# Shielding and environmental monitoring for the ALFA accelerator at ELI Beamlines

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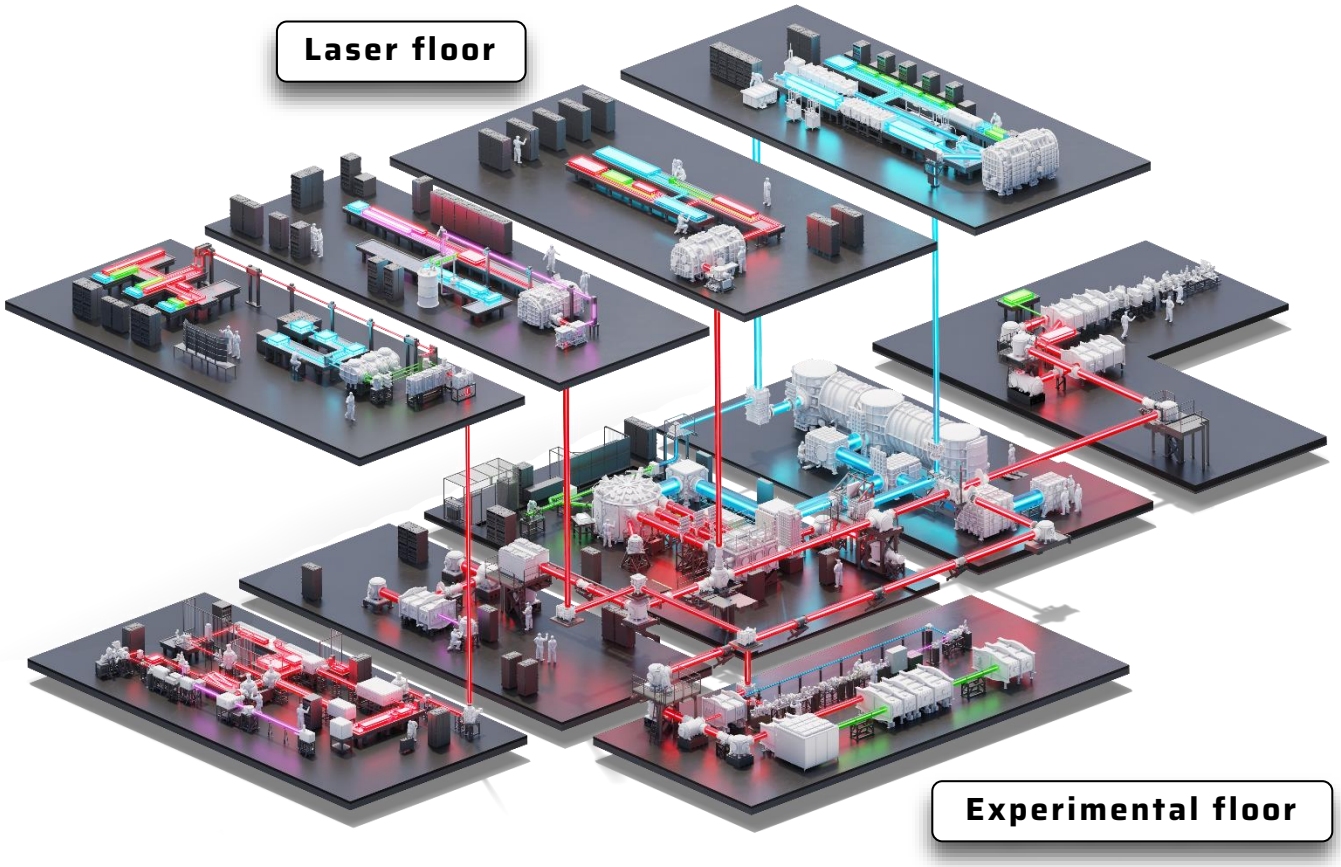
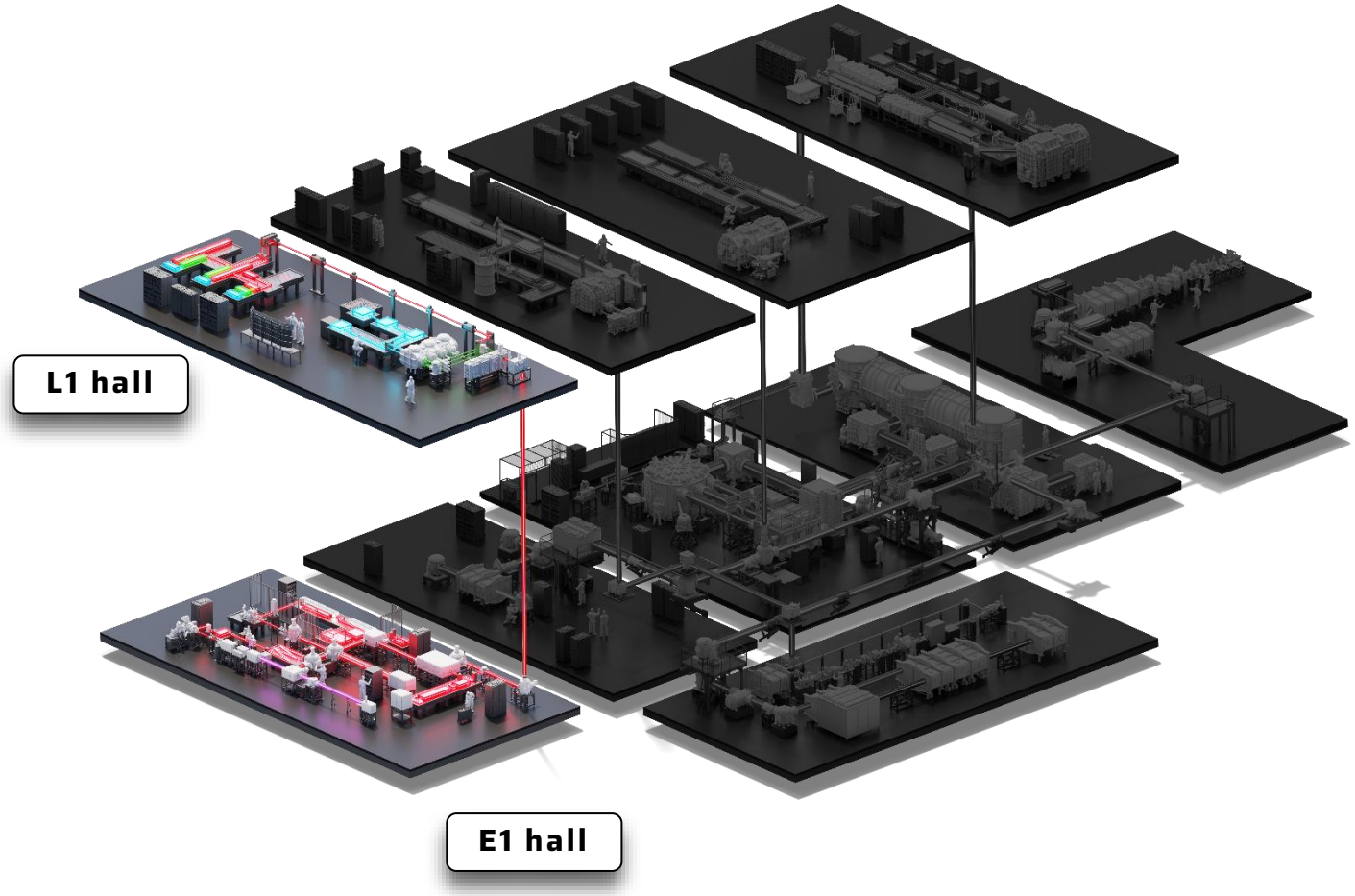
# Outline

1. The ALFA laser-plasma accelerator
2. Shielding design
   - Source term
   - Evolution of the design
3. Environmental Dose Monitoring
   - Passive – OSL
   - Active – Pandora
4. Conclusions

# ELI Beamlines Facility



# ELI Beamlines Facility



# L1 – Allegra

In house development

Design parameters:

- 100 mJ energy per pulse
- 15 fs pulse length
- 1 kHz repetition rate

Currently:

- ~ 40 mJ max energy

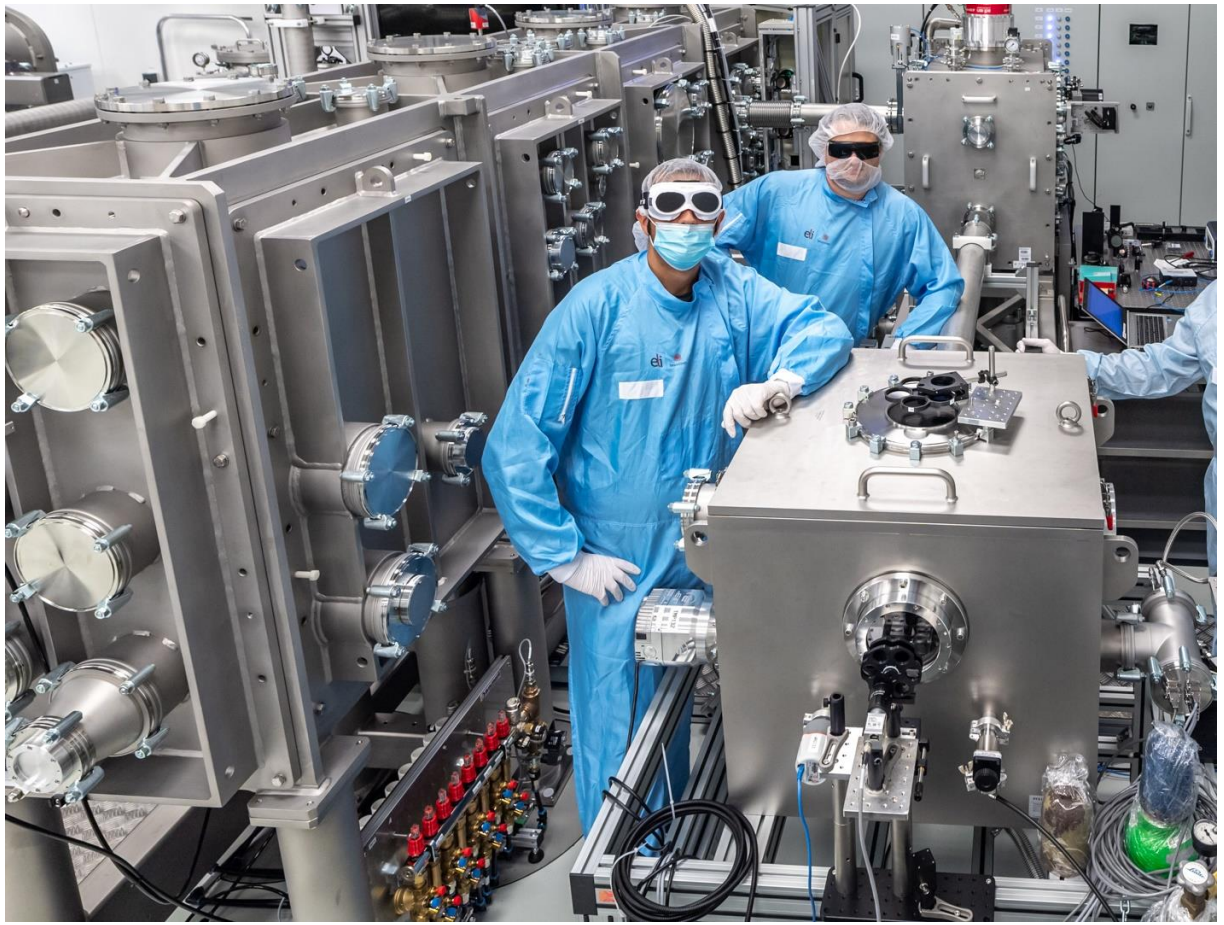
# ALFA

**A**llegra **L**aser **F**or **A**cceleration

Utilizing laser wakefield acceleration (LWFA) to accelerate electrons

Located in the L1 hall

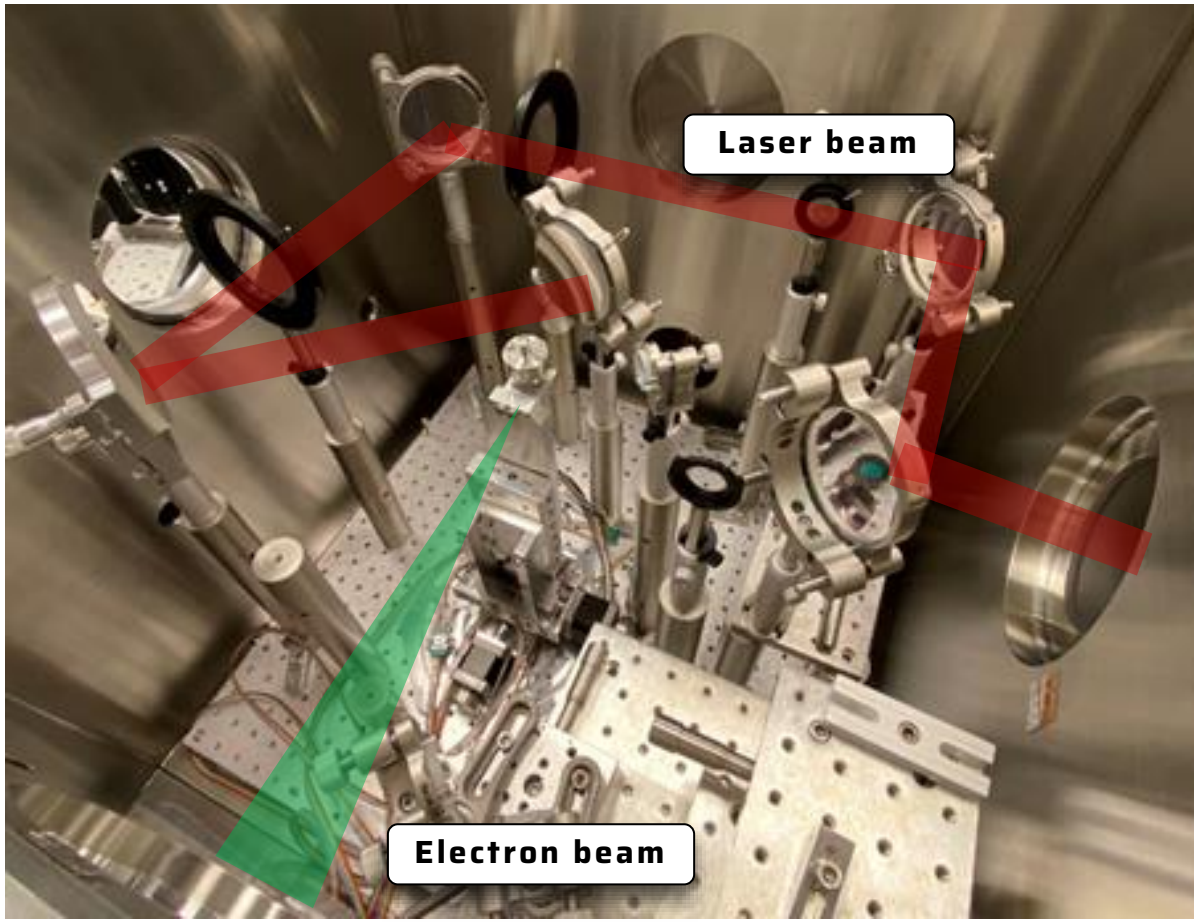
Under continuous development



# ALFA

During commissioning:

- With 26 mJ laser power:
  - ~ 32 MeV average and
  - > 50 MeV maximum electron energy
- Operated only in bursts
- Successful user experiments



# RP challenges at ALFA

## Main issues

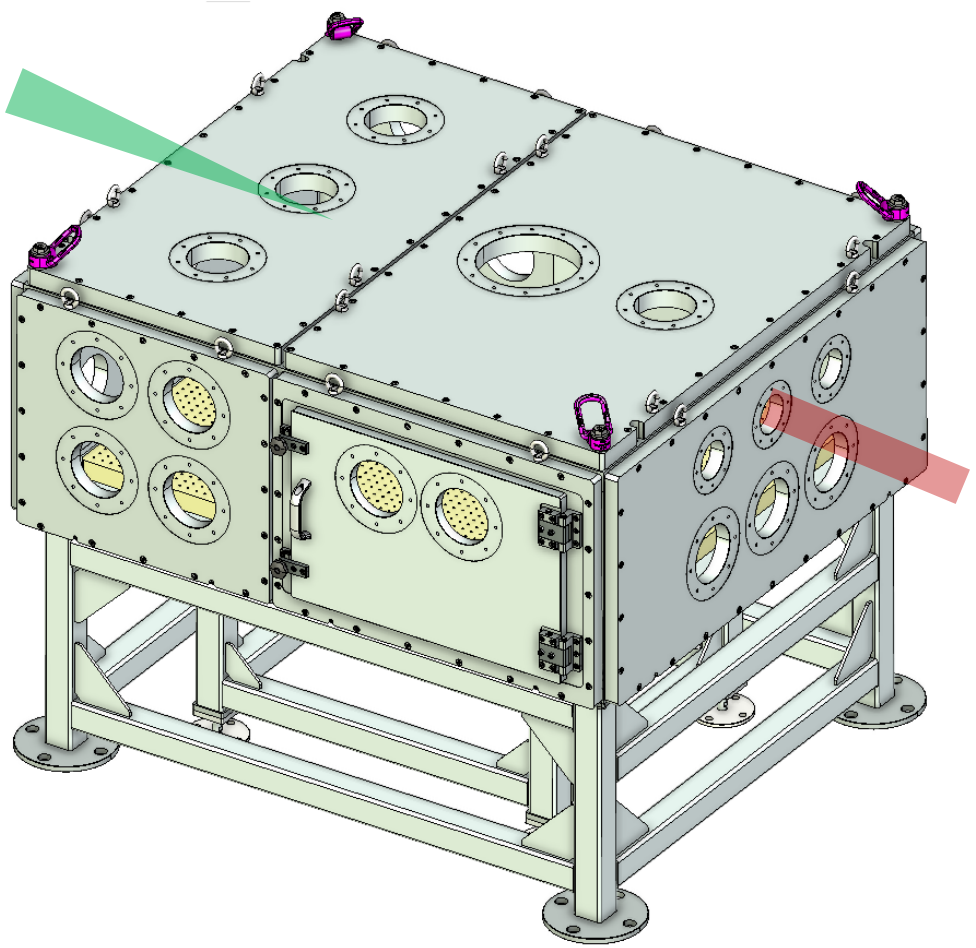
The laser floor was not designed for particle acceleration

- Wall – 40 cm, calcium silicate bricks
- Large penetrations, no labyrinth
- Limited floor load capacity
- Sparse active radiation monitoring on the laser floor

# RP challenges at ALFA

New chamber – change in beam direction:

- *Old:* Low occupancy “south” corridor
- *New:* Frequently used “west” corridor, entrance to changing room



Future developments:

- Higher laser power
- Continuous operation

# Source term

Source term @ 1 kHz – 26 mJ laser power

- Quasi monoenergetic electrons:
  - Gaussian: 50 MeV mean, 10 MeV FWHM
  - 2.1 mrad divergence + 7 mrad pointing uncertainty
  - 10 fC/shot
- Background electrons:
  - Uniform: 0 – 20 MeV
  - 10 mrad divergence + 10 mrad pointing uncertainty
  - 100 fC/shot
- Background photons:
  - Gaussian: 80 keV mean 16 keV FWHM
  - 10 mrad divergence + 10 mrad pointing uncertainty
  - $10^{10}$ photons/shot

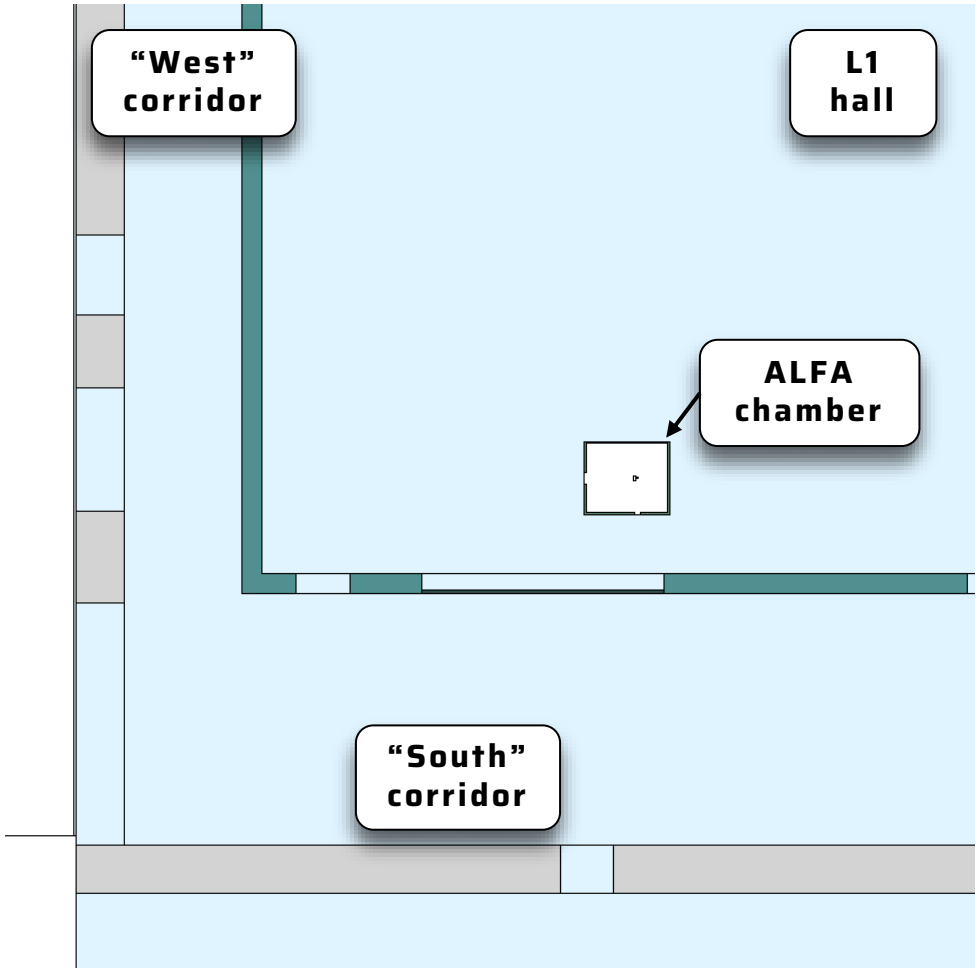
# Monte Carlo simulation

Using FLUKA v4.3-3

Using JEFF-3.3 low energy neutron cross-sections

Photo- and electronuclear interactions enabled

Scoring ambient dose (H*) [ICRP116]



# Monte Carlo simulation

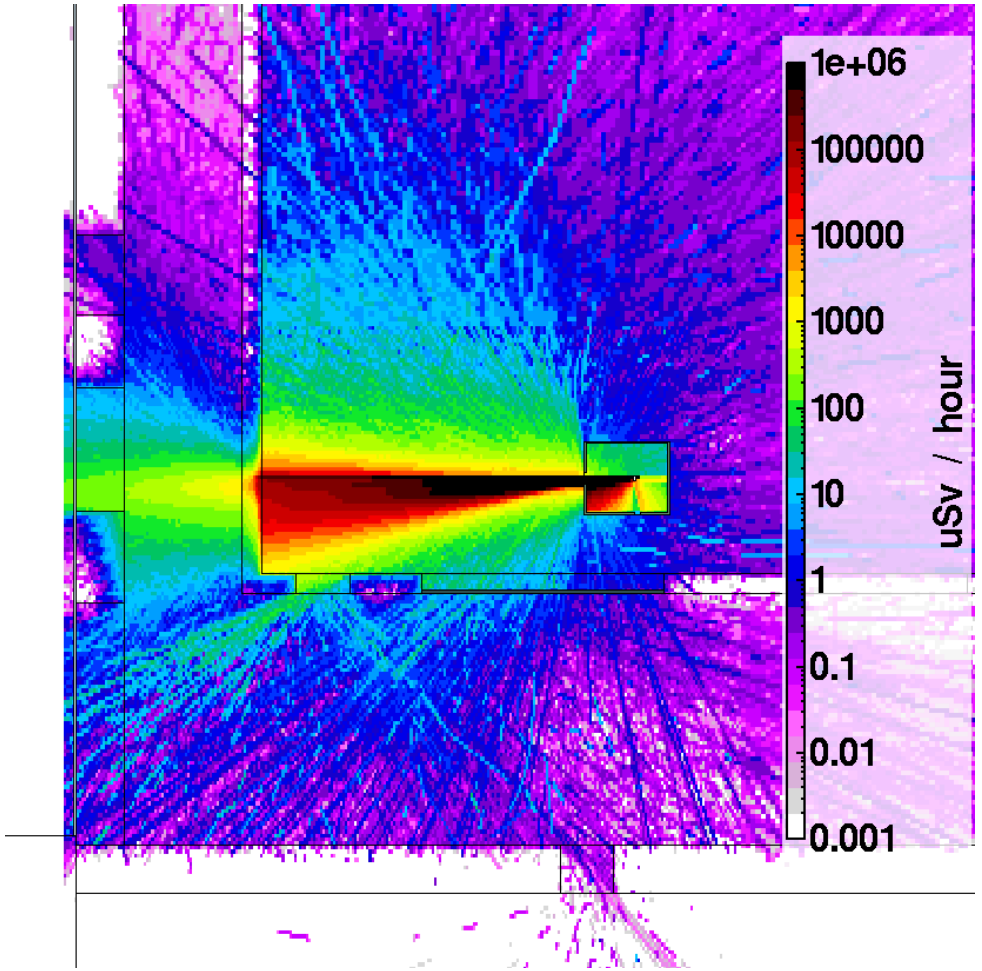
- No objects downstream
- Small 0.1 T magnet for spectrometer

H* rate in the hall:

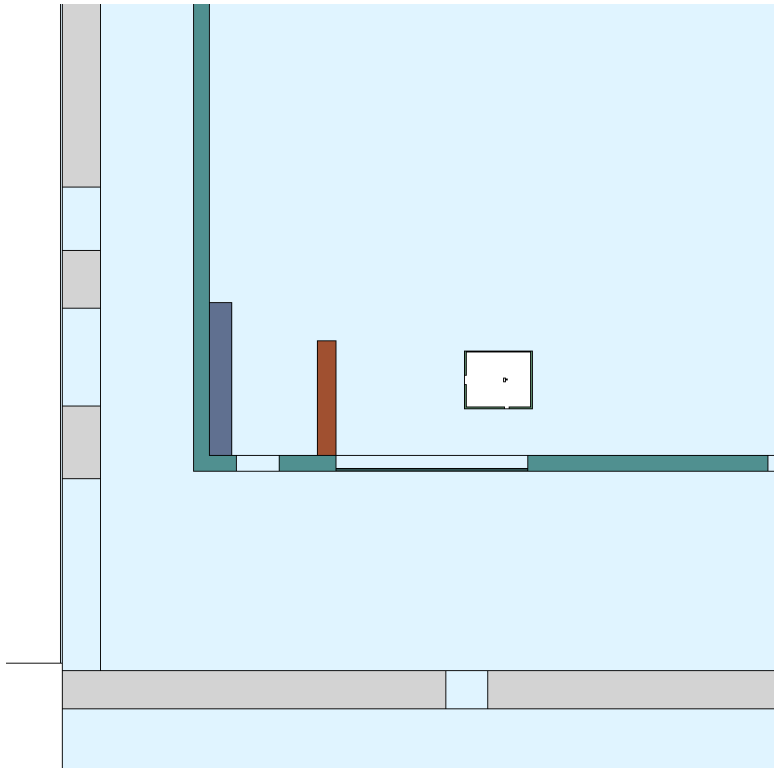
> 1 Sv/hour

H* rate in the “west” corridor:

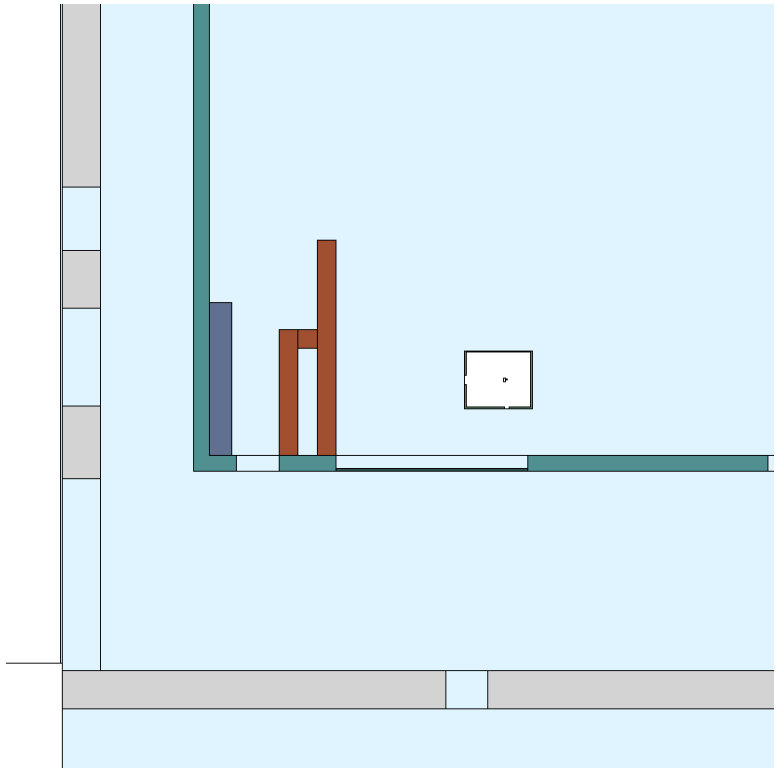
~ 1 mSv/hour



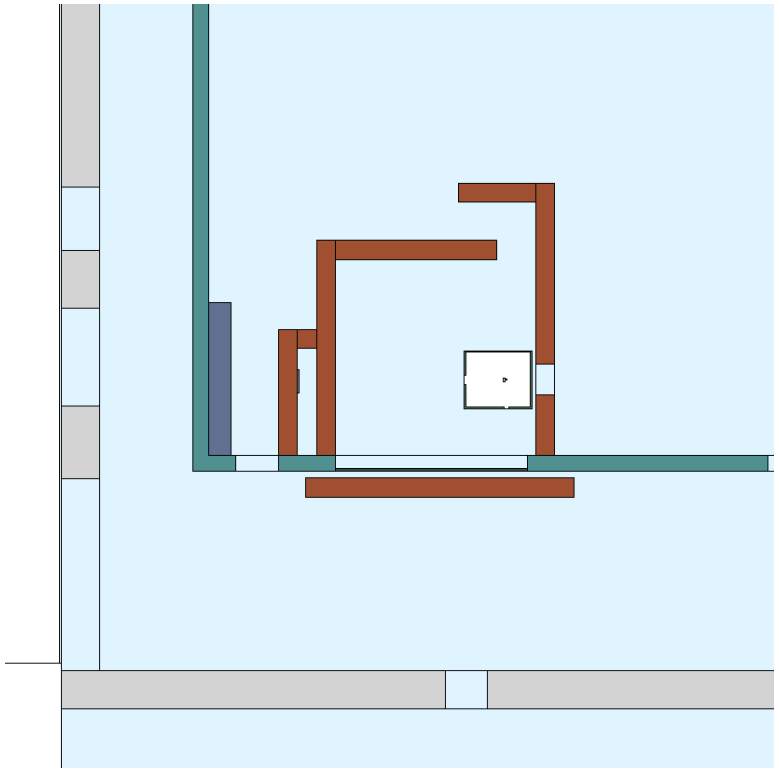
# Shield designs



Concrete: 4.8 $m^3$ - 12.48 t
Granite: 3 $m^3$ - 8.1 t

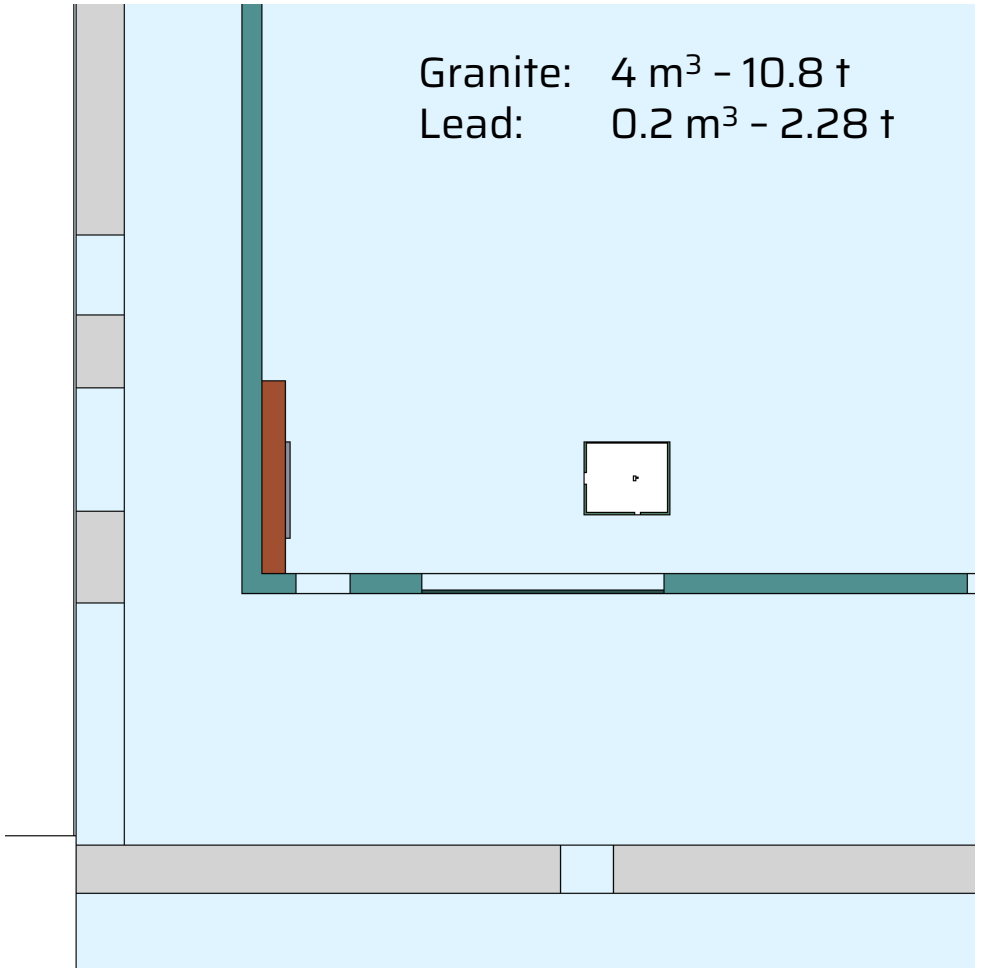


Concrete: 4.8 $m^3$ - 12.48 t
Granite: 9.42 $m^3$ - 25.4 t



Concrete: 4.8 $m^3$ - 12.48 t
Granite: 29.5 $m^3$ - 79.7 t
Lead: 16.5 $dm^3$ – 188 kg

# Final design

# Final design

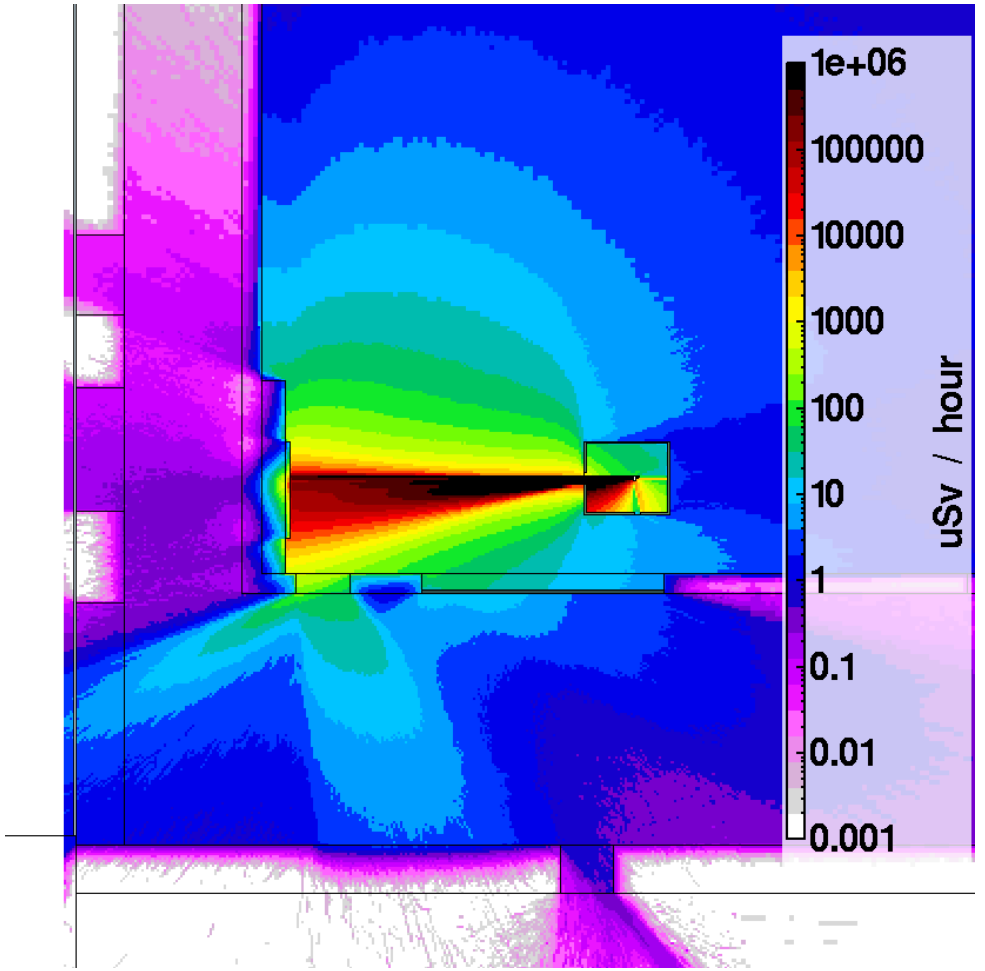
H* rate in the “west” corridor:

< 1 µSv / hour

H* rate in the “south” corridor:

max. ~ 100 µSv / hour

No access during operation



# Environmental monitoring

**Passive measurements**

BeO OSL dosimeters

**O**ptically **S**timulated **L**uminescence

Good dosimetric properties:

- High sensitivity to radiation
- Linear response: from 1 µGy to 1 Gy

Sets of 4 in lighttight package

# Environmental monitoring

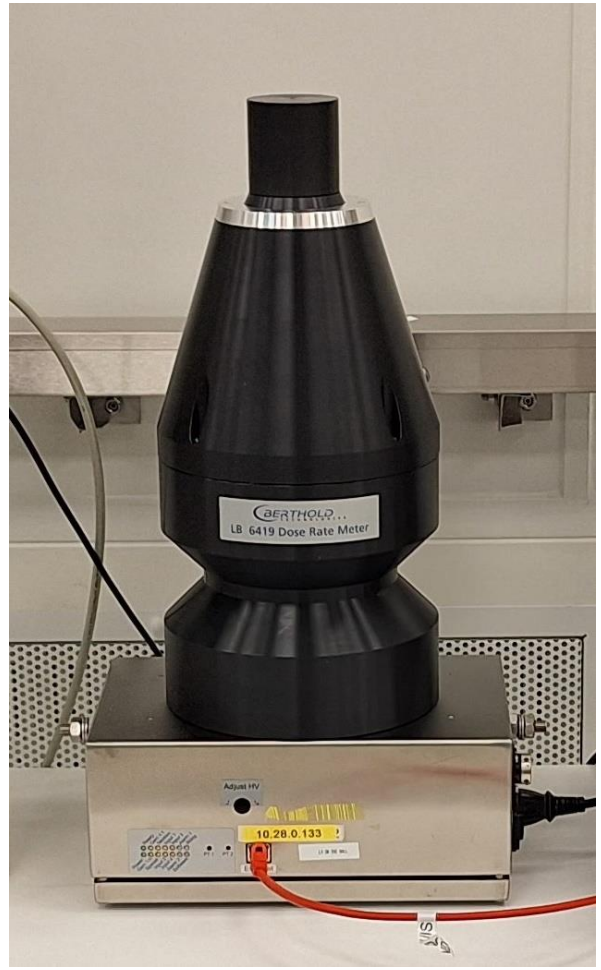
**Active measurements**

Pandora (LB 6419) by Berthold

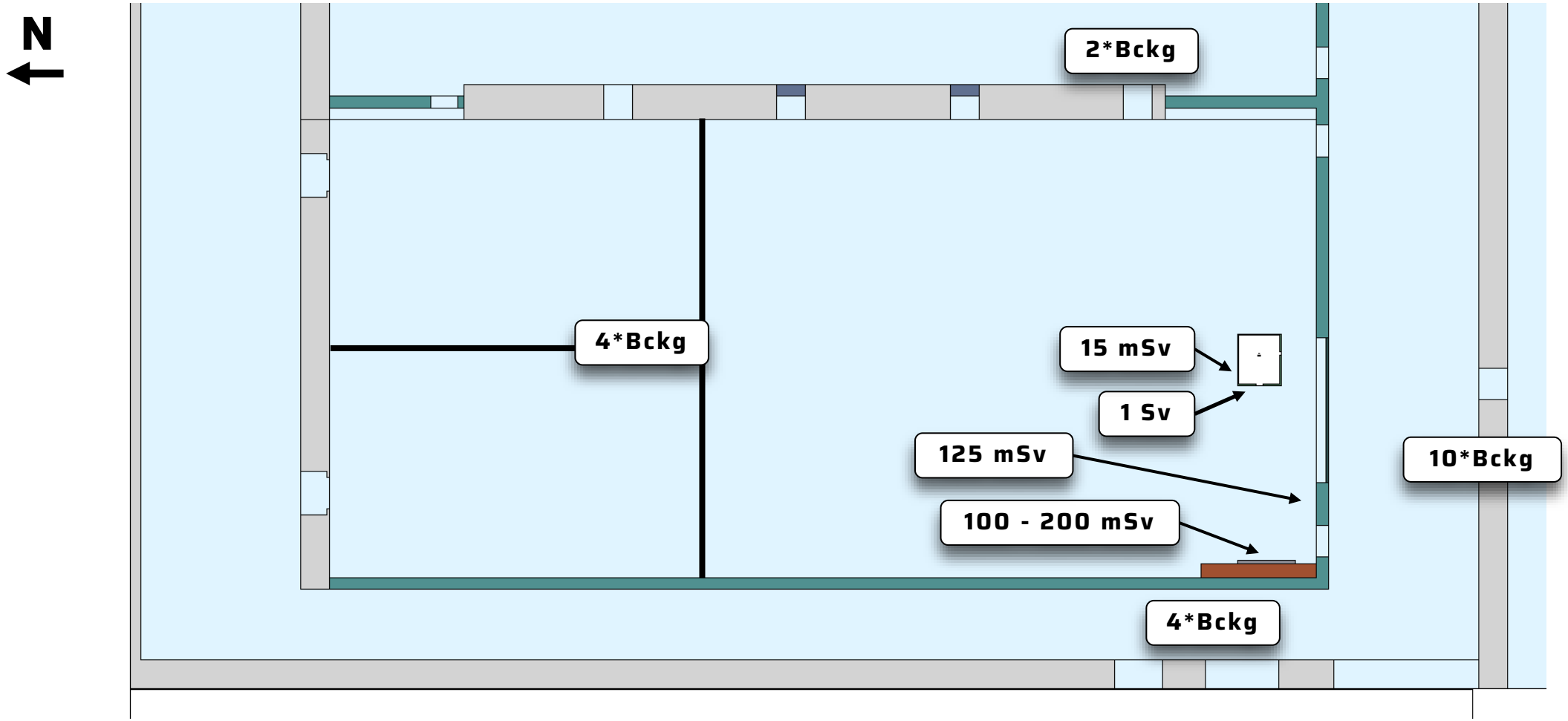
**P**hoton **A**nd **N**eutron **Do**se **R**ate meter for **A**ccelerators

Scintillator and $^{3}$He counter

Continuous and pulsed fields



# OSL results (1 week)



# Pandora results

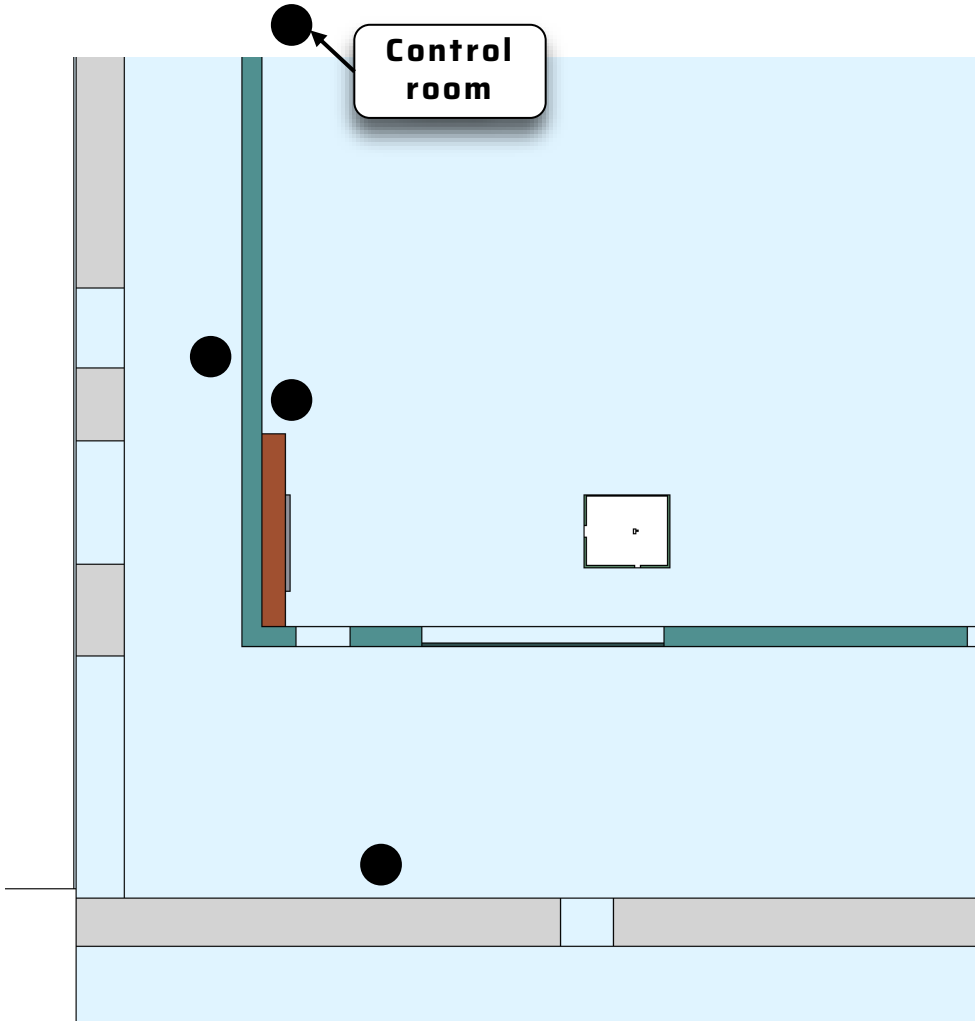
Pandoras had to be relocated

Dose rate:

- Control room: up to 5 µSv/hour
- “West” corridor: up to ~ 100 µSv/hour

Immediate action:

- Close “west corridor” and changing room



# Conclusions

Monte Carlo simulation only can be as good as its input

- Source term is just an assumption

Experimental setup is in constant change

Shot-by-shot differences

Fast moving research field – Difficulty to scale up radiation protection

# Thank you for your attention!

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