The NMX Experimental cave

Giuseppe Aprigliano
Instrument Project Engineer NMX

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Summary

NMX project structure

Requirements (General-radiological)

Cave Outline

Cave envelope and floor loading

Accessibility

Penetrations through the walls and roof

Infrastructure (internal crane and HVAC)

Construction technology

Effect of gaps

Conclusions and acknowledgement

Project structure

Instrument Project Leader: Esko Oksanen, ESS

Instrument Project Engineer: Giuseppe Aprigliano, ESS

Seconded Design Engineer: Endre Kósa, Wigner research Centre

Zoe Fisher	(ESS-SAD)
Dorothea Pfeiffer	(ESS- Detector group/CERN)
Valentina Santoro	(ESS-NOSG)
Damian Martin Rodriguez	(ESS-NOSG)
Markus Olsson	(ESS-NCG)
Erik Nilsson	(ESS-NCG)
Stuart Birch	(ESS-PSS)
Laurence Page	(ESS-Vacuum Group)
Paul Barron	(ESS-MCA)
Thomas Holm Rod	(ESS-DMSC)
Jonathan Taylor	(ESS-DMSC)
Jean-Luc Ferrer	(IBS – GSY Group, FR)
Márton Markó	(Wigner Research Centre, HU)
Petri Kursula	(University of Bergen, NO)

Shielding design is part of the Hungarian IK contribution to NMX

Szabina Török
Centre for Energy Research HU

General requirements

- Roof completely removable using overhead crane
- Roof section easily removable in correspondence of sample position (desired)
- Compatible with installation of 1.5t inner local crane on side walls
- Inner geometry requirements
- Outer geometry constraints
- Logistics requirements
- HVAC requirements
- Media/ electrical chicanes requirements
- ……
- Dismountable without dust contamination using 10t overhead crane
- Cost effectiveness

Radiological requirements

- Neutronic input $5x10^{10}$ n/s

- NMX Cave H1 and H2 Scenarios ESS – 0100307

  H1 limits 3uSv/h

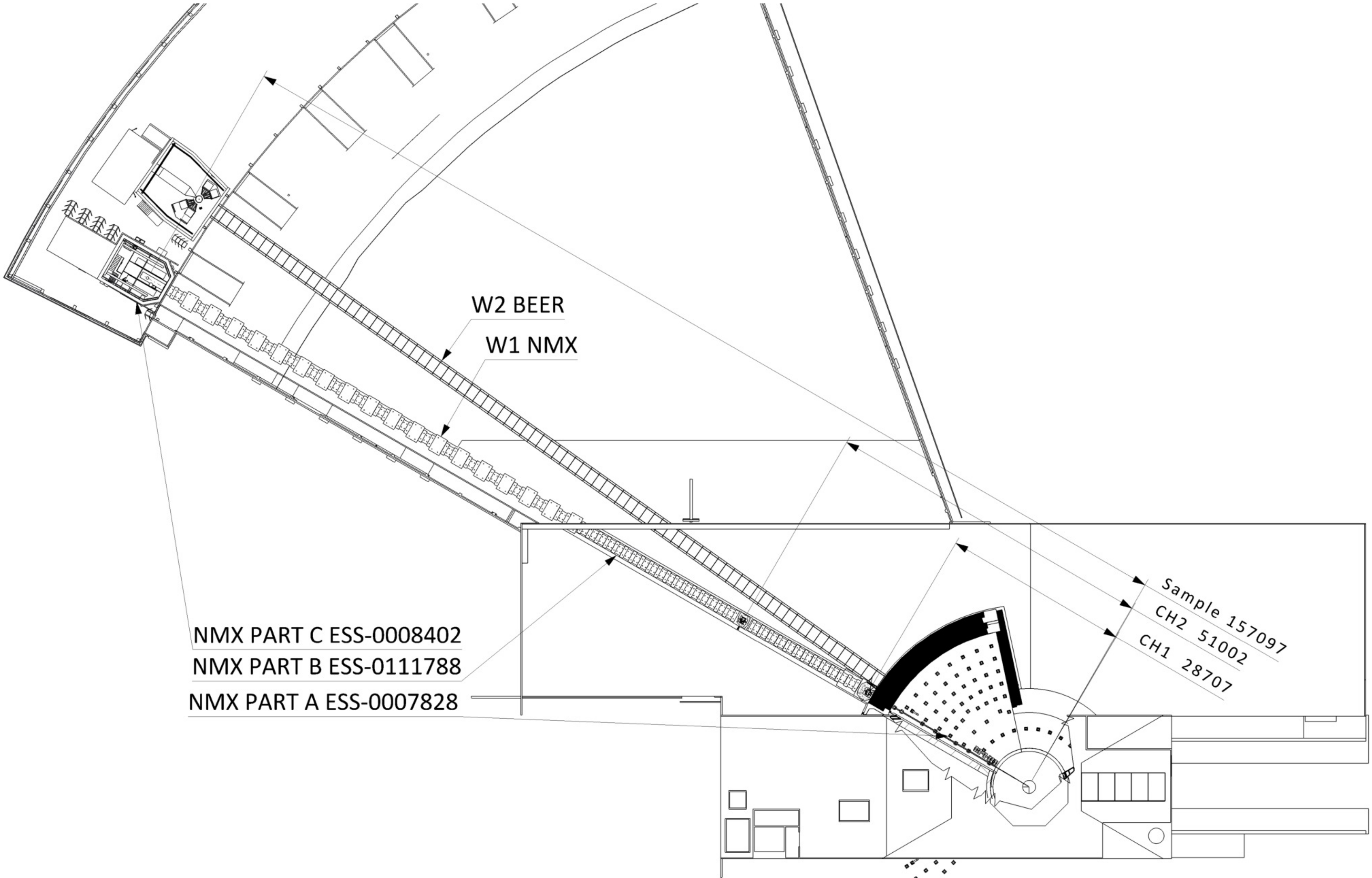
  H2 limit 2mSv /event

Identified worst scenario H1-13

  – 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.

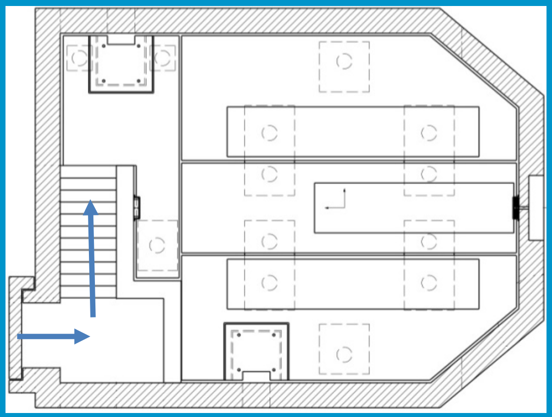
- Simulations result for H1-13: 90 cm of concrete 2.4 g/cm^3 (1,5 µSv/h)

NMX Outline

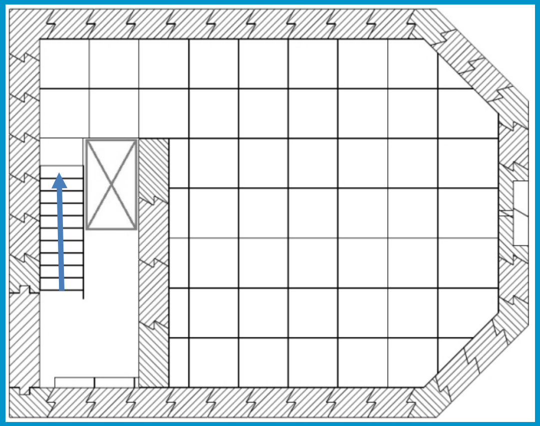

W2 BEER
W1 NMX
NMX PART C ESS-0008402
NMX PART B ESS-0111788
NMX PART A ESS-0007828
Sample 157097
CH2 51002
CH1 28707

NMX Outline

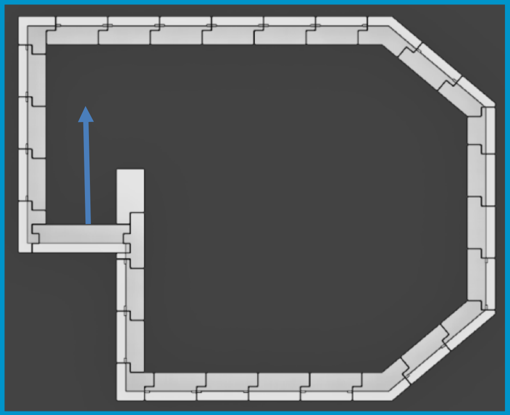
Versions: different layouts, various wall and slab versions were considered



- Stairs inside,
- Half-height labirinth wall

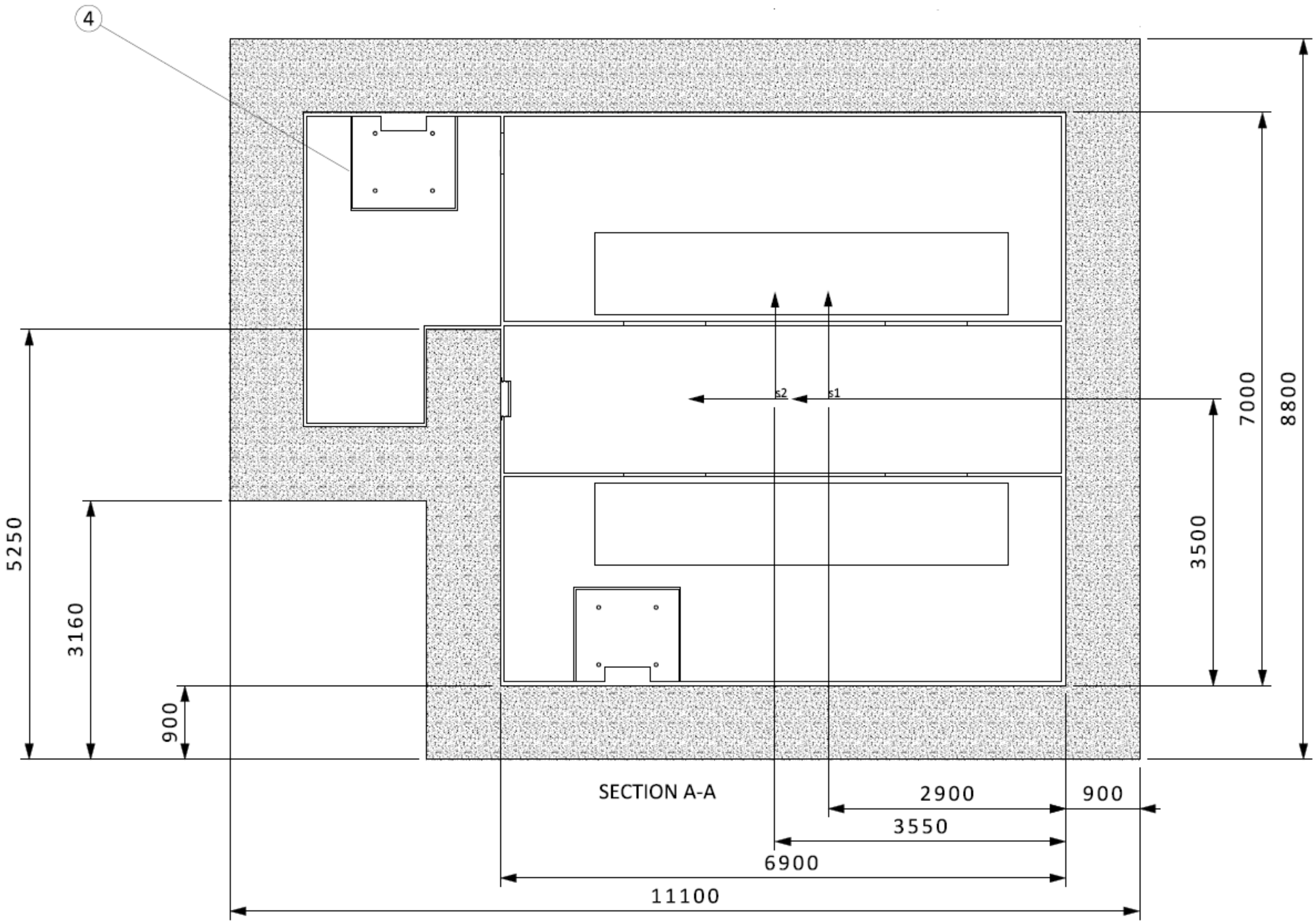


- Stairs inside,
- Full-height labirinth wall

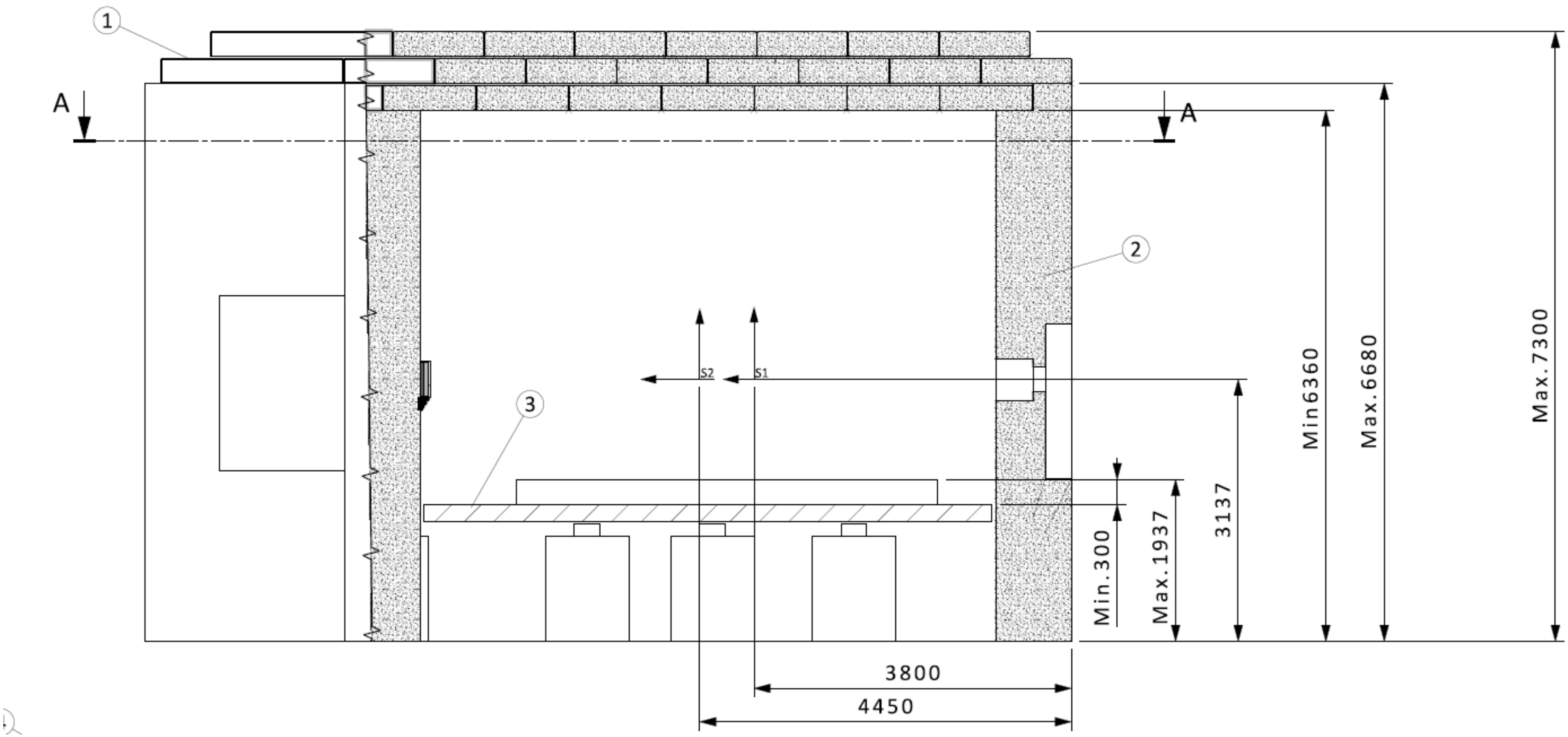


- Stairs outside,
- L shaped layout, wall pushed for better protection of the door

Cave outline



Cave outline



Cave outline

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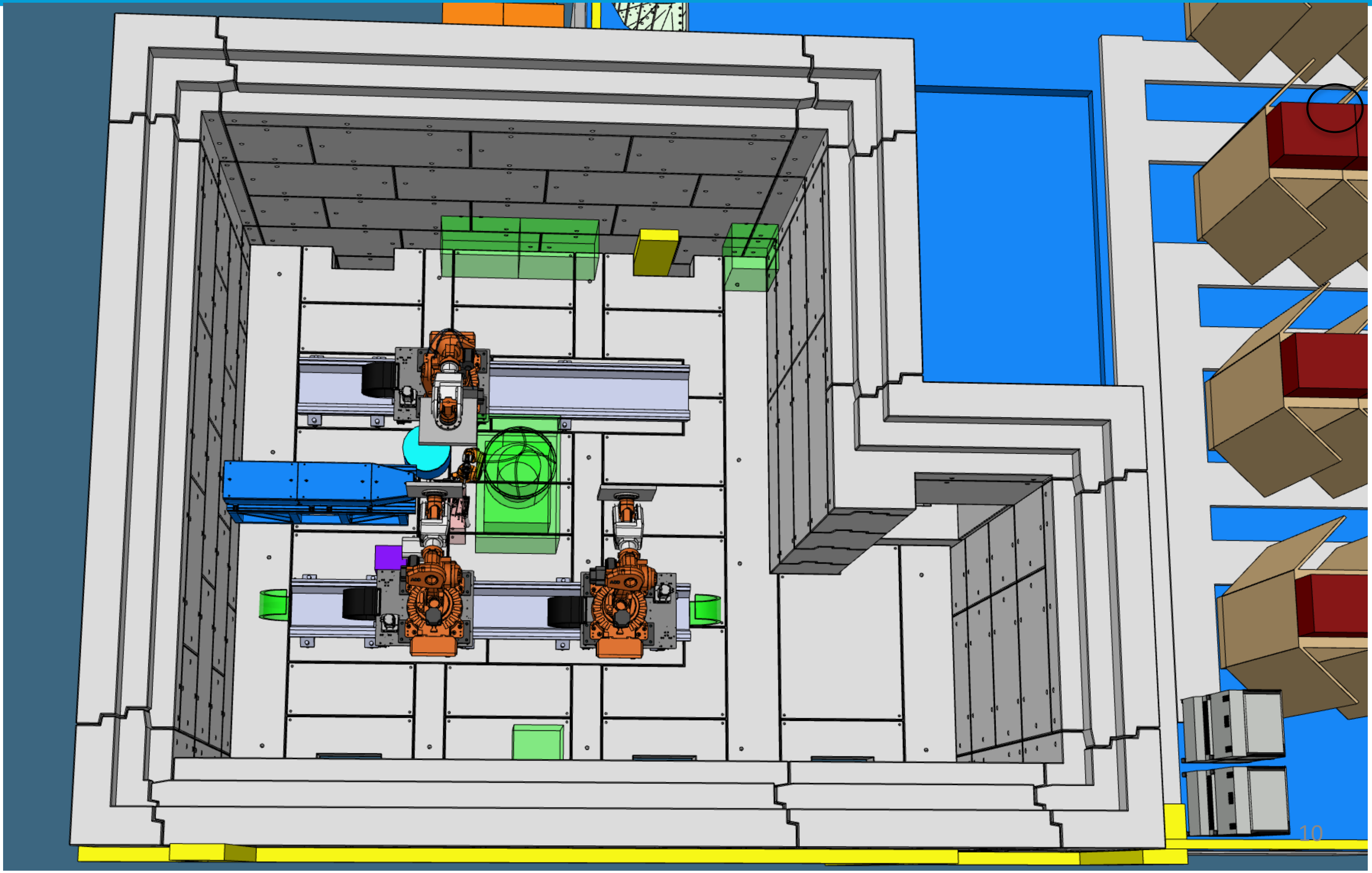


NMX Cave Envelope and floor loading

Changed the takeoff angle from moderator helped improve accessibility to E02

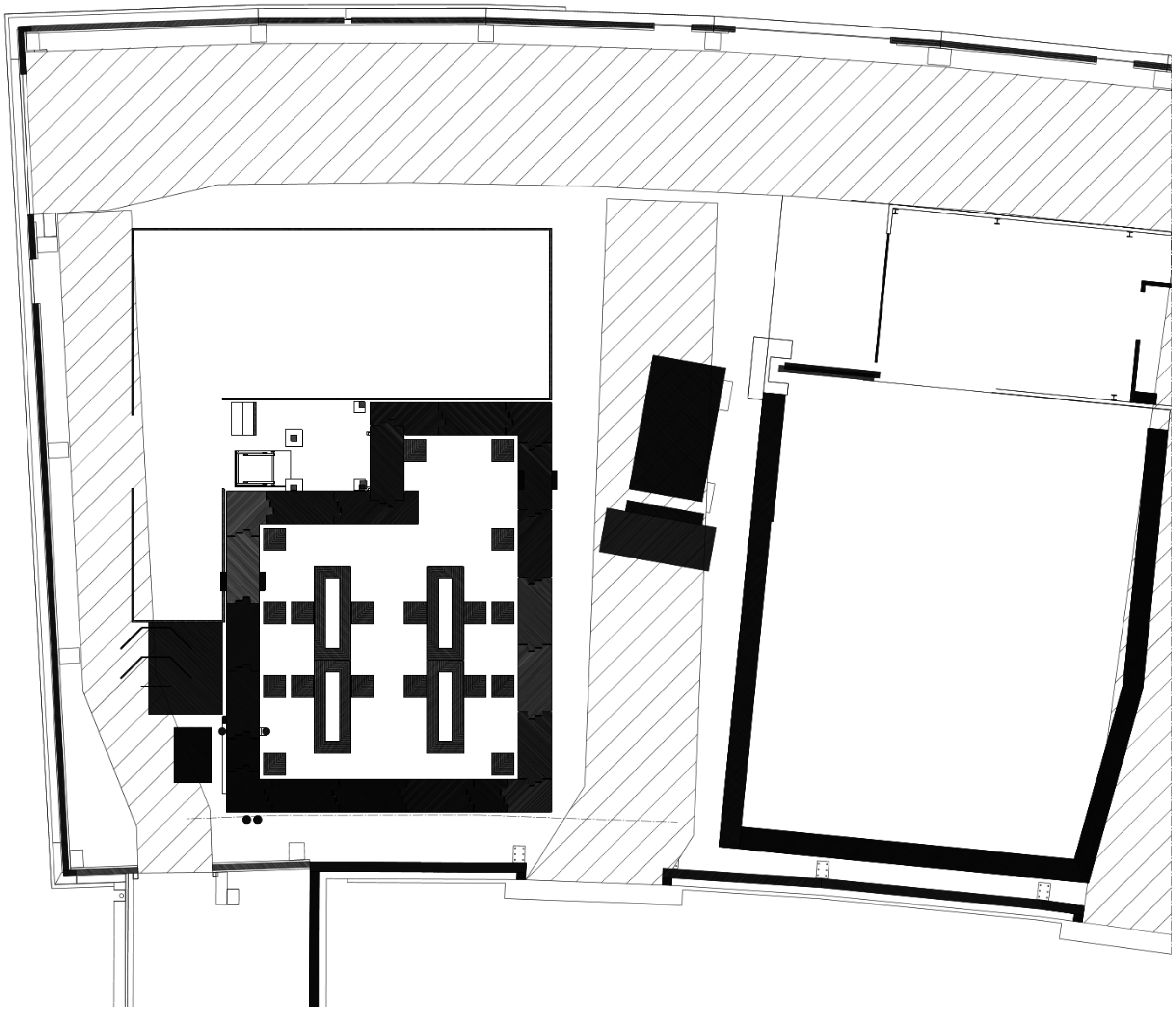
E02 access for forklift is guaranteed but at the limit of requirements

Floor loading:

$$r'_{car} := \frac{R_{l.car}}{h_w + 0.5 \cdot m}$$

$$r'_{car} = 187.4 \cdot \frac{kN}{m^2}$$

Less than 20t/m² at centre of slab.



NMX Cave Envelope and floor loading

EUROPEAN SPALLATION SOURCE

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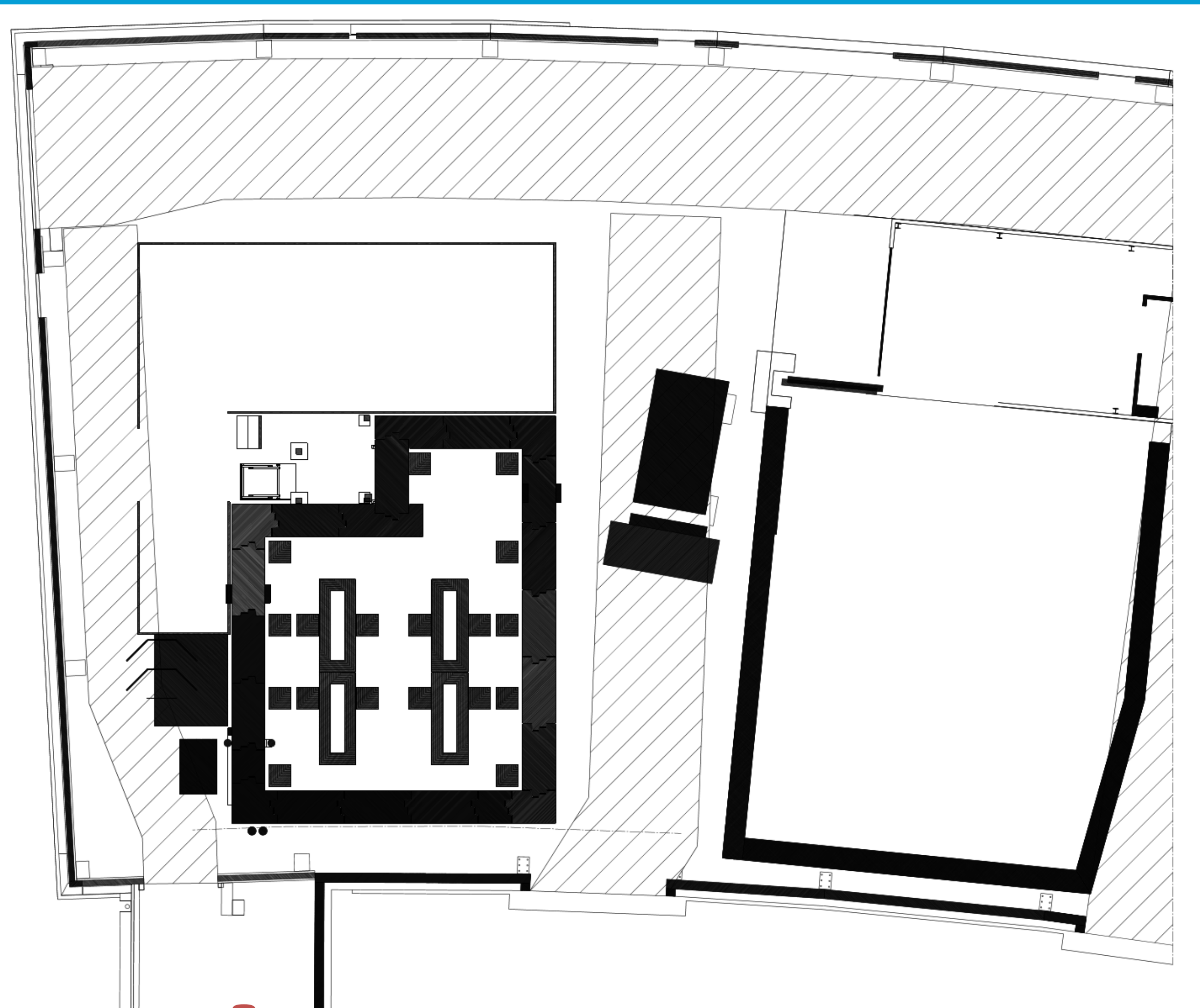
Floor loading:

$$r'_{car} := \frac{R_{l.car}}{h_w + 0.5\cdot m} \qquad r'_{car} = 187.4\cdot\frac{kN}{m^2}$$

Less than 20t/m^2 at centre of slab.

$$r_{car} := \frac{R_{l.car}}{h_w} = 291.5\cdot\frac{kN}{m^2} \qquad r_{car} = 291.5\cdot\frac{kN}{m^2}$$

More than 28t/m2 at slab surface (28t/m^2 80cm wall) !



Accessibility

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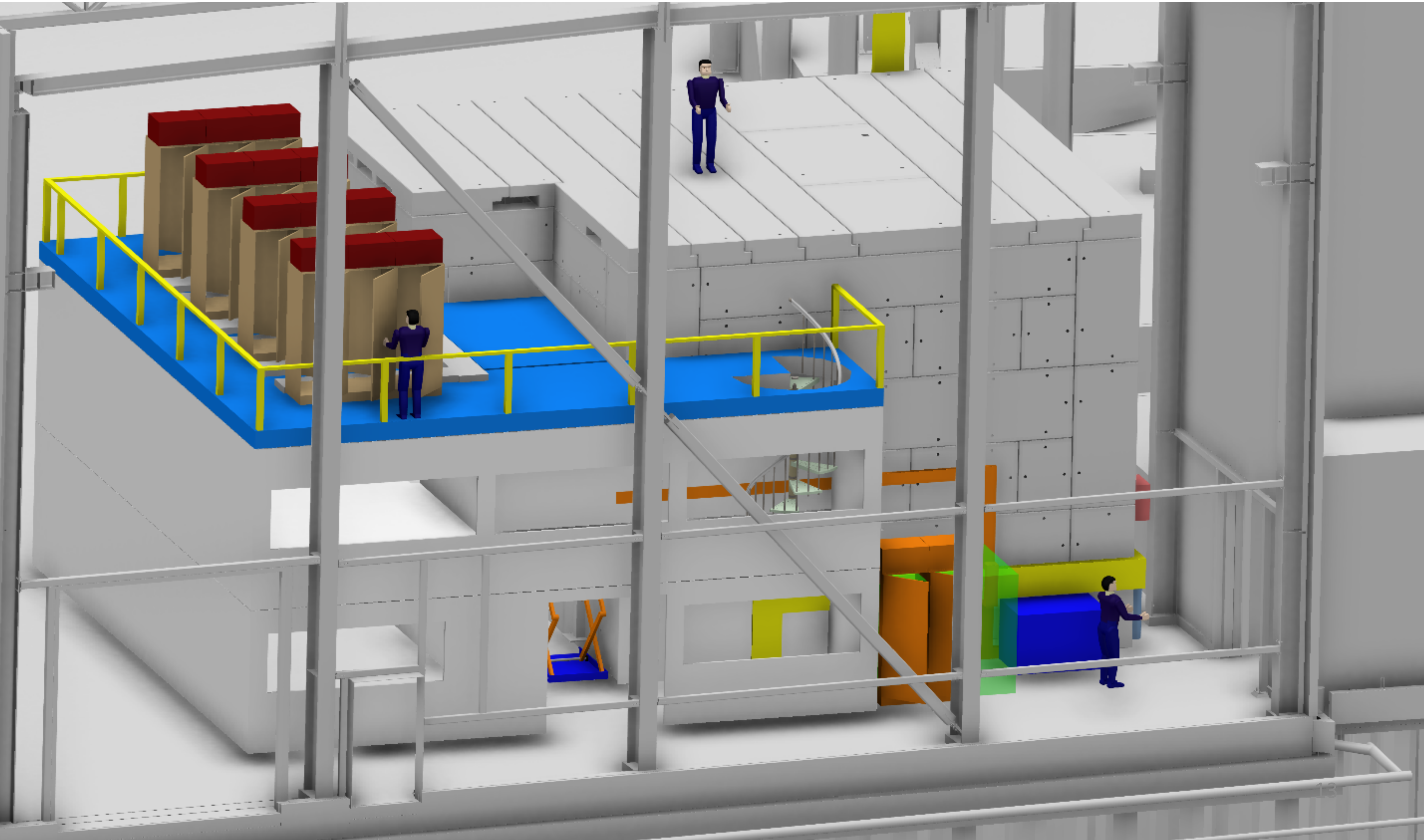
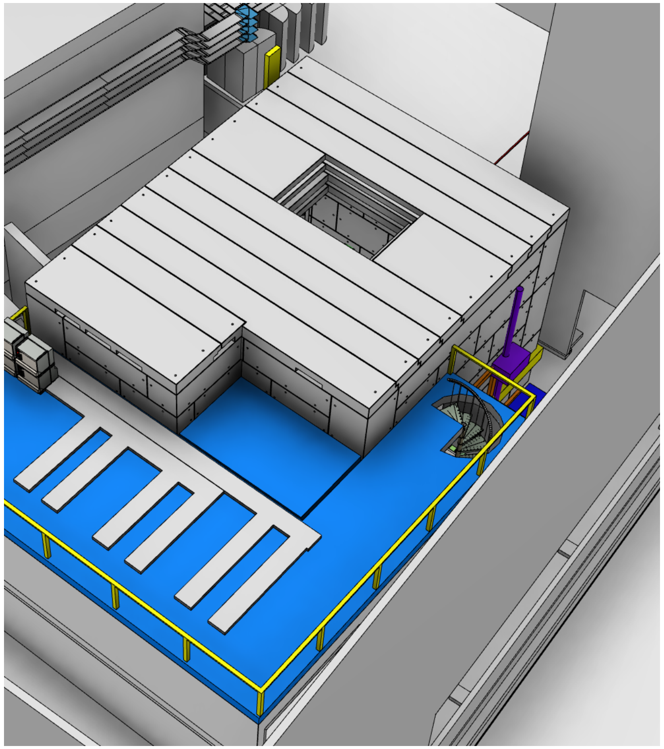


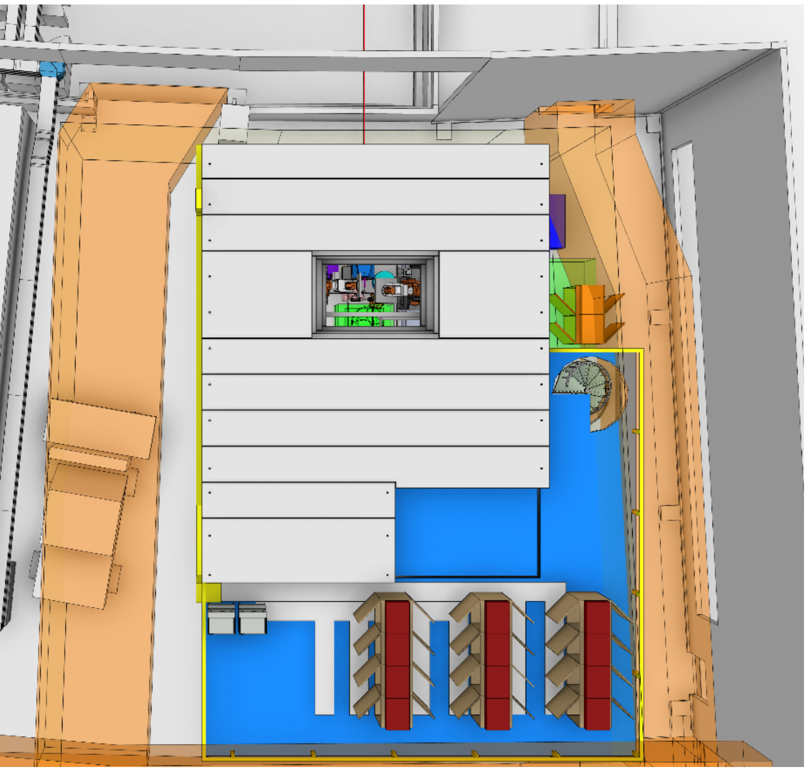
Accessibility

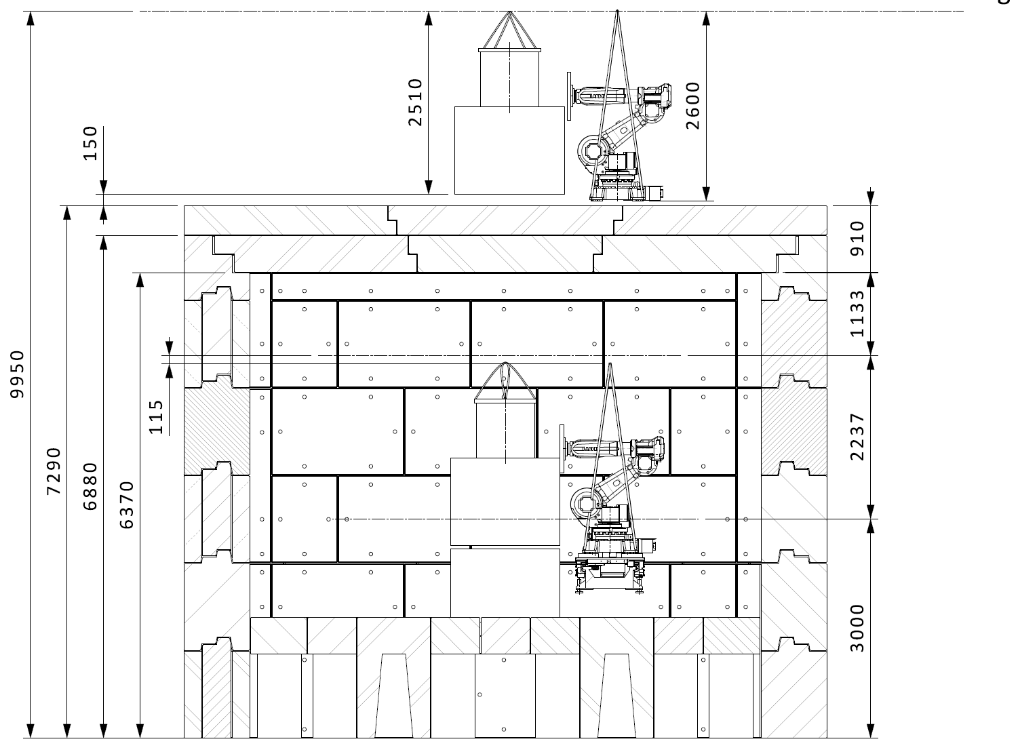
Personnel and goods
Access from control hutch.



Optional opening on the roof to easily access sample position.

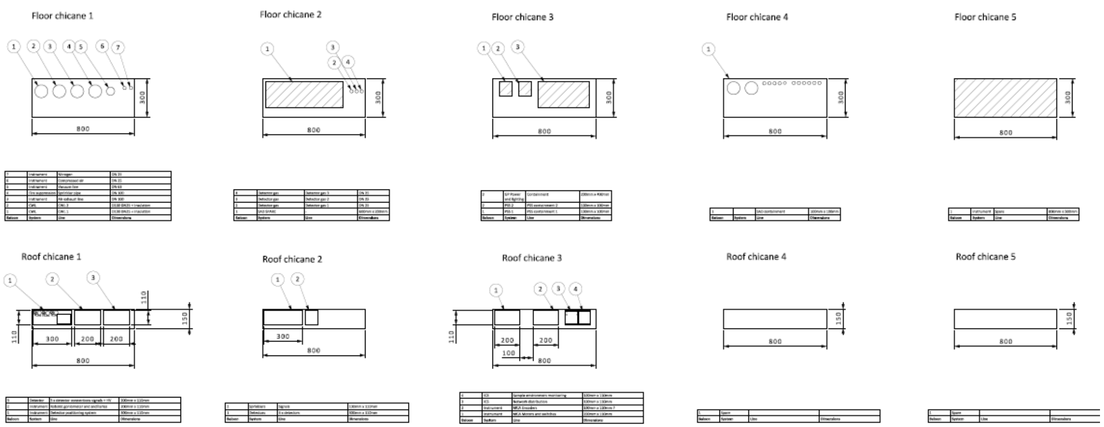
Accessibility

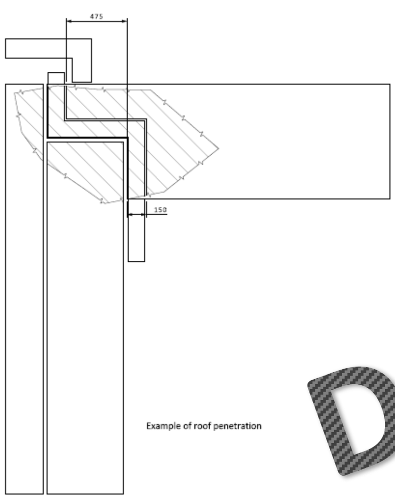




Roof in two layers to fulfill crane capacity limitation
Roof can be opened completely
Manhole is considered for accessing second sample position

Penetrations through the walls and roof



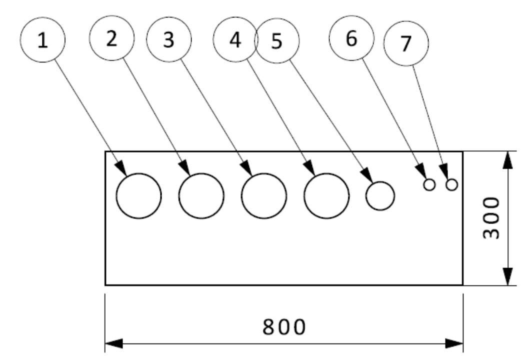


Example of roof penetration

Door chicane

The door chicane is located under or beside the access door, it shall allow temporary components (hooked to a supply line) to be installed in the cave without disconnecting the supply line.

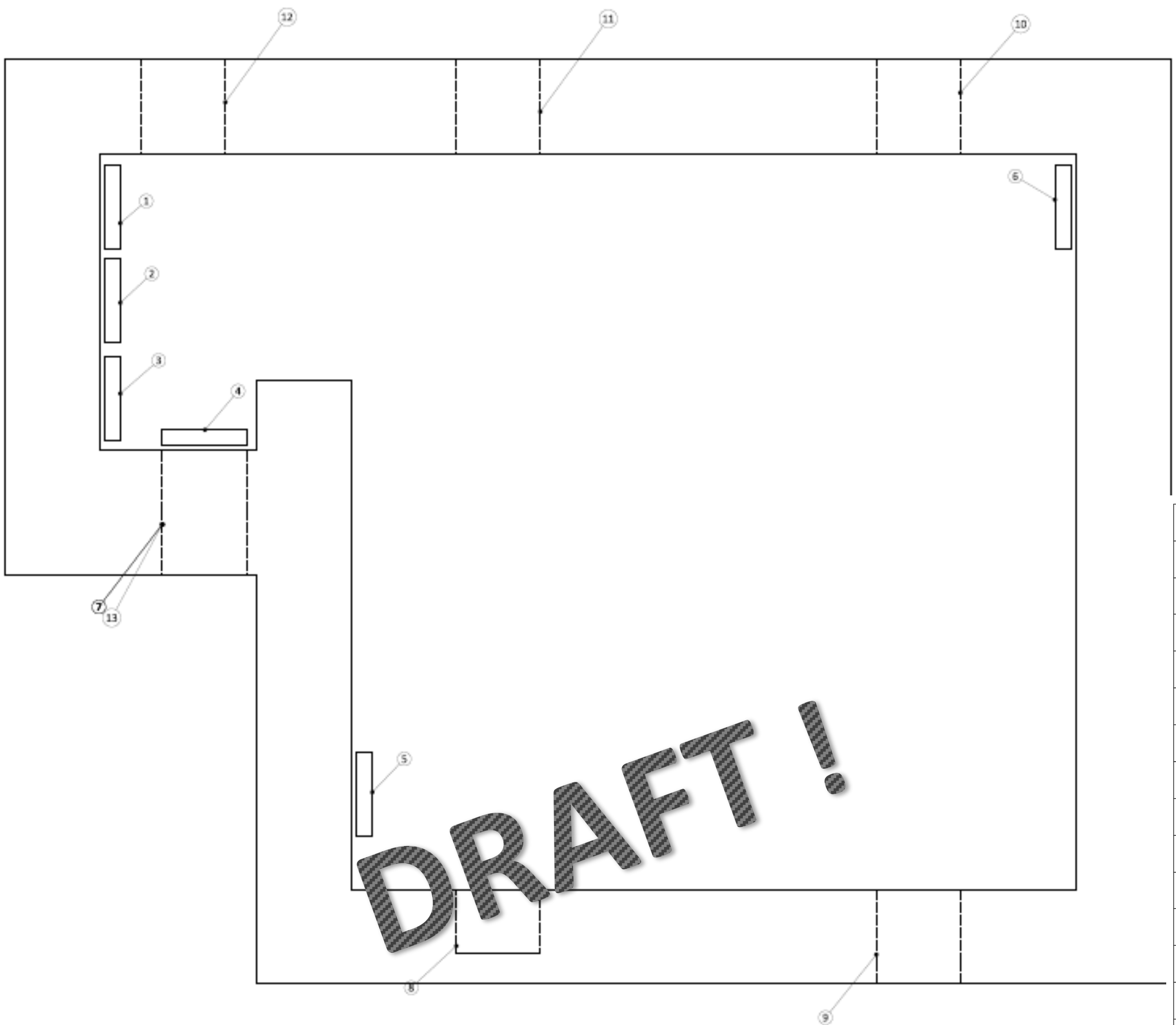
Floor chicane 1



Baloon	System	Line	Dimensions
7	Instrument	Nitrogen	DN 25
6	Instrument	Compressed air	DN 25
5	Instrument	Vacuum line	DN 63
4	Fire suppression	Sprinkler pipe	DN 100
3	Instrument	Air exhaust line	DN 100
2	CWL	CWL 2	D100 DN25 + Insulation
1	CWL	CWL 1	D100 DN25 + Insulation

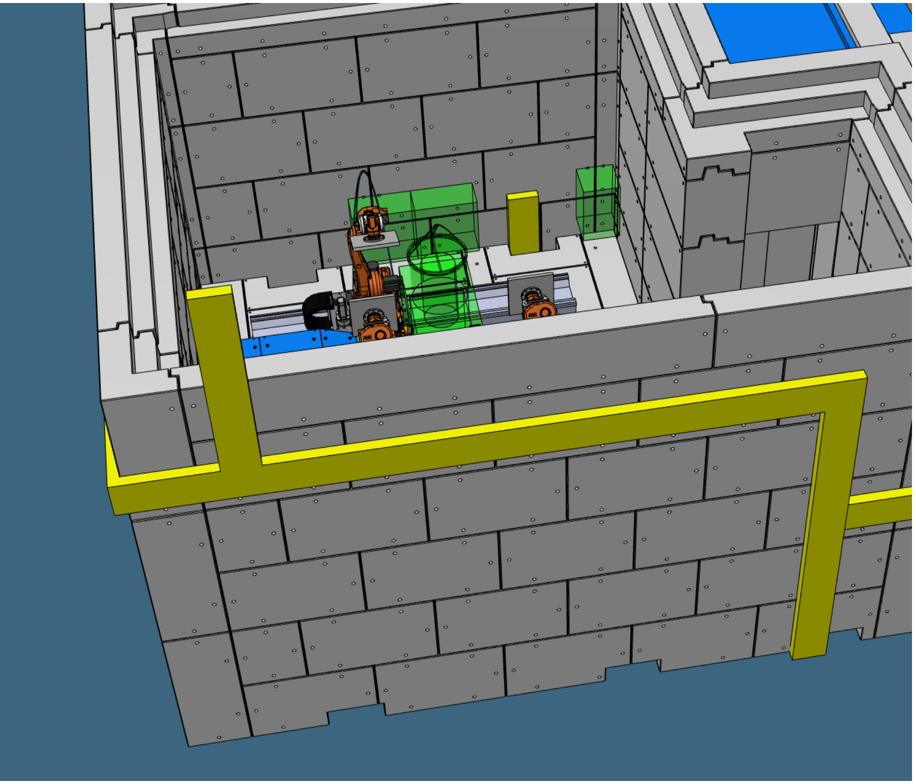
DRAFT !

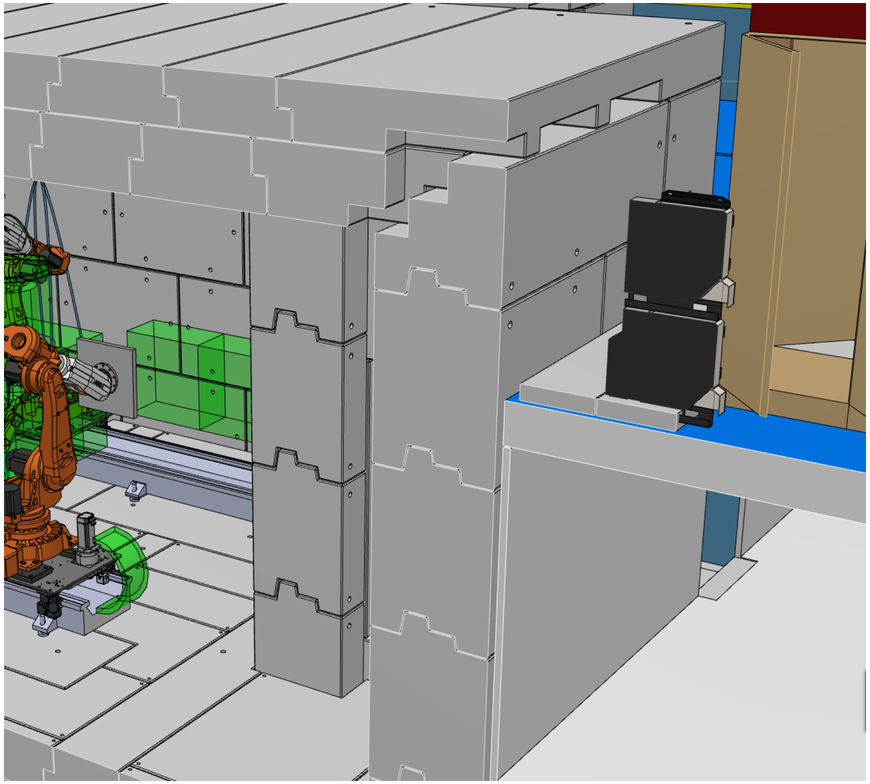
Penetrations through the walls and roof



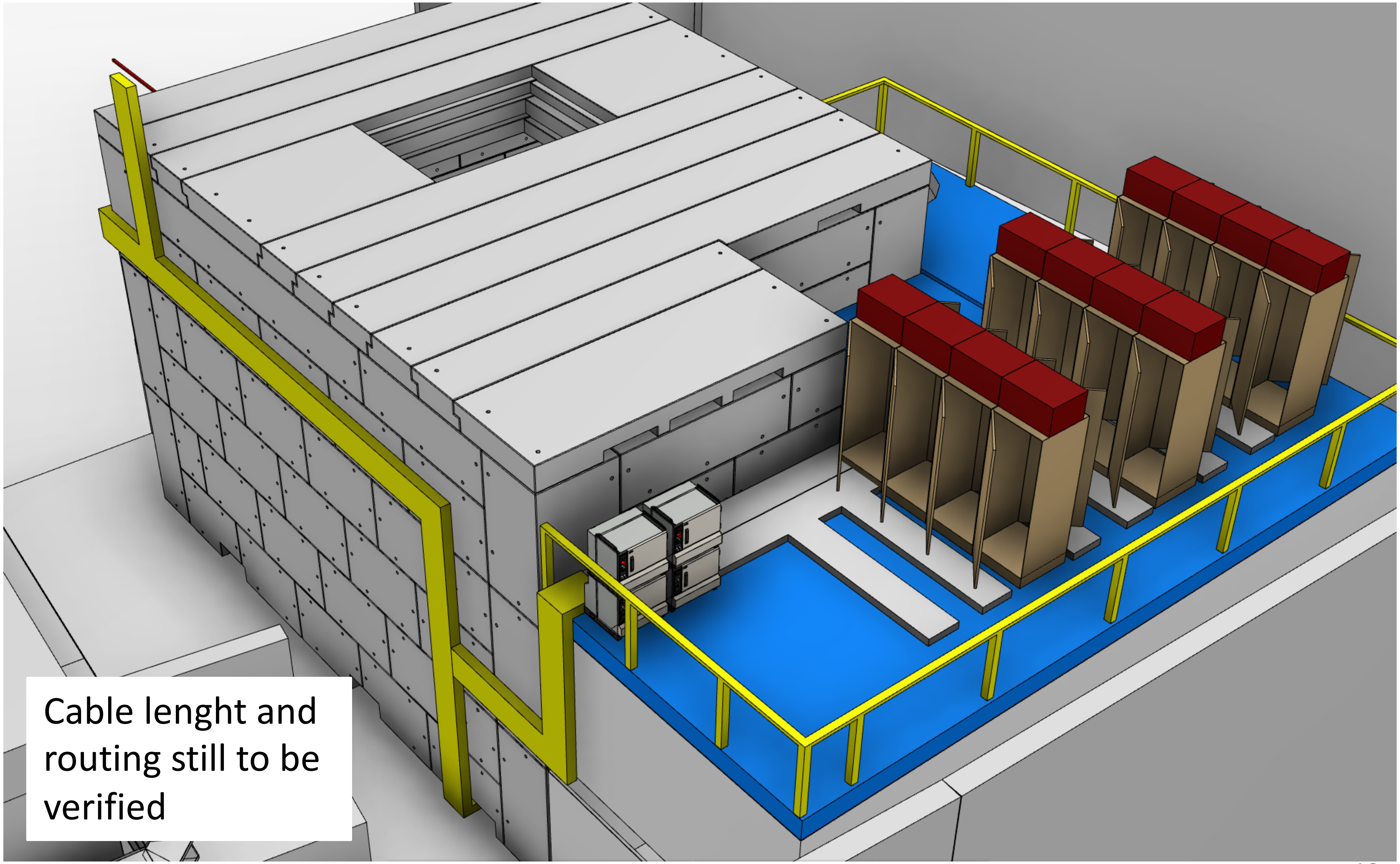
13	Floor chicane 800mm x 300mm
12	Floor chicane 800mm x 300mm
11	Floor chicane 800mm x 300mm
10	Floor chicane 800mm x 300mm
9	Floor chicane 800mm x 300mm
8	Floor chicane 800mm x 300mm
7	Door chicane 800mm x 100mm
6	Roof chicane 800mm x 150mm
5	Roof chicane 800mm x 150mm
4	Roof chicane 800mm x 150mm
3	Roof chicane 800mm x 150mm
2	Roof chicane 800mm x 150mm
1	Roof chicane 800mm x 150mm
Position	**Description**

Penetrations through the walls and roof

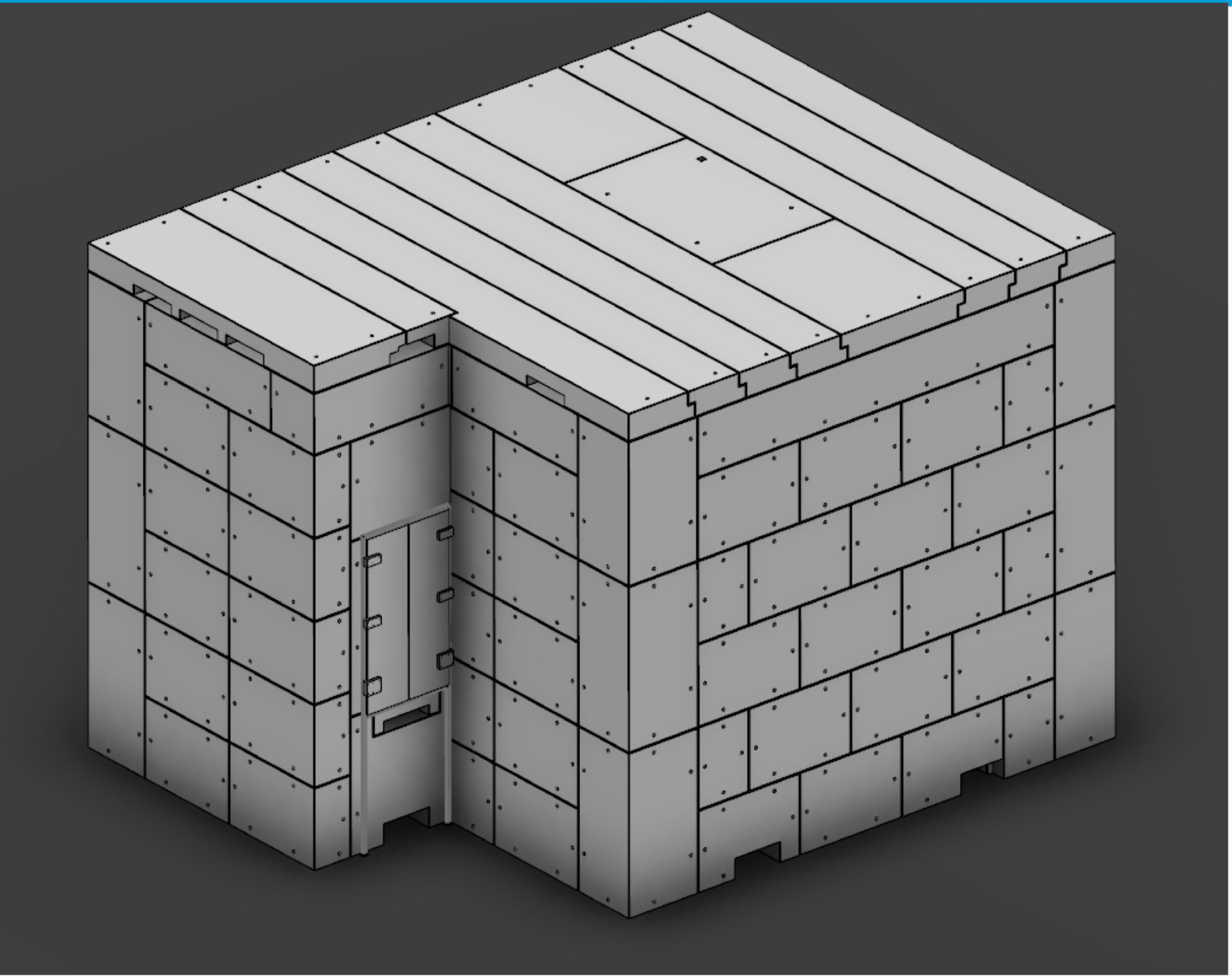




Penetrations through the walls and roof



Door



Double door to reduce weight

Height as requested from SE

50mm steel with borated inner layer

Internal crane and HVAC under development

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Scenario	Persons in the cave	Duration	Classification ESS-0058709	Airflow ESS-0058709	Max Noise ESS-0058709
a)Experiment	0	>1 Day	No occupancy	0.35 l/s*m^2	-
b)Setup	2	<2 Hours	Mechanical Lab	0.35 l/s*m^{2+} 10.45l/s*person	LpA 35dB(A) LpC 55dB(C)
c)Maintenance	3	>1 Day	Mechanical Lab	0.35 l/s*m^2 + 10.45l/s*person	LpA 35dB(A) LpC 55dB(C)

Parameter	Value	Note
Thermal stability aim stability after 2 hours should ideally be better than	+/- 0.1K	To be achieved with cave door closed.
Thermal stability aim stability after 2 hours shall be better than	+/- 0.5K	To be achieved with cave door closed.
Temperature range in the cave	20°C – 24°C	It shall be possible to set the temperature in the cave independently from the outer environment temperature.

Conceptual solution:

-Closed circuit temperature control system in the cave in the cave,

-Separate ventilation system with possibility of containing airflow.

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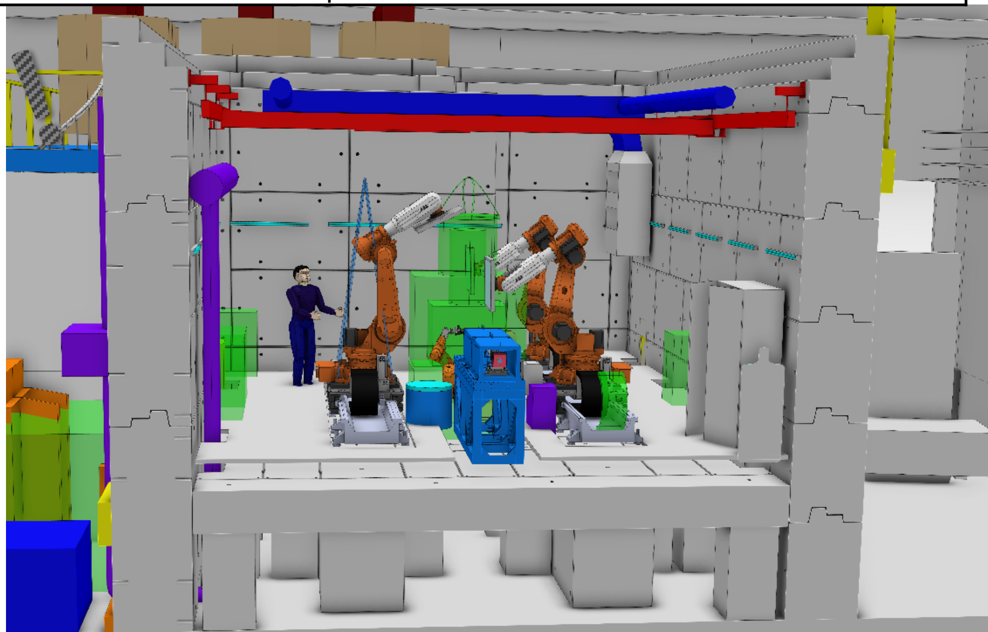
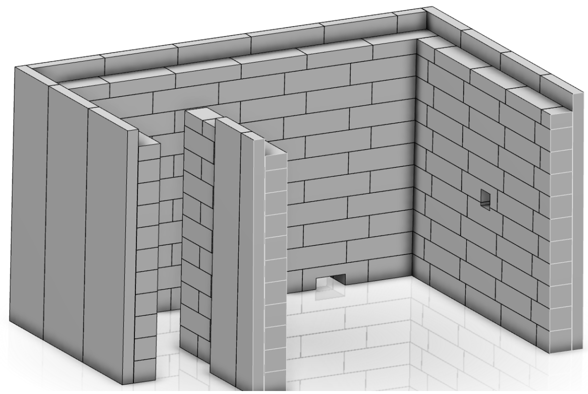
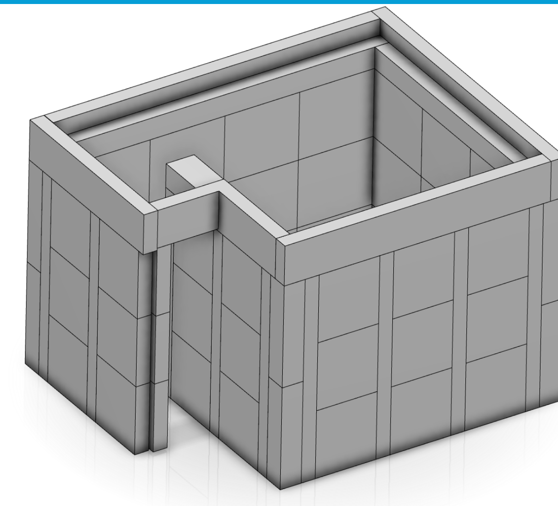
Work is ongoing to define HVAC requirements

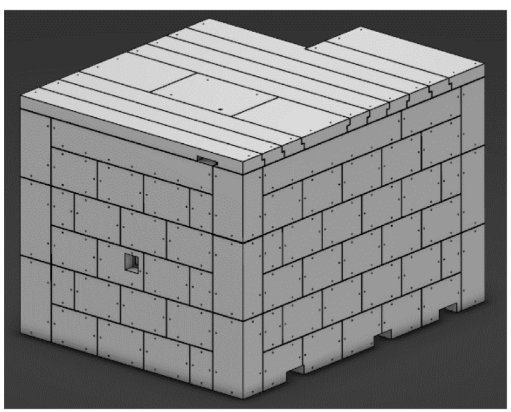


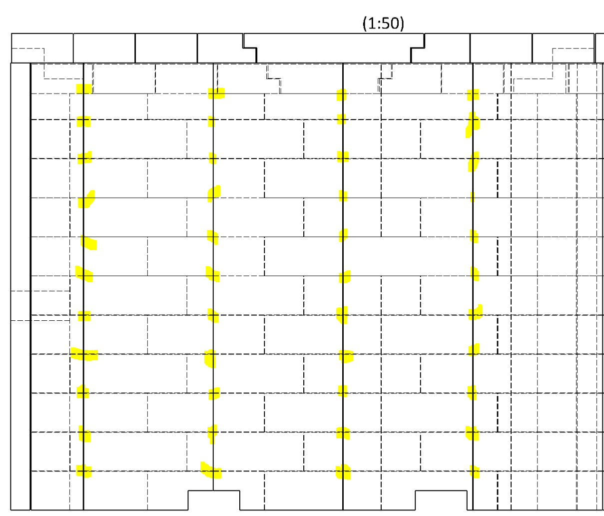
Construction technology

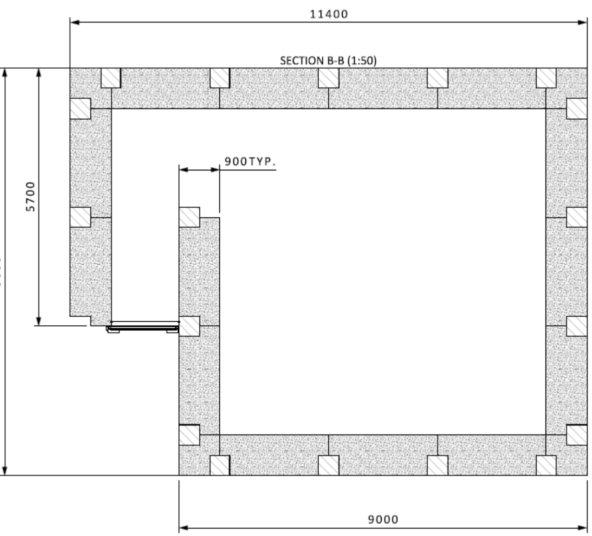
Cast in place considered
dry assembly is preferred











Effect of gaps in the shielding efficiency

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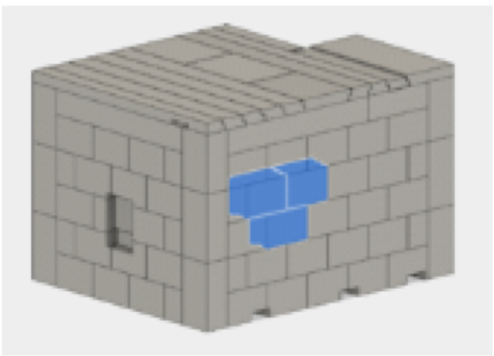
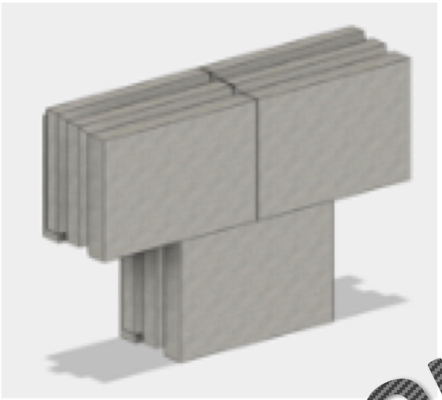
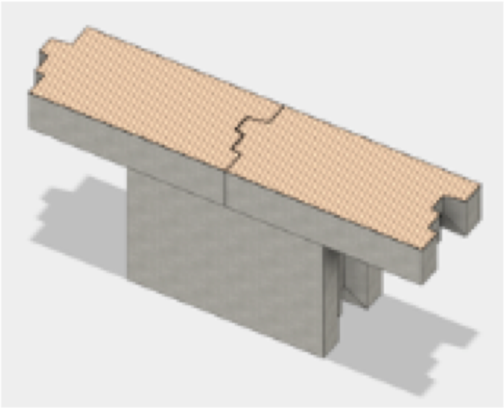
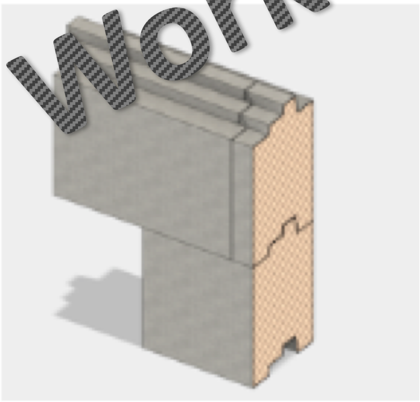








Work ongoing

Two separate models were built for the calculations:

1. model with 3 separate concrete blocks with the gaps, chicane between them
2. model with one solid concrete block

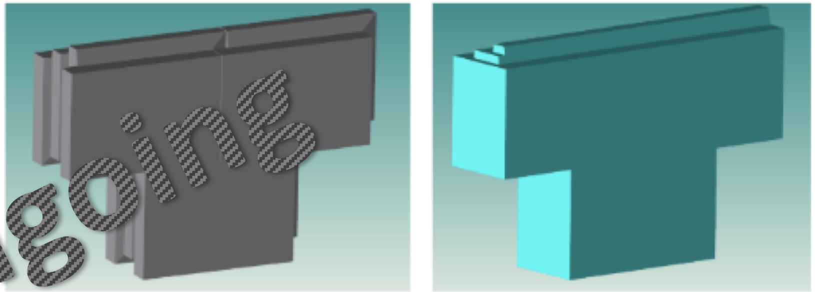


Figure 27: The two separate models built for simulation

A 100 cm x 100 cm surface source was created parallel to the concrete blocks wall in order to investigate the effect of the chicanes. This source emitted photons with 8 MeV energy.

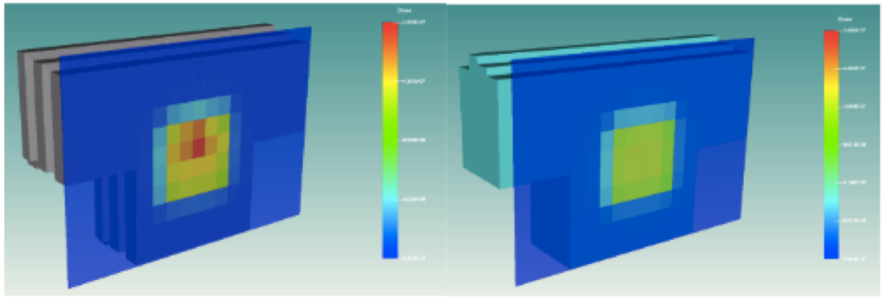


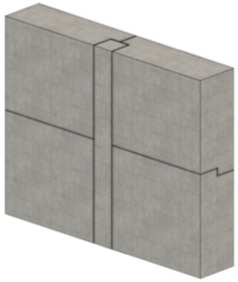
Figure 28: The two separate models built for simulation and the simulation results (with chicane on left, without chicane on right)

Result for the 20cm x 20cm resolution flux tally:

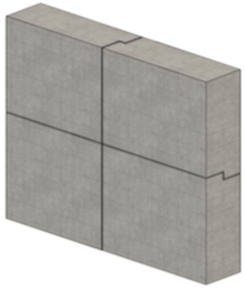
Maximum dose rate with chicane:	1.6016E-07 µSv/h/particle
Maximum dose rate without chicane:	1.2208E-07 µSv/h/particle

RESULT: Dose increases from chicane less model by 31 %

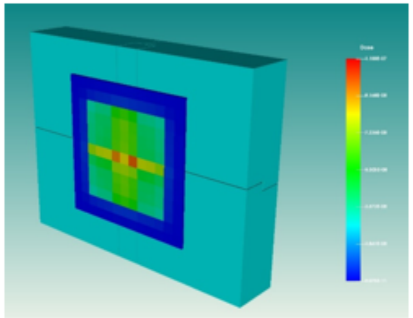
Courtesy Szabina Torok
Centre for energy research EK



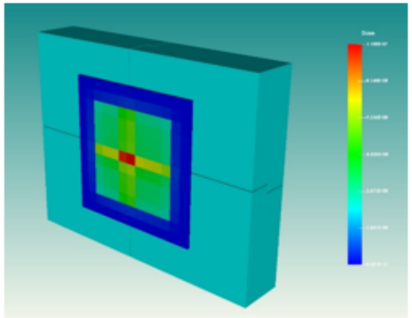
1. Figure: Cave wall model using the latest cave concept



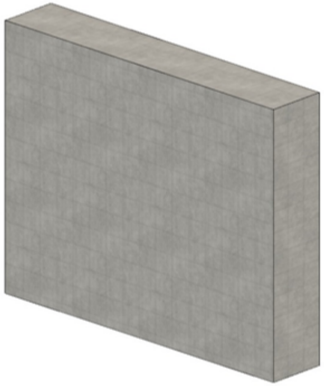
2. Figure: Cave wall model with single step chicane



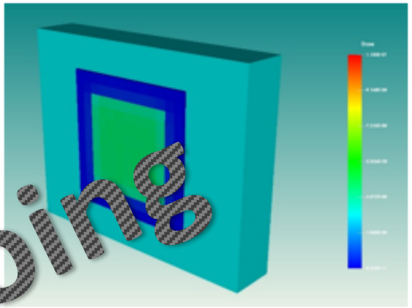
6. Figure: Dose rate result for the cave concept model. [Unit: uSv/h/photon]



7. Figure: Dose rate result for the single step model. [Unit:uSv/h/photon]



3. Figure: Solid cave wall model



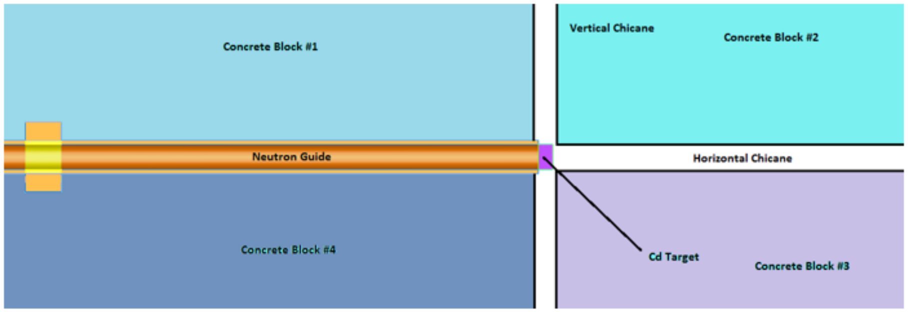
ure: Dose rate result for the solid cave model. [Unit: uSv/h/photon]

Work ongoing

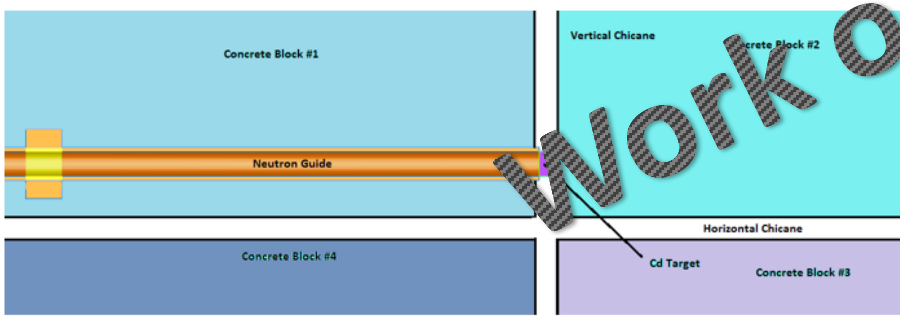
8.995 MeV	GAP [mm]	MAX DOSE [µSv/h/photon]	ERROR [-]	DELTA [%]
Solid model	0	4.27E-08	0.0090	-
Cave Concept	2	4.83E-08	0.0086	13%
Cave Concept	5	5.92E-08	0.0079	39%
Cave Concept	7	6.62E-08	0.0075	55%
Cave Concept	10	7.90E-08	0.0069	85%
Cave Concept	15	9.84E-08	0.0063	130%
Simple Chicane	2	5.16E-08	0.0083	21%
Simple Chicane	5	7.05E-08	0.0073	65%
Simple Chicane	7	8.15E-08	0.0068	91%
Simple Chicane	10	1.01E-07	0.0062	137%
Simple Chicane	15	1.12E-07	0.0059	162%

Courtesy Szabina Torok
Centre for Energy Research EK

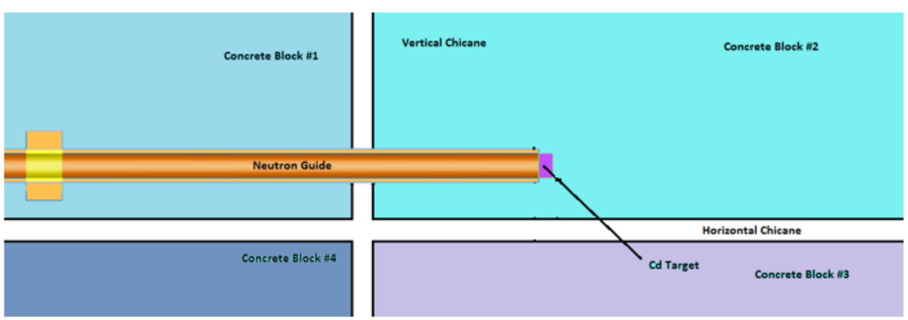
Effect of gaps in the shielding efficiency

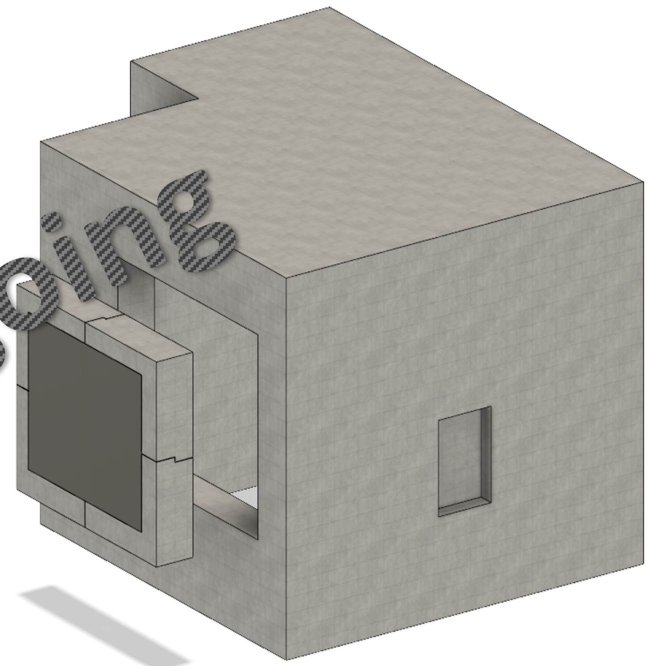


12. Figure: Source in line with both chicanes ***SETUP A***



13. Figure: Source in line with vertical chicane ***SETUP B***

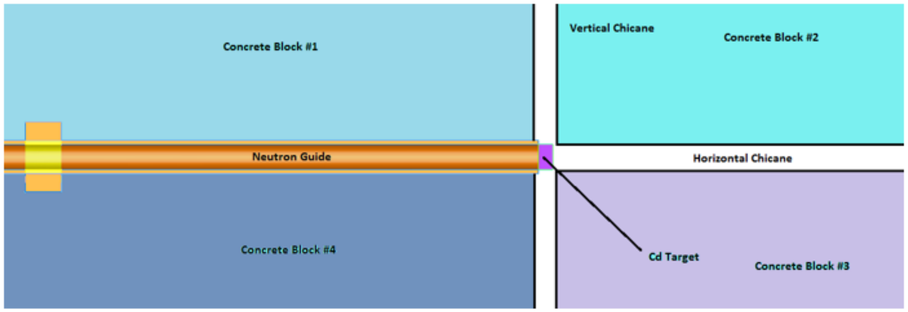




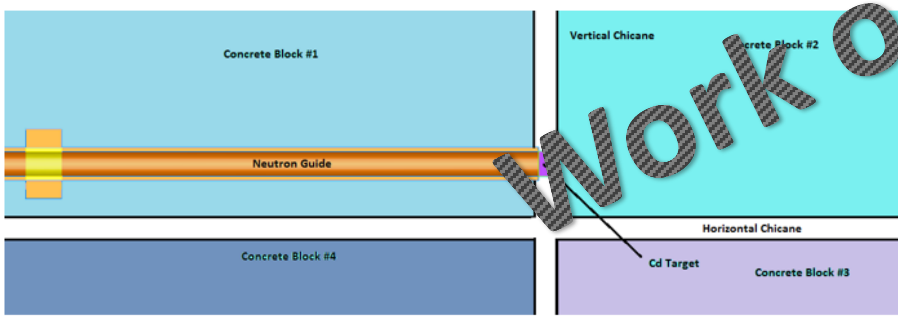
Work ongoing

Courtesy Szabina Török
Centre for energy research EK

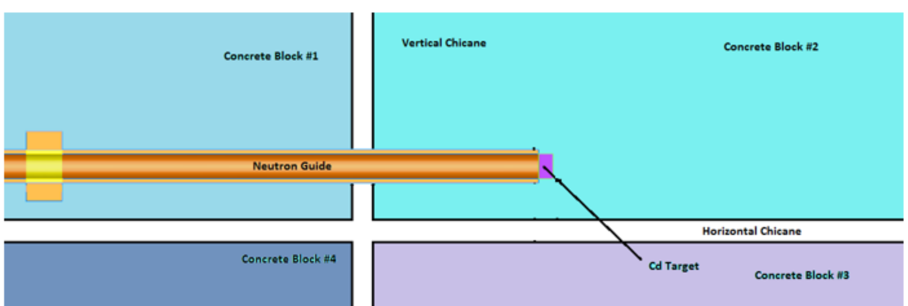
Effect of gaps in the shielding efficiency

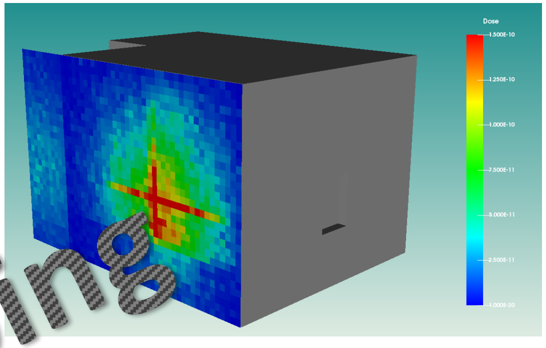


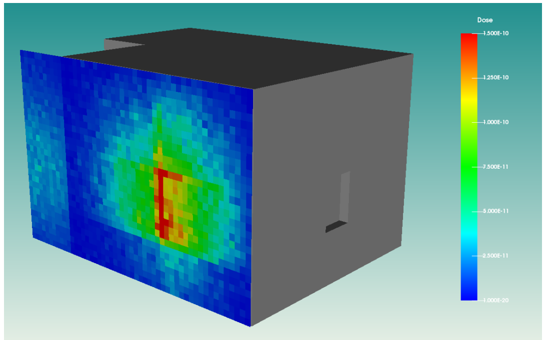
*12. Figure: Source in line with both chicanes **SETUP A***

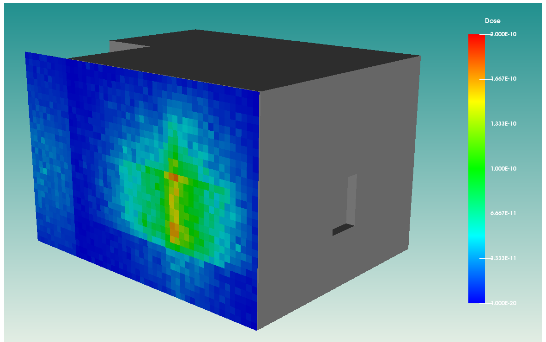


*13. Figure: Source in line with vertical chicane **SETUP B***









Work ongoing

Conclusions

- Main parameters are defined, optimization work is being made to reduce manufacturing costs by relaxing shielding requirements.
- Structural stability seem confirmed by calculations.
- Ongoing work to consolidate support infrastructure and confirm mechanical interfaces.
- Next:
  - Identify construction technique, detail design elements,
  - Design of internal support structure and access door.

Aknowledgments:

- Szabina Török
- Viktória Sugár
- Gábor Nafrádi
- Tamás Bozsó

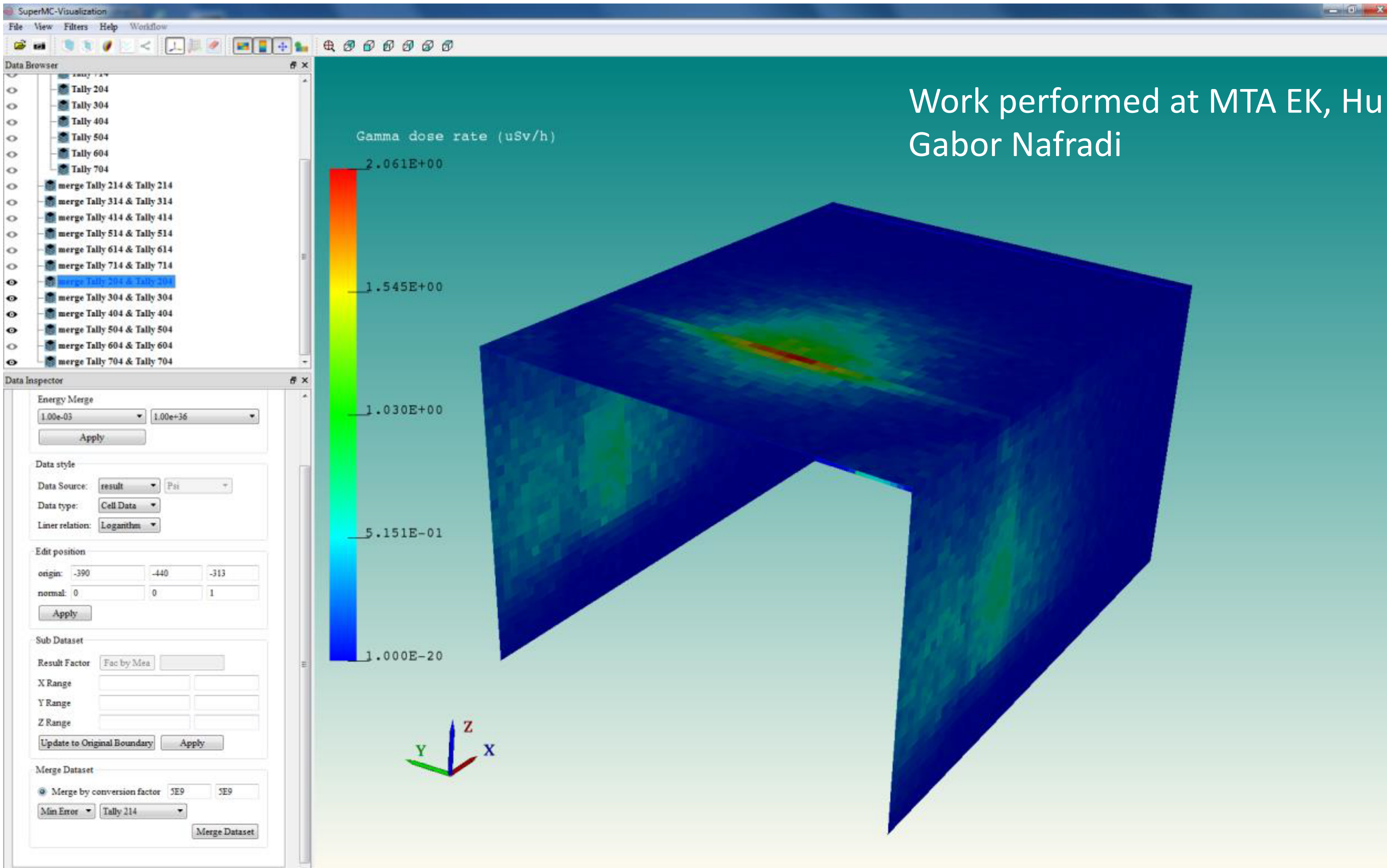
Centre for Energy Research, HU

- Valentina Santoro

Extra slides

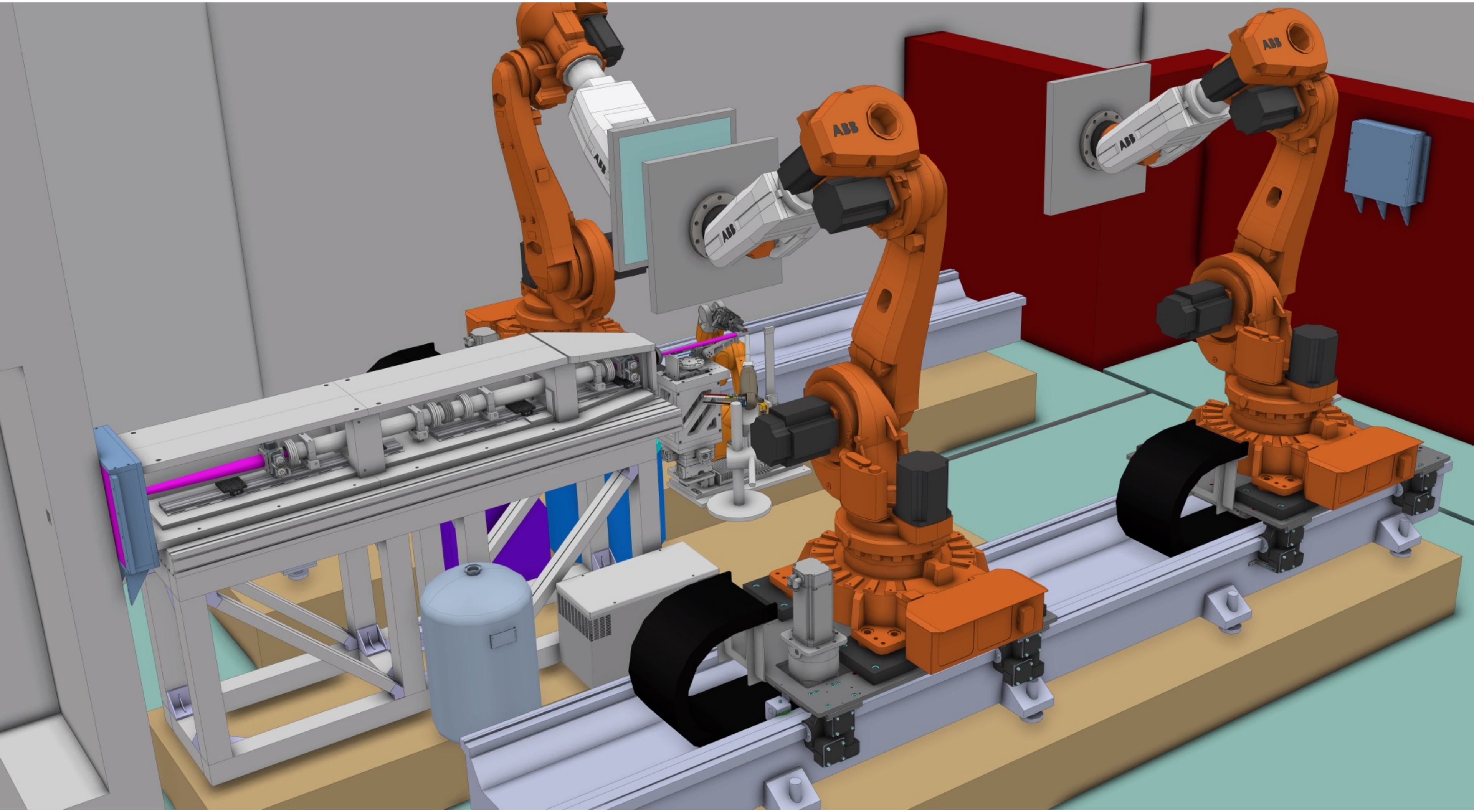
Gamma dose rate from Gd target at the sample position with 90 cm concrete for $5 * 10^9 n/s$

EUROPEAN SPALLATION SOURCE



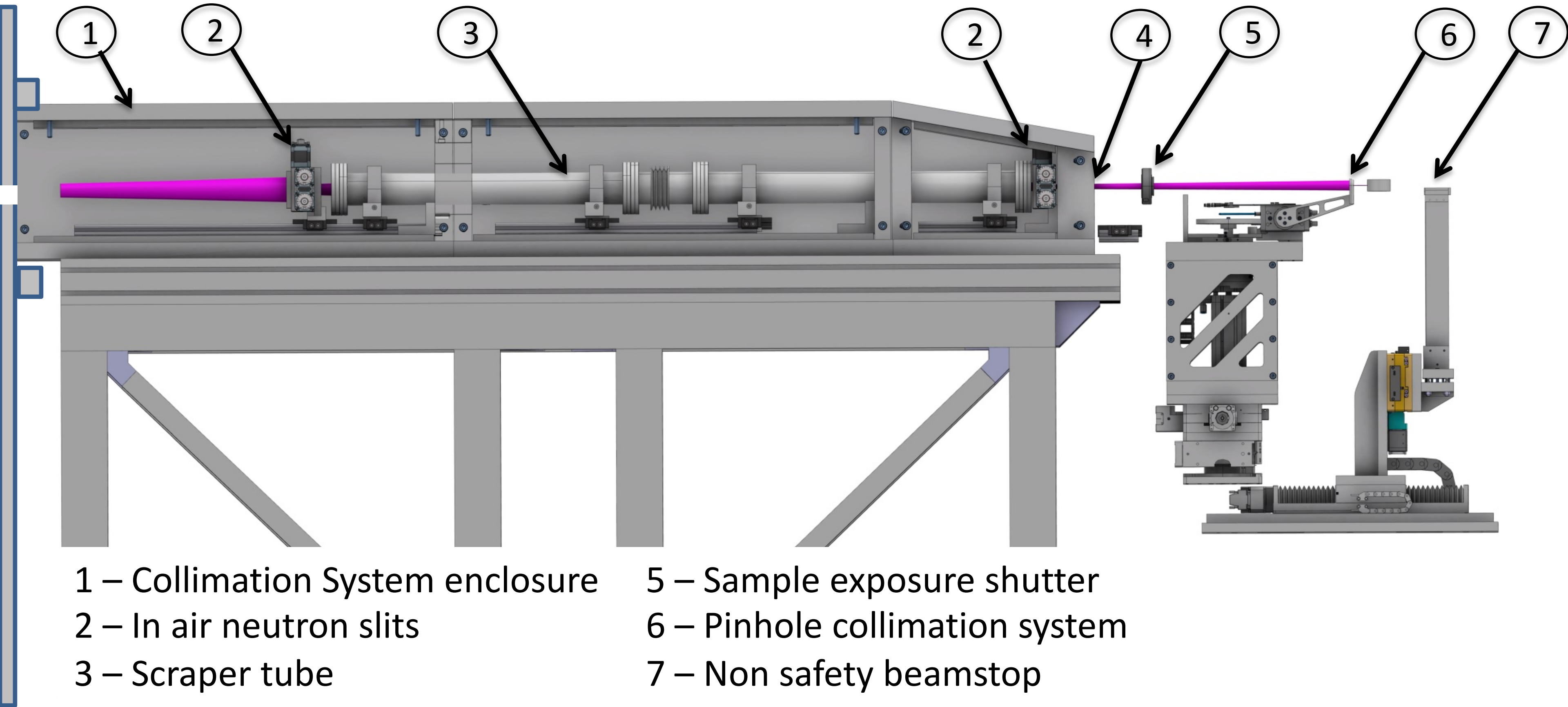
Work performed at MTA EK, Hu
Gabor Nafradi

Endstation Components



Endstation Components Collimation

The fixed aperture(4) limits the neutron current in the sample area from n/s to n/s
90% of neutrons entering the cave is 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