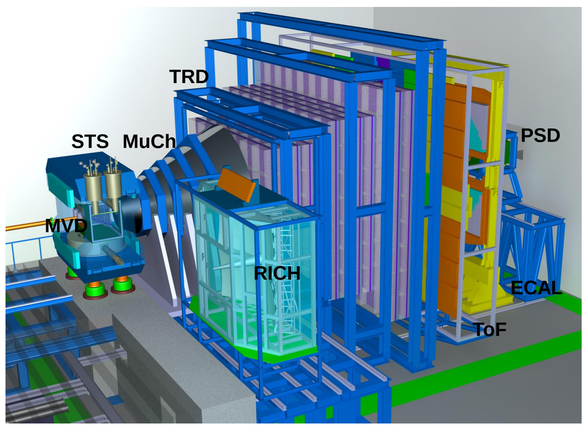
Concept and performance of the Silicon Tracking System for the CBM experiment at FAIR

Minni Singla, for the CBM Collaboration

The CBM experiment and its Technical Challenges



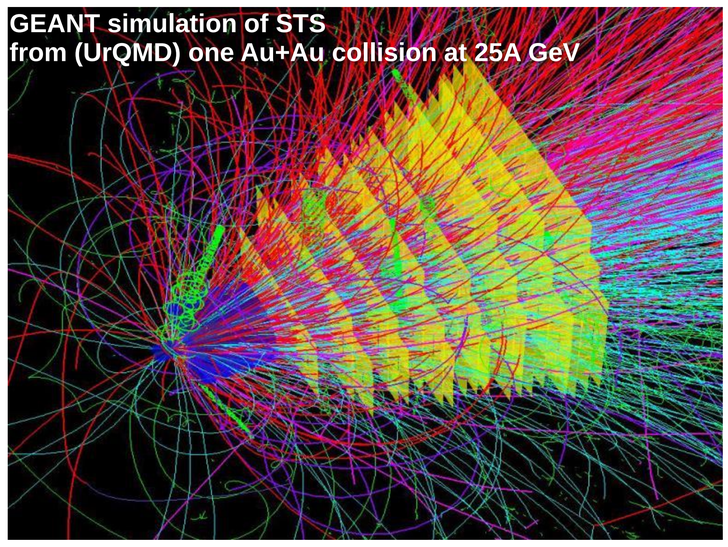
Compressed Baryonic Matter experiment:
- stationary target
- 2 – 45 AGeV

➢ explore QCD phase diagram the region of high baryon densities and moderate temperatures

➢ study of the equation-of-state of nuclear matter at high densities

➢ search for the de-confinement & chiral phase transitions

➢ measure both bulk observables & rare diagnostic probes (charmed particles, vector mesons)



rare probes:

➔ require upto10MHz Au+Au reactions/sec

➔ ~700 charged particles per collision

➔ fast and radiation hard detectors

➔ low material budget to reduce multiple scattering

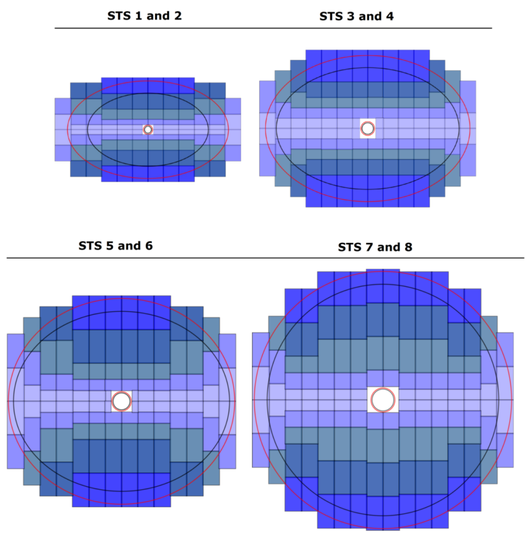
➔ free-streaming fast readout electronics

➔ high speed data acquisition and high performance computer farm for online event selection

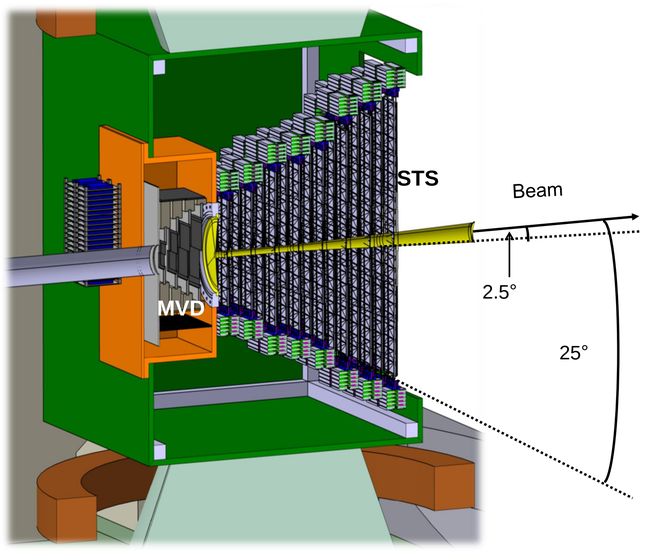
Silicon Tracking System

- **coverage**
  - rapitidies from center-of mass to close to beam
  - aperture 2.5° < Θ < 25°
- **low material budget** large-area detector
  - high-resolution momentum determination
  - track matching into MVD and RICH/MUCH
- **momentum resolution**
  - δp/p ≅ 1%
  - field integral 1 Tm
  - material budget per station ~1% X_0
- **25 µm single-hit spatial resolution**
- **efficient hit & track reconstruction**
  - close to 100% hit and tracking efficiency
- **read-out**
  - self-triggering read-out
  - signal shaping time < 20 ns
  - no pile-up
  - fast free-streaming readout
  - online event selection

layout of STS stations

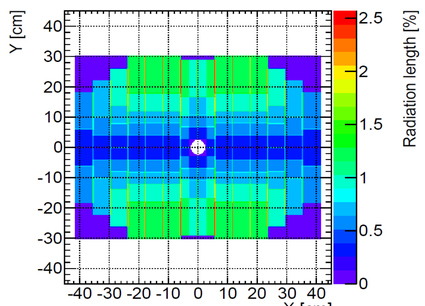


- stations arranged in 4 duplets
- first stations enlarged in horizontal axis (for low momentum particles)
- granularity according to the hit densities

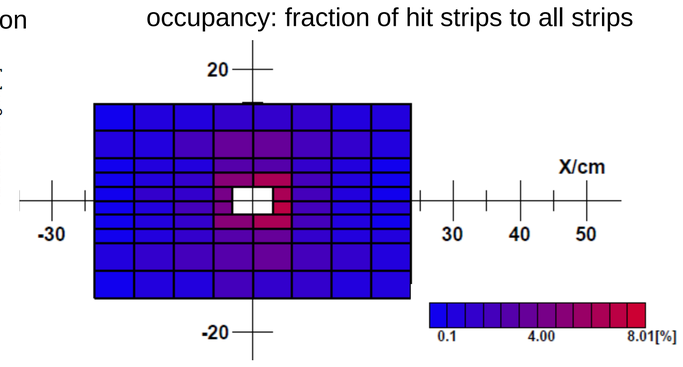


- 8 tracking stations
- double-sided micro-strip silicon sensors
- minimized number of channels
- minimized material budget
- read-out electronics outside the physics aperture

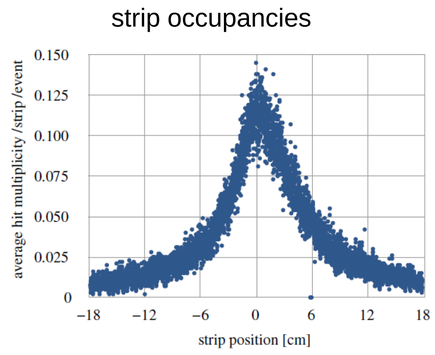
material Budget Distribution in station



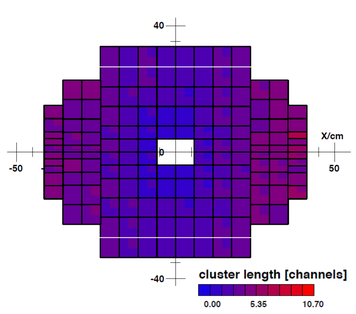
occupancy: fraction of hit strips to all strips

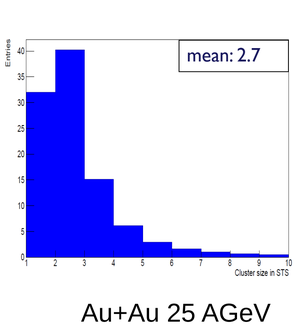


strip occupancies



cluster size distribution in the sensors of a station



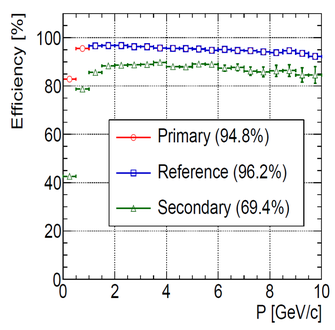


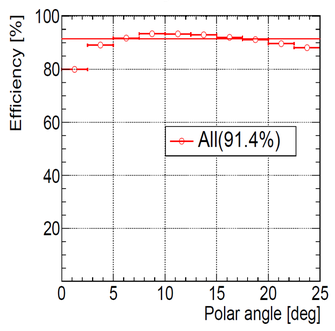
Au+Au 25 AGeV

Tracking Performance

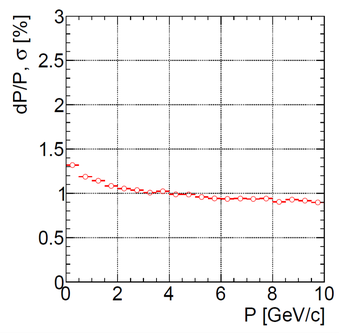
Au+Au 25 AGeV

track reconstruction efficiency



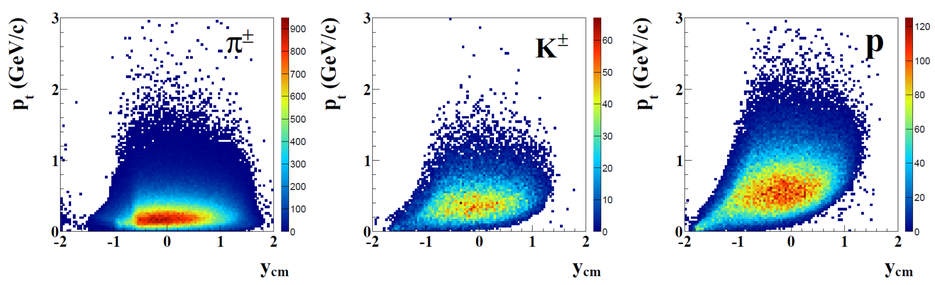


momentum resolution



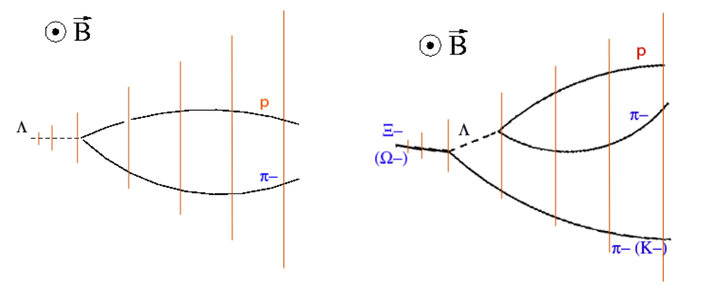
Physics Performance

Au+Au 25 AGeV

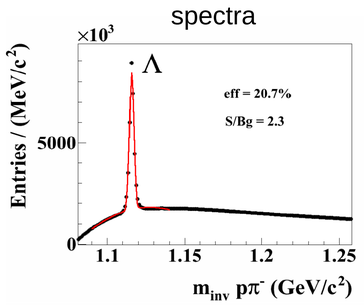


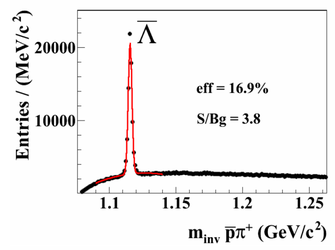
phase space coverage of bulk probes

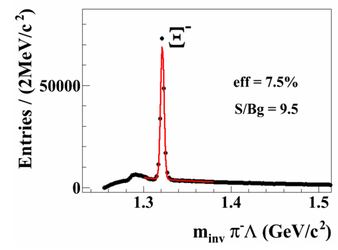
decay topology of hyperons

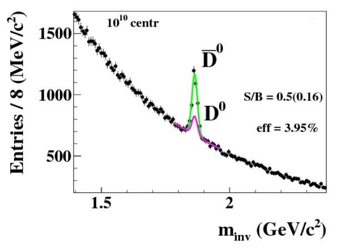


invariant mass spectra

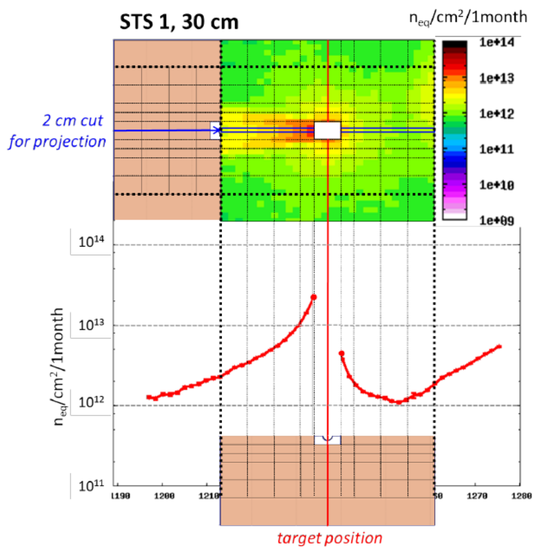








Radiation Environment



- FLUKA calculation for non-ionizing dose
- delta electrons included
- extreme case (1 month run)
- Au + Au collision at 35 AGeV
- compatible with the CBM physics program
  - 1 × 10^{13} n_{eq}/cm^2 (SIS100)
  - 1 × 10^{14} n_{eq}/cm^2 (SIS300)
- replacement of sensors after exposure to the fluence of 1 × 10^{14} n_{eq}/cm^2
- highest Fluence (1 × 10^{14} n_{eq}/cm^2) up to 10% of sensors