IR Hall Dose Rate Estimates for a "Self-shielding" Detector

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SLAC

- Dose rate around the detector
  - **Shielding and area classification**

    → Size of experimental hall
    → Design shield between hall wall and detector
    → Accessible or not during beam operation
    → Which kind of occupancies?

  - **“Effective to cost estimation”**

- Whether the detector can act itself as radiation shield or not.

1. Dose rate around the detector
   - → **Effect of gaps for cables and tubes**
   - → **Effect of iron resonance around keV region**
   - → **3D evaluation of shield between detector and BDS tunnel**

2. Design of connection part between BDS tunnel and Exp hall
   - → **Effect of tunnel offset and diameter changing**

3. Contribution of upstream part
   - → **Muon from collimator**

We need 3D Monte-Carlo simulation
- → **MARS15-MCNP, FLUKA code are used**

[SLAC rule]

- Normal operation :
  → **0.05mrem/h (= 0.5μSv/h) for GERT, 0.5mrem/h (= 5μSv/h) for RW**

- Miss steering :
  → **400mrem/h (= 4mSv/h)**

- System Failure :
  → **25rem/h (250mSv/h) for maximum credible beam loss in any accessible area**
  assuming that the BCS devices that limit beam power have failed

Design Goal

[LHC design] **(from http://indico.cern.ch/conferenceDisplay.py?confId=1561 talk of D. Forkel-Wirth)**

- Normal operation :
  - → 0.3 mrem/h (= 3μSv/h) for Simple controlled area
  - → 0.1 mrem/h (= 1μSv/h) for Supervised area
  - → 0.01 mrem/h (= 0.1μSv/h) for Non-designated area
- Total Beam loss :
  - → 5 rem (50mSv) for Simple controlled area
  - → 250 mrem (2.5mSv) for Supervised area
  - → 30 mrem (0.3mSv) for Non-designated area

[J-PARC design] **(from Dr. Nakashima, JAEA)**

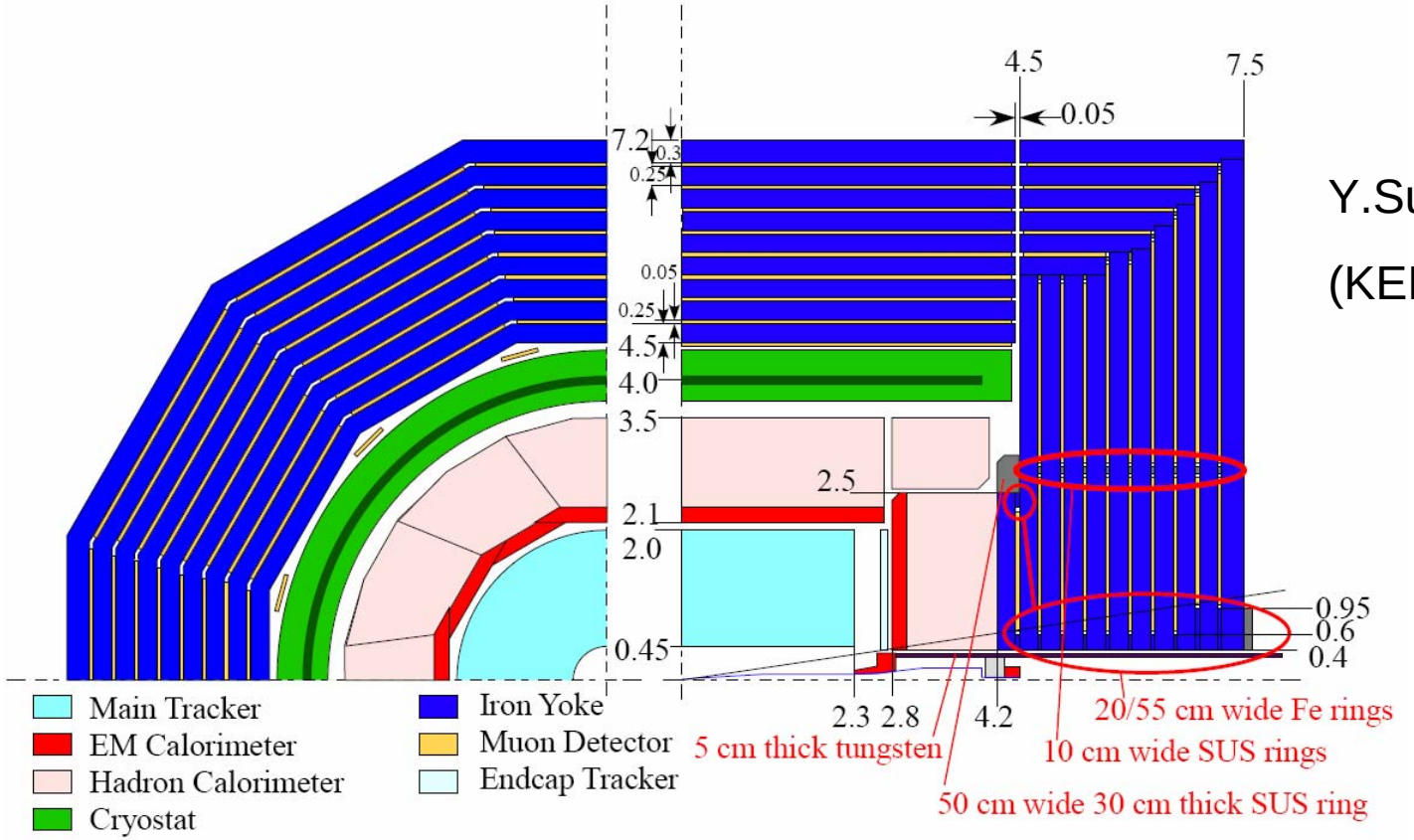
- Normal operation : (**1W/m beam loss assumed for 1MW**)
  - → 1.25 mrem/h (= 12.5μSv/h) for Controlled area
  - → 0.025 mrem/h (= 0.25μSv/h) for In-site

Total Beam loss :

Accelerator stops within 1 sec
by monitoring beam current, beam loss and 1 hour integrated dose rate

	Perfectly modeled	Modeled with simplification	Ignore
GLD (Large detector)	Iron Yoke, Endcap	Beam tube, VTX, BIT, FIT, ET, TPC, ECAL, HCAL, FCAL,BCAL, Cryostat, Mag. Field	Muon chamber
SiD (Small detector)	Iron Yoke, End cap	EMcal, Hadron cal, Solenoid , Mag. field	Vertex Det, Tracker, Muon chmabers

Shield effective part (underlined parts) must be taken into account.



Y.Sugimoto

(KEK)

Endcap Tracker, FCAL, BCAL, EM Calorimeter

→ W (ρ=9.9) for >20MeV, W+CH2 (ρ=9.9) for <20MeV

Hadron Calorimeter →Pb(8.88) for >20MeV, Pb+CH2 (ρ=8.88) for <20MeV

SiD

Use structure and values described in
http://confluence.slac.stanford.edu/display/ilc/sid00

Iron Yoke → Octagonal shape

EM Calorimeter → W plates 0.275cm x 20layers + 0.50cm x 10layers

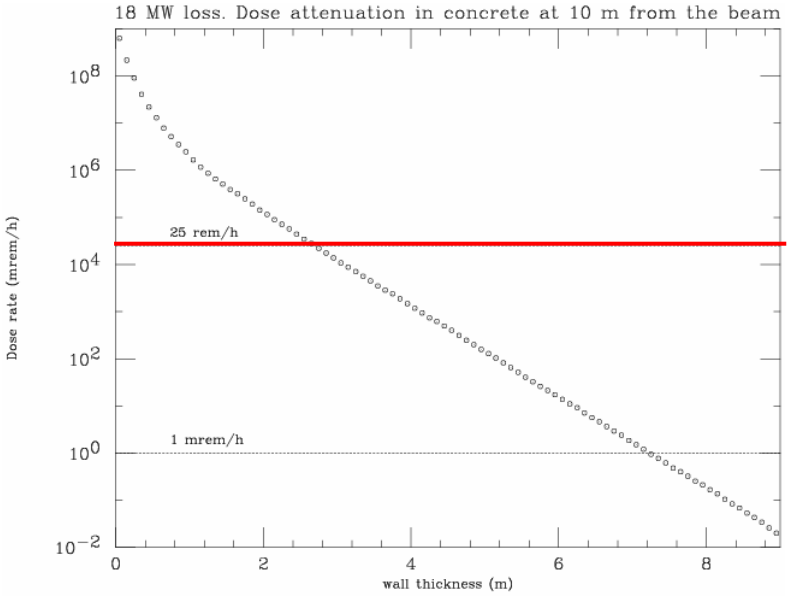
Hadron Calorimeter →Fe plates 2.0cm x 34layers

Modeling of the other part

- Experimental hall : 30m long – 30m width – 30m height
  - **Tentative, depend on crane size, how to assemble detectors,, etc.**

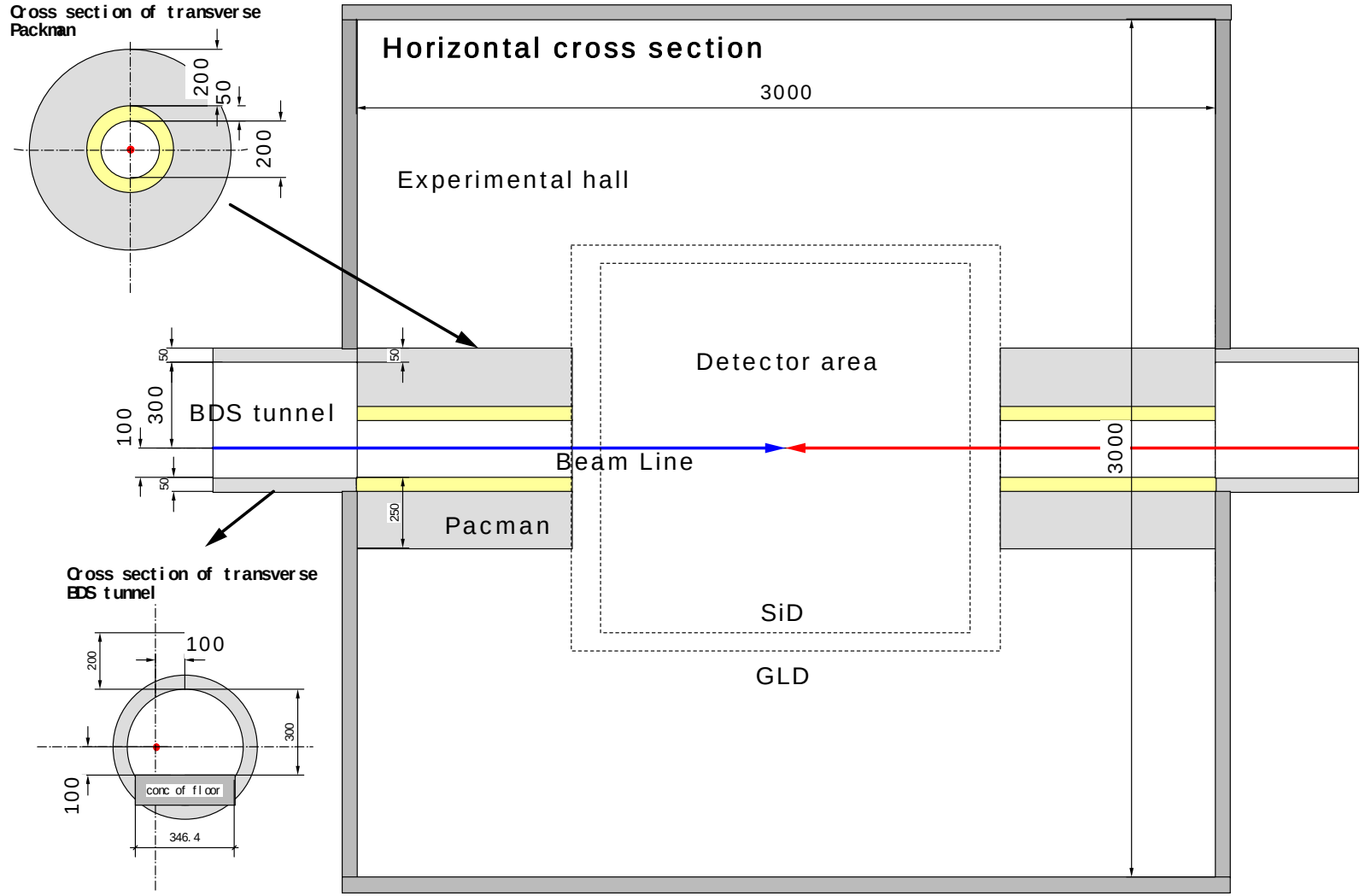
- BDS tunnel and Pacman
  - **Tentative, depend on shield design, scheme of detector exchange, etc.**

- Minimum shield for 18MW electron beam
  - **Concrete 3m**
    (Determined by our previous work)

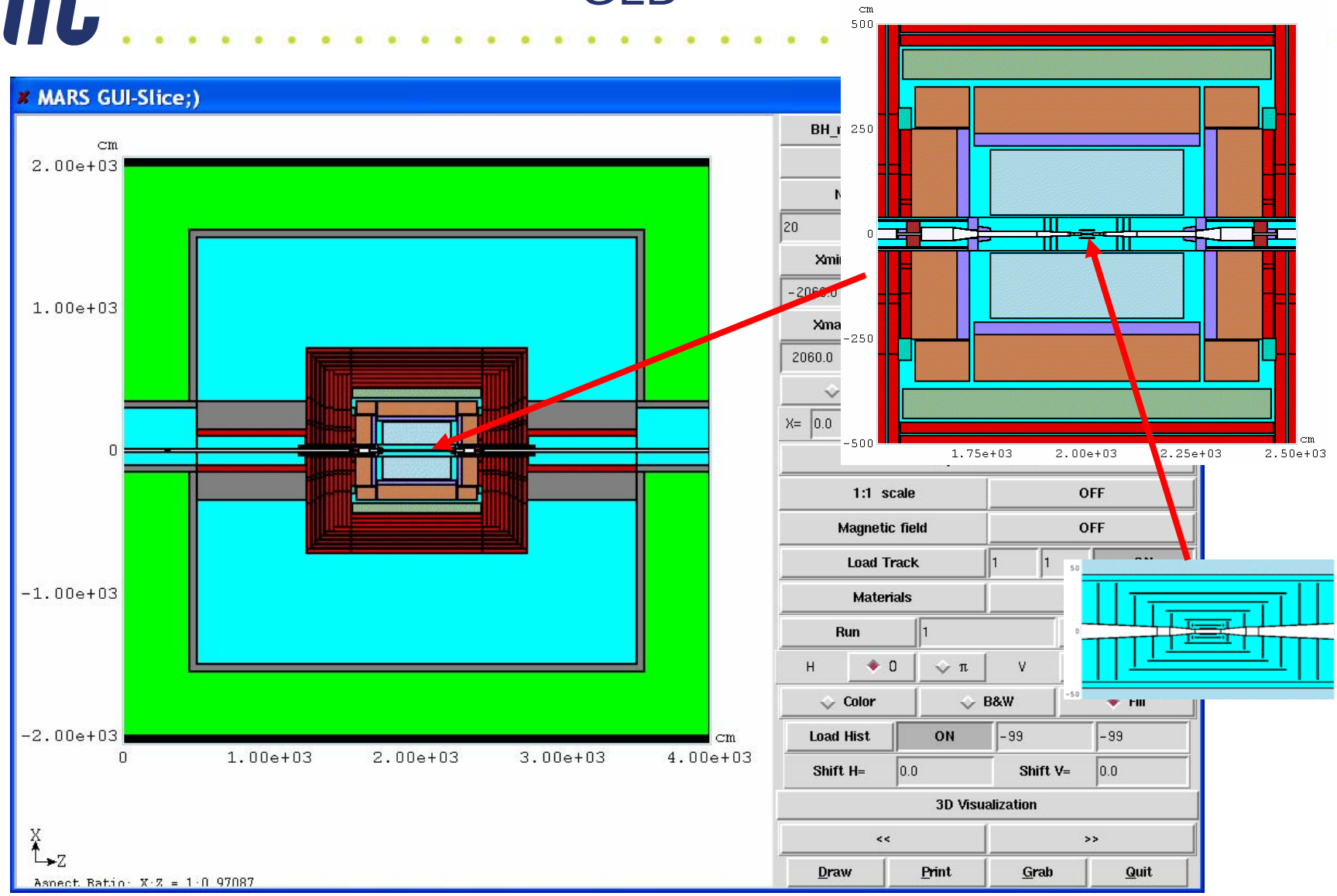


18MW loss Dose attenuation in concrete at 10m from the beam

Experimental hall, BDS tunnel and Pacman



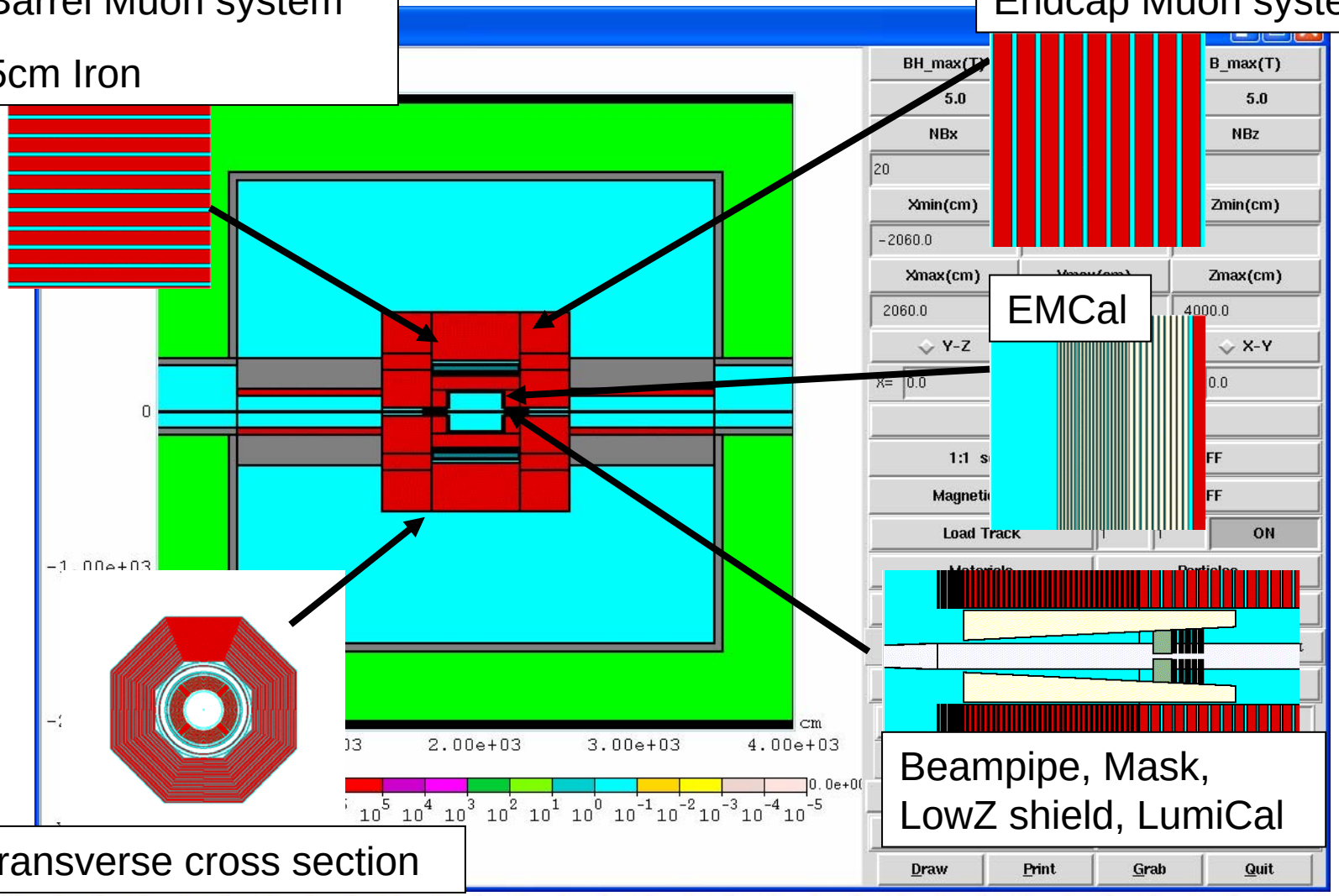
GLD


MARS GUI-Slice;)
cm
2.00e+03
1.00e+03
0
-1.00e+03
-2.00e+03
0
1.00e+03
2.00e+03
3.00e+03
4.00e+03
cm
X
Z
Aspect Ratio: X:Z = 1.0 .97087
BH_r
20
Xmi
Xma
2060.0
X= 0.0
1:1 scale
OFF
Magnetic field
OFF
Load Track
1
Materials
Run
1
H
0
π
V
Color
B&W
Load Hist
ON
-99
-99
Shift H=
0.0
Shift V=
0.0
3D Visualization
<<
>>
Draw
Print
Grab
Quit
cm
500
250
0
-250
-500
1.75e+03
2.00e+03
2.25e+03
2.50e+03
cm

SiD

Barrel Muon system

5cm Iron

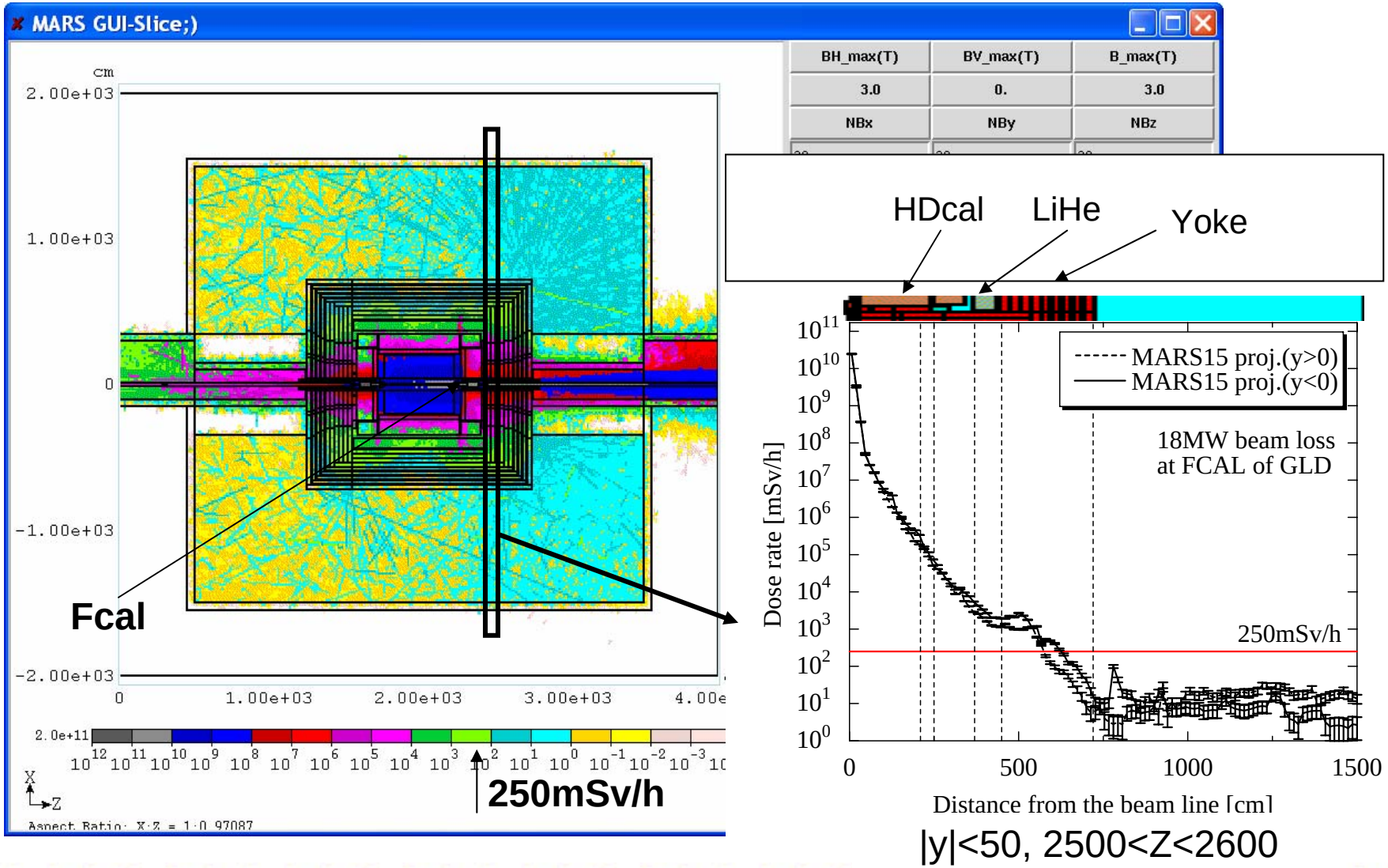


How many cases ?

Case #	Detector	Target	To check….
1	GLD	FCAL	Overall self-shielding capability of detector
2	SiD	LowZ	Overall self-shielding capability of detector
3	GLD	Cu $20X_0$@BDS	Connection point between BDS tunnel and Pacman
4	If you request…		

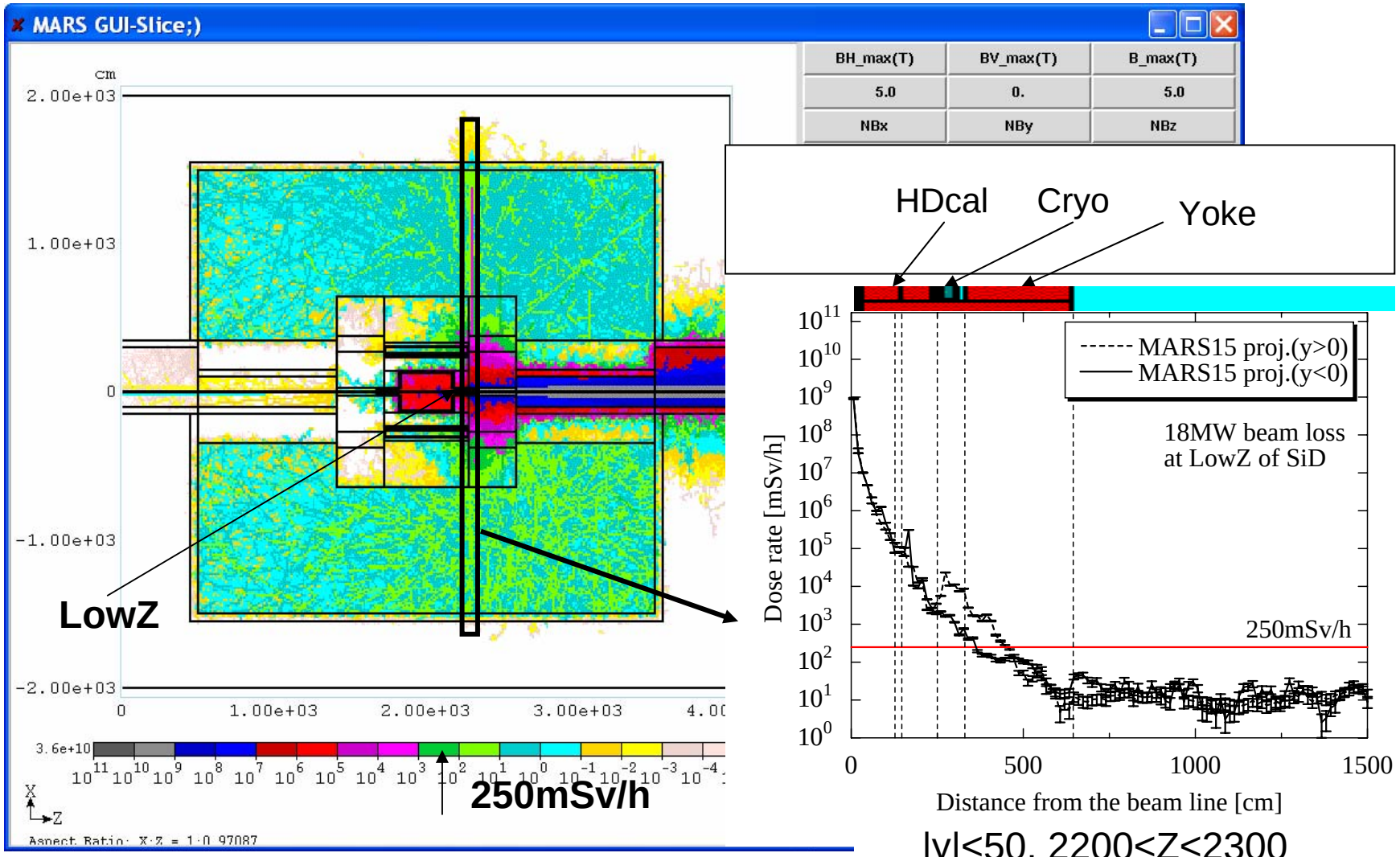
All dose rates are calculated for 18MW beam loss !

Result #1 GLD FCAL hit case



|y|<50, 2500<Z<2600

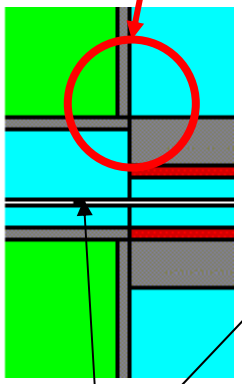
Result #2 SiD LowZ hit case



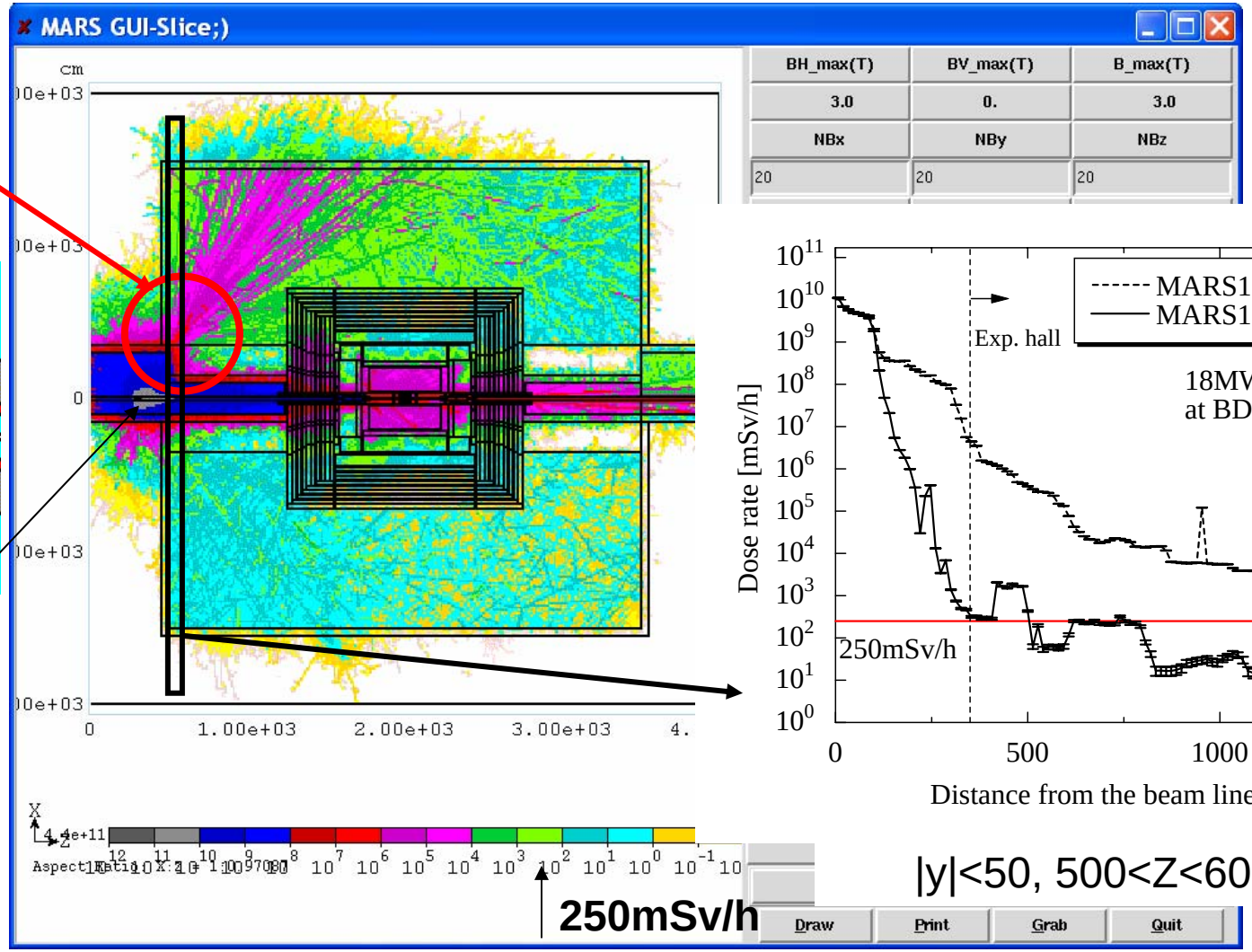
|y|<50, 2200<Z<2300

Result #3 Beam loss in BDS tunnel

Relatively thin



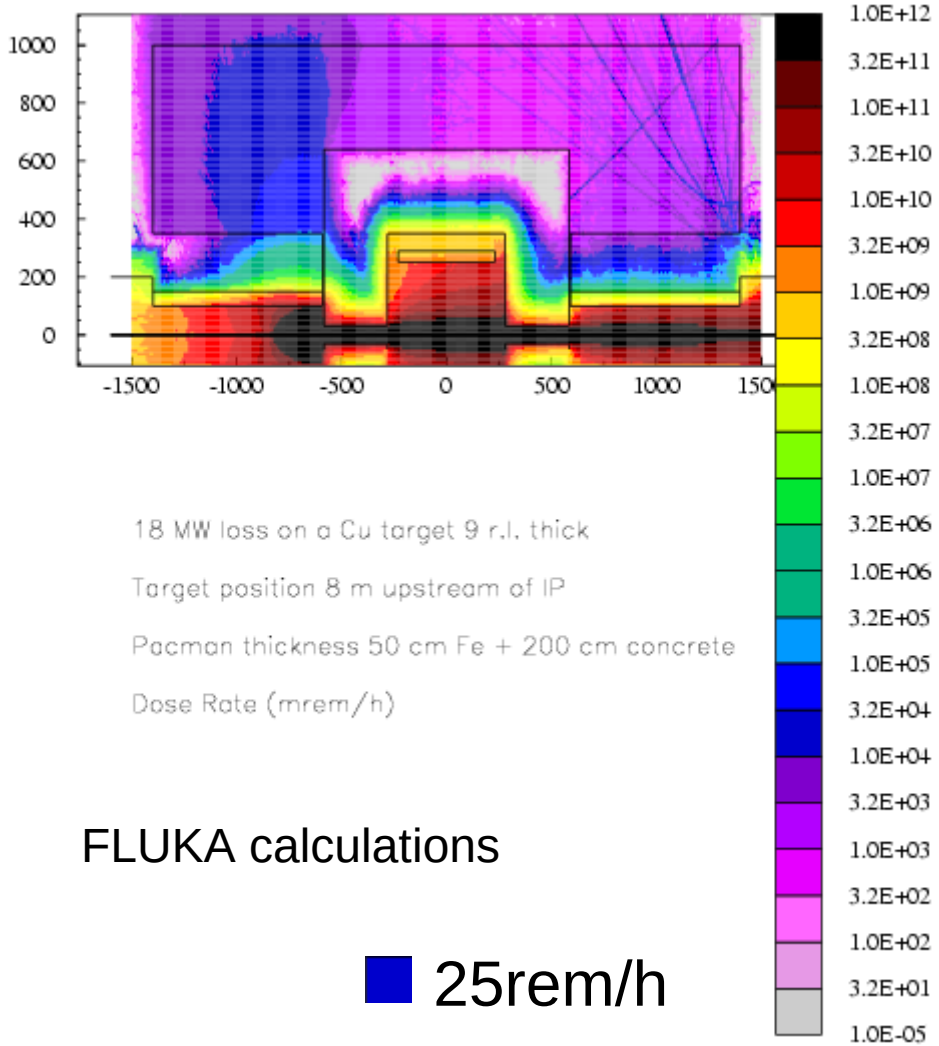
20X$_0$ Cu



250mSv/h

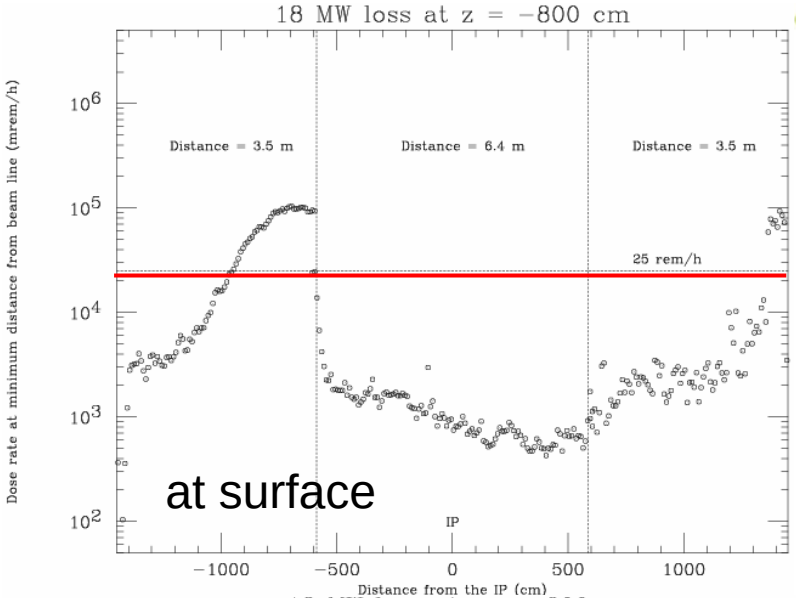
|y|<50, 500<Z<600

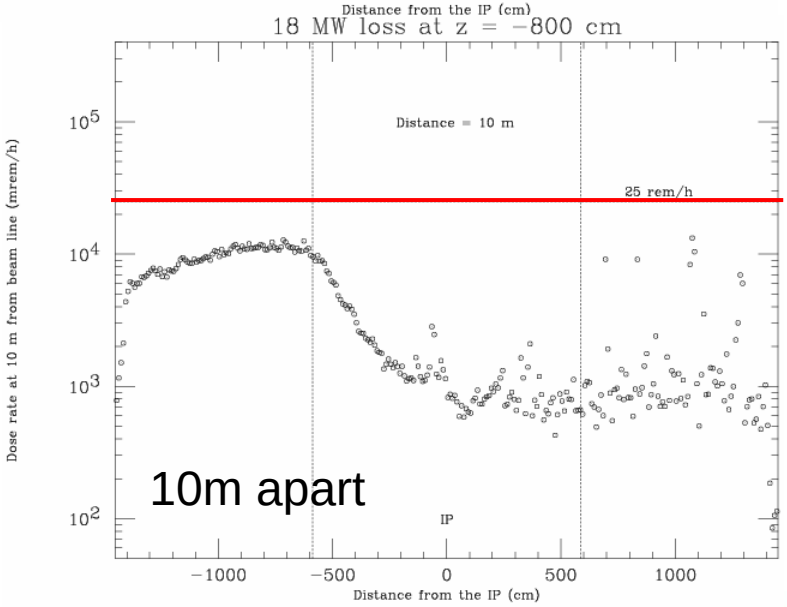
Thickness of Pacman (50 iron+200 conc.)



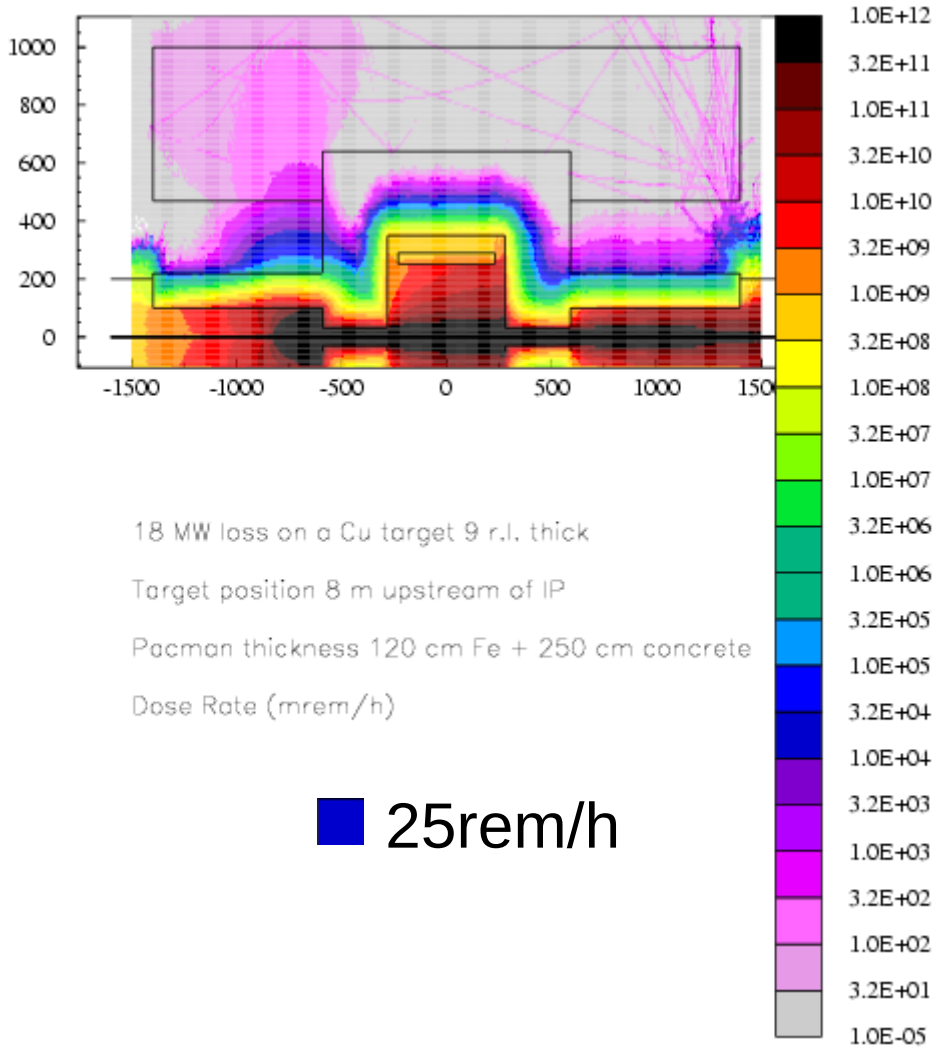
FLUKA calculations

25rem/h

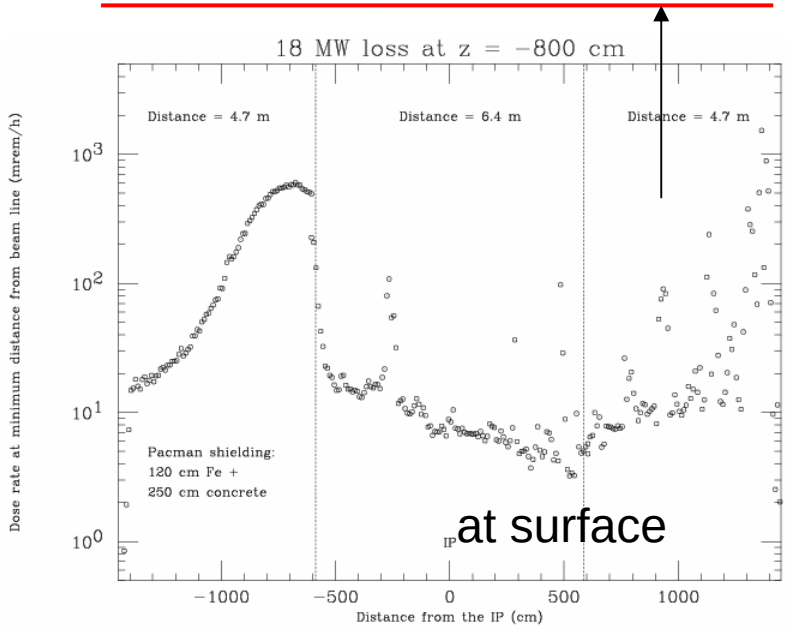




Thickness of Pacman (120 iron+250 conc.)

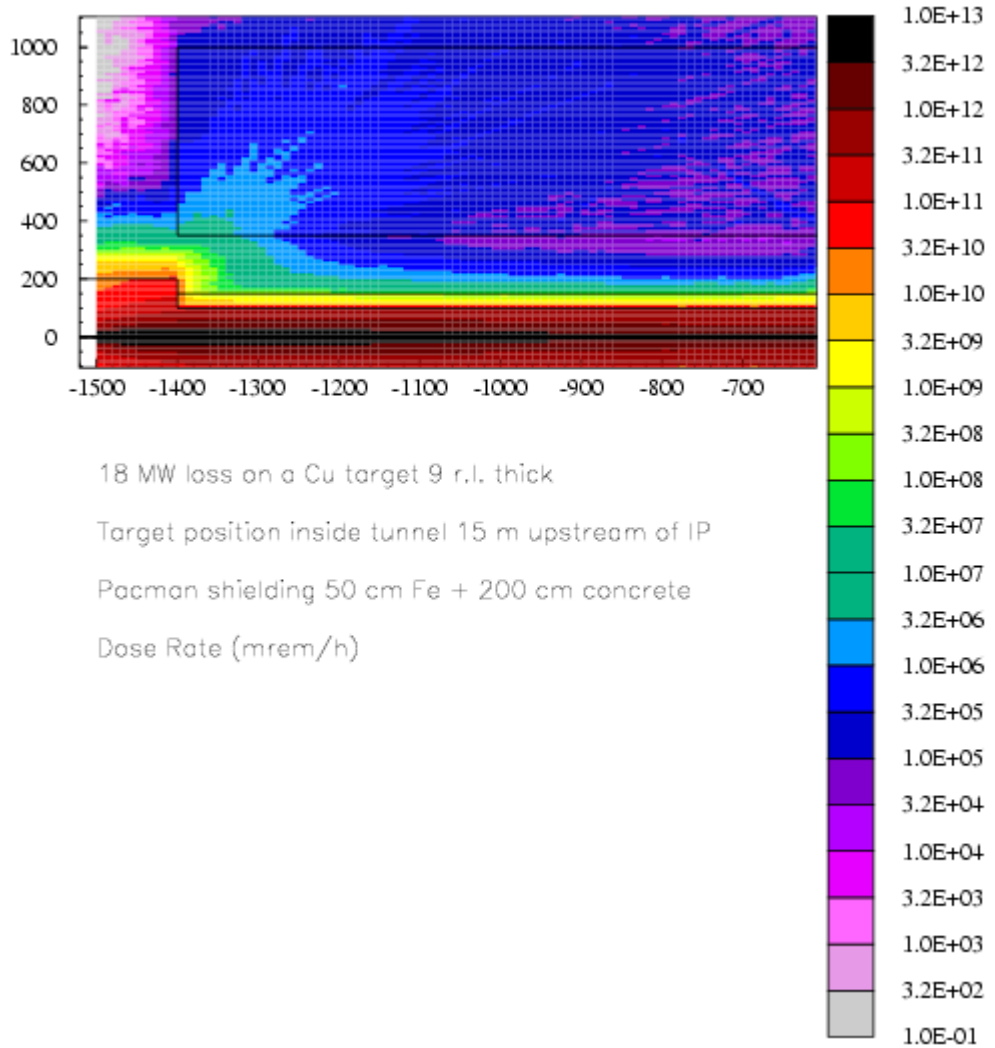


25rem/h



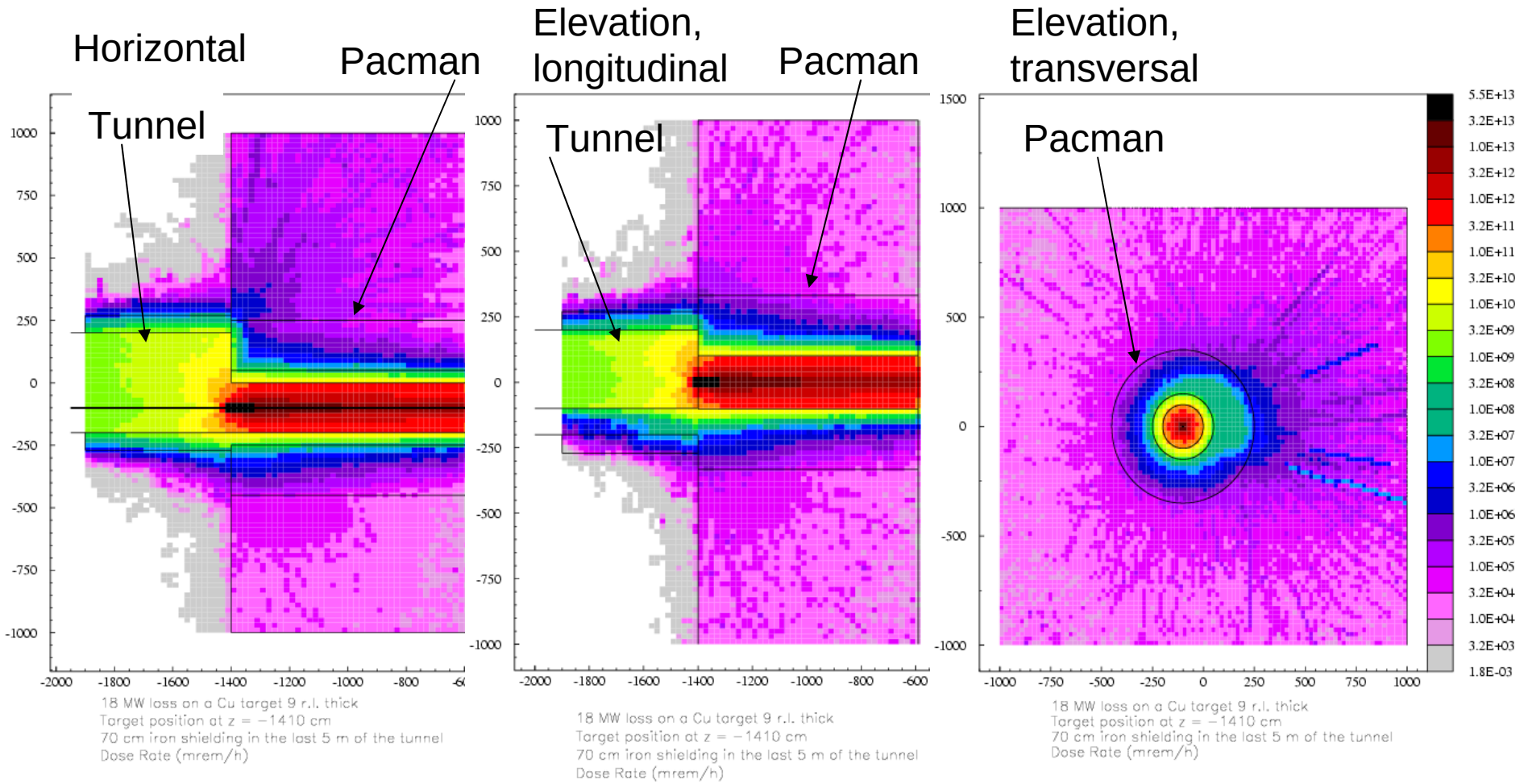
at surface

Beam loss inside the tunnel



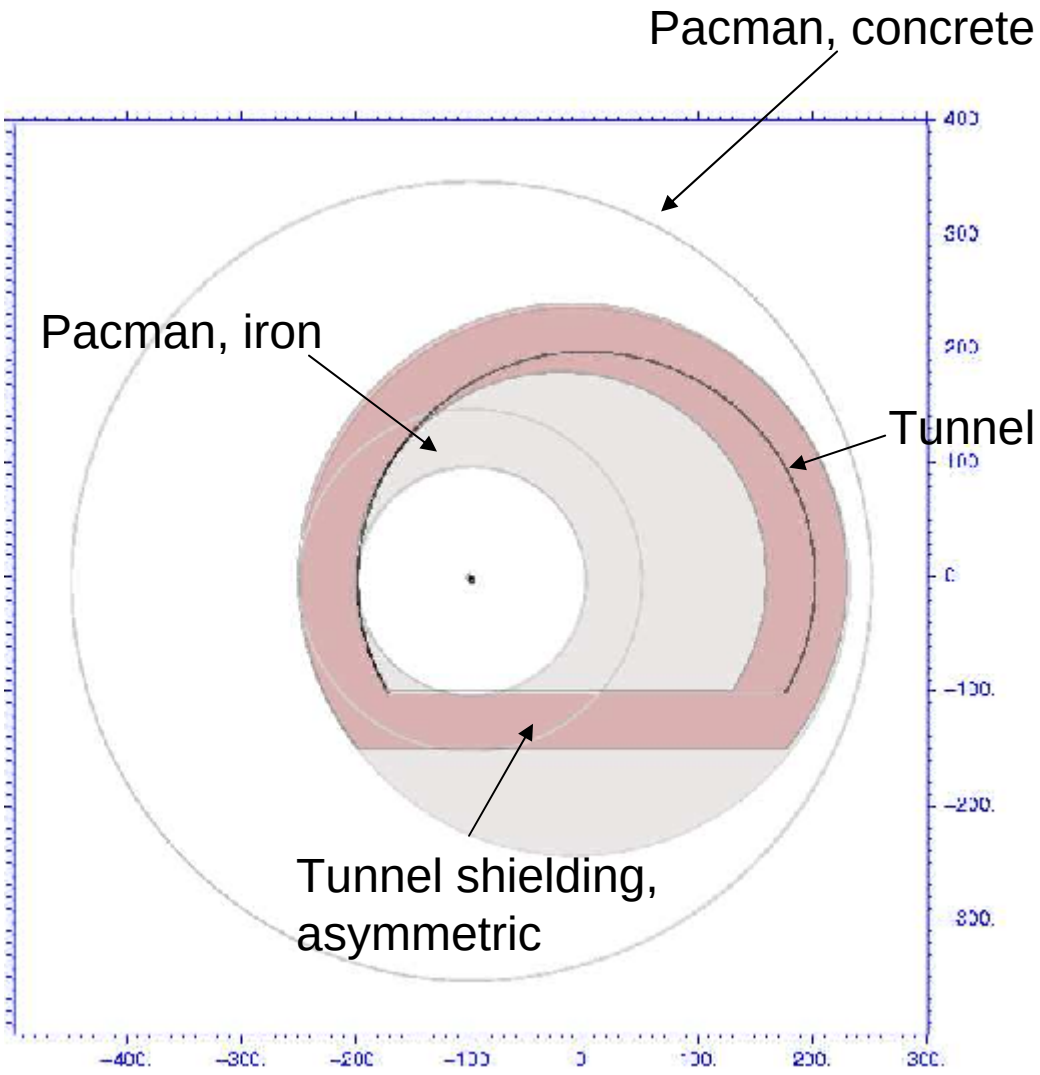
25rem/h

Beam loss inside the tunnel



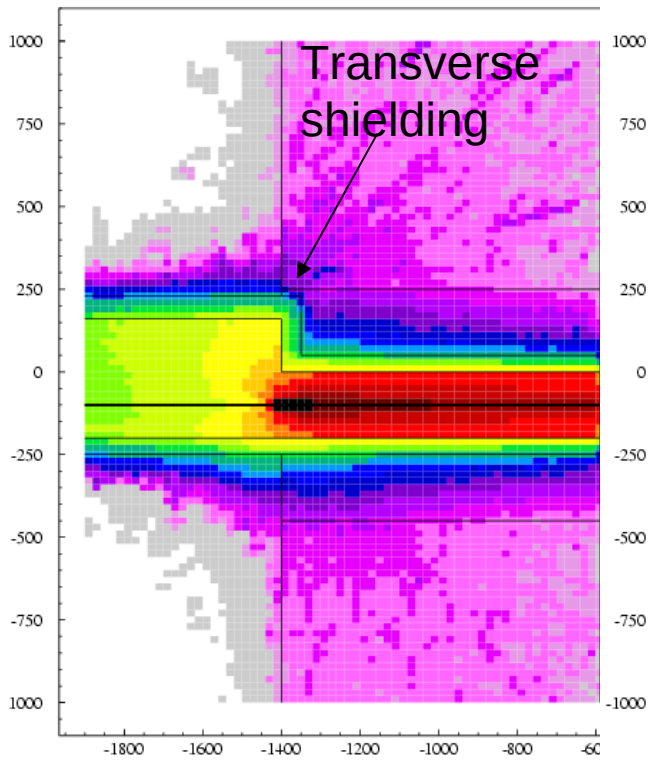
25rem/h

Asymmetrical shield necessary at the end of BDS tunnel



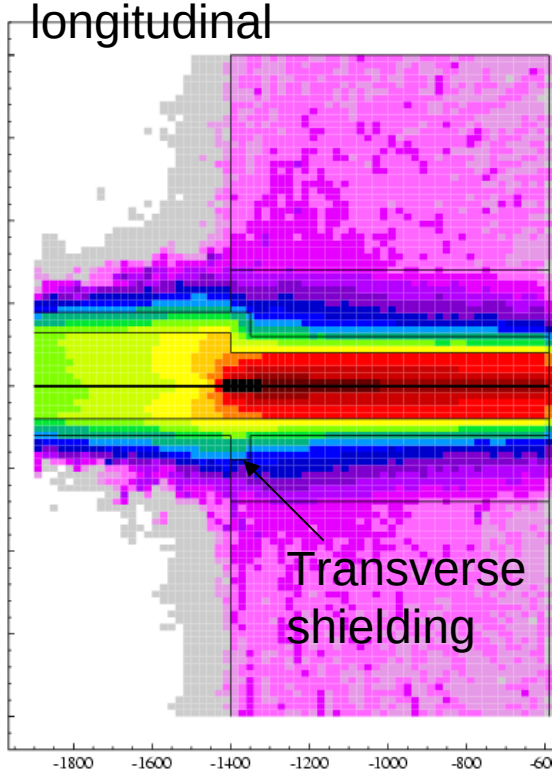
Asymmetrical shield, transverse iron disc between tunnel and Pacman

Horizontal



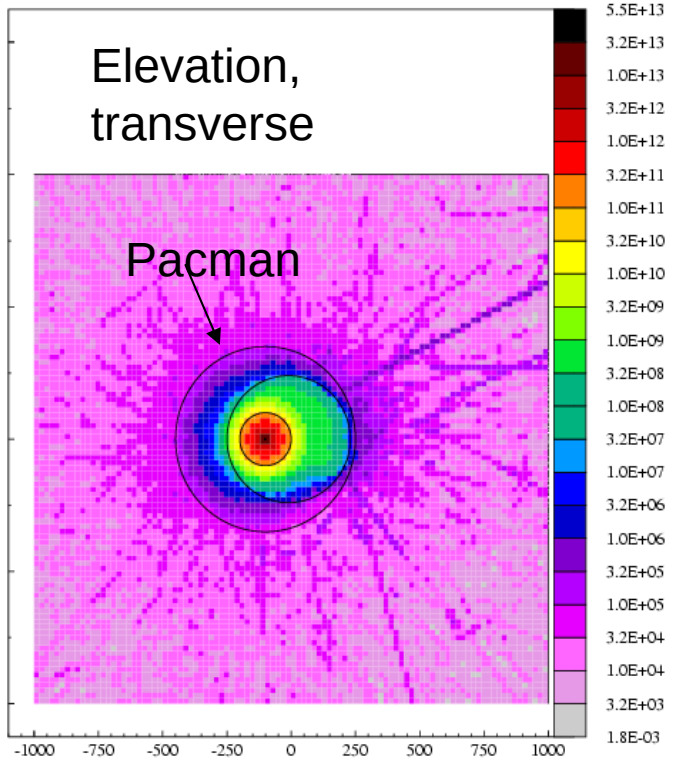
Dose Rate (mrem/h) for a 18 MW loss on a Cu target 9
Target position at z = −1410 cm
50 to 70 cm iron shielding in the last 5 m of the tunnel
50 cm transverse iron shielding in Pacman

Elevation, longitudinal



Dose Rate (mrem/h) for a 18 MW loss on a Cu target 9
Target position at z = −1410 cm
50 to 70 cm iron shielding in the last 5 m of the tunnel
50 cm transverse iron shielding in Pacman

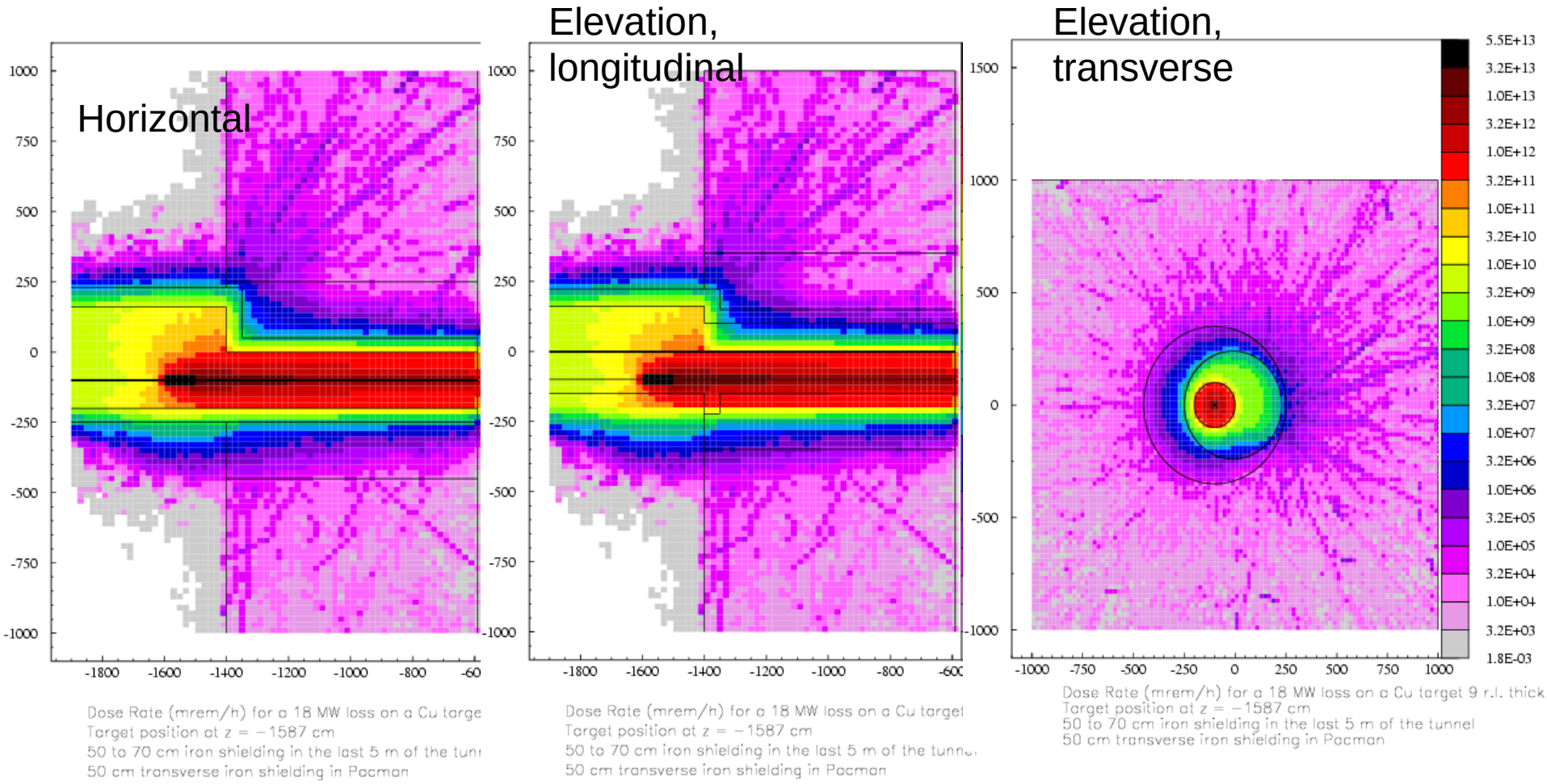
Elevation, transverse



Dose Rate (mrem/h) for a 18 MW loss on a Cu target 9 r.l. thick
Target position at z = −1410 cm
50 to 70 cm iron shielding in the last 5 m of the tunnel
50 cm transverse iron shielding in Pacman

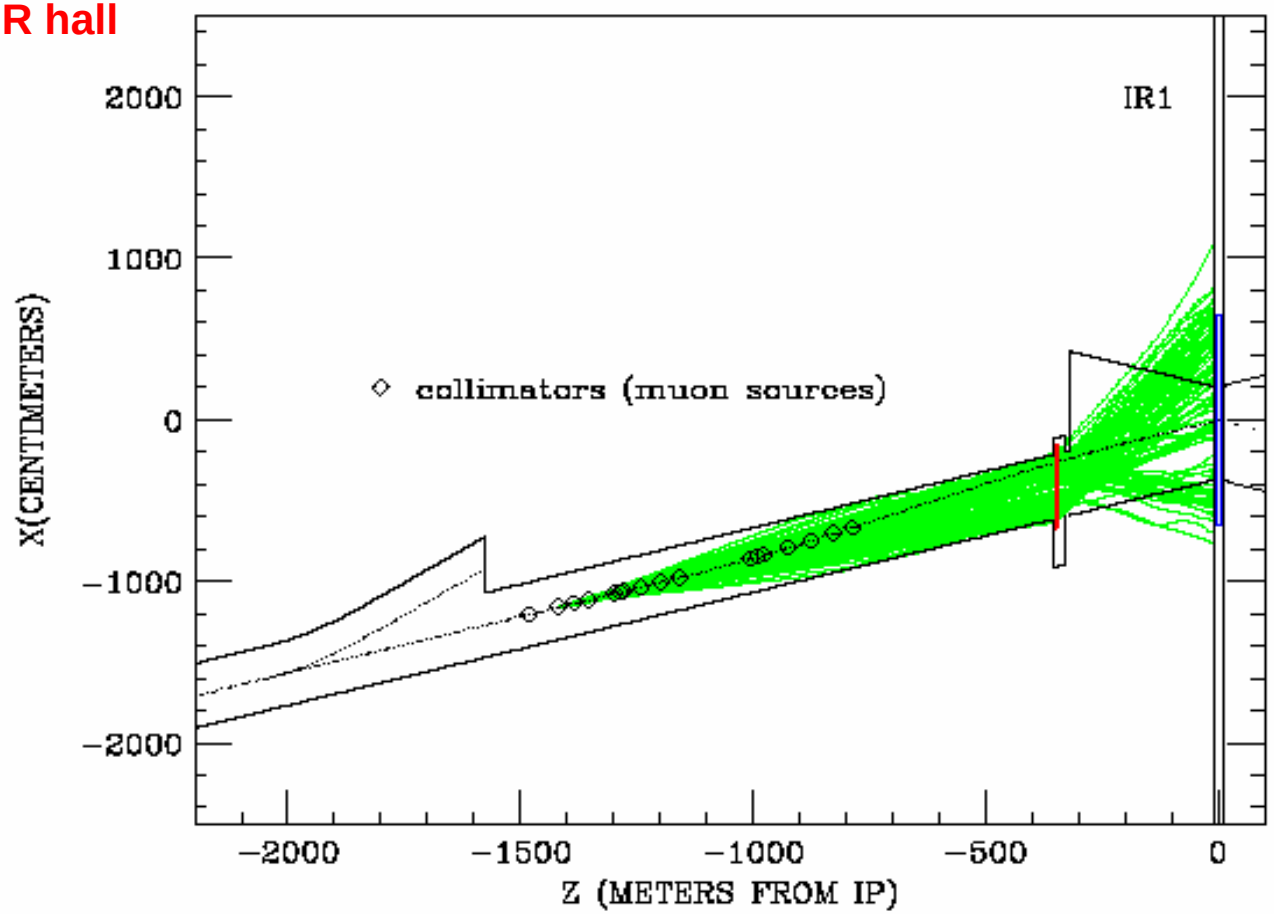
25rem/h

Asymmetrical shield, transverse iron disc between tunnel and Pacman, with loss 2 m upstream



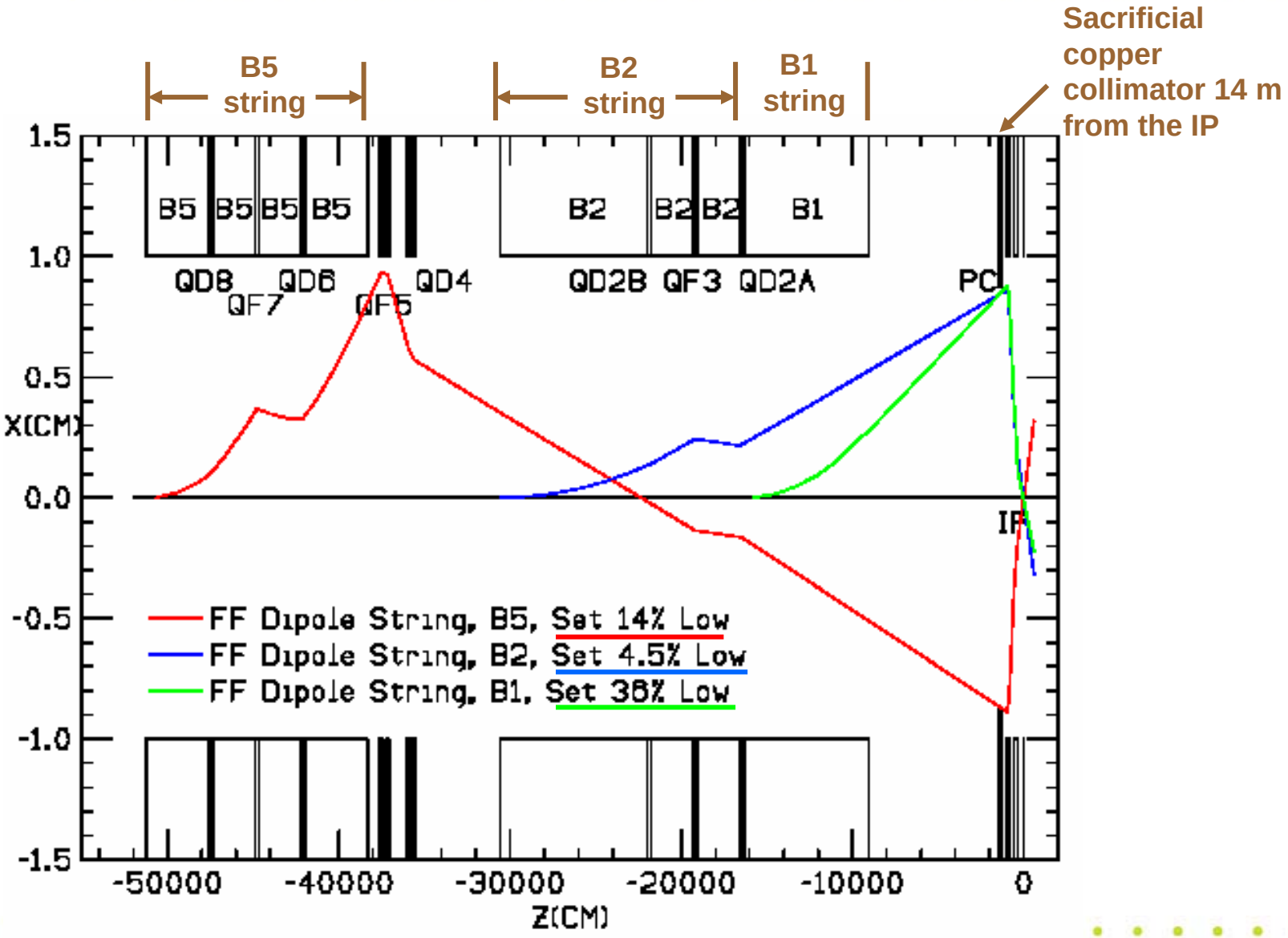
Question: Do muons from sources in the collimation section cause a dose rate problem outside a self-shielded detector?

Plot showing how the 5 m magnetized wall disperses muons from a single source which reach the IR hall



Answer: The estimated dose rate outside a 6.5 m radius detector from all sources, 0.1% collimated halo, both beams, is 0.045 mrem/h – SLAC limit is 0.05 mrem/h

Examples of FF Soft Bend Mis-settings which Steer Bunches into the Final Doublet



Summary

- Normal operation :
  - **0.045 mrem/h muons from BDS collimator sections**
  - **Contributions from inside of detector and pacman will be small**
    - → less than 1W loss that gives less than 25rem/h / 18×10^6 = 0.0014mrem/h

- System Failure :
  - **Detector can reduce dose rate less than 25rem/h**
  - **Pacman is one weak point ← Should be improved !**

- Should be performed in near future
  - **Further calculation under the engineering design** (More gaps and holes)
  - **Consider beam loss scenario in miss-steering case**