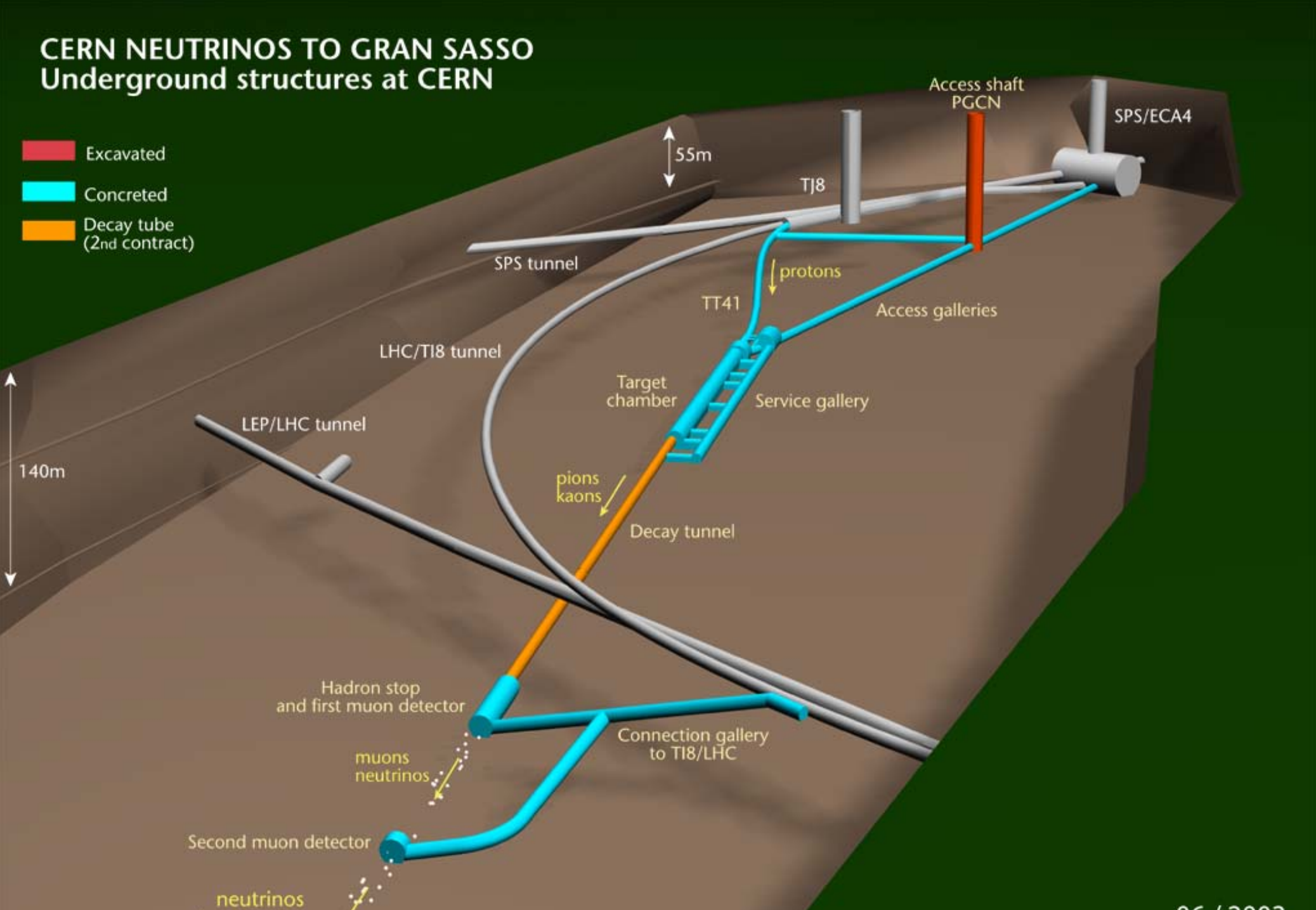
CNGS:
Status
and
Perspectives for 2007

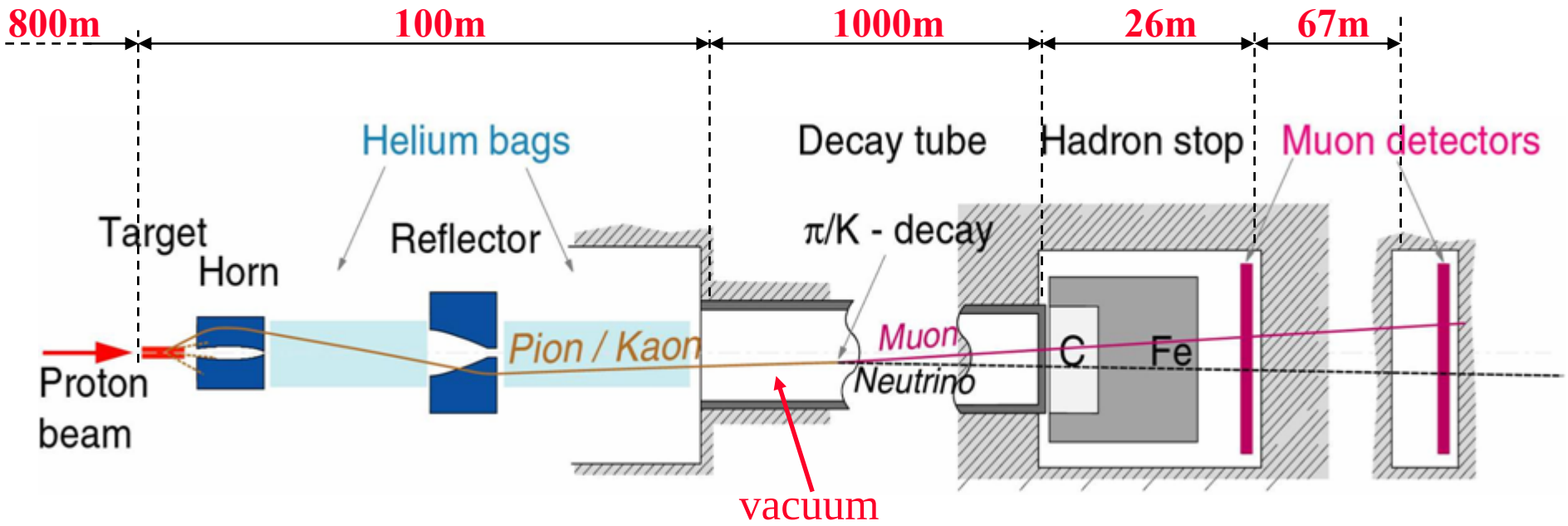
Edda Gschwendtner , CERN, Geneva

Outline

- CNGS Commissioning and Physics Operation 2006
- Reflector Leak
- Perspectives 2007


CERN NEUTRINOS TO GRAN SASSO
Underground structures at CERN
Excavated
Concreted
Decay tube
(2nd contract)
55m
140m
Access shaft
PGCN
SPS/ECA4
TI8
SPS tunnel
protons
TT41
Access galleries
LHC/TI8 tunnel
Target
chamber
Service gallery
LEP/LHC tunnel
pions
kaons
Decay tunnel
Hadron stop
and first muon detector
Connection gallery
to TI8/LHC
muons
neutrinos
Second muon detector
neutrinos

CNGS Layout

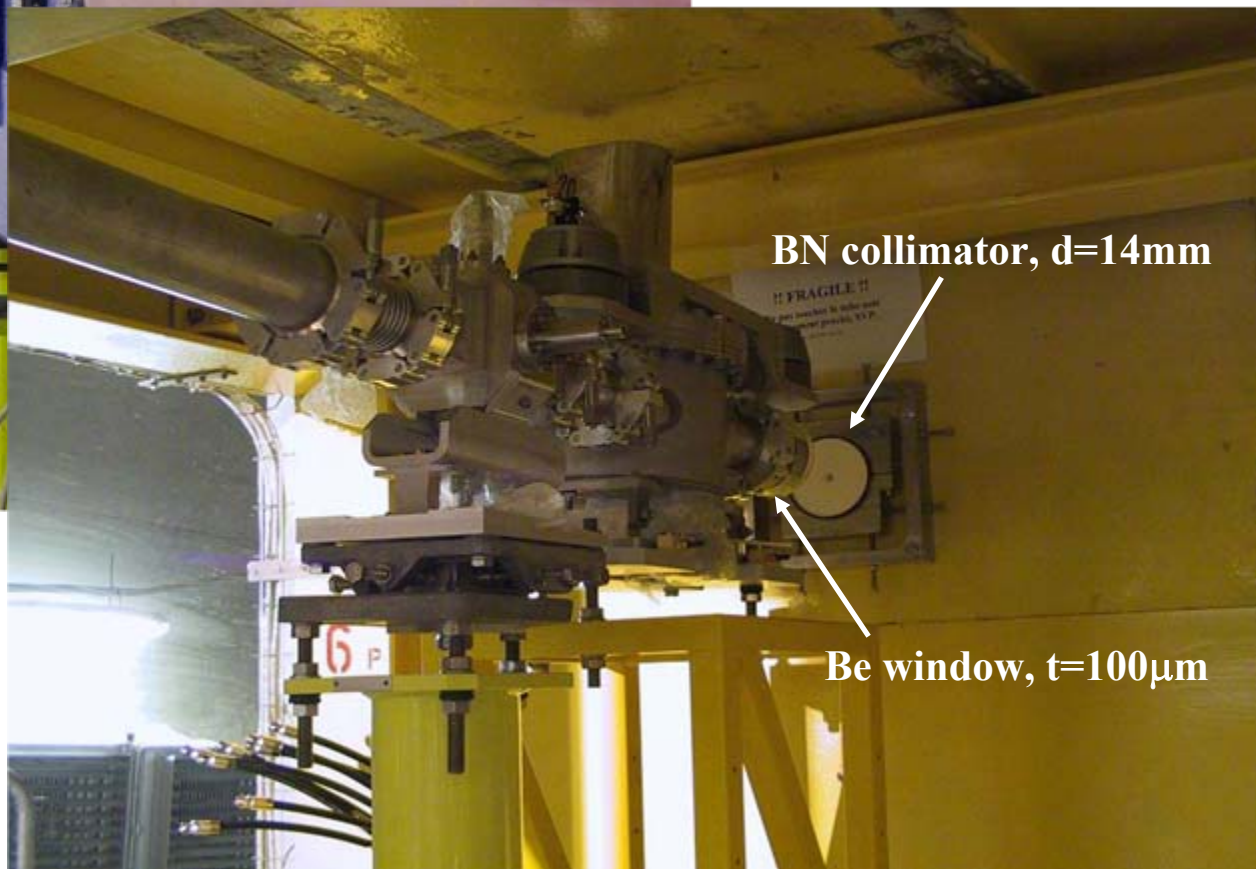


$$p + C \rightarrow \text{(interactions)} \rightarrow \pi^+,\ K^+ \rightarrow \text{(decay in flight)} \rightarrow \mu^+ + \nu_\mu$$

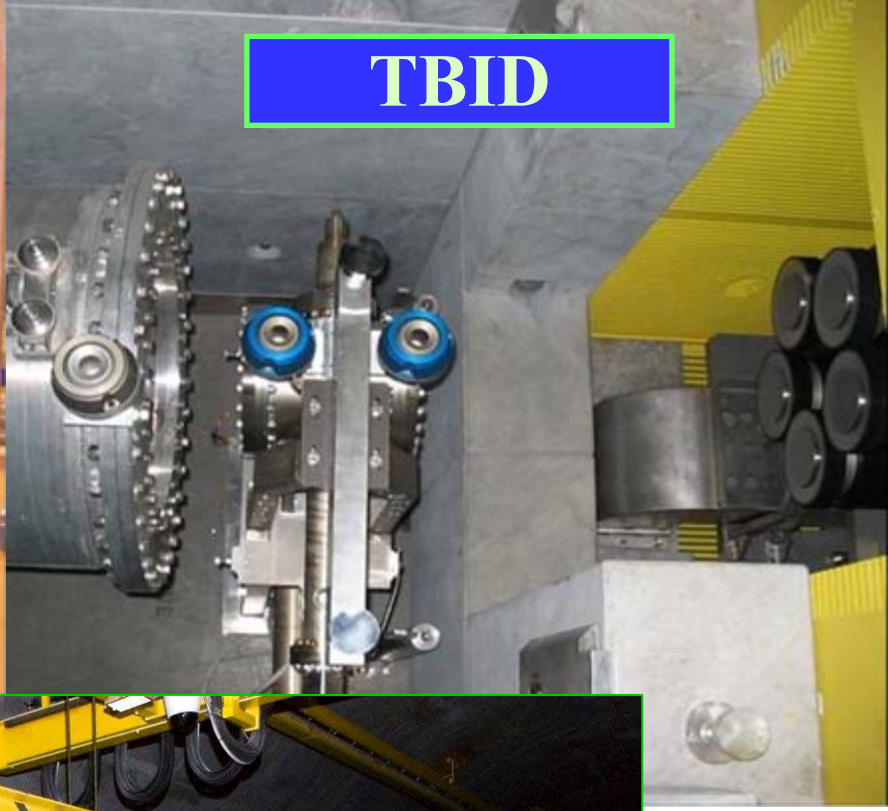
73 MBG (Dipoles)

20 QTG (Quadruples)

12 MDG (Corrector Magnets)



Proton Beam Line

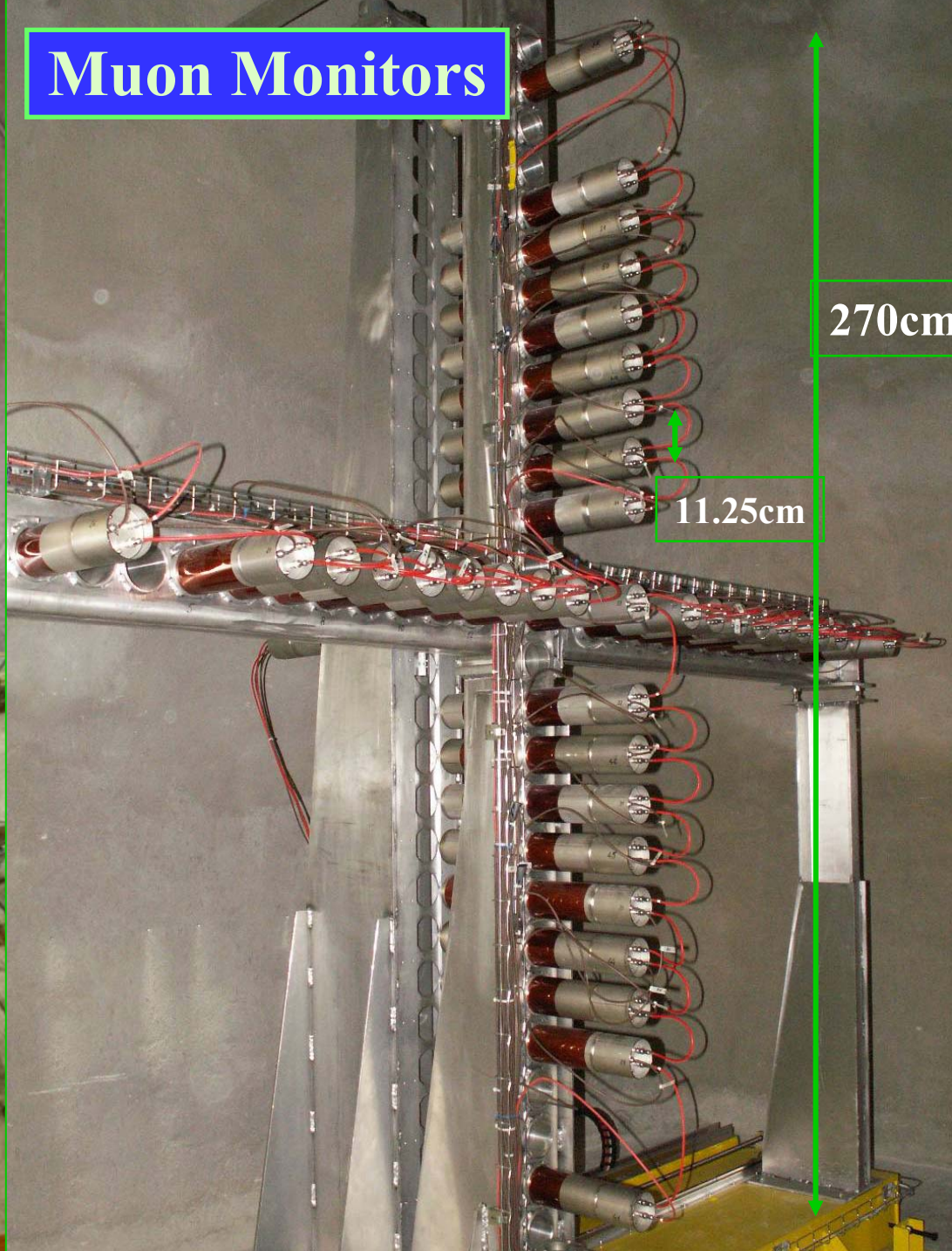


Horn

Decay Tube

Hadron Stop

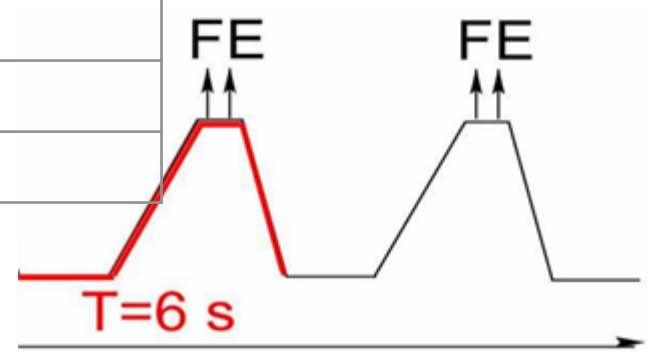
Muon Monitors



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

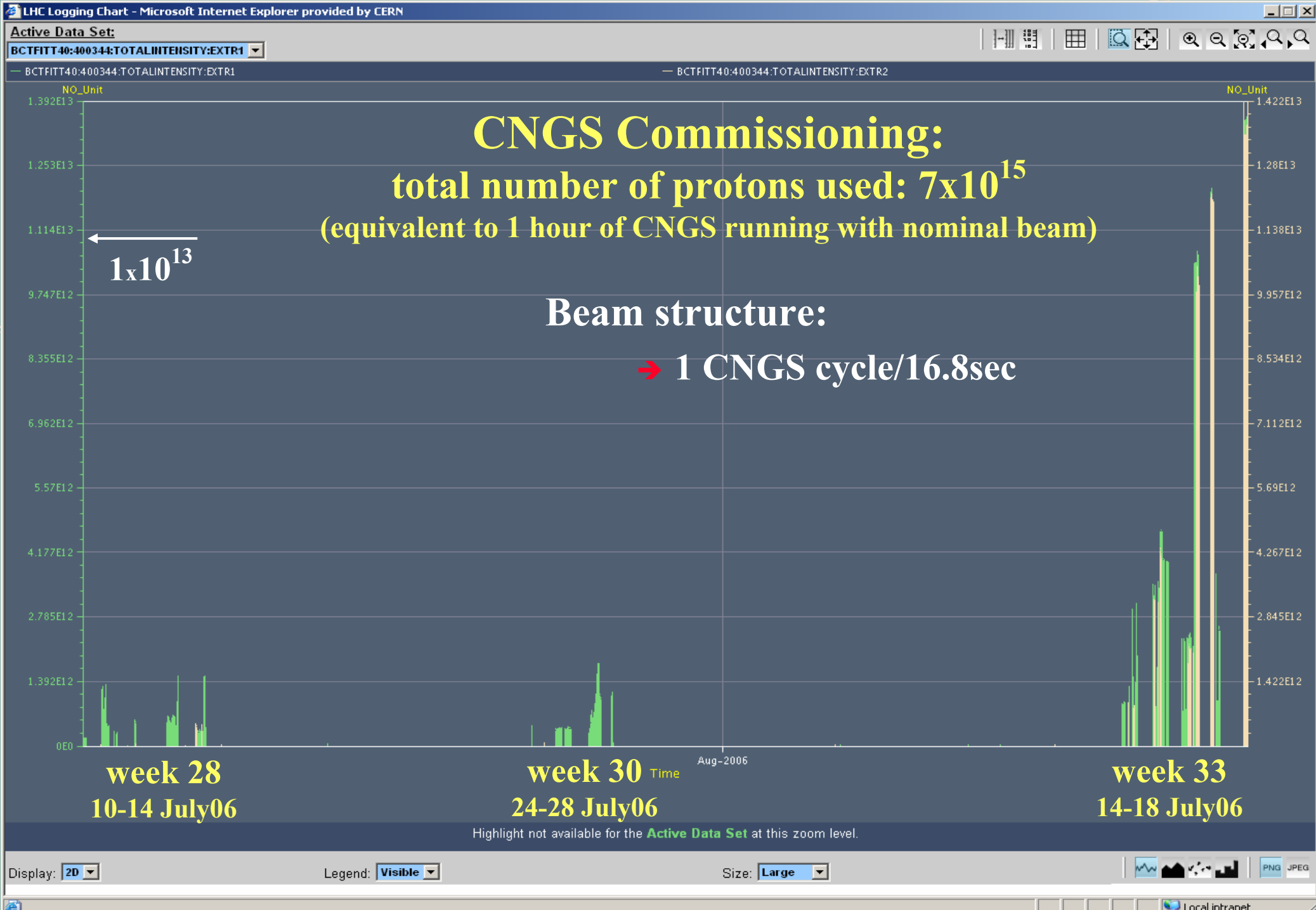
~500kW beam power



Expected beam performance: 4.5 x 10^{19} protons/year on target

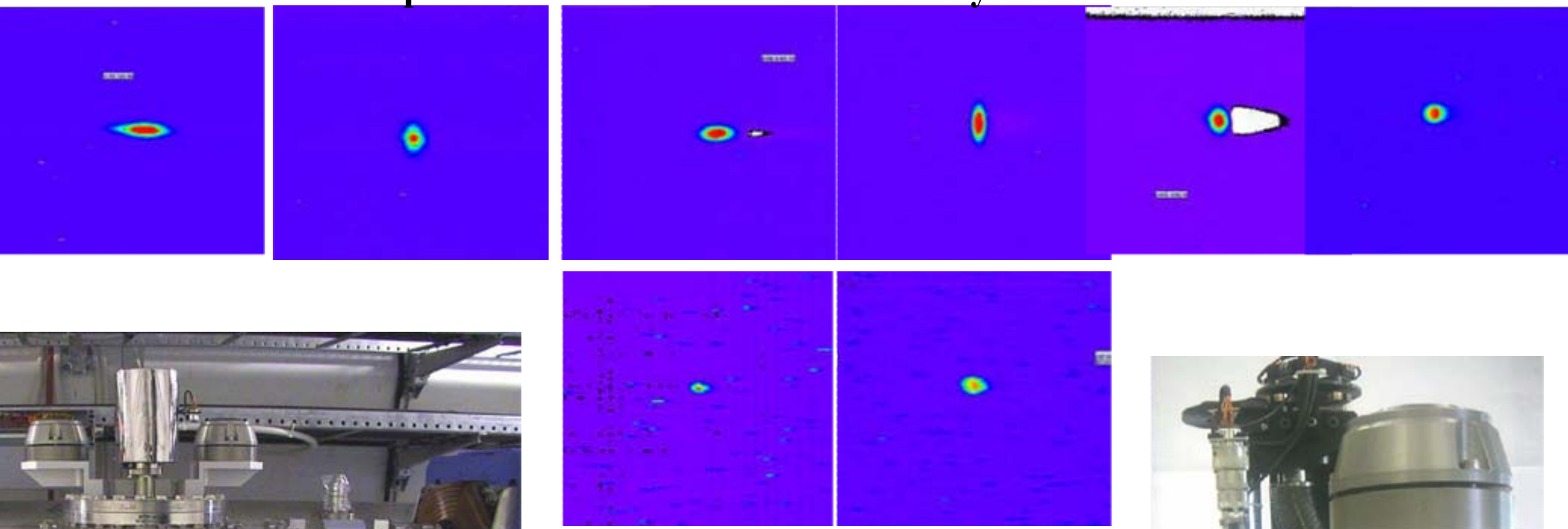
CNGS Schedule

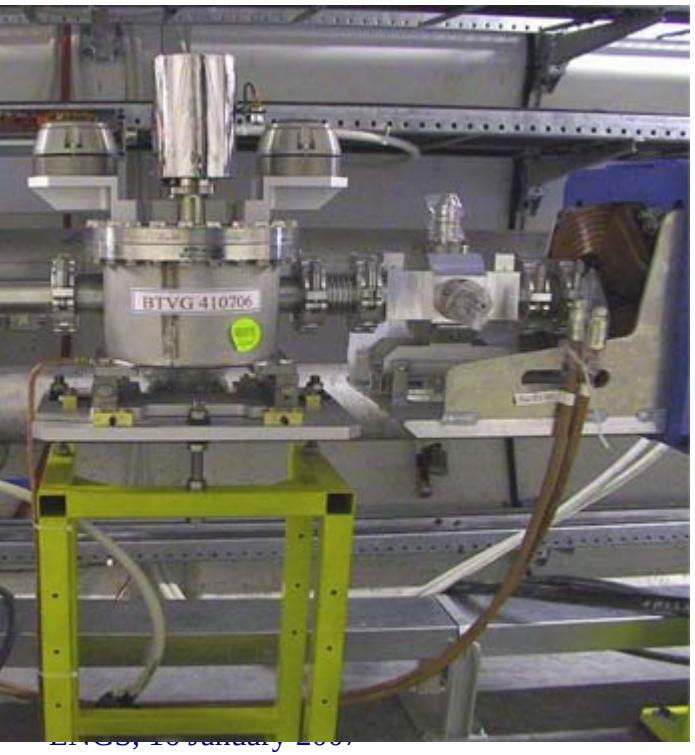
- **Construction**
  - ➔ **2000 – 2006**
- **Hardware commissioning**
  - ➔ **Feb. – April 2006**
- **'Dry runs' from CCC**
  - ➔ **April – May 2006**
- **Commissioning with beam**
  - ➔ **weeks 28, 30 and 33 in July/August 2006**
- **Physics Runs:**
  - ➔ **18-30 August 2007**
  - ➔ **26-27 October 2007**


LHC Logging Chart - Microsoft Internet Explorer provided by CERN
Active Data Set:
BCTFITT40:400344:TOTALINTENSITY:EXTR1
BCTFITT40:400344:TOTALINTENSITY:EXTR1
BCTFITT40:400344:TOTALINTENSITY:EXTR2
NO_Unit
NO_Unit
1.392E13
1.253E13
1.114E13
9.747E12
8.355E12
6.962E12
5.57E12
4.177E12
2.785E12
1.392E12
0E0
1.422E13
1.28E13
1.138E13
9.957E12
8.534E12
7.112E12
5.69E12
4.267E12
2.845E12
1.422E12
CNGS Commissioning:
total number of protons used: 7x10^15
(equivalent to 1 hour of CNGS running with nominal beam)
1x10^13
Beam structure:
1 CNGS cycle/16.8sec
Aug-2006
week 28
10-14 July06
week 30
24-28 July06
Time
week 33
14-18 July06
Highlight not available for the Active Data Set at this zoom level.
Display: 2D
Legend: Visible
Size: Large
PNG
JPEG
Local intranet

FIRST SHOT 11 July 2006

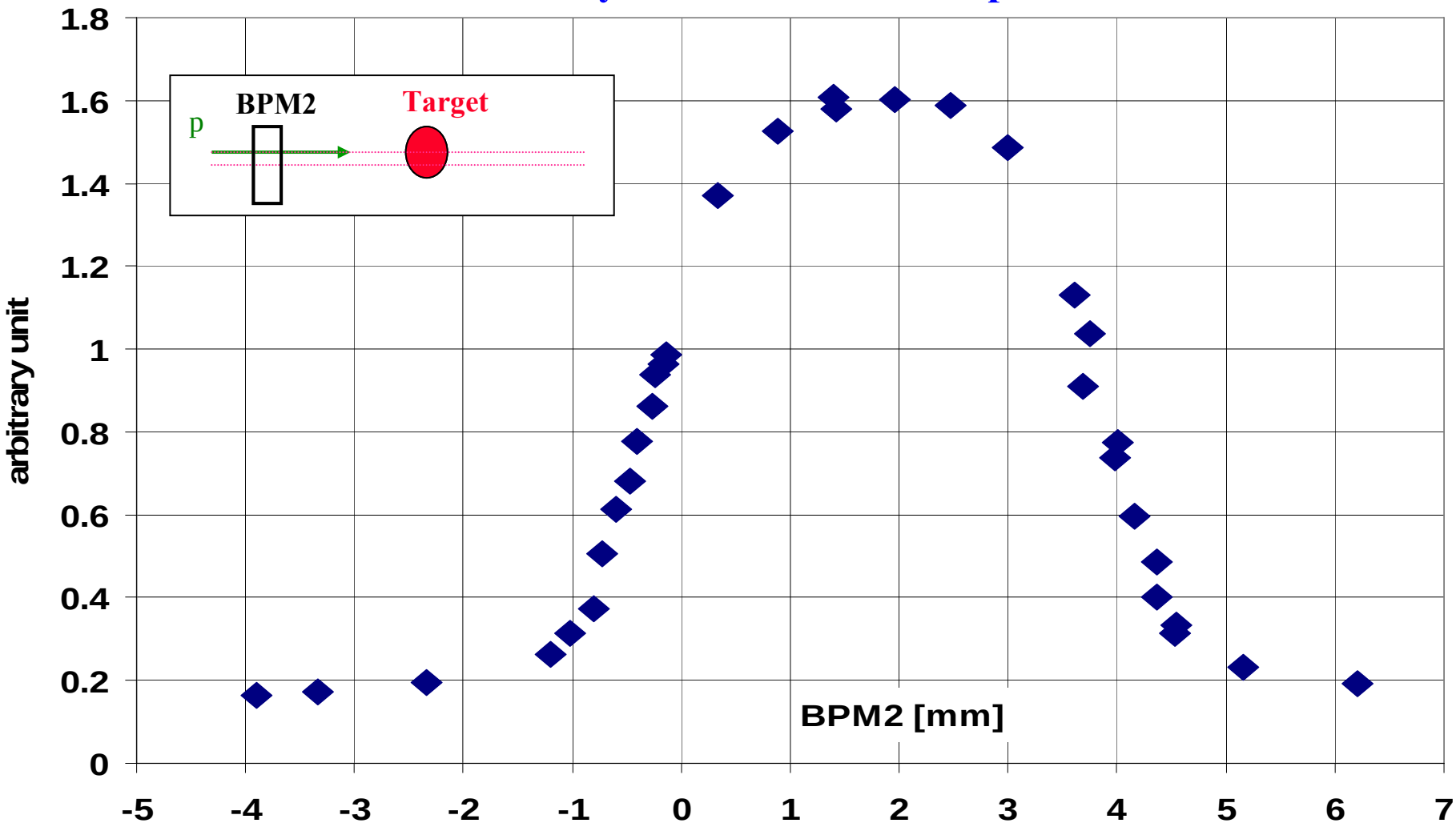
1st shot down proton beam line: beam is already well centered on screens



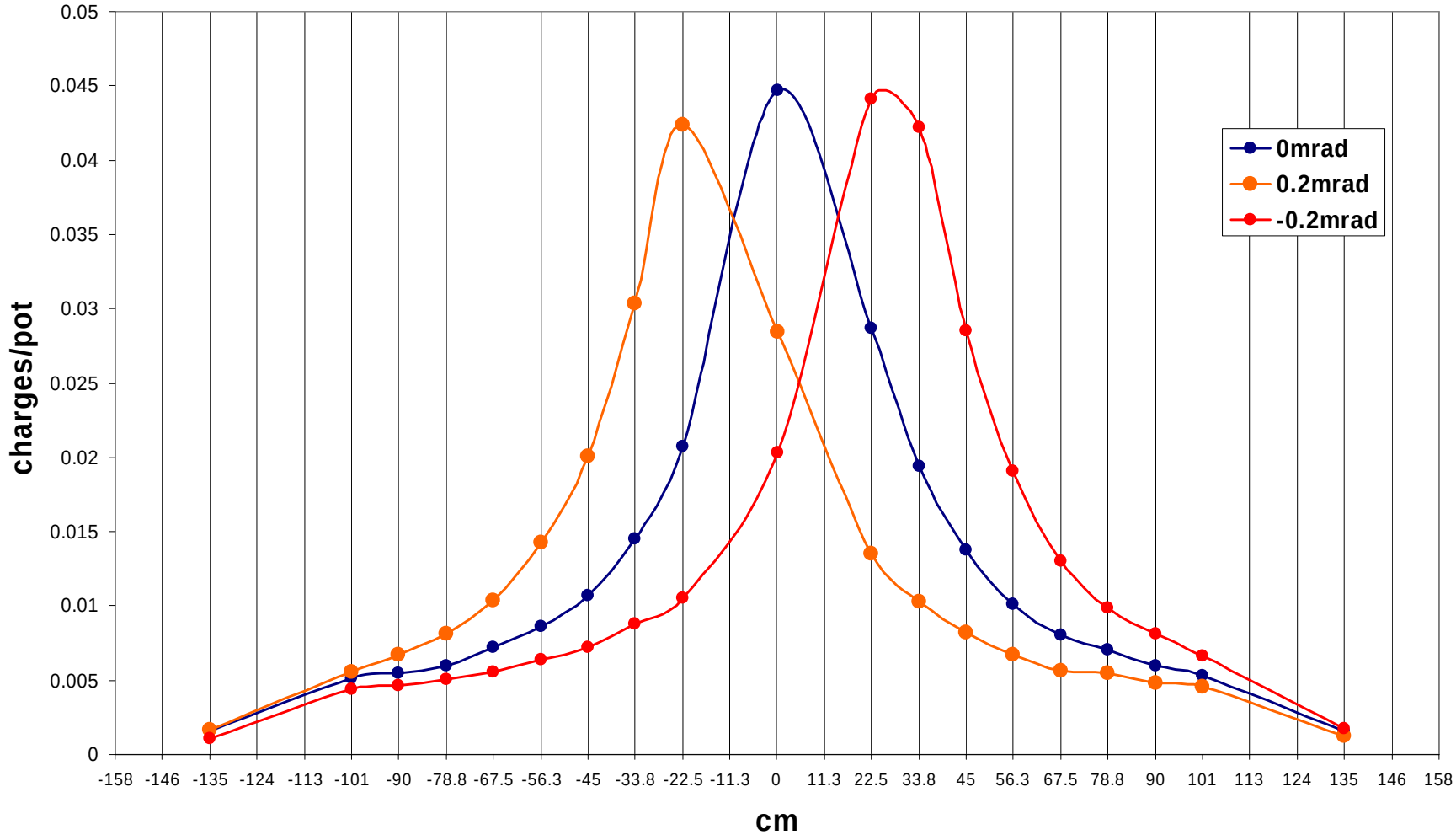


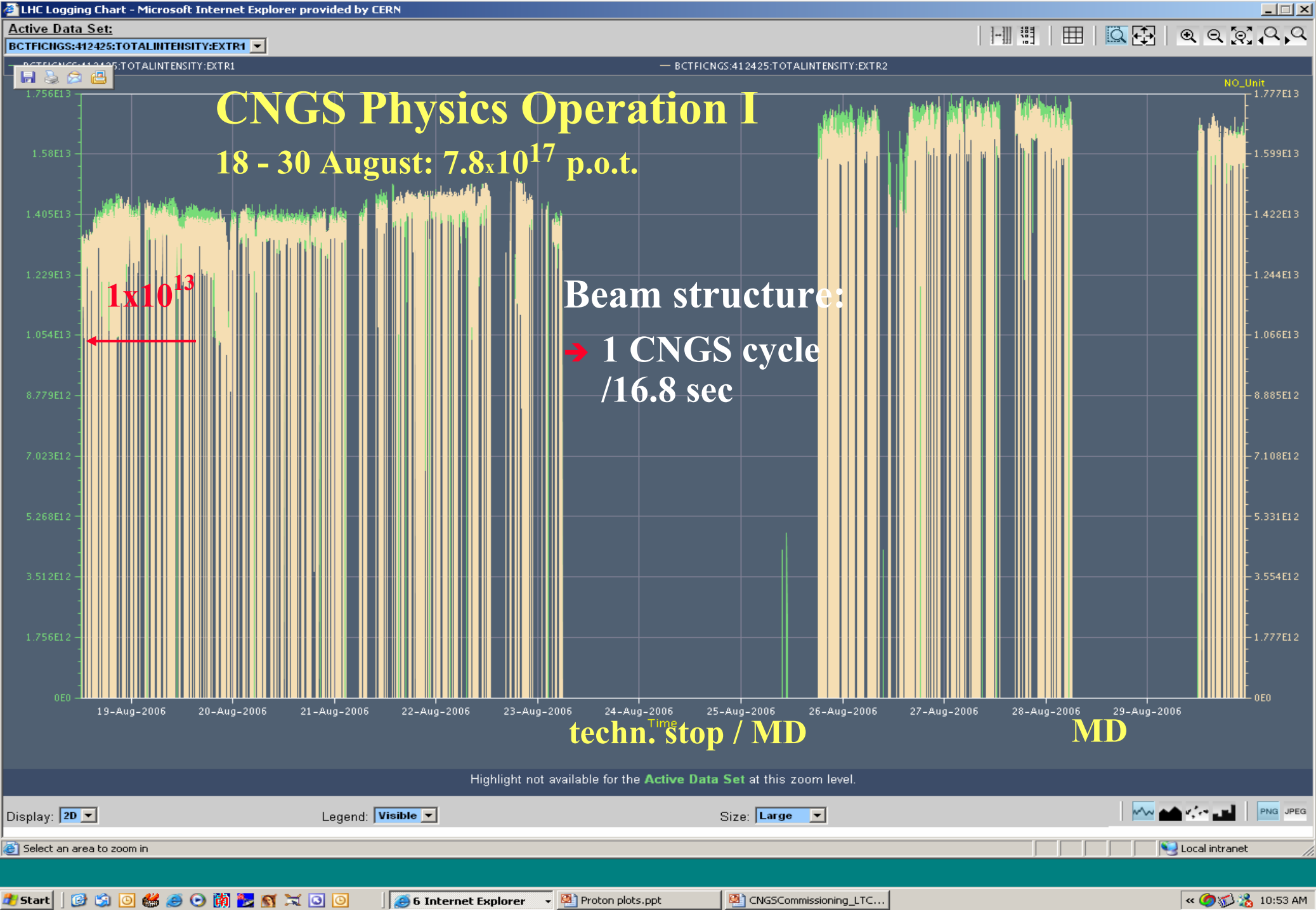
8 profile monitors (BTVG):
Optical Transition Radiation screens:
- **75 μm carbon**
- **12 μm titanium screens**

Horizontal Beam Scan, Target IN

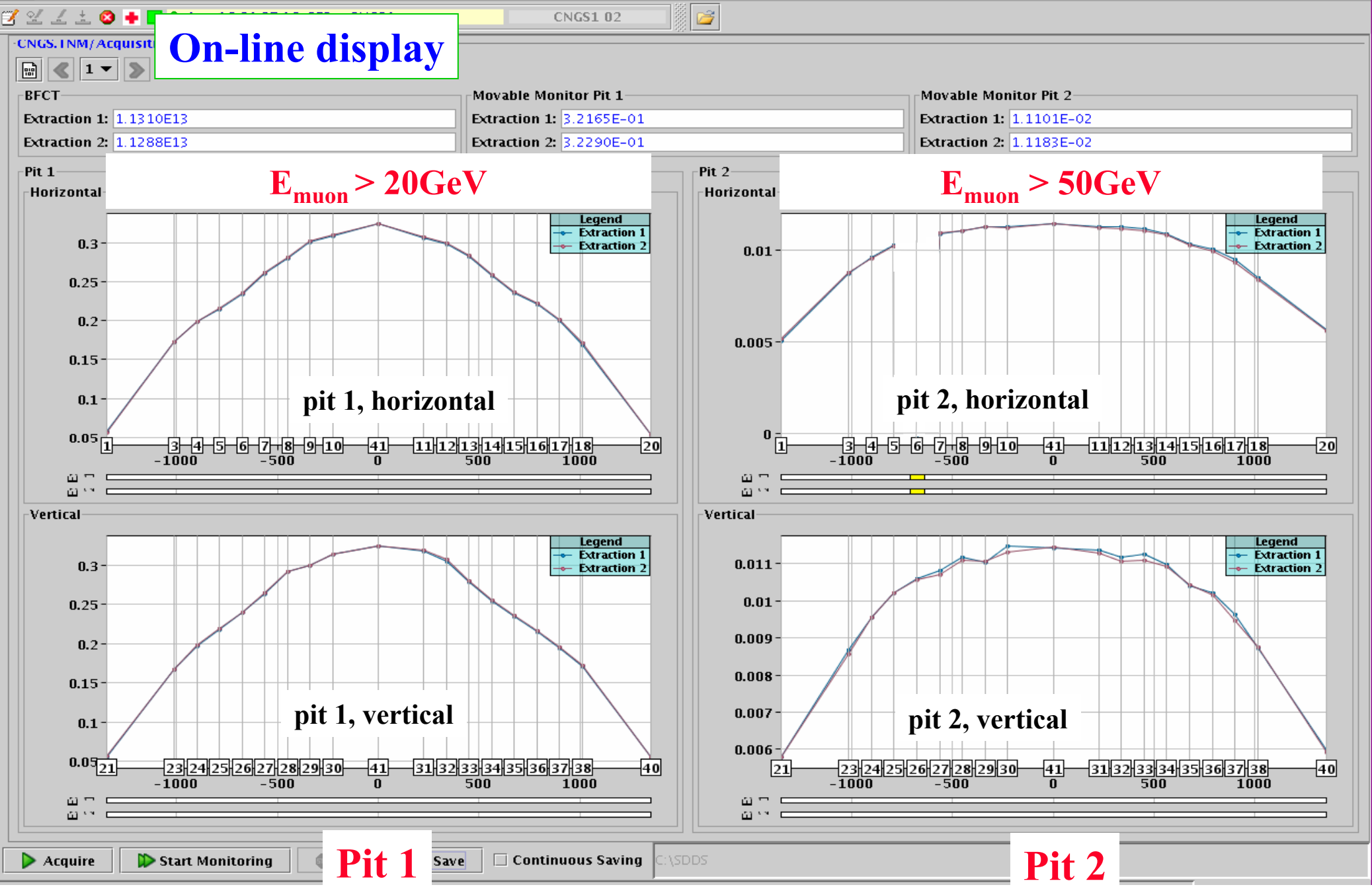


Horizontal Angular Scan, Target Out




LHC Logging Chart - Microsoft Internet Explorer provided by CERN
Active Data Set:
BCTFICNGS:412425:TOTALINTENSITY:EXTR1
BCTFICNGS:412425:TOTALINTENSITY:EXTR1
BCTFICNGS:412425:TOTALINTENSITY:EXTR2
NO_Unit
CNGS Physics Operation I
18 - 30 August: 7.8x10^17 p.o.t.
1x10^13
Beam structure:
1 CNGS cycle /16.8 sec
1.756E13
1.58E13
1.405E13
1.229E13
1.054E13
8.779E12
7.023E12
5.268E12
3.512E12
1.756E12
0E0
1.777E13
1.599E13
1.422E13
1.244E13
1.066E13
8.885E12
7.108E12
5.331E12
3.554E12
1.777E12
0E0
19-Aug-2006
20-Aug-2006
21-Aug-2006
22-Aug-2006
23-Aug-2006
24-Aug-2006
25-Aug-2006
26-Aug-2006
27-Aug-2006
28-Aug-2006
29-Aug-2006
Time
techn. stop / MD
MD
Highlight not available for the Active Data Set at this zoom level.
Display: 2D
Legend: Visible
Size: Large
PNG JPEG
Select an area to zoom in
Local intranet
Start
6 Internet Explorer
Proton plots.ppt
CNGSCommissioning_LTC...
10:53 AM

On-line display



$E_{muon} > 20GeV$

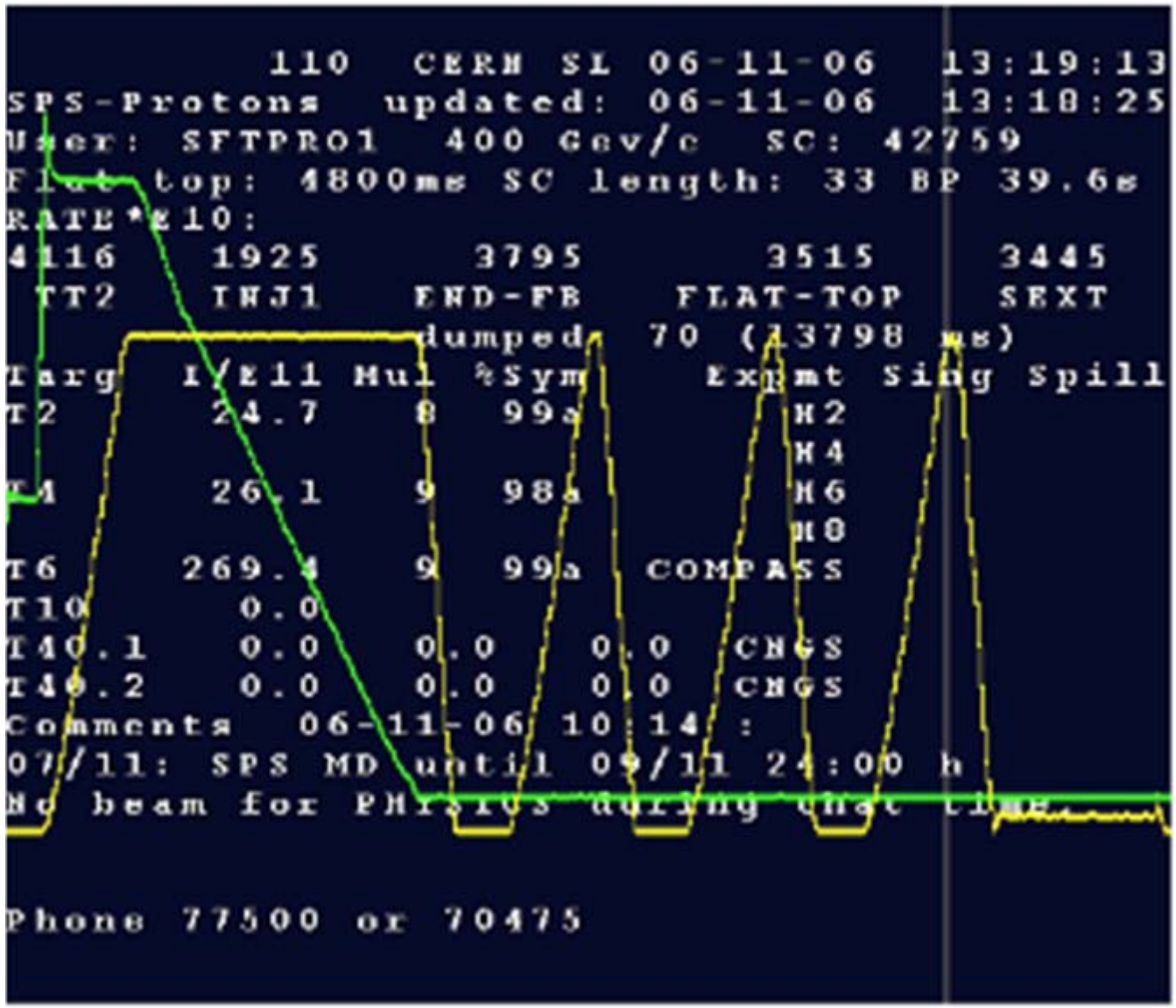
$E_{muon} > 50GeV$

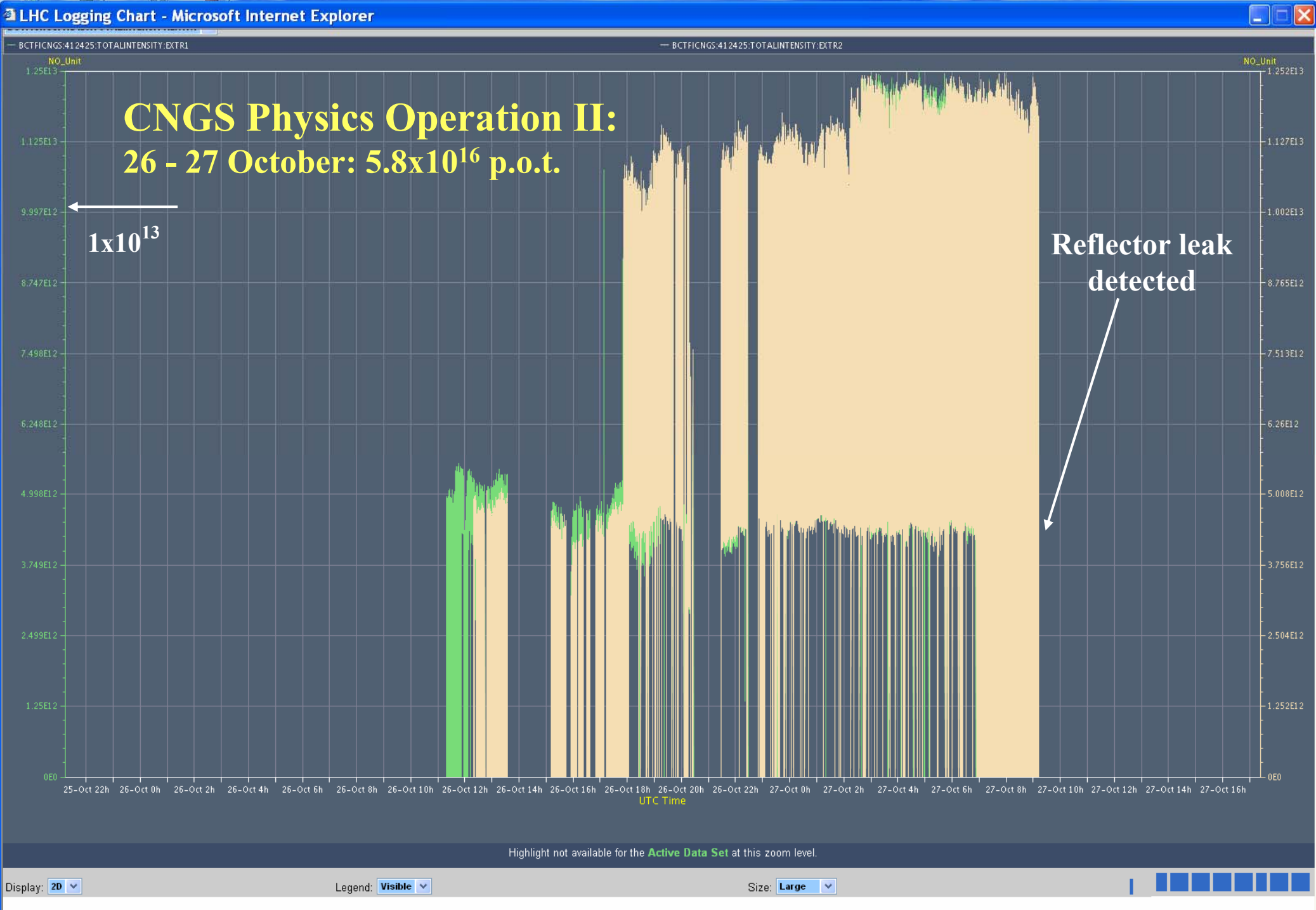
Pit 1

Pit 2

Physics Operation II: 26-27 October 2006

- **Beam structure**
  - ➔ **3 CNGS cycles/34.8 sec**




LHC Logging Chart - Microsoft Internet Explorer
BCTFICNGS:412425:TOTALINTENSITY:EXTR1
BCTFICNGS:412425:TOTALINTENSITY:EXTR2
NO_Unit
CNGS Physics Operation II:
26 - 27 October: 5.8x10^16 p.o.t.
1x10^13
Reflector leak detected
UTC Time
Highlight not available for the Active Data Set at this zoom level.
Display: 2D
Legend: Visible
Size: Large

CNGS Run 2006

	Date	Extractions	Protons
Commissioning W28	10 – 14 Jul. 2006	300	1.3 E14
Commissioning W30	31 Jul. – 4 Aug. 2006	500	2.4 E14
Commissioning W33	14 – 18 Aug. 2006	1300	6.5 E15
Physics Operation I	18 – 30 Aug. 2006	53000	7.8 E17
Low Intensity Tests	12 – 13 Oct. 2006	2500	9.5 E15
Physics Operation II	26 – 27 Oct. 2006	8300	5.8 E16

- Maximum proton intensity reached in 2006: 3.5 $\cdot 10^{13}$/cycle at 400GeV
  - ➔ Corresponds to 60% of SPS record intensitiy reached in 2004
- Radiation limits at PS prevented reaching higher intensities
  - ➔ Problem seems to be understood
- While setting up high intensities for all 3 cycles, reflector leak appeared

What Have We Learnt?

- **Commissioning was very successful**
  - ➔ **Detailed hardware commissioning**
  - ➔ **'Dry runs'**
    - **Allowed early debugging of all systems**
- **Smooth start-up**
  - ➔ **Beam interlock system very good**
  - ➔ **Extraction channel well tuned**
  - ➔ **Beam well centered along beam line**
    - **Beam position stability: 50 μm rms**
    - **Beam spot at target: 0.5 mm rms.**
  - ➔ **Centering of beam vs. target and horn**
  - ➔ **Muon monitors: very sensitive to any beam changes**
    - **Used as on-line feedback for quality control of neutrino beam.**

What Have We Learnt II ?

Radiation Protection constraints to CNGS operation

- **Cool down limit for starting access into CNGS**
  - ➔ **2hr + 4hr (i.e. 4 hr ventilation on)**
- **RP inspection mandatory before any access is granted:**
  - ➔ **Takes ~1/2 day (surveys, taking samples, etc.)**
- **Dose planning mandatory for any interventions**

Issues Requiring more Studies

- **TBID calibration:**
  - ➔ **Move target out**
- **Polarity change:**
  - ➔ **Understand different muon signals**
- **Muon detectors:**
  - ➔ **linearity effects with high intensity**

- **Alignment of beam with respect to target and horn**
  - ➔ **Might need to be done regularly (every month)**

CNGS Reflector

The CNGS Reflector

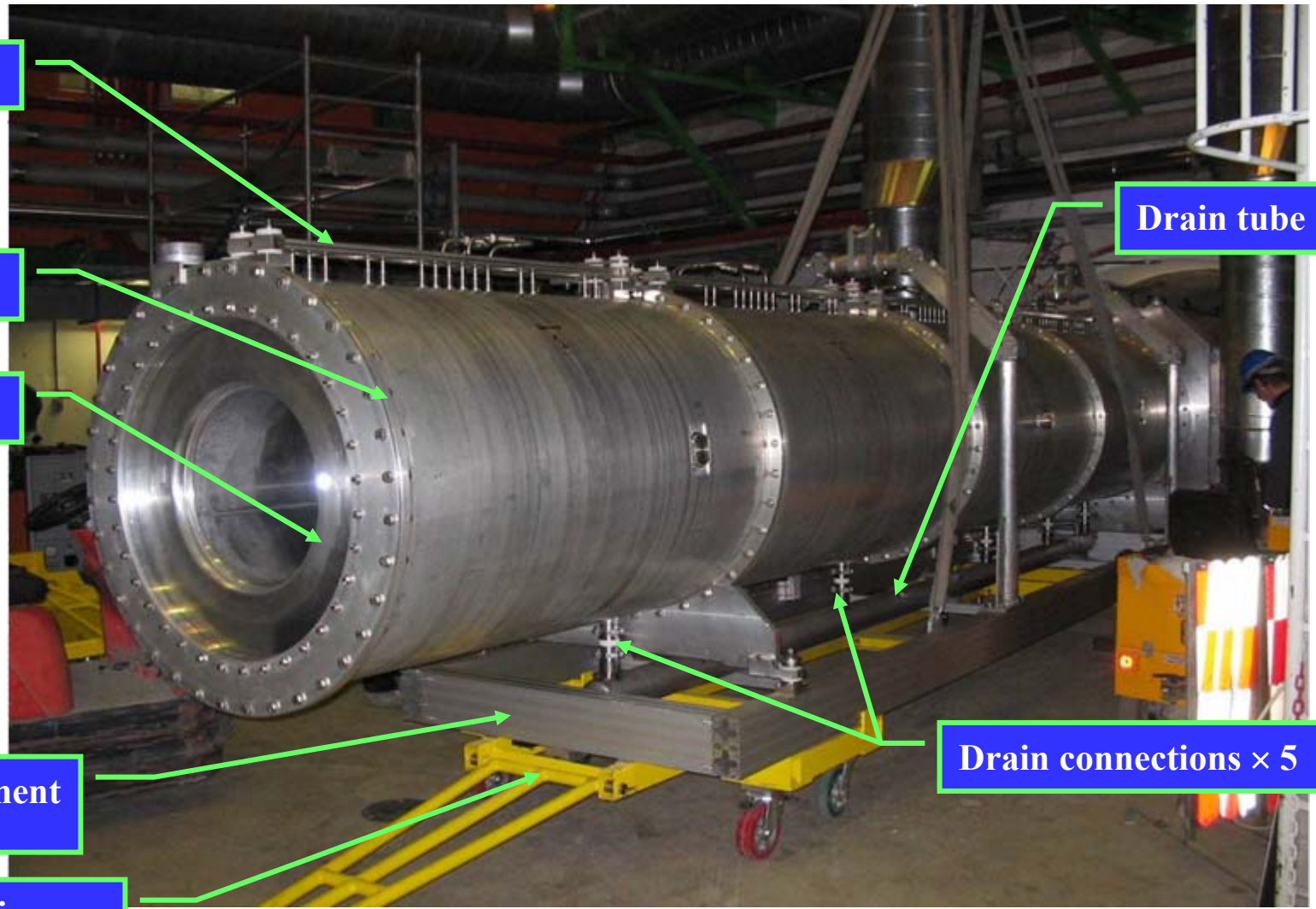
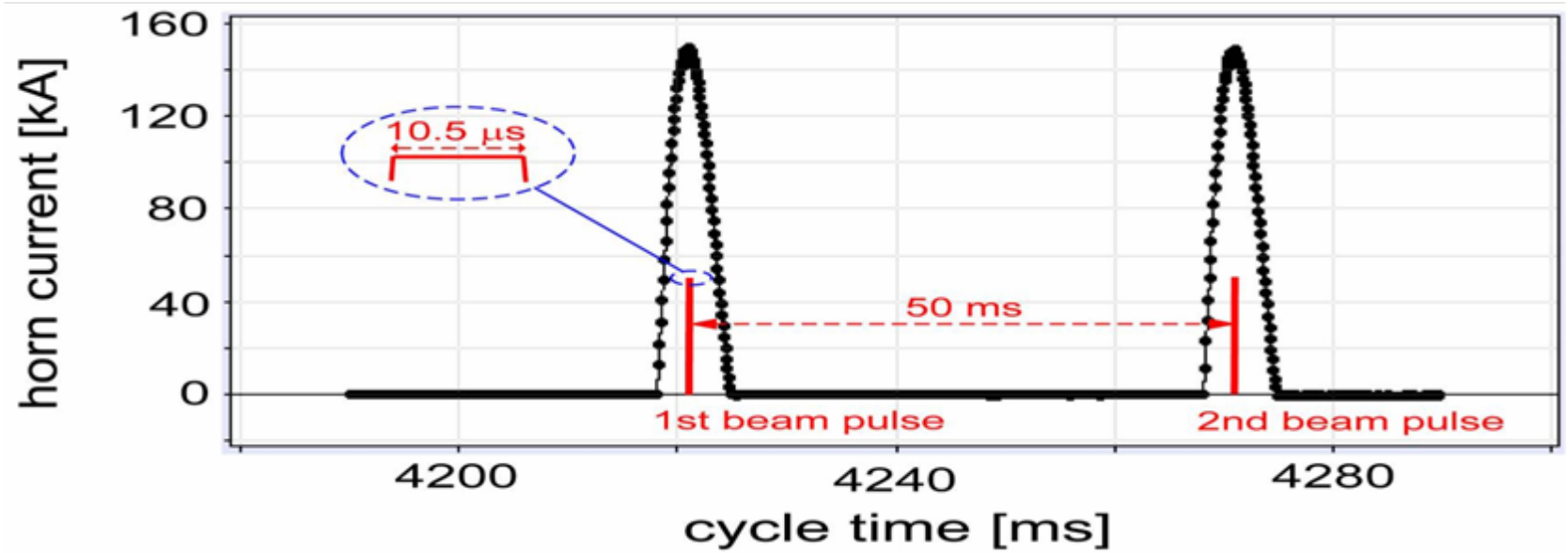


Photo of the CNGS reflector during its transport to TCC4.

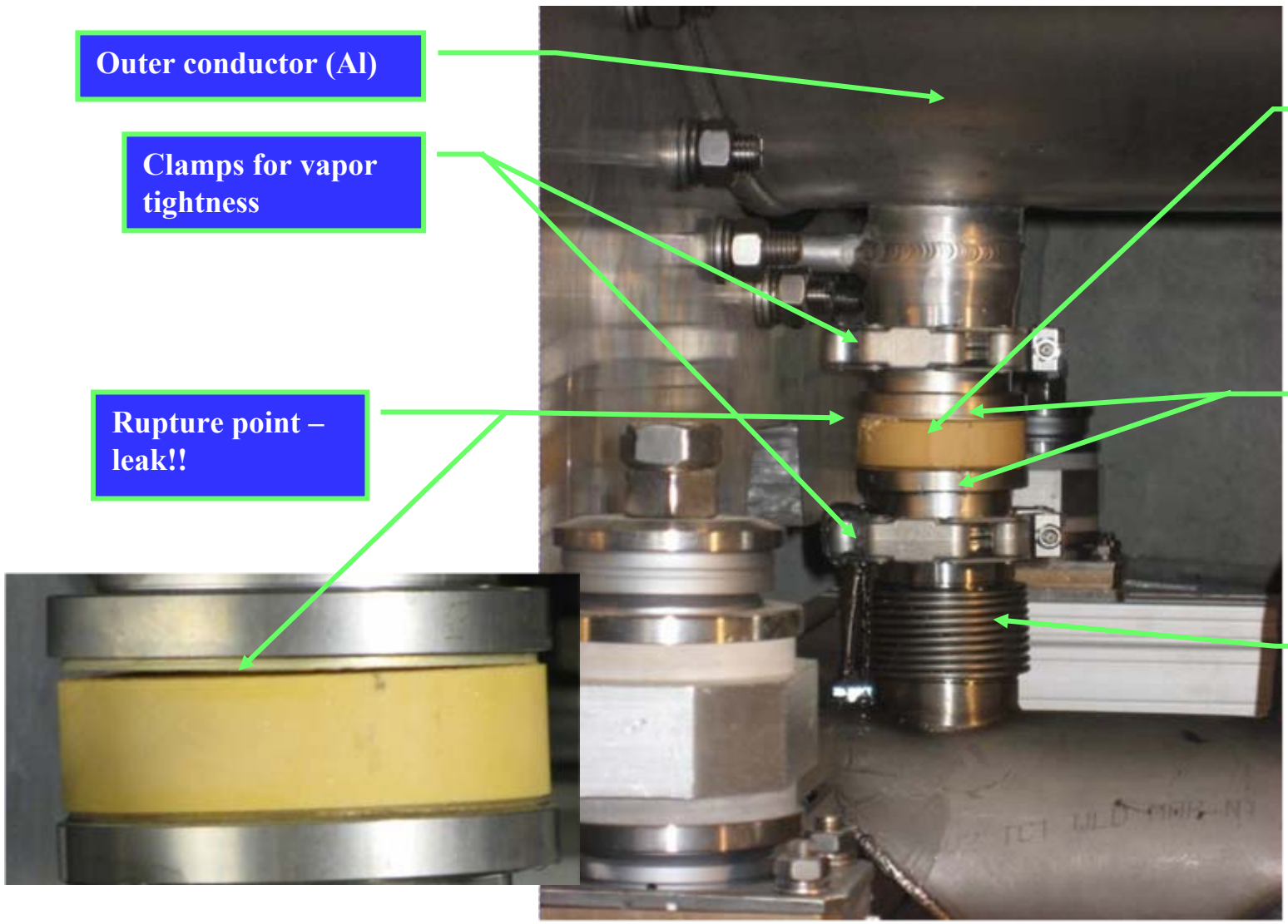
Horn/Reflector Power System



In total:
~ 400000 pulses

	Unit	HORN System	REFLECTOR System
Load Peak current	kA	150	180
Pulse duration	ms	6.5	9.8
Transformer ratio		16	32
Primary peak current	A	9375	5646
Charging voltage	V	6300	5800
Water flow for delta T=5C	l/min	50	50
Pressure	bar	1.2	1.2

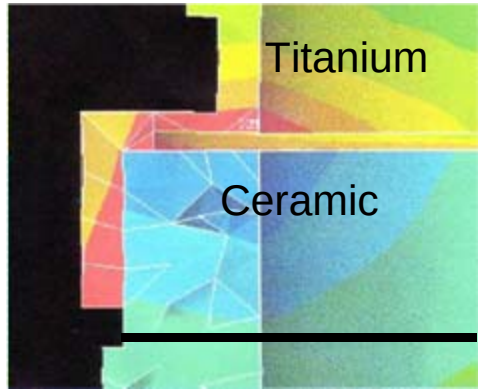
Leaking Drain Connection

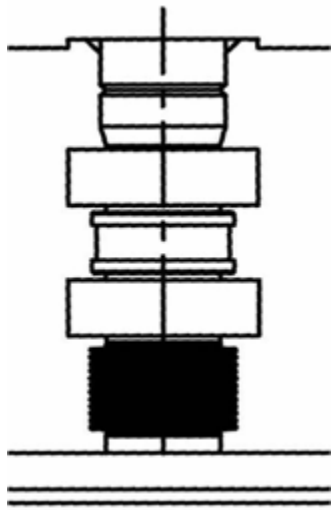


Reasons for Rupture

- **Alignment errors**
  - ➔ **Pile up of tolerances**
  - ➔ **Error during assembly**

  Additionally, the geometry is very rigid:
  - ➔ **Collars for vapor tightness (seal)**
  - ➔ **Insufficient flexibility of the bellows**
- **Brazing**
  - ➔ **Thermal cool-down of after brazing**
  - ➔ **Machining of ceramic**
    - **Several pieces were broken after the first brazing attempts**
    - **new design adopted for the final production pieces (no failures detected)**
- **Vibration**
- **Accident during assembly?**





Reflector Review

CNGS Reflector Leak Review Meeting with AB, TS and RP experts, held on 29th November 2006

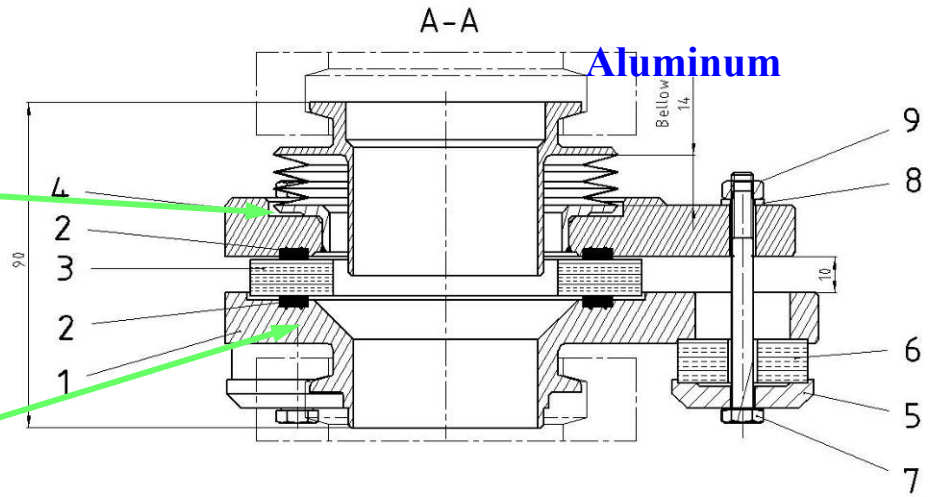
➔ **Outcome:**

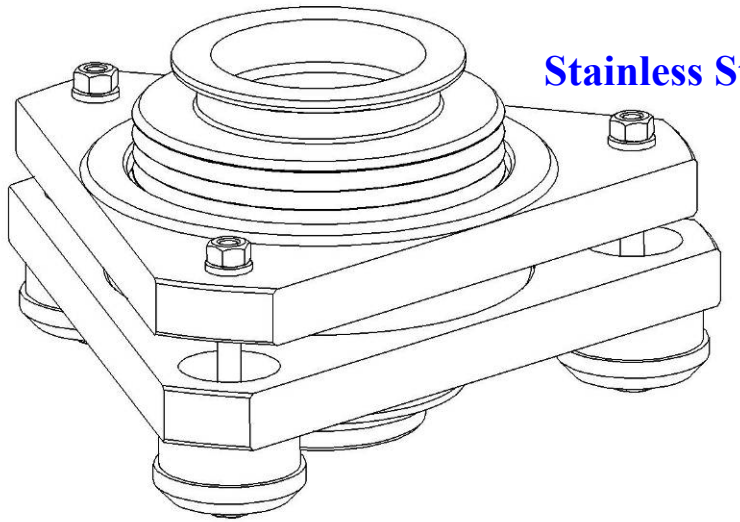
- **Improved design required to sustain the long operation of CNGS.**
- **Extensive tests of the new design with the spare horn must be done.**
- **Misalignment effects have to be compensated for.**
- **Vibration effects can not be neglected.**
- **Vapour tightness is maintaining.**
- **Repair on both the reflector and the horn should be foreseen.**
- **Several designs have been presented and reviewed.**

New Design for Drain Connection

Improvements of new design

- **Second welded bellows**
  - ➔ **Absorb better any misalignment errors**
- **Water and vapour tightness maintained**
  - ➔ **tightening the ceramic between flanges with bolts**
- **Brazing is avoided**
- **Rigorous QA during assembly**
  - ➔ **Tracing of equipment and record history**





Next Steps

Tests

- on spare horn with new drain connection prototype
  - ➔ Electrical pulsing
  - ➔ vibration measurements

Repair

- Radiation Issues
  - ➔ Careful dose planning needed
- Repair is not trivial

Radiation Levels inside Reflector Shielding

31st October 2006

Dossier d'Intervention en Milieu Radioactif N° : CNGS/03-06

Intitulé de l'intervention : Retrait partiel du blindage du réflecteur et recherche de l'origine de la fuite.

Date : 30/10/06

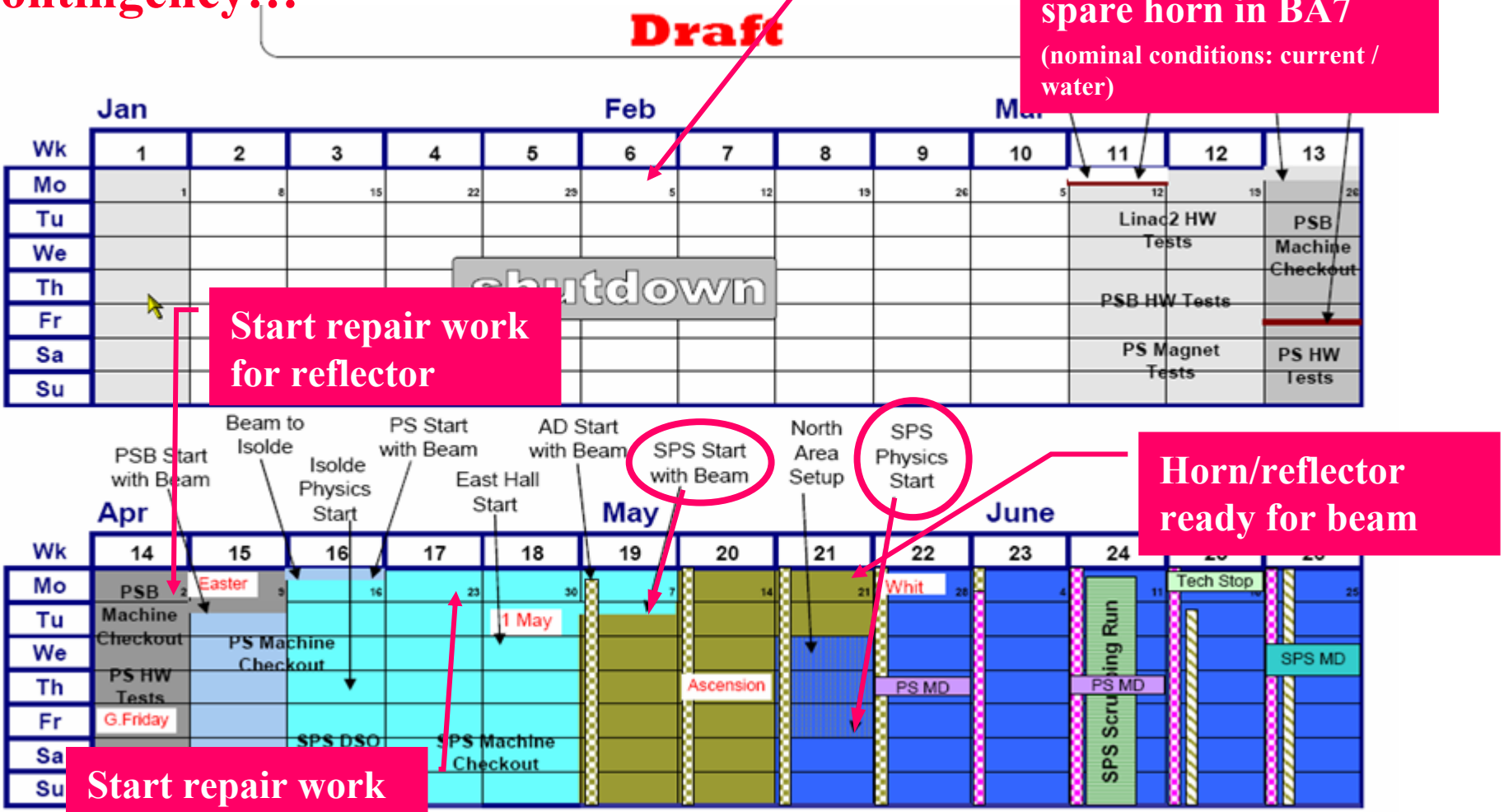
Radiation x 5 for the horn

Repair Procedure

- The top and side shielding blocks are removed with overhead crane
  - ➔ for the horn everything can be done remotely
  - ➔ for the reflector the side shielding requires manual intervention
- Repair cannot be done in the beam position of the reflector (horn)
  - ➔ access is limited
  - ➔ radiation levels higher inside the shielding
- The reflector and horn moved to upstream area of the target chamber
  - ➔ sufficient space available
- Chariot foreseen for the horn transport can be used as pedestal during the works
- Outer conductor part of reflector/horn has to be disconnected from the bottom chassis
  - ➔ bellows flexibility not sufficient to remove ceramic pieces.

Reflector Repair Schedule

Most optimistic scenario!
No contingency…



Perspectives for 2007

Nominal CNGS beam: 4.5 ·10^{19} protons/year at 400GeV

- **Repair of Reflector and Horn ongoing**
  - ➔ **Finished by week 21 for SPS Physics Start-Up**

    …if everything goes well!!

- **SPS: setting up of CNGS beam in weeks 19-21**

- **2 weeks needed to complete the setting up schedule of October 2006 of the CNGS primary & secondary beam.**
  - ➔ **Understand polarity change, muon detector linearity, etc…**

- **MD slots during the run will be scheduled for the Secondary Beam Line**

Schedule 2007