

A detailed wireframe model of a particle detector, likely a synchrotron. It features a large, oval-shaped main ring with a complex internal structure, and a smaller, more intricate section at the top. The model is rendered in a light gray wireframe style, showing the various components and their arrangement.

# Detector Laboratory at GSI

Irakli Keshelashvili  
[i.keshelashvili@gsi.de](mailto:i.keshelashvili@gsi.de)

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





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



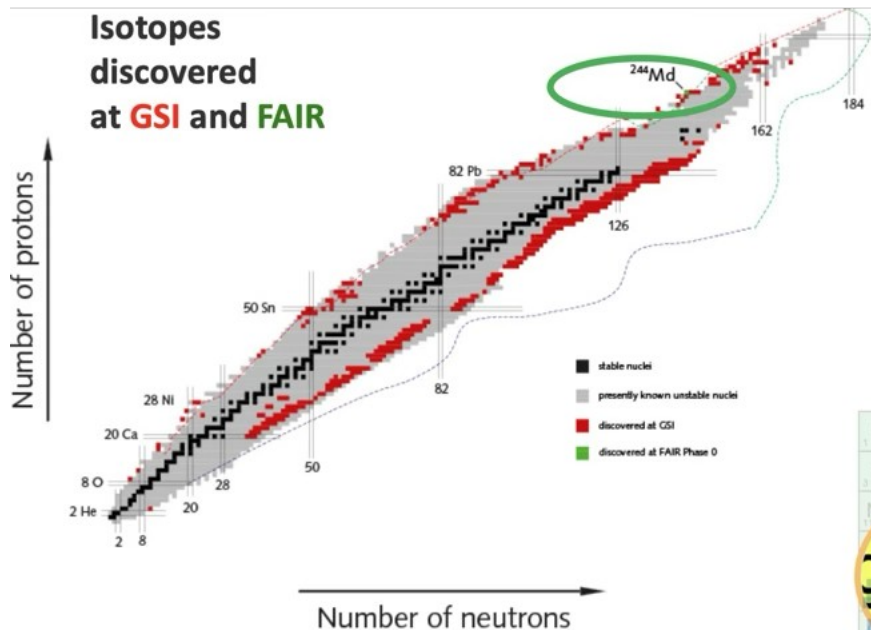


- Existing facility: GSI Darmstadt (Foundation: 1969)
- Shareholders: federal government (90%), Hesse (8%), Rhineland-Palatinate (1%), Thuringia (1%)
- Further locations in Mainz and Jena
- Future facility: FAIR (Foundation: 2010)
- Employees on location: approx. 1450
- Integrated organization FAIR and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

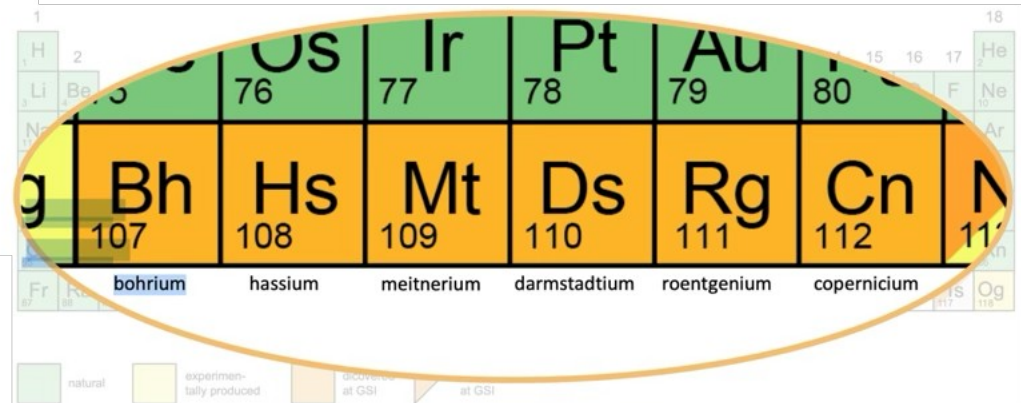


# Production of new elements

Isotopes  
discovered  
at GSI and FAIR



- 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.







## Construction volumes

**2 million m<sup>3</sup> of earth**

to be moved

As much as for 5,000 single-family homes



**600,000 m<sup>3</sup> of concrete**

to be used

As much as eight Frankfurt soccer stadiums



**65,000 tons of steel**

to be utilized

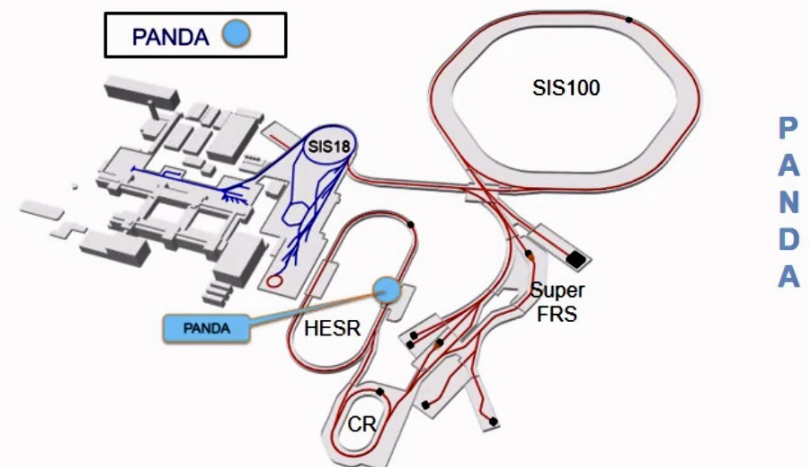
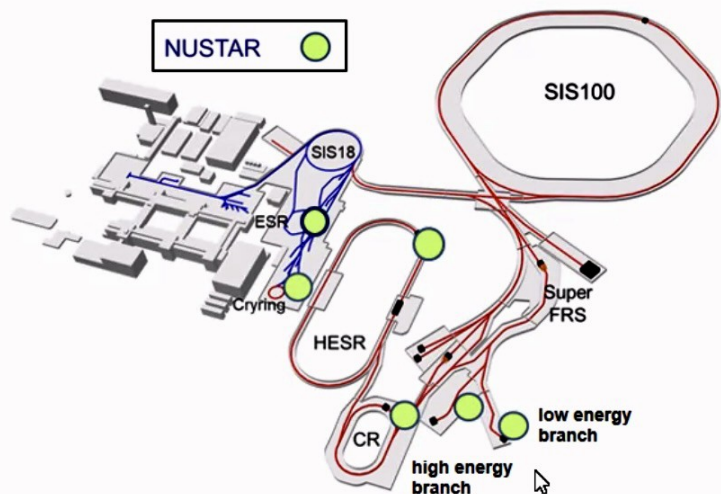
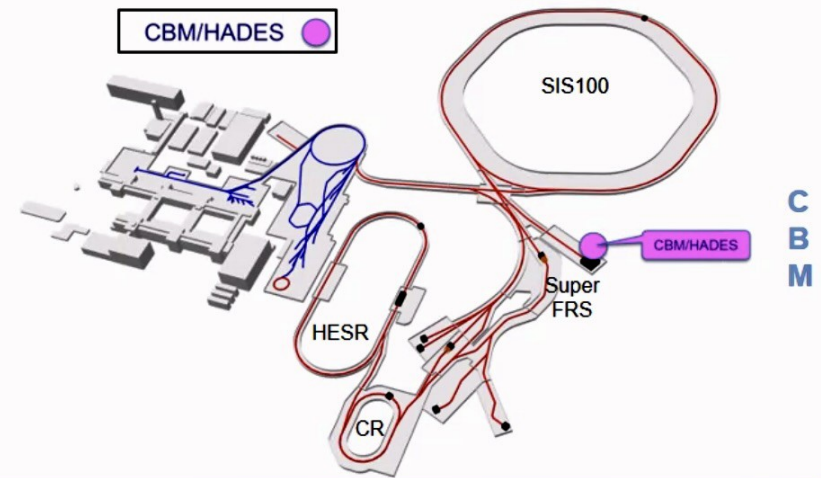
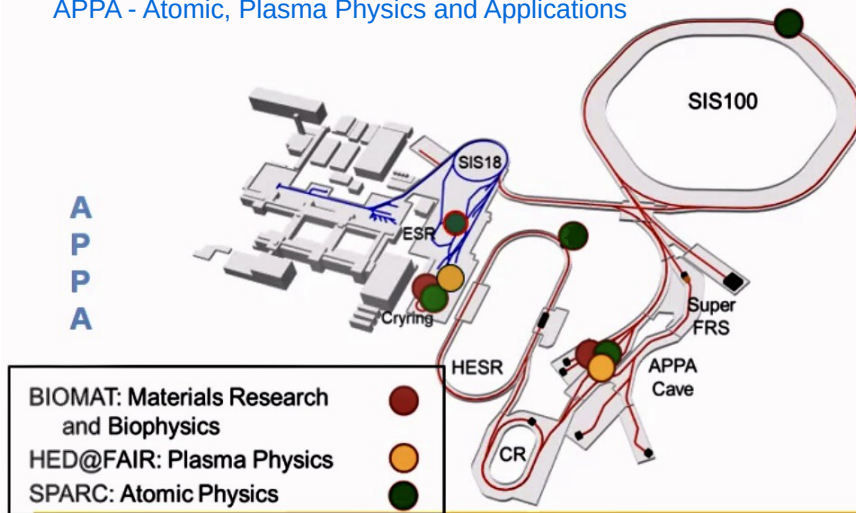
As much as nine Eiffel Towers





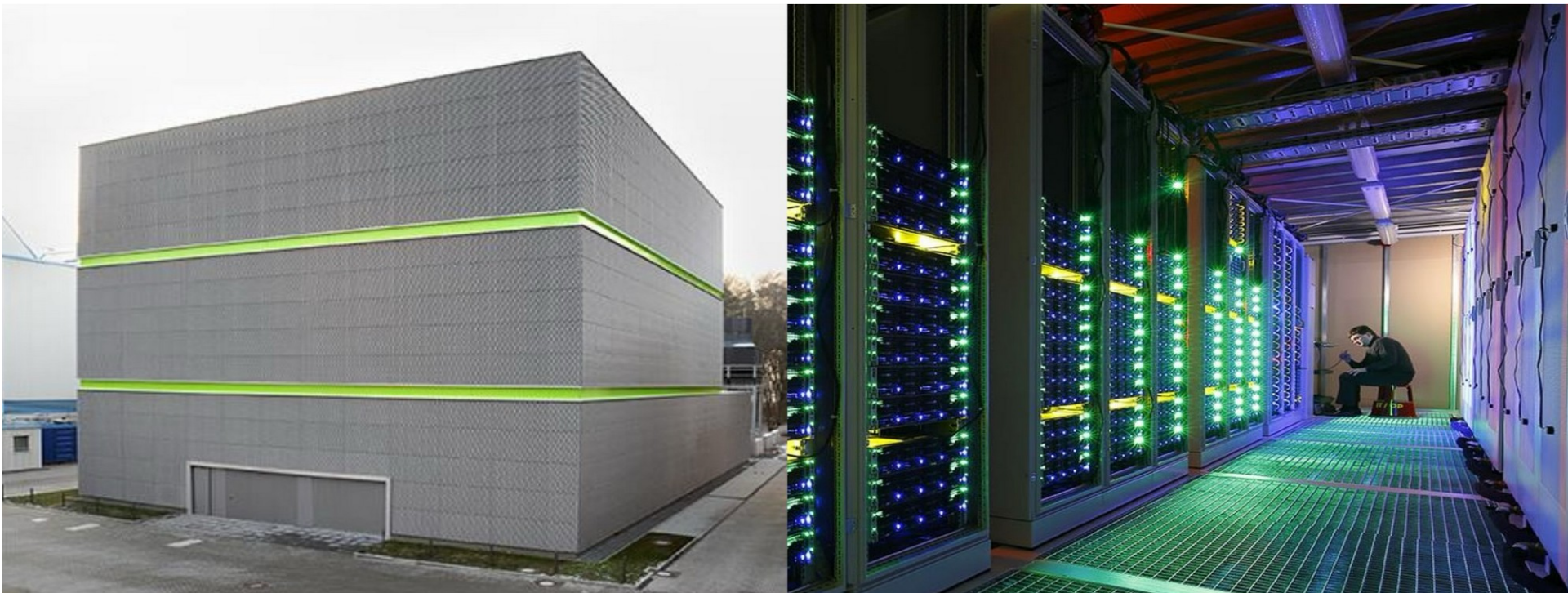
# FAIR Experiment Locations

## APPA - Atomic, Plasma Physics and Applications

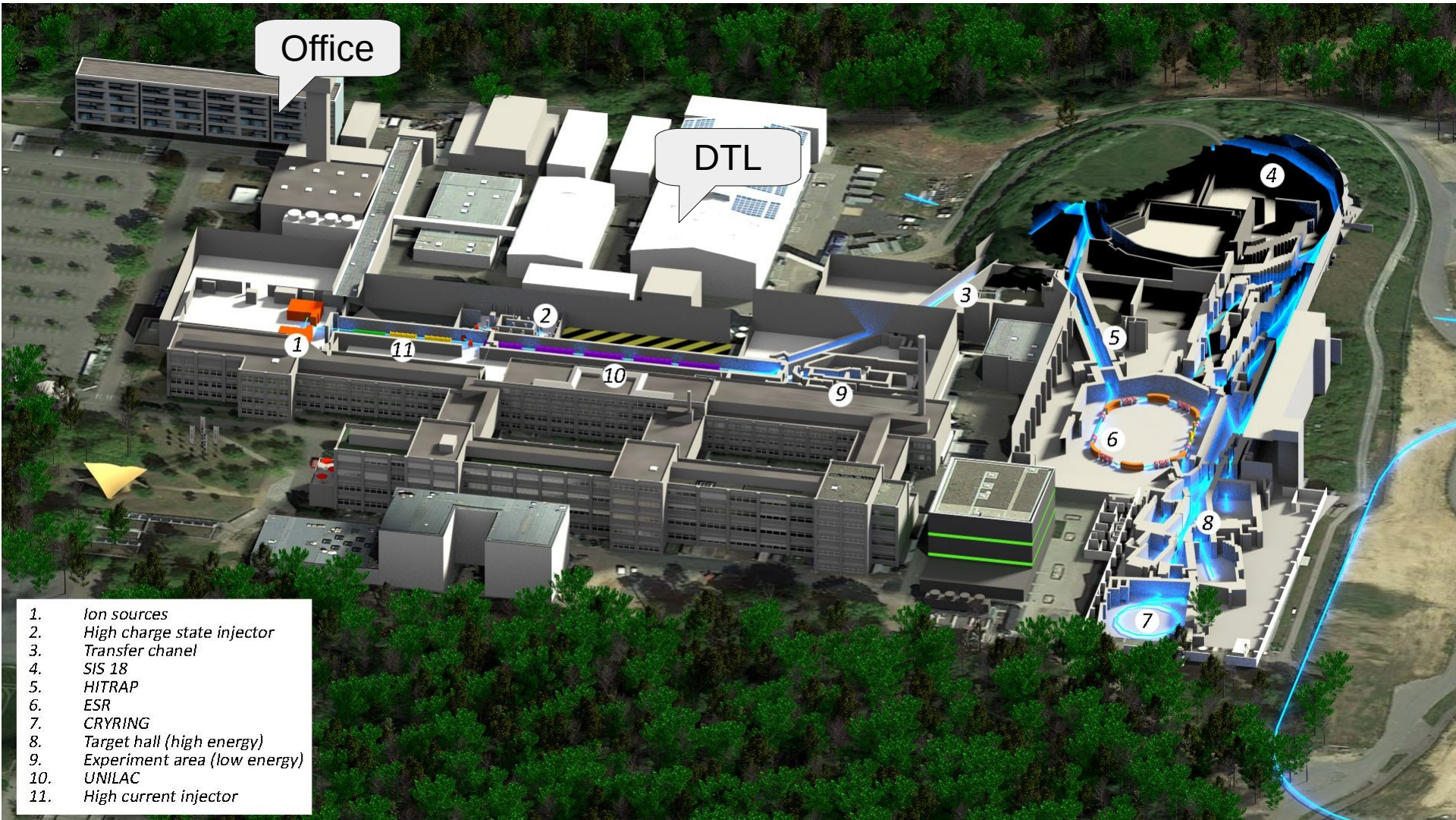


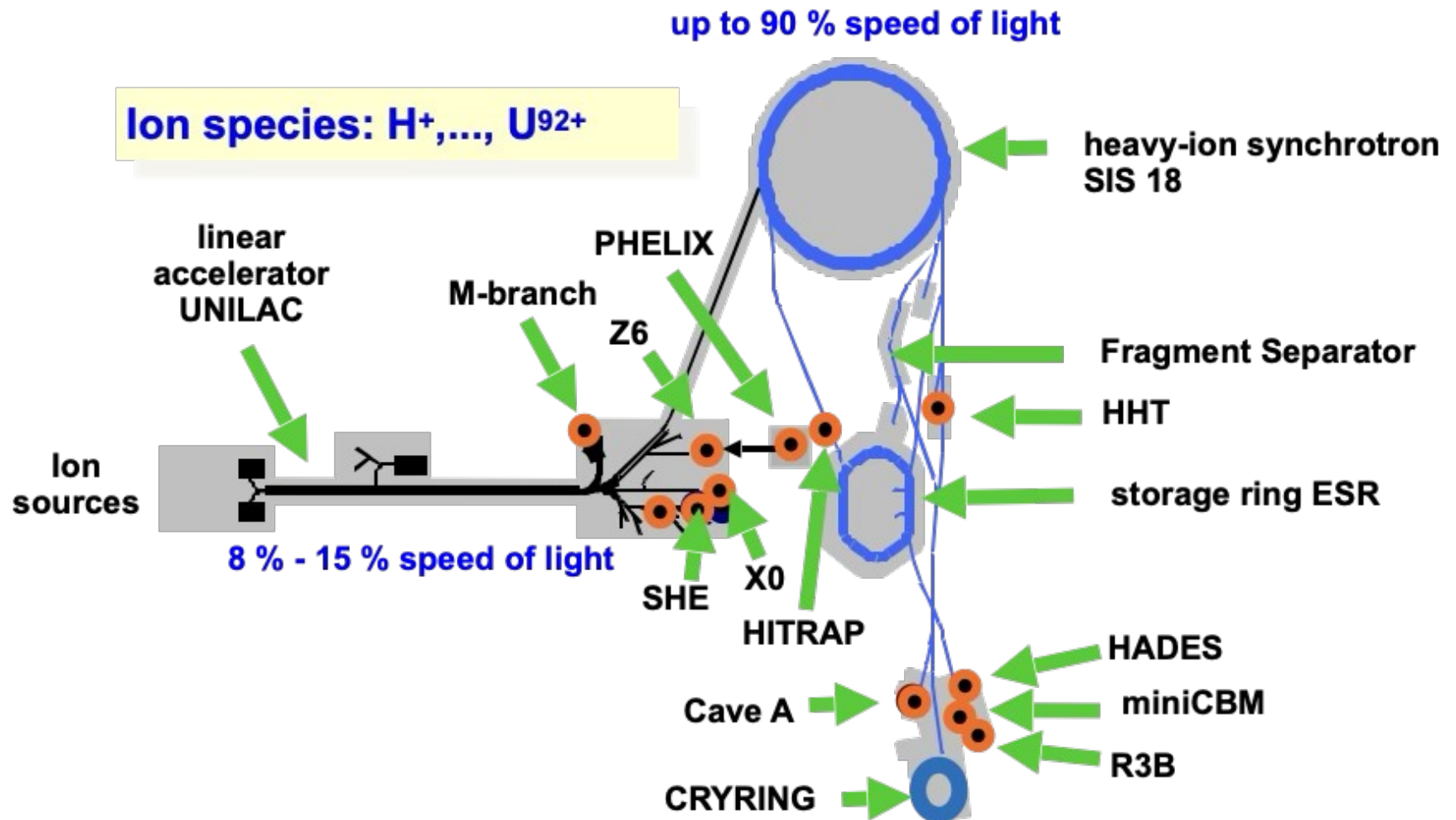
## NUSTAR - Nuclear Structure, Astrophysics and Reactions

# High-performance scientific computing, Big Data, Green IT





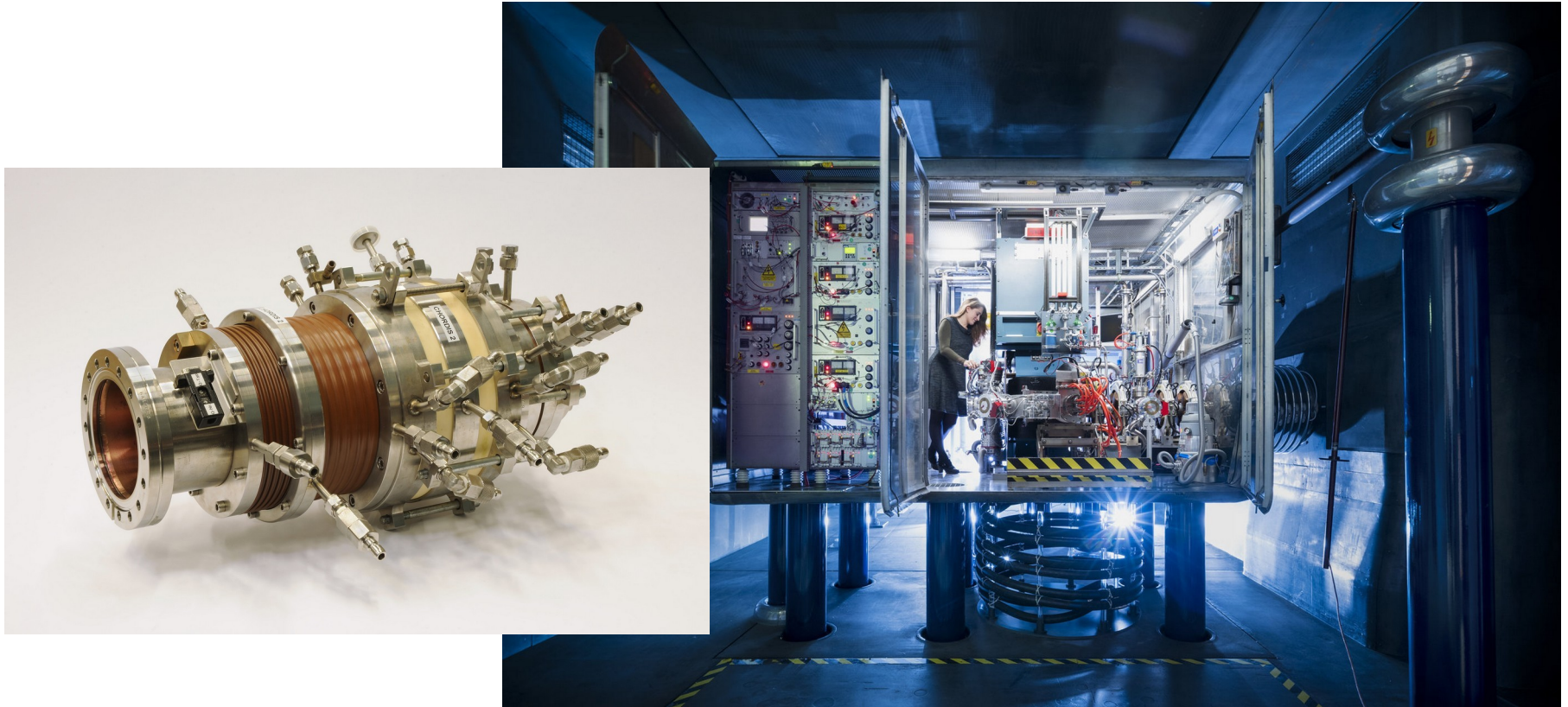






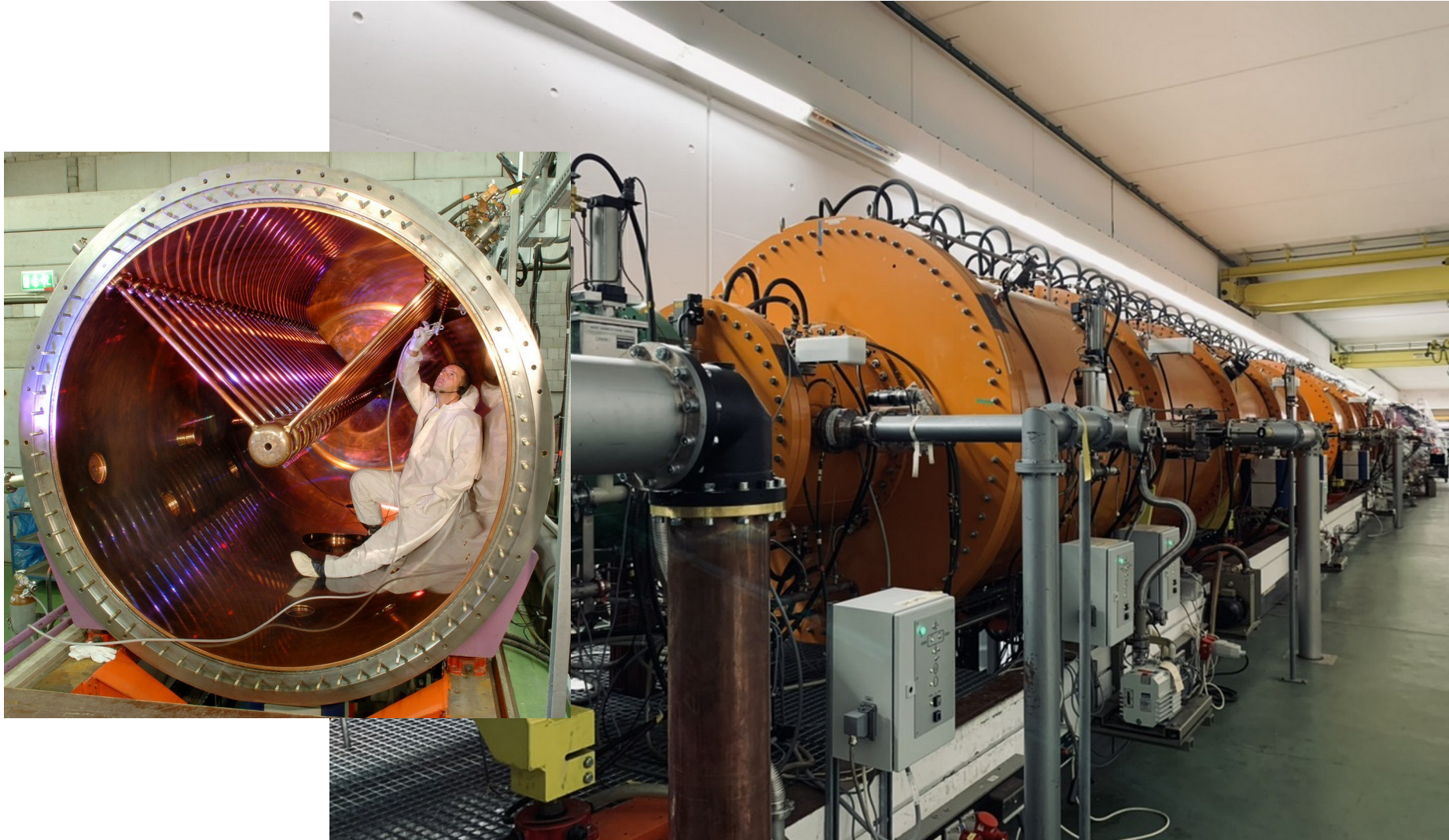
# Starting point accelerator: Ion sources

[https://www.gsi.de/en/researchaccelerators/accelerator\\_facility/ion\\_sources](https://www.gsi.de/en/researchaccelerators/accelerator_facility/ion_sources)





# The UNlversal Linear Accelerator





# The UNlversal Linear Accelerator



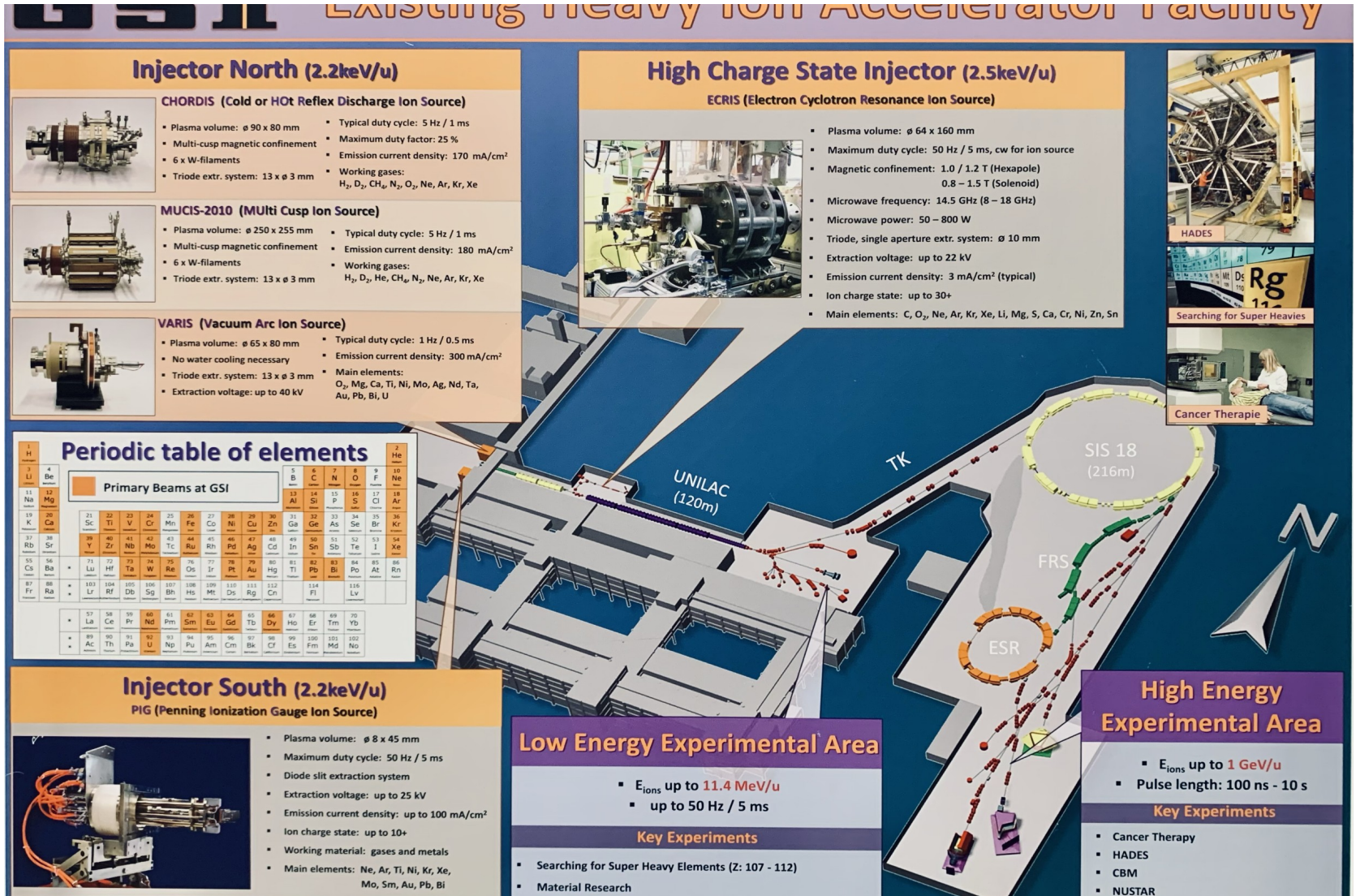


# The UNiversal Linear Accelerator

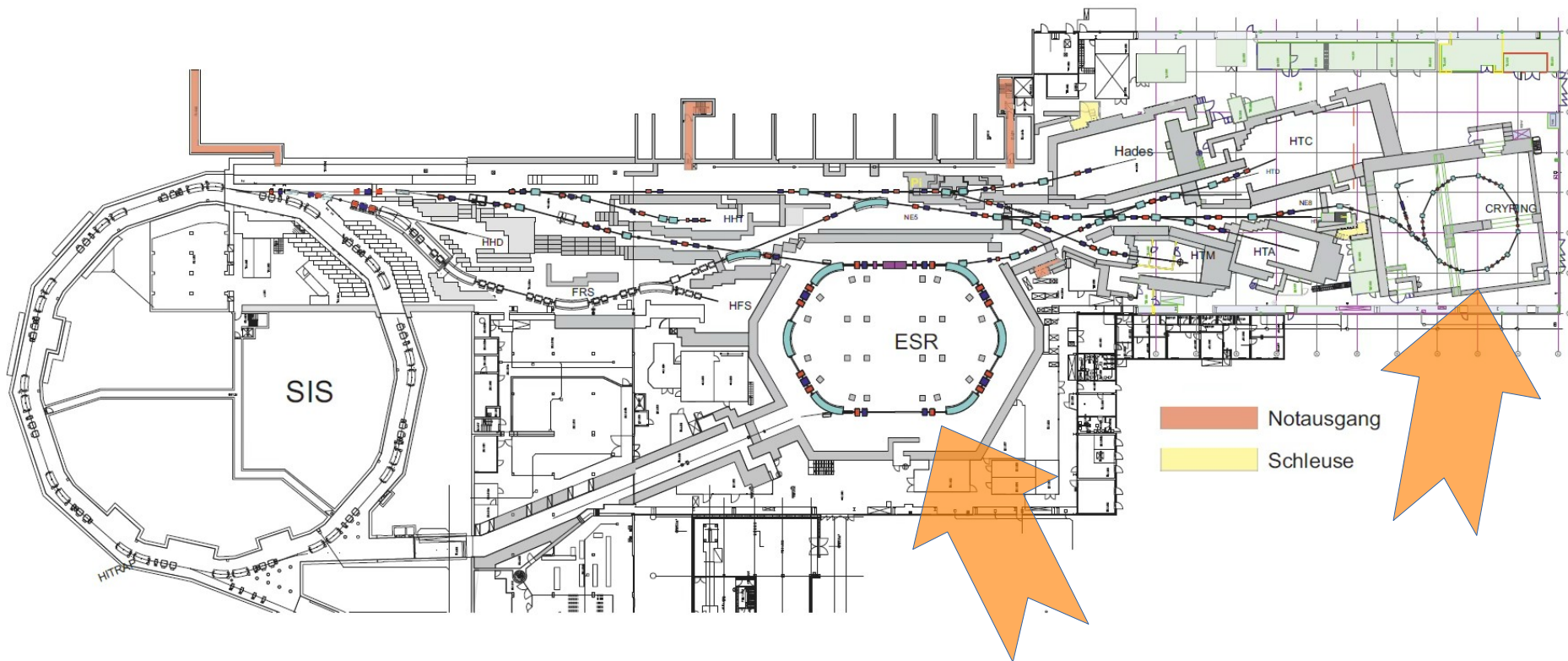


**Total leangth 120m**



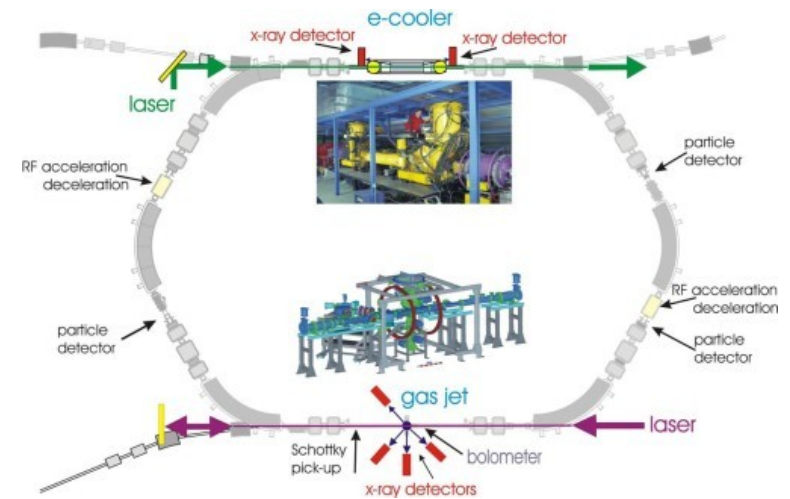
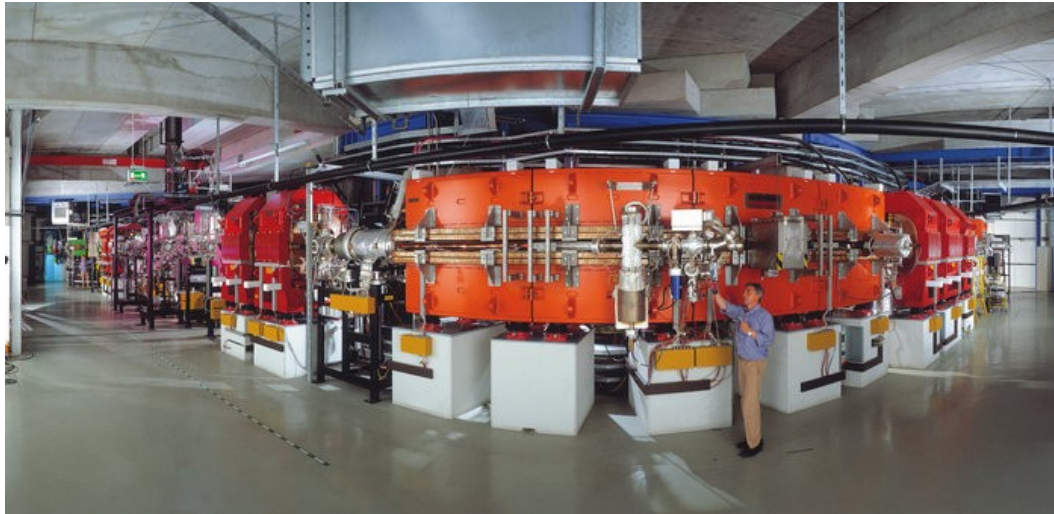


# SIS18 and Experimental Area





# The Heavy Ion Storage Ring ESR



# CRYRING



2015, M. Lestinsky (GSI)



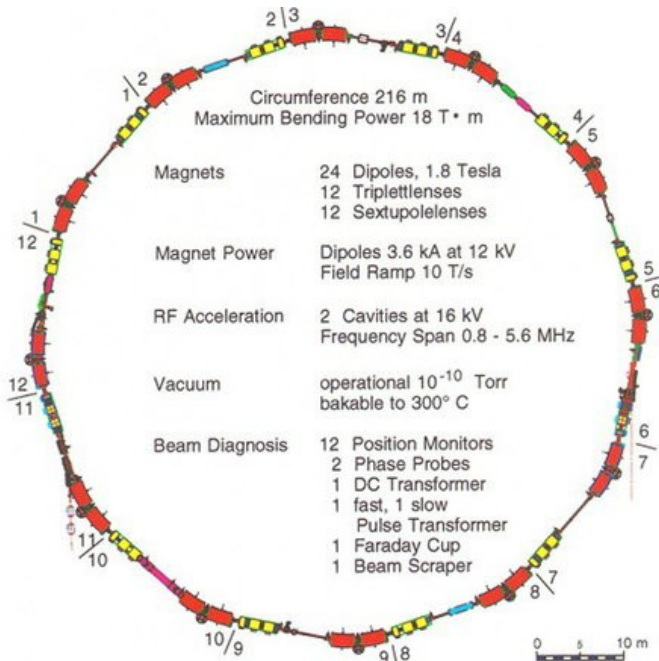
# SIS (German: SchwerionenSynchrotron)

Illustration: Heavy-ion synchrotron SIS18 with sections

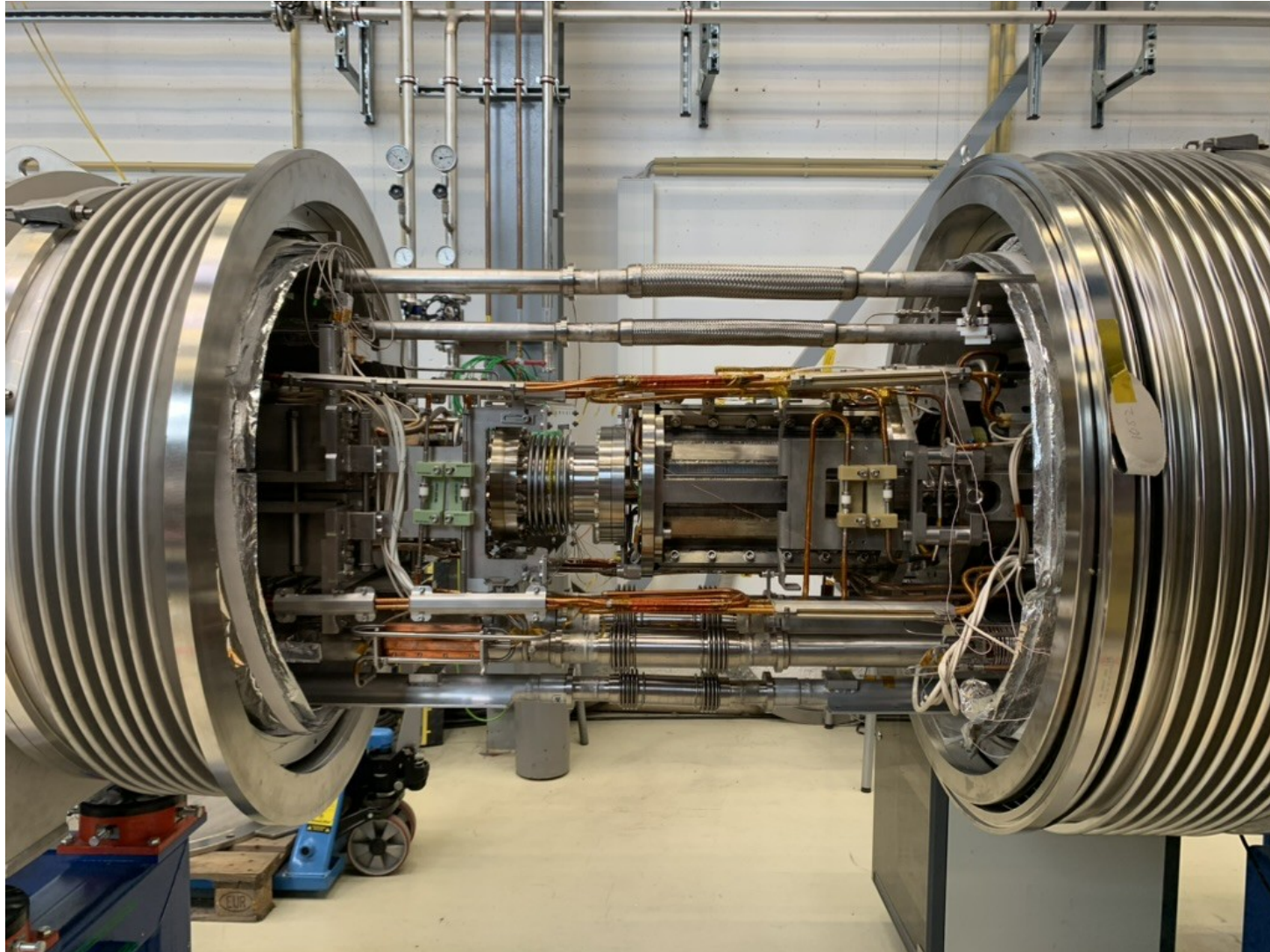
Circumference: 216 m

Maximum magnetic rigidity: 18 Tm

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

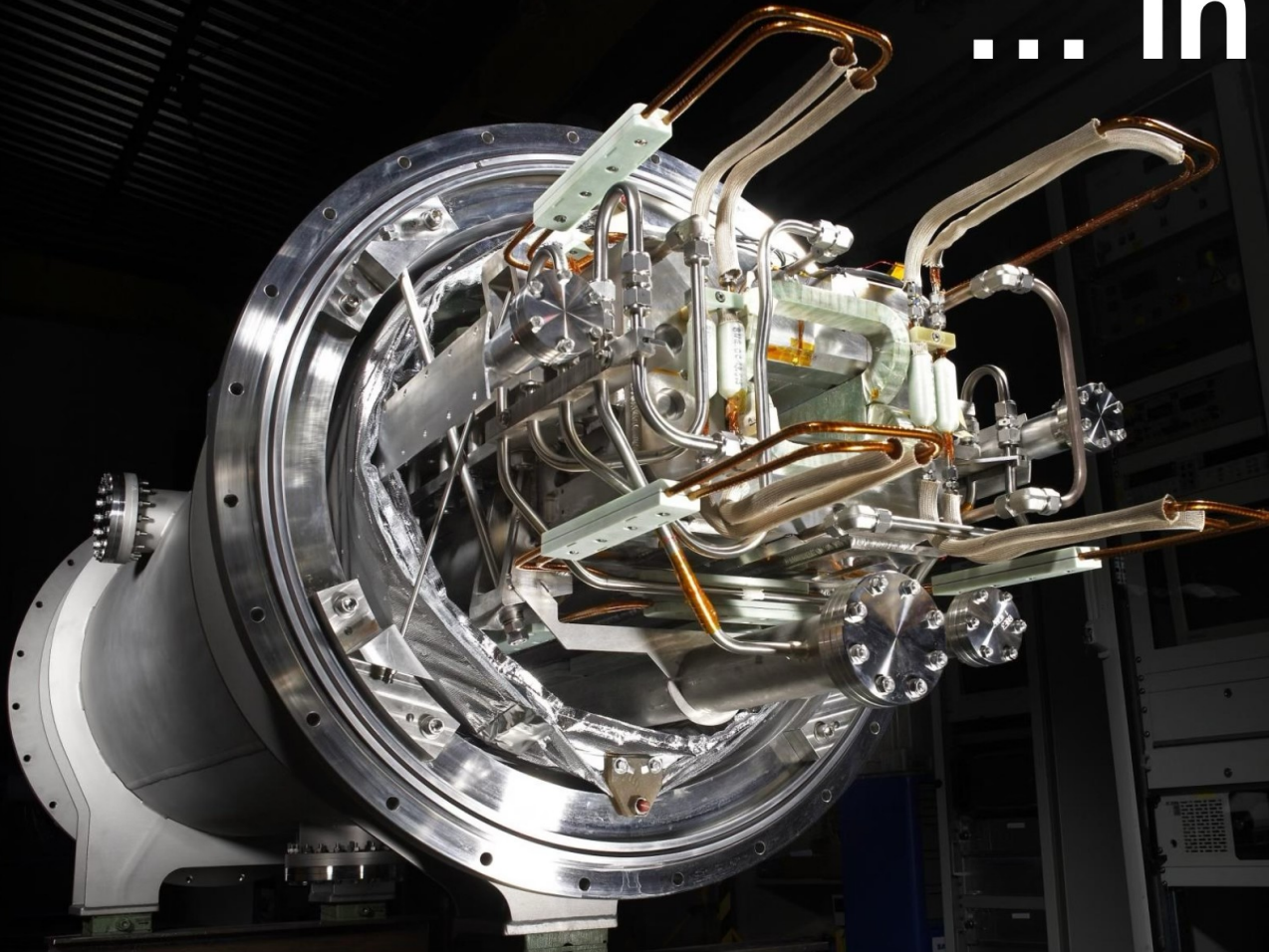


# SIS 100 Super Conducting Dipole





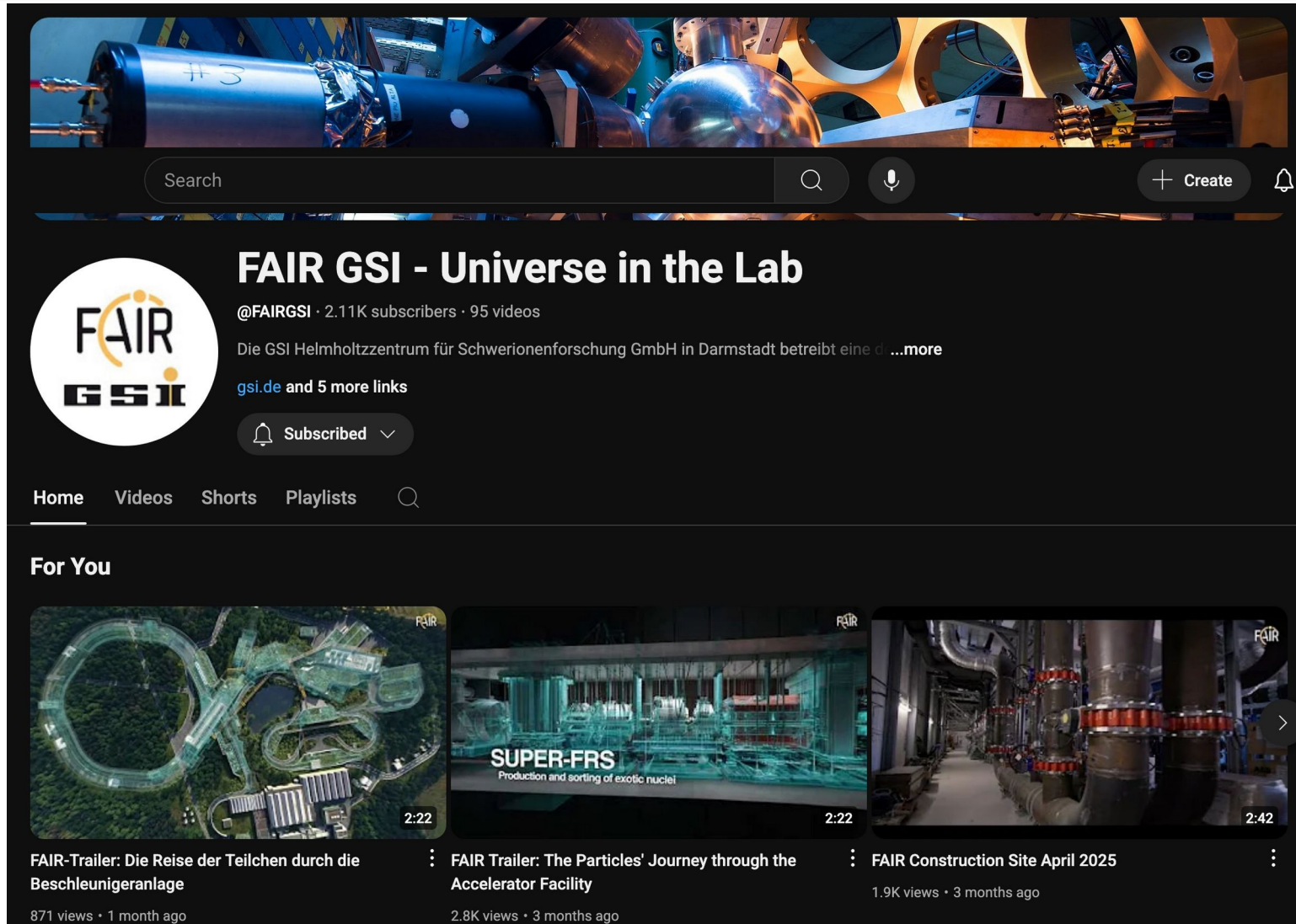
... in the lab.



<https://www.youtube.com/FAIRGSITheUniverseinthelab>







The image shows the YouTube channel page for 'FAIR GSI - Universe in the Lab'. The header features a banner image of a particle accelerator component. Below the banner is a search bar and a '+ Create' button. The channel's profile picture is a circular logo with 'FAIR' and 'GSI' text. The channel name 'FAIR GSI - Universe in the Lab' is prominently displayed, followed by the handle '@FAIRGSI', 2.11K subscribers, and 95 videos. A description states that the GSI Helmholtzzentrum für Schwerionenforschung GmbH in Darmstadt operates a... more. Below the description are links to 'gsi.de' and 5 more links. A 'Subscribed' button with a bell icon is visible. The navigation bar includes 'Home', 'Videos', 'Shorts', and 'Playlists'. The 'For You' section displays three video thumbnails: 'FAIR-Trailer: Die Reise der Teilchen durch die Beschleunigeranlage' (871 views, 1 month ago), 'FAIR Trailer: The Particles' Journey through the Accelerator Facility' (2.8K views, 3 months ago), and 'FAIR Construction Site April 2025' (1.9K views, 3 months ago).

Search

+ Create

**FAIR GSI - Universe in the Lab**

@FAIRGSI · 2.11K subscribers · 95 videos

Die GSI Helmholtzzentrum für Schwerionenforschung GmbH in Darmstadt betreibt eine d...more

[gsi.de](#) and 5 more links

Subscribed

Home Videos Shorts Playlists

**For You**

**FAIR-Trailer: Die Reise der Teilchen durch die Beschleunigeranlage**

871 views · 1 month ago

**FAIR Trailer: The Particles' Journey through the Accelerator Facility**

2.8K views · 3 months ago

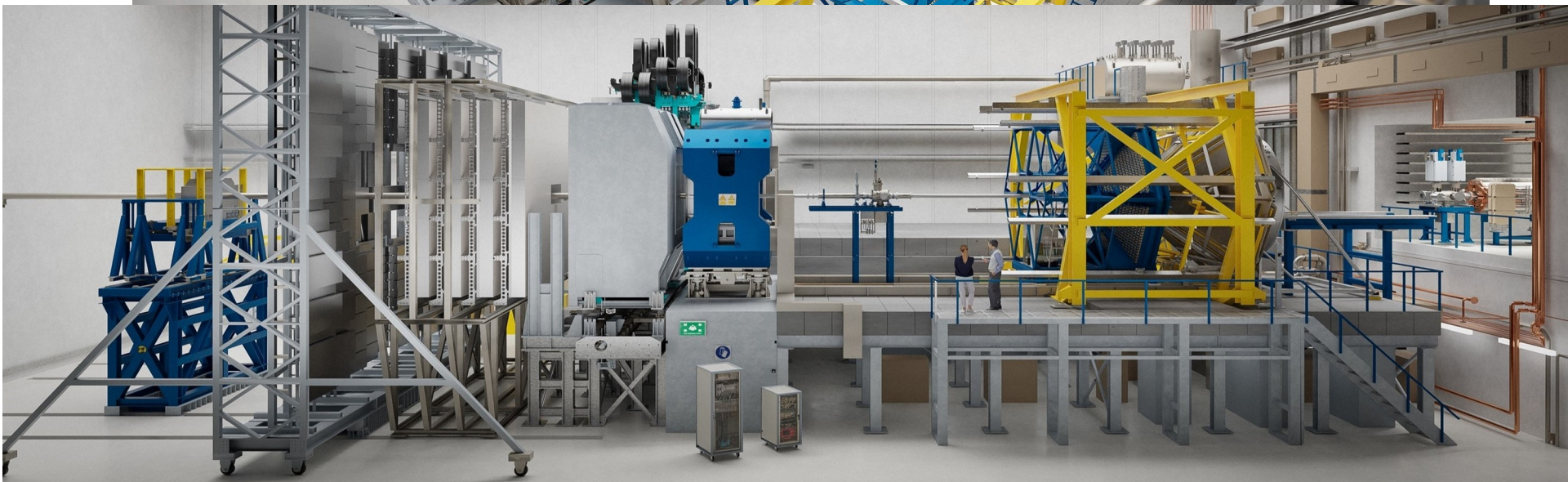
**FAIR Construction Site April 2025**

1.9K views · 3 months ago





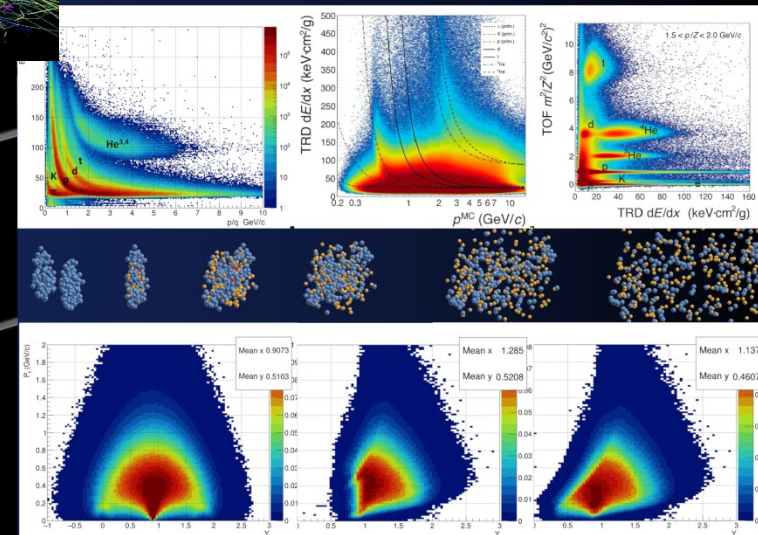
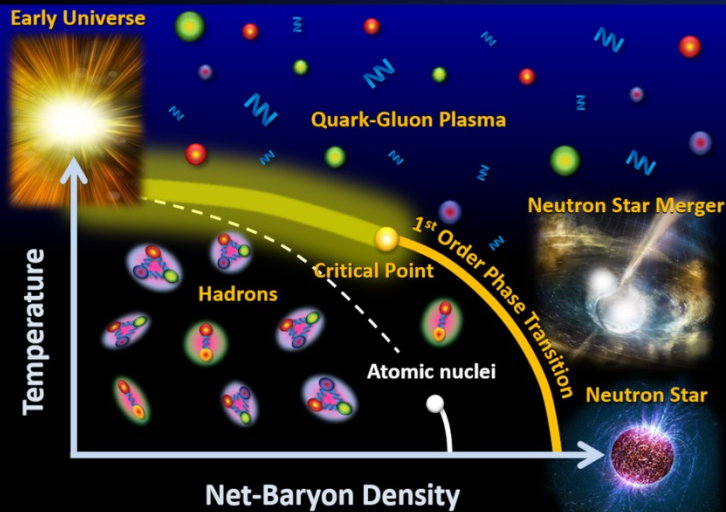
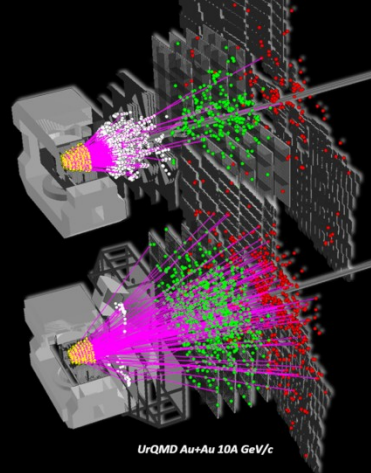
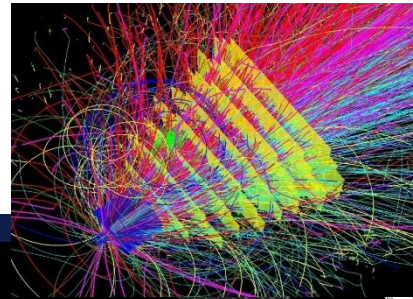
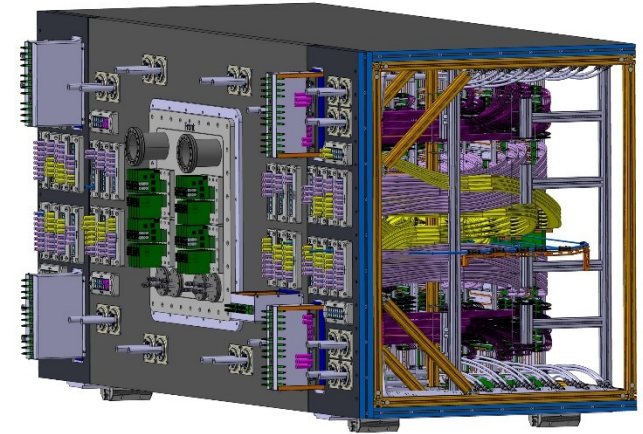
# CBM Compressed Baryonic Matter





# CBM Compressed Baryonic Matter

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

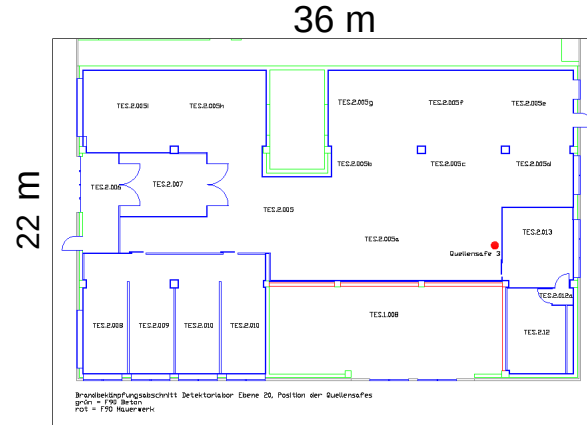




# Detector Laboratory at GSI

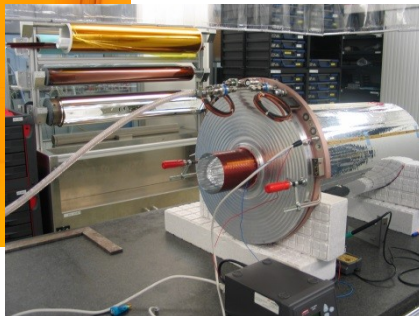
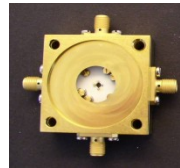
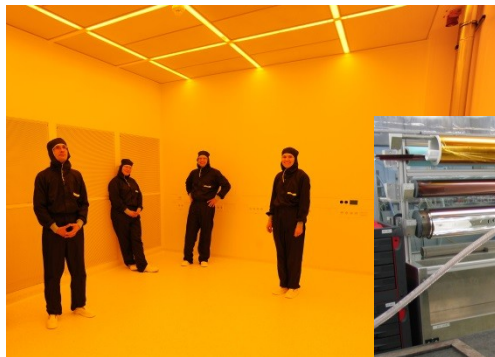


# Detector Laboratory: 600 m<sup>2</sup> Clean-Room



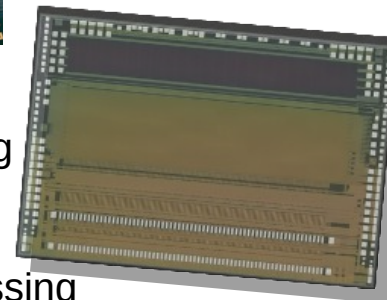
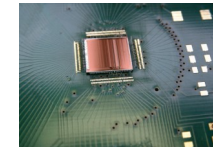
## Competences:

- 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

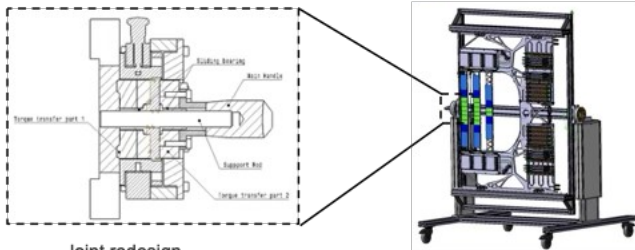




- Topology optimization of the C-Frames
- All Units of STSD optimized, STSU almost done
- Front wall updated for the new Roptec
- Small component finalization e.g. ROB
- Unit assembly table joint update

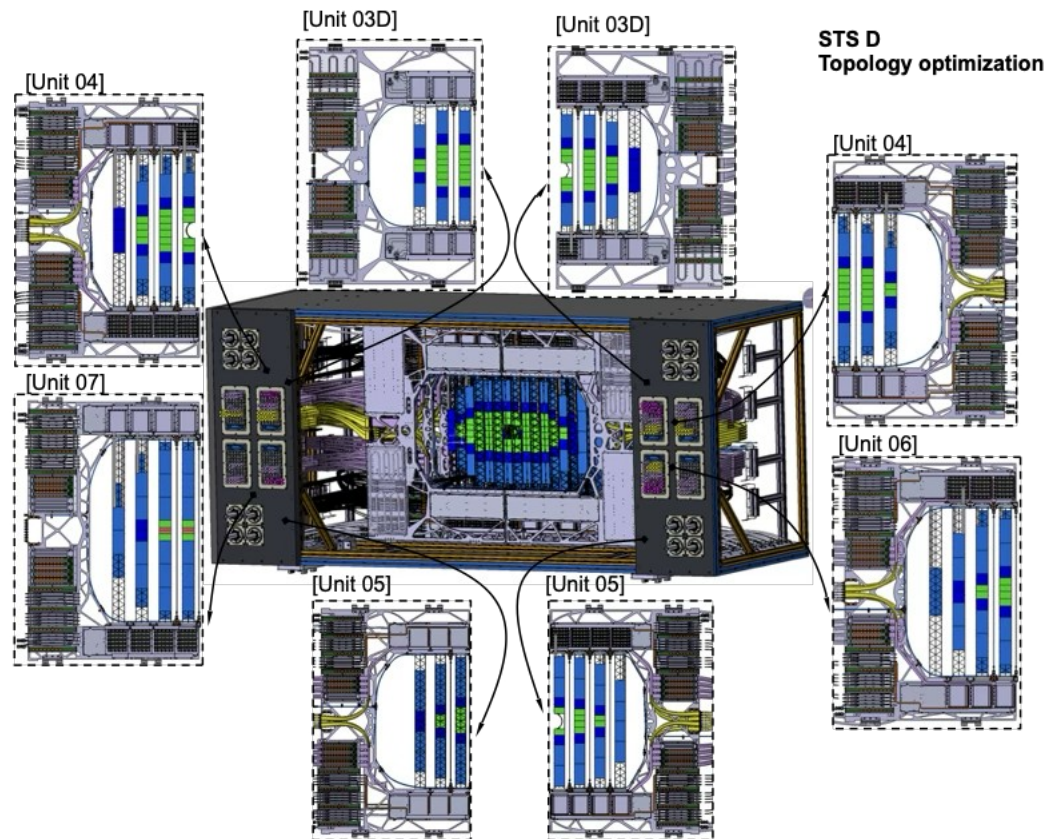
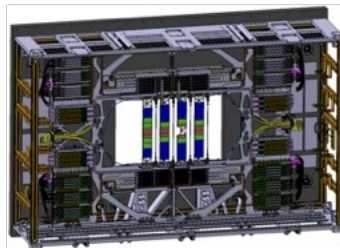


Updating ROB & its cooling block Design



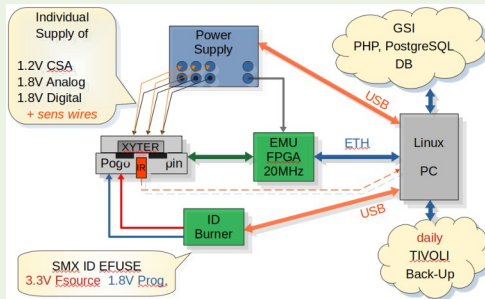
- Joint redesign
- Increased stiffness and fixation point amount
- 3D Printed prototype
- Production soon

STS U  
Topology optimization

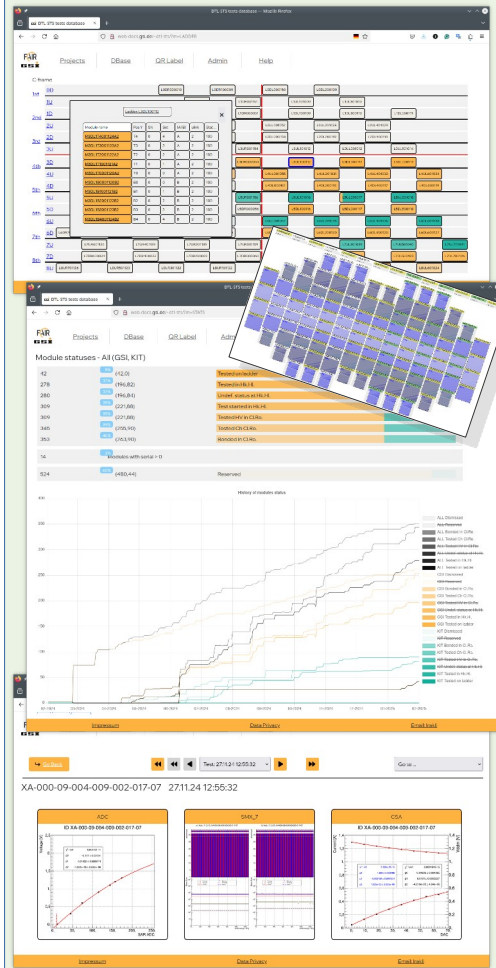


O. Vasylyev/GSI Status of mechanics for STS Engineering

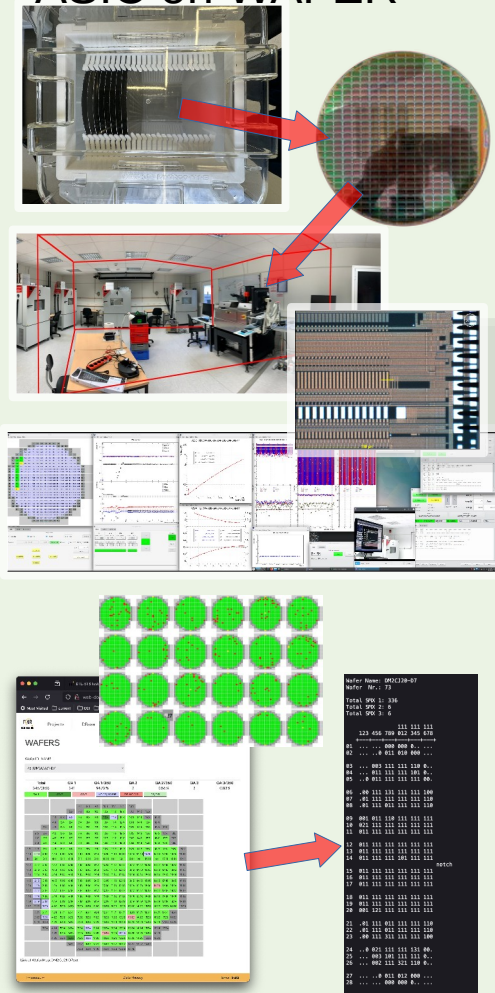
## Test SW/HW



## DB / Web interface

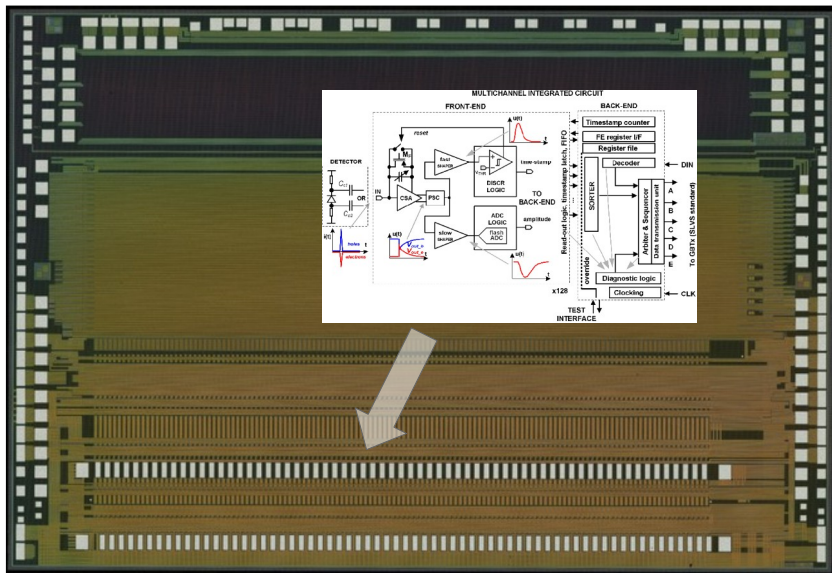


## ASIC on WAFER





# Test of XYTER ASIC



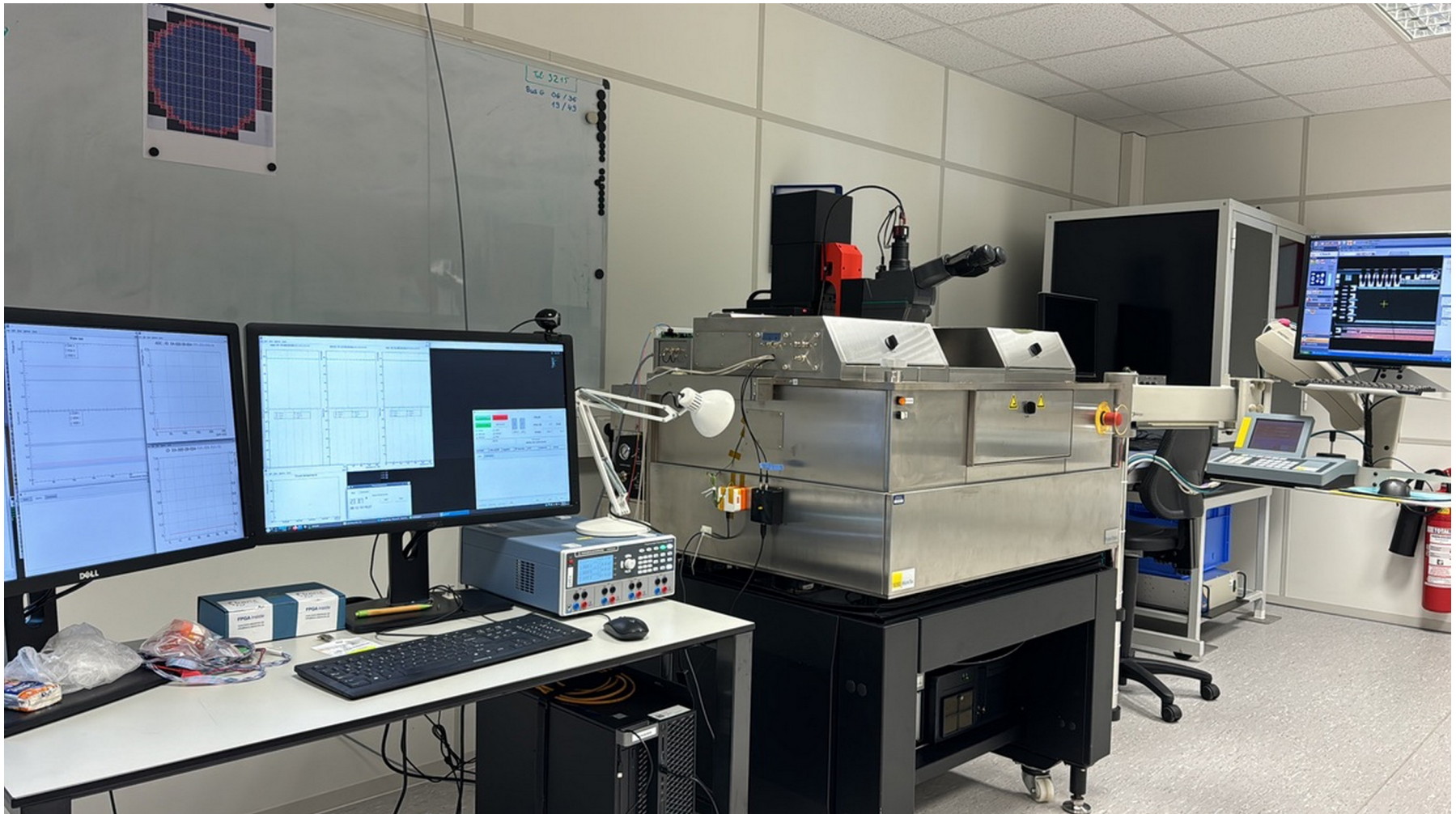
## Introduction

Step-by-step test procedure

FAIR GSI

Data base  
With Web interface  
Accessible from all  
Assembly sites

FAIR GmbH | GSI GmbH    Module in-production quality assurance    2/21





# Wafer test software (5 x module)

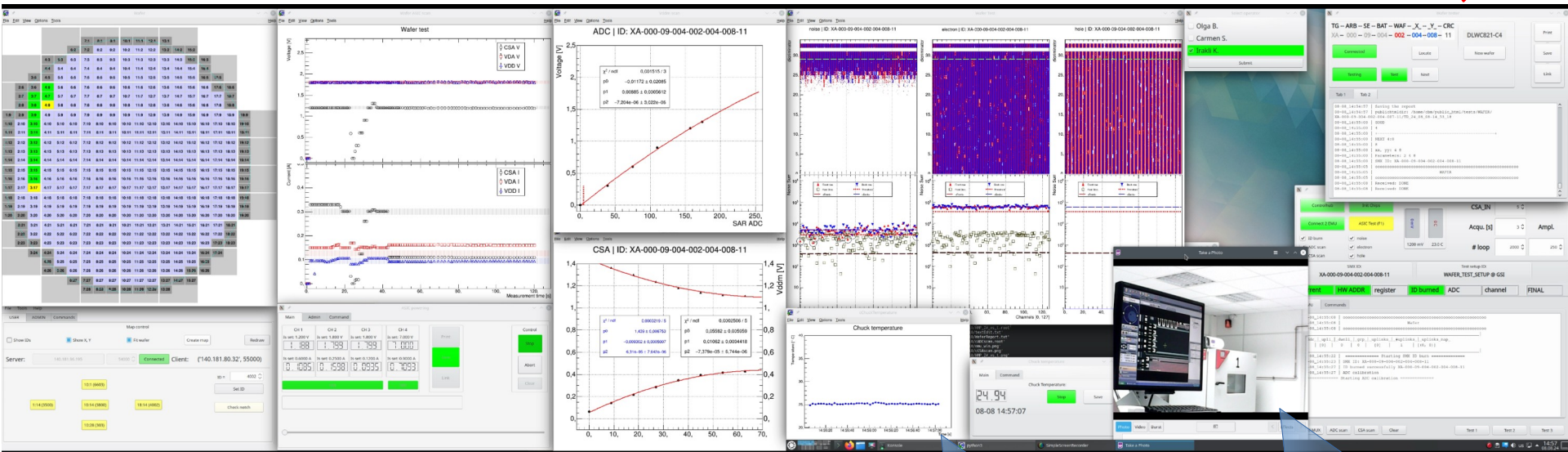


WAFER  
Prober server

ADC calib.  
CSA calib.

Channel test  
Noise, Neg., Pos.,

MAIN  
server

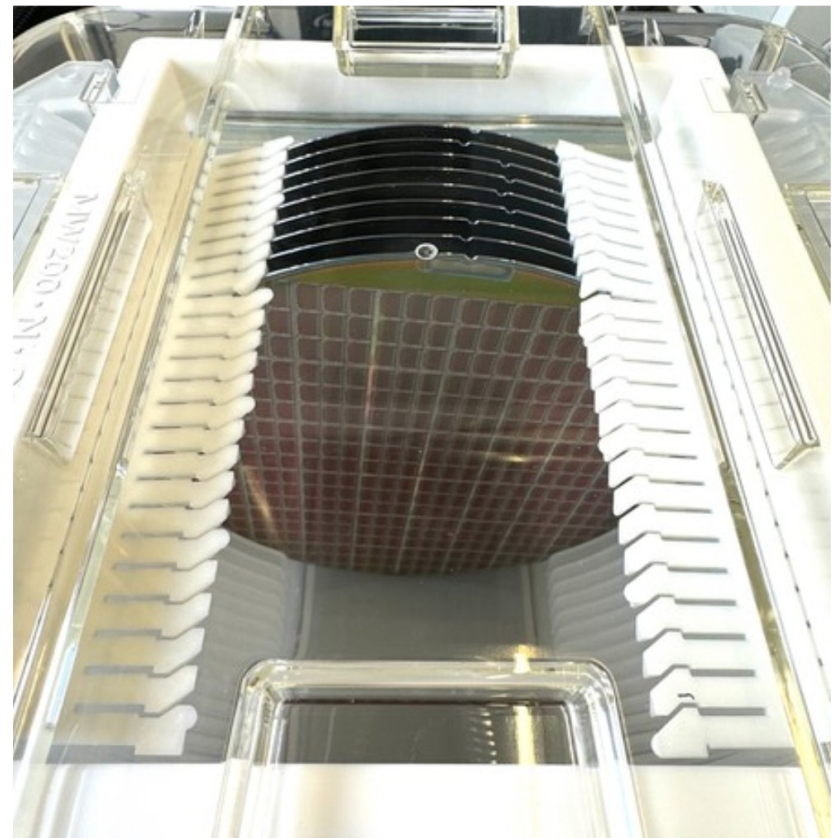
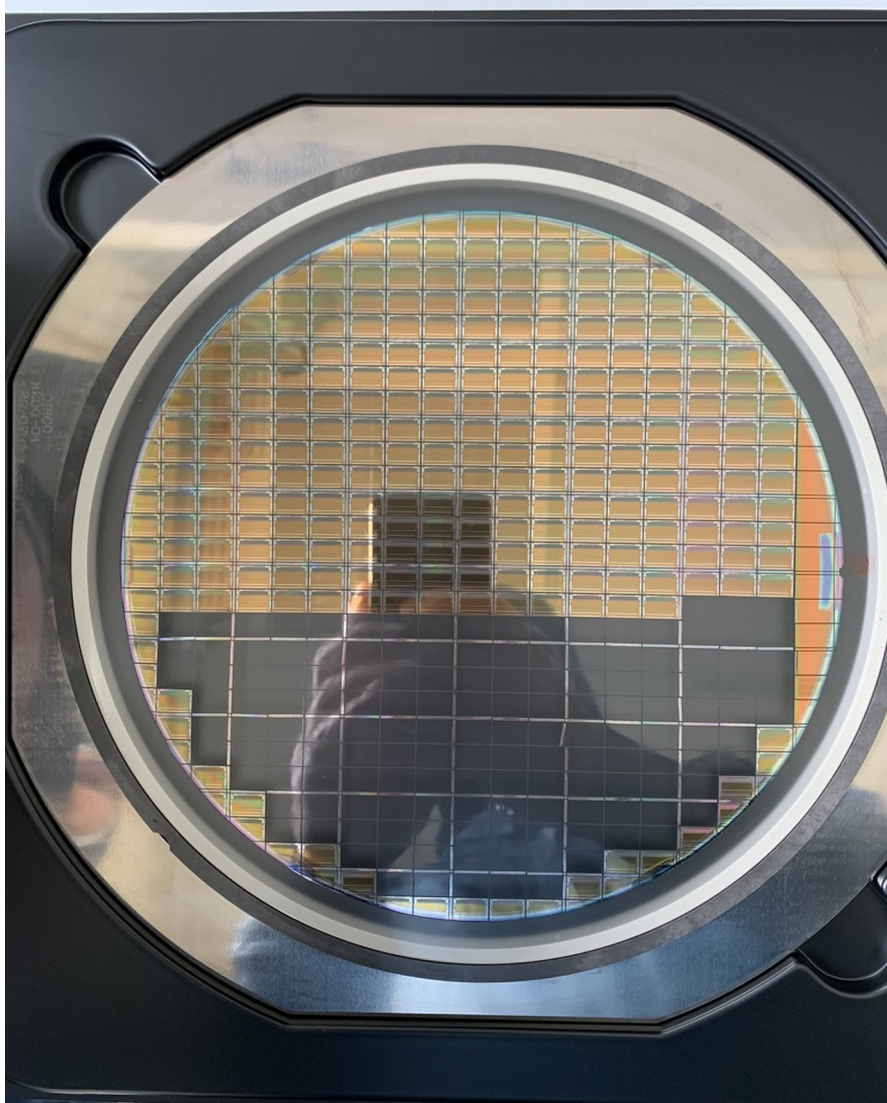


Power supply  
server

WAFFER/Chuck  
Temperature

Test card

## ASIC Wafer 80 x 360 chips





# Wafer level ASIC test



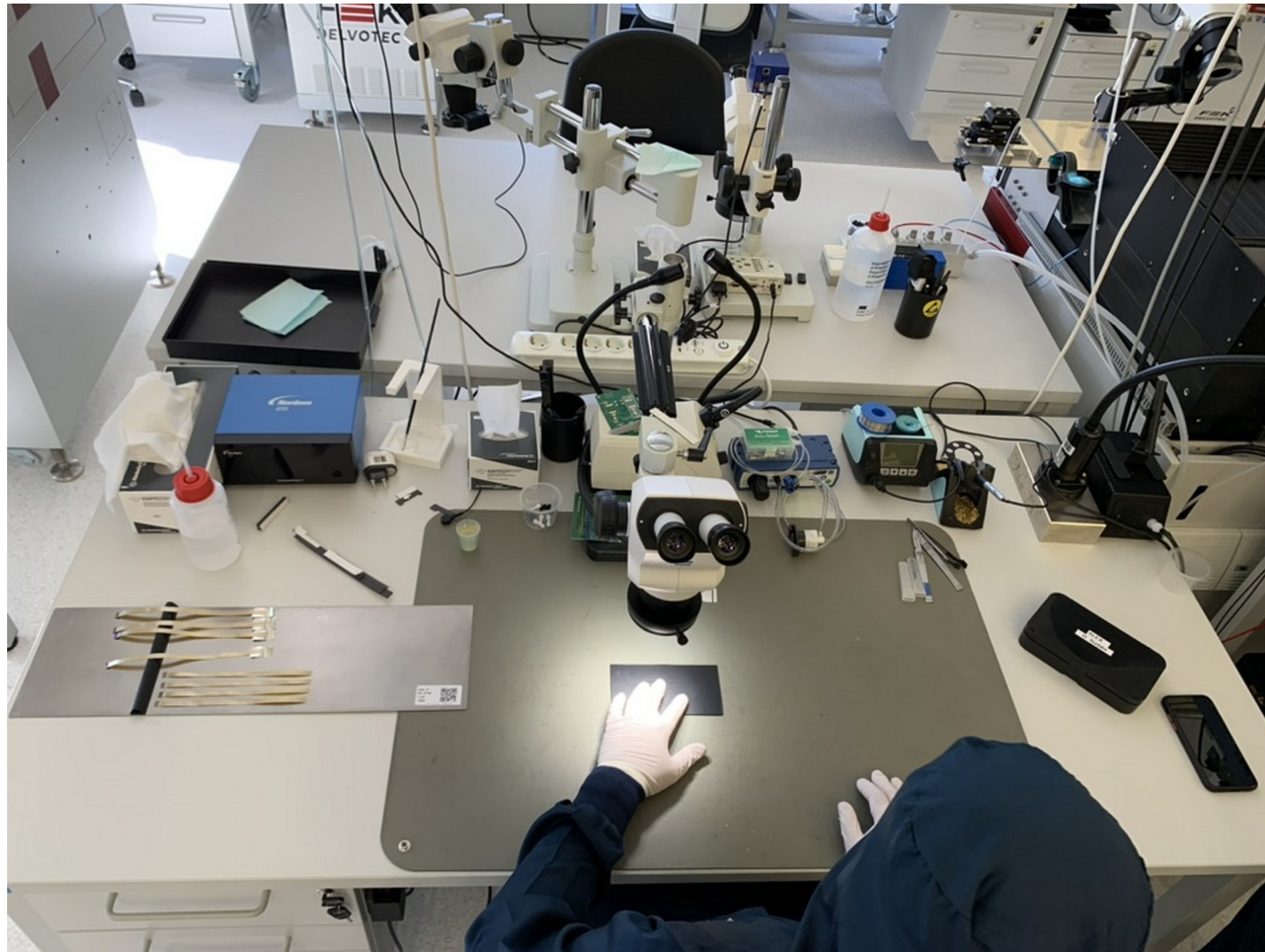
DTL-STs tests database
DTL-STs tests database
web-docs.gsi.de/~dtl-sts/?m=67%
Most Visited
current
GSI
DTL
CBM
work
edu
Physics
Projects
DBase
QR Label
Admin
Help
WAFERS
Wafer ID: NAME
75:DM2CJ21-D7

Total	QA 1	QA 1/360	QA 2	QA 2/360	QA 3	QA 4
346/(360)	341	94.72 %	2	0.56 %	3	0

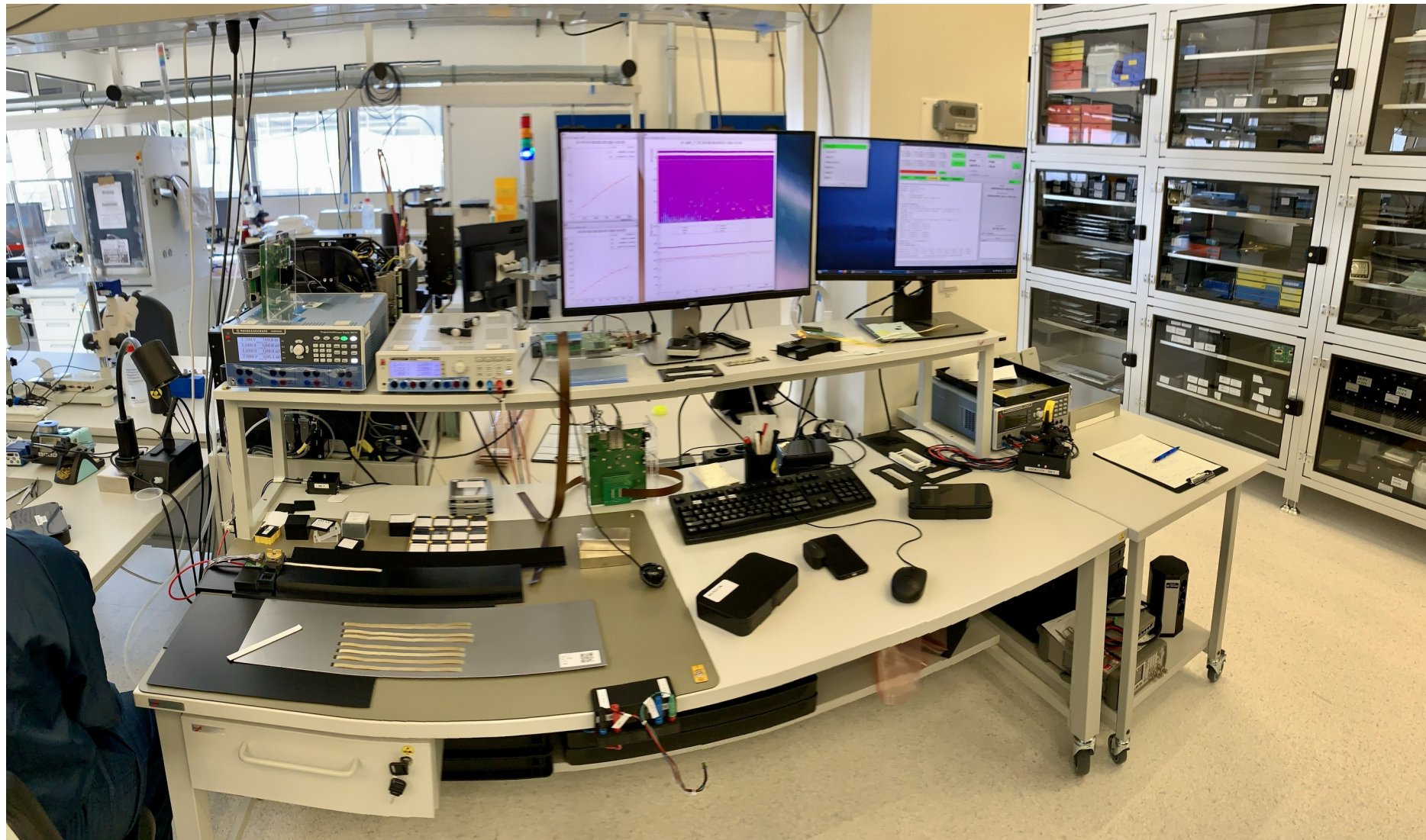
QA1	QA2	QA3	NO DB, NO DIR	DB, NO DIR	DB, DIR
7.1	8.1	9.1	10.1	11.1	12.1
13.1	14.1	15.1	16.1	17.1	18.1
19.1	20.1	21.1	22.1	23.1	24.1
25.1	26.1	27.1	28.1	29.1	30.1
31.1	32.1	33.1	34.1	35.1	36.1
37.1	38.1	39.1	40.1	41.1	42.1
43.1	44.1	45.1	46.1	47.1	48.1
49.1	50.1	51.1	52.1	53.1	54.1
55.1	56.1	57.1	58.1	59.1	60.1
61.1	62.1	63.1	64.1	65.1	66.1
67.1	68.1	69.1	70.1	71.1	72.1
73.1	74.1	75.1	76.1	77.1	78.1
79.1	80.1	81.1	82.1	83.1	84.1
85.1	86.1	87.1	88.1	89.1	90.1
91.1	92.1	93.1	94.1	95.1	96.1
97.1	98.1	99.1	100.1	101.1	102.1
103.1	104.1	105.1	106.1	107.1	108.1
109.1	110.1	111.1	112.1	113.1	114.1
115.1	116.1	117.1	118.1	119.1	120.1
121.1	122.1	123.1	124.1	125.1	126.1
127.1	128.1	129.1	130.1	131.1	132.1
133.1	134.1	135.1	136.1	137.1	138.1
139.1	140.1	141.1	142.1	143.1	144.1
145.1	146.1	147.1	148.1	149.1	150.1
151.1	152.1	153.1	154.1	155.1	156.1
157.1	158.1	159.1	160.1	161.1	162.1
163.1	164.1	165.1	166.1	167.1	168.1
169.1	170.1	171.1	172.1	173.1	174.1
175.1	176.1	177.1	178.1	179.1	180.1
181.1	182.1	183.1	184.1	185.1	186.1
187.1	188.1	189.1	190.1	191.1	192.1
193.1	194.1	195.1	196.1	197.1	198.1
199.1	200.1	201.1	202.1	203.1	204.1
205.1	206.1	207.1	208.1	209.1	210.1
211.1	212.1	213.1	214.1	215.1	216.1
217.1	218.1	219.1	220.1	221.1	222.1
223.1	224.1	225.1	226.1	227.1	228.1
229.1	230.1	231.1	232.1	233.1	234.1
235.1	236.1	237.1	238.1	239.1	240.1
241.1	242.1	243.1	244.1	245.1	246.1
247.1	248.1	249.1	250.1	251.1	252.1
253.1	254.1	255.1	256.1	257.1	258.1
259.1	260.1	261.1	262.1	263.1	264.1
265.1	266.1	267.1	268.1	269.1	270.1
271.1	272.1	273.1	274.1	275.1	276.1
277.1	278.1	279.1	280.1	281.1	282.1
283.1	284.1	285.1	286.1	287.1	288.1
289.1	290.1	291.1	292.1	293.1	294.1
295.1	296.1	297.1	298.1	299.1	300.1
301.1	302.1	303.1	304.1	305.1	306.1
307.1	308.1	309.1	310.1	311.1	312.1
313.1	314.1	315.1	316.1	317.1	318.1
319.1	320.1	321.1	322.1	323.1	324.1
325.1	326.1	327.1	328.1	329.1	330.1
331.1	332.1	333.1	334.1	335.1	336.1
337.1	338.1	339.1	340.1	341.1	342.1
343.1	344.1	345.1	346.1	347.1	348.1
349.1	350.1	351.1	352.1	353.1	354.1
355.1	356.1	357.1	358.1	359.1	360.1

Link of Wafer Map: DM2CJ21-D7
Impressum

Wafer tester
CH1: Is set: 1.200 V, Is set: 1.800 V, Is set: 1.800 V, Is set: 7.000 V, Is set: 0.6000 A, Is set: 0.7000 A, Is set: 0.7000 A, Is set: 2.5000 A, 0.4505, 0.0941, 0.4584, 0.6991, ON/OFF, ON/OFF, Init Chips, Controlhub, ASIC Test (F1), CSA\_IN: 15, # loop: 200, Calib Pls. A: 100, ID burn, VDDM scan, Channels, CSA scan, TG -- ARB -- SE -- BAT -- WAF -- X -- Y -- CRC, WAFAER SN: SOM3SN, current, HW ADDR, register, ID burner, ADC, channel, FINAL, UpLink 0: xxxxxx, UpLink 1: xxxxxx, UpLink 2: xxxxxx, UpLink 3: xxxxxx, UpLink 4: xxxxxx, Data phase characteristics: UpLink 0: Optimal Phase: 14, Window Length: 34, Eye Window: xxxxxx, UpLink 1: Optimal Phase: 13, Window Length: 34, Eye Window: xxxxxx, UpLink 2: Optimal Phase: 14, Window Length: 34, Eye Window: xxxxxx, UpLink 3: Optimal Phase: 14, Window Length: 34, Eye Window: xxxxxx, UpLink 4: Optimal Phase: 15, Window Length: 34, Eye Window: xxxxxx, 18:00:37:setup\_element:INFO: beginning SMT XDRs map scan, 18:00:37:master:INFO: Setting encoding mode S08 for groups [0], downlinks [0], 18:00:37:master:INFO: Setting encoding mode K.28.1 for groups [0], downlinks [0], 18:00:37:master:INFO: Setting encoding mode S08 for groups [0], downlinks [0], 18:00:37:master:INFO: Setting encoding mode FRAME for groups [0], downlinks [0], 18:00:37:uplink:INFO: Setting uplink mask [0, 1, 2, 3, 4], 18:00:39:setup\_element:INFO: Adding ASIC 0x7, ASIC uplink 0, uplink 0, 18:00:39:setup\_element:INFO: Adding ASIC 0x7, ASIC uplink 1, uplink 1, 18:00:39:setup\_element:INFO: Adding ASIC 0x7, ASIC uplink 2, uplink 2, 18:00:39:setup\_element:INFO: Adding ASIC 0x7, ASIC uplink 3, uplink 3, 18:00:39:setup\_element:INFO: Adding ASIC 0x7, ASIC uplink 4, uplink 4

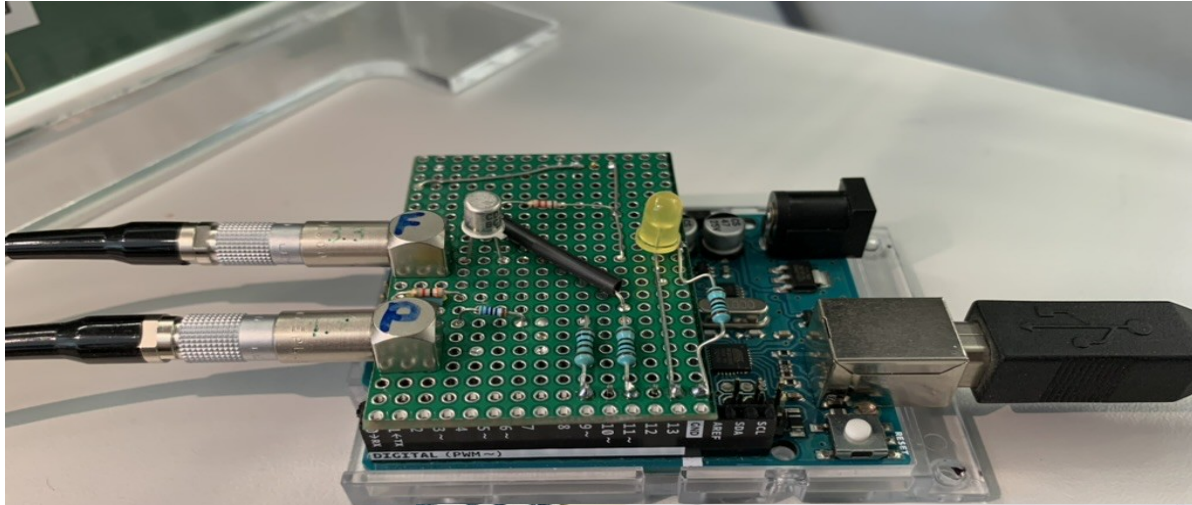






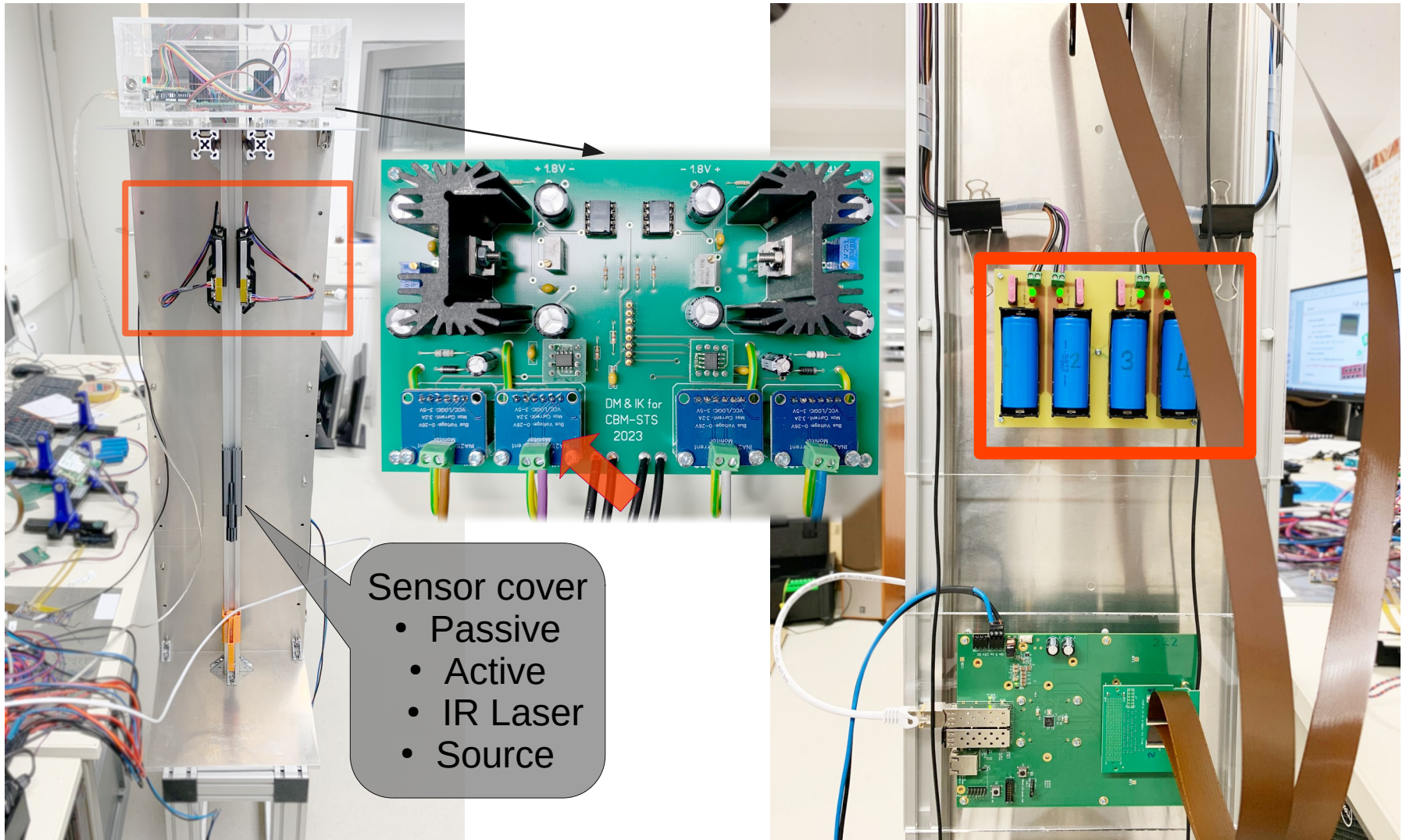


# ASIC ID burner

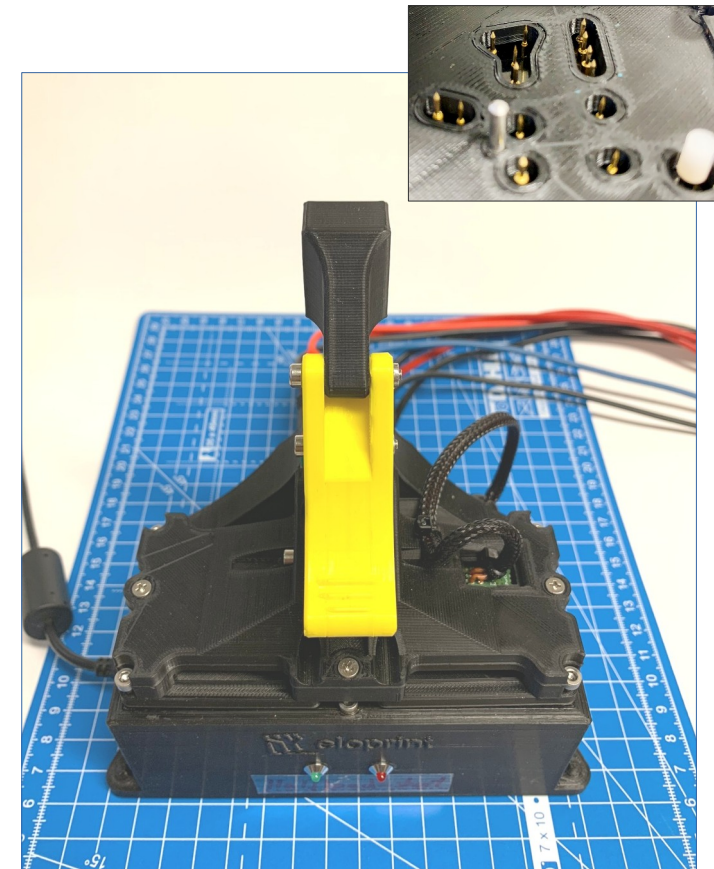
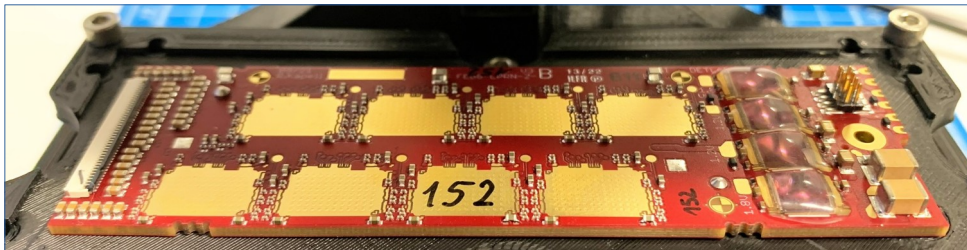
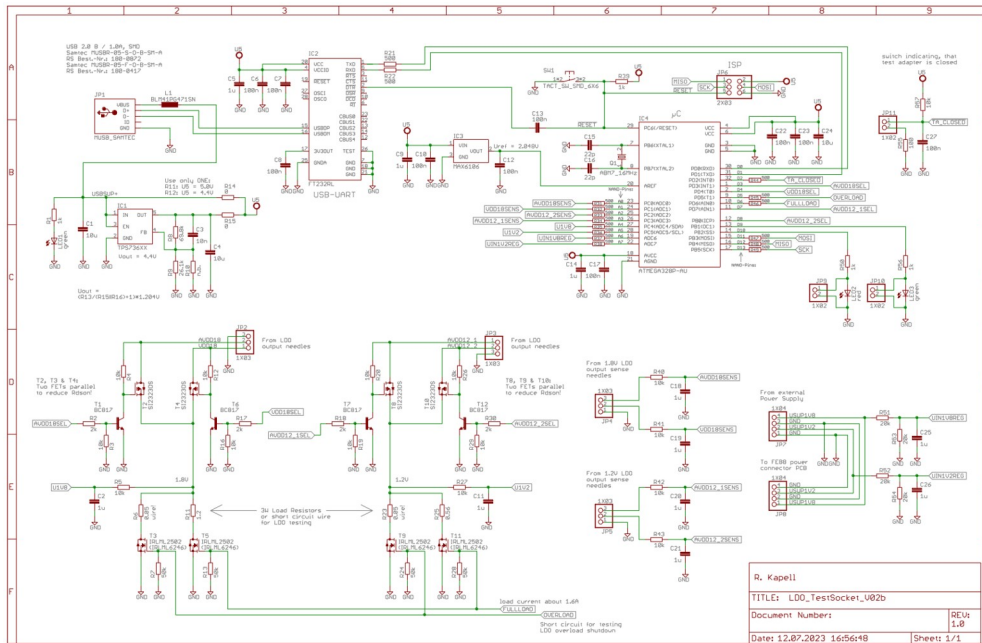




# Module test setup



## LDO test setup

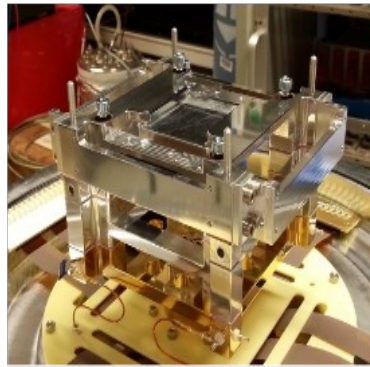




# 2D Segmented Si(Li) and HPGe Detectors for Compton Polarimetry

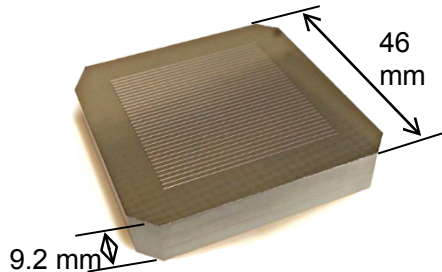
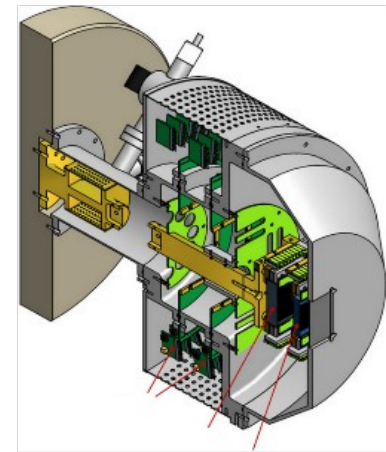


Compton telescope

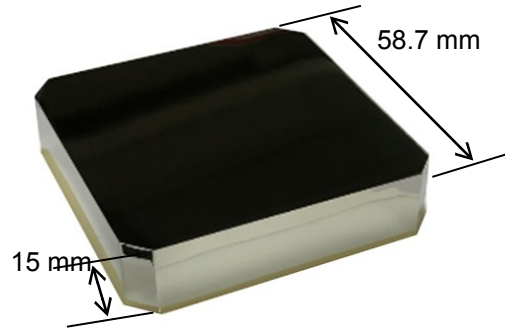


Crystal placement

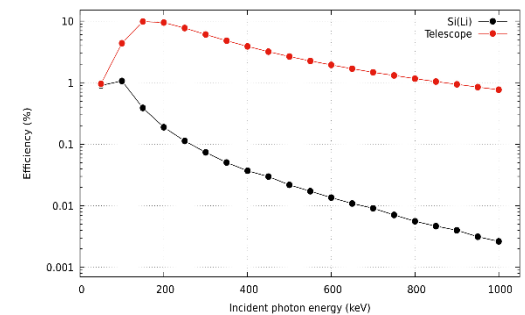
Double sided segmented **Si(Li)- and HPGe-crystal** mounted in telescope configuration increases energy range from previously 200 keV to **1 MeV**



Si(Li) crystal



HPGe crystal

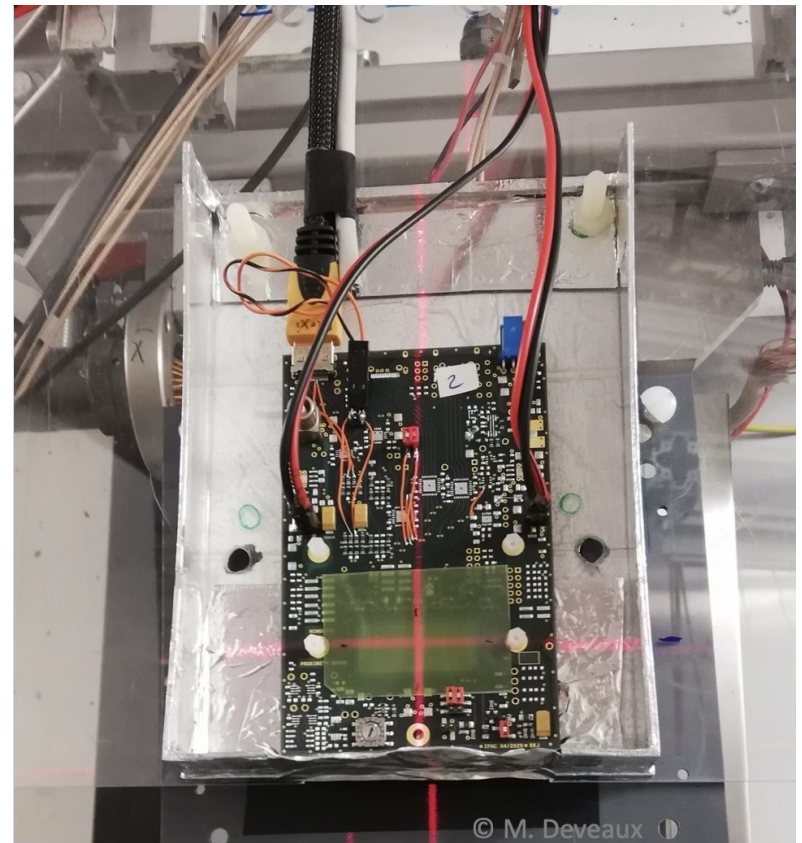
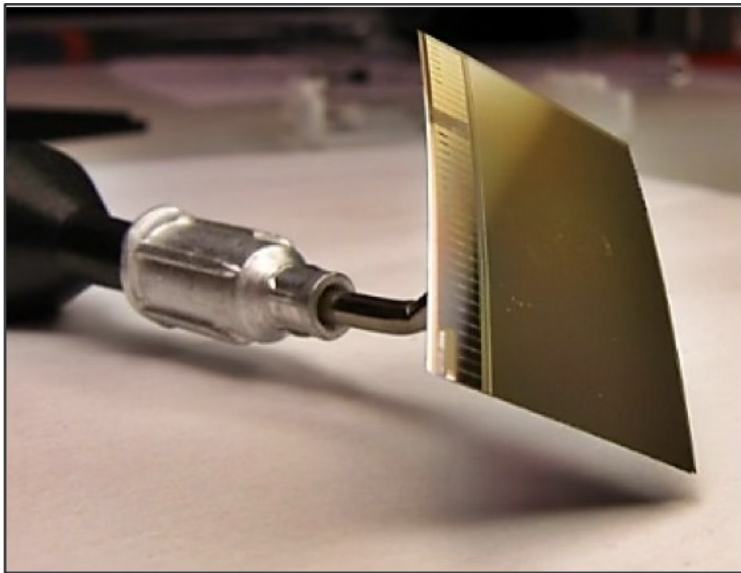


The **Time Projection Chamber (TPC)** is the main device for charged particle tracking and identification in the central barrel of the ALICE experiment at the CERN Large Hadron Collider. It is a 90 m<sup>3</sup> cylinder filled with gas and divided in two drift regions by a central electrode located 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 ( $5 \mu\text{s}$  time resolution) and to resist radioactive doses of  $>5 \text{ MRad}$  and  $>10^{14} \text{ n}_{\text{eq}}/\text{cm}^2$ .



## 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):

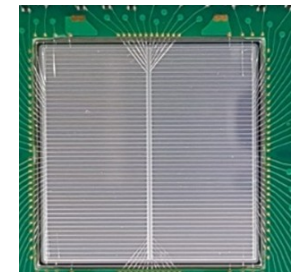
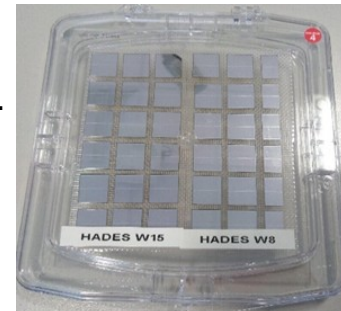
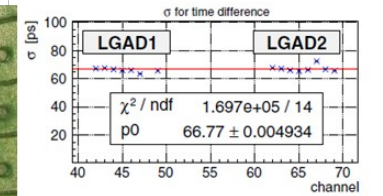
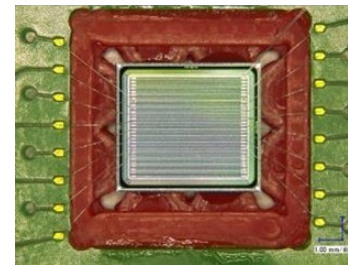
- **Exceptional time precision** below **50 ps**.
- **Ultra-thin sensor design** with thickness below **200  $\mu\text{m}$** .
- **Efficient operation** with passive cooling at room temperature.
- **Fine pitch** below **100  $\mu\text{m}$**  for high spatial resolution.

## 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  $\times$  2 cm).
- **2025:** High fill-factor LGAD production at FBK, featuring:
  - Novel Trench-Isolated (TI-LGAD) technology.
  - Fill factor close to 100%.

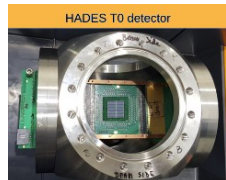
Several beam tests conducted at MedAustron confirmed the expected performance.

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



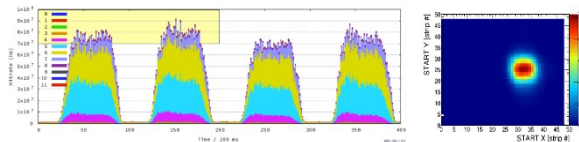


## 1. Start reaction time (T0) detector at HADES:

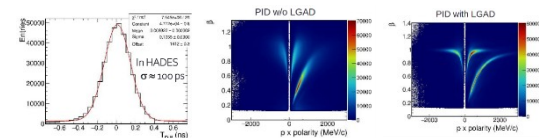


LGADs were used in a p-p production testbeam at HADES in 2022

- 2x2cm<sup>2</sup> LGADs strip sensors with 2x48 half strips
- Additional carbon implanting for radiation hardness

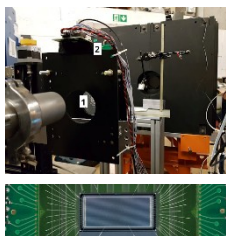


LGADs for online rate and beam spot measurements



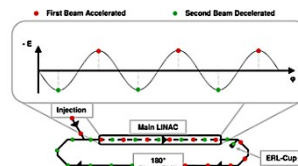
T0 estimation for particle identification (PID)

## 2. LGADs at S-DALINAC in Darmstadt

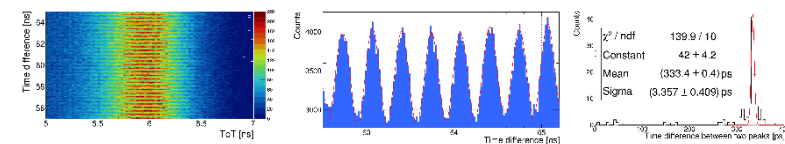


Beam monitoring at S-DALINAC

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

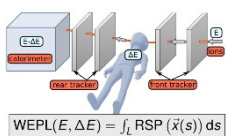


ERL concept at S-DALINAC



Performance of time structure measurement

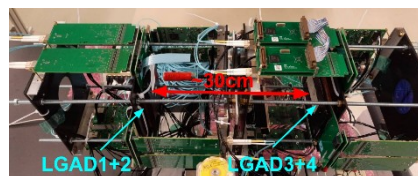
## 3. LGADs for ion computed tomography (iCT)



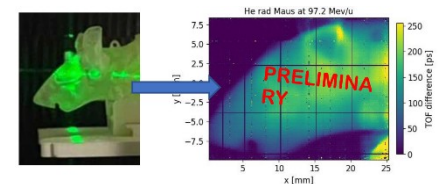
Direct measurement of stopping power map inside the patient

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

$$WEPL(E, \Delta E) = \int_L RSP(\vec{x}(s)) ds$$



LGAD-based TOF-iCT demonstrator at GSI



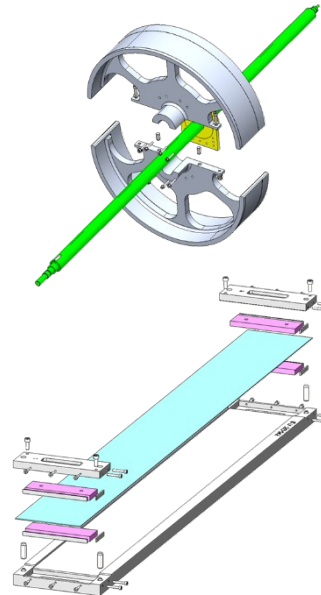
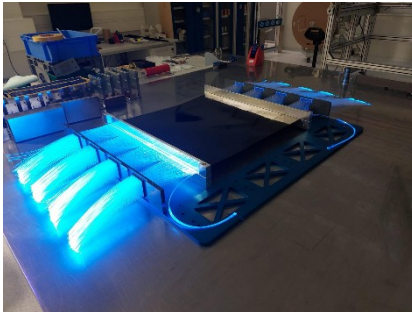
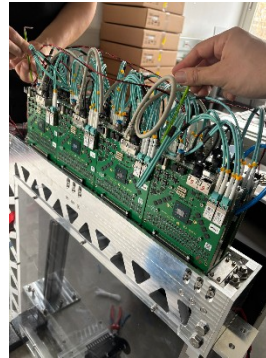
First experimental TOF-Helium radiography of a mouse phantom

# 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  $\mu\text{m}$ .





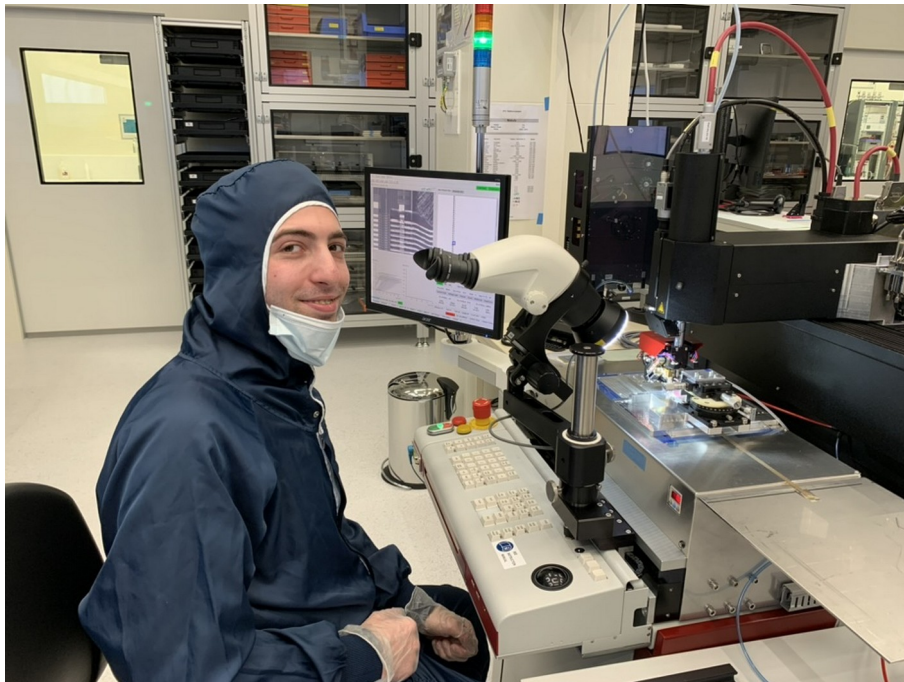
David & Dachi







Nika & Otari









Thanks / Questions

