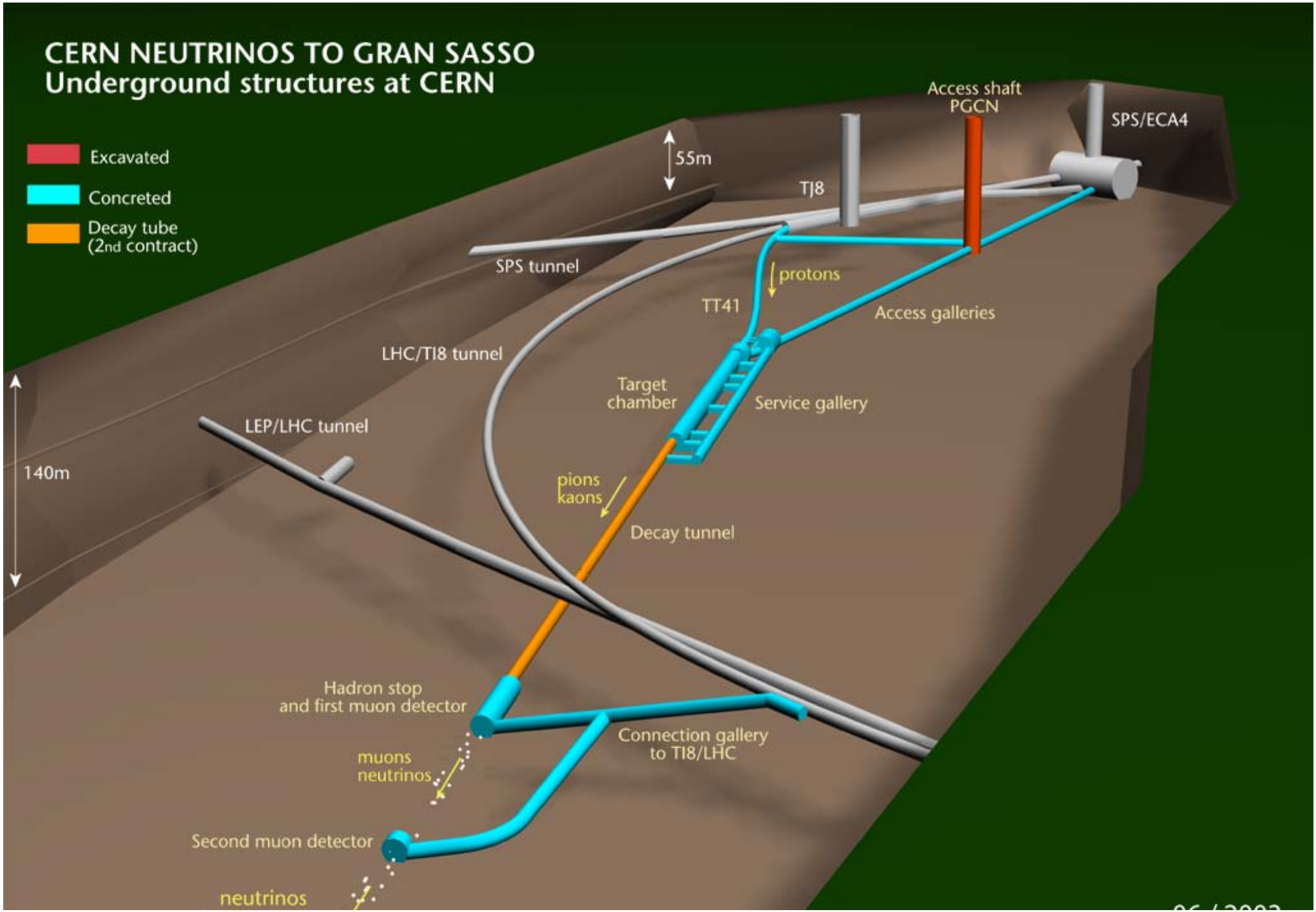
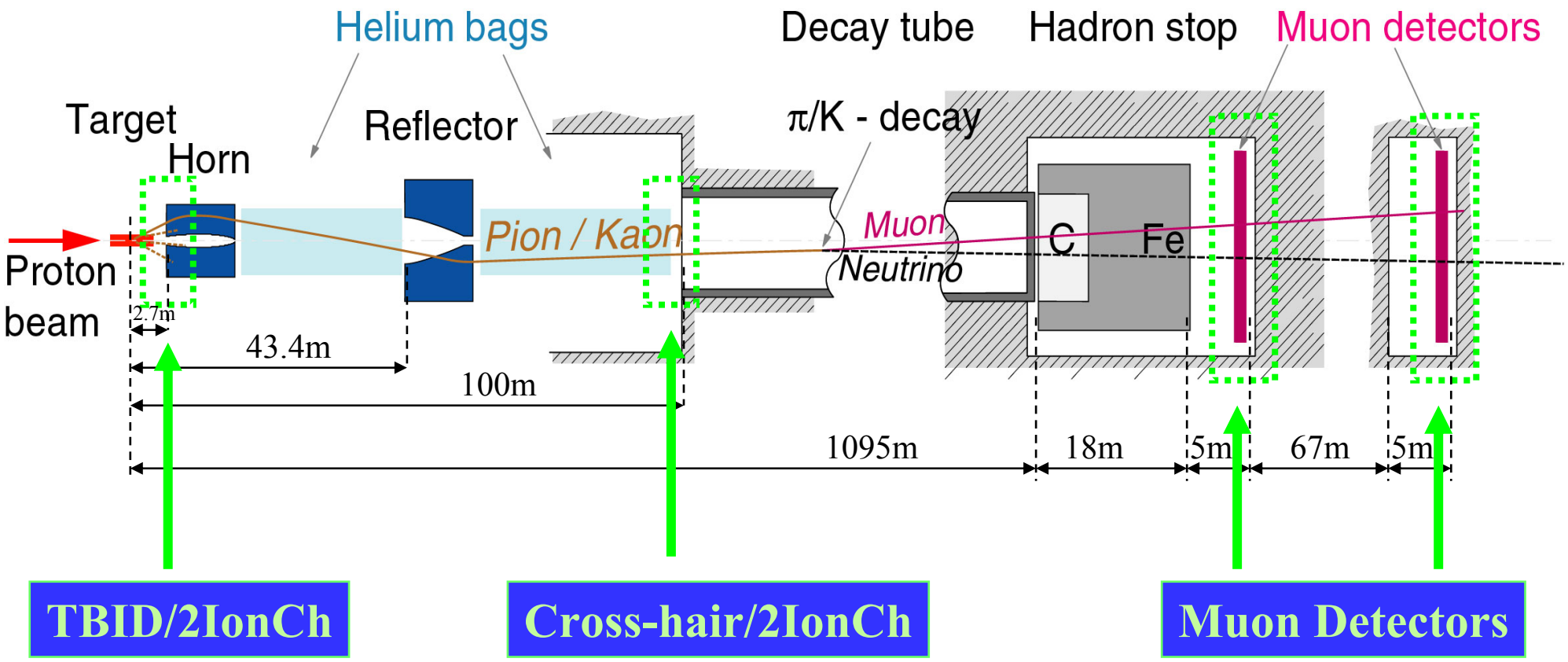
CNGS Secondary Beam Monitors: Design and Performance

1. Design
2. Commissioning
3. Performance


CERN NEUTRINOS TO GRAN SASSO
Underground structures at CERN
Excavated
Concreted
Decay tube
(2nd contract)
55m
Access shaft
PGCN
SPS/ECA4
TJ8
SPS tunnel
protons
TT41
Access galleries
LHC/TI8 tunnel
Target
chamber
Service gallery
LEP/LHC tunnel
140m
pions
kaons
Decay tunnel
Hadron stop
and first muon detector
Connection gallery
to TI8/LHC
muons
neutrinos
Second muon detector
neutrinos

- **Secondary Beam Design and Layout**

CNGS Secondary Beam Layout

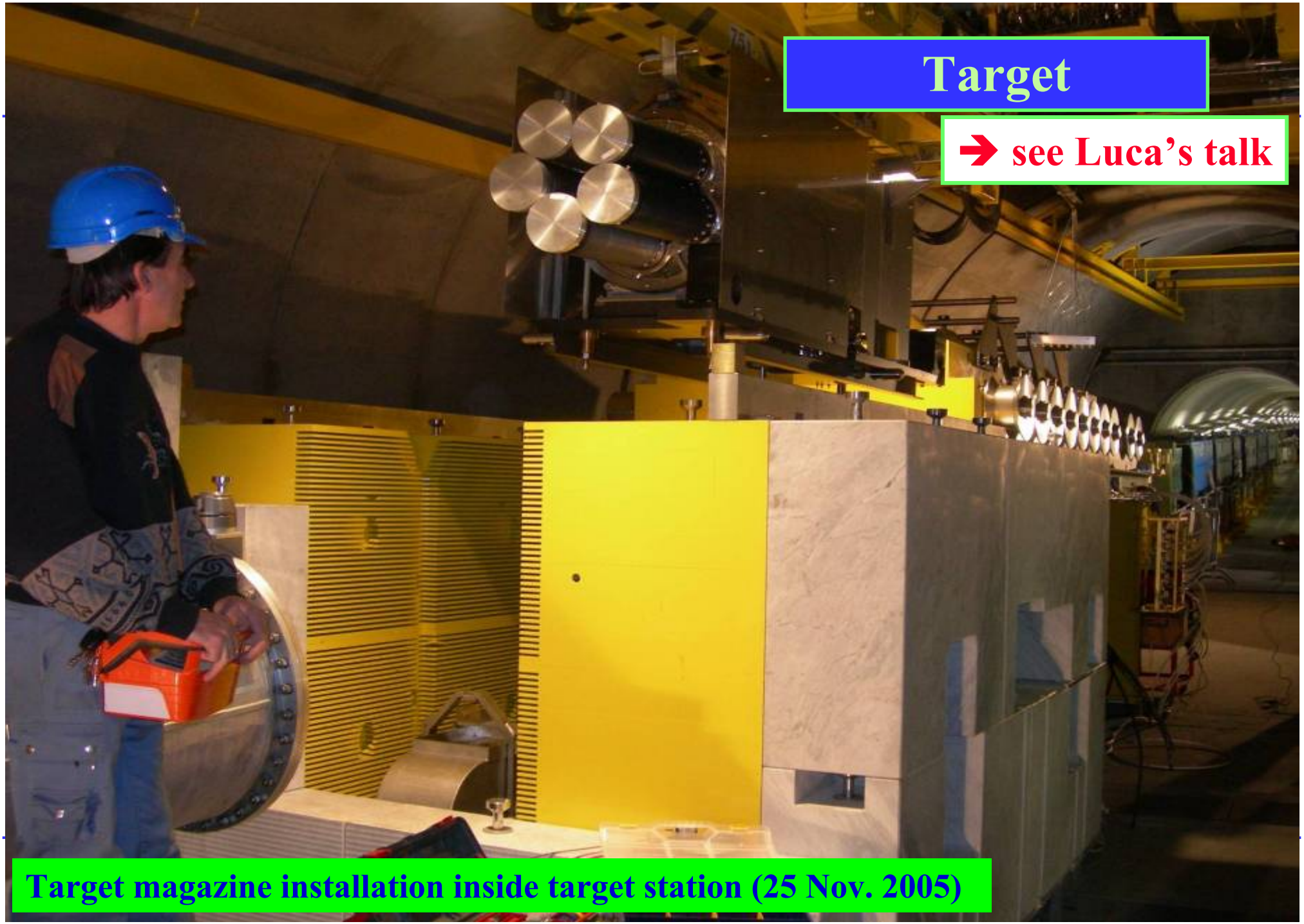


TBID: Target Beam Instrumentation Downstream

IonCh: Ionization Chamber

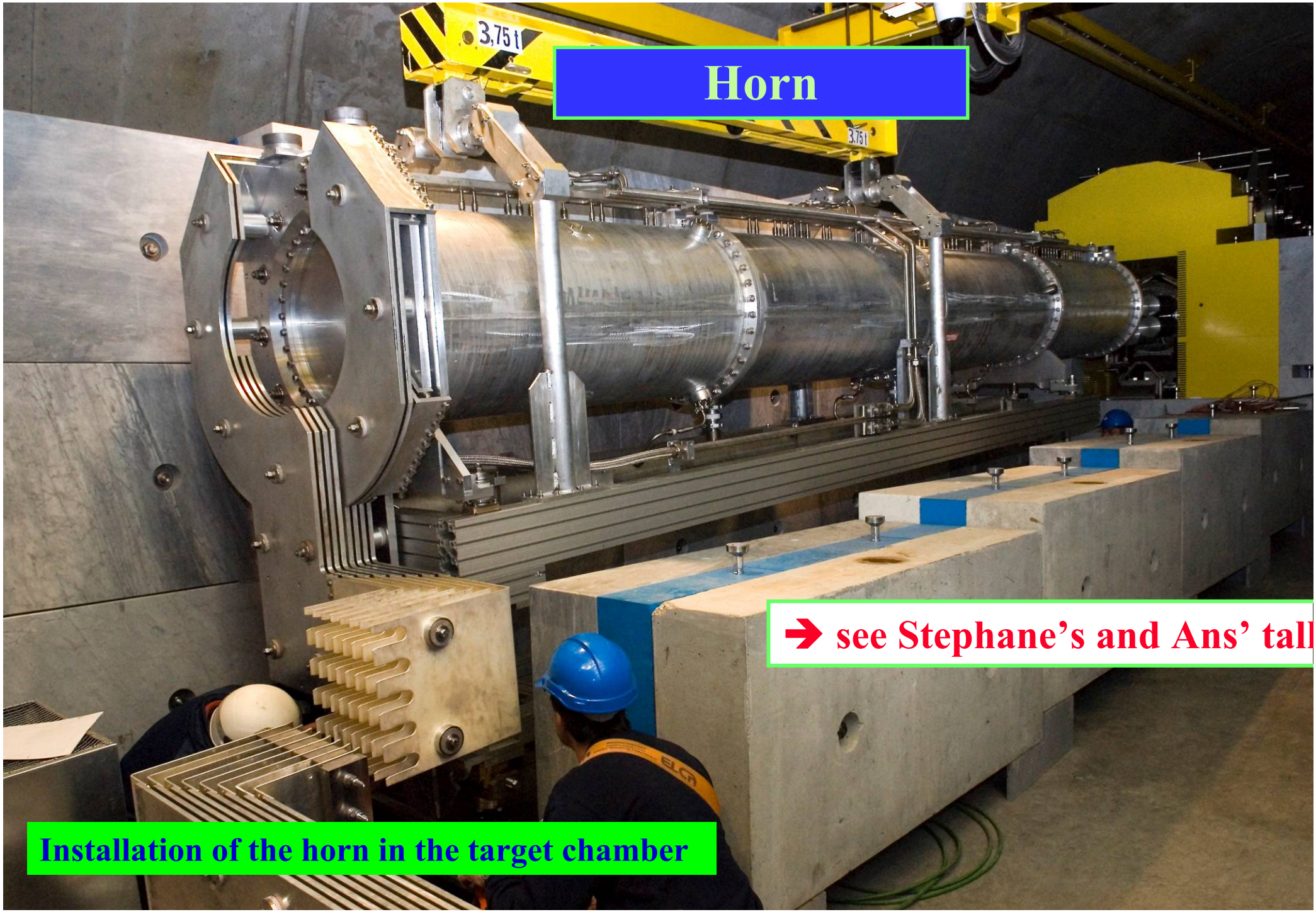
Target

➔ see Luca's talk



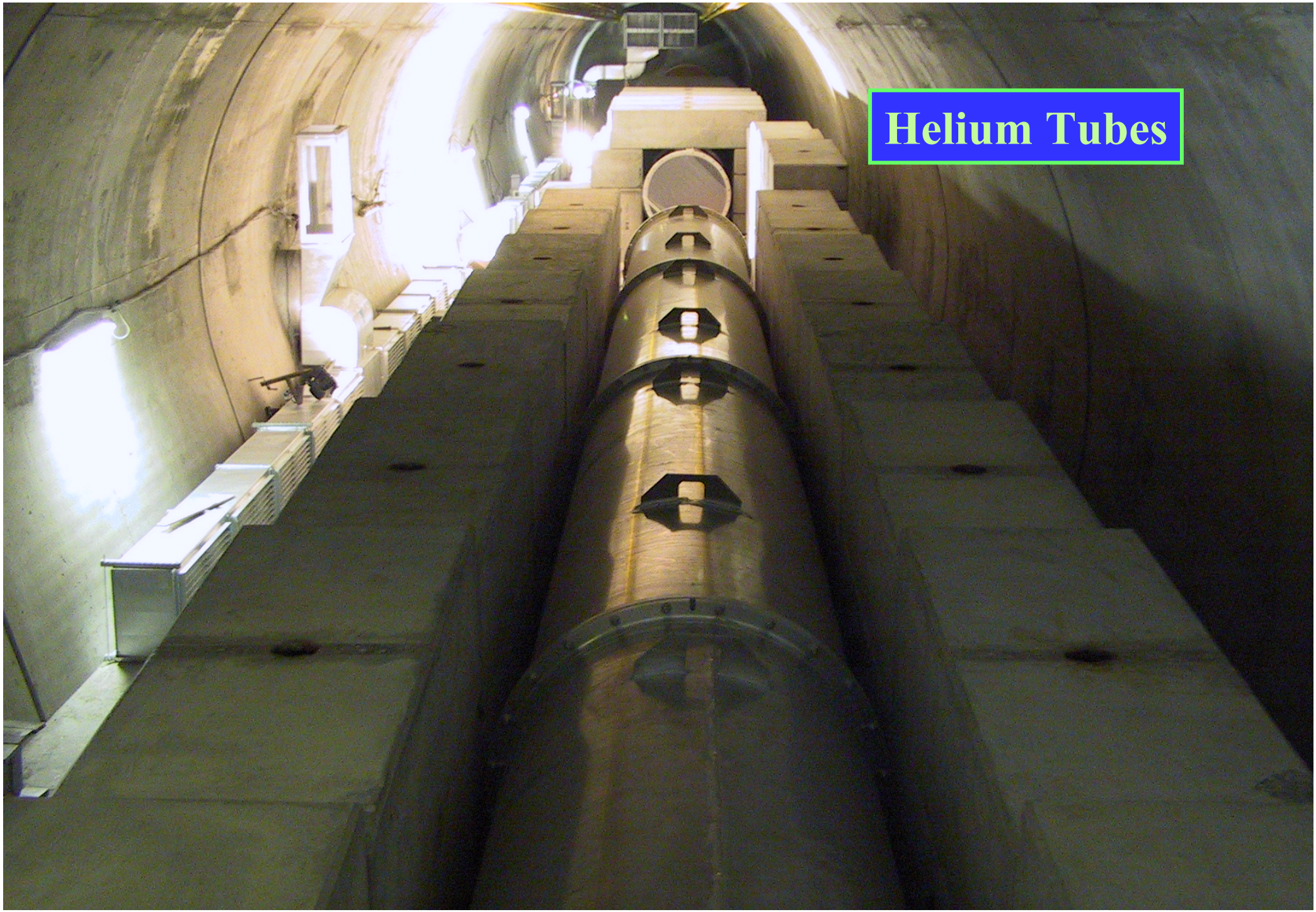
Target magazine installation inside target station (25 Nov. 2005)

Horn



➔ see Stephane's and Ans' tall

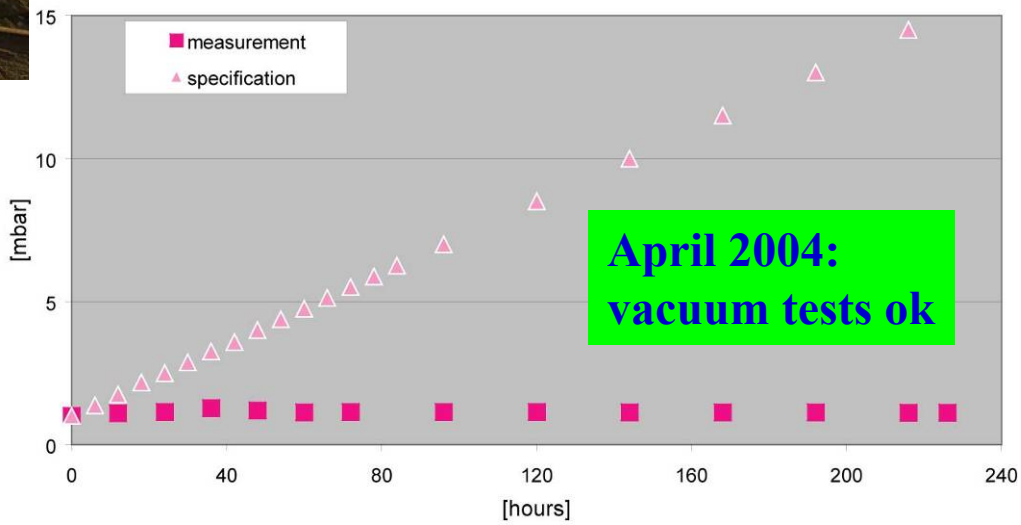
Installation of the horn in the target chamber


Helium Tubes

Decay Tube

- steel pipe
- 1mbar
- 994m long
- 2.45m diameter
- entrance window: 3mm Ti
- exit window: 50mm carbon steel, water cooled

Decay tube: pressure increase vs. time



Shutter

Decay tube is closed with
→ 3mm Titanium window

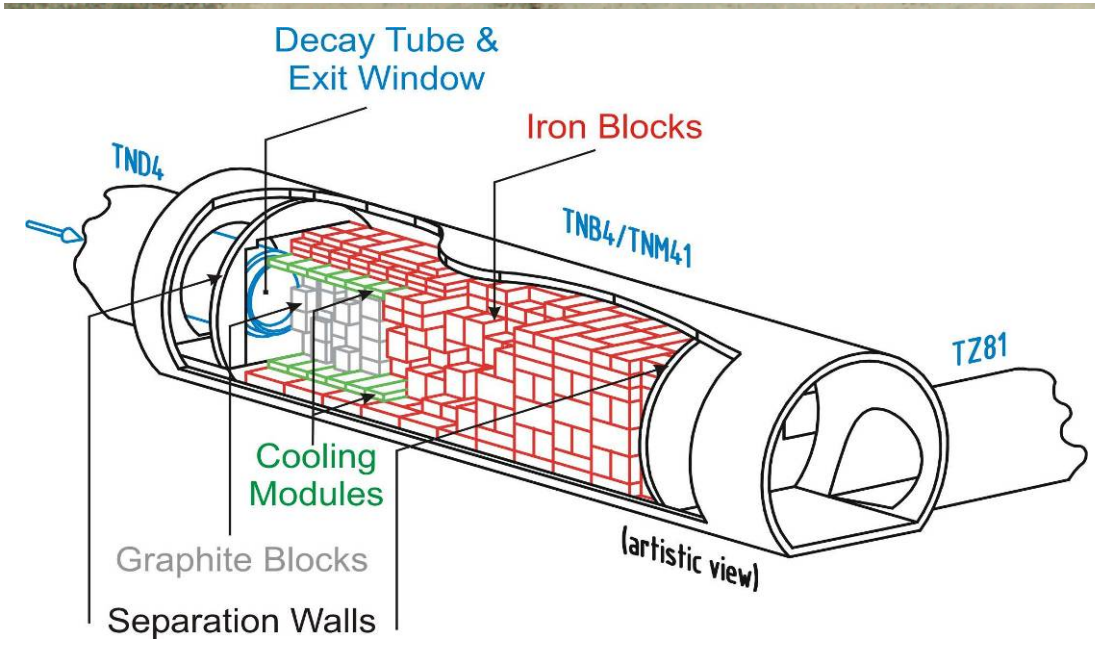
Must be protected by a 'shutter' when access
→ Hardware Interlocked!!!

Hadron Stop

graphite

cooling modules

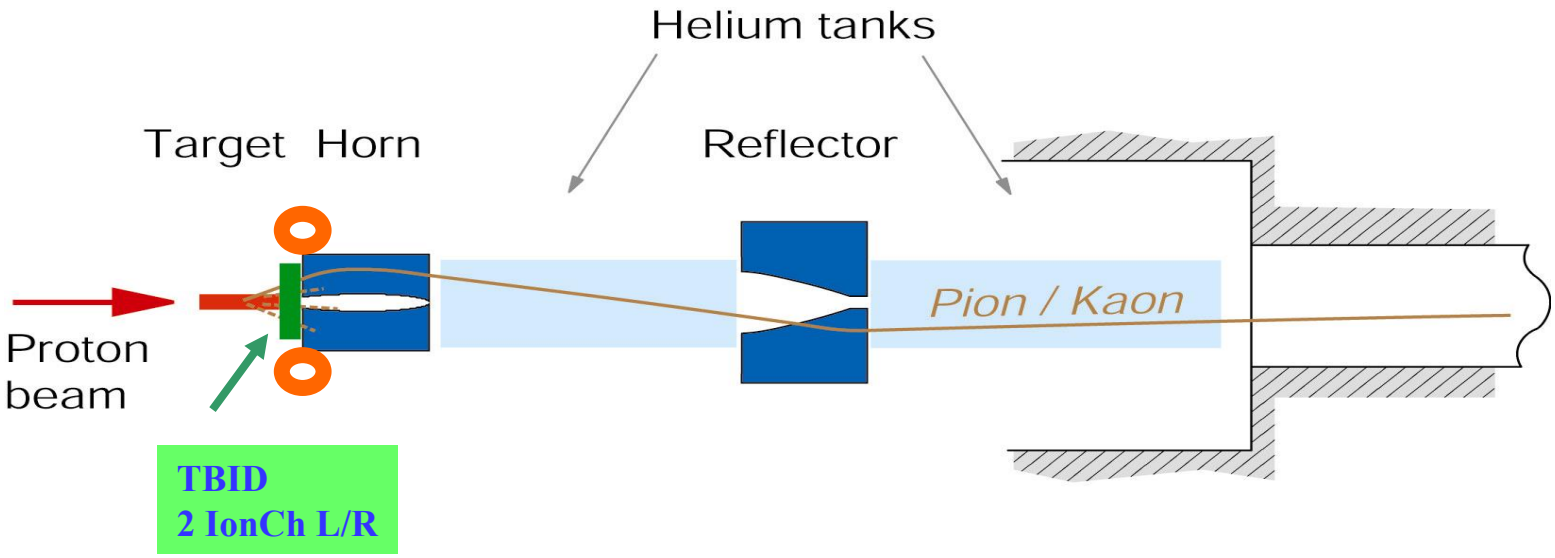
- **Cooling modules: stainless steel tubes in Al blocks**
- **Several temperature sensors (both in target chamber and in hadron stop)**



Hadron Stop
finished Sept. 2003

- **Secondary Beam Instrumentation**

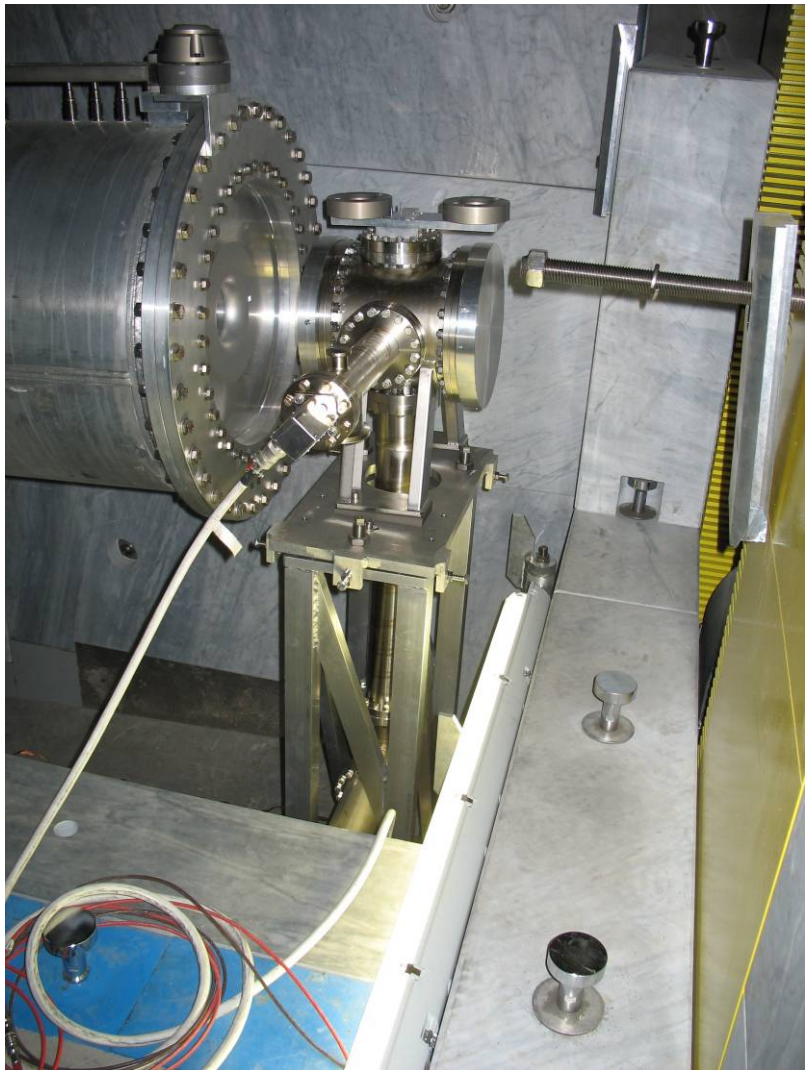
TBID + 2 Ionization Chambers



Purpose:

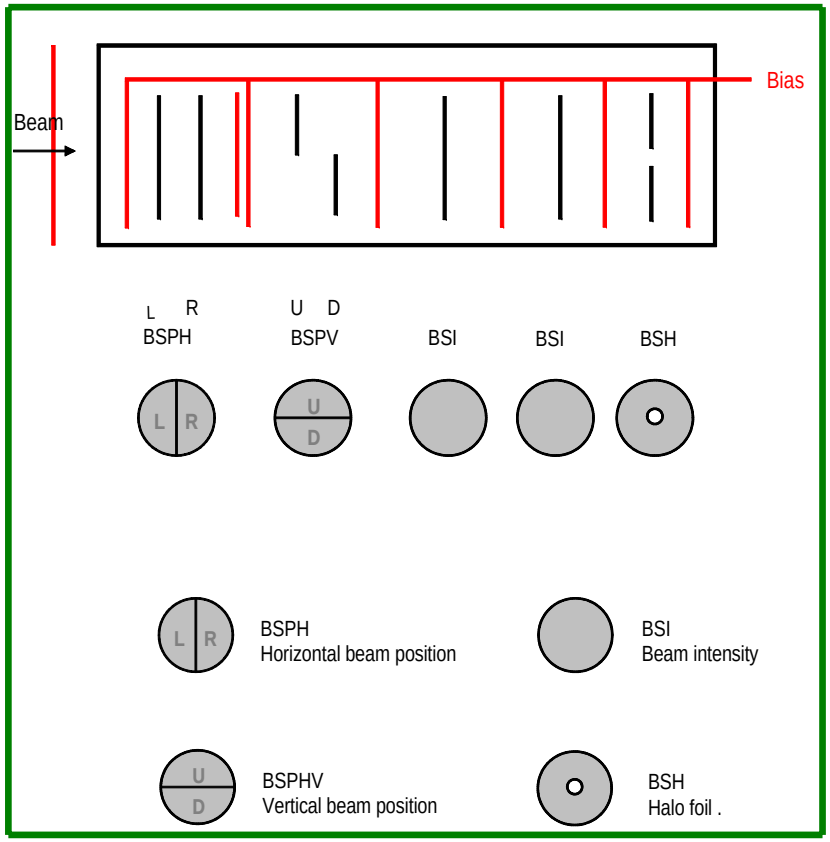
- ➔ **Check efficiency with which protons are converted into secondaries**
  - ⟶ **Multiplicity (Compare with BFCT upstream of the target)**
  - ⟶ **Misalignment of the Beam**

TBID (Target Beam Instrumentation Downstream)

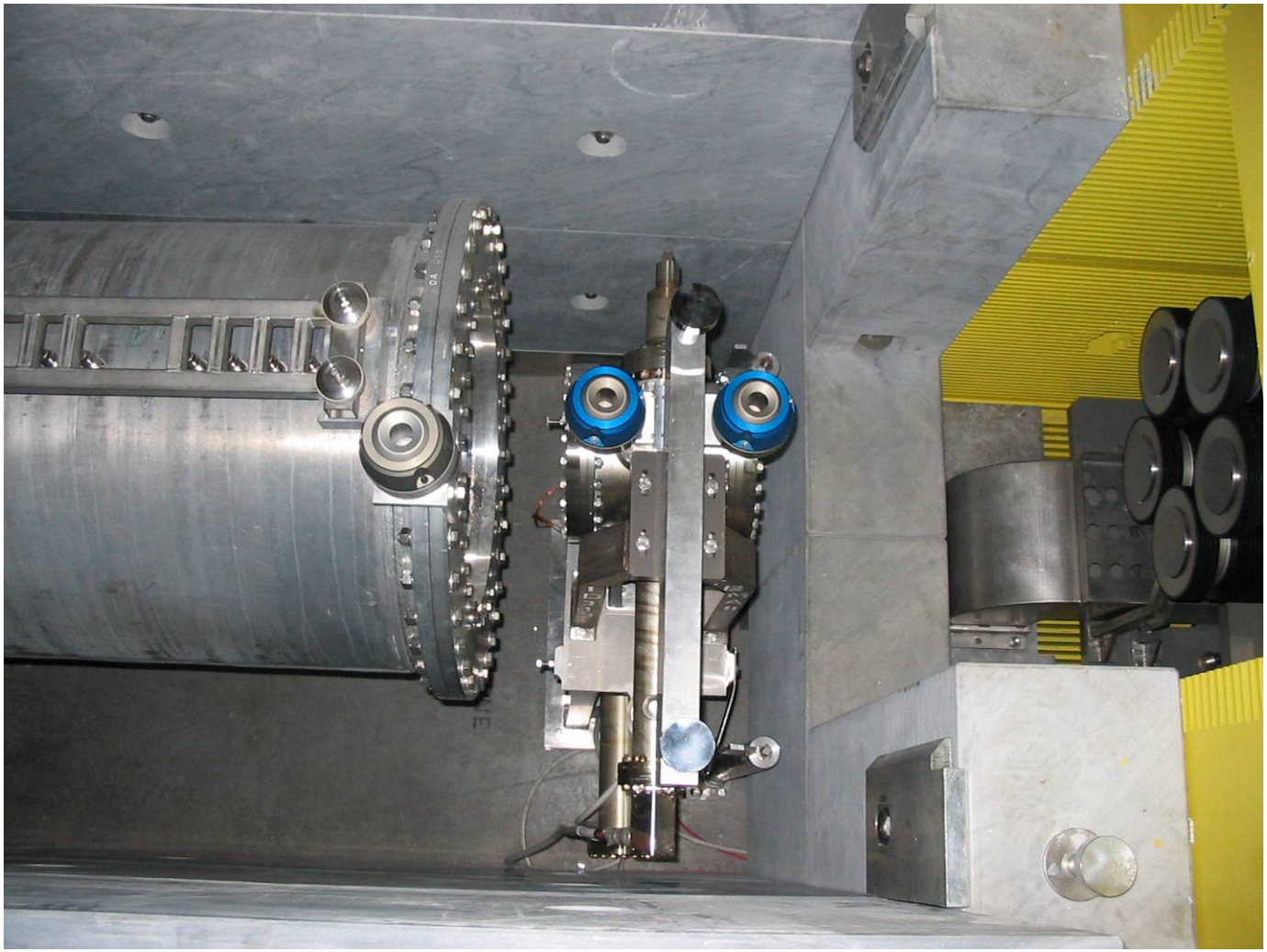


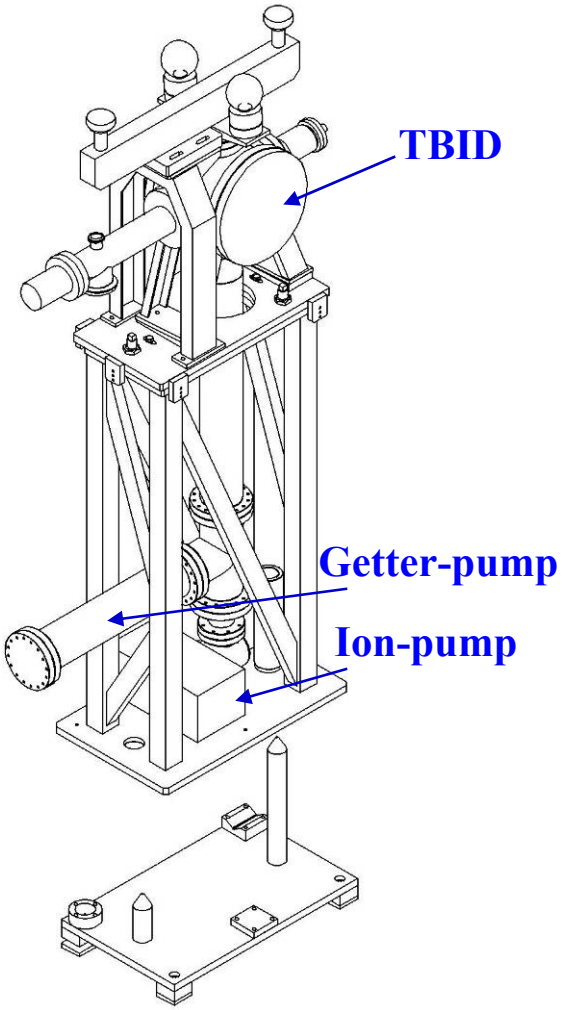
TBID Monitor

- Secondary emission monitor
- 12 µm Ti foils
- better than 10^{-4} mbar vacuum



TBID

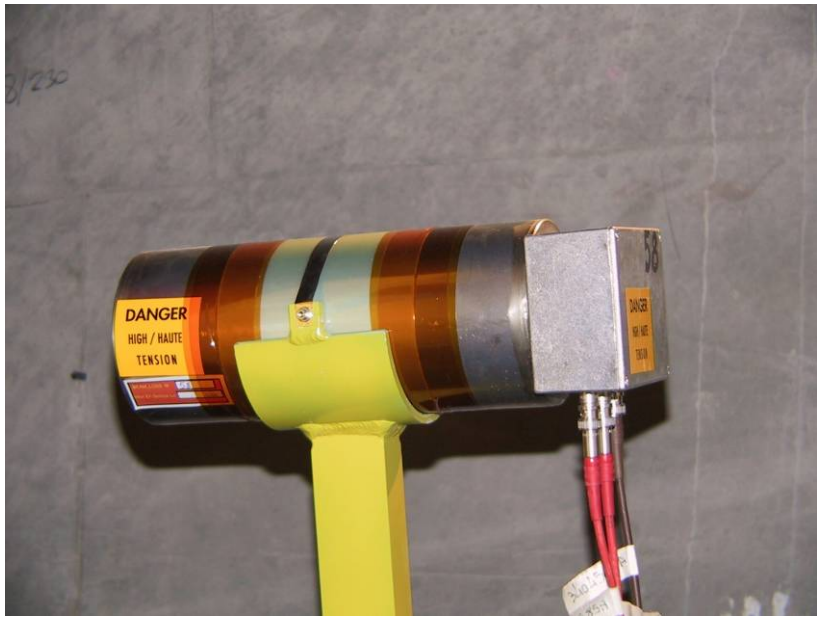




Ionization Chambers in Target Chamber

TBID Monitor might not survive if high intensity beam misses the target

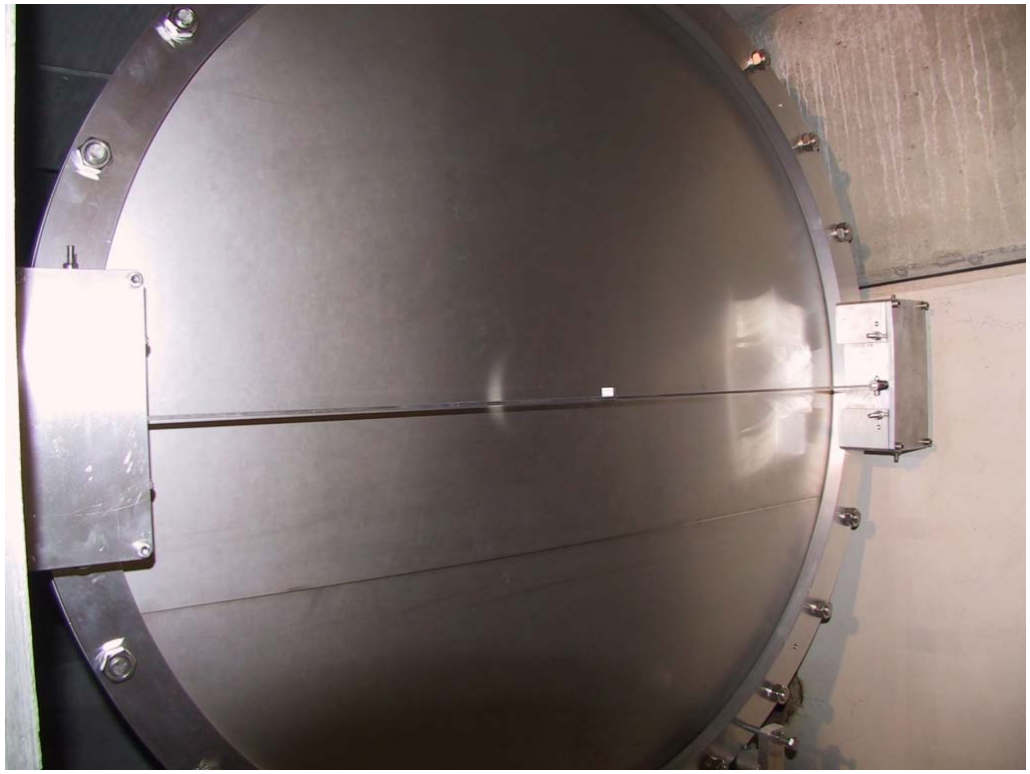
→Ionization Chambers as back-up



SPS type BLM

- **N_2 filled ionization chamber**
- **Radius = 4.75 cm**
- **Gap-width = 0.55 cm**
- **30 gaps**
- **Bias: 800V-1500V**

Cross-Hair

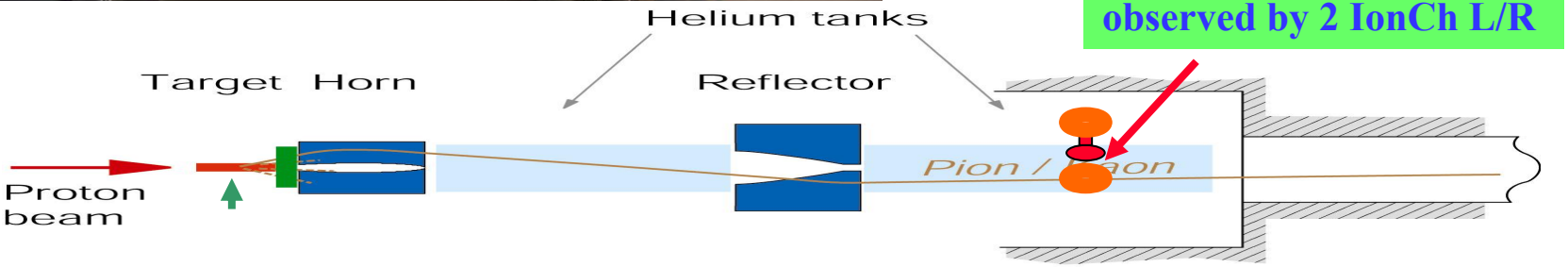


Layout:

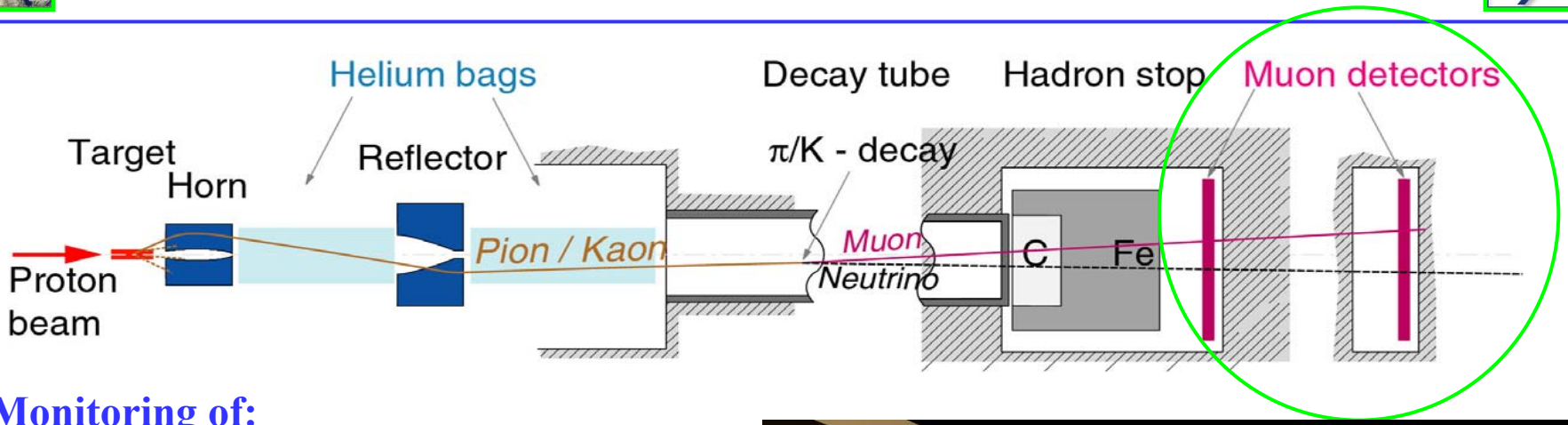
- 4mm wide
- appendix 10mm long
- 20mm thick along the beam-axis
- Beam 10mm off X-hair

Cross-hair beam view (schematic)

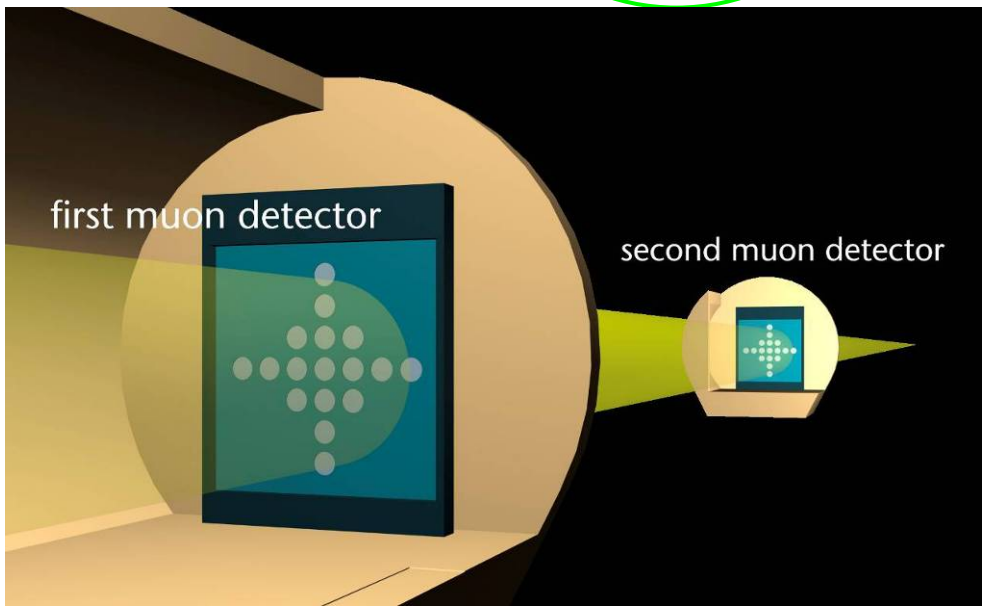
Cross-Hair observed by 2 IonCh L/R



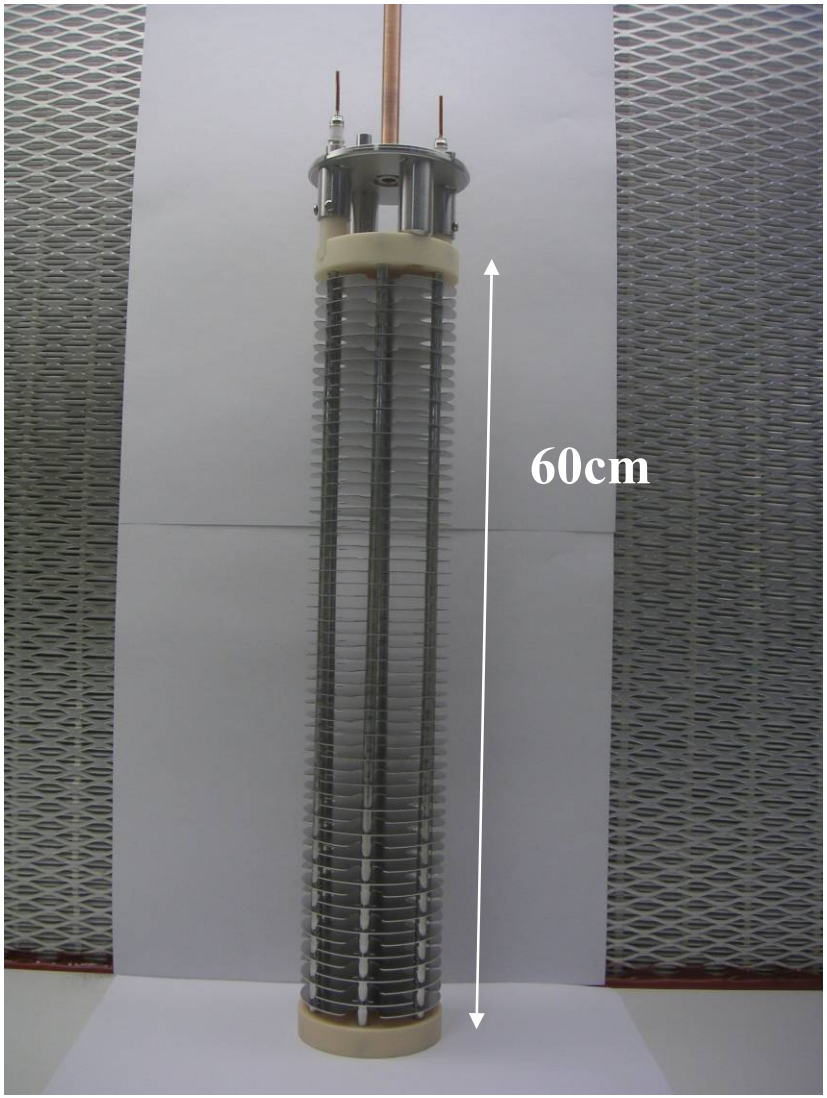
Muon Monitors



- **Monitoring of:**
  - ➔ **muon intensity**
  - ➔ **muon beam profile shape**
  - ➔ **muon beam profile centre**
- **Muon intensity:**
  - ➔ **Up to 7.7×10^7 per cm^2 and 10.5µs**
- **Dynamic range: 10^5**
- **Accuracies:**
  - ➔ **absolute 10 %**
  - ➔ **relative 3 %**
  - ➔ **reproducibility: cycle to cycle 1%, one year 5%**



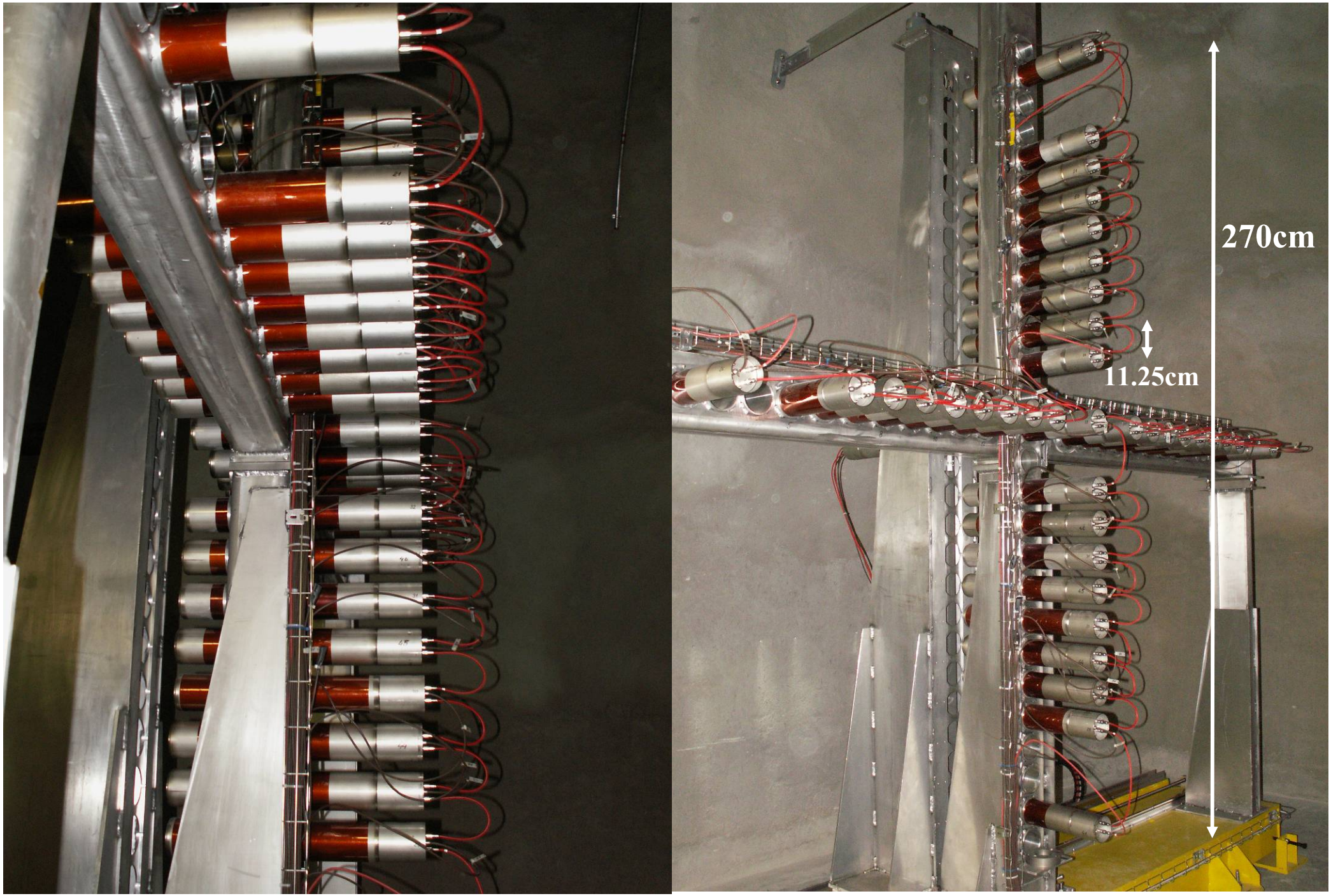
Muon Monitor Layout



LHC type BLMs (Beam Loss Monitors for LHC)

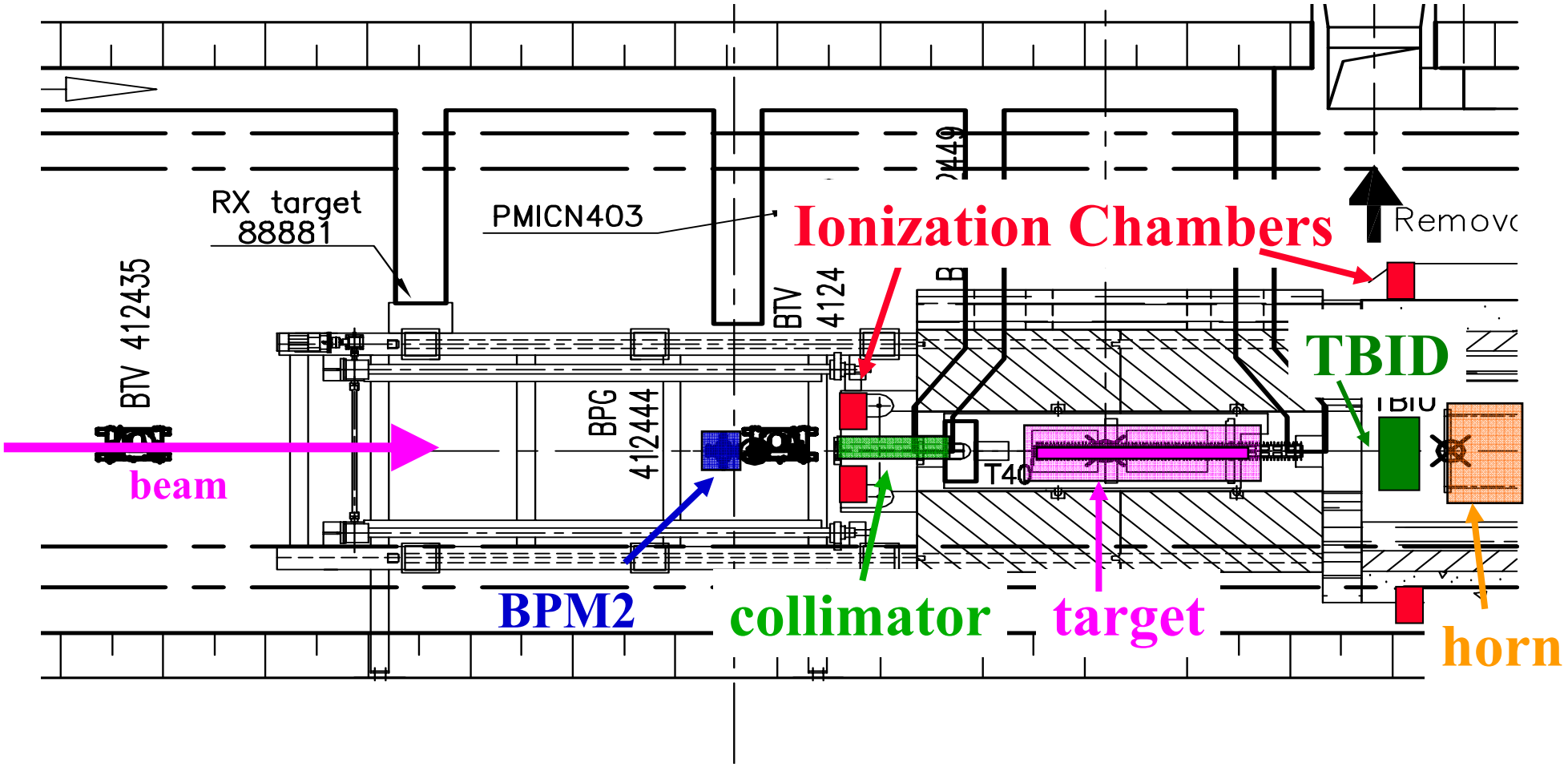
- Parallel electrodes separated by 0.5 cm
- Stainless steel cylinder
- Al electrodes
- N_2 gas filling at 100 mbar over pressure
- Diameter=8.9cm, length=60cm, 1.5 litre

- 37 fixed monitors (Ionization Chambers)
- 1 movable chamber behind fixed monitors for relative calibration
- Movement by stepping motors


270cm
11.25cm

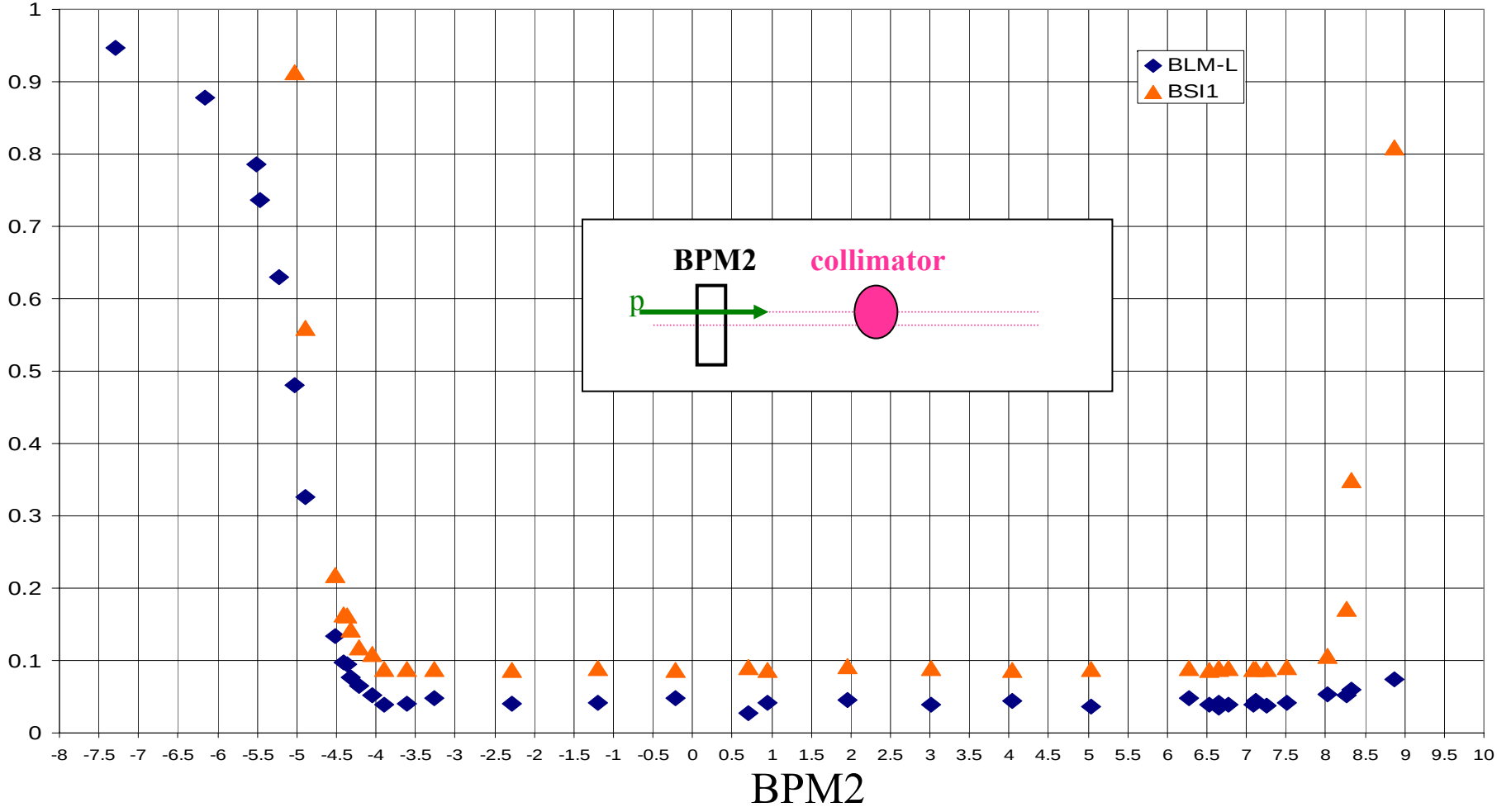
- **Secondary Beam Commissioning**

Target Region Layout



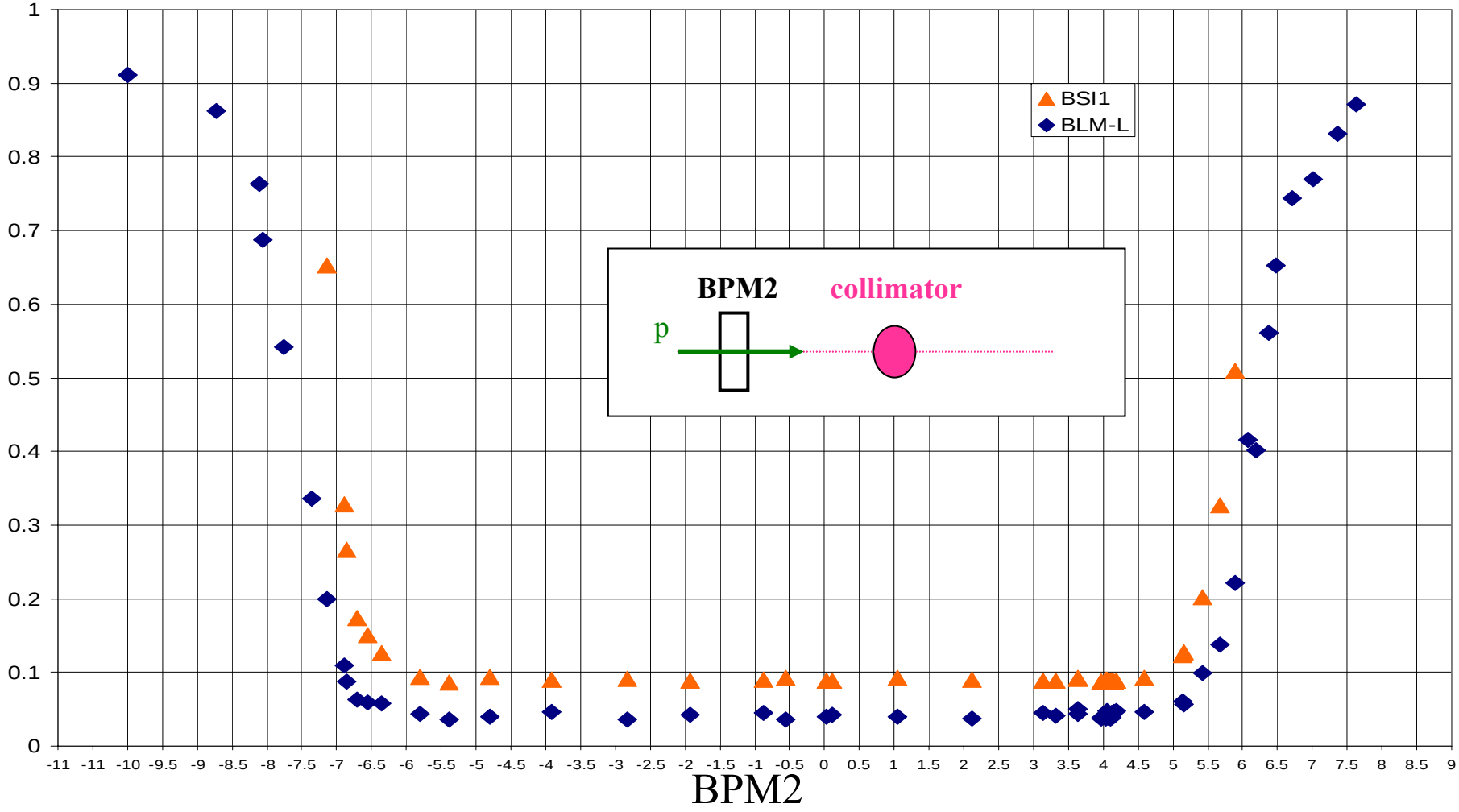
Horizontal Beam Scan, Target Out

Reading from TBID and collimator's ionization chambers vs. BPM2



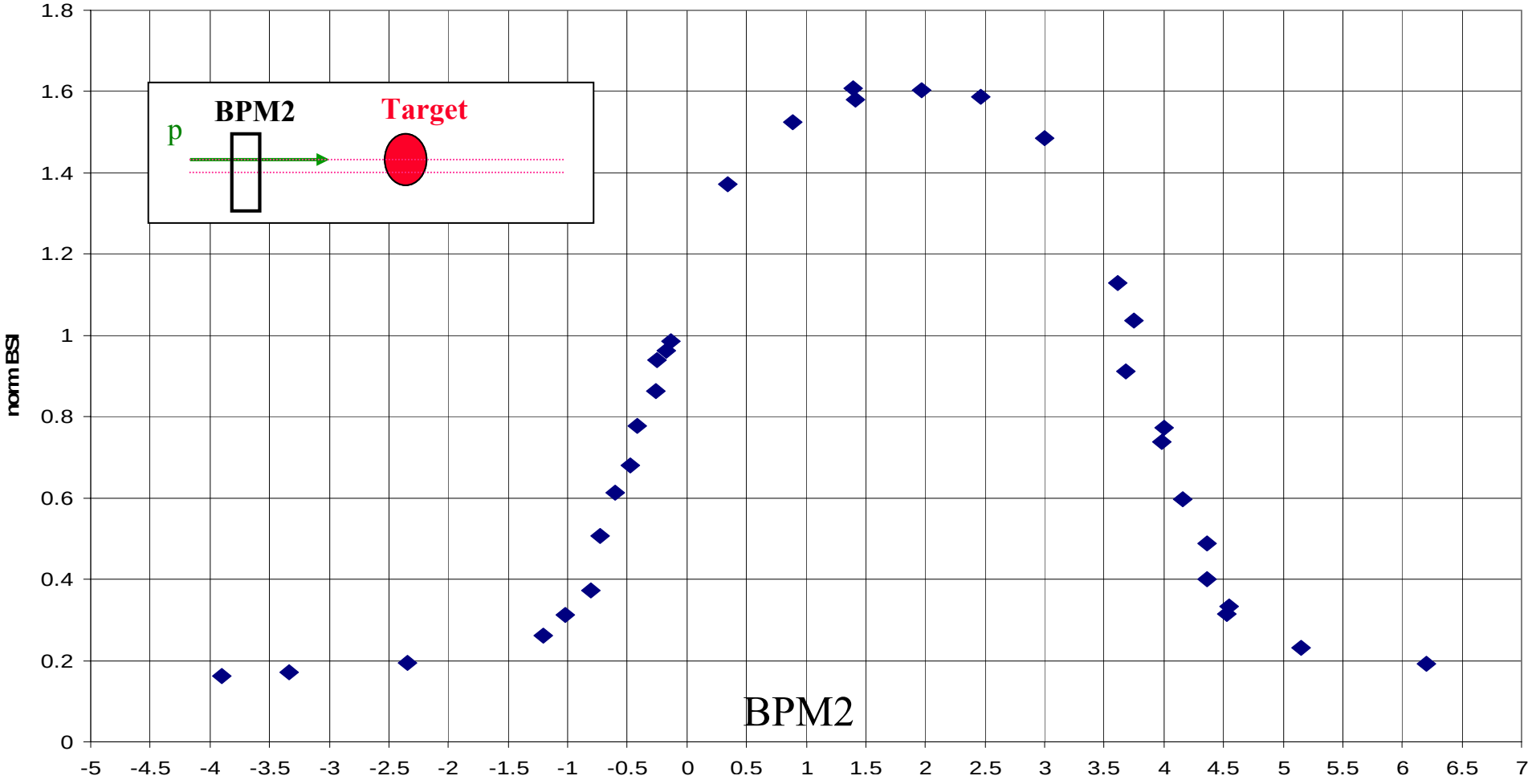
Vertical Beam Scan, Target Out

Reading from TBID and collimator's ionization chambers vs. BPM2



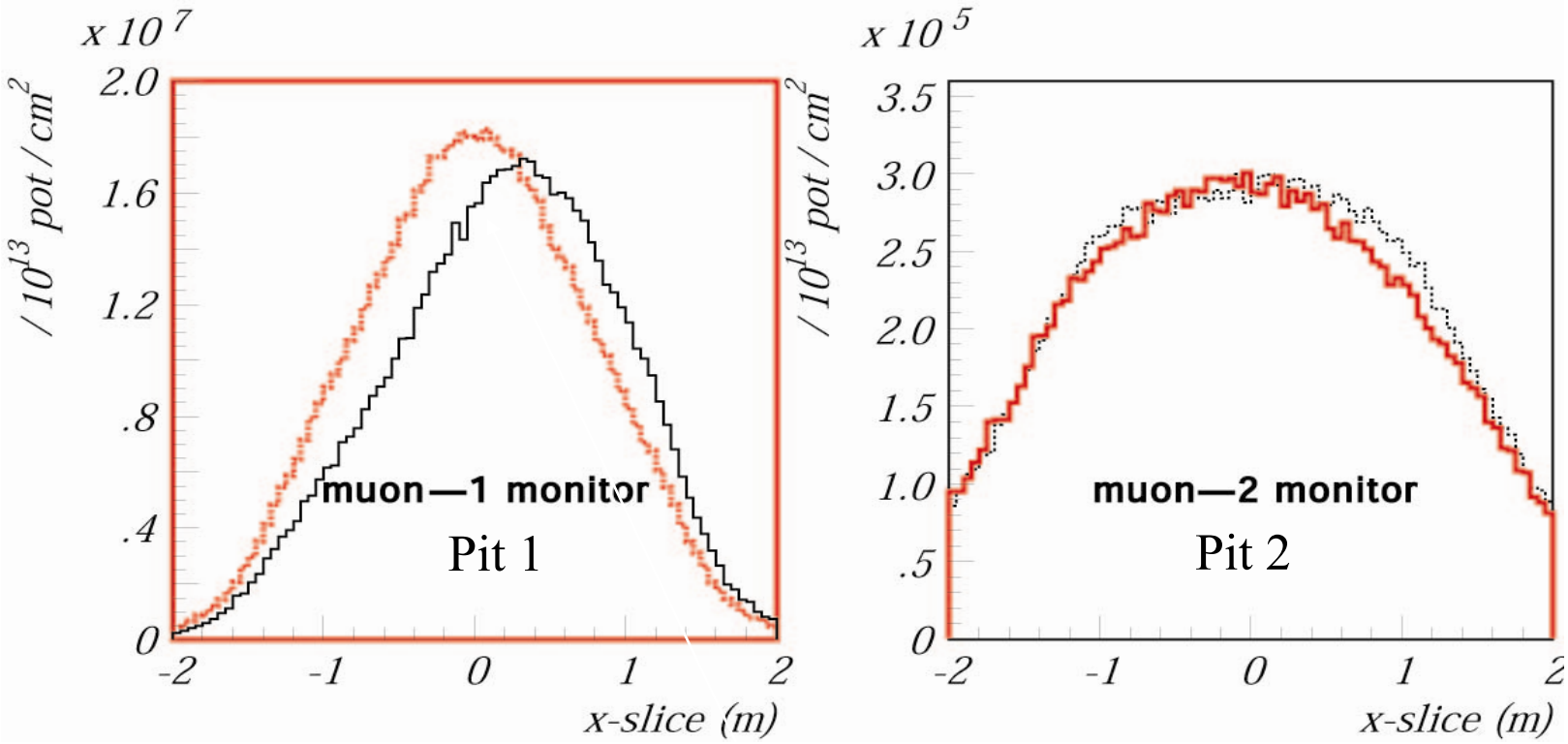
Horizontal Beam Scan, Target IN

Intensity on TBID vs. BPM2 position



Target vs. Horn Alignment

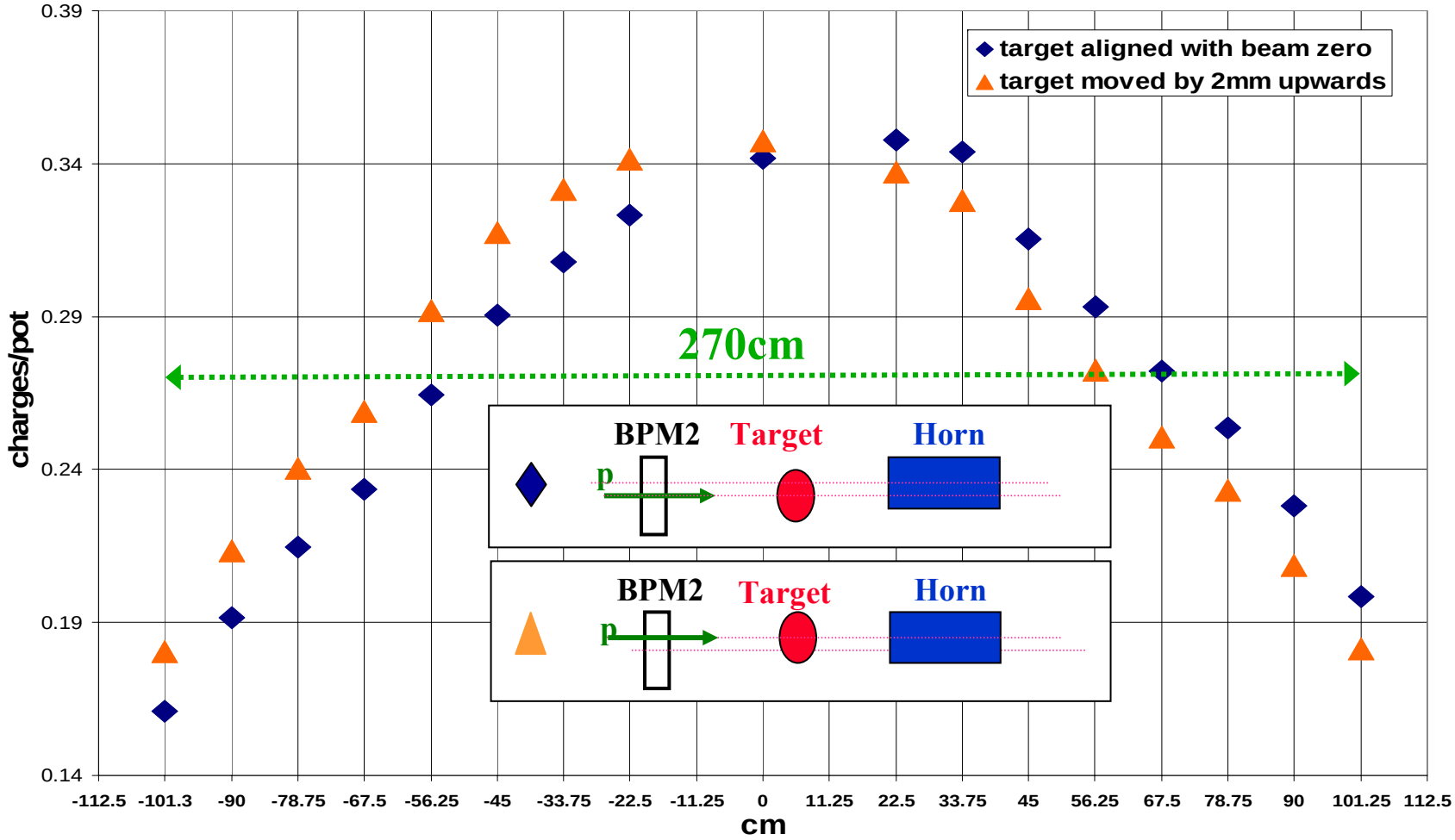
A.E. Ball et al. SL-2001-016-EA



target vs. horn misalignment: 3 mm → 10.1 cm shift in Muon Pit1
6 mm → 19.1 cm
9 mm → 24.3 cm

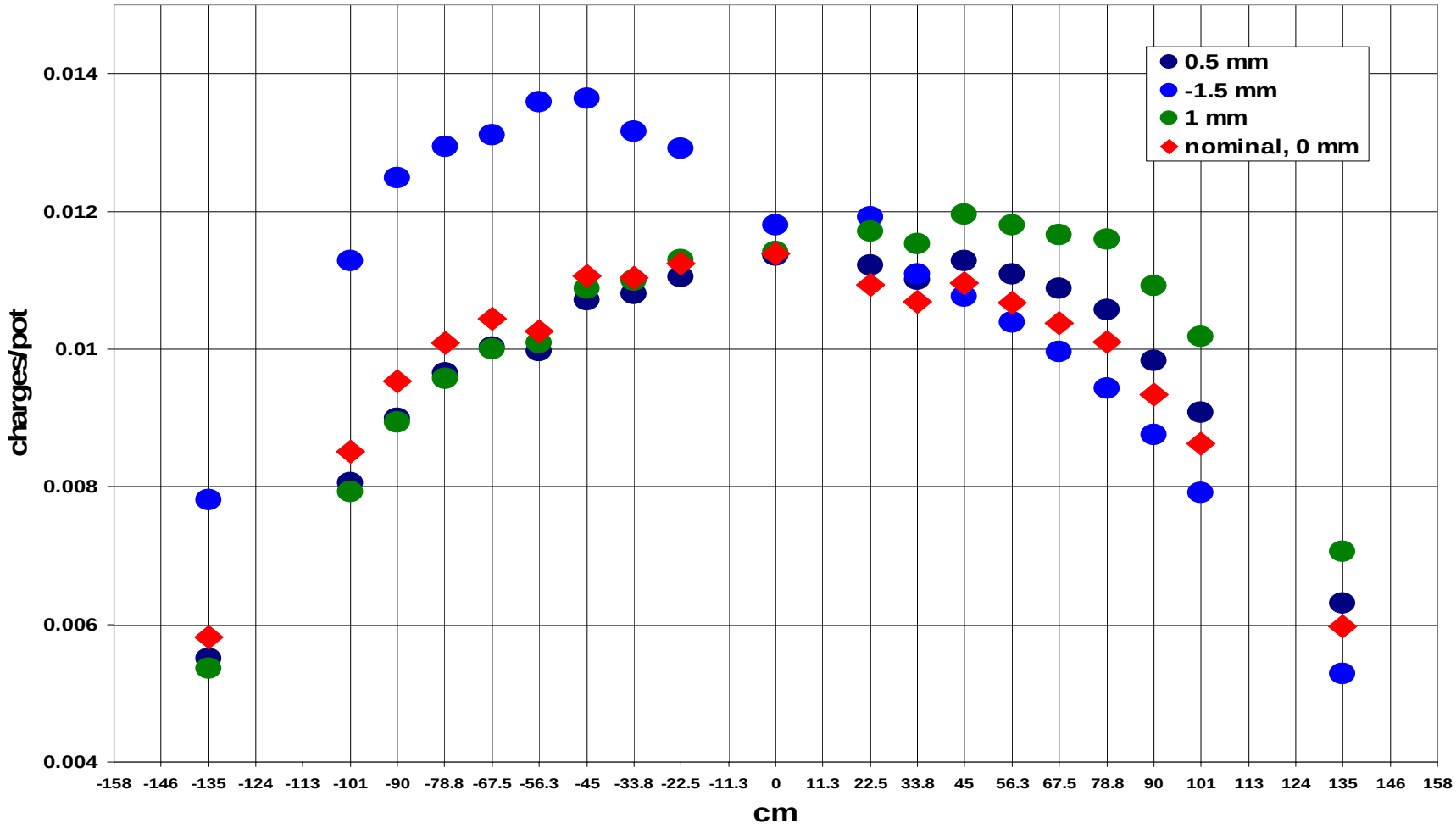
Target vs. Horn Alignment

Muon pit 1: more sensitive to target vs. horn alignment

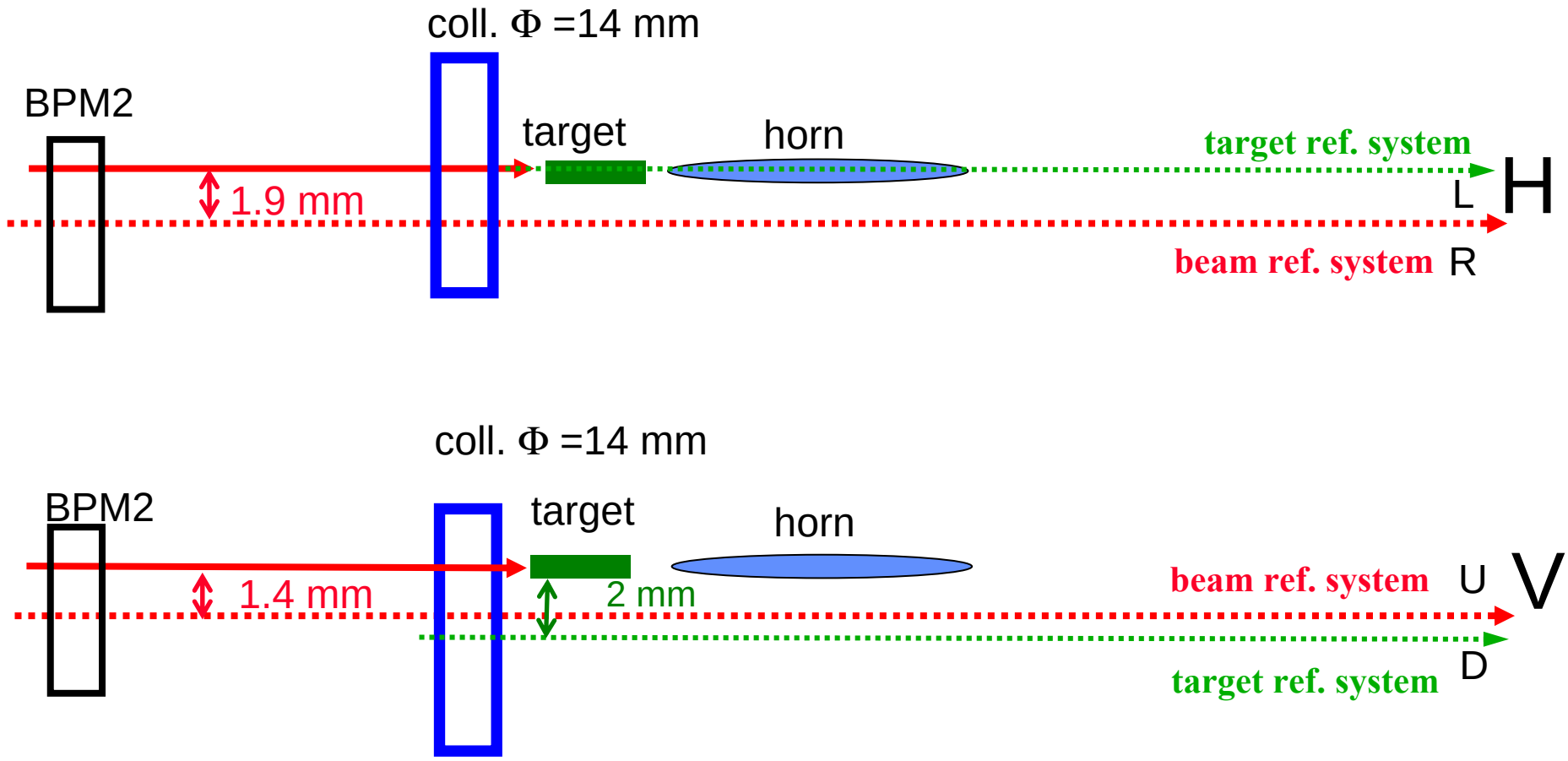


Vertical Beam vs. Target Alignment

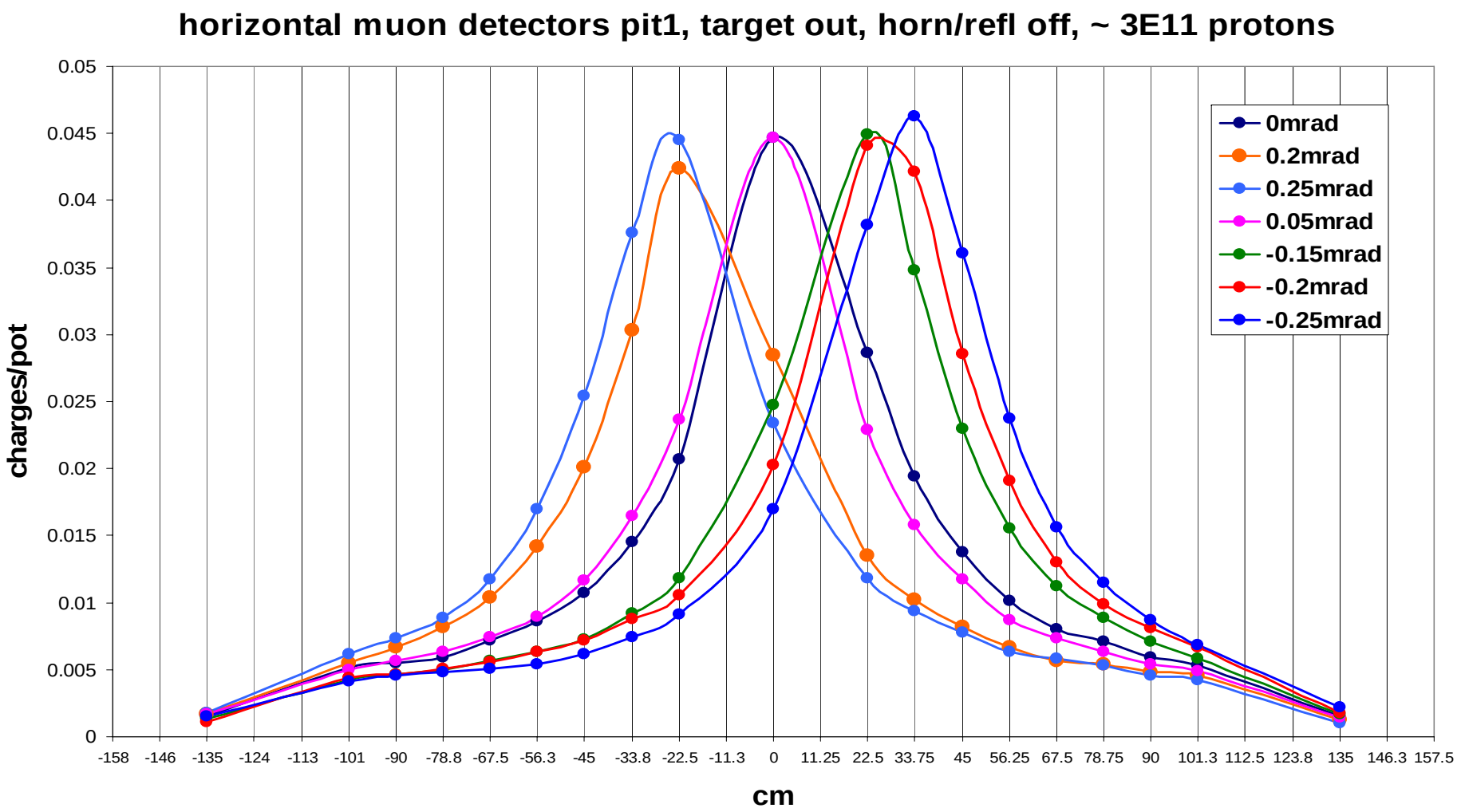
Muon pit 2: more sensitive to beam vs. target alignment



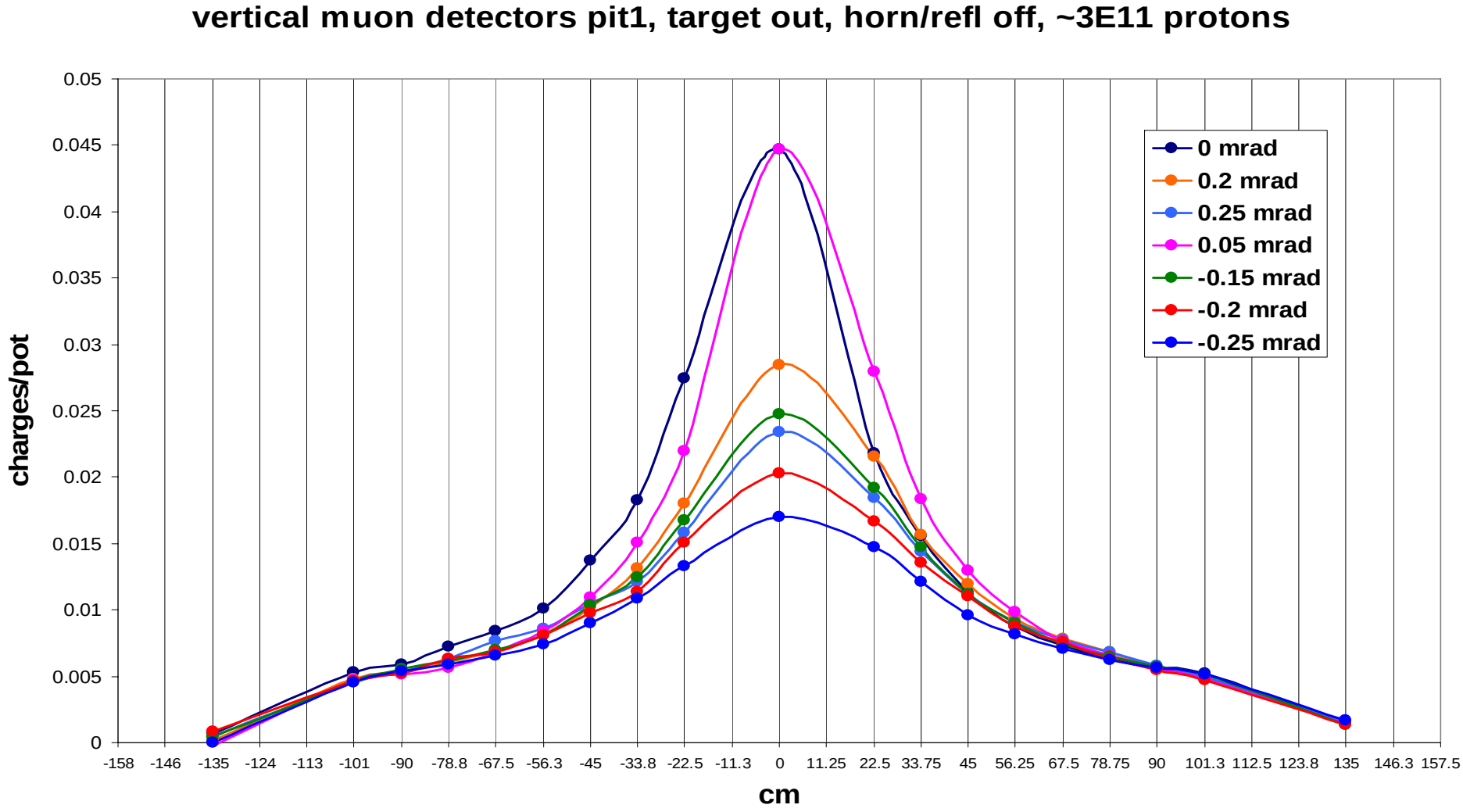
Final Alignment



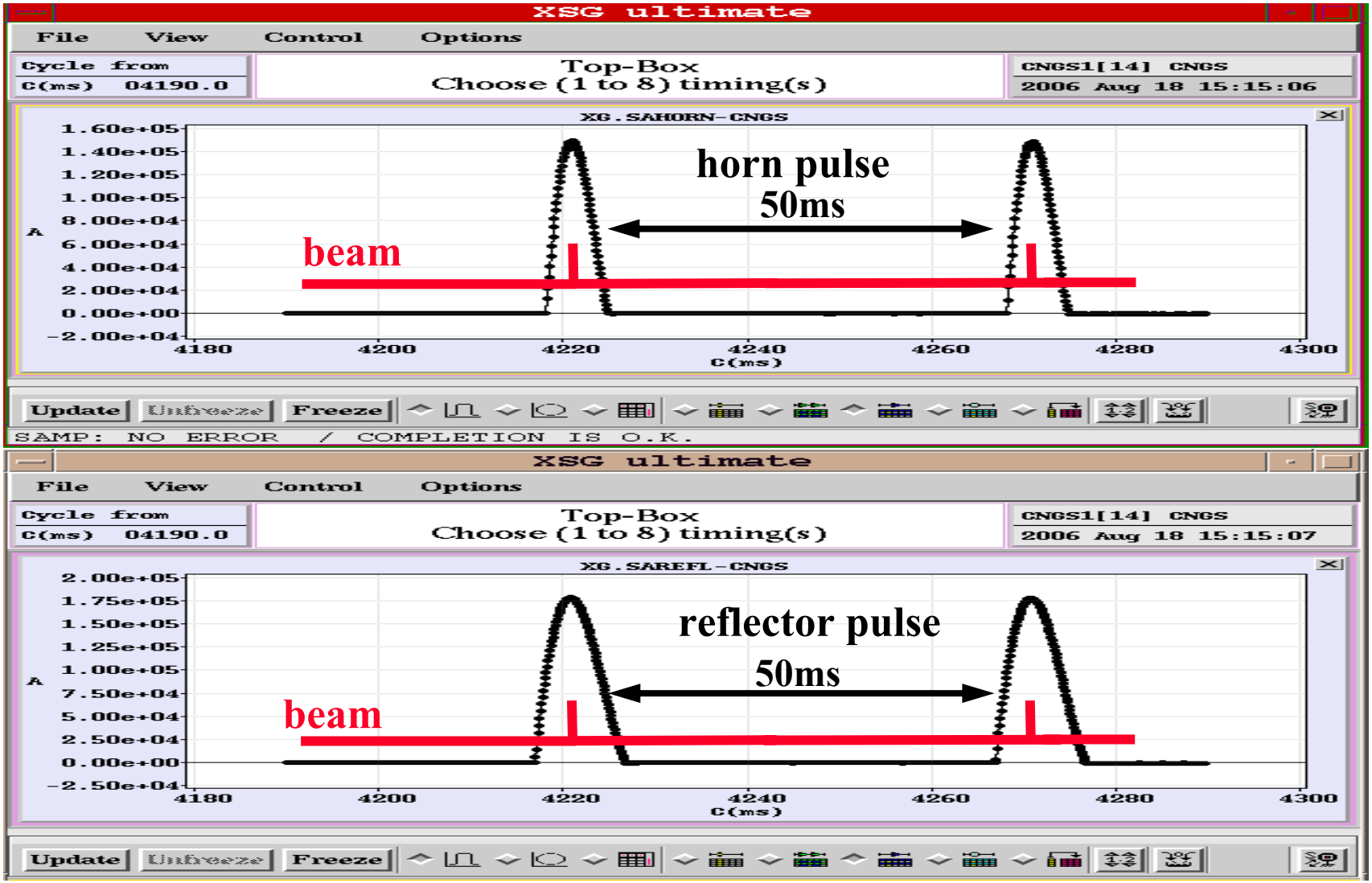
Horizontal Angular Scan, Target Out



Horizontal Angular Scan, Target Out

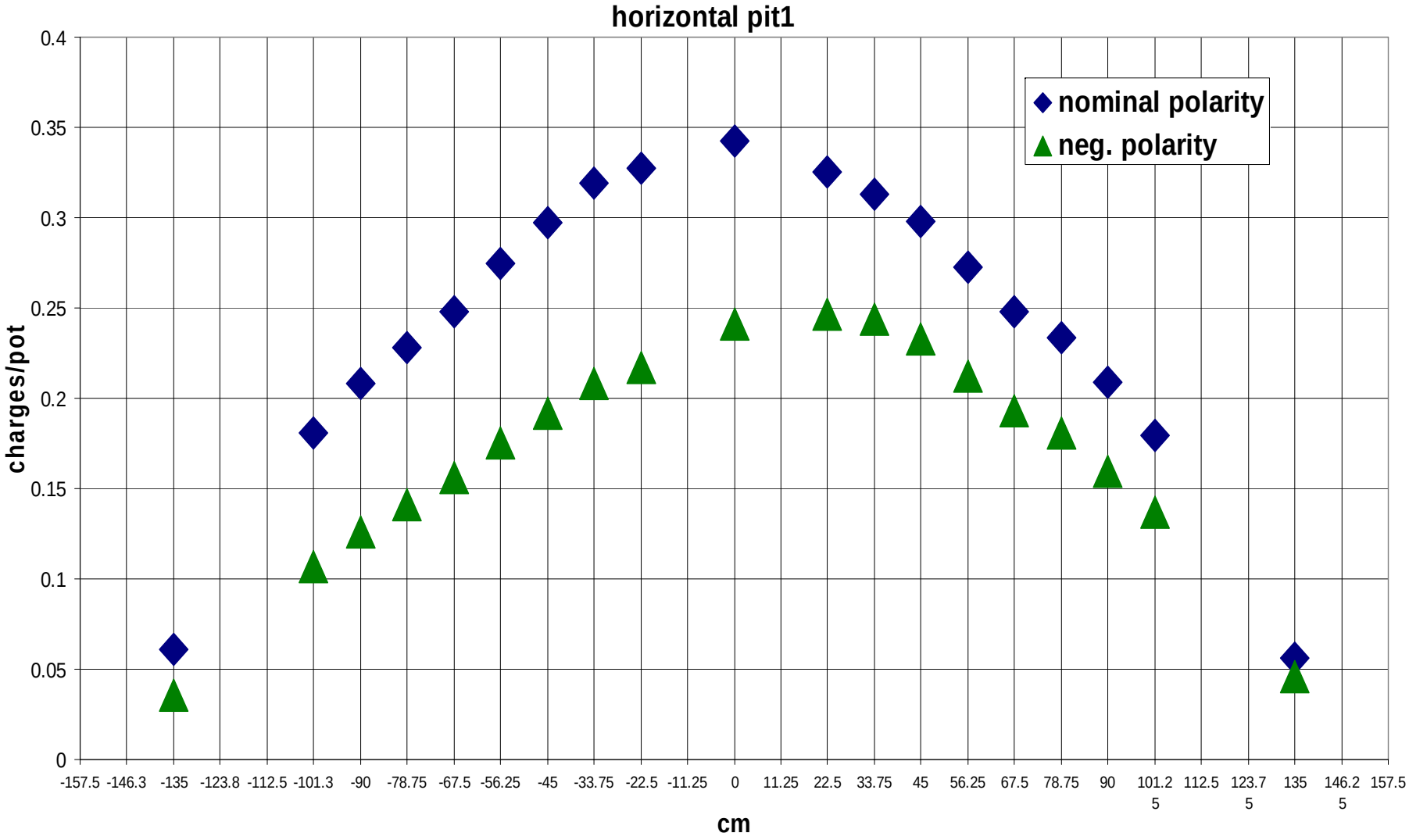


Horn/Reflector Timing Tests

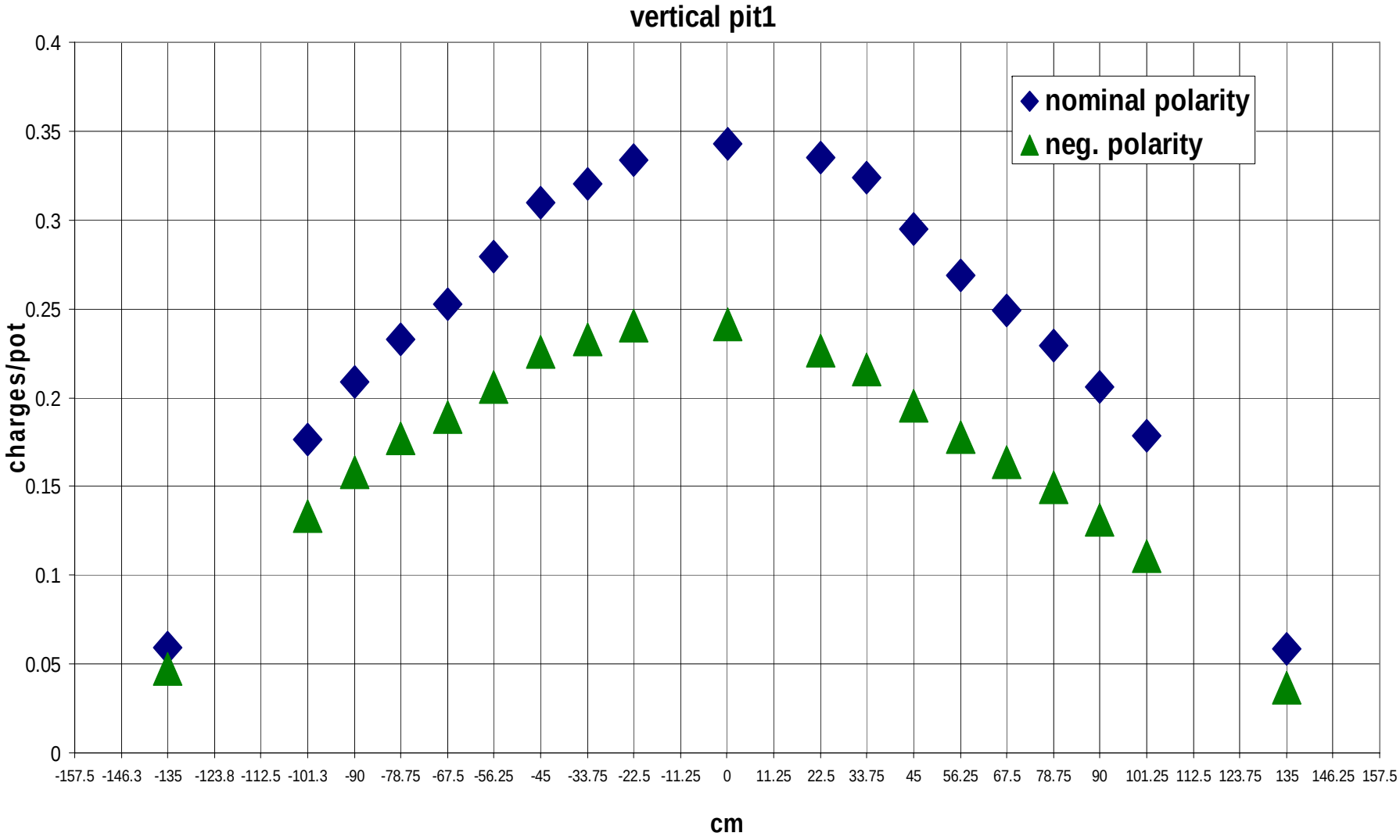


Horn/Reflector Timing Tests

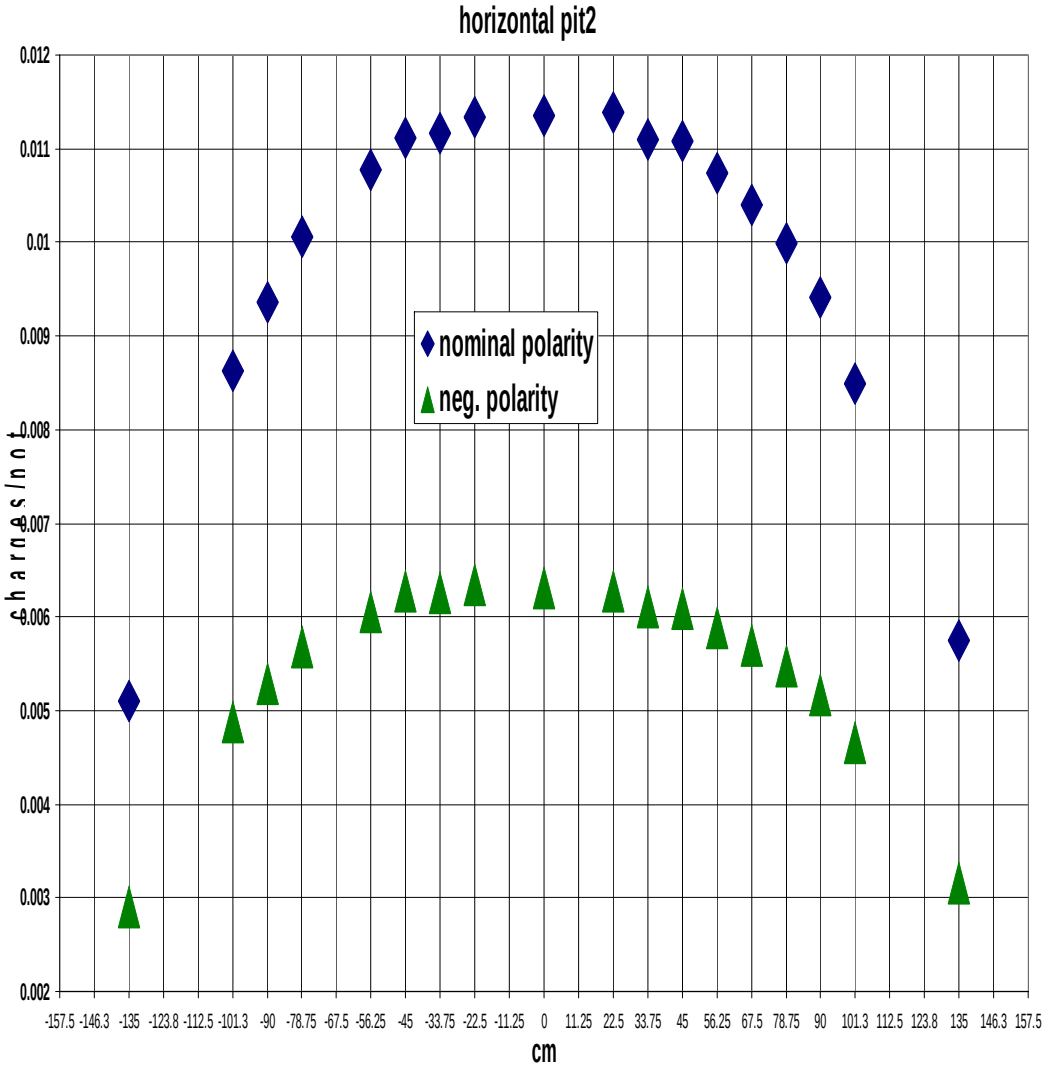
Comparison Nominal-Negative Polarity I

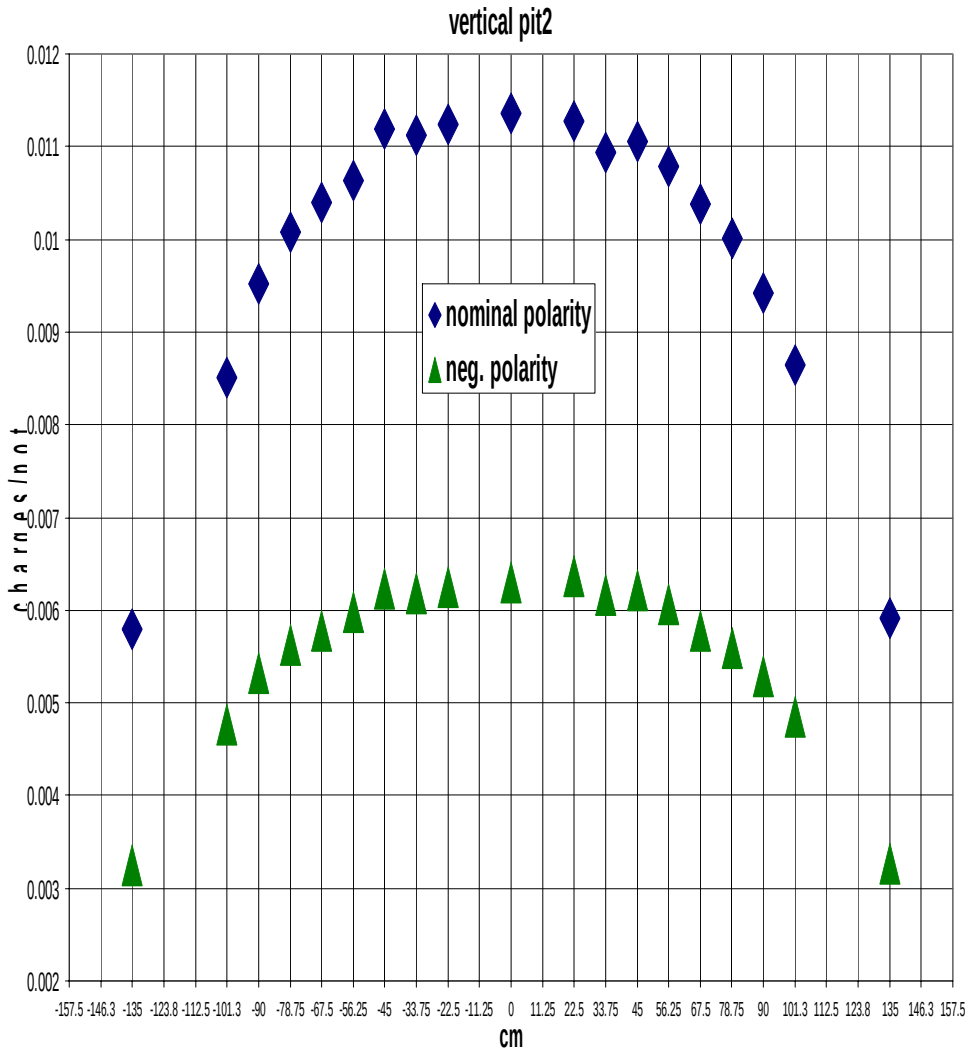


Comparison Nominal-Negative Polarity II

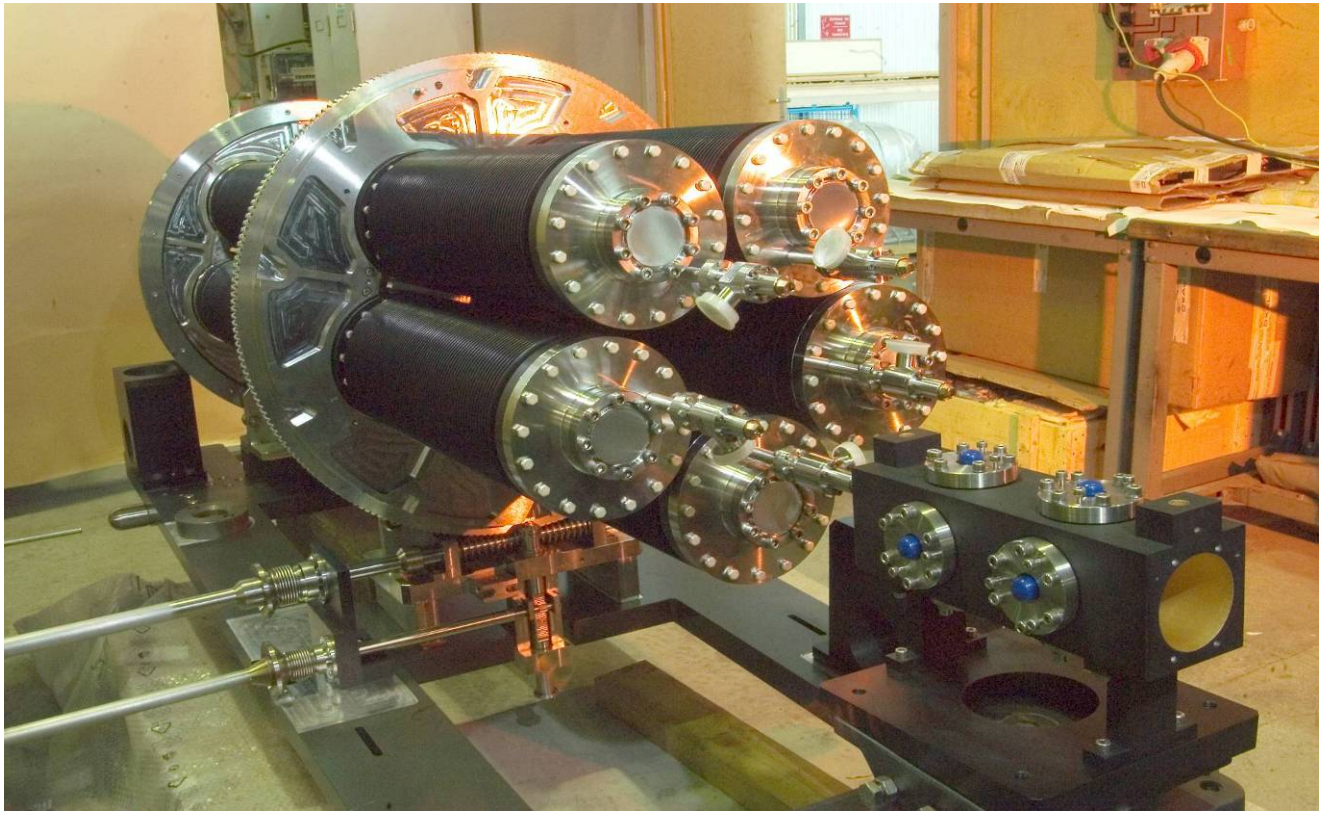


Comparison Nominal-Negative Polarity III





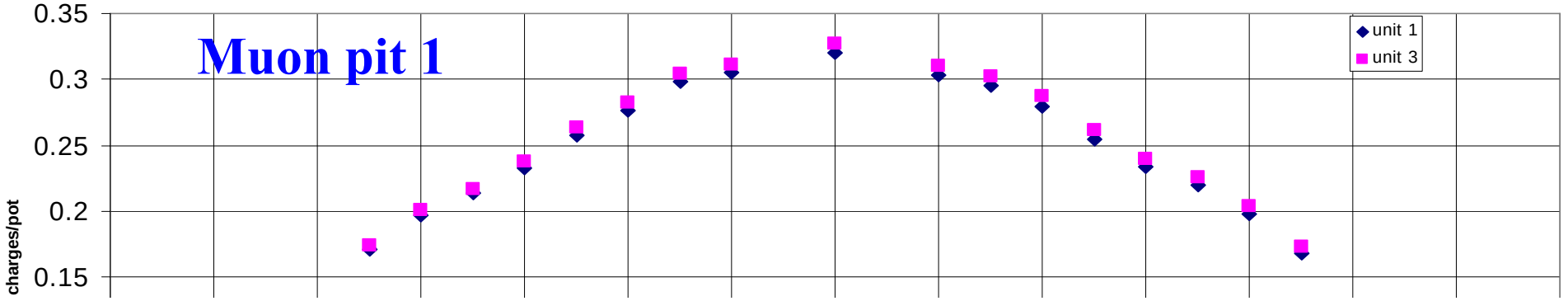
Target Unit Tests



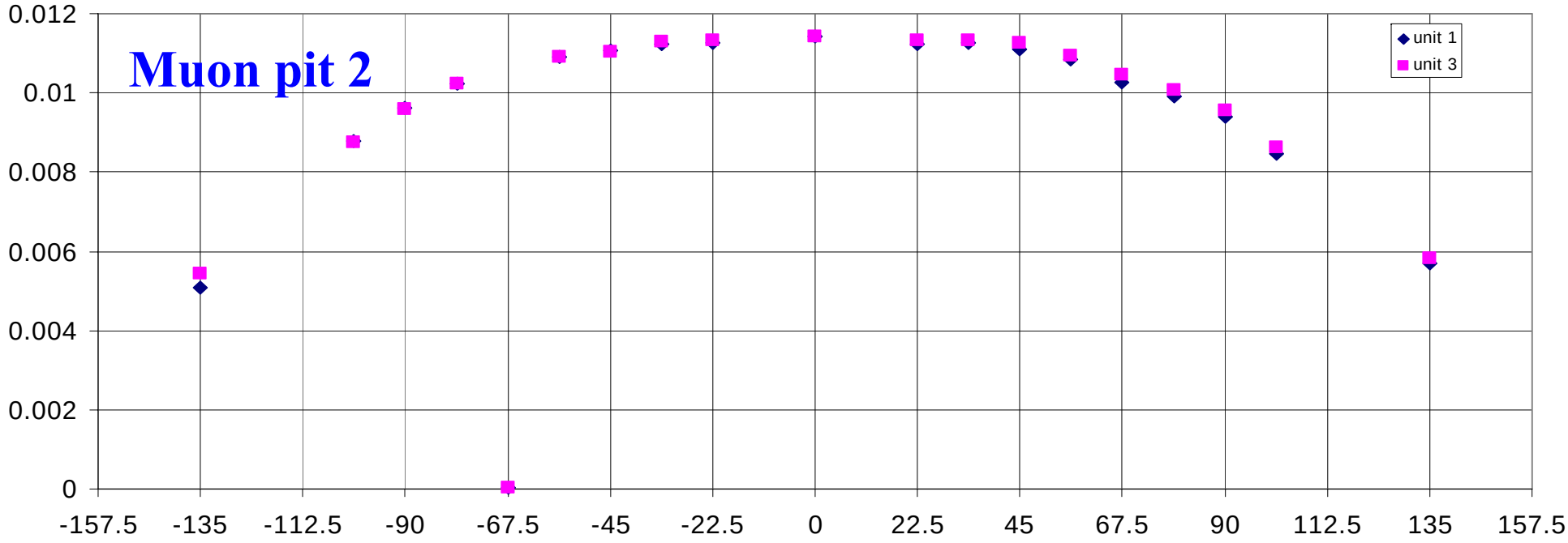
unit 1 : polycrystalline graphite by Carbone-Lorraine 2020 PT
density 1.76 g/cm3

unit 3: carbon-carbon composite by Carbone-Lorraine A035
density >1.75 g/cm3

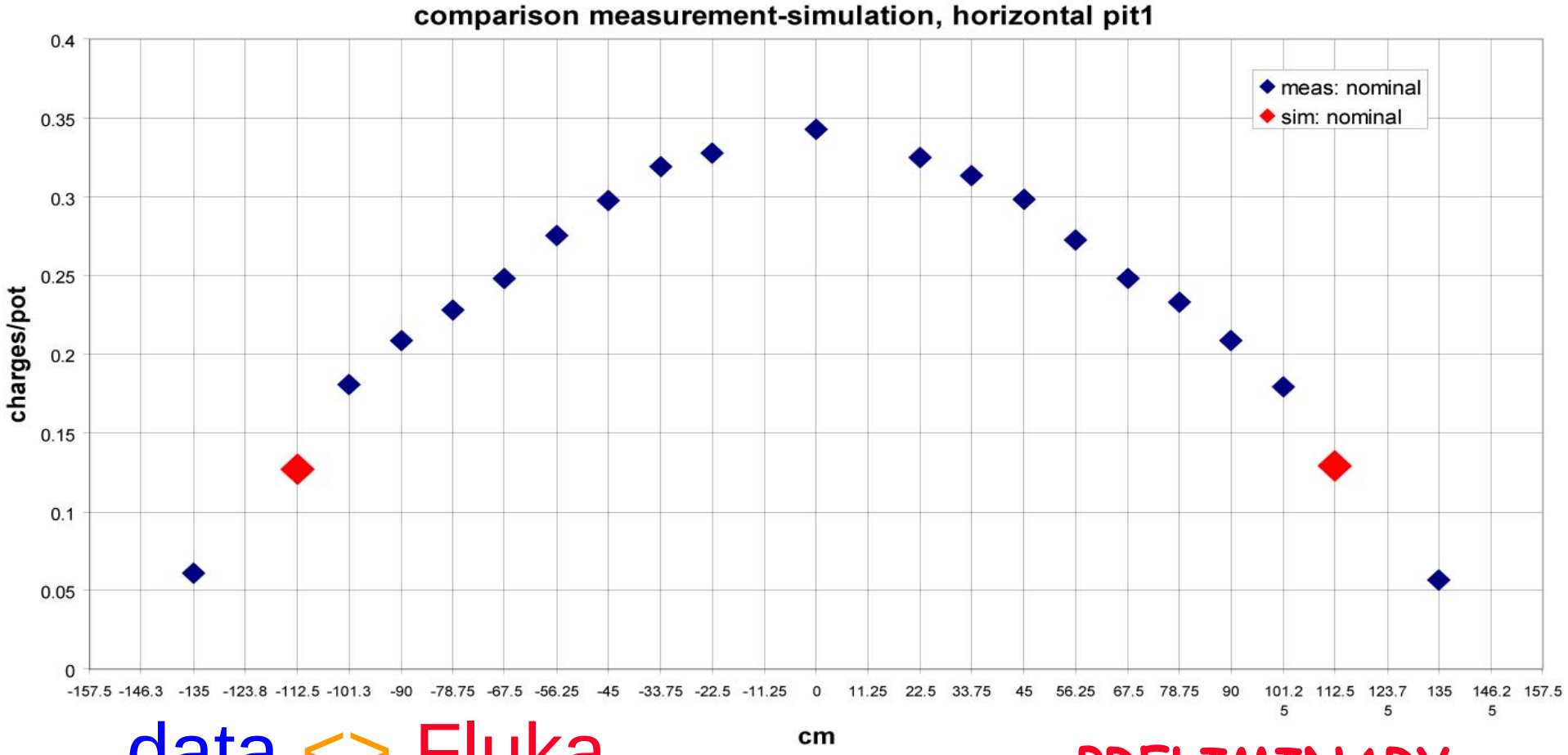
Comparison Unit 1 and Unit 3



Average of 2 extraction, ~1.2E13 protons



Quality check – muon monitors (example: Pit 1 - horizontal plane)

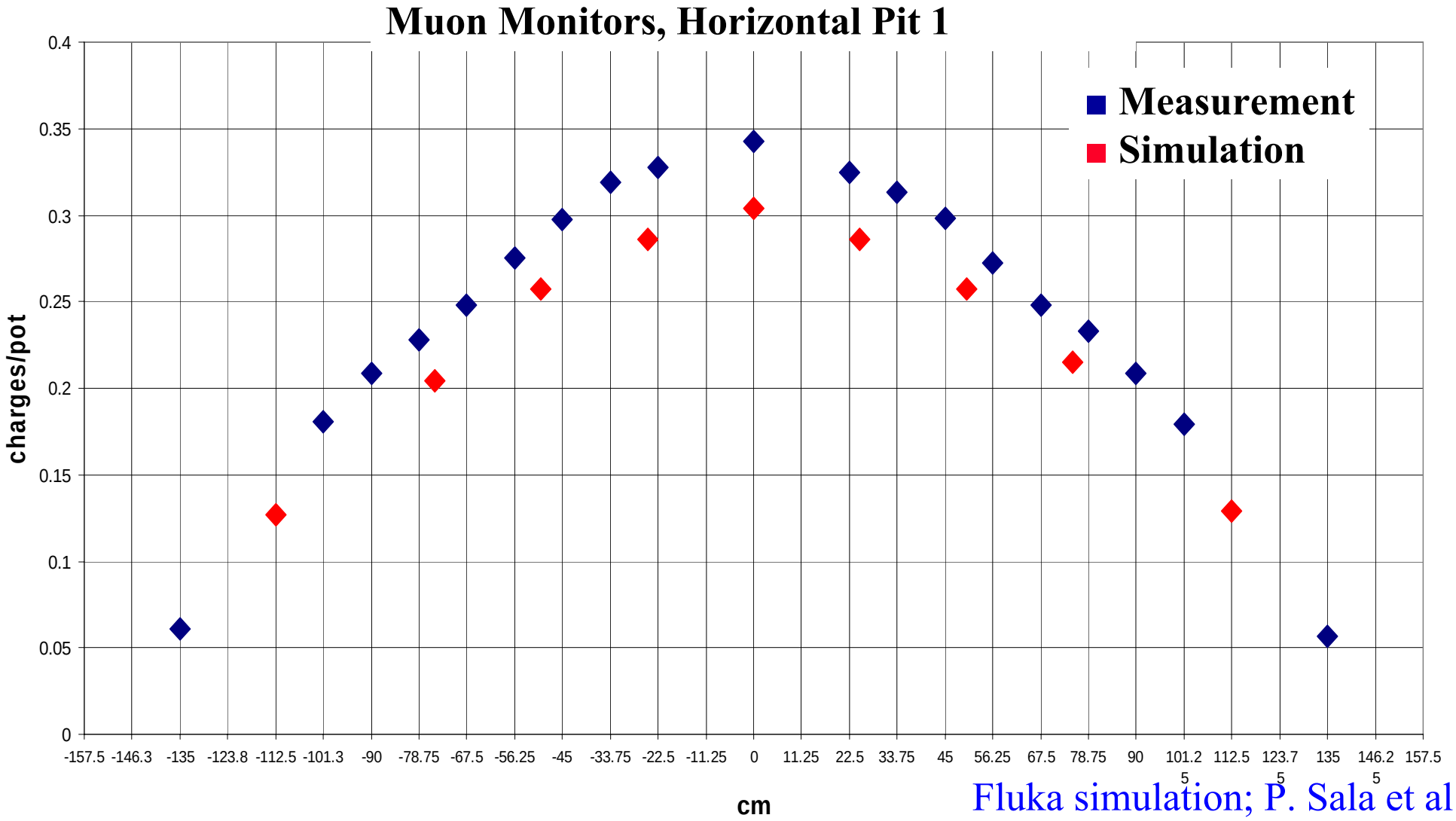


data <> Fluka

PRELIMINARY

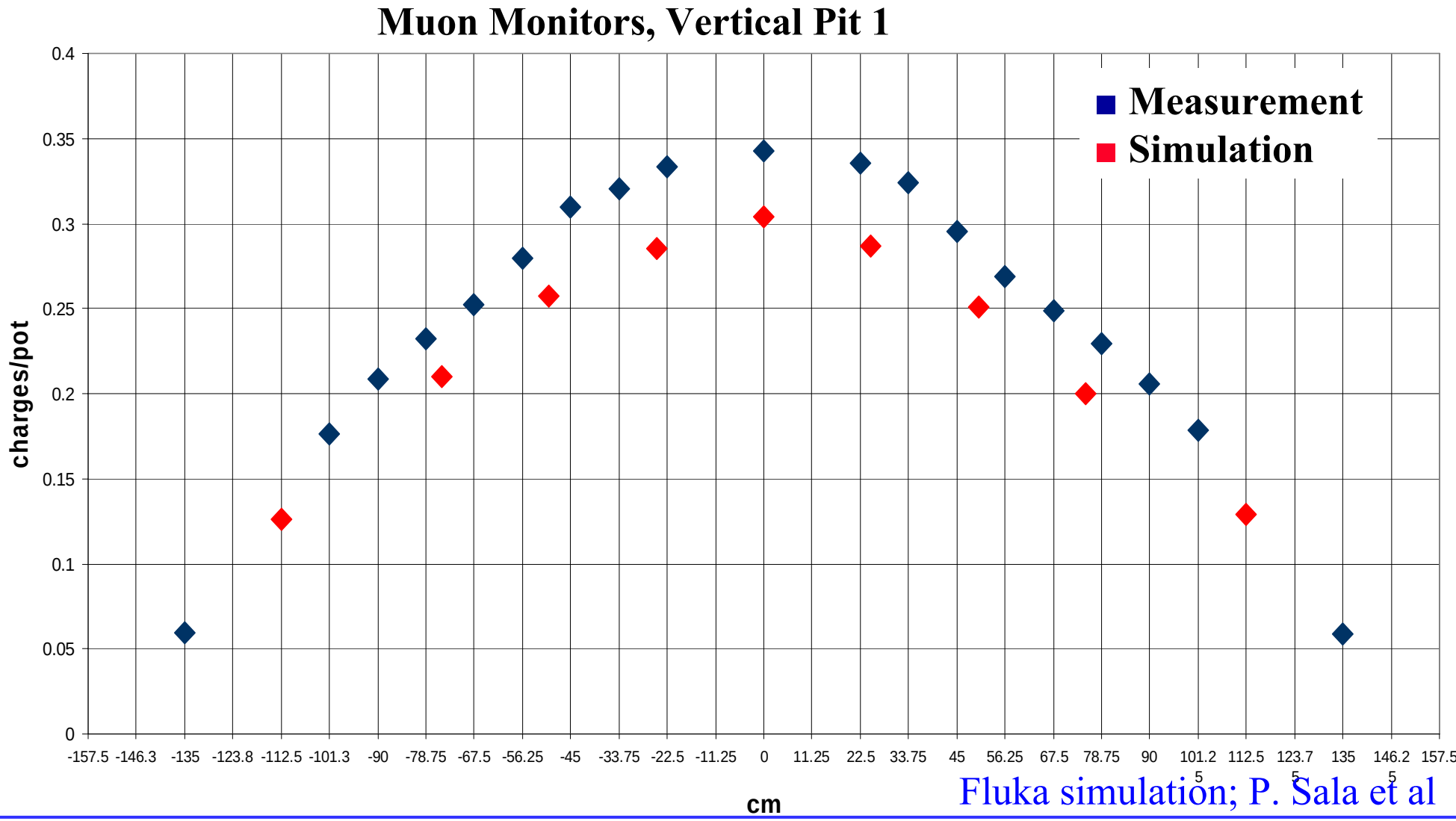
more on Friday, 8 Sept. (Edda's talk)

Comparison Meas.-Sim. I (Preliminary)



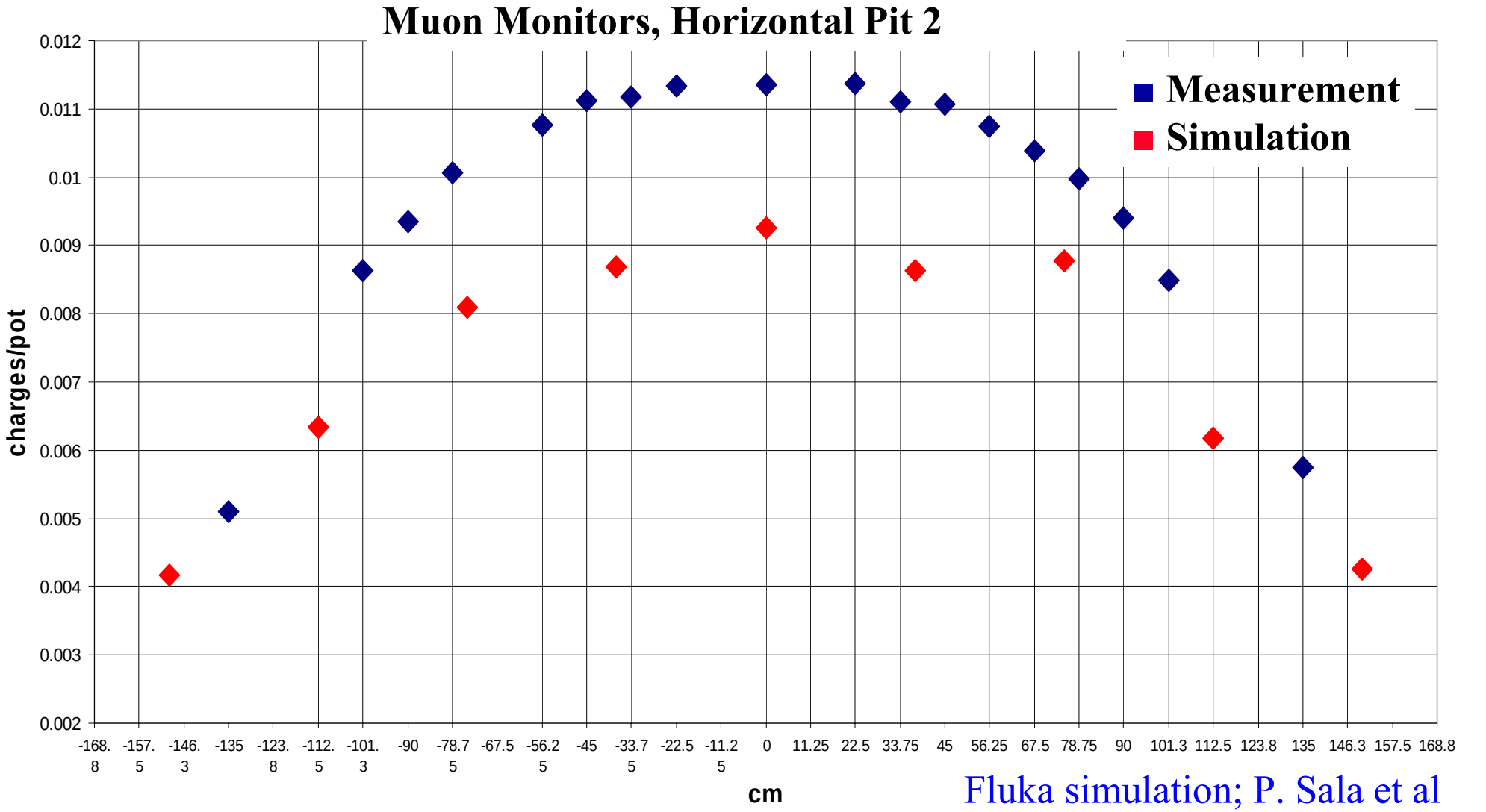
Fluka simulation; P. Sala[5] et al

Comparison Meas.-Sim. II (Preliminary)



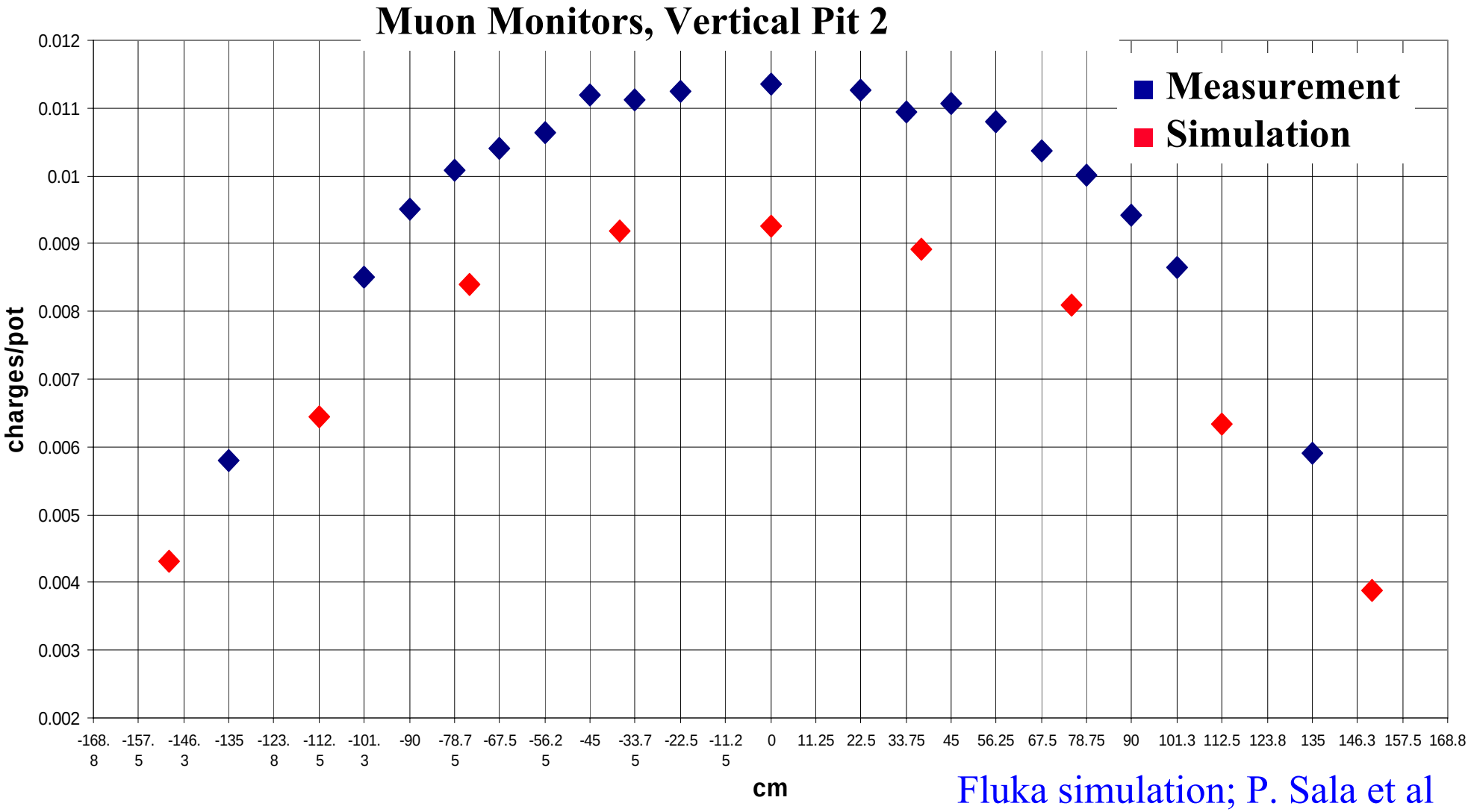
Fluka simulation; P. Sala et al

Comparison Meas.-Sim. III (Preliminary)



Fluka simulation; P. Sala et al

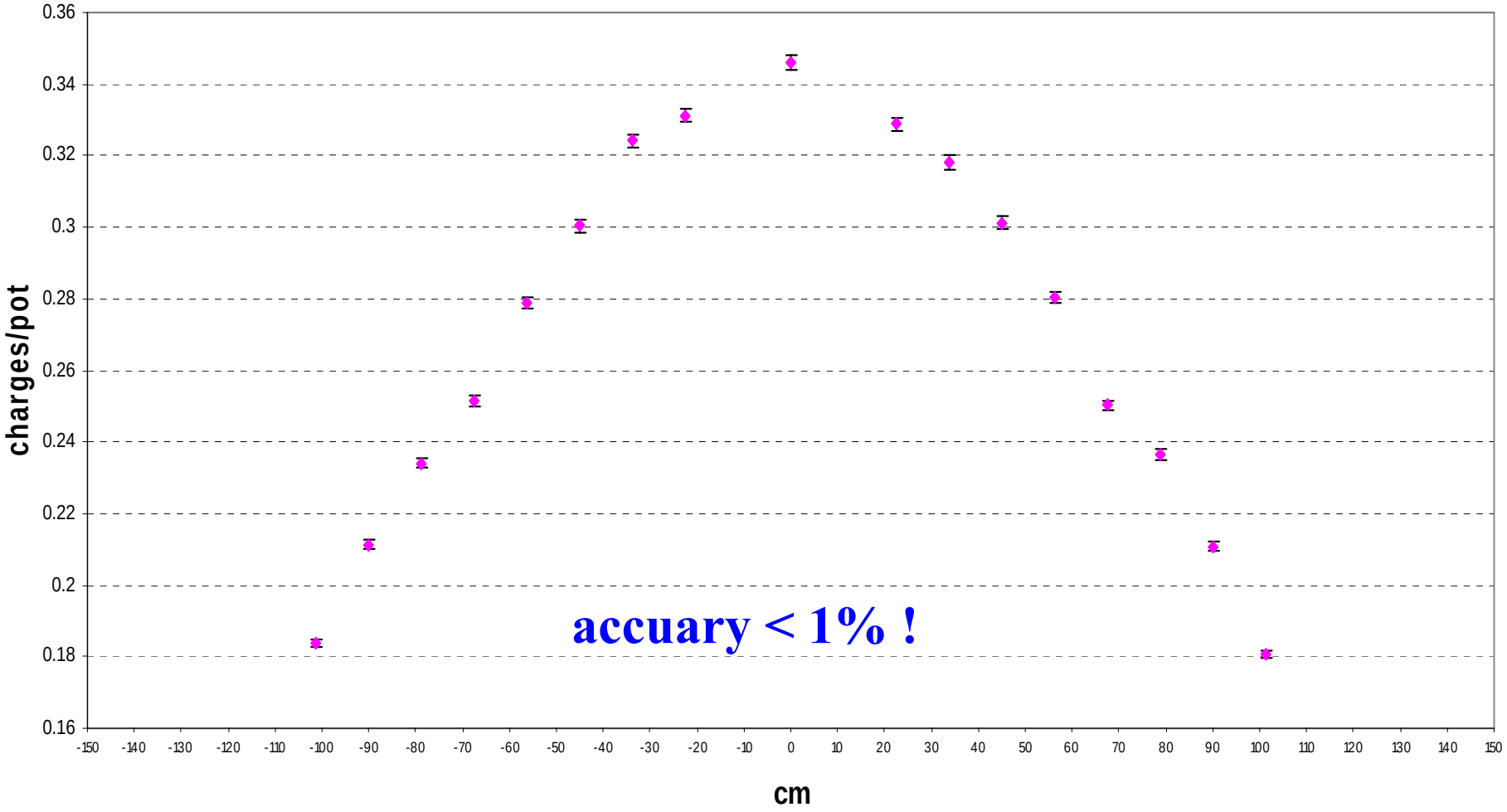
Comparison Meas.-Sim. IV (Preliminary)



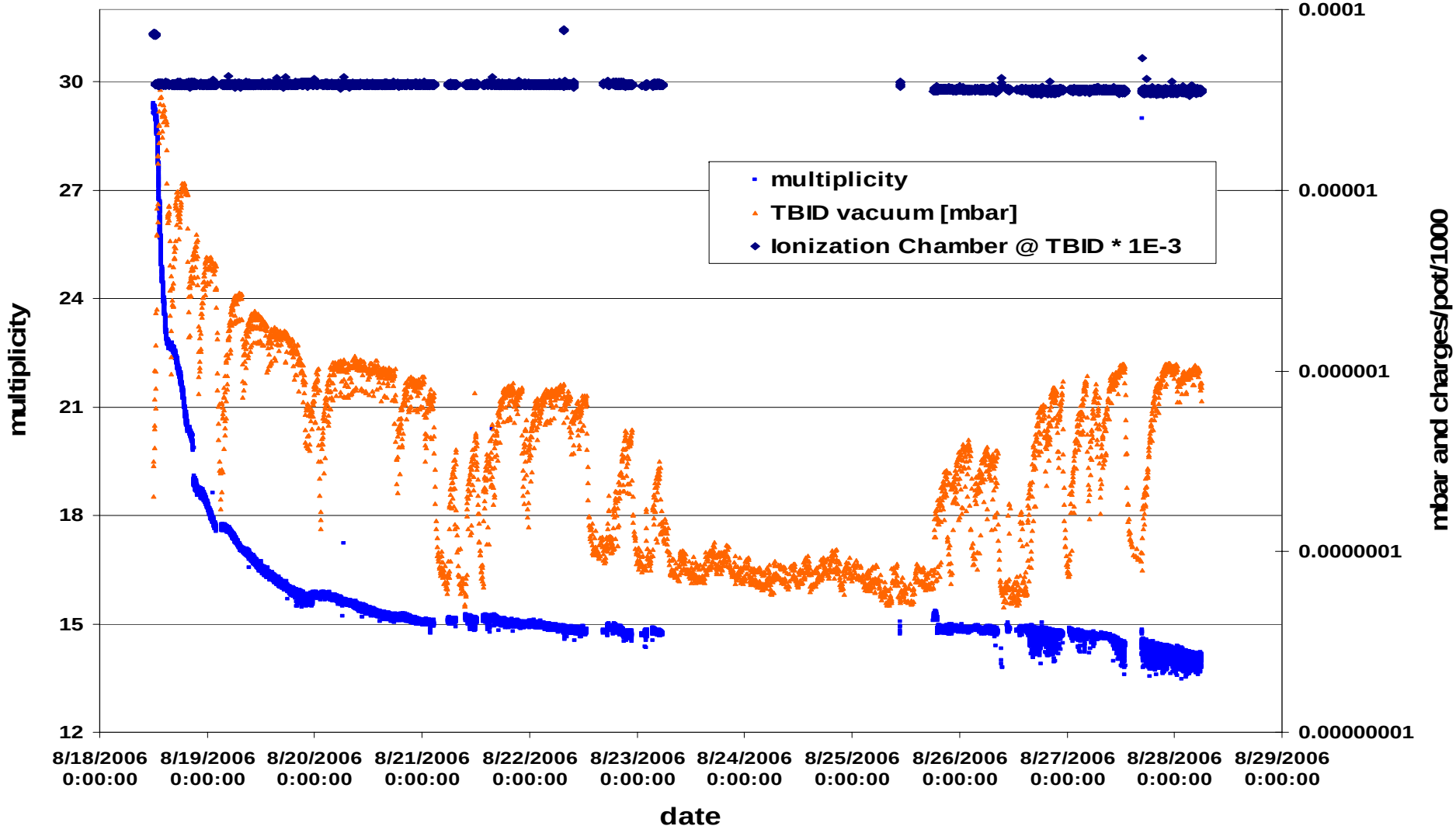
Fluka simulation; P. Sala et al

- **Secondary Beam Instrumentation Performance during Operation**

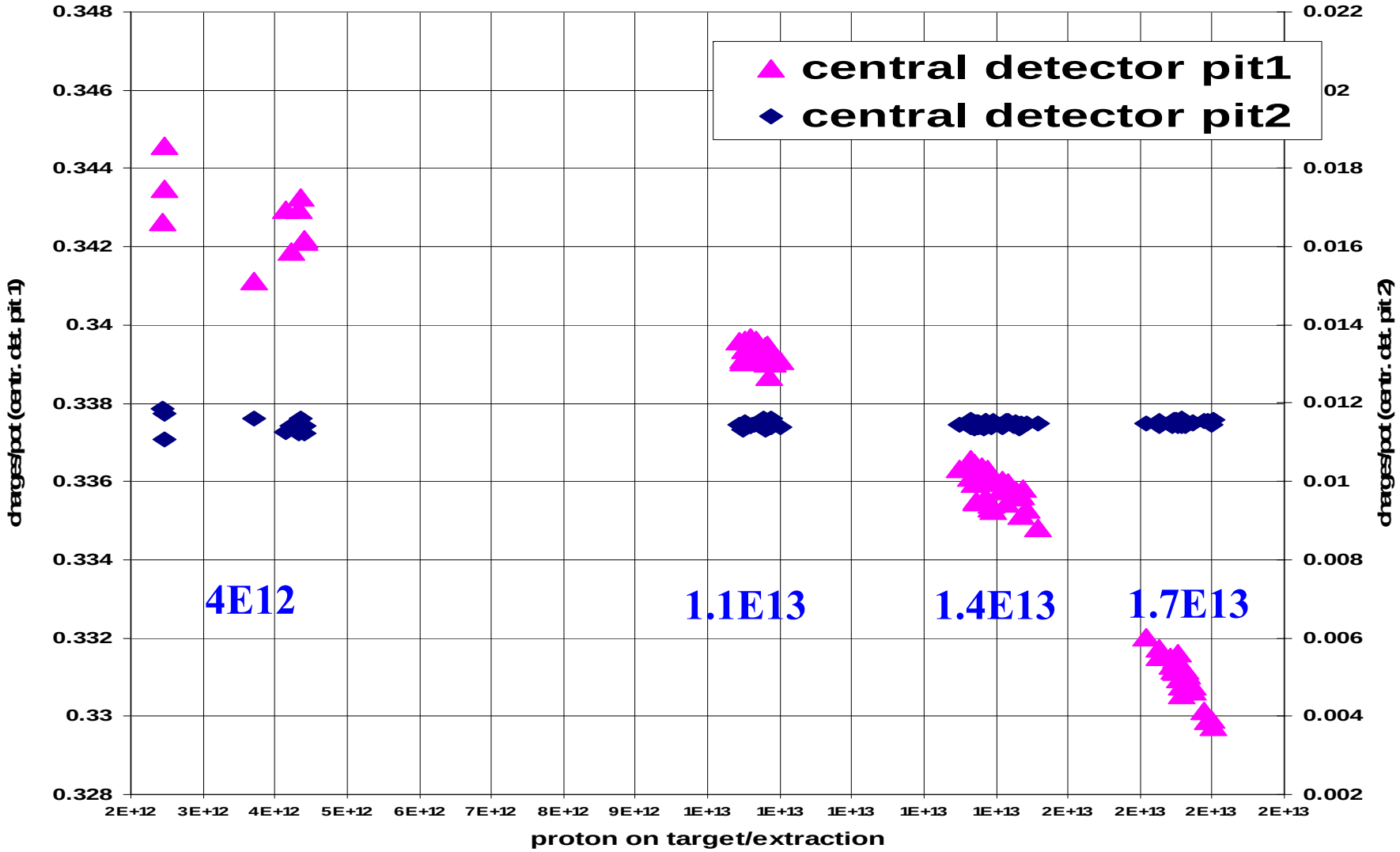
Muon Monitor Repeatability



TBID Performance



Muon Monitor Linearity



Summary

- Detailed hardware commissioning
- 'Dry runs' paid off!
  - ➔ Hardly any problems with the control system
- Secondary beam line has been successfully commissioned

→ CNGS is operational

Now operational work starts:

- Performance studies,
- Systematics,
- etc……