Multi-differential analysis of Σ hyperons in the CBM experiment

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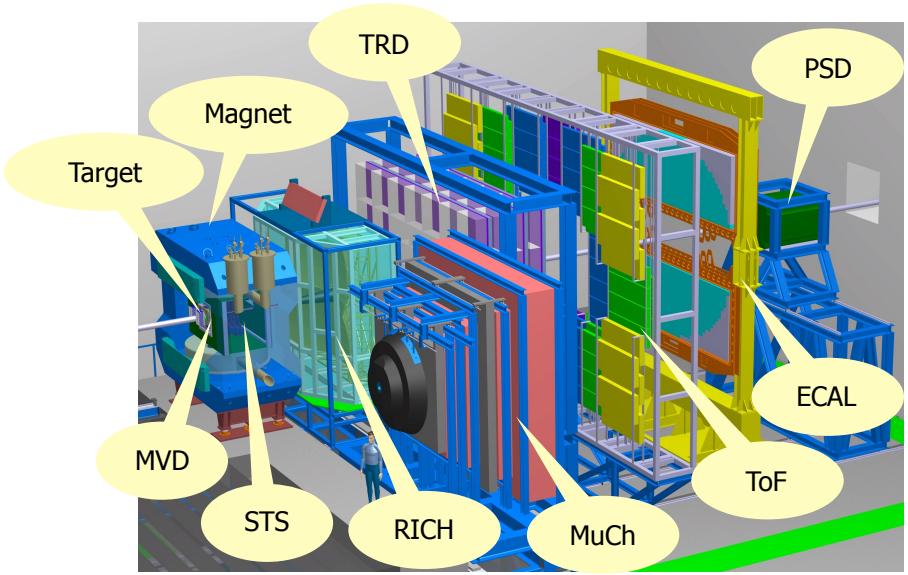
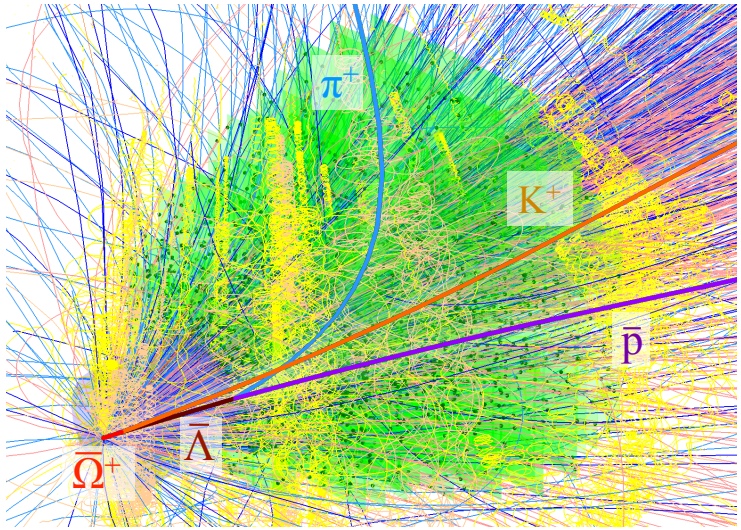
CBM Experiment



- 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 for Σ reconstruction

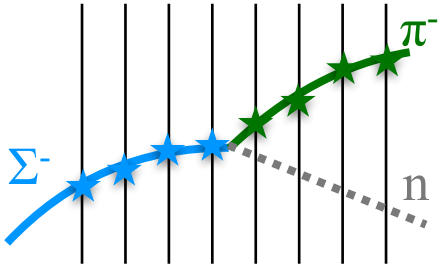
Σ^+ and Σ^- physics: completes the picture of strangeness production: abundant particles, carry out large fraction of strange quarks.

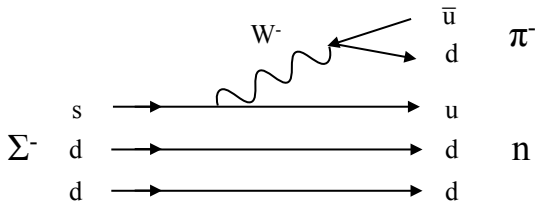
- Σ^+ and Σ^- have only channels with at least one neutral daughter.

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

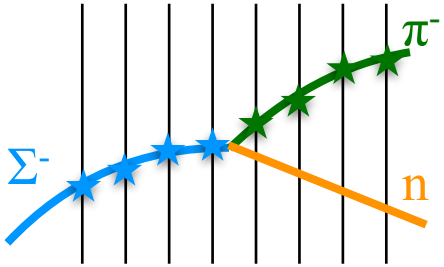
- Lifetime is sufficient to be registered by the tracking system: $c\tau$ = 2.4 cm for Σ^+ and $c\tau$ = 4.4 cm for Σ^-.
- Can not to be identified by the PID detectors.
- Identification is possible by the decay topology:

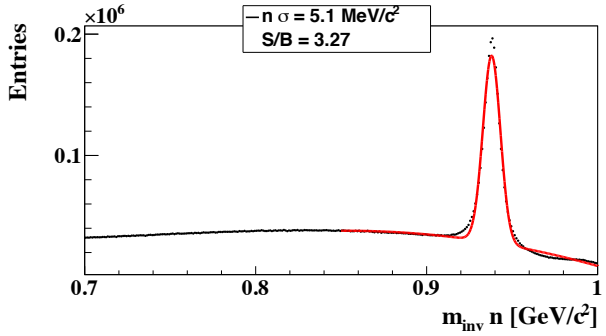
Find tracks of Σ and its daughter in STS and MVD



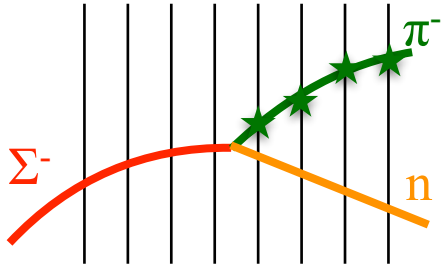


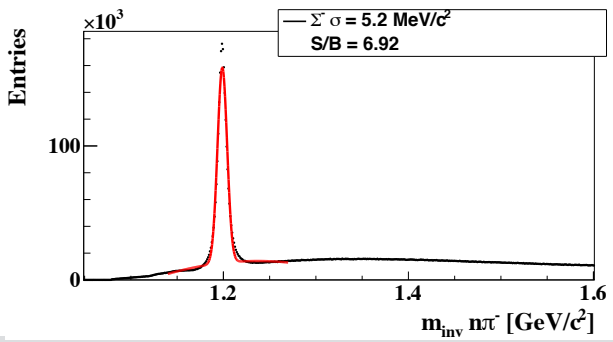
Reconstruct a neutral daughter from the mother and the charged daughter





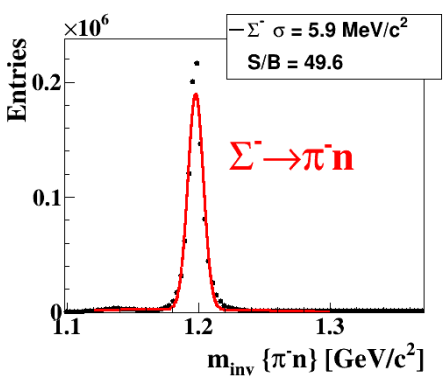
Reconstruct Σ mass spectrum from the charged and obtained neutral daughters

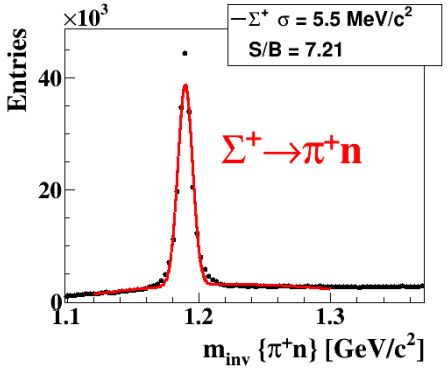


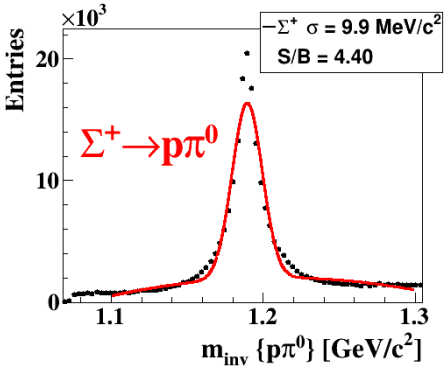


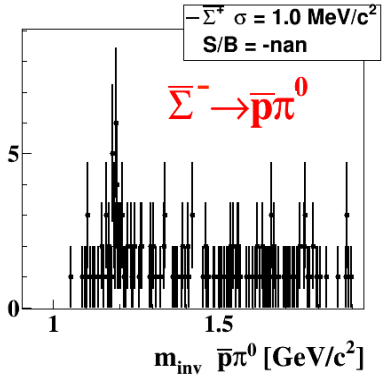
Mass spectra of reconstructed particles

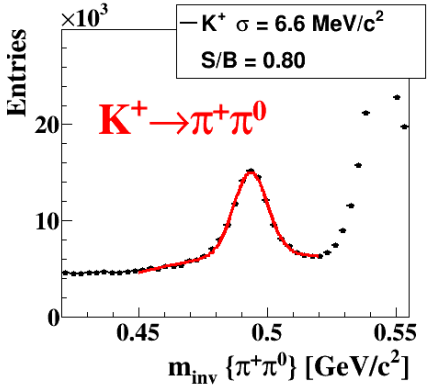
The goal is to have a clean sample of short-lived particles for further physics analysis

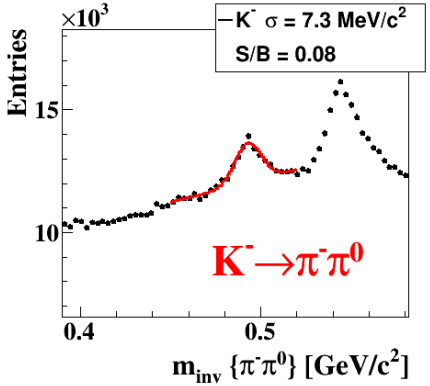


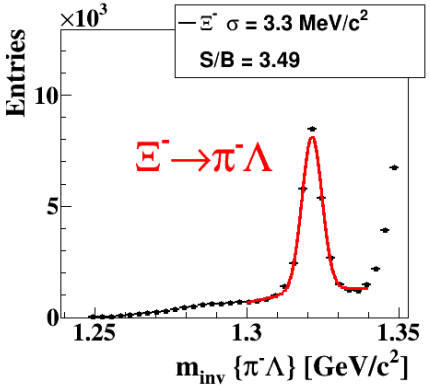


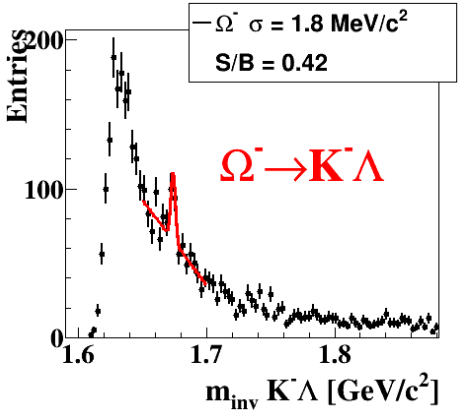






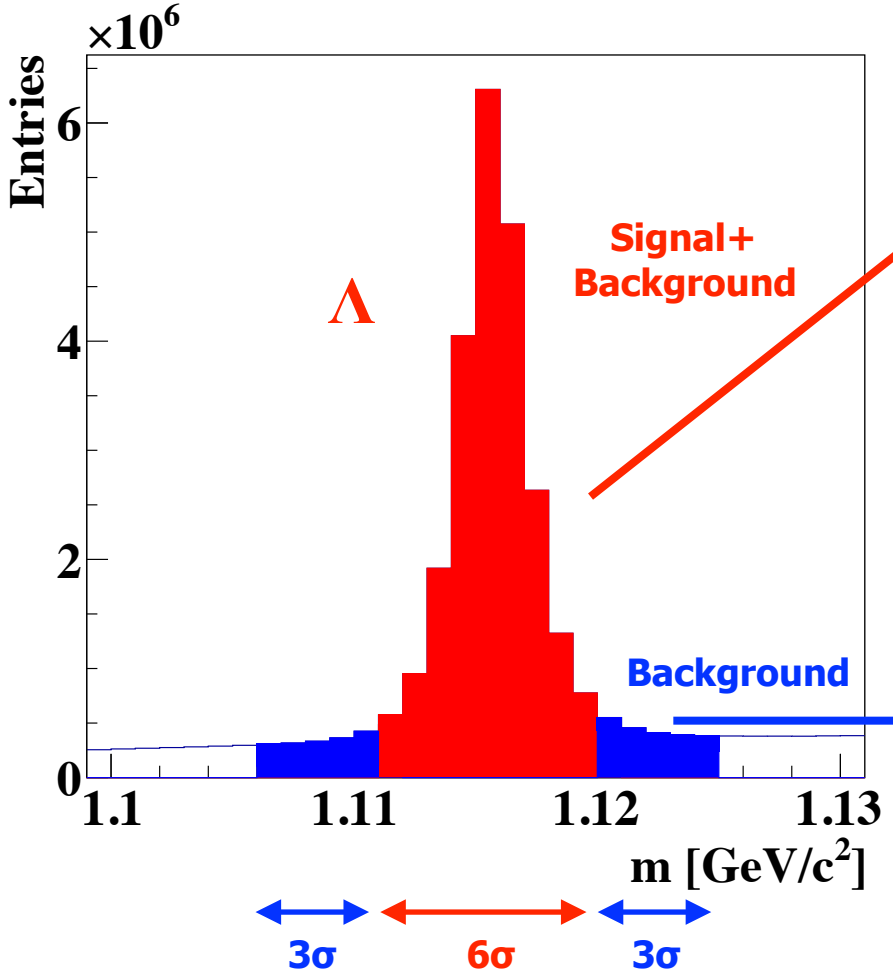


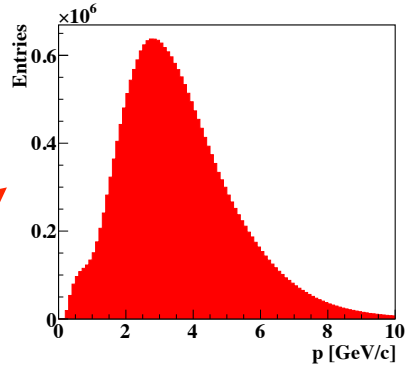




5M Au+Au central events, 10 AGeV, TOF PID

Extraction of the signal: Side bands method





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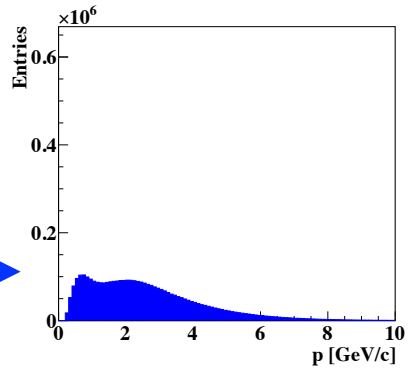

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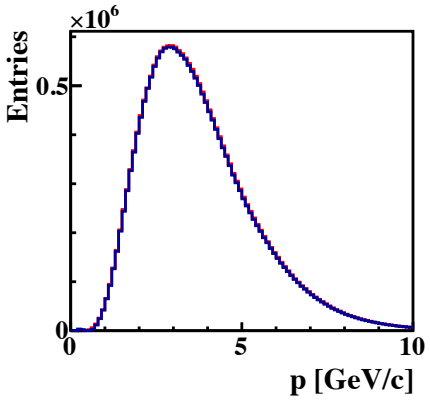
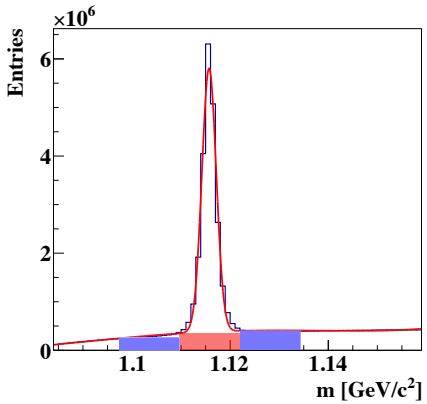


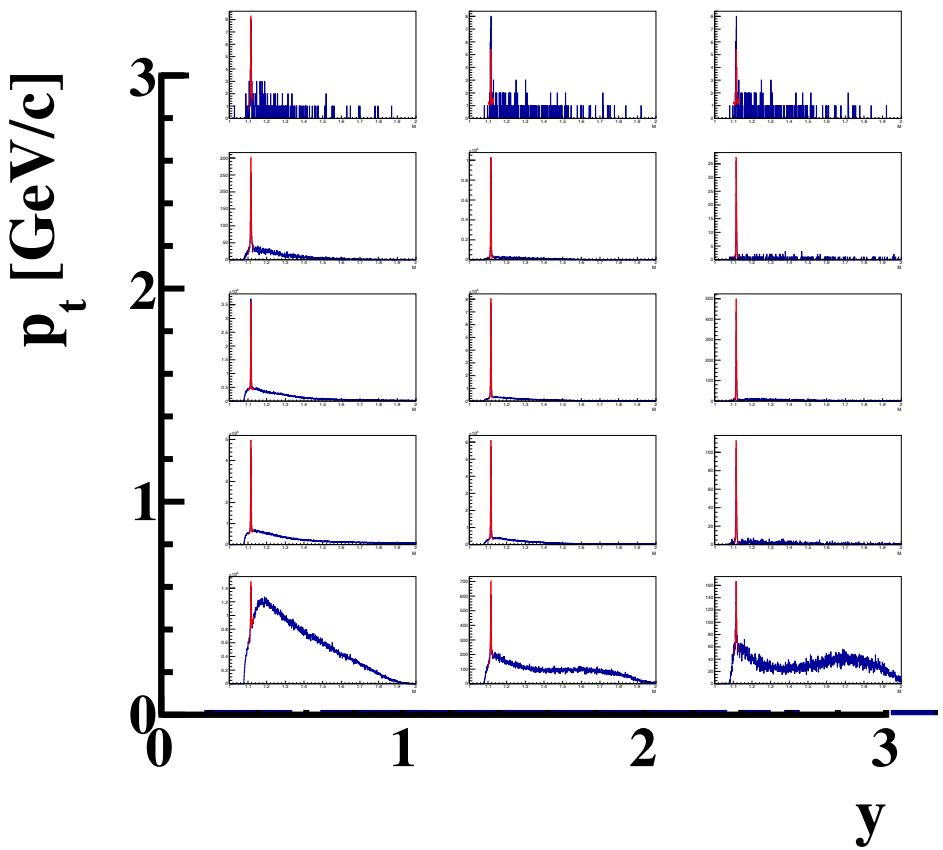


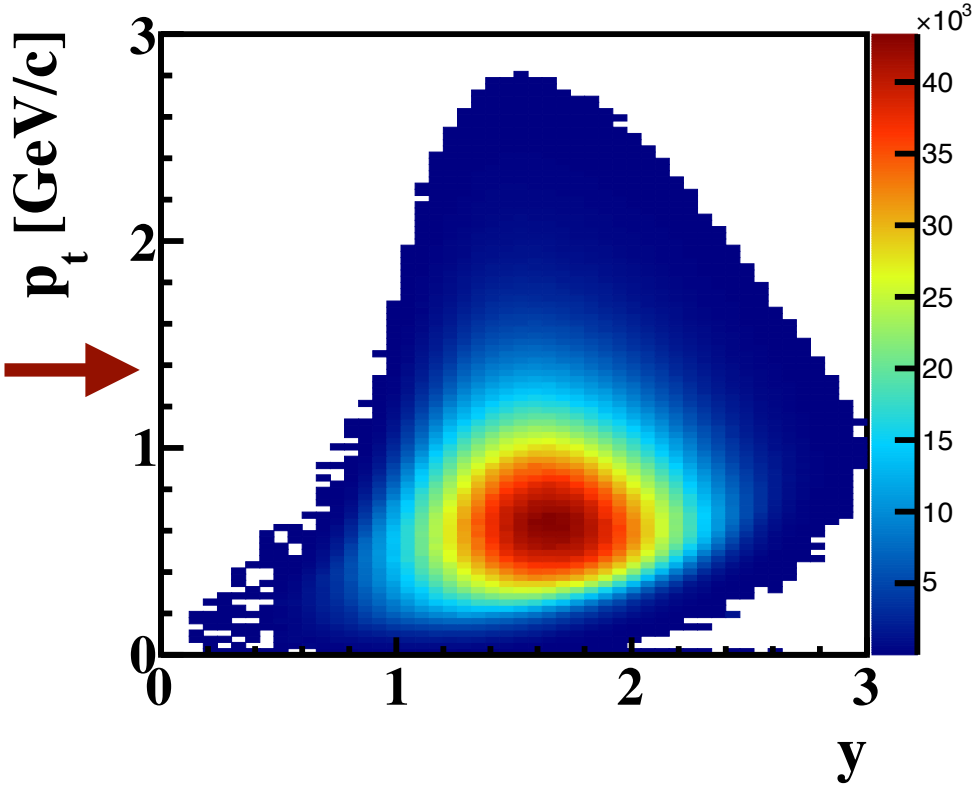
$$\times \frac{BG_{\pm 3\sigma}}{BG_{\{-6\sigma,-3\sigma\}} + BG_{\{3\sigma,6\sigma\}}}$$

- 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.

M.Zyzak, Friday 15:15, HZO 60

Extraction of the signal: Polynomial background fit





- 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 axis.

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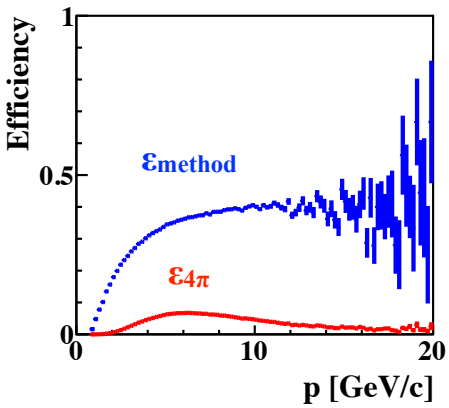
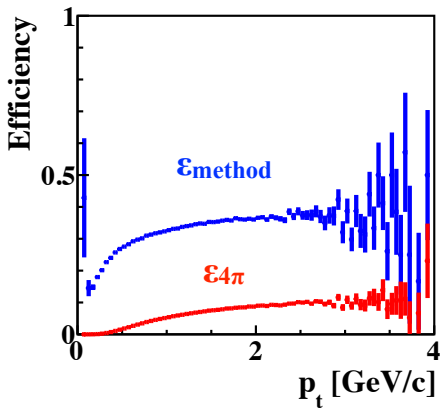
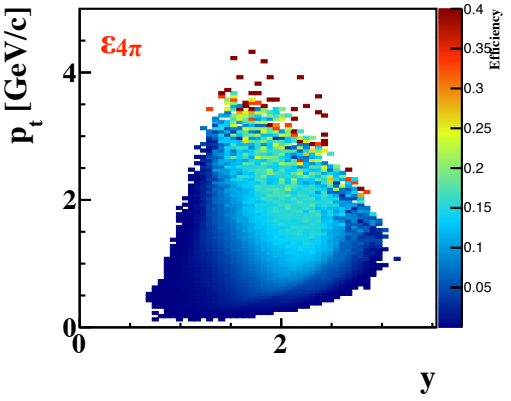
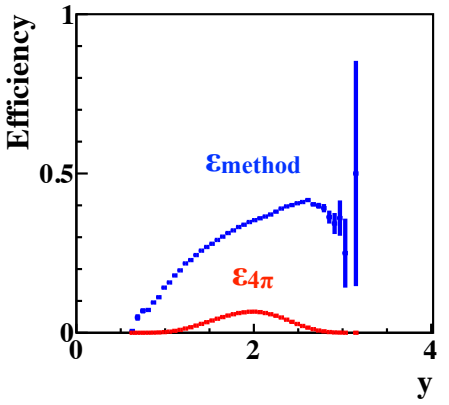
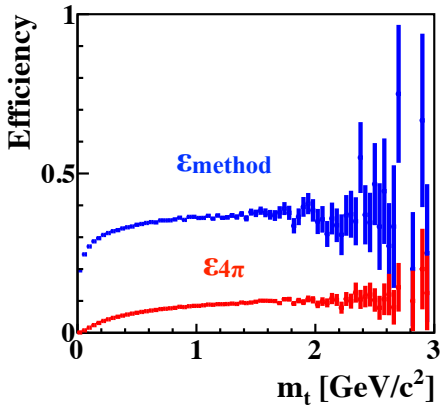
Reconstruction efficiency at the $\Sigma^- \to n\,\pi^-$ example

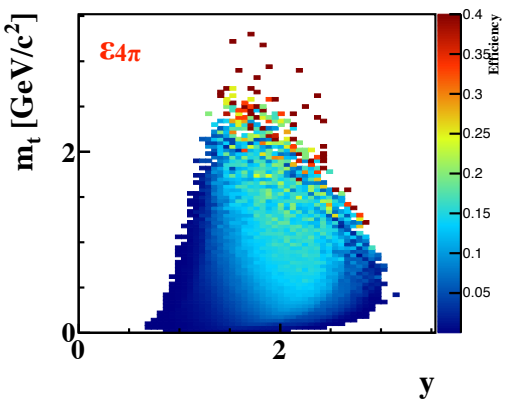








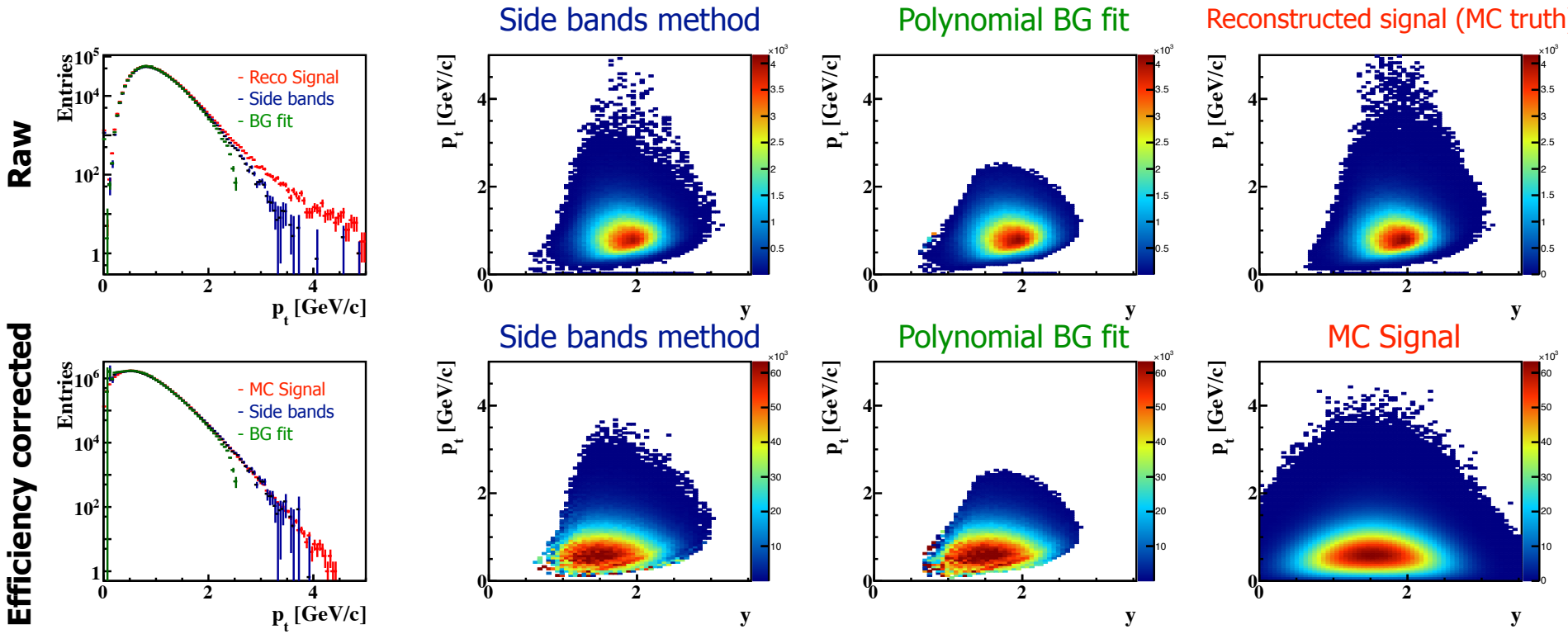




5M central AuAu UrQMD events at 10 AGeV

- A set of efficiency plots is collected for each particle decay.
- The efficiencies are shown at the example of $\Sigma^- \to n\,\pi^-$.
- Efficiencies are used for extraction of the signal spectra.

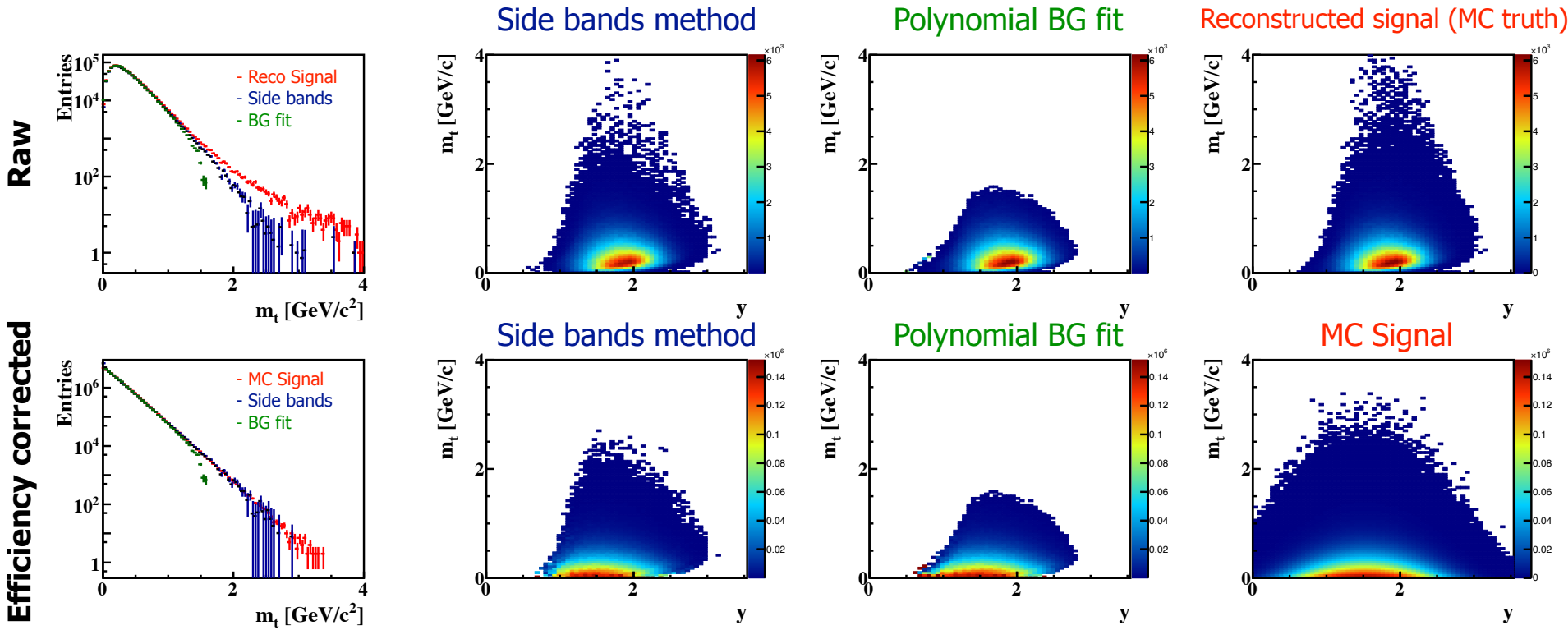
Efficiency corrected spectra in y-p_t bins, $\Sigma^-_{n\,\pi^-}$ example



5M central AuAu UrQMD events at 10 AGeV

- Results are shown at the example of $\Sigma^- \rightarrow n\,\pi^-$.
- Similarly to the 1D case, analysis was performed in y-p_t bins.
- Efficiency corrected spectra nicely reproduce MC signal distributions.

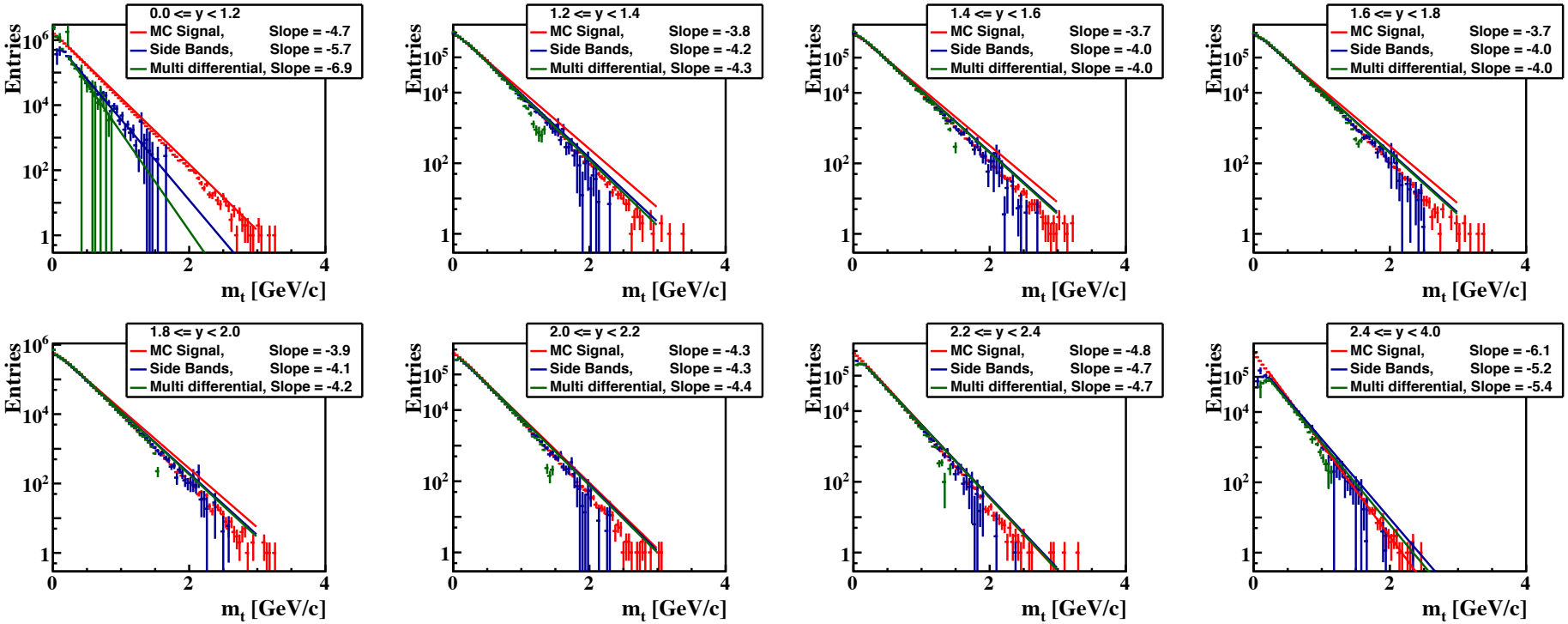
Efficiency corrected spectra in y-m_t bins, $\Sigma^- \to n\,\pi^-$ example



5M central AuAu UrQMD events at 10 AGeV

- Results are shown at the example of $\Sigma^- \to n\,\pi^-$.
- Similarly to the y-p_t, analysis was performed in y-m_t bins.
- m_t spectra provide a tool for extraction of the inverse slope and, as a result, effective temperature.
- Efficiency corrected spectra nicely reproduce MC Signal distributions.

Extraction of the slope from efficiency corrected spectra, Σ^-

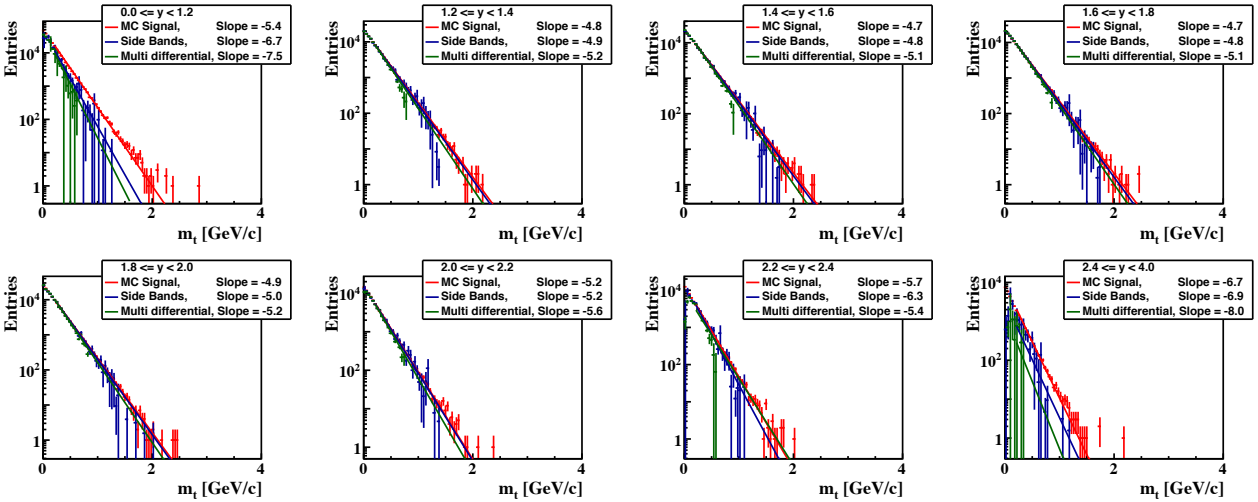


5M central AuAu UrQMD events at 10 AGeV

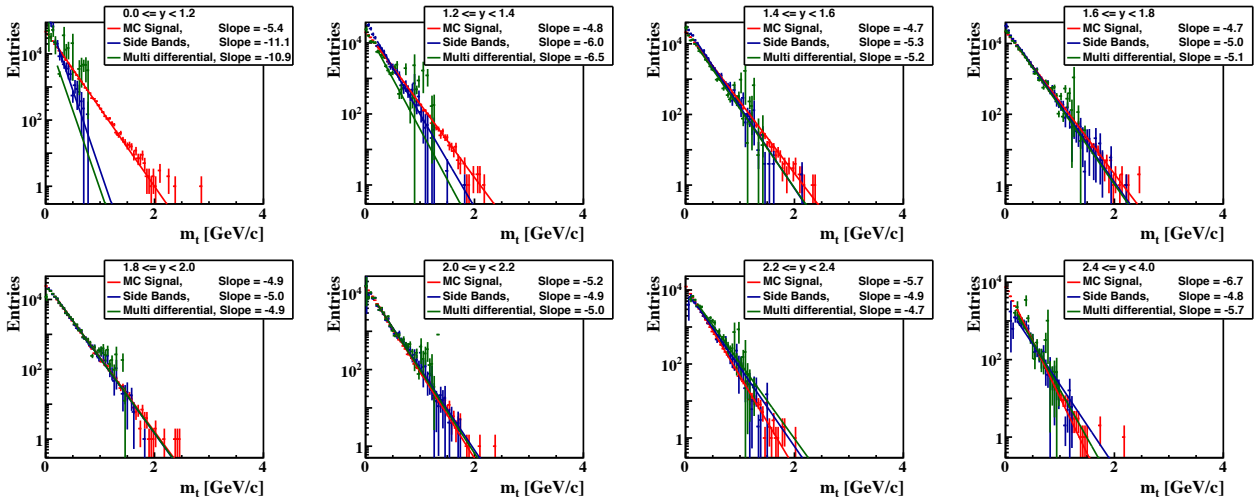
- The developed tools work nicely for particles reconstructed with the missing mass method.
- Results are shown at the example of $\Sigma^- \rightarrow n\,\pi^-$.

Reconstruction of Ξ^- efficiency corrected spectra

Conventional method



Missing mass method



5M central AuAu UrQMD events at 10 AGeV

- Results in the midrapidity regions with high statistics are comparable.
- Two independent methods provide a powerful tool for systematics study.

Summary and Plans

- ✓ The missing mass method for reconstruction of Σ has been further developed.
- ✓ The methods to obtain efficiency corrected spectra have been implemented.
- ✓ Resulting reconstructed distributions are in a good agreement with the simulated signal.
- ✓ The missing mass method provides tools for comprehensive study of the systematic errors.

- 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 within the FAIR Phase 0 program.