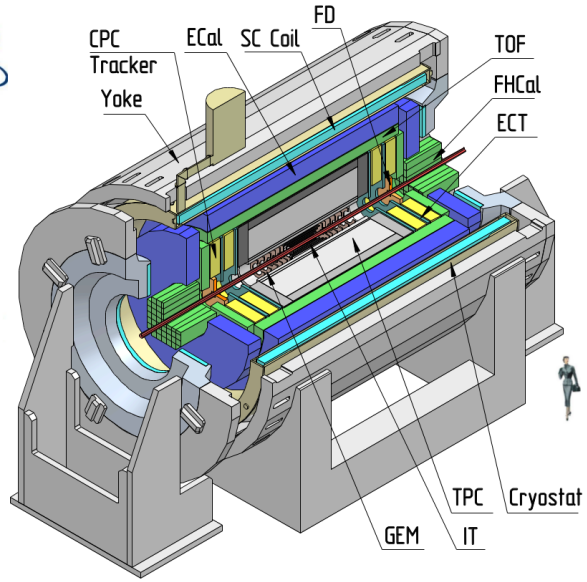

Use of the KFParticle formalism within the MPD experiment: status and first promising results obtained

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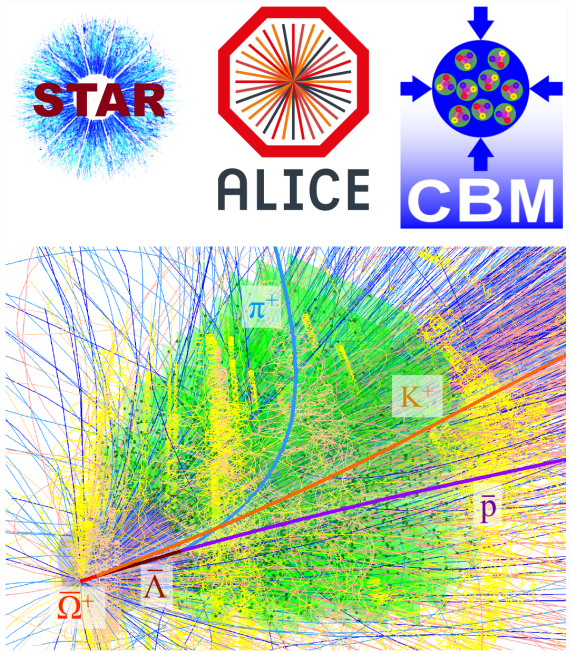
[3]GSI Helmholtz Center for Heavy Ion Research, Darmstadt, Germany

Outline:

- **KFParticle formalism: idea, algo scheme, benefits, use within the MpdRoot software**
- **Use of KFParticle with MPD reconstructed data (vertex reconstruction, Λ^0, K_s^0 ...)**
- **QA of obtained results comparing with Monte Carlo**

KFParticle formalism

Particles in heavy-ion collision:



KFParticle:

- developed for complete reconstruction of short-lived particles with their P, E, m, $c\tau$, L, Y

Main benefits:

- based on the Kalman filter mathematics
- idependent in sense of experimental setup (collider, fixed target)
- allows one reconstruction of decay chains (cascades)
- daughter and mother particles are described and considered the same way
- daughter particles are added to the mother particle independently

To get more info on, see PhD thesis of S. Gorbunov and M. Zyzak

HTTP://PUBLIKATIONEN.UB.UNI-FRANKFURT.DE/FILES/29538/GORBUNOVTHESIS.PDF
HTTP://PUBLIKATIONEN.UB.UNI-FRANKFURT.DE/FILES/41428/MAKSYM_ZYZAK_THESIS.PDF

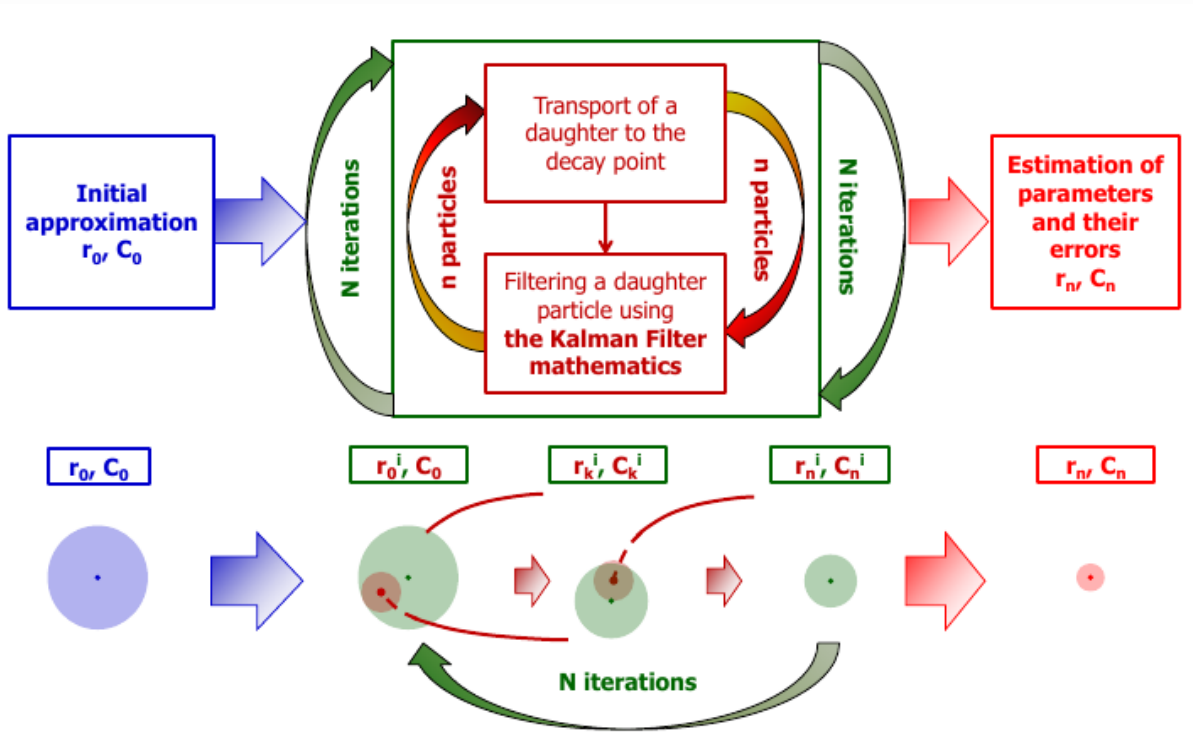
KFParticle formalism

Particle state vector:

$$\mathbf{r} = \{x, y, z, p_x, p_y, p_z, E\}$$

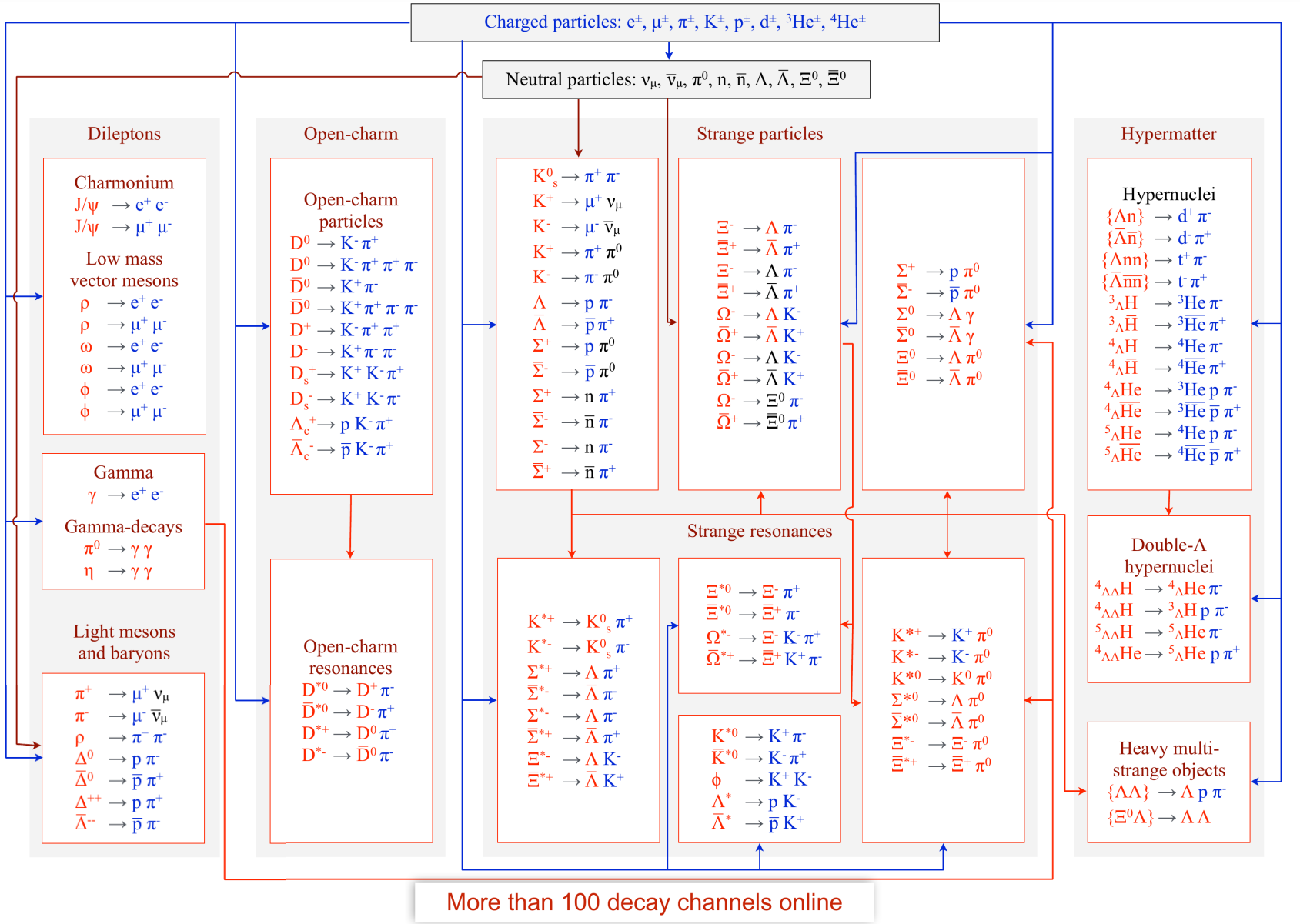
- The state vector allows full reconstruction of a particle (decay vertex, P, E)
- Covariance matrix is estimated together with the state vector

KFParticle algo scheme:



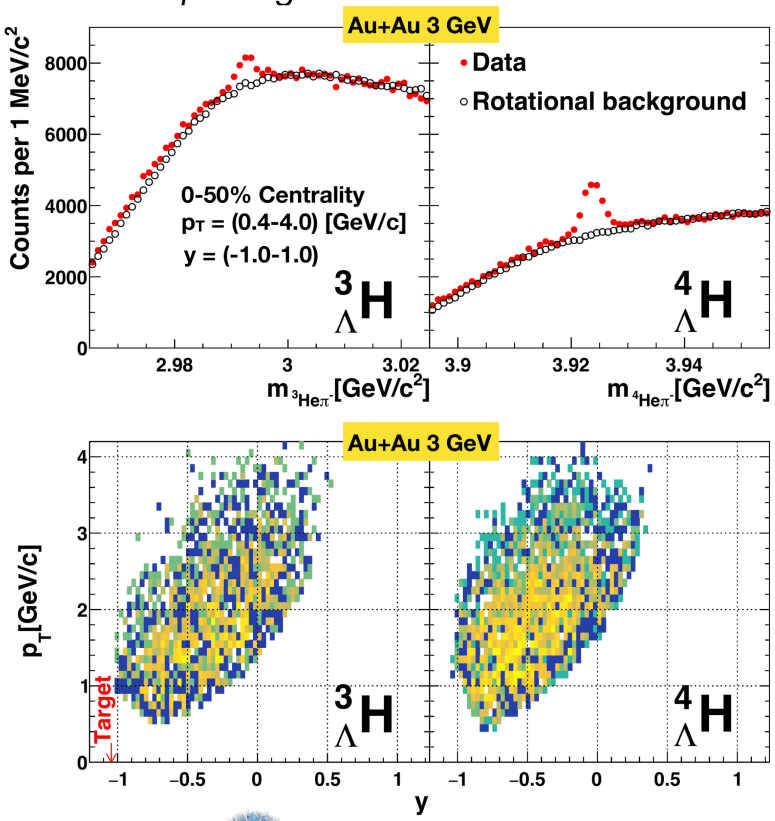
- Initialization of parameters
- Extrapolation of a measurement (daughter particle) to the point of the closest approach with a current estimation of decay point
- Correction of the mother particle on a daughter particle

KFParticle, decays which can be reconstructed



KFParticle in the STAR & CBM experiments

**KFParticle package used for reconstruction*

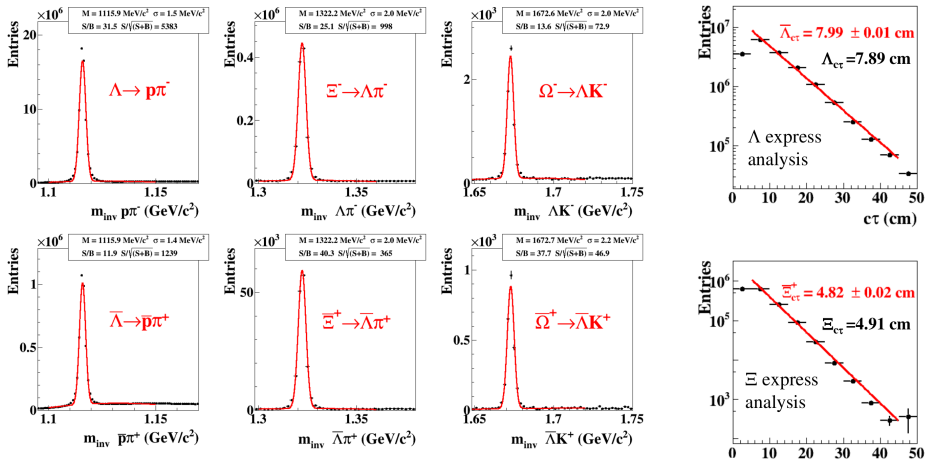


CPOD2021 STAR

Yue-Hang Leung *for the STAR collaboration*

$\bar{\Lambda}$ and Ξ^+ Hyperons lifetime (year 2020)

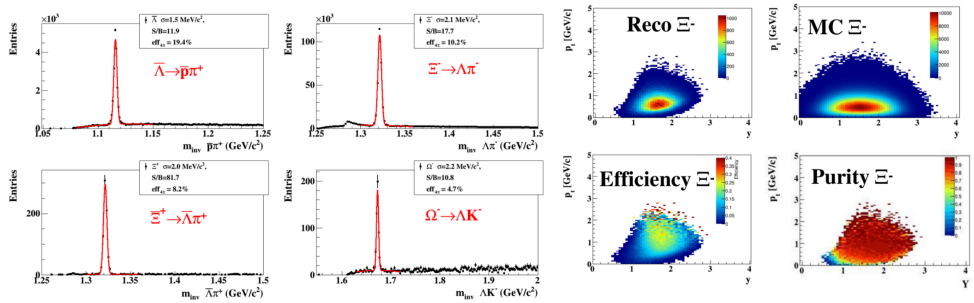
(STAR performance express analysis, BES-II)



CBM

Multi Strange particle reconstruction performance

5M central AuAu collisions 10AGeV/c



Use of KFParticle with MPD

Benefits:

- Mother particle is constructed from daughter particles
- Addition and subtraction of daughters to (from) mother
- Access to physics parameters
- Transport to an arbitrary point
- Mass constraints on production point of particle
- ...

First version of finder is ready (surely, written based on the FairRoot task conception) and planned to be pushed to the repository a.s.a.p.

How to use the benefits of KFParticle in MPD?

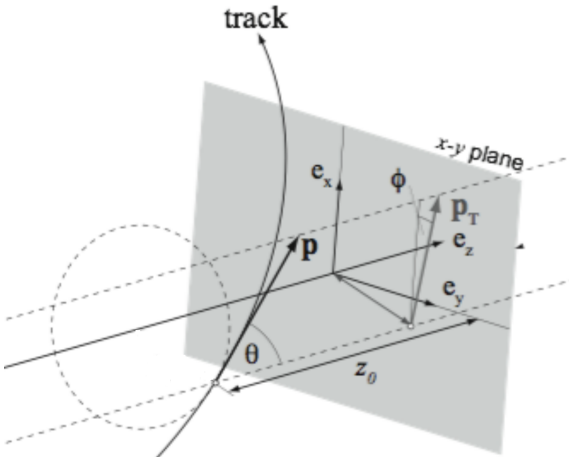
A finder to be developed is required!

Finder:

- A software that uses the benefits of KFParticle respectively to the experimental software (MpdRoot), data formats (MiniDst, standard dst ...)
- Takes into account a correct track state vector parameterisation to be used to construct particle state vector (The most important that differs for each experiment)
- Optimizes different cuts to be used in course of KFParticle use (dca's, mass constraints and so on)

Use of KFParticle with MPD

$$\begin{cases} x = r\cos\phi_t \\ y = r\sin\phi_t \\ z = z \\ P_x = |P_t|\cos\phi \\ P_y = |P_t|\sin\phi \\ P_z = |P_t|\tan\lambda \end{cases}$$



Track params. are given at 2D DCA point to beamline (X, Y = 0)

$$Track\ state\ vector = \begin{pmatrix} r\phi_t \\ z \\ \phi \\ \lambda = \pi/2 - \theta \\ -q/P_t \end{pmatrix}$$

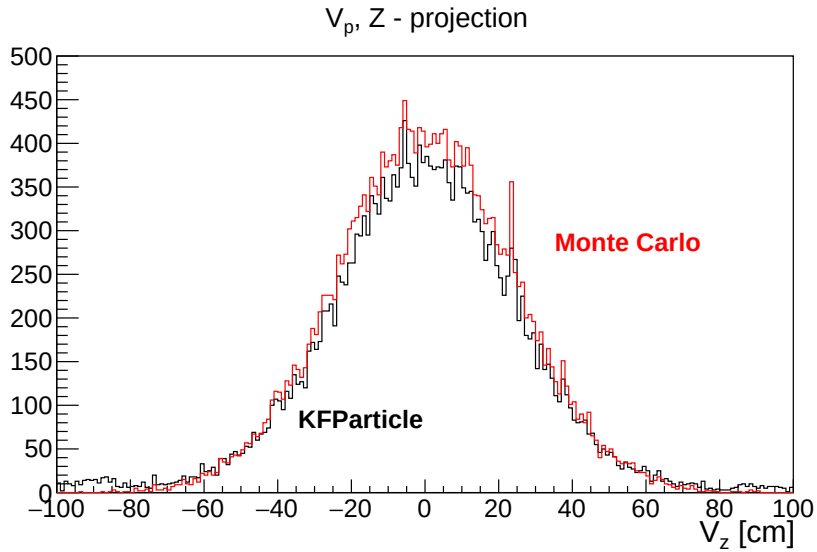
$$C_{out} = JC_{in}J^T$$

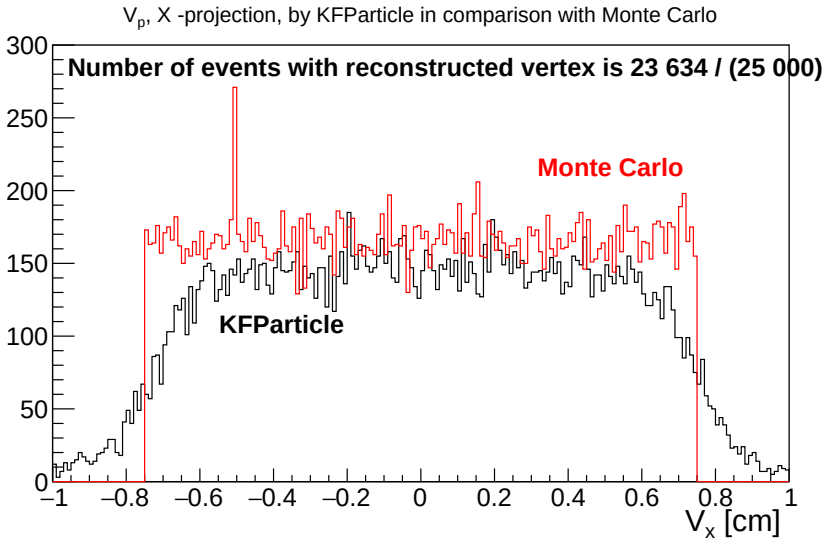
$$J_{A\to B} = \begin{pmatrix} 1 & 0 & 0 & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 & 0 & 0 \\ 0 & 0 & 1 & 0 & 0 & 0 \\ 0 & 0 & 0 & -|P_t|\sin\phi & 0 & \frac{p_t^2\cos\phi}{q} \\ 0 & 0 & 0 & |P_t|\cos\phi & 0 & \frac{p_t^2\sin\phi}{q} \\ 0 & 0 & 0 & 0 & \frac{|P_t|}{\cos^2\lambda} & \frac{p_t^2\tan\lambda}{q} \end{pmatrix}$$

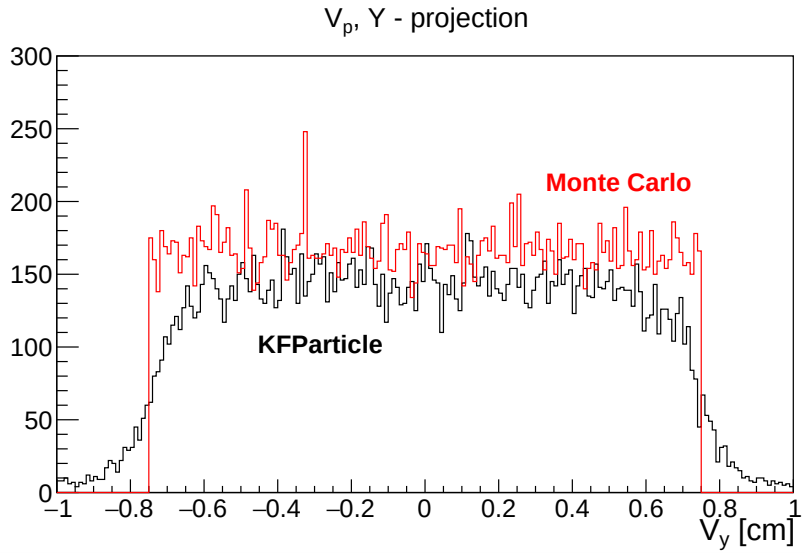
Required extrapolation of track params. to the TPC inner shell (first hit position)

Used dataset, anal. details. Reconstruction of primary vertex (V_p)

- **UrQMD, BiBi @ $\sqrt{s_{NN}} = 9$ GeV, min. bias, 25 kEvents, looking for Λ^0 and K_s^0**
- **Very simple PID: q > 0 (p), q < 0 (π^-)**
- **Smearing of beam IP:**
  - **Uniform for X-, and Y- around zero with $\sigma = 0.75$ cm**
  - **Gaussian for Z- around zero with $\sigma = 24$ cm**

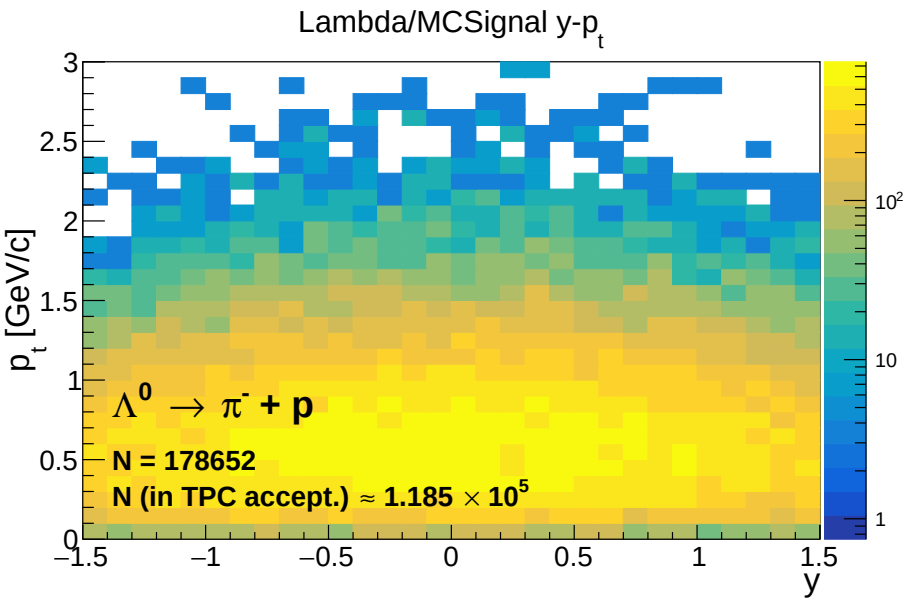


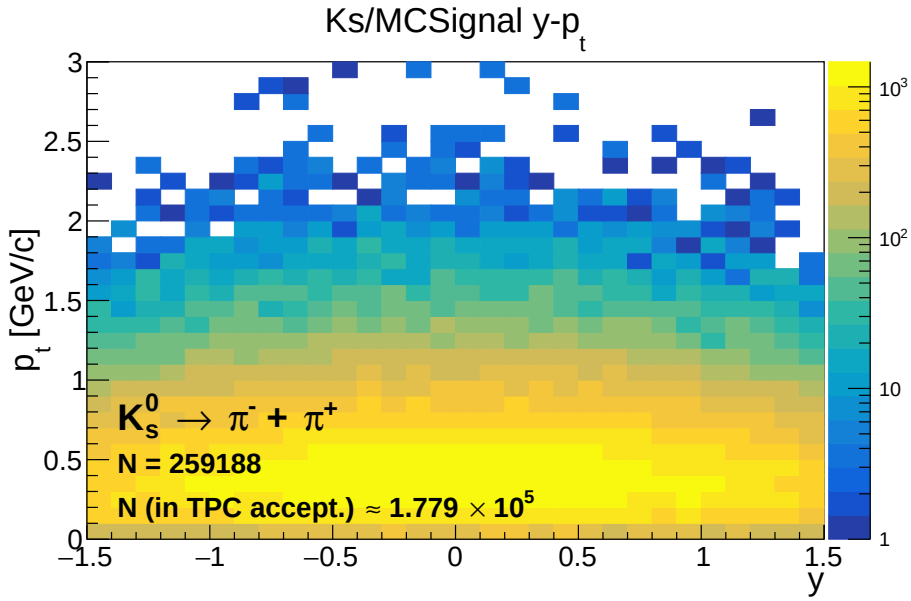


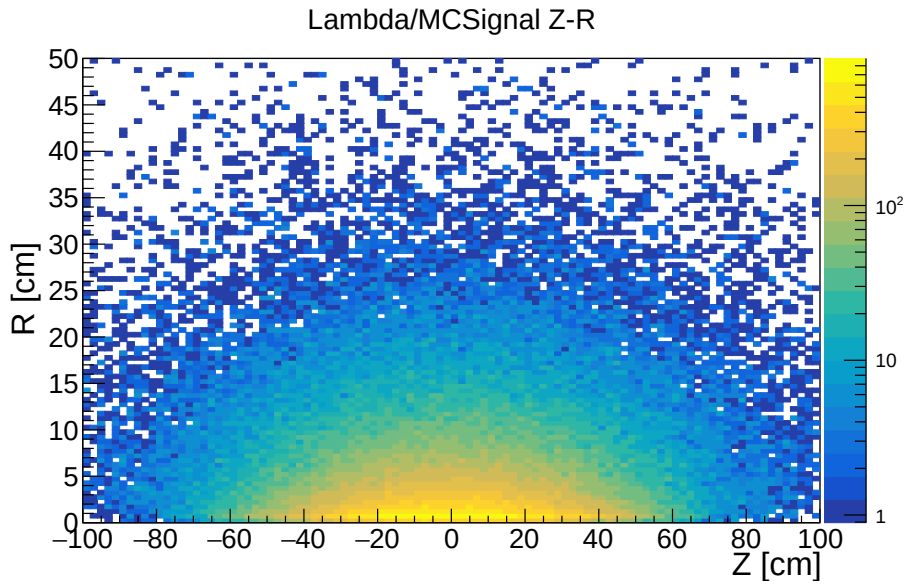


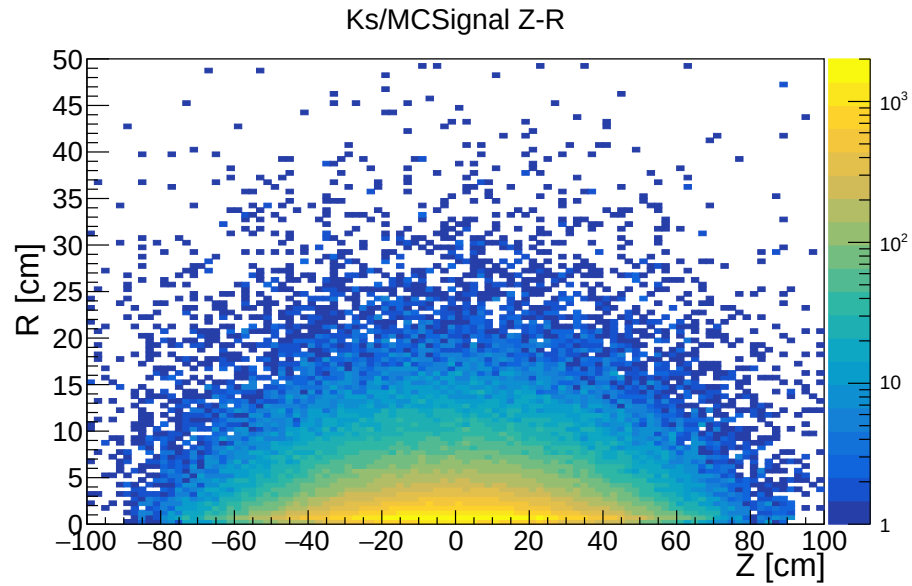
- **Good reconstruction in Z-direction**
- **Relatively good reconstruction in X-, Y-directions**
- **“Edge" effects (due to limited TPC resolution) are visible for X- and Y-**

What do we have in Monte Carlo?

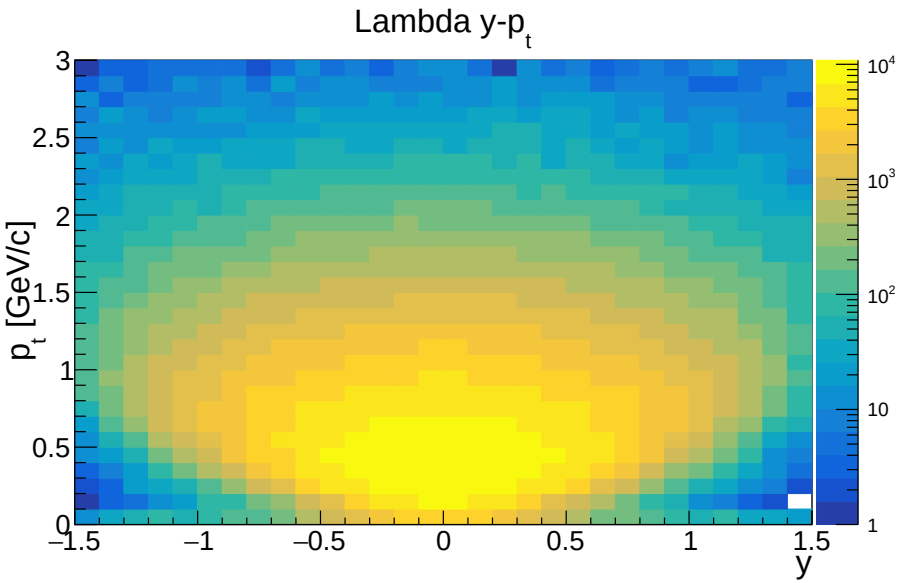


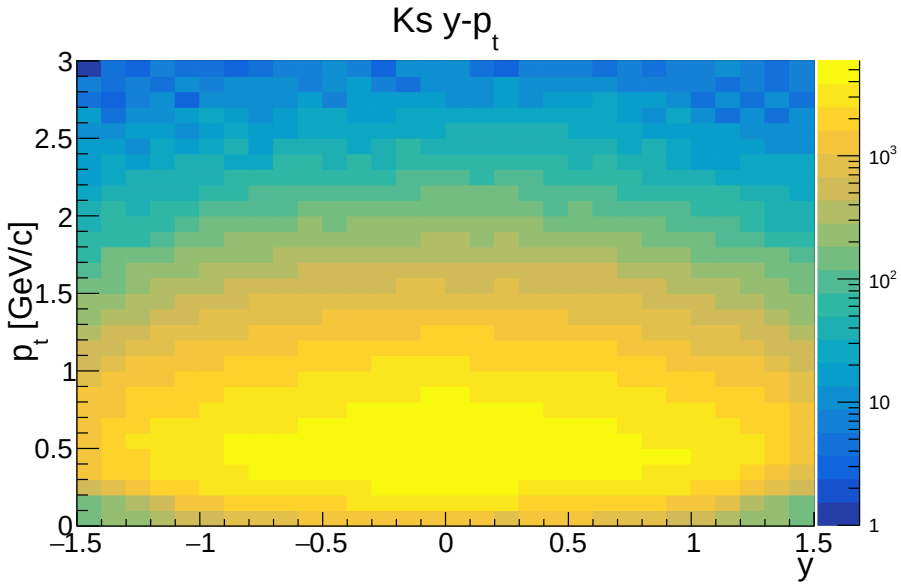


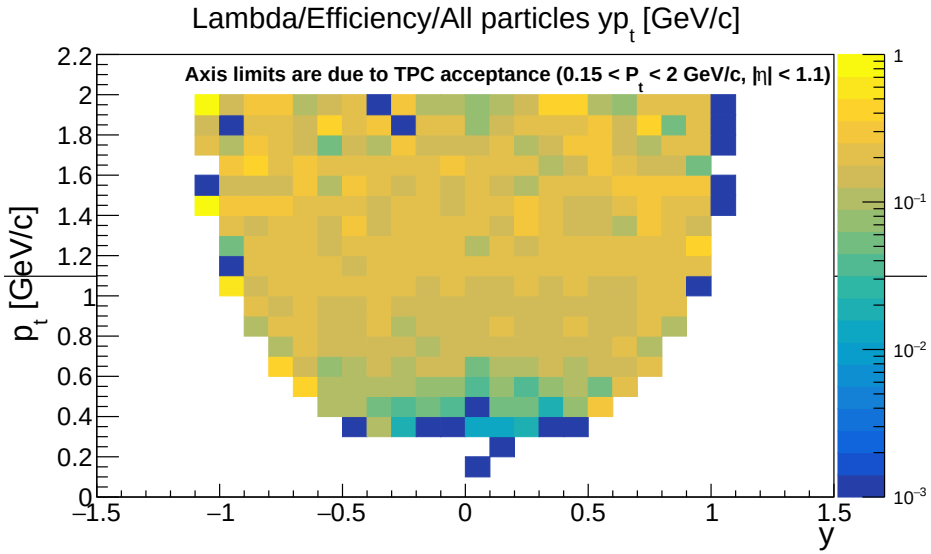


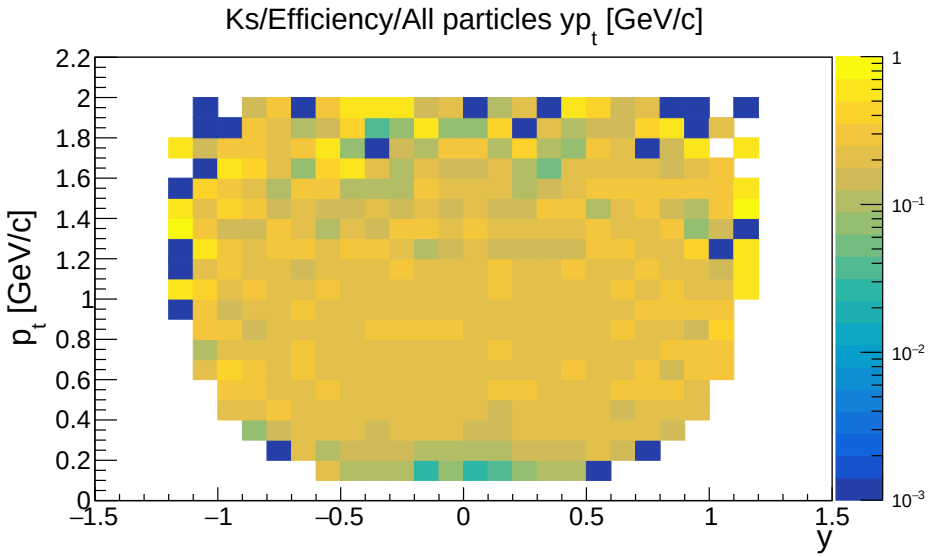


Looking at potential candidates to be Λ^0 or K_s^0

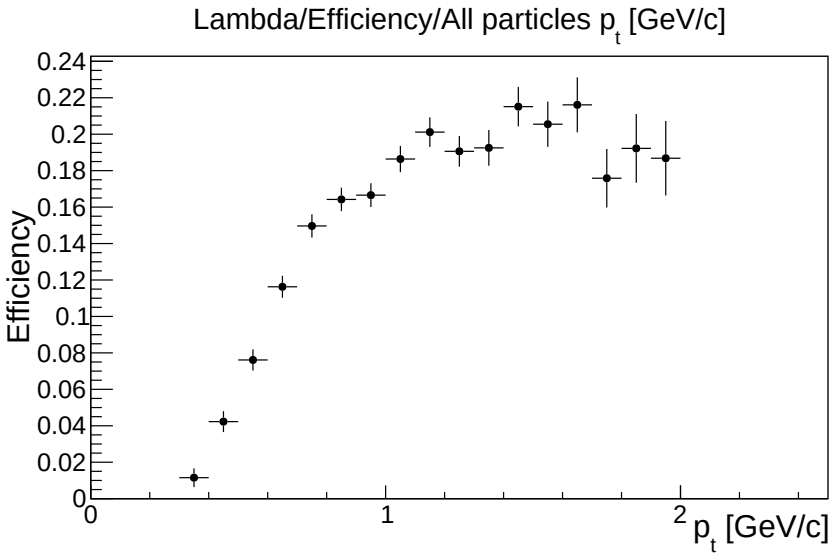


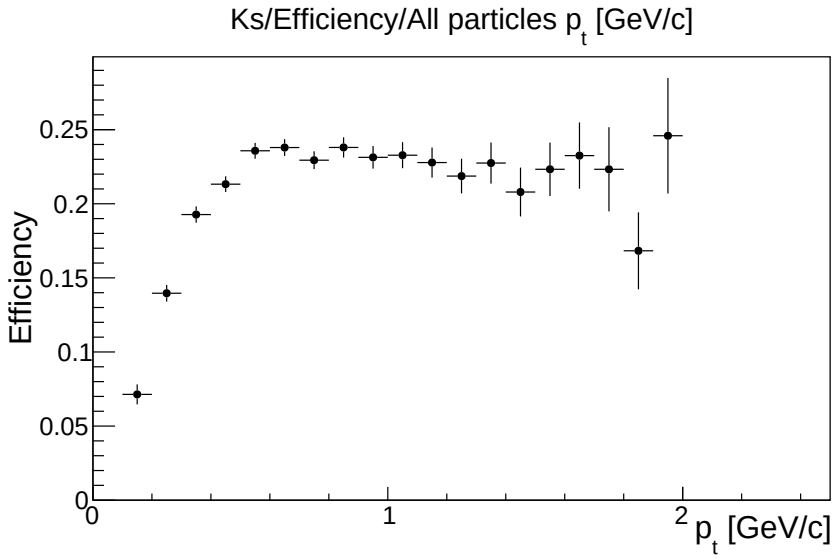


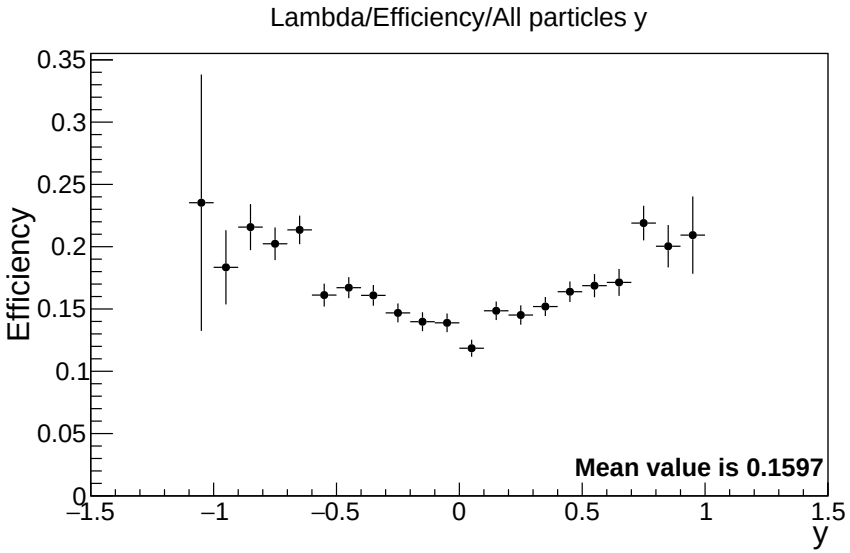


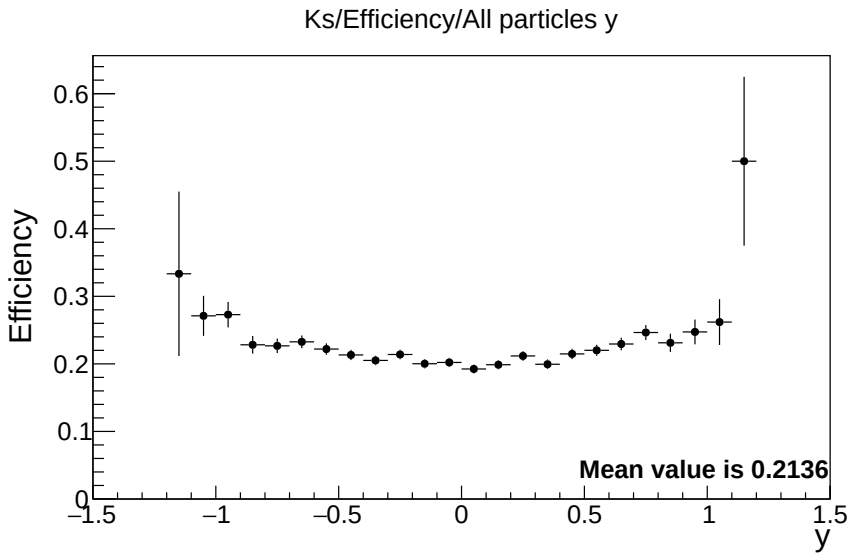


Looking at potential candidates to be Λ^0 or K_s^0

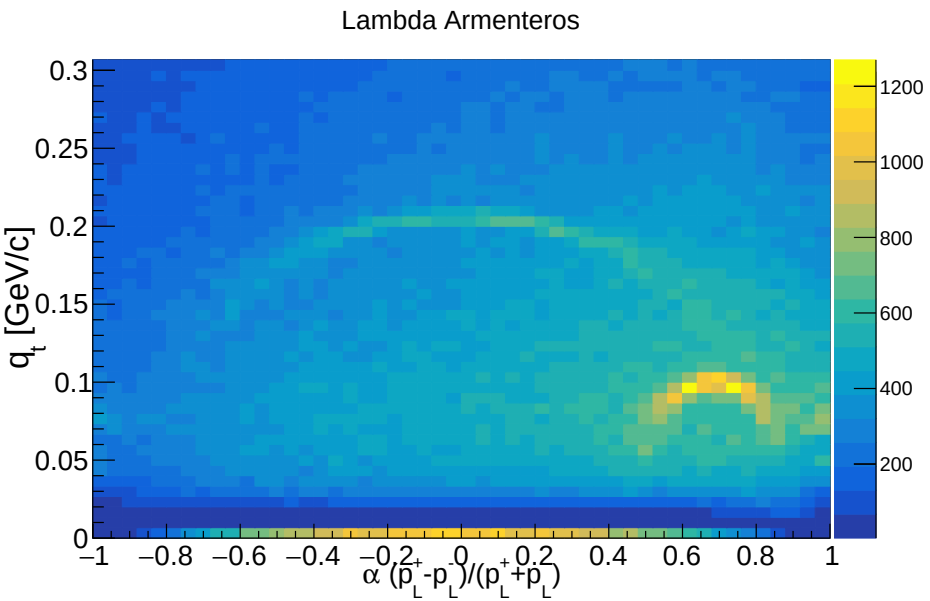


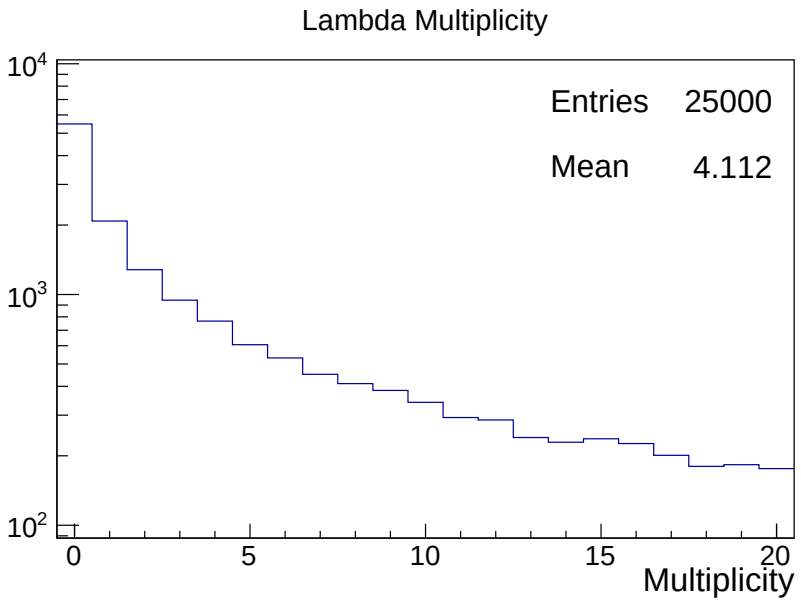




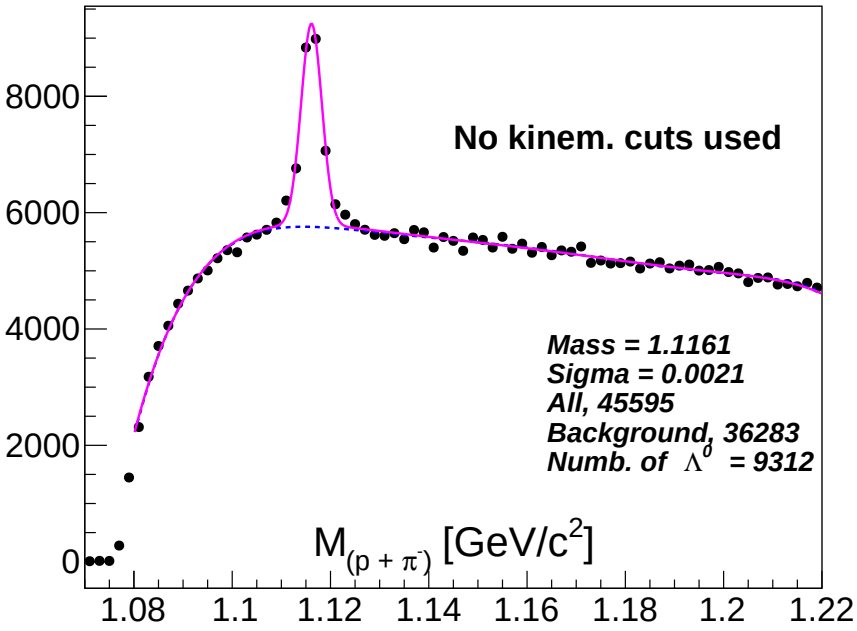


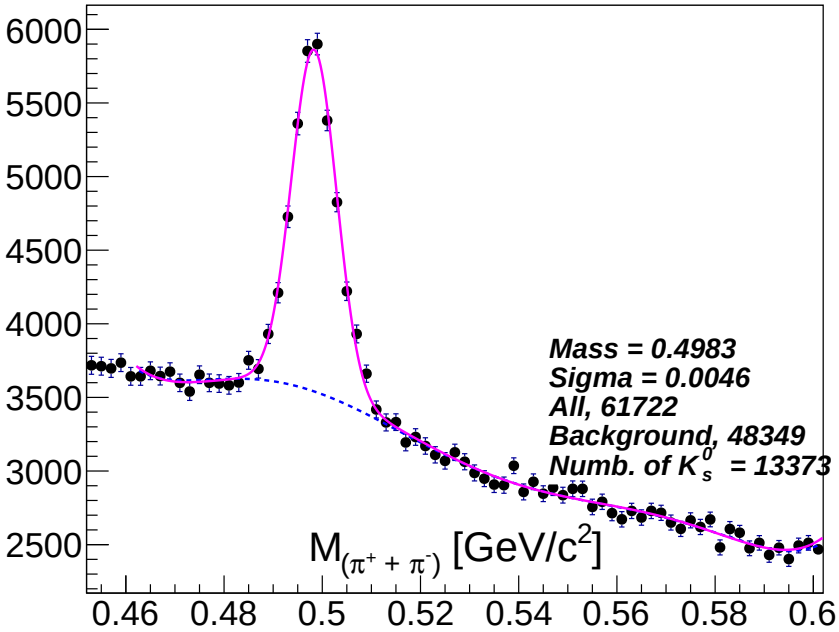
Looking at potential candidates to be Λ^0





Reconstructed mass spectra

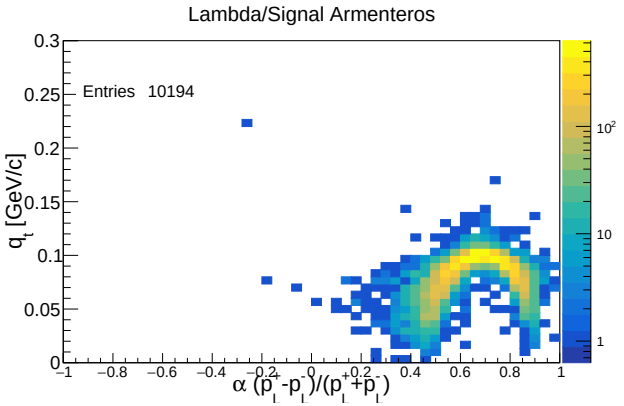


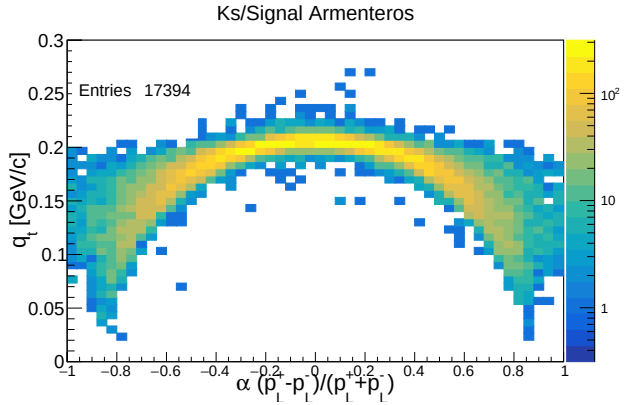


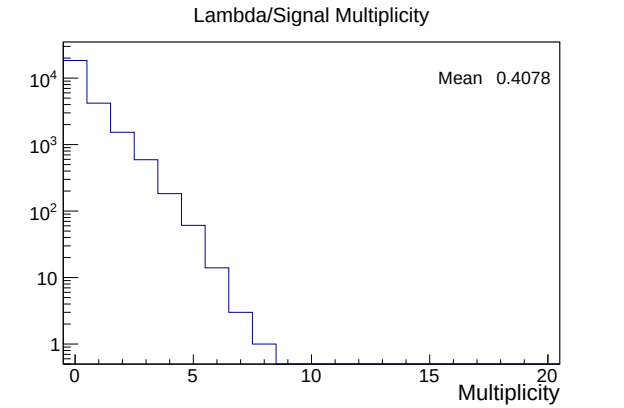
KF Particle Finder scheme assumes that each mass spectrum consists of:

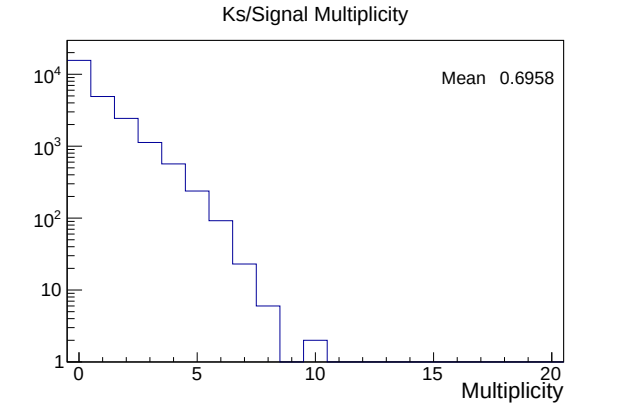
- Signal (S) (daughter particles come from real decaying particle)
- Background related to misidentification (MB) (daughter particles come from decaying particle, but either pdg (PID) hypothesis is incorrect or not all daughters from decay are reconstructed)
- Combinatorial background (CB) (tracks do not form a real secondary vertex)

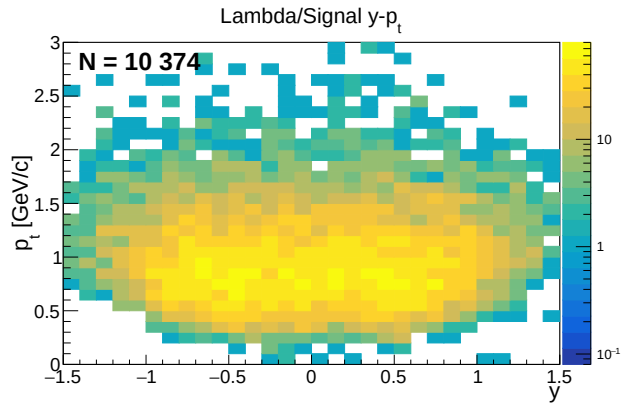
Looking at signal (S)

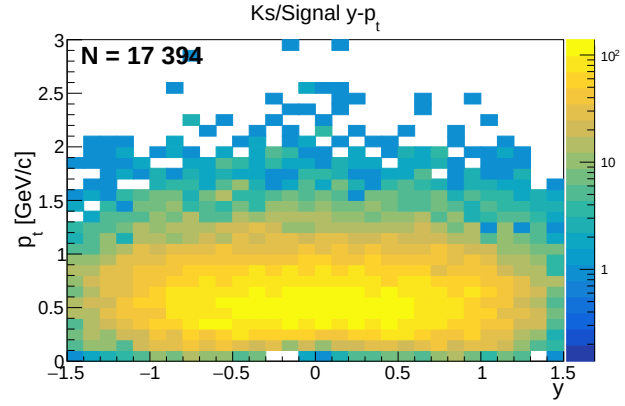




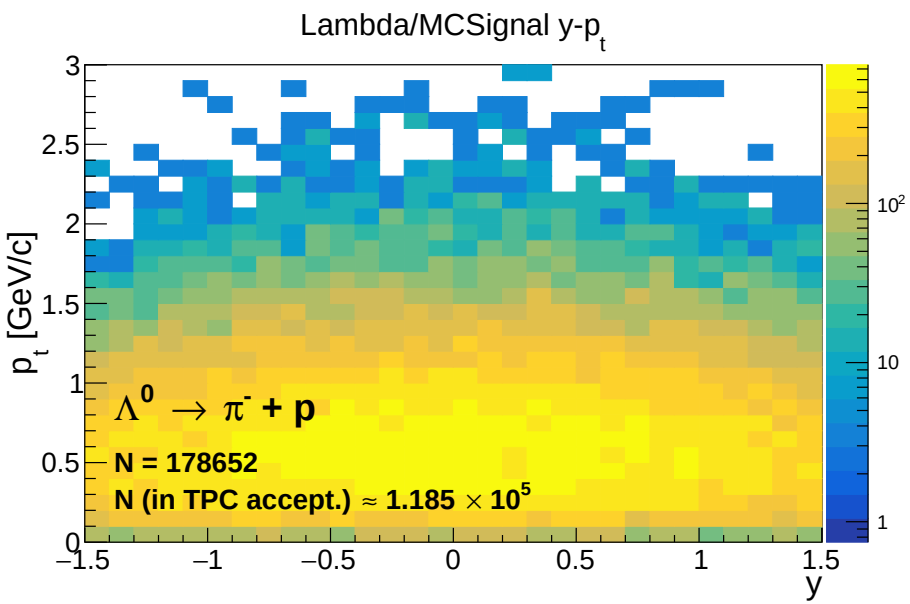


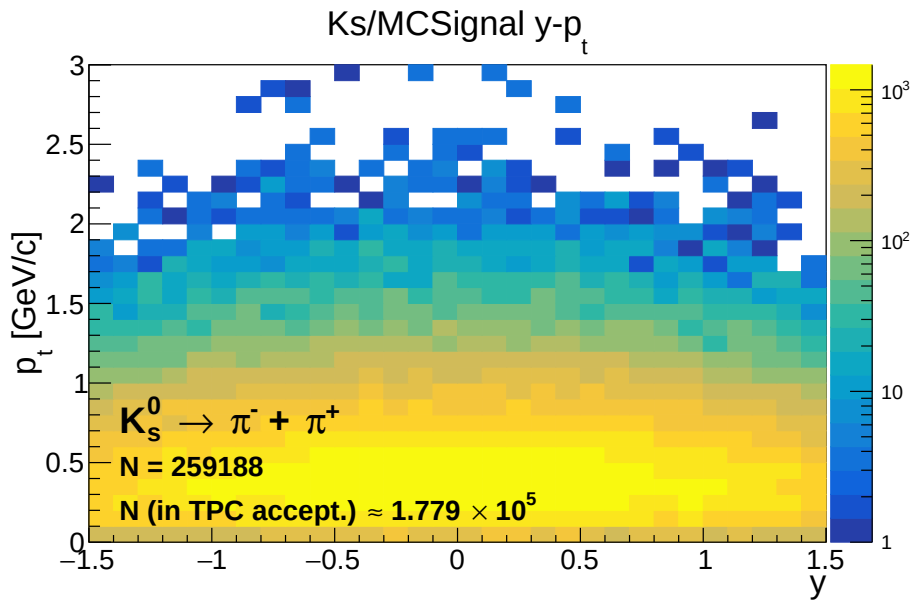


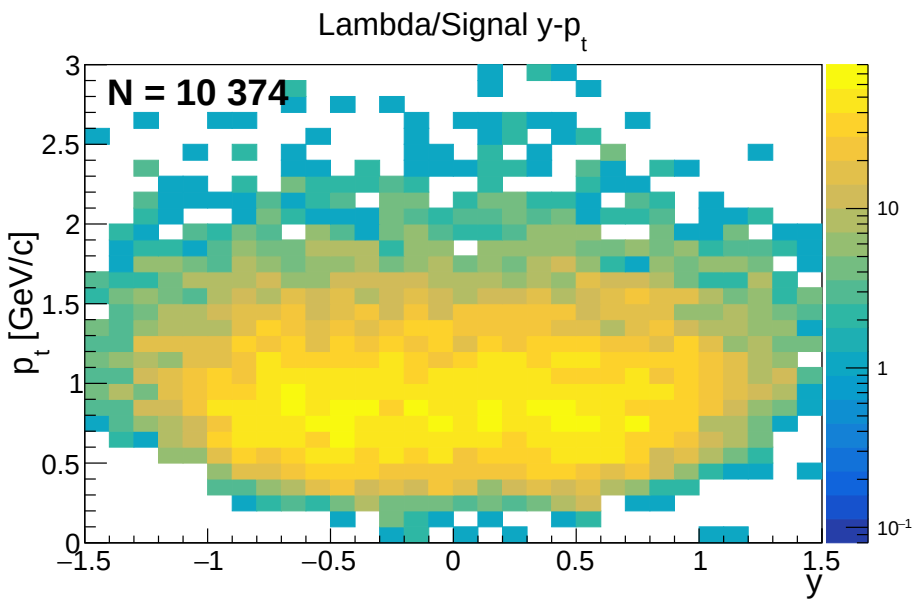


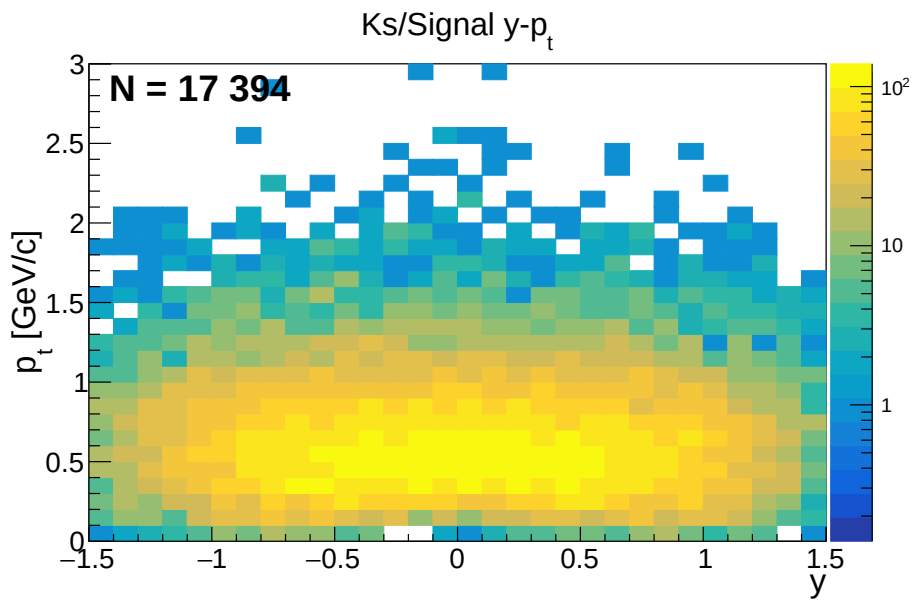


Looking at signal (S) comparing with MC

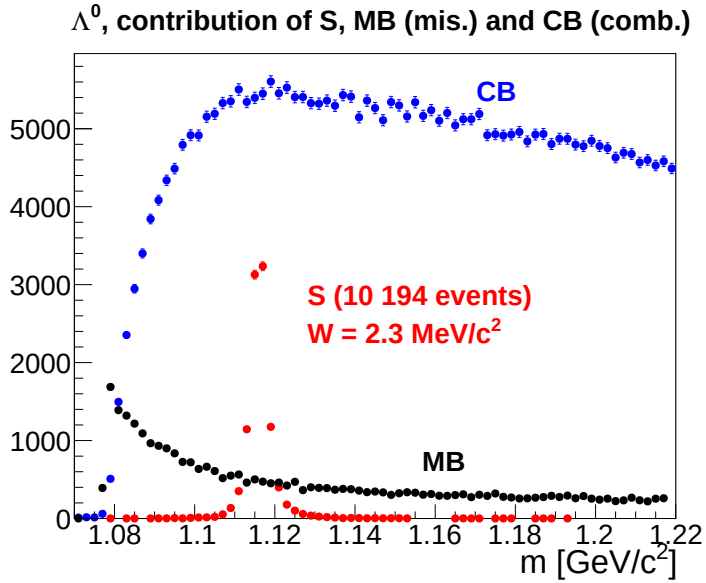


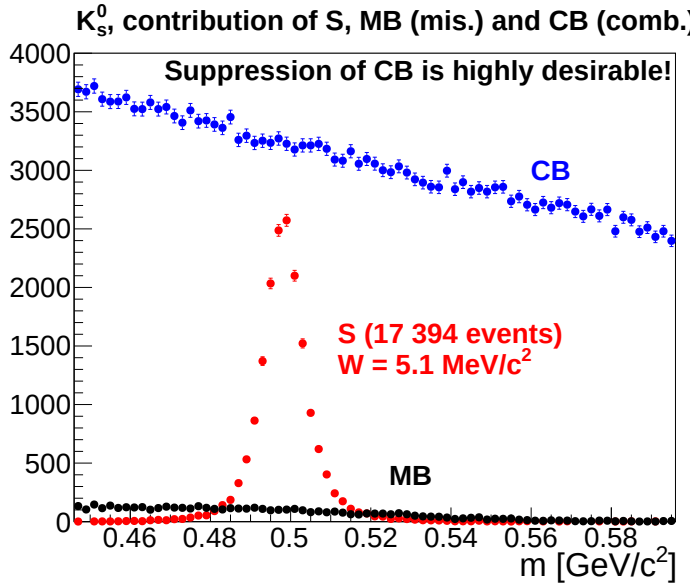


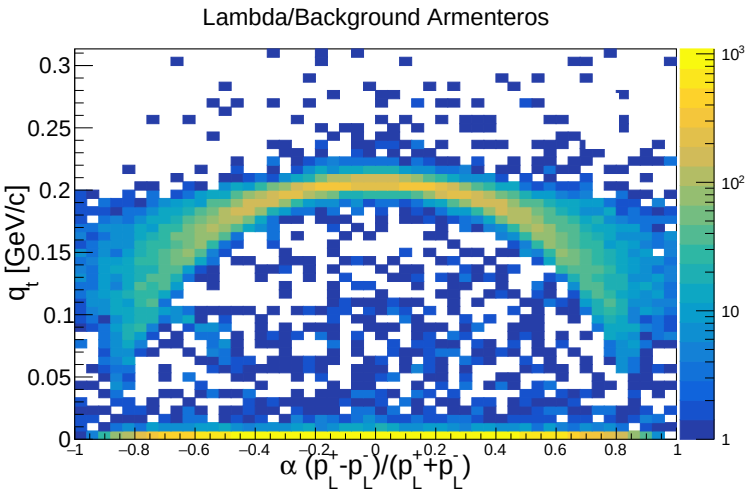


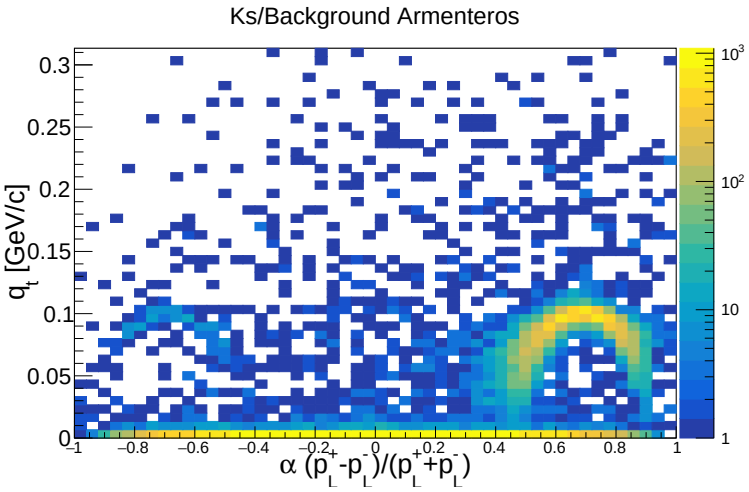


Contribution of MB (mis.) and CB (comb.)



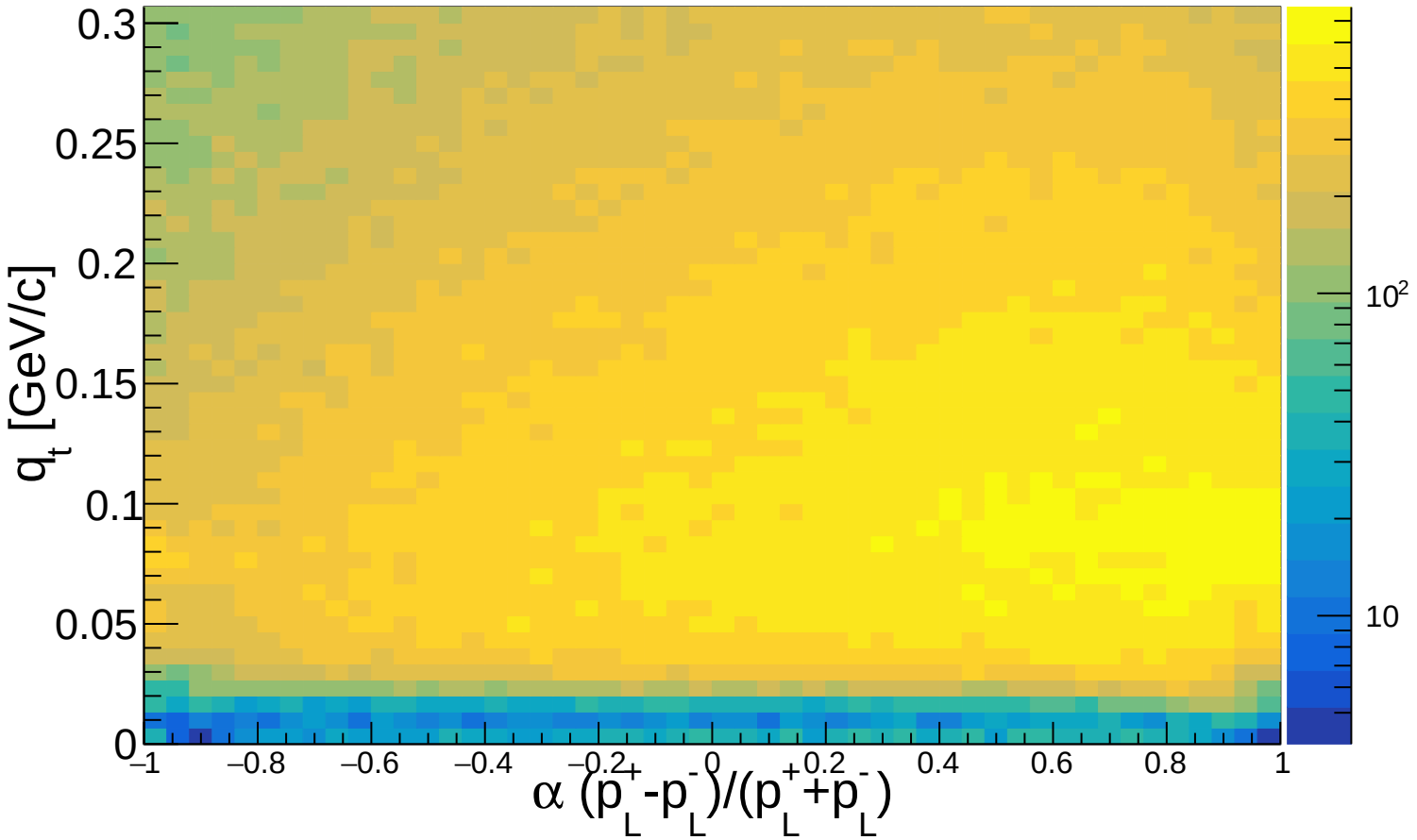






Use of such a simple PID hypo (assuming all particles as p and π^- depending on charge) will be improved with full PID selection

Contribution of CB (comb.) for Λ^0 candidates

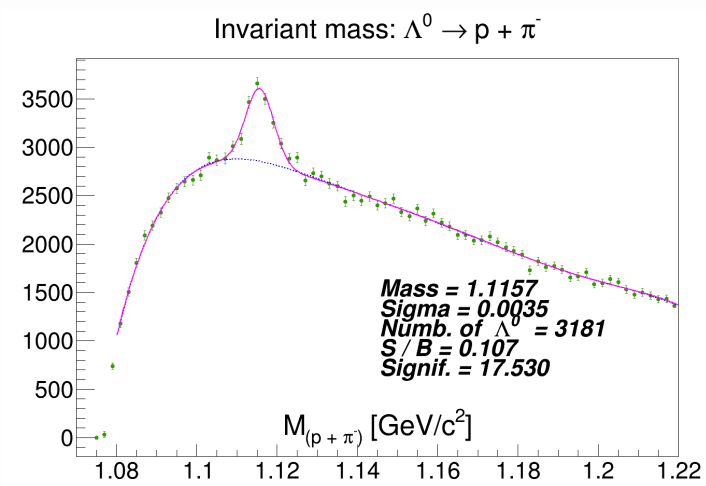


Combinatorial background does not reveal any structures (as should be and expected)

Instead of conclusion ...

- **The first version of finder is expected to be open for further development to be continued a.s.a.p.**
- **Experience of colleagues from the CBM collaboration is planned to be used (BM@N & MPD & CBM synergy)**

BM@N, run of 2018, Ar + X



If I were using KFParticle, could I get it better? So, there is a nice chance to check it!

- **Obtained results on Λ^0 and K_s^0 look promising thus motivating development of software**

Instead of conclusion ...

- Set of possible decays to be searched for is planned to be extended
- Possibility to use output in physical analysis (flow, femto ...)
- Manuals, examples and so on ....

Thank you for your attention!

Temporary page!

LaTeX was unable to guess the total number of pages correctly
was some unprocessed data that should have been added to th
page this extra page has been added to receive it.
If you rerun the document (without altering it) this surplus pa
away, because LaTeX now knows how many pages to expect fo
document.