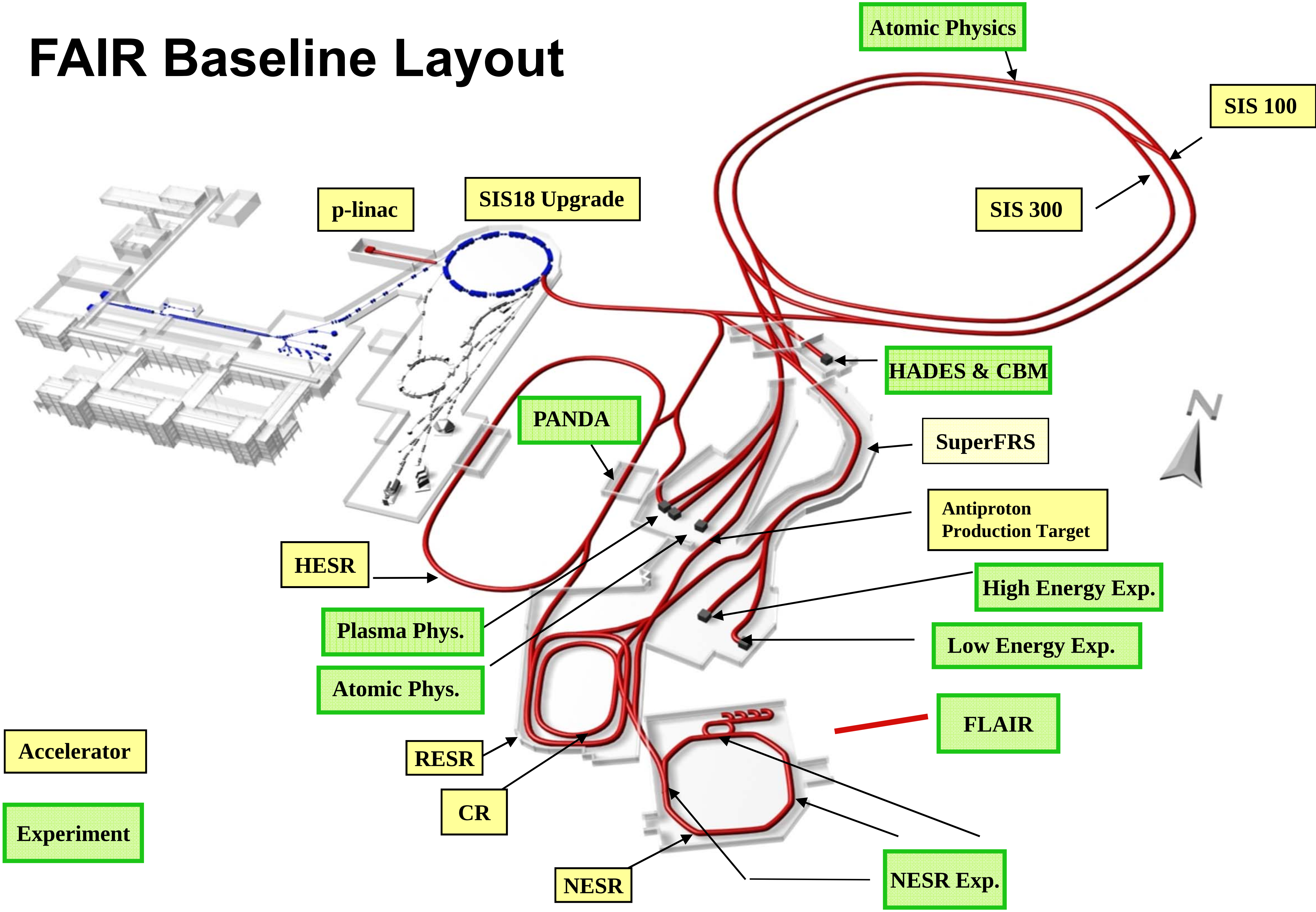
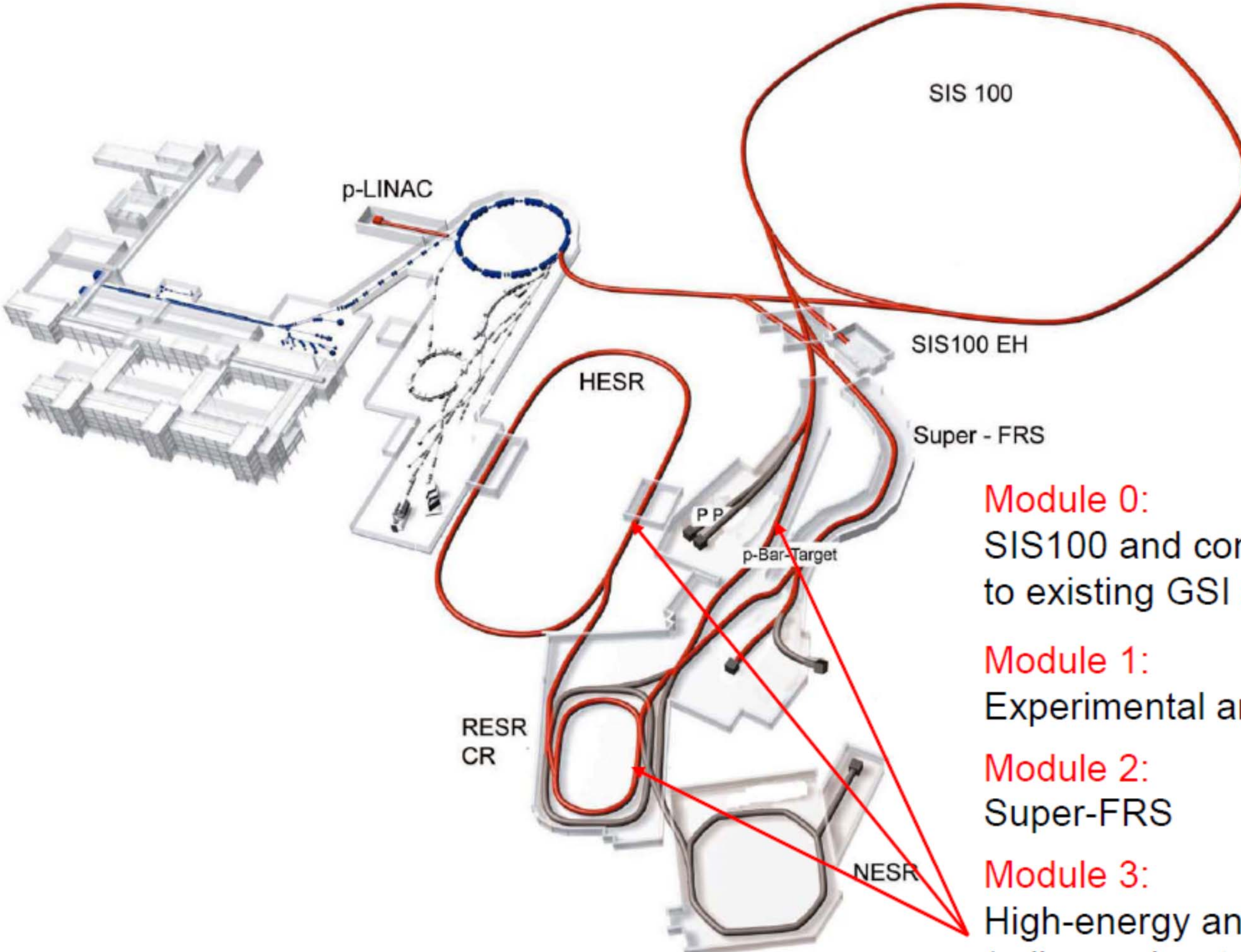
Status of the FAIR pbar Source

K. Knie

May 3, 2011

FAIR Baseline Layout



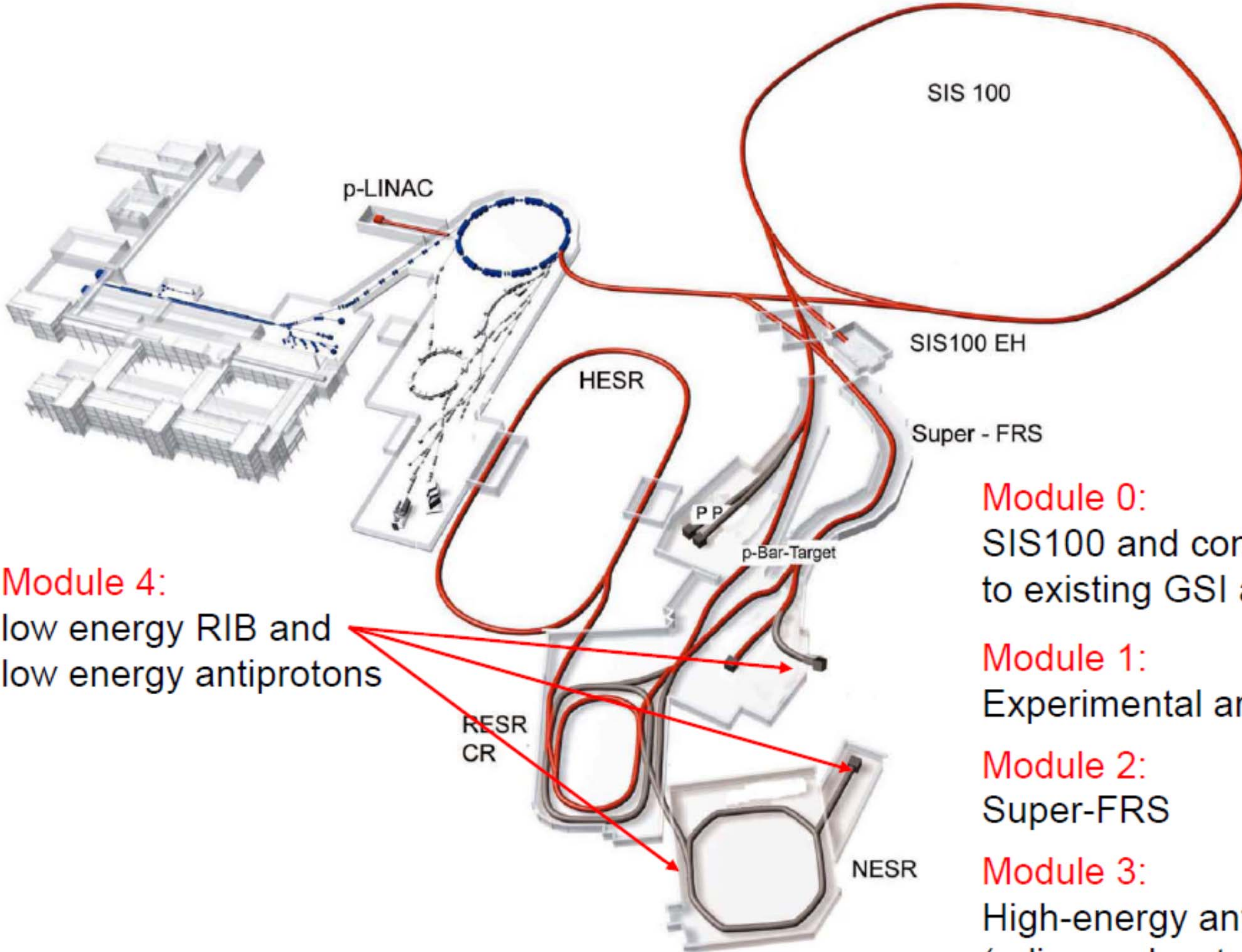


Module 0:
SIS100 and connection to existing GSI accel.

Module 1:
Experimental areas

Module 2:
Super-FRS

Module 3:
High-energy antiprotons (p-linac, pbar-target, CR, HESR)



Module 4:
low energy RIB and
low energy antiprotons

Module 0:
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Module 1:
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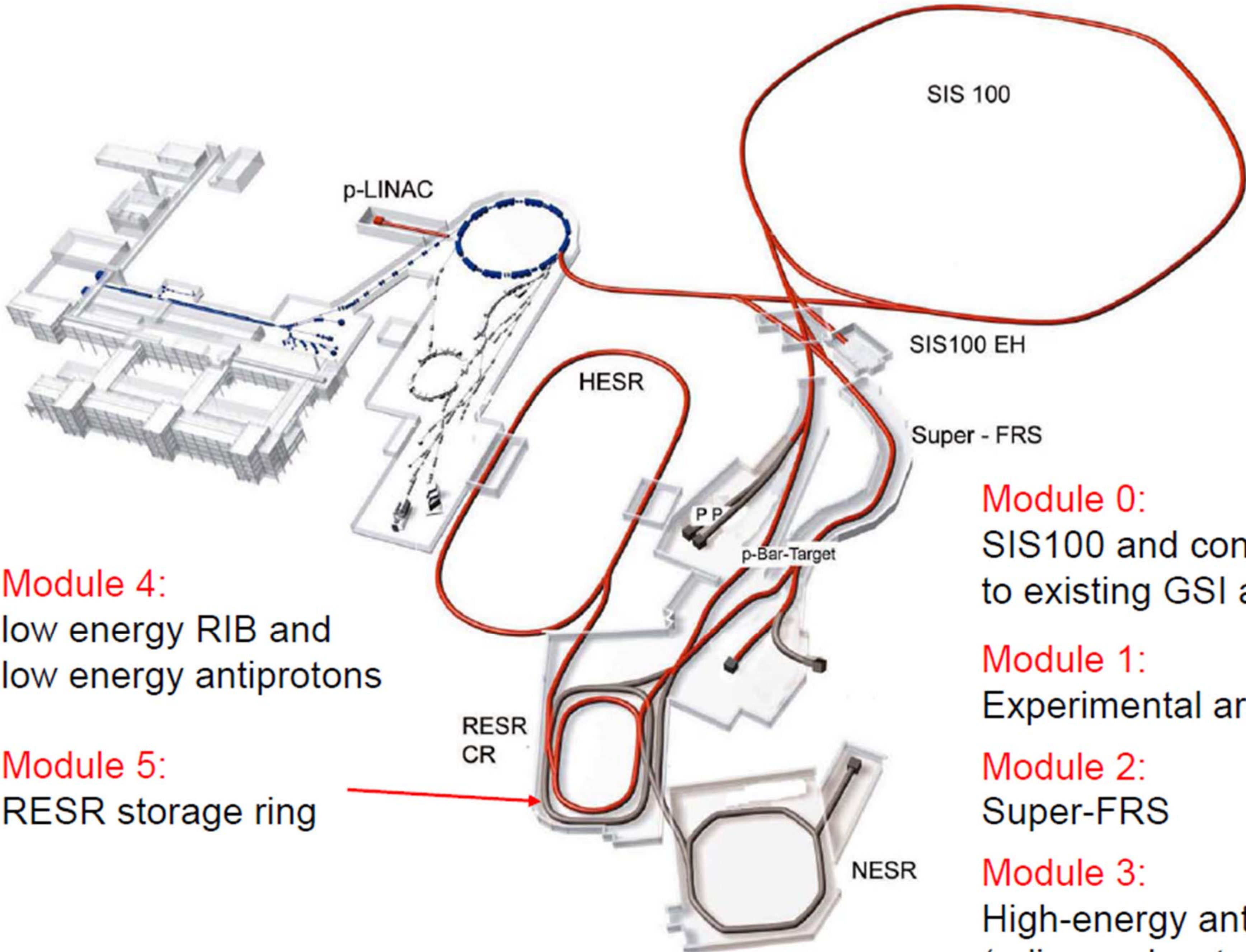


Module 4:
low energy RIB and
low energy antiprotons

Module 5:
RESR storage ring

Module 0:
SIS100 and connection
to existing GSI accel.

Module 1:
Experimental areas

Module 2:
Super-FRS

Module 3:
High-energy antiprotons
(p-linac, pbar-target, CR,
HESR)

FAIR / CERN / FNAL pbar Sources

	FAIR	CERN (AC+AA)	FNAL
E(p), E(pbar)	29 GeV, 3 GeV	25 GeV, 2.7 GeV	120 GeV, 8 GeV
acceptance	240 π mm mrad	200 π mm mrad	$\approx$ 30 π mm mrad
protons / pulse	2×10^{13}	$1 - 2 \times 10^{13}$	$\geq 5 \times 10^{12}$
pulse length	single bunch (50 ns)	5 bunches in 400 ns	single bunch 1.6 μs
cycle time	10 s	4.8 s	1.5 s

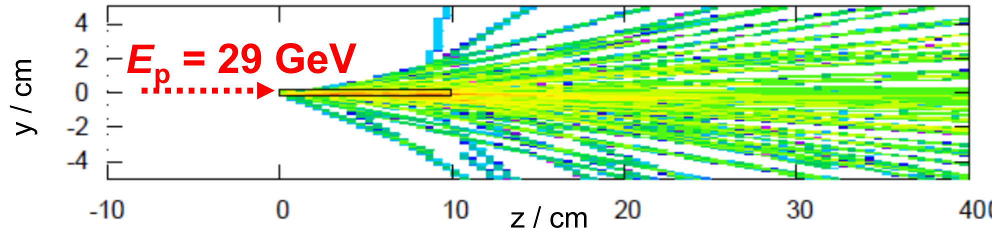
Increases the pbar yield by $\approx$ 50 %

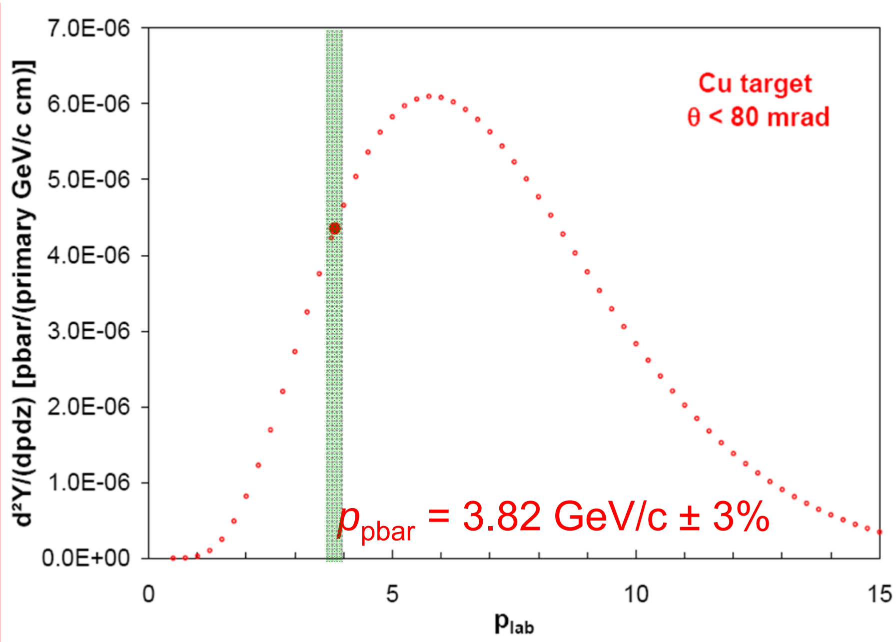
cycle time 10 s (cooling time in the CR)
overall pbar yield: 5×10^{-6} pbar/p (scaled CERN data) $\rightarrow$ 1×10^{7} pbar/s

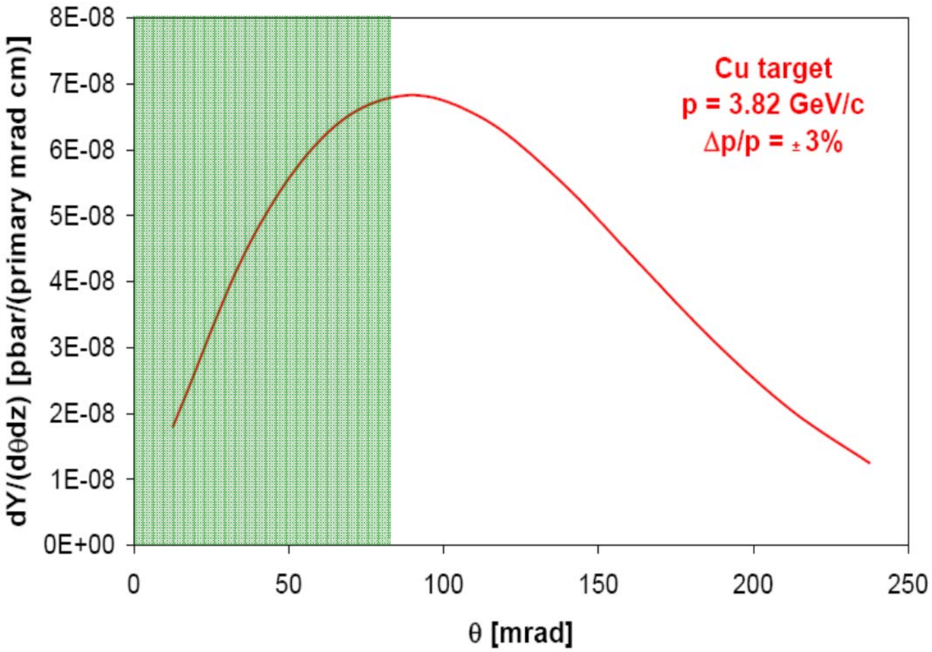
FAIR Collector ring will be operated at h = 1, CERN ring was operated at h = 6

Time needed for stochastic cooling in CR (AC), upgrade possible

pbar Distribution After the Target



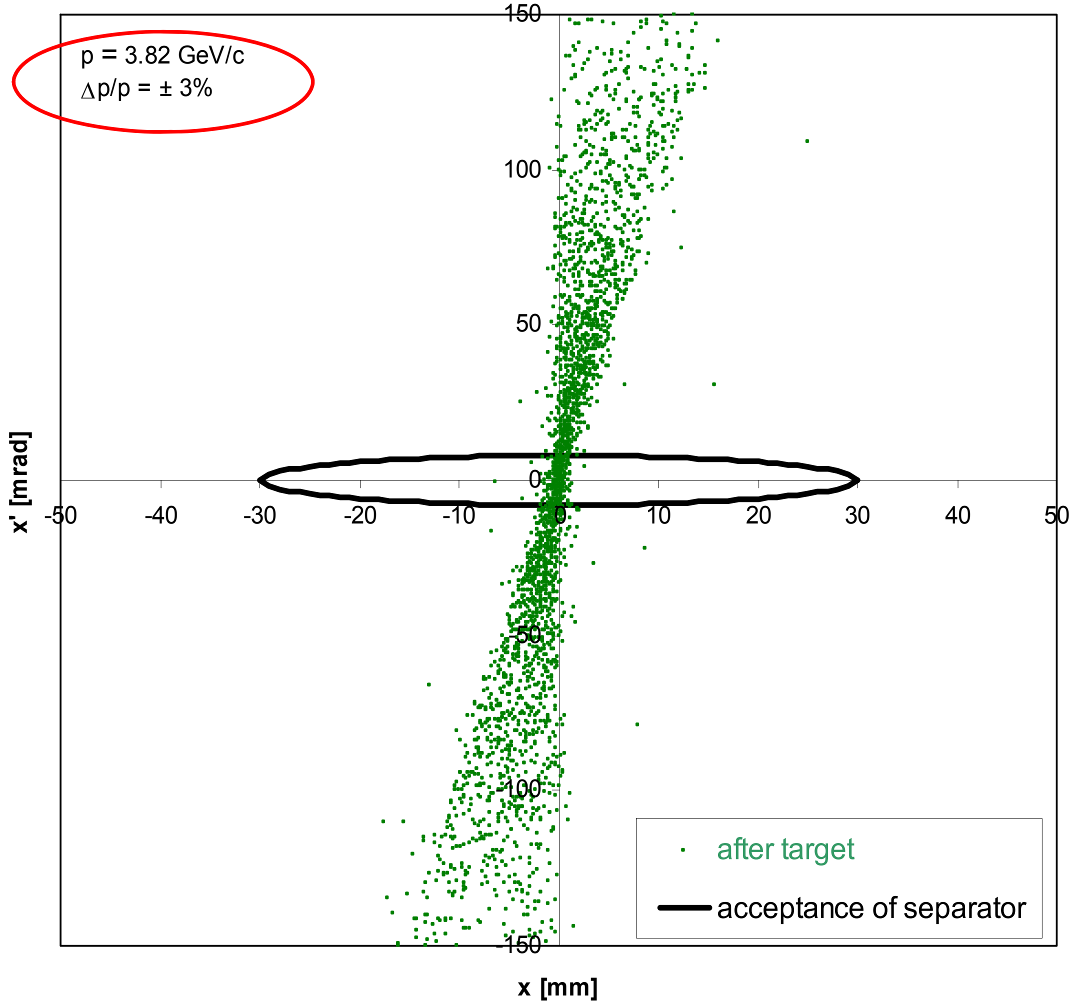




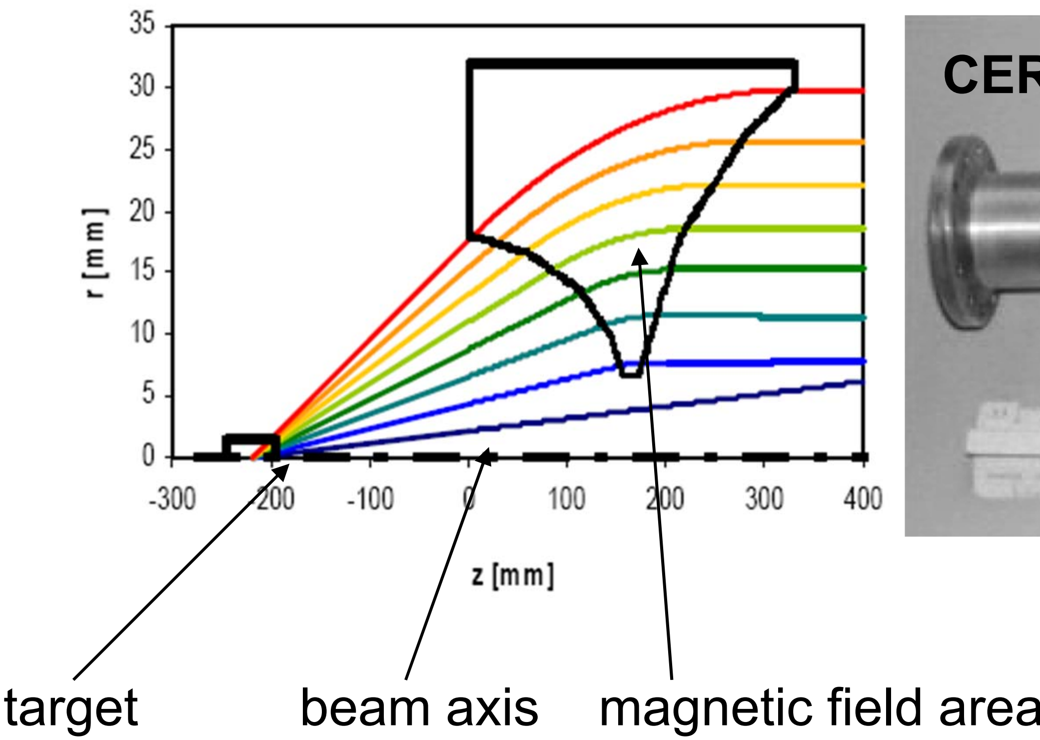
From ~ 2.5×10^{-4} pbar / (p cm target) ~ 5×10^{-6} (or 2 %) are "collectable"

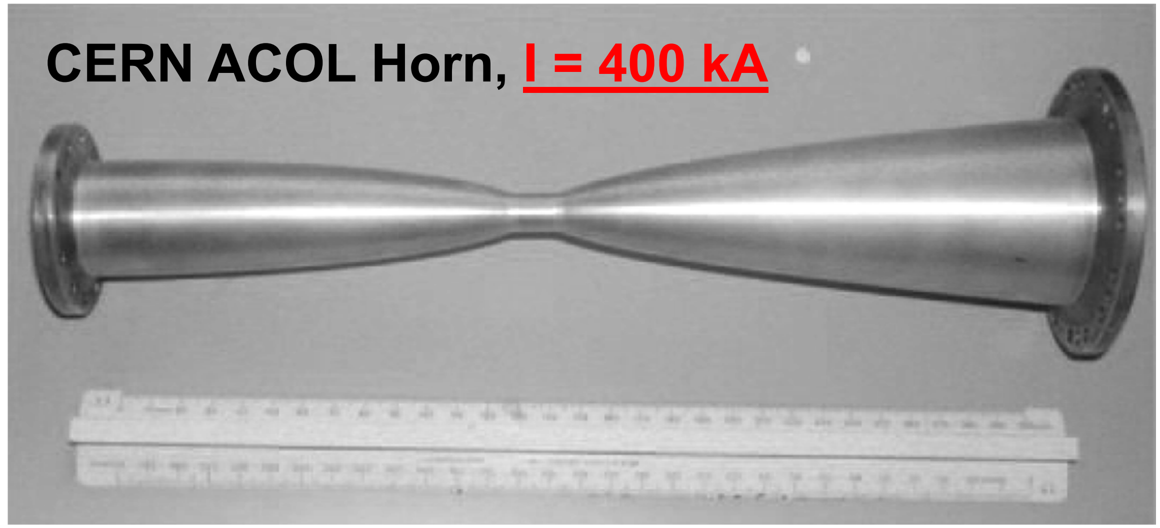
R.P. Duperray et al., Phys. Rev. **D 68**, 094017 (2003)

MARS Simulation of the pbar Distribution After the Target



Collecting pbars: Magnetic Horn





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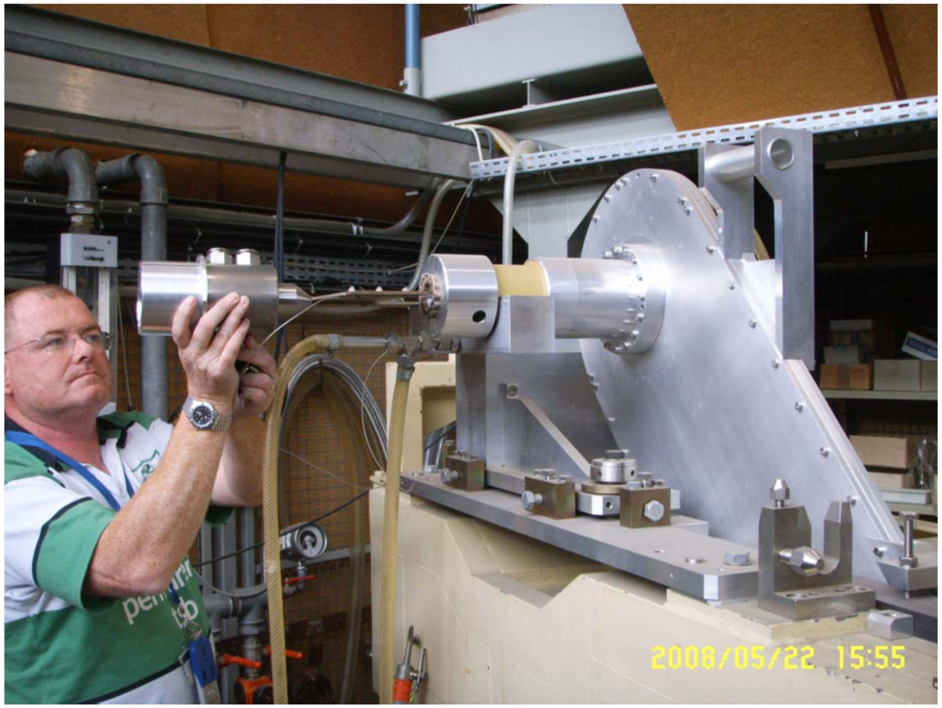
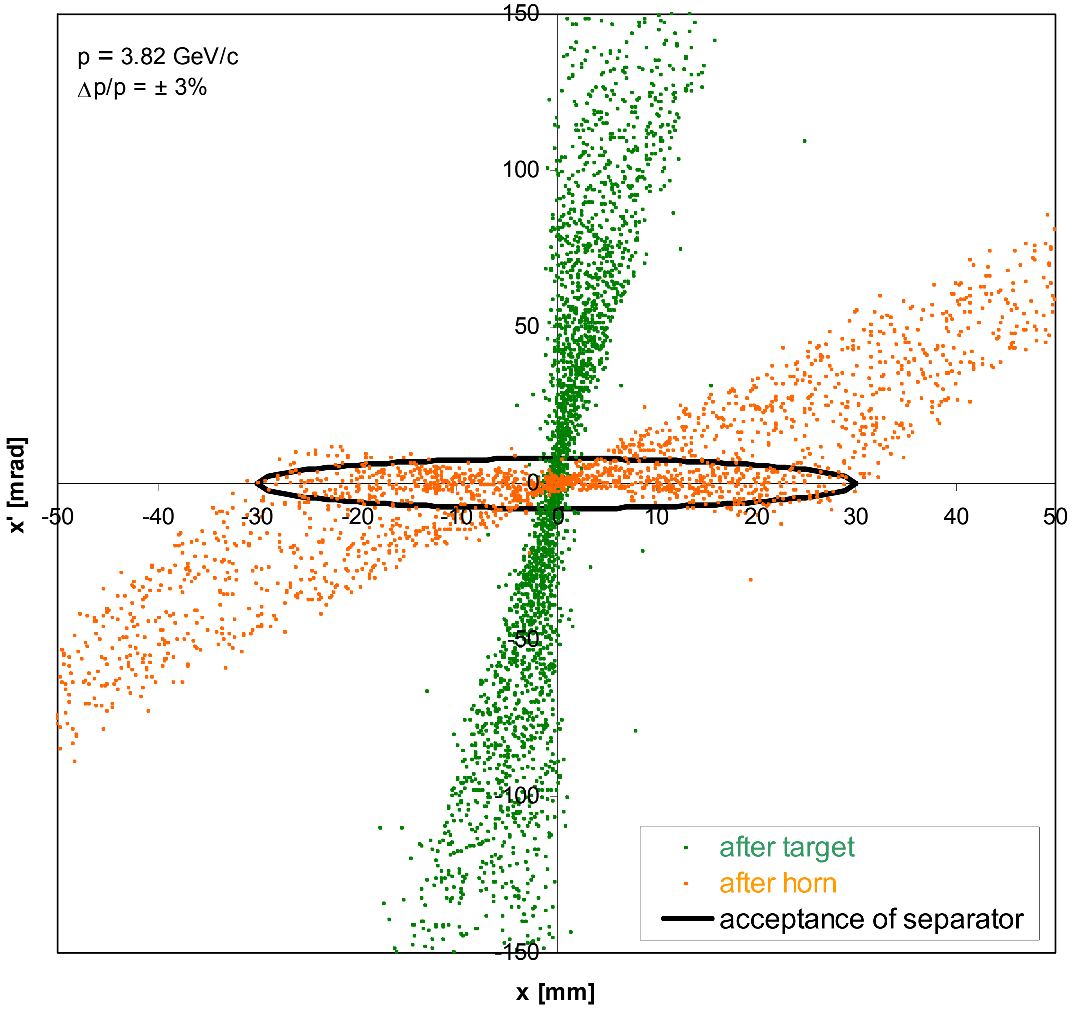
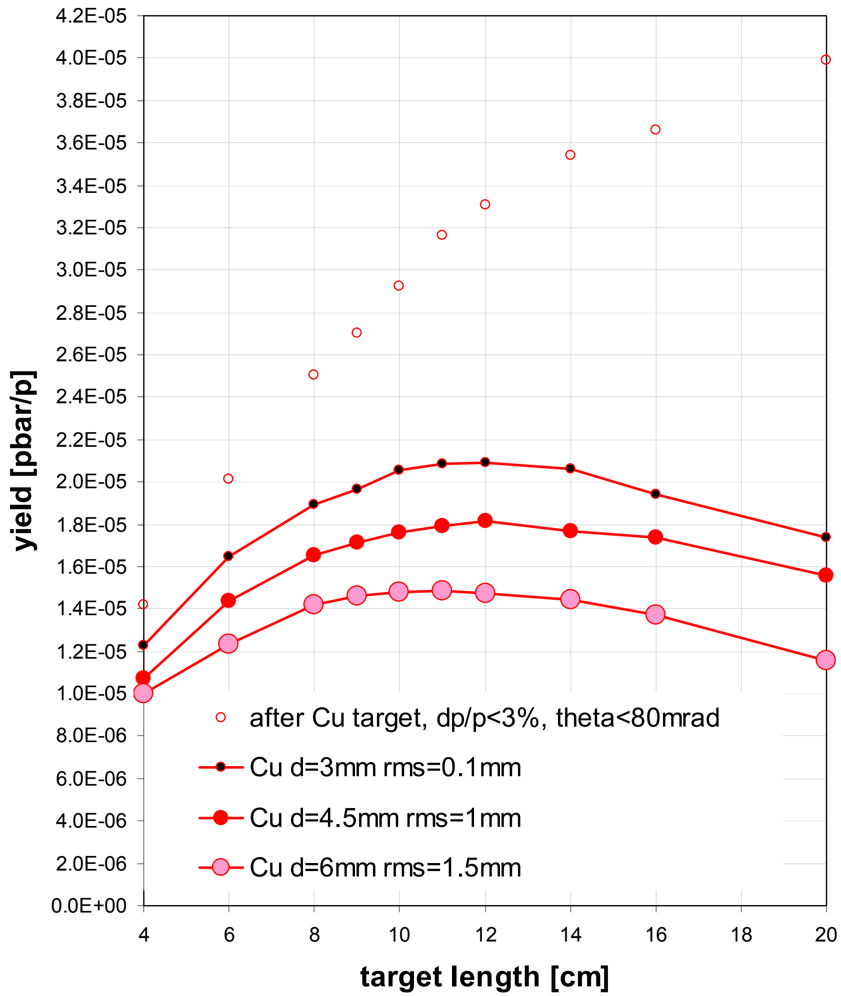


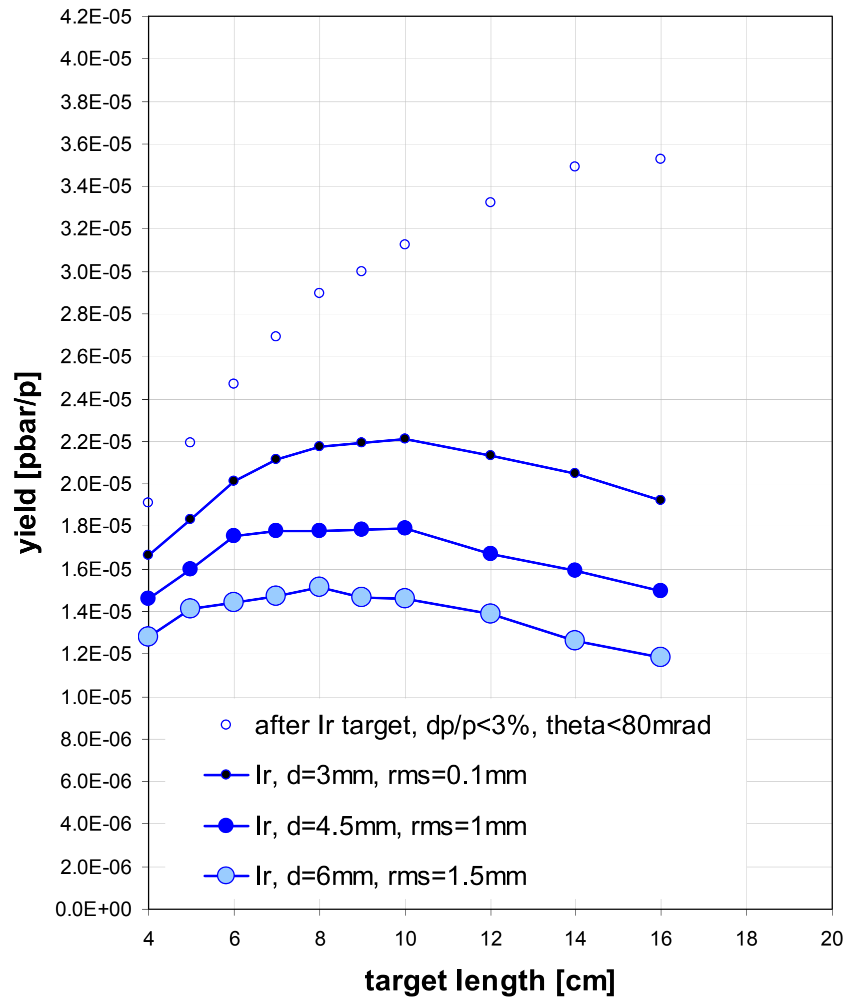
MARS Simulation of the pbar Yields



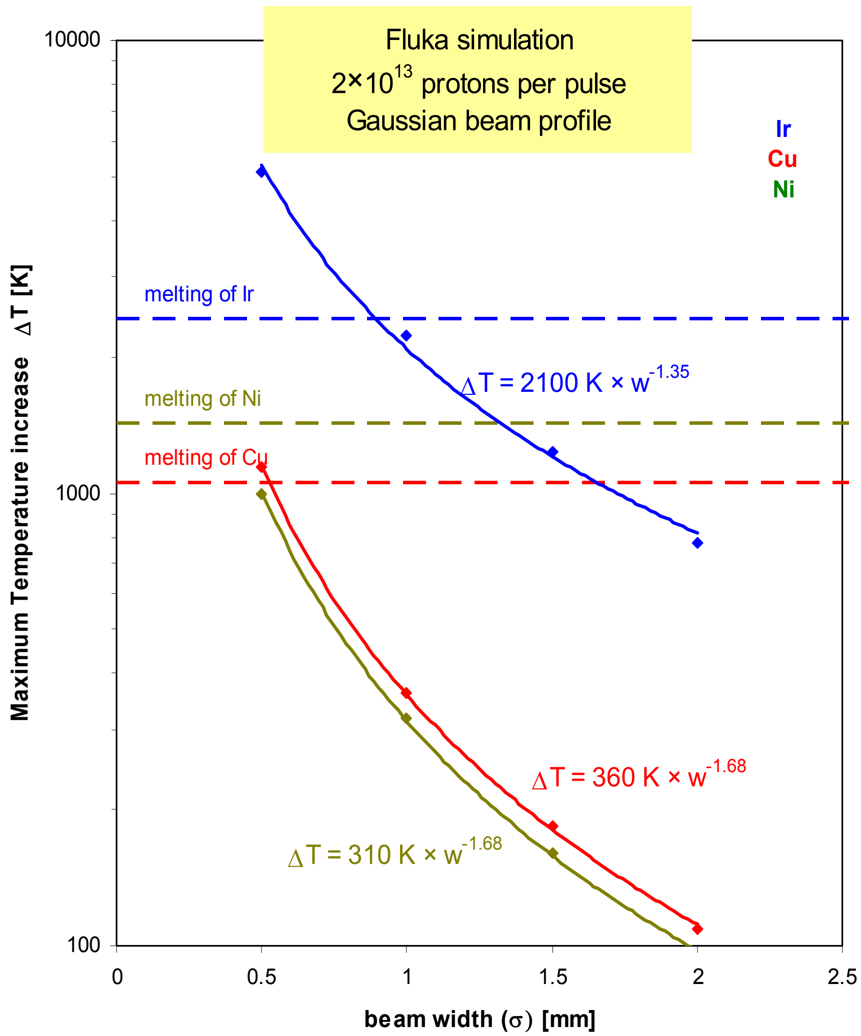
$$\text{yield} = \frac{\text{pbars in the ellipse}}{\text{primary protons}}$$

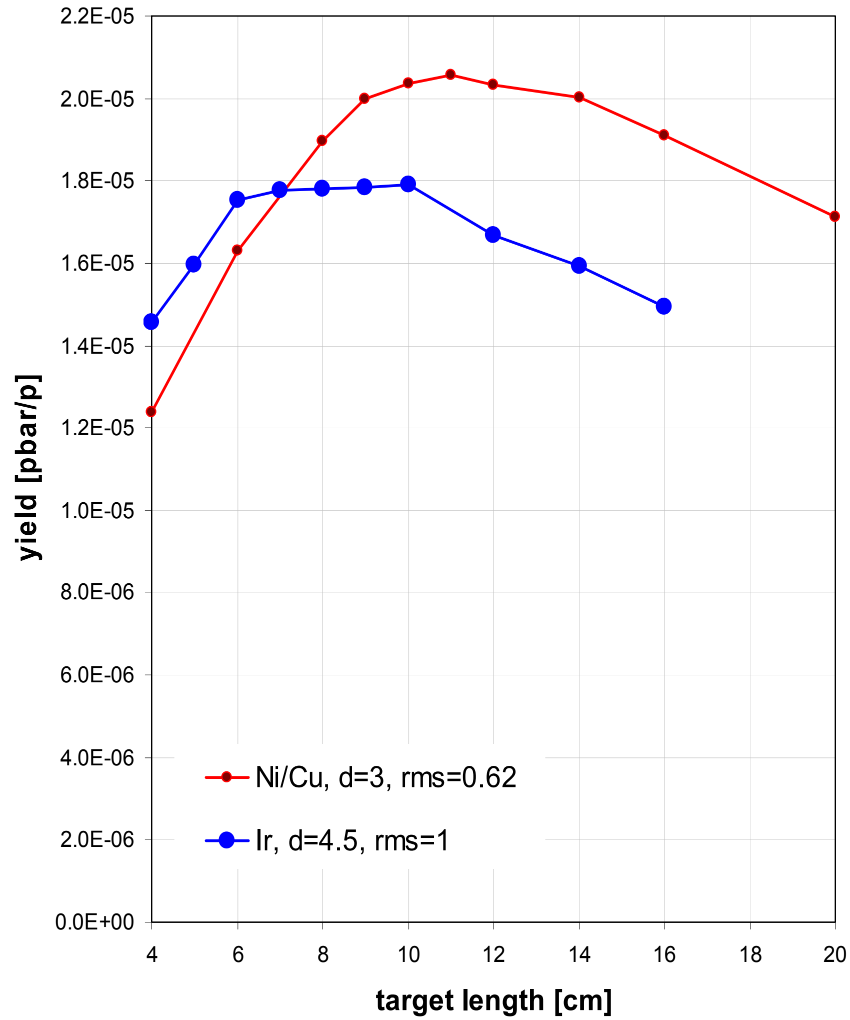
MARS Simulation of the pbar Yields





Temperature Increase in the Target





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Increases the pbar yield by $\approx$ 50 %

cycle time 10 s (cooling time in the CR)
overall pbar yield: 1×10^{-5} pbar/p $\rightarrow$ 2×10^{7} pbar/s ***scaled CERN data: 1×10^{7} pbar/s***

FAIR Collector ring will be operated at h = 1, CERN ring was operated at h = 6

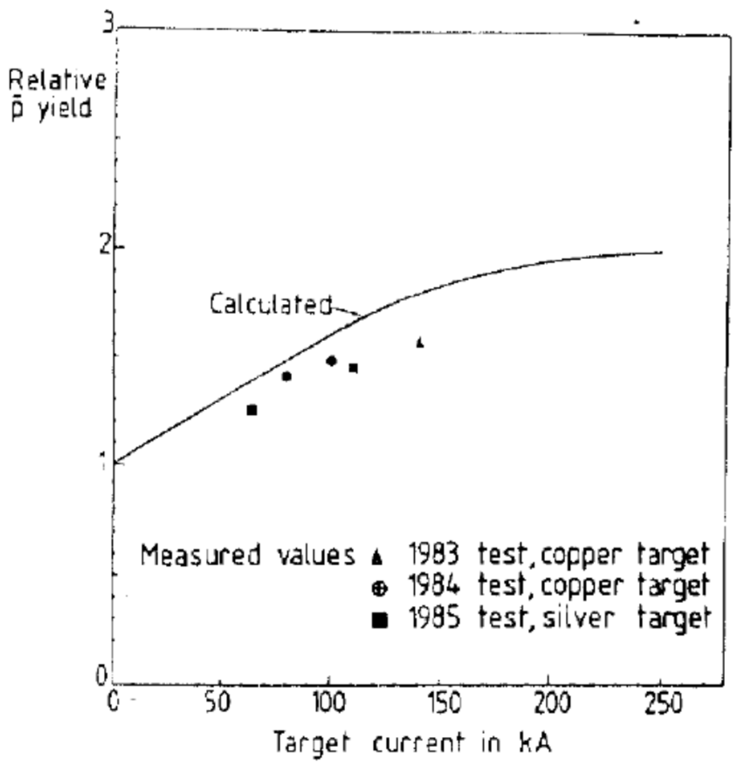
Time needed for stochastic cooling in CR (AC), upgrade possible

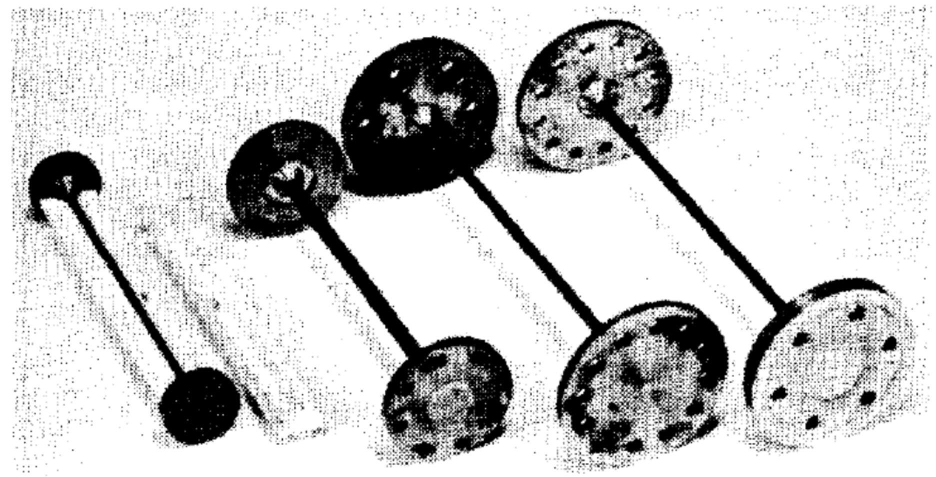
Pulsed Target: FLUKA Simulation

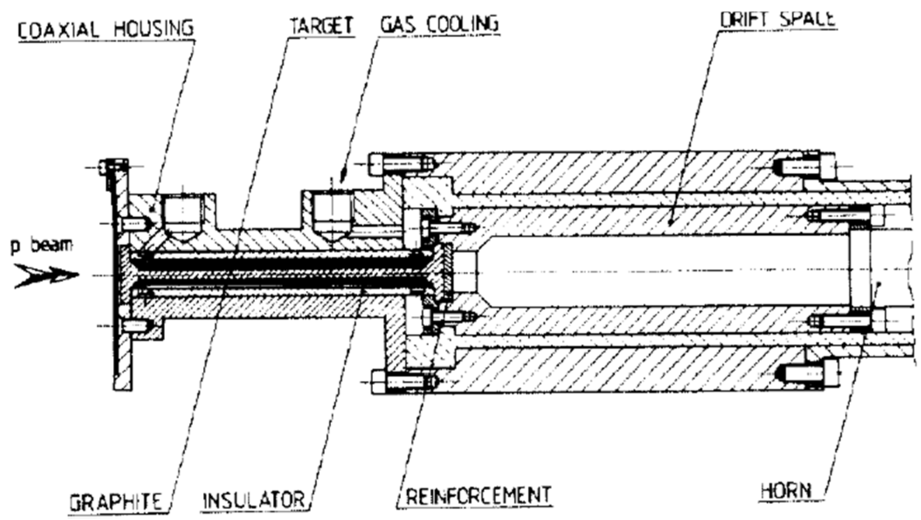
IEEE Transactions on Nuclear Science, Vol. NS-30, No. 4, August 1983

ANTIPROTON PRODUCTION AND COLLECTION
FOR THE CERN ANTIPROTON ACCUMULATOR

E. Jones, S. Van der Meer, F. Rohner, J.C. Schnuriger, and T.R. Sherwood
CERN
Geneva, Switzerland





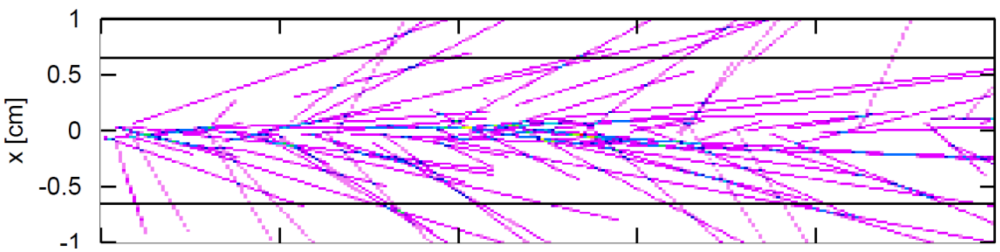


horn

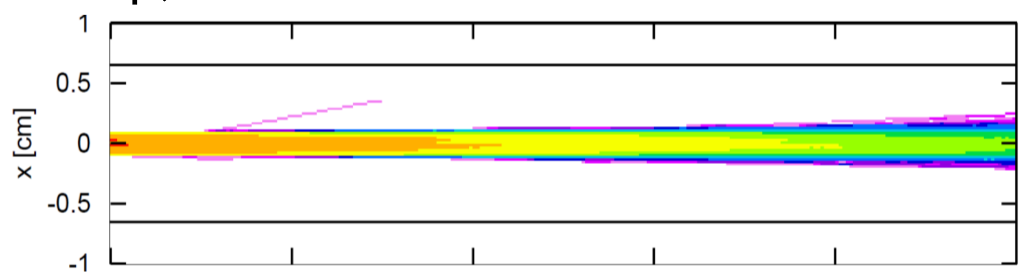
FLUKA results

Cu target, r = 6.5 mm
primary protons homogeneously distributed in a disc with r = 1 mm

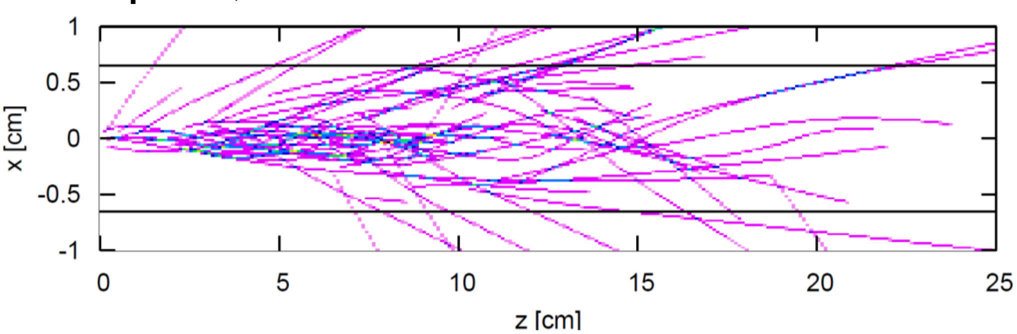
pbar, 0 A



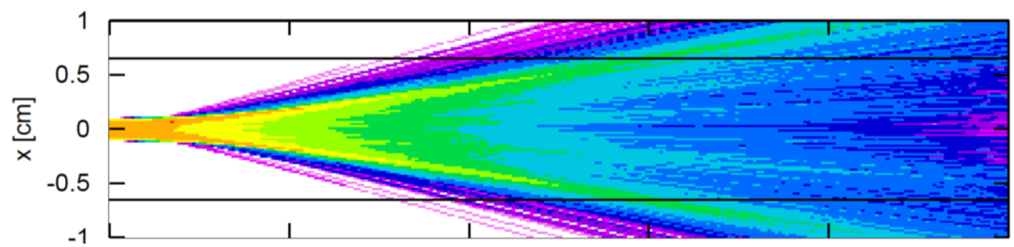
p, 0 A



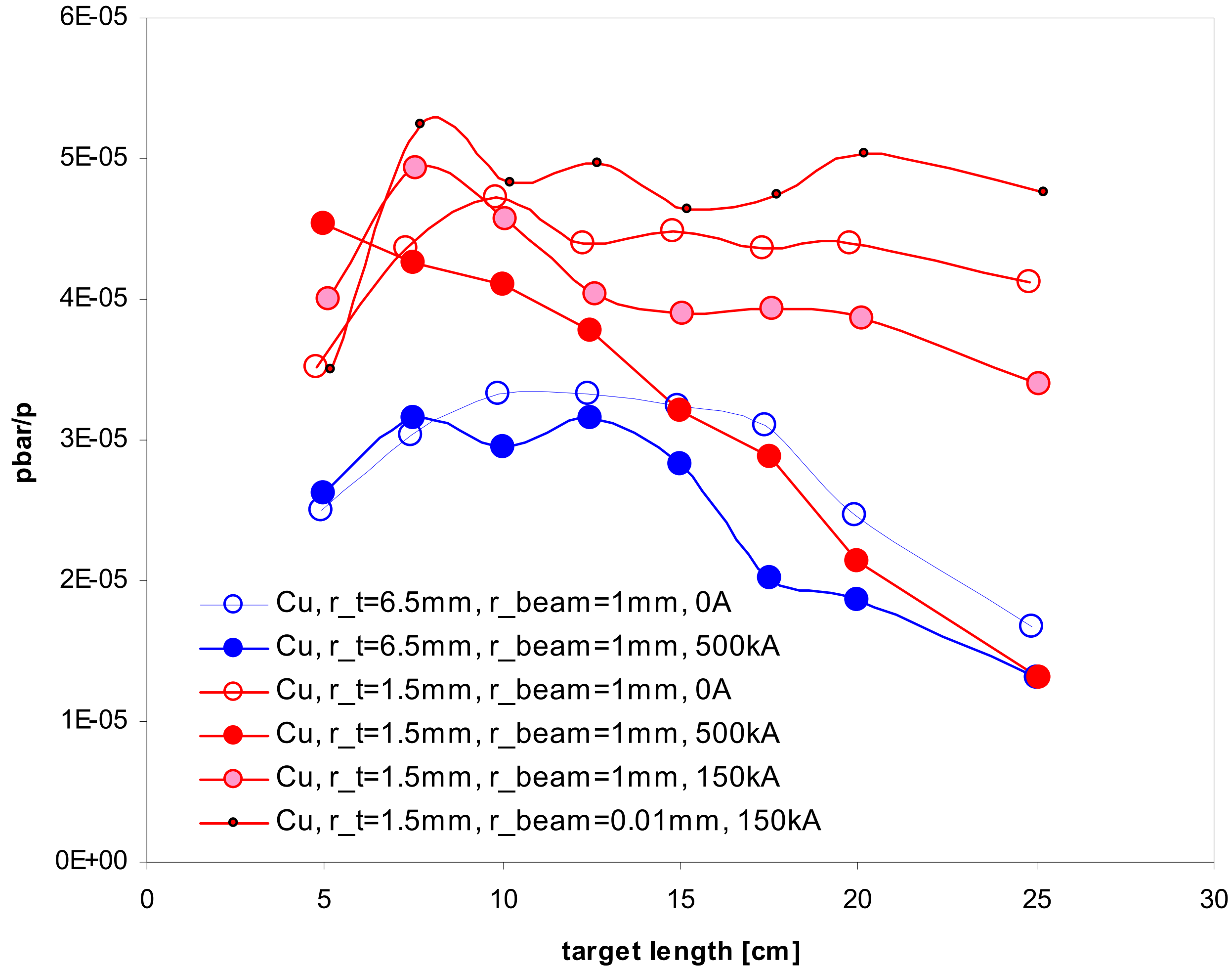
pbar, 500 kA



p, 500 kA

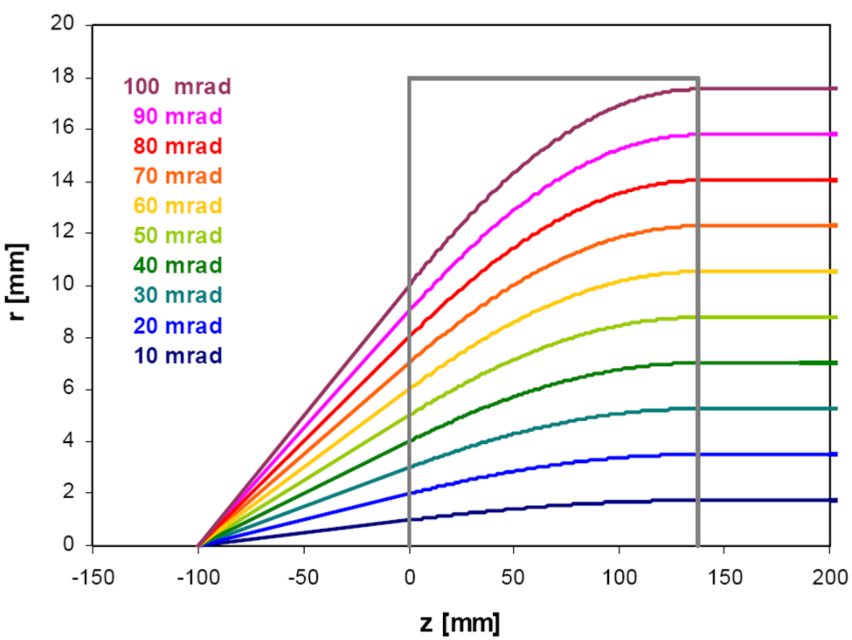


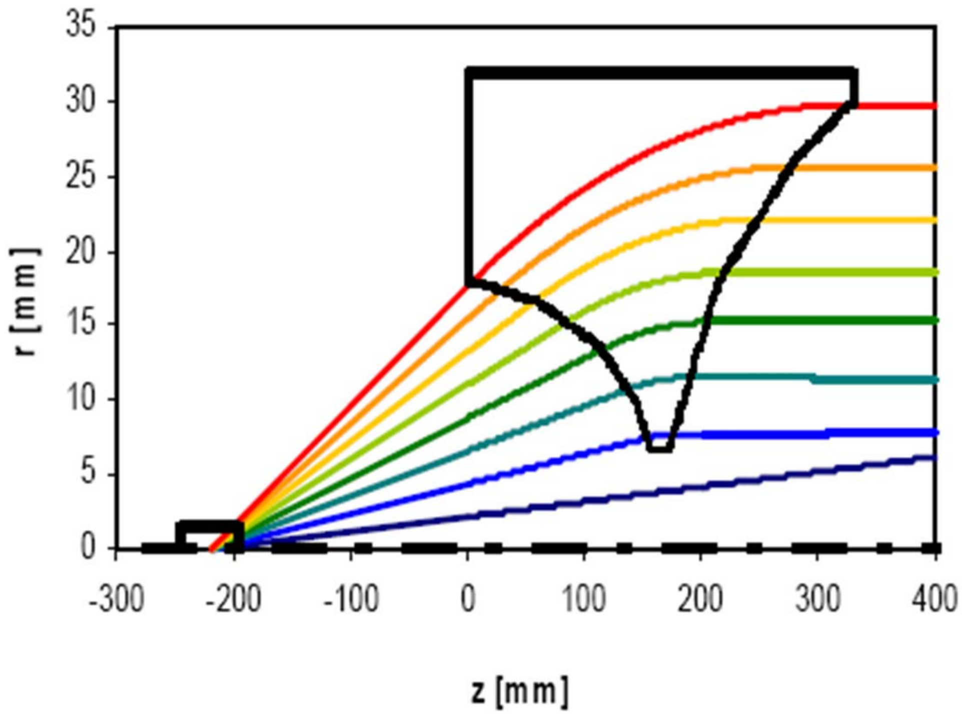
FLUKA results



It is likely that FLUKA overestimates the production cross section.
Therefore, the absolute yields might be a factor 2 to high.

Li Lens – A Possible Upgrade?





θ < 100 mrad can be collected

I = 1 MA (I ~ r^2)

Distance target center - lens: 100 mm

technically challenging / expensive

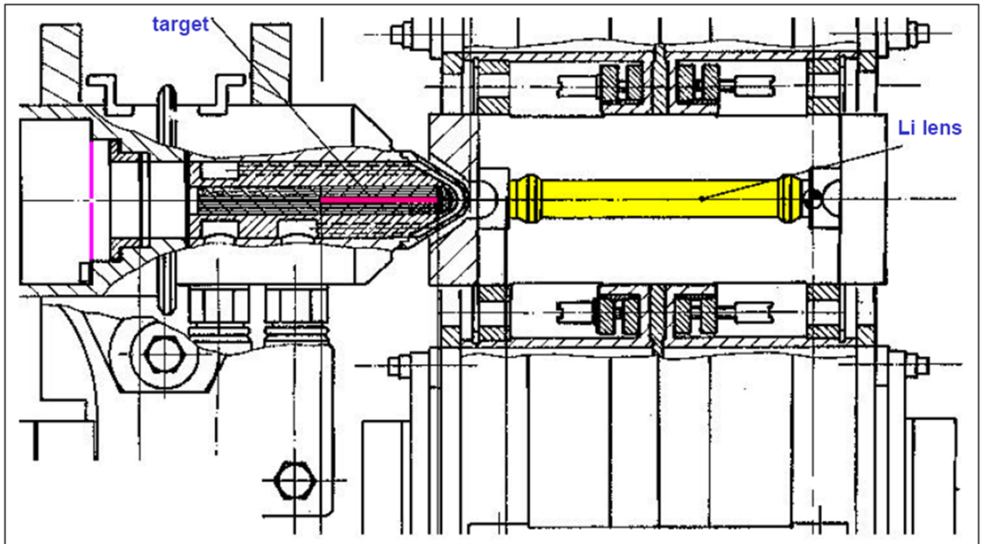
20 mrad < θ < 80 mrad can be collected

I = 0.4 MA

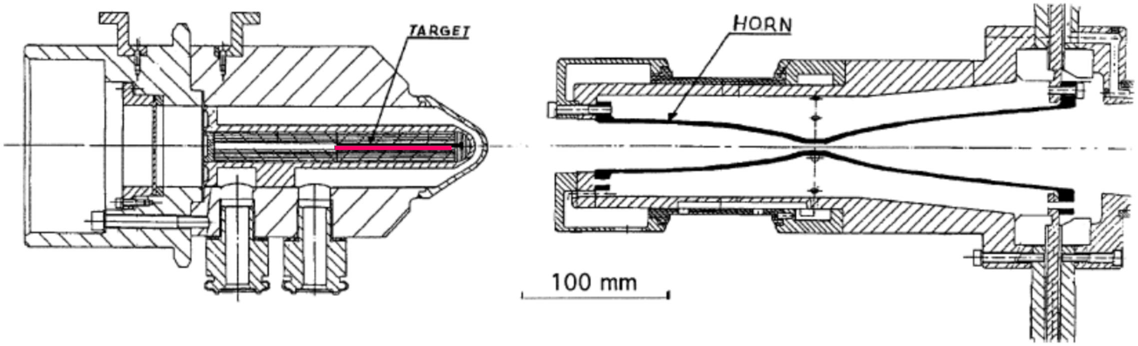
Distance target center - lens: 220 mm

more simple and reliable, less expensive

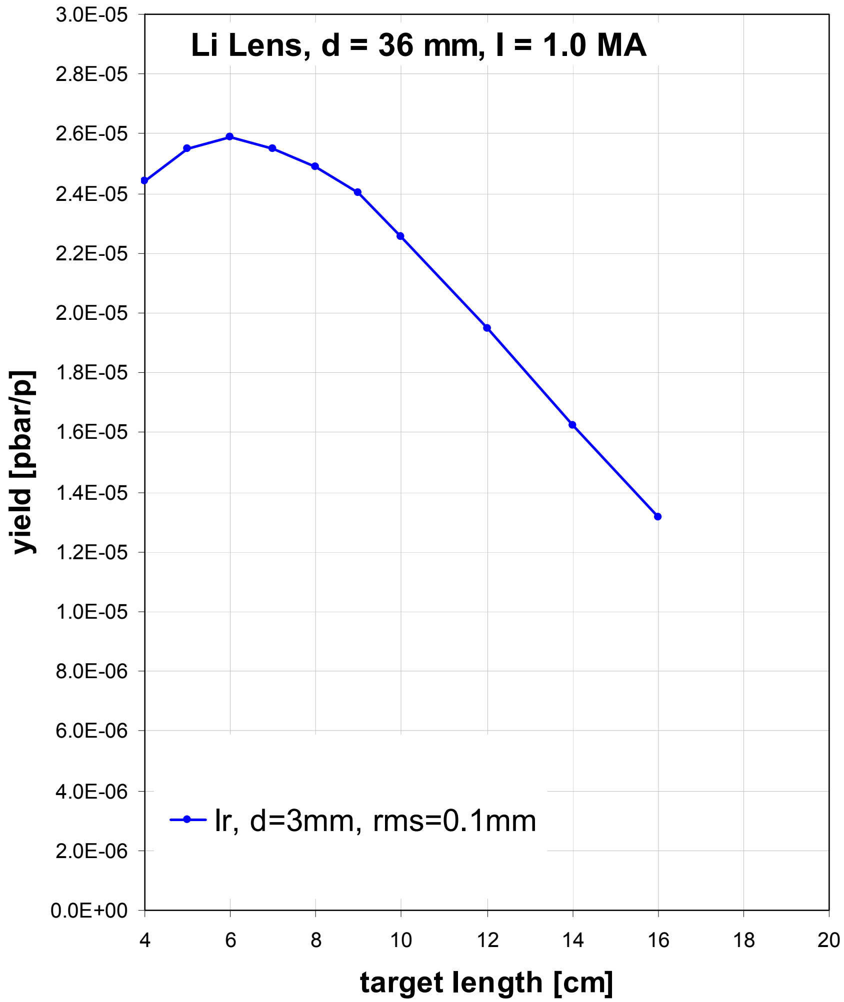
Li Lens – A Possible Upgrade?

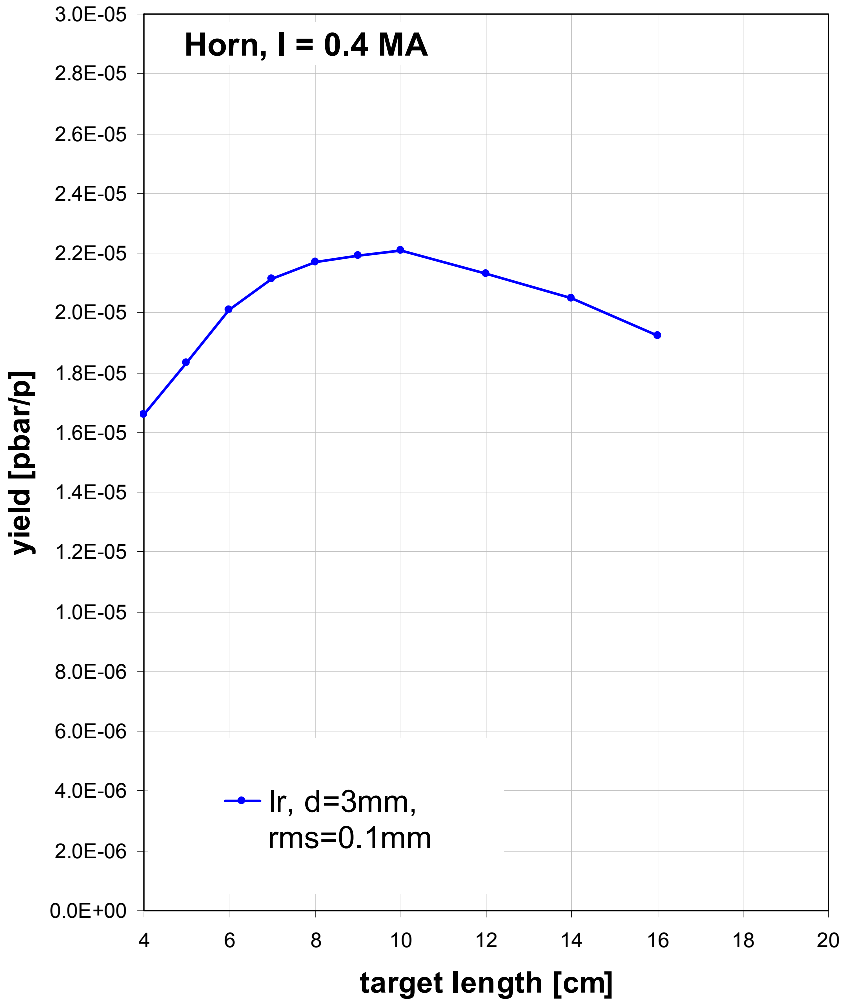


ACOL target - lithium lens assembly



Li Lens – A Possible Upgrade?





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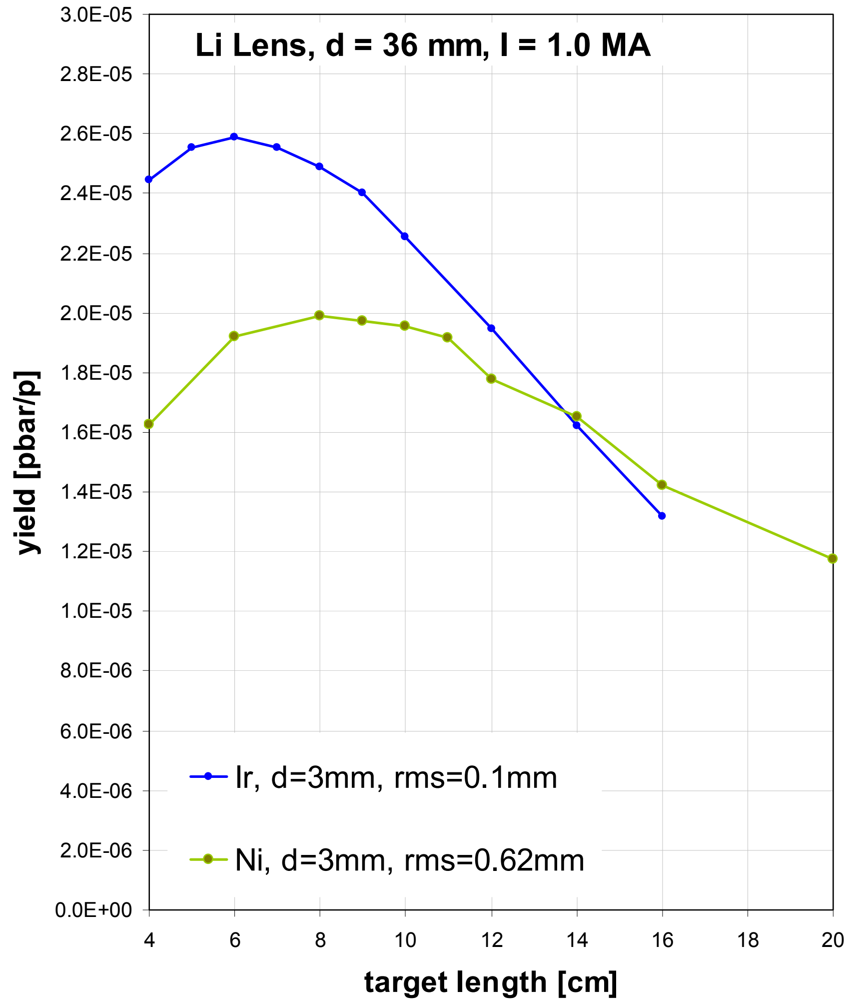
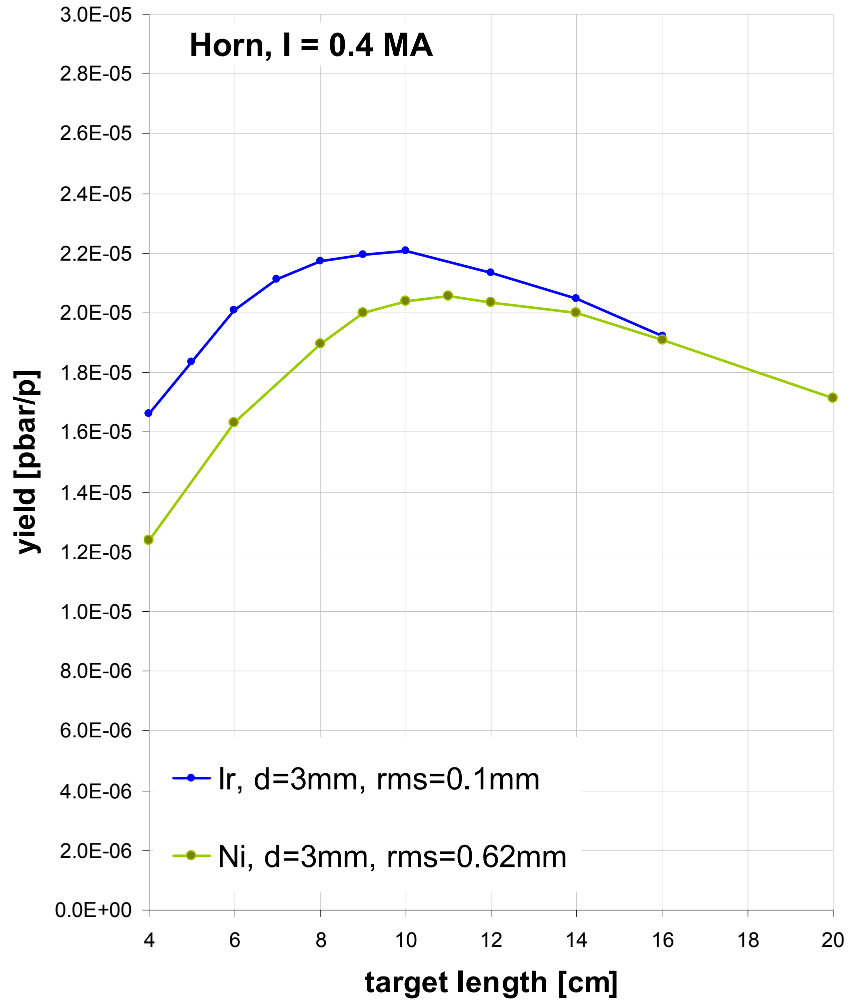
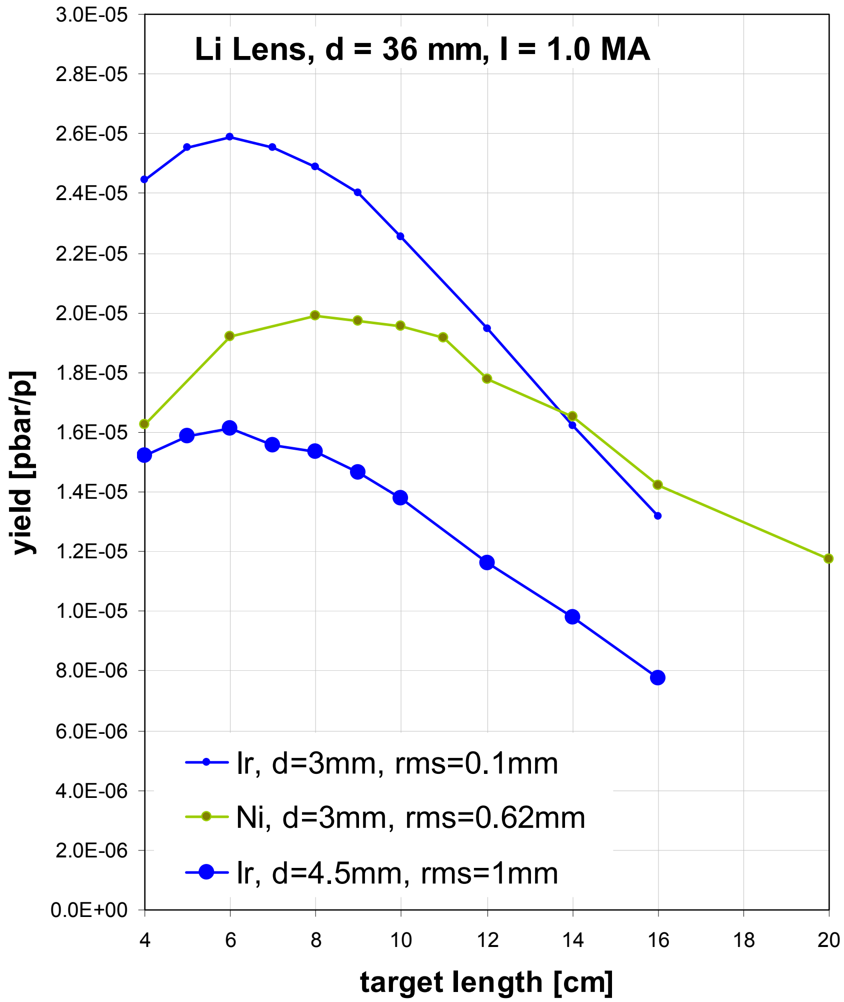


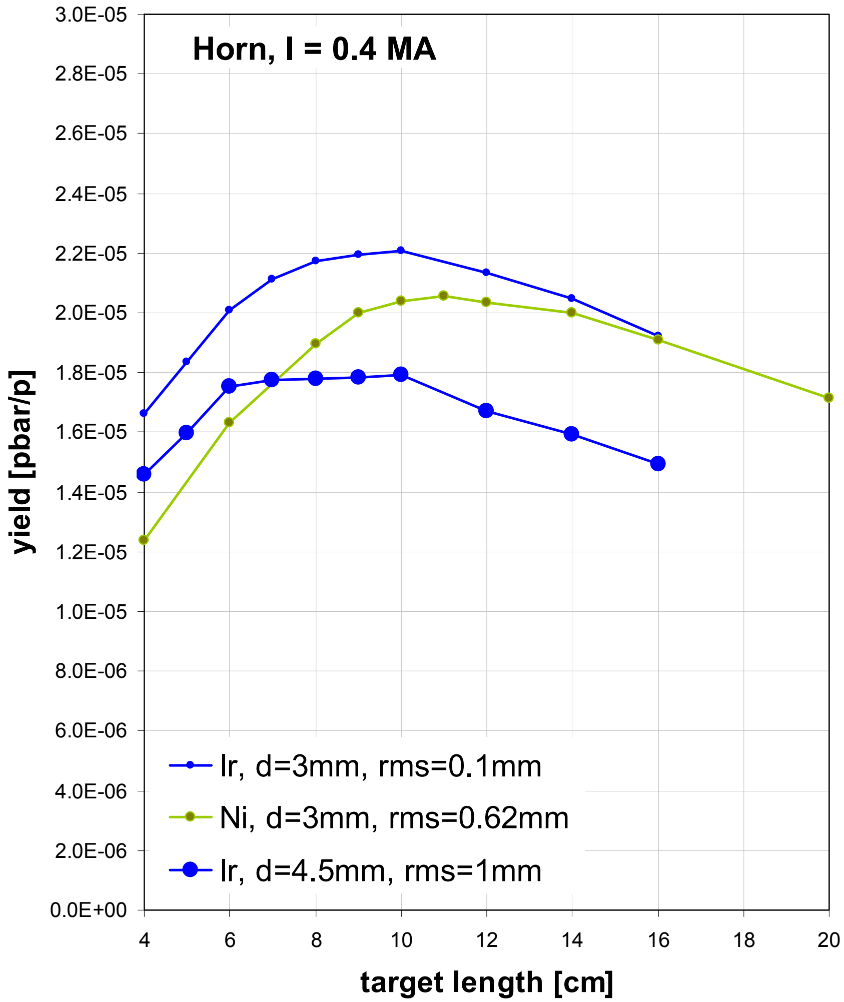


GSI

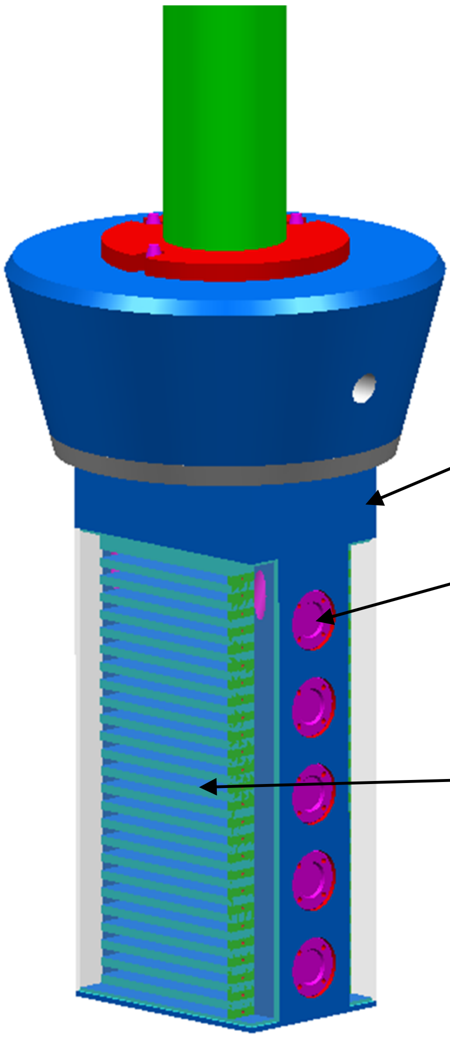
Li Lens – A P

Experimental data from CERN:
A 36 mm/1.3 MA lens gave a 30% higher yield (with nominal production beam) compared to a 0.4 MA horn.
(with a target optimized for the Li lens)





The Production Target



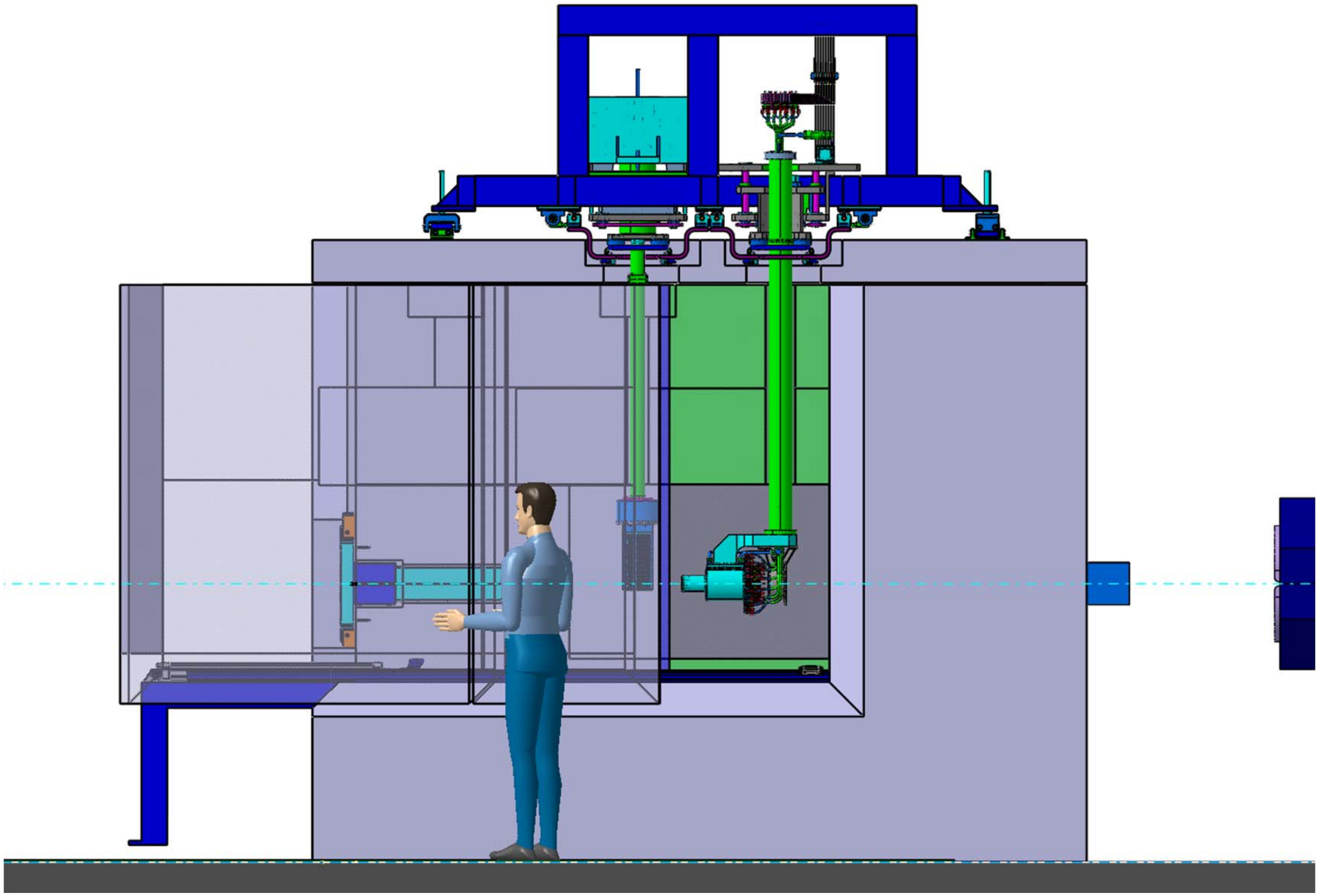
Al block

Ti window

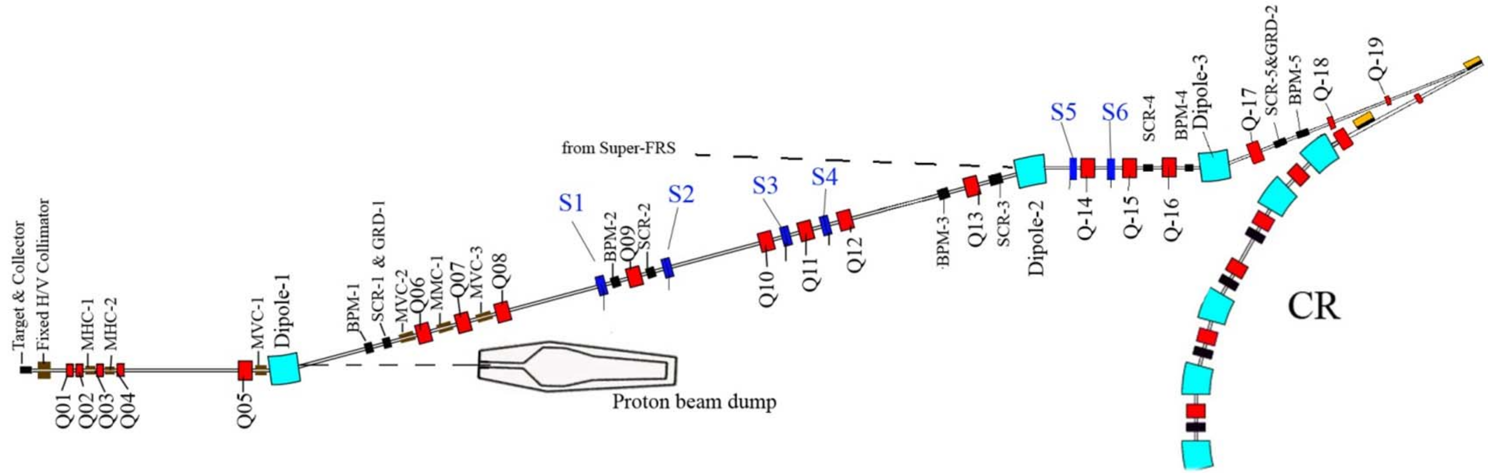
inside: Ni rod (r = 0.15 cm, l = 10 cm) within graphite cylinder (r = 1 cm)

air cooling

Target Station



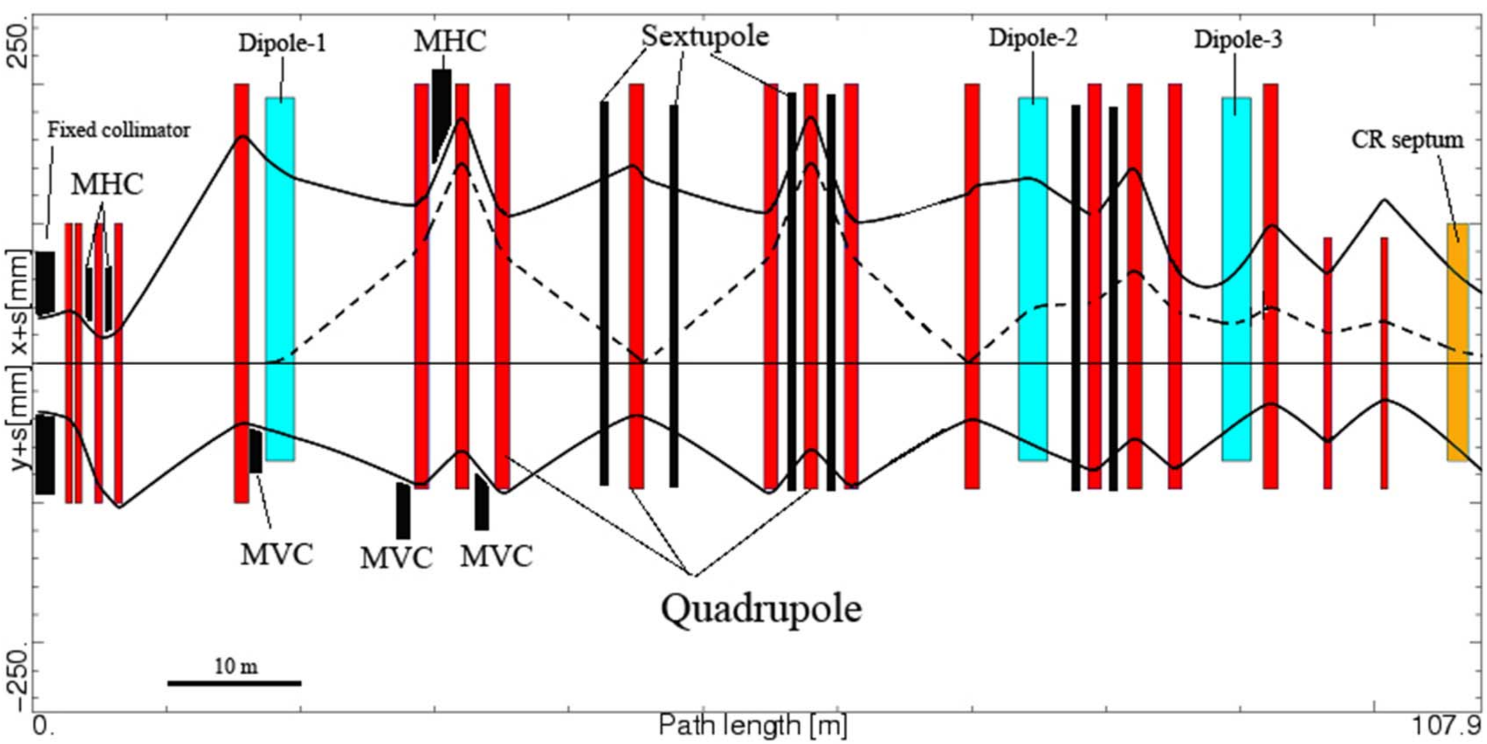
The pbar Separator



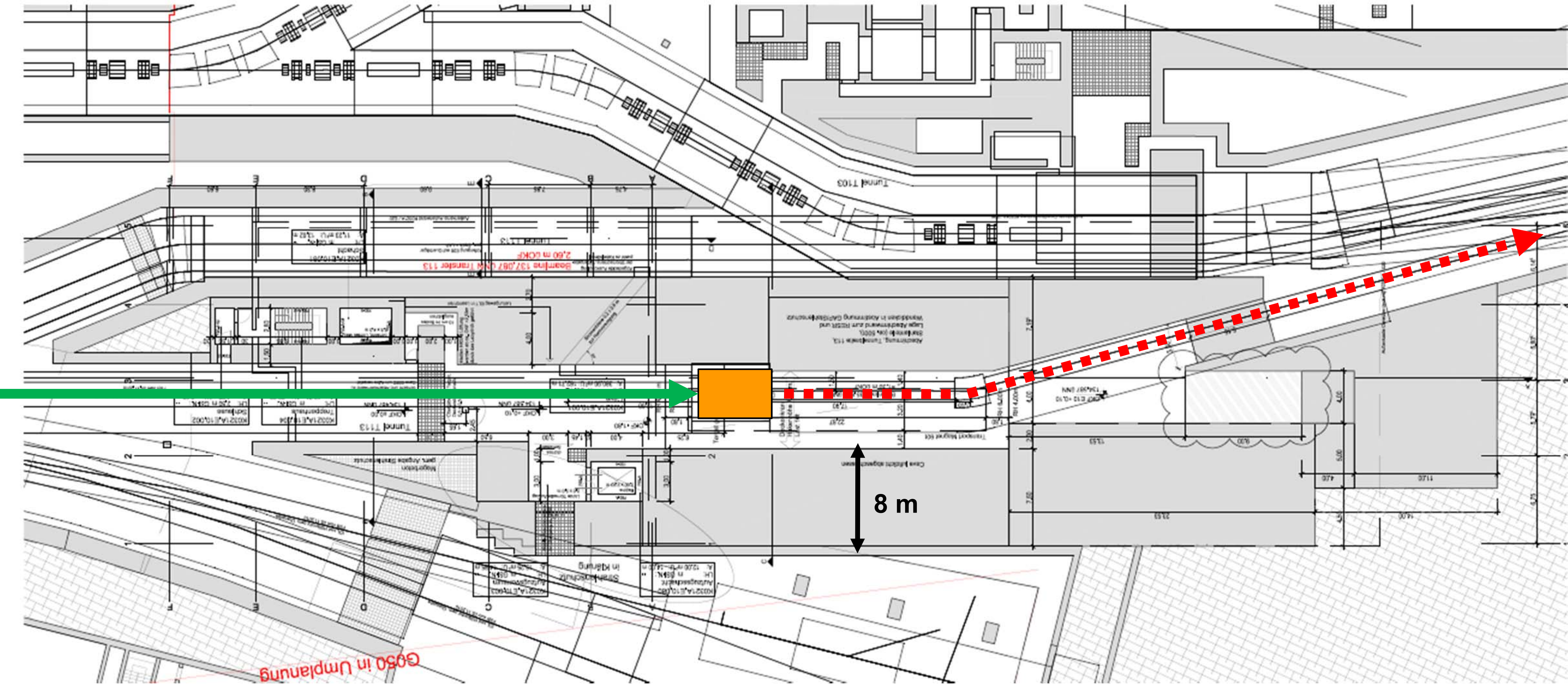
240 π mm mrad

$\Delta p/p = \pm 3$ %

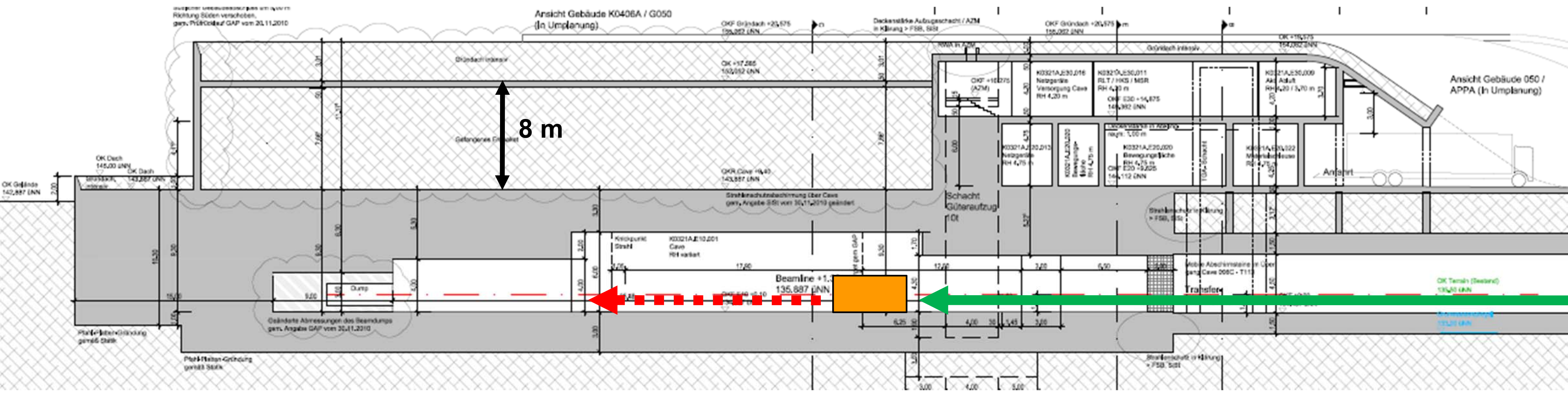
CR-type magnets



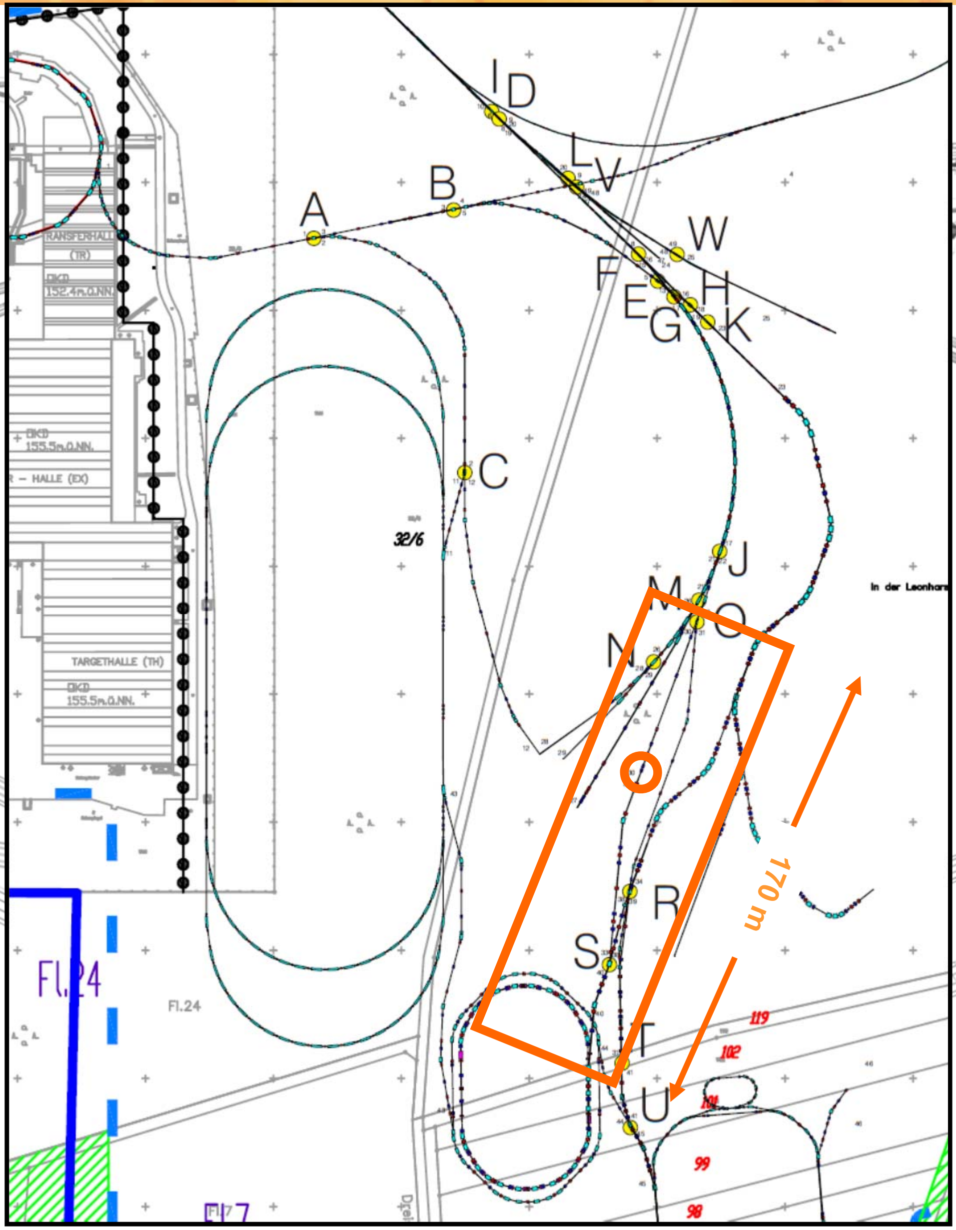
Pbar Target Building: Horizontal Cut



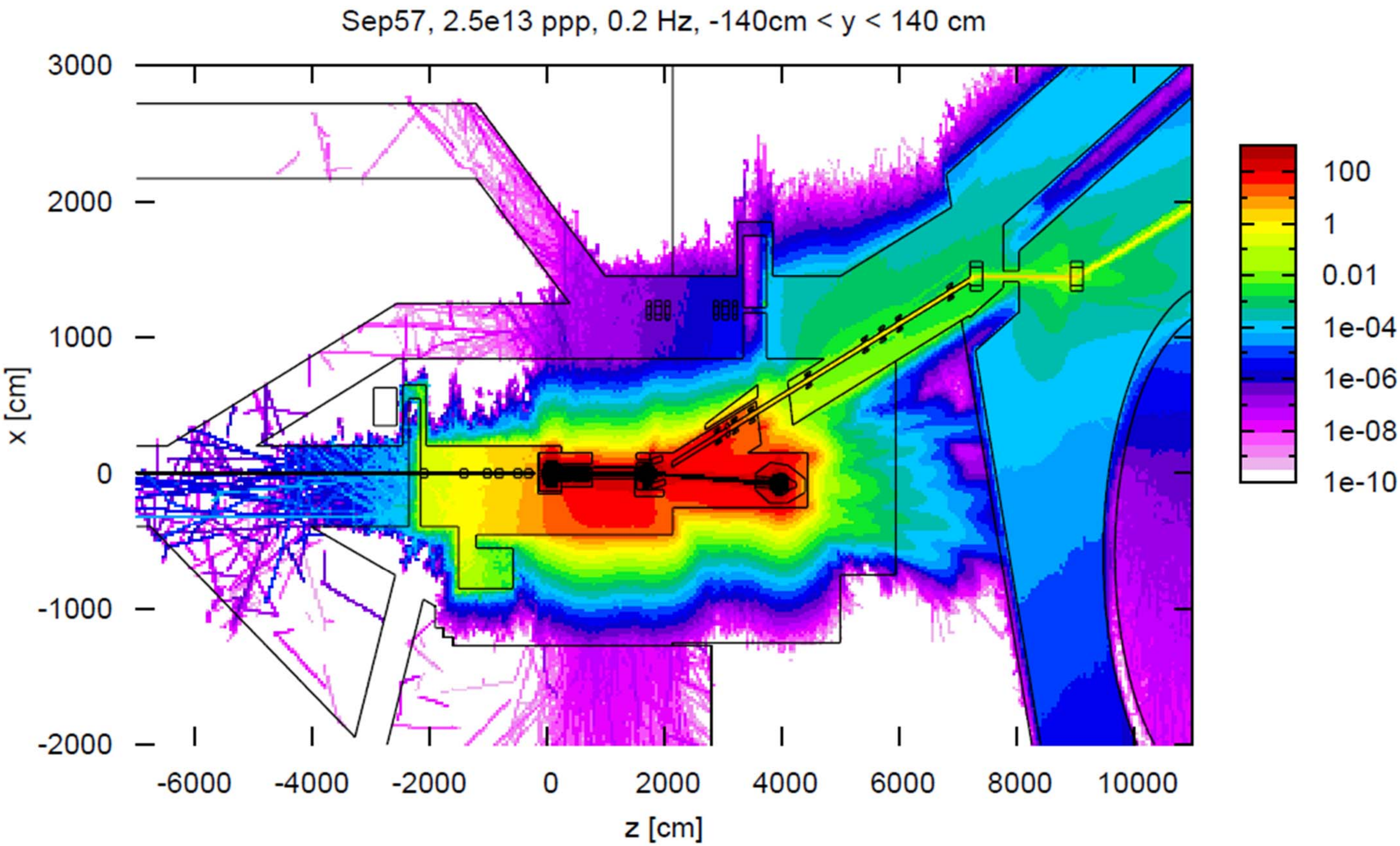
Pbar Target Building: Vertical Cut



Dose rates around the pbar target



Equivalent dose rates during operation



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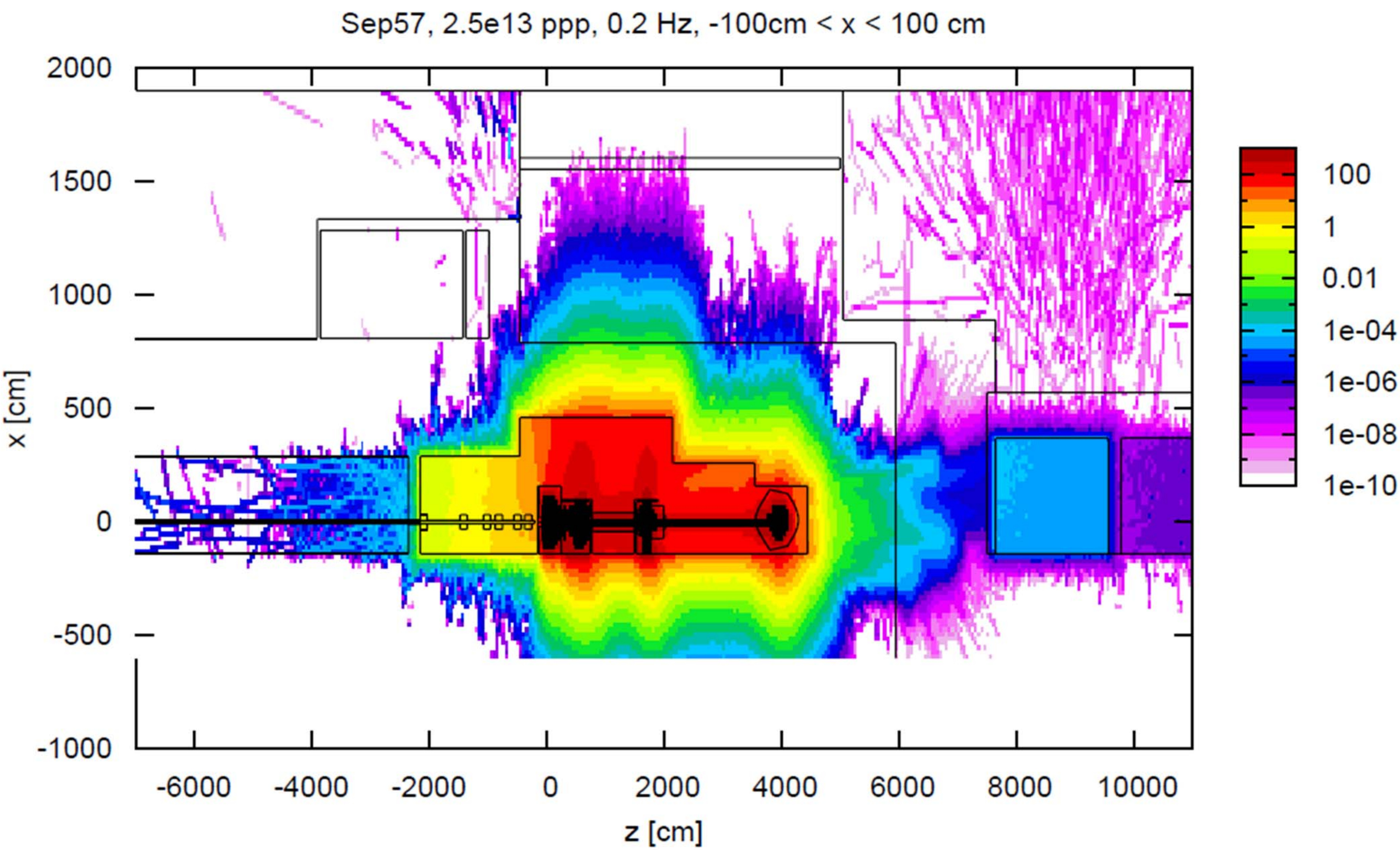

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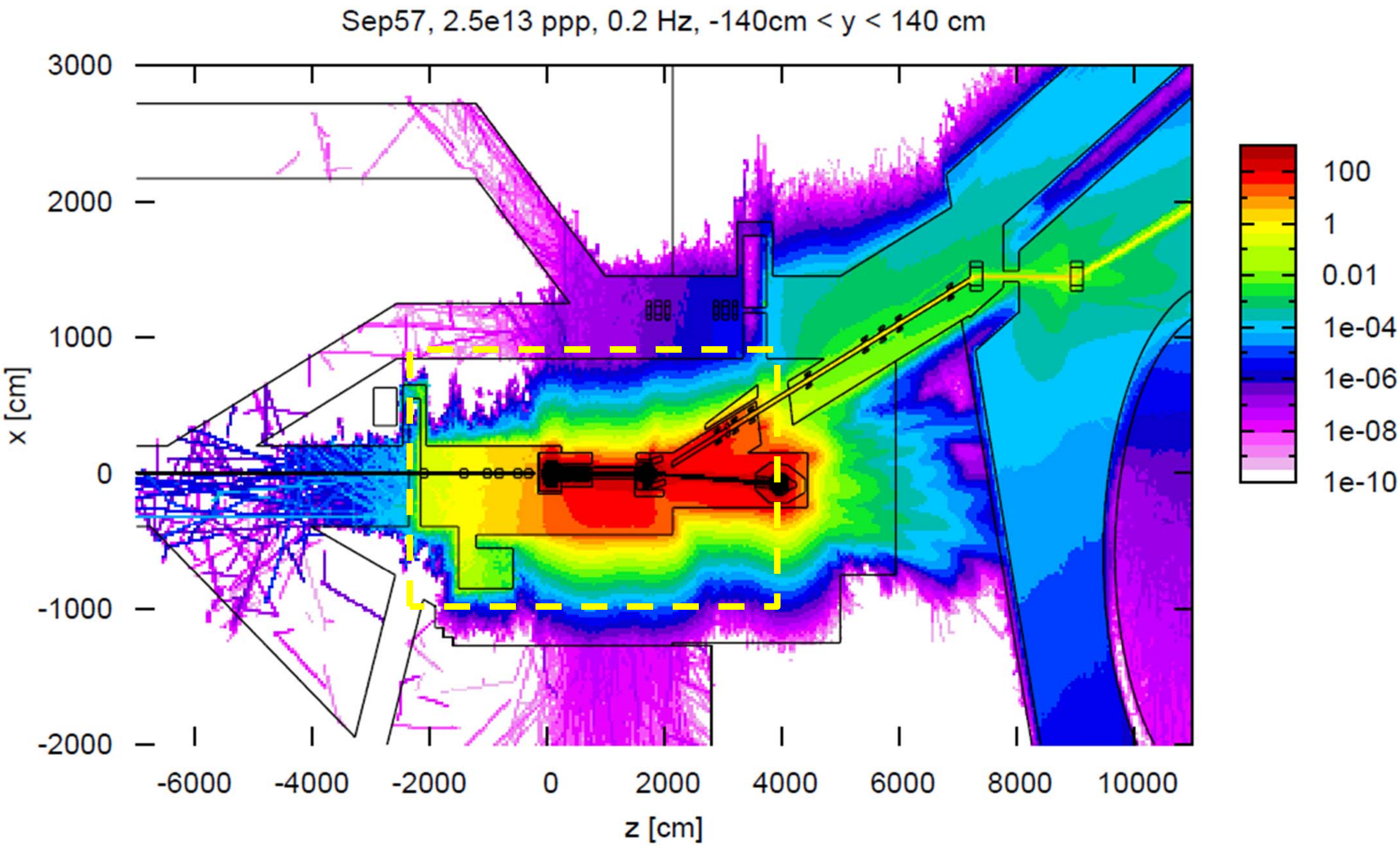
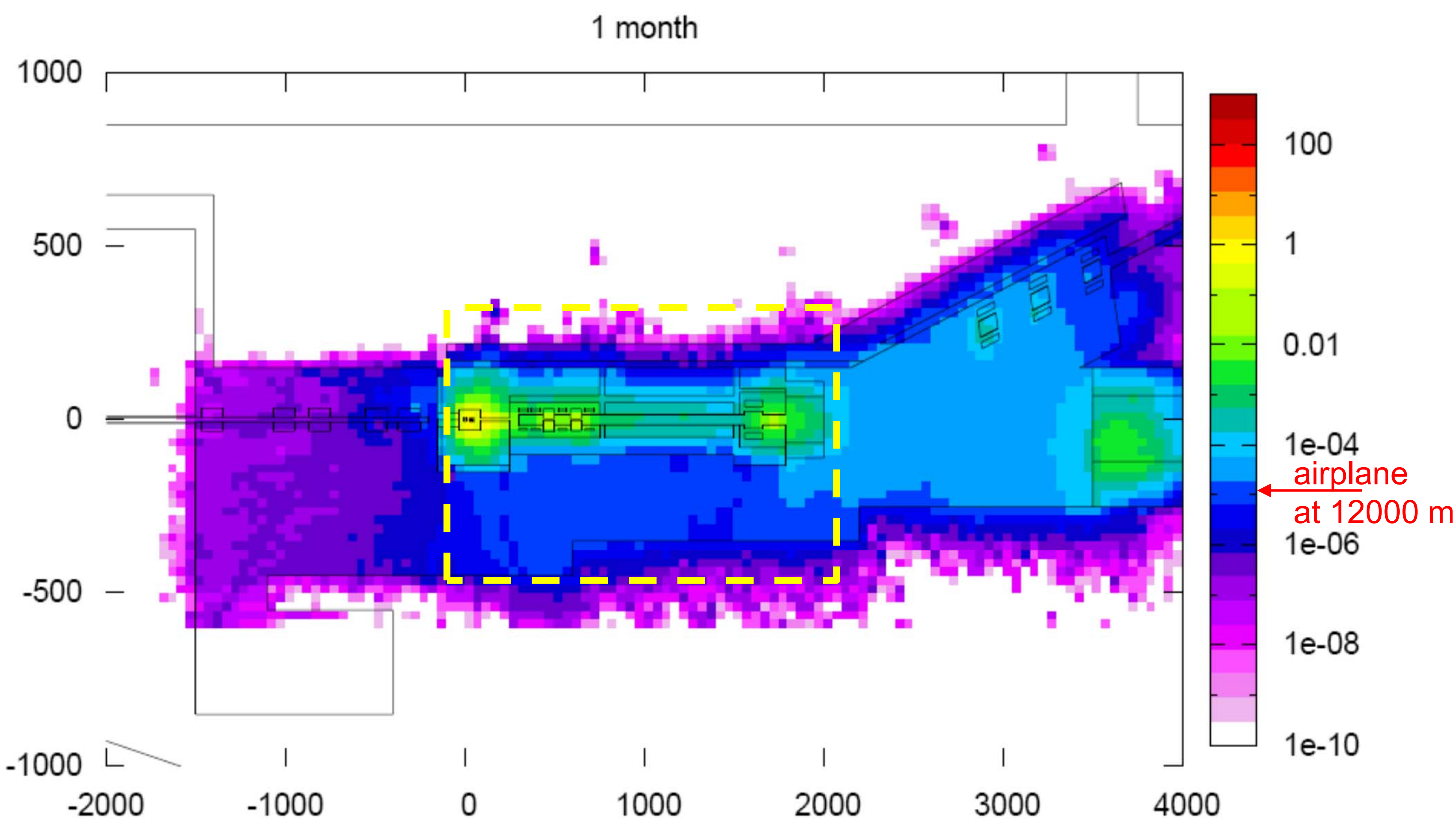


Induced Activity after Shut-Down



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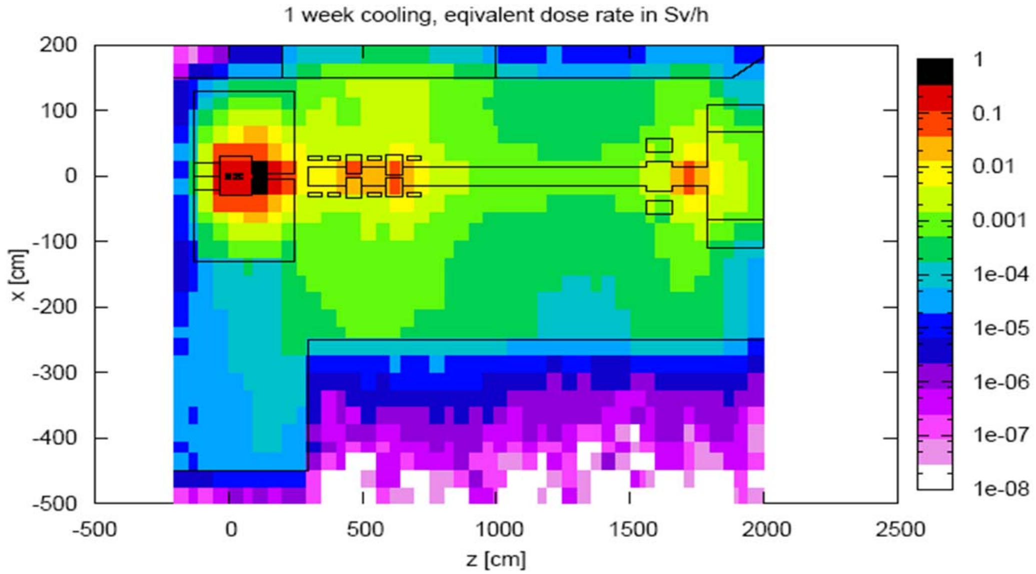
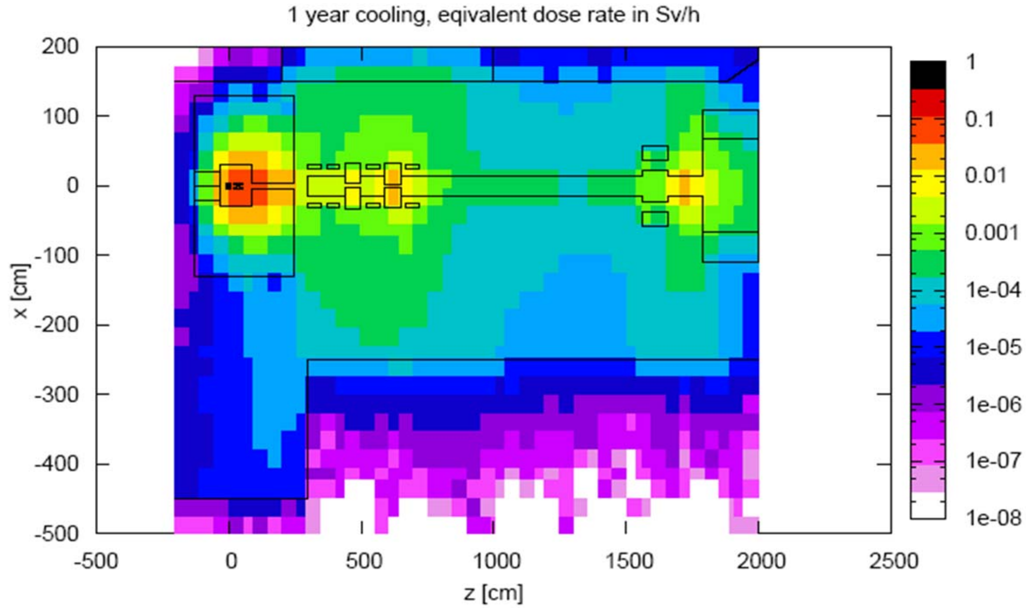
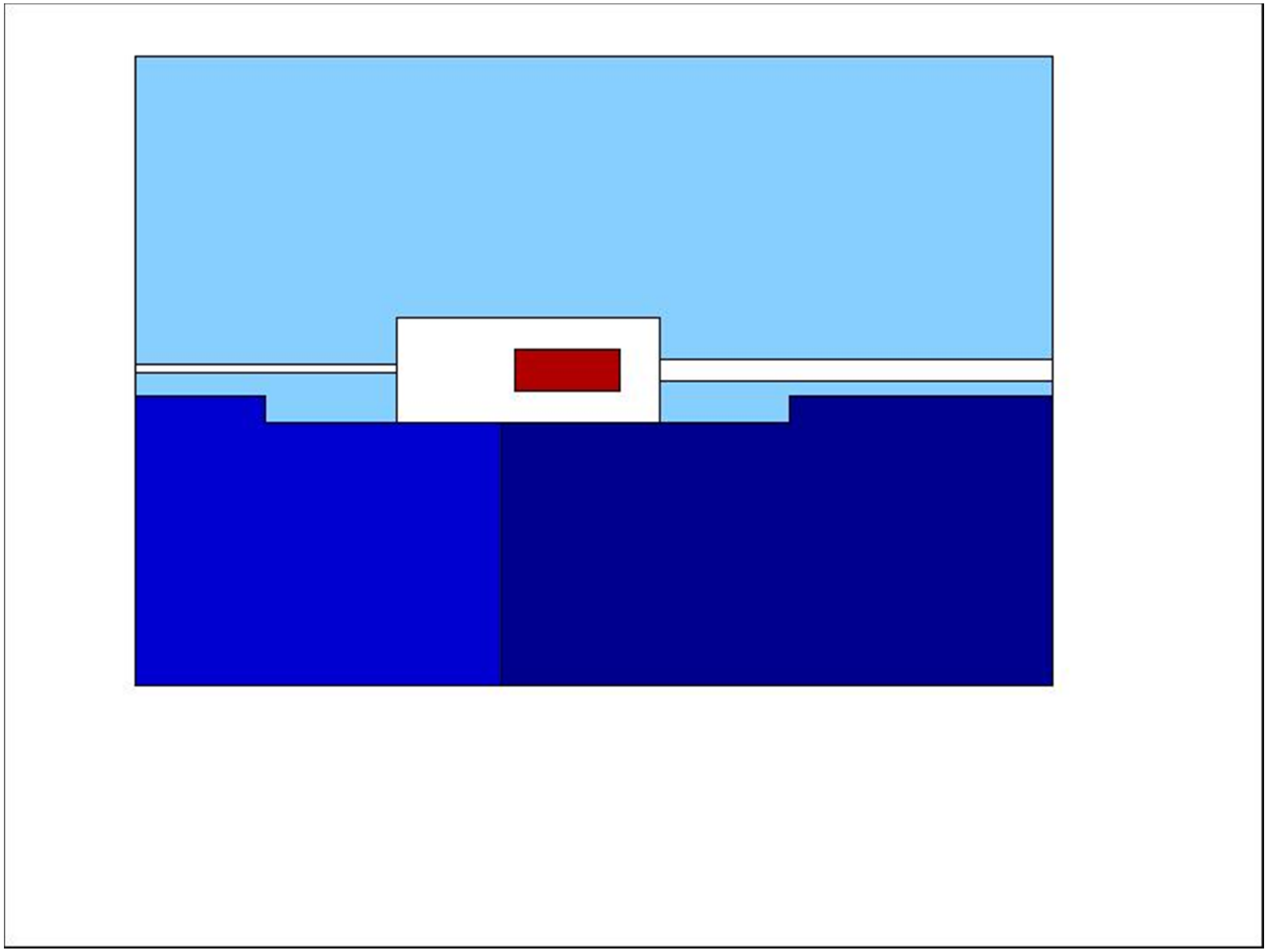


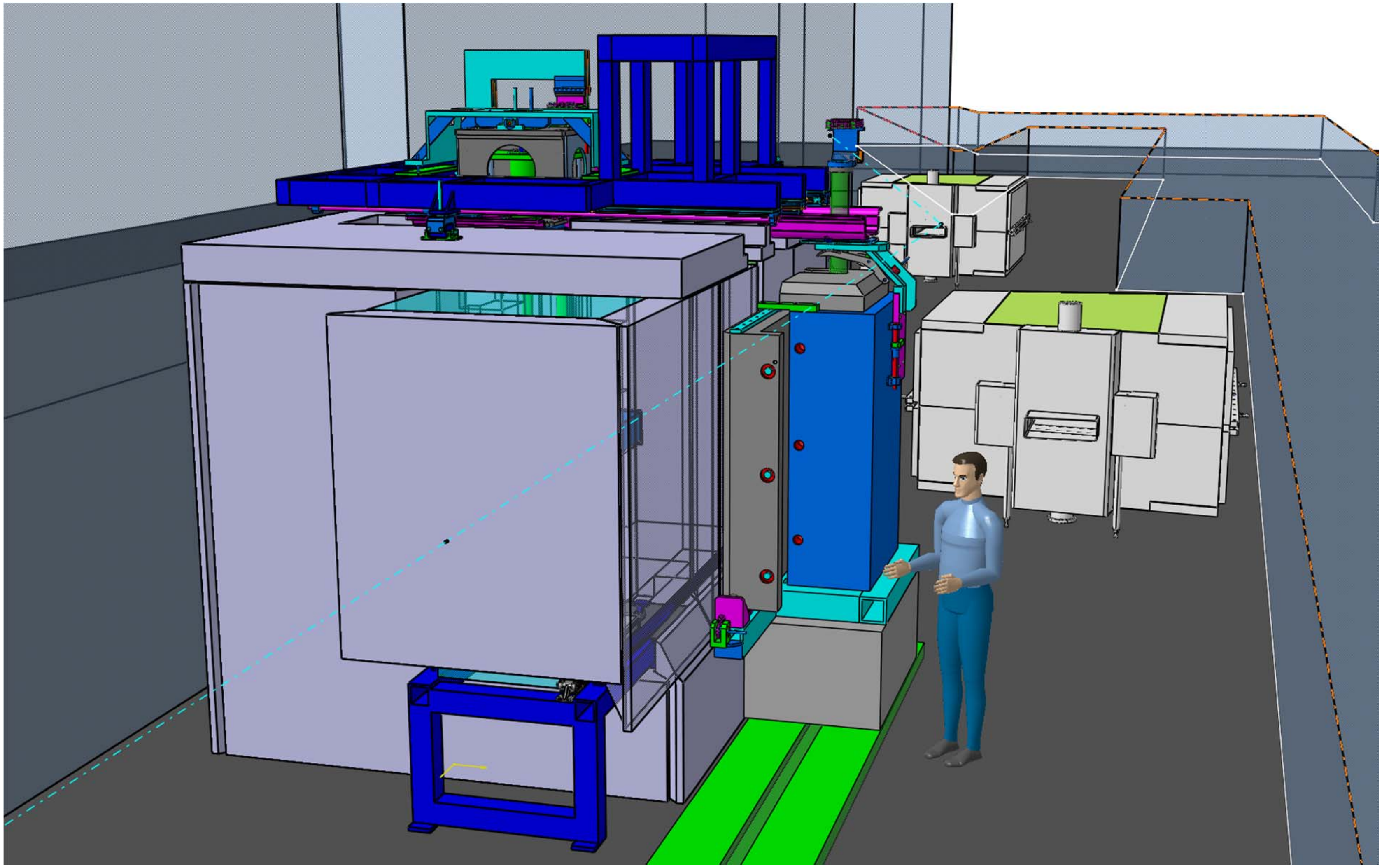


Operation on air for 20 m after the target.
pbar losses are about 5 % when He bags are used.

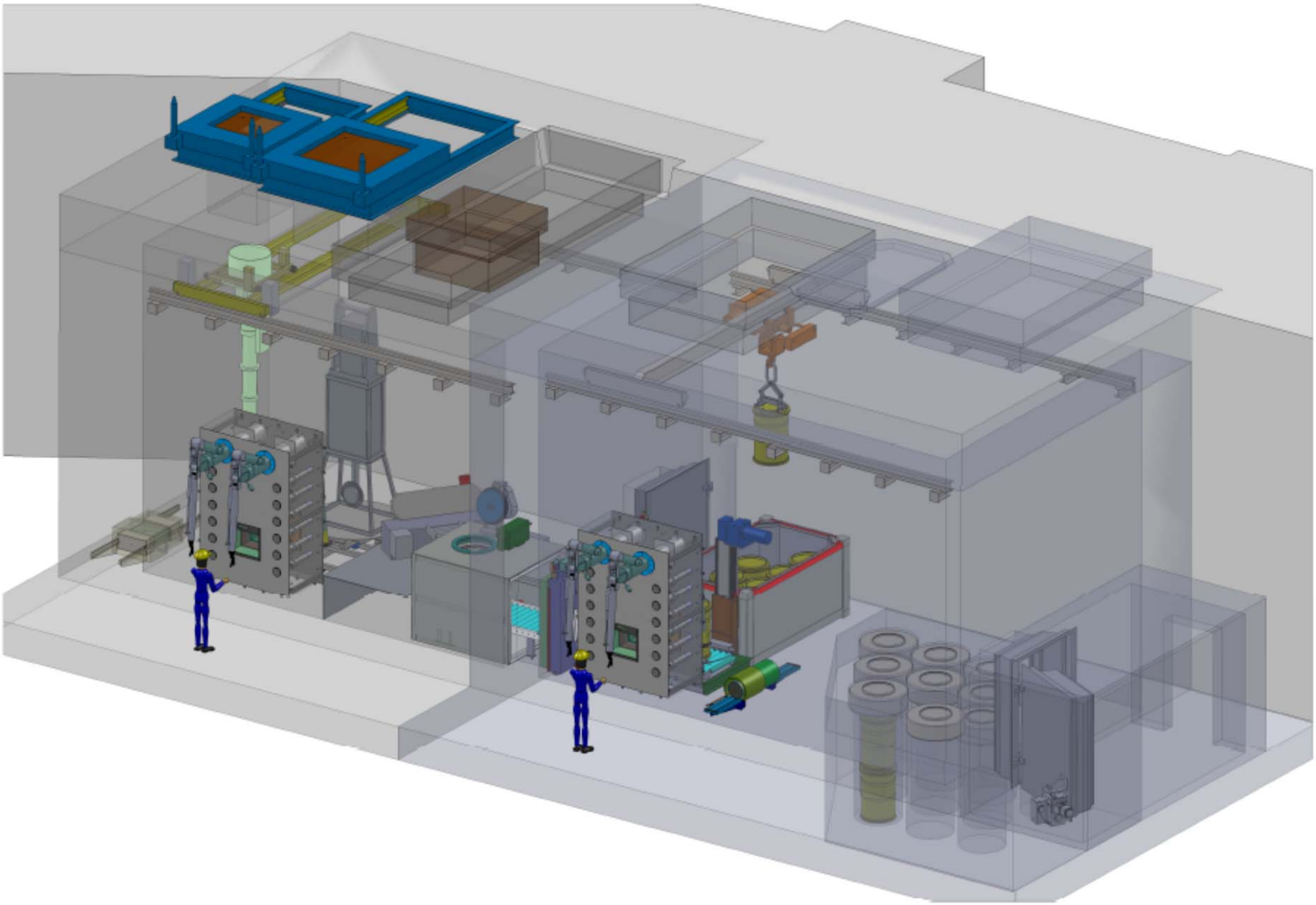
Target Exchange (target on air!)



Target Station



Hot Cell



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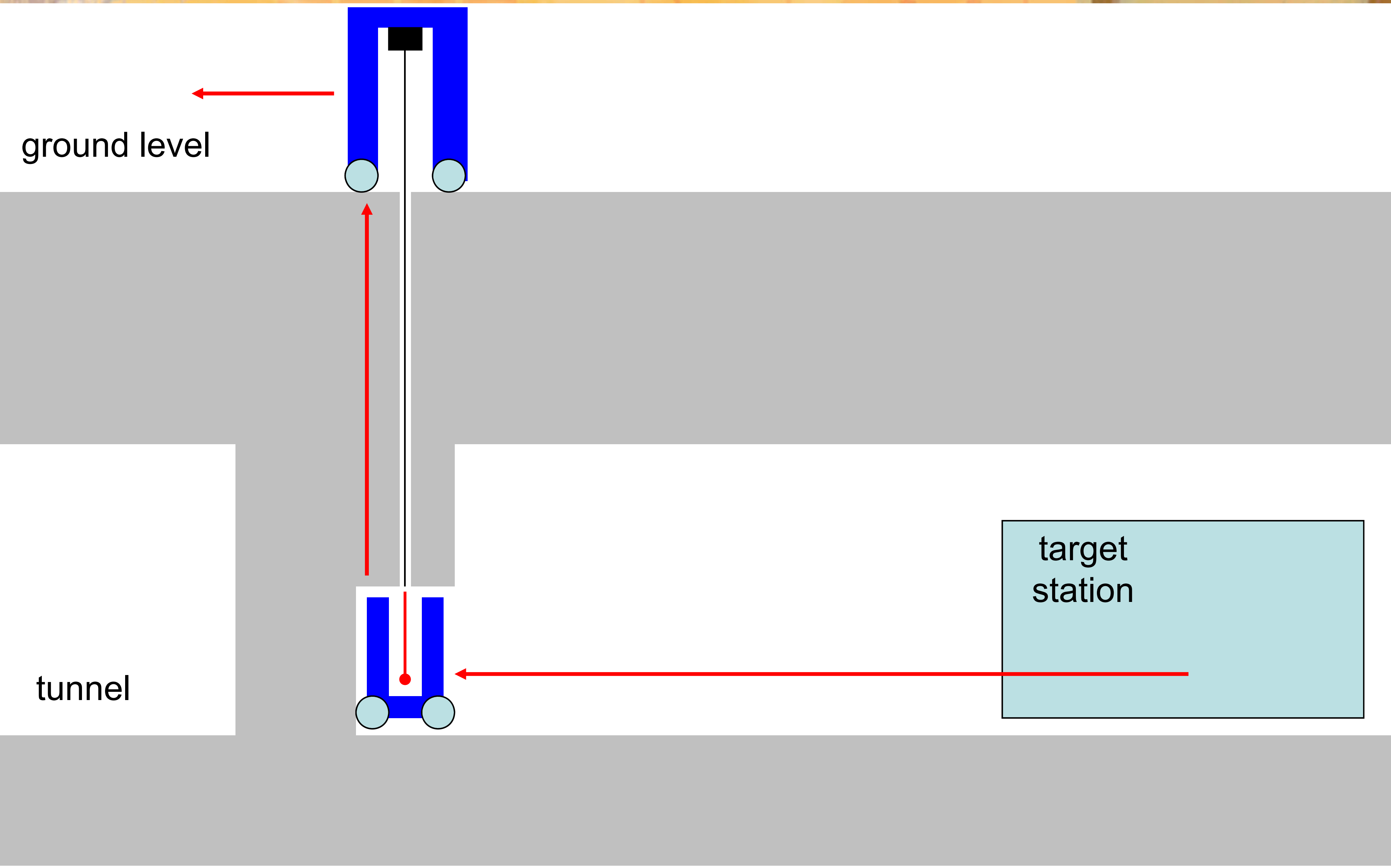
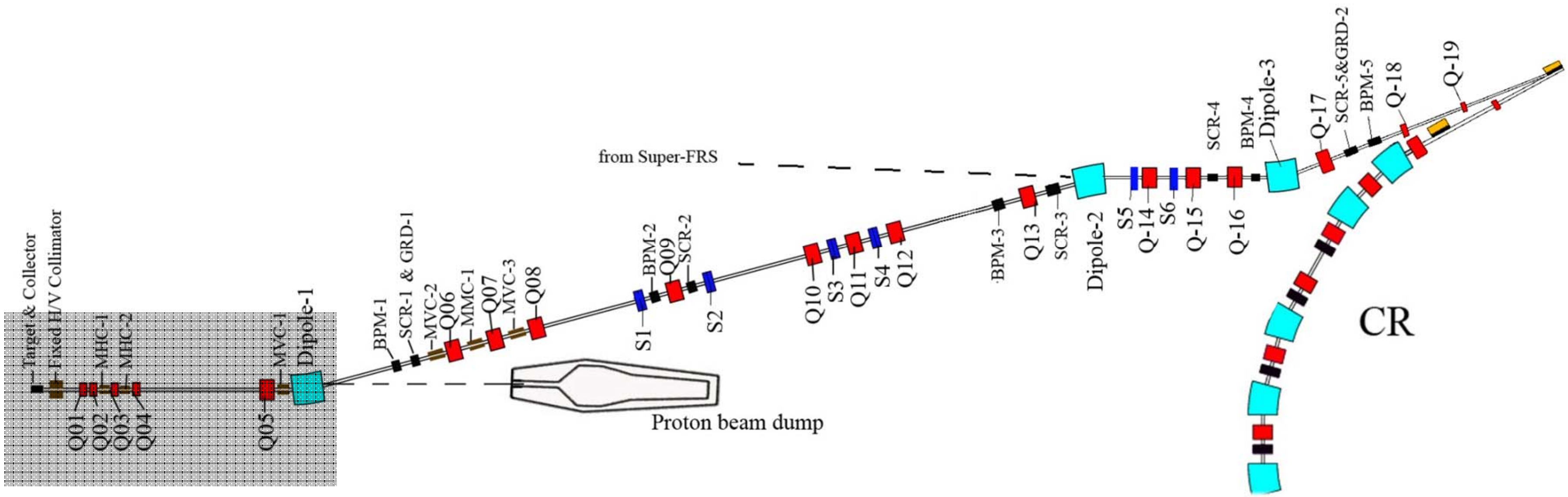
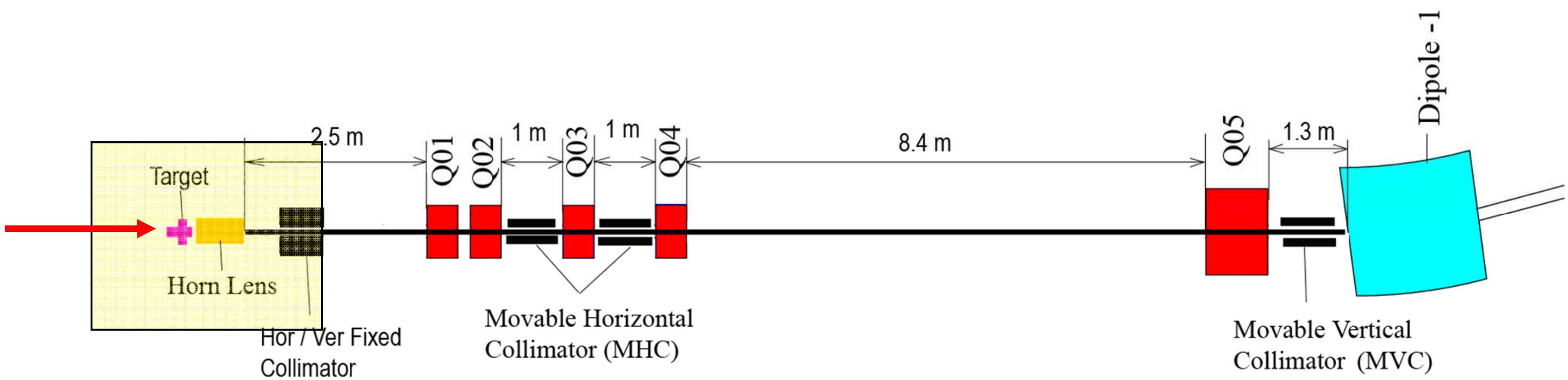


Life time doses for the magnet coils





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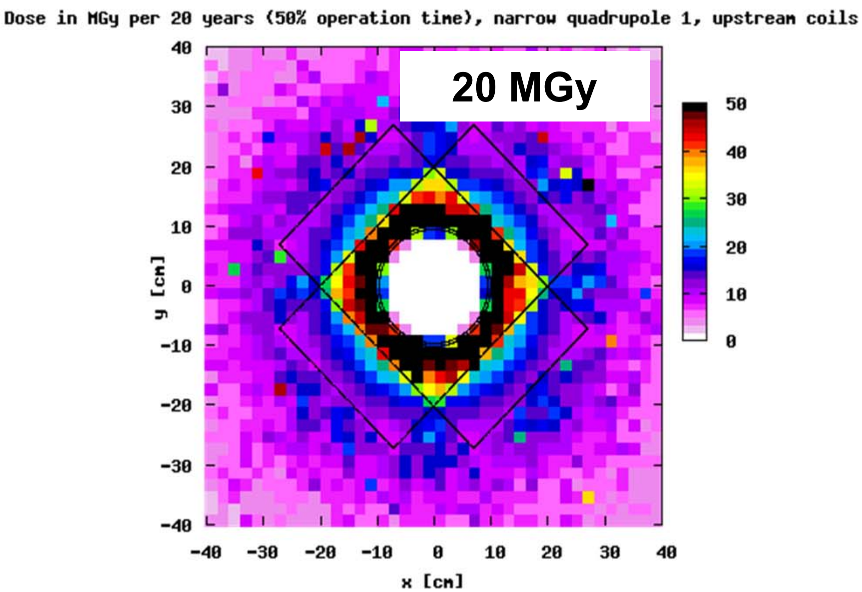
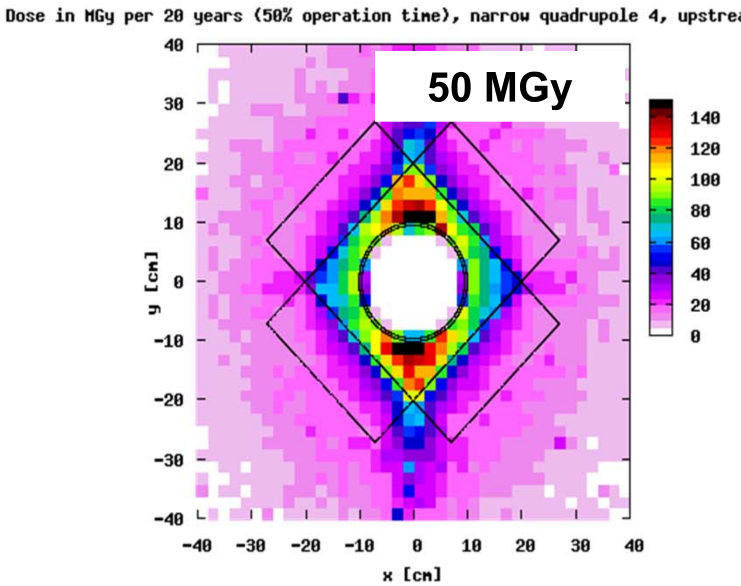
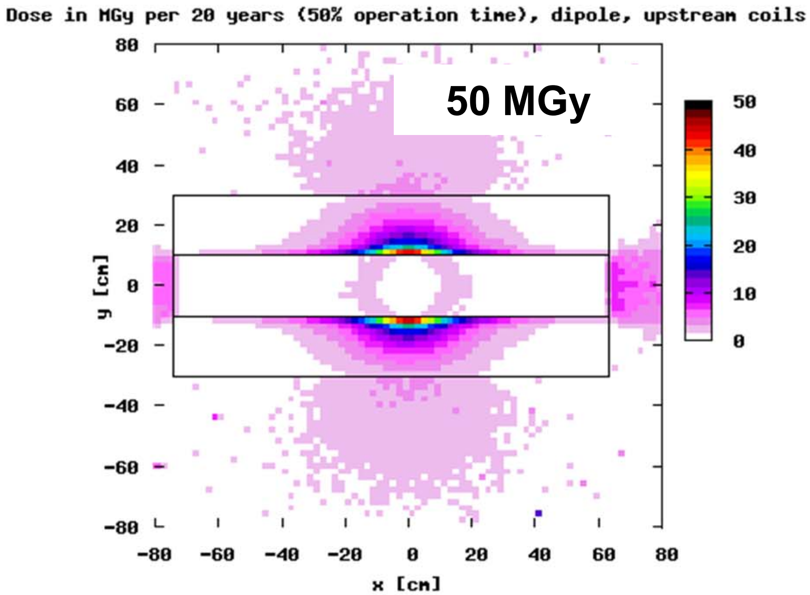






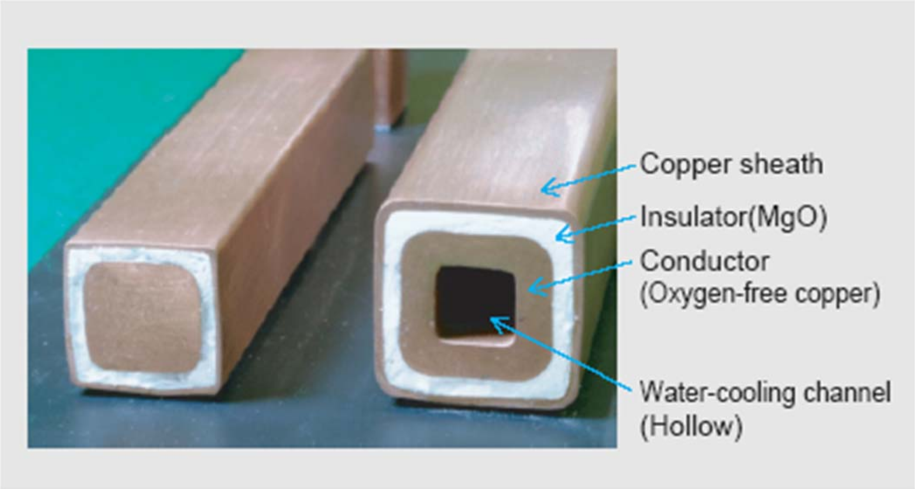
Polyimide insulation required

Life time doses for the magnet coils

Table1 Comparison of radiation-resistant service life

	Organic compound		Inorganic compound
Insulator	Epoxy resin	Polyimide resin	MgO
Radiation-resistant life (Gy)	10^7 Gy	10^9 Gy	$>10^{11}$ Gy

Gy(Gray) : Radiological dosage when energy applied from radiation to a substance is 1J per kg



J-PARC::
1) Polyimide resin insulation (PI) for up to 100 MGy;
2) Mineral insulation magnet cables (MICs) with larger cross sections for higher radiation dose up to 100 GGy.

Approximately 20 polyimide insulation magnets and 10 MIC magnets were designed.
The fabrication started in 2005.

The stranded conductors impregnated by the polyimide resin to form the coil