CERN 60-42
Proton Synchrotron Division
17th November, 1960

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

CERN PROTON SYNCHROTRON

Machine Group

OPERATION AND DEVELOPMENT

Quarterly report No. 3
July - September 1960

GENEVE
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Correspondence concerning this quarterly report should be addressed to the CPS Machine Group Editor

J. Gervaise
CERN PS
Genève 23 (Cern)
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This is the third quarterly report issued by the Machine Group of the CERN Proton Synchrotron. Amongst the interesting features of this third quarter one can mention:

(a) The slope of the "Flat-Top" can now be adjusted between $\pm 4 \text{ kG s}^{-1}$. Lengths up to 500 ms are available.

(b) The coupling between vertical and horizontal betatron oscillations has been cancelled by energizing skewed quadrupole windings.

(c) With optimum conditions for injection and beam control take-over a trapping efficiency of 70% could be obtained.

(d) Up to four simultaneous, independent secondary beams have been utilized and target sharing has been used for bubble chamber and counter experiments.

During the third quarter the total running hours amounted to 630 hours. Some 300 hours were given to Nuclear Physics compared to 180 for the second quarter and 95 for the first quarter.

CPS Machine Group
I. MACHINE STATUS

1. Linear accelerator.

This period from July - September saw the institution of a 39 1/2 hour continuous run for the Linac on Mondays and Tuesdays of each week. The new problems resulting were mainly organizational as this period was also the peak holiday period. The Linac itself functioned fairly reliably apart from the vacuum system, with currents of the order of 10 mA generally, a little lower than previously due to vagaries of the ion source. On one occasion 17 mA were injected into the synchrotron for a short test period.

Some study was made of the random variation of RF levels and phases during operation, and of their effects on the beam mean energy and energy spread. Under the worst conditions, with the Linac timing locked to the CPS magnet supply generator frequency instead of to the mains, the total RF voltage variation was about 6%, and this corresponded to an energy spread change from ±150 to ±200 keV. Random changes in phase caused negligible change in energy spread and mean energy.

Concerning the vacuum troubles mentioned above, the most persistent of these was caused by rust in the heat exchangers of the refrigerators which supply trichlorethylene at -30 and -80° C to the mercury pump baffles. It appears that this rust has been building up for some time, becoming dislodged and causing damage to the pump seals and subsequently, leaks. In addition, filters became blocked and air was drawn into the circulating trichlorethylene system, stopping the flow to the baffles which then shut themselves off automatically. These incidents reached a climax in the last week of operation before the September shut-down, when hundreds of litres of trichlorethylene were drawn off in purging air blockages, and the system could only be kept running with the aid of liquid nitrogen. Fortunately, very little beam was lost. During the shut-down the heat exchangers were opened up and cleaned, and attempts are being made to retard or prevent further corrosion in the future. Continuing the vacuum history, an ion gauge on the first tank was broken one morning while a pump shut-off valve was locked in the open position for repairs to the actuator, and both tank and pump were therefore let up to atmospheric pressure. Pumping was resumed as soon as possible and although the RF power had to be fed in rather gently because of accelerating gap breakdown, full power was restored in about eight hours. Fortunately, this occurred on a day reserved for machine
part testing.

The final vacuum incident occurred when air and presumably mercury leaked into the second tank through a faulty shut-off valve while the pump stack was at atmospheric pressure; this also required about a day before full RF power could be fed in. This time the incident cost about five hours of synchrotron operation.

During the September shut-down both tanks were opened up in order to find out what had been the effects of these incidents on the accelerating structures and in order to replace RF monitoring diodes. The tank I drift tubes were in fact in fairly good condition, apart from the first ten which were stained and pitted near the aperture. These marks were removed by means of liquid metal polish, and all of the drift tubes were carefully cleaned, finishing with alcohol.

Tank II drift tubes were more extensively pitted over the accelerating faces in all of the gaps, the effect diminishing towards the output. However the damage was very shallow and quite easily removed with metal polish. One was interested to observe two multipactor bands of spectral colours encircling the drift tubes.

At the end of the shut-down the Linac was started up again, breakdown and multipactoring in Tank I causing considerable beam pulse loss at the beginning, but by the time the beam was required for injection into the synchrotron, this loss had become quite small and was negligible the next day.

2. RF system.

a) Measurement of mean radial position of the beam.

A system has been developed to determine the radial position of the beam, averaged over the closed orbit, at different proton energies by measuring the bunch frequency.

The bunch frequency can be mixed with a quartz frequency equal to the correct bunch frequency on the ideal closed orbit (r = 100.00 m) and the difference frequency counted for an interval of 10.5 ms at the chosen energy. If the measurement is made at high energies when the bunch frequency ≈ 9.53 MHz the counter output in cycles will be equal to the radial displacement of the beam in mm, but the sign of the displacement will be unknown. To overcome this ambiguity the quartz frequency is made 1% higher, so that zero counter output corresponds to an inward displacement of 100 mm. Different
Fig. 1 RF accelerating gap, showing discoloration on glass insulator (See Machine Status - RF system).

Fig. 2 Main Control Room, with provisional control desk in the foreground.
quartzes will be available so that the counter can read directly at different energies.

The analogue output voltage of the counter will be distributed.

b) Accelerating units.

Difficulties have arisen with the glass cylinders which are sealed across the accelerating gaps in the metal vacuum pipe passing through each accelerating unit. After about 1000 hours of operation, brownish deposits can be seen on the inside surfaces of these glass cylinders (see Fig. 1). The deposits are mainly organic; by their consistency they appear to be a resinous substance which could well be polymerized oil. Traces of Fe, Cu, Si, Mg and Mo have also been detected by spectroscopic analysis.

These deposits may either decrease the surface conductivity of the glass or increase the dielectric losses. In either case the glass could fail. Cleaning the surfaces is difficult as they are very inaccessible and, furthermore, the deposits do not dissolve easily. A new method of construction, in which the glass section can be removed for cleaning, is being studied.

3. Magnet power supply.

The grid control equipment of the static converters has been modified in order to improve the "Flat-Top" operation. With the previous system the voltage of one set of static converters was inverted at the beginning, and the voltage of the second set at the end of the "Flat-Top". The desired magnet voltage was obtained by adjusting the voltage, i.e. the phase of ignition, of the set of static converters being in inversion. With the new system the voltage of both sets of static converters is reduced simultaneously at the beginning of the "Flat-Top" by the same amount to the desired value. The new system has the advantages of doubling the ripple frequency and improving the stability of the magnet voltage and hence of the magnet field during the "Flat-Top". The slope of the "Flat-Top" can now be varied from the Main Control Room between the limits ± 4 kG s⁻¹ when using the normal machine cycle (B = 12 kG, rise time 1s).

The single phase rectified DC premagnetization of the two interphase reactors has been replaced by two three phase systems. The high ripple of the previous system induced, in the period between two magnet cycles, a voltage in the interphase reactor which appeared as a distortion of the anode voltages.
This distortion brought two of the grid pulses into the positive part of the respective anode voltages and therefore small peaks appeared on the magnet voltage during the period in which the voltage should have been zero.

The corroded aluminium tube bundles of the magnet cooling heat exchangers have been replaced. One set of heat exchangers is now fitted with stainless steel tube bundles, the other with specially treated aluminium tube bundles.

The present jitter of about ±40 G in the peak magnet field (and hence the corresponding jitter in the peak proton energy) can be reduced by improving the mean speed regulation of the main converter set. Some preliminary work has been done on this problem.


The regulation of the pole face winding current has been adjusted for producing a constant field correction over the entire length of an experimental 500 ms "Flat-Top" at 12 kG. The field display system has been modified so that the slope of the "Flat-Top" may be measured.

5. Vacuum system.

The vacuum pumping stations have in general been working satisfactorily, but certain items have not functioned very well. This situation has been reviewed and improvements have been carried out or planned e.g. change of the mechanical centrifugal switches on the rotary pumps which are to be replaced by small dynamos.

Design work on the vacuum equipment for the ejection systems has continued in conjunction with the Propane Chamber and Engineering Groups.

6. Targets.

The fast target mentioned in Report No.2 has given the possibility of single pulse beam sharing between a track chamber and counter experiments. This target can cut through the circulating proton beam at speeds up to 35 m/s and it can produce low intensity bursts of duration as short as 250 μs. The original version of this target has now been modified for easier installation in the machine. Further studies are continuing.

A vertical line source target giving a long pulse (50 ms) on the
"Flat-Top" for counter experiments has been produced using a 0.5 mm square aluminium rod.

Several targets have been investigated for use with the long "Flat-Top" of 500 ms. The preliminary results are hopeful and the work is continuing.

The special target cable network came into operation and has been in use throughout the period under review.

A prototype target programme selector has been used for producing a test beam for investigation by a Wilson chamber team every fortieth machine pulse.

7. Controls.

Two closed loop television links have been installed so that the Main Control Room crew can check that only authorized people enter the ring when the appropriate door interlocks are suspended. The external fences round the machine and the South Experimental Area have been almost completed and the gates equipped with magnetic switches as position indicators.

Installation of the new door interlock control system (see Quarterly Report No. 2 - II/7) was finished at the end of the quarter. This system uses plug-in units and is considerably more flexible than the previous one. Testing facilities for the plug-in units are provided in the Main Control Room.

During the quarter, the air cooling system for the Main Control Room has been put into service. The fan and cooling coil units in the room are connected to the same chilled water line feeding the Counting Room. A third refrigerating machine has been added in parallel to the two existing ones.

The South Bubble Chamber Area has been equipped with telecommunications, timing signal boxes and circulating beam intensity meters as already provided for the Counting Room. Additional "call-in" telephones (direct lines to a loudspeaker in the Main Control Room) have been installed on the outer wall of the Ring and the existing ones modified for better performance.

The TV cameras and receivers have been slightly modified so that spare wires in the cable link can be used for intercommunication during setting up and for remote adjustment and switching of a lamp illuminating the camera field of view.

The installation of the boxes for the Beam Status Warning Lights,
to be operated either by push-buttons (or possibly automatically) from the Main Control Room, was completed in the Counting Room and in the Bubble Chamber Area. The investigation and preliminary design of the Control Desk to be installed in the Main Control Room was continued.

A transistorized version of the CPS Standard Blocking Oscillator (positive pulse 40 V - 1 µs) was designed and a prototype gave very satisfactory results in the laboratory. A first series of 20 units will be put on trial shortly.

The Machine Group documentation service was staffed and organized. The complete documentation of the 48 V DC supplies and distribution was prepared, also that of standard units such as the CPS double pulse generator.

8. Radiation measurements and security precautions.

There has been no significant increase in beam intensity during the period under review, and therefore no urgent requirements for surveys (or re-surveys) of normally occupied zones. Apart from one or two special measurements around experimental apparatus, attention has been mainly concentrated on the problem of the East Site Junction development. Further improvements and modifications continue to the operational procedures, notably in connection with security interlocks, and additions have been planned to the permanent monitoring installation.

a) Special Surveys.

The two bubble chambers so far employed with the CPS (30 cm liquid hydrogen and 1 metre propane) have used pion beams of 16 - 18 GeV/c and proton beams of 24 GeV/c. Normally, the number of particles entering such chambers (1 - 10 per burst) and the degree of collimation required is such that no health hazard would be expected. However, during preliminary setting-up larger and less well-defined beams are used, and moreover the concurrent operation of a counter burst target means that up to 100 times the usable number of particles actually pass into the bubble chambers. A series of measurements has therefore been made; up to the present it has not been necessary to introduce any serious restriction in the working region. Measurement of beam intensity with scintillation counters has been correlated reasonably well with ionization chamber results.
b) **East Site Junction.**

Construction of the junction between the Ring tunnel and the new East Experimental Area will begin early in 1961. It will entail stripping the outer earth shielding from the tunnel over a length of some 50 m, and subsequently contractors' men will have to work in close proximity to the wall of the Ring itself for a period of several months. This would be impossible during normal operation under present circumstances; indeed, it would certainly result in a high level of stray radiation over a considerable area of the CERN site. It is hoped, however, that by placing shielding material at strategic points within the Ring, external radiation levels can be sufficiently lowered so that operation can continue, perhaps at reduced intensity for part of the time. Since there is insufficient space to build up a continuous shielding wall of adequate thickness, a careful study is being made of the direction and intensity of the primary radiation flux in this region. The Emulsion Group are cooperating in this study, and have already devoted a considerable amount of time to scanning exposed plates. Measurements have also been made by Health Physics of the radiation penetrating the earth shielding with and without targets operating in this region. Taken in conjunction with preliminary results of a shielding experiment* using 25 GeV protons, these experiments have shown that a small amount of earth shielding (about 2 m radially) can already be removed providing that no target is working in the vicinity.

c) **Security Precautions.**

As mentioned elsewhere (Section 7), the new and more flexible control system for interlocked doors has been installed and will be brought into service in the next quarter. This will enable new, and temporary, safety barriers to be readily connected into the system, and now that more experience has been gained of experimental conditions it is planned to introduce interlocked gates and doors into the external beam zone, on a trial basis. The major part of the earth embankment over the machine will also be closed in future.

d) **Permanent Monitoring Network.**

The monitoring equipment (using tissue-equivalent chambers) at present in service having proved satisfactory and reliable, a further order has been placed with the same manufacturer. Certain modifications will be made to the new instruments, in particular to allow the use of channels of increased

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* Citron, A., Hoffmann, L. et al - to be reported elsewhere.
sensivity. A study has been made of monitoring requirements for the East Site Junction problem (see above) and orders for supplementary equipment to cover this are being placed.


a) Injection behaviour.

The extra skewed quadrupole windings for cancelling the coupling between vertical and horizontal betatron oscillations were added to the octupole lenses during the June shut-down. On test they have performed very satisfactorily: when excited to about the predicted current, the imaging of a point source round a complete turn was very nearly anastigmatic, and when some small difference in wavelength (q) was introduced by the normal machine quadrupoles, the line images were now horizontal and vertical rather than at ± 45°. With the spiralling beam, the normal modes of oscillation produced by offsetting inflection controls were now horizontal and vertical, each type of pick-up electrode showing independent oscillations, which were excited only by the relevant steering magnet etc. on the inflected beam.

The result is that small corrections to these controls can now be made during operation, without stopping the machine, and that the setting-up procedure is simplified.

b) Q values at various energies.

The measurements of betatron frequencies (Q_R, Q_V) with the RF knock-out have been extended with the bringing into use of a vertical knock-out system, which uses an electric field rather than magnetic (taking advantage of the proportions of the vacuum chamber to make an economical electrode structure). The measurements, taken at several radial displacements of the beam at each energy, show that at medium field levels Q_R and Q_V are nearly equal, changing with radius, and therefore relative momentum, in about the expected way. At higher fields, Q_R variations become much larger, pointing to a sextupole type field error in the magnet which is not properly compensated by the pole-face windings as at present set up. Some increase in the p.f.w. excitation should reduce the Q vs r variation. This at the moment is so large at high fields that a beam displaced about 3 cm outwards gets close to the Q_R = 6 resonance so that the closed orbit distortion reaches the chamber wall at
some points round the machine.

c) Acceleration behaviour.

The trapping behaviour with early beam control take-over was investigated in some detail, because efficiencies as high as 70% were found when the machine was restarted after the June shut-down. The optimum conditions found were with the beam control take-over time during the fourth revolution, and with the frequency prior to this set about 0.7% too high. The high trapping efficiency was measured in two ways: first, by comparing in a pick-up electrode signal the height of the first revolution pulse with the baseline shift of the bunched beam waveform at, say, 1 ms, and second, by the measured current at injection and at high energies. Resonable agreement was found between the results.

The explanation of this unexpected, and welcome, behaviour was given by K. Johnsen, and confirmed by digital computer results. The effect of the offset radio-frequency during the first four revolutions is to bunch the protons with an energy spread less than the trapping width, instead of about 50% greater, which is the case if the frequency is correct. Thus when beam control is switched on and the phase of the RF system adjusts itself so that the maximum number of protons are within the stable phase limits, they are also within an energy range small enough to be held, and efficiencies of 85% should be possible if the energy spread in the initial beam is also small. This latter property should be ensured when the debuncher is brought into operation in the Linac.

Further studies of the low current limit in the machine, with a re-arrangement of the beam control switching circuits and of pick-up station sensitivities, now make it possible to accelerate from $10^8$ to $3 \times 10^{11}$ protons, without critical adjustments.

An extra phase shifter in the beam control, programmed with a voltage proportional to $\hat{B}$, has made it possible to hold the beam safely trapped during the flat top target period, and then to decelerate it down to transition energy; this can avoid background from unused beam in some critical experiments.

d) Target measurements.

Various new shapes of targets have been tried, to suit the need for better spot geometry and for longer counter bursts. An aluminium wire, $\frac{1}{2}$ mm
square in section will absorb the beam as well as the normal foil target placed on the outside of the beam, giving a very narrow source and a burst length of 20-40 ms. With a long flat top to the magnet cycle, both the foil and the wire target will give burst lengths up to 100 ms long as the rate at which the beam drifts onto the target is reduced, but the operation tends to become critical for longer burst times. The longest bursts, up to $\frac{1}{2}$ second, have been obtained with a thin, nearly horizontal wire target, onto the end of which the beam drifts slowly. This shape gives nearly a point source if the wire is aligned along the secondary beam direction.

Measurements on the "fast flip" wire target used for producing short bursts for bubble chamber beams showed a burst of 200-400 $\mu$s length, in agreement with the known diameter of the beam and the wire velocity, and with about the calculated absorption of the beam viz. 0.7% for a Copper Beryllium strip 0.1 mm thick and mean width 0.4 mm intercepting about 1/4 of the beam cross-section.

These measurements require a reliable monitor of burst shape, and comparisons have been made between single scintillator and Čerenkov counters with different integrating time constants. As had been suspected the scintillation counters were found to give a rather longer and more favourably shaped burst, but it is assumed that the Čerenkov counter's sensitivity only to particles with $\beta > 0.7$ makes its signals a truer indication of burst shape.

Preliminary measurements comparing the shape of the integrated target burst with the way in which the proton beam diminishes show that, roughly, target efficiency is the same throughout the burst time, and so probably, rather near to unity as other losses of protons from the beam should be very small at the beginning of the burst.
II. MACHINE OPERATION
(July 2 – October 2)

In the new operating schedule, started on July 18th, the weekly available time was divided as follows:

a) Tests on parts of the machine and setting-up : 18.0 hours
b) Technical developments and operational training : 15.5 hours
c) Nuclear physics experiments : 30.5 hours

Nuclear physicists were also able to "parasite" on external beams available during 6.5 hours of Technical development time.

The peak accelerated beam intensity was $3.2 \times 10^{11}$ protons/pulse. The average, generally higher than $1.5 \times 10^{11}$ protons/pulse.

The "administration" was also revised with the adoption of the new General Log Sheet and the introduction of a standard form of detailed daily instructions to the Operating Staff.
STATISTICS of PS OPERATION

Third Quarter
July 4 - September 30

QUARTERLY TOTALS

- Time for part tests and setting up
- Time for Technical Developments (includes hours 50 MeV operations)
- Time for Nuclear Physics
- Total time for operation, maintenance, and installation.

* 1 day holiday
** 2 days - shut down
DISTRIBUTION OF MACHINE ACCELERATION TIME

<table>
<thead>
<tr>
<th>WEEK BEGINNING</th>
<th>Total acceleration time (hours)</th>
</tr>
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<tr>
<td>4 July</td>
<td>28.7</td>
</tr>
<tr>
<td>11 July</td>
<td>33.3</td>
</tr>
<tr>
<td>18 July</td>
<td>46.4</td>
</tr>
<tr>
<td>25 July</td>
<td>45.4</td>
</tr>
<tr>
<td>1 August</td>
<td>46.3</td>
</tr>
<tr>
<td>8 August</td>
<td>46.1</td>
</tr>
<tr>
<td>15 August</td>
<td>37.0</td>
</tr>
<tr>
<td>22 August</td>
<td>46.0</td>
</tr>
<tr>
<td>29 August</td>
<td>46.0</td>
</tr>
<tr>
<td>5 September</td>
<td>46.2</td>
</tr>
<tr>
<td>12 September</td>
<td>35.0</td>
</tr>
<tr>
<td>19 September</td>
<td></td>
</tr>
<tr>
<td>26 September</td>
<td>SHUT DOWN</td>
</tr>
<tr>
<td>QUARTERLY TOTALS</td>
<td>77%</td>
</tr>
<tr>
<td></td>
<td>12%</td>
</tr>
<tr>
<td></td>
<td>6%</td>
</tr>
<tr>
<td></td>
<td>456.4</td>
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</tbody>
</table>

- Actual accelerated beam time
- Setting up time for external beams
- Interruptions requested by users
- "Off" time due to components failure
III. EXPERIMENTS

During the period considered, a substantial number of the new beam transport magnets have become available: a total of nine new bending magnets (five 2 m long and four 1 m long) have been used in addition to two provisional bending magnets already used earlier in the year. Four new focusing quadrupoles (1 m long) have been utilized in addition to two smaller units on loan from the Synchro-cyclotron Division.

Eight new generators (six of 200 V, 800 A and two of 400 V, 800 A) have been used in addition to the ones quoted in previous reports; moreover, two provisional generators (60 V, 400 A non-stabilized) have also been used. Extensive use has been made of the new d.c. cabling and distribution system, whereas all magnets have still been cooled with the unpurified water mains. The magnets of the bubble chambers have been energized via the cable link from the Synchro-cyclotron building.

A maximum of four simultaneous, independent beams have been utilized (see below-Counter Teams No. 1, 2, 3 and 4) and target sharing has been used in connection with bubble chambers and counter experiments.

The following is a summary of the time allocated to the various groups; no attempt is made here to describe the experiments themselves.

### A. Counter Teams

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<th>Beam</th>
<th>Scheduled Time</th>
<th>Programme and Techniques used</th>
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<td>1. G. Bernardini</td>
<td>Neutral, 3°</td>
<td>107 hours and several runs as parasites</td>
<td>Exploration of neutral beam (γ rays and neutrons); preliminary study of Compton effect using two lead glass Čerenkov counters.</td>
</tr>
<tr>
<td>W. Middelkoop</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2. G. Cocconi</td>
<td>Scattered protons, 10 to 28 GeV, momentum analysed</td>
<td>24 hours and several runs as parasites</td>
<td>Cross-section measurements of protons on hydrogen and several other elements at different energies.</td>
</tr>
<tr>
<td>3. G. von Dardel</td>
<td>Charged, 6°, 5 to 11 GeV/c Positive, 3°, 3 to 18 GeV/c</td>
<td>30 hours and several runs as parasites. Use of liquid hydrogen target for a total of 90 hours</td>
<td>Exploration of charged beams by means of a gas Čerenkov counter. Cross-section measurements of p $\bar{p}$, K$^+$ K$^-$, $\pi^+$ $\pi^-$ on H$_2$ (100 liquid hydrogen target).</td>
</tr>
</tbody>
</table>
4. A. Lundby  
Charged, 8.5°, 0 to 10 GeV/c  
Several runs as parasites or in parallel with teams No 1, 2 and 3  
Investigation of beam composition using scintillation and Čerenkov counters.

5. B.D. Hyams  
Negative muons, 0°, 12 GeV/c  
30 hours and several runs as parasites  
Preparation for an experiment on scattering of polarized muons on electrons, using scintillation counters.

6. A. Faissner  
W. Love  
Background surveys in view of the neutrino experiment.

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<th>B. Bubble Chambers</th>
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<td>7. C. Peyrou</td>
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<td>Scattered protons, 24 GeV, momentum analysed.</td>
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<tr>
<td>30 hours continuous run with hydrogen.</td>
</tr>
<tr>
<td>15 hours and several runs as parasites for beam setting-up</td>
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<tr>
<td>30 cm liquid hydrogen chamber. Exploratory run in preparation for a longer run.</td>
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<td>1 m propane chamber. Exploratory runs in preparation for a longer run.</td>
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<td>8. A. Lagarrique</td>
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<tr>
<td>(Ecole Polytechnique, Paris)</td>
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<tr>
<td>C.A. Ramm</td>
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<tr>
<td>Scattered protons, 24 GeV, momentum analysed.</td>
</tr>
<tr>
<td>30 hours continuous run.</td>
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<tr>
<td>16 hours and several runs as parasites for beam setting-up</td>
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<tr>
<td>20 cm freon (CF₂Br) chamber. Measurement of relativistic increase of bubble density in freon. Assistance to teams No. 7 and 8 to set up their beams. Run in parallel with propane chamber. Investigation of background for the neutrino experiment.</td>
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<table>
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<tr>
<th>C. Wilson Chamber</th>
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<tr>
<td>9. B. Hahn</td>
</tr>
<tr>
<td>(Université de Fribourg, Switzerland)</td>
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<tr>
<td>Scattered protons, 24 GeV, momentum analysed.</td>
</tr>
<tr>
<td>Several runs in conjunction with teams No. 7 and 8. 30 hours continuous run in parallel with team No. 8</td>
</tr>
</tbody>
</table>

| 10. B. Hahn  |
| F. Krienen.  |
| R. Salmeron  |
| J. Steinberger  |
| Background study  |
| 6 hours and some parasiting  |
| Investigation of background using the 20 cm freon bubble chamber in view of the neutrino experiment.  |

| 11. F. Preiswerk |
| Scattered protons, 24 GeV, momentum analysed  |
| Some parasiting  |
| Investigation by means of counters of time-dependent background in preparation for use of the 400 l Wilson Chamber.  |
D. Emulsions

12. W. Gibson
   W. Lock

In co-operation with the Universities of Amsterdam, Bari,
Berkeley, Bern, Bombay, Bristol, Clermont-Ferrand, Copenhagen,
Illinois, Lausanne, U.C. London, Milan, Moscow, Oxford,
Stockholm, Strasbourg, Tokio, Warsaw:

Investigation of composition of secondary beams, exposures to scattered proton beam, measurements of shielding efficiency, background measurements.

Scheduled time: 5 hours. In total 8 sessions of exposures took place, two of them involving a large number of stacks for CERN and the institutes listed above. Details as follows:

a. Scattered proton beam (8 to 28 GeV) 2
b. Do., momentum analysed, 24 GeV 1
c. Shielding efficiency, scattered proton beam 25 GeV. In co-operation with A. Citron and the Hamburg Electron Synchrotron Group (DESY) 2
d. Momentum analysed beams (18 GeV/c, π- and others) 2
e. Background survey 1

E. Radio-chemistry

13. G. Rudstam
    K. Goebel

Five 1/4-hour exposures of targets to the internal proton beam.

F. Radiation survey

14. B. Wheatley
    P. Guillot

Several runs as parasites General and special surveys around the PS and its experimental areas in co-operation with the Machine Group.