONSTRUCTION STARTED (date)</th>
<th>1975</th>
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</thead>
<tbody>
<tr>
<td>FIRST BEAM OBTAINED, OR GOAL (date)</td>
<td>1983</td>
</tr>
<tr>
<td>TOTAL COST OF FACILITY</td>
<td>300</td>
</tr>
<tr>
<td>TOTAL ACCELERATOR STAFF (now)</td>
<td>100</td>
</tr>
<tr>
<td>ANNUAL OPERATING BUDGET (now)</td>
<td>(without salaries)</td>
</tr>
<tr>
<td>ANNUAL OPERATING TIME</td>
<td>4700 h</td>
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</table>

**ACCELERATOR PARAMETERS**

**General**

<table>
<thead>
<tr>
<th>ACCELERATED PARTICLES</th>
<th>protons</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>1.5</td>
</tr>
<tr>
<td>RING DIAMETER (m)</td>
<td>31.6</td>
</tr>
<tr>
<td>TUNNEL SECTION (W x H)</td>
<td>4.5 x 4.5 m</td>
</tr>
</tbody>
</table>

**Injector**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>RFO Linac</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT (max)</td>
<td>100 mA at 30 MeV</td>
</tr>
<tr>
<td>EMITTANCE*</td>
<td>30 nmm-mrad</td>
</tr>
<tr>
<td>INJECTION PERIOD</td>
<td>1,3 sec/turn, 1 to 5 turns</td>
</tr>
<tr>
<td>INJECTOR TYPE</td>
<td>4 kicks, 1 septum</td>
</tr>
</tbody>
</table>

**Magnet System**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>AG FIELD INDEX n=</th>
</tr>
</thead>
<tbody>
<tr>
<td>FOCUSING ORDER</td>
<td>triplets, separate function</td>
</tr>
<tr>
<td>BETATRON FREQUENCY, νh</td>
<td>3.85 ( ν_0 )</td>
</tr>
<tr>
<td>BENDING FIELD, B (T)</td>
<td>1.3</td>
</tr>
<tr>
<td>NO. QUADS</td>
<td>12/24</td>
</tr>
<tr>
<td>LENGTH (m)</td>
<td>0.77/0.33</td>
</tr>
<tr>
<td>No. GRAD. at inj.</td>
<td>0.013 m</td>
</tr>
<tr>
<td>at max</td>
<td>0.11 m</td>
</tr>
<tr>
<td>No. LONG STRAIGHT SECT</td>
<td>3</td>
</tr>
<tr>
<td>LENGTH (m)</td>
<td>2.0</td>
</tr>
<tr>
<td>No. SHORT STRAIGHT SECT</td>
<td>24</td>
</tr>
<tr>
<td>LENGTH (m)</td>
<td>0.76</td>
</tr>
<tr>
<td>RISE TIME</td>
<td>30 sec</td>
</tr>
<tr>
<td>FLAT TOP TIME</td>
<td>5 sec</td>
</tr>
<tr>
<td>POWER INPUT PEAK</td>
<td>10 MW; MEAN 2.5 MW</td>
</tr>
</tbody>
</table>

**Acceleration System**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>G</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH (m)</td>
<td>1.2</td>
</tr>
<tr>
<td>HARMONIC NUMBER</td>
<td>2</td>
</tr>
<tr>
<td>RF RANGE</td>
<td>0.75 Mhz</td>
</tr>
<tr>
<td>ENERGY GAIN</td>
<td>2800 (max) KeV/turn</td>
</tr>
<tr>
<td>RADIATION LOSS</td>
<td>- KeV/turn</td>
</tr>
<tr>
<td>RF POWER INPUT PEAK</td>
<td>500 kW</td>
</tr>
</tbody>
</table>

**Vacuum System**

<table>
<thead>
<tr>
<th>MATERIAL OF VAC. CHAMBER</th>
<th>Stainless Steel</th>
</tr>
</thead>
<tbody>
<tr>
<td>APERTURE OF VAC. CHAMBER</td>
<td>140 x 61 mm</td>
</tr>
<tr>
<td>AVERAGE PRESSURE</td>
<td>2 x 10^-7 torr</td>
</tr>
</tbody>
</table>

**Extraction System**

<table>
<thead>
<tr>
<th>TYPE</th>
<th>one turn</th>
</tr>
</thead>
<tbody>
<tr>
<td>LENGTH OF SPILL</td>
<td>0.1 μs</td>
</tr>
</tbody>
</table>

**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th>Energy (GeV)</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.35</td>
<td></td>
<td>1.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resolution (Δε/ε) (%)</th>
<th>16.2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Repet. Rate (pulses)</td>
<td>20</td>
</tr>
<tr>
<td>Pulse Width at Peak E</td>
<td>8-10^11</td>
</tr>
<tr>
<td>Internal Beam (pulses)</td>
<td>9.5-10^11</td>
</tr>
<tr>
<td>Emittance at Peak E</td>
<td>15 nmm-mrad</td>
</tr>
</tbody>
</table>

**SECONDARY BEAMS**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other info.</th>
</tr>
</thead>
</table>

**EXPERIMENTAL FACILITY**

<table>
<thead>
<tr>
<th>TOTAL EXPERIMENTAL AREAS</th>
<th>m²</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. INTERNAL TARGETS</td>
<td>No. EXT. TARGETS</td>
</tr>
<tr>
<td>No. SEPARATED BEAMS</td>
<td></td>
</tr>
<tr>
<td>No. BEAMS SERVED AT SAME TIME</td>
<td></td>
</tr>
<tr>
<td>TOTAL POWER USED (AVERAGE) FOR RESEARCH</td>
<td>MW</td>
</tr>
<tr>
<td>No. USER GROUPS, in house</td>
<td>outside</td>
</tr>
<tr>
<td>TOTAL RESEARCH STAFF, in house</td>
<td>outside</td>
</tr>
<tr>
<td>ANN. RESEARCH BUDGET, in house</td>
<td>[without sol.]</td>
</tr>
<tr>
<td>ANNUAL RESEARCH TIME</td>
<td>h</td>
</tr>
</tbody>
</table>

**Other Relevant Parameters, Recent Improvements, etc.**

*Emittance = Area × θ at 90% of current (for p-machines)*
**NAME OF LINAC**: I-100 linear proton accelerator (Alvarez type)  
**INJECTOR FOR**:  
**LOCATION**: Serpukhov, Moscow region  
**PERSON IN CHARGE**: V. M. Ledenev  
**DATE**: 01.07.89

**HISTORY AND STATUS**

| CONSTRUCTION STARTED (date) | 1961 |
| FIRST BEAM OBTAINED, or GOAL (date) | 1967 |
| TOTAL COST OF FACILITY |  |
| TOTAL ACCELERATOR STAFF (now) | 40 |
| ANN. OPERATING BUDGET (now) | 5000 (without salaries) |
| ANN. OPERATING TIME | h |

**ACCELERATOR PARAMETERS**

**Physical Dimensions**
- TOTAL LENGTH: 80 m; NO. TANKS: 3
- TANK DIAM: *** m
- DRIFT TUBE LENGTHS: 62 + 623 + 83 mm
- DRIFT TUBE DIAMETERS: 130 + 100 mm
- GAPCELL LENGTH: 0.250; 0.255; 0.185; 0.284; 0.222 m
- APERTURE DIAM: 20 mm to 40 mm

**Ion Source**
- TYPE: Plasmotron
- OUTPUT: 1500 mA at 0.01 KeV
- EMITTANCE*: 2 nmm-mrad

**Injector**
- TYPE: Pulsed DC accelerator
- OUTPUT: 1000 mA at 700 KeV
- EMITTANCE*: 2.5 nmm-mrad

**Bunchers**
- TYPE: Cystron
- MODULATION: 25, 4 KeV, DRIFT #, 995 mm at 148, 5 MHz
- KeV, DRIFT #, mm at MHz

**Acceleration System**
- RF FREQ: 168.5 MHz
- FIELD MODE: Q
- EQUIL. PHASE: 37°
- ACCEL. RATE: 0.8 MeV/m
- REPETITION RATE: 10 Hz
- DUTY FACTOR: 30 % (RF); 63 % (Beam)
- PULSE LENGTH: 300 µs (RF); 100 µs (Beam)
- EFFECTIVE SHUNT IMPEDANCE: MD/m
- FILLING TIME: µs
- RF POWER INPUT PEAK: 5 MW; MEAN: MW

**Focusing System**
- No. QUADS: ***
- TYPE: FODO
- ORDER H=2; E=1
- GRADIENTS: 50 to 4 T/m
- OTHER:  

**Vacuum System**
- MATERIAL CHAMBER: Copper
- AVERAGE PRESSURE: 10^-7 torr

**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th>OUTPUT ENERGY (MeV)</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>ENERGY SPREAD ΔE/E (%)</td>
<td>2.3</td>
<td>2.3</td>
</tr>
<tr>
<td>CURRENT (mA)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>EMITTANCE*</td>
<td>8 nmm-mrad</td>
<td></td>
</tr>
</tbody>
</table>

*Other Relevant Parameters, Recent Improvements, etc.*

** 1.324 m; 1.22 m; 1.087 m  
** 1/2 + 93 + 1/2; 1/2 + 41 + 1/2; 1/2 + 26 + 1/2  

**Emittance = Area x β at 90% current**
NAME OF SYNCHROTRON U-10
INSTITUTION ITEP
LOCATION Moscow
PERSON IN CHARGE L.I. Goldin
DATA SUPPLIED BY L.I. Goldin

HISTORY AND STATUS
CONSTRUCTION STARTED (date) —
FIRST BEAM OBTAINED, OR GOAL (date) 1981
TOTAL COST OF FACILITY —
TOTAL ACCELERATOR STAFF (now) —
ANN. OPERAT. BUDGET — (without salaries)
ANN. OPERATING TIME — h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES \( p \)
ENERGY 9.3 GeV (up) 4.7 GeV/\( \sqrt{s} \) (lhc)
RING DIAMETER 80 m TUNNEL SECT. (W \times H) 12 \times 12 m

Injector
TYPE Linac (U-2)
OUTPUT (max) 200 mA at 254 MeV
EMITTANCE \( \times 10^{-6} \) mmm-mrad
INJECTION PERIOD 3.8 \( \mu \)s or 1 turns
INJECTOR TYPE Electrostatic

Magnet System
FOCUSING TYPE strong FIELD INDEX \( n = 300 \)
FOCUSING ORDER YODO
BETATRON FREQ. \( \nu \)
9.3\( \nu \)
9.3
NO. MAGNETS 46 LENGTH (m) 1.4 m
BENDING FIELD (at mid) 0.024 T; at max 1.0 T
NO. QUADS — LENGTH (m)
GRAD. at inj. — Tm; at max — Tm
NO. SHORT STRAIGHT SECT 80 LENGTH 0.35 m
NO. LONG STRAIGHT SECT 16 LENGTH 2.4 m
RISE TIME 0.65 ns FLAT-TOP TIME 1.2 s
POWER INPUT PEAK 18.0 MW; MEAN 2.5 MW

Acceleration System
NO. CAVITIES 5 LENGTH (m) 1.6 m
HARMONIC NUMBER 4
RF RANGE 1.1 to 10 GHz
ENERGY GAIN 33 KeV/turn
RADIATION LOSS — KeV/turn
RF POWER INPUT PEAK 12 \( \times 5 \) kW; MEAN 3 \( \times 5 \) kW

Vacuum System
MATERIAL OF VAC. CHAMBER stainless steel
APERTURE OF VAC. CHAMBER 110 x 80 mm
AVERAGE PRESSURE 1.3 Torr

Extraction System
TYPE i) Internal Targets, slow
ii) Internal Targets, fast
iii) Fast, for medicine, up to 200 MeV
LENGTH OF SPILL 1 sec to 200 MeV

ACCELERATOR PERFORMANCE

ENERGY (GeV) Normal (or Goal) Maximum achieved
9.3 10.0

SECONDARY BEAMS

Particle Momentum range No. of beams Other inform.
neutral \( d, ^{3}He \) 1 - 4 GeV/c \( d \)
\( ^{3}He \) 5.5 GeV/c \( ^{3}He \)

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS 5000 m²
NO. INTERNAL TARGETS — NO. EXT. TARGETS 5
NO. SEPARATED BEAMS 2
NO. BEAMS SERVED AT SAME TIME 6
TOTAL POWER USED (AVERAGE) FOR RESEARCH 3 MW
NO. USER GROUPS, IN HOUSE 12 outside
TOTAL RESEARCH STAFF, IN HOUSE — outside
ANN. RESEARCH BUDGET, IN HOUSE — (without salary)
ANNUAL RESEARCH TIME 3500 h

OTHER RELEVANT PARAMETERS, RECENT IMPROVEMENTS, ETC.

*Emittance = Area \( \times f \) at 90% of current (for p-machines)
**NAME OF SYNCHROTRON**: ITEP Proton and Heavy Ion Accelerator Complex (U-10, Saving Ring)

**INSTITUTION**: ITEP

**LOCATION**: Moscow

**PERSON IN CHARGE**: L. L. Goldin

**DATE**: __________

**DATA SUPPLIED BY**: L. L. Goldin

---

**HISTORY AND STATUS**

- **CONSTRUCTION STARTED (date)**: 1985
- **FIRST BEAM OBTAINED, or GOAL (date)**: 1990
- **TOTAL COST OF FACILITY**: __________
- **TOTAL ACCELERATOR STAFF (now)**: __________
- **ANN. OPERAT. BUDGET**: (without salaries)
- **ANN. OPERATING TIME**: __________

---

**ACCELERATOR PARAMETERS**

**General**

- **ACCELERATED PARTICLES**: p, u
- **ENERGY**: 3.5 - 9.3 GeV/A
- **RING DIAM**: 48 m
- **TUNNEL SECT. (W x H)**: 12 x 7 m

**Injector**

- **TYPE**: Resonator with four accelerating gaps
- **OUTPUT (max)**: max = 3 - 8 MeV
- **EMITTANCE**: 20 - 100 μm-mrad
- **INJECTION PERIOD**: 20 - 100 μs, or 1 turns
- **INJECTOR TYPE**: Electrostatic

**Magnet System**

- **FOCUSING TYPE**: strong
- **FIELD INDEX**: __________
- **FOCUSING ORDER**: __________
- **NO. MAGNETS**: __________
- **LENGTH (m)**: __________
- **BENDING FIELD (T)**: __________
- **NO. QUADS**: __________
- **LENGTH (m)**: __________
- **GRAD. at the**: __________
- **LENGTH (m)**: __________
- **NO. SHORT STRAIGHT SEG**: __________
- **LENGTH (m)**: __________
- **NO. LONG STRAIGHT SEG**: __________
- **LENGTH (m)**: __________
- **RISE TIME**: __________
- **FLAT-TOP TIME**: __________
- **POWER INPUT PEAK**: __________
- **MW, MEAN**: __________

**Experimental System**

- **NO. CAPTIVE**: __________
- **LENGTH (m)**: __________
- **HARMONIC NUMBER**: __________
- **RF RANGE**: __________
- **ENERGY GAIN**: < 10 kV
- **RADIATION LOSS**: __________
- **RF POWER INPUT PEAK**: __________
- **kW, MEAN**: __________

**Vacuum System**

- **MATERIAL OF VAC. CHAMBER**: Stainless steel
- **APERTURE OF VAC. CHAMBER**: __________
- **AVERAGE PRESSURE**: 1 x 10^-6 torr

**Extraction System**

- **TYPE**: i) Slow Extraction
- **ii) Fast Extraction
- **iii) Mass Exclusion
- **LENGTH OF SPILL**: __________

---

**ACCELERATOR PERFORMANCE**

- **ENERGY (GeV)**: 3.5 - 9.3 GeV/A
- **RESOLUTION ΔE/E (%)**: __________
- **REPET. RATE (pulses/s)**: __________
- **PULSE WIDTH AT PEAK E**: __________
- **INTERNAL BEAM**: (part/peaks)
- **EMITTANCE AT PEAK E**: __________

---

**SECONDARY BEAMS**

- **Particle**: __________
- **Momentum range**: __________
- **No. of beams**: __________
- **Other inform**: __________

---

**EXPERIMENTAL FACILITY**

- **TOTAL EXPERIMENTAL AREAS**: __________ m²
- **NO. INTERNAL TARGETS**: __________
- **NO. EXTERNAL TARGETS**: __________
- **NO. SEPARATED BEAMS**: __________
- **NO. BEAMS SERVED AT SAME TIME**: __________
- **TOTAL POWER USED (AVERAGE) FOR RESEARCH**: __________ MW
- **TOTAL RESEARCH STAFF**: __________
- **ANNUAL RESEARCH TIME**: __________

---

**Other Relevant Parameters, Recent Improvements, etc.**

---

*Emittance = Area x y at 90% of current (for p-machines)
**HISTORY AND STATUS**

- **CONSTRUCTION STARTED (date):** 1962
- **FIRST BEAM OBTAINED, or GOAL (date):** 1966
- **TOTAL COST OF FACILITY:**
- **TOTAL ACCELERATOR STAFF (now):**
- **ANN. OPERAT. BUDGET (without salaries):**
- **ANN. OPERATING TIME:** 6000 h

**ACCELERATOR PARAMETERS**

**Physical Dimensions**
- **TOTAL LENGTH:** 16.6 m; **NO. TANKS:** 2
- **TANK DIAM.:** 1.9 m; **NO. DRIFT TUBES:** 20
- **DRIFT TUBE LENGTHS:** 137-313; 198-314
- **DRIFT TUBE DIAMETERS:** 190-130
- **CELL LENGTH:** 0.2-0.3; 0.16-0.2
- **APERTURE DIAM.:** 20 mm to 25 mm
- **Ion Source**
  - Type: Gold cathode duoplasmatron
  - **OUTPUT:** 2000 mA at 40 kV
  - **EMITTANCE:** mm-mrad

**Injector**
- Type: Pulse transformer
- **OUTPUT:** 1200 mA at 700 kV
- **EMITTANCE:** mm-mrad

**Bunchers**
- Type: One gap
  - **MODULATION:** 30 kV, DRIFT 4.5 m at 146.5 MHz

**Acceleration System**
- **RF FREQUENCY:** 146.5 MHz
- **FIELD MODE:** 100
- **EQUIV. PHASE:** 37
- **ACCEL. RATE:** 1.3 MeV/m
- **REPETITION RATE:** 0.3-2 Hz
- **DUTY FACTOR:** 0.002 % (RF); 0.002 % (Beam)
- **PULSE LENGTH:** 300 μs (RF); 3-30 μs (Beam)
- **EFFECTIVE SHUNT IMPEDANCE:** 22 MΩ
- **FILLING TIME:** 150 μs
- **RF POWER INPUT PEAK:** 1.0 MW; **MEAN:** 0.002 MW

**Focusing System**
- **No. QUADS:** 36+68
- **TYPE:** d, c
- **ORDER:** 000
- **GRADIENTS:** 5
- **OTHER:** Each drift tube contains 2 lenses of opposite signs

**Vacuum System**
- **MATERIAL CHAMBER:** Stainless steel
- **AVERAGE PRESSURE:** 2.3 × 10⁻⁶ torr

**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT ENERGY (MeV)</td>
<td>24.6</td>
</tr>
<tr>
<td>ENERGY SPREAD ΔE/E (%)</td>
<td>1.0</td>
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<tr>
<td>CURRENT (mA)</td>
<td>270</td>
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<tr>
<td>EMITTANCE*</td>
<td>10</td>
</tr>
</tbody>
</table>

**Other Relevant Parameters, Recent Improvements, etc.**

For He⁺ ions acceleration by the linac 1-2 the APF structure is installed between the preinjector and the first resonator. After stripping He⁺ ions are injected into the first resonator, which is used only as a focusing channel. The ions are accelerated by second resonator with period of acceleration.

**Accelerator performance for He⁺**

- **Output energy (MeV):** 6
- **Energy spread ΔE/E (%):** 1.2
- **Current (mA):** 3.5
- **Emittance:** 10 mm mrad

---

*Emittance = Area × π × r at 90% current*
**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUT ENERGY (MeV)</td>
<td>1.22</td>
<td>3</td>
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<tr>
<td>ENERGY SPREAD ΔE/E (%)</td>
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<td></td>
</tr>
<tr>
<td>CURRENT (mA)</td>
<td>120</td>
<td>250</td>
</tr>
<tr>
<td>EMITTANCE*</td>
<td>5 (3,7)</td>
<td>mm-mrad</td>
</tr>
</tbody>
</table>
NAME OF SYNCHROTRON: ELSA (Electron Stretcher and Accelerator)

INSTITUTION: Bonn University, Physics Institute

LOCATION: D-5300 Bonn 1, Western Germany, Nussallee 12

PERSON IN CHARGE: Dirk Huesmann

DATA SUPPLIED BY: Dirk Huesmann

DATE: July 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date): June 1983
FIRST BEAM OBTAINED, or GOAL (date): Febr. 1988

TOTAL COST OF FACILITY: 18.5 MD

TOTAL ACCELERATOR STAFF (now): 23

ANN. OPERAT. BUDGET: 3.2 MD (without salaries)

ANN. OPERATING TIME: 4,500 h

ACCELERATOR PARAMETERS

General

ACCELERATED PARTICLES: electrons

ENERGY: max. 5.5 GeV

RING DIAM: 52.3 m; TUNNEL SECT. (W x H): 2.3 x 2.3 m

Injector

TYPE: 2.5 GeV Synchrotron

OUTPUT (max): 30 mA at 500 - 2,000 MeV

EMITTANCE*: unmm-mrad

INJECTION PERIOD: 0.548 μs, or 1 turn

INJECTOR TYPE: septum magnet

Magnet System

FOCUSING TYPE: AC, sep. fct., FIELD-INDEX n =

FOCUSING ORDER: FORQ

BETATRON FREQ.: 4.65 ν0 = 4.60

No. MAGNETS: 26 LENGTH (mm): 3.24 8.34 m

BENDING FIELD ar max: 0.45 0.45 T

No. QUADS: 32 + 4 LENGTH (mm): 2.65 T

GRAD. at max: 0.64 T/m; at max INJECTOR: 0.45 T

No. SHORT STRAIGHT SECT: 24 LENGTH (mm): 1.60 m

No. LONG STRAIGHT SECT: 8 LENGTH (mm): 5.69 m

RISE TIME: 150 μs FLAT-TOP TIME: 500 μs

POWER INPUT PEAK: 5.7 MW; MEAN: 1.6 MW

ACCELERATION System (two systems)

No. CAVITIES: 2/1 LENGTH (mm): 1.5/0.3 m

HARMONIC NUMBER: 274

RF RANGE: 2 A 500 MHz

ENERGY GAIN: 5,000 eV

RADIATION LOSS: 1,225 MeV

RF POWER INPUT PEAK: 200 kW; MEAN: 200 kW

Vacuum System

MATERIAL OF VAC CHAMBER: stainless steel

APERTURE OF VAC CHAMBER: 100 x 50 mm

AVERAGE PRESSURE: 10-9 Torr

Extraction System

TYPE: Horizontal betatron resonance (μν = 14/3)

i) scattering on carbon fiber (for low intensity)

Length of spill:

i) stretcher: to 19.8 x 10^3 μs

ii) post accel.: to 500 x 10^3 μs

iii) to μs

*) Staff and Budget: together for ELSA and injector synchrotron

**) only relevant for post accelerator mode

***) ELSA is operated in three different modes:

1) Stretcher

2) Post Accelerator

3) Storage Ring (dedicated SR source)

NAME OF SYNCHROTRON
2.5 GeV Electron Synchrotron

INJECTOR FOR
ELSA (Electron Stretcher and Accelerator)

LOCATION
D - 5300 Bonn 1, Western Germany, Nussallee 12

PERSON IN CHARGE
Dirk Husmann

DATA SUPPLIED BY
Dirk Husmann

DATE: July 1980

HISTORY AND STATUS

CONSTRUCTION STARTED (DATE) April 1965
FIRST BEAM OBTAINED, OR GOAL (DATE) March 1967
TOTAL COST OF FACILITY 12.3 MM
TOTAL ACCELERATOR STAFF (now) ≈ 23
ANN. OPER. BUDGET × 0.2 MM (without salaries)
ANN. OPERATING TIME 8,000 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES: electrons
ENERGY: now: 0.5 - 2.0 GeV
RING DIAMETER: 22.15 m; TUNNEL SECTOR (W x H) 3.5 x 2.2 m

Injector
TYPE: linac
OUTPUT (max) 500 mA, 21 MV
EMITTANCE: 3 nmm-mrad
INJECTION PERIOD: 1.0 µs, or 5 turns
INFLECTOR TYPE: septum magnet

Magnet System
FOCUSING TYPE: AG, com. field INDEX n = 22.20
FOCUSING ORDER: 0E00
BETATRON FREQ. V: 3.4 keV, 3.4 m
No. MAGNETS: 12 LENGTH (m) 4.005 m
BENDING FIELD AT INJ: 0.009 T; at max: 0.87 T
No. QUADS: LENGTH (m) m
GRAO, at inj: Tm, at max: Tm
No. SHORT STRAIGHT SECT. 12 LENGTH: 1.80 m
No. LONG STRAIGHT SECT.: LENGTH (m) m
RISE TIME: 6.8 µs; FLAT-TOP TIME: 3.0 µs
POWER INPUT PEAK: MW; MEAN: 0.55 MW

Acceleration System
No. CAVITIES: 1 LENGTH (m) 0.90 m
HARMONIC NUMBER: 116
RF RANGE: 499.67 MHz
ENERGY GAIN: 500 KeV/turn
RADIATION LOSS: at 2 GeV: 186 KeV/turn
RF POWER INPUT PEAK: 100 kW; MEAN: 40 kW

Vacuum System
MATERIAL OF VAC. CHAMBER: porcelain and Al2O3
APERTURE OF VAC. CHAMBER: 125 x 42 mm
AVERAGE PRESSURE: 5 x 10⁻⁷ mbar

Extraction System
TYPE: fast extraction, shaving method
LENGTH OF SPILL: 0.736 µs

ACCELERATOR PERFORMANCE

(after conversion to injector synchrotron)

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>0.5 - 2.0</td>
<td></td>
</tr>
<tr>
<td>REPEAT RATE (pulses)</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>PULSE WIDTH AT PEAK E</td>
<td>0.25 - 0.60 µs</td>
<td></td>
</tr>
<tr>
<td>INTERNAL BEAM (part/pulse)</td>
<td>5 x 10⁻⁶</td>
<td></td>
</tr>
<tr>
<td>BEAM EMITTANCE*</td>
<td>2.5 x 10⁻⁹</td>
<td></td>
</tr>
<tr>
<td>BEAM LINES TO ELSA</td>
<td></td>
<td>nmm-mrad</td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent Improvements, etc.

* Emittance = Area × p at 90% of current (for p-machines)

*) Budget and Staff: together for injector synchrotron and ELSA
NAME OF SYNCHROTRON 1.3 GeV Electron Synchrotron (INS-ES)

INSTITUTION Institute for Nuclear Study, University of Tokyo

LOCATION Hidari-cho, Tamagishi-ku, Tokyo 188, Japan

PERSON IN CHARGE K. Yoshihara

DATE: June, 1989

DATA SUPPLIED BY K. Yoshihara

HISTORY AND STATUS

CONSTRUCTION STARTED (date) 1957
FIRST BEAM OBTAINED, OR GOAL (date) 1961
TOTAL COST OF FACILITY $310,000
TOTAL ACCELERATOR STAFF (now) 10
ANNUAL OPERATING BUDGET $30,000 (without salaries)
ANNUAL OPERATING TIME 3,000 hours

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES Electron
ENERGY 1.3 GeV
RING DIAM. 11.05 m, TUNNEL SECT. (W x H) = 1.4 m

Injector
TYPE Linac
OUTPUT (max) 150 mAat, 35 MeV
EMITANCE* 1 mm-mrad
INJECTION PERIOD 1.2 µs, or 10 turns
INJECTOR TYPE Electromagnetic

Magnet System
FOCUSING TYPE A, O
FOCUSING INDEX n = 1/4, 3
FOCUSING ORDER 1/2 D = 1/2F + D/2F + 1/2F = 0
BETATRON FREQ. 2.25, 1.25, 1.25 MHz
NO. MAGNETS 8
BENDING FIELD at INJECT 0.0125 T, at max. 1.08 T
NO. QUADS LENGTH (ea) 3 m
GRAD. at INJECT 70 µrad
NO. SHORT STRAIGHT SECT 8
LENGTH 1.2 m
NO. LONG STRAIGHT SECT 1
LENGTH 1 m
RSTE TIME 20 µs; FLAT-TOP TIME 5 µs
POWER INPUT PEAK 0.05 MW; MEAN 0.045 MW

Acceleration System
NO. CAVITIES LENGTH (ea) 0.3 m
HARMONIC NUMBER 16
RF RANGE 138 MHz (Fixed) to 500 MHz
ENERGY GAIN 100 KeV/turn
RADIATION LOSS 63 KeV/turn
RF POWER INPUT PEAK 20 kW; MEAN 6.5 kW

Vacuum System
MATERIAL OF VAC. CHAMBER Welded stainless-steel bellow
APERTURE OF VAC. CHAMBER 23 mm
AVERAGE PRESSURE 1 x 10⁻⁹ torr

Extraction System
TYPE i) Slow extraction system of Piccioni method
ii) Internal radiator
iii) Fast extraction system for storage ring
LENGTH OF SPILL i) 10 ms (max.), 10 µs
ii) 10 ms (max.), 10 µs
iii) 100 µs

ACCELERATOR PERFORMANCE

ENERGY (GeV) Normal Maximum
(Value) (or Goal) achieved
1.3 1.3 1.27

RESOLUTION & E (%) 0.1 0.1

REP. RATE (pulses) 21.5 21.5

PULSE WIDTH AT PEAK 5 x 10⁻¹² s 5 x 10⁻¹² s

EMITTANCE* AT PEAK 1 x 10⁻¹² m rad

SECONDARY BEAMS

Particle Tagged Momentum range < 1.1 MeV/amu No. of beams Other inform.

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS 1,000 m²
No. INTERNAL TARGETS 3
No. EXT. TARGETS 1
No. SEPARATED BEAMS
No. BEAMS SERVED AT SAME TIME 6
TOTAL POWER USED (AVERAGE) FOR RESEARCH 0.7 MW
No. USER GROUPS, in house 2 outside 5
TOTAL RESEARCH STAFF, in house 50 outside 50
Ann. RESEARCH BUDGET, in house $50,000 (without sal.)
ANNUAL RESEARCH TIME 3,000 h

Other Relevant Parameters, Recent Improvements, etc.

The synchrotron works as a injector of 400 keV storage ring for synchrotron radiation utilization.
The duty cycle of extracted electron beam (and also of the tagged γ beam) has been extended to be 20% at maximum.

*Emittance = Area \times \beta at 90% of current (for p-machines)
NAME OF SYNCHROTRON: Cornell Electron Synchrotron
INSTITUTION: Laboratory of Nuclear Studies, Cornell University
LOCATION: Ithaca, NY, USA
PERSON IN CHARGE: David Rice
DATA SUPPLIED BY: David Rice

HISTORY AND STATUS

CONSTRUCTION STARTED (date): April 1965
FIRST BEAM OBTAINED, OR GOAL (date): May 1967
TOTAL COST OF FACILITY: $11.5 Million
TOTAL ACCELERATOR STAFF (now): 60 **
ANN. OPER. BUDGET: $3.5 M ** (without salaries)
ANN. OPERATING TIME: 6000 ** h

ACCELERATOR PARAMETERS

** General **
ACCELERATED PARTICLES: ** e-, e^+
ENERGY: 4-12 GeV
RING DIAM: 240 m; TUNNEL SECT. (W x H): 3 x 2.4 m

** Injector **
TYPE: TH linac 2656 MHz
OUTPUT (max): 100 mA, at 300 MeV
EMITTANCE*: 6/6 mm-mrad
INJECTION PERIOD: 2.5 μs, or 1 turns
INJECTOR TYPE: magnetic

** Magnet System **
FOCUSING TYPE: AG
FIELD INDEX: n = 437
FOCUSING ORDER: FDD
BETA RITCH FREQS. V: 10.7, 10.8
FOCUSING INDEX: 192
LENGTH (ea): 3.4 m
BENDING FLD. INDEX: 0.01
TH. & MAX: 0.4 T
NO. QUADS (comb. func.): LENGTH (ea) --- m
GRAD. AT INF: --- T/m; MAX --- T/m
NO. SHORT STRAIGHT SECT: 4
LENGTH: 6.1 m
NO. LONG STRAIGHT SECT: 2
LENGTH: 12.2 m
RISE TIME: 0.008 s; FLAT-TOP TIME: 60 Hz sine wave s
POWER INPUT PEAK: MW; MEAN: 1.1 MW

** Acceleration System **
NO. CAVITIES: 5
LENGTH (ea): 5 m
HARMONIC NUMBER: 1600
RF RANGE: --- to 713.94 MHz
ENERGY GAIN: 50000 Kev/turn
RADIATION LOSS: 88000 Kev/turn
RF POWER INPUT PEAK: 500 kW; MEAN: 1200 kW

** Vacuum System **
MATERIAL OF VAC. CHAMBER: s.s. (magnets internal)
APERTURE OF VAC. CHAMBER: 50 x 25 mm
AVERAGE PRESSURE: 10^-5 torr

** Extraction System **
TYPE: i) single turn
ii) resonant
iii)....
LENGTH OF SPILL: i) 1 bunch to 1 μs
ii) 30 to 3000 μs
iii)....

** ACCELERATOR PERFORMANCE **

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>NORMAL (or Goal)</th>
<th>MAXIMUM achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>12</td>
<td>12.2</td>
</tr>
<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td>0.5</td>
<td>0.5</td>
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<tr>
<td>REPET. RATE (pulse/s)</td>
<td>60</td>
<td>60</td>
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<tr>
<td>PULSE WIDTH AT PEAK E</td>
<td>2 μs</td>
<td>2 μs</td>
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<tr>
<td>INTERNAL BEAM (part/pulse)</td>
<td>1001</td>
<td>3x10^14</td>
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<tr>
<td>EMITTANCE AT PEAK E</td>
<td>0.1</td>
<td>unmm-mrad</td>
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</table>

** SECONDARY BEAMS **

<table>
<thead>
<tr>
<th>PARTICLE</th>
<th>MOMENTUM RANGE</th>
<th>NO. OF BEAMS</th>
<th>OTHER INFO</th>
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</tbody>
</table>

** EXPERIMENTAL FACILITY **

TOTAL EXPERIMENTAL AREAS: N.A. ** m^2
No. INTERNAL TARGETS: No. EXT. TARGETS
No. SEPARATED BEAMS: No. BEAMS SERVED AT SAME TIME
TOTAL POWER USED (AVERAGE) FOR RESEARCH: MW
No. USER GROUPS, in house outside
TOTAL RESEARCH STAFF IN HOUSE: outside
ANN. RESEARCH BUDGET, in house: (without sal.) ANNUAL RESEARCH TIME: h

** Other Relevant Parameters, Recent Improvements, etc. **

*Synchrotron is used as injector for Cornell Electron Storage Ring only. Operating figures are for complete accelerator facility. Present operation: 4.5-6 GeV, 14 bunches, single turn extraction.*
NAME OF SYNCHROTRON  Syrinx (Electron Synchrotron)

INSTITUTION  Institute for Nuclear Physics, Polytechnical Institute of Tomsk

LOCATION  USSR, Tomsk

PERSON IN CHARGE  J.P. Uslov, Dir.

DATA SUPPLIED BY  N.A. Laasuk

DATE:  July, 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date)  1958
FIRST BEAM OBTAINED, OR GOAL (date)  1965
TOTAL COST OF FACILITY

TOTAL ACCELERATOR STAFF (now)
Ann. Operat. Budget (without salaries) h
Ann. Operating Time 3000 h

ACCELERATOR PARAMETERS

**General**

ACCELERATED PARTICLES: electron
ENERGY 1.3 GeV
RING DIAM: 10.47 m; TUNNEL SECT. (W x H) m

**Injector**

TYPE Microtron
OUTPUT(ma) 80 ma
EMITTANCE* 6.3 x 1.6 x 0.4 mm-mrad
INJECTION PERIOD 5 ms, or 50 turns
INJECTOR TYPE electrostatic

**Magnet System**

FOCUSING TYPE weak
FIELD INDEX n = 0.58
FOCUSING ORDER
No. MAGNETS 4
LENGTH (m) 0.85
BENDING FIELD (T) 0.53
NO. QUADS 10
LENGTH (m) 1.02
GRAD. AT ING. 1 Tm; at max. 1 Tm
NO. SHORT STRAIGHT SECT 4
LENGTH (m) 6.28
NO. LONG STRAIGHT SECT 4
LENGTH (m) 6.28
INSERT TIME 0.04 s, FLAT-TOP TIME 0.02 s
POWER INPUT PEAK MW; MEAN MW

**Acceleration System**

No. CAVITIES 1
HARMONIC NUMBER 4
RF RANGE 36.5 MHz
ENERGY GAIN 3.25 Kev/Vturn
RADIATION LOSS 65 Kev/Vturn
RF POWER INPUT PEAK 80 kW; MEAN 25 kW

**Vacuum System**

MATERIAL OF VAC CHAMBER porcelain
APERTURE OF VAC. CHAMBER 200x294 mm
AVERAGE PRESSURE 1.1 x 10^-6 torr

**Extraction System**

TYPE i) Septum-magnet
ii) ii)

LENGTH OF SPIKE 10 μs
ii) 10 μs
iii) 10 μs

*Emittance = Area x μ at 90% of current (for p-machines)
NAME OF SYNCHROTRON: Yerevan 6-GeV Electron Synchrotron (YRES)

INSTITUTION: Yerevan Physical Institute

LOCATION: Yerevan, Armenia, USSR

PERSON IN CHARGE: A. T. Amatuni, Director

DATA SUPPLIED BY: V. T. Manukyan, Head of Accelerator

DATE: June 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date): 1962
FIRST BEAM OBTAINED, or GOAL (date): 1978, 10.67 m
TOTAL COST OF FACILITY: 14.3 M11, Rb.
TOTAL ACCELERATOR STAFF (now): 96
ANN. OPERAT. BUDGET: 2.5 Mill. Rb. (without salaries)
ANN. OPERATING TIME: 3600 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES: e-
ENERGY: 6 GeV
RING DIAM: 52.98 m
TUNNEL SECT (W x H): 6.8 x 7.5 m

Injector
TYPE: linear
OUTPUT (max): 210 mA
EMITTANCE*: 5 (horizontal) 2 (vertical) mm-mrad
INJECTION PERIOD: 1 µs, or 1 turn
INDUCTOR TYPE: pulsed electrostatic 68 kV

Magnet System
FOCUSING TYPE: AG
FIELD INDEX n = 114.76
FOCUSING ORDER: 0 (POP/DON)
BETA/BRON FREQ. WHERE: 5.31
No. MAGNETS: 48
LENGTH (ea): 3.21 m
BENDING FIELD at max: 0.61 T
No. QUADS: 6
LENGTH (ea): 0.15 m
GRAD. at ea: 0.24 T/m
No. SHORT STRAIGHT: 4
LENGTH 1.29 m
No. LONG STRAIGHT: 24
LENGTH 1.328 m
RISE TIME: 9.3 µs; FLAT-TOP TIME: 4 µs
POWER INPUT PEAK: 1.9 MW; MEAN 1.9 MW

Acceleration System
No. CAVITIES: 22
LENGTH (ea): 0.7 m
HARMONIC NUMBER: 95
RF RANGE: 0.7 to 132.8 MHz
ENERGY GAIN: 720 keV/turn
RADIATION LOSS: 4500 keV/turn
RF POWER INPUT PEAK: 520 kW; MEAN 70 kW

Vacuum System
MATERIAL OF VAC. CHAMBER: ceramic
APERTURE OF VAC. CHAMBER: 42 x 120 mm
AVERAGE PRESSURE: 10-6 torr

Extraction System
TYPE: quad., sext., beam, bump, septums for exp.
LENGTH OF SPILL: 1000 to 3000 µs

ACCELERATOR PERFORMANCE

ENERGY (GeV): Normal: 6 (Goal: 6.1)
RESOLUTION ΔE/E (%): 0.25
REPET. RATE (pulses): 50
PULSE WIDTH AT PEAK E: 4 ns
INTERNAL BEAM (part/pulse): 1 x 10^11
EMITTANCE* AT PEAK E: 5 x 10^-12 mm-mrad

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other inform.</th>
</tr>
</thead>
<tbody>
<tr>
<td>e^-</td>
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<td>internal target</td>
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</tr>
<tr>
<td>Y</td>
<td></td>
<td>internal target</td>
<td>polarized</td>
</tr>
<tr>
<td>synch. radiation</td>
<td>3</td>
<td>***</td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS: 2600 m²
No. INTERNAL TARGETS: 3
No. EXT. TARGETS: 2
No. SEPARATED BEAMS: 2
No. BEAMS SERVED AT SAME TIME: 2
TOTAL POWER USED (AVERAGE) FOR RESEARCH: 2 MW
No. USER GROUPS, in house: 1
outside 6
TOTAL RESEARCH STAFF, in house: 9
outside: 11
ANN. RESEARCH BUDGET, in house: 2.5 Mill. Rb. (without sal.)
ANNUAL RESEARCH TIME: 4500 h

Other Relevant Parameters, Recent Improvements, etc.

* with flat-top
** without flat-top

*** Parameters of synchrotron radiation:
500 - 2500 Å VUV intensity: 10^3 fotons/s Å
50 - 500 Å soft X-ray: 10^3 fotons/s Å
5 - 50 Å Lithography
0.4 - 1.5 Å KVAPS

*Emittance = Area x p at 90% of current (for p-machines)
NAME OF ELECTRON LINEAR ACCELERATOR: The 1.1/1.4 GeV Electron Positron Linac

INSTITUTION: Institute of High Energy Physics

LOCATION: Beijing, China

PERSON IN CHARGE: ZHOU Shu

DATA SUPPLIED BY: ZHOU Shu

DATE: June, 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date): April, 1984

FIRST BEAM OBTAINED, or GOAL (date): Dec., 1987

TOTAL COST OF FACILITY: $ 8 million

TOTAL ACCELERATOR STAFF (now): 40

ANNUAL OPERAT. BUDGET: $1.5 million (without salaries)

ANNUAL OPERATING TIME: 5700 h

ACCELERATOR PARAMETERS

**Physical Dimensions**

- **ACCELERATOR LENGTH:** 202 m
- **TUNNEL SIZE (L x W x H):** 215 x 3.5 x 3 m

**Injector**

- **TYPE:** Travelling wave linac
- **OUTPUT:** 500 mA - 3 A, maat 300 MeV
- **BEAM EMITTANCE:** / umns mmrad
- **INJECTION PERIOD:** 0.0025 μs, 12.5 RF cycles

**Acceleration System**

- **No. SECTIONS:** 56
- **FIELD MODE:** 273 ± mode FREQUENCY: 2856 MHz
- **GROUP VELOCITY:** 0.0208-0.0070 c, PHASEVEL: 1 c
- **WAVELENGTH:** IN μm, FILLING TIME: 0.63 μs
- **SHUNT IMPEDANCE:** 53.MΩ
- **ATTENUATION:** 0.19 Np/M
- **IRIS, APERTURE: 26.231-19.263 mm, THICKNESS:** 6 mm
- **IRIS SPACING:** 34.99 mm
- **Q:** 15000
- **POWER UNITS, No.:** 15
- **TYPE:** klystron amplifier
- **POWER VOLTAGE:** 16-22 MV/unit
- **FEED SPACING:** 3 m
- **RF POWER INPUT PEAK:** 277 MW, MEAN: 0.01 MW

**Focusing System**

- **TYPE, No. OF LENSES AND SPACING:** Solenoid and triplets
- **LONGITUDINAL:** Long, positioning source solenoid with a length of 1 meters
- **VACUUM SYSTEM:** The vacuum chamber with a length of 9 meters long, and 15 sets of triplets with varia-
- **Aperture of VAC. CHAMBER:** 20 mm
- **AVERAGE PRESSURE:** 5 x 10⁻⁶ torr

Other Relevant Parameters, Recent Improvements, etc.

<table>
<thead>
<tr>
<th>ELECTRON PERFORMANCE</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>1.1/1.4</td>
<td>1.1/1.3</td>
</tr>
<tr>
<td>ENERGY GAIN (MeV/m)</td>
<td>8 - 10</td>
<td>9</td>
</tr>
<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td>± 0.6%</td>
<td>± 0.6%</td>
</tr>
<tr>
<td>REPET. RATE (pulses)</td>
<td>7 - 14</td>
<td>12.5</td>
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<tr>
<td>PULSE WIDTH (μs)</td>
<td>0.0025</td>
<td>0.0025</td>
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<tr>
<td>DUTY FACTOR, macroscopic (%)</td>
<td>3 x 10⁻⁶</td>
<td>3 x 10⁻⁶</td>
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<tr>
<td>BEAM CURRENT (μA)</td>
<td>2 x 10⁸</td>
<td>1 x 10⁸</td>
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<tr>
<td>BEAM EMITTANCE (μm rr)</td>
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<td>0.15</td>
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</table>

<table>
<thead>
<tr>
<th>Positrons</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
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<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>1.1/1.4</td>
<td>1.3</td>
</tr>
<tr>
<td>ENERGY GAIN (MeV/m)</td>
<td>8 - 10</td>
<td>9</td>
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<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td>± 1%</td>
<td>± 1%</td>
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<td>REPET. RATE (pulses)</td>
<td>7 - 14</td>
<td>12.5</td>
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<td>0.0025</td>
</tr>
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<td>DUTY FACTOR, macroscopic (%)</td>
<td>3 x 10⁻⁶</td>
<td>3 x 10⁻⁶</td>
</tr>
<tr>
<td>BEAM CURRENT (μA)</td>
<td>4 x 10⁸</td>
<td>6 x 10⁸</td>
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<tr>
<td>BEAM EMITTANCE (μm rr)</td>
<td></td>
<td>1.6</td>
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</table>

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other inform.</th>
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<td>e⁺, K⁰ e⁻</td>
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<td>2</td>
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RESEARCH PROGRAMME

<table>
<thead>
<tr>
<th>TOTAL EXPERIMENTAL AREAS</th>
<th>m²</th>
<th>No. INTERNAL TARGETS</th>
<th>No. EXT. TARGETS</th>
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</thead>
<tbody>
<tr>
<td>No. SEPARATED BEAMS</td>
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<td></td>
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<tr>
<td>NO. BEAMS SERVED AT SABE TIME</td>
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</tr>
<tr>
<td>TOTAL POWER USED (AVG.) FOR RESEARCH</td>
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<td></td>
<td></td>
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<tr>
<td>No. USER GROUPS, in house</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>NO. TOTAL RESEARCH STAFF, in-house</td>
<td>outside</td>
<td>(without sal.)</td>
<td></td>
</tr>
<tr>
<td>ANNUAL RESEARCH BUDGET, in-house</td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>
**NAME** OF ELECTRON LINEAR ACCELERATOR  
KEK Photon Factory  2.5 GeV Electron Linac  

**INSTITUTION**  
National Laboratory for High Energy Physics  

**LOCATION**  
1-1, Oho, Tsukuba-shi, Ibaraki-ken, 305 JAPAN  

**PERSON IN CHARGE**  
Akira Asami  

**DATE:**  
August 1, 1989  

**HISTORY AND STATUS**  
CONSTRUCTION STARTED (date)  
April 1, 1978  
FIRST BEAM OBTAINED, or GOAL (date)  
Feb., 1982  
TOTAL COST OF FACILITY  
7000 HV  
TOTAL ACCELERATOR STAFF (now)  
25  
ANN. OPERAT. BUDGET  
668 HV (without salaries)  
ANN. OPERATING TIME  
5,100 (in 1988) h  

**ACCELERATOR PARAMETERS**  
**Physical Dimensions**  
ACCELERATOR LENGTH  
415 m  
TUNNEL SIZE (L × W × H)  
400 × 5 × 3 m  

**Injector**  
TYPE  
Gun, PB, B, 2 × 2 m, Acc. guidea  
OUTPUT  
50 mA  
BEAM EMITTANCE  
1.5 μm-mdrad  
INJECTION PERIOD  
2 ns ∼ 2 μs  
RF cycles  
25 pps  

**Acceleration System**  
No. SECTIONS  
160  
LENGTH(eg)  
1.9 m  
FIELD MODE  
2/3 τ  
FREQUENCY  
2856 MHz  
GROUP VELOCITY  
0.019 ∼ 0.0083 c  
PHASEVEL.  
1 c  
WAVELENGTH  
Const. grad.  
FILLING TIME  
0.46 ∼ 0.56 μs  
SHUNT IMPEDANCE  
55.4 ∼ 60.3 Ω  
ATTENUATION  
0.12 ∼ 0.29  
Npdm  
IRIS, APERTURE  
24 ∼ 19.5 mm, THICKNESS  
5 mm  
IRIS SPACING  
35 mm  
Q  
≥ 13,000  
POWER UNITS, No.  
40  
TYPE  
Klystron  
POWER RATING  
30 MW/unit  
FEED SPACING  
τ 10 m  
RF POWER INPUT PEAK  
1200 MW; MEAN  
0.09 MW  

**Focusing System**  
TYPE, No. of LENSES and SPACING  
Quadrupole triplets,  
28 triplets, ∼ 10 m interval in the first fifth,  
∼ 20 m interval in the remainder of accelerator.  

**Vacuum System**  
MATERIAL OF VAC.CHAMBER  
stainless steel  
APERTURE OF VAC. CHAMBER  
57/40 mm  
AVERAGE PRESSURE  
< 10⁻⁴ torr  

Other Relevant Parameters, Recent Improvements, etc.
**NAME OF ELECTRON LINEAR ACCELERATOR**

**INSTITUTION**
Pohang Light Source, POSTECH, KOREA

**LOCATION**
Pohang, KOREA

**PERSON IN CHARGE**
Seo Young Park

**DATE**
June 21, 1989

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**HISTORY AND STATUS**

<table>
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<tr>
<th>CONSTRUCTION STARTED (date)</th>
<th>1989.4 (project started)</th>
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<td>FIRST BEAM OBTAINED, OR GOAL (date)</td>
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<tr>
<td>TOTAL COST OF FACILITY</td>
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<td>TOTAL ACCELERATOR STAFF (now)</td>
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<tr>
<td>ANN. OPERAT. BUDGET (without salaries)</td>
<td></td>
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<tr>
<td>ANN. OPERATING TIME</td>
<td>h</td>
</tr>
</tbody>
</table>

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**ACCELERATOR PARAMETERS**

**Physical Dimensions**
- TUNNEL SIZE (L x W x H): 250 x 3.5 x 3.0 m

**Injector**
- TYPE: Linac
- OUTPUT: 100 mA
- BEAM EMITTANCE: 1.25 mm-mrad
- INJECTION PERIOD: 0.0025 ms
- RF CYCLES: 2856

**Acceleration System**
- No. SECTIONS: 58
- LENGTH (ea): 3.02 m
- FIELD MODE: TH01
- FREQUENCY: 2686 MHz
- GROUP VELOCITY: 0.600 → 0.005 c
- PHASE VEL: 1.9 c
- WAVELENGTH: 0.12 mm
- TRAVELLING: 0.81 µs
- FILLING TIME: 0.81 µs
- SHUNT IMPEDANCE: 135 MΩ
- ATTENUATION: 0.57 Np/m
- IRIS, APERTURE: 26.7 → 19.1 mm
- THICKNESS: 5.84 mm
- IRIS SPACING: 35.014 mm
- Q: 130,000

**Power Units, No.**
- 16 TYPE: Klystron
- POWER RATING: 65 MWatt
- POWER SPACING: 3 m
- RF POWER INPUT PEAK: 45 MW; MEAN: 0.04 MW

**Focusing System**
- TYPE, No. OFLENSES and SPACING: Triplet, 18
- Spacing: varies

**Vacuum System**
- MATERIAL OF VAC. CHAMBER: |
- APERTURE OF VAC. CHAMBER: |
- AVERAGE PRESSURE: |

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**ACCELERATOR PERFORMANCE**

<table>
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<tr>
<th>Particles</th>
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<td>RESOLUTION ΔE/ΔE (%)</td>
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<td>PULSE WIDTH (µs)</td>
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<td>DUTY FACTOR, macroscopic (%)</td>
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<tr>
<td></td>
<td>BEAM CURRENT (µA)</td>
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<tr>
<td></td>
<td>BEAM EMITTANCE (mm-mrad)</td>
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<td>BEAM EMITTANCE (mm-mrad)</td>
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**RESEARCH PROGRAMME**

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<td>MW</td>
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</tr>
<tr>
<td>ANN. RESEARCH BUDGET, in house</td>
<td>(without salary)</td>
</tr>
<tr>
<td>ANN. RESEARCH TIME</td>
<td>h</td>
</tr>
</tbody>
</table>

Other Relevant Parameters, Recent Improvements, etc.
NAME OF ELECTRON LINEAR ACCELERATOR: CEBAF Superconducting Linear

INSTITUTION: CEBAF

LOCATION: Newport News, VA

PERSON IN CHARGE: Christoph Leemann, Director of Operations

DATE: June 30, 1989

DATA SUPPLIED BY: CEBAF Accelerator Division Staff

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HISTORY AND STATUS

CONSTRUCTION STARTED (DATE): February 1987


TOTAL COST OF FACILITY: $200M

TOTAL ACCELERATOR STAFF (now/required): 170

ANN. OPER. BUDGET: $50M (without salaries)

ANN. OPERATING TIME: 760 h

---

ACCELERATOR PARAMETERS

**Physical Dimensions**

ACCELERATOR LENGTH: (active superconducting) 160 m

TUNNEL SIZE (L x W x H): recetrack 1400 x 4 x 3 m

**Injector**

TYPE: Ternomtype gun; 1 m temp. + 18 superconducting accel. sections

OUTPUT: 0.25A max, 45 MeV

BEAM EMITTANCE: < 0.044 mm-mrad

INJECTION PERIOD: CW

**Acceleration System**

No. SECTIONS: 318 Supercond

LENGTH (m): (active) 0.5 m

FIELD MODE: cell type

FREQUENCY: 1407 MHz

GROUP VELOCITY: Standing wave

PHASE VELOCITY: c

WAVE TYPE: m

FILLING TIME: 1400 ps

SHUNT IMPEDANCE: 2300 nH/m

ATTENUATION: ———— Np/m

IRIS, APERTURE: 70 mm, THICKNESS: ———— mm

IRIS SPACING: ———— mm

Q: 2.4 x 10^10

POWER UNITS, No.: 318 TYPE: Klystron

POWER RATING: 0.605 MW/unit

FEED SPACING: ———— m

RF POWER INPUT PEAK: ———— MW; MEAN: ———— MW

**Focusing System**

TYPE, No. OF LENSES AND SPACING: Nine isochronous

Transport beams for 5 passes

**Vacuum System**

MATERIAL OF VAC. CHAMBER: Stainless Steel

APERTURE OF VAC. CHAMBER: ———— mm

AVERAGE PRESSURE: < 10^-9 in vac. regions

< 10^-8 torr in cold regions

Other Relevant Parameters, Recent Improvements, etc.

---

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th></th>
<th>Normal (or Goal)</th>
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</thead>
<tbody>
<tr>
<td><strong>Electrons</strong></td>
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<td>4</td>
<td></td>
</tr>
<tr>
<td>ENERGY GAIN (MeV/nm)</td>
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<tr>
<td>RESOLUTION ΔE/E (%)</td>
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<td>REPET. RATE (pulse/s)</td>
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<tr>
<td>PULSE WIDTH (μs)</td>
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<tr>
<td>DUTY FACTOR, macroscopic (%)</td>
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<tr>
<td>BEAM CURRENT (μA)</td>
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</tbody>
</table>

**Positrons**

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>ENERGY GAIN (MeV/nm)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>REPET. RATE (pulse/s)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PULSE WIDTH (μs)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DUTY FACTOR, macroscopic (%)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>BEAM CURRENT (μA)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>BEAM EMITTANCE (mm-mrad)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**SECONDARY BEAMS**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum Range</th>
<th>No. of Beams</th>
<th>Other Inform.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**RESEARCH PROGRAMME**

TOTAL EXPERIMENTAL AREAS: 3 experimental halls

No. INTERNAL TARGETS: 0

No. EXTERNAL TARGETS: 3

No. SEPARATED BEAMS: 0

No. BEAMS SERVED AT THE SAME TIME: 3

TOTAL POWER USED (AVERAGE) FOR RESEARCH: ———— MW

No. USER GROUPS, in house 100; outside 100

TOTAL RESEARCH STAFF, in house 160; outside 100

ANN. RESEARCH BUDGET, in house $50M (without Salaries)

ANN. RESEARCH TIME: 760 h

---

CEBAF is a superconducting cw, standing wave recirculating linac.

1) Total projected operating expense in 1995 (accelerator ops, research, and administration, including salaries).

2) Total power used, accelerator and experimental equipment.

---
NAME OF ELECTRON LINEAR ACCELERATOR: SLAC Three-Kilometer-Long Linear Accelerator
(Also see under Linear Colliders)

INSTITUTION: Stanford Linear Accelerator Center (SLAC)

LOCATION: Stanford, California 94309 USA

PRISON IN CHARGE: Burton Richter

DATA SUPPLIED BY: Gregory A. Loew

DATE: June 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date): 1962
FIRST BEAM OBTAINED, or GOAL (date): May 21, 1966
TOTAL COST OF FACILITY: $14,114,000
TUNNEL COST (INCLUDING LABOR): Approximately $1,400
ANN. OPERAT. BUDGET: $14,000
ANN. OPERATING TIME: 1,400

ACCELERATOR PARAMETERS

Physical Dimensions

ACCELERATOR LENGTH: 3050 m
TUNNEL SIZE (L x W x H): 4 x 3.5 x 3.3 m

Injector:

TYPE: Linac with thermionic and polarized guns
OUTPUT: 40 mA
BEAM EMITTANCE: mm-mrad
INJECTION PERIOD: 0.1 µsec

Acceleration System

No. SECTIONS: 92
LENGTH: 3.05 m
FIELD MODE: 275 MHz
FREQUENCY: 2856 MHz
GROUP VELOCITY: 0.01 - 0.033
PHASE LEVEL: 1.0 c
WAVEFORM: THP
FILLING TIME: 0.83 µsec
SHUNT IMPEDANCE: 57 MΩ
ATTENUATION: 0.3 V/m
 iris, aperture: 26 - 19 mm, thickness: 5.84 mm
iris spacing: 35 mm
Q: 1,000
POWER UNITS: 247
TYPE: Klystron
POWER RATING: 65 MW/beam
FEED SPACING: 3.05 m; each klystron feeds 4 sections
RF POWER INPUT PEAK: 30,000 MW; MEAN 7 at 120 ppm MW

Focusing System

TYPE, no. of LENSES AND SPACING: Quad FODO Array
Quad Spacing: 3 m to 200 m points, 6 m to 400 m points,
12 m to 3000 m points

Vacuum System

MATERIAL OF VACUUM CHAMBER: Cu and SS
APERTURE OF VACUUM CHAMBER: 37 mm
AVERAGE PRESSURE: 3 x 10^-8 Torr

ACCELERATOR PERFORMANCE

Electrons

ENERGY (GeV): 50
ENERGY GAIN (MeV/nucleon): 12.5 ± 0.5
RESOLUTION (µE): 21
REPT. RATE (pulses): 200
PULSE WIDTH (µsec): 2.5 ± 0.1
DUTY FACTOR, macroscopic: 0.02 ± 0.001
BEAM CURRENT, peak (mA): 50
BEAM EMITTANCE (mm-mrad): 400

Positrons

ENERGY (GeV): 50
ENERGY GAIN (MeV/nucleon): 12.5 ± 0.5
RESOLUTION (µE): 21
REPT. RATE (pulses): 200
PULSE WIDTH (µsec): 2.5 ± 0.1
DUTY FACTOR, macroscopic: 0.02 ± 0.001
BEAM CURRENT, peak (mA): 50
BEAM EMITTANCE (mm-mrad): 400

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum ratio</th>
<th>No. of beams</th>
<th>Other Info</th>
</tr>
</thead>
<tbody>
<tr>
<td>K⁺</td>
<td>1-16 GeV/c</td>
<td>1</td>
<td>10/pulse</td>
</tr>
<tr>
<td>p</td>
<td>1-16 GeV/c</td>
<td>1</td>
<td>10/pulse</td>
</tr>
<tr>
<td>n</td>
<td>1-16 GeV/c</td>
<td>1</td>
<td>10/pulse</td>
</tr>
<tr>
<td>γ</td>
<td>0-120 GeV/100 MeV</td>
<td>1</td>
<td>A x 10⁸ Eq</td>
</tr>
</tbody>
</table>

RESEARCH PROGRAMME (Other than SLC and PEP)

TOTAL EXPERIMENTAL AREAS: 2650 m²
No. INTERNAL TARGETS: 4
No. EXTERNAL TARGETS: 3
No. BEAMS SERVED AT SAME TIME: 4
TOTAL POWER USED (AVG): 7 MW
No. USER GROUPS: in house: 1, outside: 8
AMM. RESEARCH BUDGET: in house: 42, outside: 183
AMM. RESEARCH TIME: in house: 30, outside: 60

Other Relevant Parameters, Recent Improvements, etc.

1. There are presently two injectors on the linac: one at the front end and one at Sector 25, approximately 600 m from the end. The first injector is used predominantly for the SLC and to fill SPEAR and FEP with single bunches of electrons and positrons. This injector can produce single or pairs of bunches with up to 10¹⁸ electrons/bunch (1-16 x 10¹⁶) at 40 MeV with an invariant emittance of 200 mm-mrad at 100 pulses per second. In the near future it will also have a photocathode gun capable of producing longitudinal polarised electrons of similar characteristics. The second injector at Sector 25 is used predominantly for SPEAR for SISRL (e⁻ only) and for medium energy nuclear physics experiments (up to 2.5 GeV). This injector can produce trains of bunches (from 2 to 2000 per bunch) with a peak current of up to 100 mA, an energy of 35 MeV, an invariant emittance of approximately 100 mm-mrad, a pulse length of up to 2.7 µsec, and 120 pulses per second.

2. The first number refers to the "non-SLC" mode in which the SLED cavities are de-tuned, the second to the "SLED" mode in which the cavities are tuned. The SLED energy gain is ~1. The maximum energy actually achieved with the SLC at the end of the linac is approximately 52 GeV.

3. The non-SLC energies for electrons are limited by the present capabilities of the End-station A line (26 GeV) and the End-station B line (32 GeV).

4. This position source, located at the 1000-meter point, is not presently in operation.

Published Articles Describing Machine:


NAME OF MACHINE
TRIUMF Cyclotron

INSTITUTION
TRIUMF (Universities of Alberta, B.C., Simon Fraser and Victoria)

LOCATION
4064 Wesbrook Mall, Vancouver, B.C., CANADA V6T 2A3

PERSON IN CHARGE
E.W. Vogt

DATA SUPPLIED BY
D.R. Pearce

DATE: August 8, 1989

HISTORY AND STATUS
CONSTRUCTION STARTED (date) January 1970
FIRST BEAM OBTAINED (date) December 1971
TOTAL COST OF FACILITY $40M Can. (1989)
TOTAL ACCELERATOR STAFF (now) 110
ANN. OPERATING BUDGET $8M Can. (without salaries)
ANN. OPERATING TIME 5,500 h

ACCELERATOR PARAMETERS

** Ion Source**
INTERNAL $^6$ He, CUSF and Lamb Shift Polarized Sources
EXTERNAL

** Magnet**
Pole Faced: 34.34 m; Rect 7.8 m
Gap: mm Field: 5.8 T
Max: mm Field: 2.0 T at 0.5 cm AT
Ave Field at R max: 4.6
Ave Fields: 6
Total Power: 1.338 MW

** Acceleration System**
No. DEES: 2 Width 16.23 m
Harmonic Number: 5
RF Range: 110 MHz
RF Power Input Peak: 140 MW, Mean: 110 MW

** Vacuum System**
Material of Vac Chamber: Stainless steel
Average Pressure: 5 x 10^-4 torr

** Extraction System**
Type: Electron stripping in carbon foil

ACCELERATOR PERFORMANCE - EXTERNAL P-BEAM

<table>
<thead>
<tr>
<th>Party</th>
<th>Energy range</th>
<th>No. of beams</th>
<th>Other info.</th>
</tr>
</thead>
<tbody>
<tr>
<td>a</td>
<td>20-80 MeV/c</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>b</td>
<td>80-100 MeV/c</td>
<td>1</td>
<td>RF separator</td>
</tr>
<tr>
<td>c</td>
<td>100-150 MeV/c</td>
<td>1</td>
<td>biomedical</td>
</tr>
<tr>
<td>d</td>
<td>200-300 MeV/c</td>
<td>1</td>
<td>polarised</td>
</tr>
<tr>
<td>e</td>
<td>300-500 MeV/c</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>f</td>
<td>500-800 MeV/c</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>g</td>
<td>800-1200 MeV/c</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

SECONDARY BEAMS

ENERGY (MeV) | Normal | Maximum achieved
------------|--------|-----------------|
70-110 | 400 @ 50% duty factor |
140-180 | 99 |
250-320 | 99 |

EMITTANCE* AT PEAK E |
0.3 mm-mrad

OTHER DATA: 3 beams simultaneously extracted with a split ratio down to 10^-4

RESEARCH PROGRAMME

TOTAL EXPERIMENTAL AREAS: 17 m²
No. INTERNAL TARGETS: 250
No. SEPARATED BEAMS: 10
No. BEAMS SERVED AT SAME TIME: 10
TOTAL POWER USED (AVERAGE) FOR RESEARCH: 2 MW
User's

Other Relevant Parameters, Recent Improvements, etc.

Superconducting muon channel

*Emittance = Area x p at 90% of current (for p-machines)
### NAME OF MACHINE
PSI 590 MeV Ring Cyclotron

### INSTITUTION
PSI, Paul Scherrer Institute

### LOCATION
CH-5232 Villigen PSI Switzerland

### PERSON IN CHARGE
Dr. Urs Schryber

### DATA SUPPLIED BY
Dr. Urs Schryber

### DATE: 07/27/89

## HISTORY AND STATUS

- **Construction Started (date):** 1969/1974
- **First Beam Obtained (date):** 01/18/1976
- **Total Cost of Facility:** CHF 1.4 million (1975)
- **Total Accelerator Staff (now):** 70
- **Air-Operated Budget (HFR):** 5 (without salaries)
- **Air Operating Time:** 3,000 h

## ACCELERATOR PARAMETERS

### Ion Source
Injection from 72 MeV

### Internal
Cyclotron into the 590 MeV ring*

### External

### Magnet
- Pole Face Diameter: 9.20 m; Next 4.42 m
- Gap: min 50 mm; Field 2.09 T
- Max 90 mm; Field 1.50 T at 150,000 AT
- AVF Field at Max 0.87
- AVF Sectors 8
- Total Power 0.65 MW

### Acceleration System
- No. of DEES 4 cavities
- Width 45 cm
- Harmonic Number 6
- Range 50.63 MHz
- Energy Gain 0.75
- RF Power Input Peak 5 MW
- RF Power Input Mean 0.68 MW

### Vacuum System
- Material of Vacuum Chamber: Aluminum
- Average Pressure 2*10^-6 torr

### Extraction System
- Type: Electrostatic aperture

## ACCELERATOR PERFORMANCE-EXTERNAL P-BEAM

### Normal
- **Energy (MeV):** 595
- **Current (µA):** 250
- **Resolution ∆E/E (%):** < 0.05
- **Repeat Rate (pulses):** 50
- **Duty Factor, macroscopic (%):** 100
- **Emittance* at peak (mm-mrad):** 1 (axial), 2 (radial)

### Maximum Achieved
- **Energy (MeV):** 595
- **Current (µA):** 170

### Other Data

## SECONDARY BEAMS

### Particle
- **Energy Range:** p: 590 MeV
- **No. of Beams:** 1
- **Other Information:** 6 µA
- **p(trans):** 590 MeV
- **No. of Beams:** 1
- **p(eat):** 5.10^12 / (µm² s)
- **plan:** 40 - 150 MeV
- **No. of Beams:** 1
- **Plan:** Medical plan therapy program

## RESEARCH PROGRAMME

### Total Experimental Areas
- ~ 1000 m²
- **No. Internal Targets:** 3
- **No. External Targets:** 2
- **No. Separated Beams:** 2
- **No. Beams Served at Same Time:** 2 protons 4 pions 2 muons
- **Total Power Used (Average) for Research:** 5 MW
- **No. User Groups, Inhouse:** 6
- **Outside:** 53
- **Total Research Staff, Inhouse:** ~ 50
- **Annual Research Budget, Inhouse:** 1.6 HFR (without salaries)

### Other Relevant Parameters, Recent Improvements, etc.

* Emittance = Area x p at 90% of current (for p-machines)
NAME OF MACHINE: LAMPF (Clinton P. Anderson Meson Physics Facility)
INSTITUTION: Los Alamos National Laboratory
LOCATION: Los Alamos, New Mexico 87545 USA
PERSON IN CHARGE: Gerald T. Carney, Director
DATA SUPPLIED BY: L. Agnew, G. Swan, and O. van Dyck

HISTORY AND STATUS

CONSTRUCTION STARTED (date): 1968
FIRST BEAM OBTAINED, OR GOAL (date): 1972
TOTAL COST OF FACILITY: $255 M
TOTAL ACCELERATOR STAFF (now): 245 (direct staff)
ANN. OPER. BUDGET (without salaries): $800,000
ANN. OPERATING TIME: >8000 h

ACCELERATOR PARAMETERS

**Physical Dimensions**
- ACCELERATOR LENGTH: 800 m
- TUNNEL SIZE (L x H x W): 800 x 3.6 x 4 m

**Injection System**
- OUTPUT: 320 mA (peak)
- EMITTANCE*: ~ 3 mm-mrad

**ACCELERATOR SYSTEM**

<table>
<thead>
<tr>
<th>TYPE (Linac)</th>
<th>Drift Tube</th>
<th>Side-coupled</th>
</tr>
</thead>
<tbody>
<tr>
<td>BEAM ENERGY (MeV)</td>
<td>0.75-100</td>
<td>100-800</td>
</tr>
<tr>
<td>TOTAL LENGTH (m)</td>
<td>227</td>
<td></td>
</tr>
<tr>
<td>ENERGY GAIN (MeV/m)</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>RF FREQUENCY (MHz)</td>
<td>285.25</td>
<td></td>
</tr>
<tr>
<td>FIELD MODE</td>
<td>0.67/2.3/2.0/2.7</td>
<td></td>
</tr>
<tr>
<td>EQUIL PHASE (degree)</td>
<td>-26</td>
<td></td>
</tr>
<tr>
<td>SHUNT IMPED. (M2/2m)</td>
<td>62</td>
<td></td>
</tr>
<tr>
<td>FILLING TIME (µs)</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>TANK DIAM.</td>
<td>50 cm</td>
<td></td>
</tr>
<tr>
<td>NO. DRIFT TUBES</td>
<td>160/2</td>
<td></td>
</tr>
<tr>
<td>DRIFT TUBE LENGTH (m)</td>
<td>300 to 30</td>
<td></td>
</tr>
<tr>
<td>GAPCELL LENGTH RATIO</td>
<td>0.25-0.33</td>
<td></td>
</tr>
<tr>
<td>IRIS THICKNESS</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>IRIS SPACING</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>No. QUADS</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>No. RF POWER UNITS</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td>RF POWER INPUT, PEAK (MW)</td>
<td>2.7 per unit</td>
<td></td>
</tr>
<tr>
<td>RF POWER INPUT, MEAN (MW)</td>
<td>0.25 per unit</td>
<td></td>
</tr>
</tbody>
</table>

Vacuum System
- MATERIAL OF VAC. CHAMBER: copper(int), stainless steel((ext)
- APERTURE OF VAC. CHAMBER: 20 to 1000 mm
- AVERAGE PRESSURE: 5 x 10^-7 torr

Two additional injection systems:
- H: Co converter source, 18 mA (peak), and polarized
- H: optically pumped source, 100 A (peak). Both have injectors similar to H.

**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th>ENERGY (GeV)</th>
<th>Goal</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>RESOLUTION 1/1/1</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>REPEATER RATE (pulses/second)</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>DIPOLE FACTOR, macroscopic (%</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>TOTAL CURRENT (pulses/second)</td>
<td>3 x 10^11</td>
<td>3 x 10^11</td>
</tr>
<tr>
<td>EMITTANCE* AT PEAK E</td>
<td>2 x 10^-13</td>
<td></td>
</tr>
</tbody>
</table>

**SECONDARY BEAMS**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range (MeV/c)</th>
<th>No. of beams</th>
<th>Other info.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Protons</td>
<td>100-1000 MeV/c</td>
<td>1</td>
<td>up to 3 x 10^10 s^-1</td>
</tr>
<tr>
<td>Helium ions</td>
<td>50-150 MeV/c</td>
<td>1</td>
<td>10^11 s^-1</td>
</tr>
<tr>
<td>Deuterons</td>
<td>700-1500 MeV/c</td>
<td>1</td>
<td>10^10 s^-1</td>
</tr>
<tr>
<td>Neutrons</td>
<td>700-1500 MeV/c</td>
<td>1</td>
<td>7 x 10^9 cm^-2</td>
</tr>
</tbody>
</table>

**RESEARCH PROGRAMME**

<table>
<thead>
<tr>
<th>TOTAL EXPERIMENTAL AREAS</th>
<th>3 acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>8000 m²</td>
<td></td>
</tr>
<tr>
<td>No. INTERNAL TARGETS</td>
<td>5</td>
</tr>
<tr>
<td>No. SEPARATED BEAMS</td>
<td></td>
</tr>
<tr>
<td>No. BEAMS SERVED AT SAME TIME</td>
<td>4</td>
</tr>
<tr>
<td>TOTAL POWER USED (AVERAGE FOR RESEARCH)</td>
<td>25 MW</td>
</tr>
<tr>
<td>No. USER GROUPS</td>
<td>36</td>
</tr>
<tr>
<td>TOTAL RESEARCH STAFF</td>
<td>100 ap</td>
</tr>
<tr>
<td>ANN. RESEARCH BUDGET</td>
<td>2800 h</td>
</tr>
<tr>
<td>(without salaries)</td>
<td></td>
</tr>
</tbody>
</table>

- About 40 full time equivalents.

Other Relevant Parameters, Recent Improvements, etc.

LAMPF also provides beam to 800 MeV Proton Storage Ring (PSR) which delivers 270-ps-long pulses at 20 Hz with average current of 500 ps (1989 performance) to intense spallation neutron source for condensed matter research. PSR operating parameters and research program not included in above compilation.
NAME OF MACHINE: INR Moscow Meson Factory Linac
INSTITUTION: Institute for Nuclear Research of the Academy of Sciences of the USSR
LOCATION: Troitsk, Moscow Region, USSR
PERSON IN CHARGE: Professor V.A. Matveev - Director
DATA SUPPLIED BY: Professor S.K. Yessen - Head of Accelerator Department

HISTORY AND STATUS
CONSTRUCTION STARTED (date): 1977
FIRST BEAM OBTAINED, OR GOAL (date): 1980
TOTAL COST OF FACILITY: 4,500,000 rubles
TOTAL ACCELERATOR STAFF (now): 200
ANNUAL OPERATING BUDGET: 5,500,000 rubles (without salaries)
ANNUAL OPERATING TIME: n

ACCELERATOR PARAMETERS
Physical Dimensions
ACCELERATOR LENGTH: 450 m
TUNNEL SIZE (L x H x W): 65 x 60 x 60 m

Injection System
ION SOURCE: duoplasmatron; I = Dubnikov-type
OUTPUT: 250 mA, EMITTANCE: 1.0 mm-mrad
INJECTOR TYPE: pulsed transformer-accelerating tube
OUTPUT: 120 mA, EMITTANCE: 4.0 mm-mrad
BUNCHER: 198.2 MHz, Two-cavity

ACCELERATOR SYSTEM
TYPE (Line): I Drift-tube, II DAW
BEAM ENERGY (MeV): 100.1, 602.0
TOTAL LENGTH (m): 68, 260, 82
ENERGY GAIN (MeV/m): 2.0, 1.5
RF FREQUENCY (MHz): 198.2, 991
FIELD MODE: TM10a, TM10a
Q (x 10): 25, 25
EQUIV. PHASE (degrees): 50, 50
SHUNT IMPEDANCE (MΩ/m): 24, 24
FILLING TIME (ns): 200, 190
No. TANK DIAM. (cm): 5
No. DRIFT TUBES: 180, 172, 10
DRIFT TUBE LENGTH (mm): 4,5, 5
DRIFT TUBE DIAM. (mm): 150
CAP/G cell LENGTH RATIO: 0.24, 0.42
IRIS THICKNESS:

<table>
<thead>
<tr>
<th>MATERIAL</th>
<th>Cell length (mm)</th>
<th>6.2-6.4</th>
<th>6.5-12.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>No. QUADS</td>
<td>196, 115 doubles</td>
<td></td>
<td></td>
</tr>
<tr>
<td>GRADIENT (T/m)</td>
<td>60, 0-8.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>No. RF POWER UNITS</td>
<td>5+2</td>
<td></td>
<td></td>
</tr>
<tr>
<td>RF POWER INPUT, PEAK (MW)</td>
<td>4.0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MEAN (MW)</td>
<td>0.15</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Vacuum System
MATERIAL OF VAC. CHAMBER: copper + stainless steel
APERTURE OF VAC. CHAMBER: 28 - 28 mm
AVERAGE PRESSURE: 6 x 10^-4 torr

ACCELERATOR PERFORMANCE
ENERGY (GeV) | Goal | Maximum achieved
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 602</td>
<td>602</td>
<td></td>
</tr>
<tr>
<td>RESOLUTION (%)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>REPEAT RATE (pulses)</td>
<td>100</td>
<td>100</td>
</tr>
<tr>
<td>PULSE WIDTH AT PEAK</td>
<td>100 μs.</td>
<td>100 μs.</td>
</tr>
<tr>
<td>DUTY FACTOR, macroscopic (%)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>INTERNAL BEAM</td>
<td>1.0</td>
<td>1.0</td>
</tr>
<tr>
<td>INTERNAL BEAM (part/pulse)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>EMITTANCE* AT PEAK</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>OTHER DATA</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

SECONDARY BEAMS (Goal)
<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range (MeV/c)</th>
<th>No. of beams</th>
<th>Other info.</th>
</tr>
</thead>
<tbody>
<tr>
<td>10^15 η^+</td>
<td>200-520</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10^16 η^+</td>
<td>200-520</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10^17 η^+</td>
<td>&lt; 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10^18 η^+</td>
<td>&lt; 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10^19 η^+</td>
<td>&lt; 200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10^10 η^+</td>
<td>800-1200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10^11 η^+</td>
<td>400-1200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10^12 η^+</td>
<td>~ 100</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

RESEARCH PROGRAMME
TOTAL EXPERIMENTAL AREAS: 7800 m²
No. INTERNAL TARGETS | No. EXT. TARGETS
| 9 |
No. SEPARATED BEAMS: 1
No. BEAMS SERVED AT SAME TIME: 9
TOTAL POWER USED (AVERAGE FOR RESEARCH): 35.0 MW
No. USER GROUPS, in house: 11
TOTAL RESEARCH STAFF, in house: 75
ANN. RESEARCH BUDGET, in house: 4500
ANNUAL RESEARCH TIME (Goal): 4500 h

Other Relevant Parameters, Recent Improvements, etc.
Proton stretcher-compressor ring is under development (Energy - 600 MeV, circulating current - 1 A, orbit circumference 106.7 m, duty factor max-98%, min-3.10^-5%, rep.rate-100 Hz).

*Emittance = Area x Pe at 90% of current
NAME: HEAVY ION ACCELERATOR  
LOCATION: Prevessein (France)  
PERSON IN CHARGE: B. de Raad  
INSTITUTION: CERN  
DATA SUPPLIED BY: G. Brianti

HISTORY AND STATUS

| CONSTRUCTION STARTED (date) | 1986 |
| TOTAL COST OF FACILITY | 2. WCUP (ion source and pre-injector) |
| TOTAL ACCELERATOR STAFF (now) | 400 |
| ANN. OPER. BUDGET | 2. WCUP (without salaries) |
| ANN. OPERATING TIME | 720 h |

ACCELERATOR PARAMETERS

**General**
- ACCELERATED PARTICLES: $^{16}$O$^+$, $^{12}$C$^+$, $^{16}$O$^+$
- ENERGY: 200 GeV/n
- RING DIAMETER: 2200 m, TUNNEL SECTION (WxH): 6 x 3 m

**Injector**
- TYPE: Proton Synchrotron
- OUTPUT (max): 0.3 mA at 10 kV/m, mm-mrad
- EMITTANCE*: 0.3 mm-mrad
- INJECTION PERIOD: 2 µs, or 1/11 turns
- INJECTOR TYPE: Fast kicker

**Magnet System**
- FOUCUSING TYPE: Sep function
- FOUCUSING ORDER: 1D00
- BETAHROM FREQUENCY: 26.6 T
- No. MAGNETS: LENGTH (ea): 26.6 m
- BENDING FIELD AT: 2.4 T, at max: 1.8 T
- No. QUADS: 216 LENGTH (ea): 3.05 m
- GRAD. AT: 0.1 T, at max: 0.2 T
- No. SHORT STRAIGHT SECTORS: 216 LENGTH: 1.3 m
- No. LONG STRAIGHT SECTORS: 6 LENGTH: 128 m
- RISE TIME: 1-5, FLAT-TOP TIME: 4-10 s (200 GeV/n)
- POWER INPUT PEAK: 150 MW, MEAN 17 MW

**Acceleration System**
- No. CAVITIES: 4 LENGTH (ea): 20 m
- HARMONIC NUMBER: 4630
- RF RANGE: 199.4 MHz to 200.4 MHz
- ENERGY GAIN: 7200 KeV/turn
- RF POWER INPUT PEAK (each): 750 kW, MEAN 500 kW

**Vacuum System**
- MATERIAL OF VACUUM CHAMBER: St. steel
- APERTURE OF VACUUM CHAMBER: 130 x 30 mm
- AVERAGE PRESSURE: 10\(^{-9}\) torr

**Extraction System**
- TYPE: slow 1/3 integer resonant
- LENGTH OF SPACE: 1) 5.7 sec, 2) 5.2 sec, 3) 1.7 sec, 4) 0.7 sec

**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Energy (GeV/n)</th>
<th>Resolution ΔE/E(%)</th>
<th>Beam (PART./PULSE)</th>
<th>PULSE WIDTH AT PEAK E</th>
<th>EMITTANCE* AT PEAK E</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{16}$O$^+$</td>
<td>60</td>
<td>10</td>
<td>4 x 10(^{3})</td>
<td>4.2 x 10(^{-3})</td>
<td>0.07 mm-mrad</td>
</tr>
<tr>
<td>$^{22}$C$^+$</td>
<td>200</td>
<td>10</td>
<td>6 x 10(^{7})</td>
<td>0.07 mm-mrad</td>
<td></td>
</tr>
</tbody>
</table>

**SECONDARY BEAMS (1990)**

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other info.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$^{16}$O</td>
<td>60, 200 GeV/n</td>
<td>2</td>
<td>H, H3</td>
</tr>
<tr>
<td>$^{32}$C</td>
<td></td>
<td>1</td>
<td>P, H, H8, H5</td>
</tr>
</tbody>
</table>

**EXPERIMENTAL FACILITY**

- TOTAL EXPERIMENTAL AREAS: 3 2900 sq m
- No. INTERNAL TARGETS: 4, No. EXTERNAL TARGETS: 3
- No. SEPARATED BEAMS: All beams pure
- No. BEAMS SERVED AT SAME TIME: 3
- TOTAL POWER USED (AVERAGE) FOR RESEARCH: 15 MW
- No. USER GROUPS, IN HOUSE: 1, OUTSIDE: 30
- ANNUAL RESEARCH BUDGET IN HOUSE: 0.3 WCUP (without salaries)
- ANNUAL RESEARCH TIME: 800 h

**Other Relevant Parameters, Recent Improvements, etc.**

A project exists to accelerate heavier ions, up to $^{208}$Pb$^{124+}$ of $5 \times 10^7$ Pb ions/pulse to a maximum energy of 150 GeV/n.
HISTORY AND STATUS

CONSTRUCTION STARTED (date) 1974
FIRST BEAM OBTAINED, OR GOAL (date) 1978
TOTAL COST OF FACILITY
TOTAL ACCELERATOR STAFF (now)
ANN. OPER. BUDGET (now) $10,000 (without salaries)
ANN. OPERATING TIME 5000 H

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES p, d, HI, H, D, T
ENERGY 3 GeV-p
RING DIAM. 33.6 m, TUNNEL SECT. (W X H) 14m

Injector
TYPE LINAC (p, d) ; Synchrotron (others)
OUTPUT (max) mA
EMITTANCE* µm-mrad
INJECTION PERIOD µs, truns
INJECTOR TYPE Electrostatic

Magnet System
FOCUSING TYPE STRONG - SEP. FUNCTIONS
FOCUSING ORDER 4700
BETA-TRON FREQ. 2.366 V1.8 3.61
NO. MAGNETS 10 LENGTH (mm) 2.49 m
BENDING FIELD atin. 0.1 T, at max 1.9 T
NO. QUADS 24 LENGTH (mm) 0.45 ± 0.47 m
GRAD. at in. 0.1 T, at max 0.07 T

No. SHORT STRAIGHT SECT. 92 LENGTH 0.73 m
NO. OEMAG STRAIGHT SECT. 8 LENGTH 3.94 m
RISE TIME 0.5 µs, FLAT-TOP TIME 2 µs
POWER INPUT PEAK 16 MW, MEAN 9 MW

Acceleration System
NO. CAVITIES 2 LENGTH (mm) 3.94 m
HARMONIC NUMBER 1

RF RANGES p: 1.7 to 8.3 MHz
ENERGY GAIN µp 2.6 keV/µm
RF POWER INPUT PEAK 16 each kW, MEAN 7 kW

Vacuum System
MATERIAL OF VAC. CHAMBER Stainless Steel
APERTURE OF VAC. CHAMBER 240 x 120 mm
AVERAGE PRESSURE 4.10-9 TORR

Extraction System
TYPE Third Integr. Res. Extraction

LENGTH OF SPILL
\( \mu s \)
1) 30 ne
2) 1000 ne

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Particle</th>
<th>Energy(GeV/n)</th>
<th>Resolution (ΔE/E)%</th>
<th>Beam (PART/PULSE) (IN mm-mrad)</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>3</td>
<td>3.10^-4</td>
<td>1.5 10^-12</td>
</tr>
<tr>
<td>d</td>
<td>1.15</td>
<td></td>
<td>0.7 10^-12</td>
</tr>
<tr>
<td>c</td>
<td>&quot;</td>
<td>9.10^-8</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>&quot;</td>
<td>8.10^-8</td>
<td></td>
</tr>
<tr>
<td>Ne</td>
<td>&quot;</td>
<td>2.10^-8</td>
<td></td>
</tr>
<tr>
<td>Ar 16+</td>
<td>0.62</td>
<td></td>
<td>10^-8</td>
</tr>
<tr>
<td>Kr 90+</td>
<td>0.7</td>
<td></td>
<td>2.10^-8</td>
</tr>
<tr>
<td>P</td>
<td>0.3</td>
<td></td>
<td>1.5 10^-8</td>
</tr>
<tr>
<td>R</td>
<td>1.15</td>
<td></td>
<td>2.10^-8</td>
</tr>
</tbody>
</table>

p - extracted beam

polarization > 90% P, > 80% P

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other inform.</th>
</tr>
</thead>
<tbody>
<tr>
<td>d</td>
<td>0.6 - 1.9 GeV/c</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS 6000 m²
NO. INTERNAL TARGETS / NO. EXT. TARGETS 9 / 12
NO. SEPARATED BEAMS 9
NO. BEAMS SERVED AT SAME TIME 2
TOTAL POWER USED (AVERAGE) FOR RESEARCH 7 MW
NO. USER GROUPS, in house 120 outside 120
TOTAL RESEARCH STAFF, in house 60 (without sal.)
ANNUAL RESEARCH TIME 5000 h

other Relevant Parameters, Recent Improvements, etc.
1) See Linac and Synchrotron MINAS
2) to cover all ion species
   \( f_{min} = 0.8 MHz \)
   \( f_{max} = 6.3 MHz \)
3) a long straight section is
   \( \theta \) of 3.94 m each

*Emittance = Area x ζ at 90% of current
NAME OF HEAVY ION ACCELERATOR: SCHWER Ionen SYNCHROTON (SIS)

INSTITUTION: GSI - GESELLSCHAFT FUR SCHWERIONENFORSCHUNG mbH, POB 110552

LOCATION: DARMSTADT, FEDERAL REPUBLIC GERMANY

PERSON IN CHARGE: K. BLASCHE

DATE: 30.6.1989

DATA SUPPLIED BY: K. BLASCHE

HISTORY AND STATUS

CONSTRUCTION STARTED (DATE): 1.11.1986
FIRST BEAM OBTAINED, OR GOAL (DATE): April 1989
TOTAL COST OF FACILITY: 44 MM
TOTAL ACCELERATOR STAFF (now): 20
ANN. OPER. BUDGET: ~2 M; M (without salaries)
ANN. OPERATING TIME: 5000 h

ACCELERATOR PARAMETERS

<table>
<thead>
<tr>
<th>General</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCELERATED PARTICLES</td>
<td>(p) - U</td>
</tr>
<tr>
<td>ENERGY</td>
<td>1 - 2 (4.5) GeV/n</td>
</tr>
<tr>
<td>RING DIAM.</td>
<td>69 m; TUNNEL SECT. (W x H) 4.5 x 3.5 m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Injector</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>TYPE (HEAVY ION LINAC)</td>
<td></td>
</tr>
<tr>
<td>OUTPUT (max)</td>
<td>3 mA@10-20 MeV</td>
</tr>
<tr>
<td>EMITTANCE</td>
<td>10 mm-mrad</td>
</tr>
<tr>
<td>INJECTION PERIOD</td>
<td>~200 us or 40 turns</td>
</tr>
<tr>
<td>INFLECTOR TYPE</td>
<td>ELECTROSTATIC SEPARATOR</td>
</tr>
</tbody>
</table>

Magnet System

FOCUSING TYPE: DOUBLET / TRIPLET
FOCUSING ORDER: FD (F)
BETATRON ORDERム: 4
HARMONIC NUMBER: 24
ENERGY GAIN: 0.95 to 5.6 MeV
RF POWER INPUT PEAK: 22 x charge state / 30 kW

Vacuum System

MATERIAL OF VAC. CHAMBER: STAINLESS STEEL
APERTURE OF VAC. CHAMBER: 200 x 80 mm
AVERAGE PRESSURE: 5.10^-11 mbar

Extraction System

<table>
<thead>
<tr>
<th>TYPE</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>i) FAST EXTRACTION</td>
<td></td>
</tr>
<tr>
<td>ii) RESONANT EXTRACTION</td>
<td></td>
</tr>
<tr>
<td>iii) ULTRA SLOW EXTRACTION</td>
<td></td>
</tr>
<tr>
<td>LENGTH OF SPILL</td>
<td></td>
</tr>
<tr>
<td>i) 0.2 to 3 ns</td>
<td></td>
</tr>
<tr>
<td>ii) 10^4 to 10^4 ns</td>
<td></td>
</tr>
</tbody>
</table>

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Particle</th>
<th>Energy (GeV/n)</th>
<th>Resolution ΔE/E (%)</th>
<th>Beam (PART / PULSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>p</td>
<td>4.5</td>
<td>1.10^-2</td>
<td>2.10^-4</td>
</tr>
<tr>
<td>Ar</td>
<td>1.8</td>
<td>1.10^-3</td>
<td>2.10^-4</td>
</tr>
<tr>
<td>Kr</td>
<td>1.5</td>
<td>1.10^-3</td>
<td>1.10^-4</td>
</tr>
<tr>
<td>Xe</td>
<td>1.4</td>
<td>1.10^-3</td>
<td>5.10^-4</td>
</tr>
<tr>
<td>U</td>
<td>0.9</td>
<td>1.10^-3</td>
<td>2.10^-4</td>
</tr>
</tbody>
</table>

1) Space charge limit

REPT. RATE (pulses): Normal (or Goal) 1-3
EMITTANCE* AT PEAK E: 1-20 nmm-mrad

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other inform.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Neutron</td>
<td></td>
<td></td>
<td>Neutron or proton rich projectile fragments separated by a magnetic system</td>
</tr>
<tr>
<td>protons</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS: 3000 m²
No. INTERNAL TARGETS: No. EXT. TARGETS: 6-8
No. SEPARATED BEAMS: 6
No. BEAMS SERVED AT SAME TIME: 1
TOTAL POWER USED (AVERAGE) FOR RESEARCH: 5 MW
No. USER GROUPS, IN HOUSE: 1
TOTAL RESEARCH STAFF, IN HOUSE: 1
ANN. RESEARCH BUDGET, IN HOUSE: (without sal.)
ANNUAL RESEARCH TIME: ca. 4000 h

OTHER RELEVANT PARAMETERS, RECENT IMPROVEMENTS, ETC.

*Emittance = Area x β at 90% of current
NAME OF HEAVY ION ACCELERATOR
EXPERIMENTAL STORAGE RING (ESR)

INSTITUTION
GSI - GESELLSCHAFT FUR SCHWEITZERPFORCHUNG MBH

LOCATION
DARMSTADT, FEDERAL REPUBLIC OF GERMANY

PERSON IN CHARGE
BERNHARD FRANZKE

DATA SUPPLIED BY
BERNHARD FRANZKE

DATE: 30.6.1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date) November 1986
FIRST BEAM OBTAINED, or GOAL (date) January 1990
TOTAL COST OF FACILITY 26 MDM

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES Ne = U (protons)
ENERGY 3 to 800 MeV/u
RING DIAM. m; TUNNEL SECT. (W x H) m

Injector
TYPE SYNCHRTRON (SIS)
OUTPUT (max) 100 mA at 500-600 MeV/u
EMITTANCE* 0.6 x 0.6 mm-mrad
INJECTION PERIOD 0.5 s, 1 turn
INJECTOR TYPE Status magnet

Magnet System
FOCUSING TYPE COMBINED DOUBLET/TRIPLLET
FOCUSING ORDER variable
BETATRON FREQ. VV 2.72 VV 2.38
NO. MAGNETS 6
NO. QUADS 20
GRAD. B. AT RING 0.08
NO. SHORT STRAIGHT 3
NO. LONG STRAIGHT 2
TIME TO RECOVER 1.5 s
POWER INPUT PEAK 7.5 MW; MEAN 2.5 MW

Acceleration System
NO. CAVITIES 2
HARMONIC NUMBER 2 or 4
RF RANGE 0.85 to 6.6 MHz
ENERGY GAIN ~ 0.7 x charge state
RF POWER INPUT PEAK 20 kw; MEAN 10 kw

Vacuum System
MATERIAL OF VAC. CHAMBER stainless steel
APERTURE OF VAC. CHAMBER (mean) 220 (h) x 60 (v) mm
AVERAGE PRESSURE 5 x 10^-11 mbar
EXTRACTION SYSTEM
TYPE 1) FAST
2) BY CHARGE EXCHANGE OF IONS
LENGTH OF SPILL 5 x 10^-9 to 10^-8 s

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>PARTICLE</th>
<th>ENERGY (MeV/u)</th>
<th>R. Δ(E/ΔE) (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ne⁺⁺⁺⁺</td>
<td>834</td>
<td>0.05</td>
</tr>
<tr>
<td>X⁺⁺⁺⁺</td>
<td>709</td>
<td>0.05</td>
</tr>
<tr>
<td>Xe⁺⁺⁺⁺</td>
<td>566</td>
<td>0.05</td>
</tr>
<tr>
<td>Cr⁺⁺⁺⁺</td>
<td>566</td>
<td>0.05</td>
</tr>
</tbody>
</table>

1) With electron cooling up to 560 MeV/u
2) Space charge limits Normal Max. achieved

REPT. RATE (p.u/sec) 0.3
PULSE WIDTH AT PEAK 1.7 mm Mrad
EMITTANCE* AT PEAK 1.7 mm Mrad

SECONDARY BEAMS

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS 3000 m²
NO. INTERNAL TARGETS 1
NO. EXT. TARGETS 5
NO. SEPARATED BEAMS 1
NO. BEAMS SERVED AT SAME TIME 3
TOTAL POWER USED (AVERAGE) FOR RESEARCH 5 MW
NO. USER GROUPS, in house - outside -
TOTAL RESEARCH STAFF, in house - outside -
ANN. RESEARCH BUDGET, in house
ANNUAL RESEARCH TIME 4000 h

Other Relevant Parameters, Recent Improvements, etc.

Electron cooling: 30 - 560 MeV/u
Stochastic cooling at 500 MeV/u
Internal gas jet target: 10^11 - 10^14 atom/cm²

*Emittance = Area x p at 90% of current
NAME OF HEAVY ION ACCELERATOR
Alternating Gradient Synchrotron

INSTITUTION
Brookhaven National Laboratory

LOCATION
Upton, New York 11973

PERSON IN CHARGE
D.I. Leventhal/Th. Snyders

DATA SUPPLIED BY
L.A. Ahrens, Y.Y. Lee

DATE: 6/23/89

HISTORY AND STATUS

CONSTRUCTION STARTED (date) 1953
FIRST BEAM OBTAINED, OR GOAL (date) October, 1986

TOTAL CORR. OF FACILITY

TOTAL ACCELERATOR STAFF (now) 20 + High Energy
ANN. OPERAT. BUDGET $1.0 M (without salaries)
ANN. OPERATING TIME 1,000 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES H, O, S
ENERGY 14.5 GeV/n
RING DIAM 256.9 m TUNNEL SECT. (W x H) 5.5 x 5.5 m

Injector
TYPE Tandem Van de Graaff
OUTPUT (max) 20 UA (31) XM at 6.7 MeV/n
EMITANCE* 0.35 mm-mrad
INJECTION PERIOD 260 µs, or 12 turns
INJECTOR TYPE Electrostatic

Magnet System
FOCUSING TYPE AG, Comb. Function
FOCUSING ORDER (7/2)(5/2)(4/2) (h/2) (h/2)
BETATRON FREQUENCY ω 8.75 ω' 8.75
NO. MAGNETS 260 LENGTH (a) 2.28 or 1.90 m
BENDING FIELD (T) 0.009 T; at max 1.32 T
NO. QUADS 260 LENGTH (a) 2.28 or 1.90 m
NO. SHORT STRAIGHT SECT. 72 LENGTH 1.76 m
NO. LONG STRAIGHT SECT. 27 LENGTH 3.15 m
RISE TIME 1.0 s; FLAT-TOP TIME 1-2 s
POWER INPUT PEAK 60 MW; MEAN 6 MW

Acceleration System
NO. CAVITIES 1, 2, 4, 8, 16 LENGTH (a) 2 m
HARMONIC NUMBER 12
RF RANGE 0.5 to 4.46 MHz
ENERGY GAIN 192 ReV/turn
RF POWER INPUT PEAK 1,000 kW; MEAN 800 kW

Vacuum System
MATERIAL OF VAC. CHAMBER Inconel-750
APERTURE OF VAC. CHAMBER 173 x 77.8 mm
AVERAGE PRESSURE 1.0 x 10^-7 torr

Extraction System
TYPE i) Slow Extraction
ii) fast i)
iii) slow i)

LENGTH OF SPILL i) 0.5 to 2.5 sec µs
ii) to µs
iii) to µs

ACCELERATOR PERFORMANCE

Particle Energy (GeV/n) Resolution ΔE/E(%) Beam (Particle/Pulse)
H 14.5 0.05 1 x 10^9
O 14.5 0.05 1 x 10^9
S 14.5 0.05 1 x 10^9

SECONDARY BEAMS

Normal Maximum
REPT. RATE (pulses/s) 0.4 achieved
PULSE WIDTH AT PEAK E 0.5-2.5 sec
EMITANCE AT PEAK E 20 mm-mrad

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS 15,000 m²
NO. INTERNAL TARGETS 0 NO. EXT. TARGETS 0
NO. SEPARATED BEAMS 0
NO. BEAMS SERVED AT SAME TIME 0
TOTAL POWER USED (AVERAGE) FOR RESEARCH 20 MW
NO. USER GROUPS, IN HOUSE 4 outside 50
TOTAL RESEARCH STAFF, IN HOUSE 25 outside 225
ANNUAL RESEARCH BUDGET, IN HOUSE 50.7M (operat.) (without sal.)

ANNUAL RESEARCH TIME 1,000 h

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x √t at 90% of current
NAME OF HEAVY ION ACCELERATOR: Bevalac
INSTITUTION: University of California Lawrence Berkeley Laboratory
LOCATION: Berkeley, CA
PRINCIPAL IN CHARGE: June R. Alonso
DATA SUPPLIED BY: Fred Loethen

DATE: June 30, 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date): 1949
FIRST BEAM OBTAINED (date): 1954
TOTAL COST OF FACILITY: $12M (1954 dollars)
TOTAL ACCELERATOR STAFF (now): 450
ANNUAL OPER. BUDGET: $5.25M (without salaries)
ANNUAL OPERATING TIME: 5000 h

ACCELERATOR PARAMETERS

General
ACCELERATED PARTICLES: Protons through uranium
ENERGY: 3.5 to 7.0 GeV
RING DIAM: 60 m; TUNNEL Sect. (W x H): n/A x m

Injector
TYPE: two Alvarez-type linacs
OUTPUT (max): 0.5 mA at 8.5 A MeV
EMITTANCE*: 2 x 10^-10 mm-rad
INJECTION PERIOD: 500 µs or turns
INJECTOR TYPE: electrostatic

Magnet System
FOCUSING TYPE: weak
FOCUSING ORDER: n/A
BETATRON FREQ. v: 0.6
BENDING FIELD at max: 1.25 T
NO. QUADS: n/A
LENGTH (m): n/A
NO. QUADS AT MAX: n/A
GRAD. at quads: n/A
LENGTH (m): n/A
NO. LONG STRAIGHT SECT.: 4
LENGTH (m): 6
RISE TIME: 1.5 s
FLAT-TOP TIME: 1 - 1.5 s
POWER INPUT PEAK: 60 MW; MEAN 5.0 MW

Acceleration System
NO. CAVITIES: 1
LENGTH (m): 4
HARMONIC NUMBER: 1
RF RANGE: 0.26 to 2.50 MHz
ENERGY GAIN: 1.3 KeV/µm
RF POWER INPUT PEAK: 50 kW; MEAN 50 kW

Vacuum System
MATERIAL OF VAC CHAMBER: Copper + NIM C-10 epoxy glass
APERTURE OF VAC CHAMBER: 160 x 1160 mm
AVERAGE PRESSURE: 2 x 10^-7 torr

Extraction System
TYPE: resonant
LENGTH OF SPACE:

ACCELERATOR PERFORMANCE

Particle | Energy(GeV) | Resolution ΔE/E(%) | Beam (PART / PULSE)
---------|-------------|---------------------|---------------------
Protons  | 4.9         | 0.1                 | 3e9
He       | 2.7         | 0.1                 | 3e10
Ne       | 2.1         | 0.1                 | 3e2
Ar       | 1.2         | 0.1                 | 1e9
Fe       | 1.8         | 0.1                 | 5e8
Mg       | 1.4         | 0.1                 | 3e8
La       | 1.25        | 0.1                 | 5e8
Al       | 1.08        | 0.1                 | 1e7
Y        | 0.96        | 0.1                 | 3e8

SECONDARY BEAMS

REPT. RATE (pulses): 0.25
PULSE WIDTH AT PEAK: 1 sec
EMITTANCE* AT PEAK: 15

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS: 2400 ft²
No. INTERNAL TARGETS: 0
No. EXT. TARGETS: 10
No. SEPARATED BEAMS: 0
No. BEAMS SERVED AT SAME TIME: 1
TOTAL POWER USED (AVERAGE) FOR RESEARCH: 8 MW
No. USER GROUPS, IN HOUSE: 5
OUTSIDE: 20
TOTAL RESEARCH STAFF, IN HOUSE: n/A
OUTSIDE: n/A
ANNUAL RESEARCH BUDGET: 600K

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x p at 90% of current
### NAME OF STORAGE RINGS
Large Hadron Collider (LHC)

### INSTITUTION
CERN

### LOCATION
CH-1211 Genève 23 Switzerland

### PERSON IN CHARGE
G. Brianti

### DATE
June 1989

### DATA SUPPLIED BY
L. Bourd

---

### HISTORY AND STATUS

<table>
<thead>
<tr>
<th>CONSTRUCTION STARTED (date)</th>
<th>Existing LEP tunnel</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST COLLISIONS, or GOAL (date)</td>
<td>1996</td>
</tr>
<tr>
<td>TOTAL COST OF FACILITY</td>
<td></td>
</tr>
<tr>
<td>TOTAL MACHINE STAFF (now)</td>
<td></td>
</tr>
<tr>
<td>ANN. OPERAT. BUDGET (without salaries)</td>
<td>h</td>
</tr>
<tr>
<td>ANN. OPERATING TIME</td>
<td></td>
</tr>
</tbody>
</table>

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### STORAGE RINGS PARAMETERS

#### General

- **Colliding Particles**: proton-proton
- **Energy**: 2 x 8000 GeV
- **Approx. Shape**: circular
- **Dimensions**: 8486 m
- **Orbit Length**: 26658.8 m
- **Time**: 60.92 μs
- **No. Intersect**: 3 to 5
- **Crossing Angle**: 36 μrad

#### Injector System

- **Type**: Synchrotron (CERN-SPS)
- **Inj. Energy**: 26 GeV
- **Output**: 450 GeV
- **Emittance**: 15 mm-mrad
- **Filling Speed**: 8.7 mA/s
- **Total Filling Time**: 200 s

#### Magnet System

- **Focusing Type**: Strong
- **Bend. Rad.**: 2668.5 m
- **No. Magnets**: 1760
- **Length (ea)**: 9.54 m
- **No. Quadrupoles**: 568
- **Length (ea)**: 3.08 m
- **Max. Bend. Field**: 10 T
- **Max. Grad.**: 250 T/m
- **Other Magnets**: Damping quads, sextupoles, corr. dipolem
- **Betalas. Freq. (GHz)**: 20.28, 30, 70, 31
- **Ampl. Funct. at Intersect. (GHz)**: 0.25 m, 0.25 m

#### Acceleration System

- **Harmonic No.**: 35640
- **Frequency**: 400.8 MHz
- **No. Transmitters**: 7
- **No. Cavities**: 7
- **Bunch to Bunch Time**: 15 ns
- **Bunch Size (L x W x H)**: (30 x 0.5 x 0.5) mm²
- **Peak RF Voltage per Beam**: 18 MV
- **Max RF Power**: 2 x 7 MW

#### Vacuum System

- **Pressure in Rings, No Beam**: 3 x 10⁻¹² Torr
- **Pressure at Intersections**: Torr

#### Storage Rings Performance

<table>
<thead>
<tr>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Energy (GeV)</strong></td>
<td>2 x 8000</td>
</tr>
<tr>
<td><strong>Resolution ΔE/E (%)</strong></td>
<td>0.23</td>
</tr>
<tr>
<td><strong>Luminosity (cm⁻² sec⁻¹)</strong></td>
<td>3.6 x 10³⁴</td>
</tr>
<tr>
<td><strong>Beam Size, horizontal</strong></td>
<td>21 μm</td>
</tr>
<tr>
<td><strong>Beam Size, vertical</strong></td>
<td>21 μm</td>
</tr>
<tr>
<td><strong>Current, Per Beam (mA)</strong></td>
<td>865</td>
</tr>
<tr>
<td><strong>Beam Life, At 865 mA</strong></td>
<td>12.5 h</td>
</tr>
</tbody>
</table>

---

### RESEARCH PROGRAM

- **Approx. Experimental Area**: 3 x 1150 m²
- **No. Experimental Intersects**: 3
- **No. Experiment/Intersect**: 1
- **Special Research Equipment or Facilities**: 1

---

**Other Relevant Parameters, Recent Improvements, etc.**

---

*Emittance $= \text{Area} \times 1 \%$ at 90% of current (for p-machines)*
### NAME OF STORAGE RINGS
SPPS Proton-Antiproton Collider (SppS)

**LOCATION**
Précessin (France)

**INSTITUTION**
CERN

**PERSON IN CHARGE**
B. de Raad

**DATE**
1-7-89

**DATA SUPPLIED BY**
G. Brianli

### HISTORY AND STATUS

<table>
<thead>
<tr>
<th>CONSTRUCTION STARTED (date)</th>
<th>1980</th>
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<tr>
<td>FIRST COLLISIONS, or GOAL (date)</td>
<td>July 1981</td>
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<tr>
<td>TOTAL COST OF FACILITY</td>
<td>200 MCHP (incl. 1980 CHF)</td>
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<tr>
<td>TOTAL MACHINE STAFF (now)</td>
<td>400</td>
</tr>
<tr>
<td>ANNUAL OPERATING BUDGET</td>
<td>9 MCHP (with salaries)</td>
</tr>
<tr>
<td>ANNUAL OPERATING TIME</td>
<td>2500 h</td>
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</tbody>
</table>

### STORAGE RINGS PARAMETERS

**General**

<table>
<thead>
<tr>
<th>COLLIDING PARTICLES</th>
<th>Protons + Antiprotons</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>315</td>
</tr>
<tr>
<td>APPR. SHAPE</td>
<td>Circular</td>
</tr>
<tr>
<td>DIMENSIONS</td>
<td>1100 m rad</td>
</tr>
<tr>
<td>ORBIT LENGTH</td>
<td>6911 m, time</td>
</tr>
<tr>
<td>No. INTERSECTS</td>
<td>2</td>
</tr>
<tr>
<td>CROSSING ANGLE</td>
<td>0</td>
</tr>
</tbody>
</table>

**Injector System**

| TYPE | Proton Synchrotron |
| INJ. ENERGY | 800 MeV (P.M. 850 MeV) |
| OUTPUT | 26 GeV |
| EMMITANCE | 10 μm rad |
| FILLING SPEED | 26.8 sec |

**Magnet System**

| FOCUSING TYPE | Sep Function |
| BEND, RAD. | 740 m |
| LATTICE ORDER | P4BD |
| LENGTH (m) | 6.26 m |
| No. QUADS | 216 |
| LENGTH (m) | 5.05 m |
| MAX BEND FIELD | 1.4 T; MAX GRAD. | 15.7 T/m |
| OTHER MAGNETS | |
| BETA Freq. | 26.2 |
| AMPL. FUNCT. AT INTERSECT | 1 m |
| V | 27.7 |
| V0 | 0.5 m |
| Acceleration System | (Combined 100 MHz and 200 MHz) |
| HARMONIC No. | 4620 |
| FREQUENCY | 200.6 MHz |
| No. TRANSMITTERS | 4 |
| No. CAVITIES | 4 |
| BUNCH TO BUNCH TIME | 3.83 microseconds |
| BUNCH SIZE (L x W x H) | 0.9 m x 2 mm x 1.3 mm |
| PEAK RF VOLTAGE PER BEAM | 3.6 kV |
| MAX RF POWER (per cav) | 750 kW ON BEAMS |

**Vacuum System**

| PRESSURE IN RINGS, NO BEAM | 10^-10 Torr |
| PRESSURE WITH BEAM | Torr/μA |
| PRESSURE AT INTERSECTIONS | 10^-6 Torr |

### STORAGE RINGS PERFORMANCE

<table>
<thead>
<tr>
<th>ENERGY (GeV)</th>
<th>Normal</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>270</td>
<td>315</td>
</tr>
<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td>0.1%</td>
<td>0.1%</td>
</tr>
<tr>
<td>LUMINOSITY (cm^-2 s^-1)</td>
<td>1 x 10^30</td>
<td>2.8 x 10^30</td>
</tr>
<tr>
<td>BEAM SIZE, horizontal</td>
<td>0.2 mm</td>
<td>0.2 mm</td>
</tr>
<tr>
<td>BEAM SIZE, vertical</td>
<td>0.15 mm</td>
<td>0.15 mm</td>
</tr>
<tr>
<td>CURRENT, PER BEAM (mA)</td>
<td>400</td>
<td>400</td>
</tr>
<tr>
<td>BEAM LIFE, AT 500 mA</td>
<td>200 hours</td>
<td></td>
</tr>
</tbody>
</table>

### RESEARCH PROGRAM

| APPROX. EXPERIMENTAL AREA | 1200 m² |
| No. EXPERIMENTAL INTERSECTS | 2 |
| No. EXPERIMENT/INTERSECT | 2 |

**SPECIAL RESEARCH EQUIPMENT OR FACILITIES:**

1. Internal gas jet

**Other Relevant Parameters, Recent Improvements, etc.**

* Emittance = Area x p; at 90% of current (for p-machines)
**NAME OF STORAGE RINGS**
LEP (Large Electron Positron) Collider

**INSTITUTION**
CERN

**LOCATION**
Geneva, Switzerland

**PERSON IN CHARGE**
E. Picasso

**DATA SUPPLIED BY**
G. Plass

**DATE:** 27.6.89

---

**HISTORY AND STATUS**

<table>
<thead>
<tr>
<th>CONSTRUCTION STARTED (DATE)</th>
<th>1.9.83</th>
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<tbody>
<tr>
<td>FIRST COLLISIONS,衮 Goal (DATE)</td>
<td>August 1989</td>
</tr>
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</table>

**TOTAL COST OF FACILITY:** 1294 MCH

**TOTAL MACHINE STAFF (NOW): APPROX. 750**

**ANN. OPERAT. BUDGET (1989):** To be determined (without salaries)

**ANN. OPERATING TIME:** To be determined

---

**STORAGE RINGS PARAMETERS**

**General**

<table>
<thead>
<tr>
<th>COLLIDING PARTICLES</th>
<th>Electrons - Positrons</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>20 to 55</td>
</tr>
<tr>
<td>APPROX. SHAPE</td>
<td>Circular</td>
</tr>
<tr>
<td>DIMENSIONS: R = 42/72.89 m</td>
<td></td>
</tr>
<tr>
<td>ORBIT LENGTH</td>
<td>26.655.883 m, time 88.915 s</td>
</tr>
<tr>
<td>NO. INTERSECTS</td>
<td>8</td>
</tr>
<tr>
<td>CROSSING ANGLE</td>
<td>Zero</td>
</tr>
</tbody>
</table>

**Injector System**

| TYPE | Synchrotron |
| OUTPUT | 20 GeV |
| EMITTANCE* | 0.64 mm-mrad |
| FILLING SPEED | 0.25 mA/min |
| TOTAL FILLING TIME | 24 min |

**Magnet System**

| FOCUING TYPE | Strong |
| LENGTH (a) | 5.75 m |
| NO. MAGNETS | 3304+6424 |
| NO. QUADS | 816 |
| MAX BEND FIELD | 0.155 T |
| MAX GRAD | 10.0 T/m |
| OTHER MAGNETS | 504 sextupoles + 516 correctors |
| BETATRON FREQ | 78.42 Hz |
| AMPL. FUNCT. AT INTERSECT | 0.375 m | 0.07 m |

**Acceleration System**

| HARMONIC NO. | 31-320 |
| FREQUENCY | 352-390 kHz |
| NO. TRANSMITTERS | 10 |
| NO. CAVITIES | 128 |
| BUNCH TO BUNCH TIME | 22.23 μs |
| BUNCH SIZE (x x y x z) | 18 mm x 3 mm x 0.4 mm |
| PEAK RF VOLTAGE PER BEAM | 360 MW |
| MAX RF POWER | 16 MW |

**Vacuum System**

| PRESSURE IN RINGS, NO BEAM | 8 x 10^-12 Torr |
| PRESSURE AT INTERSECTIONS | 10^-9 Torr |
| PRESSURE WITH BEAM | 10^-7 to 10^-9 Torr |

---

**STORAGE RINGS PERFORMANCE**

<table>
<thead>
<tr>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>55</td>
</tr>
<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td>0.7</td>
</tr>
<tr>
<td>LUMINOSITY (cm^-2 sec^-1)</td>
<td>1.7 x 10^31</td>
</tr>
<tr>
<td>BEAM SIZE, horizontal</td>
<td>300 μm</td>
</tr>
<tr>
<td>BEAM SIZE, vertical</td>
<td>12 μm</td>
</tr>
<tr>
<td>CURRENT, PER BEAM (mA)</td>
<td>3</td>
</tr>
<tr>
<td>BEAM LIFE, AT 3 mA</td>
<td>5 h</td>
</tr>
</tbody>
</table>

**RESEARCH PROGRAM**

| APPROX. EXPERIMENTAL AREA | 4 m² |
| No. EXPERIMENTAL INTERSECTS | 1 |

**SPECIAL RESEARCH EQUIPMENT OR FACILITIES:**

**Other Relevant Parameters, Recent Improvements, etc.**

- **Alohi:** CERN + 28 outside Groups
- **Opal:** CERN + 24
- **L3:** CERN + 40
- **Delphi:** CERN + 38

---

*Emittance = Area x π/2 at 90% of current (for p-machines)
NAME OF STORAGE RINGS: Beijing Electron Positron Collider (BEPC)

INSTITUTION: Institute of High Energy Physics

LOCATION: Beijing, China

PERSON IN CHARGE: Fang Shoushan

DATE: June 20, 1989

DATA SUPPLIED BY: Fang Shoushan

HISTORY AND STATUS

CONSTRUCTION STARTED (date): April 24, 1984
FIRST COLLISIONS, or GOAL (date): Oct. 16, 1988
TOTAL COST OF FACILITY: 8.80 million
TOTAL MACHINE STAFF (now): 500
ANNUAL OPERATING BUDGET: $5 million (without salaries)
ANNUAL OPERATING TIME: 6000 h

STORAGE RINGS PARAMETERS

General

COLLIDING PARTICLES: e⁻, e⁺
ENERGY: 1.55-2.8 GeV
APPROX. SHAPE: round
DIMENSIONS: 38.25 m in radius
ORBIT: Length 240.4 m, time 0.601 µs
NO. INTERSECT: 2
CROSSING ANGLE: 0

Injector System

TYPE: Electron Linac
INJECTION ENERGY: 1.1-1.4 GeV
OUTPUT: 600 mA, 6.6 mA e⁺
EMITTANCE*: 0.15 (for e⁻), 2 (for e⁺) mm-mrad
FILLING SPEED: 2 mA/min (e⁻), 120 mA/min (e⁺)
TOTAL FILLING TIME: 60 min

Magnet System

FOCUSED: Sep. funct.
BEND, RAD.: 10, 345 m
LATITUDE ORDER: FABODORO
NO. MAGNETS: 40, 48 (Lb x 3), LENGTH (mm): 1.6 m
NO. QUADS: 600 x 310, LENGTH (mm): 0.410, 0.6110 m
MAX BEND FIELD: 0.8 T, MAX BEND: 3.3 km
OTHER MAGNETS: 5 wigglers
BETATRON FREQ. Wh: 6.18 Wh
AMPL. FREQ. AT INTERSECT: 1.3 m, 0.3 m

ACCELERATION SYSTEM

HARMONIC NO.: 160
FREQUENCY: 199.53 MHz
NO. TRANSMITTERS: 8
NO. CAVITIES: 2
BUNCH SIZE: L x W x H: 104 mm x 1.8 mm x 0.14 mm (1.5)
PEAK RF VOLTAGE PER BEAM: 1.55 MV x 2
MAX RF POWER: 200 kW ON BEAMS

Vacuum System

PRESSURE IN RINGS, NO BEAM: 5 x 10⁻¹⁰ Torr
PRESSURE AT INTERSECTIONS: 10⁻⁸ Torr

STORAGE RINGS PERFORMANCE

ENERGY (GeV): Normal (normal) 2.8 GeV
MAXIMUM achieved: 3.2 GeV
RESOLUTION ΔE/E (%): 1.5 x 10⁻⁴
LUMINOUSITY (cm⁻²sec⁻¹): 1.7 x 10⁻¹³
BEAM SIZE, horizontal: 0.14 mm
BEAM SIZE, vertical: 0.16 mm
CURRENT, PER BEAM (mA): 65 mA
BEAM LIFE, AS: 6 hrs
RESEARCH PROGRAM

APPROX. EXPERIMENTAL AREA: 1000 m²
NO. EXPERIMENTAL INTERSECT: 3
NO. EXPERIMENT INTERSECT: 1
SPECIAL RESEARCH EQUIPMENT OR FACILITIES:

BES-- Beijing Spectrometer

TOTAL POWER USED (average) FOR RESEARCH: 1.5 MW
NO. USER GROUPS: 1
NO. USER GROUPS, in house: 1
TOTAL RESEARCH STAFF, in house: 80
TOTAL RESEARCH STAFF, outside: 10
ANN. RESEARCH BUDGET: 1.5 millions (without salaries)
ANN. RESEARCH TIME: 8000 h

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x r at 90% of current (for p-machines)
NAME OF STORAGE RINGS: DESY II

INSTITUTION: Deutsches Elektronen-Synchronronenlabor

LOCATION: Hamburg, Germany

PERSON IN CHARGE: H. Neumann

DATE: June 89

DATA SUPPLIED BY: H. Neumann, H. Schröder

HISTORY AND STATUS

CONSTRUCTION STARTED (DATE): 1970
FIRST COLLISIONS, or GOAL (DATE): Dec. 1973
TOTAL COST OF FACILITY: 120 MDM
TOTAL MACHINE STAFF (now) see "DESY II"
ANN. OPERAT. BUDGET see "DESY II" (without salaries)
ANN. OPERATING TIME: 600 h

STORAGE RINGS PARAMETERS

General
COLLIDING PARTICLES: e- and e+
ENERGY: 5.6 GeV
APPROX. SHAPE: oval
DIMENSIONS: 55 x 311 m
ORBIT LENGTH: 288 m, time: 0.96 µs
No. INTERSECTS: 2
CROSSING ANGLE: 0

Injector System
TYPE: Synchrotron, DESY II
INJ. ENERGY: working energy of DESY II
EMITTANCE: 1560 x 5.3 x 10^-6 m.m.rad
FILLING SPEED: e-: 1/1.2 mA/sec; e+: 1/2 mA/sec
TOTAL FILLING TIME: 1 - 2 min

Magnet System
FOCUSING TYPE: separated function
RADIUS, RAD.: 12.22 m
LATTICE ORDER:
No. MAGNETS: 24
No. QUADS: 68
LENGTH (ea): 0.6 x 11 m
MAX. BEND, FIELD: 1.5 T; MAX. GRAD.: 21 T/m
OTHER MAGNETS: 40 sextupoles
BETATRON FREQ.: 71.163 kHz
AMPL. FUNCT. AT INTERSECT: 0.63 m, 0.04 m

Acceleration System
HARMONIC NO: 480
FREQUENCY: 500 MHz
NO. TRANSMITTERS: 4
NO. CAVITIES: 11

BUNCH TO BUNCH TIME: 2 - 960 nsec
BUNCH SIZE (L x W x H): 36 x 6 x 2.6 mm
PEAK RF VOLTAGE PER BEAM: 13 MV
MAX RF POWER: 1.2 MW ON BEAMS; 0.5 MV

Vacuum System
PRESSURE IN RINGS, NO BEAM: 2 x 10^-9 Torr
WITH BEAM: 0.2 x 10^-9 Torr
PRESSURE AT INTERSECTIONS: 1 x 10^-9 Torr

STORAGE RINGS PERFORMANCE

<table>
<thead>
<tr>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>5.3</td>
</tr>
<tr>
<td>RESOLUTION ΔE/E(%)</td>
<td>0.33</td>
</tr>
<tr>
<td>LUMINOSITY (cm^-2 sec^-1)</td>
<td>3.3 x 10^-1</td>
</tr>
<tr>
<td>BEAM SIZE, horizontal</td>
<td>600 µm</td>
</tr>
<tr>
<td>BEAM SIZE, vertical</td>
<td>53 µm</td>
</tr>
<tr>
<td>CURRENT, PER BEAM (mA)</td>
<td>0.2</td>
</tr>
<tr>
<td>BEAM LIFE, AT</td>
<td>62 mA</td>
</tr>
</tbody>
</table>

RESEARCH PROGRAM

APPROX. EXPERIMENTAL AREA: 2100 m²
No. EXPERIMENTAL INTERSECTS: 2
No. EXPERIMENT INTERSECT: 1 and 0
SPECIAL RESEARCH EQUIPMENT OR FACILITIES:

TOTAL POWER USED (average) FOR RESEARCH: 2 MW
No. USERS GROUPS, IN HOUSE: 1
TOTAL RESEARCH STAFF, IN HOUSE: 20
ANN. RESEARCH BUDGET: 20 (without)
ANN. RESEARCH TIME: 4000 h

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x p; at 90% of current (for p-machines)
NAME OF STORAGE RINGS  HERA

INSTITUTION  Deutsches Elektronen-Synchrotron DESY

LOCATION  Notkestraße 85, 2000 Hamburg 52, West Germany

PERSON IN CHARGE  G.-A. Voas, B. H. Wiik

DATA SUPPLIED BY  J. Rößbach

DATE: June 20, 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date)  May 1984
FIRST COLLISIONS, or GOAL (date)  1990
TOTAL COST OF FACILITY
TOTAL MACHINE STAFF (now)
ANN. OPERAT. BUDGET (without salaries)
ANN. OPERATING TIME  h

STORAGE RINGS PARAMETERS

General
COUPLING PARTICLES  electrons or positrons vs. protons
ENERGY  26 x 820 GeV
APPROX. SHAPE  Ring
DIMENSIONS  2 km Ø
ORBIT  Length  6336 m, time  21.13 h
No. INTERSECTS  3
CROSSING ANGLE  0.8

Injector System
TYPE  Linac → Synchrotron → Booster Storage Ring
INF. ENERGY  14 GeV/40 GeV
OUTPUT  mmm-mrad
EMITANCE  0.039 (e) / 17.7, (p)
FILLING SPEED
TOTAL FILLING TIME  35 min / 20 min

Magnet System
FOCUSING TYPE  FODO
LING, RAD.  611/584 m
LATITUDE ORDER  AX (straight section - ABC)
No. MAGNETS  395/416
LENGTH (m)  9.115/8.824
No. QUADS  580/580
LENGTH (m)  0.76 / 1.86
MAX. BEND. FIELD  0.278 T
MAX. GRAD.  19.91 T/m
OTHER MAGNETS  septupoles, skew quad, 10-pole, 12-pole
BETATRON FREQ.  47.2 (e)/31.15 (p)
AMPL. FUNCT. AT INTERSECT  0.24 m (e)/1.31 m (p)

Acceleration System
HARMONIC No.  10560/4000
FREQUENCY  500/208 MHz
No. TRANSMITTERS  12 (a)/1 (p)
No. CAVITIES  8276
BUNCH TO BUNCH TIME  90 ns
BUNCH SIZE (x x y x h)  24 x 1 x 1 x 1 mm²
PEAK RF VOLTAGE PER BEAM  24V / 8.5 V
MAX RF POWER  8.2 / 0.24 MW
ON BEAMS  4.17 / 0.055 MW

Vacuum System
PRESSURE IN RINGS, NO BEAM  < 4 x 10⁻⁹ (e) / < 3 x 10⁻¹¹ (p) Torr
PRESSURE AT INTERSECTIONS  3.9 Torr

STORAGE RINGS PERFORMANCE

<table>
<thead>
<tr>
<th>ENERGY (GeV)</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>26/820</td>
<td>26/820</td>
<td>13.9 /</td>
</tr>
</tbody>
</table>

| RESOLUTION ΔE/E (%) | 0.170/13 |
| LUMINOSITY (cm⁻²sec⁻¹) | 1.6 x 10¹⁵ |
| BEAM SIZE, horizontal at IP | 280/265 µm |
| vertical | 377/38 µm |
| CURRENT, PER BEAM (mA) | 38/163 |
| BEAM LIFE, AT GOAL, mA | > 5 / > 10 h |

<table>
<thead>
<tr>
<th>RESEARCH PROGRAM</th>
</tr>
</thead>
<tbody>
<tr>
<td>APPROX. EXPERIMENTAL AREA</td>
</tr>
<tr>
<td>No. EXPERIMENTAL INTERSECTS</td>
</tr>
<tr>
<td>No. EXPERIMENT/INTERSECT</td>
</tr>
</tbody>
</table>

SPECIAL RESEARCH EQUIPMENT OR FACILITIES:
Electron spin rotator for longitudinally polarized e⁺⁻ beam at IP

Other Relevant Parameters, Recent Improvements, etc.

ε⁺⁻ polarization time: 24 min
beam-beam tune shifts per IP:
Δ Qₓ = 0.019 (e) / 0.0011 (p)
Δ Qᵧ = 0.021 (e) / 0.0068 (p)

*Emittance = Area x β at 90% of current (for p-machines)
**NAME OF SYNCHROTRON**
PETRA II

**INJECTOR FOR**
HERA

**LOCATION**
DESY, Hamburg

**PERSON IN CHARGE**
Martin Leneke

**DATE**
21.06.89

**DATA SUPPLIED BY**
Martin Leneke

---

**HISTORY AND STATUS**

**CONSTRUCTION STARTED (date)**
Nov. 86

**FIRST BEAM OBTAINED, or GOAL (date)**
Max. 87 (Okt. 89)

**TOTAL COST OF FACILITY**
98 MDM (PETRA I)

**TOTAL ACCELERATOR STAFF (now)**
see DESY II

**ANN. OPERAT. BUDGET**
see DESY II [without salaries]

**ANN. OPERATING TIME**
see below h

---

**ACCELERATOR PARAMETERS**

**General**

ACCELERATED PARTICLES: e ± (p)

ENERGY
16 (40) GeV

RING DIAMETER: 733.4 m; TUNNEL SECT. (WxH) 3.1 x 2.5 m

**Injector**

TYPE: Synchrotron DESY II (DESY III)

OUTPUT (max) mA at MeV

EMITTANCE* mm-mrad

INJECTION PERIOD: µs or turns

**FILTECTOR TYPE**

---

**Magnet System**

FOCUSING TYPE: sep. fact. FIELD INDEX: n =

FOCUSING DIVERG: 25.20 (11.4)

BETATRON FREQUENCY ν, 25.24 (11.16)

NO. MAGNETS: 224 + 8

LENGTH (m): 5.317

**BENDING FIELD**

at F Phar. 0.12 7; at max 0.26 (0.7) 1

NO. QUADS: 232/72

LENGTH (m): 0.66/1.8

**GRAD. ALIGN.: 8**

at max 16.4 m

**NO. SHORT STRAIGHT SECT.: 4**

**LENGTH:** 64.8 m

**NO. LONG STRAIGHT SECT.: 4**

**LENGTH:** 106.0 m

RISE TIME: 60 (120) 5; FLAT-TOP TIME: 5

**POWER INPUT PEAK:** 4.1 (15.5) MW; **MEAN:** 4.1 MW

**Acceleration System**

NO. CAVITIES: 16 (2)

**LENGTH (m): 2.2 (1.6)**

HARMONIC NUMBER: 5840 (490)

RF RANGE: 499.665 (51.6) to 499.865 (52.0) MHz

ENERGY GAIN: KeVturn

RADIATION LOSS: 17.7 at 14 GeV KeVturn

RF POWER INPUT PEAK: 2000 (1000) kW; **MEAN:** 1000 kW

**Vacuum System**

MATERIAL OF VAC. CHAMBER: AL

APERTURE OF VAC. CHAMBER: 114 x 30 mm

AVERAGE PRESSURE: 10^−8 torr

**Extraction System**

TYPE: Fast kicker with variable pulse width for single or multibunch extraction

LENGTH OF SPILL: to µs

---

*Emittance = Area × β, at 90% of current (for p-channels)

**ACCELERATOR PERFORMANCE**

**ENERGY (GeV)**

14 (40) Normal (or Goal)

**Maximum achieved**

**RESOLUTION ΔE/Ε (%)**

8.4 x 10⁻²

**PULSE WIDTH AT PEAK E**

1.7 5 min

**INTERNAL BEAM**

part p-part e

**BEAM EMITTANCE**

0.1 (13.7) mm-mrad

**BEAM LINES TO HERA**

e⁻/e⁻ and p⁺ main rings

---

Other Relevant Parameters, Recent Improvements, etc.

Data in brackets relate to operation with protons.

For high energy physics operation until the end of 1986 the annual operating time was typically 6000 hours. 1987 to 1989 PETRA is being modified as e⁻/e⁺ and p⁺-injector for the HERA main rings. Consequently, 1990 if the operating time will be determined by HERA.
**NAME OF SYNCHROTRON**
DESY III

**INJECTOR FOR**
PETRA II protons

**LOCATION**
DESY, Hamburg, West Germany

**PERSON IN CHARGE**
Günter Henrie

**DATE:** 23.06.89

---

**HISTORY AND STATUS**

<table>
<thead>
<tr>
<th>Construction Started (date)</th>
<th>Nov. 1986</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Beam Obtained or Goal (date)</td>
<td>Feb. 22, 1989</td>
</tr>
<tr>
<td>Total Cost of Facility</td>
<td>10 Hm</td>
</tr>
<tr>
<td>Total Accelerator Staff (now)</td>
<td>600</td>
</tr>
<tr>
<td>Ann. Operat. FAC/Gen. Staff</td>
<td>600</td>
</tr>
<tr>
<td>ANN, Operating Time</td>
<td>(without holidays)</td>
</tr>
</tbody>
</table>

**ACCELERATOR PARAMETERS**

**General**

- Accelerated Particles: \(1.1 \times 10^{12}\) p (goal)
- Energy: 7.5 GeV
- Ring Diameter: 100.84 m
- Tunnel Sector (W×H): 8.8 × 3.7 m

**Injector**

- Type: H RFU + 3 x Alvarez
- Output (max): 7 mA at 50 MeV
- Emittance*: 8 nmm-mrad
- Injection Period: 30 μs, or 10 turns
- Injector Type: stripping foil + 4 kicker bump

**Magnet System**

- Focusing Type: A0
- Field Index: \(m = 0.95, \; n = 0.16\)
- Betatron Freq., \(\sigma_{y} = 5.34, \; \sigma_{x} = 4.82\)
- No. Magnets: 48
- Length (ea): 4.15 m
- Beam Field at inj.: 0.0326 T, at max: 0.788 T
- No. Quads: 32
- Length (ea): 0.53 m
- Grad. at inj.: 0.7 Tm; at max: 10.9 Tm
- No. Short Straight Sect.: 8
- Length: 1.85 m
- No. Long Straight Sect.: 8
- Length: 5.54 m
- Rise Time: 0.5 ms
- Power Input Peak: 1.5 MW; Mean: 0.5 MW

**Acceleration System**

- No. Cavities: 1
- Length (ea): 2.2 m
- Harmonic Number: 11
- RF Range: 3.27 to 10.326 MHz
- Energy Gain: 5 keV/turn
- Radiation Loss: keV/turn
- RF Power Input Peak: 7 kW; Mean: 13 kW

**Vacuum System**

- Material of Vac. Chamber: Stainless Steel
- Average Pressure: 10⁻⁷ torr

**Extraction System**

- Type: Beam Bump + Septum + 2 kicker
- Length of Spill: 0 to 0 ps

**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th></th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>7.5</td>
<td>7.5</td>
</tr>
<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td>0.1</td>
<td>-</td>
</tr>
<tr>
<td>REPET. RATE (pulses)</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>PULSE WIDTH AT PEAK E</td>
<td>1.1 x 10⁻ⁱ²</td>
<td>6 x 10⁻¹⁰ (May 89)</td>
</tr>
<tr>
<td>INTERNAL BEAM (part/pulse)</td>
<td>1.1 x 10⁻¹⁰</td>
<td>1.5 x 10⁻¹⁰</td>
</tr>
<tr>
<td>BEAM EMITTANCE*</td>
<td>2.75 x 10⁻⁶</td>
<td>1.5 x 10⁻⁶</td>
</tr>
<tr>
<td>BEAM LINES TO</td>
<td>PETRA II</td>
<td></td>
</tr>
</tbody>
</table>

*Other Relevant Parameters, Recent Improvements, etc.*

* without buildings and components already in existence from DESY 1

**Emittance = Area \times \text{μrad} at 90% of current (for p-machines)**
ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>7</td>
<td>8</td>
</tr>
<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>REPEAT RATE (pulses)</td>
<td>12.5</td>
<td>12.5</td>
</tr>
<tr>
<td>PULSE WIDTH AT PEAK E (ns)</td>
<td>&lt;1</td>
<td>&lt;1</td>
</tr>
<tr>
<td>INTERNAL BEAM (particles)</td>
<td>2 x 10^9</td>
<td>2 x 10^9</td>
</tr>
<tr>
<td>(pulses)</td>
<td>2 x 10^9</td>
<td>2 x 10^9</td>
</tr>
<tr>
<td>BEAM EMITTANCE* EY, EZ</td>
<td>1 x 10^-4</td>
<td>1 x 10^-4</td>
</tr>
<tr>
<td>(√πmm-mrad)</td>
<td>7 x 10^-4</td>
<td>7 x 10^-4</td>
</tr>
<tr>
<td>BEAM LINES TO DORIS (e^+, e^-)</td>
<td>1 x 10^-3</td>
<td>1 x 10^-3</td>
</tr>
<tr>
<td>PETRA (e^+, e^-) + 3 - test</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*Emittance = Area x π at 90% of current (for p-machines)

Other Relevant Parameters, Recent Improvements, etc.

The DESY accelerator complex consisting of LINAC I (200 MeV e^-), LINAC II with PTA (450 MeV e^-), LINAC III (50 MeV p^-), DESY II, DESY III, PETRA and DORIS, into which the 2 MEGA-Main Rings will be incorporated after completion in 1990, is operated by the Accelerator Division, including also the electrical power, cooling, ventilation and heating facilities for the entire institute, and the experimental support group.

Total staff (now) 380
Ann. Operat. Budget without salaries and electrical power but including R&D and current 15 MRM investments for the accelerators already in existence
NAME OF STORAGE RINGS
ADONE

INSTITUTION
I.N.F.N. - Istituto Nazionale di Fisica Nucleare

LOCATION
I.N.F. - Laboratori Nazionali di Frascati - c.p. 13 - 00044 Frascati (Roma) - Italy

PERSON IN CHARGE
Miro Andrea PREGI, P. TAZZIOLI

DATA SUPPLIED BY
Miro Andrea PREGI, F. TAZZIOLI

DATE: 29/6/1989

HISTORY AND STATUS
CONSTRUCTION STARTED (date) 1964
FIRST COLLISIONS, or GOAL (date) 1969
TOTAL COST OF FACILITY $9 x 10^6 US$
TOTAL MACHINE STAFF (now) 80
ANN. OPERAT. BUDGET $100 K 8 (without salaries)
ANN. OPERATING TIME 1600 h

STORAGE RINGS PARAMETERS

General
COLLIDING PARTICLES $e^+ e^-$
ENERGY 3.5 GeV

APPROX. SHAPE circular
DIMENTIONS 33.42 m 0

LENGTH 106.9 m
TIME OF 0.35 ps

No. INTERSECTS 6
CROSSING ANGLE 0

Injector System
TYPE LINAC
E = 350 MeV OUTPUT 100 mA, 2 mA (bas)
EMITTANCE $10^{-10} m$ imm-nan
FILLING SPEED $10^{-3} m/s$ 1 m/s
TOTAL FILLING TIME 20 minutes

Magnet System
FOCUSING TYPE Separated Functions
BEND, RAD. 5.00 m
LATITUDE ORDER 0/2, 0/2, 0/2, 0/2
No. MAGNETS 12
LENGTH (m) 2.618 m
No. QUADS 12
LENGTH (m) 0.322 m
MAX BEND FIELD 5.1 T
MAX GRAD. 8 Tm
OTHER MAGNETS 1 WIGGLER (5 Polex - 1.85 T)
REJECTION FREQUENCY 9.08 2.05 1.05
AMPL. FUNCT. AT INTERSECT. $4.5 x 9.9 m 8.15 x 3$

Acceleration System
HARMONIC No. 18
FREQUENCY 51.8 MHz
No. TRANSMITTERS 16
No. CAVITIES 1

BUNCH TO BUNCH TIME 50 ps (1 bunch, beam) 117 ps (3 bunches/beam)
BUNCH SIZE (L x W x H) (250 x 1.3 x 2.6) 1.5 GeV FWHM
MAX RF VOLTAGE PER BEAM 200 KV
MAX RF POWER 10 kW

Vacuum System
PRESSURE IN RINGS, NO BEAM 5 x 10^{-10} Torr
PRESSURE AT INTERSECTION 5 x 10^{-9} Torr

STORAGE RINGS PERFORMANCE
ENERGY (GeV) 1.55
NORMAL RESOLUTION 5.7 x 10^{-3} m rad
LUMINOSITY (cm^2 s^{-1} sr^{-1}) 3 x 10^{29}
BEAM SIZE, horizontal 3 x 10^{-3}
BEAM SIZE, vertical 3.2 (20)
CURRENT PER BEAM (mA) 30
BEAM LIFE AT 100 mA 1 h

RESEARCH PROGRAM
APPROX. EXPERIMENTAL AREA ~ 80 m²
No. EXPERIMENTAL INTERSECTS 1

SPECIAL RESEARCH EQUIPMENT OR FACILITIES:
- LAMON: Laser backscatter monochromatic
- TAGG: + ray facility (5 GeV x 80 MeV)
- JET TARGET: Integral gap target for nuclear physics
  (10^{-3} g/cm²)

See Storage Rings for Synchrotron Radiation Sources

Other Relevant Parameters, Recent Improvements, etc.
The storage rings has been used with a single electron beam since 1978.
Colliding beam operation foresen in 1989 for $e^+ e^- \rightarrow WW$ experiment.

* Emittance = Area x 8 at 90% of current (f p-machines)
NAME OF STORAGE RINGS
TRISTAN Main Ring

INSTITUTION
National Laboratory for High Energy Physics, KEK

LOCATION
1-1 Oho, Tashiba, Ibaraki, 305, Japan

PERSON IN CHARGE
Koji Takata / Shin-Ichi Kurokawa

DATE
July, 1989

DATA SUPPLIED BY
Shin-Ichi Kurokawa

HISTORY AND STATUS

CONSTRUCTION STARTED (date) Nov, 1981
FIRST COLLISIONS, or GOAL (date) Nov, 1986
TOTAL COST OF FACILITY 8 x 10^9 Yen
TOTAL MACHINE STAFF (now) 100
ANN. OPER. BUDGET 1.0 x 10^8 Yen (without salaries)
ANN. OPERATING TIME 3500 h

STORAGE RING PARAMETERS

General
COLLIDING PARTICLES electron and positron
ENERGY 2 x 3 GeV
APPROX. SHAPE * DIMENSIONS 960 m diameter
ORBIT: Length 3018 m, Time 10 ks
No. INTERSECTS 4 CROSSING ANGLE 0 degree

Injector System
TYPE TRISTAN Accumulation Ring**
INJ. ENERGY 2.5 GeV OUTPUT 8.0 GeV
EMITTANCE 0.44 mmm-mrad
FILLING SPEED 4 x 6 fill / beam
TOTAL FILLING TIME 20 - 30 min

Magnet System
FOCUSING TYPE separated function BEND. RAD. 247 m
LATTICE ORDER 3000
No. MAGNETS 272 LENGTH (mm) 3.86 m
NO. QUADS 344 LENGTH (mm) 0.8 or 1.0 m
MAX BEND. FIELD 0.66 T MAX GRAD. 11.1 mT
MAXIMUM CURRENT 18.6 A
OTHER MAGNETS 240 sextupole, 48 experimental insertion quads
BETATRON FREQUENCY 38.6 V 38.7 V
AMPL. FUNCT. AT INTERSECT p0 1.8 m p0 0.1 m

Acceleration System
HARMONIC No. 5120 FREQUENCY 508.58 MHz
No. TRANSMITTERS 30 KV X-ray No. CAVITIES **
BUNCH TO BUNCH TIME 5 lines
BUNCH SIZE (X x Y x Z) 1.2 cm x 1 mm x 0.1 mm (a)
PEAK RF VOLTAGE PER BEAM 400 MV
MAX RF POWER 22 MW ON BEAMS 3 MW

Vacuum System
PRESSURE IN RINGS, NO BEAM 1 x 10^-9 Torr
WITH BEAM 2 x 10^-10 Torr/MA
PRESSURE AT INTERSECTIONS 2 x 10^-9 (with beam) Torr

* Four quadrant arcs of 347 m in the main bending radius are connected together by four 194-m long straight sections
** Injector for the TRISTAN Accumulation Ring is KEK 2.5 GeV linac (see KEK 2.5 GeV linac).
*** 104 9-cell APS cavities and 16 5-cell superconducting cavities

* Emittance = Area x p at 90% of current (for p-machines)

STORAGE RINGS PERFORMANCE

ENERGY (GeV) Normal (or Goal) Maximum achieved
30.0 30.7

LUMINOUSITY (cm^-2sec^-1)
1.0 x 10^31 1.4 x 10^31

BEAM SIZE, horizontal, vertical
650 μm (a) 18 μm (a)

CURRENT, PER BEAM (mA)
7 mA

BEAM LIFE, AT 10 mA 3 h

RESEARCH PROGRAM

APPROX. EXPERIMENTAL AREA 5600 (sum of 4 exp. area) m²
No. EXPERIMENTAL INTERSECTS 4
No. EXPERIMENT INTERSECT 1
SPECIAL RESEARCH EQUIPMENT OR FACILITIES:

Three out of four experimental intersections are occupied. The name of detectors are: VENUS, TOPAZ, and AMP.

TOTAL POWER USED (average) FOR RESEARCH 10 MW
No. USER GROUPS 3
TOTAL RESEARCH STAFF, in House 64 outside 246
ANN. RESEARCH BUDGET 2 x 10^8 Yen (without salaries)
ANN. RESEARCH TIME 2500 h

Other Relevant Parameters, Recent Improvements, etc.

1. Superconducting cavities were installed during the summer shutdown of 1988. The RF voltage supplied by conventional cavities is 320 MV, and that by superconducting cavities is 100 MV at 30.7 GeV operation.

2. During the summer shutdown of 1989, another 16 5-cell cavities will be installed; this increases the energy of TR to 32-33 GeV.

3. During the summer shutdown of 1989, mini-β superconducting quadrupole magnets are to be installed; factor two increase of the luminosity is expected.
**NAME OF STORAGE RINGS**  
RELATIVISTIC HEAVY ION COLLIDER (RHIC)

**INSTITUTION**  
BROOKHAVEN NATIONAL LABORATORY

**LOCATION**  
UPTON, NEW YORK 11973 USA

**PERSON IN CHARGE**  
S. OZAKI

**DATE:**  
OCTOBER 1989

**DATA SUPPLIED BY**  
E. B. FORSYTH

---

**HISTORY AND STATUS**

| CONSTRUCTION STARTED (date) | October 1990 |
| FIRST COLLISIONS, or GOAL (date) | September 1996 |
| TOTAL COST OF FACILITY | $395M |
| TOTAL MACHINE STAFF (now) | 33 |
| ANNUAL OPER. BUDGET | $22M (without salaries) |
| ANNUAL OPERATING TIME | 6700 h |

---

**STORAGE RINGS PARAMETERS**

**General**

| COLLIDING PARTICLES | Protons and ions up to gold |
| ENERGY | 100 GeV/amu |
| APPROX. SHAPE | Circular |
| ORBIT LENGTH | 3831 m |
| CROSSING ANGLE | 0 |

**Detector System**

| INJ. ENERGY | ≈ 30 GeV |
| EMMITTANCE | 20 (protons) 30 (HI.) mm.mrad |
| FILLING SPEED | ≈ 1 bunch/second |
| TOTAL FILLING TIME | < 2 min (both rings) |

**Magnet System**

| FOCUSING TYPE | Separated Function |
| BEND, RAD. | 381 m |
| No. MAGNETS | 288(areca) |
| LENGTH(GA) | 9.71 m |
| No. QUADS | 276(areca) |
| LENGTH(GA) | 1.1 m |
| MAX BEND FIELD | 3.5 T |
| MAX GRAD | 72 T/m |

**BetatronFreq.**  
• 28.825 MHz |
• 28.825 MHz

**Ampl. Func. At Intersect.**  
• 2 to 6 m |
• 2 to 6 m

**Acceleration System**

| HARMONIC NO. | 342(accel) 2052 (store) |
| FREQ (store) | 160 MHz |
| No. TRANSMITTERS | 4(accel) 12(store) |
| No. CAVITIES | 4(accel) 12(store) |
| BUNCH TO BUNCH TIME | 225 ns |
| PEAK RF VOLTAGE PER BEAM | 400 kV (Accel) 4.3 MeV (Store) |
| MAX RF POWER | 180 kW (accel) 500 kW (on beams) |

**Vacuum System**

| PRESSURE IN RINGS, NO BEAM | < 10⁻¹⁶ Torr |
| PRESSURE AT INTERSECTIONS | < 10⁻¹⁴ Torr |

---

**STORAGE RINGS PERFORMANCE**

| ENERGY (GeV) | 100 GeV/amu |
| RESOLUTION ΔE/E (%) | 0.25 x 10⁻⁴ (rms) |
| LUMINOSITY (cm⁻². sec⁻¹) | 1.6 x 10⁻¹¹ (protons) 1 x 10⁻¹⁰ (gold) |
| BEAM SIZE, horizontal | 2 μm |
| CURRENT, PER BEAM (mA) | 67 (protons) |
| BEAM LIFE, AT | 1.0 h |

---

**RESEARCH PROGRAM**

**(a) APPROX. EXPERIMENTAL AREA**  
4046 m²

**(b) No. EXPERIMENTAL INTERSECTS**  
6

**SPECIAL RESEARCH EQUIPMENT OR FACILITIES**

The research equipment will include approximately 3 large colliding particle detectors whose design and performance specifications will be determined by a process of proposals and review by a proposal committee. It is expected that the call for proposals will be made in October 1990.

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**Other Relevant Parameters, Recent Improvements, etc.**

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*Emittance = Area x β at 90% of current (for p-machines)
NAME: STORAGE RINGS  CESR - Cornell Electron Storage Ring

INSTITUTION: Cornell University

LOCATION: Ithaca, NY, USA

PERSON IN CHARGE: David Rice

DATE: July, 1989

DATA SUPPLIED BY: David Rice

HISTORY AND STATUS

CONSTRUCTION STARTED (date): Nov. 1978
FIRST COLLISIONS, OR GOAL (date): June, 1979
TOTAL COST OF FACILITY: $20 Million
TOTAL MACHINE STAFF (now): 60
ANN. OPERAT. BUDGET: $3.5 Million (without salaries)
ANN. OPERATING TIME: 6000 h

STORAGE RINGS PARAMETERS

General

COLLIDING PARTICLES: e+ e-
ENERGY: 8 x 8 GeV
APPROX. SHAPE: circular
DIMENSIONS: R = 120 m
ORBIT: Length 768 m, Time 2.5 μs
No. INTERSECT: 2
CROSSING ANGLE: 0

Injector System

TYPE: Synchrotron / linac
INJ. ENERGY: 300 MeV
OUTPUT: 8 GeV
EMITTANCE*: 0.1 mm-mrad
FILLING SPEED: 12 mA/min e+, 30 mA/min e-
TOTAL FILLING TIME: 20 minutes

Magnet System

FOCUSING TYPE: AG
BEND. RAD.: 88 m
LATTICE ORDER: 1000
No. MAGNETS: 94
LENGTH (ea): 6.6 m
No. QUADS: 104
LENGTH (ea): 0.6 m
MAX. BEND. FIELD: 1.1 T
MAX. GRAD.: 15 T/m
OTHER MAGNETS: REC. perm mag. quads, 1.5 T wigglers
BETATRON FREQ.: 9.43
AMPL. FUNCT. AT INTERSECT.: 1.0

Acceleration System

HARMONIC No.: 1281
FREQUENCY: 500 MHz
No. TRANSMITTERS: 2
No. CAVITIES: 2
BUNCH TO BUNCH TIME: 360 ns
BUNCH SIZE (L x W x H): 17 x 0.5 x 0.011 mm
PEAK RF VOLTAGE PER BEAM: 8 MV
MAX RF POWER: 700 kW

Vacuum System

PRESSURE IN RINGS, NO BEAM: 10^-9 Torr
WITH BEAM: 10^-1 Torr
PRESSURE AT INTERSECTIONS: 5 x 10^-9 Torr

STORAGE RINGS PERFORMANCE

ENERGY (GeV): Normal (or Goal): Maximum achieved
8: 6
6: 6

RESOLUTION ΔE/E (%): 0.1: 0.07
LUMINOSITY (cm^-2 sec^-1): 10^32: 10^32
BEAM SIZE, horizonatal: 0.5 nm
vertical: 11 μm
CURRENT, PER BEAM (mA): 100: 80
BEAM LIFE, AT __ x 80 mA: 3 hours

RESEARCH PROGRAM

APPROX. EXPERIMENTAL AREA 1000 m²
No. EXPERIMENTAL INTERSECTS: 2
No. EXPERIMENT/INTERSECT: 1
SPECIAL RESEARCH EQUIPMENT OR FACILITIES:

CLEO II - general purpose magnetic detector w/ photon calorimeter
CUSB - photon detector
CHESS - synchrotron radiation facility

TOTAL POWER USED (average) FOR RESEARCH: 2.7 MW
No. USER GROUPS, in house: 1
outside: 15
TOTAL RESEARCH STAFF, in house: 38
outside: 75
ANN. RESEARCH BUDGET: $ 1 M (without salar)
ANN. RESEARCH TIME: 4000 h

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x p at 90% of current (for p-machines)
NAME OF STORAGE RINGS: Tevatron
INSTITUTION: Fermilab
LOCATION: Batavia, IL 60510
PERSON IN CHARGE: David Finley
DATA SUPPLIED BY: David Finley, et al

DATE: June 27, 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (DATE): 1979
FIRST COLLISIONS, or GOAL (DATE): October 1985
TOTAL COST OF FACILITY: $1.6B
TOTAL MACHINE STAFF (now): 10 physicists
ANNUAL OPERATING BUDGET: $4.7M (without salaries)
ANNUAL OPERATING TIME: 4000 h

STORAGE RINGS PARAMETERS

General

COLLIDING PARTICLES: proton and antiproton
ENERGY: 1.8 TeV center-of-mass
APPROX. SHAPE: circular
DIMENSIONS: 7m radius
ORBIT: Length: 22km; Major radius: 27m
No. INTERSECTS: 12 (1989)
CROSSING ANGLE: 0°

Injector System

TYPE: alternating gradient synchrotron
INL. ENERGY: 150 GeV
OUTPUT: 800 GeV (1989)
EMITTANCE*: 15 um-mrad
FILLING SPEED: 1 bunch per 8 seconds
TOTAL FILLING TIME: 1.5 minutes

Magnet System

FOCUSING TYPE: Gradient
FREQUENCY: 53 MHz
No. MAGNETS: 774
LENGTH (m): 6.12
No. QUADS: 216
LENGTH (m): 1.68
MAX. BEND: 4.4°; MAX. GRAD. : 76.0°/m
MAX. MAGNETS: 6 low-beta quads
BETATRON FREQUENCIES: 20, 410, 19, 410
AMPL. FUNCTION AT INTERSECT.: 1/2 m x 1/2 m

Acceleration System

HARMONIC NO.: 1113
No. TRANSMITTERS: 8
No. CAVITIES: 8
BUNCH TO BUNCH TIME: 3.8 μs for 6 bunches
BUNCH SIZE (L x W x H): 240 cm x 3.0 mm x 3.0 mm
PEAK RF VOLTAGE PER BEAM: 1.2 MV
MAX RF POWER: 800 kW ON BEAMS, neglect.

Vacuum System

PRESSURE IN RINGS: 1.0-10 Torr
PRESSURE AT INTERSECTIONS: 1.0-9 Torr

STORAGE RINGS PERFORMANCE

<table>
<thead>
<tr>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>2x10^10</td>
</tr>
<tr>
<td>RESOLUTION ΔE/E (%)</td>
<td>0.6%</td>
</tr>
<tr>
<td>LUMINOSITY (cm^-2 sec^-1)</td>
<td>1x10^30</td>
</tr>
<tr>
<td>BEAM SIZE, horizontal</td>
<td>43 μm</td>
</tr>
<tr>
<td>CURRENT, PER BEAM (mA)</td>
<td>see below</td>
</tr>
<tr>
<td>BEAM LIFE, AT mA</td>
<td>40 hours</td>
</tr>
</tbody>
</table>

RESEARCH PROGRAM

APPROX. EXPERIMENTAL AREA: 740 m
No. EXPERIMENTAL INTERSECTS: 4
No. EXPERIMENT/INTERSECT: one
SPECIAL RESEARCH EQUIPMENT OR FACILITIES:

TOTAL POWER USED (average) FOR RESEARCH: 3 MW
No. USER GROUPS, in house: 3
TOTAL RESEARCH STAFF, in house: 40
ANN. RESEARCH BUDGET: (without salaries)
ANN. RESEARCH TIME: 4000 h

Other Relevant Parameters, Recent Improvements, etc.

"Current, per beam (mA)" is not convenient for the Tevatron Collider. Rather we propose:

<table>
<thead>
<tr>
<th>Normal (or goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>protons: 6x10^10</td>
<td>7x10^10</td>
</tr>
<tr>
<td>antiprotons: 6x10^10</td>
<td>3x10^10</td>
</tr>
</tbody>
</table>

*Emittance = Area x β at 90% of current (for p-machines)
NAME OF STORAGE RINGS: PEP (Positron Electron Project)

INSTITUTION: Stanford Linear Accelerator Center (SLAC)

LOCATION: Stanford, California 94309 USA

PERSON IN CHARGE: Burton Richter

DATA SUPPLIED BY: Max Cornacchia, Martin Donald

DATE: June 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date): April 1976
FIRST COLLISIONS, OR GOAL (date): May 1980
TOTAL COST OF FACILITY: $76 Million
TOTAL MACHINE STAFF (now): Ann Operat. Budget: (without salaries)
ANN. OPERATING TIME: 1700 h

STORAGE RINGS PARAMETERS

General
COLLIDING PARTICLES: Electron - Positron
ENERGY: 13.7 GeV
APPROX. SHAPE: Hexagon
DIMENSIONS:
ORBIT: Length: 2,200 m, Time: 7.33 ms
No. INTERSECTS: 1 CROSSING ANGLE: 0°

Injector System
TYPE: Linear
INJ. ENERGY: 13.7 GeV
EMITTANCE: unmonitored
FILLING SPEED: 10 mA/min
TOTAL FILLING TIME: 10 minutes

Magnet System
FOCUSING TYPE: Yodo BEND, RAD. 166 m
LATTICE ORDER:
No. MAGNETS: 192 LENGTH (m): 5.6 m
No. QUADS: 242 LENGTH (m): various
MAX. BEND FIELD: 0.28 T; MAX. GRAD: 7.8 Tm
OTHER MAGNETS: Sextupoles
BETATRON FREQ: YH 21.28 VY 18.2
AMPL. FUNCT. AT INTERSECT: 0.15, 0.054

Acceleration System
HARMONIC NO.: 2592 FREQUENCY: 353.21 MHz
NO. MACHINERS: 12 NO. CAVITIES: 24
BUNCH TO BUNCH TIME: 2.4 nsec (1 beam)
BUNCH SIZE (LxWxH): 0.97 x 0.36 x 0.012 cm³ (at TP)
PEAK RF VOLTAGE PER BEAM: 30 MV
MAX. RF POWER: 0.7 MW
13.7 GeV for 20W/beam

Vacuum System
PRESSURE IN RINGS, NO BEAM: 1 x 10⁻⁵ Torr
WITH BEAM: 1 x 10⁻⁵ Torr
PRESSURE AT INTERSECTORS: 1 x 10⁻⁵ Torr

Other Relevant Parameters, Recent Improvements etc.

Published Articles Describing Machine:

STORAGE RINGS PERFORMANCE

ENERGY (GeV): Recent: 13.7 Maximum achieved: 13.7
RESOLUTION ΔE/E (%): 0.91
LUMINOSITY (cm⁻² sec⁻¹): 3.6 x 10⁻²¹
BEAM SIZE, horizontal: 3.9 x 10⁻¹⁴ mm
vertical: 6.5 mm
CURRENT, PER BEAM (mA): 20
BEAM LIFE, AT 18 mA: 4 hours

RESEARCH PROGRAM

APPROX. EXPERIMENTAL AREA: 1000 m²
No. EXPERIMENTAL INTERSECTS: 1
No. EXPERIMENTAL INTERSECT: 1
SPECIAL RESEARCH EQUIPMENT OR FACILITIES:

TOTAL POWER USED (average) FOR RESEARCH: 12 MW
No. USER GROUPS, IN HOUSE: 1 outside: 6
TOTAL RESEARCH STAFF, IN HOUSE: 5 outside: 16
ANN. RESEARCH BUDGET: (without Salaries)
ANN. RESEARCH TIME: h

† The numbers here are 0's.
‡ Not obtained simultaneously.
§ This number includes the ring and one detector.
### NAME OF STORAGE RINGS
Superconducting Super Collider

### INSTITUTION
SSC Laboratory

### LOCATION
Stoneedge Office Park, 2550 Beckleymead Ave. Suite 260, Dallas, TX 75237

### PERSON IN CHARGE
Roy Scheitler

### DATE
7/24/89

### DATA SUPPLIED BY
A. Chao, M. Edwards

---

### HISTORY AND STATUS

<table>
<thead>
<tr>
<th>Configuration STARTED (date)</th>
<th>Goal 1990</th>
</tr>
</thead>
<tbody>
<tr>
<td>FIRST COLLISIONS, OR GOAL (date)</td>
<td>1998</td>
</tr>
<tr>
<td>TOTAL COST OF FACILITY (est.) $6000</td>
<td></td>
</tr>
<tr>
<td>TOTAL MACHINE STAFF (max) 10</td>
<td></td>
</tr>
<tr>
<td>AVE. OPER. BUDGET 160 $ (without salaries)</td>
<td></td>
</tr>
<tr>
<td>AVE. OPERATING TIME 6000 h</td>
<td></td>
</tr>
</tbody>
</table>

### STORAGE RINGS PARAMETERS

**General**
- COLLIDING PARTICLES proton, proton
- ENERGY 20 x 20 TeV
- APPROX. SHAPE recettrack
- DIMENSIONS 311.6 x 14.2
- ORBIT: LENGTH 86.760 m, TIME 289 μs
- NO. INTERSECTIONS 6
- CROSSING ANGLE 75 μrad

**Injector System**
- TYPE Cascade chain, 3 synchrotron, linac
- INJ. ENERGY 2 ToV
- OUTPUT 4.6 mm-mixed
- FILLING SPEED 372 hr.

**Magnet System**
- FOCUSING TYPE 5D/0
- BEND. RAD. 10187 m
- LAT. ORDER
- No. MAGNETS 5040 x 2
- LENGTH/ea 12.7 m
- No. QUADS 802 x 2 (coll.) LENGTH/ea 5.2 m
- MAX. BEND. FIELD 6.6 T
- MAX. GRAD. 203 T/m
- OTHER MAGNETS: triplets, 10 quadrupoles, insertion, utilities
- BETATRON FREQ. 121,285 x 1
- AMPLE. FUNCT. AT INTERSECT. 0.5 m

**Acceleration System**
- HARMONIC No. 104112
- FREQUENCY 360 MHz
- NO. TRANSMITTERS 2 x 3
- NO. CAVITIES 3 x 3
- BUNCH TO BUNCH TIME 16.7 nsec
- BUNCH SIZE (L x W x H) 75 mm x 0.13 mm x 0.13 mm
- MAX. RF VOLTAGE PER BEAM 200 KV
- MAX. RF POWER 2 MW

**Vacuum System**
- PRESSURE IN RINGS, NO BEAM 10^-8 Torr
- PRESSURE AT INTERSECTIONS 10^-8 Torr, full beam

### STORAGE RINGS PERFORMANCE

<table>
<thead>
<tr>
<th>Energy (GeV)</th>
<th>Normal (or Goal)</th>
<th>Maximum achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>20,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Resolution Δφ/Δη (%)</th>
<th>0.172 in</th>
</tr>
</thead>
<tbody>
<tr>
<td>Luminosity (cm⁻² sec⁻¹)</td>
<td>10⁻¹² /10⁻¹³</td>
</tr>
<tr>
<td>Beam Size, horizontal</td>
<td>3 μm, TP</td>
</tr>
<tr>
<td>Beam Size, vertical</td>
<td>5 μm, TP</td>
</tr>
<tr>
<td>CURRENT, PER BEAM (mA)</td>
<td>73</td>
</tr>
<tr>
<td>Beam Life, at 77 mA</td>
<td>24 h</td>
</tr>
</tbody>
</table>

### RESEARCH PROGRAM

APPROX. EXPERIMENTAL AREA 7500 m² (4.18 Halla) m²

No. EXPERIMENT/INTERSECT 6

SPECIAL RESEARCH EQUIPMENT OR FACILITIES:

4 π detectors, etc.

---

*Emittance = Area x β at 90% of current (for p-machines)*
NAME OF STORAGE RINGS
UNK (3 TeV Accelerating and Storage Complex)

INSTITUTION
IHEP

LOCATION
Serpukhov, Moscow Dist., USSR

PERSON IN CHARGE
K. P. Myznikov

DATE:
27.06.89

DATA SUPPLIED BY
K. P. Myznikov

HISTORY AND STATUS

CONSTRUCTION STARTED (date):
1982

FIRST COLLISIONS, or GOAL (date):
1992

TOTAL COST OF FACILITY
1.5 x 10^9

TOTAL MACHINE STAFF (now)
500

ANN. OPERAT. BUDGET
(without salaries)

ANN. OPERATING TIME
5000 h

STORAGE RINGS PARAMETERS

General

COLLIDING PARTICLES
p-p

ENERGY
3000 GeV

APPROX. SHAPE
ellipse

DIMENSIONS
3.1 x 3.5 km

ORBIT: Length
20772 m, time
69.3 µs

No. INTERSECTS
4

CROSSING ANGLE
350 µrad

Injector System

TYPE
synchrotron

INJ. ENERGY
400 GeV

OUTPUT
30 nmm-mrad

FILLING SPEED
10 min

TOTAL FILLING TIME

Magnet System

FOCUSING TYPE
PODO

BEND. RAD.
2003.619 m

LATTICE ORDER
1

No. MAGNETS
2194

LENGTH (ea)
5.8 m

No. QUADS
496

LENGTH (ea)
3.7 m

MAX. BEND. FIELD
5 T

MAX. GRAD. 17 T/m

OTHER MAGNETS

BETATRON FREQ. γν
36.70 νν

AMPL. FUNCT. AT INTERSECT.
00 1 m (νν 1 m

Acceleration System

HARMONIC No.
13860

FREQUENCY
200 MHz

No. TRANSMITTERS
No. CAVITIES
8

BUNCH TO BUNCH TIME
25 ns

BUNCH SIZE (L x W x H)
10 cm x 1 mm x 1 mm

PEAK RF VOLTAGE PER BEAM
7 MV

MAX. RF POWER
6 MW

ON BEAMS
1.46 MW

Vacuum System

PRESSURE IN RINGS, NO BEAM
5 x 10^-18 Torr

WITH BEAM

PRESSURE AT INTERSECTIONS
1 x 10^-18 Torr

STORAGE RINGS PERFORMANCE

ENERGY (GeV)
3000

NORMAL (or Goal)

MAXIMUM achieved

RESOLUTION ΔE/E (‰)
± 5 x 10^-3

LUMINOSITY (cm^-2 sec^-1)
4 x 10^32

BEAM SIZE, horizontal
100 µm

vertical
100 µm

CURRENT, PER BEAM (mA)
550

BEAM LIFE, AT
10 H

RESEARCH PROGRAM

APPROX. EXPERIMENTAL AREA
3 x 10000 m²

No. EXPERIMENTAL INTERSECTS
2

No. EXPERIMENT/INTERSECT
1

SPECIAL RESEARCH EQUIPMENT OR FACILITIES:

TOTAL POWER USED (average) FOR RESEARCH
160 MW

No. USER GROUPS, in house

outside

TOTAL RESEARCH STAFF, in house

outside

ANN. RESEARCH BUDGET

(withoutsal.

ANN. RESEARCH TIME

h

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x √at 90% of current (for p-machines)
NAME OF STORAGE RINGS: VEPP-4M

INSTITUTION: Institute of Nuclear Physics

LOCATION: Novosibirsk, USSR

PERSON IN CHARGE: L.Ya. Protopopov, A.A. Sholents

DATE: July 12, 1989

HISTORY AND STATUS

CONSTRUCTION STARTED (date): 1987
FIRST COLLISIONS, or GOAL (date): 1990
TOTAL COST OF FACILITY:

STORAGE RINGS PARAMETERS

General
COLLIDING PARTICLES: e+, e-
ENERGY: 6 GeV
APPROX. SHAPE: ring
DIMENTIONS: ring
ORBIT: Length 365 m, time -
No. INTERSECTS: 7
CROSSING ANGLE: 0

Injector System
TYPE: linear synchrotron booster storage ring VEPP-3
INJ. ENERGY: 1.05 GeV
OUTPUT: 6.0 GeV
EMITTANCE: 0.002 (mm rad)
FILLING SPEED: 3 mA/min
TOTAL FILLING TIME: 15 min

Magnet System
FOCUSING TYPE: POXD+combine+fundamental RAD. 33 m
LATTICE ORDER:
No. MAGNETS: 78
No. QUADS: 150
MAX BEND FIELD: 1 T; MAX GRAD: 6 W/m
OTHER MAGNETS:
BETATRON FREQ.: 0.6
AMPL. FUNCT. AT INTERSECT: 0.6 M; 0.05 M

Acceleration System
HARMONIC NO.: 222
FREQUENCY: 180 MHz
NO. TRANSMITTERS:
NO. CAVITIES: 6
BUNCH TO BUNCH TIME: 0.6 mks
BUNCH SIZE (LxWxH): 1.5 cm
PEAK RF VOLTAGE PER BEAM: 5 MV
MAX RF POWER: 1 MW

Vacuum System
PRESSURE IN RINGS, NO BEAM: 10^-9 Torr
PRESSURE AT INTERSECTIONS: Torr

STORAGE RINGS PERFORMANCE

ENERGY (GeV): 6.5
RESOLUTION (1%):
LUMINOSITY (cm^-2 sec^-1):
BEAM SIZE, horizontal:
BEAM SIZE, vertical:
CURRENT PER BEAM (mA):
BEAM LIFE, AT:

RESEARCH PROGRAM

APPROX. EXPERIMENTAL AREA: 20 m
NO. EXPERIMENTAL INTERSECTS: 1
NO. EXPERIMENTAL INTERSECT:
SPECIAL RESEARCH EQUIPMENT OR FACILITIES: tagging system scattering electrons

TOTAL POWER USED (average) FOR RESEARCH:
NO. USER GROUPS, IN HOUSE:
TOTAL RESEARCH STAFF, IN HOUSE:
FUND. RESEARCH BUDGET, IN HOUSE:
ANN. RESEARCH BUDGET:
ANN. RESEARCH TIME:

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x 1.9 at 90% of current (for p-machines)
### NAME OF LINEAR COLLIDER
SLAC Linear Collider (SLC) (Also see under SLAC LINAC)

### INSTITUTION
Stamford Linear Accelerator Center (SLAC)

### LOCATION
Stamford, California 94309 USA

### PERSON IN CHARGE
Burton Richter

### DATE
June 1989

### DATA SUPPLIED BY
Andrew Hutton, John Sheppard

### HISTORY AND STATUS

| CONSTRUCTION STARTED (date) | October 1983 |
| FIRST BEAM OBTAINED, or GOAL (date) | March 1987 |
| TOTAL COST OF FACILITY | $115 Million |
| TOTAL ACCELERATOR STAFF (now) | (without salaries) |
| ANN. OPERATING TIME | h |

### ACCELERATOR PARAMETERS

<table>
<thead>
<tr>
<th>Physical Dimensions</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>ACCELERATOR LENGTH</td>
<td>3050 m</td>
</tr>
<tr>
<td>TUNNEL SIZE (L X W X H)</td>
<td>$3050 \times 3.02 \times 3.25$ m</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Damping Ring and Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
</tr>
<tr>
<td>CIRCUMFERENCE</td>
</tr>
<tr>
<td>DAMPED EMITTANCE</td>
</tr>
<tr>
<td>Hor.</td>
</tr>
<tr>
<td>Ver.</td>
</tr>
<tr>
<td>DAMPED Δ/E</td>
</tr>
<tr>
<td>DAMPING TIME</td>
</tr>
<tr>
<td>$\sigma_{v}$</td>
</tr>
<tr>
<td>$\sigma_{\beta}$</td>
</tr>
<tr>
<td>BUNCHER, PRE-ACCELERATION</td>
</tr>
<tr>
<td>POSITION SOURCE</td>
</tr>
</tbody>
</table>

### FINAL FOCUS

| FINAL FOCUS LENGTH (1 beam) | 132 m |
| CHROMATIC CORRECTION | 2 sextupole families |
| FINAL QUAD. PRESENTLY IN USE | Quadruplet, Superconducting |
| CROSSING ANGLE | Zero mrad |
| Quadruplet in 1988 |

### COLLIDER PERFORMANCE

<table>
<thead>
<tr>
<th>at Inter.</th>
<th>Normal</th>
<th>Maximum$^1$ achieved</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV/acc)</td>
<td>46</td>
<td>46.5</td>
</tr>
<tr>
<td>ENERGY SPREAD $\Delta E/\beta$ (%)</td>
<td>0.2</td>
<td>0.2</td>
</tr>
<tr>
<td>LUMINOSITY (cm$^{-2}$/sec)</td>
<td>$10^{30}$</td>
<td>$1.3 \times 10^{31}$</td>
</tr>
<tr>
<td>REPEET. RATE (gives)</td>
<td>60 (200 goal)</td>
<td>60</td>
</tr>
<tr>
<td>No. PART/BUNCH</td>
<td>$1.5 \times 10^{12}$</td>
<td>$2 \times 10^{12}$</td>
</tr>
<tr>
<td>BUNCH LENGTH (mm)</td>
<td>~1</td>
<td>1</td>
</tr>
<tr>
<td>BUNCH / TRAIN</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>BEAM SIZE, horizontal (μm)</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>vertical (μm)</td>
<td>3 (1.6 goal)</td>
<td>2</td>
</tr>
<tr>
<td>β* at COLL. POINT, horizontal (μm)</td>
<td>10 (5 goal)</td>
<td>10</td>
</tr>
<tr>
<td>vertical (μm)</td>
<td>10 (5 goal)</td>
<td>10</td>
</tr>
<tr>
<td>FREE SPACE AT COLL. POINT (m)</td>
<td>5.6</td>
<td>5.6</td>
</tr>
</tbody>
</table>

### EXPERIMENTAL PROGRAMME

| TOTAL EXPERIMENTAL AREAS | 1400 m$^2$ |
| TOTAL POWER USED (AVERAGE) FOR RESEARCH | 3.5 MW |
| No. USER GROUPS, in house | 6 |
| outside | 40 |
| TOTAL RESEARCH STAFF, in house | 86 |
| outside | 268 |
| ANN. RESEARCH BUDGET, in house | (without sal.) |
| ANN. RESEARCH TIME | ~6000 h |

### SPECIAL RESEARCH EQUIPMENT FACILITIES:

- This power includes only the Collider Hall and Mark II detector.
- Not obtained simultaneously.
- This number will be reduced to 4.4 m when the Superconducting Quads are installed in 1990.

### OTHER RELEVANT PARAMETERS, RECENT IMPROVEMENTS ETC.

### Published Articles Describing Machine:
NAME OF SYNCHROTRON LIGHT SOURCE
BERL

LOCATION
Institute of High Energy Physics, Beijing, 100039, P.R. China

PERSON IN CHARGE
Prof. Dingcheng Xian

DATA SUPPLIED BY
Shouzian Peng and Dingcheng Xian

DATE: June 16, 1989

HISTORICAL AND STATUS

TYPE OF SOURCE RING: STORAGE RING X, SYNCHROTRON
CONSTRUCTION STARTED (date) Apr. 1984
FIRST BEAM, OR GOAL (date) Oct. 16, 1988
TOTAL COST OF FACILITY $80 M
TOTAL MACHINE STAFF (now) 500
ANNUAL OPERATING BUDGET $5.5 M (without salaries)
ANNUAL OPERATING TIME 5000 h
OPERATION TIME OF RING: hrs dedicated, hrs parasitic
USER EXPERIMENT h: day, days/week
MACHINE STUDY hrs/day, days/week

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period (cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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<td></td>
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<td></td>
</tr>
</tbody>
</table>

STORAGE RINGS PARAMETERS

General Ring Parameters

TYPE OF INJECTOR electron LINAC
INJECTION CYCLE (h) 12.5
INJECTION ENERGY (GeV) 1.1 - 1.4
ORBITAL PERIOD (rad) 801.313
BENDING RADIUS (m) 10.344
RF ACCELERATION FREQUENCY (MHz) 199.955
MAXIMUM ENERGY ACHIEVED (GeV) 1.6 at 200 mA
MAXIMUM ENERGY PLANNED (GeV) 2.8 at 150 mA
BEST BEAM CURRENT ALIGNED (mA) at GeV
BEST BEAM CURRENT PLANNED (mA) at GeV

Typical Electron Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

LATITUDE NAME
ELECTRON OR POSITRON
ENERGY (GeV)
NUMBER OF BUNCHES
INITIAL CURRENT (mA)
AVERAGE CURRENT (mA) FOR USER
LIFETIME (h) at mA
EMITANCE (nm rad) at GeV
BUNCH DURATION (ns) at GeV

Beam Lines

MAIN PORTS: IN OP, IN CONST 3, TOTAL POSSIBLE 20

EXPERIMENTAL STATION TYPE

IN OP | IN CONST | PLANNED
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>IRVISBLE (&lt;8 eV)</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>UV/VUV (8-300 eV)</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>SOFT X (&gt;300-3000 eV)</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>X (&gt;3000 eV)</td>
<td>5</td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL ACTIVITIES

No. USER GROUPS, in house 0, outside 0
TOTAL RESEARCH STAFF, in house 40, outside 0
ANNUAL RESEARCH BUDGET, in house (without salary)
ANNUAL RESEARCH TIME h
ACTIVE PROPOSALS (total)
SOLID STATE PHYSICS/MATERIAL SCIENCE
BIOLOGY/BIOCHEMISTRY
CHEMISTRY/ATOM AND MOLECULAR PHYS
MEDICINE
TECHNOLOGY/INDUSTRIAL USE
EARTH/SPACE SCIENCE
OTHERS

Other Relevant Parameters, Recent Improvements, etc.

All beam lines and experimental stations are in commissioning/construction stage.
NAME OF SYNCHROTRON LIGHT SOURCE: EUROPEAN SYNCHROTRON RADIATION FACILITY
LOCATION: GRENoble, FRANCE
PERSON IN CHARGE: R. HAINSEL, DIRECTOR GENERAL
DATA SUPPLIED BY: JL LACLARE, PROJECT DIRECTOR; M. ALTARELLI, A. MILLER, DIRECTORS OF RESEARCH

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING  SYNCHROTRON
CONSTRUCTION STARTED (DATE): 01.01.86
FIRST BEAM, OR GOAL (DATE): 01.07.92
TOTAL COST OF FACILITY: 1400 MFP
TOTAL MACHINE STAFF (NOW): 50
ANN. OPERAT. BUDGET: 75 MFP (without salaries)
ANN. OPERATING TIME: 7000 h
OPERATION TIME OF RING:
USER EXPERIMENT: 6000 h dedicated, hrs parasitic
MACHINE STUDY: 1000 h
TYPICAL OPERATION: 24 hrs/day, 7 days/week

STORAGE RINGS PARAMETERS

General Ring Parameters
TYPE OF INJECTOR: 200 MeV e^-/MeV e^+ Linac-Synchrotron
INJECTION CYCLE (Hz): 10
INJECTION ENERGY (GeV): 6
ORBITAL PERIOD (ns): 2847
BENDING RADIUS (m): 25
RF ACCELERATION FREQUENCY (MHz): 352.2
MAXIMUM ENERGY ACHIEVED (GeV): 6 at 100 mA
BEST BEAM CURRENT ACHIEVED (mA): 10 at 6 GeV

Typical Electron/Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>LATTICE NAME</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRON OR POSITRON</td>
<td>e^-</td>
<td>e^+</td>
<td></td>
</tr>
<tr>
<td>ENERGY (GeV)</td>
<td>6</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>1</td>
<td>992</td>
<td></td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>10</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIFE TIME (hr) at</td>
<td>8</td>
<td>8</td>
<td></td>
</tr>
<tr>
<td>EMITTANCE (mmrad) Hor</td>
<td>6.3</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>Ver</td>
<td>0.63</td>
<td>0.63</td>
<td></td>
</tr>
<tr>
<td>BUNCH DURATION (nsec)</td>
<td>0.05</td>
<td>0.02</td>
<td></td>
</tr>
</tbody>
</table>

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>DEG</td>
<td>Build</td>
<td>0.5</td>
<td>66</td>
<td>2.4</td>
<td>0</td>
</tr>
<tr>
<td>DEG</td>
<td>Design</td>
<td>0.8</td>
<td>40</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>AW</td>
<td>Design</td>
<td>1.6</td>
<td>9</td>
<td>20</td>
<td>4</td>
</tr>
<tr>
<td>RU</td>
<td>Design</td>
<td>0.16</td>
<td>32</td>
<td>1</td>
<td>4</td>
</tr>
<tr>
<td>U</td>
<td>Design</td>
<td>0.5</td>
<td>66</td>
<td>40</td>
<td>2</td>
</tr>
</tbody>
</table>

U: undulator, SCW: superconducting wiggl er
MPW: wiggl er or undulator beam available
EMPW: elliptically polarized source
HU: helical undulator
AW: asymmetric wiggl er

EXPERIMENTAL ACTIVITIES (planned for 1994)

No. USER GROUPS, IN house outside 2000
TOTAL RESEARCH STAFF, in house outside 100 outside
ANNUAL RESEARCH BUDGET, in house outside 10 M (without sal)
ACTIVE PROPOSALS (total)
SOLID STATE PHYSICS/MATERIAL SCIENCE
BIOLOGY/BIOCHEMISTRY
CHEMISTRY/ATOM AND MOLECULAR PHYS
MEDICINE
TECHNOLOGY/INDUSTRIAL USE
EARTH/SPACE SCIENCE
OTHERS

Other Relevant Parameters, Recent Improvements, etc.

Beam Lines

MAIN PORTS: IN OP ______, IN CONST ______, TOTAL POSSIBLE 50
EXPERIMENTAL STATION TYPE
IN OP IN CONST PLANNED
IRVISIBILITY (<6 eV) | | |
UV/UV/UV (6 - 300 eV) | | |
SOFT X (> 300 - 3000 eV) | | |
X (>3000 eV) | | | 7-10 |
LOCATION: 209 D Universite Paris-Sud 91405 Orsay France
PERSON IN CHARGE: Y. Petroff
DATE: August 9, 1989
DATA SUPPLIED BY: 

HISTORY AND STATUS

Type of Source: Storage Ring, SYNCHROTRON
Construction Started (date): 
First Beam or Goal (date): July 1975
Total Cost of Facility: 
Total Machine Staff (now): 80*
Annual Operat. Budget: 35 M€ = 5.2 Hs (without salaries)
Ann. Operating Time: 3000 hrs
Operation Time of Ring:
User Experiment: 2600 hrs dedicated, 3200 hrs parasitic
Machine Study: 400 hrs
Typical Operation: 16 hrs/day, 4 or 5 days/week

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>8(T)</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon Energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wiggler</td>
<td>Op.</td>
<td>4.8</td>
<td>5</td>
<td>3 - 70 keV</td>
<td></td>
</tr>
</tbody>
</table>

U: undulator, SCW: superconducting wiggler
MPWU: wiggler or undulator mode available
EMPW: elliptically polarized source

STORAGE RINGS PARAMETERS

General Ring Parameters
Type of Injector: LINAC
Injection Cycle (Hz): 25
Injection Energy (GeV): 1.1
Orbital Period (ns): 315
Bending Radius (m): 3.82
RF Acceleration Frequency (MHz): 25.35
Maximum Energy Achieved (GeV): 1.87 at 300 mA
Maximum Energy Planned (GeV): at 2 mA
Best Beam Current Achieved (mA): 50 at 1.1 GeV
Best Beam Current Planned (mA): at GeV

Typical Electron/Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>Lattice Name</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron or Positron Energy (GeV)</td>
<td>1.85</td>
<td>1.85</td>
<td></td>
</tr>
<tr>
<td>Number of Bunches</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Initial Current (mA)</td>
<td>300</td>
<td>300</td>
<td></td>
</tr>
<tr>
<td>Average Current (mA) for User</td>
<td>200</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Lifetime (ns) at 200 mA</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Emittance (mm-arcsec-m)</td>
<td>170</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Bunch Duration (ns)</td>
<td>1</td>
<td>1</td>
<td></td>
</tr>
</tbody>
</table>

Beam Lines

Main Ports: IN OP | IN CONST | TOTAL POSSIBLE 8

Experimental Station Type

<table>
<thead>
<tr>
<th>IR/Visible (≤60 eV)</th>
<th>In OP</th>
<th>In Const</th>
<th>Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>U/VUV (6-300 eV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Soft X (&gt;300-3000 eV)</td>
<td>17</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>X (&gt;3000 eV)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL ACTIVITIES

No. User Groups in House: 80 outside 700
Total Research Staff, in House: 50 outside (without sal)
Annual Research Time: h
Active Proposals (total): 520
Solid State Physics/Material Science: 125
Biology/Biochemistry: 25
Chemistry/Atom and Molecular Physics: 160
Medicine: 20
Technology/Industrial Use: 10
Earth/Space Science: 20
Others: 20

Other Relevant Parameters, Recent Improvements, etc.

* The machine staff has also to take care of Super ACO (E = 0.8 GeV): 22 experiments at the end of 1989.

The 420 proposals concern DCI and Super ACO.
HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING
CONSTRUCTION STARTED (date) 1970
FIRST BEAM, or GOAL (date) 1971
TOTAL COST OF FACILITY 120 MDM
TOTAL MACHINE STAFF (now) 20
ANN. OPERATING BUDGET 6900 (without salaries)
ANN. OPERATING TIME 6600 h
OPERATION TIME OF RINGS: USER EXPERIMENT 2400 hrs dedicated, 4400 hrs parasitic
MACHINE STUDY 6 hrs/day, 7 days/week

STORAGE RINGS PARAMETERS

General Ring Parameters
TYPE OF INJECTOR Synchrotron DESY I
INJECTION CYCLE (ms) 12.5
INJECTION ENERGY (GeV) Working energy of DORIS II
ORBITAL PERIOD (ms) 560
BENDING RADIUS (m) 12.2
RF ACCELERATION FREQUENCY (MHz) 500
MAXIMUM ENERGY ACQUIRED (GeV) 5.1 at 90 mA
MAXIMUM ENERGY PLANNED (GeV) 5.6 at 30 mA
BEST BEAM CURRENT ACHIEVED (mA) 100 at 3.7 GeV
BEST BEAM CURRENT PLANNED (mA) 100 at 3.7 GeV

Typical Electron/Positron Beam Characteristics for User Experiments

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATTICE NAME</td>
<td>SYR</td>
<td>L1MD</td>
</tr>
<tr>
<td>ELECTRON OR POSITRON</td>
<td>e^-</td>
<td>e^-</td>
</tr>
<tr>
<td>ENERGY (GeV)</td>
<td>3.7</td>
<td>3.7</td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>4</td>
<td>4</td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>100</td>
<td>42 + 42</td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td>65</td>
<td>31 + 31</td>
</tr>
<tr>
<td>LIFETIME (hrs) at</td>
<td>3</td>
<td>1.5</td>
</tr>
<tr>
<td>EMITTANCE (nm rad)</td>
<td>270</td>
<td>560</td>
</tr>
<tr>
<td>BUNCH DURATION (ns)</td>
<td>15</td>
<td>6-60</td>
</tr>
</tbody>
</table>

Beam Lines
MAIN PORTS: IN OP 26, IN CONST 1, TOTAL POSSIBLE 31

EXPERIMENTAL STATION
TYPE
INVISIBILE (<6 eV) 7
UV/VUV (6 - 300 eV) 3
SOFT X (300 - 3000 eV) 24
X (>3000 eV) 1

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>MPS/v0</td>
<td>INOP</td>
<td>.60</td>
<td>32</td>
<td>12.2</td>
<td>20 eV - 20 KeV</td>
</tr>
<tr>
<td>MPS/v0</td>
<td>INOP</td>
<td>.94</td>
<td>32</td>
<td>24</td>
<td>2 KeV - 20 eV</td>
</tr>
<tr>
<td>MPS/v1</td>
<td>INOP</td>
<td>.31</td>
<td>32</td>
<td>12</td>
<td>5 eV - 5 GeV</td>
</tr>
<tr>
<td>MPSW</td>
<td>INOPER</td>
<td>.68</td>
<td>24</td>
<td>14</td>
<td>5 KeV - 20 eV</td>
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<tr>
<td>MPSW</td>
<td>PLAN</td>
<td>.44</td>
<td>24</td>
<td>3.1</td>
<td>5 eV - 9 GeV</td>
</tr>
<tr>
<td>MPSW</td>
<td>PLAN</td>
<td>.01</td>
<td>24</td>
<td>14</td>
<td>5 eV - 30 GeV</td>
</tr>
<tr>
<td>MPSW</td>
<td>PLAN</td>
<td>.01</td>
<td>24</td>
<td>22</td>
<td>50 eV - 200 eV</td>
</tr>
<tr>
<td>MPSW</td>
<td>PLAN</td>
<td>1.3</td>
<td>24</td>
<td>22</td>
<td>200 eV - 1000 eV</td>
</tr>
<tr>
<td>MPSW</td>
<td>PLAN</td>
<td>.30</td>
<td>24</td>
<td>6.5</td>
<td>800 eV - 2000 eV</td>
</tr>
</tbody>
</table>

EXPERIMENTAL ACTIVITIES

No. USER GROUPS, in house 5, outside 16
TOTAL RESEARCH STAFF, in house 21, outside 25
ANN. RESEARCH BUDGET, in house 2 MHD, without salary
ANNUAL RESEARCH TIME 6600 h
ACTIVE PROPOSALS (total) 200
SOLID STATE PHYSICS/MATERIAL SCIENCE 100
BIOLOGY/BIOMEDICINE 20
CHEMISTRY/ATOMIC AND MOLECULAR PHYS 10
MEDICINE 5
TECHNOLOGY/INDUSTRIAL USE 10
EARTHS/SPACE SCIENCE 5
OTHERS 5

Other Relevant Parameters, Recent Improvements, etc.
# History and Status

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Source Ring: Storage Ring</td>
<td>Synchrotron</td>
</tr>
<tr>
<td>Construction Started (date)</td>
<td>1964</td>
</tr>
<tr>
<td>First Beam, or Goal (date)</td>
<td>1978</td>
</tr>
<tr>
<td>Total Cost of Facility</td>
<td>$3 x 10^9</td>
</tr>
<tr>
<td>Total Machine Staff (now)</td>
<td>300</td>
</tr>
<tr>
<td>Ann. Oper. Budget</td>
<td>$1000</td>
</tr>
<tr>
<td>Ann. Operating Time</td>
<td>4500</td>
</tr>
<tr>
<td>Operation Time of Ring:</td>
<td></td>
</tr>
<tr>
<td>User Experiment 4000-5000 hrs dedicated</td>
<td></td>
</tr>
<tr>
<td>Machine Study</td>
<td>200</td>
</tr>
<tr>
<td>Typical Operation</td>
<td>24 hrs/day 6 days/week</td>
</tr>
</tbody>
</table>

## Storage Rings Parameters

### General Ring Parameters

- **Type of Injector**: LIMAC
- **Injection Cycle (Hz)**: 300
- **Injection Energy (GeV)**: 0.41
- **Orbital Period (ns)**: 350
- **Bending Radius (m)**: 51.4
- **RF Acceleration Frequency (MHz)**: 1.5
- **Maximum Energy Achieved (GeV)**: 1.5 at 100 mA
- **Maximum Energy Planned (GeV)**: 1.5 at 100 mA
- **Best Beam Current Achieved (mA)**: 150 at 1.5 GeV
- **Best Beam Current Planned (mA)**: 150 at 1.5 GeV

### Typical Electron/Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>Lattice Name</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electron or Positron</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Energy (GeV)</td>
<td>1.5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Number of Bunches</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Initial Current (mA)</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average Current (mA) for User</td>
<td>60</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lifetime (hrs) at 400 mA</td>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Emittance (nm*rad)</td>
<td>Hot</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Ver</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bunch Duration (ns)</td>
<td>1.6E+11</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

## Beam Lines

- **Main Ports**: IN OP 8 IN CONST 2 TOTAL POSSIBLE 12

## Experimental Activities

- **No. User Groups, in house**: 7 outside 50
- **Total Research Staff, in house**: 15 outside 180
- **Ann. Research Budget, in house**: 6.105 (without sal)
- **Annual Research Time**: 2160 h

### Other Relevant Parameters, Recent Improvements, etc.

- **Solid State Physics/Material Science**: 130
- **Biology/Biochemistry**: 28
- **Chemistry/Atom and Molecular Phys**: 12
- **Others**: 2

Shared with H.E.P. and nuclear physics (see Storage Rings)
NAME OF SYNCHROTRON LIGHT SOURCE: ELETTTRA
LOCATION: SINCHROTRON, TRIESTE, TRIESTE - ITALY
PERSON IN CHARGE: MARIO POULI
DATA SUPPLIED BY: ALBIN WULICH

DATE: 22 - 6 - 1989

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING, SYNCHROTRON
CONSTRUCTION STARTED (date): 1992
FIRST BEAM, OR GOAL (date): 2nd of 1992
TOTAL COST OF FACILITY: 180 M US$
TOTAL MACHINE STAFF (now): 10
ANNUAL OPERATING BUDGET: 20 M US$ (without salaries)
ANNUAL OPERATING TIME: 1993: 1430 h
OPERATION TIME OF RING: 1992: 1977 h
USER EXPERIMENT: N.A., hrs dedicated, N.A., hrs parasitic
MAINTENANCE: N.A., hrs/day, N.A., days/week
TYPICAL OPERATION: N.A., hrs/day, N.A., days/week

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0.8</td>
<td>51</td>
<td>9.1</td>
<td>10 - 1000</td>
<td></td>
</tr>
<tr>
<td>U</td>
<td>0.47</td>
<td>88</td>
<td>6.1</td>
<td>100 - 1500</td>
<td></td>
</tr>
<tr>
<td>E</td>
<td>0.20</td>
<td>11</td>
<td>2.1</td>
<td>500 - 2500</td>
<td></td>
</tr>
<tr>
<td>MPW</td>
<td>1.5</td>
<td>63</td>
<td>12.5</td>
<td>10 - 50000</td>
<td></td>
</tr>
</tbody>
</table>

U: undulator, SCW: superconducting wigglers
MPW/U: wigglers or undulator mode available
EMPW: elliptically polarized source

STORAGE RING PARAMETERS

General Ring Parameters

TYPE OF INJECTOR: LLNL-ROOSTER SYNNCHROTRON
INJECTION CYCLE (Hz): 10
INJECTION ENERGY (GeV): 2
ORBITAL PERIOD (sec): 864
BENDING RADIUS (m): 5
RF ACCELERATION FREQUENCY (MHz): 500
MAXIMUM ENERGY ACHIEVED (GeV): 2 at 400 mA
MAXIMUM BEAM CURRENT PLANNED (m): 2 at 4 GeV
BEST BEAM CURRENT PLANNED (mA): 400 at 2 GeV

Typical Electron/Positron Beam Characteristics for User Experiment

LATTICE NAME | I | II | III
--------------|---|----|-----
EXPANSION CHAMBER | Green
ELECTRON OR POSITRON BEAM | Electrons
ENERGY (GeV) | MAX 20 GeV
NUMBER OF BUNCHES | MAX 400
INITIAL CURRENT (mA) | MAC 400 mA
AVERAGE CURRENT (mA) FOR USER | 10 mA
LIFETIME (hr) | 10 hrs
EMITTANCE (mmrad) | Hor: 1, Ver: 7.1
BUNCH DURATION (nsec) | 0.025

Beam Lines

MAIN PORTS: IN OP, IN CON, TOTAL POSSIBLE

EXPERIMENTAL STATION TYPE

INVISIBLE (<5eV) | IN OP | IN CON | PLANNED
UV/ULV (6-300 eV) | | |
SOFT X (> 300 - 3000 eV) | | |
X (>3000 eV) | | |
NAME OF SYNCHROTRON LIGHT SOURCE: Photon Factory

LOCATION: National Laboratory for High Energy Physics (KEK), Tsukuba, Japan

PERSON IN CHARGE: Jun-ichi Chikawa

DATA SUPPLIED BY: Hidashi Kobayakawa

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING - SYNCHROTRON

CONSTRUCTION STARTED (date): April 11, 1976
FIRST BEAM, or GOAL (date): March, 1982
TOTAL COST OF FACILITY: 18.3 billion yen
TOTAL MACHINE STAFF (now): 53
ANN. OPERAT. BUDGET: 2060 million yen (without salaries)
ANN. OPERATING TIME: 3,400 h
OPERATION TIME OF RING:
USER EXPERIMENT: 2,720 hrs dedicated, 150 hrs parasitic
MACHINE STUDY: 680 hrs
TYPICAL OPERATION: 24 hrs/day, 1 day/2 weeks/week

STORAGE RINGS PARAMETERS

General Ring Parameters

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>EIT</th>
<th>Poles</th>
<th>Period/cm</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCW</td>
<td>Op</td>
<td>5.0</td>
<td>3</td>
<td>6</td>
<td>400 - 5,000</td>
</tr>
<tr>
<td>MPW/U</td>
<td>Op</td>
<td>1.47</td>
<td>0.6</td>
<td>29</td>
<td>1,100</td>
</tr>
<tr>
<td>MPW/I</td>
<td>Op</td>
<td>1.8</td>
<td>0.6</td>
<td>29</td>
<td>1,100</td>
</tr>
<tr>
<td>SMPW</td>
<td>Op</td>
<td>1.0</td>
<td>0.6</td>
<td>16</td>
<td>10 - 20,000</td>
</tr>
</tbody>
</table>

U: undulator, SCW: superconducting wiggler
MPW/U: wiggler or undulator mode available
SMPW: elliptically polarized source

EXPERIMENTAL ACTIVITIES

No. USER GROUPS, in house: 25
TOTAL RESEARCH STAFF, in house: 25
ANN. RESEARCH BUDGET, in house: 560 million yen (without sal)
ANNUAL RESEARCH TIME: 2700 h

ACTIVE PROPOSALS (total): 420
SOLID STATE PHYSICS/MATERIAL SCIENCE: 160
BIOLOGY/BIOCHEMISTRY: 105
CHEMISTRY/ATOMIC AND MOLECULAR PHYS: 71
MEDICINE: 13
TECHNOLOGY/INDUSTRIAL USE: 20
EARTH/SPACE SCIENCE: 6
OTHERS: 37

Other Relevant Parameters, Recent Improvements, etc.

INSERTION DEVICES

Beams Lines

MAIN PORTS: IN OP 18 IN CONST 2 TOTAL POSSIBLE 25

EXPERIMENTAL STATION TYPE

IN OP IN CONST PLANNED

IRVISIBLE (<6 eV) 0 0 0
UV+VUV (5 - 300 eV) 12 2 1
SOFT X (> 300 - 3000 eV) 16 0 3
X (> 3000 eV) 24 1 2

Beams Lines

LATTICE NAME

<table>
<thead>
<tr>
<th>ELECTRON OR POSITRON</th>
<th>FOOS</th>
<th>FOOS</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>332</td>
<td>332</td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>320</td>
<td>320</td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA)</td>
<td>195</td>
<td>200</td>
</tr>
<tr>
<td>LIFETIME (hrs)</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>EMITTANCE (nmrad)</td>
<td>130</td>
<td>130</td>
</tr>
<tr>
<td>BUNCH DURATION (msec)</td>
<td>2.0</td>
<td>0.4</td>
</tr>
</tbody>
</table>

Beam Lines

18 IN OP 2 TOTAL POSSIBLE 25

EXPERIMENTAL STATION TYPE

IN OP IN CONST PLANNED

IRVISIBLE (<6 eV) 0 0 0
UV+VUV (5 - 300 eV) 12 2 1
SOFT X (> 300 - 3000 eV) 16 0 3
X (> 3000 eV) 24 1 2
### History and Status

<table>
<thead>
<tr>
<th>Type of Source Ring: Storage Ring</th>
<th>Synchrotron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Construction Started (date)</td>
<td>November 1981</td>
</tr>
<tr>
<td>First Beam, or Goal (date)</td>
<td>October 1983</td>
</tr>
<tr>
<td>Total Cost of Facility</td>
<td></td>
</tr>
<tr>
<td>Total Machine Staff (now)</td>
<td>2</td>
</tr>
<tr>
<td>Ann. Operat. Budget</td>
<td>(without salaries)</td>
</tr>
<tr>
<td>Ann. Operating Time</td>
<td>4500 h</td>
</tr>
<tr>
<td>Operation Time of Ring:</td>
<td></td>
</tr>
<tr>
<td>User Experiment</td>
<td>1100 hrs dedicated, 1100 hrs parasitic</td>
</tr>
<tr>
<td>Machine Study</td>
<td>300 hrs</td>
</tr>
<tr>
<td>Typical Operation</td>
<td>24 hrs/day, 7 days/week</td>
</tr>
</tbody>
</table>

### Storage Rings Parameters

#### General Ring Parameters

<table>
<thead>
<tr>
<th>Type of Injector</th>
<th>Linear</th>
</tr>
</thead>
<tbody>
<tr>
<td>Injection Cycle (Hz)</td>
<td>25</td>
</tr>
<tr>
<td>Injection Energy (GeV)</td>
<td>2.5</td>
</tr>
<tr>
<td>Orbital Period (msce)</td>
<td>1250</td>
</tr>
<tr>
<td>Bending Radius (m)</td>
<td>23.2</td>
</tr>
<tr>
<td>RF Acceleration Frequency (MHz)</td>
<td>508.38</td>
</tr>
<tr>
<td>Maximum Energy Achieved (GeV)</td>
<td>8.0 at 25 mA</td>
</tr>
<tr>
<td>Maximum Energy Planned (GeV)</td>
<td>at mA</td>
</tr>
<tr>
<td>Best Beam Current Achieved (mA)</td>
<td>40 at 5 GeV</td>
</tr>
<tr>
<td>Best Beam Current Planned (mA)</td>
<td>at GeV</td>
</tr>
</tbody>
</table>

**Typical Electron/Positron Beam Characteristics for User Experiment**

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lattice Name</td>
<td>FOOD</td>
<td></td>
</tr>
<tr>
<td>Electron or Positron</td>
<td>Electron</td>
<td></td>
</tr>
<tr>
<td>Energy (MeV)</td>
<td>5.8 - 6.5</td>
<td></td>
</tr>
<tr>
<td>Number of Bunches</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Initial Current (mA)</td>
<td>20</td>
<td></td>
</tr>
<tr>
<td>Average Current (mA) for User</td>
<td>10</td>
<td></td>
</tr>
<tr>
<td>Lifetime (hrs)</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>Emittance (mmrad)</td>
<td>250</td>
<td></td>
</tr>
<tr>
<td>Bunch Duration (nsec)</td>
<td>20-0.13</td>
<td></td>
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</tbody>
</table>

**Beam Lines**

<table>
<thead>
<tr>
<th>MAIN PORTS: IN OP</th>
<th>IN CONST</th>
<th>TOTAL POSSIBLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>1</td>
<td>3</td>
</tr>
</tbody>
</table>

**Experimental Station Type**

<table>
<thead>
<tr>
<th>Invisible (&lt; 5 eV)</th>
<th>IN OP</th>
<th>IN CONST</th>
<th>PLANNED</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV/VUV (6 - 300 eV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOFT X (&gt; 300 - 3000 eV)</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X (&gt; 3000 eV)</td>
<td>4</td>
<td>2</td>
<td></td>
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### Insertion Devices

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period (cm)</th>
<th>Photon Energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>EMU UV</td>
<td>Const</td>
<td>0.6</td>
<td>310</td>
<td>16</td>
<td>100 ~ 70,000</td>
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</tr>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SCW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPW/MPW</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EXPRESS ACTIVITIES**

- No. USER GROUPS, in house: 4 outside: 4
- Total Research Staff, in house: 9 outside: 19
- Ann. Research Budget, in house: 127 million yen (without salary)
- Annual Research Time: 17 h
- Active Proposals (total): 17
  - Solid State Physics/Material Science: 10
  - Biology/Biochemistry: 0
  - Chemistry/Aтом and Molecular Physics: 2
  - Medicine: 3
  - Technology/Industiral Use: 2
  - Earth/Space Science: 1
- Others: 1

### Other Relevant Parameters, Recent Improvements, etc.

1. **TRISTAN Accumulation Ring (AR)** is the injector to **TRISTAN Main Ring (MR)**. **AR** is operated as a synchrotron light source when MR is not operated or during the interval between the beam fillings in MR.

2. **AR** is operated as a part of **TRISTAN** complex. See **TRISTAN Main Ring**.
NAME OF SYNCHROTRON LIGHT SOURCE: RIKEN-JAERI SR FACILITY (TENTATIVE)
LOCATION: HARIMA SCIENCE GARDEN CITY, HYOGO-PREF., JAPAN
PERSON IN CHARGE: Hiromichi KAMITSUBO
DATA SUPPLIED BY: Masahiro HARA

DATE: July 1989

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING X SYNCHROTRON
CONSTRUCTION STARTED (DATE): 1990
FIRST BEAM, OR GOAL (DATE): 1995
TOTAL COST OF FACILITY: \$100 Billion Yen
TOTAL MACHINE STAFF (NOW): 38
ANN. OPER. BUDGET (without salaries): h
ANN. OPERATING TIME: h
OPERATION TIME OF RINGS:
USER EXPERIMENT: hrs dedicated, hrs parasitic
MACHINE STUDY: hrs
TYPICAL OPERATION: hrs/day, days/week

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U: undulator, SCW: superconducting wiggler</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MPW/U: wiggler or undulator mode available</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EMPW: elliptically polarized source</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

STORAGE RINGS PARAMETERS

General Ring Parameters

<table>
<thead>
<tr>
<th>TYPE OF INJECTOR</th>
<th>Synchrotron</th>
</tr>
</thead>
<tbody>
<tr>
<td>INJECTION CYCLE (Hz)</td>
<td>1</td>
</tr>
<tr>
<td>INJECTION ENERGY (GeV)</td>
<td>8</td>
</tr>
<tr>
<td>ORBITAL PERIOD (sec)</td>
<td>6.7</td>
</tr>
<tr>
<td>BENDING RADIUS (m)</td>
<td>43.7</td>
</tr>
<tr>
<td>RF ACCELERATION FREQUENCY (MHz)</td>
<td>508.58</td>
</tr>
<tr>
<td>MAXIMUM ENERGY ACHIEVED (GeV)</td>
<td>8 at 100 mA</td>
</tr>
<tr>
<td>BEST BEAM CURRENT ACHIEVED (mA)</td>
<td>100 at 8 GeV</td>
</tr>
</tbody>
</table>

Typical Electron/Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>LATTICE NAME</th>
<th>ELECTRON OR POSITRON</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>8</td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>12/2424</td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>1</td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td>1</td>
</tr>
<tr>
<td>LIFETIME (hrs)</td>
<td>10</td>
</tr>
<tr>
<td>EMITTANCE (mm mrad)</td>
<td>Hor</td>
</tr>
<tr>
<td></td>
<td>Ver</td>
</tr>
<tr>
<td>BUNCH DURATION (nsec)</td>
<td>1</td>
</tr>
</tbody>
</table>

Beam Lines

MAIN PORTS: IN OP | IN CONST | TOTAL POSSIBLE: 50

EXPERIMENTAL STATION

<table>
<thead>
<tr>
<th>TYPE</th>
<th>IN OP</th>
<th>IN CONST</th>
<th>PLANNED</th>
</tr>
</thead>
<tbody>
<tr>
<td>IR/visible (&lt;6 eV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UV/VUV (6-300 eV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOFT X (&gt; 300-3000 eV)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>X (&gt;3000 eV)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL ACTIVITIES

No. USER GROUPS, in house outside
TOTAL RESEARCH STAFF, in house outside
ANN. RESEARCH BUDGET, in house outside (without salaries)
ANNUAL RESEARCH TIME: h
ACTIVE PROPOSALS (total):
| SOLID STATE PHYSICS/MATERIAL SCIENCE |
| BIOLOGY/BIOCHEMISTRY |
| CHEMISTRY/ATOM AND MOLECULAR PHYS |
| MEDICINE |
| TECHNOLOGY/INDUSTRIAL USE |
| EARTH/SPACE SCIENCE |
| OTHERS |

Other Relevant Parameters, Recent Improvements, etc.
**NAME OF SYNCHROTRON LIGHT SOURCE**
Pohang Light Source

**LOCATION**
POSTECH, Pohang, KOREA

**PERSON IN CHARGE**
Seewon Oh

**DATA SUPPLIED BY**
Young-Soo Kim, Kwanghee Nam, Ki Bong Lee

**DATE:**
June 20, 1989

---

**HISTORY AND STATUS**

<table>
<thead>
<tr>
<th>INSERTION DEVICES</th>
</tr>
</thead>
<tbody>
<tr>
<td>Device</td>
</tr>
<tr>
<td>--------</td>
</tr>
<tr>
<td></td>
</tr>
</tbody>
</table>

**STORAGE RINGS PARAMETERS**

**General Ring Parameters**

<table>
<thead>
<tr>
<th>TYPE OF INJECTOR</th>
<th>Linear (full energy)</th>
<th>1.0</th>
</tr>
</thead>
<tbody>
<tr>
<td>INJECTION ENERGY (GeV)</td>
<td>2.0</td>
<td></td>
</tr>
<tr>
<td>ORBITAL PERIOD(nsec)</td>
<td>924</td>
<td></td>
</tr>
<tr>
<td>BENDING RADIUS(m)</td>
<td>6.3</td>
<td></td>
</tr>
<tr>
<td>RF ACCELERATION FREQUENCY(MHz)</td>
<td>500.1</td>
<td></td>
</tr>
<tr>
<td>MAXIMUM ENERGY ACHIEVED(GeV)</td>
<td>2.5 at 100 mA</td>
<td></td>
</tr>
<tr>
<td>MAXIMUM ENERGY PLANNED (GeV)</td>
<td>2.5 at 100 mA</td>
<td></td>
</tr>
<tr>
<td>BEST BEAM CURRENT ACHIEVED (mA)</td>
<td>250 at 2.0 GeV</td>
<td></td>
</tr>
<tr>
<td>BEST BEAM CURRENT PLANNED (mA)</td>
<td>250 at 2.0 GeV</td>
<td></td>
</tr>
</tbody>
</table>

**Typical Electron/Positron Beam Characteristics for User Experiment**

<table>
<thead>
<tr>
<th>LATTICE NAME</th>
<th>TBA</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRON OR POSITRON</td>
<td>electron</td>
</tr>
<tr>
<td>ENERGY (GeV)</td>
<td>2.5-2.5</td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>462 (max)</td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td></td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td>100 (planned)</td>
</tr>
<tr>
<td>LIFETIME (hrs) at</td>
<td></td>
</tr>
<tr>
<td>EMITTANCE (mmrad)</td>
<td>Hor: 13 mmrad (theoretical)</td>
</tr>
<tr>
<td>BUNCH DURATION (ns)</td>
<td></td>
</tr>
</tbody>
</table>

**Beam Lines**

<table>
<thead>
<tr>
<th>MAIN PORTS: IN OP</th>
<th>IN CONST</th>
<th>TOTAL POSSIBLE</th>
</tr>
</thead>
<tbody>
<tr>
<td>EXPERIMENTAL STATION</td>
<td></td>
<td></td>
</tr>
<tr>
<td>TYPE</td>
<td></td>
<td></td>
</tr>
<tr>
<td>IR/VISIBILE (&lt;5 eV)</td>
<td>IN OP</td>
<td>IN CONST</td>
</tr>
<tr>
<td>UV/UVU (6 - 300 eV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SOFT X (&gt; 300 - 3000eV)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>X (&gt;3000eV)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
NAME OF SYNCHROTRON LIGHT SOURCE
Synchrotron Radiation Research Center (SRRC)

LOCATION
Hsinchu, TAIWAN, R. O. C.

PERSON IN CHARGE
Professor Edward Yen

DATA SUPPLIED BY
Project Management Division SRRC

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING X, SYNCHROTRON
CONSTRUCTION STARTED (date) Sept. 1987
FIRST BEAM, or GOAL (date) Dec. 1997
TOTAL COST OF FACILITY 90 MILLION US $
TOTAL MACHINE STAFF (now) X
ANN. OPERAT. BUDGET (without salaries) X

ANN. OPERATING TIME X h
OPERATION TIME OF RING:
LEGS EXPERIMENT X hrs dedicated, X hrs parasitic
MACHINE STUDY X hrs/day, X days/week

STORAGE RINGS PARAMETERS

General Ring Parameters
TYPE OF INJECTOR Synchrotron
INJECTION CYCLE (Hz) 10
INJECTION ENERGY (GeV) 1.3
ORBITAL PERIOD (sec) 408.777

RF ACCELERATION FREQUENCY (MHz) 500
MAXIMUM ENERGY ACHIEVED (GeV) at mA
MAXIMUM ENERGY PLANNED (GeV) 1.3 at 200 mA
BEST BEAM CURRENT PLANNED (mA) at GeV

Typical Electron/Positron Beam Characteristics for User Experiment

LATTICE NAME TBA
ENERGY (GeV) 1.3
NUMBER OF BUNCHES 140
INITIAL CURRENT (mA) 200
AVERAGE CURRENT (mA) FOR USER
LIFETIME (hrs) at 200 mA 10
EMITTANCE (nm/rad) Hor. 19.0
Ver. 1.9
BUNCH DURATION (sec) 0.05

Beam Lines
MAIN PORTS: IN OP X, IN CONST X, TOTAL POSSIBLE 22

EXPERIMENTAL STATION
TYPE IN OP IN CONST PLANNED
IR/VISIBLE (<6 eV) X
UVA/UV (6 - 300 eV) X
SOFT X (< 300 - 3000 eV) X
X (>3000 eV) X

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period (cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
</table>

U: undulator, SCW: superconducting wigglers
MPWJ: wigglers or undulator mode available
EMPW: elliptically polarized source

EXPERIMENTAL ACTIVITIES

No. USER GROUPS, in house X outside X
TOTAL RESEARCH STAFF, in house X (outside) X
ANN. RESEARCH BUDGET, in house X (without salaries) X

ANNUAL RESEARCH TIME X h
ACTIVE PROPOSALS (total) X
SOLID STATE PHYSICS/MATERIAL SCIENCE X
BIOLOGY/BIOCHEMISTRY X
CHEMISTRY/ATOM AND MOLECULAR PHYS X
MEDICINE X
TECHNOLOGY/INDUSTRIAL USE X
EARTH/SPACE SCIENCE X
OTHERS X

Other Relevant Parameters, Recent Improvements, etc.
NAME OF SYNCHROTRON LIGHT SOURCE: SRS

LOCATION: Daresbury Laboratory, England

PERSON IN CHARGE: D. J. Thompson/J. Hordas

DATA SUPPLIED BY: D. J. Thompson

DATE: 21.6.84

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING | SYNCHROTRON

CONSTRUCTION STARTED (date): 1975

FIRST BEAM, or GOAL (date): 1980

TOTAL COST OF MACHINES: £500

TOTAL MACHINE STAFF (now): approx. 70 man years per year

ANN. OPERAT. BUDGET: £1.3M (machine) (without salaries)

ANN. OPERATING TIME: 6500 h

OPERATION TIME OF RING:

USER EXPERIMENT 5750 hrs dedicated, 0 hrs parasitic

MACHINE STUDY 750 hrs

TYPICAL OPERATION 24 hrs/day, 7 days/week

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>BT</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SCW</td>
<td>Oper.</td>
<td>5</td>
<td>3</td>
<td>50</td>
<td>11.3 keV</td>
</tr>
<tr>
<td>SCW</td>
<td>Plan</td>
<td>6</td>
<td>3</td>
<td>50</td>
<td>16.6 keV</td>
</tr>
<tr>
<td>U</td>
<td>Oper.</td>
<td>0.4</td>
<td>21</td>
<td>10</td>
<td>300 eV</td>
</tr>
</tbody>
</table>

U: undulator, SCW: superconducting wiggler
MPWIO: wiggler or undulator mode available
EMPW: elliptically polarized source

STORAGE RINGS PARAMETERS

General Ring Parameters

<table>
<thead>
<tr>
<th>TYPE OF INJECTOR</th>
<th>Linac &amp; Synchrotron</th>
</tr>
</thead>
</table>

INJECTION CYCLE (h): 10

INJECTION ENERGY (GeV): 0.6

ORBITAL PERIOD (ns): 320

BENDING RADIUS (m): 5.96

RF ACCELERATION FREQUENCY (MHz): 300

MAXIMUM ENERGY ACHieved (GeV): 2.0 at mA

MAXIMUM ENERGY PLANNED (GeV): 2.0

BEST CURRENT ACHieved (mA): 150 at 2.0 GeV

BEST CURRENT PLANNED (mA): 500 at 2.0 GeV

Typical Electron/Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATTICE NAME</td>
<td>888-2</td>
<td>888-2</td>
</tr>
<tr>
<td>ELECTRON OR POSITRON</td>
<td>e+</td>
<td>e-</td>
</tr>
<tr>
<td>ENERGY (GeV)</td>
<td>2.0</td>
<td>2.0</td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>160</td>
<td>1</td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>300</td>
<td>40</td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td>220</td>
<td>20</td>
</tr>
<tr>
<td>LIFETIME (hr) at 200 mA</td>
<td>35</td>
<td>20</td>
</tr>
<tr>
<td>EMITTANCE (nmrad) Hor</td>
<td>110</td>
<td>268</td>
</tr>
<tr>
<td>Ver</td>
<td>3.3</td>
<td>3.4</td>
</tr>
<tr>
<td>BUNCH DURATION (ns)</td>
<td>0.2</td>
<td>0.25</td>
</tr>
</tbody>
</table>

Beam Lines

MAIN PORTS: IN OP 9, IN CONST 3, TOTAL POSSIBLE 12

EXPERIMENTAL STATION

<table>
<thead>
<tr>
<th>TYPE</th>
<th>IN OP</th>
<th>IN CONST</th>
<th>PLANNED</th>
</tr>
</thead>
<tbody>
<tr>
<td>UV/UV (5-300 eV)</td>
<td>8</td>
<td>4</td>
<td>0</td>
</tr>
<tr>
<td>SOFT X (&gt;300 eV)</td>
<td>3</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>X (&gt;3000eV)</td>
<td>14</td>
<td>4</td>
<td>6*</td>
</tr>
</tbody>
</table>

* Funded but construction not yet started.

EXPERIMENTAL ACTIVITIES

No. USER GROUPS, in house 8, outside 120

TOTAL RESEARCH STAFF, in house 24, outside 1600

ANN. RESEARCH BUDGET, in house £120,000 (without sal.)

ANNUAL RESEARCH TIME: 5750 h

ACTIVE PROPOSALS (total): 208

SOLID STATE PHYSICS/MATERIAL SCIENCE: 35

BIOLOGY/BIOCHEMISTRY: 70

CHEMISTRY/ATOM AND MOLECULAR PHYS: 27

MEDICINE: 1

TECHNOLOGY/INDUSTRIAL USE: 12

EARTH/SPACE SCIENCE: 2

OTHERS: 0

OTHER Relevant Parameters, Recent Improvements, etc.
NAME OF SYNCHROTRON LIGHT SOURCE: Cornell High Energy Synchrotron Source

LOCATION: Cornell University, Wilson Laboratory, Ithaca, NY 14853, USA

PERSON IN CHARGE: Professor Boris W. Batterman

DATA SUPPLIED BY: Professor Boris W. Batterman

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING, SYNCHROTRON

CONSTRUCTION STARTED (date)

FIRST BEAM, or GOAL (date)

TOTAL COST OF FACILITY (Storage Ring $20M, Synch. Lab $15M)

TOTAL MACHINE STAFF (now) Sync. Lab only: 12, overall: 18.

ANNUAL OPERATING BUDGET: $1,000,000 (without salaries)

ANNUAL OPERATING TIME: 7,000 h (800)

OPERATING TIME OF RING:

USER EXPERIMENT: 540 hrs dedicated, 640 hrs parasitic

MACHINE STUDY: 28 hrs/day, 7 days/week

STORAGE RINGS PARAMETERS

General Ring Parameters

Type of Injector: Linac/Synchrotron

Injection Cycle (Hz): 60

Injection Energy (GeV): 5, 5

Orbital Period (ms): 2560

Bending Radius (m): 22

RF Acceleration Frequency (MHz): 500

Maximum Energy Achieved (GeV): 5.5 at 100 mA

Maximum Energy Planned (GeV): 5.5 at 200 mA

Best Beam Current Achieved (mA): 1.3 at 5.5 GeV

Best Beam Current Planned (mA): 2.0 at 5.5 GeV

Typical Electron/Positron Beam Characteristics for User Experiment

Lattice Name

Beamline

Energy (GeV)

Number of Bunches

Initial Current (mA)

Average Current (mA)

Emission (mm rad)

Lifetime (hrs)

Bunch Duration (ns)

Beam Lines

Main Ports: IN OP

Experimental Station Type

Invisible (<6 eV)

UV/Vis (6 - 300 eV)

Soft X (300 - 3000 eV)

X (>3000 eV)

Insertion Devices

Device Status (ft)

Wiggler

WMG

CONSG

Operation Time of Ring

USER EXPERIMENT

MACHINE STUDY

Typical Operation 28 hrs/day, 7 days/week

Experimantal Activities

No. USER GROUPS, IN house outside

Total Research Staff, IN house 4 outside

Annual Research Time

Active Proposals (total)

Solid State Physics/Material Science

Biology/Biochemistry

Chemistry/Atom and Molecular Physics

Medicine

Technology/Industrial Use

Earth/Space Science

Others

Other Relevant Parameters, Recent Improvements, etc.

We are currently completing a doubling of the synchrotron radiation capabilities. Part of the facility is a high level bio-secure x-ray station. We run an undulator with a fundamental in the hard x-ray regime in a dedicated mode for one month per year.
HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING SYNCHROTRON
CONSTRUCTION STARTED (date) 1970
FIRST BEAM, or GOAL (date) 1972
TOTAL COST OF FACILITY $37M excluding rings
TOTAL MACHINE STAFF (now) Changing
ANN. OPERATING BUDGET ~ $3M (without salaries)
ANN. OPERATING TIME ~ 2500 h
OPERATION TIME OF RING: USER EXPERIMENT ~2000 hrs dedicated, ~1000 hrs parasitic
MACHINE STUDY ~150 hrs/day, 7 days/week

STORAGE RINGS PARAMETERS

General Ring Parameters
TYPE OF INJECTOR Linac (Booster Synch in construction)
INJECTION CYCLE (Hz) 10-30 (10 with Booster)
INJECTION ENERGY (GeV) 2-35 (3.5 with Booster)
ORBITAL PERIOD (sec) 780
BENDING RADIUS (m) 12.7
RF ACCELERATION FREQUENCY (MHz) 358
MAXIMUM ENERGY ACHIEVED (GeV) 5.7 at 60 mA
MAXIMUM ENERGY PLANNED (GeV) 3.7 at 100 mA
BEST BEAM CURRENT ACHIEVED (mA) 200 at X GeV
BEST BEAM CURRENT PLANNED (mA) 200 at 5 GeV

Typical Electron/Positron Beam Characteristics for User Experiment

LATTICE NAME M E M
ELECTRON OR POSITRON Electron Electron
ENERGY (GeV) ~3 ~3
NUMBER OF BUNCHES ~20 ~20
INITIAL CURRENT (mA) 80-100
AVERAGE CURRENT (mA) FOR USER 50
LIFETIME (msec) ~50 ~50
EMITANCE (mm-mrad) Hor ~10 ~10
Ver ~130 ~130
BUNCH DURATION (msec) ~0.2 ~0.2

Beam Lines

MAIN PORTS : IN OP 9, IN CONST., TOTAL POSSIBLE 17

EXPERIMENTAL STATION TYPE IN OP IN CONST. PLANNED
TYPE 0 0 0
INOP (<6 eV) 0 0 0
UV/VIS (~6-300 eV) 7 1 1
SOFT X (~300-3000 eV) 15 1 1
X (>3000 eV) 1

INSERTION DEVICES

Device Status Bit Pole Period (cm) Photon energy (eV)
W Oper 1.9 8 45 \(E_0 = 11,400\)
W Oper 1.9 8 45 \(E_0 = 11,400\)
MWU Oper 1.2 30 7 \(E_0 = 7,200\)
MWU Oper 1.4 30 12 \(E_0 = 8,400\)
U Oper 1.7 20-60 6-18 10-1200 in Fund.

U: undulator, SCW: superconducting wiggle
MPWU: wiggle or undulator mode available
EMPW: elliptically polarized source

EXPERIMENTAL ACTIVITIES

No. USER GROUPS, in house 10 outside 149
TOTAL RESEARCH STAFF, in house 20 outside 400
ANNUAL RESEARCH TIME 5.5,000 h
ACTIVE PROPOSALS (total) 299
SOLID STATE PHYSICS/MATERIAL SCIENCE 198
BIOLOGY/BIOCHEMISTRY 71
CHEMISTRY/ATOM AND MOLECULAR PHYS 24
MEDICINE 2
TECHNOLOGY/INDUSTRIAL USE 4
EARTH/SPACE SCIENCE 4
OTHERS 0

Other Relevant Parameters, Recent Improvements, etc.

A 3 GeV, 10 Hz Booster Synchrotron is in construction as a dedicated electron injector to SPEAR. It is expected to be operational by the Fall of 1990. Operation of SSLR has been limited by the lack of availability of the SLAC Linac as an injector due to its use for the SLC Program.
NAME OF SYNCHROTRON LIGHT SOURCE: PEP/SSRL  
LOCATION: Stanford Linear Accelerator Center/Stanford University  
PERSON IN CHARGE: Arthur Bienenstock  
DATA SUPPLIED BY: Heinz-Dieter Nuhn  

HISTORY AND STATUS

See listing under Storage Rings*

<table>
<thead>
<tr>
<th>TYPE OF SOURCE RING: STORAGE RING</th>
<th>x*-SYNCHROTRON</th>
</tr>
</thead>
<tbody>
<tr>
<td>CONSTRUCTION STARTED (date)</td>
<td></td>
</tr>
<tr>
<td>FIRST BEAM, or GOAL (date)</td>
<td></td>
</tr>
<tr>
<td>TOTAL COST OF FACILITY</td>
<td></td>
</tr>
<tr>
<td>TOTAL MACHINE STAFF (NOW)</td>
<td></td>
</tr>
<tr>
<td>ANN. OPERAT. BUDGET (without salaries)</td>
<td></td>
</tr>
<tr>
<td>ANN. OPERATING TIME</td>
<td>h</td>
</tr>
<tr>
<td>OPERATION TIME OF RING: USER EXPERIMENT</td>
<td>hrs dedicated, hrs parasitic</td>
</tr>
<tr>
<td>MACHINE STUDY</td>
<td></td>
</tr>
<tr>
<td>TYPICAL OPERATION</td>
<td>hrs/day, days/week</td>
</tr>
</tbody>
</table>

STORAGE RINGS PARAMETERS

**General Ring Parameters**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>INJECTION CYCLE (H)</td>
<td>40</td>
</tr>
<tr>
<td>INJECTION ENERGY (GeV)</td>
<td>5-15</td>
</tr>
<tr>
<td>ORBITAL PERIOD (nsec)</td>
<td>2338</td>
</tr>
<tr>
<td>BENDING RADIUS (m)</td>
<td>105.5</td>
</tr>
<tr>
<td>RF ACCELERATION FREQUENCY (MHz)</td>
<td>353.21</td>
</tr>
<tr>
<td>MAXIMUM ENERGY ACHIEVED (GeV)</td>
<td>at mA</td>
</tr>
<tr>
<td>MAXIMUM ENERGY PLANNED (GeV)</td>
<td>at mA</td>
</tr>
<tr>
<td>BEST BEAM CURRENT ACHIEVED (mA)</td>
<td>33 at 7 GeV</td>
</tr>
<tr>
<td>BEST BEAM CURRENT PLANNED (mA)</td>
<td>100 at 7-10 GeV</td>
</tr>
</tbody>
</table>

**Typical Electron/Positron Beam Characteristics for User Experiment**

<table>
<thead>
<tr>
<th>LATTICE NAME</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>ELECTRON OR POSITRON</td>
<td>Electrons</td>
<td>PEP23</td>
<td></td>
</tr>
<tr>
<td>ENERGY (GeV)</td>
<td>13-15</td>
<td>7-10</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>5</td>
<td>1-60</td>
<td></td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>24</td>
<td>15</td>
<td></td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td>mA</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LIFETIME (min) at</td>
<td>102</td>
<td>8.2</td>
<td></td>
</tr>
<tr>
<td>EMMITTANCE (mm mrad)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>BUNCH DURATION (nsec)</td>
<td>0.020</td>
<td>0.044</td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL ACTIVITIES**

No. USER GROUPS, in house ______ outside ______
TOTAL RESEARCH STAFF, in house ______ (without sal)
ANN. RESEARCH BUDGET, in house ______
ANNUAL RESEARCH TIME ______ h
ACTIVE PROPOSALS (total) ______
SOLID STATE PHYSICS/MATERIAL SCIENCE ______
BIOLOGY/VIRUSCHEMISTRY ______
CHEMISTRY/ATOMIC AND MOLECULAR PHYS ______
MEDICINE ______
TECHNOLOGY/INDUSTRIAL USE ______
EARTHS-space SCIENCE ______
OTHERS ______

Other Relevant Parameters, Recent Improvements, etc.

**PEP is not routinely running at present.

References:


NAME OF SYNCHROTRON LIGHT SOURCE: Aladdin
LOCATION: SRC, University of Wisconsin-Madison, Stoughton, WI USA
PERSON IN CHARGE: David L. Nuber
DATE: June 26, 1989
DATA SUPPLIED BY: Walter Trzecikw

HISTORY AND STATUS
TYPE OF SOURCE RING: STORAGE RING
CONSTRUCTION STARTED (date): Fall 1977
FIRST BEAM, OR GOAL (date): Jan. 1982
TOTAL COST OF FACILITY: $9M (without beamlines)
TOTAL MACHINE STAFF (now): 6
ANN. OPERAT. BUDGET: $1M (without salaries)
ANN. OPERATING TIME: 3300 h
OPERATION TIME OF RING:
USER EXPERIMENT: 2700/yr hrs dedicated, 0 hrs parasitic
MACHINE STUDY: 600/yr hrs
TYPICAL OPERATION: 12 hrs/day, 5 days/week

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>Oper</td>
<td>0.51</td>
<td>60</td>
<td>6.1</td>
<td>1.8 ± 140 (2)</td>
</tr>
</tbody>
</table>

(2) Depends on storage ring energy: 0.17 ≤ x ≤ 0.47 GeV
U: undulator, SCW: superconducting wigglr
MPWU: wigglr or undulator mode available
EMPW: elliptically polarized source

STORAGE RINGS PARAMETERS

General Ring Parameters
TYPE OF INJECTOR: microtron
INJECTION CYCLE (Hz): 1.25
INJECTION ENERGY (GeV): 0.309
ORBITAL PERIOD (sec): 296
INJECTION RADIUS (m): 2.08
RF ACCELERATION FREQUENCY (MHz): 50.28
MAXIMUM ENERGY ACHIEVED (GeV): 1.0 at 100 mA
MAXIMUM ENERGY PLANNED (GeV): 1.0 at 500 mA
BEST BEAM CURRENT ACHIEVED (mA): 326 at 0.8 GeV
BEST BEAM CURRENT PLANNED (mA): 500 at 1.0 GeV

Typical Electron/Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATITUDE NAME</td>
<td>Aladdin</td>
<td>Aladdin</td>
</tr>
<tr>
<td>ELECTRON OR POSITRON</td>
<td>electron</td>
<td>electron</td>
</tr>
<tr>
<td>ENERGY (GeV)</td>
<td>0.6</td>
<td>1.0</td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>200</td>
<td>80</td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td>93</td>
<td></td>
</tr>
<tr>
<td>LIFETIME (hrs) at 100 mA</td>
<td>3.6</td>
<td>6</td>
</tr>
<tr>
<td>EMITTANCE (mmrad)</td>
<td>82</td>
<td></td>
</tr>
<tr>
<td>BUNCH DURATION (nsec)</td>
<td>1.0</td>
<td>1.0</td>
</tr>
</tbody>
</table>

Beam Lines
MAIN PORTS: IN OP 21, IN CONST 6, TOTAL POSSIBLE 26

EXPERIMENTAL STATION
TYPE
IR/VISIBLE (<6 eV) IN OP 21, IN CONST 21, PLANNED 1
UV/VUV (6 - 300 eV) 9
SOFT X (> 300 - 3000 eV) 10
X (3000 eV) 0

(1) machine diagnostic ports are classified as visible lines

EXPERIMENTAL ACTIVITIES

No. USER GROUPS, in house 3 outside 62
TOTAL RESEARCH STAFF, in house 3 outside 300
ANN. RESEARCH BUDGET, in house $0.3M (without salaries)
ANNUAL RESEARCH TIME 2700 h
ACTIVE PROPOSALS (total) 65
SOLID STATE PHYSICS/MATERIAL SCIENCE 50
BIOLOGY/BIOCHEMISTRY 13
CHEMISTRY/ATOM AND MOLECULAR PHYSICS 13
MEDICINE 2
TECHNOLOGY/INDUSTRIAL USE 2
EARTHSPACE SCIENCE 2
OTHERS 2

Other Relevant Parameters, Recent Improvements, etc.


NAME OF SYNCHROTRON LIGHT SOURCE: NSLS X-RAY RING
LOCATION: USA, INL, Upton, New York
PERSON IN CHARGE: Samuel Krinsky
DATA SUPPLIED BY: Samuel Krinsky

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING
SYNCHROTRON
CONSTRUCTION STARTED (date): October 1977
FIRST BEAM, OR GOAL (date):
TOTAL COST OF FACILITY: 180,000 K
TOTAL MACHINE STAFF (now): 150
ABN. OPERAT. BUDGET 5,875 K (without salaries)
ANNUAL OPERATING TIME: 5,800 h
OPERATION TIME OF RING:
USER EXPERIMENT: 5,100 hrs dedicated, hrs parasitic
MACHINE STUDY: 5 days/month
TYPICAL OPERATION: 26 hrs/day, 7 days/week

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td></td>
<td>0.3</td>
<td>11</td>
<td>8</td>
<td>250-2000</td>
</tr>
<tr>
<td>MPW</td>
<td></td>
<td>1.1</td>
<td>17</td>
<td>12</td>
<td>6000-15000</td>
</tr>
<tr>
<td>SCW</td>
<td></td>
<td>1.1</td>
<td>17</td>
<td>12</td>
<td></td>
</tr>
</tbody>
</table>

U: undulator, SCW: superconducting wiggler
MPW: wigglers or undulator mode available
EMPW: elliptically polarized source

STORAGE RINGS PARAMETERS

**General Ring Parameters**
- Type of injector: 50 MeV linac, 750 MeV Booster
- Injection cycle (Hz): 0.7
- Injection energy (GeV): 0.75
- Orbital period (sec): 587
- Bending radius (m): 8.875
- RF Acceleration frequency (MHz): 32.888
- Maximum energy achieved (GeV): 2.5 at 250 mA
- Maximum energy planned (GeV): 2 at mA
- Best beam current achieved (mA): 25 at GeV
- Best beam current planned (mA): 25 at GeV

**Typical Electron/Positron Beam Characteristics for User Experiment**

<table>
<thead>
<tr>
<th>Lattice Name</th>
<th>Electron</th>
<th>Positron</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy (GeV)</td>
<td>3.5</td>
<td>3.5</td>
</tr>
<tr>
<td>Number of Bunches</td>
<td>320</td>
<td></td>
</tr>
<tr>
<td>Average current (mA) for User</td>
<td>200</td>
<td></td>
</tr>
<tr>
<td>Lifetime (hrs) at 300 mA</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td>Emission (mm-rad)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Bunch Duration (ns)</td>
<td>0.3</td>
<td></td>
</tr>
</tbody>
</table>

**Beam Lines**

<table>
<thead>
<tr>
<th>Main Ports</th>
<th>In OP</th>
<th>In Const</th>
<th>Total Possible</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52</td>
<td>16</td>
<td>69</td>
</tr>
</tbody>
</table>

**EXPERIMENTAL ACTIVITIES**

No. USER GROUPS, In house: 2 outside: 120
TOTAL RESEARCH STAFF, In house: 13 outside: 1000
ANNUAL RESEARCH BUDGET, In house: 5100 (without sal)
ANNUAL RESEARCH TIME: 5100 h
ACTIVE PROPOSALS (total): 422
SOLID STATE PHYSICS/MATERIAL SCIENCE
BIOLOGY/BIOCHEMISTRY
CHEMISTRY/ATOM AND MOLECULAR PHYS
MEDICINE
TECHNOLOGY/INDUSTRIAL USE
EARTH/SPACE SCIENCE
OTHERS

Other Relevant Parameters, Recent Improvements, etc.

<table>
<thead>
<tr>
<th>Beam Line</th>
<th>In OP</th>
<th>In Const</th>
<th>Planned</th>
</tr>
</thead>
<tbody>
<tr>
<td>In OP</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UV/UVV (6 - 300 eV)</td>
<td>2</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>Soft X (&gt; 300 - 3000 eV)</td>
<td>15</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>X (&gt; 3000 eV)</td>
<td>35</td>
<td>11</td>
<td>1</td>
</tr>
</tbody>
</table>
NAME OF SYNCHROTRON LIGHT SOURCE: ADVANCED LIGHT SOURCE

LOCATION: LAWRENCE BERKELEY LABORATORY, BERKELEY, CA 94720 USA

PERSON IN CHARGE: JAY N. MARX

DATE: JUNE 20, 1989

DATA SUPPLIED BY: ARTHUR L. ROBINSON

HISTORY AND STATUS (SEE NOTE 1 BELOW)

TYPE OF SOURCE RING: STORAGE RING SYNCHROTRON

CONSTRUCTION STARTED (date): OCTOBER 1987

FIRST BEAM, OR GOAL (date): APRIL 1993

TOTAL COST OF FACILITY (construction): $99.5 million

TOTAL MACHINE STAFF (now): NA

ANN. OPER. BUDGET (without salaries): NA

ANN. OPERATING TIME: h

OPERATION TIME OF RING:

USER EXPERIMENT NA hrs dedicated, NA hrs parasitic

MACHINE STUDY NA hrs

TYPICAL OPERATION: 24 hrs/day, 7 days/week

PLANNED:

STORAGE RINGS PARAMETERS

General Ring Parameters

TYPE OF INJECTOR: LINAC + SYNCHROTRON

INJECTION CYCLE (Hz): 1

INJECTION ENERGY (GeV): 1 - 1.9 (matched to storage ring)

INJECTION ORBITAL PERIOD (sec): 656.4

BENDING RAD (mm): 4,009

RF ACCELERATION FREQUENCY (MHz): 499.654

MAXIMUM ENERGY ACHIEVED (GeV): at mA

MAXIMUM ENERGY PLANNED (GeV): 1.9 at 400 mA

BEST BEAM CURRENT PLANNED (mA): 400 at 1.9 GeV

Typical Electron/Positron Beam Characteristics for User Experiment:

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>Periods (hours)</th>
<th>Period (cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>PLANNED</td>
<td>0.82</td>
<td>98</td>
<td>52 - 1900</td>
</tr>
<tr>
<td>U</td>
<td>PLANNED</td>
<td>0.58</td>
<td>123</td>
<td>3.9</td>
</tr>
<tr>
<td>W</td>
<td>PLANNED</td>
<td>2.07</td>
<td>16</td>
<td>169 - 2500</td>
</tr>
</tbody>
</table>

** Peak Field

First, Third, and Fifth Harmonics

U: undulator, SCW: superconducting wiggler

MPWJW: wiggler or undulator mode available

EMPW: elliptically polarized source

EXPERIMENTAL ACTIVITIES (SEE NOTES 2, 4 BELOW)

No. USER GROUPS, in house outside

TOTAL RESEARCH STAFF, in house outside

ANN. RESEARCH BUDGET, in house outside

ACTIVE PROPOSALS (total)

SOLID STATE PHYSICS/MATERIAL SCIENCE

BIOLOGY/BIOCHEMISTRY

CHEMISTRY/ATOM AND MOLECULAR PHYS

MEDICINE

TECHNOLOGY/INDUSTRIAL USE

EARTH/SPACE SCIENCE

OTHERS (SURFACE SCIENCE)

Other Relevant Parameters, Recent Improvements, etc.

(1) Initial operations for users are planned to begin in April 1993.

(2) Participating Research Teams will help provide beam lines and experimental facilities.

(3) Eleven straight sections will be available for insertion devices.

(4) PRT proposals for the initial experimental facilities are due August 15, 1989. Proposals are expected in all the checked experimental areas.
### NAME OF SYNCHROTRON LIGHT SOURCE
- **Advanced Photon Source**

### LOCATION
- Argonne National Laboratory, Argonne, Illinois, USA

### PERSON IN CHARGE
- David E. Monkton

### DATA SUPPLIED BY
- Lee C. Teng

### DATE
- June 15, 1989

### HISTORY AND STATUS
- **TYPE OF SOURCE RING:** STORAGE RING, SYNCHROTRON
- **CONSTRUCTION STARTED (DATE):** 1980 (EST)
- **FIRST BEAM, OR GOAL (DATE):** 1985 (EST)
- **TOTAL COST OF FACILITY:** $300 million (1982)
- **TOTAL MACHINE STAFF (now):** Approx. 30
- **ANNUAL OPERATING BUDGET:** $25 million (1982) (without salaries)
- **ANNUAL OPERATING TIME:** 7000 hours (EST)
- **OPERATION TIME OF RING:**
  - USER EXPERIMENT: his dedicated, her parasitic
  - MACHINE STUDY: his, hers
- **TYPICAL OPERATION:** his/day, her/week

### STORAGE RINGS PARAMETERS

#### General Ring Parameters
- **TYPE OF INJECTOR:** Linac + Accumulator + Synchrotron
- **INJECTION CYCLE (Hz):** 2.0
- **INJECTION ENERGY (GeV):** 7.0
- **ORBITAL PERIOD (sec):** 3682.5
- **BENDING RADIUS (m):** 36.90
- **BETA SQUAD (m):** 151.93
- **MAXIMUM ENERGY ACHIEVED (GeV):** 8.0 at 100 mA
- **BEST BEAM CURRENT ACHIEVED (mA):** 0.0 at 7 GeV
- **BEST BEAM CURRENT PLANNED (mA):** 0.0 at 7 GeV

#### Typical Electron/Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATTICE NAME</td>
<td>C-G</td>
<td></td>
</tr>
<tr>
<td>ENERGY (GeV)</td>
<td>7.0</td>
<td></td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>10d0</td>
<td></td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>LIFETIME (hrs) @ 100 mA</td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>EMITTANCE (mmrad)</td>
<td>0.8</td>
<td></td>
</tr>
<tr>
<td>BUNCH DURATION (nsec)</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

### INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period (cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>U</td>
<td>Plan</td>
<td>0.77</td>
<td>156</td>
<td>3.5</td>
<td>3,500</td>
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<tr>
<td>U</td>
<td>Plan</td>
<td>0.25</td>
<td>226</td>
<td>2.3</td>
<td>2,300</td>
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<tr>
<td>U</td>
<td>Plan</td>
<td>0.24</td>
<td>86</td>
<td>6.0</td>
<td>4,000</td>
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<tr>
<td>U</td>
<td>Plan</td>
<td>0.27</td>
<td>38</td>
<td>13.6</td>
<td>500</td>
</tr>
<tr>
<td>W</td>
<td>Plan</td>
<td>1.0</td>
<td>10</td>
<td>15.0</td>
<td>32,600</td>
</tr>
<tr>
<td>W</td>
<td>Plan</td>
<td>0.3</td>
<td>20</td>
<td>22.0</td>
<td>9,800</td>
</tr>
</tbody>
</table>

U: undulator, SCW: superconducting wiggle
MPWU: wiggle or undulator mode available
EMPW: elliptically polarized source

### EXPERIMENTAL ACTIVITIES

<table>
<thead>
<tr>
<th>No. USER GROUPS, in house</th>
<th>outside</th>
</tr>
</thead>
<tbody>
<tr>
<td>TOTAL RESEARCH STAFF, in house</td>
<td>outside</td>
</tr>
<tr>
<td>ANNUAL RESEARCH BUDGET, in house</td>
<td>(without sal)</td>
</tr>
<tr>
<td>ANNUAL RESEARCH TIME</td>
<td>h</td>
</tr>
<tr>
<td>ACTIVE PROPOSALS (total)</td>
<td></td>
</tr>
<tr>
<td>SOLID STATE PHYSICS/MATERIAL SCIENCE</td>
<td></td>
</tr>
<tr>
<td>BIOLOGY/BIOCHEMISTRY</td>
<td></td>
</tr>
<tr>
<td>CHEMISTRY/ATOM AND MOLECULAR PHYS</td>
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</tr>
<tr>
<td>MEDICINE</td>
<td></td>
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<tr>
<td>TECHNOLOGY/INDUSTRIAL USE</td>
<td></td>
</tr>
<tr>
<td>EARTH/SPACE SCIENCE</td>
<td></td>
</tr>
<tr>
<td>OTHERS</td>
<td></td>
</tr>
</tbody>
</table>

### Other Relevant Parameters, Recent Improvements, etc.

### Beam Lines
- **MAIN PORTS:** IN OP, IN CONST, TOTAL POSSIBLE 70

### EXPERIMENTAL STATION
- **TYPE:** IN OP, IN CONST, PLANNED
- **INVISIBLE (<60 eV):**
- **UV/VUV (6-300 eV):**
- **SOFT X (>300-3000 eV):**
- **X (>3000 eV):**
NAME OF SYNCHROTRON LIGHT SOURCE: VEP-3

LOCATION: Institute of Nuclear Physics, Novosibirsk

PERSON IN CHARGE: Kalipazov G.N. (concerning SR works)  DATE: 13.07.69

DATA SUPPLIED BY: Findyurin V.P.

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING [Y] SYNCHROTRON

CONSTRUCTION STARTED (date) 1965
FIRST BEAM OR GOAL (date) 1970
TOTAL COST OF FACILITY
TOTAL MACHINE STAFF (now) 50
Ann. Oper. Budget
Ann. Operating Time
OPERATION TIME OF RING:
USER EXPERIMENT 48 per week plus dedicated 36 per week parasitic
MACHINE STUDY 1 per week
TYPICAL OPERATION 24 hr/day, 7 days/week

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wigglener</td>
<td>In op</td>
<td>2</td>
<td>3</td>
<td>3000-30000</td>
</tr>
</tbody>
</table>

U: undulator, SCW: superconducting wiggler
MPW/PW: wiggler or undulator mode available
EMPW: elliptically polarized source

STORAGE RINGS PARAMETERS

General Ring Parameters

TYPE OF INJECTOR: Synchrotron

INJECTION CYCLE (s) 1
INJECTION ENERGY (GeV) 0.15
ORBITAL PERIOD (sec) 250
BENDING RADIUS (m) 6.15
RF ACCELERATION FREQUENCY (MHz) 4 and 72
MAXIMUM ENERGY ACHIEVED (GeV) 2 at 250 mA
MAXIMUM ENERGY PLANNED (GeV) at mA
BEST BEAM CURRENT ACHIEVED (mA) 250 at 2 GeV
BEST BEAM CURRENT PLANNED (mA) at GeV

Typical Electron/Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>LATITUDE NAME</td>
<td>=</td>
<td>=</td>
</tr>
<tr>
<td>ELECTRON OR POSITRON</td>
<td>e-</td>
<td>e+</td>
</tr>
<tr>
<td>ENERGY (GeV)</td>
<td>2</td>
<td>0.35</td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td>=</td>
<td>=</td>
</tr>
<tr>
<td>LIFETIME (hrs) at 50 mA</td>
<td>3</td>
<td>10 min at 20 mA</td>
</tr>
<tr>
<td>EMITTANCE (mm rad)</td>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>BUNCH DURATION (nsec)</td>
<td>1.2</td>
<td>0.3</td>
</tr>
</tbody>
</table>

Beam Lines

MAIN PORTS: IN OP = 8, IN CONST = 1, TOTAL POSSIBLE

EXPERIMENTAL STATION TYPE

IRRISIVABLE (<6 eV) 1 (P3L) IN CONST PLANNED
UV/VUV (6 - 300 eV) 2
SOFT X (>300-3000 eV) 1
X (>3000 eV) 1
**NAME OF SYNCHROTRON LIGHT SOURCE**

**YEP-4M**

**LOCATION**

Institute of Nuclear Physics, Novosibirsk

**PERSON IN CHARGE**

Kulipanov G.N. (concerning SR works)

**DATE**

13.07.89

**DATA SUPPLIED BY**

Pindyurin V.P.

## HISTORY AND STATUS

- **Type of Source Ring:** Storage Ring YEP-4M
- **Construction started (date):** Reconstruction 1988
- **First beam, or goal (date):** Planned 1990
- **Total cost of facility:**
- **Total machine staff (now):** 30
- **Ann. operat. budget (without salaries):**
- **Ann. operating time:** h
- **Operation time of Ring:** 50% planned of total
- **User experiment:** hrs dedicated, oper., hrs parasitic
- **Machine study:** hrs
- **Typical operation:** hrs/day, days/week

## STORAGE RINGS PARAMETERS

**General Ring Parameters**

- **Type of Injector:** Storage ring YEP-3
- **Injection cycle (Hz):**
- **Injection energy (GeV):** 1.05
- **Orbital period (nsec):** 1200
- **Bending radius (m):** 33
- **RF Acceleration frequency (MHz):** 180 (Q=222)
- **Maximum energy achieved (GeV):** at mA
- **Maximum energy planned (GeV):** at mA
- **Best beam current achieved (mA):** at GeV
- **Best beam current planned (mA):** at 5.5 GeV

**Typical Electron/Positron Beam Characteristics for User Experiment**

<table>
<thead>
<tr>
<th></th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lattice name</strong></td>
<td>Electron or positron</td>
<td>9.5</td>
<td>6.3</td>
</tr>
<tr>
<td><strong>Energy (GeV)</strong></td>
<td>5.5</td>
<td>5.3</td>
<td></td>
</tr>
<tr>
<td><strong>Number of bunches</strong></td>
<td>80</td>
<td>80</td>
<td></td>
</tr>
<tr>
<td><strong>Average current (mA)</strong></td>
<td>40</td>
<td>40</td>
<td></td>
</tr>
<tr>
<td><strong>Lifetime (hrs) at mA</strong></td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td><strong>Emittance (mmrad)</strong></td>
<td>1260</td>
<td>1260</td>
<td></td>
</tr>
<tr>
<td><strong>Bunch duration (nsec)</strong></td>
<td>0.77</td>
<td>0.77</td>
<td></td>
</tr>
</tbody>
</table>

**Beam Lines**

- **Main Ports:** IN OP, IN CONST, TOTAL POSSIBLE

**Experimental Station**

- **Type:**
- **Invisible (< 0.6 eV):** IN OP, IN CON, PLANNED
- **UV/VUV (6 - 300 eV):**
- **Soft X (> 300 - 3000 eV):**
- **X (> 3000 eV):**

---

**INSERTION DEVICES**

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>R(T)</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**EXPERIMENTAL ACTIVITIES**

- **No. user groups, in house:**
- **Outside:**
- **Total Research Staff, in house:**
- **Outside (without sal):**
- **Annual Research Time:** h
- **Active Proposals (total):**
- **Solid State Physics/Material Science:**
- **Biology/Biochemistry:**
- **Chemistry/Atom and Molecular Physics:**
- **Medicine:**
- **Technology/Industrial Use:**
- **Earth/Space Science:**
- **Others:**

Other Relevant Parameters, Recent Improvements, etc.
NAME OF SYNCHROTRON LIGHT SOURCE: Siberia-2

LOCATION: Kurchatov Institute, Moscow

PERSON IN CHARGE: Korchuganov V. Kh., Novosibirsk. E.B., Novosibirsk

DATE: 13.07.09

DATA SUPPLIED BY: Fedyanin V. F.

HISTORY AND STATUS

TYPE OF SOURCE RING: STORAGE RING, SYNCHROTRON
CONSTRUCTION STARTED (DATE): 1980
FIRST BEAM, OR GOAL (DATE): 1981
TOTAL COST OF FACILITY: [Missing information]
TOTAL MACHINE STAFF (now): [Missing information]
ANN. OPERAT. BUDGET: [Missing information] (without salaries)
ANN. OPERATING TIME: [Missing information] h
OPERATION TIME OF RING:
USER EXPERIMENT [Missing information] dedicated, [Missing information] parasitic
MACHINES IN STUDY: [Missing information]
TYPICAL OPERATION: [Missing information] h/day, [Missing information] days/week

INSERTION DEVICES

<table>
<thead>
<tr>
<th>Device</th>
<th>Status</th>
<th>B(T)</th>
<th>Poles</th>
<th>Period(cm)</th>
<th>Photon energy (eV)</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>SW</td>
<td>12</td>
<td>3</td>
<td>32</td>
<td>50000</td>
</tr>
<tr>
<td>5</td>
<td>MPW/U</td>
<td>0.7</td>
<td>23</td>
<td>11</td>
<td>30000</td>
</tr>
</tbody>
</table>

U: undulator, SW: superconducting wiggler
MPW: wigglers or undulator mode available
FWMPW: elliptically polarized source

STORAGE RINGS PARAMETERS

General Ring Parameters

TYPE OF INJECTOR: booster storage ring "Siberia-1"
INJECTION CYCLE (ns): 0.5
INJECTION ENERGY (GeV): 0.450
ORBITAL PERIOD (ms): 414
BENDING RADIUS (m): 4.905, 19.62
RF ACCELERATION FREQUENCY (MHz): 181.14, q=75
MAXIMUM ENERGY ACHIEVED (GeV): at mA
MAXIMUM ENERGY PLANNED (GeV): 2.5 at 100/300 mA
BEST BEAM CURRENT ACHIEVED (mA): at GeV
BEST BEAM CURRENT PLANNED (mA): 1000

Typical Electron/Positron Beam Characteristics for User Experiment

<table>
<thead>
<tr>
<th>LATTICE NAME</th>
<th>I</th>
<th>II</th>
<th>III</th>
</tr>
</thead>
<tbody>
<tr>
<td>ENERGY (GeV)</td>
<td>2.5</td>
<td>2.5</td>
<td>2.5</td>
</tr>
<tr>
<td>NUMBER OF BUNCHES</td>
<td>15</td>
<td>15</td>
<td>15</td>
</tr>
<tr>
<td>INITIAL CURRENT (mA)</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
</tr>
<tr>
<td>AVERAGE CURRENT (mA) FOR USER</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
</tr>
<tr>
<td>LIFETIME (hrs) at 100</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
</tr>
<tr>
<td>EMITTANCE (mmrad)</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
</tr>
<tr>
<td>BUNCH DURATION (nsec)</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
<td>[Missing information]</td>
</tr>
</tbody>
</table>

Beam Lines

MAIN PORTS: IN OP = [Missing information], IN CONST = [Missing information], TOTAL POSSIBLE = 39

EXPERIMENTAL STATION

TYPE: IN OP | IN CONST | PLANNED
| IRVISIBL (≤6 eV) | [Missing information] | [Missing information] | [Missing information] |
| UV/VIS (6-300 eV) | [Missing information] | [Missing information] | [Missing information] |
| SOFT X (>300-3000 eV) | [Missing information] | [Missing information] | [Missing information] |
| X (>3000 eV) | [Missing information] | [Missing information] | [Missing information] |

EXPERIMENTAL ACTIVITIES

No. USER GROUPS, in house [Missing information] outside [Missing information]
TOTAL RESEARCH STAFF, in house [Missing information] outside [Missing information]
ANN. RESEARCH BUDGET, in house [Missing information] (without sal.)
ANNUAL RESEARCH TIME [Missing information] h

ACTIVE PROPOSALS (total):
SOLID STATE PHYSICS/MATERIAL SCIENCE [Missing information]
BIOLOGY/BIOCHEMISTRY [Missing information]
CHEMISTRY: ATOM AND MOLECULAR PHYS [Missing information]
MEDICINE [Missing information]
TECHNOLOGY: INDUSTRIAL USE [Missing information]
EARTHS/SPACE SCIENCE [Missing information]
OTHERS [Missing information]

Other Relevant Parameters, Recent Improvements, etc.
**NAME OF SYNCHROTRON**
SYNCHROPHASEotron

**INSTITUTION**
Joint Institute for Nuclear Research

**LOCATION**
Dubna, USSR

**PERSON IN CHARGE**
A. N. Balbin

**DATA SUPPLIED BY**
I. B. Isajinetsky

**DATE:** August 1999

---

**HISTORY AND STATUS**

**CONSTRUCTION STARTED** March 1957

**TOTAL COST OF FACILITY** 160

**TOTAL OPERATING HOURS** 1,200

**ACCELERATOR PARAMETERS**

**ENERGY** 9.2 GeV

**RING DIAMETER** 66.2 m

**INJECTOR**

**OUTPUT (max)** 50 mA

**EMITTANCE** 1 mm-mrad

**INJECTION Period** 100 µs

**INJECTOR TYPE** electrostatic

**Magnet System**

**FOCUSING TYPE** weak

**FIELD INDEX** n = 0.67

**BETATRON FREQUENCY** 0.626, 0.892

**NEUTRALIZER**

**NO. QUADS** 4

**INTERNAL FIELD** 10 mT

**GRAD. INC.** 1 mT/m

**NO. LONG STRAIGHT SECTORS** 1

**RISE TIME** 0.6 s

**POWER INPUT PEAK** 7.2 MW

**ACCELERATION SYSTEM**

**NO. CAVITIES** 1

**HARMONIC NUMBER** 2

**RF RANGE** 0.565 to 2.87 MHz

**ENERGY GAIN** 2.4

**RADIATION LOSS** KeV/m

**VACUUM SYSTEM**

**MATERIAL OF VACUUM CHAMBER** stainless steel

**APERTURE OF VAC. CHAMBER** 400 x 2000 mm

**AVERAGE PRESSURE** 1.10^-7 Torr

**Extraction System**

**TYPE** (a) slow resonance 2/3

**LENGTH OF SPILL** 0.3 to 0.6 µs

**EMITTANCE = Area x β at 90% of current (for p-machines)**

---

**ACCELERATOR PERFORMANCE**

<table>
<thead>
<tr>
<th>PARTICLE</th>
<th>MOMENTUM RANGE</th>
<th>NO. OF BEAMS</th>
<th>OTHER INFO</th>
</tr>
</thead>
<tbody>
<tr>
<td>e^-</td>
<td>1 - 7 GeV/μc</td>
<td>2</td>
<td>no</td>
</tr>
<tr>
<td>µ</td>
<td>1 - 7 GeV/μc</td>
<td>2</td>
<td>separated</td>
</tr>
</tbody>
</table>

**SECONDARY BEAMS**

**EXPERIMENTAL FACILITY**

**TOTAL EXPERIMENTAL AREAS** 10,000 m²

**NO. INTERNAL TARGETS** 1

**NO. EXTERNAL TARGETS** 5

**NO. BEAMS SERVED AT SAME TIME** 2

**TOTAL POWER USED (AVERAGE) FOR RESEARCH** 9.3 MW

**NO. USER GROUPS** in house 12, outside 7

**TOTAL RESEARCH STAFF, IN HOUSE** 320, outside 40

**ANN. RESEARCH BUDGET, IN HOUSE** 348,001, (without sal.)

**ANNUAL RESEARCH TIME** 1,100 h

Other Relevant Parameters, Recent Improvements, etc.
**HISTORY AND STATUS**

<table>
<thead>
<tr>
<th>Construction Started (date)</th>
<th>1969</th>
</tr>
</thead>
<tbody>
<tr>
<td>First Beam Obtained, or Goal (date)</td>
<td>1974</td>
</tr>
<tr>
<td>Total Cost of Facility</td>
<td>$18,000,000</td>
</tr>
<tr>
<td>Annual Operating Budget (now)</td>
<td>$1,800,000</td>
</tr>
<tr>
<td>Annual Operating Time</td>
<td>4,500 hours</td>
</tr>
</tbody>
</table>

**ACCELERATOR PARAMETERS**

**Physical Dimensions**

- **Total Length**: 14.5 m
- **Tank Diameter**: 1.4 m
- **No. Drift Tunes**: 18
- **Drift Tube Length**: 50 mm to 320 mm
- **Drift Tube Diameter**: 135 mm to 90 mm
- **Aperture Diameter**: 17 mm to 23 mm

**Ion Source**

- **Type**: Beam, Linac, EBIS, D
- **Output**: 300 (p) mA at 40 keV
- **Emittance**: 3 mm-mrad

**Injector**

- **Type**: Pulse Transformer
- **Output**: 300 (p) mA at 600 keV
- **Emittance**: 5.0 mm-mrad

**Bunchers**

- **Type**: One-gap Buncher
- **Modulation**: 50 keV, DM 1200 mm at 164.5 MHz
- **Kev, DM 1200 mm at 164.5 MHz**

**Acceleration System**

- **RF Freq**: 164.5 MHz
- **Field Mode**: 78.87 MHz
- **Equil Phase**: 30°
- **Accel Rate**: 1.4 MeV/m
- **Repetition Rate**: 0.15 MHz
- **Duty Factor**: 90% (RF), 80% (Beam)
- **Pulse Length**: 400 μs (RF), 500 μs (Beam)
- **Effective Shunt Impedance**: 40 MΩ
- **RF Power Input Peak**: 3.4 MW, Mean 2.0 MW

**Focusing System**

- **No. Quadrupoles**: 58
- **Type**: Magnetic
- **Order**: 58
- **Helm**: 1.157

**Vacuum System**

- **Material Chamber**: Steel
- **Average Pressure**: 6.10^-7 torr

---

*Emittance = Area x J at 90% current*
NAME OF HEAVY ION ACCELERATOR: SYNCHROPHASOTRON

INSTITUTION: Joint Institute for Nuclear Research

LOCATION: Dubna, 1988

PERSON IN CHARGE: A. M. Baldin

DATA SUPPLIED BY: L. N. Lissinin

DATE: August 1989

HISTORY AND STATUS

CONSTRUCTION BEGUN (date) 1957
FIRST BEAM OBTAINED, OR GOAL (date) March 1957
TOTAL COST OF FACILITY 36 MlrbC/kg
TOTAL ACCELERATOR STAFF (now) 160
AVER. OPERATING TIME 4.4 MlrbC/kg (without salaries)

ACCELERATOR PARAMETERS

**General**
ACCELERATED PARTICLES: D, He, Ne, O, F, Ar
ENERGY: 4.2 GeV
RING DIAM: 64.2 m; TUNNEL SECT (W x H) 10 x 10 m

**Injector**
TYPE: Alvarez line
OUTPUT (max) 1 - 10 mA at 5 MeV
EMITTANCE*: 5 mm-mrad
INJECTION PERIOD 20 - 400 μs, or 1 - 60 turns
INJECTOR TYPE: Electrostatic

**Magnet System**
FOCUSING TYPE: Weak
FOCUSING ORDER 8
BETATRON FREQUENCY: λν 0.626, 0.892
NO. MAGNETS: 4, LENGTH (m): 43.9, R = 1.2 m
NO. QUADS: 0.011,LENGTH (m): 43.9, R = 1.2
GRAD. MAX: T/m, MAX: T/m
NO. SHORT STRAIGHT SEC: 1, LENGTH: 8 m
NO. LONG STRAIGHT SEC: 1, LENGTH: 8 m
RISE TIME: 3 s
FLAT-TOP TIME: 0.6 s
POWER INPUT PEAK: 6.2 MW, MEAN: 6 MW

**Acceleration System**
NO. CAVITIES: 1, LENGTH (m): 6.1 m
HARMONIC NUMBER: 2
RF RANGE: 0.297 to 2.8 GHz
ENERGY GAIN: 2.4 kV/μm
POWER INPUT PEAK: 90 kW, MEAN: 30 kW

**Vacuum System**
MATERIAL OF VAC. CHAMBER: Stainless steel
APERTURE OF VAC. CHAMBER: 400 x 2000 mm
AVERAGE PRESSURE: 1.107 Torr

**Extraction System**
TYPE: 1) slow resonance 2/3
2) fast resonance 2/3
3) slow resonance 2/3
LENGTH OF OPEN 1) 0.1 to 0.6 μs
2) 0.6 to 1.5 μs
3) 1.5 to 4.5 μs

ACCELERATOR PERFORMANCE

<table>
<thead>
<tr>
<th>Particle</th>
<th>Energy (GeV)</th>
<th>Resolution ΔE/E (%)</th>
<th>Beam (PART/PULSE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>D</td>
<td></td>
<td></td>
<td>1.10^7</td>
</tr>
<tr>
<td>O</td>
<td></td>
<td></td>
<td>1.10^7</td>
</tr>
<tr>
<td>Ne</td>
<td></td>
<td></td>
<td>5.10^7</td>
</tr>
<tr>
<td>Ar</td>
<td></td>
<td></td>
<td>5.10^7</td>
</tr>
<tr>
<td>F</td>
<td>0.2 - 4.2</td>
<td>0 - 0.1</td>
<td>5.10^7</td>
</tr>
<tr>
<td>He</td>
<td></td>
<td></td>
<td>5.10^7</td>
</tr>
<tr>
<td>Ar</td>
<td></td>
<td></td>
<td>5.10^7</td>
</tr>
</tbody>
</table>

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other inform.</th>
</tr>
</thead>
<tbody>
<tr>
<td>H</td>
<td>1 - 0.5 MeV</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td>ST</td>
<td>1 - 4.5 GeV</td>
<td>2</td>
<td></td>
</tr>
</tbody>
</table>

EXPERIMENTAL FACILITY

TOTAL EXPERIMENTAL AREAS: 10,000 m²
NO. INTERNAL TARGETS: 1
NO. EXTERNAL TARGETS: 1
NO. SEPARATED BEAMS: 2
NO. BEAMS SERVED AT SAME TIME: 2
TOTAL POWER USED (AVERAGE) FOR RESEARCH: 9.3 MW
NO. USER GROUPS, IN house: 12
TOTAL RESEARCH STAFF, in house: 220
ANN. RESEARCH STAFF, in house: 3 MlrbC/kg (without sal.)
ANNUAL RESEARCH TIME: 2,500 h

Other Relevant Parameters, Recent Improvements, etc.

*Emittance = Area x β at 90% of current
ACCELERATOR PERFORMANCE

**Electrons**
- ENERGY (GeV) 2
- ENERGY GAIN (MeV/m) 10.0
- Resolution (as %) 3
- REPET. RATE (pushback) 50/500
- PULSE WIDTH (μs) 3.5
- DUTY FACTOR, macroscopic (%) 0.011
- BEAM CURRENT (μA) 2
- BEAM EMITTANCE (μm-mrad) <0.15

**Positrons**
- ENERGY (GeV) 1.2
- ENERGY GAIN (MeV/m) 0.8
- REPET. RATE (pushback) 500/1000
- PULSE WIDTH (μs) 1.5
- DUTY FACTOR, macroscopic (%) 0.014
- BEAM CURRENT (μA) 0.02
- BEAM EMITTANCE (μm-mrad) <0.5

SECONDARY BEAMS

<table>
<thead>
<tr>
<th>Particle</th>
<th>Momentum range</th>
<th>No. of beams</th>
<th>Other inform.</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
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</table>

RESEARCH PROGRAMME

<table>
<thead>
<tr>
<th>TOTAL EXPERIMENTAL AREAS</th>
<th>800 m²</th>
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</thead>
<tbody>
<tr>
<td>No. INTERNAL TARGETS</td>
<td>1</td>
</tr>
<tr>
<td>No. EXTERNAL TARGETS</td>
<td>3</td>
</tr>
<tr>
<td>No. SEPARATE BEAMS</td>
<td>2</td>
</tr>
<tr>
<td>TOTAL POWER USED (AVERAGE)</td>
<td>1.0 MW</td>
</tr>
<tr>
<td>No. USER GROUPS, in-house</td>
<td>outside</td>
</tr>
<tr>
<td>TOTAL RESEARCH STAFF, in-house</td>
<td>outside</td>
</tr>
<tr>
<td>ANN. RESEARCH BUDGET, in-house (without salary)</td>
<td>3200</td>
</tr>
</tbody>
</table>