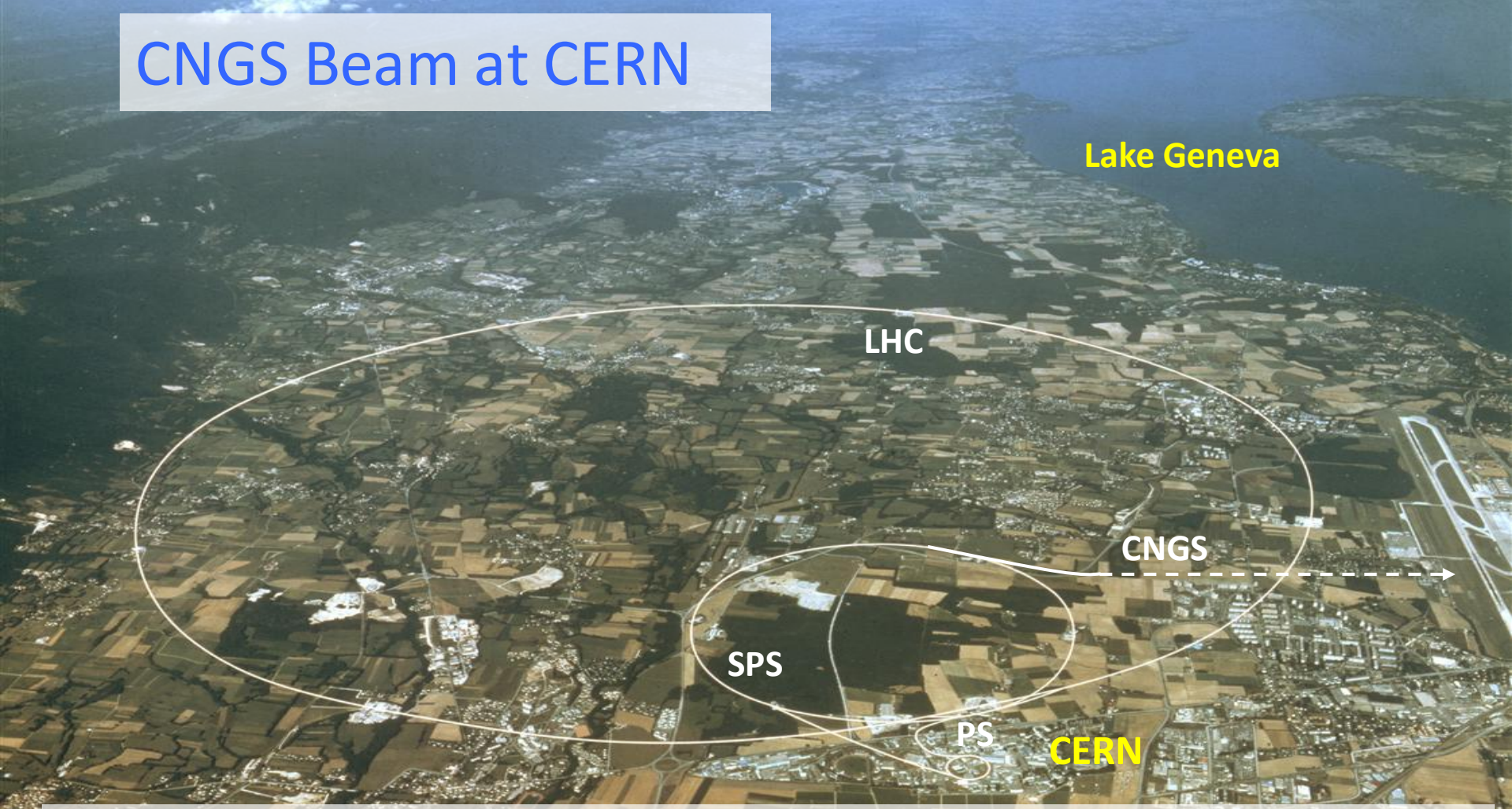
CNGS Operation Summary

Edda Gschwendtner, CERN

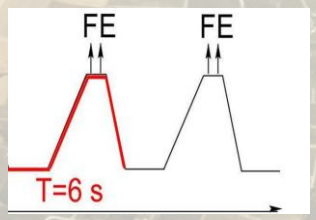
Outline

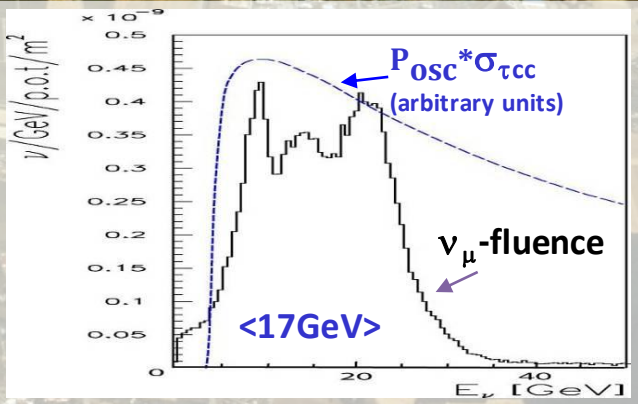
- Introduction
- CNGS Performance
- Highlights since last NBI 2010 in Japan
- Issues
- Summary

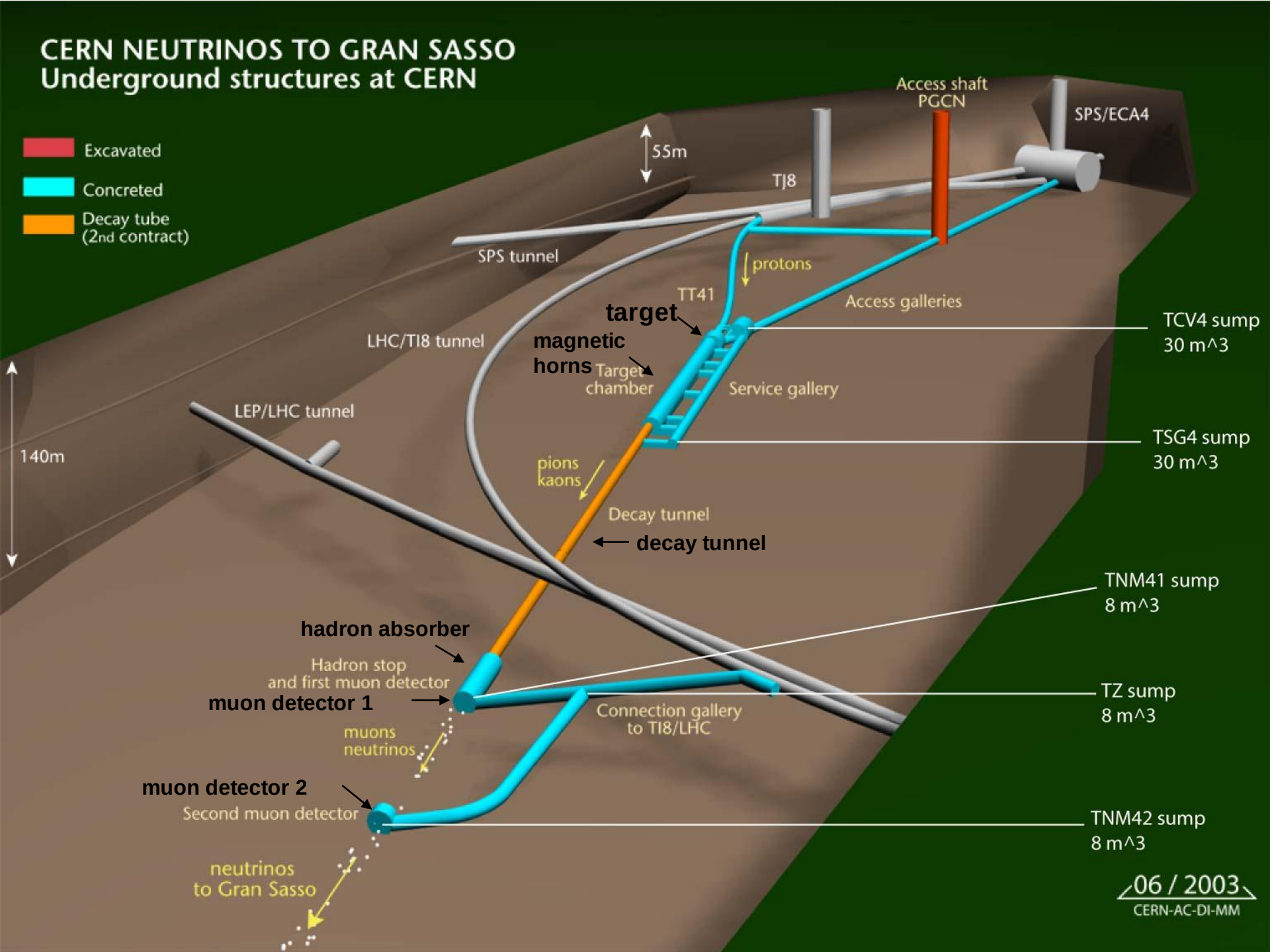
CNGS Beam at CERN



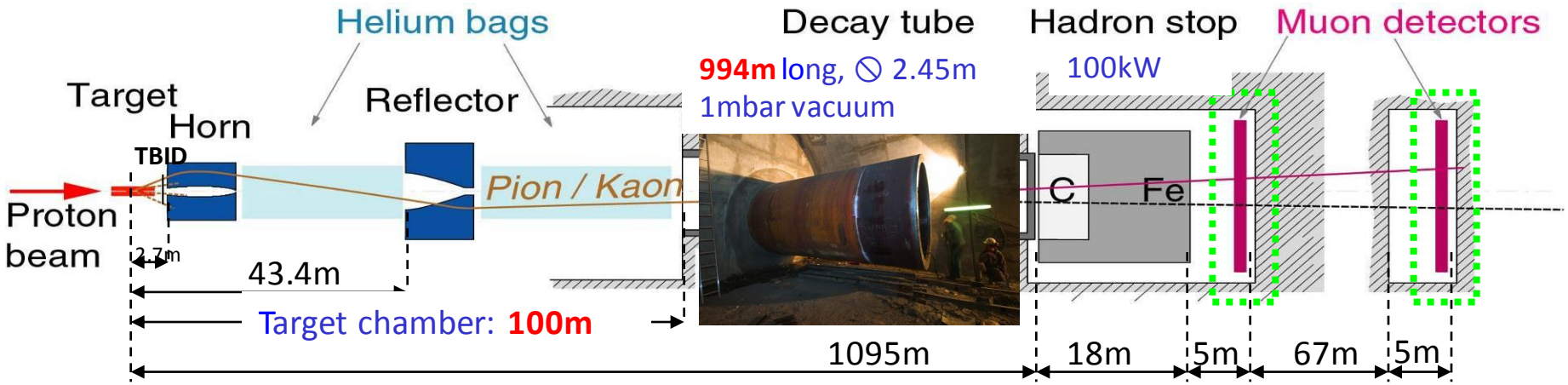
- From SPS: 400 GeV/c
- Cycle length: 6 s
- 2 Extractions: separated by 50ms
- Pulse length: 10.5μs
- Beam intensity: 2x 2.4 · 10^{13} ppp
- Βεαμ ποωερ: υπ το 500κΩ
- σ ~0.5mm



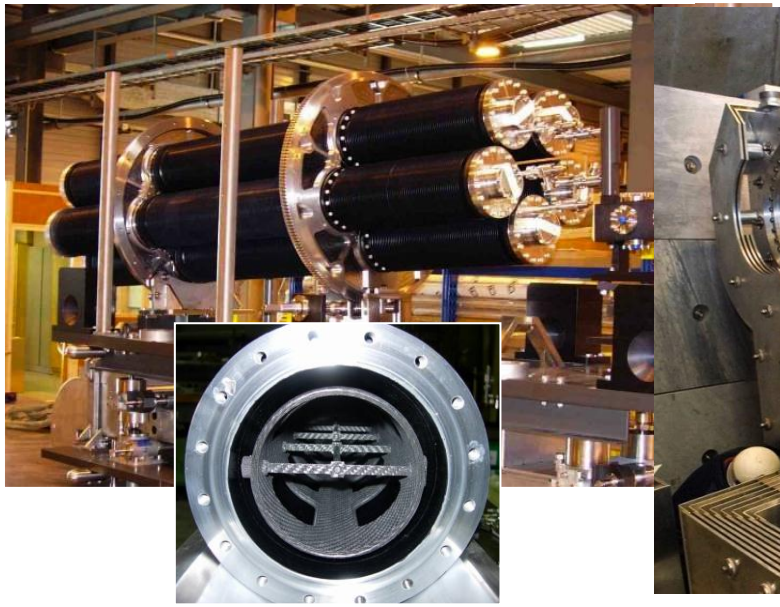


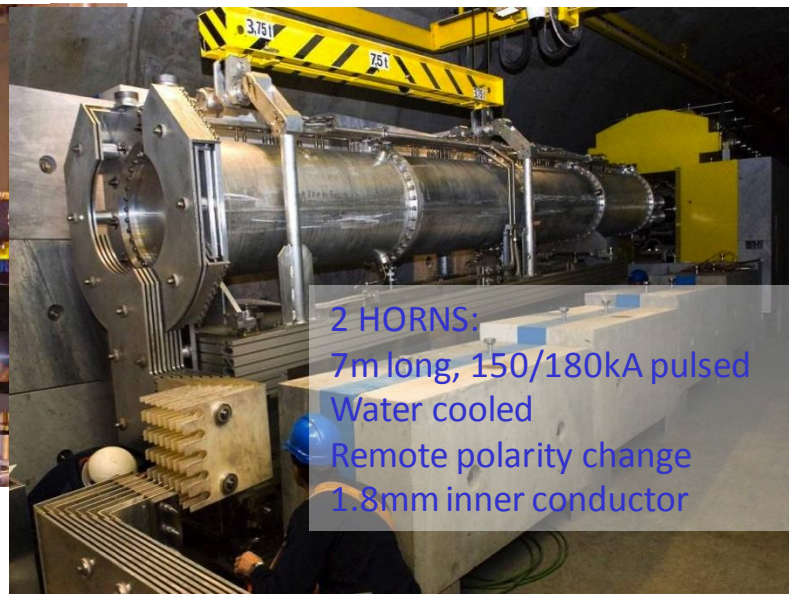

CERN NEUTRINOS TO GRAN SASSO
Underground structures at CERN
Excavated
Concreted
Decay tube
(2nd contract)
Access shaft
PGCN
SPS/ECA4
55m
TI8
SPS tunnel
protons
TT41
target
Access galleries
TCV4 sump
30 m^3
LHC/TI8 tunnel
magnetic
horns
Target
chamber
Service gallery
LEP/LHC tunnel
140m
TSG4 sump
30 m^3
pions
kaons
Decay tunnel
decay tunnel
TNM41 sump
8 m^3
hadron absorber
Hadron stop
and first muon detector
muon detector 1
TZ sump
8 m^3
Connection gallery
to TI8/LHC
muons
neutrinos
muon detector 2
Second muon detector
TNM42 sump
8 m^3
neutrinos
to Gran Sasso
06 / 2003
CERN-AC-DI-MM

CNGS Secondary Beam Line

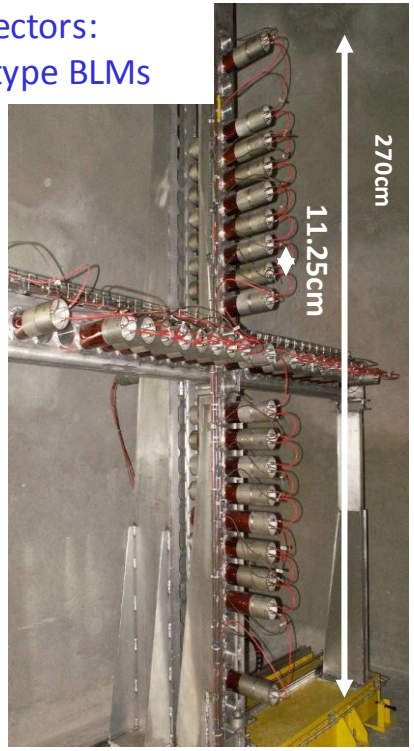


1 Target unit: 13 graphite rods 10cm
1 Magazine: 1 unit used, 4 in situ spares

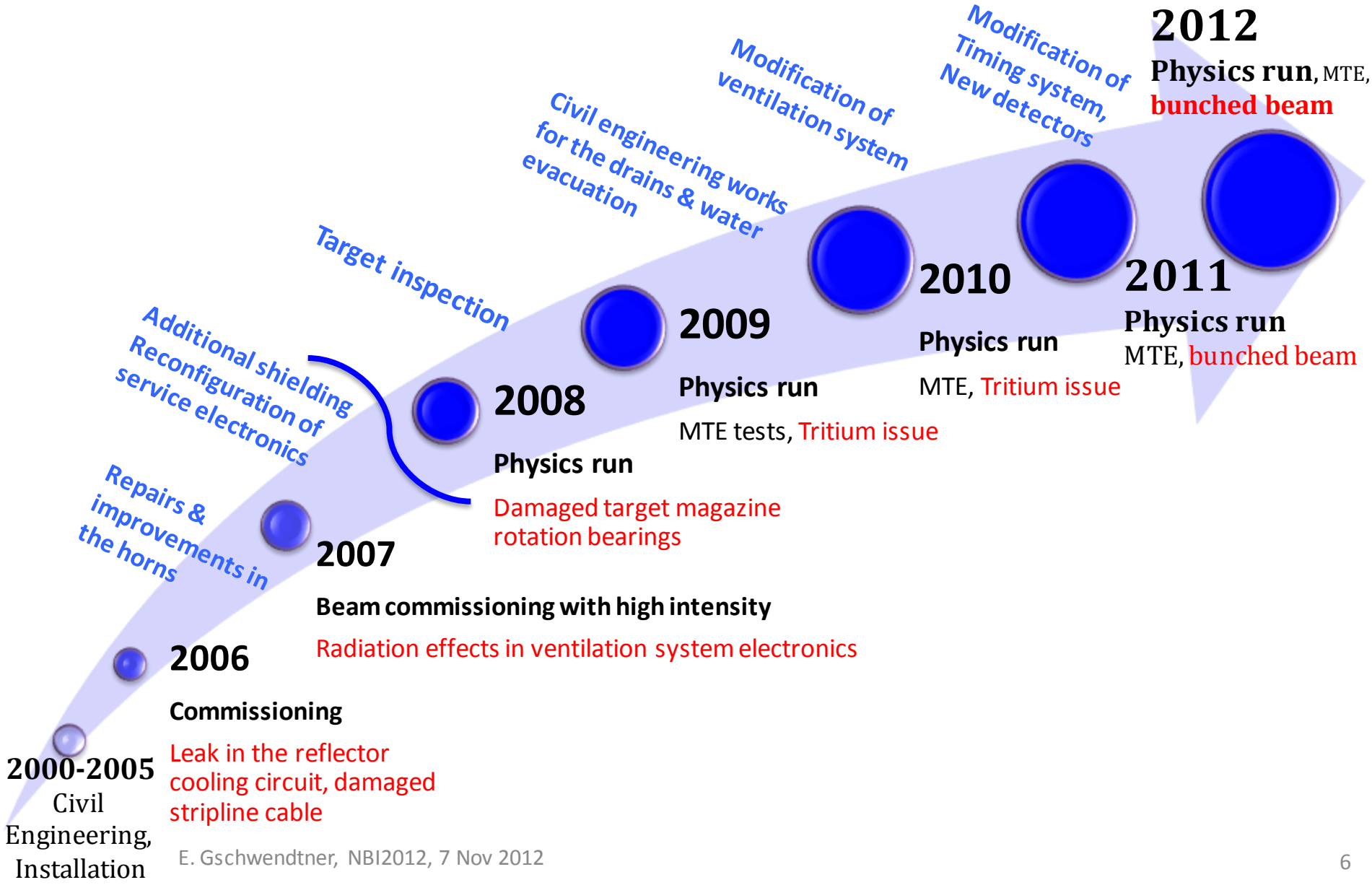




Muon detectors:
2x41 LHC type BLMs



CNGS Timeline until Today

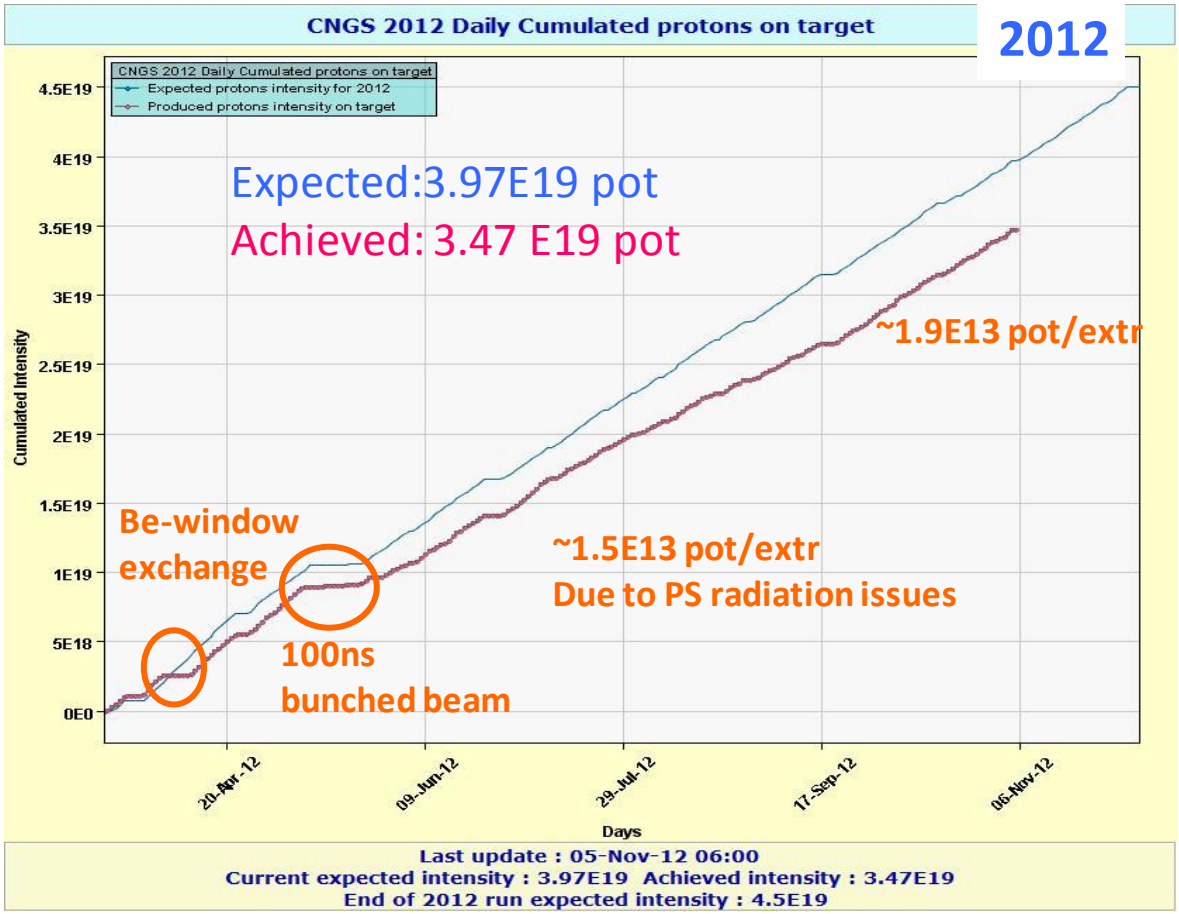


Total Integrated Intensity since CNGS Start in 2006

CNGS approved for 22.5E19 pot → i.e. 5 years with 4.5E19 pot/yr

→ Expect ~10 ν_τ events in OPERA → 2 ν_τ candidates published

Protons on target/year	
2006	0.08 E19
2007	0.08 E19
2008	1.78 E19
2009	3.52 E19
2010	4.04 E19
2011	4.84 E19
2012	3.47E19
Total (today)	**17.81 E19**

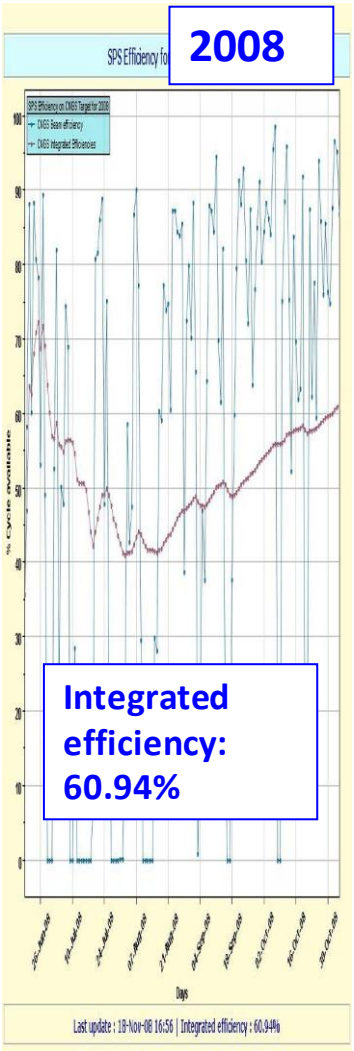


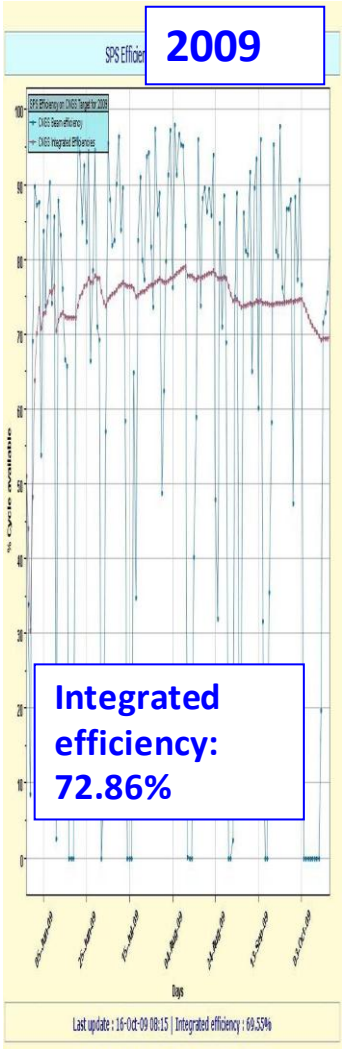
By end 2012:

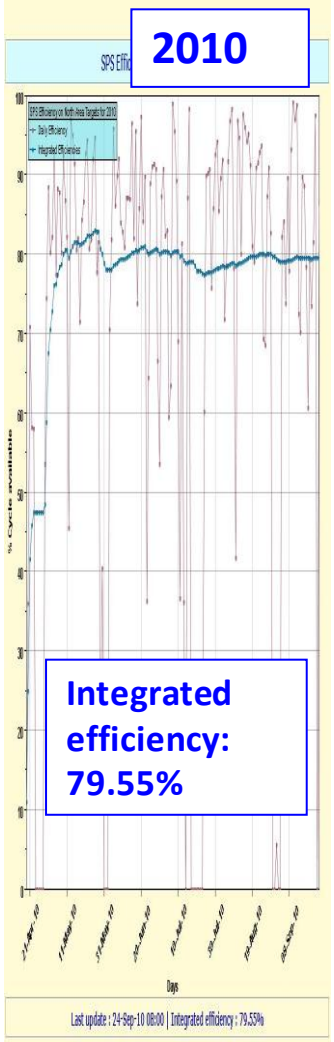
→ **Expect ~18.3E19 protons on target**

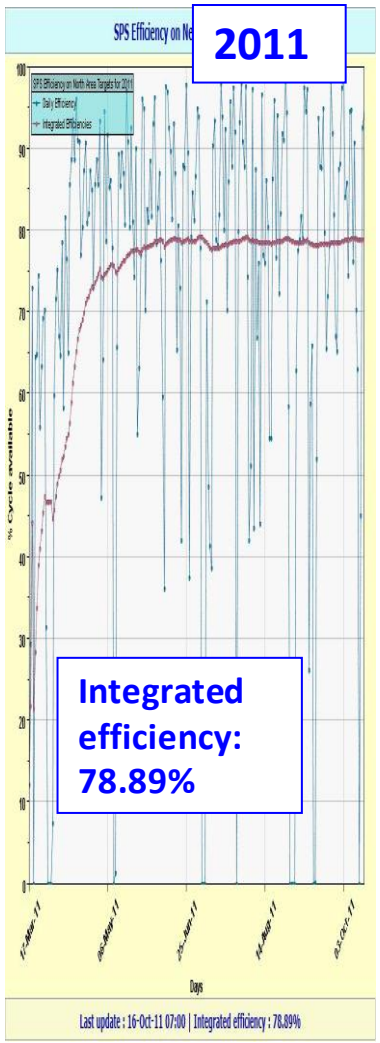
→ **81% of approved pot**

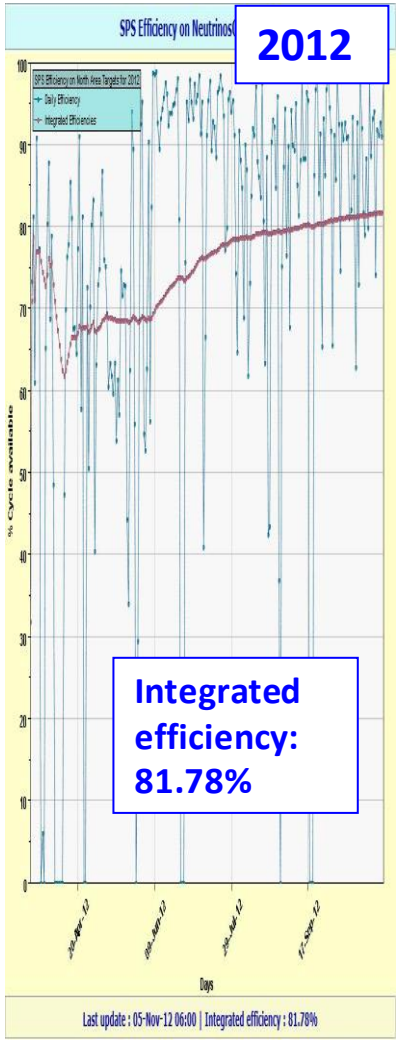
SPS Efficiencies for CNGS



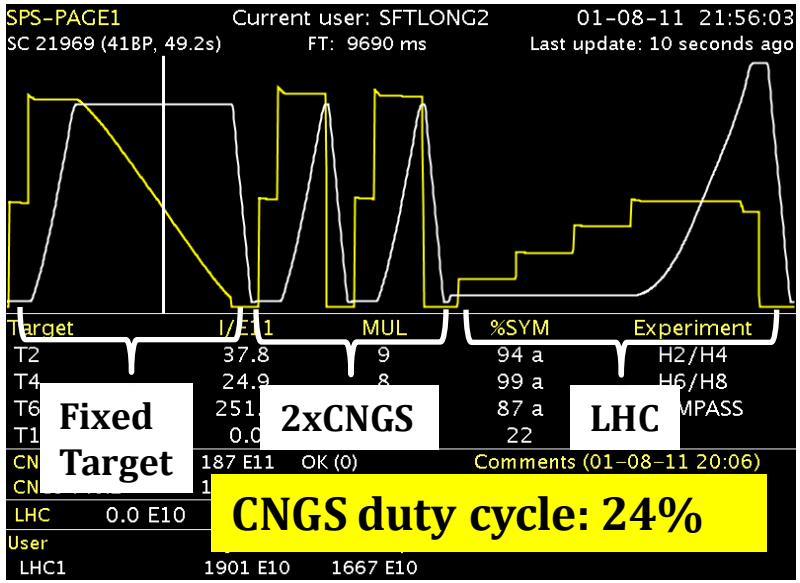


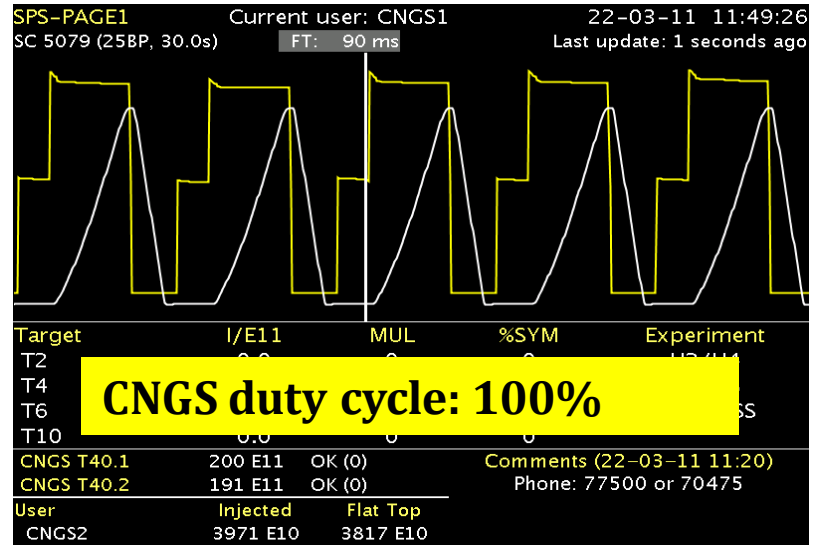


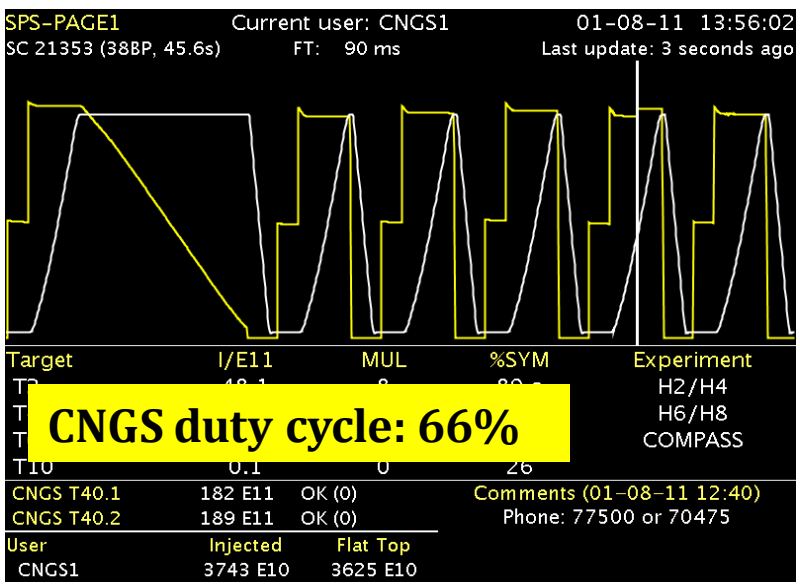


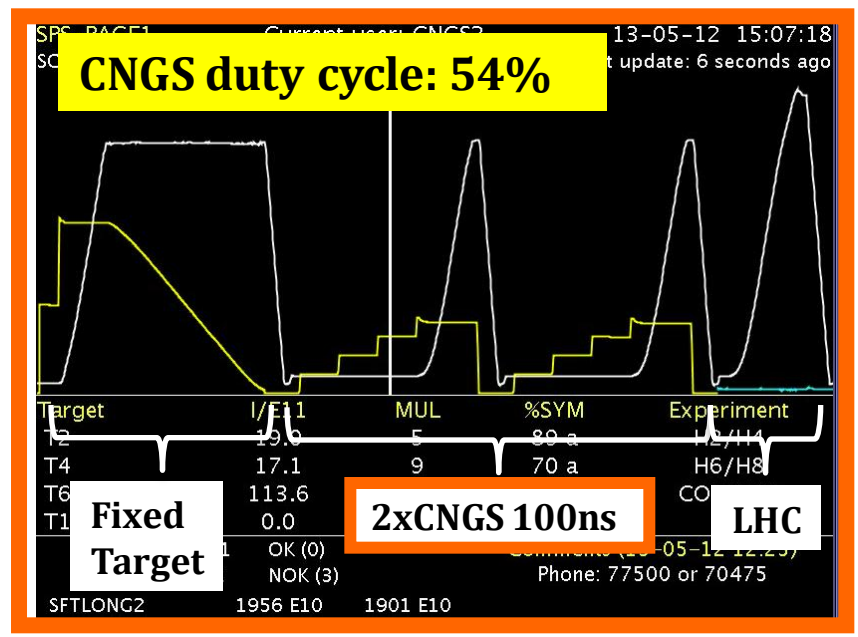


Different CNGS Duty Cycles



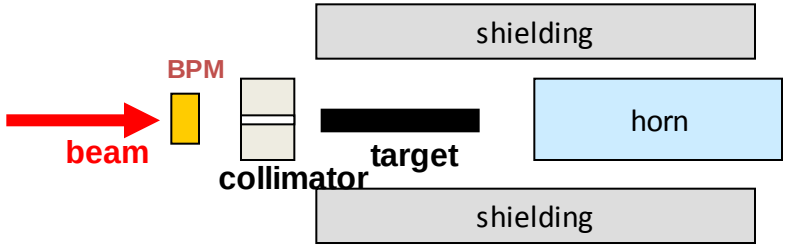






CNGS Performance

Beam Position on Target

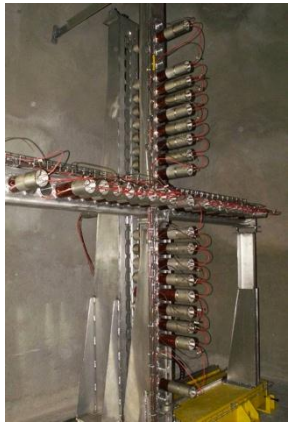


- Excellent position stability; ~50 (90) μm horiz (vert) over entire run.
- No active position feedback is necessary
  - 1-2 small steerings/week only

Power on Target

- Maximum: 480kW
- Sustained Maximum during 1 day (dedicated CNGS running): 330kW
- With LHC, Fixed Target, MDs…: 156kW

Muon Monitors: Online Feedback



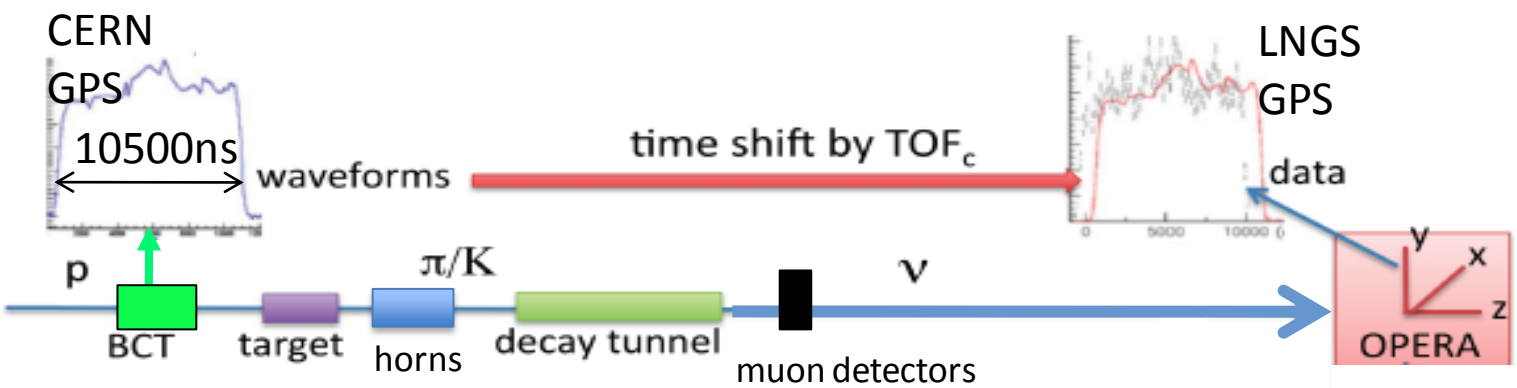
- Offset of target vs horn at 0.1mm level → Muon profiles Pit 1
- Offset of beam vs target at 0.05mm level → Muon profiles Pit 2

→ See NBI2010 CNGS presentation:

http://kds.kek.jp/getFile.py/access?contribId=5&sessionId=5&resId=0&materialId=slides&confId=5611

Highlights of CNGS Activities since NBI2010

Consequence of the OPERA Results on the Neutrino Velocity Measurements



CNGS nominal beam is 10500ns long

- A lot of statistics needed for time of flight analysis
- Many possible systematic effects along the secondary beam line

Activities:

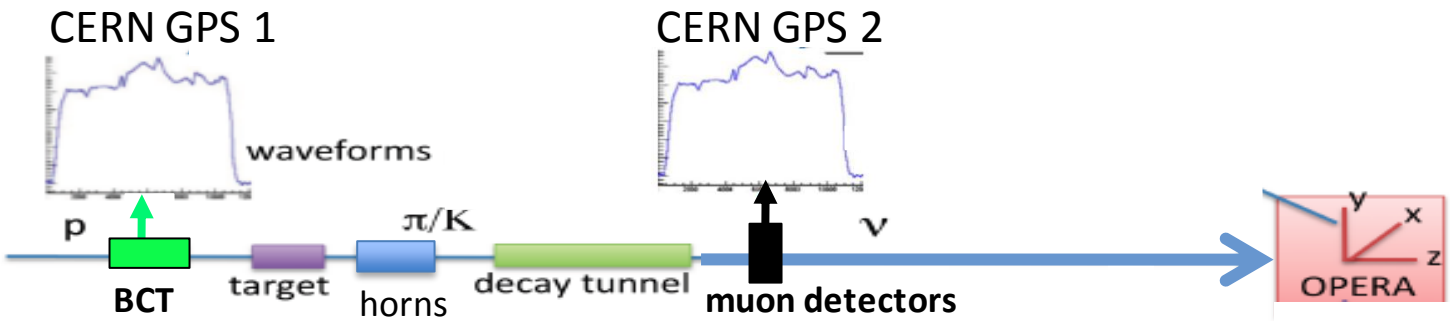
1. Install new muon detectors

- Measurement of the GPS timing signal at CERN independently from the BFCT
- Measure time structure of the muon spill

2. Send LHC type bunched beam to CNGS

- Precise timing of each neutrino interaction
- Many systematic effects excluded

2011/2012: Installation of New Additional Muon Detectors

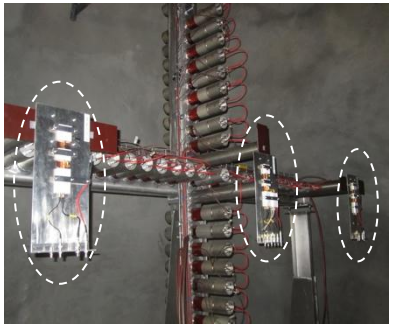


→Use kicker extraction signal to trigger the scope (like done for BCFT)
→Measure the time structure of muon spills with ~1GS/s
→Perform cable delay measurements

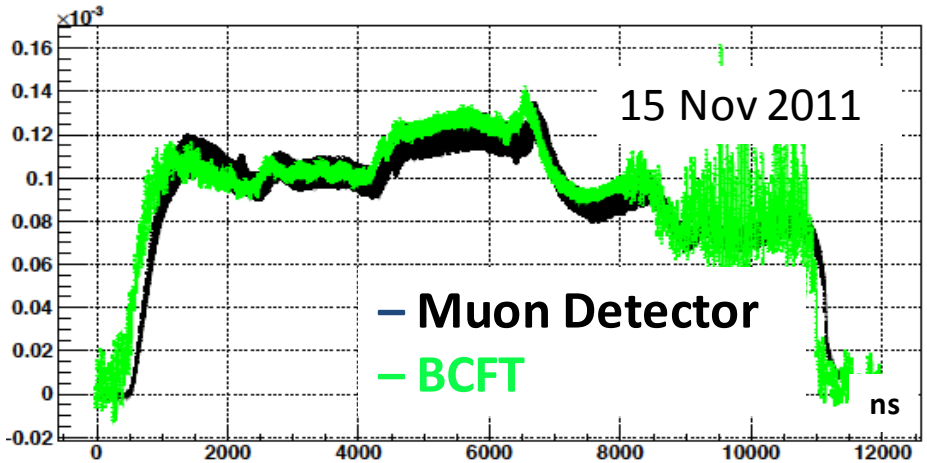
Detector challenge:

→Pit 1: ~1 THz/cm^2
→Pit 2: ~10-100 GHz/cm^2

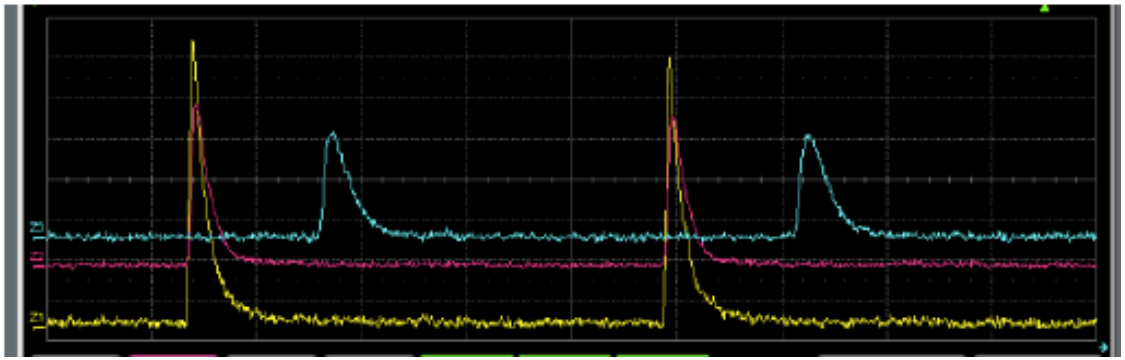
Diamond Detectors



Diamond Detector Results



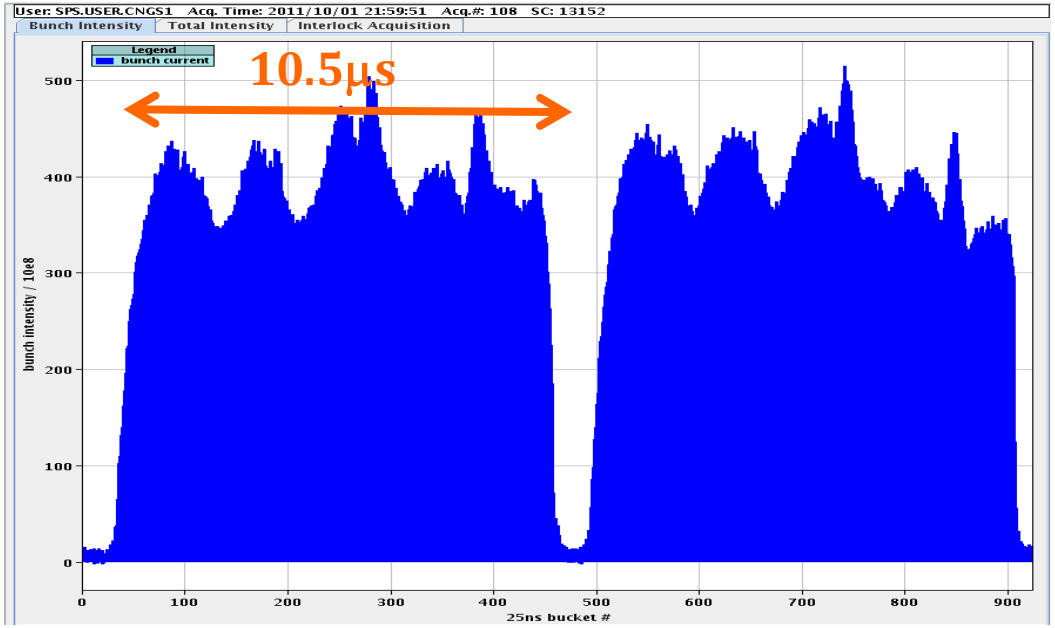
See Hendrik Jansen's talk, We, 17:45-18:00



10 May 2012: 100ns bunched beam

→ GPS timing measurement is consistent between the BFCT and the diamond monitors.

Nominal CNGS Beam

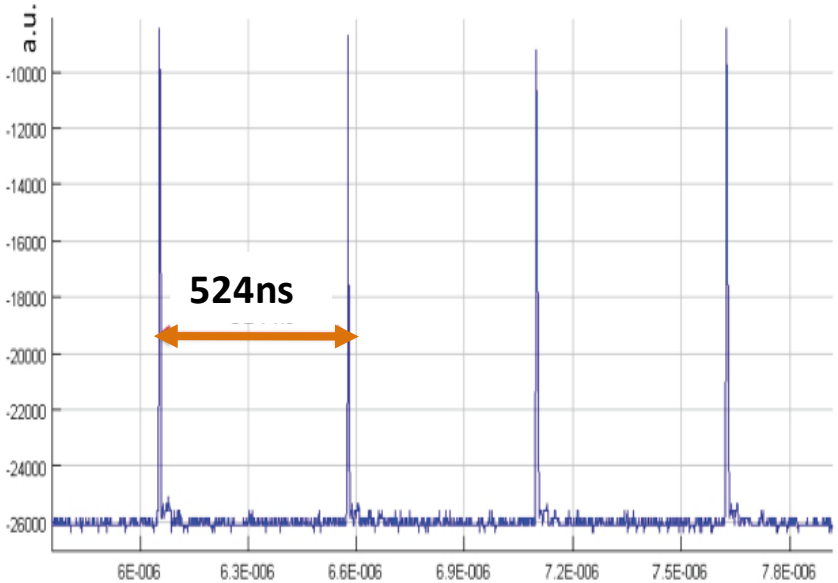


- Bunch intensity: ~1 E10 p
- Bunch separation: 5ns
- 2100 bunches
- 2 extraction/cycle
- Cycle length: 6s

→ ~35 neutrino-events/day

2011/2012: LHC Type Bunched Beam to CNGS

21 October to 6 November 2011:



- Bunch intensity: ~2.5 E11 p
- Bunch separation: 524ns
- 4 bunches/batch, 1 batch
- 1 extraction/cycle
- Cycle length: 6s

→ 1 neutrino-event/day

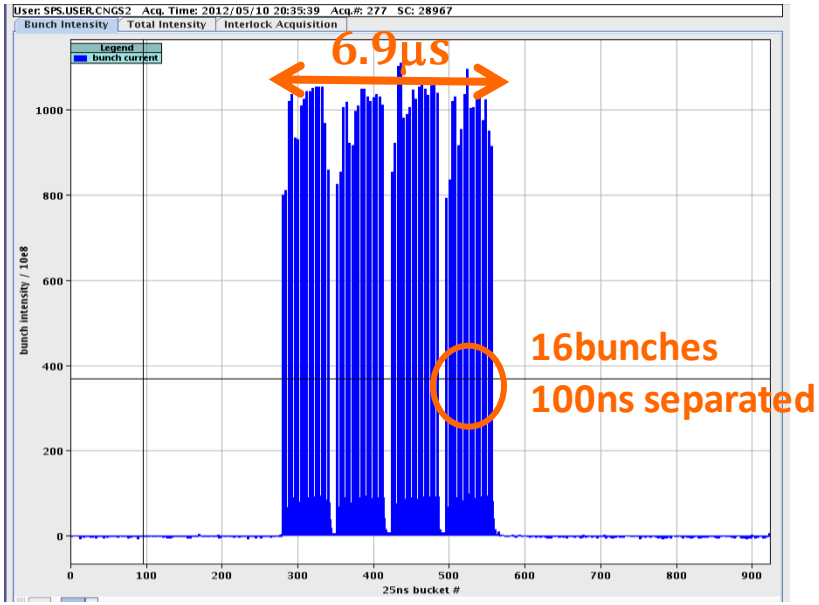
Issue: BPMs didn't work

→ For steering use muon detectors

→ Magnet HW interlock

→ Beam position at exit of SPS extraction

10 – 24 May 2012:



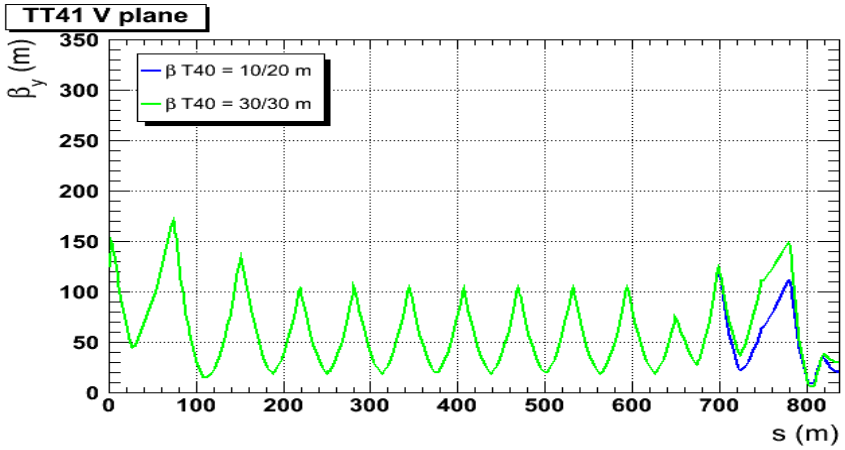
- Bunch intensity: ~1.25 E11 p
- Bunch separation: 100ns
- 16 bunches/batch
- 4 batches, Batch separation: ~300ns
- 1 extraction/cycle
- Cycle length: 13.2s

→ 4 neutrino-events/day

New Optics in 2012

Courtesy J. Wenninger

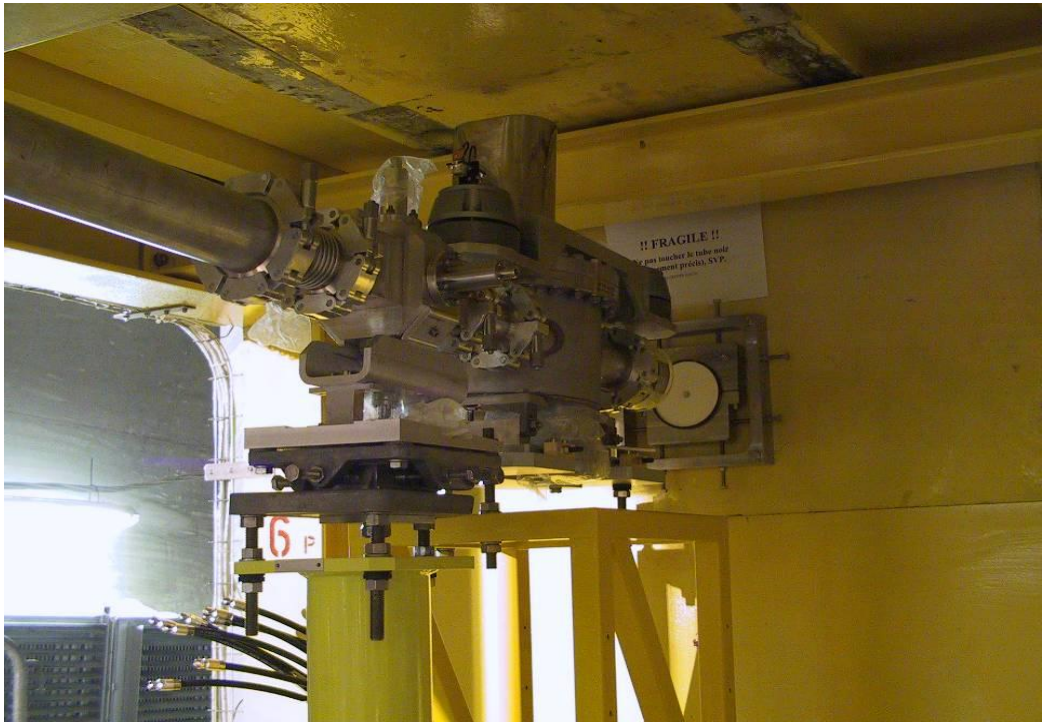
- Nominal beam size on target T40 is **0.53 mm** for the ultimate intensity of **7×10^{13} p** / cycle. Emittance assumed to be ~10 mm.
- Since 2006 we are operating at a maximum of **4.2×10^{13} p** / cycle, but with smaller emittances of **4-5 μm**.
  - The resulting beam sizes on CNGS target are **~0.3/0.4 mm** (H/V).
  - But the beam density is similar as the brightness ~constant.
- Following some worries last year about the state of the target → rematch a new optics that would restore a beam size of **~0.53 mm**.
  - Optics changes are limited to matching section in front of T40.
  - Target β on CNGS target was set to **30 m** instead of 10/20 m (H/V).



Vacuum Be-Window

- Be-window (0.25mm thick, diameter 70mm on 114mm flange) at the downstream end of the proton beam-line, just in front of the target had to be exchanged twice:
  - March 2011 before startup (after 14.34E19 pot)
  - April 2012 after ~2 weeks of beam (after 4.9E19 pot)

- Due to high radiation level no study on reason of window-breaking done yet



Summary

- CNGS is still running fine.
  - BUT: Operating and maintaining a high-intensity facility is very challenging
    - Tritium issue, fatigue, corrosion,…
- Exciting two years since the last NBI2010 in Japan
  - Proton delivery record in 2011
  - LHC type bunched beam
  - Installation of new detectors
- CNGS will stop on 3rd December 2012
  - Not yet decided/requested whether CNGS will continue after LS1 in 2015

CNGS Talks during NBI2012

- We, 16:15-16:30:
  - **Experience with CNGS Primary Beam Line Instrumentation**, Lars Jensen
- We, 17:45-18:00:
  - **Diamond Detectors for CNGS**, Hendrik Jansen
- Thu, 9:40-10:00:
  - **CNGS Target Operation and Modified Design**, Marco Calviani
- Thu, 13:30-13:40:
  - **CERN Horn Experience**, Ans Pardons
- Fr, 8:45-9:05:
  - **CNGS Operation and Environmental Issues**, Heinz Vincke
- Sa, 10:10-10:30:
  - **Remote Handling Activities at CERN**, Jean-Louis Grenard