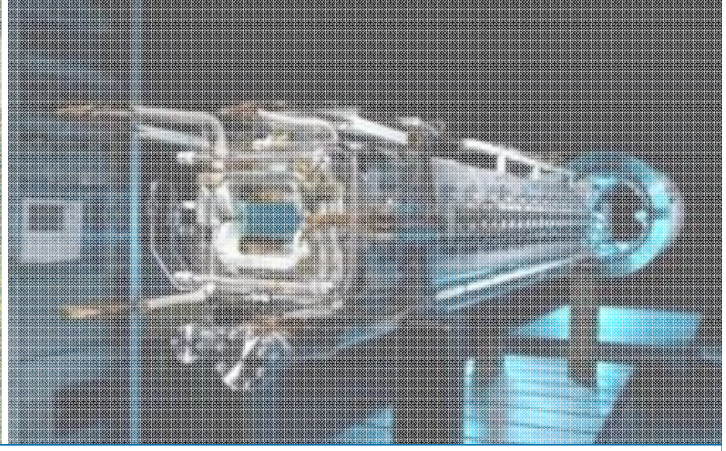




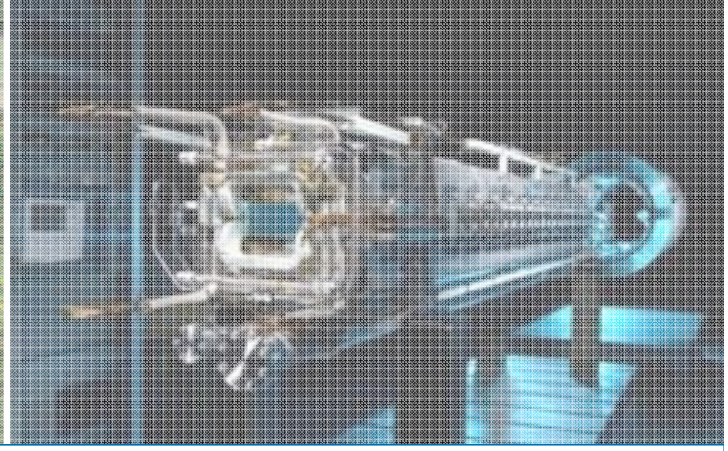
APPA collaborations - progress report

ECE meeting, November 2019

Angela Braeuning-Demian
SPARC coordinator

Finland France Germany India Poland Romania Russia Slovenia Sweden UK





Supported by:

S. Neff, HED coordinator
A. Blazevic, HED coordinator
C. Trautmann, MAT local contact
M. Durante, local contact BIO
D. Severin, BIOMAT local coordinator
R. Pleskac, BIOMAT coordinator
F. Herfurth, WPL CRYRING
M. Lestinksy, WPL CRYRING experiments
Th. Stöhlker, SPARC local contact
..many others WPLs in APPA

Finland France Germany India Poland Romania Russia Slovenia Sweden UK

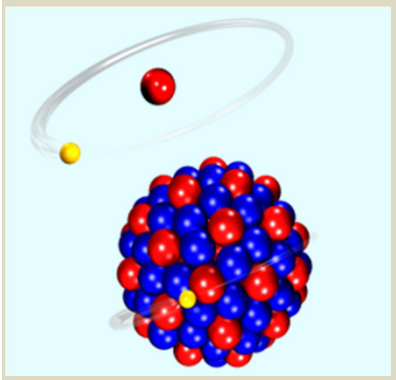
FAIR

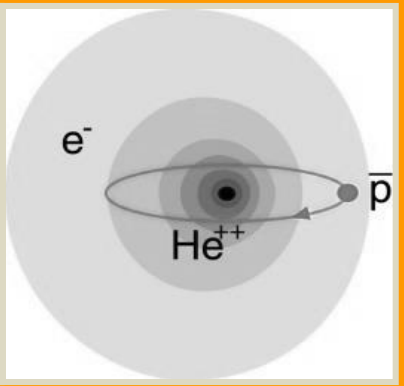
Atomic Physics, Plasma Physics, and Applied Sciences

from fundamental to applied research

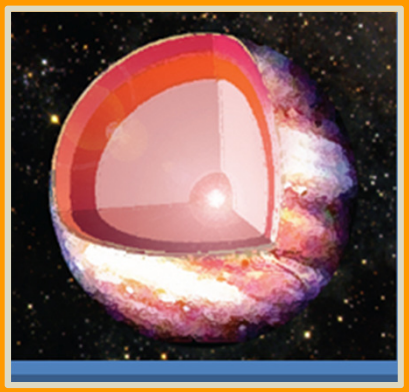
FACILITY CAPABILITY	SCIENTIFIC CAPABILITY
Highest Charge States	*Extreme Static Fields*
Relativistic Energies	*Extreme Dynamical Fields and Ultrashort Pulses*
High Intensities	*Very High Energy Densities and Pressures*
High Charge at Low Velocity	*Large Energy Deposition*
Low-Energy Anti-Protons	*Antimatter Research*

Atomic Physics





Plasma Physics



Materials

Biophysics

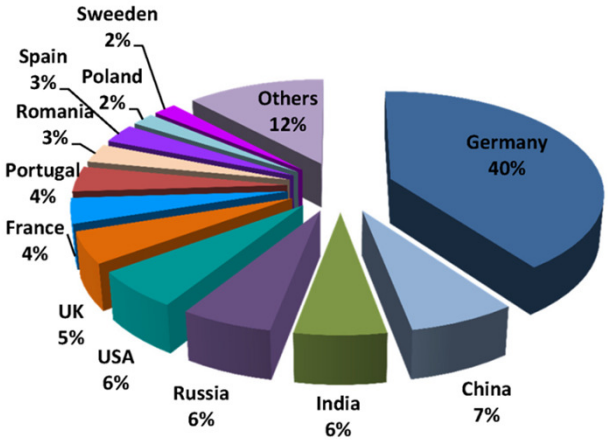
SPARC	FLAIR	HED@FAIR	MAT/BIOMAT	BIO/BIOMAT
strong field research … probing of fundamental laws of physics	**antimatter** … matter / anti-matter symmetry	**extreme states of matter** … states of matter common in astrophysical objects	**radiation effects** … degradation and nanostructuring of materials	**space travel & therapy** … cosmic radiation risk and theranostics

APPA collaborations at FAIR: ~ 1000 members

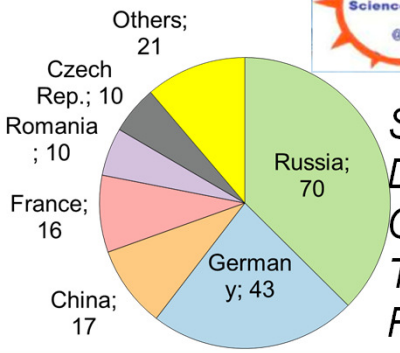
187 members from 12 countries:

Russia, Germany, China, France, Romania, Czech Republic, USA, Spain, Norway, Israel, and UK

442 members from 30 countries



Spokesperson Prof. R. Schuch
Deputy spokesperson Prof. J.-P. Santos
GSI contact person Prof. Th. Stöhlker
Coordinator A. Bräuning-Demian



Spokesperson Prof. Alex. Golubev
Deputy Spokesperson K. Schonberg
Chair of Coll. board V. Bagnoud
Technical coordinator A. Blazevic
Resource coordinator S. Neff

APPA collaborations at FAIR

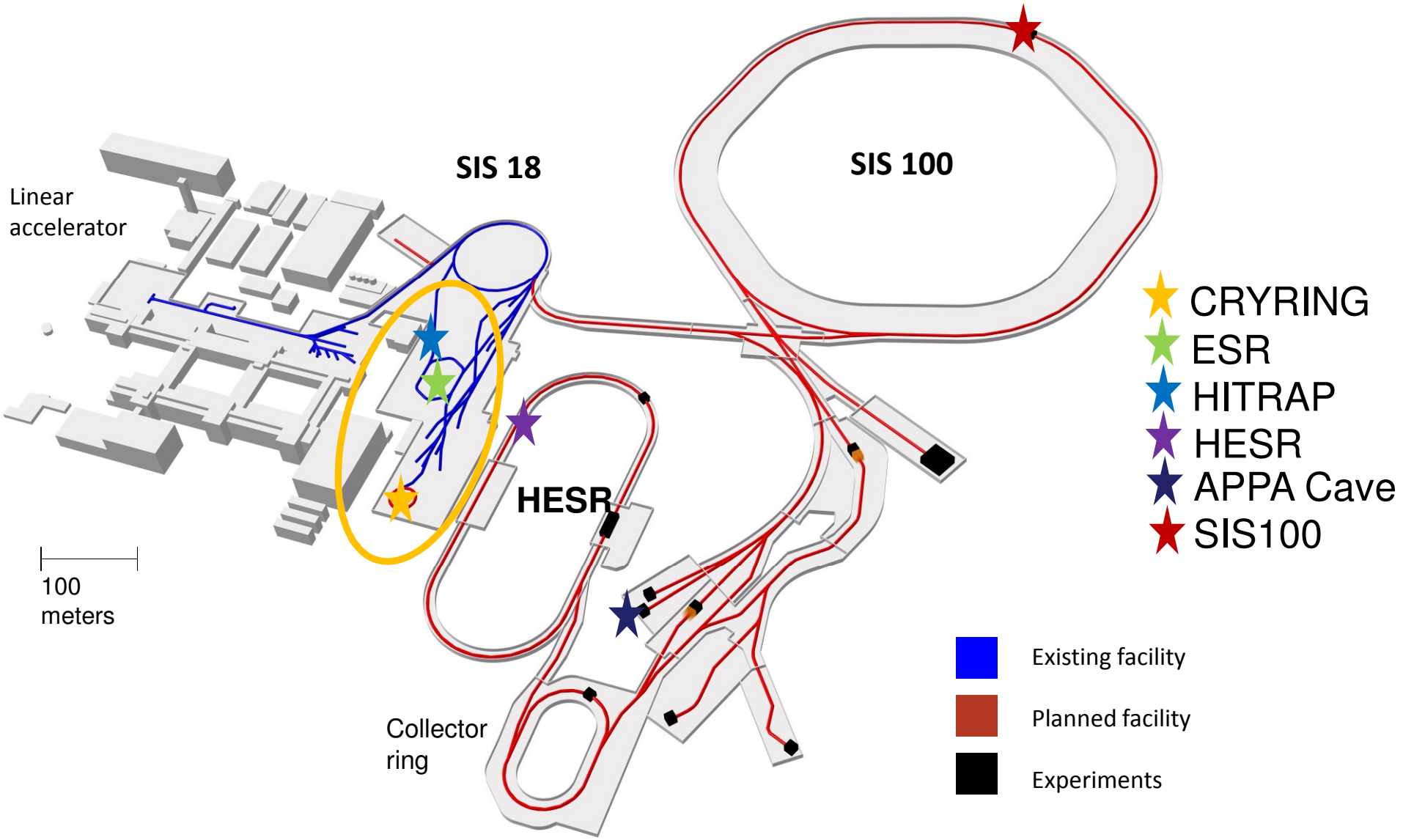
250 members from 27 countries

Spokesperson Prof. Vincenzo Patera.
Deputy spokesperson Prof. Yolanda Prezado.
GSI contact person Prof. Marco Durante
BIOMAT coordinator Radek Pleskac

137 members from 21 countries

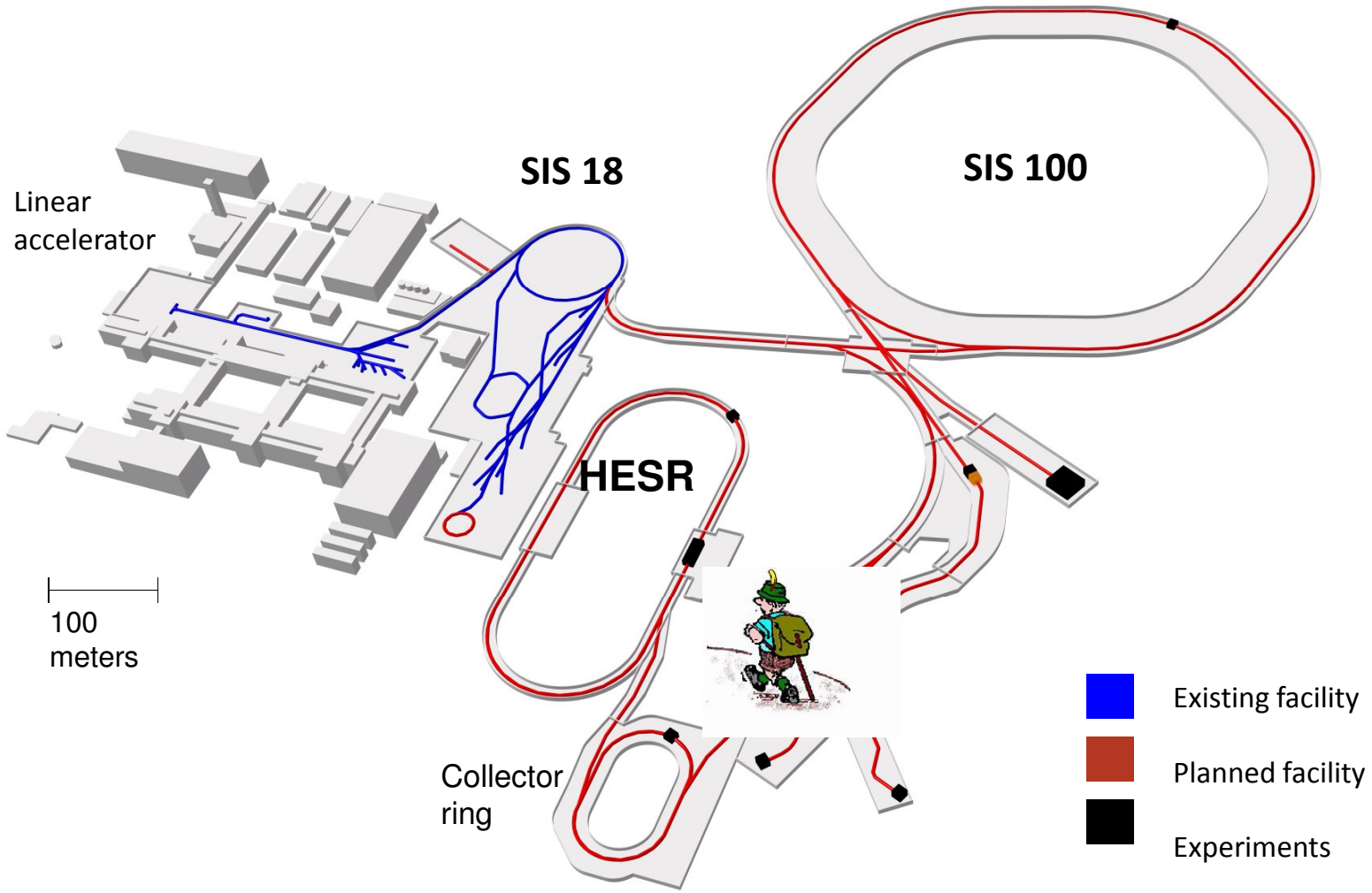
GSI contact person: Prof. C. Trautmann
Local BIOMAT Group coordinator: Daniel Severin

Facilities of APPA at FAIR

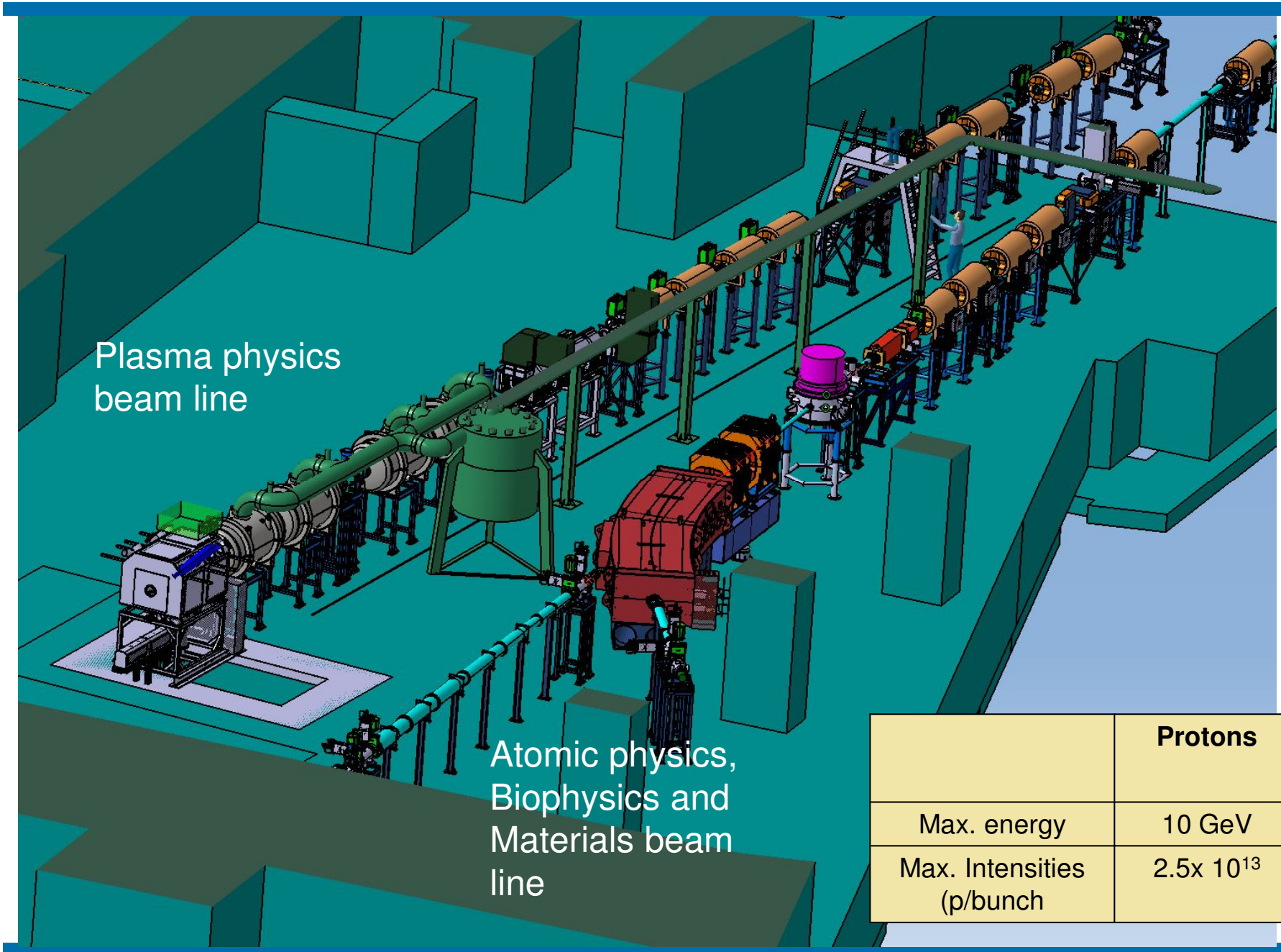


Facilities of APPA at FAIR

★ **APPA Cave** All APPA collaborations are using this area



APPA cave installations

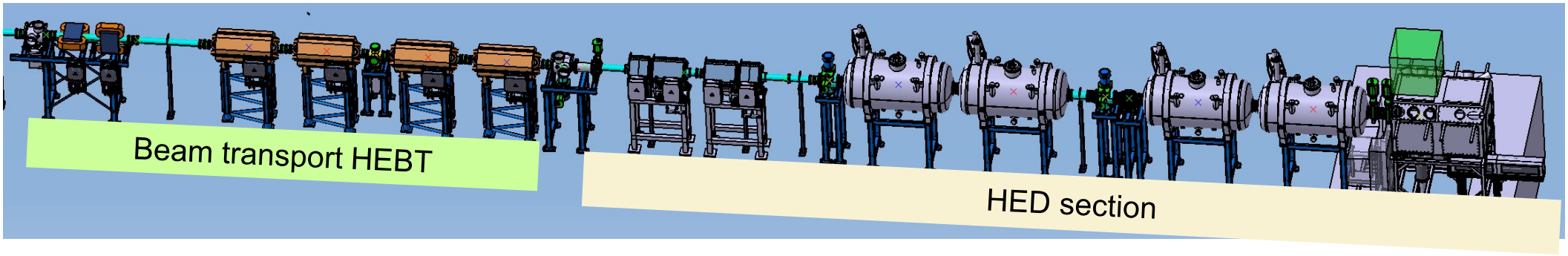


	Protons	Ions (up to U^{92+})
Max. energy	10 GeV	10 Gev/u
Max. Intensities (p/bunch	2.5×10^{13}	5×10^{11}

Beam Matching Section

Beam Matching Section prepares the beam for the different experimental scenarios:

- HIXEX (U, smallest focus)
- PRIOR (p, large area)
- LAPLAS (U, parallel)



- Front part of BMS recommended by CBWG to be transferred to the Accelerator; the WP taken over by accelerator groups:
  Cost reduction of the HED WP by 783 k€ (2005 price)
- Component Specifications defined, magnets contracted and ordered

The Work package BMS left to the HED was reduced to
– beam diagnostics
– vacuum systems
WP value: 152 k€

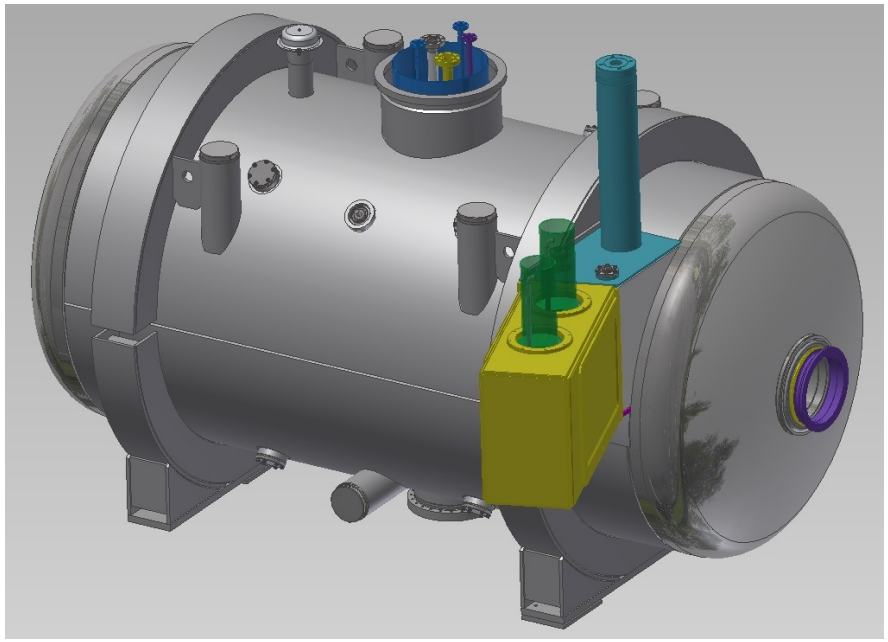
→ all are HEBT–like components

Final Focusing System

4 superconducting, large-aperture, high-gradient quadrupoles (inkind RU and DE)

- ✓ Second FDR passed in June 2019
- ✓ Procurement and magnet construction started at BINP, Russia
- ✓ First samples of the superconducting cable build and tested
- ✓ Test facility is prepared
- ✓ Specifications for the current leads in release process, tendering will start soon

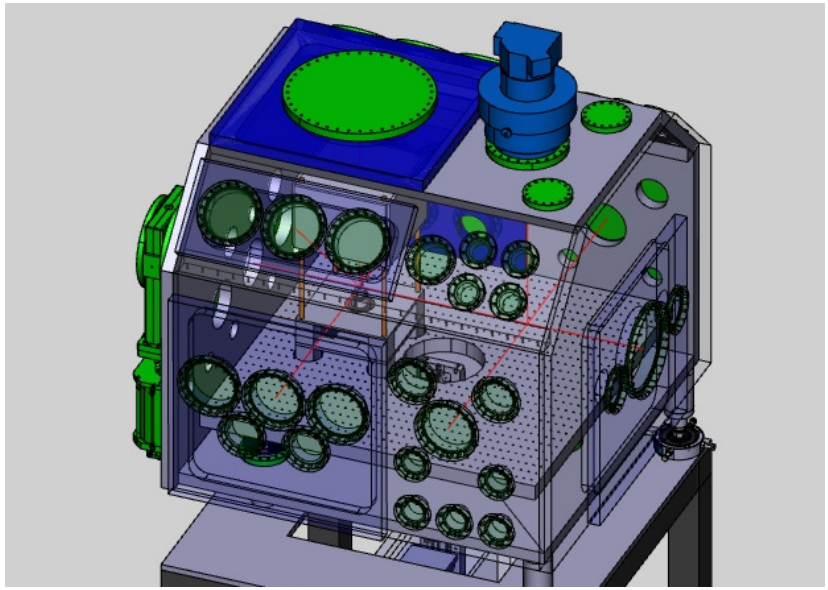
- ➢ Cryogenic station, transfer line and feed box will be supplied by the CRYO group (Accel. cost book CB8)
- ➢ Power supplies (inkind DE): specification are ready, the cost evaluation was updated: present cost ~1040 k€(2019 prices) ;
- ➢ new cost book value 695 k€ vs 422 k€ (old on) in 2005 prices
- ➢ The request for funding release (to FAIR Council) is in preparation



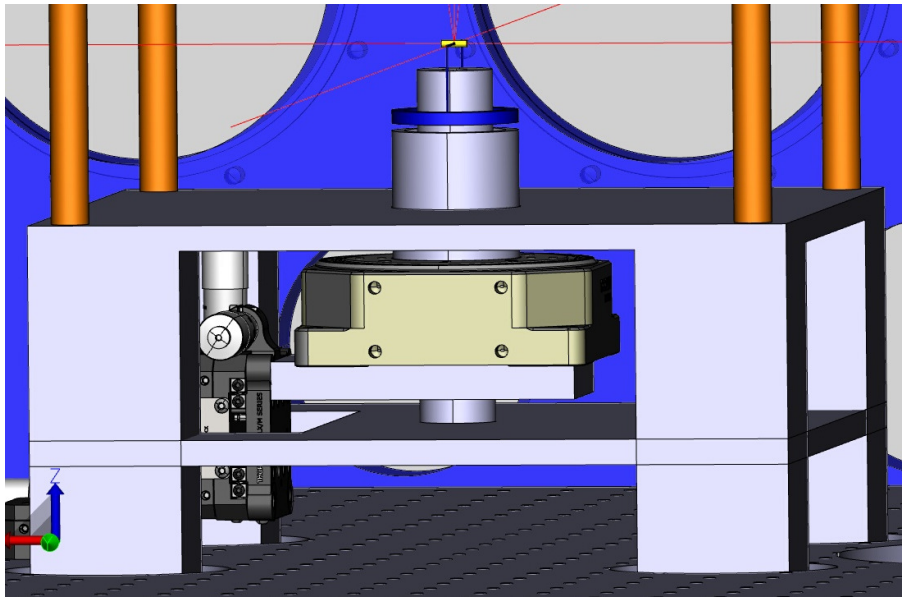
Target chamber

Contributed by the Univ. Frankfurt, Darmstadt, and Jena: 562,8 k€ investment

- ✓ According to the recommendations of the ECE and budget constrains, a new concept for a down-sized vacuum chamber has been worked out. Tendering is in preparation
- The concept for the target exchange and positioning system is existing. Software development and component tests have been started.
- The designs of systems for debris and protection of the beam entrance window are currently detailed
- The procedure for the chamber cleaning is in work.
- First experiments with the chamber are planned from 2021 on with SIS-18 beam and a 200J beamline from PHELIX at HHT/GSI.



Down-sized chamber for HHT (phase 0) and APPA (Day 1)



Concept for debris mitigation and protection of positioning system

Detectors

Significant progress towards diagnostic equipment for day-one experiments

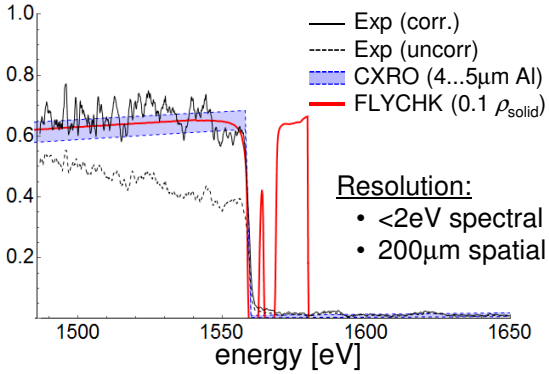
Visible:

- ✓ High-resolution gated camera for beam imaging and testing of PRIOR-II has been ordered
- ✓ EoI from IMP/Lanzhou to provide streak-camera and spectrometers for Surface Optical Pirometry

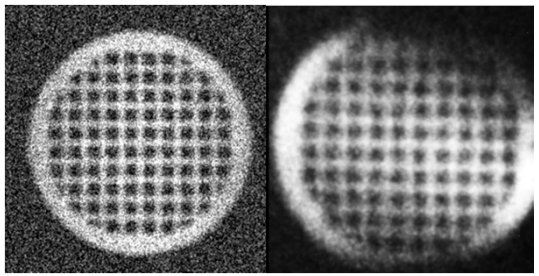
X-ray detection:

- ✓ High-resolution x-ray CCD camera for spectroscopic applications purchased and commissioned (FSU Jena)
- ✓ Demonstration of K-edge absorption spectroscopy using a new spectrometer (FSU Jena)
- ✓ Characterization of scintillation-based x-ray imaging and application at beam-foil interaction experiment at UNILAC (U Frankfurt)
- ✓ Optimization of nanosecond-pulse laser-driven x-ray sources and demonstration of various x-ray probing techniques

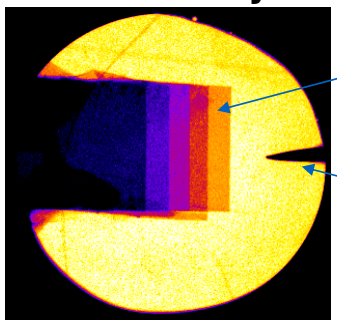
K-edge absorption (Al)



Scintillation-based x-ray imaging



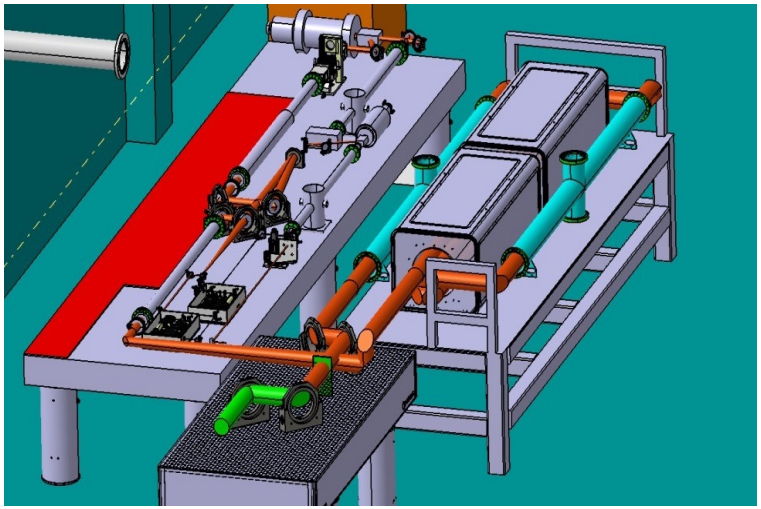
X-ray radiography



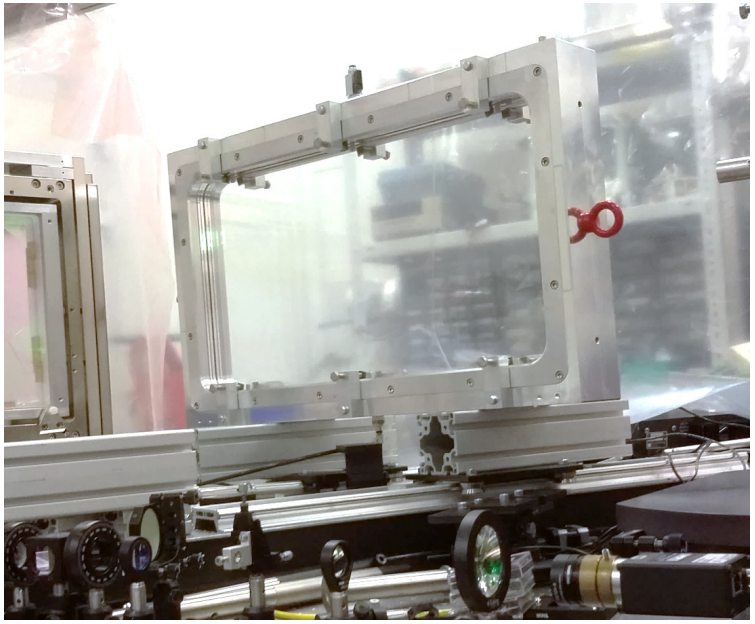
→Resolution 50 µm

Diagnostic Laser (100 J @ 2 ω, ns)

- ✓ front end development in Jena: 50 % completed, awaiting further funding
- ✓ preamplifier: power supplies delivered, optical layout in progress
- ✓ main amplifier:
  - ✓ amplifier module prototype on test bench
  - ✓ flashlamp cooling system on test bench
  - ✓ laser glass for one amplifier delivered



flashlamp module prototype



amplifier module prototype

PRIOR-II - Proton Microscope

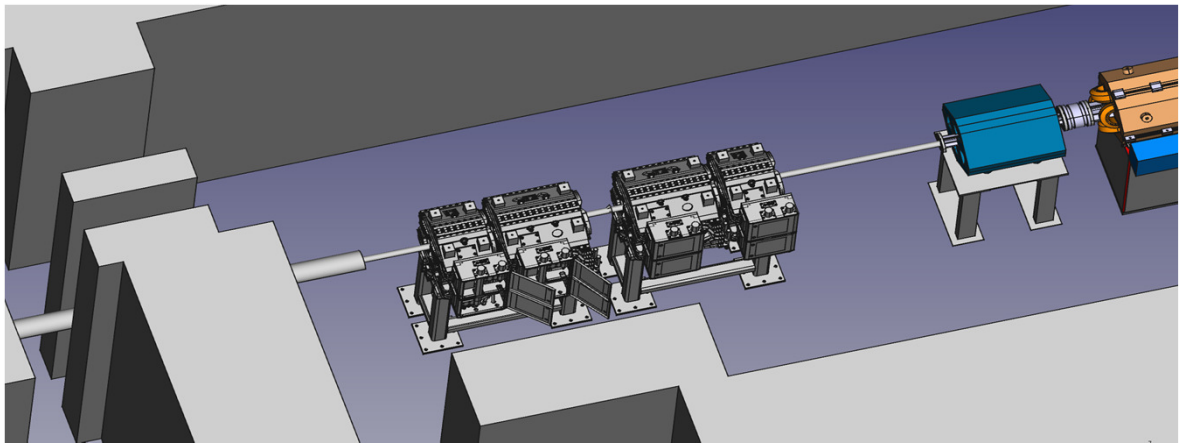
New design with radiation hard electromagnets: **PRIOR-II**

- ✓ manufacturing of magnets (SigmaPhi) and power supplies (Ampulz) started in 2019, expected to be completed in early 2020
- ✓ water cooled cables delivered and laid at HHT
- ✓ development of new detector system is ongoing

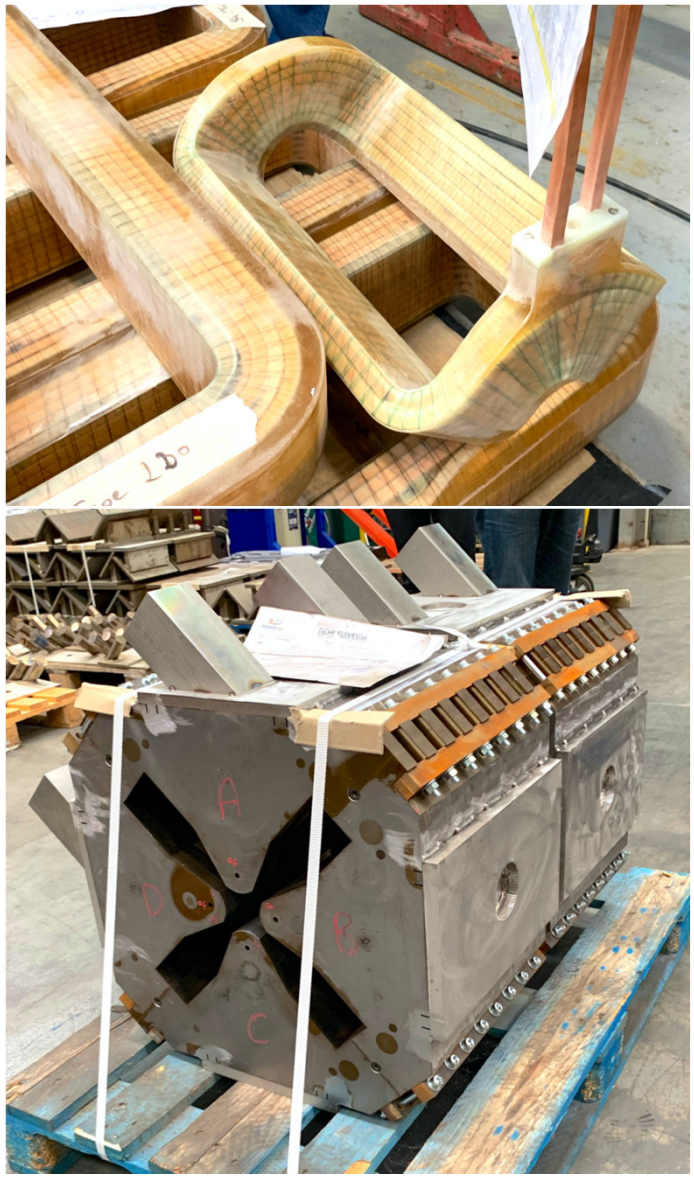
For FAIR Phase-0 the PRIOR will be installed at GSI/HHT,

- ➢ upgrade of HHT area infrastructure

Commissioning and first physics experiments at HHT (2 experimental proposals approved by PPAC) are scheduled for 2020.



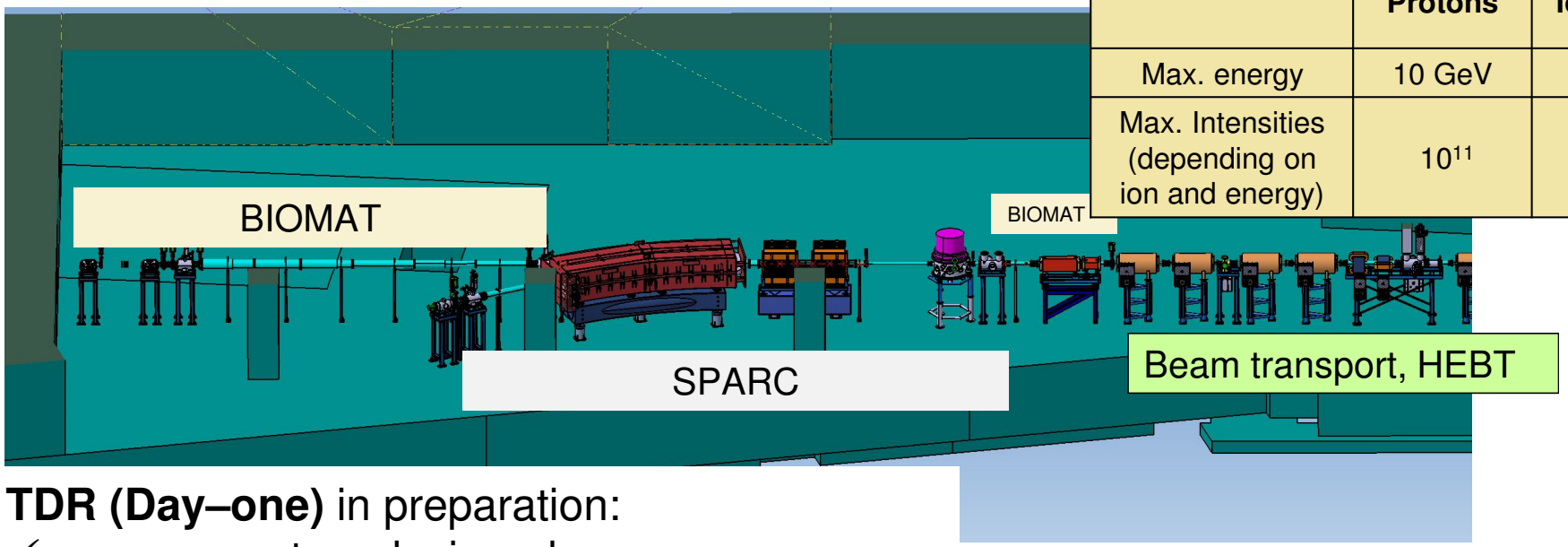
PRIOR-II setup at the HHT area of GSI.



Radiation hard electromagnets

APPA cave installations

SPARC and BIOMAT beam line: fixed- target experiment and irradiation station for various probes

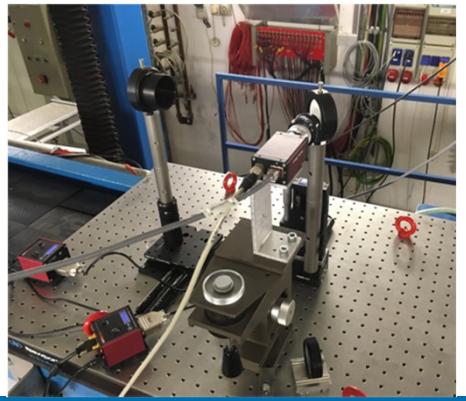


	Protons	Ions (up to U^{92+})
Max. energy	10 GeV	10 Gev/u
Max. Intensities (depending on ion and energy)	10^{11}	$5x10^{10}$

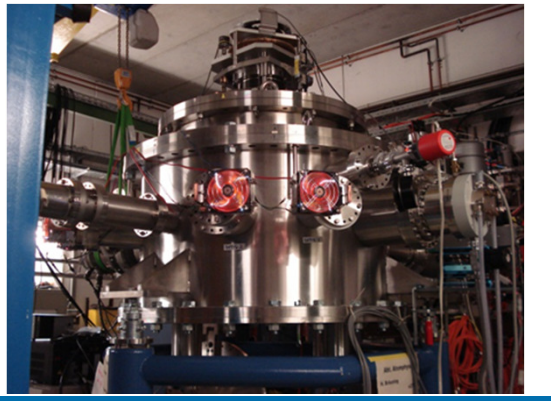
TDR (Day–one) in preparation:

- ✓ vacuum system designed
- ✓ beam diagnostics planed
- ✓ SPARC setup available
- ✓ day-one configuration without magnets (funding not available)
- ✓ approved experiments and tests in FAIR Phase-0
  - SPARC experiment: RCE in Li-like U
  - tests for irradiation equipment

MAT: testing in-situ analysis options

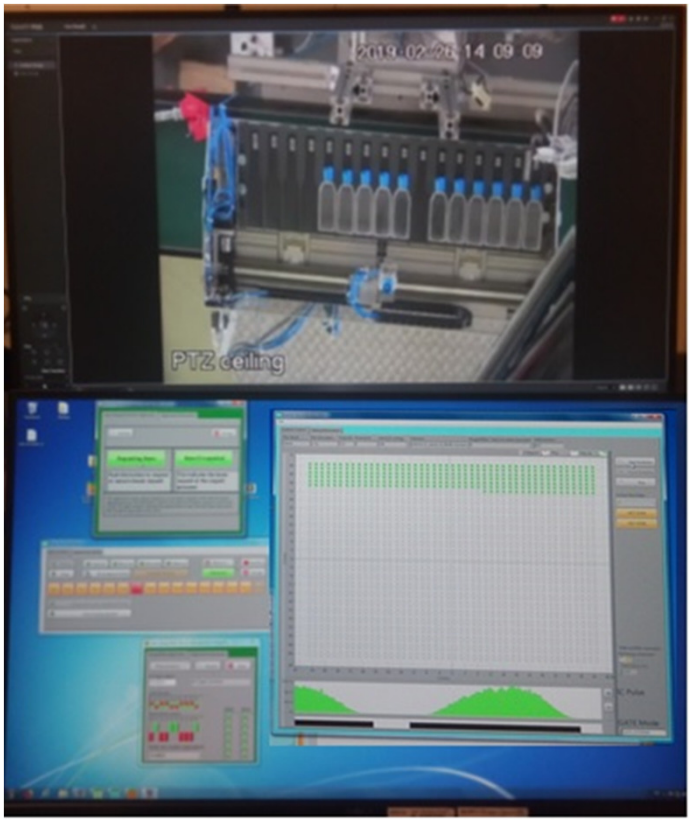


SPARC setup for the RCE studies

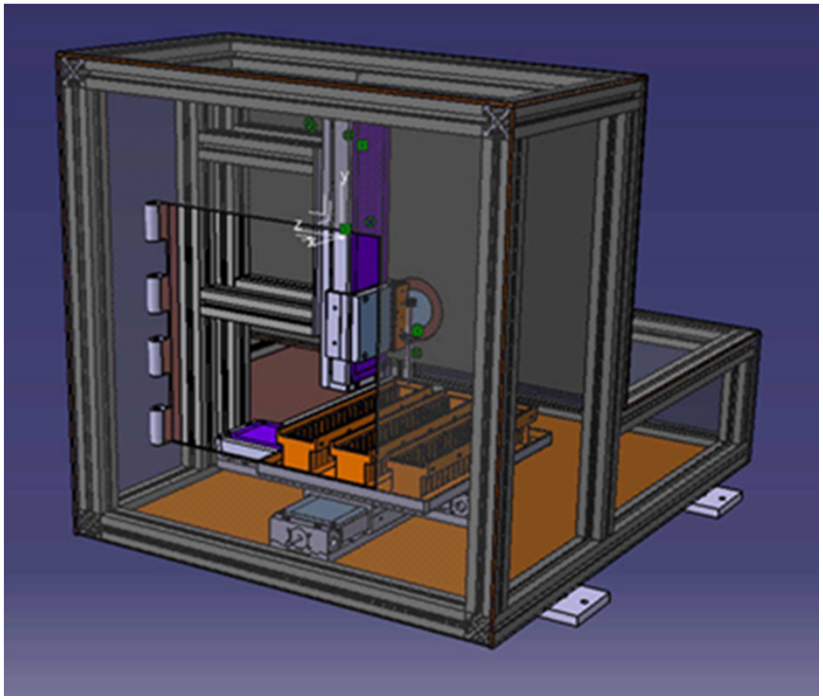


FAIR Phase-0, February 2019

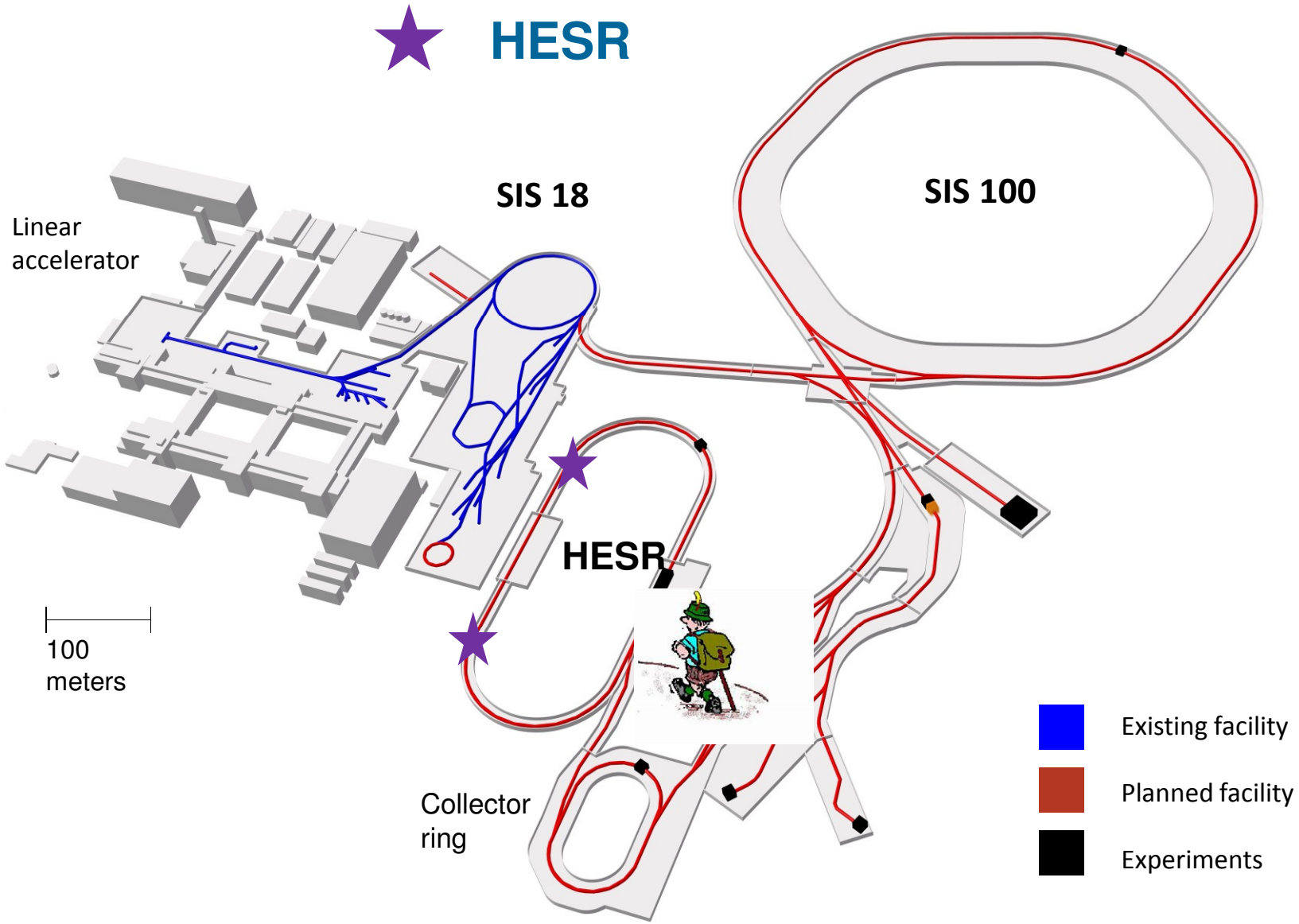
New scanner control and target handling system for large probes



New target handling and irradiation system for small probes

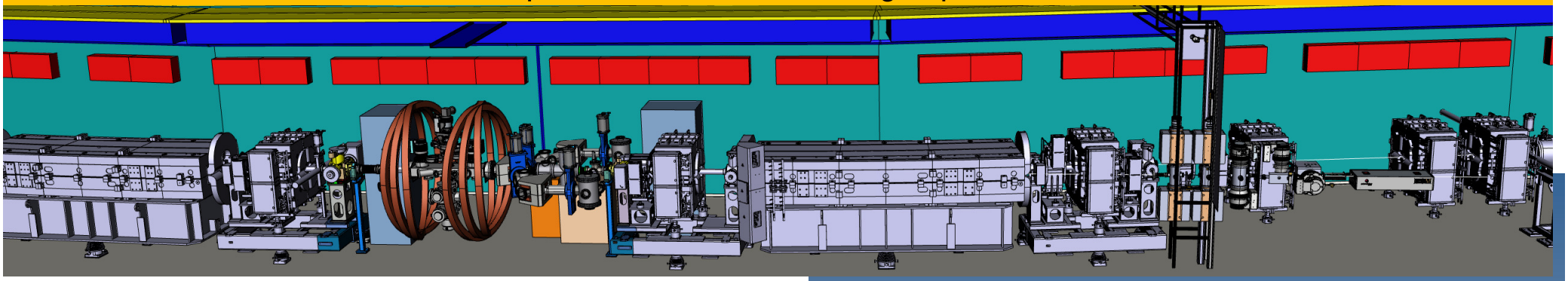


Facilities of APPA at FAIR



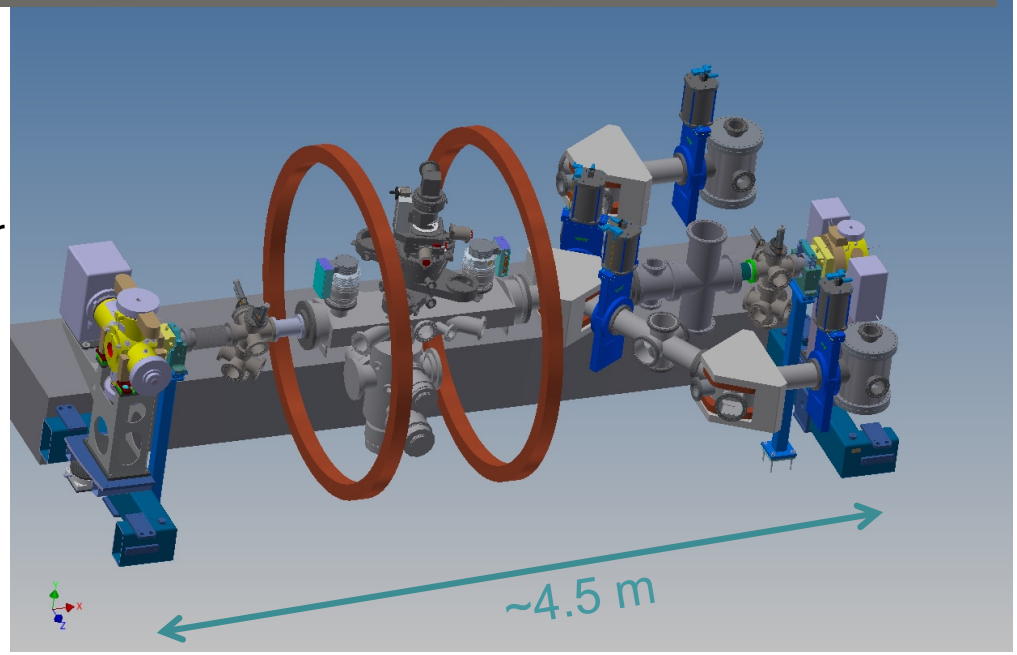
FAIR Phase 1: SPARC@HESR

SPARC Setup in the Northern-Missing-Dipole Section



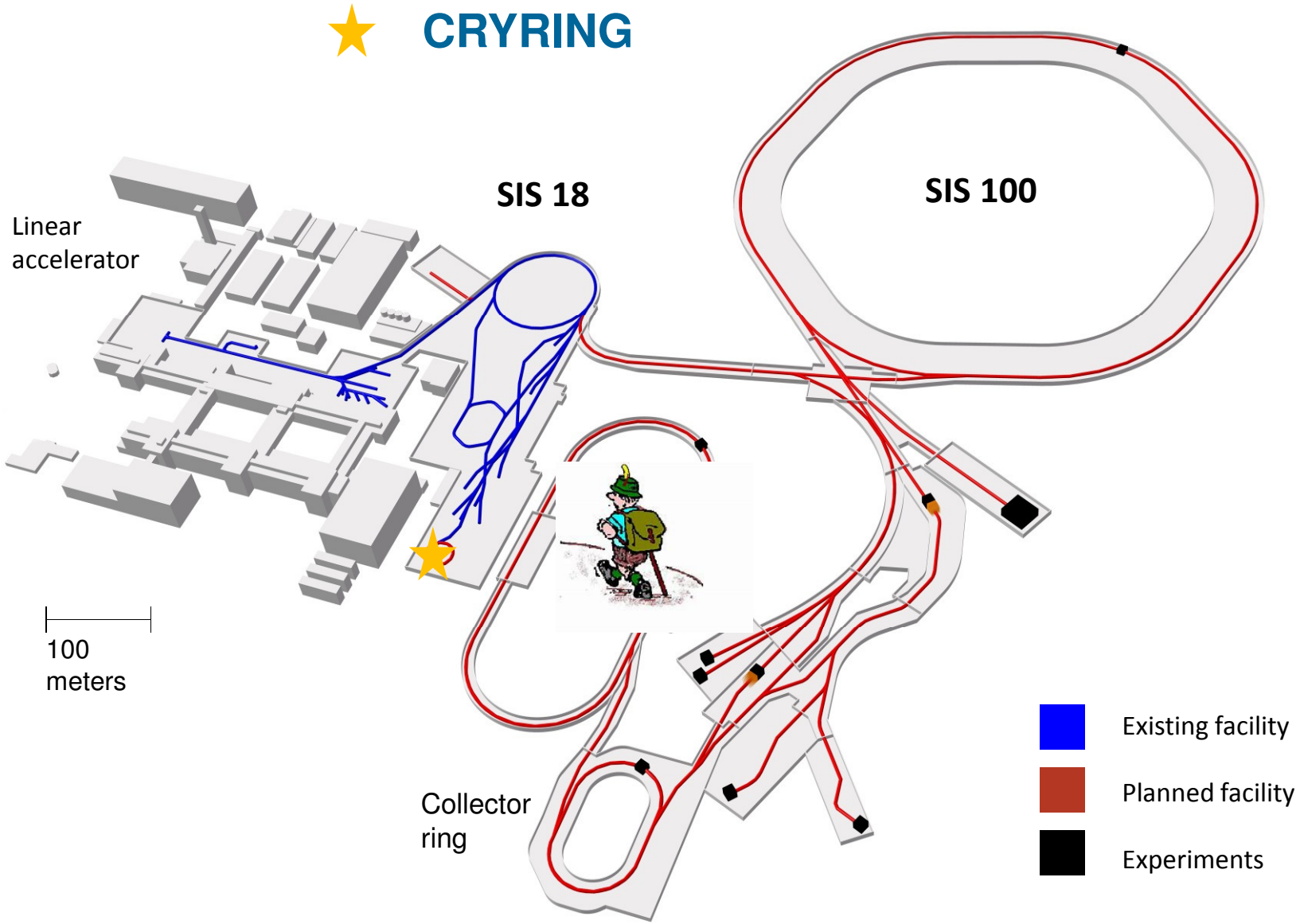
- ✓ **All TDRs for the Day-one are approved**

- Design of the lepton spectrometer is progressing
- Internal target: DE inkind, contract for funding ready for signatures
- Engineering of the Schottky detectors is in progress
- ✓ X-ray detectors are ready for installation
- currently the experiment integration in the HESR is prepared
- the local experiment infrastructure is updated
- ✓ the XUV-laser setup is currently tested at CRYRING

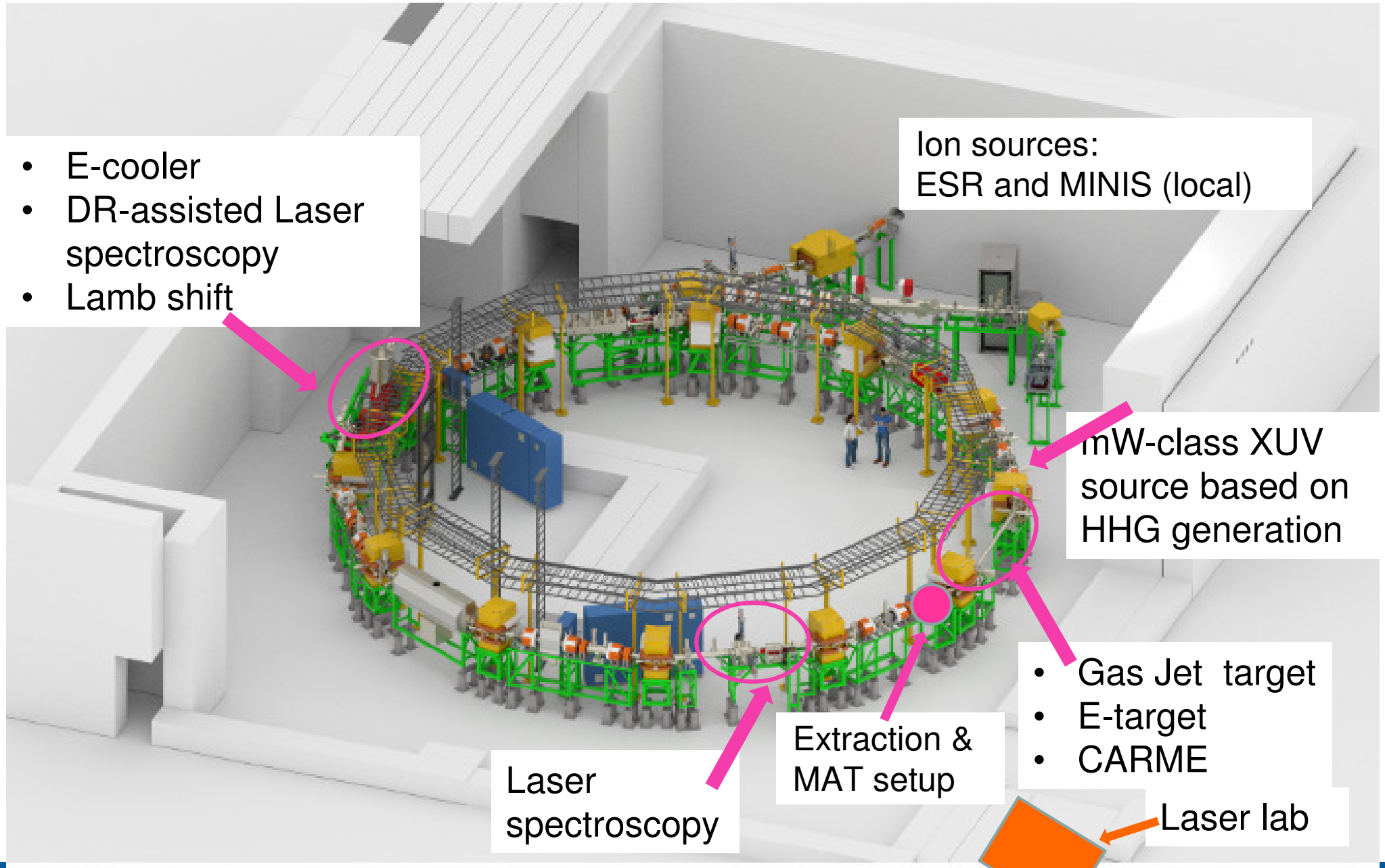


❖ Installation start in HESR: 2024-2025

Facilities of APPA at FAIR



CRYRING

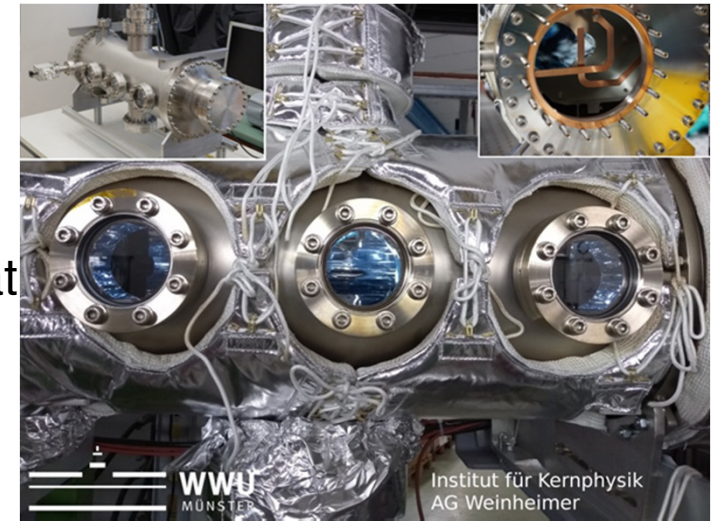

• E-cooler
• DR-assisted Laser spectroscopy
• Lamb shift
Ion sources:
ESR and MINIS (local)
mW-class XUV source based on HHG generation
• Gas Jet target
• E-target
• CARME
Laser spectroscopy
Extraction & MAT setup
Laser lab

CRYRING@ESR: October 2019

Commissioning runs with local ion source

- **March**: Mg^+ beam,

✓ test of the Laser spectroscopy setup at section 7



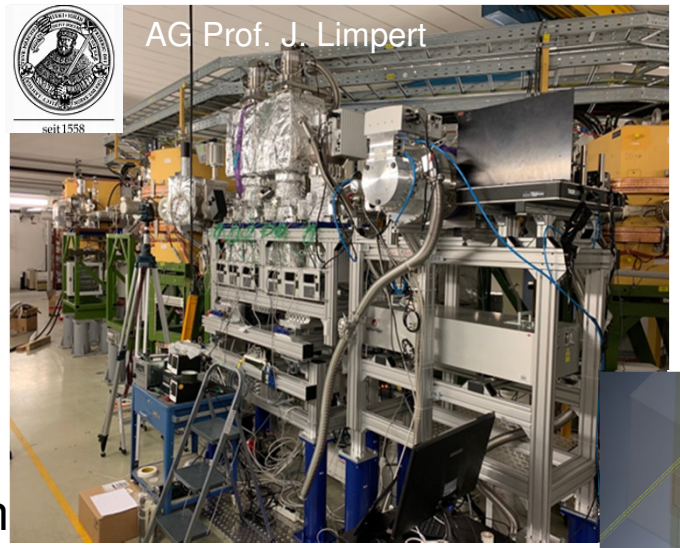
Laser (DE contribution:)

✓ ready to be installed at CRYRING

- **September-October** : C^+ beam ,

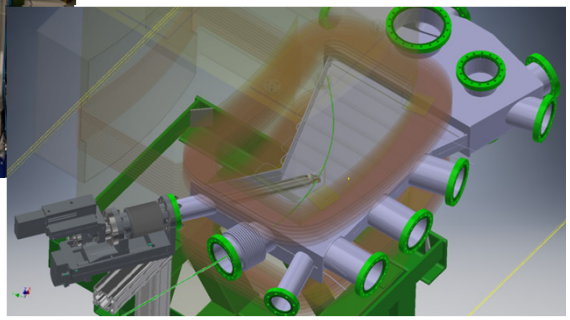
✓ installation and test of the Photo-ionization setup (XUV-Laser and UHV-coupling unit) at section 9

E129 approved experiment



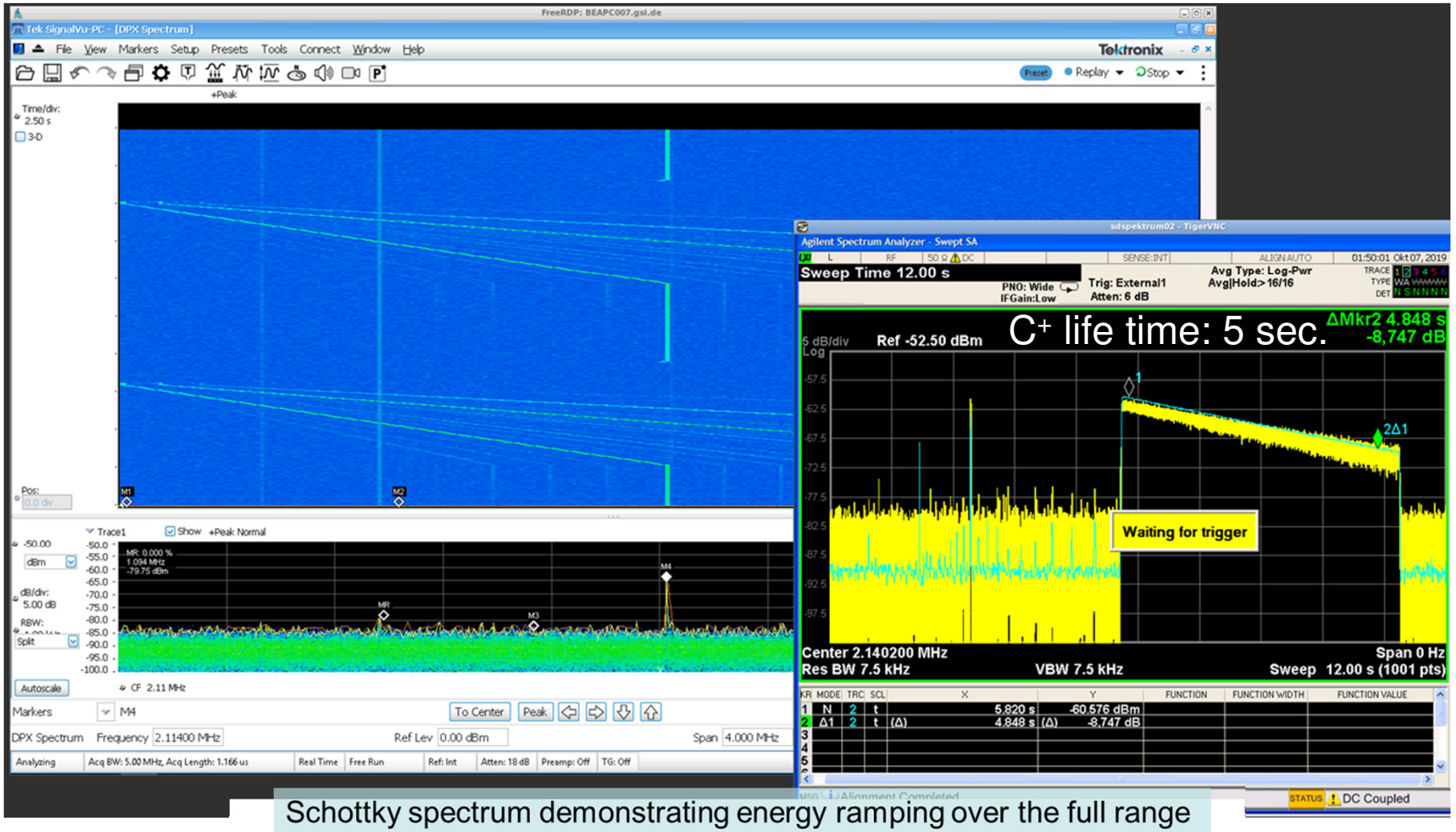
mW-class XUV source for CRYRING based on high harmonic generation with UHV coupling unit
(U. Jena, INFLPR Bucharest)

YAP:Ce scintillation detector for ions (DE, U. Giessen)

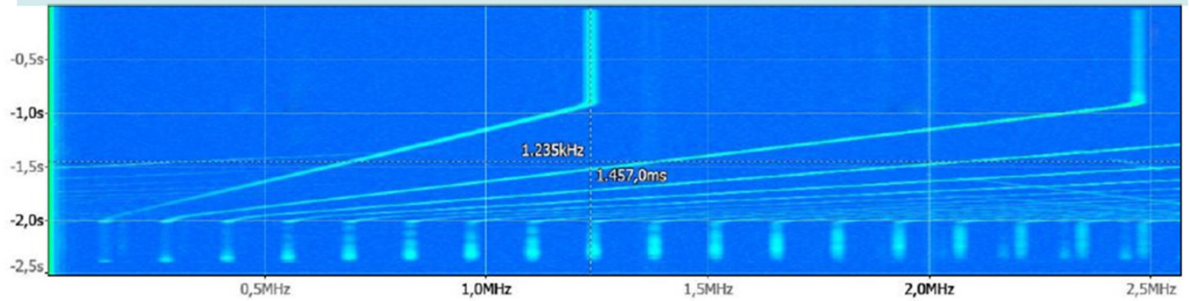


- **November-December**: Engineering run for the ESR-CRYRING coupling: storing ESR-beam in the CRYRING

CRYRING@ESR: C⁺ @ 400 keV/u



Schottky spectrum demonstrating energy ramping over the full range



H_2^+ beam from 0.3 -> 24 MeV/u / i.e. acceleration to max. rigidity

CRYRING@ESR: commissioning status

- started in 2016 with the ESR-CRYRING transport beam line
- all the following tests performed with the MINIS local ion source

✓ Both ion paths towards CRYRING@ESR, from ESR and from the local injector, are operational

✓ Assembly, alignment, baking of the ring is complete ($p \leq 1e^{-10}$ mbar); backing of the newly built extraction section is scheduled for November 2019

✓ FAIR control system installed and is opeartional

✓ the local **MINIS source is in operation** (q=1+, H_2, D_2, Ar, Mg, C)

✓ **Storage with vacuum-limited lifetimes** (D^+ @ 300 keV/u: 42 s)

✓ **E-cooler is operational: first signs of cooled ion beam have been detected**

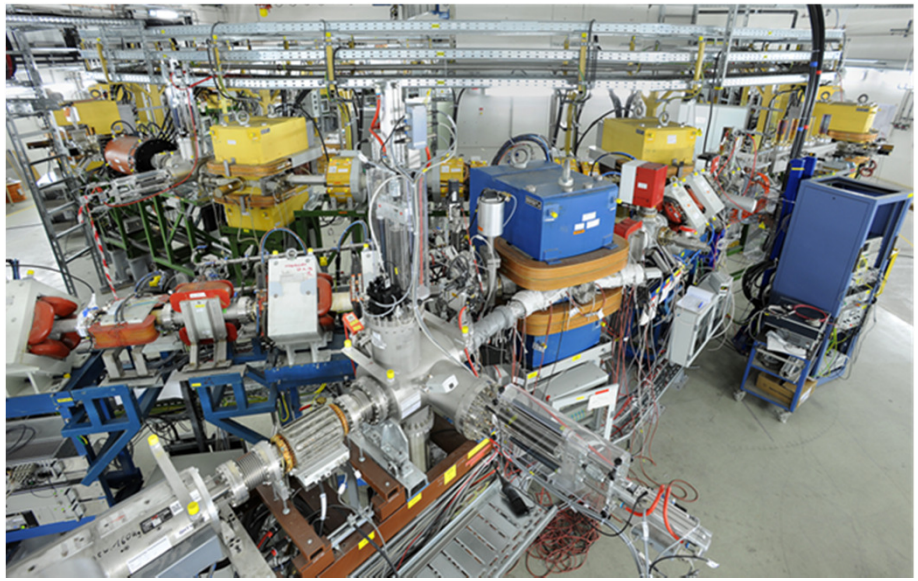
✓ Multiturn injection: n = 3...4.

✓ Beam acceleration successful 0.3 → 24 MeV/u, but beam losses are still high

✓ Beam deceleration successfully tested

Next steps towards the full ring commissioning

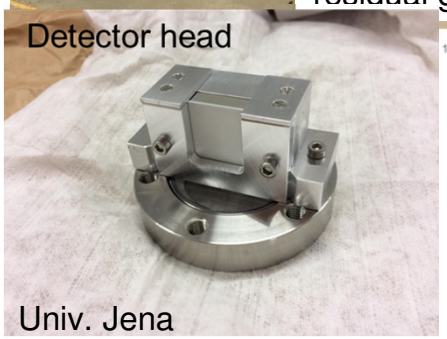
- test of the new injection kicker
- test the extraction
- improvement of the the cooling time of the e-cooler magnet
- injection and storage of ESR beam
- improve the vacuum / beam life time

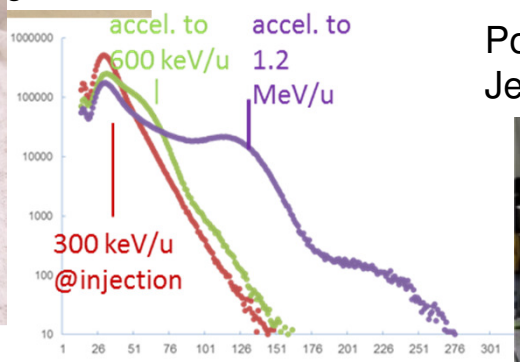


CRYRING@ESR: new equipment

Two UHV detector driver systems (DE, Uni. Frankfurt)

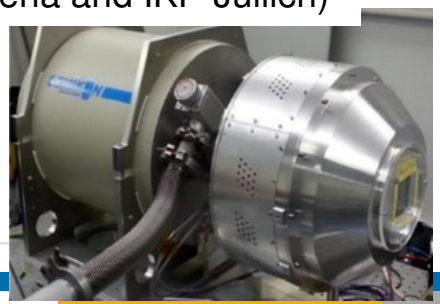
H_2^+ recombining / fragmenting in residual gas collisions



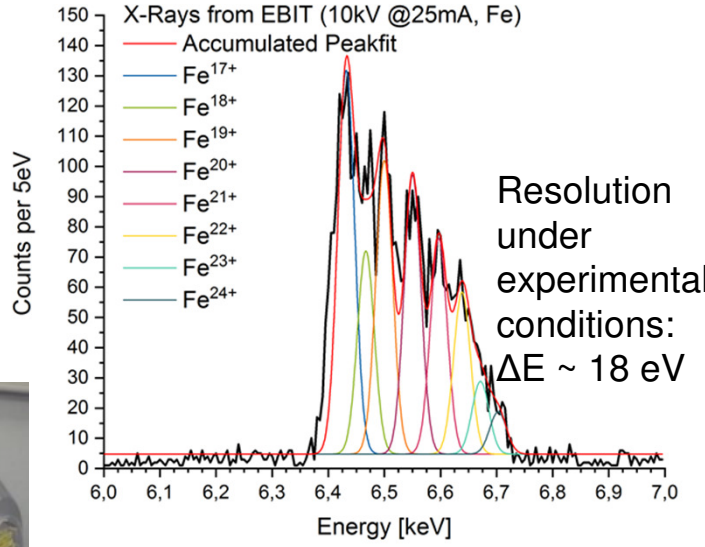


High Voltage divider for the e-cooler (DE, Uni. Münster)

Polarimeter (DE, Uni. Jena and IKP Jüllich)

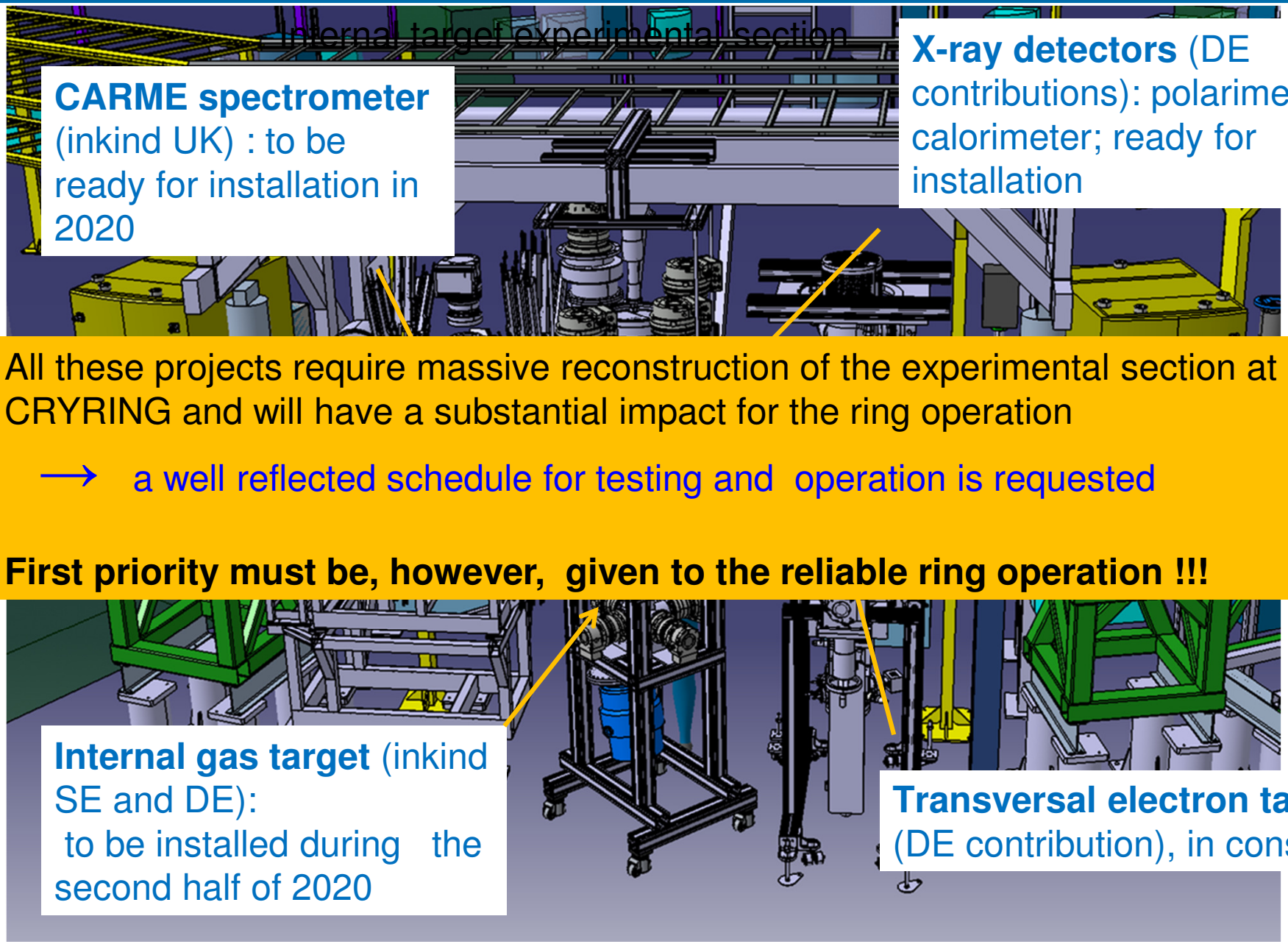


Micro-calorimeter (DE, Uni. Heidelberg)



Resolution under experimental conditions: ΔE ~ 18 eV

CRYRING experiments



CARME spectrometer (inkind UK) : to be ready for installation in 2020

X-ray detectors (DE contributions): polarimeters, calorimeter; ready for installation

All these projects require massive reconstruction of the experimental section at CRYRING and will have a substantial impact for the ring operation

⟶ a well reflected schedule for testing and operation is requested

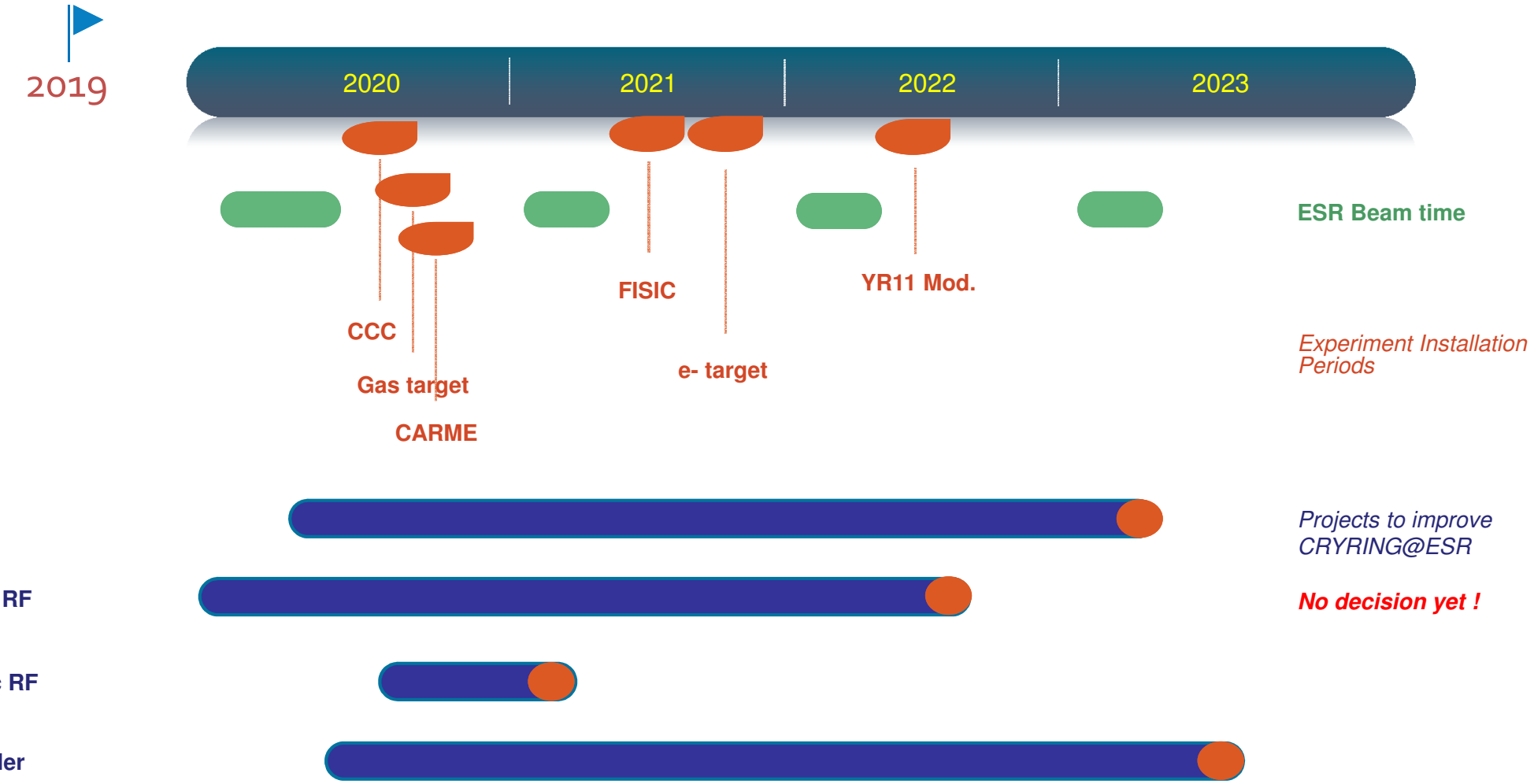
First priority must be, however, given to the reliable ring operation !!!

Internal gas target (inkind SE and DE):
to be installed during the second half of 2020

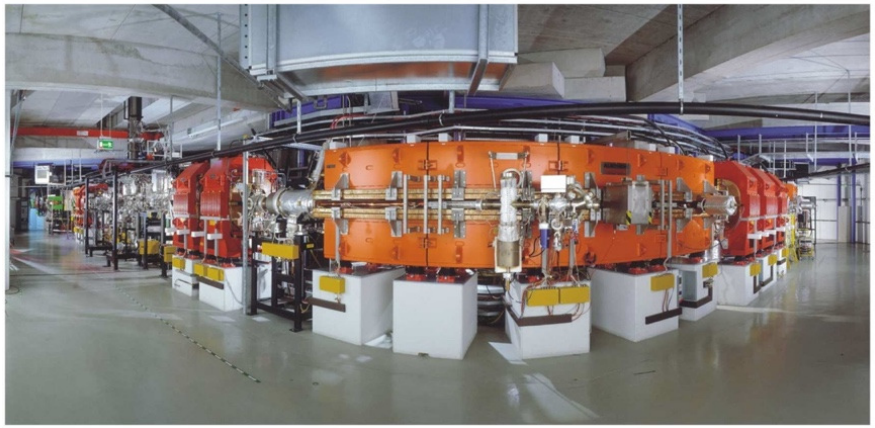
Transversal electron target (DE contribution), in construction

CRYRING@ESR 2020 and beyond

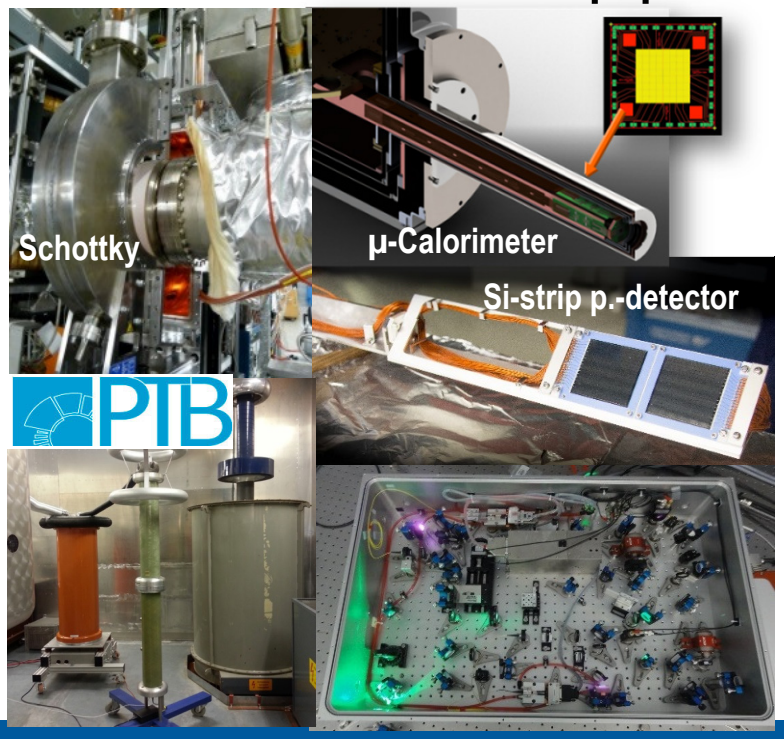
- pending discussion/funding/resource loading



Experiments for FAIR Phase-0



Dedicated & novel FAIR equipment



Experiments

E125 Δn=0 in He- and Li-like U (**target, x-ray**) **A-**

E137 RCE in Li-like U (**extracted ions, x-ray**) [2020] **A**

E128 Hyperfine Spectroscopy (**laser, DR**) (delayed/postponed???)**A**

E135 Spectroscopy of $^3P_0$ in Be-like Kr (**laser, XUV**) **A-**

E132 1s-1s Ioniz. & Charge Transfer (**target, e⁻-spectr.**)]2020] **A**

E133 Collective effects; cluster target (**target, XUV**) **(para. Mode)**

E121 Bound state beta-decay (**Schottky**) [2020] **A**

E127 Astrophys. p-process (p,γ) **(internal target)** [2020] **A**

Challenges

Commissioning of **new FAIR control system (progress)**
diagnostics, and in-ring instrumentation; (progress)
re-establishment of deceleration capability (progress)

Day-one Technical Design Reports and Their Status

Collaboration	Experiment	Day-1 TDRs
SPARC	APPA cave	1 TDR to be submitted
	SPARC at HESR	4 TDRs Approved
	SPARC at CRYRING	5 TDR Approved
	CRYRING Installation	1 TDR Approved
	Laser cooling	1 TDR to be submitted
HED@FAIR	PRIOR, HIHEX	7 TDR Approved
BIOMAT	APPA cave beam line	1 TDR to be submitted

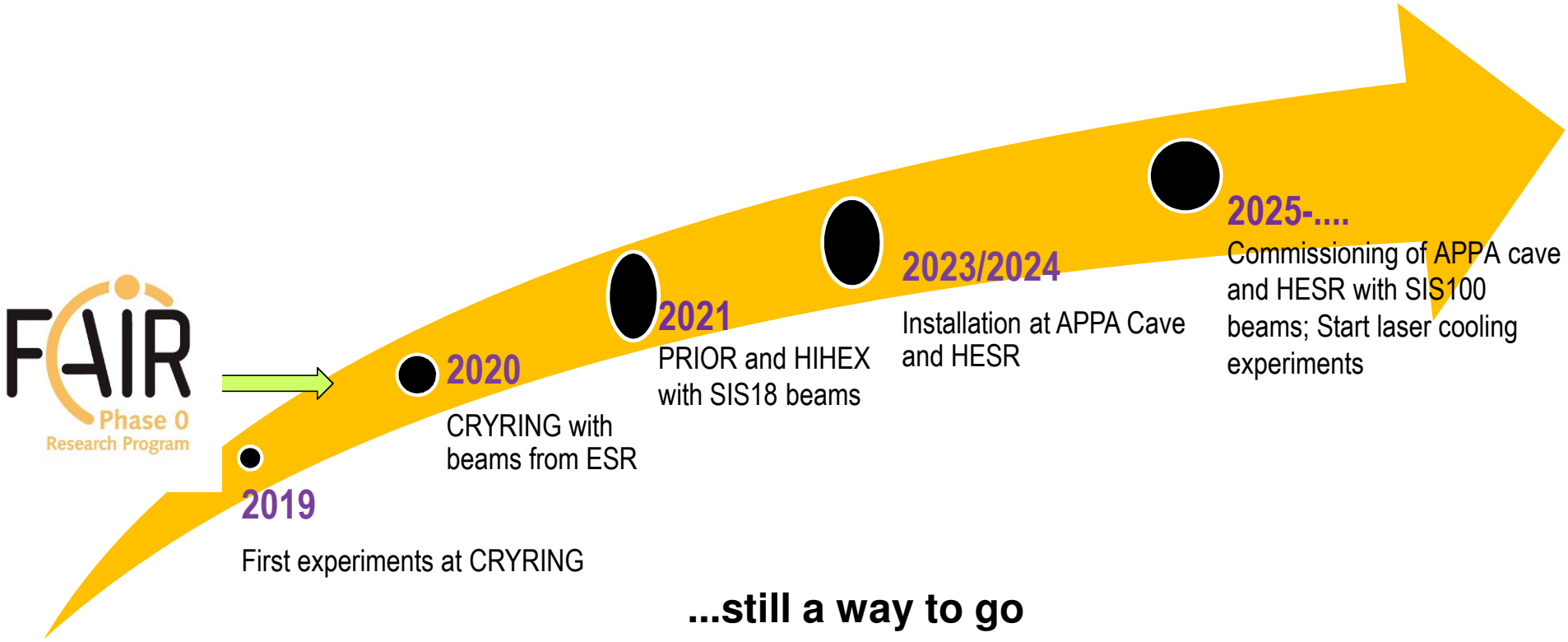
- Two more Day-one TDRs must be prepared and submitted (SPARC and BIOMAT prepare one common TDR for the beam line in APPA cave)
- Currently SPARC submitted an additional TDR to FAIR for evaluation: *A high-resolution asymmetric Von-Hamos spectrometer for low-energy x-ray spectroscopy at the CRYRING electron cooler*

Status APPA Day-one , October 2019

	APPA	TDR	Cost [k€ 2005]	Funding	Construction	Date completion	Test/ Commissioning
Day-1	SPARC, CRYRING installation		3,801			04/2017	
	SPARC, CRYRING experiments		2,268			11/2023	
	SPARC in APPA cave		933			09/2022	
	SPARC at SIS100		466			04/2024	
	SPARC at HESR		2,727			11/2023	
	HED@FAIR		6,525			06/2023	
	BIOMAT		1,228			04/2024	
		85% *value weighted*	17,948	87% *secured*	41% *value weighted*		

Additional funding is expected to be secured from the German pledge: BMBF Collaborative Program

Timeline towards FAIR Project completion



...still a way to go

FAIR Phase-zero is an essential step toward the full project accomplishment

- testing and commissioning of some components
- maintain the groups competences and know-how
- young scientists training
- smoothen the transit from the construction/installation phase to operation

New beam time proposals are in preparation

Summary and Outlook

- APPA is an important pillar of the FAIR research, with a large discovery potential
- **significant progress** in the realization of APPA at FAIR was achieved in 2019: many components are already available or in an advanced stage of realization
- **CRYRING** commissioning is in **a visible progress**
- few day-one components are still waiting for resources (funding and/or manpower)
- **two more Day-one-relevant TDRs** must be finalized
- **FAIR Phase-zero** started with good results for BIOMAT

- CRYRING must be ready for operation with ESR beams in 2020
- experiments integration in the CRYRING is of outmost importance
- Installation of PRIOR and HIHEX at GSI/HHT in 2020 is essential for the HED Phase-0 program
- preparation of the approved ESR experiments

- new beam time proposals, involving the new instrumentation are in preparation
- evaluation of the local experiment infrastructure to be completed in 2020
- further planning of the experiments installation and integration at FAIR: procedure, time line, resources

Thank you for your attention