Study of the material budget and data rates for the STS detector system of the CBM experiment

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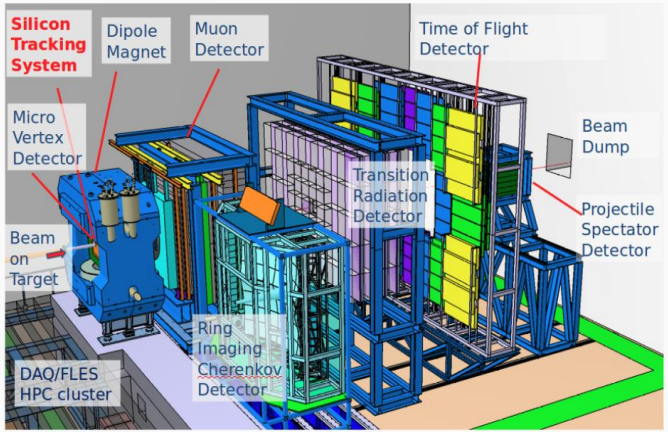
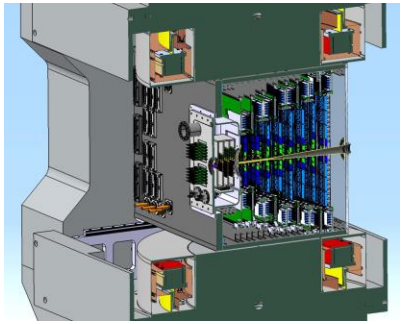
Abstract: The Compressed Baryonic Matter (CBM), a fixed target experiment is under development at the Facility for Anti-Proton and Ion Research (FAIR) in Darmstadt, Germany. The aim of the experiment is to study the QCD phase diagram of strongly interacting matter at high density and moderate temperature employing heavy-ion beams in the energy range between 2 AGeV – 11 AGeV.

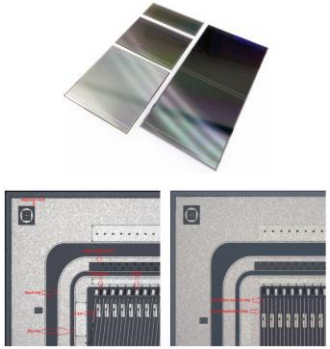
The experiment is designed to run with beam intensities up to 10^9 Au +Au particles/sec and an interaction rate of up to 10^7 collisions/sec. Therefore, fast and free streaming electronics is needed for read-out and data transfer. The silicon tracking system (STS), installed inside a 1 Tm magnet, is the key detector for tracking charged particles. It uses double-sided microstrip silicon sensors of four different sizes to match the varying particle occupancy from the beam axis towards the detector periphery. The read-out electronics are connected to the sensors via polyimide - Al micro-cables placed outside the active region of STS to minimize the material budget. Detailed realistic knowledge of the detector geometry, including both active and passive material, is necessary to estimate the material budget of the detector which has a large impact on the absorption of delta electrons created in beam-target interaction, as well as in nuclear interaction of particles created in the heavy-ion collision with the active and passive materials. We present the status of the simulations of the STS detector geometry and its impact on the expected signal rates.



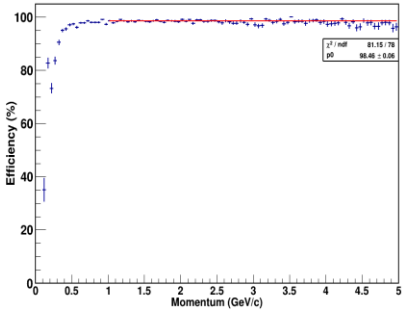
- CBM: fixed target experiment.
- Physics aim: QCD phase diagram at high net baryon densities and moderate temperatures
- SIS 100 energies: 2 - 12 AGeV
- Two possible experiment setup
  - Hadron setup
  - Electron setup
- High interaction rates up to 10 MHz
- Triggerless, free-streaming readout chain
  - Self triggered Front End Electronics

Silicon Tracking System of CBM



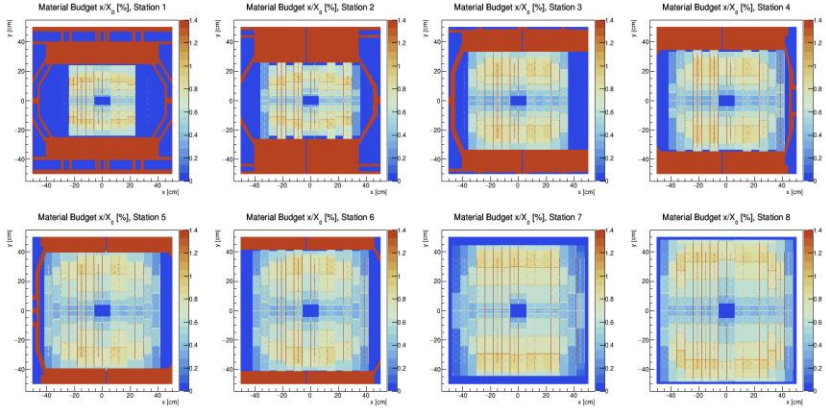


- Total 8 detector stations.
- 105 mm pitch between stations.
- Acceptance: 2.5 ≤ θ ≤ 25
- ~ 876 modules mounted on CF frame.
- Double-sided micro-strips sensors of four different size:
  - 6×2 cm , 6×4 cm , 6×6 cm and 6×12 cm
  - 1024 read-out strips on both n and p - side.
  - 7.5 inclined strips on p-side.
  - Thickness: 320 ± 15 µm.
  - Pitch: 58 µm, σ = 16 µm

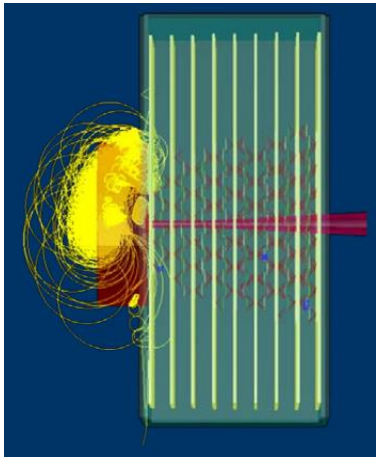


- ~ 98.5 % efficiency for primary particles
- Overall material budget < 1.4% in active region of the STS

Material budget per station of STS



Studies of delta electrons

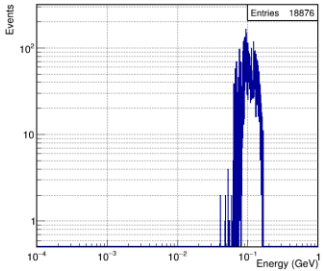


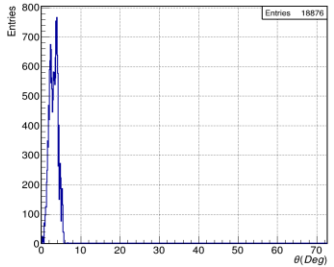
- Delta electrons: Secondary electrons, knocked out from atoms by charged particle
- Source of origin
  - Beam-target interaction
  - Beampipe interaction
  - Anywhere from the detector

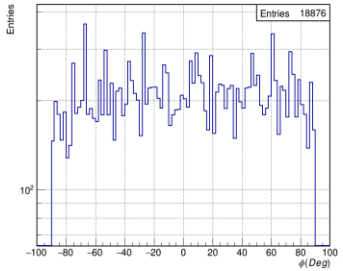
Taken from: A. Senger, Influence of passive materials on the delta electron background in MVD, STS and RICH, 32nd CBM collaboration meeting, 2018.

- Insulation box around the STS stations considered during study
- Geant3 used to transport Au ions through target
- Standard delta electron energy cut value 1 MeV was used
- Delta electron selection criteria
  - PID PDG = 11
  - Mother ID = 0
  - |X| < 1.5 cm
  - |Y| < 1.5 cm
  - Z < -3.9 cm
  - E > 10 keV

Energy, theta and phi distribution of delta electrons

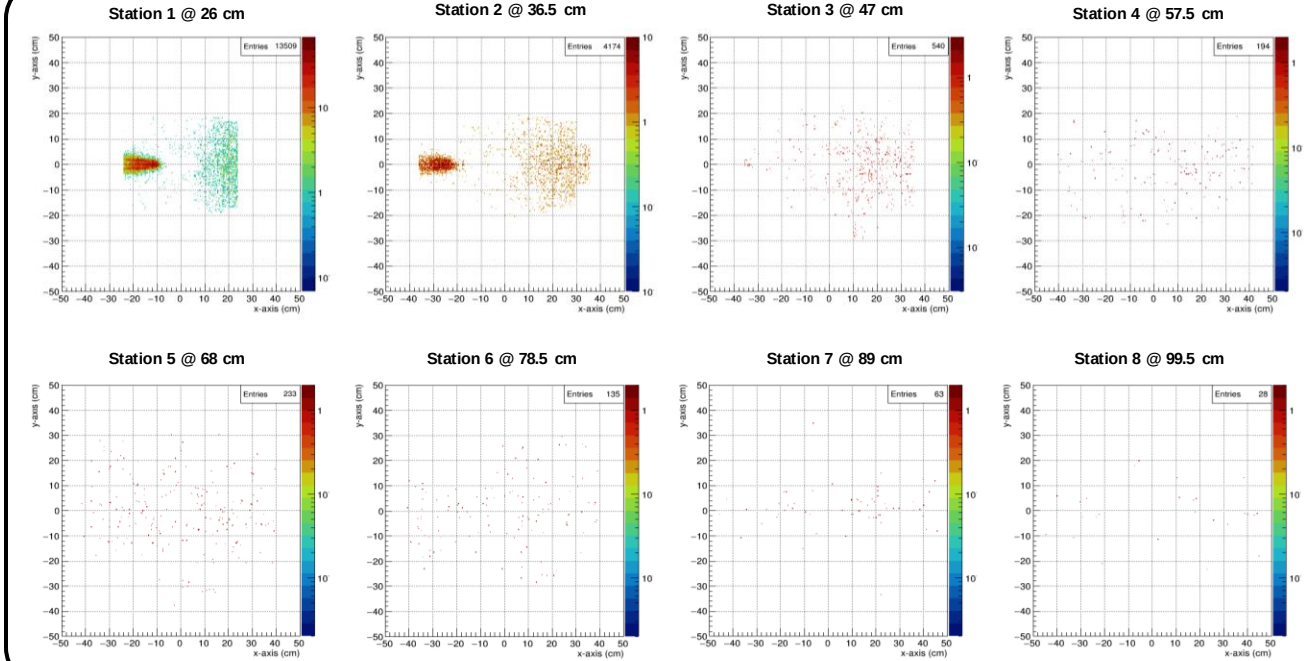




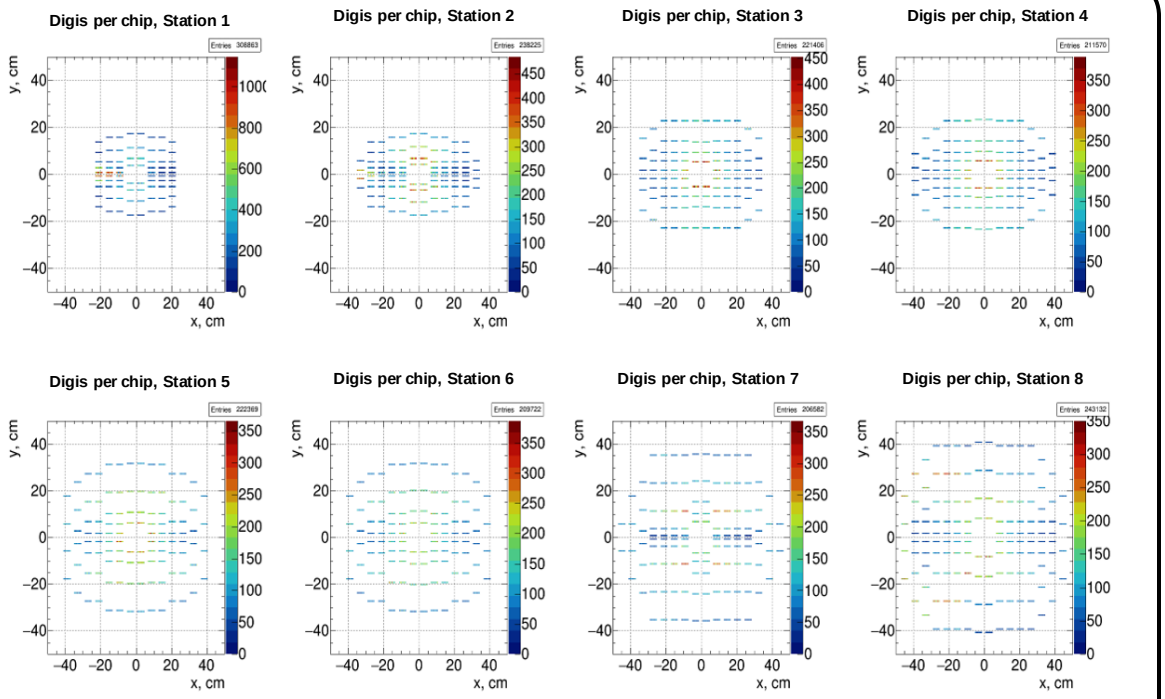


Studies of delta rates

- Digi: Detector response for the detailed physics processes for the given MC events
- FEBs: ASICs per module



Studies of digis per chip



Summary

- There are substantial amount of delta electrons seen in the very first two STS detector stations.
- It is clearly seen that delta electrons are concentrated in a very small part of the detector on the left side.
- Data rate of the nuclear collision will be studied. Studies of data rates due to the delta electrons produced from beam-target interaction is under investigation.
- The rate studies is under investigation.