CNGS Status

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Outline

- Introduction
- Summary CNGS Run 2009
- CNGS Shutdown Work 2009/2010
- Status OPERA
- Status ICARUS
- Summary

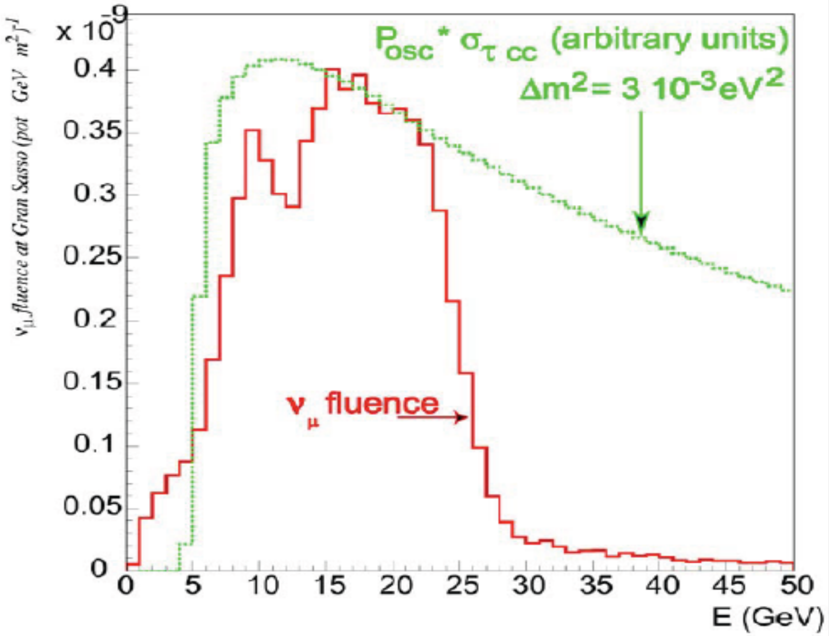
CERN Neutrinos to Gran Sasso

Long base-line appearance experiment: $\nu_\mu \rightarrow \nu_\tau$

Approved for 22.5 $\cdot 10^{19}$ protons on target
i.e. 5 years with $4.5 \cdot 10^{19}$ pot/ year
(200 days, nominal intensity)

→ $2.2 \cdot 10^{17}$ pot/day
→ $\sim 10^{17}\ \nu_\mu$ /day
→ $\sim 10^{11}\ \nu_\mu$ /day at detector in Gran Sasso

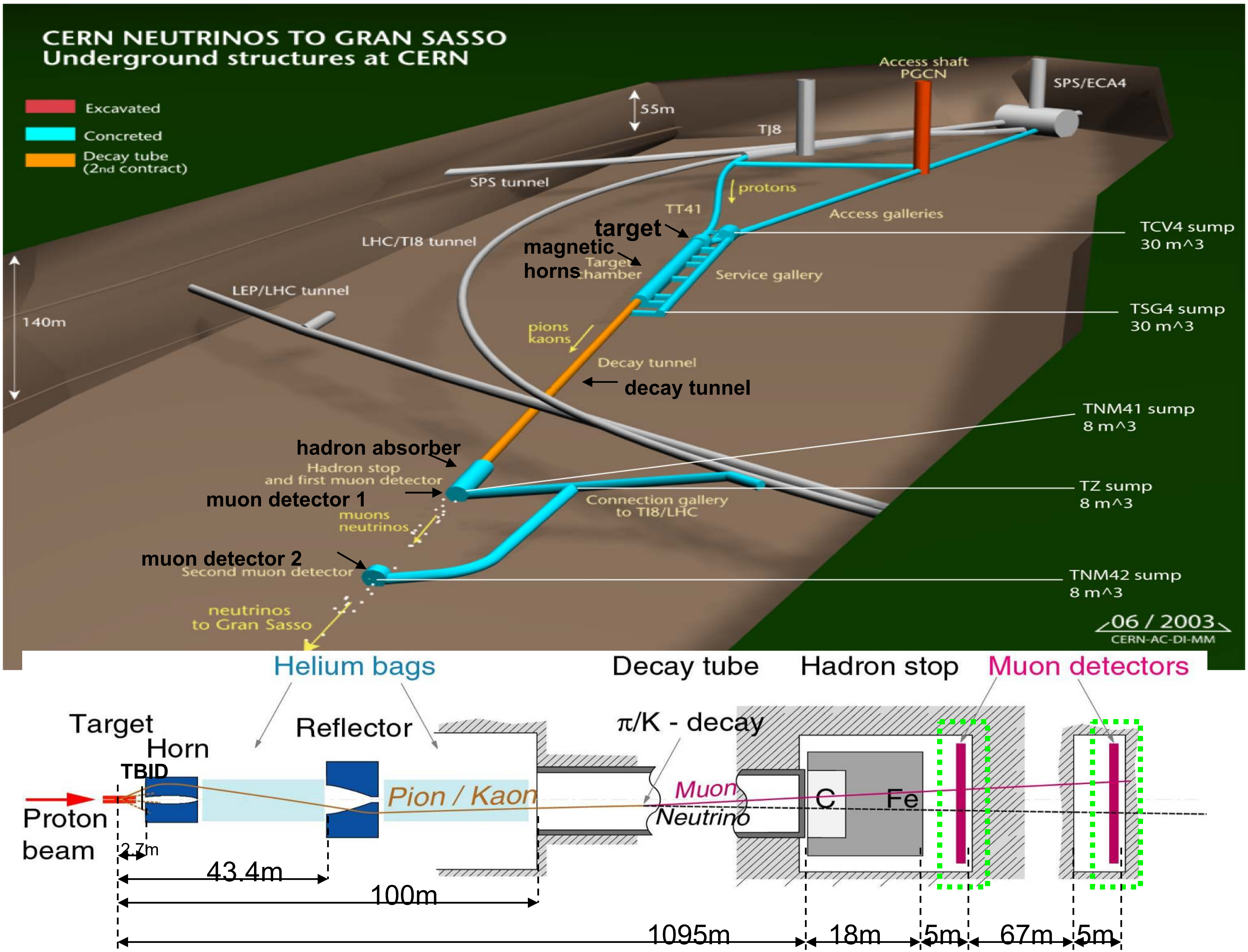
→ 23600 ν_μ CC + NC interactions/ 5 year in OPERA



$\sim 1\nu_\tau$ observed interaction in OPERA for $2 \cdot 10^{19}$ pot

→ Run 2008: $1.78 \cdot 10^{19}$ pot
→ Run 2009: $3.52 \cdot 10^{19}$ pot
→ Run 2010 expected: $3.8 \cdot 10^{19}$ pot

5.30×10^{19} pot


CERN NEUTRINOS TO GRAN SASSO
Underground structures at CERN
Excavated
Concreted
Decay tube
(2nd contract)
55m
140m
SPS tunnel
TJ8
Access shaft
PGCN
SPS/ECA4
protons
TT41
target
magnetic
horns
Target
chamber
Access galleries
Service gallery
TCV4 sump
30 m^3
TSG4 sump
30 m^3
LHC/TI8 tunnel
LEP/LHC tunnel
pions
kaons
Decay tunnel
decay tunnel
TNM41 sump
8 m^3
hadron absorber
Hadron stop
and first muon detector
muon detector 1
muons
neutrinos
Connection gallery
to TI8/LHC
TZ sump
8 m^3
muon detector 2
Second muon detector
TNM42 sump
8 m^3
neutrinos
to Gran Sasso
06 / 2003
CERN-AC-DI-MM
Helium bags
Decay tube
Hadron stop
Muon detectors
Target
Horn
TBID
Reflector
π/K - decay
Pion / Kaon
Muon
Neutrino
C
Fe
Proton
beam
2.7m
43.4m
100m
1095m
18m
5m
67m
5m

CNGS Equipment

CNGS Target

- 13 graphite rods, each 10cm long
- Diameter = 5mm and/or 4mm
- 2.7mm interaction length

Ten targets (+1 prototype) have been built → assembled in two magazines

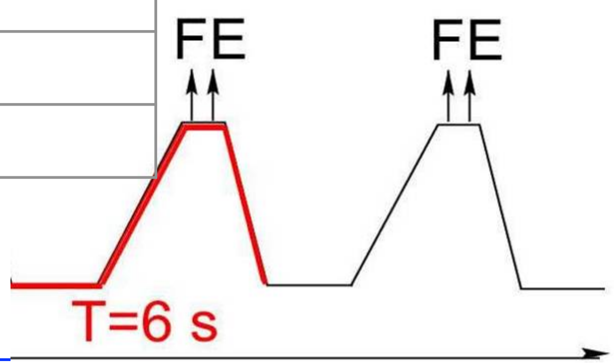
CNGS Horn and Reflector:

- 150kA/180kA, pulsed
- 7m long, inner conductor 1.8mm thick
- Designed for $2 \cdot 10^7$ pulses
- Water cooling to evacuate 26kW
- 1 spare horn (no reflector yet)

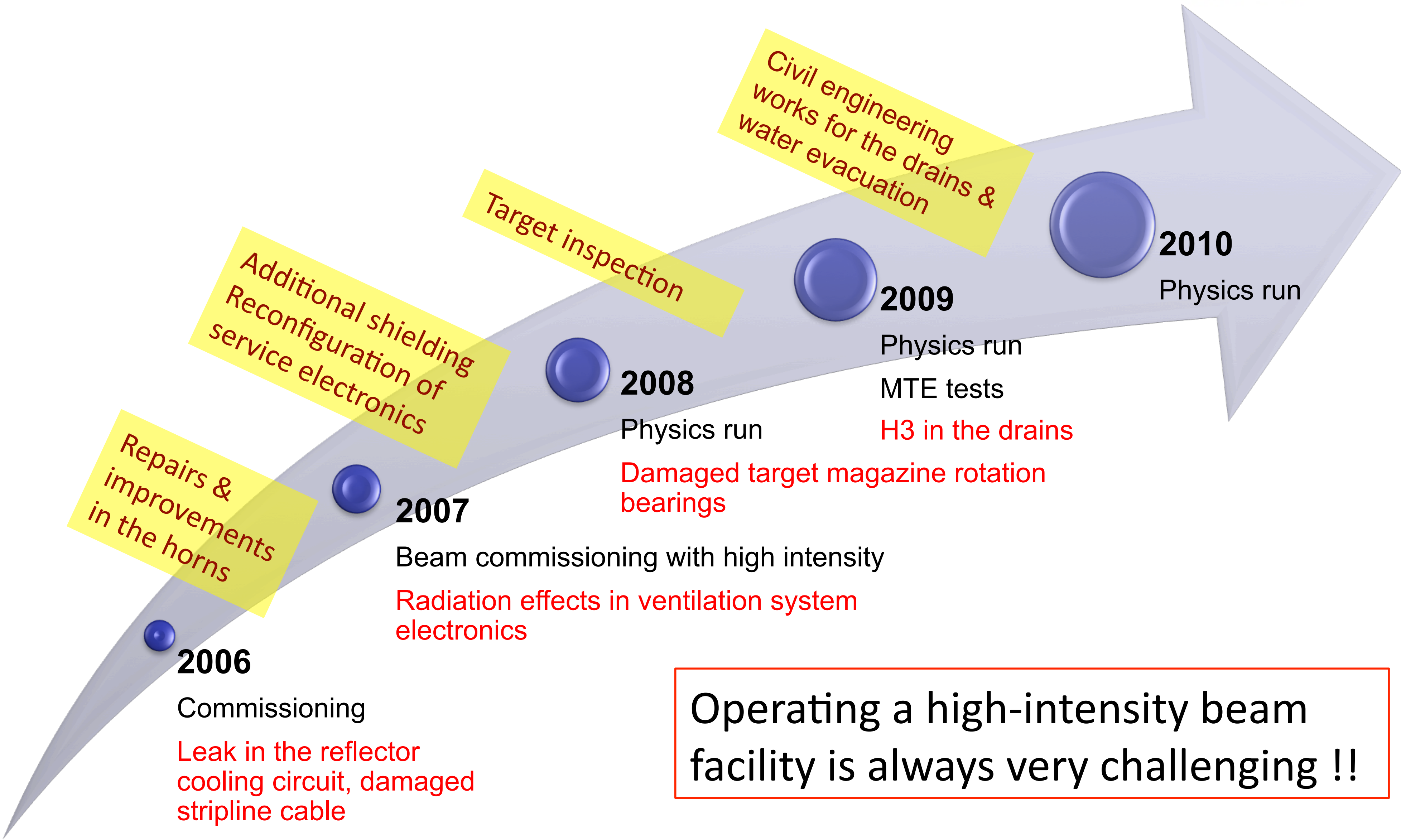
CNGS Proton Beam Parameters

Beam parameters	Nominal CNGS beam
Nominal energy [GeV]	400
Normalized emittance [μm]	H=12 V=7
Emittance [μm]	H=0.028 V= 0.016
Momentum spread Δp/p	0.07 % +/- 20%
# extractions per cycle	2 separated by 50 ms
Batch length [μs]	10.5
# of bunches per pulse	2100
Intensity per extraction [10^{13} p]	2.4
Bunch length [ns] (4σ)	2
Bunch spacing [ns]	5
Beta at focus [m]	hor.: 10 ; vert.: 20
Beam sizes at 400 GeV [mm]	0.5 mm
Beam divergence [mrad]	hor.: 0.05; vert.: 0.03

500kW beam power

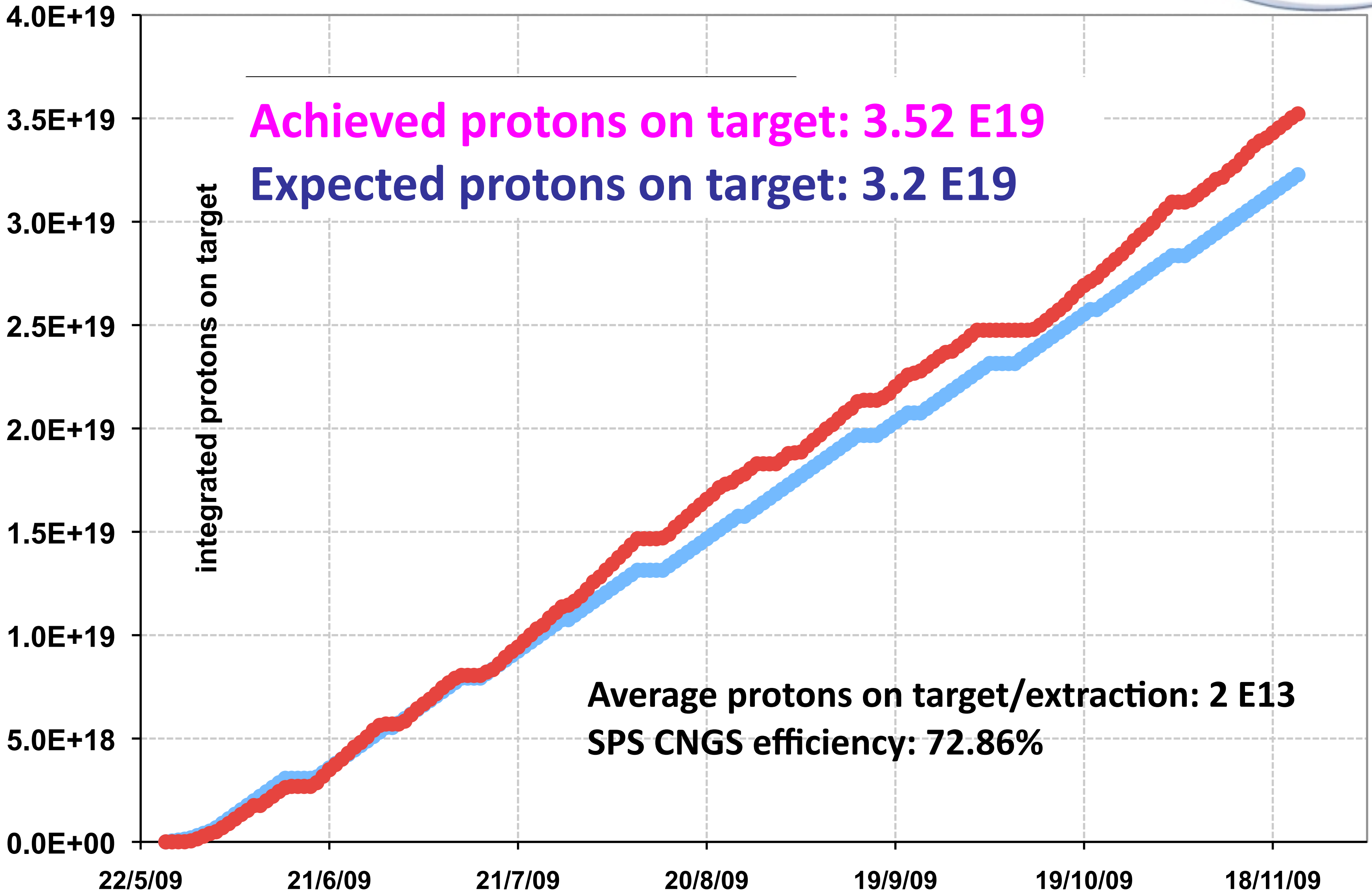


CNGS Timeline



Operating a high-intensity beam facility is always very challenging !!

CNGS Operation in 2009

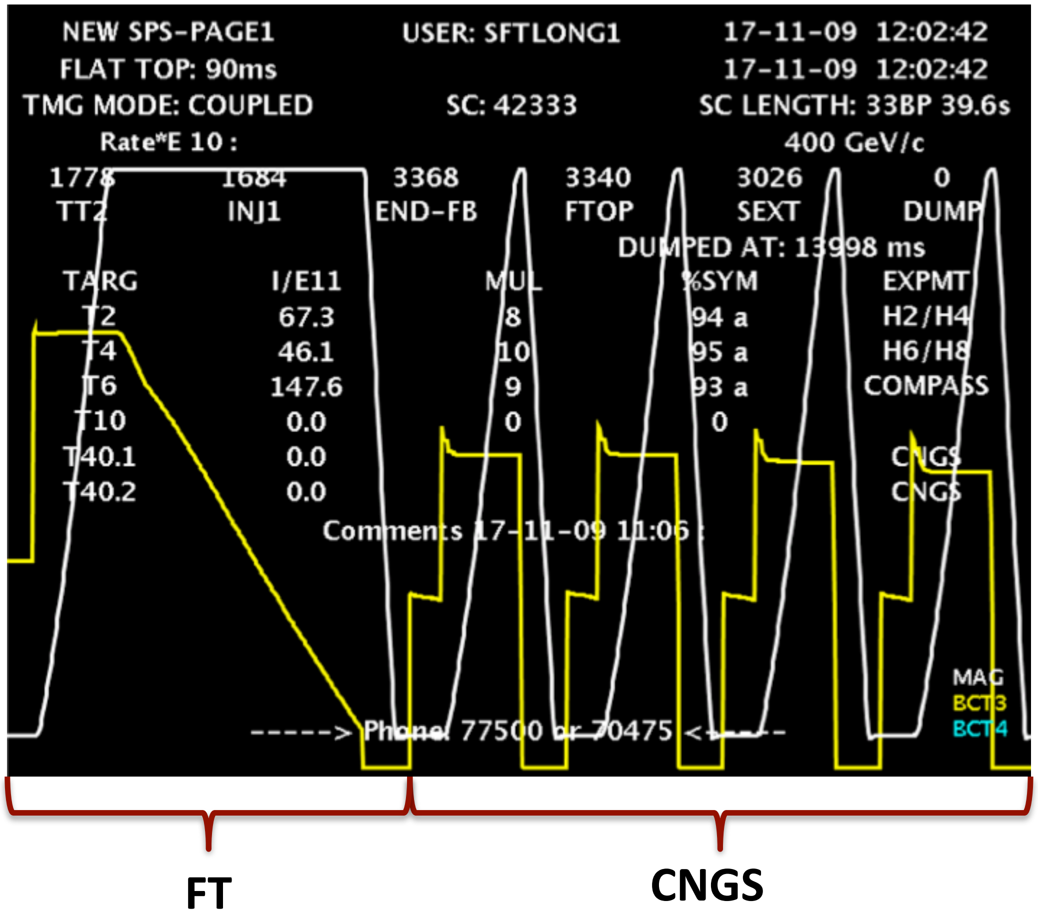


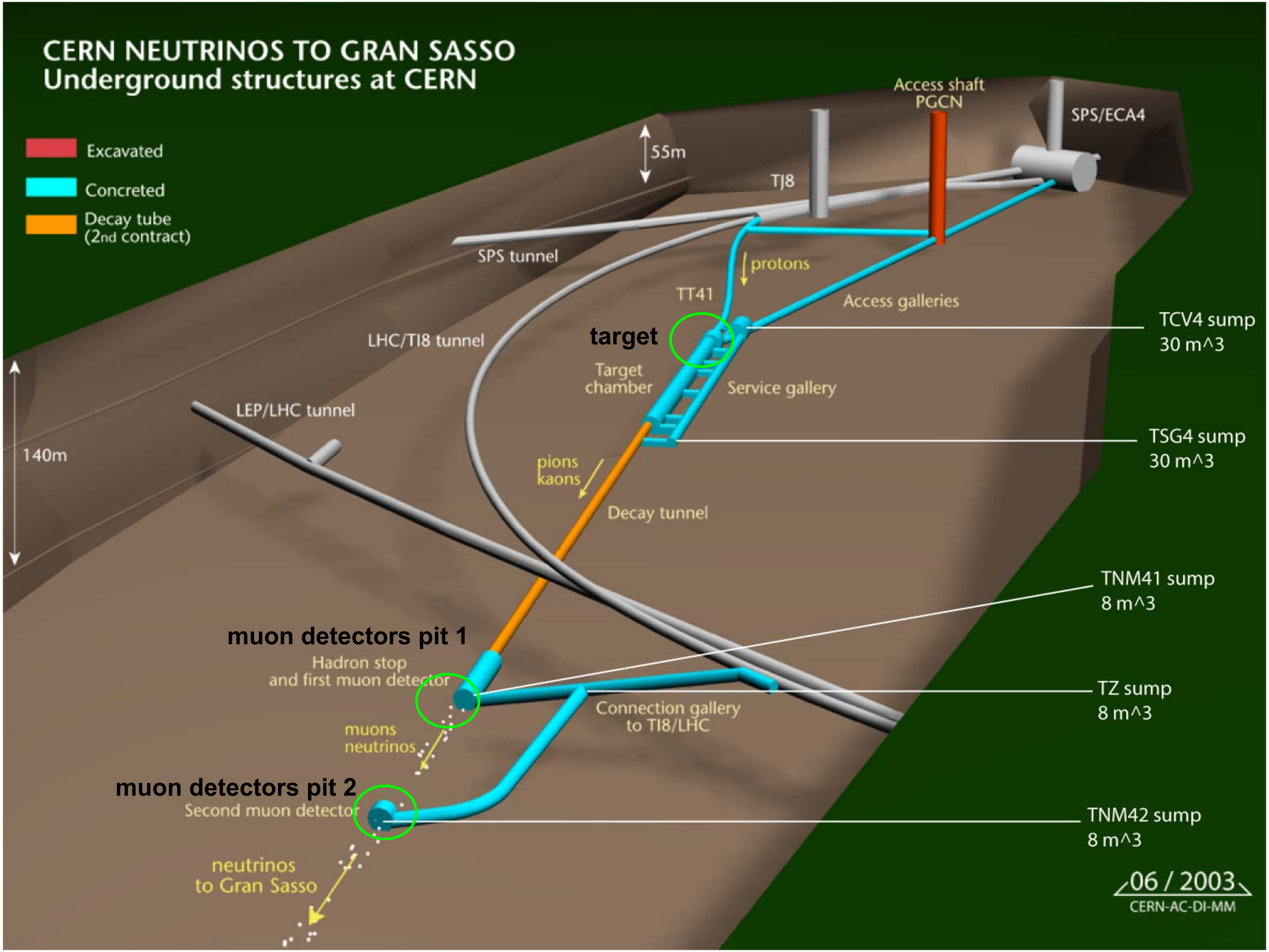
CNGS Operation in 2009

- CNGS profited from improvements made in the SPS control system to make it a real ppm machine!
  - Allows fast switching between super cycles → gain in time
- Also the shutdown work and improvements in the facility paid off
  - No additional stops for maintenance

11% gain in the pot this year

- Typical CNGS "night cycle" operation → **60.6% duty cycle for CNGS → 303kW**
  - This particular one during the MTE test – still under R&D

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neutrinos to Gran Sasso
06 / 2003
CERN-AC-DI-MM

Muon Monitors

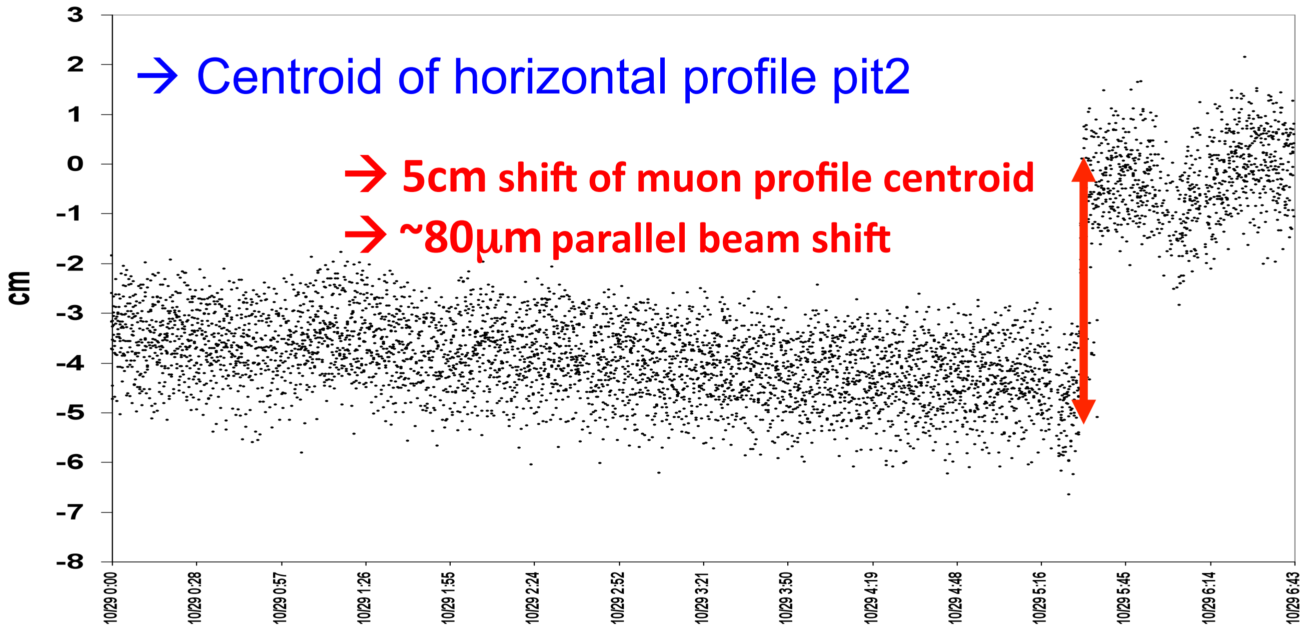
Very sensitive to any beam changes! → Online feedback on quality of neutrino beam

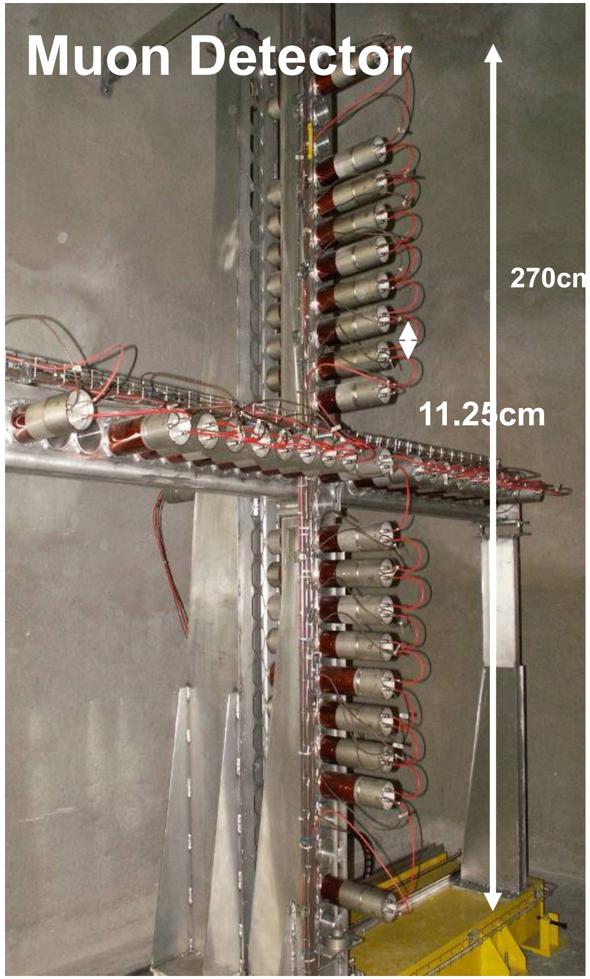
- Offset of beam vs target at 0.05mm level

  → Muon Profiles Pit 2

- Offset of target vs horn at 0.1mm level
  - Target table motorized
  - Horn and reflector tables not

  → Muon Profiles Pit 1

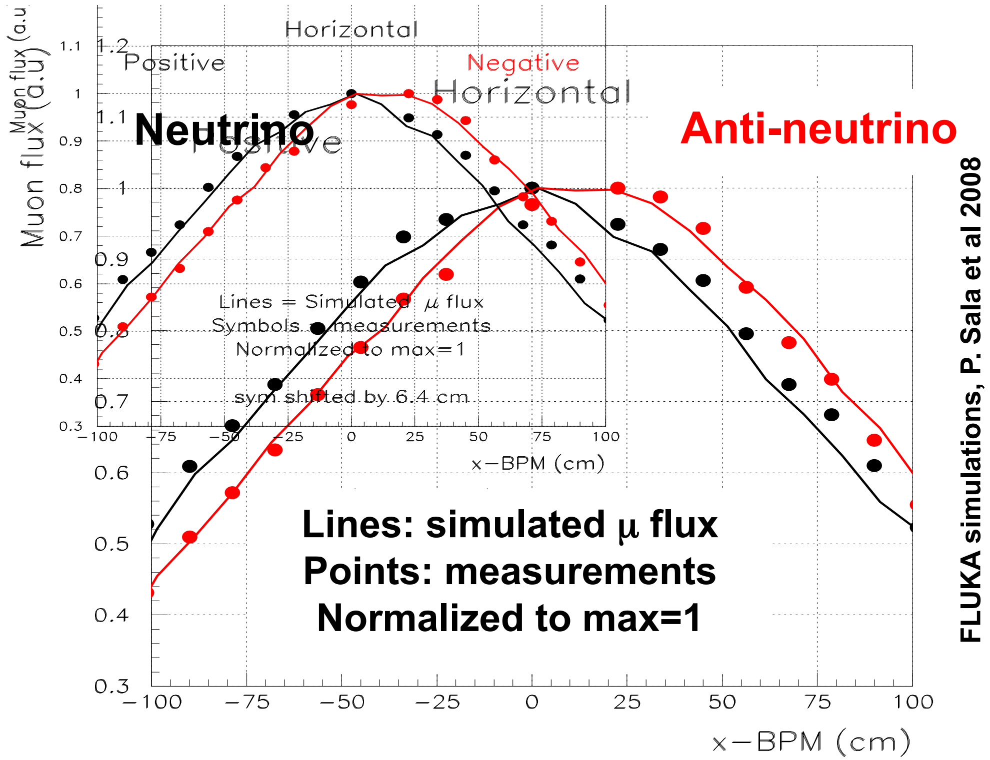




Muon Monitors

- Muon detectors were calibrated in M2 (COMPASS) muon beam line
- Observed asymmetry in the horizontal direction of the muon detector profile between
  - neutrinos (horn focusing on positively charged mesons) and
  - anti-neutrinos (horns focusing on negatively charged mesions)

was finally attributed to the earth magnetic field in the 1km long decay tube

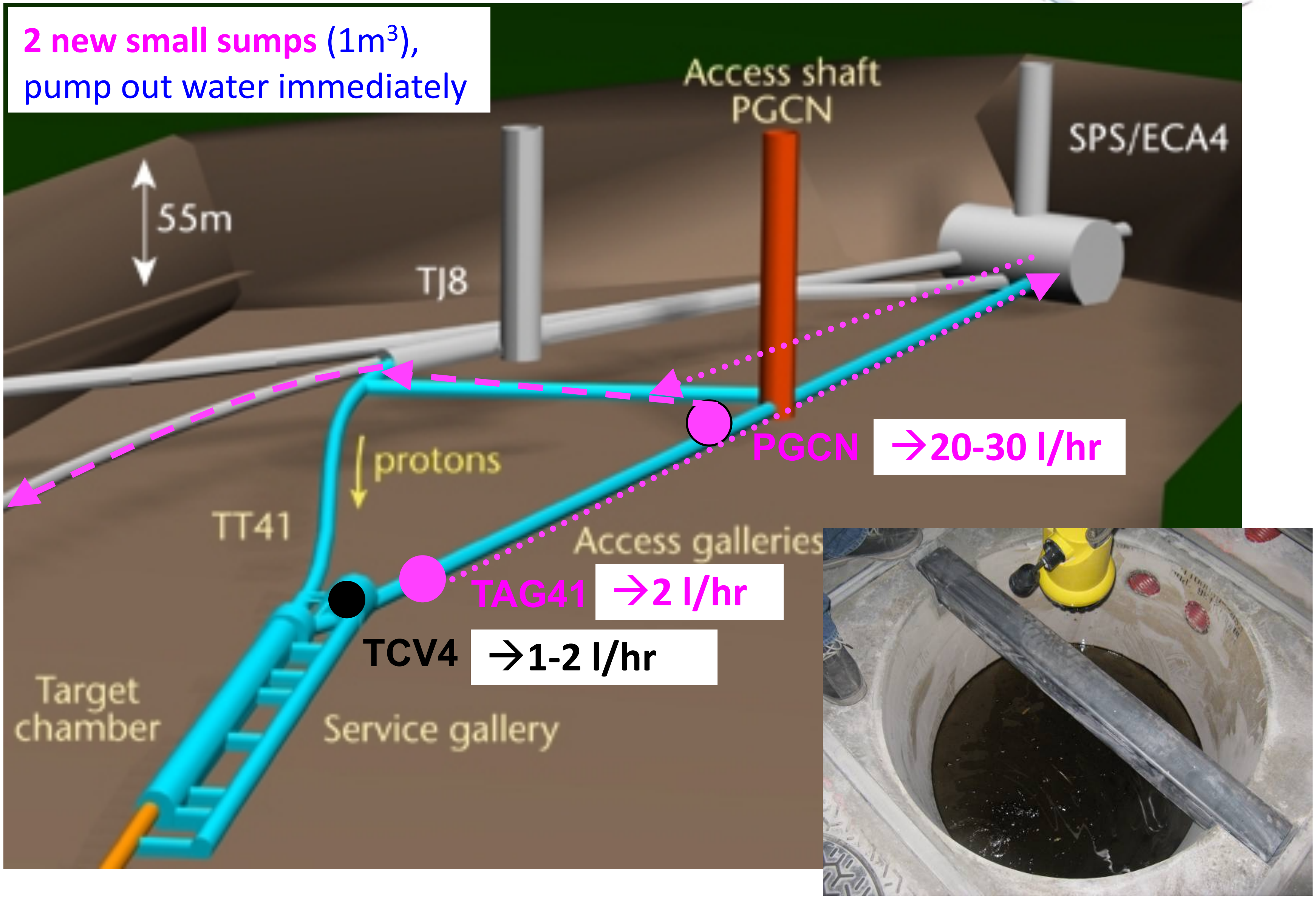


→Data & simulation agree within 5% (~10%) in first (second) muon pit

CNGS Shutdown Work 2009/2010

- General maintenance
- Modifications of the sump system in the CNGS area to avoid contamination of the drain water by tritium produced in the target chamber
  - Try to remove drain water before reaches the target areas and gets in contact with the air
  - Construction of two new sumps and piping work…
- Better understanding of the ventilation system configuration and operation
  - Assure the target chamber TCC4 remains in all cases in under pressure wrt the other areas
  - Do not propagate the tritiated air into other areas and in particular being in contact with the drain water

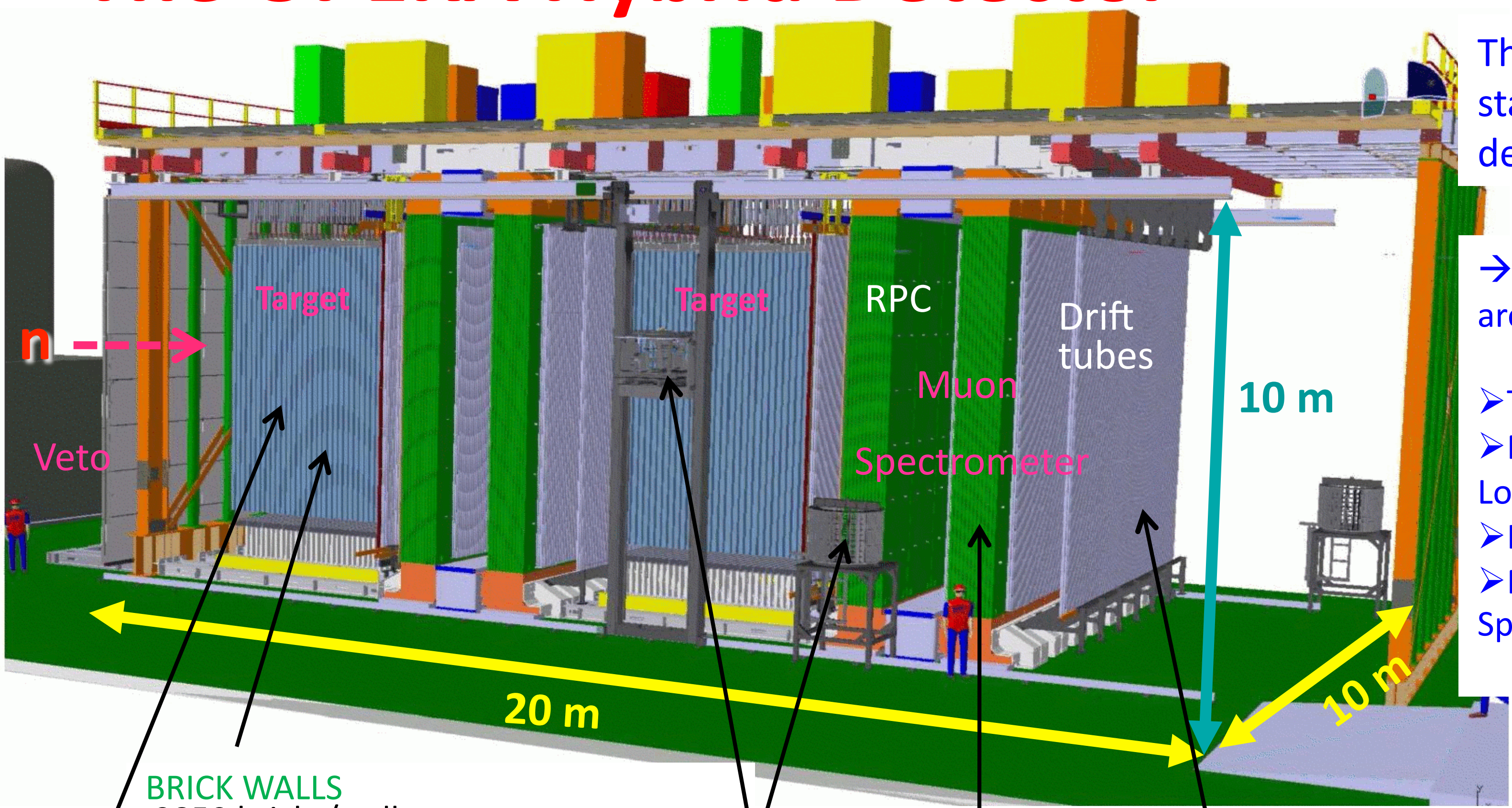
New Sump System in CNGS



- OPERA
- ICARUS

The OPERA Hybrid Detector

Courtesy of D. Autiero



The **bricks** are stand-alone passive detectors

→ **Electronic Detectors** are needed for:

- Triggering, Timing
- Neutrino interactions Location
- Hadronic calorimetry
- Muon I.D. and Spectrometry

BRICK WALLS
2850 bricks/wall
• 53 walls
•**150000 bricks ~ 1.25 kton**

BMS
Brick
Manipulator
System

HIGH PRECISION TRACKERS
6 drift-tube layers/spectrometer
spatial resolution < 0.5 mm

TARGET TRACKERS
- 2x31 scintillator strips walls
- 256+256 X-Y strips/wall
- WLS fiber readout
- 64-channel PMTs
- 63488 channels
- 0.8 cm resololution, 99% ε
- rate 20 Hz/pixel @1 p.e.

INNER TRACKERS
- 990-ton dipole magnets (B= 1.55 T), 5cm thick iron plates instrumented with 22 RPC planes
- 3050 m^2, ~1.3 cm res.

Courtesy of D. Autiero

OPERA Status

- OPERA has taken data in 2008 and 2009 for 5.3E19 pot, proving the full chain of events handling/analysis
- Electronic detectors performance reliable and well understood
- A systematic decay search was started on all 2008 (and then 2009) events in order to find all possible decay topologies
- Several charm events (20) found as expected
- Global analysis well in progress, ongoing studies on events kinematics and hadronic interactions background
- The 2010 run will start soon → hoping to achieve this year the nominal CNGS performance
- No tau signal seen yet, stay tuned!

Events location summary for 2008 run

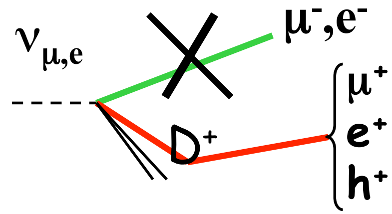
	0mu	1mu	All
Events predicted by the electronic detector	406	1292	1698
Found in CS	271	1045	1316
Vertices located in bricks	151	792	943
Vertices located in dead materials	6	38	44
Interactions in the upstream brick	6	33	39

Events location summary for 2009 run (in progress)

	0mu	1mu	All
Events predicted by the electronic detector	865	2297	3162
Extracted CS	829	2211	3040
CS Scanned	666	1802	2468
Found in CS	376	1139	1515
Vertices located in bricks	67	371	438
Vertices located in dead materials	2	11	13
Interactions in the upstream brick	3	36	39

→ About 1400 neutrino interaction vertices localized

Topological Identification and Kinematical Confirmation of a Charm Event

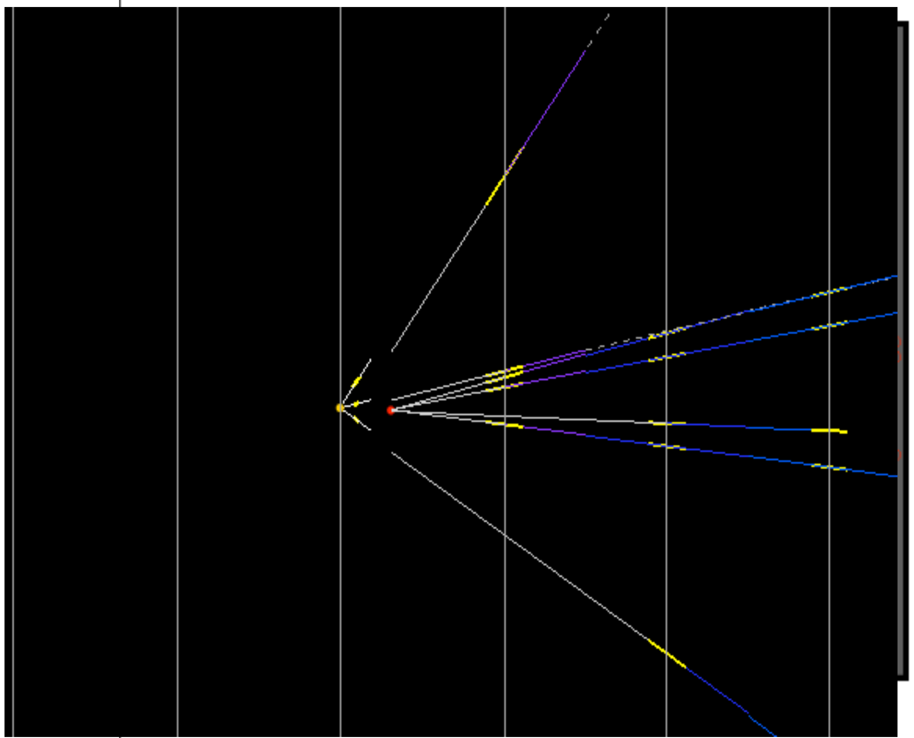


A D^0 4 prongs decay candidate:

All units are in microns !

Event 234654975

Brick 85405



VERTEX 1

	Impact Parameter
Track 1	1,36
Track 2	0,88
Track 7	0,51

X	66716,60
Y	49892,8
Z	90,9

Primary vertex

VERTEX 2

	Impact Parameter
Track 3	1,13
Track 4	1,81
Track 5	1,99
Track 6	1,39

X	66710,10
Y	49899
Z	403,9

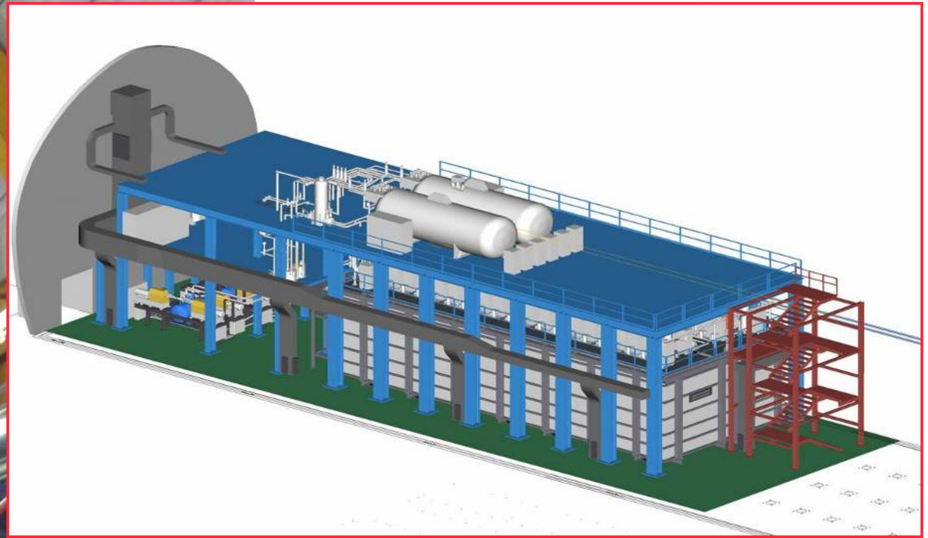
Decay vertex

D^0

Tx	Ty	Flight Length (µm)	phi	minimum mass (GeV/c²)
-0,0207	0,0198	313,1	173,2°	1,7

ICARUS – T600 @ LNGS Status

Courtesy of A. Guglielmi, P. Sala



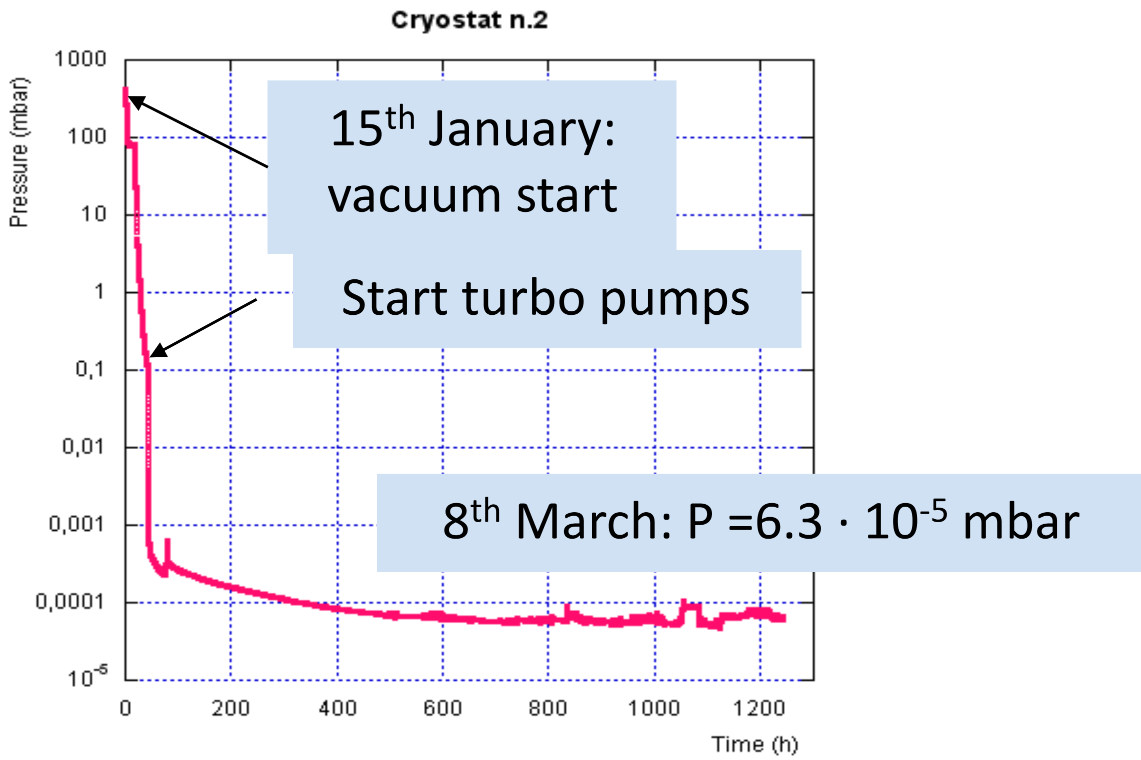
ICARUS – T600 Status

- Cryogenic plant
- Readout electronics
- Infrastructures

→ Completed in 2009

2010:

- vacuum test successful



Cooling and filling phase starting

→ Operational in May 2010

Summary

- CNGS had a smooth operation in 2009 with 11% more protons delivered to the target than originally foreseen
- The 2009/2010 shutdown was another busy year with CE works to resolve the problem with the tritium contamination in the drain water
- The physics run for 2010 will start on 29th April 2010, two weeks in advance wrt initial schedule for a dedicated CNGS run of SPS
- The data analysis in OPERA advances well; the ν_τ appearance observation maybe just around the corner !!
- Both OPERA and ICARUS experiments are ready for the first beam in 2010 for another year of smooth data-taking

Additional Slides

Why does TCV4 Water get Tritiated?

Tests with water buckets in TCV4 (March 2010): left there for 8 days

CNGS TCV4 sample 6	11-Mar-10	Bq/l	H-3: DL	metal container closed
CNGS TCV4 sample 7	11-Mar-10	Bq/l	H-3: 7080 (4%)	open bucket
CNGS TCV4 sample 8	11-Mar-10	Bq/l	H-3: 187 (9%)	bucket covered
CNGS TCV4 sample 9	11-Mar-10	Bq/l	H-3: DL	big plastic bottle with small cap
CNGS TCV4 sample 10	11-Mar-10	Bq/l	H-3: 17.1 (22%)	small plastic bottle with big cap

→ Air in target chamber TCC4 gets tritiated due to outgassing from shielding, walls, etc…
→ Air passes into TCV4 chamber (air leaks, etc…)
→ Exchange of this air with water → tritiates water (HTO)