CNGS Project: Status report

OUTLINE

1. CNGS in the new CERN structure
2. Project Overview - main components
3. Civil Engineering / Hadron Stop / Decay Tube
4. Equipment design + procurement
5. Link to LNGS / timing
6. Link to CERN / muons from the rock
7. Summary
1. CNGS and the new CERN structure

Note: J. Engelen represents CERN in the INFN/CERN bilateral committee
2. CNGS: the main components

\[ p + C \rightarrow (\text{interactions}) \rightarrow \pi^+, K^+, (\mu^+) \rightarrow (\text{decay in flight}) \rightarrow \mu^+ + \nu_\mu \]
3a. Civil Engineering Works

NB. CE works started on 12 October 2000
CERN NEUTRINOS TO GRAN SASSO
Underground structures at CERN

- Excavated
- Concreted
- Decay tube (2nd contract)

SPS tunnel
LHC/T18 tunnel
LEP/LHC tunnel
Target chamber
Service gallery
Connection gallery to T18/LHC
Access galleries

Access shaft PGCN

SPS/ECA4

140m
55m
06/2003

CERN-AC-DI-MM
3b. Hadron Stopper (beam dump)
11 July 2003 - near the CE shaft

2 April 2004 Report to LNGS Scientific Committee

presented by K. Elsener

graphite cooling modules
Hadron stop - 2 Sept 2003
3c. CNGS Decay tunnel - Decay tube

998 m long steel tube, surrounded by 50 cm of concrete evacuated to 1 Torr tube has 2.45 m diameter, is 18 mm thick
Decay Tube: choice of dimensions

-> “good events” at Gran Sasso
"A detail" : Energy deposition by particles

![Graph showing energy deposition by particles in concrete and steel](image)
Temperature increase over 10 years - no cooling
(N.B. this is for 100% SPS efficiency and CNGS only user)

to test this model: 2 x 8 temperature probes installed
Decay tube installation
target chamber: assembling the 18m long sections
Welding inside decay tube
finished decay tube  
(target chamber)
Inside decay tube: View towards hadron stop
25 March
exit window
installed
Decay tube status:

Decay tube installation completed: 16 March 2004
Install exit / entrance windows: 25 March + 1 April

Vacuum tests (by contractor): April 2004

--- keep fingers crossed ---
4. Equipment

4a. Proton beam
Nominal beam parameters

<table>
<thead>
<tr>
<th>Beam parameters</th>
<th>Nominal CNGS beam</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nominal energy [GeV]</td>
<td>400</td>
</tr>
<tr>
<td>Normalized emittance [µm]</td>
<td>H=12 V=7</td>
</tr>
<tr>
<td>Emittance [µm]</td>
<td>H=0.028 V=0.016</td>
</tr>
<tr>
<td>Momentum spread Δp/p</td>
<td>0.07% +/-20%</td>
</tr>
<tr>
<td># extractions per cycle</td>
<td>2 separated by 50 ms</td>
</tr>
<tr>
<td>Batch length [µs]</td>
<td>10.5</td>
</tr>
<tr>
<td># of bunches per pulse</td>
<td>2100</td>
</tr>
<tr>
<td>Intensity per extraction [10^{13} p]</td>
<td>2.4</td>
</tr>
<tr>
<td>Bunch length [ns] (4σ)</td>
<td>2</td>
</tr>
<tr>
<td>Bunch spacing [ns]</td>
<td>5</td>
</tr>
</tbody>
</table>

Upgrade phase: 3.5 \times 10^{13} p
Expected number of protons delivered on CNGS target:

For 1 year of CNGS operation (200 days):

4.5 x 10^{19} protons on target / year ("nominal")

based on 1998 performance:
4.8 x 10^{13} protons in SPS, 55% overall efficiency;
(+ mixed cycles with LHC and other fixed target experiments)

higher proton intensities (very much requested by OPERA and ICARUS):

High Intensity Protons Working Group;
+ "machine" studies under way
High Intensity Protons Working Group: Recommendations 26 February 2004

launch 3 projects (define in 2004, start in 2005):

(1) low loss extraction at the PS
(2) increase CNGS intensity
(3) 0.9 seconds for PS Booster basic period

Comments by the WG:

(1) irradiation of accelerators is a major concern
(2) increase for CNGS only possible via increase per extracted beam pulse
(3) in the analysis, “other SPS fixed target expts.” were given low priority
Proton beam - last 100 metres
Beam monitoring

Problem: fast extracted, very intense proton beam, focused into a very small beam spot is too hot for standard Ti windows

→ Secondary Emission Monitors don’t work

Question: beam position monitor operated in air?

→ a challenge
**Target unit**

- **Static sealed system** filled with inert gas;
- Tube with annular fins to enhance convective heat transfer;
- **Light materials** are used to limit the heat load.

### Materials

<table>
<thead>
<tr>
<th>Component</th>
<th>Material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tube</td>
<td>Al-Mg alloy</td>
</tr>
<tr>
<td>Windows</td>
<td>Be by Brush &amp; Wellman</td>
</tr>
<tr>
<td>Target Support</td>
<td>Carbon Fiber reinforced Carbon</td>
</tr>
<tr>
<td>Target rods</td>
<td>Fine-grain graphite</td>
</tr>
<tr>
<td></td>
<td>hexagonal boron nitride, CFC</td>
</tr>
</tbody>
</table>
**CNGS Horn**  
(pulsed: 150 kA, 1 ms, water-cooled)  
6.5 metres long, 1.5 tons  

[picture courtesy S. Wallon, LAL/IN2P3]
In-kind contribution by LAL/IN2P3:
first horn ready, to arrive at CERN 7 April
CNGS Muon Monitoring

Muon detectors 67m

Access to muon monitoring stations very rare!
17 BLM (fixed cross centered on beam axis) + 1 motorised monitor

SPS Type Beam Loss Monitor

Ionisation Chamber
CNGS schedule
(schematic, simplified version)

<table>
<thead>
<tr>
<th>Year</th>
<th>2000</th>
<th>2001</th>
<th>2002</th>
<th>2003</th>
<th>2004</th>
<th>2005</th>
<th>2006</th>
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<tbody>
<tr>
<td>Civil Engineering</td>
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<tr>
<td>excavate civil engineering pit, tunnels and caverns; concrete / shotcrete tunnels and caverns</td>
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<tr>
<td>Install hadron stop</td>
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<td>iron + graphite blocks, aluminum plate + water cooling</td>
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<tr>
<td>Install decay tube</td>
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<tr>
<td>lower decay tube sleeves, weld together, pour concrete</td>
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<td>Civil Engineering - phase 2</td>
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<td>finish concrete floors, close provisional CE pit</td>
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<td>Install general services</td>
<td></td>
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<tr>
<td>electrical services, ventilation, cooling water, etc.</td>
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<tr>
<td>Install equipment</td>
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<tr>
<td>proton beam line, target, hom-reflector, shielding</td>
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<td>Commissioning</td>
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<tr>
<td>First beam to Gran Sasso:</td>
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<td>May 2006</td>
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</tbody>
</table>

"today"
5. Link to LNGS / timing

reminder:

- timing between beam extraction at CERN and event at LNGS to be done with GPS “time-stamp”
- data sent via Internet – for every extraction, or after every 6 s cycle (i.e. 2 extractions)

(N.B. data transfer takes less than 30 ms “round trip” - expt. in 2001)

GPS timing at CERN: start tests with final equipment in June 2004
- accuracy expected: < 40 ns
- available for demonstration (visit) + discussion end of 2004
- available “on loan”, if LNGS is interested

expert for timing at CERN: Gary.Beetham@cern.ch
expert at LNGS: name please, thanks!
In addition to the (most important) timing information, we are planning to send

- an early warning (few seconds) to indicate whether the next cycle will have beam or not
- any data files on the beam parameters (protons, muons) as required by LNGS - please specify!

(CNGS controls co-ordinator: Veronique.Paris@cern.ch)

Note:
Information on the status of the SPS is available on the “page-1”, on the Web (longer stop, problems, etc.)
5. Link to CERN / muons from the rock

reminder (CERN-EP/2001-037):

in a 100 m² detector at LNGS, about
80 CNGS muons per day
  can be measured coming from the rock
  upstream of the caverns

CERN’s wish: please measure these muons,
  and give us fast feedback (every hour ?)
(+ ... if possible:
  please give us the GPS timestamp, for every muon ...)

2 April 2004
Summary:

• **CNGS on schedule** for beam in spring 2006

• **Infrastructure installations** will start in June

• **Equipment well advanced** – but still a lot of work ahead!
  
  [main issues: (1) radioactive handling
  (2) small, intense 10.5 $\mu$s proton beam bursts]

• **PS + SPS tests with high intensity are scheduled for 2004** – LNGS experiments must continue to make their physics case for more protons clear to everybody!
Thank you!