Prediction of particle production in pp collisions at MPD/NICA

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On behalf of the MPD Collaboration

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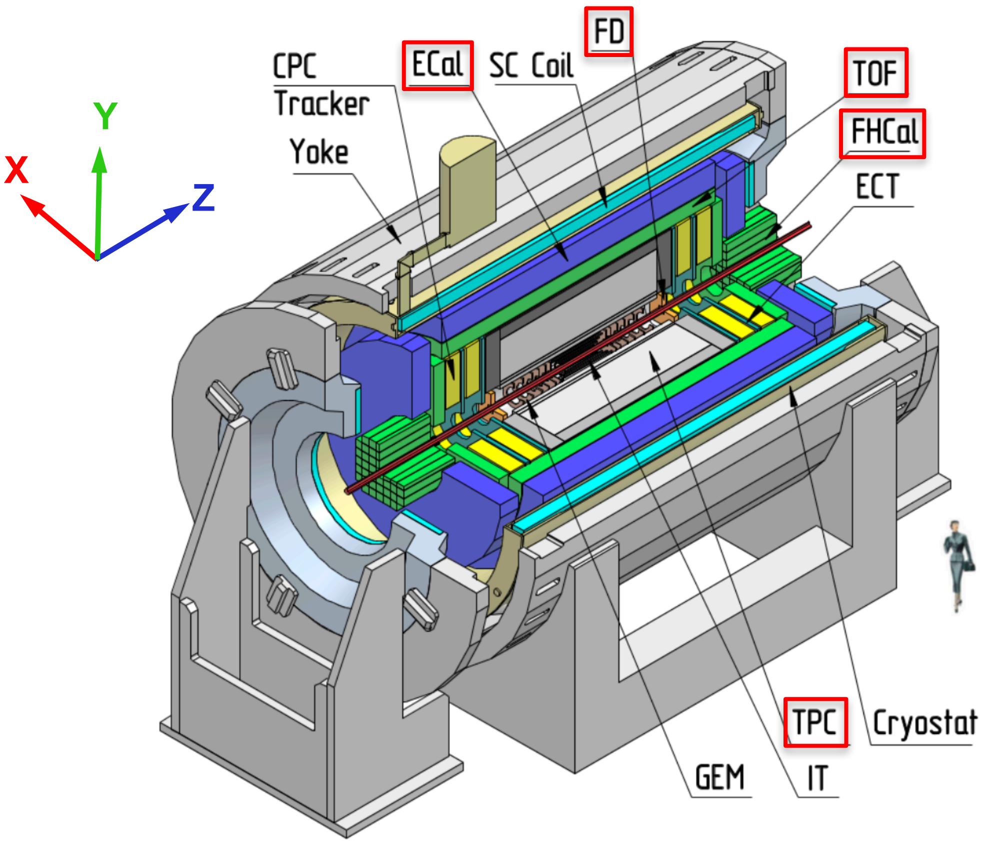
MultiPurpose Detector (MPD)

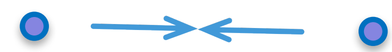
MPD: designed to accomplish a wide range of tasks of the NICA physics program.

Collisions in a wide range of atomic mass: A = 1 – 197.



Maximum centre-of-mass energy	Average luminosity
$\sqrt{s_{NN}}$ = 11 GeV (Au^{79+})	L = 10^{27} $cm^{-2}s^{-1}$
$\sqrt{s_{NN}}$ = 27 GeV (p)	L = 10^{32} $cm^{-2}s^{-1}$

The proton-proton collisions are in the MPD/NICA research program!



- Baseline for nucleus - nucleus interaction analysis.
- A good tool for detector performance studies.
- Study of fluctuations and correlations of in-medium properties as function of the system size.
- RAA – nuclear modification factor
- Horn effect, etc

pp collisions @ $\sqrt{s} = 6 - 25$ GeV

Event generation (*models*)

MC transport (*MpdRoot: GEANT*)

Reconstruction (*CF - KF*)

Event generators based on the following models:

UrQMD 3.4
(Ultra Relativistic Quantum Molecular Dynamics)

S. Bass et al., Prog. Part. Nucl. Phys. 41, 255 (1998)
M. Bleicher et al., J. Phys. G 25, 1859 (1999)

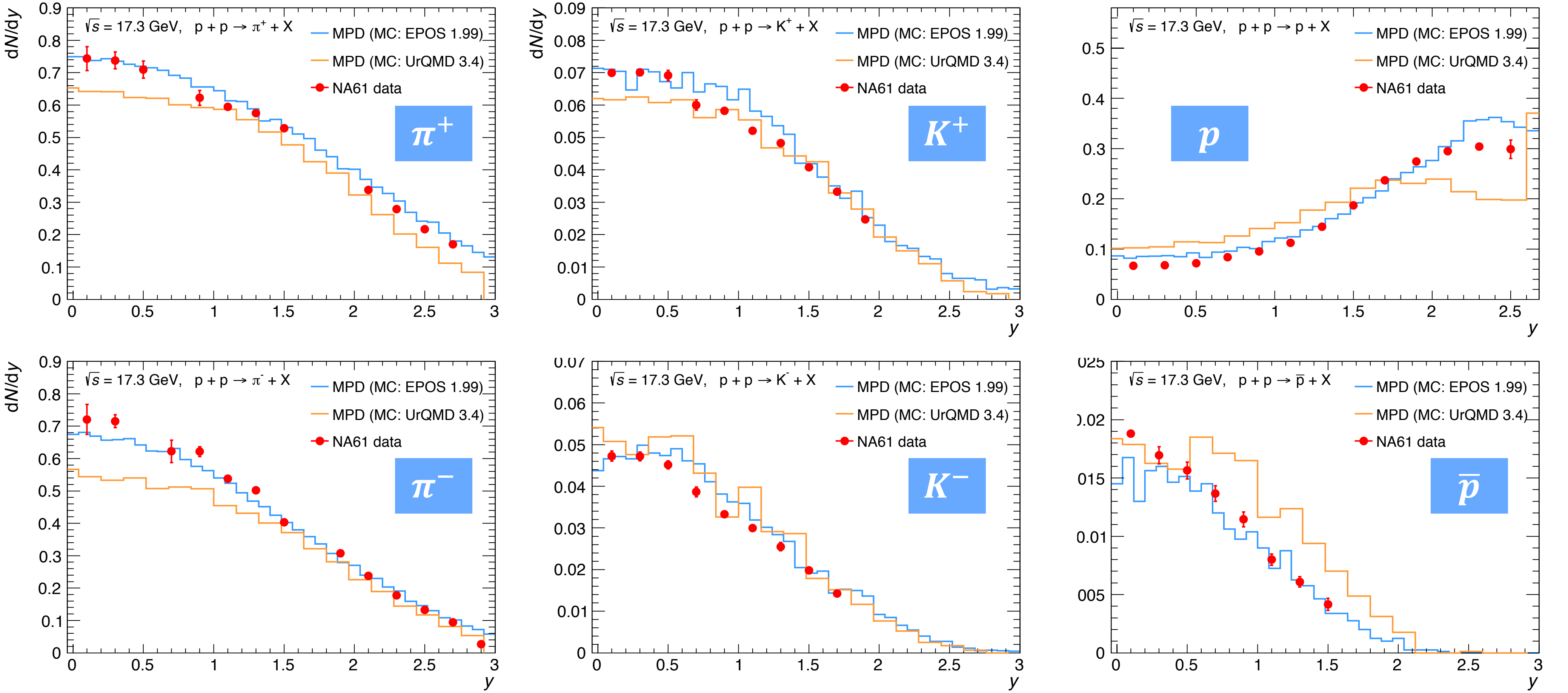
EPOS 1.99
(Energy conserving quantum mechanical multiple scattering approach, based on Partons (parton ladders), Off-shell remnants, and Splitting of parton Ladders)
Combines parton model and Gribov-Regge theory.

K. Werner, F. Liu, T. Pierog, Phys. Rev. C 74, 044902 (2006)
T. Pierog, K. Werner, Nucl. Phys. B (Proc. Suppl.) 196, 102 (2009)

pp @ $\sqrt{s}$ = 17.3 GeV

$^{dN}/_{dy}$ $vs.$ y distributions of $\pi^{+}, K^{+}, p, \pi^{-}, K^{-}, \bar{p}$

MC simulations in MPD/NICA compared with exp. data from NA61/SHINE



- EPOS 1.99 agrees better with $\pi^{\pm}$ data.
- UrQMD underestimate $\pi^{\pm}$ data mainly at central rapidity.

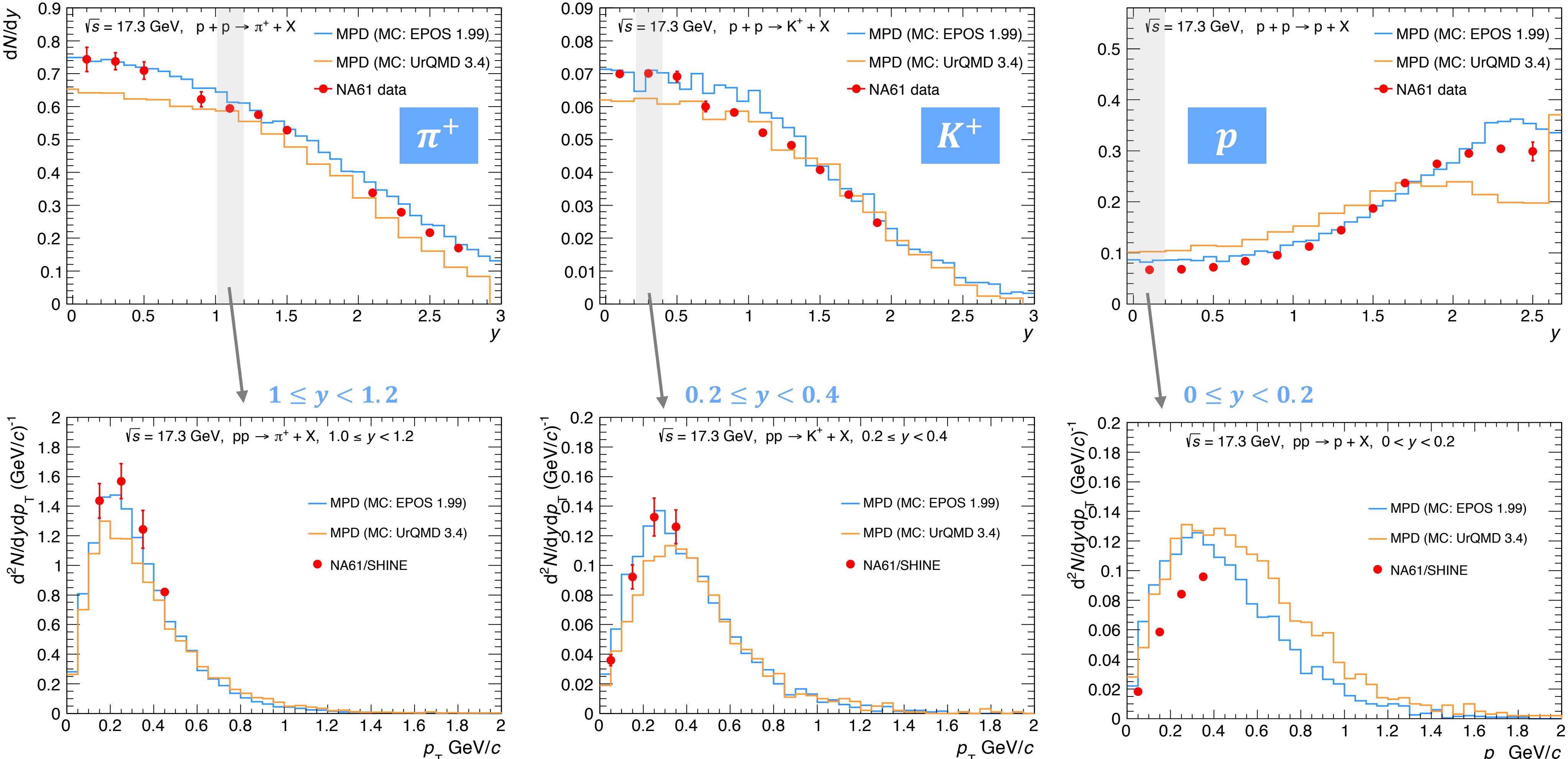
- EPOS 1.99 closer to K^{+} data at mid-rapidity and overestimates for 0.5 < |y| < 1.5. The opposite happens to UrQMD.
- UrQMD 3.4 overpredicts the K^{-} data for 0.2 < |y| < 1.4.

- EPOS 1.99 systematically agrees with p data except at foward beam rapidity, while systematically describes with $\bar{p}$ data except for mid-rapidity.
- UrQMD overestimates p data in a wide rapidity range and underpredicts it at forward rapidity.
- At mid-rapidity both models predict values larger than the p data and lower than $\bar{p}$ data.

pp @ $\sqrt{s}$ = 17.3 GeV (π^+, K^+, p)

p_T distributions were determined in rapidity intervals

MC simulations in MPD/NICA compared with exp. data from NA61/SHINE



- EPOS 1.99 agrees with data.
- UrQMD underestimates yield of pions at $p_T < 0.6$ GeV/c

- UrQMD underestimates yield at $p_T < 0.4$
- EPOS 1.99 reproduces data available at low p_T.

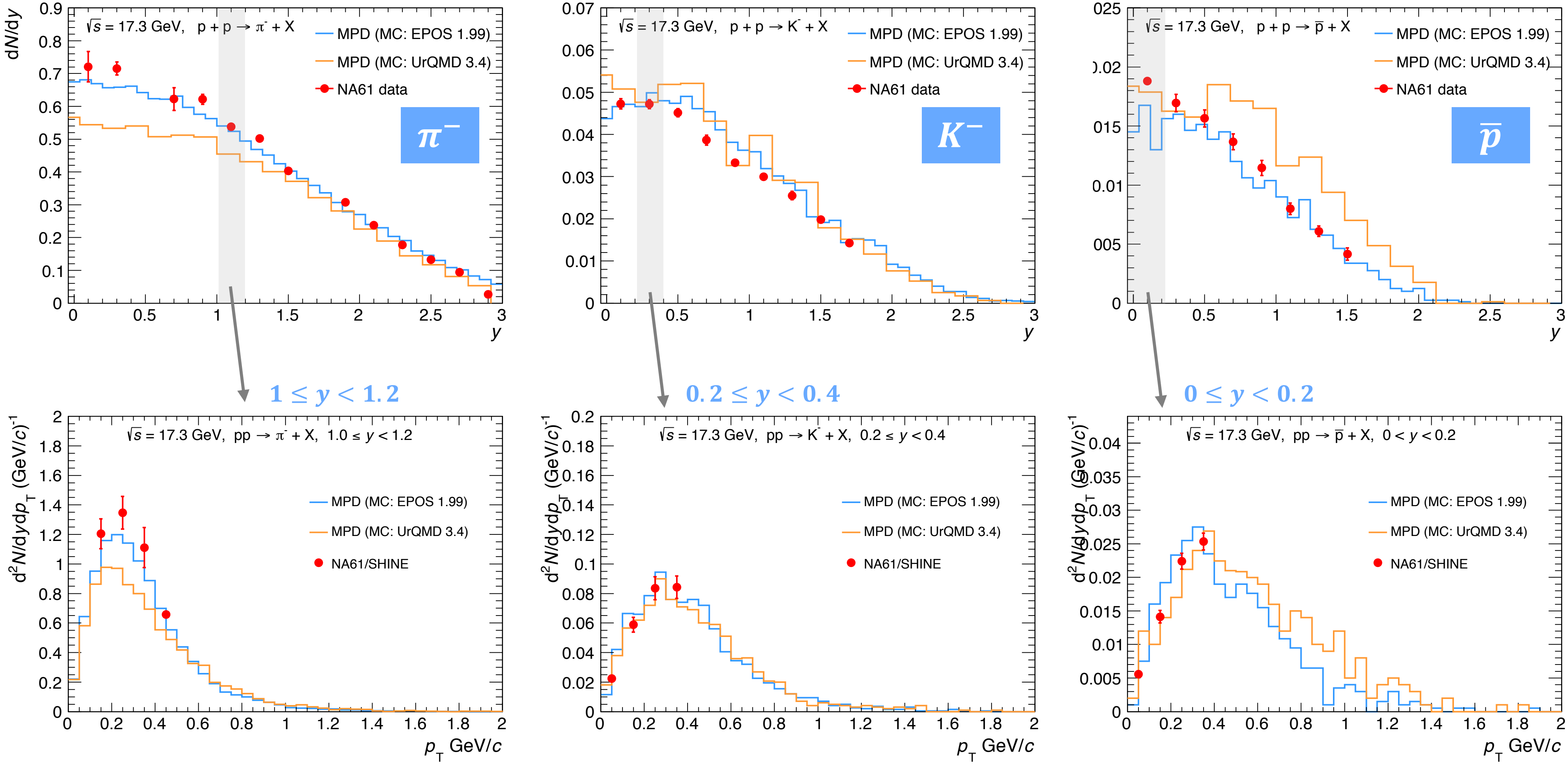
- EPOS 1.99 agrees with UrQMD at $p_T < 0.4$ but both models overestimate data.

Rapidity and transverse momentum

pp @ $\sqrt{s}$ = 17.3 GeV $(\pi^-, K^-, \bar{p})$

p_T distributions were determined in rapidity intervals

MC simulations in MPD/NICA compared with exp. data from NA61/SHINE

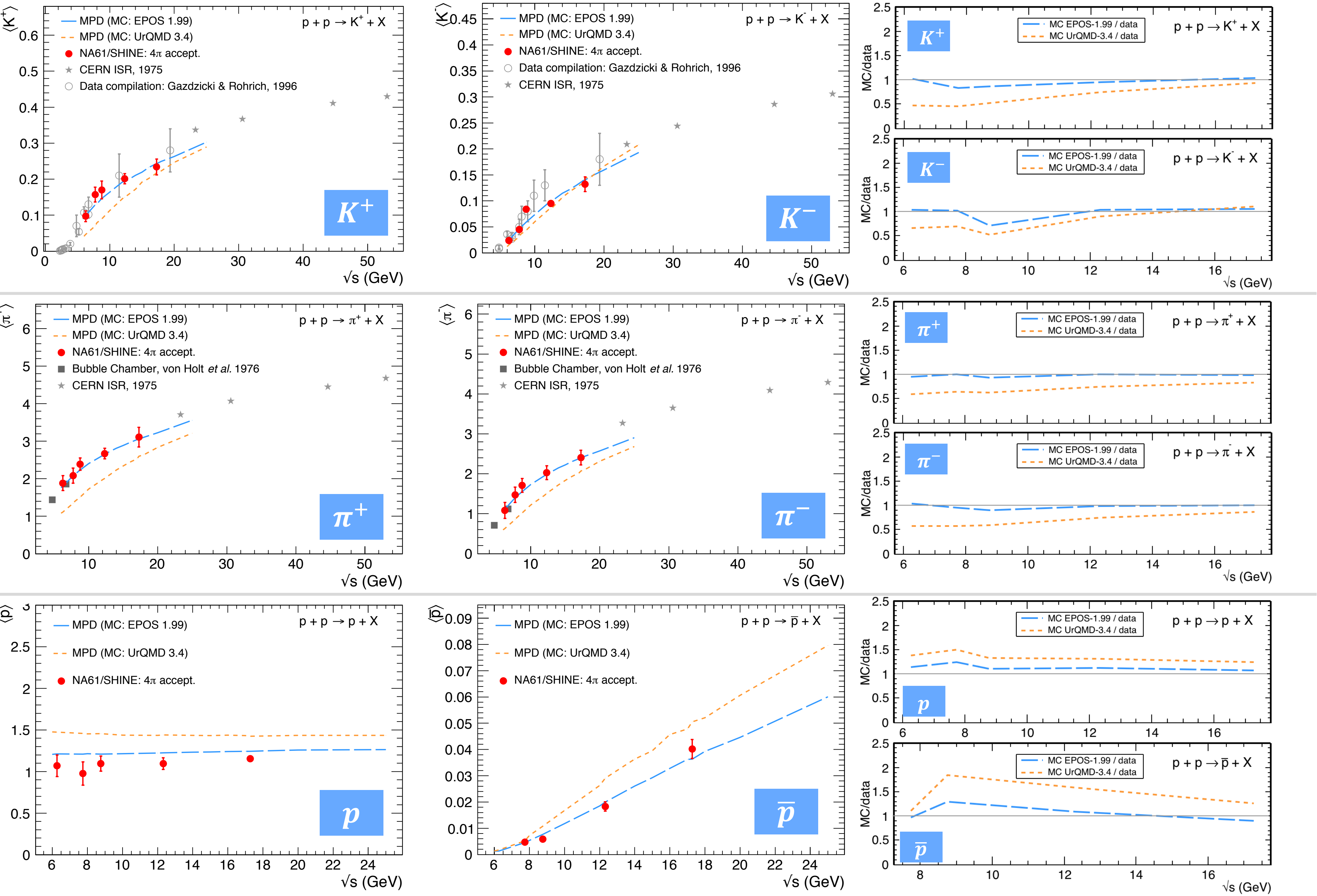


- EPOS 1.99 agrees with data.
- UrQMD underestimates at at $p_T < 0.6$ GeV/c

- Models agrees with data.

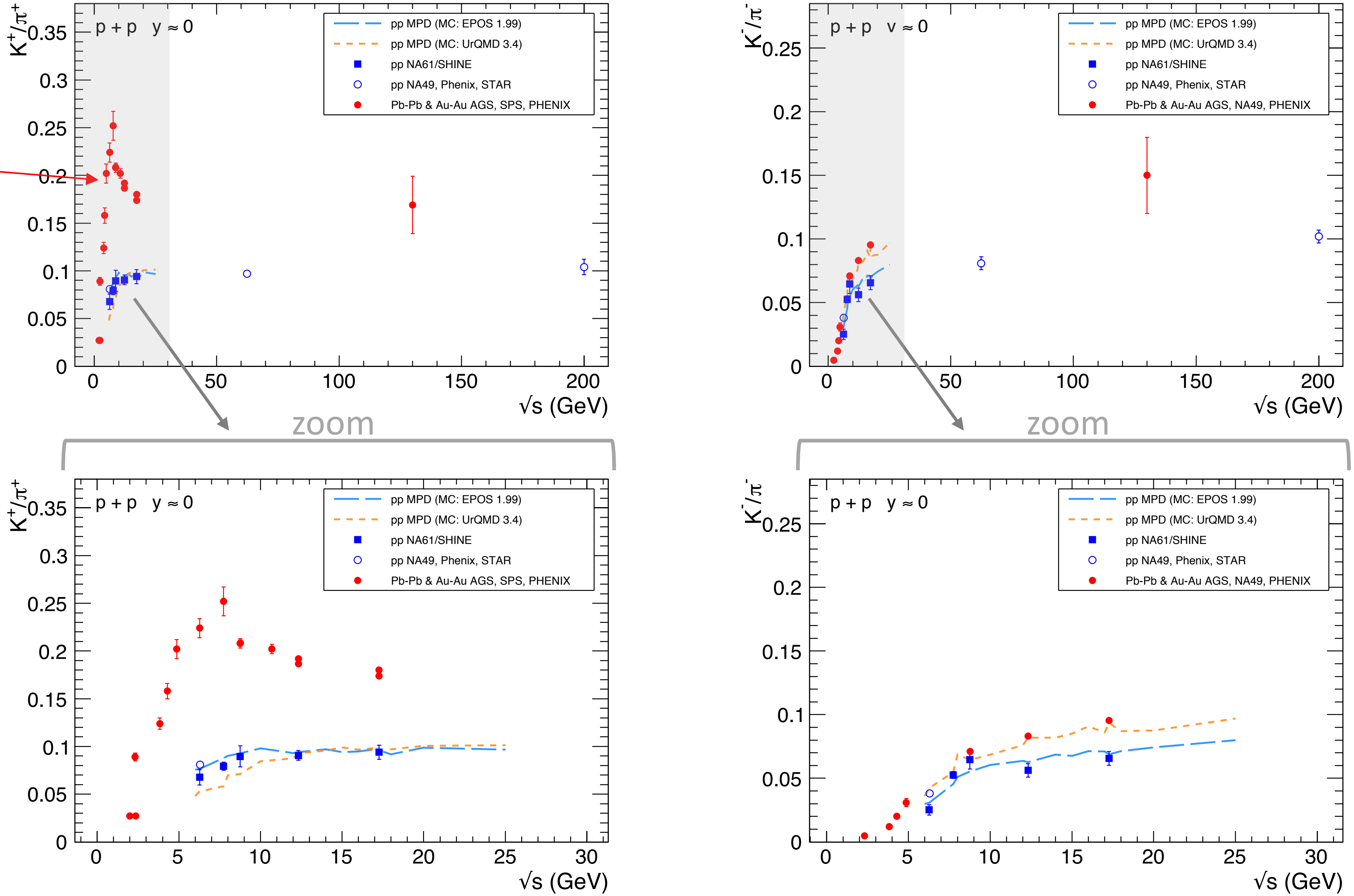
- EPOS overestimates data ($p_T < 0.4$)
- UrQMD underestimate data ($p_T < 0.4$)

Mean multiplicity *vs* collision energy



Horn effect

The ratio from heavy ion collisions is represented by red points for reference



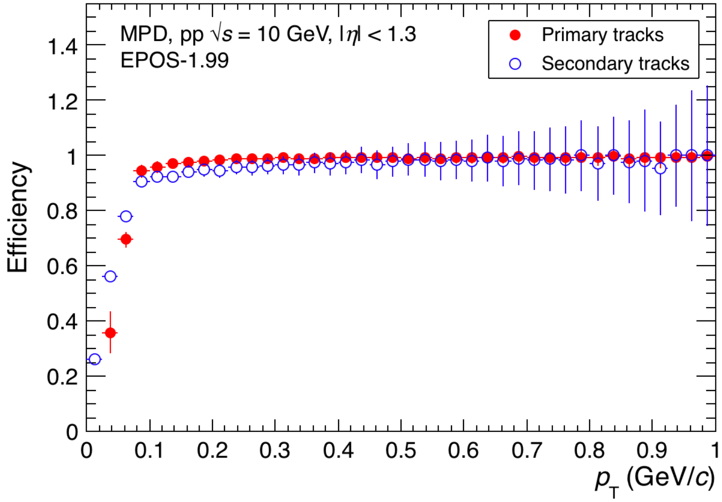
Rapid change of K^+/π^+ ratio of NN collisions at NICA energies → posible signature of deconfinement

There is a slight plateau-like structure for p+p (in exp. Data from NA61 and EPOS 1.99 prediction).

EPOS 1.99 generator provides better agreement with p+p experimental data.

UrQMD 3.4 underestimates K^+/π^+ ratio at $\sqrt{s}$ < 12 GeV and overestimates K^-/π^- ratio in all the $\sqrt{s}$ range.

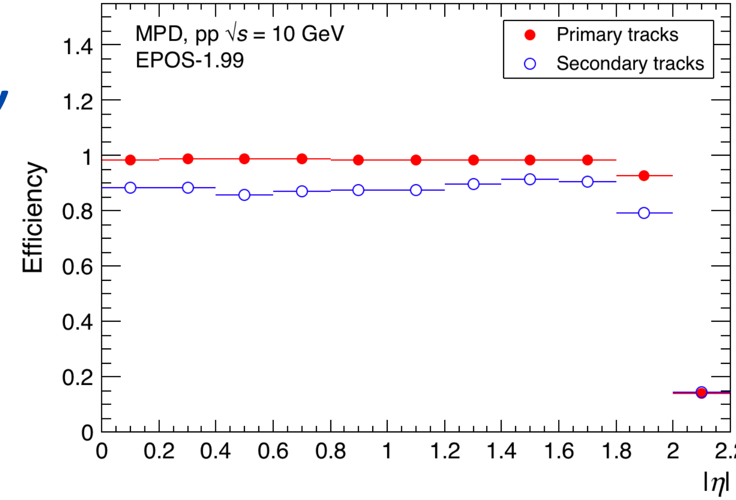
MPD performance in pp collisions

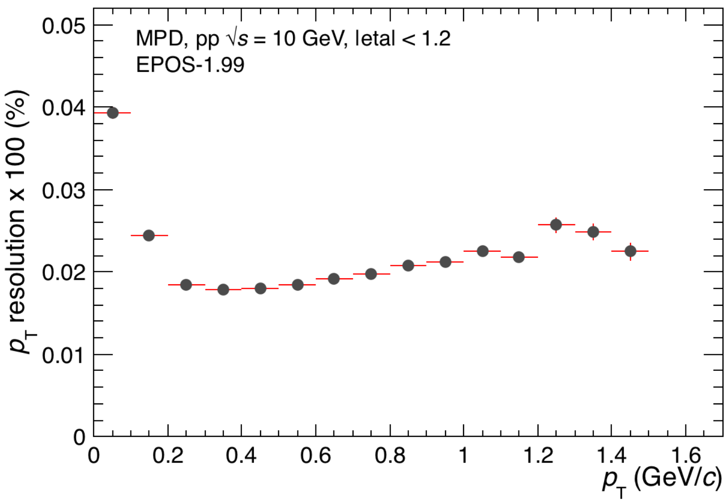


*Tracking efficiency

$$\varepsilon_{prim} = \frac{p_T \text{ good primaries}}{p_T \text{ all primaries}}$$

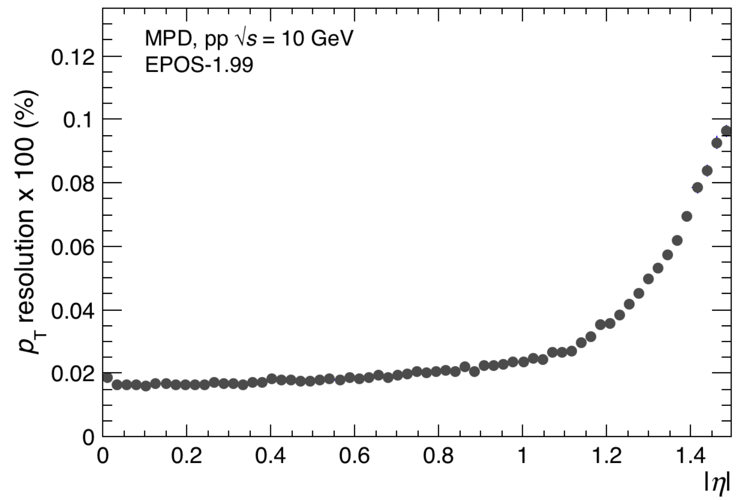
$$\varepsilon_{sec} = \frac{p_T \text{ good secondaries}}{p_T \text{ all secondaries}}$$





p_T resolution

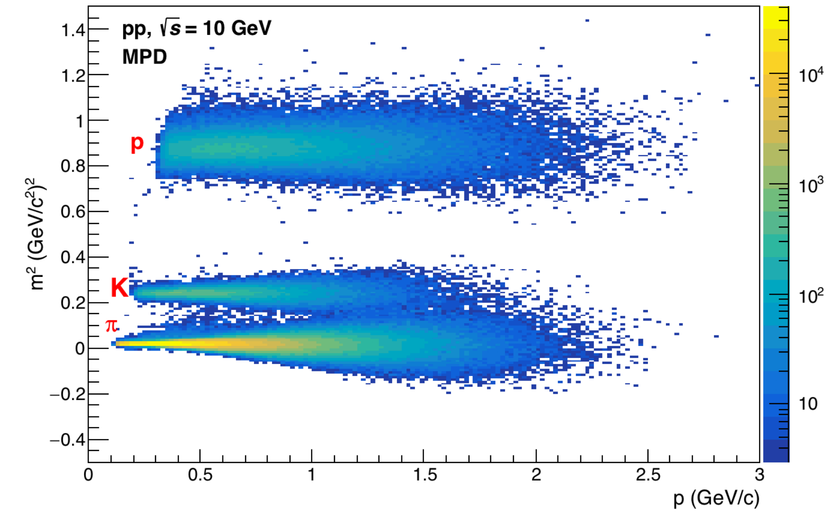
$$\delta p_T = \sigma\left(\frac{p_{T,mc} - p_{T,rec}}{p_{T,mc}}\right)$$



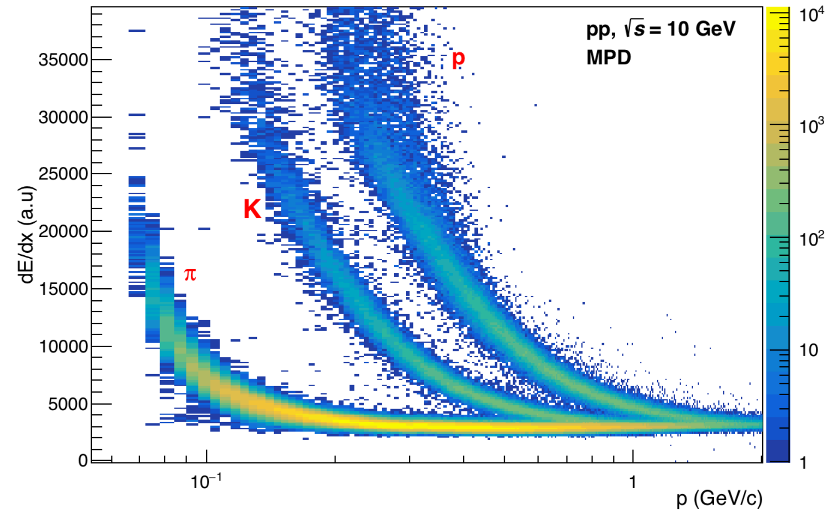
*Software written by Alexander Zinchenko

MPD performance in pp collisions

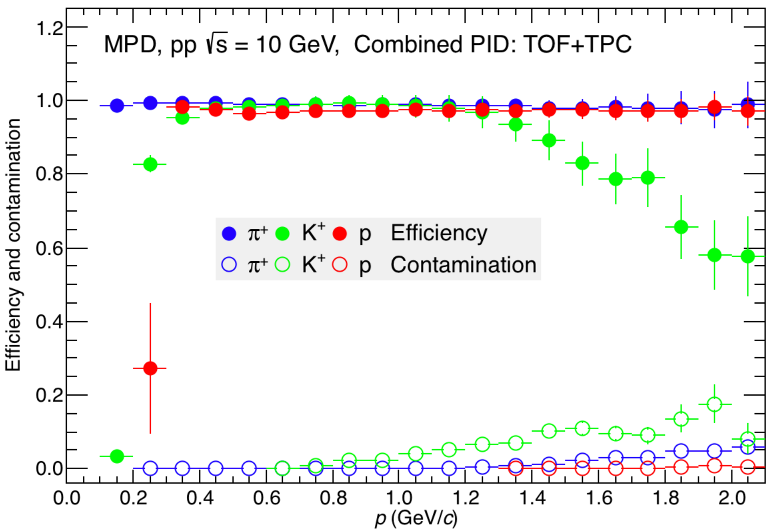
m^2 parameterization (TOF)



Realistic energy loss reconstruction(TPC)

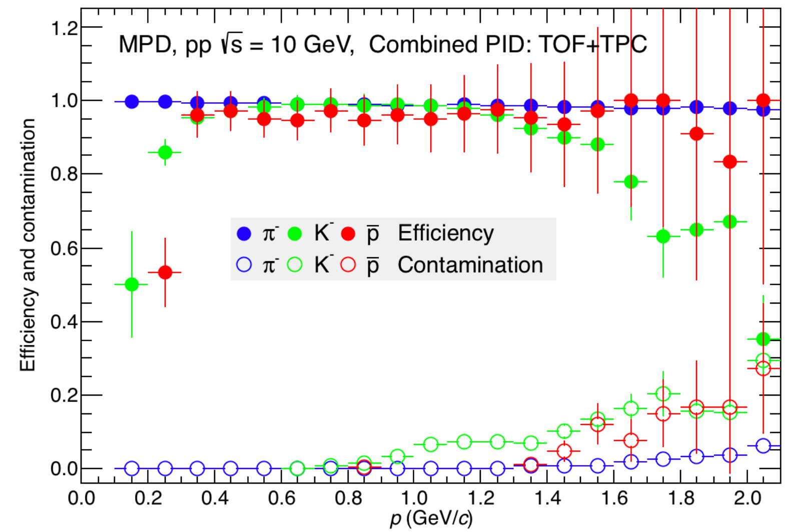


Particle identification



$$Eff = \frac{correctly\ identified}{reconstructed}$$

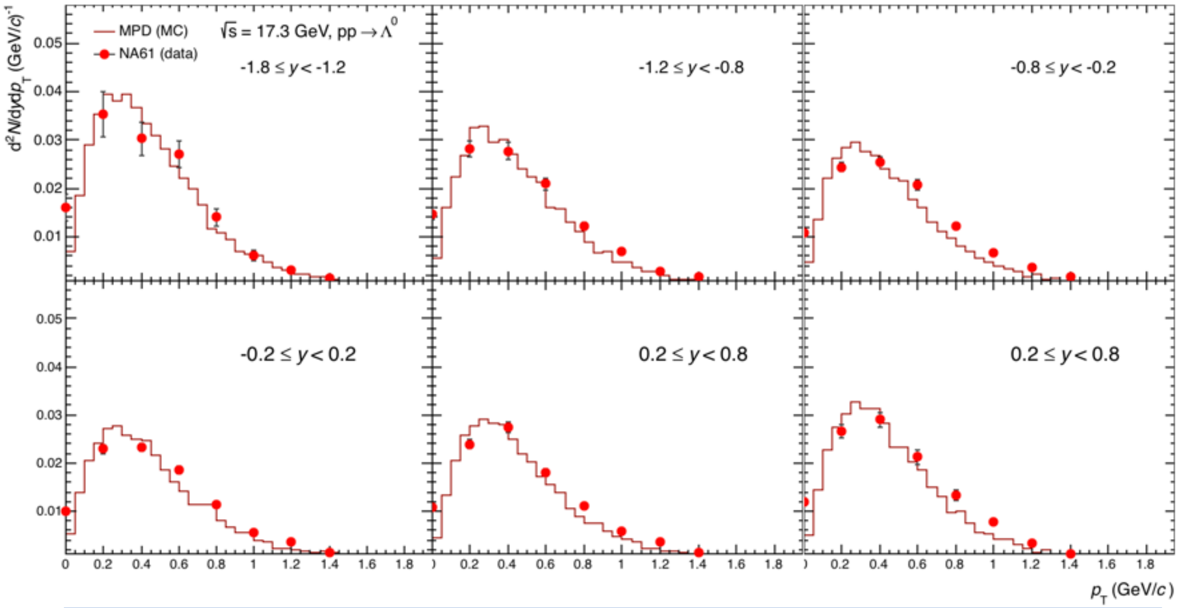
$$Contam = \frac{incorrectly\ identified}{identified}$$



*PID implemented in MPDRoot by A. Mudrokh and A. Zinchenko

Λ^0 hyperon simulation

MC simulation (MPDRoot: EPOS-1.99 generator + Geant3), compared with NA61 experimental data.



pp @ $\sqrt{s}$ = 17.3 GeV

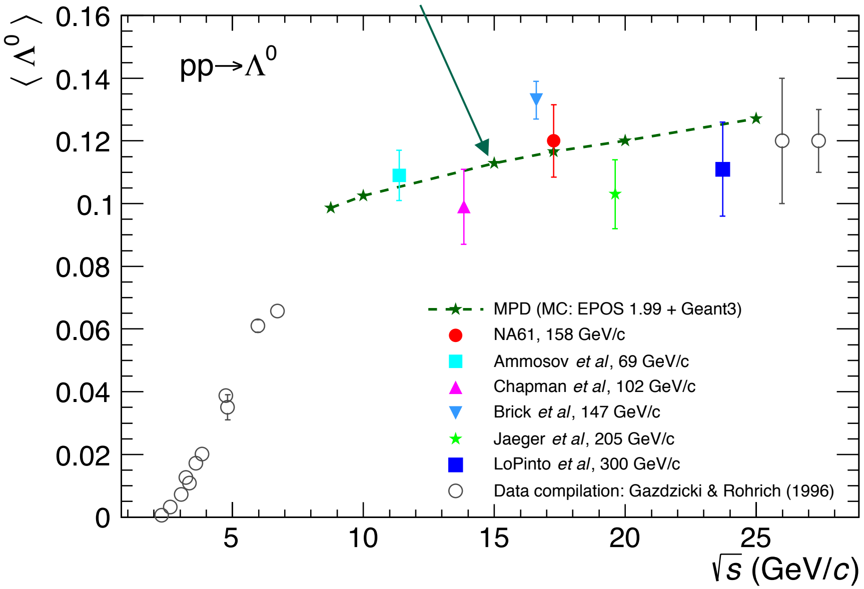
Λ^0 hyperon predicted by Monte Carlo in MPD p+p collisions

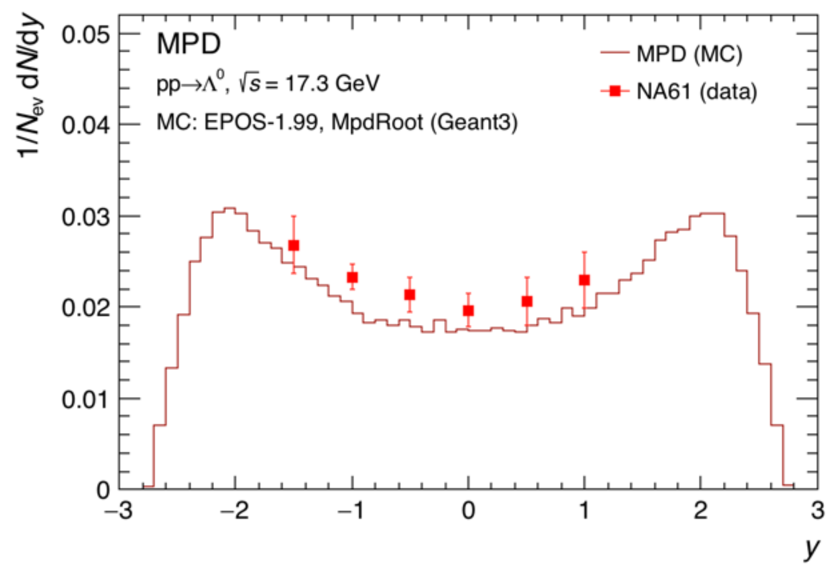
Double-differential yield $\frac{d^2N}{dydp_T}$ of $\boldsymbol{\Lambda^0}$ **hyperon** at different rapidity intervals.

MC simulation of $pp \rightarrow \Lambda^0$ with EPOS-1.99 generator, very close to the experimental data (in the NICA energy range)

Pseudorapidity density distribution $\frac{dN}{dy}$ of $\boldsymbol{\Lambda^0}$ **hyperon**

Monte Carlo in MPD

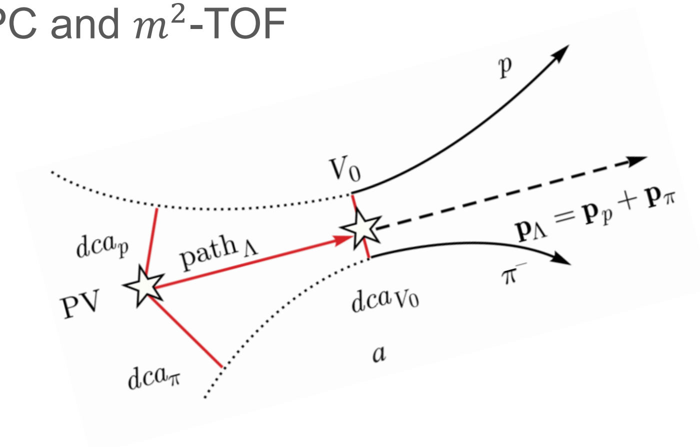


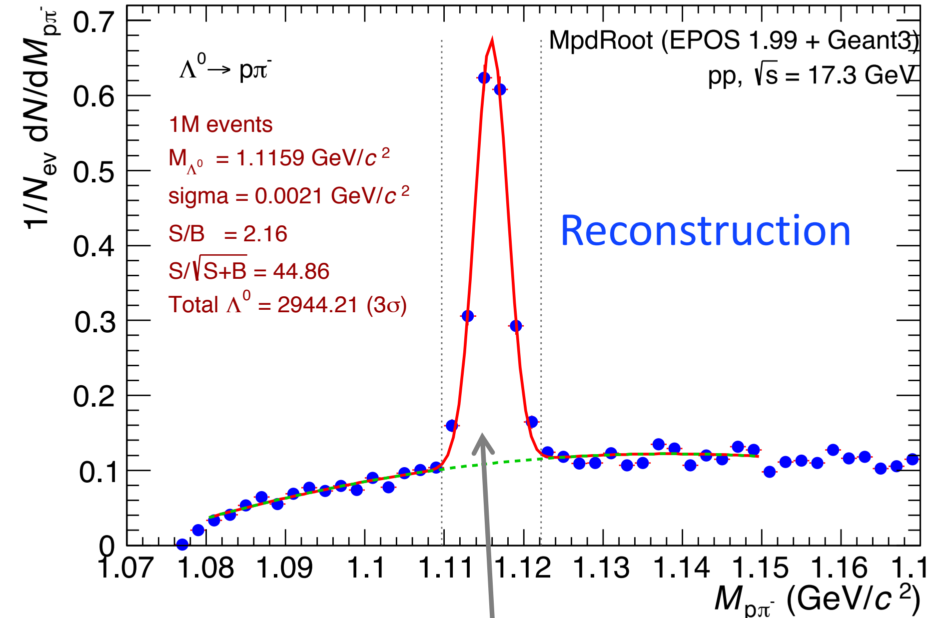


Λ^0 hyperon reconstruction

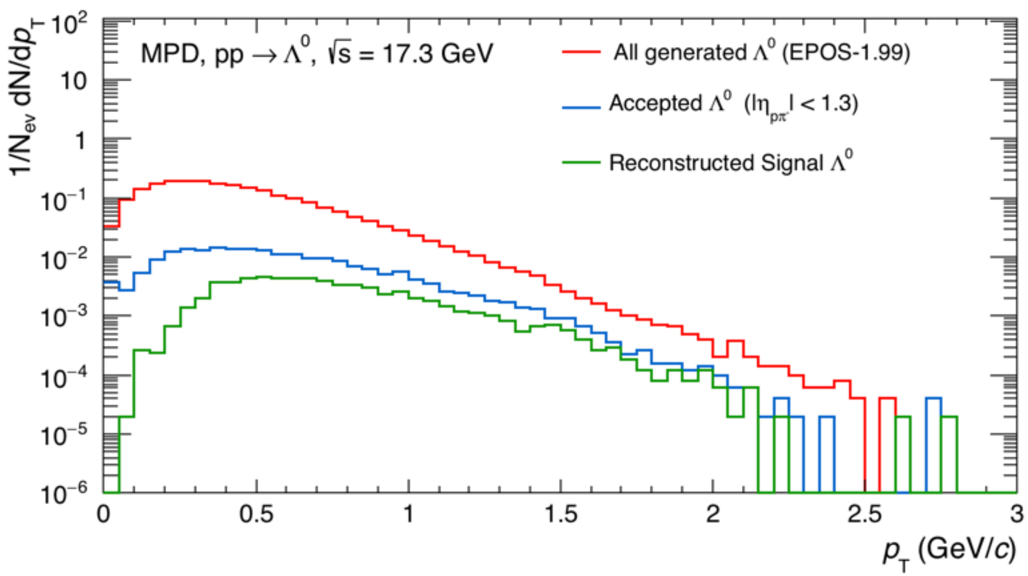
Reconstruction of Λ^0 hyperon in MPD using particle identification

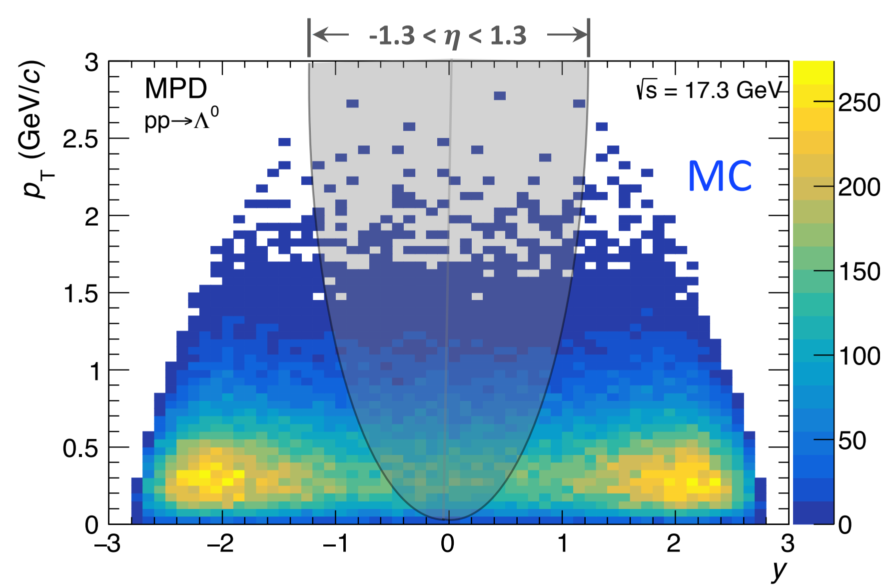
Track candidates identified via dE/dx-TPC and m^2-TOF methods.



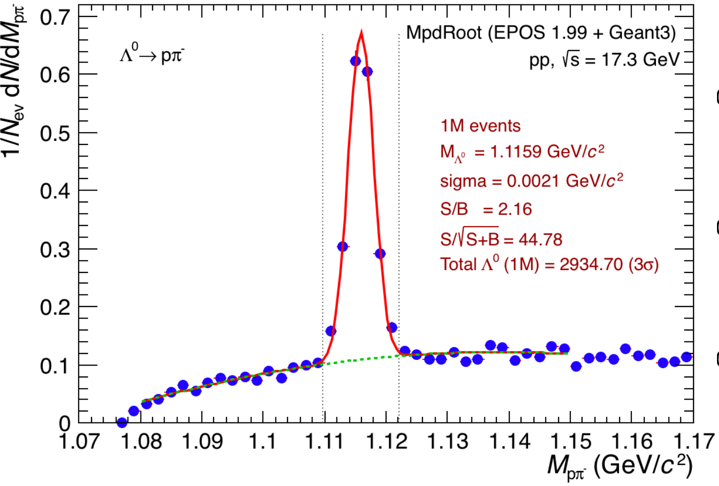


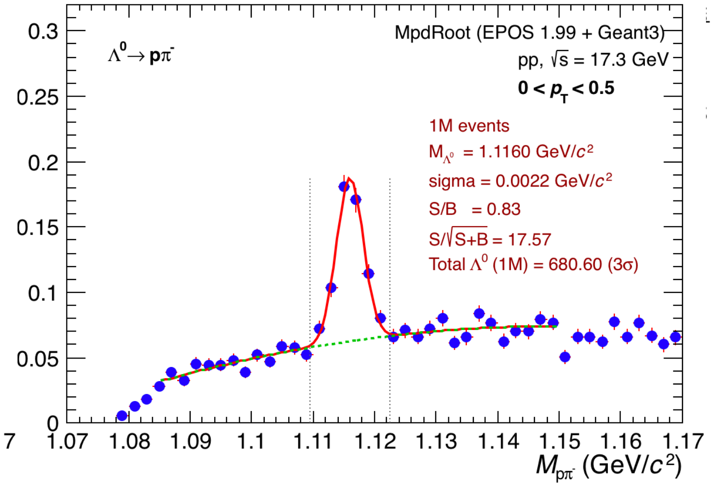
Limited geometrical acceptance so far!

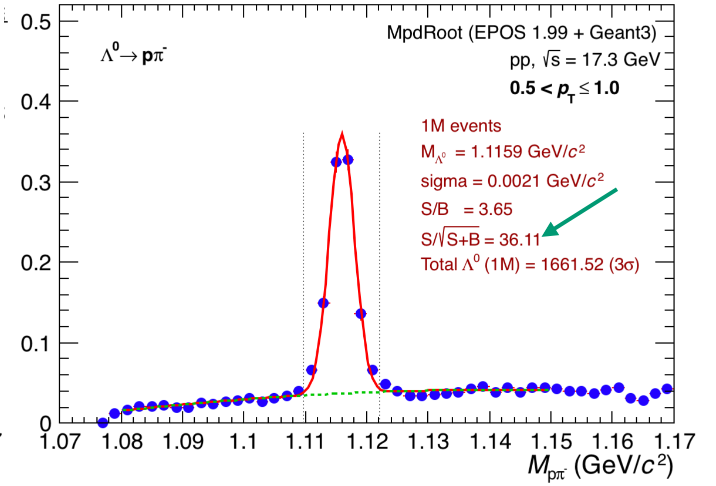


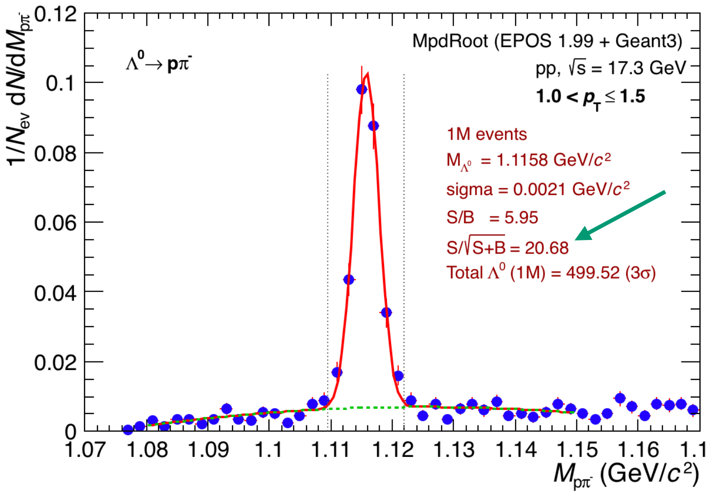


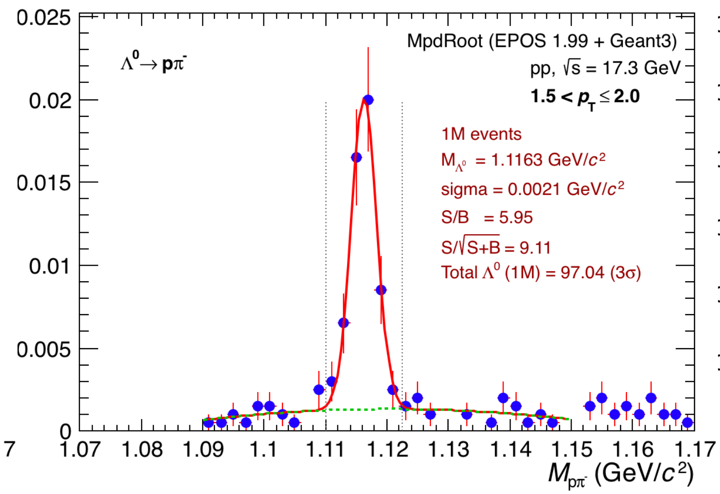
Λ^0 hyperon reconstruction in bins of p_T

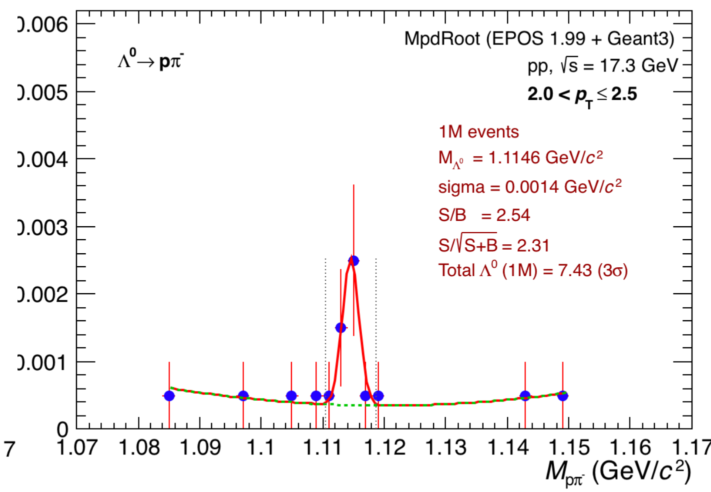


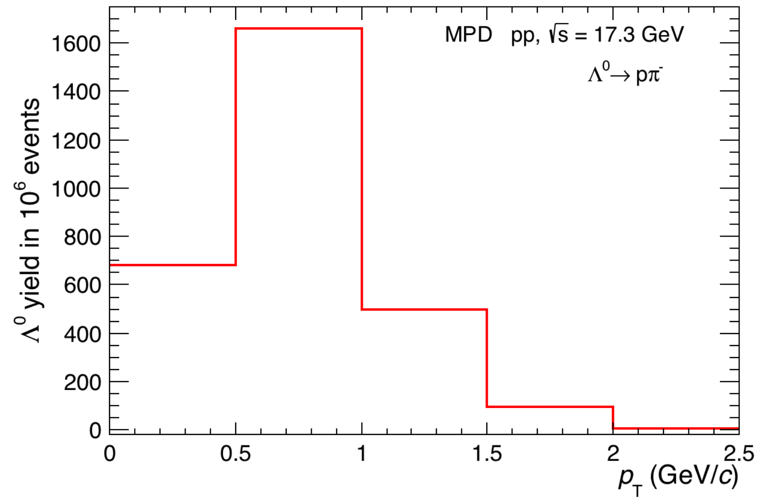












The best combination of S/B and significance are obtained at $0.5 < p_T < 1.5$

Summary

- The production of $p, \bar{p}, \pi^{\pm}$ and $K^{\pm}$ from pp @ 6 – 25 GeV was predicted through the spectra and multiplicities simulated by Monte Carlo in MPD/NICA. Comparison between predictions of two models, EPOS-1.99 and UrQMD-3.4, as well as with recent experimental results from NA61/SHINE were performed.

- EPOS 1.99 provides a reasonable description of the experimental data while UrQMD exhibits more discrepancies.

- Monte Carlo simulation of Λ^0 hyperon production from p+p collisions in MPD using EPOS 1.99 generator at $\sqrt{s}$ = 6 – 25 GeV, describes quite well experimental data reported in the literature.

- The reconstruction of the Λ^0 hyperon in the MPD geometrical acceptance given by the TPC and TOF detectors and using the PID method implemented in MPDRoot, gives rise to a well defined signal.

- Performance study of MPD for pp collisions revealed a good track finding efficiency and momentum resolution, as well as a good particle identification efficiency with the combined method.

- A systematic study of p+p collisions at the NICA energy range should provide a reference baseline, diagnostic observables from p+p collisions as well as a tool for testing and constraining model parameters describing hadron production mechanisms at lower energies.