



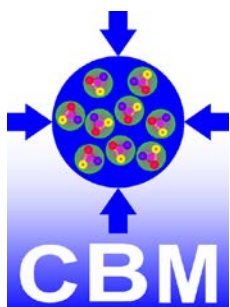
FAIR

Facility for Antiproton and Ion Research



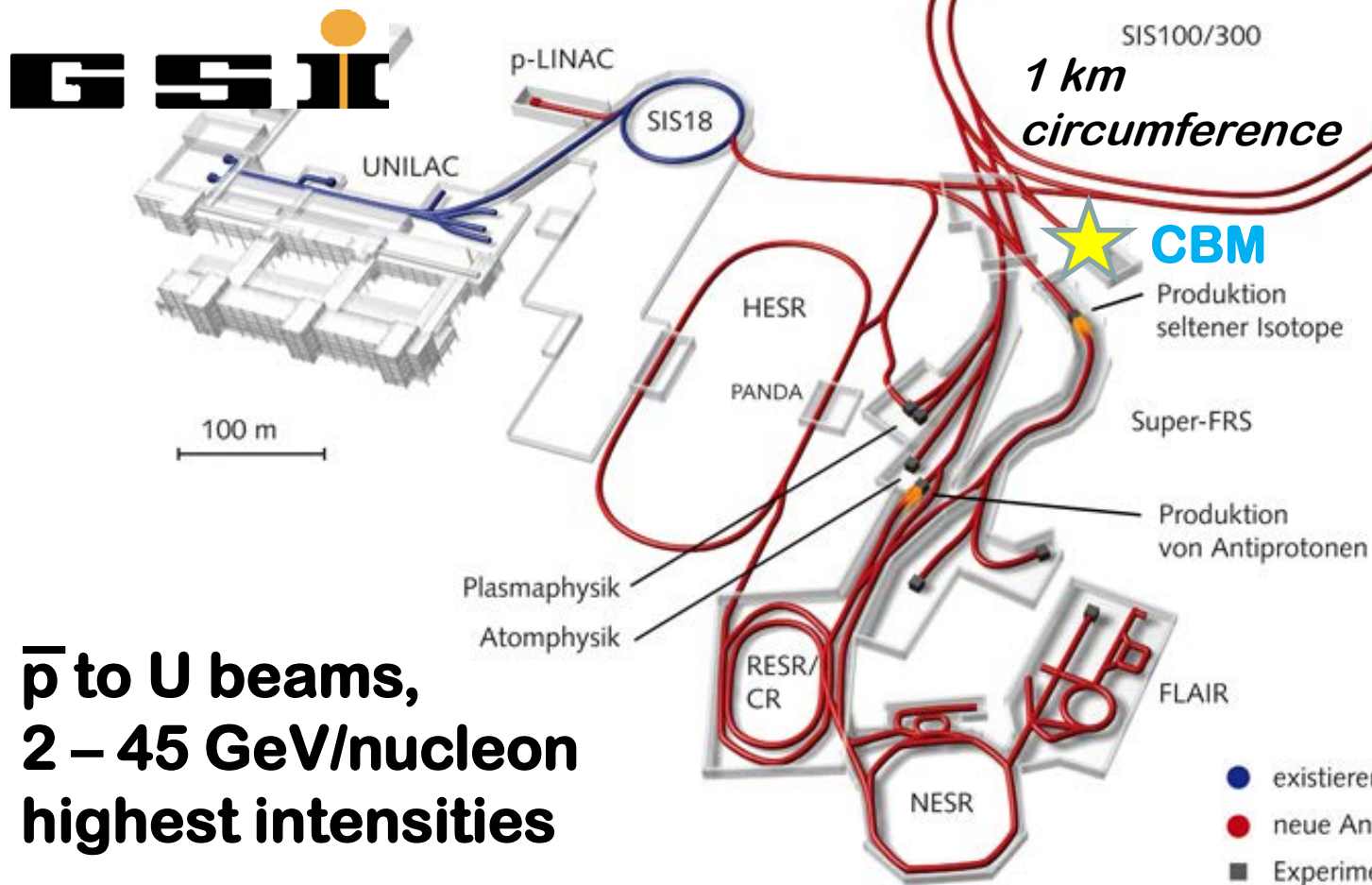
Particle Tracking Challenges: The CBM Silicon Tracking Station at FAIR

Christian J. Schmidt,
GSI Darmstadt
at Gauhati University, Assam, India



The GSI-future project under construction, operative in 2024

GSI Helmholtz Center for Heavy Ion
Research GmbH, Darmstadt, Germany



FAIR - Facility for Anti-Proton and Ion Research, Darmstadt



to of the construction site taken on July 27, 2013 (photo: Jan Schäfer for FAIR)
Spring 2017



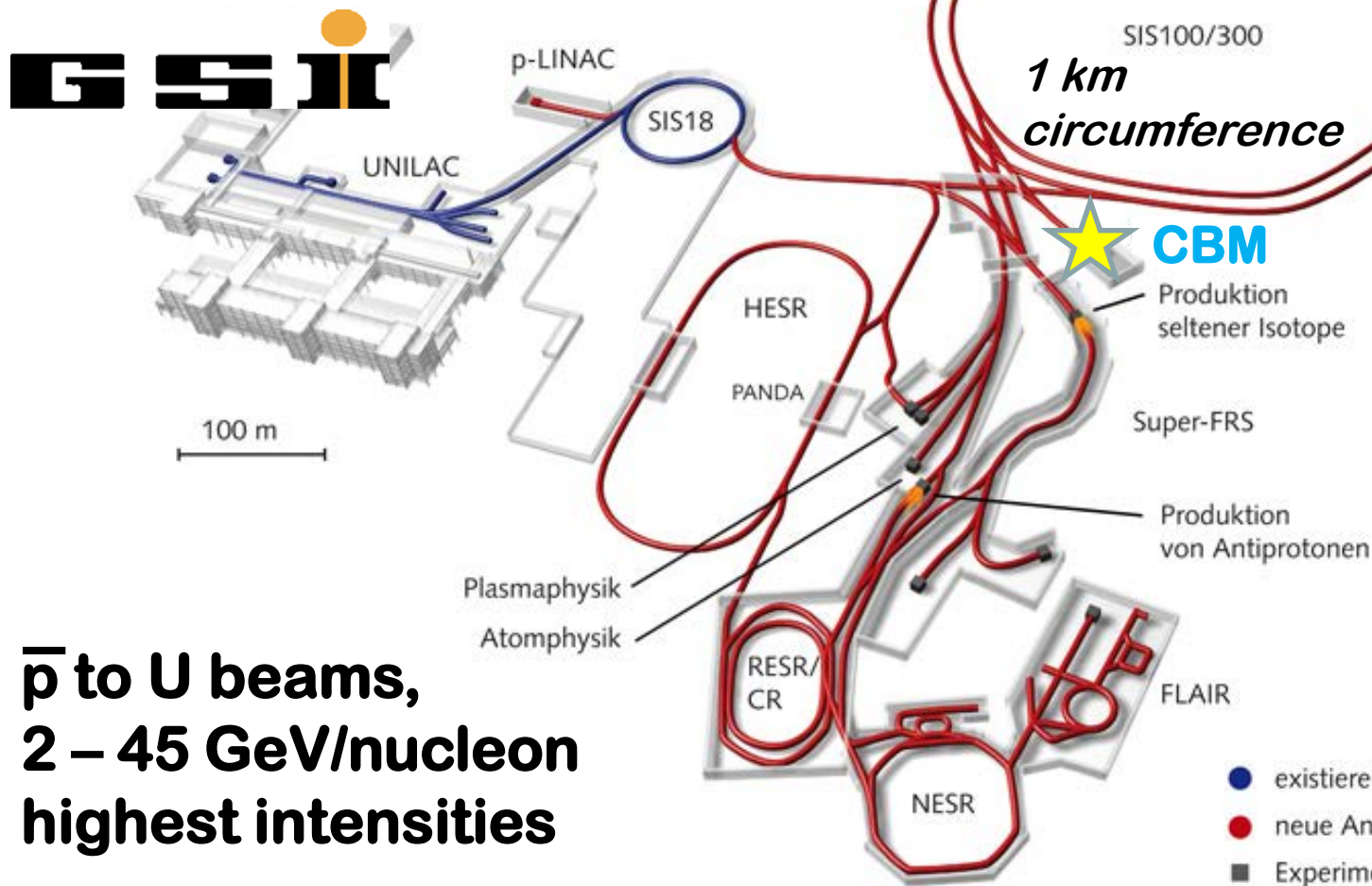






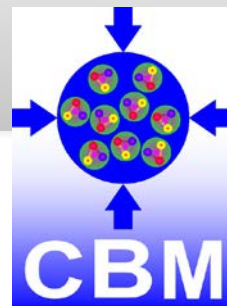
The GSI-future project under construction

GSI Helmholtz Center for Heavy Ion
Research GmbH, Darmstadt, Germany

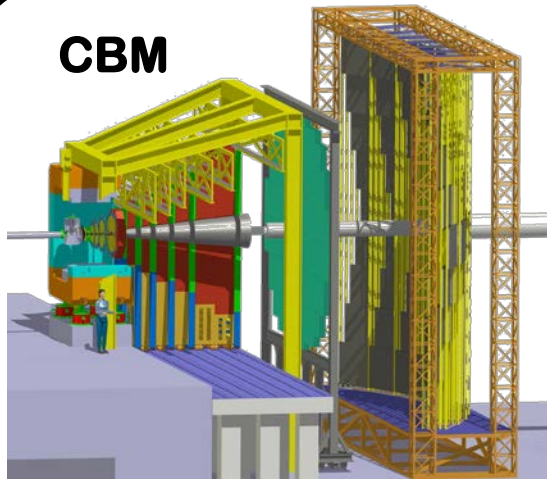


\bar{p} to U beams,
2 – 45 GeV/nucleon
highest intensities

CBM

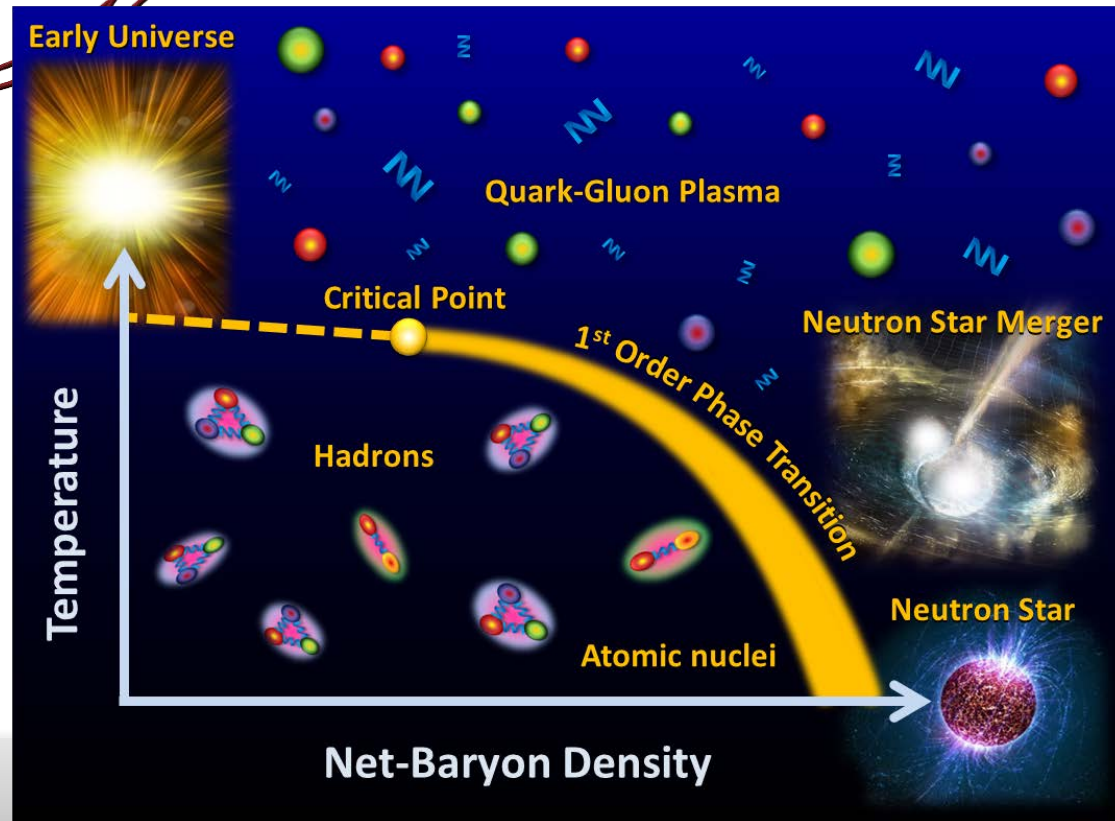


CBM



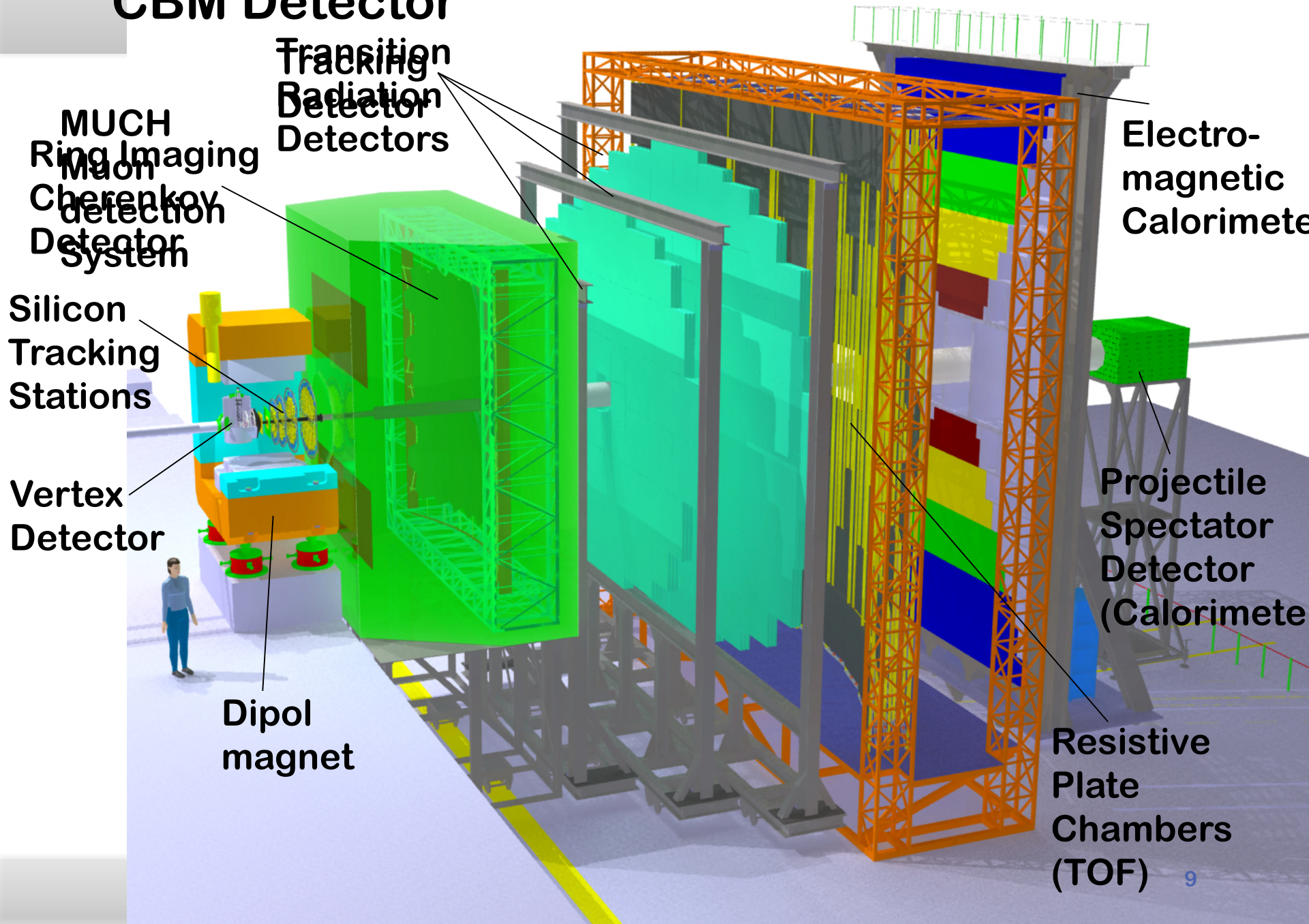
- Compressed Baryonic Matter
 - About 500 members

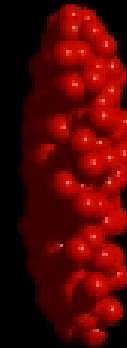
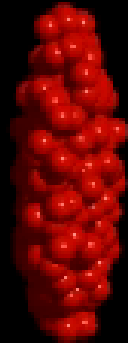
Collide Au heavy ions onto Au nuclei
in a fixed target configuration at
 ~ 10 GeV/nucleus



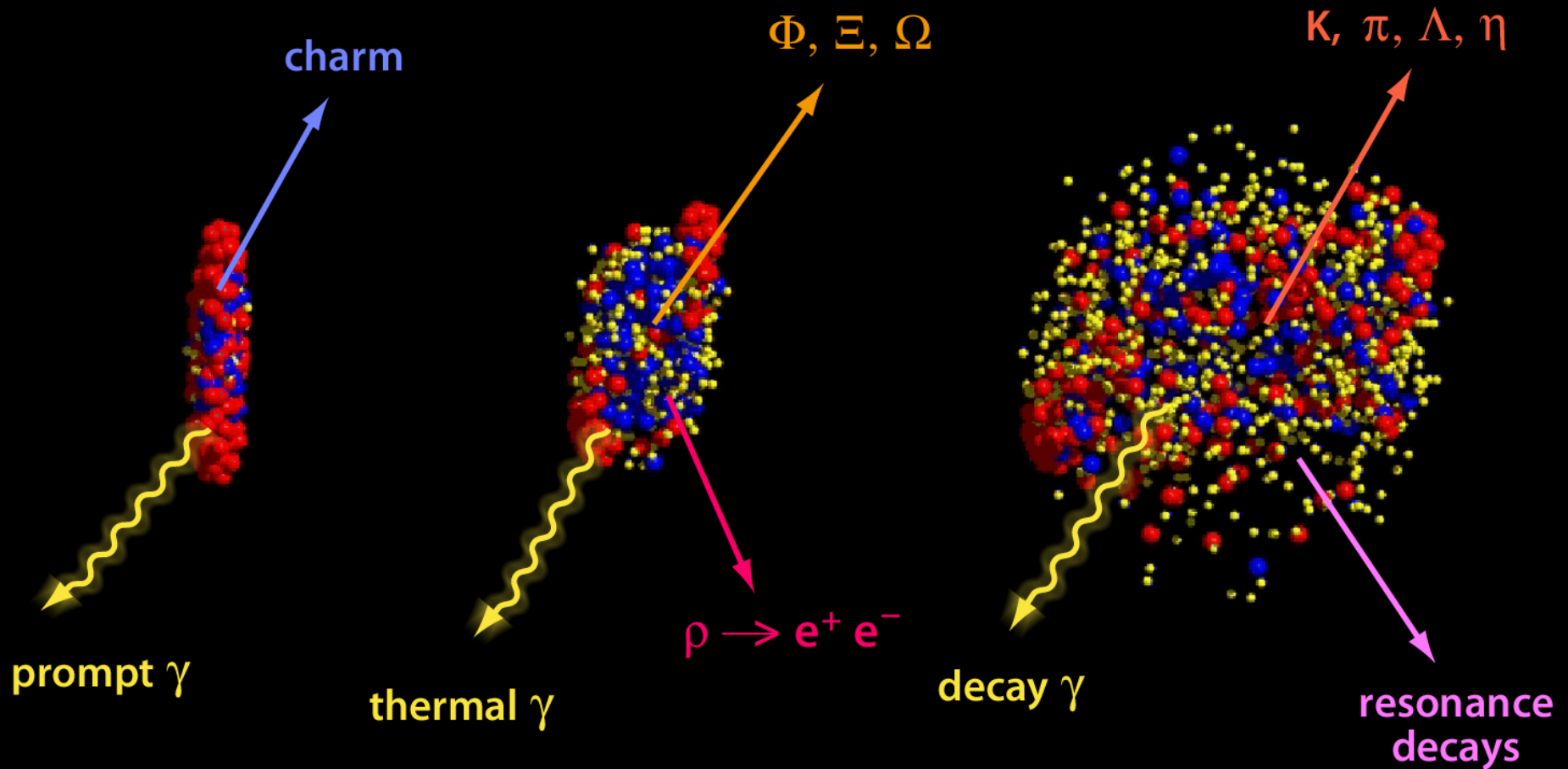


CBM Detector





Diagnostic probes

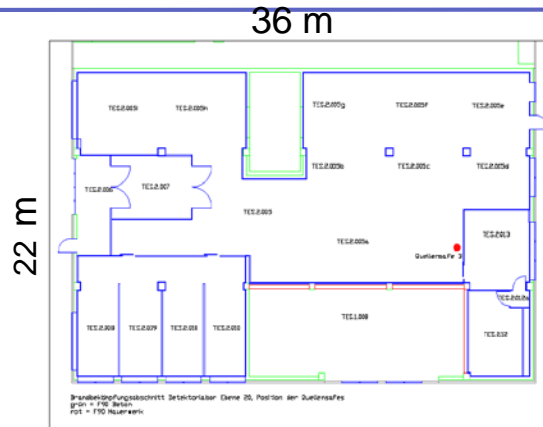


CBM technological challenges

**fixed target configuration makes 10MHz
Au+Au interaction rate feasible at FAIR**

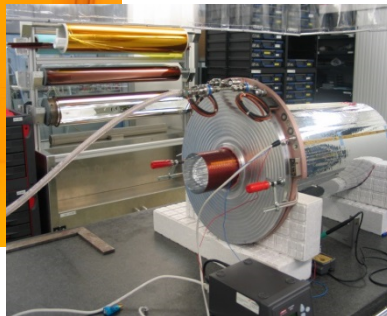
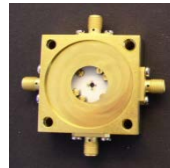
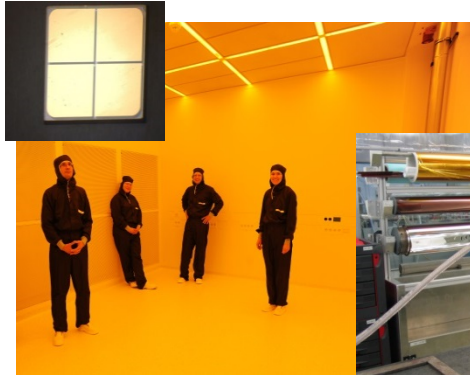
- 10 MHz \rightarrow 6 billion tracks per second
- determination of (displaced) vertices ($\sigma \approx 50 \mu\text{m}$)
- identification of leptons and hadrons
- fast and radiation hard detectors
- free-streaming readout electronics
- high speed data acquisition and high performance computer farm for online event selection
- 4-D event reconstruction

Detector Laboratory at GSI: 600 m² Clean-Room



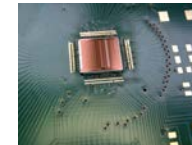
Competences:

- Micro Patterned Gaseous Detector Technology
- Silicon Strip Detector Integration
- ASIC Handling and Integration
- Diamond Detectors
- PSL APD-characterization lab

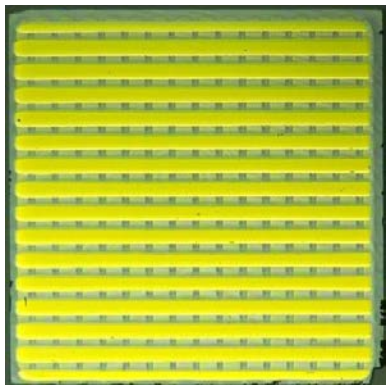


Machinery:

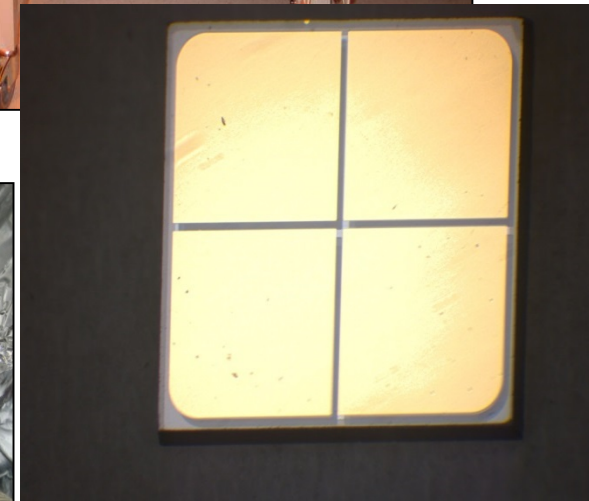
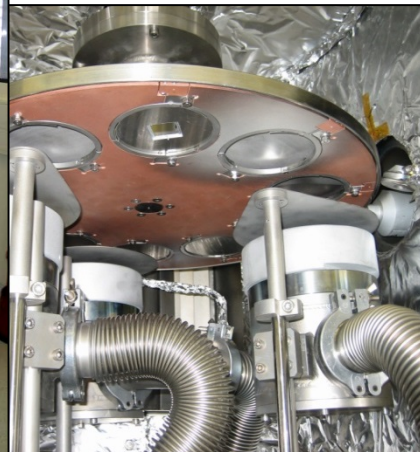
- Laser Lithography
- PVD
- Bonding Automates
- Probestation and Chip Handling
- Automated Wire Winding
- Digital Microscope
- Thin Foils Handling and Processing
- Gaseous Detector Ageing Teststands
- Large Prototyping CNC Milling Machine



ISO 3 Clean Room for Laser Lithography 1 μ



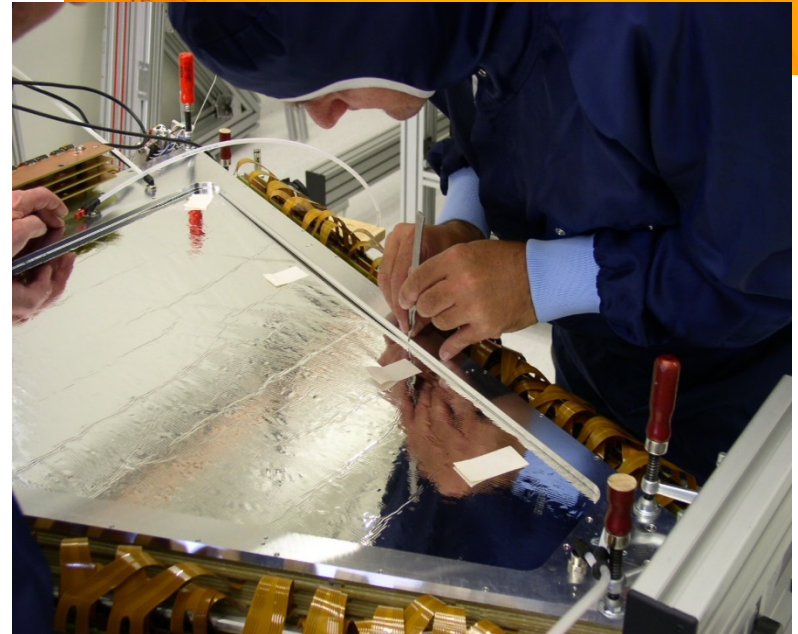
5 x 5 mm² SCDiamond



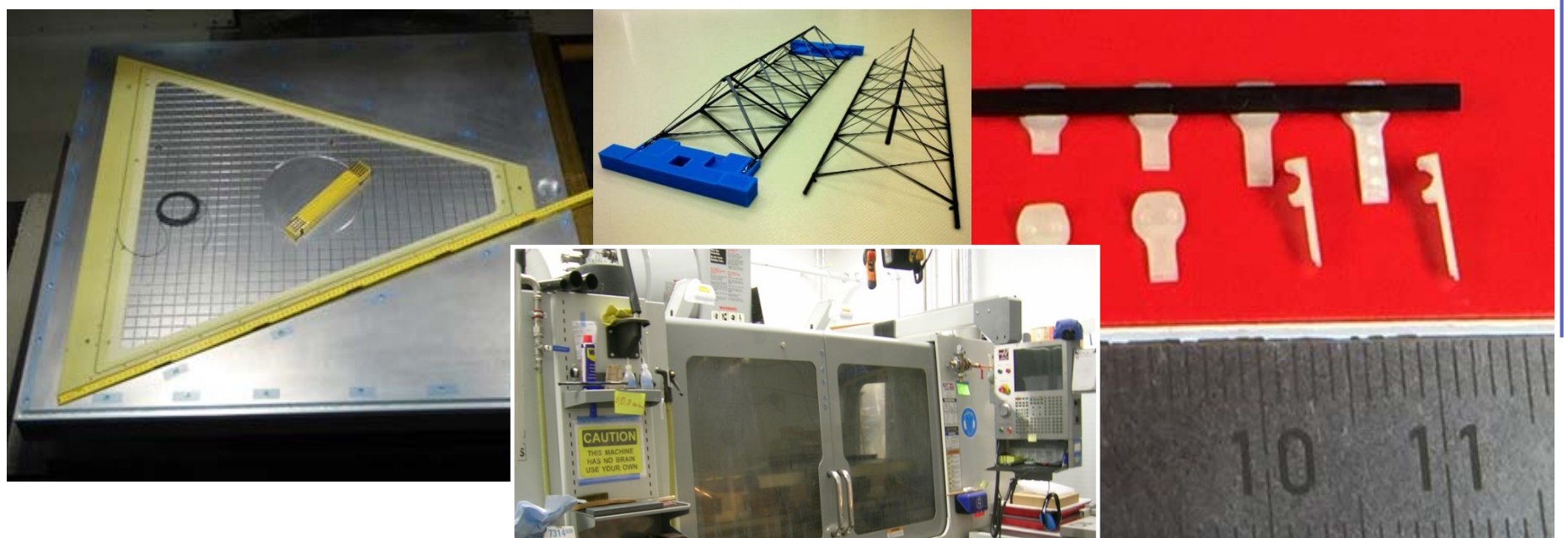
5 x 5 mm² SCDiamond



Work at GSI Detectorlab



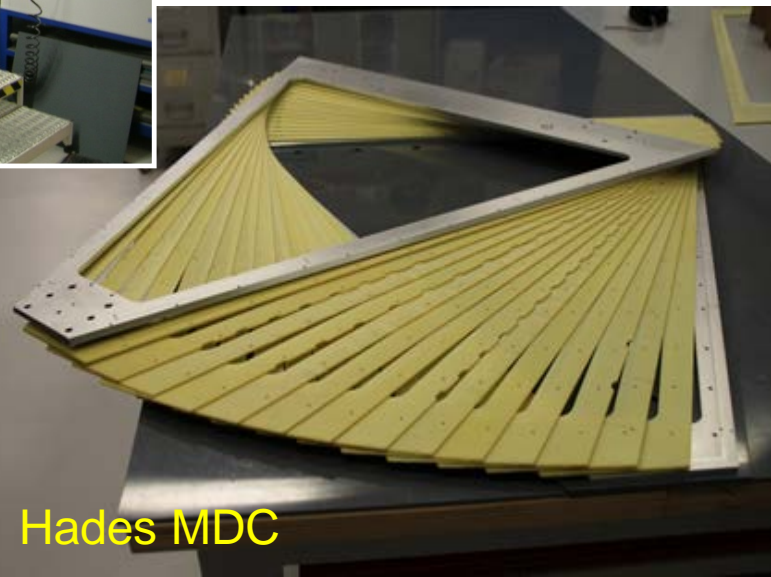
Precision fibre composite milling from very small to very large



100cm x 160cm

fibre composites
= 3D-mold
manufacturing

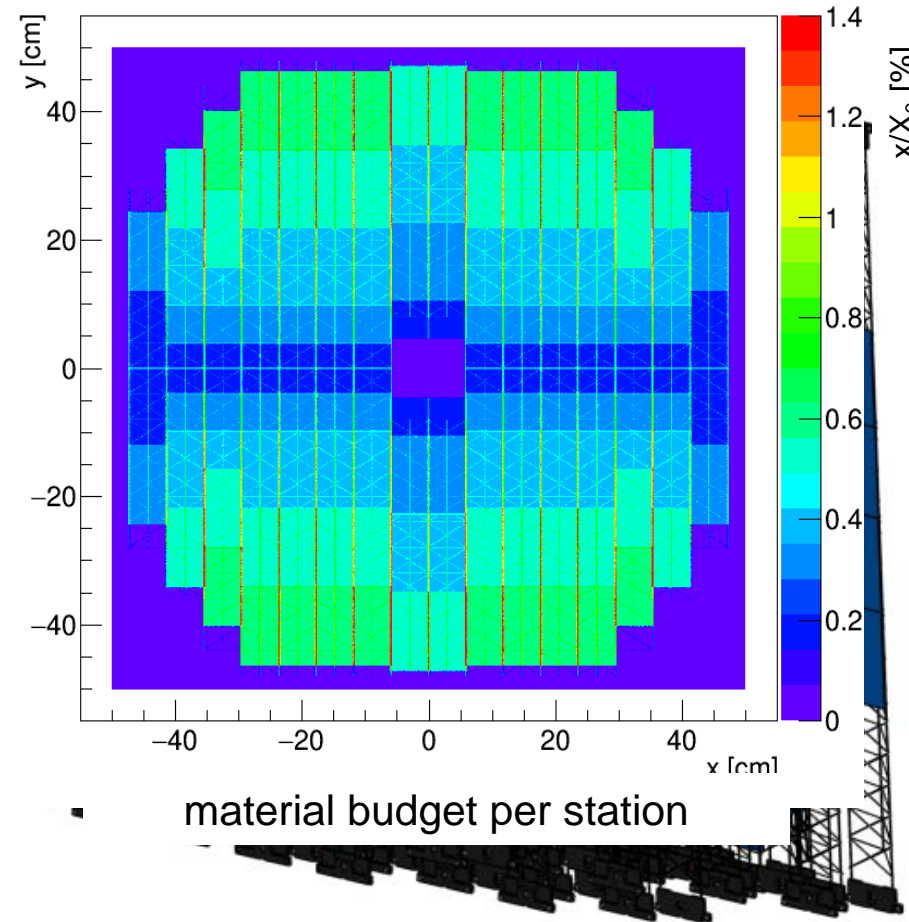
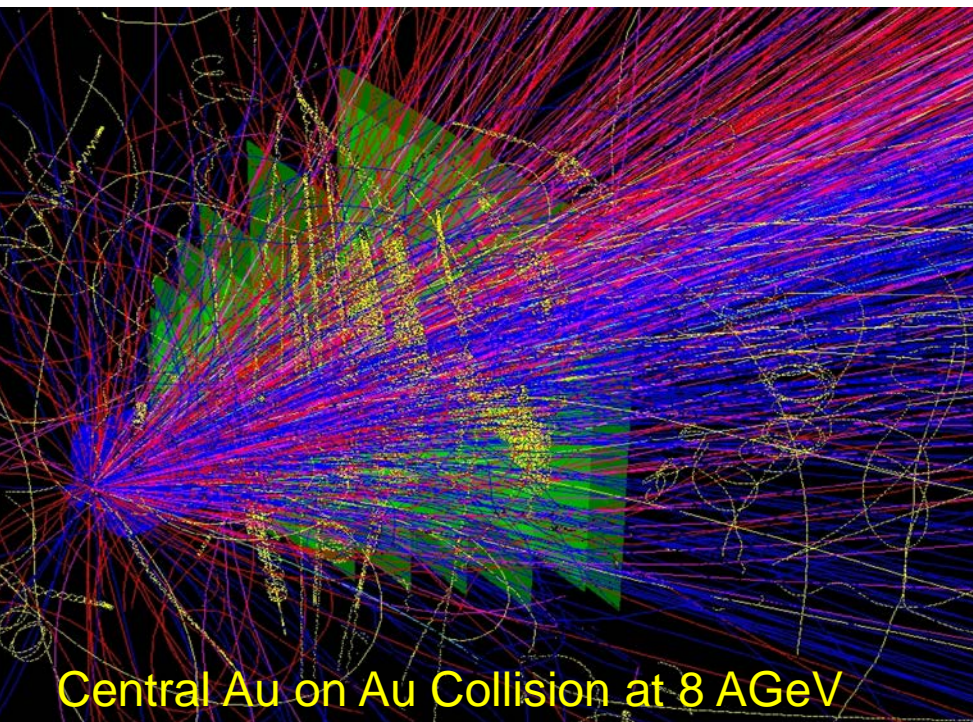
CBM-STS sensor clips



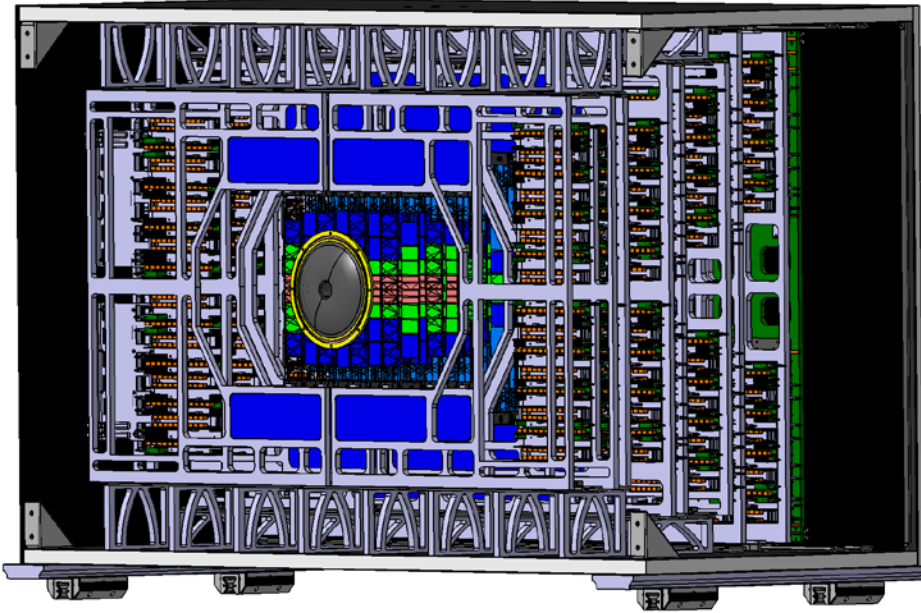
Hades MDC

CBM Silicon Tracking System STS

- Fixed Target Tracker, Acceptance $2.5^\circ < \theta < 25^\circ$ to be fit into magnet yoke (1,4m)
- Double Sided Silicon Strips in 8 Layers, $58\mu\text{m}$
- 2 Mio. readout channels, $\sim 3 \text{ m}^2$
- Event rate 10 MHz, freely streaming r/c
- less than 1% radiation length per layer

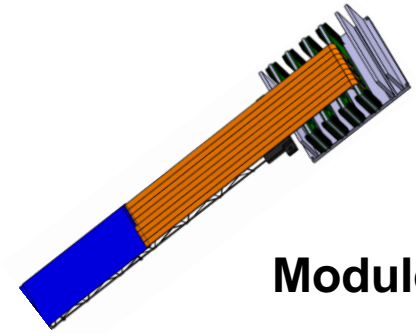


Mechanical Integration in Fixed Target Configuration

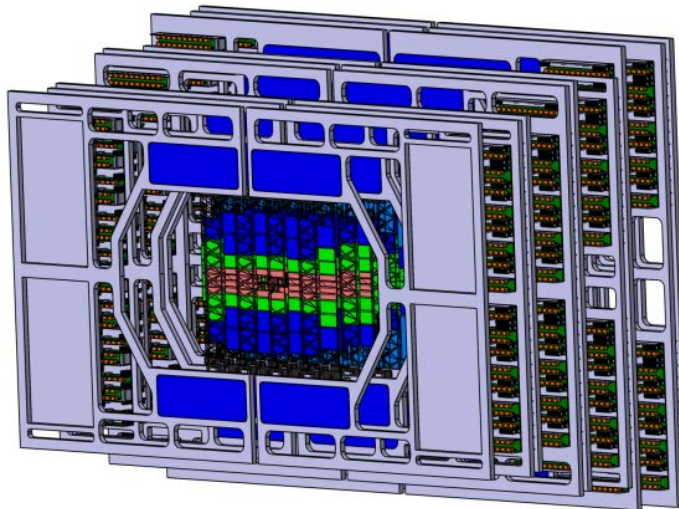


Thermal enclosure, operation at -5°C
Minimize mat. budget in acceptance
Electronics outside acceptance, 40kW

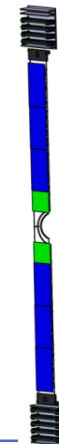
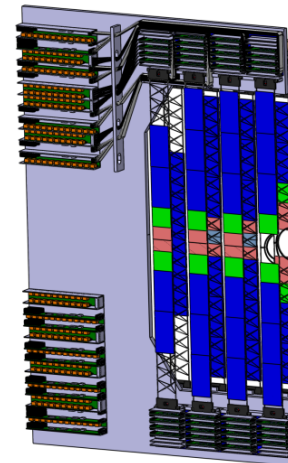
140cm



Module

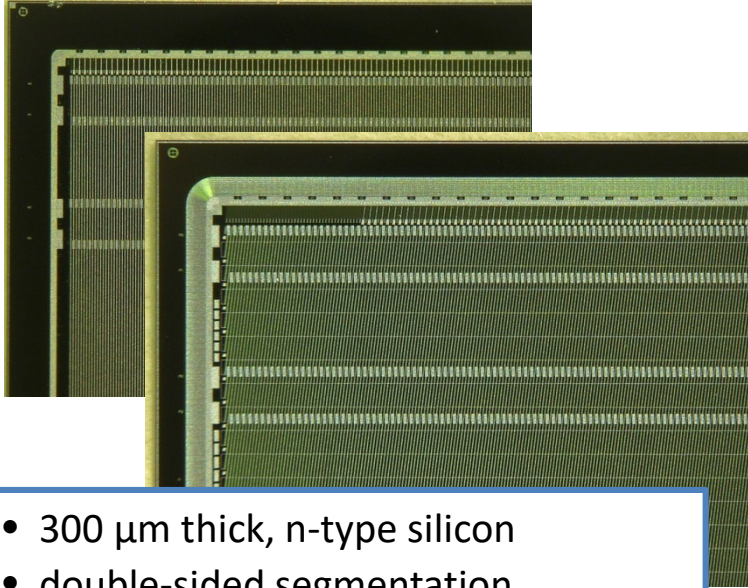


Half-Station



Ladder
of 10 modules

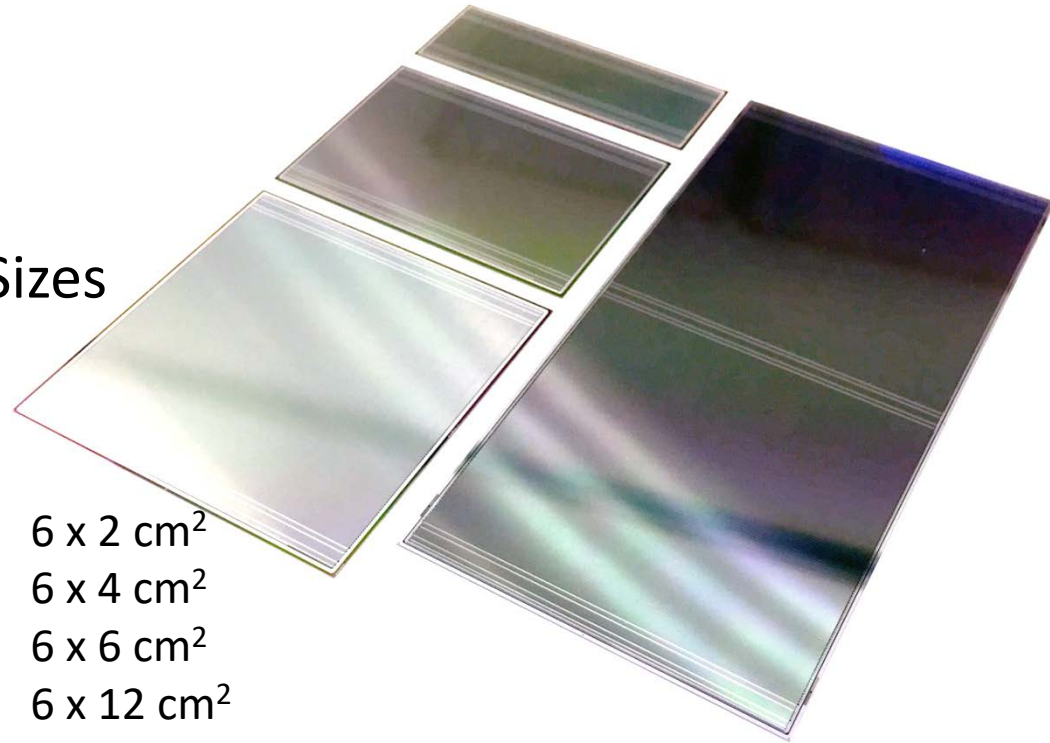
Silicon-Doublesided-Microstrip-Sensors



- 300 μm thick, n-type silicon
- double-sided segmentation
- 2nd metal routing lines
- 1024 strips of 58 μm pitch
- rad. tol. up to $10^{14} n_{\text{eq}}/\text{cm}^2$

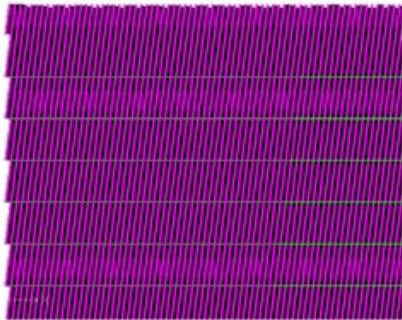
Sizes

- 6 x 2 cm^2
- 6 x 4 cm^2
- 6 x 6 cm^2
- 6 x 12 cm^2

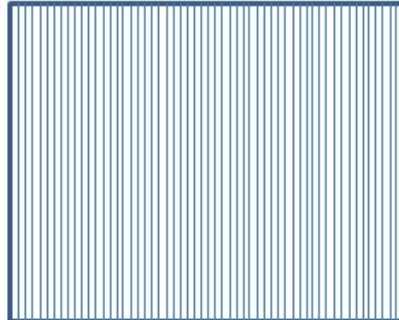


strip orientation at 58 μm pitch

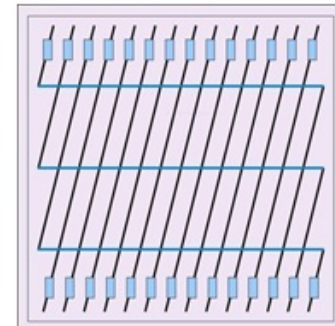
7.5 deg (front/p)



0 deg (back/n)



connectivity, r/o direction



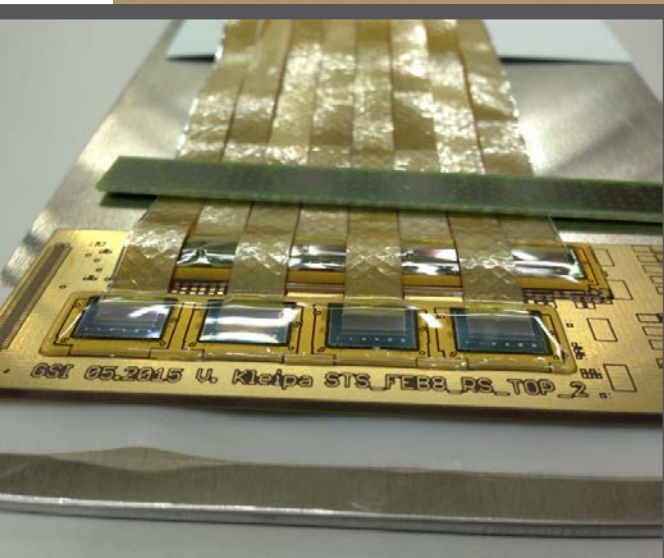
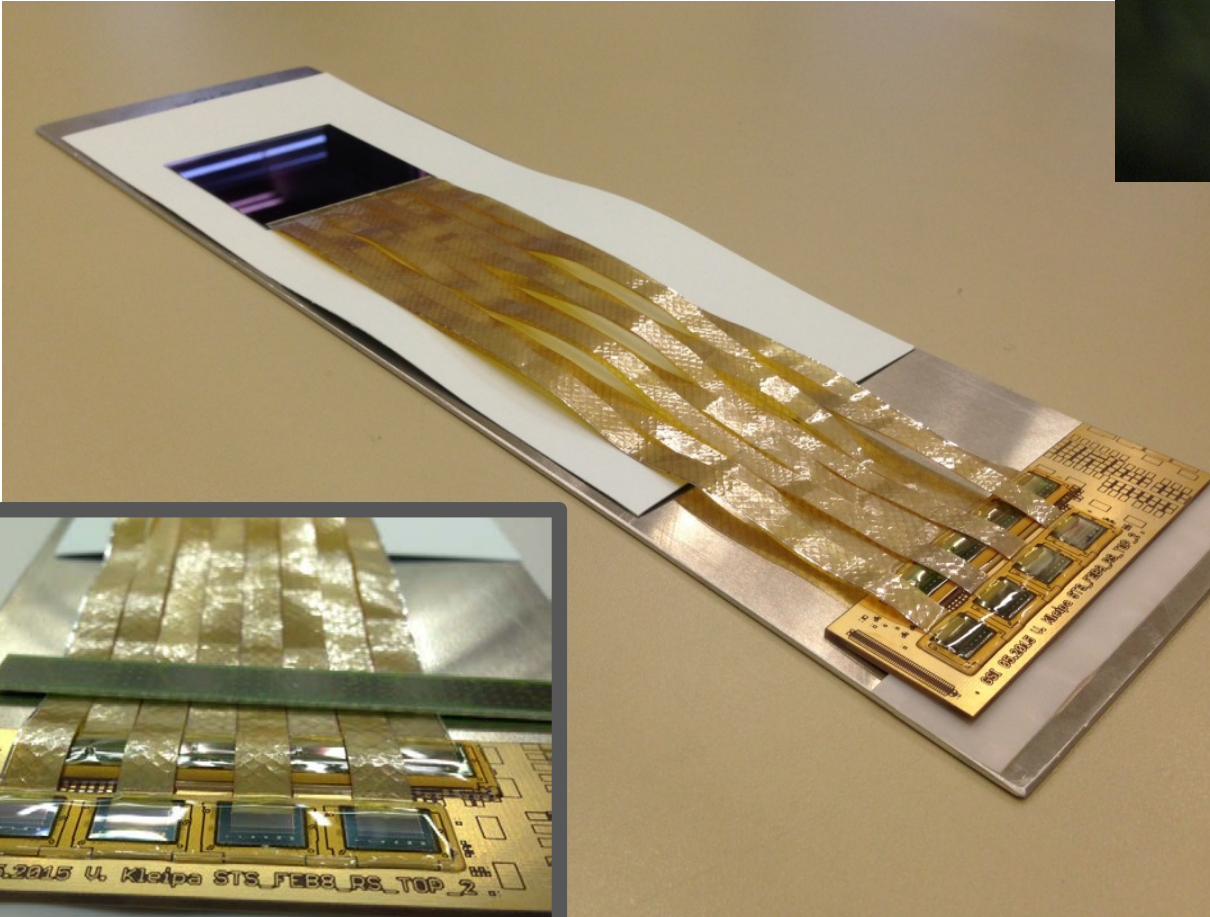
2nd metal
interconnect
required

CBM-STS-module-assembly



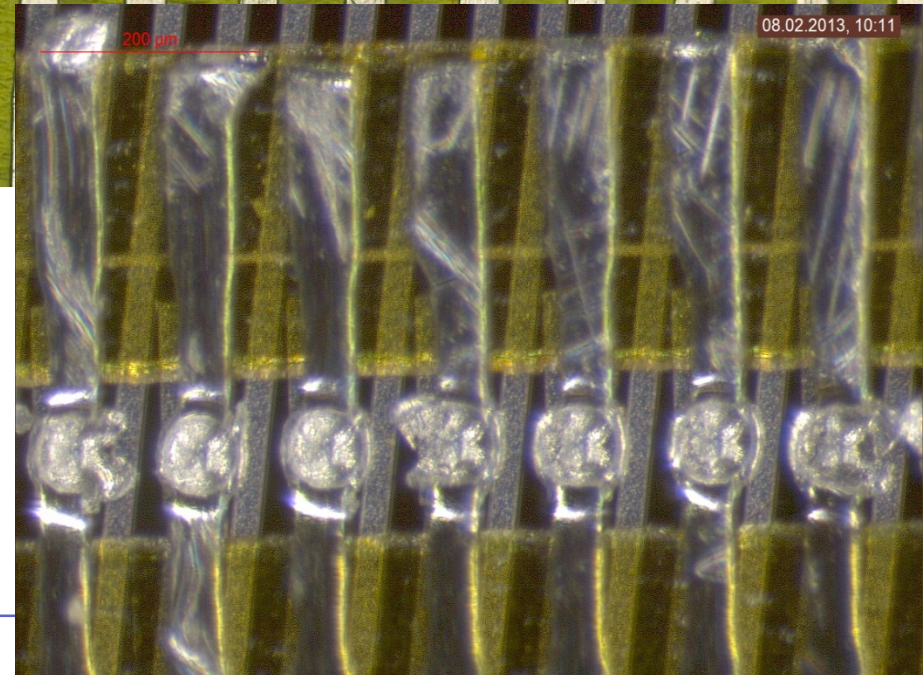
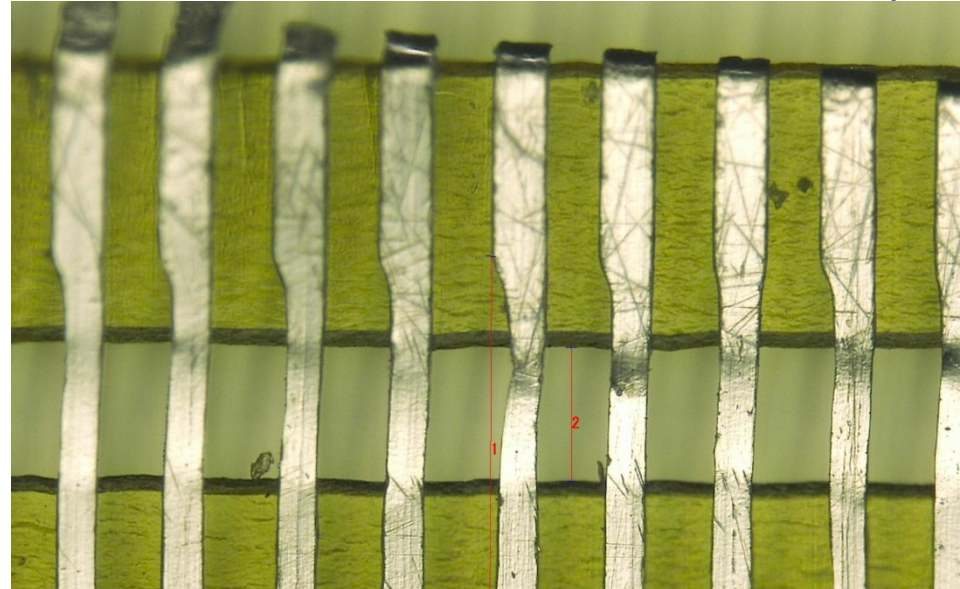
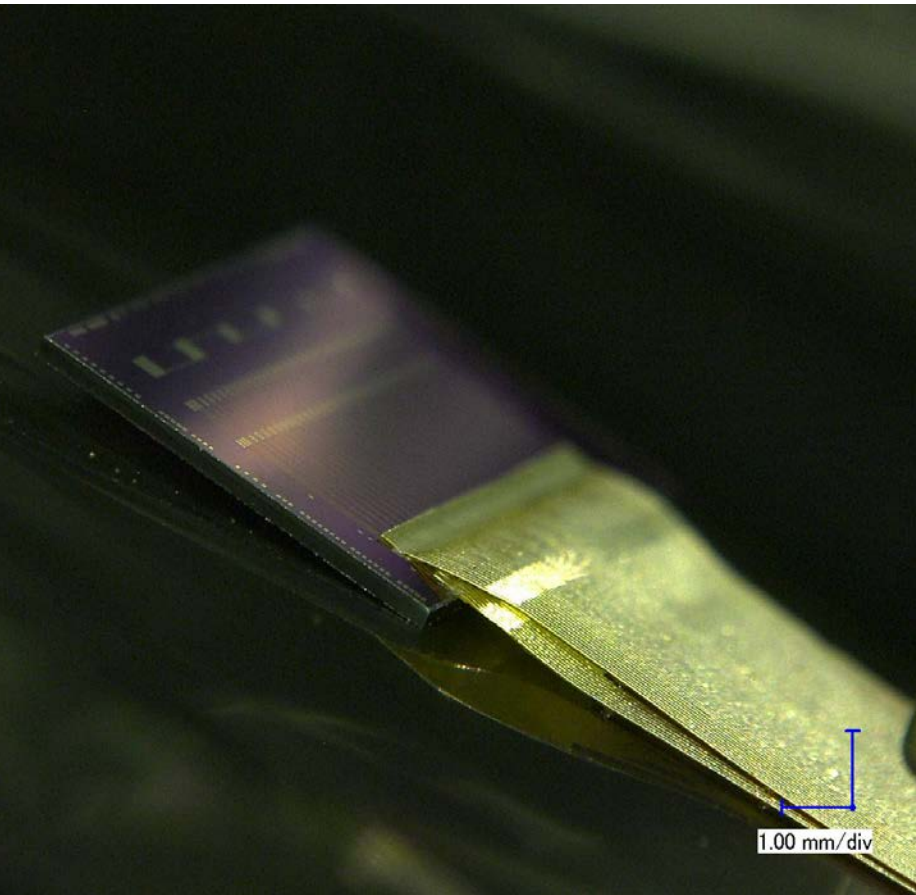
Numbers:

- 1000 Modules
- 32 cables per module
- 2048 ch per module
- Tab bonding
- Micro cables: 10 μ Polyimide
14 μ Al traces



Micro Cable Technology with TAB-Bonding

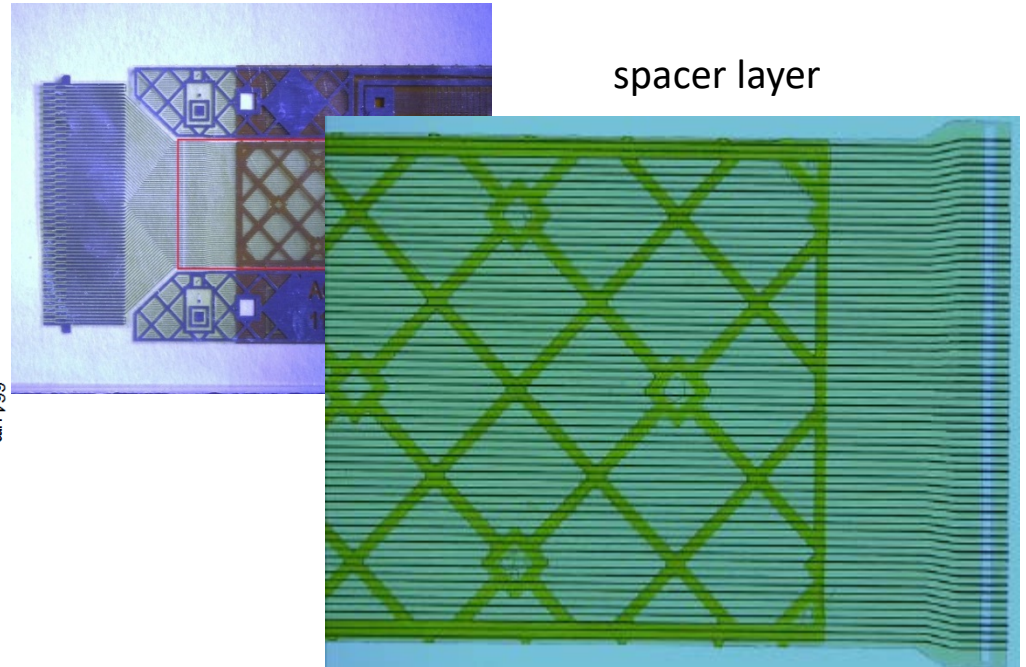
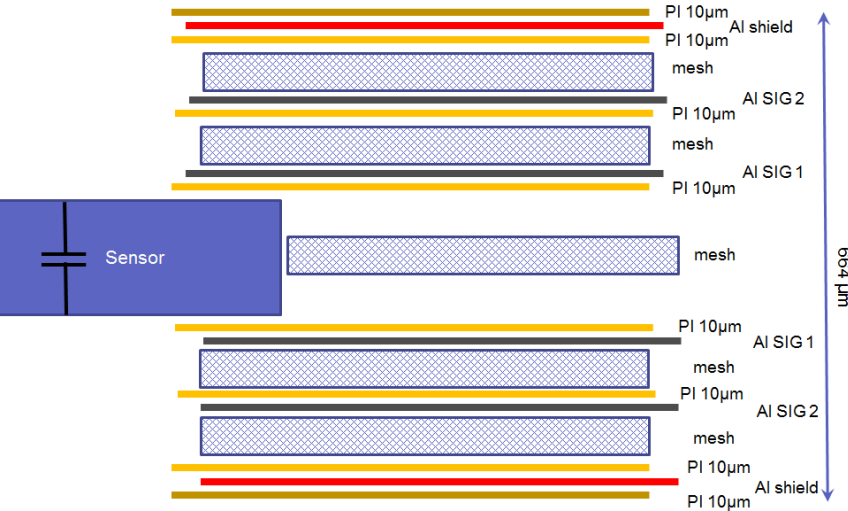
double cable layer bonded onto chip



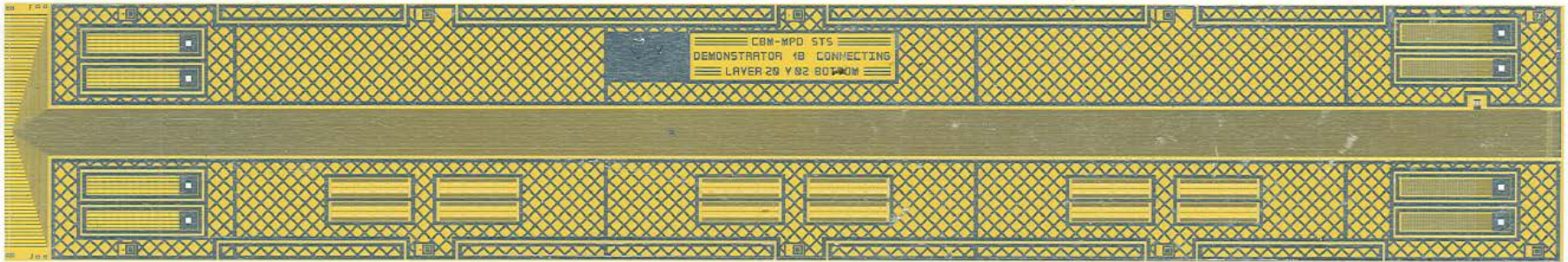
32.000 read-out cables

cooperation with LTU, Ukraine

cable stack: *thickness* $0.230 \% X_0$

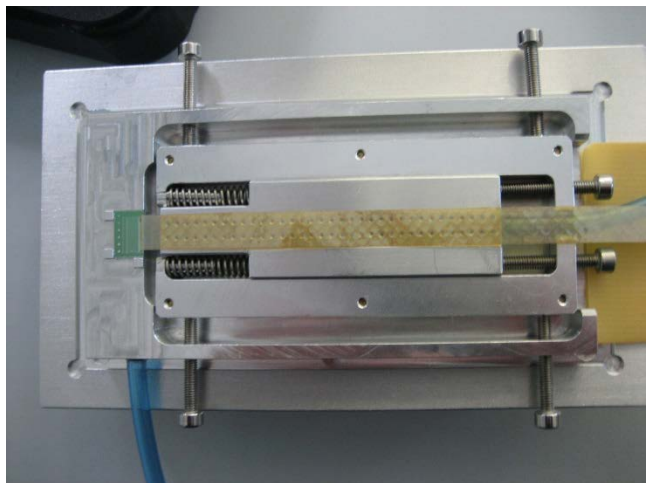


signal layer: 64 Al lines of 116 µm pitch, 14 µm thick on 10 µm polyimide, lengths up to 55 cm

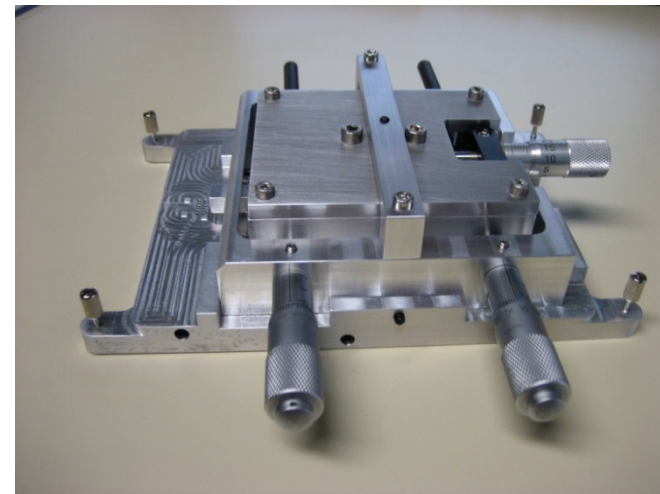




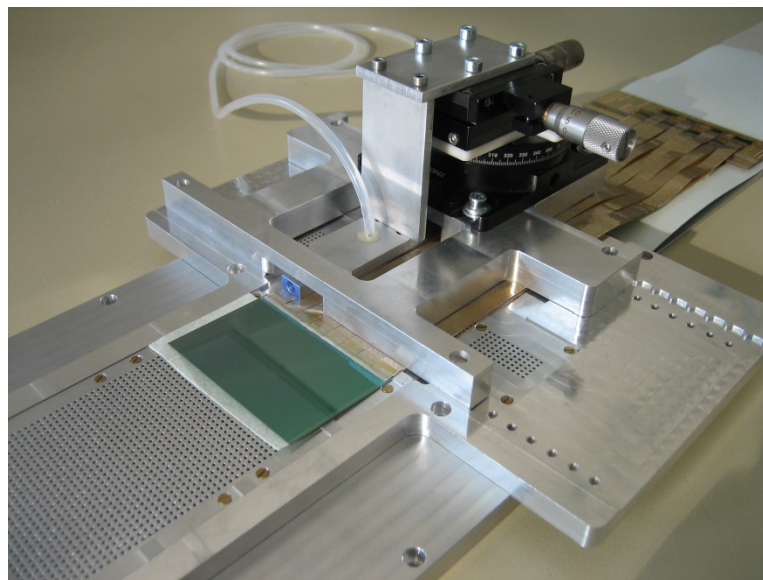
Assembly Jigs



jig for TAB-bonding 1st micro-cable layer to ASIC

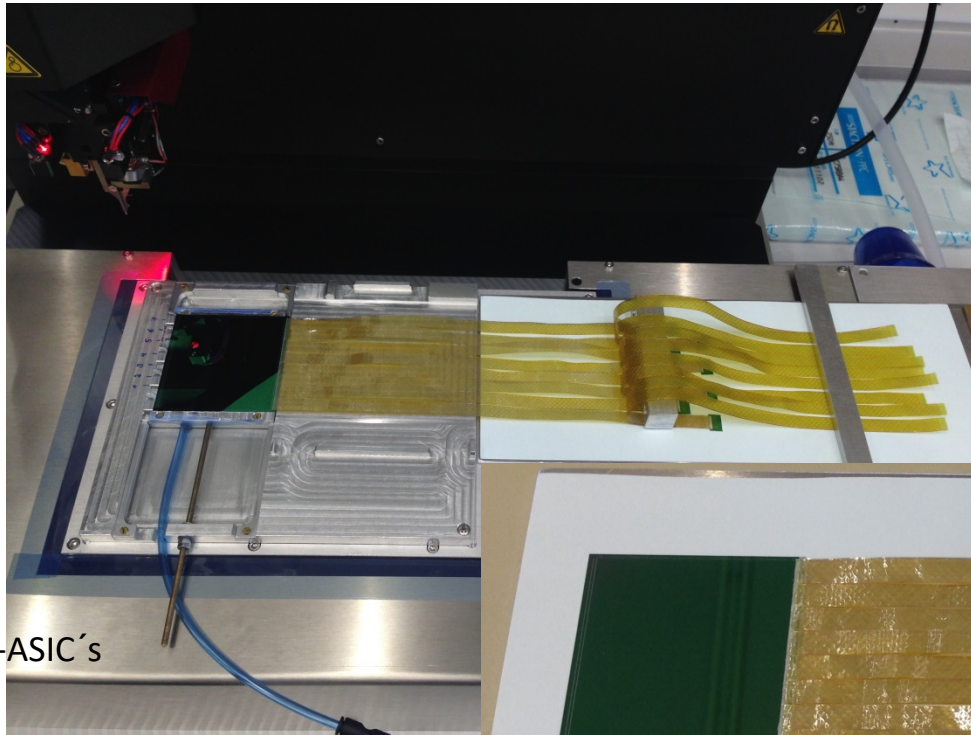


jig for TAB-bonding 1st and 2nd micro-cable layer to ASIC



jig for TAB-bonding micro-cables to sensor with micro-positioners for x-, y- and rotation

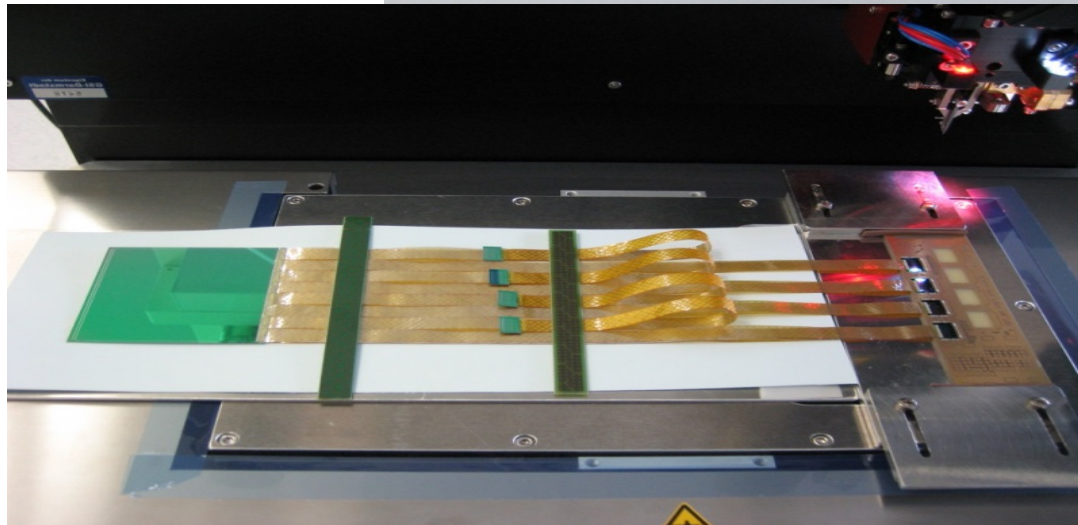
Tab-Bonding Chip-Cables to Silicon Sensor



- fixing of the microcables with vacuum and alignment
- TAB-bonding of 16 microcables to the sensor (two rows at 8 microcables)
- protection of the TAB-bonds with Globtop after QA-measurements



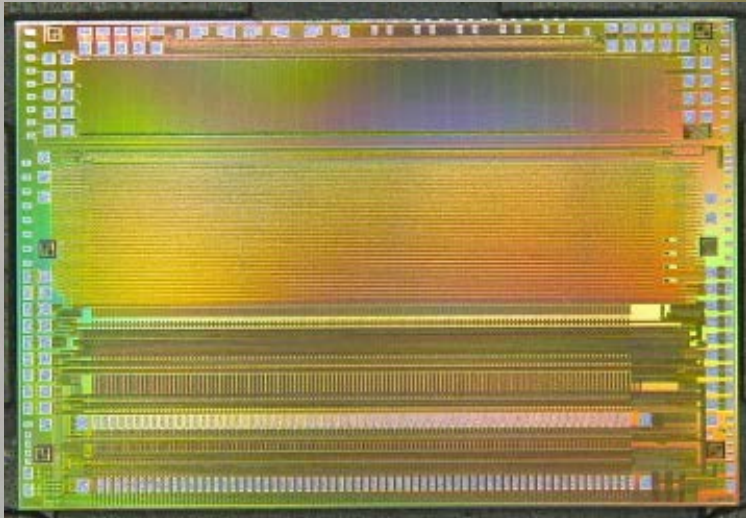
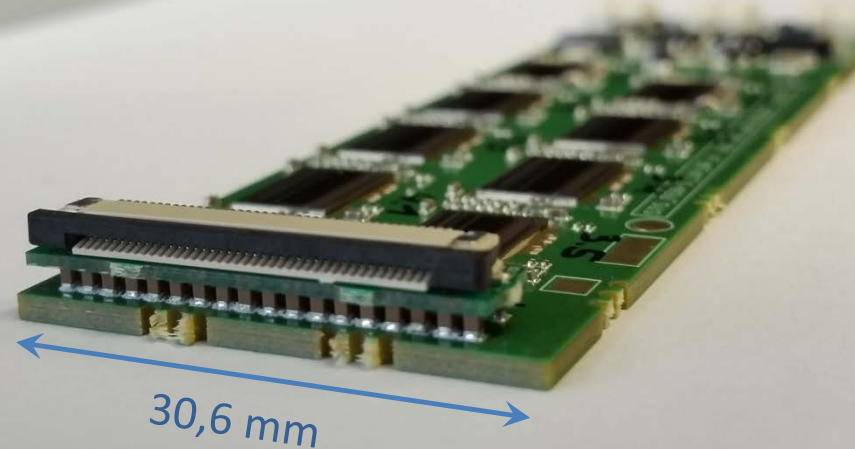
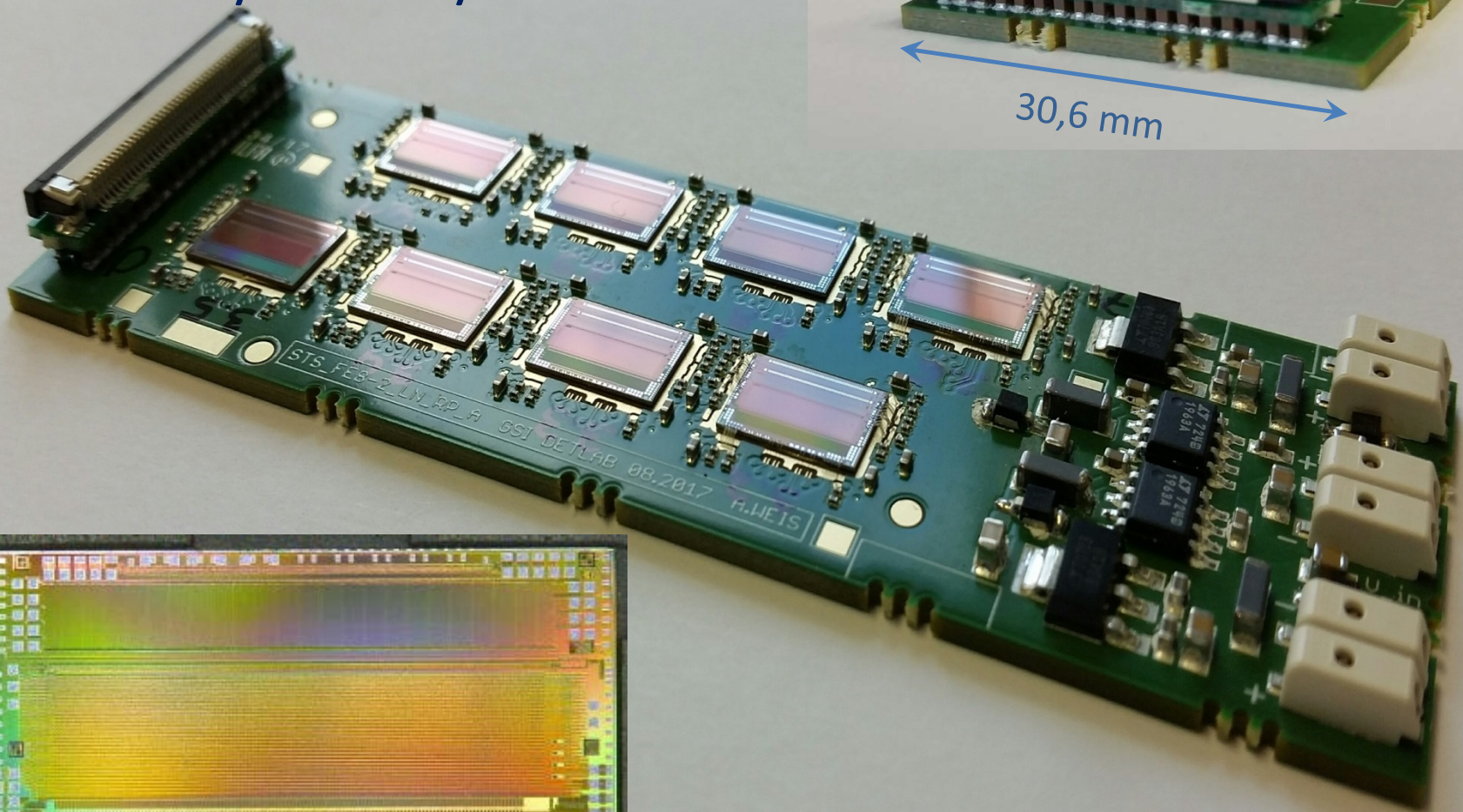
Wire Bonding Chip-Cables to Readout Board



... and then the other side...

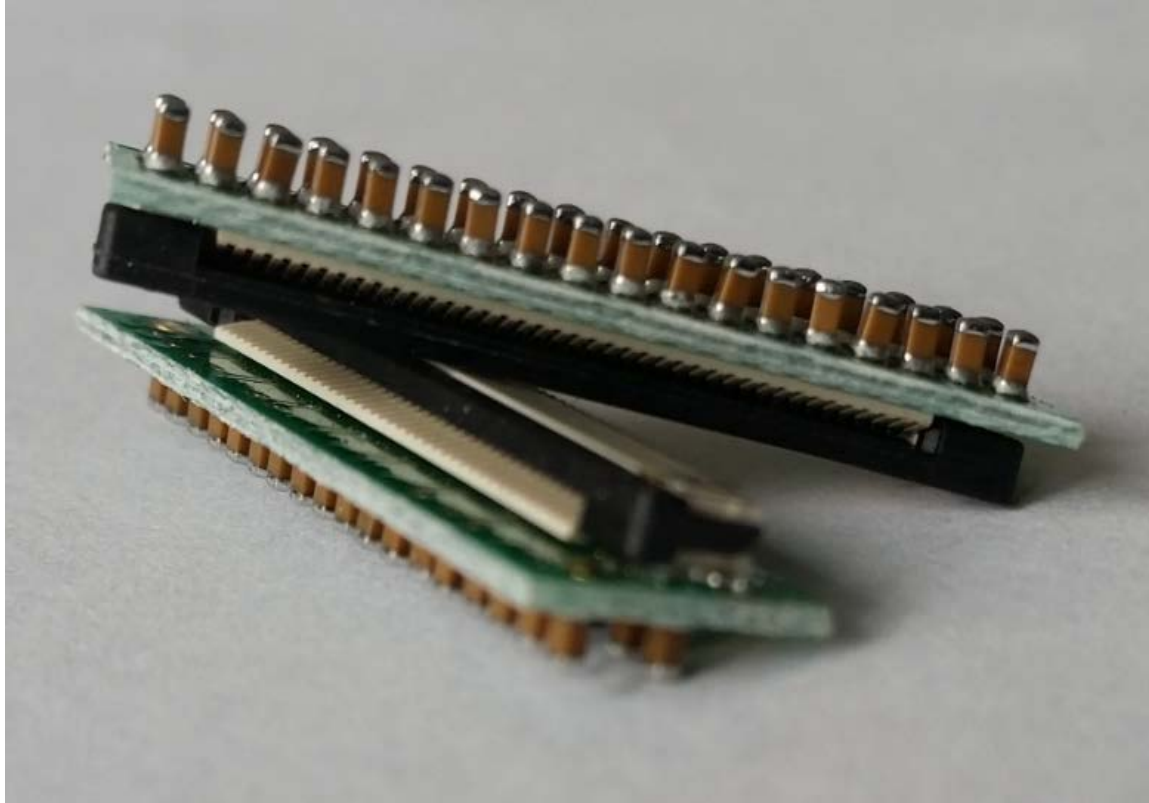
1024 ch Front End Board (FEB)

Operation: floating at bias potential
256 Mbit/s \sim 10 Gbit/s bandwidth



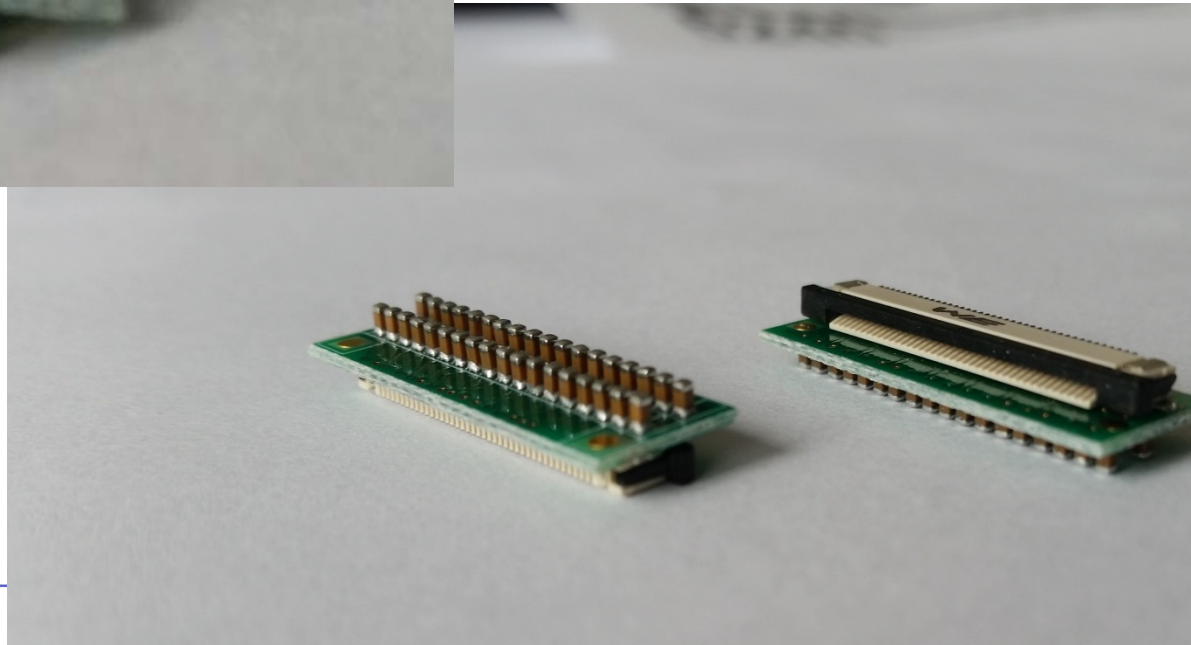
STS-XYTER: Dedicated AGH-ASIC Development for CBM
128 ch, self-triggered, dynamics 15 or 75 fC, \sim 1000 ENC
power < 10mW/ch, GBTx-compatible output

ZIF 500V-AC-Coupling Connector Part



Mounted device sensitive to shear forces: need to add glue for robustness.

- 40-pin 0.5mm pitch ZIF
- Compatible to 40-line commercial shielded flat cable
- Height to be optimized
- good for up to 18 up-links

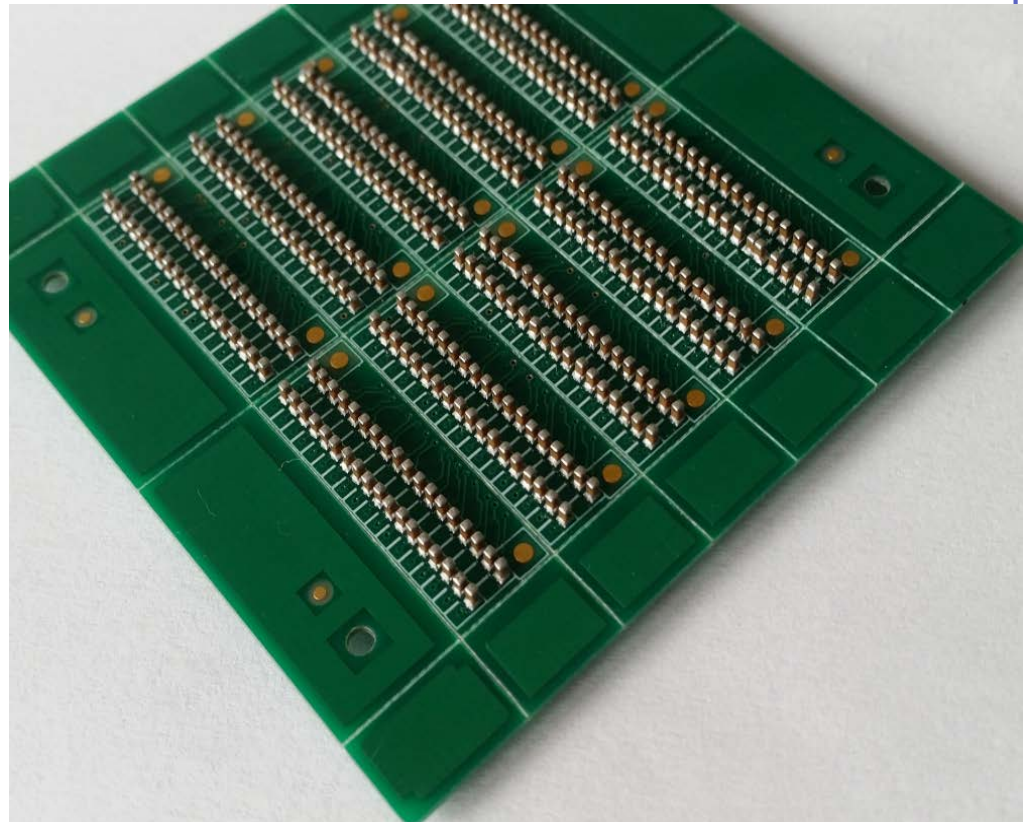


Digital Interfacing: Bridging Signals to Gnd – 3D arrangement

first tombstone tests



...after optimization

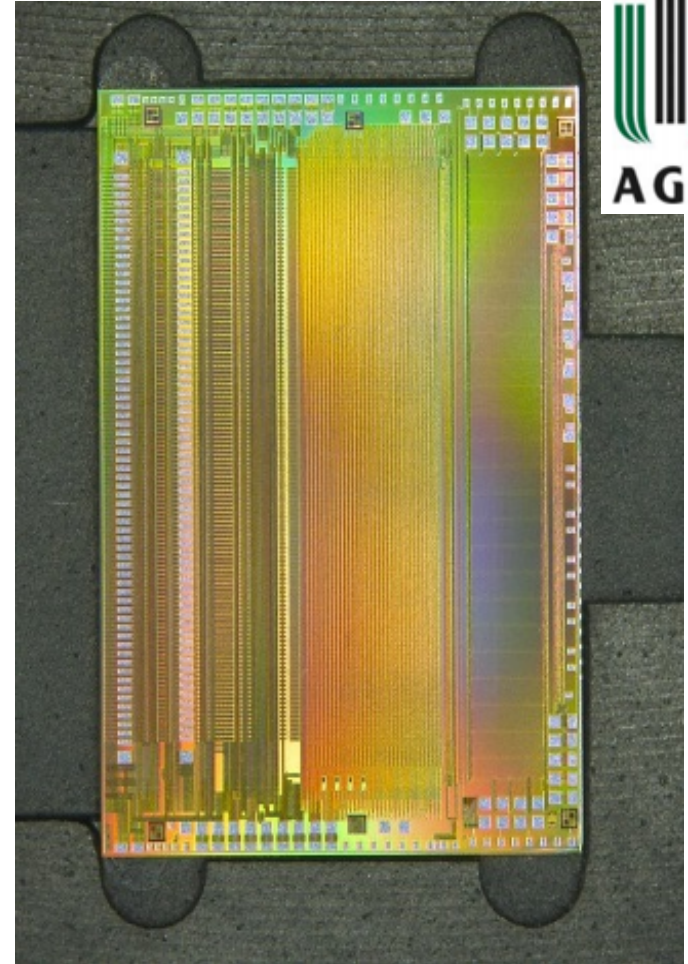


128ch Readout ASIC serves as STS-XYTER and Much-XYTER r/o

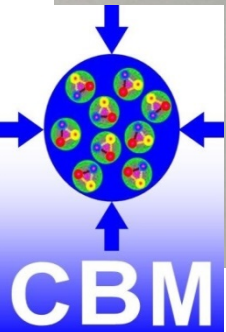
- Moderate Time ($\sim 5\text{ns}$) and Energy res. (5bit)
- 1000 electrons noise
- Switchable Gain, Identical Readout Logic
- GBTx-based DAQ, 32 Mbit/s each chip
- Power optimized, radiation tolerant



1024 ch CBM-STS readout board



- Microchip ASIC developed at AGH Krakow,
- Design internationally reviewed,
- Detector Integration by international groups

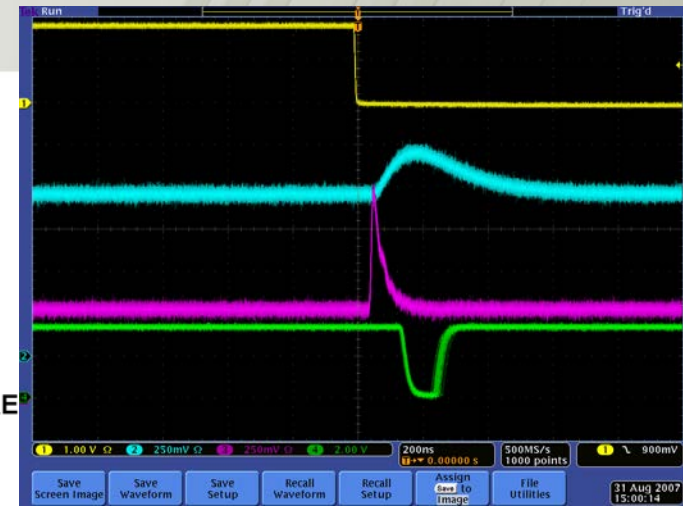
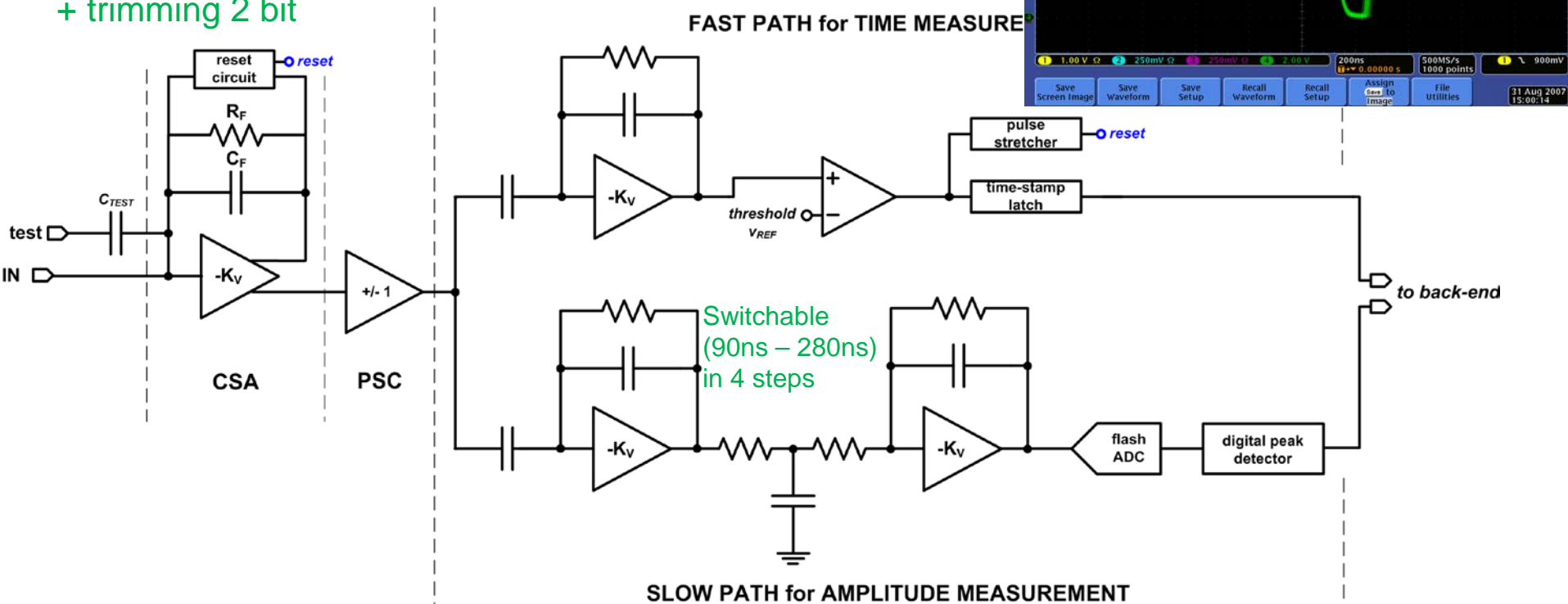


STS-XYTER Readout Microchip

Analog Front End

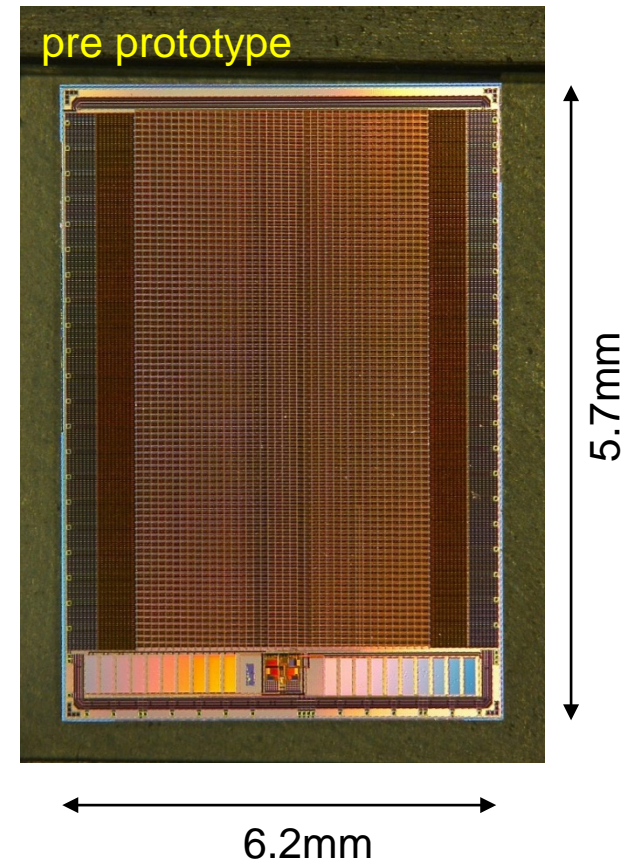
Krzysztof Kasinski and Robert Szczygiel of AGH
Krakow, Poland

Switchable gain
(5x smaller for MUCH)
+ trimming 2 bit



Skimming LDOs: Development at SCL Chandigarh

- Output noise (100kHz to 100MHz) < 70 μ V RMS
- 1/3 of STS-XYTER power-pin related signal noise (210 μ V RMS),
1/10 noise power contribution
- Final size: 5.7mm x 6.2mm
- Two versions: 1.8V/1.6A and 1.2V/1.6A
- Ripple rejection up to 100kHz
- Junction temp up to 100°C
- No self-restart upon overcurrent
- Output enable
- 5 external parts (R, 4 Caps)



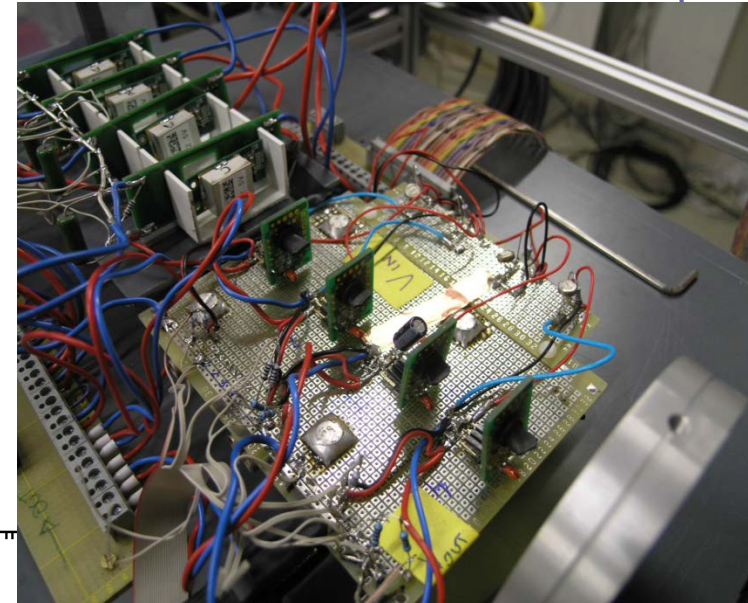
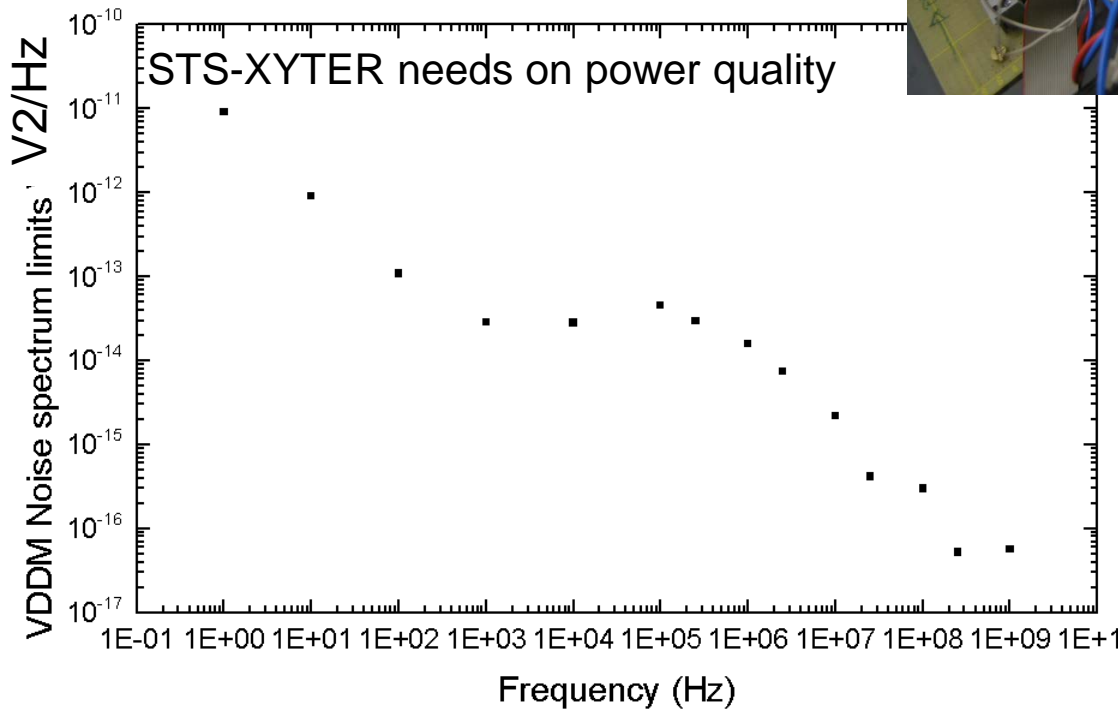
Power distribution in harsh environments

Towards Rad Hard LDOs

Cooperation with SCL Chandigarh

Three LDO chips survived $4 \times 10^{13}/\text{cm}^2$
2 GeV protons, no SEU observed

P. Koczon, S. Loechner, P. Wieczorek

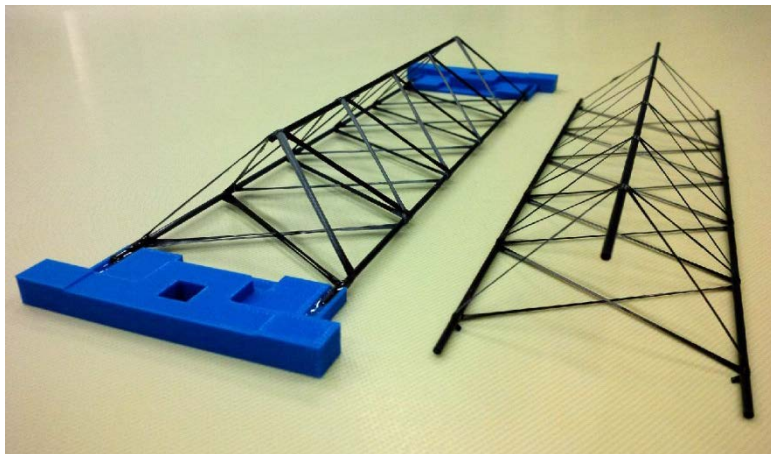
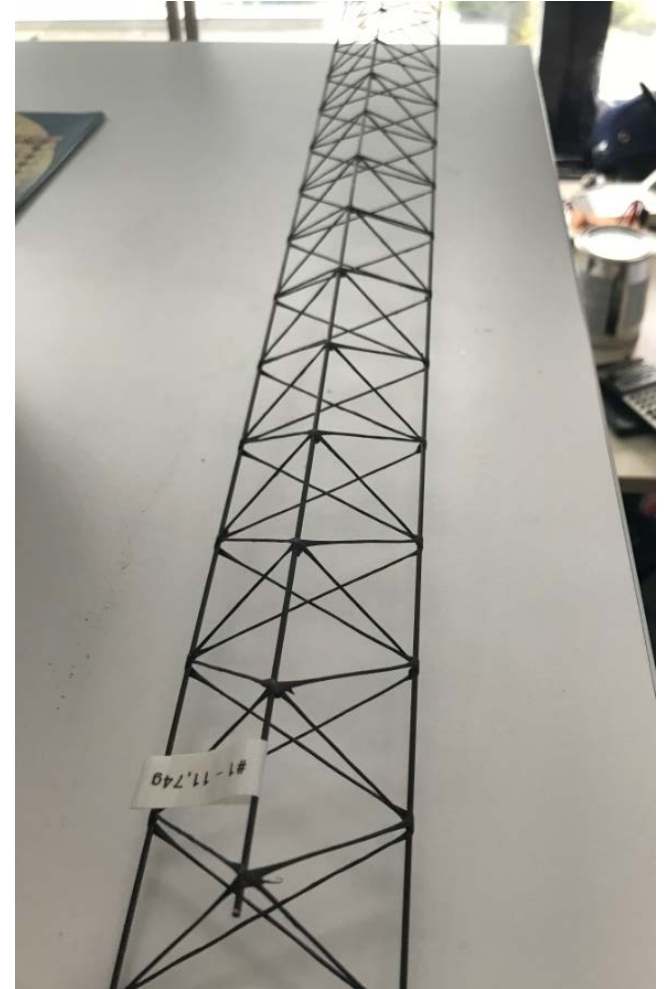




Final STS-Module:



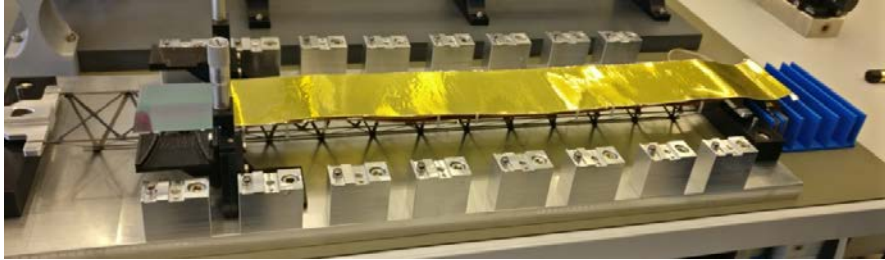
Concept inherited from ALICE ITS: Carbon fiber ladders



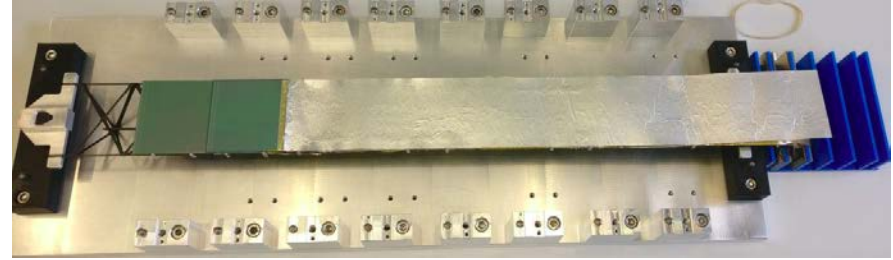
11g for 1m long ladder

mount 10 silicon modules onto one ladder

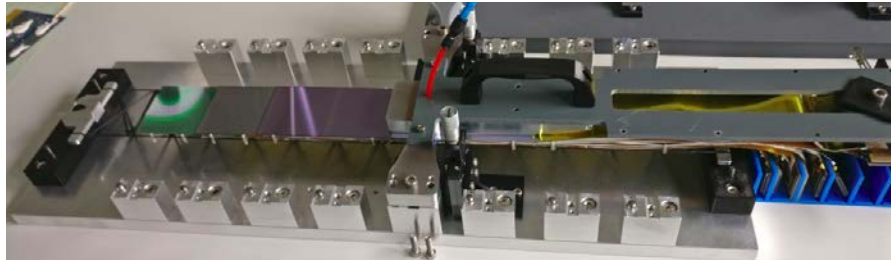
Assembly Tests : Modules onto Prototype Ladder



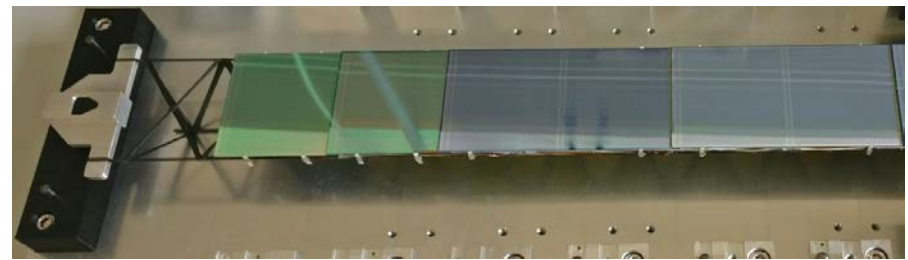
Dummy module - I



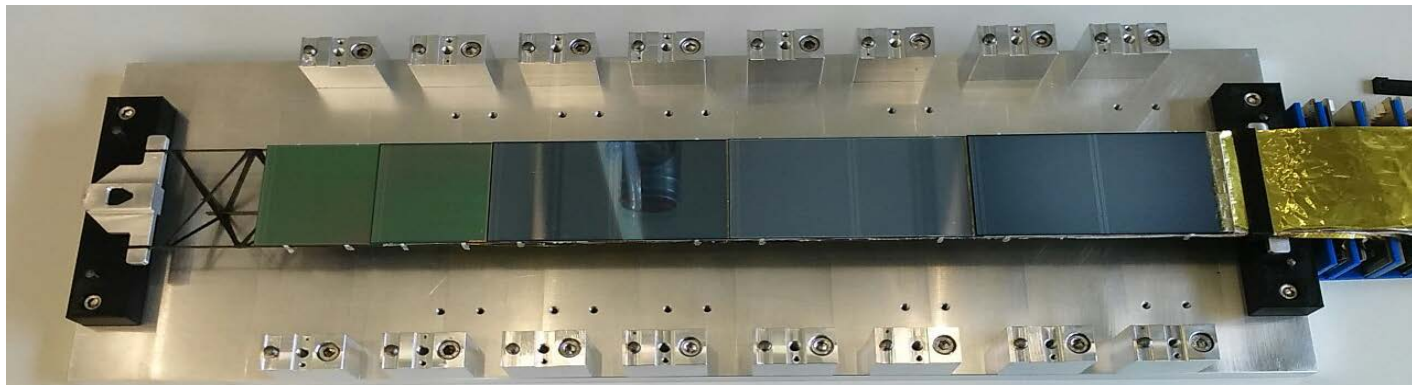
Dummy module - II



Dummy module - III

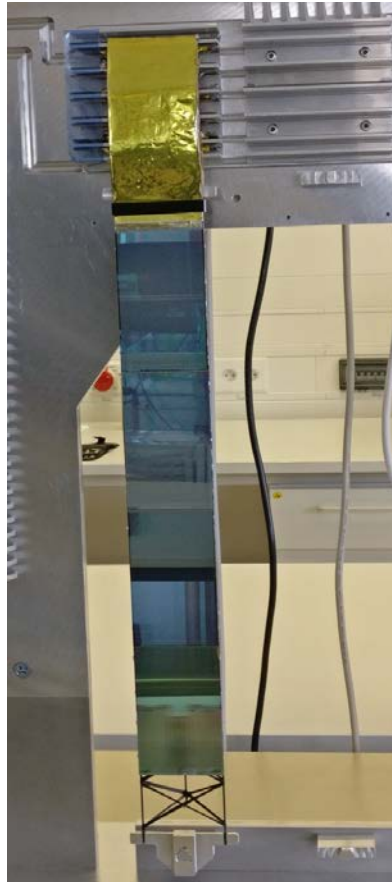
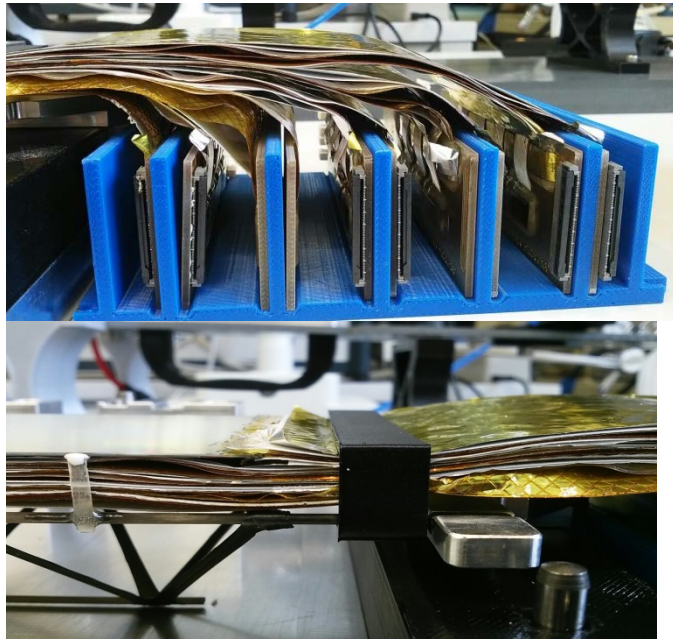


Dummy module - IV

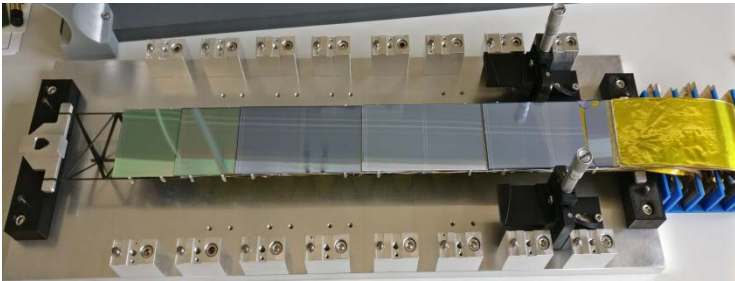


Dummy module - V

Ladder assembly imposes mechanical challenges during assembly of modules onto ladder



- Cable stack is thick and stiff
- Need precise lengths of cables so they won't fold up
- While mounting on frame, handling difficulty.



Mini-CBM @ FAIR Phase 0: fully assemble and operate small functional CBM subset

Currently: pre-series modules employed in the miniSTS of mCBM@SIS18

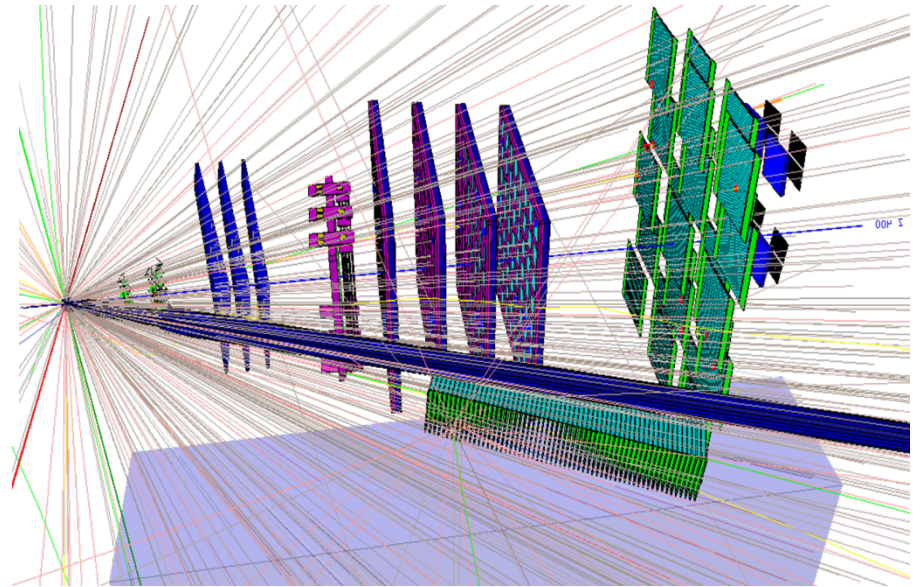
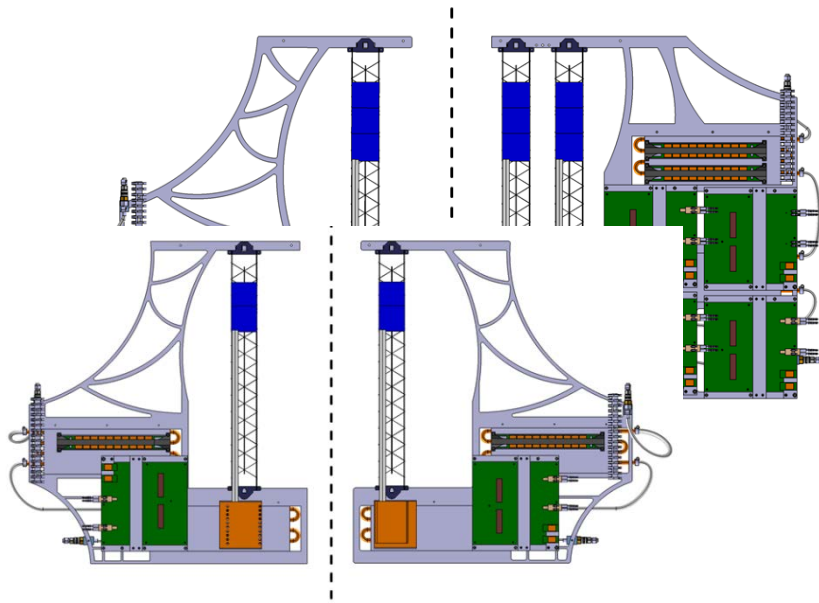
13 modules, arranged on 5 ladders, forming 2 tracking stations

mCBM run 02/2019:

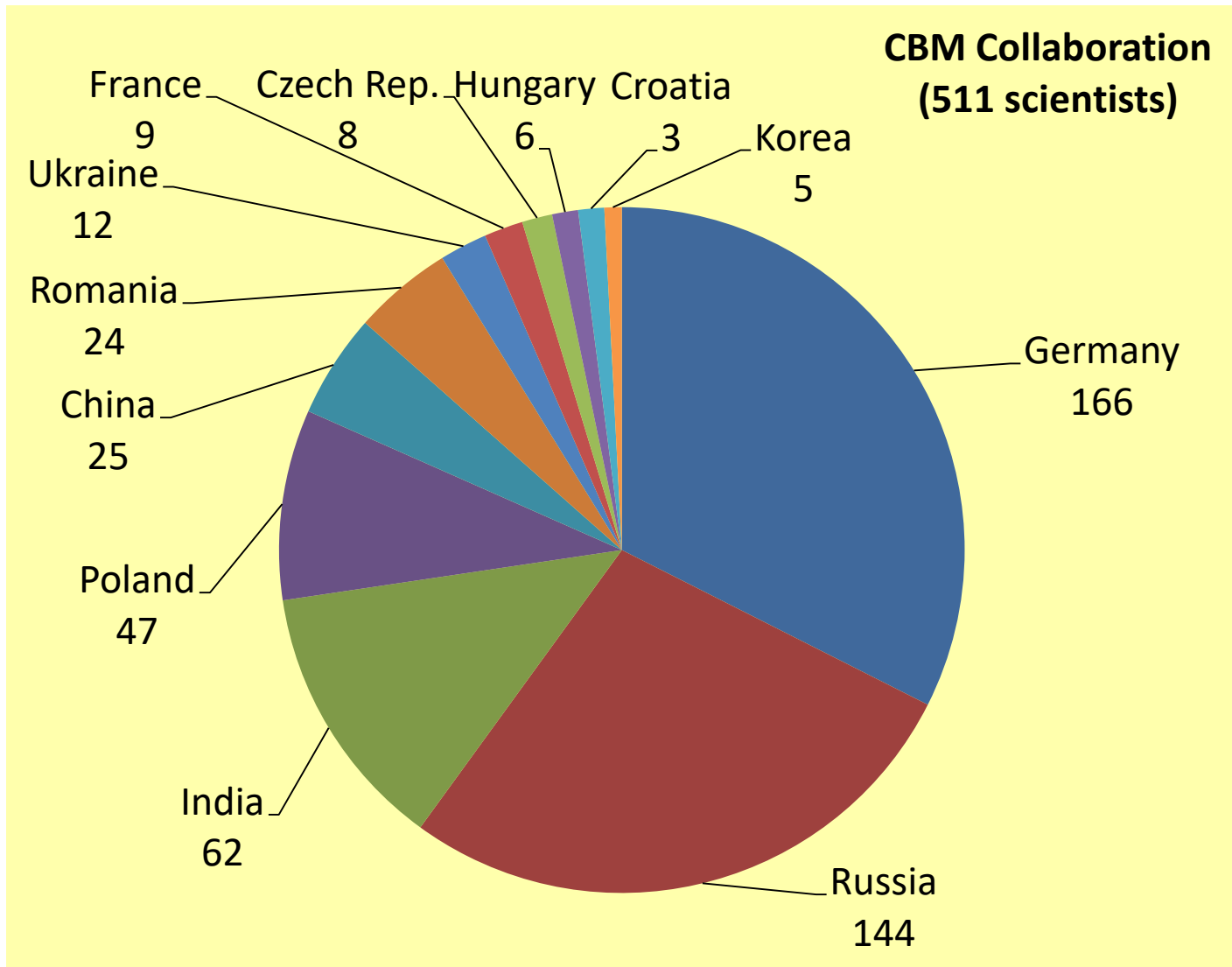
4 modules on 2 ladders

mCBM run scheduled May 2020:

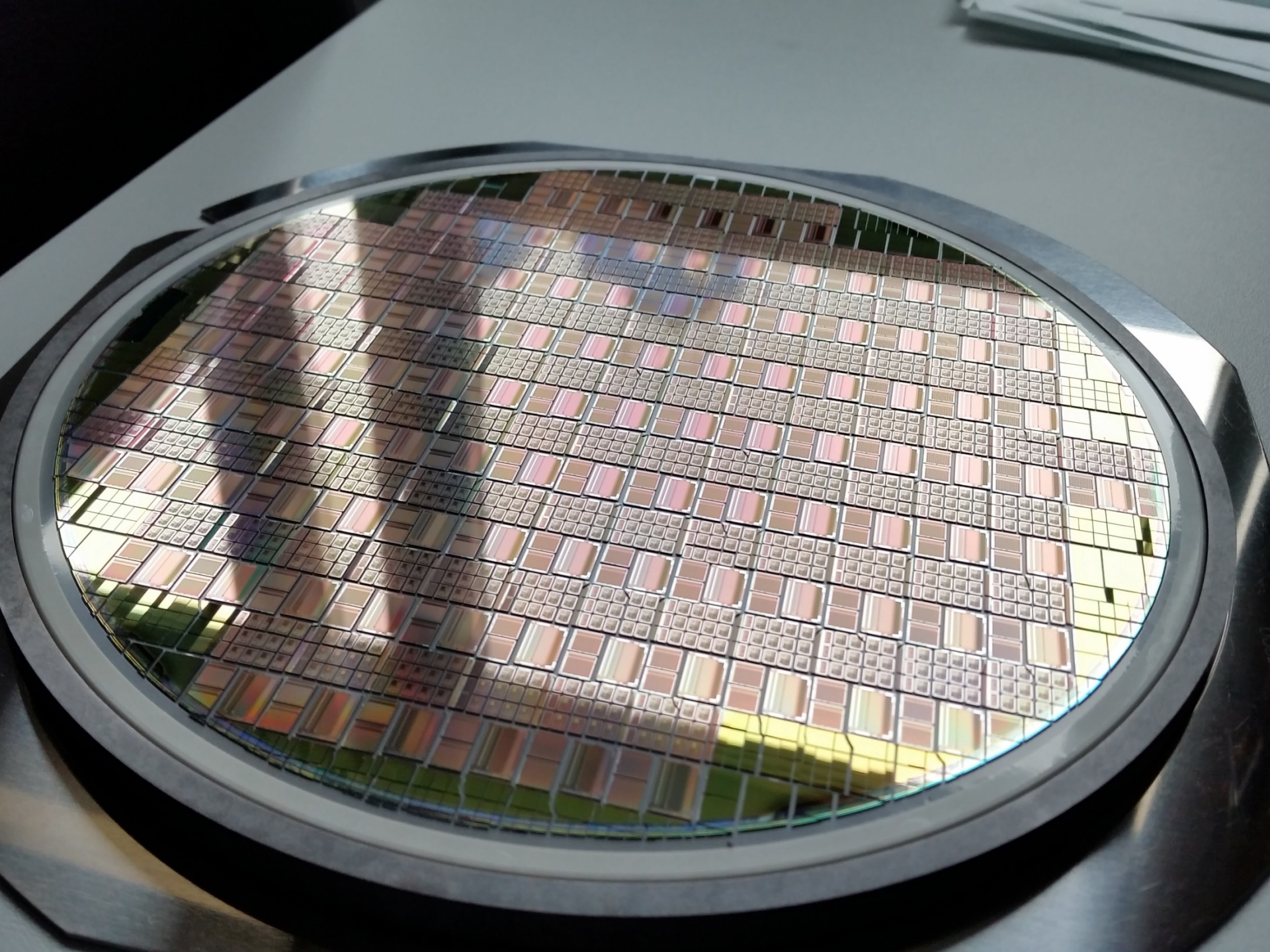
further 9 modules on 3 ladders



The CBM Collaboration



First physics beam targeted in 2024

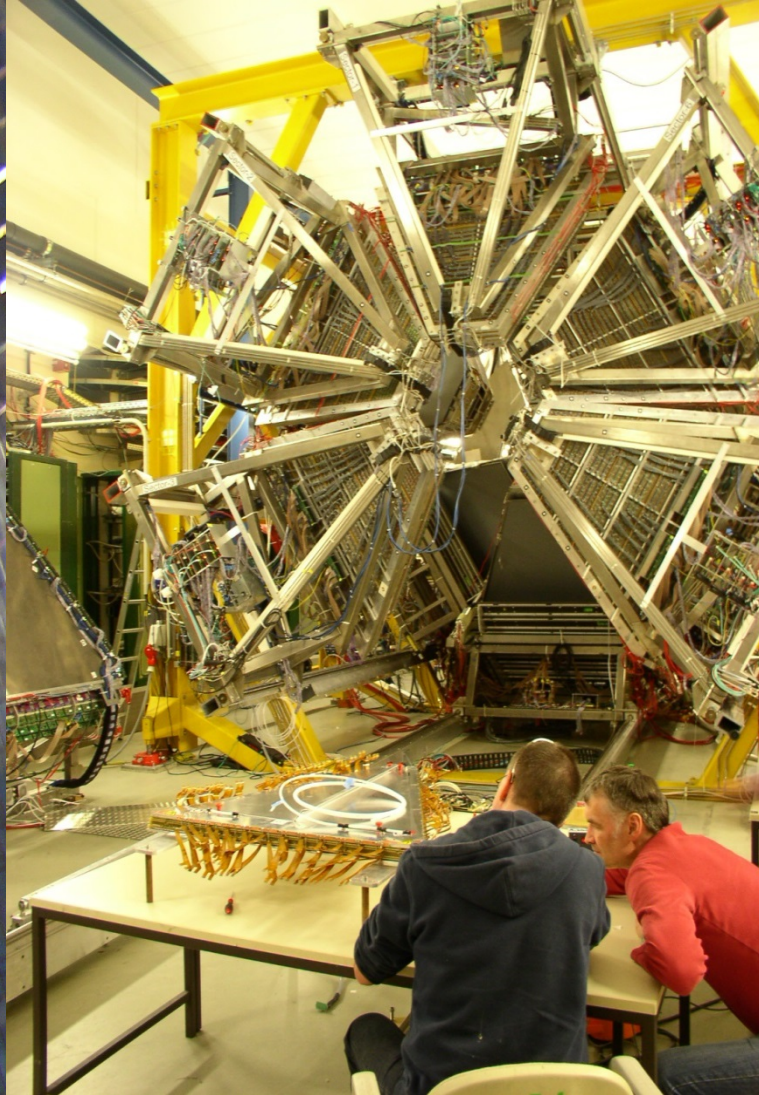


Time Projection Chamber, the Queen of Trackers

- 100 m³ gas
- Currently engagement in mayor fraction of GEM based ALICE TPC upgrade
- None-triggered continuous TPC readout



HADES- The GSI Dilepton Spectrometer



Detector lab engagement in HADES Drift Chamber design and production

