Strange Particles Reconstruction by the Missing Mass Method

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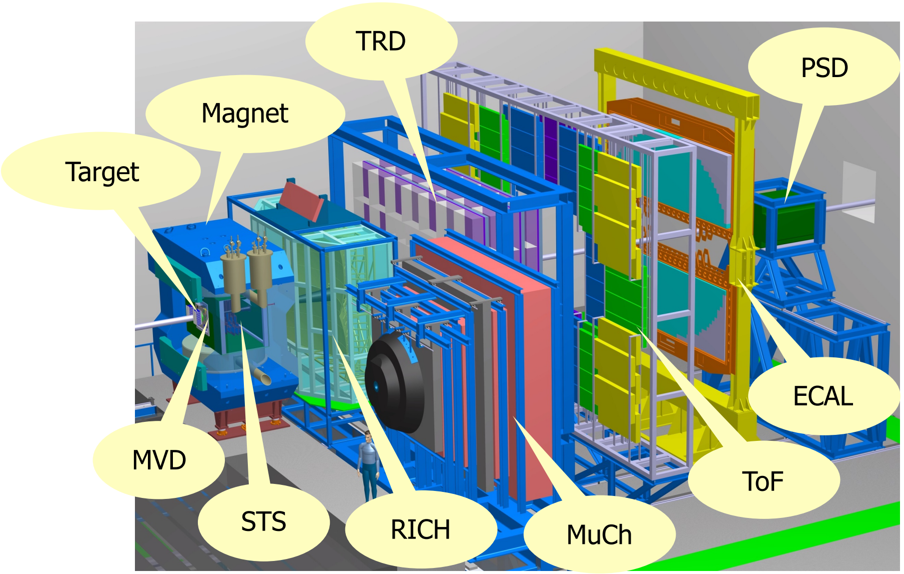
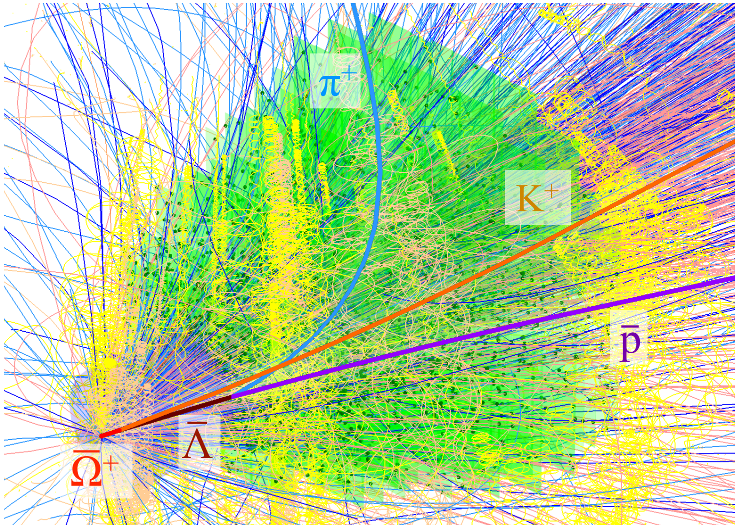


- CBM — future fixed-target heavy-ion experiment at FAIR, Darmstadt, Germany.
- 10^5-10^7 collisions per second.
- Up to 1000 charged particles/collision.
- Free streaming data.
- No hardware triggers.
- On-line time-based event reconstruction and selection is required in the first trigger level.

- On-line reconstruction at the on-line farm with 60000 CPU equivalent cores.
- High speed and efficiency of the reconstruction algorithms are required.
- The algorithms have to be highly parallelised and scalable.
- CBM event reconstruction: Kalman Filter and Cellular Automaton.



Missing Mass Method

Σ^+ and Σ^- physics:

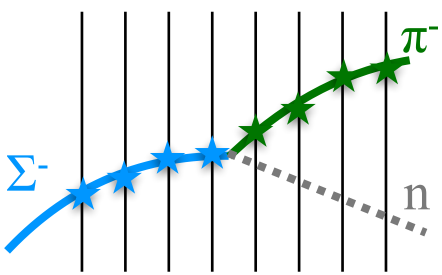
- completes the picture of strangeness production: abundant particles, carry out large fraction of strange quarks.

Main decay modes:

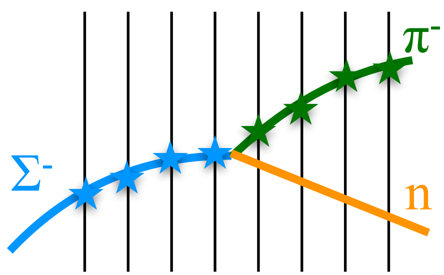
$\Sigma^+ \rightarrow p\pi^0$	$\overline{\Sigma}^+ \rightarrow \overline{p}\pi^0$	BR = 51.6%
$\Sigma^+ \rightarrow n\pi^+$	$\overline{\Sigma}^+ \rightarrow \overline{n}\pi^-$	BR = 48.3%
$\Sigma^- \rightarrow n\pi^-$	$\overline{\Sigma}^- \rightarrow \overline{n}\pi^-$	BR = 99.8%

- Σ^+ and Σ^- have only channels with at least one neutral daughter.
- A lifetime is sufficient to be registered by the tracking system: $c\tau$ = 2.4 cm for Σ^+ and $c\tau$ = 4.4 cm for Σ^-.
- Can not to be identified by the PID detectors.
- Identification is possible by the decay topology:

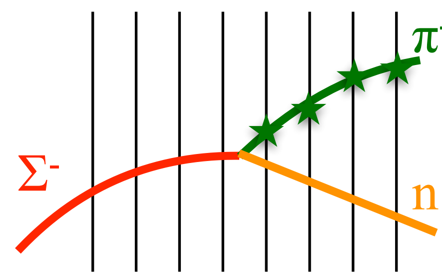
Find tracks of Σ and its charged daughter in STS and MVD



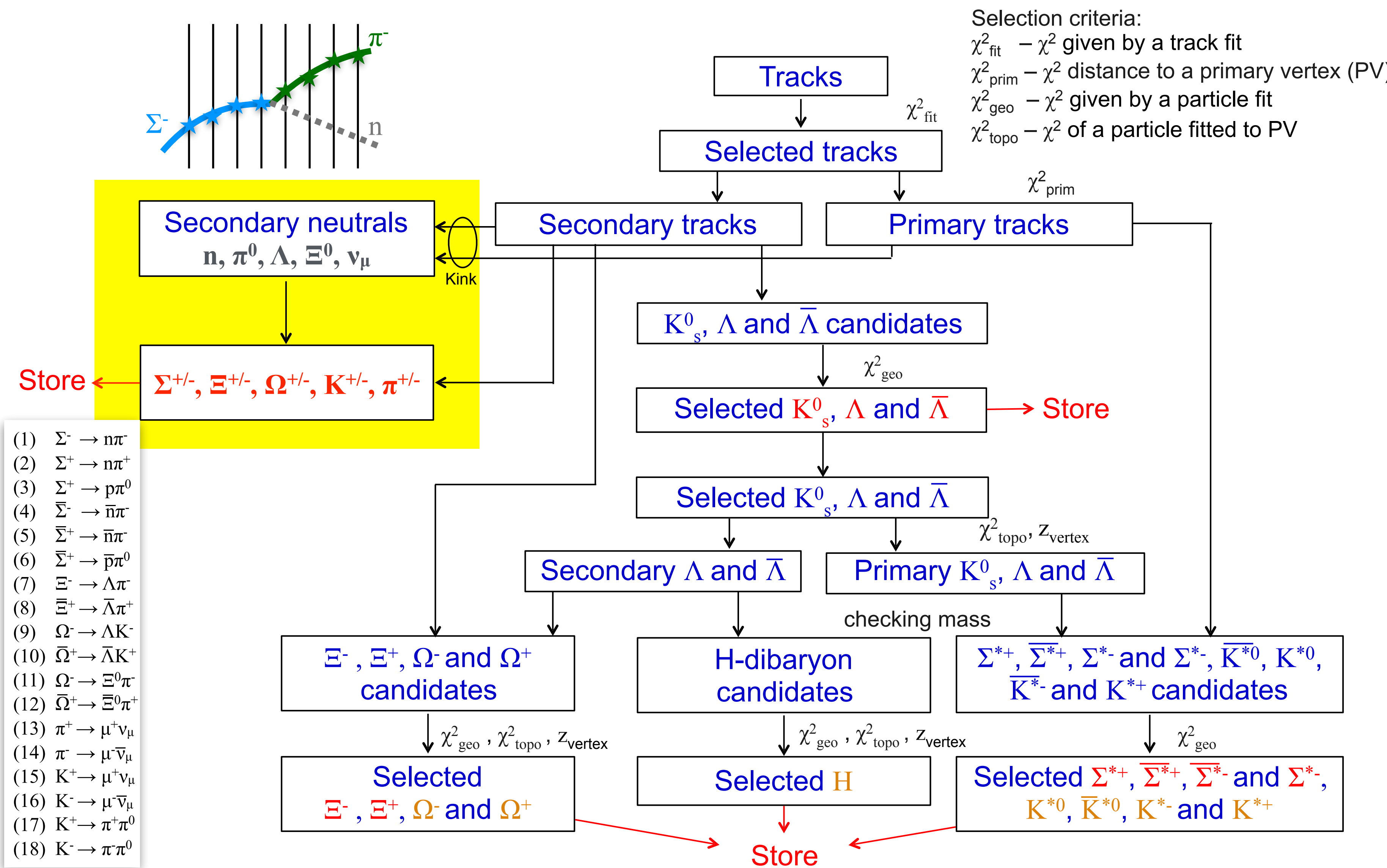
Reconstruct a neutral daughter from the mother and the charged daughter



Reconstruct Σ mass spectrum from the charged and obtained neutral daughters



KF Particle Finder Algorithm

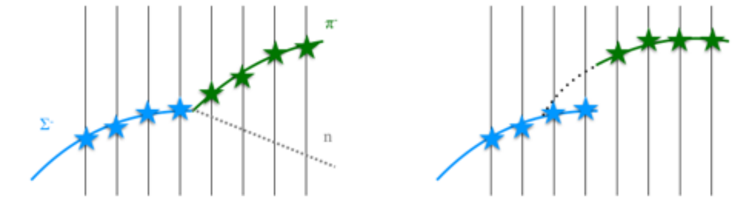


Primary and secondary reconstructed tracks

no PDG | PDG from TOF

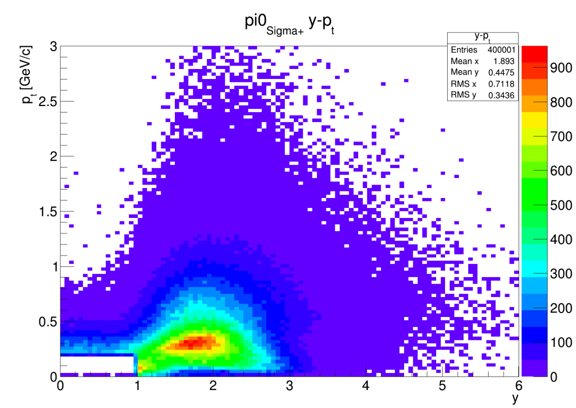
NeutralDaughterDecay(…);

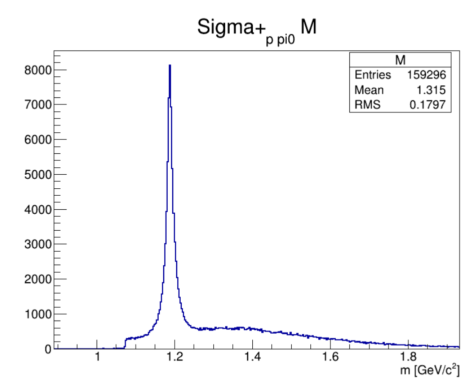
- $Z_{\text{daughter's first hit}} > Z_{\text{mother's last hit}}$
- $E_{\text{mother}} > E_{\text{daughter}}$
  - Subtract charged daughter
- Z_{decay} is between tracks
- Fit quality of neutral
- Momenta and rapidity cuts on clones for a neutral candidate
  - Set mass constraint for neutral
  - Construct mother
- Z_{decay} is between tracks
- Fit quality of constructed mother
- Is particle from vertex?
  - Collect histograms



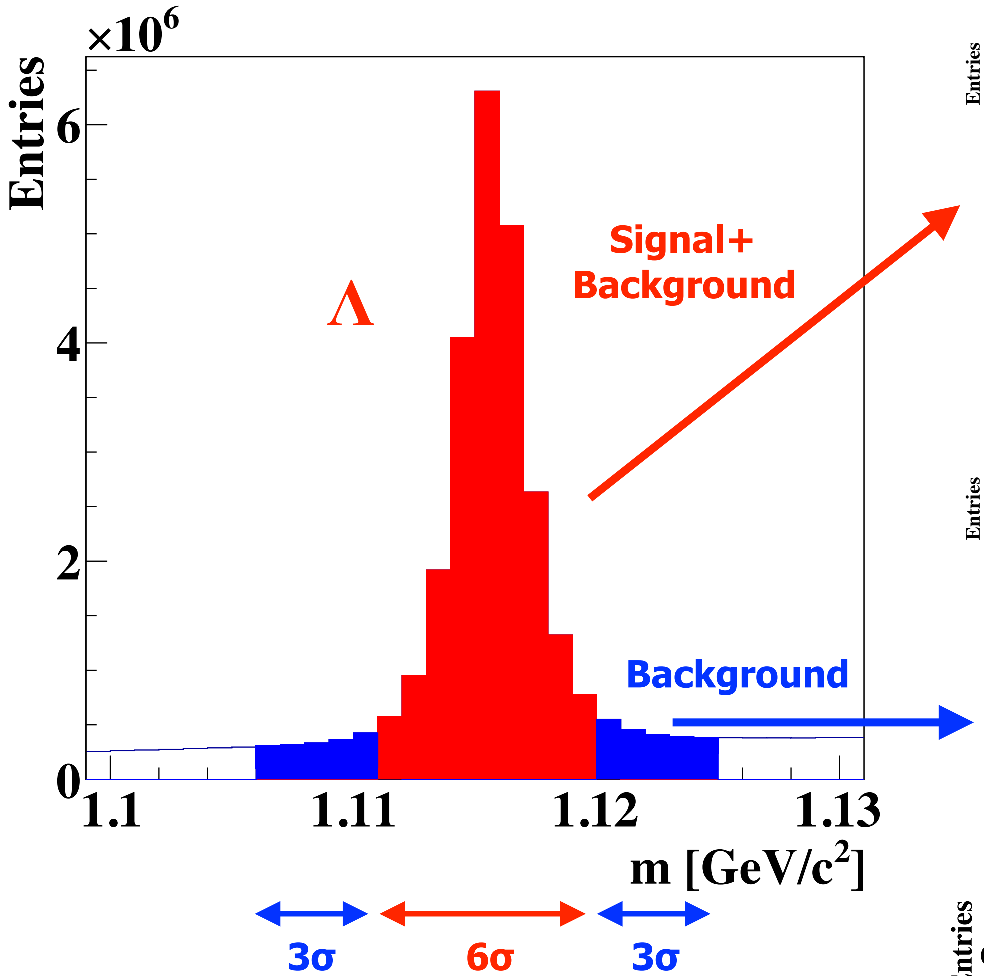
a) real decay, intersection is between tracks

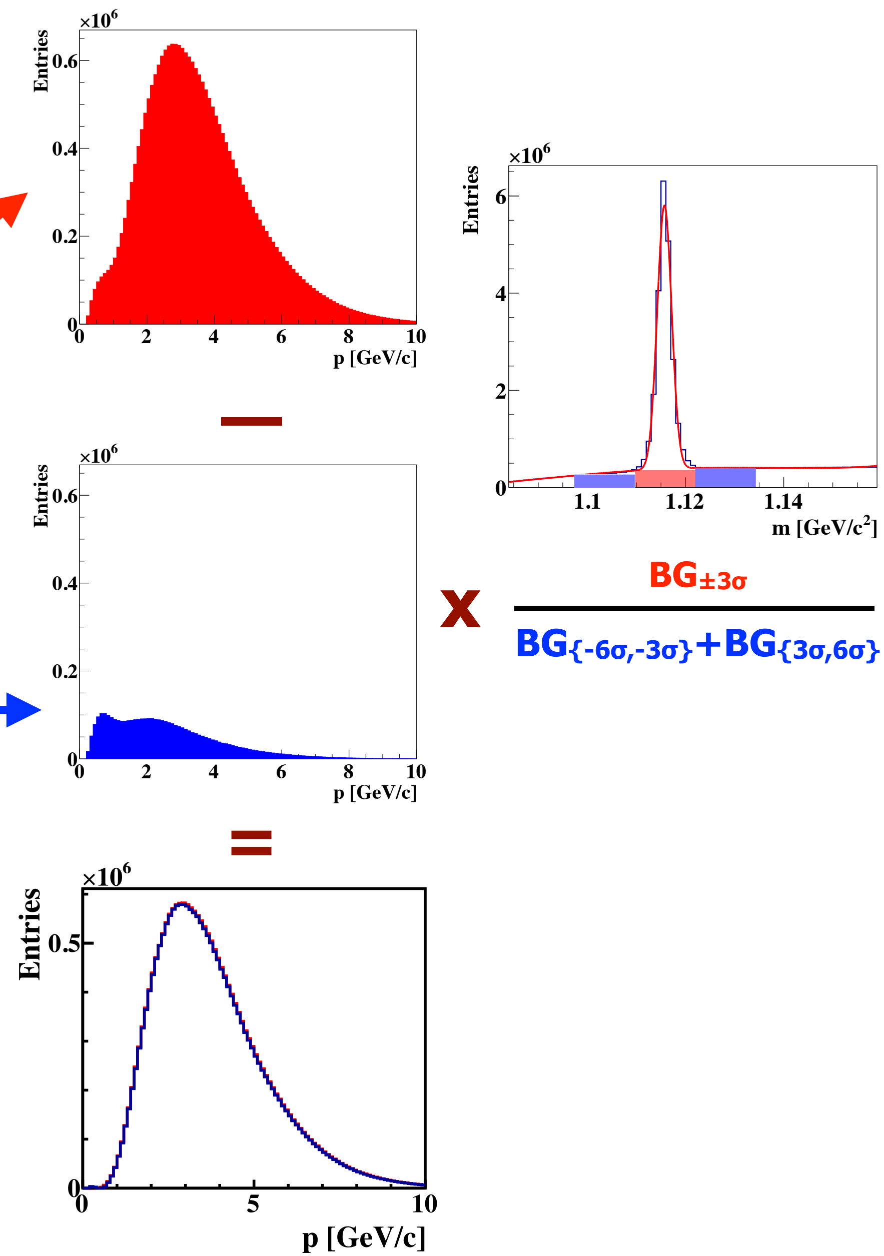
b) tracks are not from same decay



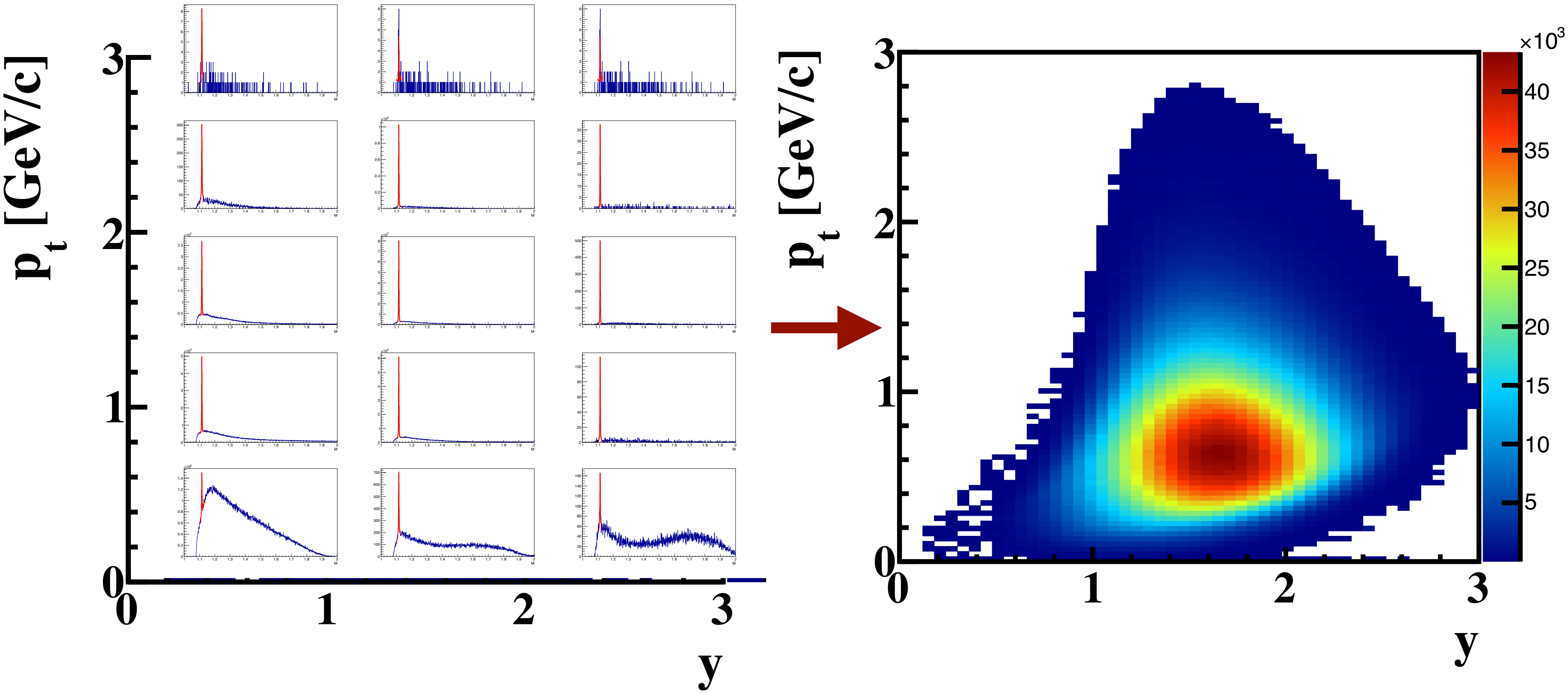


Extraction of the Signal: Side Bands Method



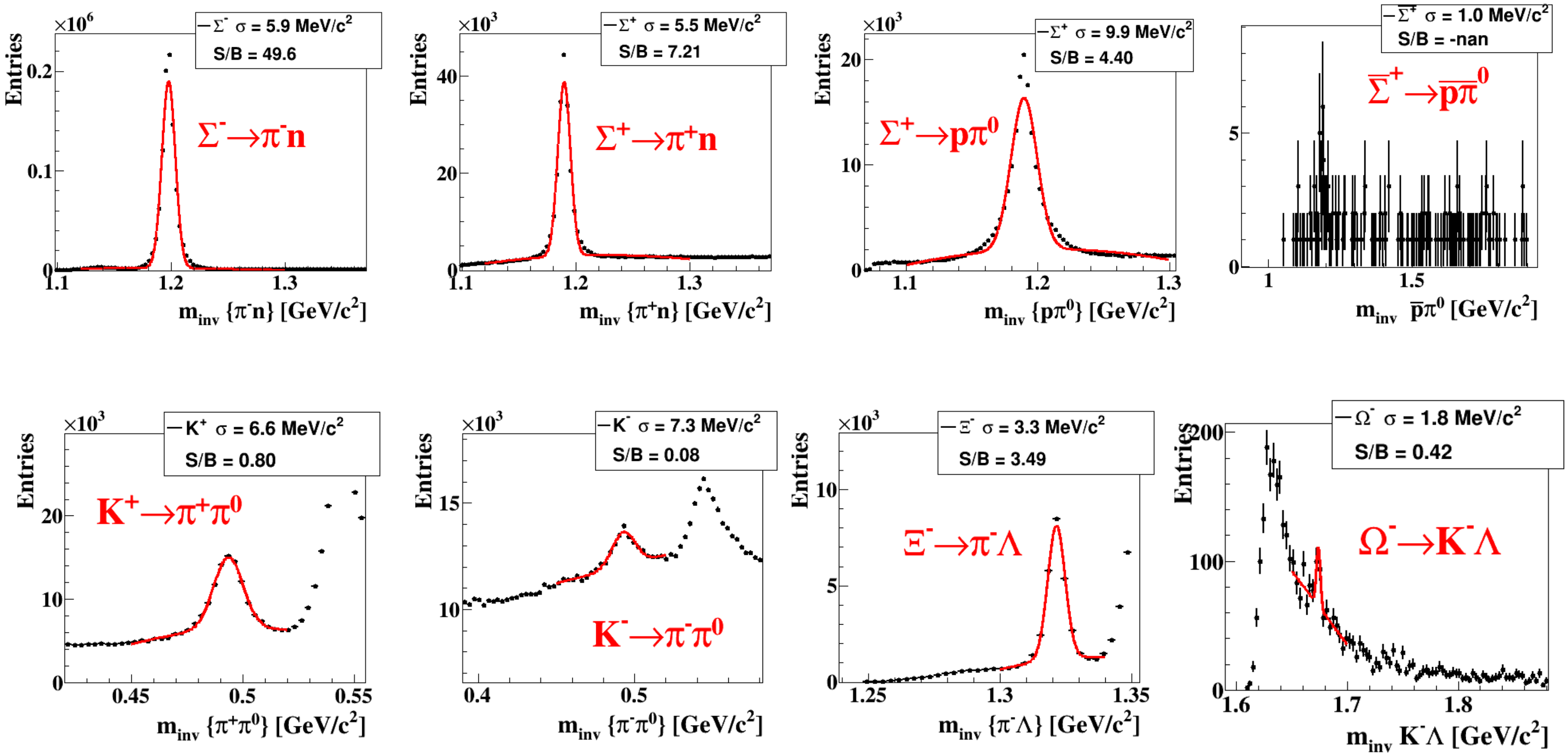


- Collect spectra (M, p, p_t, y, Z…) for the signal+BG (particles within the mass peak) and BG (particles near the peak).
- Calculate the correction factor using the fitted BG.
- Subtract the corrected BG.



- Is illustrated at the example of Λ hyperon.
- Collect mass spectra in different y-p_t bins.
- Fit the spectra with a signal+background function — calculate an integral of the signal function.
- Fill bins of the y-p_t histogram with the integral values — obtain the y-p_t distribution for the signal particles.
- Integral y and p_t distributions are obtained by projecting the multi-differential distribution to the corresponding axes.

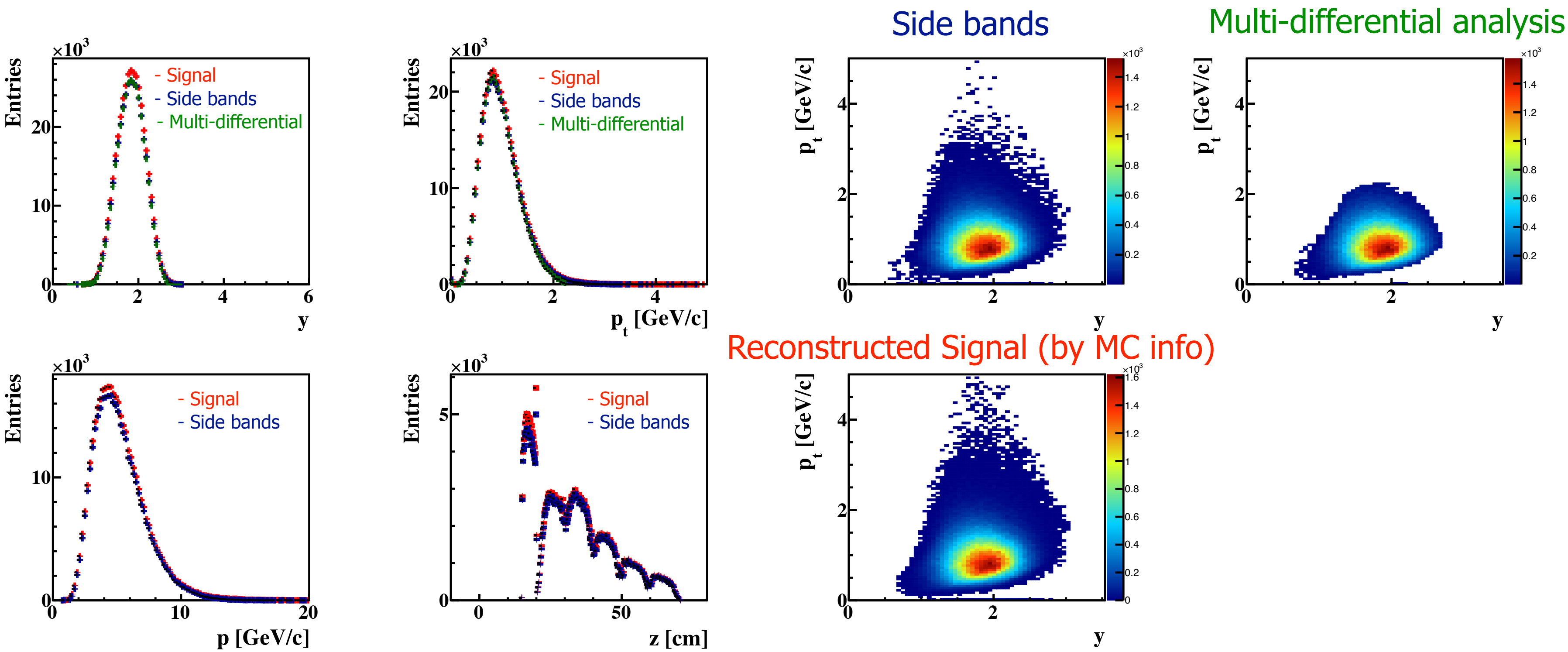
The goal is to have a clean sample of short-lived particles for further physics analysis



5M Au+Au central events, 10 AGeV, TOF PID

Σ^{-} n π^{-} signal reconstruction

1.8M Au+Au central events, 10 AGeV, TOF PID



- The signal distribution are nicely described by the extracted signal.
- Both methods show similar results.
- Due to the limited statistics in the outer regions multi-differential analysis can not be applied there, the integral distributions are describing the central region.

$\Sigma^+{}_{n\,\pi^+}$ signal reconstruction

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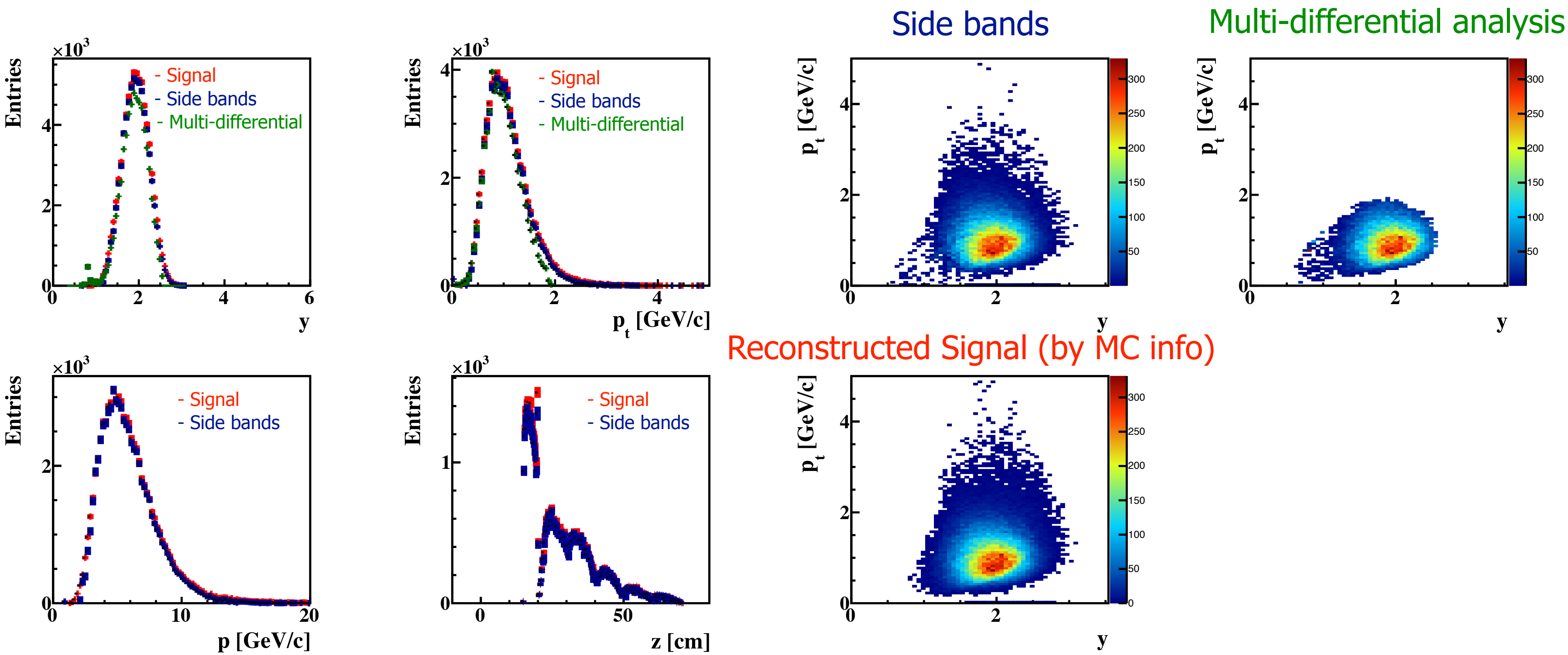

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$\Sigma^{+}_{p\,\pi^0}$ signal reconstruction

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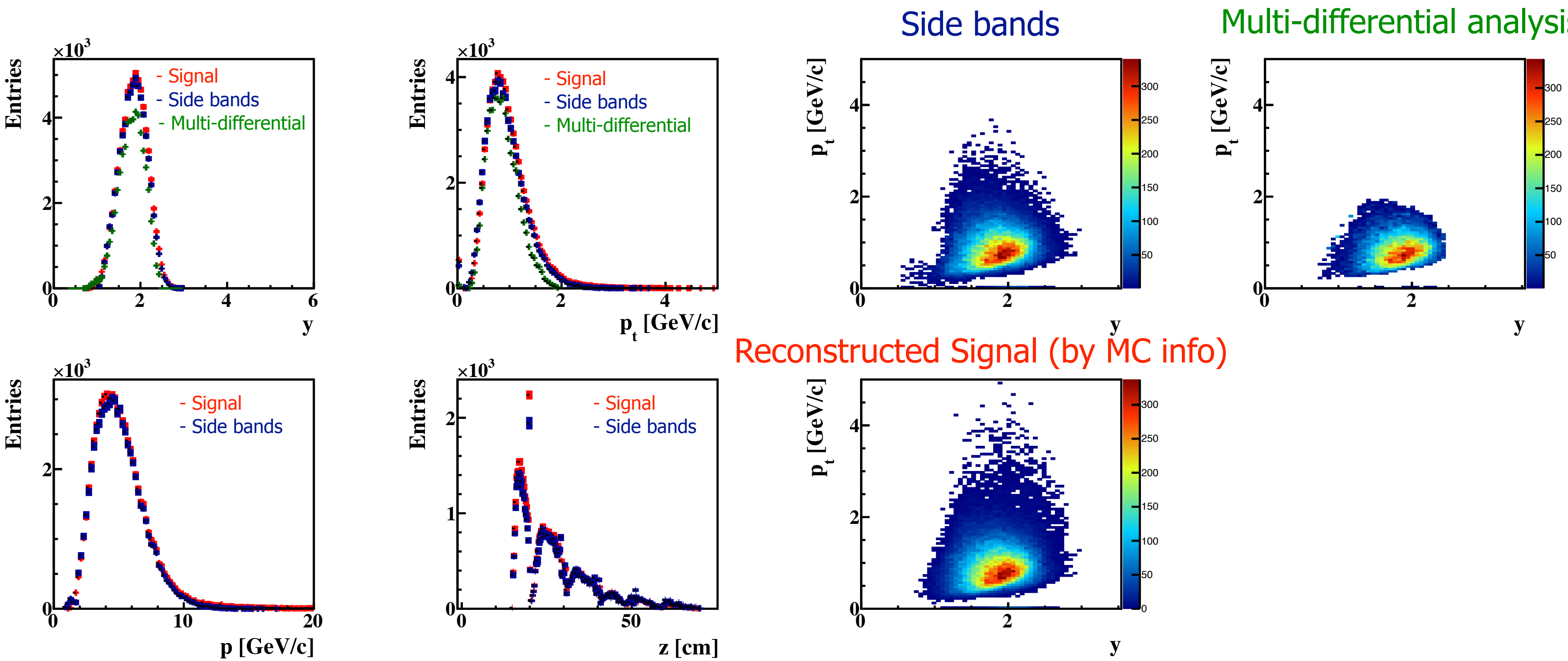

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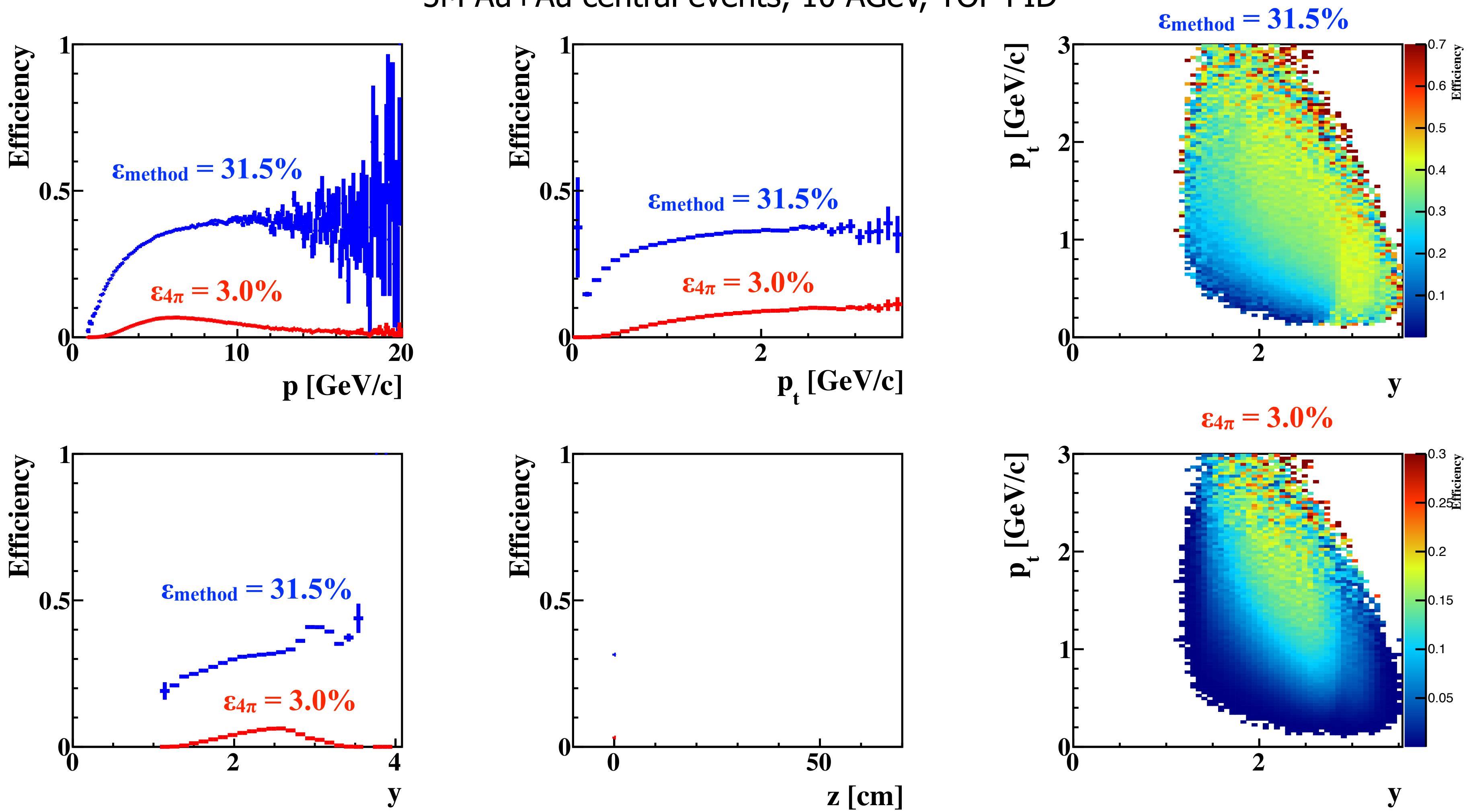
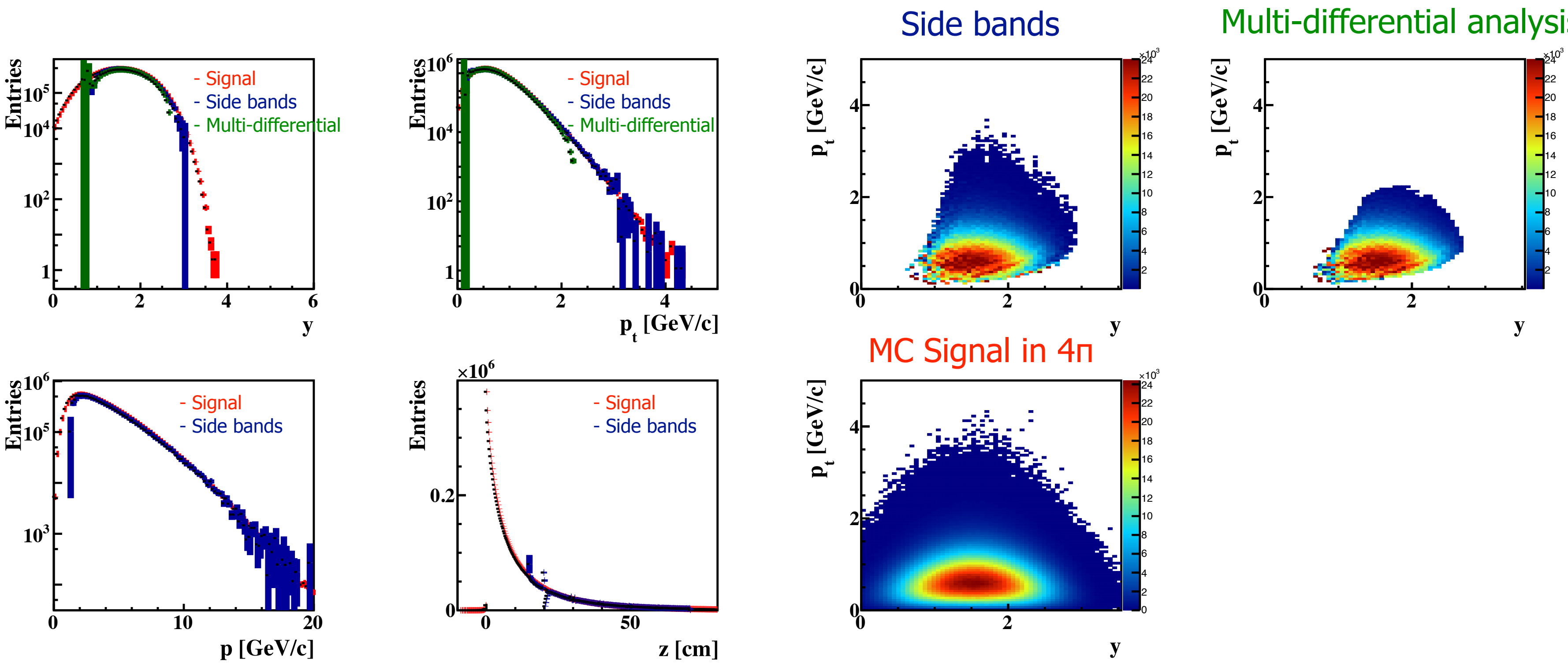


- 2D y-p_t plots for reconstruction efficiency have been added.

Efficiency Corrected Spectra for $\Sigma^{-}_{n\,\pi^{-}}$ in 4π

1.8M Au+Au central events, 10 AGeV, TOF PID



- Reconstructed spectra in 4π have few artefacts and requires further analysis

Summary and Plans

- ✓ The missing mass method for reconstruction of Σ and other particles has been further developed.
- ✓ With TOF PID the missing mass method reconstructs particles with high efficiency and S/B ratios.
- ✓ The side bands and multi-differential methods have been implemented.
- ✓ Results from both methods are in a good agreement with the simulated signal.
- ✓ Efficiency corrected spectra in 4π range are now available.

- Investigate a drop of efficiency at the station positions.
- Implement search for double reconstructed Ξ and Ω by the direct search and the missing mass method.
- Port the algorithms to the STAR High-Level Trigger for future BES-II.
- Apply the algorithms to STAR real data (with the Heavy Flavour Tracker).