

# HED@FAIR

## Status report to ECE/ECSG

*Stephan Neff*  
*on behalf of the HED@FAIR collaboration*



Finland



France



Germany



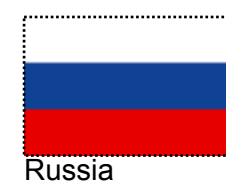
India



Poland



Romania



Russia



Slovenia



Sweden



UK

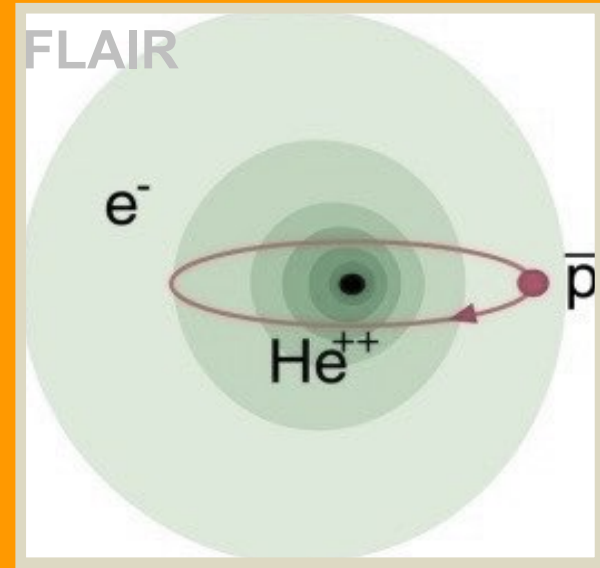


Czech Rep.

## Atomic Physics



strong field research  
... probing fundamental laws of physics



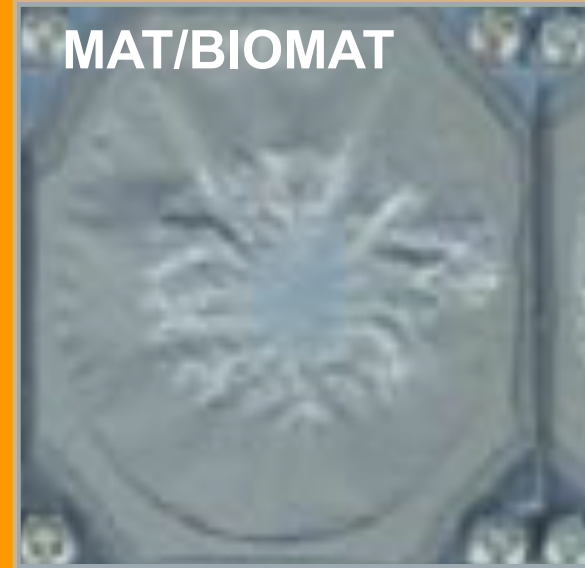
antimatter  
... matter / anti-matter symmetry (not in MSV)

## Plasma Physics



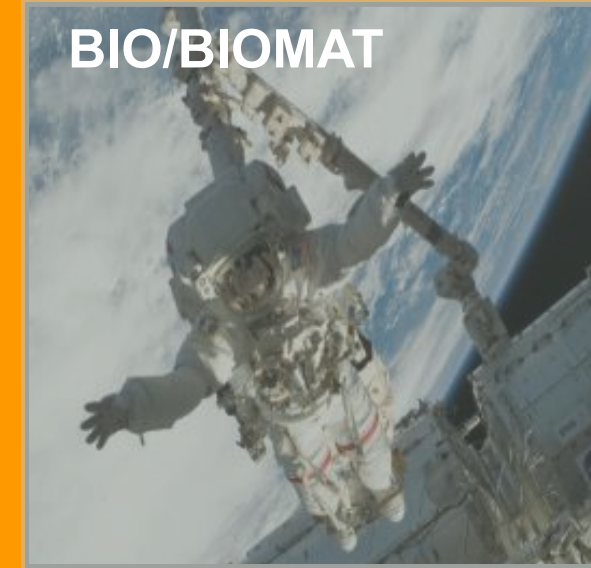
extreme states of matter  
... common in astrophysical objects

## Materials Science

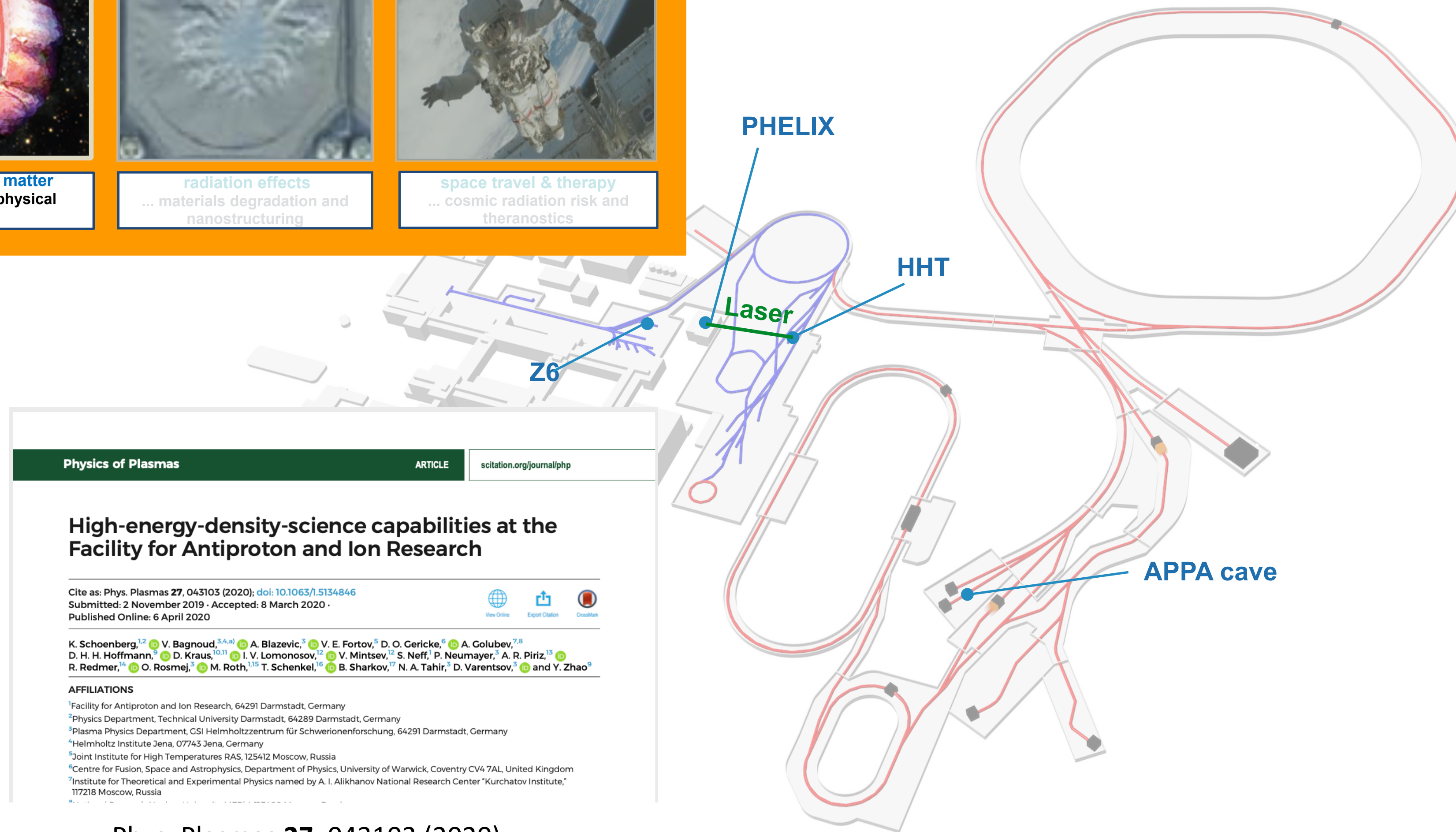
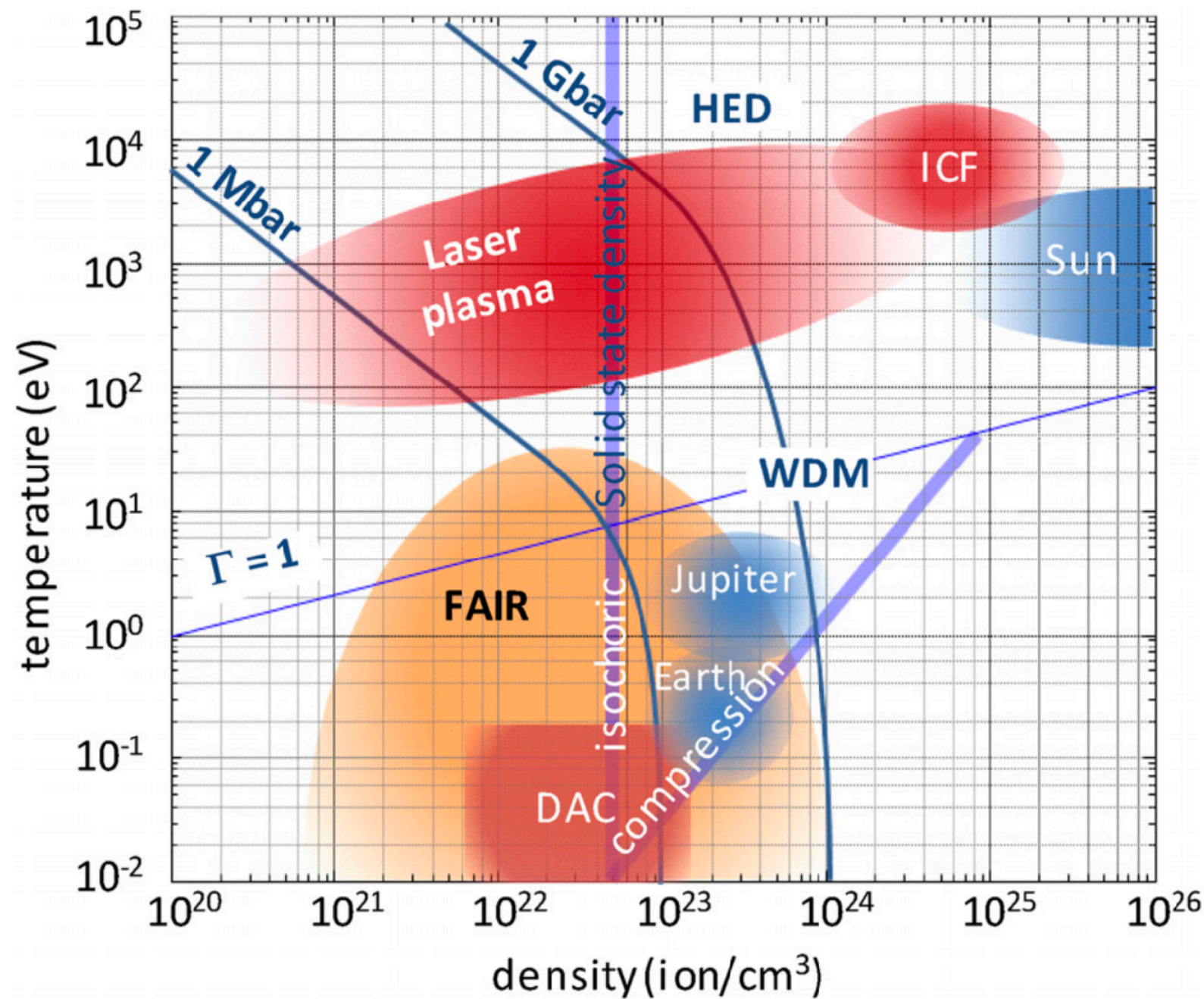


radiation effects  
... materials degradation and nanostructuring

## Biophysics



space travel & therapy  
... cosmic radiation risk and theranostics



Physics of Plasmas ARTICLE scitation.org/journal/php

### High-energy-density-science capabilities at the Facility for Antiproton and Ion Research

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Phys. Plasmas 27, 043103 (2020)

# Major developments since the last meeting

## PRIOR proton microscope

Installation & SAT currently taking place

Phase 0 experiments using proton microscopy scheduled for 2021

## Target chamber

Construction progressing

Construction to be finished by spring 2021

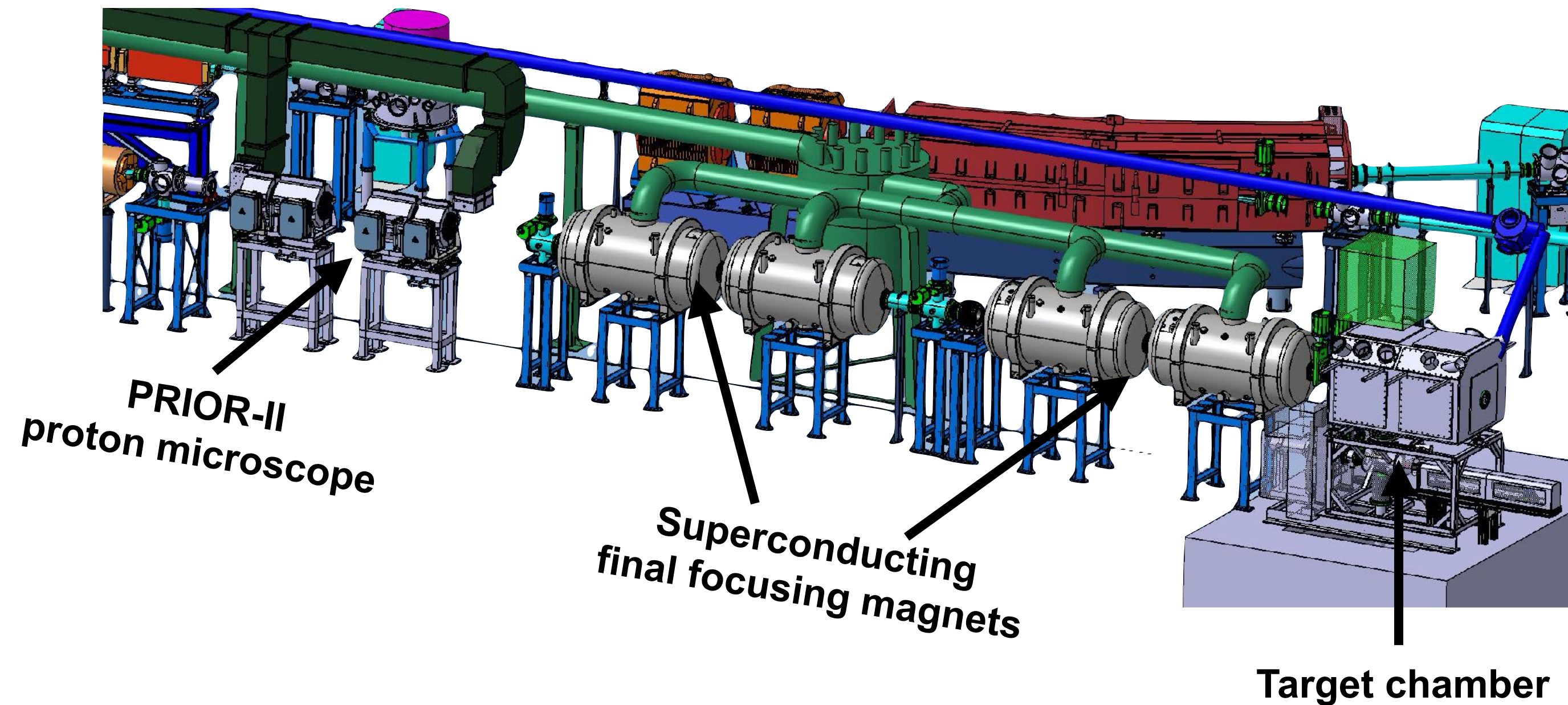
## Laser beamline to HHT area

Construction progressing according to plan

Will allow for coupled laser-ion experiments in 2022

## BMBF call for next round of Verbundforschung (2021-2024)

Applications for target positioning & cleaning, laser parts, detectors



Technical Design Report	Status	Needed for
Superconducting final focusing system	Approved	Day-1
Detectors	Approved	Day-1
Diagnostic laser	Approved	Day-1
Data acquisition, triggering, controls	Approved	Day-1
Proton microscopy (PRIOR-II setup)	Approved	Day-1
RF beam rotator	Approved	Full MSV
Target chamber	Approved	Day-1
Cryogenic target fabrication	To be submitted	Full MSV

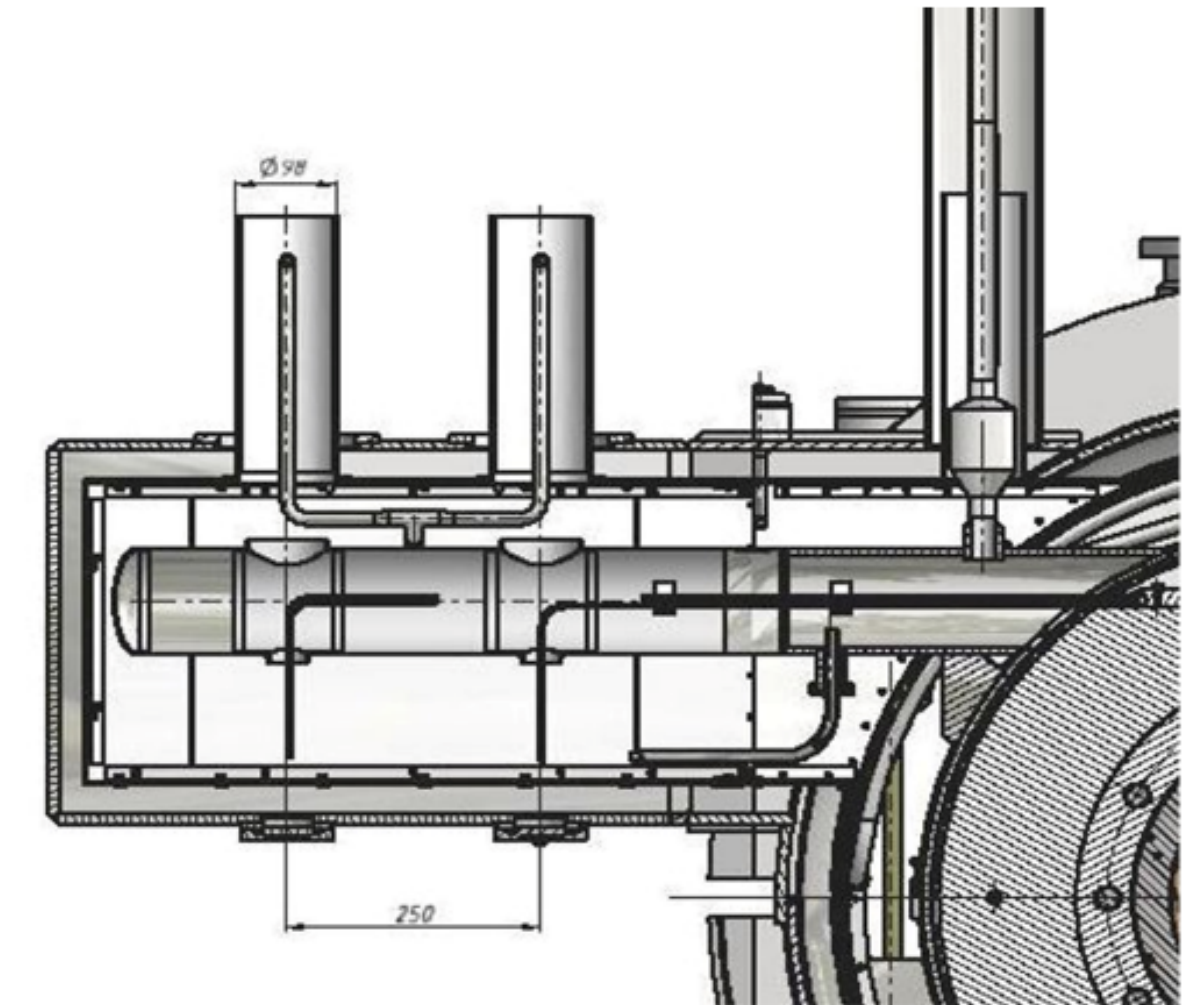
# Superconducting final focusing system (PSP 1.3.2.1.2)

## Superconducting Quadrupole Magnets (1.3.2.1.2.1)

Russian in-kind contribution (2.8 M€, 2005 prices)

IHEP is acquiring materials for production and preparing the tooling

Current leads (part of accelerator cost book) are being tendered, offers are evaluated by GSI



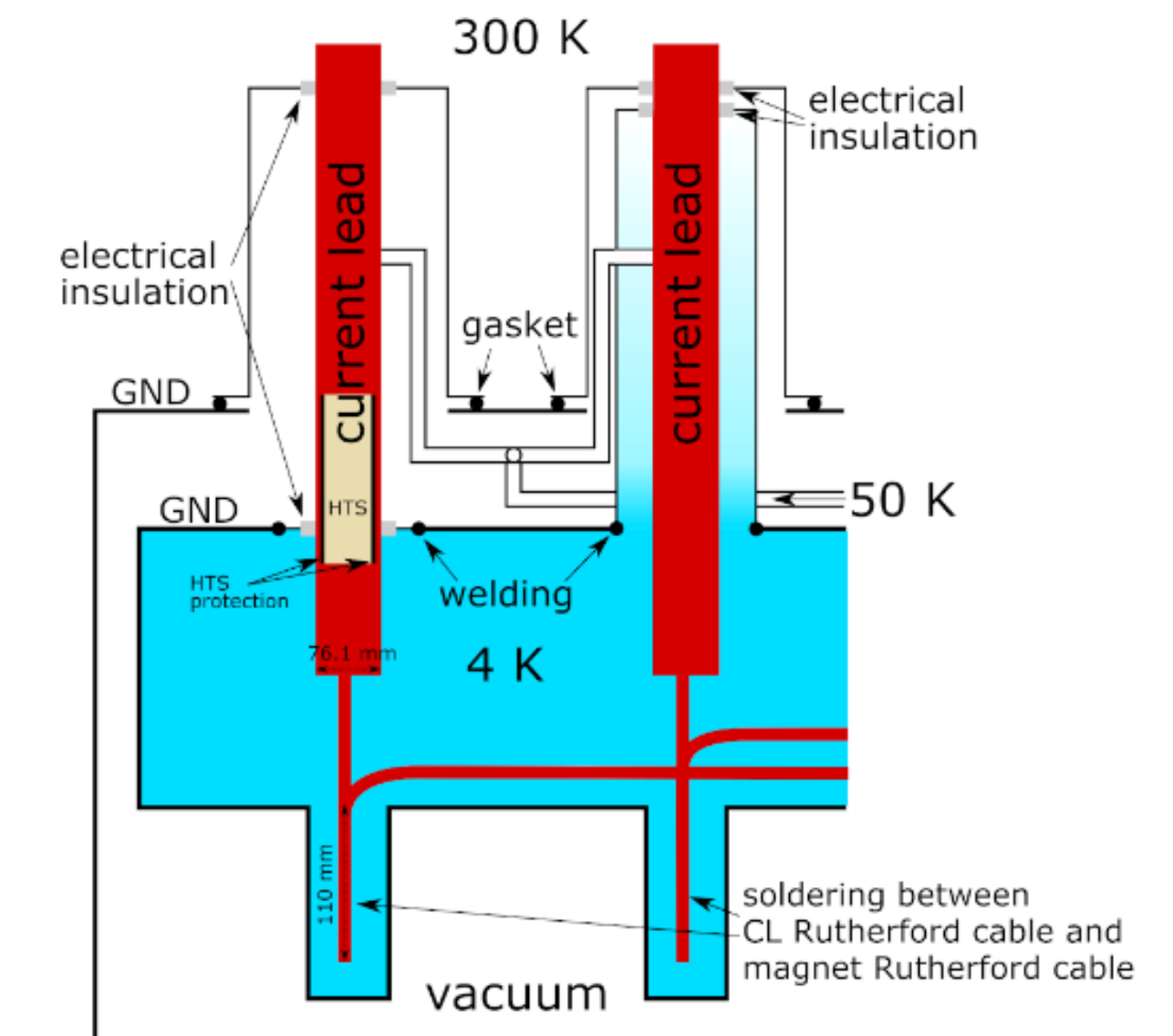
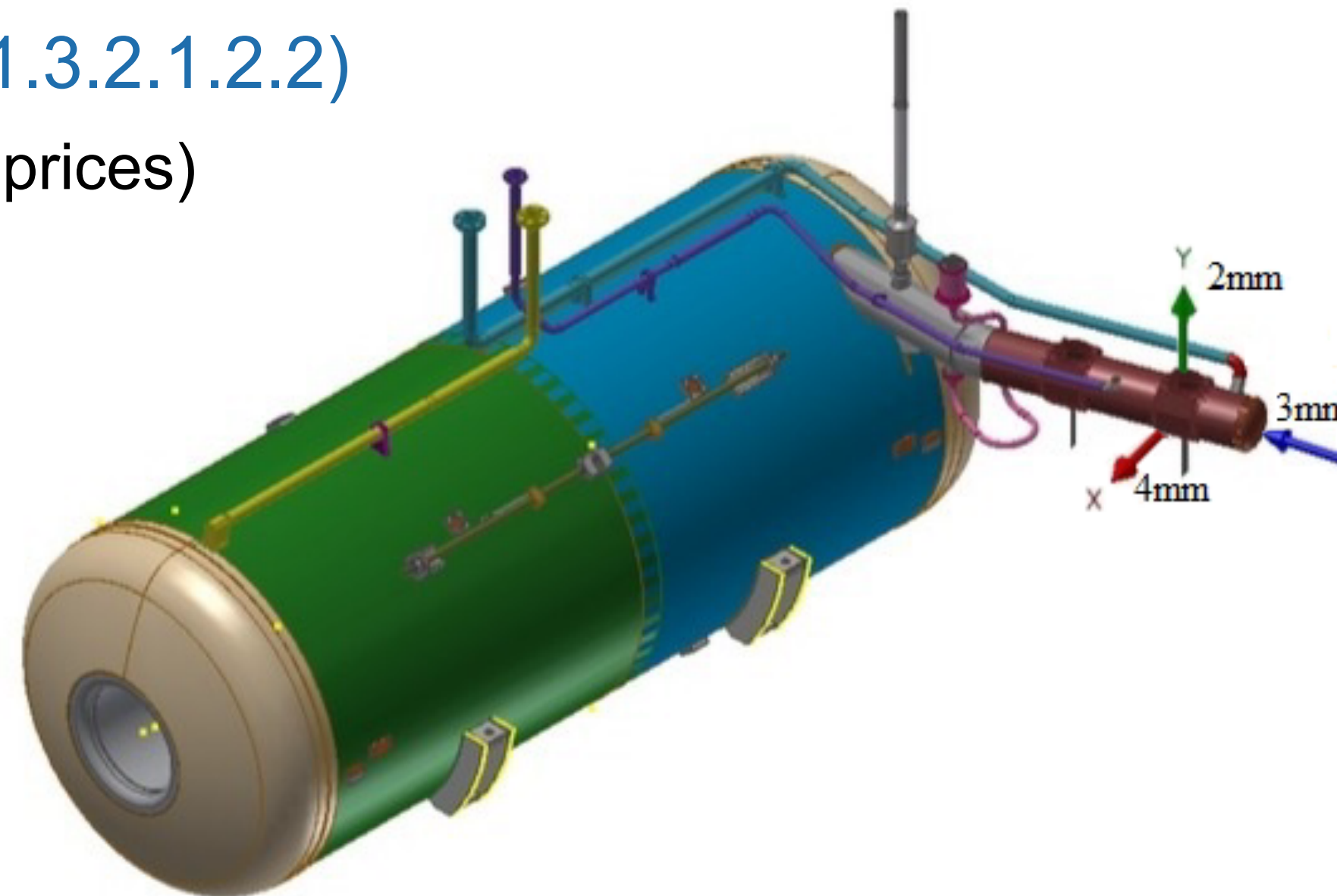
## Power Supplies and Quench Protection (1.3.2.1.2.2)

German in-kind contribution (694 k€, 2005 prices)

GSI-FAIR in-kind contract signed

Quench protection to be built by GSI

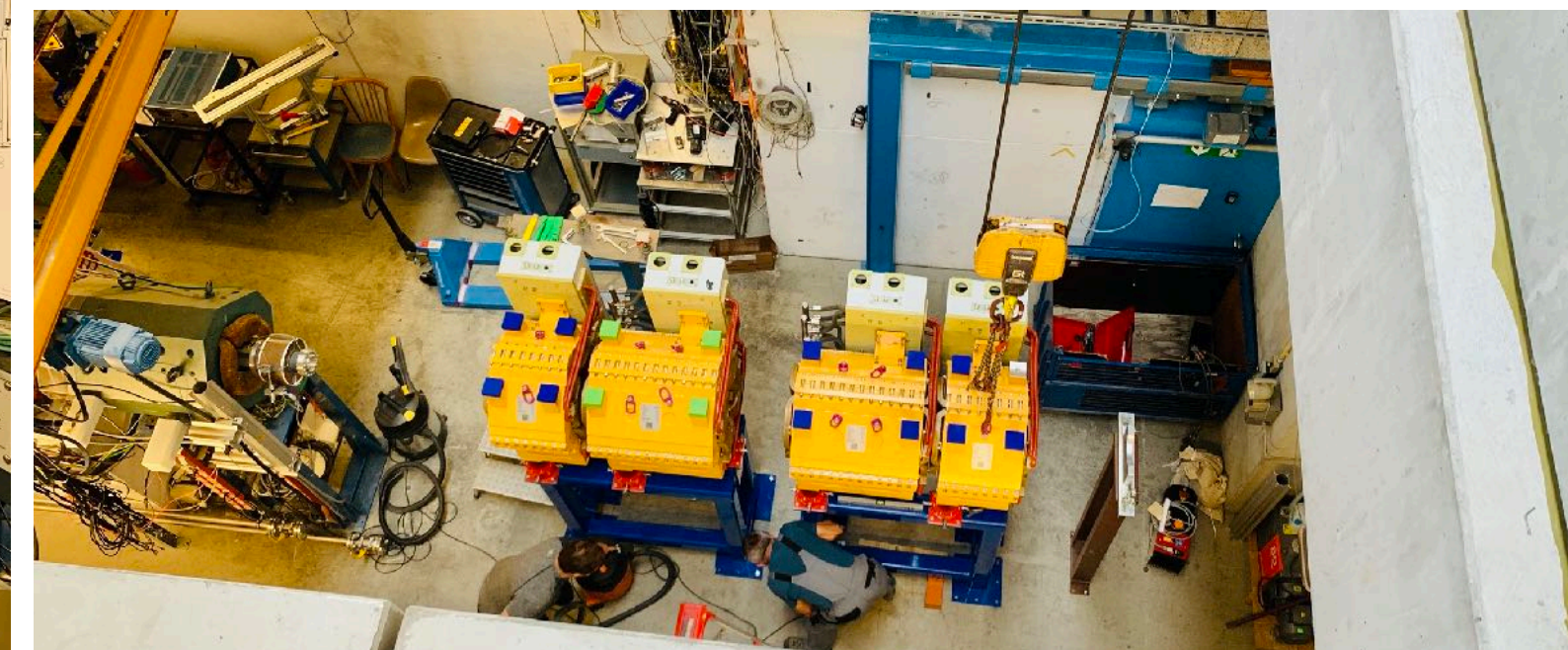
Tendering for power supplies in progress



## Magnet Installation

Jun - Sep 2020 - Craning & Mounting

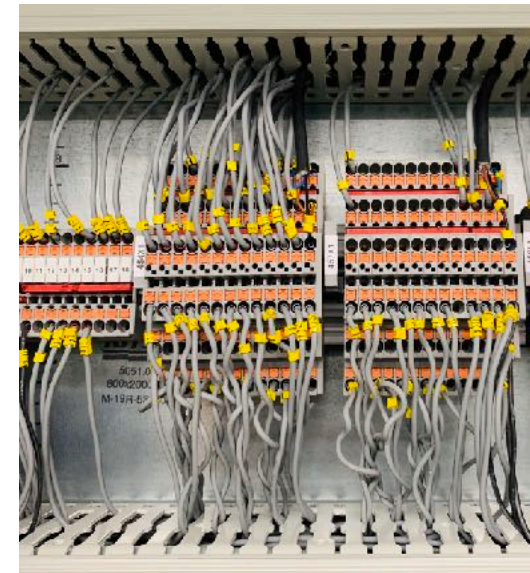
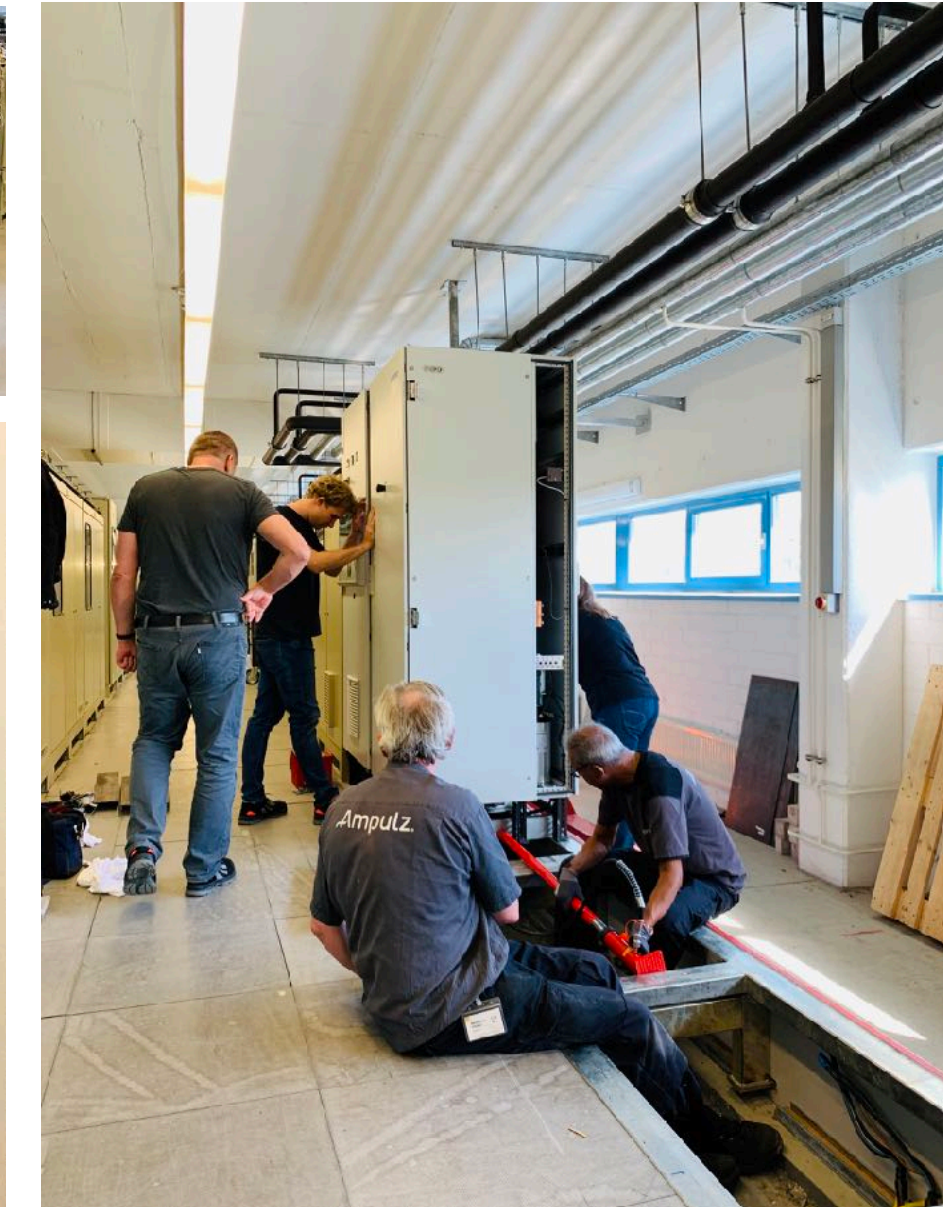
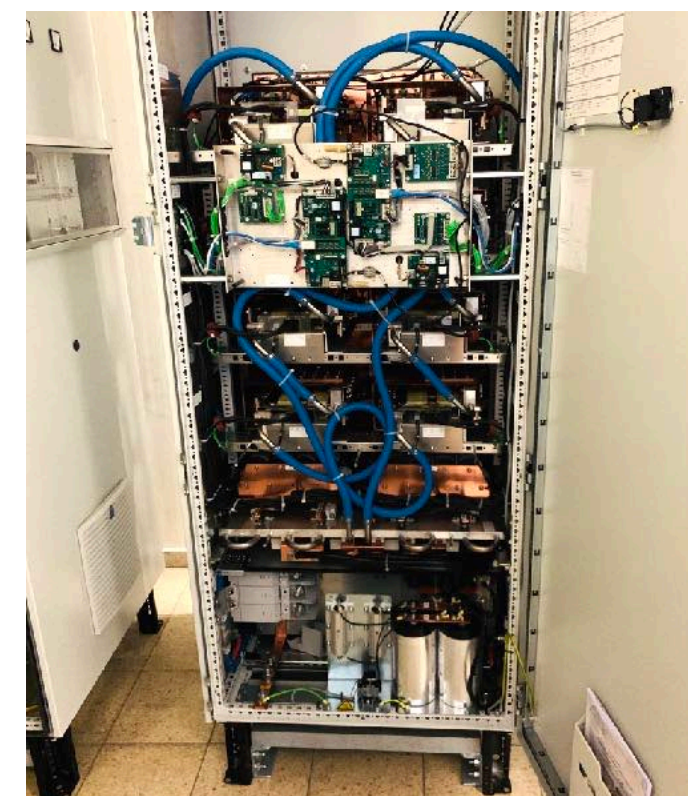
- ▶ Magnet delivery by SigmaPhi in June 2020
- ▶ Magnetic measurements of first duplet (Q1N1, Q2N1) completed at GSI in June/July 2020 - SigmaPhi results were confirmed
- ▶ Craning and mounting by TRI completed in July
- ▶ Installation of water-cooling, cable trays and grounding completed by GAT in September
- ▶ Connection of the water-cooled cables by ext. contractor (BRAR) completed in late September



## Power Converter Installation / FAT

Sep/Oct 2020

- ▶ PC preliminary FAT at Ampulz/NL completed in August
- ▶ PC transport & installation by Ampulz completed in September
- ▶ Connection of the water-cooled cables by ext. contractor (BRAR) completed in late September
- ▶ Full FAT and SAT of the PCs is currently running, completion is expected for end of October
- ▶ SCUs have been installed already, integration test is planned as soon as the FAT/SAT is complete



## Project Plan 2020/2021

### Scheduled work until beam time 2021

Oct 2020		Nov 2020				Dec 2020				Jan 2021				Feb 2021		
W43	W44	W45	W46	W47	W48	W49	W50	W51	W52	W1	W2	W3	W4	W5	W6	W7
Cave open									Cave closed							
PC FAT/SAT				Dry Run							Control System Tests				Beam Time	
	Alignment				Component mechanics test											
		Vacuum installation			UEWE installation						UEWE Tests					
		HHT Network Upgrade														
					Detector system test											

- ▶ Alignment and installation of the remaining infrastructure is planned to be finished in November
- ▶ Test of the infrastructure and installation of the scheduled experiments will take place in December before the experimental area will be closed
- ▶ Final testing before the beam time is foreseen for January 2021

## Day-1 target under construction

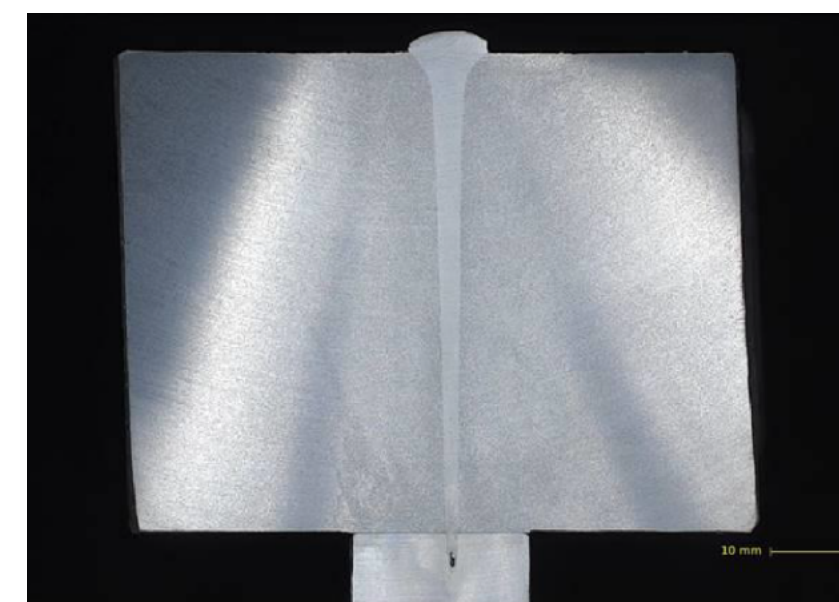
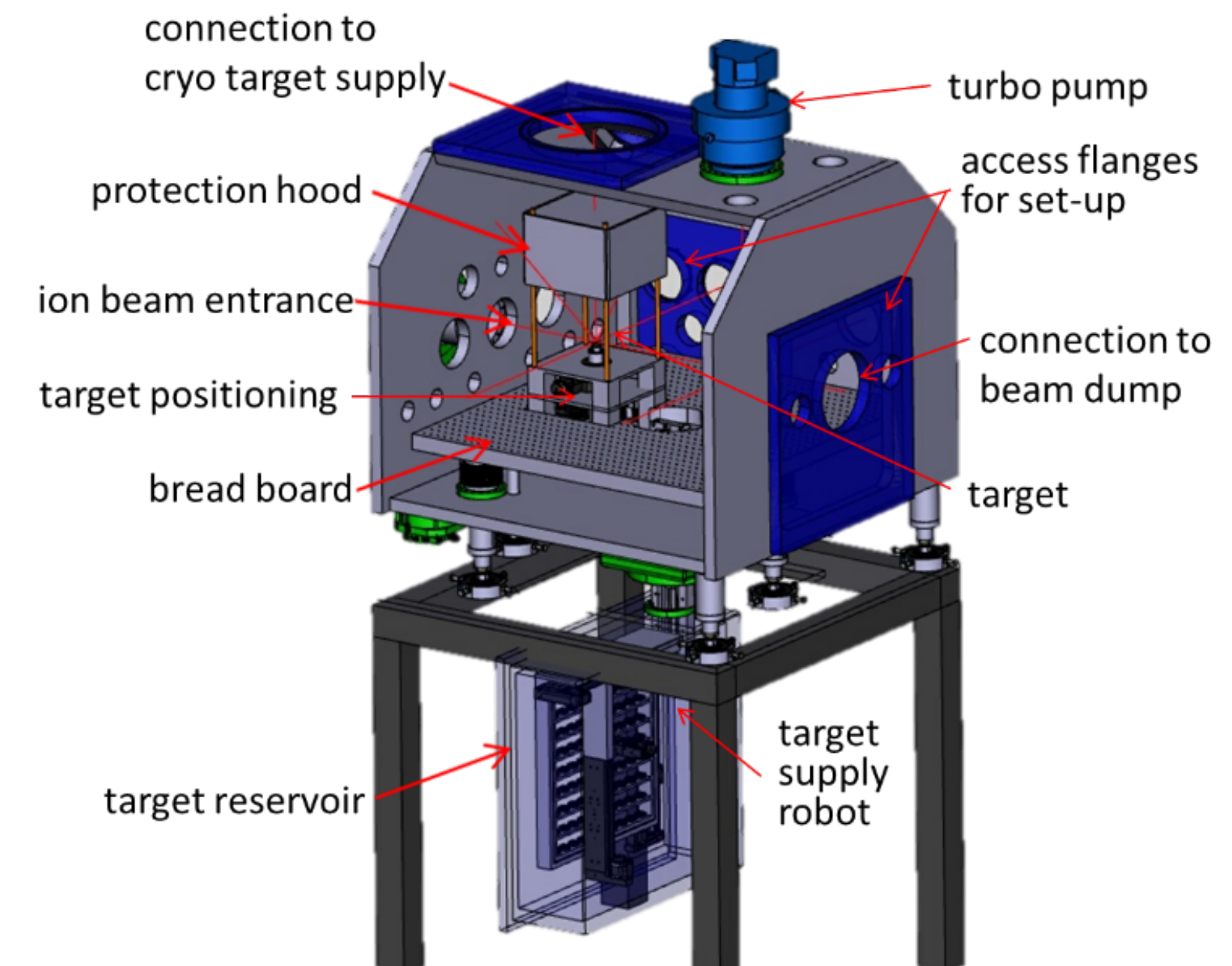
- Order was placed in May
- Due to favorable prices two identical chambers could be ordered:
  - ▶ First chamber for experimental campaigns
  - ▶ Second chamber for testing setups and diagnostics development
- Engineering model of the chamber has been finished
- Vacuum components have been ordered, work on control system has started
- Components for target supply system have been designed and are being ordered

## Risks

- Production has been delayed by problems with welding process
- Delivery still scheduled for January 2021 as planned
- However, need for formal validation of welding might lead to a delay of two months
- To be commissioned in Phase 0 in May 2021

## Next steps

- Target chamber will be installed at HHT to commission new laser beamline
- Second chamber will be used in parallel to install and test the target supply system



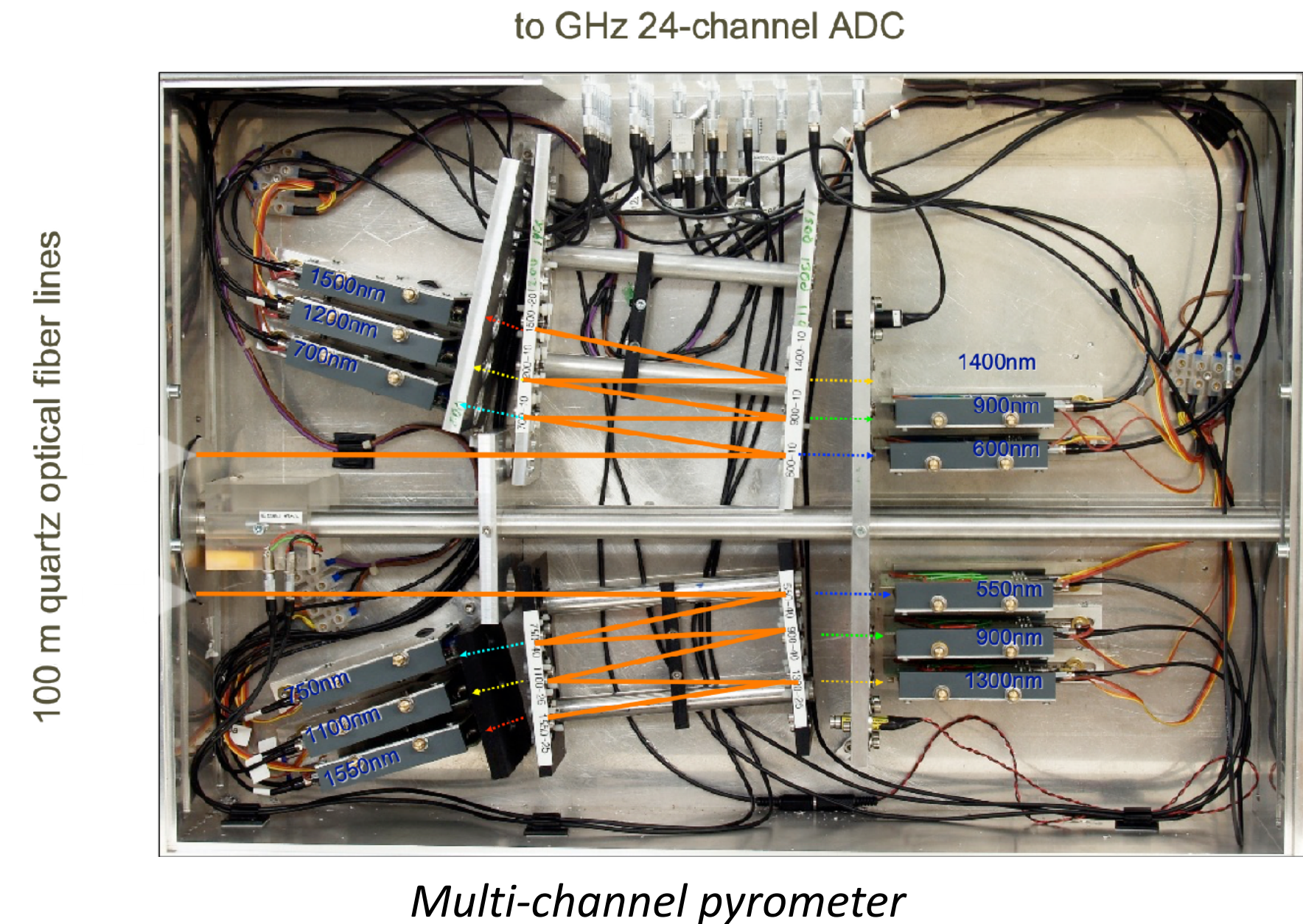
*Test of e-beam welding of the 50mm chamber walls*



## Planned proposals for BMBF Verbundforschung (2021-2024)

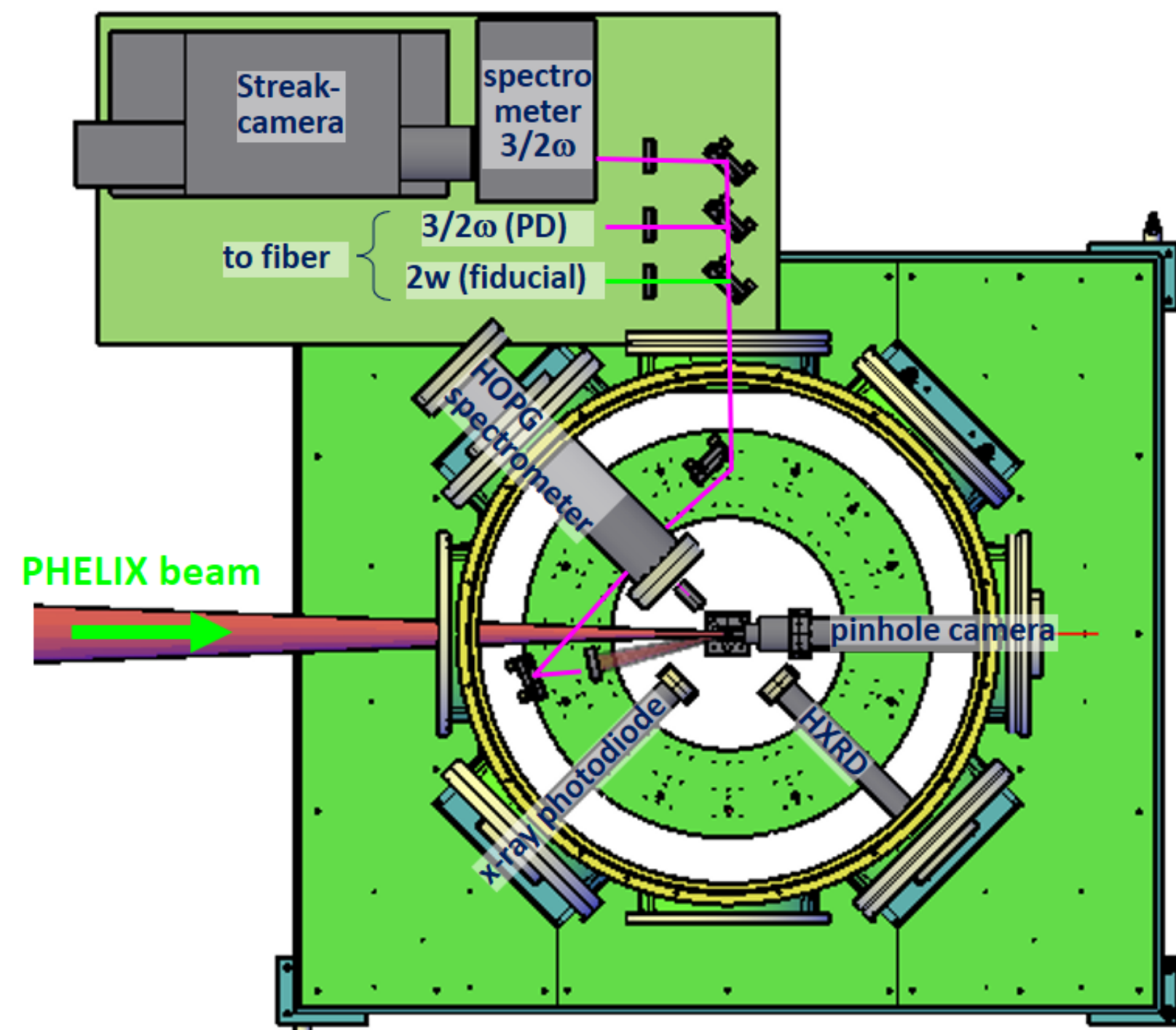
- ▶ X-ray Thomson scattering (U Rostock)
- ▶ Pyrometer for temperature measurements (GU Frankfurt)
- ▶ Streak camera (U Jena)

R&D work on backlighting is continuing with PHELIX experiments  
(see the following slide)



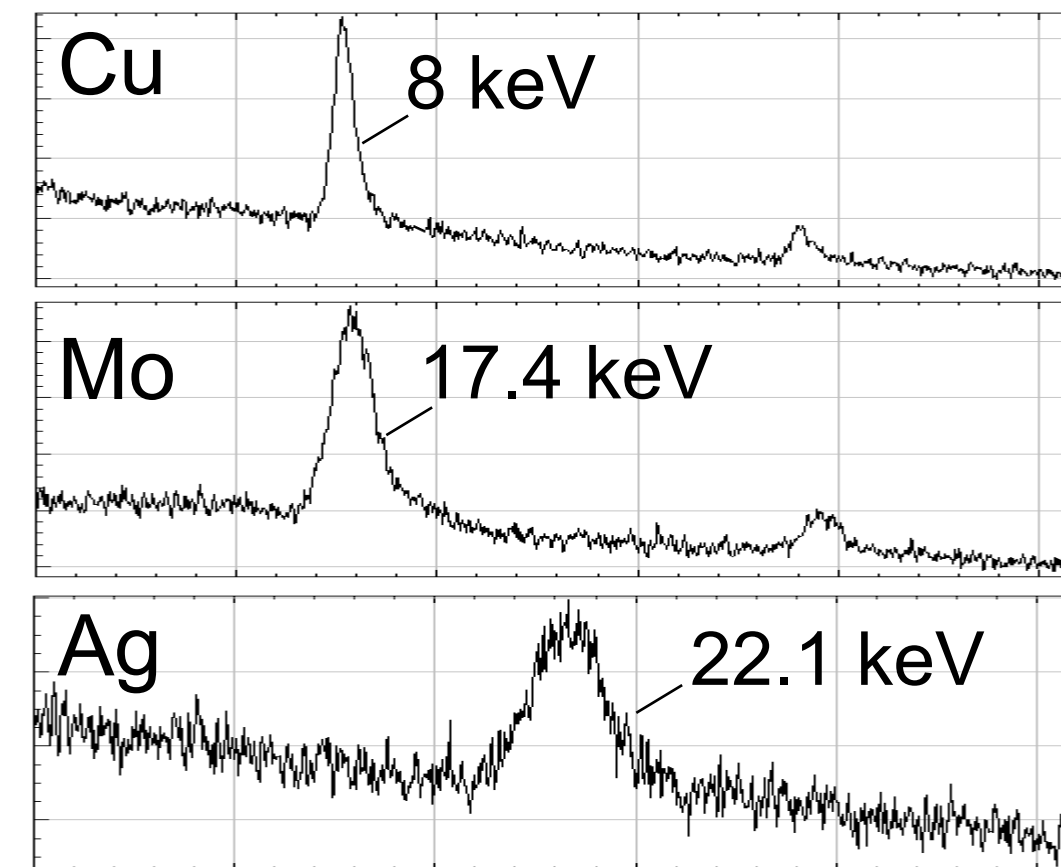
### Experimental setup at the Z6 target area

180 J @ $2\omega$ , 1-1.5 ns, focus 60  $\mu\text{m}$

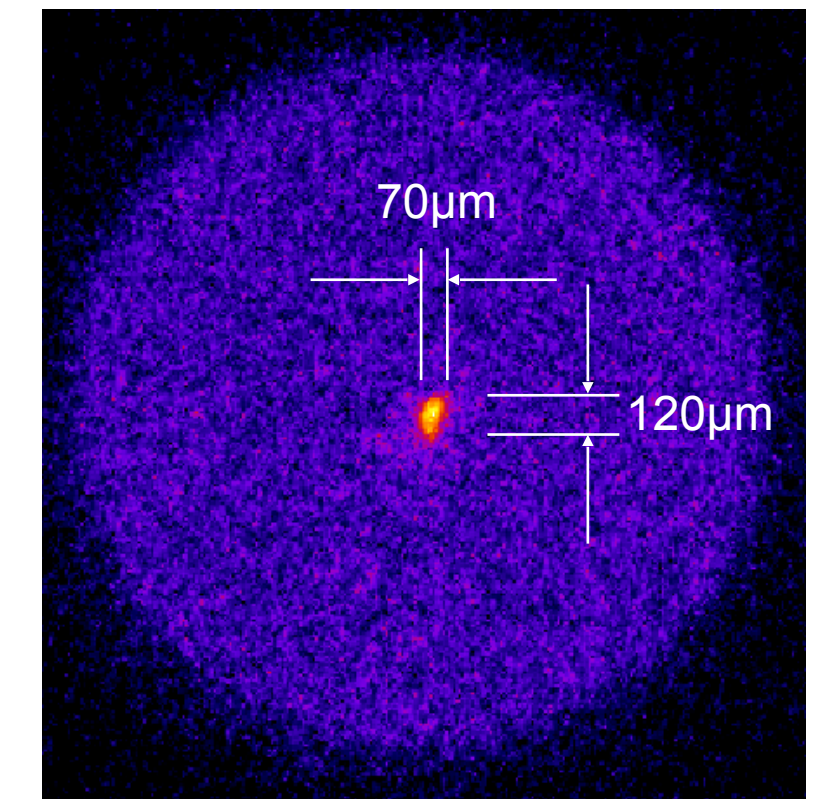


Laser parameters of Z6 will become available at the HHT cave

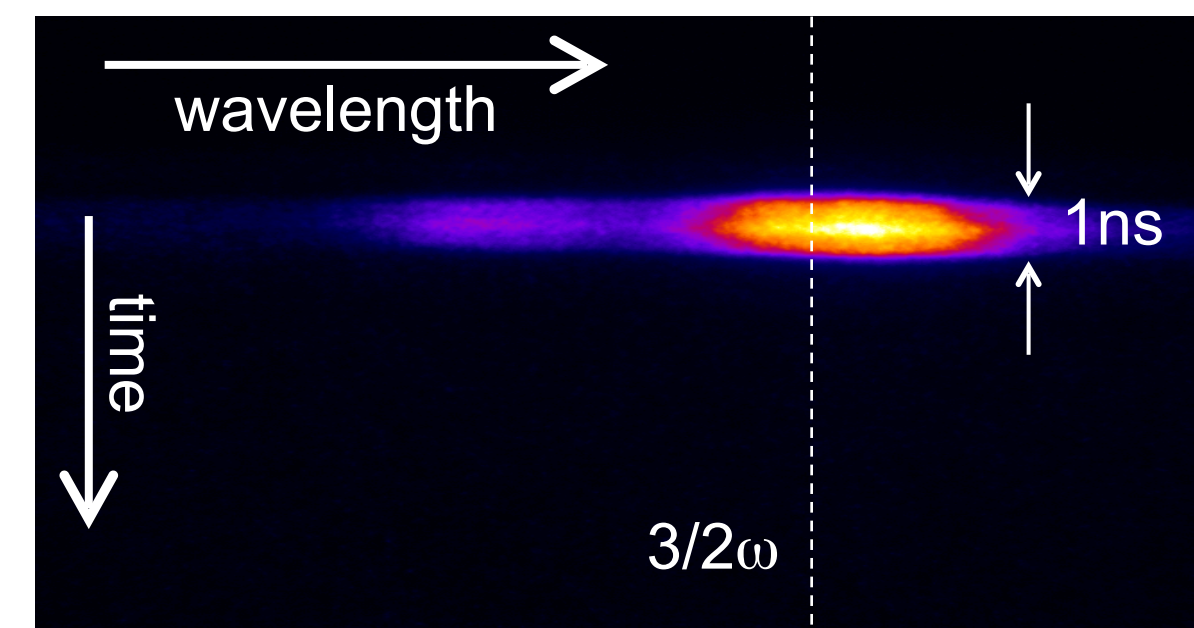
### K-alpha emission up to Ag (Z=47)



### Small x-ray source-size



### Streaked optical spectra



→ strong  $3/2\omega$  emission indicates Two-Plasmon-Decay

**Intense x-ray sources will enable x-ray backlighting diagnostics of heavy-ion heated dense plasmas for diagnostic (radiography, XRD, scattering)**

## Planned proposals for BMBF Verbundforschung (2021-2024)

- ▶ Laser heads and power supplies for the frontend (U Jena)
- ▶ Vacuum parts for 100 J amplifier (TU Darmstadt)

New laboratory (40 m<sup>2</sup>) available at GSI for setting up the diagnostic laser

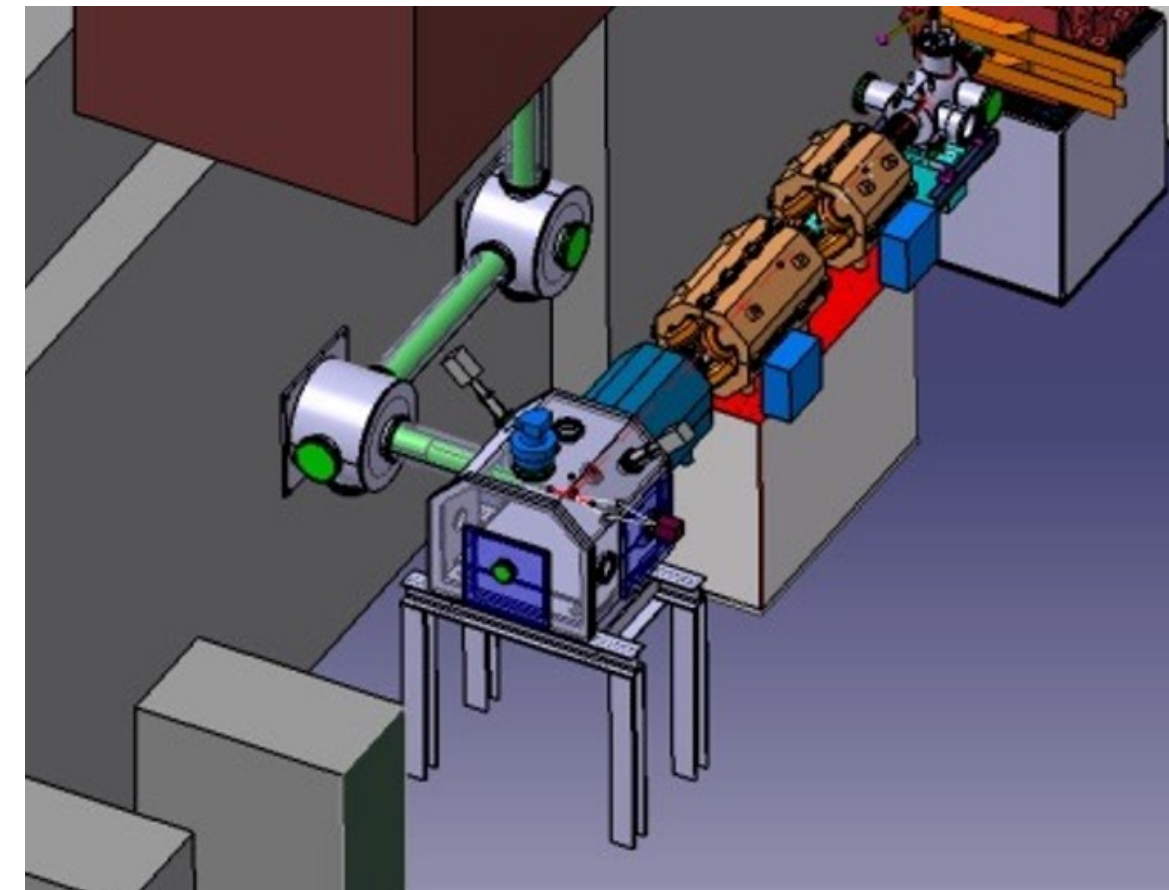
Laser beamline from PHELIX to HHT is progressing according to schedule  
(see following slides)

## Goals

- ▶ Allow coupled experiments with laser beams and high-energy ion beams
- ▶ Enable laser-driven volumetric X-ray diagnostics (absorption spectroscopy, radiography, X-ray diffraction, X-ray scattering)
- ▶ Setup at HHT will also be used to commission Day-1 target chamber

## Status of laser beam line construction

- ▶ Project started in 2019 after review by ECE
- ▶ Mechanical components in ESR hall outside HHT cave mostly set up
- ▶ Basic alignment of tubes completed
- ▶ Clean room cabin installed
- ▶ Work inside clean room in progress



### Laser-beam parameters at HHT

- 200 J
- 527 nm
- 0.33-1 ns,... up to ~10 ns
- 15 cm beam diameter



Clean room



# Laser beamline to HHT experimental area - Remaining tasks

## Mechanical components

Vacuum testing

Install components on side next to PHELIX

Install MM16 and connecting tube between MM15 and MM16

Mechanical design and production of MM17 and MM18 and connecting tubes

## Optics

Large focal length lenses L1 and L2 ordered (Asphericon)

Turning mirrors ordered (Manx), delivery October 2020

SHG-crystal: tender in preparation

Set up diagnostics in clean-room cabin

## Motion

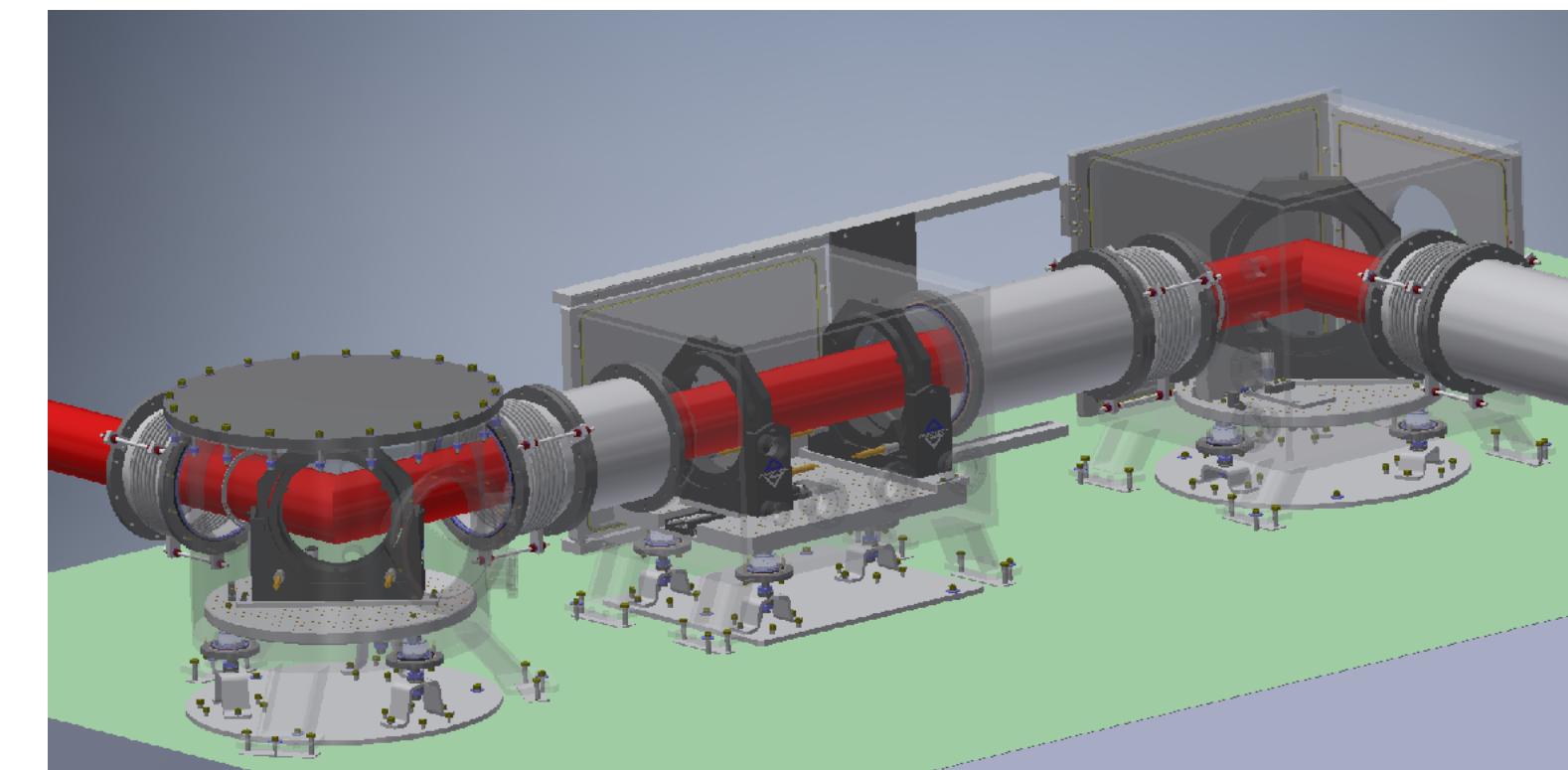
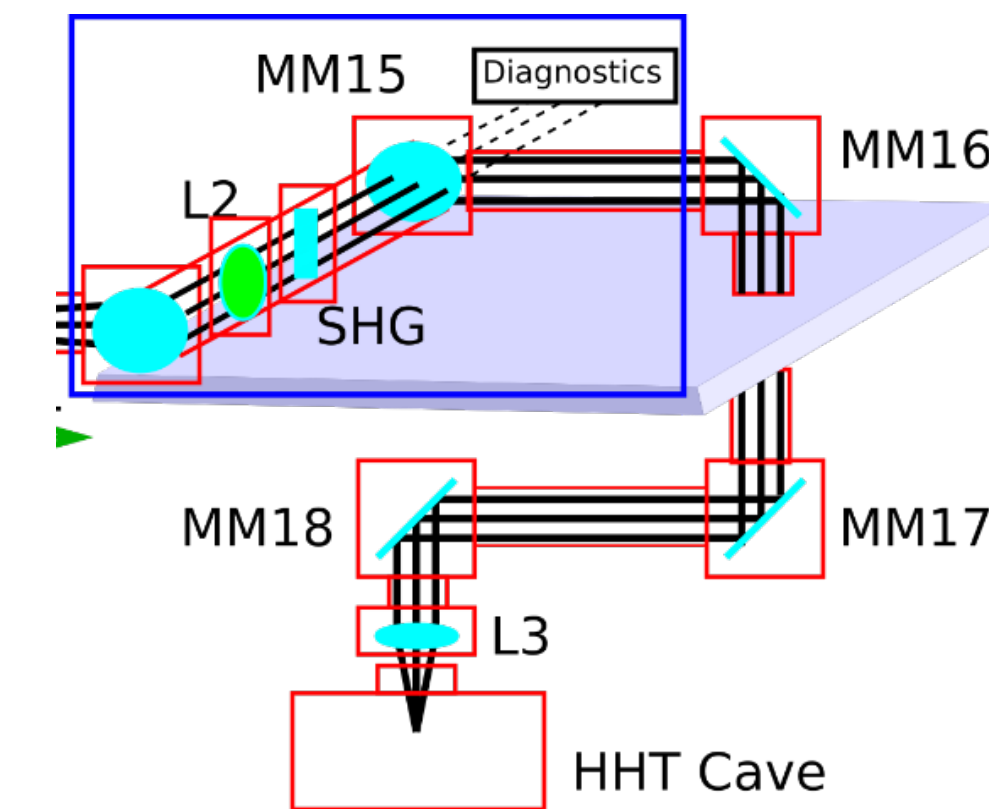
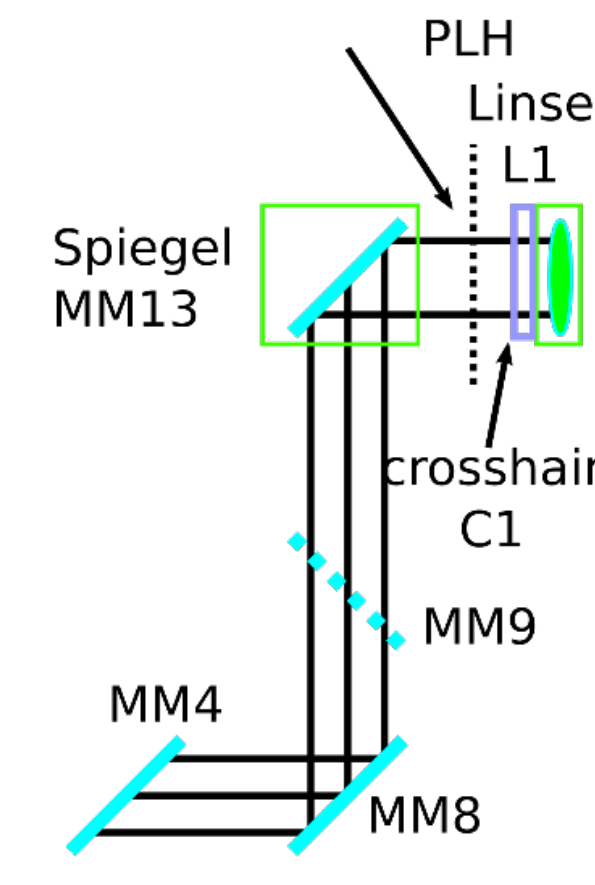
Controls for mirror mounts, crosshairs, vacuum shutters, translation stages

## Control system and safety

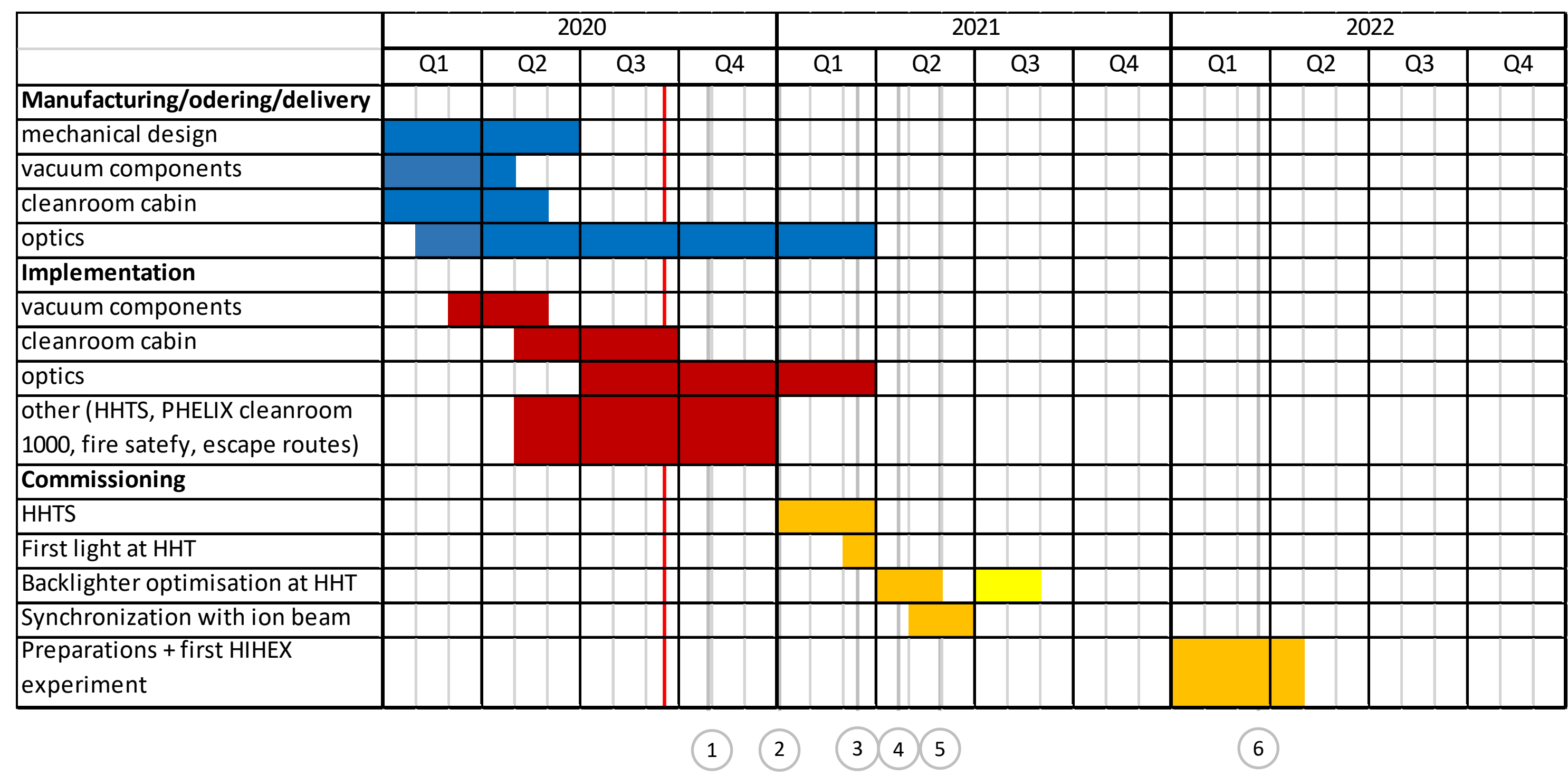
Implementation of beamline in PCS

## Synchronization and timing

Synchronize ion beam with PHELIX shot



# Laser beamline to HHT experimental area - Timeline



- (1) October 2020: Clean-room cabin fully finished
- (2) End of 2020: Installations of PHELIX-side, mechanical design (an manufacturing) of MM17/MM18, motion complete
- (3) March 2021: Start work on laser setup in HHT-cave
- (4) April/May 2021: PHELIX commissioning + Backlighter optimization experiment (Backup June/July 2021)
- (5) May 2021: Demonstrate synchronization
- (6) March 2022: First HIHEX experiment using U-ions

	Component/ Sub-System	TDR	Cost [k€ 2005]	Funding	Construction	Date completion	Test/ Commissioning
<b>HED@FAIR Day-1 setup</b>	SC FFS		3494			06/2023	
	PRIOR		420			10/2020	
	Target chamber		565			03/2021	
	Detectors		805			07/2022	
	Diagnostic laser		600			06/2023	
	DAQ		420			09/2022	
	Infrastructure		694			06/2023	
		100% <i>value weighted</i>	6998	85% <i>secured</i>	29% <i>value weighted</i>		

Scorecard as reported to AFC in August; financial data from RRB 2019

Construction of major components is progressing well

Proton microscope is currently being installed at HHT, to be tested in Phase 0 experiments in 2021

Laser beamline to HHT is being constructed and will be used to commission target chamber with coupled laser-ion experiments in 2022

All preparations on track for Day-1 experiments in the APPA cave