

# Strange particles reconstruction by the missing mass method

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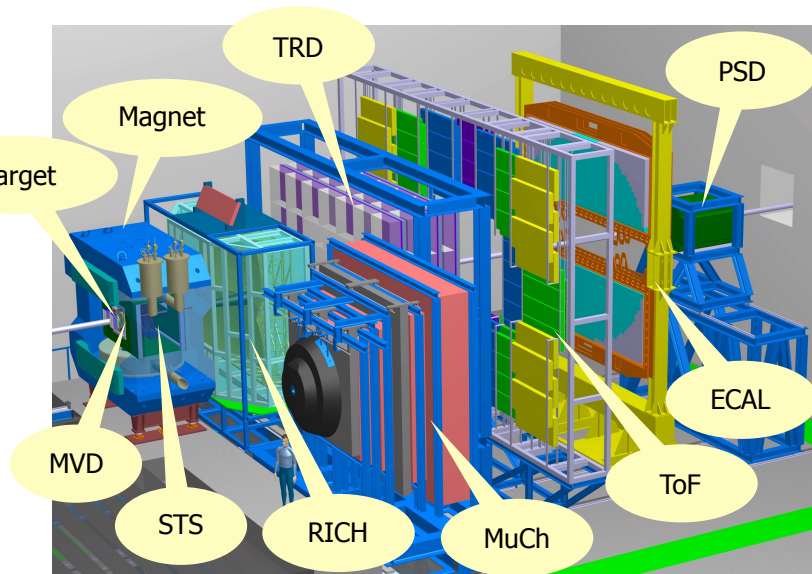
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3 – GSI Helmholtzzentrum für Schwerionenforschung GmbH, Darmstadt, Germany

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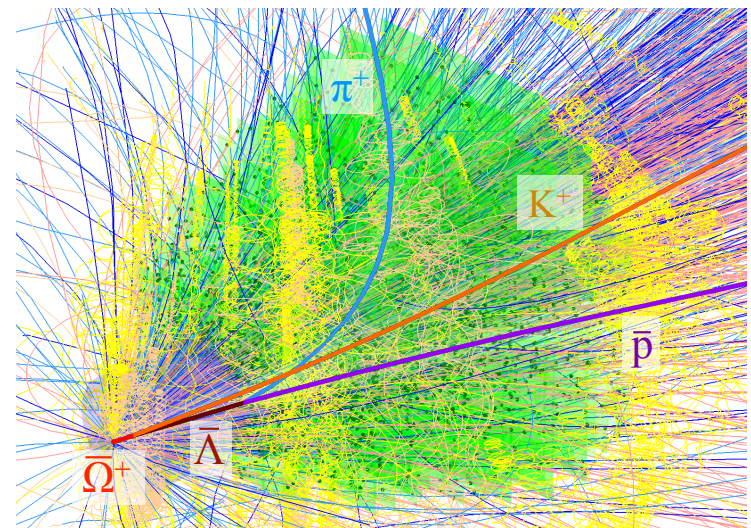
DPG-Frühjahrstagung, Münster  
31.03.2017

# 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

## $\Sigma^+$ and $\Sigma^-$ physics:

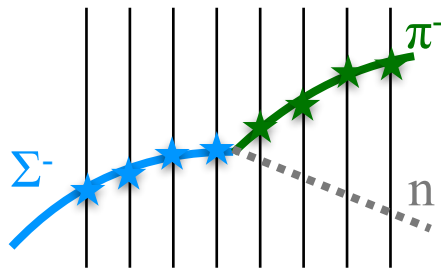
- completes the picture of strangeness production: abundant particles, carry out large fraction of strange quarks.

## Main decay modes:

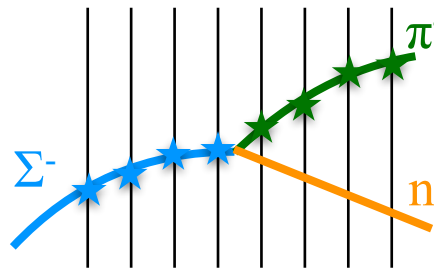
$\Sigma^+ \rightarrow p\pi^0$	$\bar{\Sigma}^+ \rightarrow \bar{p}\pi^0$	BR = 51.6%
$\Sigma^+ \rightarrow n\pi^+$	$\bar{\Sigma}^+ \rightarrow \bar{n}\pi^+$	BR = 48.3%
$\Sigma^- \rightarrow n\pi^-$	$\bar{\Sigma}^- \rightarrow \bar{n}\pi^-$	BR = 99.8%

- $\Sigma^+$  and  $\Sigma^-$  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  $\Sigma^+$  and  $c\tau = 4.4$  cm for  $\Sigma^-$ .
- Can not to be identified by the PID detectors.
- **Identification is possible by the decay topology:**

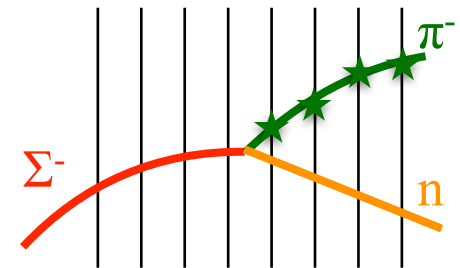
Find tracks of  $\Sigma$  and its charged daughter in STS and MVD



Reconstruct a neutral daughter from the mother and the charged daughter



Reconstruct  $\Sigma$  mass spectrum from the charged and obtained neutral daughters



# Reconstruction Procedure & Selection Cuts

- ▶  $Z$  daughter's first hit  $>$   $Z$  mother's last hit
- ▶  $E_{\text{mother}} > E_{\text{daughter}}$

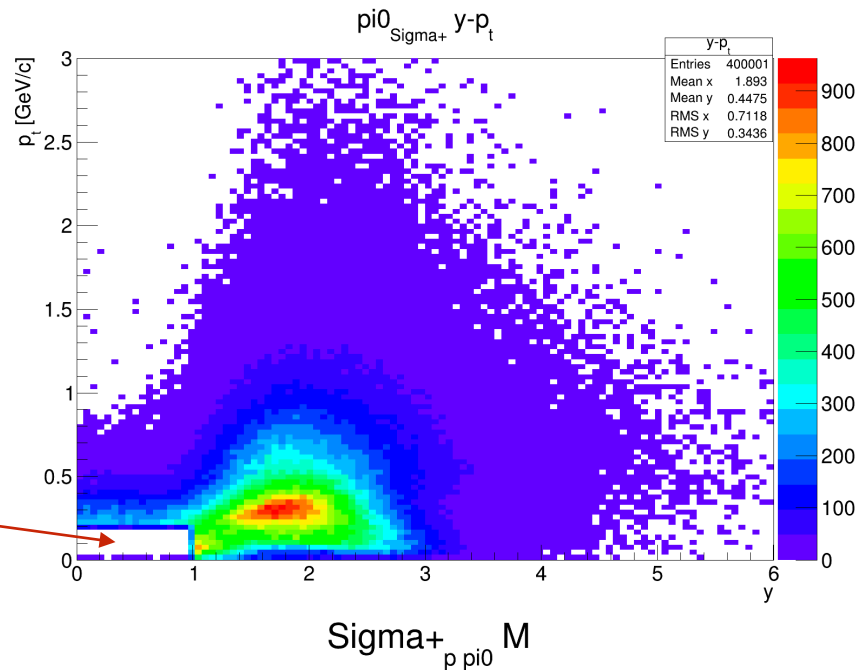
◆ Subtracting charged daughter

- ▶  $Z$  decay is between tracks
- ▶ Fit quality of neutral
- ▶ **Low momenta cut on clones for neutral candidate**

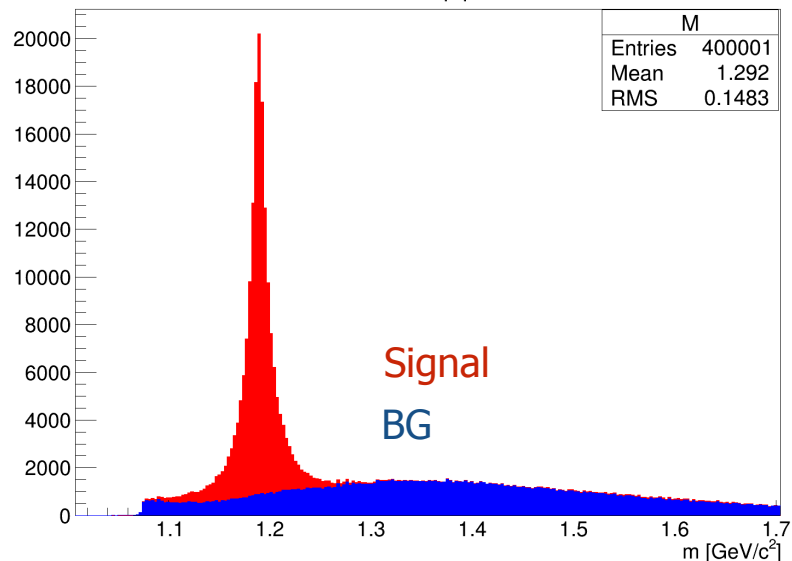
◆ Setting mass constraint for neutral

◆ Constructing mother

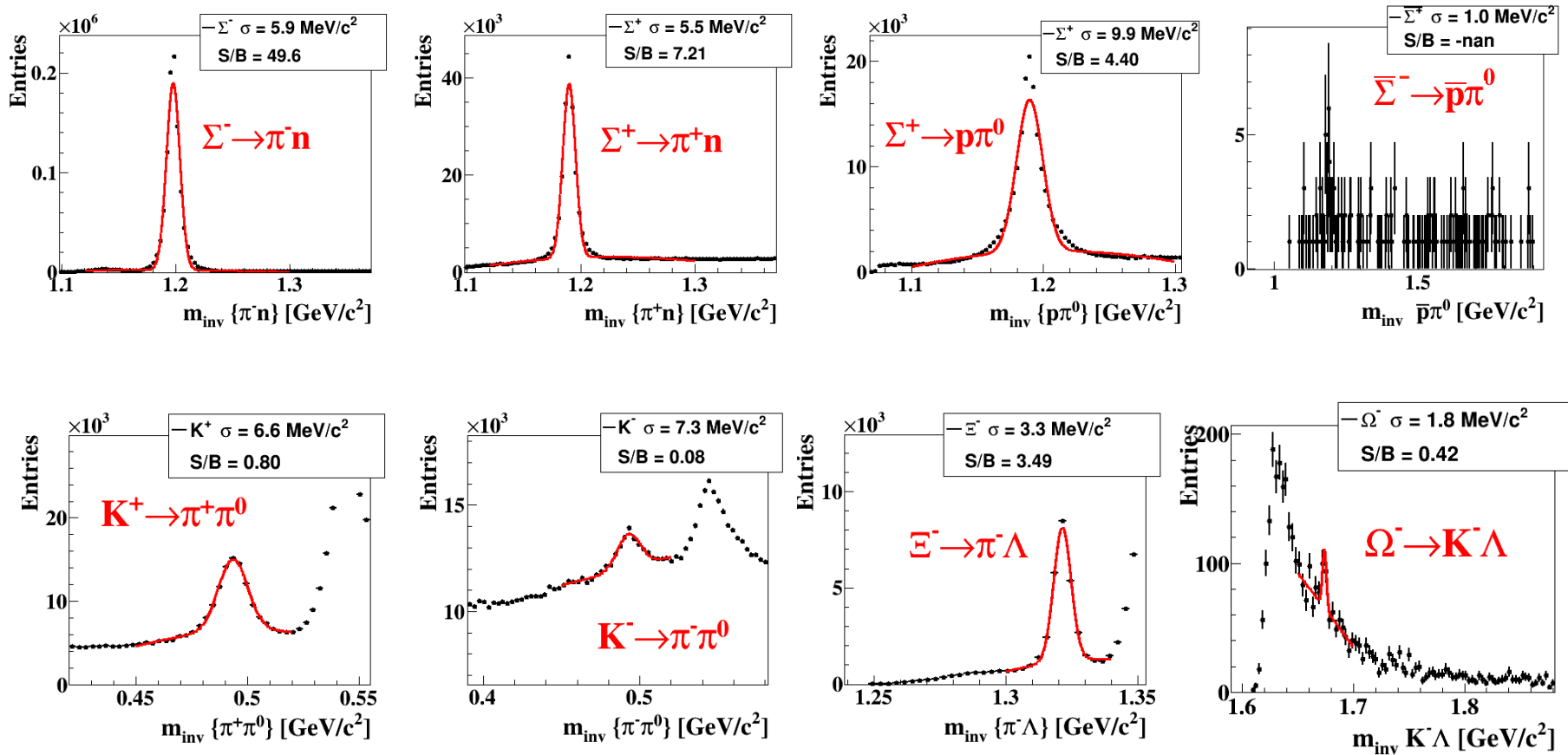
- ▶  $Z$  decay is between tracks
- ▶ Fit quality of constructed mother
- ▶ Is particle from vertex?



Result

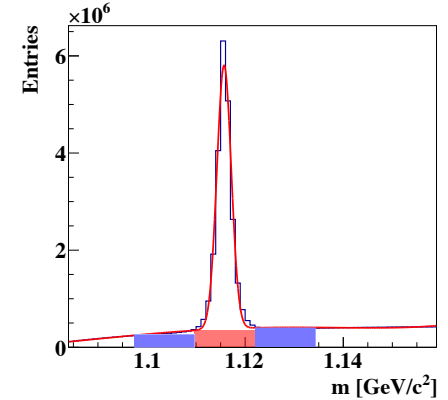
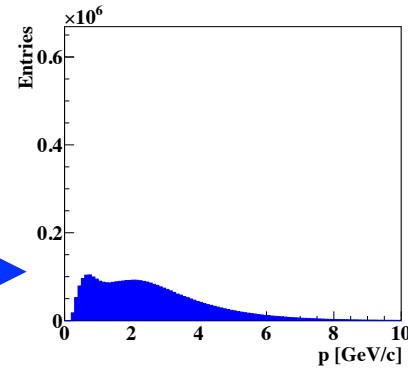
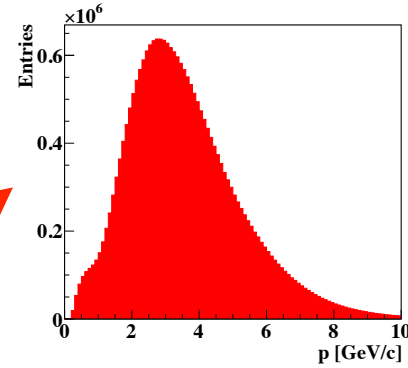
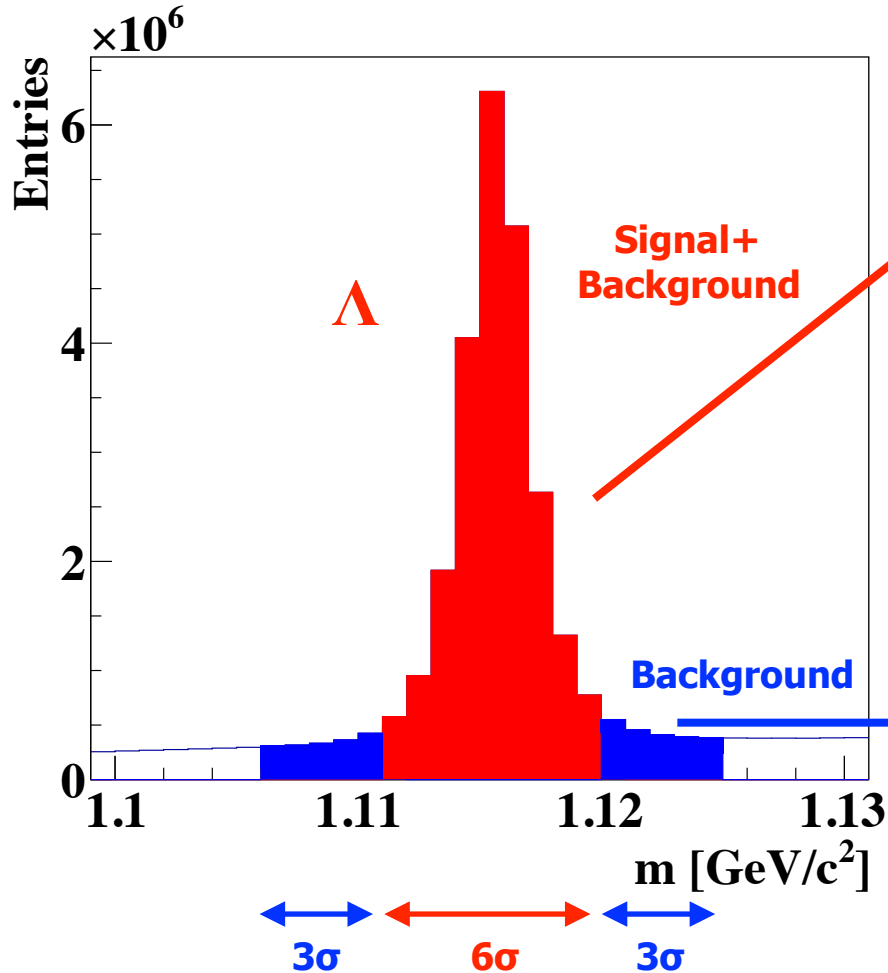


# Mass Spectra of Reconstructed Particles



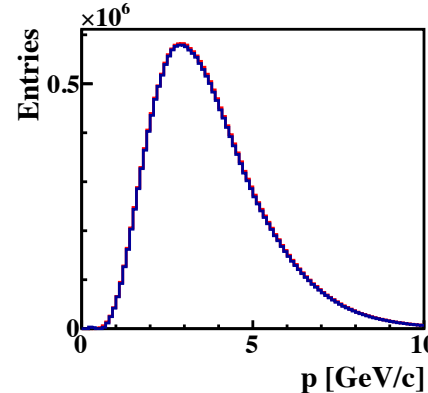
5M Au+Au central events, 10 AGeV, TOF PID

# Extraction of the Signal: Background Subtraction



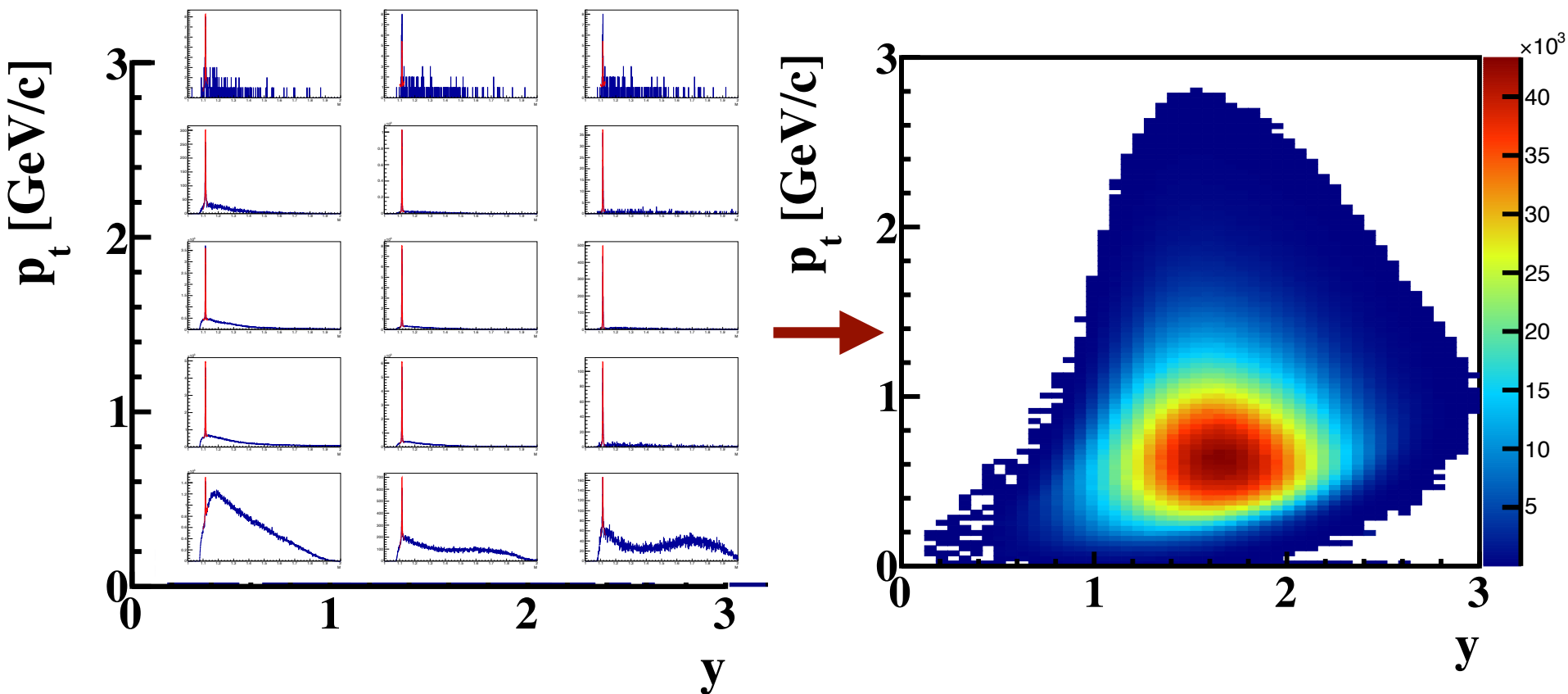
**X**

**=**



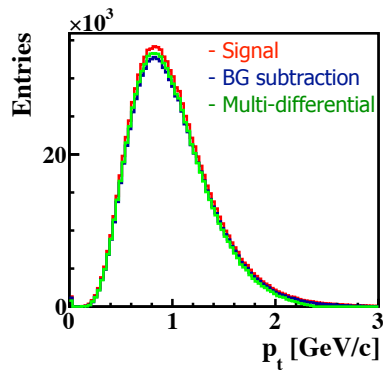
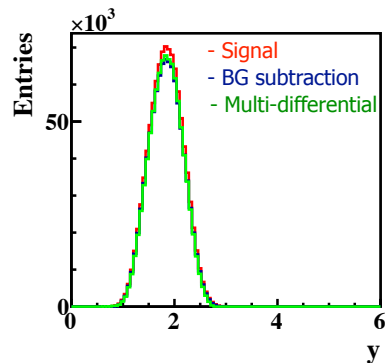
- Collect spectra ( $M$ ,  $p$ ,  $p_t$ ,  $\gamma$ ,  $Z$ ...) for the signal+BG (particles within the mass peak) and BG (particles near the peak).
- Calculate the correction factor using the fitted BG.
- Subtract the corrected BG.

# Extraction of the Signal: Multi-differential Analysis

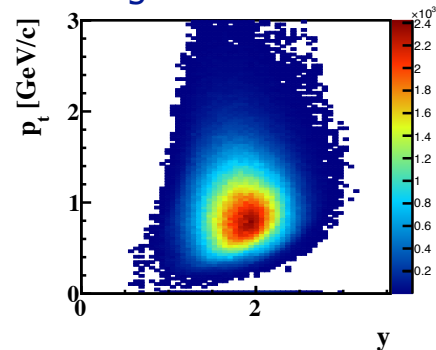


- Is illustrated at the example of  $\Lambda$  hyperon.
- Collect mass spectra in different  $y$ - $p_t$  bins.
- Fit the spectra with a signal+background function — calculate an integral of the signal function.
- Fill bins of the  $y$ - $p_t$  histogram with the integral values — obtain the  $y$ - $p_t$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

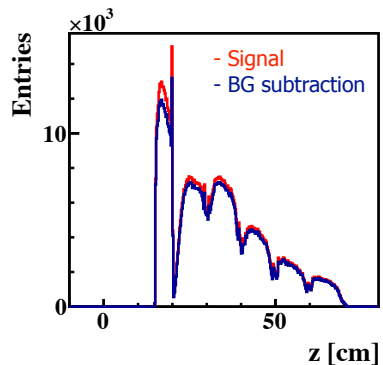
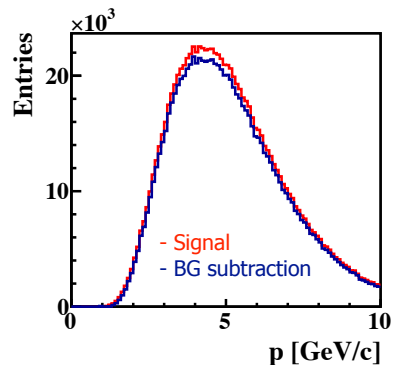
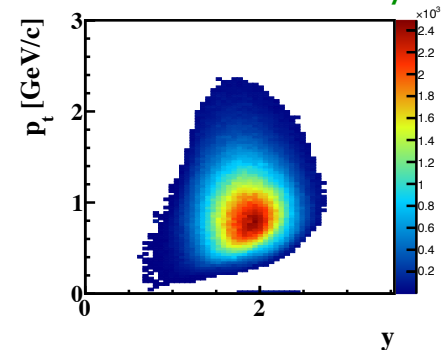
# $\Sigma^- \pi^-$ signal reconstruction



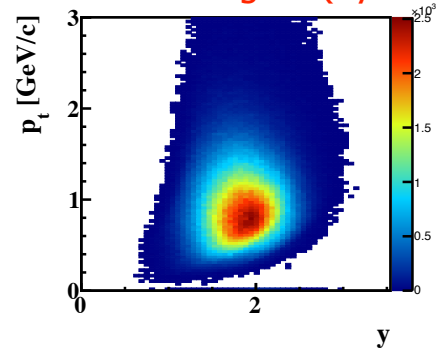
Background subtraction



Multi-differential analysis



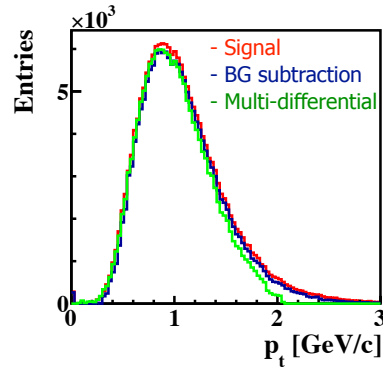
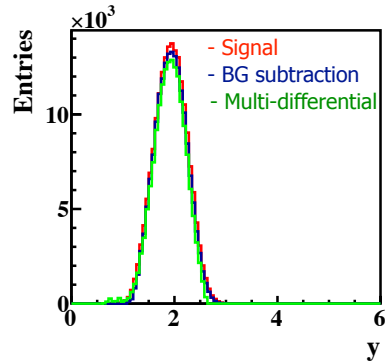
Reconstructed Signal (by MC info)



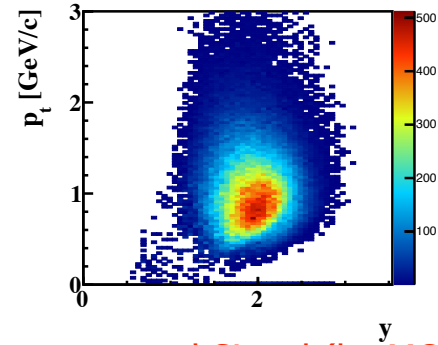
- Both methods show similar results.
- The signal distribution are nicely described by the extracted signal.



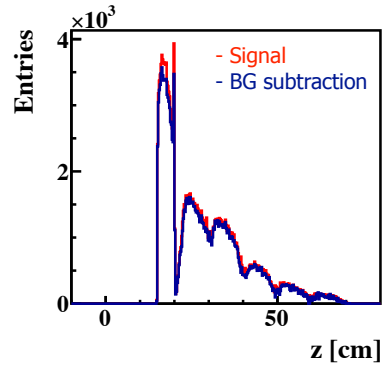
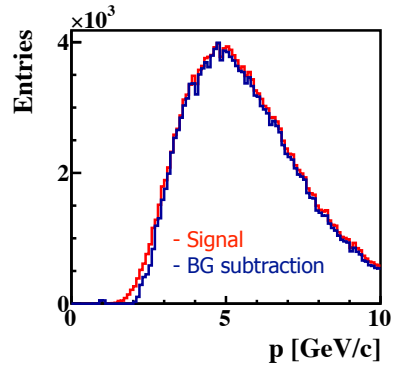
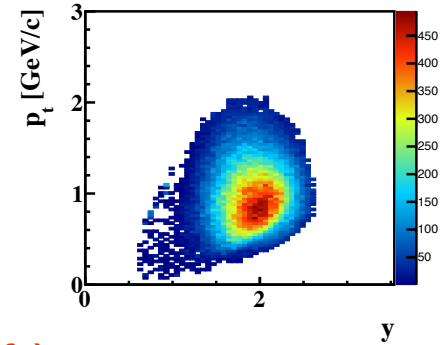
# $\Sigma^+_{n\pi^+}$ signal reconstruction



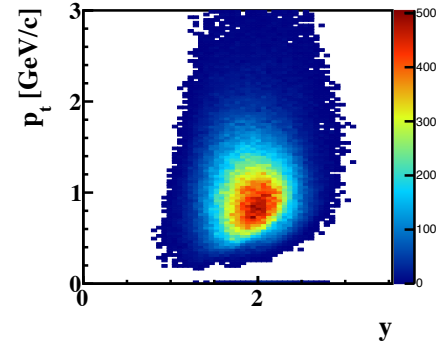
Background subtraction



Multi-differential analysis

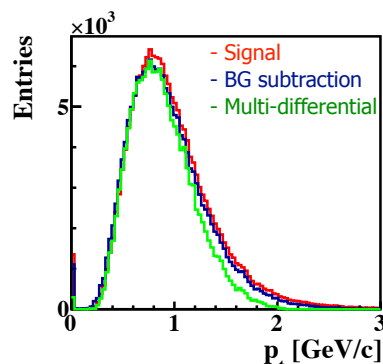
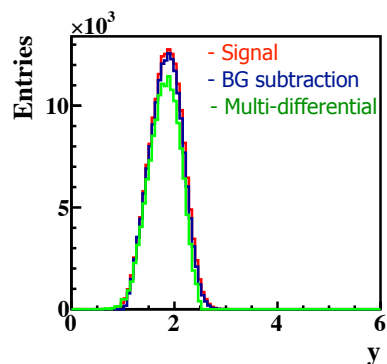


Reconstructed Signal (by MC info)



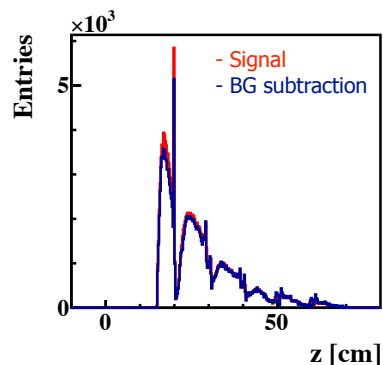
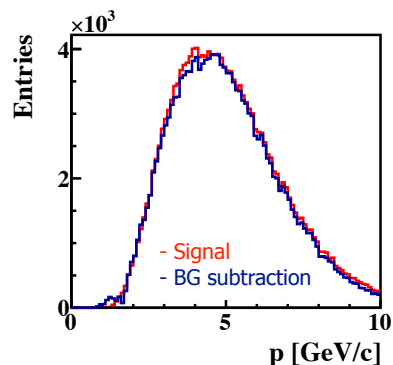
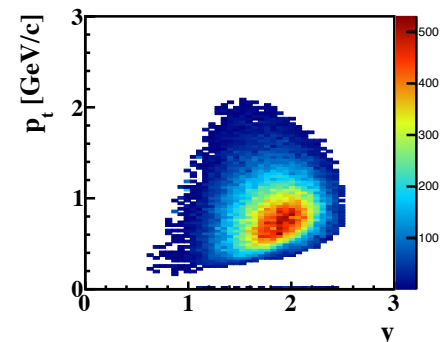
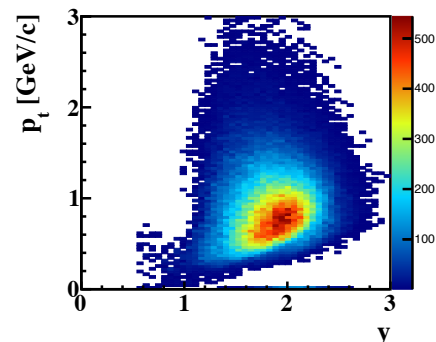
- Both methods show similar results.
- The signal distribution are nicely described by the extracted signal.

# $\Sigma^+ p \pi^0$ signal reconstruction

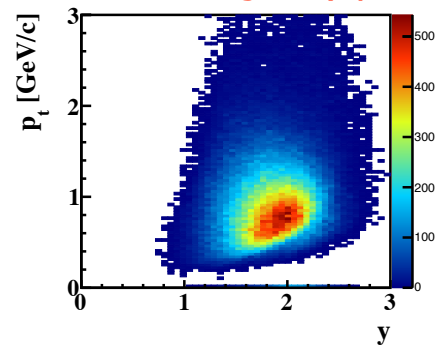


Background subtraction

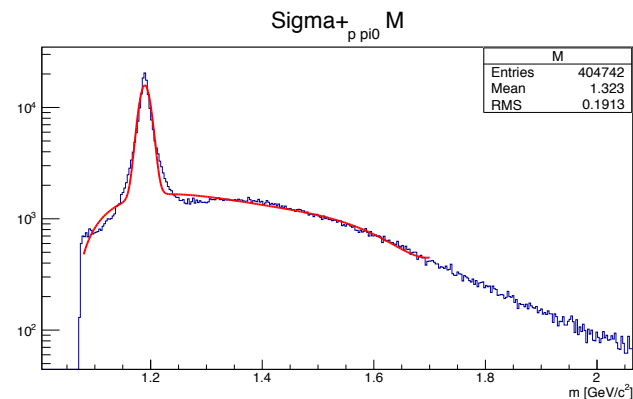
Multi-differential analysis



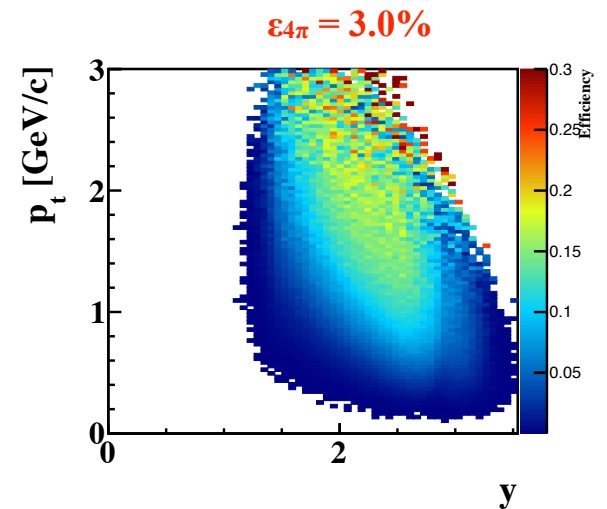
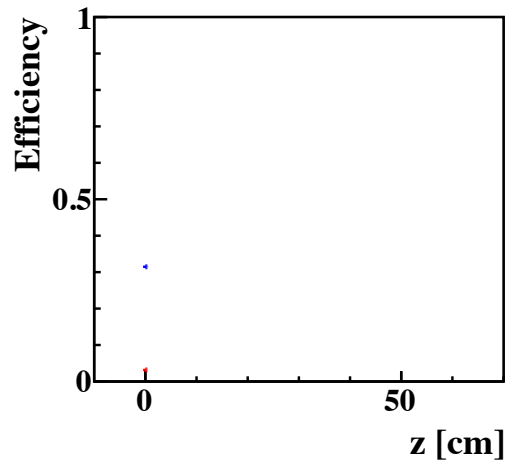
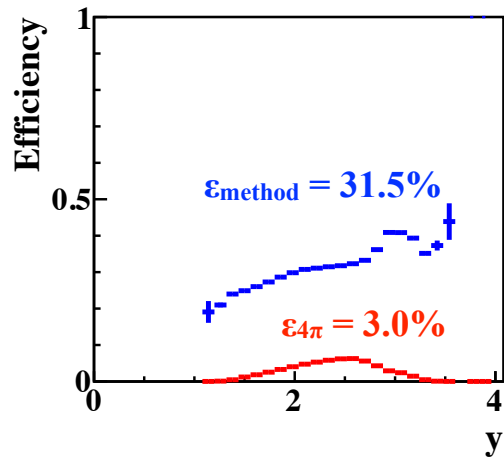
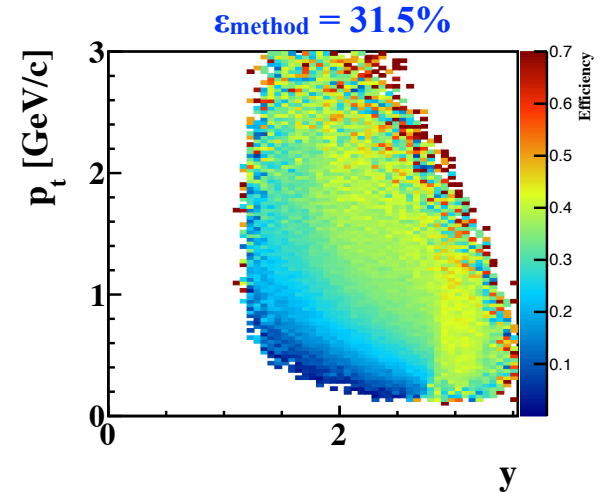
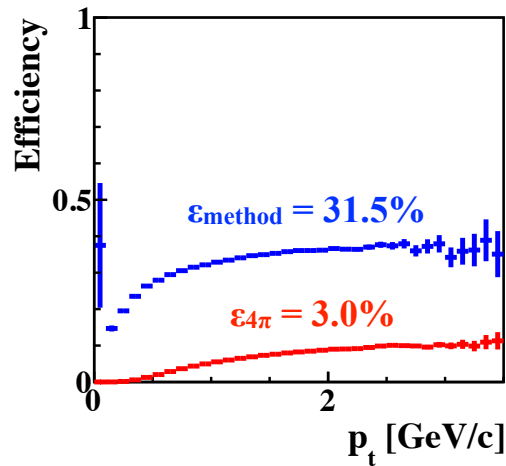
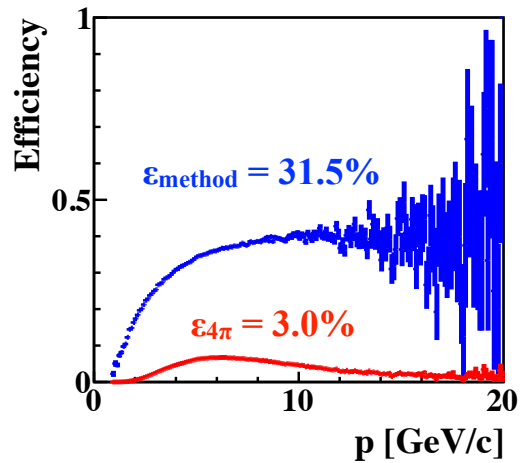
Reconstructed Signal (by MC info)



- The signal distribution are nicely described by the BG subtraction method.
- 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.
- Signal and BG approximation for  $\Sigma^+ p \pi^0$  requires further investigation



# $\Sigma_{n\pi^-}$ efficiency



- 2D  $y$ - $p_t$  plots for particle efficiency have been added.
- Next step — obtain efficiency corrected plots.

# Summary and Plans

- ✓ The missing mass method for reconstruction of  $\Sigma$  and other particles has been further developed.
- ✓ With TOF PID the missing mass method reconstructs particles with high efficiency and S/B ratios.
- ✓ The signal extraction and multi-differential methods have been implemented.
- ✓ Resulting distributions are in a good agreement with the signal.

- 📌 Improve the BG approximation.
- 📌 Implement search for double reconstructed  $\Xi$  and  $\Omega$  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)