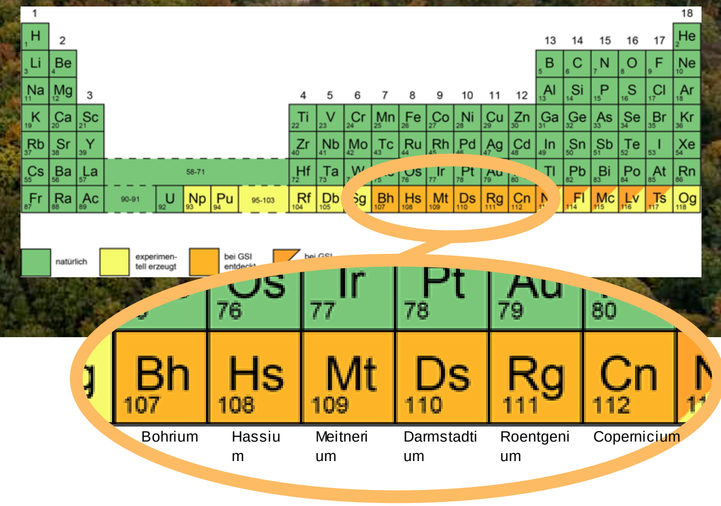
GSI/FAIR

European Cryogenic Days, GSI, March 28-29

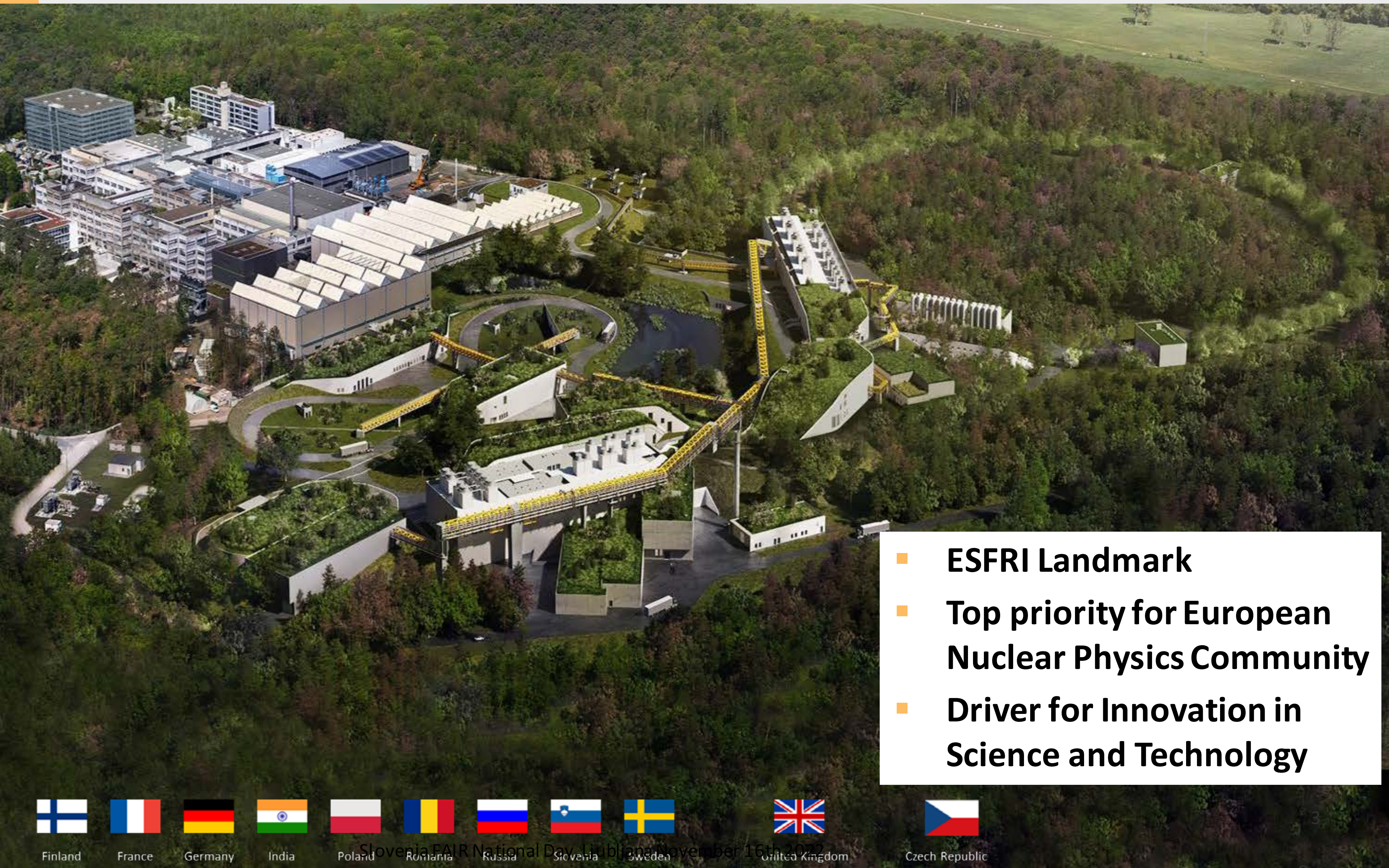
P.Giubellino

GSI GmbH – Helmholtzzentrum für Schwerionenforschung
FAIR GmbH – Facility for Antiproton and Ion Research

- Existing facility: GSI Darmstadt (Foundation: 1969)
- Shareholders: federal government (90%), Hesse (8%), Rhineland-Palatinate (1%), Thuringia (1%)
- Further locations in Mainz and Jena
- Future facility: FAIR (Foundation: 2010)
- Employees on location: approx.1580

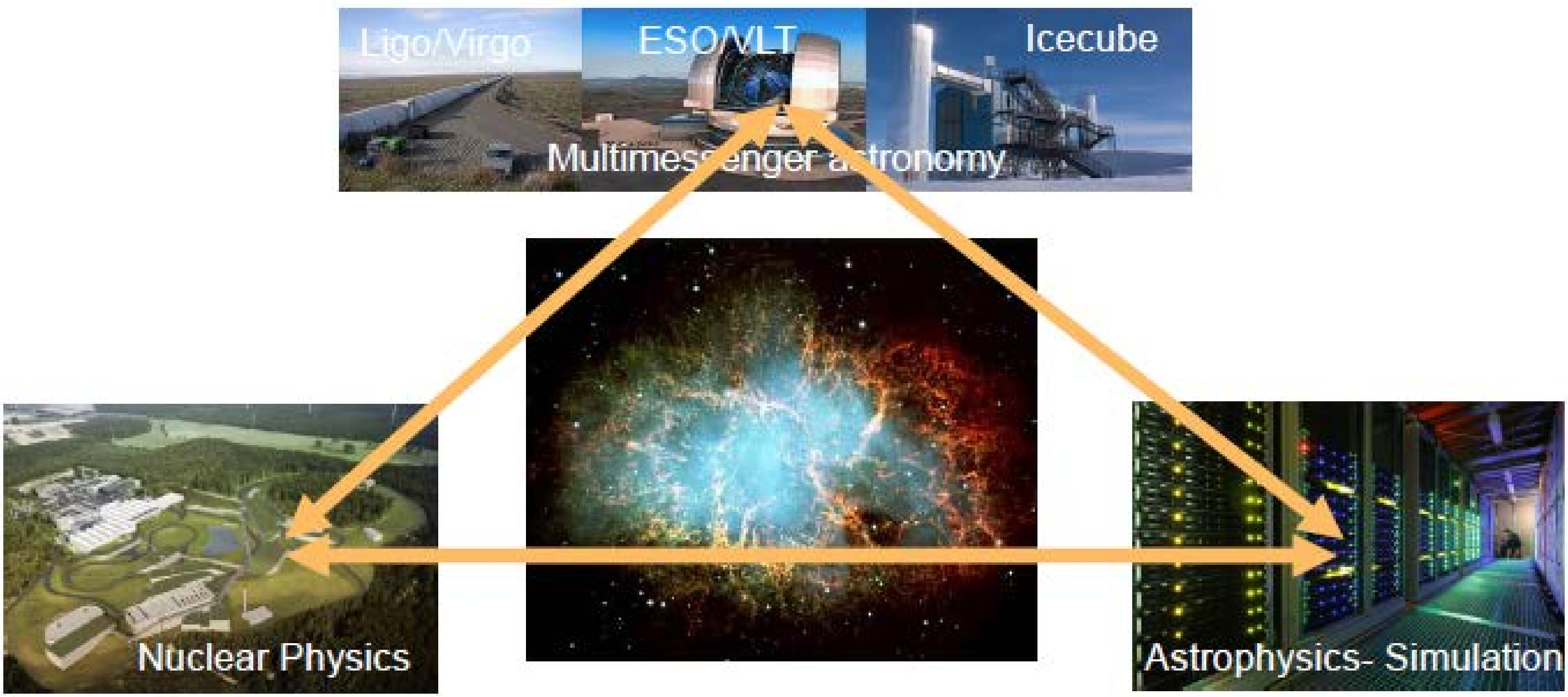


FAIR: Facility for Antiproton and Ion Research



- **ESFRI Landmark**
- **Top priority for European Nuclear Physics Community**
- **Driver for Innovation in Science and Technology**

An important moment for our understanding of the universe



Our objective:

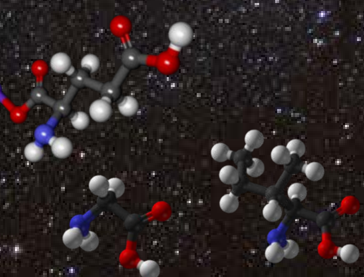
Creating extreme conditions existing in the universe with heavy ion accelerators

Foto: NASA, ESA, G. Dubner (IAFE, CONICET-University of Buenos Aires) et al.; A. Loll et al.; T. Temim et al.; F. Seward et al.; VLA/NRAO/AUI/NSF; Chandra/CXC; Spitzer/JPL-Caltech; XMM-Newton/ESA; and Hubble/STScI (oben), Penn State University (unten)

To find answers to fundamental questions about the Universe :
The Universe in the lab ...

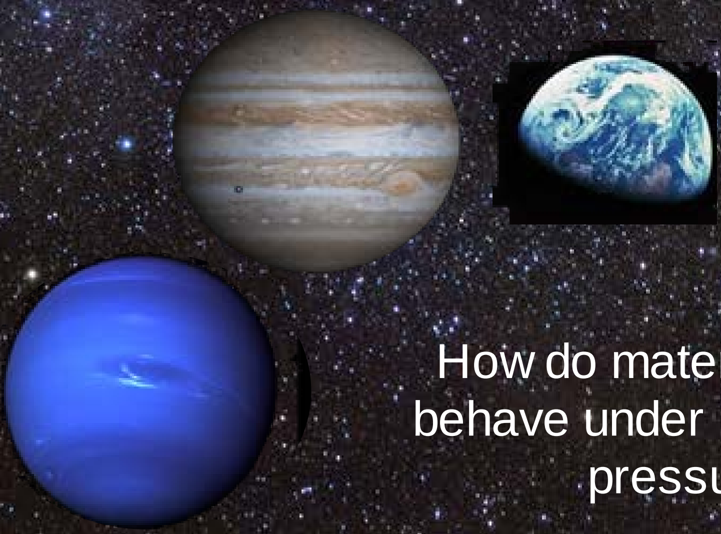
Where are heavy elements created?

What is in the interior of a neutron star?



What happens to human cells on the way to Mars?

How are complex molecules created?



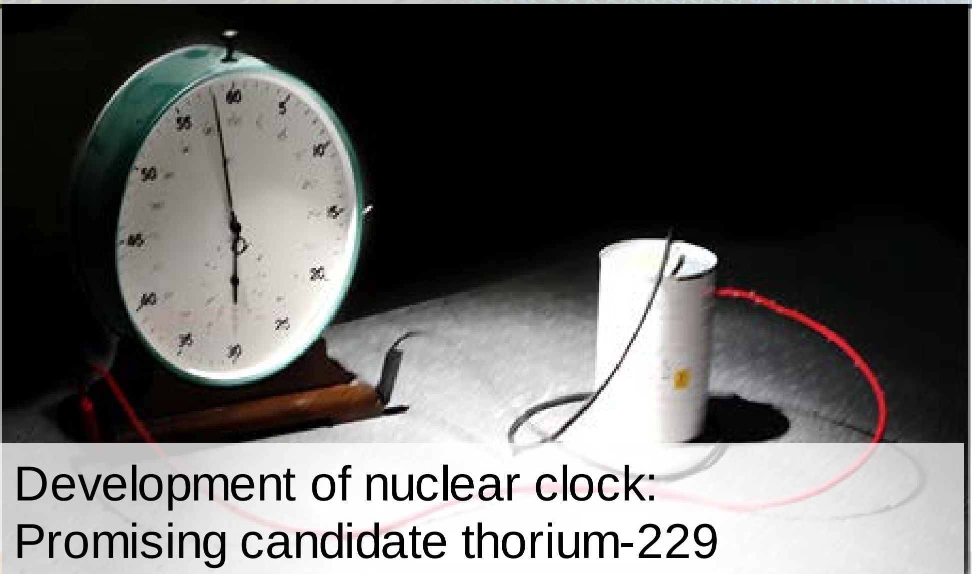
How do materials behave under high pressure?

Fotos: Uranus, Jupiter, Erde Quelle: http://de.wikipedia.org

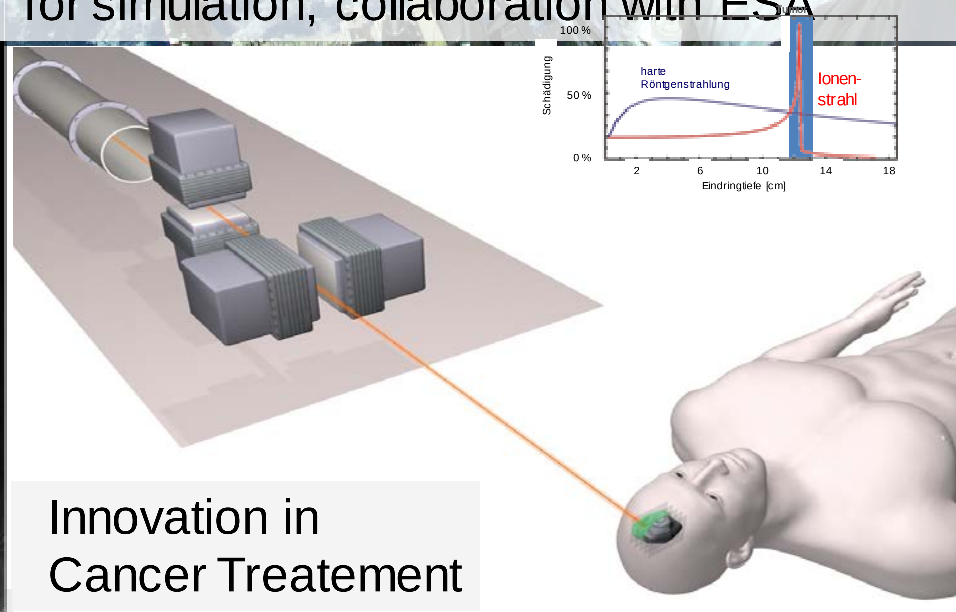
... with direct applications

High-performance and scientific computing, big data, green IT

Space radiation protection, unique facility for simulation, collaboration with ESA



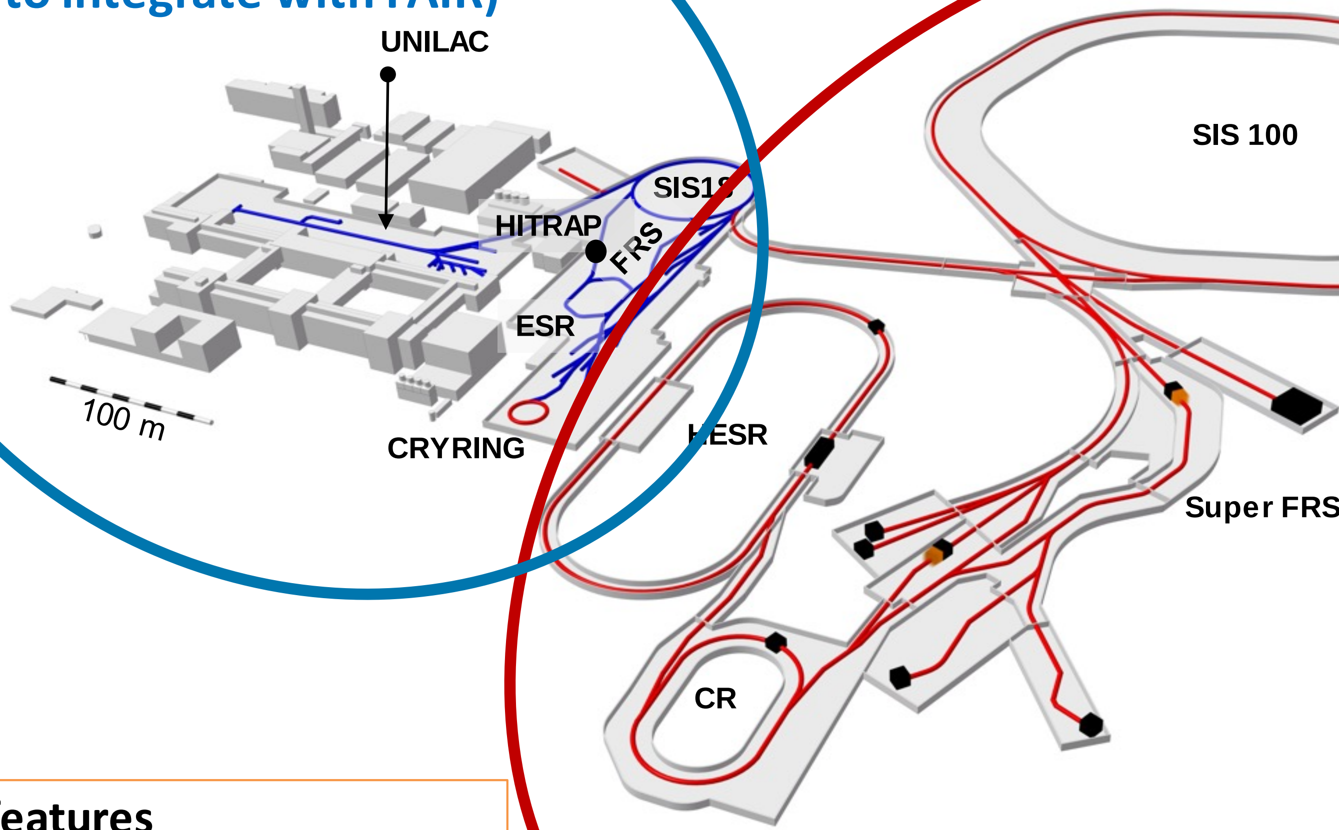
Development of nuclear clock: Promising candidate thorium-229



Innovation in Cancer Treatement

GSI and FAIR – The Facility

GSI, existing (upgraded to integrate with FAIR)



FAIR, under construction

ESR, CRYRING, & HITRAP are part of the FAIR MSV

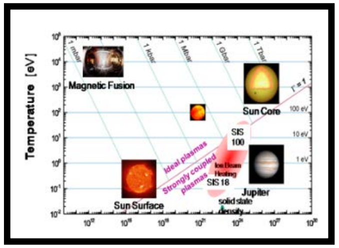
FAIR key features

- intensity for wide range of ions
- storage rings
- antiproton beams

Many superconducting magnets in FAIR!

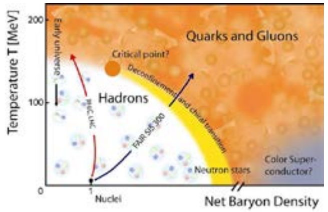
- For SIS100, superconductivity provides:
  - Huge pumping power for the beam pipe due to the activeley cooled vacuum chambers, the cryo absorption and the cryo ion catchers. This is essential for the operation with low charge state heavy ions.
  - Actually we are developing cryogenic inserts to make use of cryopumping also in sis18.
  - Furthermore, the higher current density in the coils of sc magnets enables more compact magnets.
- On the other side compact magnets lead to lower overall pulse power required for SIS100.
- Actually the pule power of SiS100 is lower than SIS18 although SIS100 is 5 times larger.
- For super FRS and storage rings it is at most energy dissipation/consumption in large aperture magnets. Which means finally operation cost.

The FAIR science: four pillars



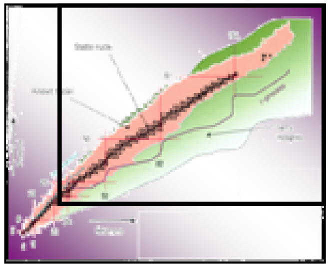
atomic physics, biophysics,
plasma physics, material research

APPA



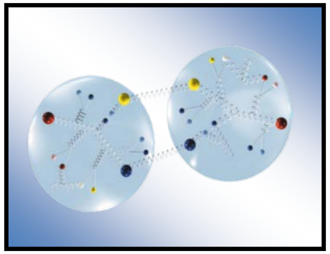
nuclear- and quark-matter

CBM



nuclear structure and
nuclear astrophysics

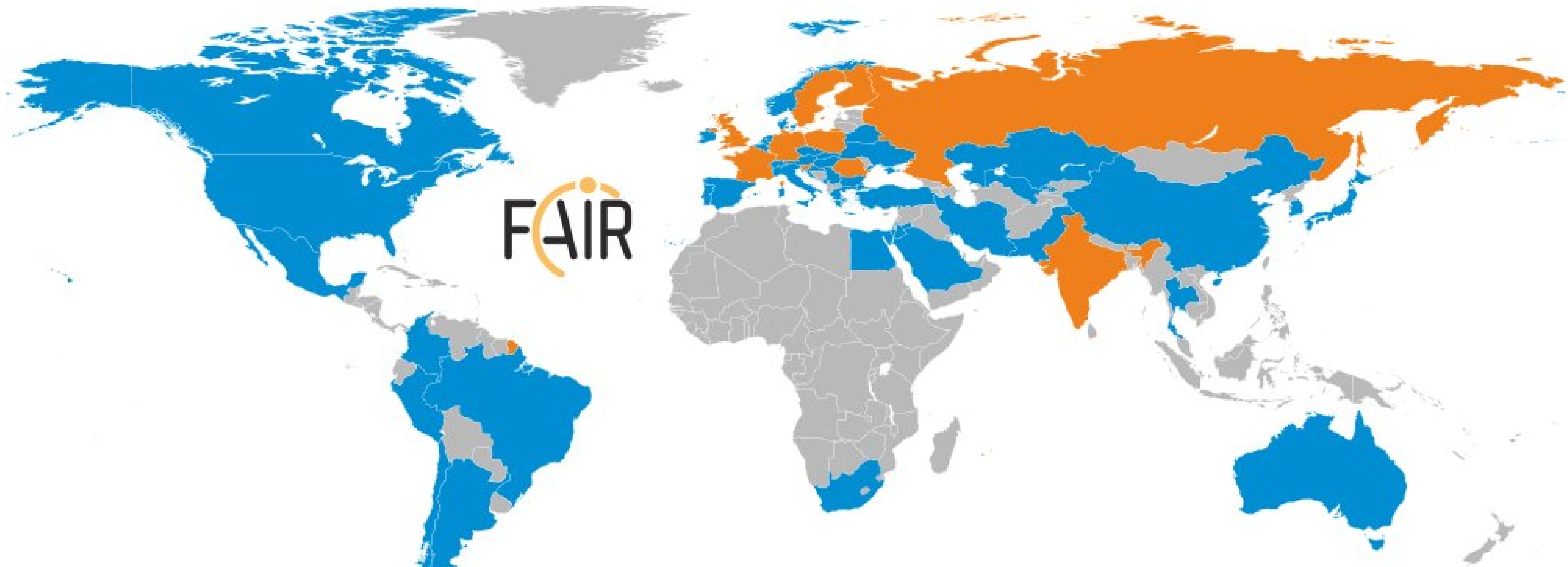
NuSTAR



hadron structure and dynamics

PANDA

FAIR: a World-wide project



- FAIR governed by international convention
  - 9 shareholders:
  - + 1 associated partner:
  - + 1 aspirant partner:
  - Over 3000 Scientists and Engineers from all over the world
- More than 200 institutions from 53 countries are involved with their scientists (orange + blue)

Civil Construction

- Civil Construction continues to make rapid progress

Movie of the construction site as of Nov 2022

https://edms.cern.ch/file/2796608/LATEST/FAIR*720p*.mp4

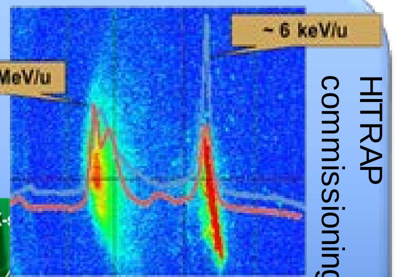
or via www.gsi.de

Accelerators: delivery of components continues steadily

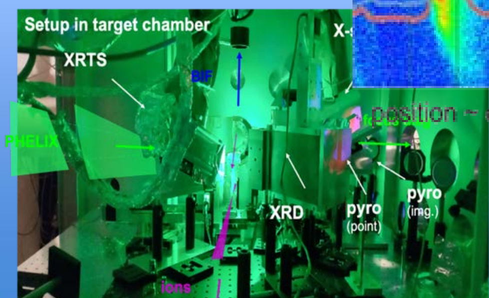
- Storage area: approx. 9.900 m²
- 4.195 objects (Components, assemblies, boxes, etc.)
- 50% of SIS100 components stored
- 90% of HESR components stored

Experiment Construction Highlights

APPA

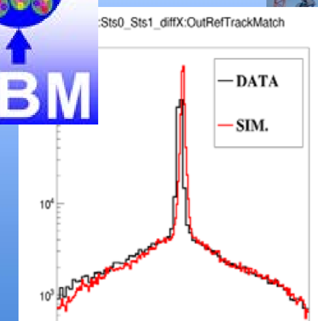


HITRAP commissioning



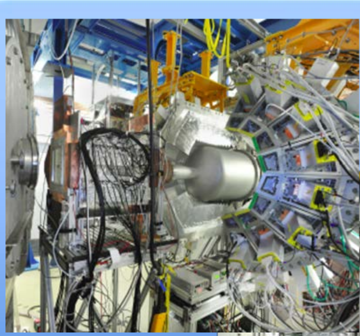
HED@FAIR diagnostics

CBM



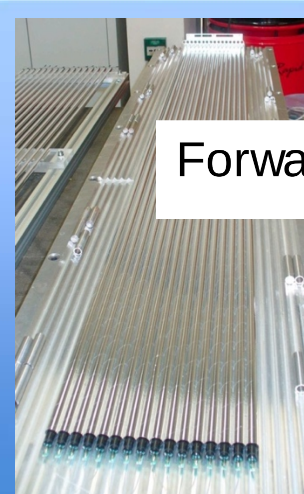
mCBM performance

NUSTAR

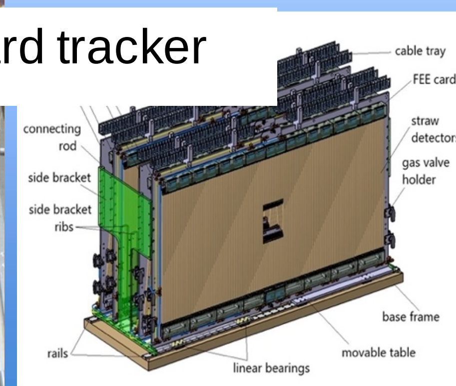


R3B: LH2 target, CALIFA, GLAD

PANDA



Forward tracker

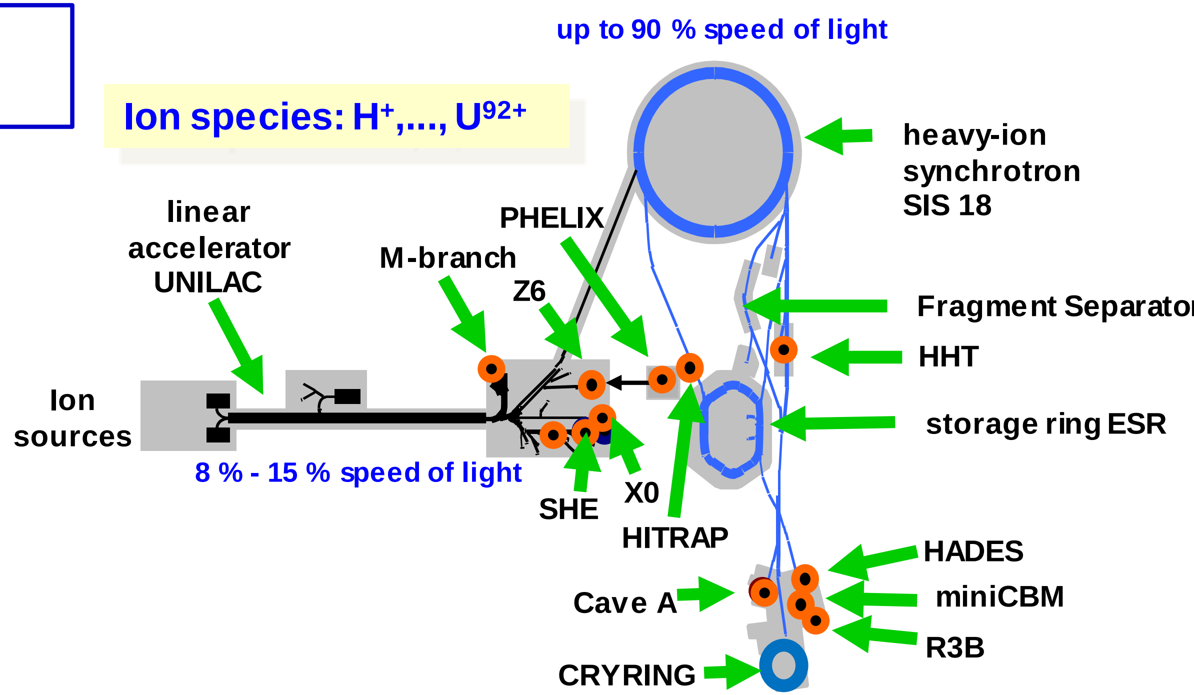


FAIR research plan

- Up to 2025 we continue with FAIR Phase-0, from 2026 onwards we enter the mixed-mode with the commissioning of the new beamlines. Annual beamtime for science will increase progressively, to reach full year operation from 2028 onwards.
- „First Science+“ includes all the facilities on the GSI campus plus the Super-FRS with the High Energy Branch, SIS100 and the CBM cave.
- Some experiments will start already in 2027 at the Super-FRS using SIS18 beams („Early Science“)
  - The amount of beam time to the new cave during Early Science will depend on the physics case, which should now be updated and detailed.
- We will try to keep a broad research program on campus, which will also serve the long-term goals of FAIR.

Early science program FAIR Phase-0

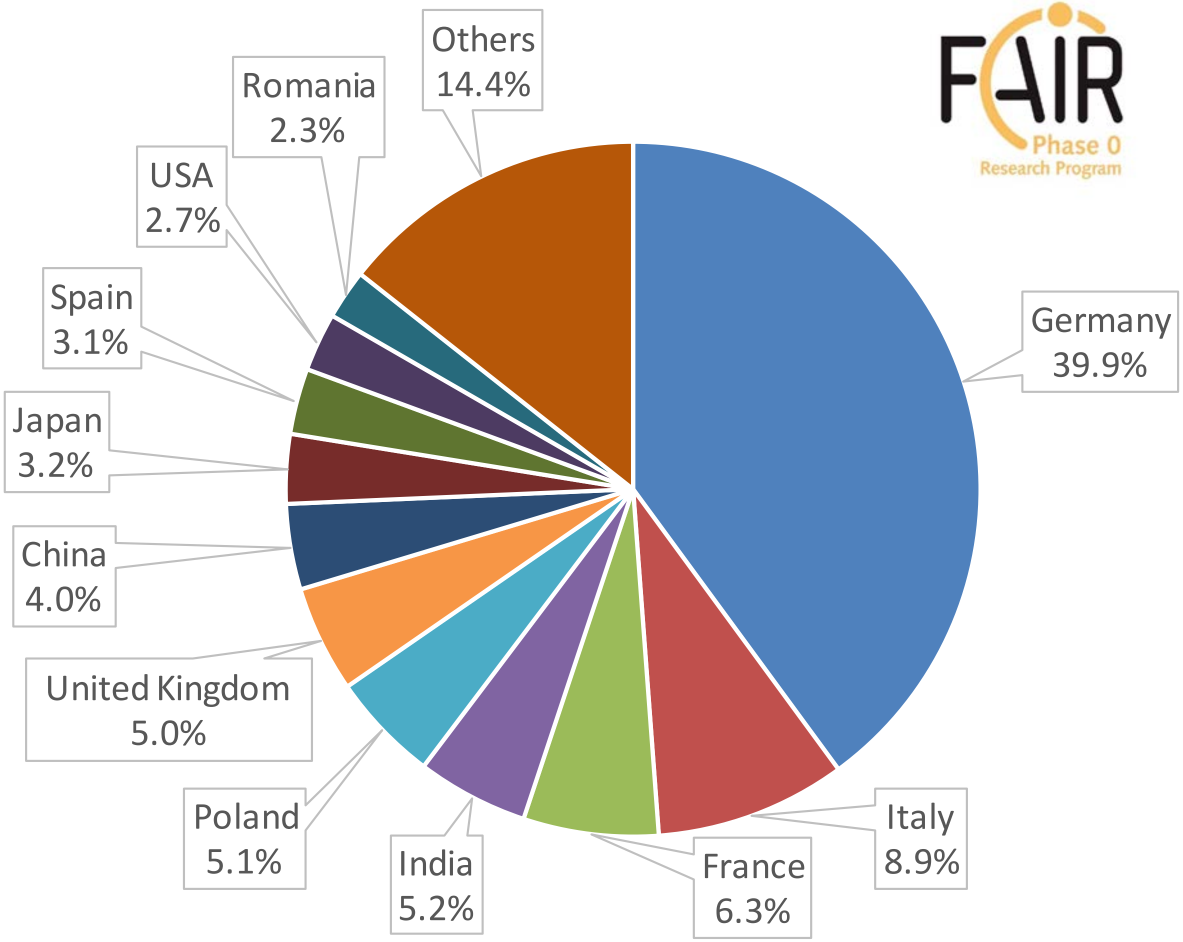
- Started in 2019, annual runs of ~110 days until FAIR operation



- Science while commissioning FAIR
  - 2021 and 2022 runs completed as planned
  - The program will continue in the coming years

Beamtime Proposals 2022 for the next two periods

- 124 proposals submitted (to all 4 PACs: G-PAC, Mat-PAC, Bio-PAC and PPAC)
- 1729 participants of proposals
- From institutes in 45 countries (15% internal users)
- Scientists from Slovenia are involved in 18 submitted proposals



Health of astronauts

- Experiments demonstrate, that artificial hibernation could protect astronauts from cosmic radiation
- Large international response in the media, e. g. Forbes (USA)

W. Tignanelli et al., Radiotherapy&Oncology, Vol.175, P185-190 (2022)

FLASH cancer therapy

- Short, highly intense ion pulses for effective and gentle tumor therapy
- Title story of the most important oncology journal

M.-C. Vozenin, Nature Reviews Clinical Oncology 19, 791-803 (2022)

Research highlights of GSI/FAIR in 2022

Pushing the boundaries of the periodic table

- Determination of the properties of the heaviest chemically studied element so far, element 114, by experimenting with only eight atoms existing for fractions of a second

A.Yajushev et al., Front. Chem., (2022)

Origin of the chemical elements

- Theoretical work regarding gravitational waves and the synthesis of elements in neutron star mergers
- Recently honored with Leibniz Award, ERC Advanced Grant, ERC Synergy Grant

K. Langanke et al., Frontiers in Physics (2021), DOI 10.1088/1361-6633/abf207
O.Just et al., Monthly Notices of the Royal Astronomical Society, Vol. 509 (2022), P1377–1412
A.Bauswein et al., Phys. Rev. Lett. 125, 141103


Thank you!!
Photo: C. Betz