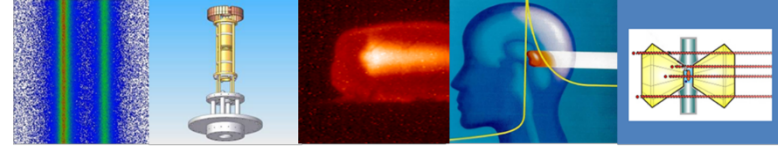


APPA



Status Report on **A**tom**i**c and **P**lasma **P**hysics and **A**pp**i**ed Sciences

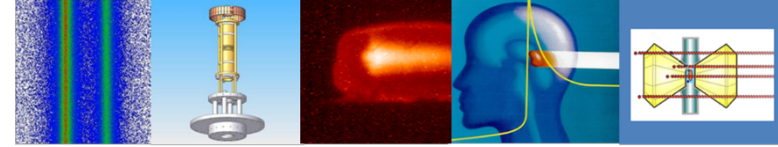


Stefan Schippers for the APPA Collaborations



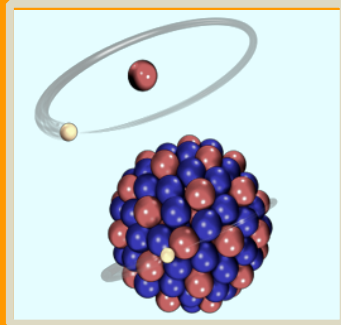
APPA R&D Coordinator

KHuK Annual Meeting, Bad Honnef, 6-7 December 2018

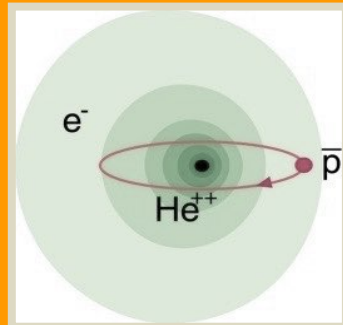


Collaborations and Research Topics

Atomic Physics



SPARC



FLAIR

Plasma Physics



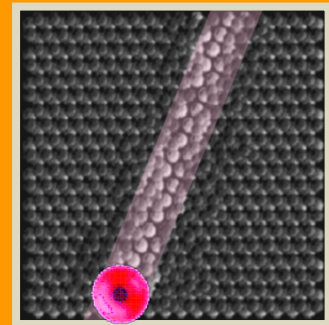
HED@FAIR

Biophysics



BIO/BIOMAT

Materials Science



MAT/BIOMAT

Strong Field Research

Probing of fundamental laws of physics

Anti-Matter (not in MSV)

Matter/anti-matter asymmetry

High Energy Density Matter

Study of matter under extreme condition - common in astrophysical objects

Radiation Biophysics

Risks of cosmic radiation, Theranostics

Materials under Extreme Conditions

Radiation hardness, modification of materials

APPA White Paper

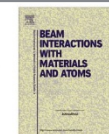
NIMB 365 (2015) 680



Nuclear Instruments and Methods in Physics Research B

journal homepage: www.elsevier.com/locate/nimb

Contents lists available at ScienceDirect



APPA at FAIR: From fundamental to applied research

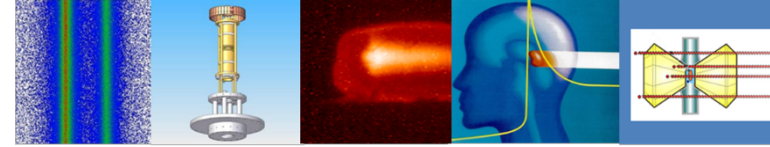


Th. Stöhlker^{a,b,c,*}, V. Bagnoud^{a,b}, K. Blaum^d, A. Blazevic^a, A. Bräuning-Demian^{a,c}, M. Durante^a, F. Herfurth^a, M. Lestinsky^a, Y. Litvinov^a, S. Neff^{a,f}, R. Pleskac^a, R. Schuch^g, S. Schippers^h, D. Severin^a, A. Tauschwitz^a, C. Trautmann^{a,f}, D. Varentsov^a, E. Widmannⁱ, on behalf of the APPA Collaborations

**Matter under Extreme
Conditions**
strong fields, high densities,
high pressures,
high temperatures,
anti-matter

SPARC

APPA

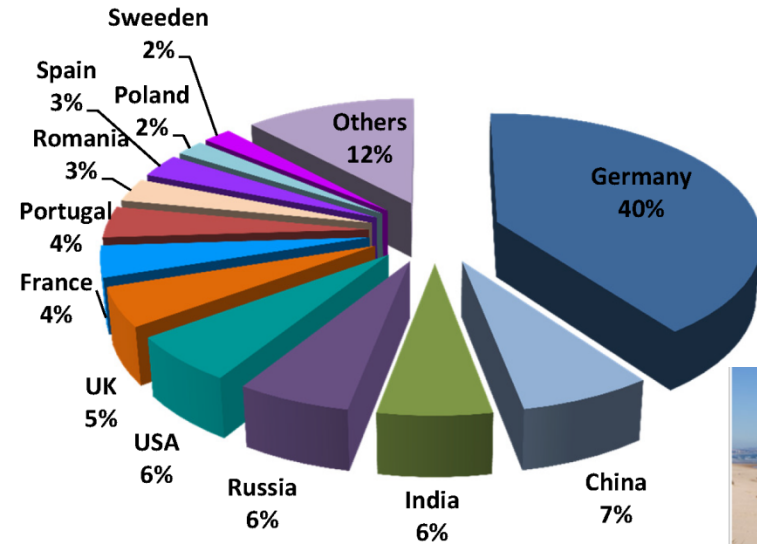


Collaboration

spare
Stored Particles Atomic Physics Research Collaboration

Stored Particles Atomic Physics Research
Collaboration

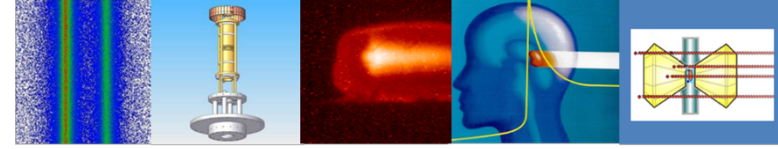
437 members



Spokesperson	Reinhold Schuch	University of Stockholm
Deputy Spokesperson	Jose-Paulo Santos	University of Lisboa
Coordinator	Angela Bräuning-Demian	GSI & FAIR
Hostlab Liason	Thomas Stöhlker	HI Jena & GSI

HED@FAIR Collaboration

APPA

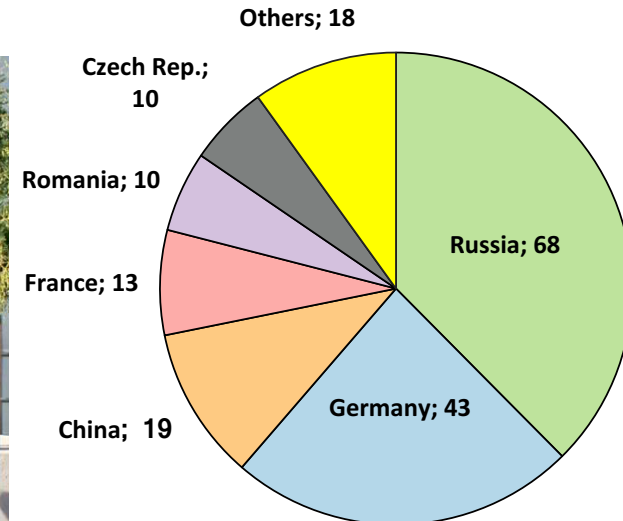


HED@FAIR

Spokesperson	Alexander Golubev (ITEP)
Deputy Spokesperson	Kurt Schoenberg (LANL)
Chair Collaboration Board	Vincent Bagnoud (GSI)
Technical Coordinator	Abel Blazevic (GSI)
Resource Coordinator	Stephan Neff (FAIR)

181 members from 11 countries
(Russia, Germany, China, France, Romania, Czech Republic, USA, Spain, Norway, Israel, UK)

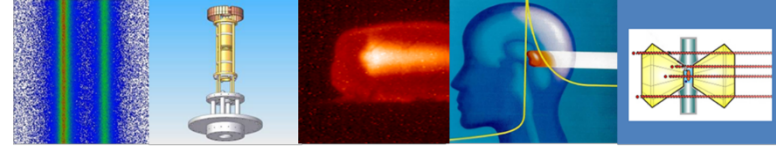
HED@FAIR Workshop
Ciudad Real, Spain, October 2018



Materials Science



APPA

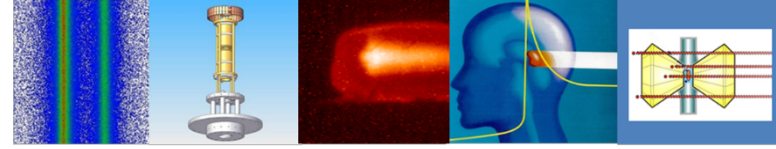


MAT science Week (24-27 April, 2018)



Broad interdisciplinary field
solid state physics, nanoscience, biophysics,
electronics, geosciences, mineralogy

APPA



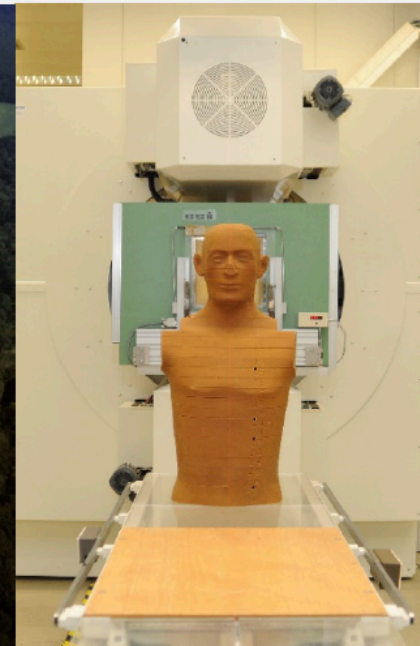
BIOphysics

International



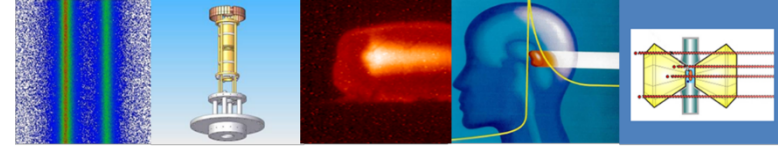
Collaboration Meeting

GSI Darmstadt, Germany 20-22 May 2019



Funding of

APPA

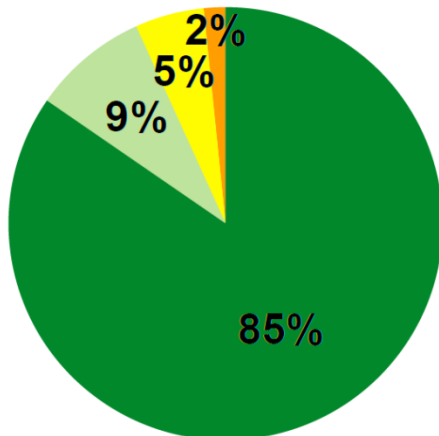


APPA Experiments

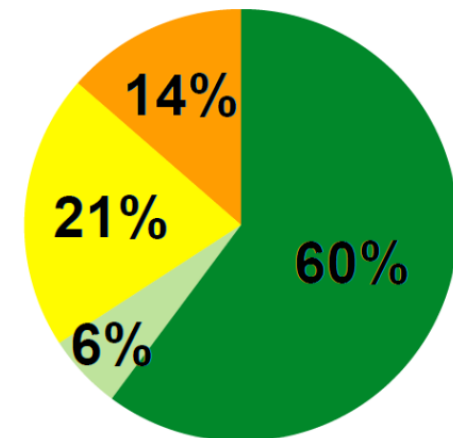
all prices in M€ (2005)
as of 8th RRB

	BIOMAT	HED@FAIR	SPARC	APPA
Total	2.36	10.93	14.17	27.46
German contribution	1.37	3.78	8.00	13.15
Verbundforschung	0.42	1.30	2.38	4.10

Day-1
18 M€



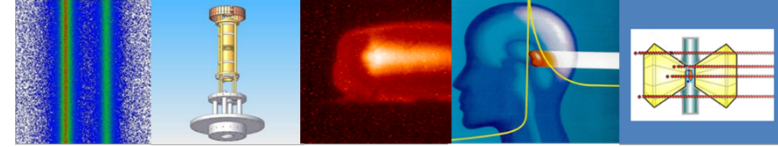
Full MSV
27.5 M€



● Secured ● Add. Secured VF
● Eol ● TbA

APPA R&D 2015-2018

APPA



SPONSORED BY THE



Federal Ministry
of Education
and Research

SPARC, HED@FAIR (2015-2018)

31 applications, 22 funded by the program
“Physics of the Smallest Particles”
coordinated by S. Schippers (Giessen)

6.8 + 1.5 M€

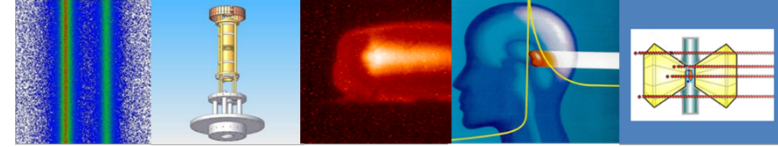
BIOMAT (2016-2019)

8 applications, 4 funded by the program
“Condensed Matter”
coordinated by M. Schleberger (Duisburg-Essen)

1.7 M€

APPA R&D 2019-2021

APPA



SPONSORED BY THE



Federal Ministry
of Education
and Research

SPARC, HED@FAIR (2019-2021)

32 applications, 16 funded by the program

“Physics of the Smallest Particles”

coordinated by S. Schippers (Giessen)

6.3 M€

BIOMAT (2019-2022)

8 applications, about 4 M€

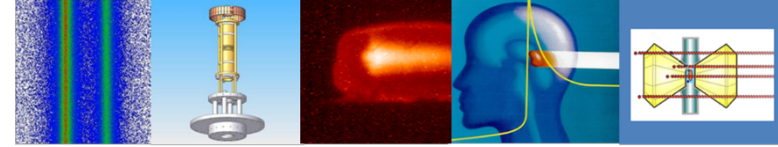
“Condensed Matter”

coordinated by M. Schleberger (Duisburg-Essen)

Projects

2019-2021

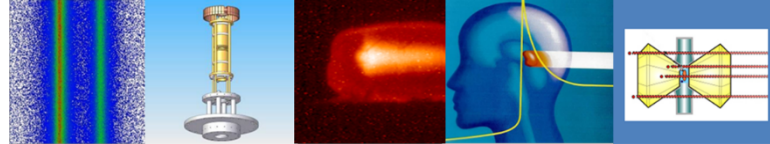
APPA



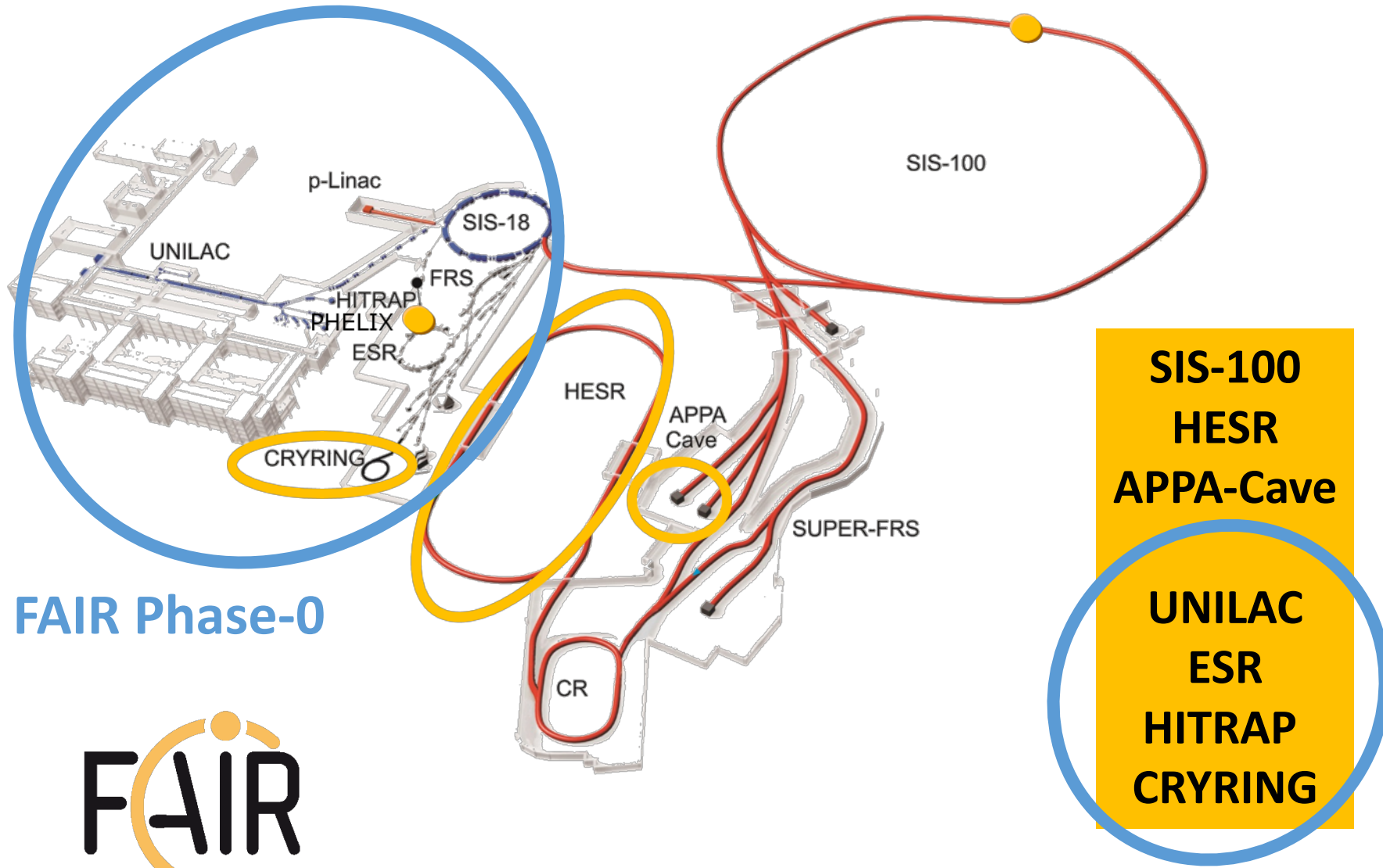
- [05P18KHFAA](#): *Development of a calibration instrument for high-intensity light sources, **HU Berlin***
- [05P18WMFA1](#): *I-BEAT, ultrasound-based energy measurements of single ion-bunches, **LMU München***
- [05P19PMFA1](#): *Development of a fluorescence detector for the laser cooling at SIS 100 and experiments with detection systems and precision-HV-systems in FAIR phase-0, **Münster***
- [05P19RDFAA](#): *Development and application of laser-based techniques for SPARC, **Darmstadt***
- [05P19RDFA1](#): *Development and setup of the target for HED, **Darmstadt***
- [05P19RFFA1](#): *Preparation and execution of APPA experiments in FAIR phase-0, **Frankfurt***
- [05P19RFFA2](#): *Reaction studies with ion storage-rings, **Frankfurt***
- [05P19RGFA1](#): *Electron-ion collision spectroscopy at the ion-storage rings of FAIR, **Gießen***
- [05P19RKFA1](#): *Development of a high-resolution Seya-Namioka-fluorescence spectrometer for experiments at storage rings for highly charged ions, **Kassel***
- [05P19SJFAA](#): *Application of new photonic methods for precision spectroscopy of stored highly-charged ions, **Jena***
- [05P19SJFA1](#): *Development of spectroscopic methods for day-1 plasma-physics experiments at FAIR, **Jena***
- [05P19VHFA1](#): *Flux-ramp SQUID-multiplexing for kilo-pixel microcalorimeter-arrays, **Heidelberg***

FAIR

APPA



APPA Facilities

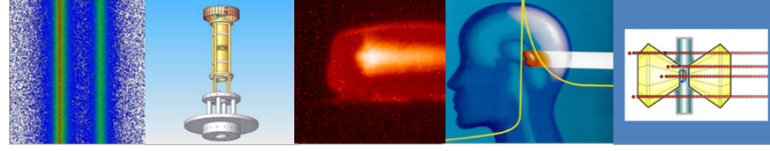


FAIR Phase-0



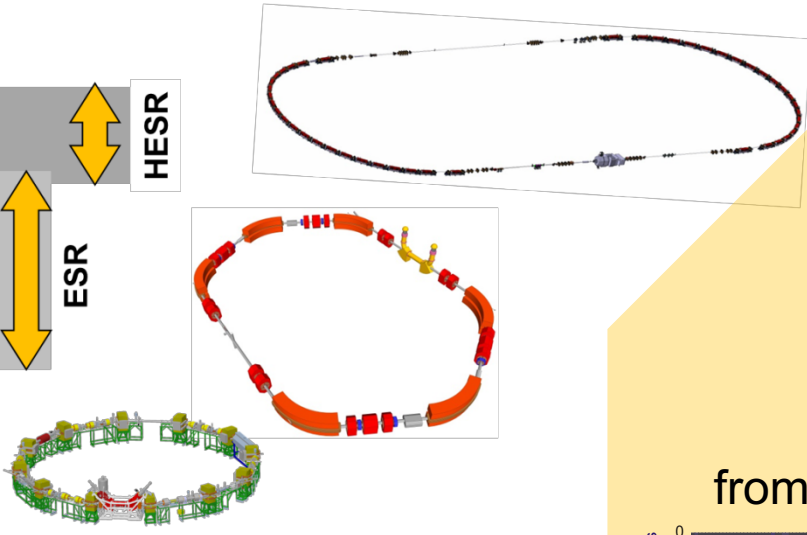
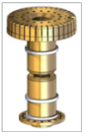
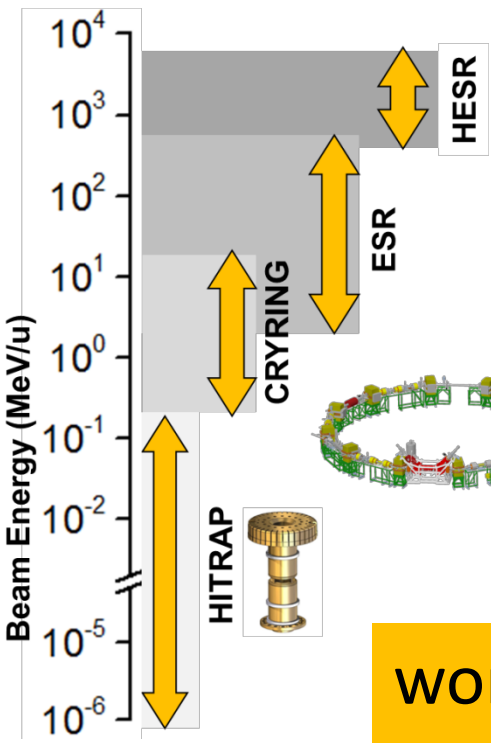
SIS-100
HESR
APPA-Cave

UNILAC
ESR
HITRAP
CRYRING



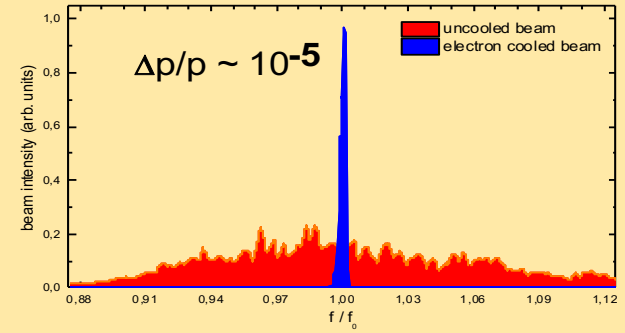
Trapping and Storage Facilities

highly charged ions (e.g. U^{92+}) and exotic nuclei
 from rest to relativistic energies (up to 6 GeV/u)

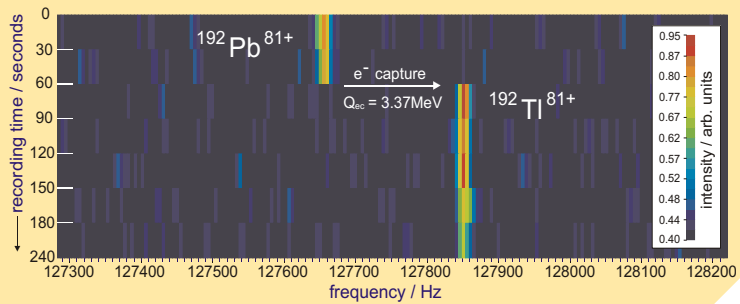


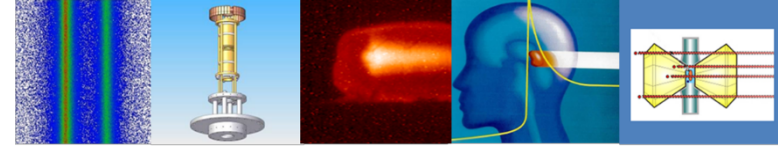
worldwide
 unique

cooling: The key for precision



from single ions to highest intensities

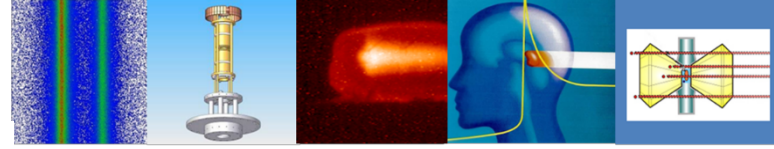




FAIR Core-Invest SPARC

(after 8th RRB in Nov. 2018)

PSP-Code	Component	Core Invest (k€, PB 2005)			University	Year of Completion
		Total (for Day 1)	2015-2018	2018-2021		
1.3.1.1.1.1	Laser cooling 1	220			Dresden	2024
1.3.1.1.1.2	Laser cooling 2	220			Darmstadt	2024
1.3.1.3.5.1	Calorimeter 1	109	109		Heidelberg	2018
1.3.1.3.10	Lepton spectrometer	334			Gießen	2024
1.3.1.3.11.2	XUV laser	367	256	41	Jena	2019
1.3.1.3.12.3	VUV/VIS spectrometer	230		117	Kassel	2024
1.3.1.5.1.2	2D-Detectors	22			Lüneburg	2021
1.3.1.5.4.1	X-ray optics	56	56		Jena	2018
1.3.1.5.5	Reaction microscope	223			Frankfurt	2021
1.3.1.5.7.1	Ion detectors	111	111		Frankfurt	2018
1.3.1.5.8.1	Laser spectroscopy 1	156	156		Darmstadt	2018
1.3.1.5.8.2	Laser spectroscopy 2	62	62		Münster	2018
1.3.1.5.9	Electron target	280	133	147	Gießen	2021
1.3.1.5.10.1	Cooler voltage control	37	19	18	Gießen	2019
1.3.1.5.10.3	Laser view ports	10	10		Darmstadt	2018
Sums	foreseen by BMBF: 2380	2380	985	323		



SPARC at CRYRING

reaction microscope

PSP 1.3.1.5.5 Univ. Frankfurt

**transverse
electron target**

PSP 1.3.1.5.9 Univ. Giessen
05P15RGFAA
05P19RGFA1

x-ray optics

PSP 1.3.1.5.4 Univ. Jena
05P15SJFAA

2D detectors

PSP 1.3.1.5.1.2 Univ. Lüneburg

laser spectroscopy

PSP 1.3.1.5.8 Univ. Darmstadt & Münster
05P15RDFAA & 05P15PMFAA

ion detectors

PSP 1.3.1.5.7 Univ. Frankfurt
05P15RFFAA

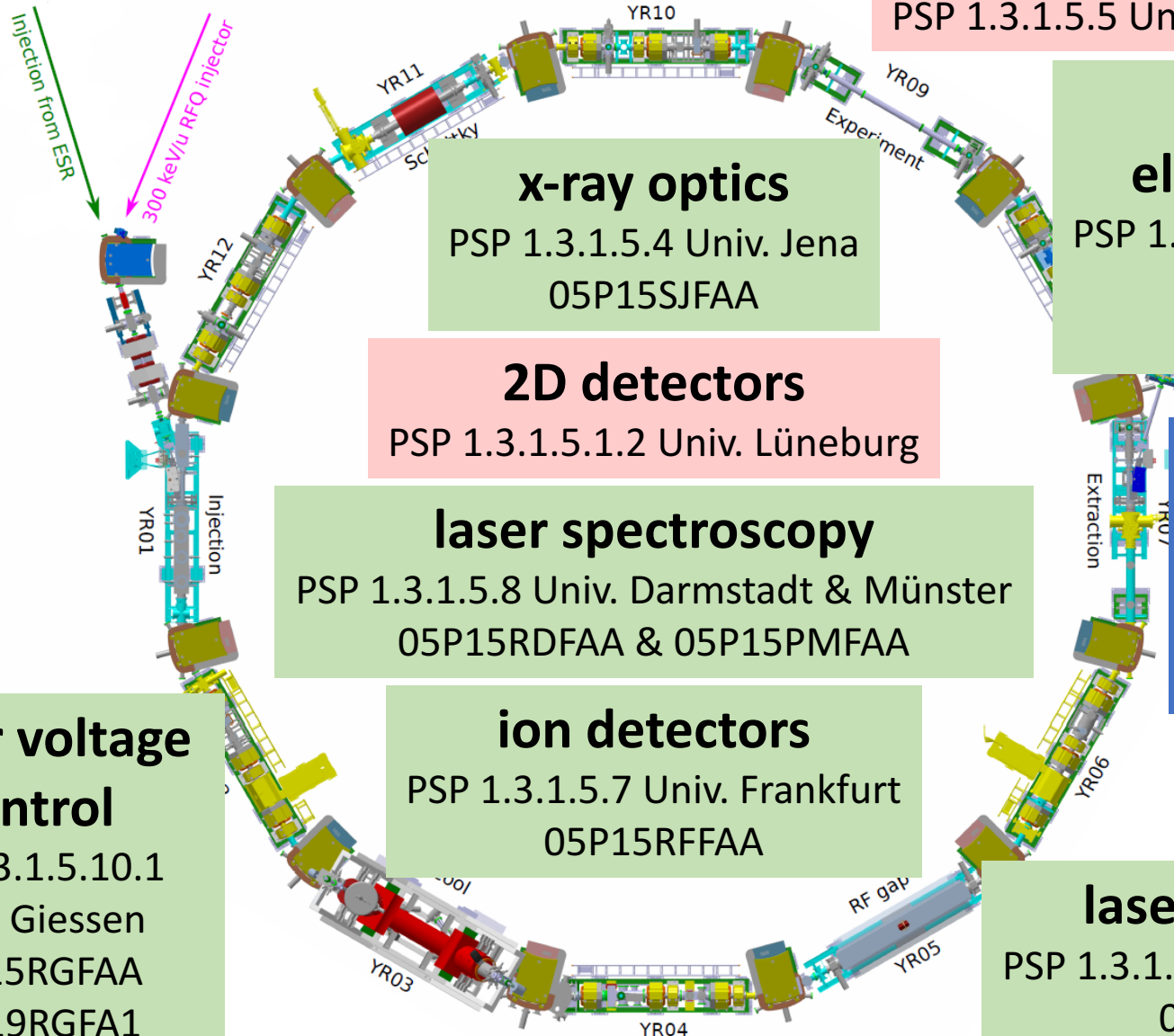
status:
fully funded
partly funded
not yet funded

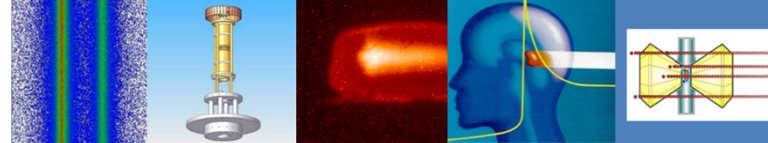
**cooler voltage
control**

PSP 1.3.1.5.10.1
Univ. Giessen
05P15RGFAA
05P19RGFA1

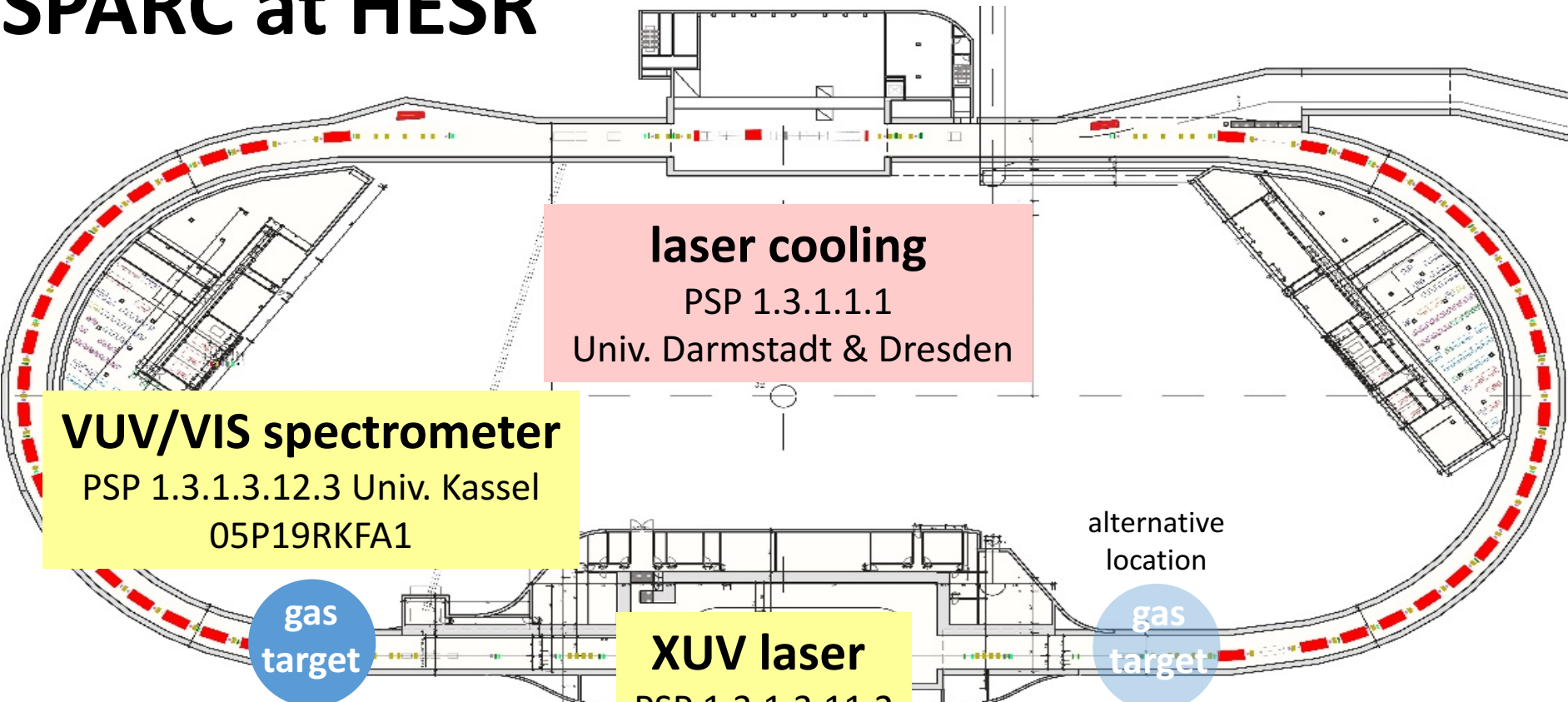
laser view ports

PSP 1.3.1.5.10 Univ. Darmstadt
05P15RDFAA





SPARC at HESR



laser cooling
PSP 1.3.1.1.1
Univ. Darmstadt & Dresden

VUV/VIS spectrometer
PSP 1.3.1.3.12.3 Univ. Kassel
05P19RKFA1

gas target

XUV laser
PSP 1.3.1.3.11.2
Univ. Jena
05P15SJFAA
05P19SJFA1

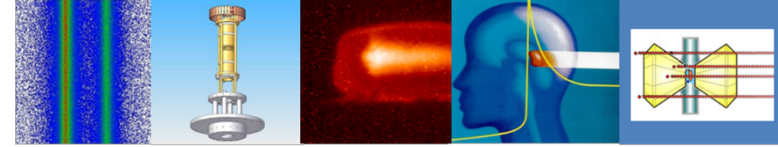
alternative location

gas target

micro-calorimeter
PSP 1.3.1.3.5.1
Univ. Heidelberg
05P15VHFAA

lepton spectrometer
PSP 1.3.1.3.10 Univ. Giessen

status:
fully funded
partly funded
not yet funded



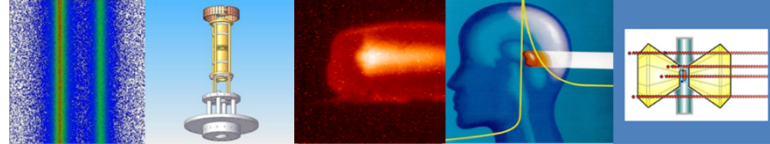
FAIR Core-Invest HED@FAIR

(after 8th RRB in Nov. 2018)

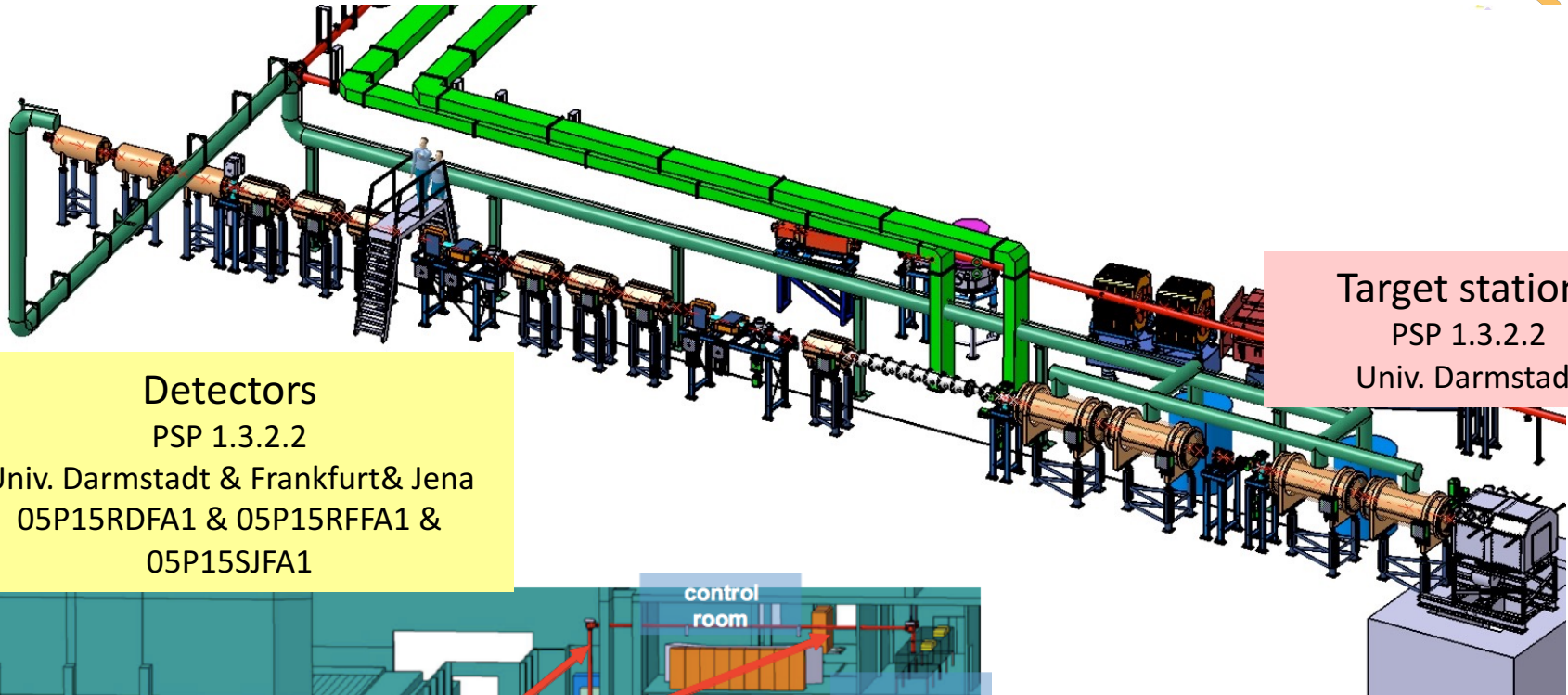
PSP-Code	Component	Core Invest (k€, PB 2005)			University	Year of Completion
		Total (for Day 1)	2015-2018	2018-2021		
1.3.2.2.1	Target Chamber for Day-1	440		184	Darmstadt	2024
				88	Frankfurt	
				57	Jena	
	Additional Funding from GSI (secured)	200				
1.3.2.3.1	Detectors	420	52		Darmstadt	2024
			56		Frankfurt	
			69		Jena	
1.3.2.4.1	Diagnostic Laser	440	130		Darmstadt	2024
				51	Jena	
	Additional Funding from GSI (secured)	160				
Sums	foreseen by BMBF: 1300	1300	307	380		

HED@FAIR

APPA

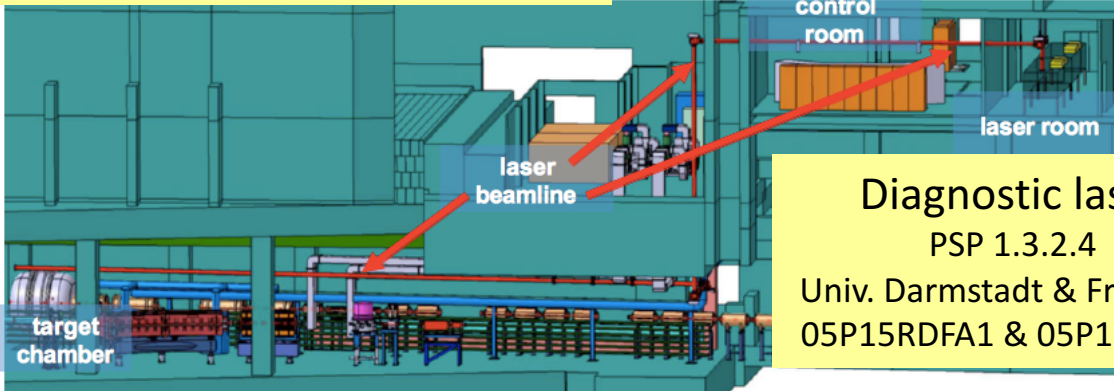


in the APPA cave



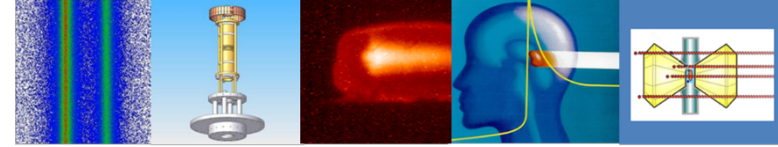
Detectors
PSP 1.3.2.2
Univ. Darmstadt & Frankfurt & Jena
05P15RDFA1 & 05P15RFFA1 &
05P15SJFA1

Target stations
PSP 1.3.2.2
Univ. Darmstadt



Diagnostic laser
PSP 1.3.2.4
Univ. Darmstadt & Frankfurt
05P15RDFA1 & 05P15RFFA1

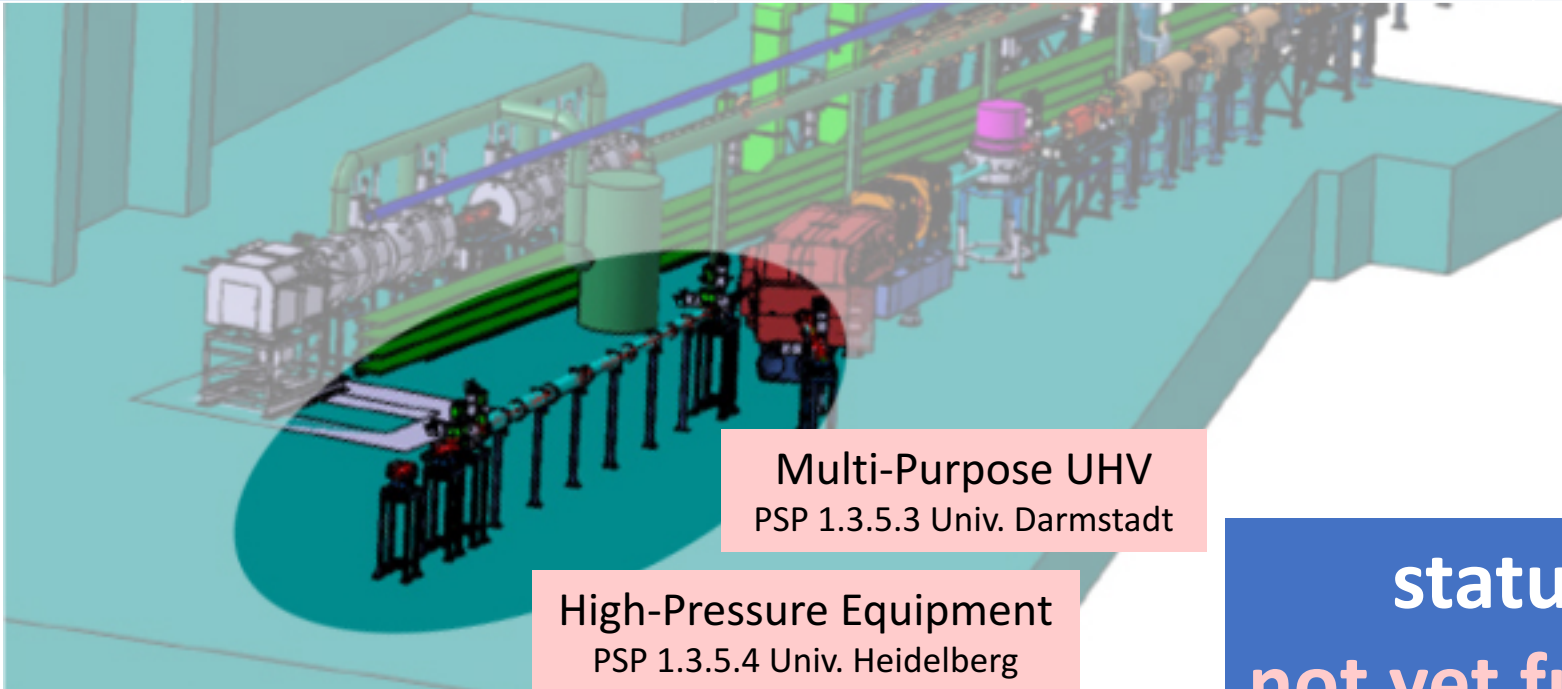
Status:
partly funded
not yet funded



FAIR Core-Invest BIOMAT

(after 8th RRB in Nov. 2018)

PSP-Code	Component	Core Invest (k€, PB 2005)			University	Year of Completion
		Total (for Day 1)	2016-2019	2019-2022 (asked for)		
1.3.5.3	Multi-Purpose UHV Chamber	198			Darmstadt	2025
1.3.5.4	High-Pressure Equipment	222			Heidelberg, Frankfurt	2025
Sums	foreseen by BMBF: 420	420				

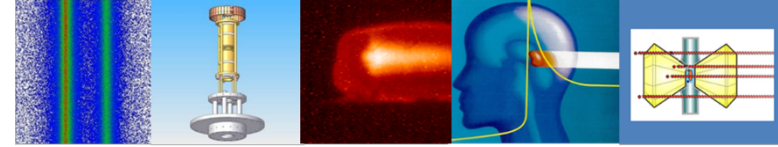


Multi-Purpose UHV
PSP 1.3.5.3 Univ. Darmstadt

High-Pressure Equipment
PSP 1.3.5.4 Univ. Heidelberg

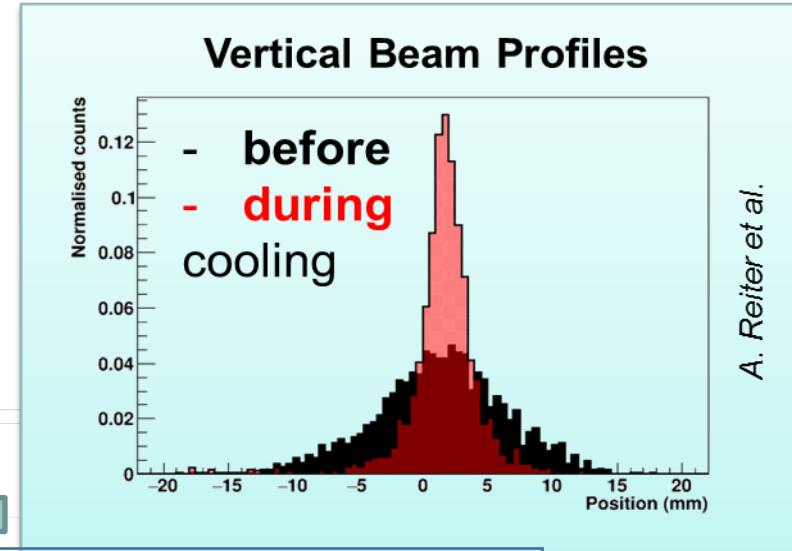
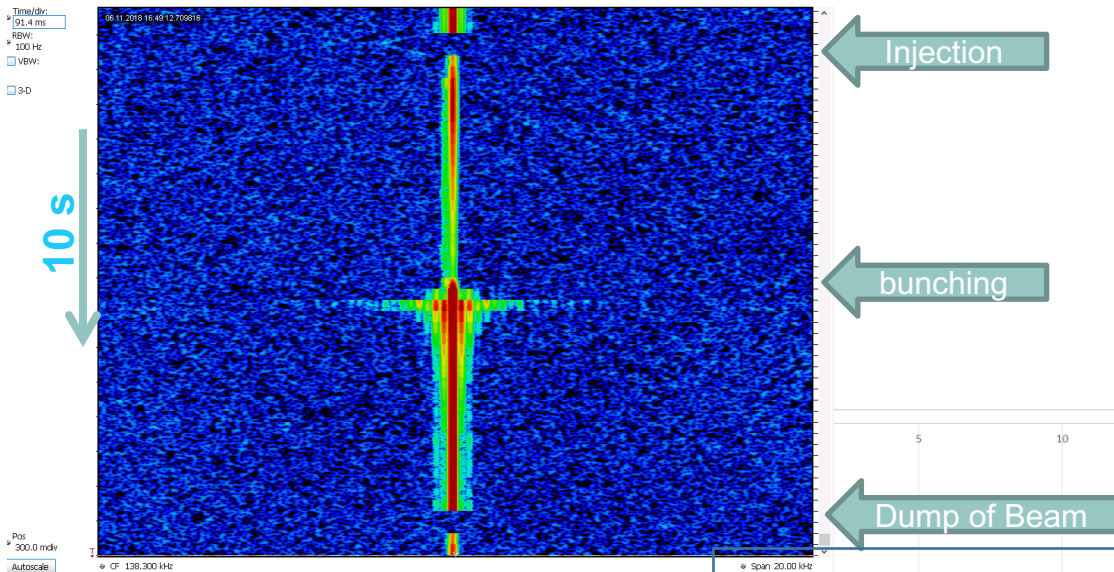
status:
not yet funded

CRYRING at ESR: APPA

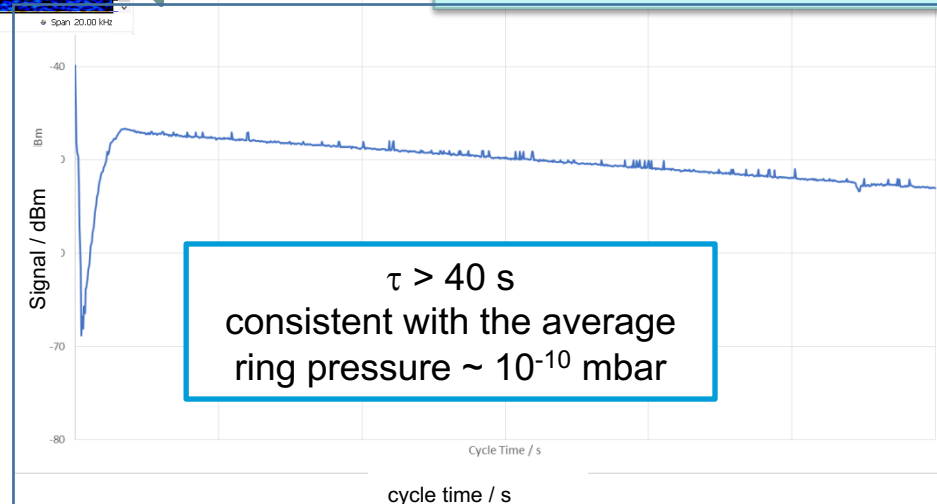


Commissioning status

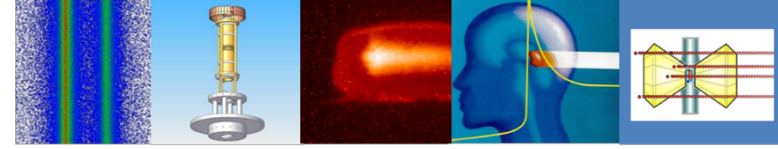
Cooling and Storage of D^+ at 300 keV/u



- ✓ Beams from the local ion source: H_2^+ , D^+ , Mg^+
- ✓ acceleration up to the maximum rigidity
- ✓ achieved beam life times: few tens of seconds
- ✓ beam cooling



CRYRING at ESR: APPA



Experiment infrastructure

spara
Stored Particles Proton Physics Research Collaboration

Two examples for many more activities at GSI and at the Universities

Installation of the UHV-compatible actuators for the particle detectors

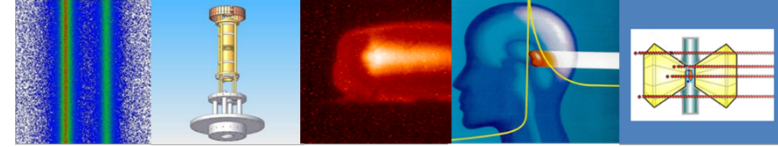


- ✓ commissioned in August 2018 together with two detector prototypes which were tested with beam

High precision Voltage Divider for the E-cooler: installed and commissioned with beam

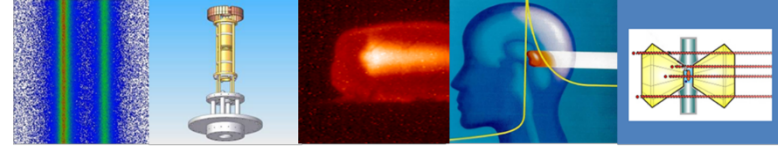


- ✓ successfully tested with beam in November 2018



Beamtimes 2019/2020 recommended by G-PAC

	Proposal Title	Spokesperson, Affiliation	Accelerator	Mark / Granted Beamtime (shifts)
E129	<i>Photoionization of C⁺ ions in CRYRING</i>	Jan Rothhardt, U Jena	CRYRING	A / 30
E131	<i>Precision spectroscopy of Be-like ions at the CRYRING@ESR electron cooler</i>	Stefan Schippers, U Gießen	CRYRING	A / 27
E138	<i>The Ground-State Lamb Shift in the Heaviest Hydrogen-like Ion (U⁹¹⁺): High Resolution X-ray Spectroscopy at the CRYRING electron cooler</i>	Günter Weber, U Jena	CRYRING	A / 39
E121	<i>Measurement of the bound-state beta decay of bare ²⁰⁵Tl ions</i>	Yuri Litvinov, U Heidelberg	ESR	A / 21
E127	<i>Measurements of proton-induced reaction rates on radioactive isotopes for the astrophysical p process</i>	René Reifarth U Frankfurt	ESR	A / 15
E128	<i>Dielectronic recombination assisted laser spectroscopy: A new tool to investigate the hyperfine puzzle in Bi^{80+,82+}</i>	Wilfried Nörtershäuser TU Darmstadt	ESR	A / 10
E130	<i>Cooling and precision spectroscopy of ²⁰⁹Bi⁸²⁺ ion ensembles with the ARTEMIS and SPECTRAP experiments at the HITRAP facility</i>	Wolfgang Quint, GSI	ESR HITRAP	A / 10
E132	<i>Electron emission following 1s adiabatic ionization and quasi-resonant 1s-1s Charge transfer in symmetric heavy-ion atom collisions</i>	Siegbert Hagmann, GSI	ESR	A / 48
E137	<i>Energy determination of the 1s² 2s_{1/2} → 1s² 2p_{3/2} radiative transition in Li-like uranium ions via resonant coherent excitation in crystals</i>	Angela Bräuning-Demian, GSI	ESR	A / 18
E125	<i>High-resolution differential measurements between two- and three-electron uranium ions for high precision tests of strong-field QED</i>	Martino Trassinelli, U Paris	ESR	A- / 48
E135	<i>Laser spectroscopy of the (1s² 2s2p) ³P₀ - ³P₁ level splitting in Be-like krypton</i>	Danyal Winters, GSI	ESR	A- / 21



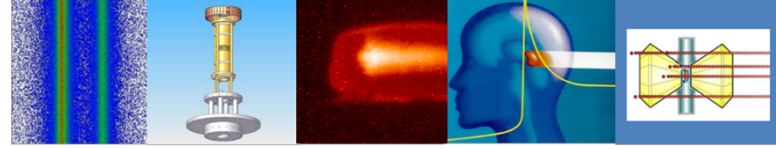
Summary

The **APPA** collaborations have devised competitive and timely research programs involving almost all facilities of the **FAIR MSV**.

APPA is well prepared to potentially make important scientific discoveries already in **FAIR phase 0**.

Thanks to the **BMBF “Verbundforschung”** funding, the **German university groups** with their **unique expertise** have leading positions in a large fraction of the research activities at FAIR.

APPA



4th APPA R&D Meeting

17./18.01.2019

at GSI

<https://indico.gsi.de/event/7990>

**Looking forward to
seeing you there!**