Shielding and activation studies for the ELI-Beamlines project

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Outline

- ELI project
- Radiation Protection Case
- Simulation goals and strategy
- First results
- Conclusions

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Structure of the ELI project

Extreme Light Infrastructure, is the European Project (ESFRI) for the next generation high intensity laser

Prague	**Beamlines facility**	**High-brightness sources of X-ray radiation & particles**
Szeged	**Attosecond facility, ALPS**	**Attosecond XUV/X-ray physics**
Magurele	**Photonuclear facility , NP**	**Laser-induced nuclear physics**
	200 PW facility (?)	**Frontier physics by exawatt lasers**

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Science Case at ELI-Beamlines

ELI-Beamlines bid: balance between fundamental science and applications

ELI-Beamlines will be international user facility within the ELI-DC consortium

Research Program 1
Lasers generating rep-rate ultrashort pulses & multi-petawatt peak powers

Research Program 2
X-ray sources driven by rep-rate ultrashort laser pulses

Research Program 3
Particle acceleration by lasers

Research Program 4
Applications in molecular, biomedical, and material sciences

Research Program 5
Laser plasma and high-energy-density physics

Research Program 6
High-field physics and theory (steps to $10^{23 W/cm^2}$, radiation reaction plays role)

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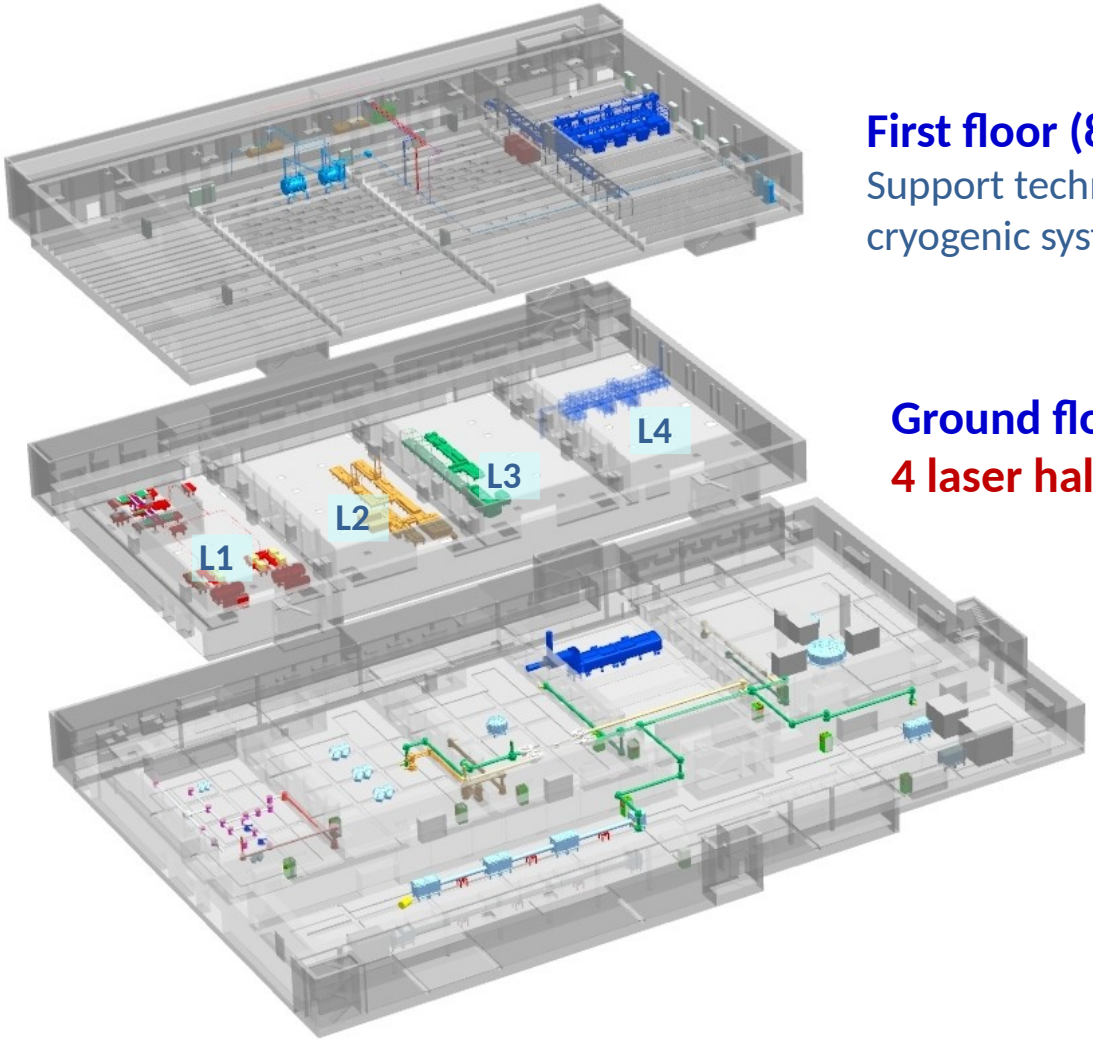
Layout of ELI-Beamlines building



First floor (80 x 40 m)
Support technologies, cooling systems, cryogenic systems

Ground floor (80 x 40 m)
4 laser halls (L1 to L4)

Basement (110 x 60 m)
6 dedicated experimental halls (E1 to E6)

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ELI-Beamlines building

Construction ongoing

Delivery 2015

First operation 2017

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Radiation Protection Problem

First civilian lasers having such energies and repetition rates

New challenges for the laser community

Unprecedented needs for RP assessments

- Shielding and beam dump definition
- Material selection

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Source terms: beam characteristics

No monochromatic beams

High repetition rate (10 Hz) electron beam lines (E_{MAX} = 2 GeV)

Low repetition rate (1 Hz) electron beam lines (E_{MAX} = 10 GeV)

Development electron beam lines (E_{MAX} = 50 GeV)

Low repetition rate (1 Hz) proton beam lines (E_{MAX} = 250 MeV)

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Simulations strategy

First studies including the final building design and

realistic definition of the source terms

Simulations performed using latest FLUKA & FLAIR versions

Great care for geometry details (mazes and penetrations)

Conservative assumptions when no available info

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Simulations goals

Dump and local shielding design
(including material selection)

Particle fluence rate

Ambient dose equivalent (#days of operation)

RP goal: <1 mSv / year all over the lab

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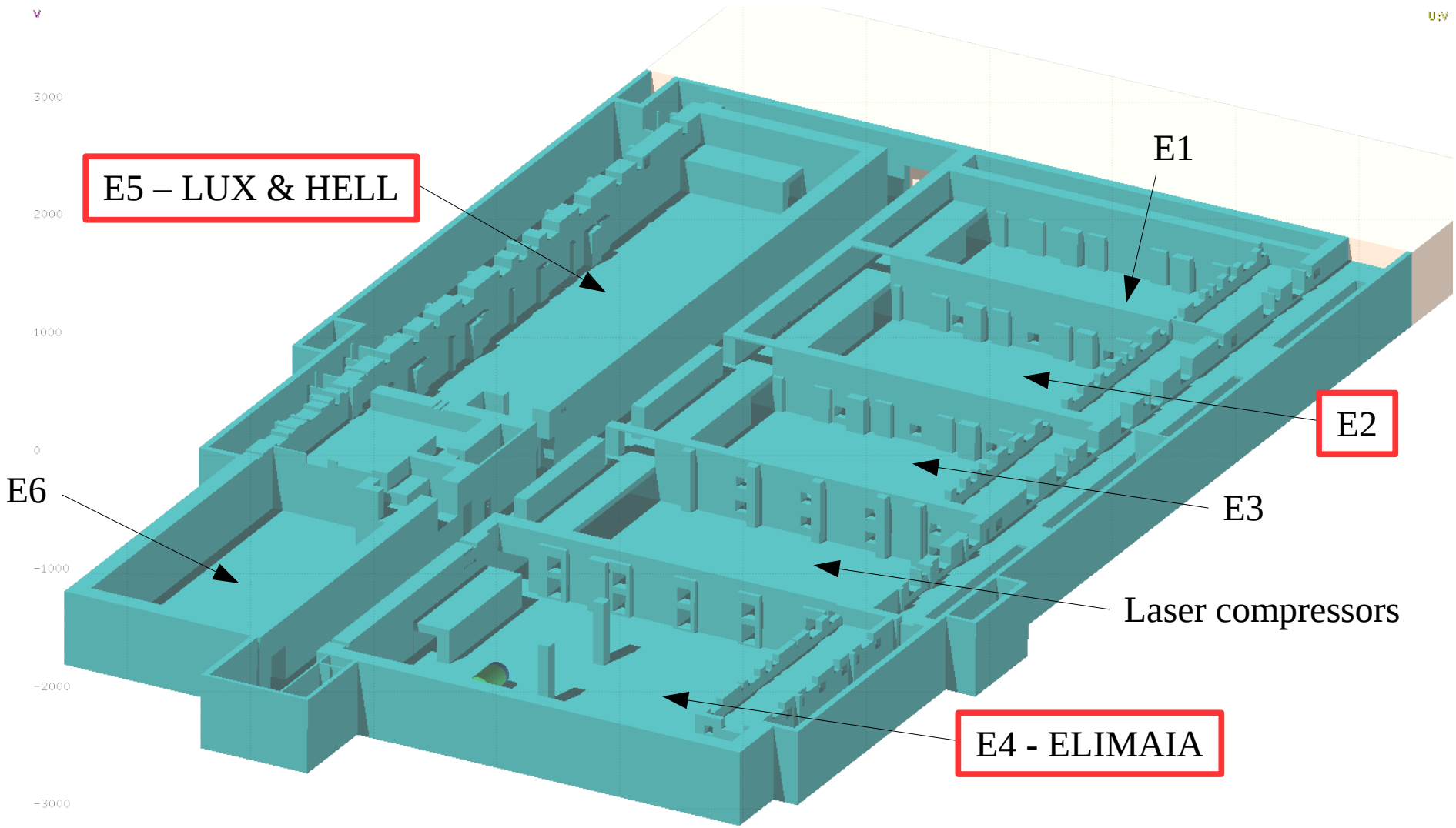
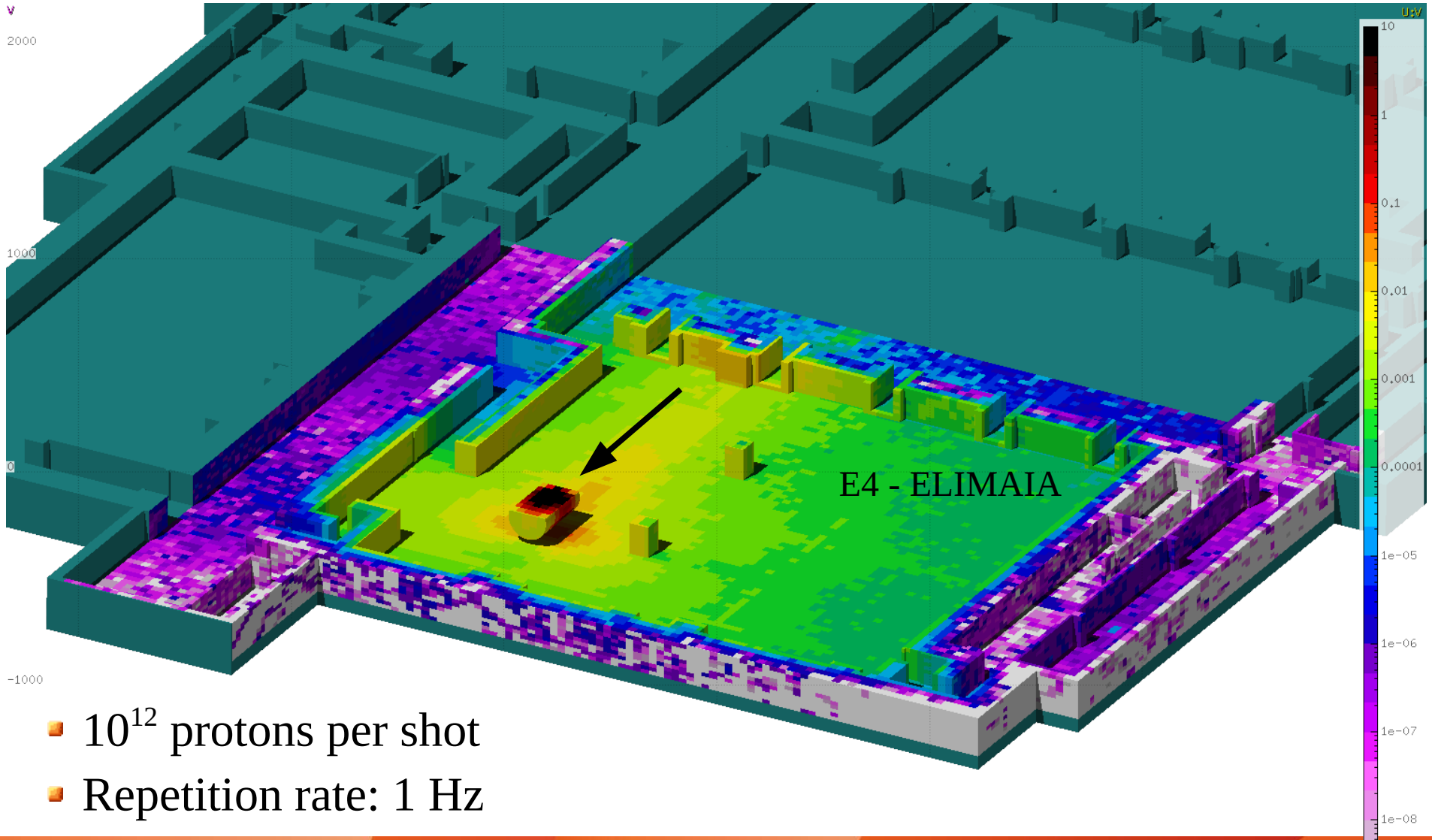
ELI laboratory



E4 - ELIMAIA 250 MeV protons



- 10^{12} protons per shot
- Repetition rate: 1 Hz

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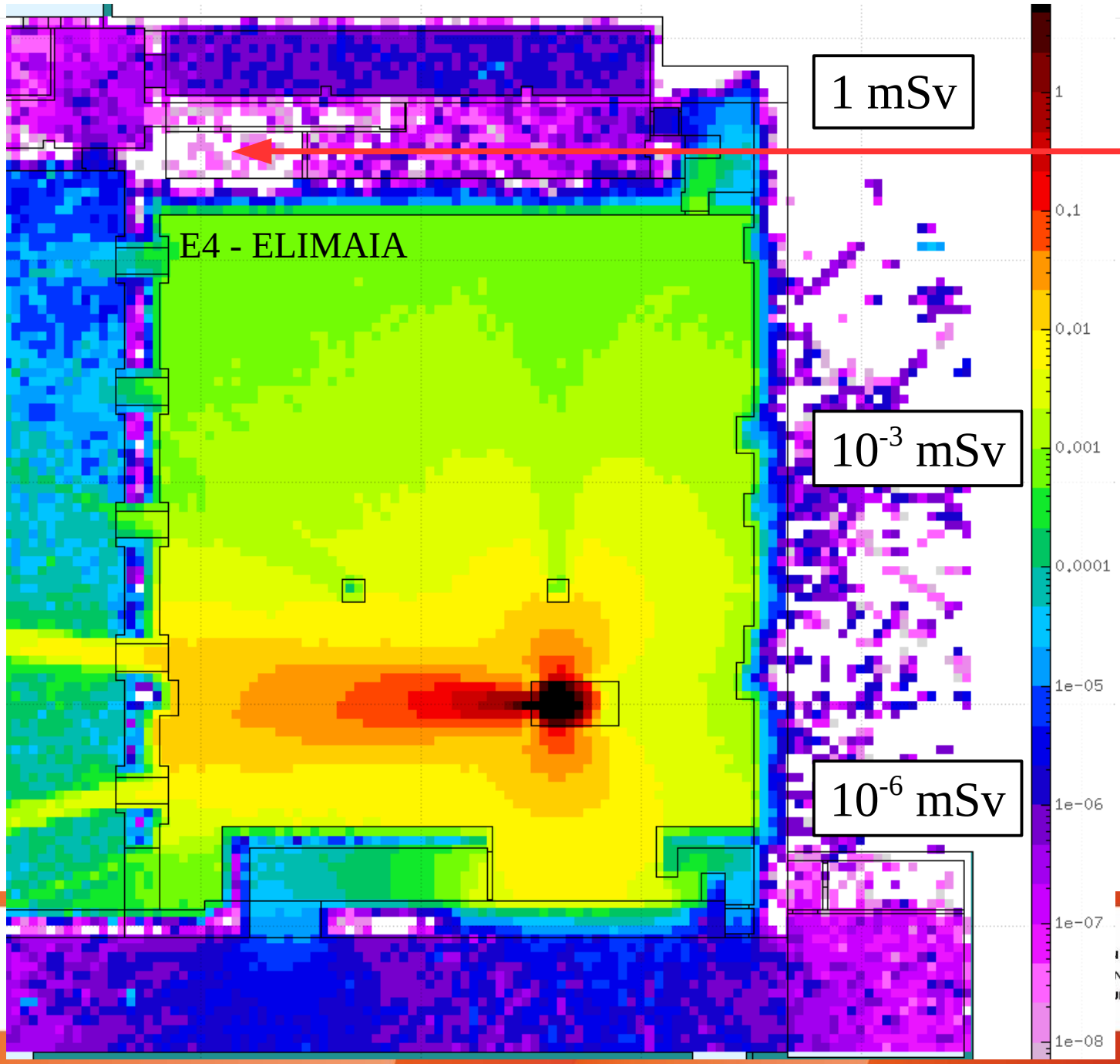
E4 - ELIMAIA 250 MeV protons



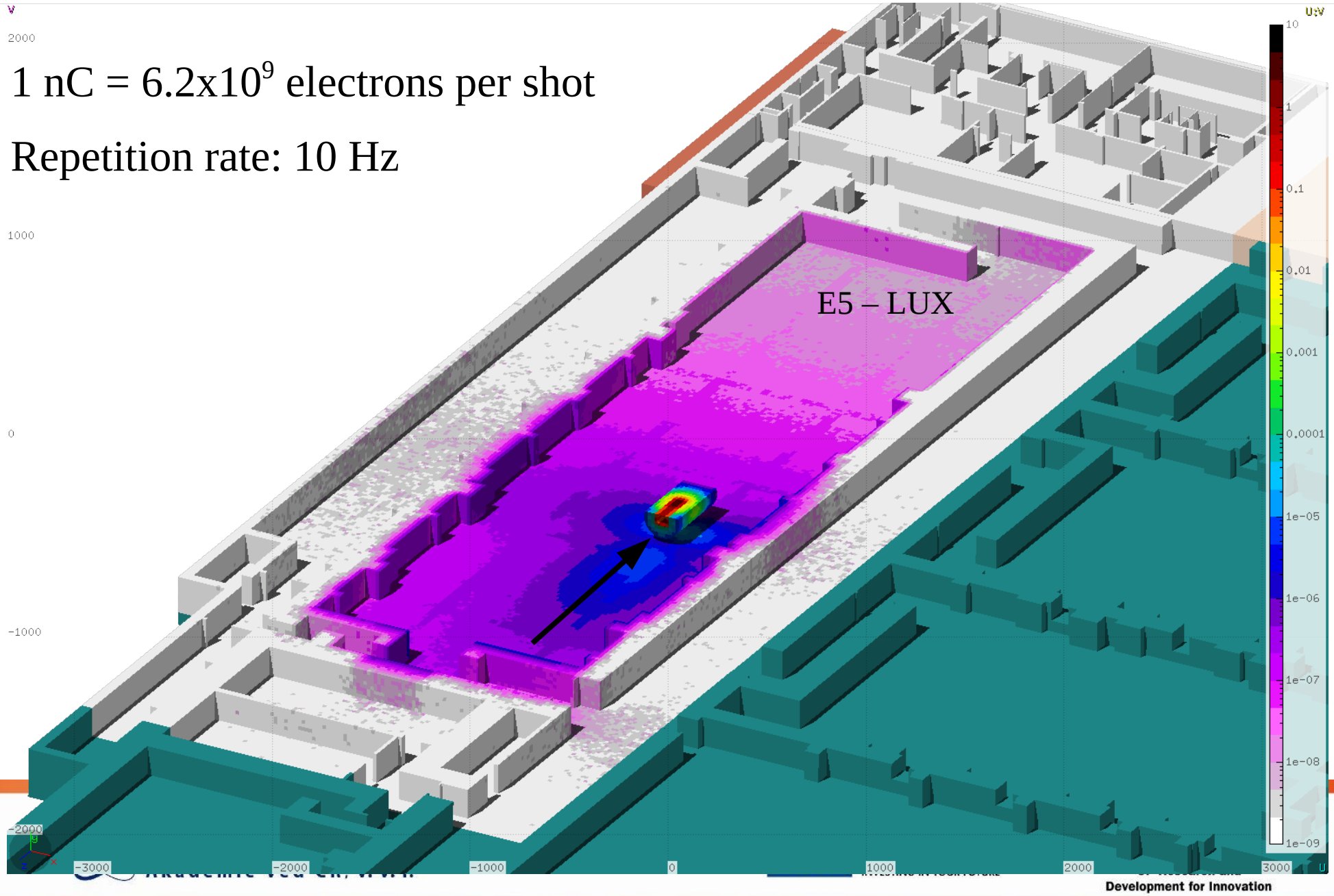
Control Room
~10^{-7} mSv per shot

Assuming 8h/day continuous operations it will require ~350 days to integrate 1 mSv

E5 - LUX

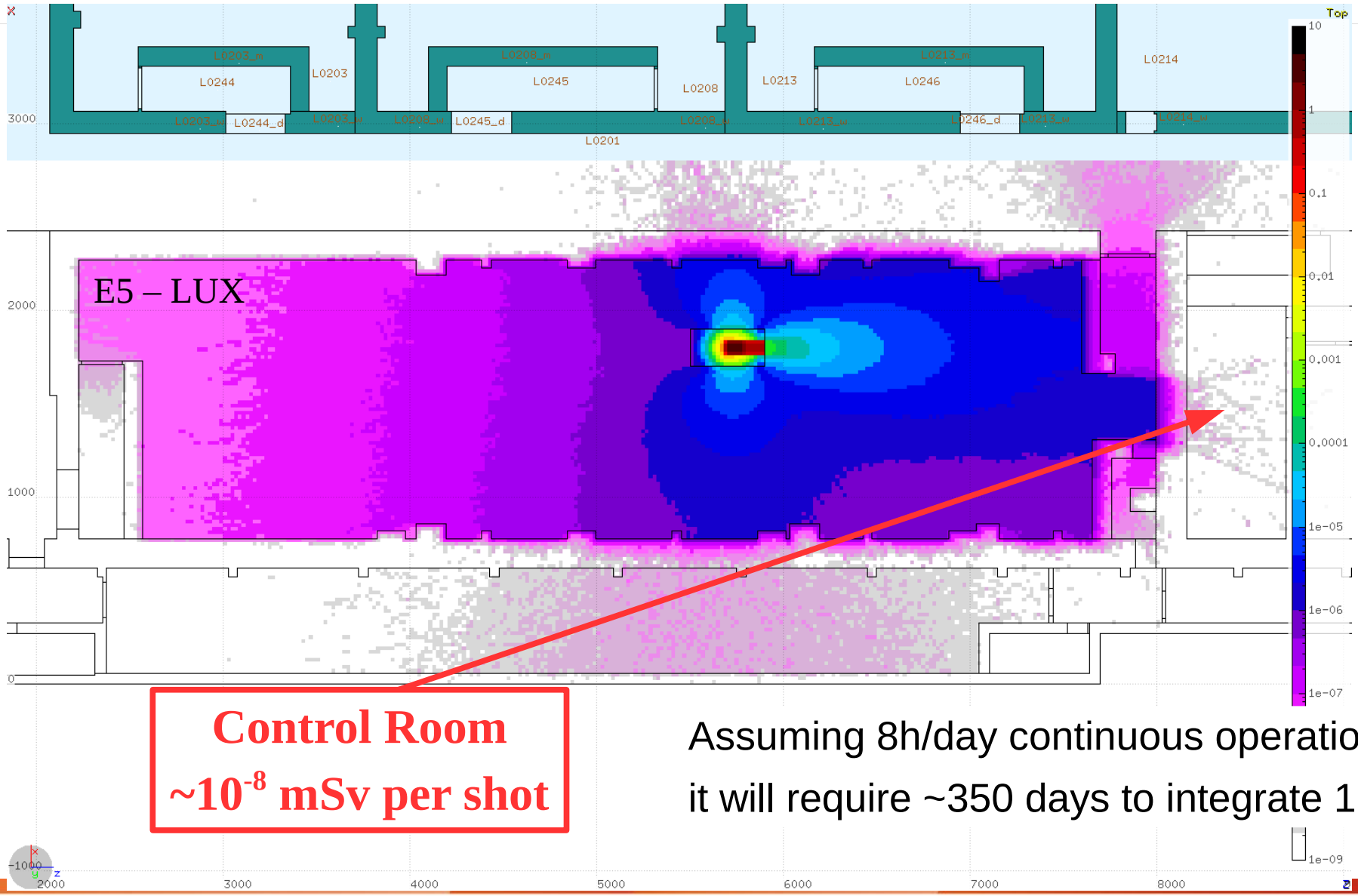
2 GeV electrons

- 1 nC = 6.2×10^9 electrons per shot
- Repetition rate: 10 Hz



E5 - LUX

2 GeV electrons



1 mSv

10^{-3} mSv

10^{-6} mSv

Control Room

~10^{-8} mSv per shot

Assuming 8h/day continuous operations

it will require ~350 days to integrate 1 mSv

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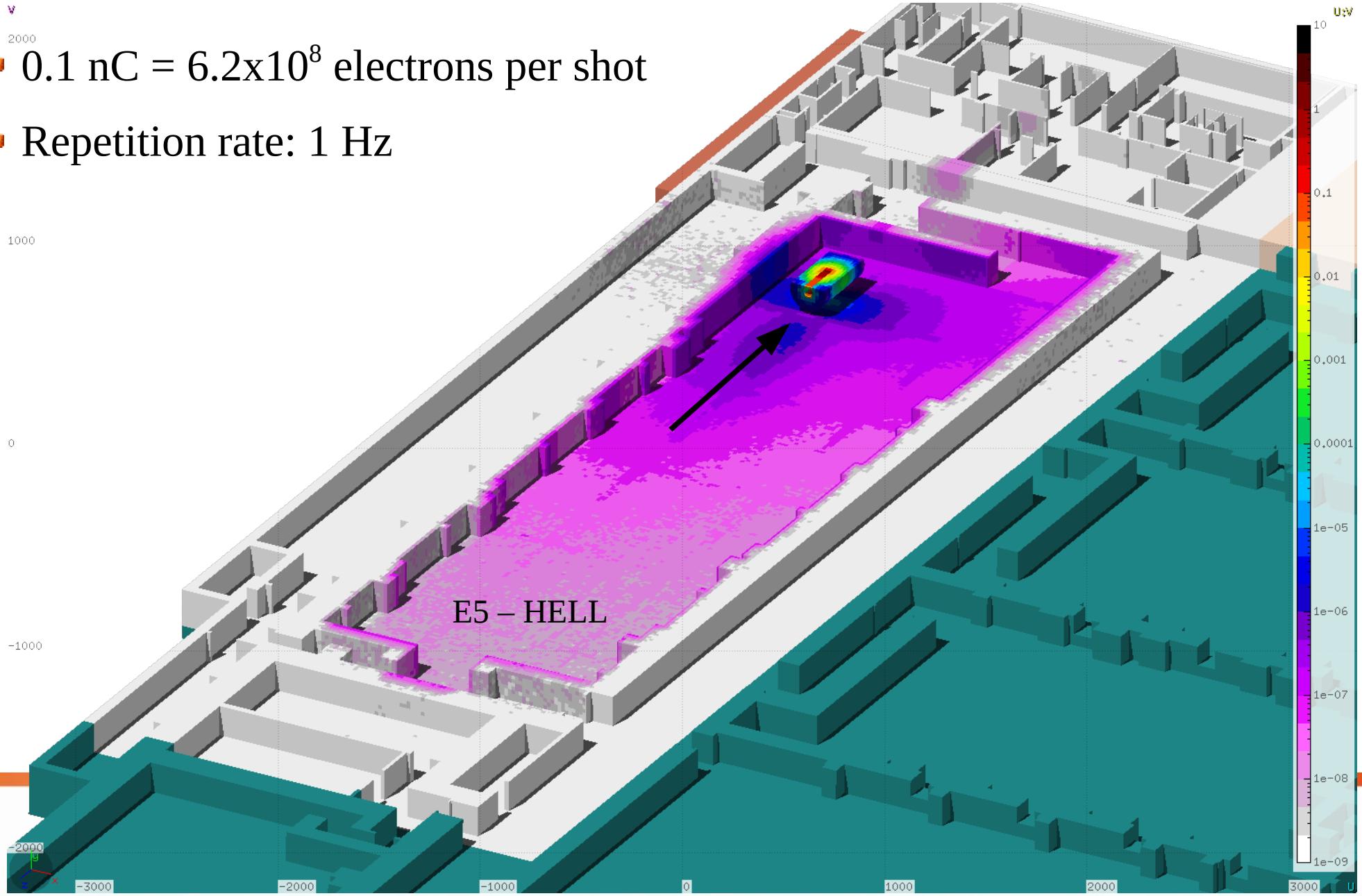
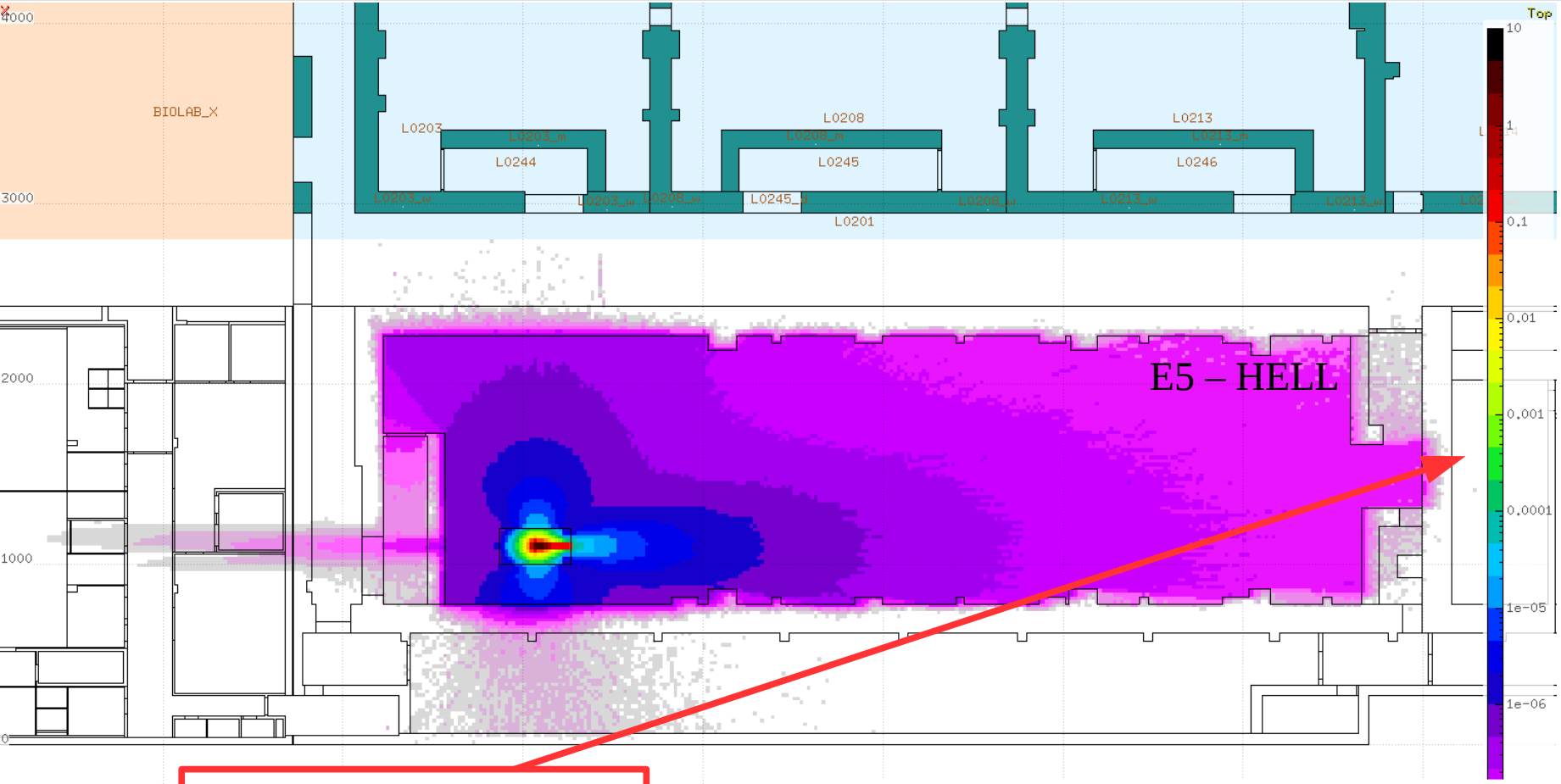
E5 - HELL 10 GeV electrons

- 0.1 nC = 6.2×10^8 electrons per shot
- Repetition rate: 1 Hz



E5 - HELL 10 GeV electrons



1 mSv

10^{-3} mSv

10^{-6} mSv

Control Room
~10^{-8} mSv per shot

Assuming 8h/day continuous operations

it will require ~35000 days to integrate 1 mSv

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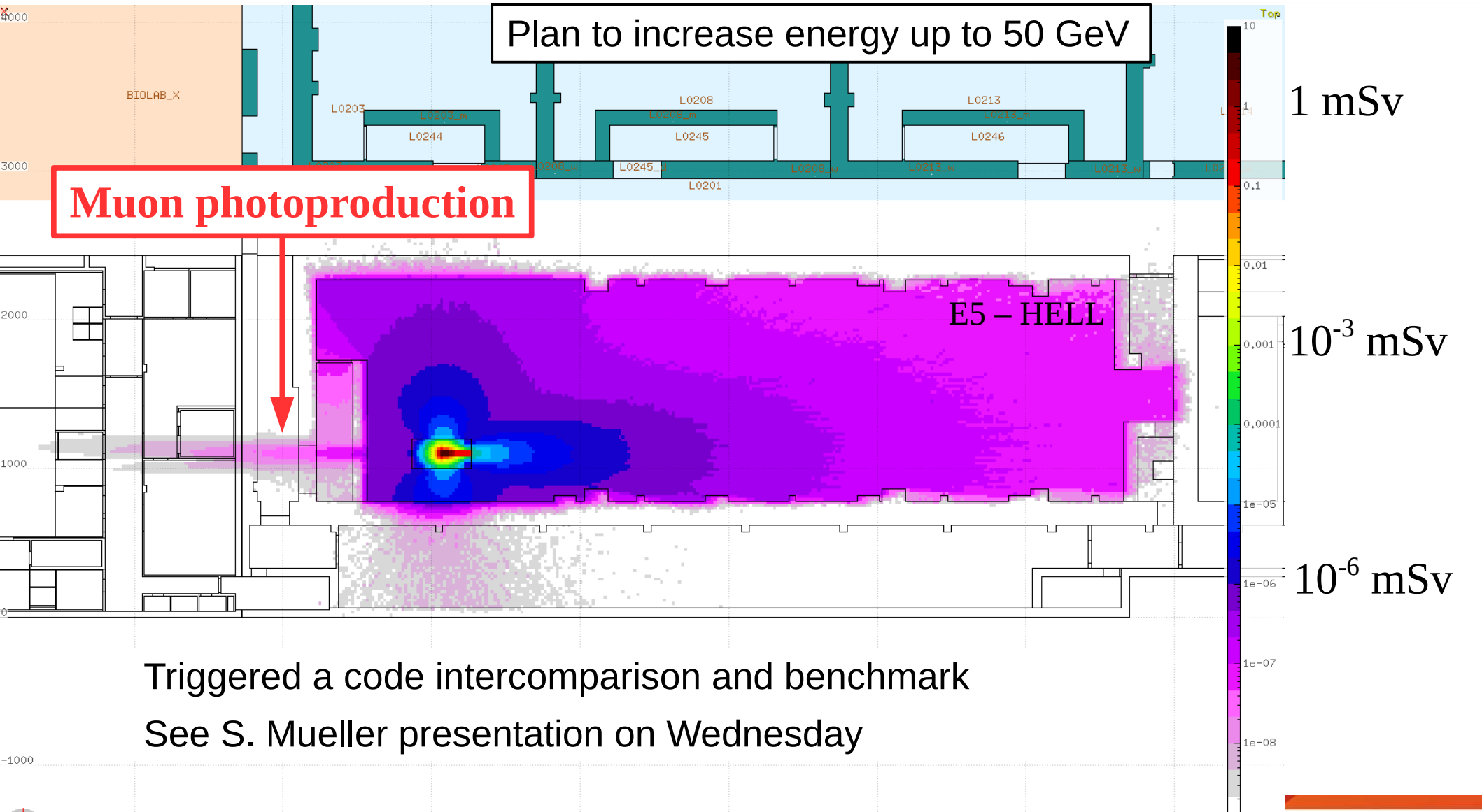
E5 - HELL 10 GeV electrons



Triggered a code intercomparison and benchmark

See S. Mueller presentation on Wednesday

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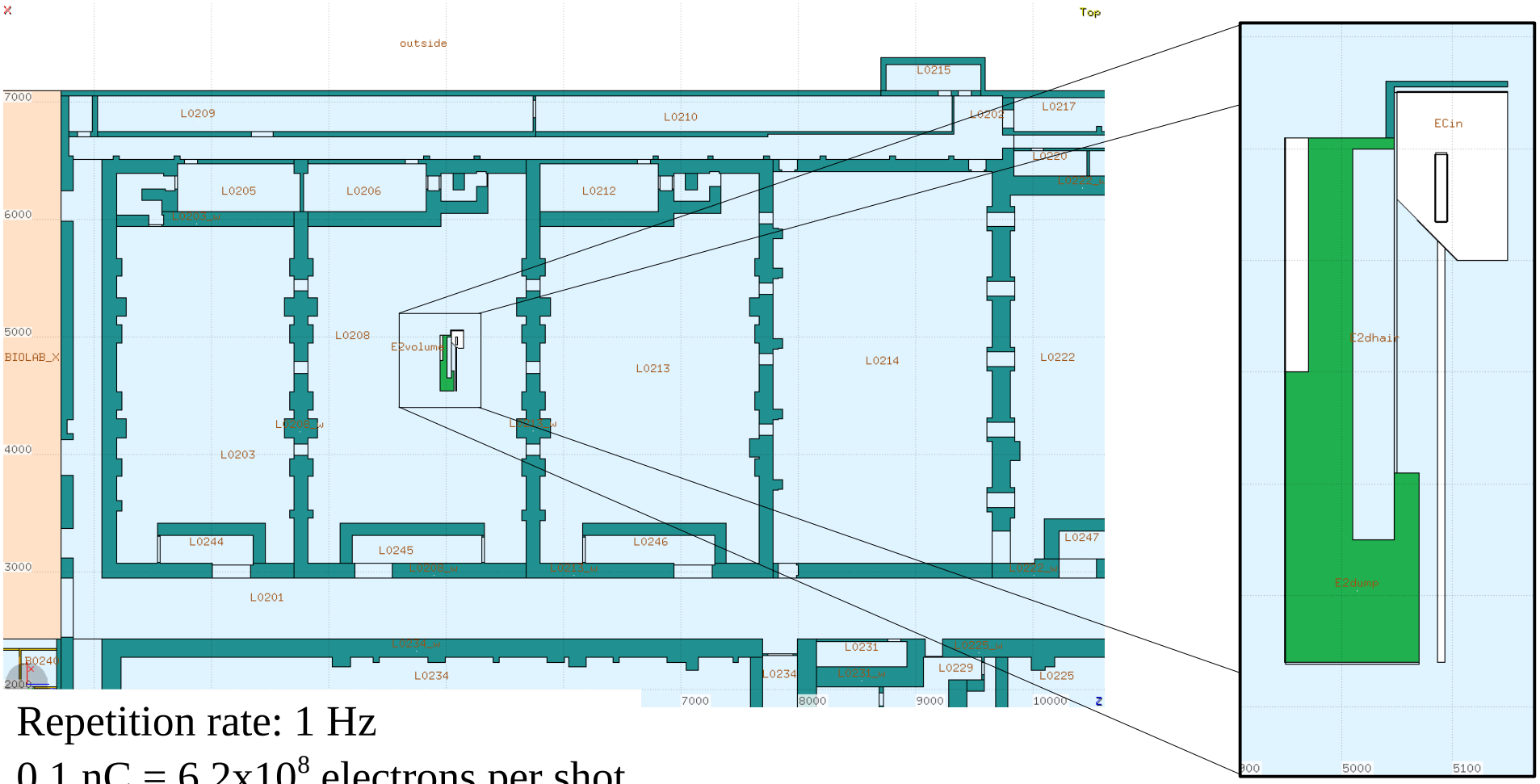
E2 2 GeV electrons

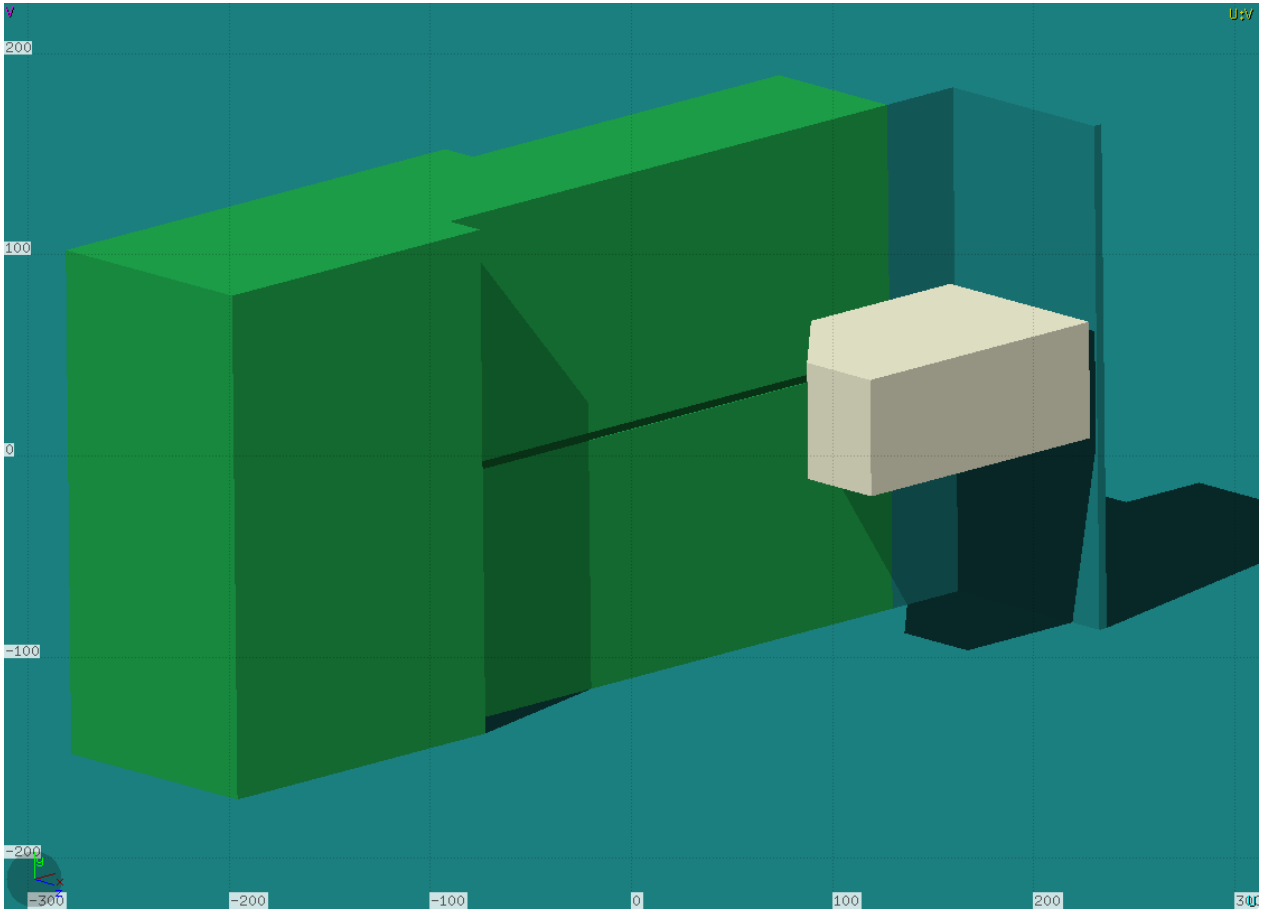
Dump design: “strange” shape because of the source term

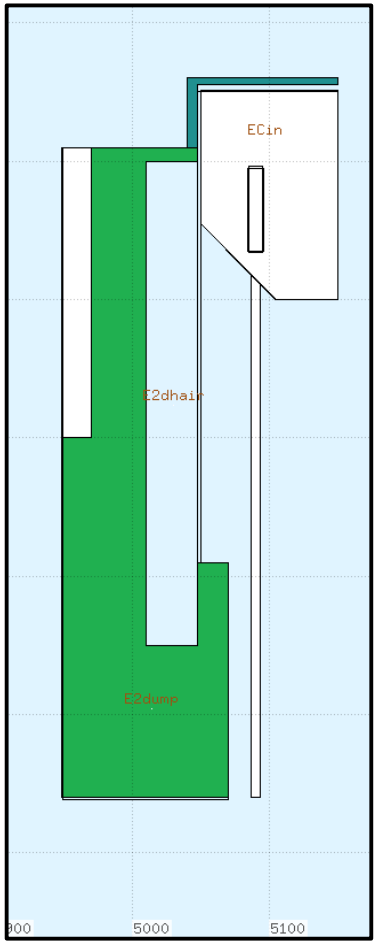


- Repetition rate: 1 Hz
- 0.1 nC = 6.2×10^8 electrons per shot

E2 2 GeV electrons

Dump design: “strange” shape because of the source term





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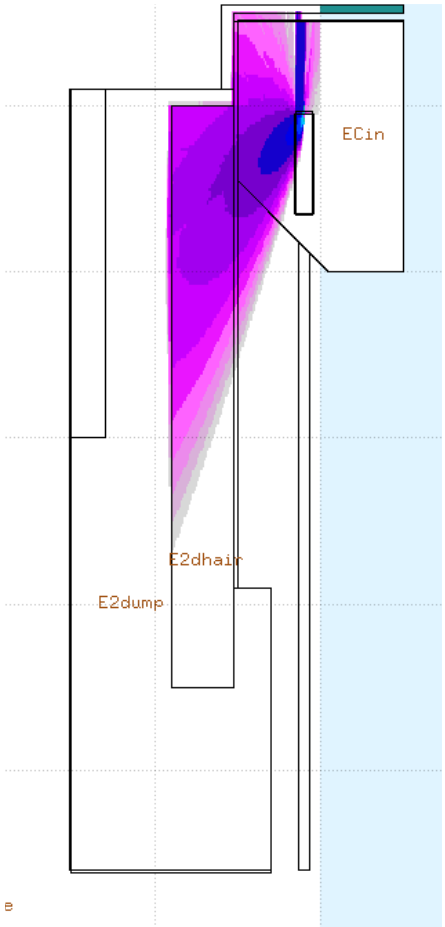
E2 2 GeV electrons

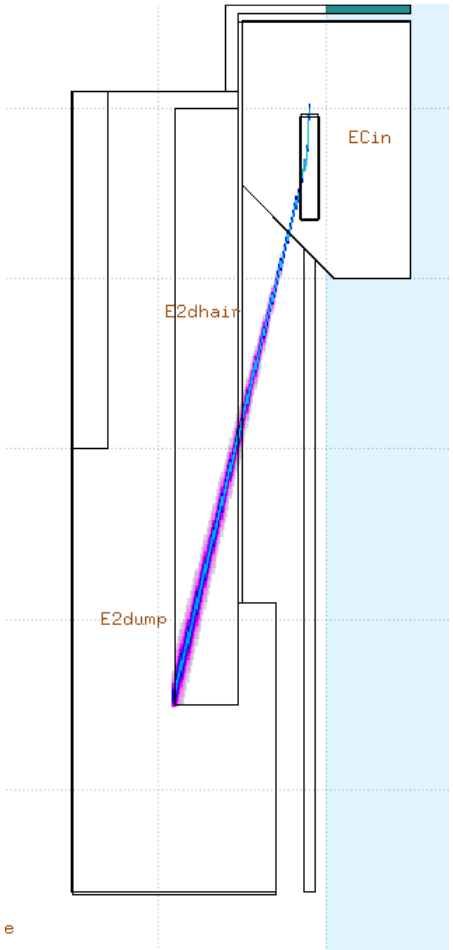
Primary particle fluence

Different operation modes imply different source terms

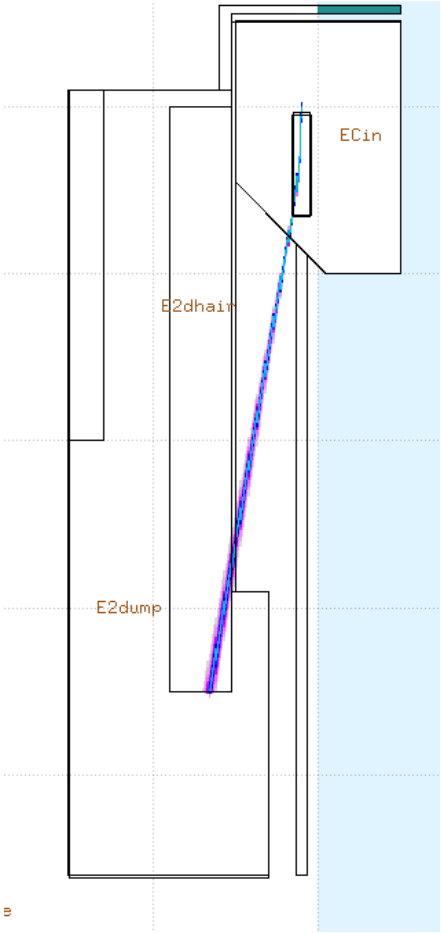
Exponential E_{min} 40 MeV



0.5 MeV monochromatic



1 GeV monochromatic

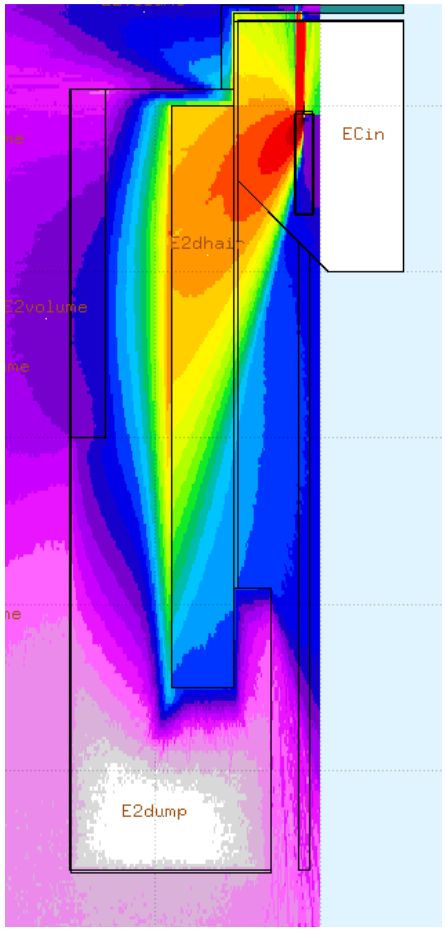


E2 2 GeV electrons

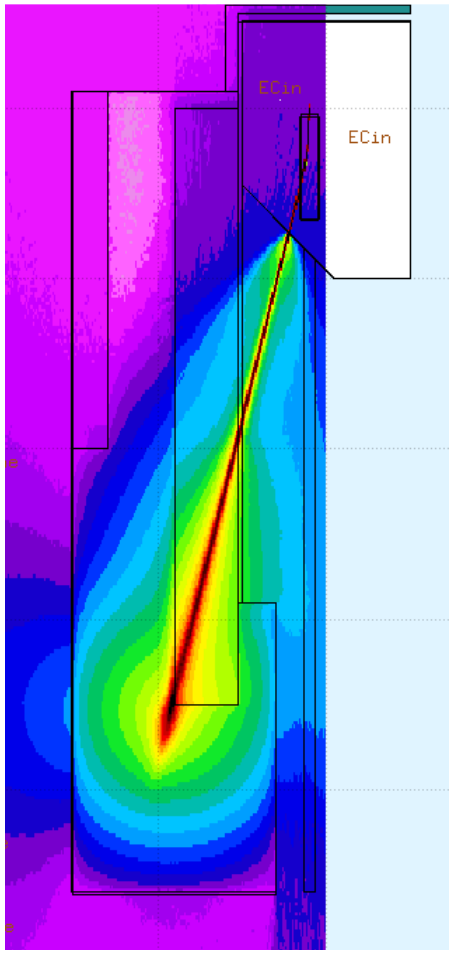
All particles fluence

Different operation modes imply different source terms

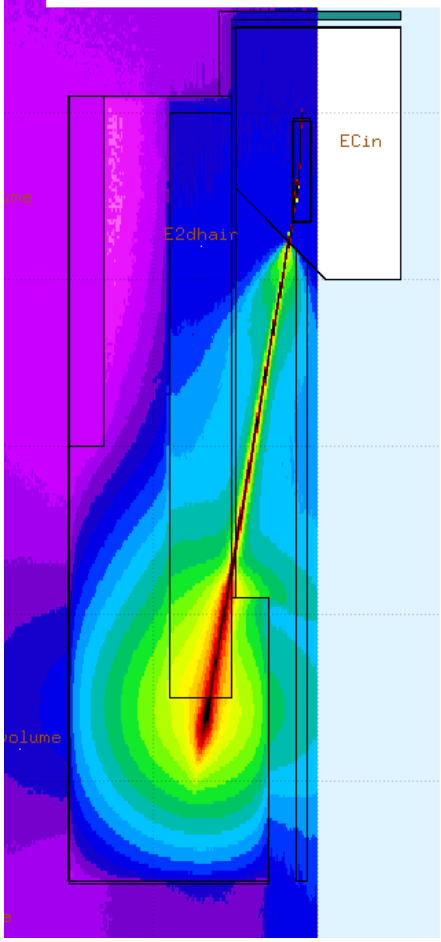
Exponential E_{min} 40 MeV



0.5 MeV monochromatic



1 GeV monochromatic



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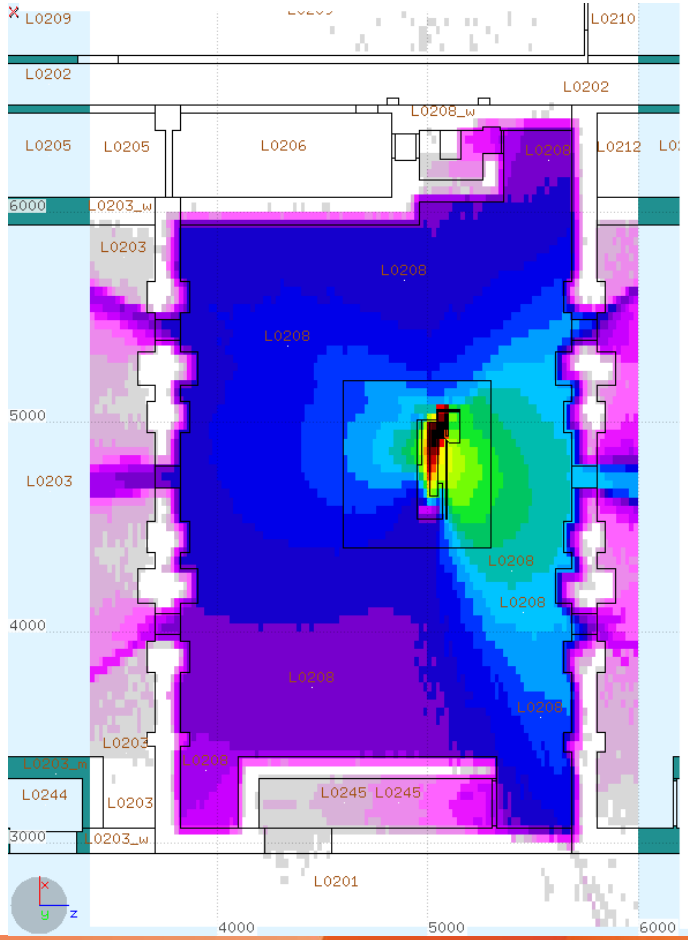
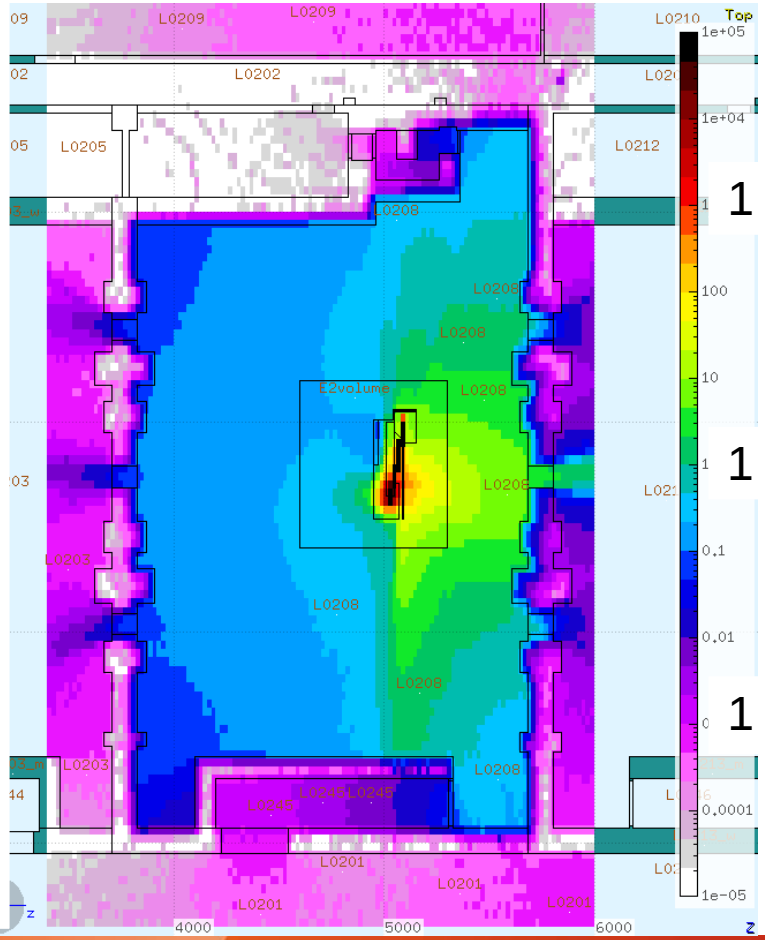
E2 2 GeV electrons

Dose equivalent per day (4h) of operation

Exponential E_{min} 40 MeV



1 GeV monochromatic



1 Sv

1 mSv

1 μSv

Materials for Experimental Chambers

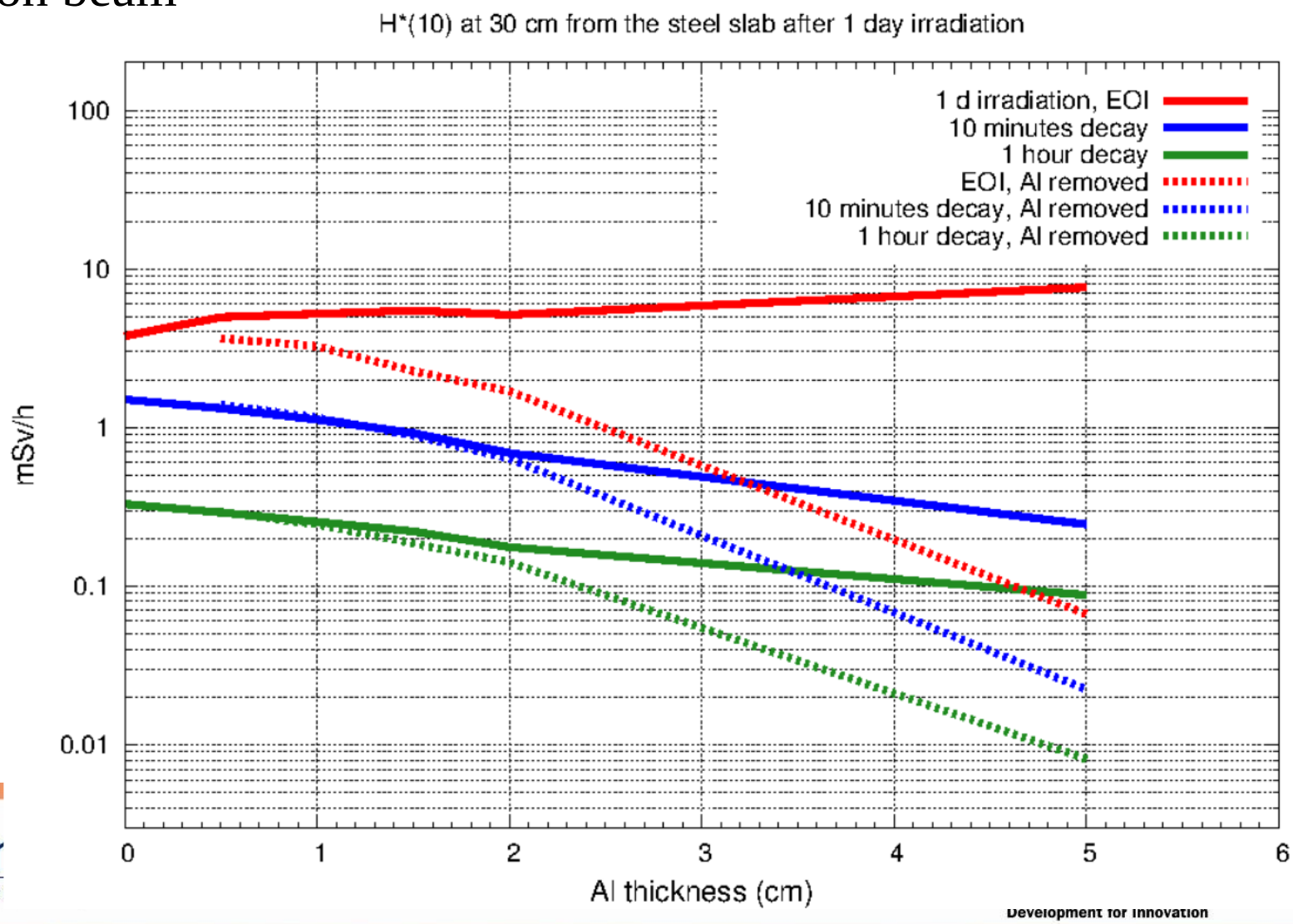
Identification of the best materials for the experimental chambers

100 MeV proton beam

H*(10) @30cm as function of target thickenss

Units:

mSv/h vs cm



Conclusions

- ELI presents new challenges for the laser community
- A large amount of RP work
- First simulation based on detailed building model
- First activation studies

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