sck cen
Belgian Nuclear Research Centre



MYRRHA

MYRRHA phase 1
MINERVA

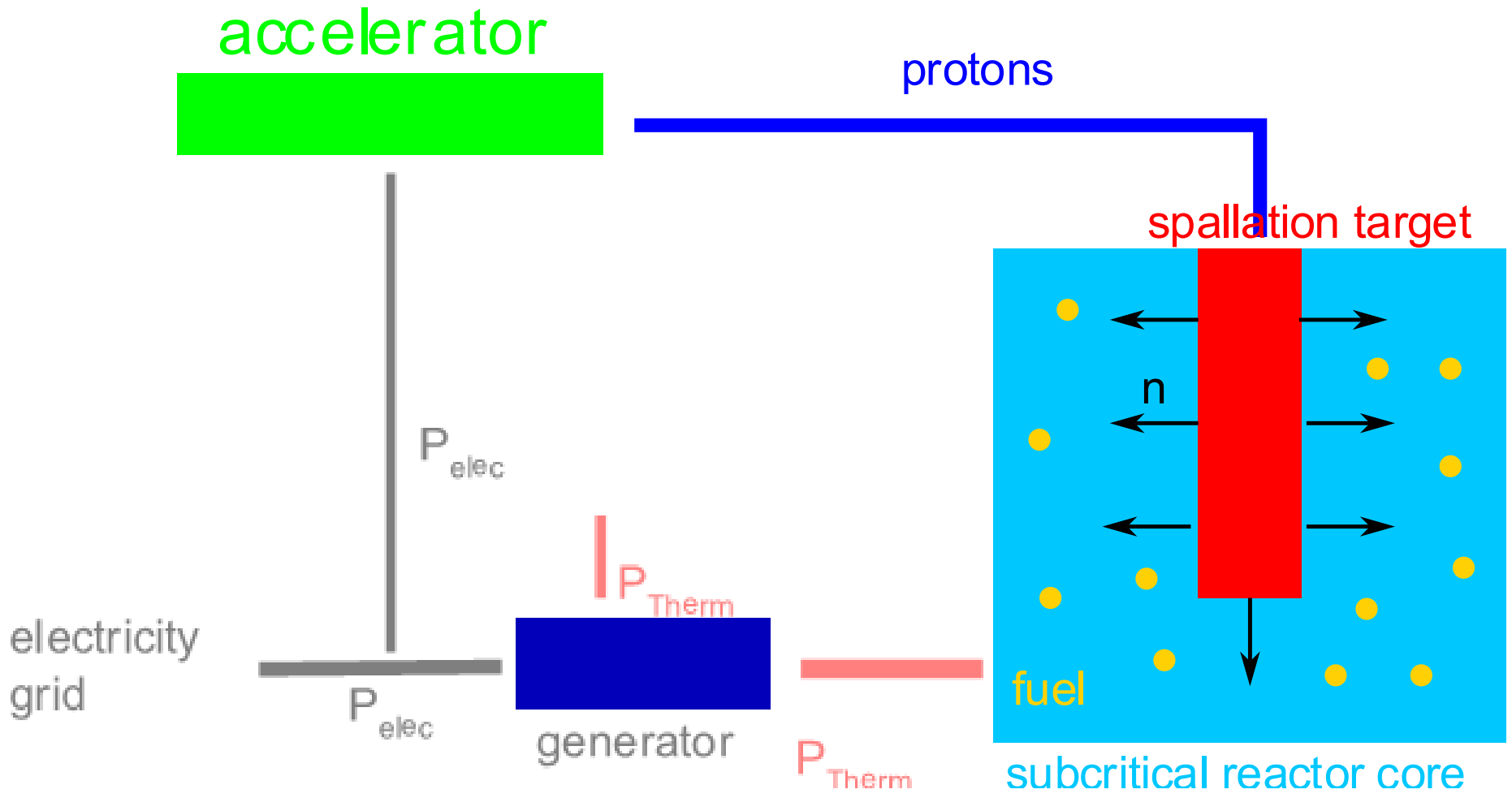
Implementation status of the MINERVA/MYRRHA phase 1 ADS project

Ulrich Dorda

20.10.2026

ADS concept: accelerator-controlled neutrons

(MYRRHAs end goal)



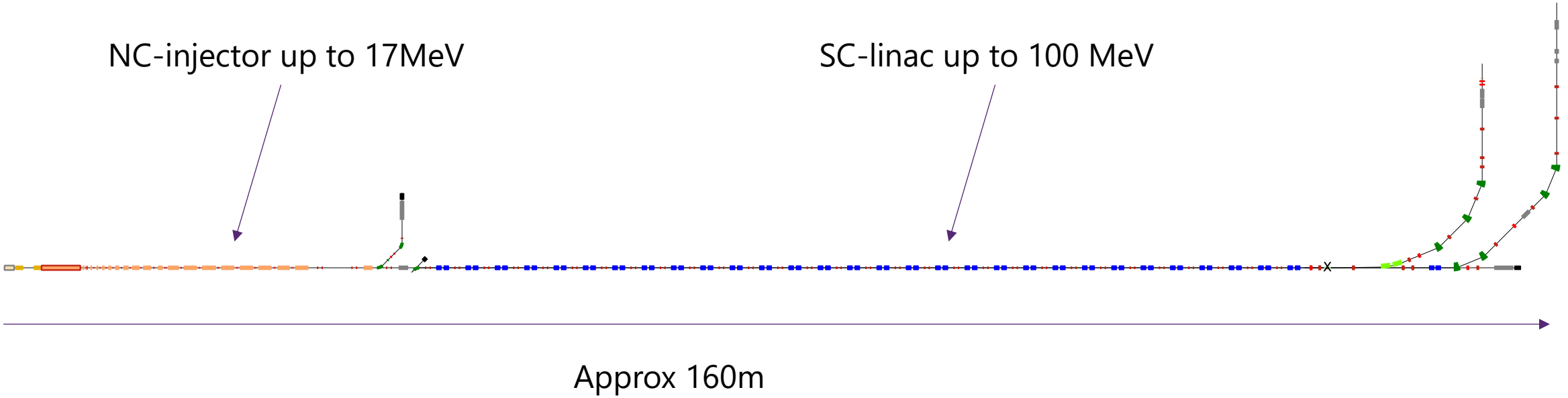
Lead-bismuth as spallation target and safer coolant

Subcritical reactor & "missing" neutrons added externally (spallation)

→ Safe, subcritical reactor with 10x rate of burning minor actinides!

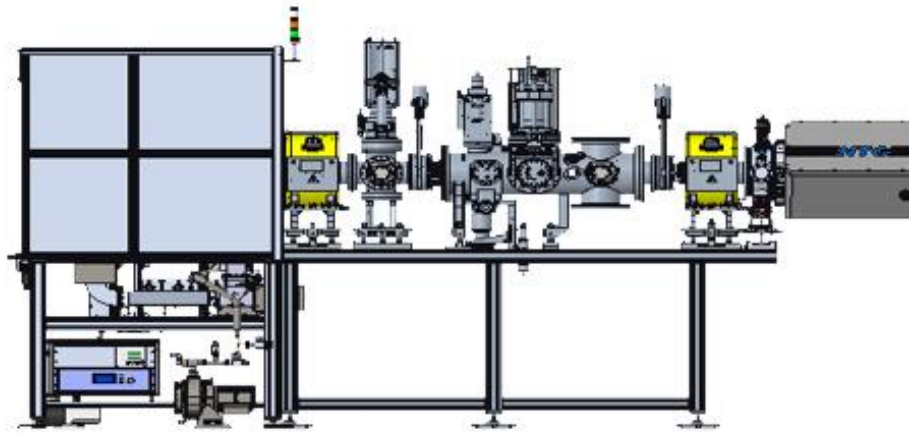
MINERVA overview

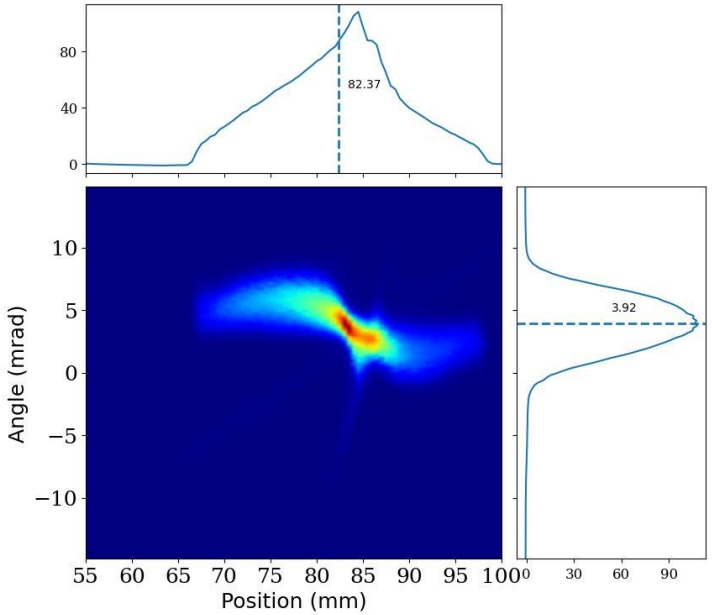
- 1st MYRRHA implementation stage
- 100 MeV, 4mA protons, DC
- SC from 17 MeV onwards (24/30 cryomodules)
- 2 user stations

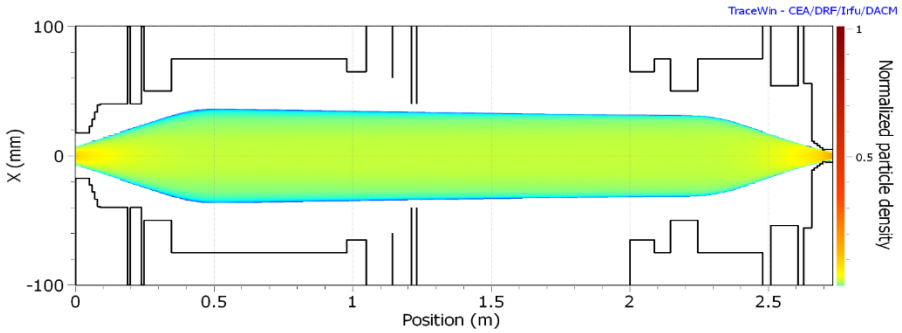


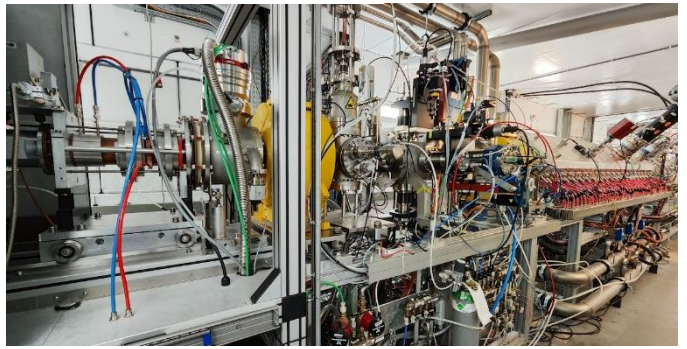
LEBT: design and matching philosophy

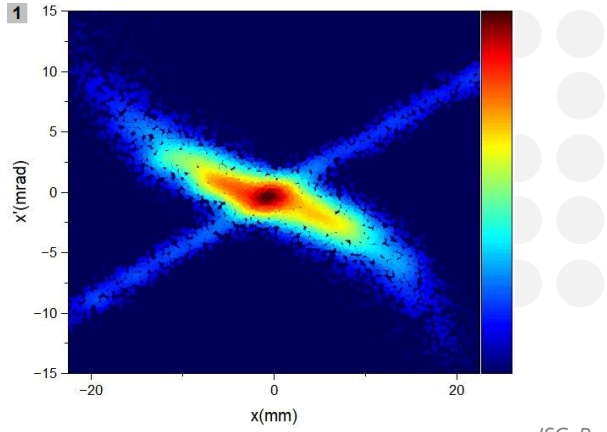
- ECR ion source (DC), 2 solenoids, chopper, diagnostics
- Validated experimentally, refurbishment needec







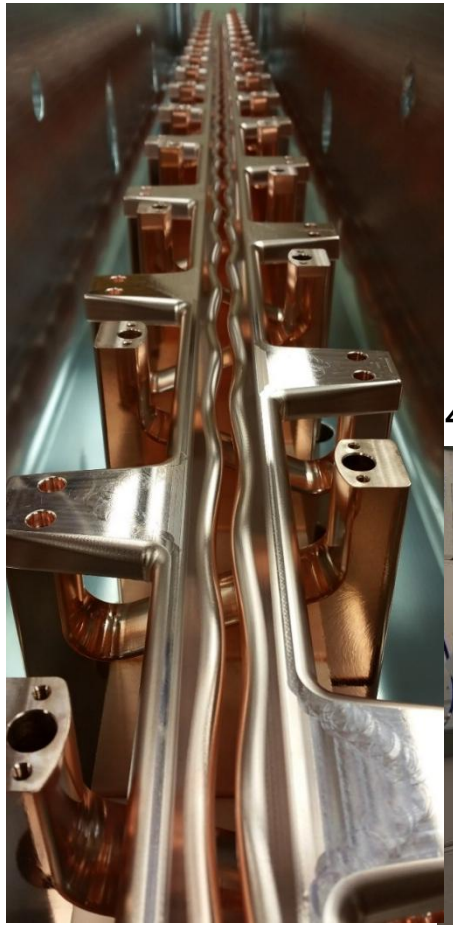




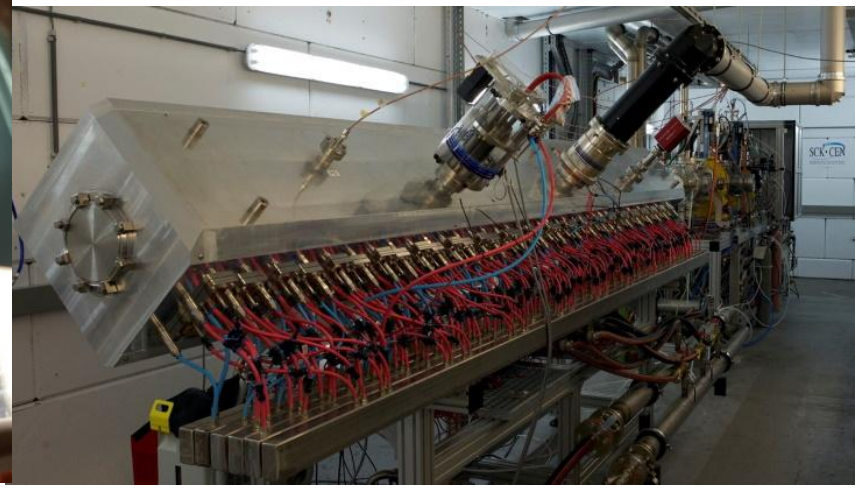
Injector cavities

2 x Quarter wave



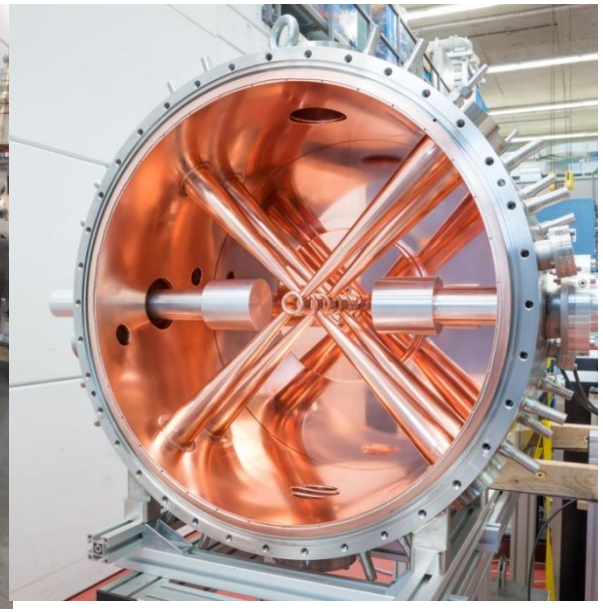


4-rod RFQ

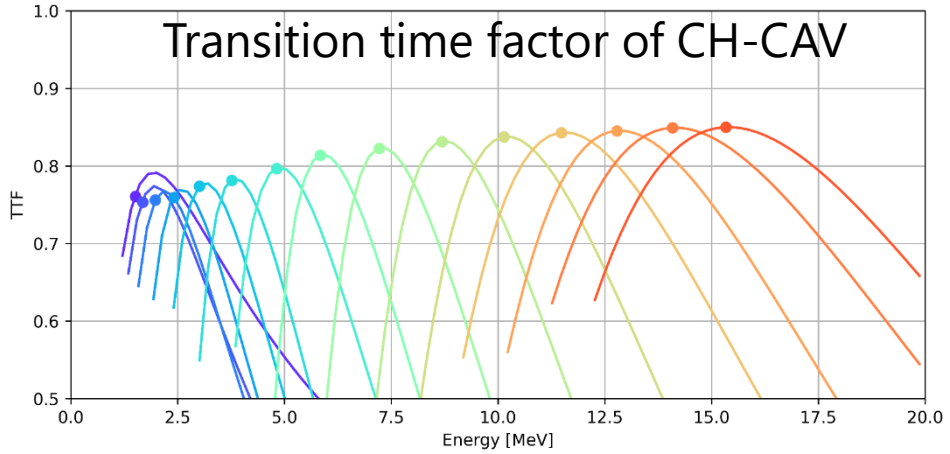


17 x CH cavities



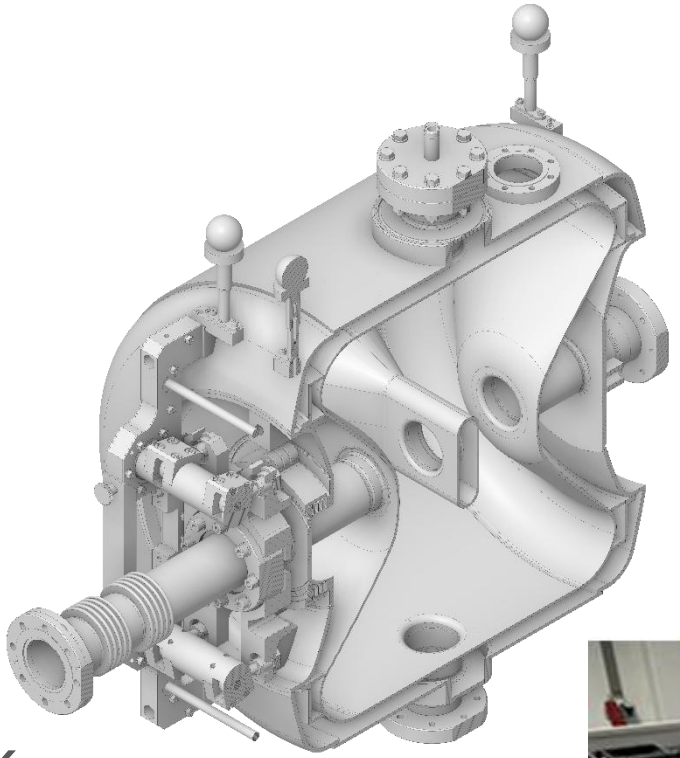


In production at RI



Single spoke cavity

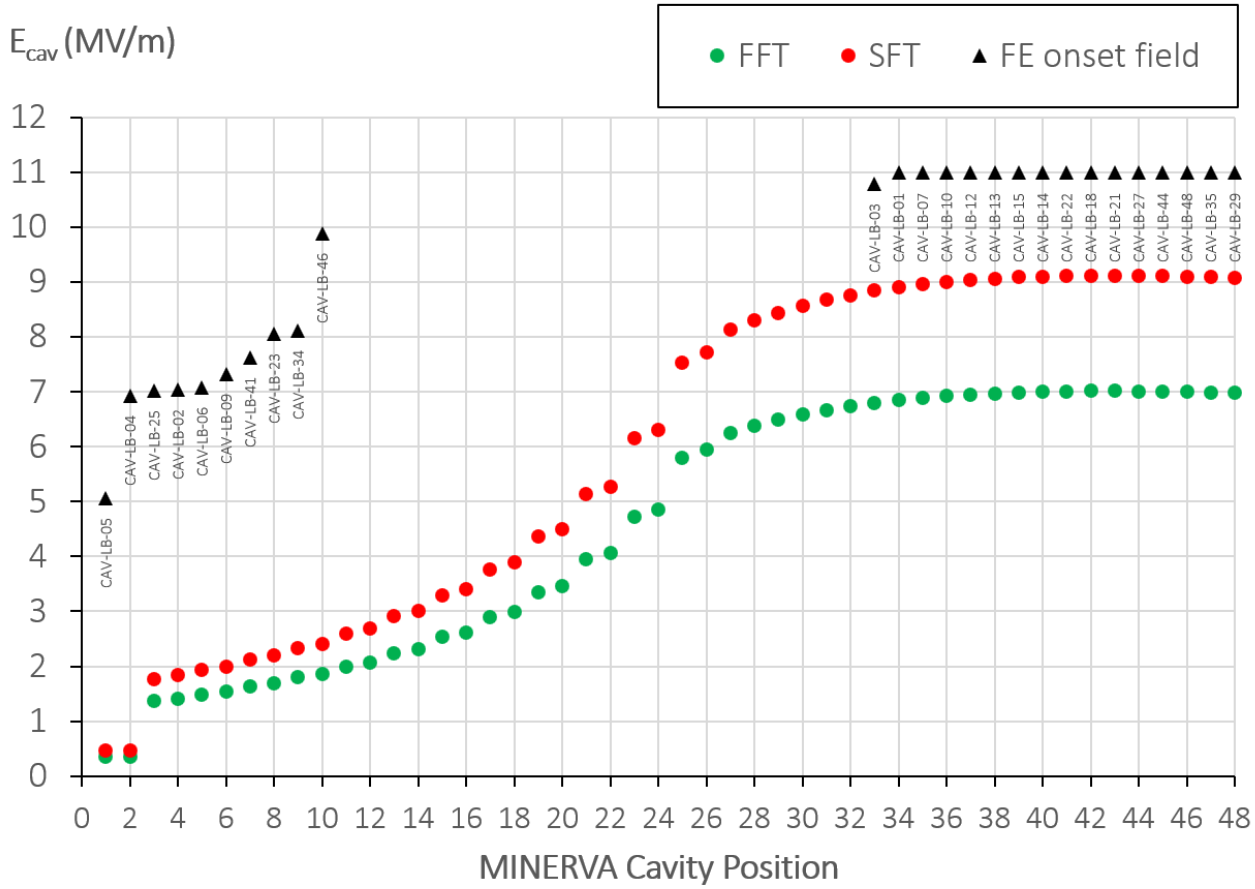
- 352.2 MHz
- 2K LHe
- Q0 > 5.2e9 in cryomodule
- E_nom = 7 MV/m
- E_fault recovery = 9.1 MV/m
- Test stretch goal : 11 MV/m
- Dynamic/static heat-load ratio @2K: MYRRHA: 9W/9W (vs ESS double spoke: 1W/16W)
- Fast detuning capability





Producing/testing SRF cavities

All 53 (48 needed) produced by RI, testing at FREIA ongoing

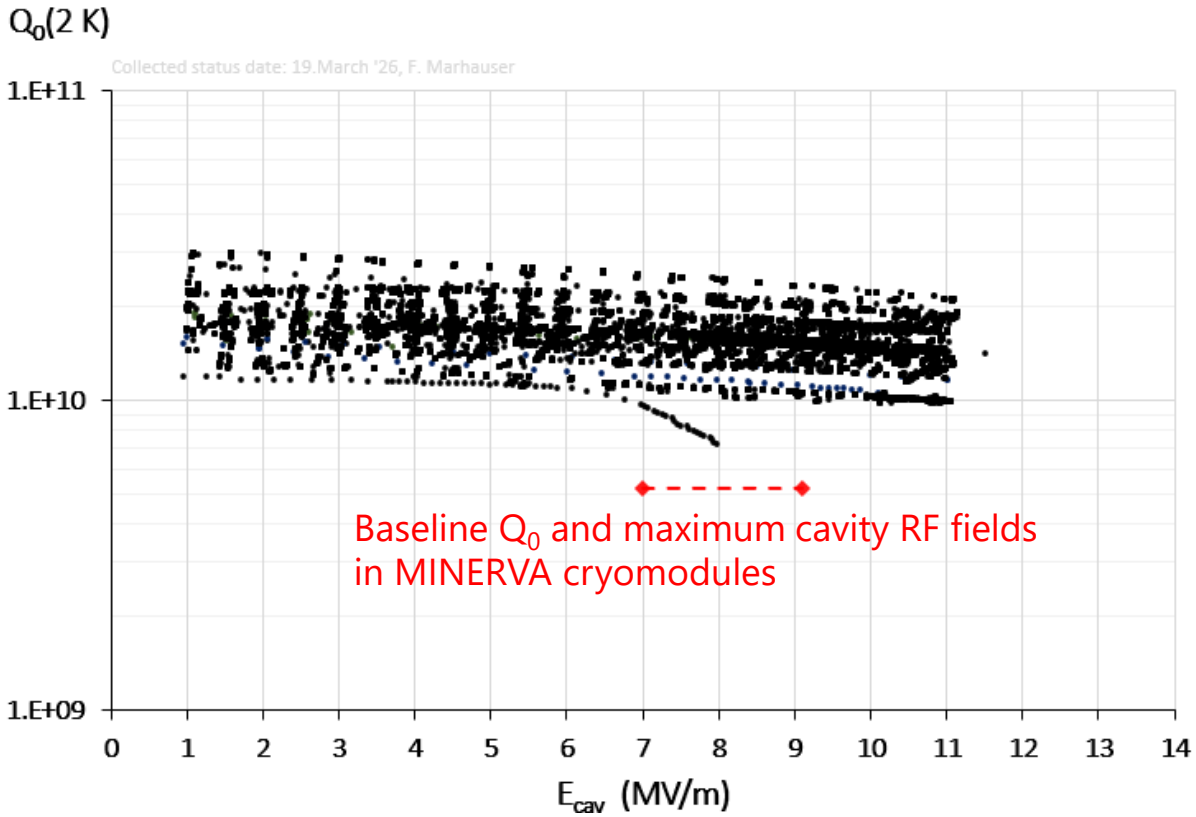


6 of them still require post-processing
8 planned to be re-tested at FREIA
6 of the 8 need retreatments (re-HPR, re-BCP, re-tuning or combination of it)

MINERVA Cavity Acceptance Test Status (at 2K) - Q_0 vs. E_{cav}

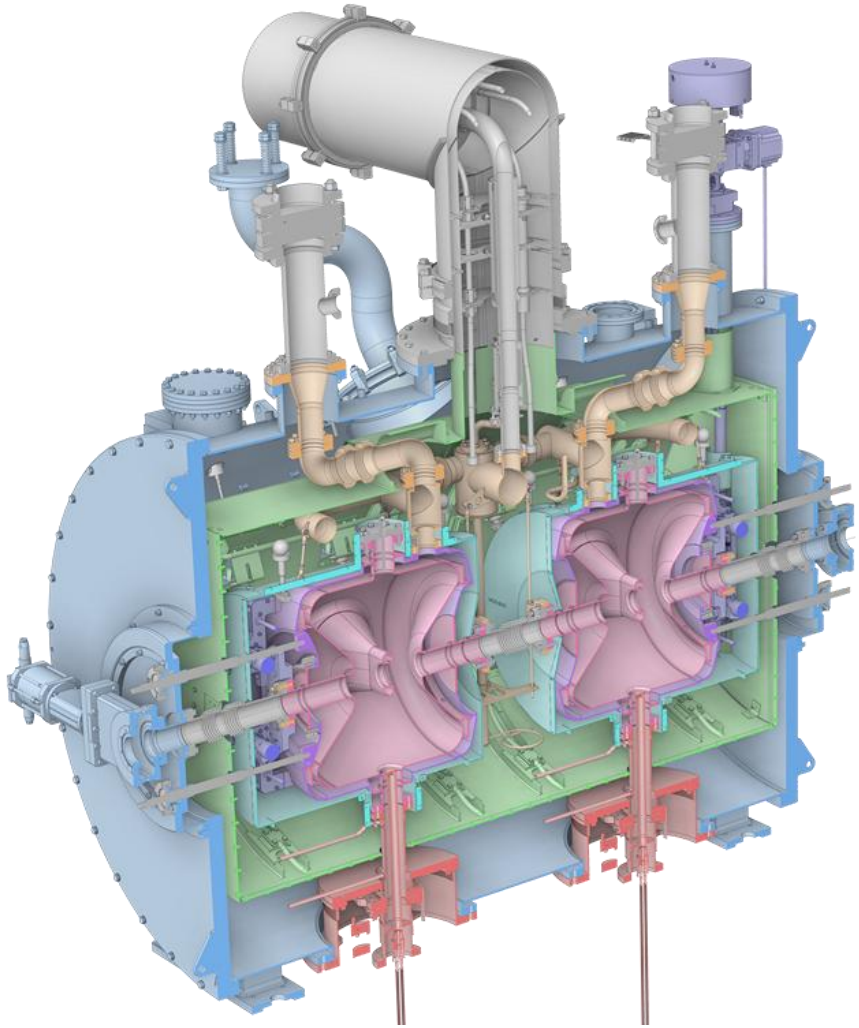
- Main RF performance limitations observed:
  - **Field emission (FE)**
  - **Multipacting (MP) barriers**
    - 1st barrier within ~3-5 MV/m
    - More MP barriers appear at higher cavity fields
- Warm to cold RF frequency shifts are systematically larger for series than for pre-series cavities → required already re-tuning of several cavities (at RI)
- No other issues yet (e.g., quenching, microphonics)
  Testing performed at FREIA
  - Cleanliness issues at FREIA are being resolved



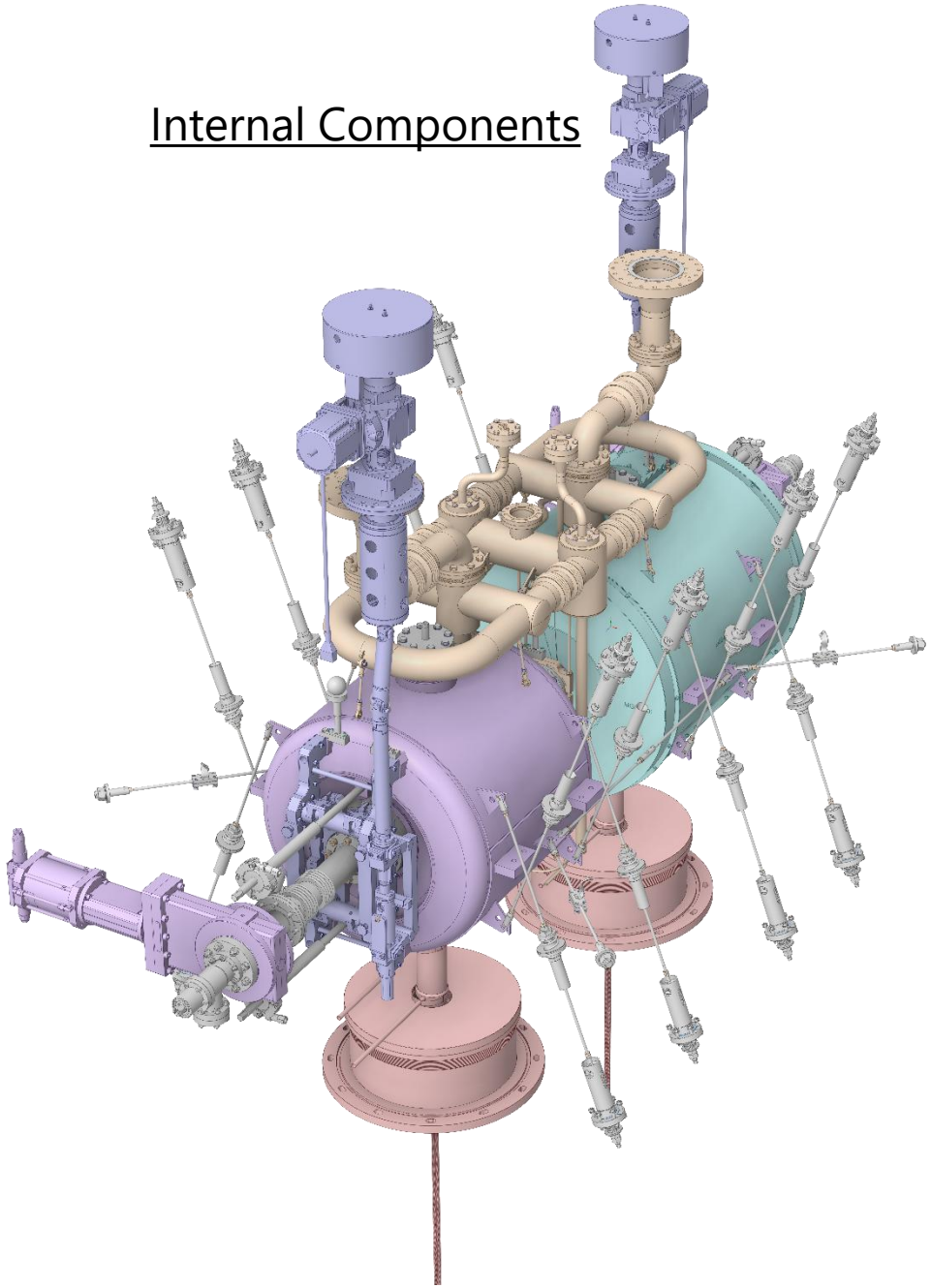


Cryomodule

Cross section



Internal Components



QM Procurement Flow

Current progress as of SEP-2026

Cavity **[CAV]**

Coupler **[CPLR]**

Tuner System **[TUN]**

Magnetic Shield **[MGS]**

Cryostat **[QMST]**

5x manufacturing tenders

QM-assembly tender

Cryomodule **[QM]**

Assembly tender

research instruments

Assembly preparations ongoing

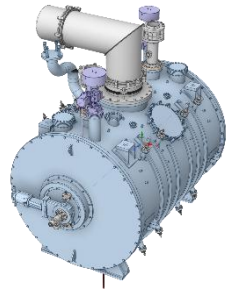
QM Prequalification at FREIA

Cryomodule **[QM]**

Collaboration activity

UPPSALA UNIVERSITET FREIA

Test stand preparations ongoing

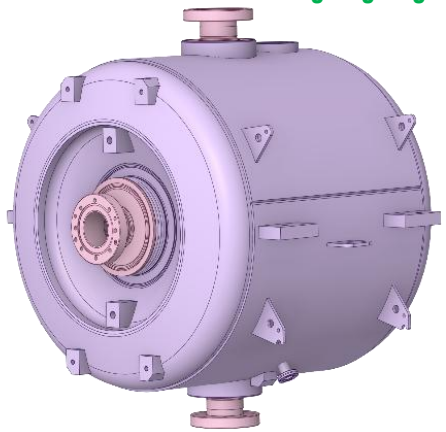


Installation

Internal activity

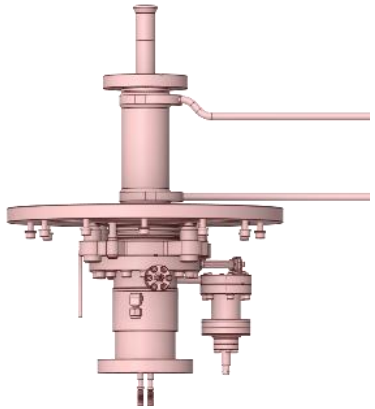
sck cen

Series Production + Testing ongoing



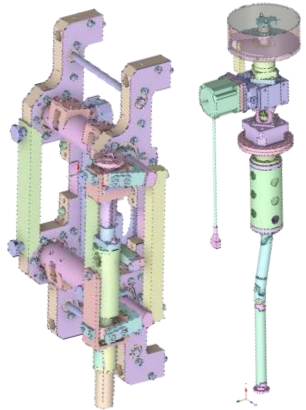
CAV | research instruments

Manufacturing qualification ongoing



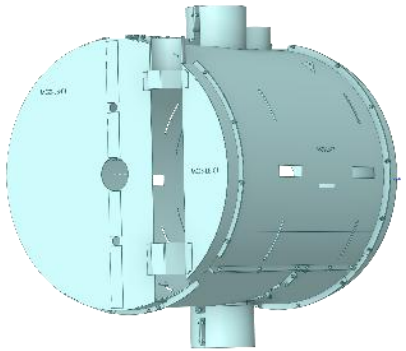
CPLR | research instruments

1st Pre-Series FAT ongoing



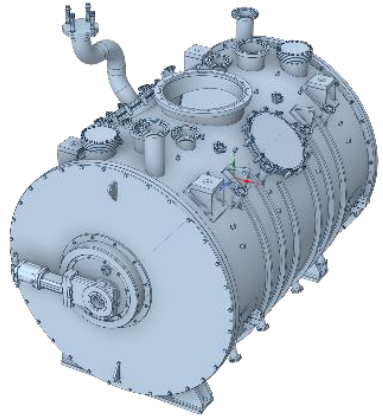
TUN | AMOS KEEP EXPLORING

Series Production ongoing



MGS | MECA MAGNETIC magnetic shielding

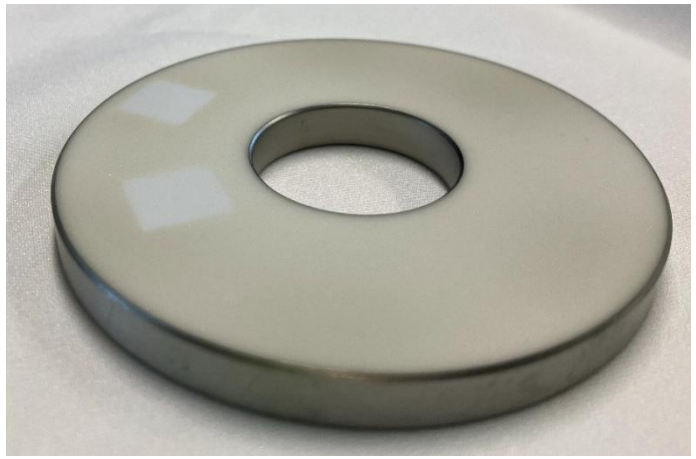
Manufacturing file under preparation

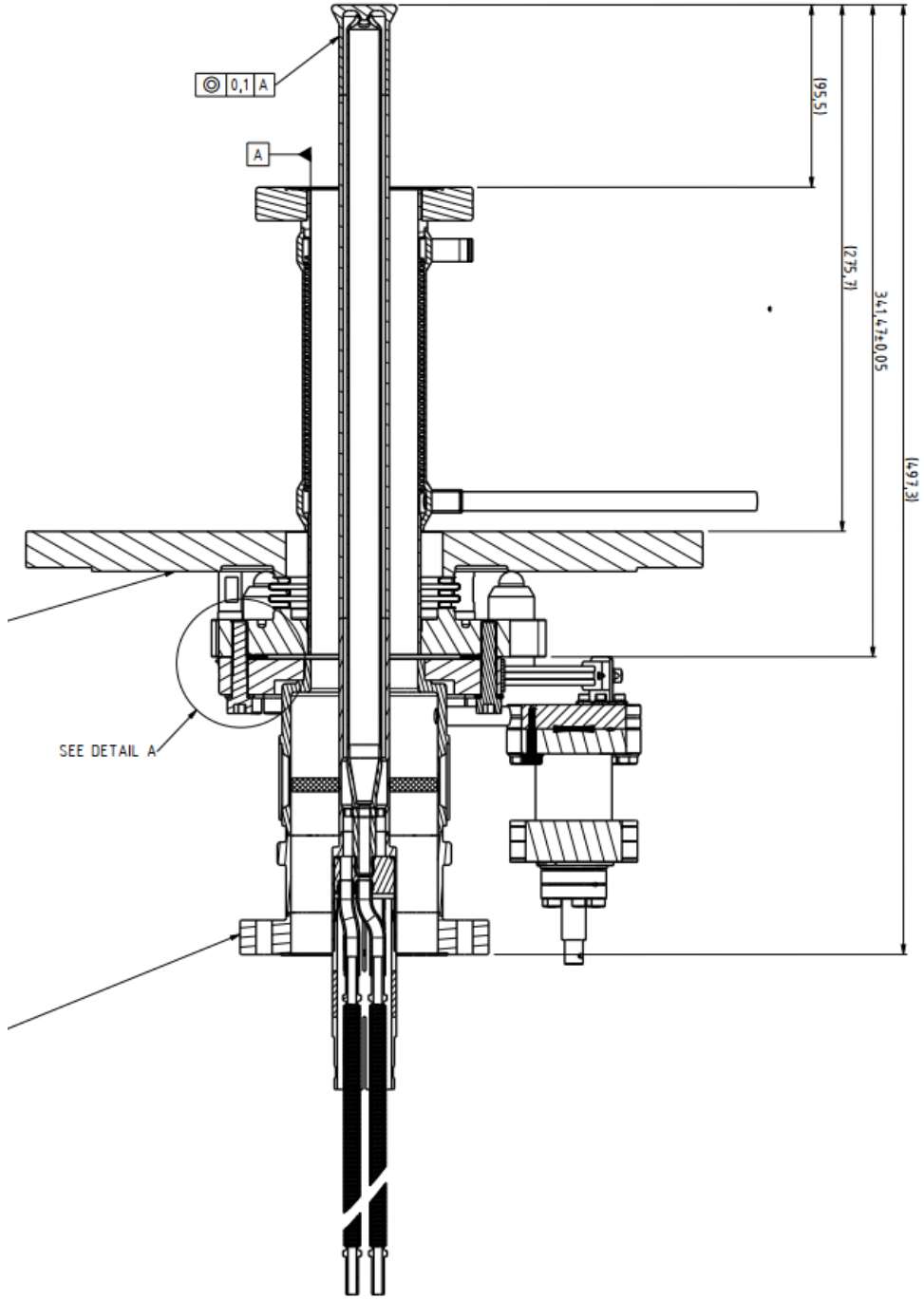


QMST | research instruments

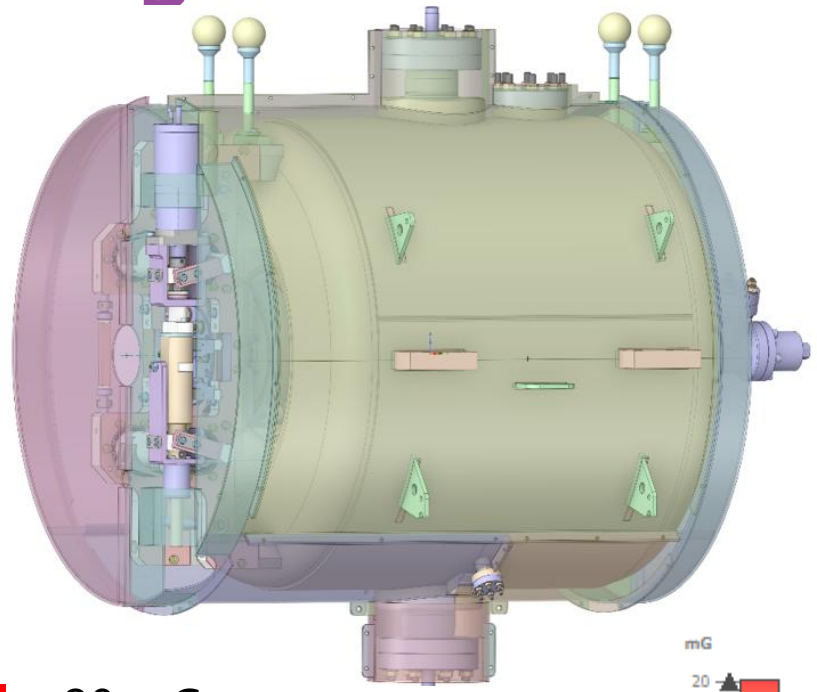
RF Power Coupler

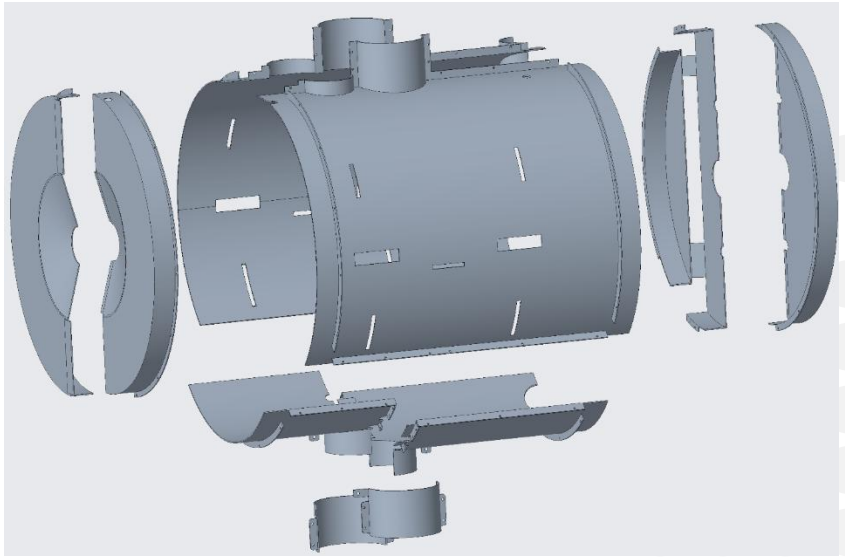
- Fixed coupler (external Q not adjustable)
- Cuff cooling with super critical He
- No choke joint needed
- Pre-series production start at RI imminent
- Copper & 10 nm TiN coating samples being evaluated



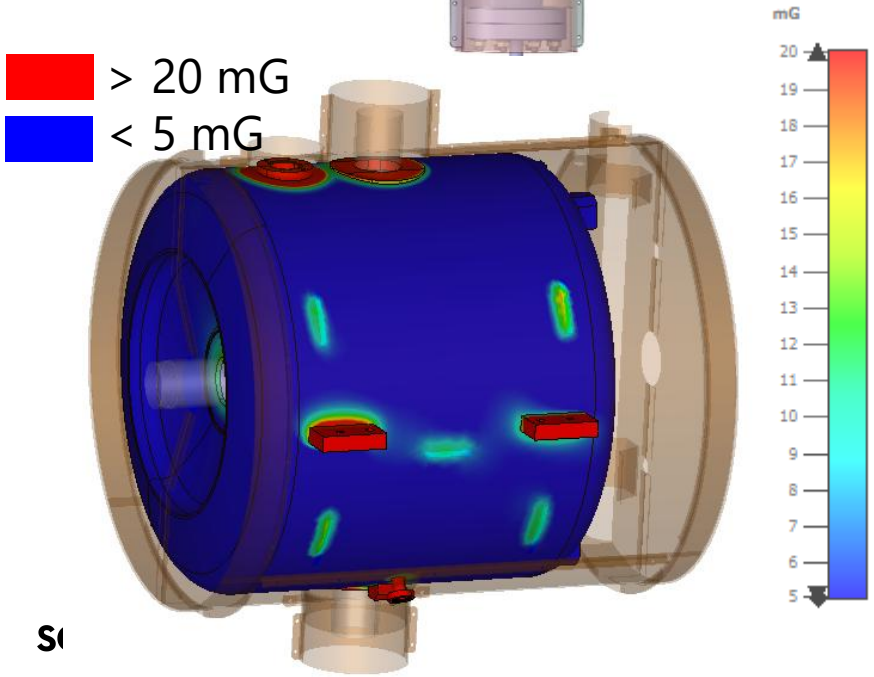


Magnetic shield









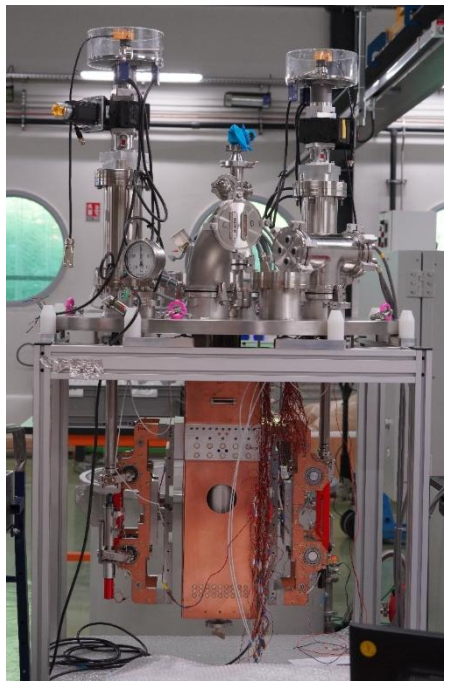
Production about 50% done.

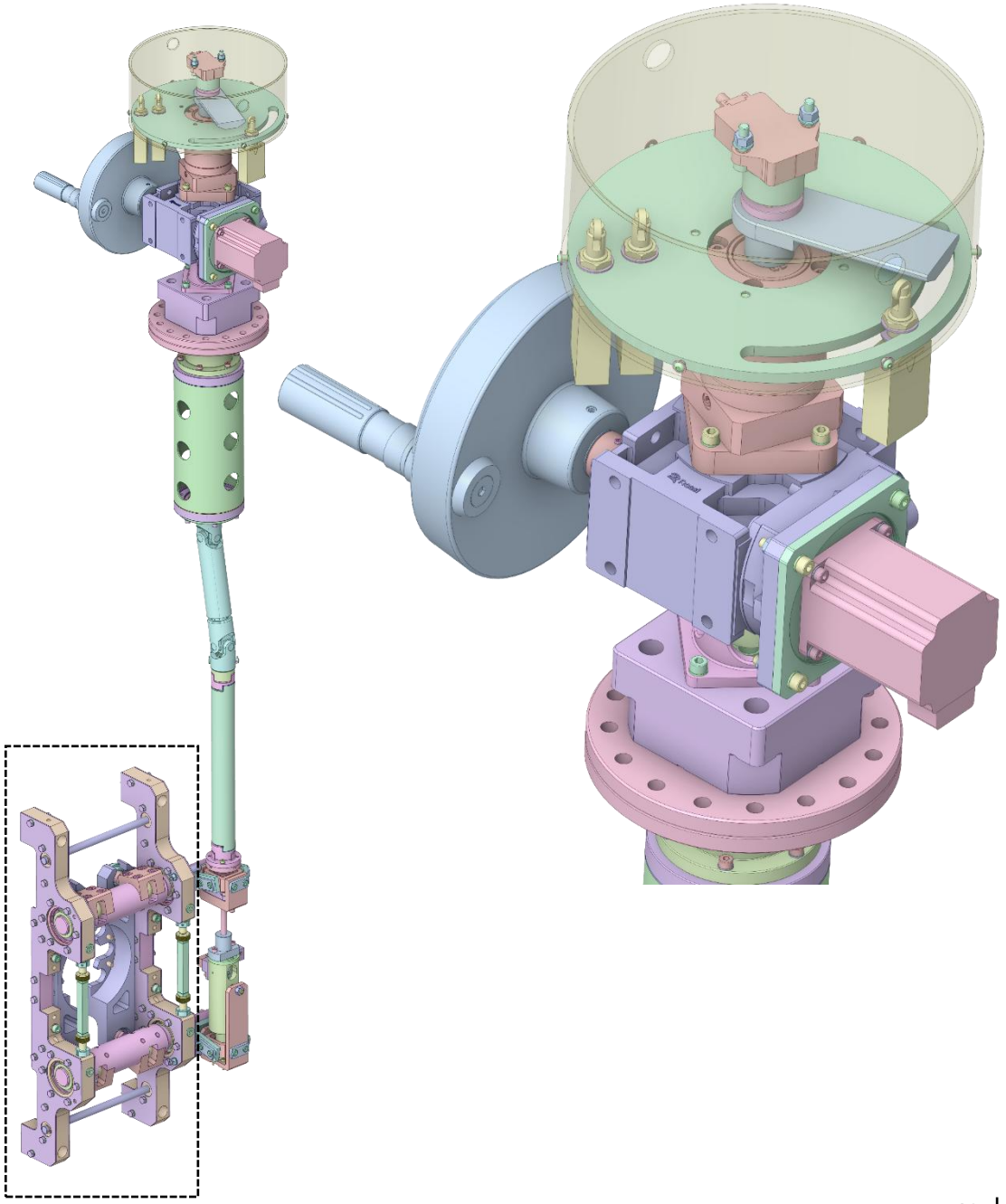
ISC: Restricted

Warm Motor Solution

- Repeated fast detuning requirement does not allow for a risky cold motor
- ex-vessel: motors, worm gear, planetary gear, indicator lever w. angle sensor, limit switches
- resulting heat flow: 0,23..0,33 W
- No cold disengage system needed as external solution: redundant motor/driver, handwheel

Successfully validated!!
(at IJCLab)





Cold part design by IJCLab

LLRF

- Collaboration with DESY who is currently developing a reference board
  - DAMC-DS5014DR with direct sampling architecture, 5 GS/s ADCs and DACs
- Phase reference distribution system being tendered
- Cavity simulator developed by WUT

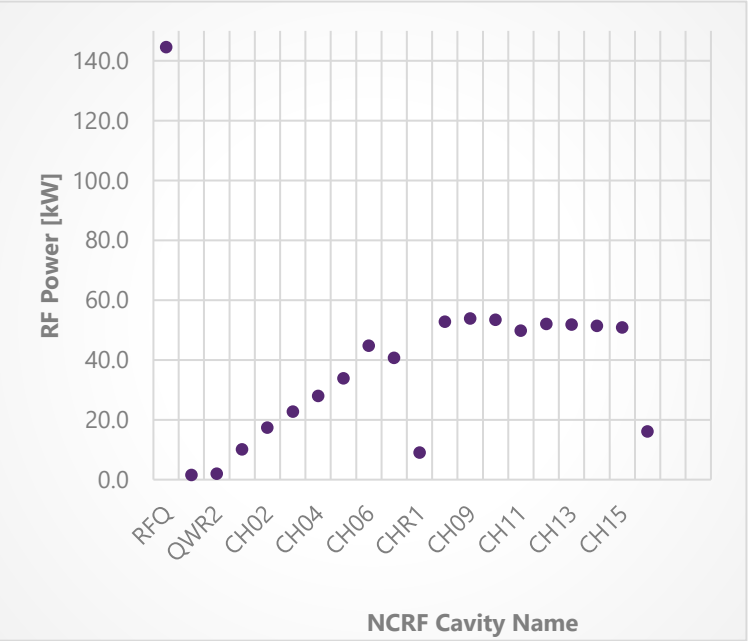
Solid state amplifiers

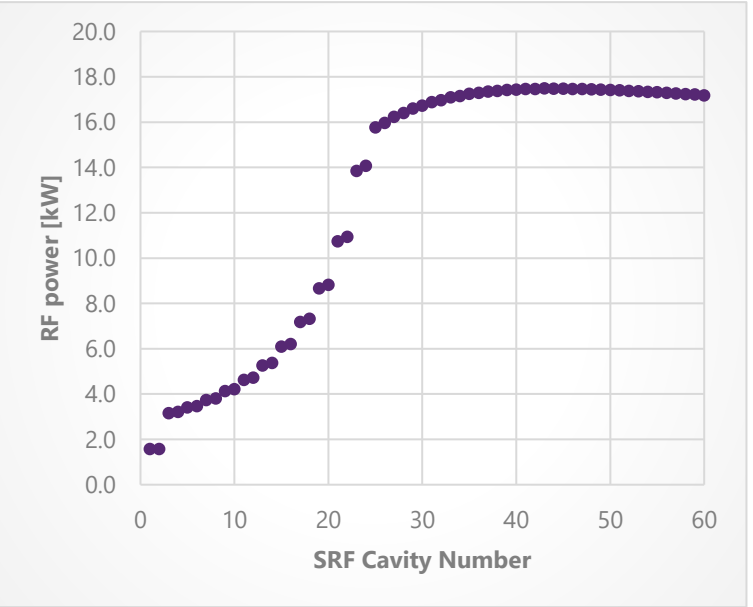
- 80 SSAs at176 MHz & 352.2 MHz

- 11 different power levels between 6 and 154 kW
- RF power for nominal working point: 1.3 MW
- Total available RF power: 1835 kW

- # of LDMOS Transistors > 2000
- Drain voltage adaptation for efficiency optimization

- Production at Cryoelectra started



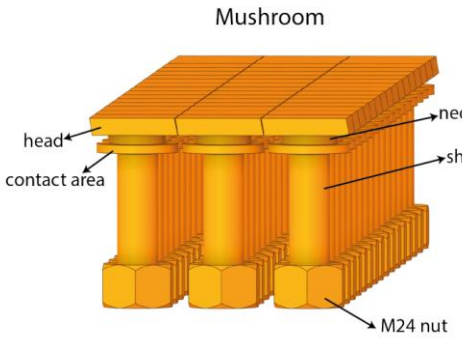


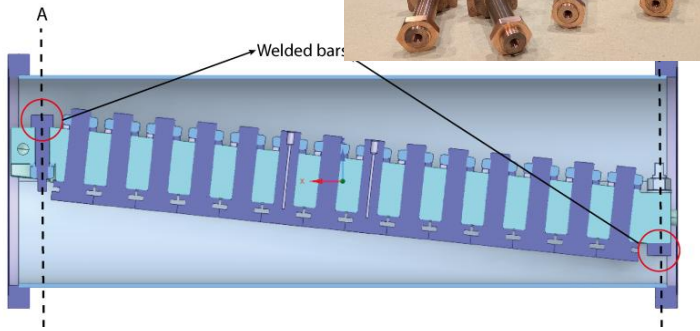
ISC: Restricted

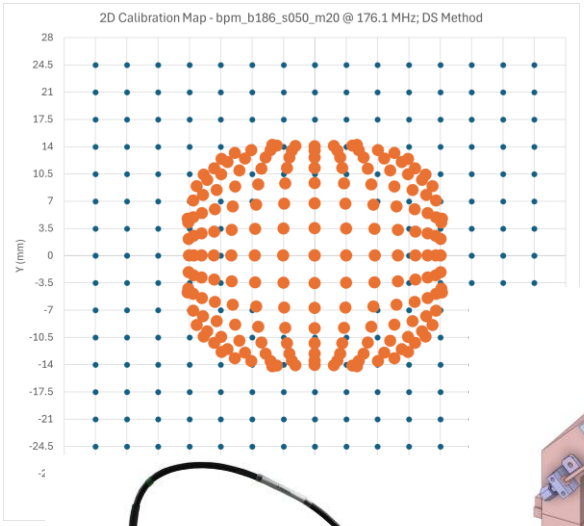
Progressing on other systems

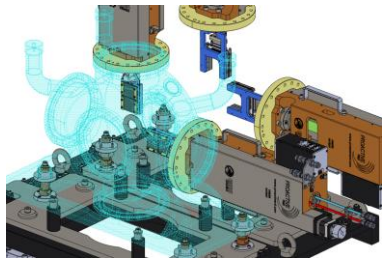
- Cryoplant 2nd stage tender just published
- Vacuum
  - All all-metal-gate valves received
  - Pumps & measurement tender in execution
  - Vacuum armature tender completed
  - 1st ISO7 clean room established
- Beam dumps by ESS Bilbao
- Collimators by Proactive
- Magnet designs progressing with ACT, Framework contract published
- ACCTs received, BPM designs completed
- Circulator contract awarded to AFT
- ….



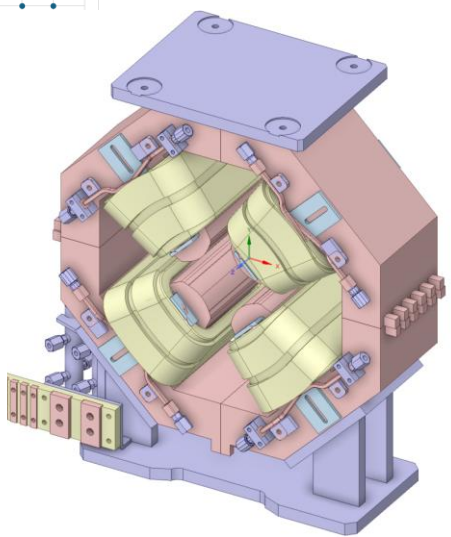










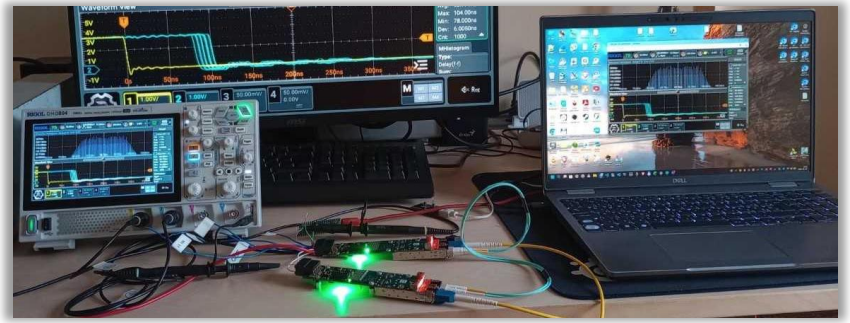


MINERVA Control- and Interlock-System Cornerstones

- **Software** layers will be fully EPICS-based: IOCs for device integration, phoebus services and UIs.
- **Slow Control** (e.g. Cryogenics, Vacuum, slow interlocks): Siemens PLCs, SIMATIC AX based
- **Fast Control** (LLRF, fast interlocks, custom beam instrumentation): FPGA on uTCA Custom development for fast interlock transmission
- **Timing System** based on White Rabbit: Port of White Rabbit Event Node (CERN development) to uTCA Card developed by DESY.

EPICS

SIEMENS



White Rabbit
COLLABORATION

Setting up teststands & Labs spaces

Revamping an old building for accelerator test stands

- Ion Source + LEBT set-up: Controls setup, beam physics, installation procedures
- NC-RF test bunker
- SAT purchased components (magnets, PCO's, ….)
- Inspect and assemble components (RFQ, mechanical subassemblies, SSA, ..)
- Availability of Clean room – test structures – offices/space
- Storage







Constructing buildings and infrastructure





- Construction of utility buildings completed
- Main building construction & infrastructure start awaiting governmental approval

Status/Outlook

- Tendering work peaked
  - Finalization of Cryoplant and Cryodistribution main missing items
- SC-Cavity production almost completed, testing ongoing
- Building construction started, progress currently slowed by government
- Linac Installation currently envisaged for 2029 – 2031

Copyright © SCK CEN

All property rights and copyright are reserved.

This presentation contains data, information and formats for dedicated use only and may not be communicated, copied, reproduced, distributed or cited without the explicit written permission of SCK CEN.
If this explicit written permission has been obtained, please reference the author, followed by 'by courtesy of SCK CEN'.

Any infringement to this rule is illegal and entitles to claim damages from the infringer, without prejudice to any other right in case of granting a patent or registration in the field of intellectual property.

SCK CEN
Belgian Nuclear Research Centre
Studiecentrum voor Kernenergie
Centre d'Etude de l'Energie Nucléaire

Foundation of Public Utility
Stichting van Openbaar Nut
Fondation d'Utilité Publique

Registered Office:
Avenue Herrmann-Debrouxlaan 40 - 1160 BRUSSELS - Belgium

Research Centre:
Boeretang 190 - 2400 MOL - Belgium