Status Report

Gran Sasso detector
Emulsion Scanning
Sensitivity to oscillations
Installation and Schedule
Conclusions

Focus is on new developments
COLLABORATION

34 groups
~ 160 physicists

Groups having joined after the Proposal are underlined

Belgium
IIHE(ULB-VUB) Brussels

China
IHEP Beijing, Shandong

CERN

Croa[cia
Zagreb

France
LAPP Annecy, IPNL Lyon, LAL Orsay, IRES Strasbourg

Germany
Berlin, Hagen, Hamburg, Münster, Rostock

Israel
Technion Haifa

Italy
Bari, Bologna, LNF Frascati, LNGS, Naples, Padova, Rome, Salerno

Japan
Aichi, Toho, Kobe, Nagoya, Utsunomiya

Russia
INR Moscow, ITEP Moscow, JINR Dubna

Switzerland
Bern, Neuchâtel

Turkey
METU Ankara
To identify τ leptons, “see” their decays at the mm scale

The challenge

ν oscillation → massive target  AND  τ decay → micron resolution

Lead – nuclear emulsion sandwich

“Emulsion Cloud Chamber”
The detector at Gran Sasso
(modular structure, three “supermodules”)

\( \nu \) target and \( \tau \) decay detector

Each “supermodule” is
a sequence of 24 “modules” consisting of
- a “wall” of Pb/emulsion “bricks”
- two planes of orthogonal scintillator strips

\( \nu \) spectrometer
Magnetised Iron Dipoles
Drift tubes and RPCs

\( \text{brick wall} \)
\( \text{scintillator strips} \)

235,000 bricks
Status of the experiment

Since the Proposal

- Full scale prototypes to finalise the detector design
- Progress in automatic scanning
- Studies of detection efficiency and backgrounds
- Sensitivity estimates updated with Super-K results
- Organisation structure for detector construction

Now: a “phase transition”
from studies and tests to construction
with related major investments of financial and human resources
Gran Sasso Detector
Ten small batch productions and one large production of emulsion films by Fuji Co.

“Emulsion Refreshing” tests
Satisfactory

Test of the complete cycle from emulsion production to readout
(refresh – transport – brick assembly – beam exposure – development - read-out)
Currently being analysed
Emulsion “refreshing”

At production

*Latent micro-track images (cosmic rays, ambient radioactivity)*

→ interference with e-shower measurements

Emulsion refreshing

*Tested at Nagoya*

A few days at ~30 °C and ~ 95% humidity

→ reduction of recognised micro-tracks by a factor ~100

In the Proposal: refreshing at Gran Sasso

*Limited underground space in relation to the large number of emulsion films (~14 million)*

Now being considered:

• *Refreshing in a Japan mine* (~ 100 m water equivalent depth)

• *Transportation of packed bricks* (without lead)

• *In the analysis: “virtual erasing” of micro-tracks recorded during transportation*
“Virtual erasing” of background tracks recorded during transportation

**Transportation**
Emulsions packed (without lead)

**Exposure**
Micro-tracks recorded during transportation appear as staggered

**Analysis**
“virtual erasing” of micro-tracks connected in the configuration without lead

Established technique in CHORUS
(for periods with different emulsion alignment)
Brick production and handling

Components
- Emulsion - 36 ton
- Lead – 2 kton
- “Origami” paper - 20,000 m²

Fill the brick walls (BMS)
235,000 bricks

Extract bricks after ν interactions
~ 40 bricks/day

Packing into bricks (BAM)

Pb-emulsion stacking

Brick packing
The Brick Assembly Machine (BAM)

27 million lead plates + emulsion sheets

A “factory” with high quality requirements

1) Stack lead plates and emulsion sheets
2) “Origami” vacuum packing and welding
3) Vacuum quality control

235,000 bricks at a rate of ~ 2 bricks/minute

Specifications formulated
Contacts with several industries ongoing
Market survey launched by CERN
Prototype packing system in October at Nagoya
The Stacking Section of the BAM
(as proposed by a firm)

- "Origami" packing and welding
- Paper box forming
- Spacer storage (last cell in brick)
- Emulsion storage
- Lead plates alignment
- Paper box closing
- Lead plates incoming in metal boxes
- Paper storage

Typical industrial production
In addition high quality requirements

~ 20 m in total
Schematics of brick vacuum control

Vacuum must be maintained for several years! Vacuum quality control is an important additional step in brick assembly.

Collaboration with industry
He-penetration tests in progress
Specifications in November

Bricks from the BAM

He pressure

ventilation

He in the brick?

Mass Spectrometer

Accept or reject

vacuum
The Brick Manipulator System (BMS)

Design
Carousel model
Brick sliding tests → “skates”
Brick insertion and retrieval tests
Position sensors and automation
Full scale – reduced size model in construction
Collaboration with industry
Final project definition in November
Support structure of the brick walls

Suspension from the top

Wall loading test

Brick loading test

Bricks inserted from the side

Tensioning from the bottom

Tests of full scale wall prototypes and components (Frascati and Naples)
Target Tracker: plastic scintillators

Full scale prototype module
(constructed at IReS Strasbourg)

• 64 strips of 6.7 m length, 2.6 cm width, 1 cm thickness
• readout by wavelength shifting optical fibres

Milestones achieved

✓ “Full size 64-strip module prototype with industrially produced scintillator” March 2001
✓ “Finalise design” July 2001
Light output

Pol.Hi.Tech
- full length extruded scintillator strips
- normal atmosphere replacing POPOP by BDB
- POPOP under inert atmosphere

Amcrys-H (Kharkov)
- extrusion tests of 2 m scintillator strips
- tests with full length fibres

> 5 p.e. / readout end
*(in the middle, worst case for two-end readout)*
Target Tracker construction

- Baseline option: plastic scintillators
  - Milestones achieved
  - Contacts with industry for assembly of full modules
- Soon final decision

Other options investigated: liquid scintillator and RPCs
- Extensive studies, tests, contacts with industry (see Status Report)
- Capability of mass production within schedule must be ensured
Dipolar spectrometer magnet
(RPCs inside gaps for muon identification)

Full scale prototype of magnet section constructed and tested at Frascati

Iron in tendering-ordering phase

Total weight ~ 1 kton
Drift tube spectrometer trackers
(muon momentum measurement)

Tests of 8.1 m tubes
- Wire stability
- Attenuation length

Overall Assembly
- Study of optimal staggering
- Mechanical design
- Negotiations for mass production
- Production of prototype (1 m) module started

End Caps
- Design and tests
- Negotiations for mass production

Electronics
- Design and tests
Emulsion scanning
From the CNGS to physics: where work is done
The new concept for the S-UTS mechanics
*(take images without stopping the stage)*

**Objective and stage movements synchronised**

*Emulsions are scanned vertically, in their reference frame*
Prototype of piezo-controlled objective lens
Achieved fluctuation of the stage movement < 0.5%

Synchronization tests completed

Real DAQ
using current CCD + UTS electronics
in September

Fast CCD + S-UTS electronics $\rightarrow$ 20 cm²/hour
March 2002

Mechanics: the critical R&D

Tests with films
The Emulsion Scanning Facility in Nagoya University

Ready to allocate the new S-UTS fast scanning systems for OPERA
Design philosophy

*Commercial components (in continuous development)*

Software approach

With present technology

10 cm²/hour already feasible

Aim*

20 cm²/hour

* e.g. by new CC or CMOS sensors

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“Sysal” system operating in Salerno
R&D by Italian and other European laboratories

New automated microscope (Naples)

**Large field of view**

(350 x 350 µm²)

No oil-immersion objectives

New small and fast stages

(change of view in ~80 ms)

1 Mpixel CCD camera

(60 frames/sec)

Parallel image processing
Plan for a Scanning Station in Europe

- The Scanning Station takes the heaviest scanning load:
  - vertex location

- A Scanning Station planned in Italy as an European facility:
  - 15 bricks/day with 24 hours/day scanning (~40 extracted daily)
  - about 13 automatic microscopes (scanning speed 20 cm²/hour)
  - Physicists and operating crew working on shifts
  - Technical support, hardware/software experts
  - About 200 m² laboratory space

- Emulsions sent to Collaboration laboratories for:
  - selection of events with decay topology
  - precision measurements on candidate events
Sharing of responsibilities
(see Status Report)

**TARGET**

**Bricks**
- emulsion films
- film refreshing
- lead plates
- brick packing paper
- brick holders
- spacers (downstream cells)
- brick assembly machine
- brick assembly
- wall support structure
- brick handling machine
- brick installation

**Emulsion facilities**
- cosmic-ray alignment
- film development
- emulsion packing
- additional contributors to bricks and emulsion facilities

**Trackers (baseline option)**
- scintillator modules
- photo-detectors
- read-out electronics
- plane assembly
- calibration system
- responsibilities to be defined

**MUON TAGGING AND MOMENTUM MEASUREMENT**

**Magnets**
- yokes
- coils
- power supplies

**Inner detectors and XPCs**
- RPCs and XPCs, strips, power supplies
- gas system
- read-out electronics

**Precision trackers**
- drift tubes, gas, power supplies
- read-out electronics

**Veto system and beam monitoring**

**Overall support structure**

**ALIGNMENT AND SURVEY**

**DAQ AND SLOW CONTROL**

**EMULSION READ-OUT (ONLINE)**

Nagoya
- Nagoya, Salerno
- CERN, INR, Münster
- INFN
  - Annecy for R&D
  - Nagoya for R&D
- CERN; Nagoya and Naples for R&D
- Collaboration
  - Frascati, Naples
  - Annecy
  - Collaboration

Rome; Bologna, Nagoya and Kobe for R&D
- Salerno, Nagoya for R&D, Bari and Rome for infrastructure
- Nagoya for R&D
- Aichi, Ankara, Beijing, Bologna, Israel, Kobe, Toho, Tsinan, Utsunomiya

Bern, Brussels, CERN, Lyon, Strasbourg
- Bern, Brussels, Lyon, Strasburg
- Bern, Brussels, Lyon, Orsay
- Bern, Brussels, CERN, Lyon, Strasbourg
- Bern, Brussels, CERN, Lyon, Strasbourg
- Israel, ITEP, JINR Dubna, Neuchatel, Zagreb

Frascati
- Frascati
- to be defined

CERN, Frascati, INR, LNGS, Padova, Zagreb
- Frascati, Padova
- CERN, Frascati, Padova

Hamburg, ITEP
- Hagen, Münster, Rostock
- INR, LNGS, Zagreb
- Frascati, Naples

to be defined
- Lyon, Strasbourg

CERN, France, Germany, Italy, Japan, Switzerland
Sensitivity to oscillations
Latest results from Super-Kamiokande and K2K
(Lepton-Photon Conference 2001)

- $\nu_\mu$ disappearance in Super-K
  
  $1.2 < \Delta m^2 < 5.4 \times 10^{-3}$ eV$^2$ at 90% CL
  
  $V_\mu - V_\tau$
  
  | $V_\mu$ | 1.0 | 7.0 | 99% |
  | $\Delta m^2$ | 2.4 $\times$ 10$^{-3}$ eV$^2$ |

  Best fit $\Delta m^2 = 2.4 \times 10^{-3}$ eV$^2$

  Sterile $\nu$ disfavoured at ~ 99%

- $\nu_\mu$ disappearance in K2K
  
  Expected (no osc.) 63.9 + 6.1 - 6.6
  
  Detected 44 (~ 2$\sigma$ effect)

  Oscillation dip in the $E_\nu$ spectrum at $\Delta m^2 \sim 3 \times 10^{-3}$ eV$^2$?

- $\nu_\tau$ appearance in Super-K
  
  Poor S/B ratio ~ 0.7%, statistical significance ~ 2$\sigma$
Improvements in the event simulation and reconstruction

- **Event generator**
  - Tuned on NOMAD data
  - Simulation of re-interactions within the lead nucleus → increased multiplicity of secondaries
  → softening of the momentum spectrum

- **Tracking by the electronic detectors**
  Use of Kalman filter techniques
  → *improved angular resolution* for the $\mu$ track: $40 \rightarrow 20$ mrad

- **Muon identification**
  Matching the muon track in the electronic detectors to the reconstructed tracks in the emulsions
Neutrino interactions

Nominal $\nu$ beam (Nov. 2000)

Shared SPS operation

200 days/year

$4.5 \times 10^{19}$ pot / year

5 year run

1.8 kton average target mass

(accounting for mass reduction with time, due to brick removal for analysis)

Expected interactions

$\sim 33000 \, \nu_\mu \text{ NC+CC}$

$\sim 120 \, \nu_\tau \text{ CC}$

at $\Delta m^2 = 2.4 \times 10^{-3} \text{ eV}^2$ and full mixing

Possible increase in SPS proton intensity for LHC not considered here
Exploited $\tau$ decay channels

- **“Long” decays**
  - Kink angle $\theta_{\text{kink}} > 20$ mrad
    - $\tau \rightarrow e$  Progr. Rep. 1999
    - $\tau \rightarrow \mu$  Progr. Rep. 1999
    - $\tau \rightarrow h (n\pi^0)$  Proposal 2000
    - + $\rho$ search  **2001**

- **“Short” decays**
  - Impact parameter I.P. $> 5$ to 20 $\mu$m
    - $\tau \rightarrow e$  Proposal 2000
    - $\tau \rightarrow \mu$  **2001**
Pointing accuracy to the vertex of e-pairs from $\gamma$ conversions

*Studied in CHORUS and DONUT by NetScan*

($\frac{1}{2} X_0$ depth in ECC)

**Important for increasing the sensitivity to** $\tau \rightarrow h \, n \pi^0$
Hadronic long decays:
higher efficiency for $\tau \rightarrow \rho \rightarrow \pi^- \pi^0$ with vertex assignment to $\gamma$s

- B.R. = 25.4% (49.5% for full $\tau \rightarrow h$)

- $\gamma$s assigned to primary or to decay vertex depending on Impact Parameter

- **if a $\gamma$ is assigned to the decay vertex**
  - $\rightarrow$ improved $p_t$ decay resolution (charged+neutral)
  - $\rightarrow$ looser cut and higher efficiency

- Improved missing $p_t$ resolution

- Probability for a hadron interaction to give a $\gamma$ pointing to a decay vertex $O(1\%)$
  - $\rightarrow$ no additional background

**Efficiency for $\tau \rightarrow h$ long decays:** 2.3 $\rightarrow$ 2.9 %

(including a 10% reduction in the brick finding efficiency and a 20% reduction due the inclusion of nuclear reinteractions in the event generator)
Muonic short decays by Impact Parameter

Main background
• charmed particle decay vertex mistaken as primary vertex
• $\mu$ from $\nu_\mu$ CC faking $\tau \rightarrow \mu$ because of its large IP

Event selection
• Reconstruct the invariant mass $M$ of the particles assigned to the vertex defined as primary ($\geq 2$ tracks)
• With 50% mass resolution and $M > 3$ GeV/$c^2$ cut only 0.2% of the charm background survives

Contribution to $\tau$ detection efficiency x BR : 0.7 %
### Summary of τ detection efficiencies

(in % and including BR)

<table>
<thead>
<tr>
<th>Channel</th>
<th>DIS long</th>
<th>QE long</th>
<th>DIS short</th>
<th>Overall*</th>
</tr>
</thead>
<tbody>
<tr>
<td>τ → e</td>
<td>2.7</td>
<td>2.3</td>
<td>1.3</td>
<td>3.4</td>
</tr>
<tr>
<td>τ → μ</td>
<td>2.4</td>
<td>2.5</td>
<td>0.7</td>
<td>2.8</td>
</tr>
<tr>
<td>τ → h</td>
<td>2.8</td>
<td>3.5</td>
<td>-</td>
<td>2.9</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>8.0</strong></td>
<td><strong>8.3</strong></td>
<td><strong>1.3</strong></td>
<td><strong>9.1 (8.7)</strong></td>
</tr>
</tbody>
</table>

* weighted sum of DIS and QE events

Efficiency given in the Proposal

Channels considered at the time of the CNGS approval in 1999:

- τ → e (DIS+QE, long) 3.0
- τ → μ (DIS+QE, long) 2.6

**Overall efficiency** ε = 5.6
Progress in understanding backgrounds

- **Large angle \( \mu \) scattering:** dedicated experiment at the CERN-PS
  - Pure \( \mu \) beam (2 m Fe dump)
  - \( \sigma(\theta) \sim 2 \text{mrad}, \sigma(p) \sim 0.06*p \)
  - Preliminary result: \( 0.6^{+0.7}_{-0.6} \times 10^{-5} N_{\mu} \)
    - consistent with Proposal’s estimate (1.0 x 10^{-5})

- **Backgrounds to \( \tau \rightarrow \mu \) long decays from re-interacting hadrons**
  (anticipated but not yet estimated in the Proposal)
  - \( \nu_{\mu} \) NC interactions with a hadron misidentified as a muon (6% probability) and matched to a track in emulsions
    - \( 4.4 \times 10^{-6} \times N\nu_{\mu} \) CC DIS events
  - \( \nu_{\mu} \) CC interactions with an identified \( \mu \) mismatched (2% probability) to a hadron in the emulsions
    - \( 2.6 \times 10^{-6} \times N\nu_{\mu} \) CC DIS events
### Expected background

(5 year run with 1.8kton average target mass)

<table>
<thead>
<tr>
<th>Decay Type</th>
<th>$\tau \rightarrow e$</th>
<th>$\tau \rightarrow \mu$</th>
<th>$\tau \rightarrow h$</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Charm production</strong></td>
<td>0.14</td>
<td>0.03</td>
<td>0.14</td>
<td>0.31</td>
</tr>
<tr>
<td>$\nu_e$ CC and $\pi^0$</td>
<td>0.01</td>
<td>-</td>
<td>-</td>
<td>0.01</td>
</tr>
<tr>
<td><strong>Large angle $\mu$ scattering</strong></td>
<td>-</td>
<td>0.10</td>
<td>-</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Hadron reinteractions</strong></td>
<td>-</td>
<td>-</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>$\nu_\mu$ CC</td>
<td></td>
<td></td>
<td>0.06</td>
<td>0.06</td>
</tr>
<tr>
<td>$\nu_\mu$ NC</td>
<td></td>
<td></td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0.15</td>
<td>0.29</td>
<td>0.24</td>
<td>0.67</td>
</tr>
</tbody>
</table>

### Short Decays

<table>
<thead>
<tr>
<th>Decay Type</th>
<th>$\nu_e$ CC and $\pi^0$</th>
<th>$\nu_\mu$ CC</th>
<th>$\nu_\mu$ NC</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Charm production</strong></td>
<td>0.03</td>
<td>0.02</td>
<td>-</td>
<td>0.05</td>
</tr>
<tr>
<td><strong>Large angle $\mu$ scattering</strong></td>
<td>-</td>
<td>0.02</td>
<td>-</td>
<td>0.02</td>
</tr>
<tr>
<td>$\nu_e$ CC and $\pi^0$</td>
<td>$\ll 0.01$</td>
<td>-</td>
<td>-</td>
<td>$\ll 0.01$</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>0.03</td>
<td>0.04</td>
<td>-</td>
<td>0.07</td>
</tr>
</tbody>
</table>

**Total**                                      | 0.18                   | 0.33         | 0.24         | 0.75   |

New estimates

0.57 in the Proposal
Full mixing, Super-Kamiokande best fit and 90% CL limits
as presented at the 2001 Lepton Photon Conference
(update with respect to the EPS 2001 results taken for the written Status Report)

<table>
<thead>
<tr>
<th>Decay mode</th>
<th>Signal $1.2 \times 10^{-3}$</th>
<th>Signal $2.4 \times 10^{-3}$</th>
<th>Signal $5.4 \times 10^{-3}$</th>
<th>Bkgnd.</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\tau \rightarrow e$ long</td>
<td>0.8</td>
<td>3.1</td>
<td>15.4</td>
<td>0.15</td>
</tr>
<tr>
<td>$\tau \rightarrow \mu$ long</td>
<td>0.7</td>
<td>2.9</td>
<td>14.5</td>
<td>0.29</td>
</tr>
<tr>
<td>$\tau \rightarrow h$ long</td>
<td>0.9</td>
<td>3.4</td>
<td>16.8</td>
<td>0.24</td>
</tr>
<tr>
<td>$\tau \rightarrow e$ short</td>
<td>0.2</td>
<td>0.9</td>
<td>4.5</td>
<td>0.03</td>
</tr>
<tr>
<td>$\tau \rightarrow \mu$ short</td>
<td>0.1</td>
<td>0.5</td>
<td>2.3</td>
<td>0.04</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>2.7</strong></td>
<td><strong>10.8</strong></td>
<td><strong>53.5</strong></td>
<td><strong>0.75</strong></td>
</tr>
</tbody>
</table>

**In the Proposal:**

| $\Delta m^2$ | 1.5 x $10^{-3}$ | 3.2 x $10^{-3}$ | 5.0 x $10^{-3}$ |
| events | 4.1 | 18.3 | 44.1 | 0.57 |
Exclusion plot in the absence of a signal
(5 year run with 1.8 kton average target mass)

$\Delta m^2 < 1.2 \times 10^{-3} \text{ eV}^2$
at full mixing

$\sin^2 (2\theta) < 5.7 \times 10^{-3}$
at large $\Delta m^2$

90% CL upper limit obtained on average by a large ensemble of experiments

Uncertainties on background (±33%) and on efficiencies (±15%) accounted for here and in the following
Probability of $\geq n\sigma$ significance

Schematic view of the Super-K allowed region

- Simulate a large number of experiments with oscillation parameters generated according to the Super-K probability distribution
- $N_{4\sigma}$ events are required for a discovery at $4\sigma$
- Evaluate the fraction $P_{4\sigma}$ of experiments observing $\geq N_{4\sigma}$ events

<table>
<thead>
<tr>
<th>Run</th>
<th>$P_{3\sigma}$ (%)</th>
<th>$P_{4\sigma}$ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 y</td>
<td>88</td>
<td>82</td>
</tr>
<tr>
<td>5 y</td>
<td>96</td>
<td>90</td>
</tr>
</tbody>
</table>

Distribution of events observed

$N_{4\sigma} = 6$
Probability of $\geq n\sigma$ significance for different $\Delta m^2$
(5 year run with 1.8 kton average target mass)

<table>
<thead>
<tr>
<th>$\Delta m^2$ (eV$^2$)</th>
<th>$P_{3\sigma}$</th>
<th>$P_{4\sigma}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$1.6 \times 10^{-3}$</td>
<td>78%</td>
<td>44%</td>
</tr>
<tr>
<td>$1.8 \times 10^{-3}$</td>
<td>89%</td>
<td>64%</td>
</tr>
<tr>
<td>$2.0 \times 10^{-3}$</td>
<td>95%</td>
<td>79%</td>
</tr>
<tr>
<td>$2.2 \times 10^{-3}$</td>
<td>98%</td>
<td>91%</td>
</tr>
<tr>
<td>$2.4 \times 10^{-3}$</td>
<td>99%</td>
<td>95%</td>
</tr>
</tbody>
</table>

Super-Kamiokande (LP 2001)

$1.2 < \Delta m^2 < 5.4 \times 10^{-3}$ eV$^2$ at 90% CL

1.0 7.0 99%

Best fit $\Delta m^2 = 2.4 \times 10^{-3}$ eV$^2$
Installation and schedule
Installation in a restricted space

“Simple” problems can be solved with time and patience! ....

... but others are by far more complex and do not have time as a free parameter
## Schedule for the installation of one supermodule

two years needed

### SM installation

<table>
<thead>
<tr>
<th>Task</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnet + RPC</td>
<td>1 year</td>
</tr>
<tr>
<td>arch support for Target Trackers</td>
<td></td>
</tr>
<tr>
<td>magnet base</td>
<td></td>
</tr>
<tr>
<td>magnet planes</td>
<td></td>
</tr>
<tr>
<td>inner tracker (RPC)</td>
<td></td>
</tr>
<tr>
<td>magnet top</td>
<td></td>
</tr>
<tr>
<td>coil &amp; cooling</td>
<td></td>
</tr>
<tr>
<td>main support SM1</td>
<td></td>
</tr>
<tr>
<td>readout support</td>
<td></td>
</tr>
<tr>
<td>electronics</td>
<td></td>
</tr>
</tbody>
</table>

### Target section

<table>
<thead>
<tr>
<th>Task</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>target</td>
<td>1 year</td>
</tr>
<tr>
<td>24 wall supports (up-down)</td>
<td></td>
</tr>
<tr>
<td>24 walls (2d wall+3d TT=1w/wall)</td>
<td></td>
</tr>
</tbody>
</table>

### Target Trackers

<table>
<thead>
<tr>
<th>Task</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 mechanical supports for TT</td>
<td></td>
</tr>
<tr>
<td>192 (8x24) TT modules</td>
<td></td>
</tr>
<tr>
<td>192 (8x24) precabling of modules</td>
<td></td>
</tr>
</tbody>
</table>

### Drift tube spectrometer trackers

<table>
<thead>
<tr>
<th>Task</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>phase 1</td>
<td></td>
</tr>
<tr>
<td>phase 2 upstream</td>
<td></td>
</tr>
<tr>
<td>phase 2 downstream</td>
<td></td>
</tr>
</tbody>
</table>

### Cabling

<table>
<thead>
<tr>
<th>Task</th>
<th>Duration</th>
</tr>
</thead>
<tbody>
<tr>
<td>Manipulators</td>
<td></td>
</tr>
<tr>
<td>mounting on SM</td>
<td></td>
</tr>
<tr>
<td>cabling</td>
<td></td>
</tr>
<tr>
<td>tests</td>
<td></td>
</tr>
<tr>
<td>robots ready for filling with bricks</td>
<td></td>
</tr>
</tbody>
</table>

### Filling (2bricks/min, 10h/day)
To have the full detector at the beam start-up in 2005

One supermodule in 2 years
Three supermodules in 3 years

The three supermodules “must”
be installed largely in parallel
(in the limited space available underground)

SM 1
SM 2
SM 3
Schedule to have the full detector ready in 2005

Large parallelism in the mounting of the supermodules
Limited space
“Challenging” schedule

Starting dates
2002  Installation
2004  Filling with emulsion bricks
2005  Data taking
in Hall B: detector close to BAM and to assembly space
Hall B or Hall C? Our answer is obvious: Hall B

- Large detector components are assembled in Hall B
  - OPERA in Hall C → transportation of large and delicate components
    load/unload transportation platforms
  - OPERA in Hall B → direct installation using the crane in the hall

- Brick are produced in “Bypass” near Hall B
  - OPERA in Hall C → transportation of ~1000 bricks (~8 ton) /day
    through hall A or B
  - OPERA in Hall B → direct access to Hall B

- Counting room is already available in Hall B
  - OPERA in Hall C → interference with detector installation&commissioning
    (A counting room on pillars above the corridor, also used for crane loading
    restricts the installation of large detector components)

---

If OPERA in Hall C:
practically impossible to be fully installed at beam start-up in 2005
Conclusions

- **Achieved**
  - Studies and construction of full scale prototypes
  - Detector design being finalised
  - Progress in automatic scanning
  - Detection efficiency improved since CNGS approval

- **Expected signal**
  - Lower $\Delta m^2$ of SK best fit: oscillation rate reduced by a factor of 2
  - In a five year run: 10.8 signal and 0.75 background events

- **Detector construction**
  - Large and complex detector, with a “challenging” schedule
  - Now the transition to the construction phase
  - Lower oscillation rate $\Rightarrow$ larger effort on various aspects
  - Strong technical support required also in terms of human resources