CNGS Project

1. Project Overview
   2. Sub-systems
      3. Results from commissioning

Malika Meddahi
for CNGS commissioning team

1. Project Overview

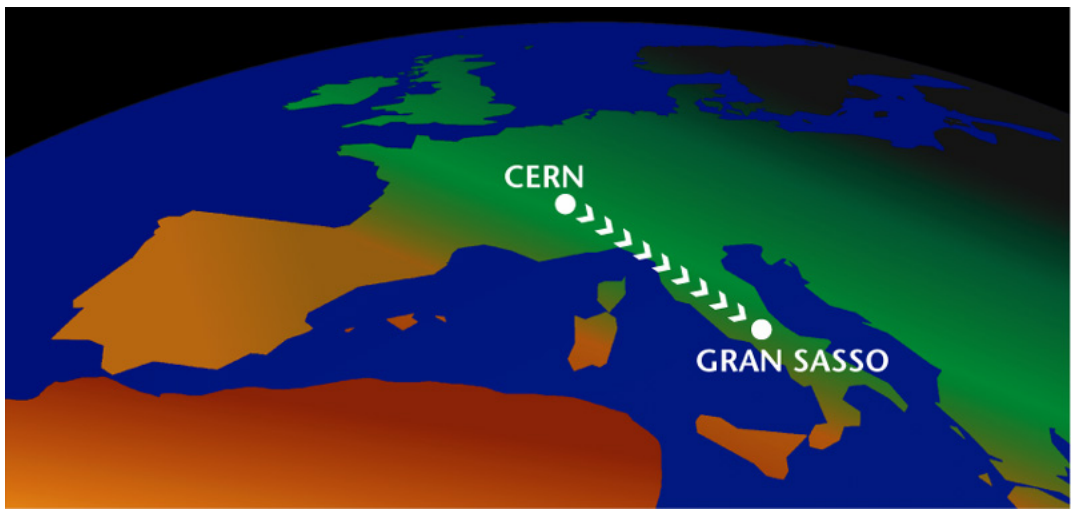
(see http://cern.ch/cngs)

CNGS - a long base-line neutrino beam facility (732 km)

send ν_μ beam -> detect ν_τ appearance

CNGS project at CERN: production of the ν_μ beam

using protons from the existing accelerator chain

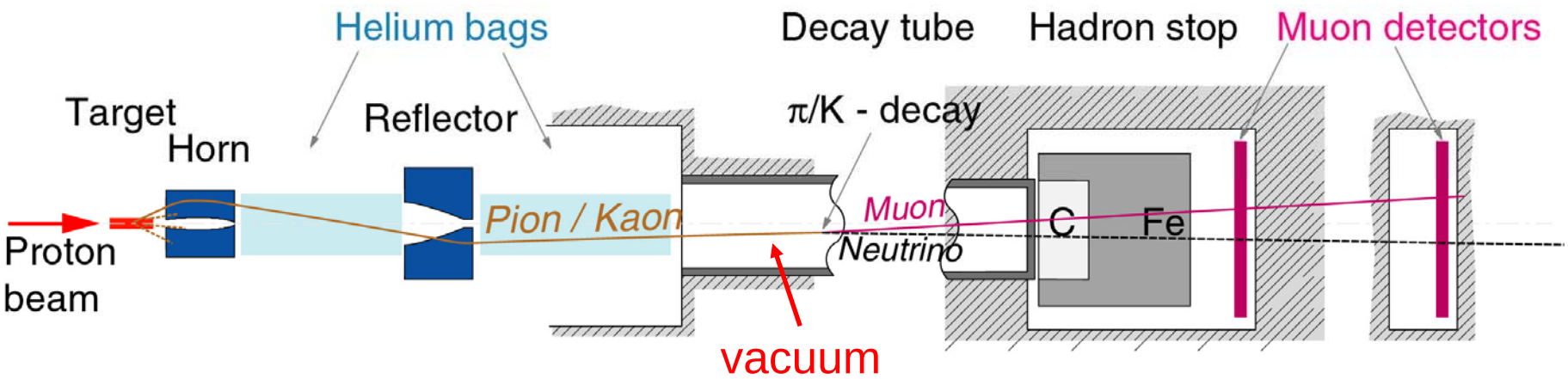


At Gran Sasso:

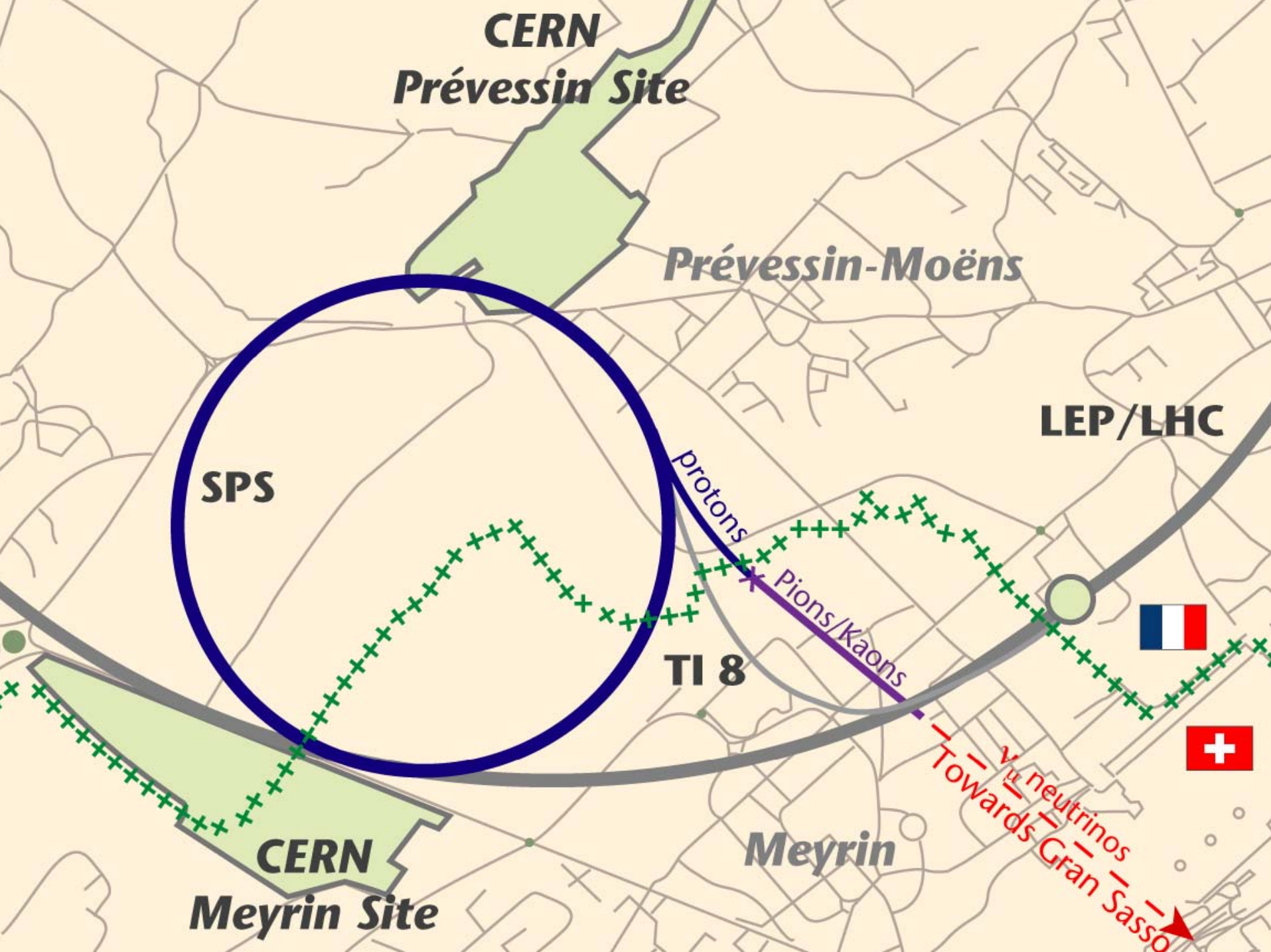
OPERA detecting ν_τ

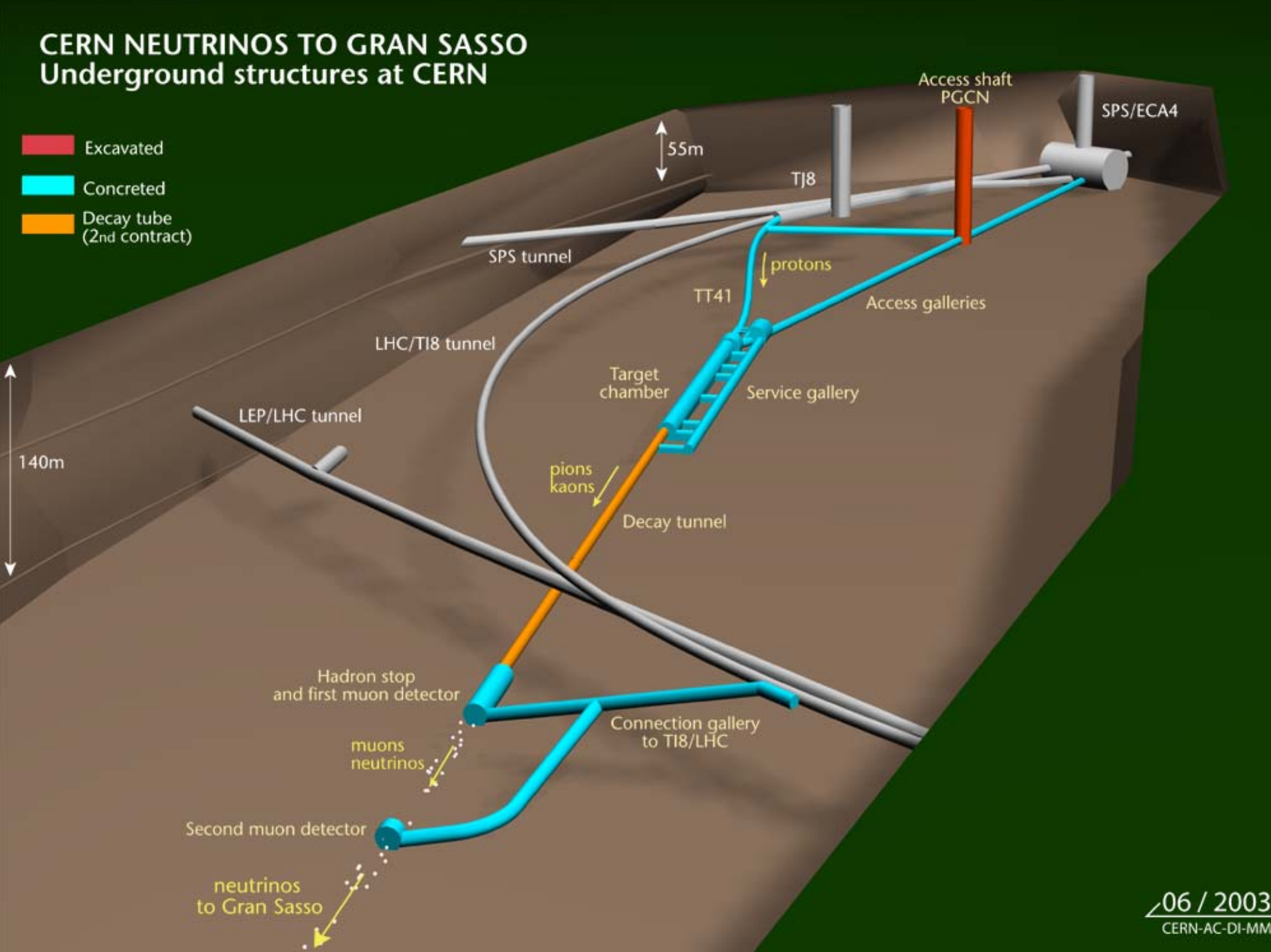
CNGS: the main components

700 m 100 m 1000m 67 m



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


CERN
Prévessin Site
Prévessin-Moëns
LEP/LHC
SPS
protons
Pions/Kaons
TI 8
CERN
Meyrin Site
Meyrin
Towards Gran Sasso


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

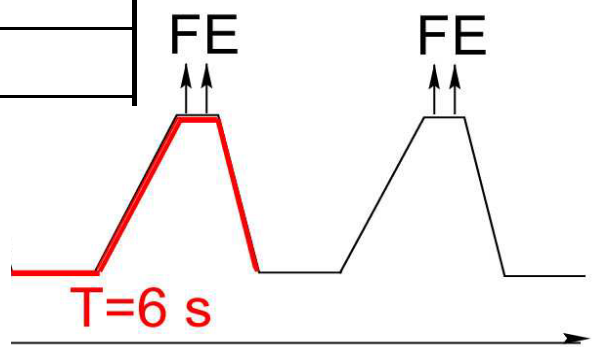
2. Sub-systems

Proton beam line

Nominal beam parameters

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 ; ver.: 20
Beam sizes at 400 GeV [mm]	0.5 mm

Upgrade phase: 3.5 10^{13} p



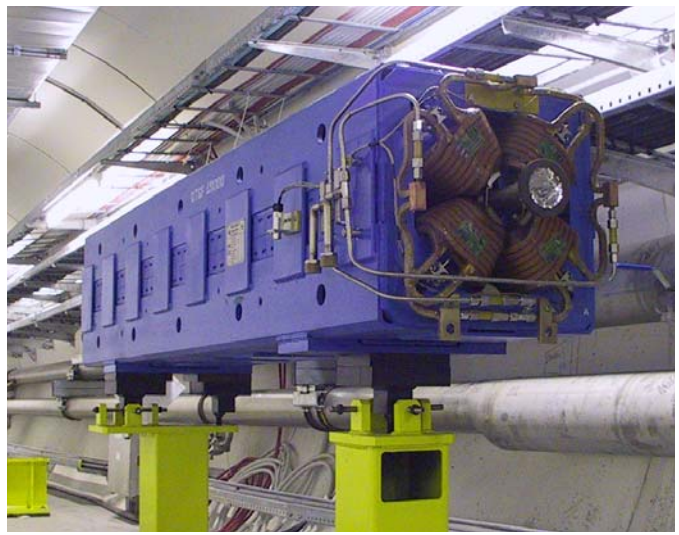
New transfer line magnets

MBG 73 magnets (78 ordered)

Nominal field : 1.7 T @ 400 GeV

Magnetic length : 6.3 m

Gap height 37 mm



QTG 20 magnets (23 ordered)

Magnetic aperture : 45 mm

Nominal gradient 40 T/m, 2.2 m

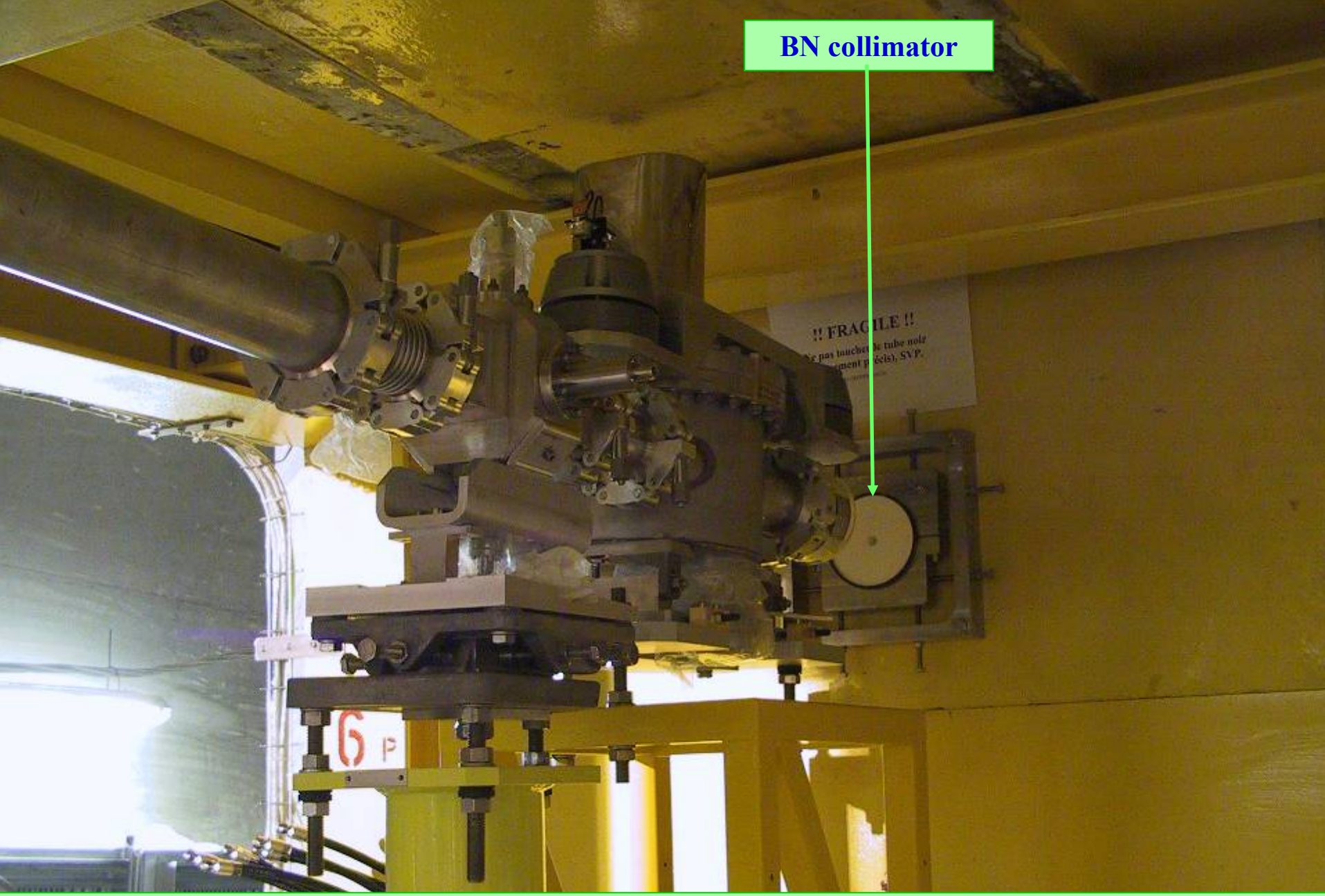
MDG 12 magnets (17 ordered)

Gap height : 45 mm

Bending angle 80 μrad

Overall length: 700mm

Final focusing onto the target (recuperated magnets)



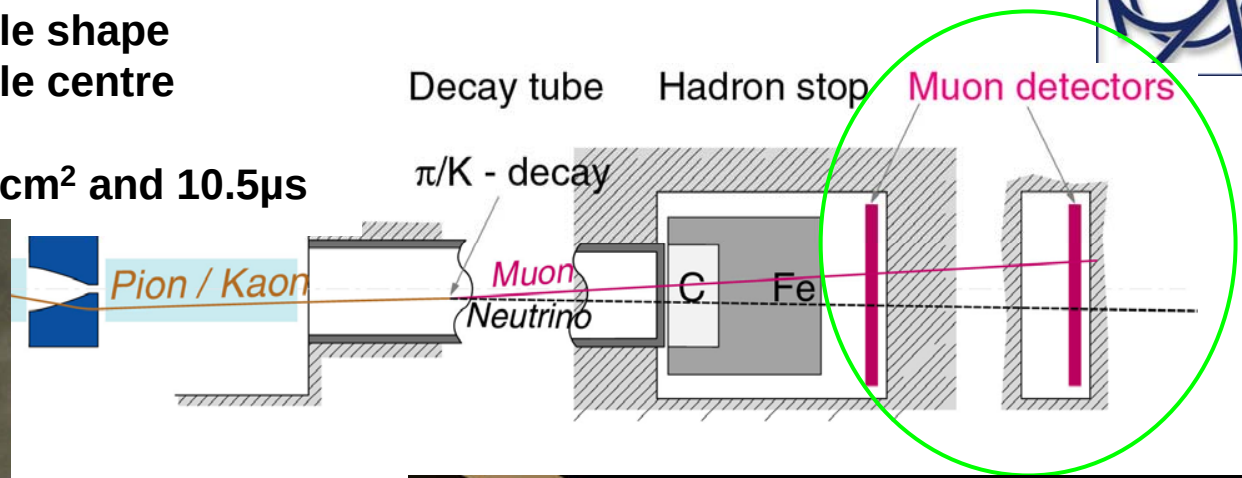
Proton beam: last beam position / beam profile monitors upstream of the target station collimator and shielding

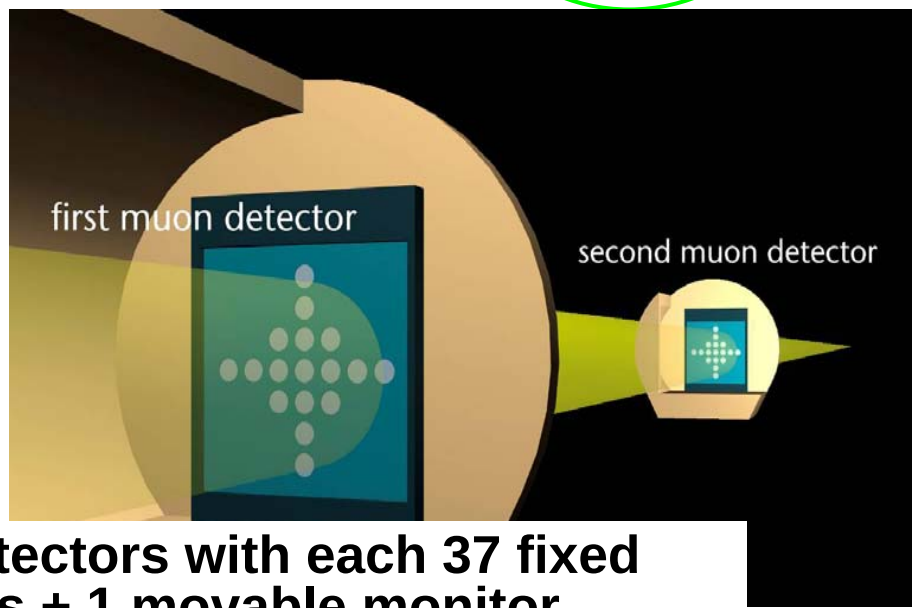
CNGS Target:
talk by Luca Bruno

Horn and Reflector: talk by Ans Pardons

Muon Monitors

- **Monitoring of:**
  - **muon intensity**
  - **muon beam profile shape**
  - **muon beam profile centre**
- **Muon intensity:**
  - **Up to 7.7x10^7 per cm^2 and 10.5µs**





2 muon detectors with each 37 fixed monitors + 1 movable monitor (ionization chambers)

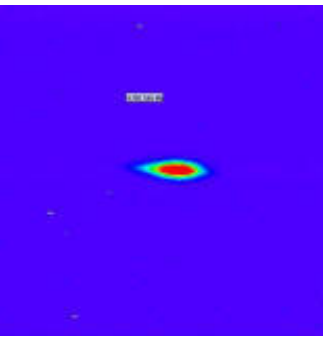
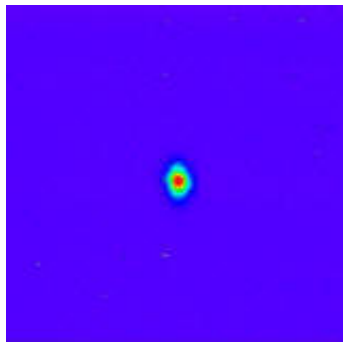
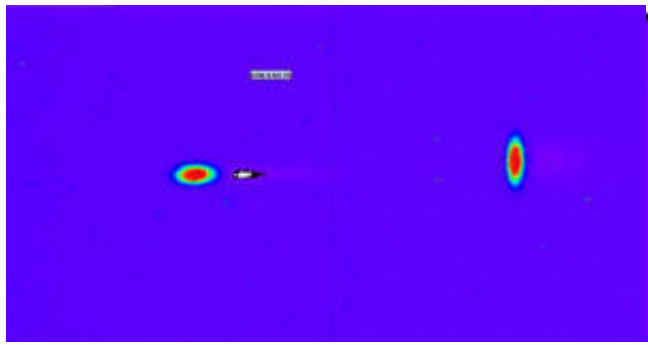
3. Commissioning results

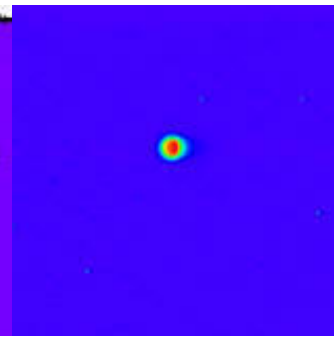
Importance of complete Hardware commissioning and dry runs
(like if beam but without beam)

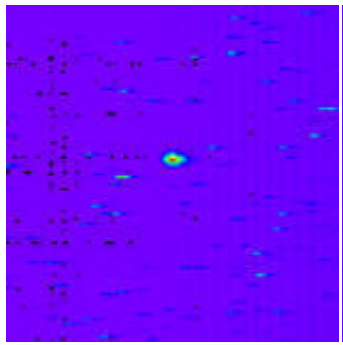
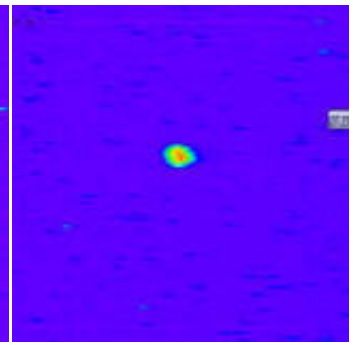
- Hardware commissioning Feb. – April 2006
  - Beam instrumentations
  - Power supplies
  - Magn ets (polarities)
  - Vacuum system
- "Dry runs" April – May 2006
  - Timing
  - Controls
  - Interlocks
  - Beam permit
  - Magnets (current & polarities)
- Commissioning with beam 2006: weeks 28, 30 and 33
  - Upper limit of protons of **1E17** for the 3 weeks (limit activation of the facility -> possible access to check equipment)

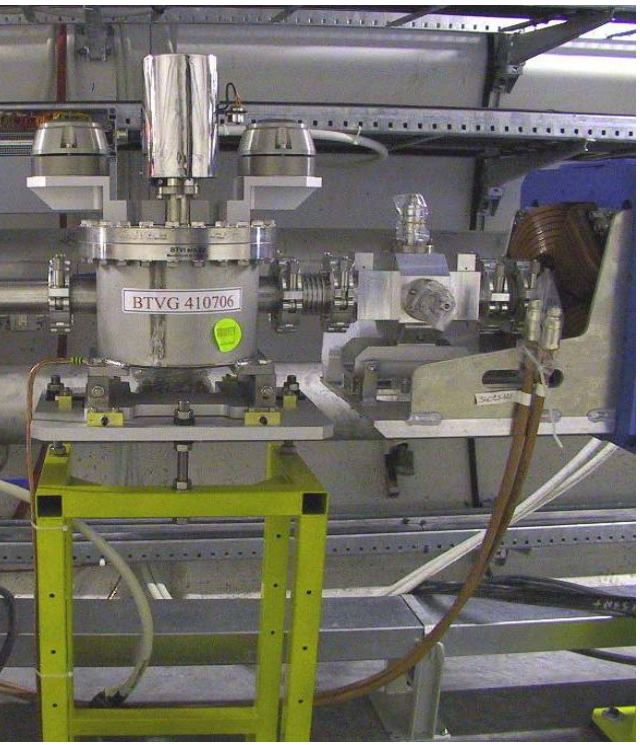
Proton beam along the 8 screens of transfer line

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





Screens:
75 μm carbon
12 μm titanium screens

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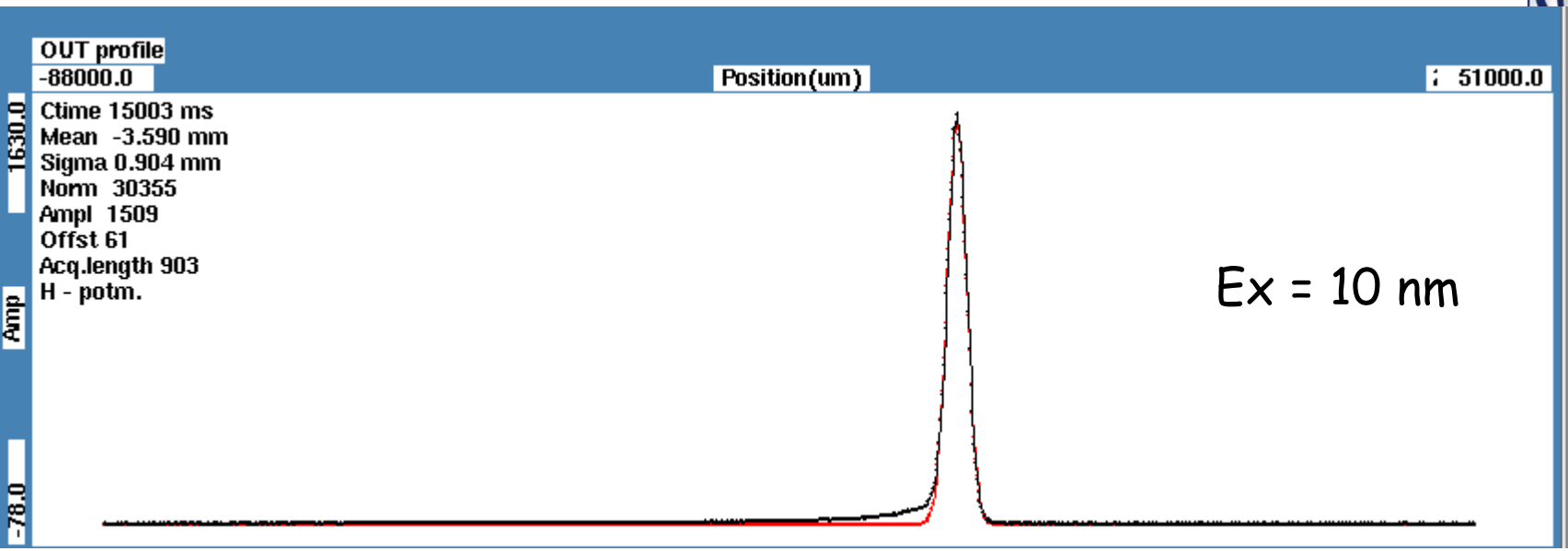
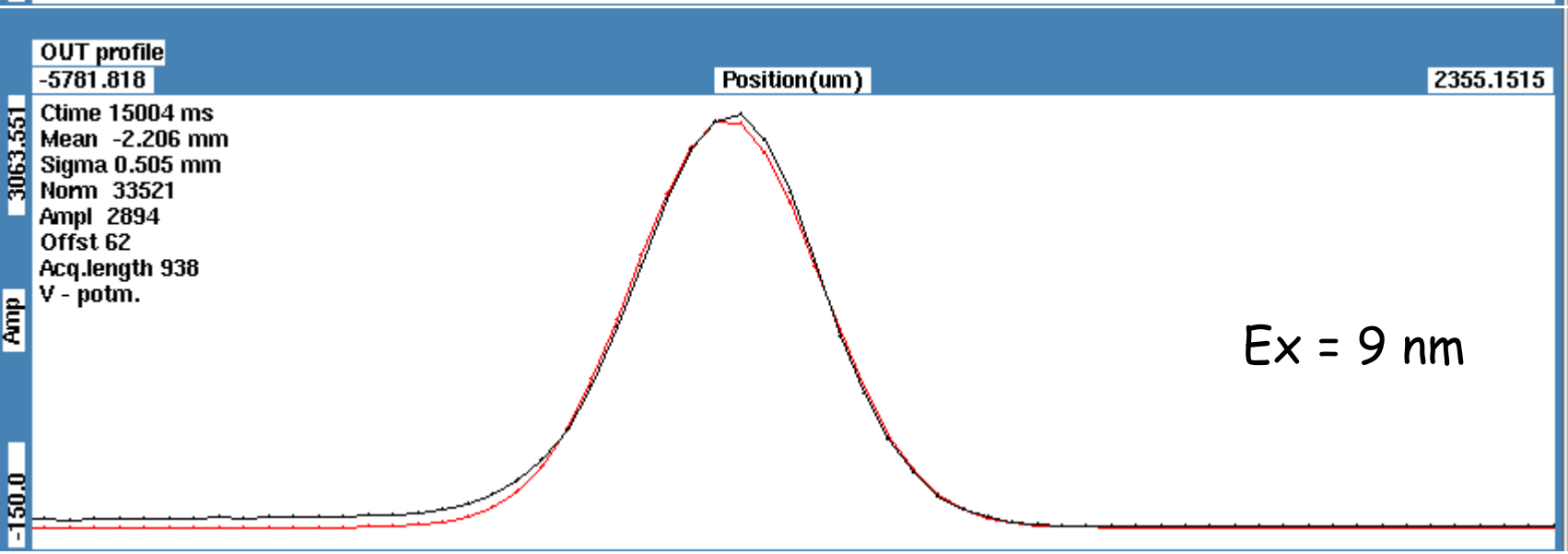
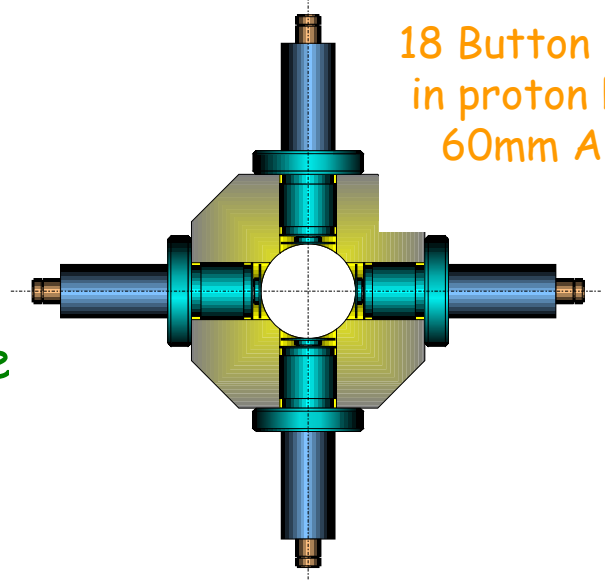
for CNGS commissioning team

Emittance measurement, 1.E13 protons per extraction, 400 GeV





Beam position monitors checked



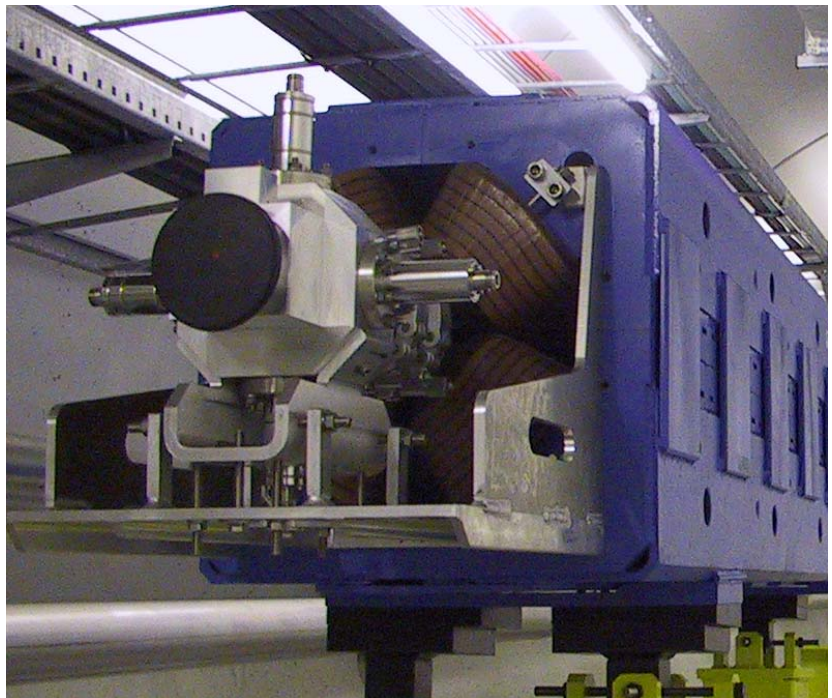
18 Button Electrode
in proton beam line
60mm Aperture

2 batch lengths

2μs, for I~2E11
Trigger at 1μs, 400ns gate

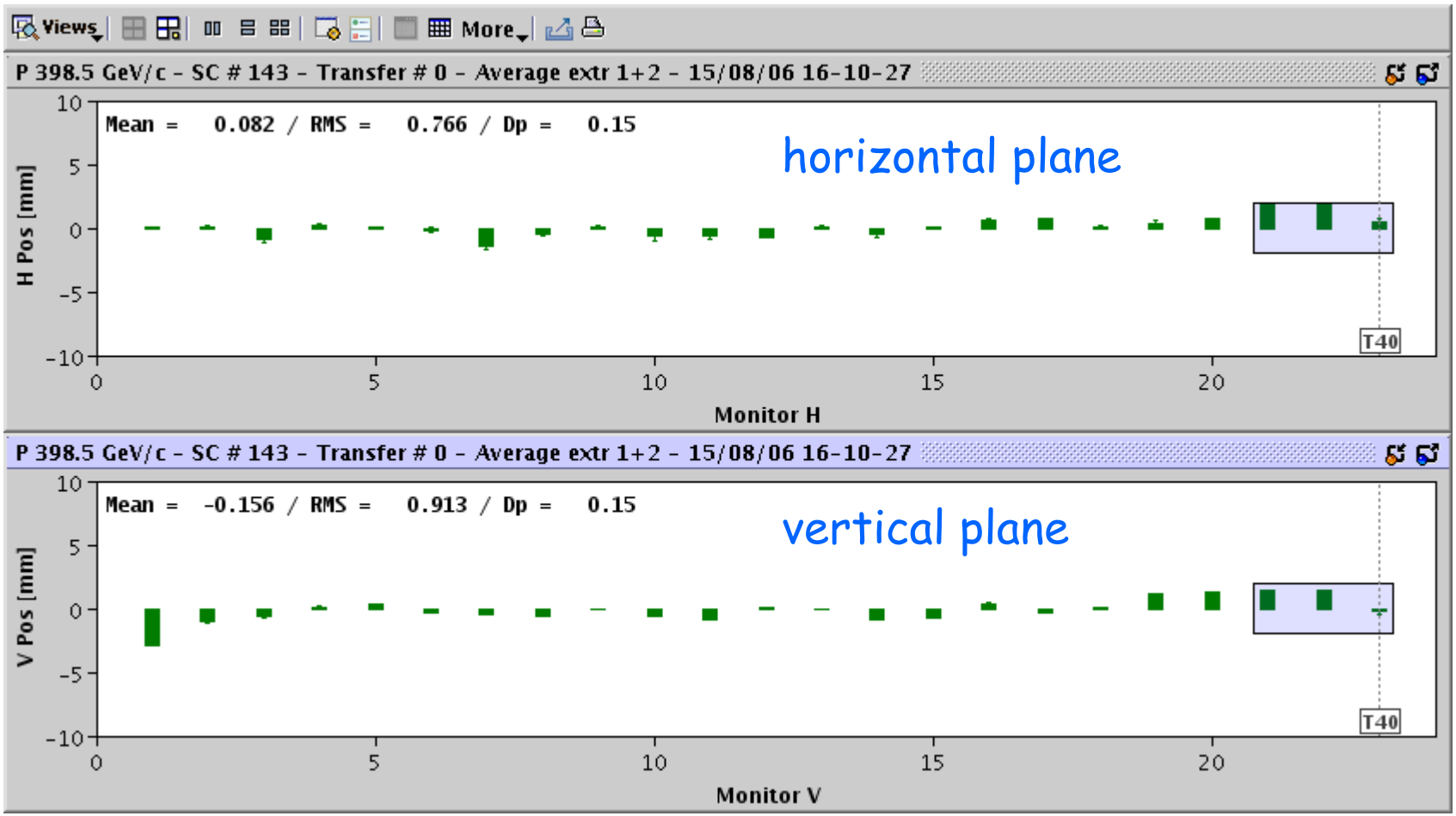
10.5μs for I>2E12
Trigger at 1μs, 8μs gate
or trigger at 2μs, 400ns gate

System is very sensitive
to batch structure and intensity.
However for nominal beam
parameters, system is reliable.



Trajectory along beam line

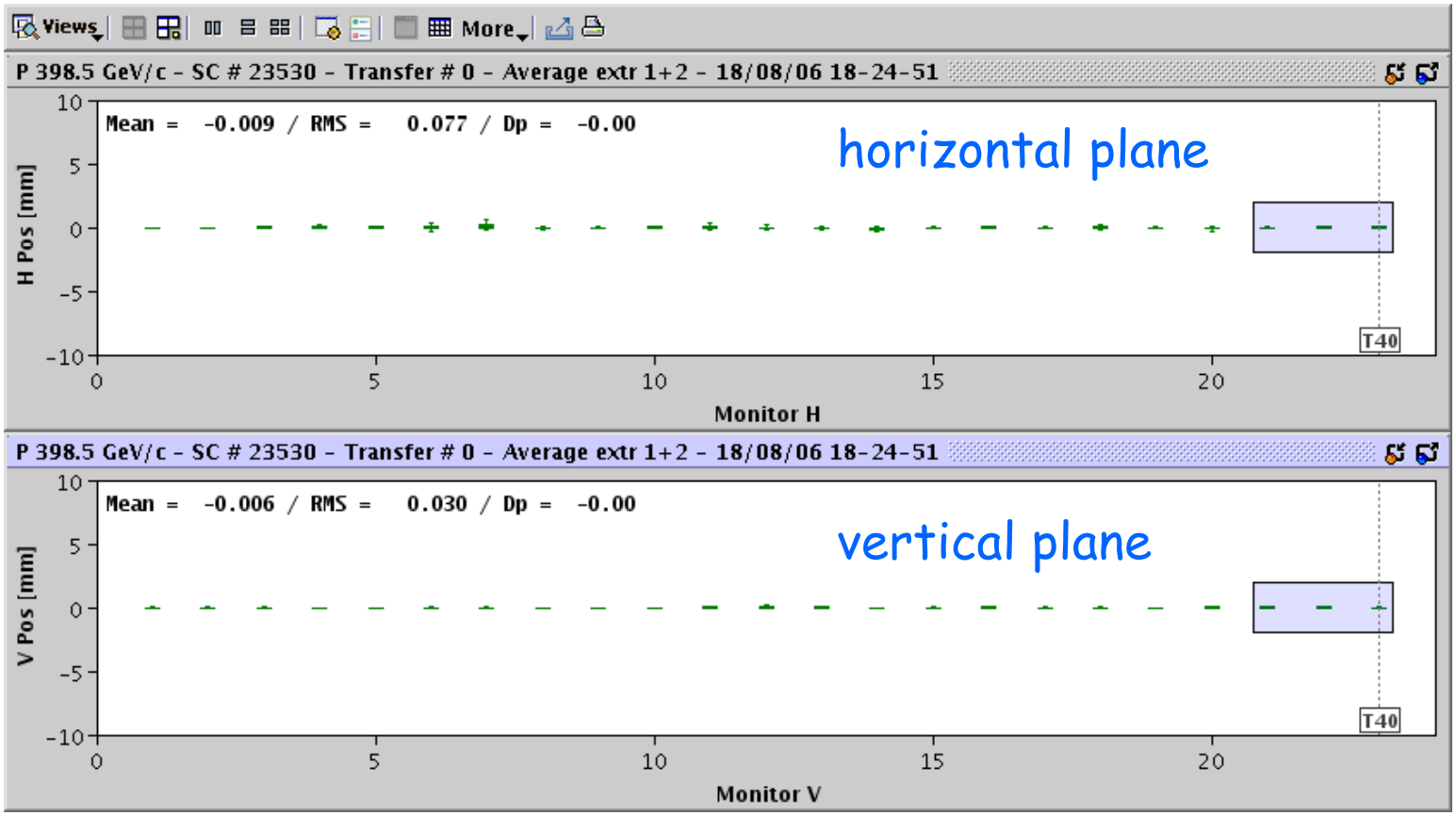
2 extractions. 1E13 protons per batch



Interpolation to Target Elements

Target	Type	Corr.	X	X' [urad]	Y	Y' [urad]	Show	History
T40	Left-Left	☑	0.002	-5.76	-0.012	-13.43	☐	☐

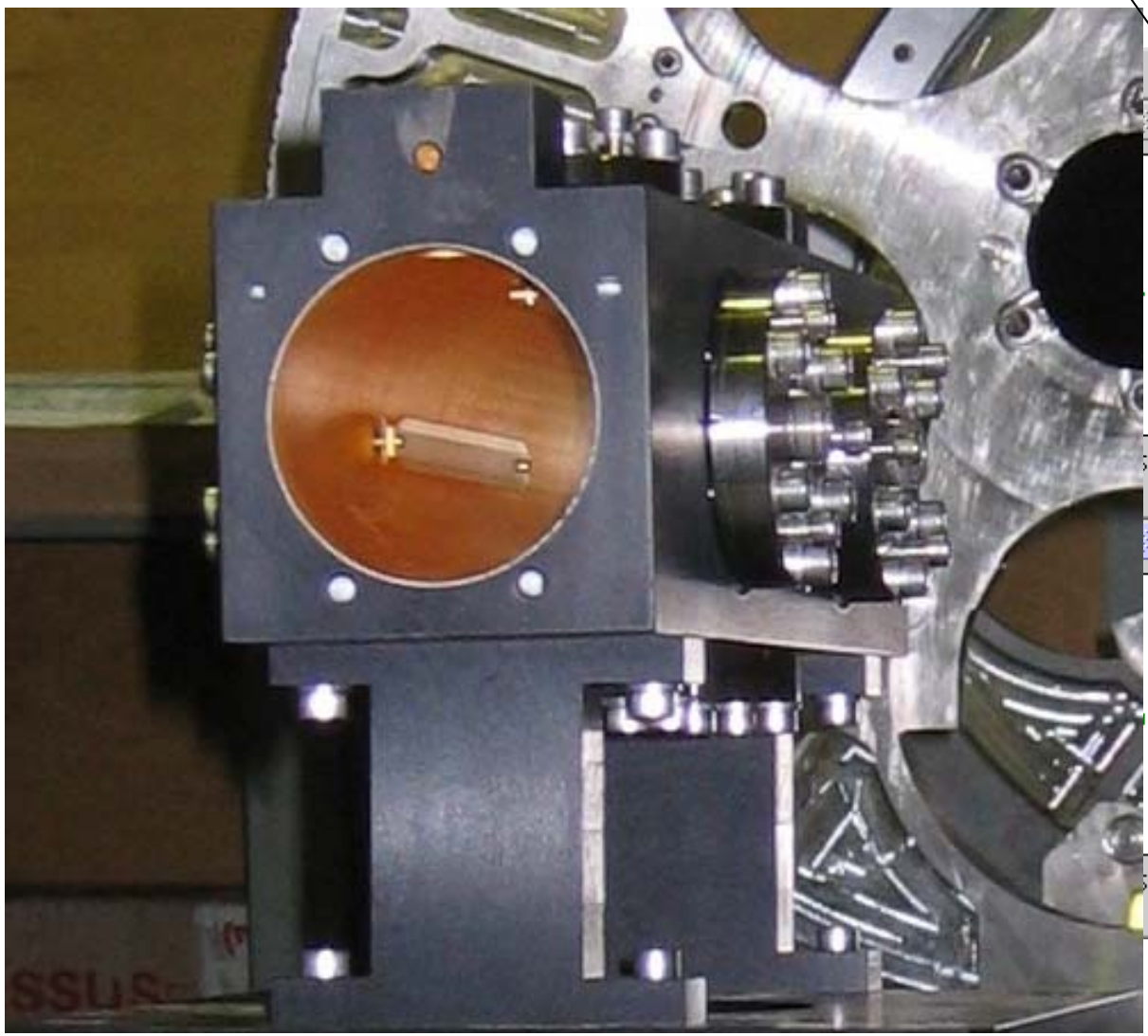
Beam position stability onto the target over 3 first days: ~50 μm rms

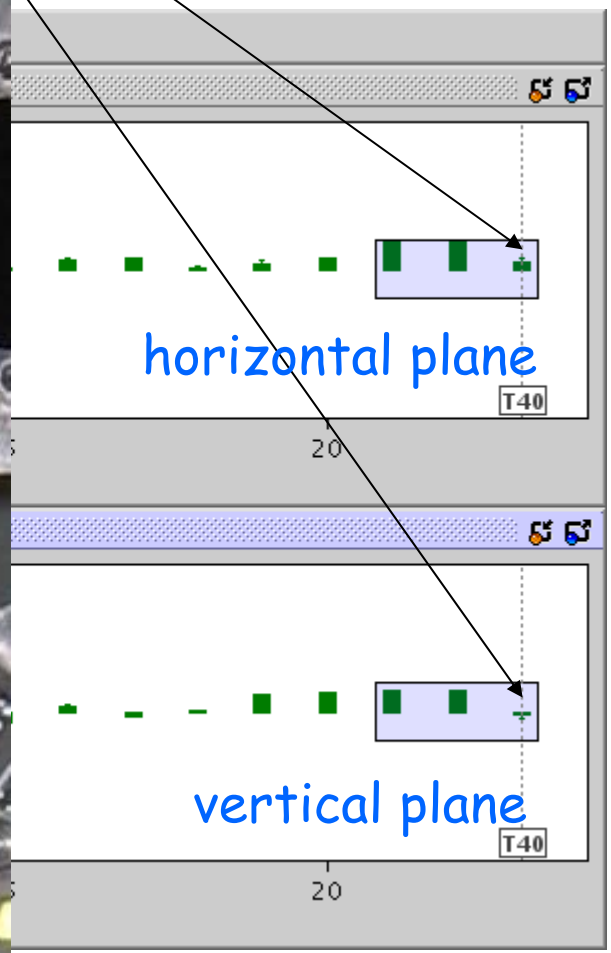


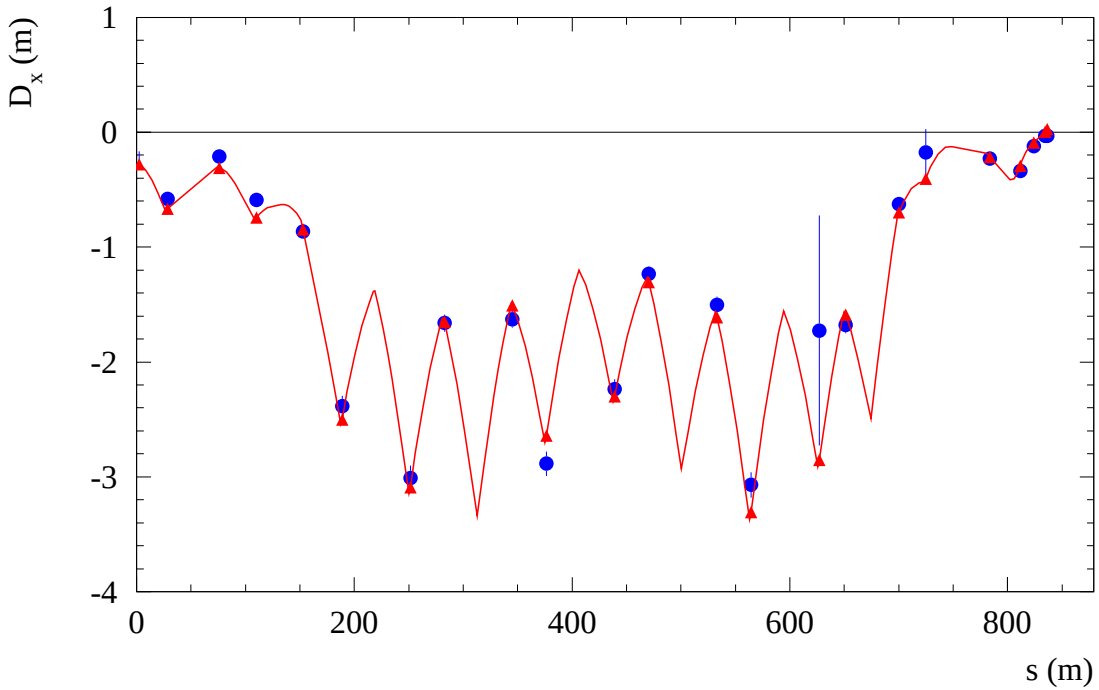
special beam position monitor on target table:

Stripline coupler Pick-up operated in air

-> very reliable position reading

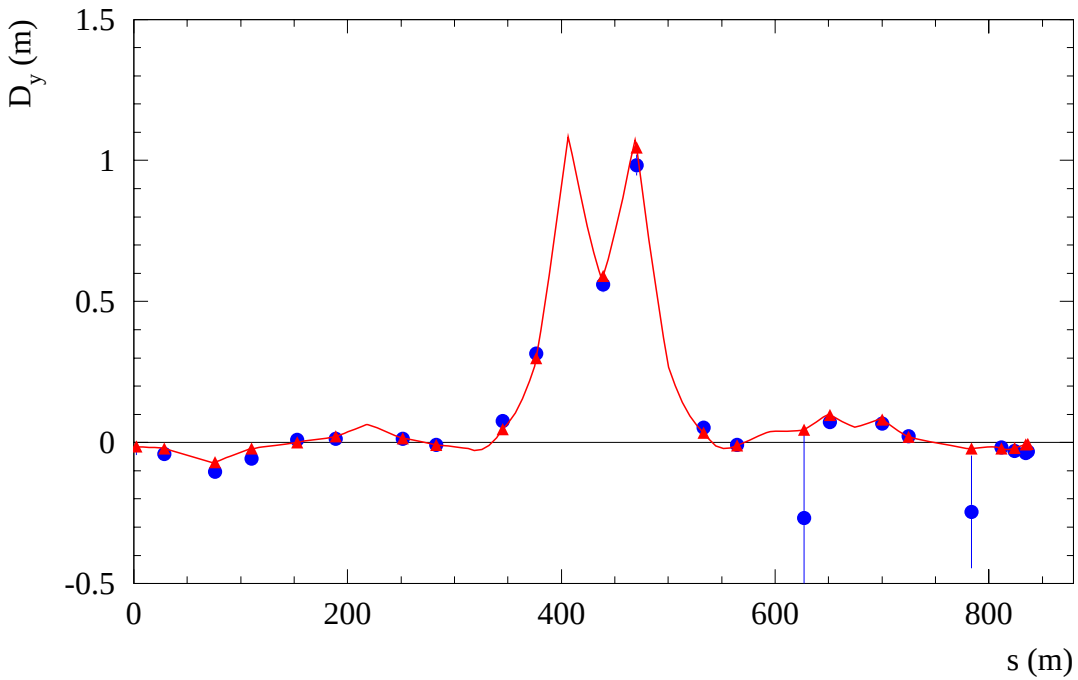






horizontal plane

Dispersion measurements

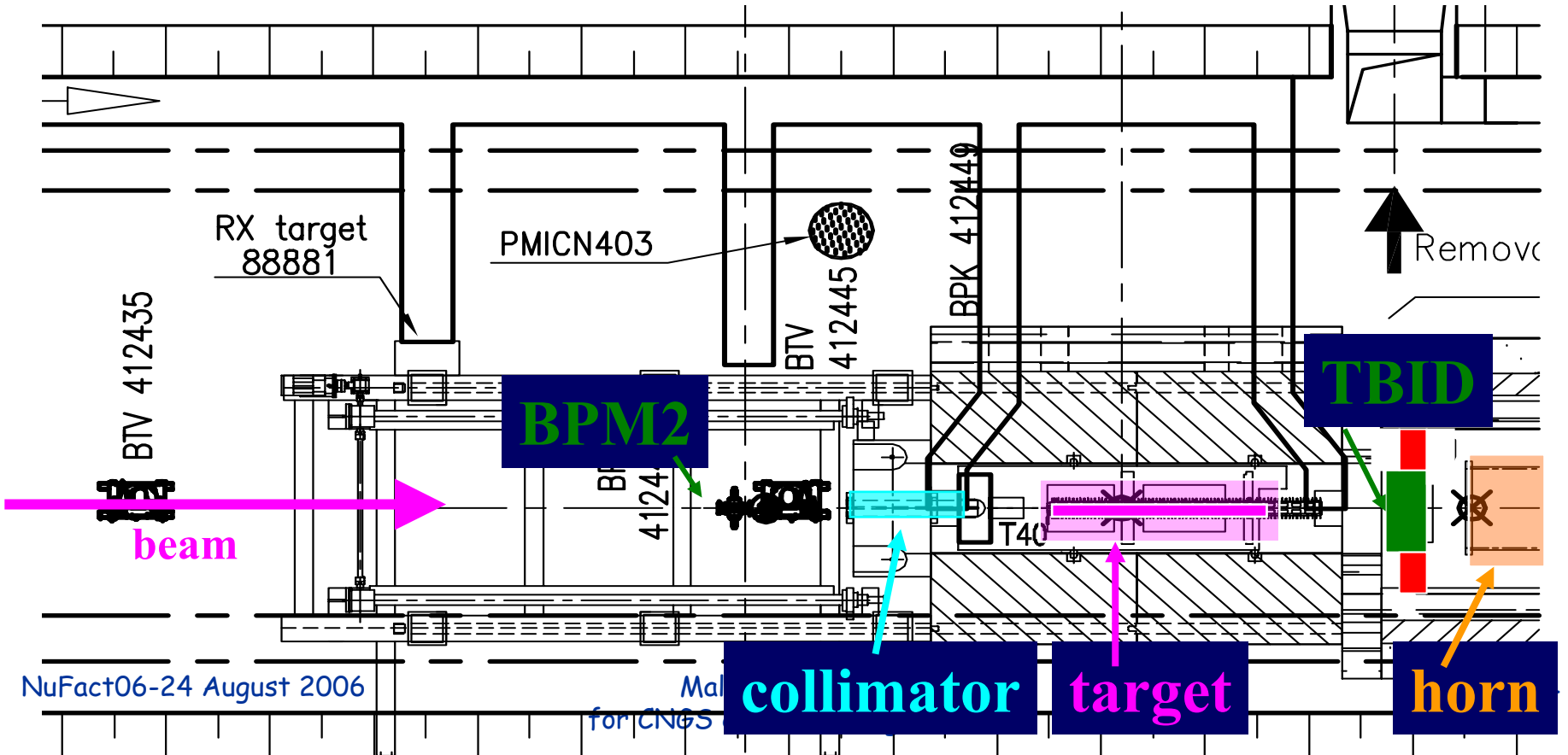


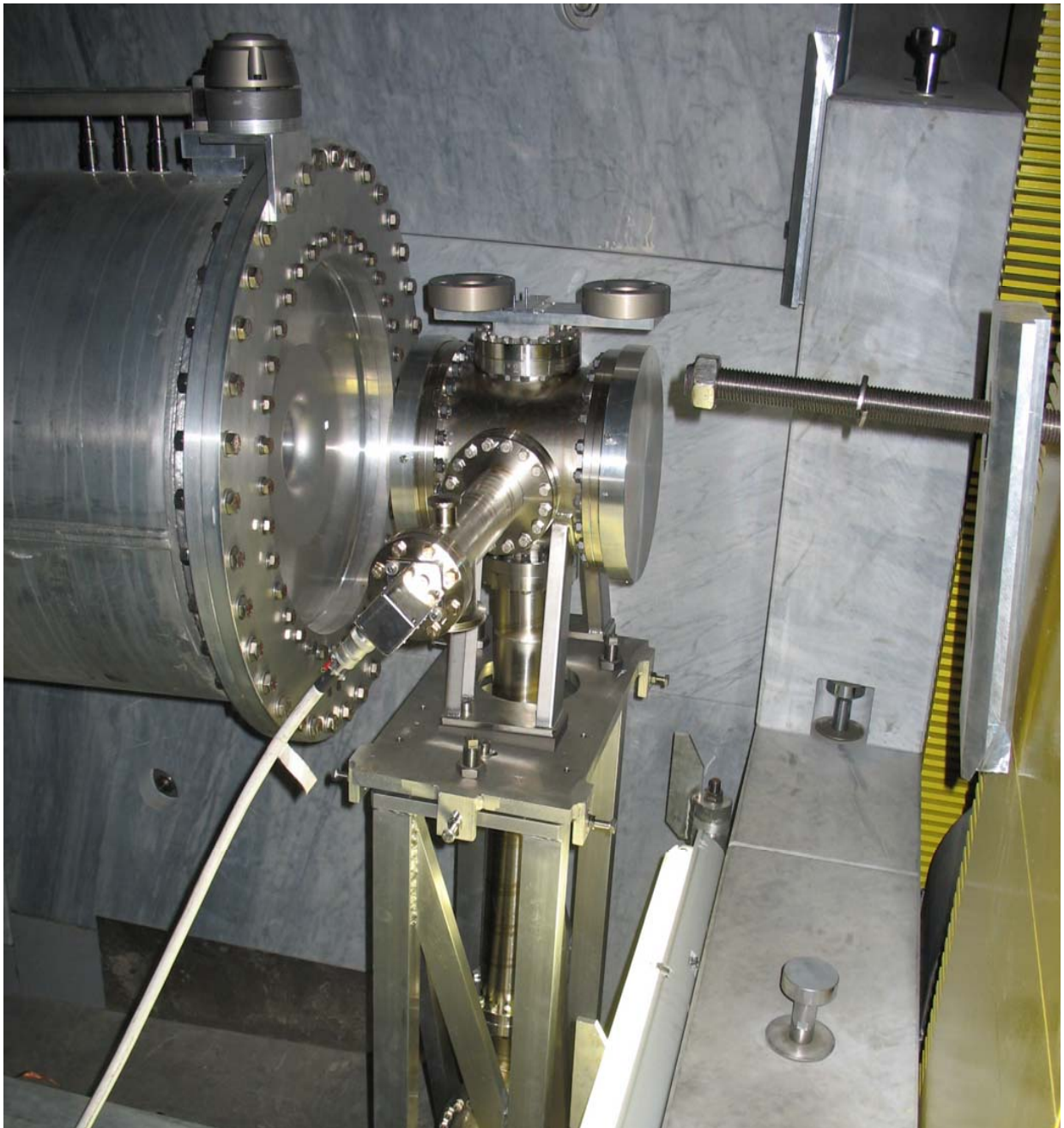
vertical plane

courtesy J. Wenninger

Proton beam scans on the target: multiplicity optimization

- **Purpose:**
  - **Check efficiency with which protons are converted into secondaries**
    - **Multiplicity (Compare with beam current monitor upstream of the target)**
    - **Misalignment of the Beam**
- **Ionization Chamber used as back-up**

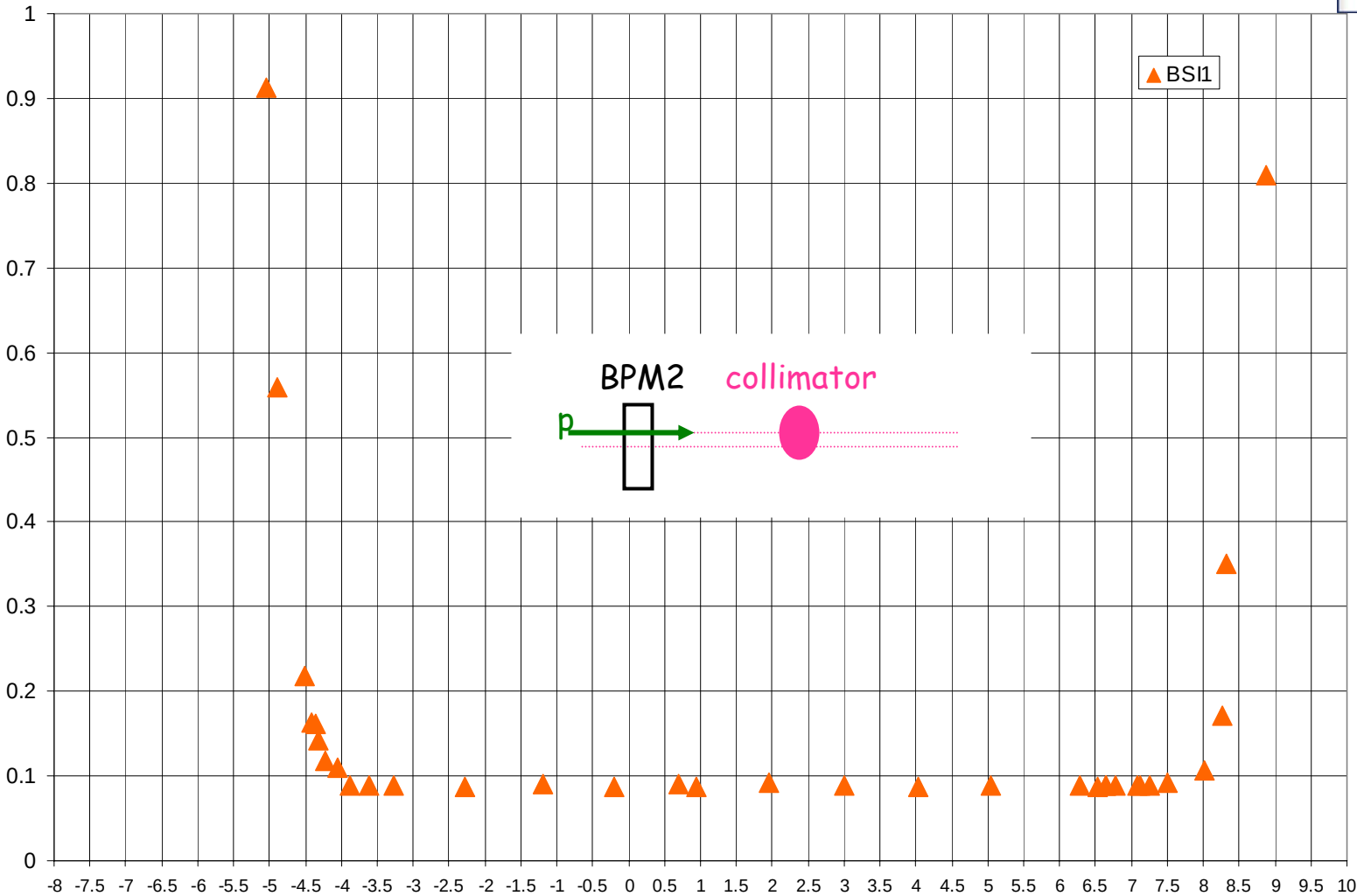




TBID Monitor

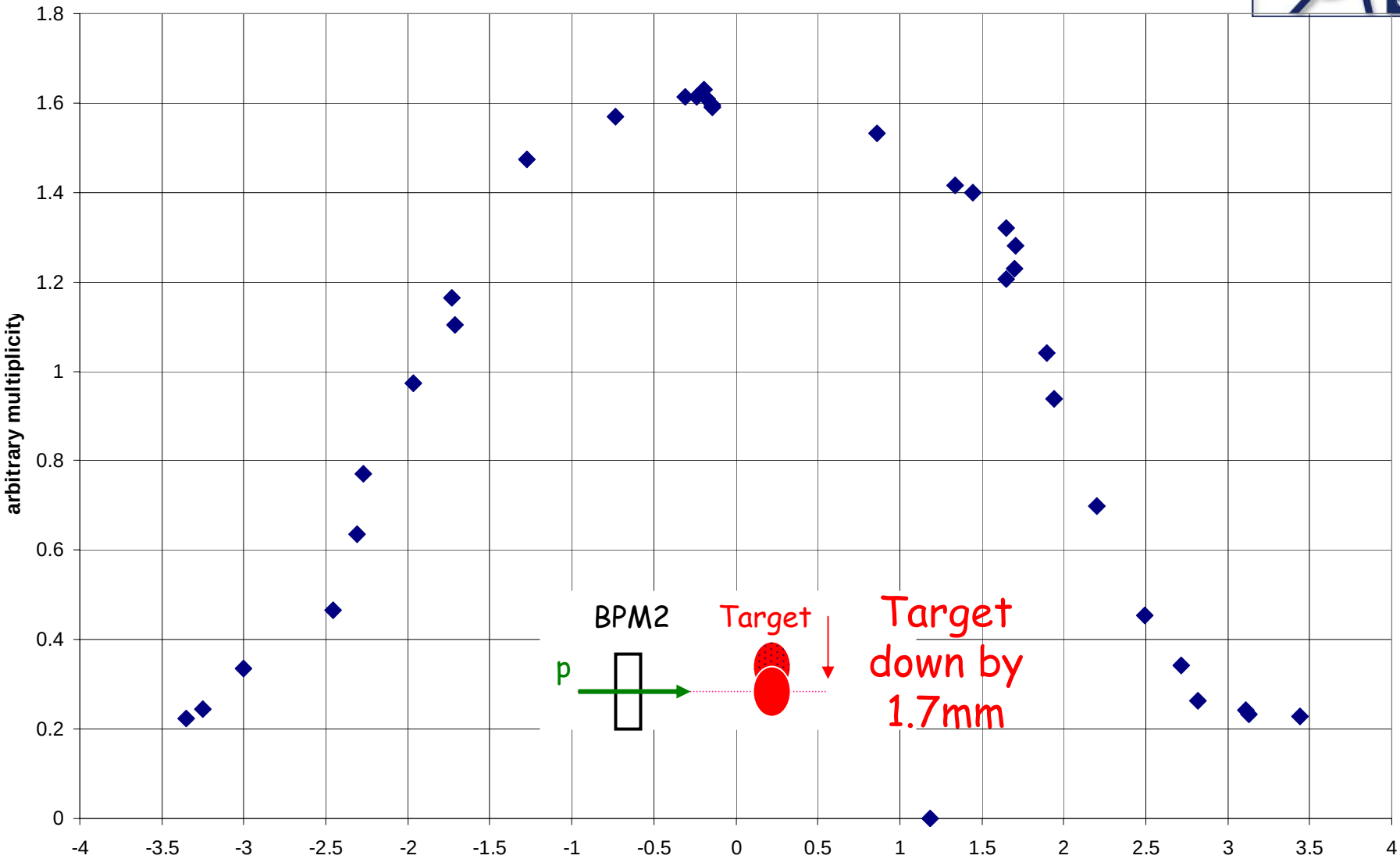
- **Secondary emission monitor**
- **12 µm Ti foils**
- **better than 10^{-4} mbar vacuum**

Horizontal beam position scan – Target OUT of beam- Reading from TBID



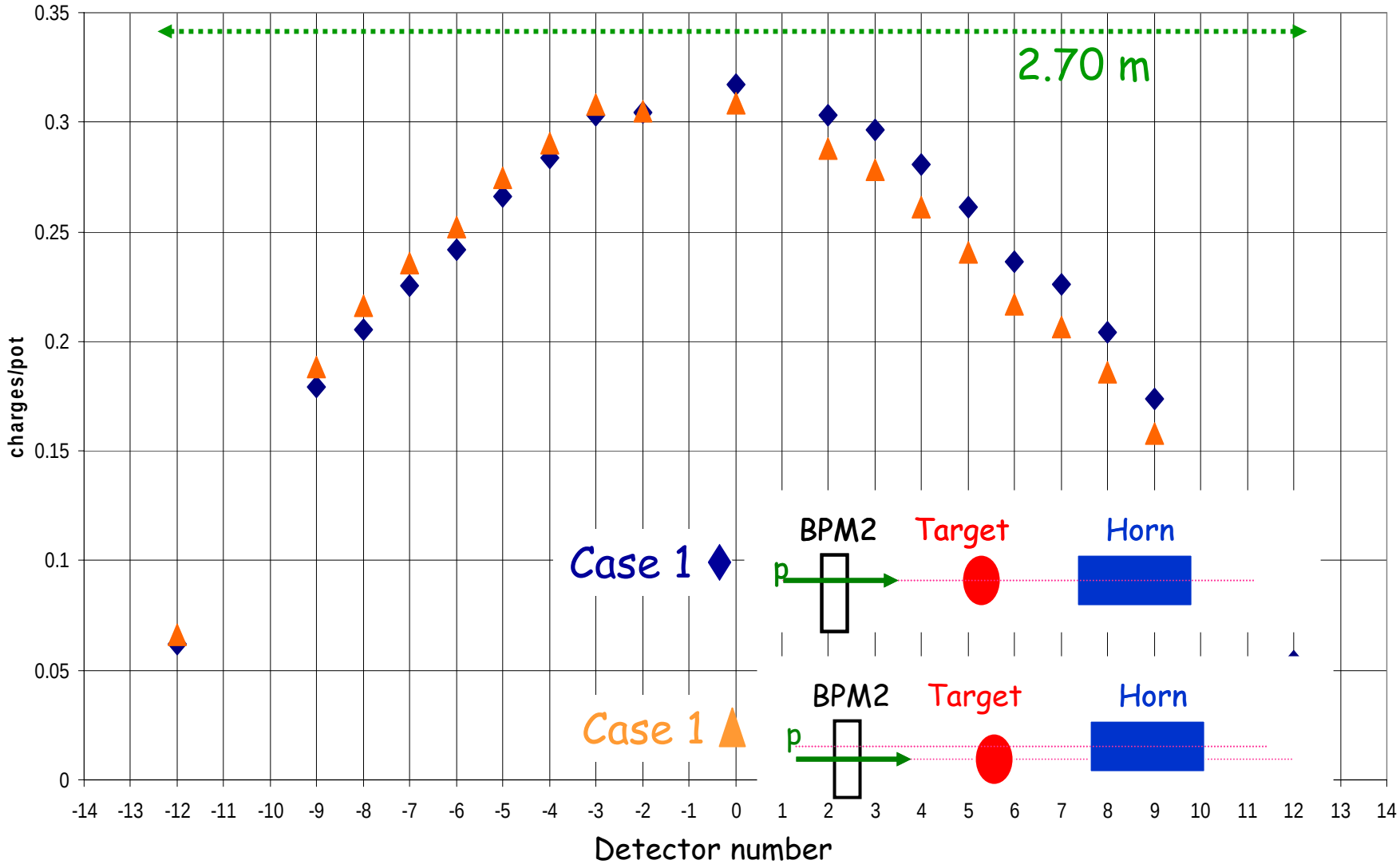
Courtesy of E. Gschwendtner

Horizontal beam position scan – Target IN beam – Intensity on TBID vs. BPM2 position

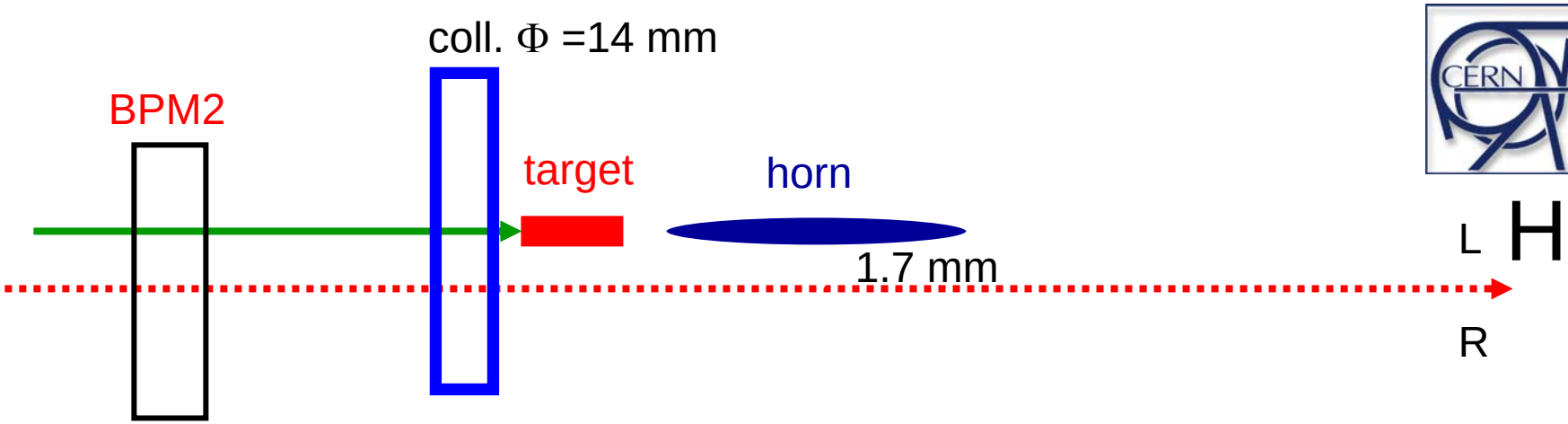


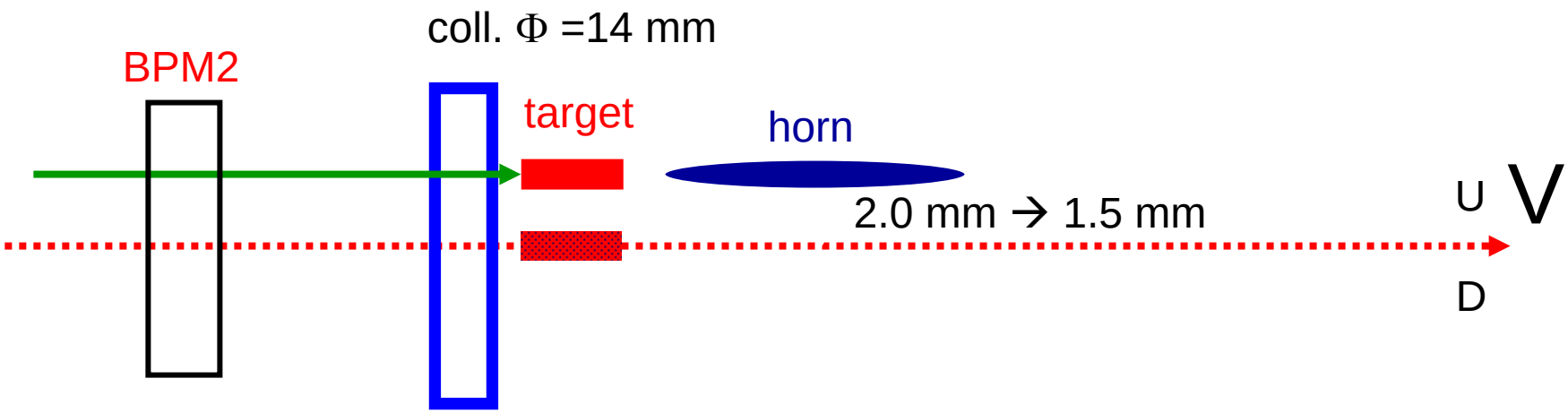
Courtesy of E. Gschwendtner

Horizontal beam position – Target IN beam – Reading from muon detectors Pit 1 vs. detector number

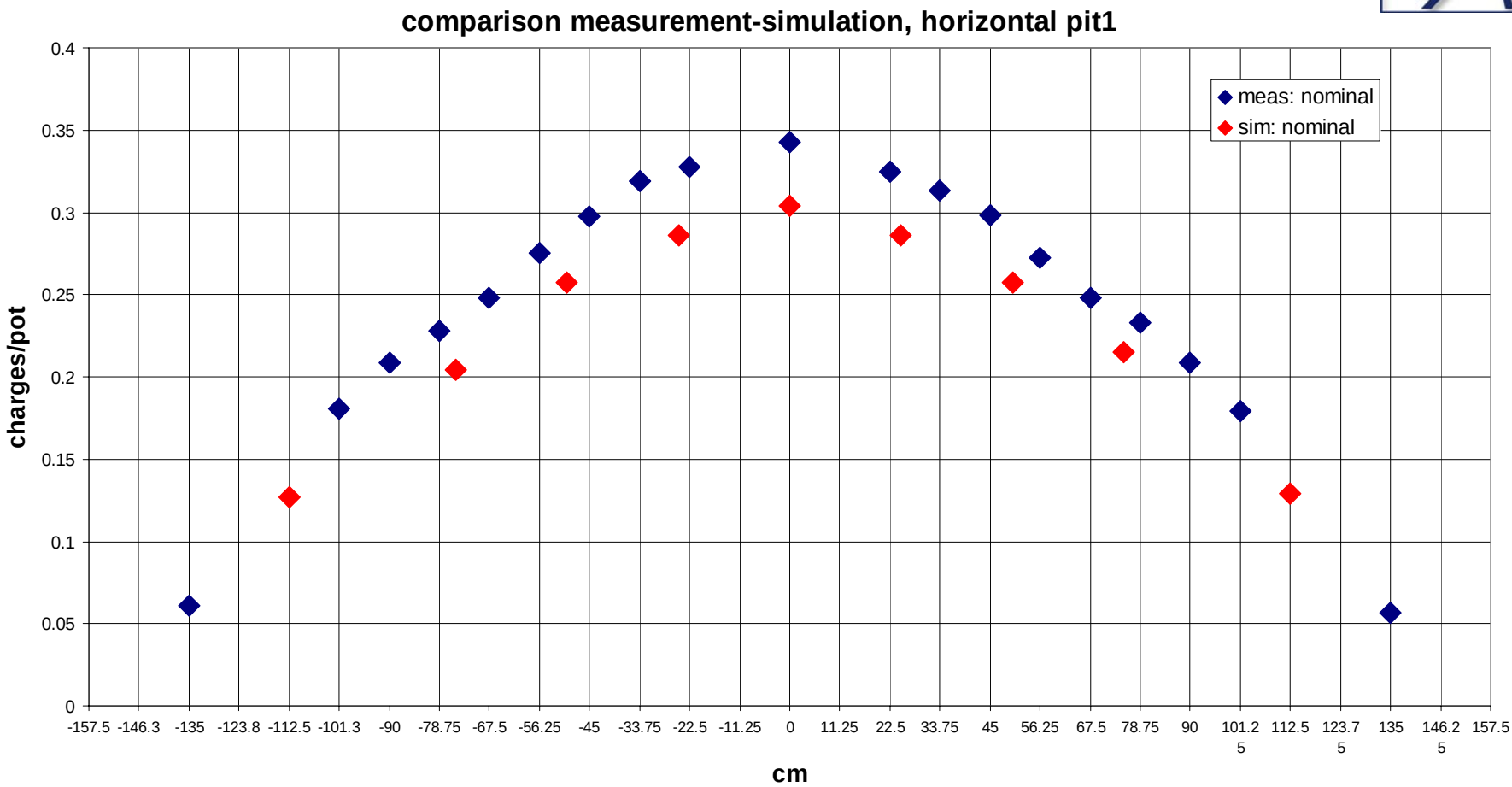


Courtesy of E. Gschwendtner

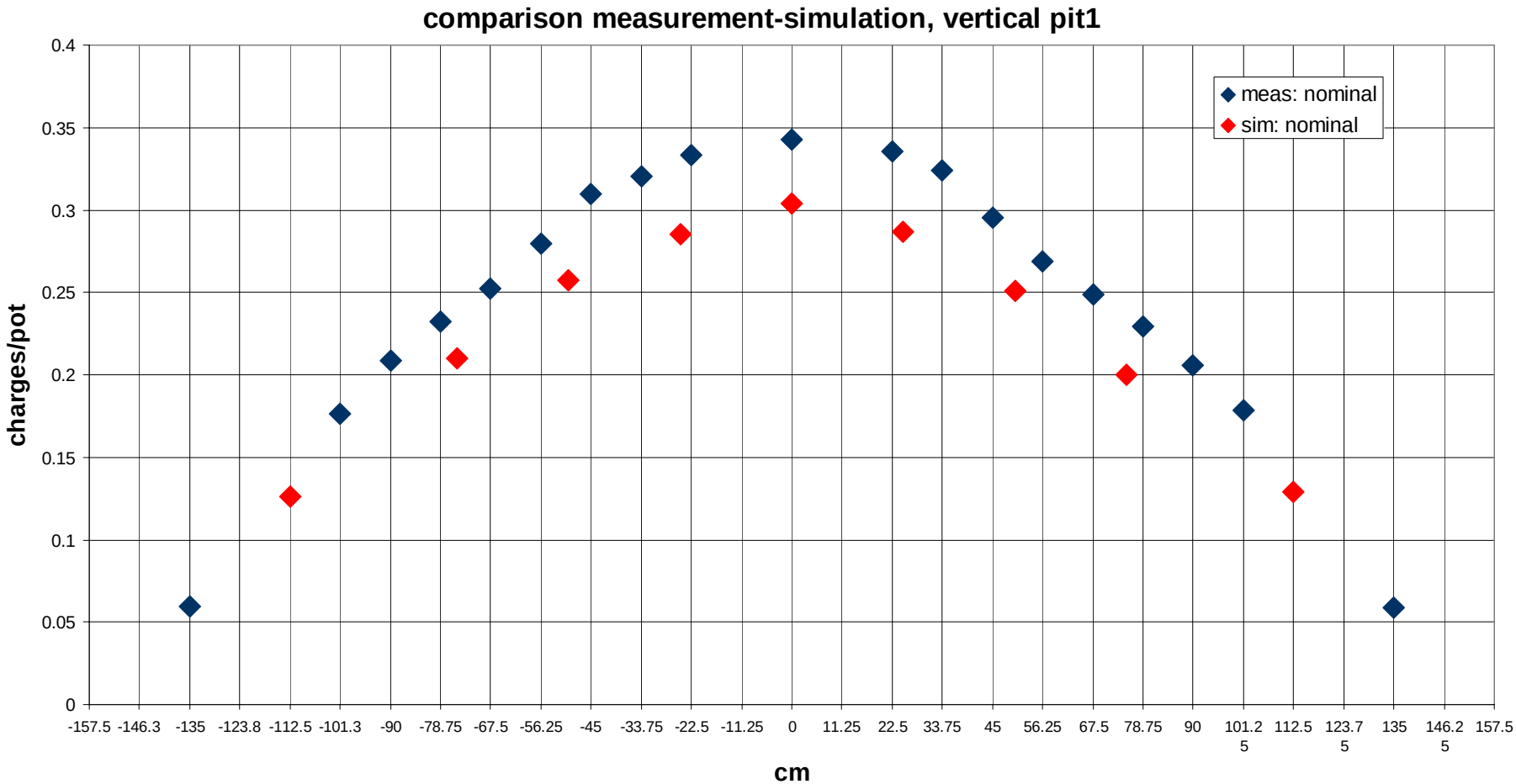




Courtesy of K. Elsener



Preliminary
Courtesy P. Sala and E. Gschwendtner



Preliminary
Courtesy P. Sala and E. Gschwendtner

CNGS project was approved on December 1999

Civil Engineering – Equipment design- production- installation phases lasted 6 years and handed over to operation on 18 August 06

Completed on budget and within schedule.

Commissioning showed that proton beam and secondary beam parameters are within specification

Thank you to all the colleagues from CERN and laboratories all over the world who contributed to the project's success.