GEM Detector Analysis

Vahe Mamyan
for
K. Allada, E. Cisbani, O. Hansen,
V. Nelyubin, I. Rachek, B. Wojtsekhowski

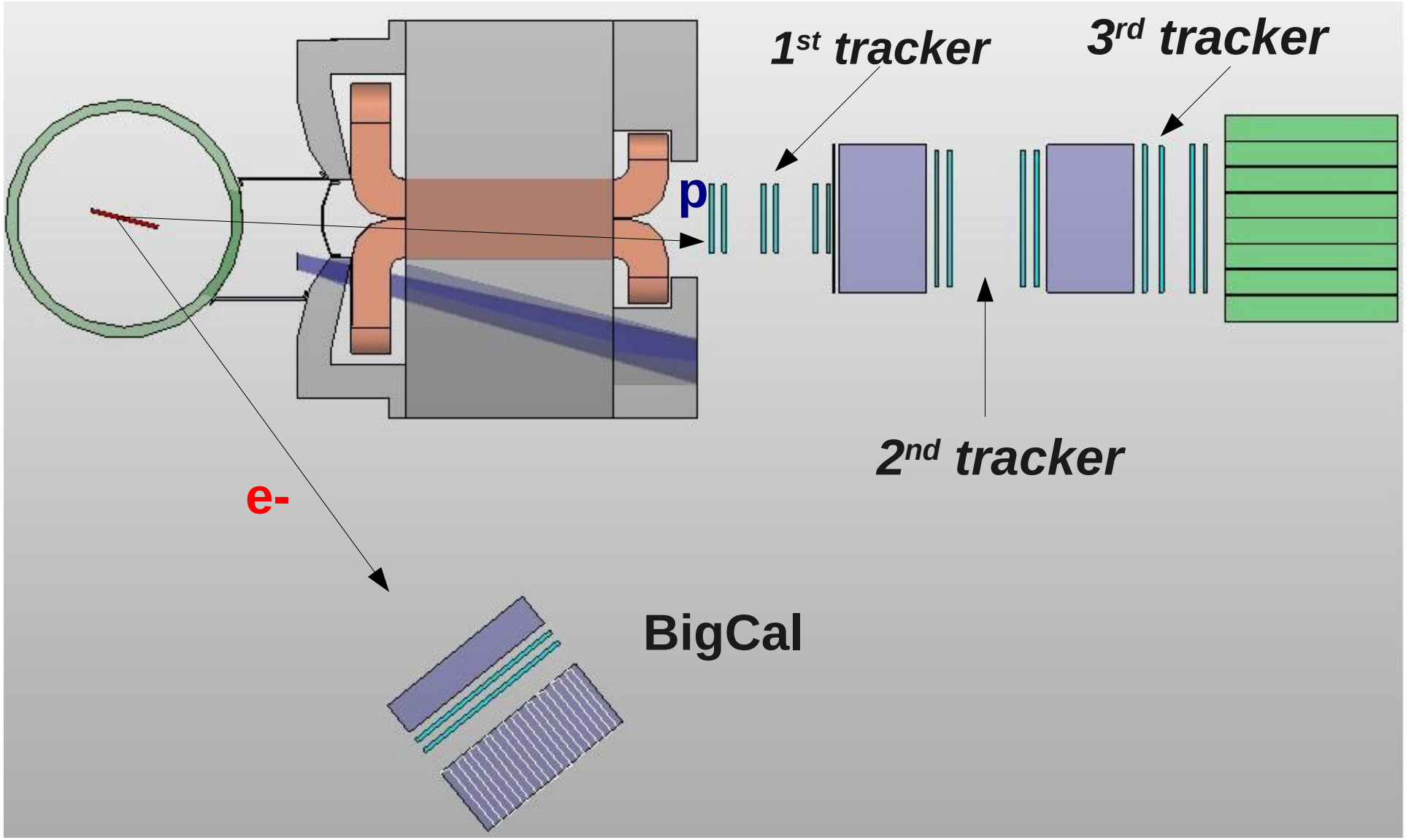
Carnegie Mellon University

Hall A Collaboration Meeting, June 9-10 2011

Outline

- SBS GEM tracker.
- Data analysis.
- Event display.
- Background filtering.
- Tracking efficiency.
- Summary.

GEp(5) Experiment Layout



The SBS GEM Tracker

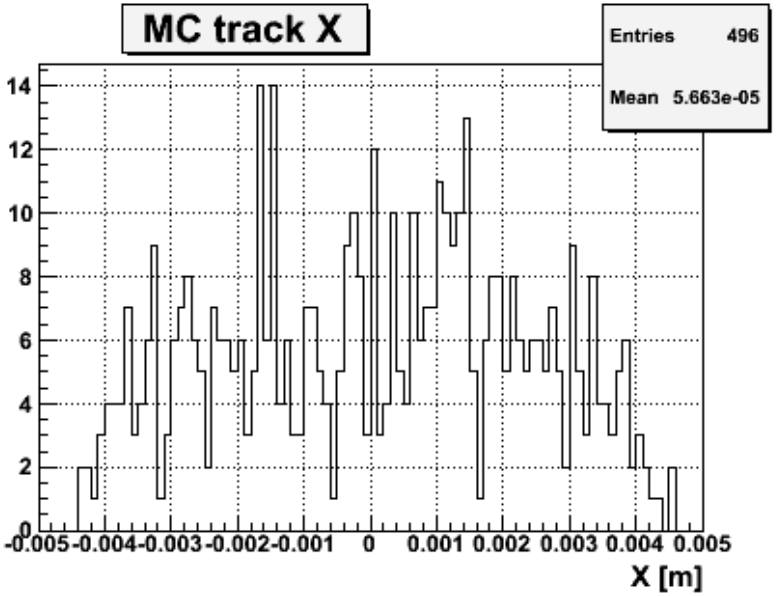
- Gep(5) experiment has four trackers.
- Front tracker has six planes of GEM chambers.
- Each module covers 40 cm x 50 cm area.
- Each chamber consists of 3 modules, 40 x 150 cm area.
- Strips are orientated in X and Y and have 0.4 mm pitch.
- Front-end electronics is based on APV25 chip.
- VME electronics to process data.

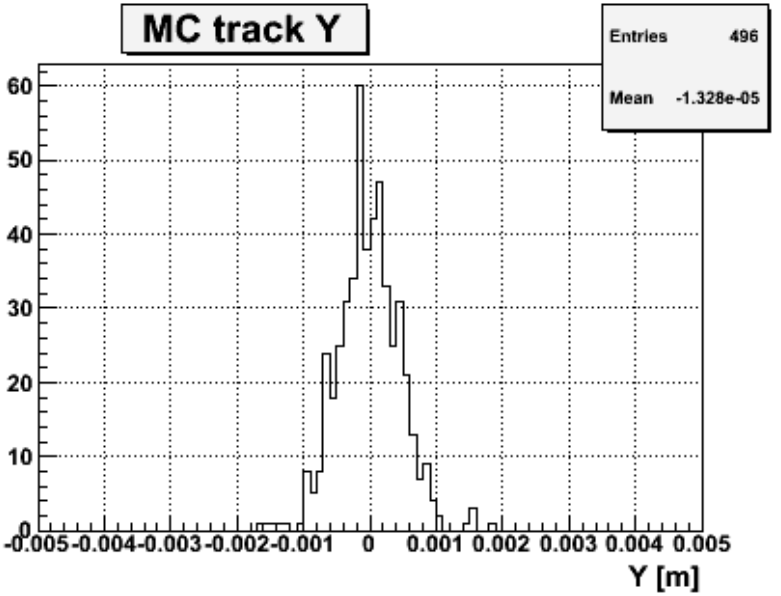
Data Analysis

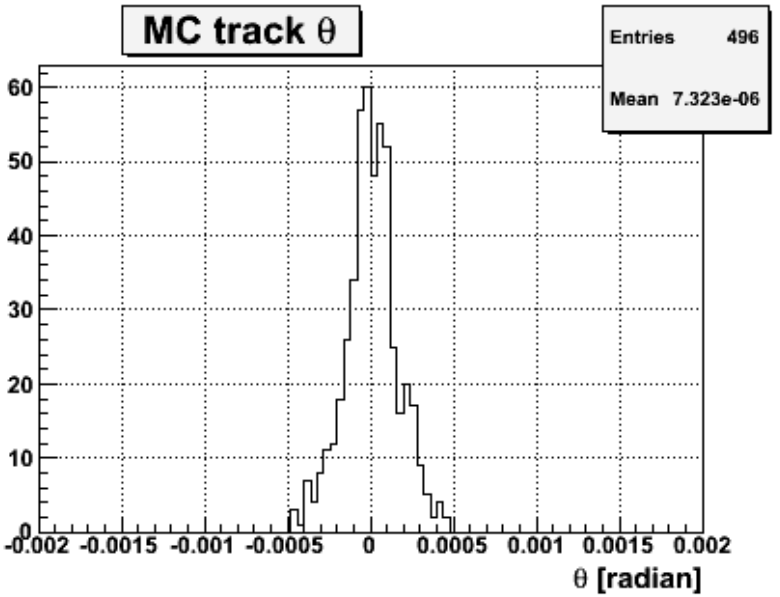
- GEANT3 (Vladimir Nelyubin) based MC simulates background conditions of GEp(5) experiment.
- GEANT4 based MC (Evaristo Cisbani) simulates GEMs with background conditions of GEp(5) and outputs it's digitized response into a ROOT tree.
- A package called TreeSearch (Ole Hansen), written in the basis of Hall A analyzer, reads digitized information from the ROOT tree and reconstructs tracks.

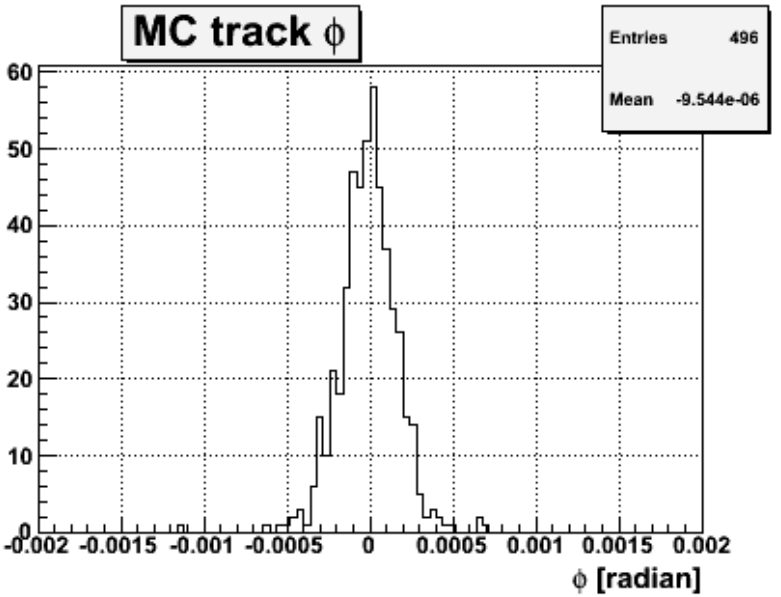
Proton Track Distribution

Simulated proton track parameters at the front face of the GEM.







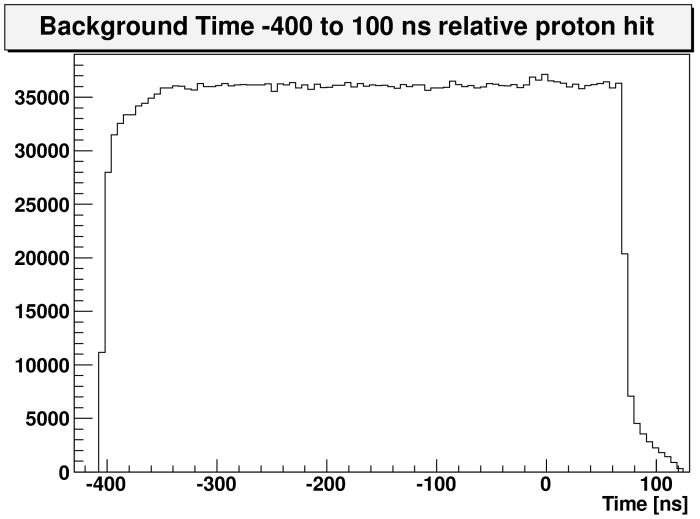


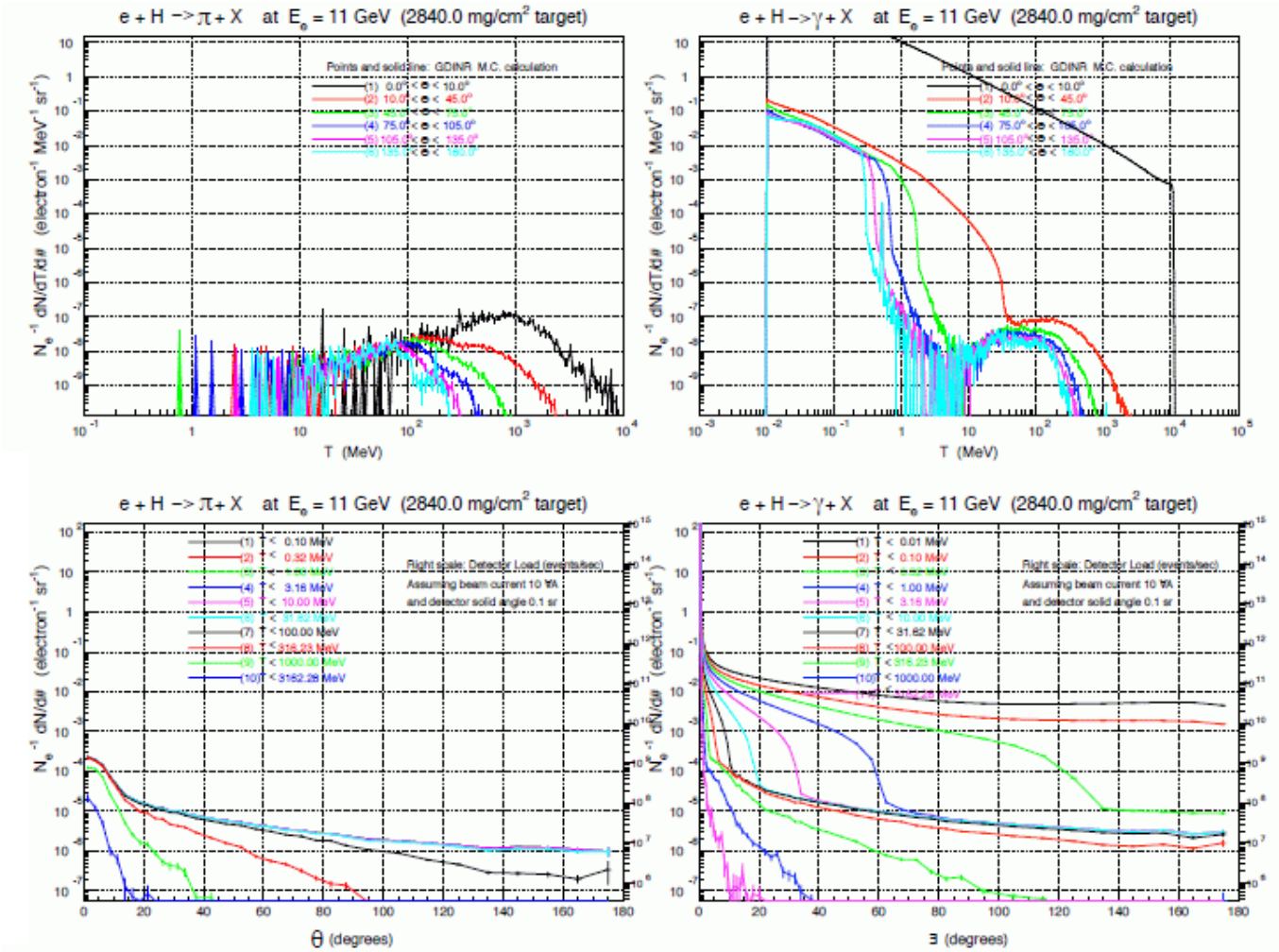
Background

Charged particles with momentum less than 1 GeV/c are swept away by 48D48 magnet. Dominant source of background is from low energy photons.

Photon background is 255 MHz/cm².

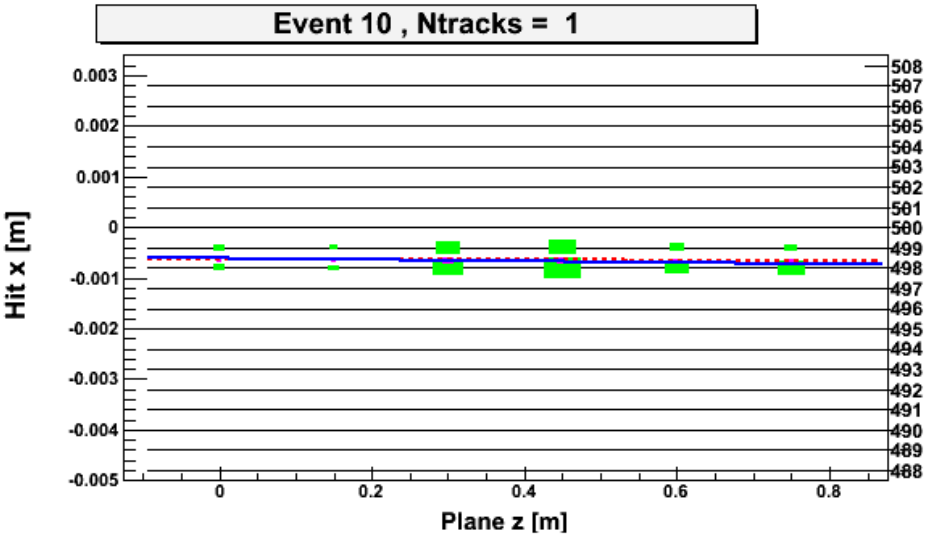
Electron background is 0.16 MHz/cm².

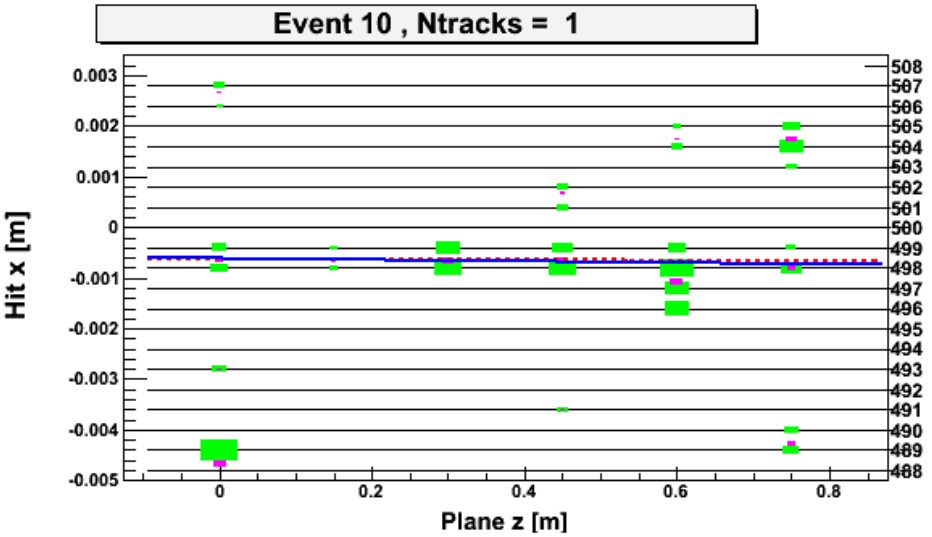


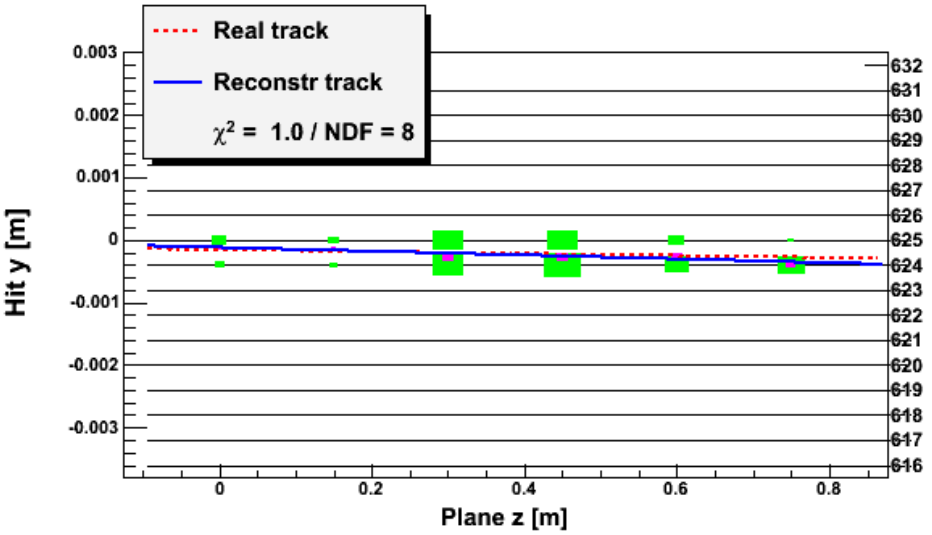


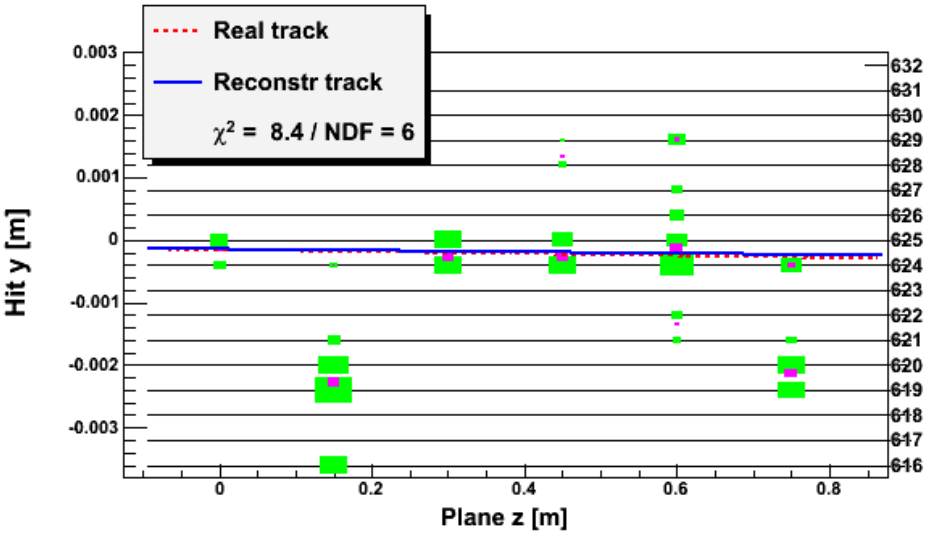
Event Display

Event display of an event for no background (left) and full background (right). Size of the green box indicates strength of the signal, magenta points indicate hit position.

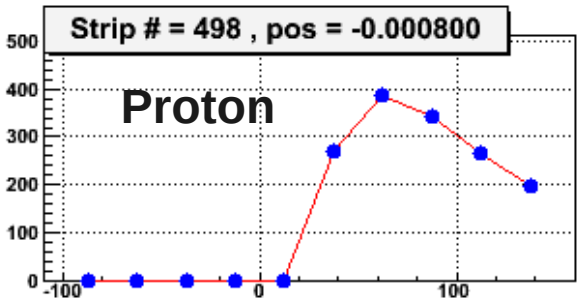


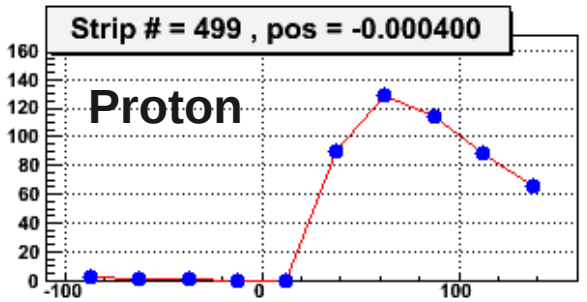


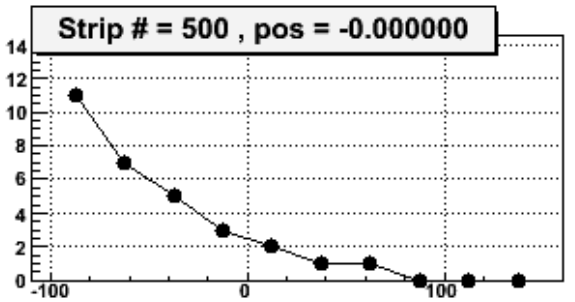


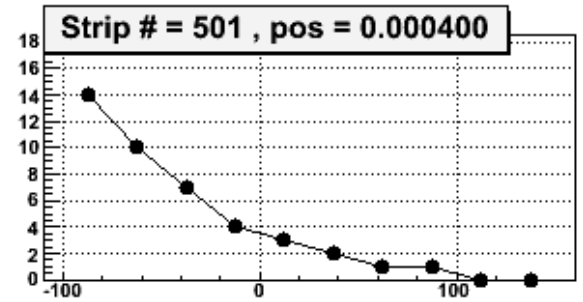


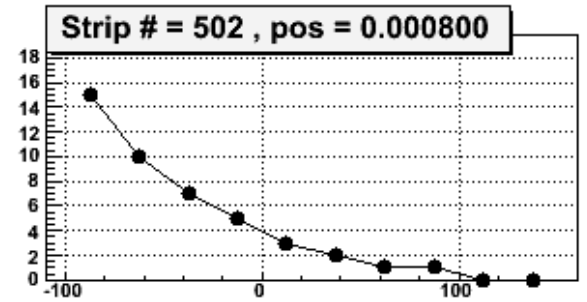
Signal Pulse Shape

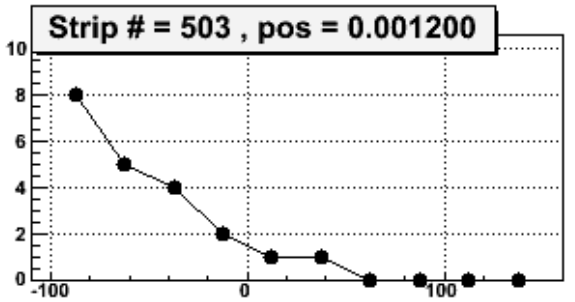


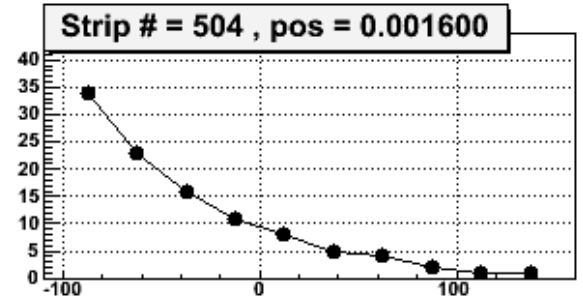


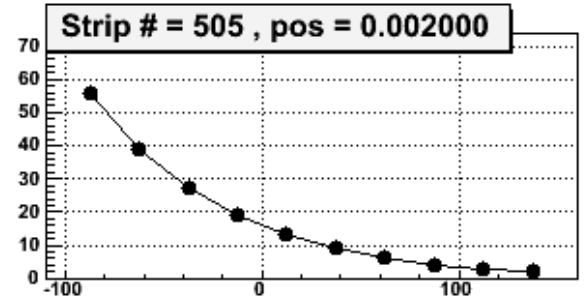


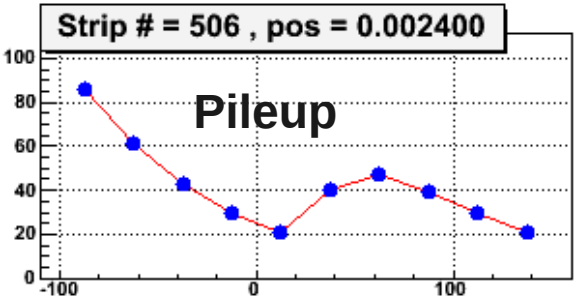


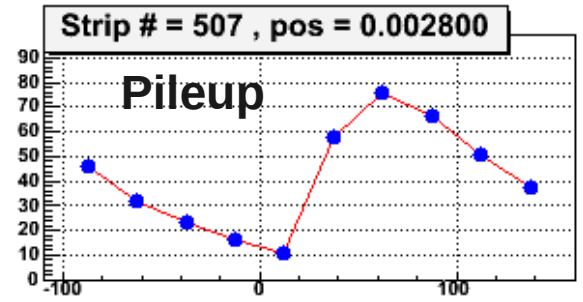












Trigger time is at 0 ns.

Red line – on time hits, passed filter cuts.

Black line – off time hits, did not pass filter cuts.

Background Filtering

- For GEp(5) background is 2-3 MHz per strip.
- High occupancy of strips – tracking problem.

  Filtering strip signals helps considerably.
- Trigger jitter time T_{cj} is uniformly distributed between

  -12.5 ans 12.5 ns and adds uncertainty in signal

  strength determination.

- S_{-1}, S_o and S_{+1} are three samples of APV25 signal.

  S_{-1} – signal 25 ns before trigger.

  S_o – signal near trigger.

  S_{+1} – signal 25 ns after trigger.

De convoluted signal is

$$D_0 = w1 \cdot S_{+1} + w2 \cdot S_0 + w3 \cdot S_{-1}$$

$$w1 = e^{x-1}/x \quad w2 = -2\,e^{-1-x}/x \quad w3 = e^{x-1}/x$$

$$x = 25\,ns\,(\,sample\ interval\,)/50\,ns\,(\,shaping\ constant\,)$$

D_o clock jitter correction

$$D = D_0 \cdot \left(1 + 1.75\left|T_{cj}/25\,ns\right|\right)$$

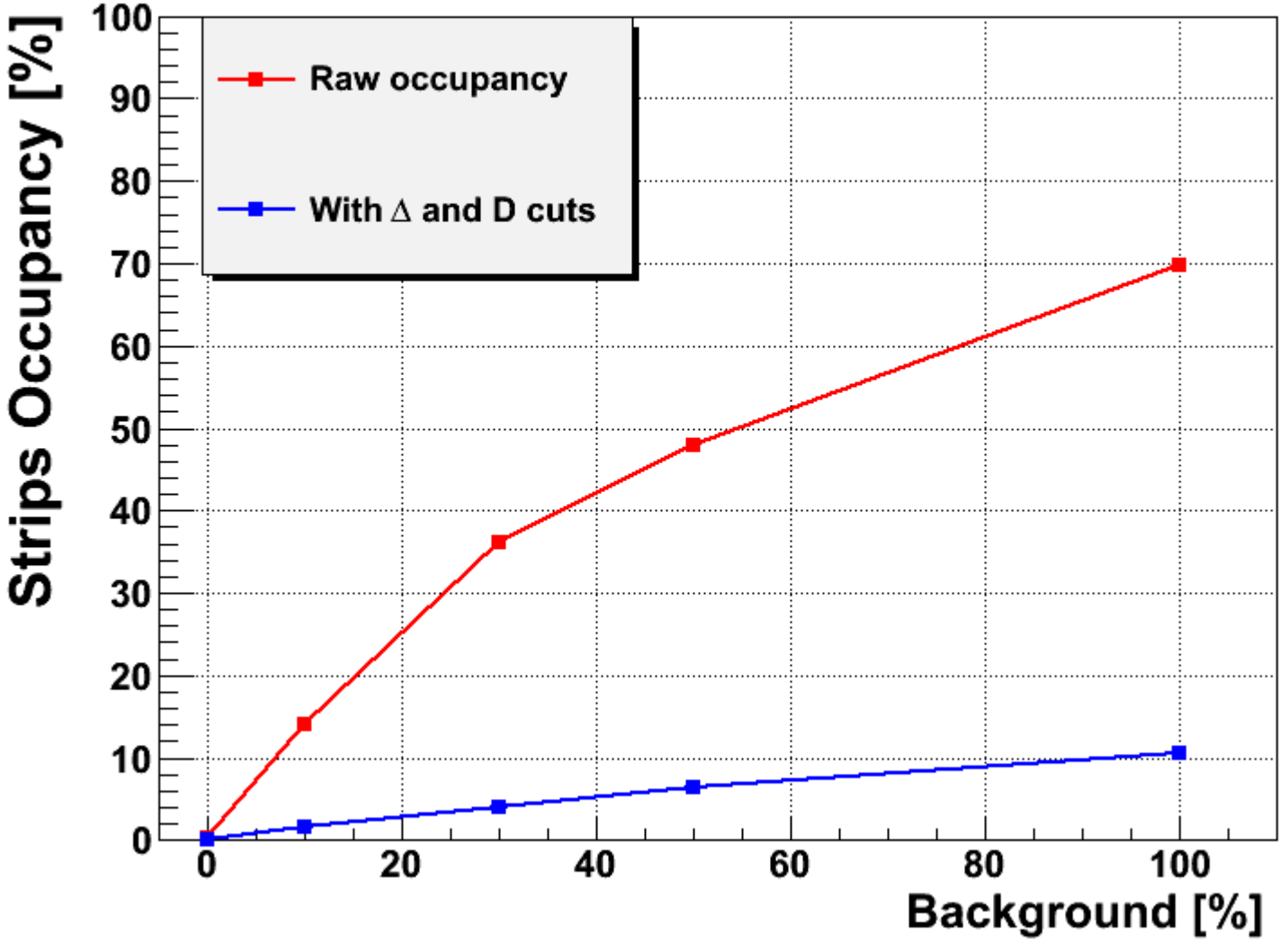
Pulse time slope

$$\Delta = \begin{cases} S_{+1} - S_0, if\ T_{cj} > 0 \\ S_0 - S_{-1}, if\ T_{cj} < 0 \end{cases}$$

For background rejection D > 35 and Δ > 15.

Strip Occupancy

Raw occupancy – all signals above threshold are used.
Δ – pulse slope cut, requires positive slope.
D – after cut on de-convoluted signal amplitude.



Track Search Region and Tracking Parameters

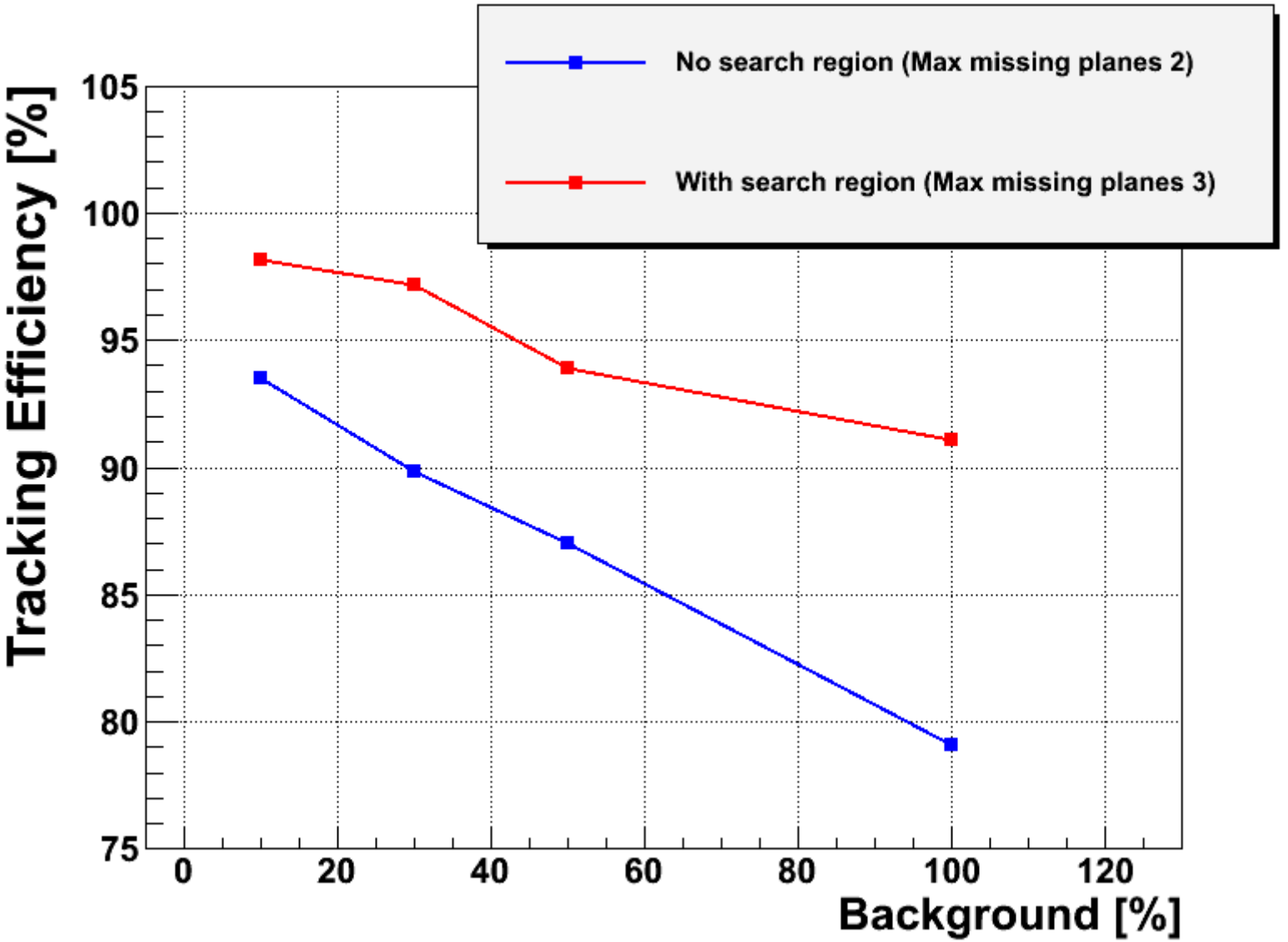
BigCal hit constrains proton search region to 18 x 0.25 cm^2 ($x \cdot y$) and 30 x 2 $mrad^2$ ($\theta \cdot \varphi$).

- **Maximum cluster size is 3 strips, any cluster that has more than 3 strips is considered as an overlap of two hits and amplitude is split when minimum is found.**
- **Only 3 planes out of 6 are allowed to have no hits.**
- **Amplitude correlation in x and y strips allows to have maximum of 4 mismatch out of 6.**
- **Search depth is 11 and corresponds to ~200 μm bin size.**

Tracking Efficiency

Kinematic window: $\Delta X < 10$ mm & $\Delta Y < 1$ mm

$|\Delta\Theta| < 2.4$ mrad & $|\Delta\Phi| < 1.0$ mrad



Tracking Efficiency

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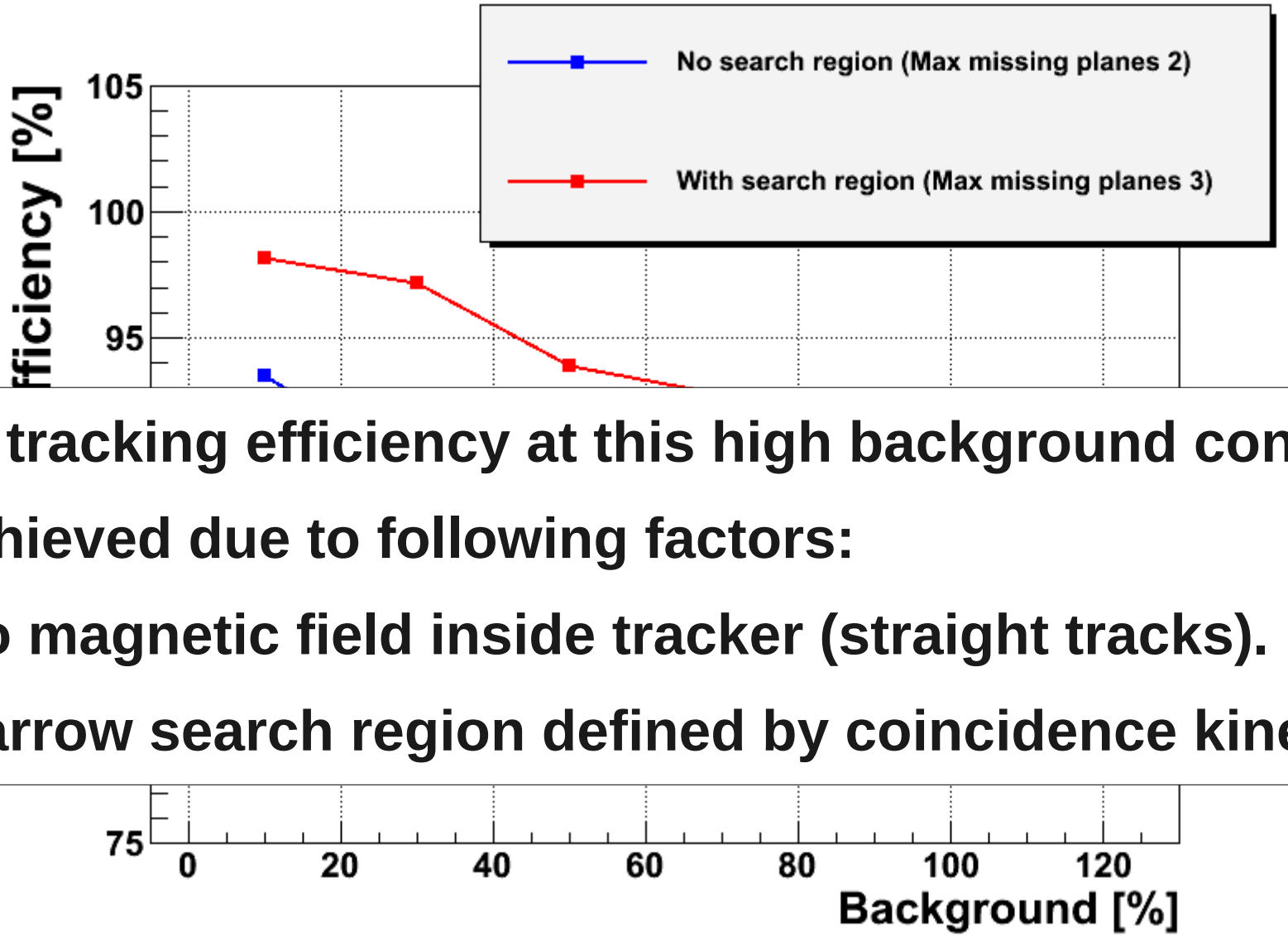
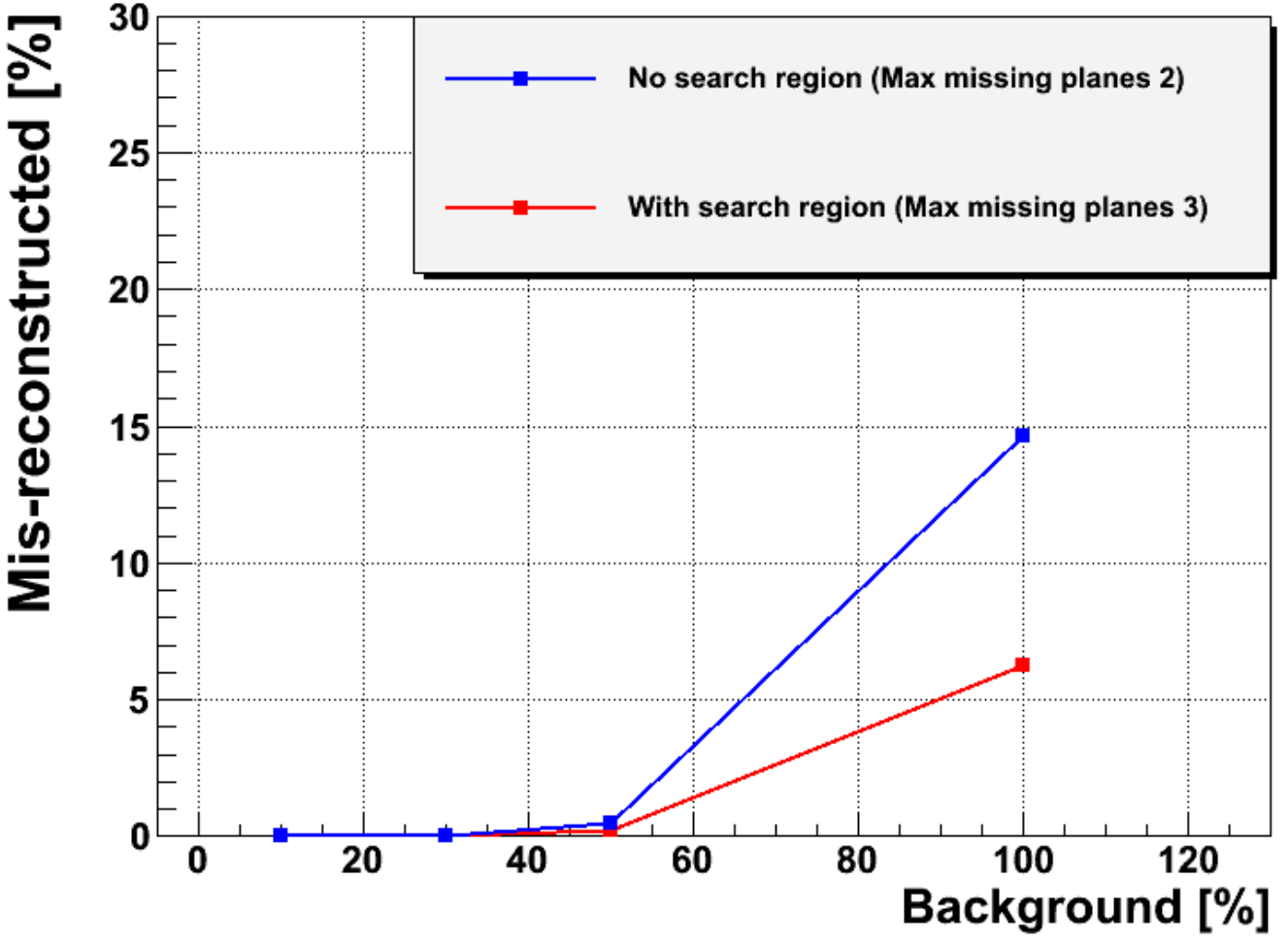


High tracking efficiency at this high background conditions is achieved due to following factors:

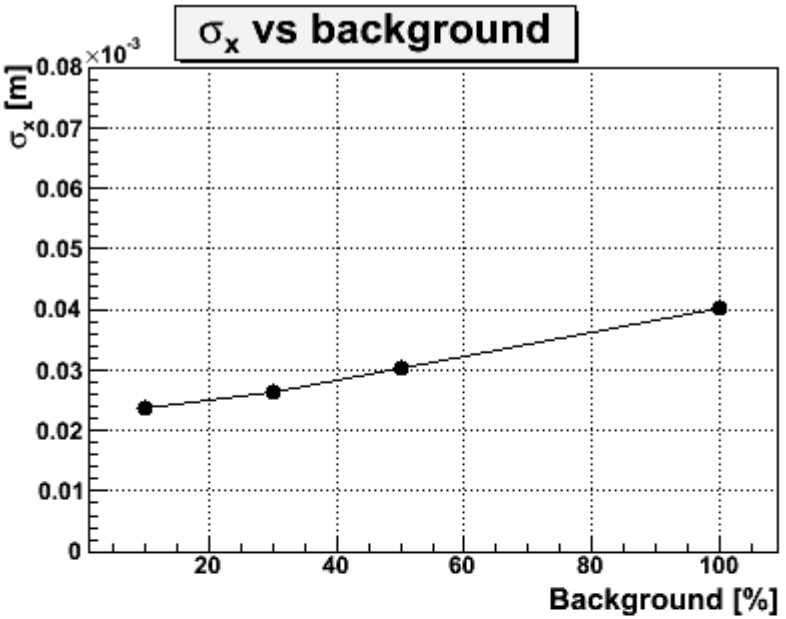
- **No magnetic field inside tracker (straight tracks).**
- **Narrow search region defined by coincidence kinematics.**

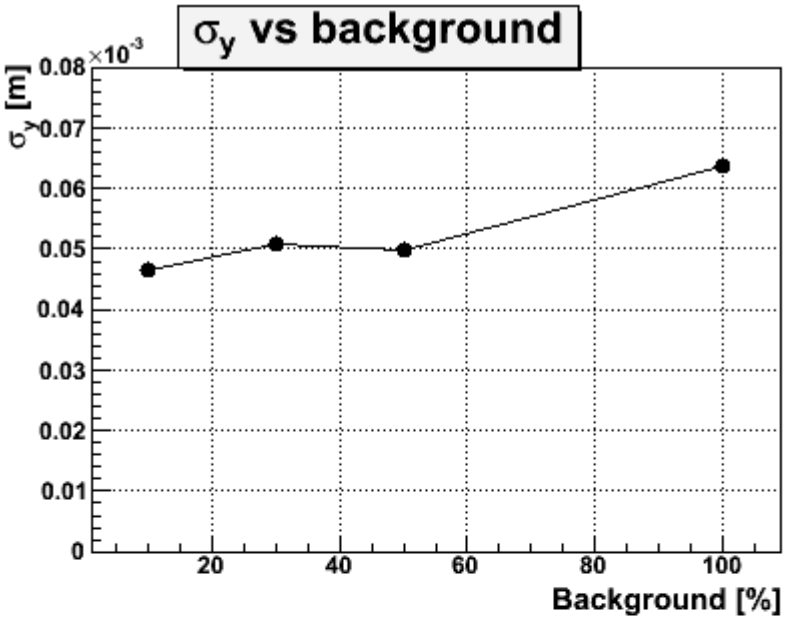
Miss-reconstructed Tracks

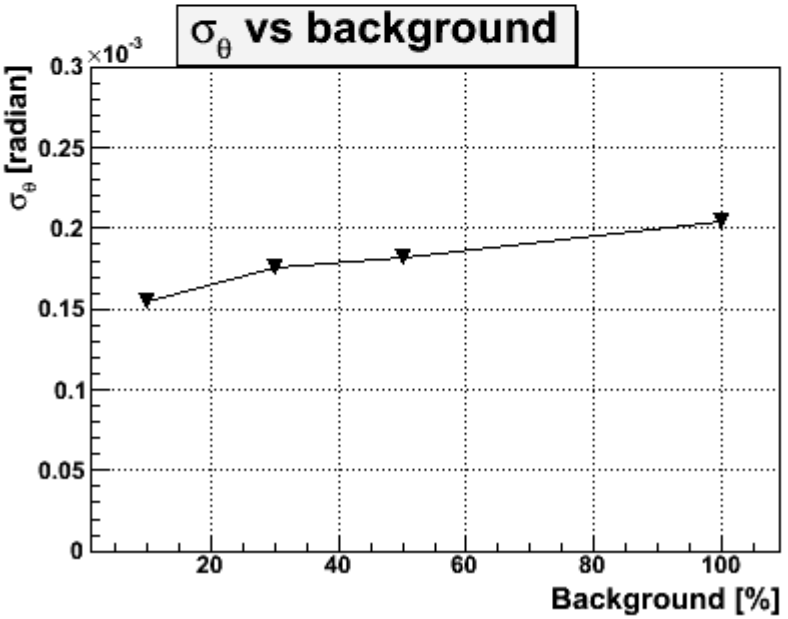
With no search region maximum number of missing planes is reduced to decrease percentage of miss-reconstructed tracks. Miss-reconstructed tracks happen when there is more than one track in the kinematic window.

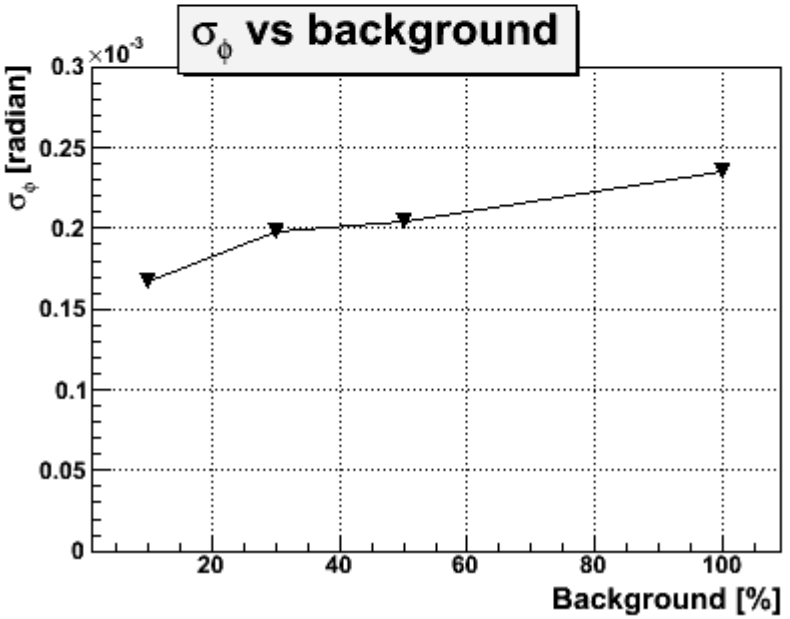


Track Reconstruction Resolution









Summary

- Event display program allows to understand possible problems in cluster finding, pileup removal and filtering.
- Using filtering allows to reduce strip occupancy and increase tracking efficiency and decrees analysis time.
- Restricting track search domain to a region defined by coincidence particle (Gep(5) experiment) improves tracking efficiency and reduces number of miss-reconstructed tracks.
- Tracking efficiency is ~90% at full background and miss-reconstructed tracks in the kinematic window is about 5%.
- Tracks are reconstructed with good position and angular accuracy.