MIRACLES
STAP Report

21-22/10/2025

BENEDETTA ROSI (ESS)
On behalf of the MIRACLES team

Agenda

1 Guides

2 Choppers

3 Analyzer

4 Radial Collimator

5 Detector

6 Cave

7 Experimental Station

8 Common Projects

Overview

MIRACLES: time-of-flight backscattering spectrometer

QUICK FACTS

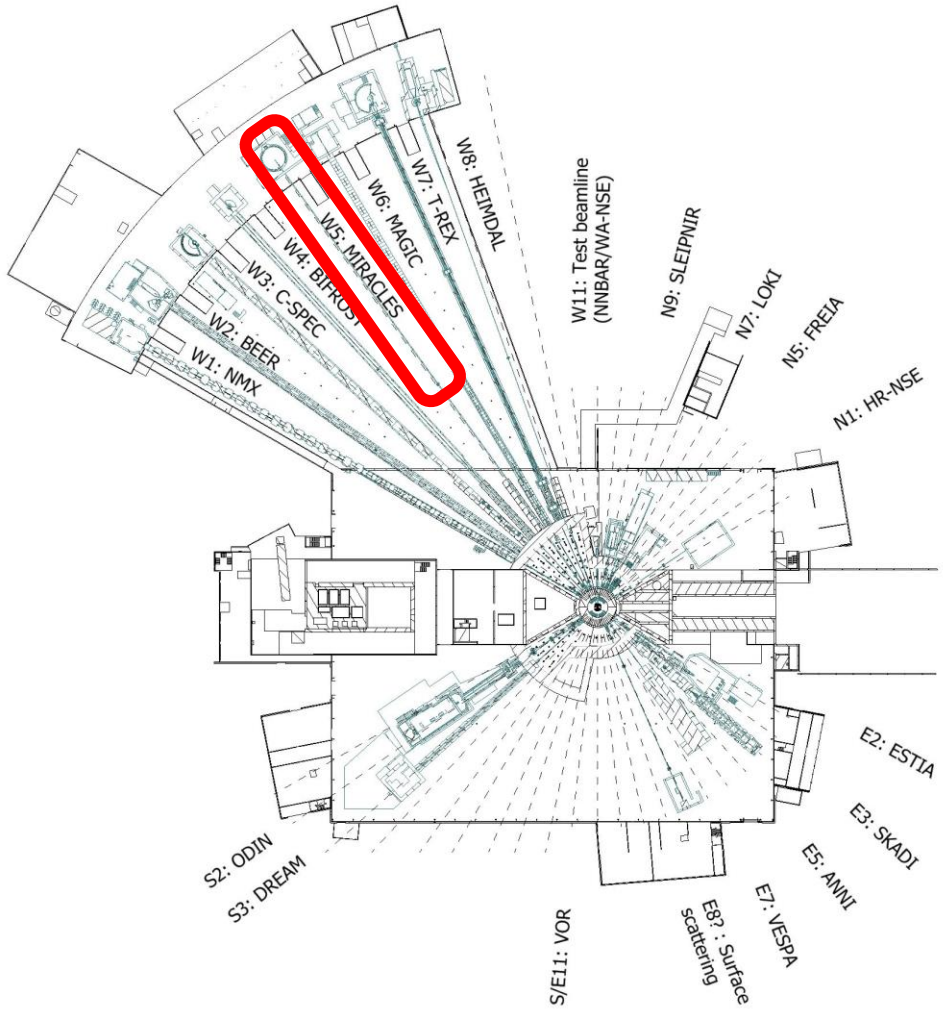
Sector & Beamport West (W5)
Length (source to sample) 162.5 m
Q-Range 0.2 – 2 $Å^{-1}$
Wavelength Band (Δλ) ~ 1.5 Å (~ ±500 μeV)
Wavelength Range 2 – 20 Å
E-Transfer Range (E=2.08 meV) -2 to +20 meV

HIGH RESOLUTION QENS MODE

Energy Resolution (QENS) δ(ħω) ~ 2.5 μeV
Pulse duration Δt = 70 μs

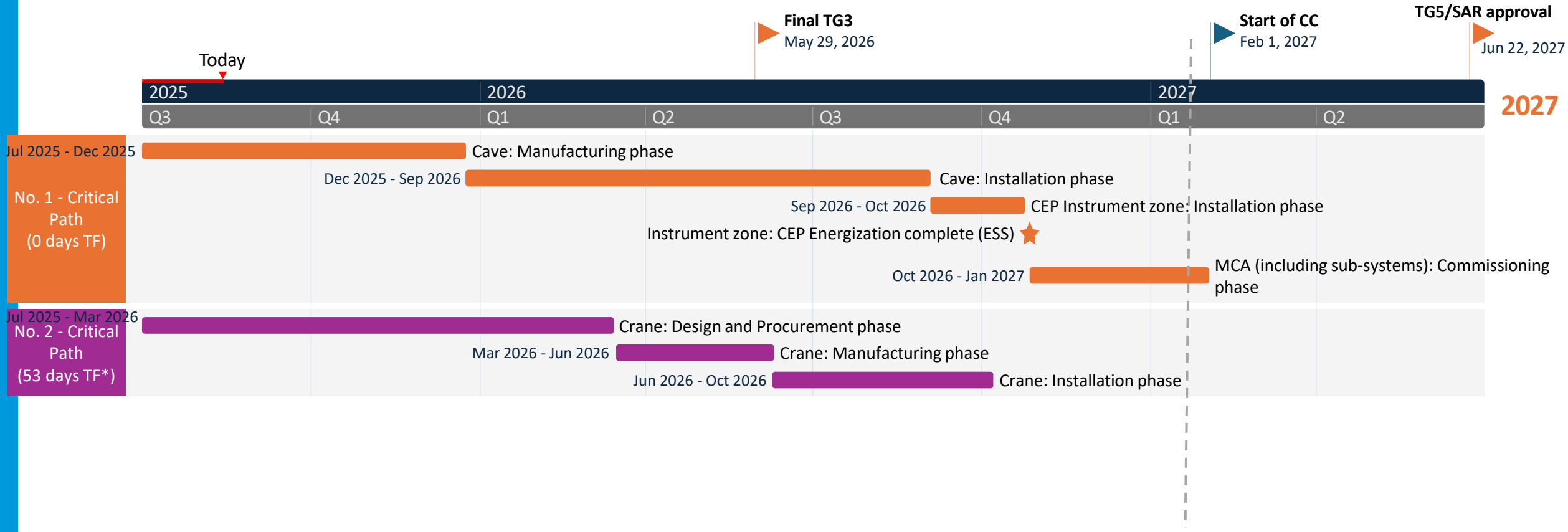
HIGH FLUX QENS MODE

Energy Resolution (QENS) δ(ħω) ~ 45 μeV
Pulse duration Δt = 2.4 ms

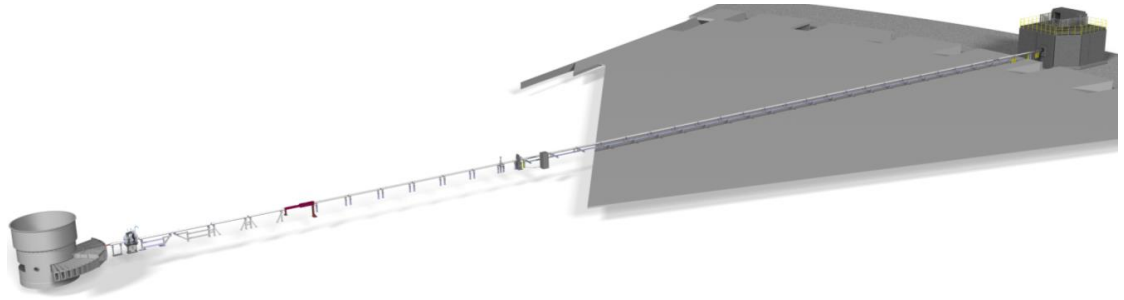


Overview

Miracles Critical Paths

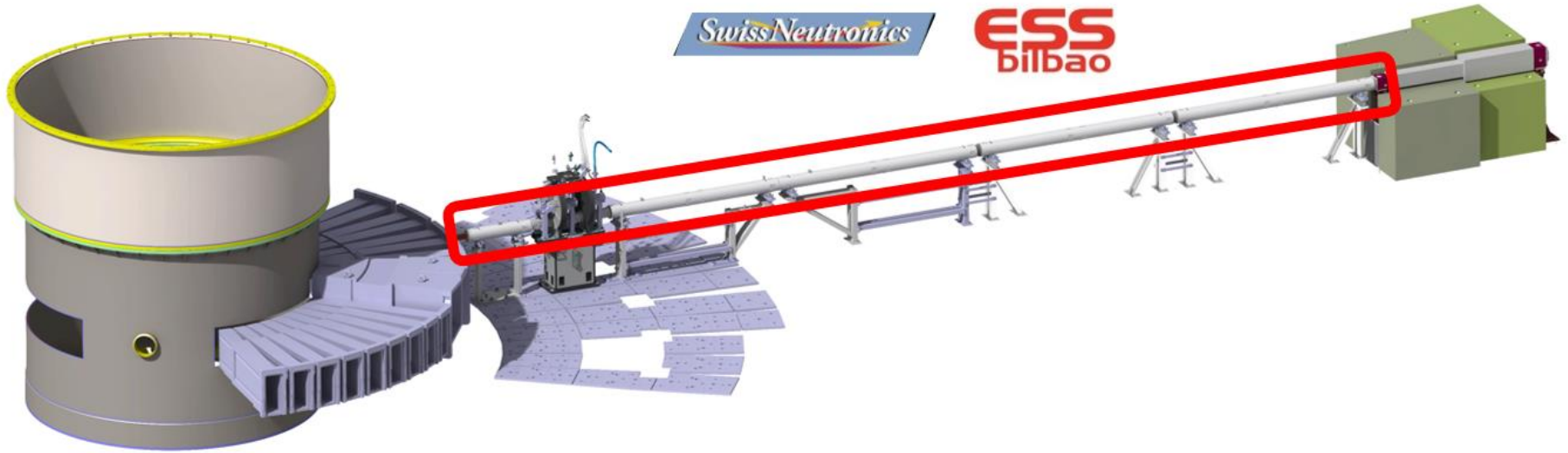


Guides

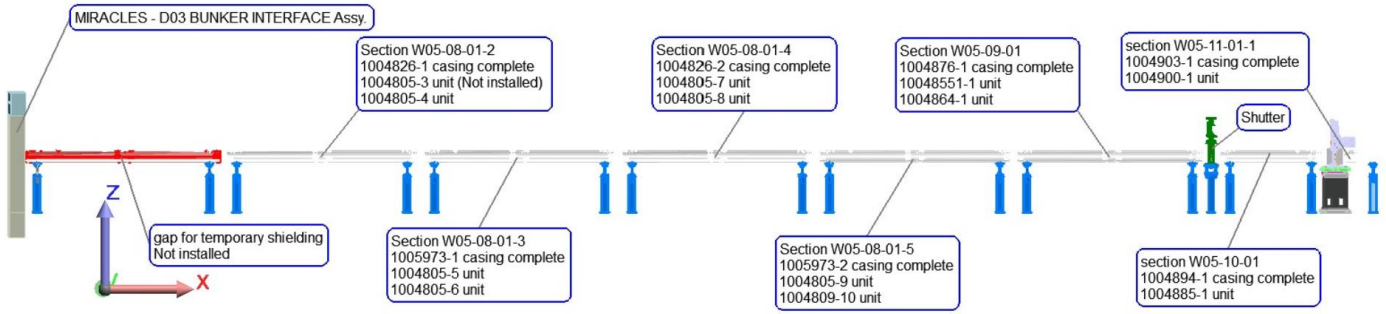


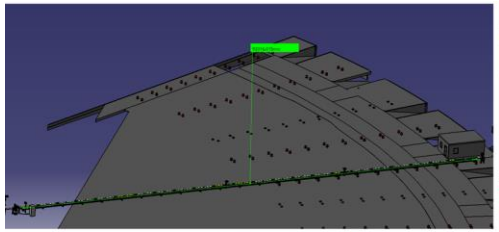
In-bunker guide system

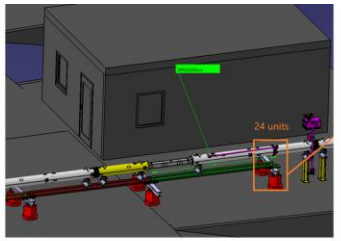
Completed in 2024
Pending: installation and integration of PWD-PS chopper module



Out-of-bunker guide system







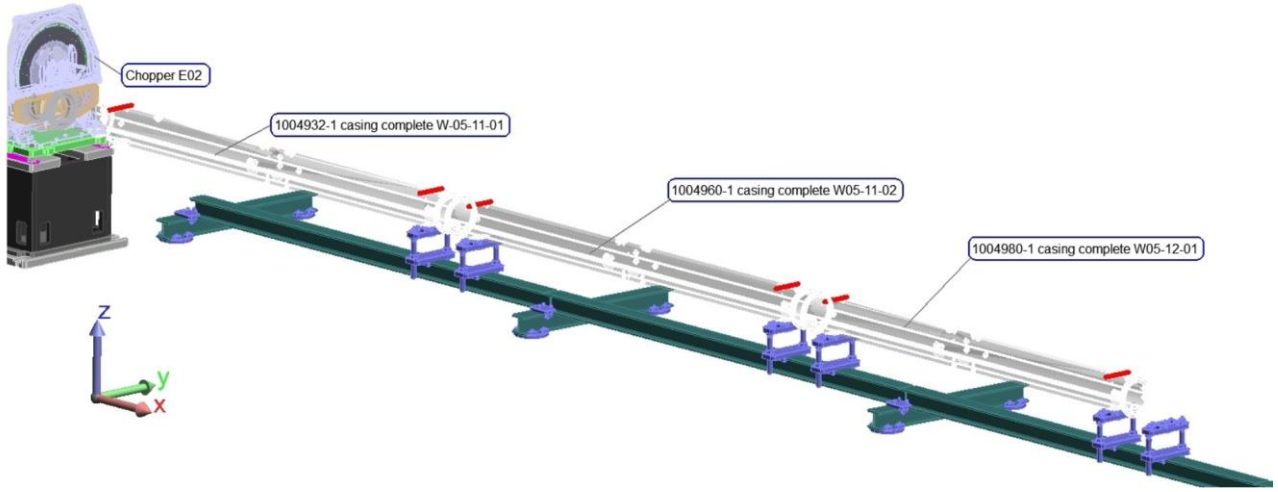
92 meters, one short beam each 4 meters -> 24 units

Installations

- Thermal shutter (March 2025)
- E02 guide supports (June 2025)
- E02 guides (March 2025, June 2025, October 2025)

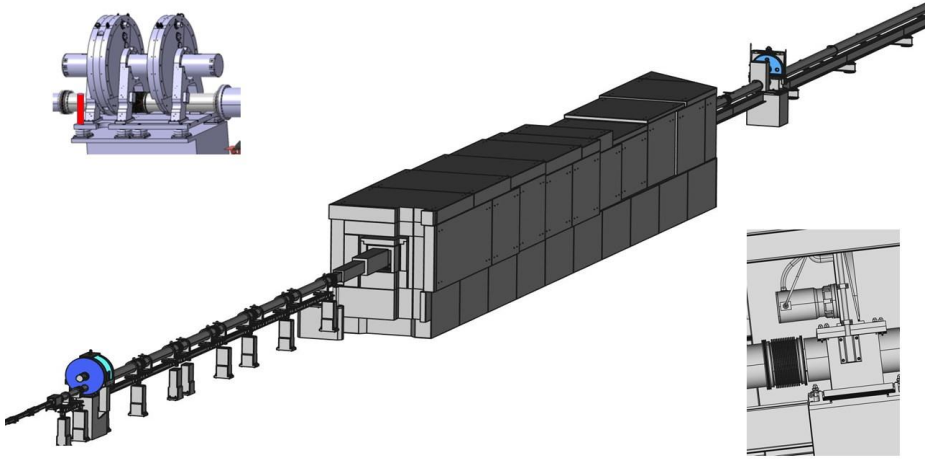
Swiss Neutronics

Out-of-bunker guide system



- Integration with thermal shutter and FO chopper
- Reported instability
  - ~1 mm along x axis for guides casing
  - ~1 mm along z axis for the chopper
- Further check will be done after completion of the guide section

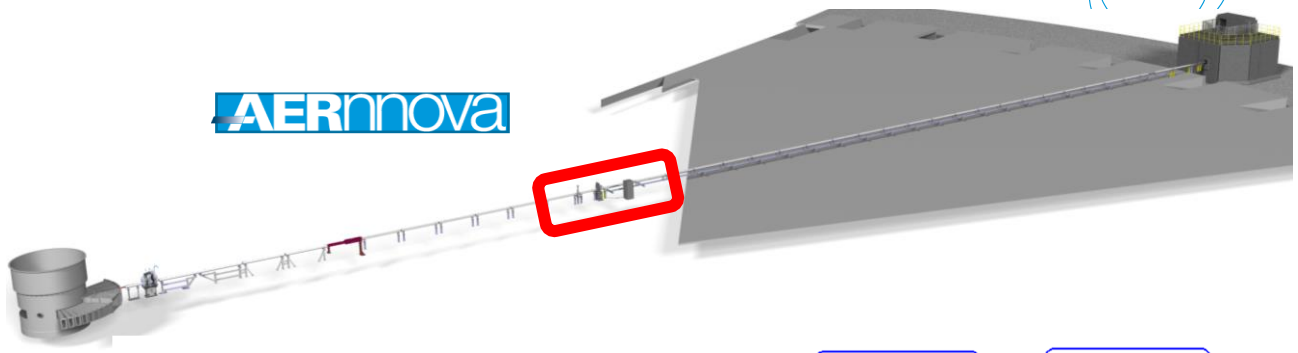
Choppers

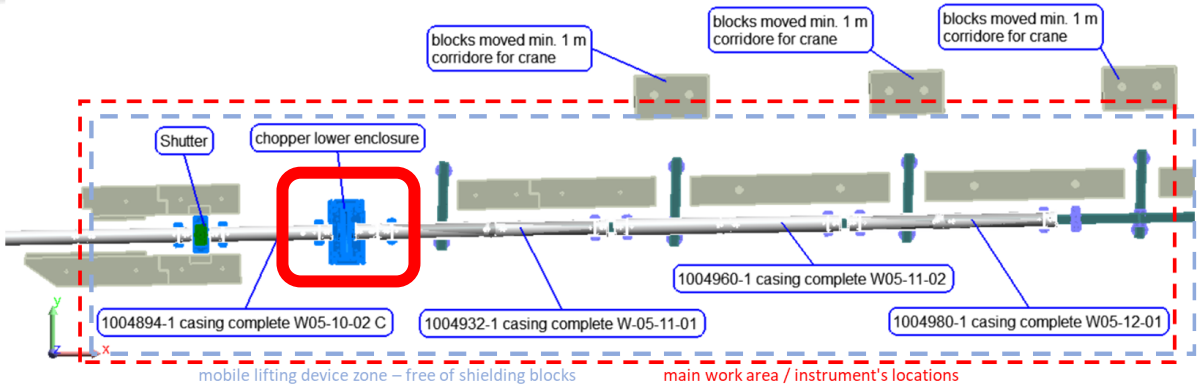


Bandwidth/frame overlap (FO) chopper

Slow (Al) chopper
α = 105°

- Installed in June 2025
- Integrated with the guide system

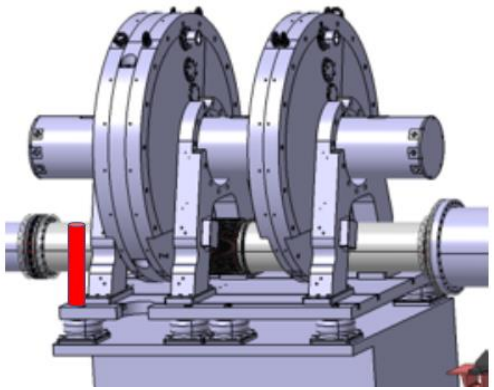


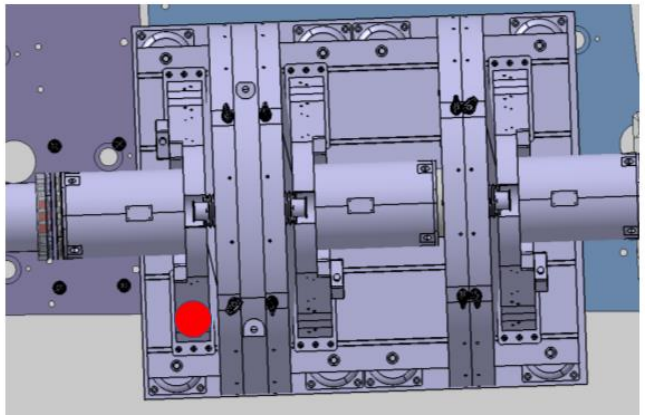


PWD-PS chopper module

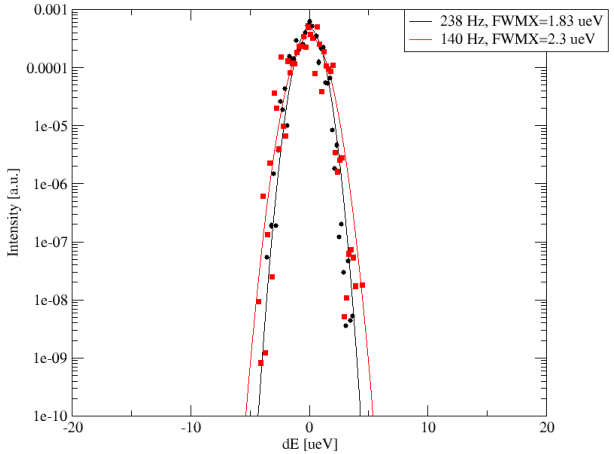
Pulse width definition (PWD) chopper
- Fast (CFRP) double-disk chopper ν = 14 Hz ... 308 Hz
- α = 12°

Pulse shape (PS)
- Slow (Al) single-disk chopper
- α = 15°





Check of performances using McStas code

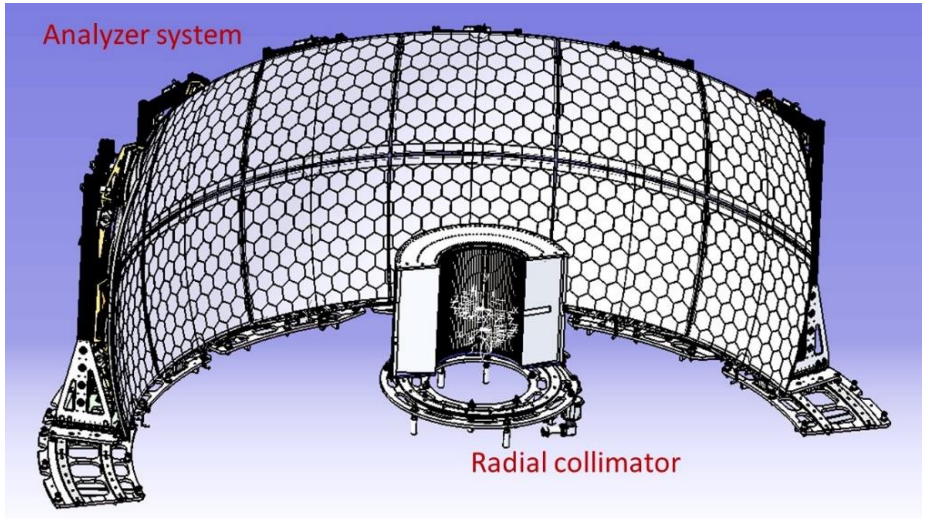


Support of DMSC (Mads, Christian)

Status:

- PWD-PS module manufactured and passed FAT tests

Analyser



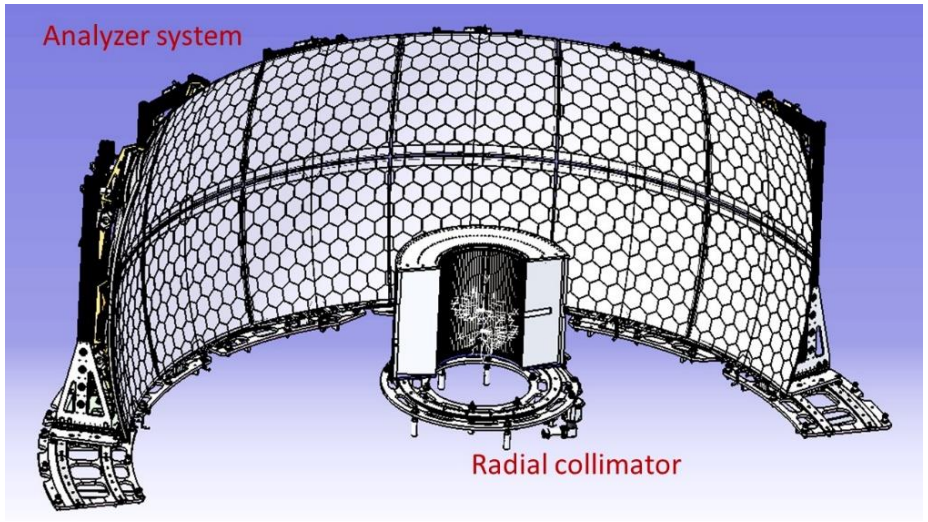
Analyser system

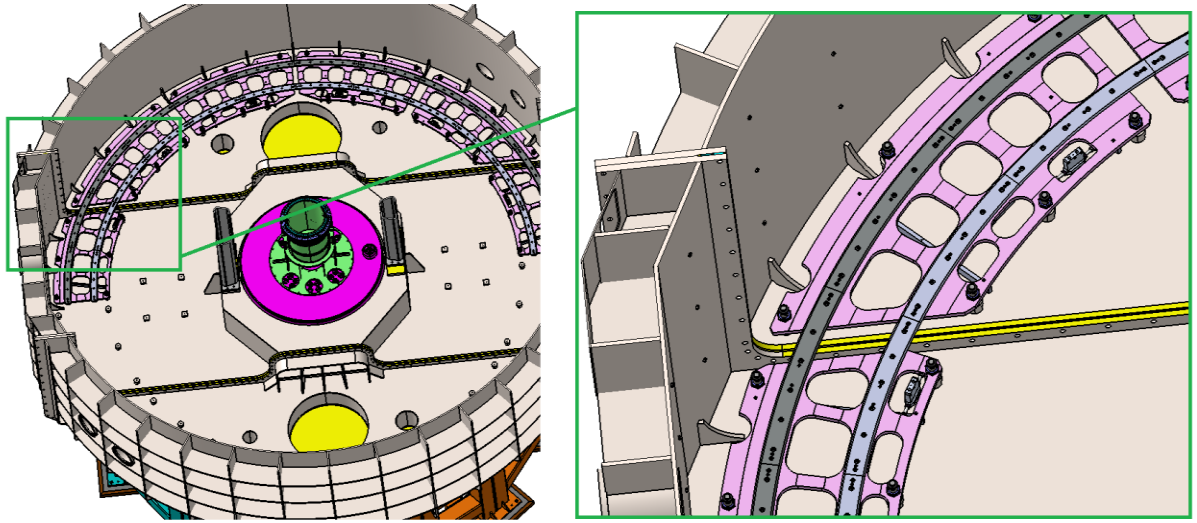
Double-spherical monochromator R=2.5 m
Horizontal acceptance: 155.52°
vertical acceptance: ±22°

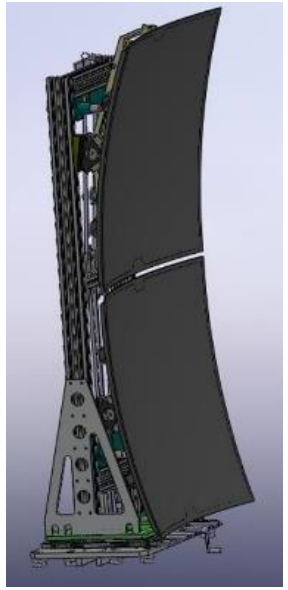
1032 Si(111) crystals (λ = 6.27 Å)

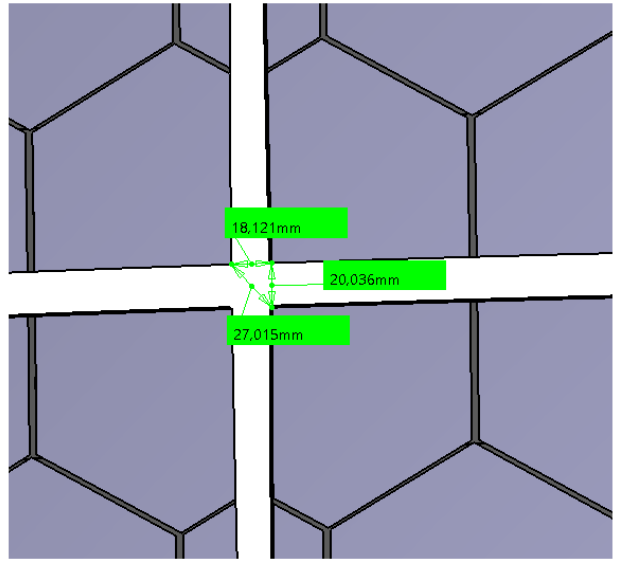
Mechanical support consisting of:

- 12 carbon fiber plates (6 top, 6 bottom)
- 6 supports
- Positioning guiding system
- Alignment system





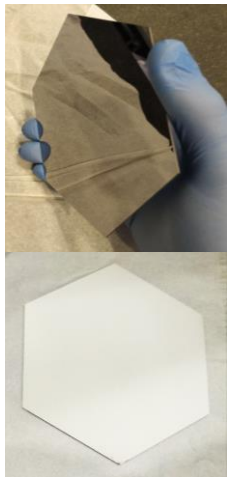


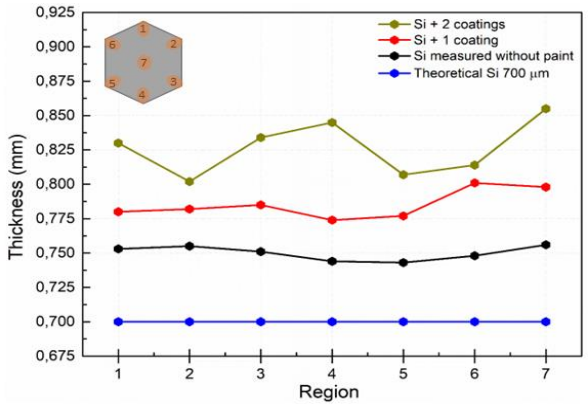


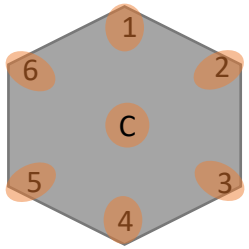
Analyser system

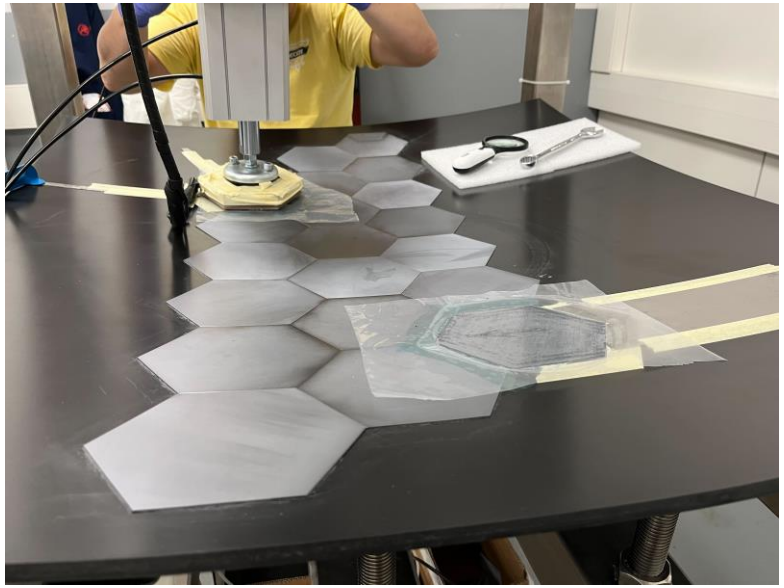
Assembling procedure

1. Coating with absorber (Gd_2O_3), thickness ~80 μm
2. Glueing (LOCTITE® EA 9466™) onto analyzer panel (3 hours, pressure P = 0.2 MPa)









Actions undertaken during 2025:

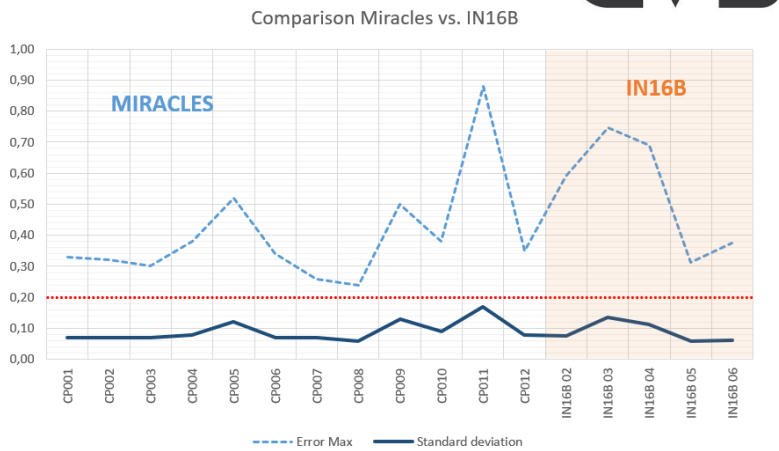
- upgrade of «coating station»
- upgrade of «assembly station» (1+2 new stations)

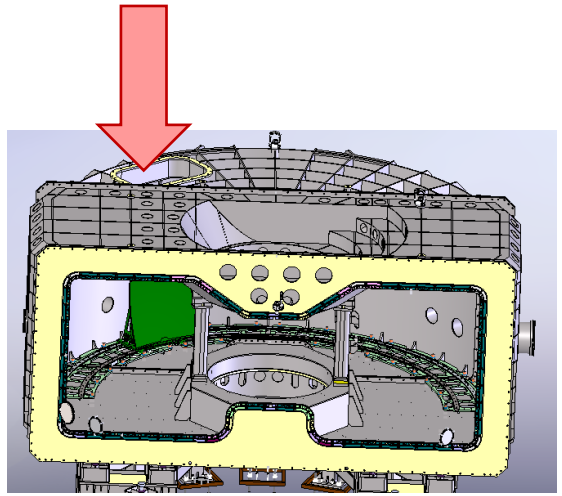
Analyser system

Verification and validation (preliminary)

Step 1: V&V of the final analyzer assembly

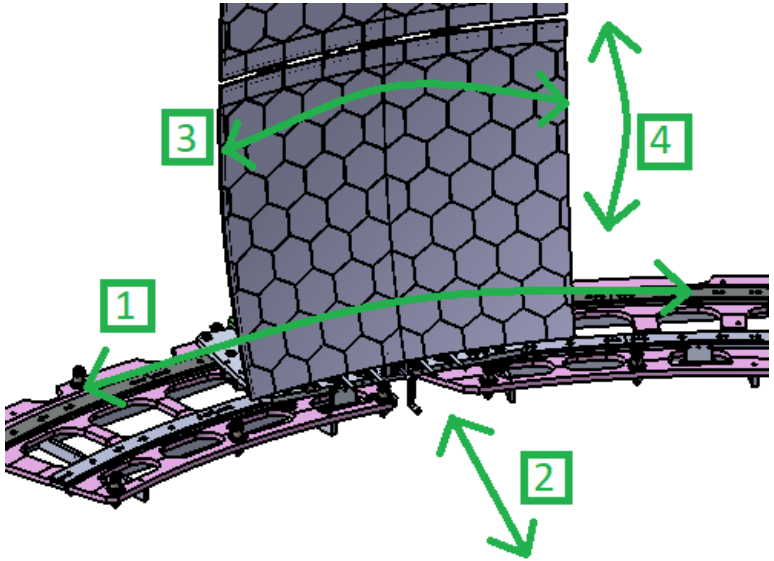
- Visual inspection
- Dimension/surface inspection (laser tracker)
- Test under vacuum



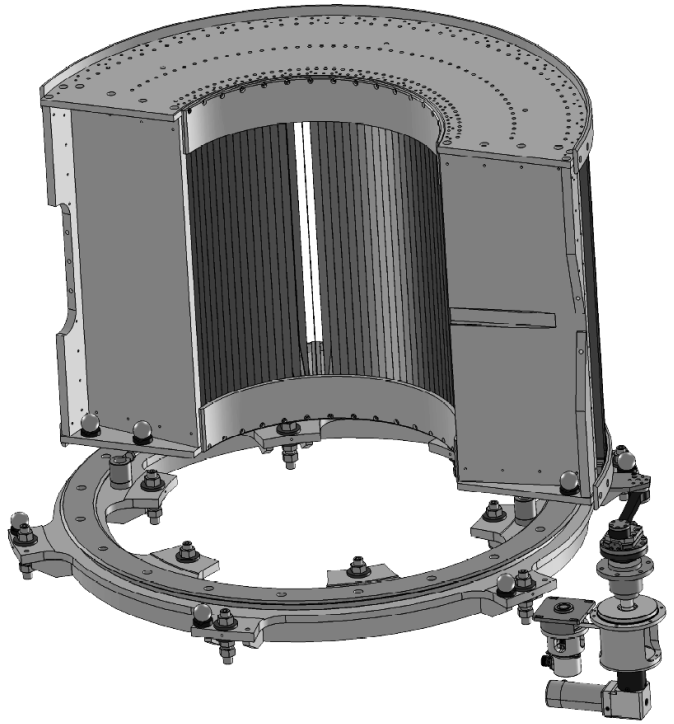


Step 2: SAT for the analyzer assembly

- Lifting/installation
- Positioning and alignment (laser tracker)
- Accuracy for sample-detector centering: ±0.15°

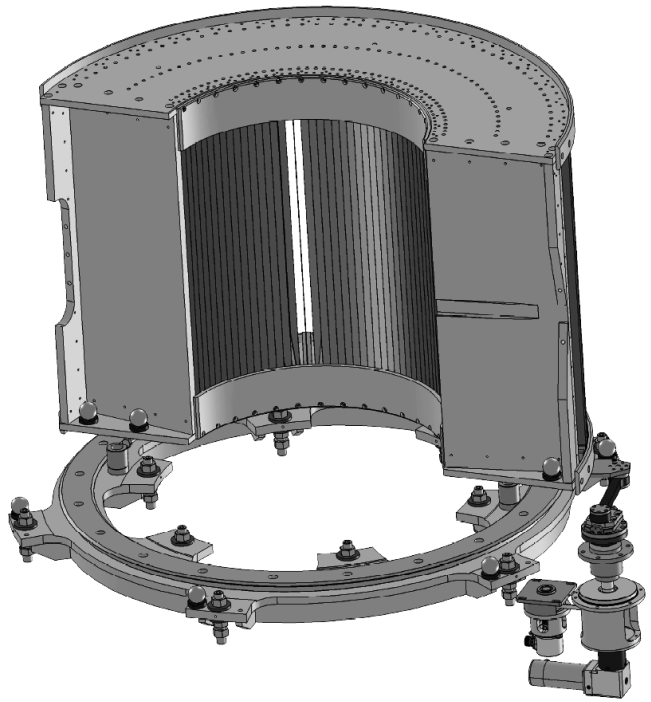


Radial Collimator



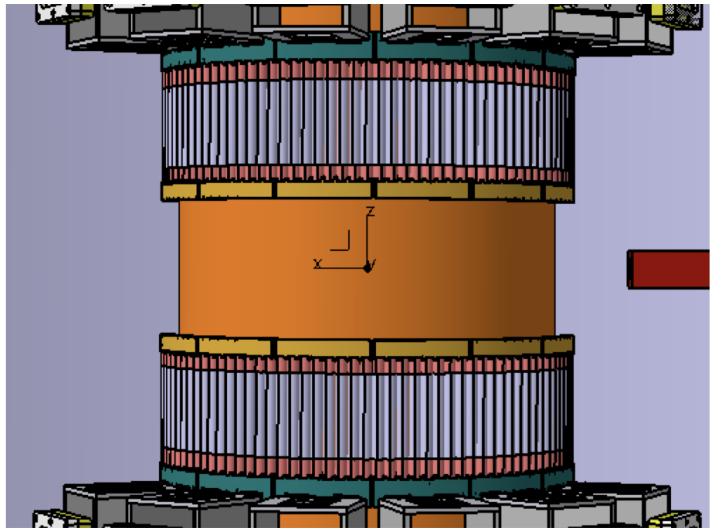
Radial oscillating collimator (ROC)

- Aluminium structure framing carbon fiber blades coated with ~30 µm Gd_2O_3 layer
- 49 Slits (width φ = 3.24°), angular coverage from 6.24° to 165°
- Inner radius: 30 cm
- Outer radius: 60 cm



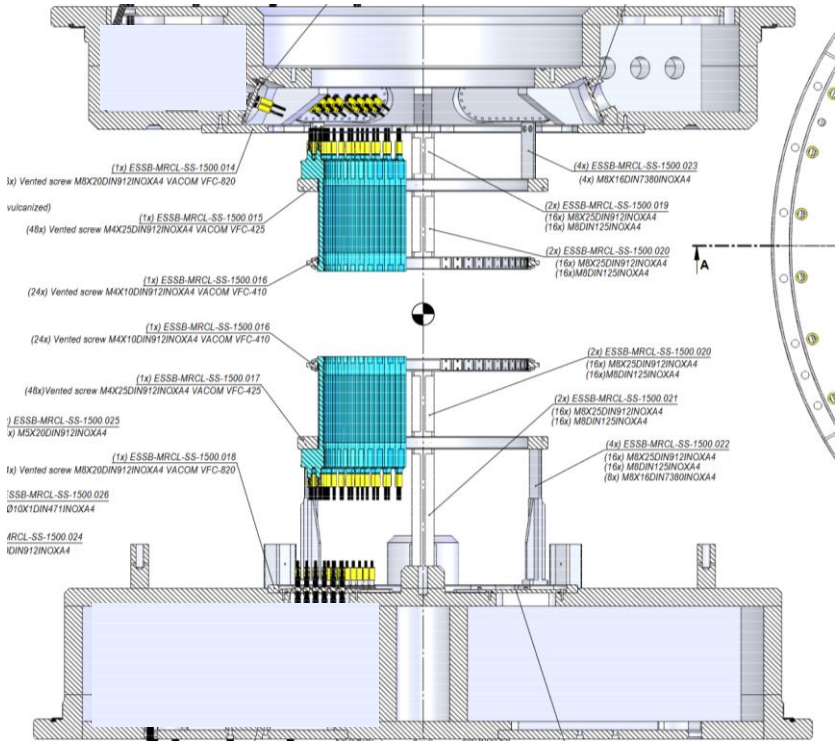
- Manufactured by AVS
- A second layer of Gd_2O_3 will be applied to the blades at ESS Bilbao (expected to be concluded before end of 2025)

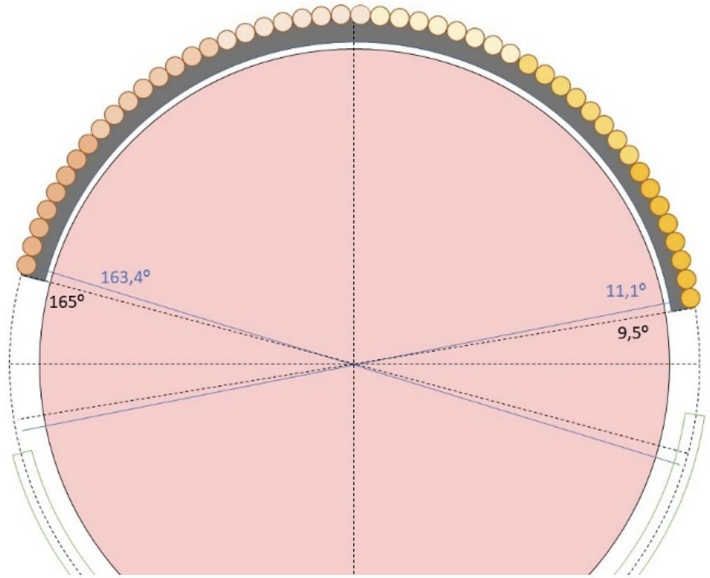
Detector

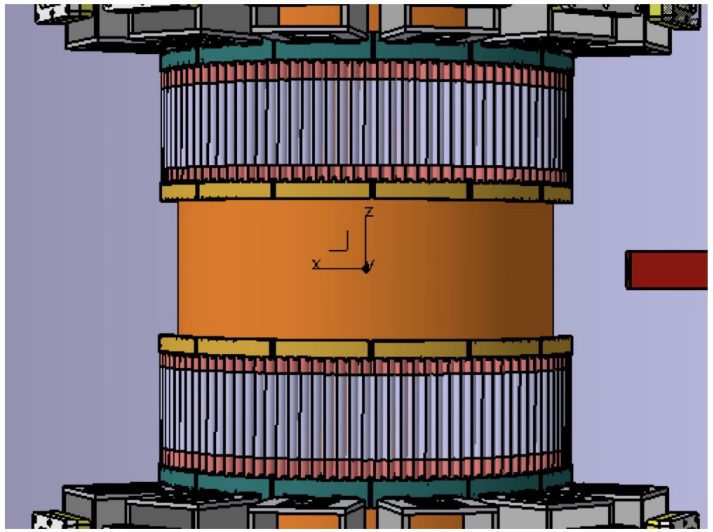


Detector system

Angular coverage:
- 9.5° to 165° (*2θ*)
- ±22° vertical acceptance



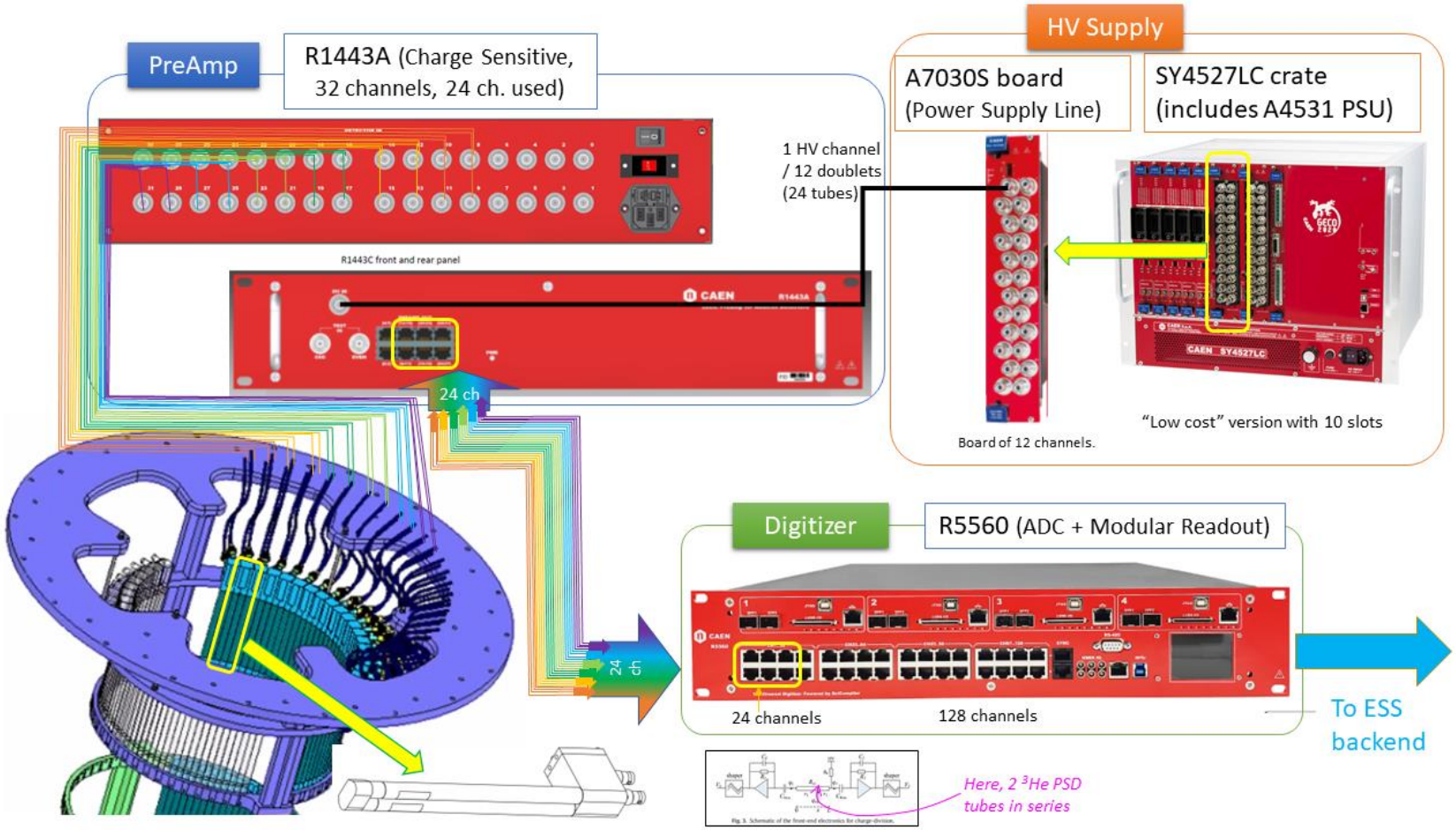




96 ^{3}He tubes (48 doublets), ⌀=12.7 mm, *P* =10 bar (LND “TwinPack”)

Detector system

4 preamps (2 top detector bank + 2 bottom detector bank) (CAEN)
1 HV supply (CAEN)
1 Digitizer (CAEN)



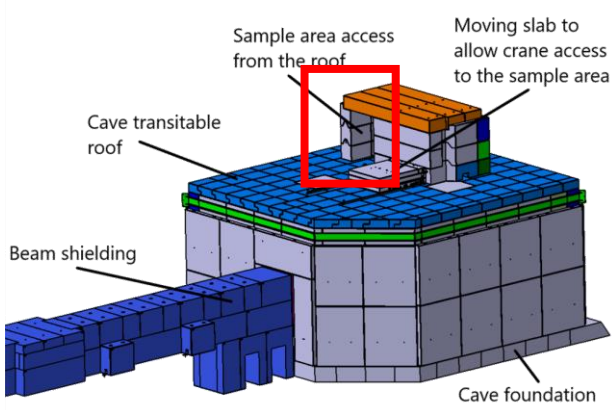
Detector system

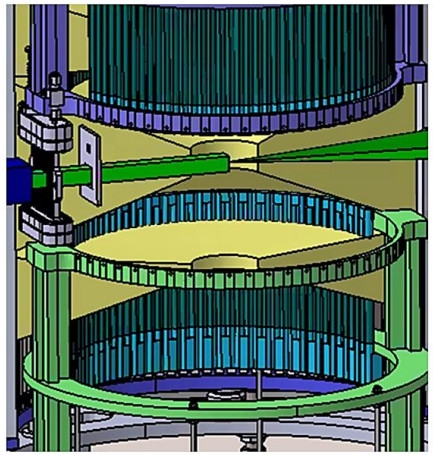
Detectors-preamps: 48 SHV cables

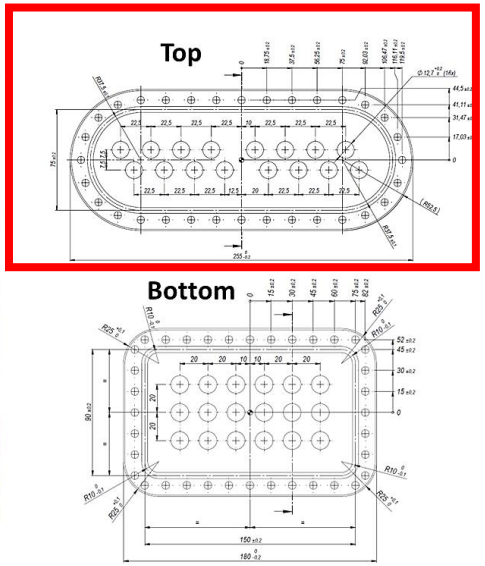
- from vessel to preamps (1.5 m)
- from detectors to patch panel (~0.3 m)

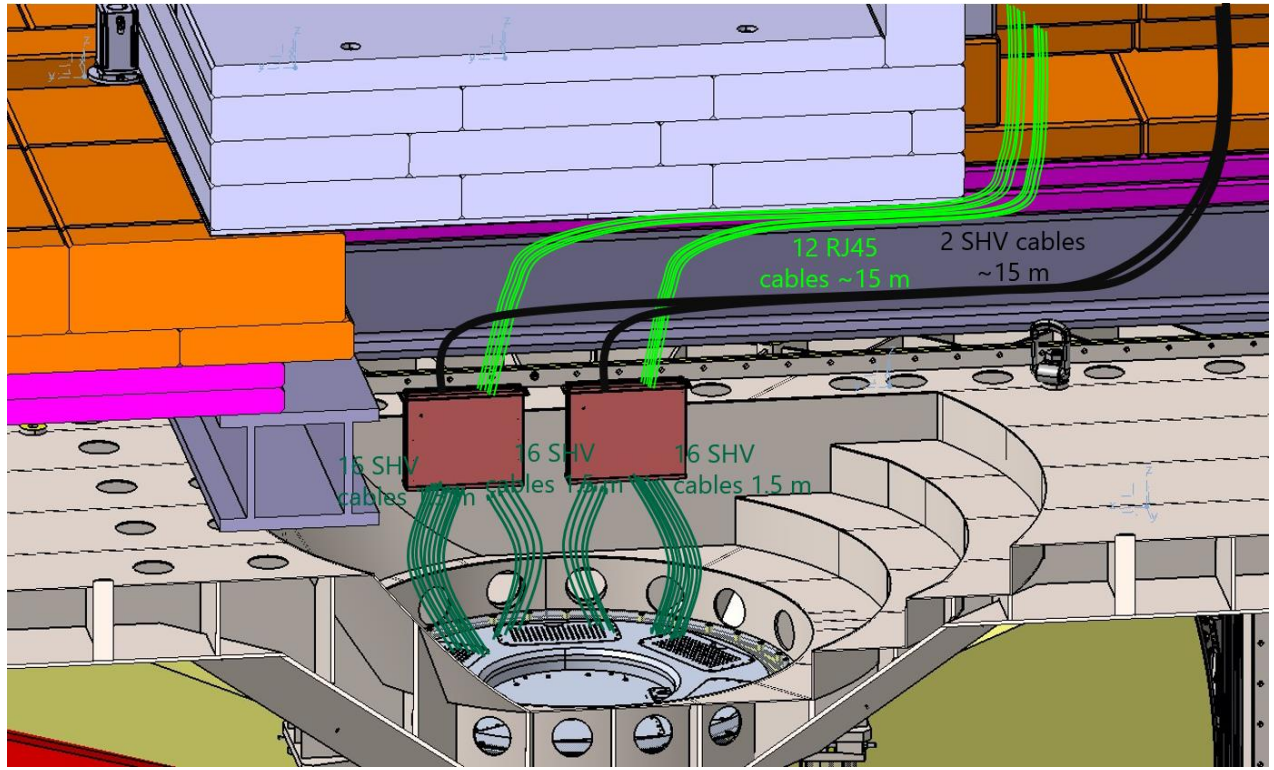
Preamps-digitizer (rack): 12 RJ45 cables (~15 m)

Preamps-power supply (rack) : 2 SHV power cables (~15 m)









Courtesy of O. Sidiropoulou and N. De La Rosa

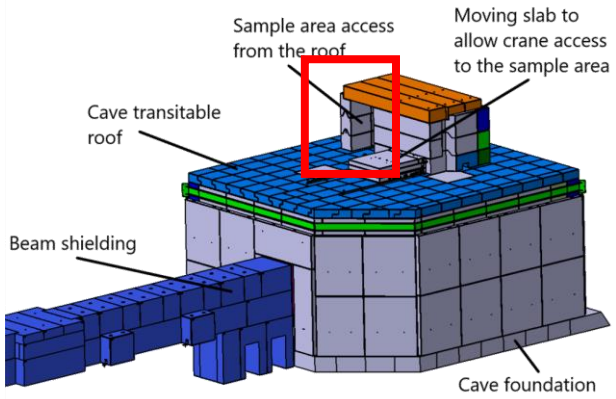
Detector system

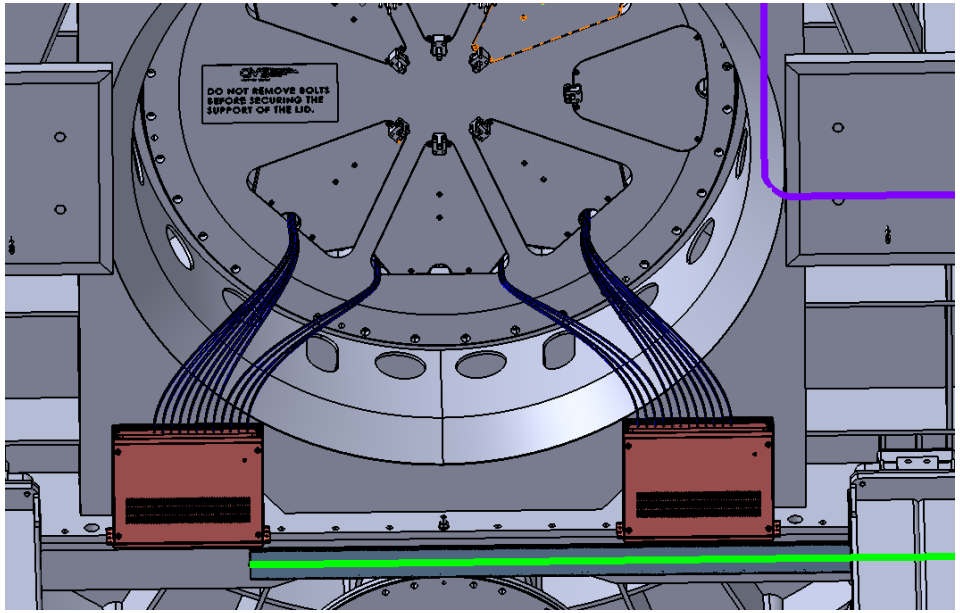
Detectors-preamps: 48 SHV cables

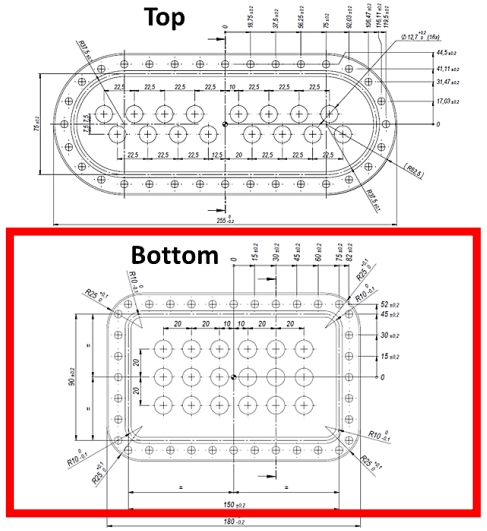
- from vessel to preamps (1.5 m)
- from detectors to patch panel (~0.3 m)

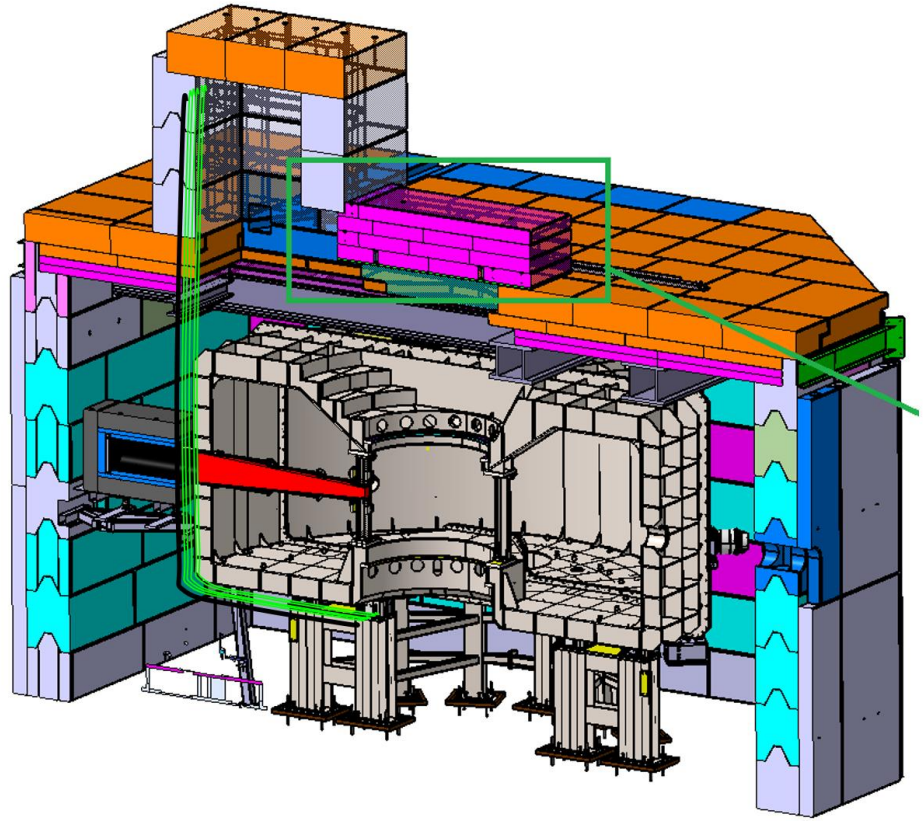
Preamps-digitizer (rack): 12 RJ45 cables (~20 m)

Preamps-power supply (rack) : 2 SHV power cables (~20 m)





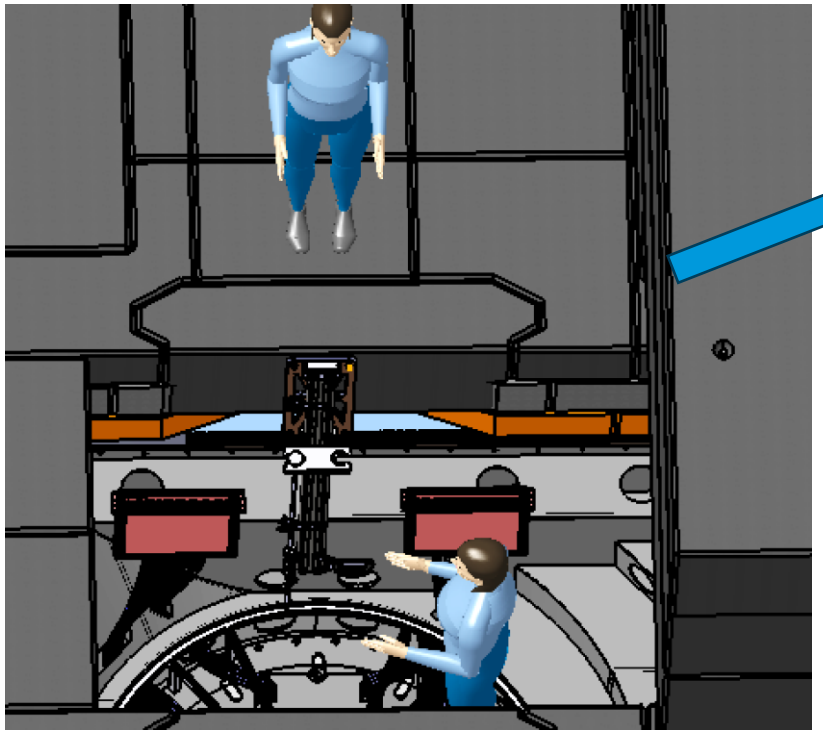


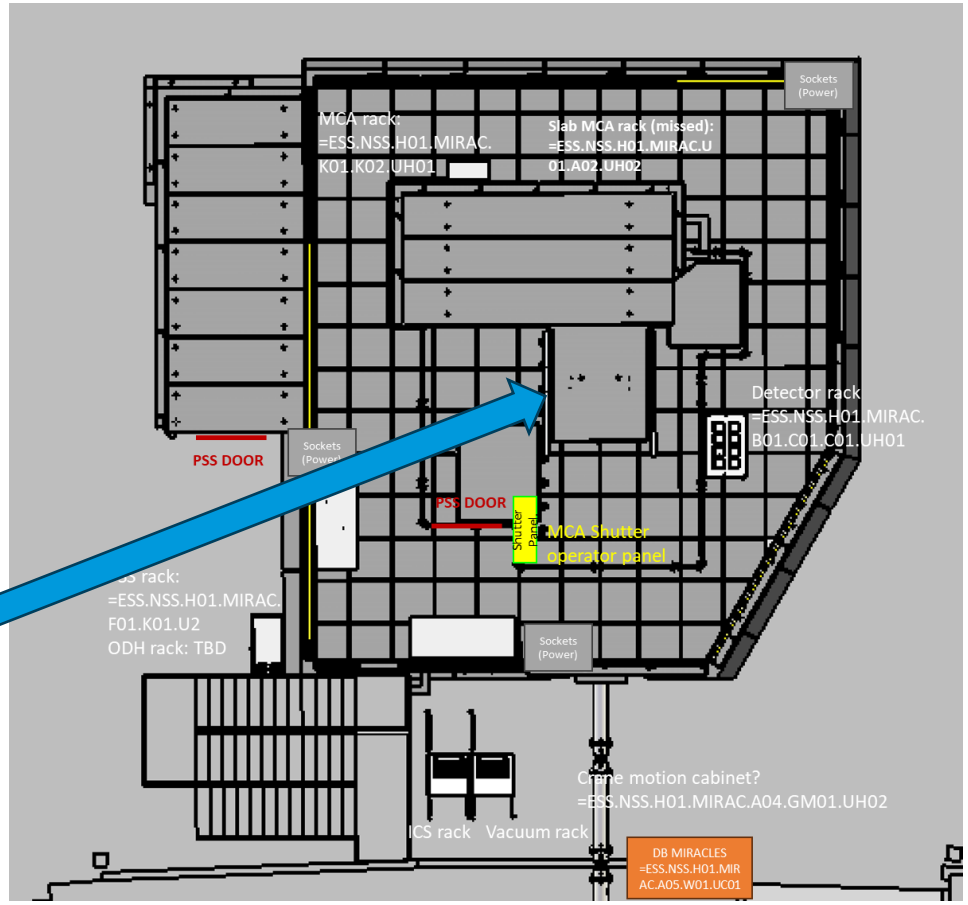


Courtesy of O. Sidiropoulou and N. De La Rosa

Detector system

- Top preamps accessible when slab is open
- Bottom preamps accessible through the cave's maintenance door at E01 floor





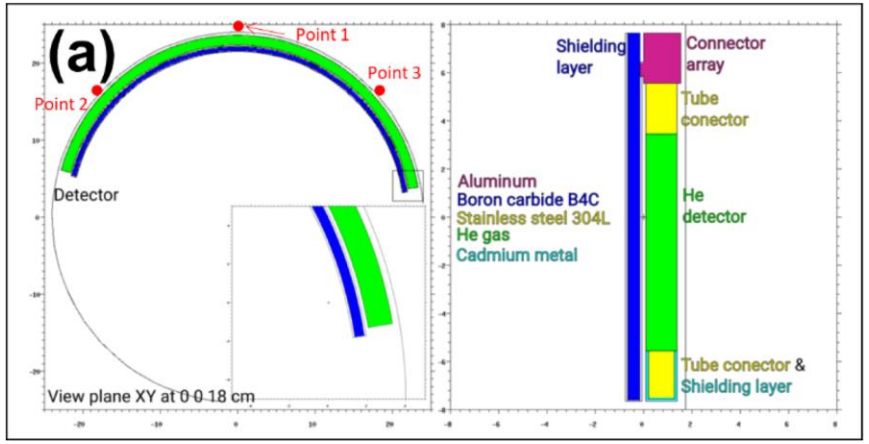
Detector system

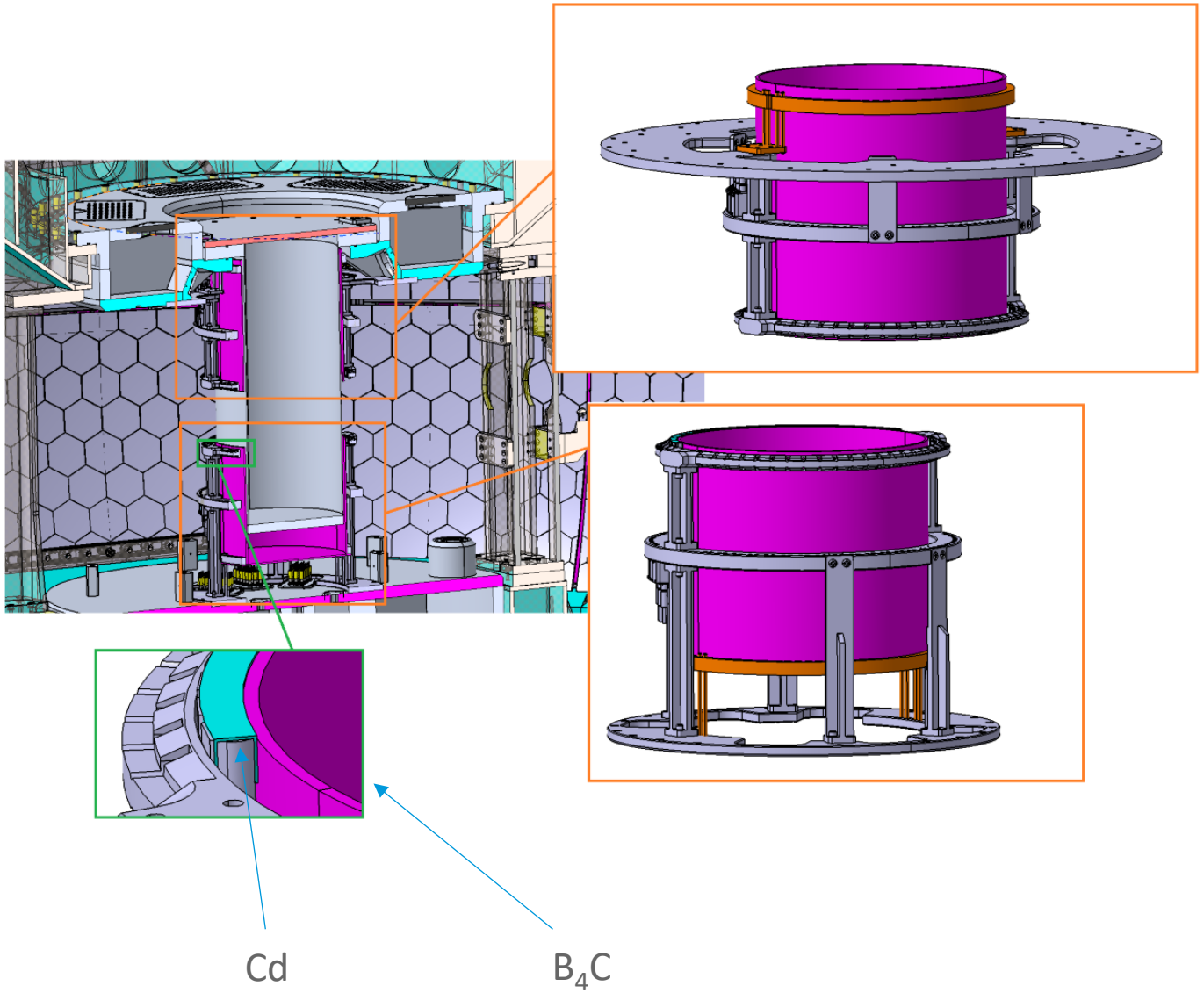
Shielding

- 1 mm Cd sheet (pink)
- 5 mm B_4C-epoxy sheets (cyan)

Neutron transmittance (flux with shielding/flux without shielding)

Layout sample/ ···/detector	Point 1	Point 2	Point 3
B_4C	1.8×10^{-6}	6.0×10^{-6}	4.2×10^{-6}
B_4C/Cd	0.5×10^{-6}	4.2×10^{-6}	2.5×10^{-6}
B_4C (±1°)	7.8×10^{-8}	8.2×10^{-8}	9.6×10^{-8}
B_4C/Cd/(±1°)	2.2×10^{-8}	3.2×10^{-8}	2.5×10^{-8}





Detector system

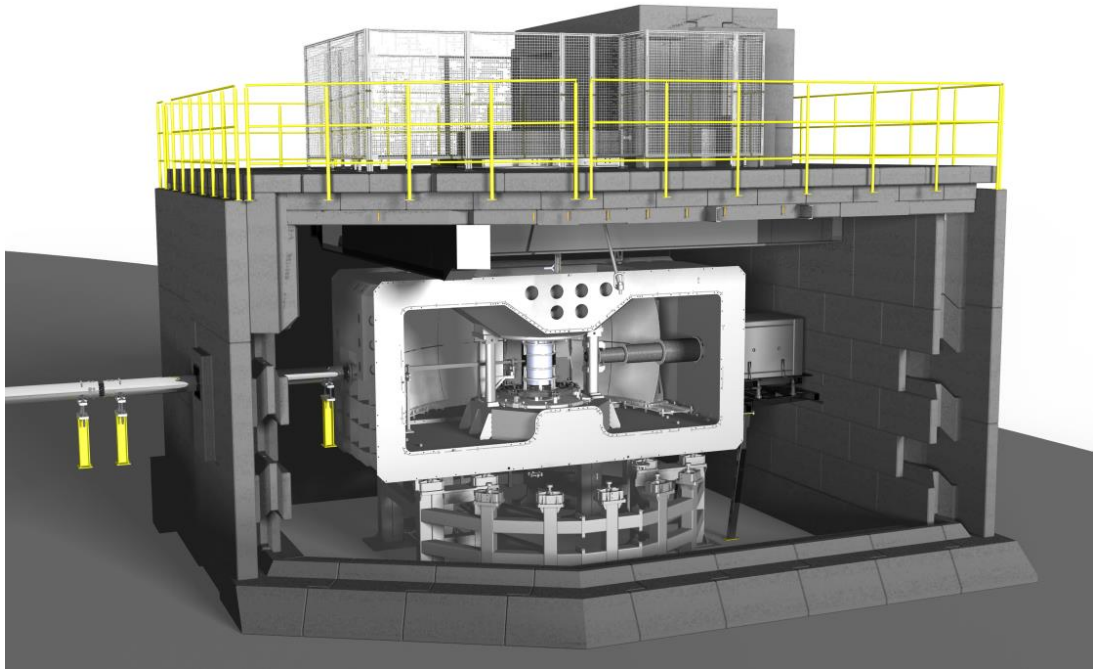
First steps:

- Check integration of 3he tubes with CAEN electronics
- Check of performances of each tube
  - Peak height
  - Energy resolution
  - Tests at different voltages (proportional range)
- Position sensitivity (Cd mask)

Tests performed at Lund University with Am/Be source

Courtesy of O. Sidiropoulou and N. De La Rosa

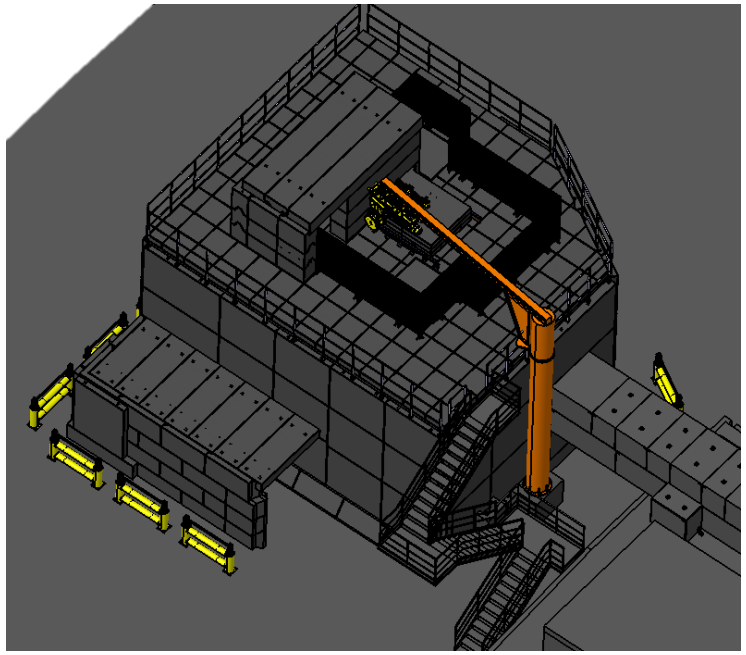
Experimental station

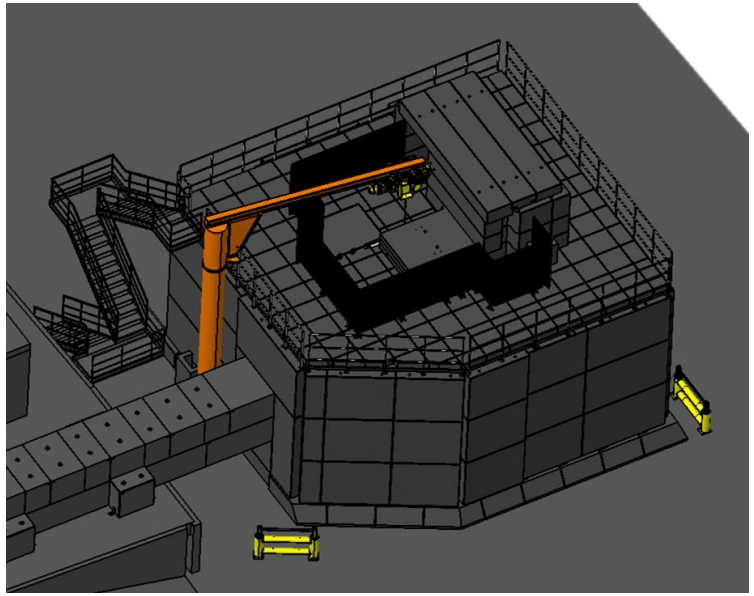


Cave

Cave dimensions:
- max. length: 11.690m
- max. width: 13.490m
- max. height: 8.794m

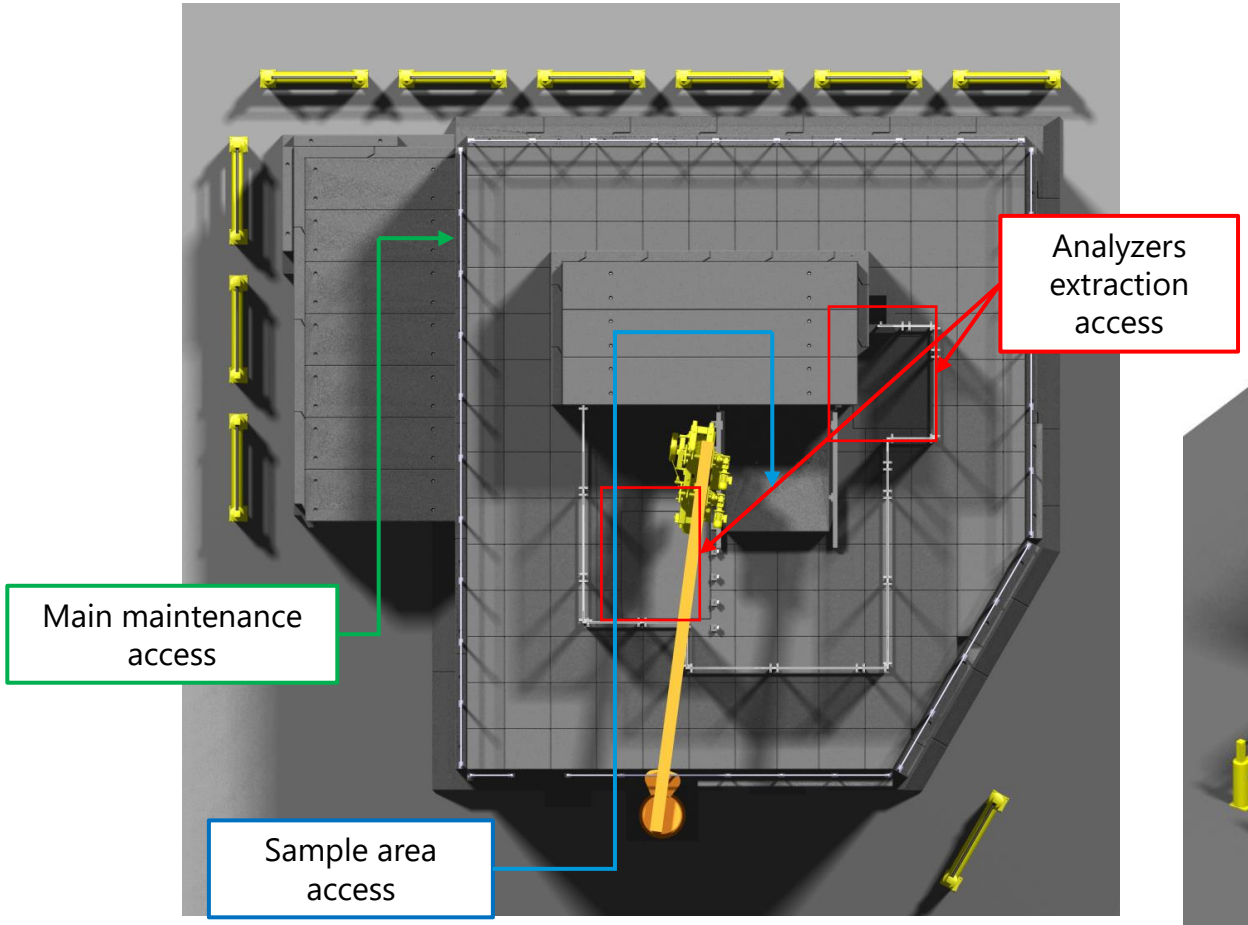
Main materials used:
- High density concrete C40/50
- Regular density concrete C40/50
- S275 JR Steel

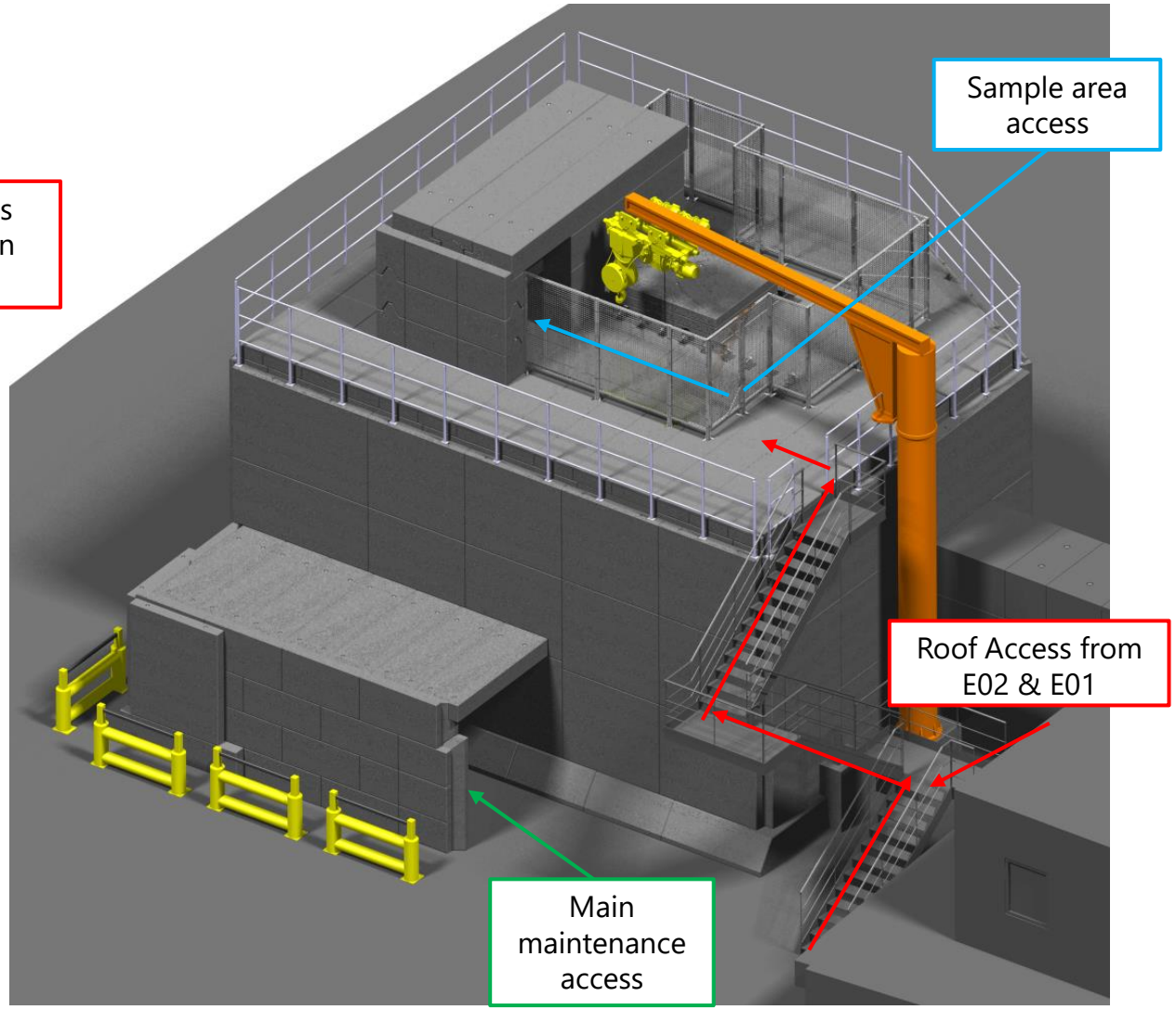




- manufacturing phase: pre-build is expected by spring 2026
- the electrical design of the slab will be tendered

Cave


Analyzers extraction access
Main maintenance access
Sample area access

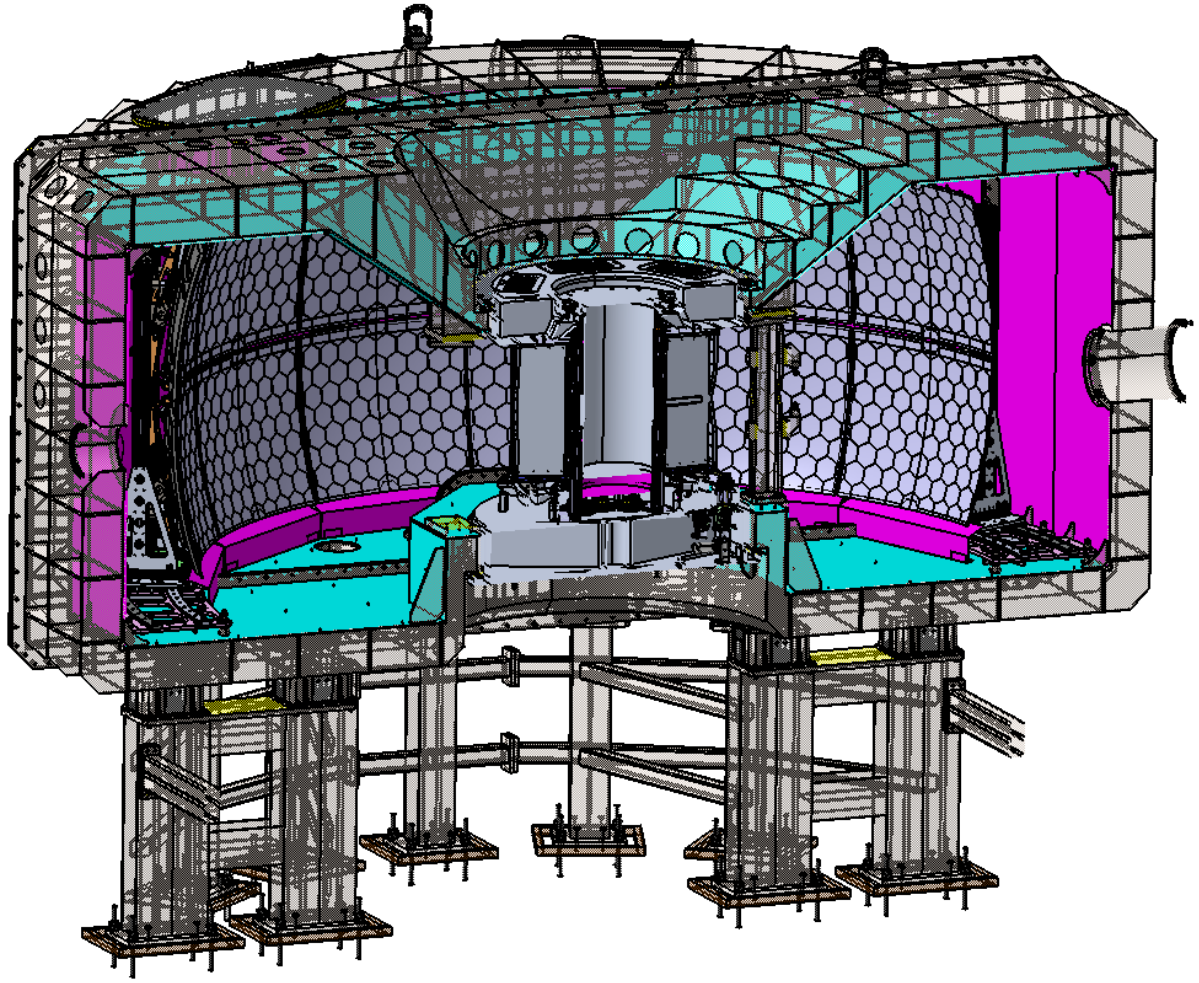

Sample area access
Roof Access from E02 & E01
Main maintenance access

Cave

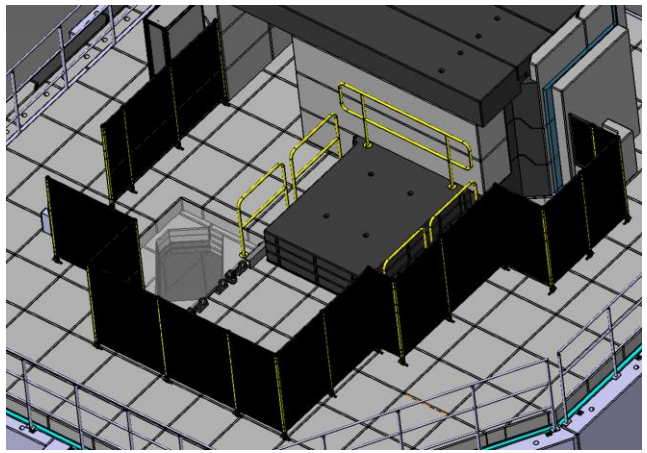
Shielding (in vessel)

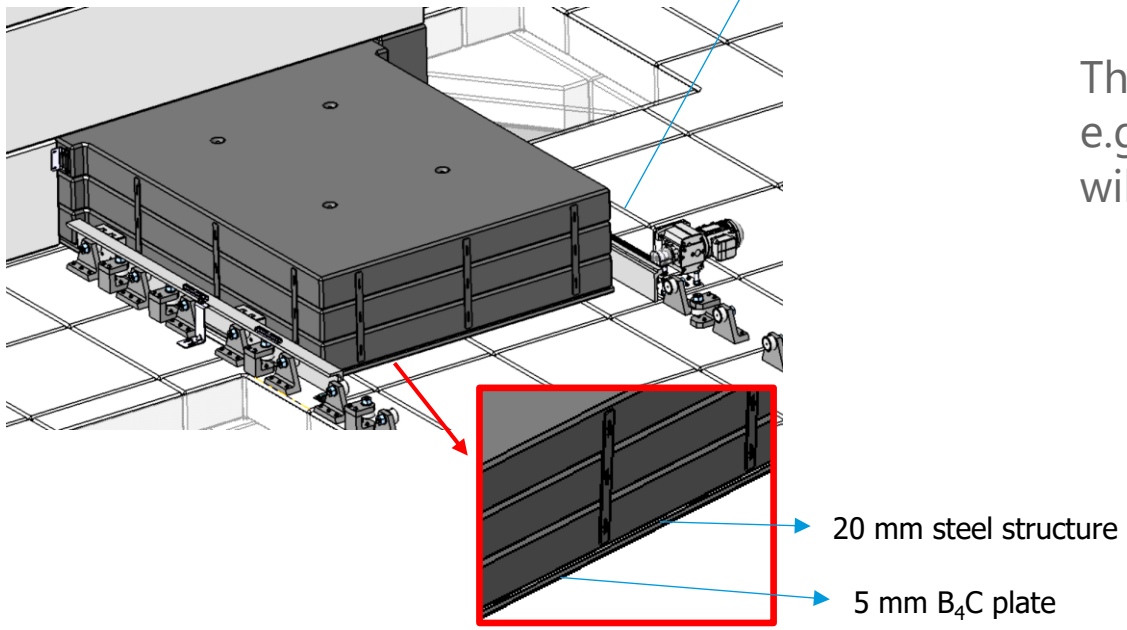
- 1 mm Cd sheet (pink)
- 5 mm B_4C-epoxy sheets (cyan)

To be installed end of 2025/beginning of 2026



Slab





Role: covering sample environment area during operation

- 3 high-density concrete blocks over a steel platform
- Additional layer of B_4C is integrated

The design passed Sub-TG3 review

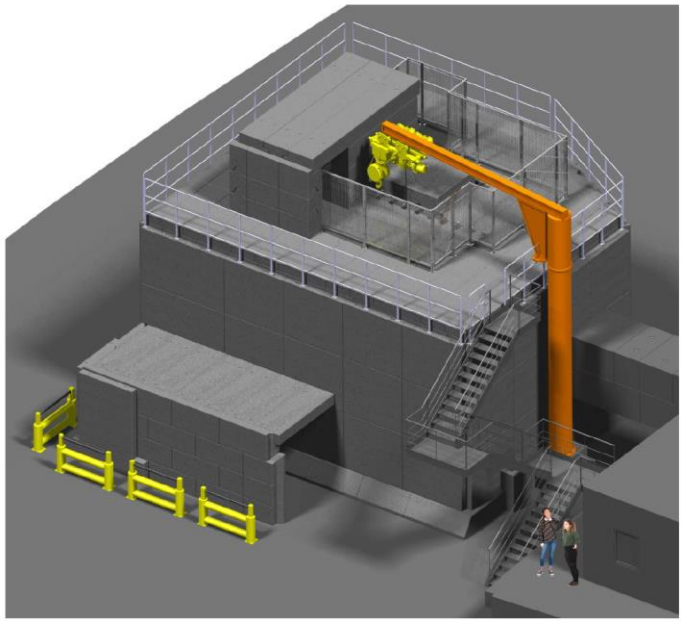
The electrical design (including safety components e.g. switches, fence, handrails, and interfaces with PSS) will be tendered

Slab

Operation

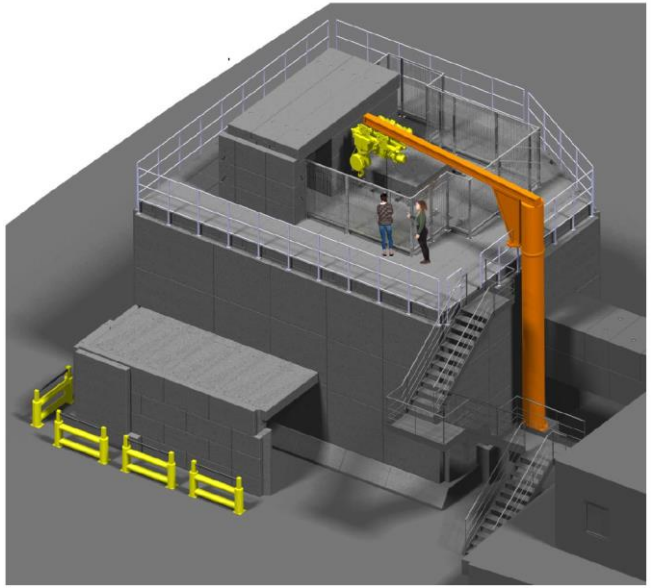
BEAM ON:
- shutter is open
- slab is closed

When shutter is open, PSS:
- Impedes opening the fence's door
- Impedes opening the slab
- Impedes opening of the maintenance door



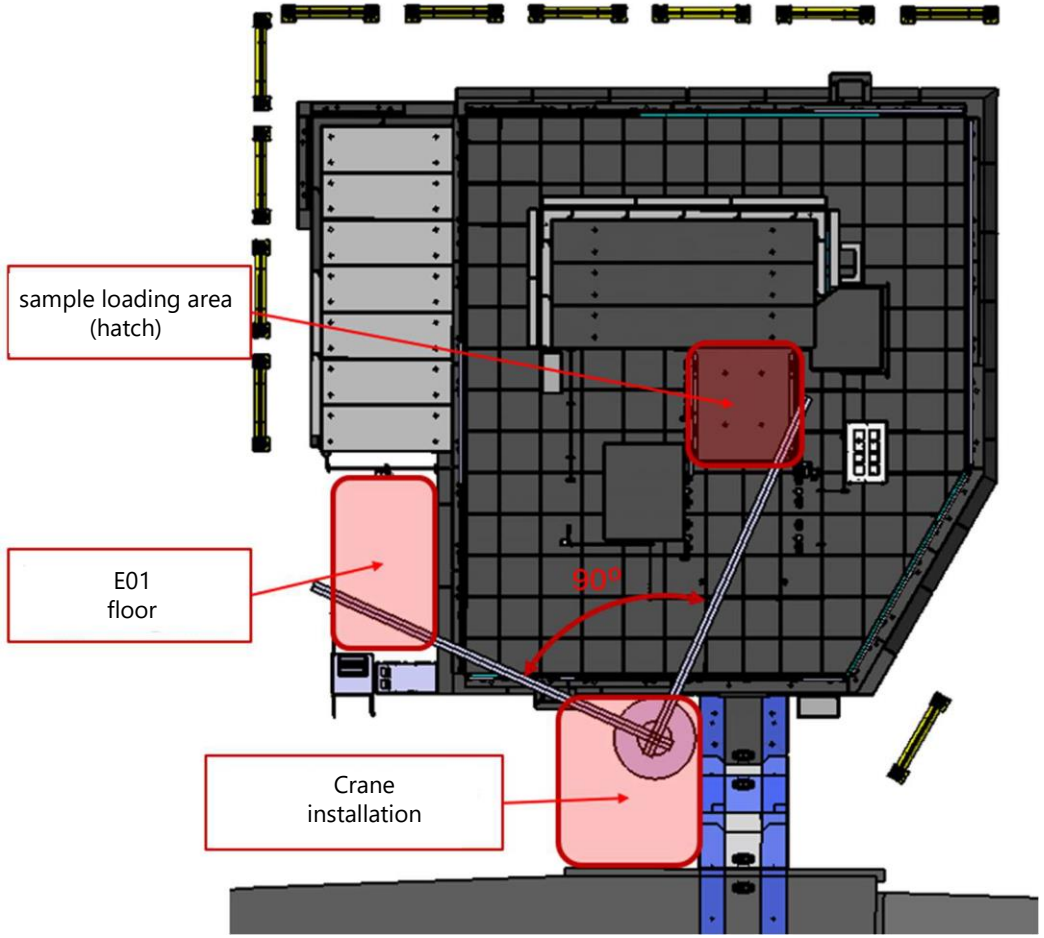
BEAM OFF:
- shutter is closed
- slab is open

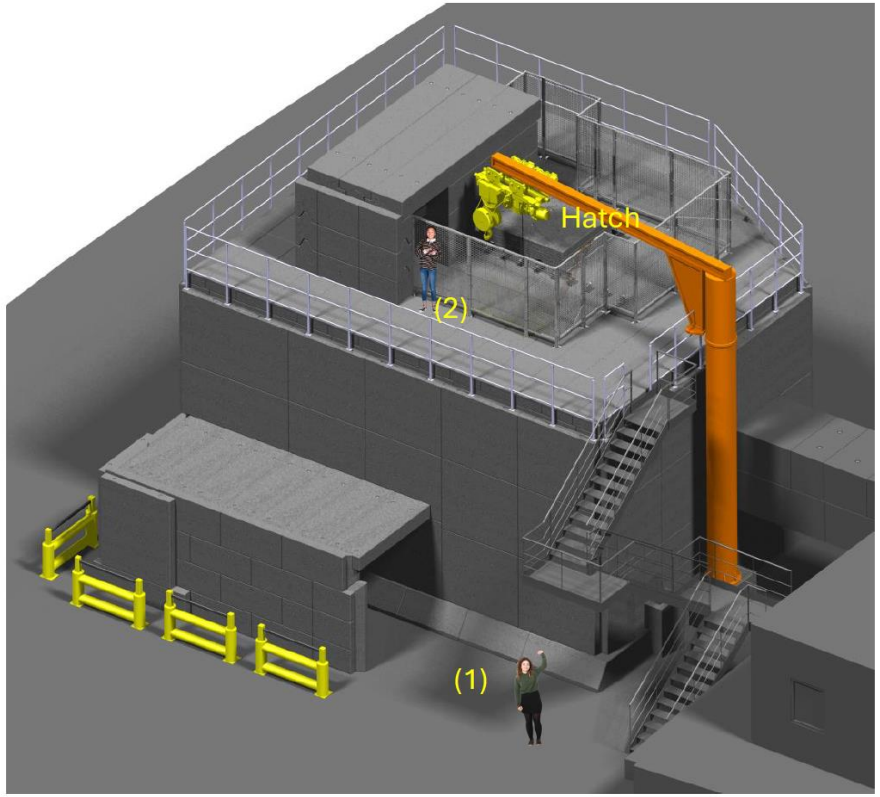
The fence's door can be opened



Crane

- used to transfer SE equipment from/to (1) E01 floor or (2) cave roof to the sample loading area
- technical specification document under review by ESS

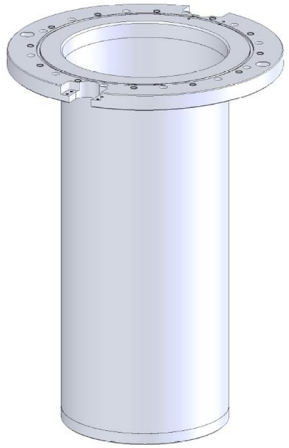


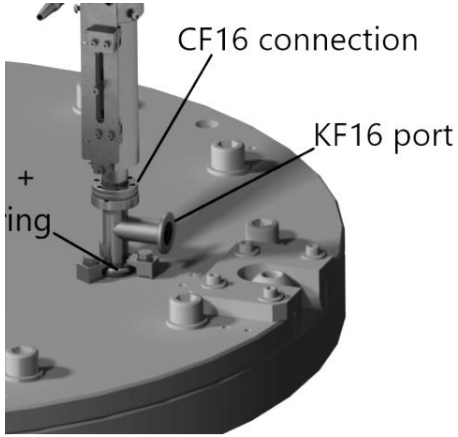


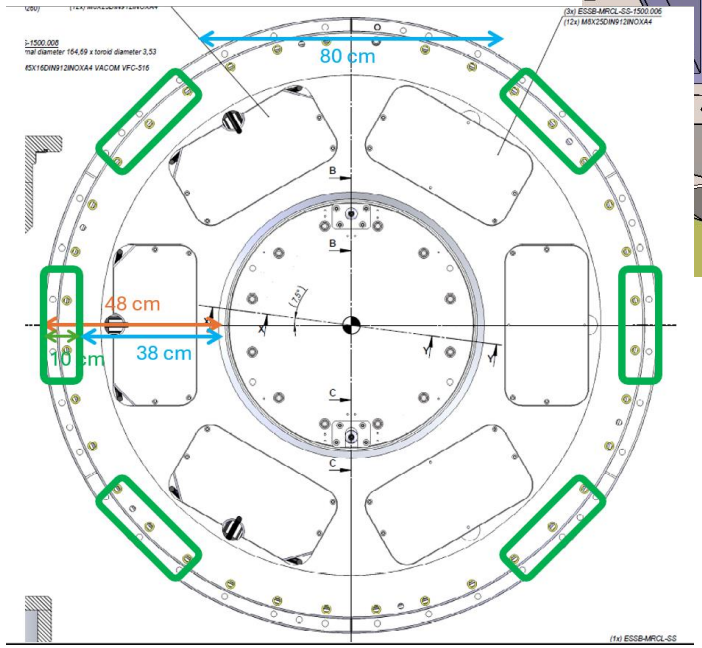
Sample exposure system

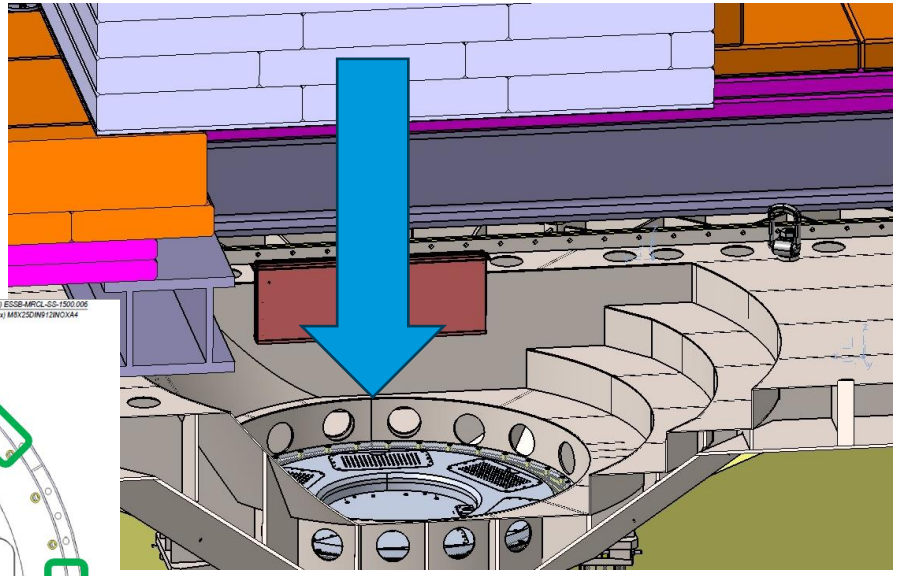
Top-load

- most SE equipment for MIRACLES can be hosted within the sample chamber (inner Ø = 420 mm)

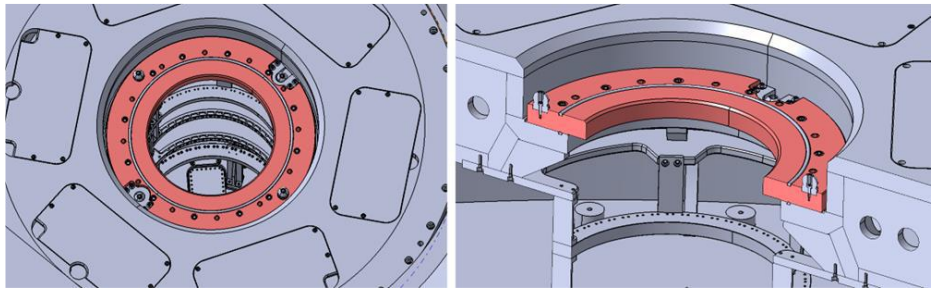




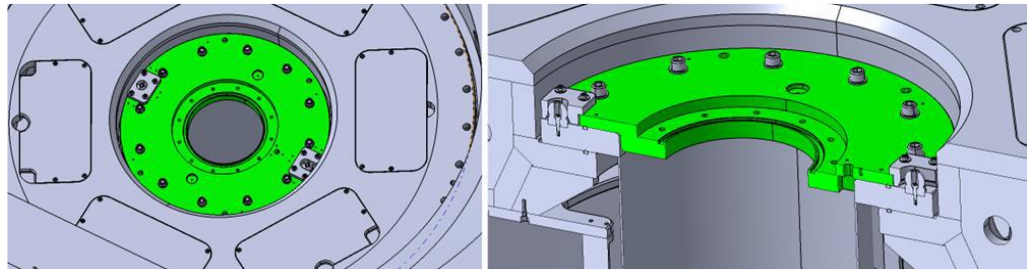




Special cases: transition flanges



L2 inner diameter: 505 mm



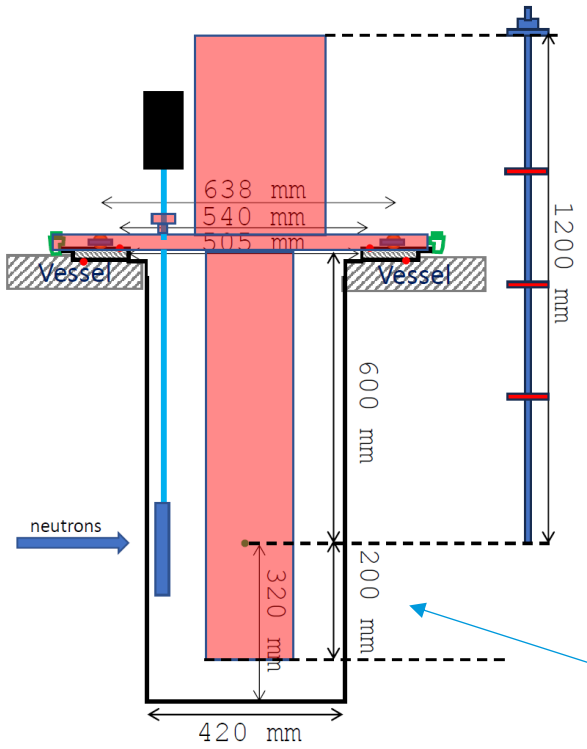
L3 inner diameter: 255 mm

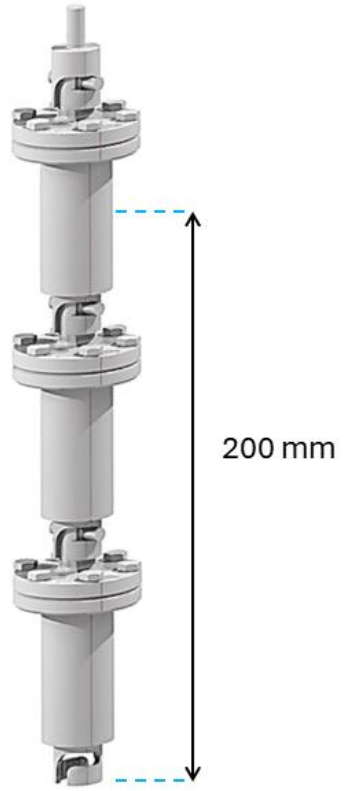
Sample environment

CCR/cryofurnace

Spacial considerations:

- Vertical space to host the linear exchanger
- Radial space to host the slits (and polarization cell)





Motion:

- Z linear motion (mainly to be used with the linear exchanger)
- θ rotational motion (around the Z axis)

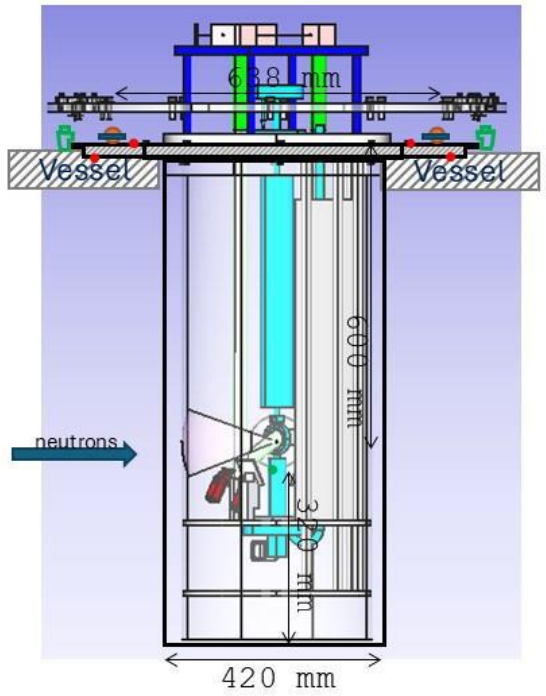
	Range	Accuracy	Repeatability	Resolution	Speed
Z (linear)	±100 mm	±0.1 mm	±0.05 mm	0.01 mm	10 mm/s
θ **(rotational)**	360°	±0.1 °	±0.05 °	0.01 °	2 °/s

Sample environment

Ongoing projects

Application for 2 RÅC proposals

- QENS setup for in situ illumination (Forschungszentrum Jülich, Tartu Universiy, ILL, Umeå University, ESS)



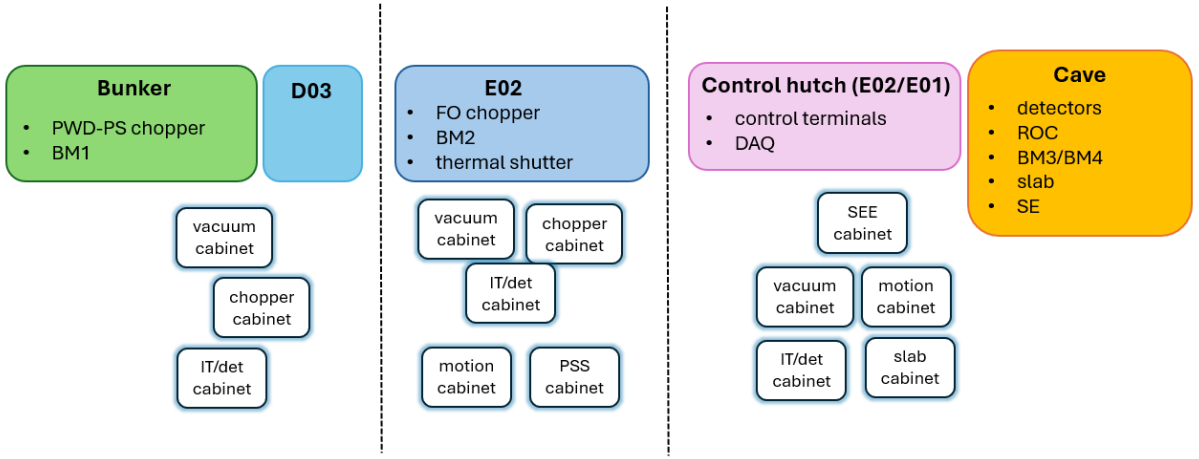
- QENS setup for rapid mixing (Lund University, Tübingen University, KTH, TU Darmstadt, ESS)

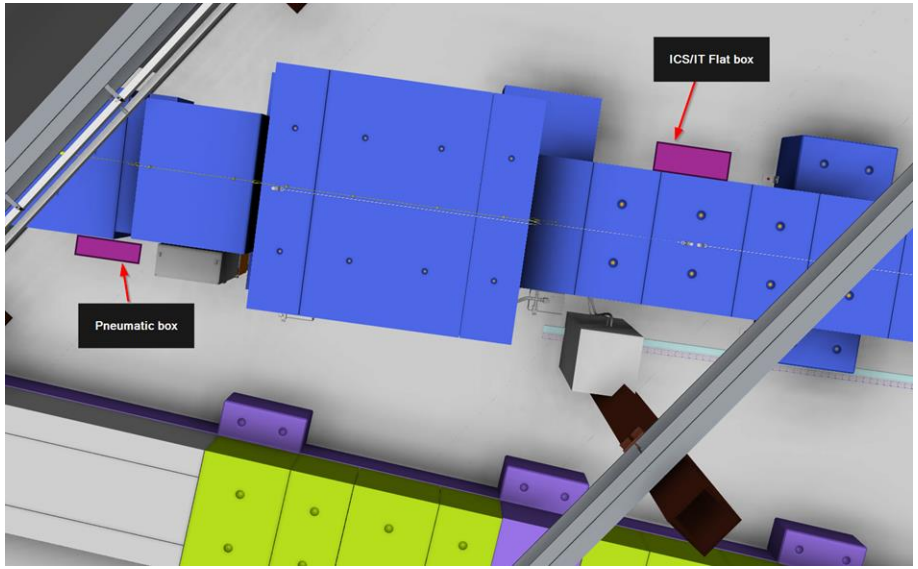
Common Projects

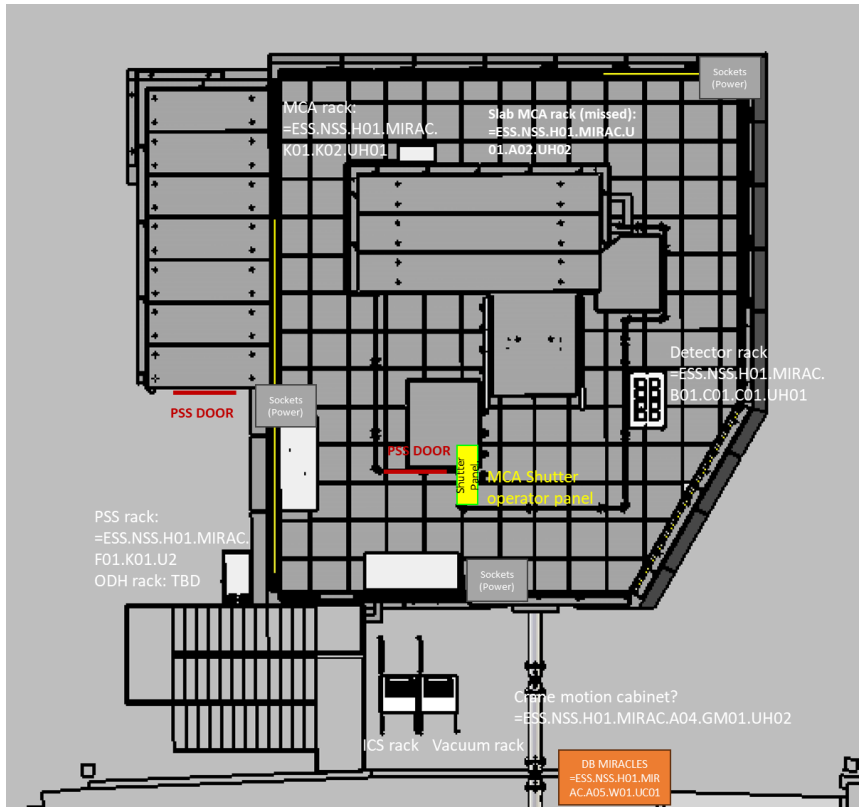
Infrastructure

CUP, CEP

- Electrical routing
- Racks layout
- Feedthroughs
- Positions of vacuum pipes, gas lines, etc.

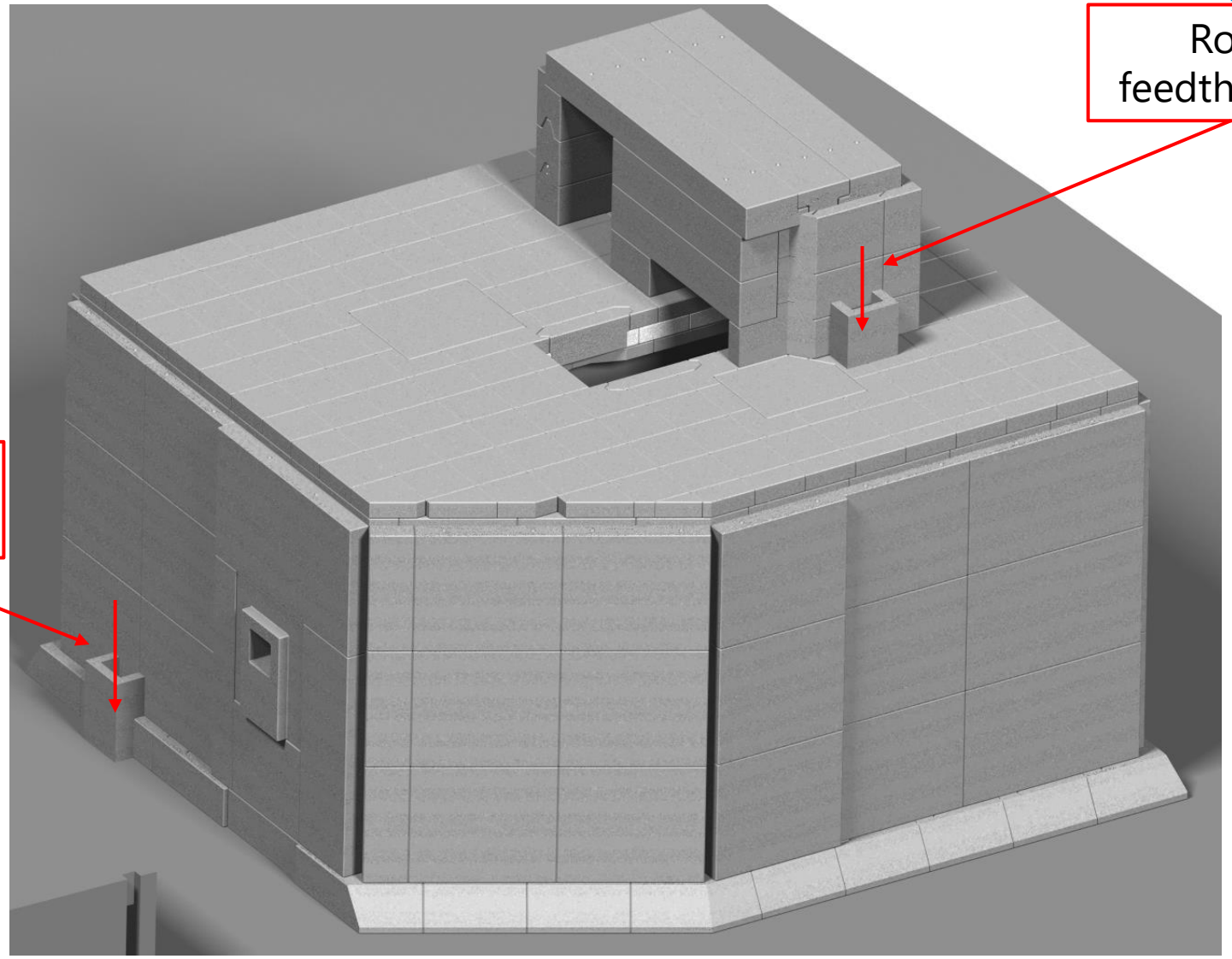






Infrastructure

Cave feedthroughs



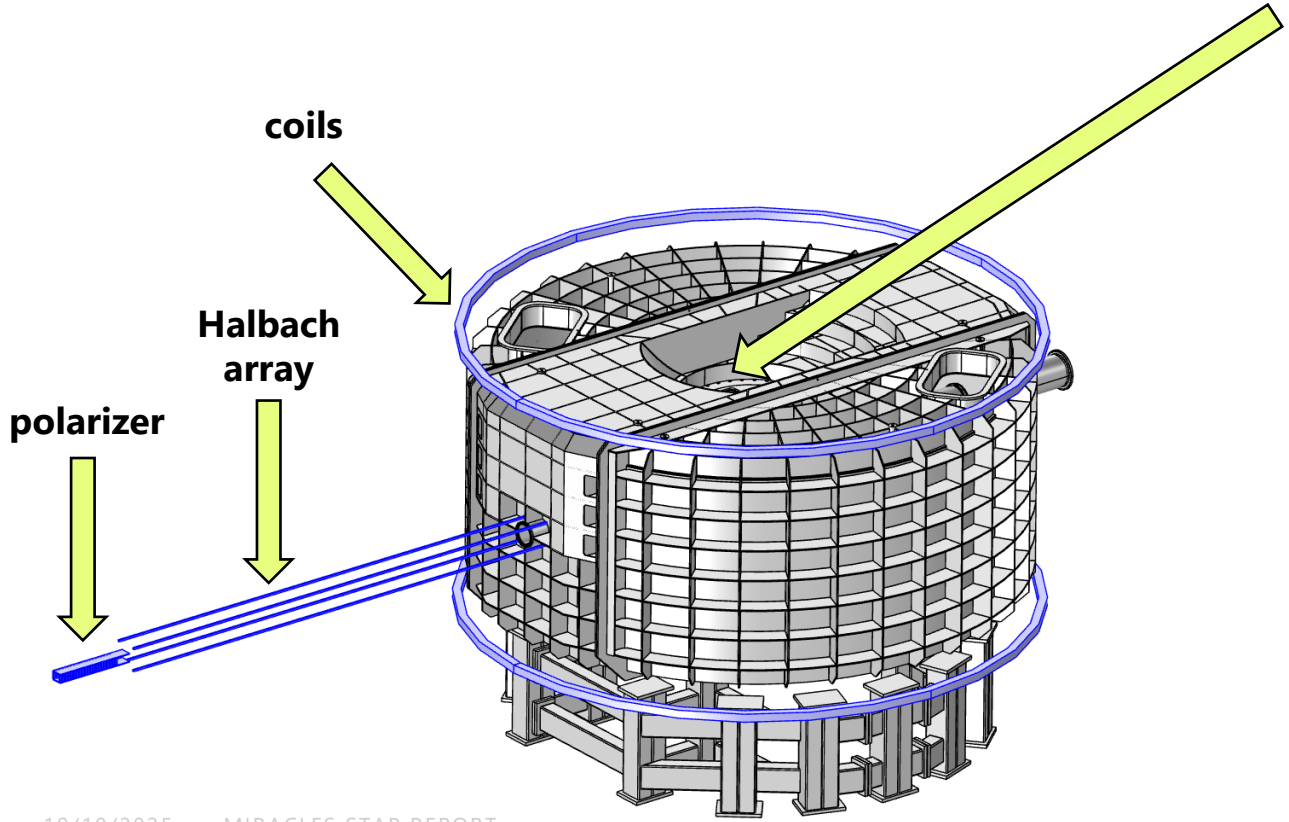
Polarization analysis capabilities

Polarizer

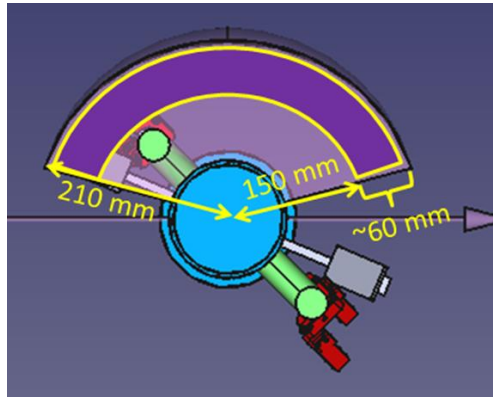
- V-cavity, Fe/Si polarising supermirror centering at 6.27 Å

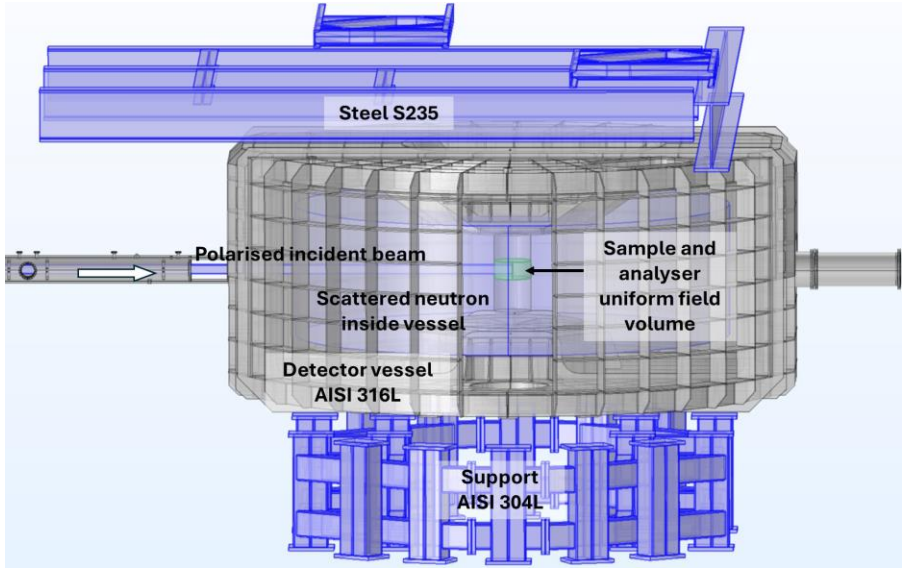
Analyzer

- Wide-angle ^{3}He analyser cell within sample vessel
- Analyser field: Ø7m coil pair outside detector vessel, 1 mT vertical field



3He cell



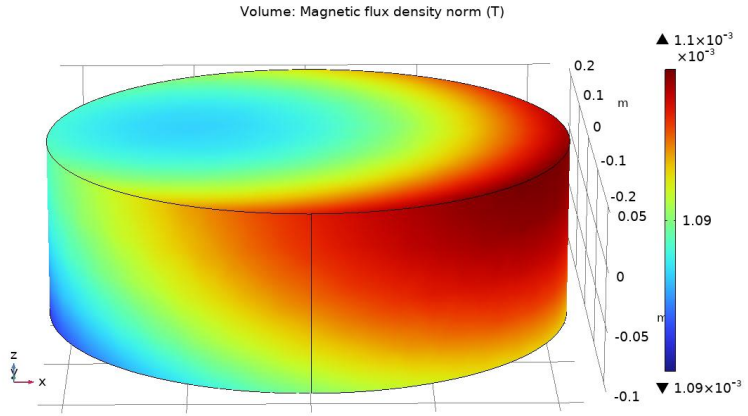


Courtesy of W. T. Lee

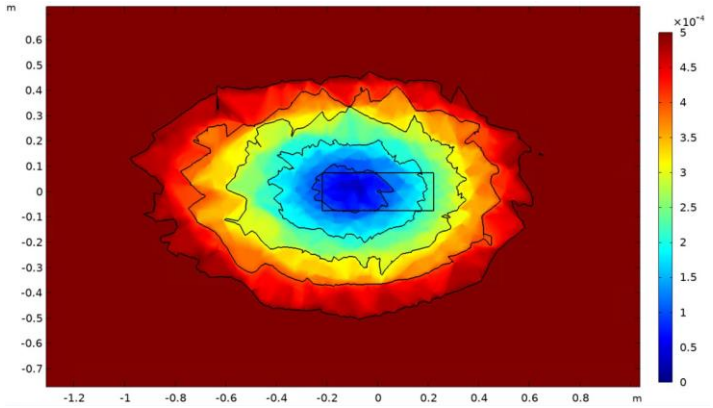
Polarization analysis capabilities

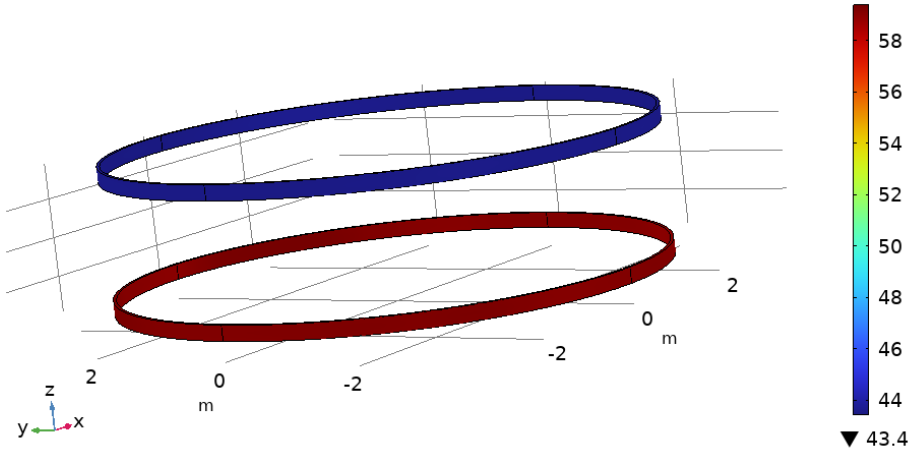
Simulated performances

Field strength: ~ 1 mT

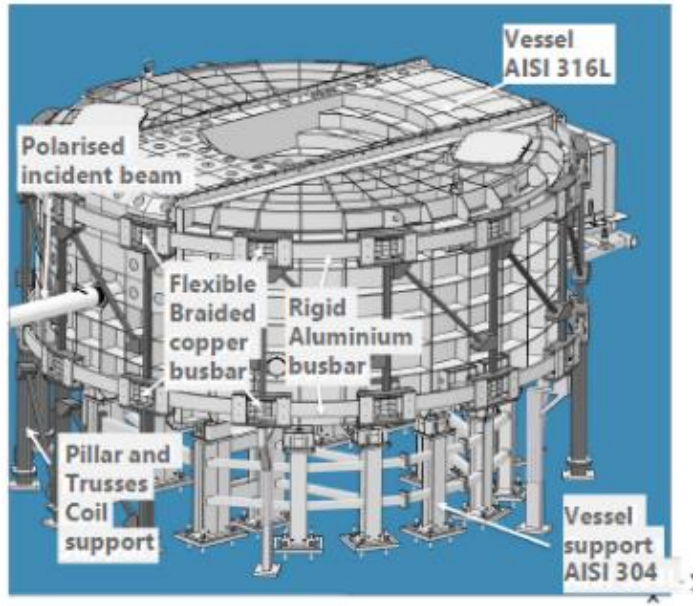


Field uniformity: $|\nabla \hat{b}| < 0.5$ mT (~ 600 hours for 3He cell)





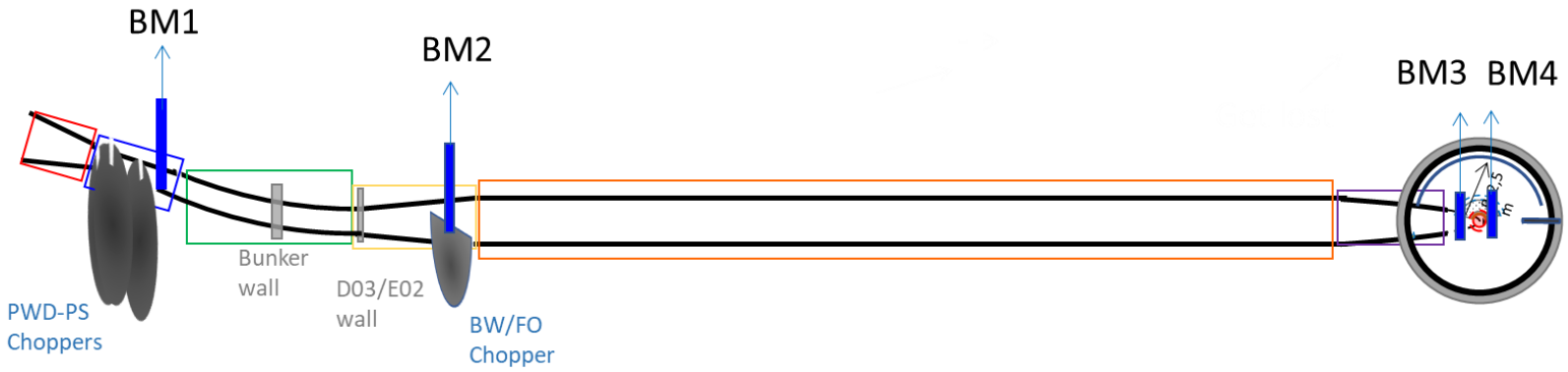
Thermal analysis: passive cooling (needed cooling system for HV power supply)



Courtesy of W. T. Lee

Beam monitors

Common Beam Monitors Project



BM1) in-bunker BM at 8.8 m, after the PWD-PS chopper module (ionization chamber)
BM2) out-of-bunker BM at 55 m, after the FO chopper (ionization chamber/bGEM)
BM3) at 162.2 m, before sample (multi-wire proportional counter)

BM4) after-sample monitor (neutron camera)

MIRACLES team

F. Villacorta
(lead scientist)

A. Conde
(lead engineer)

J. Pereira

I. Aranda

I.Mazkiaran

R. Martínez

A. Simelio
(in-kind)

B. Rosi

C. Beck
(DMSC)

H. Bordallo

Thank you!