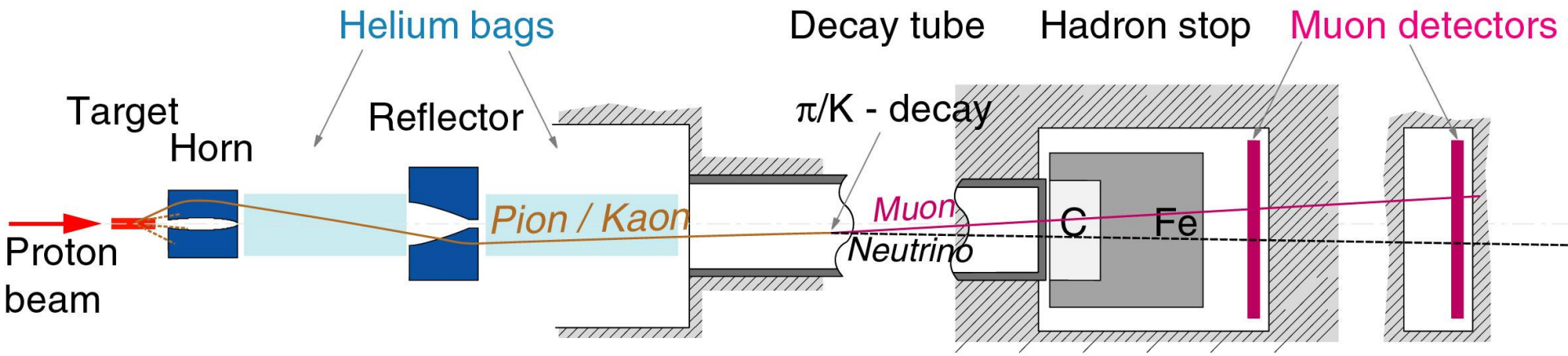
CNGS – A neutrino beam from CERN to Gran Sasso

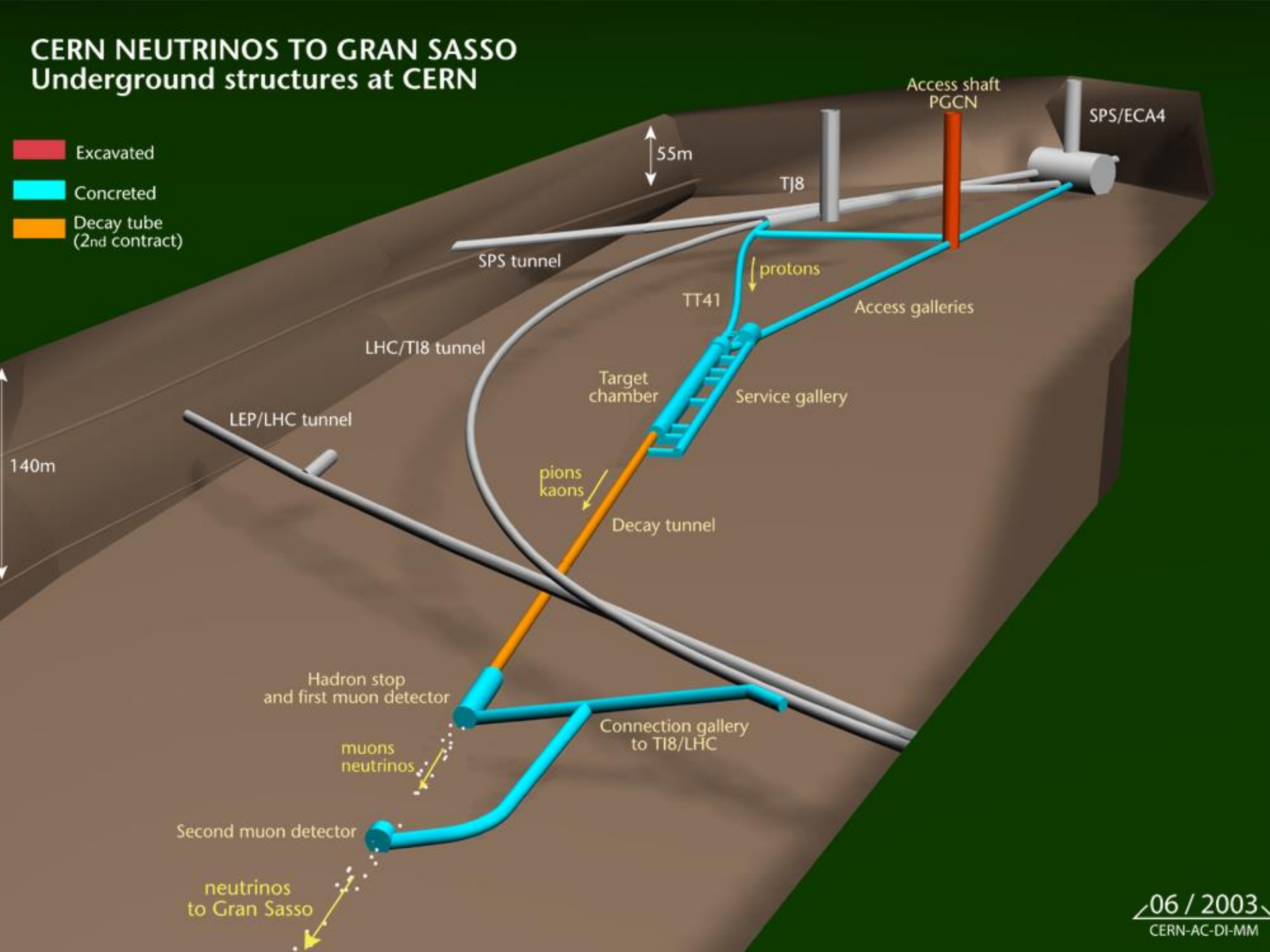
Konrad Elsener

CNGS: the main components

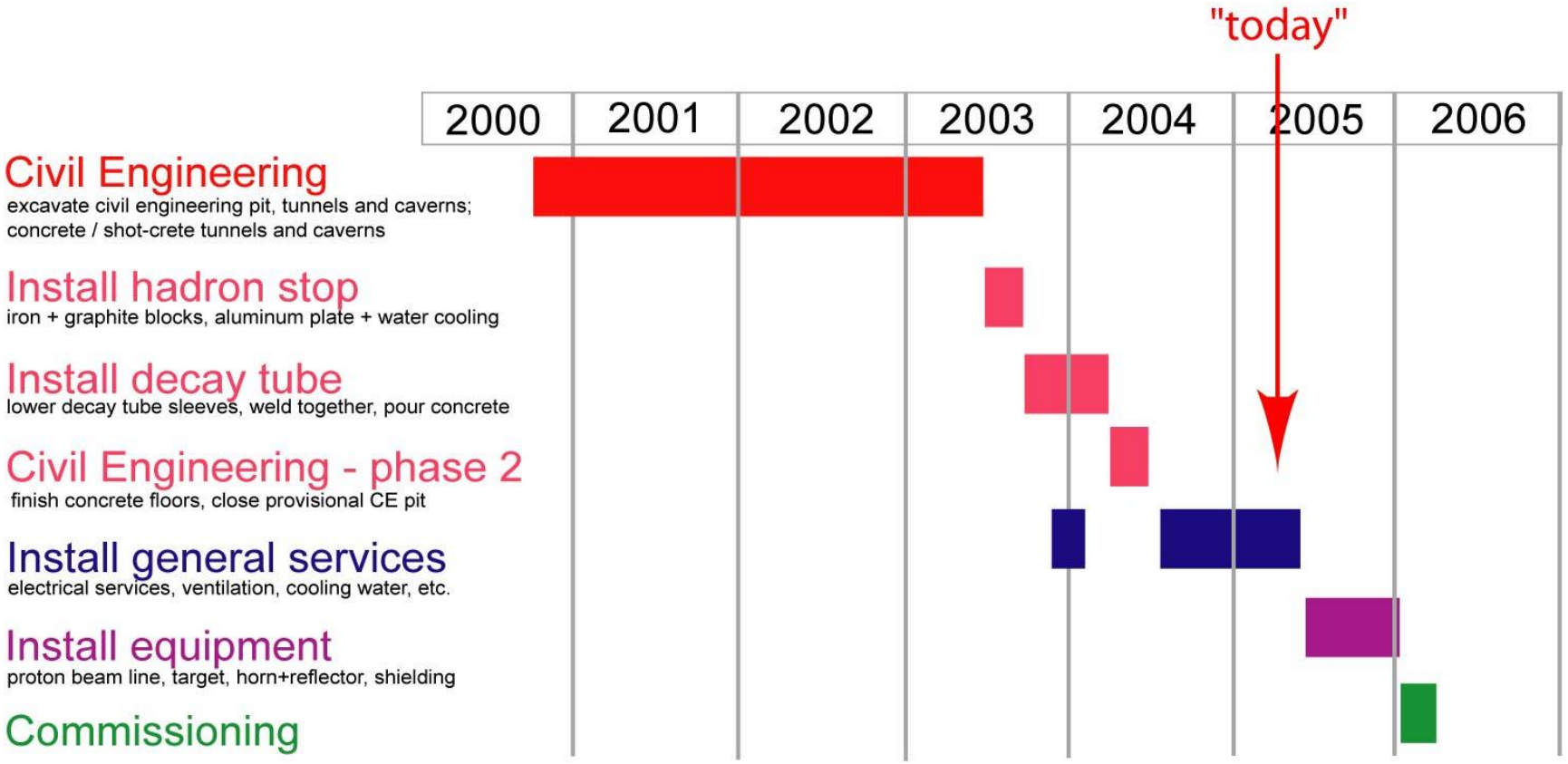
(based on CERN experience: PS / SPS neutrino beams -> WANF)



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


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

CNGS schedule (simplified)



First beam to Gran Sasso*: May 2006

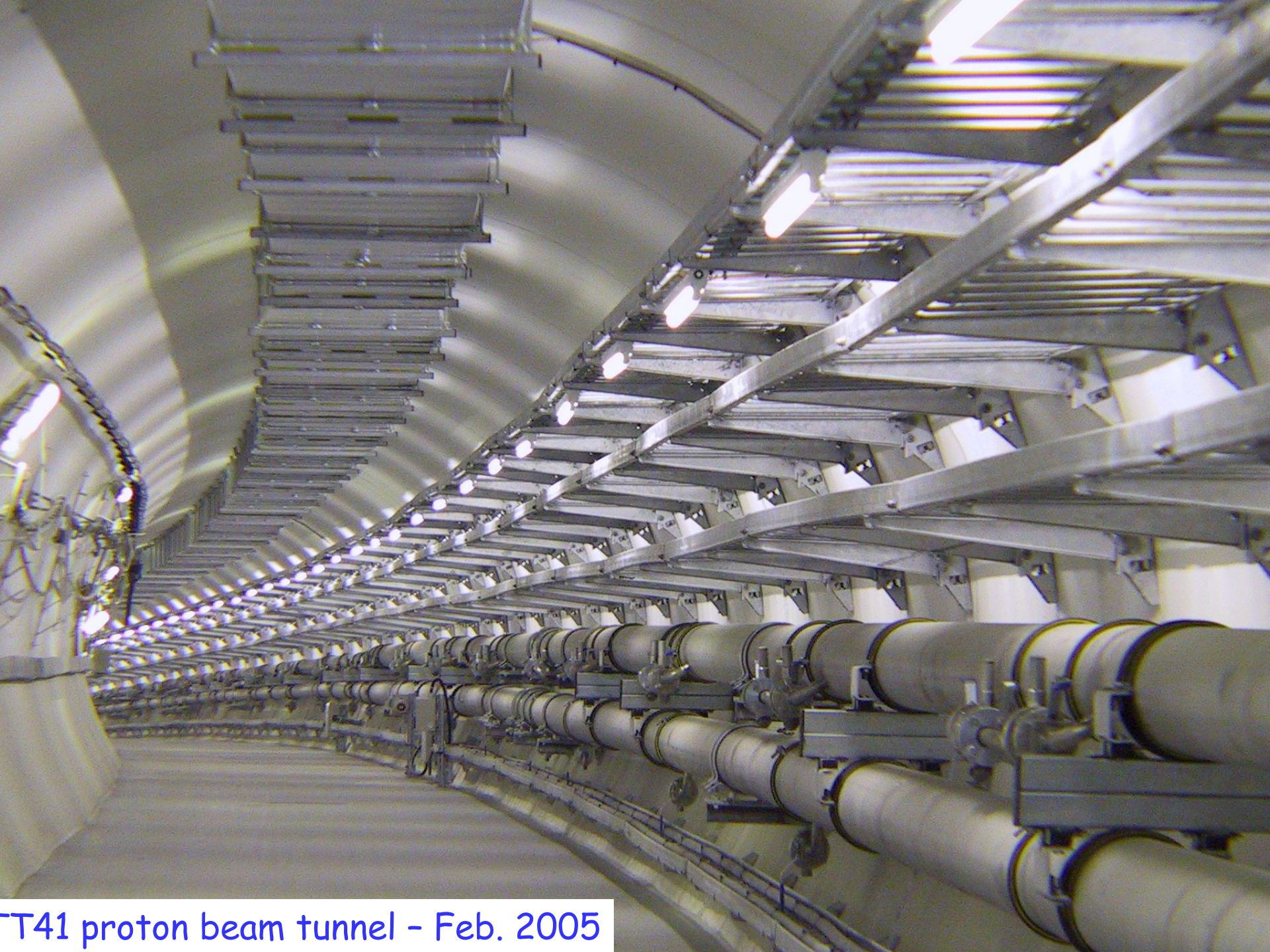
* pending details in SPS schedule for 2006


PGCN - November 200

Proton beam tunnel – Feb. 2002

TT41 proton beam tunnel – June 2004

TT41 proton beam tunnel – Jan. 2005



TT41 proton beam tunnel – Feb. 2005

CNGS: some key issues

p on target: as much as possible (per year)
p-beam intensity: "nominal", 2.4×10^{13} per extraction
"ultimate", 3.5×10^{13} per extraction

Proton beam-line (SPS- TT40 – TT41 - T40 target)

aperture VERY TIGHT / alignment important

steering and beam size EXTREMELY IMPORTANT
(max. beam excursion. ±4 mm in TT41)

losses (almost) NOT ACCEPTABLE

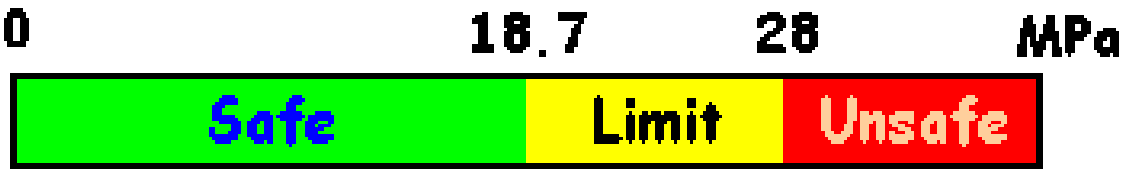
... and then, there is the target ...

2003: calculations by A. Bertarelli (TS/MME)

p-beam eccentricity could be dangerous for the target rods
(beam shock induces transverse wave, can break a rod)
(confirmed in 2004 by CRS4, Calgiari)

example:	nominal p-beam size	σ = 0.53 mm
	nominal p-beam intensity	2.4×10^{13} p / 10.5 μsec
	beam off-centre	1.5 mm
	target graphite rods, diameter 4 mm	

worst stresses for graphite: 26 MPa (calculated)



(see e.g. AB-Note-2004-063-CNGS)

… however … be aware …

a) no direct experimental evidence
b) 18.7 / 28 MPa contain an engineering safety margin
c) there are 4 in-situ spare targets
   (with different rod diameters and materials)

for ultimate intensities 3.5×10^{13} p / 10.5 μs, we can e.g.

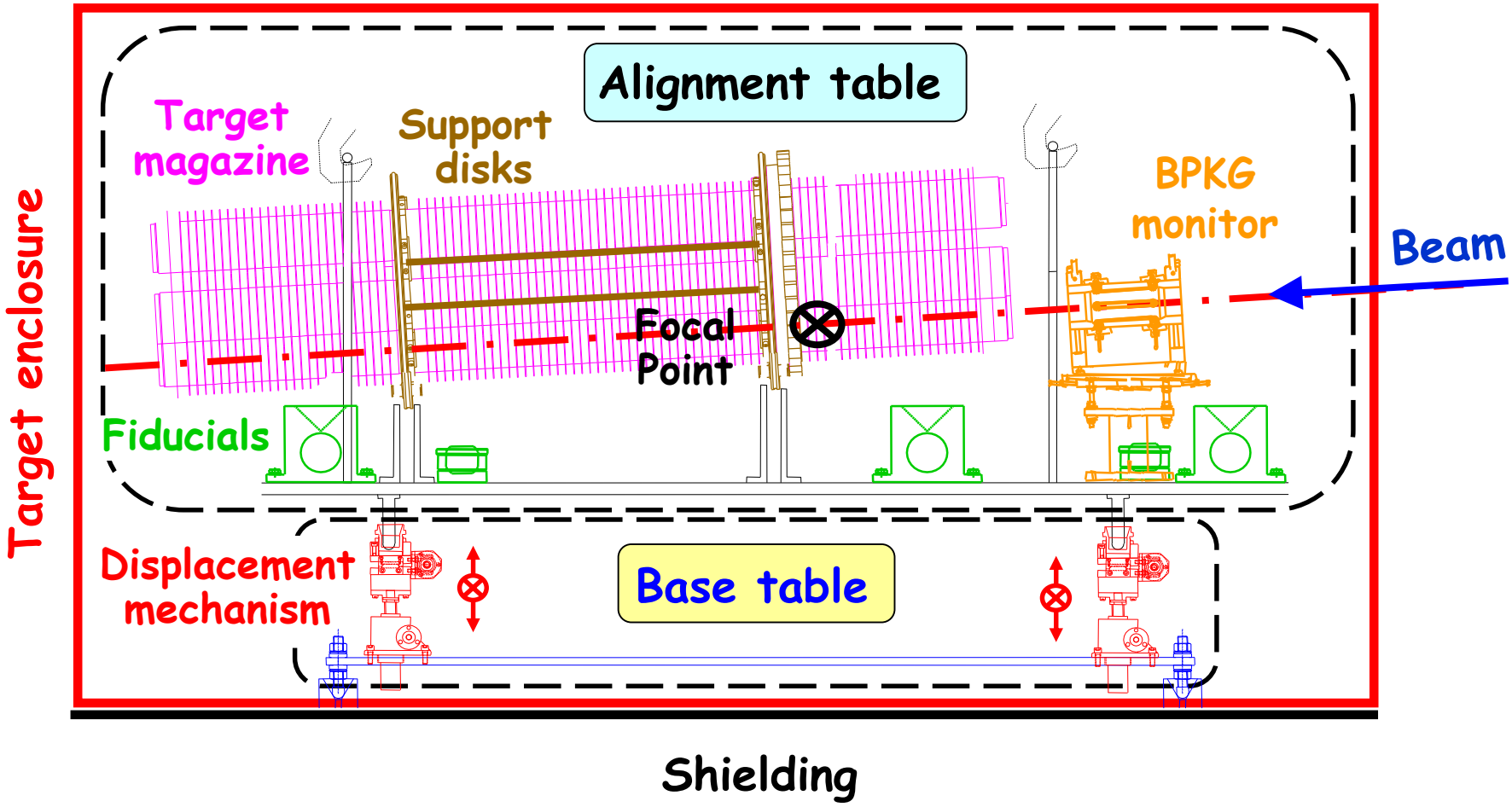
-> increase the beam size

-> increase the rod diameter

search for other materials is continuing (e.g. C-C composites)

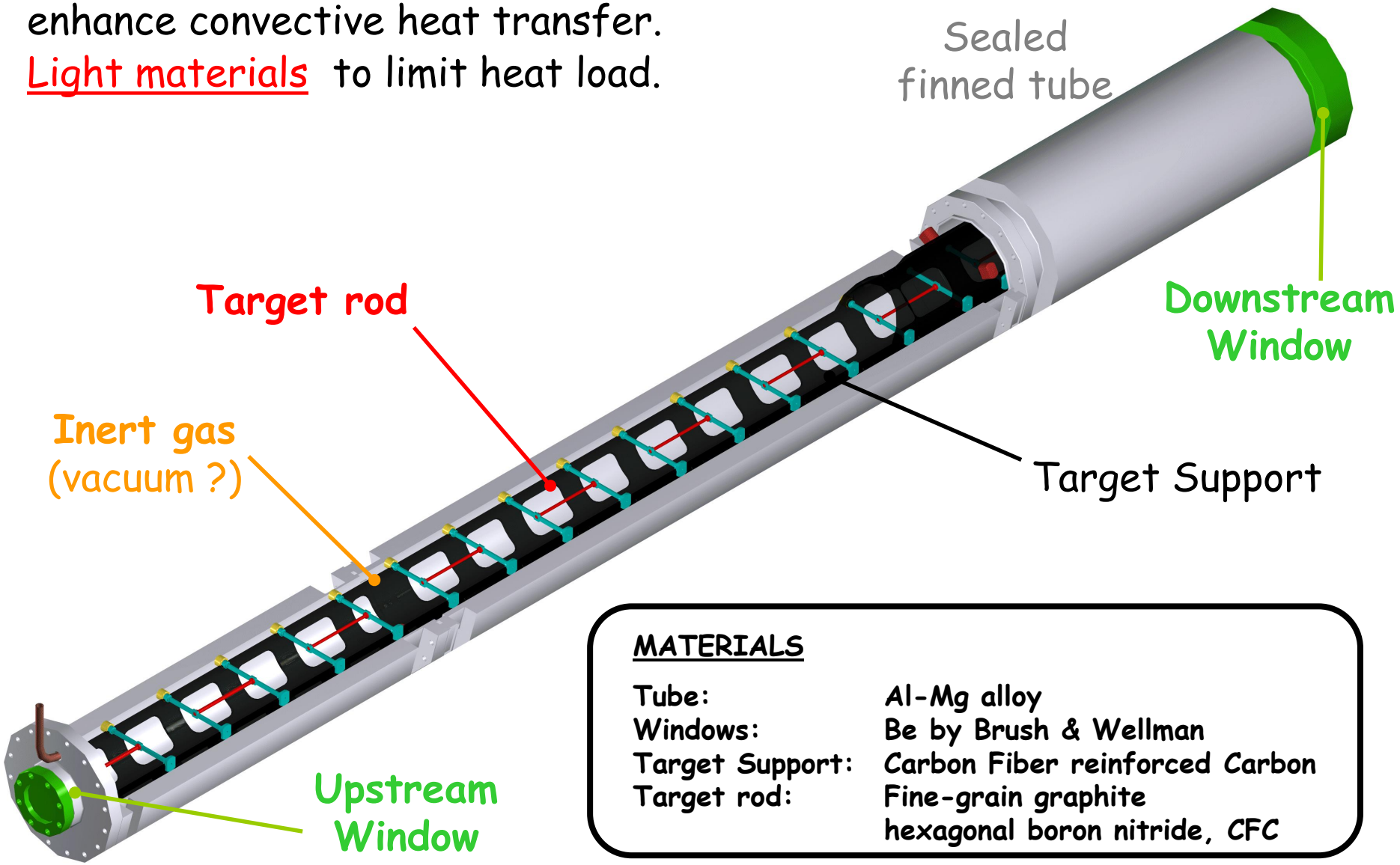
work in progress – CNGS is an experiment !

Target Assembly



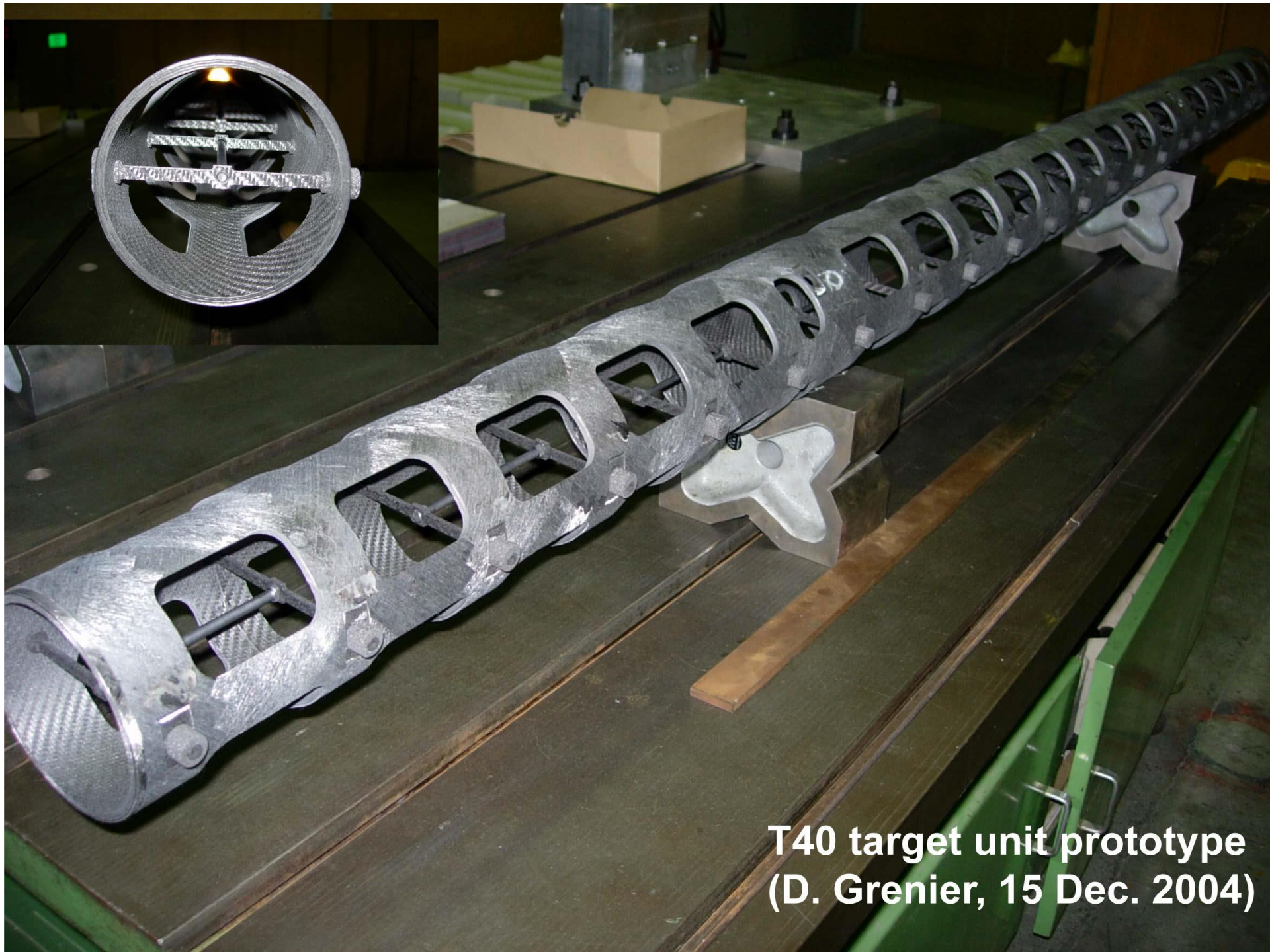
Target Unit – NOTE: 5 units = 1 magazine

Static sealed system; annular fins to enhance convective heat transfer.
Light materials to limit heat load.



MATERIALS

Tube:	Al-Mg alloy
Windows:	Be by Brush & Wellman
Target Support:	Carbon Fiber reinforced Carbon
Target rod:	Fine-grain graphite hexagonal boron nitride, CFC

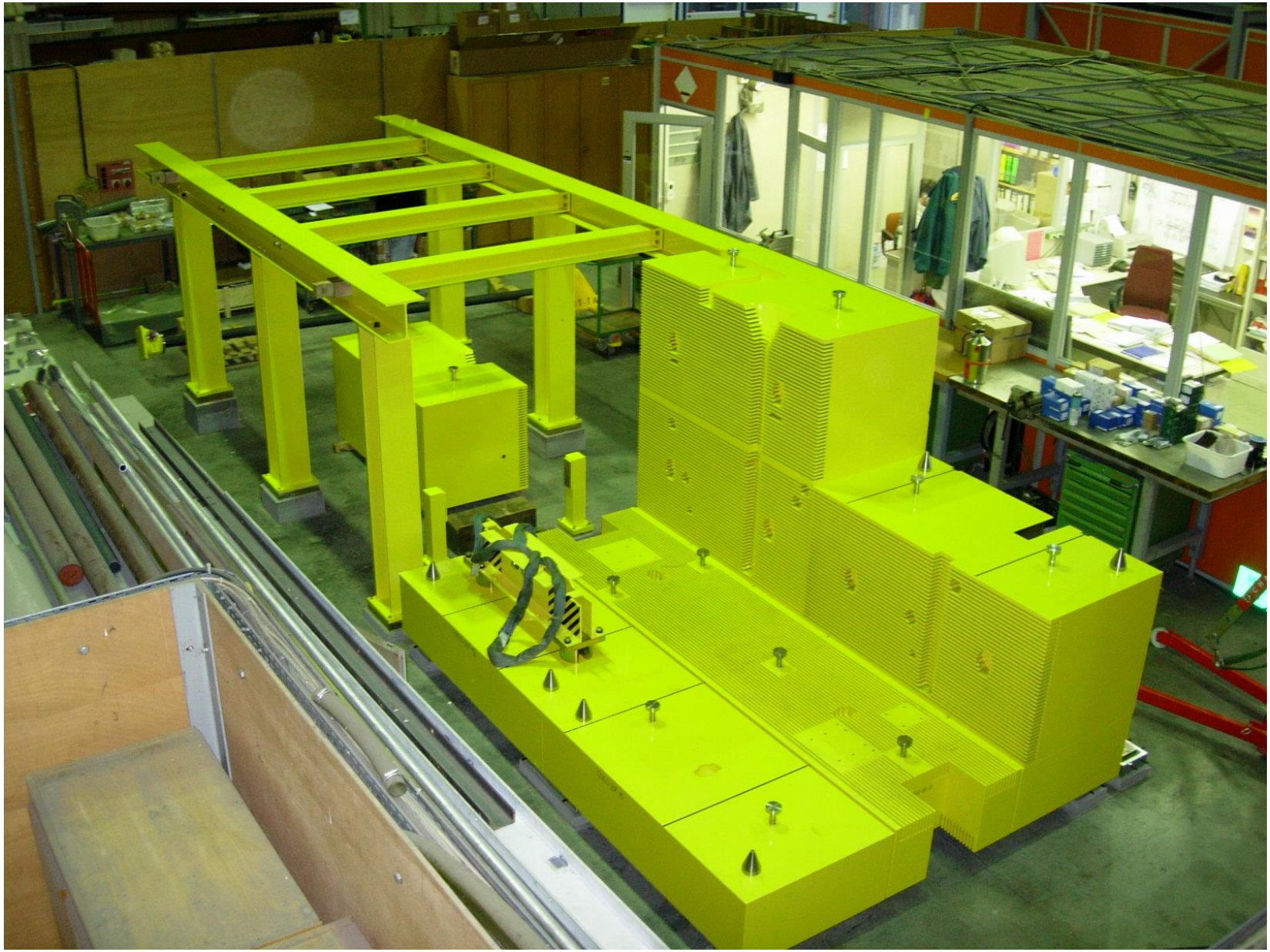

T40 target unit prototype
(D. Grenier, 15 Dec. 2004)

21 Feb. 2005

1st Target unit
He-leak tight

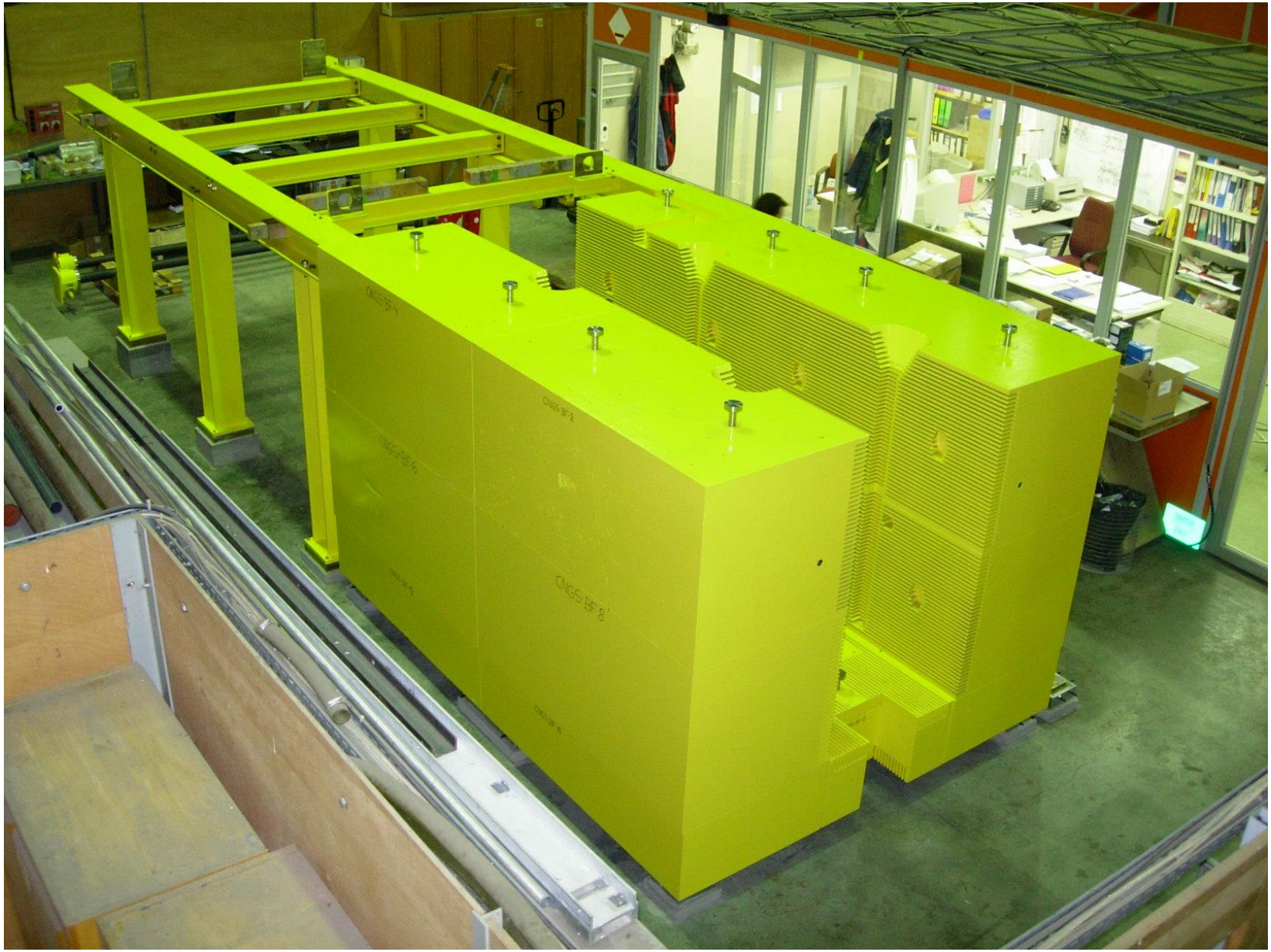
18 Feb. 2005

Target station
" montage
a blanc "



SPS Interlock Meeting, 8 April 2005

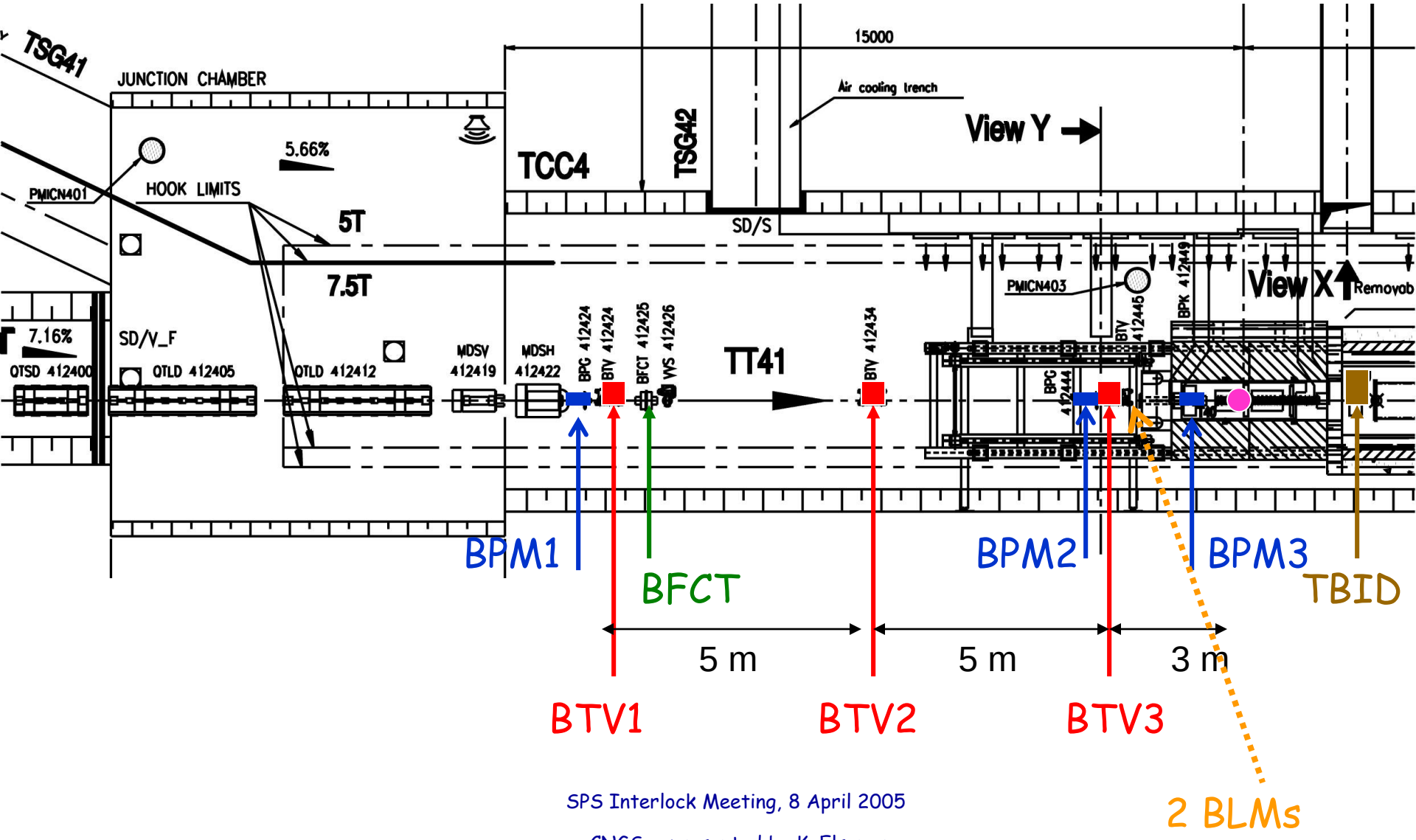
CNGS – presented by K. Elsener



18 March 2005 "montage a blanc"

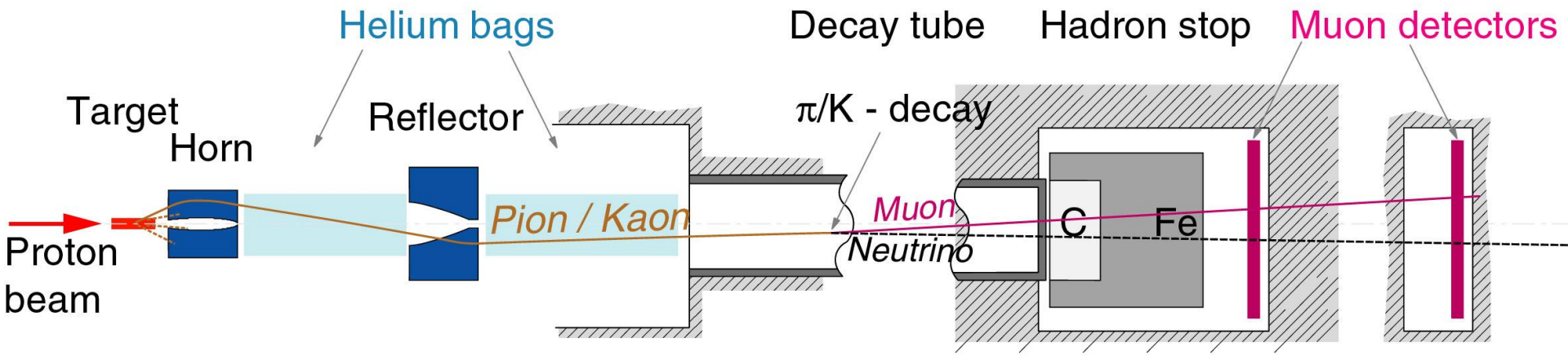
Target station: shielding wall - details

CNGS: beam monitoring around the target



CNGS: the main components

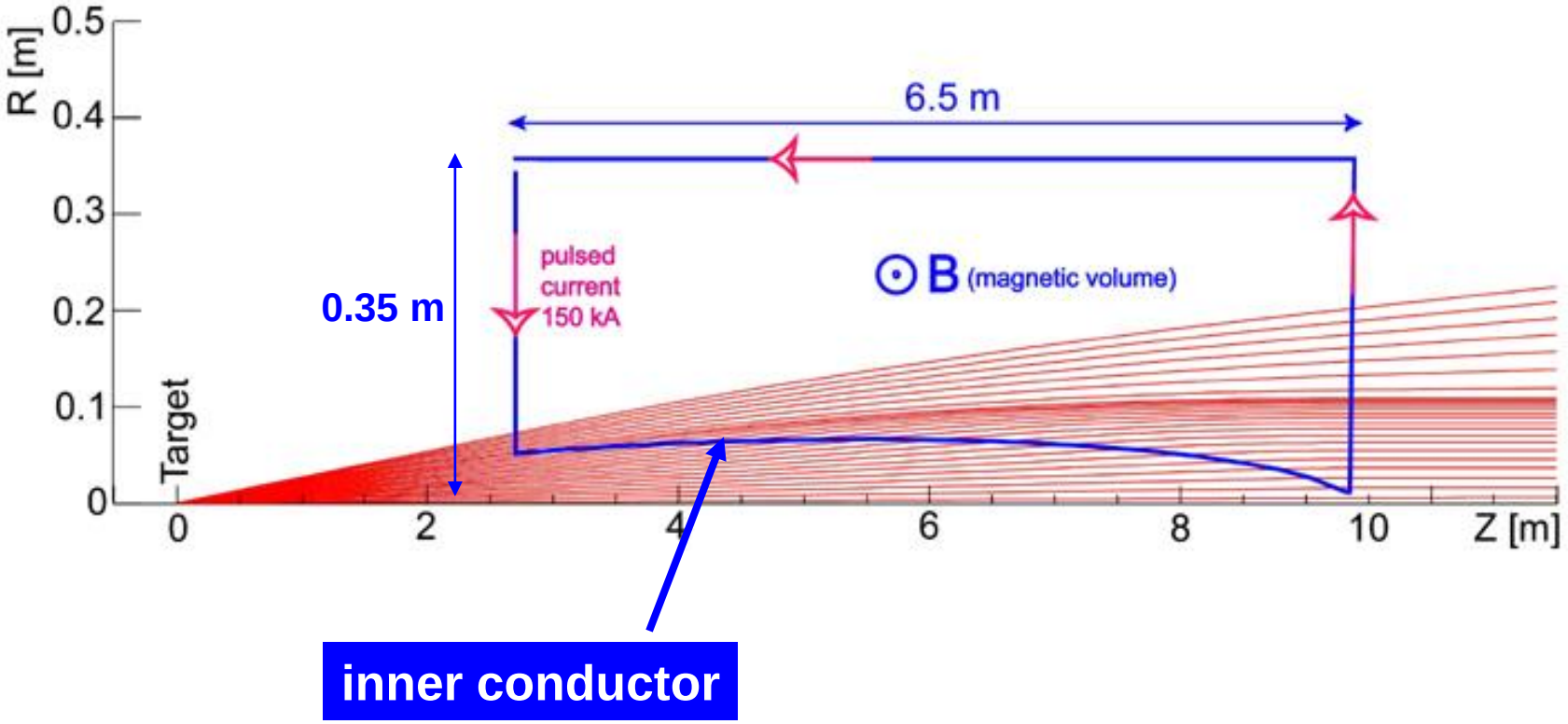
(based on CERN experience: PS / SPS neutrino beams -> WANF)



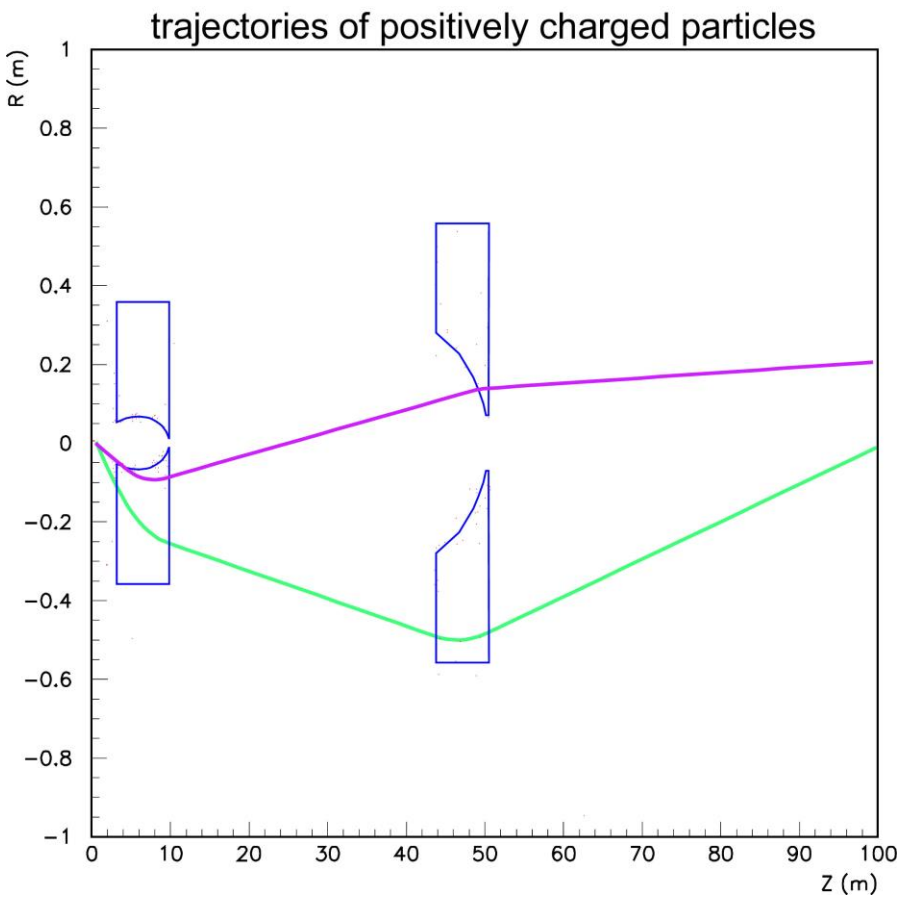
$p + C \rightarrow (\text{interactions}) \rightarrow \pi^+,\ K^+ \rightarrow (\text{decay in flight}) \rightarrow \mu^+ + \nu_\mu$

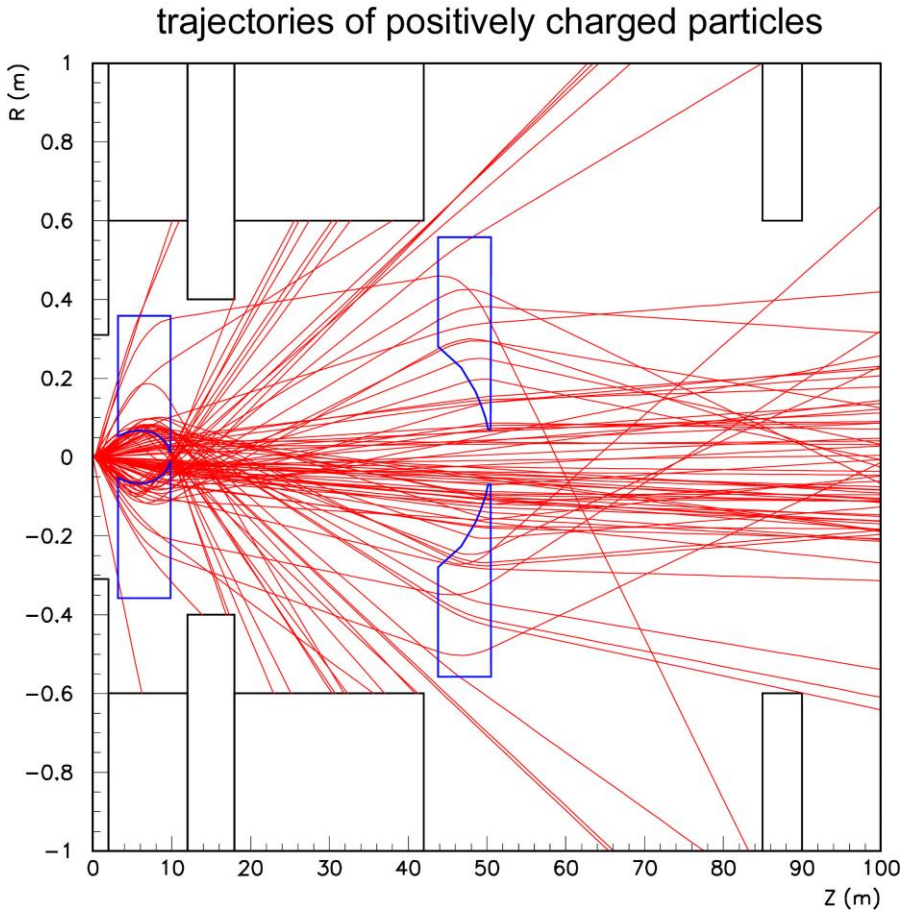
Magnetic Horn : Principle of focusing

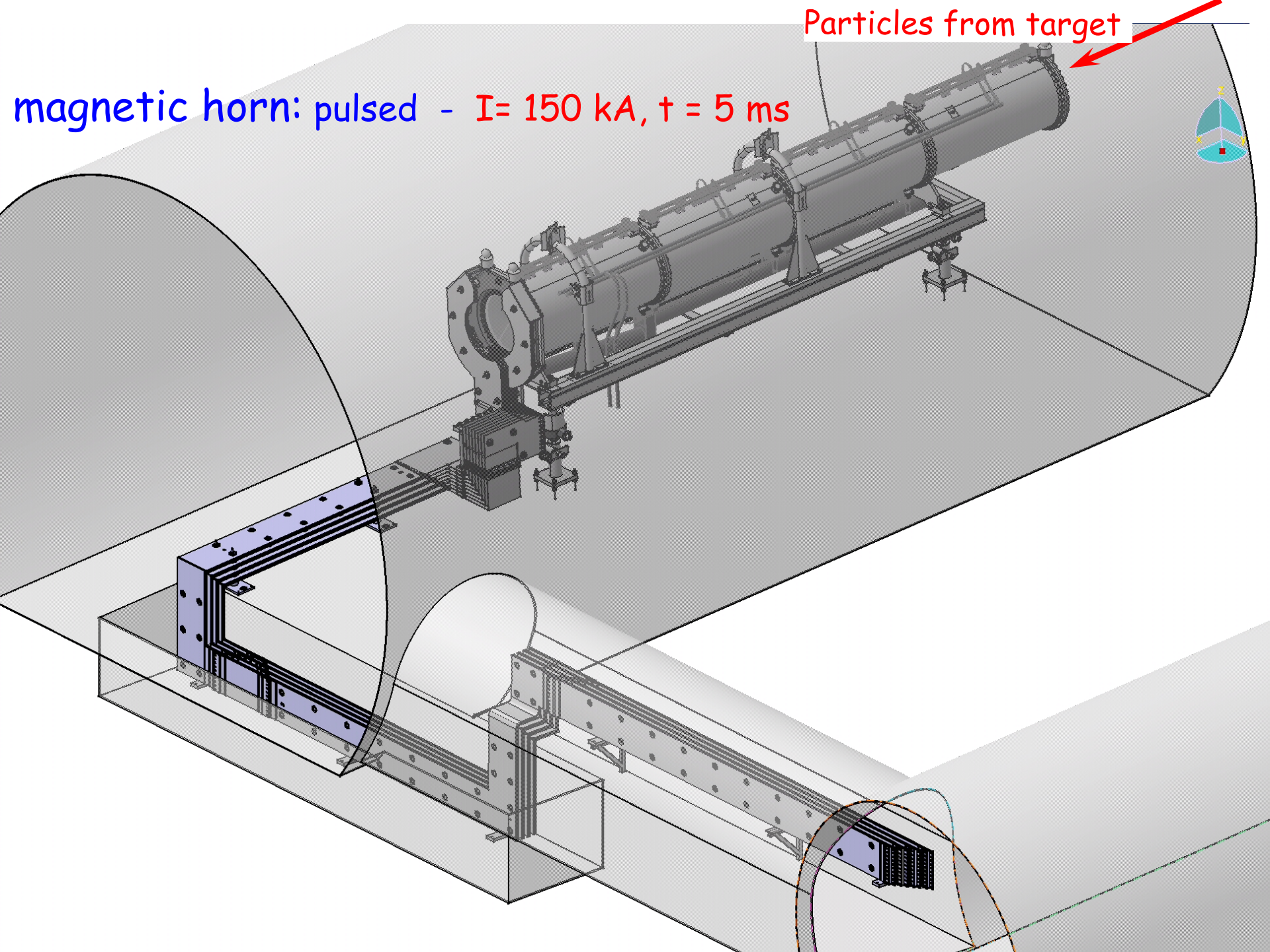
35 GeV positively charged particles leaving the target



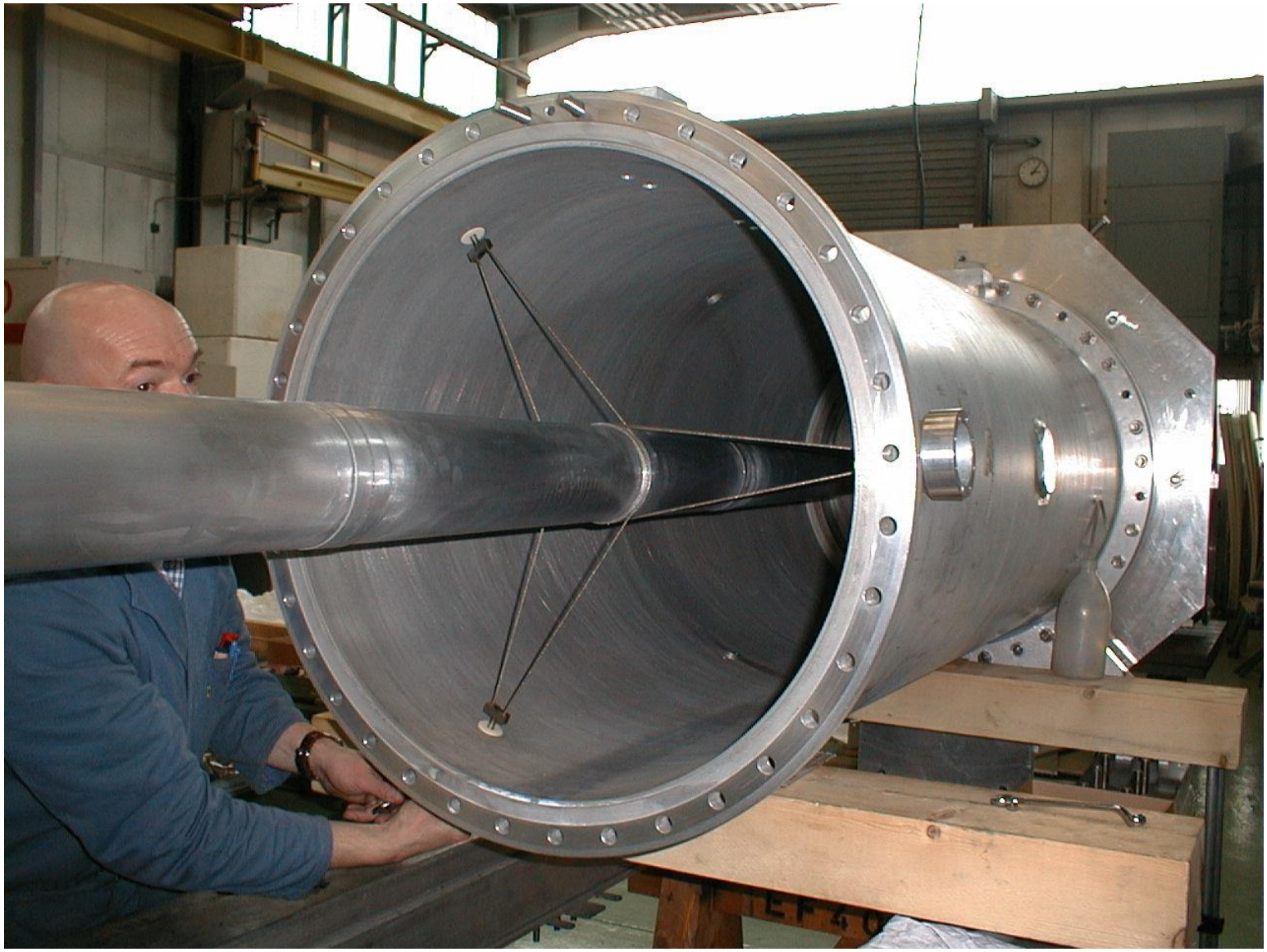
Horn / Reflector: secondary beam focusing



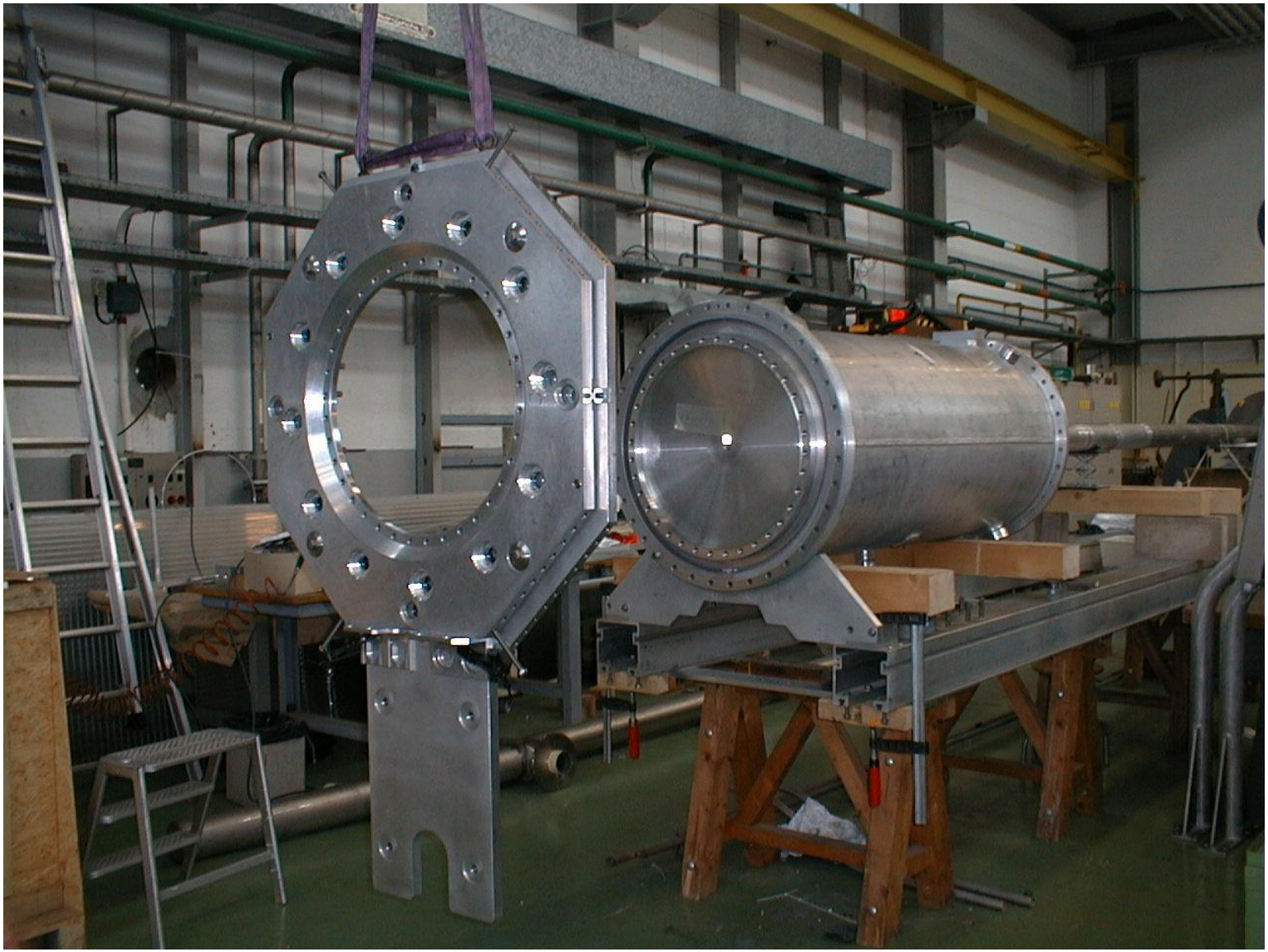



Particles from target
magnetic horn: pulsed - I= 150 kA, t = 5 ms

First Horn delivered to CERN – 7 April 2004

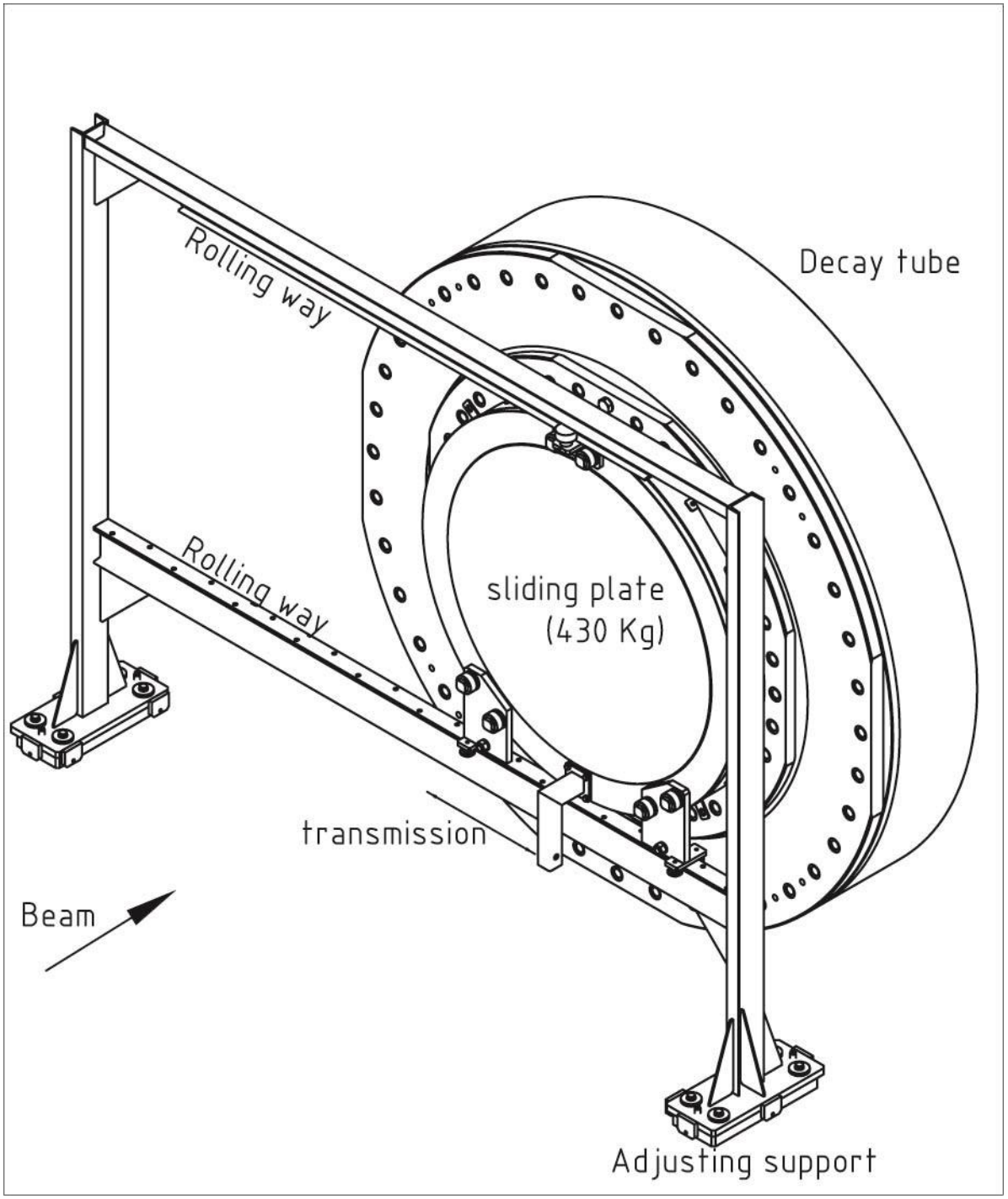


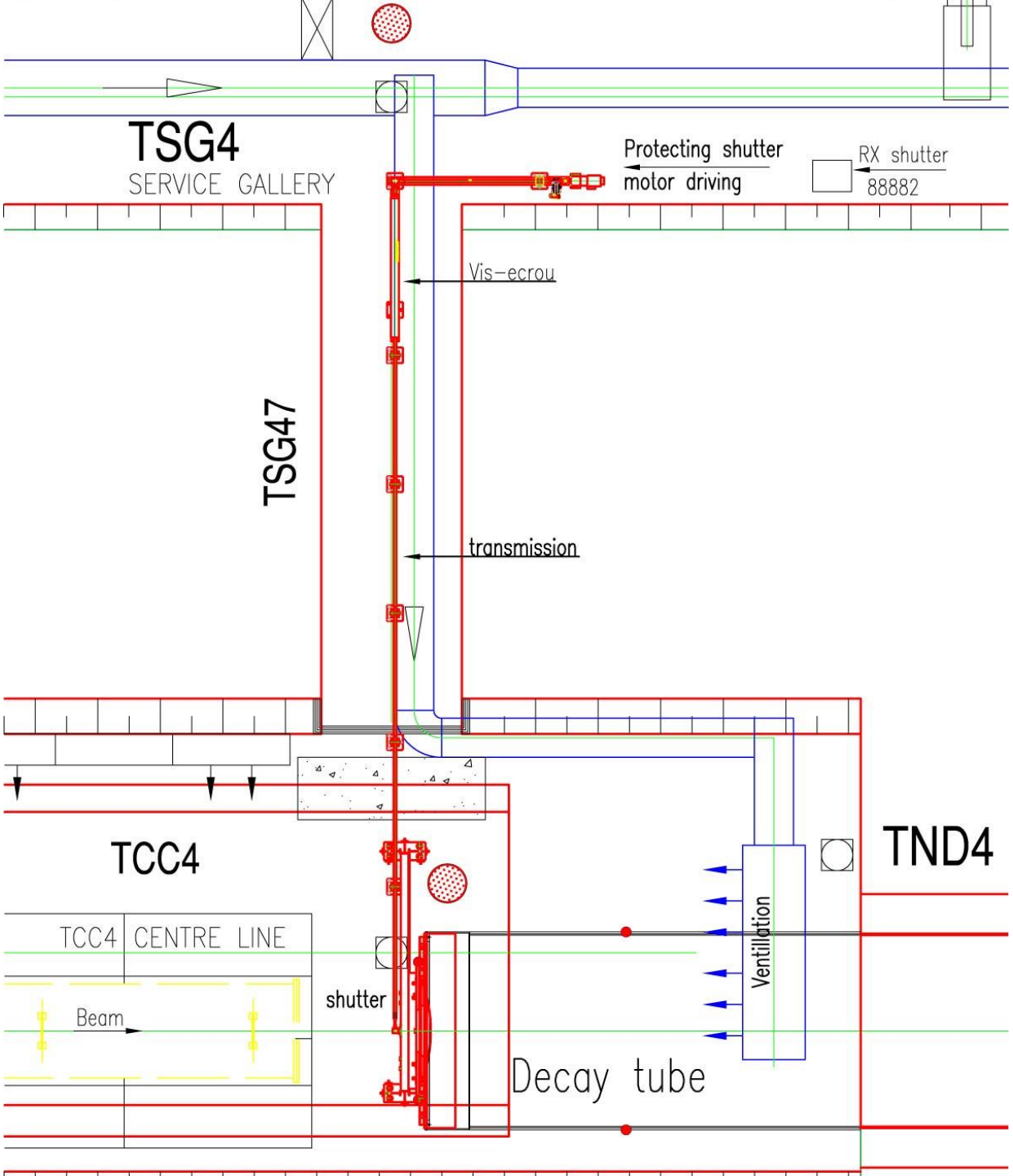
Jan. 2005
horn
re-assembly



CNGS safety shutter

(upstream of thin decay tube window)




TSG4
SERVICE GALLERY
Protecting shutter
motor driving
RX shutter
88882
Vis-ecrou
TSG47
transmission
TCC4
TND4
TCC4 CENTRE LINE
Beam
shutter
Ventilation
Decay tube

CNGS: ideas on commissioning with beam

N.B. CNGS ready for beam April 2006

PHASE 1: Target OUT – Horns OFF – TED_TT40 IN
a) low intensity 10^{12}, 1 extraction / 2 extractions
b) high intensity 10^{13}, 2 extractions

PHASE 2: Target OUT – Horns OFF – TED_TT40 OUT
steering TT41 and onto target monitors, checks
only low intensity 10^{12}, 1 extraction / 2 extractions
(N.B. beam dumped onto hadron stop)

PHASE 3: Target IN – Horns OFF – TED_TT40 OUT
low intensity 10^{12}, 2 extractions (check TBID vs. BFCT)

PHASE 4: Target IN – Horns ON – TED_TT40 OUT
low intensity 10^{12}, 2 extractions
(initial calibration of muon detectors)

PHASE 5: SECONDARY BEAM COMMISSIONING

a) low intensity 10^{12}, 2 extractions
observe muon detector response to
- Horn ON/OFF/ NEG. Polarity
- Reflector ON/OFF/ NEG. Polarity
- Horn+Reflector ON/OFF/ NEG. Polarity

b) gradually raise intensity, observe muon detector response (linearity issues)

c) high intensity 10^{13}, 2 extractions
observe muon detector response to
- Horn ON/OFF/ NEG. Polarity
- Reflector ON/OFF/ NEG. Polarity
- Horn+Reflector ON/OFF/ NEG. Polarity

rather frequently: "STOP and THINK"

Summary

◊ CNGS construction progresses on schedule

(but: difficult months ahead of us...)

◊ "ready for beam": April 2006

◊ Commissioning schedule:

- 3 periods of ~ 5 days (2 x low, 1 x high intensity)
- details under discussion

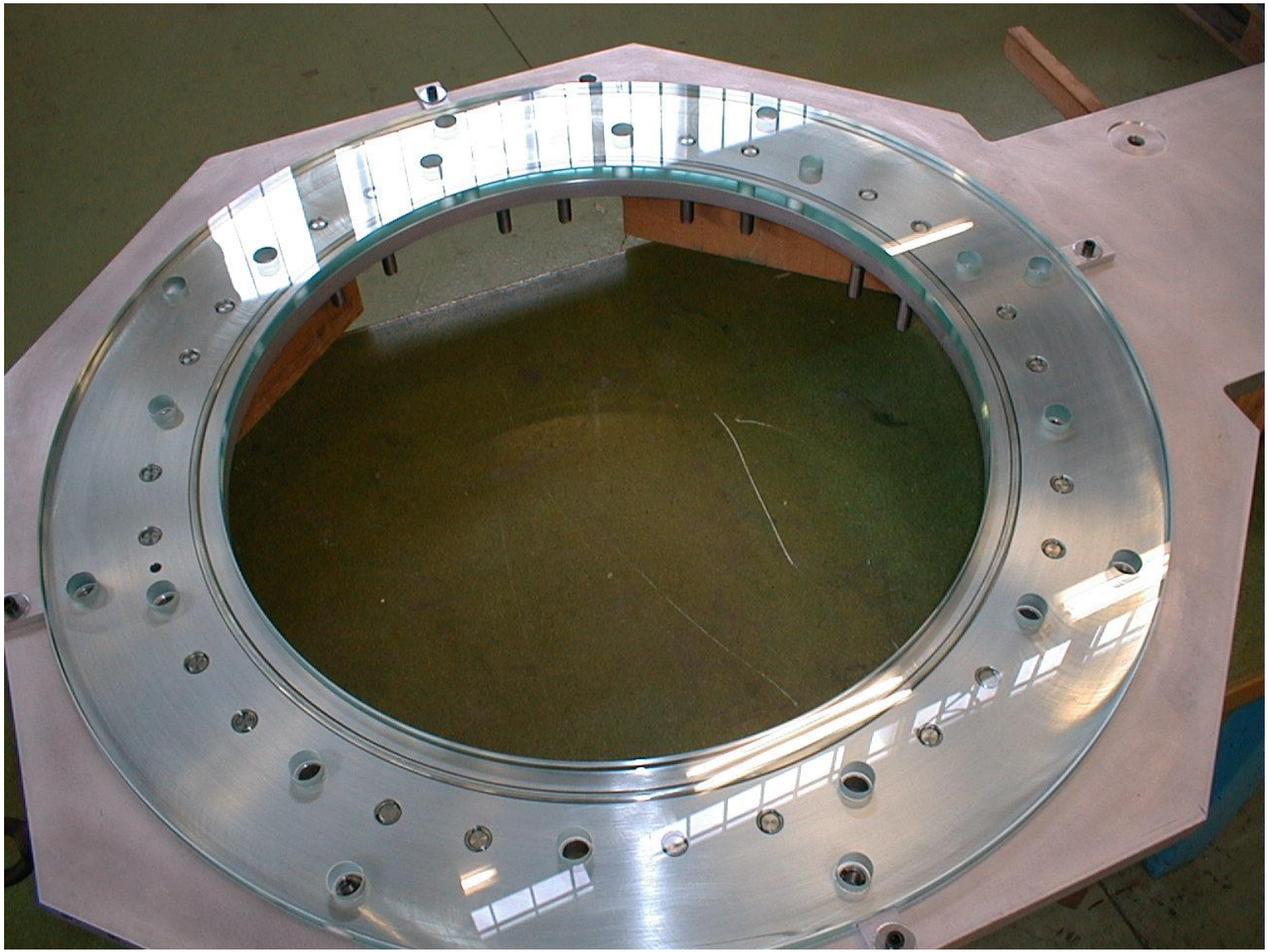
◊ Commissioning Committee:

chair: Malika Meddahi

scientific secretary:

Edda Gschwendtner

SPARE SLIDES >>>

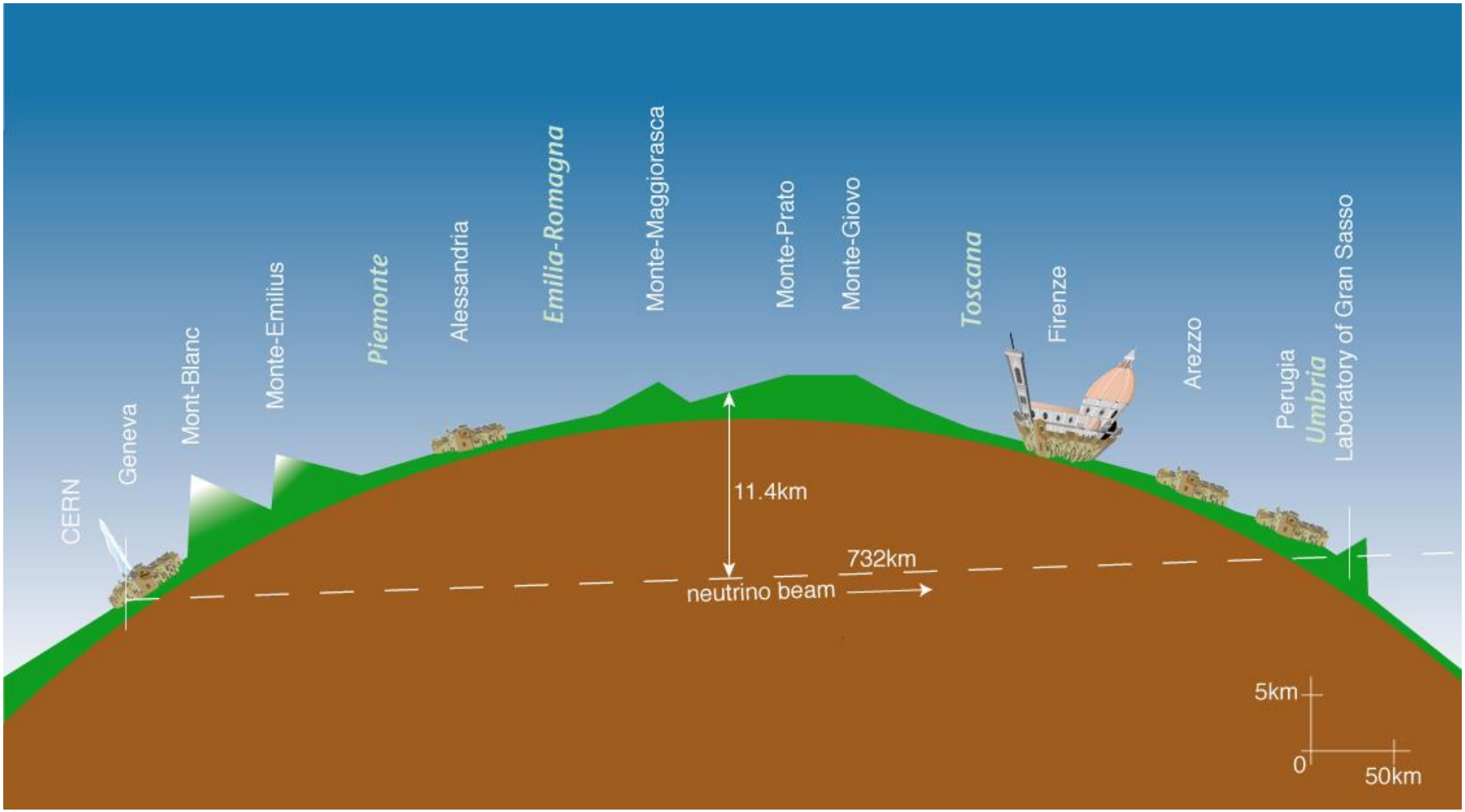


CNGS – a ν_τ "appearance" experiment

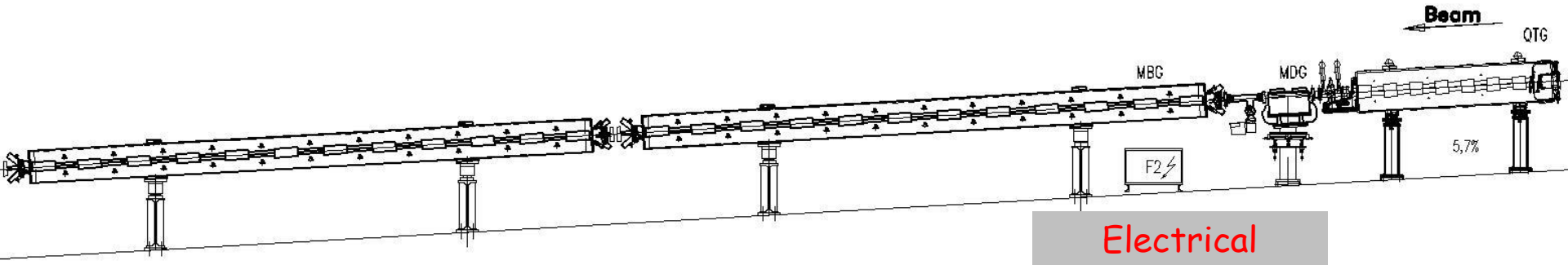
- send intense ν_μ beam from CERN
- look for ν_τ at Gran Sasso, 732 km away

final proof of ν_μ -- ν_τ oscillation

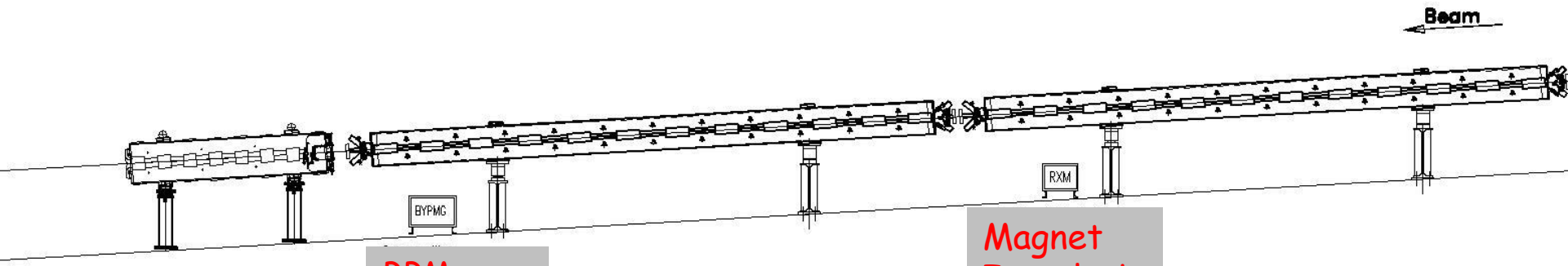
"Gran Sasso": - RESEARCH FACILITY
- mountain range ≈100 km east of Rome
"Laboratori Nazionale di Gran Sasso"


CERN
Geneva
Mont-Blanc
Monte-Emilius
Piemonte
Alessandria
Emilia-Romagna
Monte-Maggiorasca
Monte-Prato
Monte-Giovo
Toscana
Firenze
Arezzo
Perugia
Umbria
Laboratory of Gran Sasso
11.4km
732km
neutrino beam
5km
0
50km

Proton beam tunnel – TT41

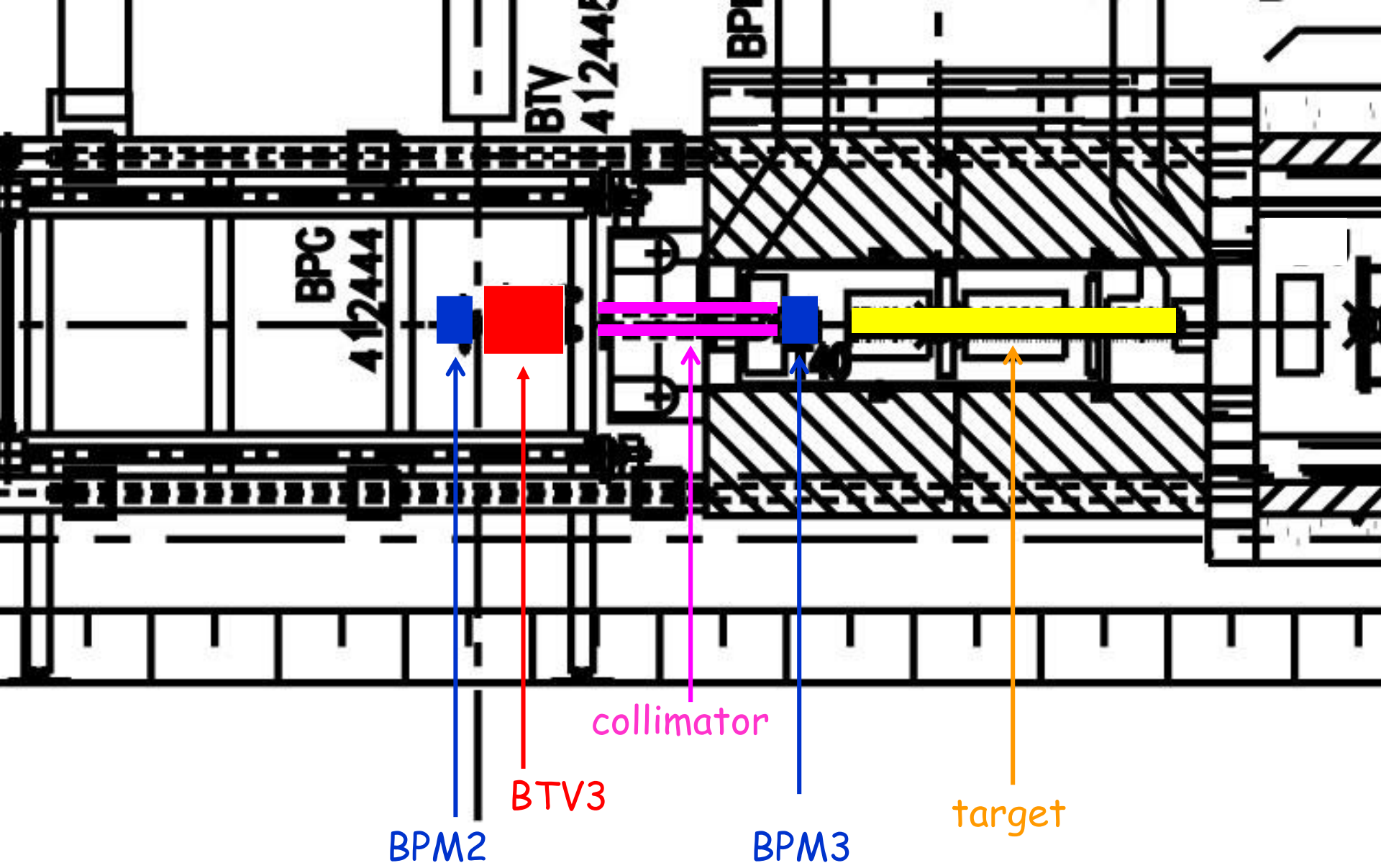


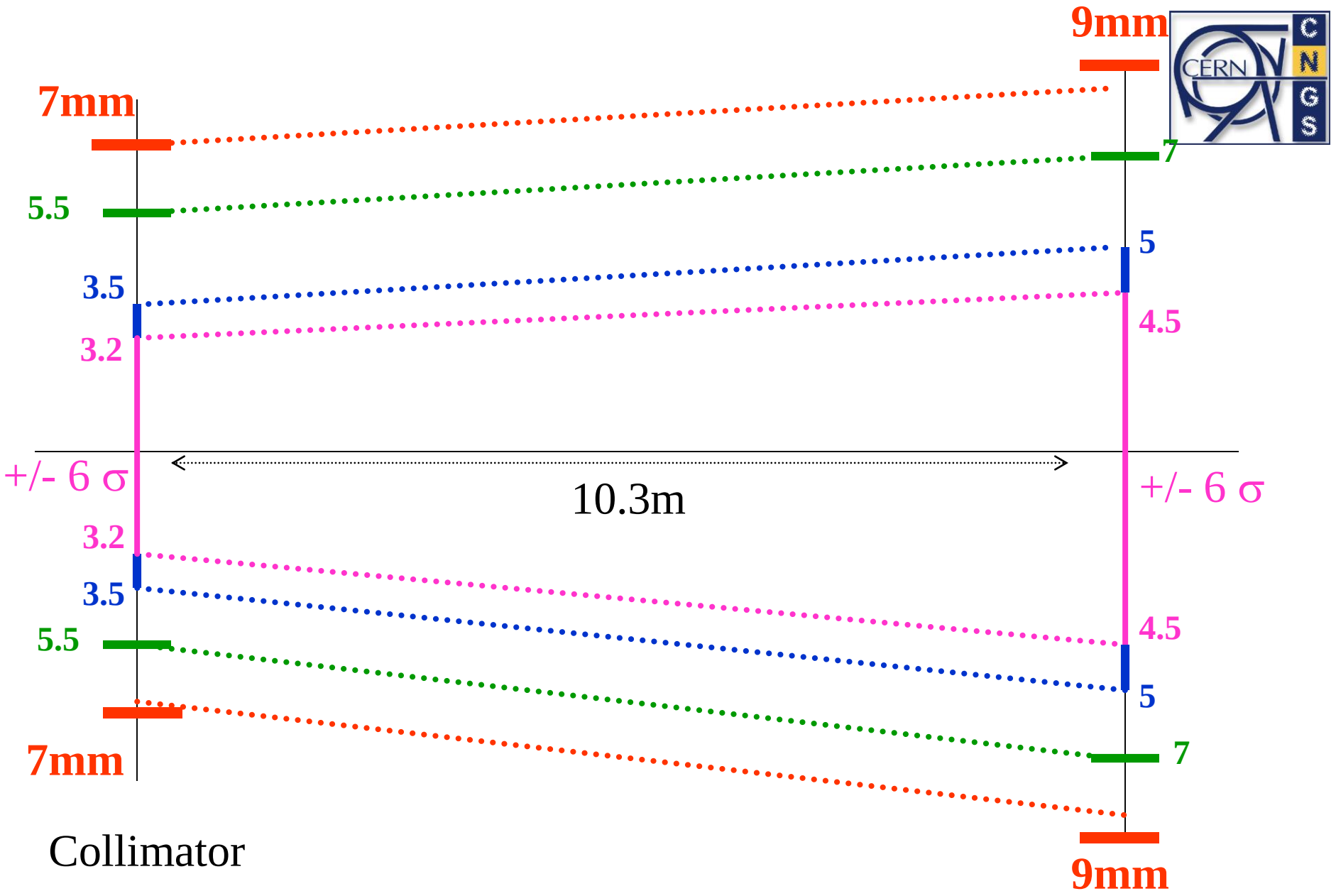
Electrical distribution box



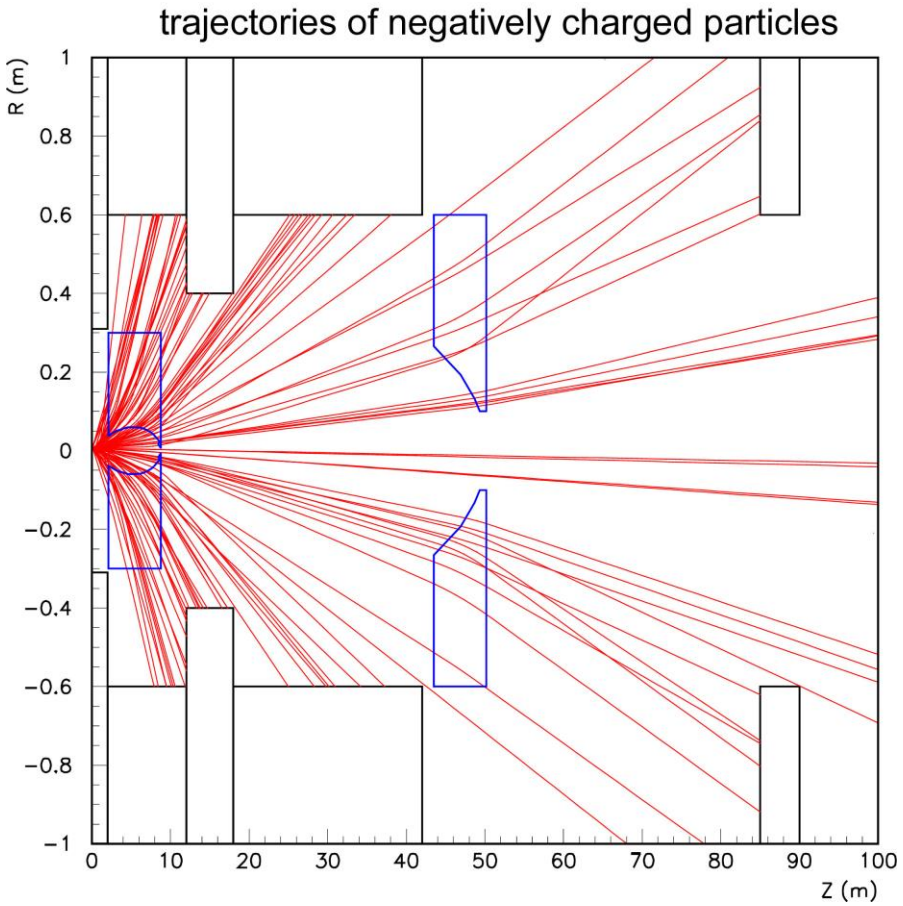
BPM control box

Magnet Interlock box


BPC
412444
BTV
412445
BPM
collimator
BTV3
BPM2
BPM3
target

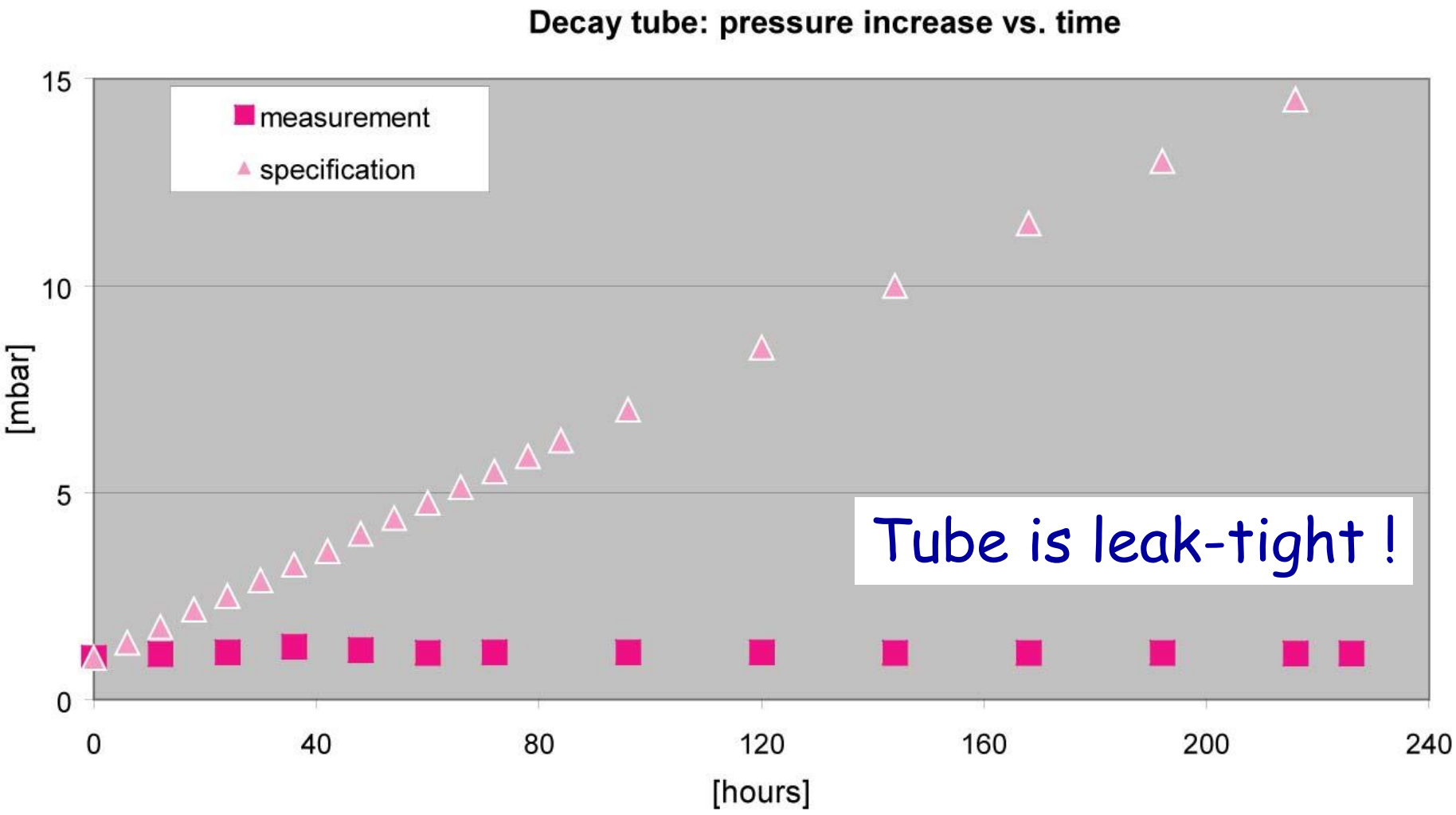

9mm
7mm
7
5.5
5
3.5
4.5
3.2
+/- 6 σ
10.3m
+/- 6 σ
3.2
3.5
4.5
5.5
5
7
7mm
9mm
Collimator
Horn neck

Horn / Reflector: negatively charged particles




6 m long section
lowered down the
CE shaft

19 April 2004: Vacuum tests (by the contractor) started


Decay tube: pressure increase vs. time
measurement
specification
15
10
5
0
[mbar]
0
40
80
120
160
200
240
[hours]
Tube is leak-tight !