The Silicon Tracking System of the CBM experiment at FAIR

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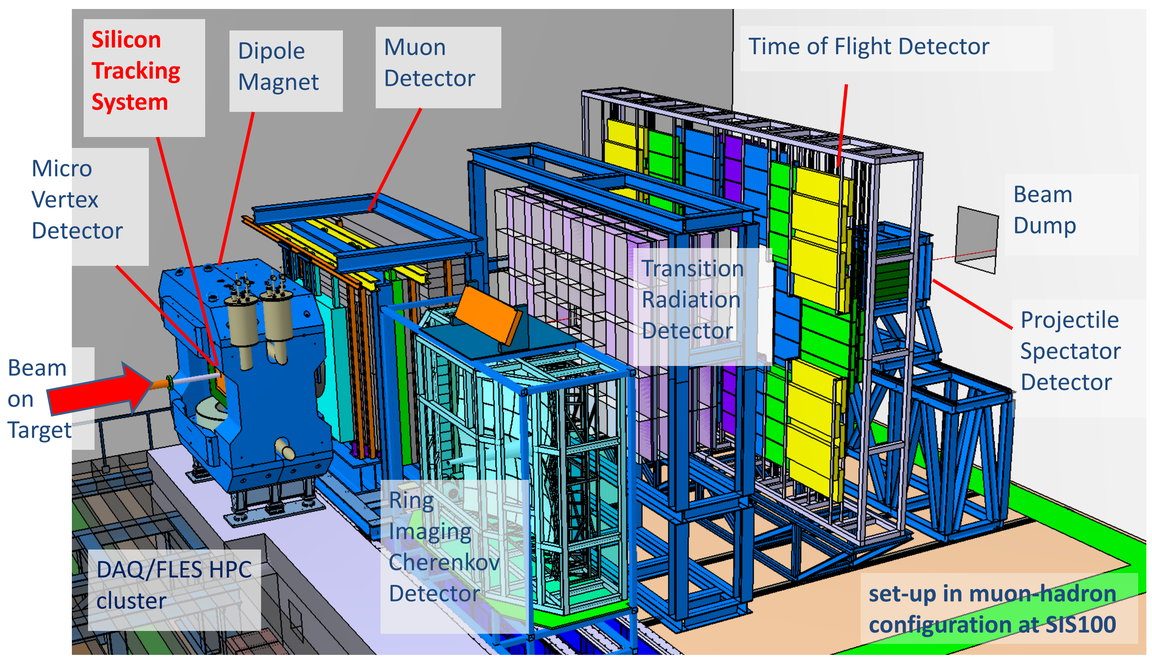
The Compressed Baryonic Matter (CBM) experiment at FAIR



Physics aim

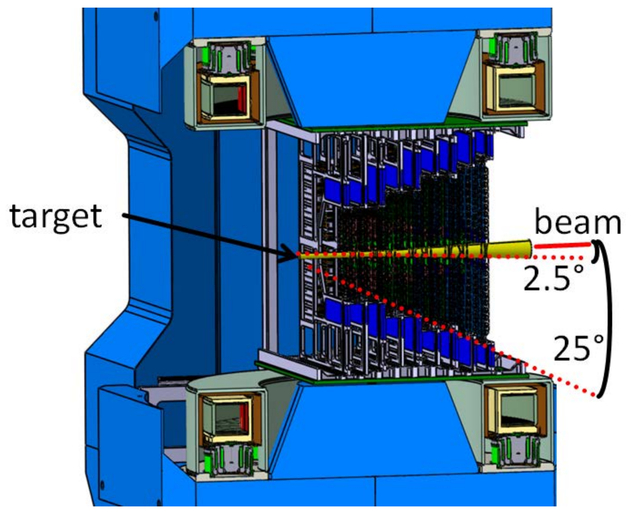
- Exploration of the QCD phase diagram at high net baryon densities and moderate temperatures
- Starting with SIS100 projectile energies: 2÷11 GeV/nucleon / $\sqrt{s_{NN}}$ = 2.7÷4.9 GeV, protons up to 29 GeV

Observables

- Hadrons, electrons, muons, photons
- Particle yields and multi-differential cross-sections
- Rare diagnostic probes: strange mesons, light vector mesons (ρ, ω, ϕ), charm production

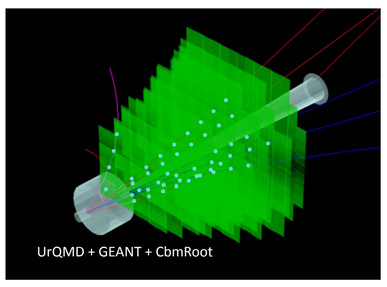
Recent paper: *Challenges in QCD matter physics – The scientific programme of the CBM experiment at FAIR;* arXiv:1607.01487v2 [nucl-ex] 24 Nov 2016

The Silicon Tracking System



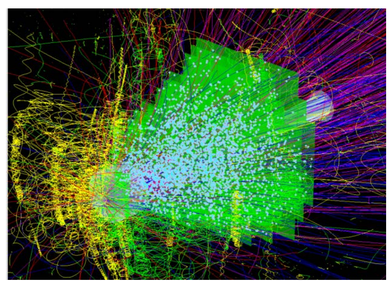
longitudinal cut – Silicon Tracking System in Dipole Magnet

- pile-up free track point determination in high-rate collision environment: $10^5 – 10^7$/s (A+A), up to 10^9/s (p+A)
- physics aperture : $2.5° \leq \Theta \leq 25°$, $0.3\ m \leq z \leq 1.0\ m$
- 8 tracking stations
- double-sided silicon microstrip sensors
- hit spatial resolution ≈ 25 µm
- self-triggering front-end electronics
- time-stamp resolution ≈ 5 ns
- material : ≈ 0.3 % – 1.2% X_0 per station
- momentum resolution: Δp/p ≈ 1.8% (p > 1 GeV/c, 1 Tm field)



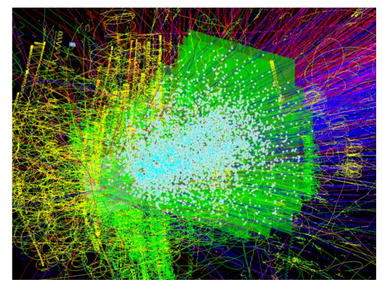
p+C, 29 GeV

few charged particles/collision



central Au+Au, 8 GeV/nucleon

≈ 350 charged particles/collision



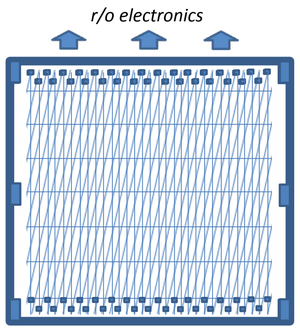
central Au+Au, 25 GeV/nucleon

≈ 700 charged particles/collision
particle densities in STS up to ≈10/cm²

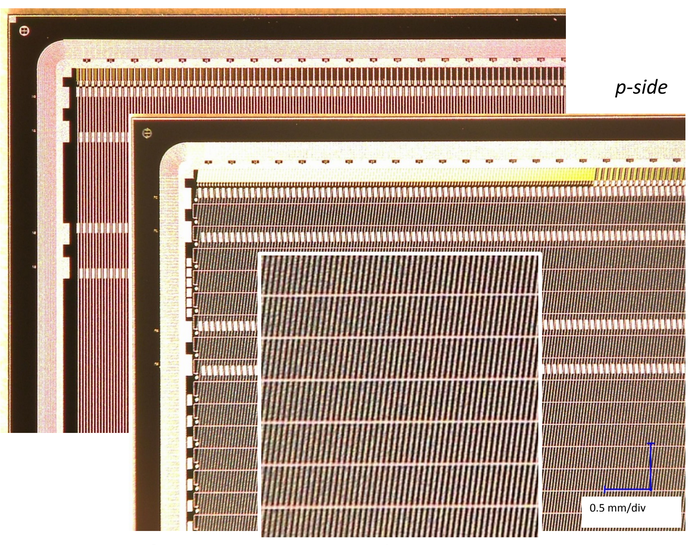
Silicon Microstrip Sensors

- 285/320 ± 15µm thick
- n-type silicon
- double-sided segmentation
- 1024 strips of 58 µm pitch
- strip length 2/4/6/12 cm
- angle front/back: 7.5°/0°
- read-out from top edge
- double-metal routing on p-side
- radiation tolerance 10^{14} n_{eq}/cm^2, 1 Mrad

r/o electronics

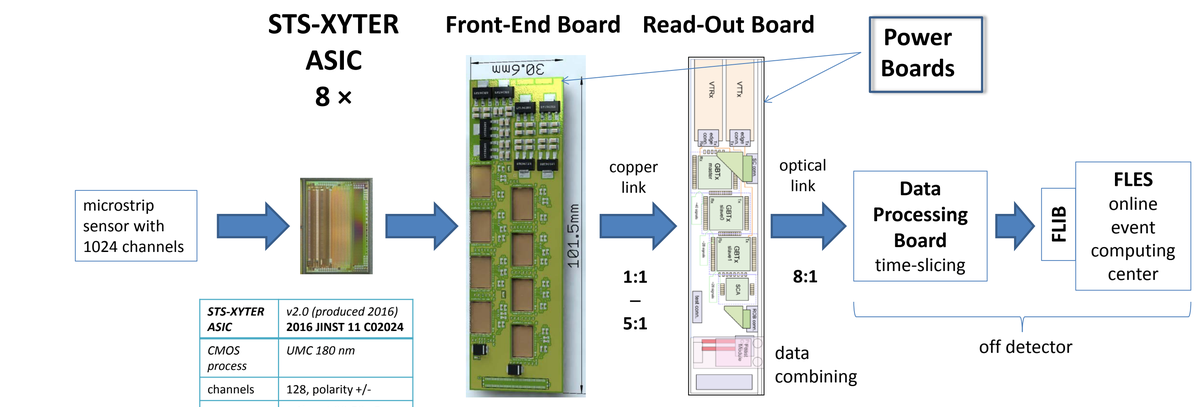


n-side



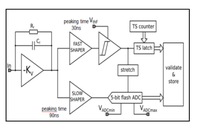
prototypes from CiS, Germany and Hamamatsu, Japan

Read-out Electronics, Data Acquisition Chain



STS-XYTER ASIC	v2.0 (produced 2016) 2016 JINST 11 C02024
CMOS process	UMC 180 nm
channels	128, polarity +/-
noise	< 1ke⁻ at 20-50 pF load
ADC range	linear up to12 fC, 5 bit
clock	250 MHz
power	< 10 mW/channel
timestamp	~5 ns resolution
out interface	5 × 500 Mbit/s LVDS

self-triggering



under verification

STS-XYTER chips
à 1/2/5 LVDS E-links out
time-stamped data

under development

GBTx chip-set (CERN):
3 GBTx, 1 VTRx, 1 VTTx, 1 SCA
42 E-links à 320 Mb/s
3 GBT optical uplinks à 4.48 Gb/s

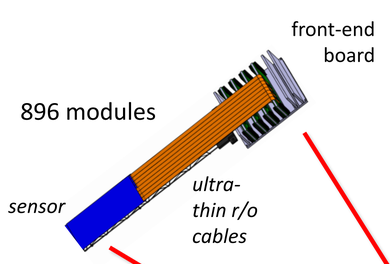
under development

prototype free-streaming DAQ system

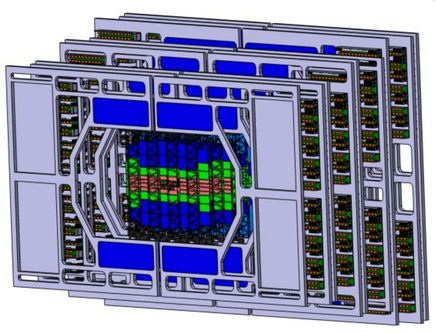
operated under beam test conditions

System Integration

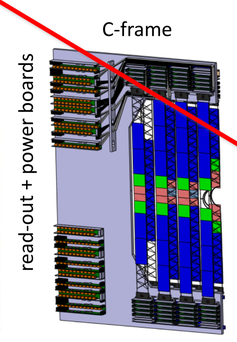
Concept:



- 8 stations, volume 2 m^3, area 4 m^2
- 896 detector modules in various lengths
  - 896 double-sided microstrip sensors
  - ~ 1.8 million read-out channels
  - ~ 16 000 r/o STS-XYTER ASICs
  - ~ 16 000 ultra-thin r/o cables (5÷50 cm long)
- 106 detector ladders with 8-10 modules
- power dissipation: ~40 kW (CO_2 cooling)
- thermal enclosure: sensors at T = -5° C

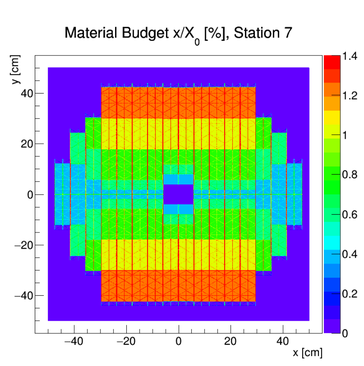


8 tracking stations

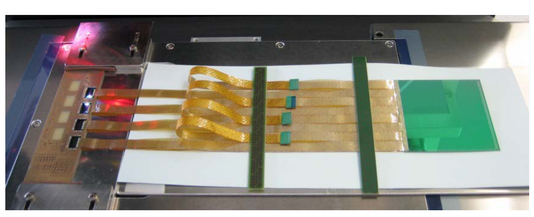


18 mechanical half-units

106 ladders

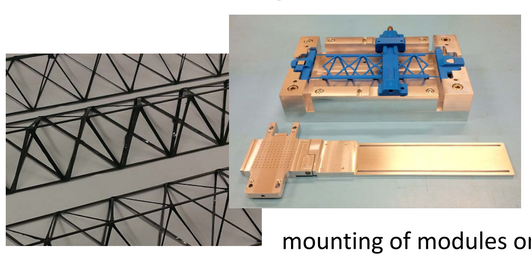


Module assembly:



tab-bonding of Al-polyimide cables between ASICs and sensor

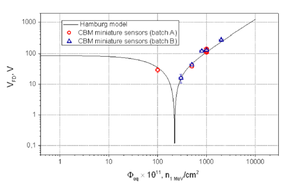
Ladder assembly:

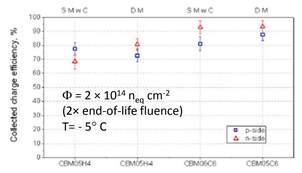


mounting of modules onto low-mass carbon-fiber supports

Current Development Activities

Radiation hardness of sensors:

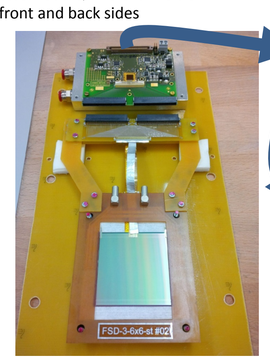


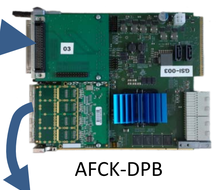


neutron-irradiated sensors tested in the laboratory and with proton beam

Module performance test stand:

test module, 128 channels on front and back sides



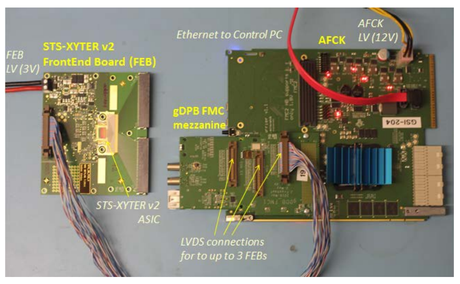


AFCK-DPB

FLIB

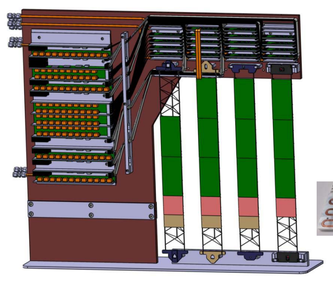
FLES node

Front-end electronics:



STS-XYTER v2 test set-up

Quarter-unit demonstrator:



- ladder mounting
- mechanical stability
- electronics cooling
- cable routing
- powering
- connectivity

cooling plate

Project

Timeline:

- 2013 – Technical Design Report*
- 2017-2018 – Production Readiness (Sensors, Electronics, System Integration)
- Detector construction until 2021

GSI Report 2013-4 (Aug. 2013)

Key Institutes:

GSI-FAIR, Darmstadt, Germany; JINR, Dubna, Russia; Univ. Tübingen, Germany; KIT, Karlsruhe, Germany; AGH, Cracow, Poland; JU, Cracow, Poland; WUT, Warsaw, Poland.

Assembly Centers: GSI-FAIR, JINR -VBLHEP

presented at *Quark Matter 2017, XXVI International Conference on Ultra-Relativistic Heavy-Ion Collisions, Chicago, IL, USA, 6-11 February 2017*

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