Charge collection study of microstrip sensors for the CBM Silicon Tracking System

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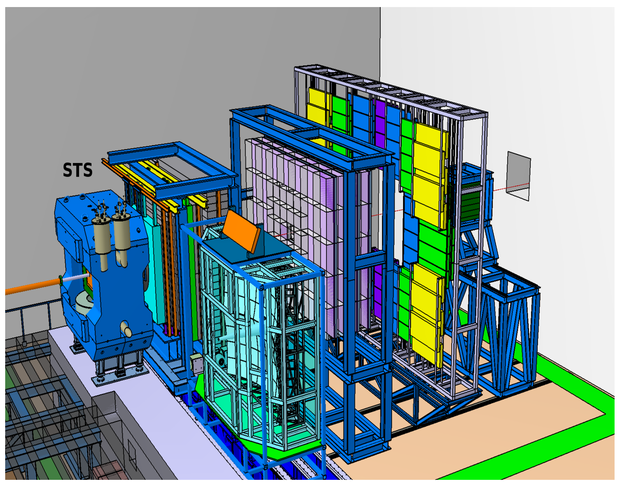
Compressed Baryonic Matter experiment and Silicon Tracking System

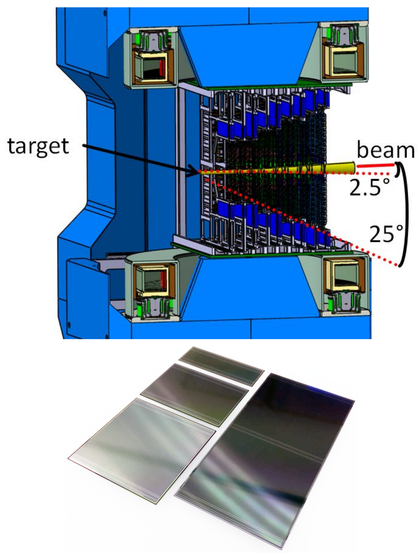


CBM experiment:

- Au+Au collisions @SIS100 2 - 11 AGeV, 10^5-10^7 interactions/s;
- up to 10^3 charged particles per central collision.

physics program @SIS100:

- Strangeness;
- Lepton pairs;
- Collective flow, correlations and fluctuations;
- Hypernuclei and hypermatter;
- Charm-anticharm quark pairs.



Silicon Tracking System:

- 8 tracking stations;
- hit rates up to 20 MHz/cm^2;
- low material budget $\sim 1\%$ X_0;
- 25 μm hit spatial resolution;
- S/N>10 for the hit reconstruction efficiency $\sim$ 98 %.

Double-sided micro-strip Si sensors:

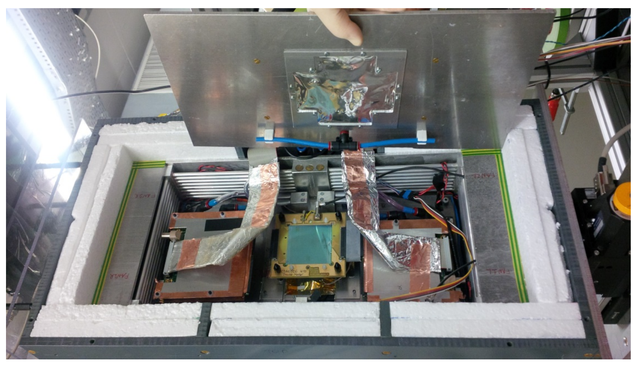
- 285/320 μm thick, 58 μm strip pitch;
- sensor sizes 6×2, 6×4, 6×6, 6×12 cm^2;
- 7.5° stereo-angle front-back sides;
- radiation hard: 10^{14} 1 MeV n_{eq}/cm^2.

Experimental set-up & program of measurement

Main components beam test COSY:

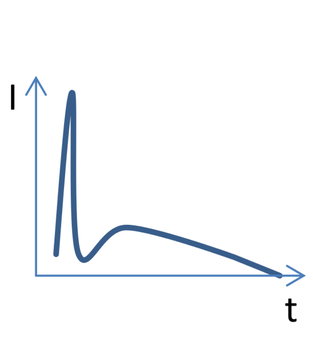
- Cold box on movable platform with r/o and exchangeable sensors;
- Warm box with sensor bonded to r/o;

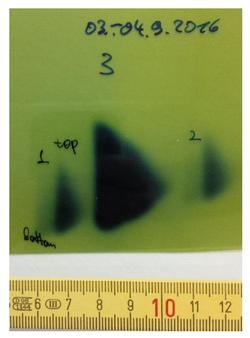
- ***Trigger:*** two scintillators in coincidence.
- ***Read out:*** ASIC front-end Beetle and DAQ system (Alibava): – 2 × 128 r/o channels;
  – 40 MHz analog rate;
  – 4 μs digitization rate.



Proton beam from COSY:

- 1.6 GeV/c ± 0.1%
- time profile of the beam:
  spill/inter-spill: 20 s/10 s.
  sharp spike: 7 $\times 10^7$;
  bulk extraction: 2×10^8.





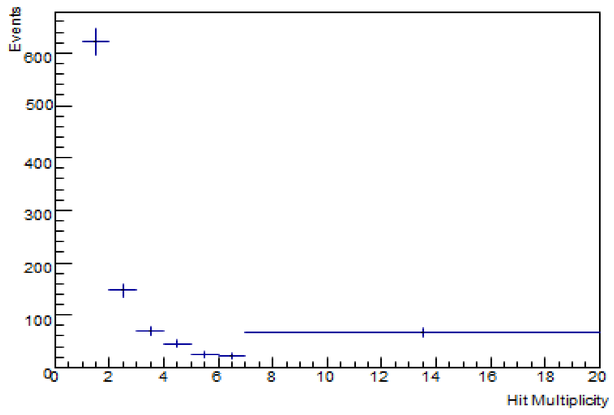
What to measure:

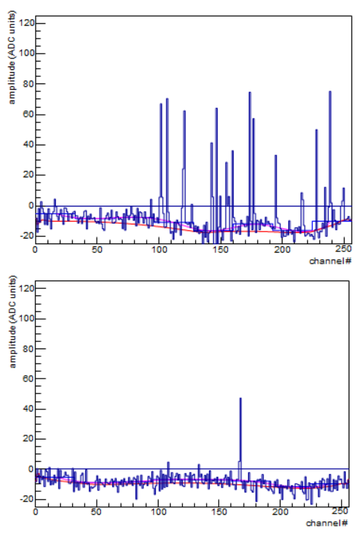
- Charge collection;
- Signal dependence on beam incidence angle;
- Cross talk.

What to compare:

- n-side & p-side performance;
- direct r/o & via metallisation;
- single/double metallisation layout;
- different connection schemes between ASIC and sensor strips.

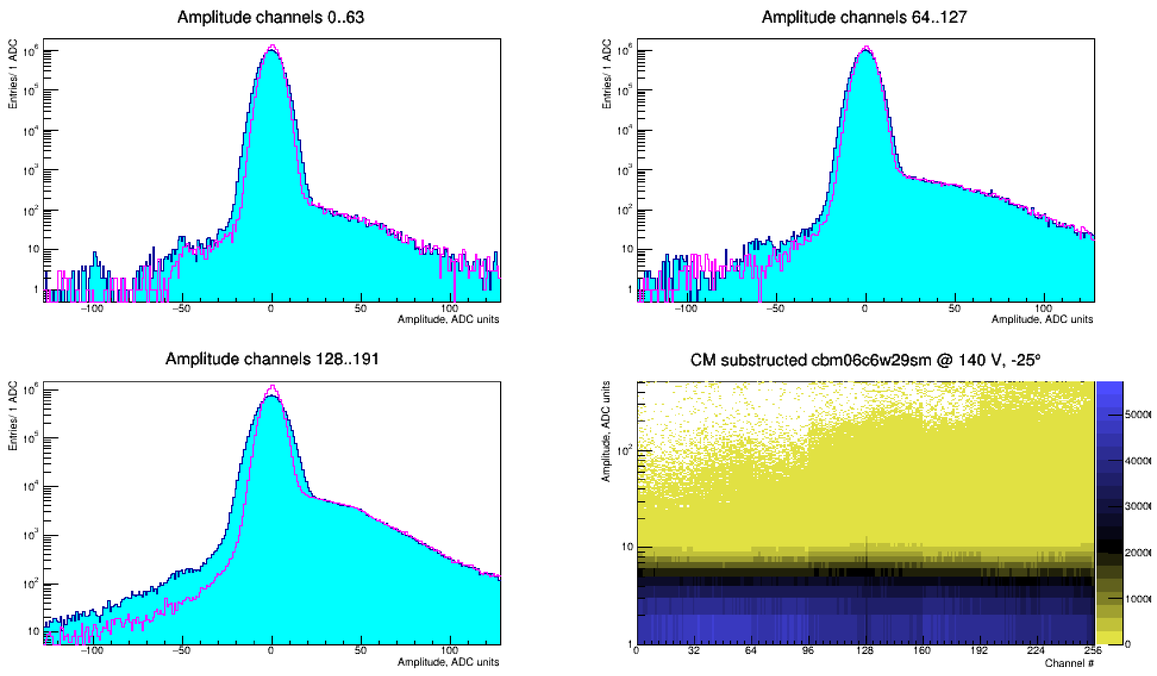
Event selection





Due to beam micro-spill structure, 50% of data are single hit events.

Common mode correction



Moving baseline was corrected for all 256 channels: blue – before correction, pink – after correction.

Charge collection at different beam angles

To improve S/N for big cluster sizes, three connection schemes between sensor strips and ASIC channels were tested with beam, incidence angles correspond to the STS acceptance: $0° \leq \Phi \leq 25°$.

Type of connection	$\Phi = 0°$	$\Phi = 25°$
$1 \rightarrow 1$ one strip correspond to one r/o	Every strip is r/o. One-, two-, three- strip clusters: Events = 10611, MPV = 89.08 ± 0.26, LWidth = 6.86 ± 0.20, GWidth = 12.48 ± 0.32	Every strip is r/o. 1-5 strip clusters @ -25 deg: Events = 16362, MPV = 98.89 ± 0.51, LWidth = 7.35 ± 0.35, GWidth = 30.29 ± 0.57
every second strip is r/o	Every second strip is r/o. One-, two-, three- strip clusters: Events = 55015, MPV = 79.06 ± 0.14, LWidth = 6.81 ± 0.10, GWidth = 16.07 ± 0.18	Every second strip is r/o. One-five strip clusters @Phi=-25 deg: Events = 28076, MPV = 84.16 ± 0.41, LWidth = 8.19 ± 0.29, GWidth = 31.89 ± 0.49
$2 \rightarrow 1$ two strips connected to one r/o	Two strips connected to one r/o. One-, two-, three- strip clusters: Events = 91237, MPV = 91.33 ± 0.09, LWidth = 8.46 ± 0.08, GWidth = 11.68 ± 0.13	Two strips connected to one r/o. One-five strip clusters @Phi=-25 deg: Events = 23224, MPV = 94.88 ± 0.32, LWidth = 7.92 ± 0.23, GWidth = 23.41 ± 0.39

Findings

- Cluster size increases with beam incidence angle as expected.
- Noise increases for large cluster sizes (larger capacitive effect).
- Study made in the lab with perpendicular β-particles agree with beam results.
- Connection scheme with every second strip is read out applicable for lateral detector areas.