Event reconstruction status

Alexander Zinchenko

Outline

- TPC fast digitizer
- TPC cluster finder
- Track reconstruction
- Application of machine learning for PID
- Hyperon reconstruction (background from event mixing)
- Machine learning at MPD
- Tracking in the end-cap region

TPC fast digitizer

HSE team

Eur. Phys. J. C (2021) 81:599
https://doi.org/10.1140/epjc/s10052-021-09366-4

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Regular Article - Experimental Physics

Simulating the time projection chamber responses at the MPD detector using generative adversarial networks

A. Maevskiy, F. Ratnikov, A. Zinchenko, V. Riabov

arXiv:2203.16355v1 [physics.ins-det] 30 Mar 2022

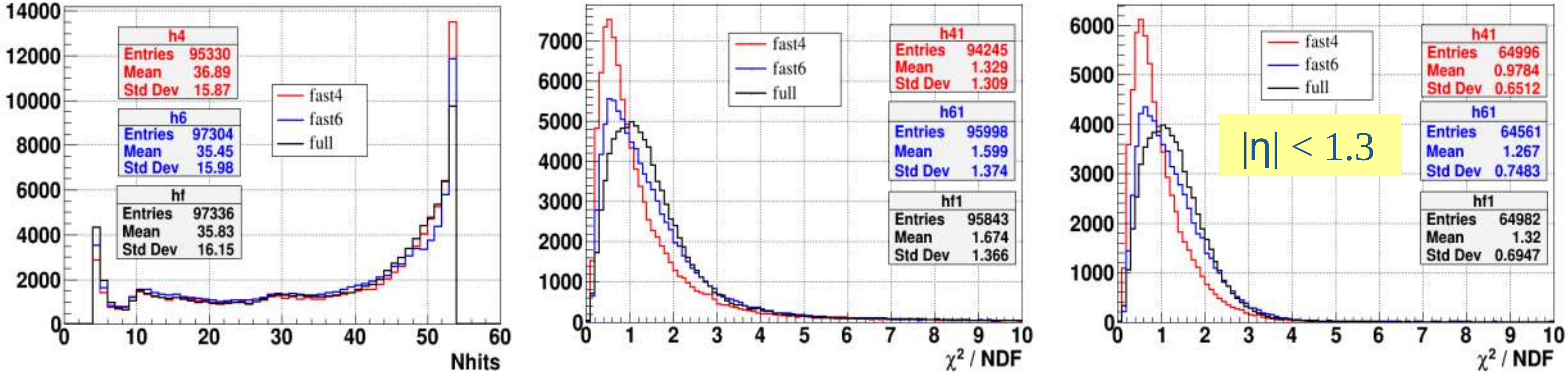
Generative Adversarial Networks for the fast simulation of the Time Projection Chamber responses at the MPD detector

A Maevskiy, F Ratnikov, A Zinchenko, V Riabov, A Sukhorosov and D Evdokimov

arXiv:2207.04340v1 [hep-ex] 9 Jul 2022

Generative Surrogates for Fast Simulation: TPC Case

TPC fast digitizer



Future steps:

- ❑ Add the 7 input track parameter;
- ❑ Generate signals for 3 (2) neighbor padrows (to account for correlations)

TPC cluster finder

Tasks: Two track separation (for femtoscopy) and cluster charge determination (for *dE/dx* identification)

Fresh ideas are welcome (Machine Learning?)

Track reconstruction: reconstructed track data members

Int_t fID; ///< trackID

Int_t fNhits; ///< number of hits (just for convenience of tree browsing)

TrackDir fTrackDir; ///< track direction (inward/outward)

TrackType fTrackType; ///< track type (kBarrel/kEndcap)

Int_t fLastLay; ///< the outermost layer number achieved

Int_t fNofWrong; ///< number of wrong hits (different from the track ID)

TString fNode; ///< node path (for local track parameters)

TString fNodeNew; ///< node path (for local track parameters)

Double32_t fPartID; ///< particle ID - dE/dx

Double32_t fPos; ///< current track radial position

Double32_t fPosNew; ///< propagated track radial position

Double32_t fPosAtHit; ///< radial position of outermost hit

Double32_t fChi2; ///< track Chi2

Double32_t fChi2Vertex; ///< track Chi2-distance to primary vertex

Double32_t fLength; ///< track length

Double32_t fLengAtHit; ///< track length at last hit

TMatrixD *fParam; ///< pointer to track parameter matrix (5x1)

TMatrixD *fParamAtHit; ///< pointer to track parameter matrix at last hit

TMatrixDSym *fCovar; ///< pointer to covariance matrix (15)

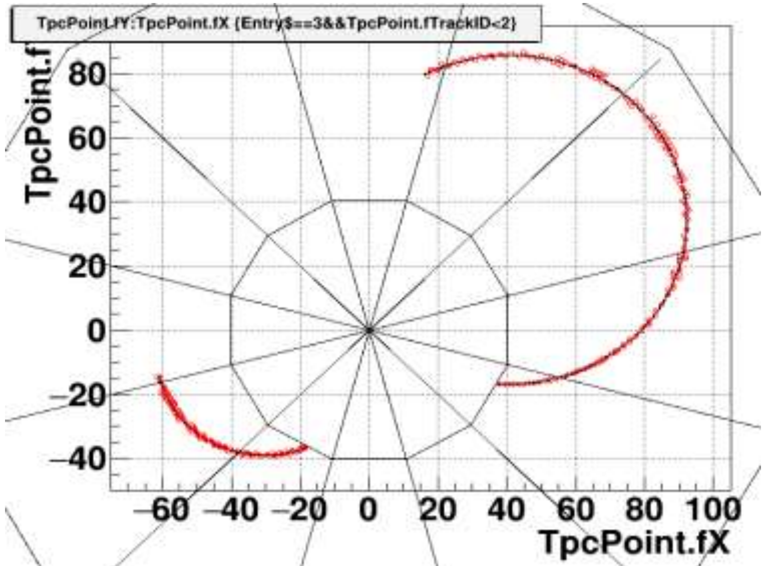
TMatrixDSym *fWeightAtHit; ///< pointer to weight matrix at last hit

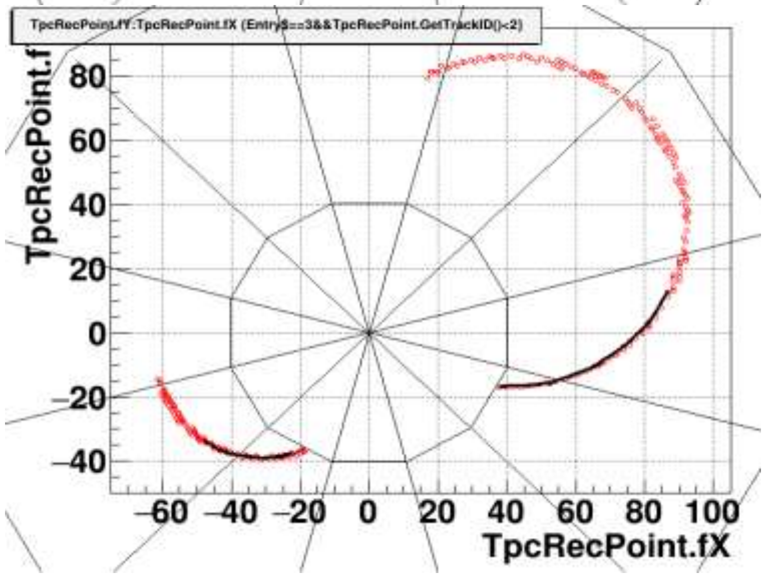
TVector3 fVertex; ///< track vertex – not used

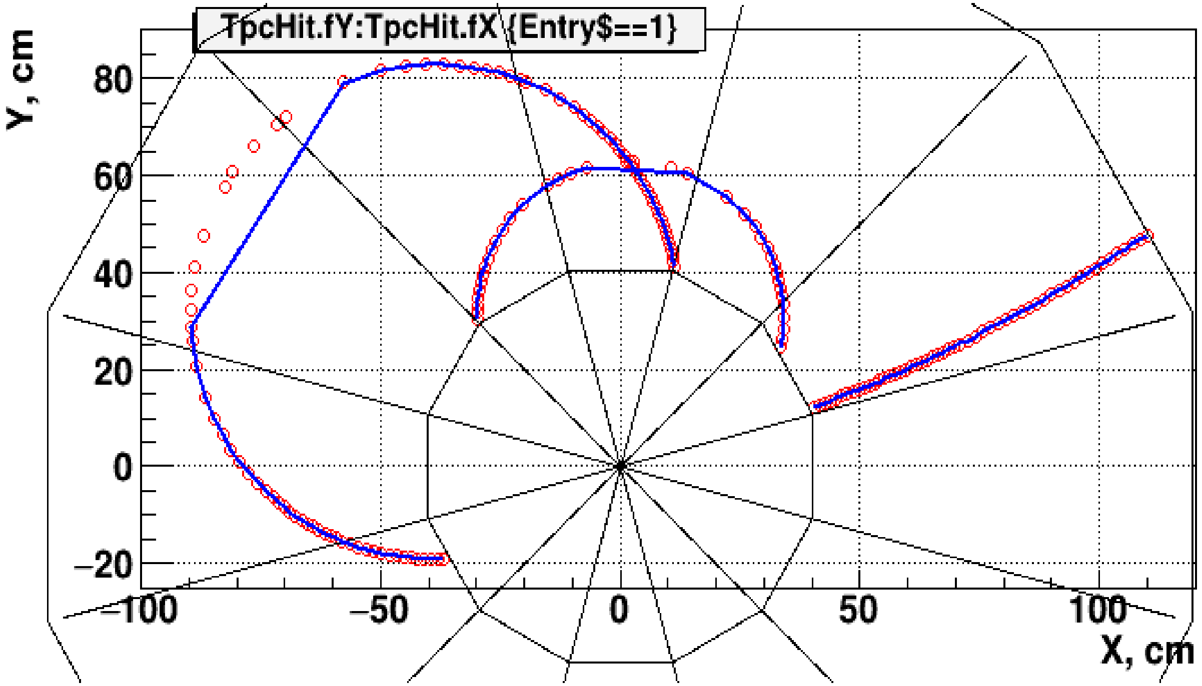
TrackFlag fFlag; ///< track flag

TClonesArray *fTrHits; ///< track hits

Track reconstruction: low-pT tracks





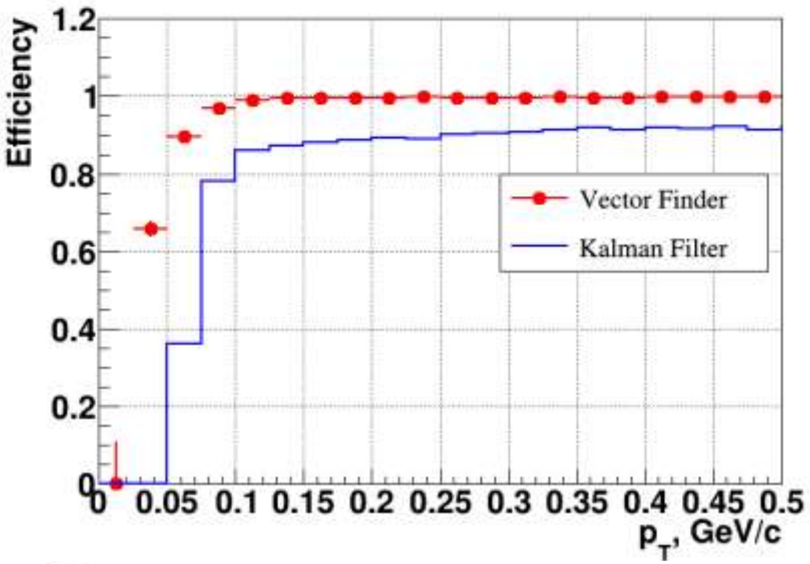


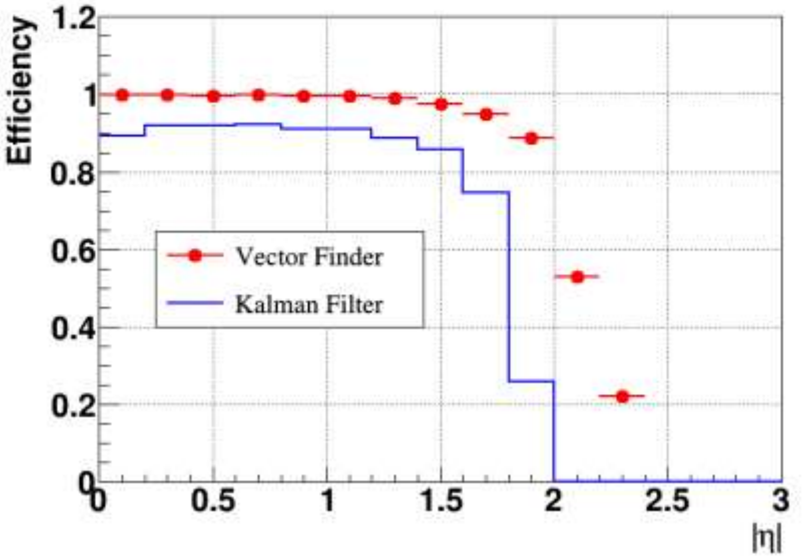
I. Tserruya,
S. Rode

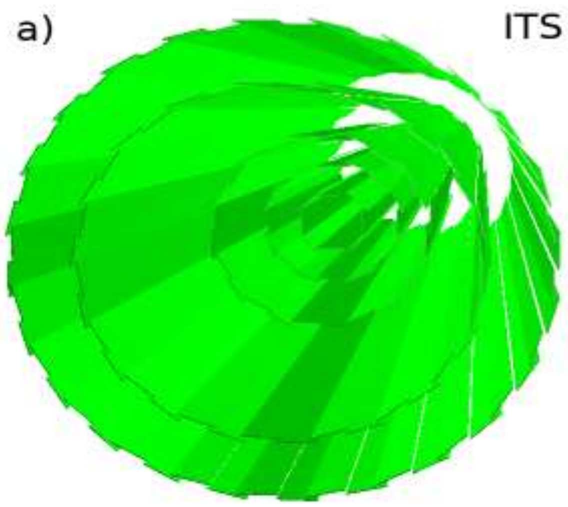
Required some changes of the Kalman filter main engine.

Some additional modifications might be necessary for realistic clusters.
Contingent on TPC response simulation for large crossing angles.
Not clear if it is possible on a short time scale.

Track reconstruction: Vector Finder toolkit for ITS

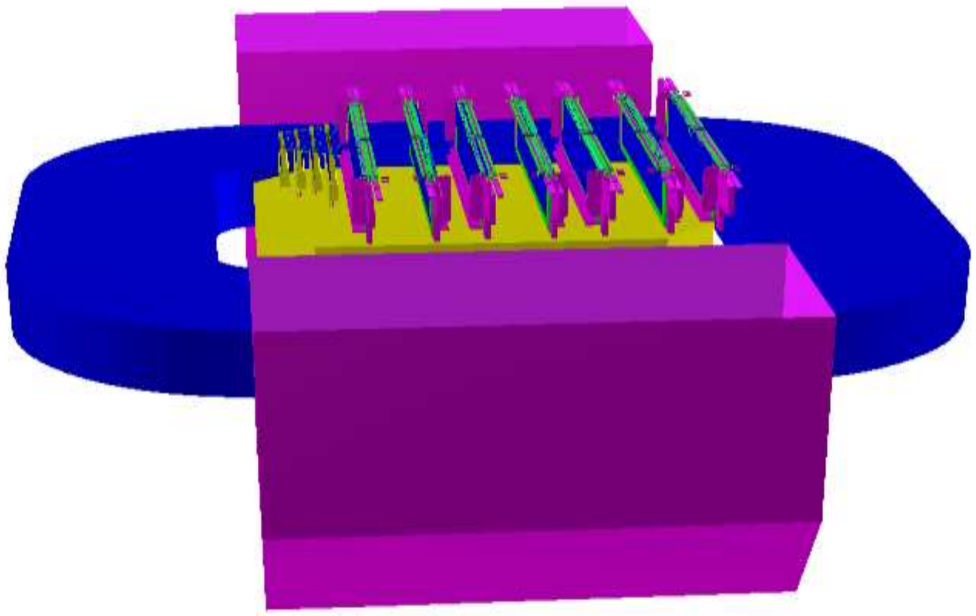




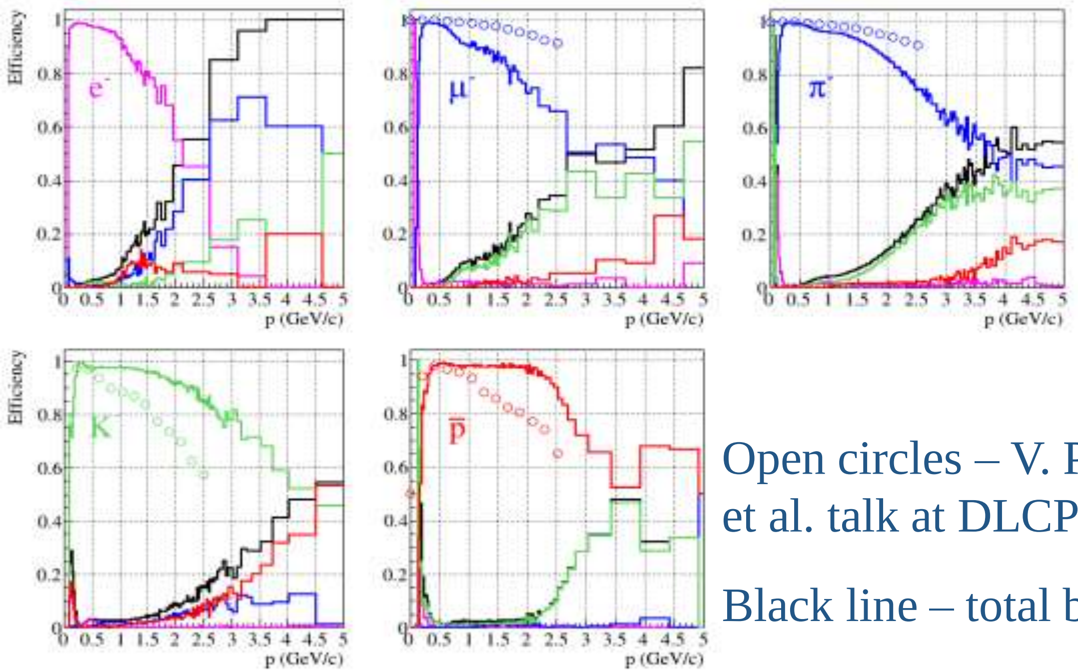


D. Zinchenko

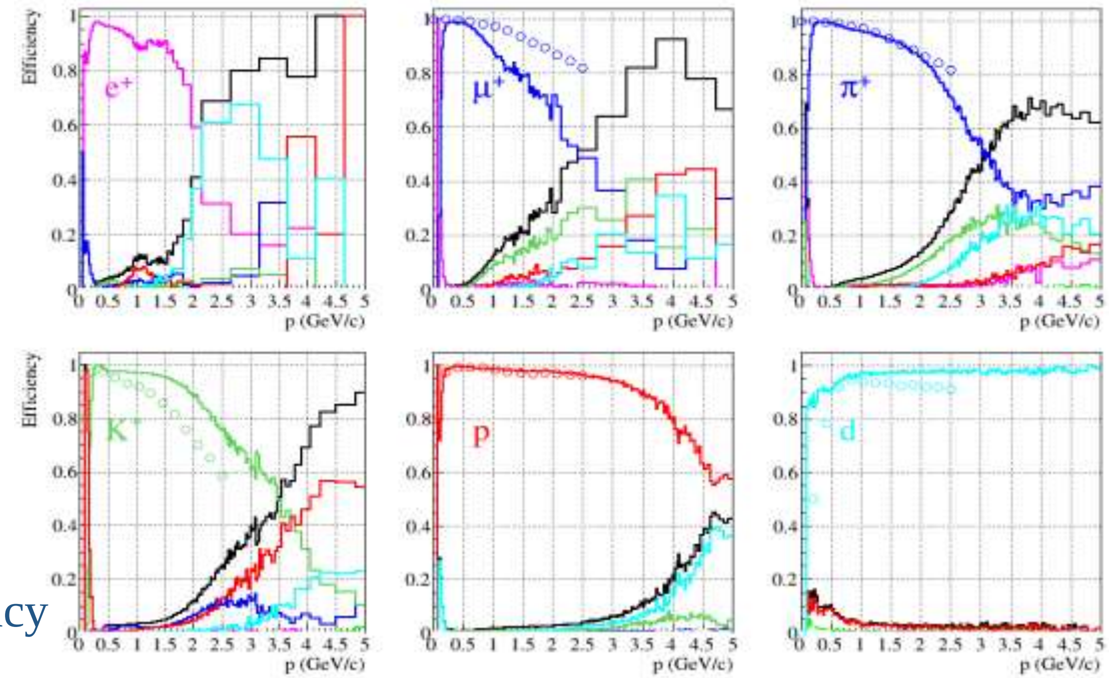
BM@N inner tracker:
VF with ML plugins



TMVA PID for TOF Matched TPC Tracks



I. Rufanov



Open circles – V. Papoyan et al. talk at DLCP-2022

Black line – total background efficiency

- Input data: MPDROOT simulation of PHQMD min. bias BiBi collisions at 9.2 GeV
- TMVA method: Neural Networks with Multilayer Perceptrons (MLP)
- Track classification variables: Q, momentum, dE/dx, TOF, N of hits, pseudorapidity and DCA
- Currently, muons and pions are considered as a same classification case

Plans: find out the reason of low-momentum miss-classification; separate muon and pion sclassification cases; choose optimal set of variables for classification (include azimuthal angle)

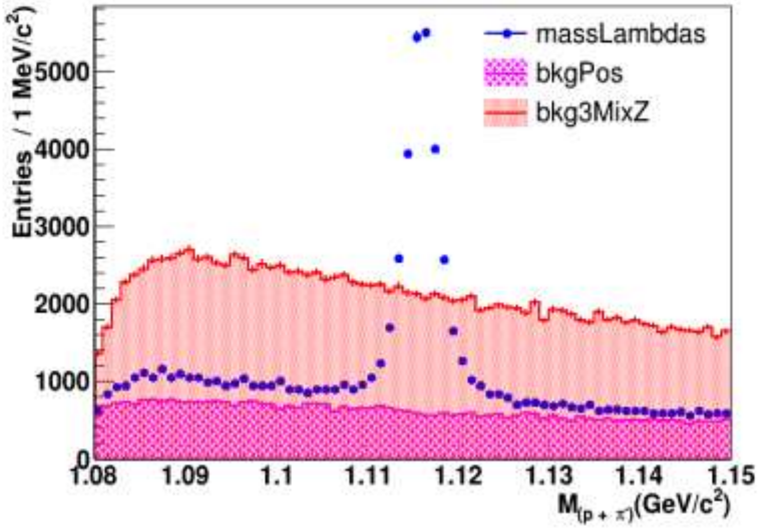
Hyperon reconstruction (background evaluation)

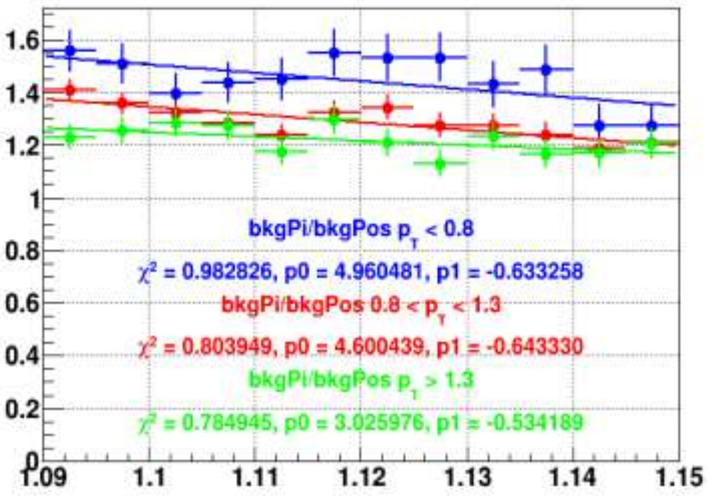
Like-sign pairs: pro – takes into account correlated effects, contra – different contamination from PID, limited statistics

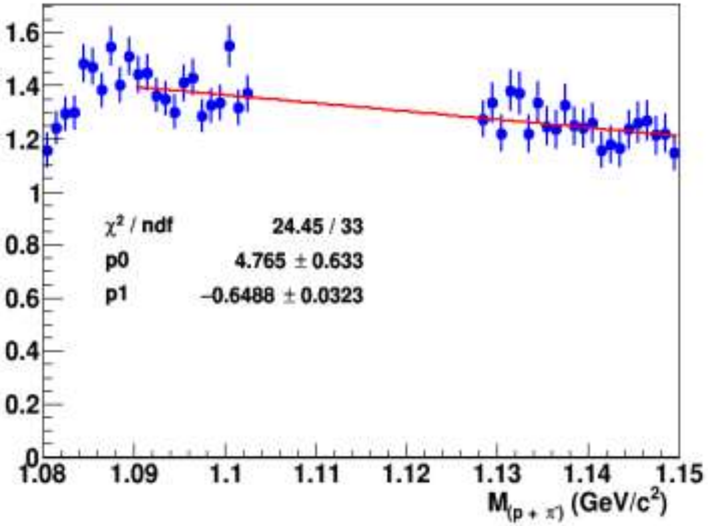
Event mixing: pro – the same contamination from PID, high statistics

Λ reconstruction (bkg from like-sign pairs)

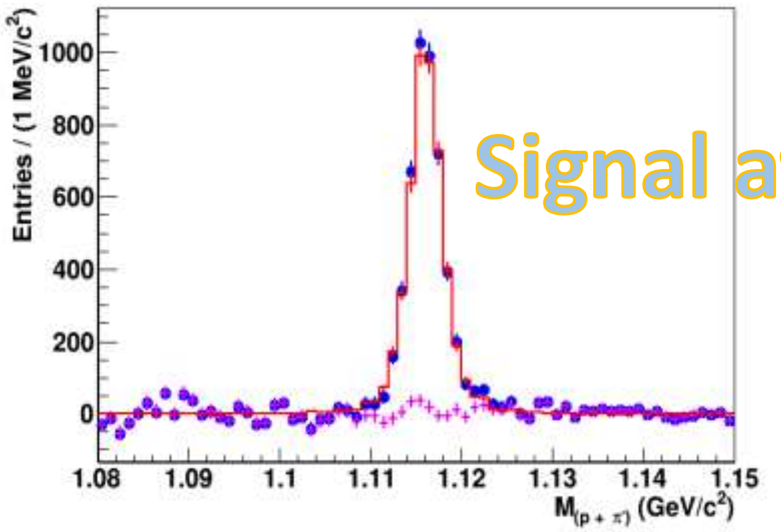
D. Suvarieva

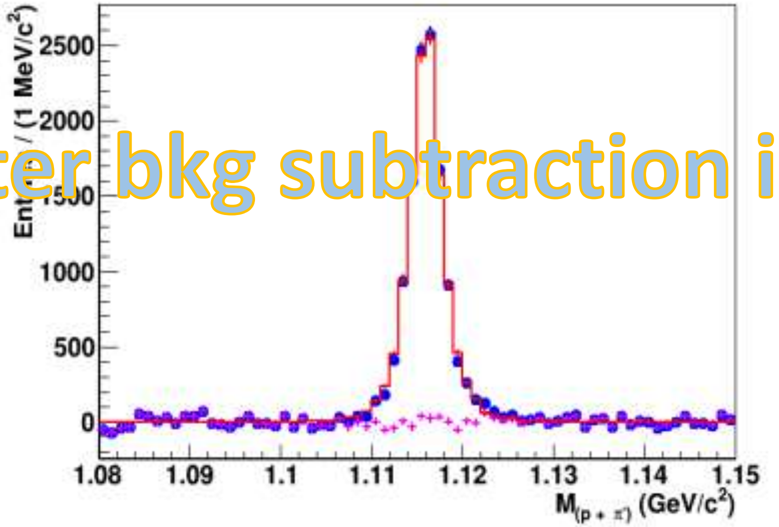


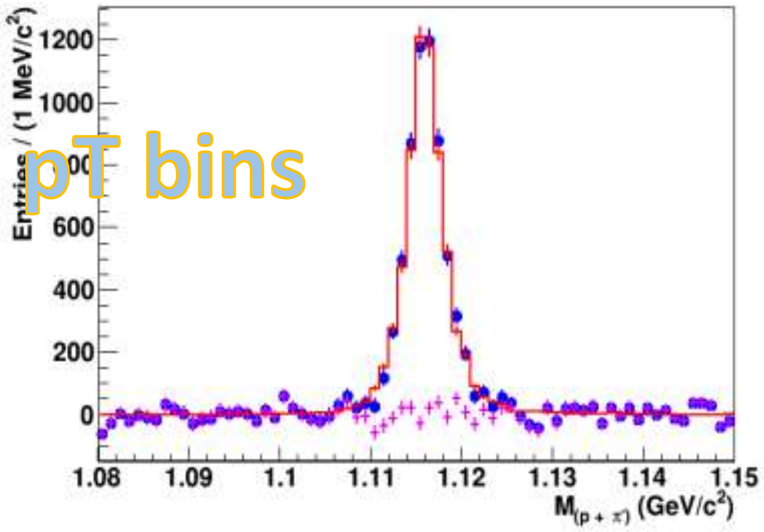




Signal after bkg subtraction in pT bins

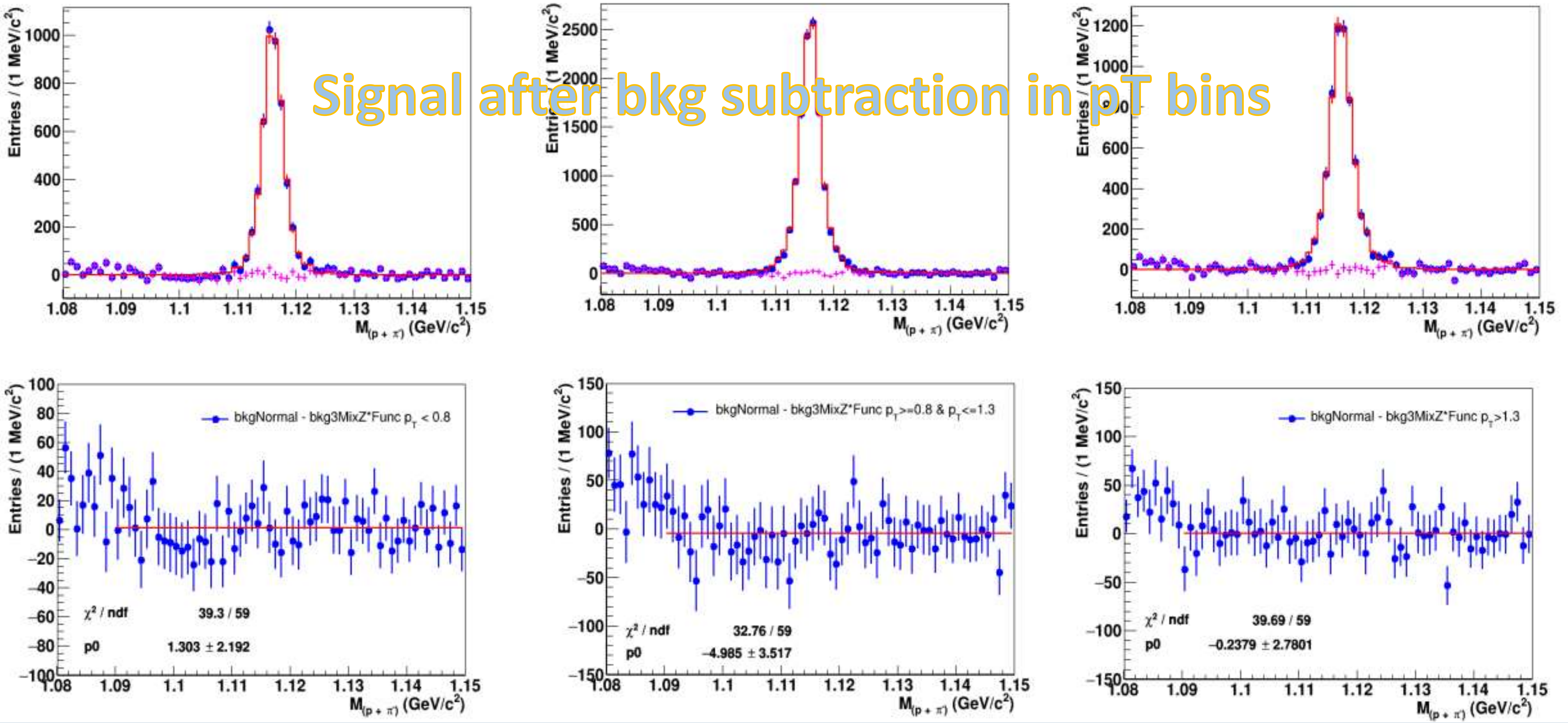






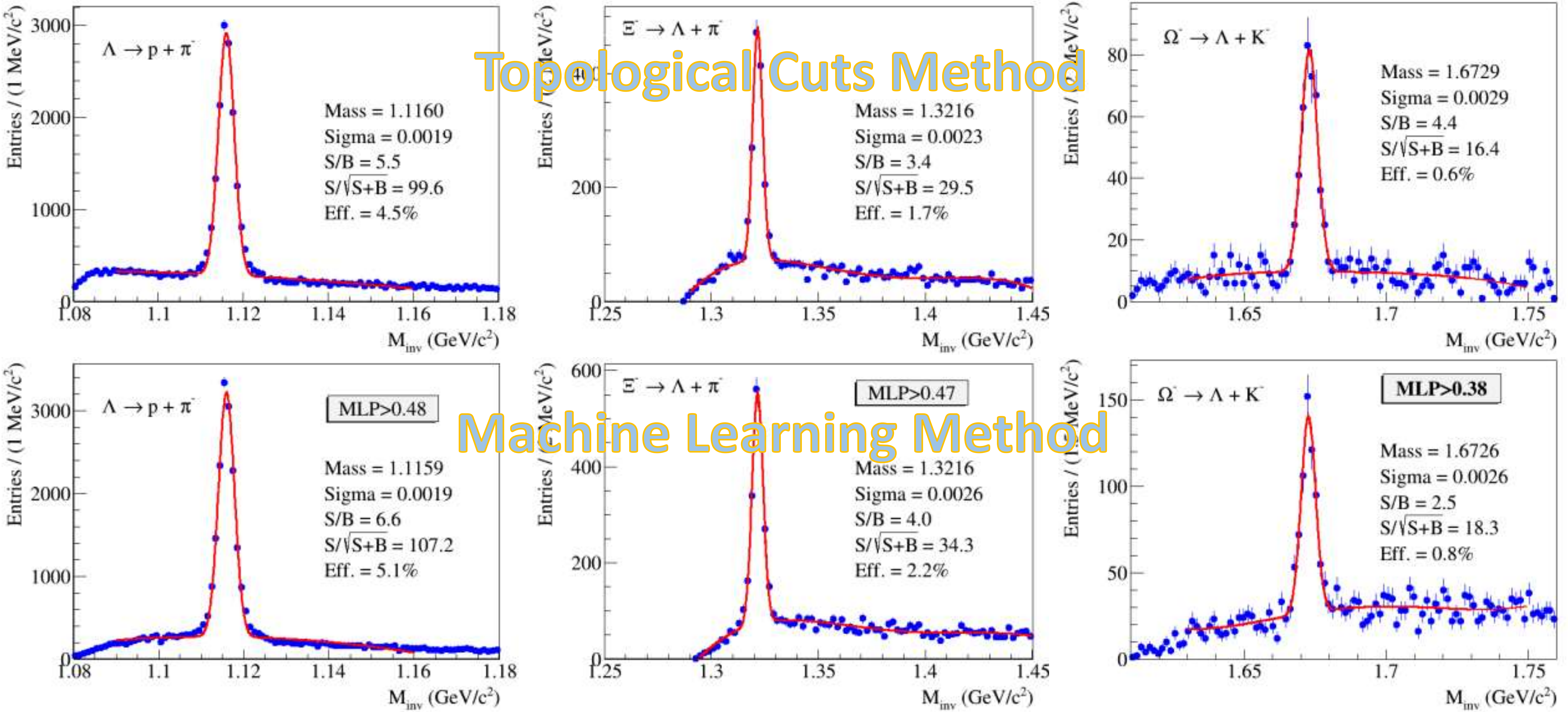
Λ reconstruction (bkg from event mixing)

Signal after bkg subtraction in pT bins

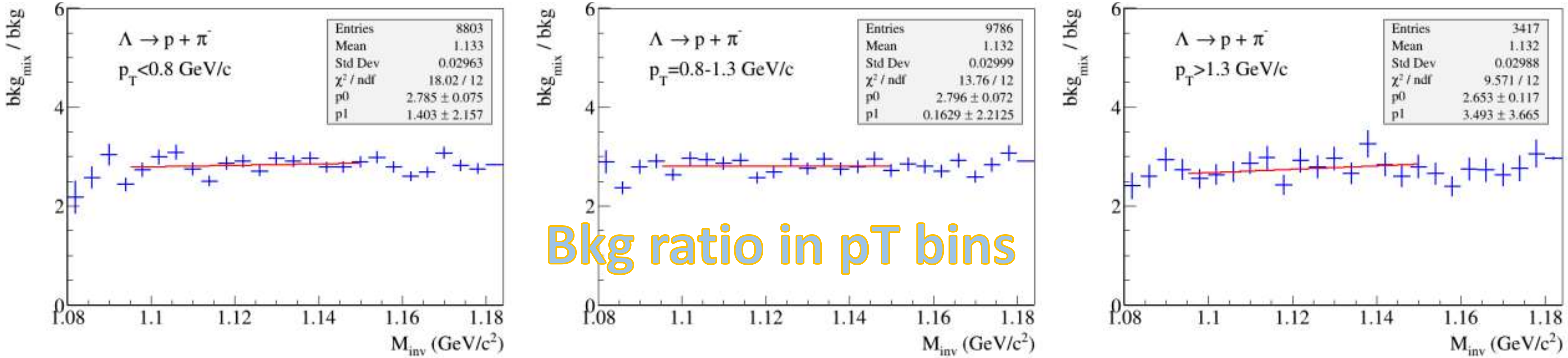


Hyperon reconstruction: TC vs TMVA

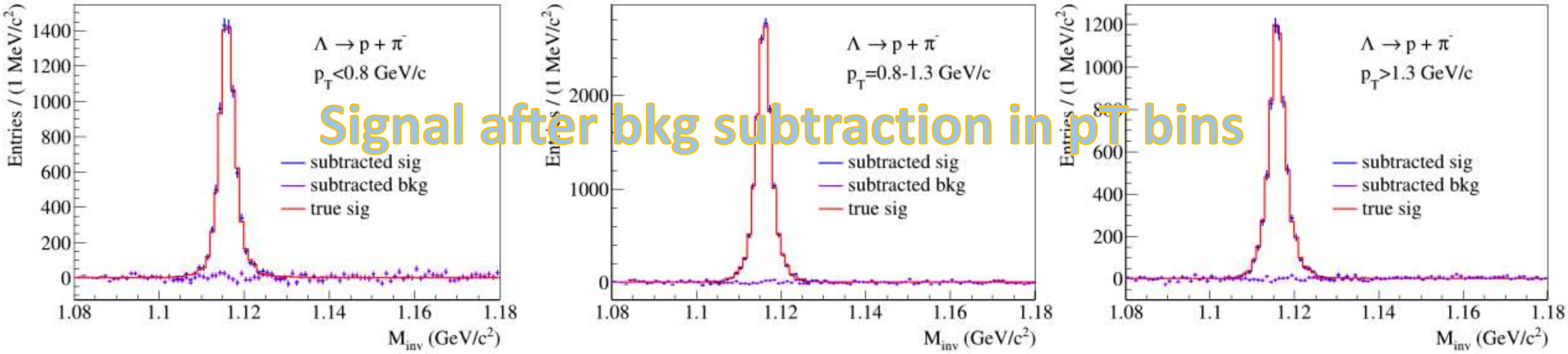
V. Vasendina



Λ reconstruction: TMVA & event mixing



Bkg ratio in pT bins



Signal after bkg subtraction in pT bins

Application of Machine Learning at MPD

Proceedings of the VIII International Conference "Distributed Computing and Grid-technologies in Science and Education" (GRID 2018), Dubna, Moscow region, Russia, September 10 - 14, 2018

POSSIBLE APPLICATION AREAS OF MACHINE LEARNING TECHNIQUES AT MPD/NICA EXPERIMENT AND EVALUATION OF THEIR IMPLEMENTATION PROSPECTS IN DISTRIBUTED COMPUTING ENVIRONMENT

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At present, the accelerator complex NICA is being built at JINR (Dubna). It is intended for performing experiments to study interactions of relativistic nuclei and polarized particles (protons and deuterons). One of the experimental facilities MPD (MultiPurpose Detector) was designed to investigate nucleus-nucleus, proton-nucleus and proton-proton interactions.
During the preparation of the physics research program, the production of a large volume of simulated data is required, including high-multiplicity events of heavy-ion interactions with high energy. Realistic modelling of the detector response for such events can be significantly accelerated with a use of generative models.
A selection of rare physics processes traditionally uses machine learning based approaches.
For the high luminosity accelerator operation for the proton-proton interaction research program it will be necessary to develop high-level trigger algorithms and methods, based on machine learning techniques.
During the data taking, the tasks of the fast and efficient processing and storage of large amounts of experimental data will become more and more important, requiring involvement of distributed computing resources.
In this work these problems are considered in connection to the MPD/NICA experimental program preparation.

Keywords: machine learning, generative models, multivariate analysis, heavy-ion collisions

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Simulation of TPC and EMC response using generative models

Multivariate analysis for dilepton and open charm selection

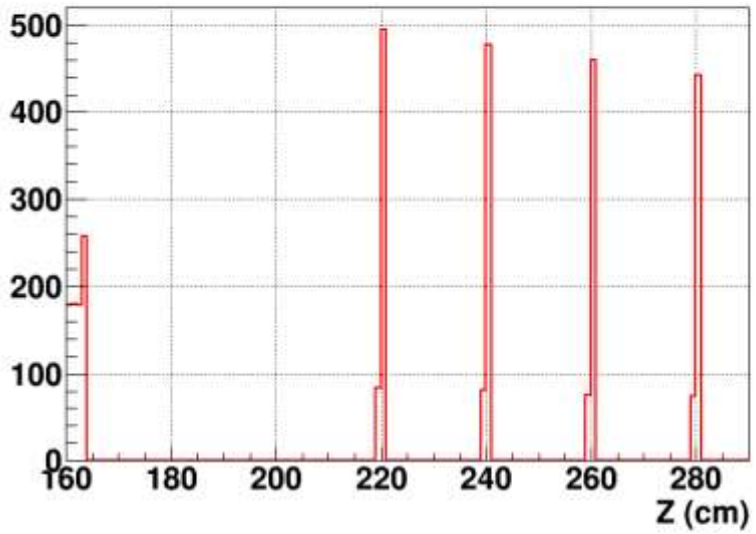
+

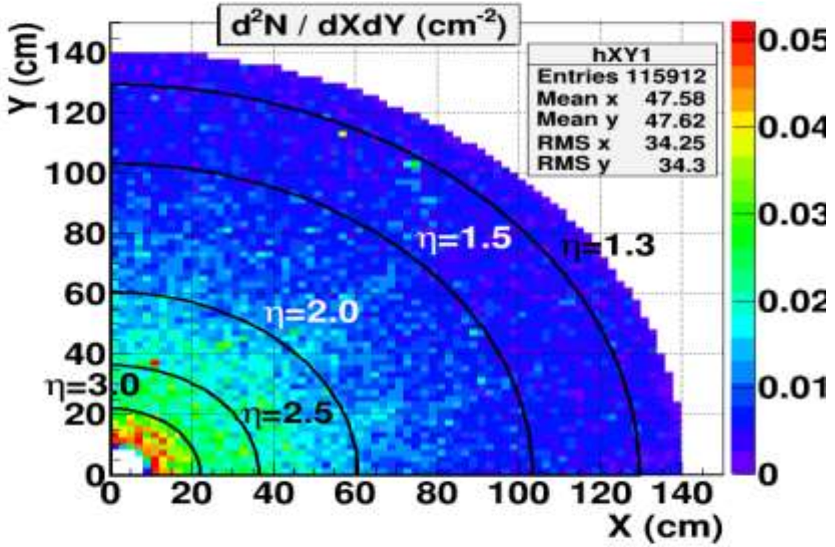
Track reconstruction

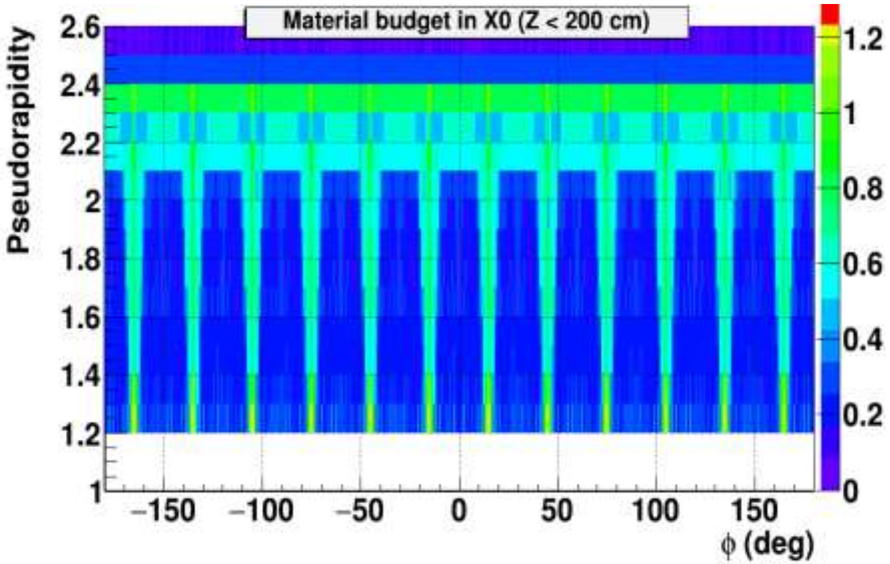
Particle identification

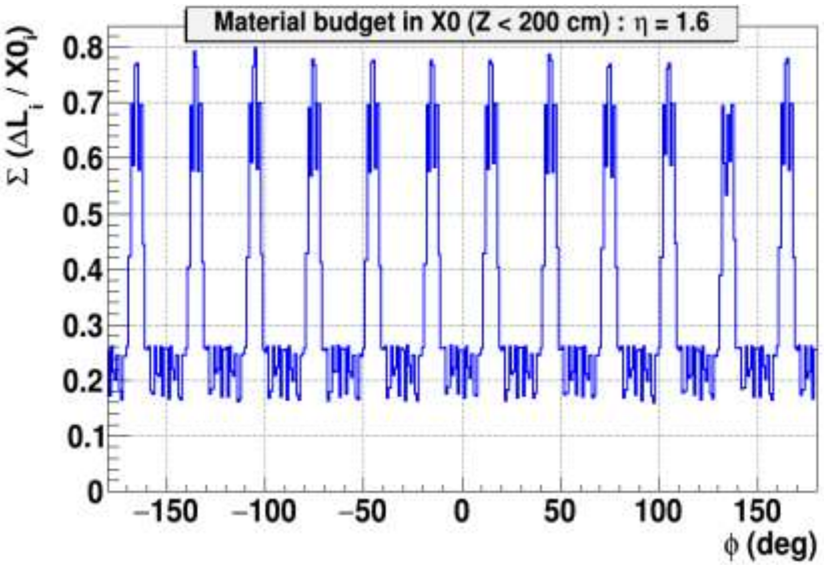
Hyperon selection

Tracking in the end-cap region

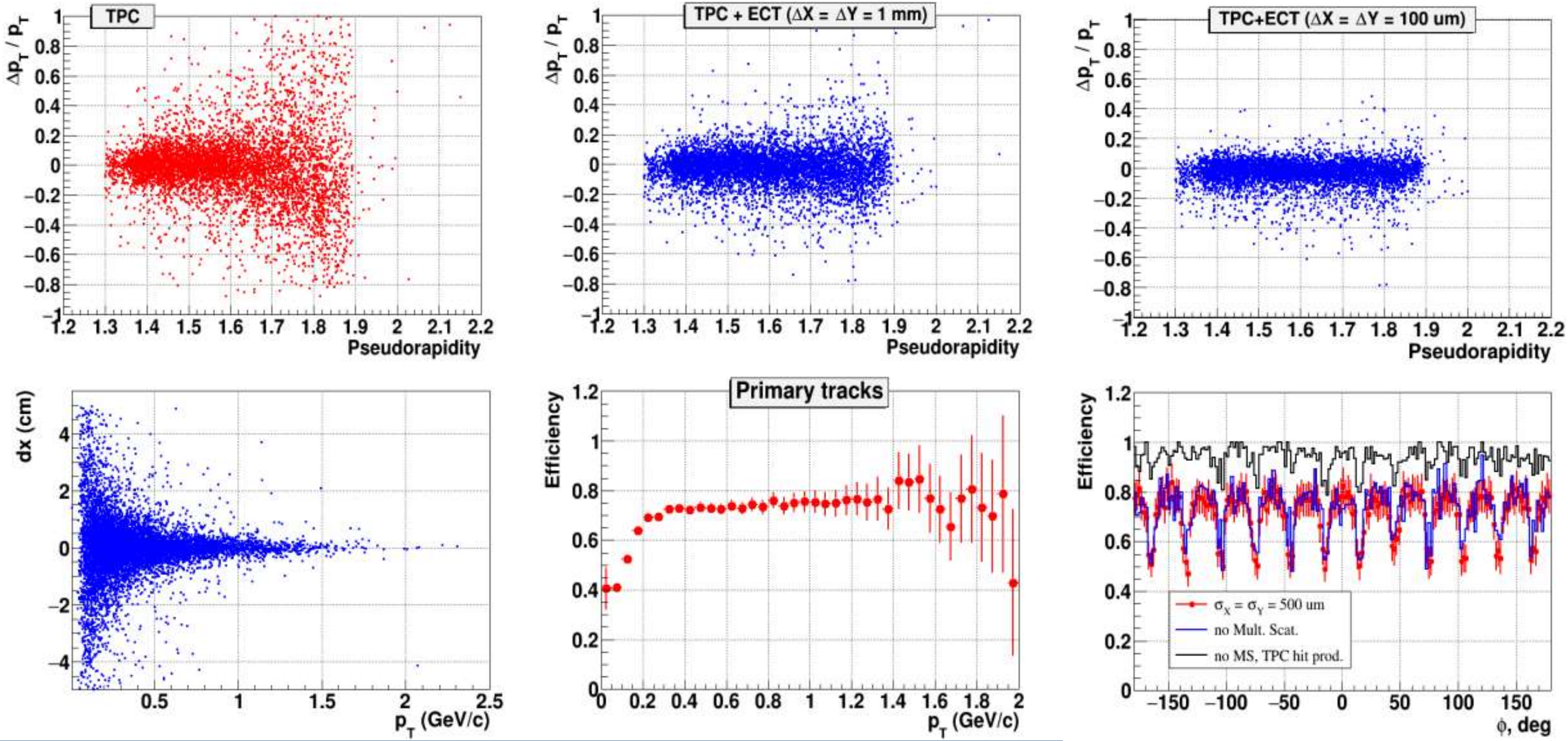








Tracking in the end-cap region



Tracking in the end-cap region

- To continue with this, some technological solutions should be proposed – GEM detectors (estimated number of channels in double-sided GEMs with strip pitch of 1 mm exceeds that of the BM@N GEM tracker); scintillating fibers(?)
- Cluster finder for large dip angles might require some work
- Track fitting in the forward region with material budget map

- There are several active tasks on reconstruction