Shielding workshop
NMX

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Instrument Project Engineer NMX

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Lund, 30 Nov 2017

Project organization

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Project organization

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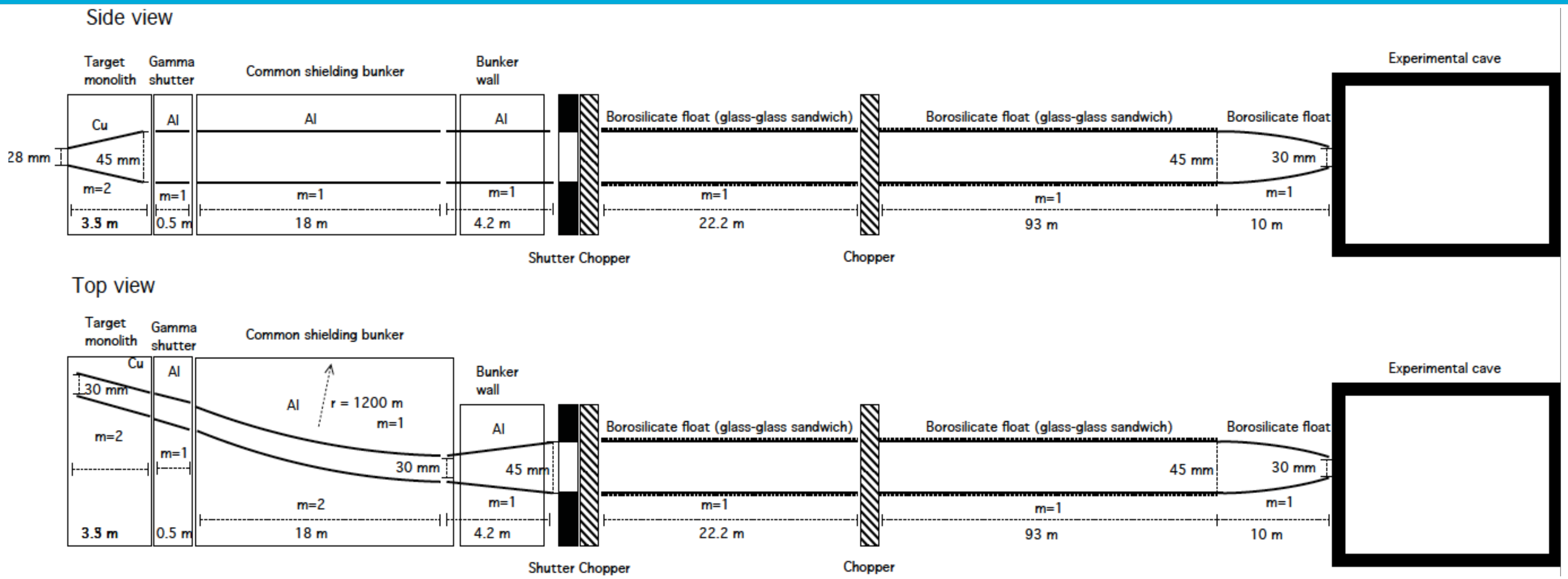
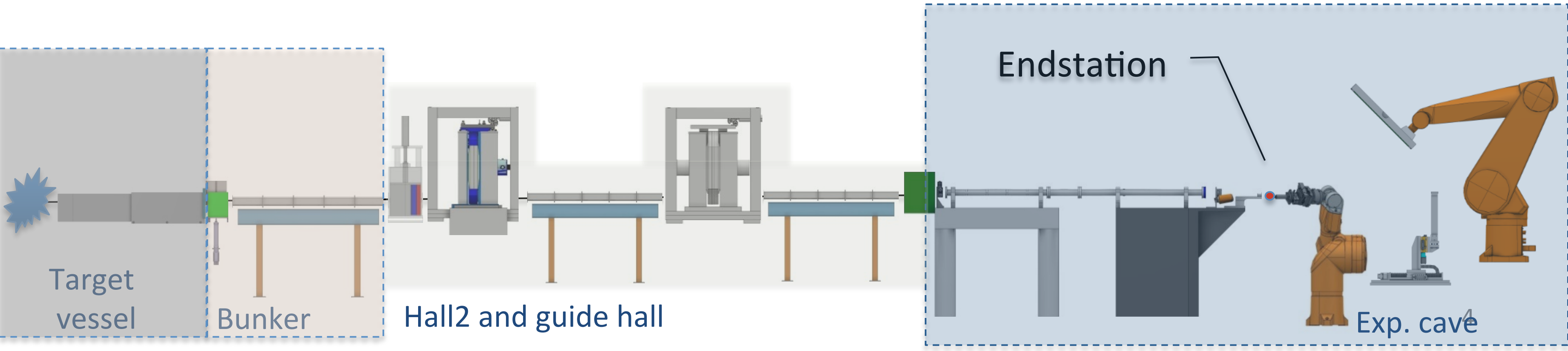
University of Bergen

Instrument outline





Instrument outline

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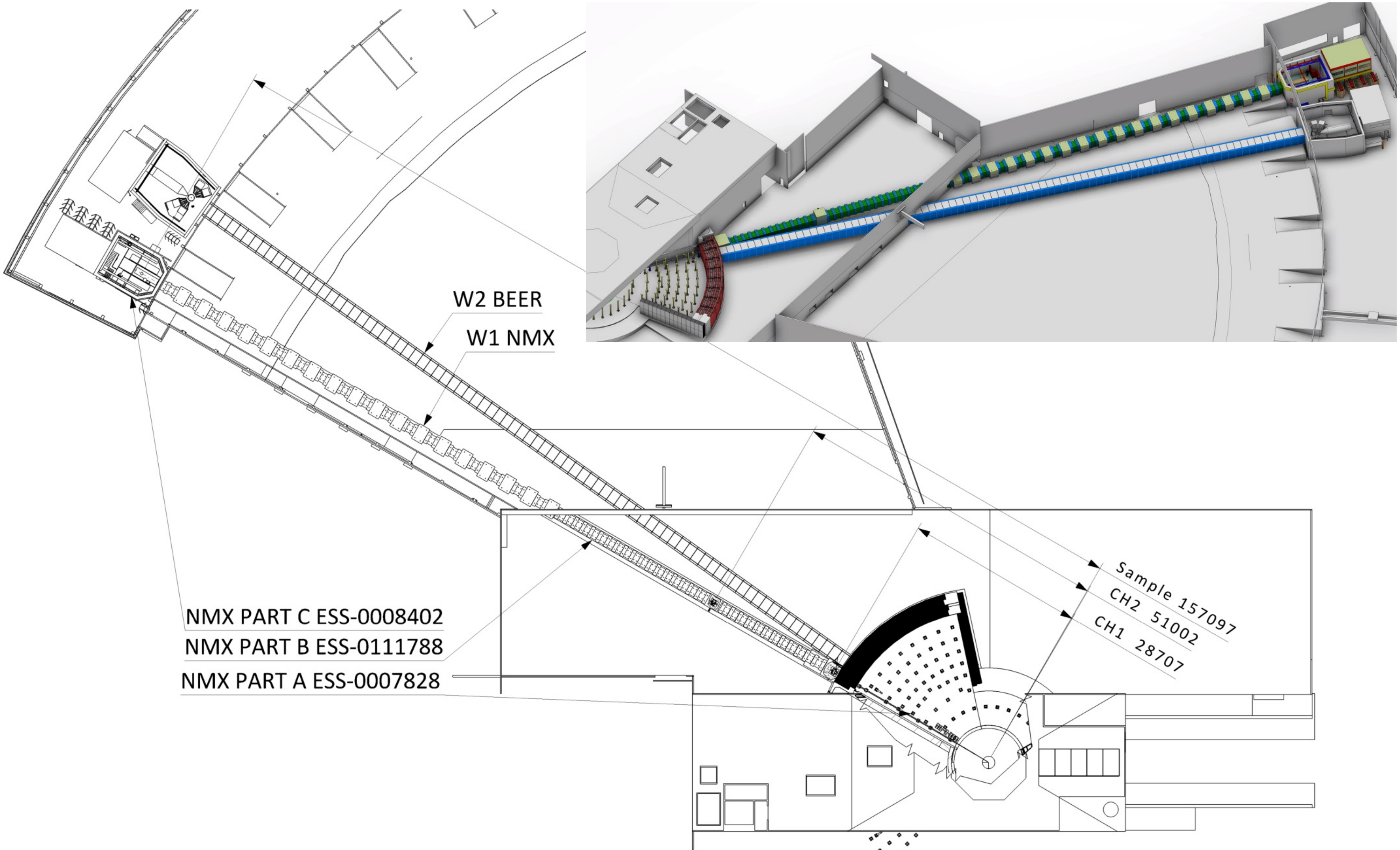
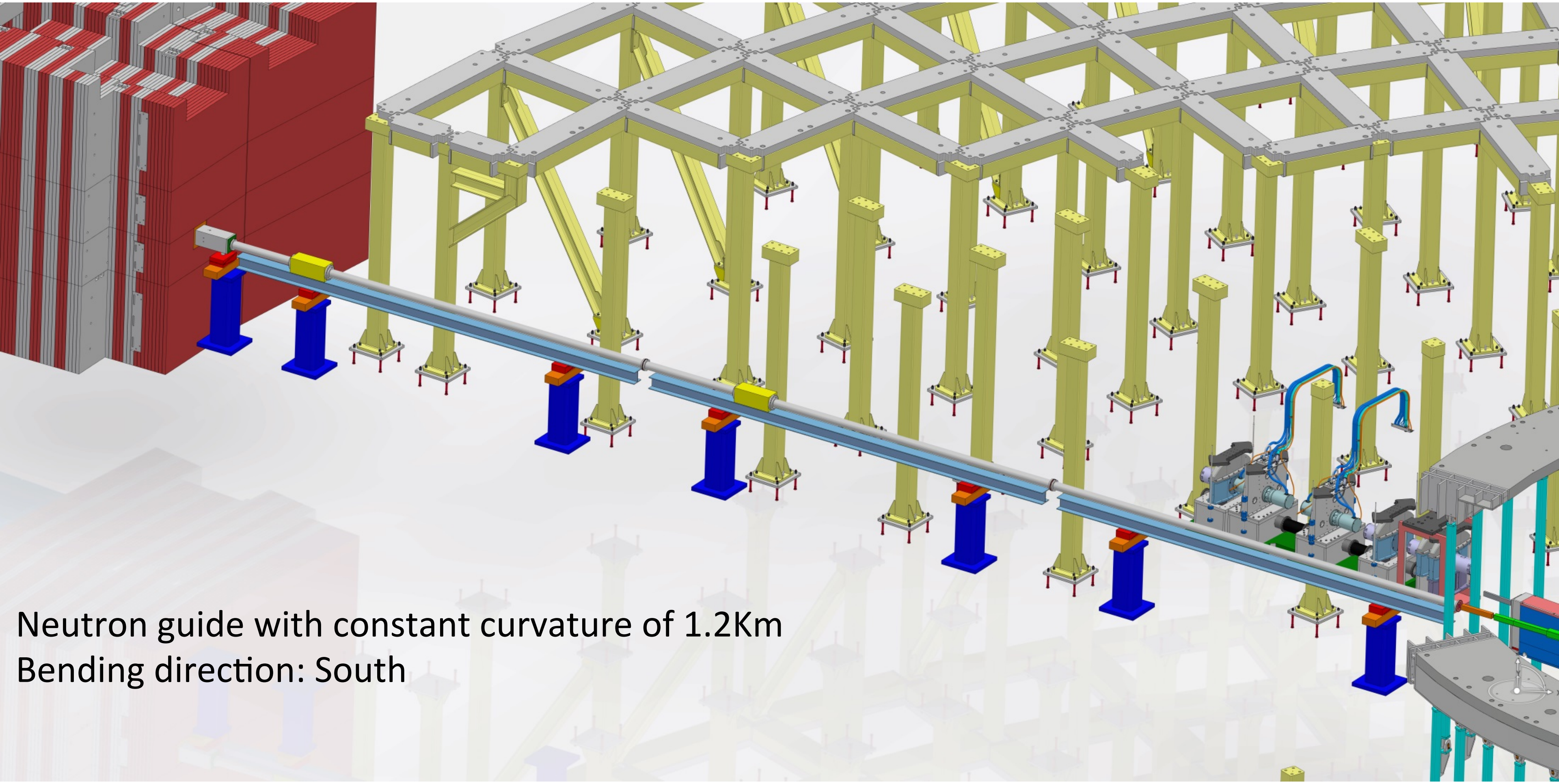
SOURCE

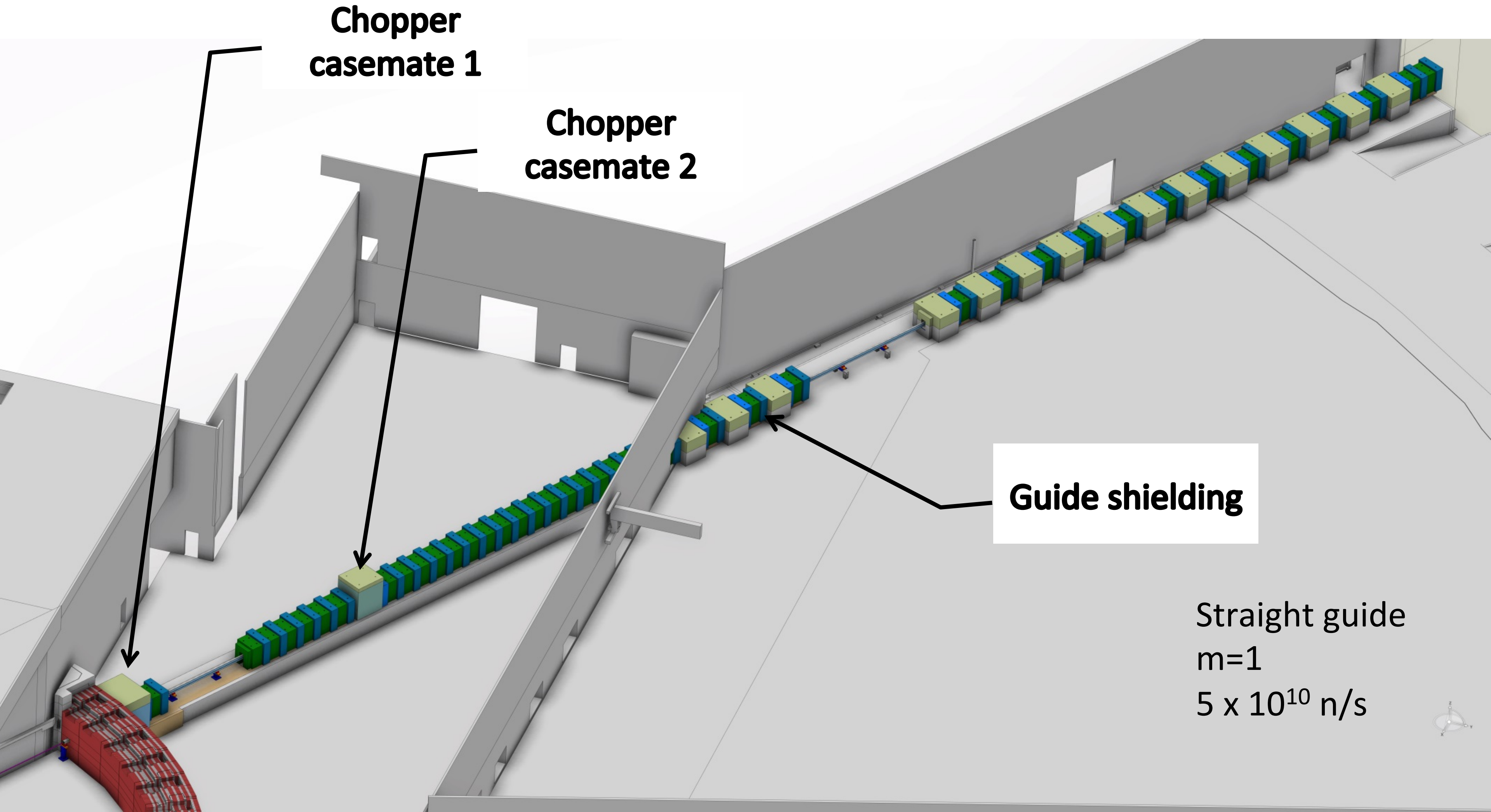


Instrument outline



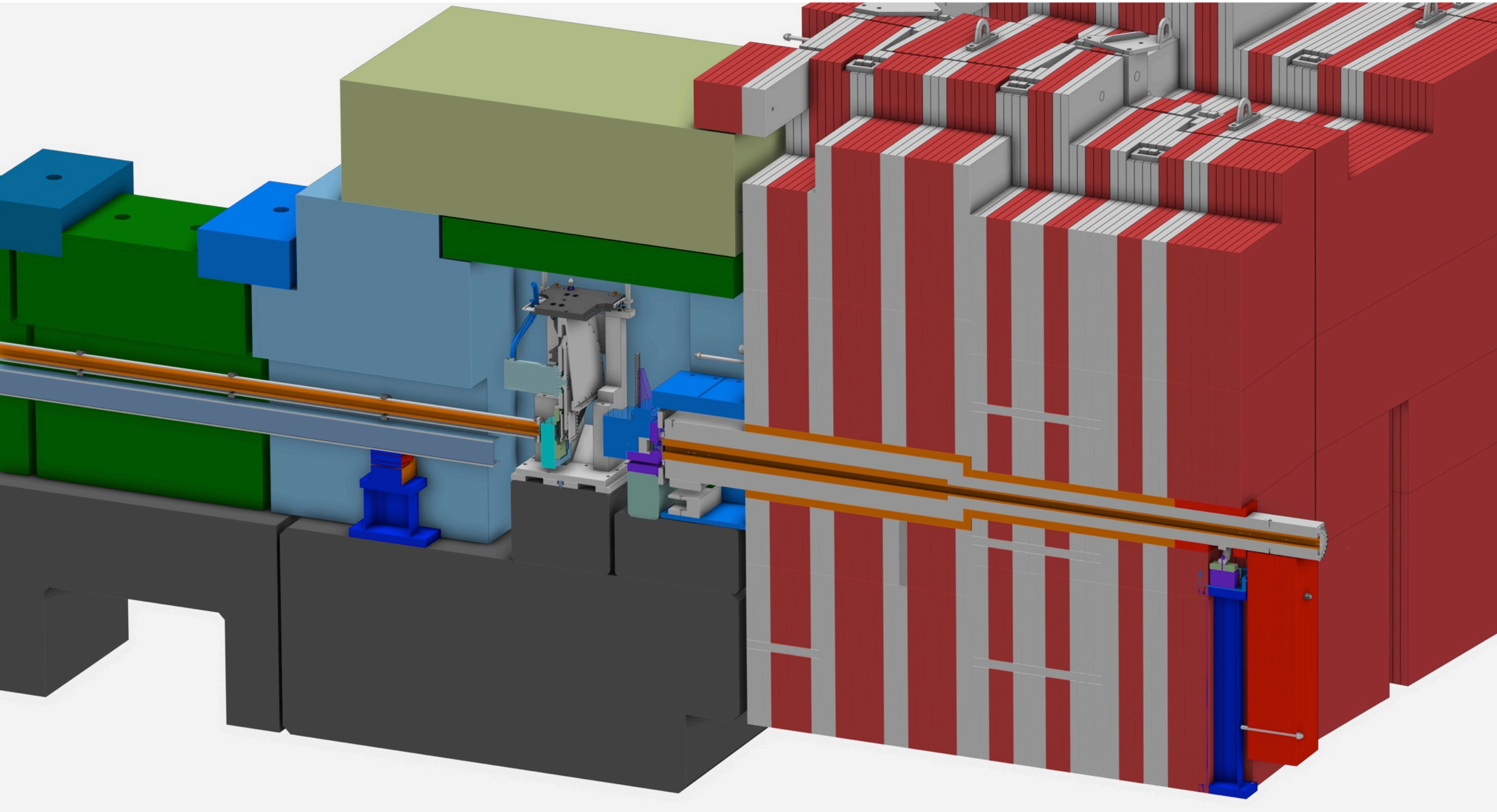
Neutron guide with constant curvature of 1.2Km
Bending direction: South

Instrument outline

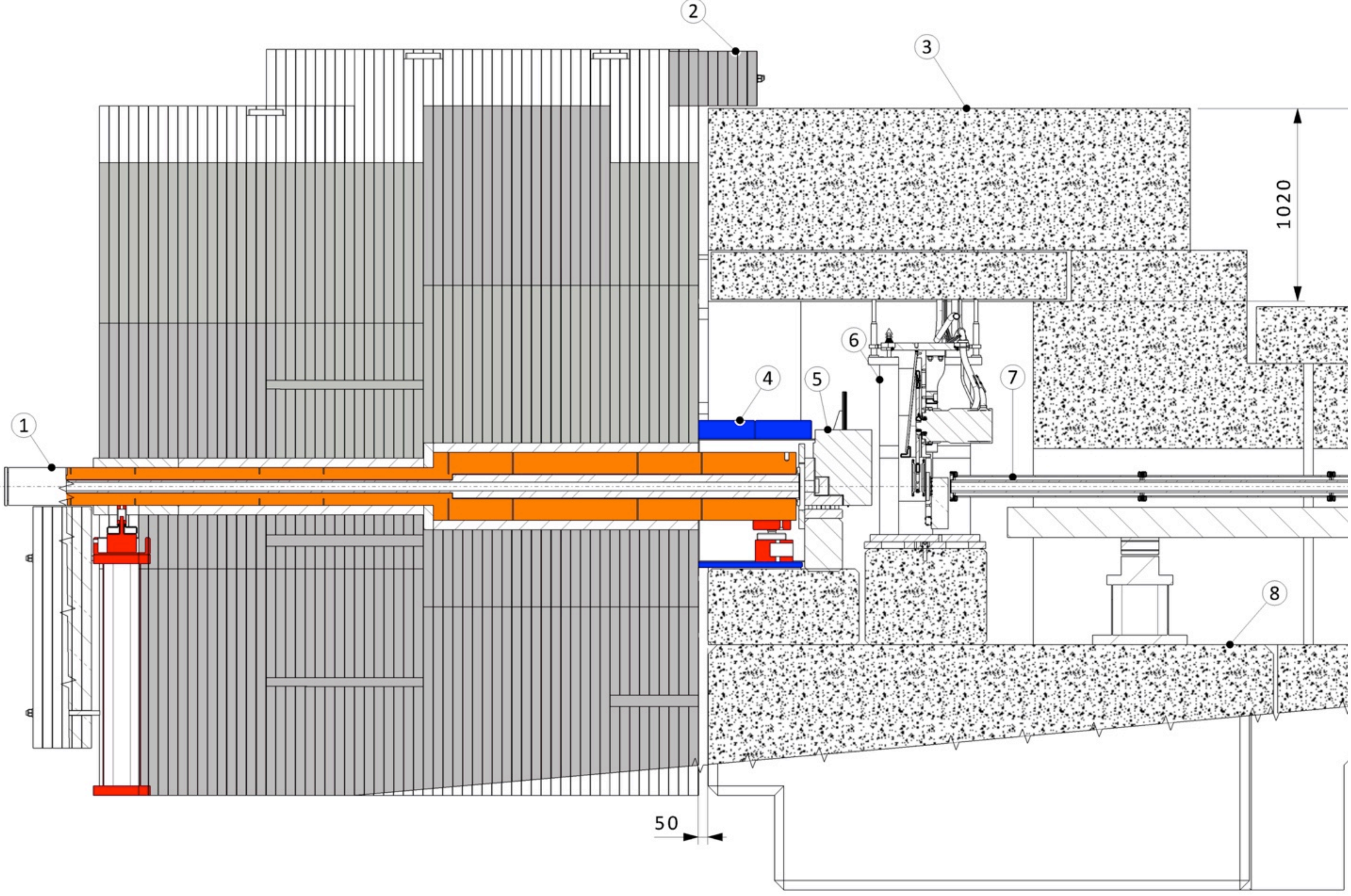


Straight guide
m=1
5 x 10^{10} n/s

Neutron guides shielding : Chopper casemate 1



Neutron guides shielding : Chopper casemate 1

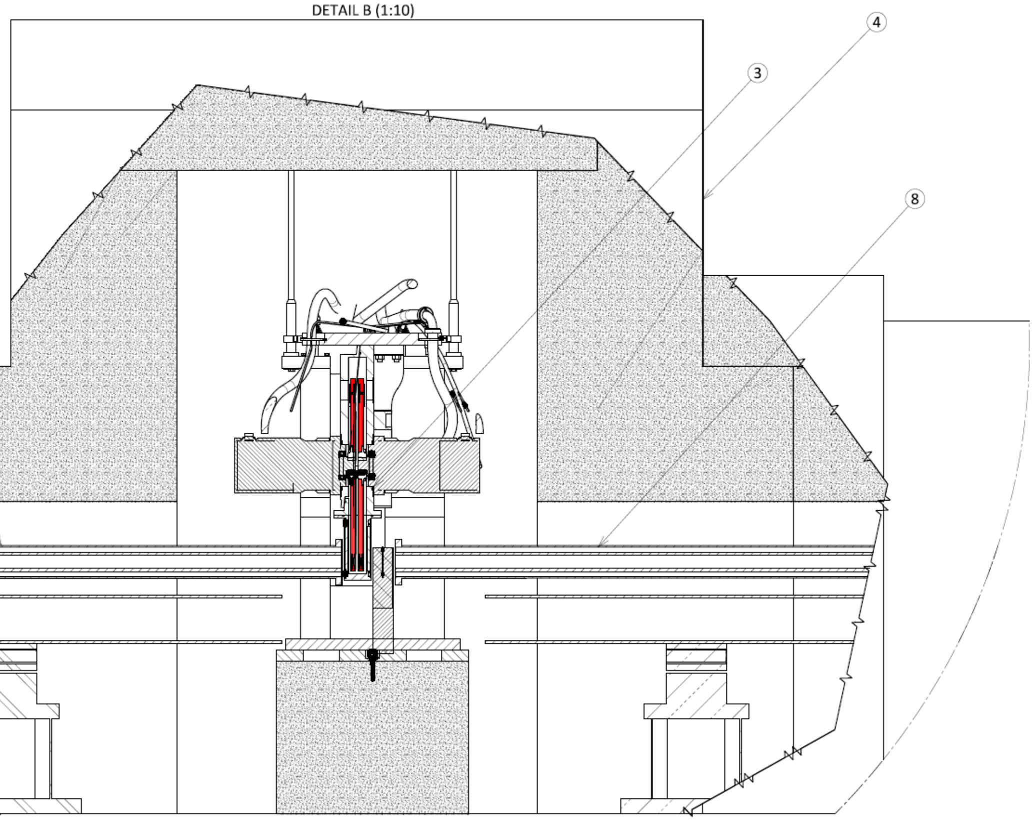


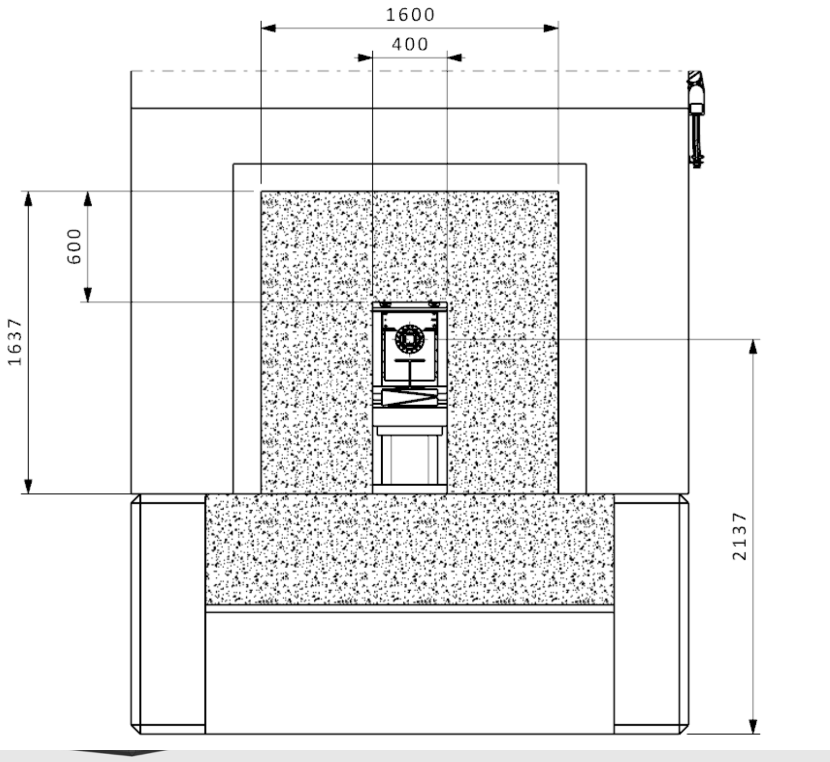
Neutron guides shielding : Guide shielding and chopper casemate 2

Baseline thickness: 60cm regular concrete 2.4 t/m^3

D03: 5.8t/m @ 60cm, Floor load 4,4t/m^2
E02: 7.7t/m @ 60cm – Floor load 6.5t/m^2

Guide shielding design will be updated after conclusion of neutronic calculations . **It is expected a considerable thickness reduction.**





Neutron guides shielding : Guide shielding and chopper casemate 2

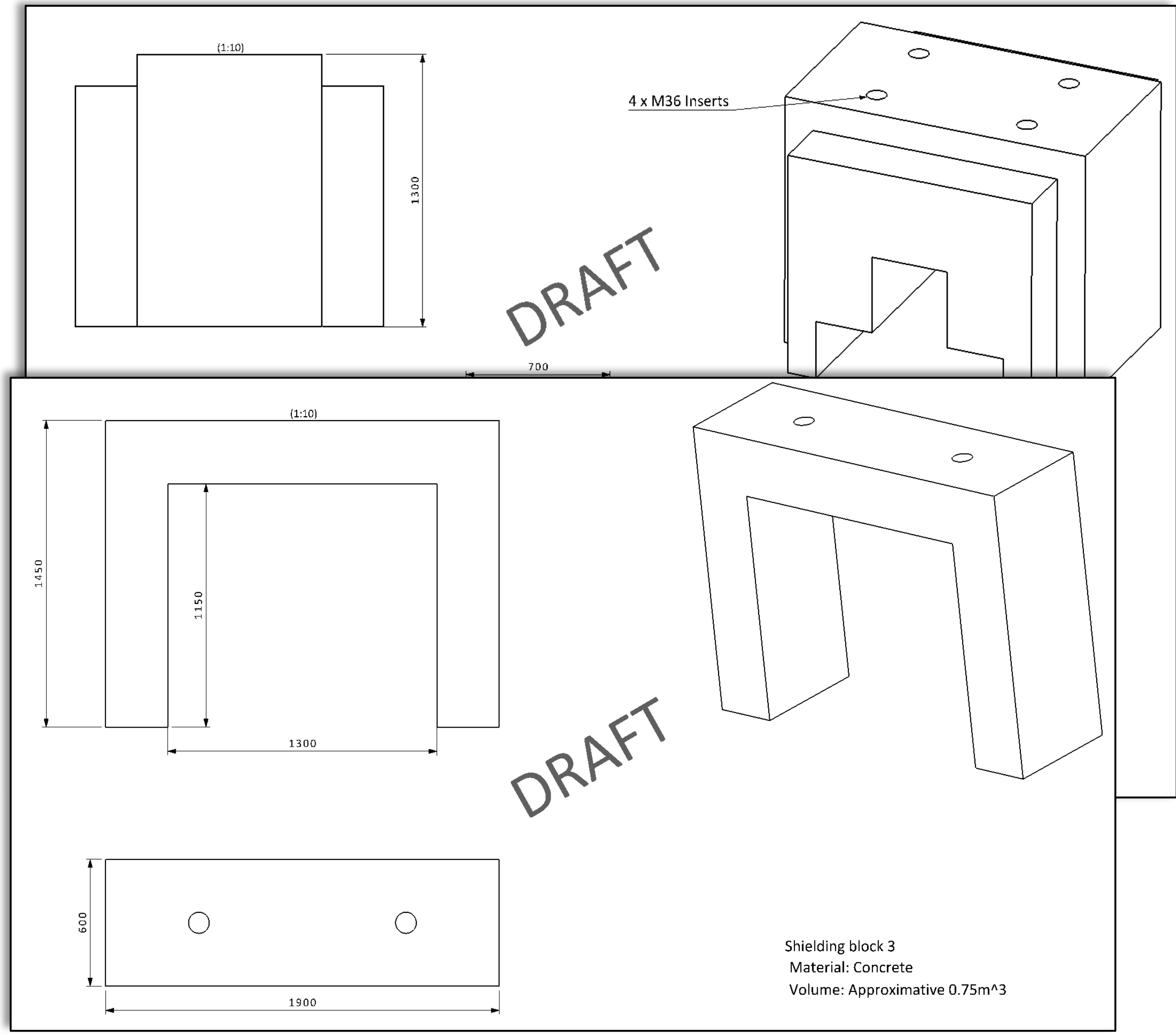
Estimator provided Swedish costs
Regular concrete 2.4t/m

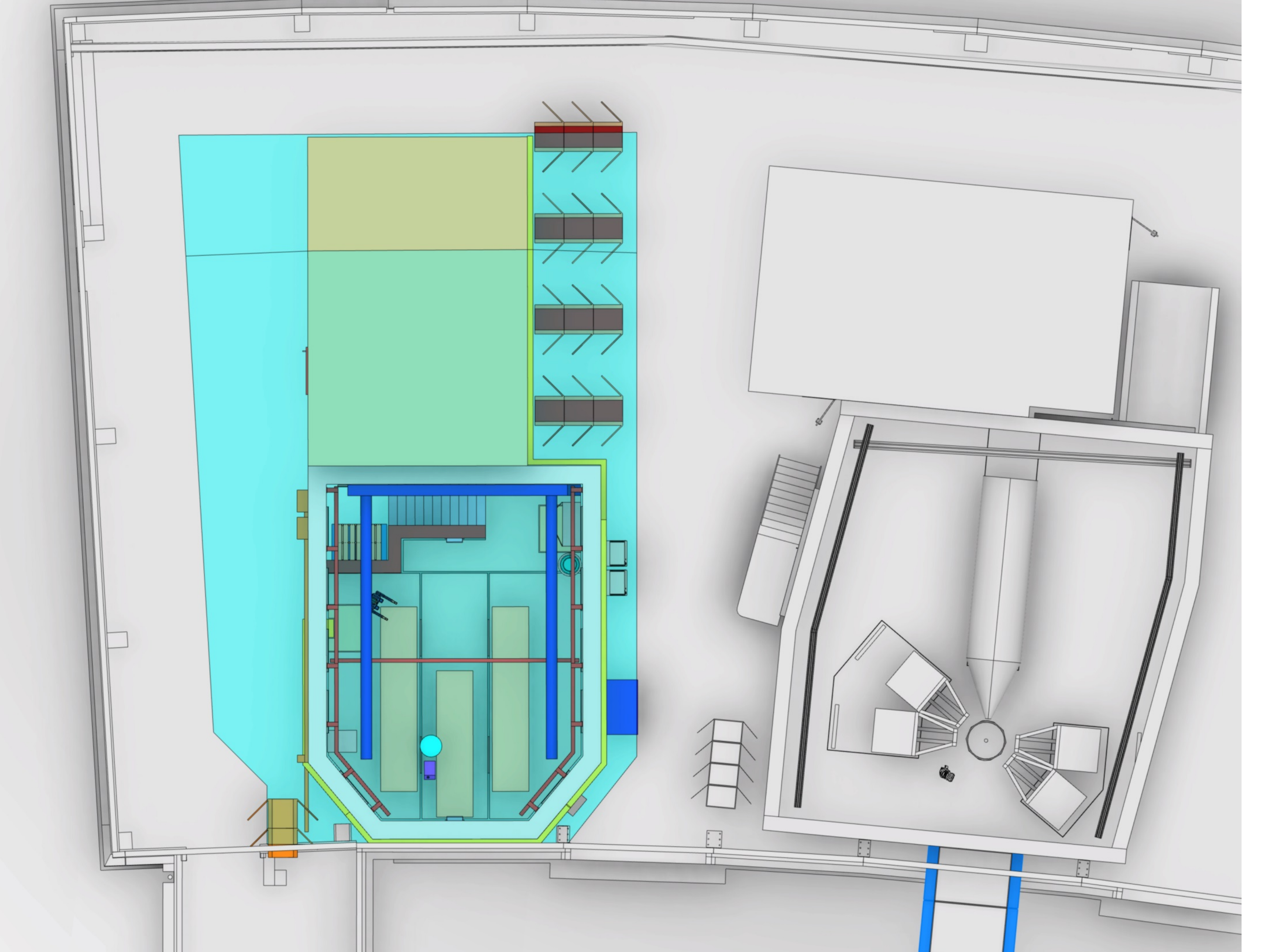
Estimated costs included:

- Cost for forming
- Reinforcement bars
- Concrete cost
- Concrete surface treatment
- Transportation (small distance)
- Manpower
- Manufacturer's overheads

Average cost: about 1800 Eur/m^3 (upper boundary)

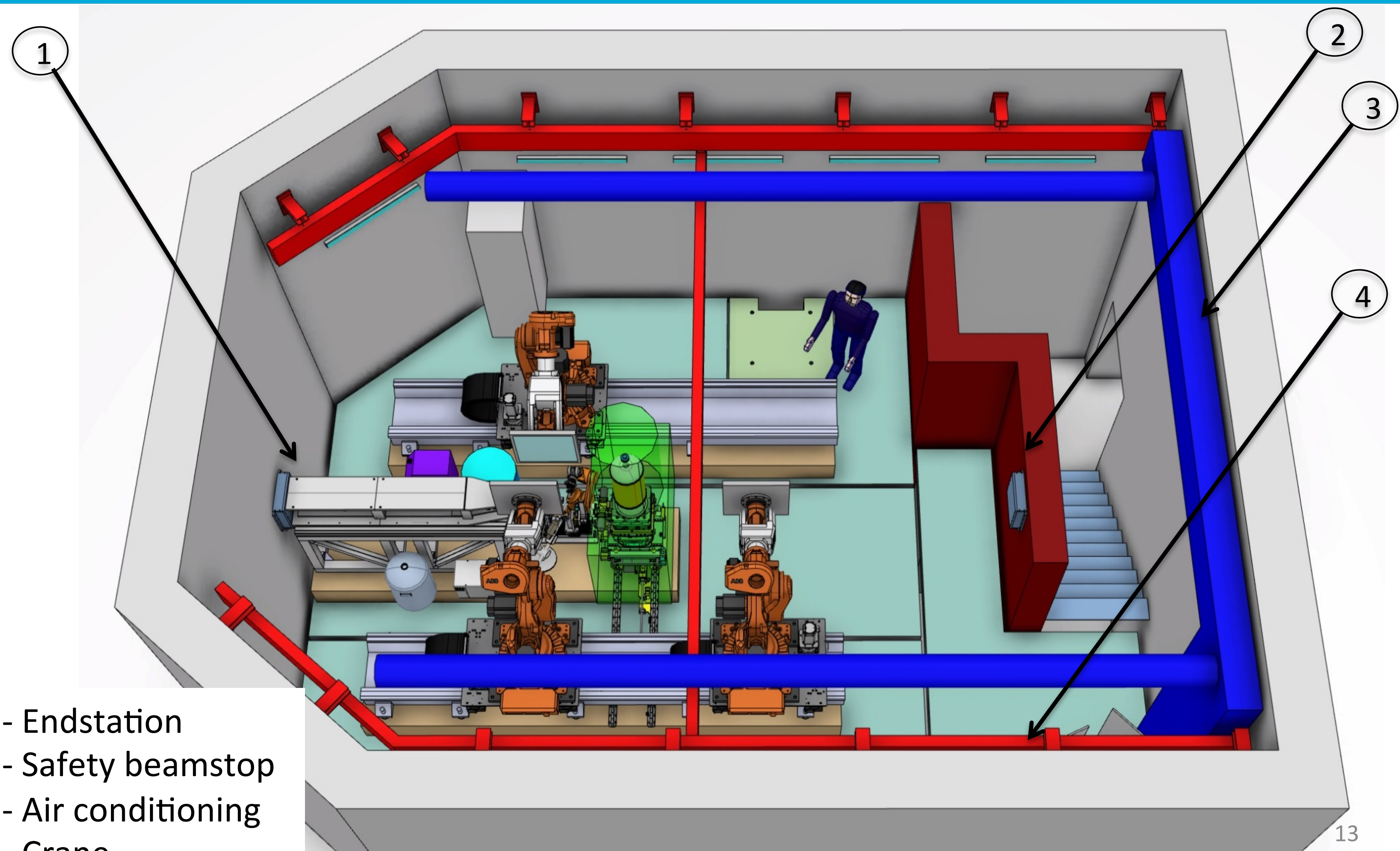
Other estimates that indicate much lower costs per m^3.





Experimental cave shielding: Introduction

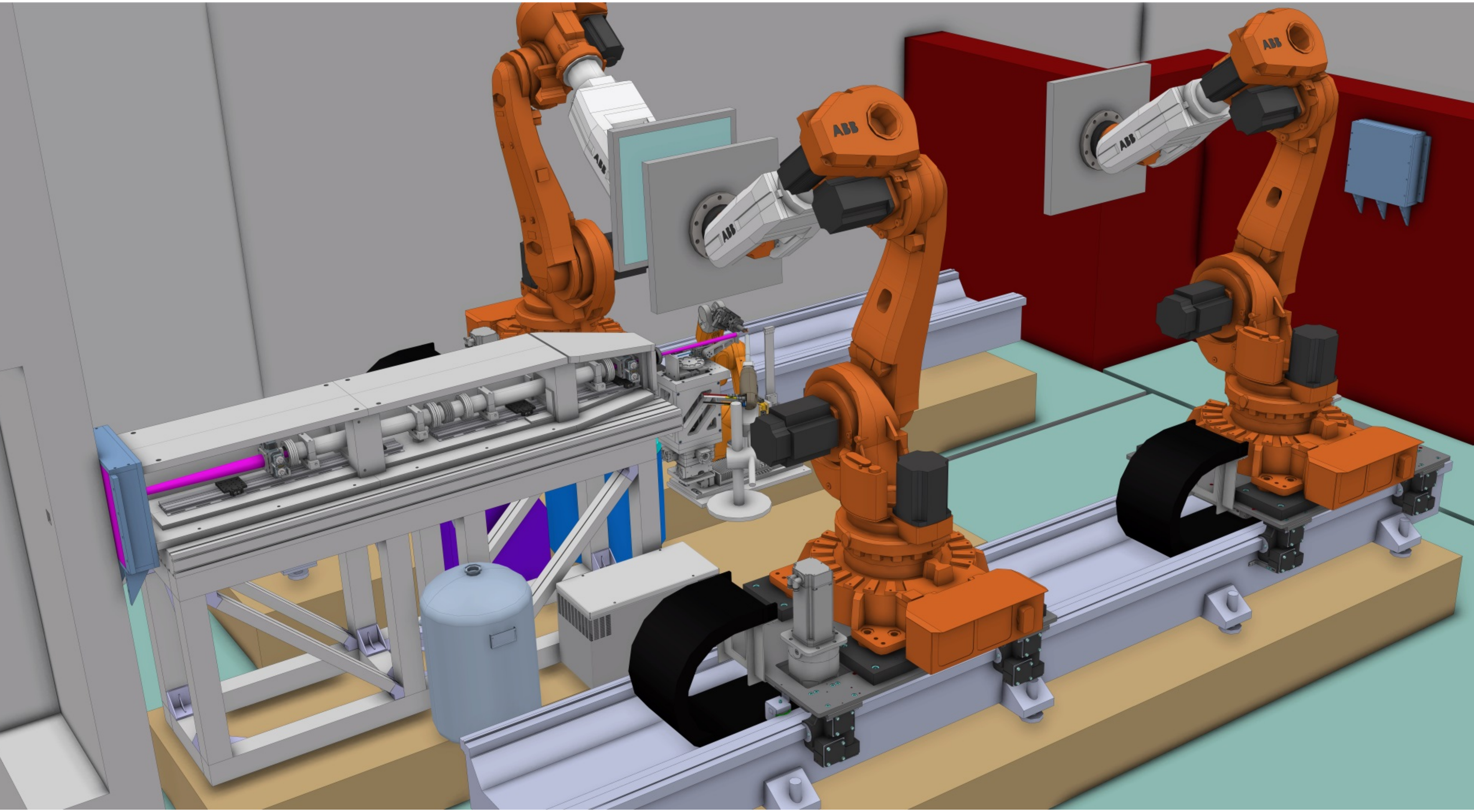
EUROPEAN SPALLATION SOURCE



1 - Endstation
2 - Safety beamstop
3 - Air conditioning
4 - Crane

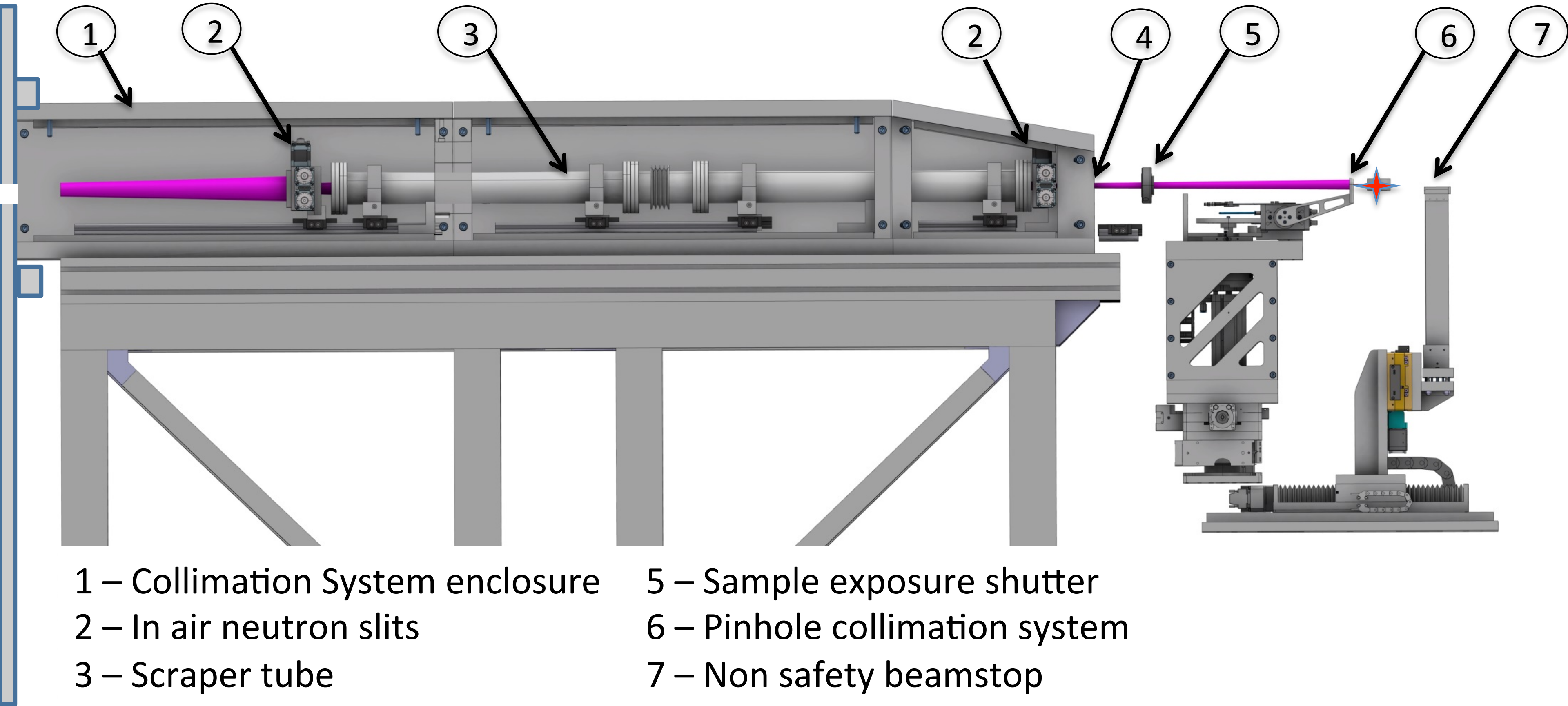
Experimental cave shielding: Introduction

EUROPEAN SPALLATION SOURCE



Experimental cave shielding: Introduction

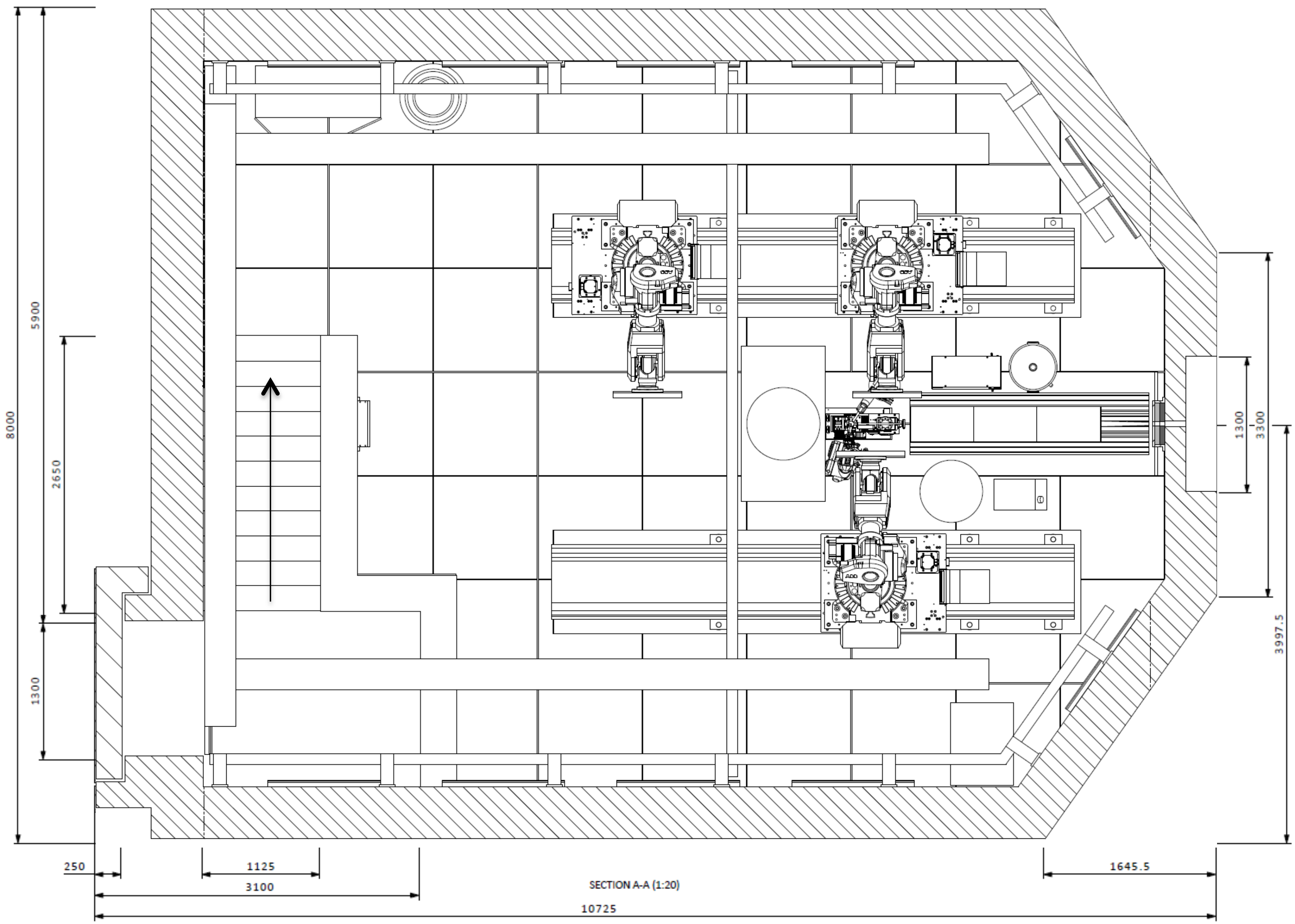
The fixed aperture(4) limits the neutron current in the sample area(from $5x10^{10}$ n/s to $5x10^{9}$ n/s.
Ambition: 90% of neutrons entering the cave are absorbed by boron absorbers within the collimation enclosure.



1 – Collimation System enclosure
2 – In air neutron slits
3 – Scraper tube
4 – Fixed aperture
5 – Sample exposure shutter
6 – Pinhole collimation system
7 – Non safety beamstop

Experimental cave shielding: Layout 1

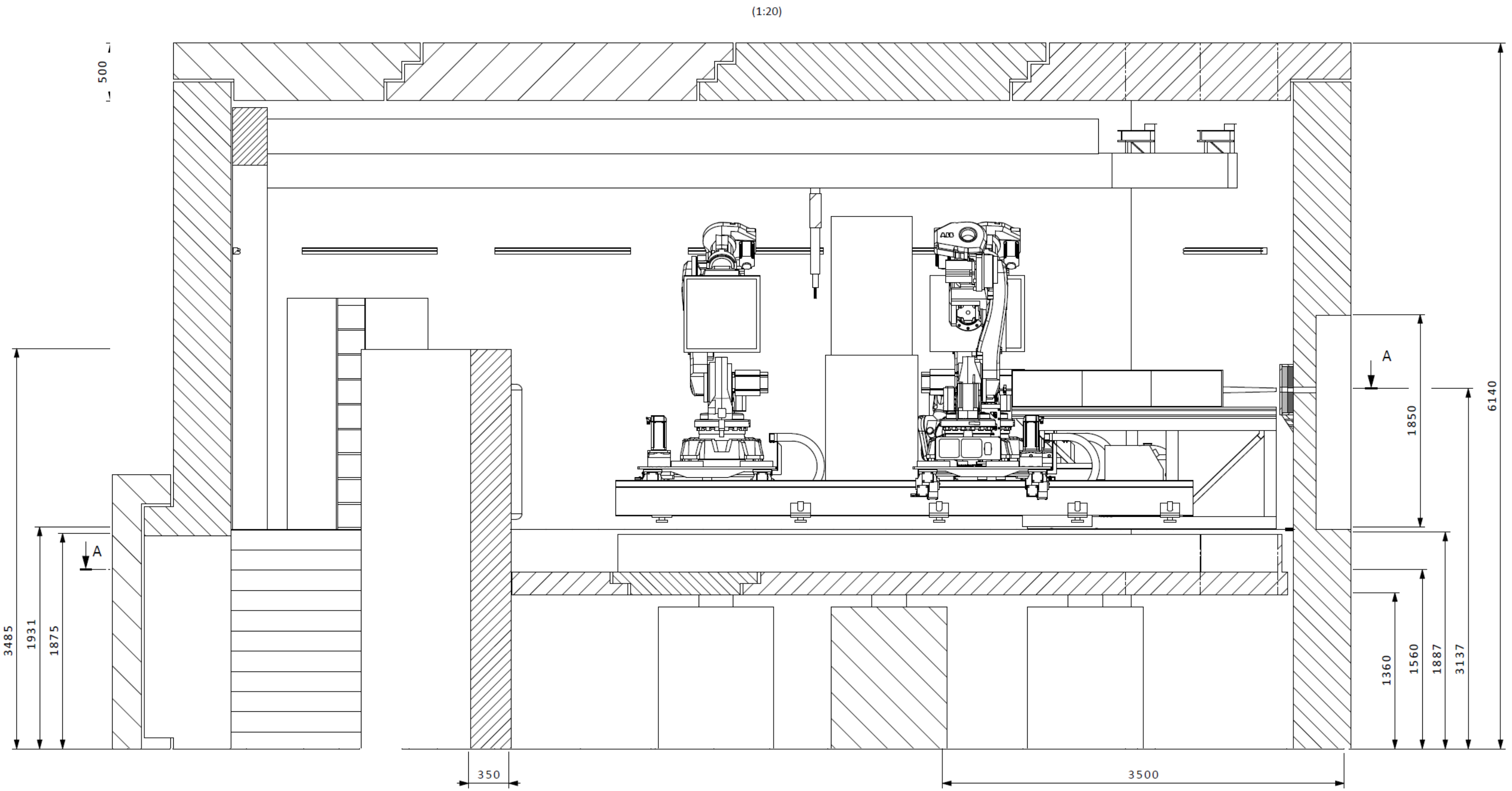
EUROPEAN SPALLATION SOURCE



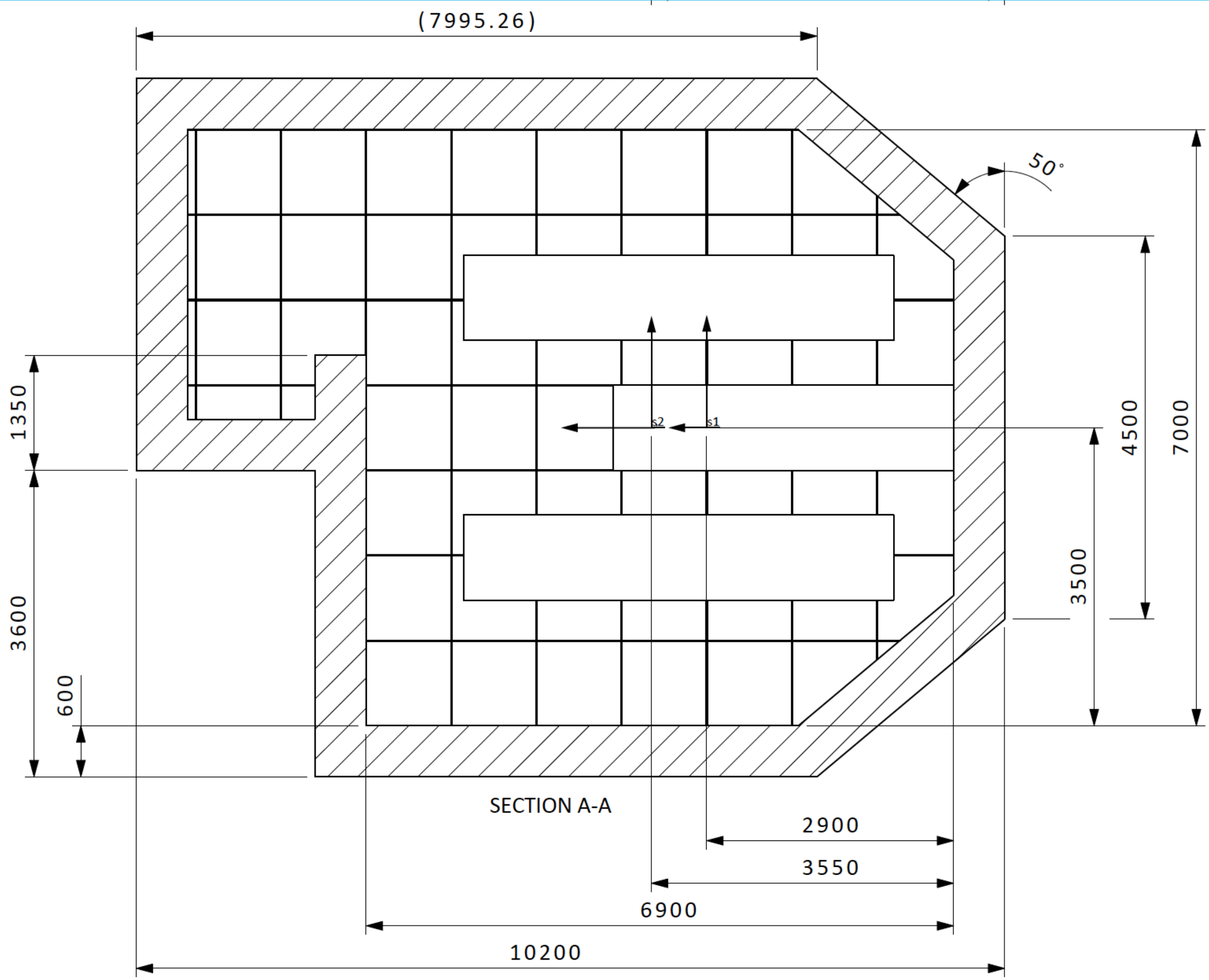
Experimental cave shielding: Layout 1

Cave height determined by need of local crane in the cave.

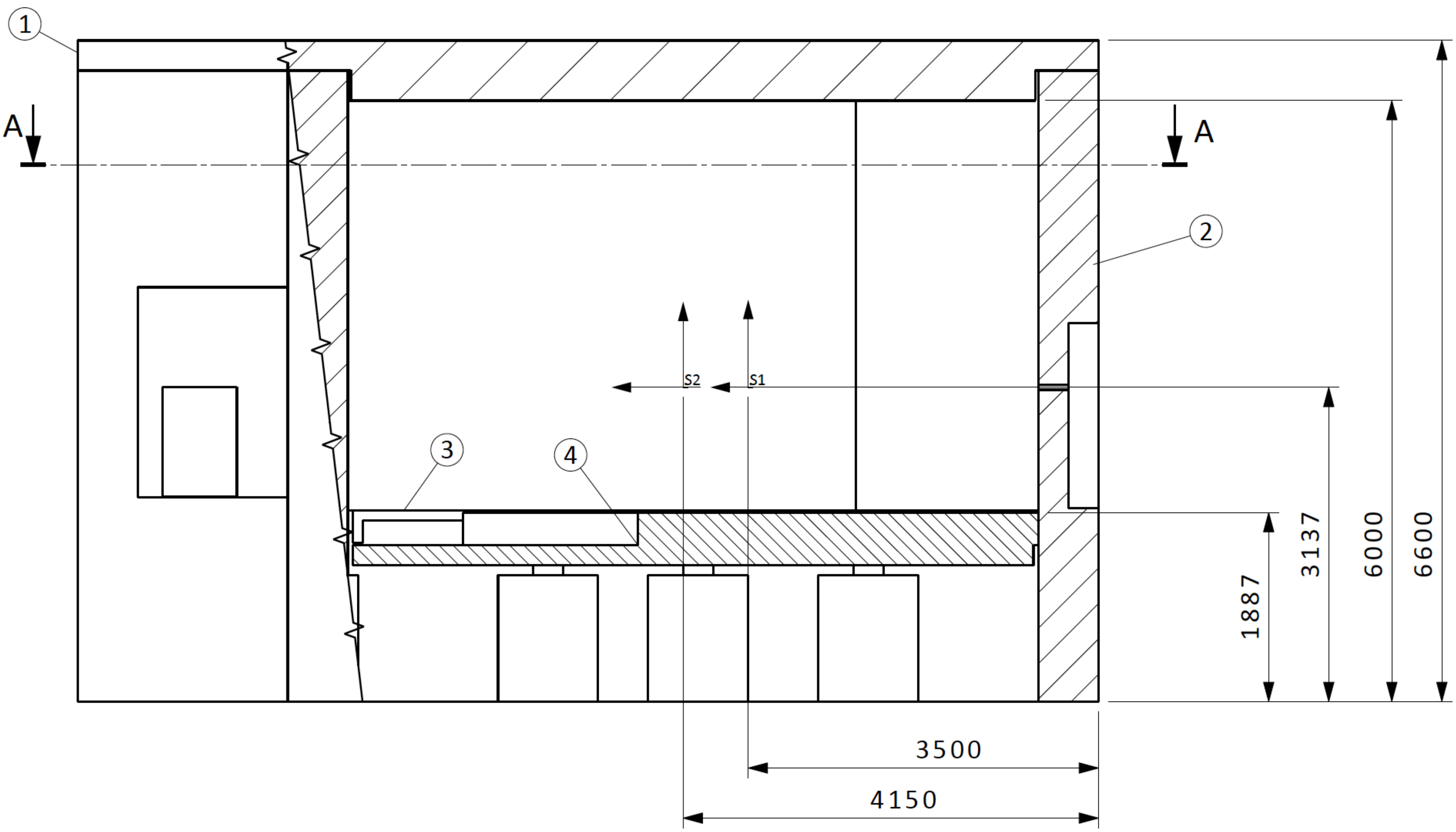
138 m^3@ 50cm Floor load: 19.4 t/m^2 (@90 cm same floor load)



Experimental cave shielding: Layout 2



Experimental cave shielding: Layout 2



#	Op. mode	Event	Consequence	Note:
H1-1	A/B	Slit1 is completely closed		
H1-2	A/B	Slit2 is completely closed		
H1-3	A/B	Pinhole collimation protection plate is raised into the beam	The collimated beam is hitting a neutron absorber (B4C) at sample position.	
H1-4	A/B	The exposure beam shutter is closed, Full beam is hitting the blade (B4C)	The full beam is hitting a neutron absorber (B4C) at sample position.	.
H1-5	A/B	Pinhole collimator absorber is in the beam	The collimated beam is hitting a neutron absorber (B4C) at sample position.	.
H1-6	A/B	Slits are fully open	The collimated beam is interacting with the safety beam-stop panel (B4C or borated aluminium with thick layer of steel on the downstream side).	.
H1-8	B	The collimated beam is illuminating the worst case sample environment equipment	The collimated beam illuminates the worst gamma converter at secondary sample position	This case is identified as a gamma source of 2MeV scattering the full beam on 4π
H1-9	A	The collimated beam is illuminating the worst case sample environment equipment	The collimated beam illuminates the worst gamma converter at primary sample position.	This case is identified as a gamma source of 2MeV scattering the full beam on 4π
H1-10	A/B	An isotropic neutron scatterer (e.g. V) is placed in the beam	The collimated beam is scattered isotropically from the sample position	May be used for detector calibration
H1-11	Maintenance	A sealed source of gamma or neutrons is used to test the detectors	Neutron source of ?? n/s/sr at ?? MeV is located in the proximity of any wall or door of the cave	.
H1-12	**A/B**	**A large single crystal is placed at the sample position**	**Intense Bragg peaks (0.3% of the collimated beam) are scattered towards the walls and the roof of the cave**	.
H1-13	**A/B**	**Detector is positioned on the beam path**	**The collimated beam illuminates a Gd plate in proximity of the primary sample position**	**·The detector may be used to characterize the neutron beam.**

#	Op. mode	Cause	Event	Note:
H2-2	A/B	Robot arm or robot tool enters the full beam	The collimated beam illuminates the worst gamma converter at any position between the beam entrance in the cave and the safety beam-stop.	This case is accounted for as the worst between H2-3 and H2-4
H2-3	A/B	A foreign object is accidentally forgotten in the beam path	The collimated beam illuminates the worst gamma converter at any position between the beam entrance in the cave and the safety beam-stop.	This case is identified as a gamma source of 2MeV scattering the full beam on 4π solid angle, see [1]-
H2-4	**A/B**	**A foreign object is accidentally forgotten in the beam path, full beam illuminate the worst neutron scatterer at any position between the beam entrance in the cave and the safety beam-stop.**	**The collimated beam is scattered isotropically from any point in the beam path**	
H2-7	A/B	A hydrogenous scatterer (Plastic or water) is accidentally placed in the beam path	A high percentage of the collimated beam is scattered isotropically from any point in the beam path onto the cave walls, floor and roof	1mm water is a ~ 50% scatterer.
H2-8	**A/B**	**Detector is positioned on the beam path**	**The collimated beam illuminates a Gd or Cd plate in any position of the beam path.**	**It accounts also for having a sheet of cadmium in the sample position [1]**

NMX Cave H1 and H2 Scenarios

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- Neutronic input
  - 5×10^{10} n/s (Full beam)
  - 5×10^{9} n/s (Collimated beam)

- Most severe scenario H1-13 (NMX Cave H1 and H2 Scenarios ESS – 0100307)

  - Detector is positioned on the beam path,
  - The collimated beam illuminates a Gd plate in proximity of the primary sample position

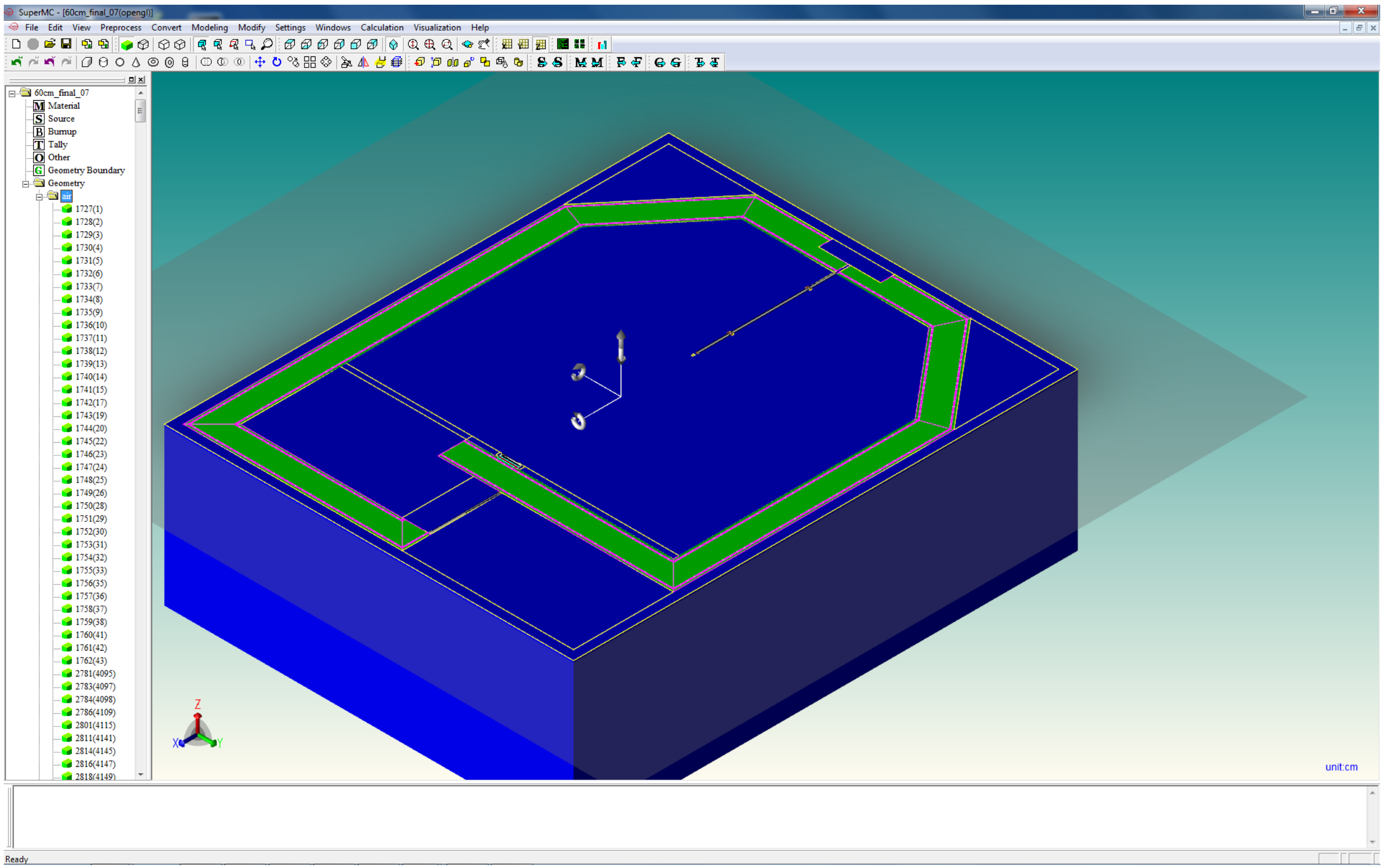
- Simulations results:
  a. Around 92 cm concrete thickness is necessary to achieve 3µSv/h for all H1 and H2 scenarios.
  b. 60 cm concrete thickness can be sufficient if safety procedures were in place to deal with H1-13, H2 scenarios and if the walls were covered with a neutron absorber layer.

Applied materials for the components of the experimental cave

Component	Applied material
Walls	Concrete, Ordinary (NIST)
False floor	Al
Stairs and bar	Concrete, Ordinary (NIST)
Door rails	Stainless steel
Sliding door	Concrete, Ordinary (NIST)
Safety beam-stops	B_4C
Non-safety beam-stops	B_4C
Slits	B_4C
Guide tube	Al

Courtesy: Szabina Török

Detailed study of selected model with steel door



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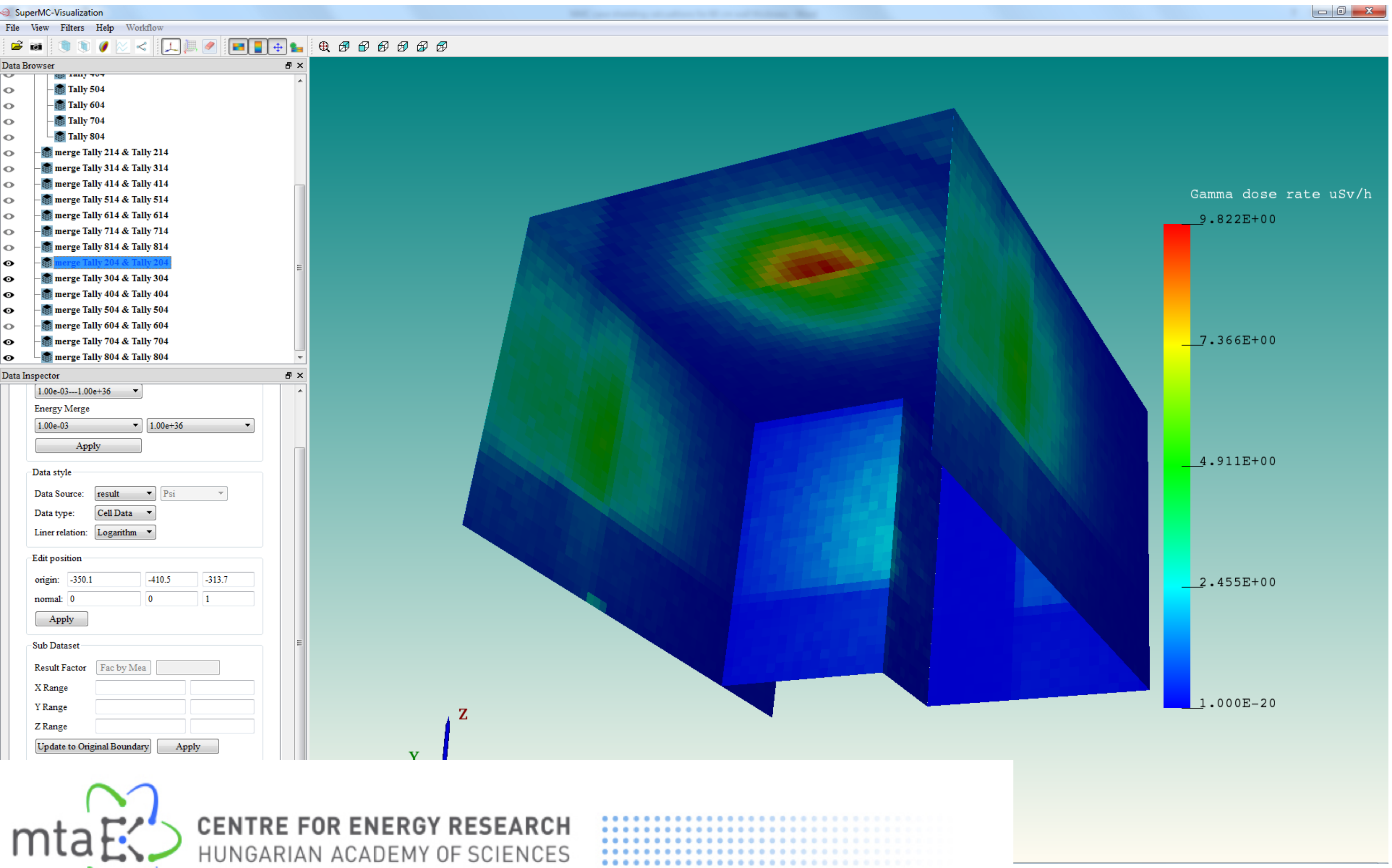
Courtesy: Szabina Török

Gadolinium, 60 cm

H1-13	**A/B**	**Detector is positioned on the beam path**	**The collimated beam illuminates a Gd plate in proximity of the primary sample position**	**The detector may be used to characterize the neutron beam.**

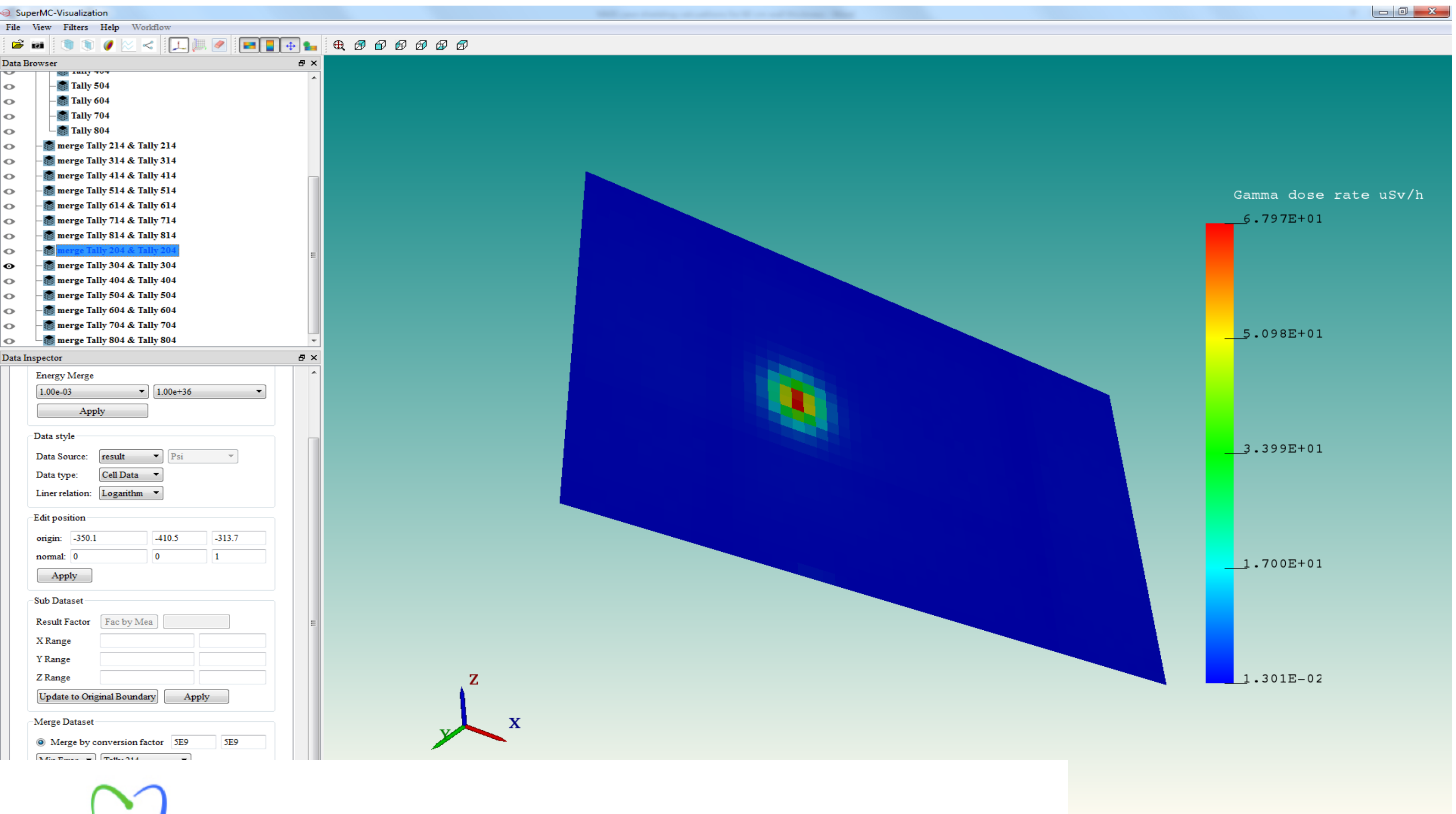


Courtesy: Szabina Török

Bragg peaks, 60cm without Boron lining on walls

EUROPEAN SPALLATION SOURCE

H1-12	**A/B**	**A large single crystal is placed at the sample position**	**Intense Bragg peaks (0.3% of the collimated beam) are scattered towards the walls and the roof of the cave**



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Courtesy: Szabina Török

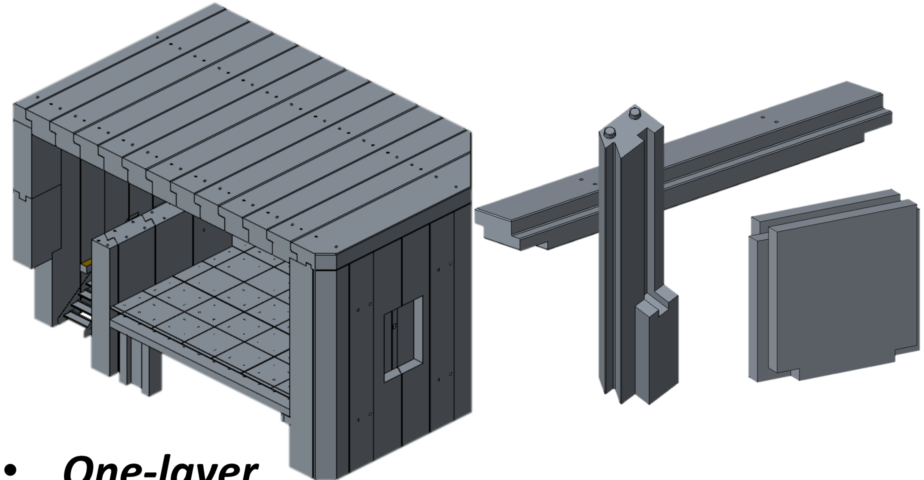
Conclusion of results for selected design

- Labyrinth efficient, sliding door can be replaced by steel door
- For H1 cases 60 cm concrete with B4C sufficient except for beam entrance that is covered by additional guide shielding
- Requested Gd target as H2 results in 18 µSv/h on roof and similar on door
- Steel door thickness should be between 25 and 50 mm, has to be optimized in further calculation

Courtesy: Szabina Török

NMX Cave Design Process

Versions: different layouts, various wall and slab versions were considered



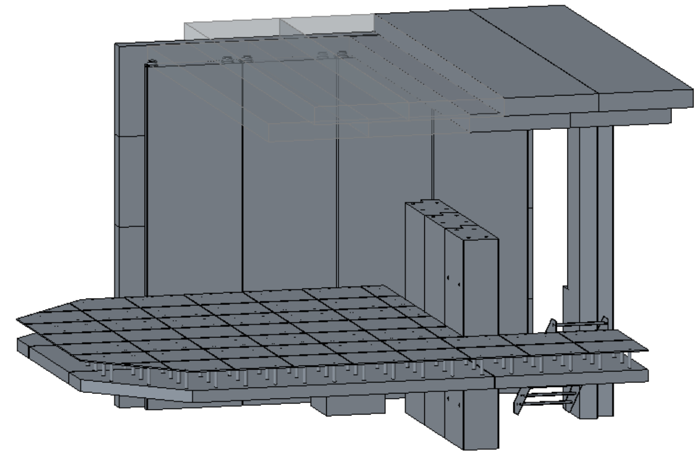
- ***One-layer***

Pros:

+ maximum number of standardized elements
+ minimum parts
+ robust design (also see in SKADI)
+ no need for extra connections between layers
→ easier assembly

Cons:

- Complex elements
- Difficult manufacturing



- ***Two-layer***

Pros:

+ ”simple shape” design
+ easy manufacturing
+ standardized elements
+ different activation in the layers

Cons:

–Connections needed between layers → complicated assembly

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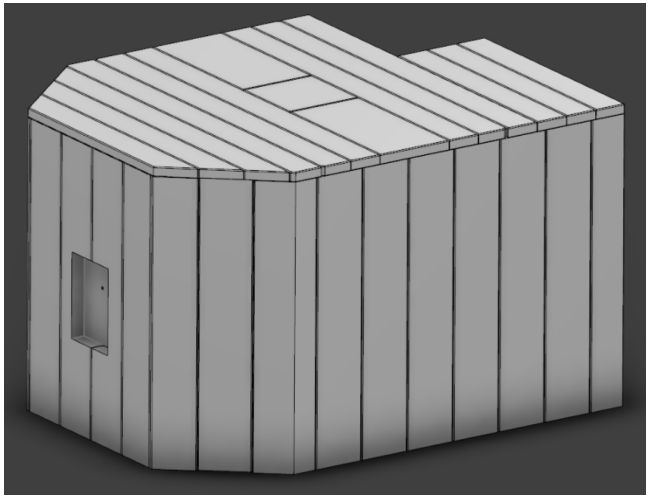
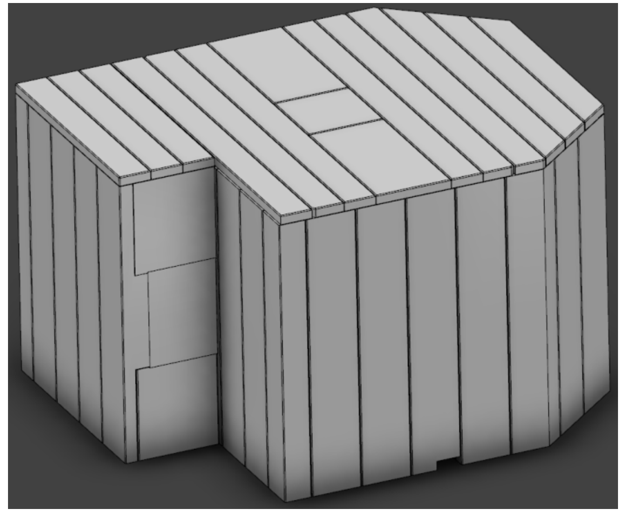
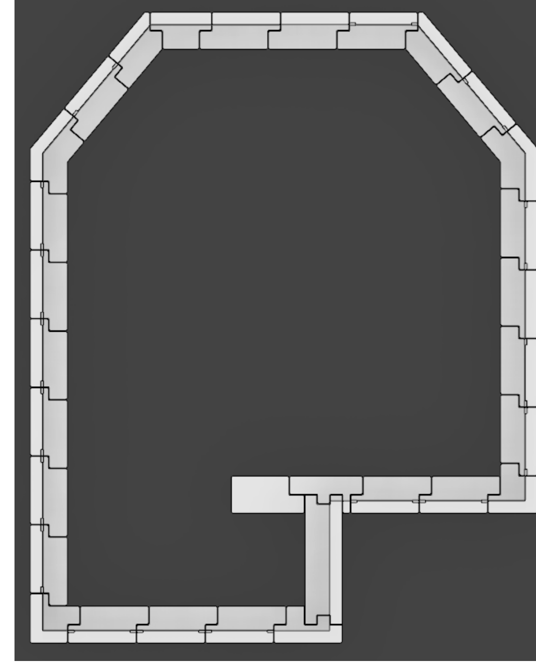
Courtesy: Szabina Török

NMX Cave Design Process

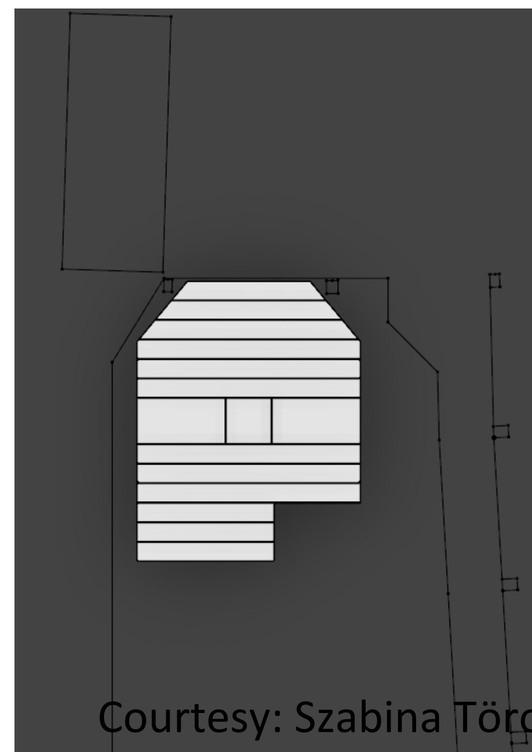
Final Version







- Maximized number of standardized wall and roof elements
- Optimal layout for reducing door thickness
- Key unit designed on roof
- Units can be assembled by the standard 10t crane



Courtesy: Szabina Török

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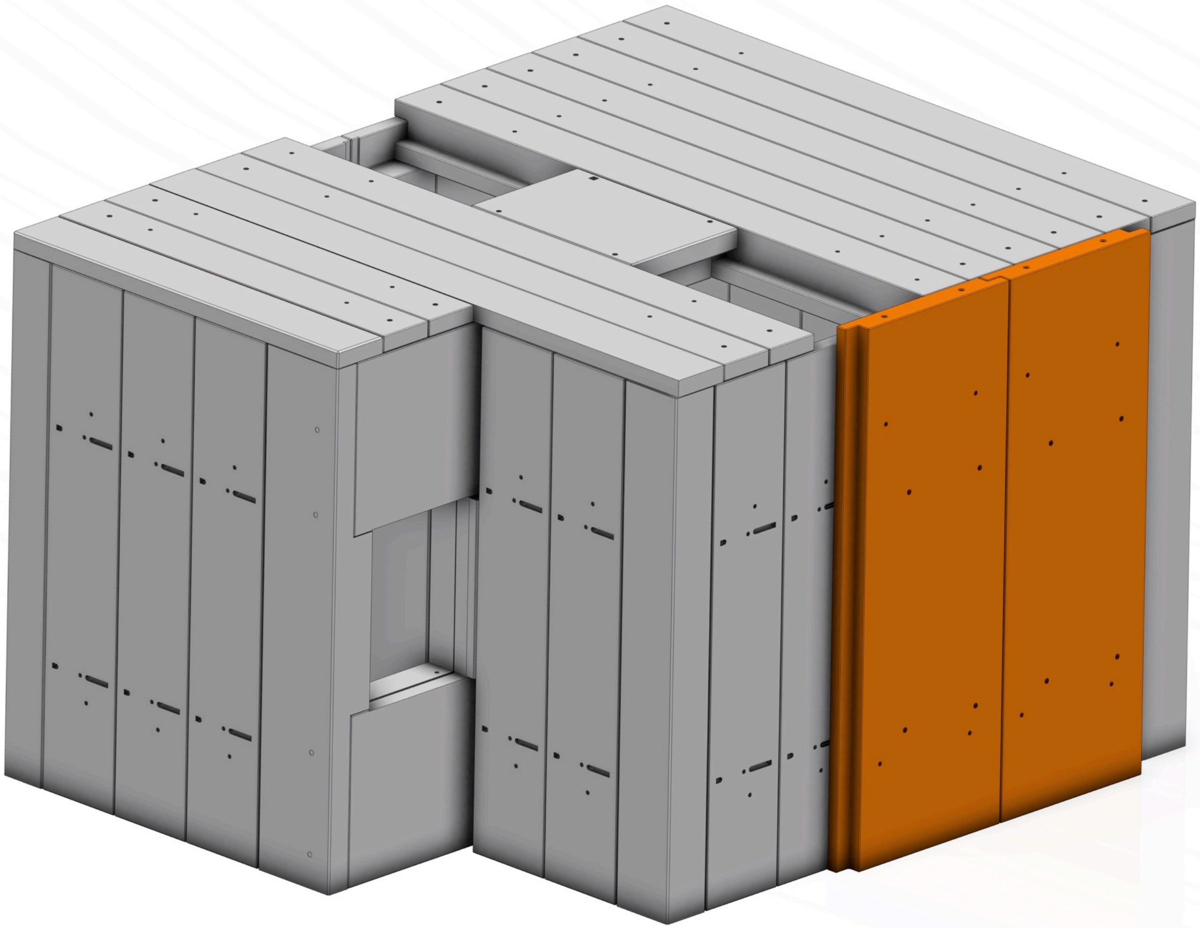
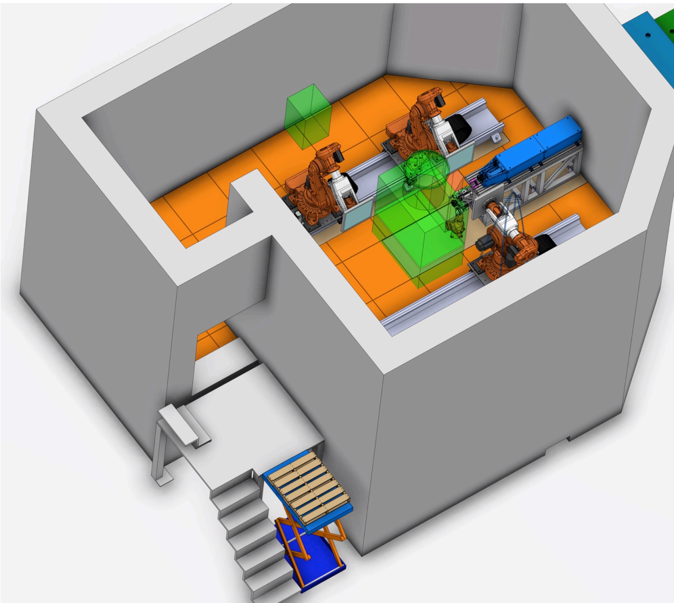
NMX Cave design process



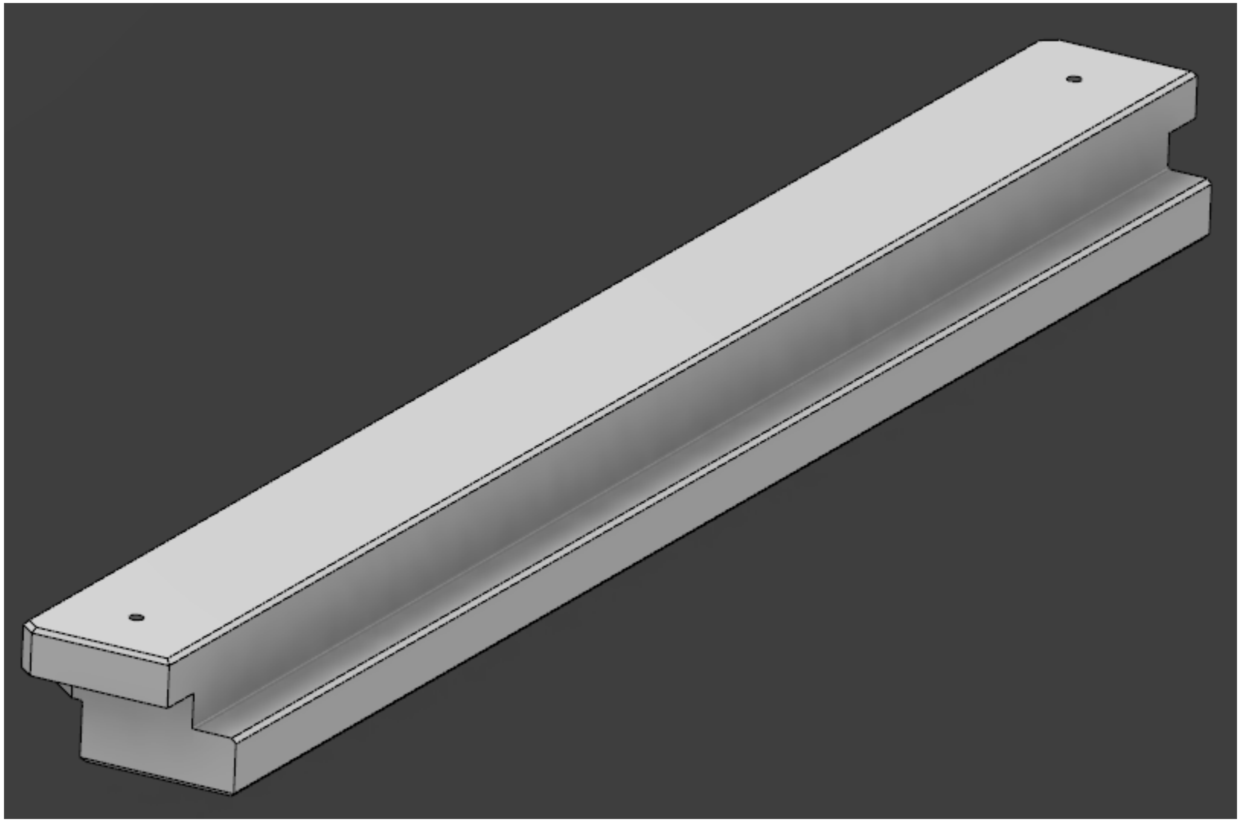
WORK IN PROGRESS!

Access to the cave is at inner floor level



Inner structural Layer
Outer layer only for shielding function

NMX Cave design process
Vertical and roof elements



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Courtesy: Szabina Török

NMX Cave design process
Connection of the vertical elements

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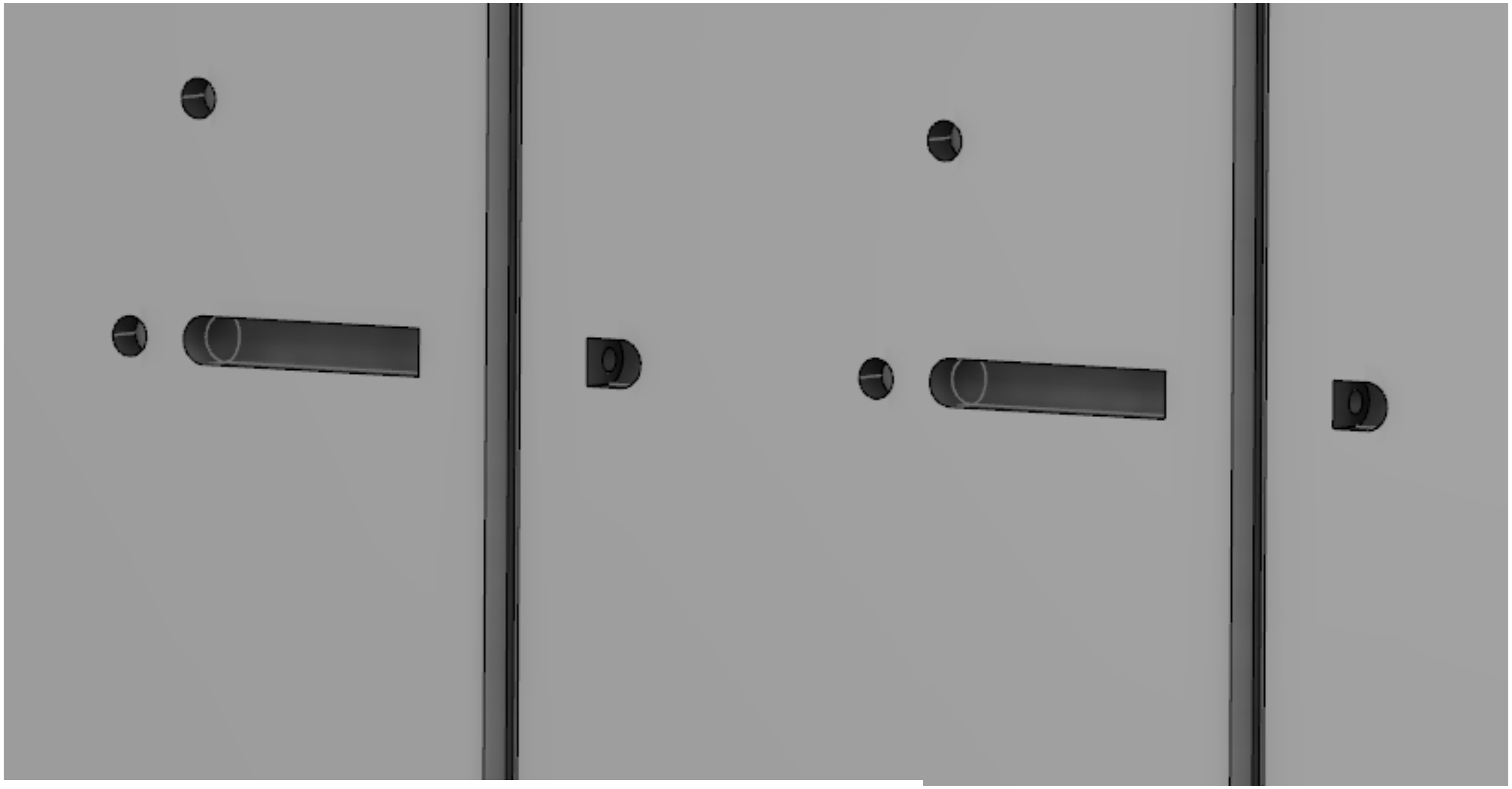

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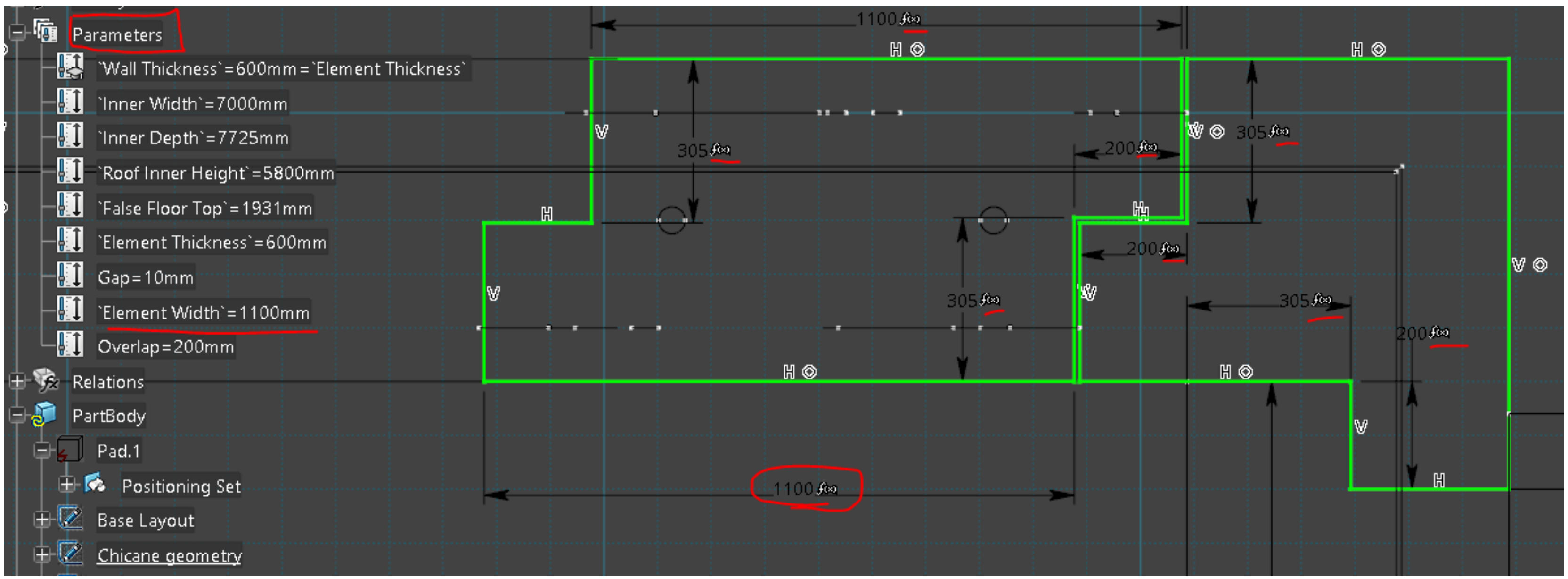
NMX Cave design process
Chicane parameters



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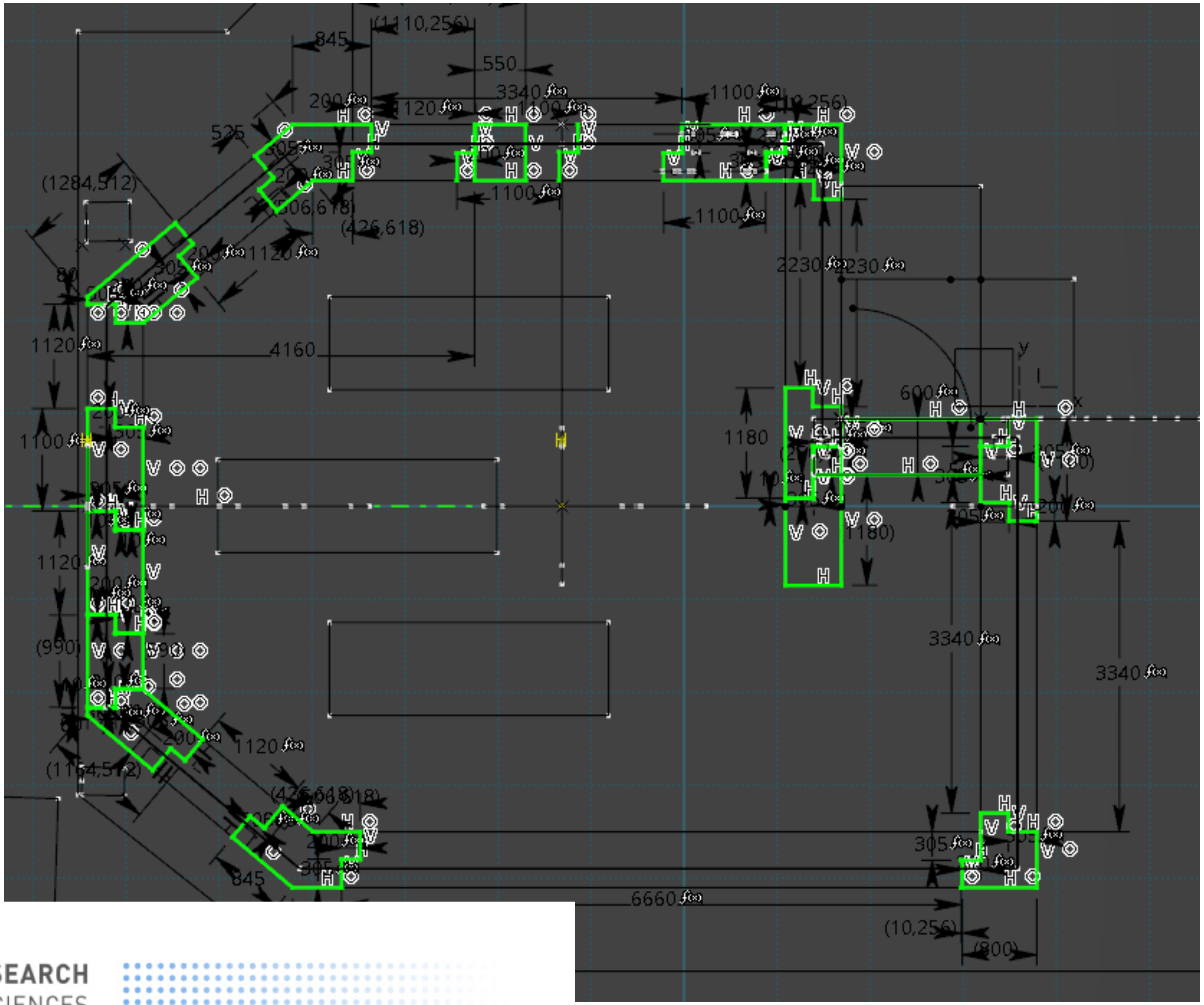
NMX Cave design process
Chicanes

EUROPEAN SPALLATION SOURCE



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Special Acknowledgement

Szabina Török, Péter Zagyvai, Viktoria Sugar,
Gábor Náfrádi, Peter Horvath,

ESS Neutron Optics and Shielding group
Valentina Santoro

Thanks

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