Update on polarisation activities

Wai Tung Lee

Common STAP 2026-04-20

Introduction

- Polarisation project aims to deliver polarisation capabilities to multiple instruments.
- 10/2019 – 8/2020 Discussed with the team of each instrument that would benefit from having polarisation capability and developed WP.
- 2021 ESS re-baseline.
- There was resource issue – lack of designer had caused delay.
- 1/2024 Project joint NSS TPG. Resource issue began to be addressed.
- Project is picking up pace with more designers.

Here we present the work units to be completed by the end of 2027.

The team

Wai Tung (Hal) Lee
Team Lead
from 10/2019

Tushar Batra
Project Engineer
from 3/2025

Joel Hagman
Project Technician
from 4/2023

Cristea Ionut
Designer
from 1/2025

Nauzet Vega Reyes
Designer (50%)
from 7/2025

Cristea Ionut
Designer
from 12/2025

Christofer Svensson
Designer
from 2/2026

SEOP Station (WBS 3)

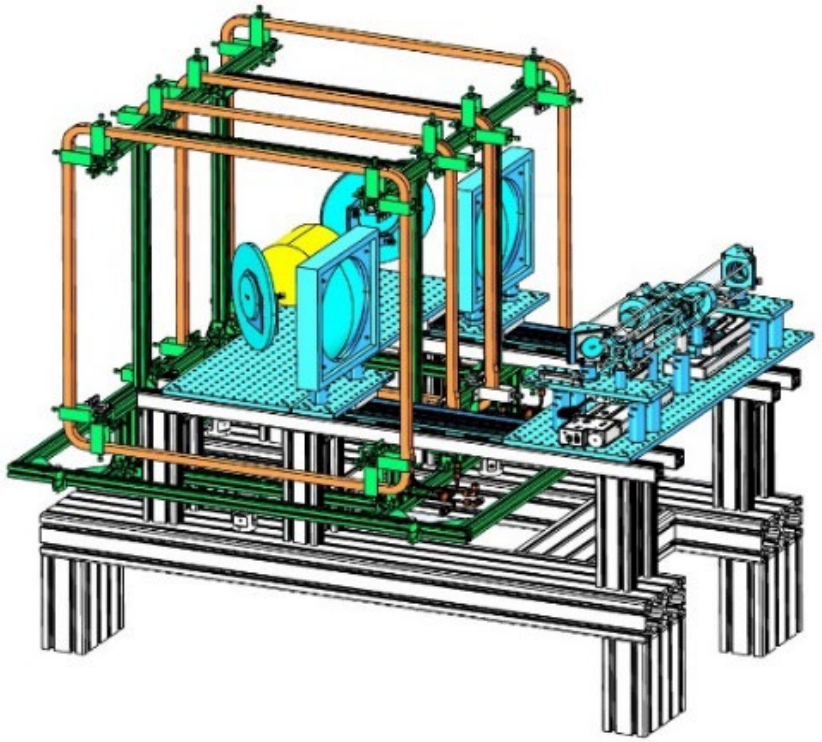
SEOP is a lab-based gas-polarising station.

- Polarises ^{3}He gas using the Spin-Exchange Optical Pumping process.
- Polarise cell of polarised ^{3}He gas to 70% - 85% over 12-24 hours.
- Short duration to construct: 8 months

Use:

- A platform for equipment development
- Supply polarised ^{3}He cells for testing equipment on instrument.

Modelling: Hal Lee, Joel Hagman
KO meeting done. On-going.



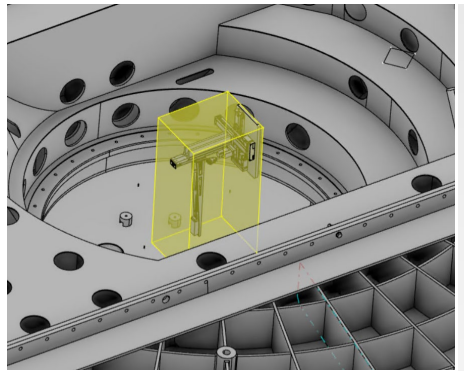
Field Mapper (WBS 4)

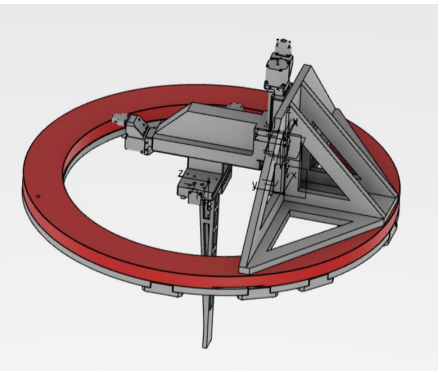
Systematically move a field probe in 3-dimensions to produce a 3d field map.

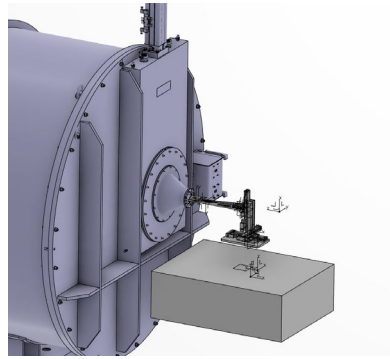
- Accommodates different field probe types.
- Design to have low magnetic signature to avoid magnetic interference to the probe.

Use:

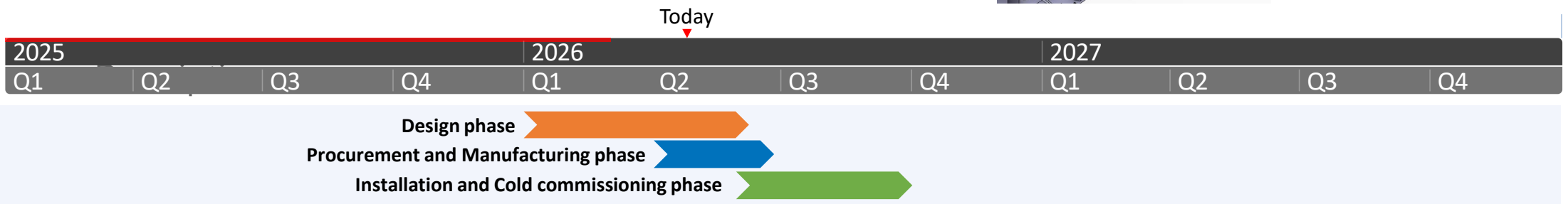
- Magnetic field equipment development.
- Mapping field environment at instruments and labs.







Designing: Nauzet Vega Reyes
KO meeting done. On-going.

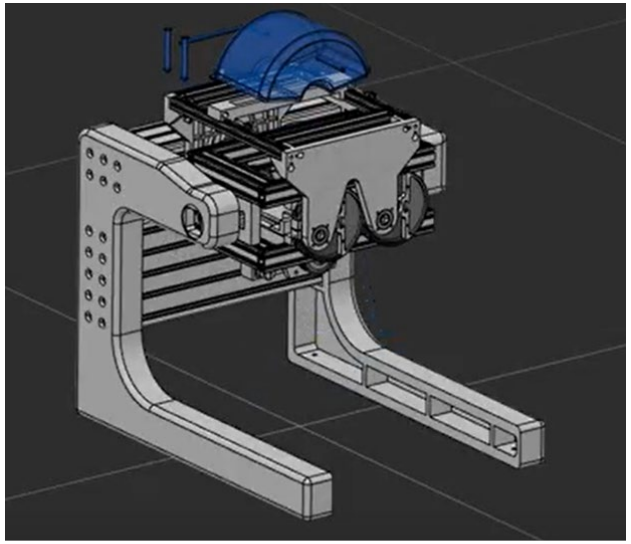


Cell Making Setup (WBS 5)

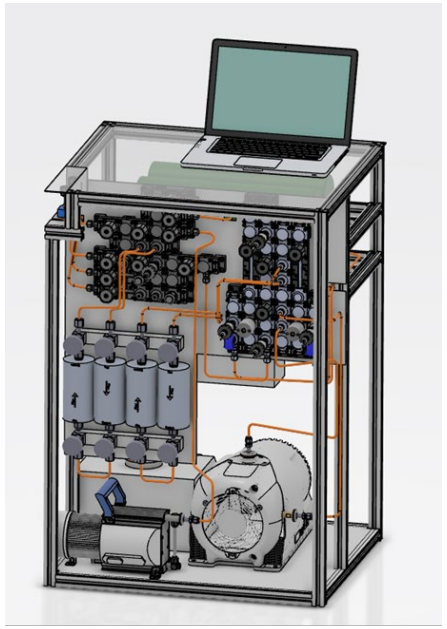
- Cell washing station to thoroughly clean cell body.
- Pressure test setup to test cell up to 1.43 x working pressure.
- Station for cell baking, alkali filling, and (for SEOP) ^3He and N_2 gas filling.

Use:
Make polarised ^3He cells for polarisers and analysers.

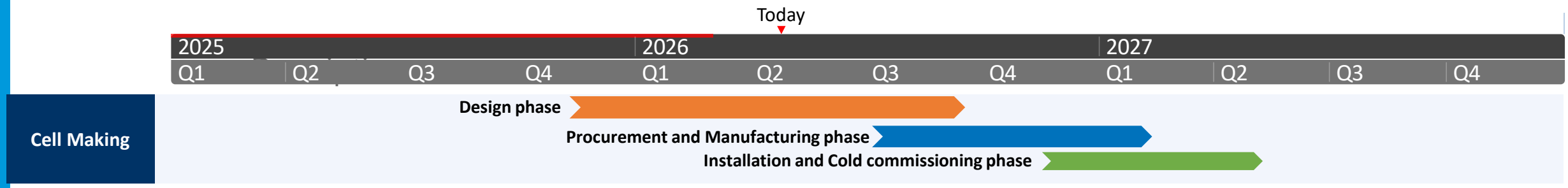
Some modelling done by Bartlomiej Markiel
Designing: Patrik Malek
KO meeting done. On-going.



Cell washing station



Cell-making station
gas circuit



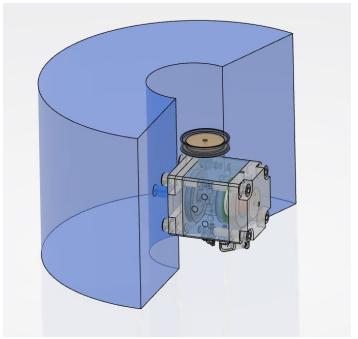
Wide-Angle Analyser 1 (WBS 6)

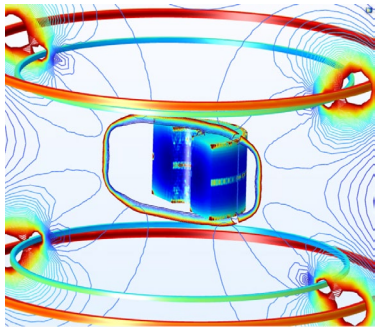
Wide-angle cell filters scattered neutrons according to spin state in diffraction and spectroscopy instruments.

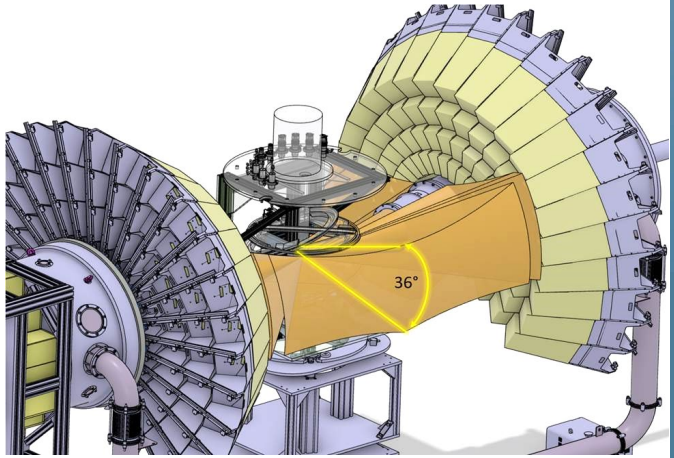
- Curved and wrapped around sample position.
- ^{3}He gas pressure and cell dimension determined by neutron wavelength and the targeted performance.

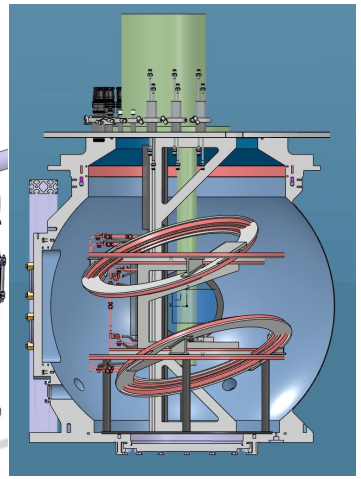
Uniform field from coils keeps ^{3}He gas polarised.

- Requires exceptional field angular uniformity <0.03°/cm





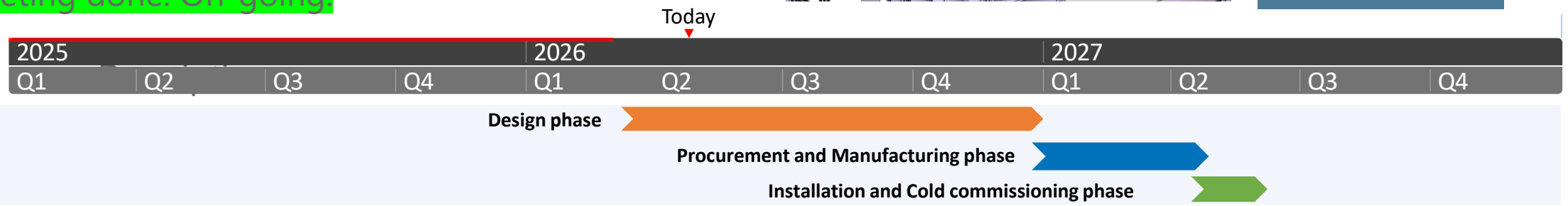




Use:

For polarization analysis on DREAM, HEIMDAL, CSPEC, MIRACLES, T-REX.

Some modelling done by Bartlomiej Markiel
Designing: Christofer Svensson.
KO meeting done. On-going.



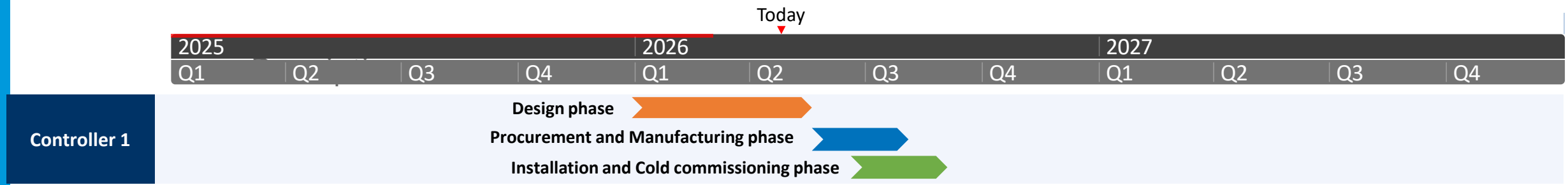
Polarisation Mobile Controller 1 (WBS 7)

A half-rack cabinet housing electronics and pneumatic control components.

- Communicate with instrument.
- Control and data processing.
- Supply current to field coils, r.f. field to flipper and diagnostic coils.
- Control pneumatic switches.
- Read and process feedbacks from sensors.

Use:
For polarisation operations at instruments and labs.

Not started. Delay.



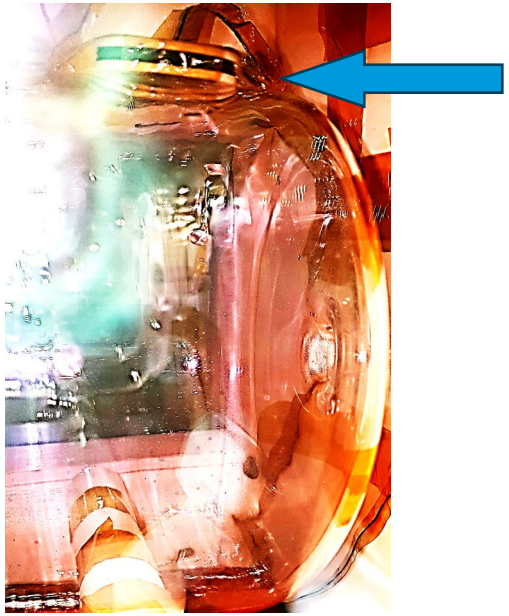
FID - ^{3}He Polarisation Measurement (WBS 8)

Free-Induction Decay is a Nuclear Magnetic Resonance method using a small coil at ^{3}He cell wall to measure relative ^{3}He polarisation

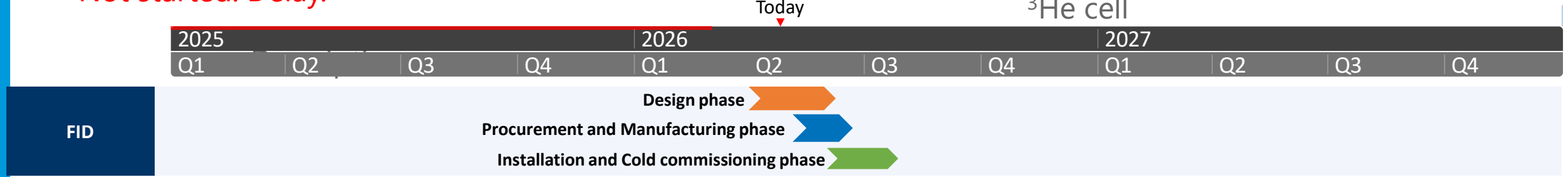
- Electronic pulse sent through the coil to excite ^{3}He spin.
- Emission due to rotation of ^{3}He spin picked up by the same coil and amplified by electronics.
- One of simplest way to track ^{3}He polarisation.

Use:
For polarisation operations at instruments and labs.

Not started. Delay.



Example of FID coil on ^{3}He cell



In-situ SEOP Station (WBS 9)

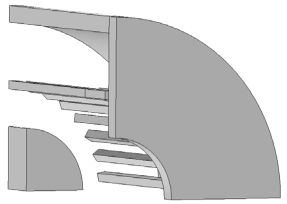
In-situ SEOP setup polarises SEOP cell on instrument during experiment, maintaining static neutron polarisation or analysing power

- SEOP cell to filter neutron according to spin state.
- Oven to heat cell to between 160°C to 210°C. Allows laser passage.
- Laser optics to optically pump Rb or K, polarising them for SEOP process.
- Magnetic field to define and maintain polarisation.

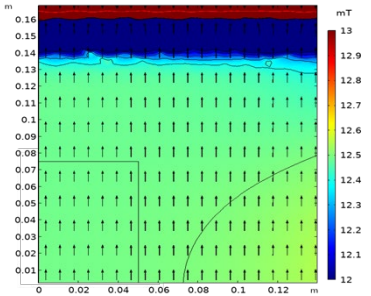
Use:

For polarisation applications on SKADI, FREIA, HEIMDAL.

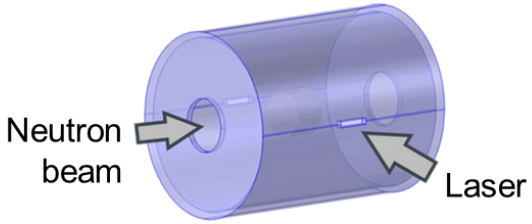
Discussion with instrument and some calculations done.
Support by VR grant. Starting with Uppsala U. Delay.

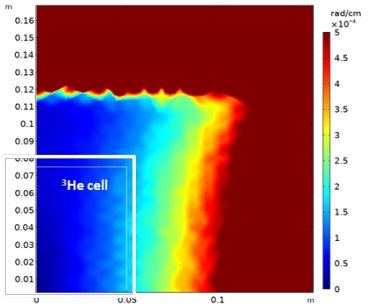


1/8 model



Field strength





Field uniformity

Today

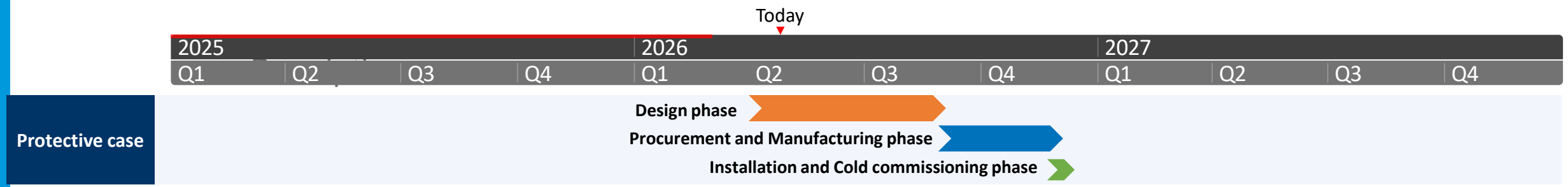
	2025				2026				2027			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
In-situ SEOP	Design phase											
					Procurement and Manufacturing phase							
									Installation and Cold commissioning phase			

Protective Case (WBS 10)

To protect both personnel and ^{3}He cell, each cell will be contained in a case most of the time, except when it is in storage between use.

Use:
For polarization applications on instrument or in lab.

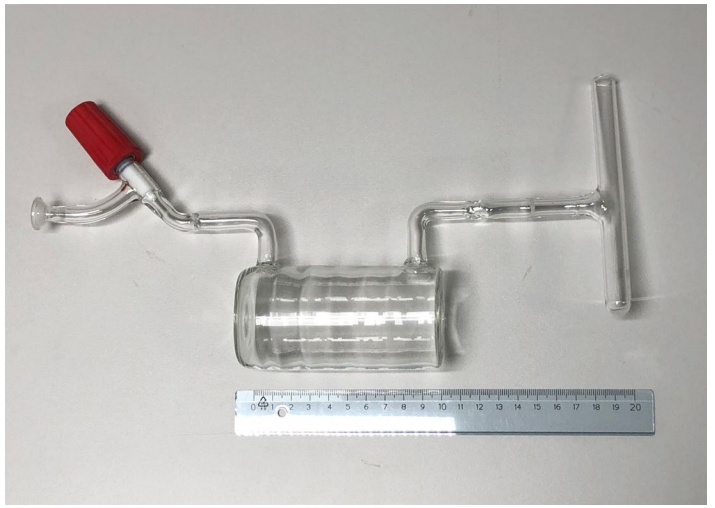
Not started. Delay.



Cylindrical SEOP cell (WBS 11)

SEOP cell filters neutron according to spin

- GE-180 aluminosilicate glass cell
- ^{3}He and nitrogen gas
- Rb and K
- The challenge is both handling GE-180 glass and the physical processes that determine cell performance are still not fully understand.
- Success rate between 50% to 90%



Use:
For polarization applications on DREAM, SKADI, FREIA, HEIMDAL.

Test cell made by Scientific-Lab Glass AB in Lund. Start in Q3.

Polarisation mobile controller 2 (WBS 12)

See WBS 7 for details

Start in Q3.

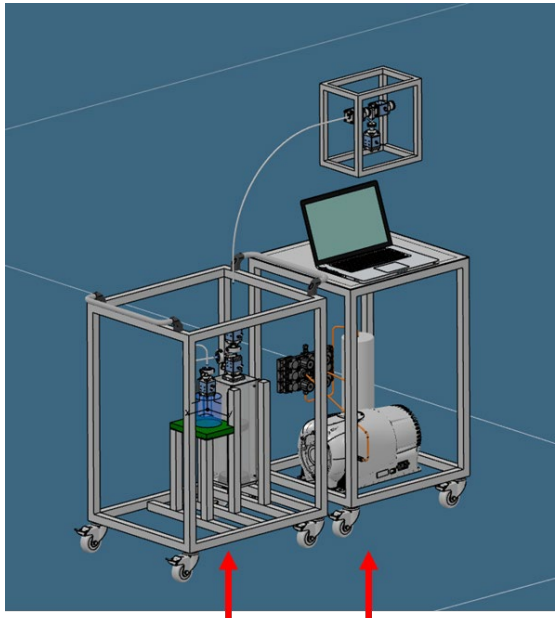
^{3}He gas transporter 1 (WBS 13)

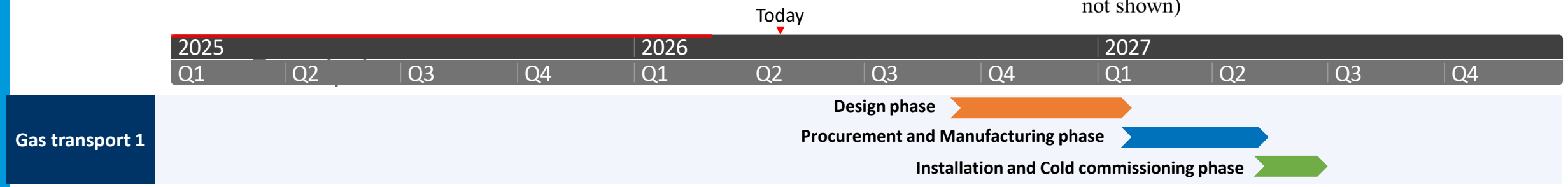
Wheeled container of a cell of polarised 3He with a highly uniform, 1 – 2 mT magnetic field and optional gas transfer circuit.

- Magnetostatic cavity made of permanent magnet arrays and μ-metal enclosure.
- If used as gas transporter, gas transfer circuit is mounted in the transporter and connect to the gas transport cell

Use:
For polarization applications on DREAM, HEIMDAL, CSPEC, MIRACLES, T-REX.

Preliminary modelling by Bartlomiej Markiel. Start in Q3





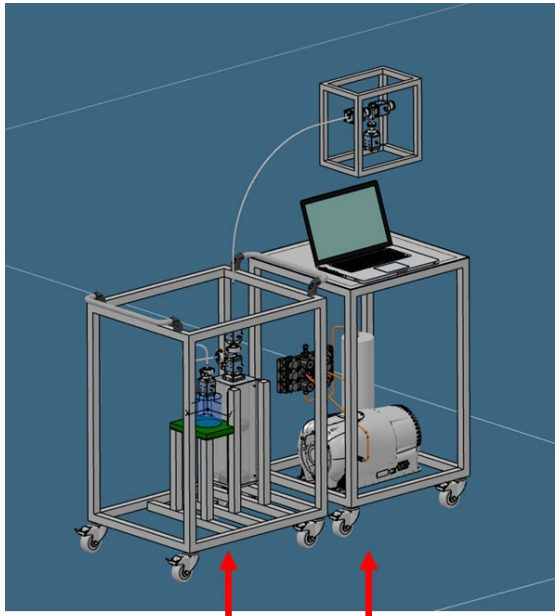
^{3}He gas exchanger 1 (WBS 14)

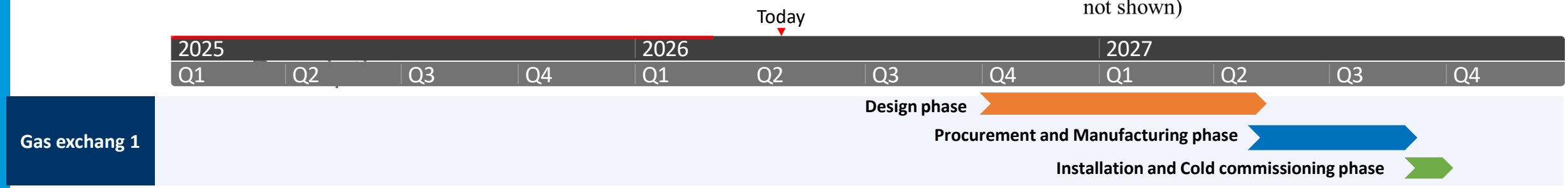
Exchange ^{3}He gas with low polarisation in a cell in instrument with freshly polarised ^{3}He gas in transporter.

- Gas flow components are designed to preserve ^{3}He ´polarisation.

Use:
For polarization applications on DREAM, HEIMDAL, CSPEC, MIRACLES, T-REX.

Start in Q4.

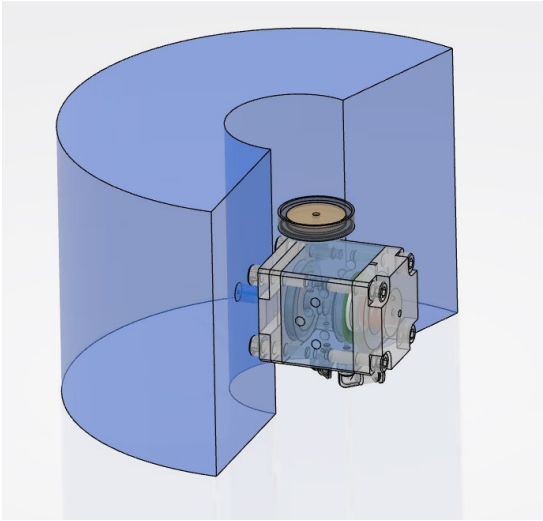




MEOP wide-angle cell (WBS 15)

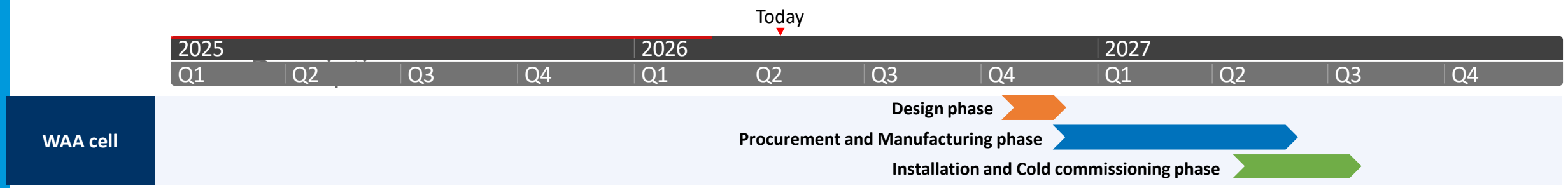
Wide-angle cell is used to filter scattered neutrons according to spin state in diffraction and spectroscopy instruments.

- Curved and wrapped around sample position.
- ^{3}He gas pressure and cell dimension determined by neutron wavelength and the targeted performance.
- Cell body is either glass or silicon.



Use:
For polarization applications on DREAM, HEIMDAL, CSPEC, MIRACLES, T-REX.

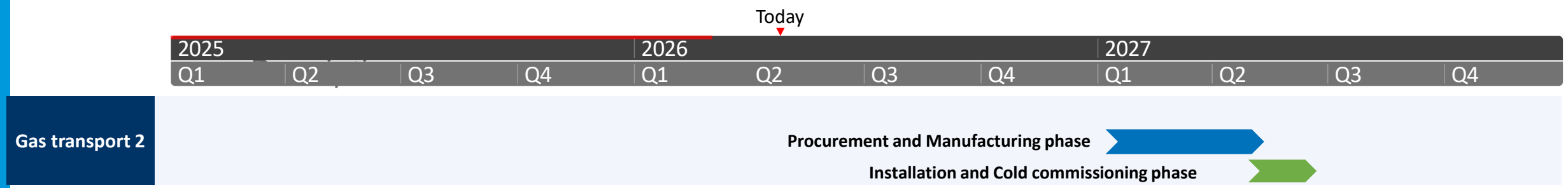
Start in Q4.



Wide-Angle Analysis 2 (WBS 16)

See WBS 6 for details

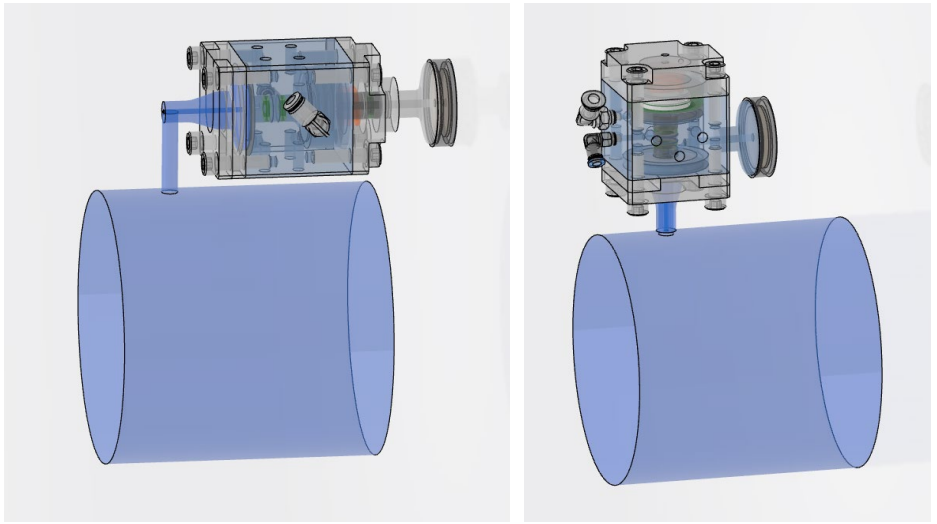
Start in Q1 2027.



MEOP cylindrical cell (WBS 17)

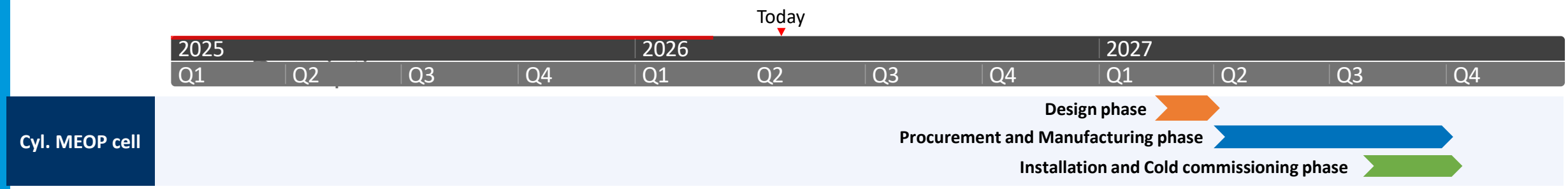
Cylindrical cell is used to filter either incident or narrow-angle scattered neutrons according to spin state.

- MEOP cells are valved.
- Neutron windows are made of circular silicon plate.
- ^{3}He gas pressure and cell dimension determined by neutron wavelength and the targeted performance.
- Cell body is either glass or silicon.



Use:
For polarization applications on SKADI, FREIA, HEIMDAL.

Start in Q1 2027.

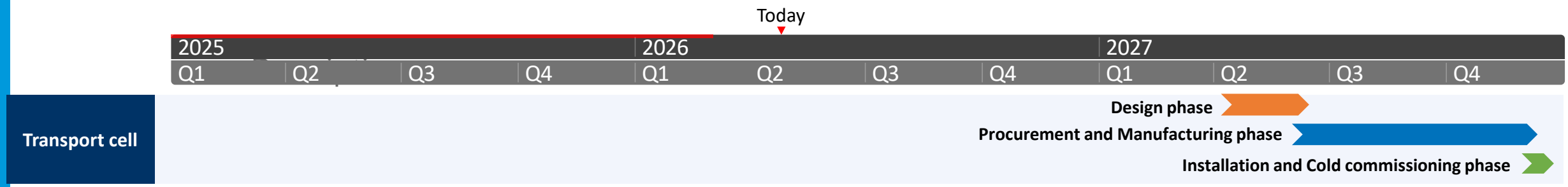


MEOP Polarised ^{3}He Transport cell (WBS 18)

A valved spherical cell with long T1 filled at MEOP station and taken in a gas transporter to instrument.

Use:
For polarization applications on DREAM, HEIMDAL, CSPEC, MIRACLES, T-REX.

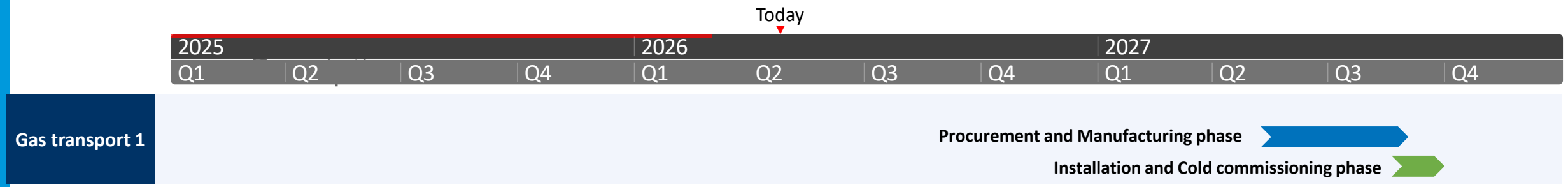
Start in Q2, 2027.



^{3}He gas transporter 2 (WBS 19)

See WBS 13 for details

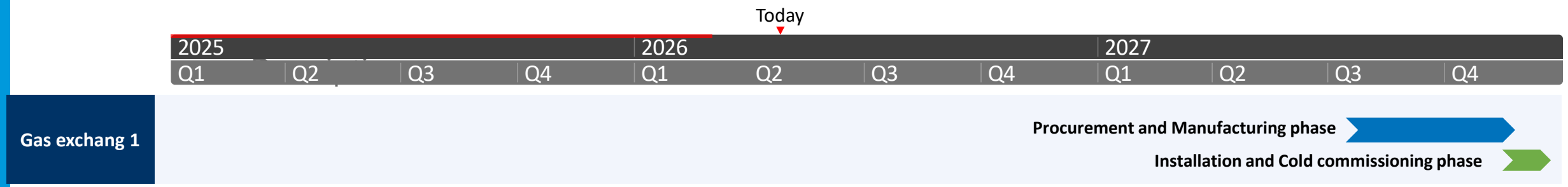
Start in Q2, 2027.



^{3}He gas exchanger 2 (WBS 20)

See WBS 14 for details

Start in Q3, 2027.

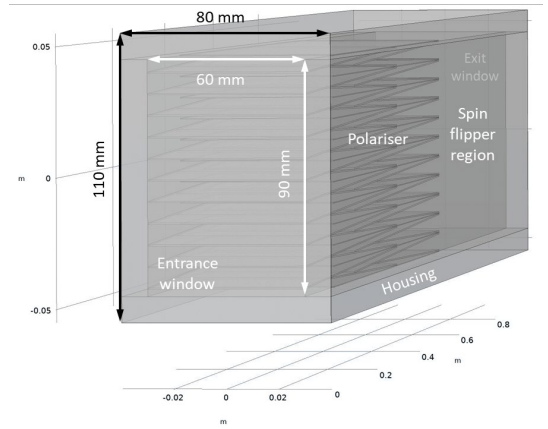


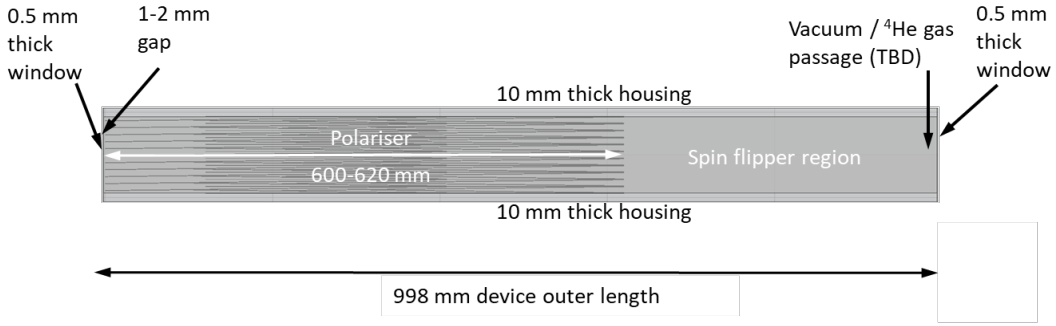
BIFROST – Polariser, inclident flipper (WBS 21)

Supermirror use spin-dependent reflection of neutron to split the beam path according to spin state. Neutrons in one spin state are then attenuated.

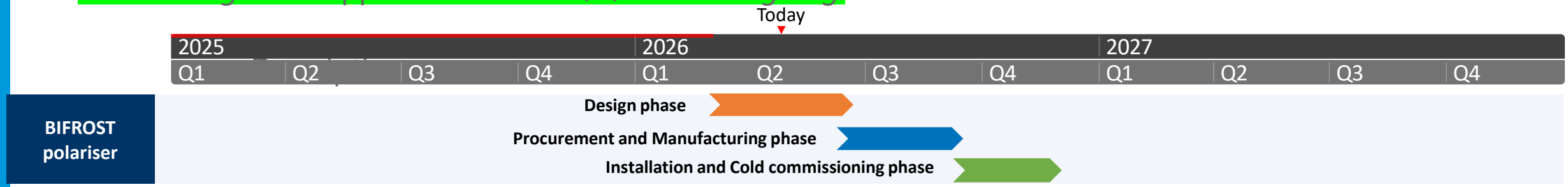
- 95% polarisation at 2 Å. Higher polarisation at longer wavelengths.
- >32% transmission at 6 Å. Higher transmission at shorter wavelengths.

Use:
Polariser on BIFROST.





Supported by VR grant.
KO meeting with supplier was held 15/4/2026. On-going.



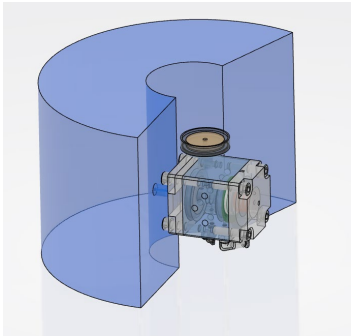
Grant: E. Blackburn, M. Månsson, W.-T. Lee, G. Nilsen, P. Deen, R. Toft-Petersen, M. Pascal, Swedish Research Council (VR) "Cooperation with ISIS: instrumentation and methods for ESS" Grant # 2021-06157.

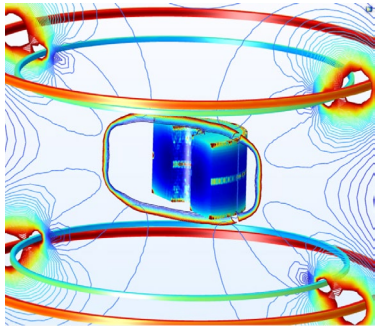
DREAM – Interface to WAA (WBS 22)

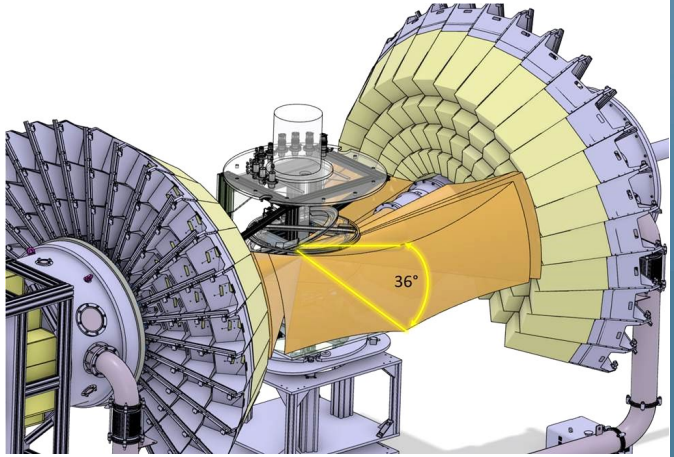
WAA integration to DREAM.

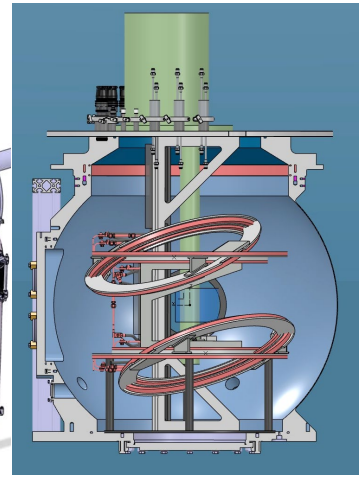
Use:
Polarisation analysis setup on DREAM.

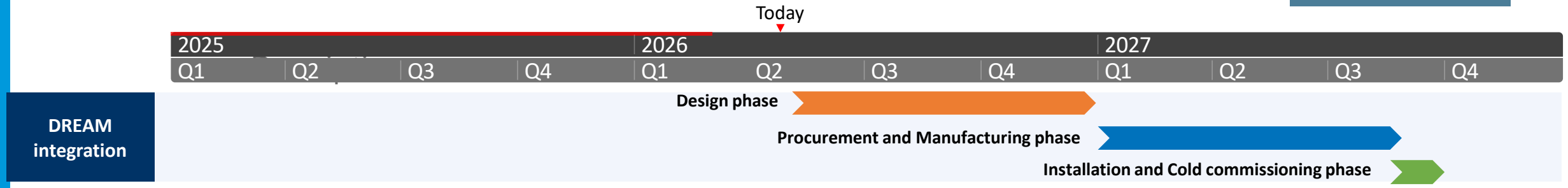
Some modelling done by Bartlomiej Markiel
Designing: Christofer Svensson.
KO meeting done. On-going.









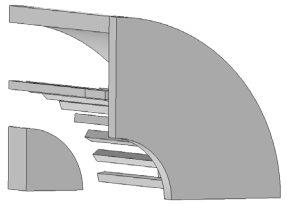


SKADI – Interface to Analyser (WBS 23)

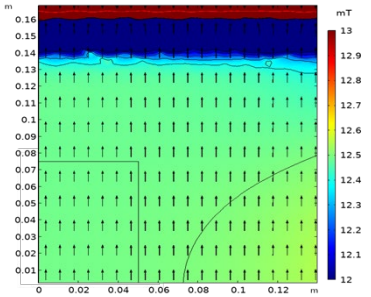
In-situ SEOP analyser integration to SKADI.

Use:
Polarisation analysis setup on SKADI.

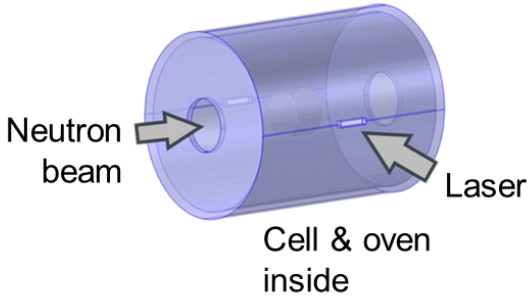
Discussion with instrument and some calculations done.
Support by VR grant. Starting with Uppsala U. Delay.

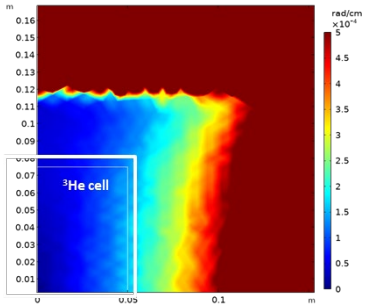


1/8 model

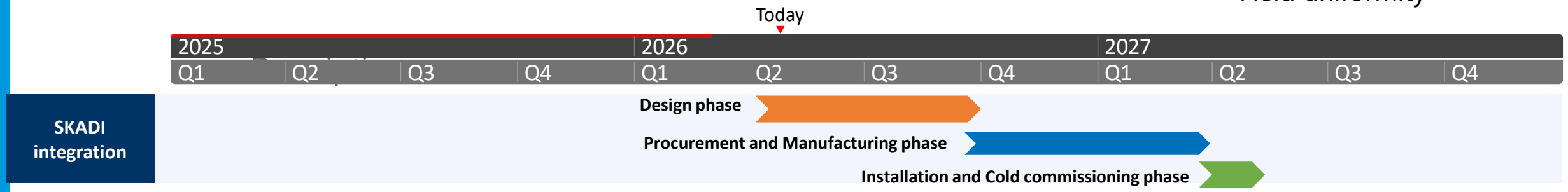


Field strength





Field uniformity



Grant: M. Wolff, E. Blackburn, D. Honecker, W. T. Lee, G.J. Nilsen, S. Parnell, A. Stellhorn, R. Woracek, Swedish Research Council (VR) "Cooperation with ISIS: instrumentation and methods for ESS" Grant # 2025-07620.

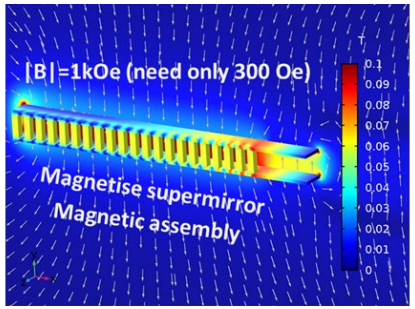
CSPEC – Guide Field, Analyser (WBS 24)

CSPEC polarisation scope includes

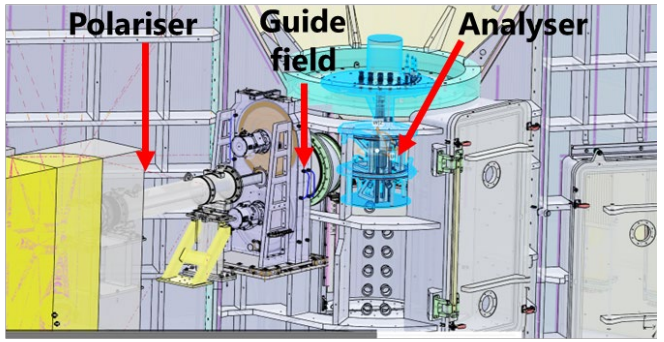
- Optics exchanger to translate polariser into and out of the beam.
- Guide fields from polariser to analyser
- Wide-angle analyser integration to sample and detector vessel.

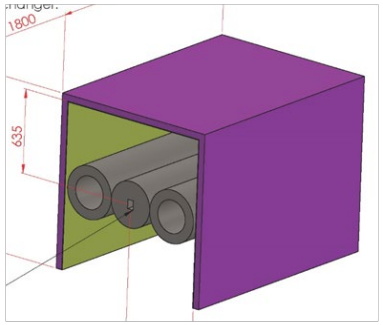
Use:
Polarisation analysis setup on CSPEC.

Discussion with instrument team, some modelling and some calculations done.
Start Q1 2027.

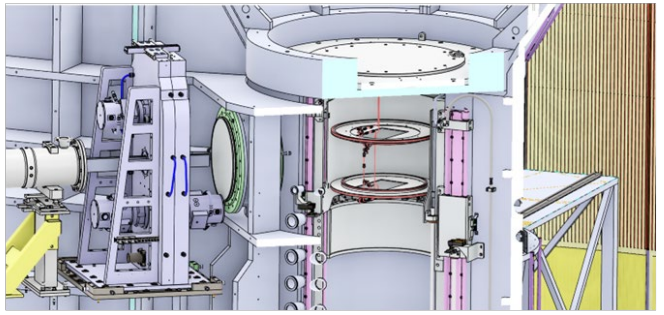


Polariser field





Exchanger steel shield (drawing from CSPEC)



Placement check of analyser in CSPEC

Today

2025				2026				2027			
Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4

SKADI integration

Design phase

Procurement and Manufacturing phase

Installation and Cold commissioning phase

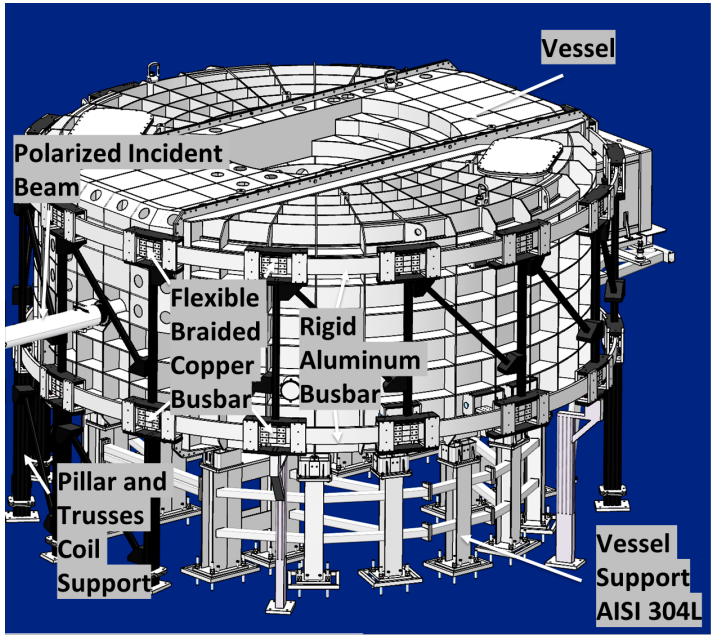
MIRACLES – Polarisation (WBS 25)

MIRACLES polarisation scope includes

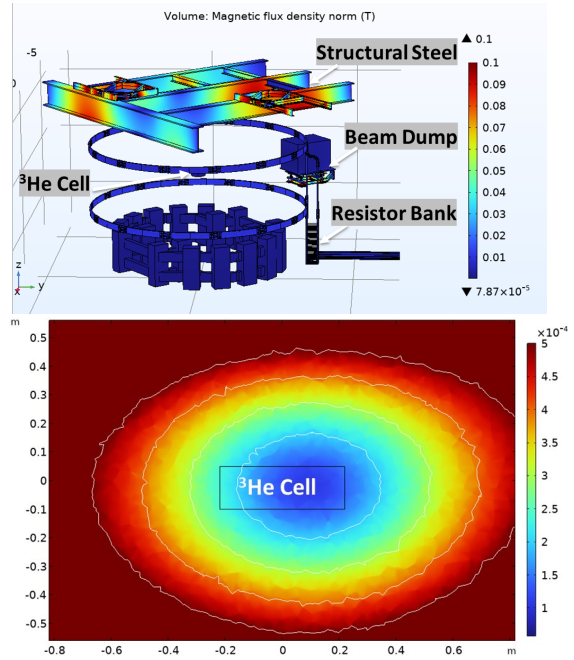
- Optics exchanger to translate polariser into and out of the beam.
- Guide fields from polariser to analyser
- Magnetic field coils around detector vessel
- Wide-angle analyser cell integration to sample and detector vessel.

Use:
Polarisation analysis setup on MIRACLES.

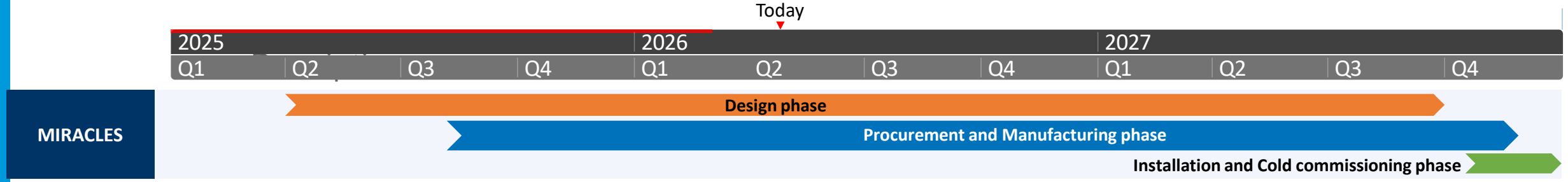
Design by Cristea Ionut, Tushar Batra, Hal Lee.
Analyser coil PDR, IDR done. On-going.



MIRACLES Ø7-m analyser coils.



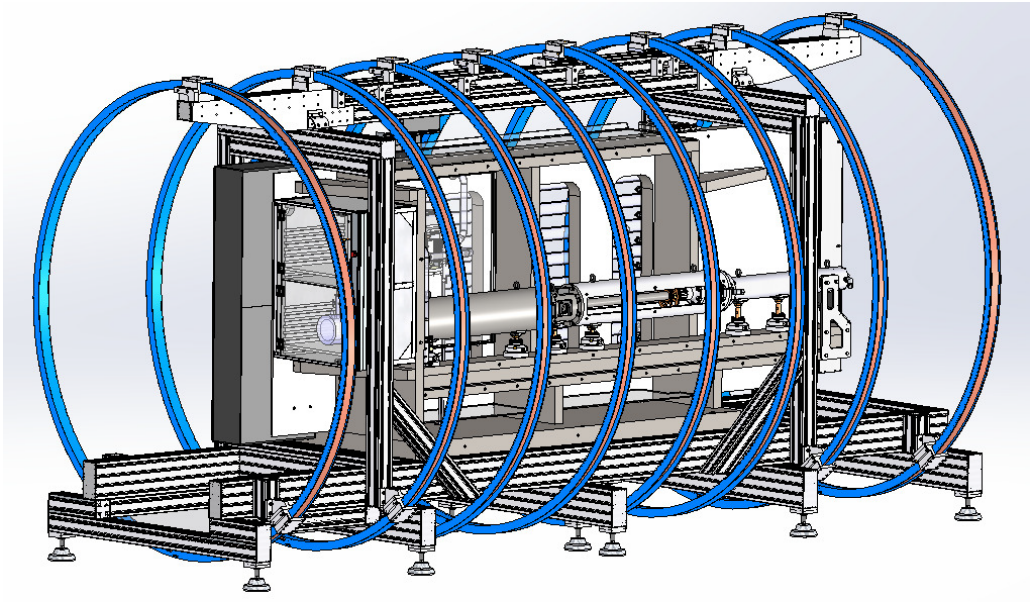
Field and uniformity



MEOP Station (WBS 26)

MEOP is a lab-based gas-polarising and cell-filling station.

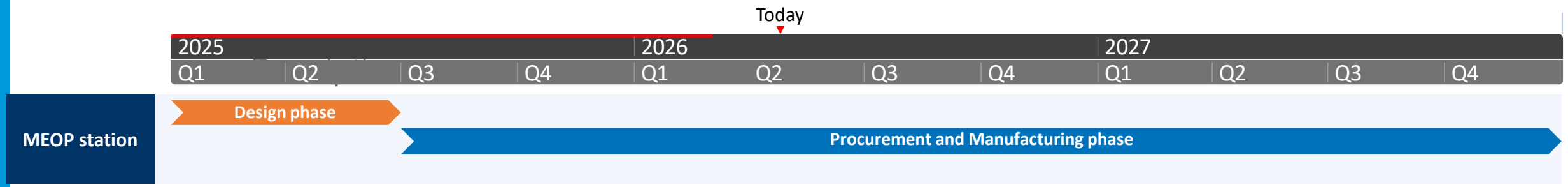
- Polarises ^{3}He gas using the Metastable Optical Pumping process.
- Fills 2 litres of 70% - 85% polarised ^{3}He gas per hour into a cell The cell is then transported to the instrument.



Use:

- DREAM, HEIMDAL, CSPEC, MIRACLES, T-REX wide-angle analysers.
- SKADI when the analyser needs to be inside the detector vessel.

Purchase from ILL. CDR meeting was held 17/4/2026. Delay.



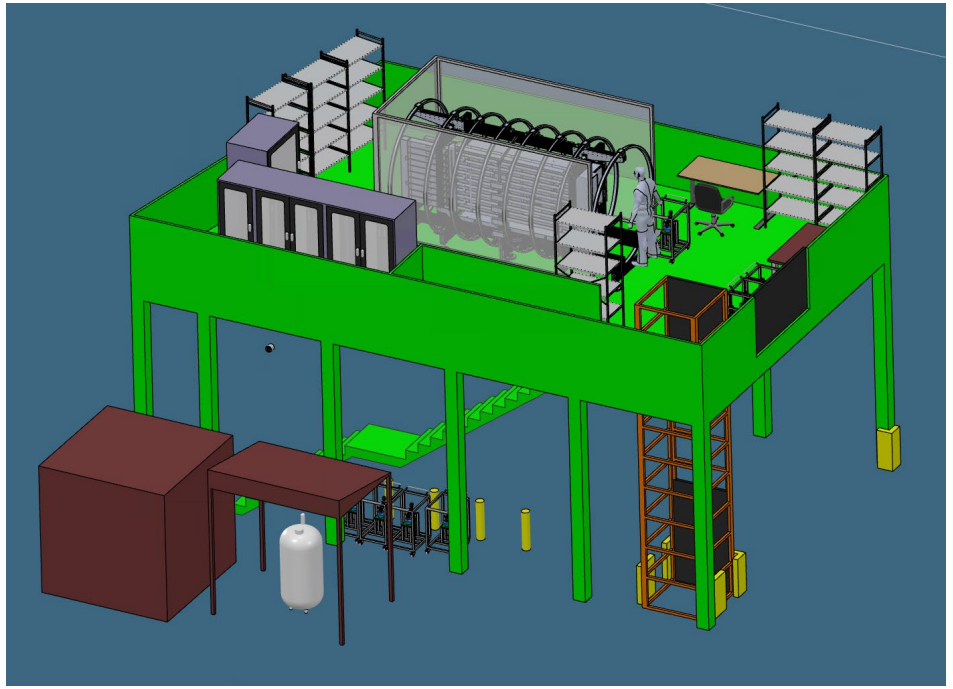
MEOP Station (WBS 26)

MEOP station will be hosted on a mezzanine in SLIME Lab.

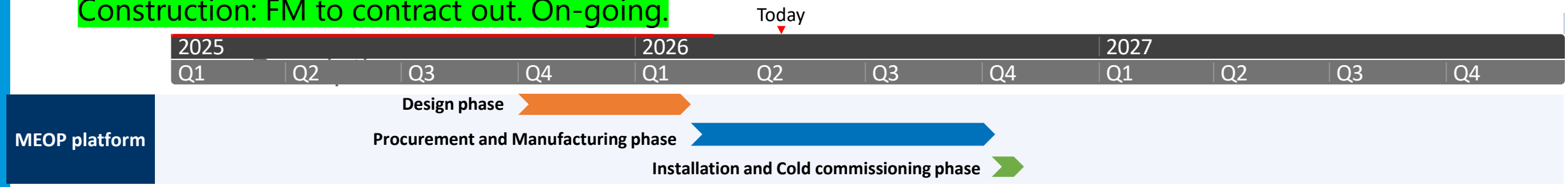
- Magnetically pristine environment.
- Access to instruments.
- Crane for installation and maintenance work.
- Mezzanine to keep floor space open for other activities.

Use:

- DREAM, HEIMDAL, CSPEC, MIRACLES, T-REX wide-angle analysers.
- SKADI when the analyser needs to be inside the detector vessel.



Modelling: Joel Hagman.
Coordinate with SSD and other stakeholders
Construction: FM to contract out. On-going.



Conclusion

- Project aims to deliver polarisation capabilities to multiple instruments.
- Lack of resources has delayed the project execution.
- Since joining NSS TPG in 2025, resource issue is being addressed
- Project is picking up pace.
- Equipment construction and installation to some instruments are on track to complete by the end of 2027.

Grants:

- Support for ODIN, SKADI/LoKI polarisation: W.- T. Lee, E. Blackburn, T. Nylander, D. Orlov, J. Houston, S. Jaksch, M. Manual, C. Pappas, S. Schmidt, M. Schulz, M. Strobl, A. Tartaglione, R. Woracek, Tillväxtverket European Regional Development Fund project SREss3 (2020-2023).
- Support for BIFROST, CSPEC polarisation: E. Blackburn, M. Månsson, W.-T. Lee, G. Nilsen, P. Deen, R. Toft-Petersen, M. Pascal, Swedish Research Council (VR) “Cooperation with ISIS: instrumentation and methods for ESS” Grant # 2021-06157.
- Swedish Research Council (VR) : In-Kind Contribution to the ESS, “Neutron Polarisation Capability Development for User Experiment Applications on ESS Instruments”, 2023-2026.
- Support for SKADI analyser: M. Wolff, E. Blackburn, D. Honecker, W. T. Lee, G.J. Nilsen, S. Parnell, A. Stellhorn, R. Woracek, Swedish Research Council (VR) “Cooperation with ISIS: instrumentation and methods for ESS” Grant # 2025-07620.