Beam Diagnostics for the Antiproton Target

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- Pbar production
- Target hall
- Detectors for target monitoring
- Summary

Pbar production I
Existing sources

P-986 Letter of Intent:

Medium-Energy Antiproton Physics at Fermilab

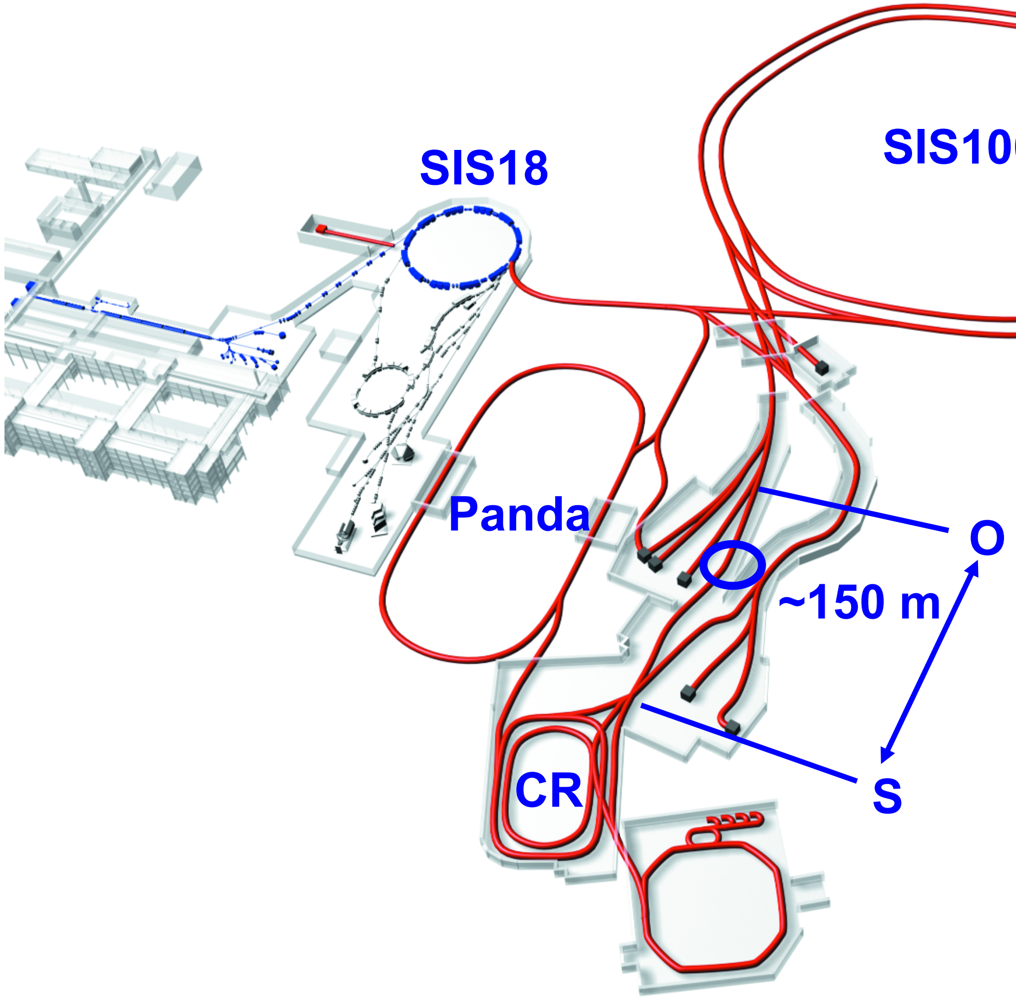
February 5, 2009

Table 2: Antiproton intensities at existing and future facilities.

Facility	Stacking: Rate (10^{10}/hr)	Stacking: Duty Factor	Clock Hours /Yr	$\overline{p}$/Yr (10^{13})
CERN AD			3800	0.4
FNAL (Accumulator)	20	15%	5550	17
FNAL (New Ring)	20	90%	5550	100
GSI FAIR	3.5	90%	2780	9

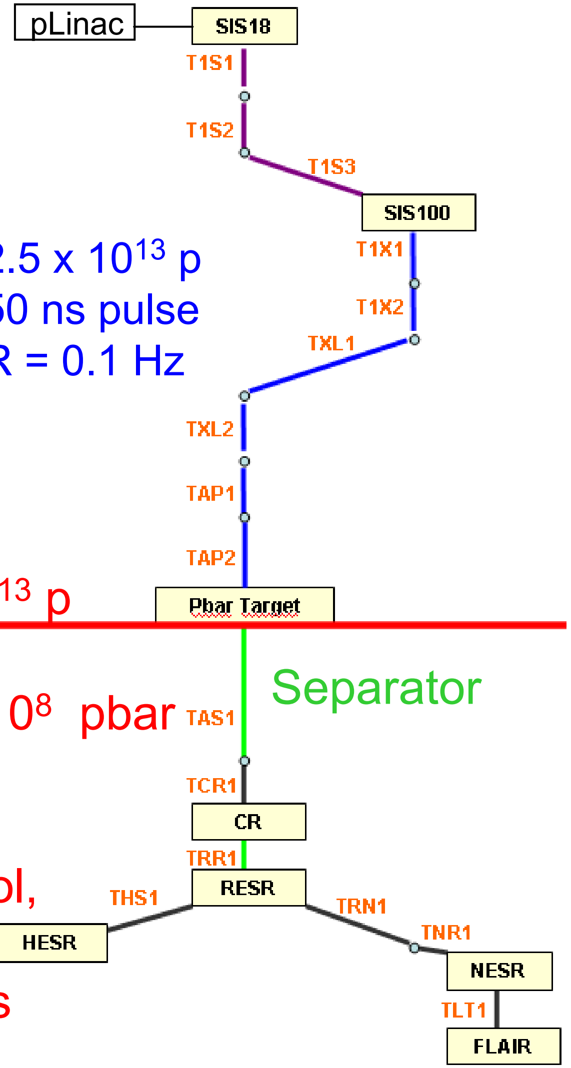
Apart from those get BD information from other secondary beam production targets:
GSI: FRS and Super-FRS
CERN: CNGS (Cern Neutrinos to Gran Sasso)

Pbar production II
FAIR setup

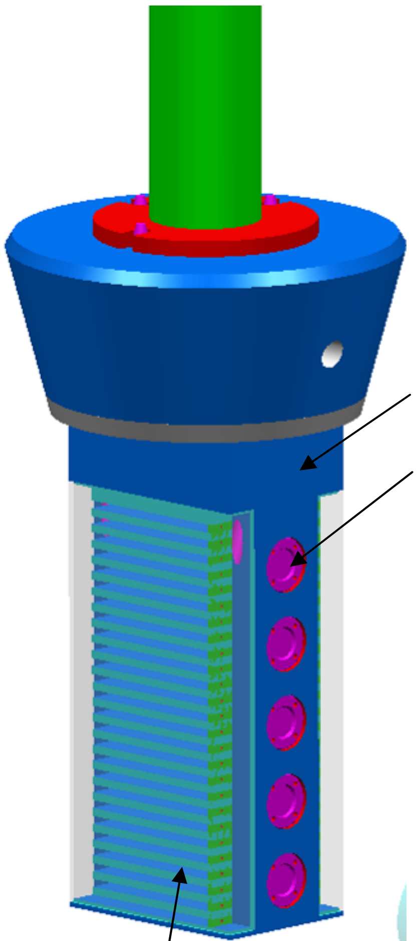


2.5 x 10^{13} p
50 ns pulse
R = 0.1 Hz

- Dump: 1 x 10^{13} p
- TAS1/TCR1:
  1×10^{10} π^- / 1×10^{8} pbar
- CR:
  π^- : decay
  pbar: store, cool, prepare beam for experiments



Pbar production III
FAIR target



Vertical target ladder

- 5 production targets („Cern type“)
- lateral movement („target finds beam“)
- target-out position

Al block

Ti window

inside:

Ni rod

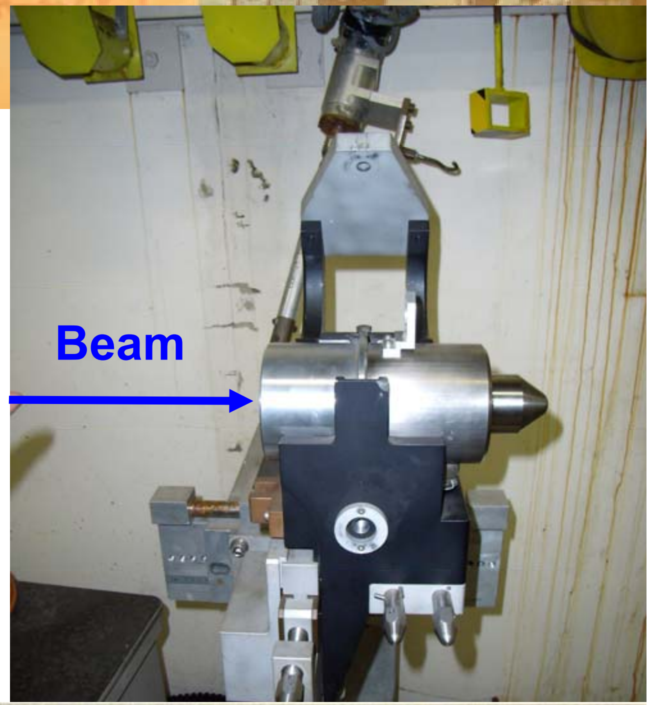
(r = 0.15 cm, l = 10 cm)

within graphite cylinder

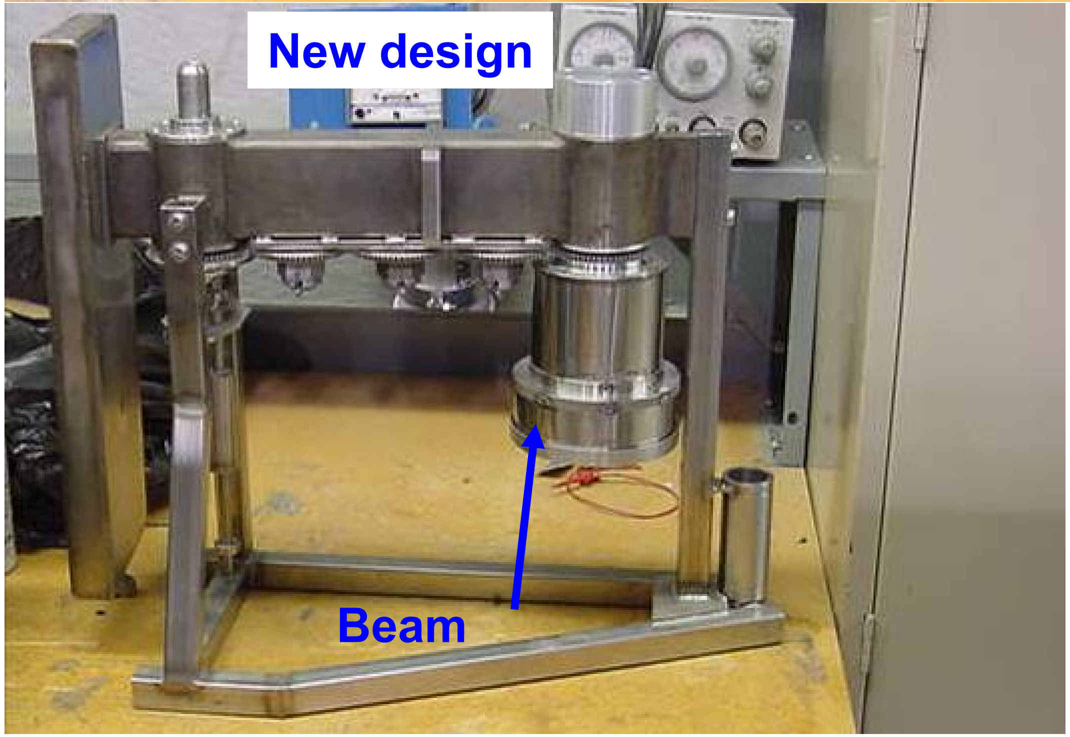
(r = 1 cm)

air cooling

CERN has experienced very few target problems



Pbar production IV
FNAL target



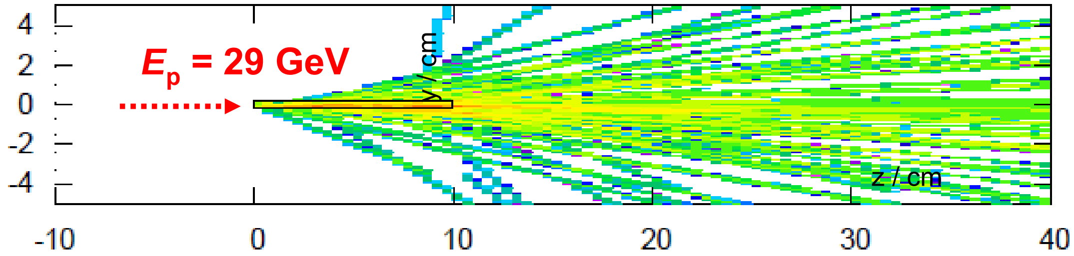
Old design

Before

After

120 GeV proton beam; $8x10^{12}$ per bunch; every 2.2 s
Sweeping magnets moves beam spot (σ~0.15 mm) by 2-3 σ to reduce local target heating
Rotating Inconel (Ni-Fe alloy) production target
Movement in 3 directions (target length, focus Li lens)
Target design still not finished (Feb. 2009 cook book)

Pbar production V
Particle distribution



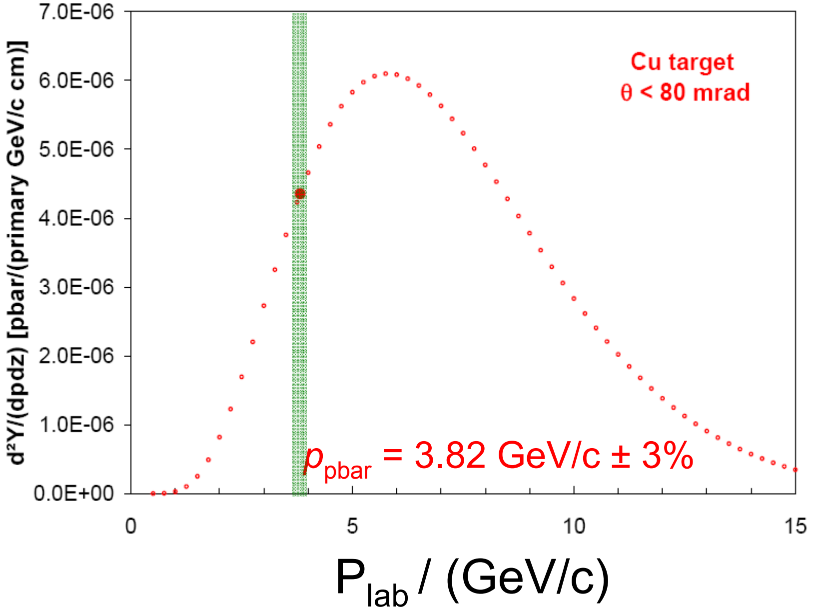
p+p -> p+p + p+pbar

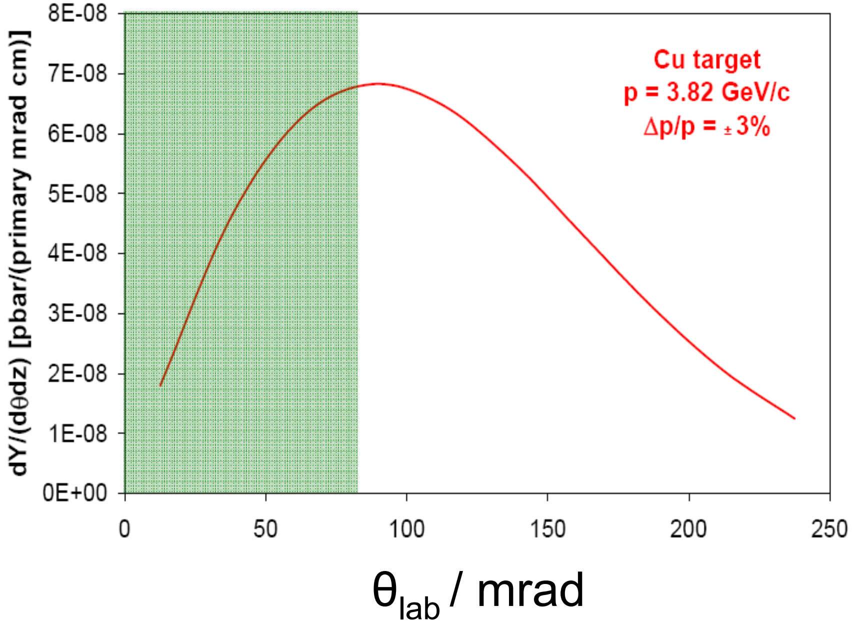
$\pi^- \rightarrow \mu^- + \overline{\nu}_\mu \quad \tau = 26.03$ ns

$\pi^+ \rightarrow \mu^+ + \nu_\mu$

$K^+ \rightarrow \pi^+ + \nu_\mu$ (63.5 %)

$K^+ \rightarrow \pi^+ + \pi^-$ (21.2 %)



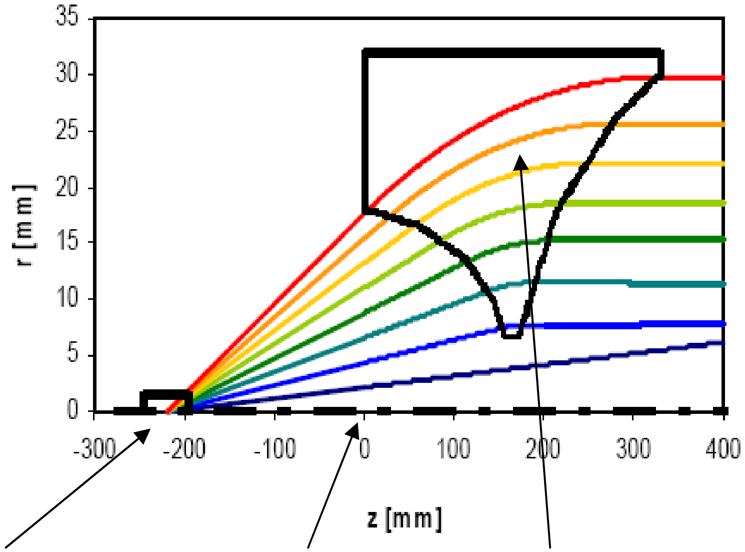


From ~ 2.5 × 10^{-4} pbar / (p cm target) ~ 5 × 10^{-6} (or 2 %) are "collectable"

R.P. Duperray et al., Phys. Rev. **D 68**, 094017 (2003)

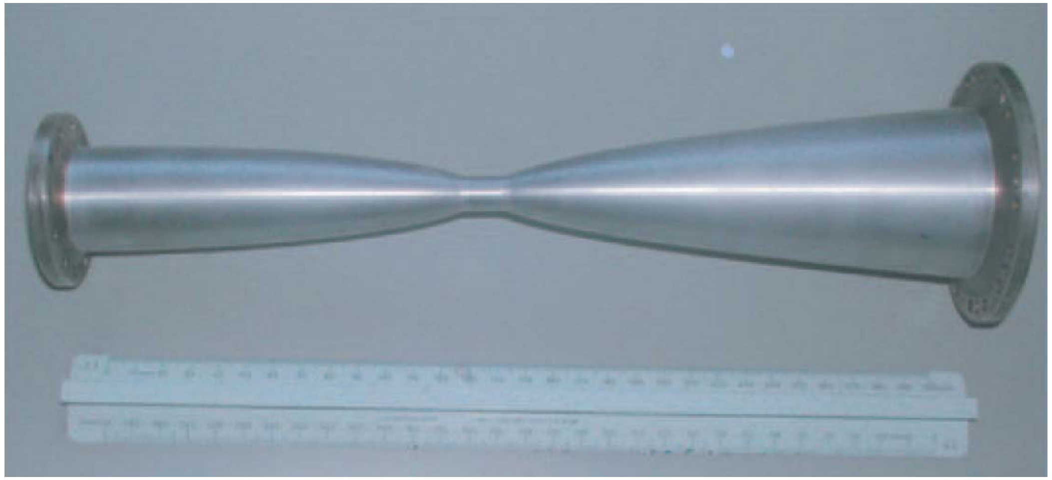
Pbar production VI
Collection via magnetic horn

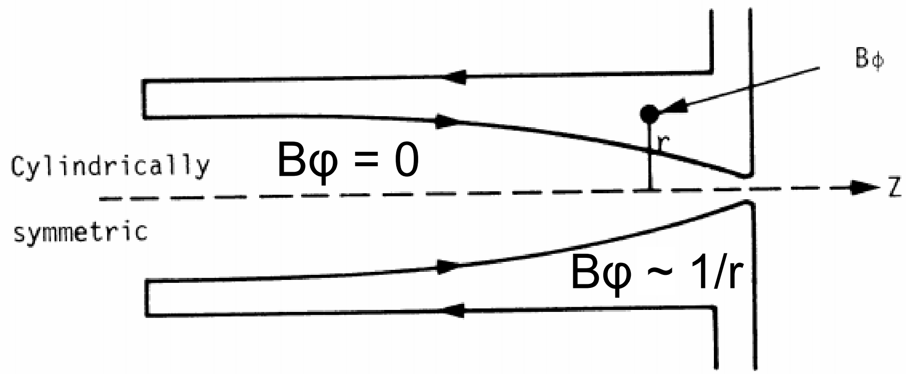
S. van der Meer; early 1960s



target beam axis magnetic field area

CERN ACOL Horn, I = 400 kA

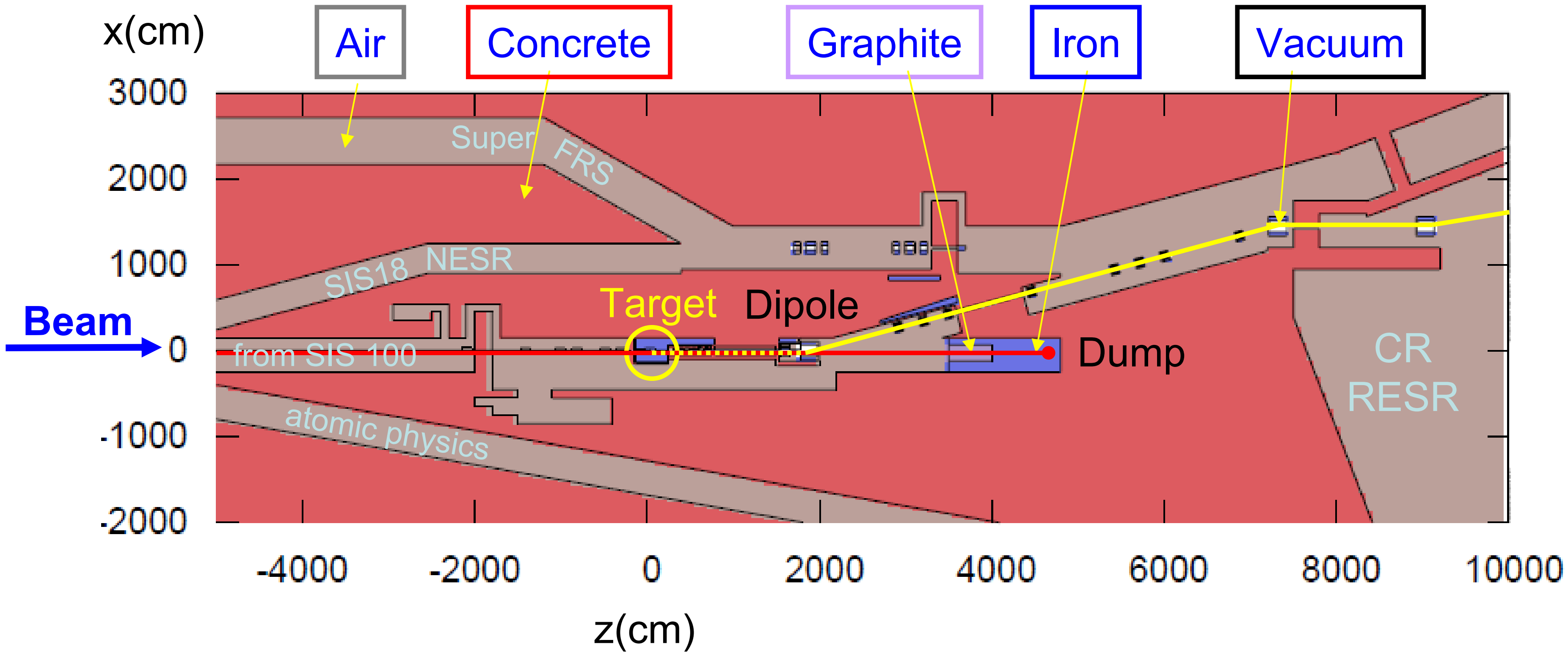




Device: “Current sheet lens”
Cylindrical lens focussing in both planes
Chose inner surface shape to optimise collection efficiency

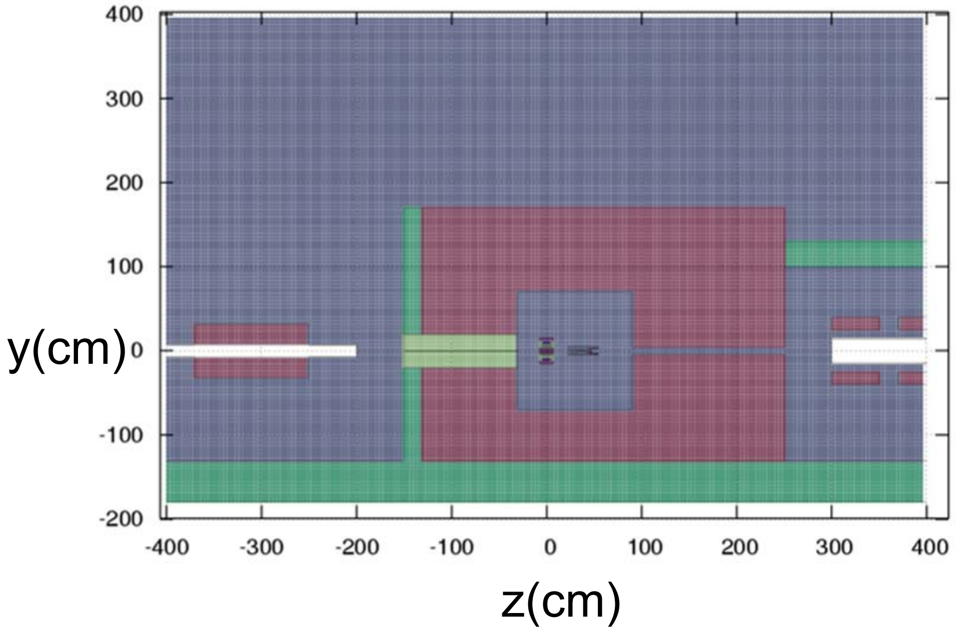
Large beam diameter after target

Target area I
Overview

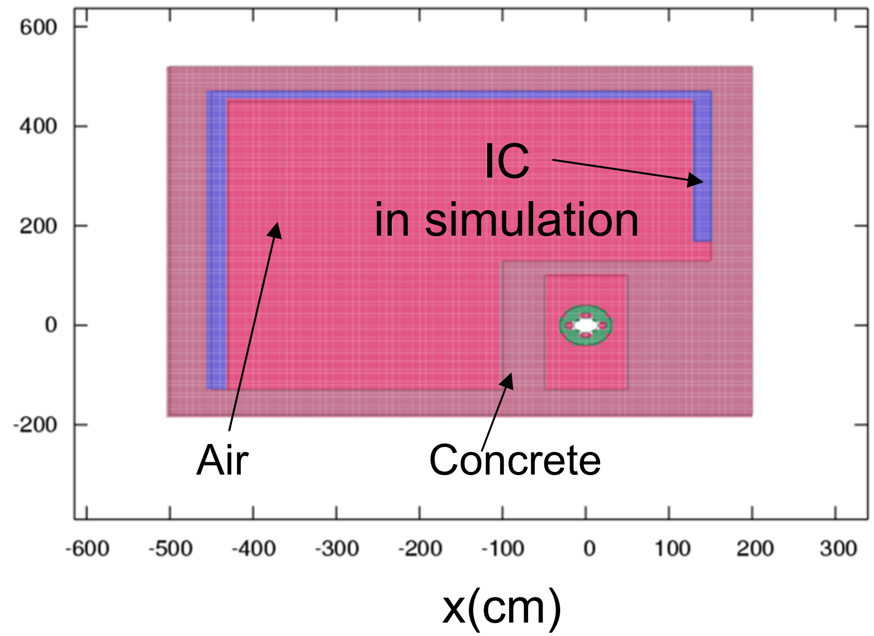


Target area II
Cross sections

Side view of target area



Vertical section (behind target)



- In front of target: ~150 cm gap for BD installation
  Only drift space to determine beam axis
  Single position measurement sufficient?
- Within target housing and behind: Huge radiation levels. Detectors might not survive.
- Behind target: small gap for BD installation

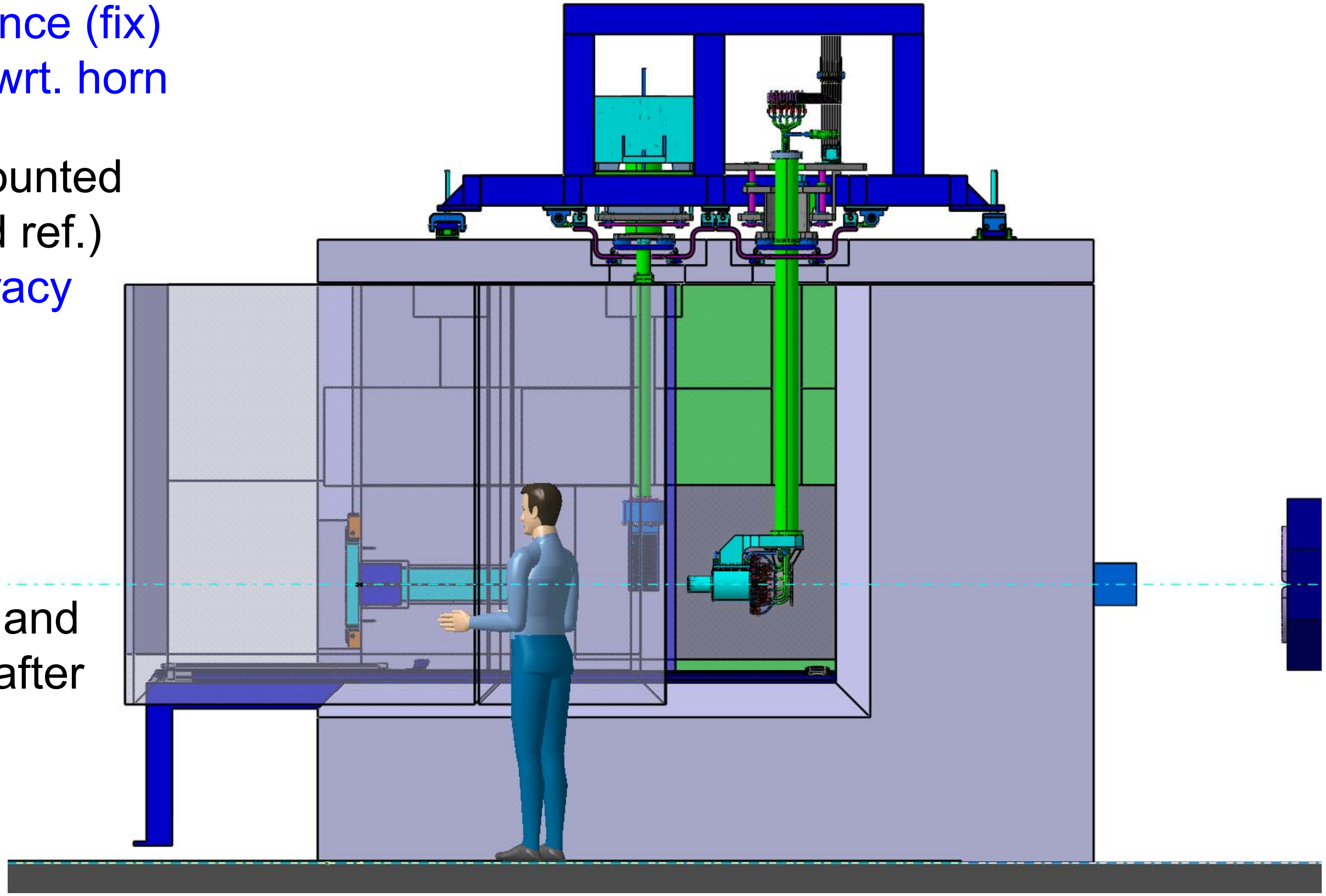
- Plenty of space along beam line
- No symmetric positioning of detectors possible -> calibration required via external reference

Target area III
Target station

Magnetic horn is reference (fix)
Align beam and target wrt. horn

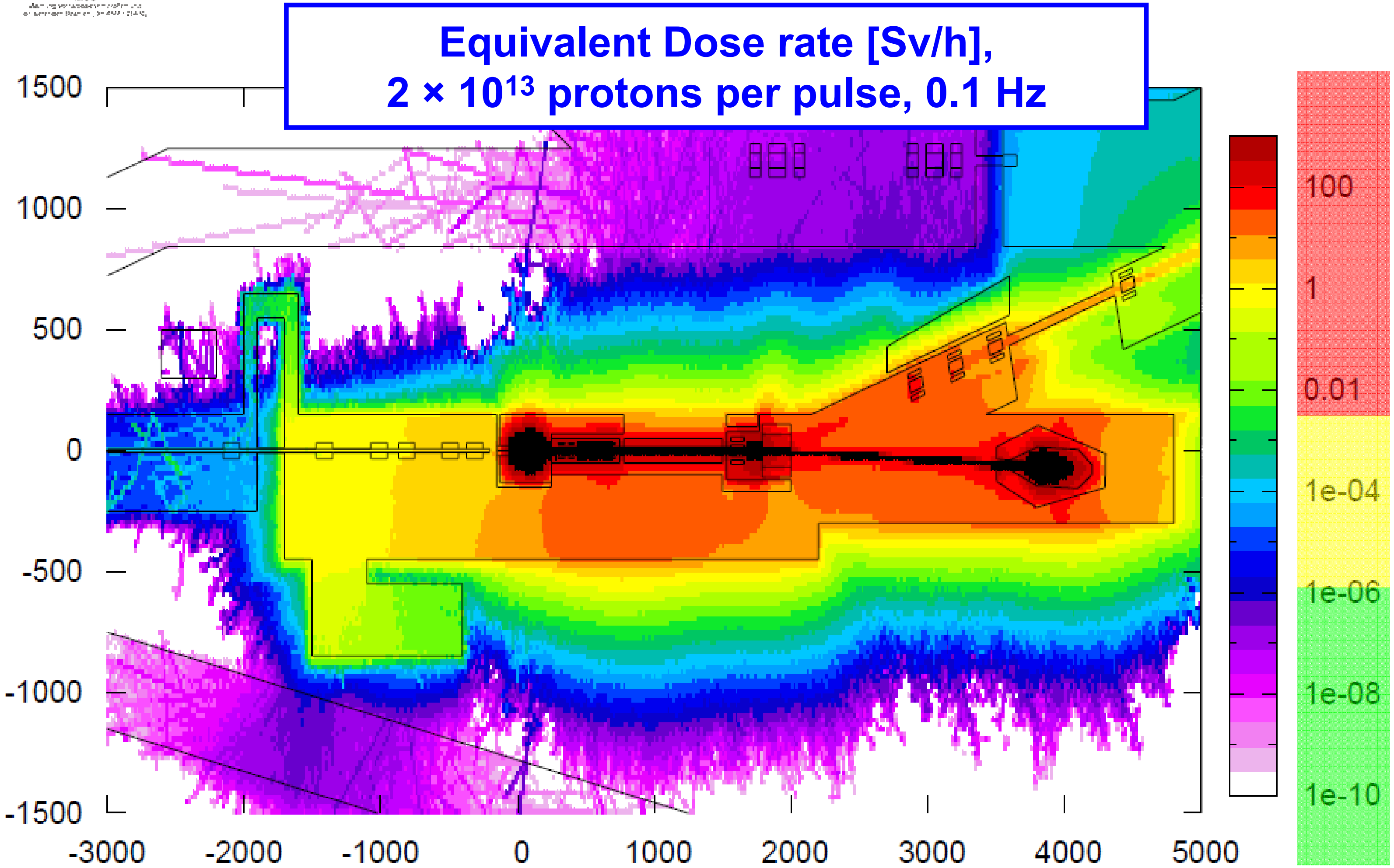
- Upstream detectors mounted on target housing (fixed ref.)
- Sub-mm position accuracy
- Sub-mm resolution

- Diagnostics on horn?
- Alignment of horn after replacement?
- Alignment of upstream and downstream detectors after replacement
- Ageing and calibration of detectors (long-term stability)
- Redundancy in case of device malfunction or failure



Target area IV
Equivalent dose rates during operation

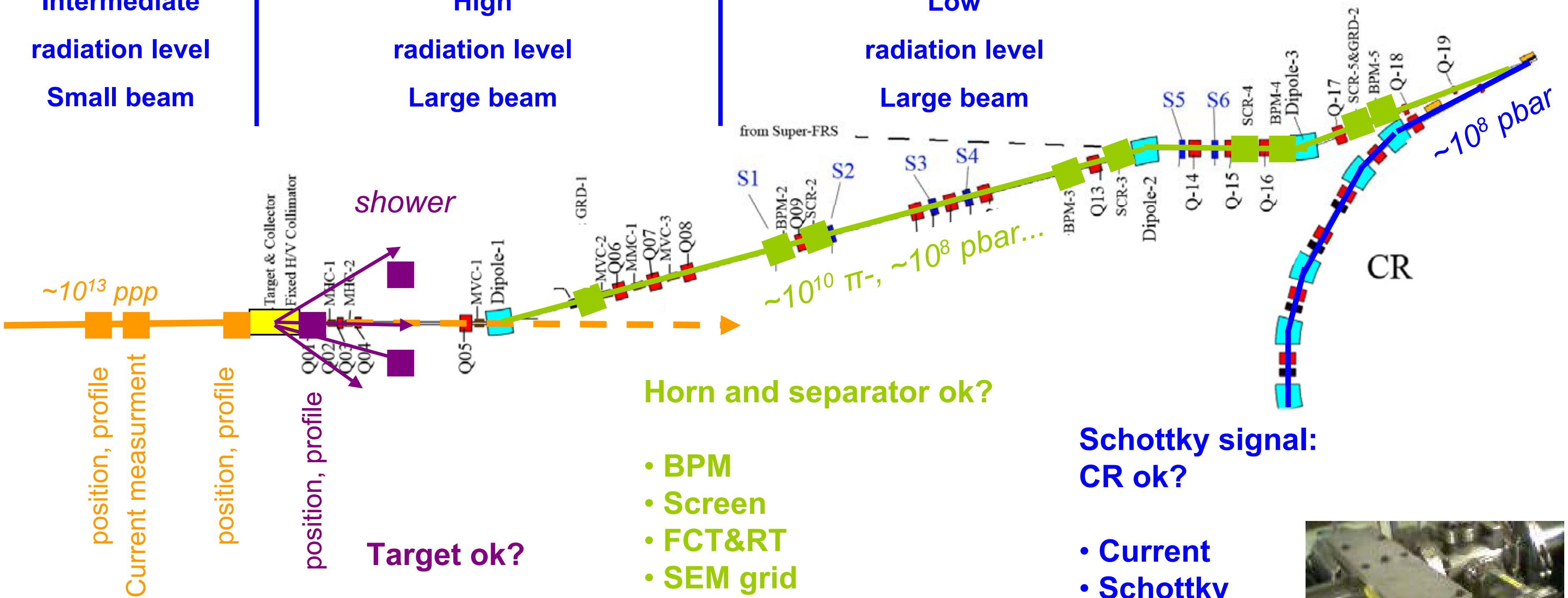
BD man



Hall accessible after shut-down after ~1 month

Pbar beam line
BD sections

Intermediate radiation level Small beam	High radiation level Large beam	Low radiation level Large beam

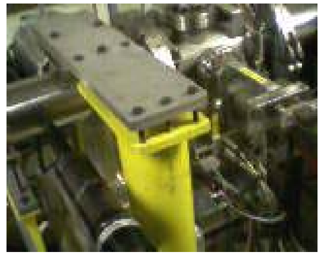


Horn and separator ok?

- BPM
- Screen
- FCT&RT
- SEM grid

Schottky signal:
CR ok?

- Current
- Schottky
- BPM
- Scraper+BLM
- Screen



Target ok?

- Segmented SEM
- BLMS & BLMI
- Screen/SEM cross-hair on horn

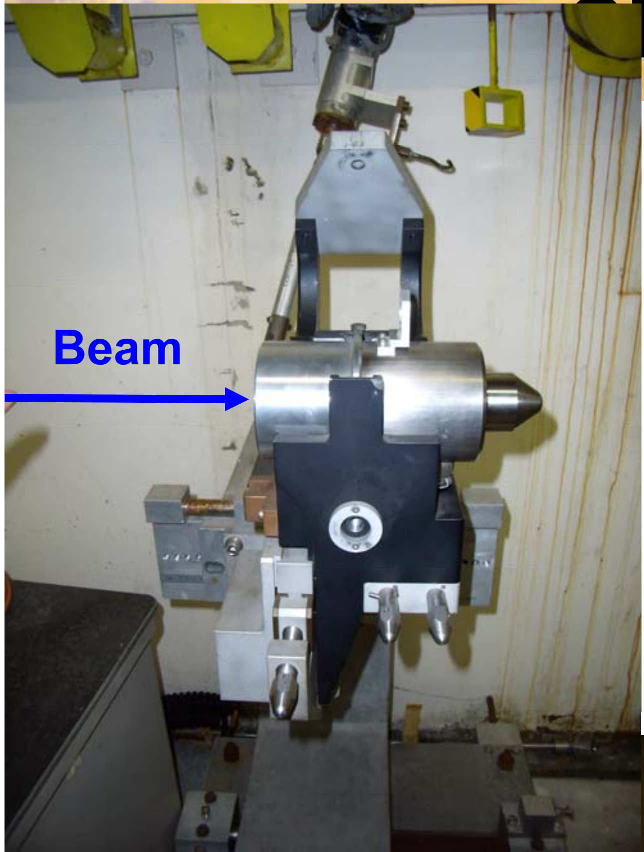
Primary beam ok?

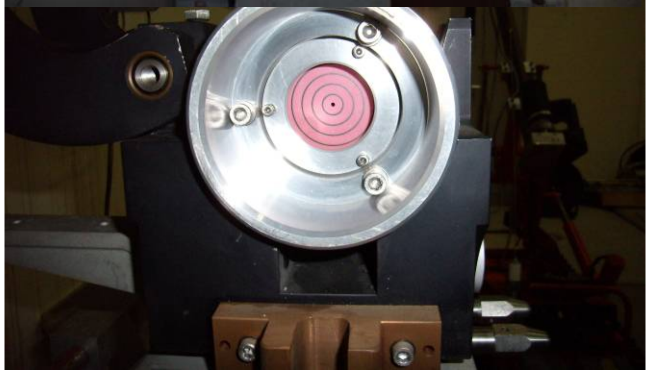
- Segmented SEM
- Screen (OTR?)
- Pick-up
- BPM

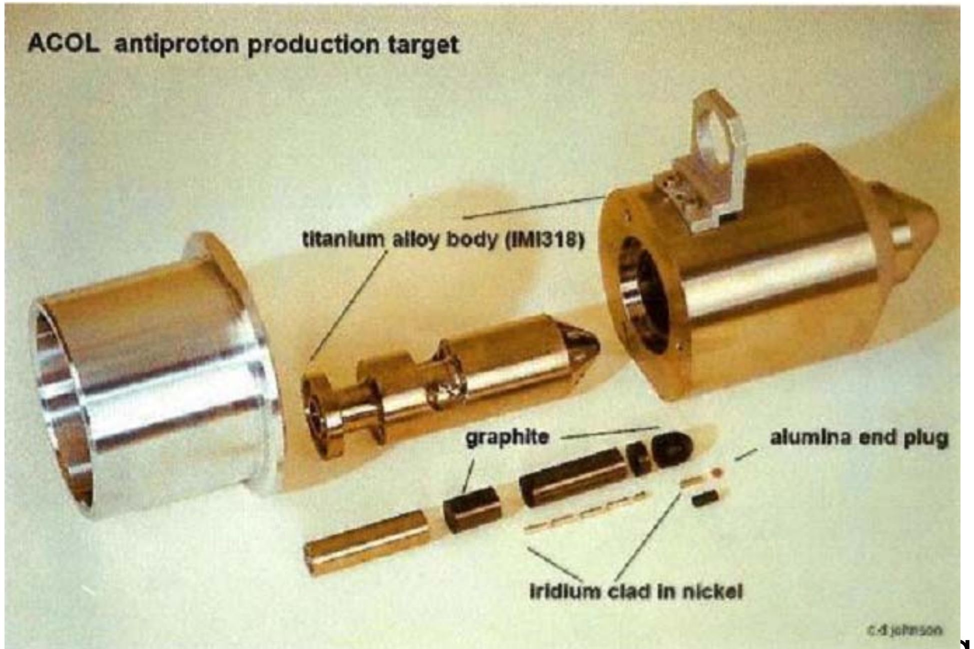
Commissioning: ~ $10^{-3} – 10^{-2}$ of nominal intensity
Correlate any of the BD informations in those 4 sections on GUI level

Primary beam monitor I

CERN target screen





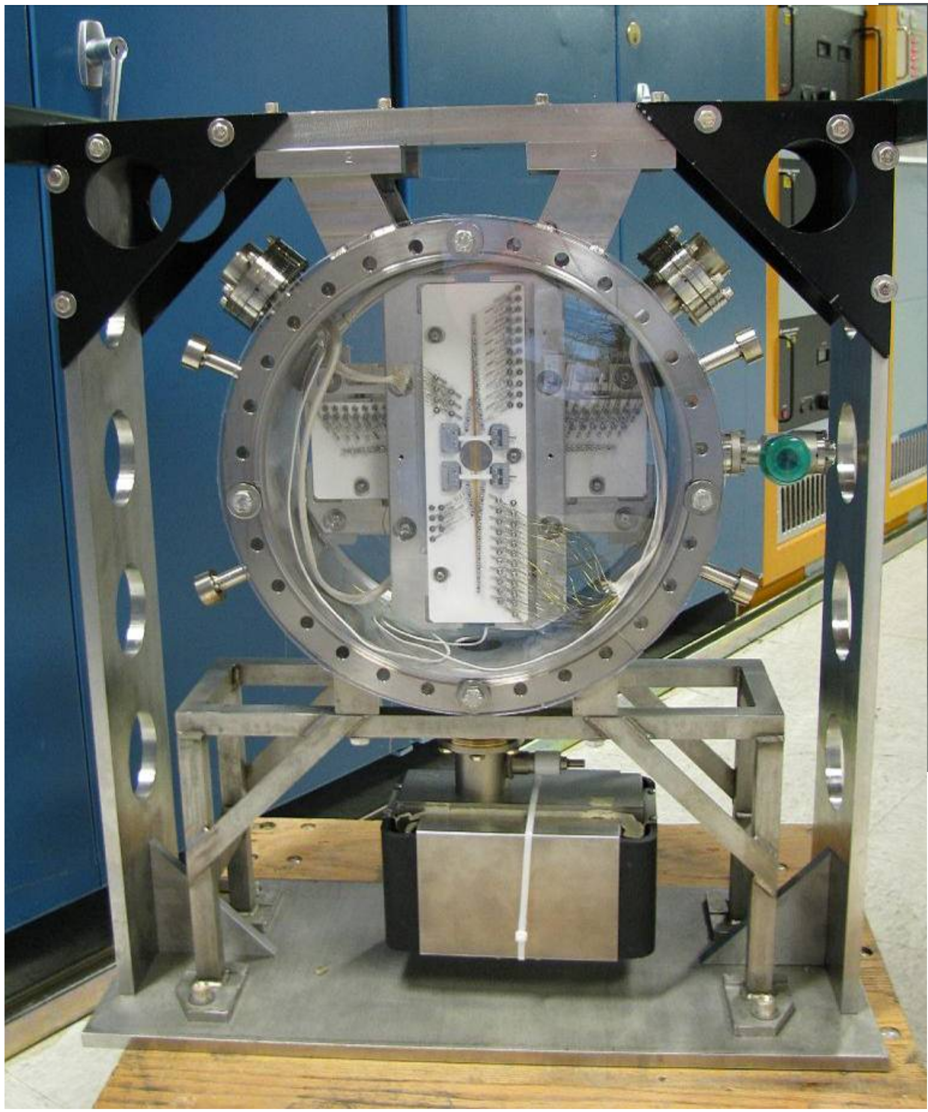


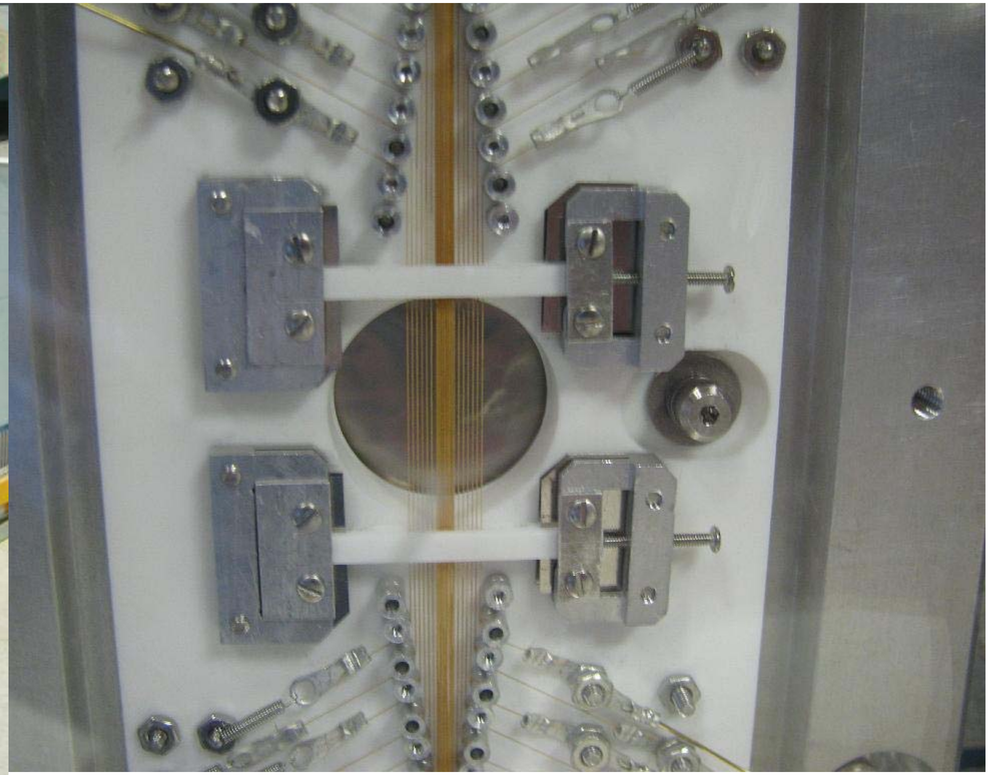
CERN AD: Alumina screen mounted on target
Central hole
Rad-hard camera (Vidicon, CID)

Future of Vidicon? Cern looks for alternatives due to increasing maintenance problems.

! Vidicons for us no option !

Primary beam monitor II
FNAL Target SEM

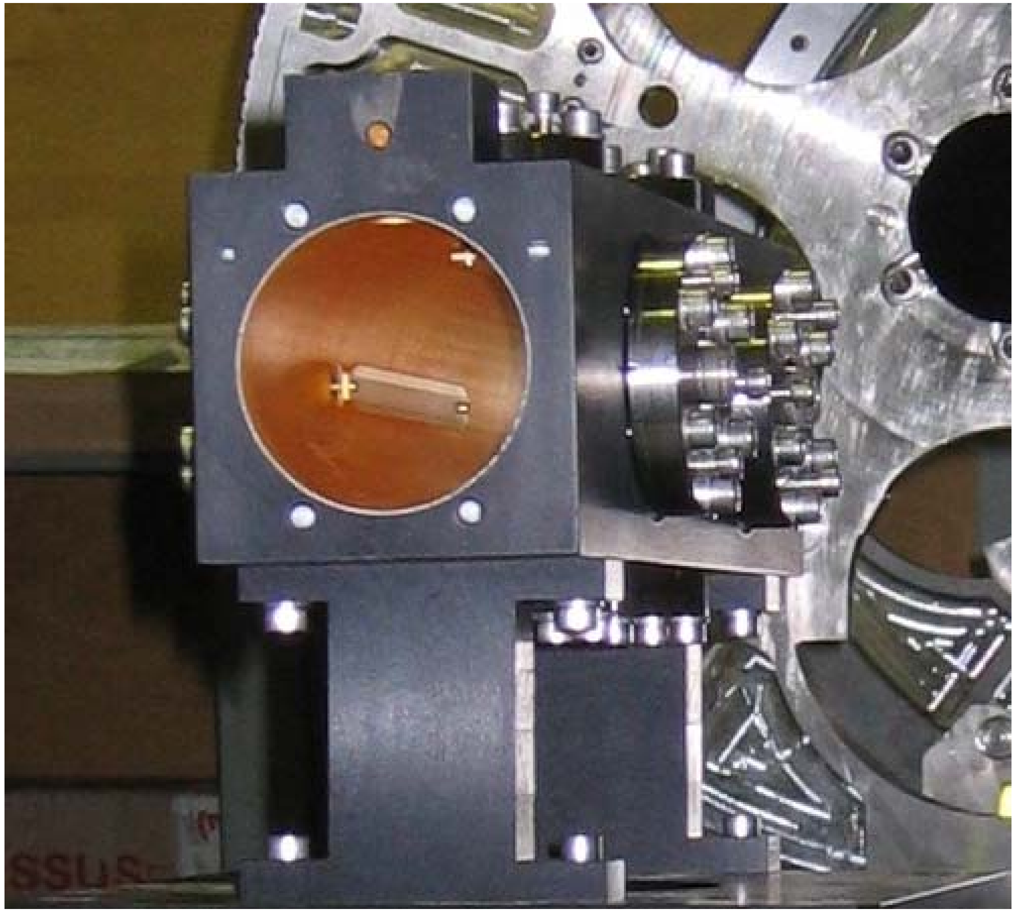




Wire spacing 0.125 mm at centre
Moved out of beam during operation
Park position: 5 mm from wires

Primary beam monitor III
CNGS Fixed Target Monitor

BPKG (stripline coupler)



! Possibility to get BPKG from Cern !

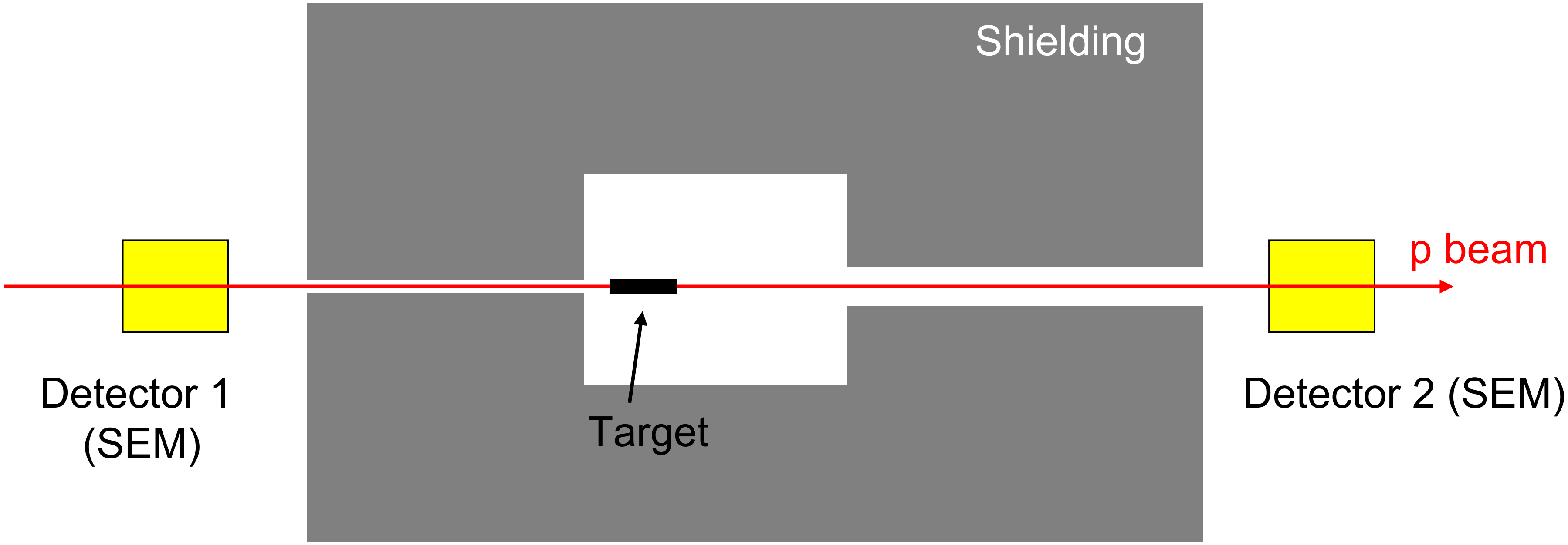
Coupler Body
- *Aluminium alloy*
- *lowers remnant radiation*

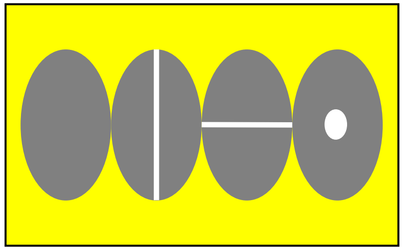
Outer Surface Treatment
- *penetrating oxide layer*
- *withstands radiation effects*
- *gives thermal stability*

Inner Surface Treatment
- *30 µm gold layer*
- *withstands radiation effects*
- *maintains good conductivity*

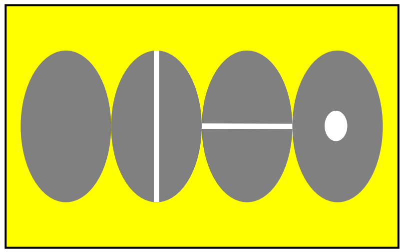
Feedthroughs
- *Ceramic dielectric (vac seal)*
- *simple 50 Ohm construction*

Primary beam monitor IV
Segmented SEM





Multiplicity
Hor. asymmetry
Vert. asymmetry
Halo



Calibration and ageing of SEM foils

Target monitor I
CNGS shower monitor proposal

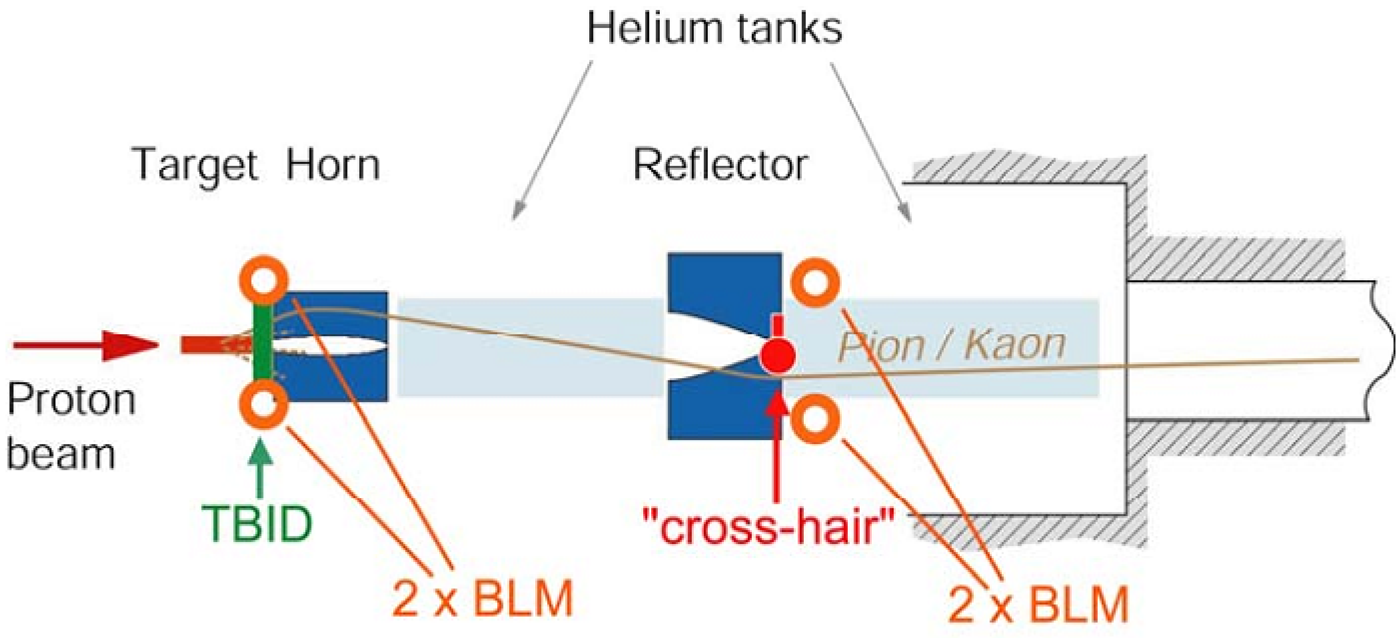
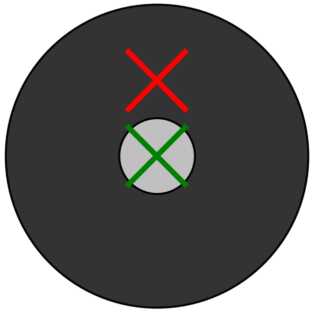


Figure 4.8 - Proposed additional monitoring equipment (BLM's) in the target chamber

- Additional BLMS and/or BLMI behind target
- 2 muon detector systems after 1000 m
- SEM cross-hair on horn and segmented SEM? Alignment of beam wrt. to horn
- CERN AD: Current transformer behind target!

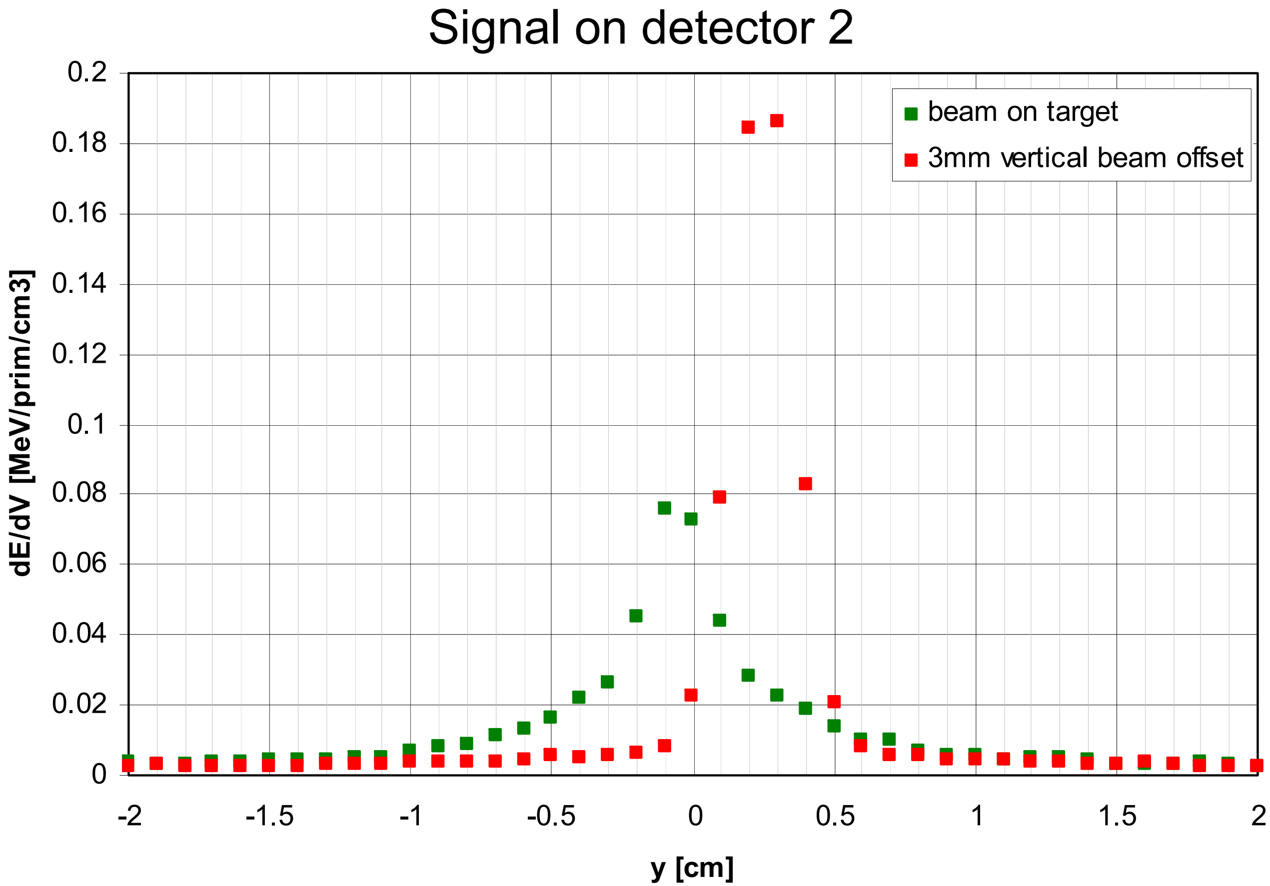
Target monitor II
Simulation: Segmented SEM

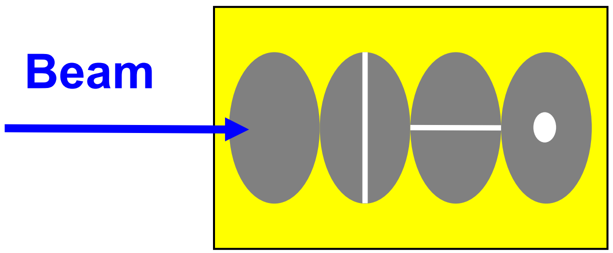
Target: Ni in graphite



Fluka simulations with realistic beam parameters:

- Beam on target
- 3 mm offset



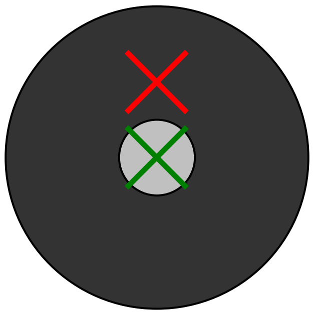


Offset beam : Fewer nucleons along trajectory yield higher transmission and smaller straggling

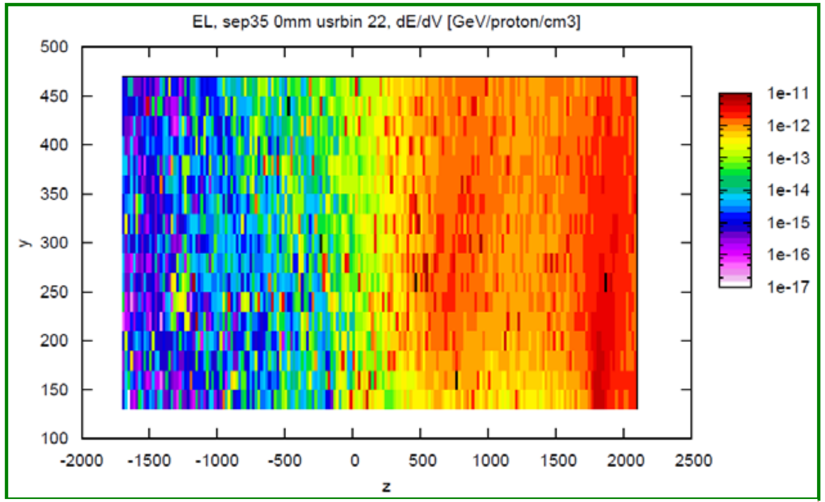
Should be detectable in segmented SEM

Target monitor III
Simulation: Shower strength

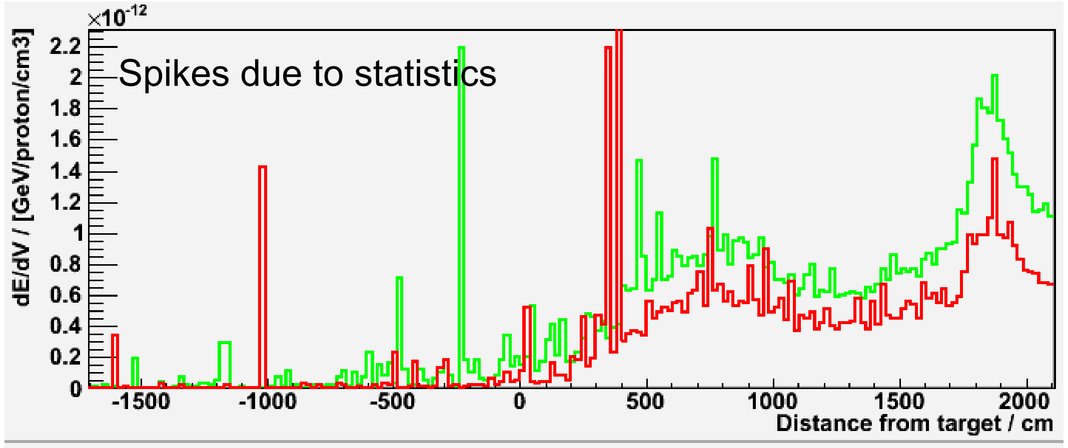
Target: Ni in graphite



FLUKA:
- E-loss in N_2 (1 bar)
- Left/right tunnel wall
- Simulate beam offset:
  - Beam on target
  - 3 mm offset



Projection onto z-axis

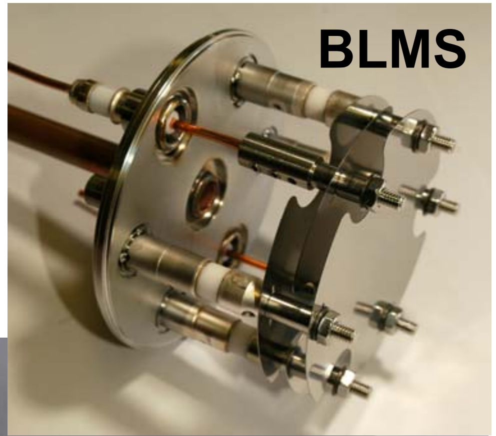


z(cm)

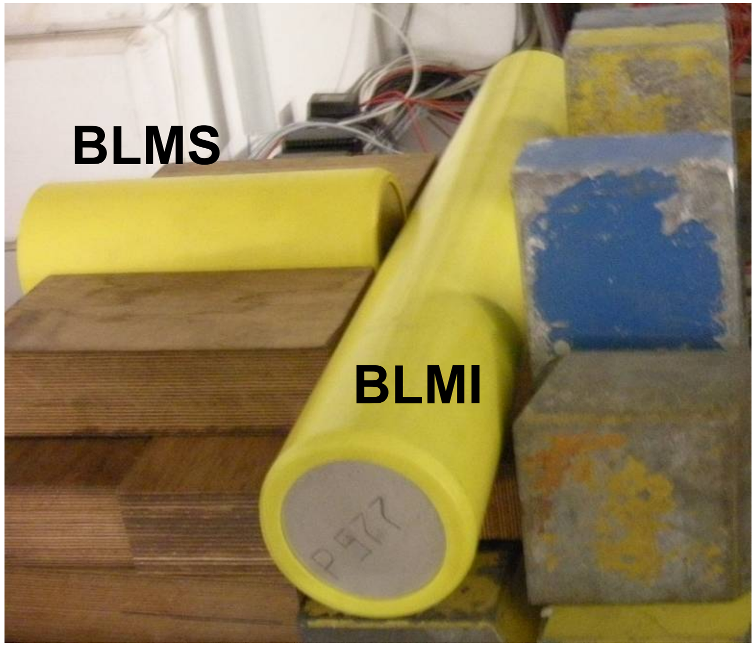
- Significant signal difference
- Identical behaviour for left/right wall
  - → **No directional information**

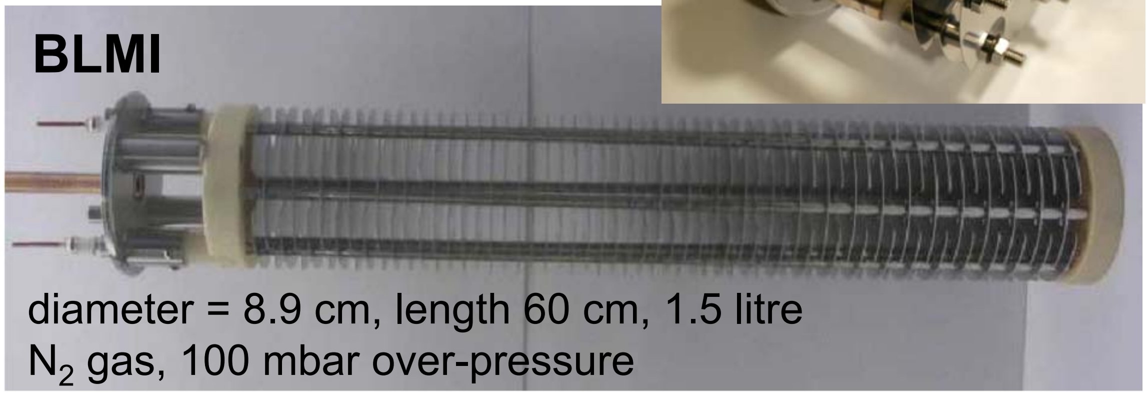
Target monitor IV
CERN detectors: BLMI / BLMS

Both detectors well understood and tested (MC & experiment)



"Setup" at TPH@GSI in front of beam dump





diameter = 8.9 cm, length 60 cm, 1.5 litre
N_2 gas, 100 mbar over-pressure

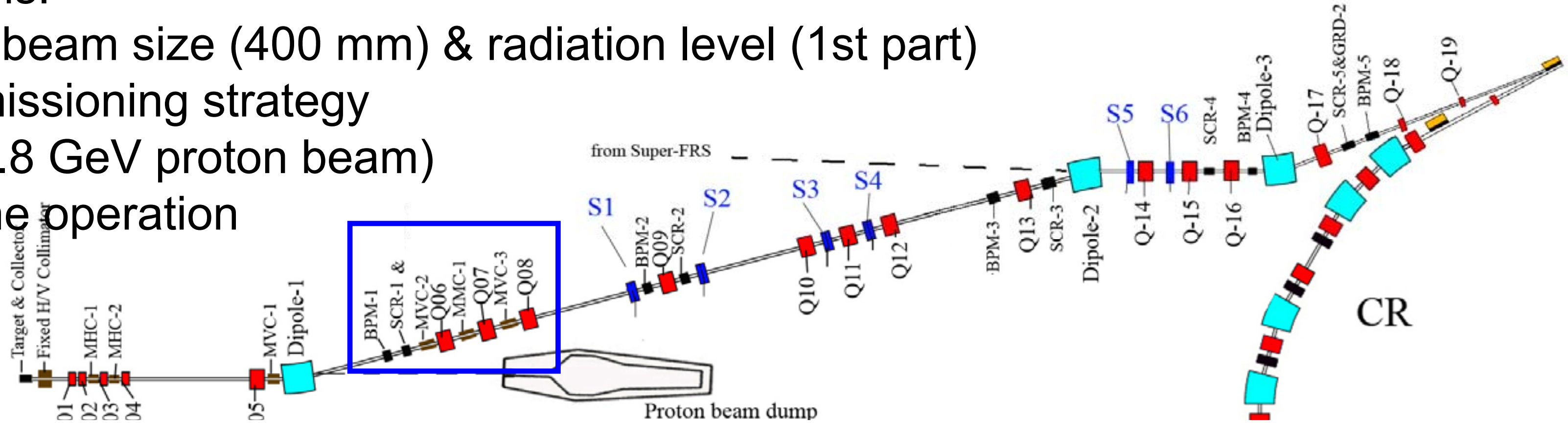
- BLMS on loan from Cern; test of detectors in June?
- Possibility to purchase BLMS from Cern
- Development of Mini-BLMI at Cern
- Concept for DAQ: I/f converter feasible for 50 ns pulses

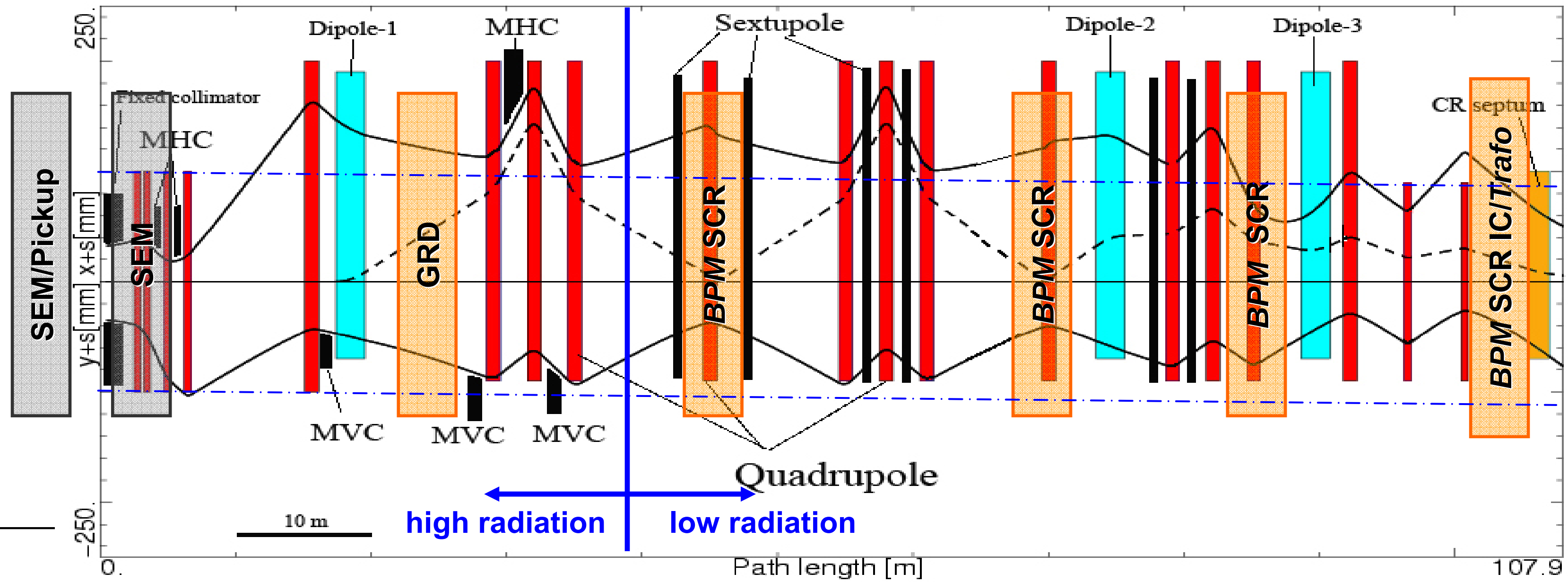
Separator
Many open issues

10^{10} π (10^{8} pbar), for commissioning factor 100-1000 less

Problems:

- Large beam size (400 mm) & radiation level (1st part)
- Commissioning strategy
  (use 3.8 GeV proton beam)
- Routine operation





Detector table

primary beam	10^{10} – 10^{13} ppp	Transformer SEM
shower	10^{6} – 10^{10} eV/pulse/cm³ @1 bar	Ionization chambers (beam loss monitors)
pions	10^{6} – 10^{10} ppp	Scintillating screens BPMs SEM Grids Transformer MWPC / IC
pbars	*10^{4} – 10^{8} ppp*	*Schottky*

Target hall: Learn about radiation hard components (detectors, cables, light guides, ...)
BD in separator: Check feasibility for each detector at each installation position
Last part of separator: pbar + Super-FRS beam

@Hannes: FNAL uses Pearson toroids; single turn large aperture; 1 V/A

Summary

Cern visit very successful: contacts, information, detector, positive feedback

Outlook of next 6 month:

- Cern: BLMS/BLMI and BPKG pickup purchase?

- Collect requirements from storage ring group
- Common commissioning strategy (simulation of SIS 18 proton beam in separator)
- Get simulations of beam profiles in separator for pions and pbar
- Simulate BLMS signal
- Test BLMS and BLMI at HTP
- Discuss construction and test of segmented SEM

- Fix type, position and number of detectors
- Write proper document
- DAQ and display in control system
- Develop rough project plan (R&D and cost estimate, construction time, tests,...)

Thank you for your attention

Zeitungsente von letzter Woche

Spargelbauer findet BLMS auf Gräfenhäuser Acker

Gefährliche Feldarbeit: Christian Mager aus Weiterstadt (links) entdeckte einen Sprengkörper, als er mit Traktor und Fräse das Feld bestellte. Ähnlich groß wie diese entschärfte Granate, die Gerhard Gossens (rechts) in den Händen hält, war die Zehn-Kilo-Bombe, die der Leiter des Kampfmittelräumdienstes gestern abtransportieren ließ. FOTO: GÜNTHER JOCKEL