

Large-scale Facilities of the Helmholtz Association

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Scientific Landscape of the Research Field Matter

Deutsches Elektronen-
Synchrotron DESY
Hamburg

Helmholtz-Zentrum Berlin für
Materialien und Energie (HZB)
Berlin

Helmholtz Center Dresden-
Rossendorf (HZDR)
Dresden

GSI Helmholtz Center for Heavy
Ion Research
Darmstadt

Forschungszentrum Jülich (FZJ)
Jülich

Helmholtz-Zentrum Hereon
Geesthacht

Karlsruhe Institute of Technology
(KIT)
Karlsruhe



Research areas (organized in Topics):

- **High Energy and Astroparticle Physics and Hadron & Nuclear Physics**
- **ATMO, Material Research, Life Science** (based on LSF for research with photons, neutrons, ions and high magnetic fields)
- **R&D on Accelerators, Detectors and Data Technologies**

Overall LSF Strategy:

- Assure a world-leading position in the **operation of its large-scale facilities** for **national and international users**
- **Strengthen cooperation** in its international projects
- **Develop advanced technology infrastructures** in key competence areas

Examples of Existing Large-scale Facilities within the Research Programs and Topics of MATTER

Particle Physics

- **TIER-Computing** – TIER1- and 2-Centers as GridKa, IDAF, GreenITCube for the LHC-Computing at CERN
- **Detector-Upgrades for LHC-HL** (ATLAS, CMS, ALICE)
- ...

Astroparticle Physics

- **KATRIN** – the Karlsruhe Tritium Neutrino Experiment
- **CTA** – Cherenkov Telescope Array
- **Pierre Auger Observatory**, ...

Research Infrastructures for R&D

- **ATHENA** – the Accelerator Technology Helmholtz Infrastructure, ...
- **DDL** – Distributed Detector Laboratory...

Hadron & Nuclear Physics

- **SIS-18** – Heavy Ion Synchrotron, **CRYRING @ ESR** – Heavy Ion Storage Ring, **UNILAC** – Universal Linear Accelerator, ...
- ⇔ **pre-acc. & facilities for FAIR** – Facility for Antiproton and Ion Research at GSI

Material Research with Photons, Neutrons, Ions & High Magnetic Fields

- **PETRA III** – Synchrotron Radiation Source for X-rays
- **BESSY II** – Synchrotron Radiation Source for soft X-rays
- **ELBE** – the Electron Linear accelerator for beams with high Brilliance and low Emittance
- **FLASH** – The Free-electron Laser at Hamburg (⇔ FLASH2020+)
- **European XFEL** – the Free-electron laser at DESY
- **GEMS & JCNS** – Synchr. Beamlines at PETRA III and Neutron Beamlines at the research reactor **FRM II** etc. (ILL, ESS, (HBS), ...)
- **IBC** – The Ion Beam Center for Materials Research & Characterization
- **HLD** – Dresden High Magnetic Field Laboratory, ...

Examples of Existing Large-scale Facilities

The largest international Facilities of the Helmholtz Association



The DESY-Linac of the European XEL

The European XFEL – *in operation since 2017*

- Operated by the European XFEL GmbH
- DESY is operating the accelerator (17.5 GeV electrons)
- The company was founded on 28 September 2009
- Science: High Energy Density Science, Materials Imaging and Dynamics, Femtosecond X-ray Experiments, Single Particles, Biomolecules, Crystallography, Soft X-ray, Small Quantum Systems, Spectroscopy & Coherent Scattering
- HIBEF – Helmholtz International Beamline for Extreme Fields (coord. by HZDR)

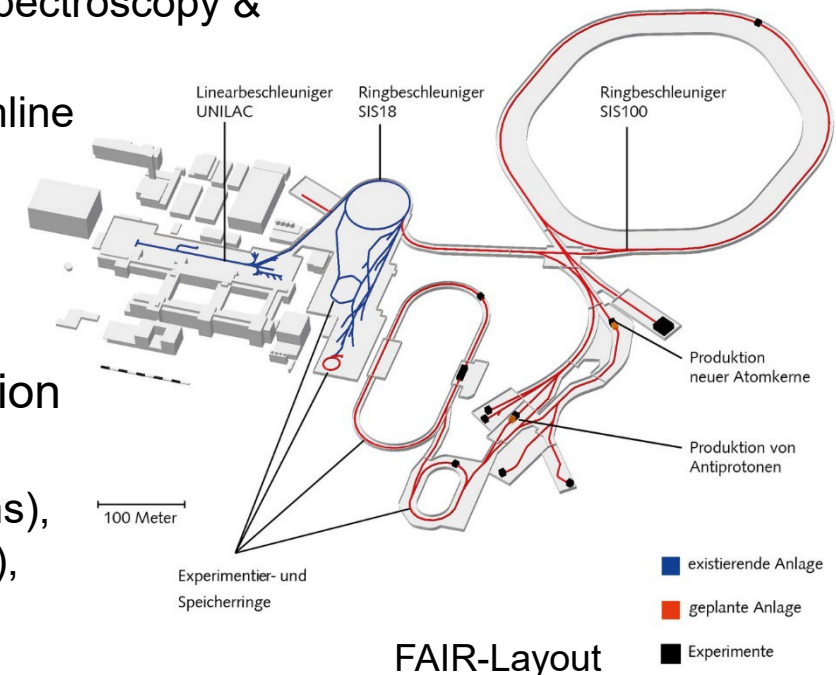


Laser in operation

The Facility for Antiproton and Ion Research FAIR

– *still in construction* (in coordination of GSI)

- The GSI pre-accelerators and temporarily in operation for R&D within the FAIR-Phase-0-Program
- Science: APPA (Atomic, Plasma Physics and Applications), NUSTAR (Nuclear Structure, Astrophysics and Reactions), CBM (Compressed Baryonic Matter Experiment), PANDA (Antiproton Annihilation at Darmstadt Experiment)



FAIR-Layout

Preparation within the fourth PoF-Period

Strategies of the Helmholtz Association

- The Program-oriented Funding (PoF): R&D activities of all research centers are affiliated to research programs strengthening competition and cooperation within the science organization
- R&D activities are following corresponding programs in PoF-Cycles (of 5 – 7 years)
- Each PoF-cycle starts with an evaluation of all programs by an international peer review with regard to: scientific excellence and strategic relevance
- Actually we are living in PoF IV
- And of course: Developing of advanced technologies for the user facilities is a key element of the HA ⇔ Strong connection to European and international strategies (ESFRI, ECFA, HEPAP, NuPECC, APPEC, OECD, etc.)

Roadmap of the Helmholtz Association

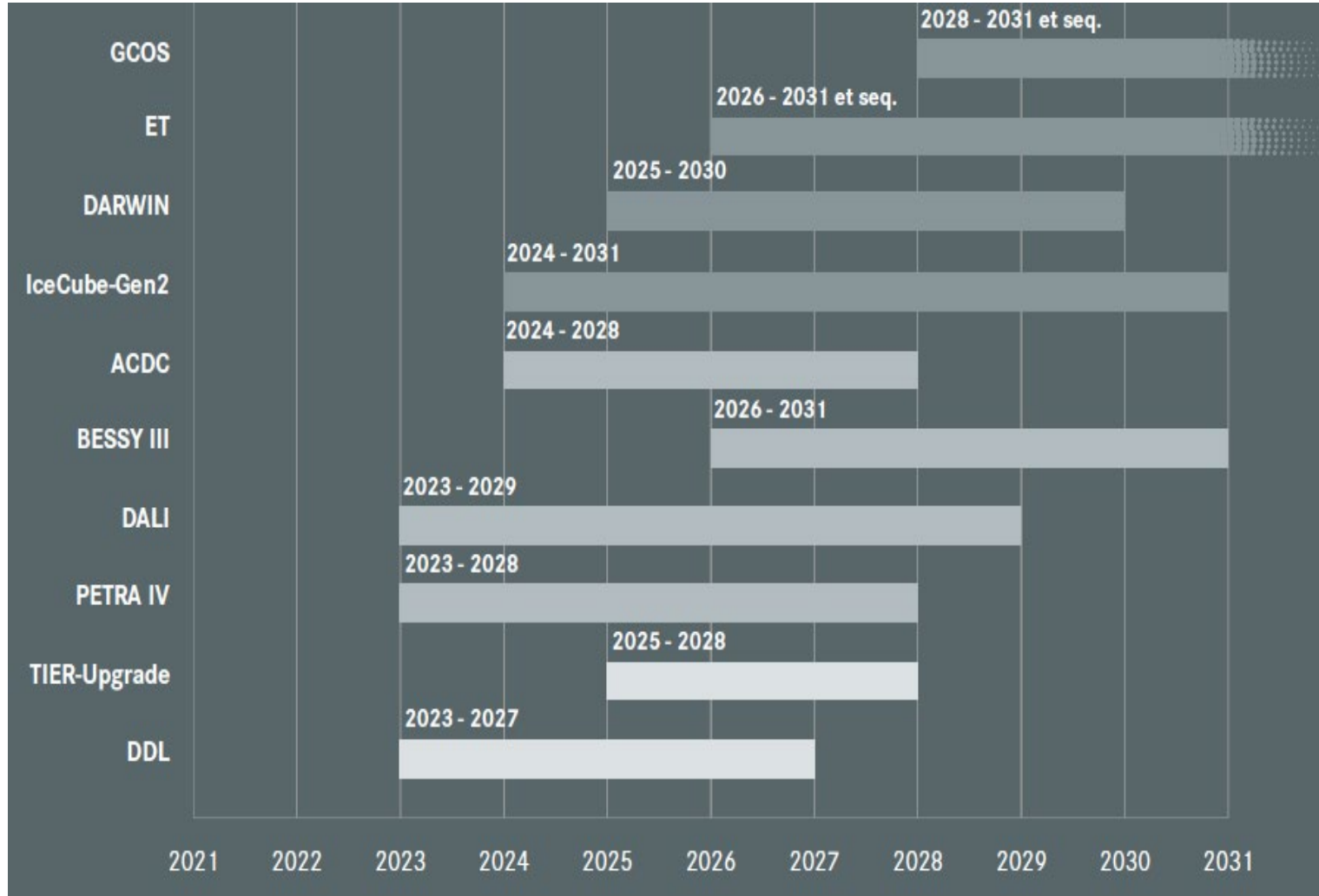
Strategies of the Research Fields of the Helmholtz Association

- In 2021 the Helmholtz Association presented the updated plan of its roadmap for major research infrastructures in its Research Fields
- This planning was preceded by an extensive portfolio and “foresight” process of the Research Fields
- In close cooperation with strategic partners and users



- This process is in a state of flux
- In dialog with scientific partners and users the plans are critically reviewed in the course of 2021ff.
- Helping the funding bodies to make balanced research policy decisions and set the course for the proposed research infrastructures pursued in the coming years.

Roadmap of the Helmholtz Association Within the Research Field MATTER



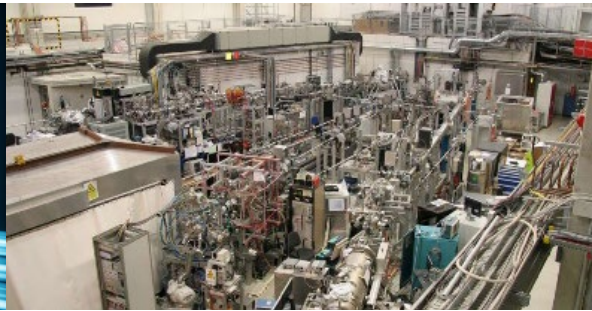
Plans in chronological order:

- **DDL** – *Distributed Detector Laboratory*
- **TIER-Upgrade** – *Computing for the HL-LHC*
- **PETRA IV** – *Upgrade of the synchr. radiation source PETRA III*
- **DALI** – *Dresden Advanced Light Infrastructure (Upgrade ELBE)*
- **BESSY III** – *Upgrade of the synchr. radiation source BESSY II*
- **ACDC** – *Accelerator-driven multipurpose ion beam complex*
- **ICECUBE-GEN2** – *Upgrades for the neutrino observatory*
- **DARWIN** – *Dark Matter Wimp Search with liquid Xenon*
- **ET** – *the Einstein Telescope*
- **GCOS** – *the Global Cosmic Ray Observatory*

Roadmap of the Helmholtz Association

Upgrades of the accelerator-based photon sources

Photon Science



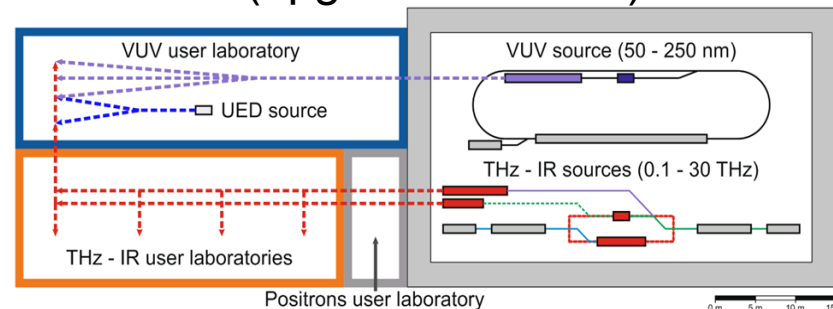
PETRA IV, BESSY III & DALI, together with **FLASH & European XFEL** ⇔ *National Photon Science Roadmap 2021*

Synchrotron radiation sources **PETRA IV** and **BESSY III**

- Upgrade of PETRA III (6 GeV) and BESSY II (~2 GeV)
- Novel electron lattice: HMBA
- Approaching the theoretical limits of coherence (DLSR)
⇔ Access to 3D Zoom X-ray technologies



DALI: High-field radiation source for IR & THz (upgrade of ELBE)



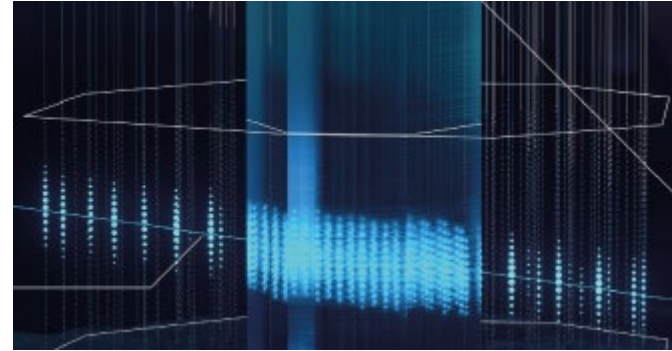
Roadmap of the Helmholtz Association

Further planned projects...

Particle Science



TIER-Upgrade – Grid-Computing for the HL-LHC (KIT, DESY, GSI)



ICECUBE-GEN2 – Upgrades for the neutrino observatory

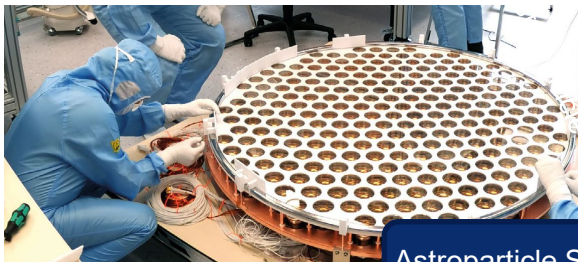
Astroparticle Science

GCOS – the Global Cosmic Ray Observatory



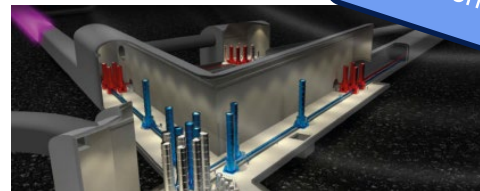
Astroparticle Science

DARWIN – Dark Matter Wimp Search with liquid Xenon



Astroparticle Science

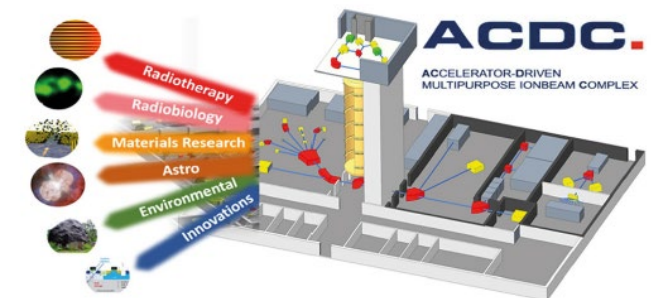
Gravitational Science



ET – the Einstein Telescope – gravitational waves - a new window of “Multimessenger”-Astronomy

ACDC – Accelerator-driven multipurpose ion beam complex

Ion Science



Cooperation with China

Some Examples of the common History



- History started with PETRA I – *Positron-Elektron-Tandem-Ring-Anlage* (1978 – 1986)
 - ↔ Worlds highest energy electron-positron colliding beam storage ring, located at DESY in Hamburg
 - ↔ 4 experiments: JADE, MARK-J, PLUTO and TASSO ↔ Discovery of the gluon by the TASSO collaboration in 1979 (one of the biggest successes of the DESY-HEP, Paul Söding, Bjørn Wiik, Günter Wolf and **Sau Lan Wu**, were awarded the High Energy and Particle Physics Prize from the European Physical Society (EPS) in 1995)
- History continued with HERA – *Hadron-Elektron-Ring-Anlage* (1992 – 2007)
 - ↔ Worlds unique hadron-lepton colliding beam storage ring...
- Presently there are several vital cooperation projects ongoing between Germany and China (and in particular Helmholtz Association and CAS)...
 - ↔ i. e. in the research area of particle and astroparticle physics BES III, JUNO, but also in areas of photon, neutron and ion sciences...

Summary and Outlook

HA and CAS share common research areas

(1) Institution's most important strategies:

↔ The programs of the Helmholtz Association based on PoF

(2) Connection to European and international strategies

↔ ESFRI, ECFA, HEPAP, NuPECC, APPEC, OECD, etc.

(3) Main directions for research infrastructures and research development

↔ Helmholtz-Roadmap for research infrastructures, which is in flux

(4) Use cases and success stories of German-Chinese cooperation

↔ PETRA I, HERA, BES III, JUNO, ...

(5) Main challenges

↔ Keep boundary conditions stable, funding questions, ...