Detector Laboratory at GSI

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Outlook

- GSI and FAIR project
- Detector Laboratory DTL at GSI
- Different projects we are involved
- GETInvolved at GSI/FAIR

The universe in the lab ...

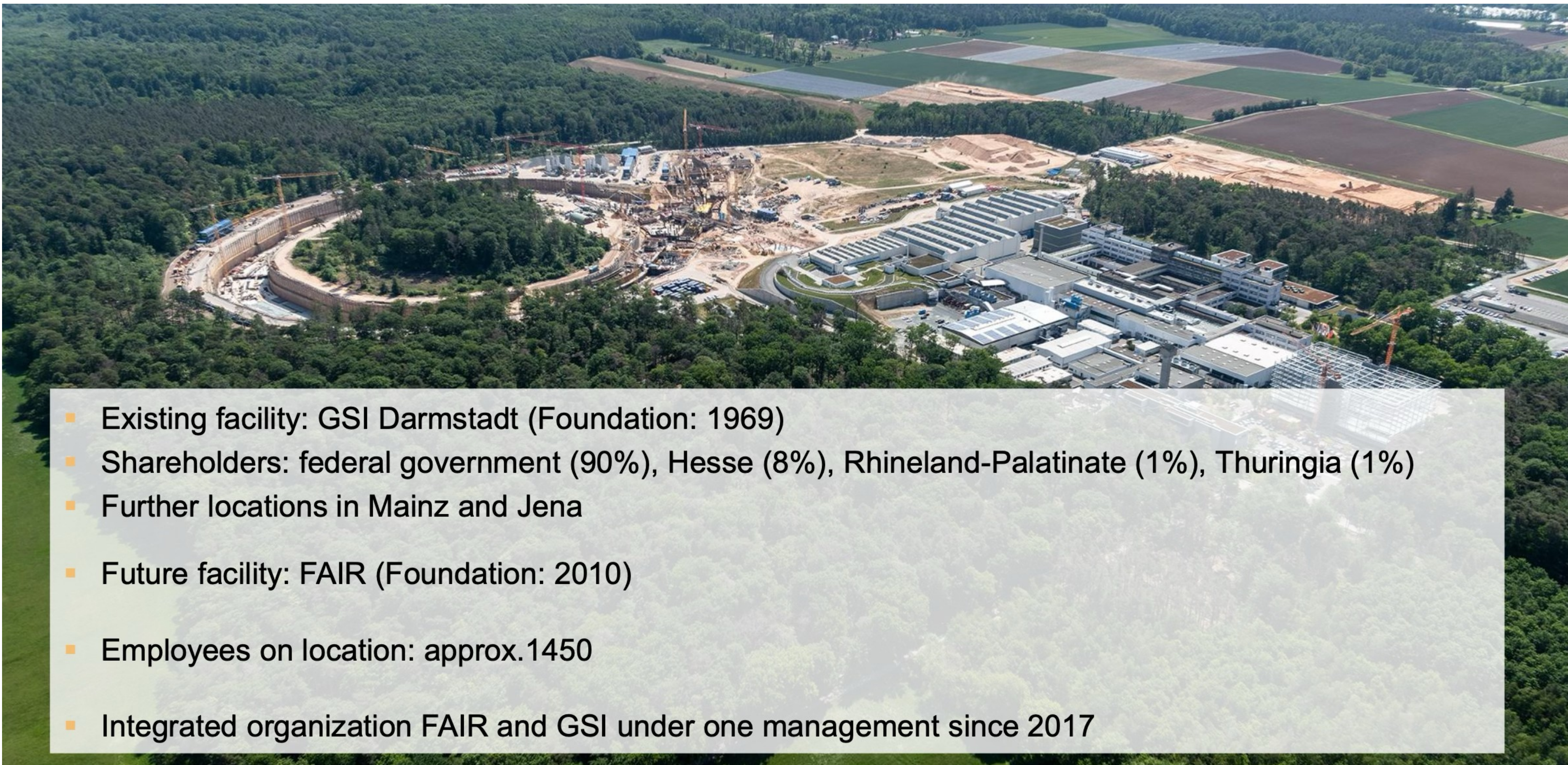
Synthesis of chemical elements in the cosmos

Building blocks of life: Production of carbon and oxygen in stars

Neutron star mergers: equation of state, strong force, neutron rich nuclei

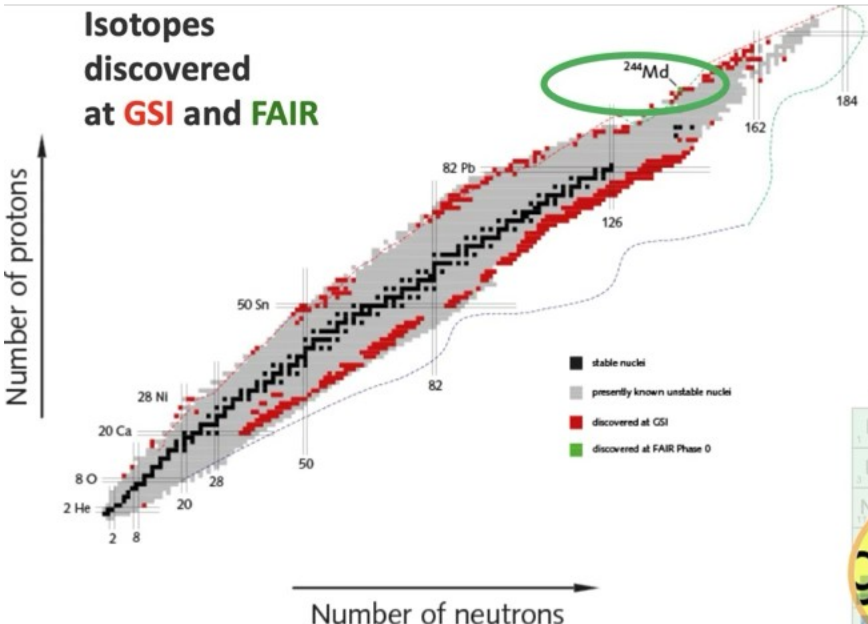
Matter in the interior of Earth and of large planets

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

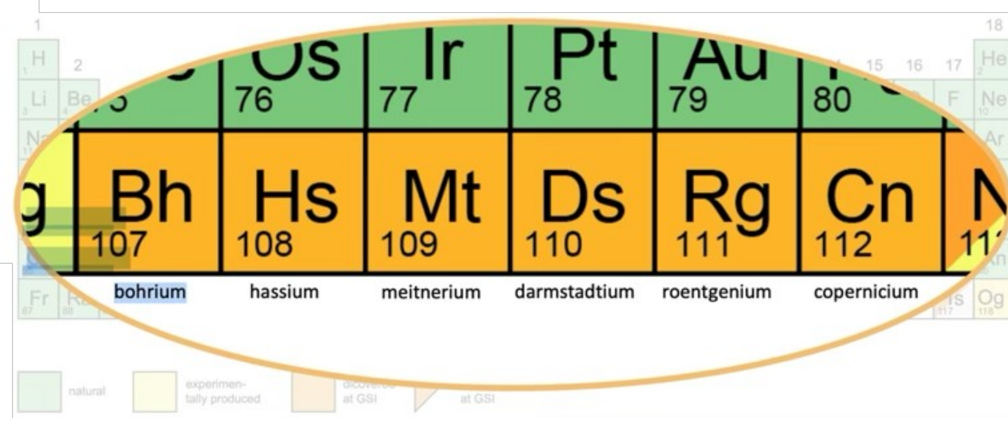


- Existing facility: GSI Darmstadt (Foundation: 1969)
- Shareholders: federal government (90%), Hesse (8%), Rhineland-Palatinate (1%), Thuringia (1%)
- Further locations in Mainz and Jena
- Future facility: FAIR (Foundation: 2010)
- Employees on location: approx.1450
- Integrated organization FAIR and GSI under one management since 2017

Production of new elements



- New chemical elements
- Hundreds of new isotopes
- New decay modes



GSI and FAIR

Research areas

- Nuclear physics: exploring the structure of matter and exotic nuclei.
- Plasma physics: creating and analyzing extreme states of matter.
- Biophysics and medicine: developing ion beam therapy for cancer treatment.
- Materials research: studying how materials behave under irradiation.

GSI and FAIR

Construction volumes

2 million m^3
of earth

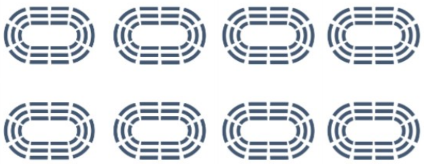
to be moved

As much as for 5,000 single-family homes

600,000 m^3
of concrete

to be used

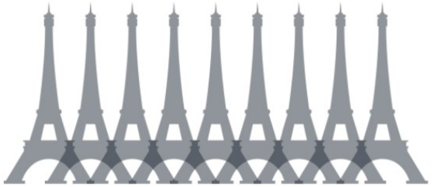
As much as eight Frankfurt soccer stadiums



65,000 tons
of steel

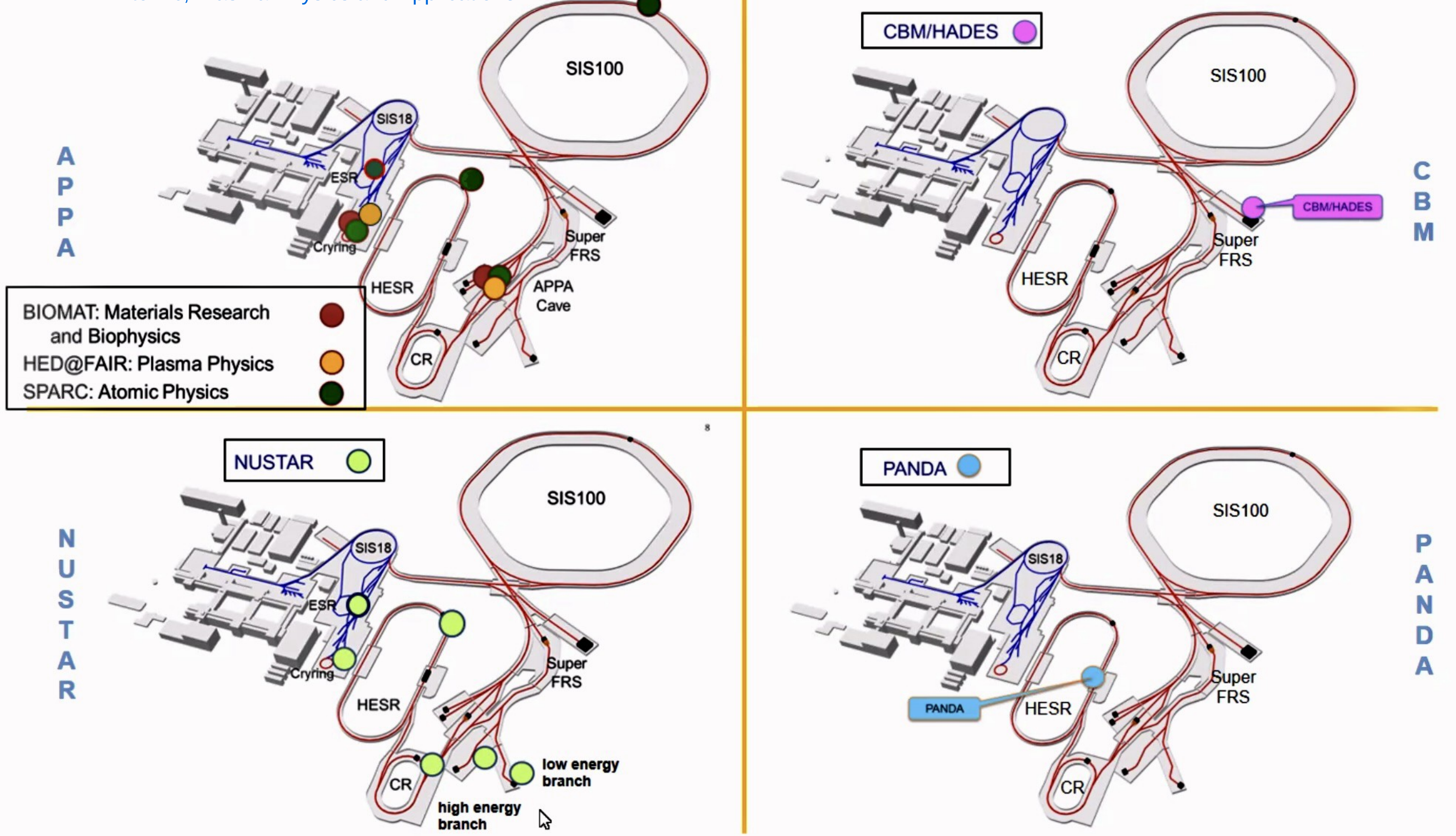
to be utilized

As much as nine Eiffel Towers



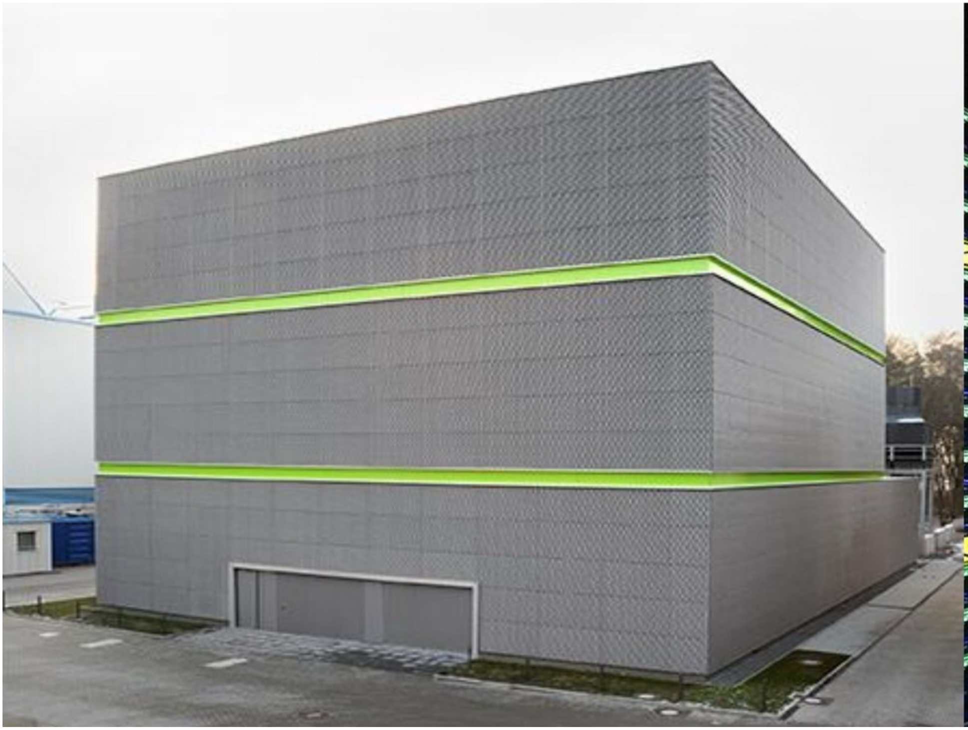
FAIR Experiment Locations

APPA - Atomic, Plasma Physics and Applications

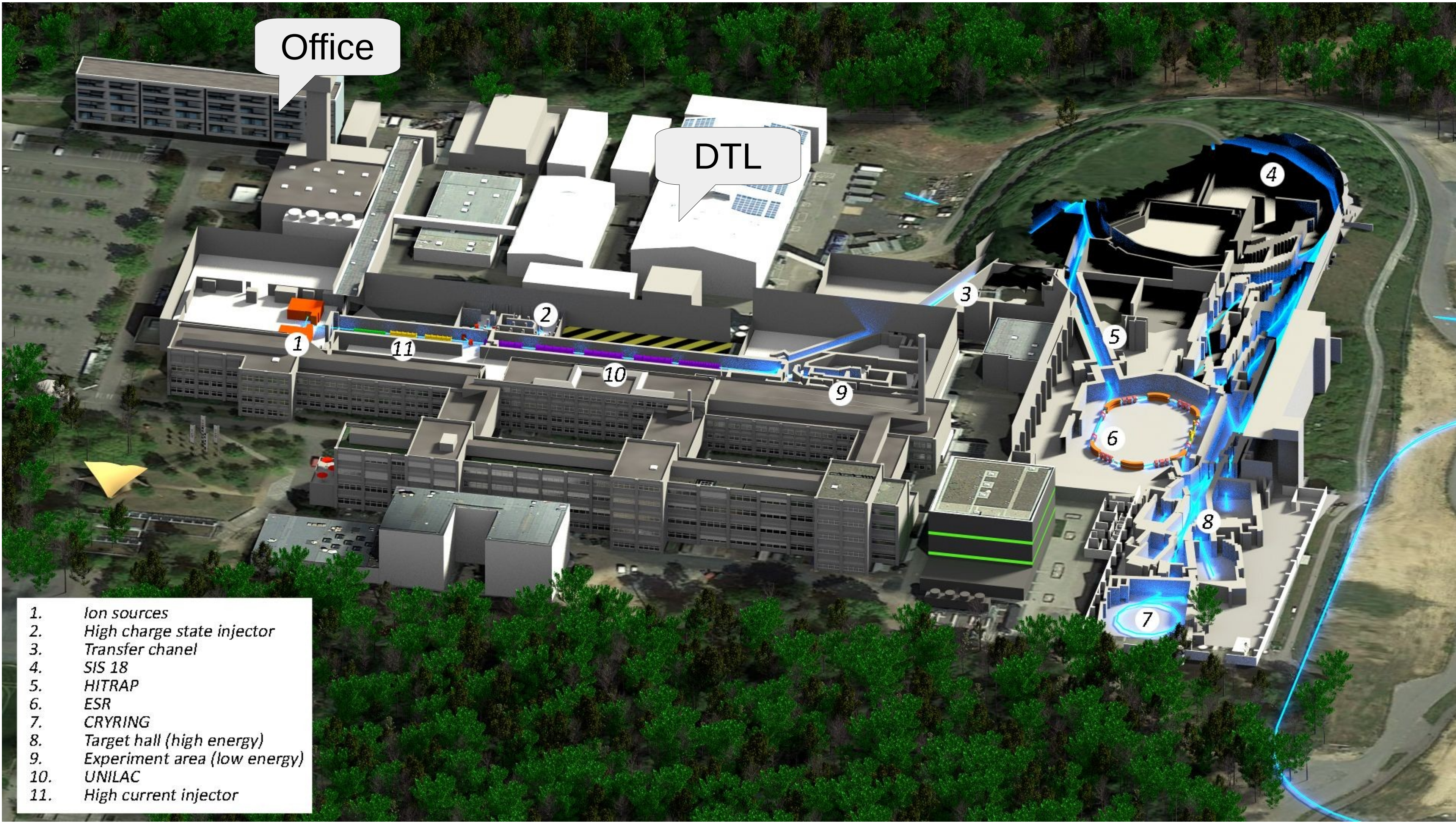


NUSTAR - Nuclear Structure, Astrophysics and Reactions

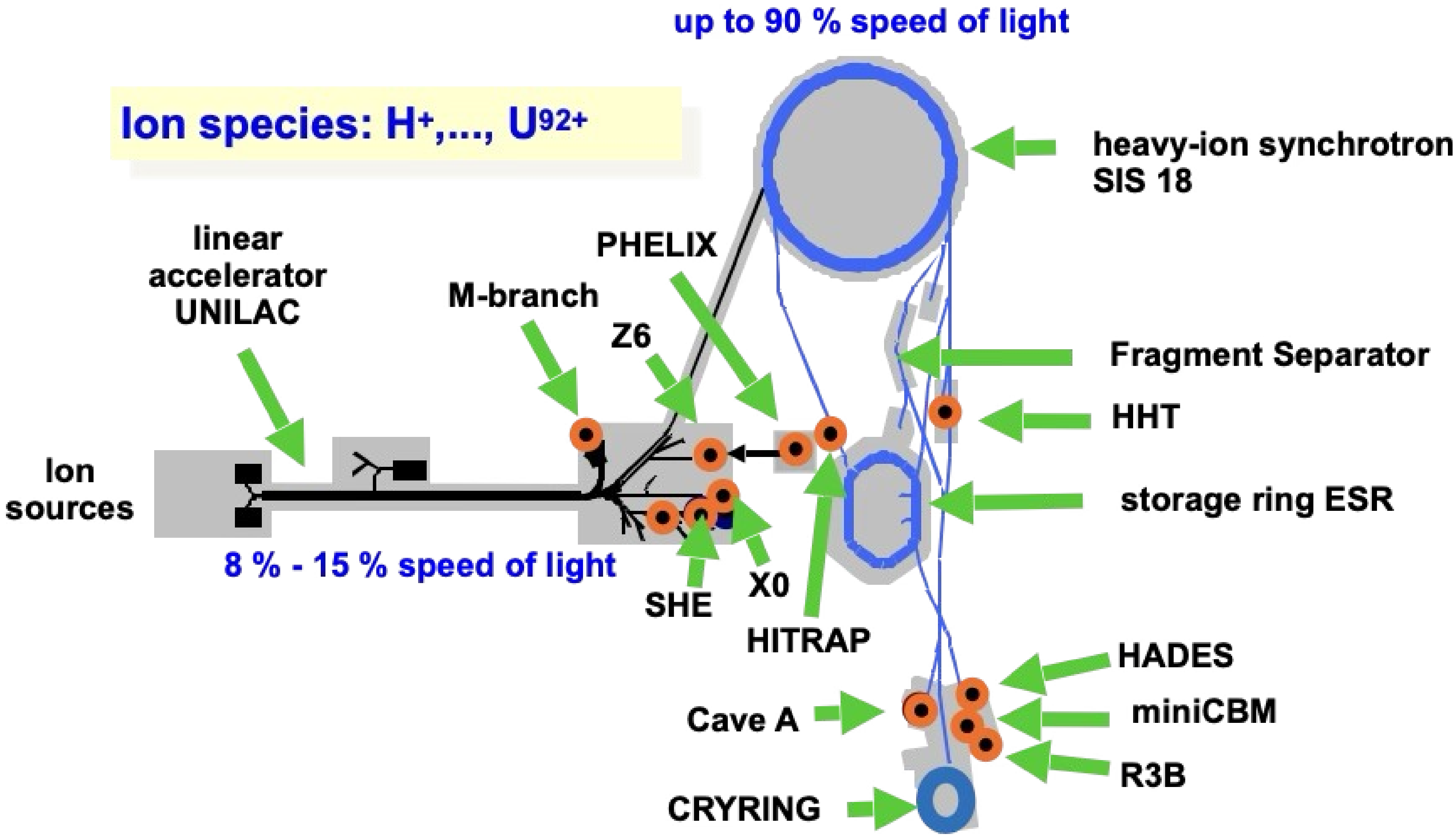
High-performance scientific computing, Big Data, Green IT



Current GSI

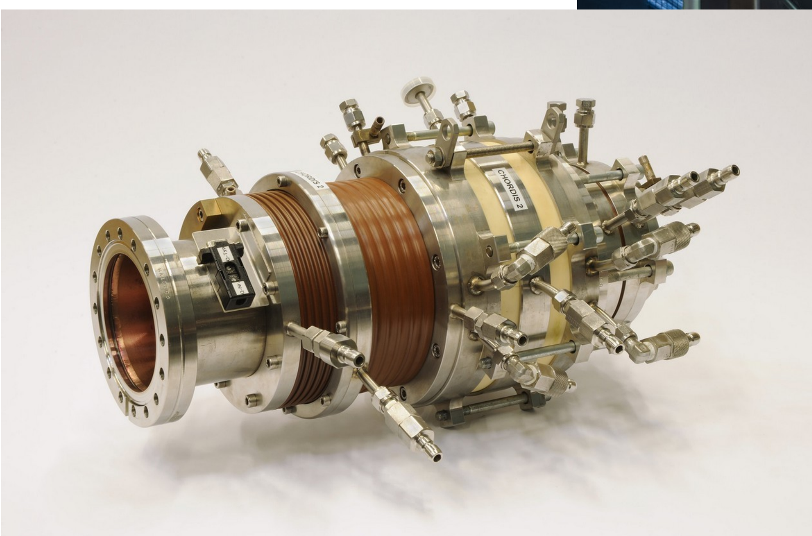


1. Ion sources
2. High charge state injector
3. Transfer chanel
4. SIS 18
5. HITRAP
6. ESR
7. CRYRING
8. Target hall (high energy)
9. Experiment area (low energy)
10. UNILAC
11. High current injector

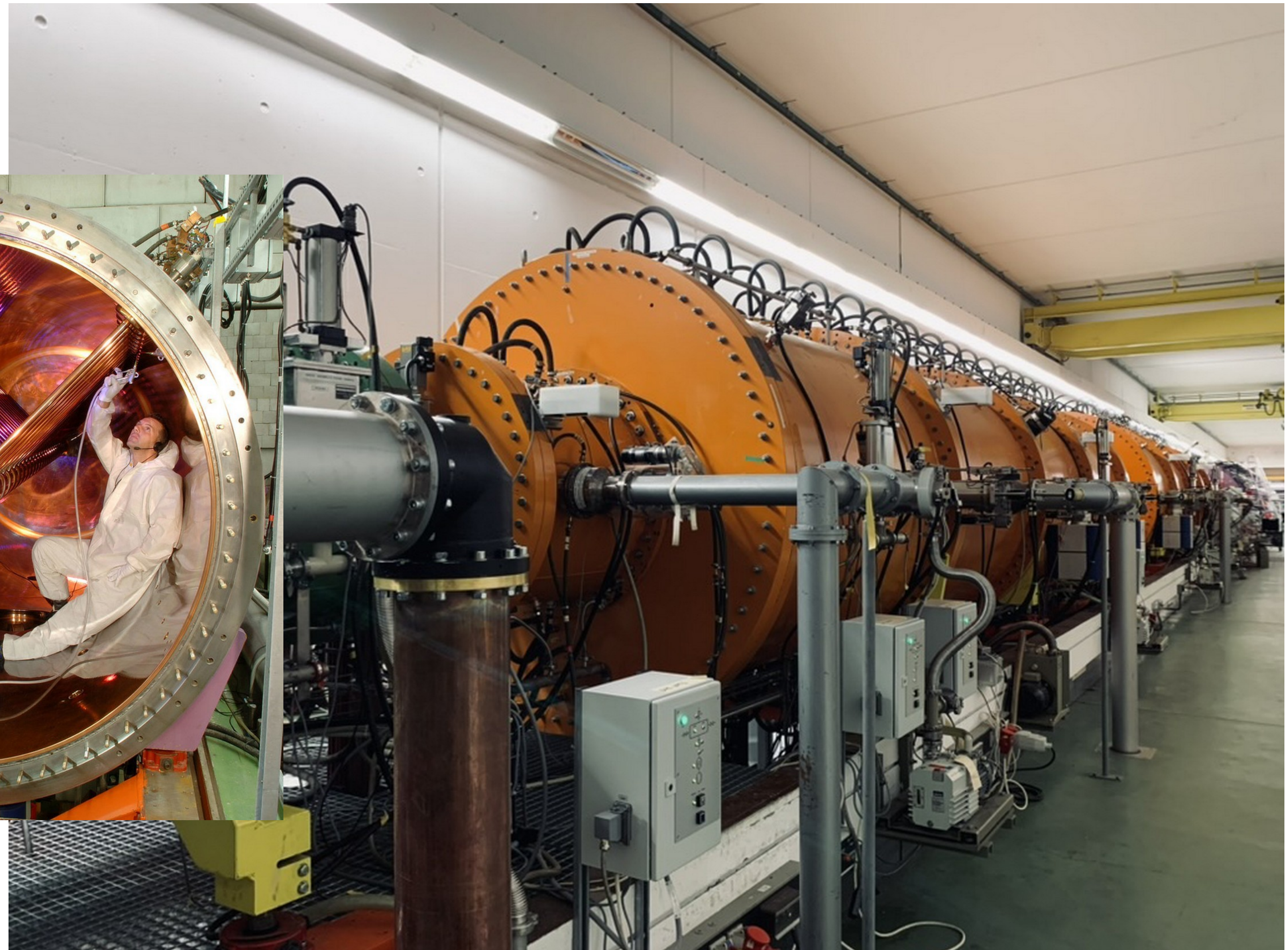

up to 90 % speed of light
Ion species: H+,..., U92+
heavy-ion synchrotron SIS 18
linear accelerator UNILAC
PHELIX
M-branch
Z6
Fragment Separator
HHT
Ion sources
storage ring ESR
8 % - 15 % speed of light
X0
SHE
HITRAP
HADES
Cave A
miniCBM
R3B
CRYRING

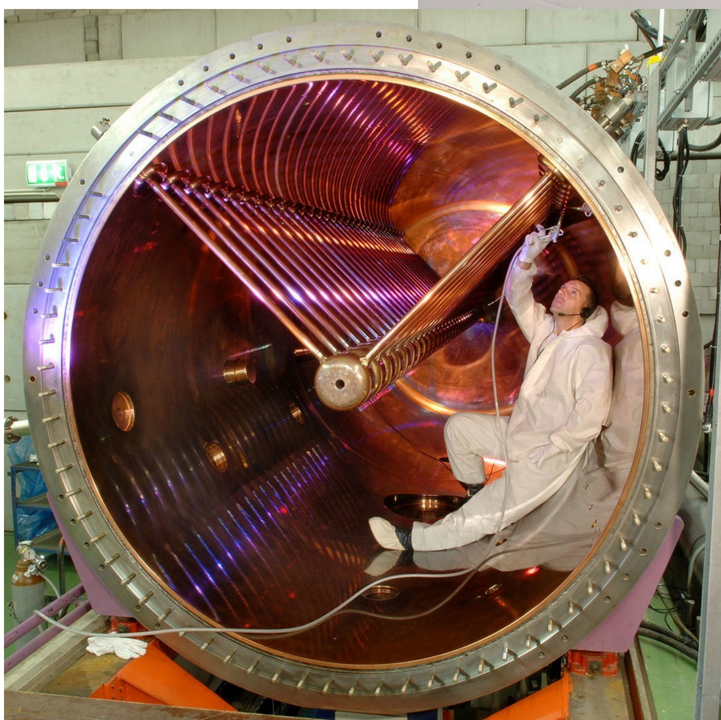
Starting point accelerator: Ion sources

https://www.gsi.de/en/researchaccelerators/accelerator_facility/ion_sources

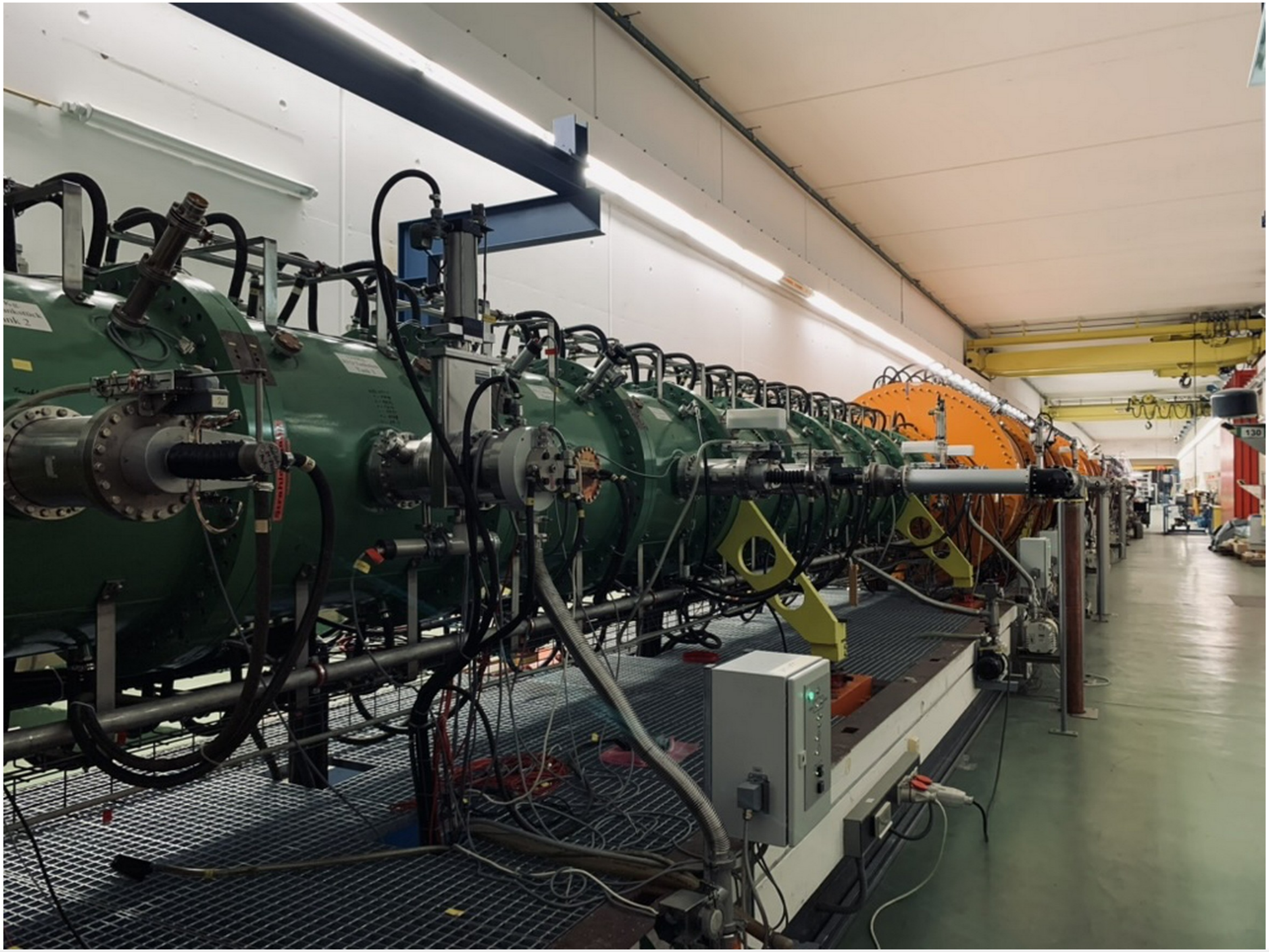


The UNIversal Linear Accelerator





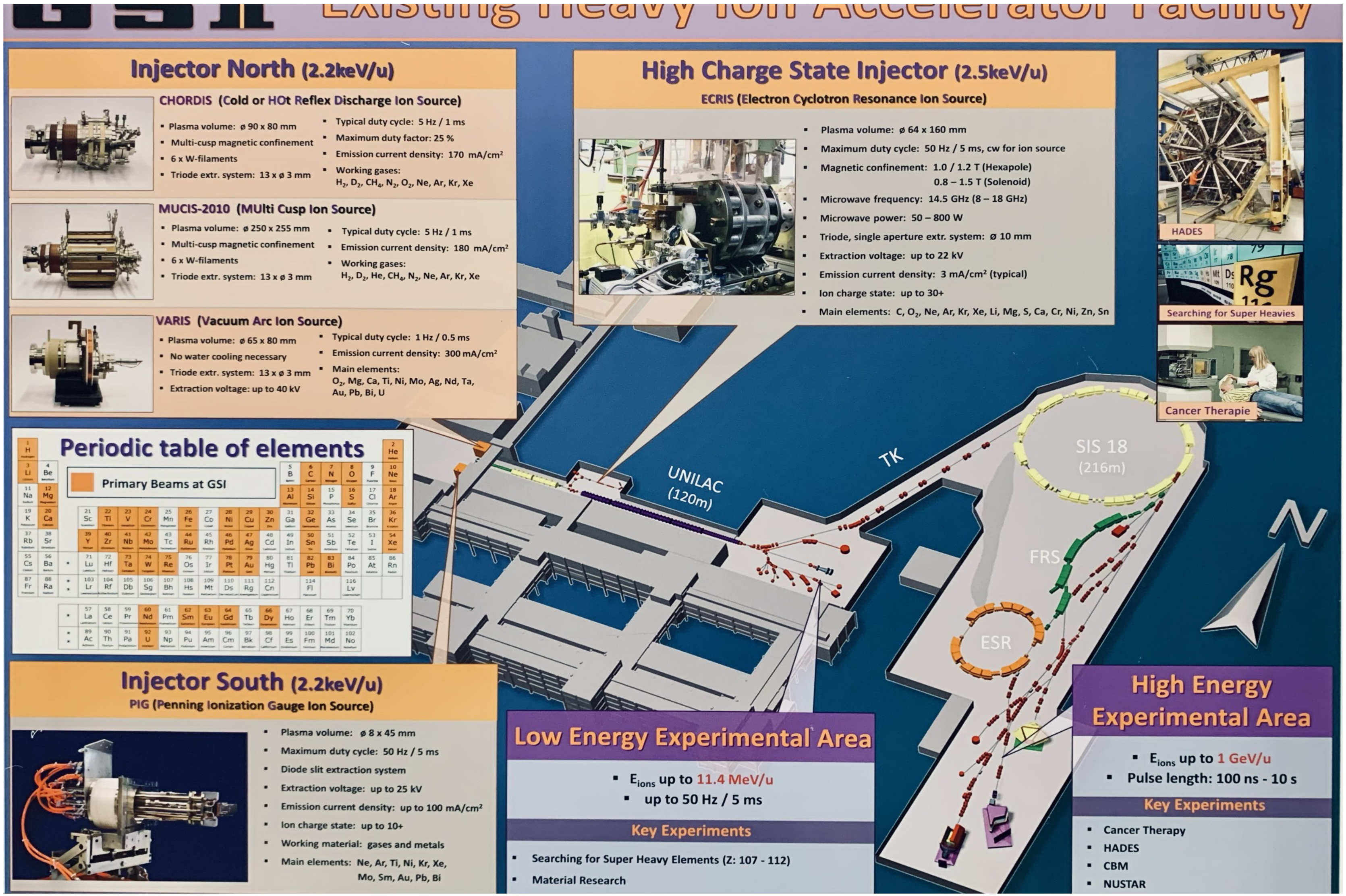
The UNIversal Linear Accelerator



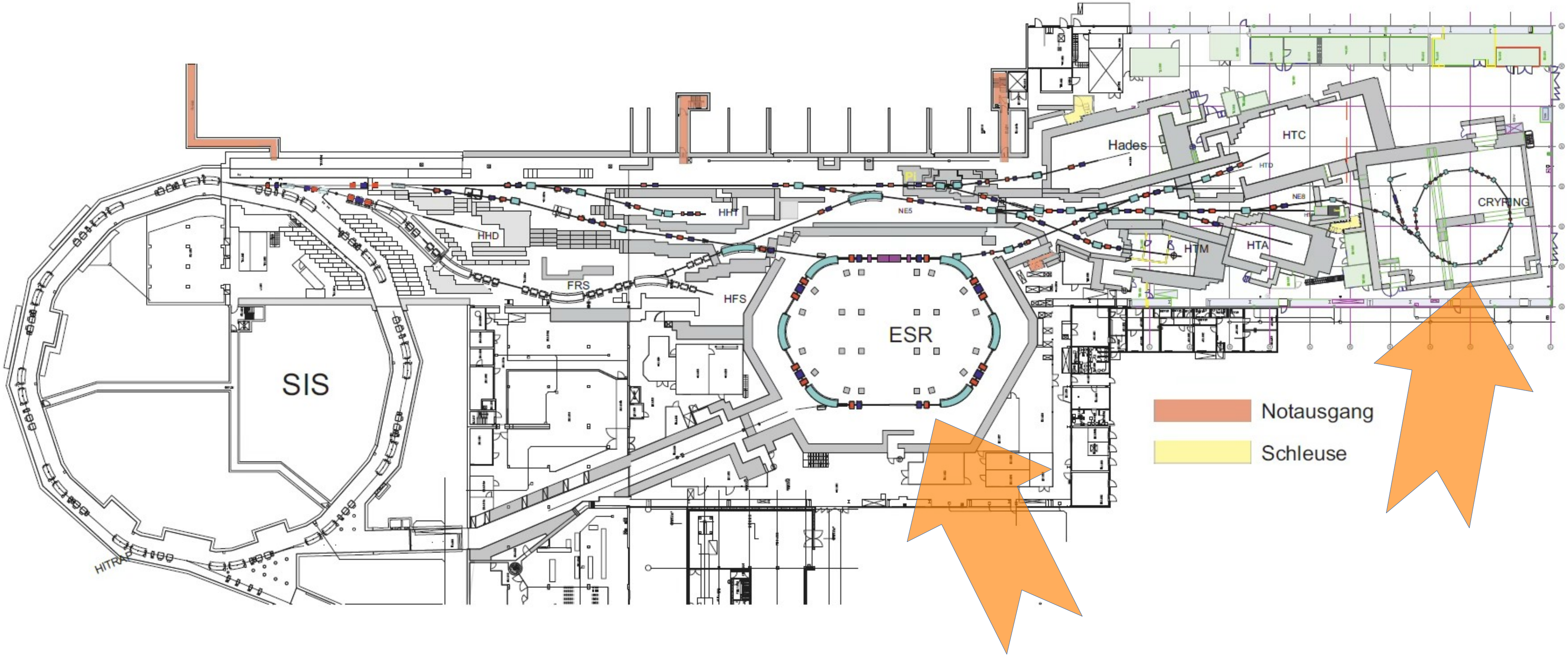
The UNIversal Linear Accelerator

Total leangth 120m

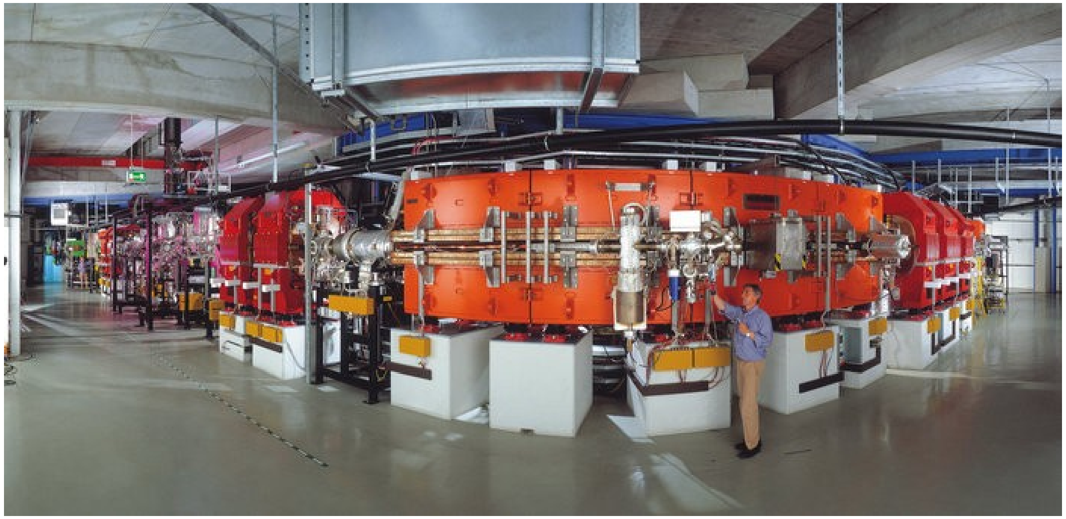
Primary Beams at GSI

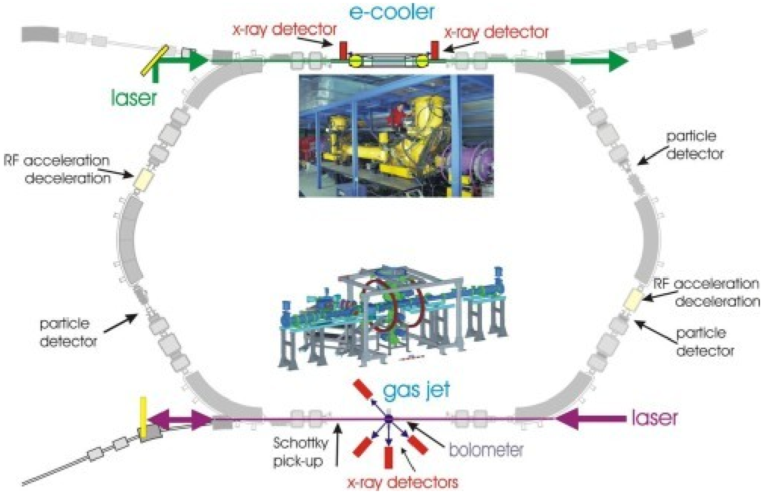


SIS18 and Experimental Area



The Heavy Ion Storage Ring ESR





CRYRING

SIS (German: SchwerIonenSynchrotron)

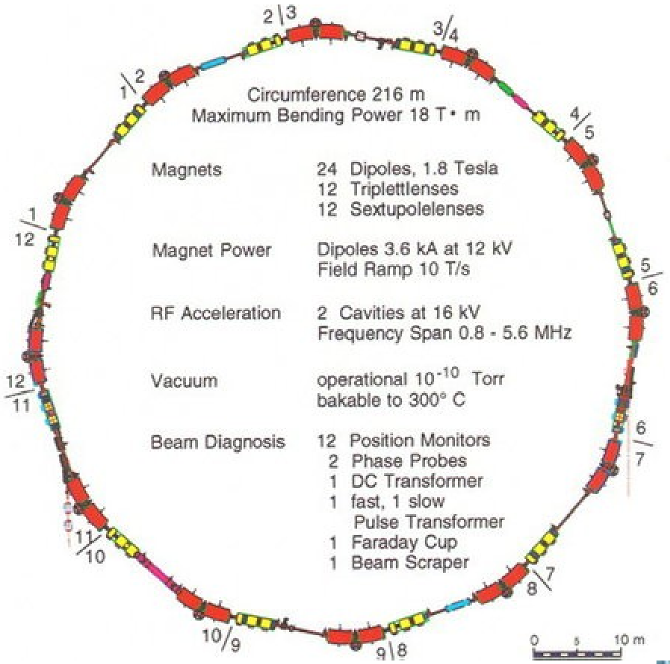


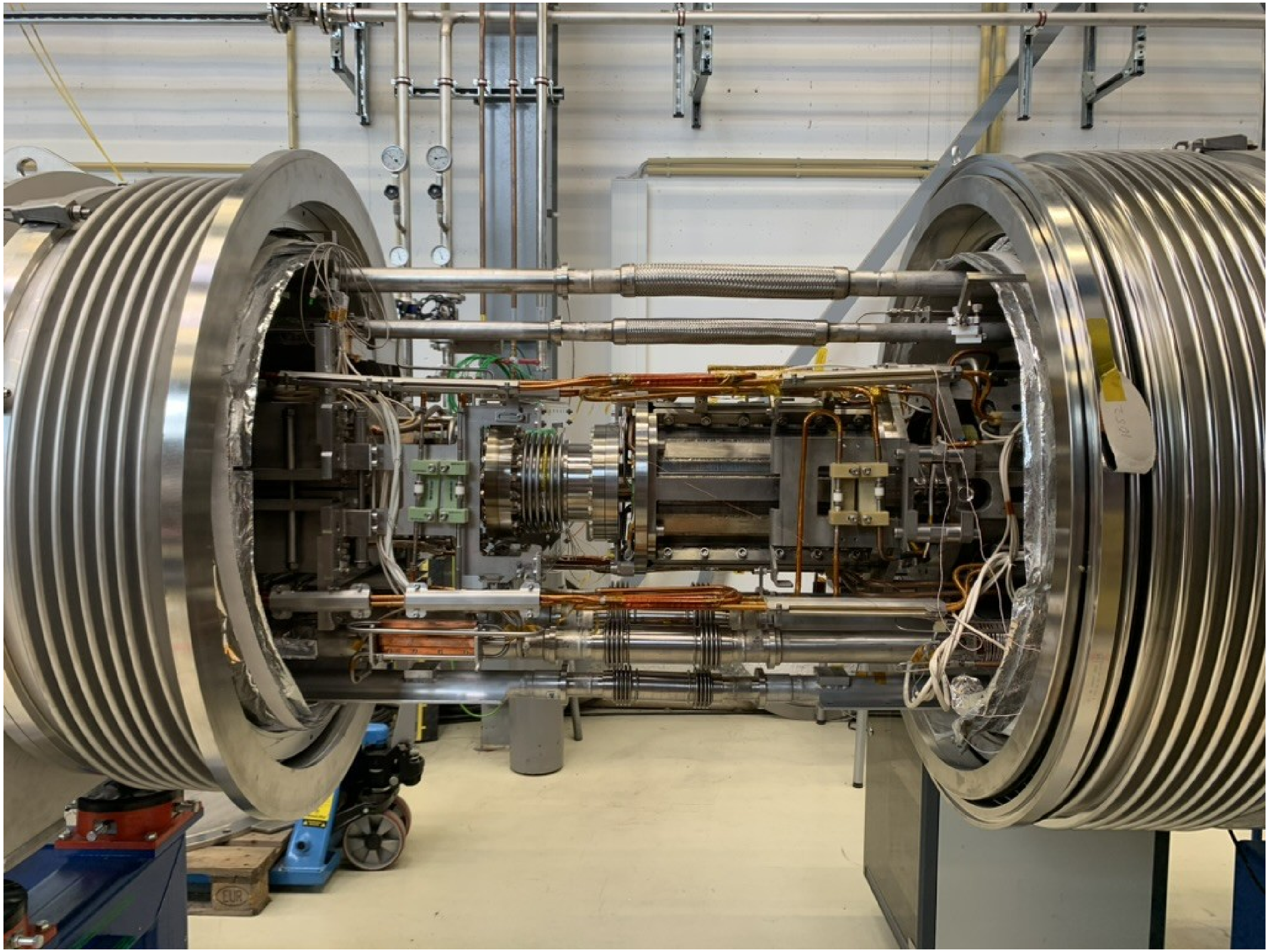
Illustration: Heavy-ion synchrotron SIS18 with sections

Circumference: 216 m

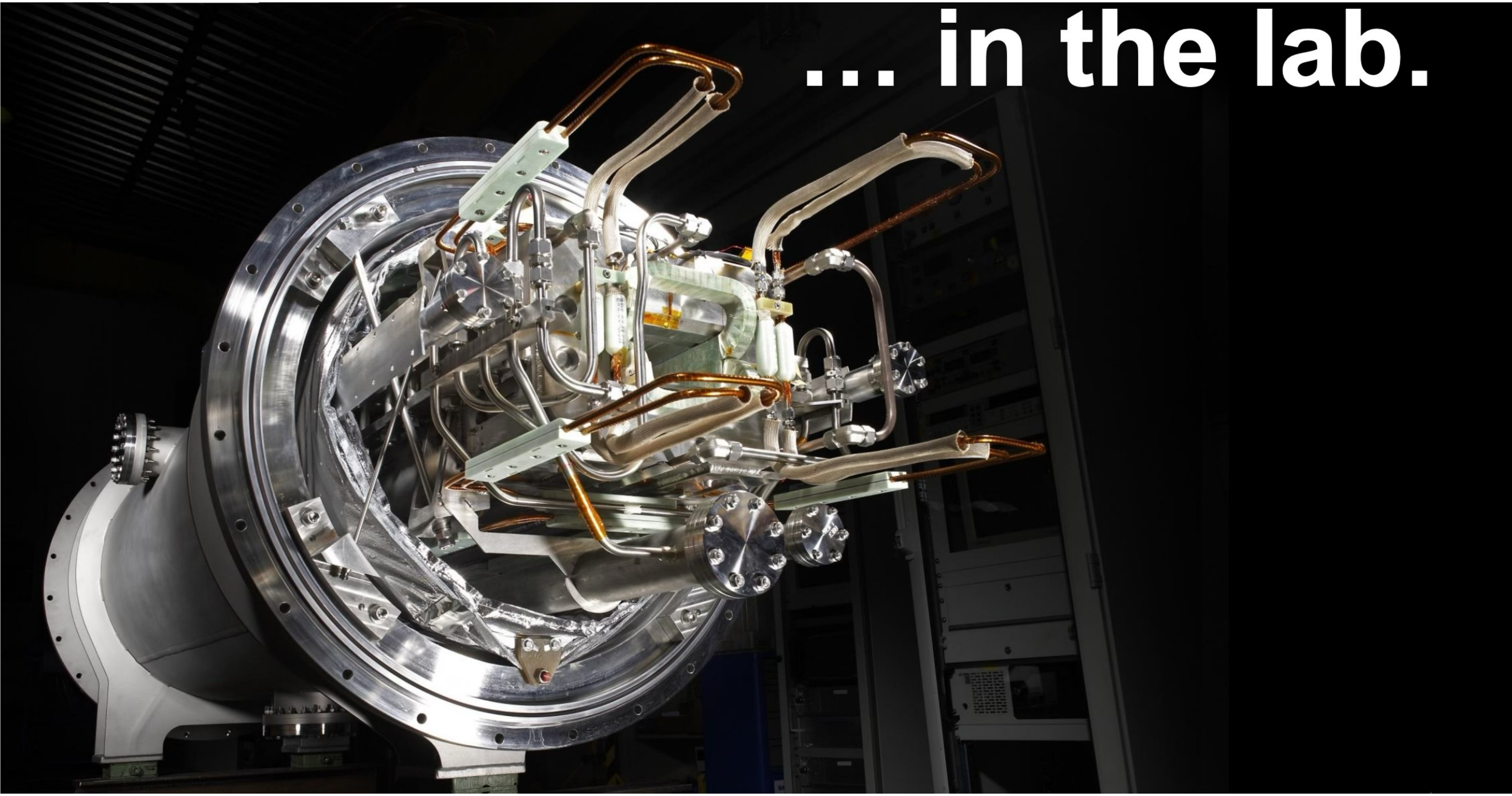
Maximum magnetic rigidity: 18 Tm

up to 90 % of light speed (270.000 km/s) in a few hundred thousand revolutions.

SIS 100 Super Conducting Dipole



SIS 100 Super Conducting Dipole



SIS100 SC Dipole

https://www.youtube.com/FAIRGSITheUniverseinthelab

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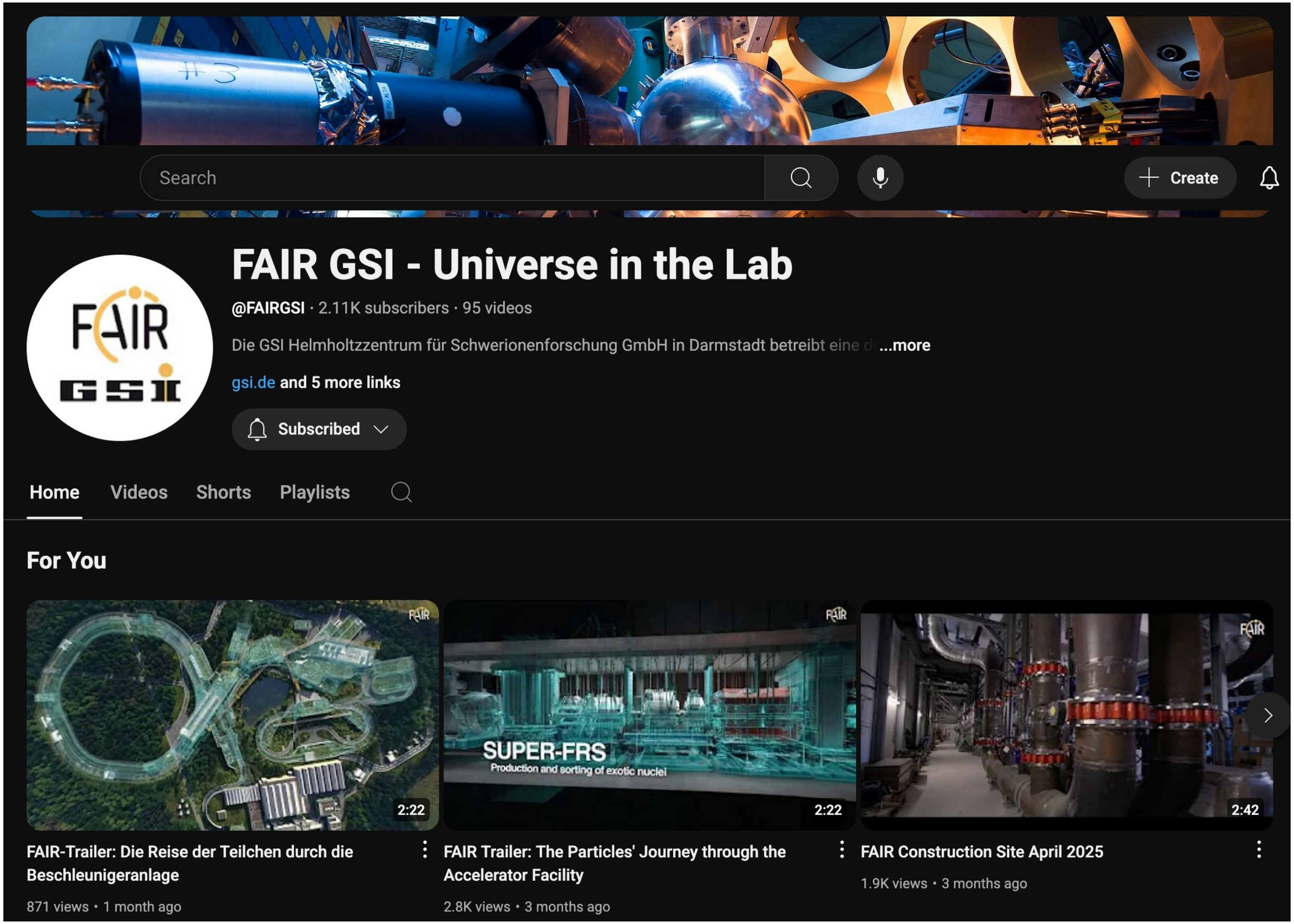
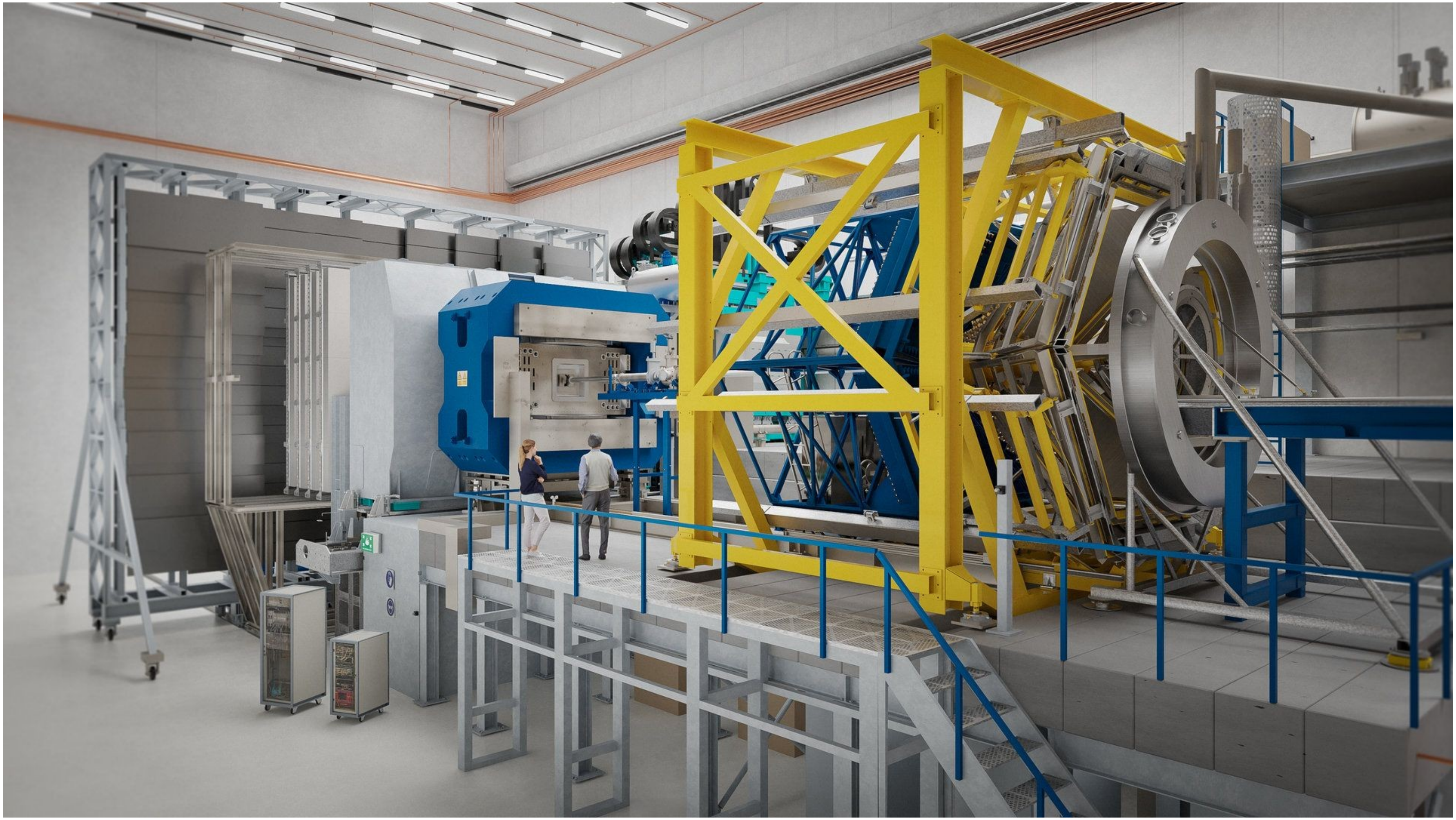
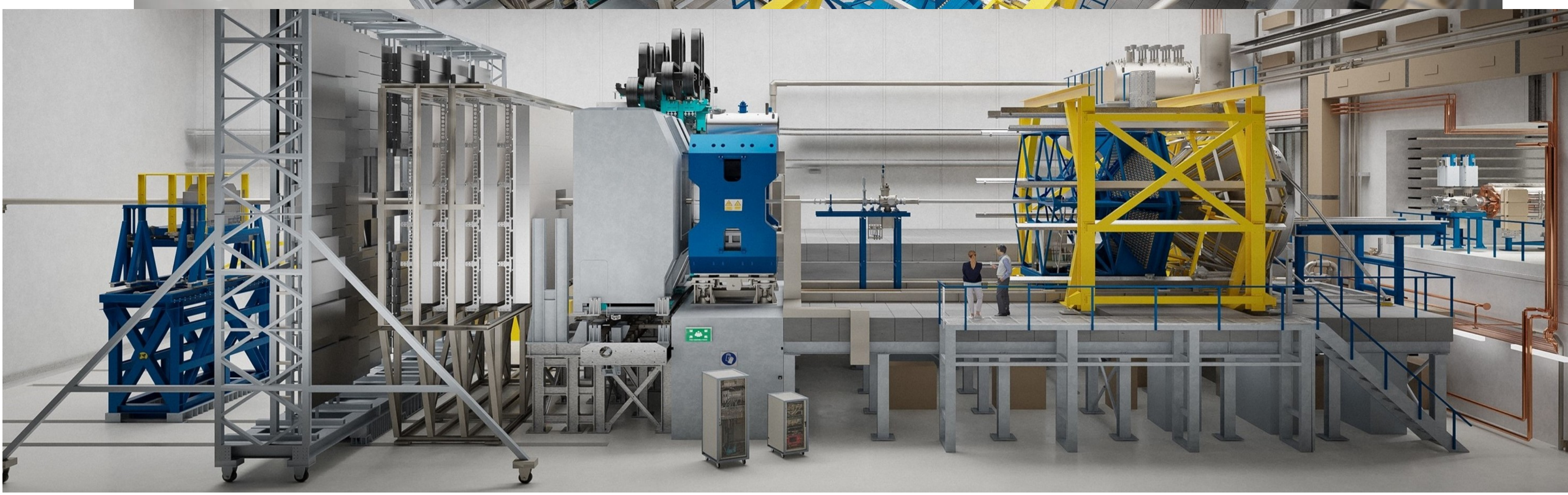


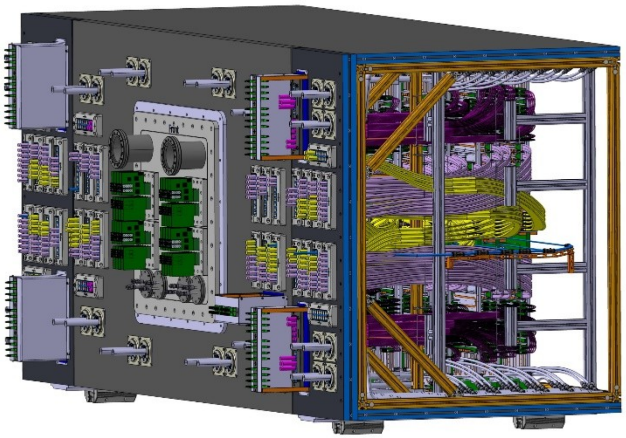
CBM Compressed Baryonic Matter



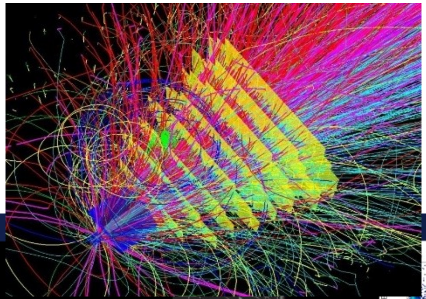
CBM Compressed Baryonic Matter

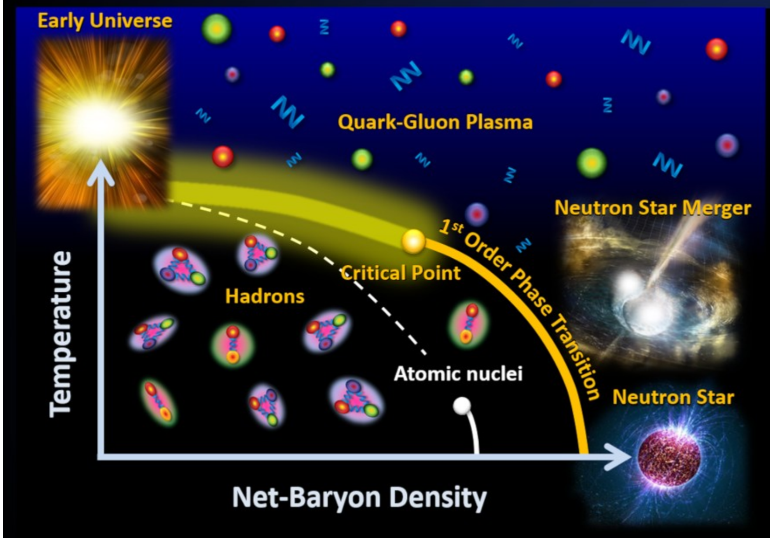


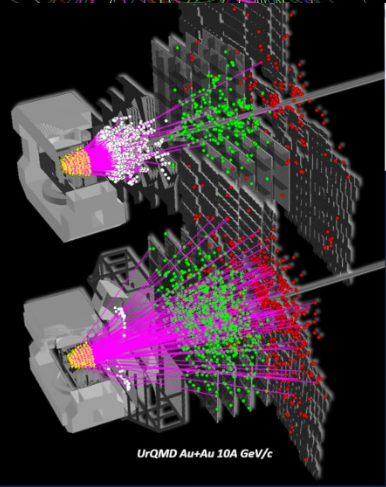
CBM Compressed Baryonic Matter

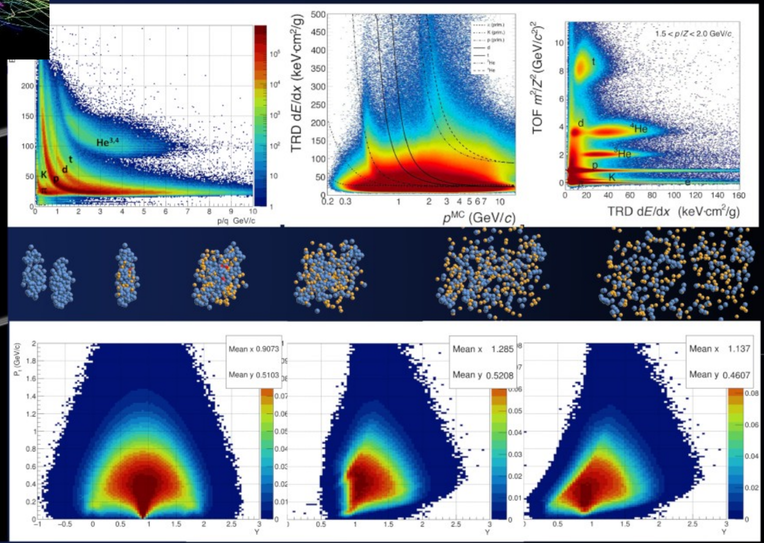


- 876 silicon strip detector modules for tracking, 2M ch
- assembled to guarantee < 1.5 $\Delta p/p$
- electronics outside acceptance



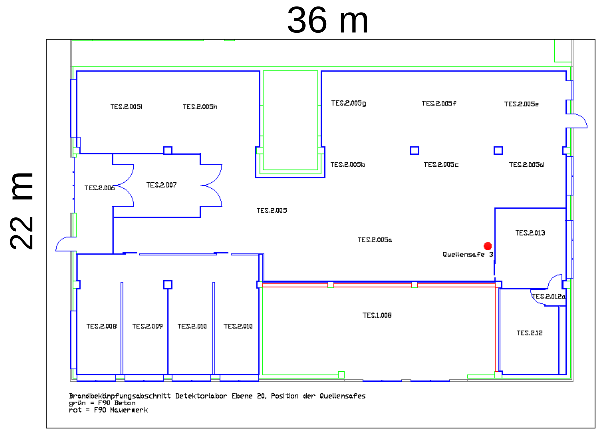






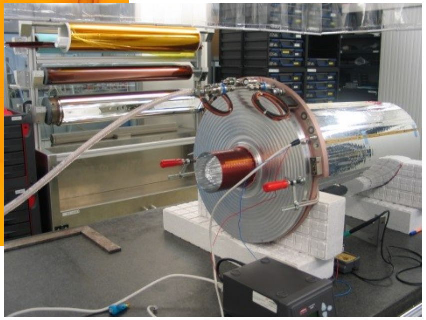
Detector Laboratory at GSI

Detector Laboratory: 600 m² Clean-Room

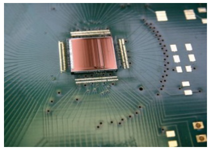


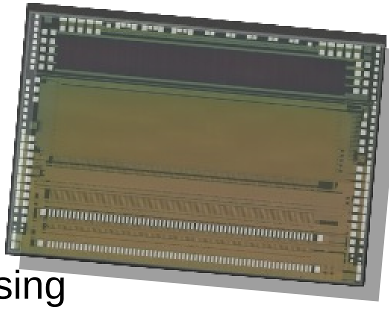
Competences:

- Micro Patterned Gaseous Detector Technology
- Silicon Strip Detector Integration
- ASIC Handling and Integration
- Diamond Detectors



Machinery:

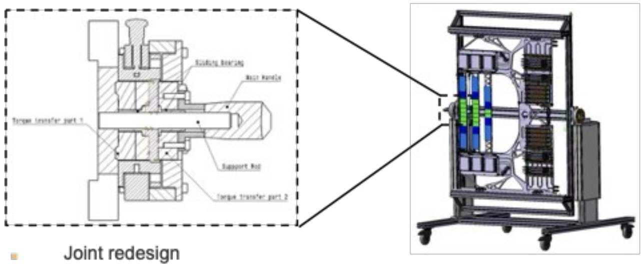




- Laser Lithography
- PVD
- Bonding Automates
- Probestation and Chip Handling
- Automated Wire Winding
- Digital Microscope
- Thin Foils Handling and Processing
- Detector Ageing Teststands
- Large Prototyping CNC Milling Machine

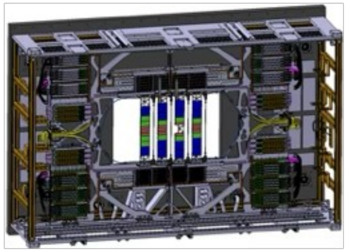
- Topology optimization of the C-Frames
- All Units of STSD optimized, STSU almost done
- Front wall updated for the new Roxtec
- Small component finalization e.g. ROB
- Unit assembly table joint update

Updating ROB & its cooling block Design

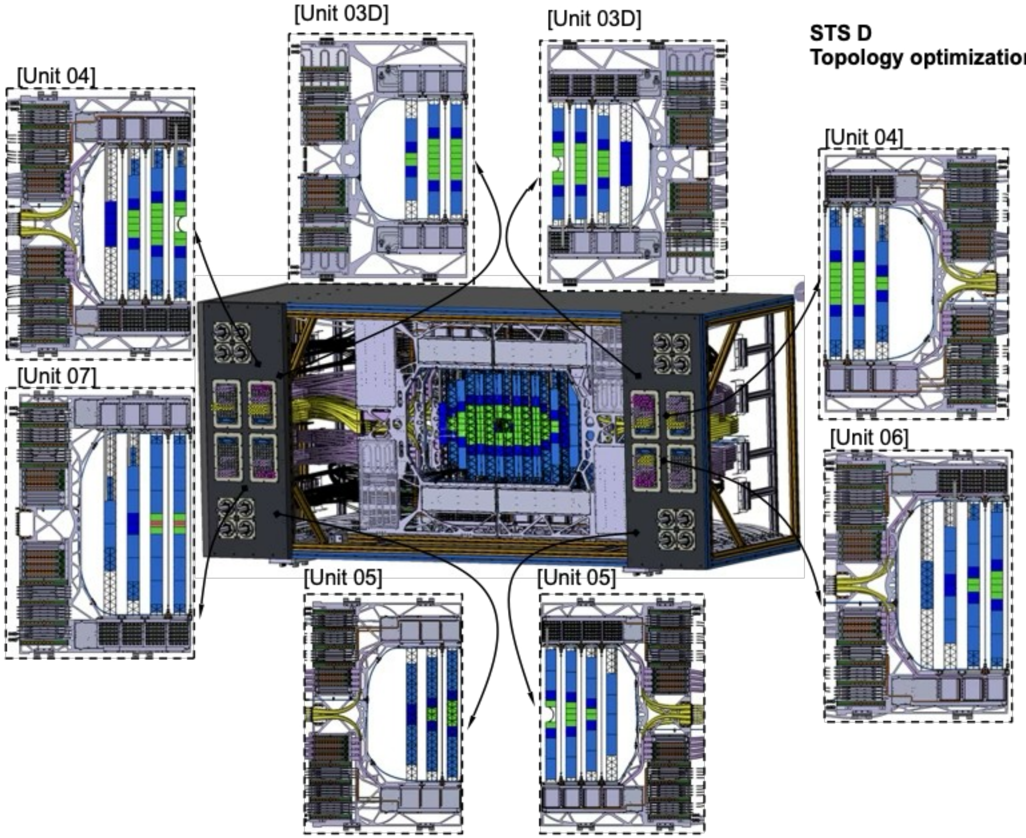


- Joint redesign
- Increased stiffness and fixation point amount
- 3D Printed prototype
- Production soon

STS U
Topology optimization



STS D
Topology optimization

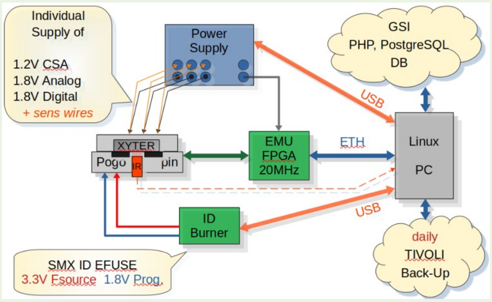


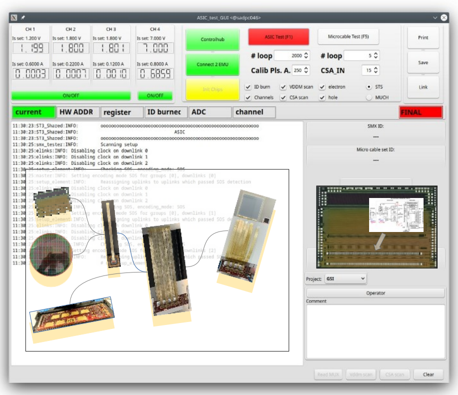
O. Vasylyev/GSI Status of mechanics for STS Engineering

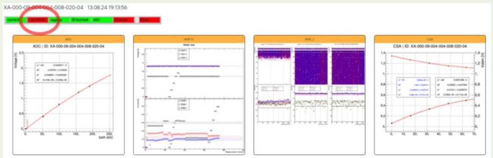
X

https://web-docs.gsi.de/~dtl-sts/

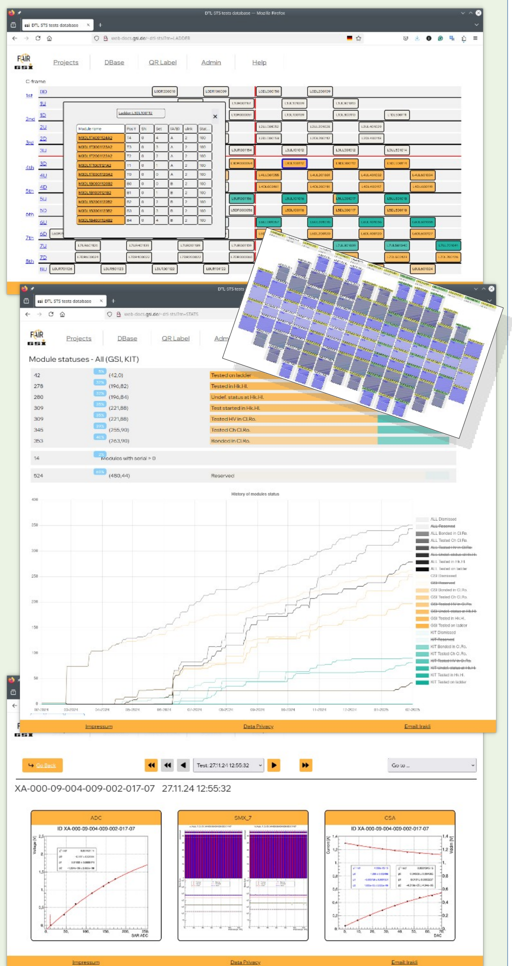
Test SW/HW



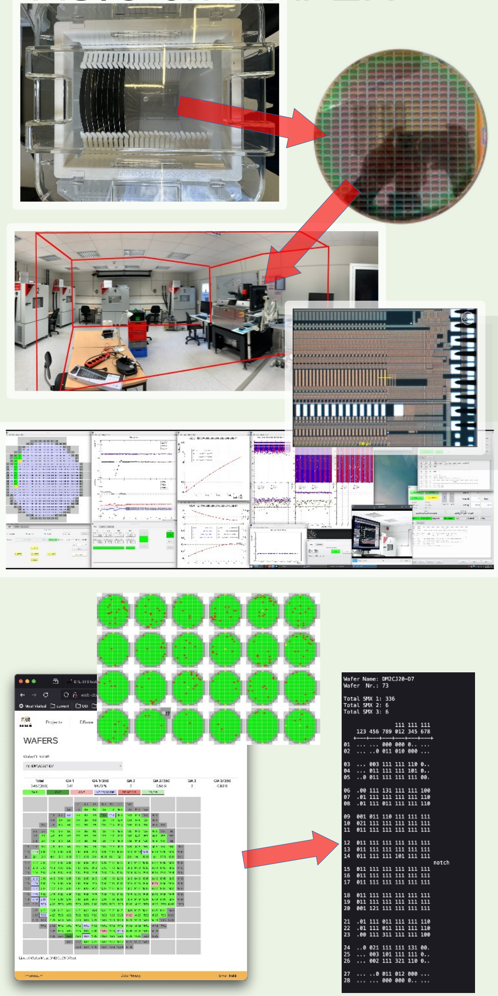




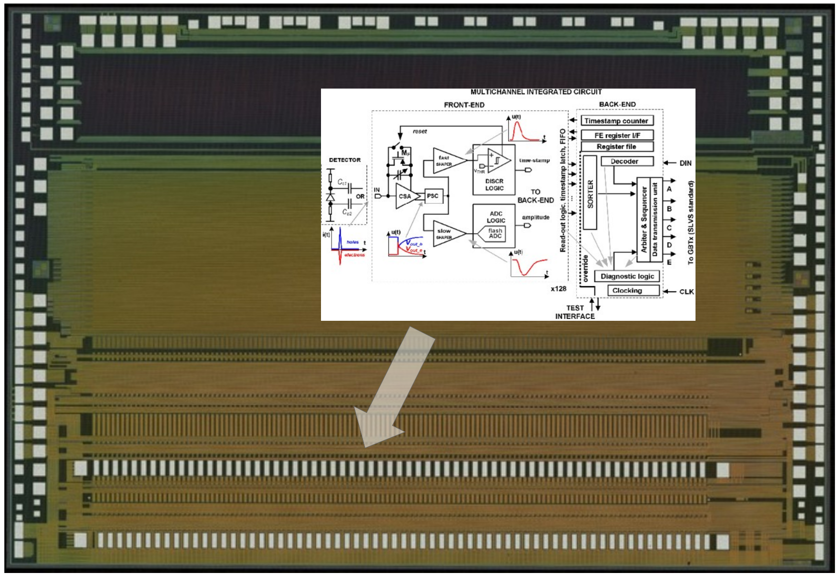
DB / Web interface

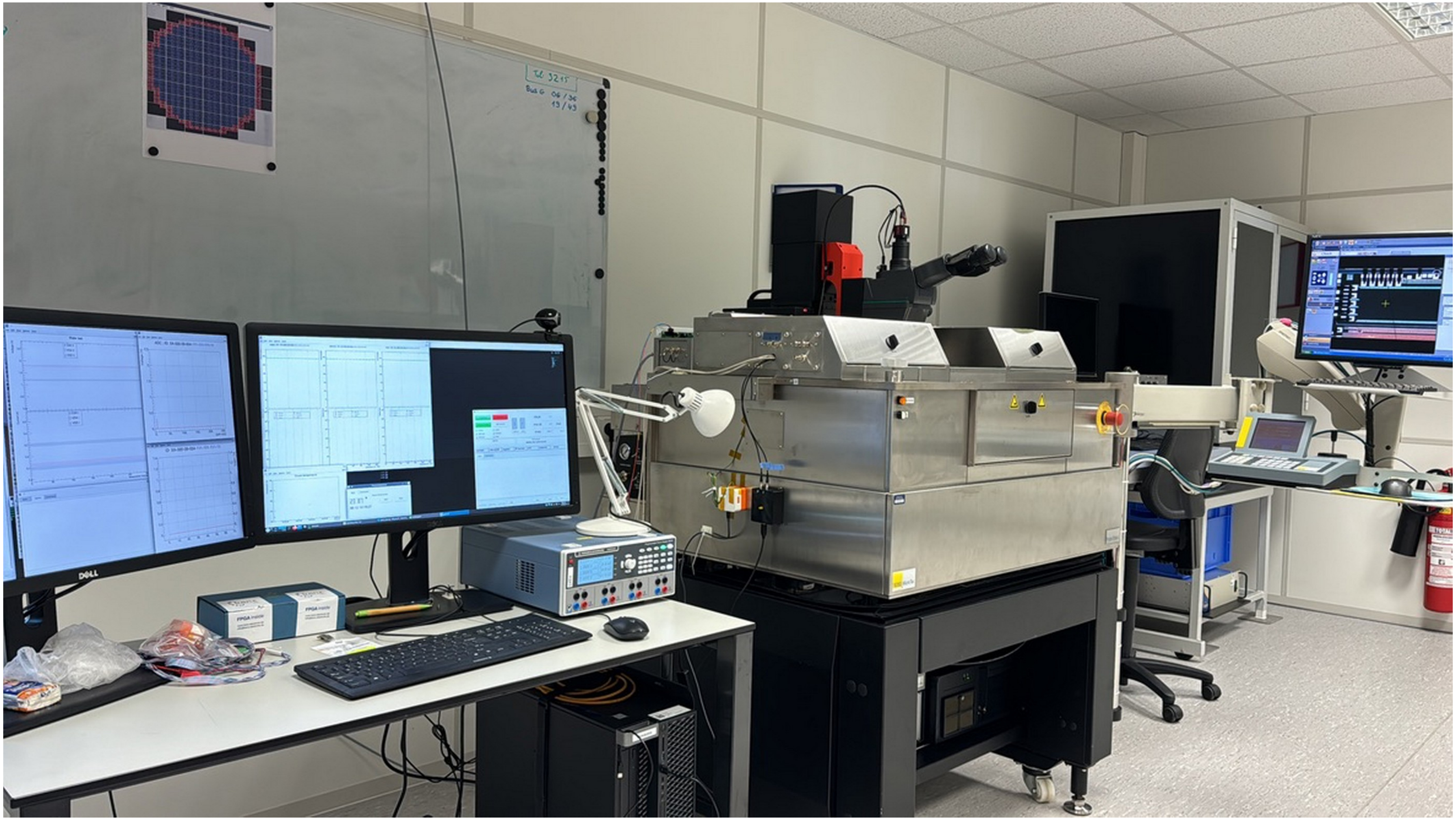


ASIC on WAFER



Test of XYTER ASIC





Wafer test software (5 x module)

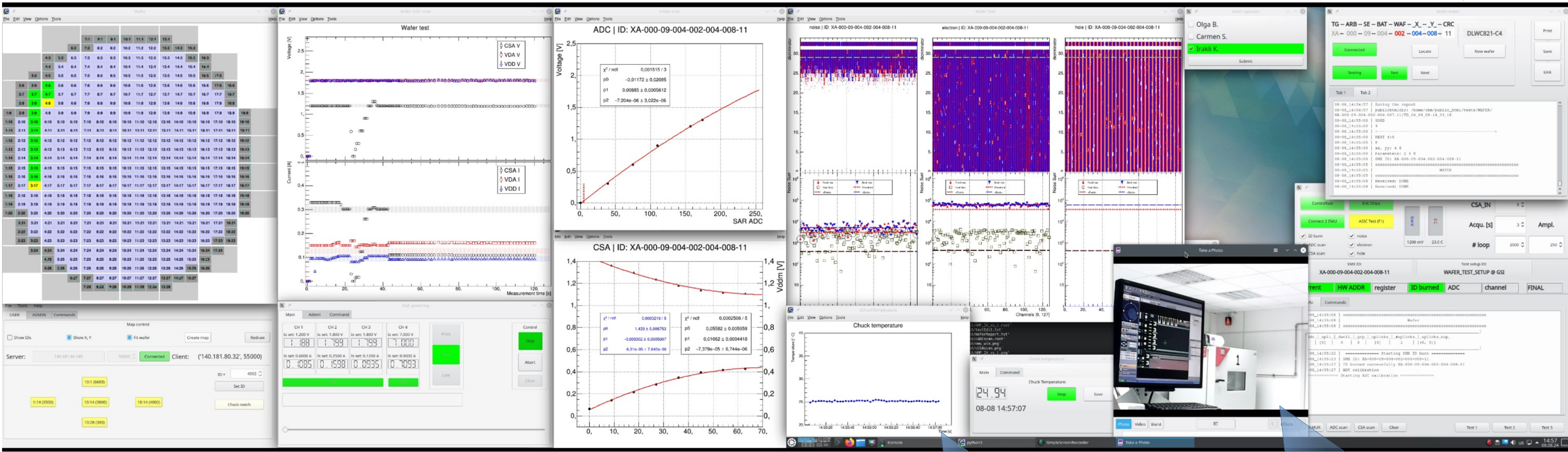
WAFER
Prober server

ADC calib.

CSA calib.

Channel test
Noise, Neg., Pos.,

MAIN
server

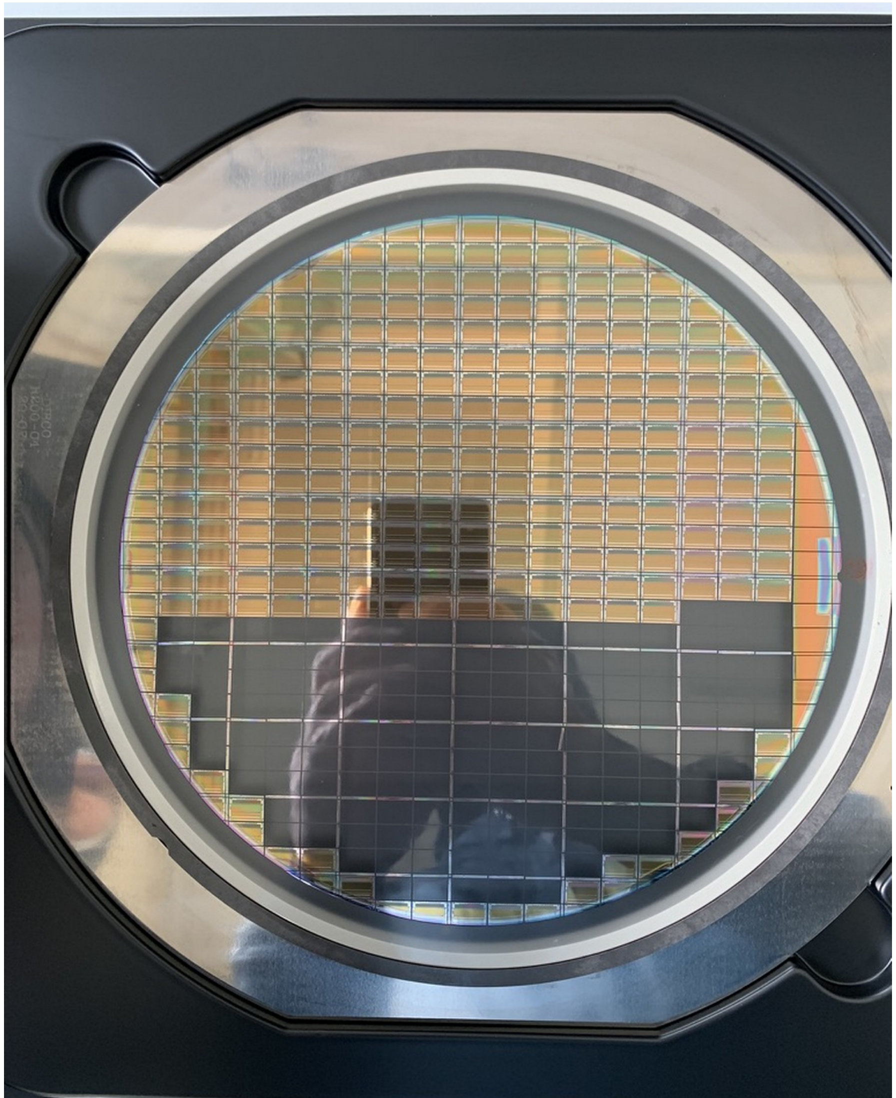


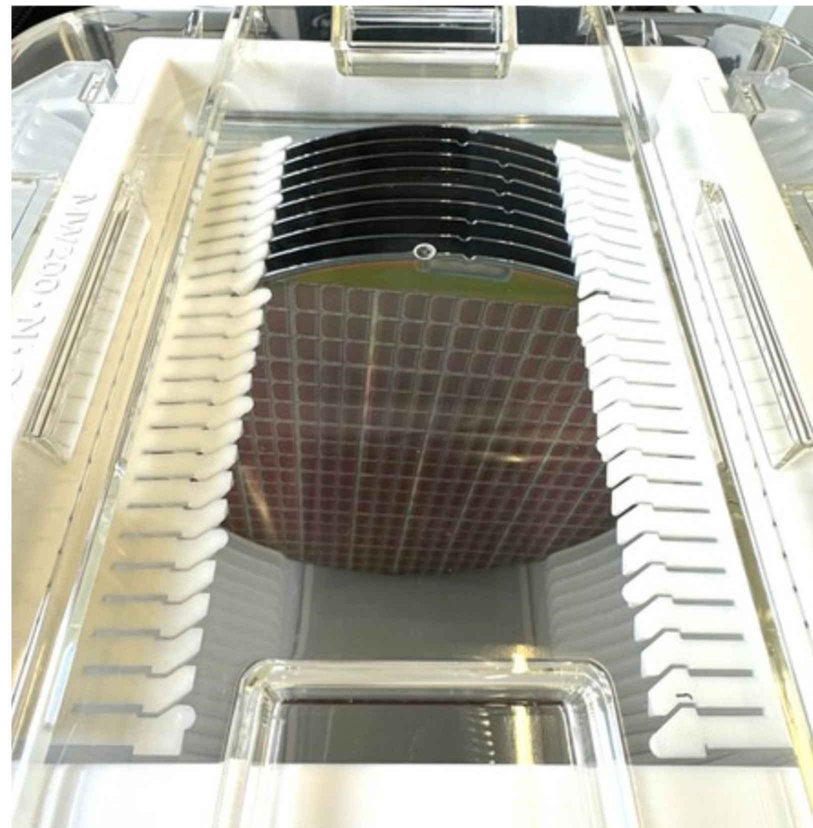
Power supply
server

WAFER/Chuck
Temperature

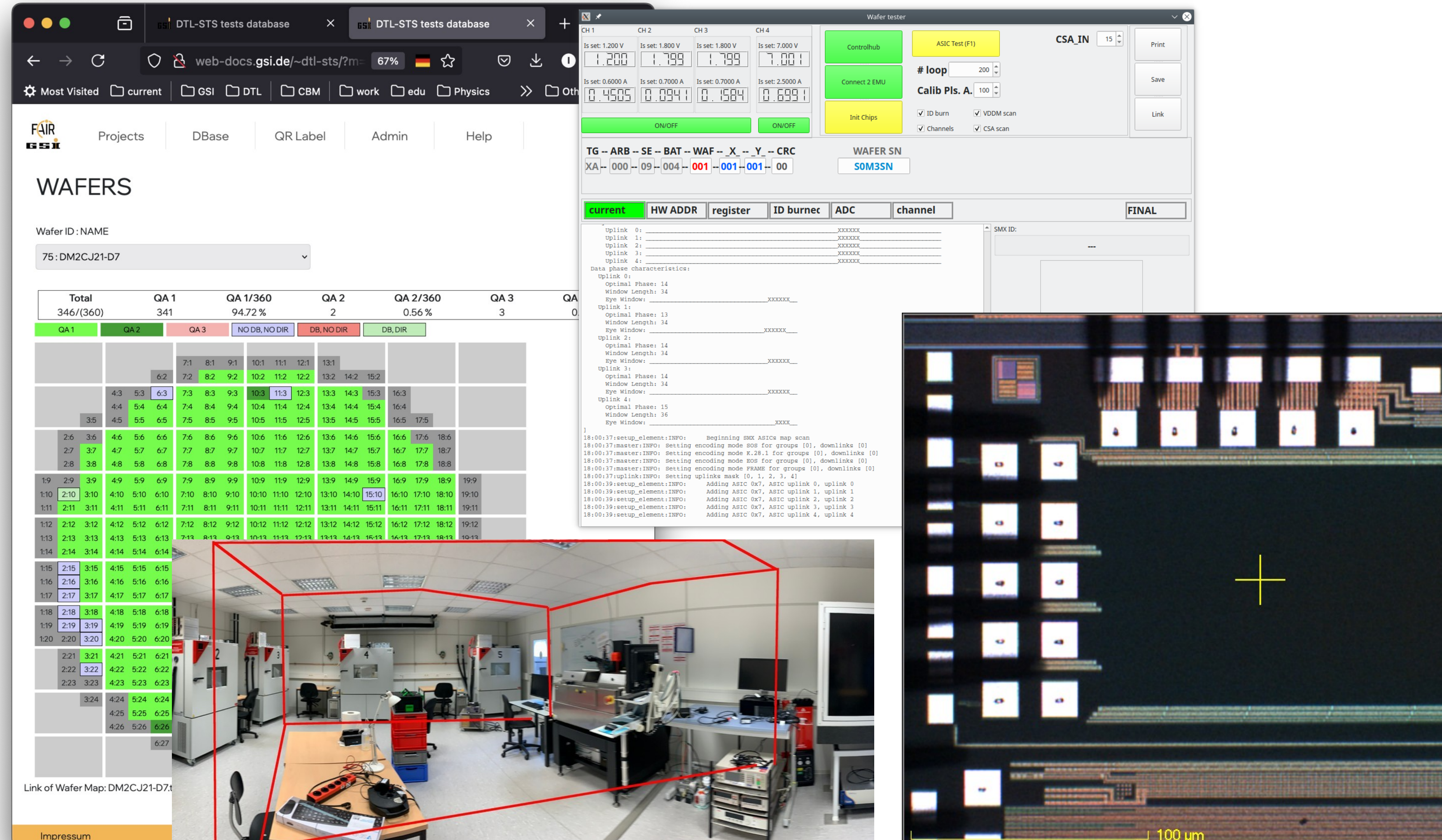
Test card

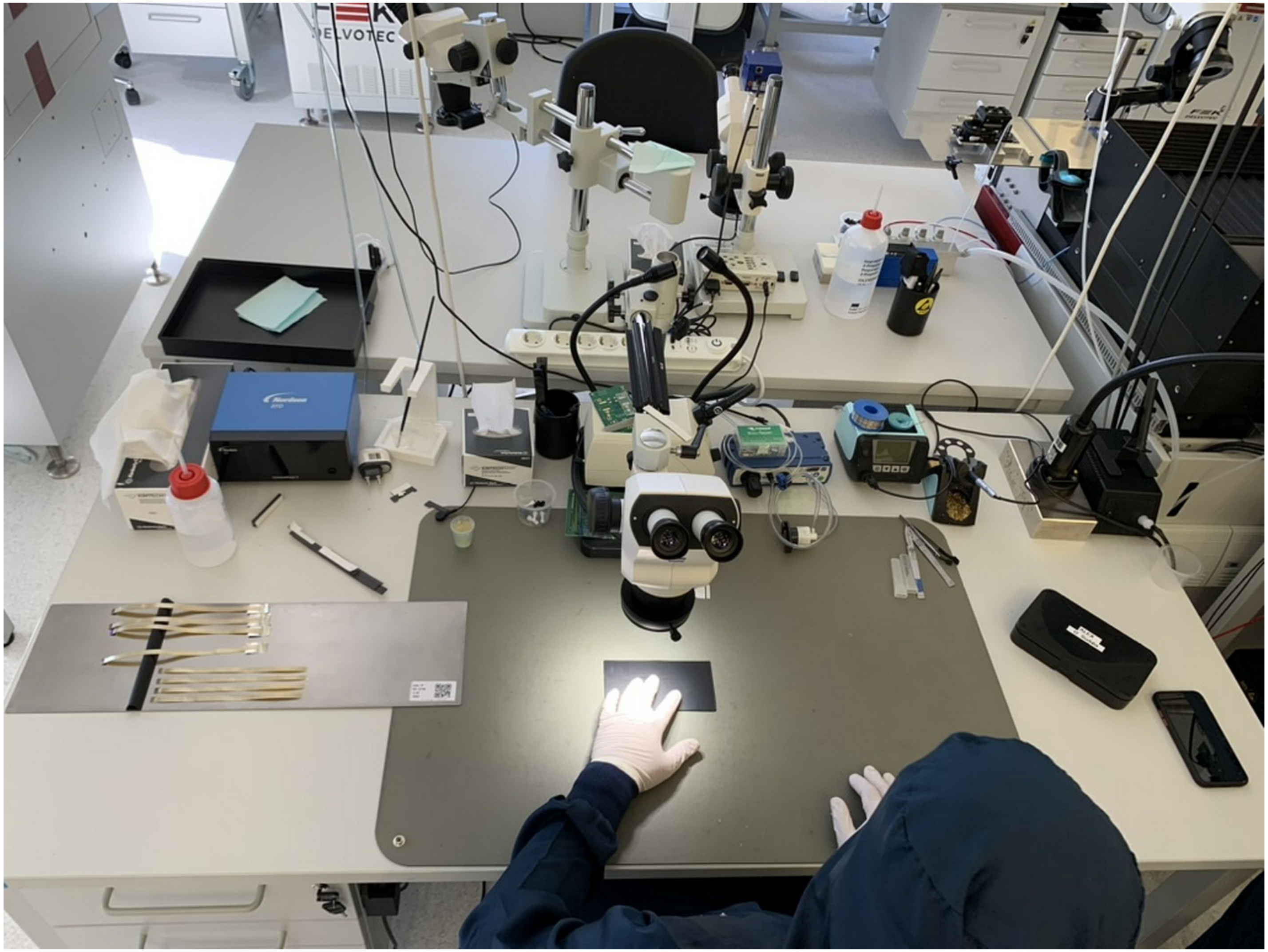
ASIC Wafer 80 x 360 chips

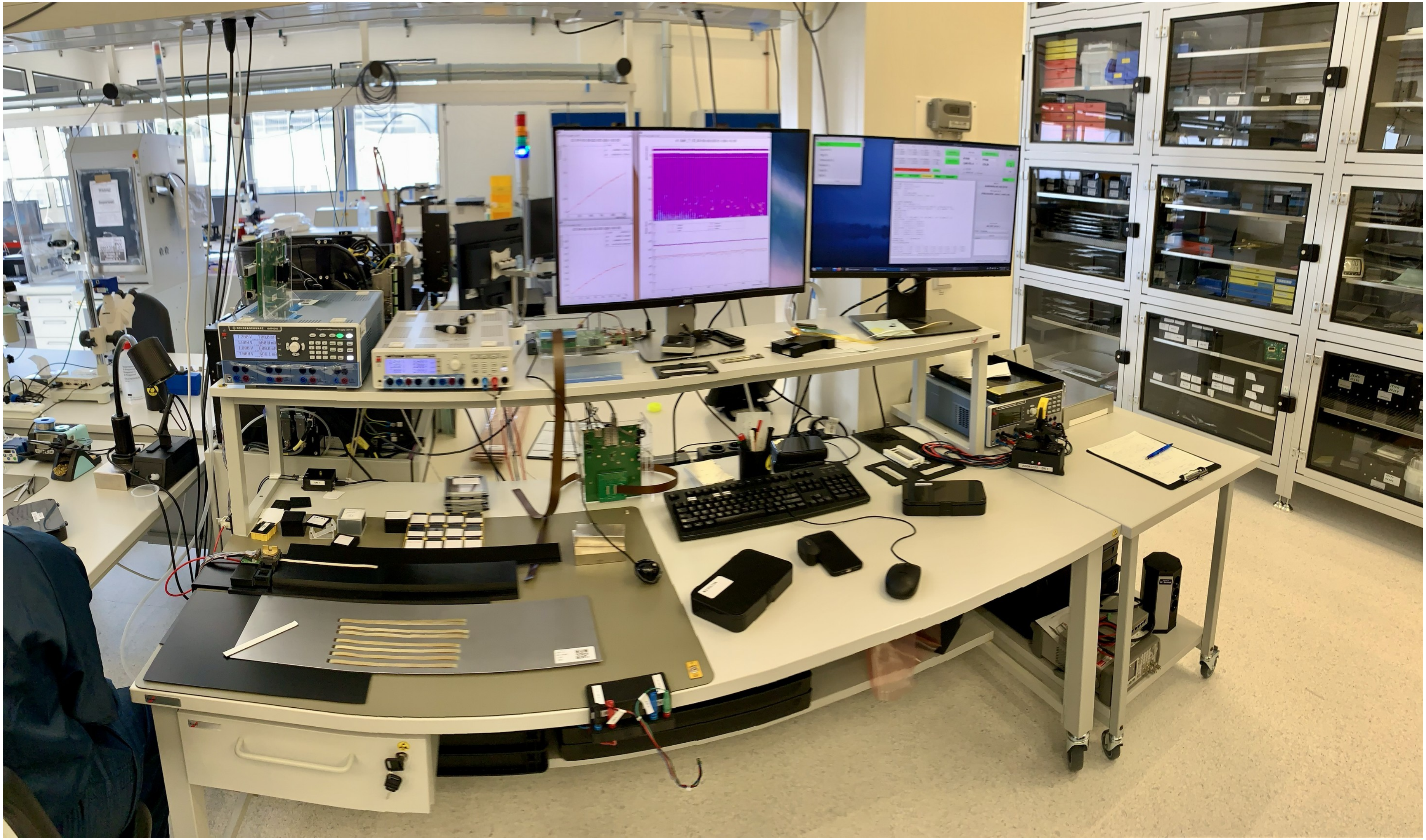




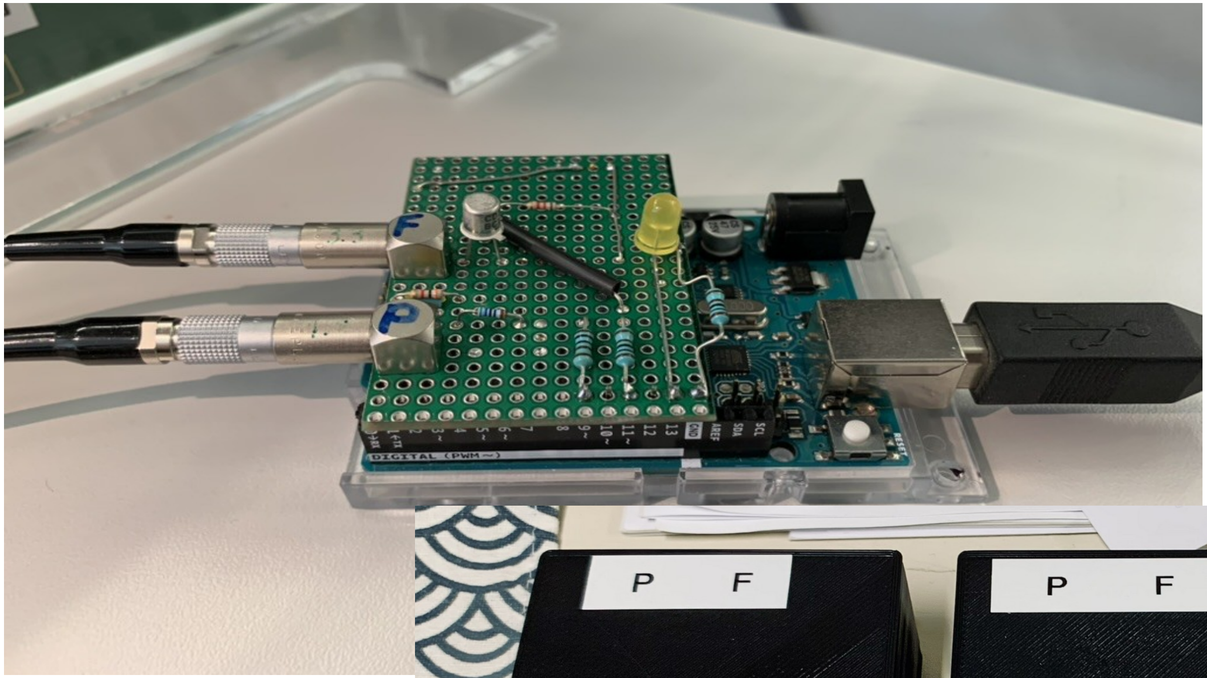
Wafer level ASIC test



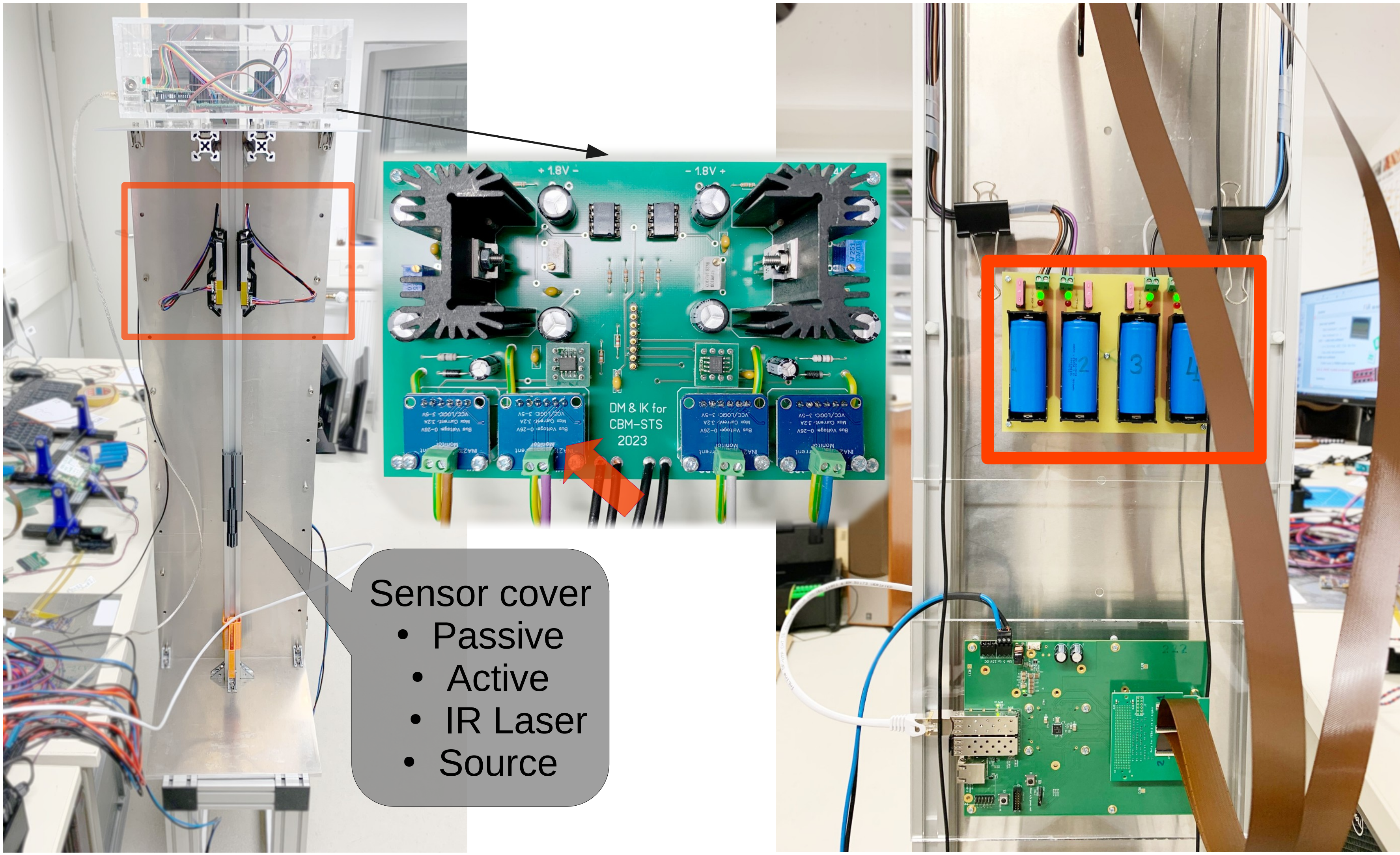




ASIC ID burner

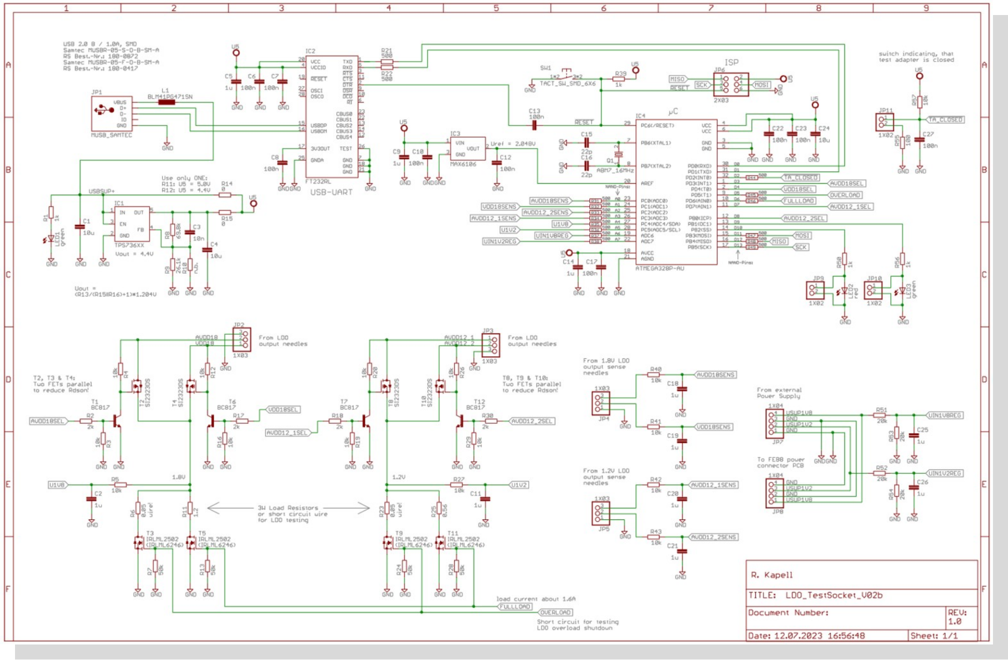


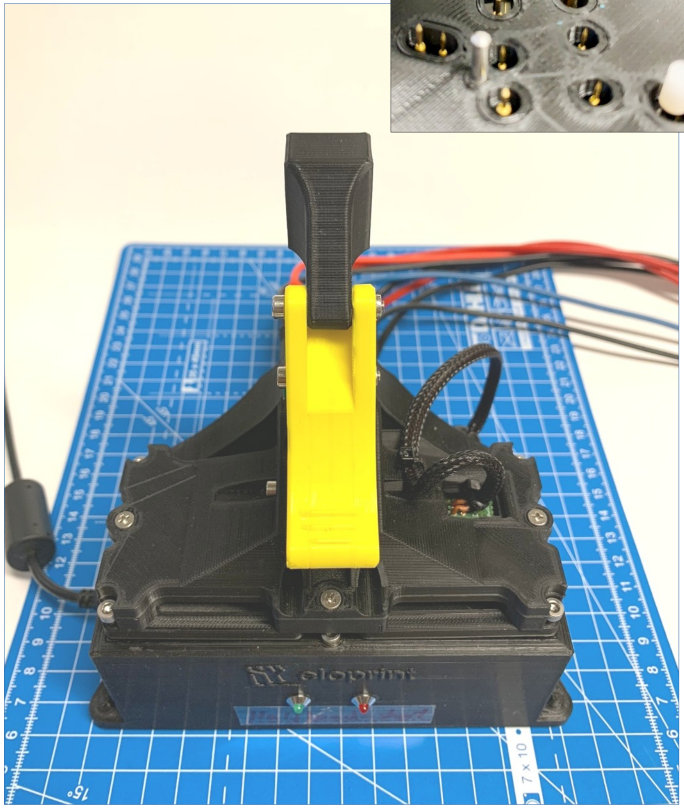
Module test setup

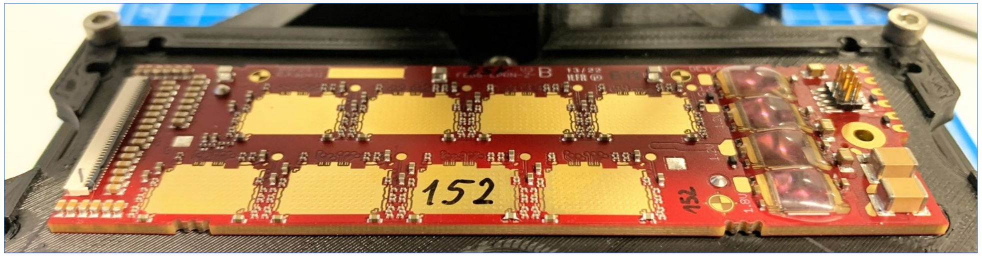


Sensor cover
- Passive
- Active
- IR Laser
- Source

LDO test setup

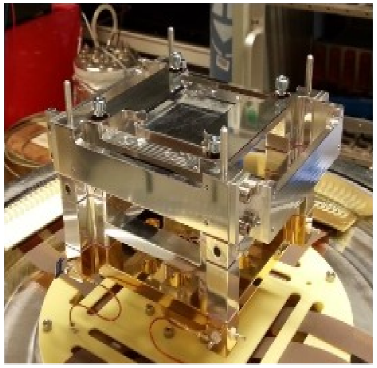






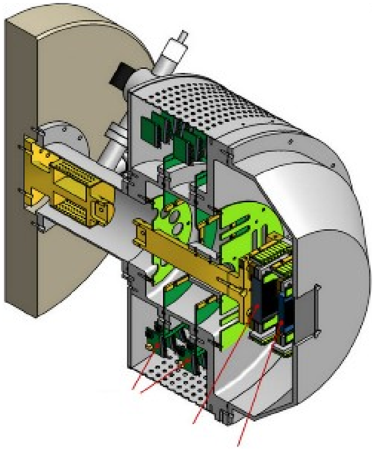
2D Segmented Si(Li) and HPGe Detectors for Compton Polarimetry

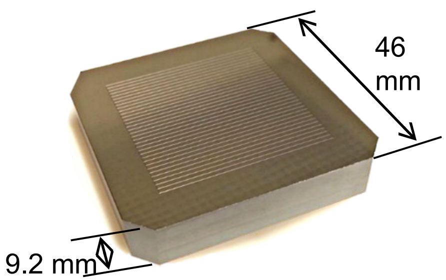
Compton telescope



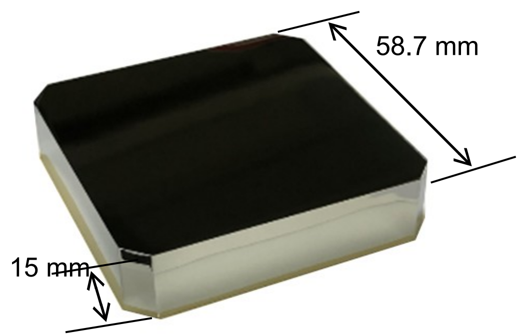
Crystal placement

Double sided segmented **Si(Li)- and HPGe-crystal mounted in telescope configuration increases energy range** from previously 200 keV to **1 MeV**

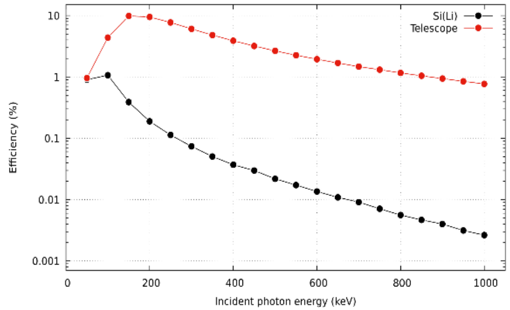




Si(Li) crystal



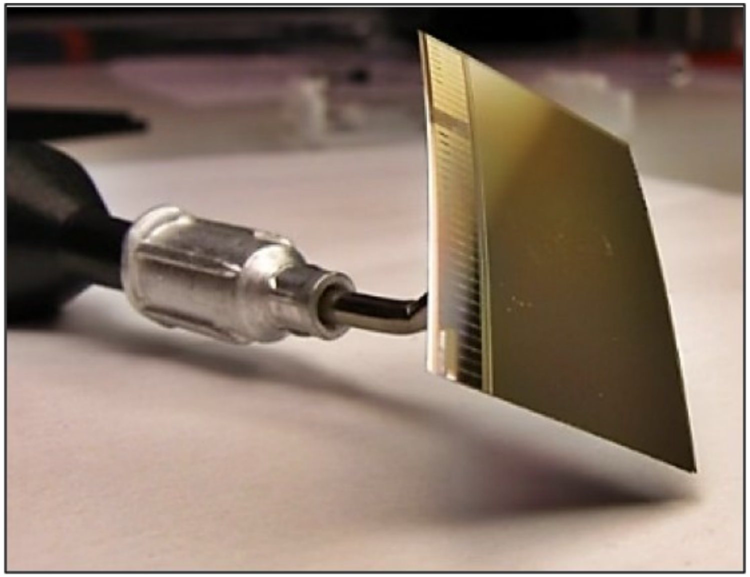
HPGe crystal

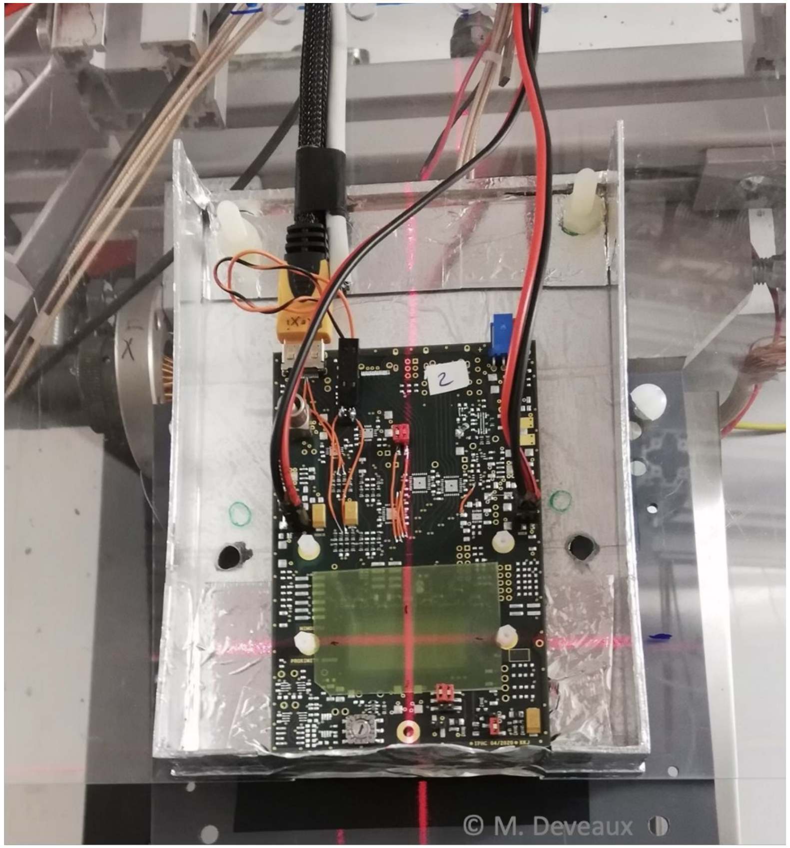


ALICE @ CERN

The **Time Projection Chamber (TPC)** is the main device for charged particle tracking and identification in the central barrel of the ALICE experiment at the CERN Large Hadron Collider. It is a 90 m3 cylinder filled with gas and divided in two drift regions by a central electrode located at its axial centre. Each of the two end plates is divided into 18 sectors holding the readout chambers. Signal amplification is provided by Gas Electron Multipliers (GEMs) in an optimized multilayer configuration, which stand up to the technological challenges imposed by continuous TPC operation at high rate. In particular, the requirement to keep the ion-induced space-charge distortions at a tolerable level leads to an upper limit of 2% for the fractional ion backflow, i.e. the ion escape probability per effective electron-ion pair produced in the gas amplification stage. The readout of the signals is done by 524160 anode pads, each one connected to a front-end electronics channel. The signals are continuously digitized on 3276 FECs, and the digitized data are sent through 6552 optical links. This leads to an unprecedented data throughput of 3.28 TB/s.

Together with the IPHC Strasbourg and the IKF of the Goethe University Frankfurt, we design and test our own CMOS Monolithic Active Pixel Sensors. Our present prototypes of the MIMOSIS-series are among the world leading sensors of this kind and are designed to take 200'000 frames per second (5 µs time resolution) and to resist radioactive doses of >5 MRad and $>10^{14}$ n_{eq}/cm^2.





LGAD technology at GSI

Detector Requirements:

- **Radiation-hard design** to ensure performance in high-radiation environments.
- **Ultra-fast in-beam time-zero detection** for precise Particle Identification (PID) via time-of-flight measurements.
- **Beam monitoring functionality** capable of detecting signals down to Minimum Ionizing Particles (MIPs).
- **Low material budget** to minimize interference with particle detection.
- **Vacuum-compatible operation** with passive cooling for efficient thermal management.

LGAD Performance Demonstrated at GSI with Strip Detectors (2020):

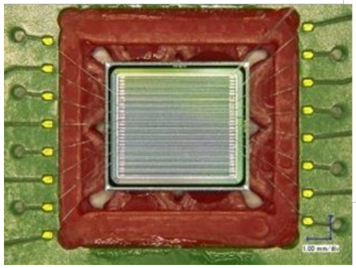
- **Exceptional time precision** below **50 ps**.
- **Ultra-thin sensor design** with thickness below **200 µm**.
- **Efficient operation** with passive cooling at room temperature.
- **Fine pitch** below **100 µm** for high spatial resolution.

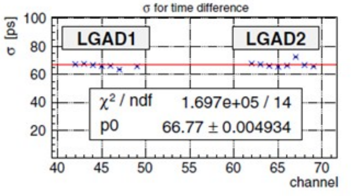
International Cooperation in Sensor Testing and Development:

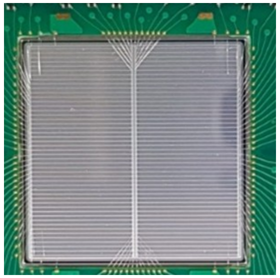
- **Two dedicated GSI LGAD productions at FBK:**
- **2020:** R&D production focused on **large-area strip sensors** (2 cm × 2 cm).
- **2025:** High fill-factor LGAD production at FBK, featuring:
  - **Novel Trench-Isolated (TI-LGAD) technology.**
  - **Fill factor close to 100%.**

Several beam tests conducted at MedAustron confirmed the expected performance.

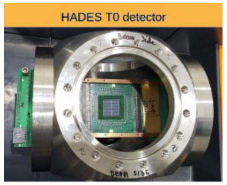
J. Pietraszko, *et al.*, Eur. Phys. J. A 56, 183 (**2020**)





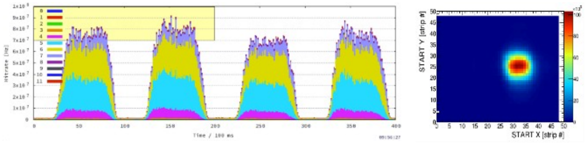


1. **Start reaction time (T0) detector at HADES:**

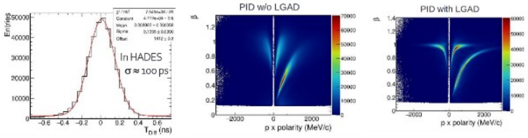


LGADs were used in a p-p production testbeam at HADES in 2022

- 2x2cm^2 LGADs strip sensors with 2x48 half strips
- Additional carbon implanting for radiation hardness

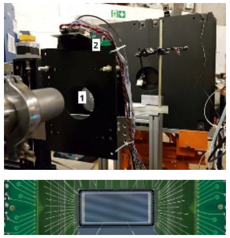


LGADs for online rate and beam spot measurements



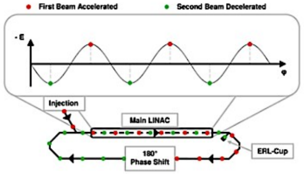
T0 estimation for particle identification (PID)

2. **LGADs at S-DALINAC in Darmstadt**

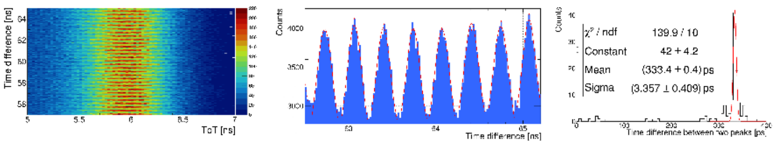


Beam monitoring at S-DALINAC

- Linear electron accelerator with energy recovery (ERL) mode (6GHz bunches) and normal 3GHz mode
- 0.5x1cm^2 LGAD strip sensors with 50µm strip pitch to measure the time structure as proof-of-concept

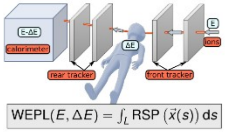


ERL concept at S-DALINAC



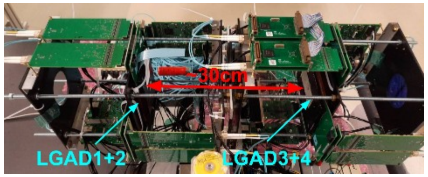
Performance of time structure measurement

3. **LGADs for ion computed tomography (iCT)**

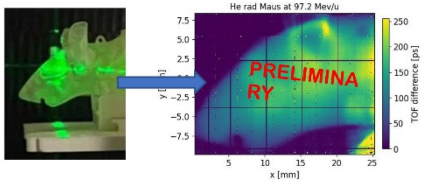


Direct measurement of stopping power map inside the patient

- Better accuracy than x-ray CT
- LGADs allow new compact and fast time-of-flight-based imaging modality (TOF-iCT)



LGAD-based TOF-iCT demonstrator at GSI

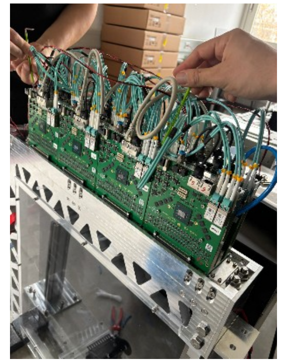


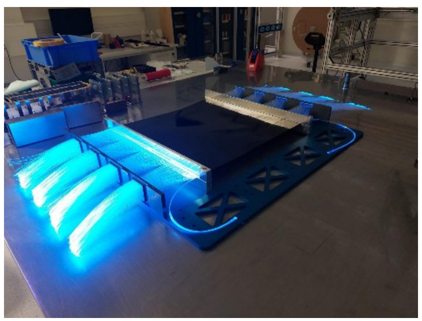
First experimental TOF-Helium radiography of a mouse phantom

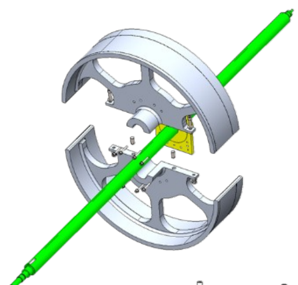
SciFi Trackers - Assembly Infrastructure

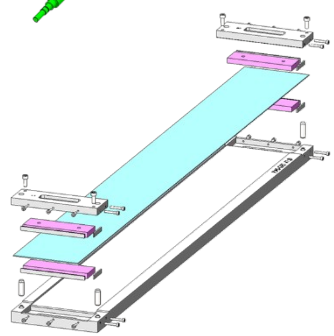
We produce inhouse square fibers ribbons. Single and multi layer ribbons with a really high homogeneity.

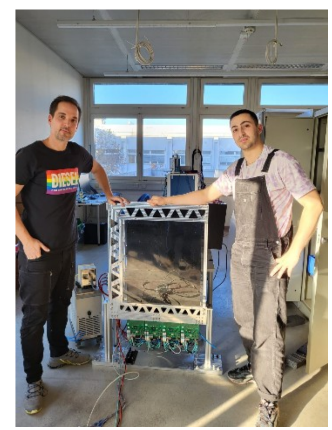
The tooling and machinery necessary has been developed at DTL and has been used with fibers (wires) from 20 to 1000 μm.







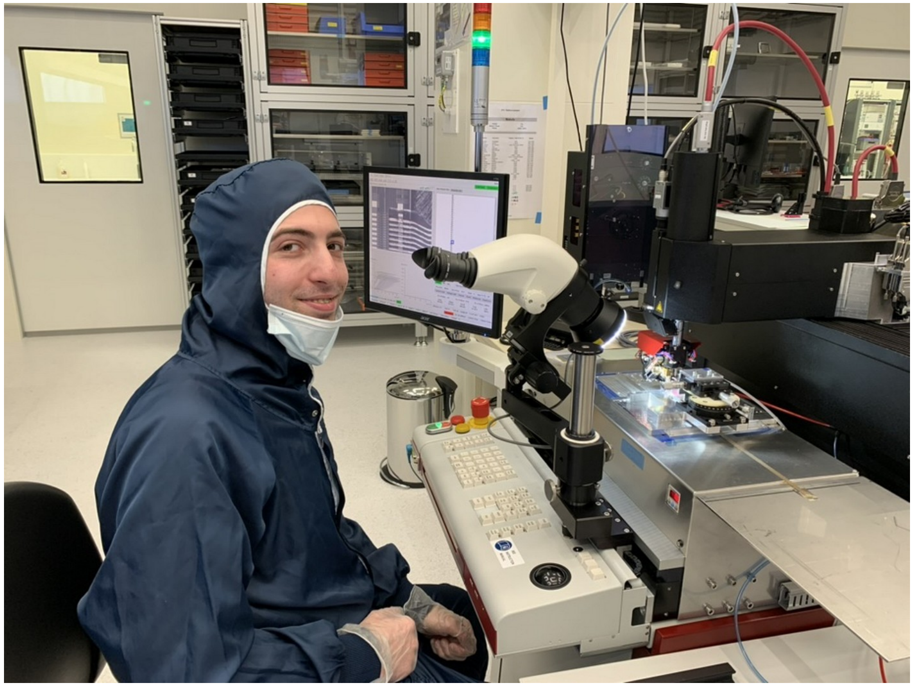




David & Dachi

TSU Physics, February 2024

Nika & Otari




14:18
LTE
universeinthelab 15m
get_involved_with_fair
These two students worked in the Detector Lab @universeinthelab
get_involved_with_fair Meet Alexander Sainishvili and Ioane Devdariani, tw... mehr
Send message

Thanks / Questions