

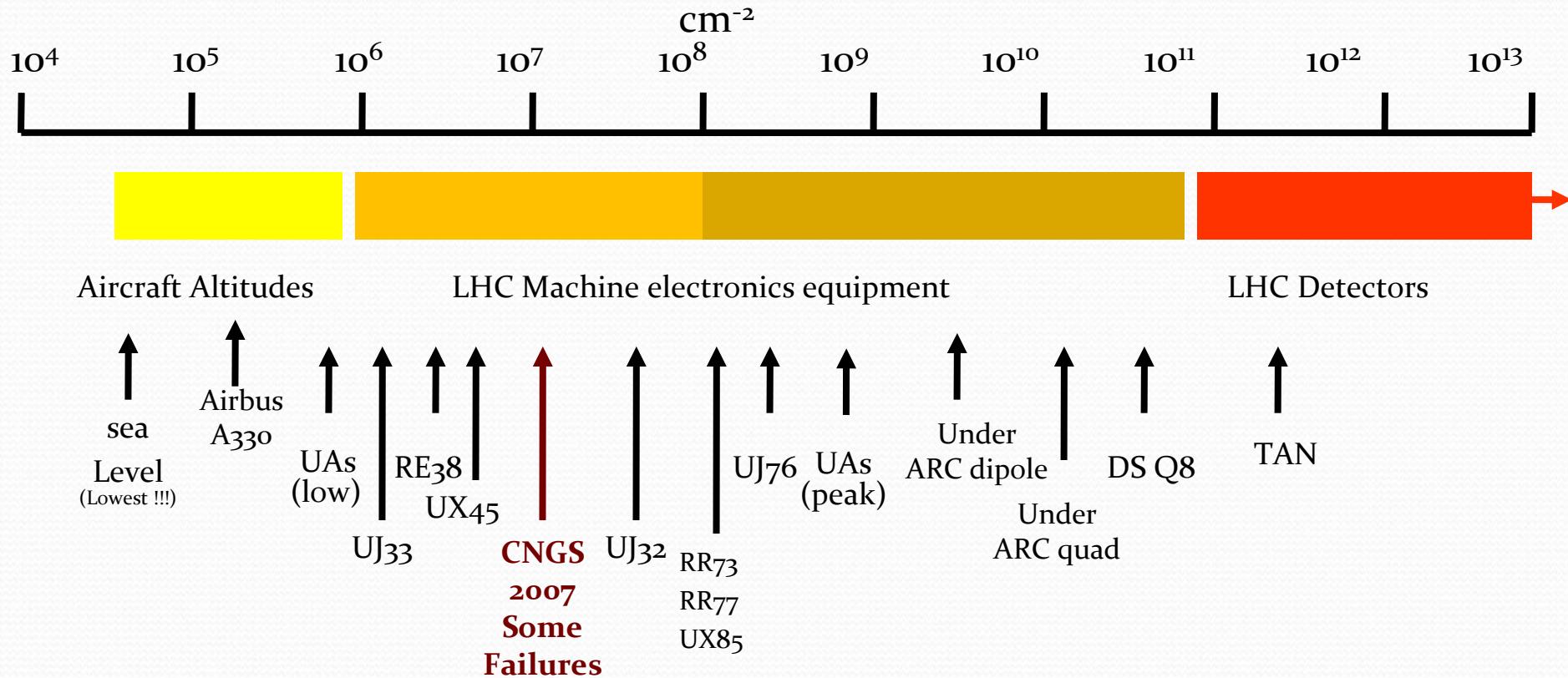
UJ76: summary of Fluka simulations

The FLUKA team

Outline

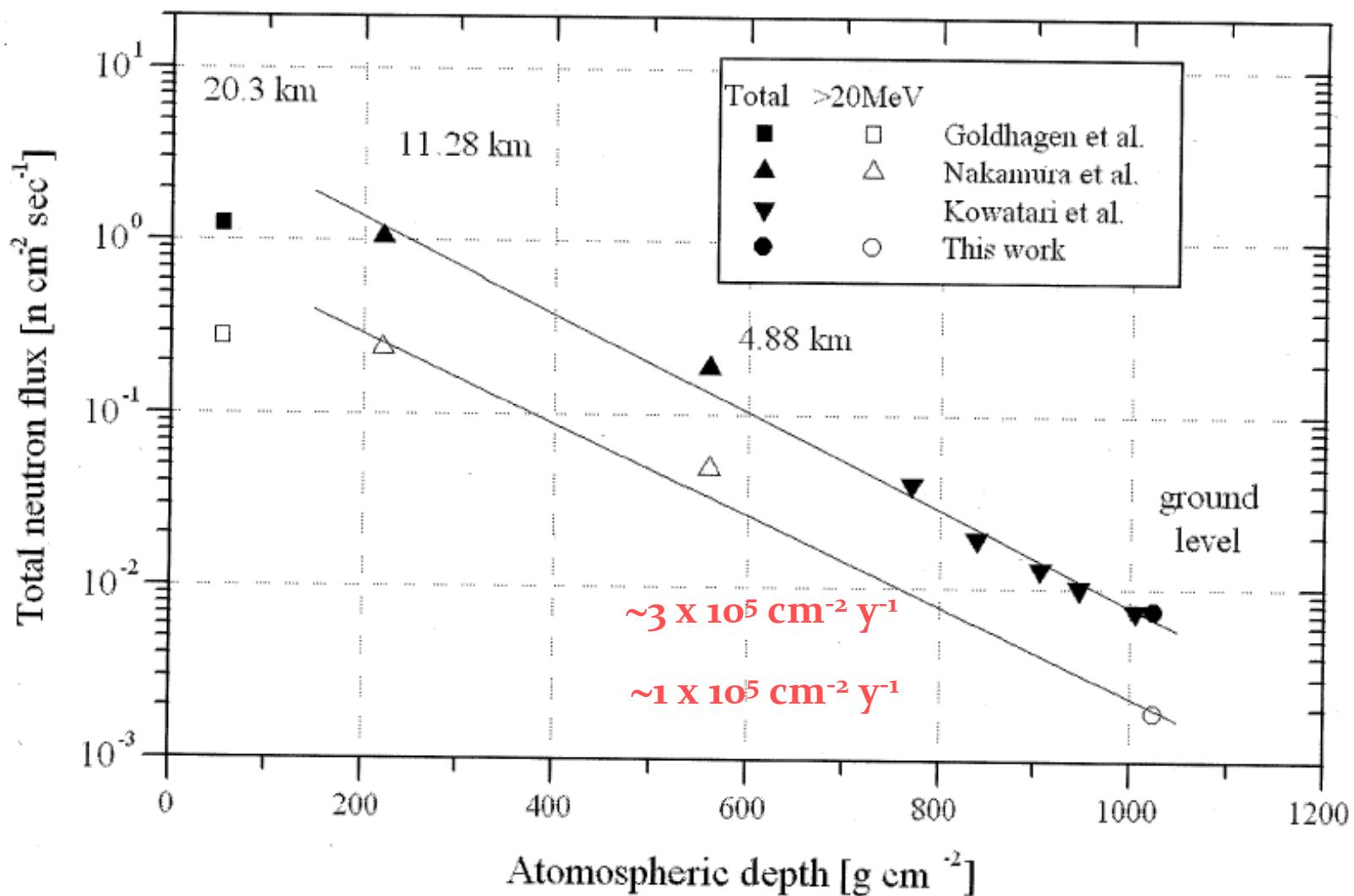
- High energy hadron fluence in LHC
- Fluka geometry of IR7 and UJ76
- Assumptions and normalization
- **Results of simulations**
- Radiation levels in UJ76 expected in the next years
- Analysis of relocation and shielding options
- Conclusions

High-Energy Hadron Fluences



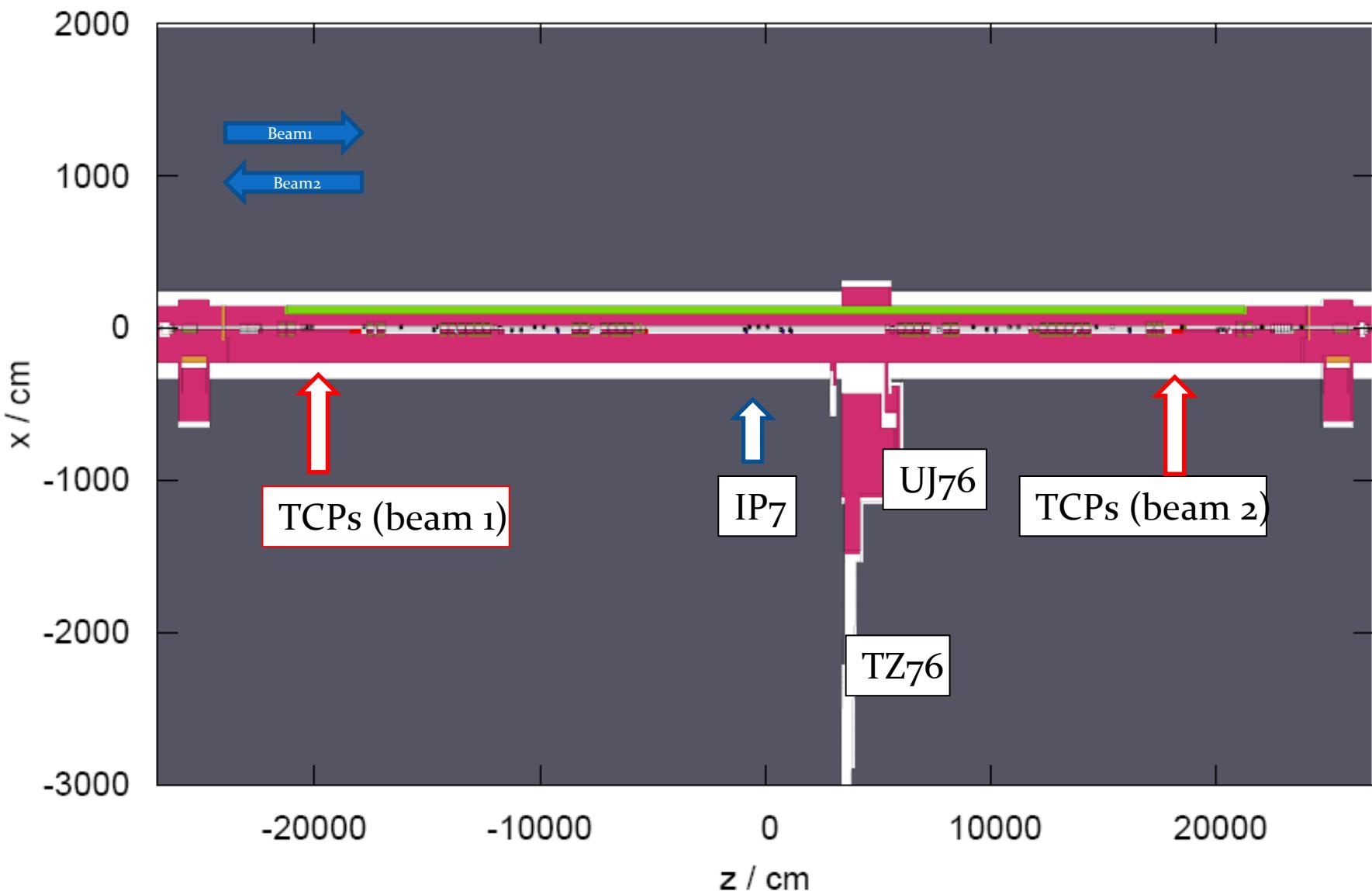
*e.g., some estimated LHC-Levels for Hadrons
($E > 20 \text{ MeV}$) per cm^2 per nominal year*

Neutron flux (> 20 MeV) in the atmosphere

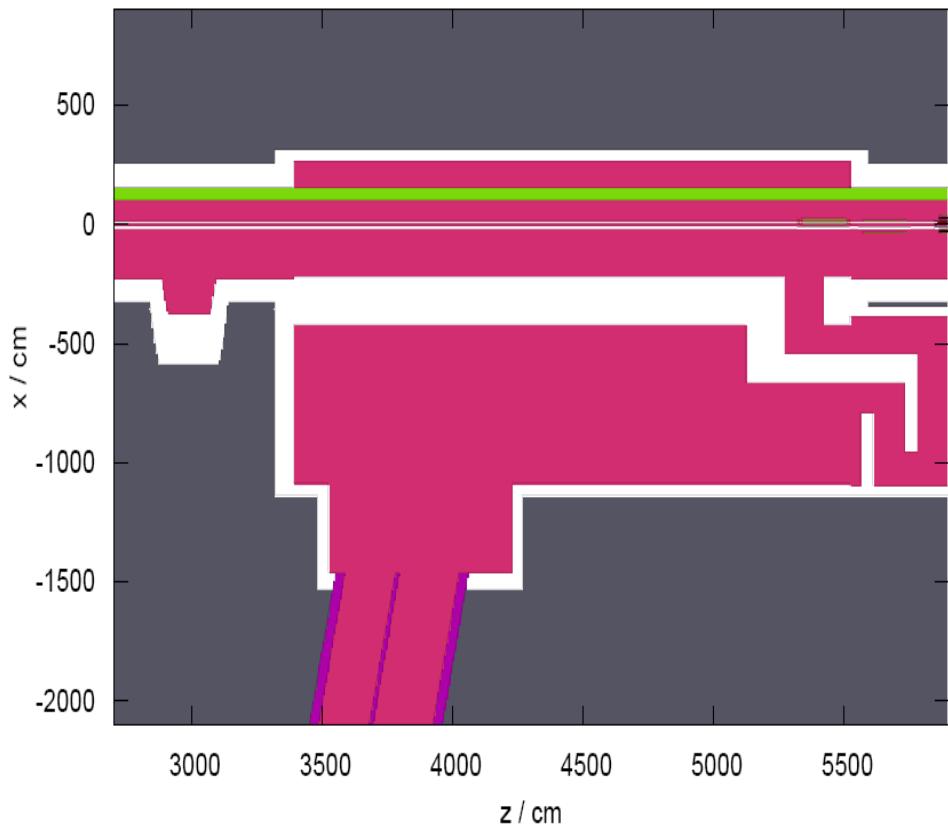
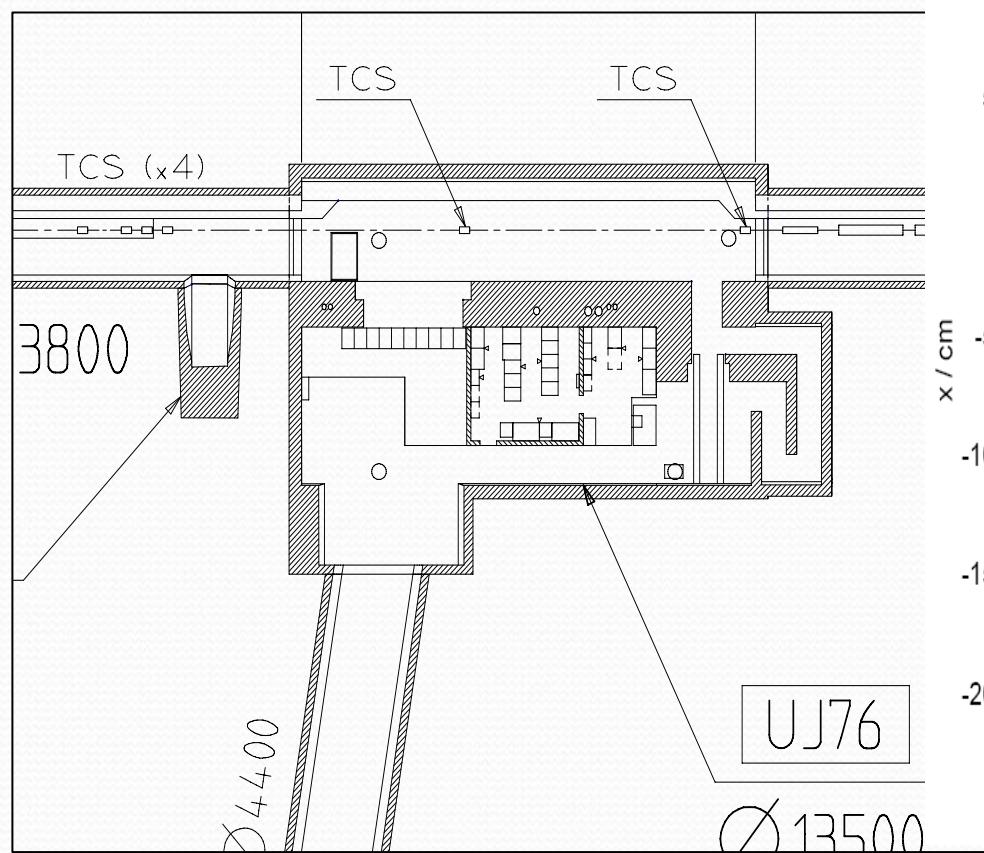


© Nakamura et al.: Terrestrial Neutron-Induced Soft Errors in Advanced Memory Devices

Fluka geometry:IR7



Fluka geometry:UJ76



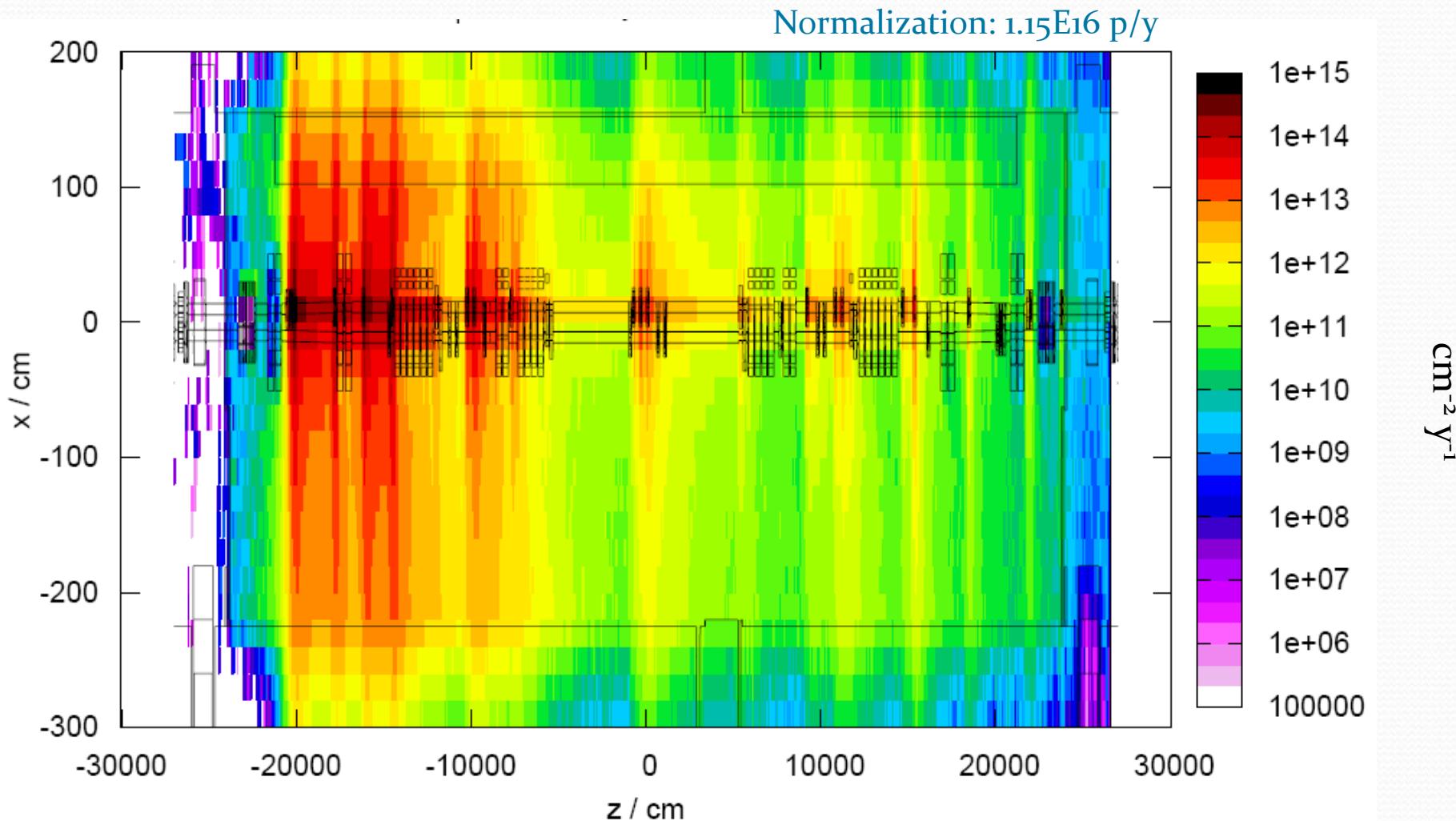
(Pass-through holes have been included in geometry and assumed completely empty)

Assumptions

- Nominal machine at 7 TeV has been considered
- Source of losses: collimation
(loss maps obtained with SIXTRACK and provided by AB/ABP, R. Assmann et al.)
- Proton lost per year in IR7:
 2.3×10^{16} p/y (both beams)
- Only beam 1 has been considered (results should be multiplied by a factor ~2)

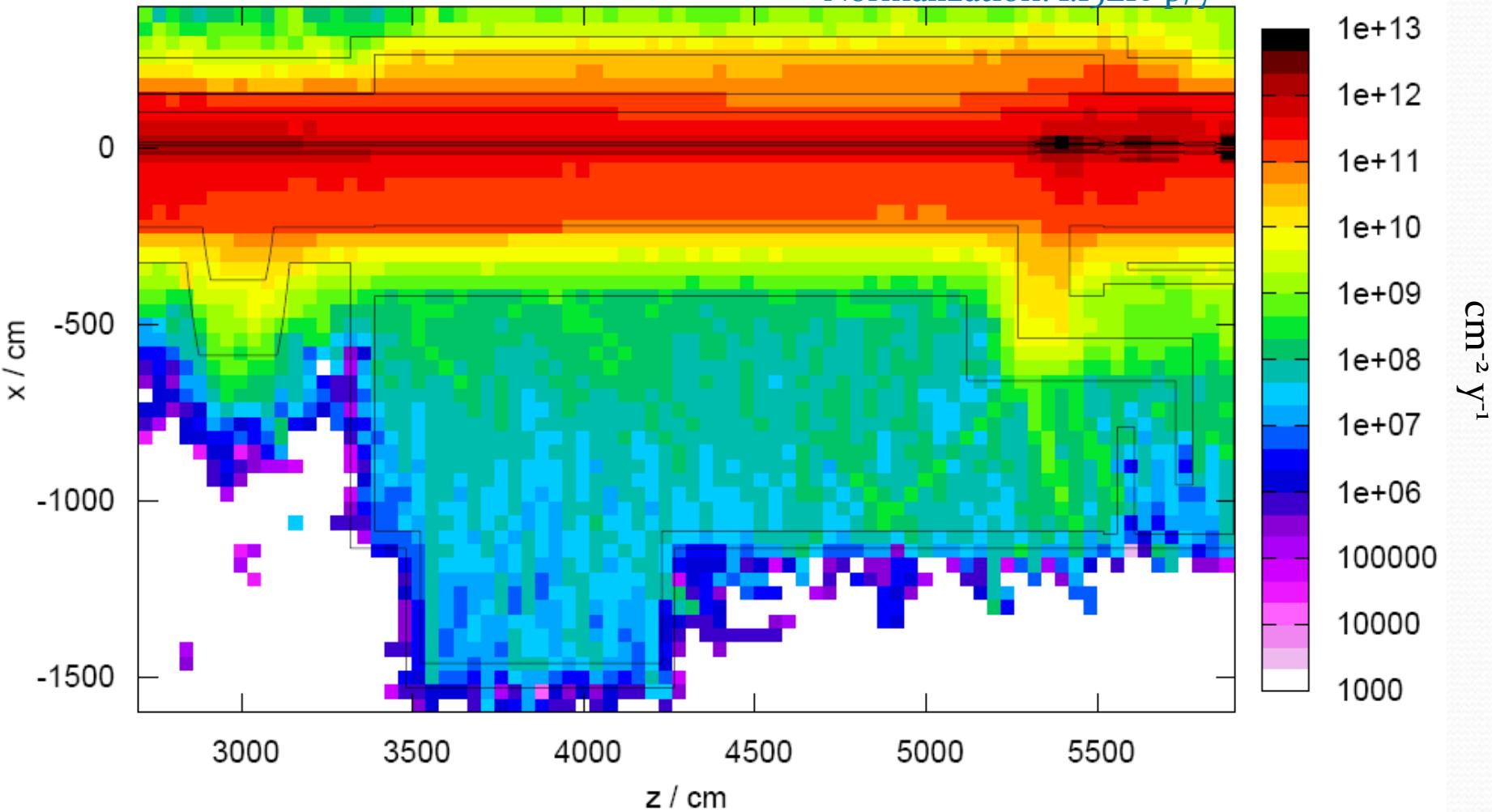
High energy hadron fluence

(full geometry)



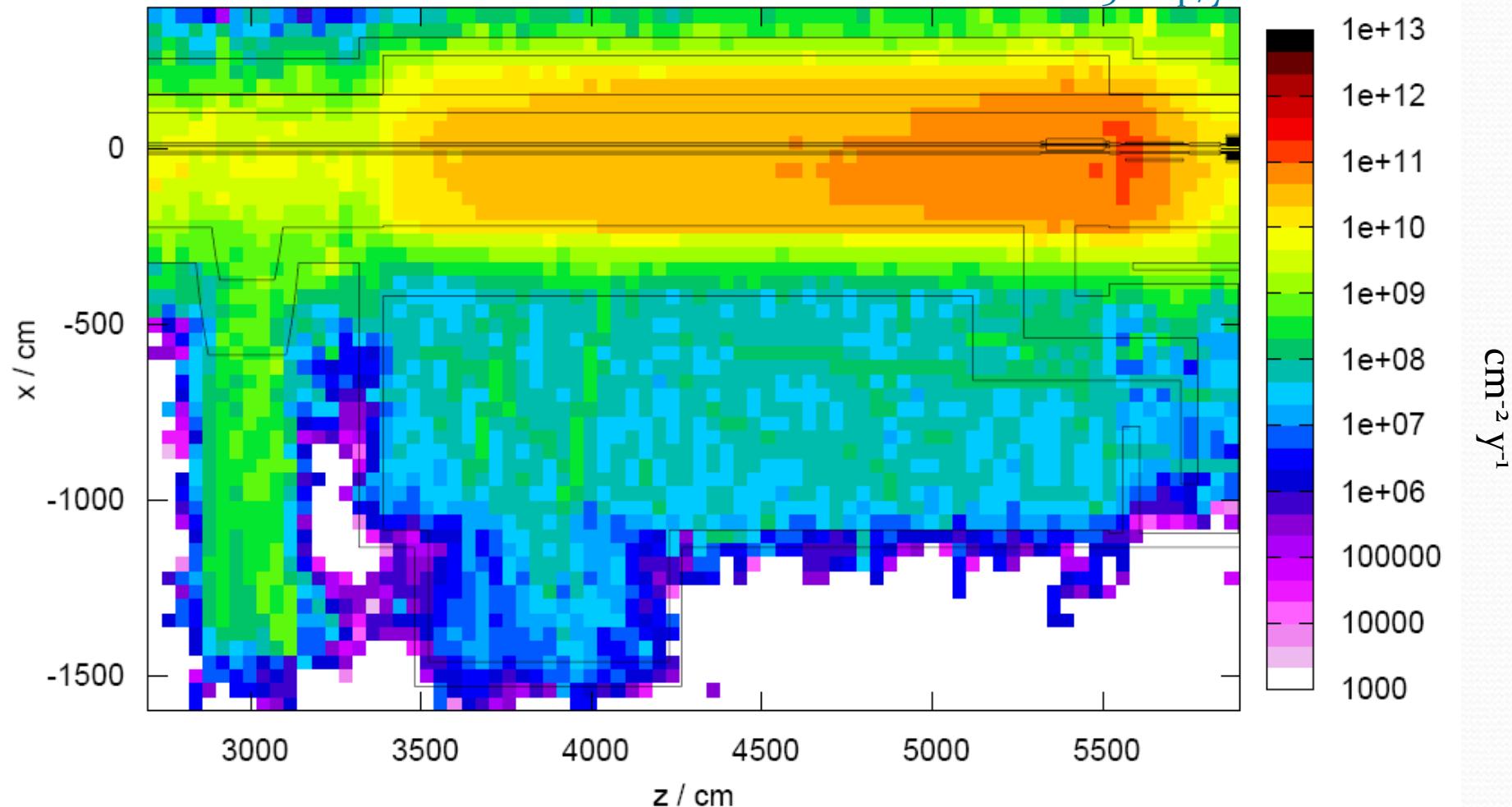
High energy hadron fluence

Normalization: 1.15E16 p/y



High energy hadron fluence (upstairs)

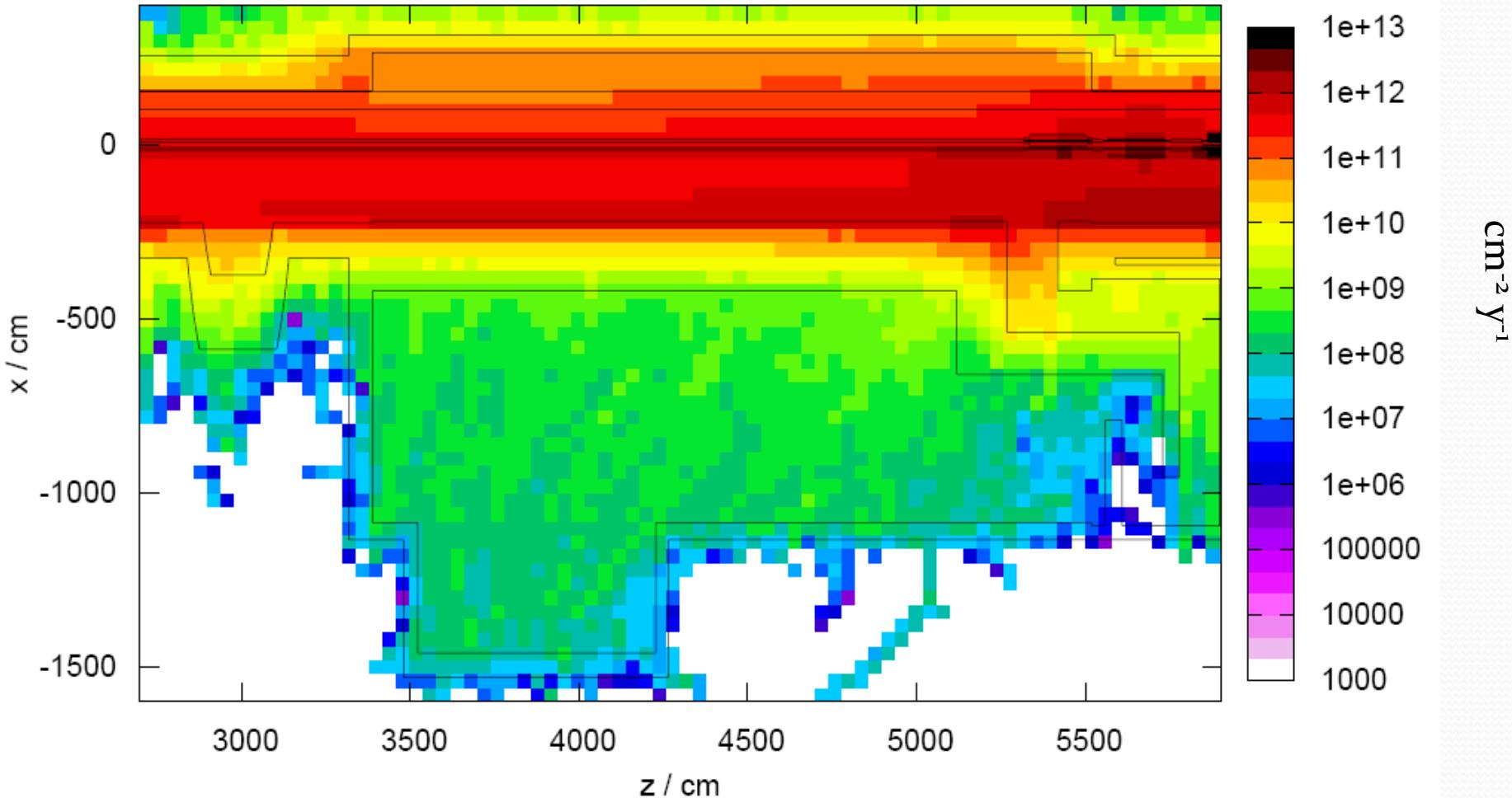
Normalization: 1.15E16 p/y



High energy hadron fluence (Beam 2)

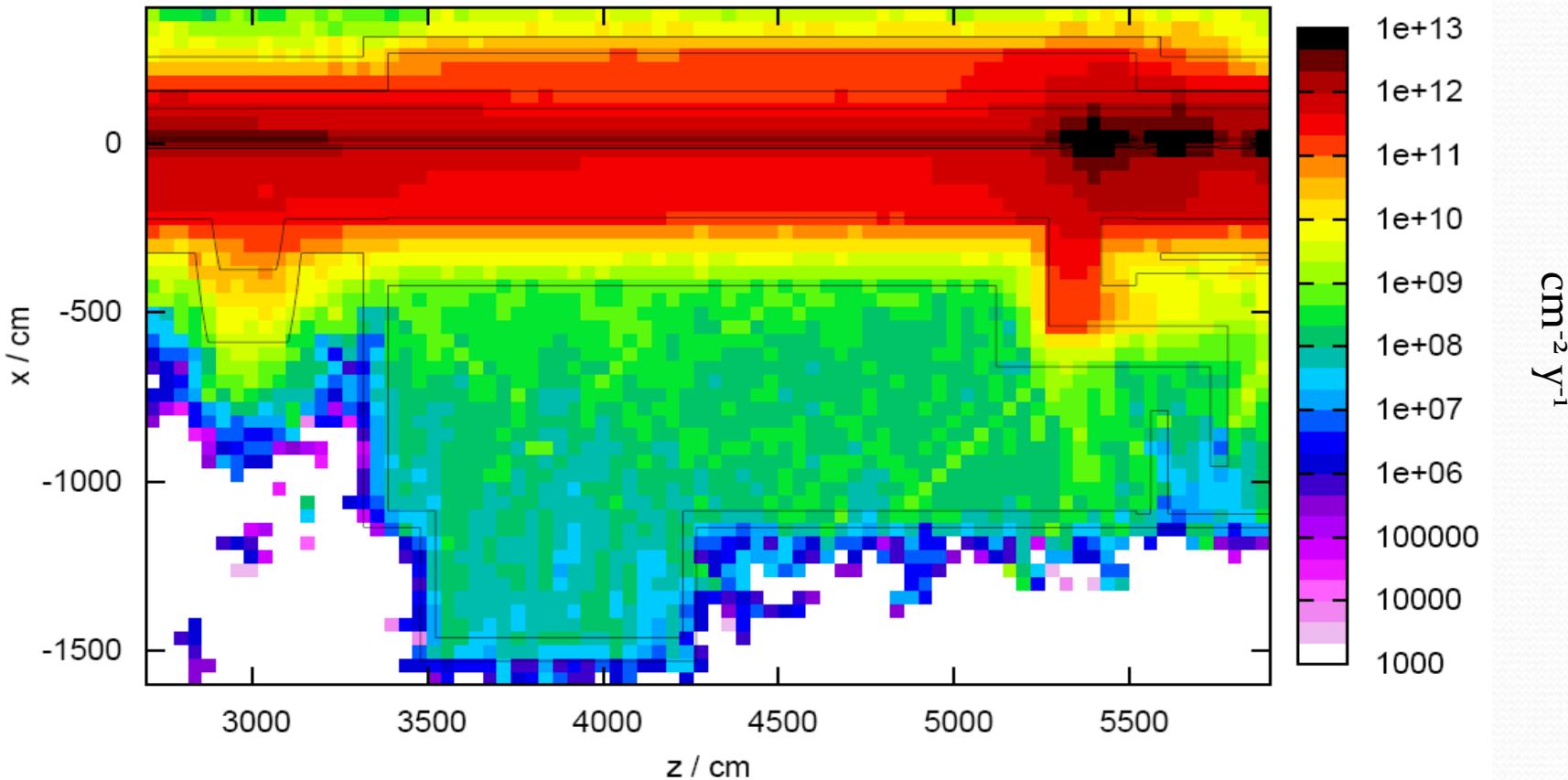
Larger uncertainty in the loss term - There is no new loss map available for beam2

Normalization: 1.15E16 p/y

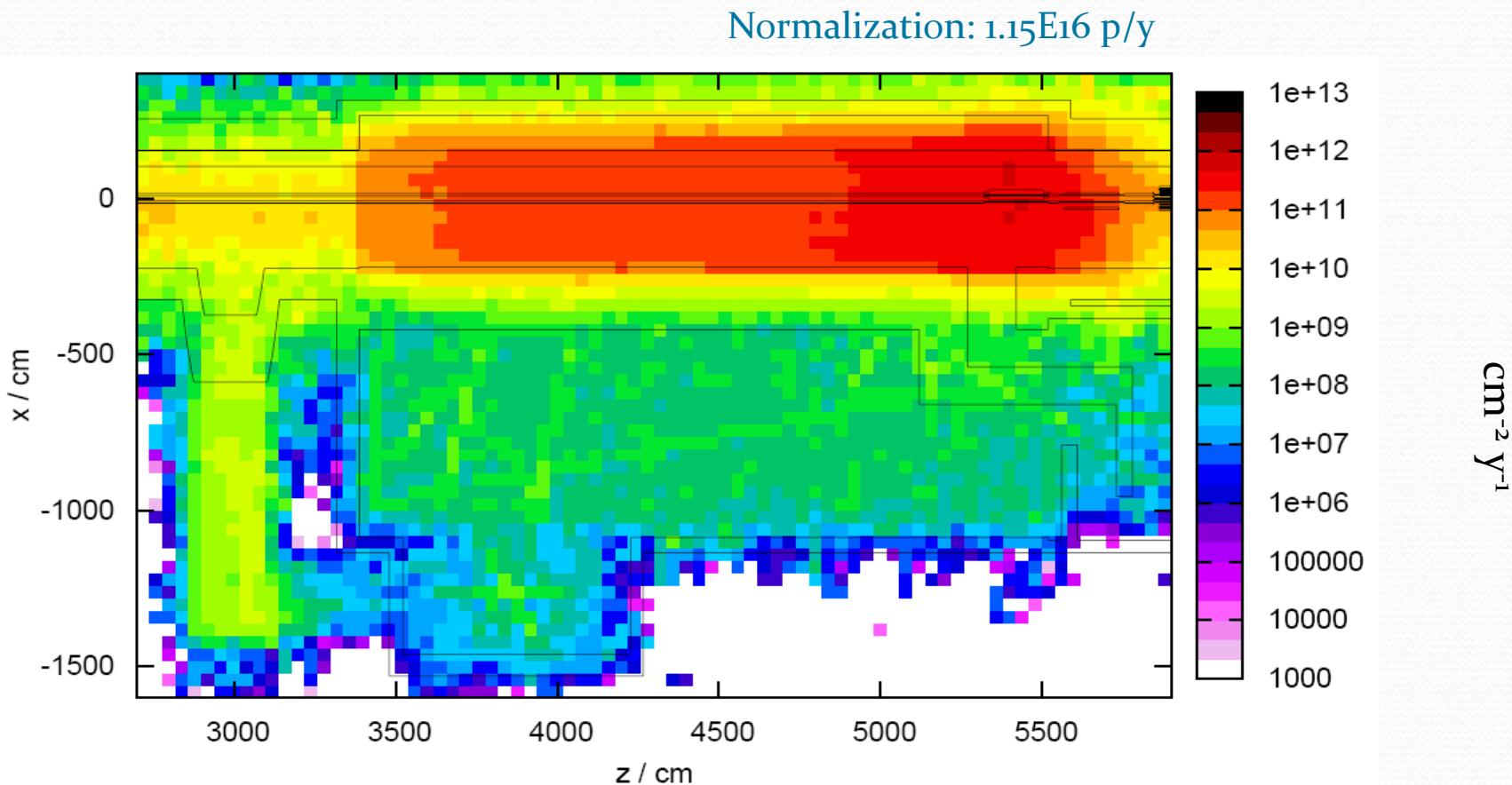


1 MeV neutron equivalent fluence

Normalization: 1.15E16 p/y

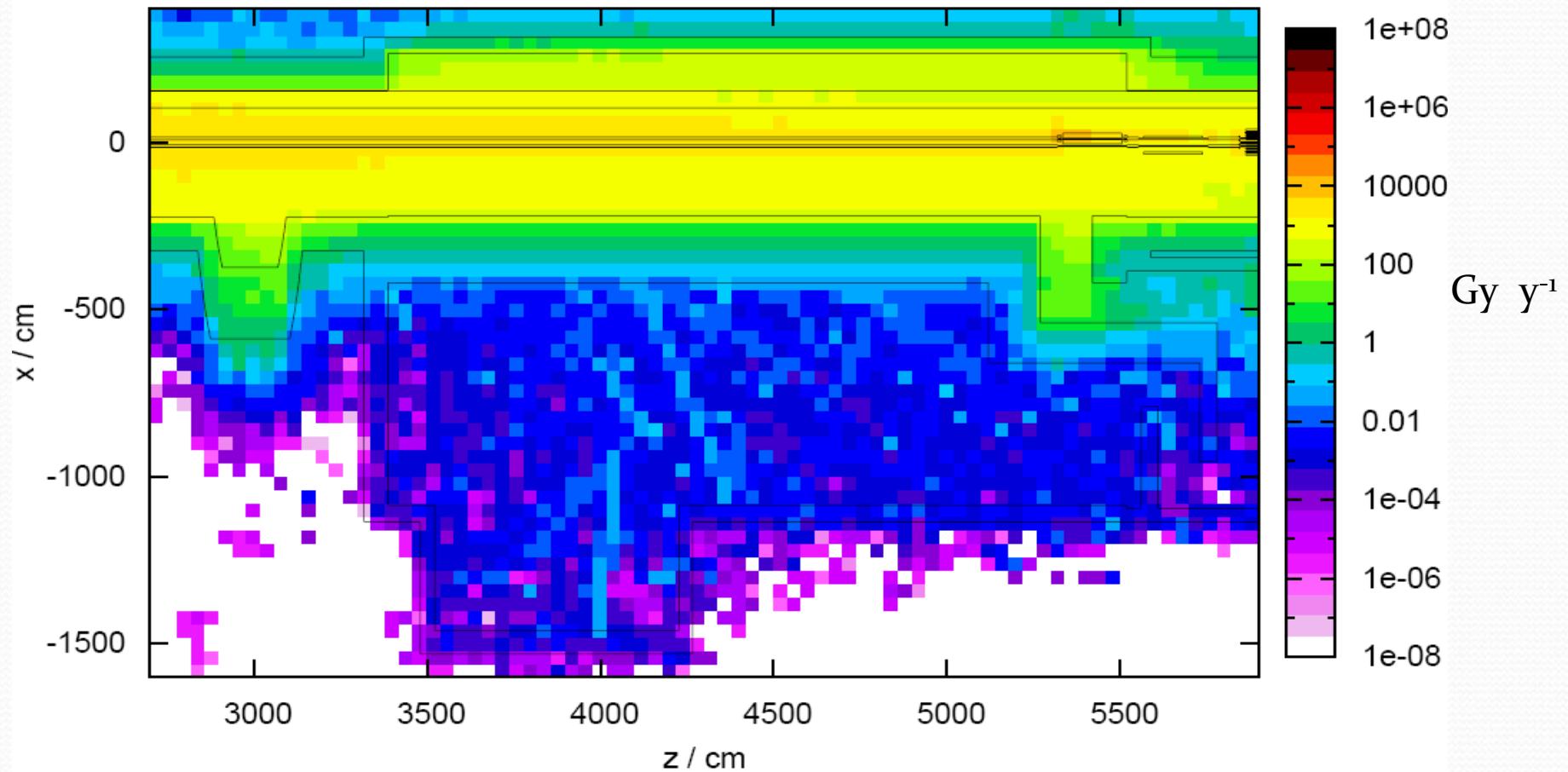


1 MeV neutron equivalent fluence (upstairs)



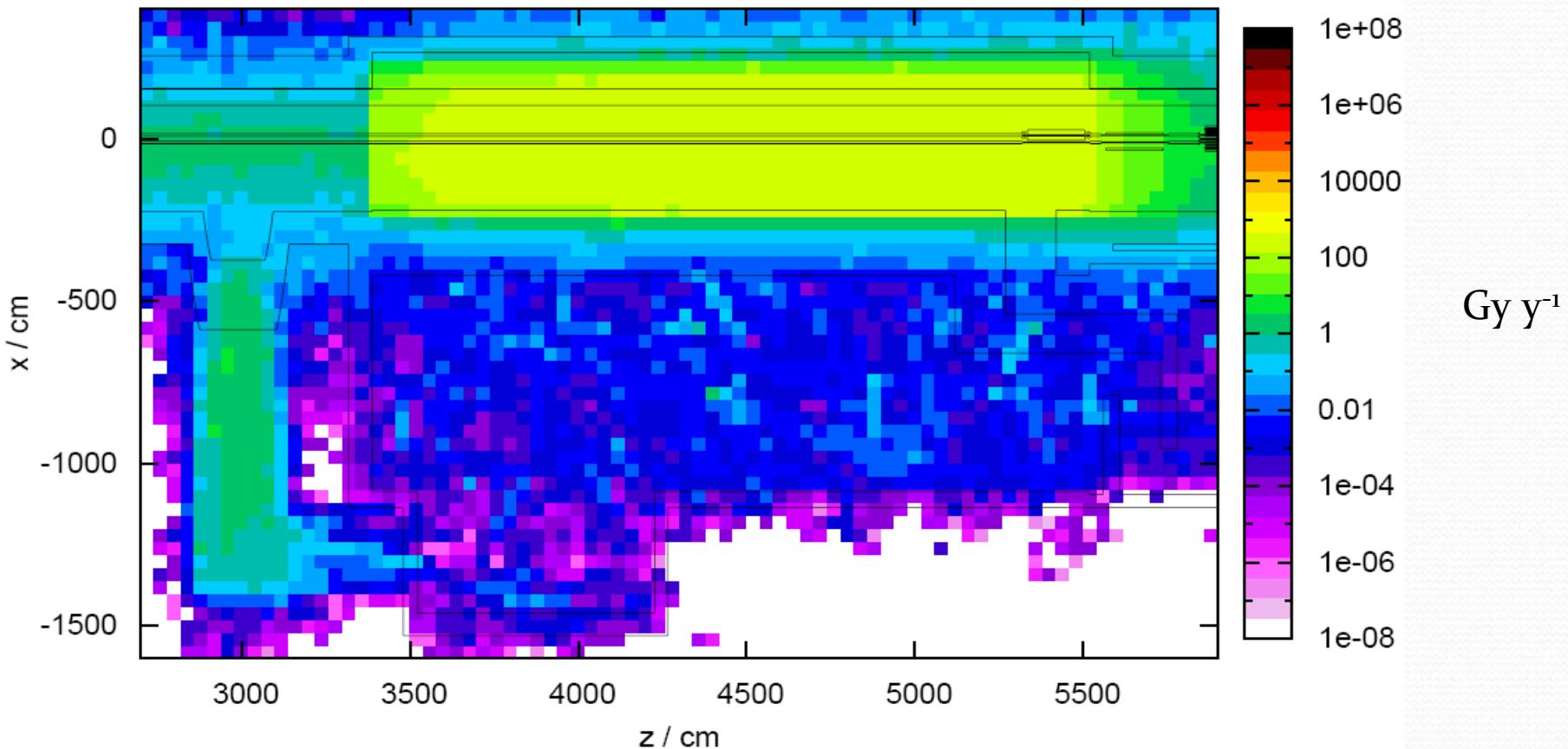
Dose

Normalization: 1.15E16 p/y

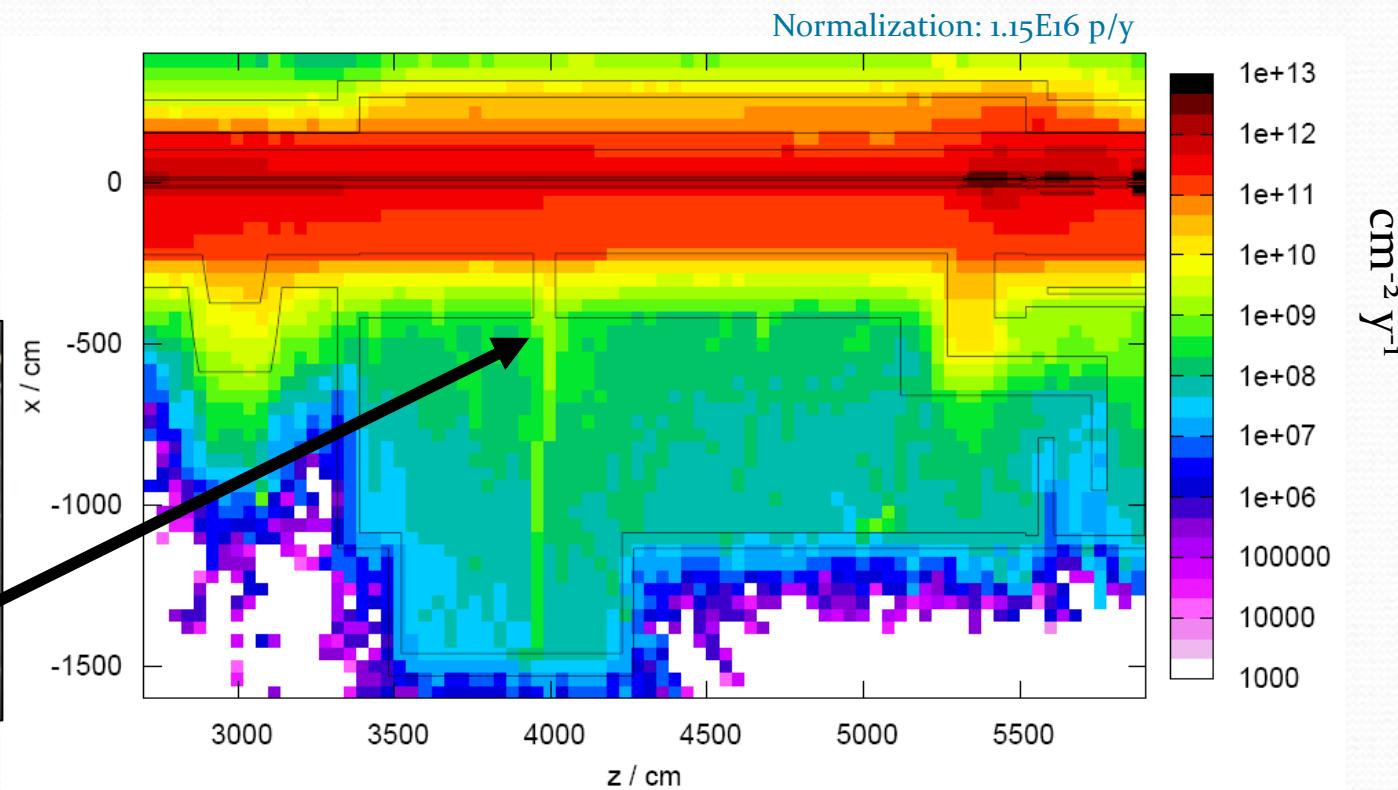


Dose(upstairs)

Normalization: 1.15E16 p/y



Example: effect of an hole in the shielding (high energy hadron fluence)



It's important to close all unnecessary holes!

Summary table

Nominal loss assumptions:

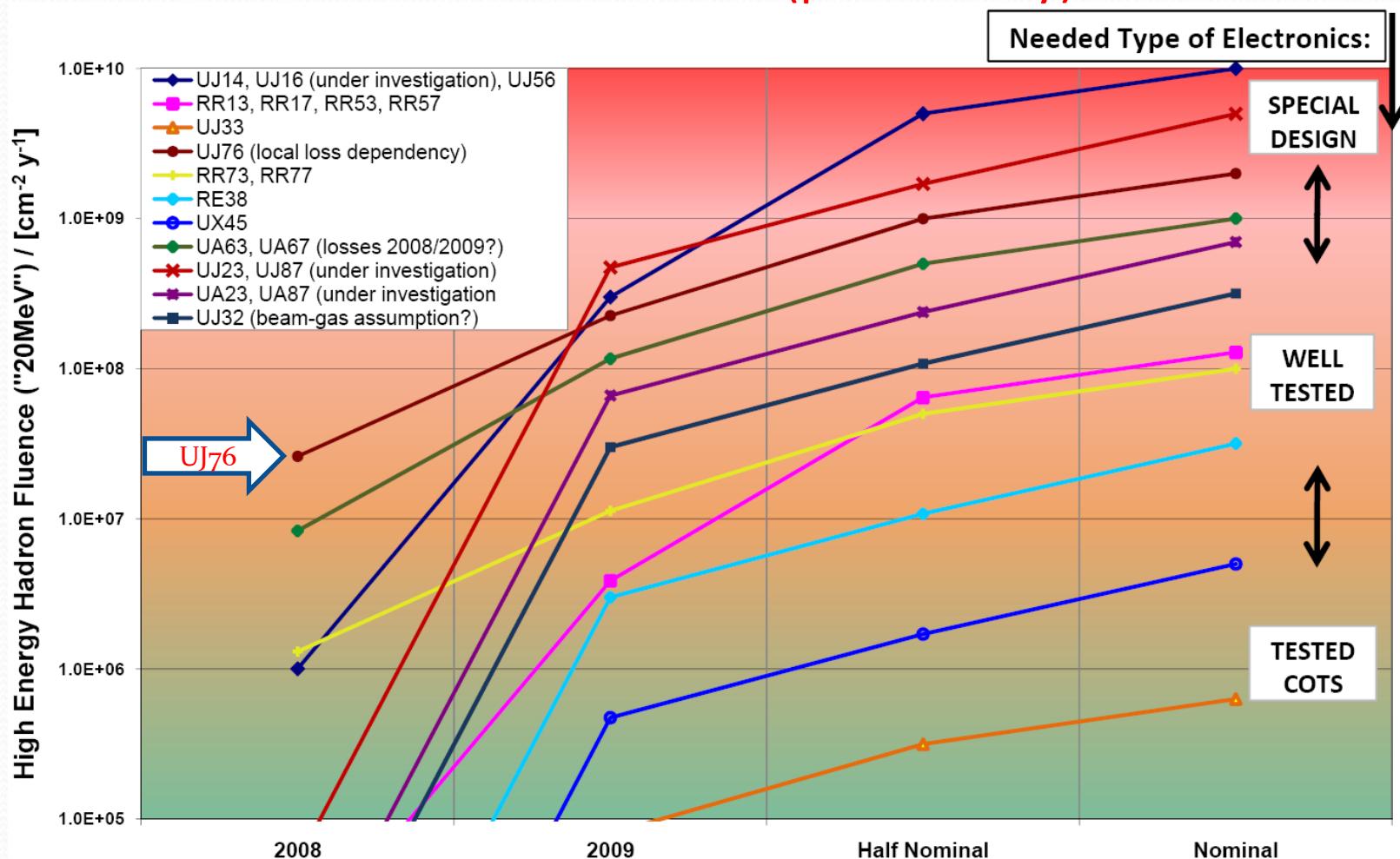
- 2.3×10^{16} proton lost in IR7 per year (both beams)
- Nominal loss distribution

Location	Quantity	Unit	Range
UJ76	20 MeV hadron fluence	$\text{cm}^{-2} \text{ y}^{-1}$	$1 \times 10^7 - 1 \times 10^9$
	Dose	Gy y^{-1}	0.001 – 1
	1 MeV neutron fluence	$\text{cm}^{-2} \text{ y}^{-1}$	$5 \times 10^7 - 5 \times 10^9$

Sources of uncertainties:

- Statistics
- FLUKA implementation and models
- Geometry (holes, materials, ...)
- Loss assumptions and distribution

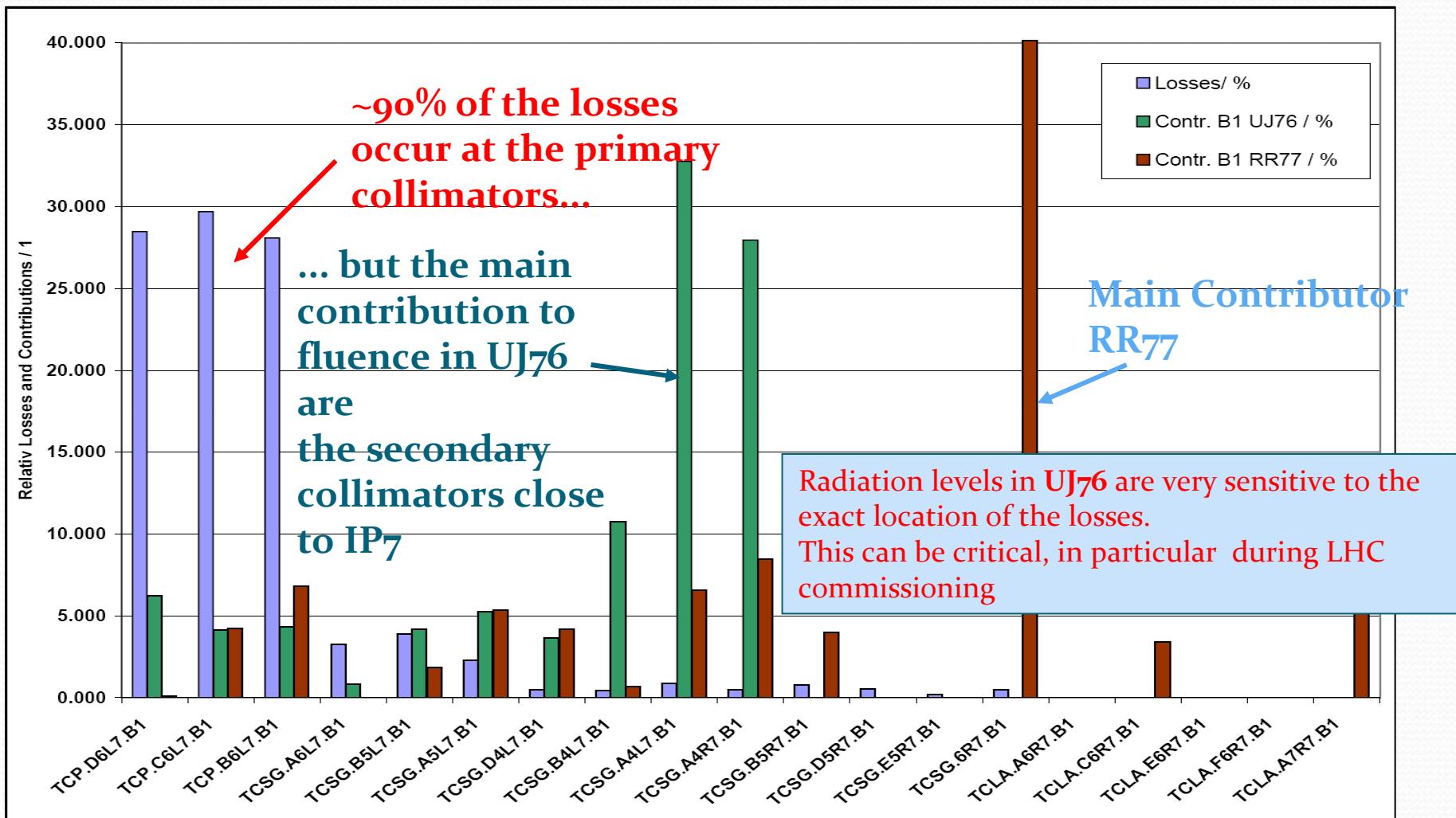
High energy hadron fluence vs time in critical LHC locations (preliminary)



Fluence in UJ76 scaled proportionally with the expected losses in IR7
(Implicitly assuming nominal distribution of losses, which is NOT true)

Contribution of different collimators

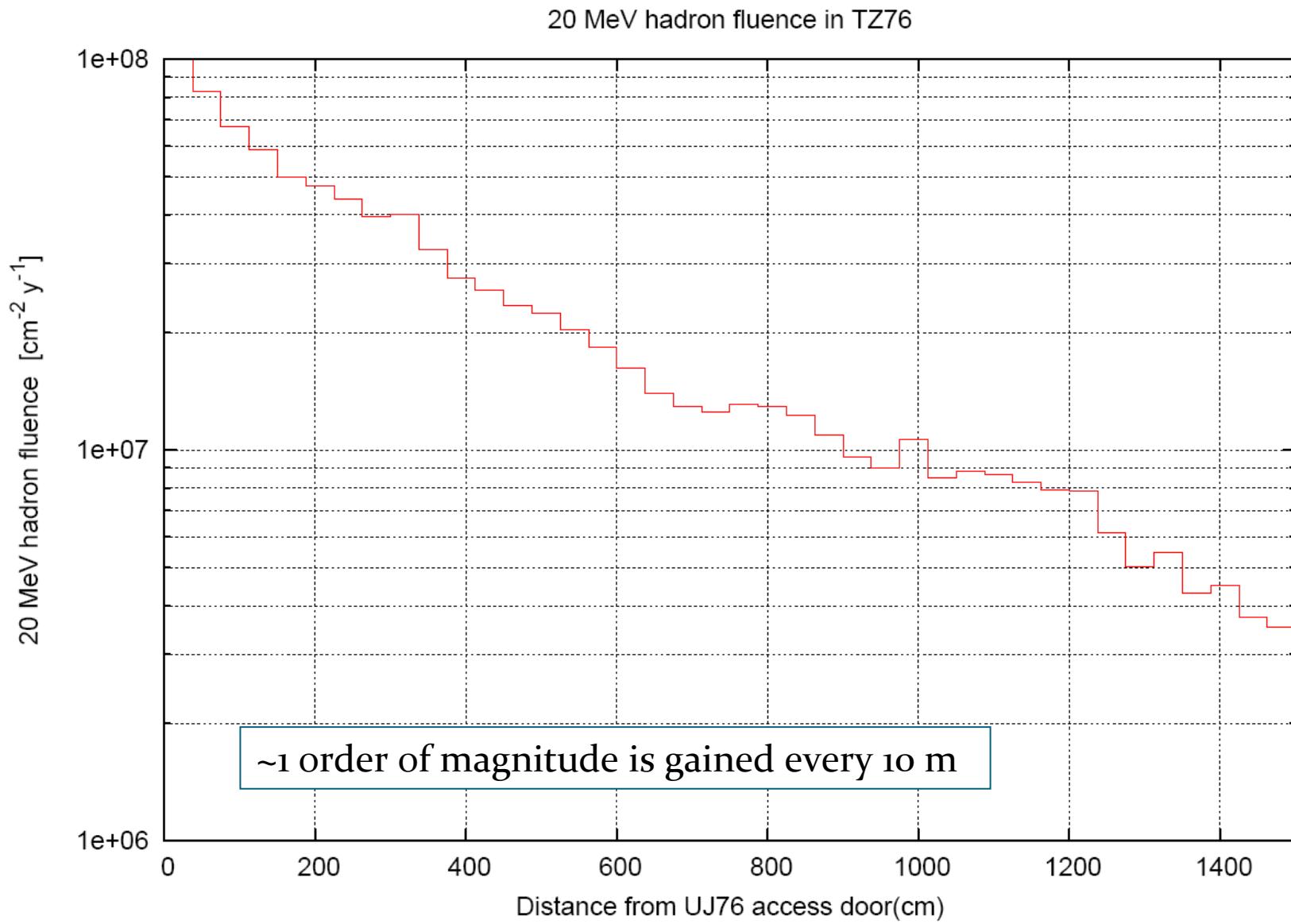
to high energy hadron fluence in UJ76



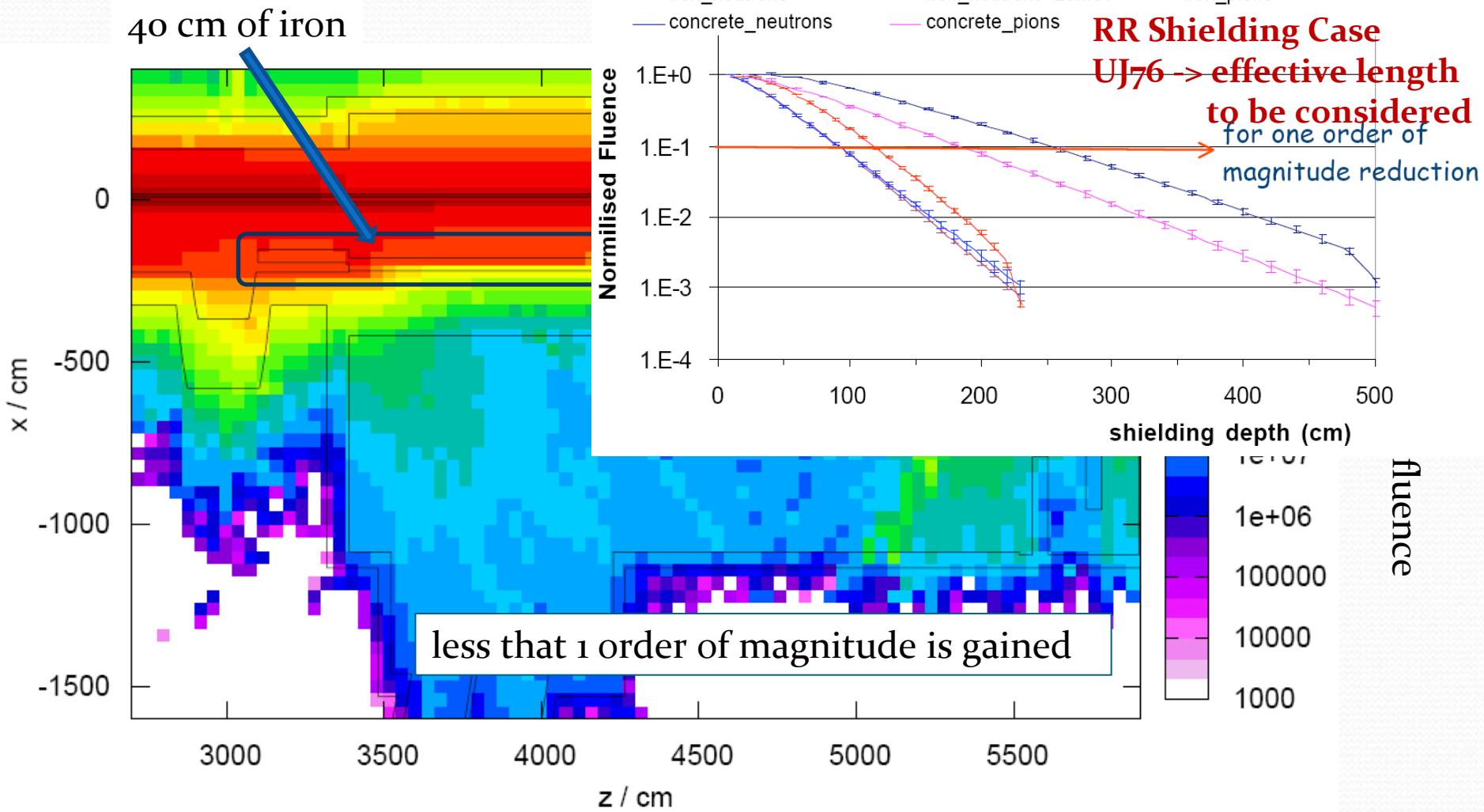
What to do ?

- To help considering the different options, additional simulations have been performed to evaluate:
 - the high energy hadron fluence in TZ76 to **check the expected radiation gradient in the TZ tunnel**
 - the effect of an **extra iron shielding** in front of the UJ76

Radiation Levels in the TZ76



Effects of extra shielding



Conclusions

- For radiation to electronics, UJ76 is one of the most critical location of the LHC
- Levels of high energy hadron fluence may exceed what has been critical for CNGS already in 2009

- Options:

- Shielding: limited
- Relocation: possible in TZ76



Next iteration:

- Partial relocation
(after electronics classification + prioritization)
- Consider placing shielding in the space gained
- Consider shielding (entry maze) TZ76 to reduce 'safe' distance
- Hybrid (relocation + separation + local shielding)
- [...]