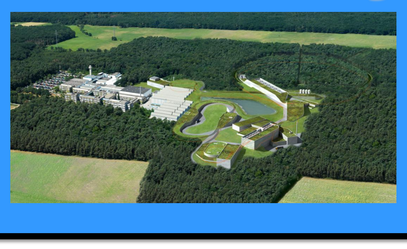
Development of the Silicon Tracking System for the Compressed Baryonic Matter (CBM) Experiment at FAIR



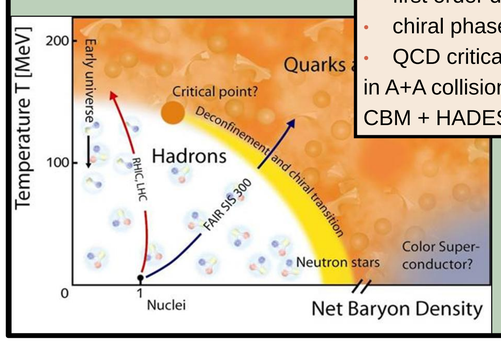
Jürgen Eschke and Johann Heuser for the CBM Collaboration

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

http://www.fair-center.eu/en/fair-users/experiments/cbm.html

Compressed Baryonic Matter @ FAIR

– high μB, moderate T:



Searching for the landmarks of the QCD phase diagram:

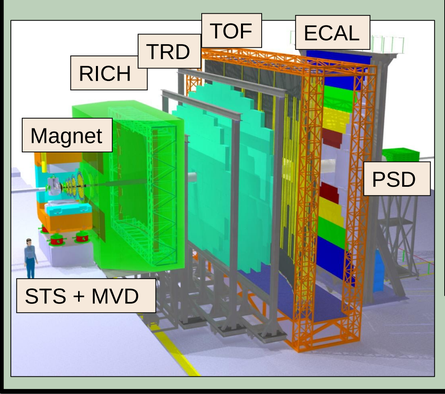
- first order deconfinement phase transition
- chiral phase transition (high baryon densities!)
- QCD critical endpoint

in A+A collisions from 2-45 AGeV starting in 2017
CBM + HADES at SIS100 and CBM at SIS300

Diagnostic probes of the high-density phase:

- open charm, charmonia
- low-mass vector mesons
- multistrange hyperons
- flow, fluctuations, correlations

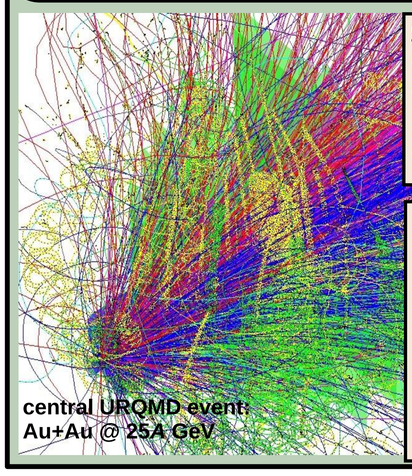
Layout of the CBM experiment (e+e- set up)



Tracking, momentum determination, vertex reconstruction:

- radiation hard silicon pixel/strip detectors (MVD+STS) in a magnetic dipole field
- hadron ID: TOF (& RICH)
- electron ID: RICH & TRD & TOF
- photons, π0, η: ECAL
- PSD for event characterization
- high speed DAQ and online event selection → rare probes !

Tracking Challenge



Challenge:

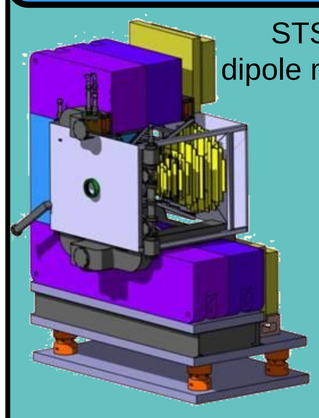
- Au+Au collisions , 25*A* GeV
- up to 1000 charged particles/event
- interaction rates up to 10 MHz

STS requirements:

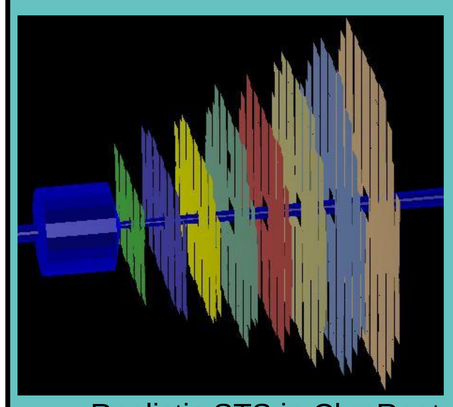
- main tracking detector system: efficient, fast, rad. hard, low-mass
- 1 MeV n fluence up to ~ 10^{14}/cm^2
- momentum resolution ~ 1.7% (p > 1 GeV/c)

Silicon Tracking System

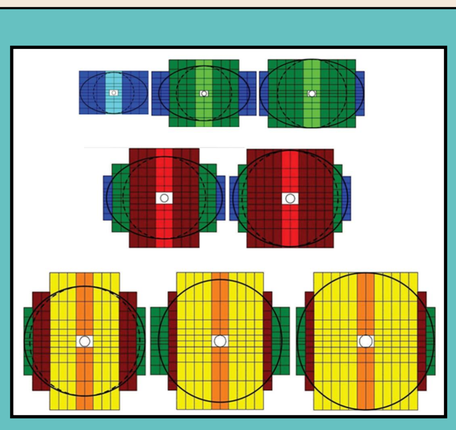
STS in dipole magnet



- 8 tracking stations: 30, 40, 50, 60, 70, 80, 90, 100 cm downstream of the target, in a 1 T dipole magnet;
- 4 m^2 active area;
- The number, positions and segmentation of the stations are optimized for efficient track reconstruction and high momentum resolution.

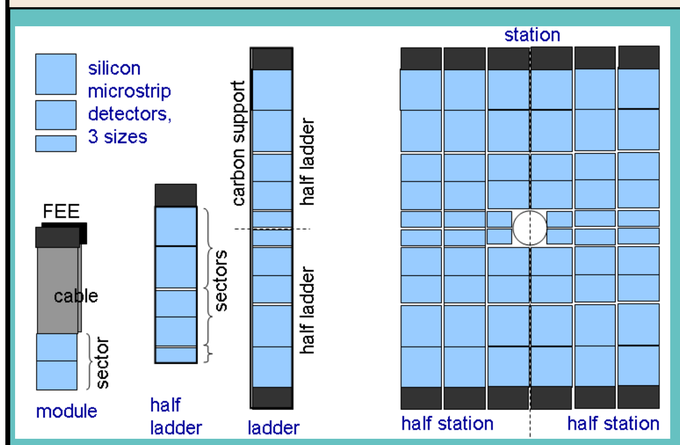


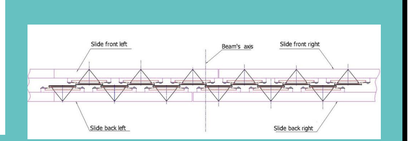
Realistic STS in CbmRoot



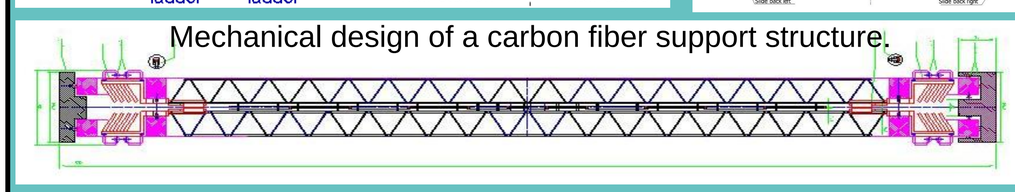
Layout of the 8 STS stations

- The STS stations have a modular structure and are constructed from:
- 4 types of 300 μm thick double-sided silicon micro-strip sensors,
- arranged on 8 types of carbon-fiber supported ladder structures.





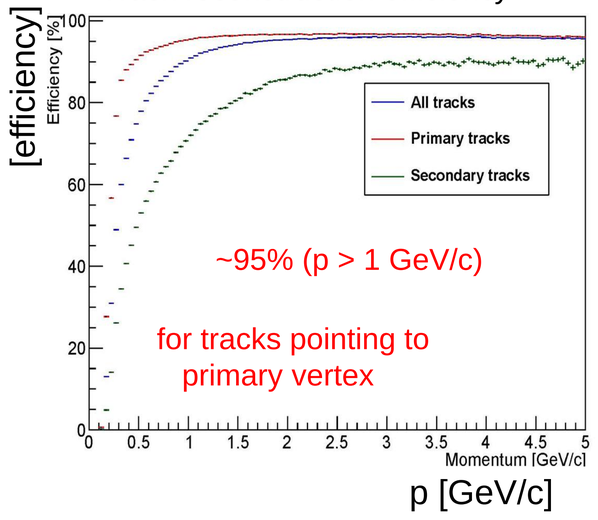
Mechanical design of a carbon fiber support structure.



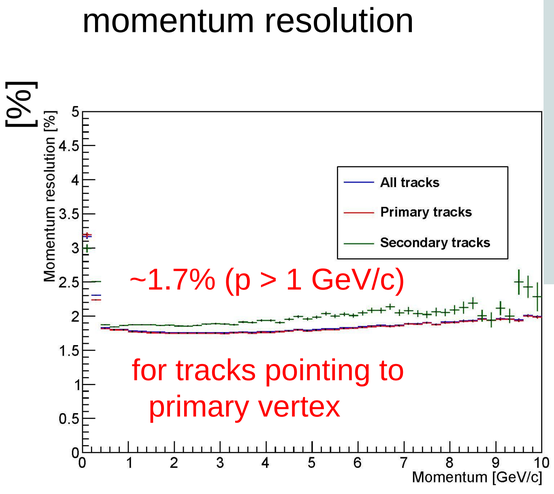
Silicon Tracking Performance

- Detailed model of the STS in CbmRoot:
- Silicon detectors with detailed physical processes caused by traversing charged particles, mechanical supports, electronics.

Track reconstruction efficiency



momentum resolution



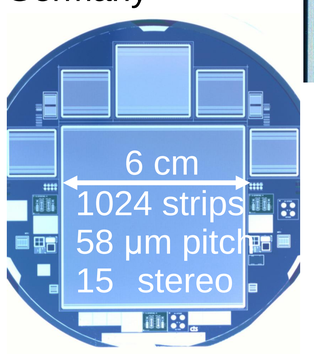
Au+Au collisions at 25 AGeV (UrQMD)

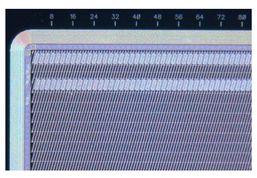
- reconstruction with a Cellular Automaton and Kalman Filter
- 2500 min. bias events/s on an 80-core server with 4 Intel E7-4860 processors

Prototype Components

Microstrip detectors

GSI-CIS, Germany





thickness: 300 μm
strip pitch: 58μm

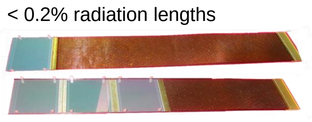
full-size prototypes:
CBM01, CBM03, CBM05

second producer of prototype sensors **HAMAMATSU**

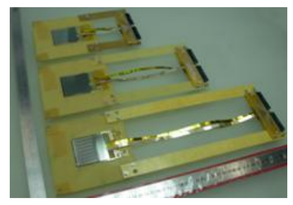
ultra-thin multi-line readout cables

SE SRTIIE, Ukraine

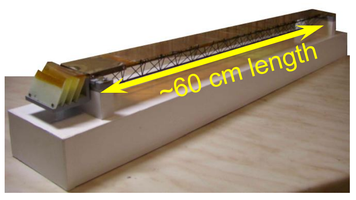
Al strips on polyamide
2 x 512 signal lines of 60 μm eff. pitch
< 0.2% radiation lengths



Stacked cable layers attached to sensors



Detector + readout cables



Mechanical mock-up

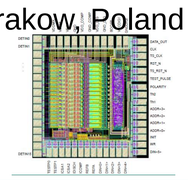
Self-triggering Front-end electronics

AGH Krakow, Poland

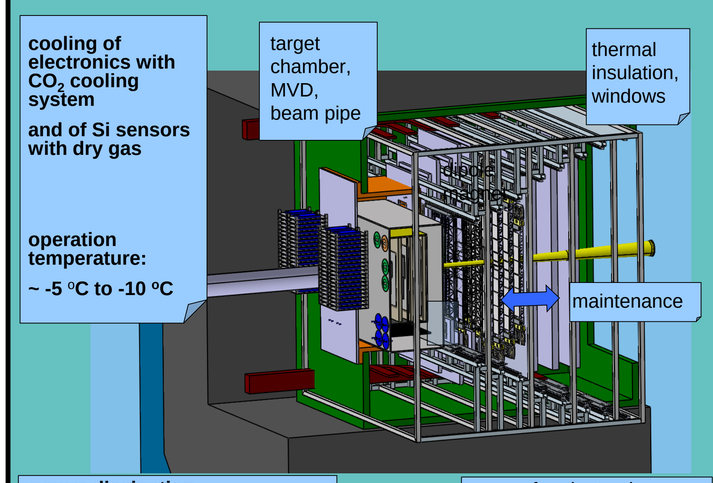
DETNI - GSI

Early prototyping with n-XYTER chip

CBM-dedicated FEE STS-XYTER chip available end 2012



System Integration Issues and Schedule



Timeline STS construction

Development & Engineering Design
2012-2013

TDR
10/2013

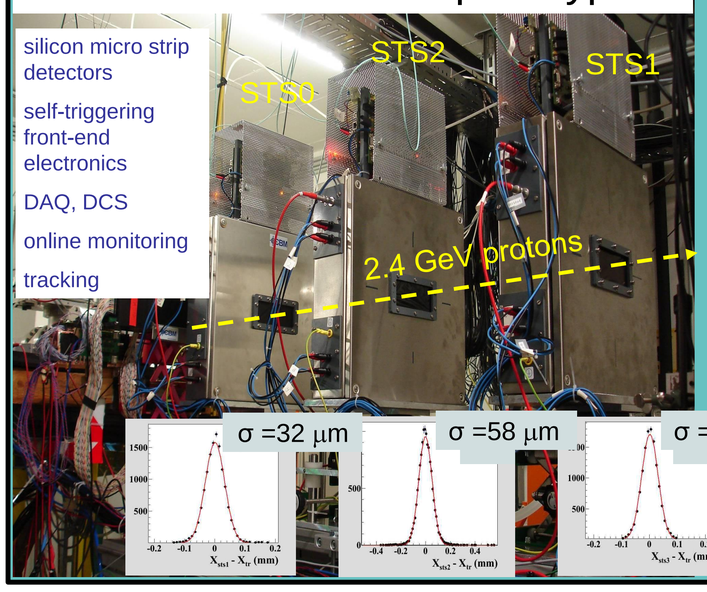
Assembly infrastructures, Prototype components
2012 – 2014

Production & integration
2014 – 2017

STS system ready for Installation
2017

Performance Evaluation

In-beam tests of STS prototypes



characterization of sensors