Radiation shield for NLC

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The 28th KEKB Accelerator Review Committee

Recent radiation issue

- A vertical collimator (D05V1) was installed in Oho area as part of the NLC system. Operation with the collimator began at the start of 2024.

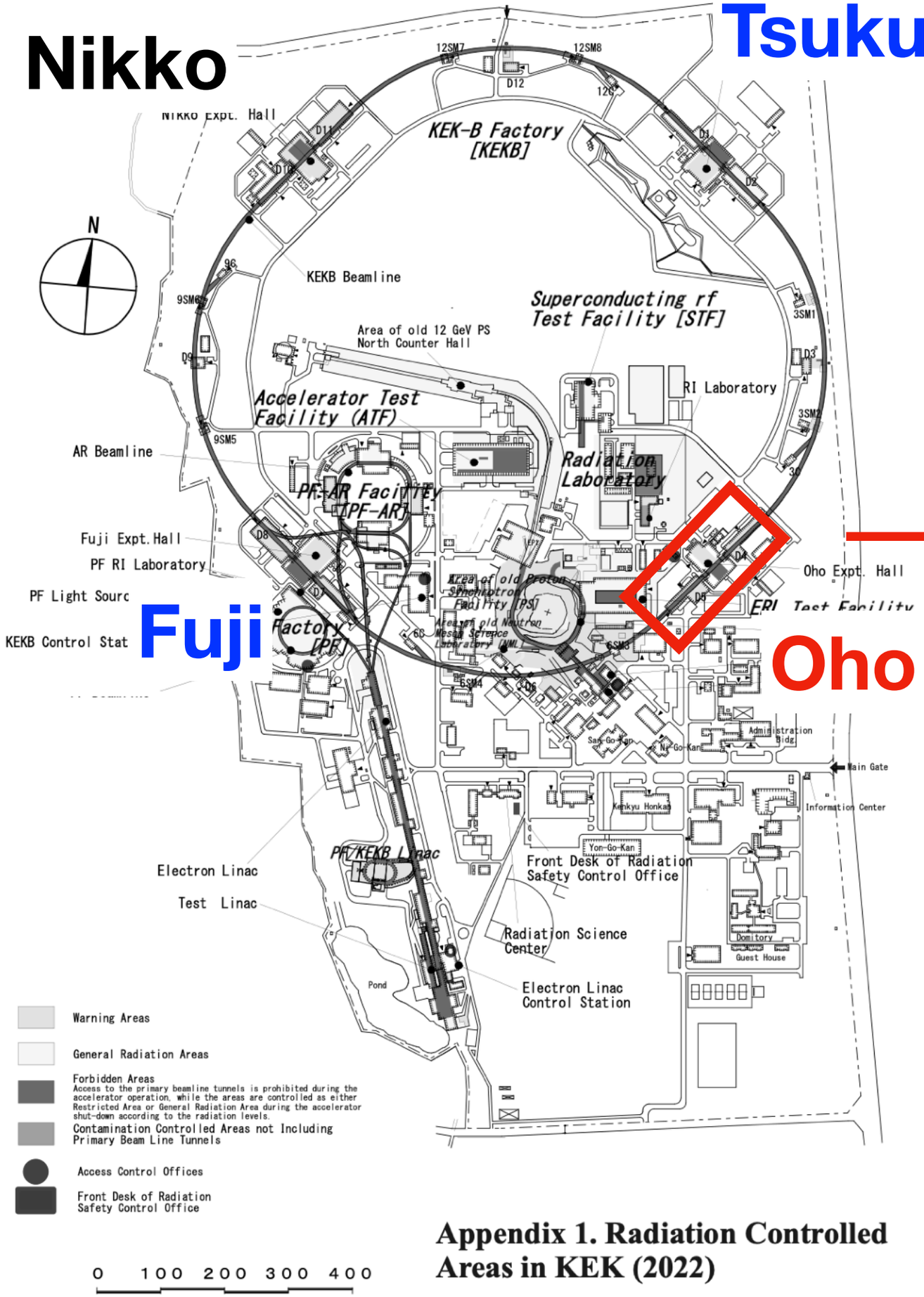
- In 2024c, beam losses significantly increased, leading to higher radiation levels.

➡ The SuperKEKB operation was partially restricted.

Discuss the current situation and future measures, such as installing new shielding.

Nikko

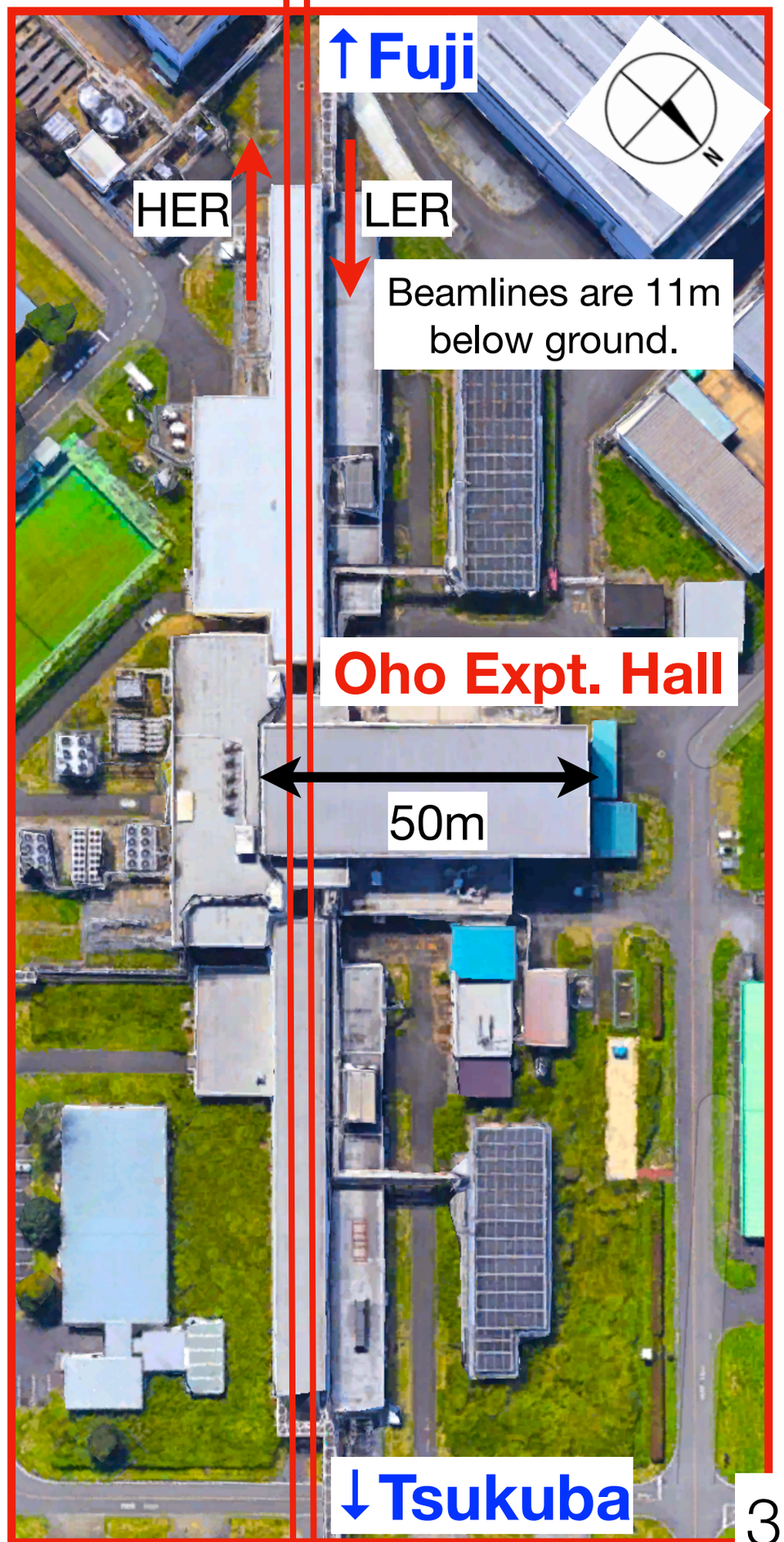
Tsukuba



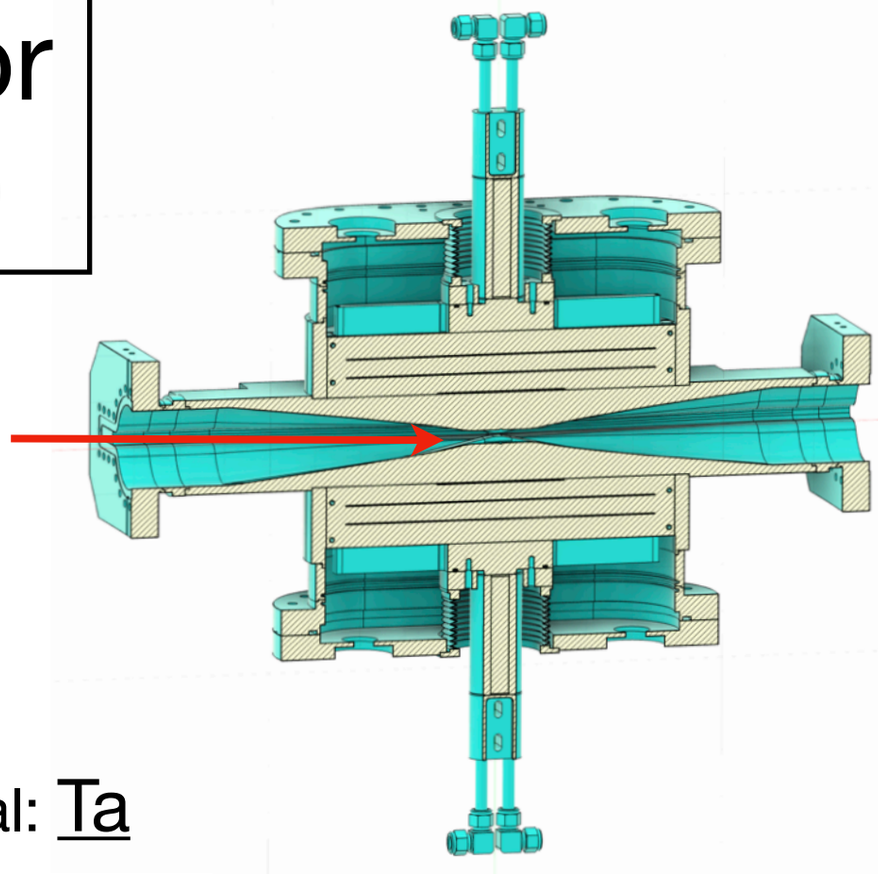
Appendix 1. Radiation Controlled Areas in KEK (2022)

Fuji

Oho



Collimator (D05V1)



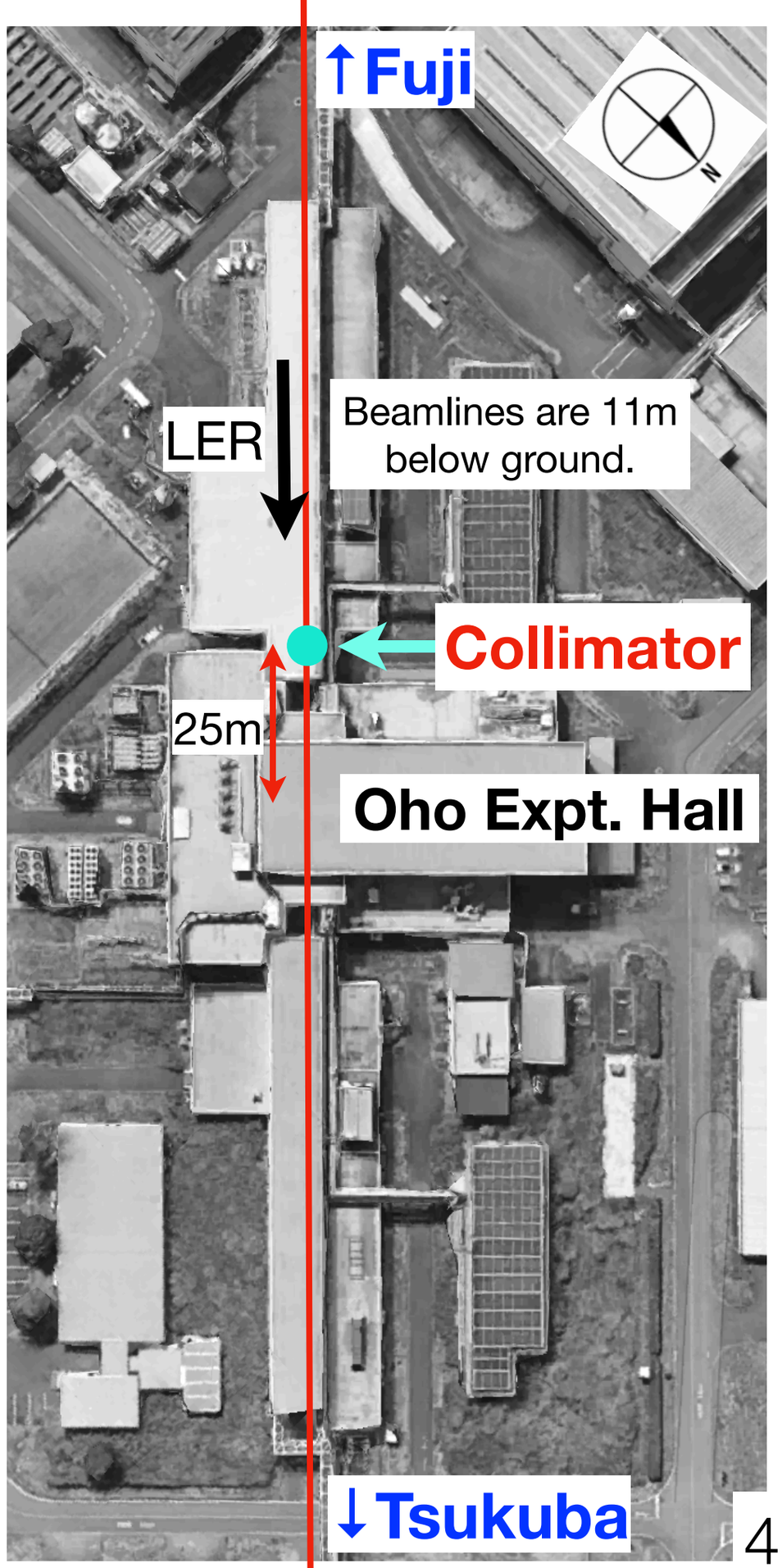
- Head Material: Ta
- Beam Loss: 8 x 10^9 e^+/s (initial assumption)

➡ The maximum loss in 2024c is guessed to be 10 to 20 times higher.

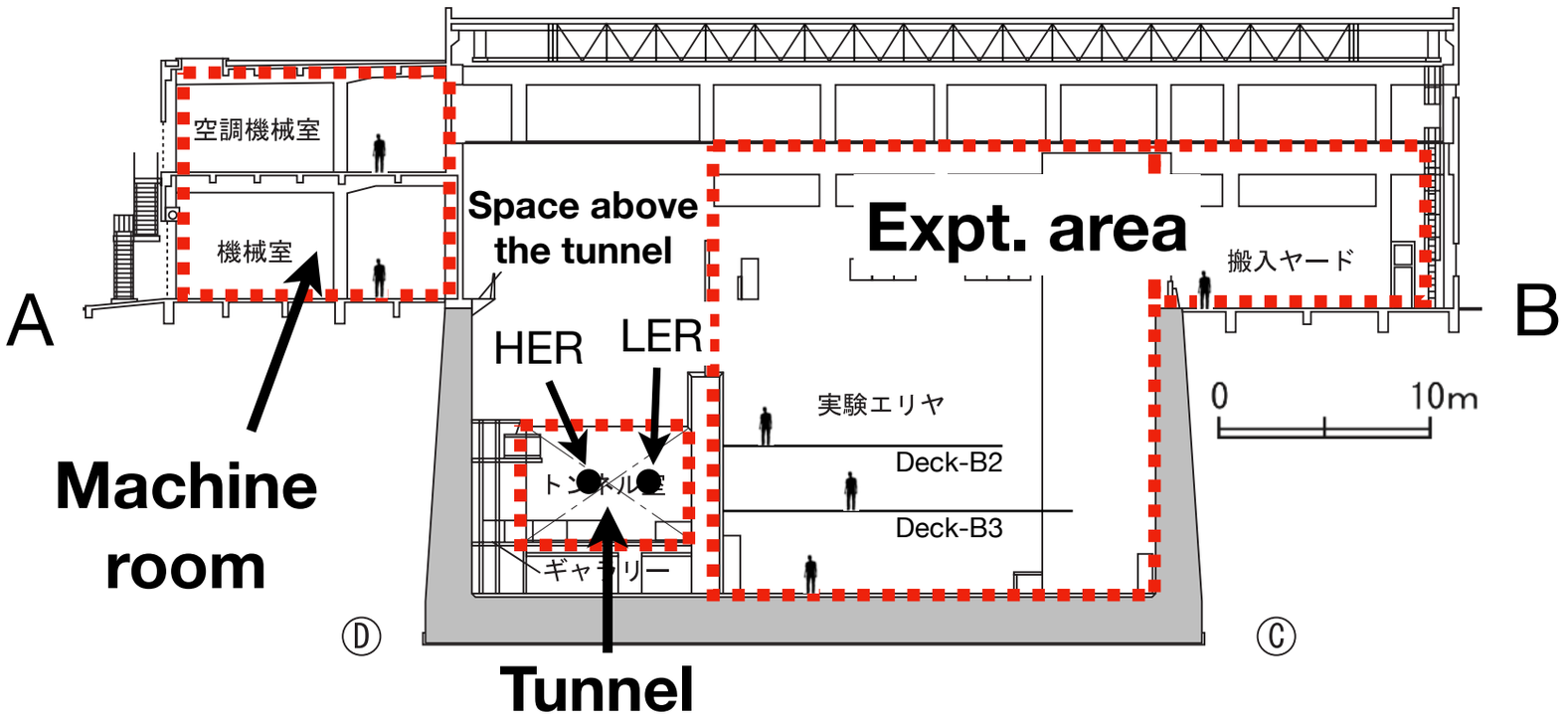
Assuming that injection loss is dominant...

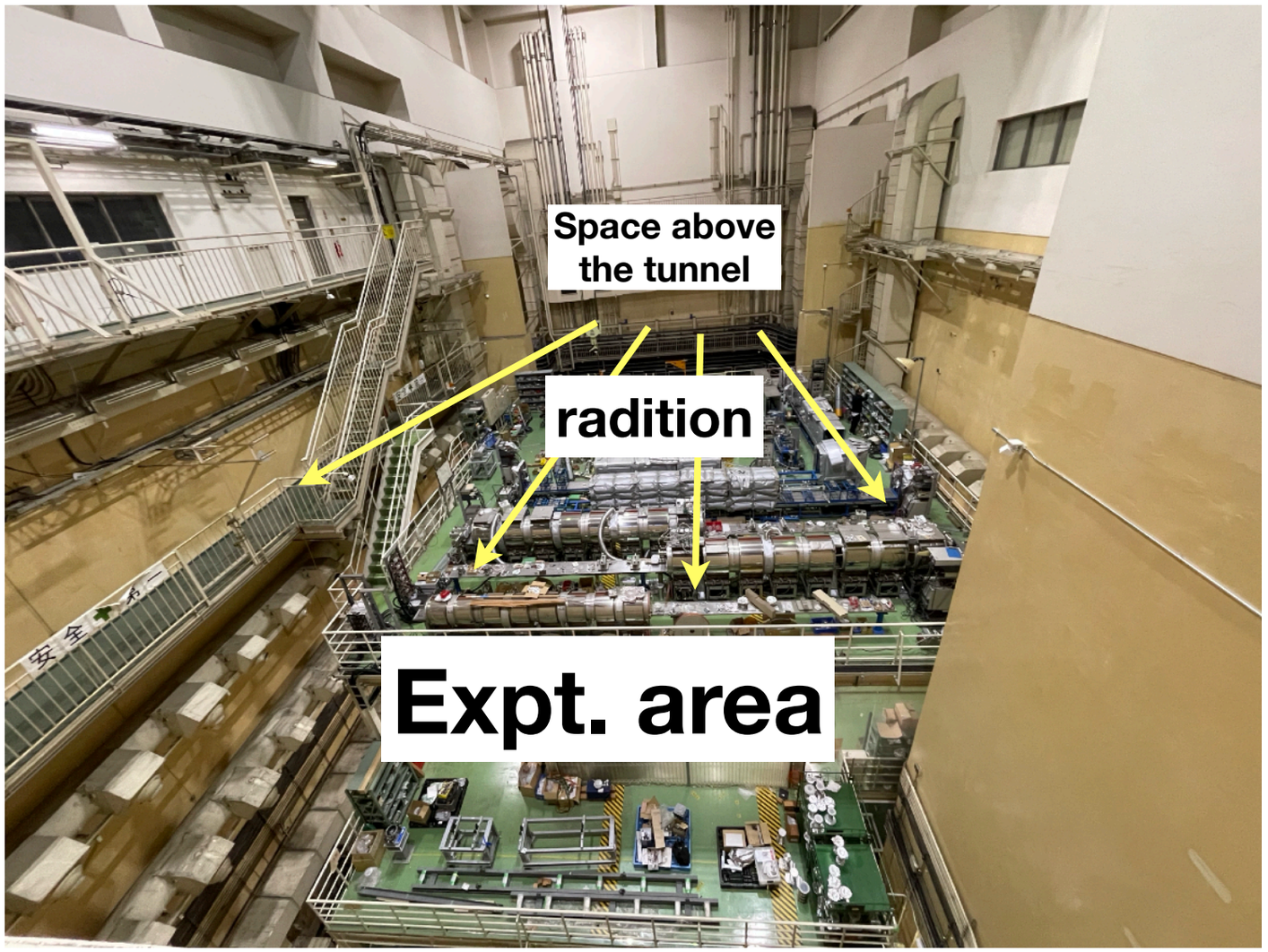
$$\text{(Number of } e^+ \text{ hitting)} \sim 8\times10^9\ \frac{\mathrm{e}^+}{\mathrm{s}} \times \frac{\text{Repitition}}{15\,\mathrm{Hz}} \times \frac{\text{1st and 2nd Bunch charge}}{(3+3)\,\mathrm{nC}} \times \frac{\text{Injection loss rate at D05V1}}{1.5\,\%}$$

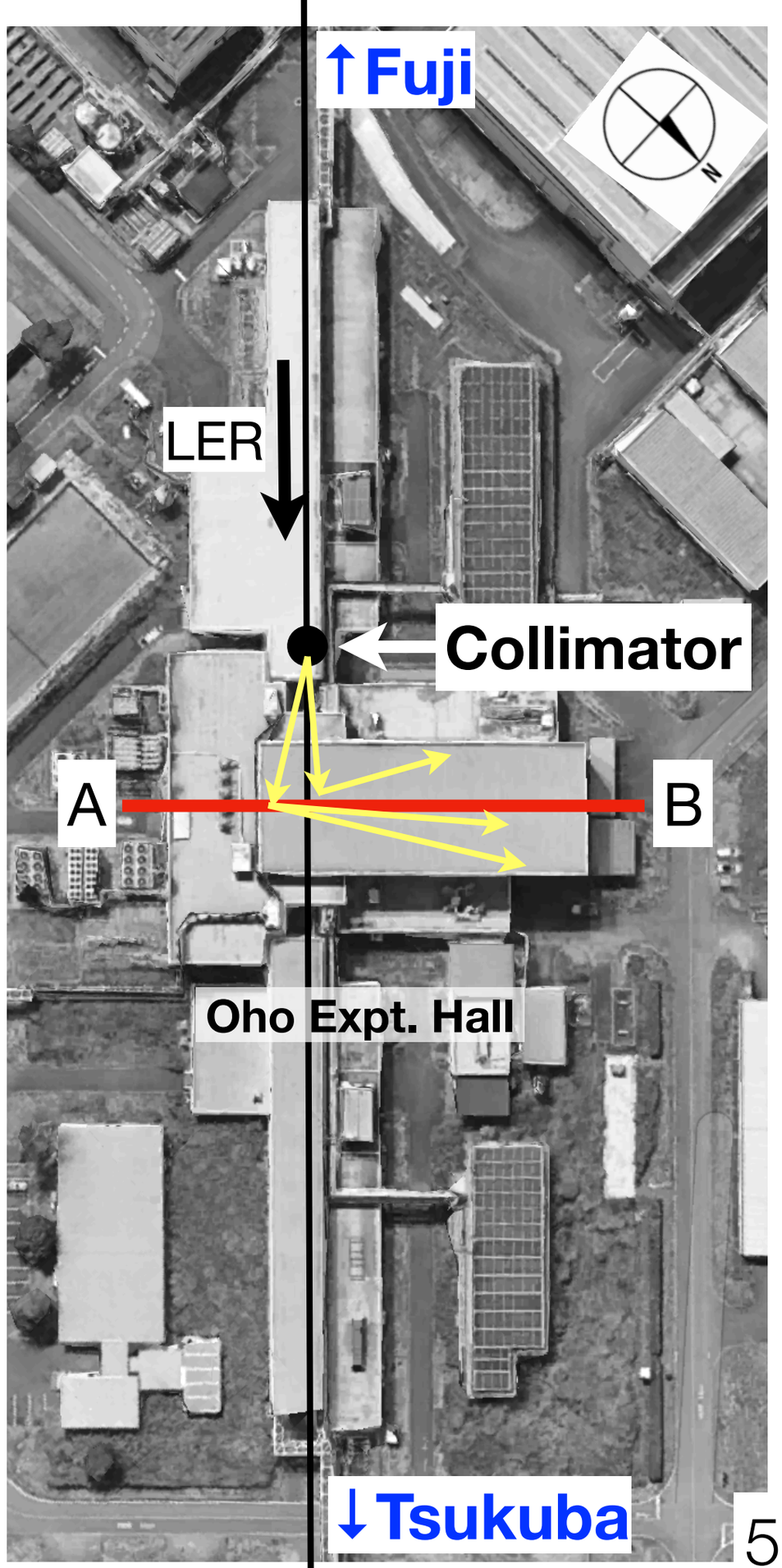
O(10)% of the injection might be lost at D05V1



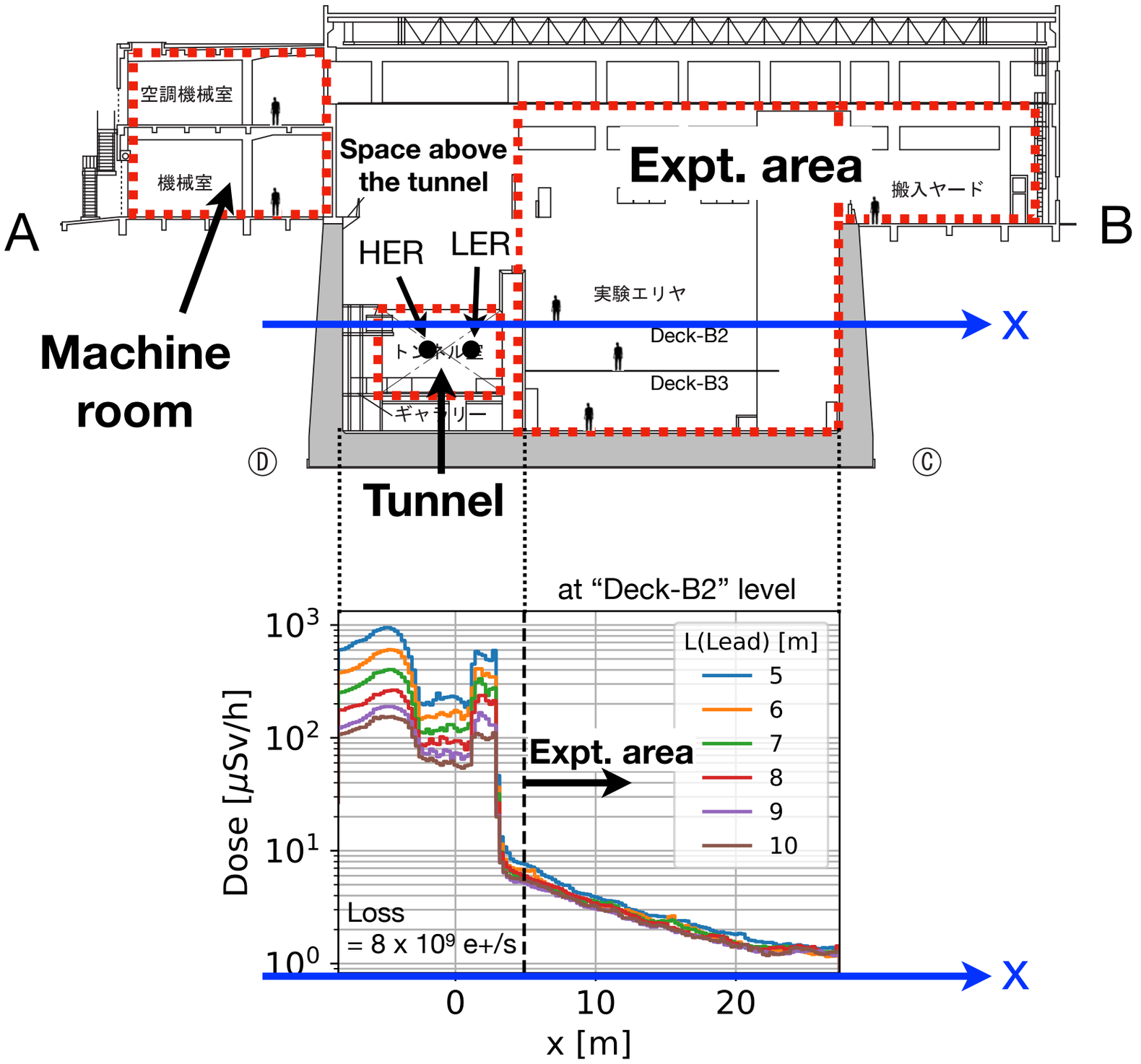
Cross section: A-B





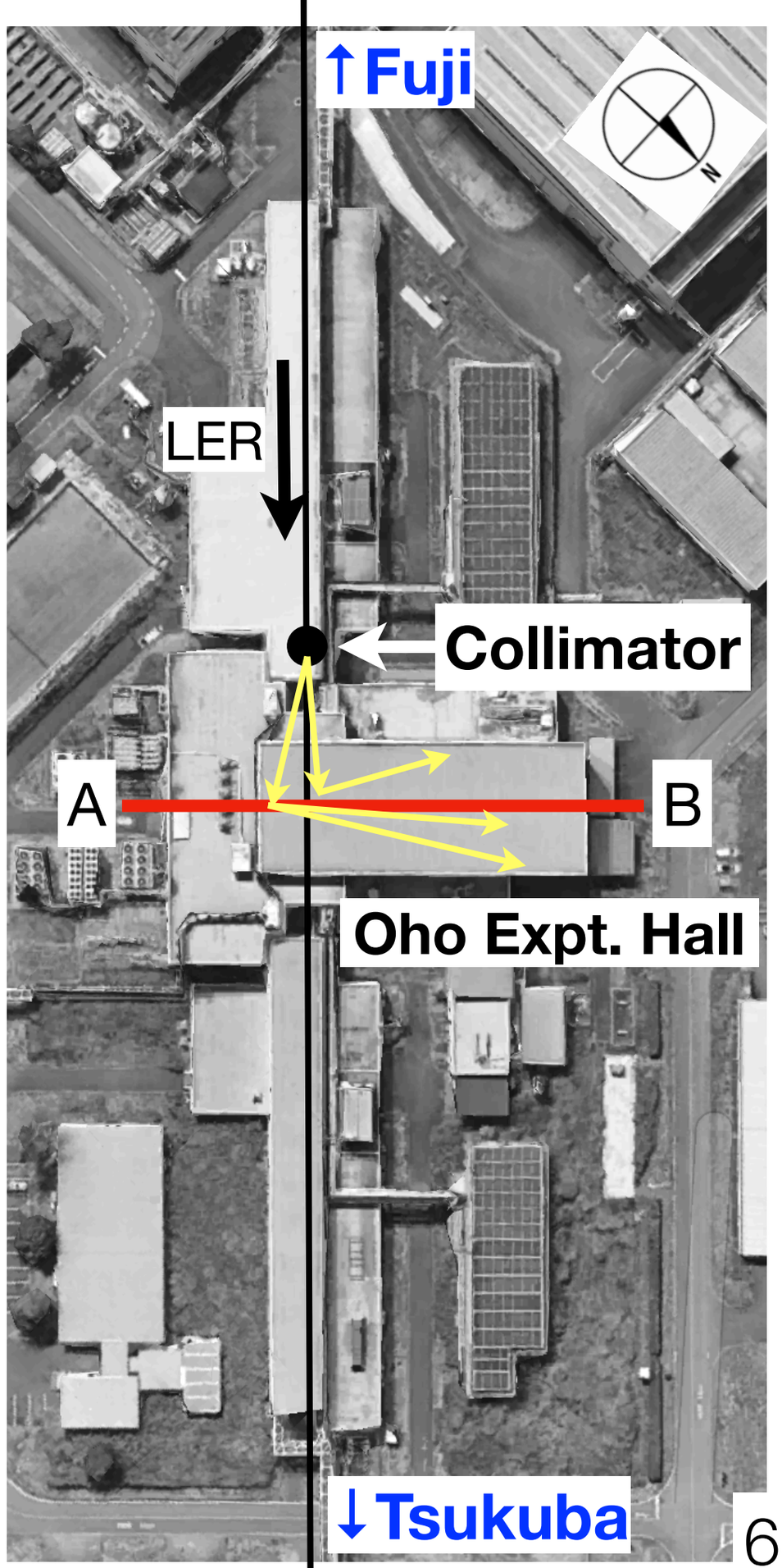


Cross section: A-B

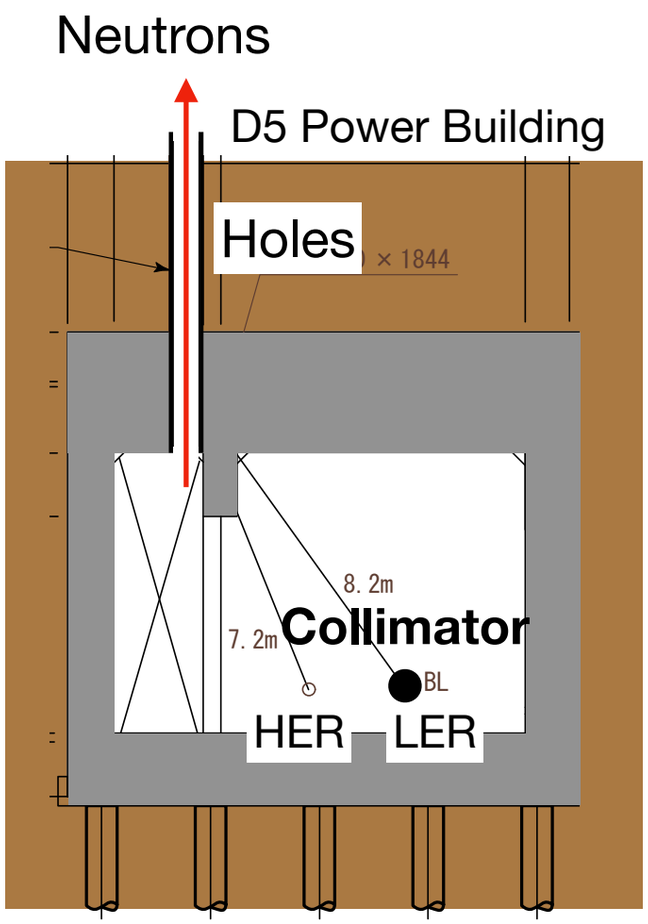


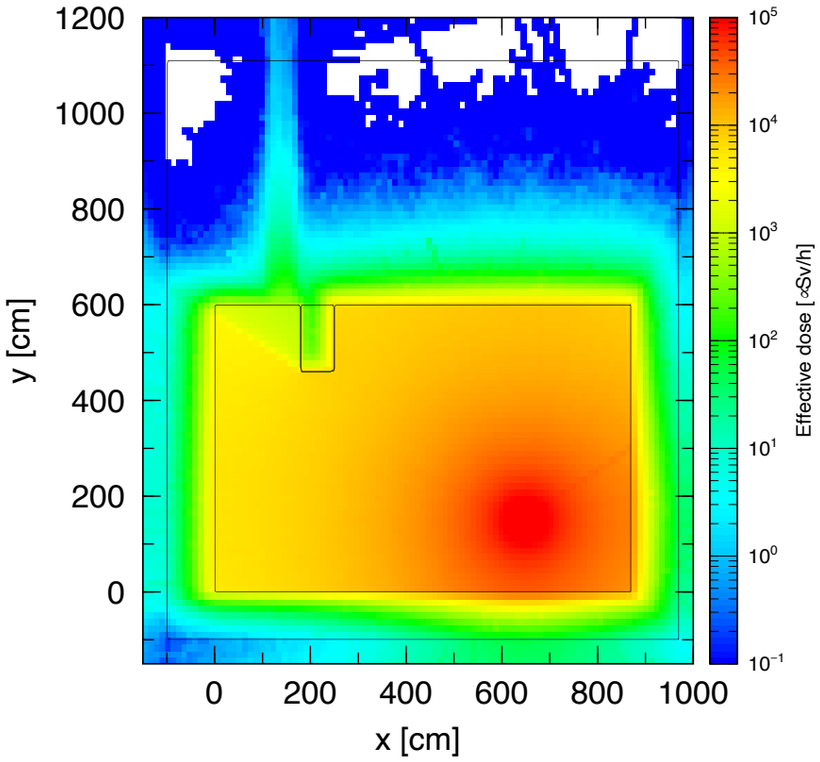
Expt. area and Machine room were applied as radiation-controlled areas, due to the potential of exceeding 1.5 μSv/h.

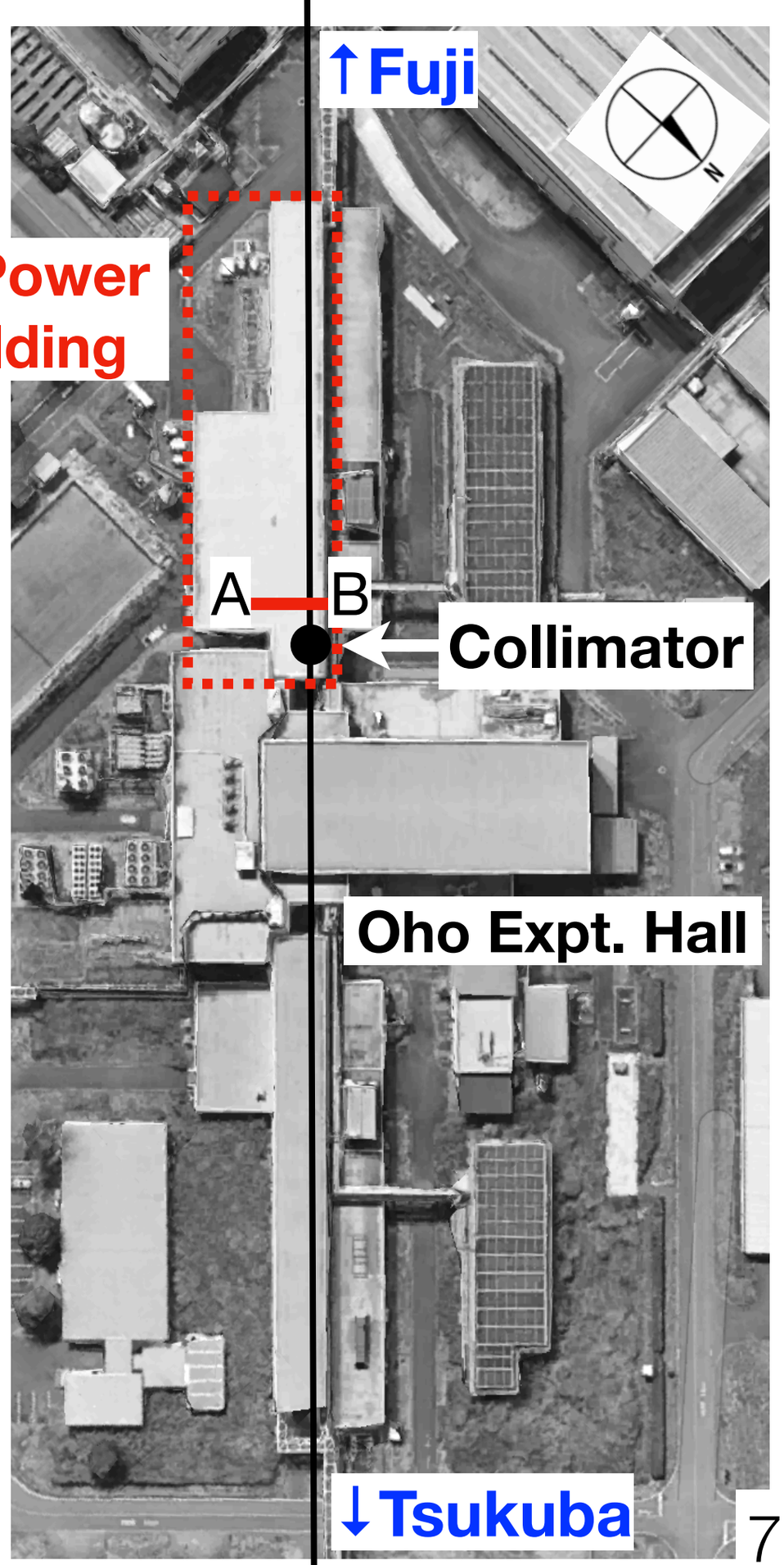
→ Accepted by the Nuclear Regulation Authority in 2023 Sep.



Cross section: A-B





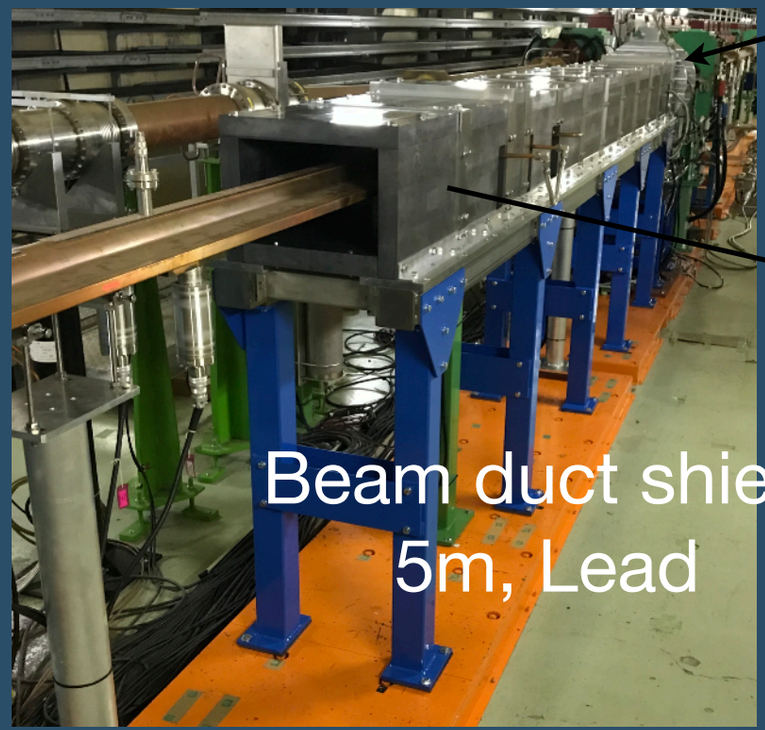


It was also applied as a **radiation-controlled area**.

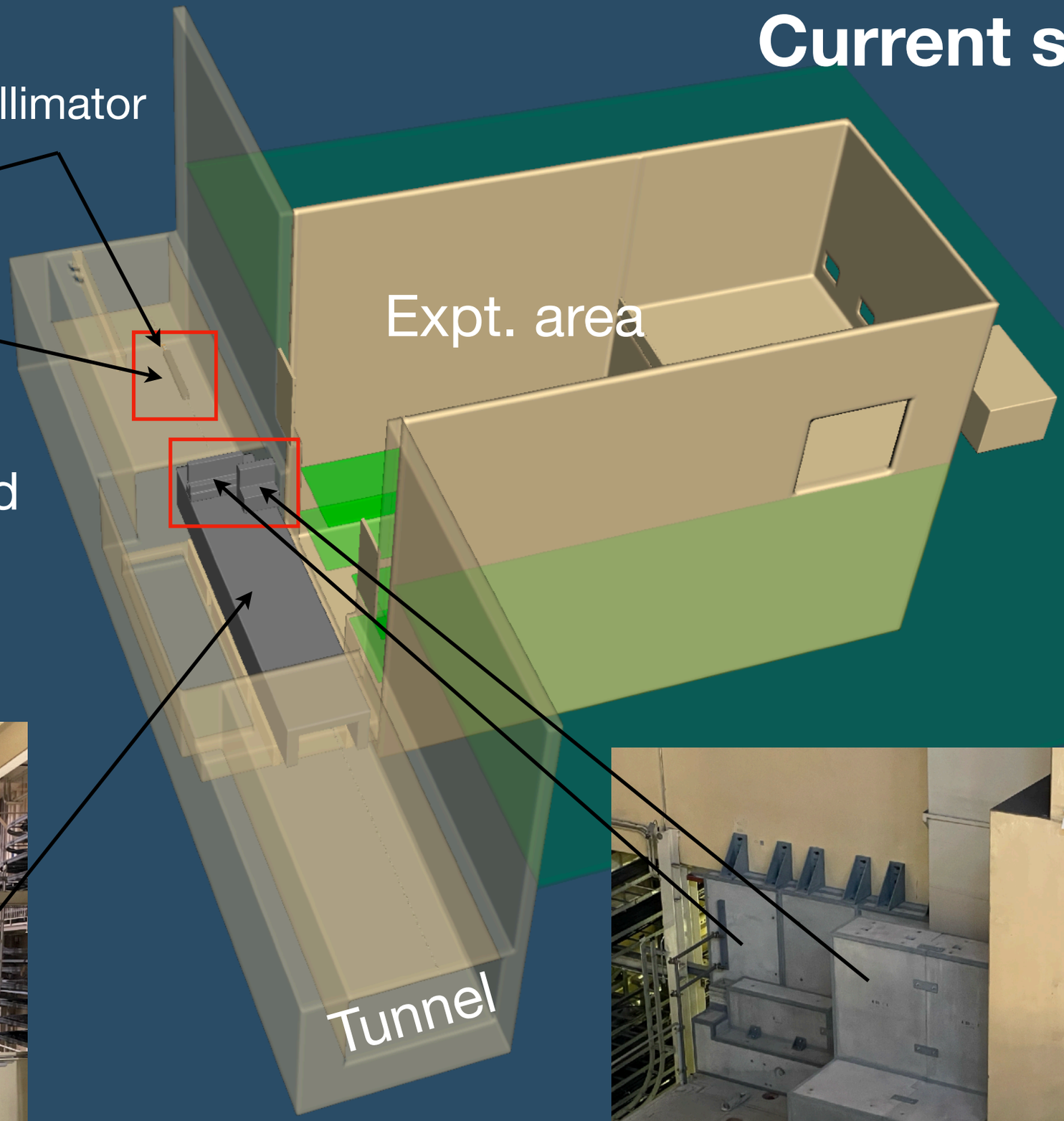
→ Accepted

Current shield

Collimator



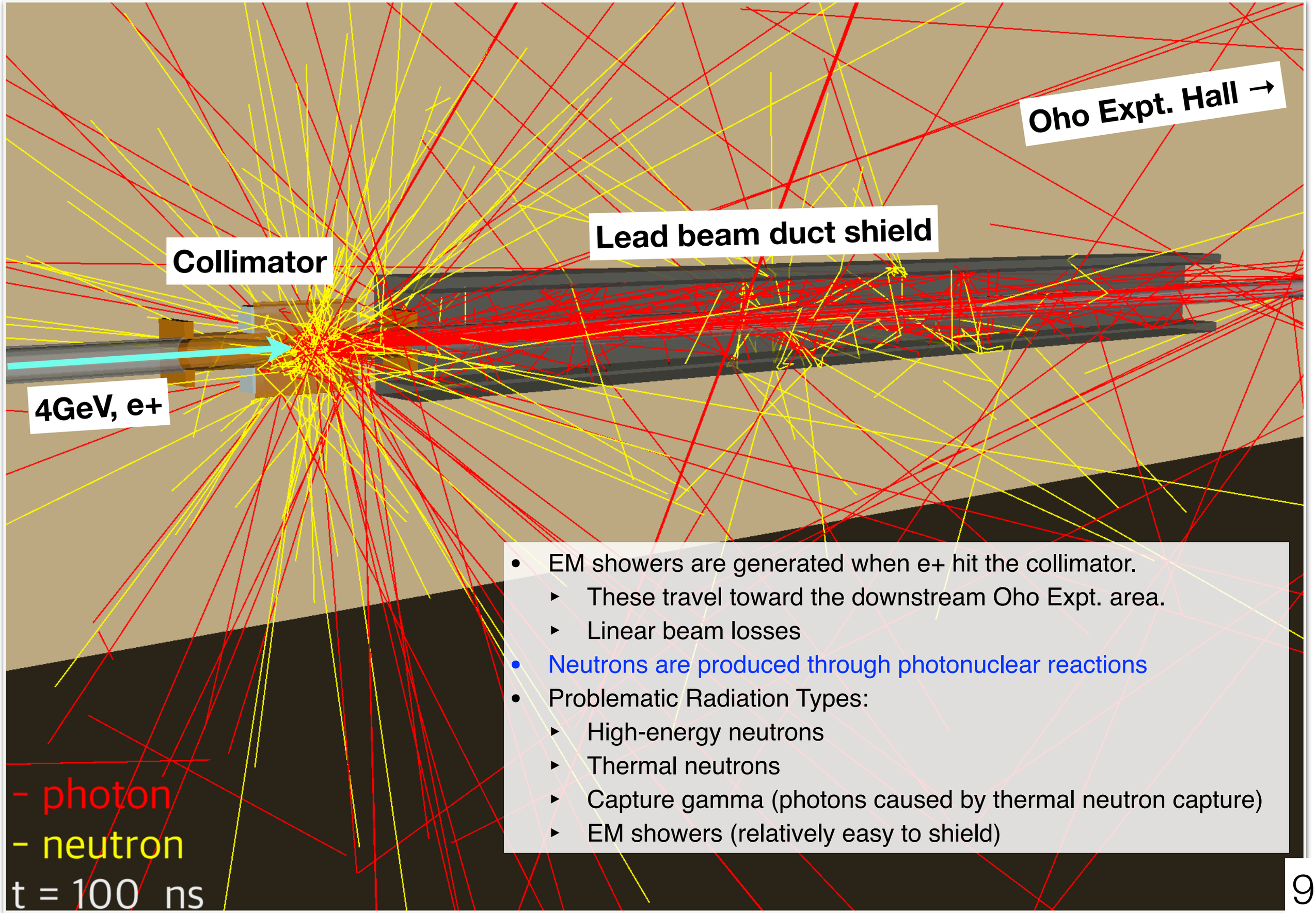
Beam duct shield
5m, Lead



“MONGATA” shield
(existing)

Shielding for the gap
above MONGATA

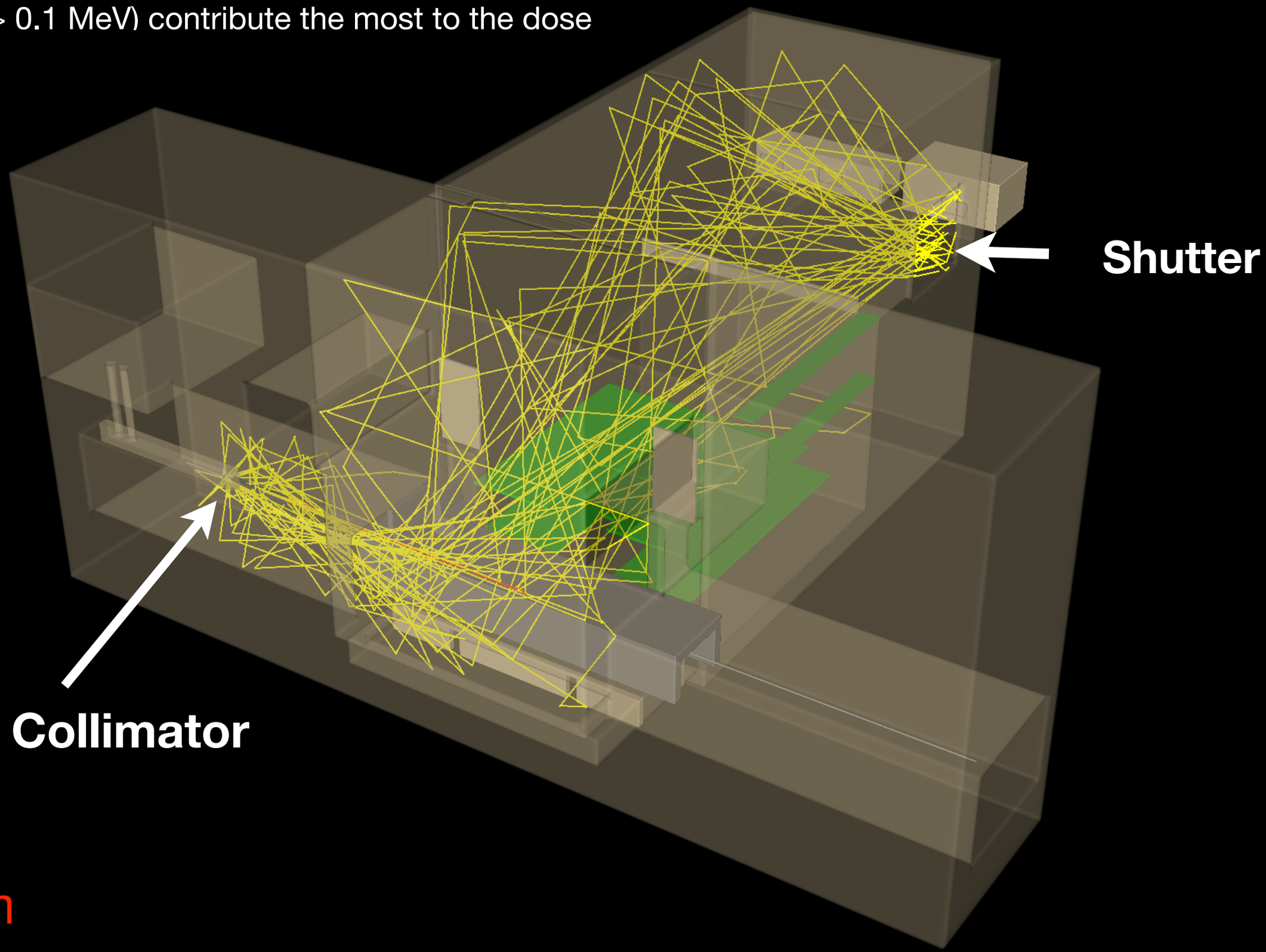
Produced radiation



- EM showers are generated when e+ hit the collimator.
  - These travel toward the downstream Oho Expt. area.
  - Linear beam losses
- Neutrons are produced through photonuclear reactions
- Problematic Radiation Types:
  - High-energy neutrons
  - Thermal neutrons
  - Capture gamma (photons caused by thermal neutron capture)
  - EM showers (relatively easy to shield)

The path of neutrons with energies above 0.1 MeV entering the shutter.

* Neutrons (> 0.1 MeV) contribute the most to the dose



- photon
- neutron

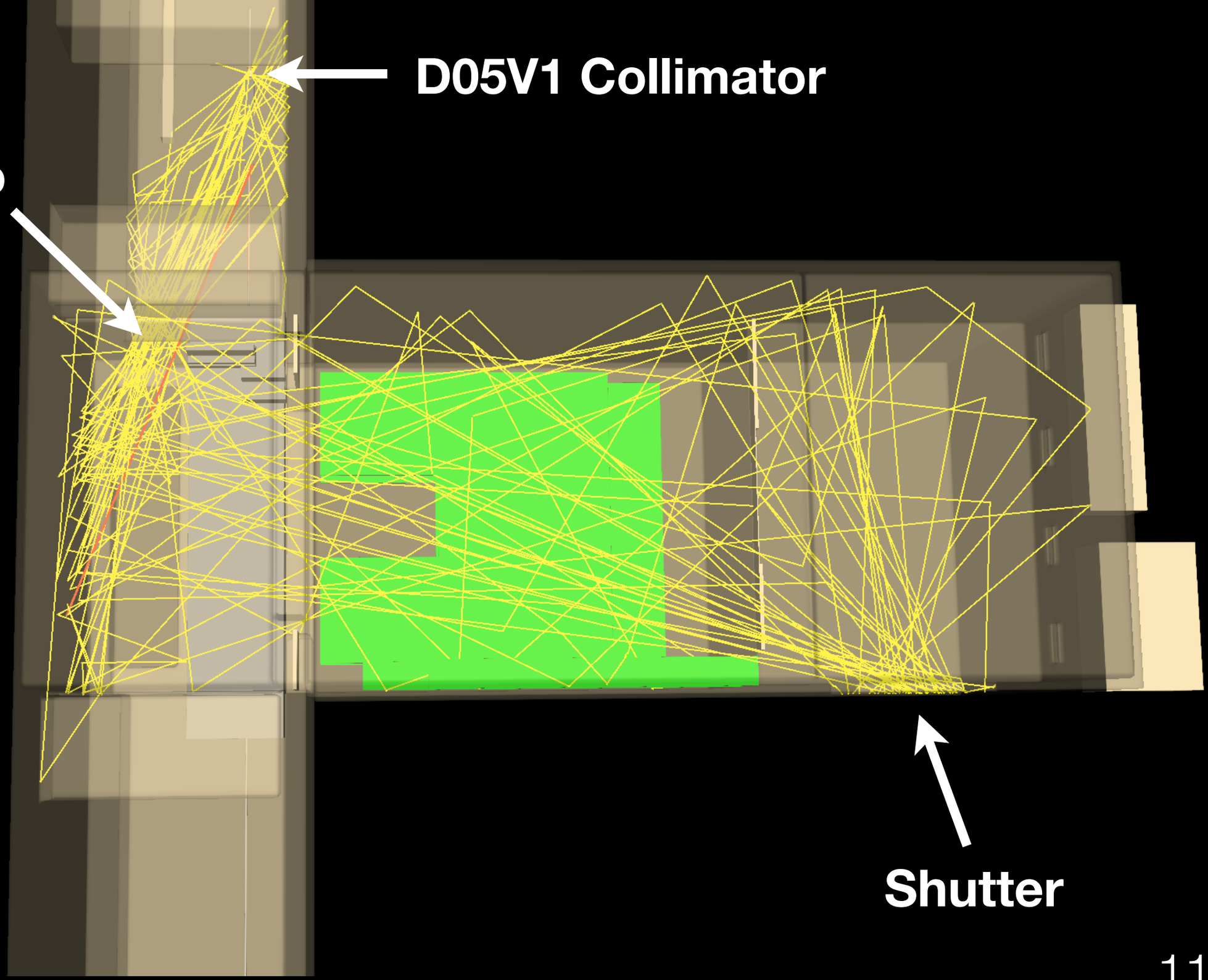
t = 20 μs

The path of neutrons with energies above 0.1 MeV entering the shutter.

* Neutrons (> 0.1 MeV) contribute the most to the dose

Neutrons leak through this gap

D05V1 Collimator



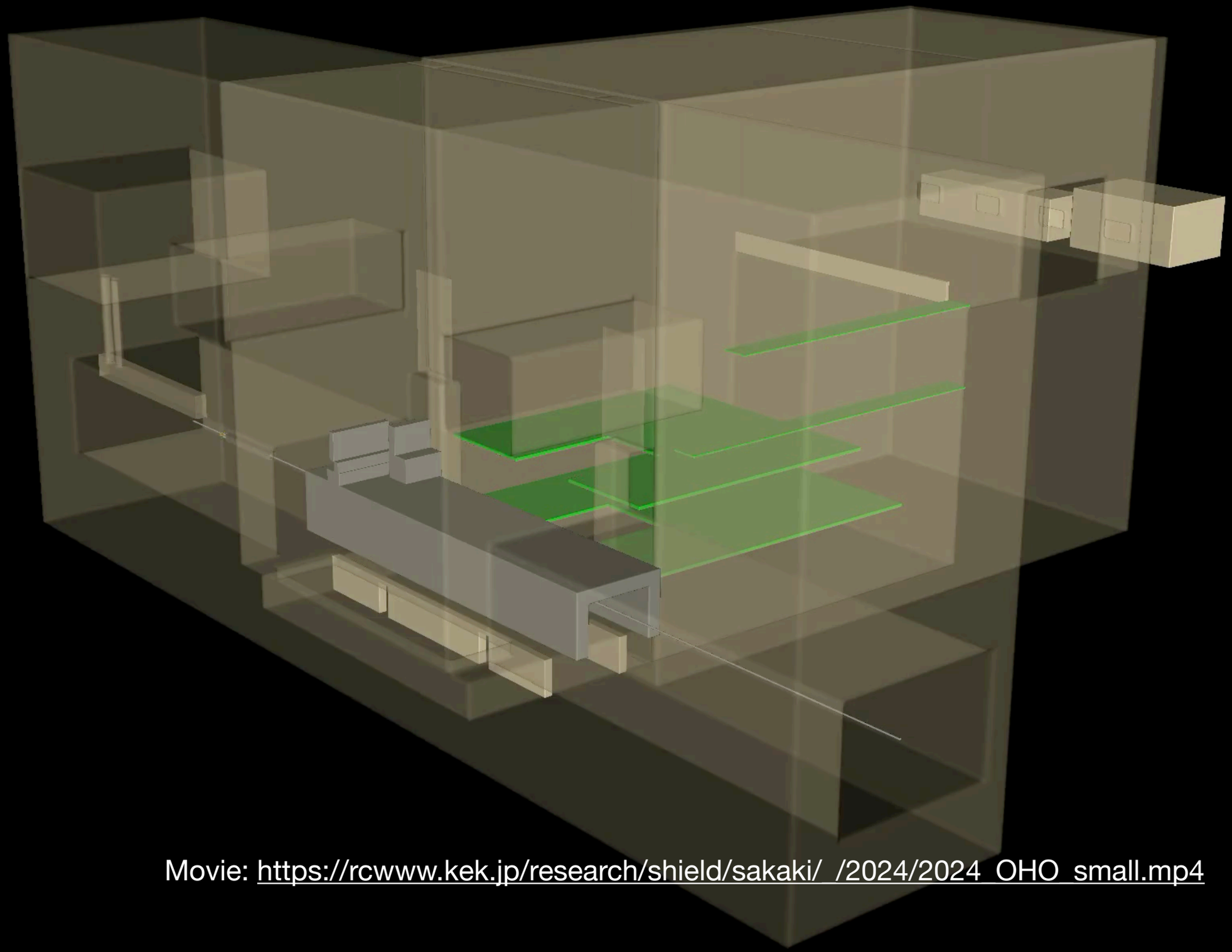
Shutter

- photon
- neutron

t = 20 μs

The path of neutrons with energies above 0.1 MeV entering the shutter.

* Neutrons (> 0.1 MeV) contribute the most to the dose



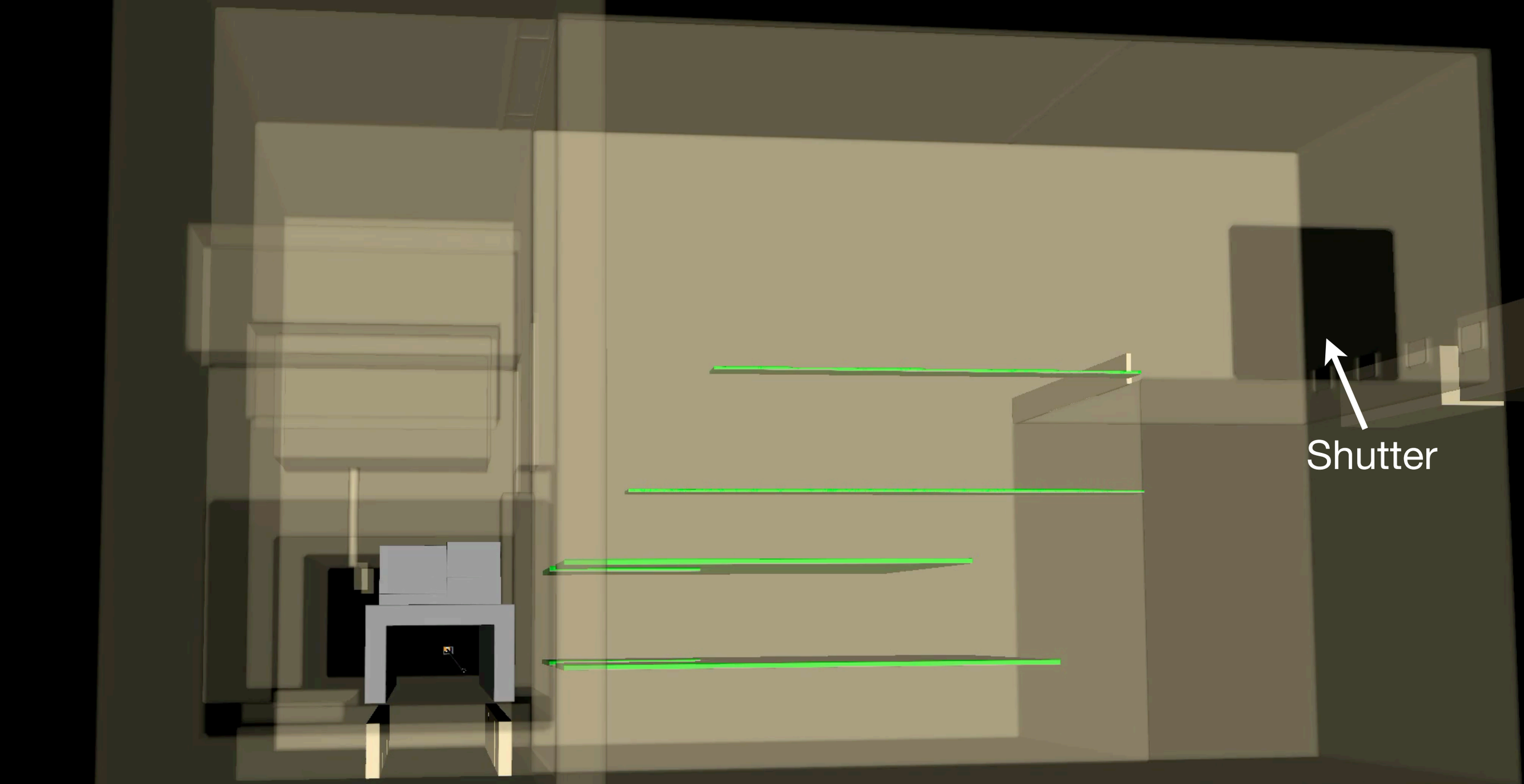
- photon
- neutron

t = 0 s

Movie: https://rcwww.kek.jp/research/shield/sakaki/_/2024/2024_OHO_small.mp4

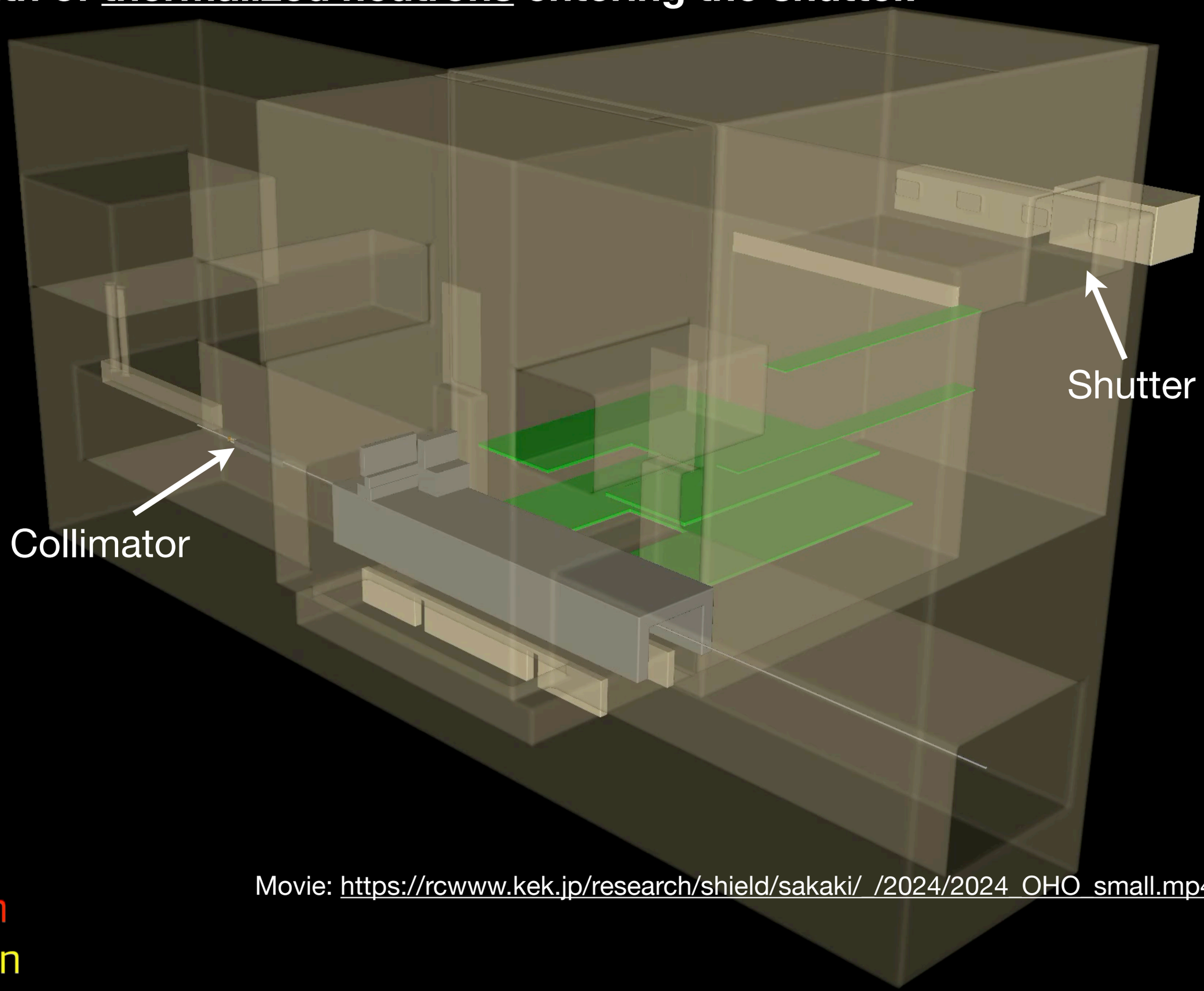
The path of neutrons with energies above 0.1 MeV entering the shutter.

* Neutrons (> 0.1 MeV) contribute the most to the dose



Movie: https://rcwww.kek.jp/research/shield/sakaki/_/2024/2024_OHO_small.mp4

The path of thermalized neutrons entering the shutter.



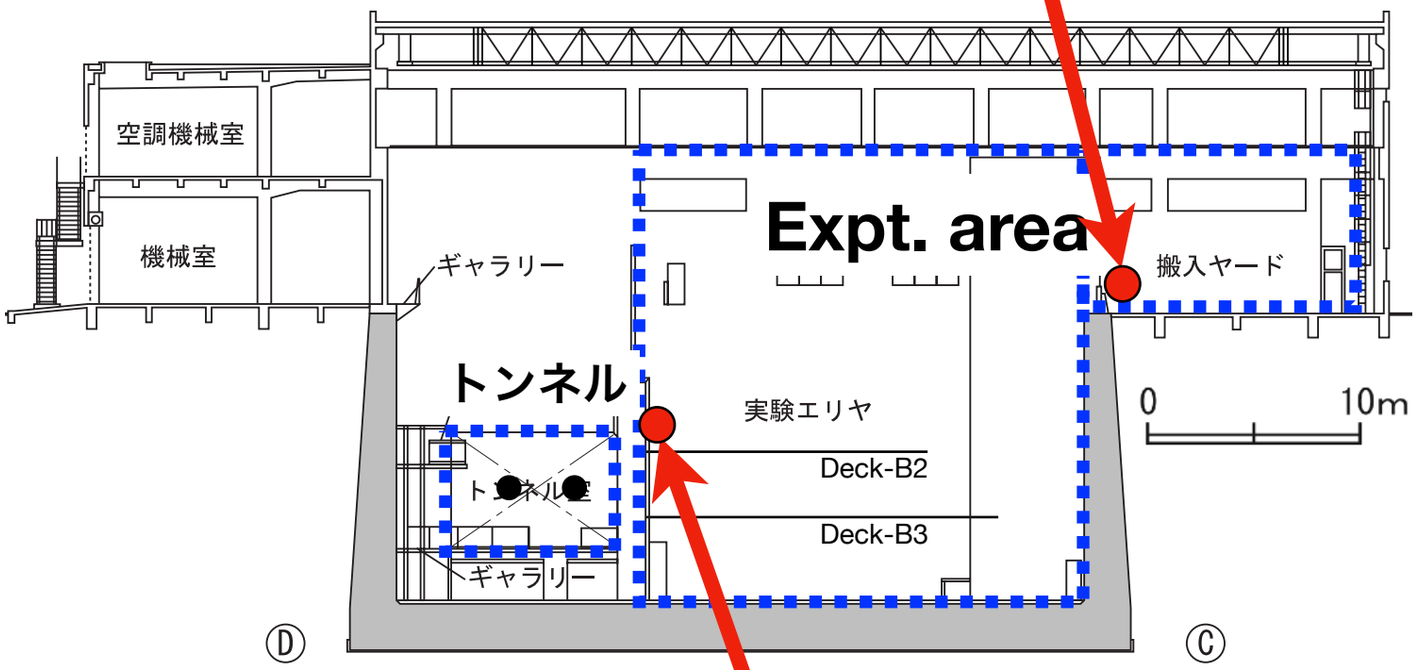
Movie: https://rcwww.kek.jp/research/shield/sakaki/_/2024/2024_OHO_small.mp4

Radiation monitors

[used for interlock]

YEL-0501

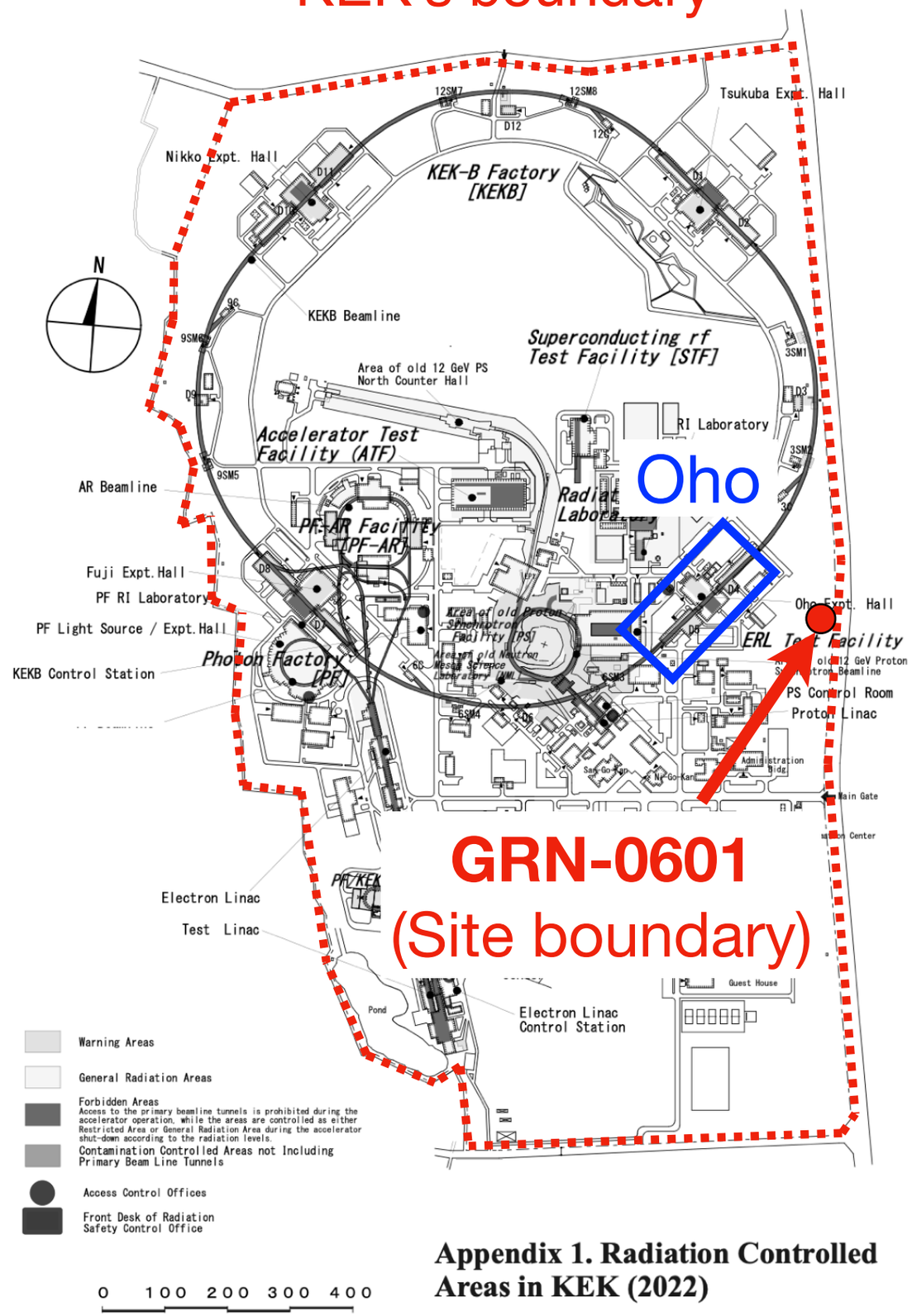
(Near the shutter)



ORG-0512

(Near the tunnel)

KEK's boundary

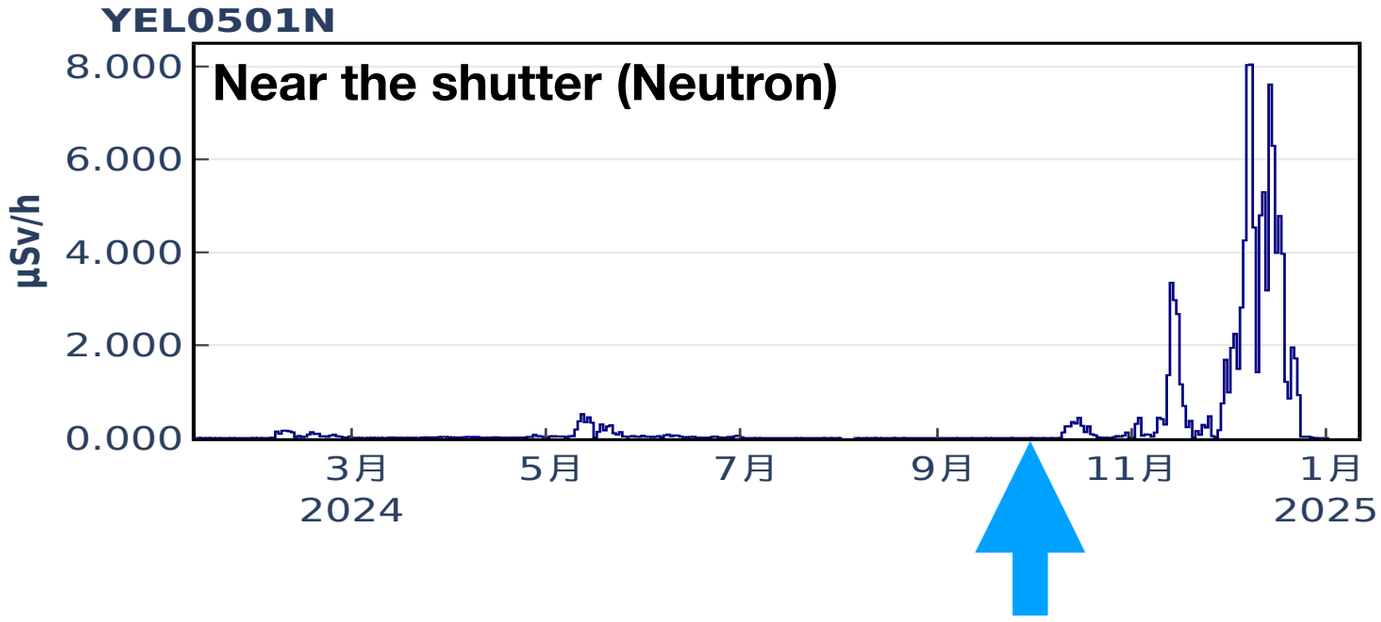


GRN-0601

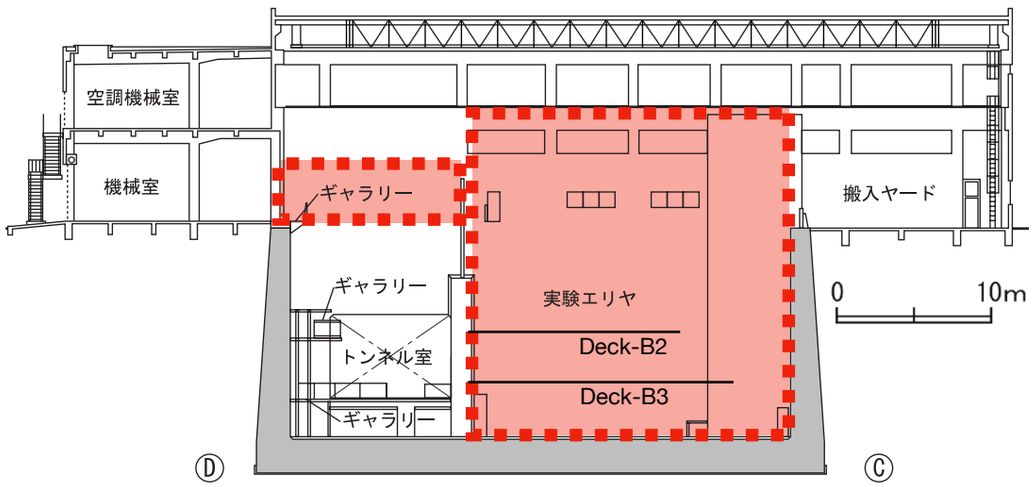
(Site boundary)

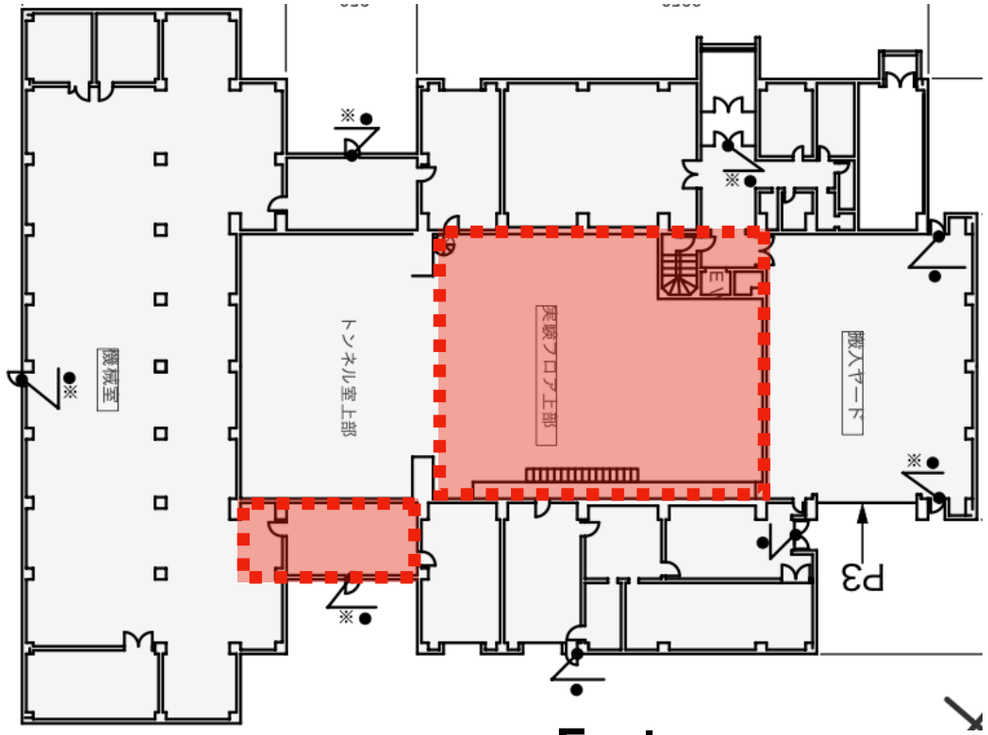
Appendix 1. Radiation Controlled Areas in KEK (2022)

Temporary measures



Partially restricted access to the deck area and part of the machine room during periods of high radiation dose.

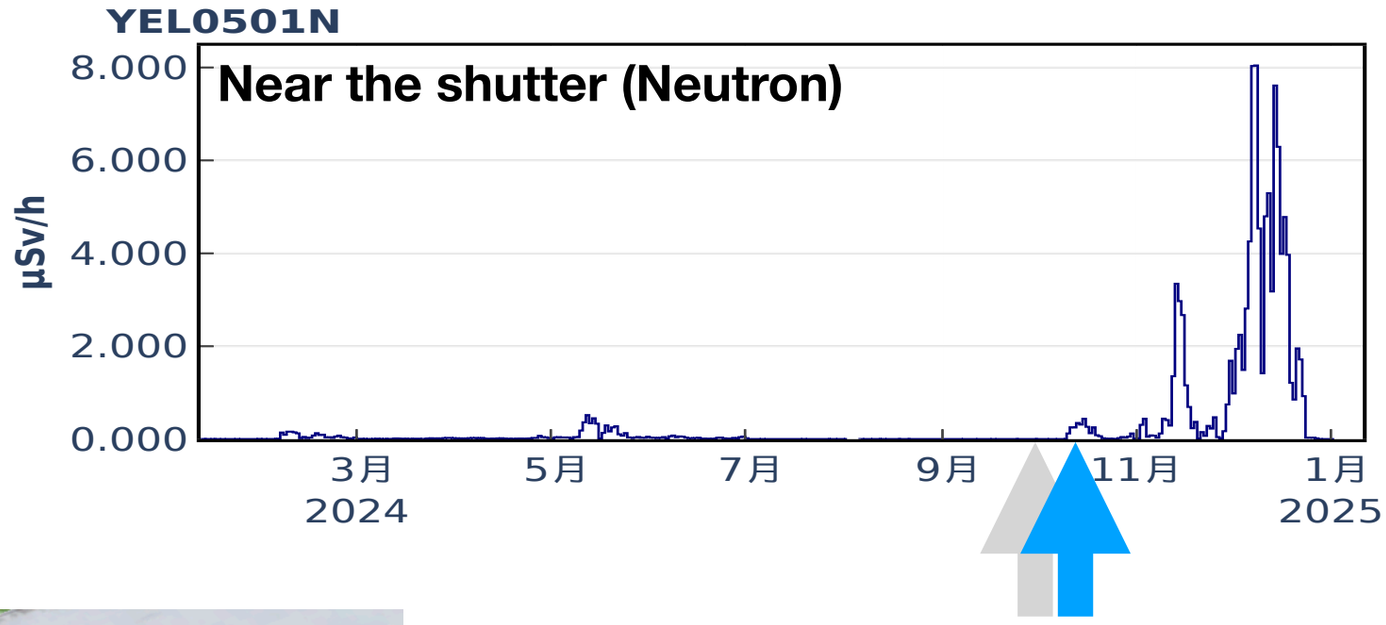


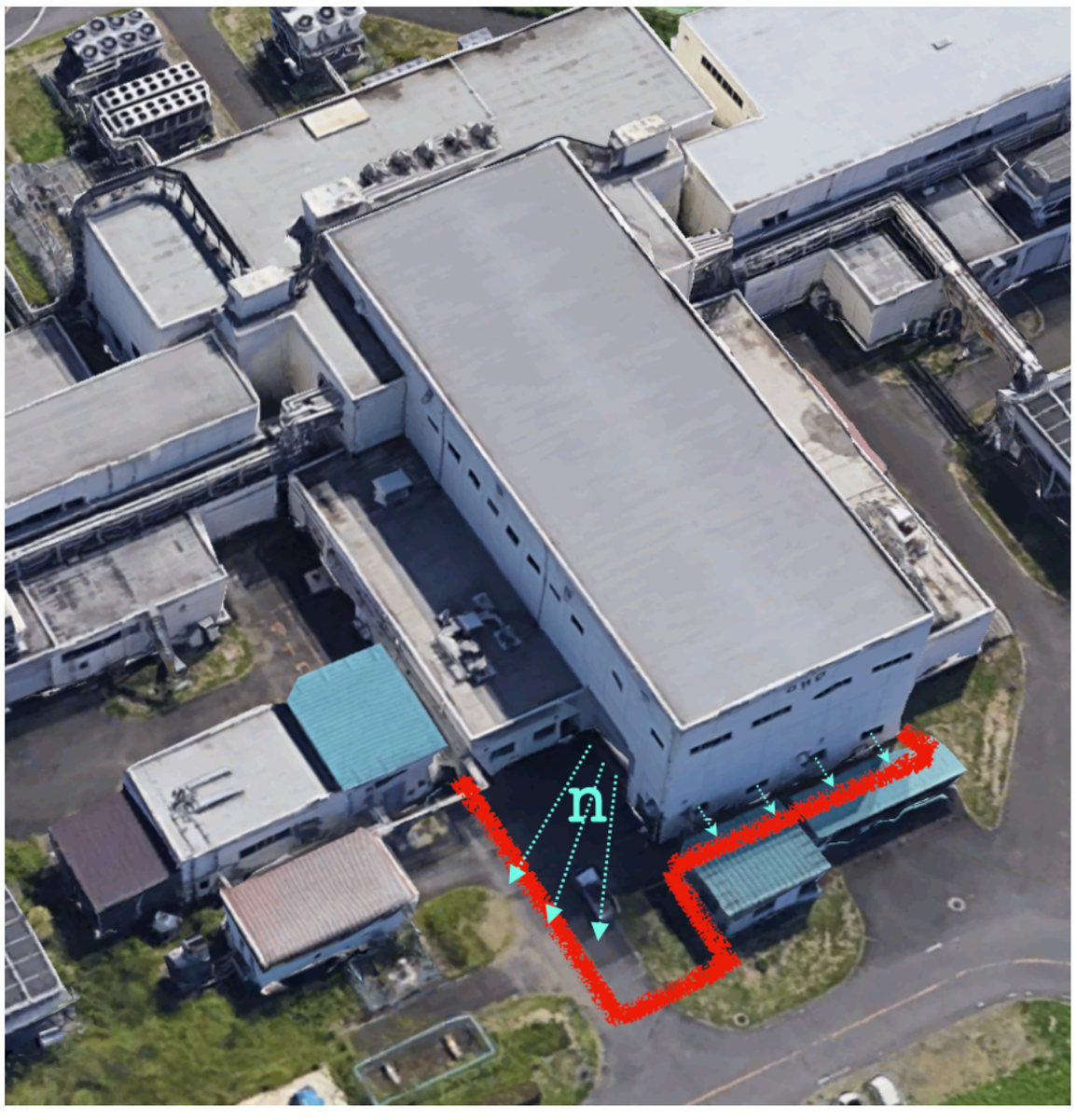


Machine room

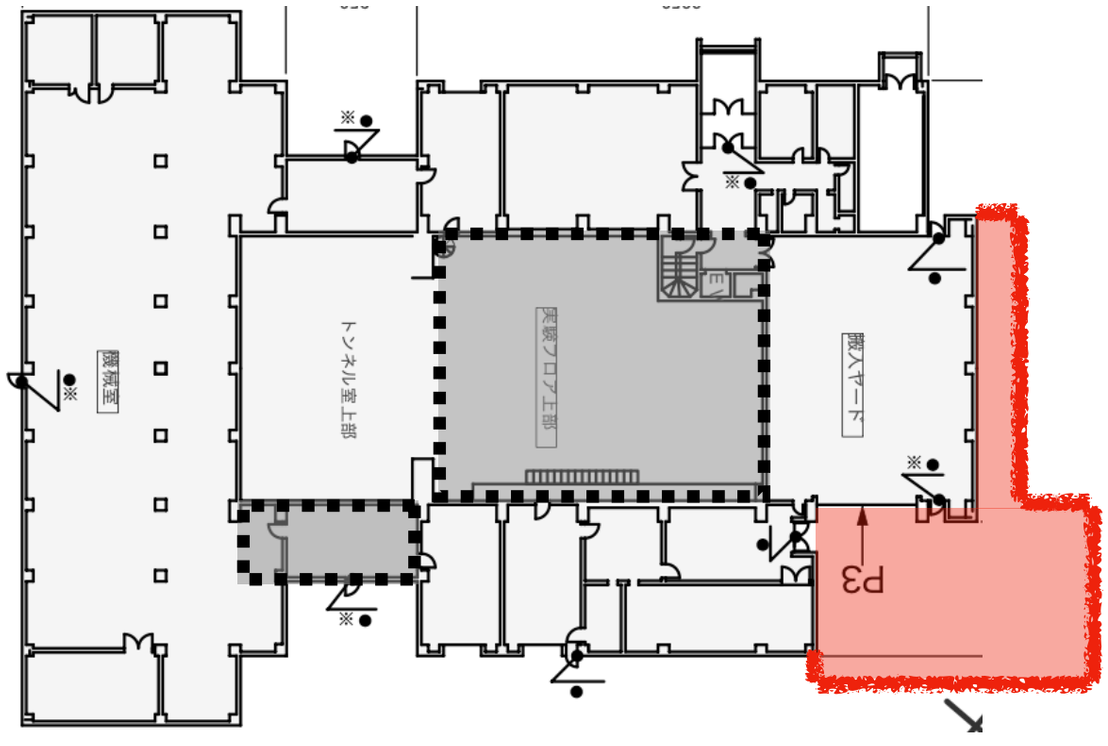
Expt. area

Temporary measures

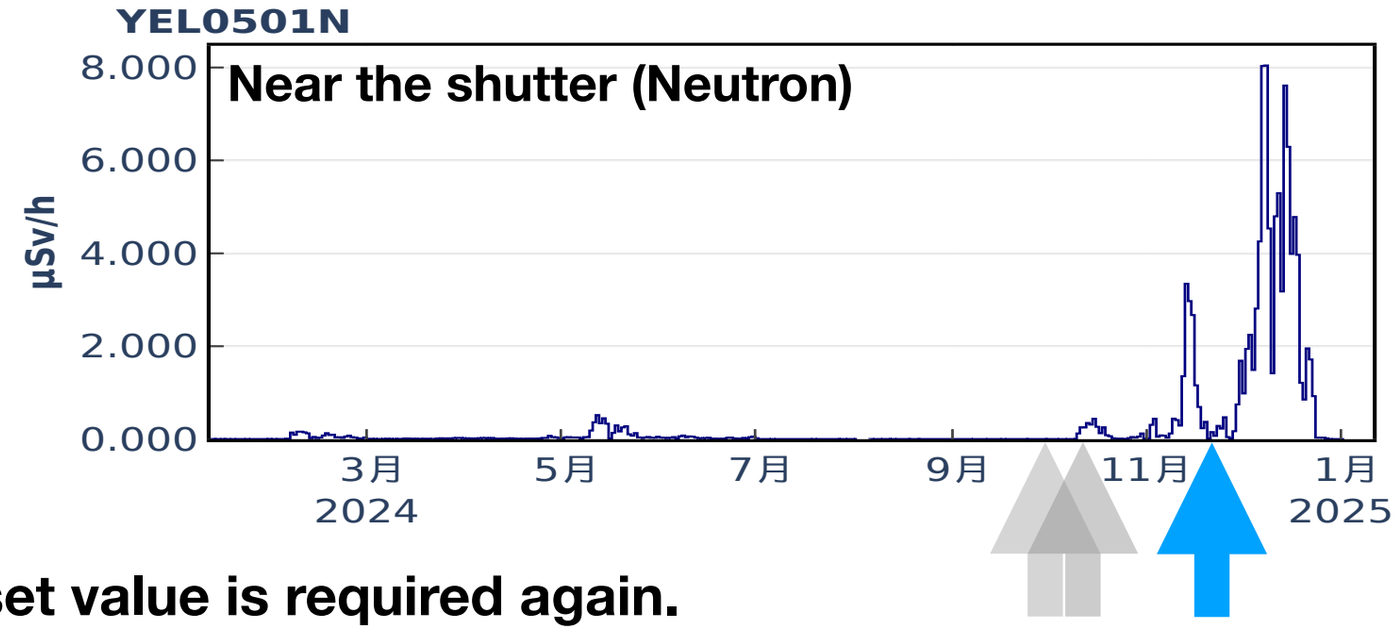




- An increase in the interlock set value is required.
  - ➡ Restricted access around the shutter area.



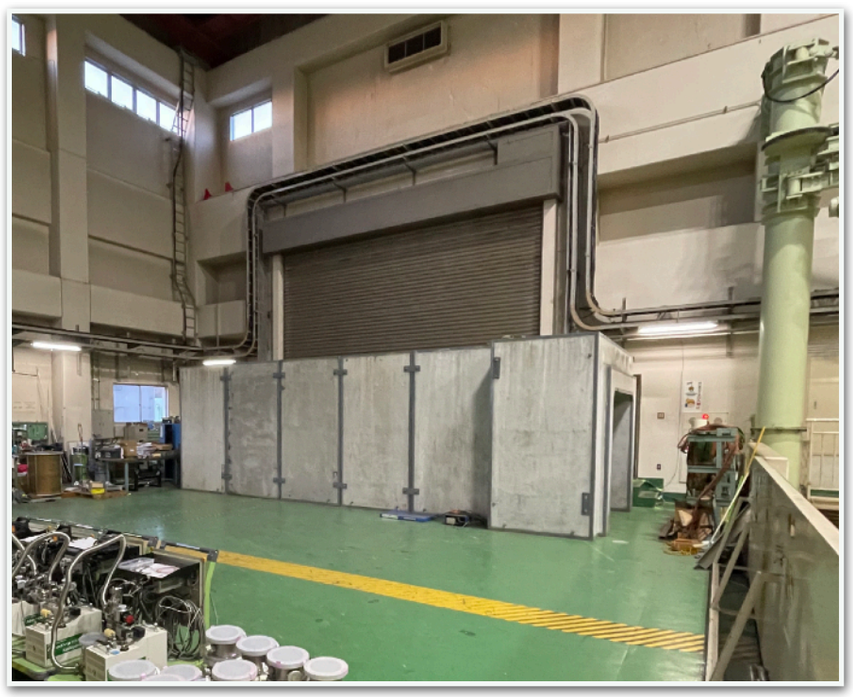
Temporary measures



An increase in the interlock set value is required again.

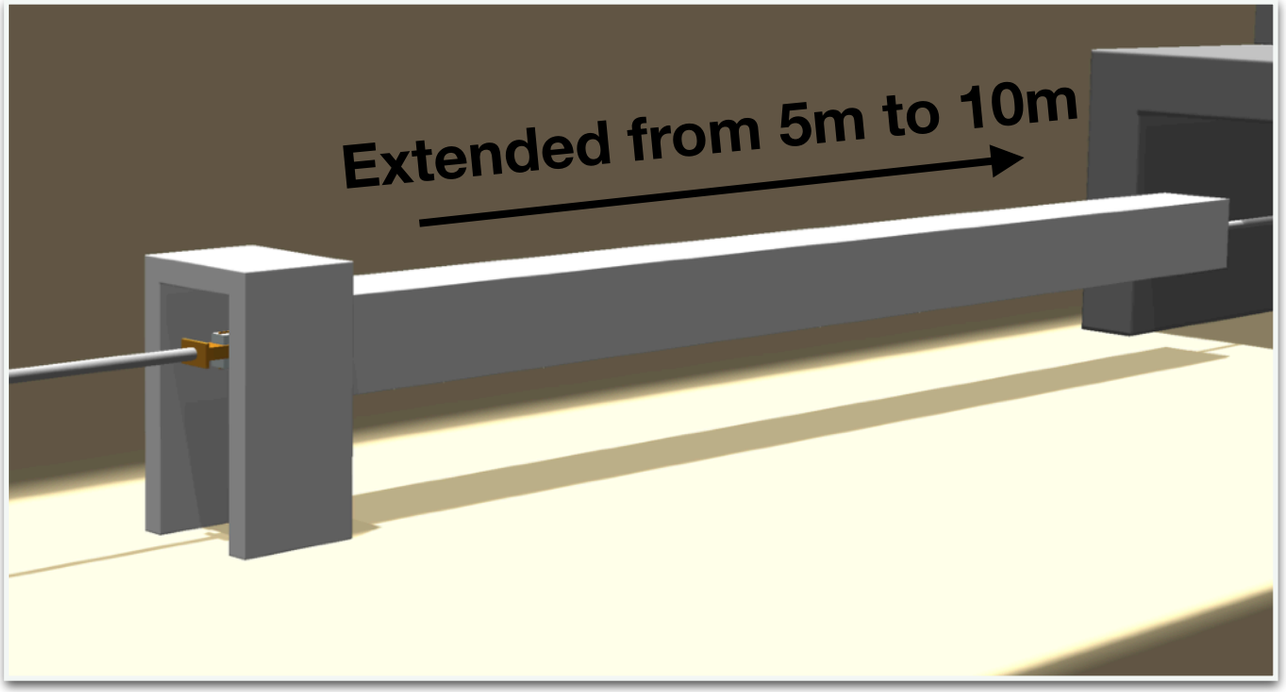
- Installed a concrete shield in front of the shutter.
- Added 10 cm thick polyethylene around the existing lead shield downstream of the collimator.
- Shielded the windows of the ECL room.
- Designated the Oho Expt. Hall and part of the machine room as “Restricted” Radiation-Controlled Areas.
- Designated the outside of Oho Expt. Hall as Warning Area.
- Restricted access near the machine room-D4 passageway.

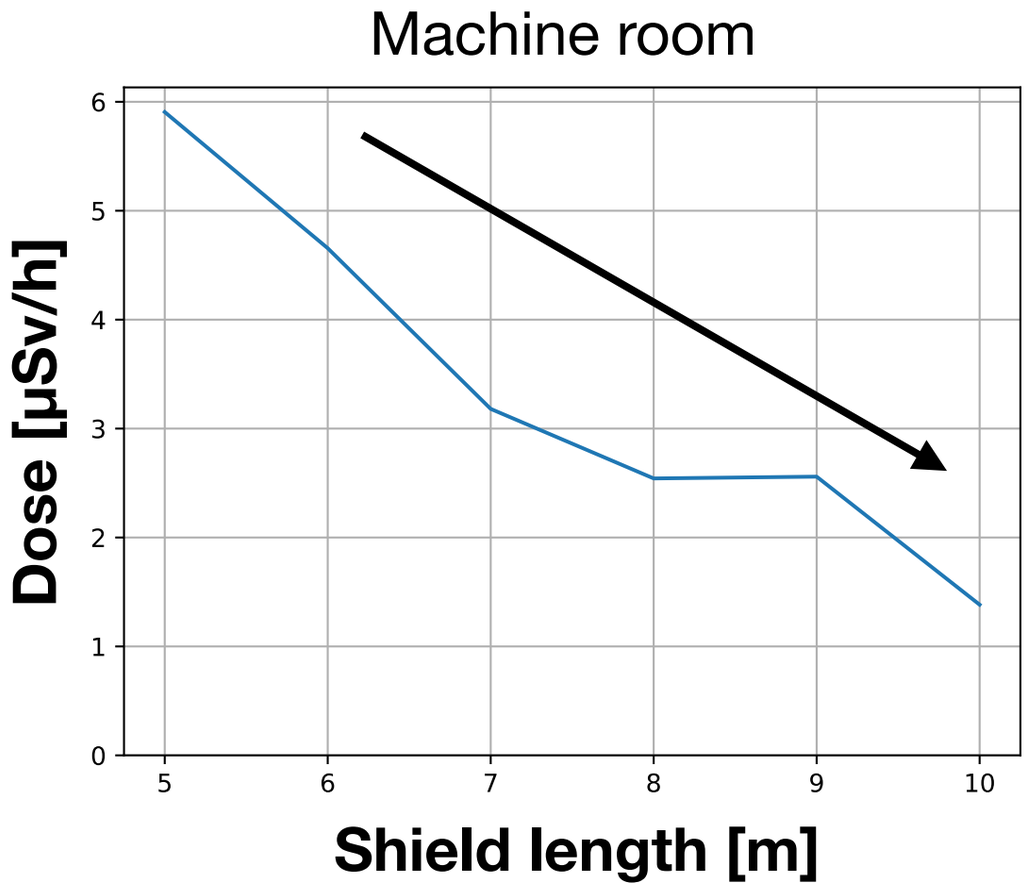
➡ With the current shielding, further increase in interlock values is difficult.



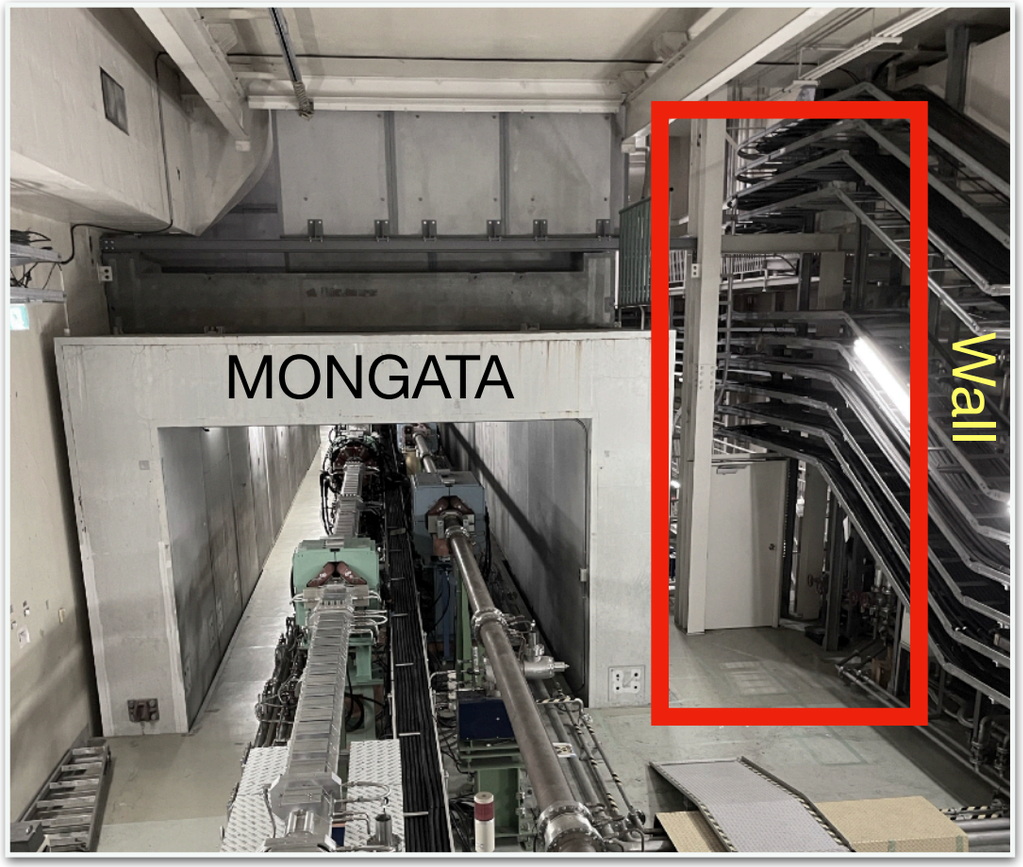
Future Plans for Shielding

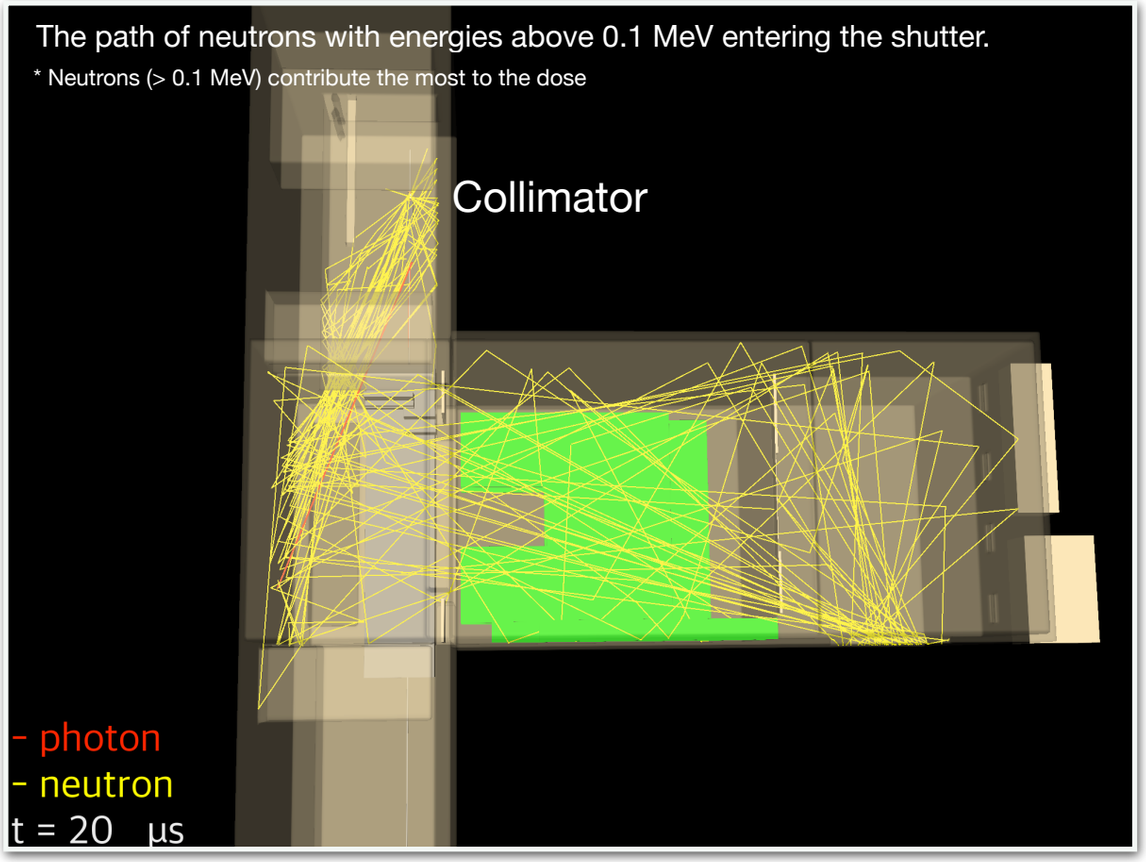
- Beam duct sheild
  - Extension
  - Adding polyethylene and/or concrete plates
    (The stand is already installed, and the materials have also been purchased.)
- Installing shielding near the collimator



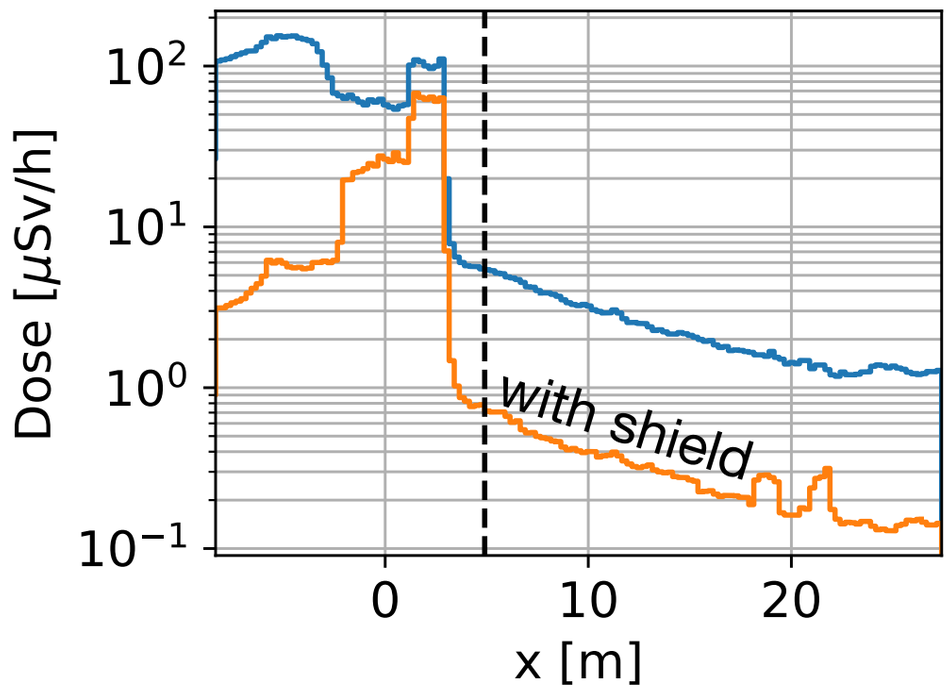


Future Plans for Shielding

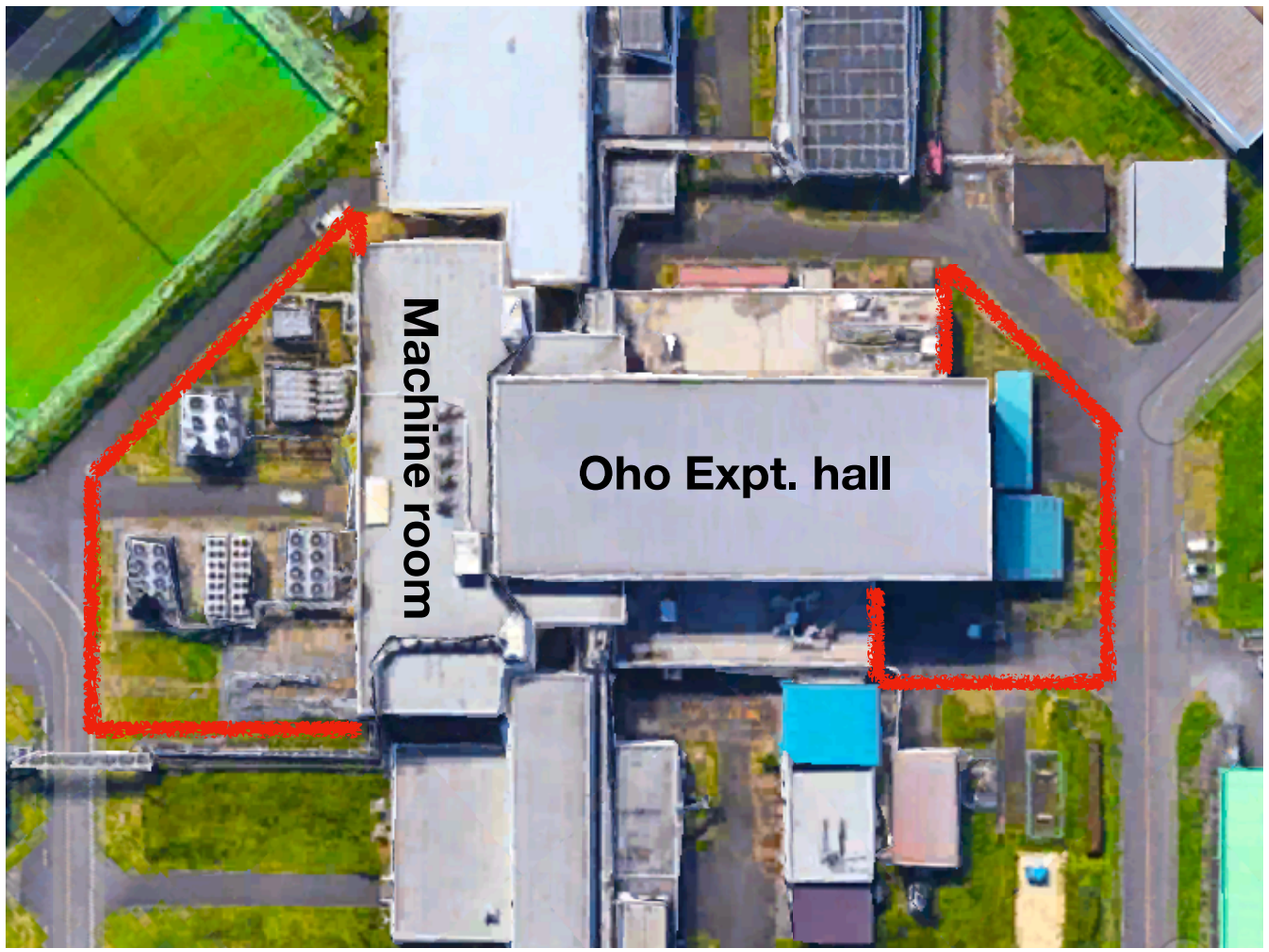




Shielding to fill the gap between the MONGATA shield and the wall.



- Expansion of radiation controlled areas outside the Oho Expt. Hall.
  - Define the shape of the shielding and the expanded area based on simulations.
- Fence installation
  - Countermeasures in case beam loss exceed expectation.
  - Predefined areas can be swiftly changed into controlled/warning areas.



Summary

- A vertical collimator (D05V1) was installed in the Oho area as part of the NLC system.
- During 2024c, the beam loss significantly increased, leading to higher radiation levels.
- To minimize operatinal restrictions, several temporary measures were taken.
- Future Measures:
  - Installing shield between MONGATA shield and wall
  - Reinforcement of beam duct shielding
  - Expansion of radiation-controlled areas outside the Oho Expt. Hall.
  - Installing shield near the collimator (until October or later)