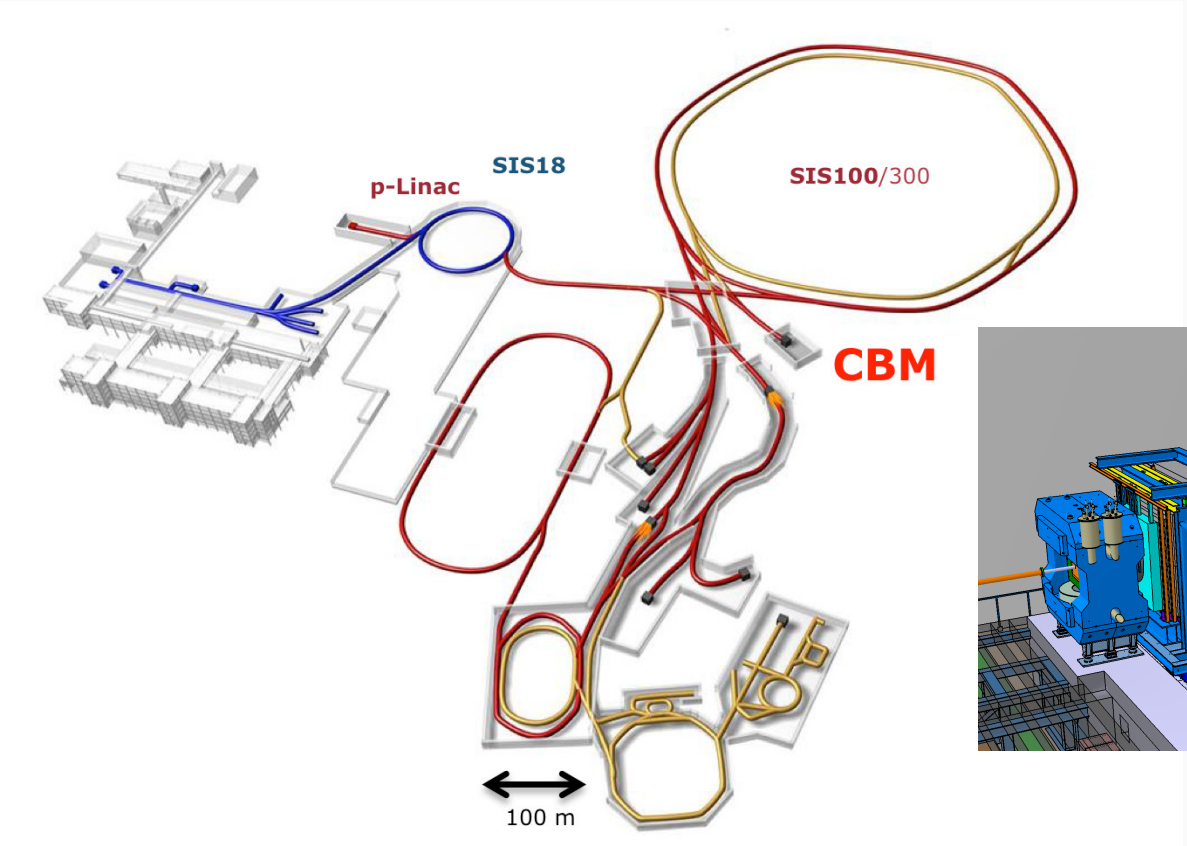
The Silicon Tracking System of the CBM Experiment at FAIR

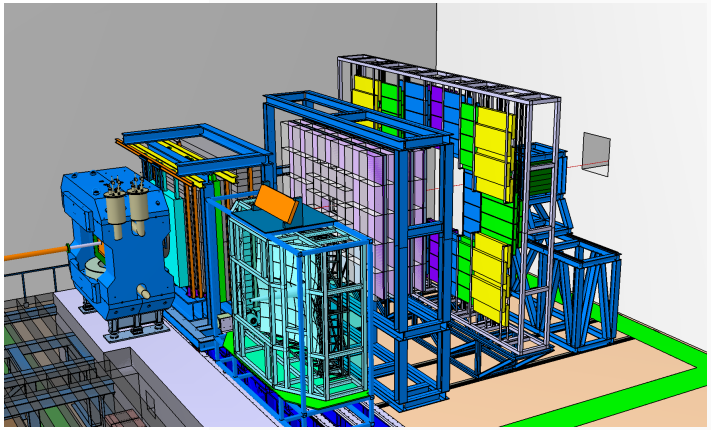
Olga Bertini for CBM collaboration

27.03.2017

GSI Helmholtzzentrum für Schwerionenforschung GmbH

Facility for Antiproton and Ion Research

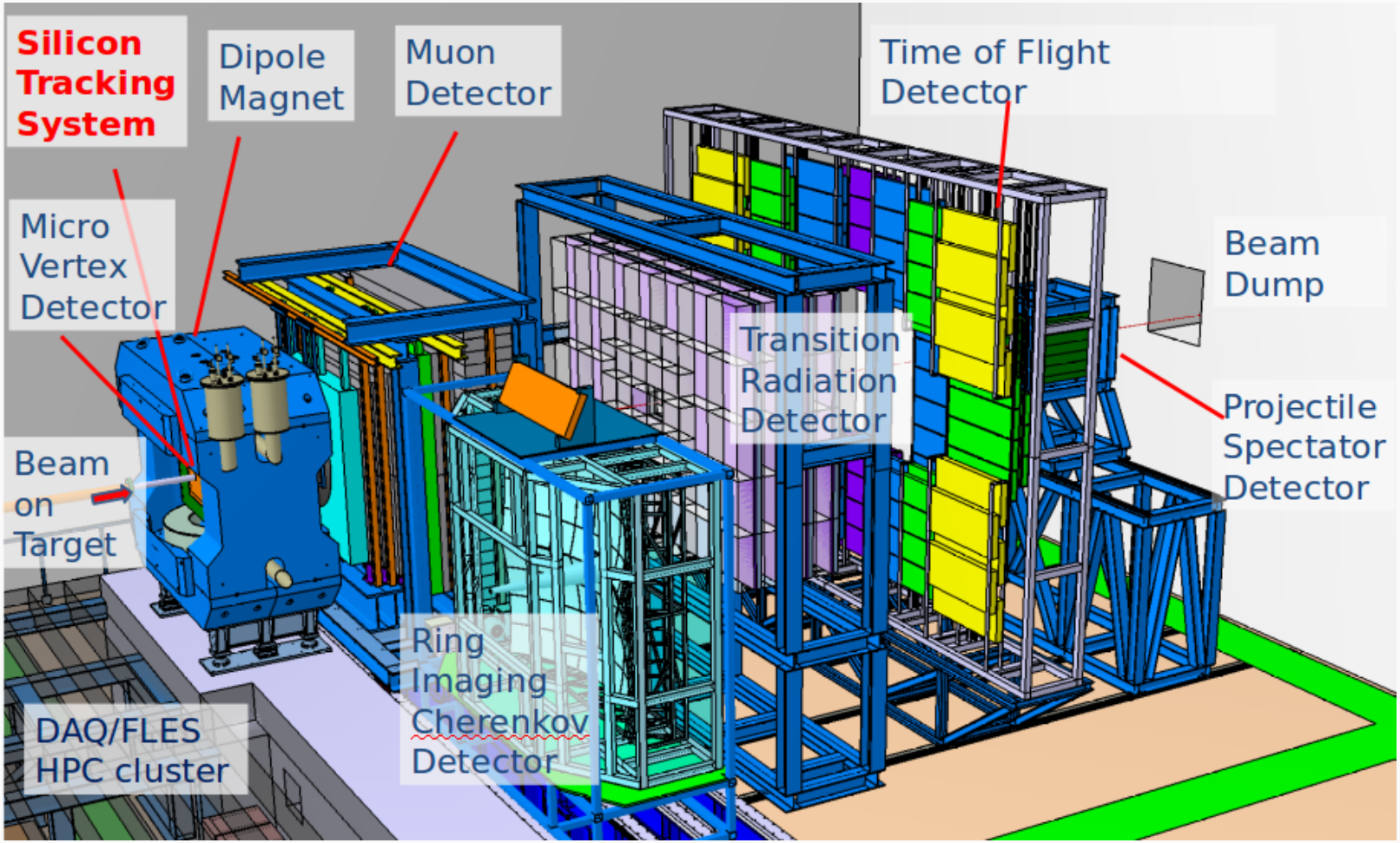




FAIR phase 1, first beam in 2025

FAIR phase 2

CBM experiment @ SIS100



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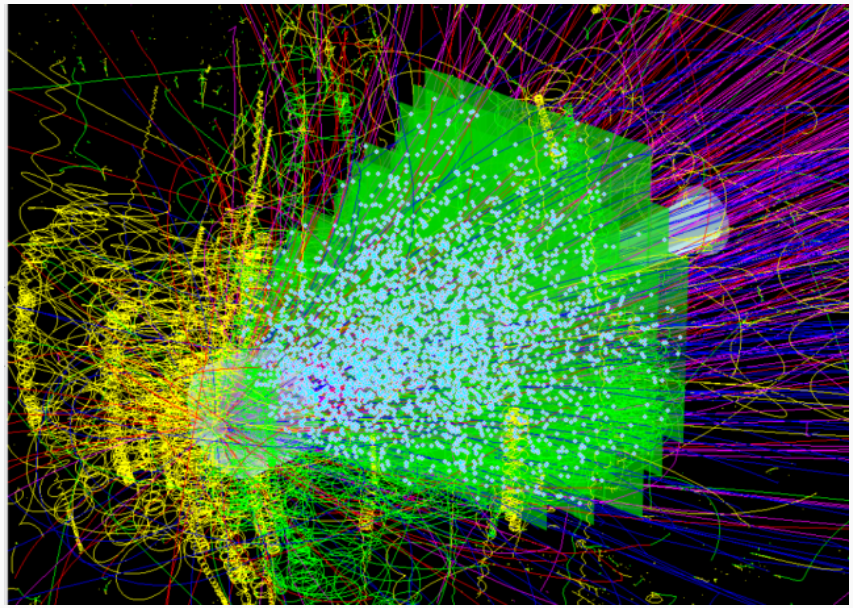
The Compressed Baryonic Matter experiment at FAIR
Jörg Lehnert, GSI, Darmstadt

Experimental challenge

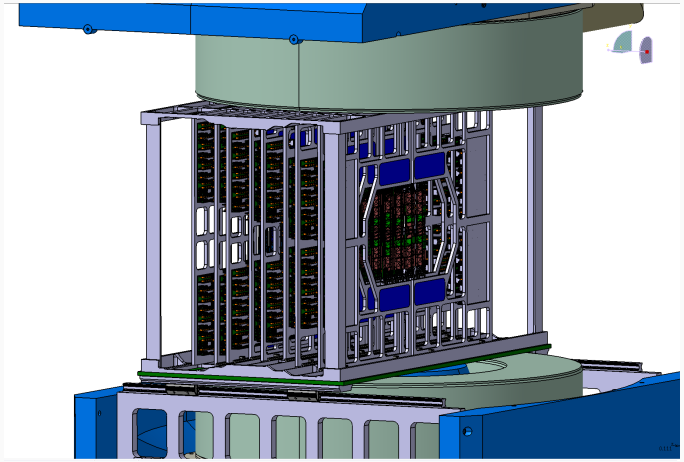
central Au+Au, 8 GeV/nucleon



Experimental requirements

- high-rate collision environment: $10^5 - 10^7$/s (AA), up to 10^9/s (pA)
- radiation tolerance up to $10^{14}\mathrm{n}_{eq}/\mathrm{cm}^2$
- free streaming front-end electronics with time-stamp resolution $\simeq$ 5ns
- momentum resolution: $\delta p/p \simeq 1.8\%$ ($p > 1$ GeV/c, 1 Tm field)
- low material budget

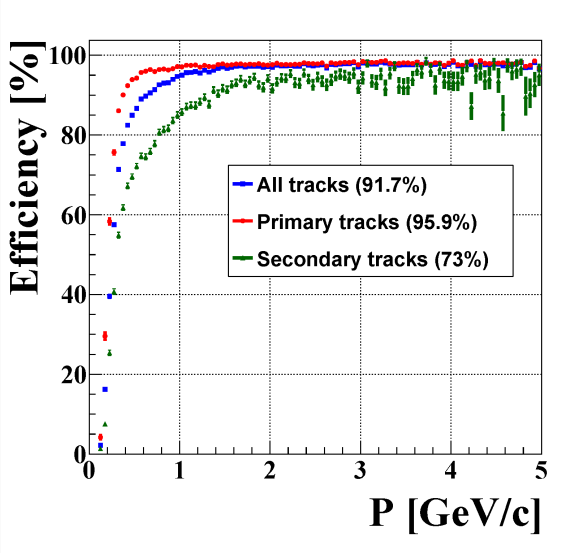
Silicon Tracking System



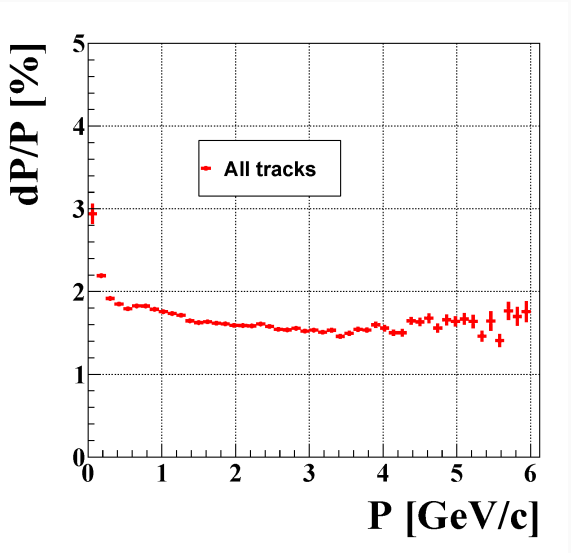
STS design

- 8 tracking station
- geometrical acceptance: $2.5° \leq \theta \leq 25°$, $0.3\text{m} \leq z \leq 1.0\text{m}$
- material budget $0.3\% - 1\%$ X_0 per station
- double-sided silicon microstrip sensors, spatial hit resolution $\simeq 25\mu\text{m}$

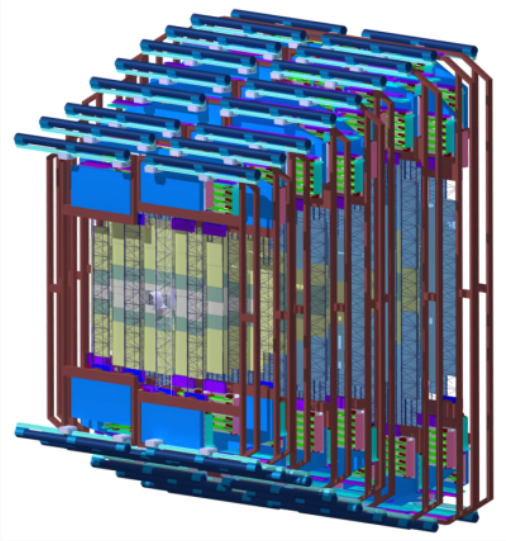
Track reconstruction efficiency



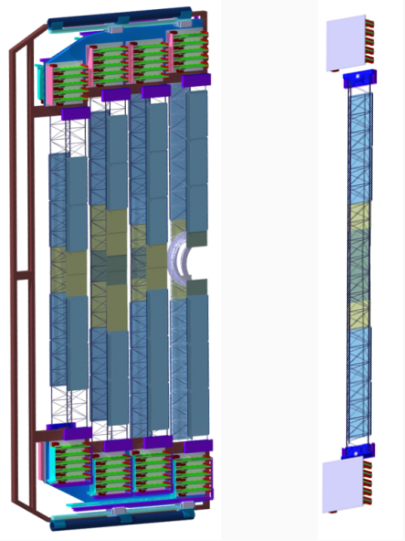
Momentum resolution



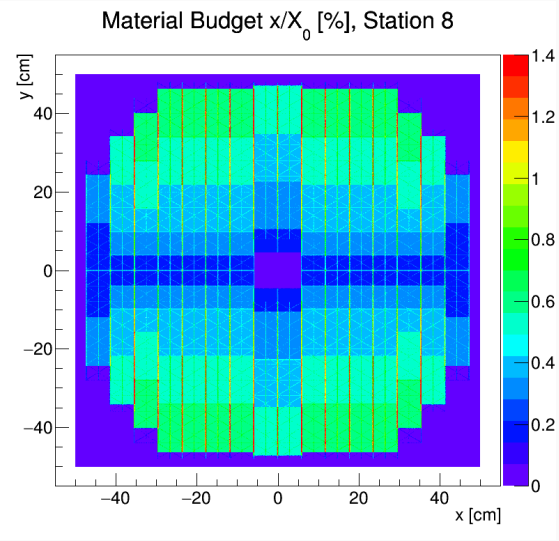
STS integration concept



8 tracking station



mechanical unit ladder

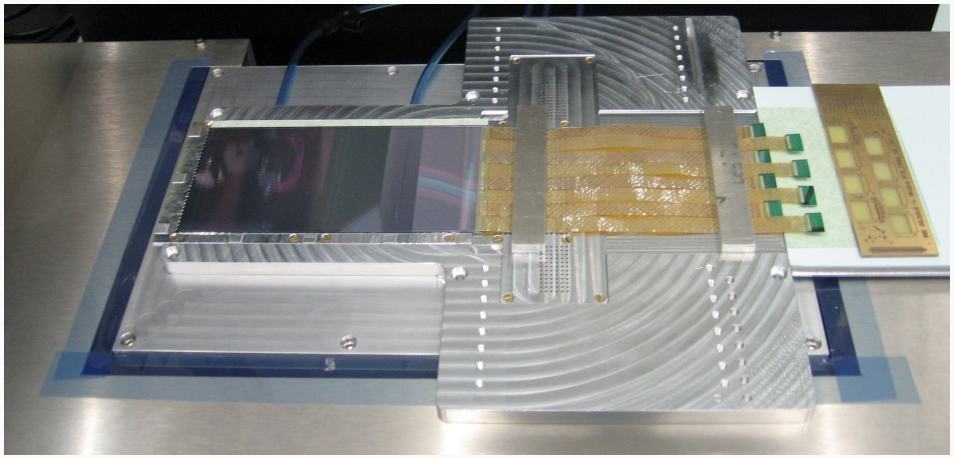


896 detector modules including:

- $\sim$ 900 double-sided microstrip sensors
- $\sim$ 1.8M readout channels
- $\sim$ 14000 readout chips and ultra-thin readout cable stacks

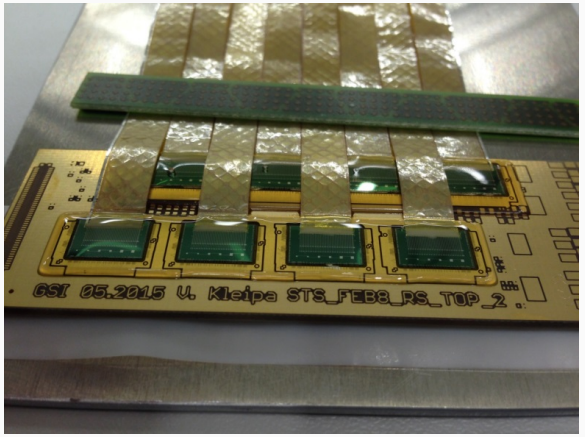
Detector module assembly

12 cm sensor in bonding fixture



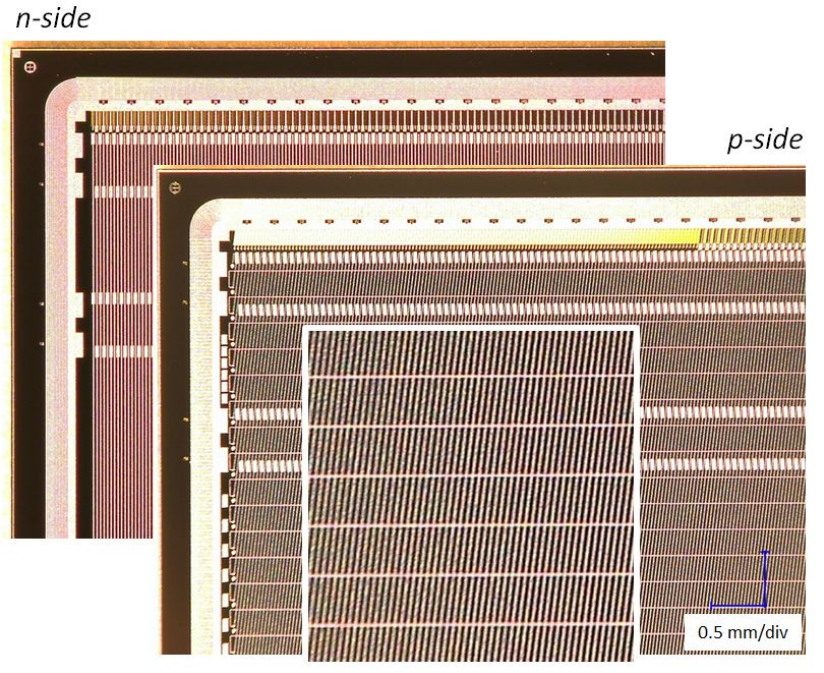
assembled dummy module

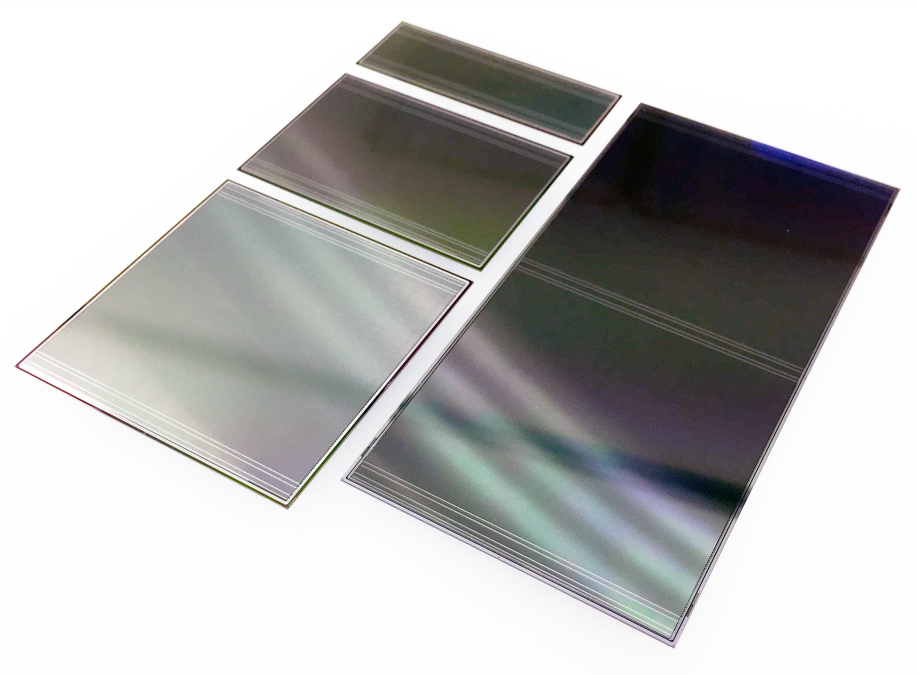
chip cables with STS-XYTER ASICs in front-end board



- 4-5 modules per ladder
- 32 tab bonded cables
- 16 chips, 8/side

Silicon microstrip sensors



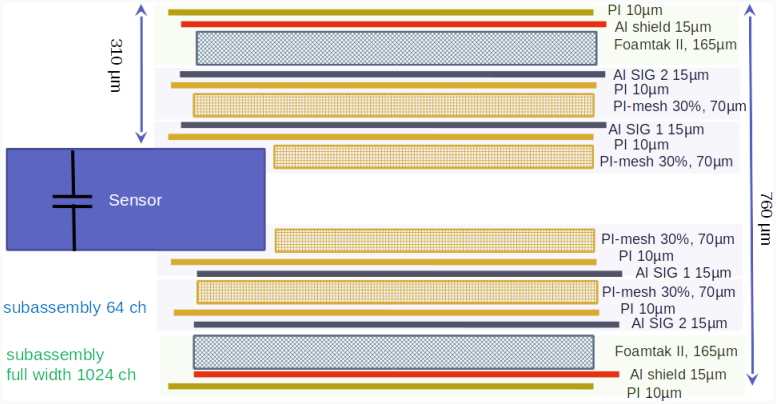


- double-sided
- 1024 channels per side
- 58 μm pitch
- 300 μm thickness
- stereo angle 7.5°(P-Side)

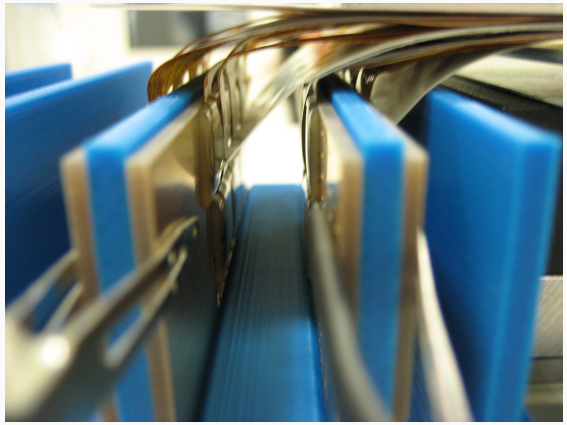
- dimensions:
  - 6×2 cm^2
  - 6×4 cm^2
  - 6×6 cm^2
  - 6×12 cm^2
- 2nd metallization to interconnect short corner strips

Ultrathin microcables

Schematic side view of the microcable stack for one CBM module

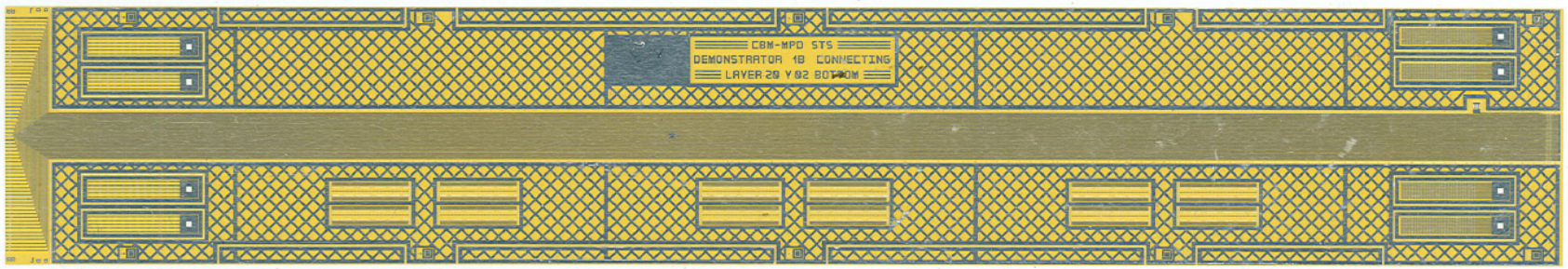


Microcables in electronic box



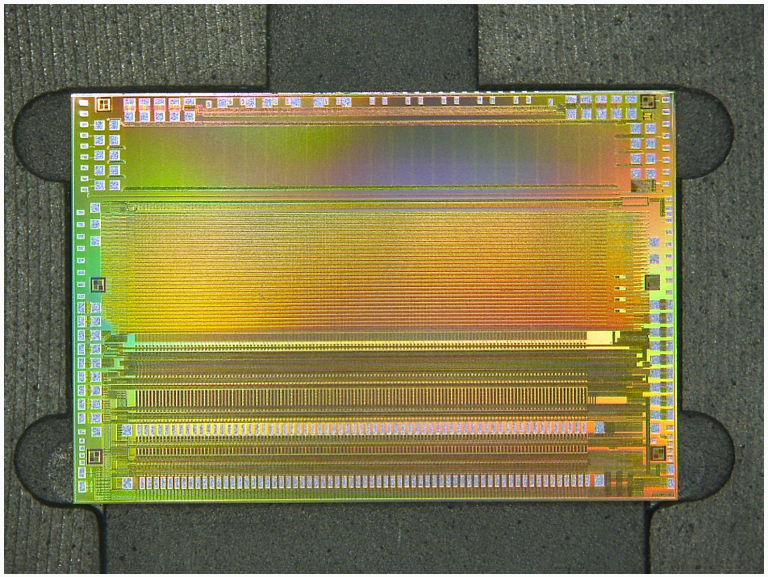
signal layer: 64 Al lines of 116μm pitch, 10μm thick on 14μm polyimide

Microcable demonstrator, length 60 cm. Top view

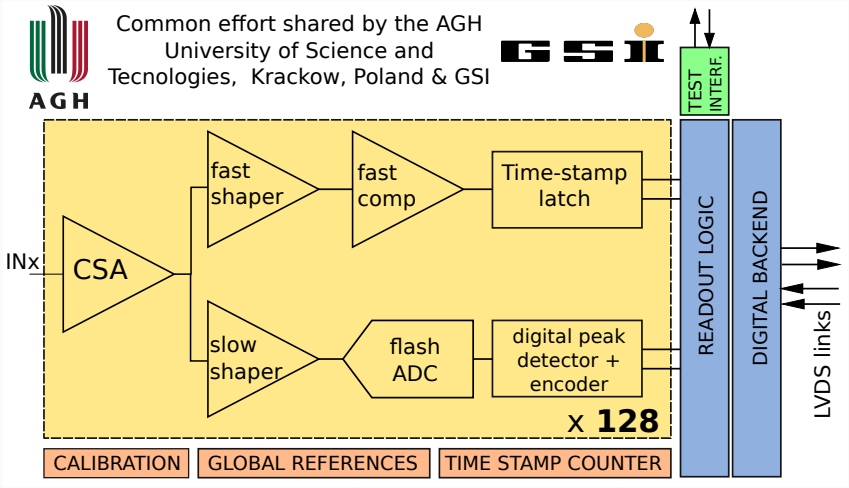


Material budget per cable stack: 0.228X_0(equivalent to 213μm Si)

Front-End Electronics. STS-XYTER ASIC



channels	128, polarity +/−
ADC range	16 fC, 5 bit
power	$<$ 10 mW/channel
timestamp	$<$ 5 ns resolution
out interface	up to 5 $\times$ 320 Mbit/s LVDS
STS-XYTER v2	Sept. 2016



- data driven architecture
- fast branch: time-stamp
- slow branch: signal digitization
- double-threshold discrimination: time stamp is vetoed if ADC produced no signal

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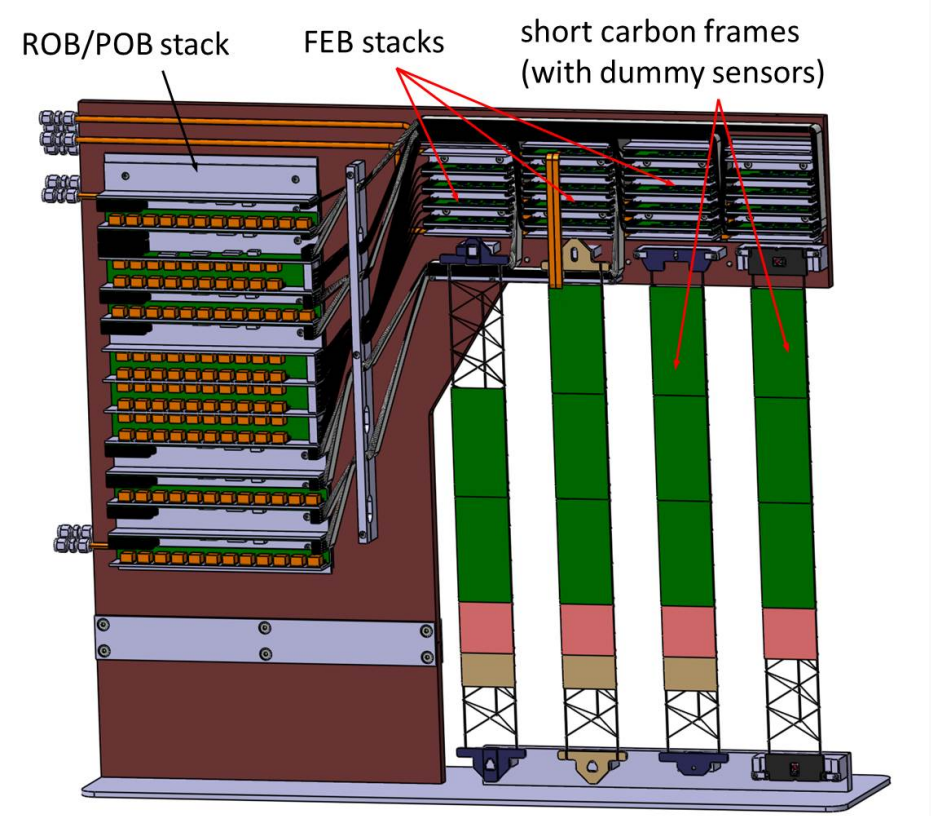
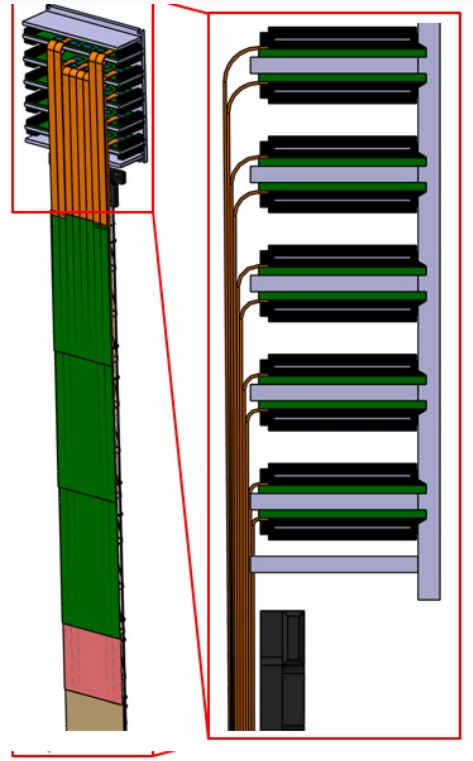
HK 63.2 Fr 14:15

Test of the STS-XYTER v.2 frontend ASIC for the CBM Silicon Tracking System
Adrian Rodriguez Rodriguez, Frankfurt University

Detector integration. Current engineering studies

Quarter-unit demonstrator





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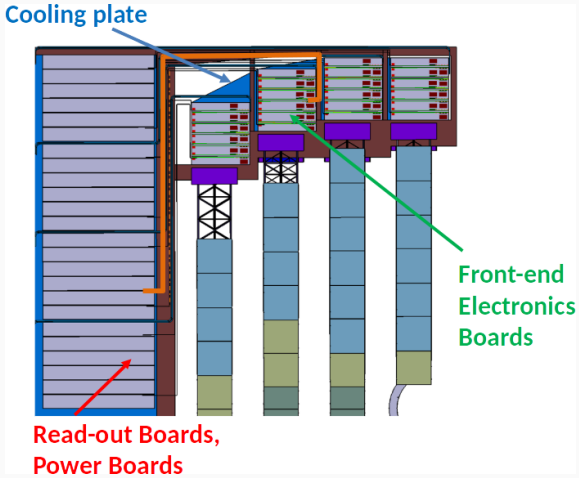
Progress with System Integration of the CBM Silicon Tracking Detector
Johann M. Heuser, GSI, Darmstadt

Detector integration. Cooling

Bi-phase CO_2 cooling
STS electronics total power dissipation: 42 kW

TRACI XL: 1 kW cooling prototype



Prototype of cooling plate with integrated channels

HK 27.71 Tue 16:45

Investigation of CO2-based Cooling for the CBM Silicon Tracking System
Kshitij Agarwal, Tübingen University

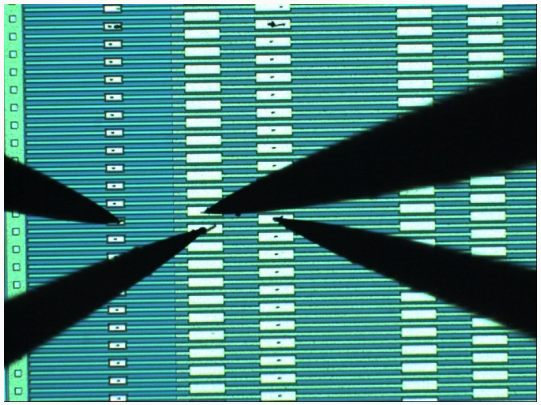
Quality Assurance

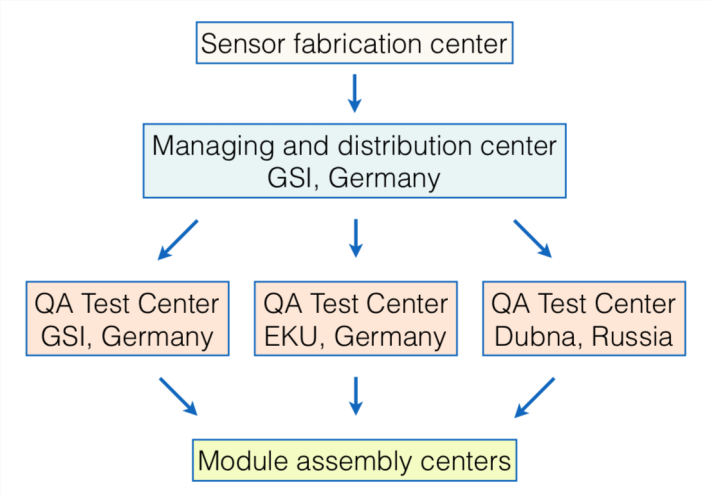
- Sensors
  - Visual inspection
  - Bulk properties tests: IV, CV
  - Strips quality tests:
    - pinhole test
    - strip leakage current
    - coupling capacitance
- Ultrathin microcables
- Front-End Electronics

Two QA centers in Germany

- GSI, Darmstadt
- Tübingen University

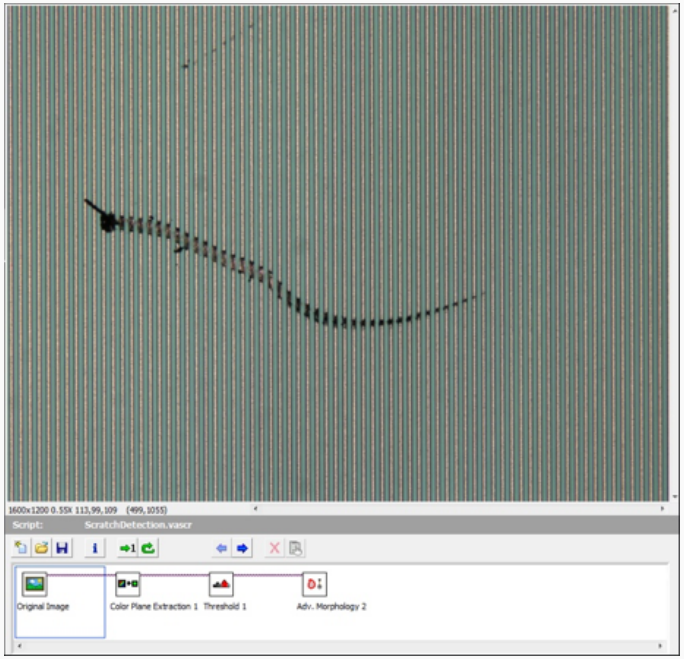
Positioning of the test needles on probe station for automatized strip test

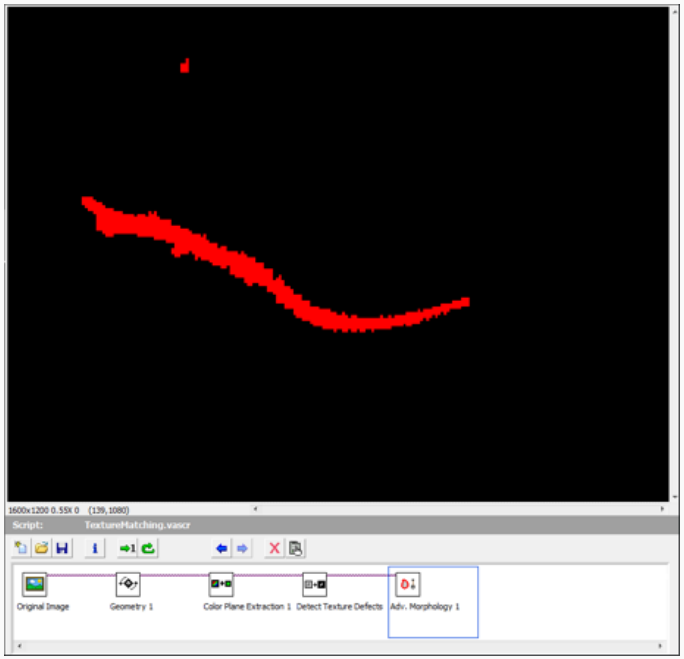




Quality Assurance. Visual inspection

Example detection of a scratch as seen in direct light source on CBM06 sensor (N-Side)





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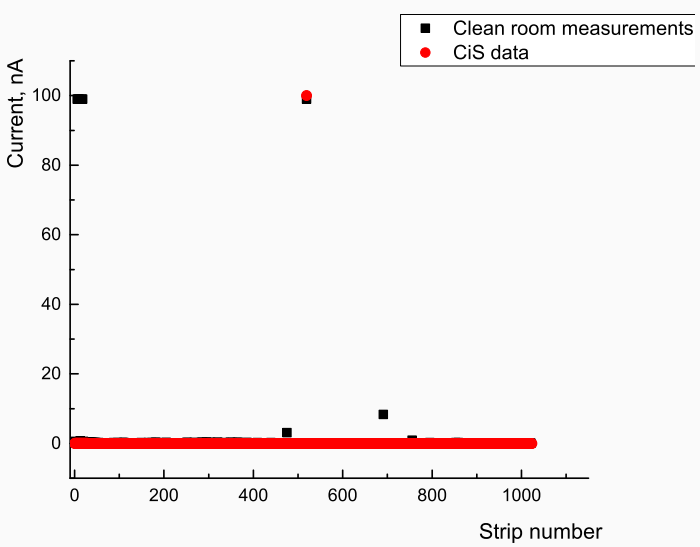
Optical quality assurance procedures for the sensors of the CBM Silicon Tracking System
Evgeny Lavrik, Tübingen University

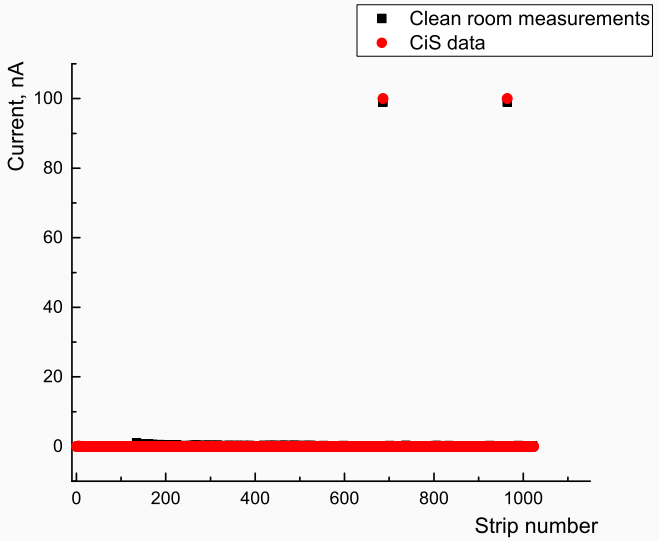
Quality Assurance. Electrical inspection

Example of comparison of the pinhole tests with vendor information for the latest prototype sensor CBM06

N-side



P-side



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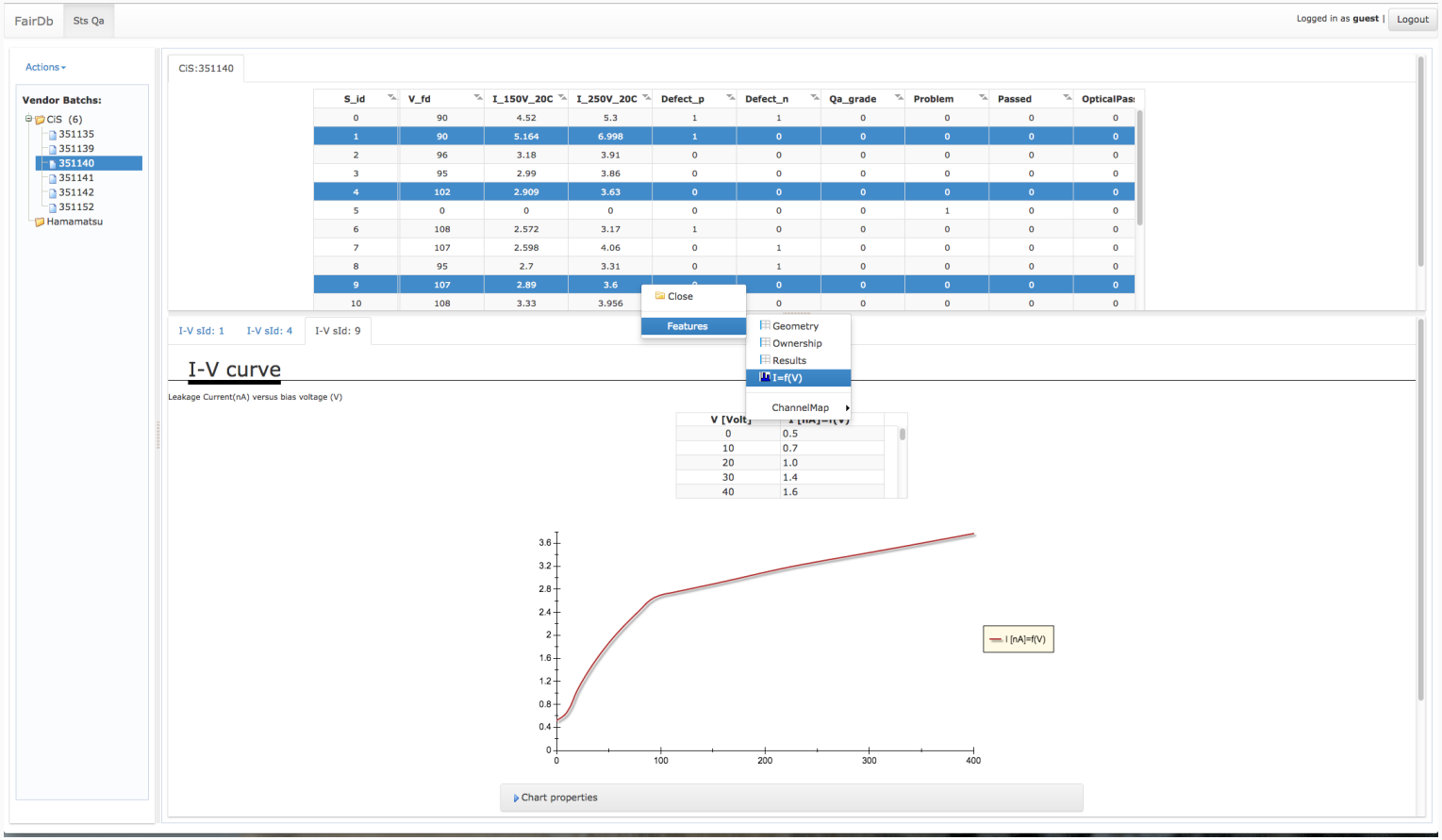
Electrical quality assurance of silicon microstrip sensors for the CBM experiment
Iaroslav Panasenko, Tübingen University

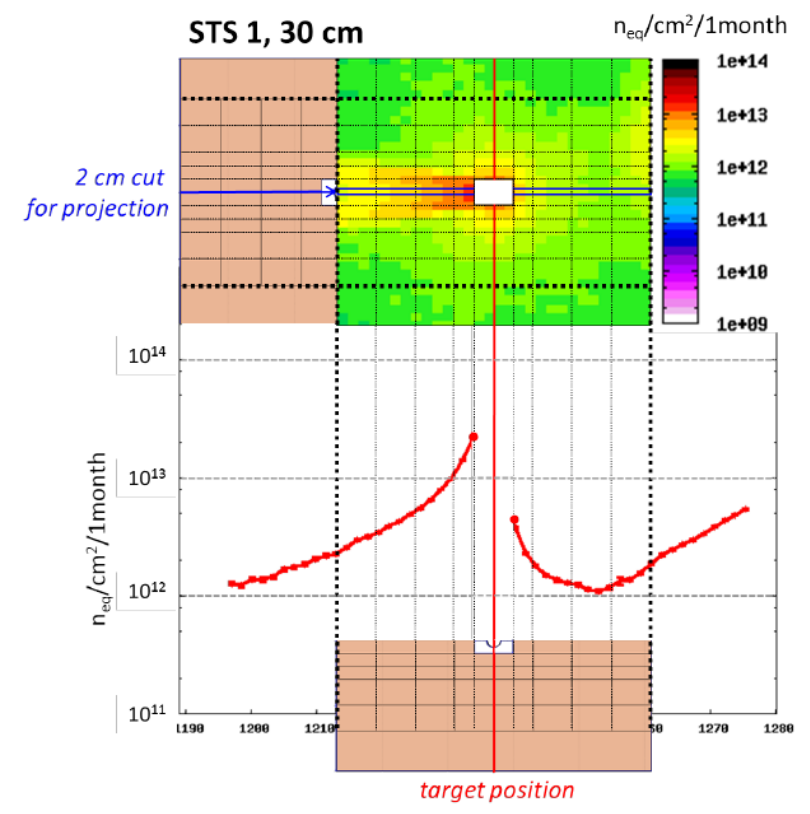
Quality Assurance. Database

Web-interface of STS QA database

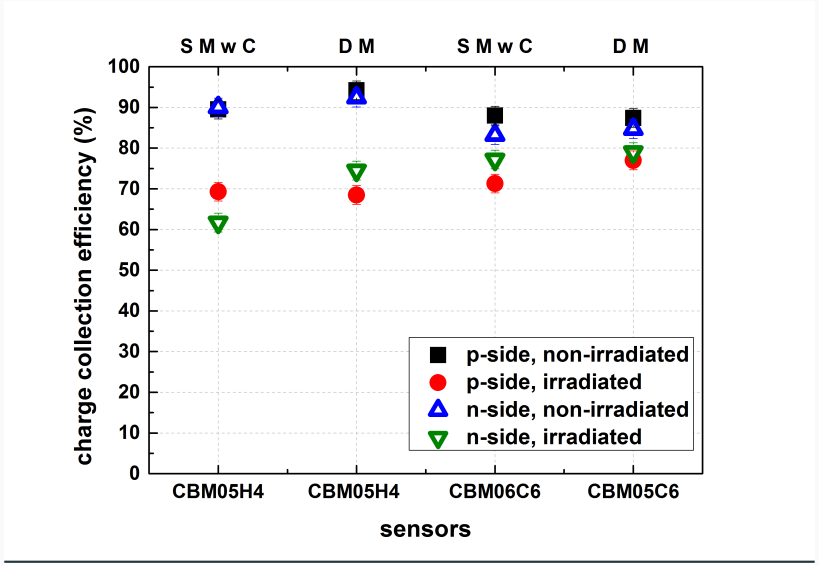


Prototype test. Radiation tolerance

FLUKA calculation of non-ionizing dose for 35 *A* GeV Au+Au collisions at SIS300



Charge collection efficiency results after irradiation up to $2 \times 10^{14} n_{eq}/cm^2$



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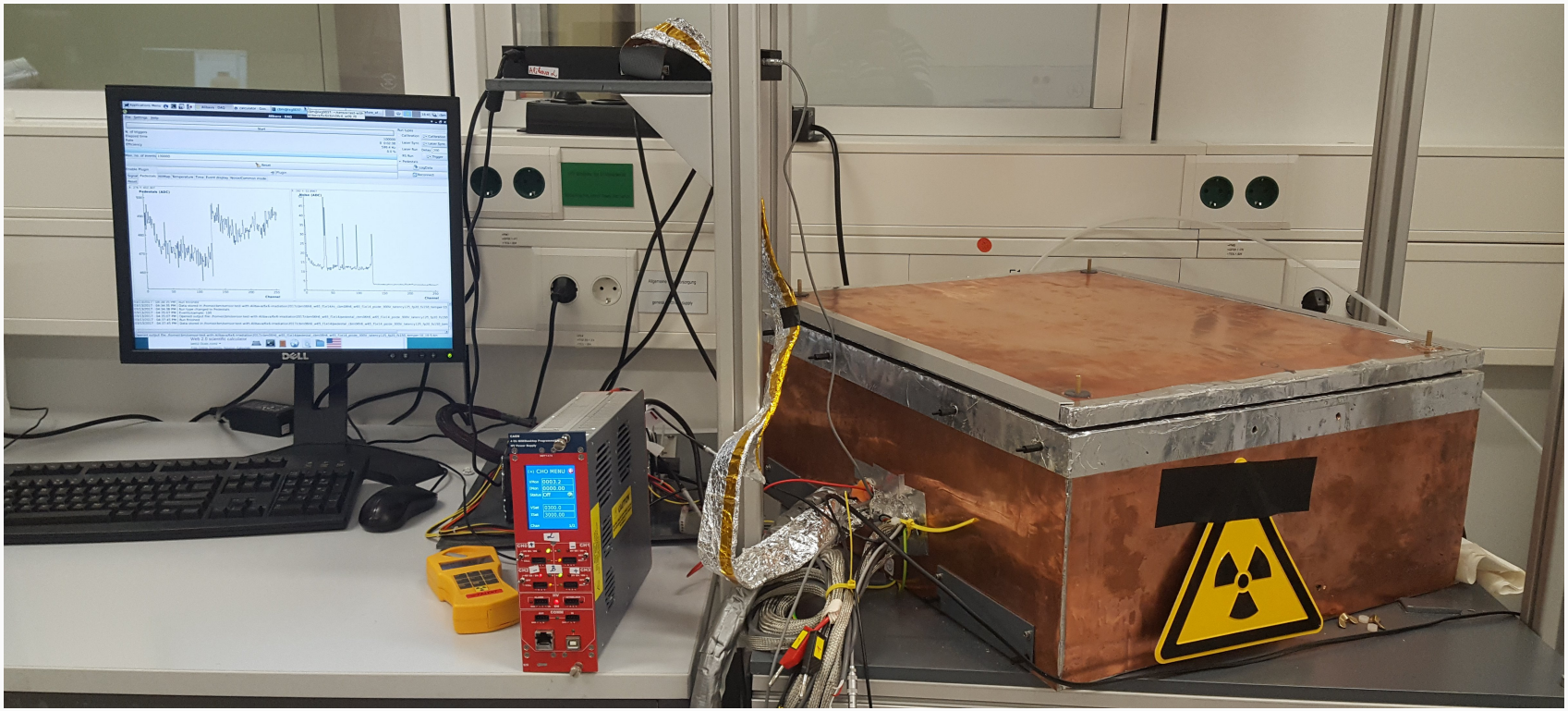
Studies of radiation field impact on microstrip sensors for the CBM Silicon Tracking System
Ievgeniia Momot, Frankfurt University

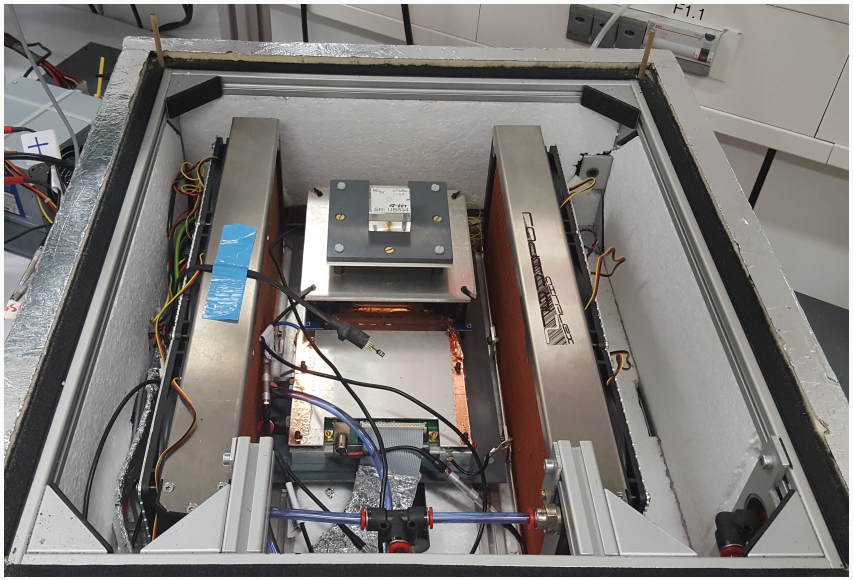
Prototype test

Test setup in the laboratory



Prototype test

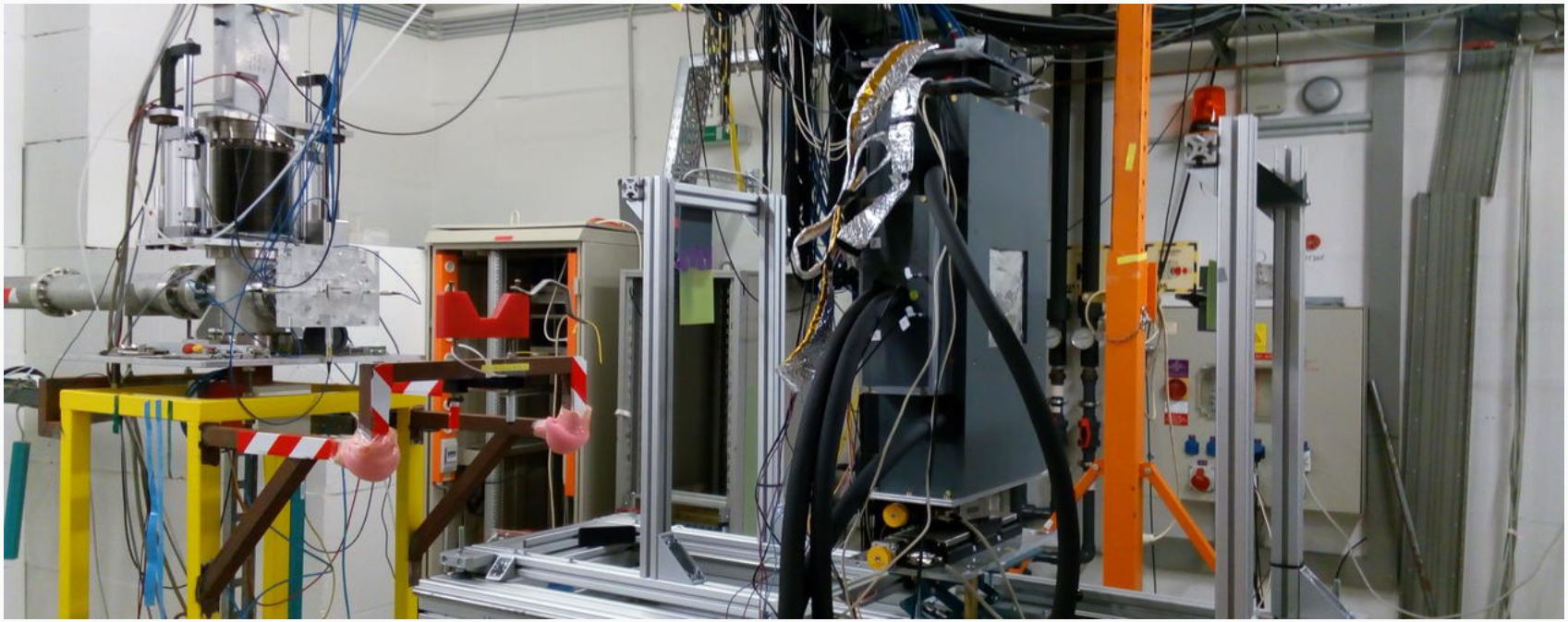
Test setup in the laboratory



- ALIBAVA readout system
- Thermal enclosure with forced convection
- Plastic scintillator underneath
- ^{90}Sr radioactive source

Prototype test

Test setup of last in beam test at COSY

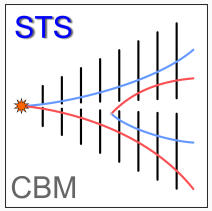


HK 9.3 Mo 17:30

Proton beam tests of silicon microstrip sensors for the CBM experiment
Maksym Teklishyn, FAIR, Darmstadt

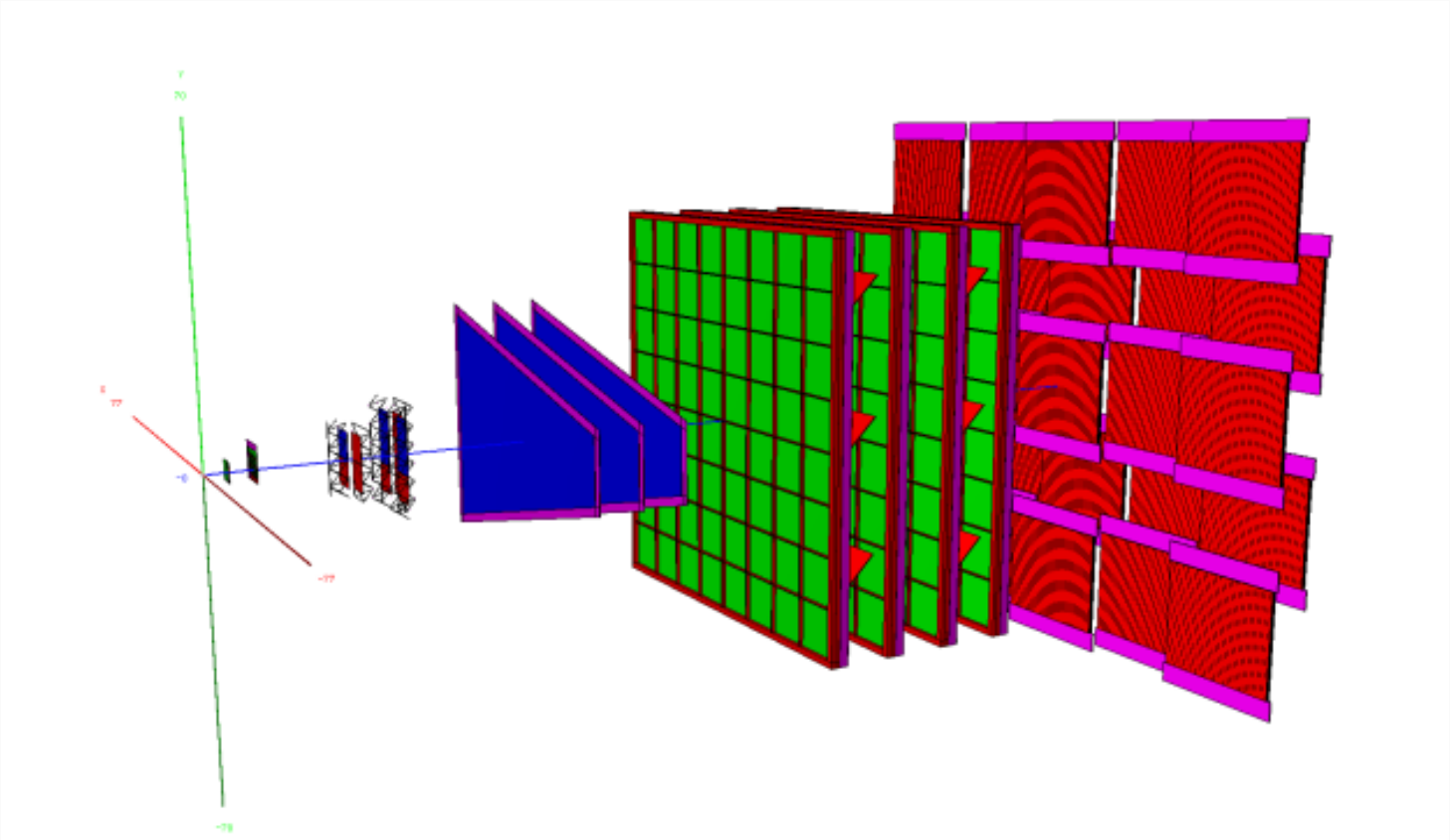
Conclusion

- STS concept has been developed.
- Building blocks are well defined.
- Components in preproduction phase:
  - sensors
  - microcables
  - front-end electronics
- Demonstrators to be delivered:
  - quater-unit
  - cooling prototype
- Development for the QA procedure are well defined.
- Production readiness toward 2018
- Installation in the cave in 2021.



Outlook

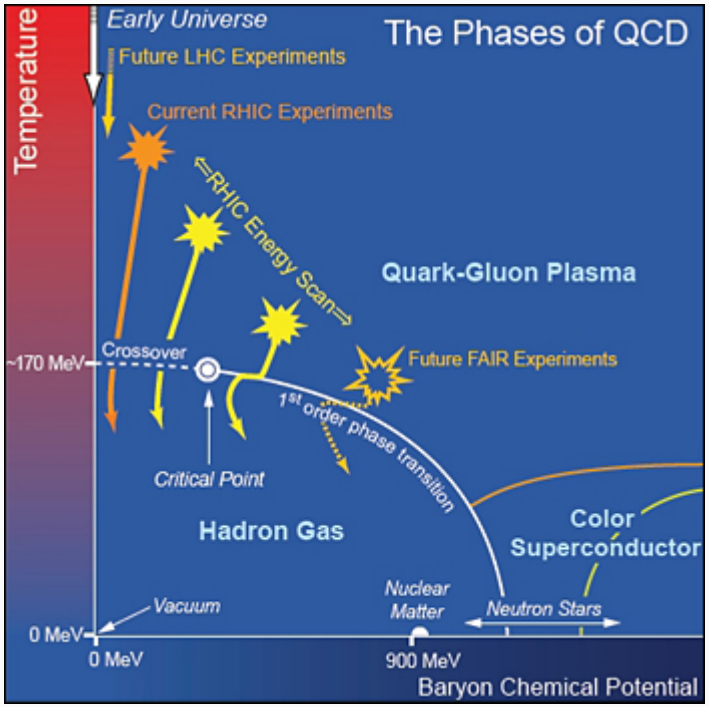
mCBM setup will be assembeled in Cave C at GSI by the end of 2018.



STS related contributions @ DPG

HK 9.3 Mo 17:30	Proton beam tests of silicon microstrip sensors for the CBM experiment
HK 9.5 Mo 18:00	Hit position error estimation for the CBM Silicon Tracking System
HK 9.6 Mo 18:15	Progress with System Integration of the CBM Silicon Tracking Detector
HK 27.71 Di 16:45	Investigation of CO2-based Cooling for the CBM Silicon Tracking System
HK 27.24 Di 16:45	Track-based Misalignment Corrections for the CBM Silicon Tracking Detector
HK 27.54 Di 16:45	Construction of a neutron source for silicon detector irradiation
HK 35.7 Mi 18:15	Electrical quality assurance of silicon microstrip sensors for the CBM experiment
HK 35.8 Mi 18:30	Optical quality assurance procedures for the sensors of the CBM STS
HK 36.3 Mi 17:15	Studies of radiation field impact on microstrip sensors for the CBM STS
HK 63.2 Fr 14:15	Test of the STS-XYTER2 front-end ASIC for the CBM Silicon Tracking System

QGP phase diagram



- Nuclear matter formation at high baryon density and temperature
- Models predict 1^{st} order phase transition with formation of mixed and exotic phases
- Existence of critical end-point

Experiments:

BES at RHIC, NA61 at CERN SPS, NICA at JINR and CBM at FAIR