T-REX
Instrument Project

75%

Christian Franz, Lead Scientist
Nicolò Violini, Lead Scientist

Marcel Serwe, Lead Engineer
Mario Koenen, Project Engineer
Teddy Kozielewski, Project Engineer

25%

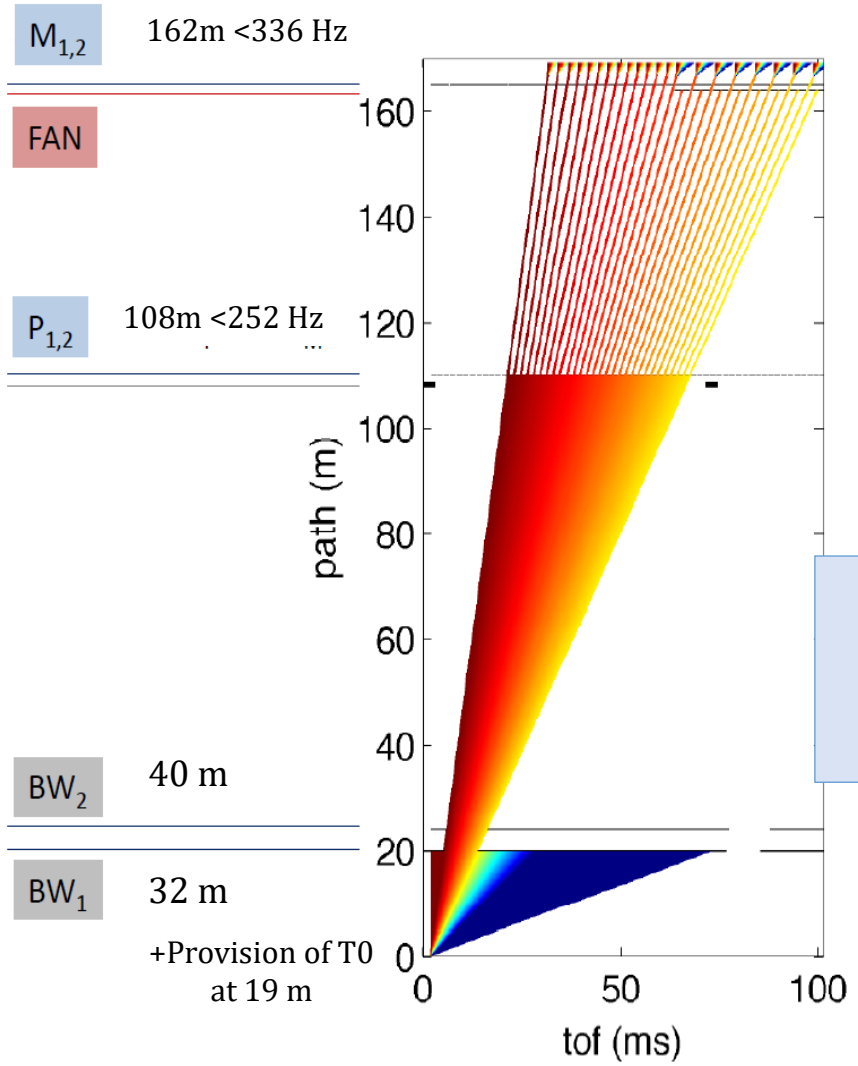
Andrea Orecchini,
CNR Work-package scientific responsible

Enrico Zanieri, Project Engineer
Francesco Sacchetti, Senior advisor
Alessio Lolani, Project Engineer

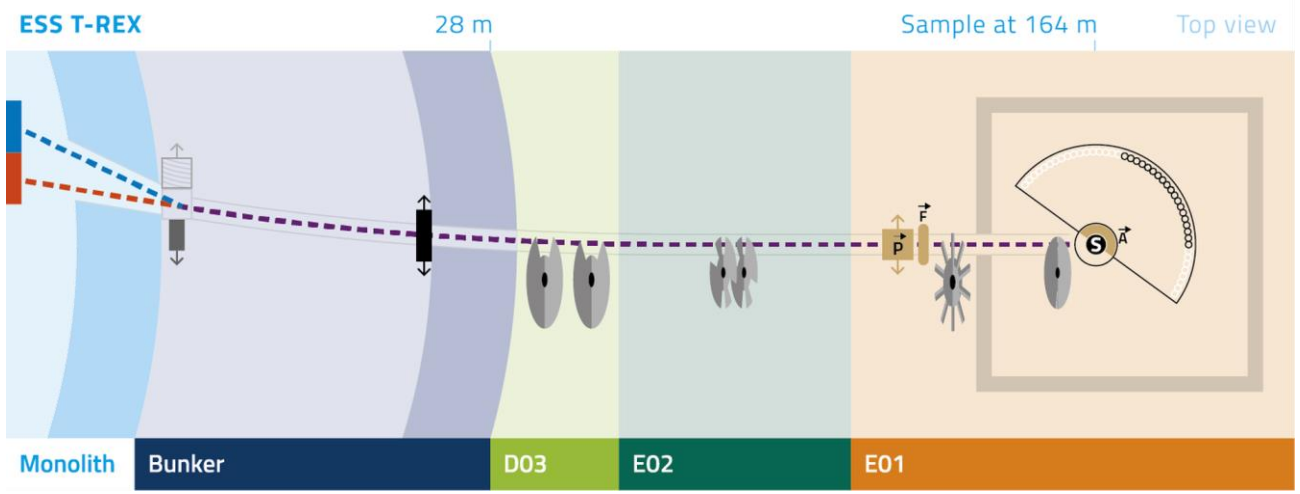
STAP 25 – 26 Apr. 2023

T-REX unique with 5D mapping

Polychromatic experiments



2 meV < Ei < 160 meV
@ 2MW ESS:
(3x 4-SEASONS, 6xIN5) x
n.of useful RRM spectra



Bispectral:

Neutron guide optimised for thermal
Cold extraction does not compromise thermal

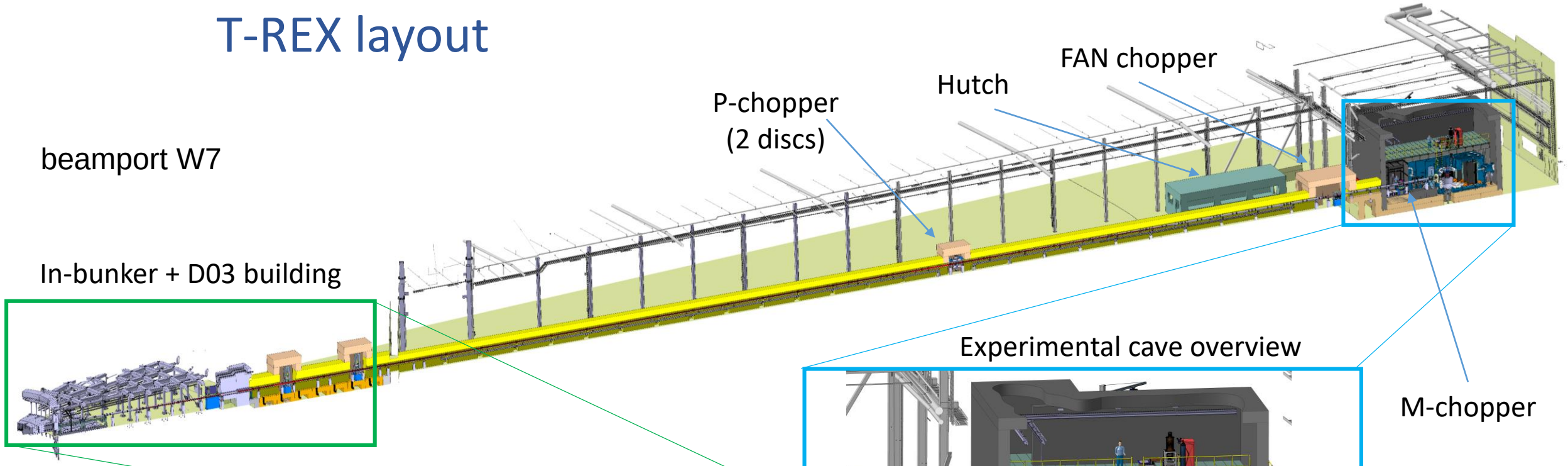
Chopper cascade:

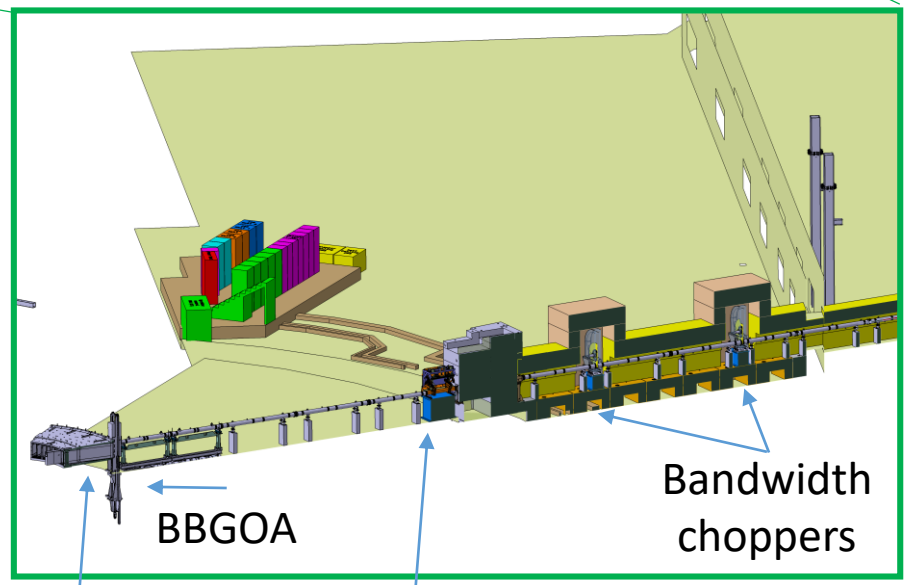
Flexible configuration
Resolution → flux
< 24 RRM pulses

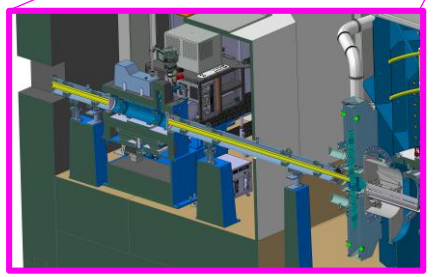
XZY Polarisation Analysis

40% detector coverage day-1

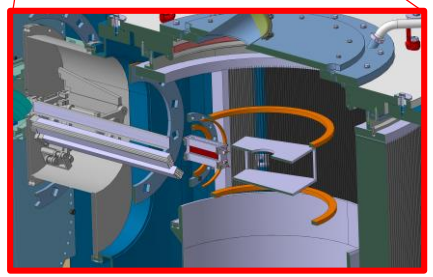
T-REX layout







cold & therm. Polarisers



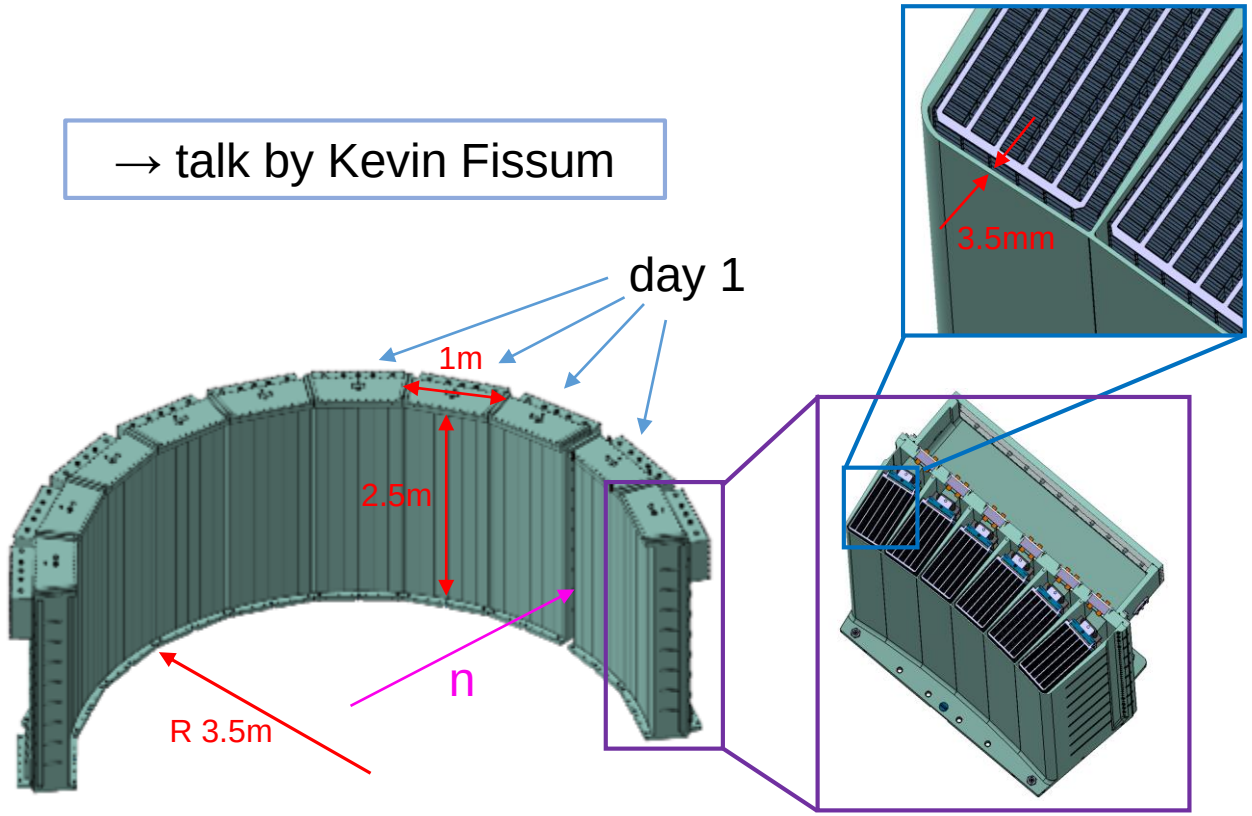
Primary collimator
Wide Angle Analyser

Upgrade stages to full scope

Multi-Grid detector

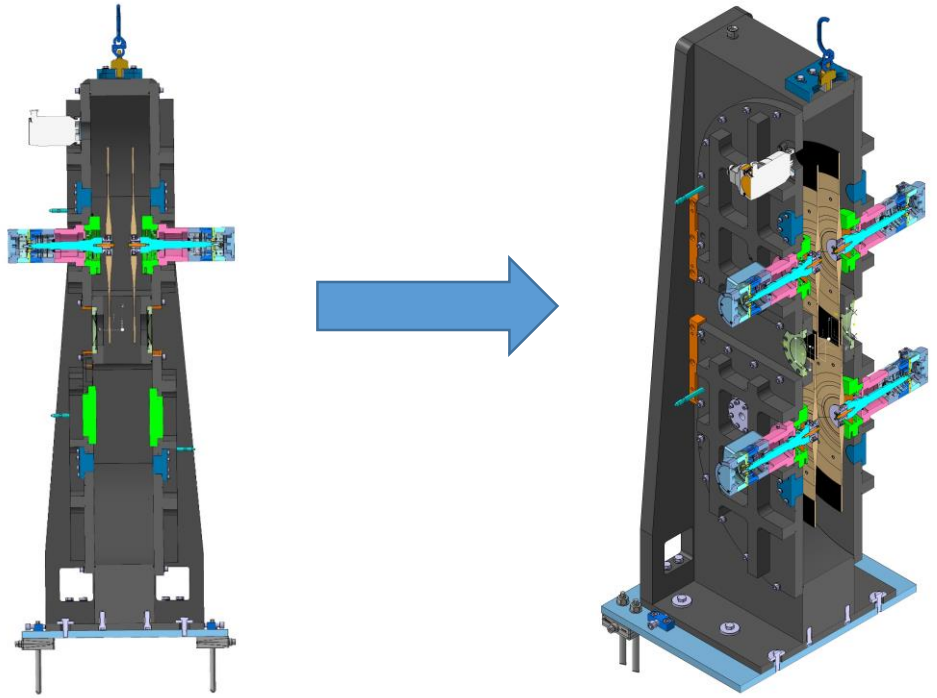
- upgrade from 40% (4 boxes) to 100% (10 boxes)
  → in total 2.2sr
- estimate from TG2 (2017):
  2.3 M€

→ talk by Kevin Fissum



P-Chopper

- upgrade from 2 to 4 discs
- improved background
- better control over pulse shape
- flexible resolution setting
- price tag: ~0.6M€



Beyond full instrument scope

T_0 chopper

- provision for T_0:
  need to exchange only one guide element
- See during operation of necessary

Supermirror analyser

- Polarisation analysis in combination with complex sample environment
- Not foreseen in instrument design
- Expensive!

Sample Environment

CCR
ILL Furnace
Clamp cells < 3 GPa
6kV HV supply

In scope:
Orange cryofurnace
(for ^{3}He cell)

→ see talk C. Curfs!

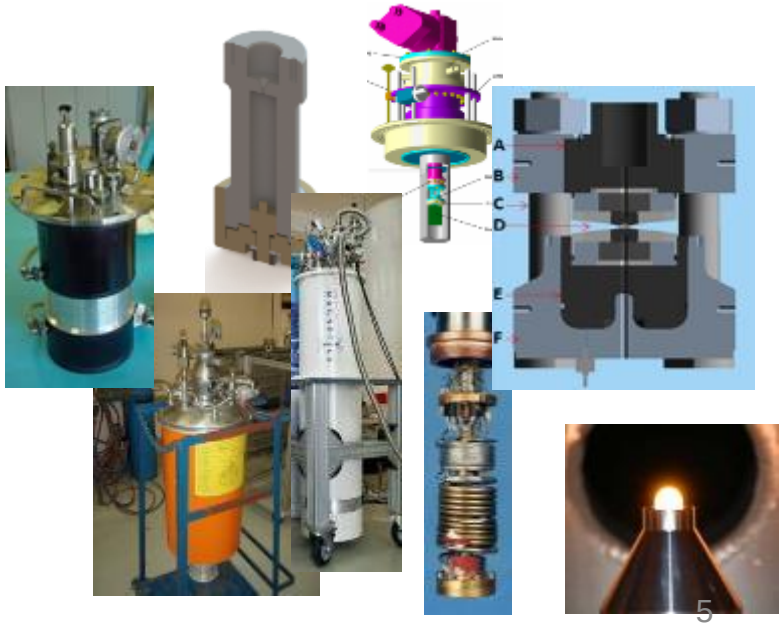
Rely on ESS-pool on day 1

Top-down, side access possible
Magic PASTIS < 1m diameter
Sample area shall enable installation of XL SEE
<1000 kg, height < 1.7 m, d < 0.8 m

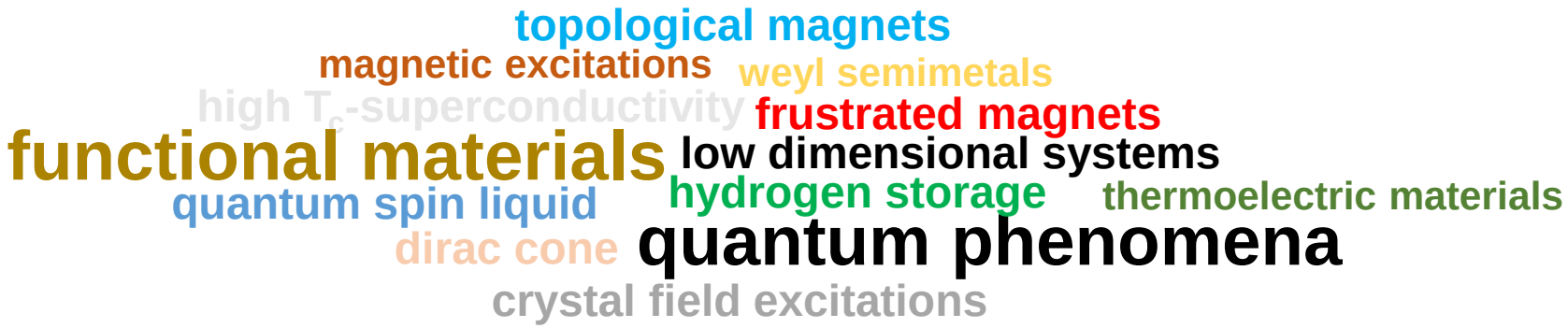
^{3}He Sorption Stick
Humidity Chamber

Future upgrade:
IR furnace
ES Levitator
Pump & Probe set-up

Vertical cryomagnet
Paris-Edinburgh Cell
Gas cells < 1 GPa
Gas Handling



Science case



Unique features of the instrument:

- **Heavy use of RRM** (<24 subpulses) over broad wavelength band of 1.7Å
  Measure „everything everywhere all at once“→ Need support from DMSC

→ see talk by Gregory Tucker

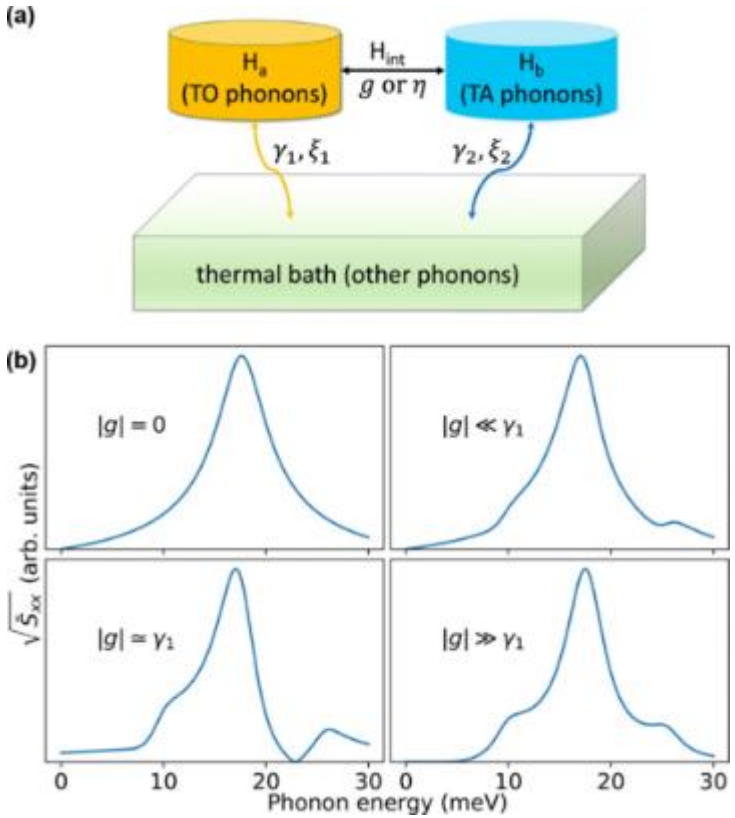
- **Bi-spectral extraction**
  Do the work of different instruments in one

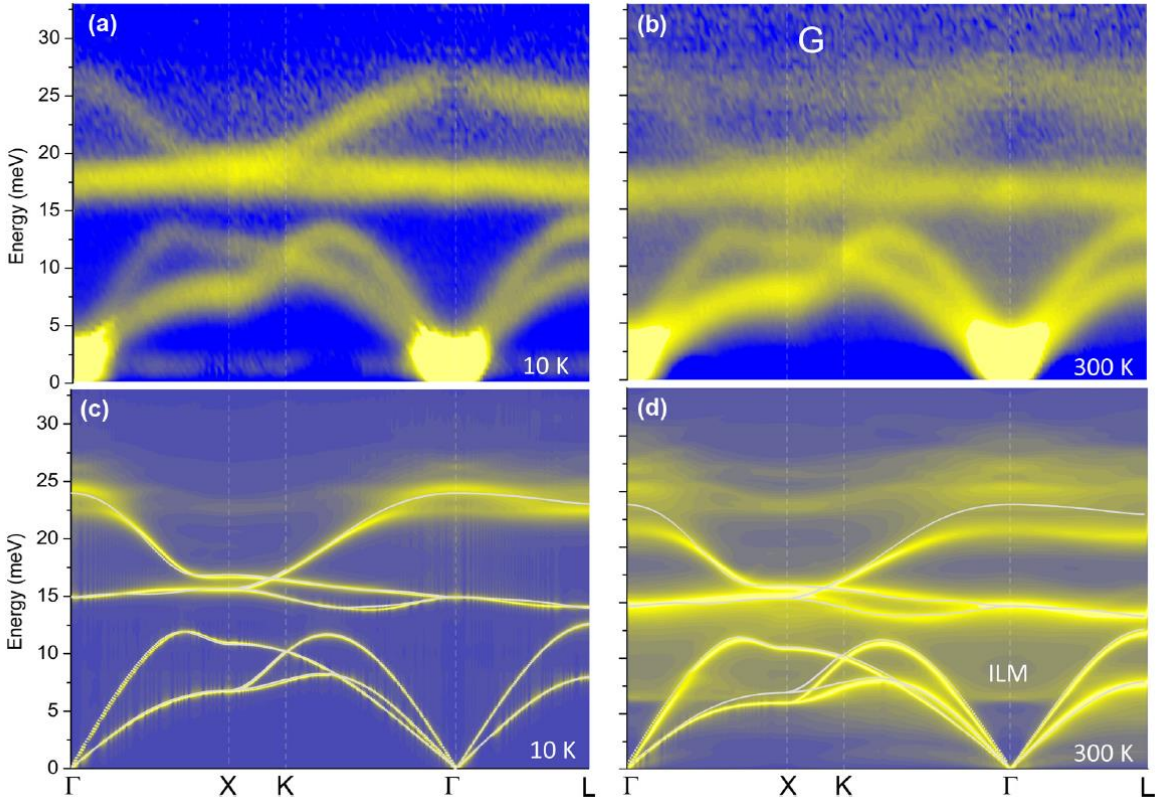
- **Full x-y-z polarisation analysis** integral part of the instrument
  Separation of magnetic/nuclear scattering and coherent/incoherent

Thermoelectic materials

Anharmonic phonons in NaBr

4D – data from ARCS
E_i = 50meV



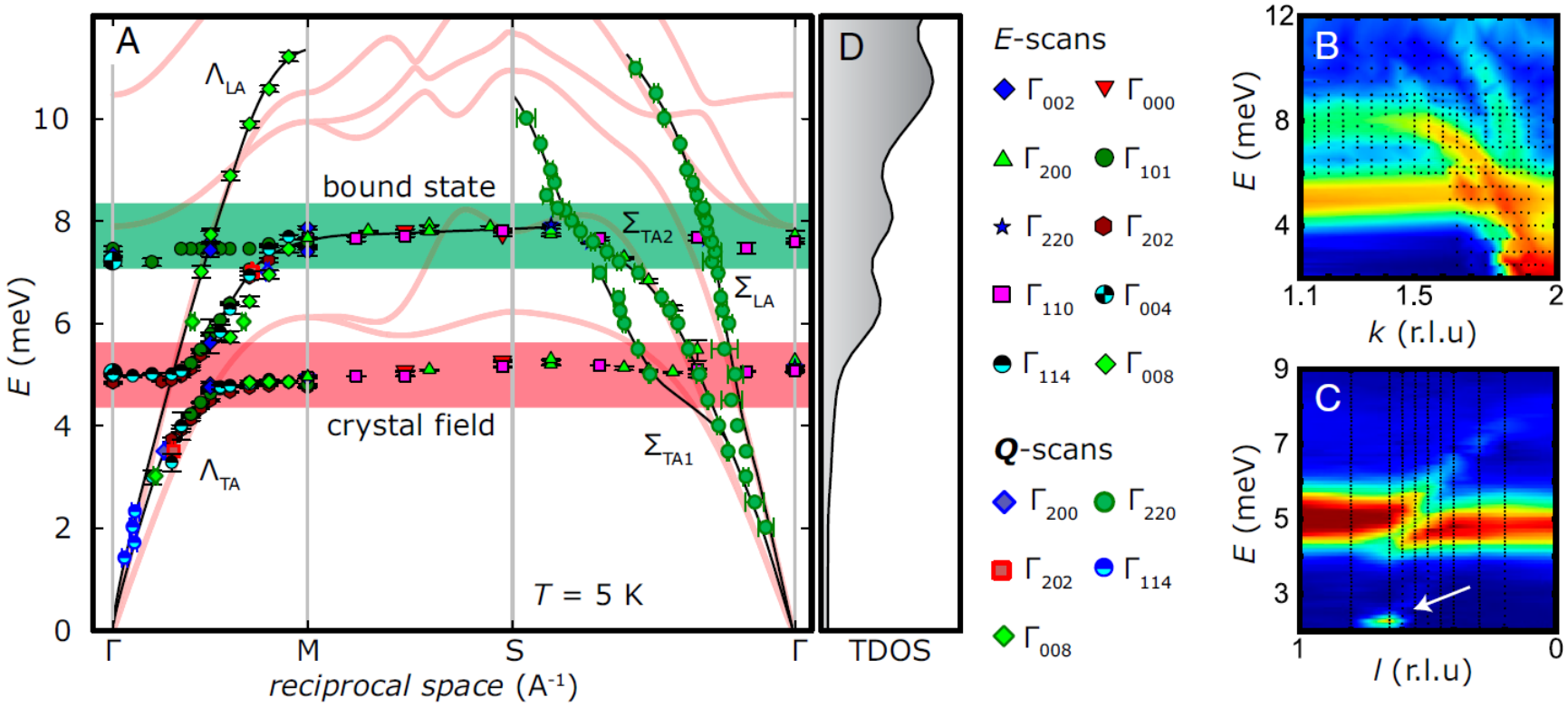


could benefit from multi – E_i mode!

Y. Shen et al. *PRB* **103** 134302 (2021) https://doi.org/10.1103/PhysRevB.103.134302

Hybrid modes

Magnetoelastic coupling in $CeAuAl_3$

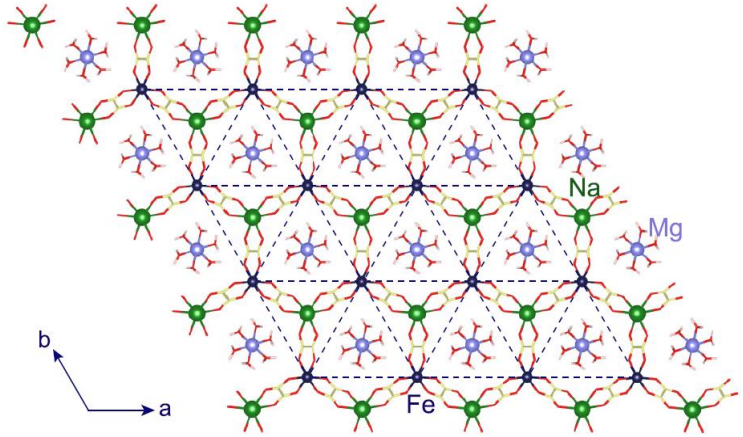


single crystal: 4D mapping, collect all information at once
polarisation analysis: dis-entangle crystal field (magnetic) and phonon (nuclear)

Čermák et al. *PNAS* **116** 14 (2019) https://www.pnas.org/doi/10.1073/pnas.1819664116

Metal Organic Frameworks (MOFs)

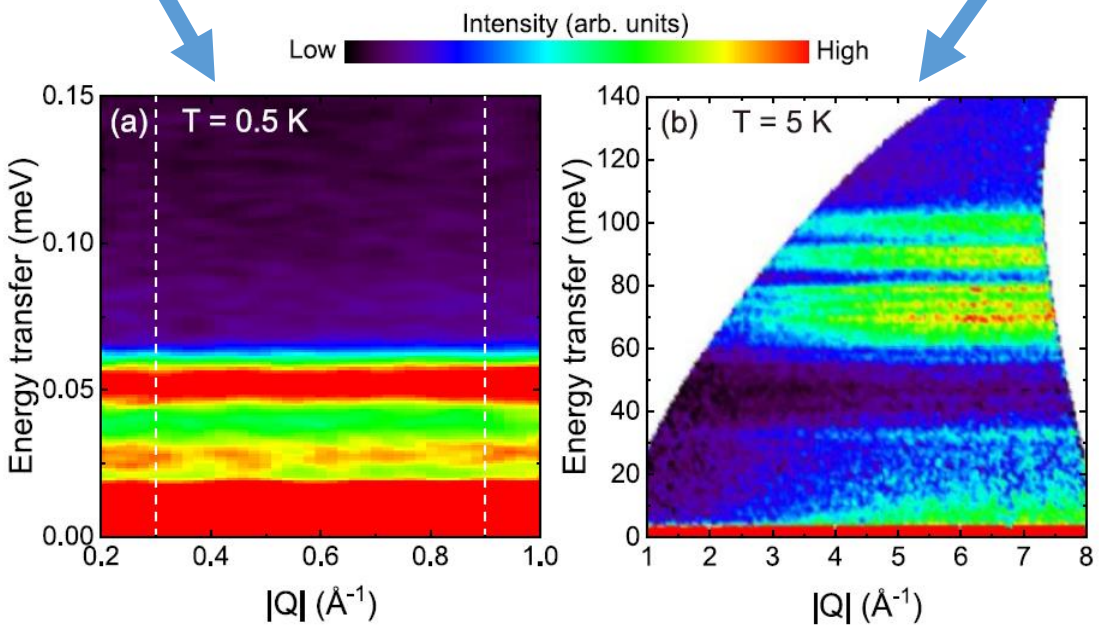
$NaMgFe(C_2O_4)_3 \cdot 9H_2O$



porous materials composed of metal ions or clusters connected by organic ligands

CNCS, E_i = 1.5meV

Sequoia, E_i = 160meV



Low energy: magnetic transitions zero-field splitting (ZFS) of $S = 5/2$ ground state multiplets of Fe^{3+} ion.

High energy: translational and librational vibrations of structural water molecules

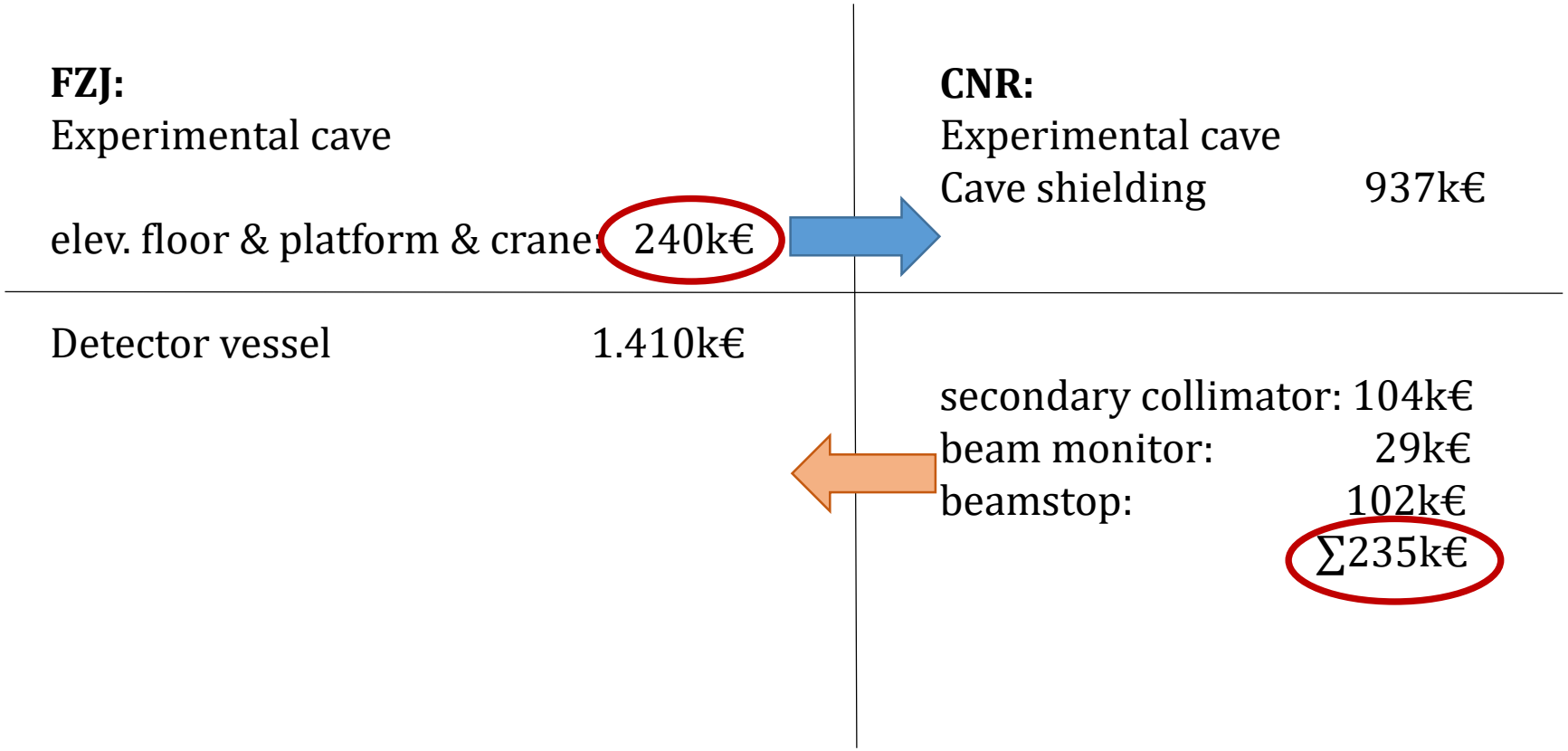
bi-spectral extraction: do work of several instruments at one!

T. Xie et al. *PRB* **103**, 024402 (2021)

T-REX project overview and status

by work-packages

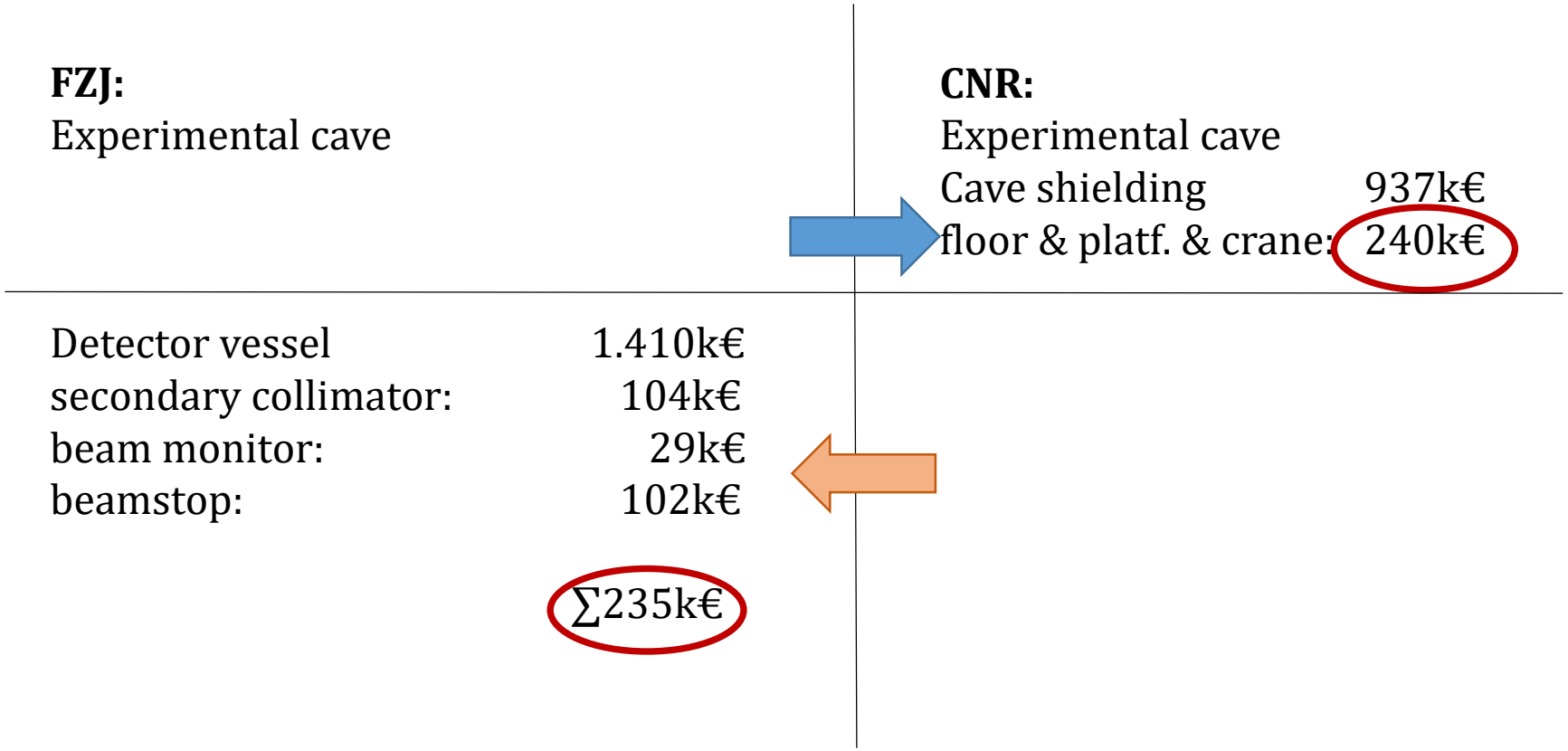
Exchange of workpackes



Cost neutral exchange of workpackages based on CBV!

cost difference based on actual value will be compensated through balance with personnel at ESS

Exchange of workpackes



Cost neutral exchange of workpackages based on CBV!

cost difference based on actual value will be compensated through balance with personnel at ESS

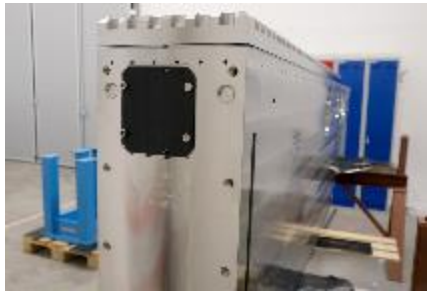
Neutron guide system & Heavy shutter

S-DH

nano optics berlin nob

NBOA

- at ESS, installed ✓



in-bunker & BWI

Sub-TG3 passed

- limited design resources at company
- Issue with Heimdal chopper solved ✓
- Issue with expansion joint ✓

out of bunker guides & BBGOA

- design started
- prioritise BBGOA and bunker wall insert
- work in parallel possible, bender is subcontracted to NOB
- Sub-TG3 will be delayed (May 2024)!

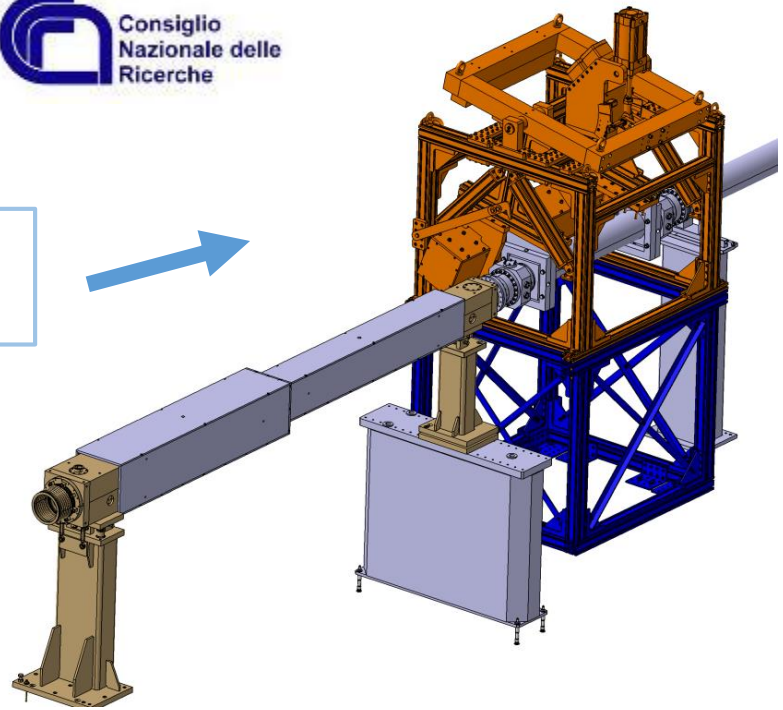
S-DH is a small company, working on many ESS projects

Installation end of 2023!

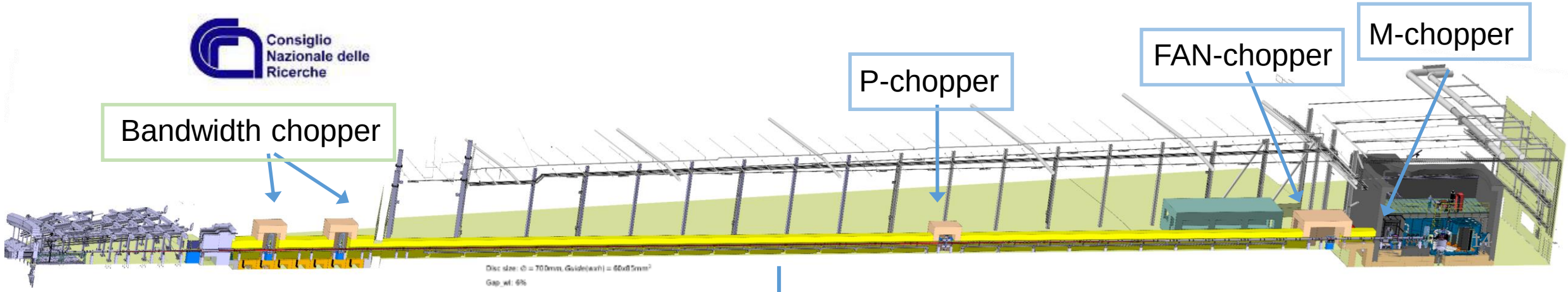
Heavy shutter:

- Ordering or parts complete
- Assembly starting soon (external)
- Final assembly and testing in Perugia (at Department workshop)
- Arrival at ESS foreseen autumn 2023

Consiglio Nazionale delle Ricerche



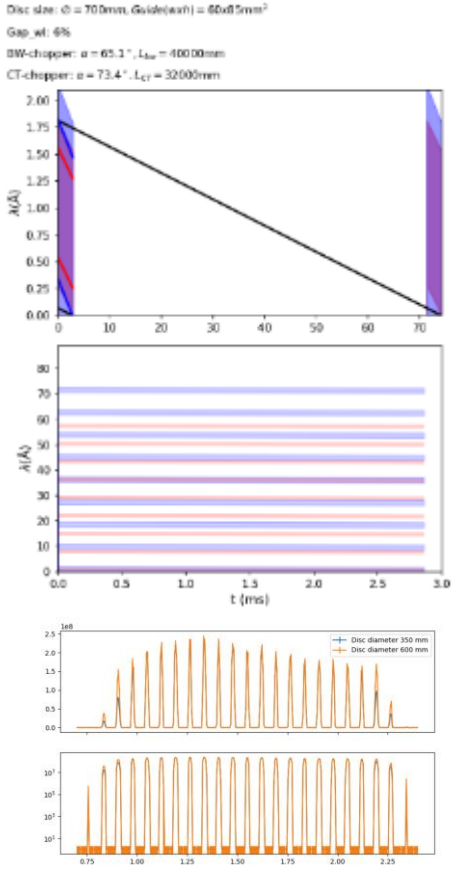
Neutron choppers



Band Width & Cross Talk Chopper (14Hz)

- Moved from 1200mm discs to 700mm (backed by analytic calculations and simulations by Jörg Voigt)
- Cost savings in invest and easy maintainance of standard size
- very little scientific impact

- Offers from commercial companys over budget
- Possibility to join the common project



- contract awarded to ZEA-1
- IDR passed
- Installation end 2025

ZEA-1

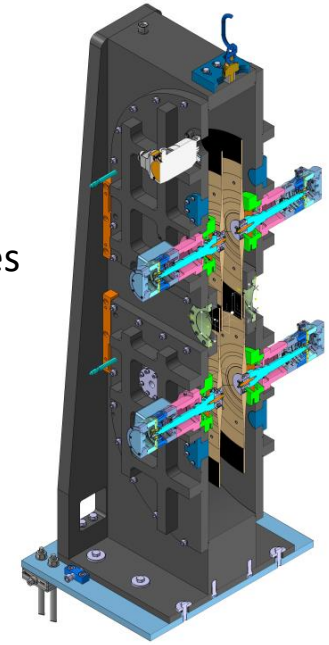
P-Chopper

- 252Hz, High-res and Low-res openings
- Scope: Two discs, upgradeable to 4 discs
- design is advancing, deceided to use ZEA spindles
- Airbus discs → long lead time!

M-chopper

- 336Hz, High-res and low res openings
- Airbus discs → long lead time!

early procurement of chopper discs!

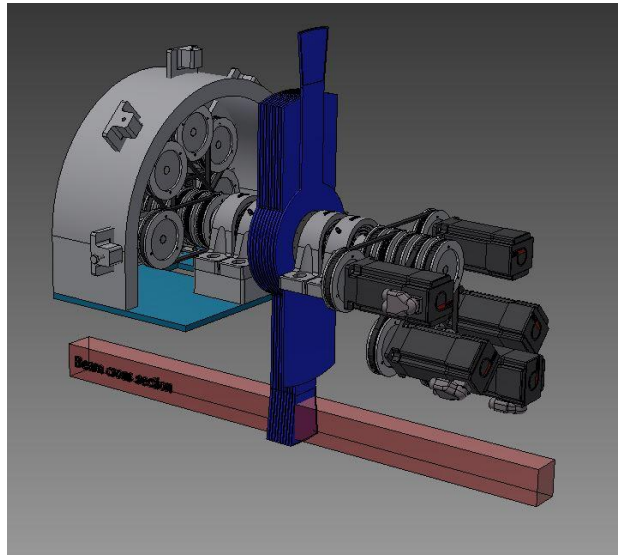


FAN chopper

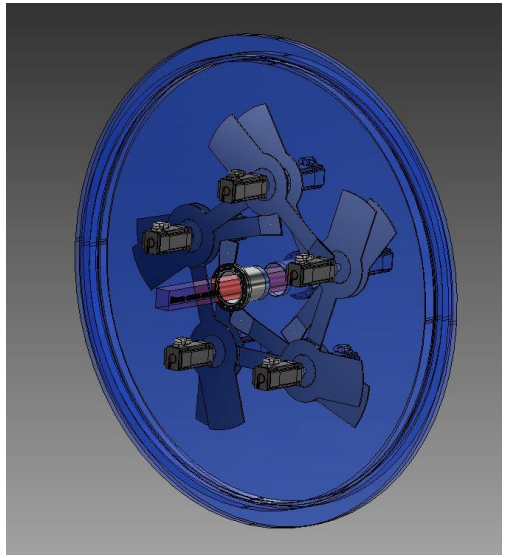
- Test at ISIS – concept study based on master thesis
- First of its kind component – high engineering effort (but limited budget)
- Considered alternative designs
- Used a rating matrix to find the best solution
- Alternative design stays as a fallback option in case of unexpected difficulties

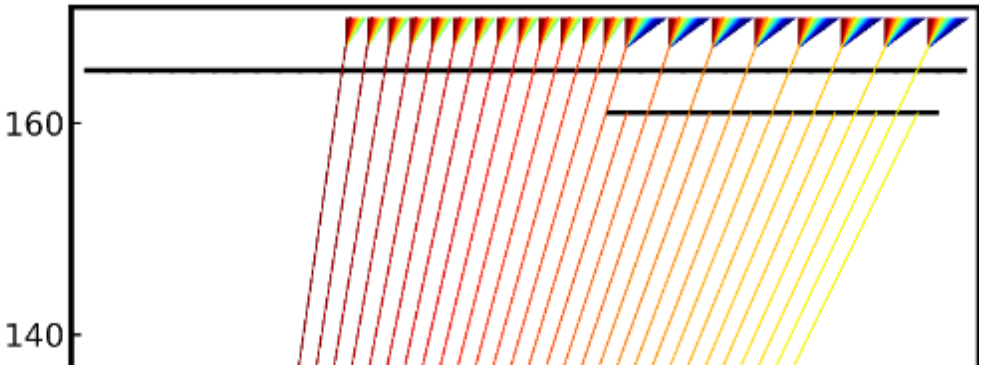
- Kick off meeting with ESS chopper group
- SubTG3.4 as soon as possible to create time contingence for extensive testing

- Installation date: 05/2026



Current model of the FAN chopper

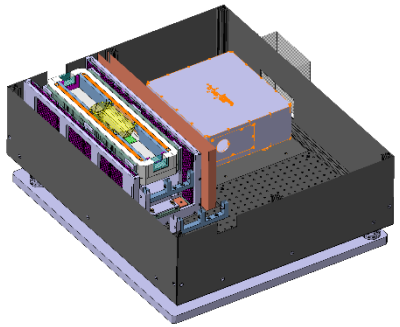

Alternative concept: Teddys Pentagon



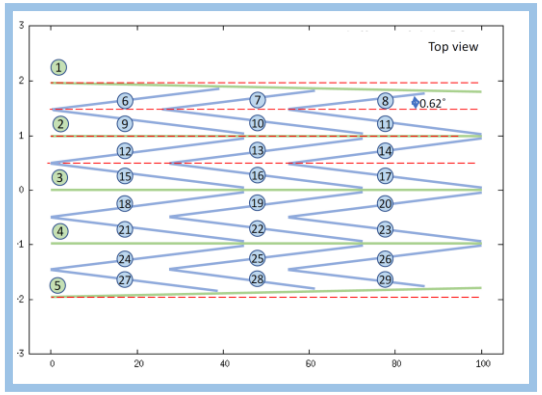
Kriterien/Konzepte	Gewichtung	Riemenantriebe		Direktantriebe		Sternanordnung		Hauptwellenantrieb	
Verschleiß / Robustheit	20%	4	0,8	4	0,8	5	1,0	3	0,6
Baugröße	5%	5	0,25	4	0,2	2	0,1	5	0,25
Wartbarkeit	15%	4	0,6	2	0,3	4	0,6	4	0,6
Entwicklungsaufwand	10%	5	0,5	3	0,3	3	0,3	3	0,3
Technologierisiko	20%	4	0,8	4	0,8	5	1,0	3	0,6
Steuerungstechnischer Aufwand	10%	4	0,4	4	0,4	4	0,4	3	0,3
Kosten Mechanik	10%	4	0,4	4	0,4	1	0,1	4	0,4
Kosten Elektrotechnik	10%	3	0,3	3	0,3	3	0,3	3	0,3
Ergebnis	100%		**4,05**		**3,50**		**3,80**		**3,35**

Polarization equipment

1. Thermal polarizer

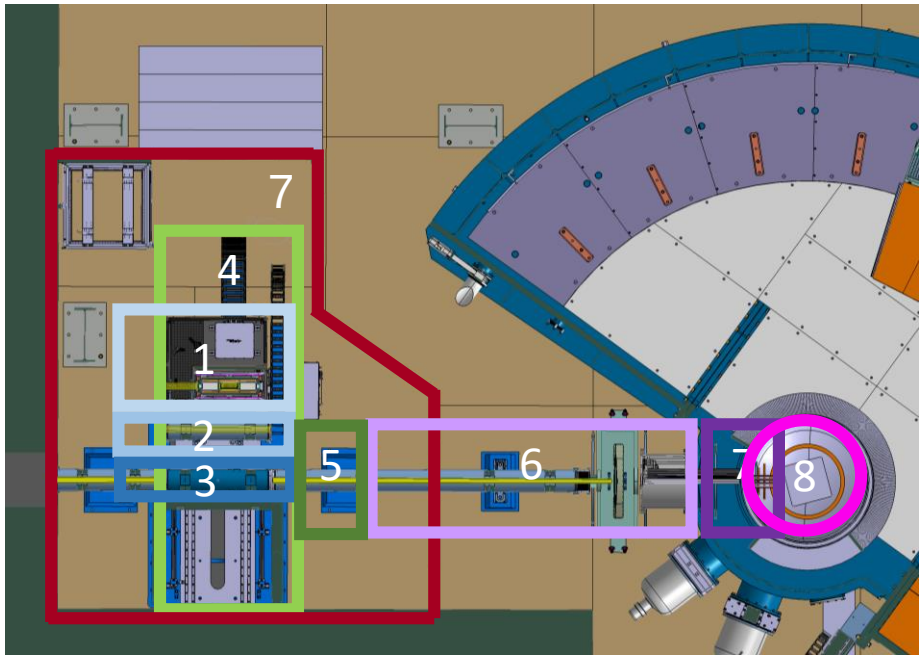


2. Cold polarizer

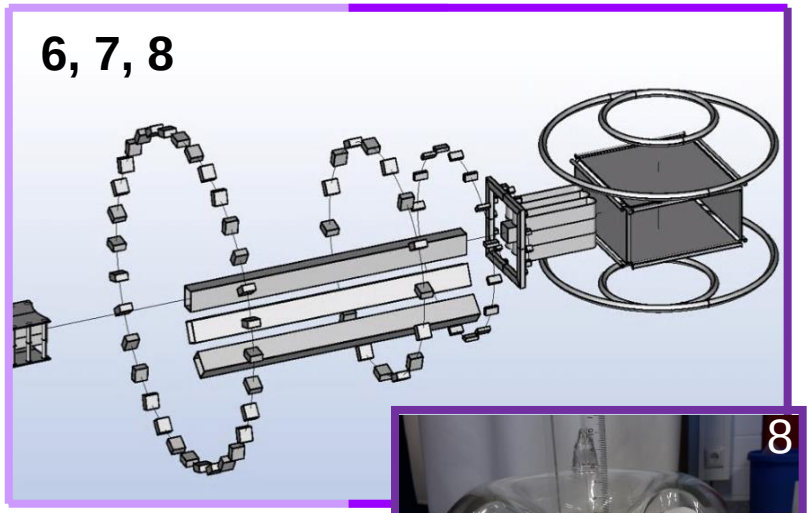


3. Neutron guide

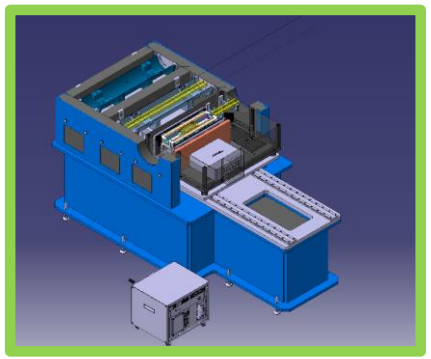
7. Laser lab



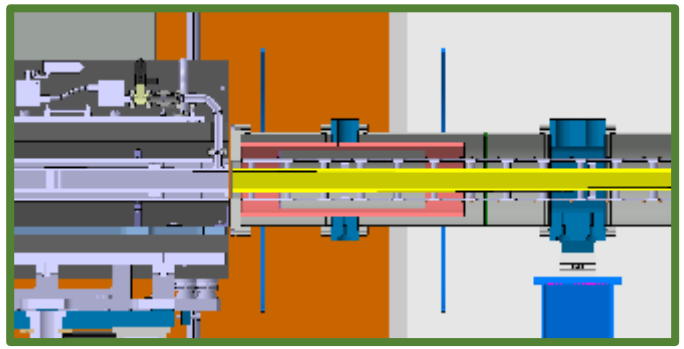
6. Guide field (spin holding)
7. Adiabatic field (spin rotation)
8 .PASTIS setup



4 Guide exchange unit



5. Spin Flipper

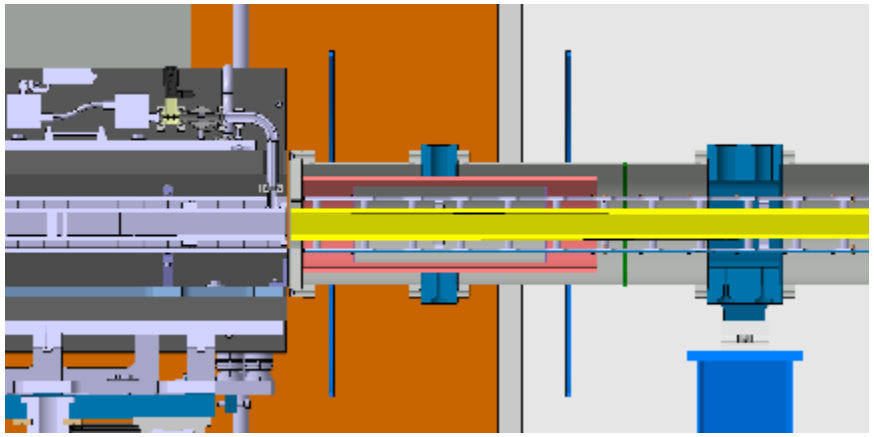


Polarization equipment

- Cold neutrons polarizer procured with SNAG
  Sub-TG3: waiting for feedback!

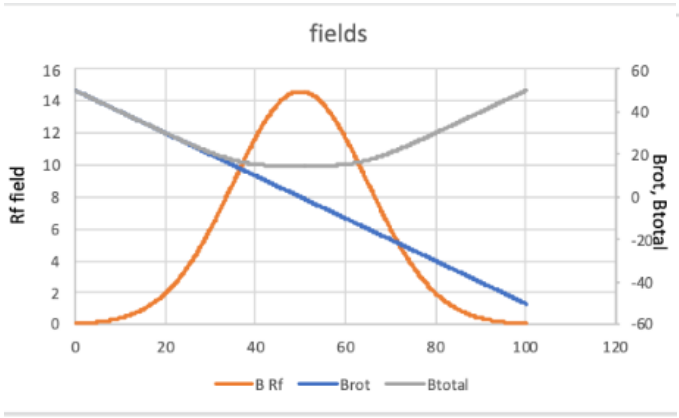
IDR readiness:

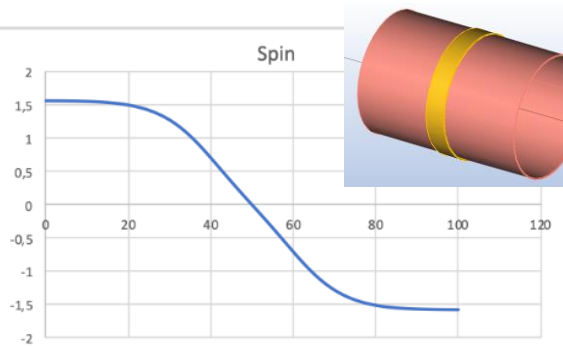
- Thermal neutrons polarizer design: ready
- Guide exchange unit design: ready
- Guide field design: only minor updates needed
- Race-track coils: ready
- PASTIS design needs to be adapted
- Spin flipper: currently in design
  (Earl Babcock & Helmut Soltner)



Option 1: Adiabatic fast passage flipper

- λ_{min} = 0.6Å
- k = 20
- f = 150kHz
- L = 400mm





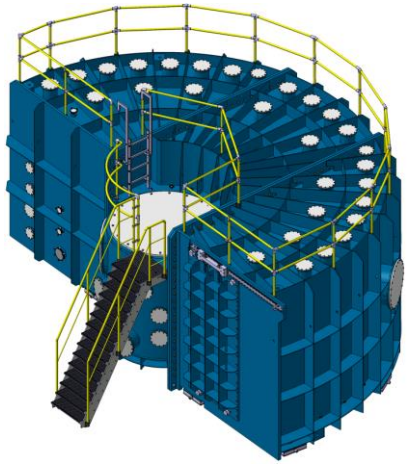
Option 2: ^{3}He + Mezei flipper

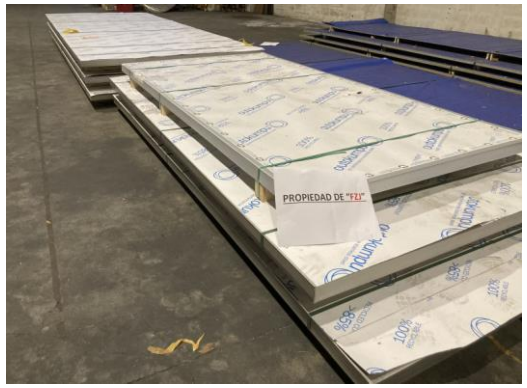
- Use ^{3}He als flipper for thermal neutrons
- Additional Mezei flipper after cold polariser (Similar to LET)
- More effort, have to change guide design, ramp with pulse

→ Fallback option

Detector Vessel & interior accessories

- Contract awarded to AVS
- Raw material arrived
- Detailed discussions about sealing strategy, exact position and size of flanges, permeability of materials etc.
- Cadmium shielding: will be done by FZJ
- FAT end of 2023

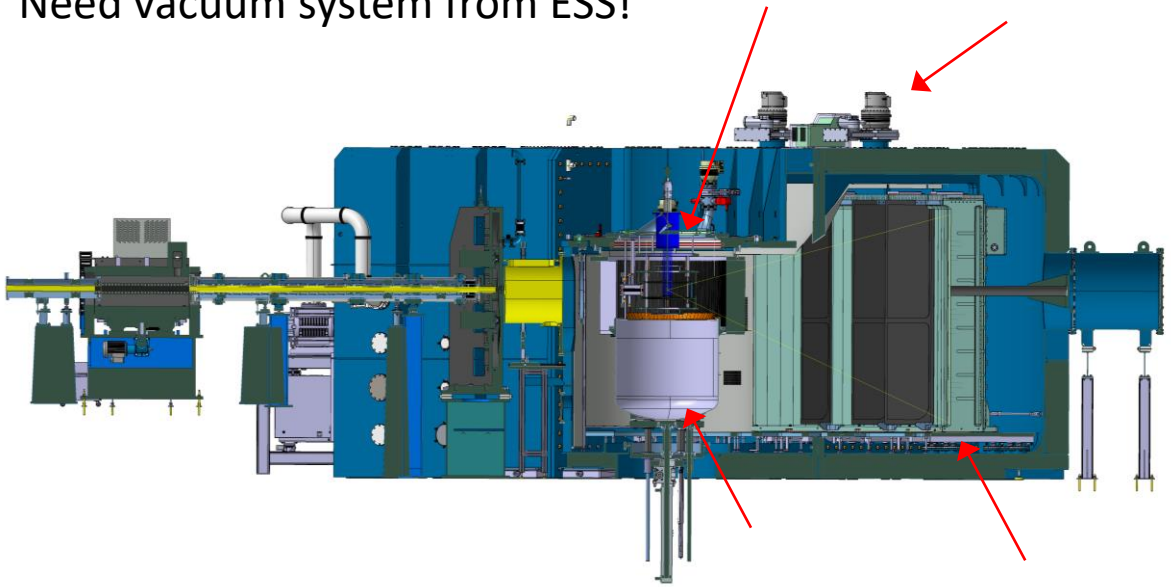




- Contains: Gate Valve; Secondary Collimator; Sample Environment flanges; Detector support; Vessel flooring
- SubTG3 passed (2022-12-16)

T-Rex Review: Agreed on pre-installation phase in Jülich (2024)

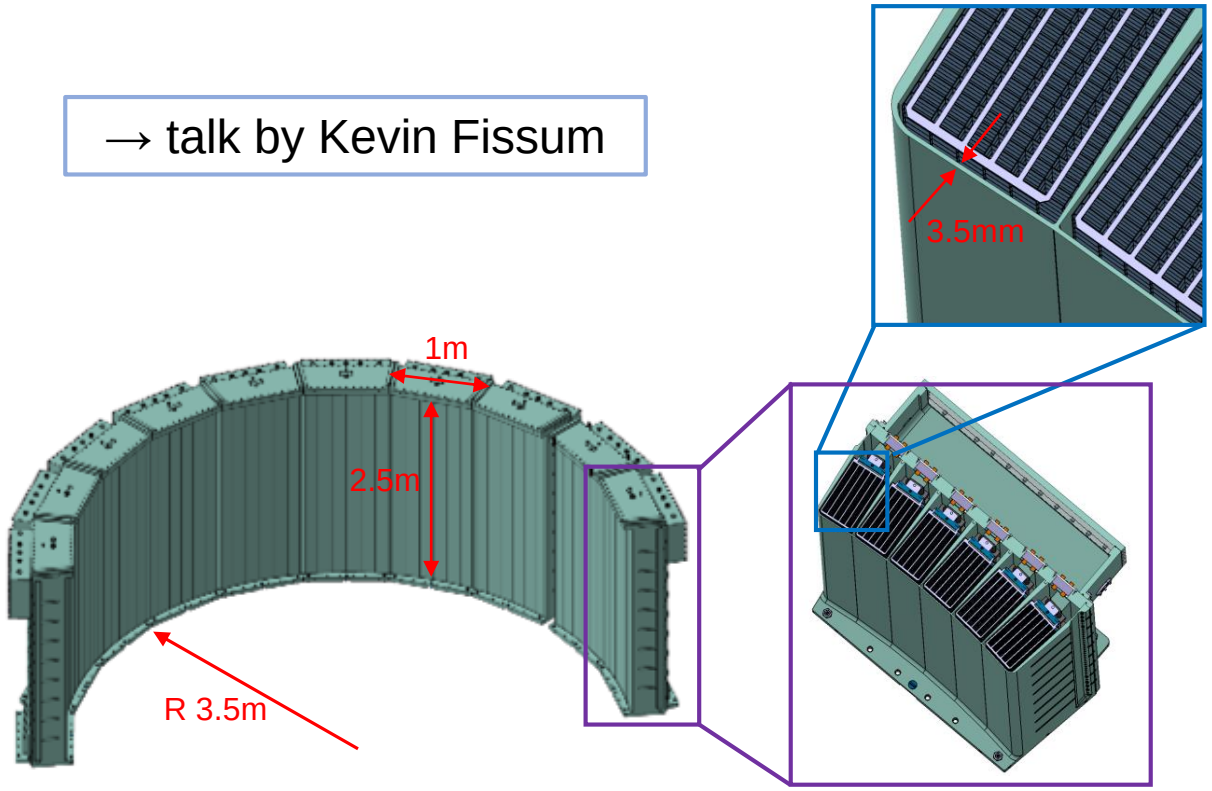
Need vacuum system from ESS!



Neutron Detector (Multi GRID) & Detector box

STAP report autumn ´22
“The NSS detector group should provide a development road map as soon as possible, more focusing on T-REX and thermal neutrons.”

→ talk by Kevin Fissum

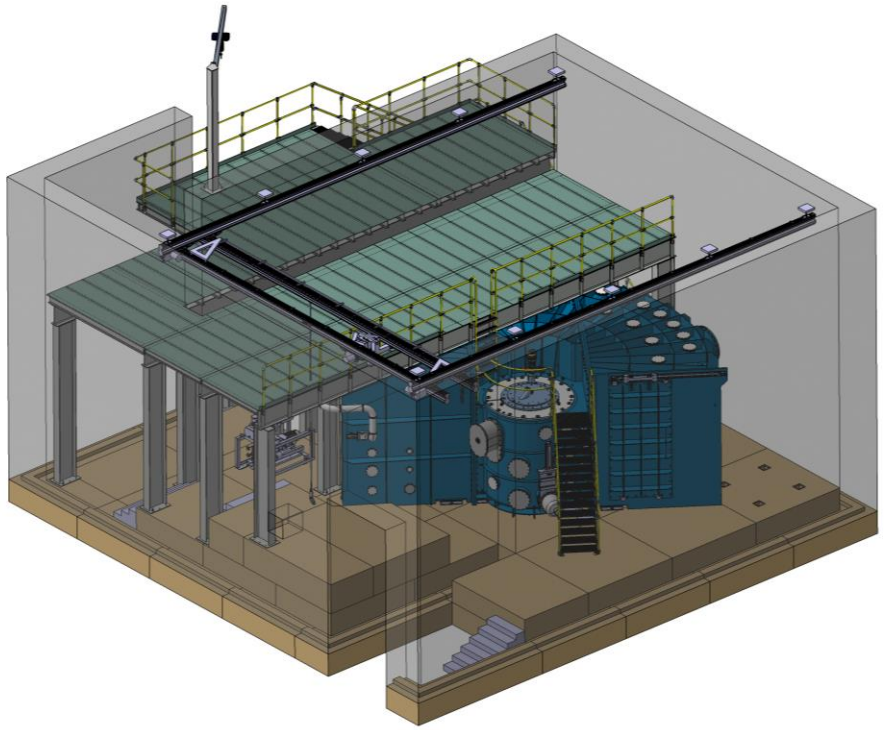


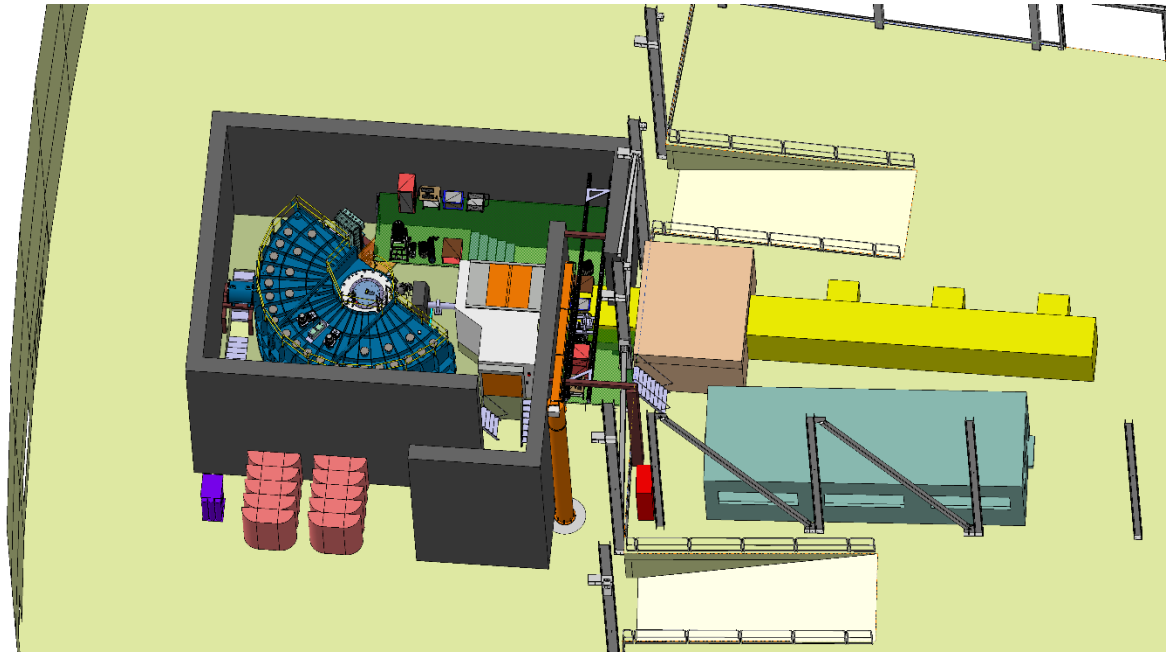
- Feb 22 tender assigned to KRESS
- Materials shipped to KRESS in April 22
- Manufacturing is ongoing
- Prototype testing March 23
- Mock-up MG for testing?

detector box

Kreß GmbH Sondermaschinenbau

Experimental cave





- Redesign of the cave!
- Easier access from experimental hutch
- Easier access to sample flange for sample changes, He-transfers etc.
- Need input from CUP, CEP

- Slab: Must be installed early 2025!
- Cave: Installed 10/25

Beamline shielding

- joined common project

Beam stop

- starting soon

Hutch and sample prep.

- not started

Primary collimator and slits

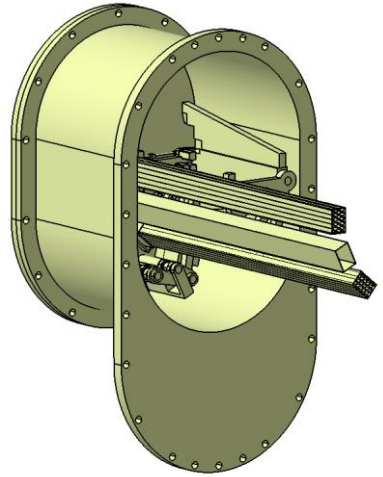
Technically challenging component!

Gather/check requirements:

- guide field interface (internal) ✓
- motion control ESS + FZJ for EPICS integration X
- metrology group ESS + S-DH alignment strategy ✓

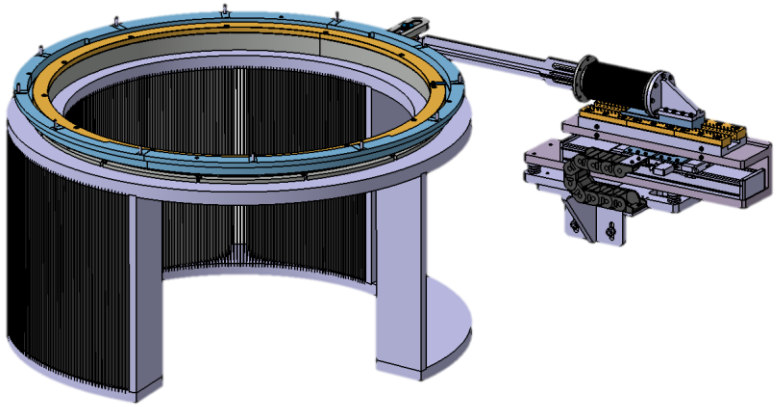
A 3D draft including slits and monitor is completed
Internal review (including S-DH) to avoid communication problems, overlooks.

Installation: After vessel (2025), before M-chopper!



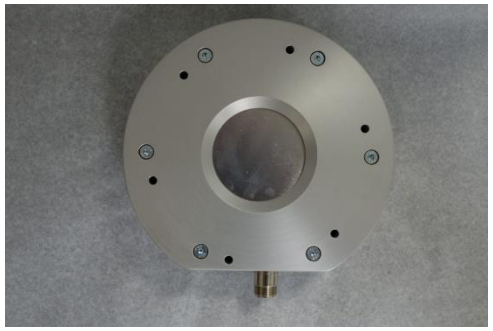
Slits: motion control options need to be discussed with MCA and FZJ.

Secondary collimator



- Two packages: drive and mount (FZJ), collimator (CNR)
- Exchange of workpackes planed between CNR and FZJ (Collimator)
- Test bench currently being set up in Jülich, all parts arrived
- Linear drive has to work against vaccuum
- Installation date: 11/25

Monitors



→ see talk Kevin Fissum

- 3 monitors in the scope: after P-chopper, after M-chopper, after sample
- Transmission monitor waiting for the exchange of workpackages
- Meanwhile: Discussion with CDT for P-Chopper and sample monitor design

  Evaluating possibility to join the common project

  Started discussions with Daria and Ioannis

Top 5 project risks

Top 5 Risks				
Title	**Rating**	**Category**	**Partner**	**Treatment**
Detector performance requirements may not be met	25	Quality	ESS	Avoid
Mulit-Grid Detector not ready for hot commisioning	25	Schedule	ESS	Avoid
Increasing costs of materials (Experimental cave)	25	Cost	CNR	Reduce
Guide suppliers working at capacity	15	Schedule	FZJ	Observe
Vacuum system not ready for pre-installation	12	Schedule	FZJ	Observe

Summary

Success:
- in-bunker guide in manufacturing
- detector vessel in manufacturing
- cold polariser in manufacturing
- heavy shutter in manufacturing
- detector box in manufacturing

→ We are moving foreward

Opportunities:
- pre-installation of detector vessel
- work package exchange will decrease the number of interfaces

Challenges:
- Cost increase in materials

Take-home message:

- T-Rex is (almost) in schedule according to new baseline! ✓
- Major threat: Detector!