The Silicon Tracking System of the CBM experiment at FAIR

– overview and development progress –

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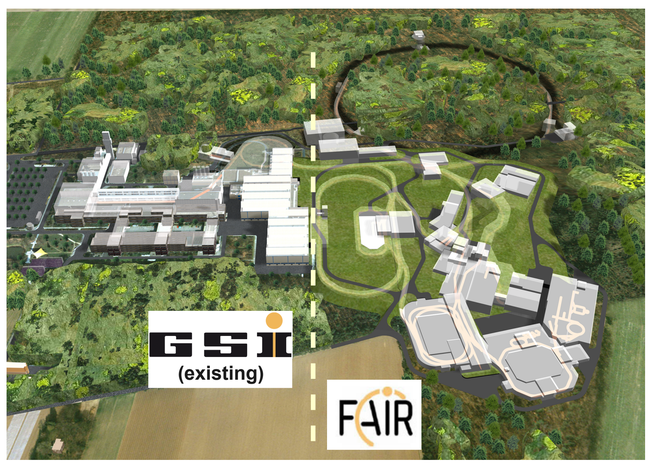
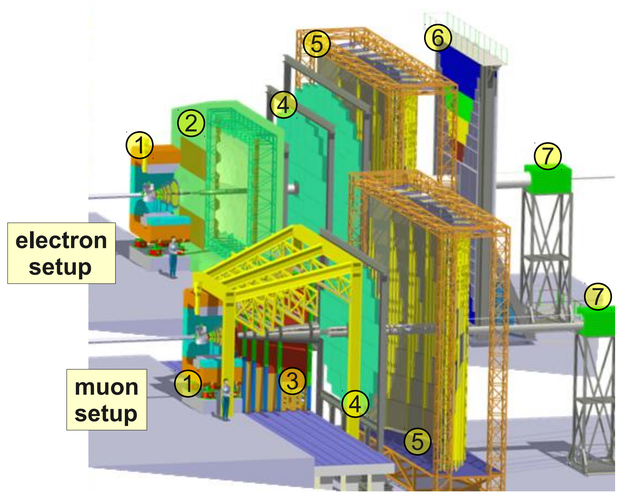
The CBM experiment at FAIR

The FAIR facility



- Accelerators: SIS-100 and SIS-300
- Main experiments: APPA, CBM, NuSTAR, PANDA
- Proton, heavy ion, secondary and anti-matter beams
- Start version commissioning planned: 2018
- Construction cost about 1 billion Euro.
- Construction started in Dec 2011.

The CBM experiment



CBM = **C**ompressed **B**aryonic **M**atter.
Fixed target experiment. A-A, A-p and p-p collisions up to 45 AGeV (incident).

Goal: explore the phase diagram of strongly-interacting matter at high baryonic densities:

- deconfinement phase transition
- critical point
- chiral symmetry restoration

(1) Target (solid)
Micro-Vertex detector (MAPS)
Silicon Tracking System (strips)
Superconducting Magnet (1T)

(2) Cherencov detector

(3) Muon detector and absorber

(4) Transition Radiation detector

(5) Time of Flight detector

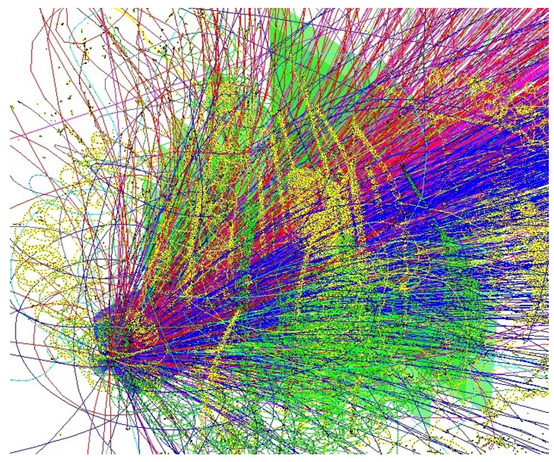
(6) Electromagnetic Calorimeter

(7) Projectile Spectator detector

Main observables:

- low mass vector mesons
- D-mesons, charmonium
- strangeness production
- collective flow
- event-by-event fluctuations

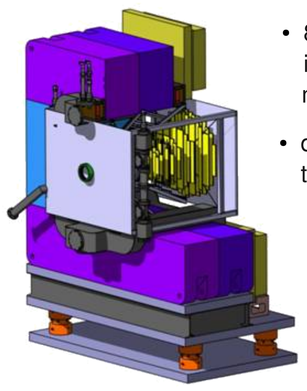
Experimental challenge



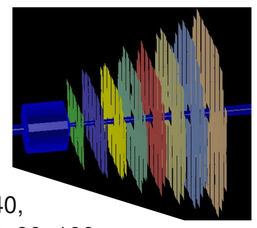
UrQMD simulation: central Au-Au @25AGeV

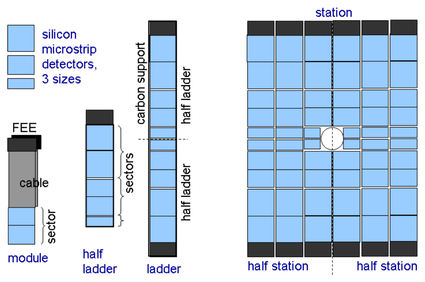
- 1000 charged products per central Au-Au collision
- up to 10^6 Au-Au or 10^7 p-p interactions
- momentum resolution about 1%
- time resolution about 5 ns
- radiation load: 10^{12} – 10^{13} n.eq. (innermost: 10^{14})

Concept

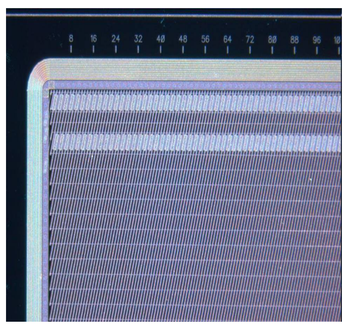


- 8 stations in 1 T dipole magnet field
- distance from the target: 30, 40, 50, 60, 70, 80, 90, 100 cm
  - self-triggering r/o electronics
    - r/o electronics outside the acceptance





Number of integration components	
Ladders	106
Sectors	1040
Detectors	1292
R/O chips	16640
Channels	2133k



Sensors:

- double-sided silicon strip
- 300 µm thickness
- 58 µm pitch
- AC-coupled
- stereo-angle 8°(or other)
- double metalization (one side)

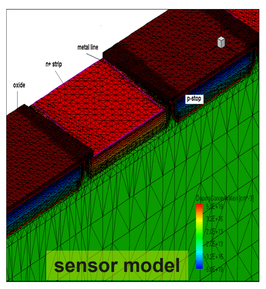
Technical challenges

Various extremes, formerly achieved in different experiments have to be combined in a single system:

- radiation hard double-sided silicon strip sensors with double metalization
- fast self-triggering read-out electronics with time and amplitude measurement capabilities.
- about 1 TB/s data rate
- large power dissipation: few x 10 kW
- sensors operated at -20 °C
- all in magnetic field
- very limited space!

Simulations

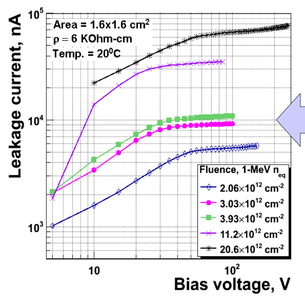
Sensor simulations



Synopsys simulation package.

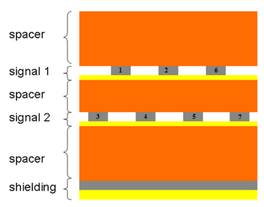
- I-V
- C-V
- MIP response
- breakdown
- radiation damage

Example results:



Reasonable agreement with the measurements!

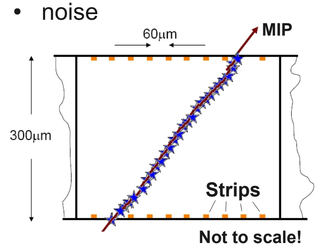
Cable simulations and optimization



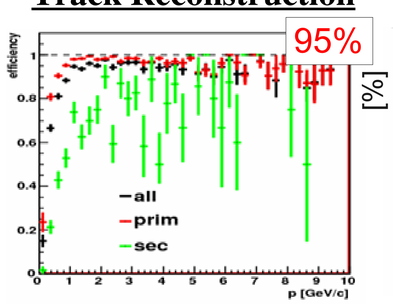
- RAPHAEL simulation package
- Capacitance and resistance simulation for noise estimate
- Optimization of geometry for minimal noise
- Cu and Al traces considered

Detector response for MC simulations

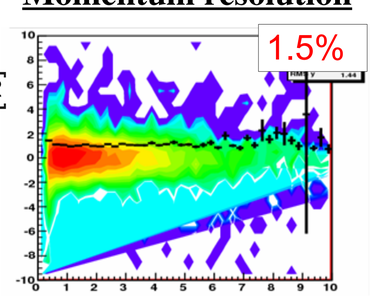
- charge sharing between strips
- charge collection inefficiency
- Lorenz shift
- channel dead time
- noise



Track Reconstruction

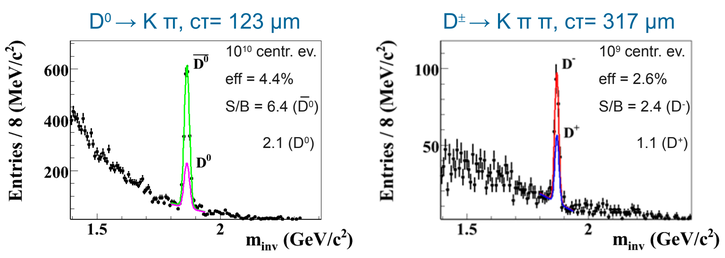


Momentum resolution



- Cellular automaton track finder + Kalman filter
- Idealistic detector model

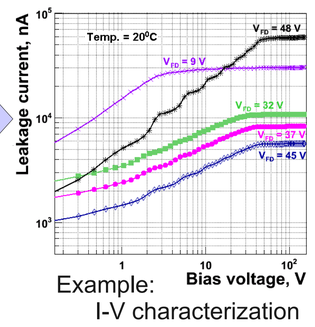
Physics performance



Au+Au@25AGeV. 2 weeks @10^6 ev./s. HSD and SHM generator

Prototypes

Sensors

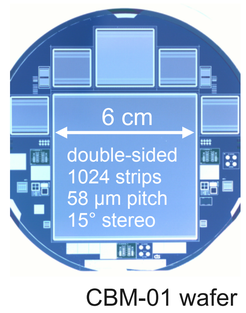


Example: I-V characterization

Main manufacturer: CiS, Erfurt, Germany

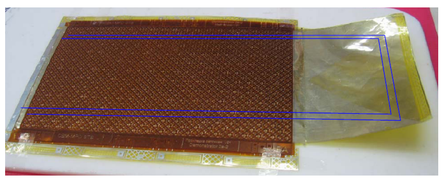
Collaborative activities:

- R & D
- characteri-zation
- quality assurance (being established)



CBM-01 wafer

Cables



Stacked cable layer

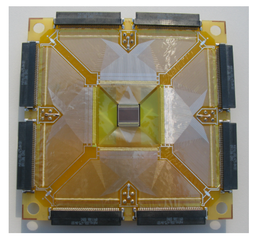
Al strips on polyimide
Produced: SE SRTIIE, Ukraine

R/O electronics

n-XYTER chip – for early prototyping (DETNI project)

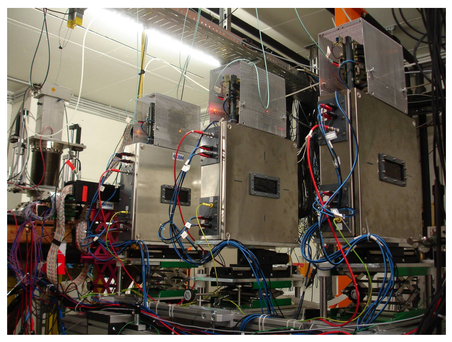
- Self-triggering
- Time and amplitude measurement
- 128 channels
- dynamic range about 120ke⁻
- 2 shapers per channel: slow, fast

Detector boards



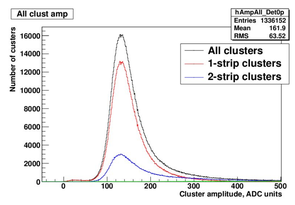
- detachable from r/o electr.
- baby sensor, 256 strips
- TAB bonded – durable

Beamtests



COSY, Jülich (Germany) – Jan 2012
3 stations in a proton beam

- General system test
- Detector response
- Position resolution
- Tracking
- Time resolution



Example: amplitude response

This is only a tiny fraction of ongoing activities