MPD PWG2 status report

Vadim Kolesnikov

(VBLHEP, JINR)

on behalf of the group

MPD Collaboration meeting
Belgrade, Serbia, October 03-05, 2023

Outline

- **Introduction : PWG2 tasks**
- **Progress in a new round of feasibility study with Bi+Bi at 9.2 GeV :**
  - Light hadrons (prod. #25)
  - Hyperons (prod. #25)
  - Hyperon polarization (prod. #30)
  - Hypenuclei and light nuclei (prod. #29)
- **Summary**

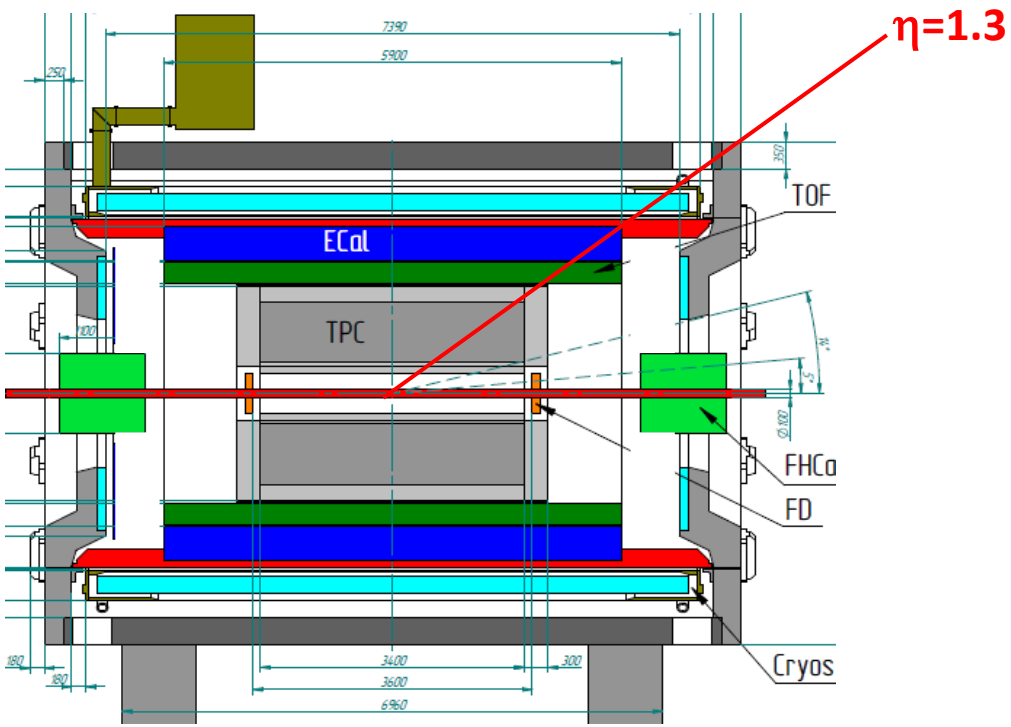
PWG2 co-conveners:

Xianglei Zhu (Tsinghua Univ., China) *zhux@tsinghua.edu.cn*
Vadim Kolesnikov (JINR, Dubna, Russia) *Vadim.Kolesnikov@cern.ch*

PWG2 physics cases

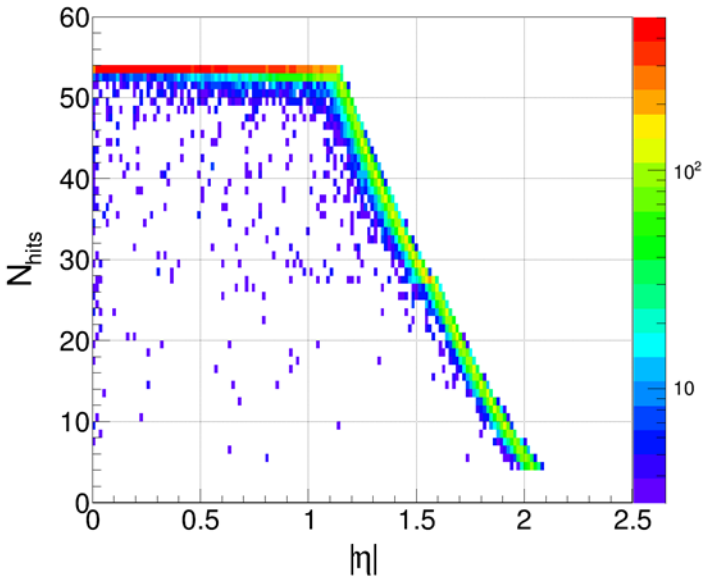
- **Light flavor hadron spectra, yields, and ratios**
  - Energy, system size and centrality dependence of the production of charged hadrons (pions, kaons, (anti)protons).
  - Extraction of transverse momentum spectra, rapidity distributions, mean multiplicities, and particle ratios.
  - Nuclear modification factor, antiparticle/particle ratio, radial flow, phase diagram mapping.
- **Strangeness (hyperons and hypernuclei)**
  - Analysis of strange hyperons (Lambda, Ksi, Omega) and their antiparticles: spectra, yields, antiparticle/particle ratio, nuclear modification factor, azimuthal anisotropy (together with PWG3).
  - (Anti)Lambda polarization.
  - Reconstruction of single and double hypernuclei: spectra, rapidity density, and lifetime.
- **Resonances**
  - Production of \rho, \phi, Kstar, Lambda(1520) etc.
- **Light nuclei**
  - Production of nucleon clusters (d, t, He3, He4) in various reactions (from p+p to Au+Au): spectra, yields, coalescence coefficients.

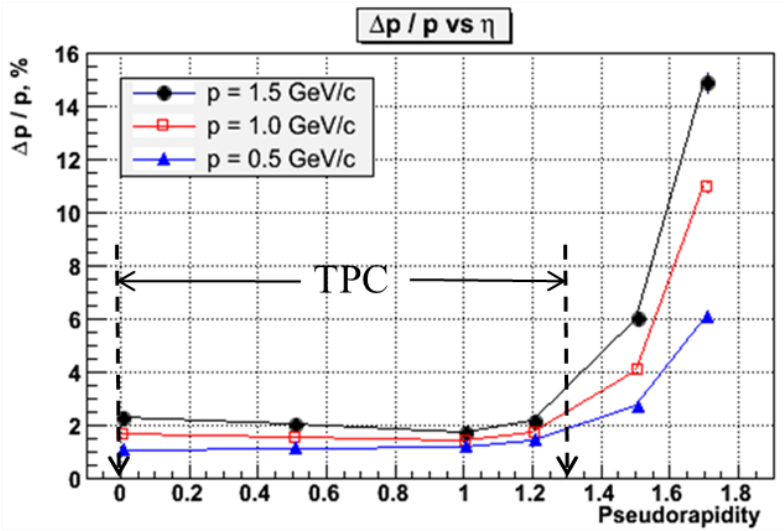
MPD setup and overall performance



MPD at Stage'1:

- ***TPC*** *tracking:* $|\eta|<1.6$ *(Npoints>15)*
- ***TOF & ECAL*** *coverage:* $|\eta|<1.3$
- ***PID****: TOF+dE/dx combined* $|\eta|<1.3$*, pT<3 GeV/c, limited PID* $1.3<|\eta|<1.6$ *(dE/dx)*



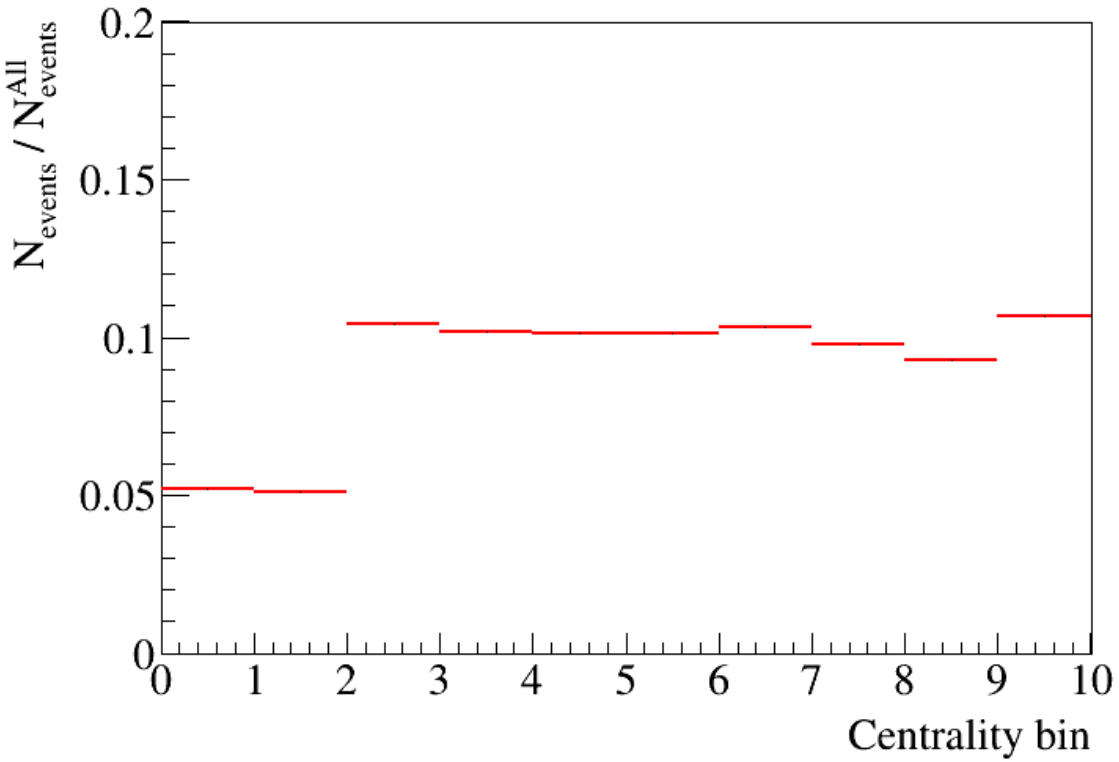


Hadrons in Bi+Bi at 9.2 GeV

A.Mudrokh

Goal: rapidity & pT-spectra, total yields and ratios of identified hadrons (π, K, p) in centrality selected Bi+Bi

- Production #25 : 50M of UrQMD events
- Centrality selection (5-10% binning) implemented in the centrality wagon (P.Parfenov)

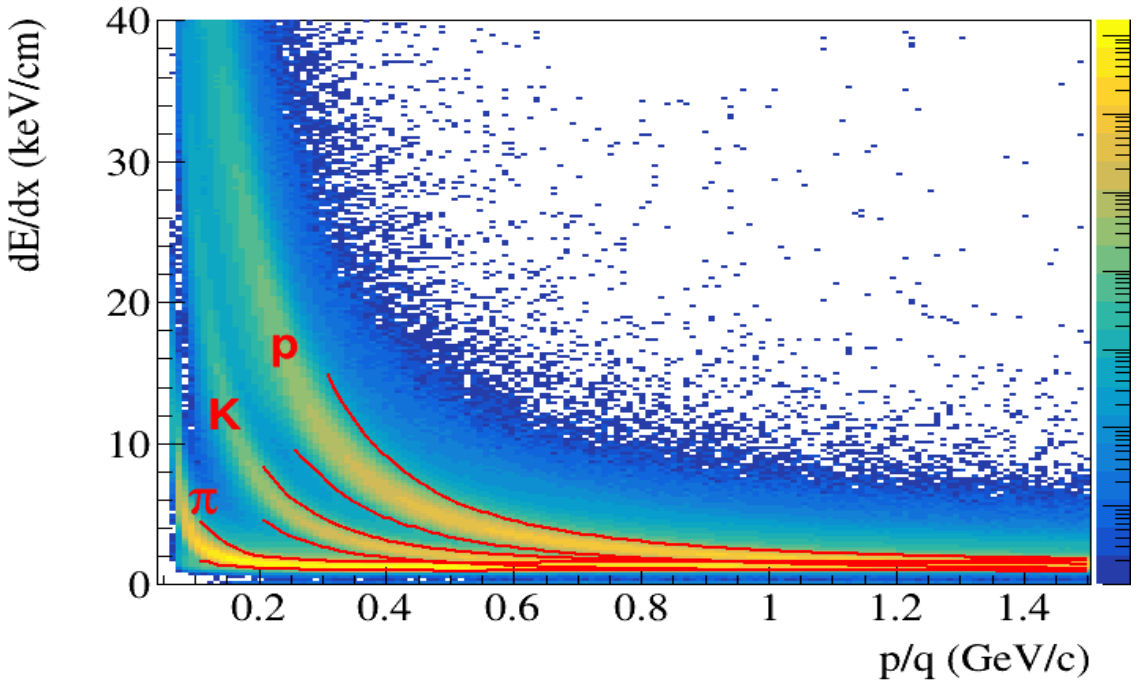


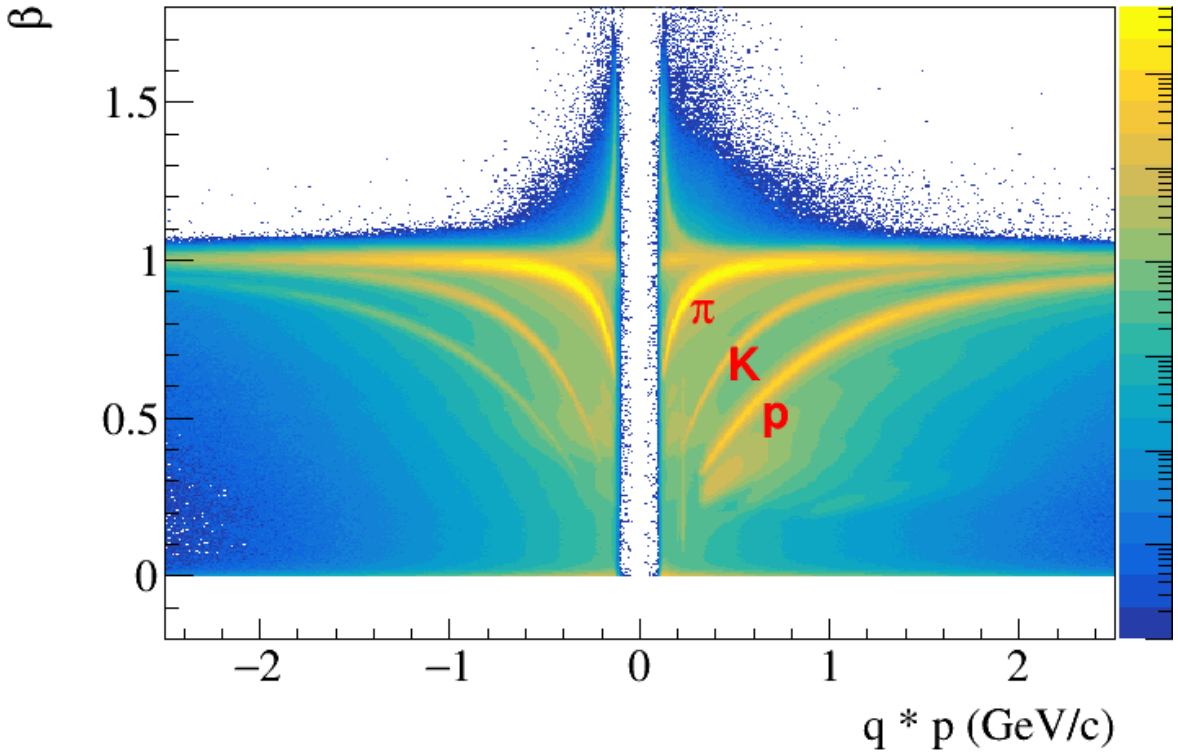
Vertex & track selection criteria:

- Cut on vertex Z coordinate: | Vz | < 100 cm
- Number of hits on a track: Nhits ≥ 20
- DCAs at the Main vertex: | $DCA_{X,Y,Z}$ | < 3 cm

Hadron in Bi+Bi at 9.2 GeV: PID

- Combined PID dE/dx+TOF, n-sigma method, PID parameterization from V.Riabov

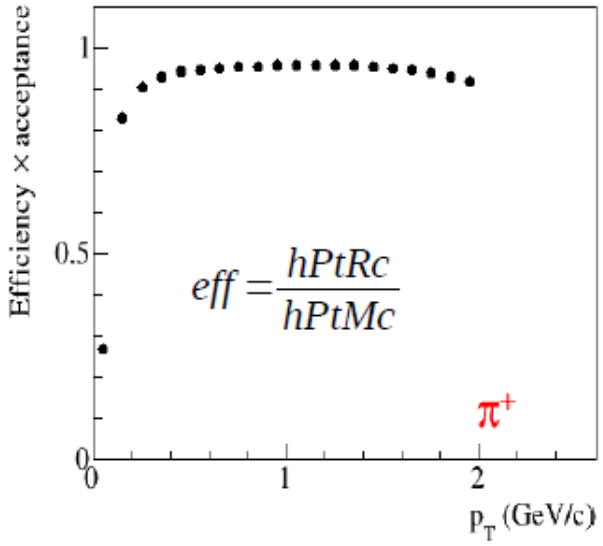


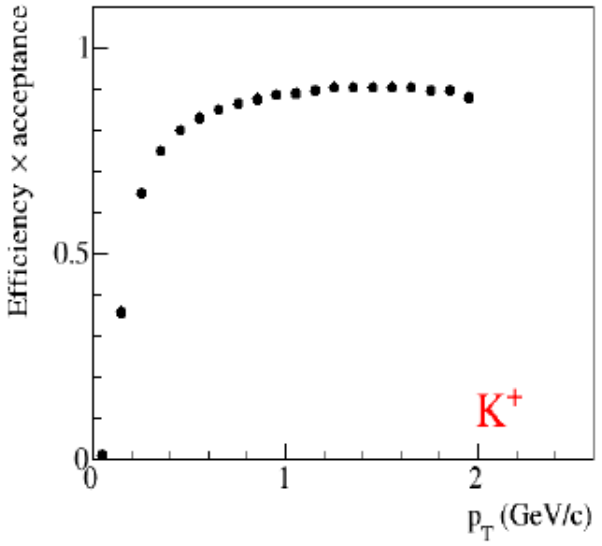


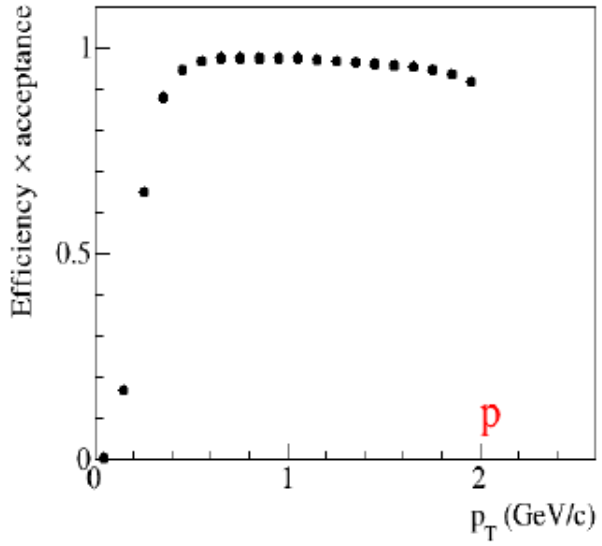
Req. #25

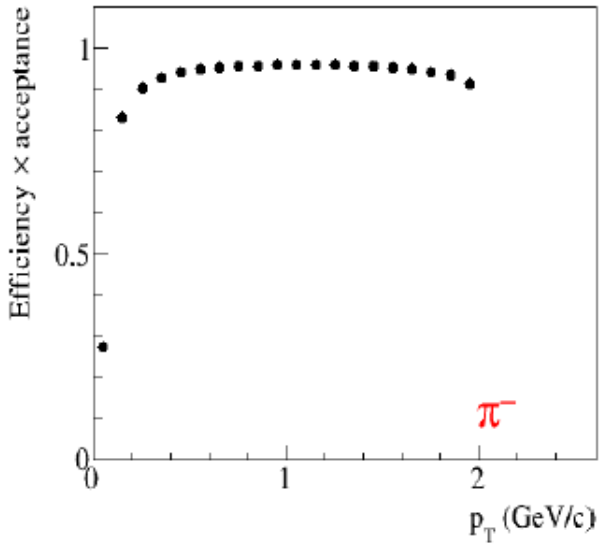
MPD efficiency: TPC efficiency

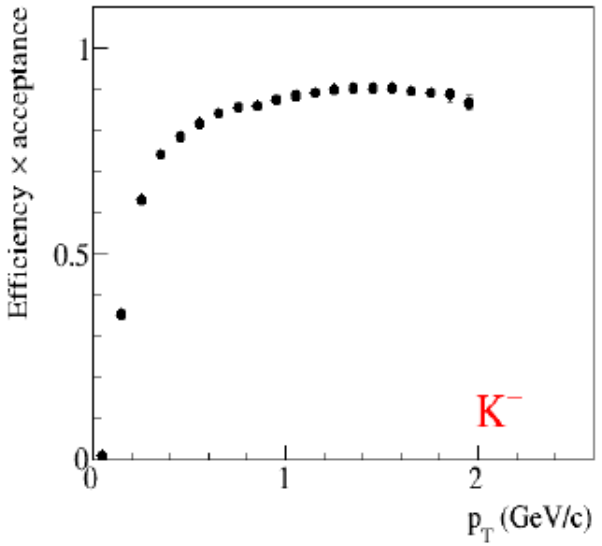
0 – 5%









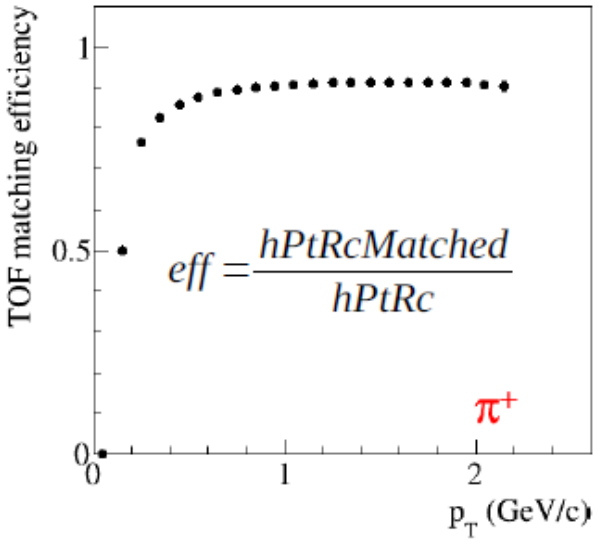


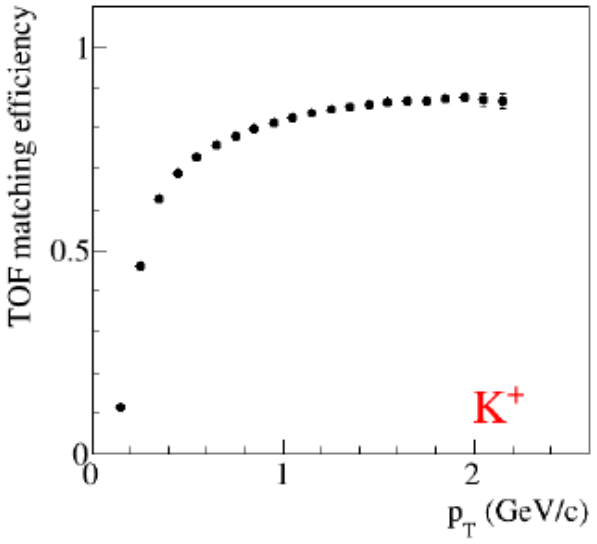
- hPtMc: counting number of generated MC tracks within a given rapidity / centrality bin
- hPtRc: counting number of reconstructed primary tracks within the same rapidity / centrality bin
- Ideal PID via MC is used

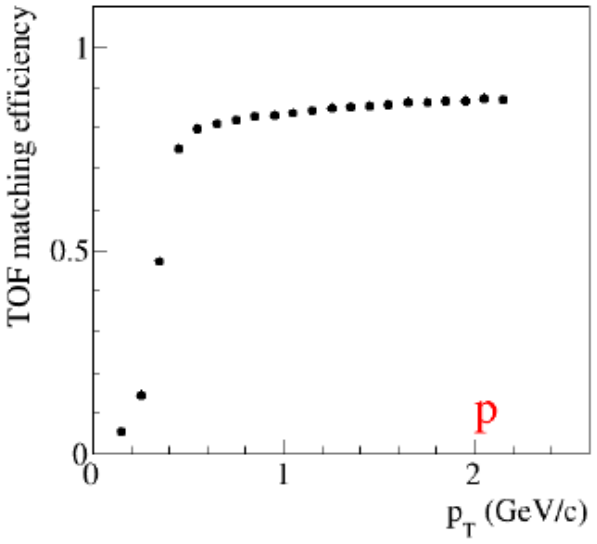
TOF efficiency

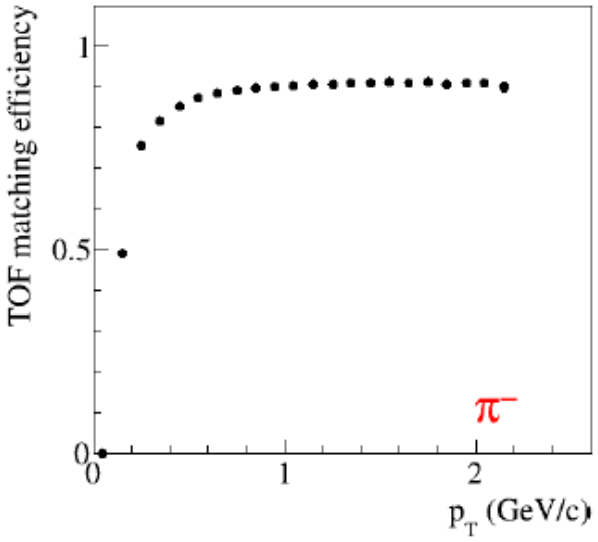
Req. #25

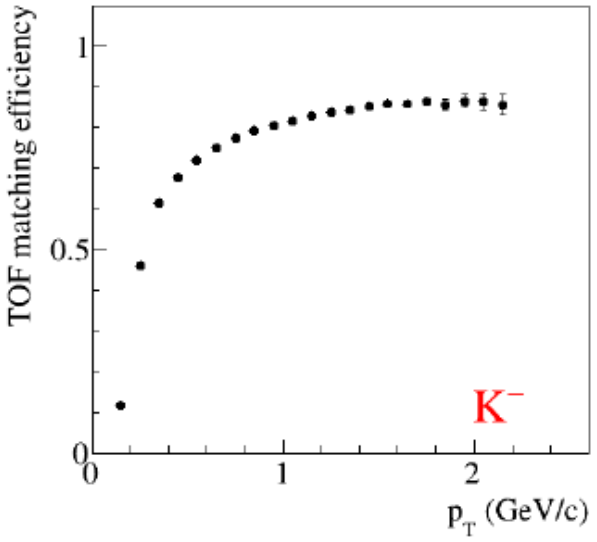
0 – 5%





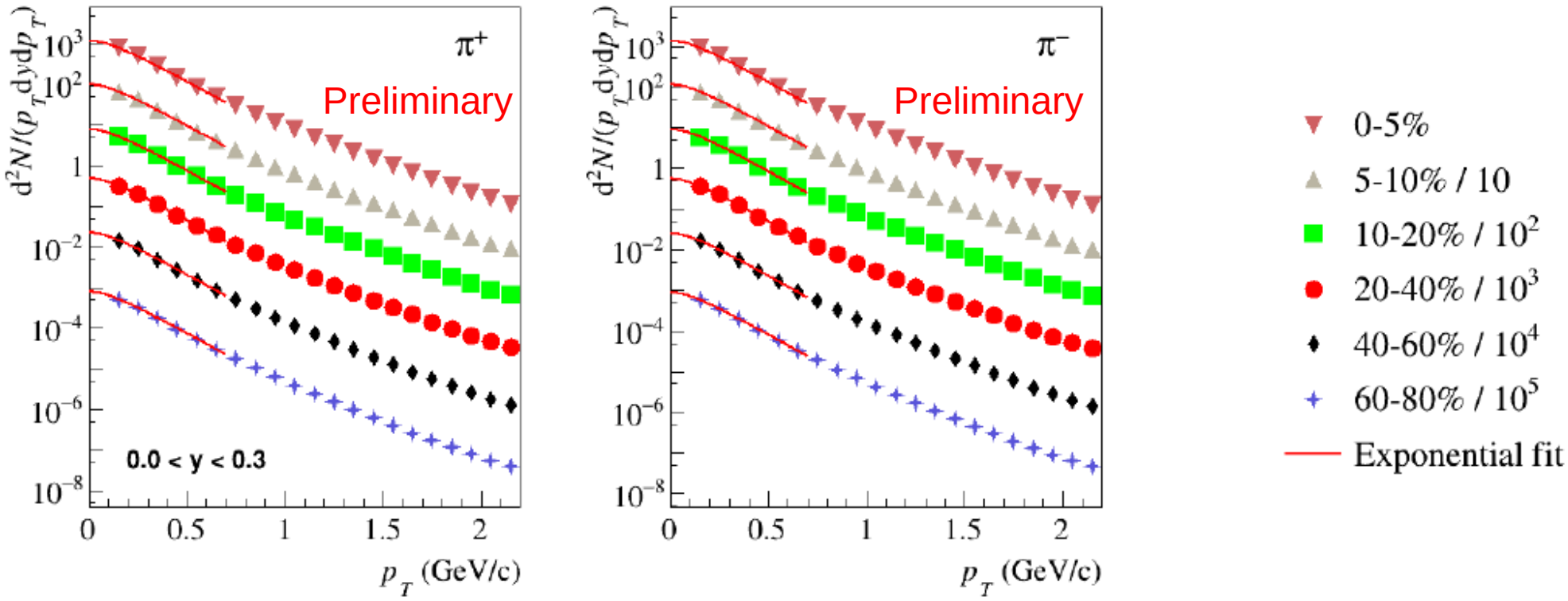






- hPtRc: counting number of reconstructed primary tracks within rapidity / centrality bin passed through the track selection criteria
- hPtRcMatched: counting how many of them have point in TOF
- Ideal PID via MC is used

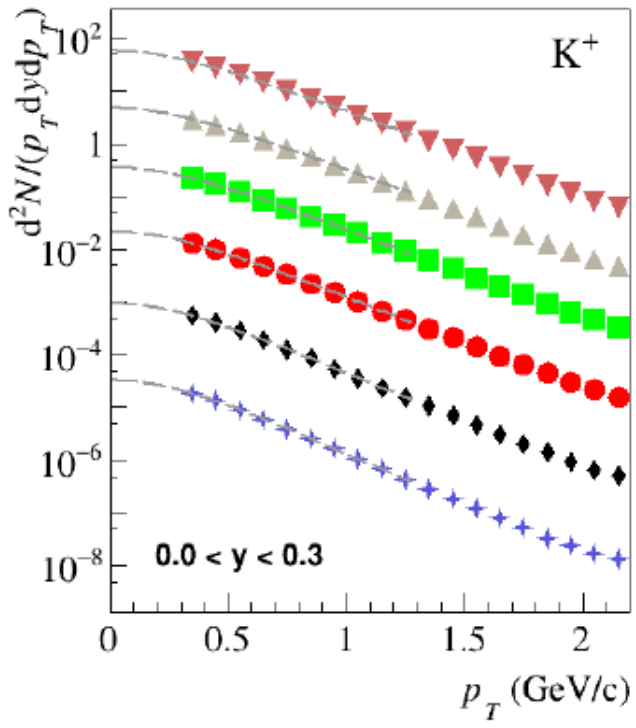
Midrapidity pT-spectra of identified hadrons in centrality bins

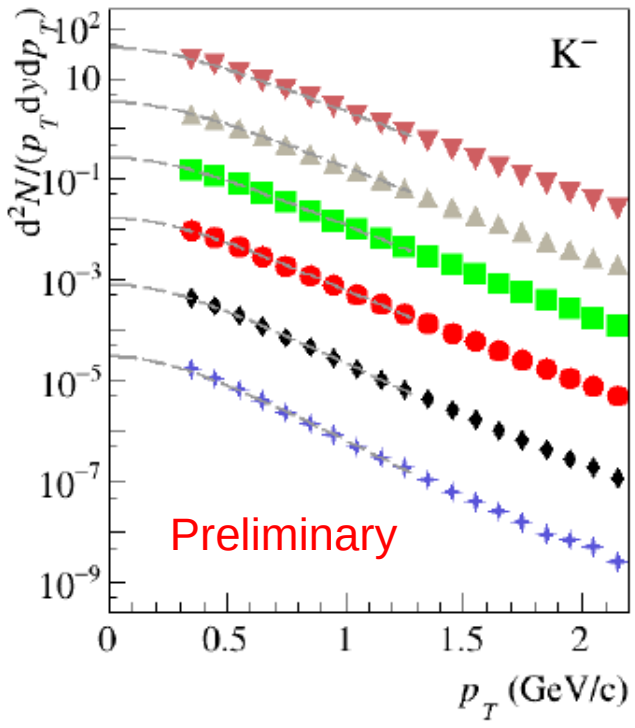


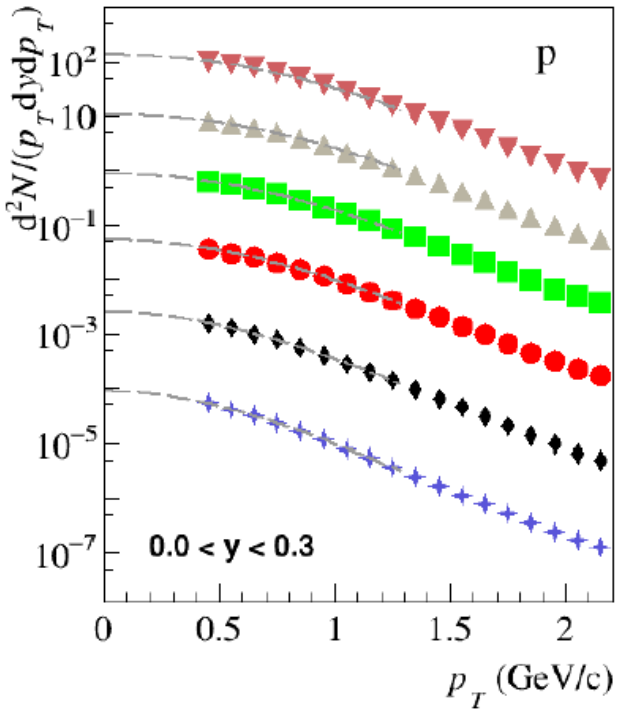
Functions used to fit spectra are m_T-exponential :

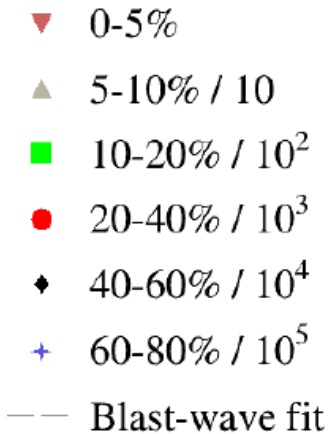
$$\frac{1}{p_T}\times\frac{d^2N}{dy\,dp_T}=\frac{dN/dy}{T(m+T)}\cdot\exp\left(-\frac{m_T-m}{T}\right)$$

Midrapidity pT-spectra of identified hadrons in centrality bins







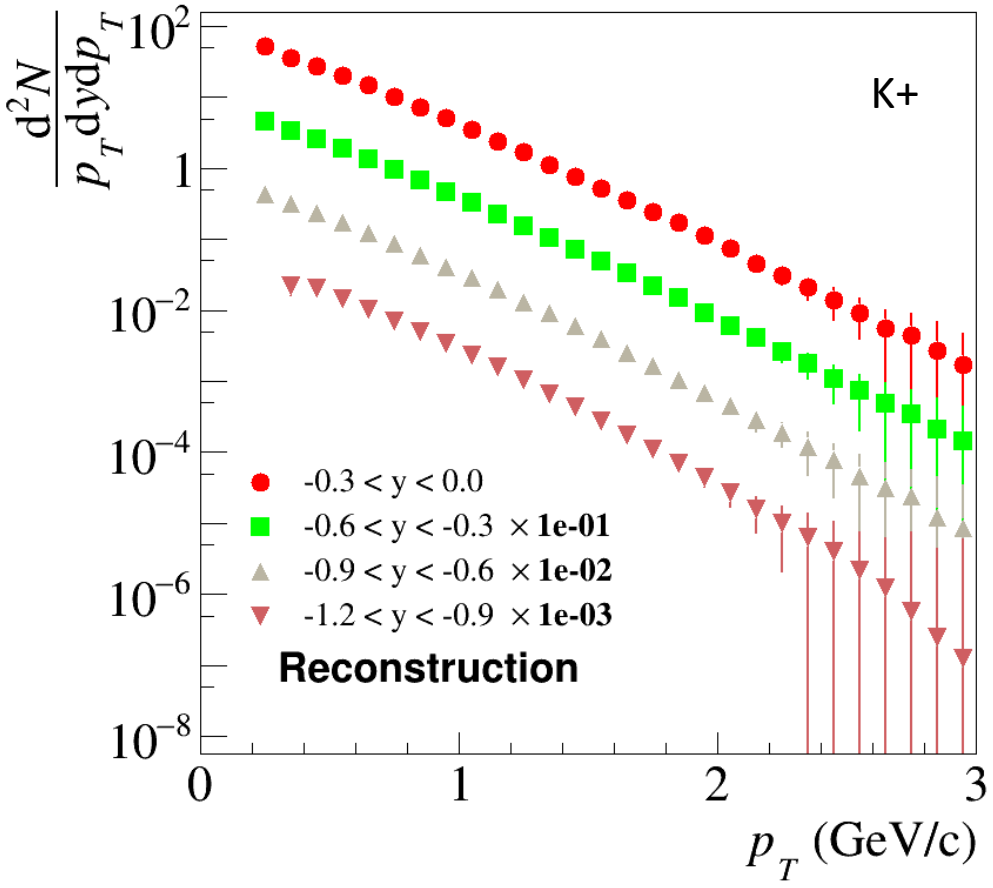


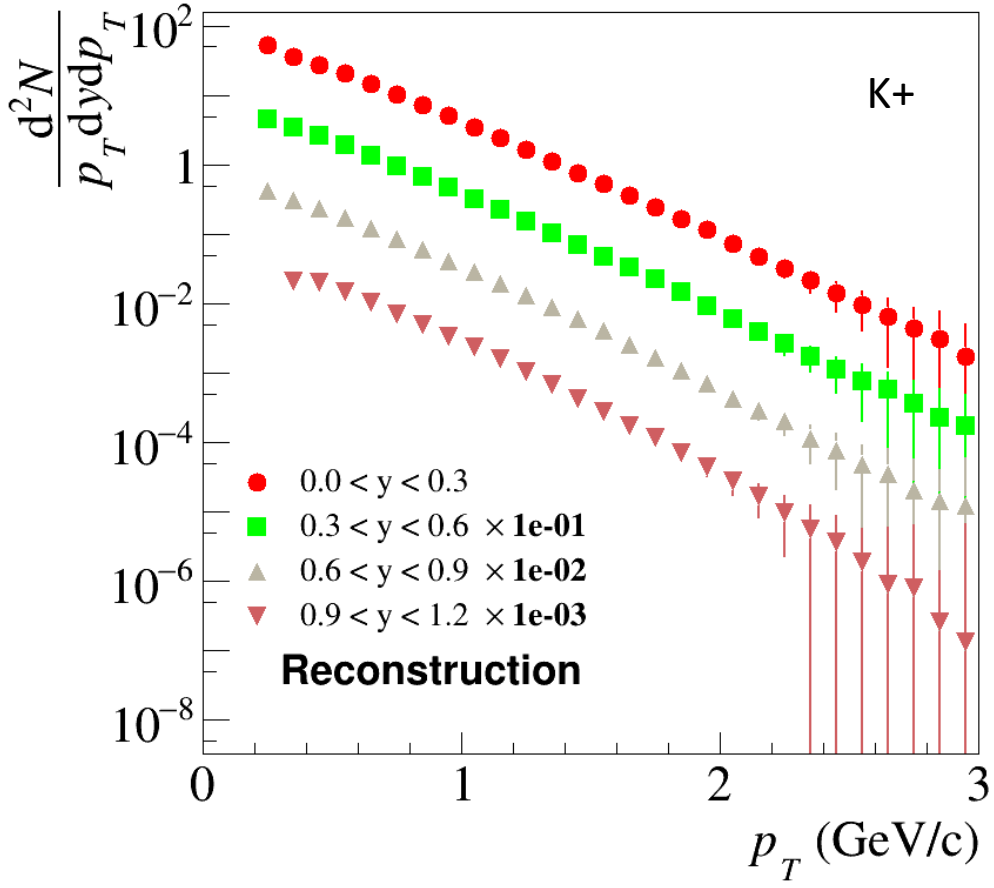
Functions used to fit spectra are blast-wave:

$$\frac{d^2N}{p_t dp_t dy} = C\int_0^1 p_t f(\xi) K_1\left(\frac{m_t \cosh(\rho)}{T}\right) I_0\left(\frac{p_t \sinh(\rho)}{T}\right) \xi\, d\xi$$

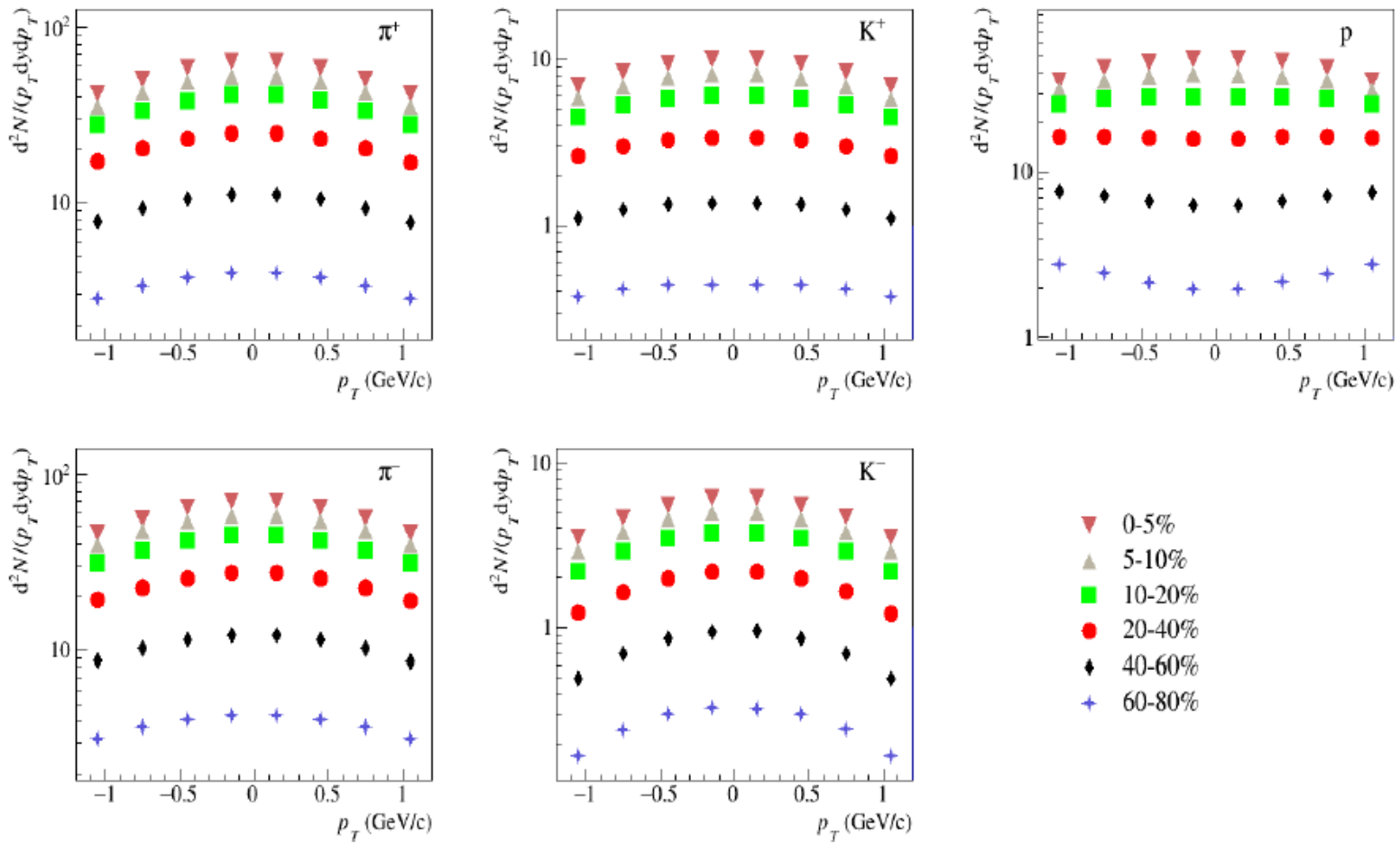
Hadrons in Bi+Bi at 9.2 GeV: K^+ spectra in rapidity bins

0 – 5% centrality bin





Rapidity spectra of identified hadrons



To Do:

- Finalizing corrections
- Finishing wagon for the spectra analysis

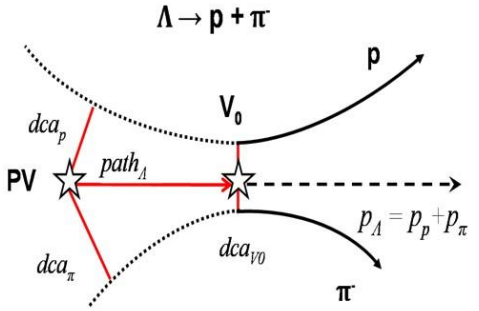
The p_T-integrated particle yield dN/dy is carried out from the p_T spectra using efficiency corrected data in the measured p_T ranges and extrapolation to the low- and high-p_T regions (up to 5 GeV/c).

Status of hyperon reconstruction in Bi+Bi at 9.2 GeV

(request #25)

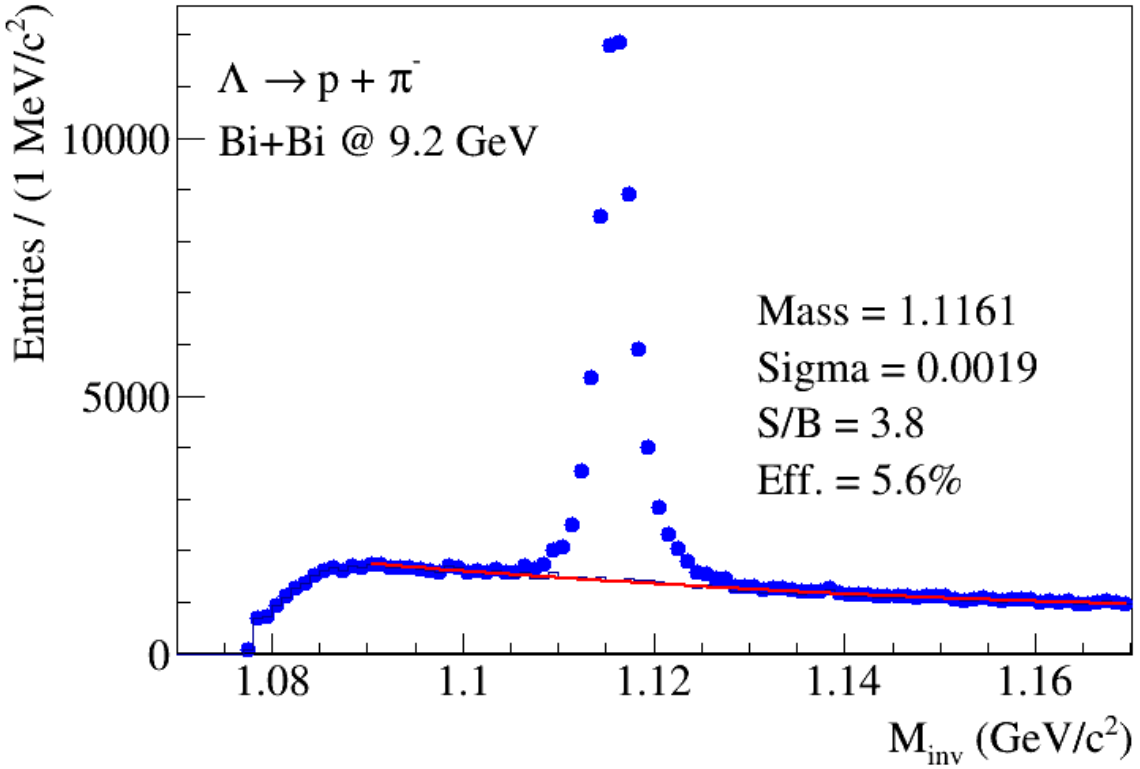
Λ-hyperon reconstruction in MPD

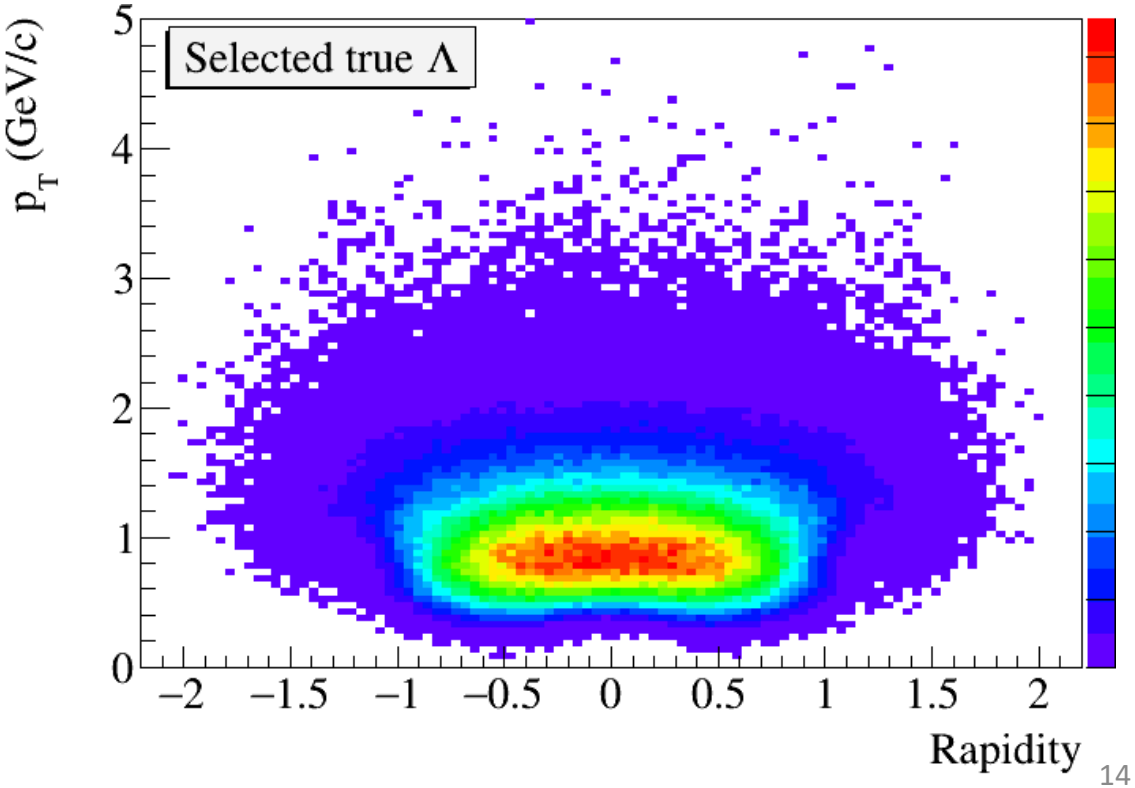
V.Vasendina, D.Suvarieva, A.Zinchenko



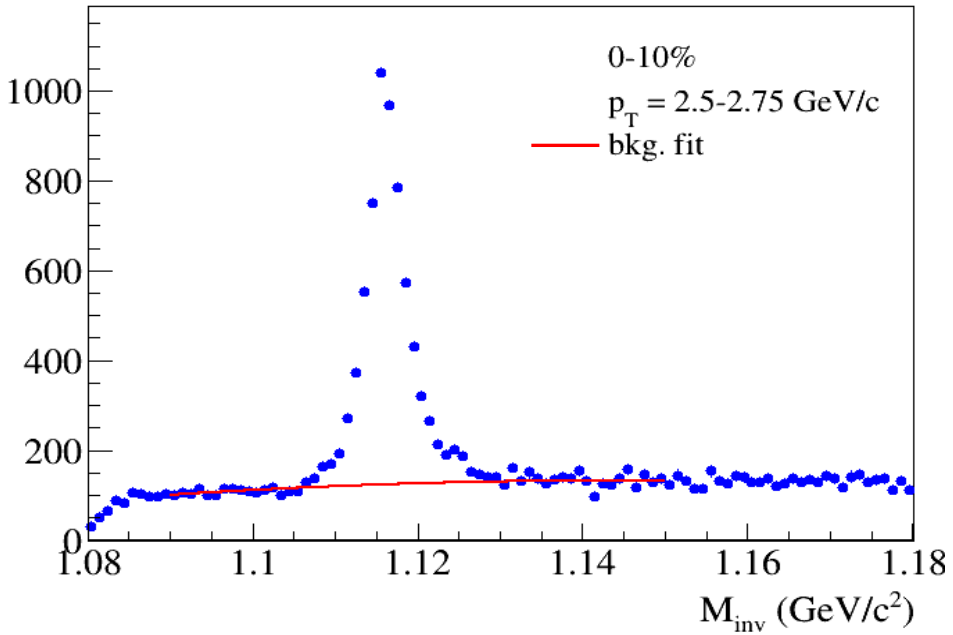
- ✓ **Data set:** Bi+Bi @ 9.2 GeV, 50M Min bias (UrQMD)
- ✓ **PID:** dE/dx+TOF
- ✓ **Selection:** $|y| < 0.5$, $Z_{PV} = \pm 130$ cm
- ✓ **Centrality bins:** TPC multiplicity 0-10%,10-20%,20-40%,40-60%, 60-80%
- ✓ **Hyperon reco**: Secondary vertex finding technique with a set of topological cuts

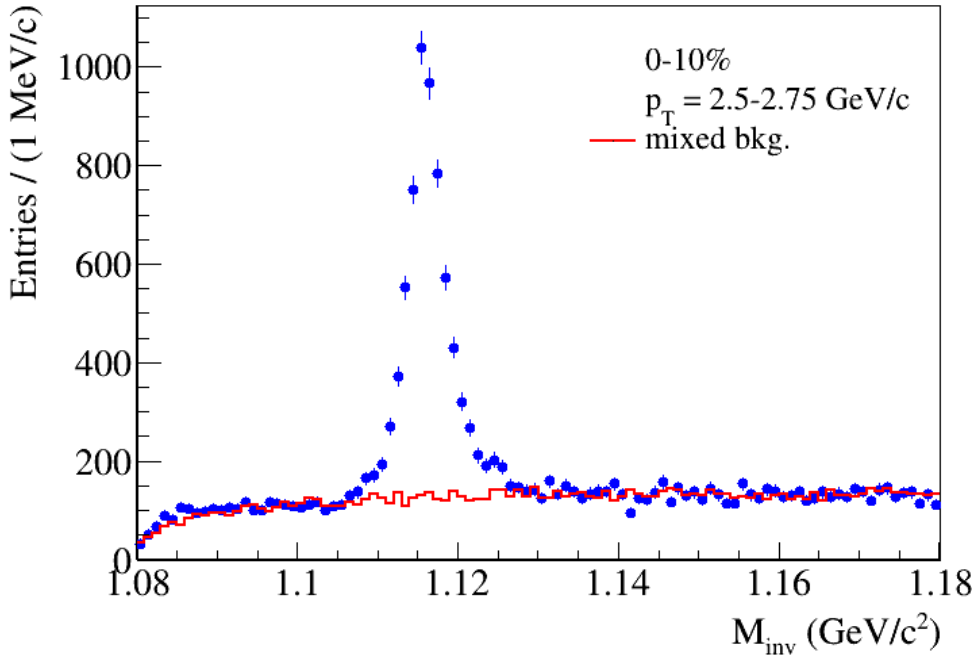
***PV** - primary vertex*
***V0** - vertex of decay*
***dca-** distance of closest approach*
***path** – decay length*

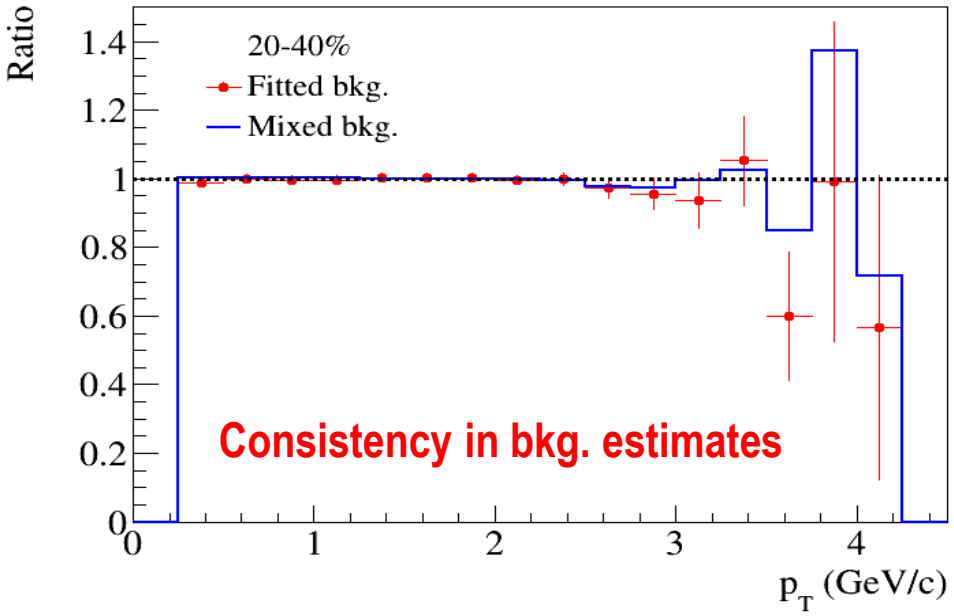




Λ-hyperon reconstruction in MPD: background estimates



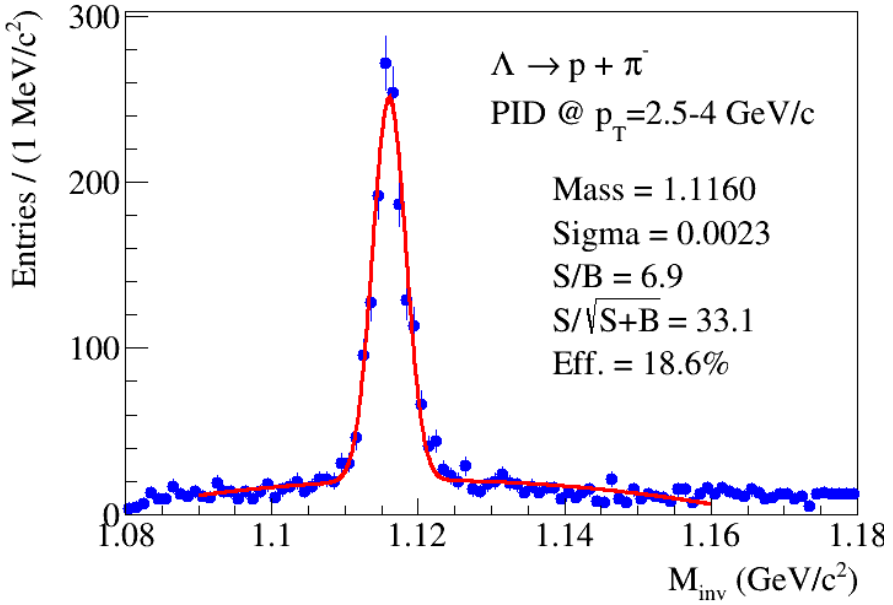


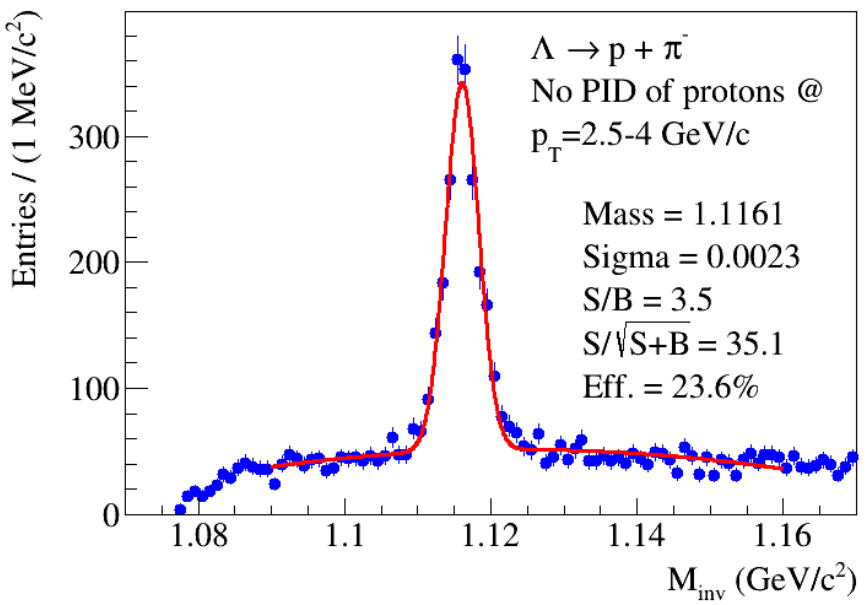


Study of systematic uncertainties and improvements in the analysis chain:

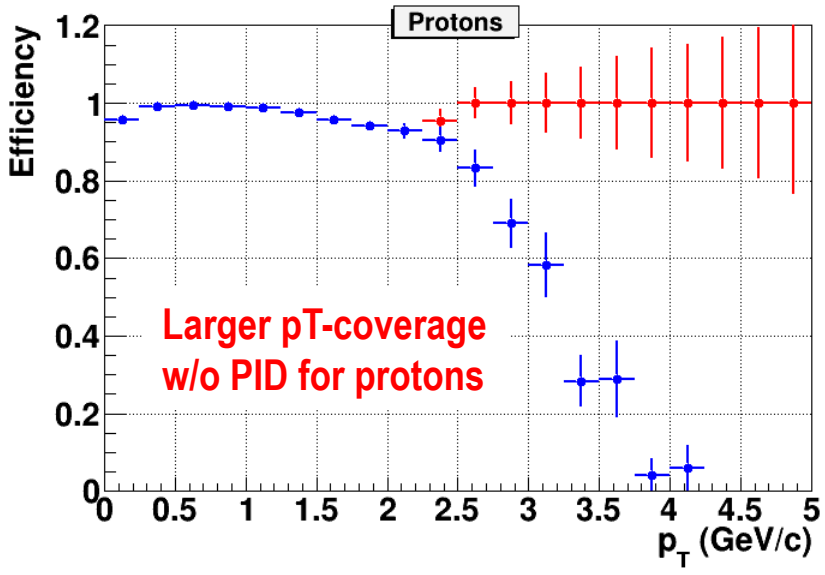
- Background estimates (fit vs. mixed background)
- Varying PID modes for high-pT protons

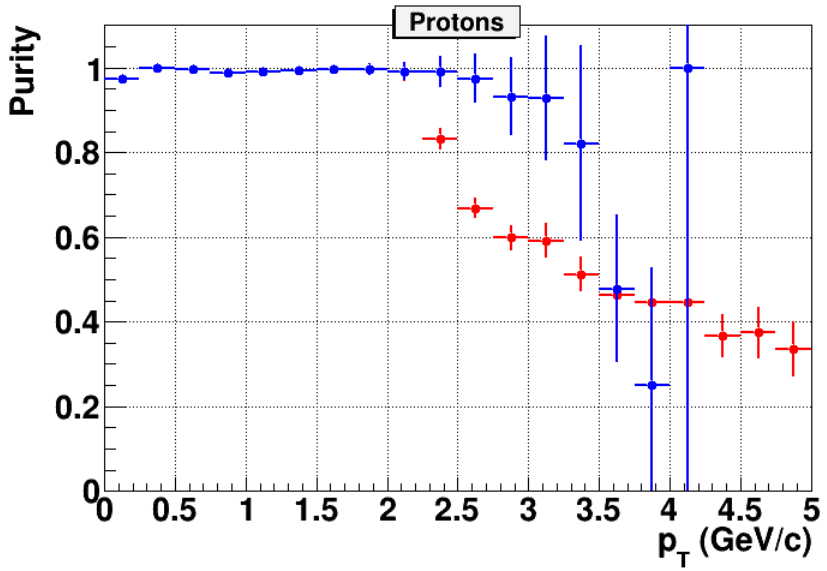
Λ-hyperon reconstruction at high pT: PID vs pairing of all charge(+1) hadrons



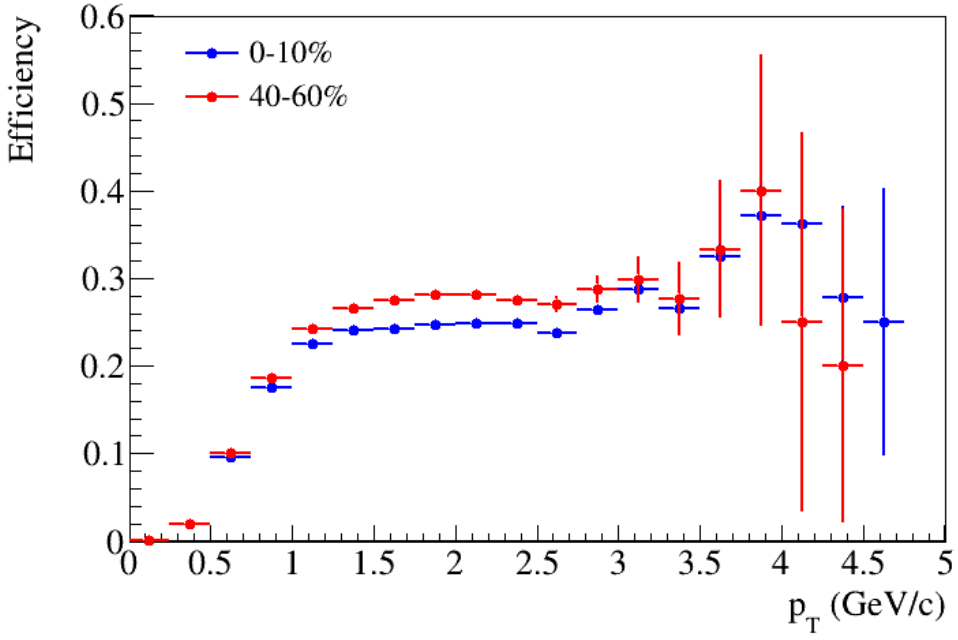


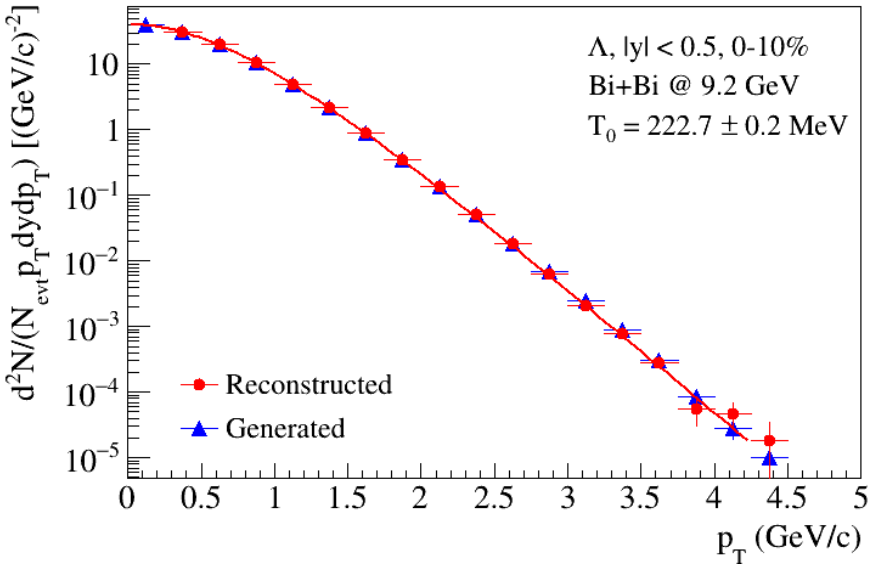
- ~40% gain in the efficiency
- Moderate drop in S/B w/o loosing fit quality

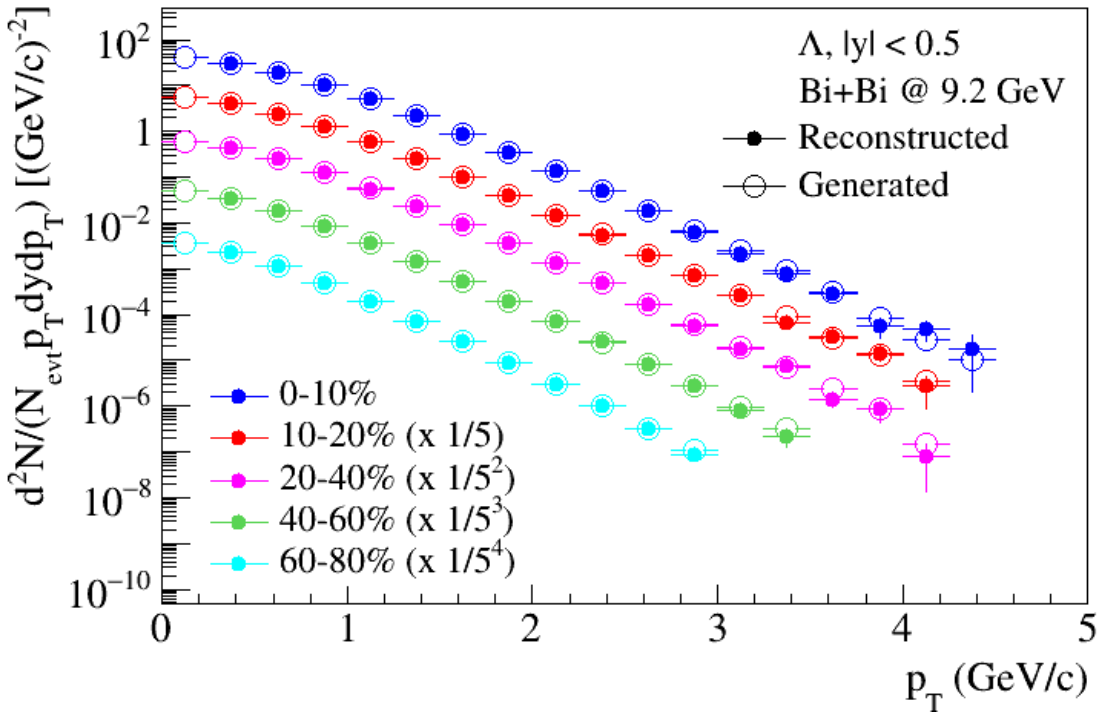




Λ analysis results: fully corrected invariant pT-spectra in centrality bins

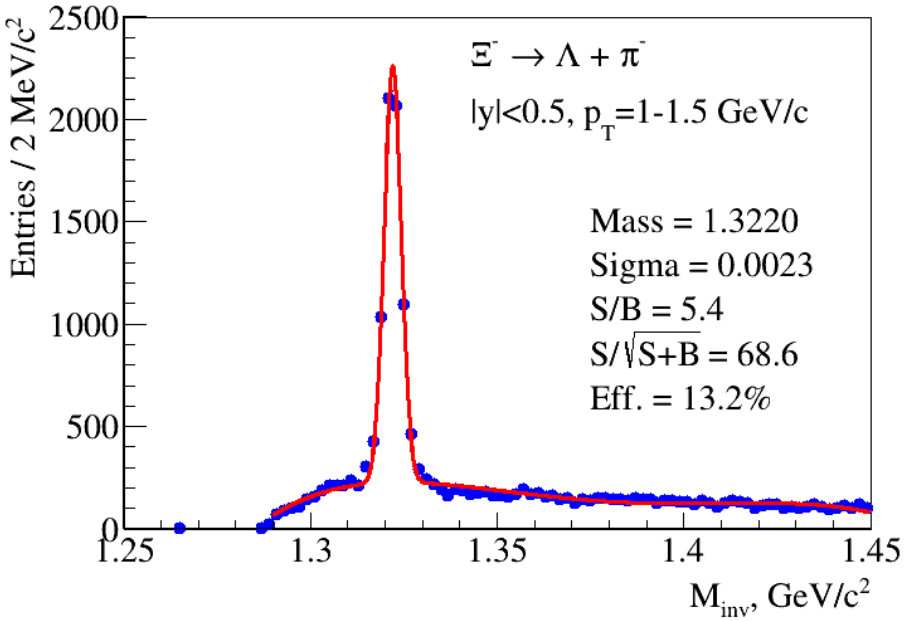


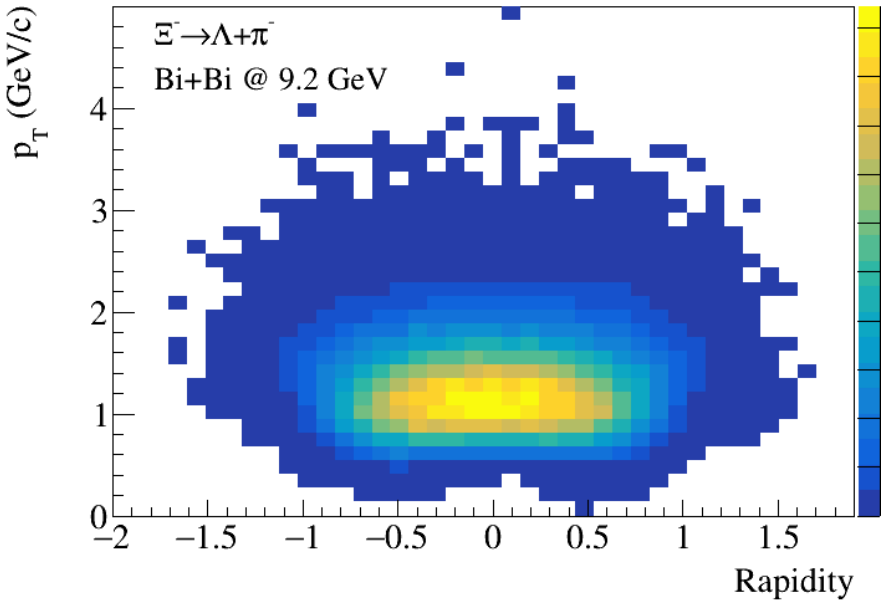




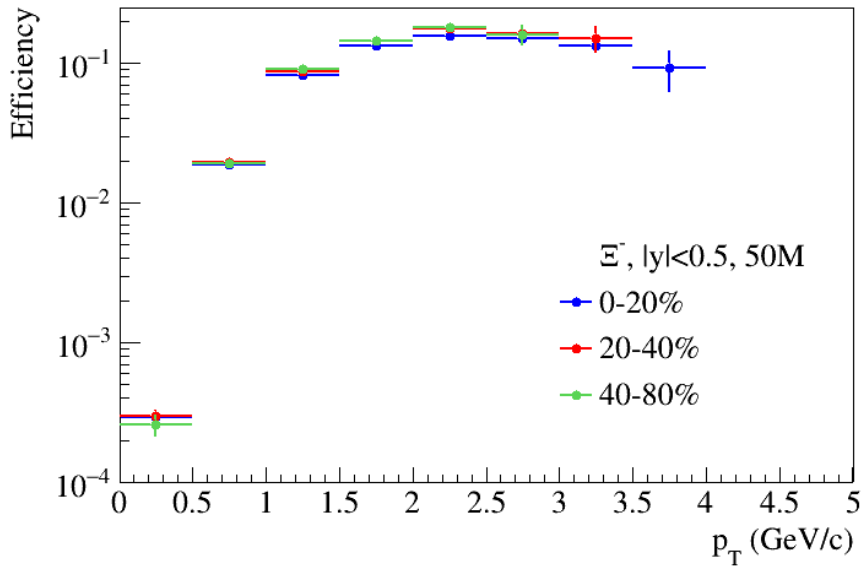
- Invariant pT-spectra of Lambda are reconstructed in several centrality bins
- Reconstructed distributions are consistent with data from model
- Thermal fits applied to data

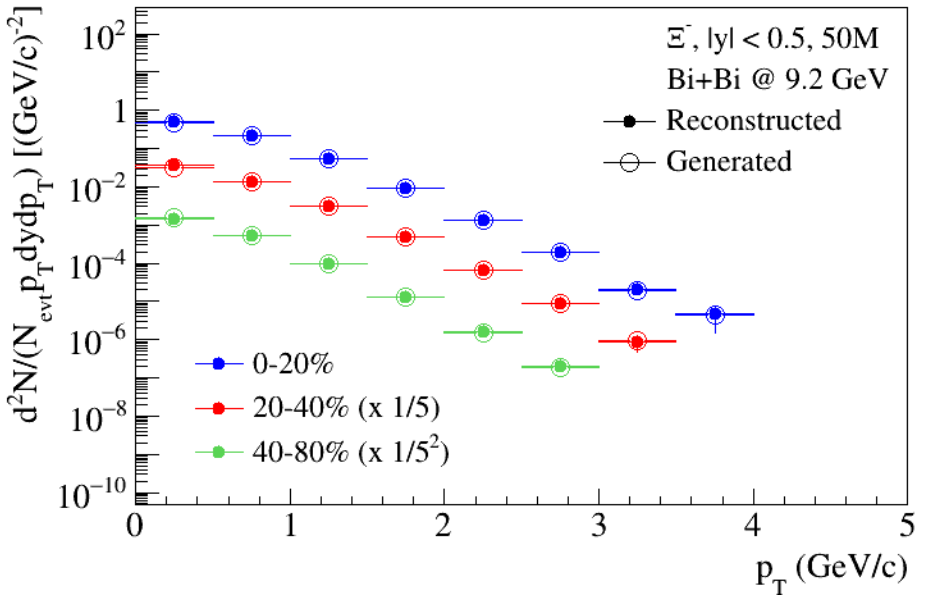
Ξ analysis: efficiency, phase-space and spectra in centrality bins





- **Good phase-space coverage for Ξ in MPD**
- **Analysis is ongoing**

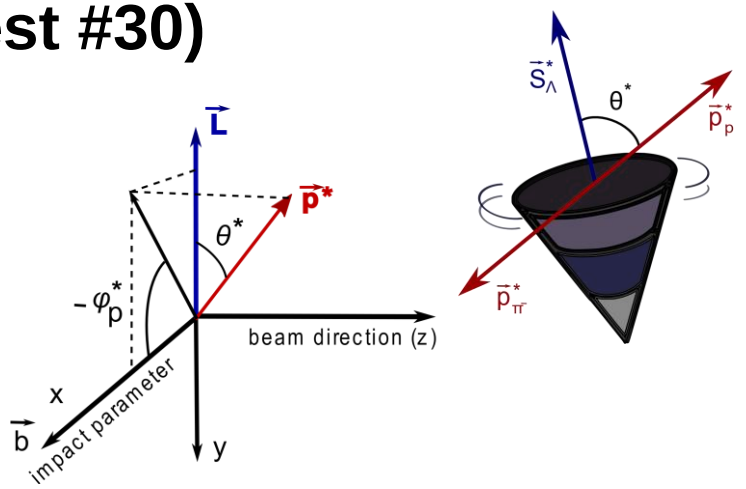




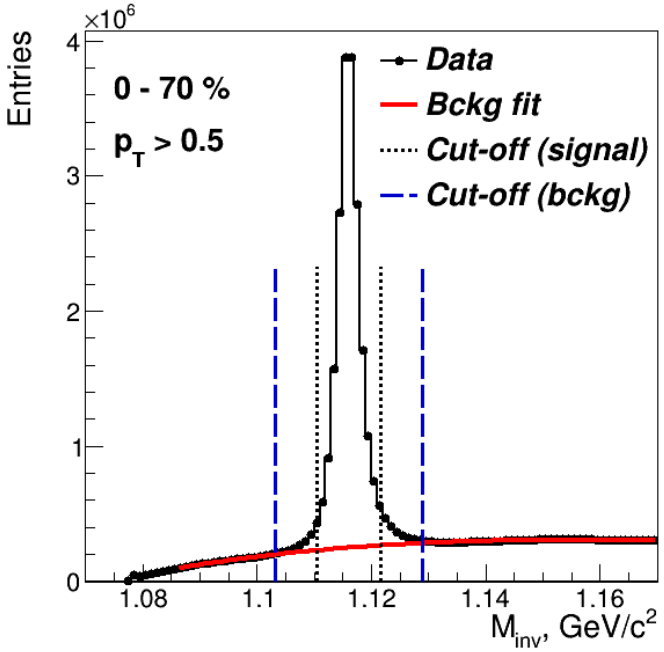
Global hyperon polarization @ NICA/MPD (request #30)

E.Nazarova

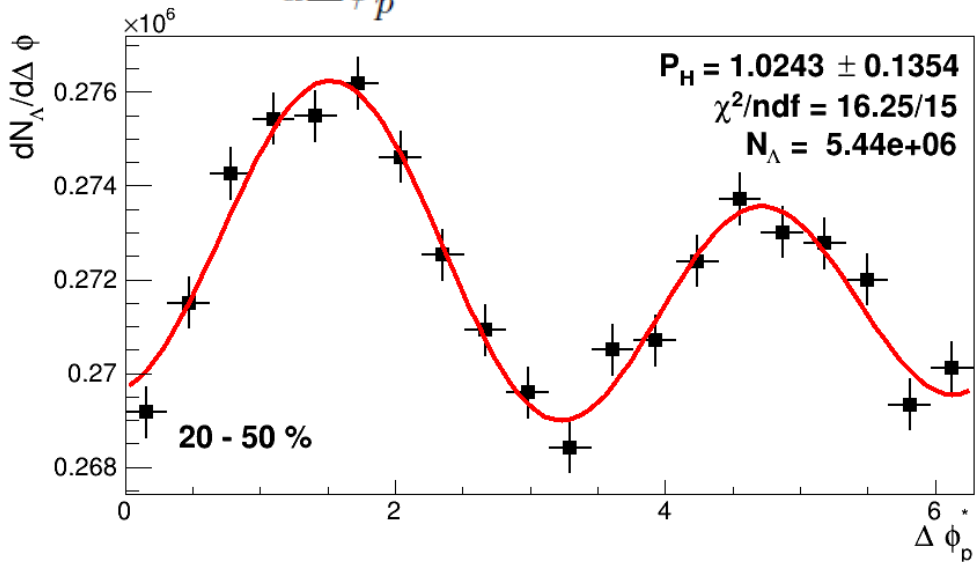
- Bi-Bi @ 9.2GeV, 15M MB events, b [0,12] fm (PHSD)
- Global hyperon polarization implemented in the model
- Centrality determined through TPC multiplicity
- Event plane reconstructed using FHCal
- Analysis implemented/structured as a MPD wagon
- Paper draft is under review

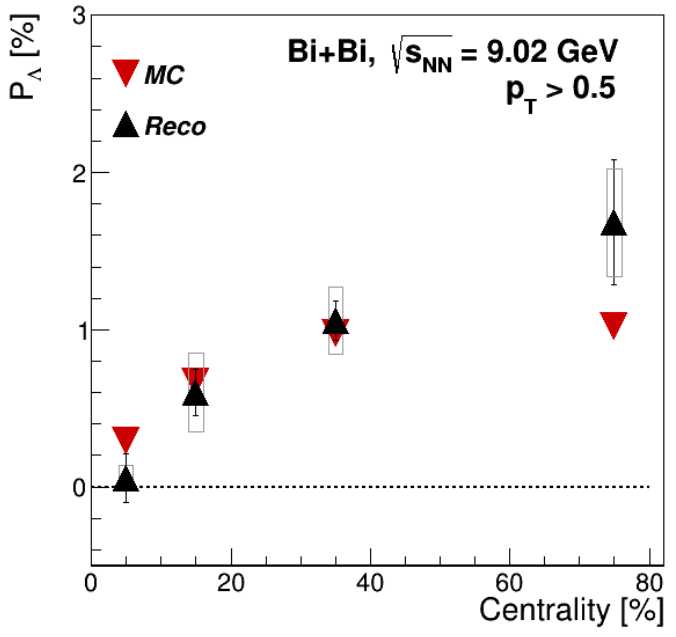


$$\overline{P}_{\Lambda/\bar{\Lambda}} = \frac{8}{\pi\alpha}\frac{1}{R^1_{\mathrm{EP}}}\left\langle \sin(\Psi^1_{\mathrm{EP}} - \phi^*_p)\right\rangle$$



$$\frac{\mathrm{d}N_\Lambda}{\mathrm{d}\Delta\phi^*_p} = p_0(1 + 2p_1\sin(\Delta\phi^*_p)$$





Production #29 (PHQMD model)

V.Kireyeu

- 20M events from the PHQMD event generator for (hyper)nuclei

Wagons:

- "evCentrality" – for the centrality selection via charged particles in the TPC.
- "evPID" – for the deuterons selection via the "N-Sigma" method for the TPC dE/dx information.
- "Nuclei" – dE/dx and phase-space plots for light nuclei (only deuterons for a while), under development.

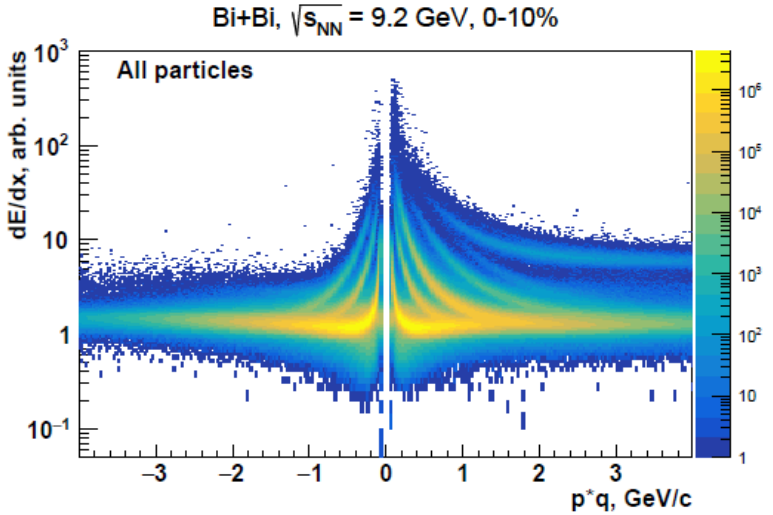
Event cuts:

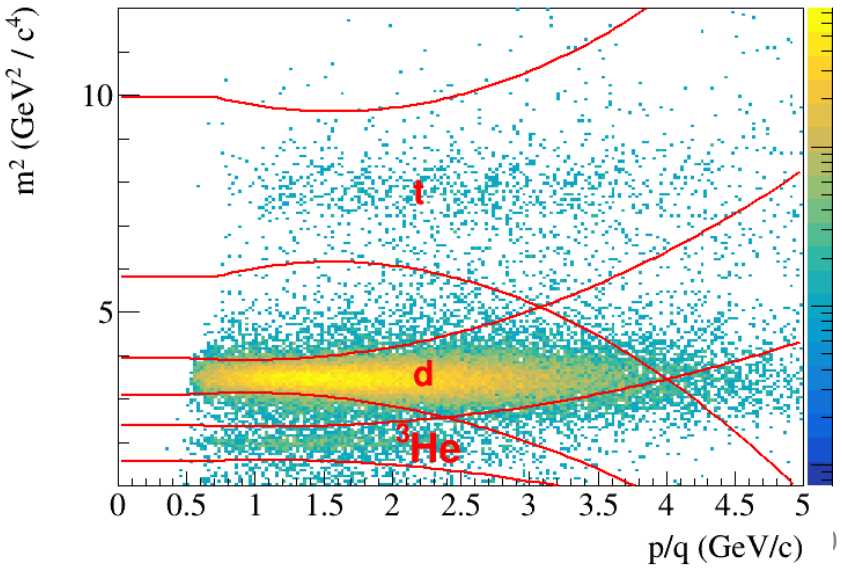
- Primary vertex exists
- Primary vertex is reconstructed ($! = 0$)
- Primary vertex $Z < 130$ cm

Track cuts:

- $N_{hits} > 10$
- $|p_T| > 50$ MeV/c
- $|DCA_{x,y,z}| < 2.0$

Additional momentum cut for the Bethe-Bloch fits case (not wagon-PID): $P > 0.2$ for deuterons and $P > 0.4$ for He^4.





Publication activities and conferences

- Not as active as before (geopolitical constrains and switch to centralized data analysis scheme)
- Only several publications/proceedings from conferences in Russia
- Needs to be improved in future

Summary

- Analysis of several new productions has started within PWG2
  - Prod. 25 (UrQMD) will the base for hadron and hyperon studies
  - Prod. 29 (PHQMD) for (hyper)nuclei
  - Prod. 30 (PHSD) dedicated to (anti)Lambda-hyperon polarization studies
- The rate of the progress is steady increased

Thank you for your attention!