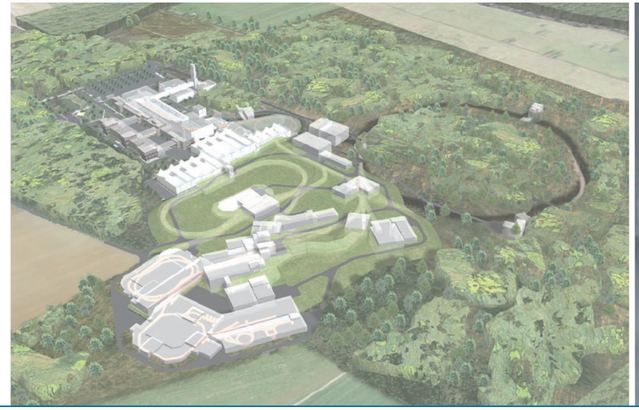
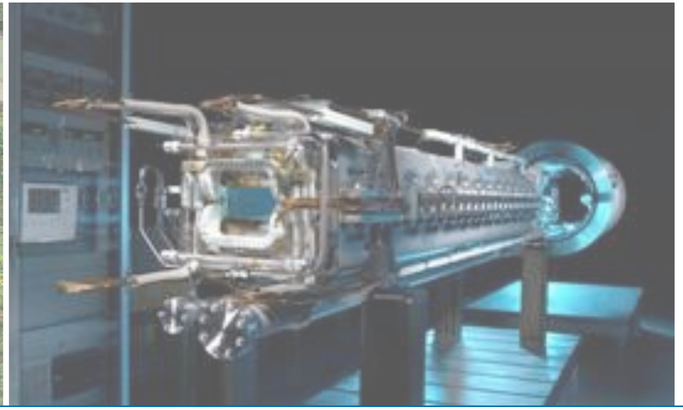




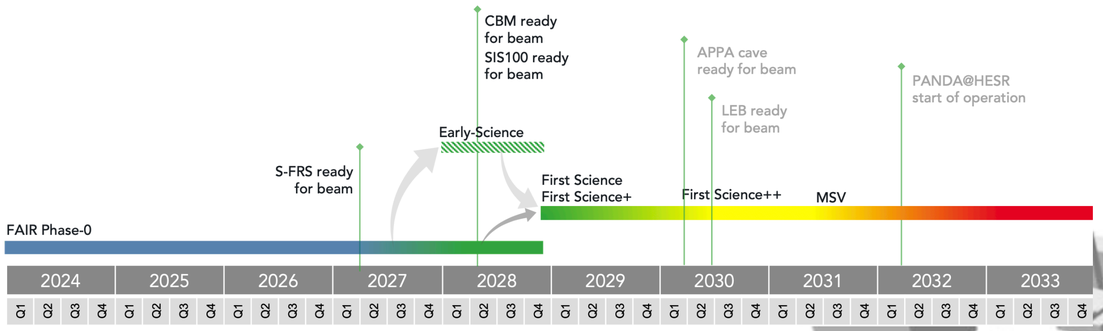
HED@FAIR Status Report

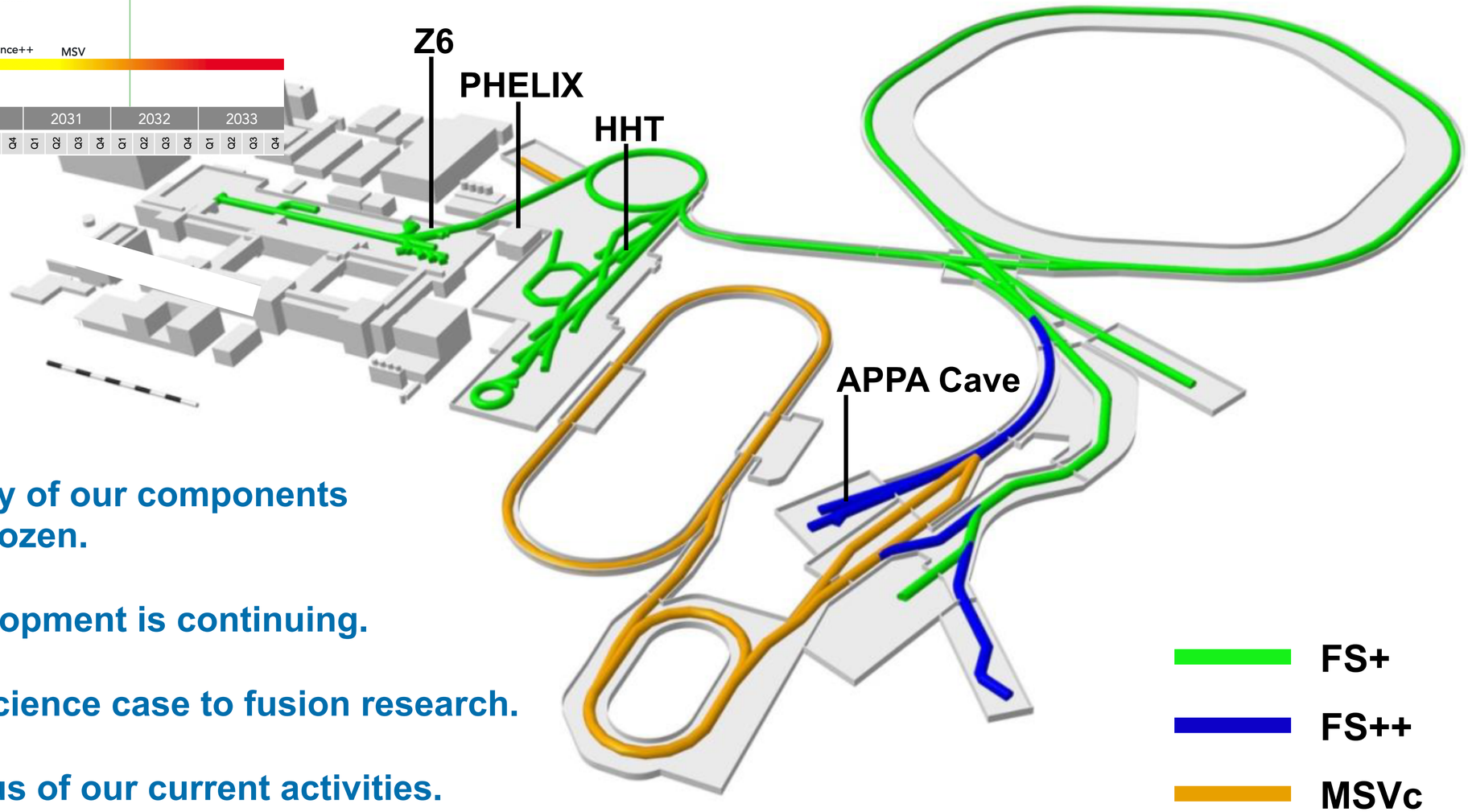
13th Meeting of the RRB

May 17th, 2024

Stephan Neff
HED@FAIR Resource Coordinator

HED@FAIR has adjusted its activities to the new commissioning strategy for FAIR





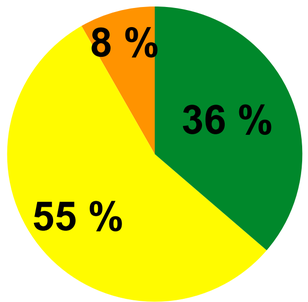
- **Work on the construction of many of our components for FAIR experiments has been frozen.**
- **Work on detector and laser development is continuing.**
- **We are exploring to extend our science case to fusion research.**
- **Phase-0 experiments are the focus of our current activities.**

Funding table for HED@FAIR

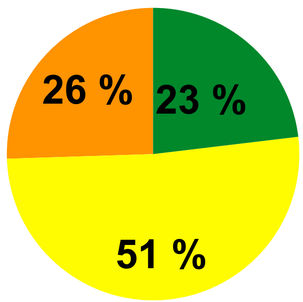
Work packages (PSP codes)	System	Estimate (k€, 2005)	Secured (k€, 2005)	EoI (k€, 2005)	TbA (k€, 2005)
1.3.2.1.2, 1.3.2.1.5, 1.3.2.2.2.1, 1.3.2.3.1, 1.3.2.3.2, 1.3.2.4.1, 1.3.2.6, 1.3.2.7.1	**Day-1 setup** HIHEX and PRIOR start setup	8,623	3,130	4,780 *	713
1.3.2.1.4, 1.3.2.2.2, 1.3.2.2.3, 1.3.2.3.4, 1.3.2.4.2, 1.3.2.5, 1.3.2.7.2	**Upgrade to MSV** HIHEX, PRIOR and LAPLAS with full performance	4,922	0	2,180	2,742
	Total cost of MSV	**13,545**	**3,130**	**6,960**	**3,455**

* The EoI include a FAIR EoI (4395 k€) for the replacement of the superconducting magnets.

Day-1 setup
8.6 M€



Full MSV
13.6 M€

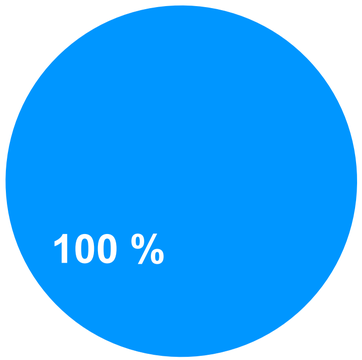


Secured
EoI
TbA

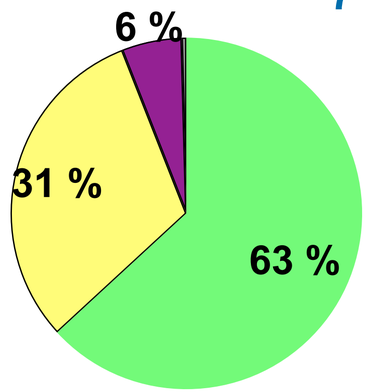
Funding by country for HED@FAIR

Funding by Country: Secured | EoI (k€, 2005 prices)										
	Germany		FAIR		Russia		China		Romania	
Day-1 setup (8,623 k€)	3,130	-	-	4,395	-	-	-	385	-	-
Upgrade to MSV (4,922 k€)	-	-	-	-	-	2,150	-	-	-	30
Grand total for MSV (13,545 k€)	3,130	0	0	4,395	0	2,150	0	385	0	30

Secured
3.1 M€



EoI
7 M€



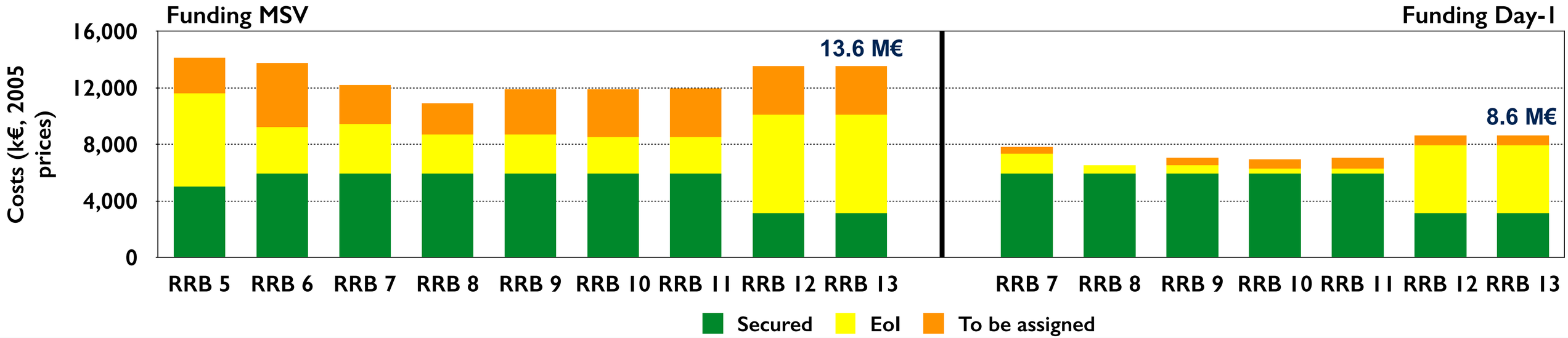
Germany
Russia
Romania
FAIR
China

Evolution of funding for HED@FAIR

The costs of the Day-1 setup are 8.6 M€, of which 36% are covered by secured funding. The costs for the replacements of the superconducting magnets (4.4 M€, 51% of total costs) are covered by an EoI from FAIR.

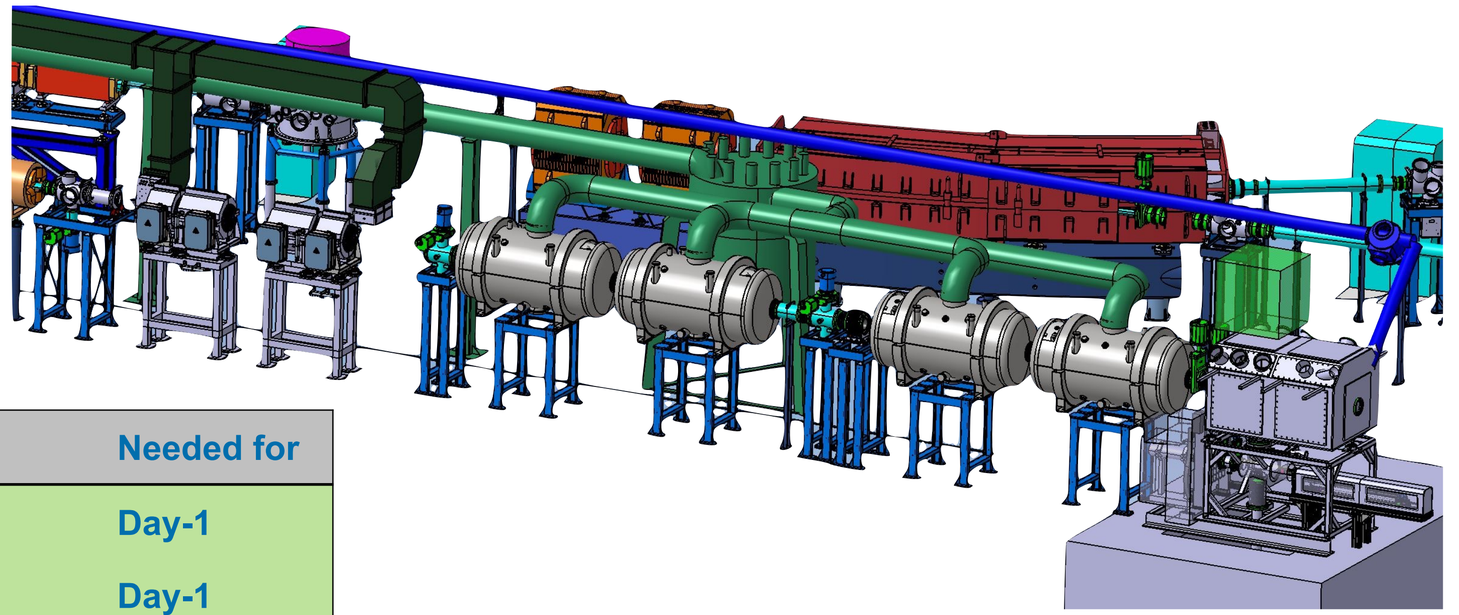
The cost of the full MSV setup is 13.6 M€, of which 23% are covered by secured funding.

There have been no changes in the cost matrix.



HED@FAIR - Status of Technical Design Reports

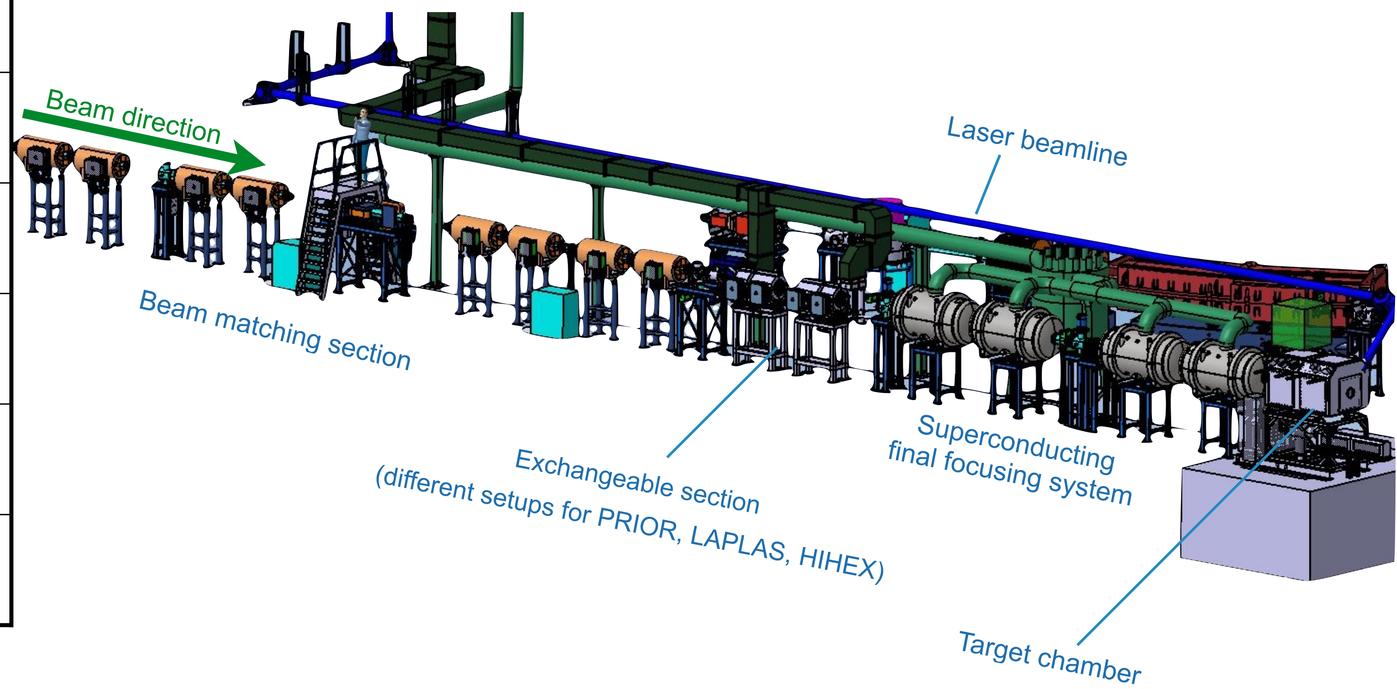
All Technical Design Reports needed for Day-1 experiments have been evaluated and approved



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

Current status of work packages for Day-1 setup

PSP	Work package	Status
1.3.2.1.2	Superconducting final focusing system	Magnets cancelled/ power supplies: contract to be paused/cancelled
1.3.2.1.5	Proton microscope PRIOR-II	In use
1.3.2.2.1	Target chamber Day-1	In use
1.3.2.3	Detectors	In use/ under construction
1.3.2.4	Diagnostic laser	Project funding frozen
1.3.2.6	DAQ, controls	Project funding frozen
1.3.2.7	Infrastructure	Project funding frozen



Currently funded projects

Four research projects have been funded in the latest call of BMBF Verbundforschung

- GU Frankfurt, B. Winkler, “Ultra-fast pyrometry” (44 k€ core invest, 2024 prices)
- HHU Düsseldorf, A. Pukhov, “Super Charge TNSA” (R&D funding)
- FSU Jena, C. Spielmann, “Diagnostics for Plasma Physics Experiments” (R&D funding)
- LMU München, J. Schreiber, “I-Beat Detector” (R&D funding)

Work on laser technology at GSI and FAIR is funded as part of the THRILL consortium

- The goal of the European THRILL project is to advance technology in the field of high energy, high repetition rate lasers and to train researchers.
- Funding for GSI and FAIR amounts to 3.3 M€.
- The deliverables include a design study for a high-energy laser at FAIR.

www.thrill-project.eu

We are exploring to extend our science case to fusion-related research

Focused Energy has decided to build its laser facility in California

➡ The installation of a laser from *Focused Energy* on the FAIR site is no longer in discussion.

We are investigating the possibility of establishing a fusion science hub in Hesse centered at GSI

- Would involve installing a new laser facility or an upgrade of PHELIX
- Would offer research opportunities to university groups

This project could be carried out in the framework of the recent calls for proposals by BMBF

1. *Basic technology for fusion - Key technologies and testing infrastructure*
2. *Young investigator research groups in the field of fusion research*

Requested are proposals for fusion-related research towards a reactor in a collaboration of academia and industry.

There will be a workshop at GSI in June to work on a science case for research related to inertial fusion within this framework.

Workshop on Laser Fusion Research Opportunities at FAIR

20-21 June 2024
GSI
Europe/Berlin timezone

Overview
Registration
Accommodation
Contact
d.lang@gsi.de

The HED@FAIR collaboration welcomes the HED physics community to a two-day workshop on laser fusion research opportunities at FAIR on June 20th and 21st, 2024, at GSI Darmstadt's main auditorium.

With the recent milestone achieved at the National Ignition Facility in the USA in inertial confinement fusion, the German government has changed its position significantly on laser-driven fusion and now fully endorses research on this subject. The HED@FAIR collaboration has expressed interest in adding laser fusion research to its research portfolio because of the many synergies between the planned activities of the collaboration at FAIR and the individual scientific interests of the collaboration partners.

The current proposal is to speed up the installation of a multi-kilojoule multi-beam laser facility on the FAIR campus in connection with the APPA cave to support, among others, laser fusion research until the compression facility becomes available. Importantly, this facility, which could be built in collaboration with the start-up company Focused Energy GmbH, will be open to academic access on a proposal-merit basis. This ensures that the HED physics community has a fair and equal opportunity to contribute to and benefit from this research.

Topics for the workshop are to help define the facility's scientific requirements for:

- Laser-plasma instability studies
- Hydrodynamic instabilities and compression studies in planar geometry
- Code development and benchmarking needs
- Fast ignition
- X-ray diagnostics
- Material studies: foam, EOS

The workshop will be coupled with a visit of the FAIR facility.

Workshop organizers: V. Bagnoud, M. Roth, P. Neumayer, K. Schoenberg, D. Kraus

Starts 20 Jun 2024, 09:00
Ends 21 Jun 2024, 14:00
Europe/Berlin

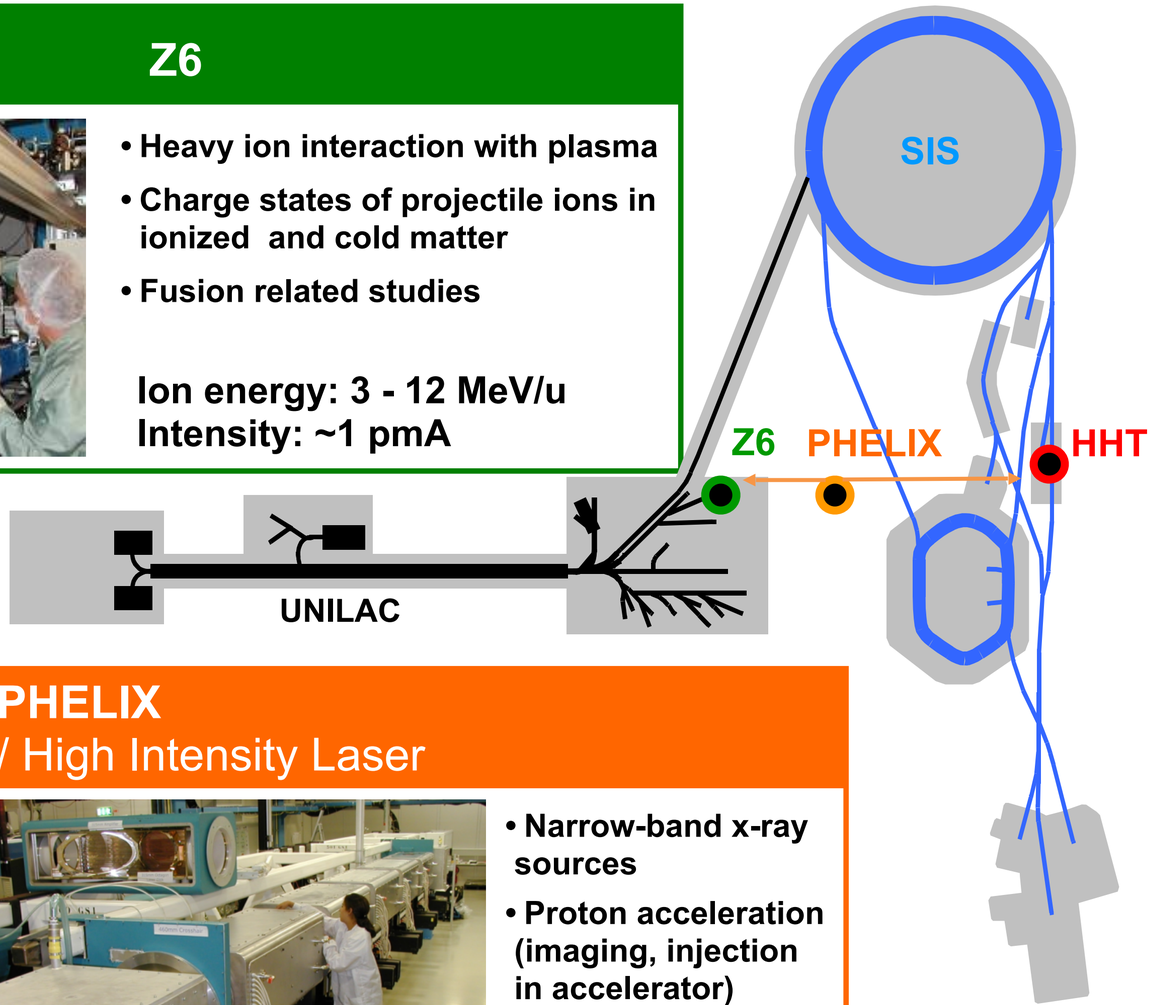
GSI
SB Lecture Hall
Planckstr. 1
64291 Darmstadt

Experiments in Phase-0 will be essential to bridge the gap until the start of FS++ experiments

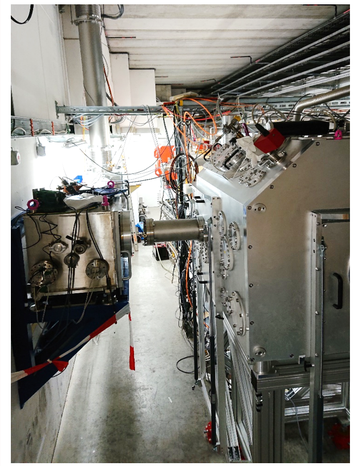
Z6

- Heavy ion interaction with plasma
- Charge states of projectile ions in ionized and cold matter
- Fusion related studies

Ion energy: 3 - 12 MeV/u
Intensity: ~1 pmA



HHT



Ion energy:
350 MeV/U U^{73+}

Intensity:
$4 \cdot 10^9$ ions/bunch

- Proton microscopy
- Heavy ion heating
- FAIR-related developments

PHELIX
High Energy / High Intensity Laser

Laser bay: 0.5 PW, 200 J @ 400 fs

Z6: 200 J @ 1 – 10 ns, 2ω
30 J @ 0.3 – 2 ps (100 TW)

HHT: 200 J @ 1 – 10 ns, 2ω

- Narrow-band x-ray sources
- Proton acceleration (imaging, injection in accelerator)
- High field effects in highly charged ions

Phase 0 experiments behind SIS-18 are using the PRIOR-II setup and the Day-1 target chamber

Coupled laser beam - ion beam experiments (target chamber)

Ion beam parameters

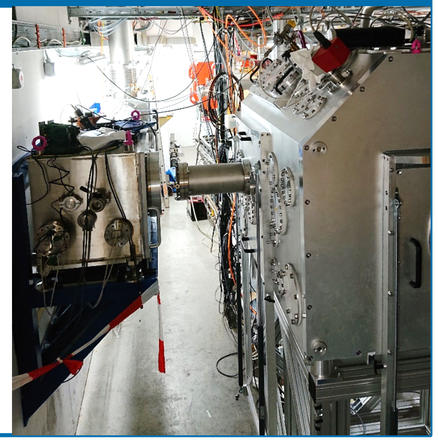
350 MeV/u U^{73+}

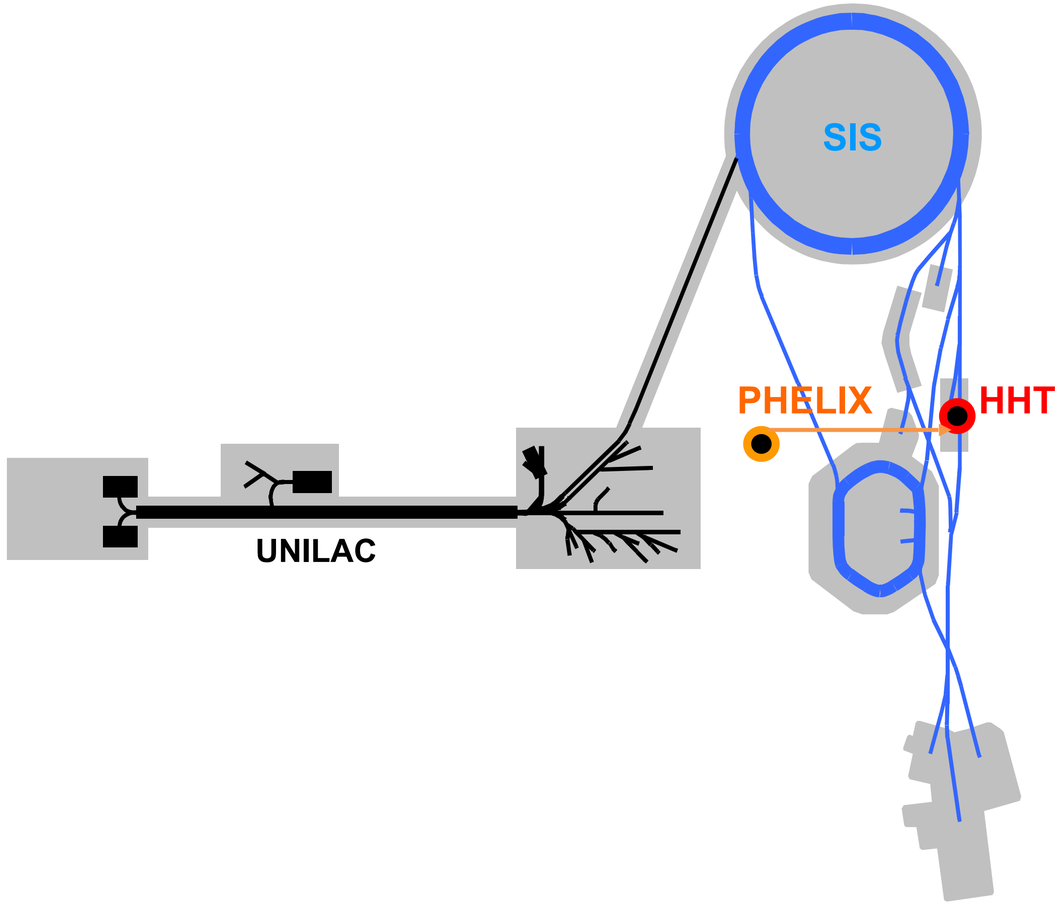
$4 \cdot 10^9$ ions/bunch

Laser beam parameters (PHELIX long pulse)

Up to 200 J @ 527 nm, 1 ns - 10 ns

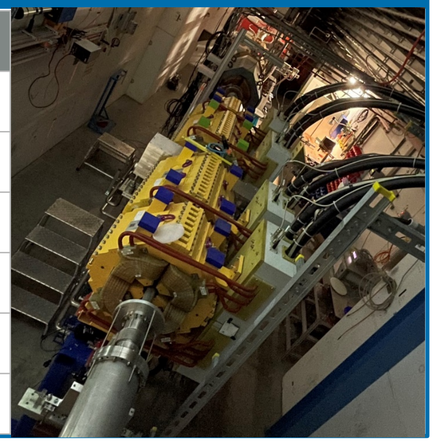
~50 µm focal spot, good stability



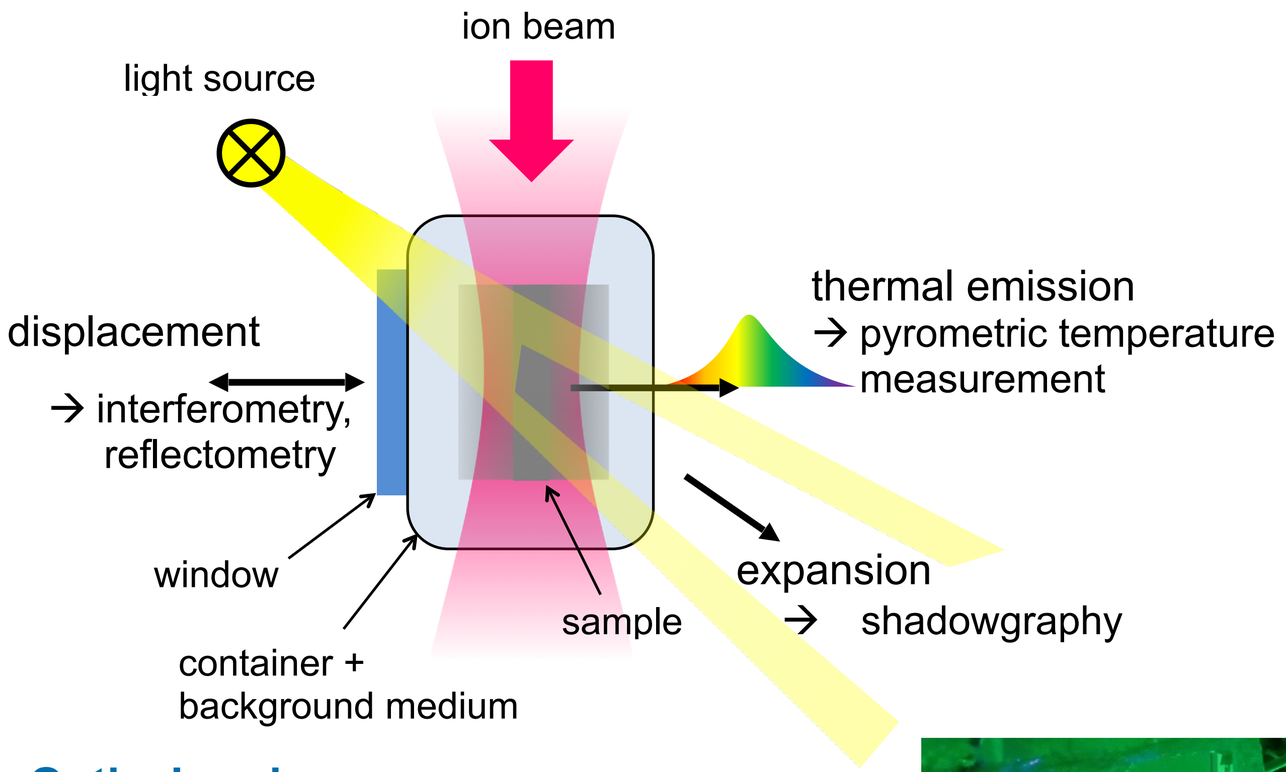


Proton microscopy (PRIOR-II)

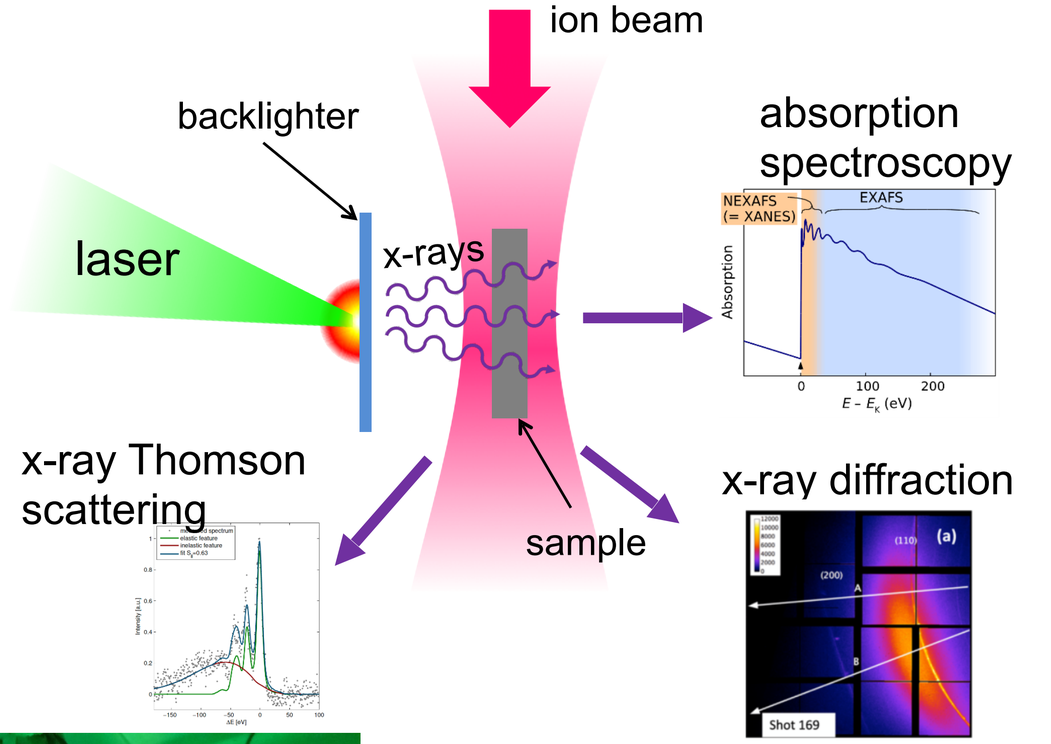
Design Parameters	PRIOR-II • GSI	
Reference energy (MeV)	4000	
Magnification	3.49	
Collimator acceptance (mrad)	2.0	5.0
Field of view(mm)	30 x 57	30 x 54
Chromatic RMS resolution (µm)	1.9 x 3.6	4.7 x 8.9
Off-Axis RMS resolution (µm)	2.1 x 4.0	5.3 x 10.1



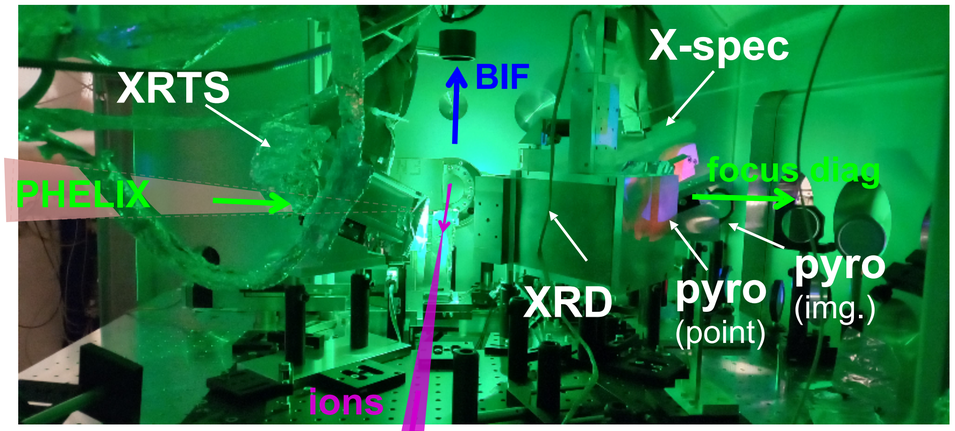
Many detectors are already used in Phase-0 in coupled laser-ion beam experiments at HHT



Optical probes
→ macroscopic observables (p,T,V)



X-rays
→ microscopic structure



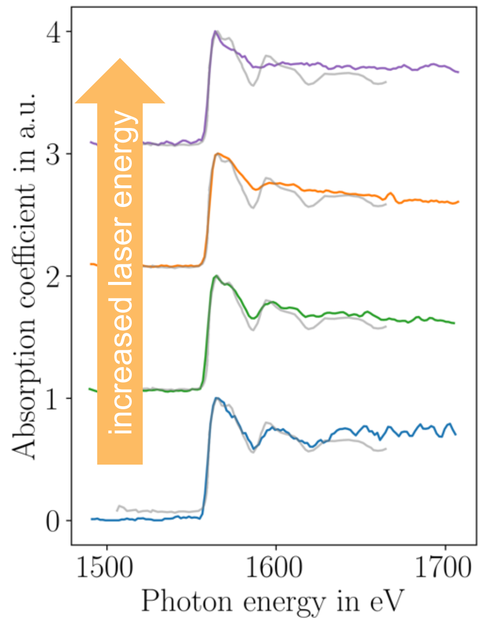
Diagnostic setup in target chamber

XRTS: *X-ray Thomson scattering*
BIF: *Beam induced fluorescence*
X-spec: *X-ray spectrometer*
XRD: *X-ray diffraction*
pyro: *Pyrometry*

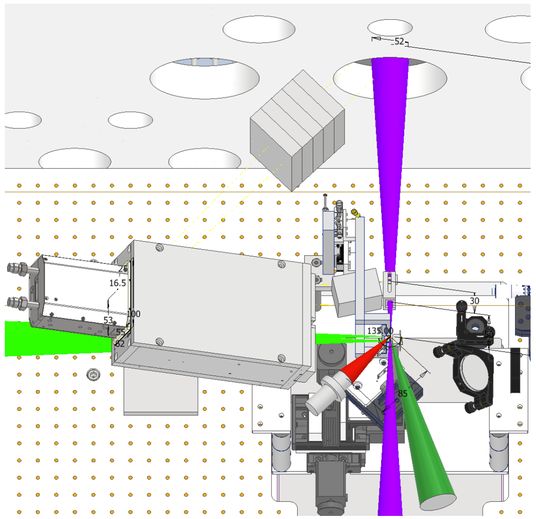
Ion beam heating experiments are scheduled for 2024 and 2025

Progress on combined experiments with SIS-18 beams and PHELIX pulses

Absorption spectra of cold Aluminum (gray: data from literature)



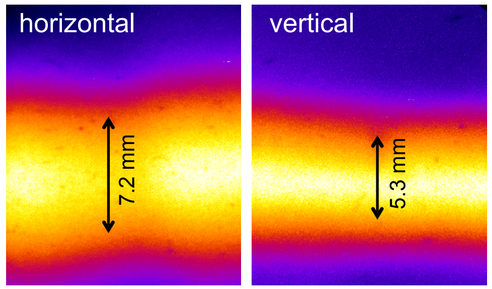
Setup of combined ion/laser experiment



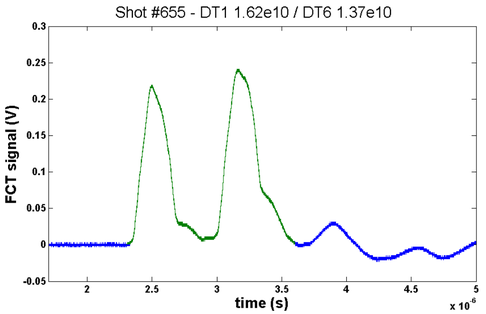
- High energy laser experiments at HHT are conducted to develop x-ray based probing techniques for HI-heated samples
- Combined laser/ion experiments in preparation (2024)

Record-high ion beam intensities at HHT

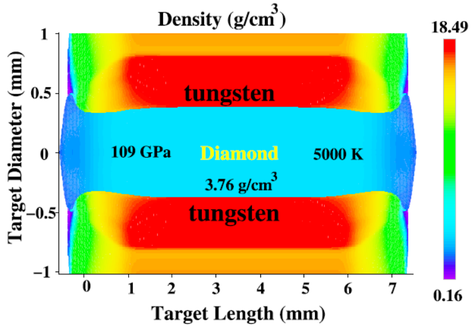
Fluorescence trace in argon at best focus



Commissioning of new fast current transformer



- >2×10^{10} particles/bunch from SIS-18 transported to HHT target chamber
- Focusability of U^{28+} limited by NC-magnets in HHT-cave (would allow accessing strongly-coupled plasma regime at APPA-cave!)



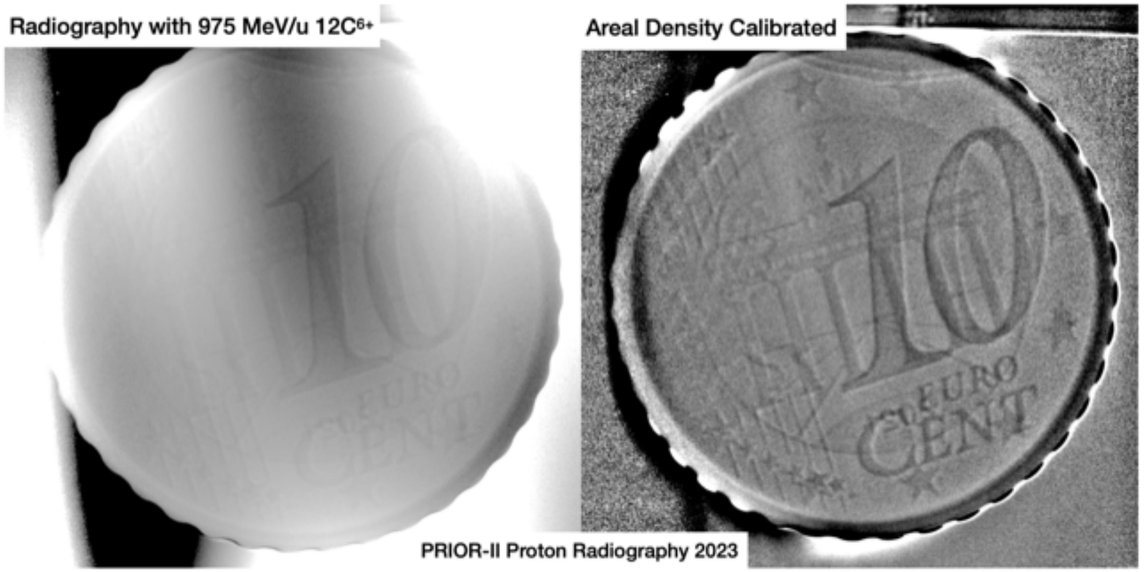
N. Tahir et al., Scientific reports **13**, 1459 (2023)

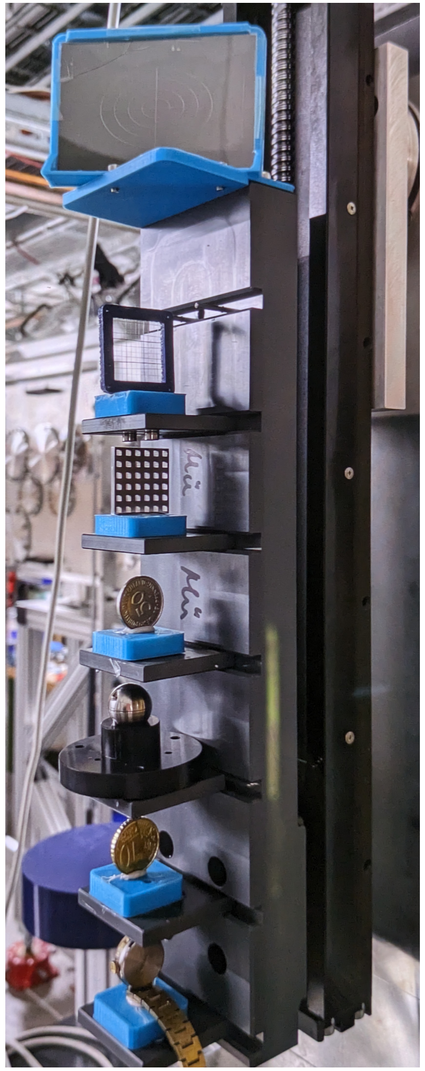
- New calculations indicate that diamond phase can be reached with SIS-100 parameters over macroscopic volumes
- First indirect heating/compression (LAPLAS-scheme) tests will be performed with U28+ in 2025

Parasitic beam during the engineering run was used for for R&D for PRIOR at the HHT experimental area

PRIOR-II

- Since the availability of proton beams will be very limited in the next years, tests with other light ion beams (^{12}C, nitrogen) have been carried out to test imaging properties.
- First imaging tests with 975 MeV/u $^{12}C^{6+}$ and nitrogen showed promising results.
- A proof-of-principle test with a dual ion beam (carbon for heating, helium for imaging) was also carried out successfully.





Target ladder

Conclusions

Work on the construction of components for FAIR has been frozen, with the exception of detector and laser development.

- Four projects have been funded via BMBF Verbundforschung.
- Work on laser technology continues as part of the THRILL project.

As a mitigation strategy, we are trying to expand our research activities into fusion-related research.

- A funding program for fusion-related research has been announced by BMBF. Proposals for projects are in preparation.
- We are investigating the possibility to establish a fusion science hub in Hesse. A workshop to work out a science case will take place in June.

Phase 0 experiments at the existing GSI facilities are continuing.

- A coupled laser beam - heavy ion beam experiment is scheduled for this summer.
- Parasitic experiments during the last engineering run have been used to optimize ion beam heating and the PRIOR-II setup.

In order to update our plans for experiments in the APPA cave, we would need:

- A resource-loaded schedule for the APPA cave.
- A funding profile for the missing beamline components.

Thank you for your attention.

44th International Workshop on High Energy Density Physics with Intense Ion and Laser Beams, January 28 - February 4th, 2024

Backup slides

Members

HED@FAIR Collaboration

- 117 members from 11 countries
  (69 members from Russian institutes currently suspended)

German members

- 43 members from Germany
  (25 from university groups, 18 from HGF)