Instrument Safety Readiness Review

Test beamline (TBL): Shielding calculations

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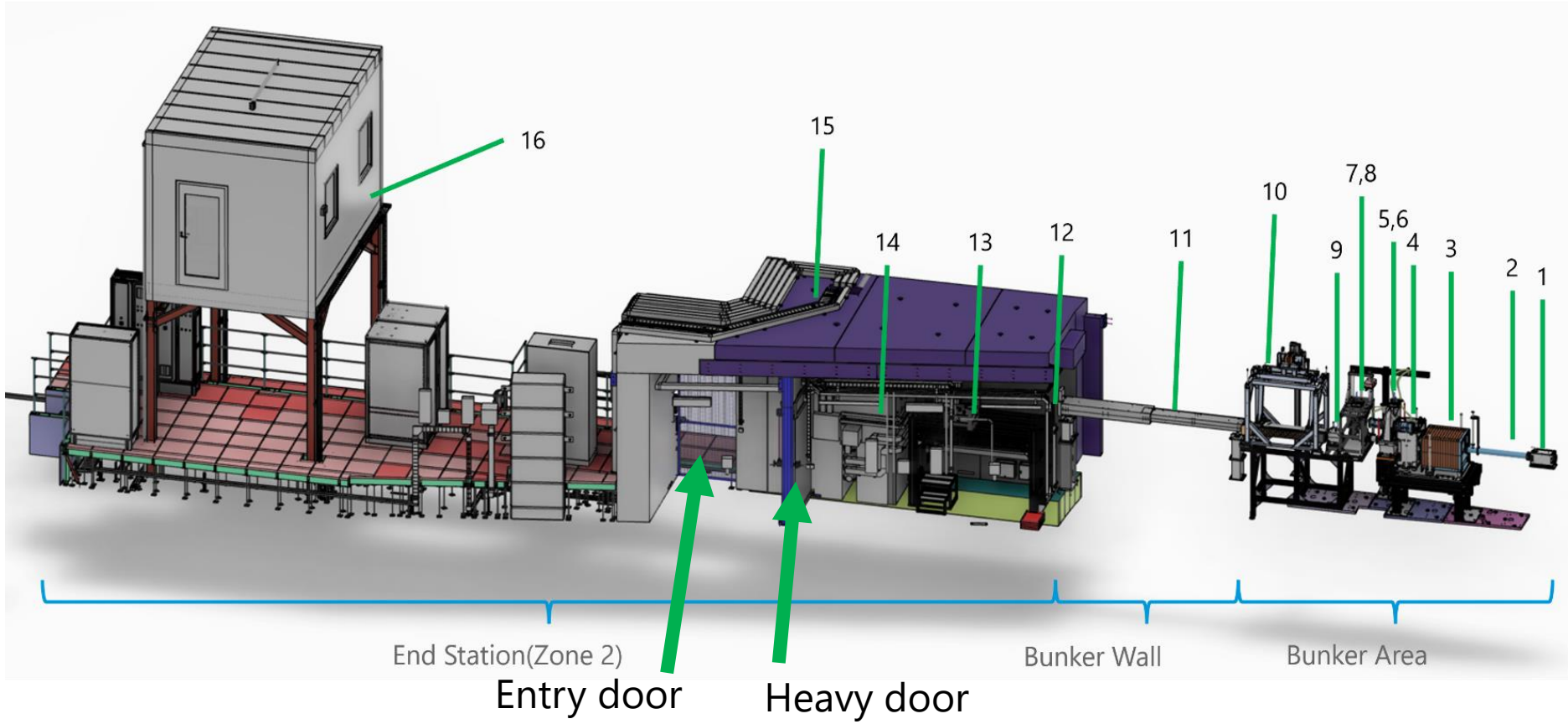
Overview

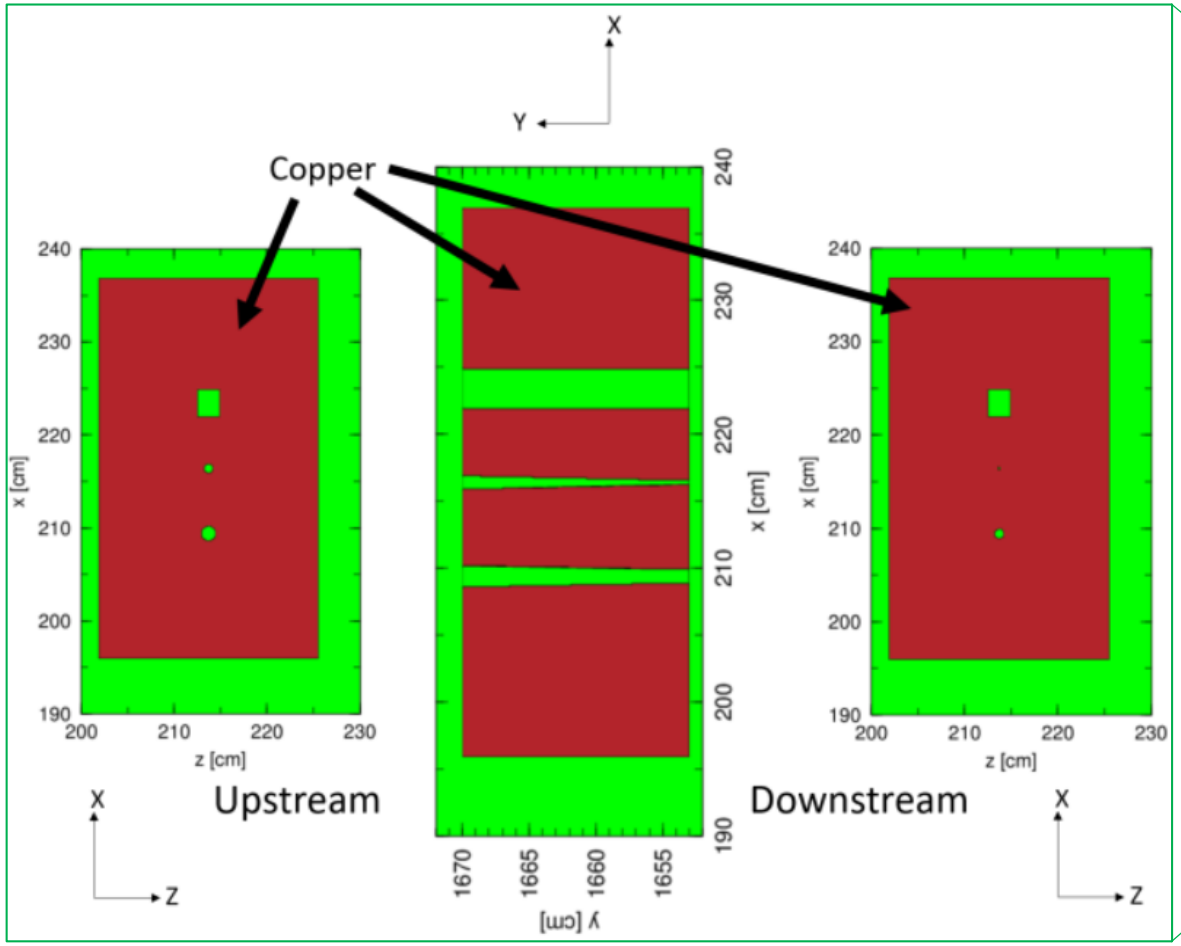
TBL has 2 doors:
Heavy door: This has shielding properties
Entry door: This is just a gate to prevent access to the first section of the cave

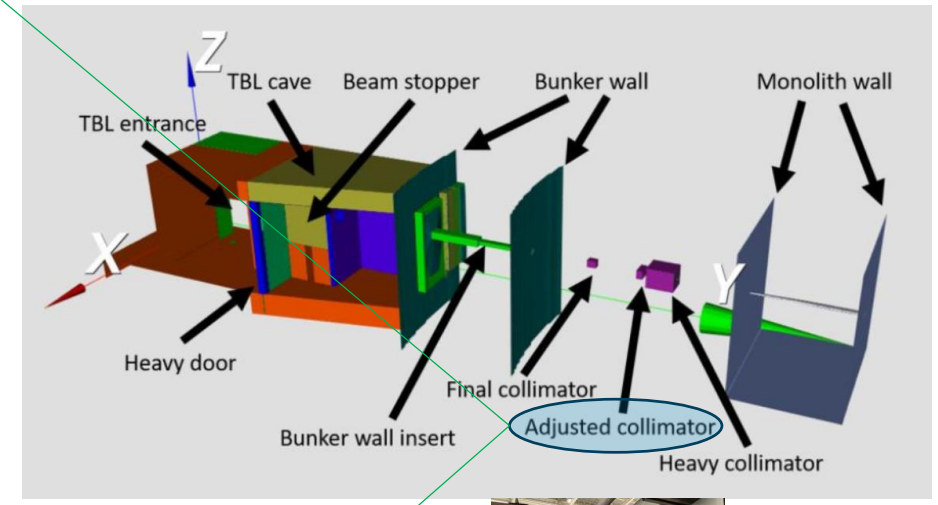


No.	Component Name	Distance from target coordinate system
1	BBGOA and Light Shutter	5.5 m – 6 m
2	Flight Tube 1	6 m – 7.4 m
3	Heavy Collimator	7.4 m – 8.2 m
4	Adjustable Collimator	8.3 m – 8.5 m
5,6	Chopper, Flight Tube 2	8.5 – 8.7 m
7,8	Filter station, In-bunker Beam Monitor	8.7 – 9.3 m
9	Final Collimator	9.3 – 9.5 m
10	Heavy Shutter	9.5 m – 11.3 m
11	Bunker Wall Feedthrough	11.5 m – 15 m
12	In-cave Beam Monitor	15.1 – 15.2 m
13	Detector Table	15.2 – 17.5 m
14	Beam Stop	17.5 m
15	Experimental Cave	15 – 21 m
16	Control Hutch	25 m

In-bunker components

- Shielding: Heavy Collimator, **Adjustable Collimator**, Final Collimator, and Cave





3 cases for each adjustable collimator channels are considered.

1) 3-mm
2) 10-mm
3) 30mm x 25mm channel.

Considered cases

- H1/H2 scenario as defined in ESS-1408051

Event ID	Event Description
H1-1	Instrument shutter is closed; shutter is interacting with full neutron beam.
H1-2	Adjustable collimator is set in closed position; full beam is interacting with largest amount of collimator material.
H1-3	Attenuators and filters are in use, interacting with the beam.
H1-4	All choppers are parked open, collimator on largest opening, full beam hitting the beam-stop (no detector or sample).
H1-5	All choppers are parked open, collimator on largest opening, full beam hitting the detector (no sample).
H1-6	All choppers are parked open, collimator on largest opening, full beam hitting a monochromator crystal.
H1-7	Worst case gamma converting object (1 mm thick sheet of Cd) in full beam.
H1-8	Worst case neutron scatterer (hydrogen, equivalent to 10 mm of H_2O) in full beam.

Event ID	Event Description
H2-1	Cadmium sheet is accidentally forgotten or slid into the beam path.
H2-2	A foreign object is accidentally forgotten in the beam path.
H2-3	Chopper is accidentally parked in closed position, interacting with the neutron beam.
H2-4	Misalignment of sample, the full beam hits parts of the sample holder.

Only *3 cases*: H1-4, H1-7 and H1-8 are included in the analysis.

H1-4: No sample inside the cave.
H1-7: 1-mm thick cadmium sheet → worst scattered gamma case
H1-8: 10-mm thick water target → worst scattered neutron case

3 cases for each adjustable collimator channels are considered.

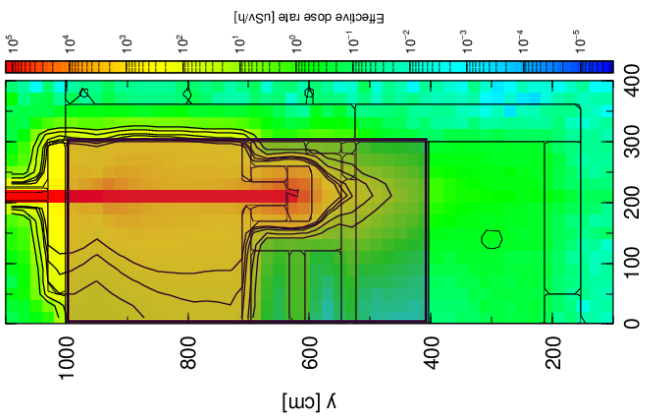
1) 3-mm
2) 10-mm
3) 30mmx25mm channel.

9 cases in total

Each configuration of Adjustable Collimator

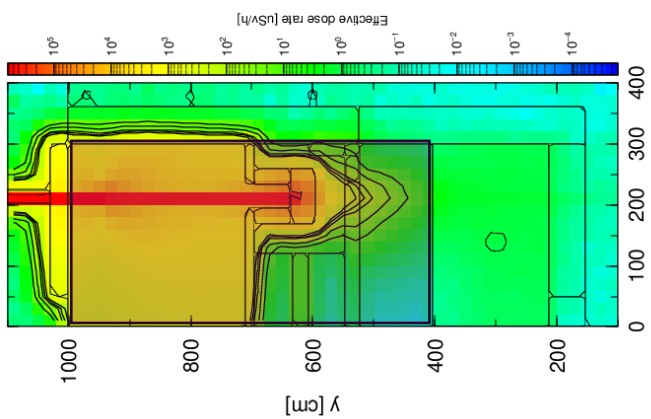
Shutter Opened

3mm



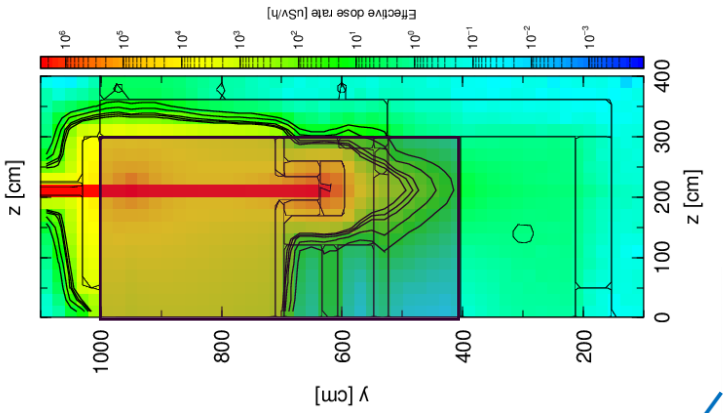
H1-8

10mm

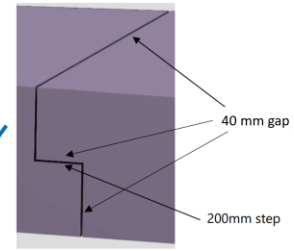


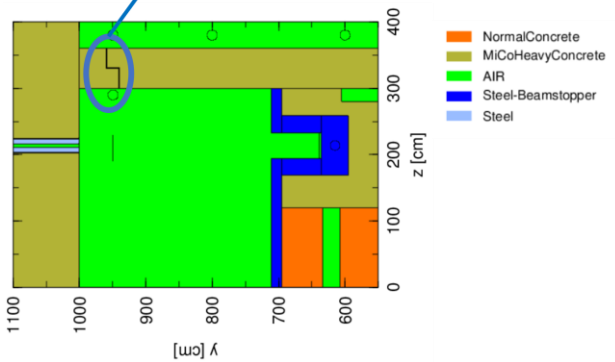
H1-8

30mm×25mm



H1-7





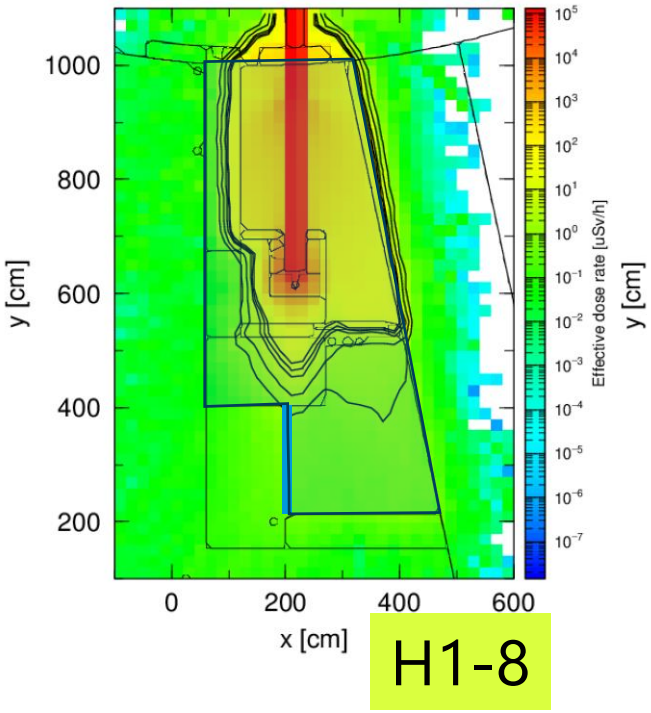
Contours:
5 MW,
2MW,
800 kW,
570 kW,
400 kW

88 % increase but still below the limit

Each configuration of Adjustable Collimator

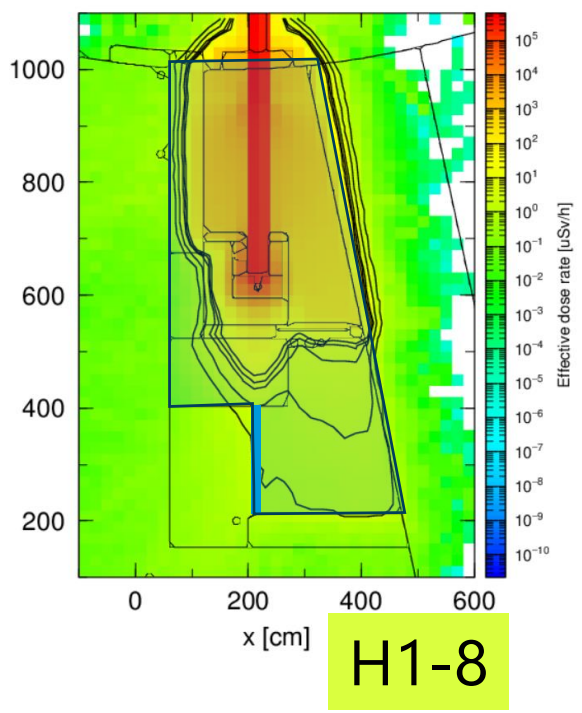
Shutter Opened

3mm



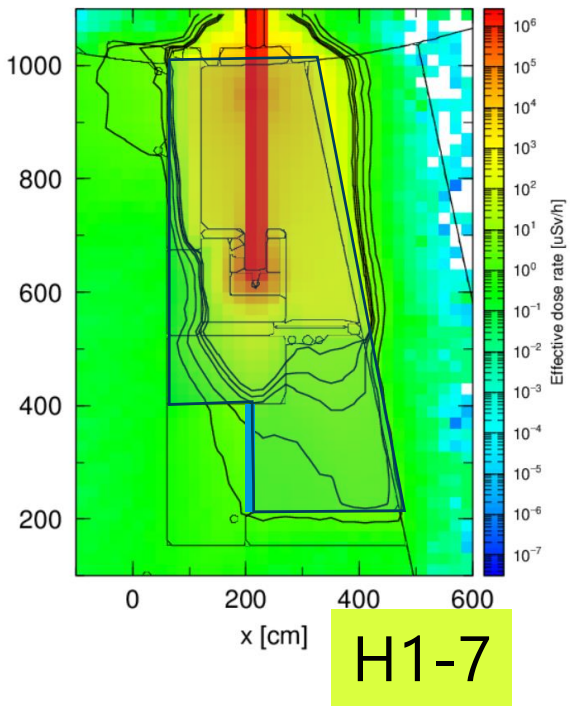
H1-8

10mm



H1-8

30mm×25mm



H1-7

Contours:
5 MW,
2MW,
800 kW,
570 kW,
400 kW

Adjustable Collimator Channel, considering all H1 cases	3mm	10mm	28x24mm
Maximum Beam Power (MW)	5	2	0.8

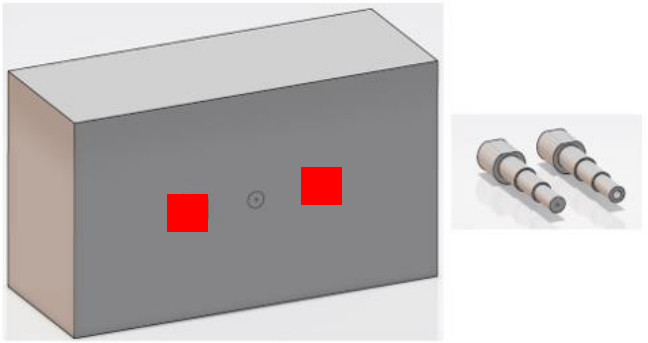
50 % increase but still below the limit

Cave and bunker wall serve as Shielding for Green Supervised Area (< 3 μSv/h), except for the roof Blue Controlled Area (< 25 μSv/h)

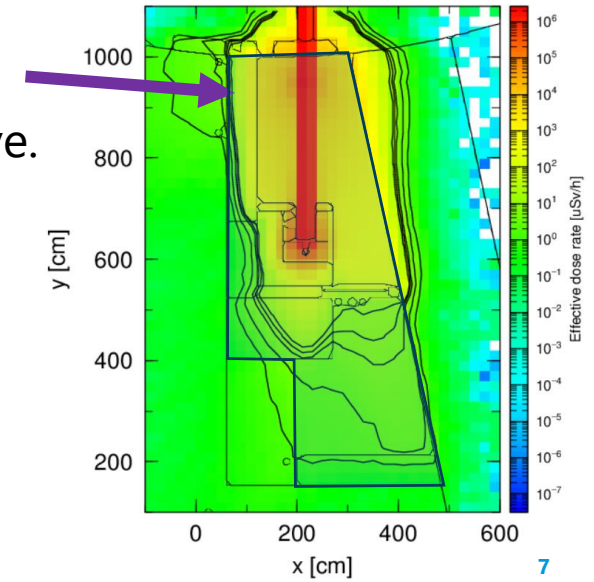
Mitigation

1) For the additional scope, the 10-mm pinhole configuration of the adjustable collimator can still be used for operations up to 2-MW beam power, concerning all H1 scenarios. However, the largest channel (30mm×25mm) can be used for operations when the proton beam power is up to 800 kW. It is recommended that the report/shielding shall be revised when the beam power is about to be higher than this level. A simple solution is to have a copper bar to fit inside this channel as a "plug" to completely block the beam in order to prevent any misuse for higher beam powers. The Concept of Operation shall be revised in accordance with the additional scope mentioned in this report.

It is also suggested that the BWI should not be exposed to the beam for long time. This is due to the fact that the BWI is made from stainless steel which will have long half-life, e.g., Fe-55 and Co-60. The in-bunker components are mostly impossible to reach due to high intense beam at TBL beamport. In order to reduce the activation, we recommend to translate the 3-mm pinhole of the adjustable collimator to be in the beam direction when there is no need for experiments.



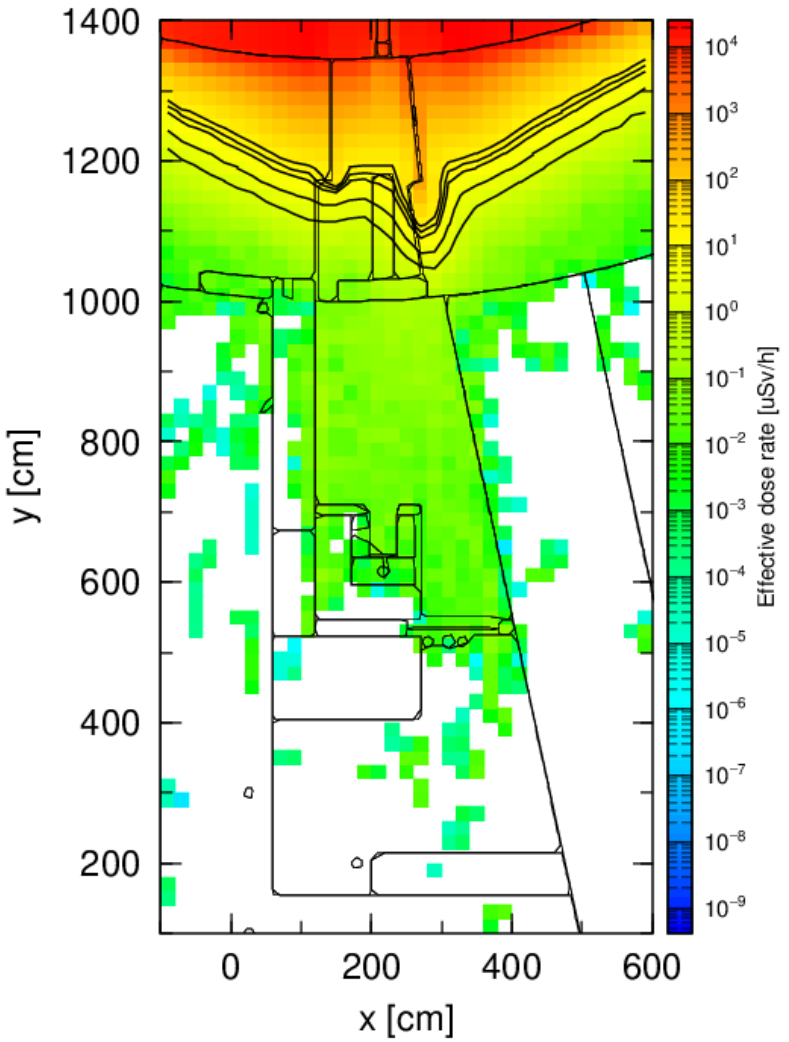
2) Declare a broader supervised area and strengthen shielding inside the cave.



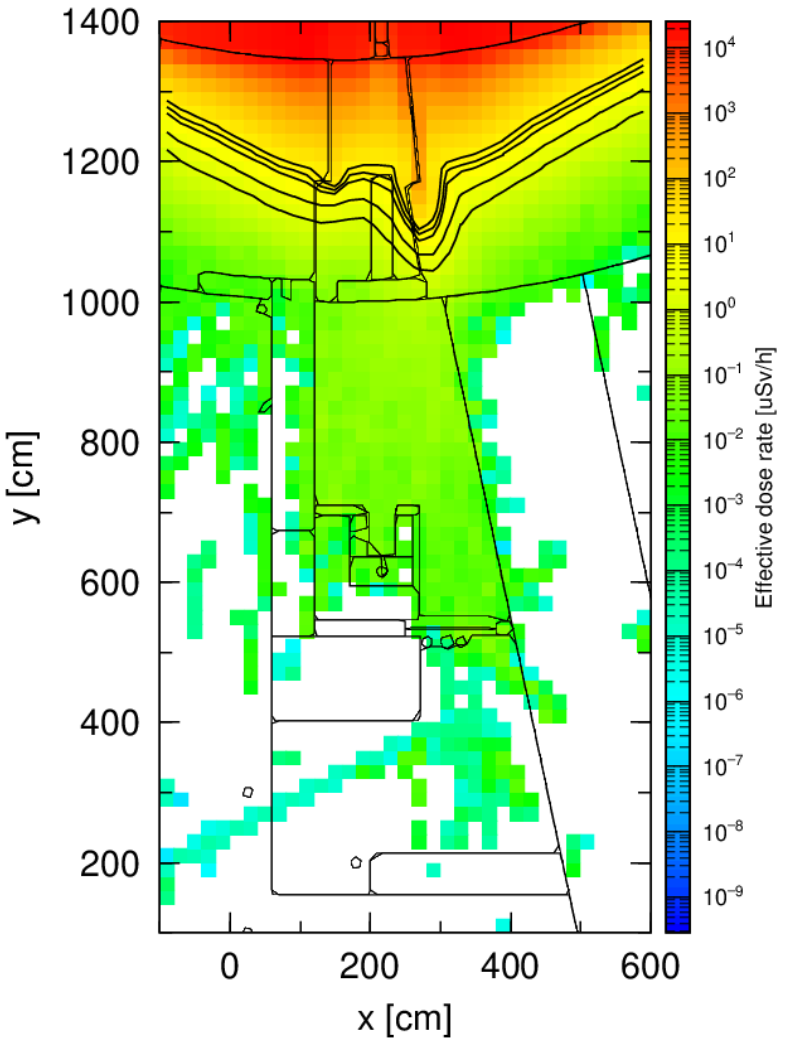
Safety Readiness: Radiation Hazards

Shutter Closed

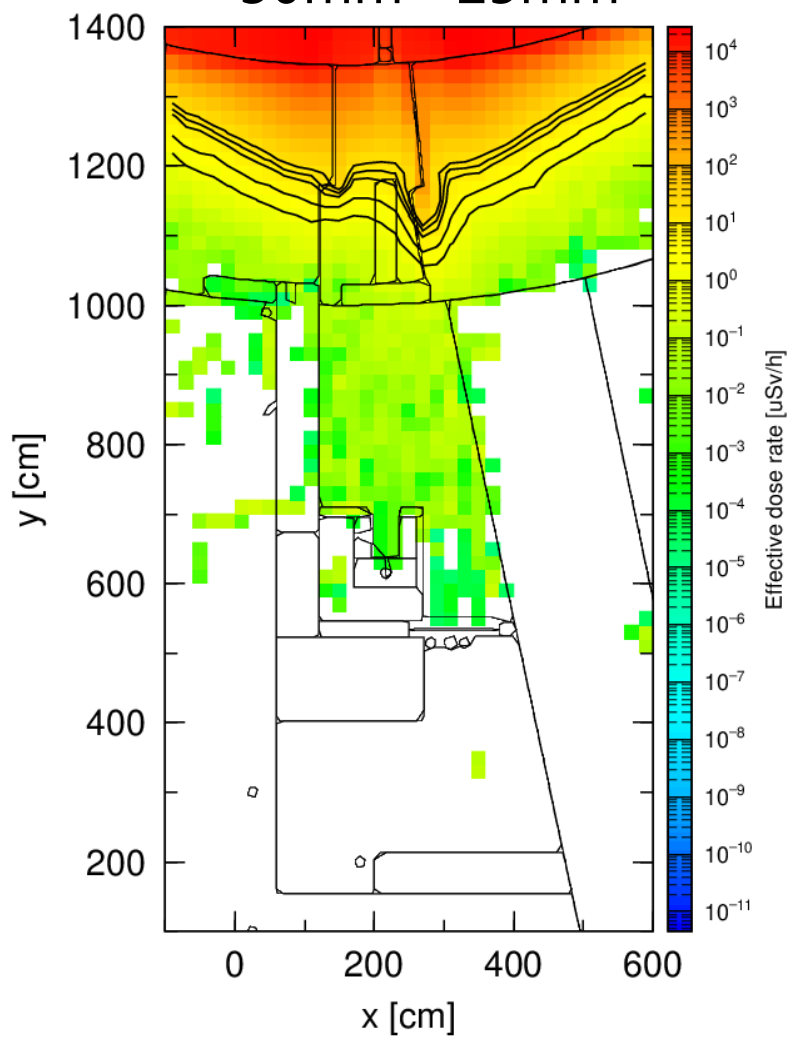
3mm



10mm

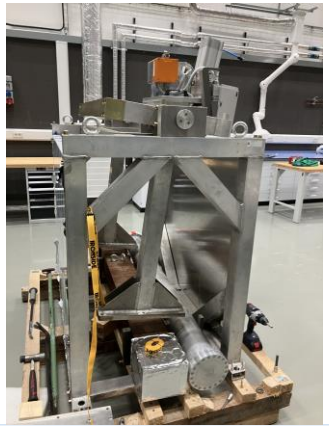


30mm×25mm

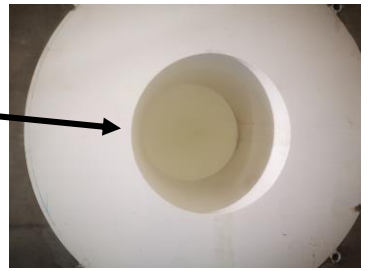


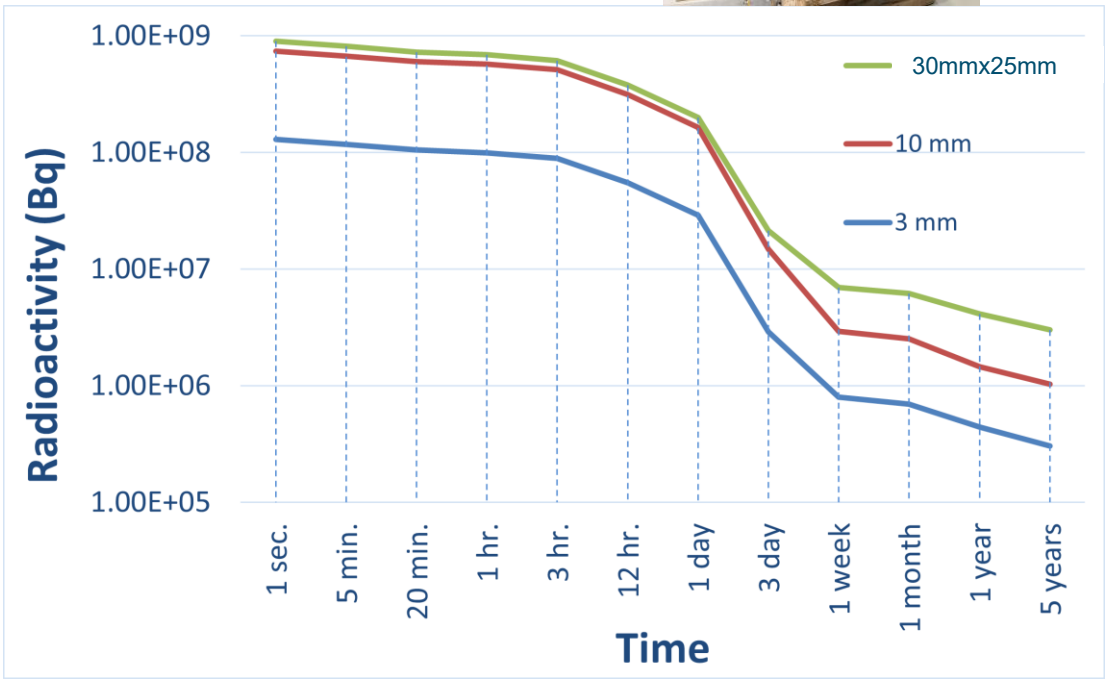
Bunker wall serves as Shielding for Green Supervised Area. (< 3 μSv/h)

Activation analysis

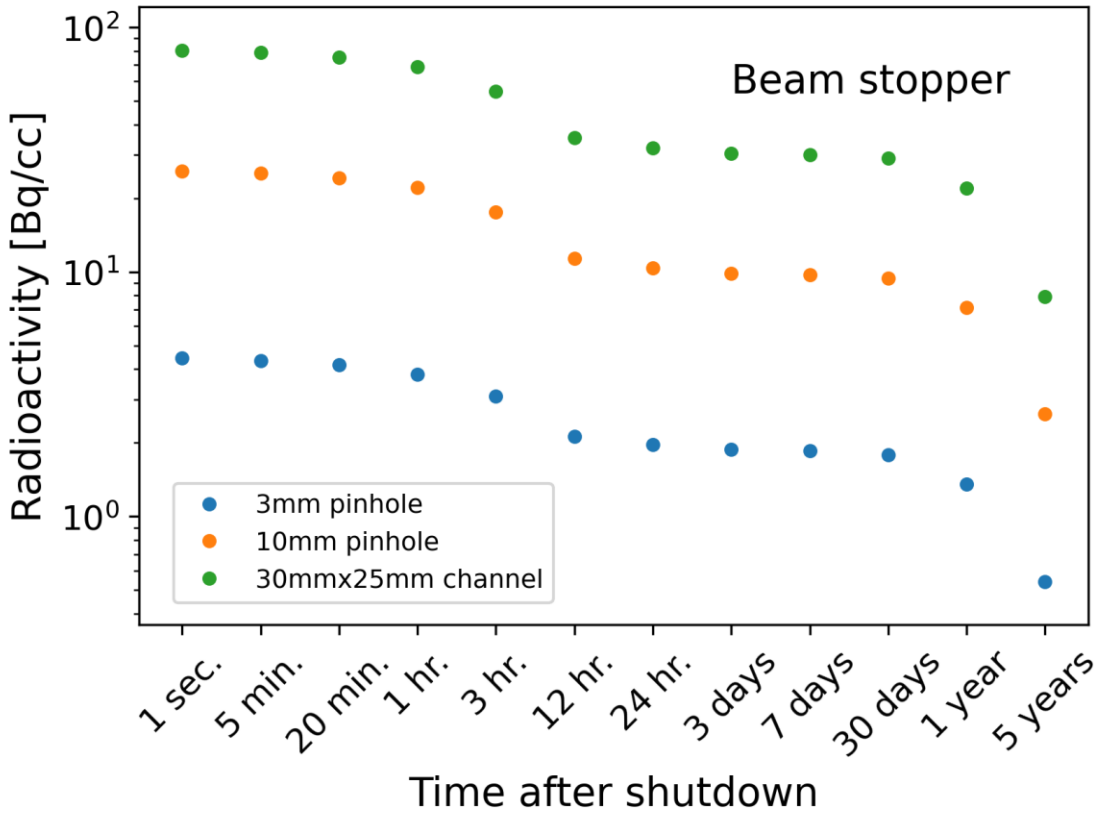


B4C tiles cover the surface and filled with mirrobor inside



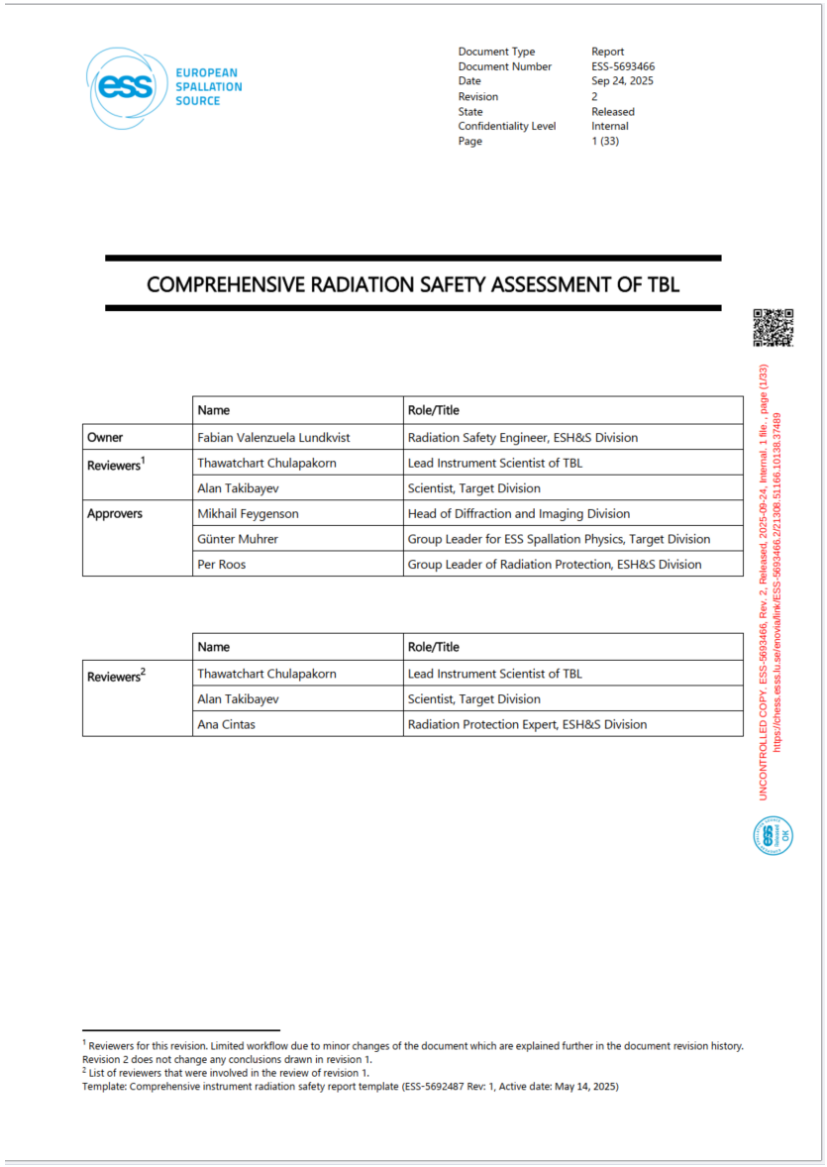


Heavy Shutter:
Long activation but not accessible during normal operation.



Beam stopper inside the cave:
Short and low activation, access to the cave is possible right-after the heavy shutter is closed.

Conclusion



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COMPREHENSIVE RADIATION SAFETY ASSESSMENT OF TBL

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[1] Reviewers for this revision. Limited workflow due to minor changes of the document which are explained further in the document revision history. Revision 2 does not change any conclusions drawn in revision 1.
[2] List of reviewers that were involved in the review of revision 1.
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8. CONCLUSIONS

The report concludes that the applied safety provisions ensure appropriate level of radiation safety: radiation safety requirements are met by the TBL with certain limitations.

Limitations of the shielding against prompt sources are elaborated in Section 7.1.2. The cave fulfils its purpose until 800 kW proton beam power without any constraints. If the TBL is to be used in higher beam powers as well, limitations in the pinhole size must be applied or a more thorough shielding analysis (and enhancement) must be performed.

Activation calculations highlighted that it is recommended to limit the neutron exposure of the bunker wall insert due to its unfavourable material composition, as it is detailed in Section 7.5.2.

Thank you!

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