

MPD PWG2 status report

V. Kireyeu* on behalf of the group

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MPD Collaboration meeting, JINR, Dubna, April 15-17, 2025

Outline

- Group status
- Activities:
 - Hadrons
 - Light nuclei
 - Hyperons
- Other
- Summary

PWG-2 «Spectra of light flavour and hypernuclei»

Co-conveners: Xianglei Zhu (Tsingua Uni., China), Viktar Kireyeu (JINR, Russia)

Viktar Kireyeu

Vadim Kolesnikov (JINR)

Natalia Kolomoyets (JINR)

Mikhail Malaev (PNPI)

Xianglei Zhu

Dilyana Suvarieva (JINR)

Veronika Vasendina (JINR)

Alexander Zinchenko (JINR)

PWG-2 «Spectra of light flavour and hypernuclei»

- **Light flavour hadron spectra, yields and ratios**

- Energy and system-size dependence of the charged hadrons production (pions, kaons, protons)
- Transverse momentum spectra, rapidity distributions, mean multiplicities, particle ratios
- Nuclear modification factor, antiparticle/particle ratio, radial flow, phase diagram mapping

- **Strangeness production: hyperons and hypernuclei**

- Hyperon yields, spectra, antiparticle/particle ratio, nuclear modification factor, azimuthal anisotropy (with PWG-3)
- (anti) Lambda polarisation
- Single and double strange hypernuclei reconstruction: spectra, rapidity, lifetime

- **Resonances production: ρ , ϕ , K^* , $\Lambda(1520)$ etc**

- **Light nuclei spectra, yields, coalescence coefficients: d, t, ${}^3\text{He}$, ${}^4\text{He}$**

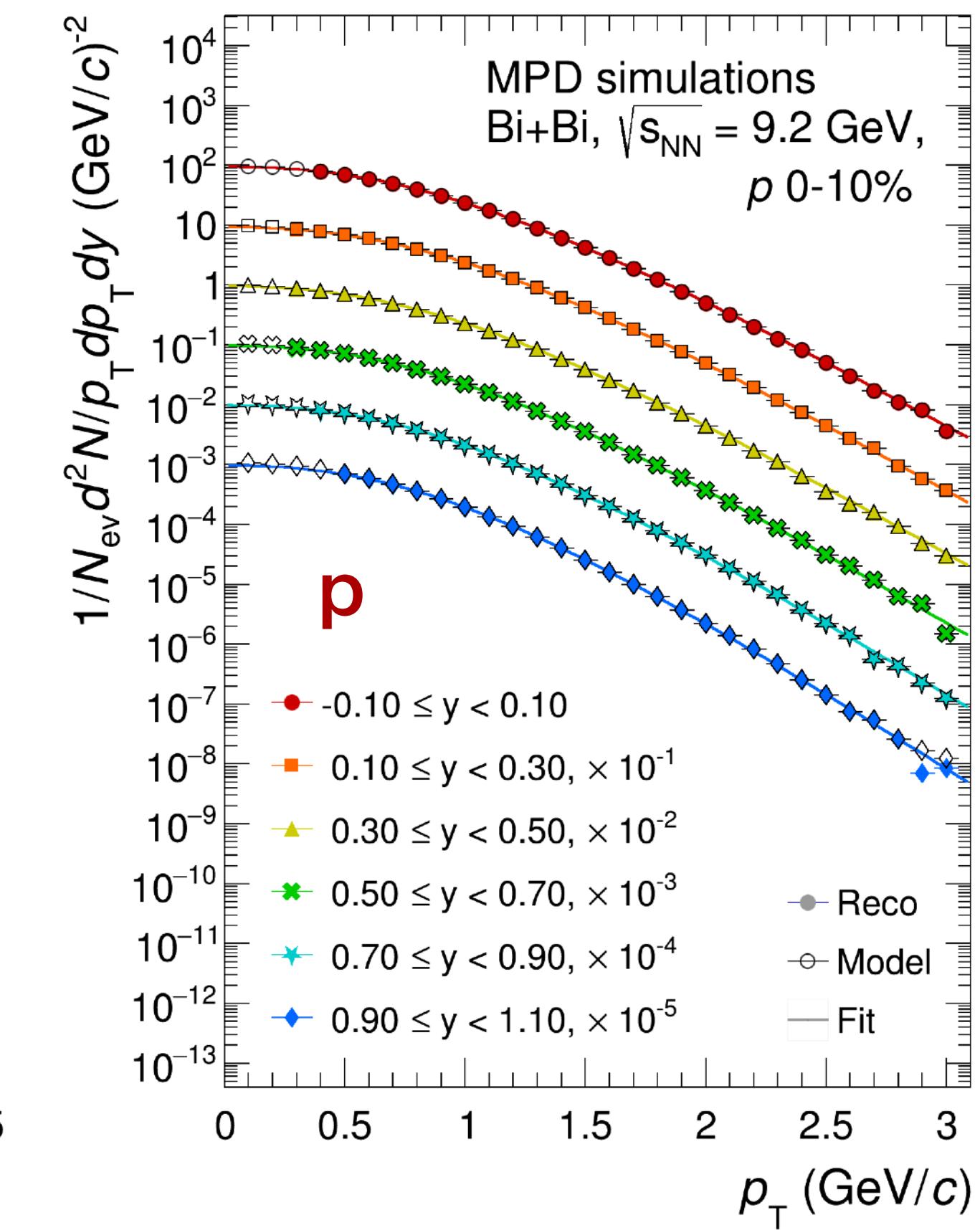
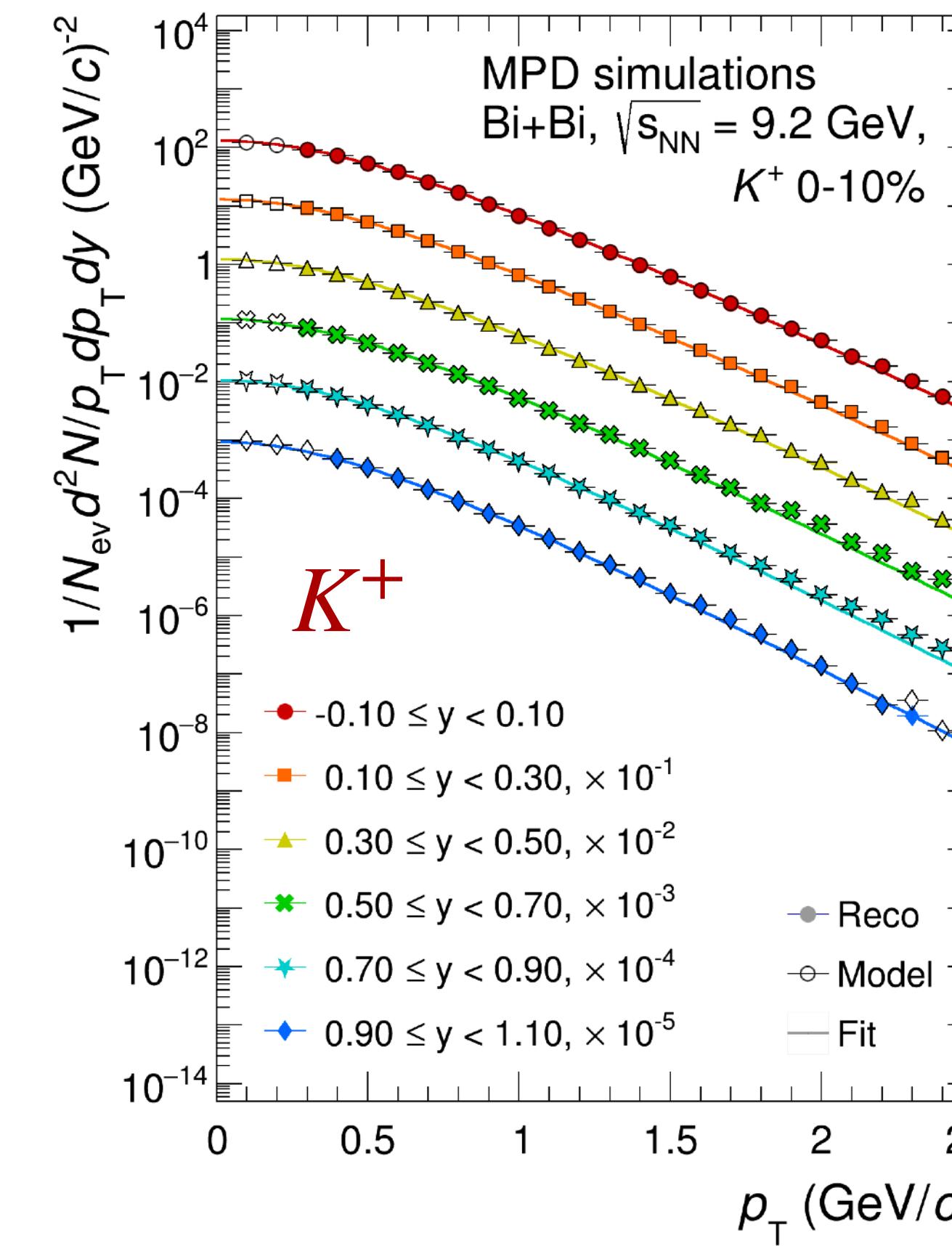
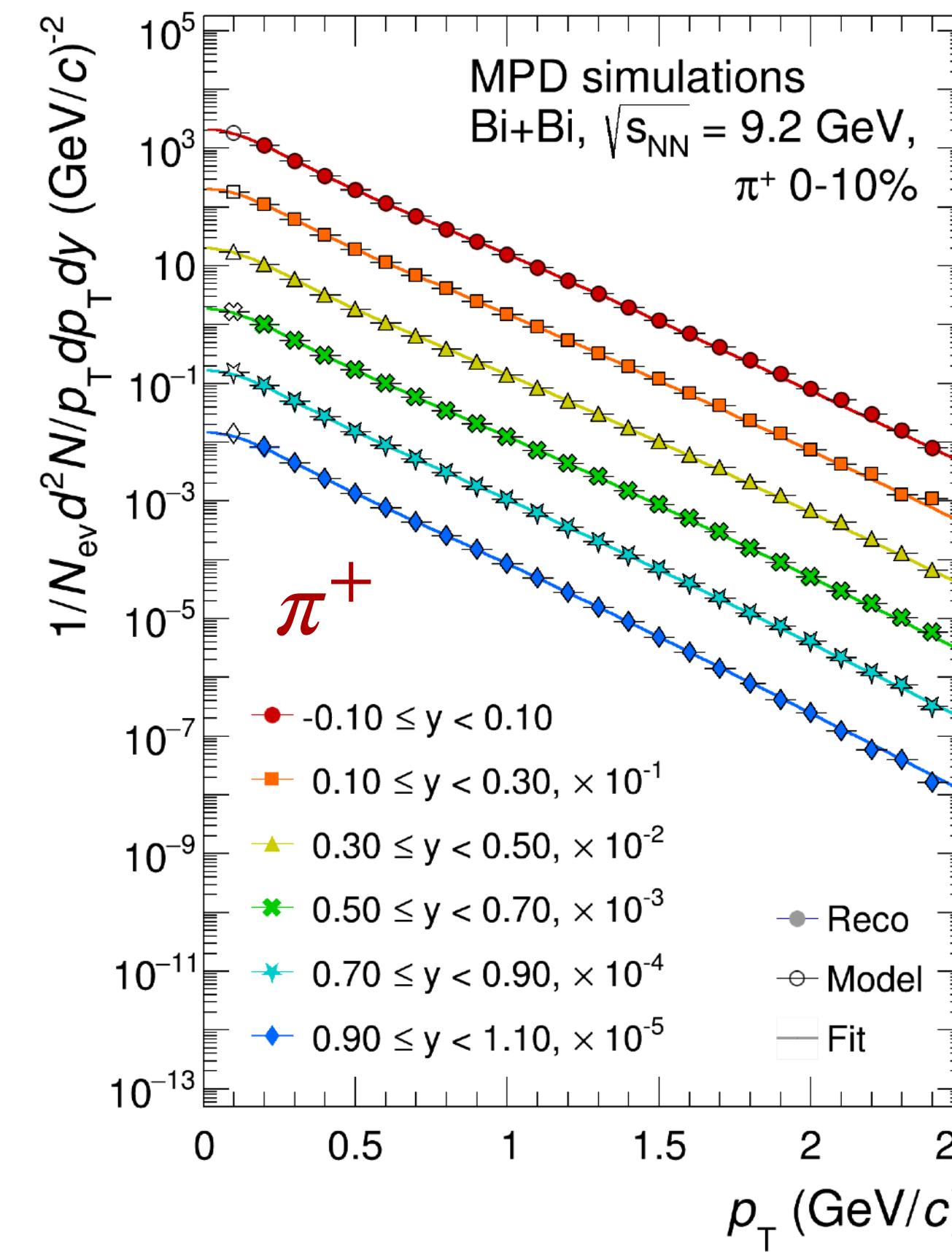
Activities

Light hadrons: since last collaboration meeting

Natalia Kolomoyets (nkolomoyets@jinr.ru)

Production 29: 20M PHQMD events, «MpdHadronSpectra» analysis wagon

Spectra included into the second Collaboration paper: [arXiv:2503.21117](https://arxiv.org/abs/2503.21117)

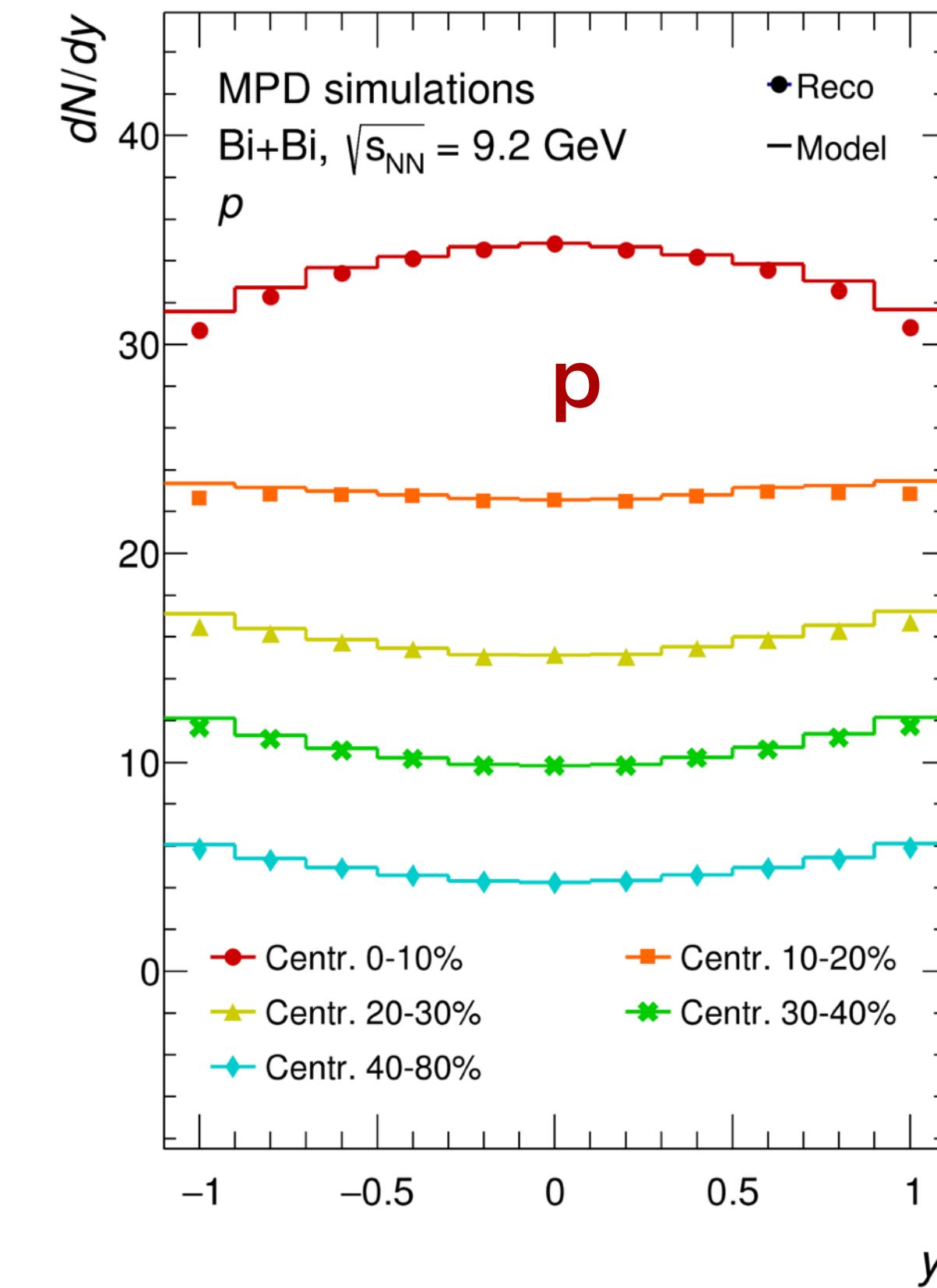
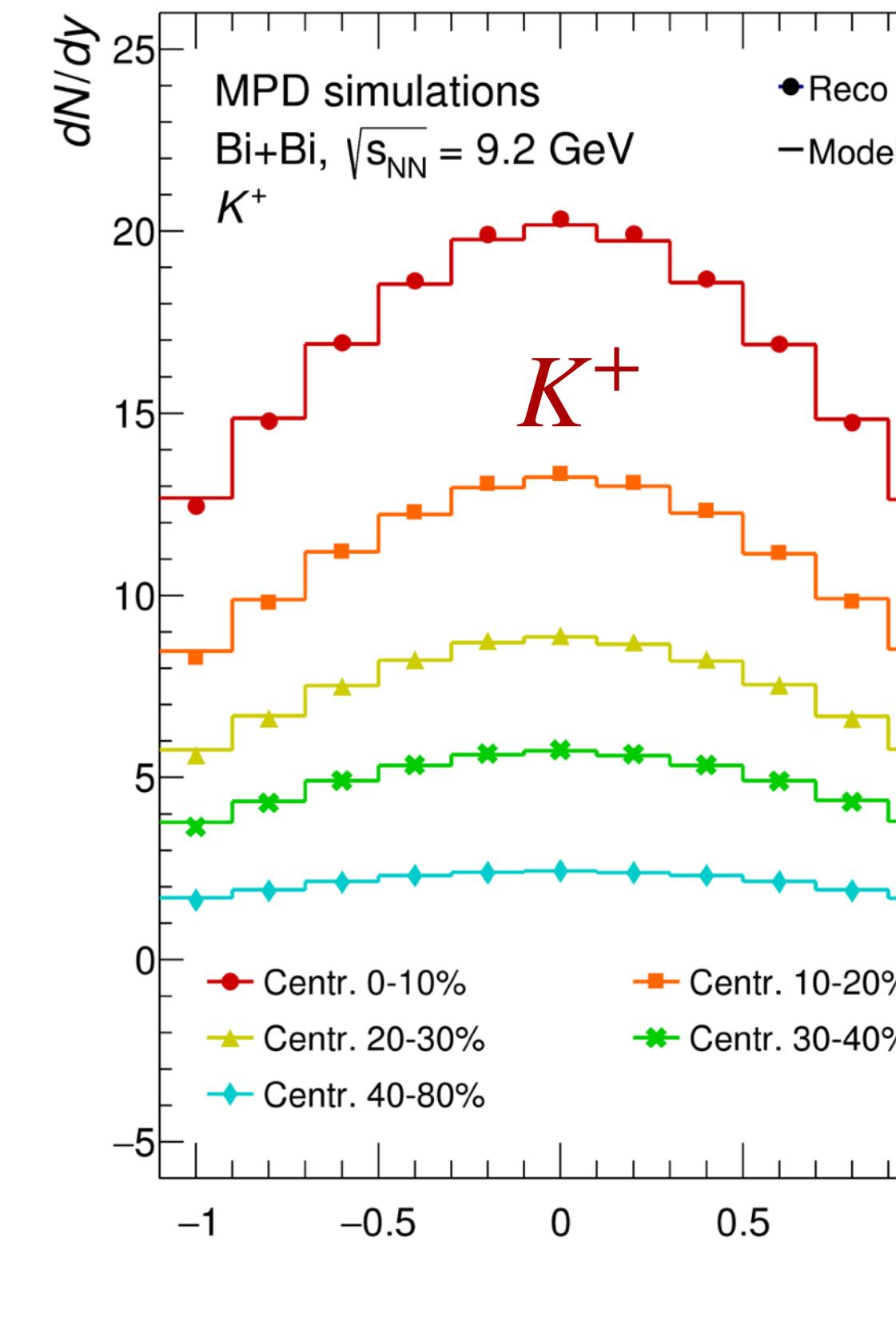
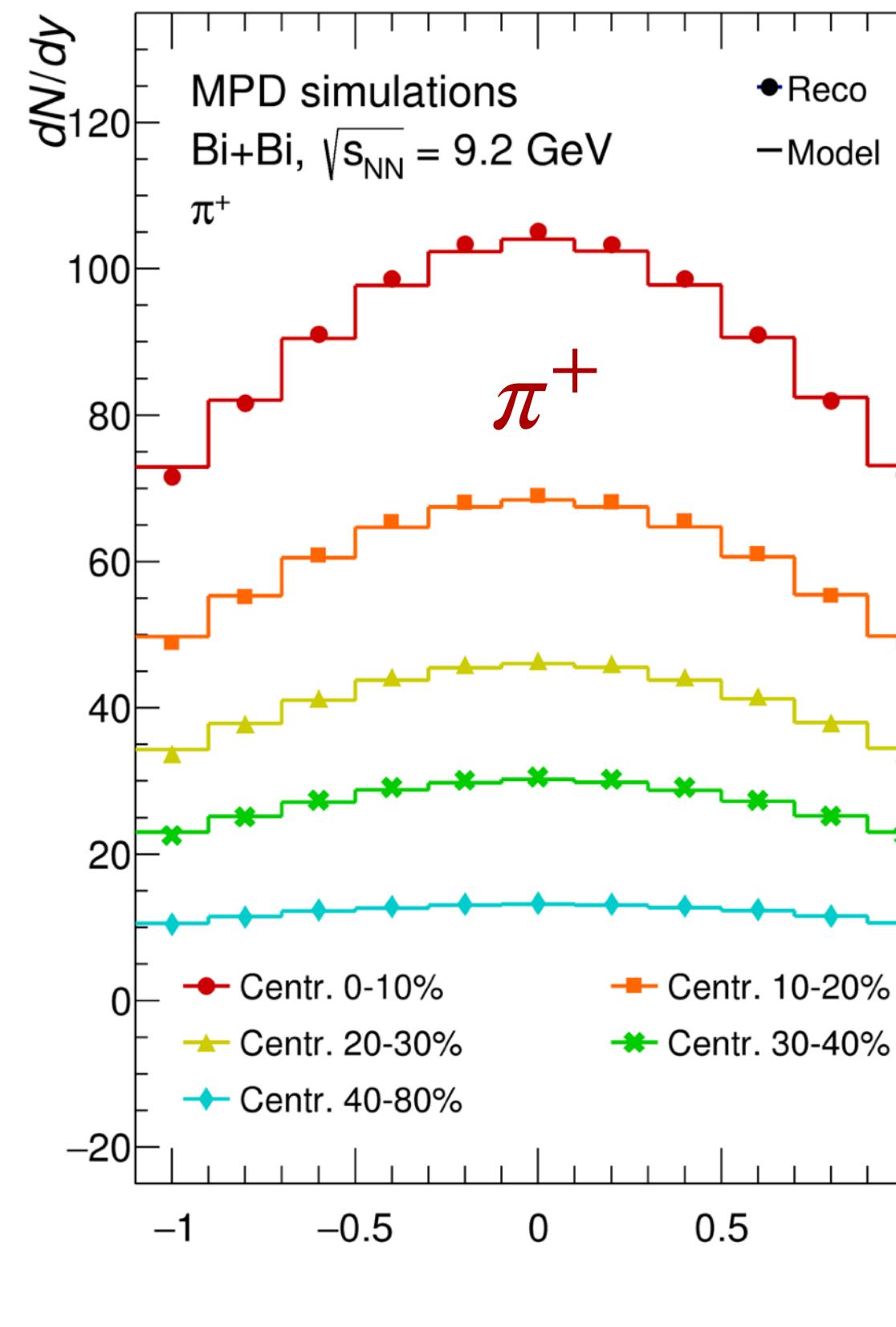


Light hadrons: since last collaboration meeting

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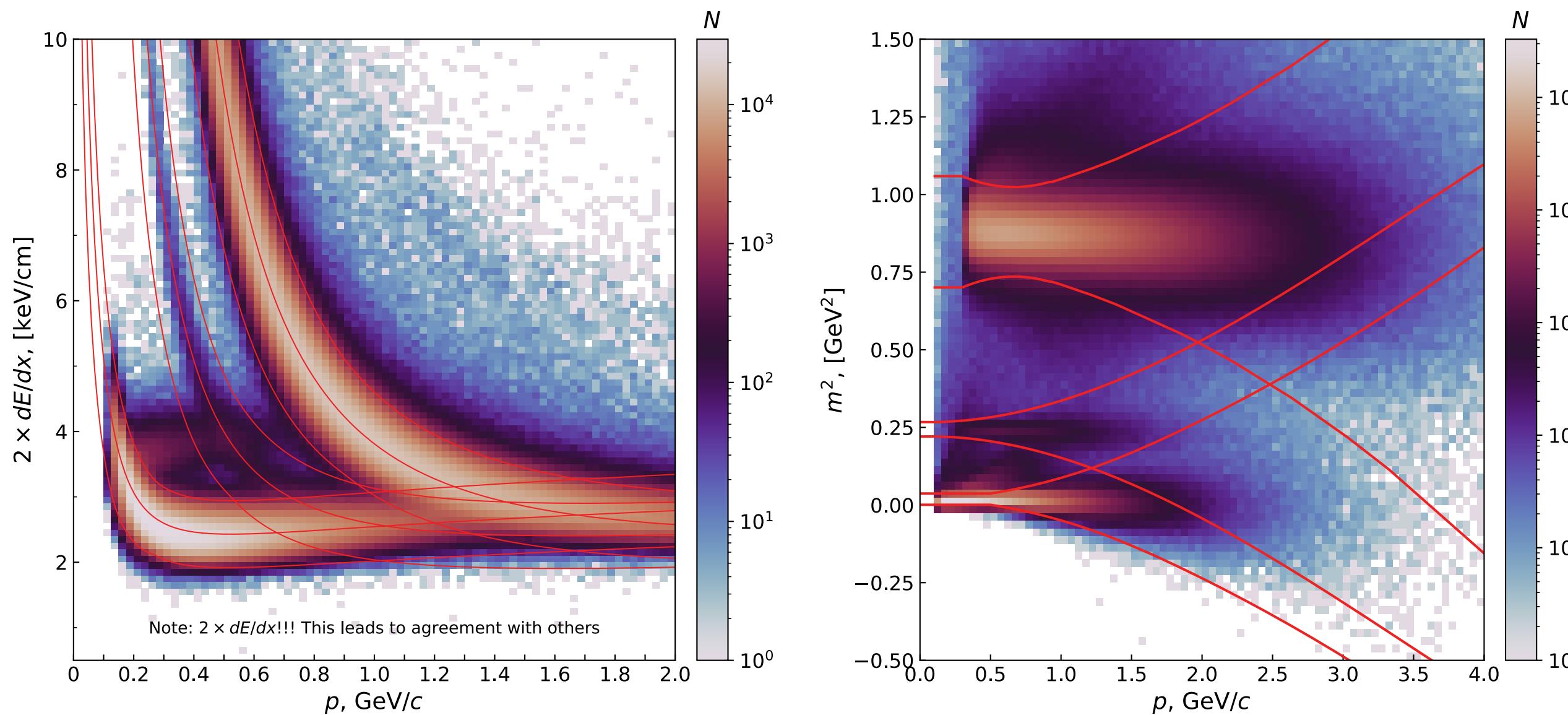


Light hadrons: current activity

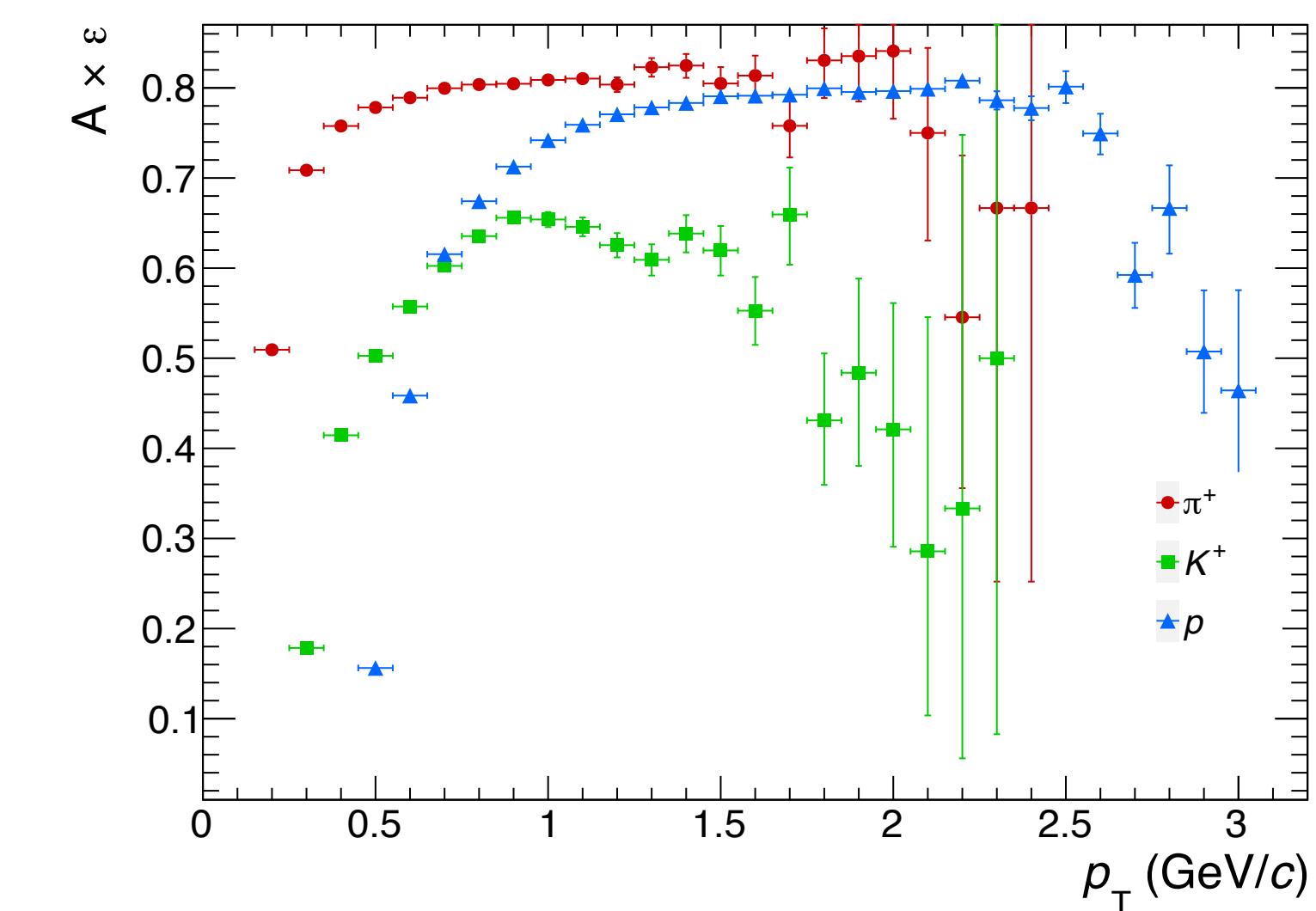
Natalia Kolomoyets (nkolomoyets@jinr.ru)

Production 36 (**FXT**): Xe+W, $E_{\text{kin}} = 2.5 \text{ A.GeV}$, 7.5M UrQMD events, «MpdpHadronSpectra» wagon
Combined dE/dx and m^2 PID used (MpdpId class)

MpdPid class parametrisation



Overall efficiency



Combined dE/dx and m^2 PID used

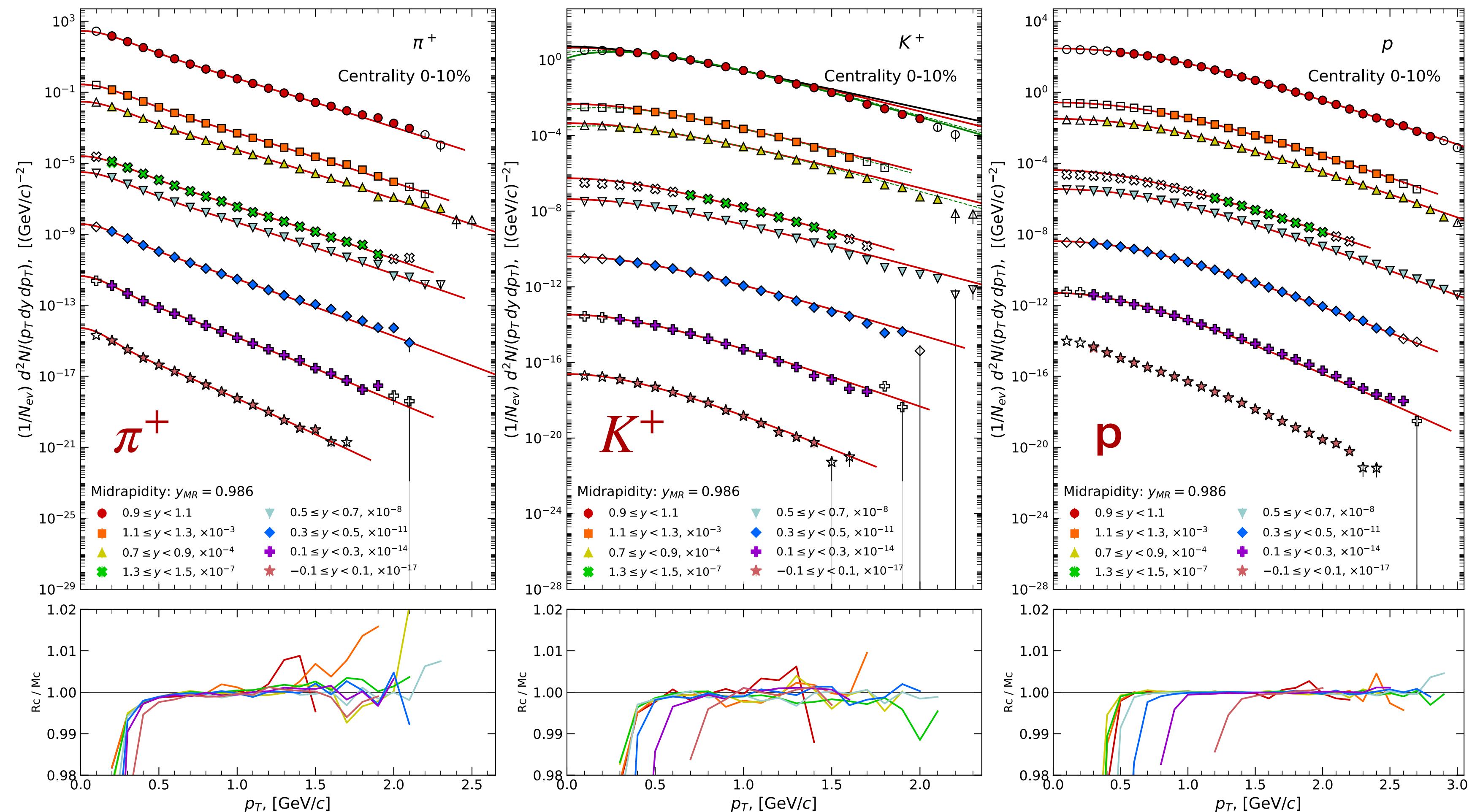
Light hadrons: current activity

Natalia Kolomoyets (nkolomoyets@jinr.ru)

Production 36 (**FXT**): Xe+W, $E_{\text{kin}} = 2.5 \text{ A.GeV}$, 7.5M UrQMD events, «MpDHadronSpectra» wagon
Combined dE/dx and m^2 PID used (MpDPid class)

- Invariant p_T -spectra are reconstructed in several rapidity bins.
- Thermal and Blast-Wave fits were used for the extrapolation.
- The work is going on: fits, rapidity spectra etc.

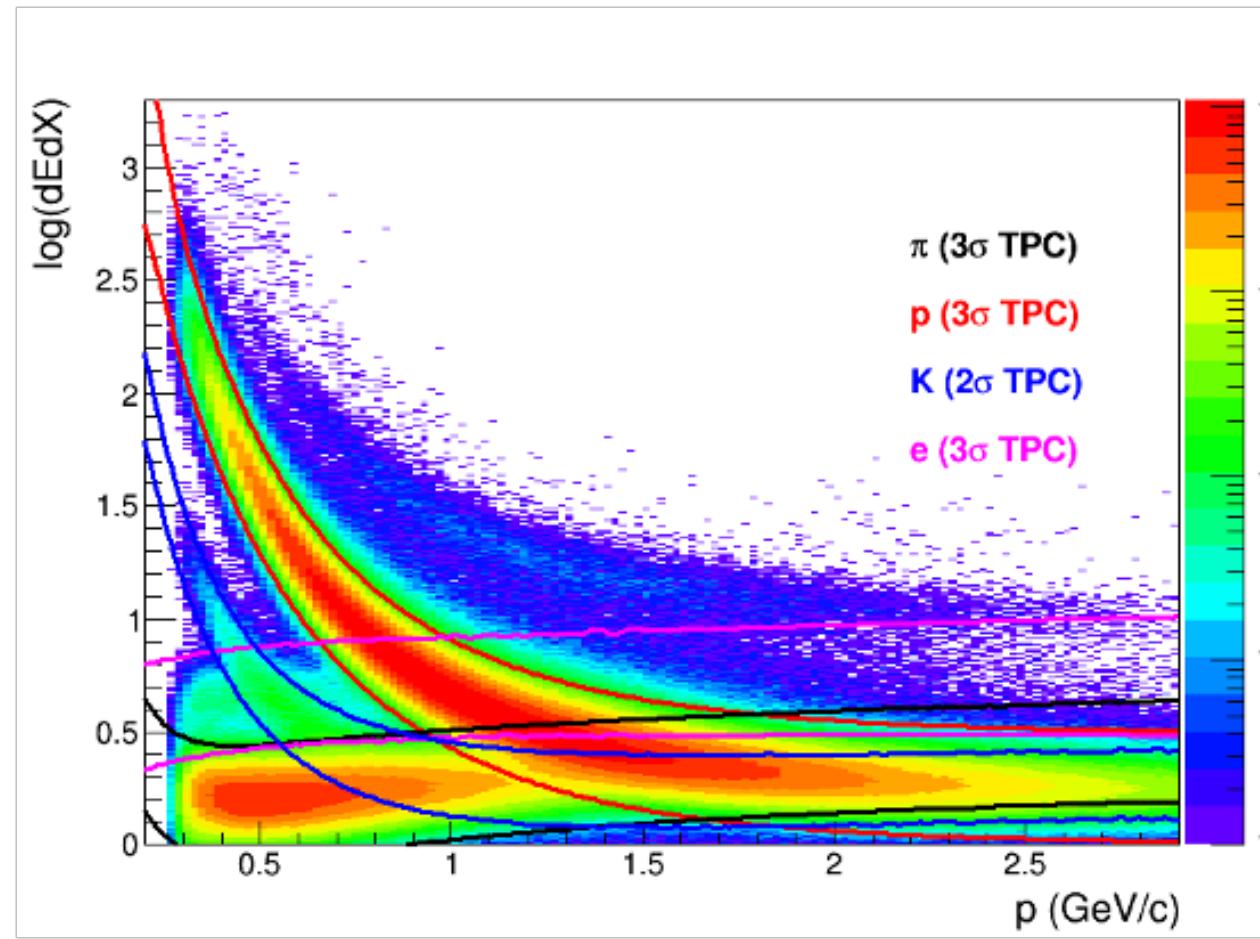
More here:
<https://indico.jinr.ru/event/5313>



Light hadrons: PID by M.Malaev and V. Ryabov

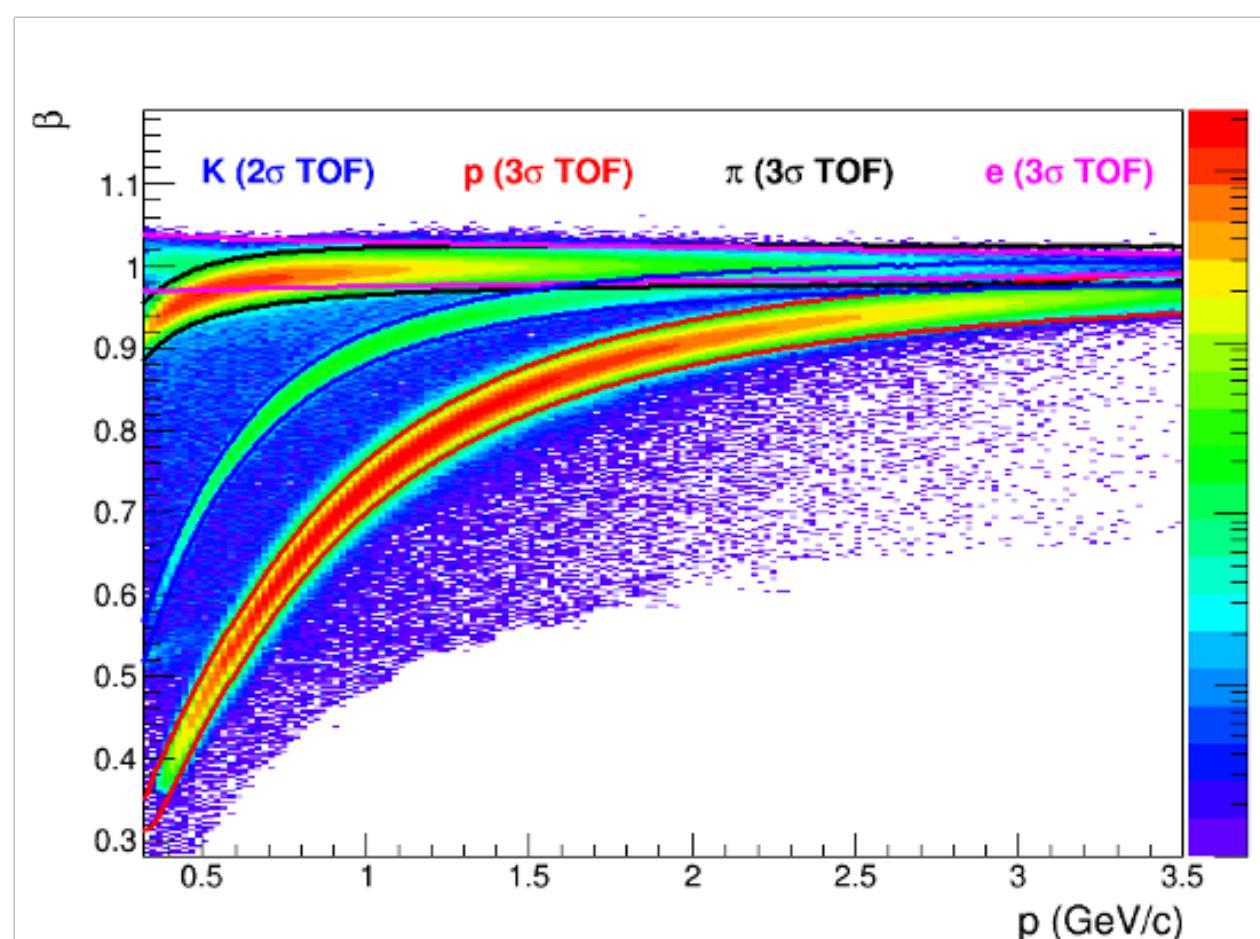
Mikhail Malaev (mmalayev@gmail.com)

Production 36 (**FXT**): Xe+W, $E_{kin} = 2.5$ A.GeV, 15M UrQMD events



- TPC-TOF

- TPC 2σ PID selection for a given specie (π, p)
- If track is 2σ -matched to TOF then TOF 2σ PID selection for a given specie (π, p)



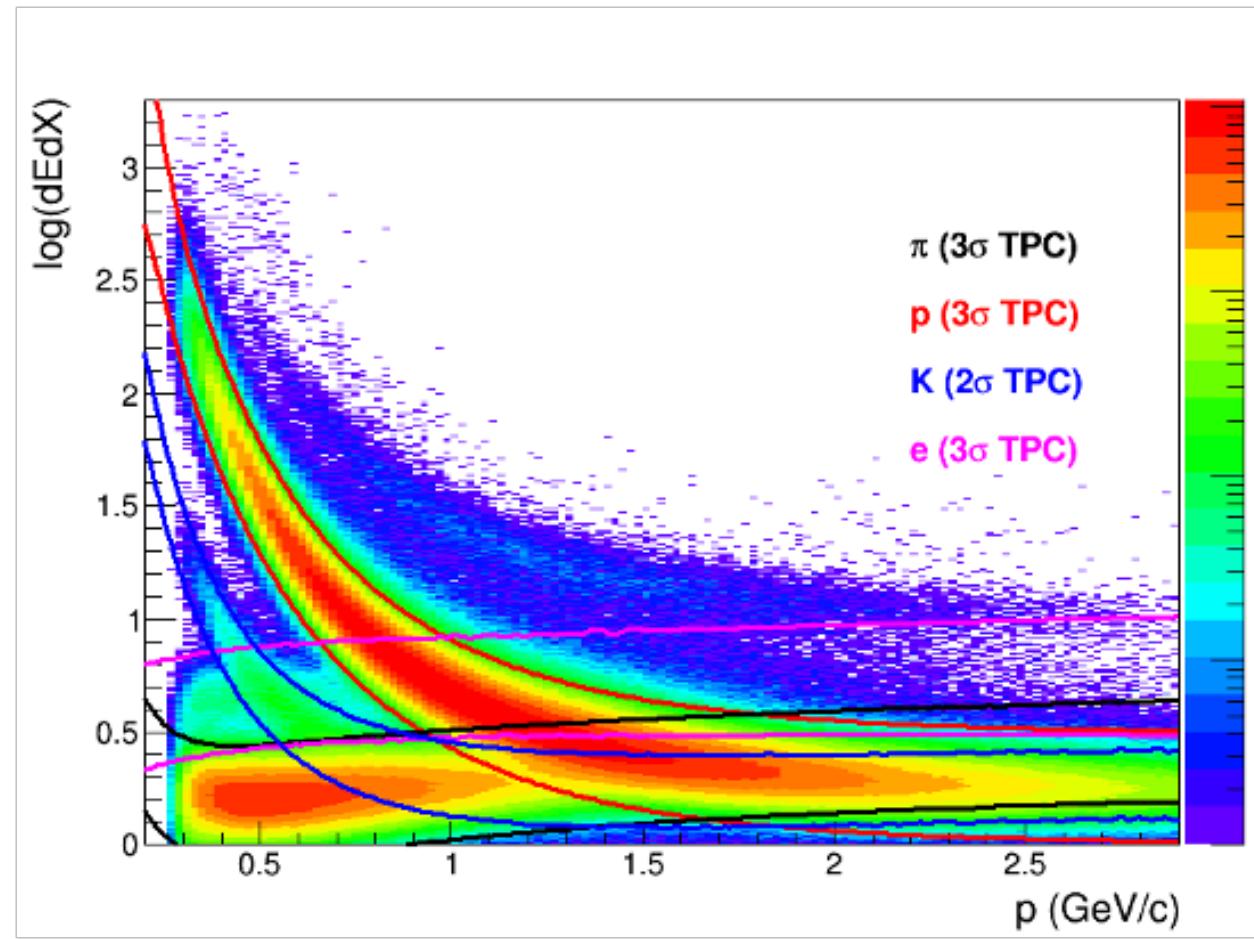
- TOF-TPC

- TOF 2σ PID selection for a given specie (π, p)
- TPC 2σ PID selection for a given specie (π, p)

Light hadrons: PID by M.Malaev and V. Ryabov

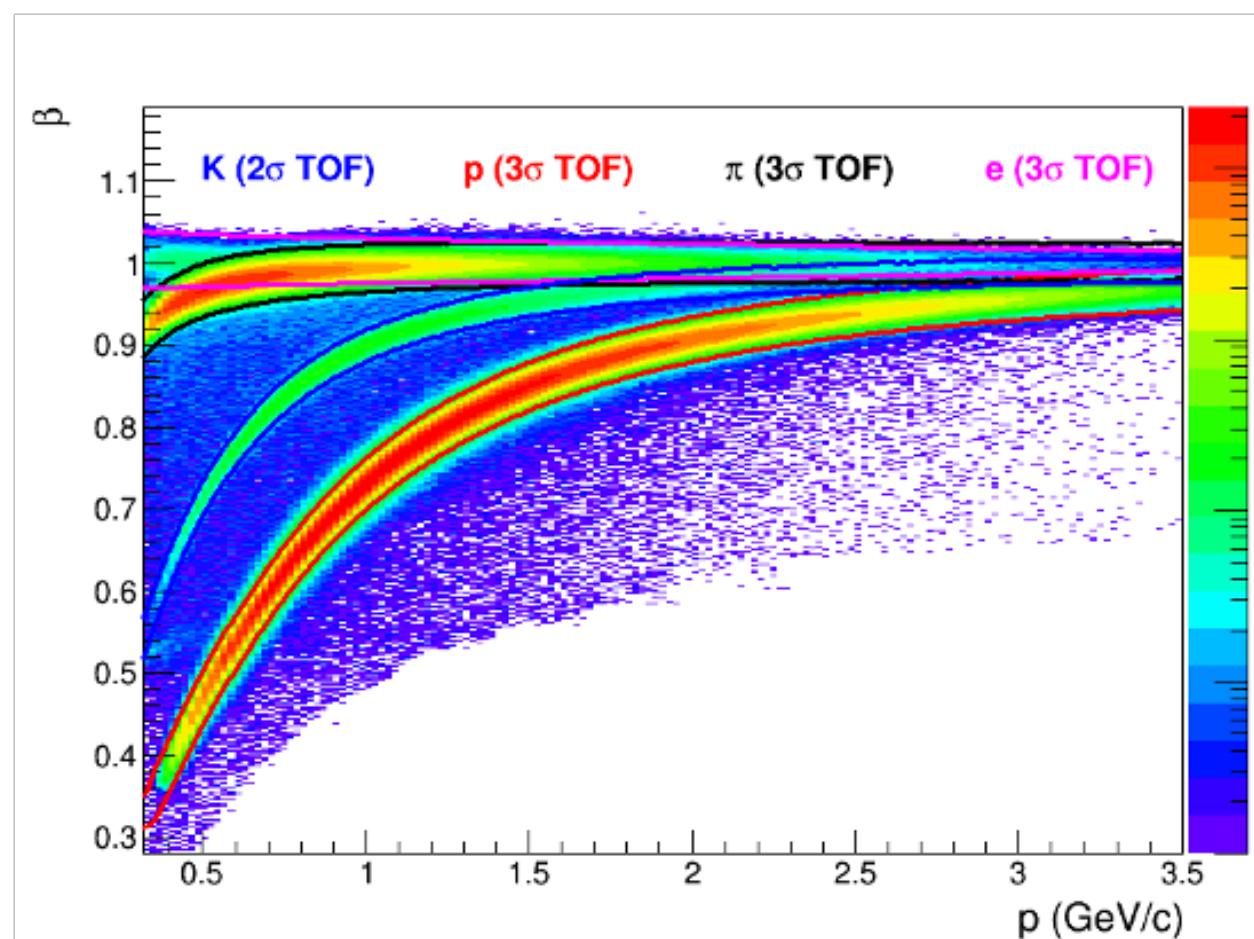
Mikhail Malaev (mmalayev@gmail.com)

Production 36 (**FXT**): Xe+W, $E_{kin} = 2.5$ A.GeV, 15M UrQMD events



- TPC-TOF

- TPC 1σ PID selection for a given specie (K)
- If track is 2σ -matched to TOF then TOF 1σ PID selection for a given specie (K)
- TPC 3σ veto-PID for other species (for K: e/ π /p veto)



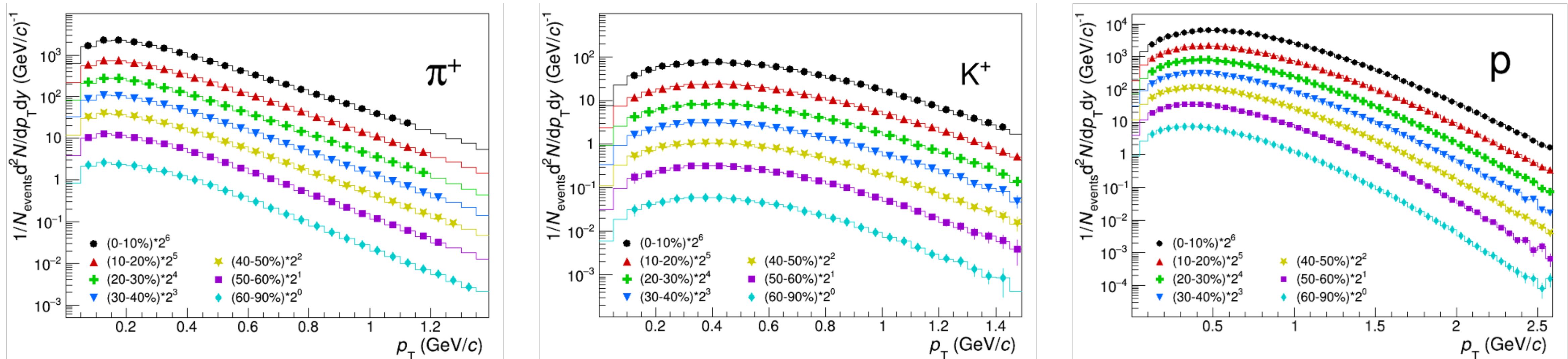
- TOF-TPC

- TOF 1σ PID selection for a given specie (K)
- TPC 1σ PID selection for a given specie (K)
- TOF 3σ veto-PID for other species (for K: e/ π /p veto)

Light hadrons: PID by M.Malaev and V. Ryabov

Mikhail Malaev (mmalayev@gmail.com)

Production 36 (**FXT**): Xe+W, $E_{\text{kin}} = 2.5 \text{ A.GeV}$, 15M UrQMD events



- Spectra starts at $p_T \sim 50 \text{ MeV}/c$ for pions, $\sim 100 \text{ MeV}/c$ for protons and K^+ , $\sim 150 \text{ MeV}/c$ for K^- .
- Losses at low p_T are $\sim 3\text{-}5\%$ for pions, protons and K^+ , $\sim 15\%$ for K^- .
- Purity $> 95\%$ for pions and protons, $> 90\%$ for kaons.
- **Active development.**

Light nuclei: since last collaboration meeting

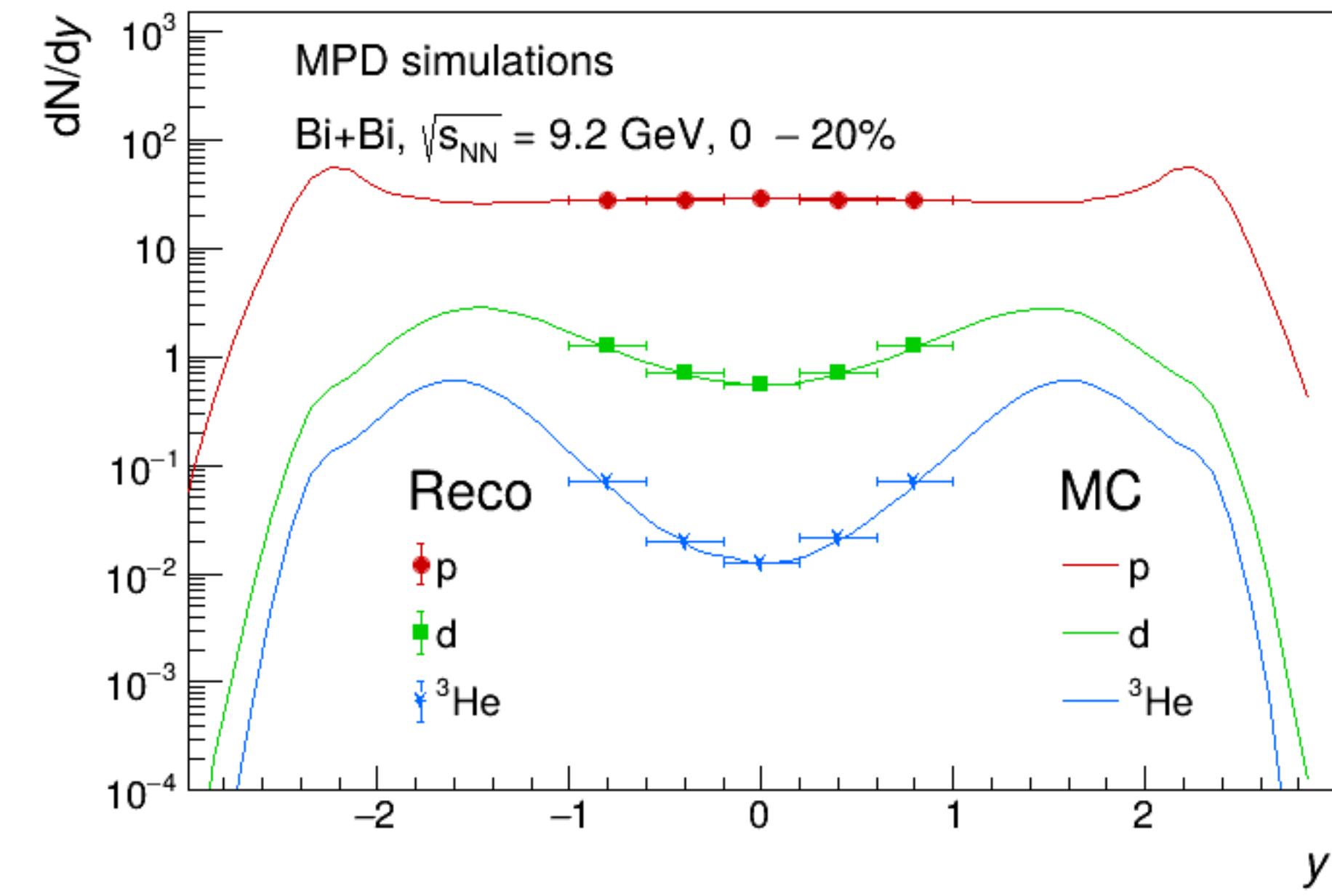
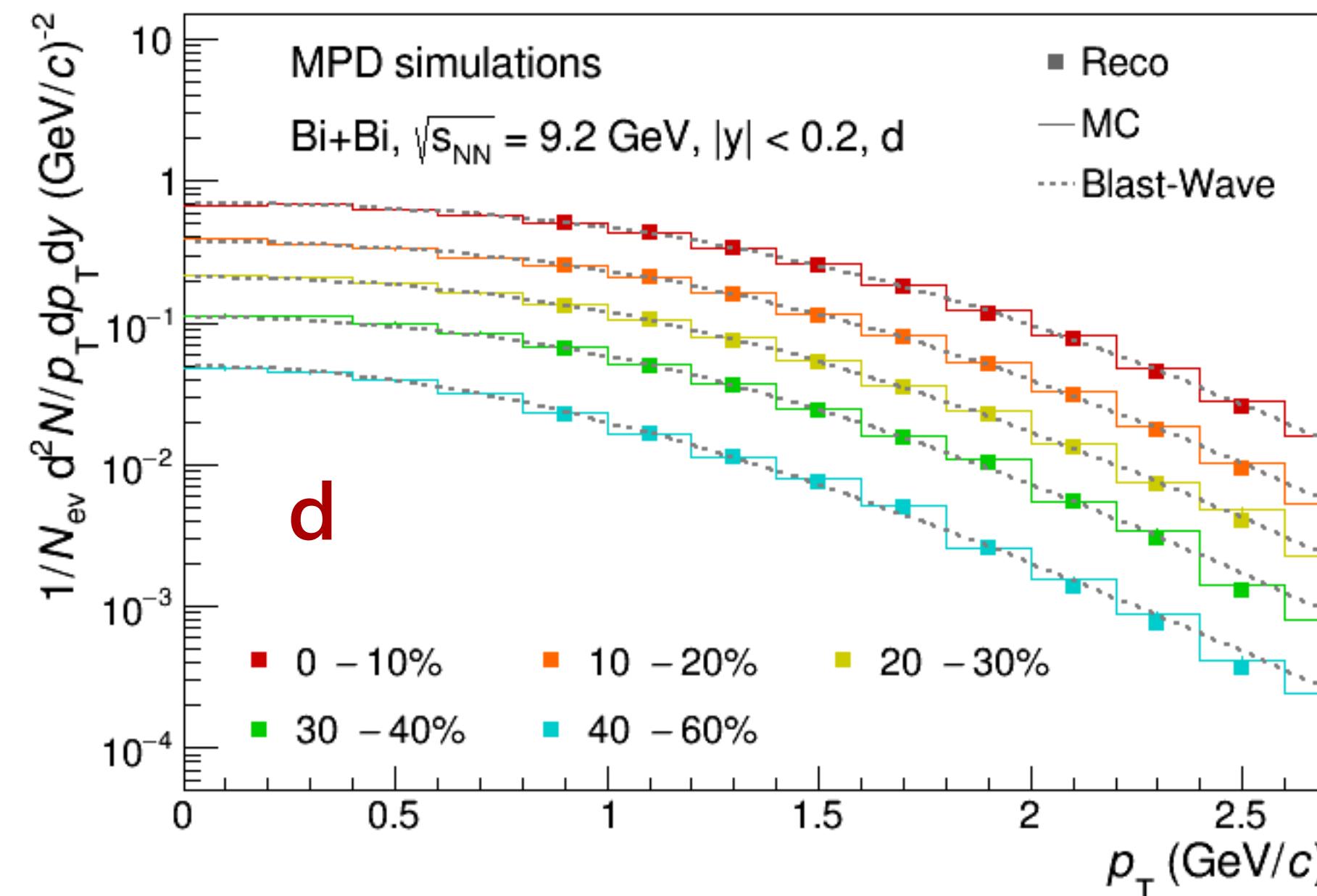
Viktar Kireyeu (vkireyeu@jinr.ru)

Production 29: Bi+Bi, $E_{cm} = 9.2$ GeV, 20M PHQMD events, «Nuclei» analysis wagon

Combined dE/dx and m^2 PID used (MpdPid class)

the most documented analysis wagon

Spectra included into the second Collaboration paper: [arXiv:2503.21117](https://arxiv.org/abs/2503.21117)



- Invariant p_T spectra: good agreement between MC and reconstruction
- Blast-Wave for the extrapolation to the low and hight p_T regions

Light nuclei: current activity

Viktar Kireyeu (vkireyeu@jinr.ru)

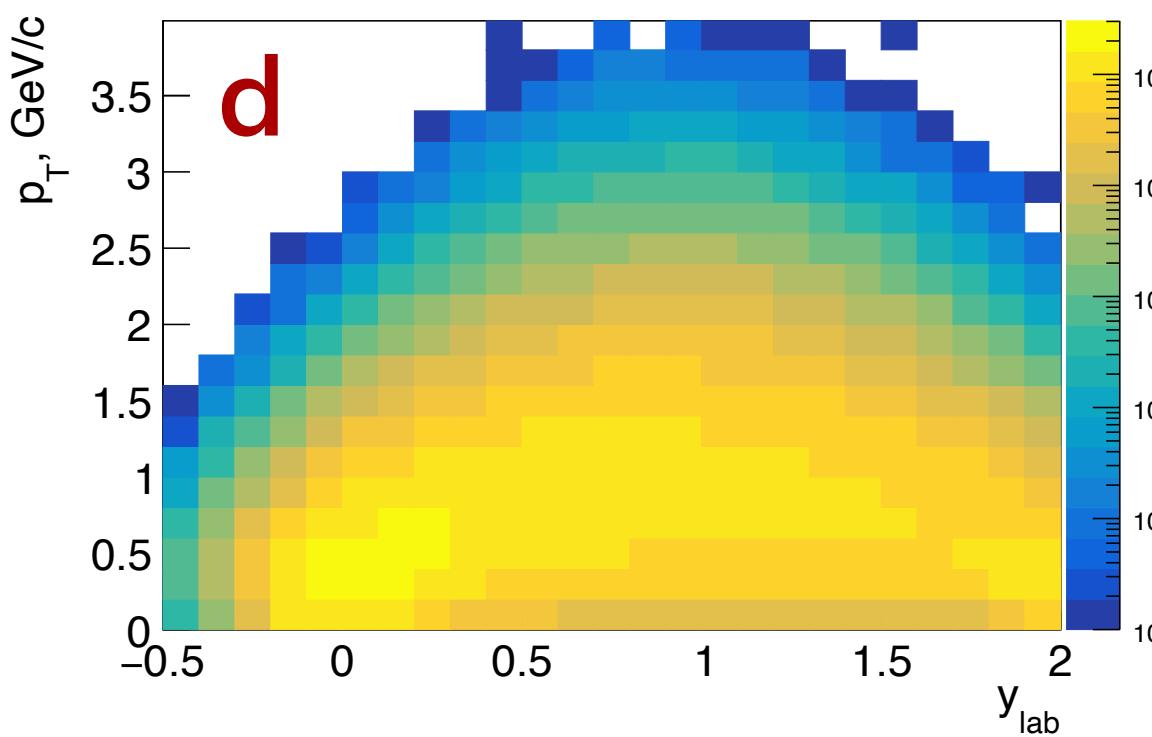
Production 37 (**FXT**): Xe+W, $E_{\text{kin}} = 2.5 \text{ A.GeV}$, 5M PHQMD events, «Nuclei» analysis wagon

- New version:**
- Refactored code
 - More documentation
 - Even more user-friendly

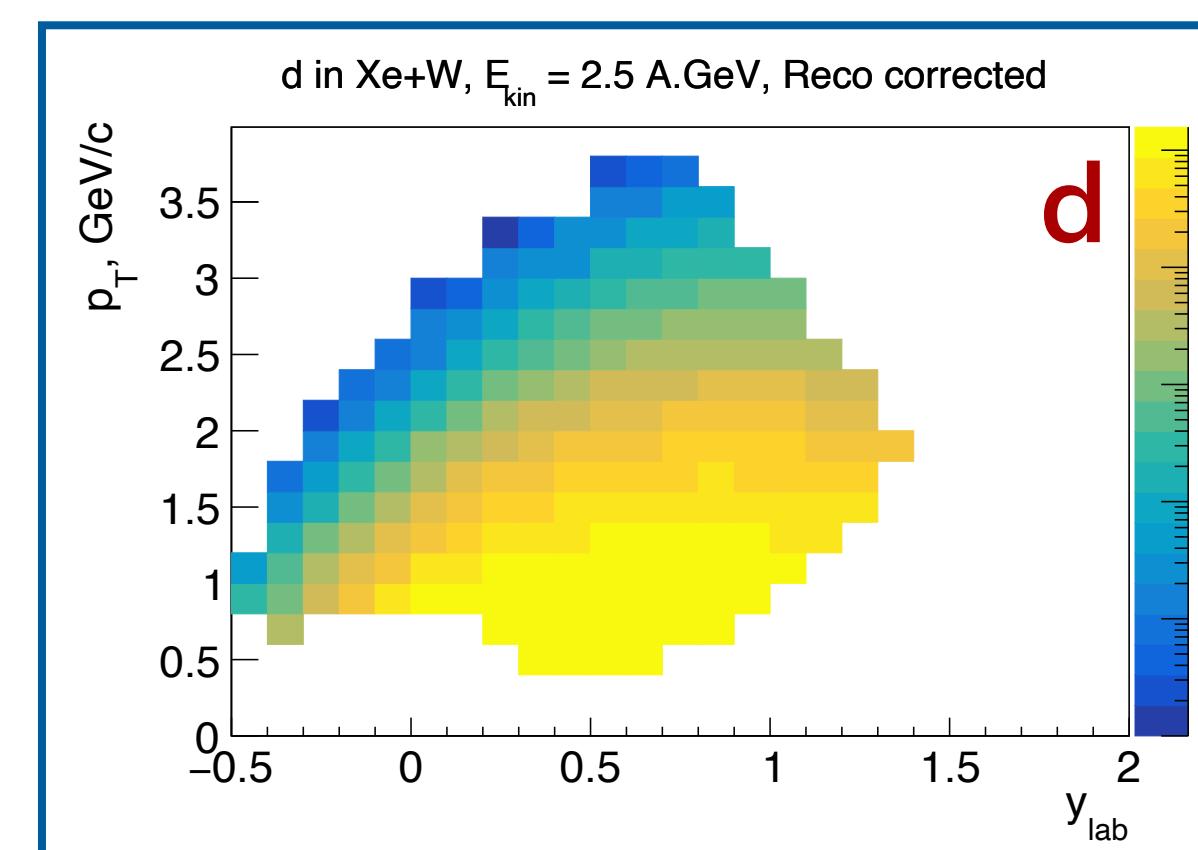
MpdPid class

Combined PID:

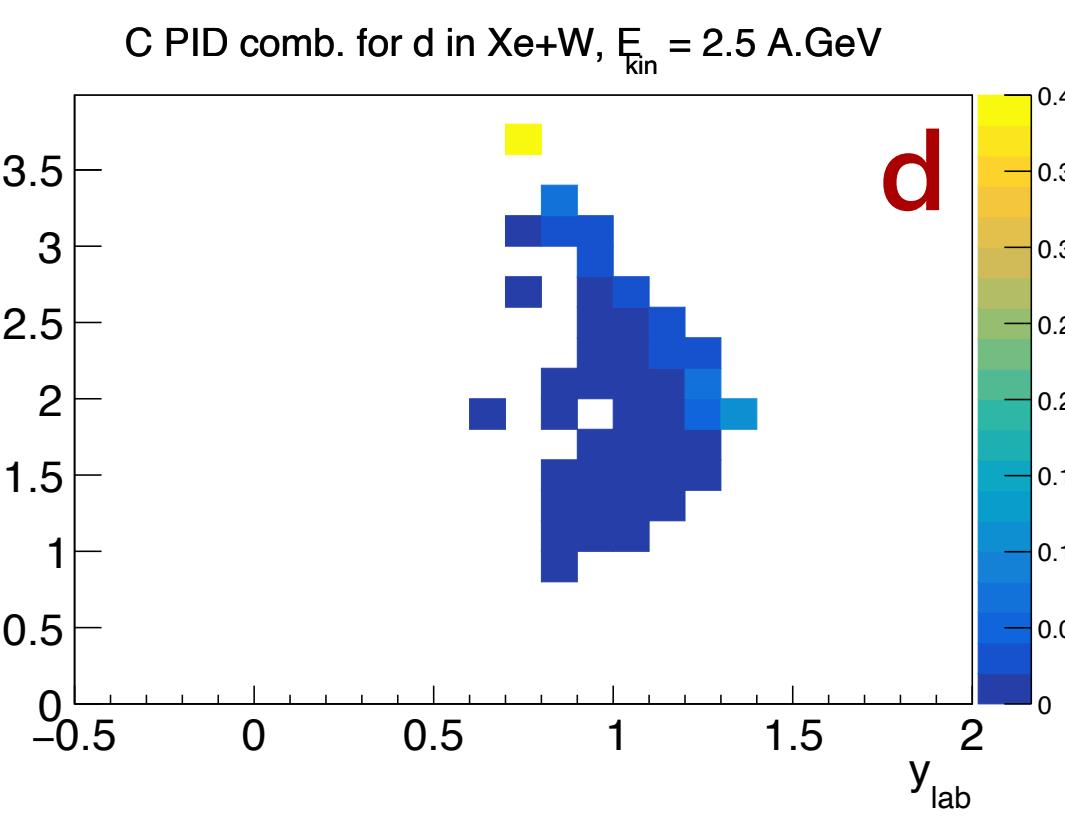
MC phase-space



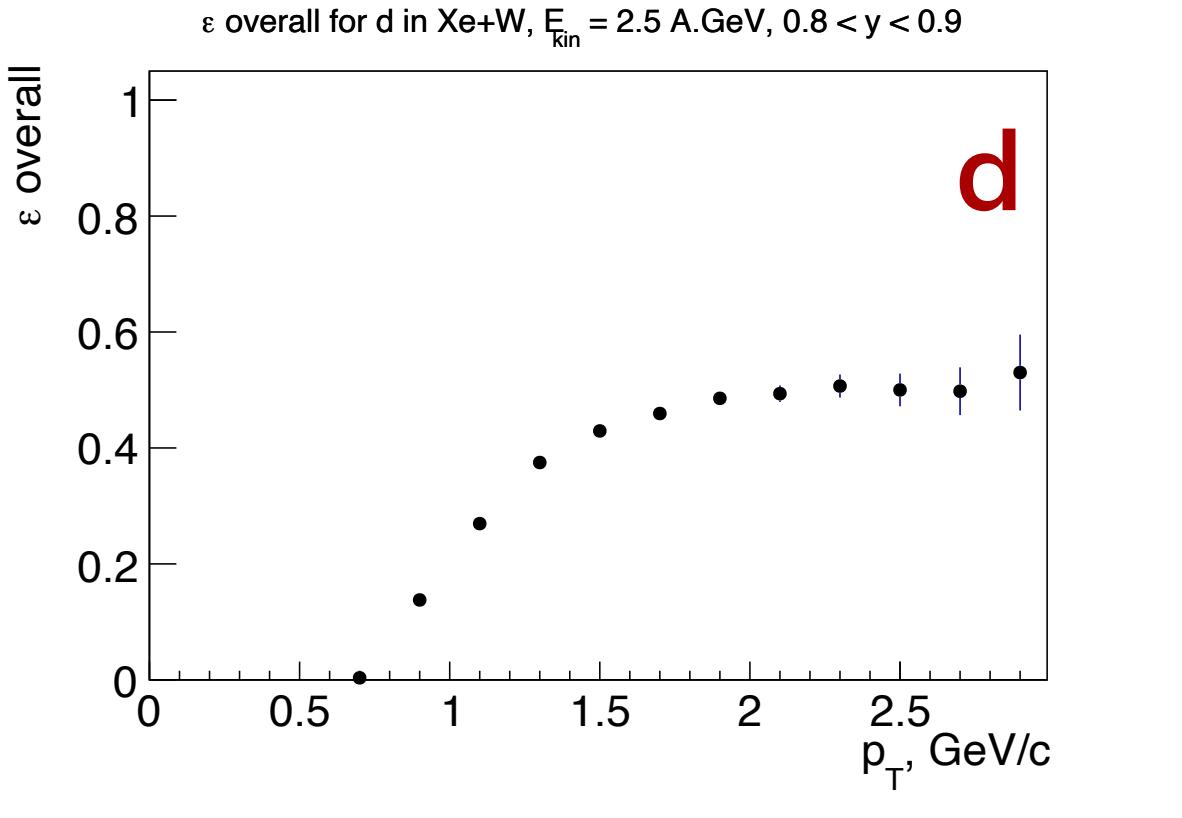
Reco phase-space



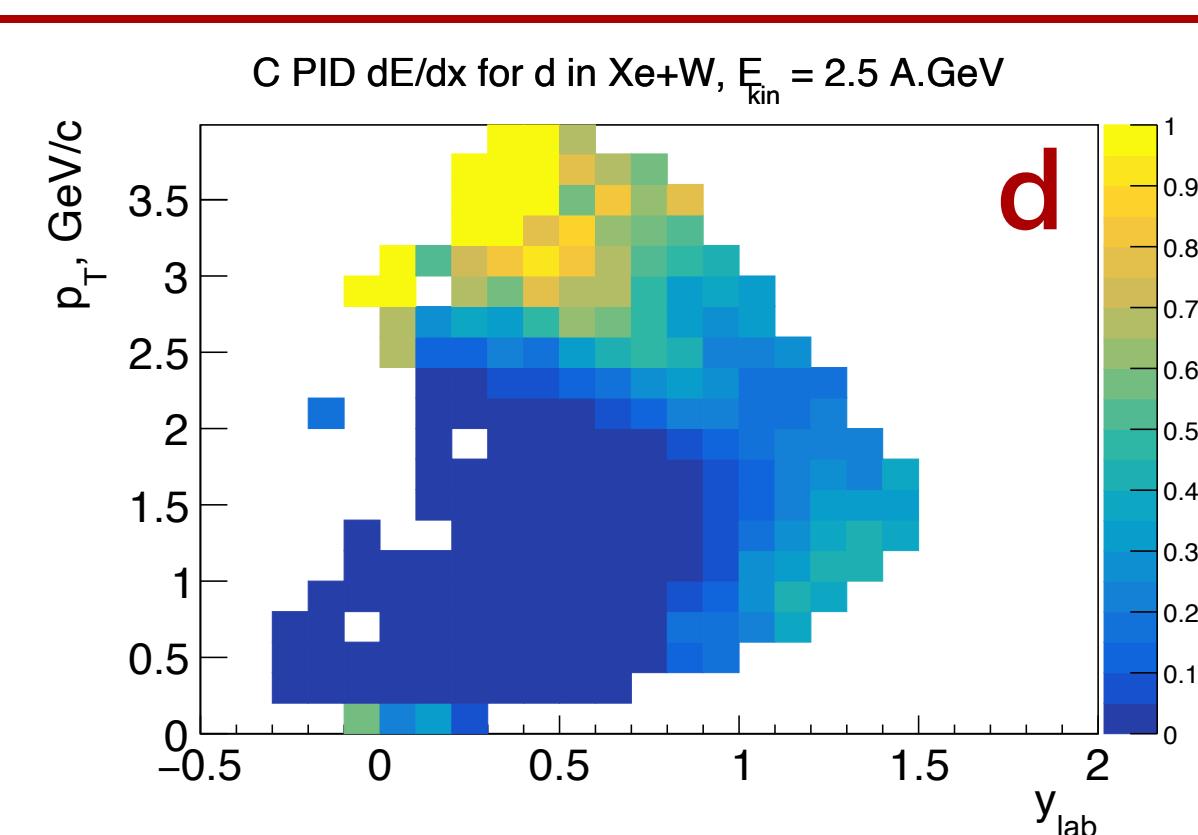
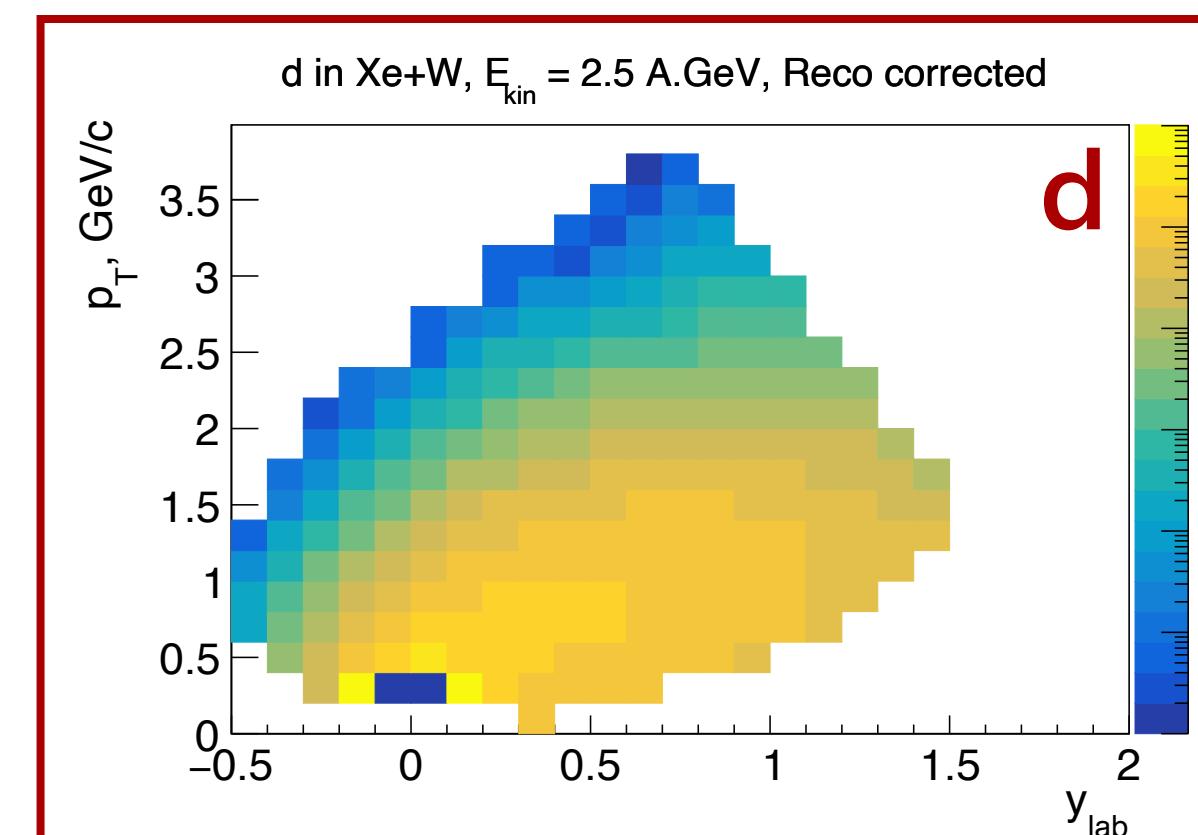
PID contamination



Overall efficiency



dE/dx only PID:



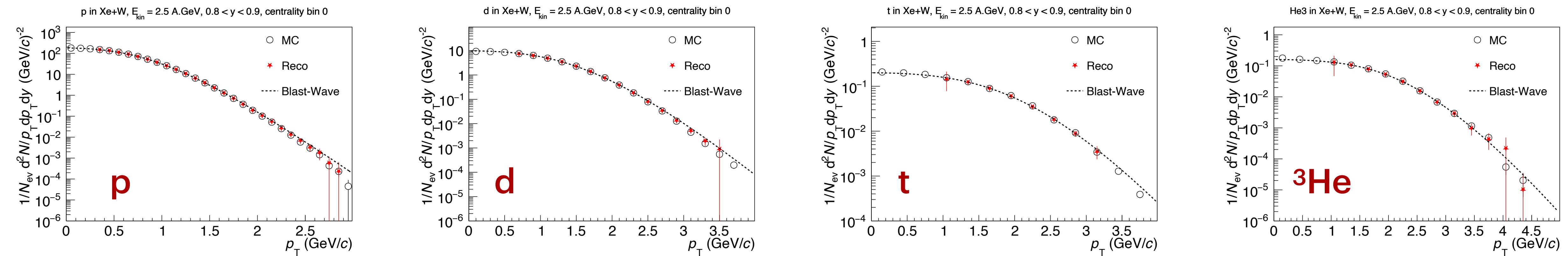
First glance!
Not presented at the
Cross PWG

Light nuclei: current activity

Viktar Kireyeu (vkireyeu@jinr.ru)

Production 37 (**FXT**): Xe+W, $E_{\text{kin}} = 2.5 \text{ A.GeV}$, 5M PHQMD events, «Nuclei» analysis wagon
Combined dE/dx and m^2 PID used (Mpdpid class)

First glance!
Not presented at the
Cross PWG

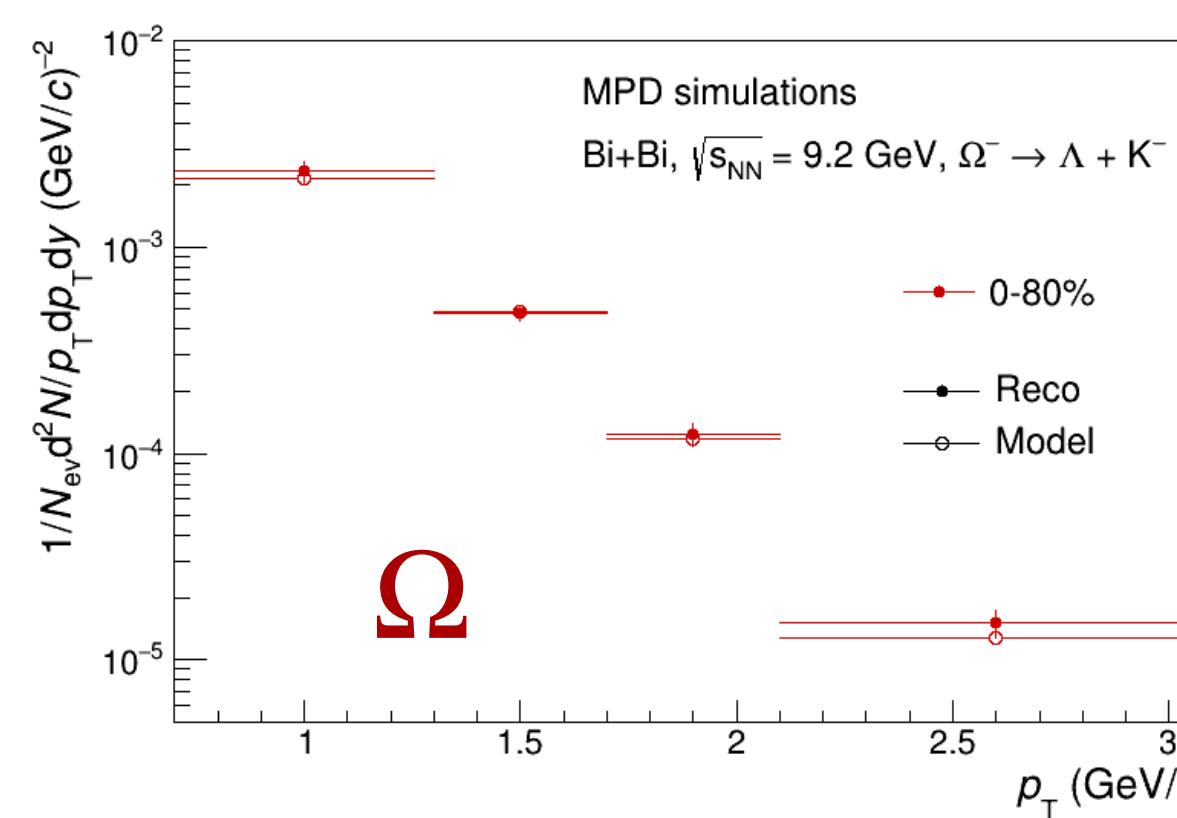
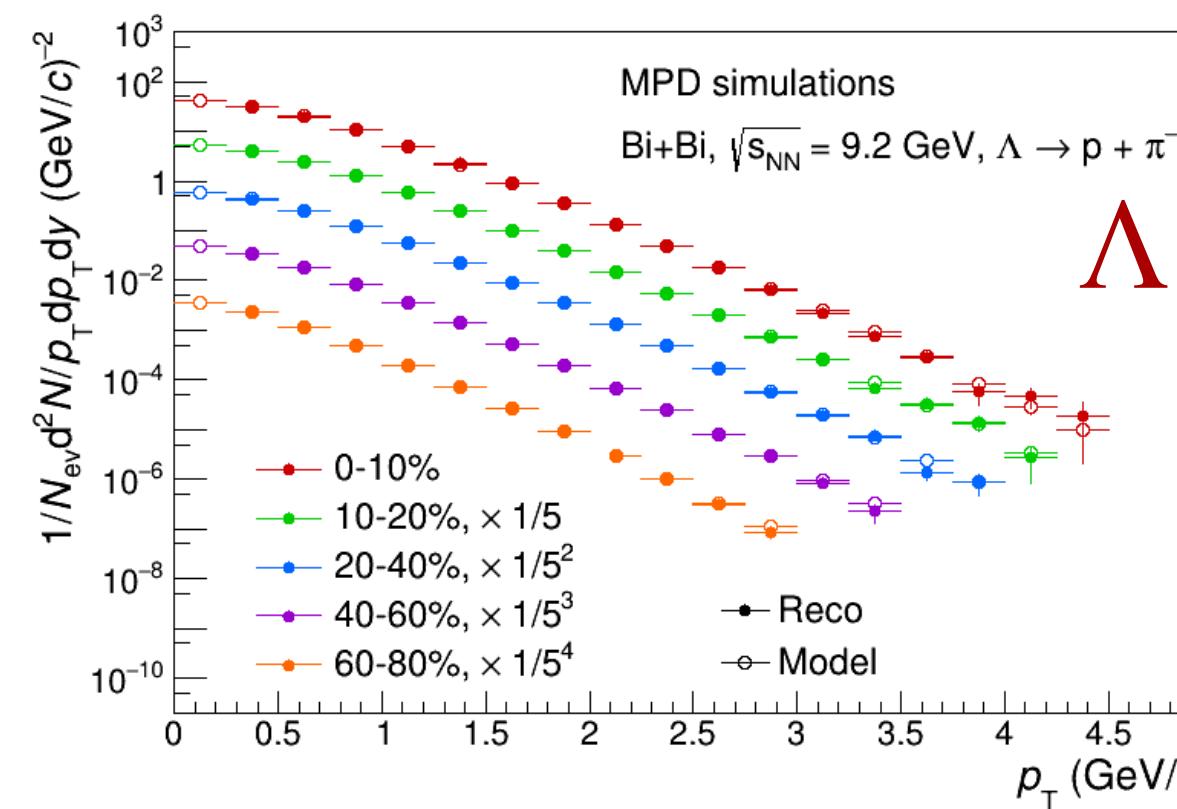
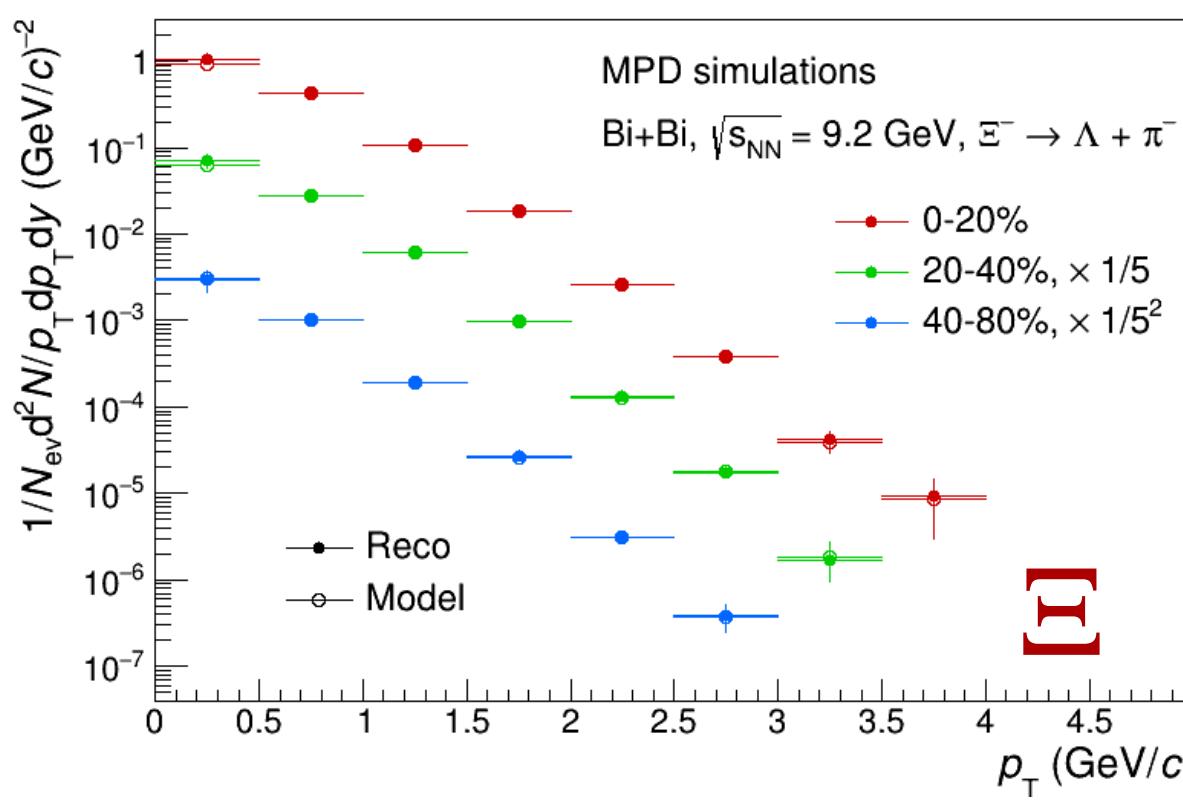
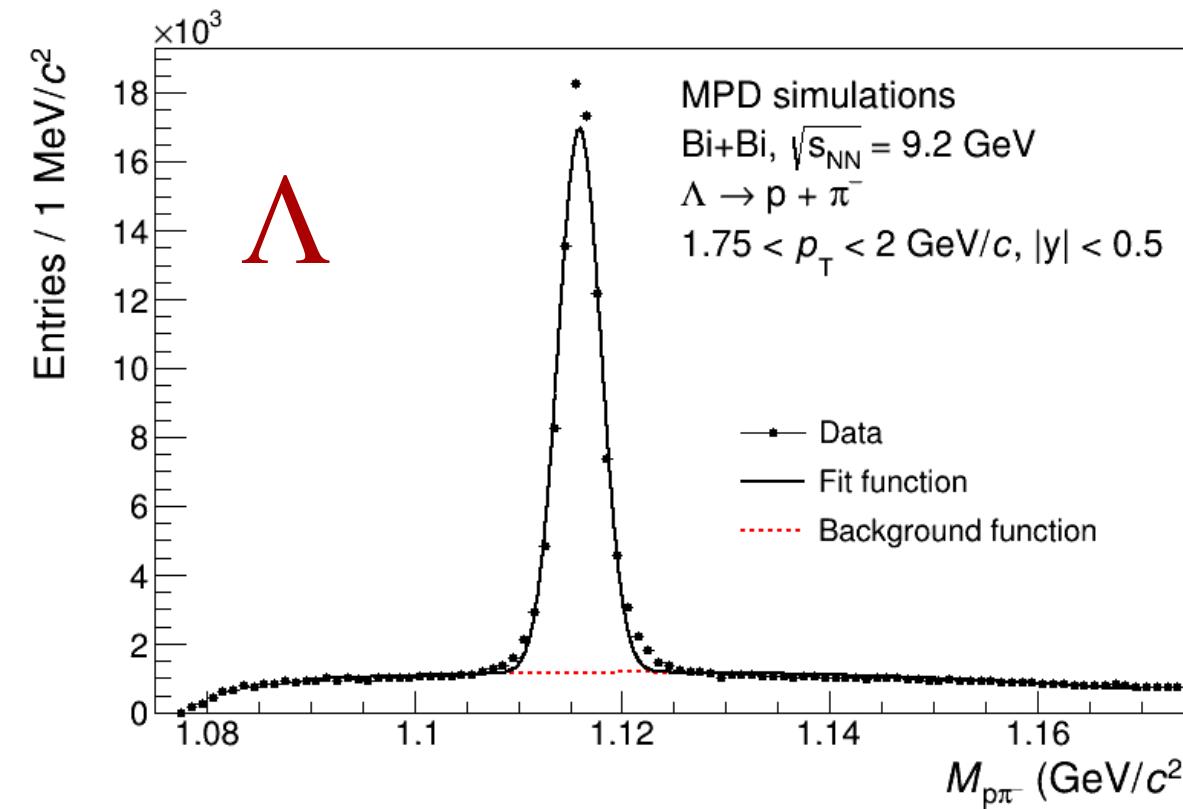


- Invariant p_T -spectra are reconstructed in several centrality and rapidity bins.
- Reco agrees with MC quite well.
- Results are preliminary, the work is going on.

Hyperons: since last collaboration meeting

Veronika Vasendina (veron@jinr.ru), D. Suvarieva, A. Zinchenko

Production 25: Bi+Bi, $E_{cm} = 9.2$ GeV, 50M UrQMD events, «Hyperon» analysis wagon
Combined dE/dx and m^2 PID used (Mpdpid class)



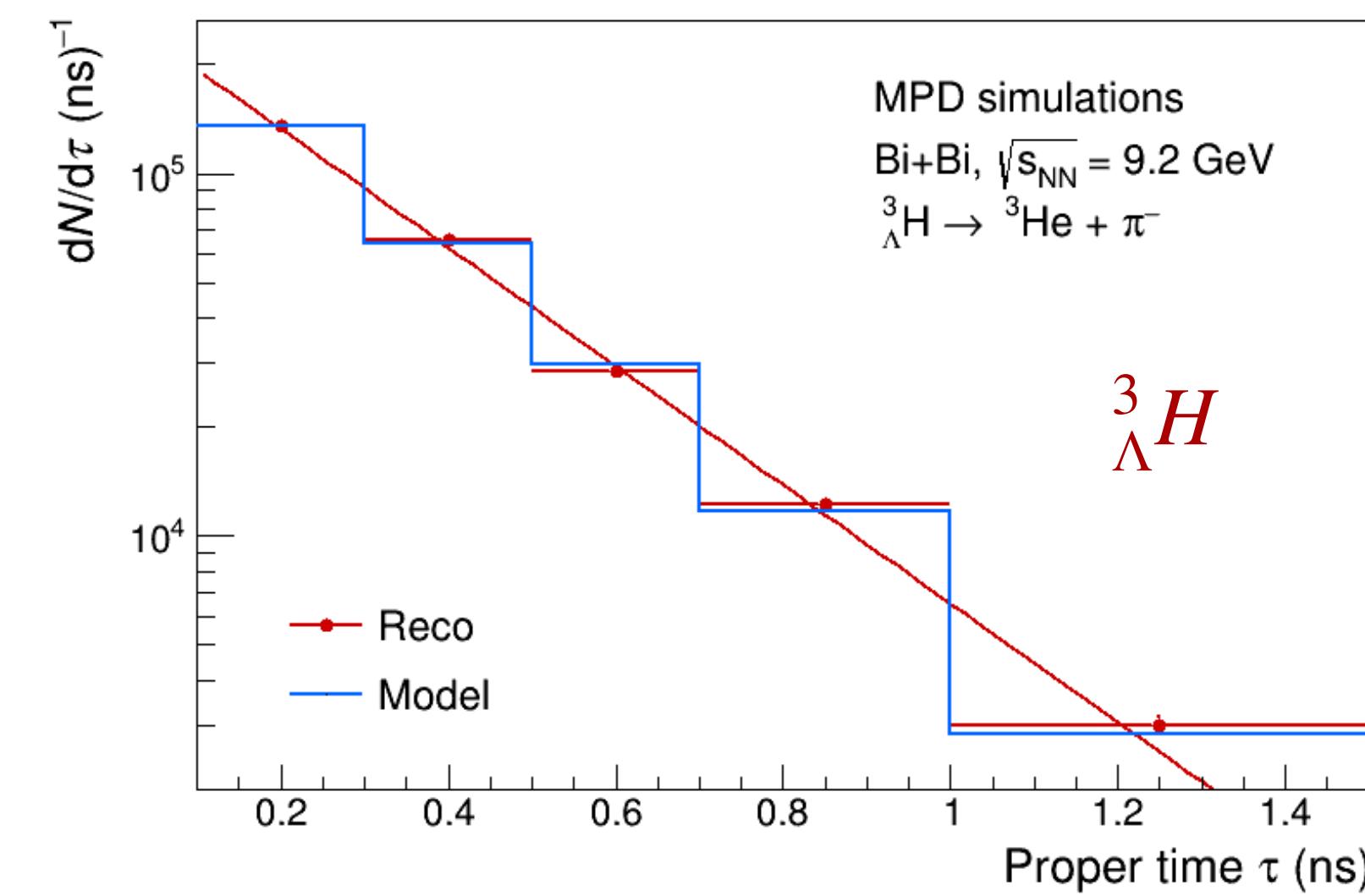
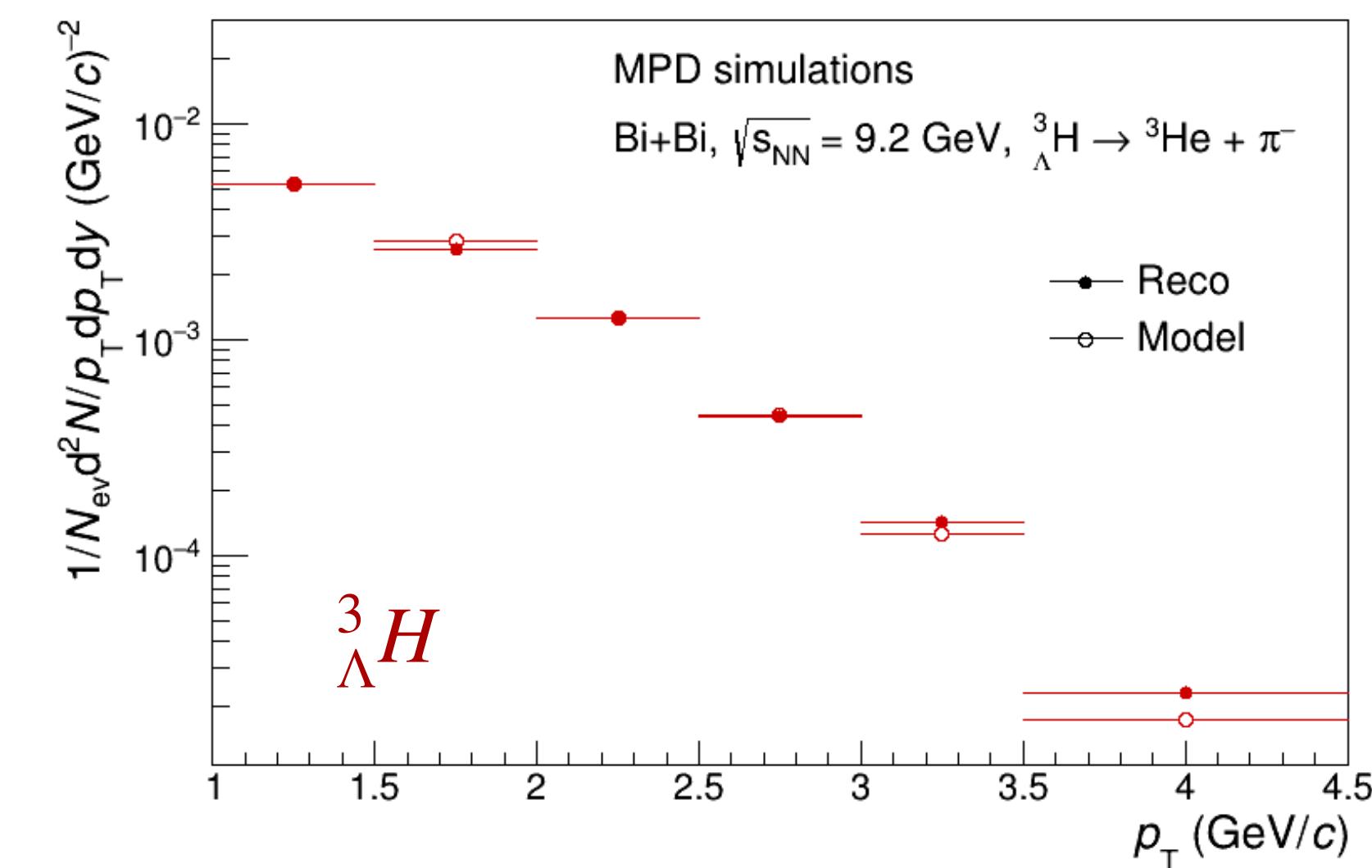
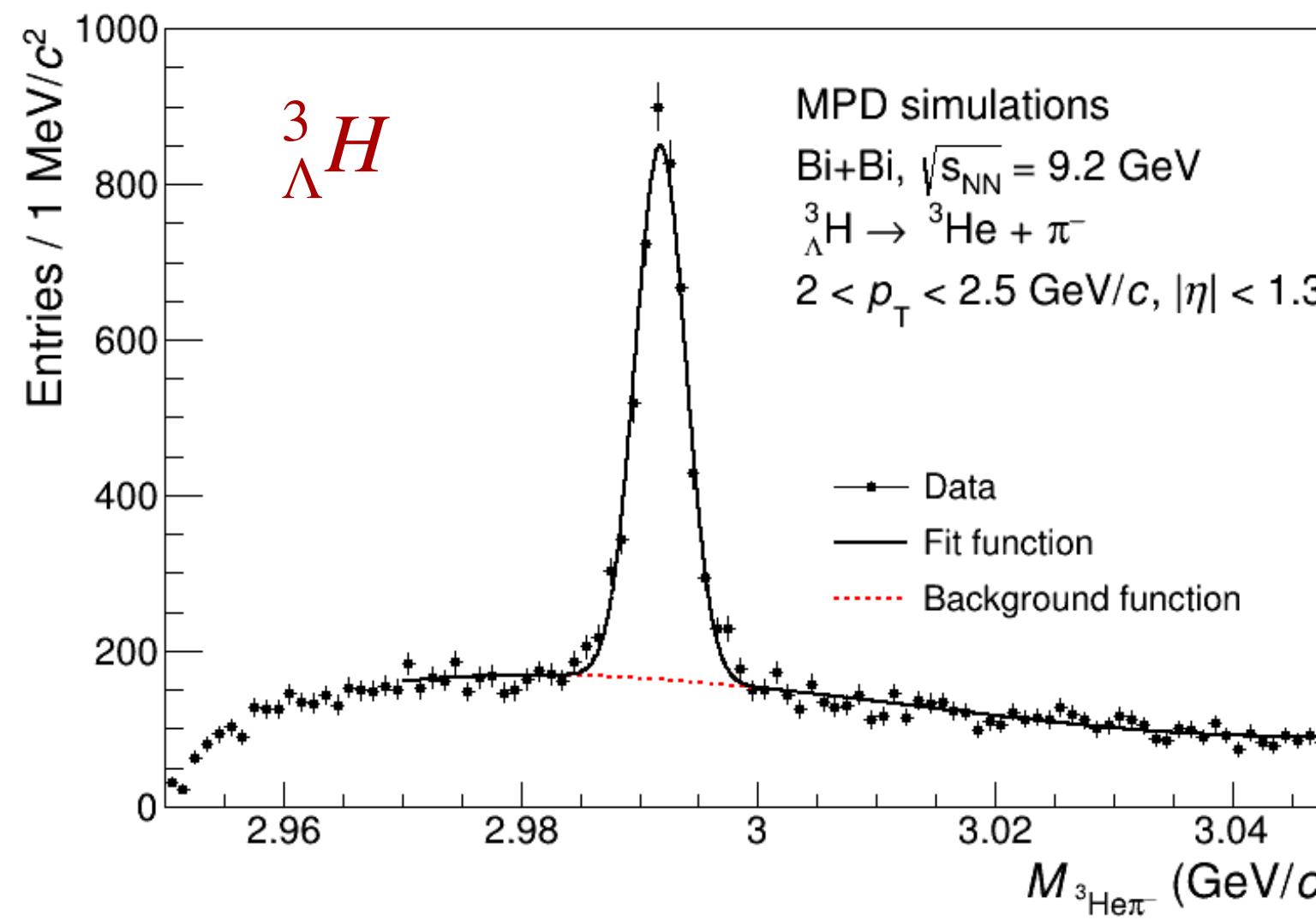
- Final results included into the second Collaboration paper: [arXiv:2503.21117](https://arxiv.org/abs/2503.21117)
- Invariant p_T -spectra of the single and double strange hyperons are reconstructed in several centrality bins
- Reconstructed distributions are consistent with MC

Hypernuclei: since last collaboration meeting

Veronika Vasendina (veron@jinr.ru), D. Suvarieva, A. Zinchenko

Production 29: Bi+Bi, $E_{cm} = 9.2$ GeV, 20M PHQMD events, «Hyperon» analysis wagon

Combined dE/dx and m^2 PID used (Mpdpid class)

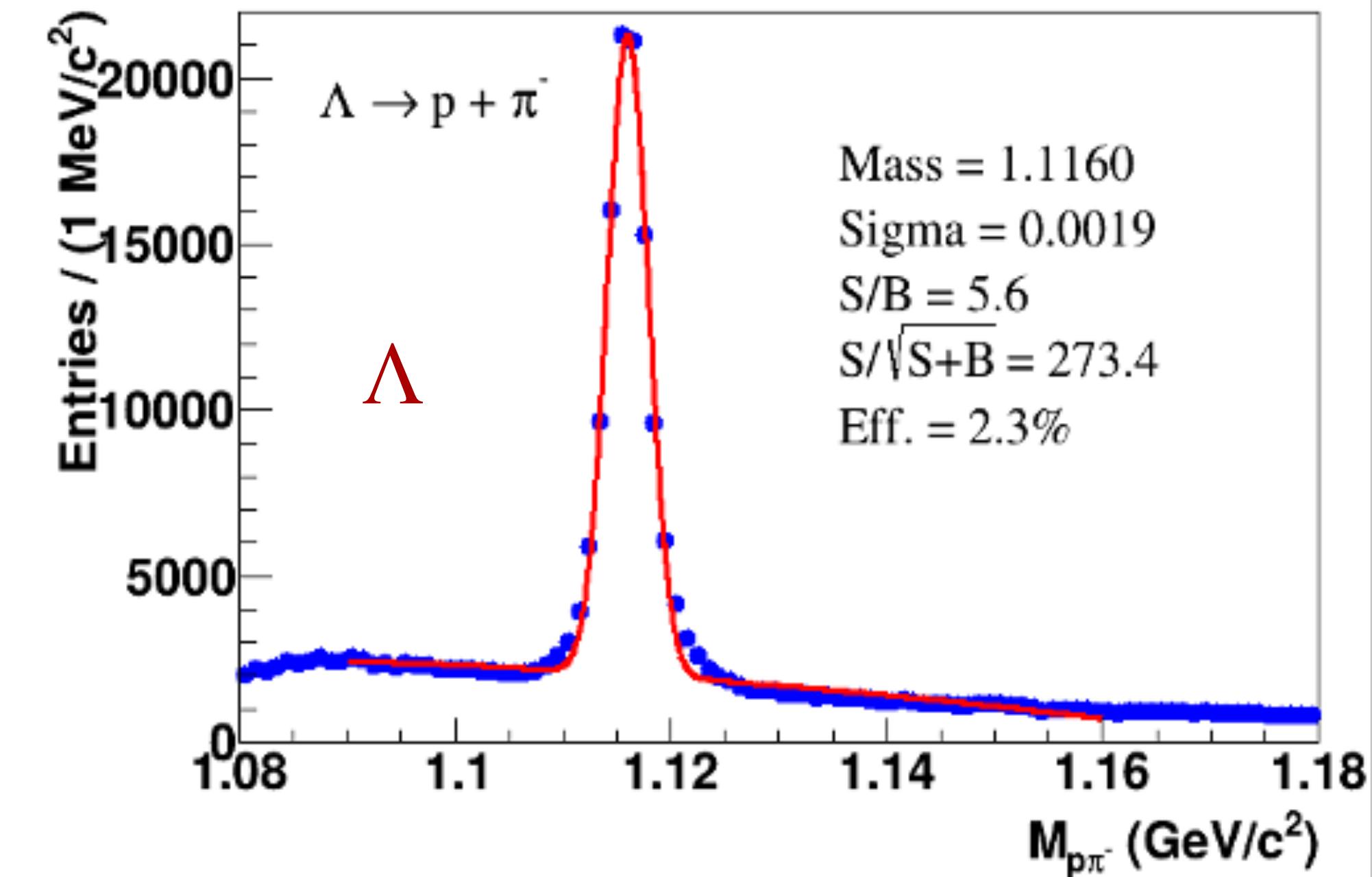
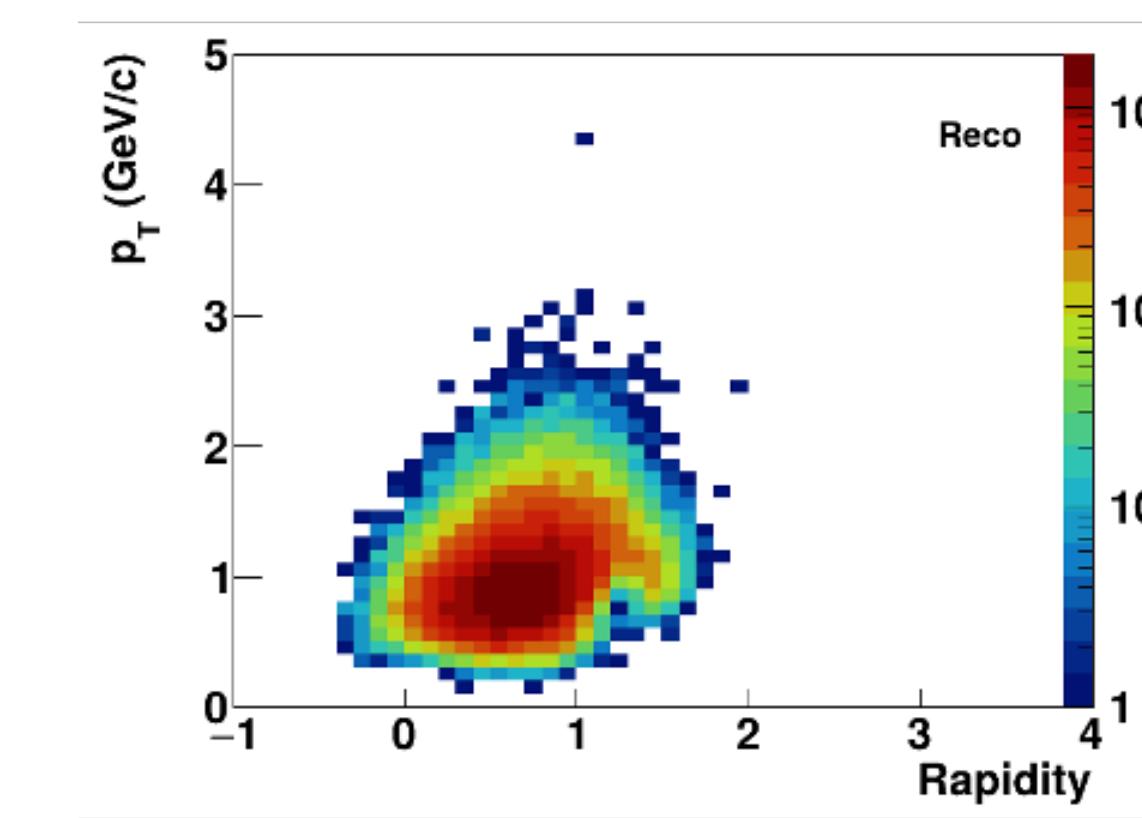
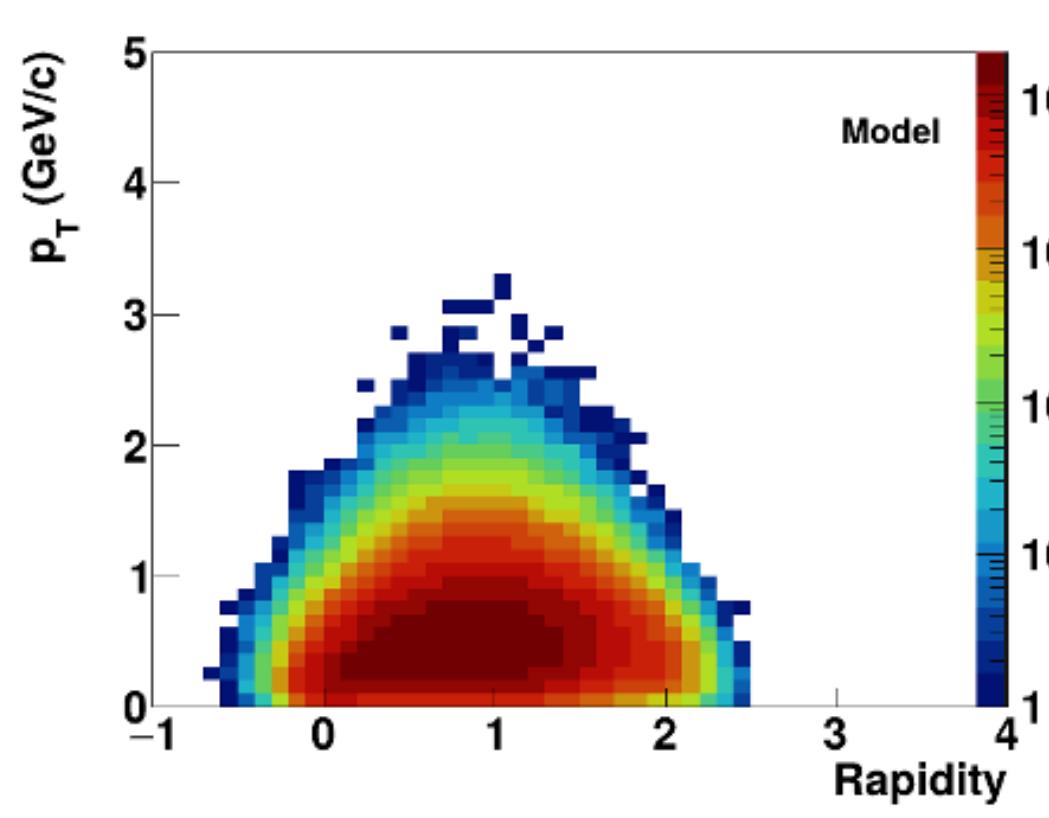


- Final results included into the second Collaboration paper: [arXiv:2503.21117](https://arxiv.org/abs/2503.21117)
- Invariant mass, invariant p_T and the proper time τ spectra are reconstructed.
- Reconstructed distributions are in agreement with the Monte-Carlo data.

Hyperons: current activity

Dilyana Suvarieva (dilyanas@jinr.ru), V. Vasendina, A. Zinchenko

Production 35 (**FXT**): Xe+W, $E_{\text{kin}} = 2.5 \text{ A.GeV}$, 15M UrQMD events, «Hyperon» analysis wagon
Combined dE/dx and m^2 PID used (Mpdpid class)



Selection cuts:

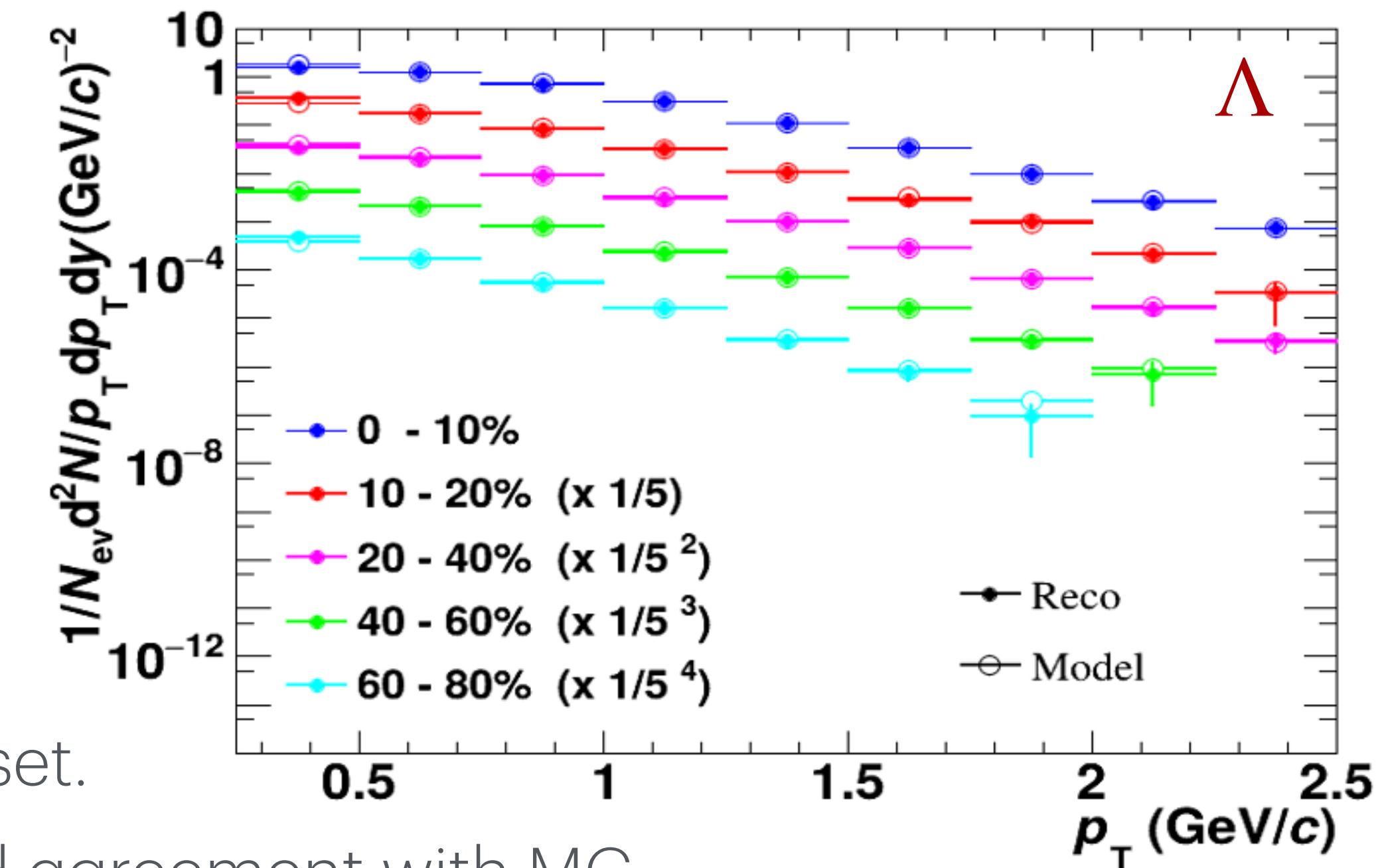
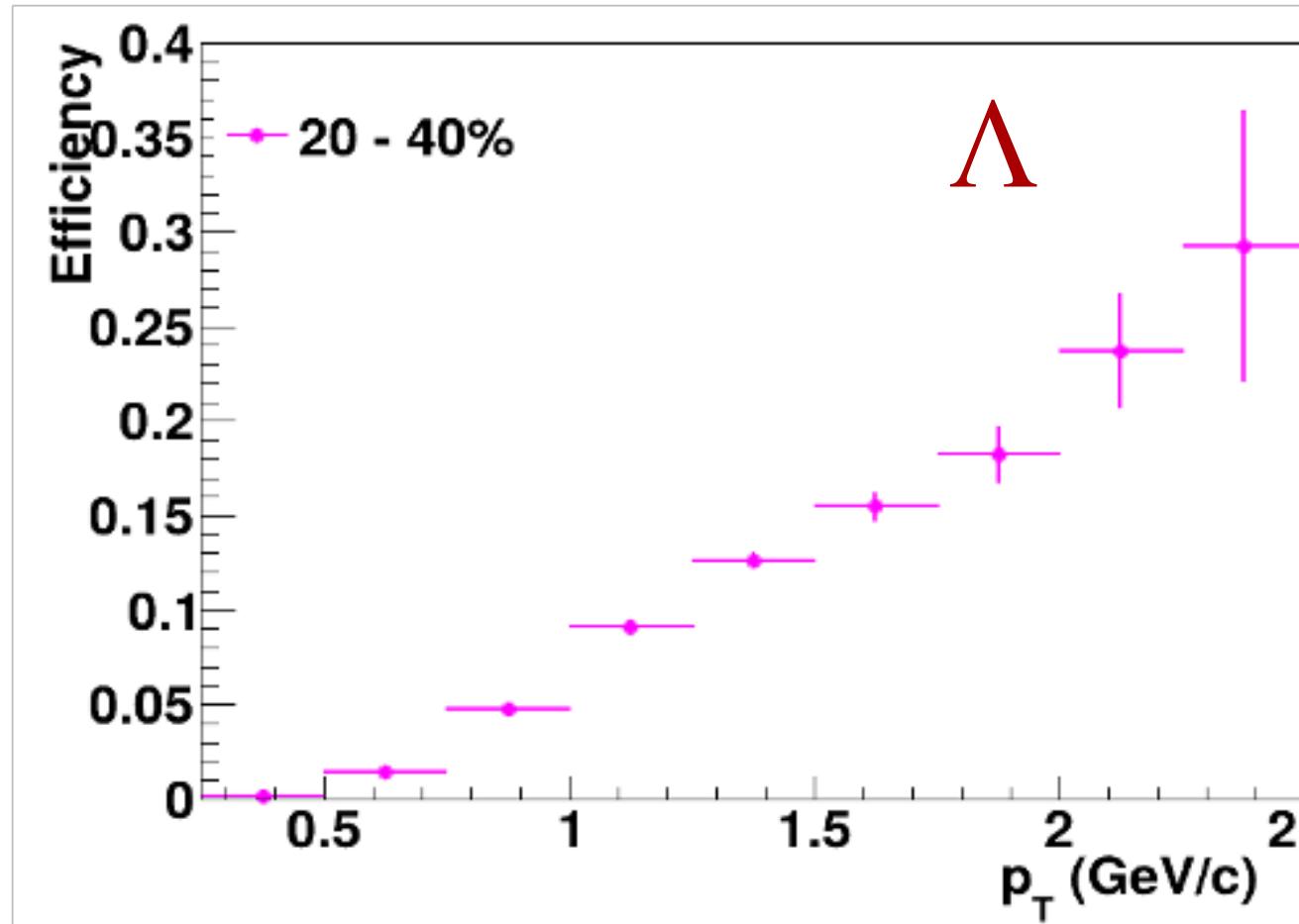
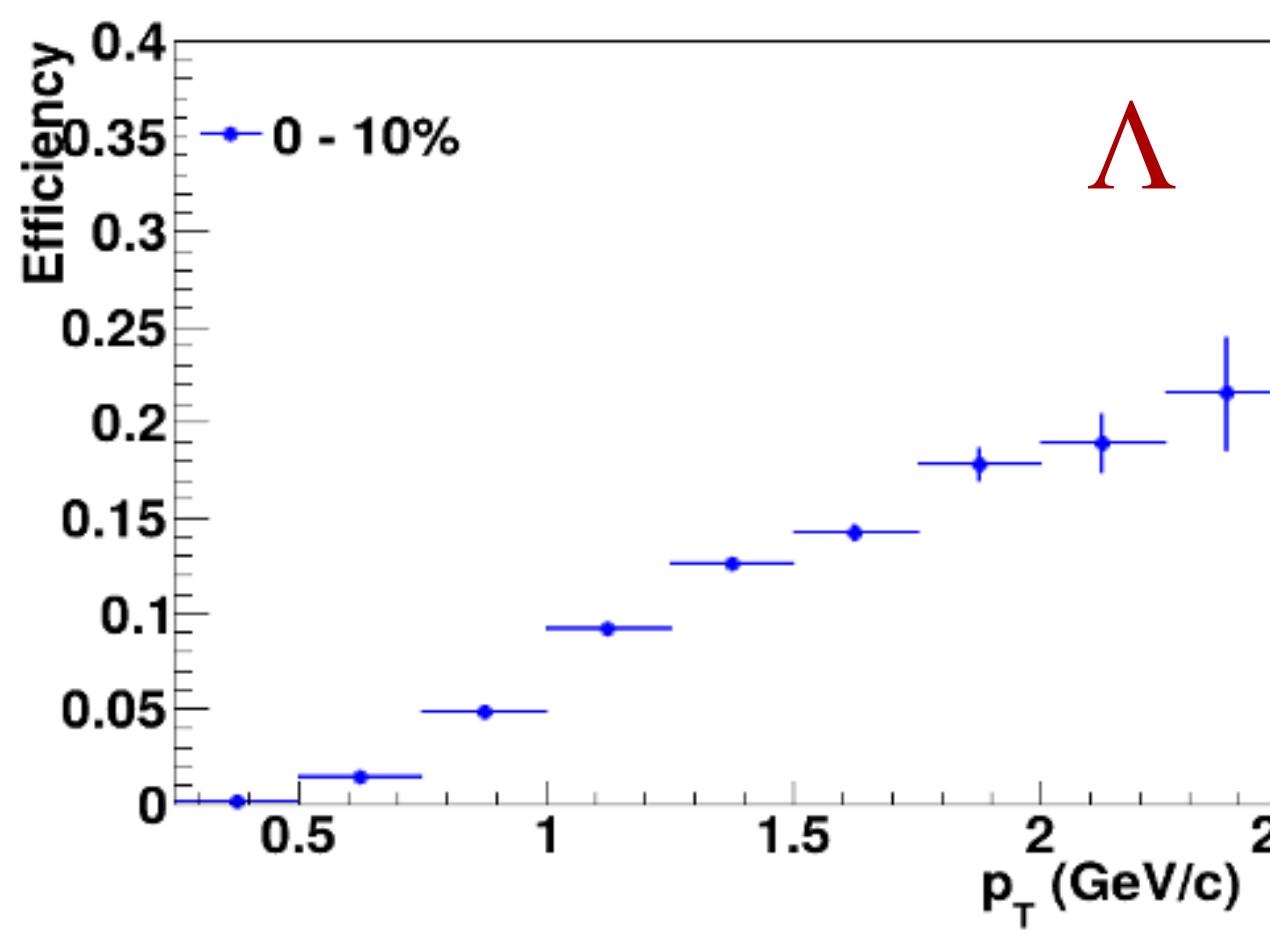
- l0.chi2s[][0] > 25.0 – normalised π^- -to-primary vertex impact parameter
- l0.chi2s[][1] > 11. – normalised proton-to-primary vertex impact parameter
- l0.chi2h < 10. – chi2 of secondary vertex reconstruction
- l0.disth < 0.8 – distance of the closest approach
- l0.path > 3. – Λ decay path
- l0.angle < 0.04 – Λ momentum and primary-to-secondary vertex vector noncollinearity

More here: <https://indico.jinr.ru/event/5313>

Hyperons: current activity

Dilyana Suvarieva (dilyanas@jinr.ru), V. Vasendina, A. Zinchenko

Production 35 (**FXT**): Xe+W, $E_{\text{kin}} = 2.5 \text{ A.GeV}$, 15M UrQMD events, «Hyperon» analysis wagon
Combined dE/dx and m^2 PID used (Mpdpid class)



- Analysis in high p_T at peripheral events is limited for this data set.
- Invariant mass and p_T spectra are reliably reconstructed: good agreement with MC.
- These results confirm the feasibility of hyperon studies in MPD/FXT.
- **The work is going on: systematic uncertainties determination**

Other stuff

- New programs to run models (PHQMD, UrQMD) on the NCX:

```
→ $ urqmd2batch --tara 197 --tarz 79 --proa 197 --proz 79 --ecm 3.0 --bmin 0.0 --bmax 14.0 --events 10  
--finalt 200.0 --njobs 10 --bin urqmd-3.4 --eos 0 --out /junk/user/  
urqmd_eos0 --stb 109  
→ $ phqmd2batch --njobs 1200 --out /junk/user/XeCs --bin phqmd52_winn_fffbc9f --massta 133 --tapr 55 --  
masspr 124 --prpr 54 --bmin 0.0 --bmax 14.5 --ekin 3.8 --num 100 --sub 10 --iglue 0 --finalt 160  
--inuclei 1 --iphqmd 1 --isaca 1 --tsaca 10.0 --dtsaca 5.0 --ntsaca 25 --flagsaca 0 --qmdeos 0
```

- New programs to run MpdRoot simulation and reconstruction on the NCX:

```
→ $ mpdsim2batch --njobs 1000 --out /junk/user/test --exclude nodes_blacklist  
→ $ mpdrec02batch --njobs 1000 --out /junk/user/test --exclude nodes_blacklist --events 200
```

- New program to run MpdRoot analysis «trains» on the NCX:

```
→ $ mpdtrain2batch -j 1200 -o /junk/user/test -d /scratch/production0 -d /scratch/production1 -d /  
scratch/production2 -d /scratch/production3 -d /scratch/production4 -e nodes_blacklist
```

- New interactive web-based QA system for the MPD simulations

- **psMST** library is available now for the MpdRoot: add clusters (nuclei, hypernuclei) to any model with baryons.

- Onboarding: overall documentation is 90% ready



from the first steps of the MC simulations till the post-processing stage



Feel free to ask and use!

Summary

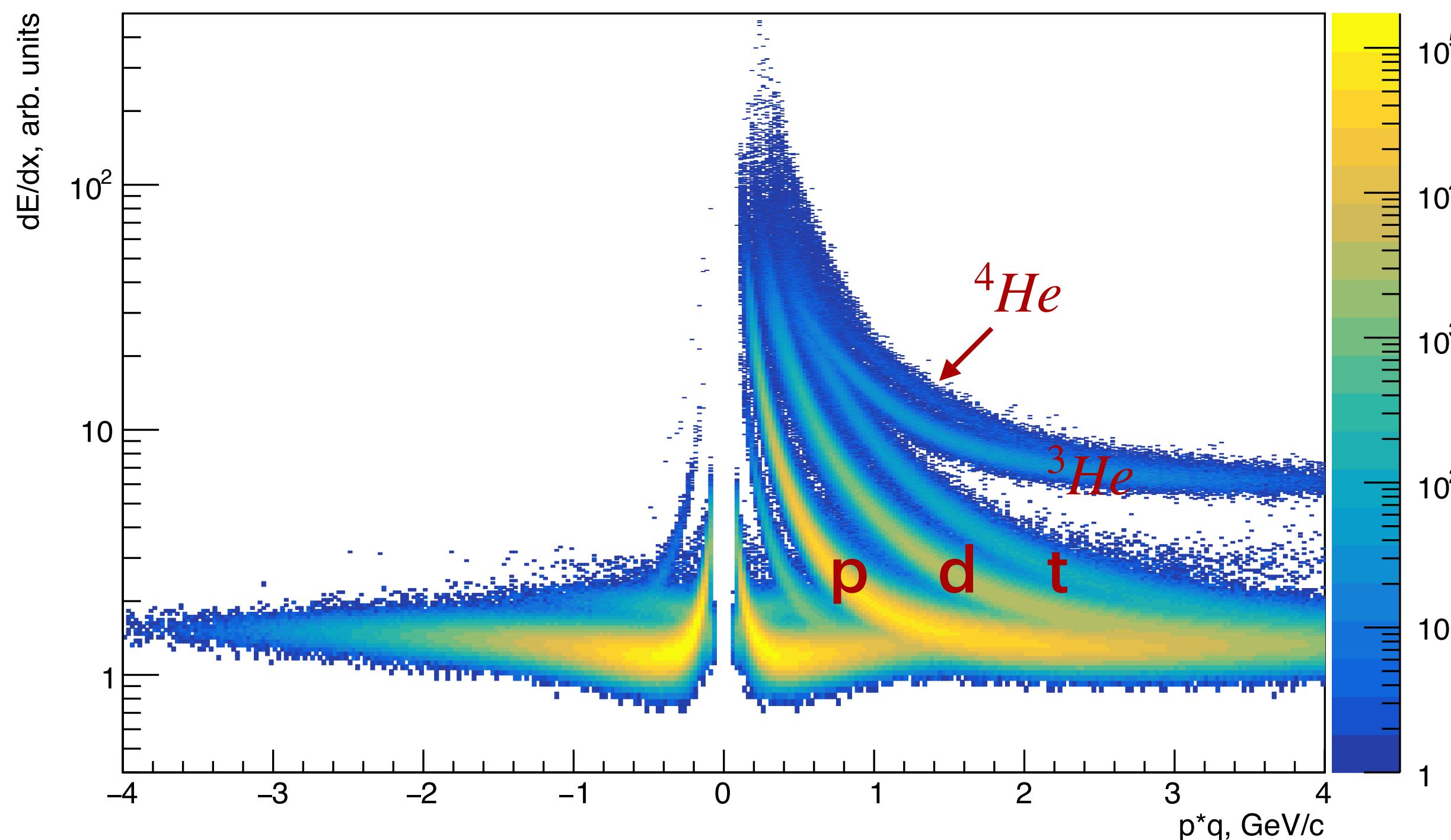
Summary

- Bi+Bi analyses are finished (Production 25, 29), results included in the second Collaboration paper.
- Light hadrons (π , K, p with Production 36):
 - Active work, preliminary results obtained.
 - New PID method developed and tested.
 - Results presented at Cross PWG meetings.
- Light nuclei (Production 37):
 - Intense development, a lot of things to implement.
- Hyperons (Production 35):
 - Results presented at Cross PWG meeting, work in progress.

Backup slides

Production 37 (**FXT**): Xe+W, $E_{\text{kin}} = 2.5 \text{ A.GeV}$, 5M PHQMD events

dE/dx vs P for all particles



m^2 vs P for all particles

