Radiation Physics requirements for the IR

T.Sanami*, A.Fasso, L.Keller, A.Seryi , S,Rokni
SLAC

*Department associate, present address: KEK

Outline

Radiation Safety design of IR

Push-pull scheme

Comparison among sites

1. Target value of dose rate

2. Dose rate estimation for each detectors

Self-shielding type,

Non Self-shielding type,

Pacman

Possibility of shielding design

Feedback to IR engineering design

Introduction

- Push-pull scheme

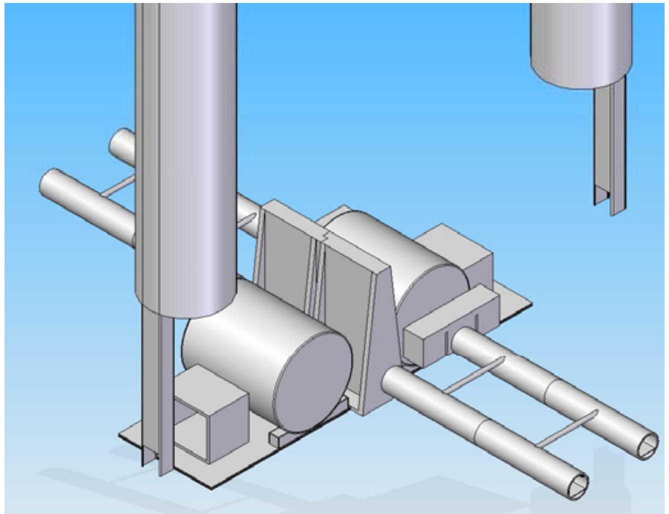
  → During one side operation, the other side could be occupied for construction or commissioning

- Area classification

  ← Site dependent

  → Dose rate limit for access

Look out for each other



John Amann
ILC Mechanical Engineering 10/24/06

Area classification : SLAC rule

- Normal operation
  - **0.5 μSv/h for GERT (General Employ Radiation Training)**
  - **5 μSv/h for Radiation Worker**
- Mis-steering
  - **4 mSv/h**
- System failure
  - **250 mSv/h and 30 mSv/event**

(from SLAC-I-720-0A05Z-002-R001 Radiation Safety Systems (Technical Basis Document, April 2006))

Area classification : LHC design

- Normal operation
  - **0.1 μSv/h for Non-designated area**
  - **1 μSv/h for Supervised area**
  - **3 μSv/h for Simple controlled area**

- Total beam loss
  - **0.3 mSv/h for Non-designated area**
  - **2.5 mSv/h for Supervised area**
  - **50 mSv/h for Simple controlled area**

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

Area classification : KEK (Belle)

- Normal operation
  - **0.2 μSv/h for Non-designated area**
  - **1.5 μSv/h for Supervised area**
  - **20 μSv/h for Simple controlled area**

- Mis-steering beam loss
  - **1 hour integration of dose rate should not exceed 1.5 μSv/h using radiation monitor.**
    (Terminate injection and wait 1 hour)

Belle Experimental floor:

Supervised area

Shielding capability

- To evaluate strawman models

→ 250 mSv/h for total (18 MW) beam loss
(SLAC system failure)
= **14 μSv/h for 1 kW beam loss**

GERT access (0.5 μSv/h) on experimental floor
Normal beam loss should be less than **36 W**

Mis-steering (4 mSv/h) on experimental floor
Beam should be turn-off less than **57 sec**

Shielding capability (Cont.)

- Shielding: **<u>250 μSv/h for 18 MW beam loss</u>**
- Normal beam loss: less than **<u>36W</u>**

  < 0.5 μSv/h on experimental floor
- Mis-steering: turn-off less than **<u>57sec</u>**

  < 4 mSv/h on experimental floor

SLAC:	GERT access
LHC:	Supervised area (turn off 35 sec because of 2.5 mSv/h)
KEK:	Supervised area

→ Design goal for evaluation of shielding structure

Evaluation for Strawman models

- 500 GeV, 18 MW beam loss

  → Design Goal : 250 mSv/h

- Beam loss point and material
  - **Design is available :**
    realistic component
  - **Design is not available :**
    pessimistic scenario, = 20 X_0 thick Cu target

- 3D Monte-Carlo simulation
  - **MARS-MCNP code**

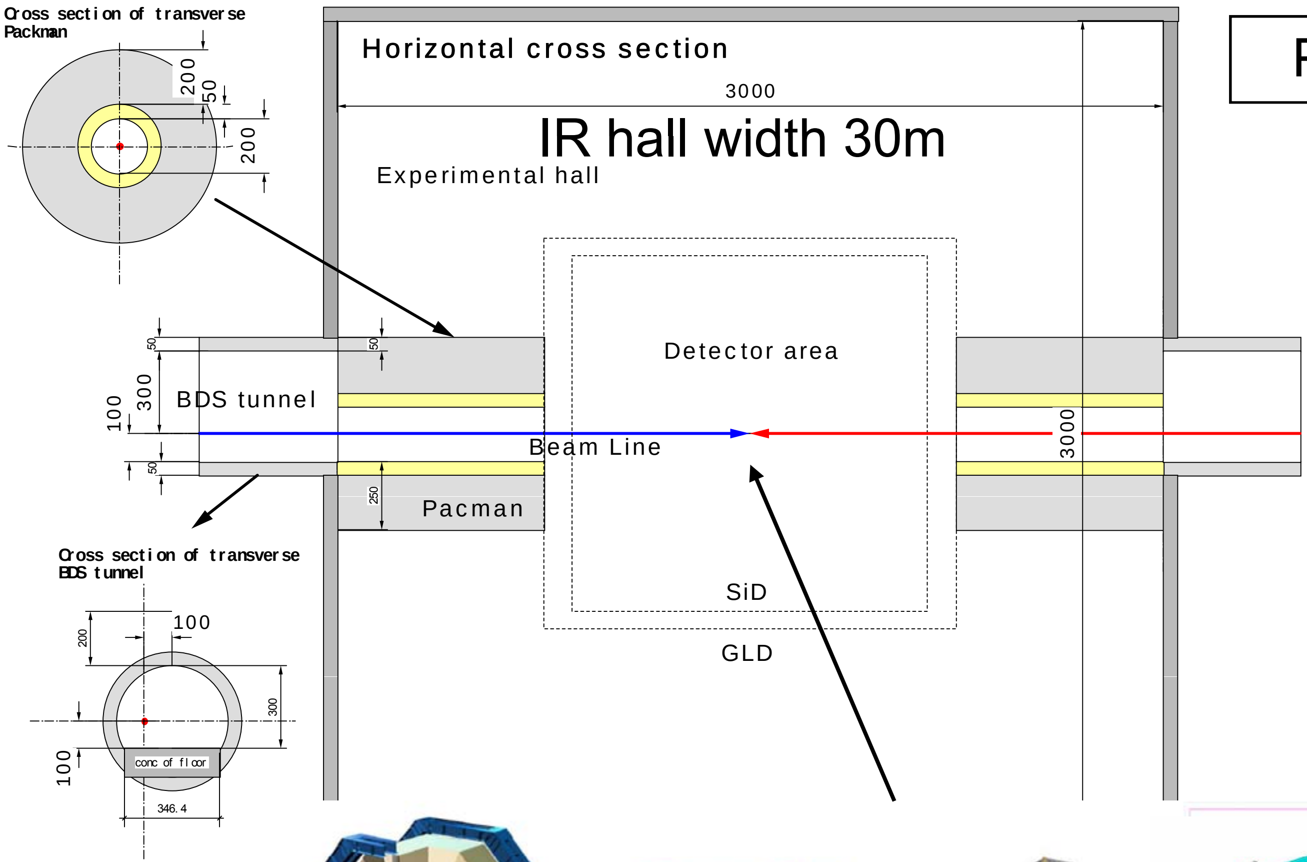
Experimental hall, BDS tunnel and Pacman

2m ID

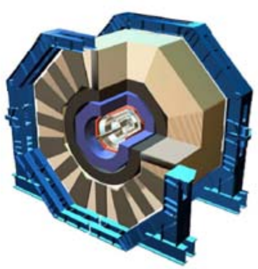
0.5m Fe

2m Conc.

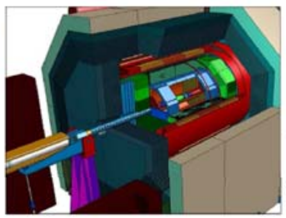
4m ID



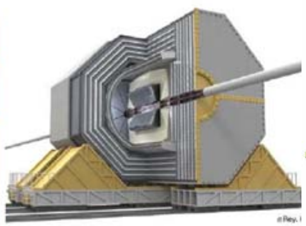
Plan view



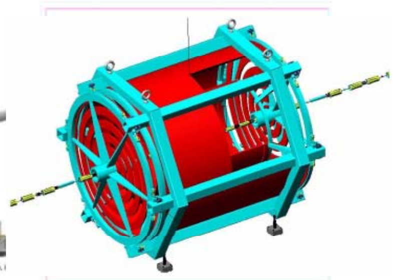
SiD



LDC



GLD

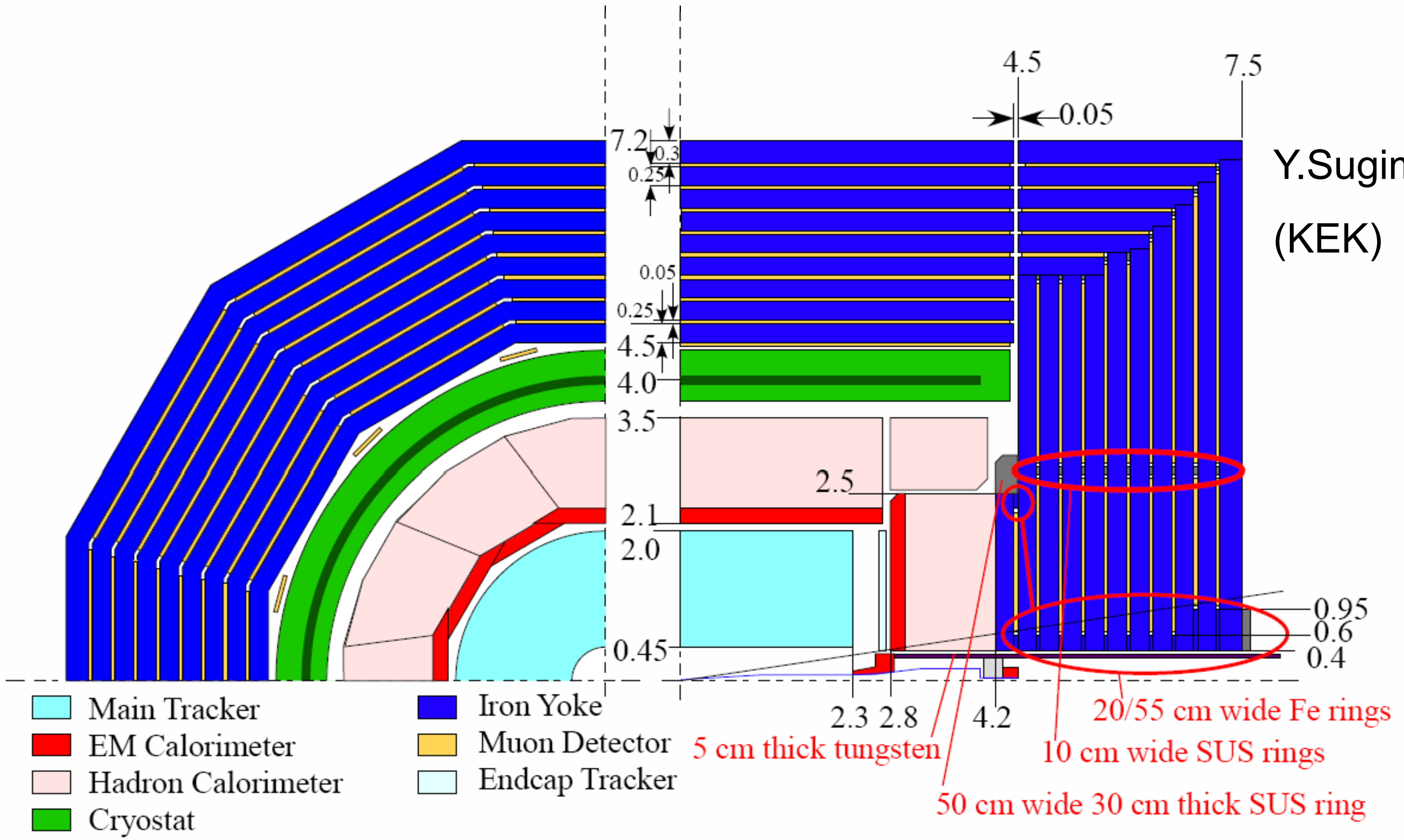


4th

Self shielding detector : GLD

Case #	Detector	Target	To know
1	GLD	FCAL	Self-shielding capability of detector
2	GLD	Cu $20X_0$@BDS	Check weak point of Pacman

GLD

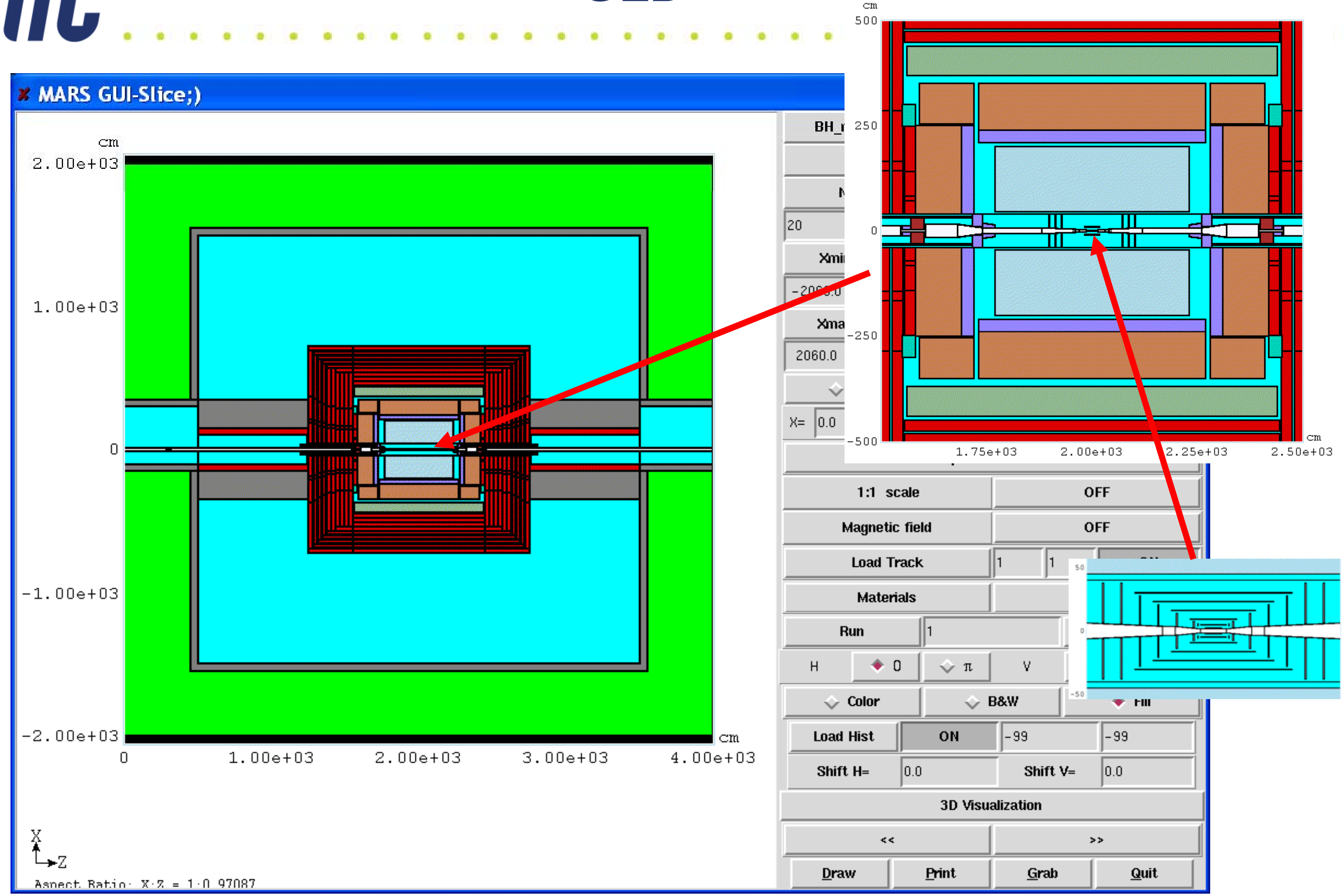


Y.Sugimoto

(KEK)

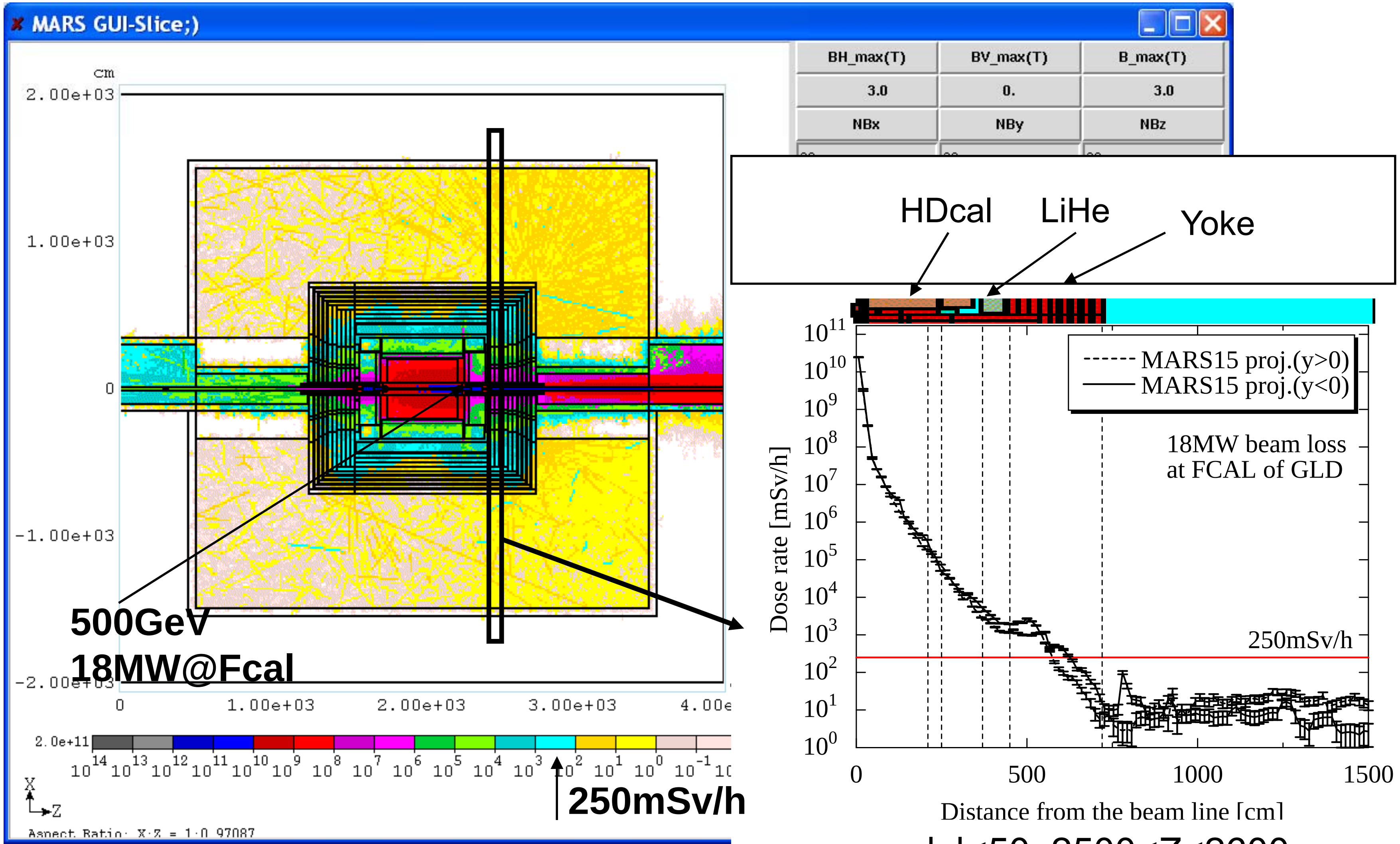
- Iron Yoke: 2.7m thick + Hadron and EM cal.
- Effect of 4.5 cm Gap

GLD



*Cryostat, magnet and beam line are not included

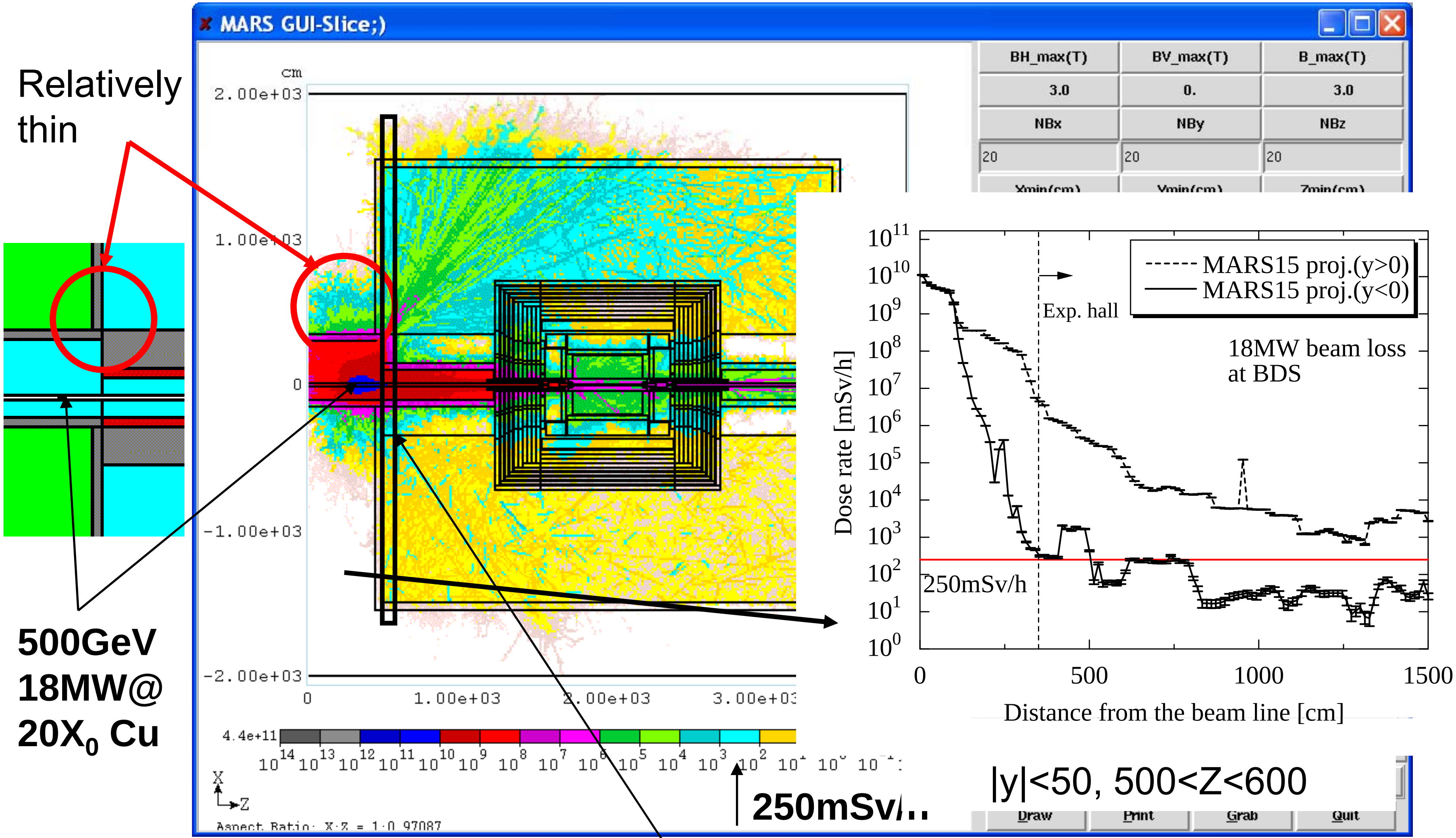
Result #1 GLD FCAL hit case



|y|<50, 2500<Z<2600

Result #2 Beam loss in BDS tunnel

Relatively thin



500GeV 18MW@ $20X_0$ Cu

250mSv/h

|y|<50, 500<Z<600

Local shield will be required

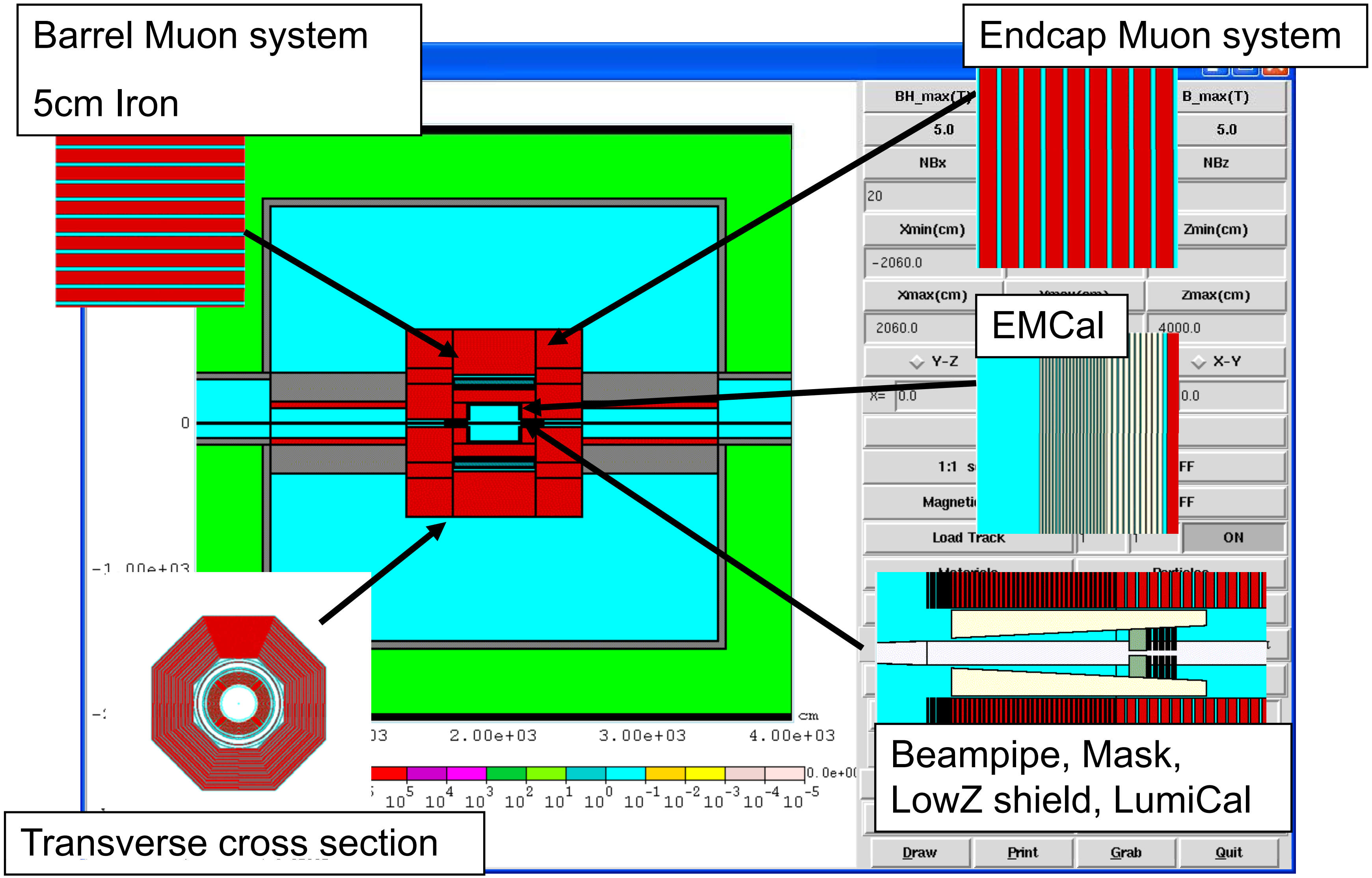
Self shielding detector : SiD

Case #	Detector	Target	To know
3	SiD	LowZ	Overall self-shielding capability of detector

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

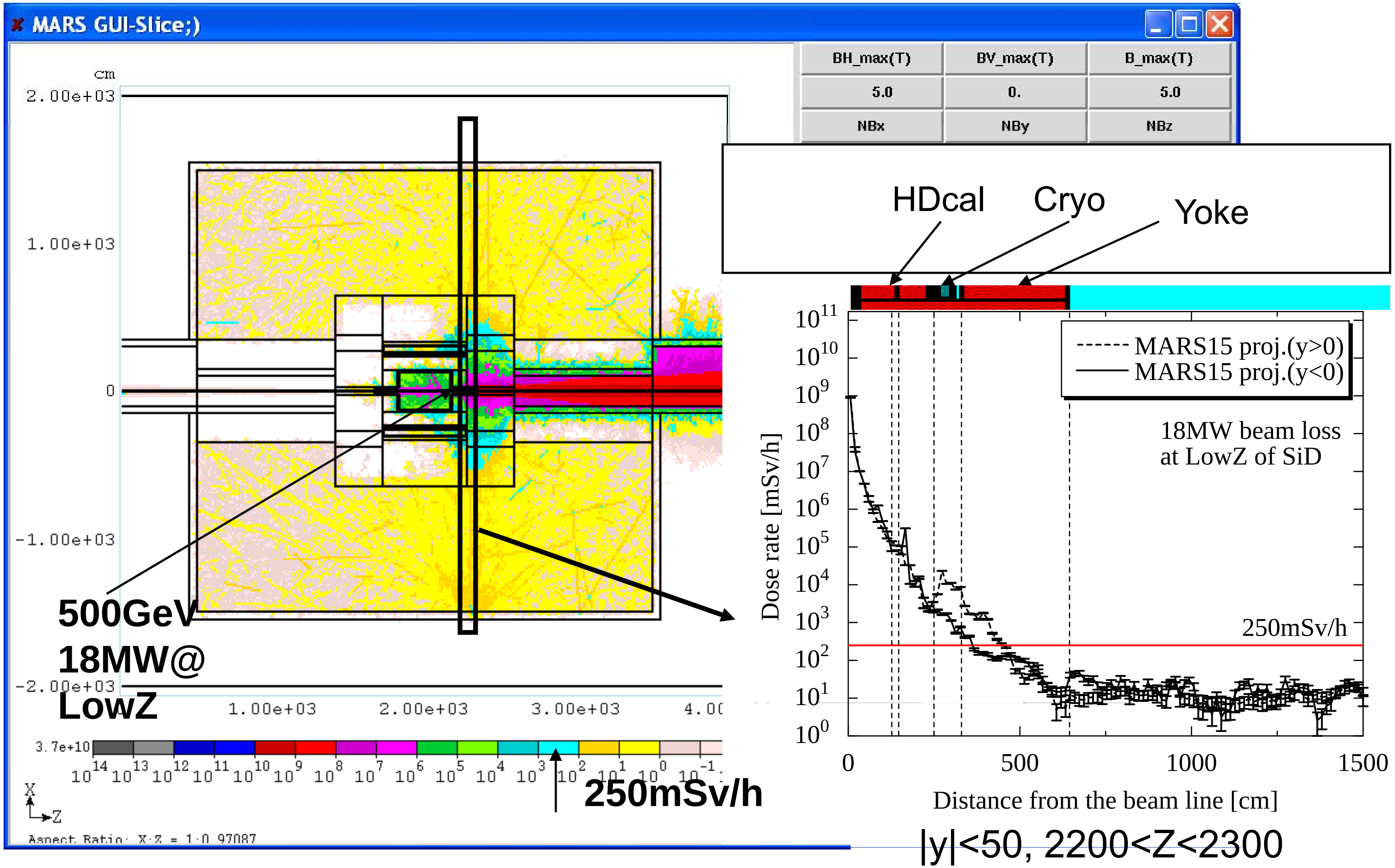
- Iron Yoke: 2.4 m thick + Hadron and EM cal.
- Effect of 0.5 cm and 4cm gaps (space for muon detector) in endcap

SiD



***Cryostat, magnet and beam line are not included**

Result #3 SiD LowZ hit case

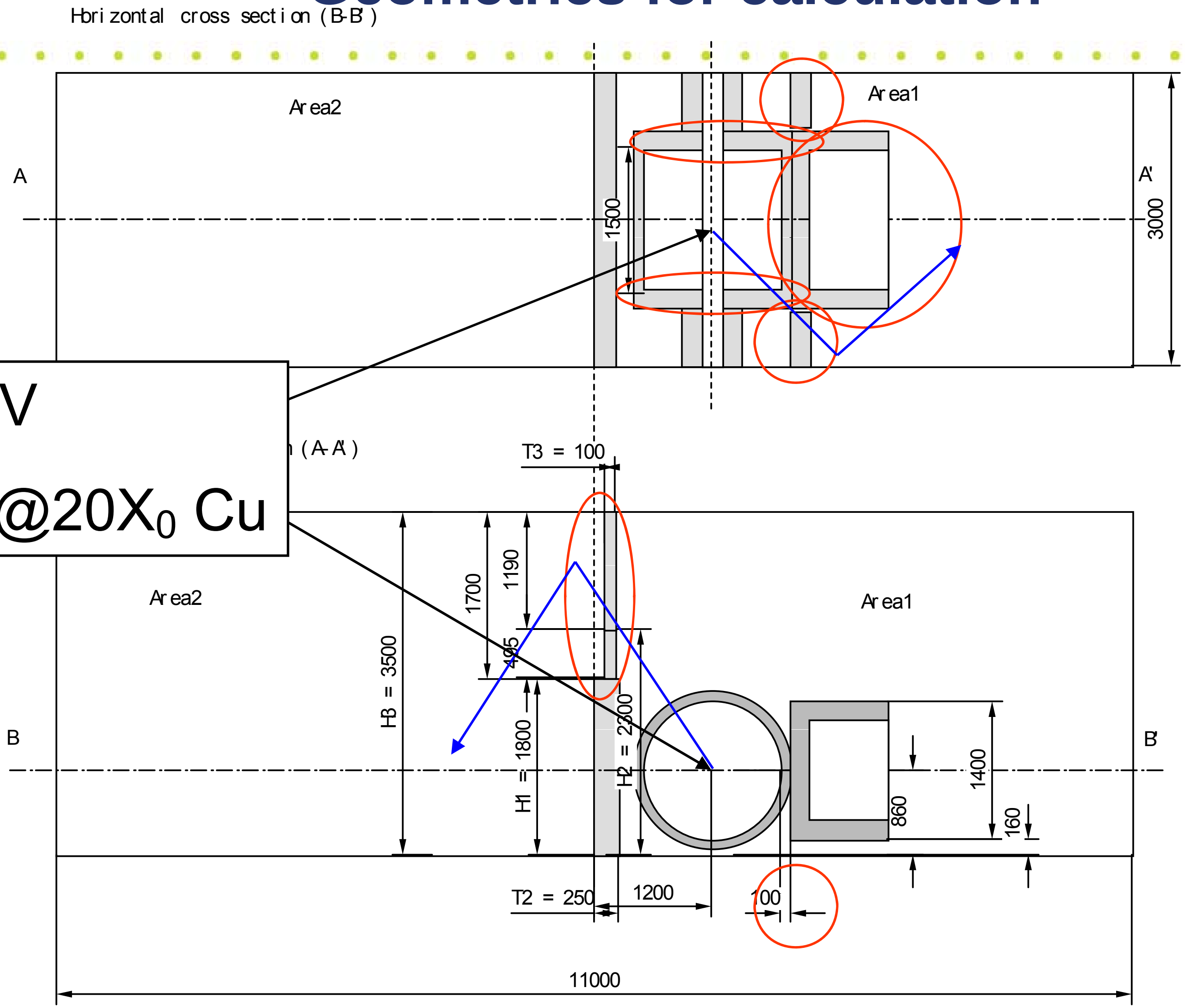


Non self shielding detector : 4th concept

Case #	Detector	Target	To know
4	4th	Cu 20 X_0	Possibility of shielding

- Iron Yoke: 0.0 m thick + Hadron and EM cal.
- Requirement of shielding

Geometries for calculation

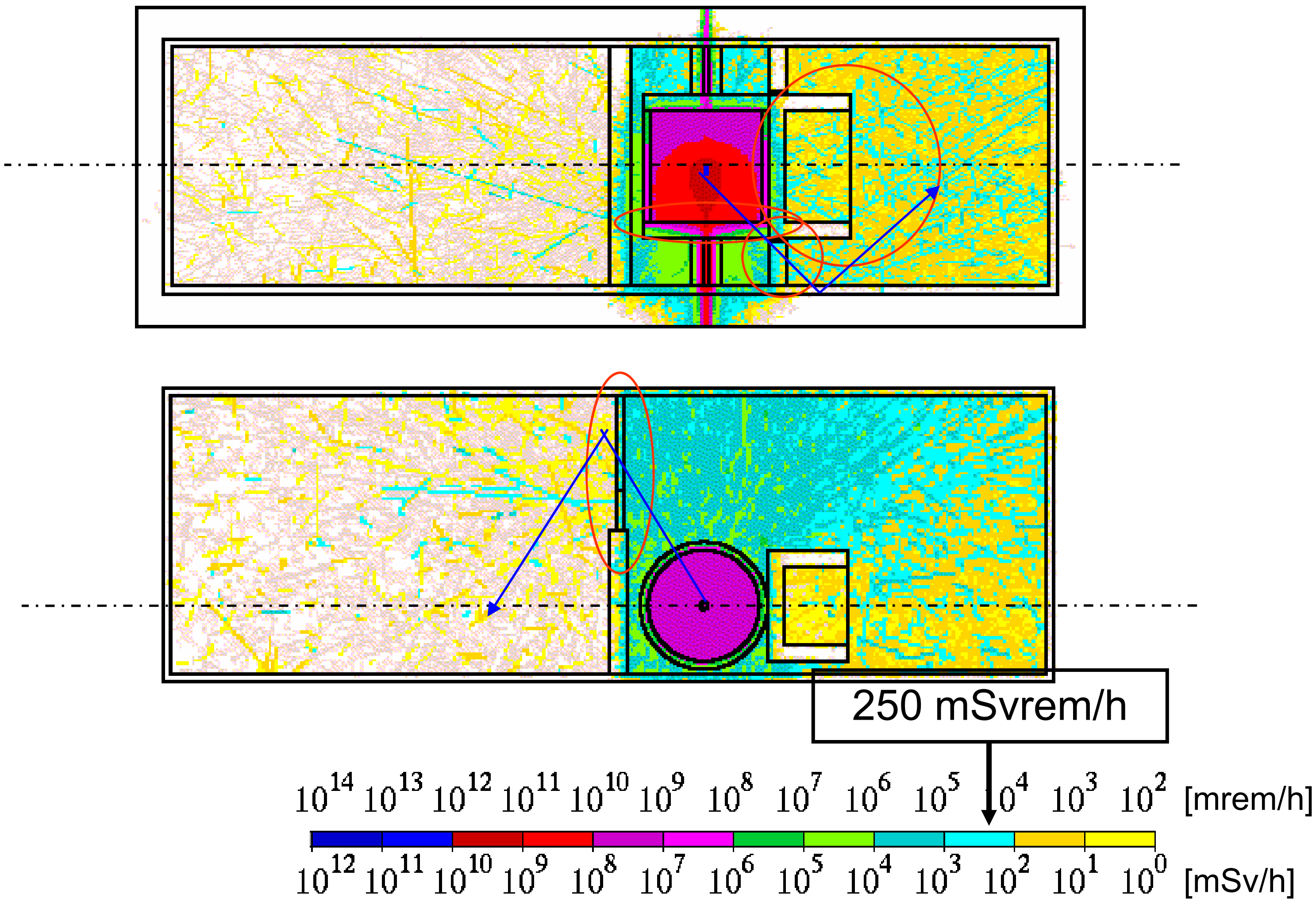


500GeV

18MW@20X_0 Cu

Concrete shield around the detector and electronics

Result #4 4th concept case



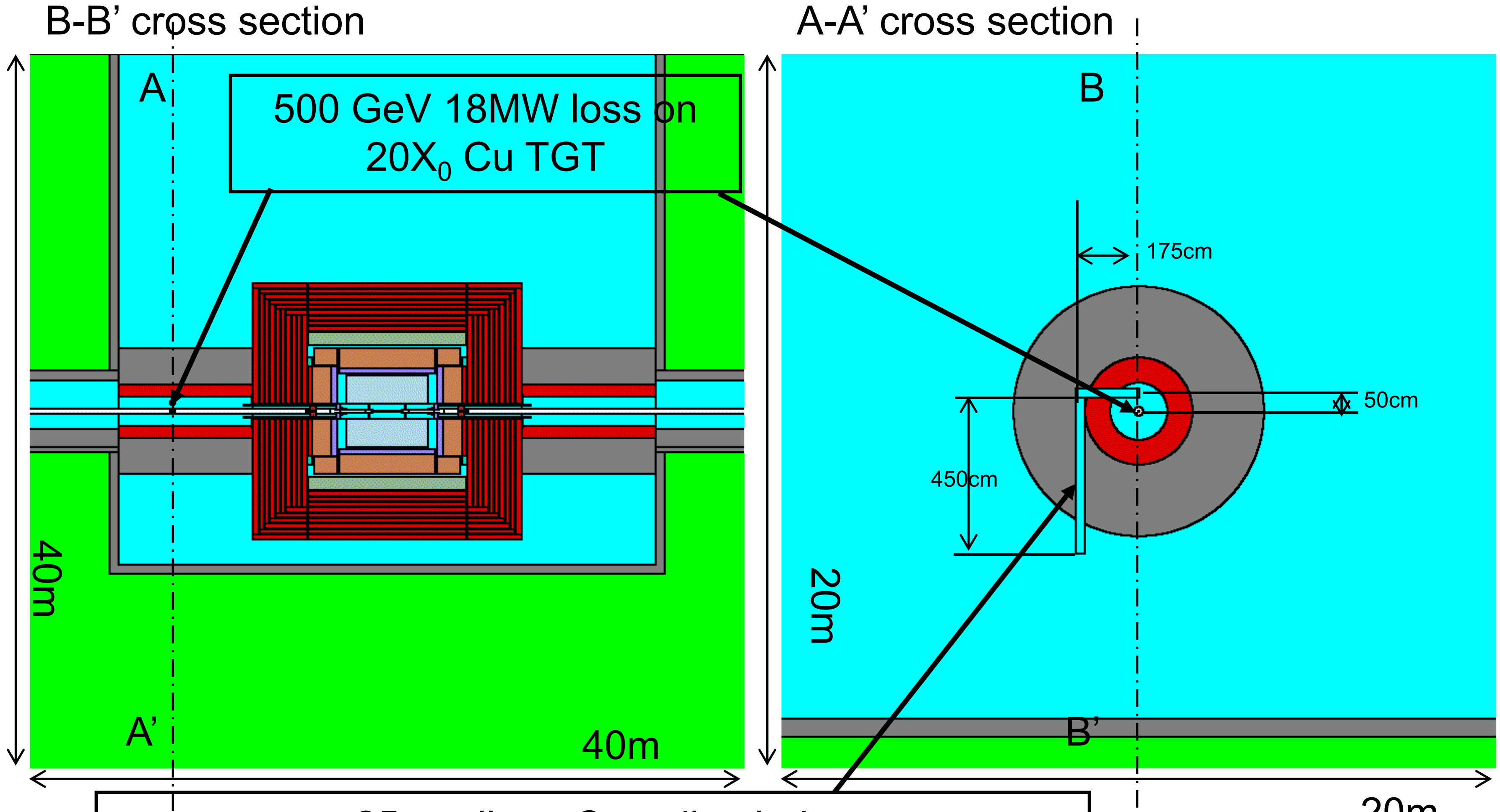
- ***Hadron Calorimeter, Cryostat, magnet and beam line are not included**

Cryo penetration

Case #	Detector	Target	To know
5	GLD	Cu 20 X_0	Penetration of pacman

- Pacman thickness
- Effect of cryo. penetration

25cm 1 knee geometry



25cm diam. Cryo. line hole

1st leg: 50cm above BL, 175cm L, 2nd leg: 450cm L

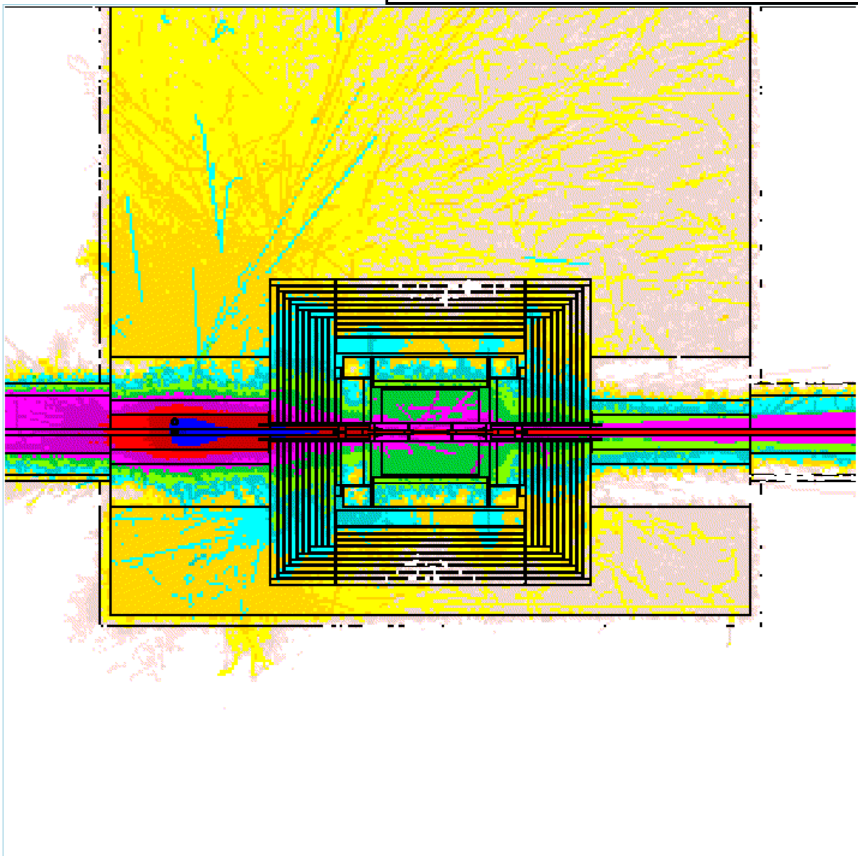
By MARS15 plotter

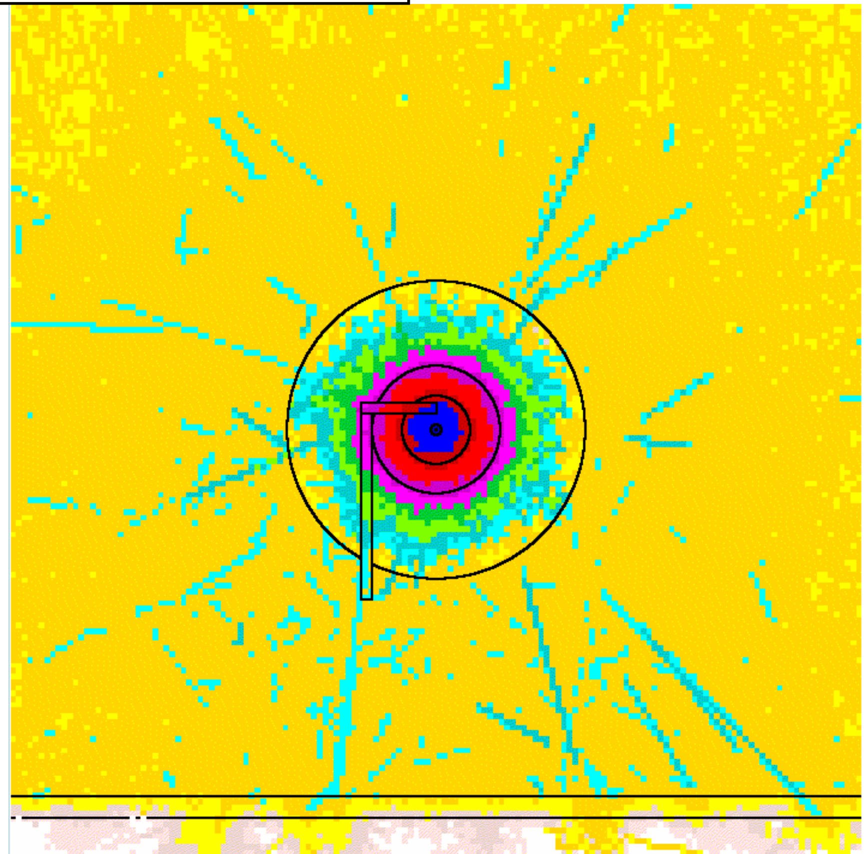
Detector: GLD, IR hall: 20m(L)x110m(W)x35m(H)

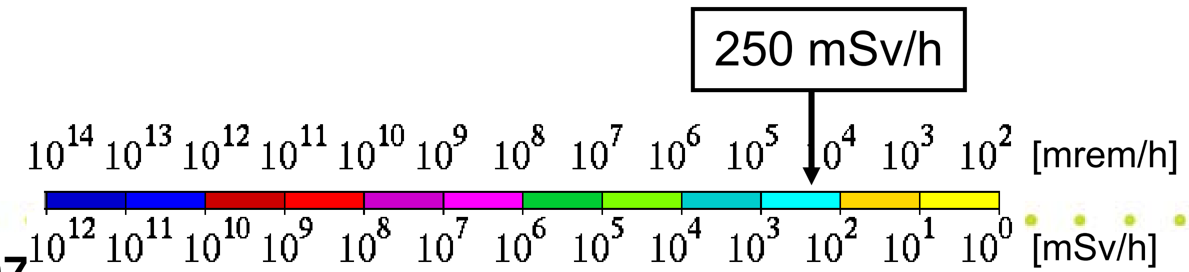
Pacman: ID:160cm, Iron 70cm, Conc 200cm → 16.2rem/h for 18MW (Shield11)

Result #5 25cm diameter, 1 knee penetration

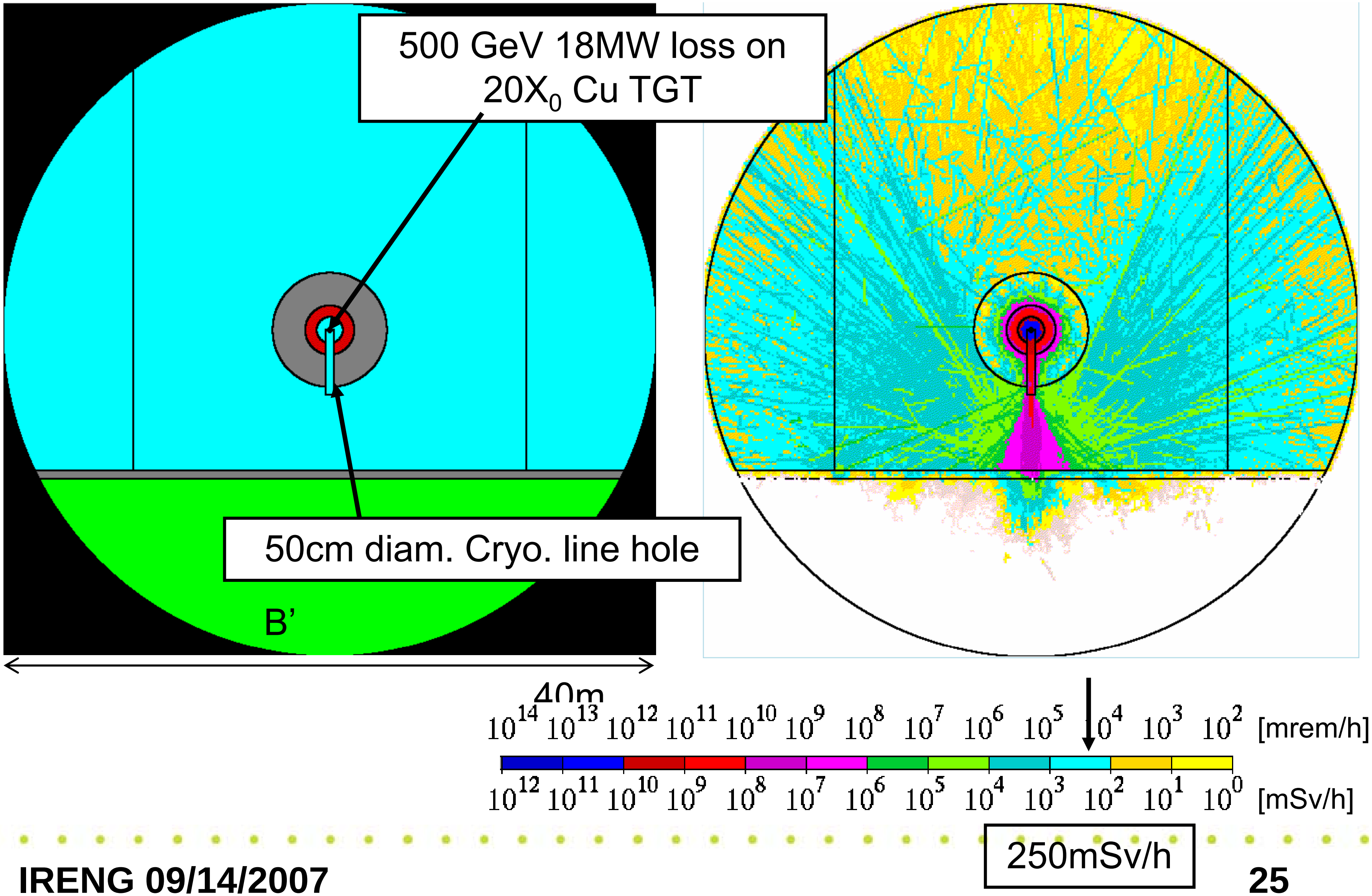
500 GeV, 18MW on $20X_0$ Cu cylinder







50cm straight geometry, no offset, no knee



Summary

- Possibility to satisfy 250 mSv/h for 18 MW loss

  $\rightarrow$ **GERT access, Supervised area**
  - **Self-shielding detector**
  - **Concrete shield with non-self shielding detector**
  - **Penetration through Pacman**

- Next Step
  - **Simulation with beam line components**
    - Cryostat module, Anti-DID solenoid, etc.
  - **Effects from upstream**
    - Dose rate from upstream part (collimator loss)
    - Air activation

Supplement slides

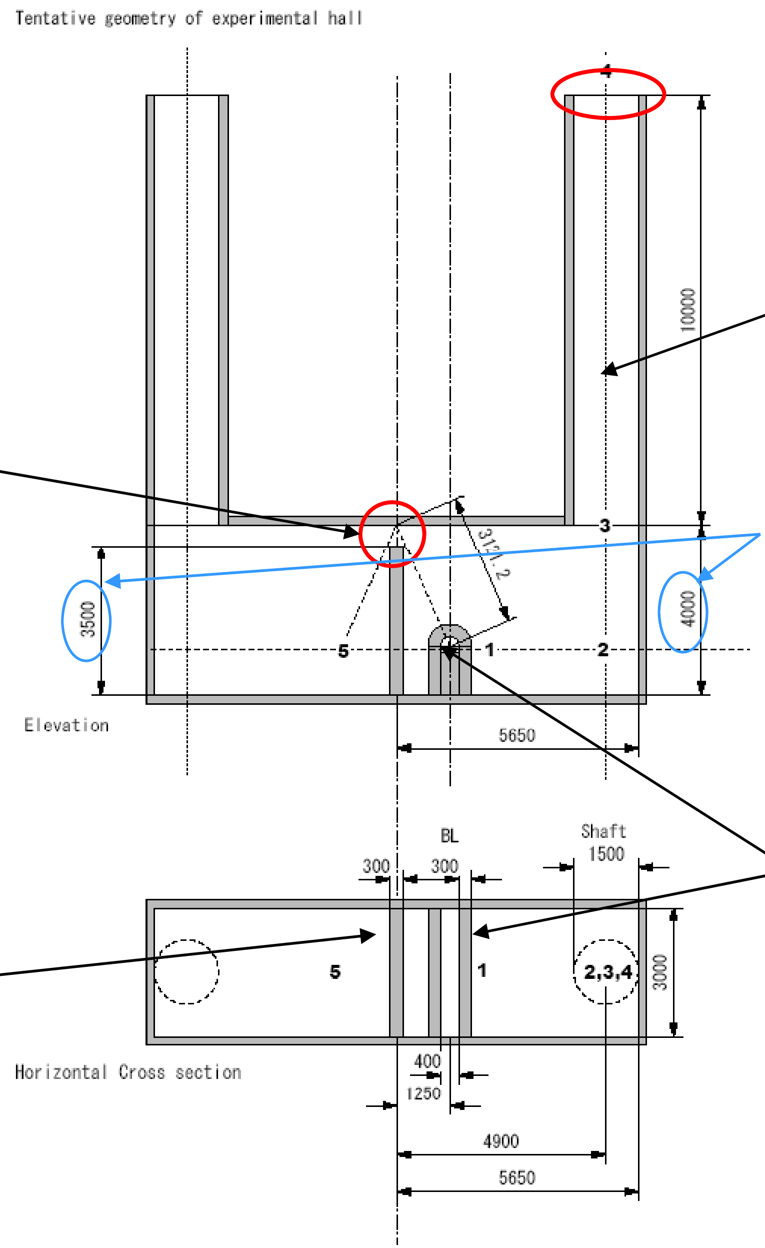
Beam loss distribution

- Normal operation
  - **Tracking to estimate beam losses**
    - Beam-Beam effect
    - Beam-Gas effect
    - Touschek effect,, etc
    - Beam loss position and amount
- Mis-steering situation
  - **Lay trace, Beam shut-off system**
- System failure
  - **Lay trace, Beam shut-off system**

Cover of shaft and wall between detectors

Case #	Detector	Target	To know
1	None (3m conc. around)	Cu $20X_0$	Requirement of shaft cover
2	None	Cu $20X_0$	Requirement of shaft cover and acceptable clearance for crane

Geometries for calculation



1. Shielding cover on access shaft over the IR hall

The shaft

Effect of gap on the top of the Wall

These values are not decided, yet

5m = 50-100t crane

Someone wants 400t class!

2. Dose rate distribution in experimental hall

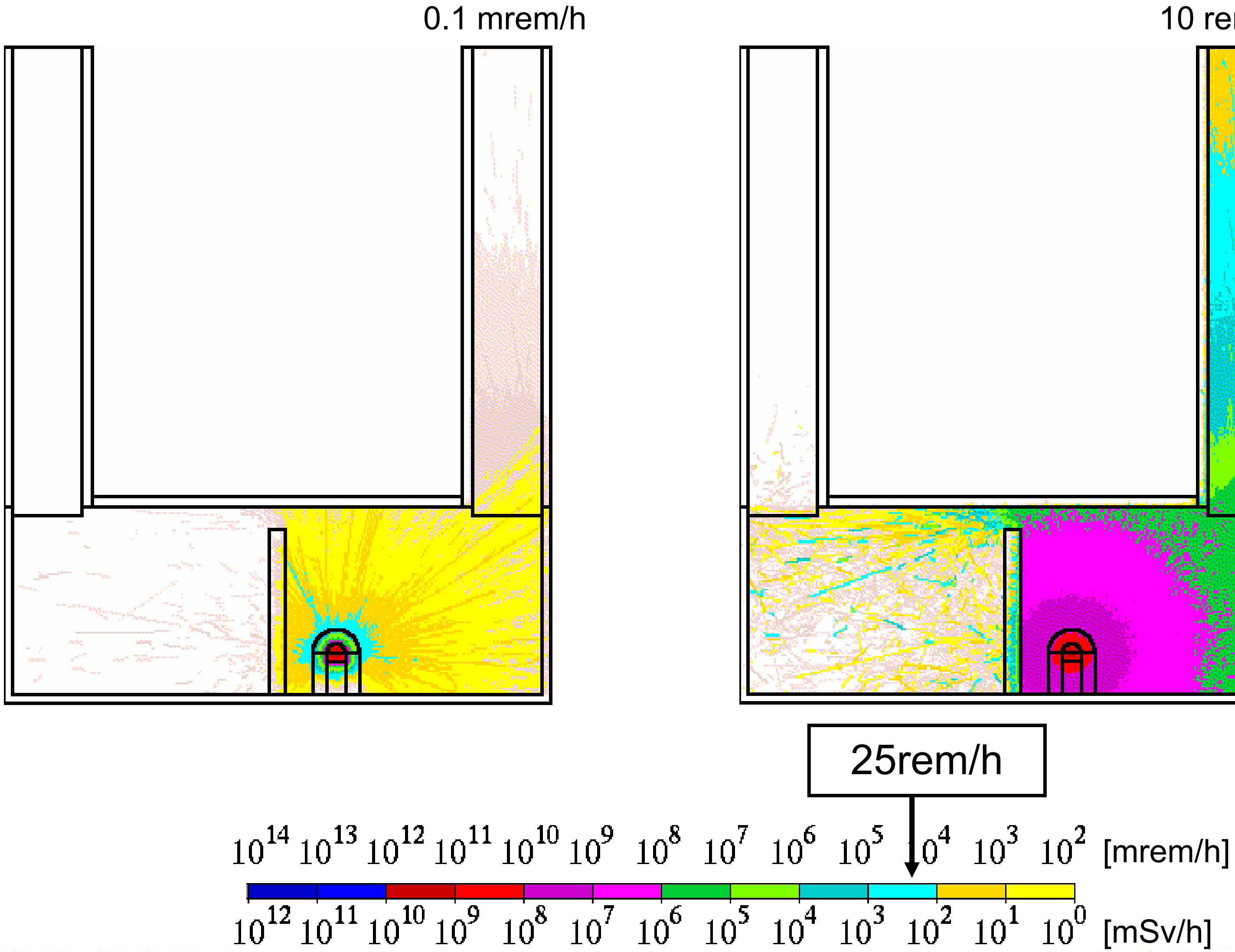
Beam line and

3m thick concrete shield

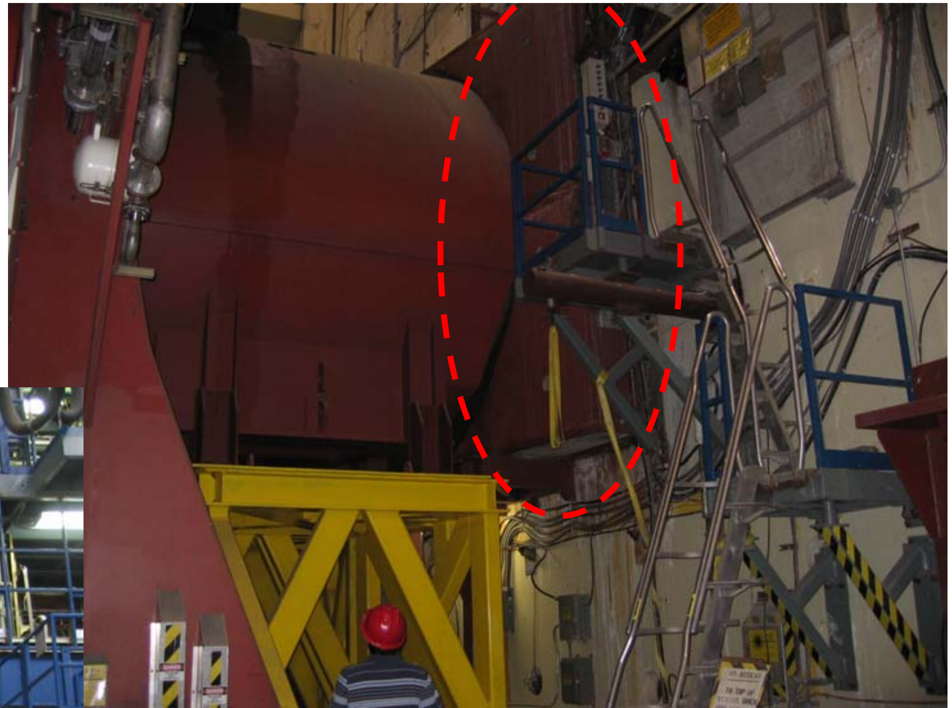
(for beam commissioning)

The wall between detectors

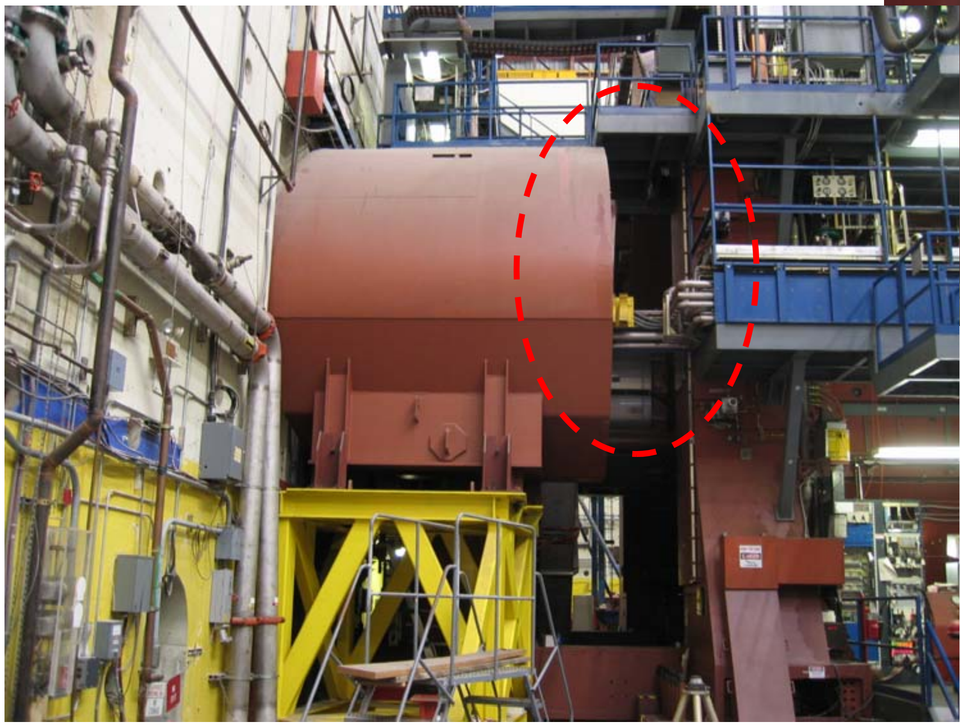
Results of calculation



Pacman



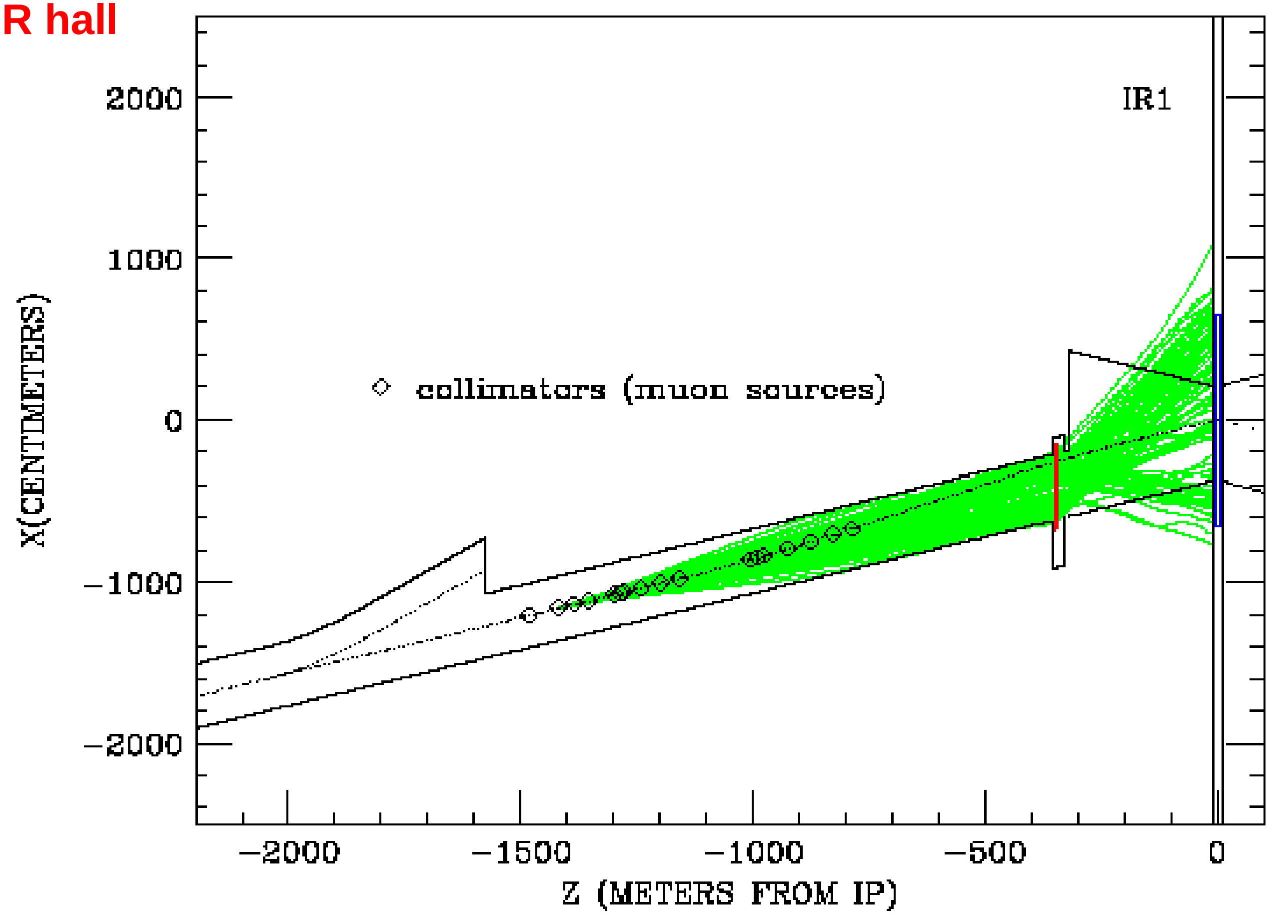
Open



Close

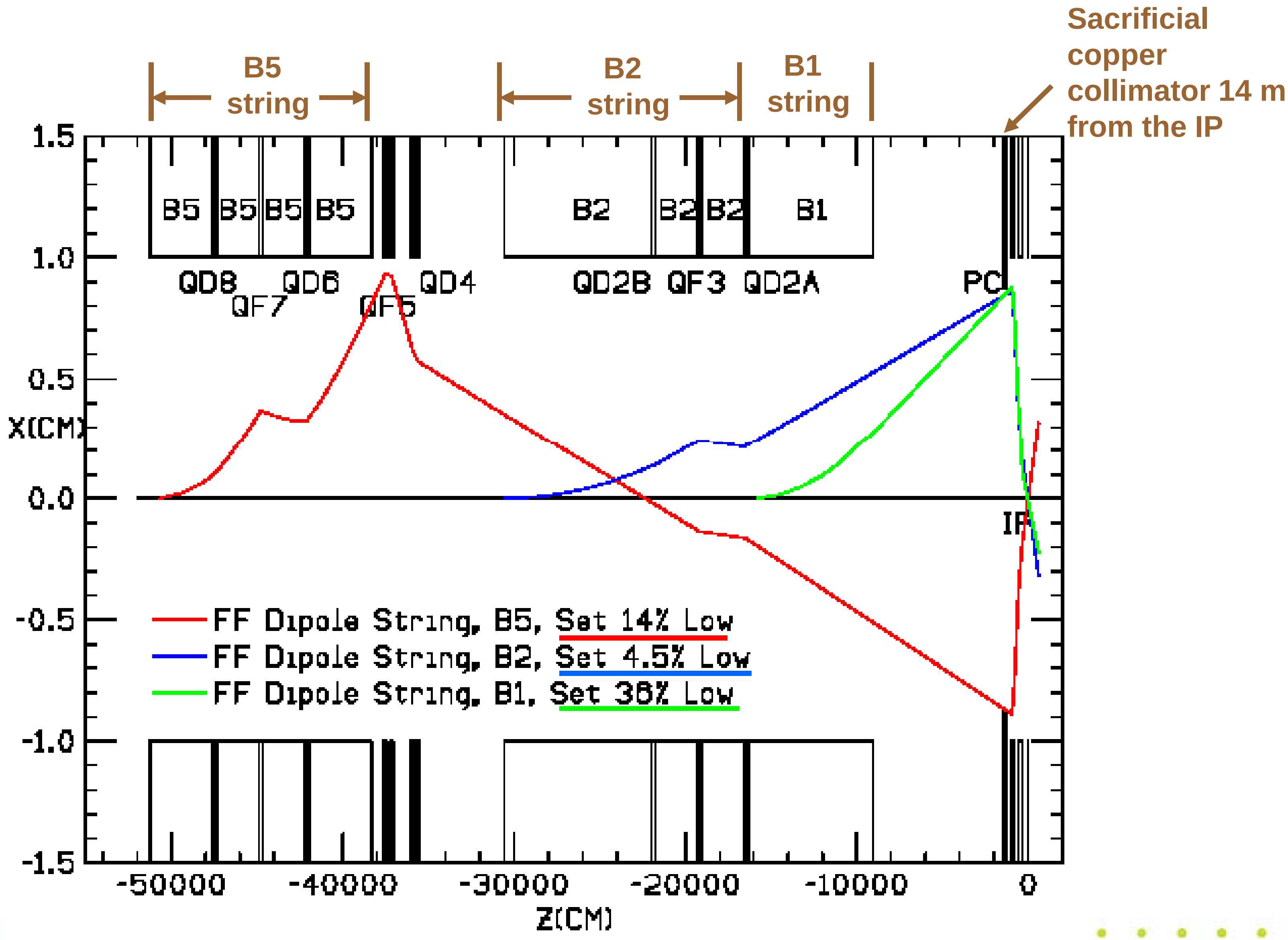
Question: Do muons from sources in the collimation section cause a dose rate problem outside a self-shielded detector?

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

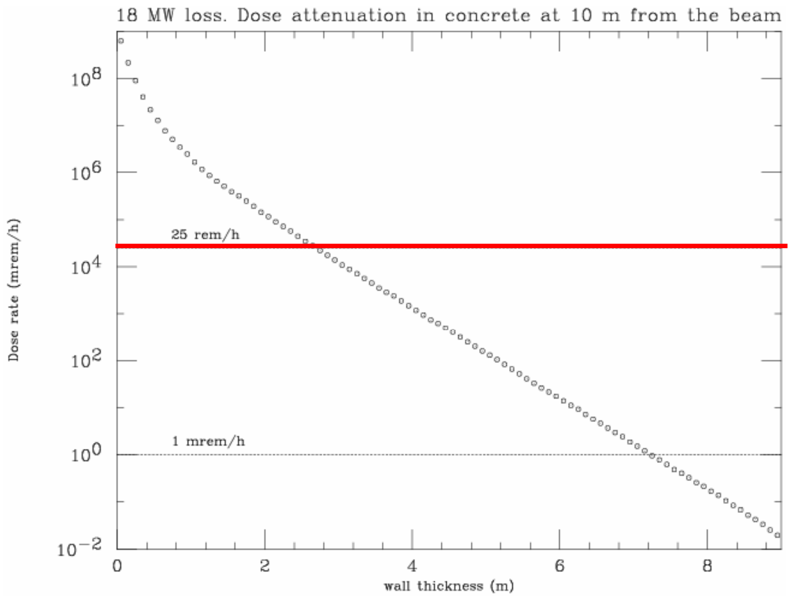
Examples of FF Soft Bend Mis-settings which Steer Bunches into the Final Doublet



- 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