Performance simulations of the Silicon Tracking System of the CBM Experiment at FAIR

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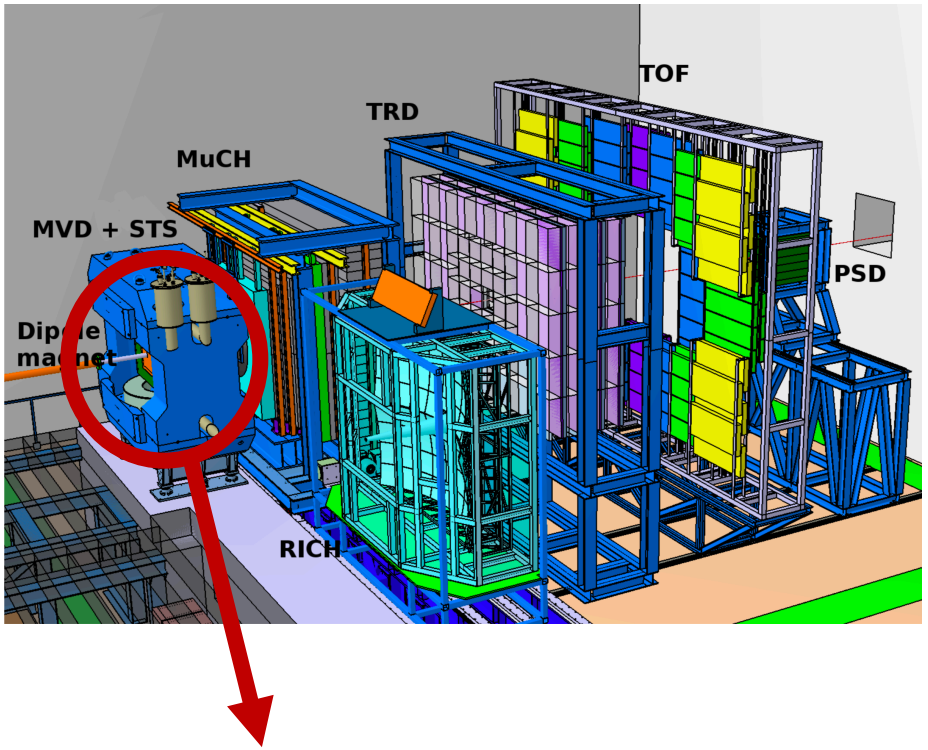
DPG Spring Meeting 2019

Compressed Baryonic Matter (CBM) experiment

- 10 MHz interaction rate allows differential measurements of rare and exotic probes at high statistics
- Beams of heavy ions with energies up to 11 *A* GeV (Au, SIS100)
- Nuclear matter densities of 5-8 ρ_0 can be reached similar to those found in NS cores
- Free-streaming read-out
- Complex signatures require software triggers

The CBM experimental setup with detector systems

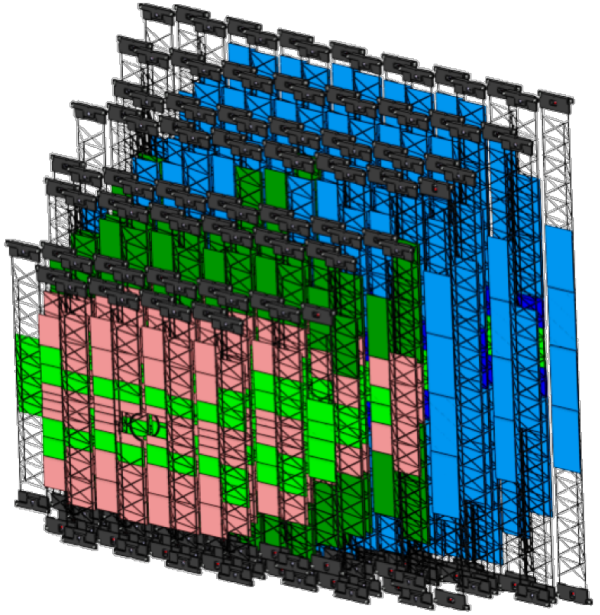


CBM
Silicon Tracking
System

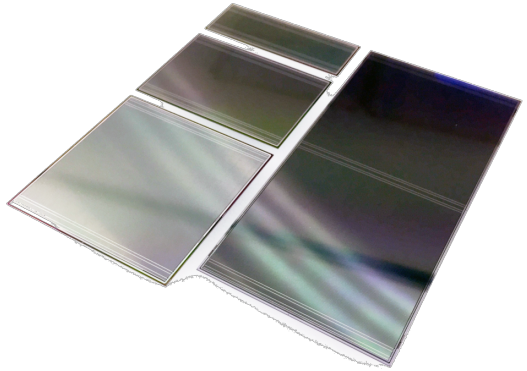
P. Giubellino
Mo, 09:15 PV I

Silicon Tracking Systems

- Key detector to reconstruct charged particle tracks and resolve their momentum with $\Delta p/p \approx 1.5\%$
- 8 tracking stations comprising ~900 silicon microstrip sensors
- Strip lengths from 2 to 12 cm
- Provide 25 µm spatial and 10 ns time resolution for hits



View of the CBM-STS detector without thermal enclosure and services



A photograph of prototype silicon sensors.

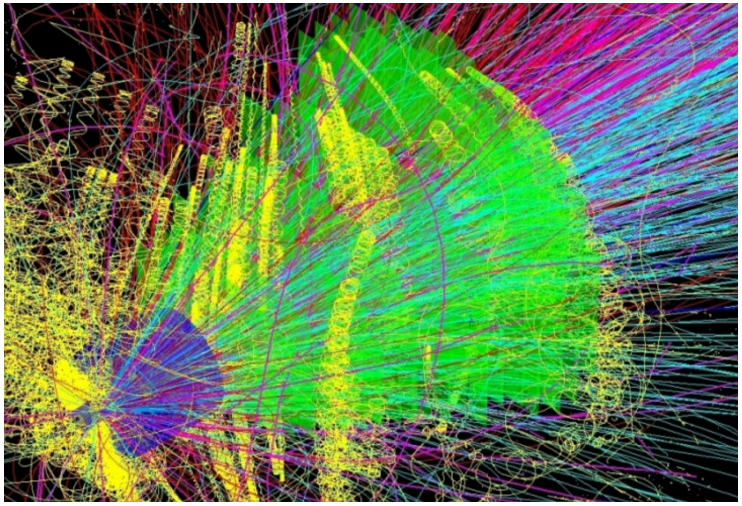
E. Momot: Wed, 16:30 HK 44.1

Detector simulations

- Detector simulations are essential for the reconstruction and analysis algorithms development before data taking with beam

- The simulation package CBMROOT provides the means for transporting and reconstructing the heavy-ion collisions

- Detailed and realistic simulation of the detector response is available, which accounts for charge generation and collection, detector noise, etc.



Tracks from a central
Au+Au collision

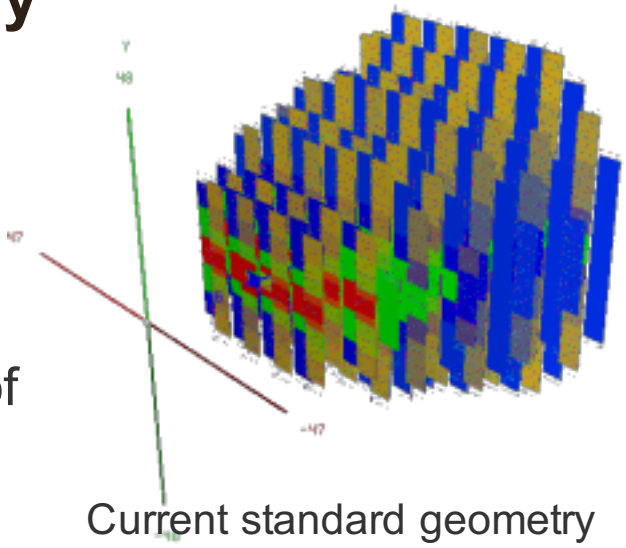
Towards improved detector geometry

- Presently, detector geometry has only active elements (sensors) and structuring elements to support them

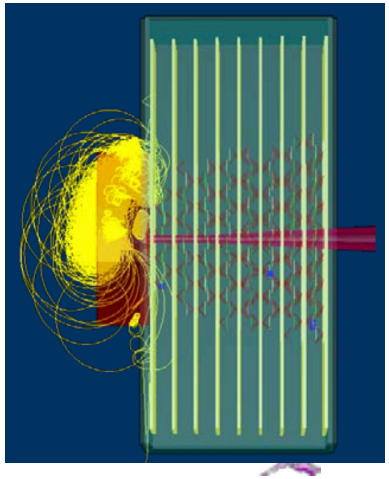
- Inclusion of other passive materials outside of acceptance should show more effects impacting performance of STS and downstream detectors

- Allows realistic estimation of data rates by shielding off the delta electrons

- Delta electrons are simulated by transporting Au ions through Au target



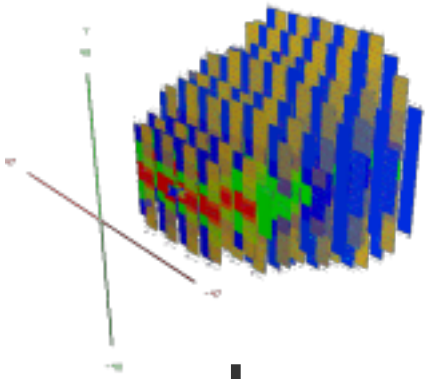
Current standard geometry



Simulated delta electron trajectories

Towards improved detector geometry

Current standard geometry



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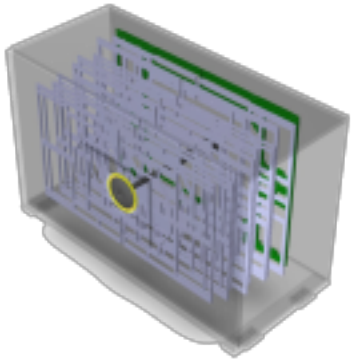
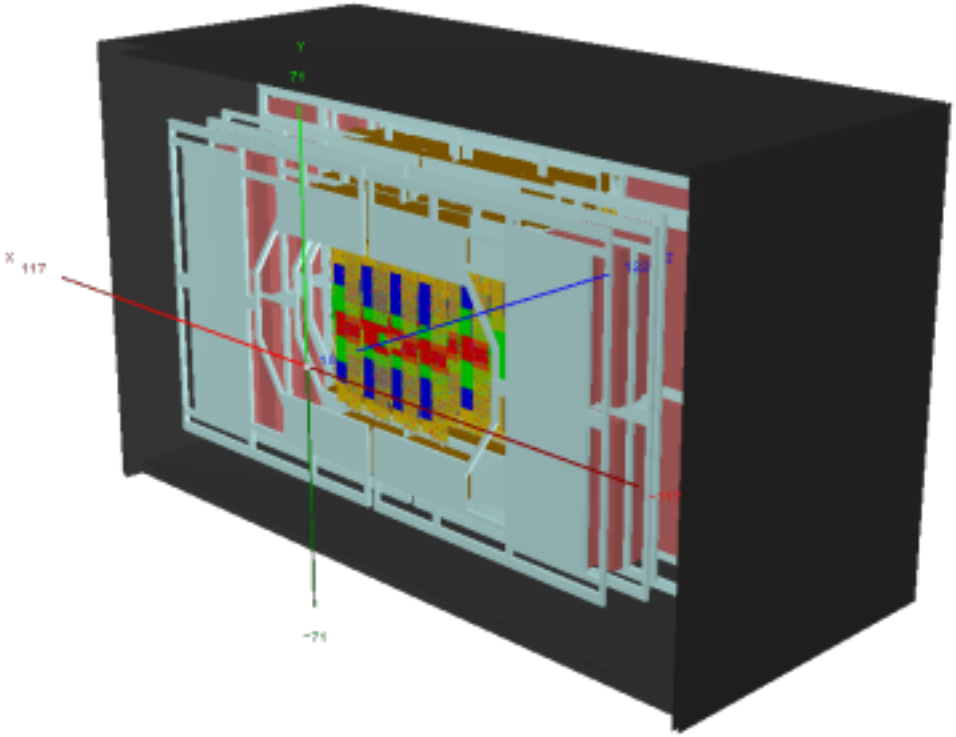


Mechanical CAD model

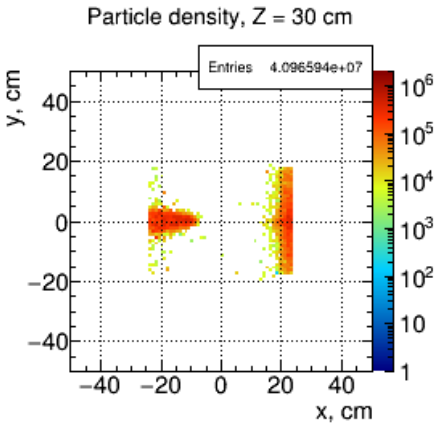
⇛

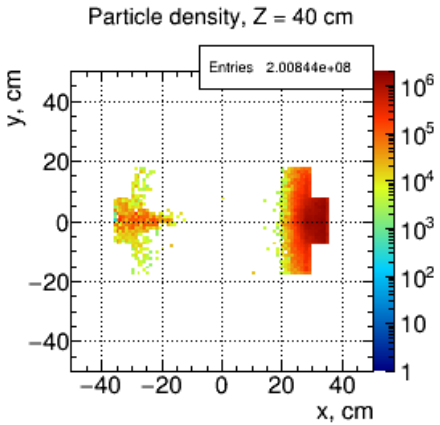


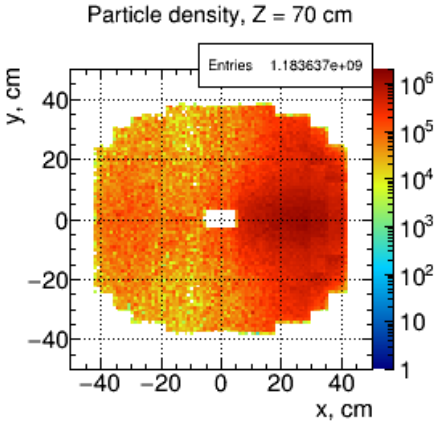
New geometry

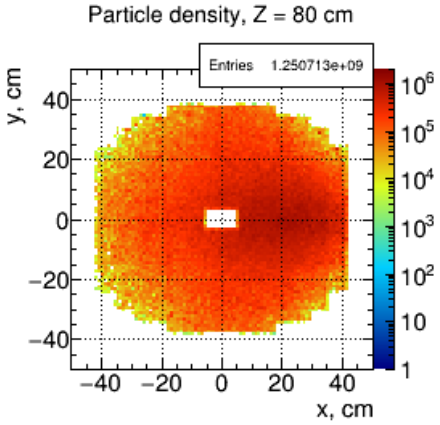
With insulation box, holding structures, front-end read-out electronics, cooling blocks, etc.

Particle hits from delta electrons in STS stations

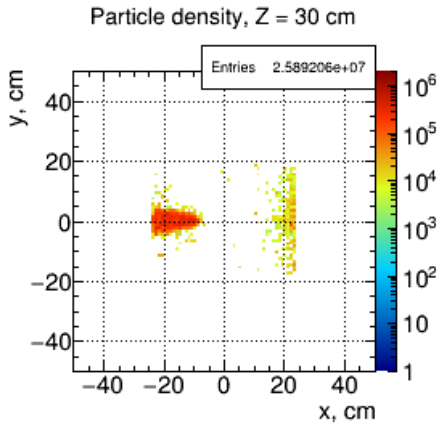


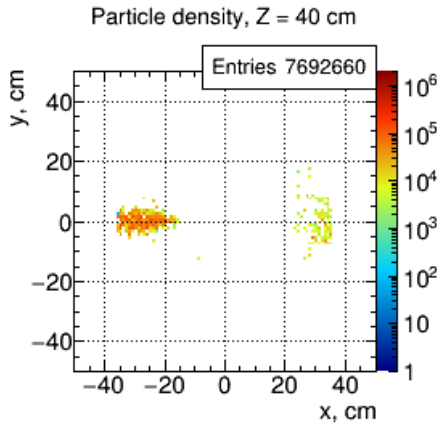


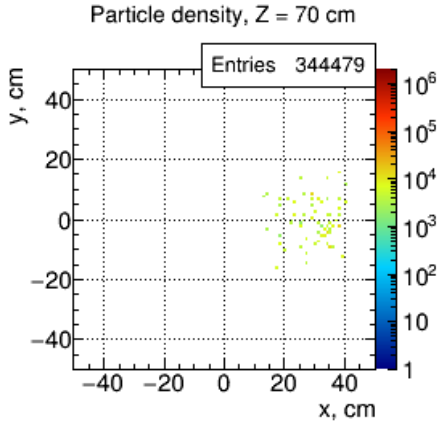


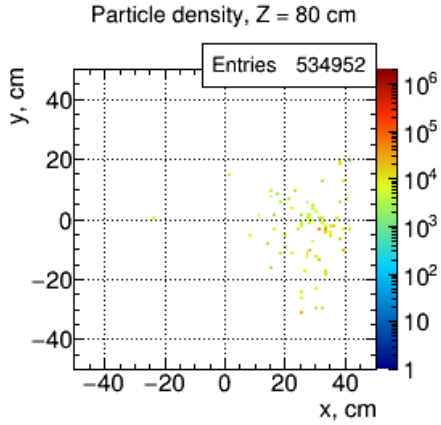


Without passives







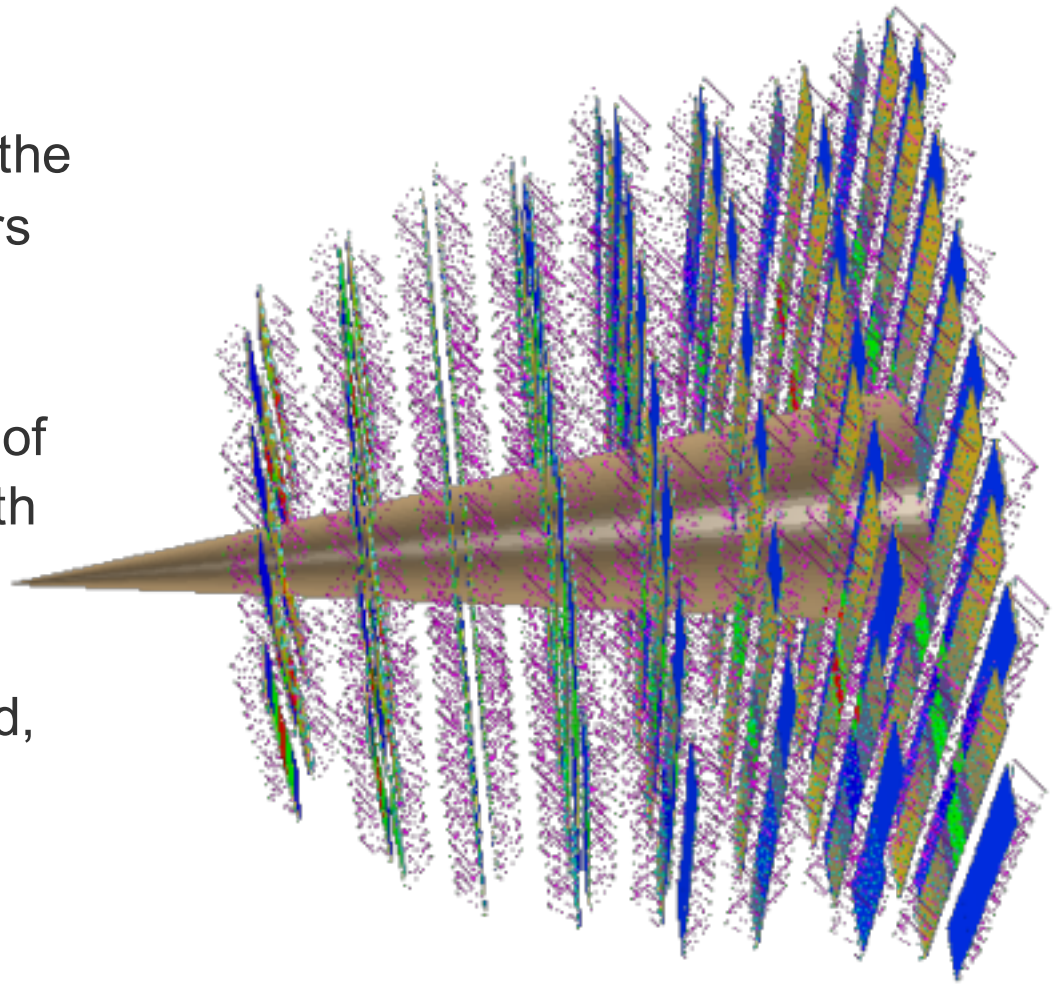


With passives

Data rate reduction by a factor of ~120

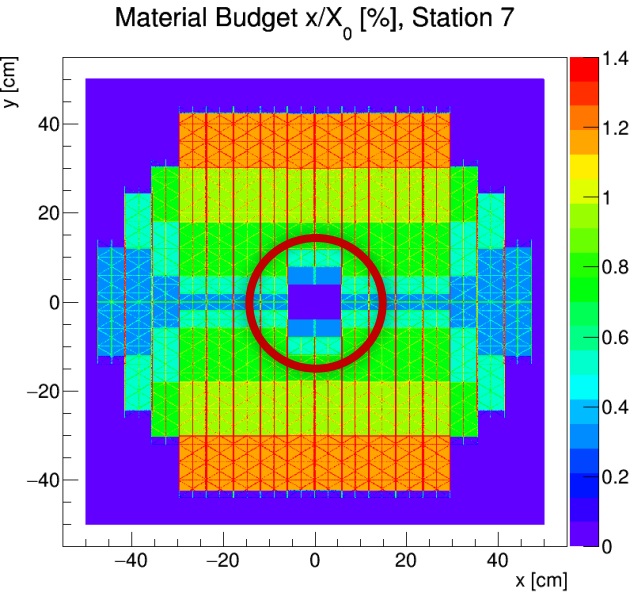
Varied sensor thickness

- Due to long read-out cables the SNR might be low for sensors around beam pipe
- Idea: increase the thickness of the sensors within a cone with opening angle $\Theta \leq 7.5°$
- Increase for SNR is expected, but what about other performance metrics?

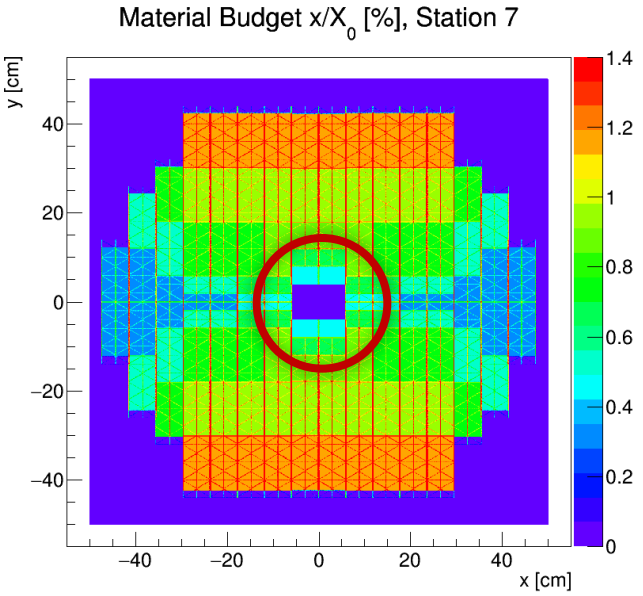


Detector material budget

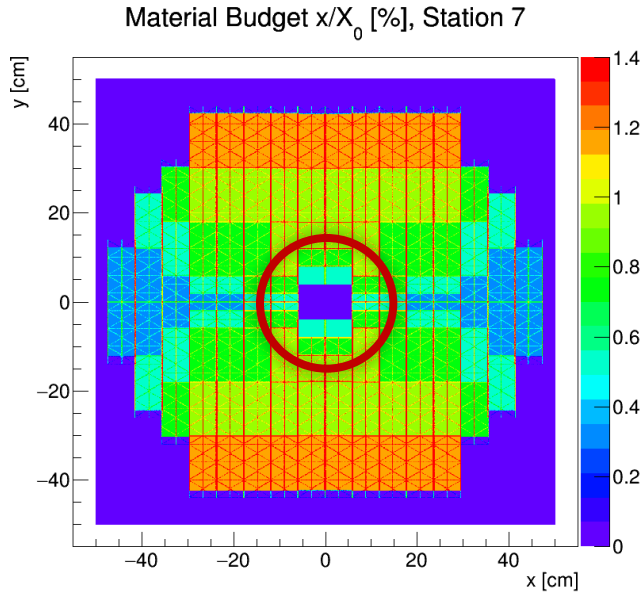
300µm



400µm



500µm

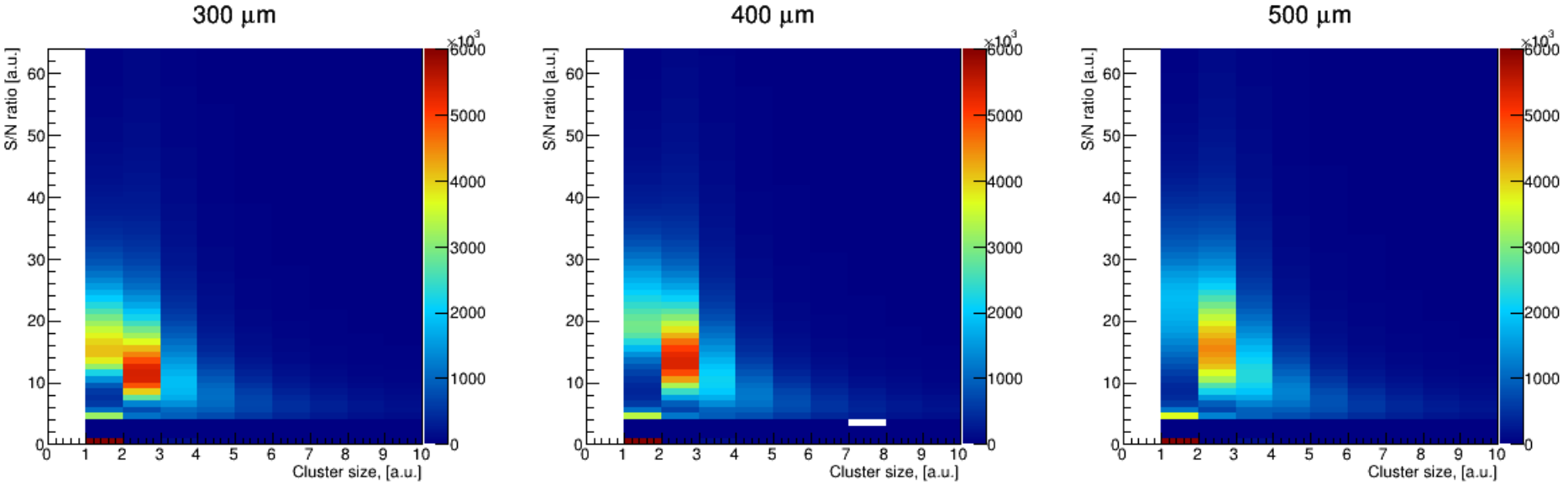


Important to keep the material budget low

- prevents multiple scattering, which worsens momentum resolution

Signal to background ratio for the strip clusters

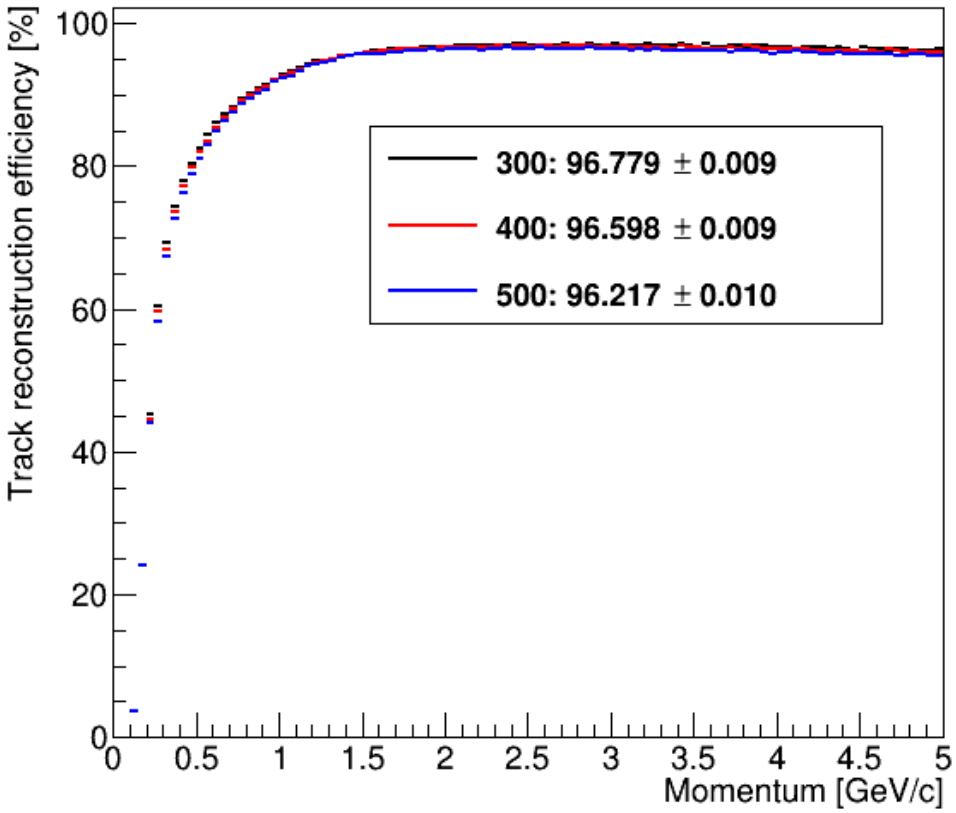
MPV SNR for 2-strip clusters 11.6; 13.1; 14.4



- Increase of signal to background ratio
- Increase of cluster size:
  - More charge sharing
  - Increase of sensor occupancy

Track reconstruction efficiency

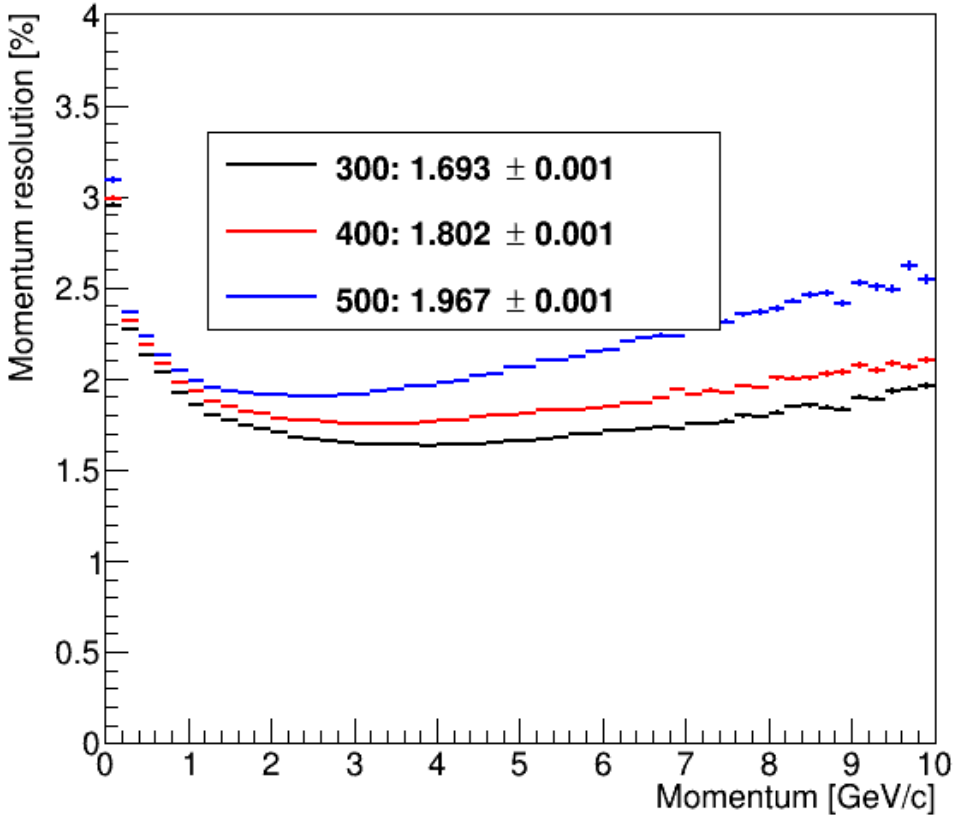
- Based on the Cellular Automaton track finding and fitting
- Ratio between reconstructable (4 MC points minimum) and reconstucted tracks
- Small effect



V. Akishina: Thu, 14:30 HK 48.2

Track momentum resolution

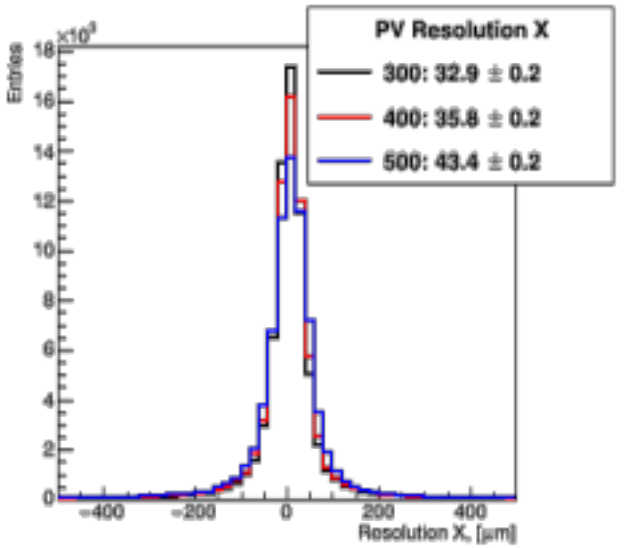
- Important performance metric
- Defines the precision of the invariant mass spectra measurements
- Both primary and secondary particle tracks are taken into account
- Significant drop of Δp/p -> wider inv. mass spectra, lower significance

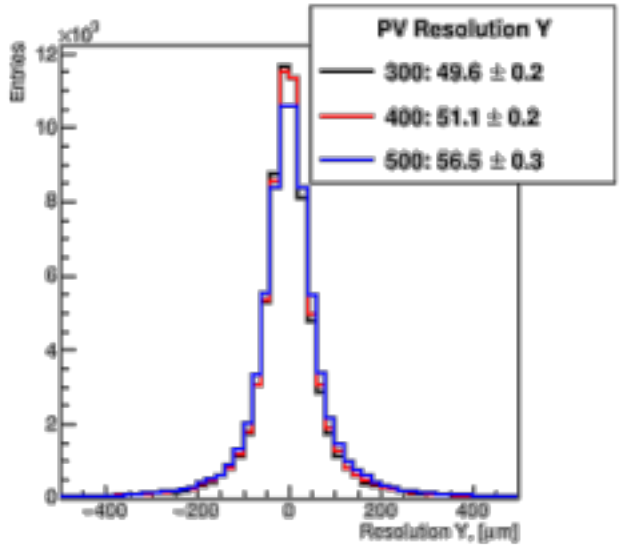


Primary vertex resolution

- PV are reconstructed with our main analysis tool KFParticleFinder based on a Kalman Filter algorithms

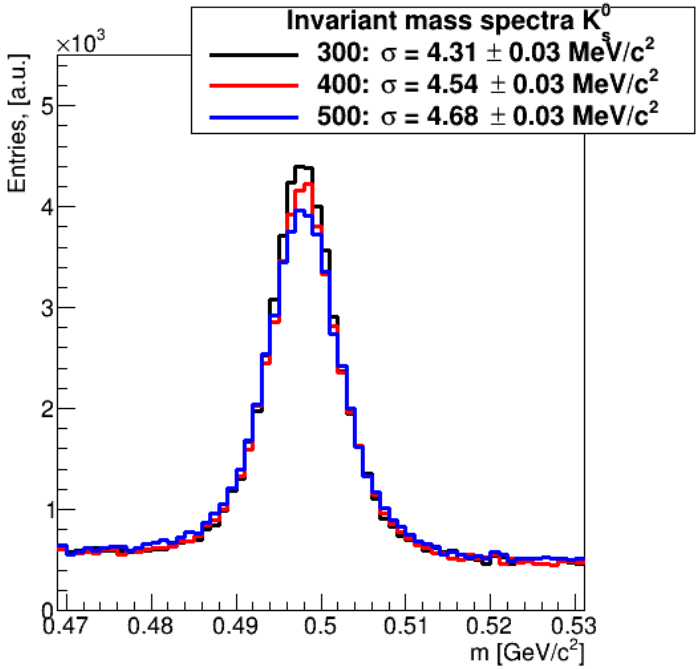
- Observable decrease of vertex resolution in both X and Y

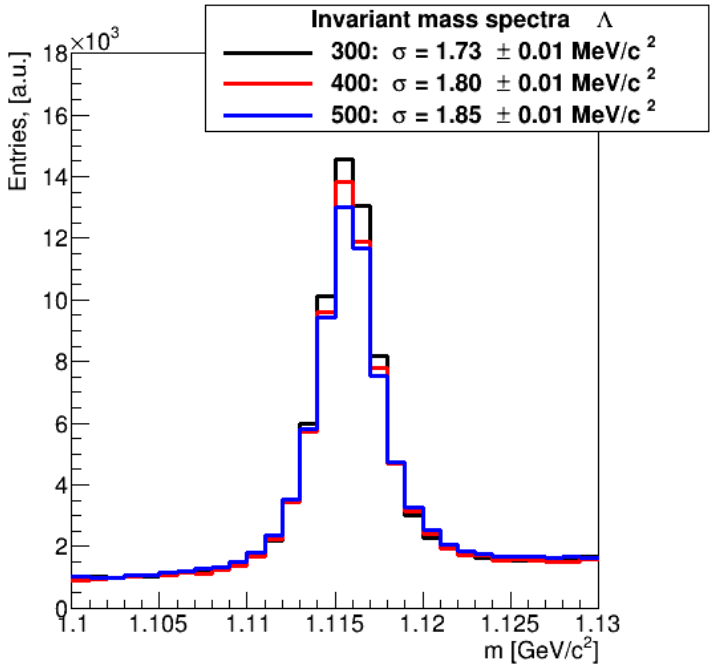




M. Zyzak: Tue, 14:30 HK 20.3

Reconstruction of short-lived particles





- Reconstructed with our main analysis tool KFParticleFinder based on a Kalman Filter algorithms

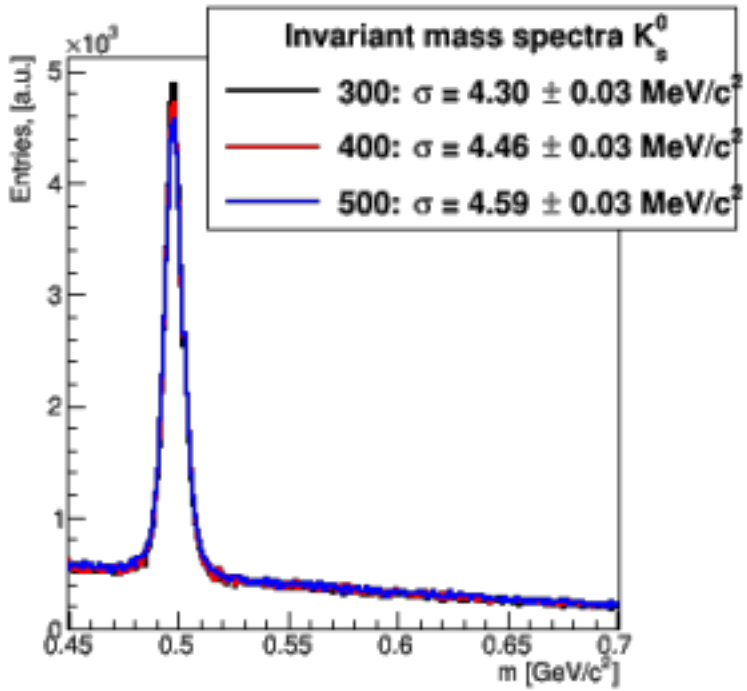
	300	400	500
K^0_s	46839	46668	46695
Λ	64203	64270	62722

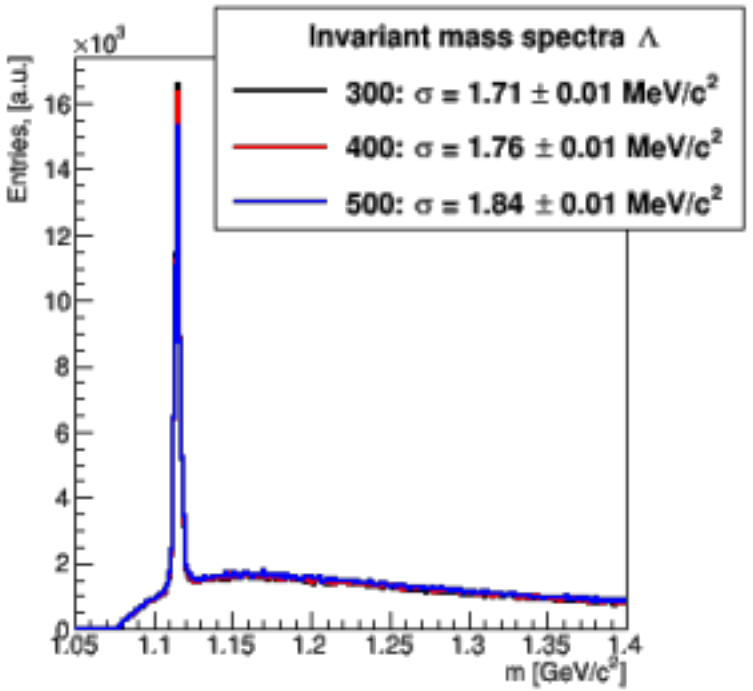
Number of particles reconstructed

Summary

- Many performance metrics are available for STS detector
- New, more realistic geometry allows to shield away delta electrons
- Allowed to estimate realistic the data rates from STS
- Impact of increased sensor thickness was investigated

Reconstruction of short-lived particles





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