Revisiting of the soft-hard separation of the transverse momentum spectra in pp collisions

Particles & Plasmas Symposium

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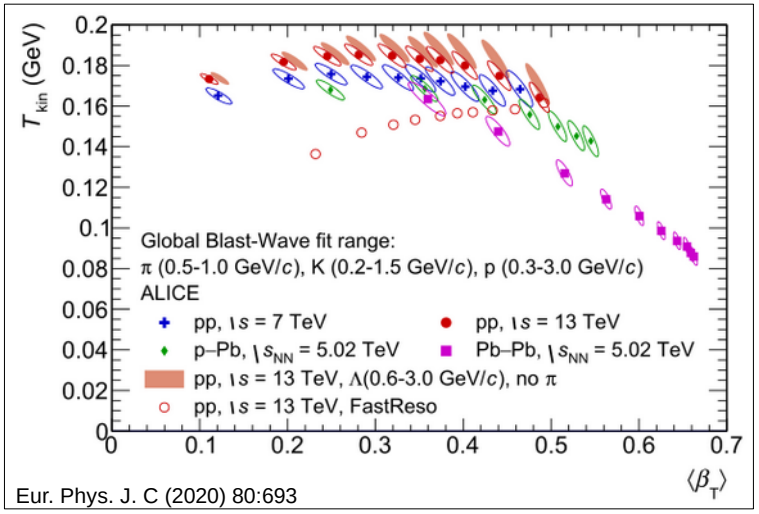
arXiv:2403.07512

Collective flow in every system

- High quality, multiplicity dependent (PID) data for various collision systems
- Traditional Blast-wave fits (Phys. Rev. C, 48 (1993), pp. 2462-2475):

$$\frac{dN}{p_T\ dp_T} \propto \int_0^R r\ dr\ m_T\ I_0\left(\frac{p_T \sinh\rho}{T_{kin}}\right) K_1\left(\frac{m_T \cosh\rho}{T_{kin}}\right)$$

where $\rho = \tanh^{-1}(\beta_T)$



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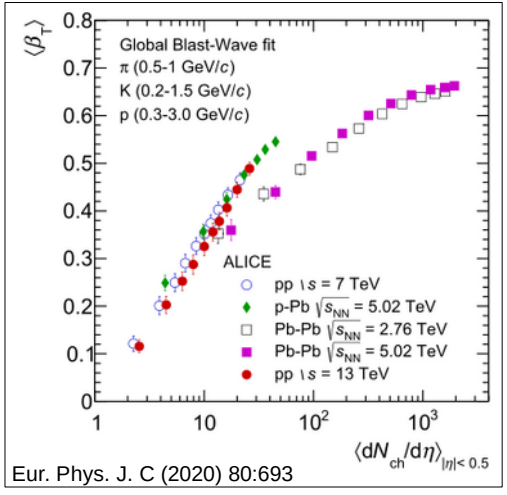

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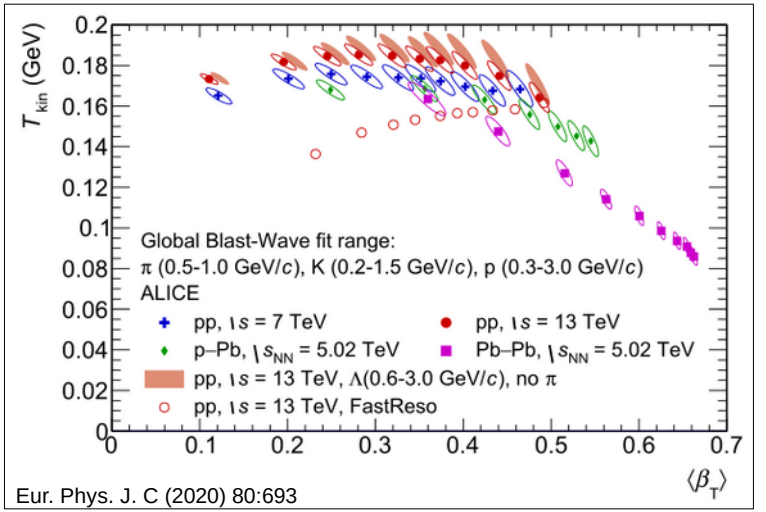

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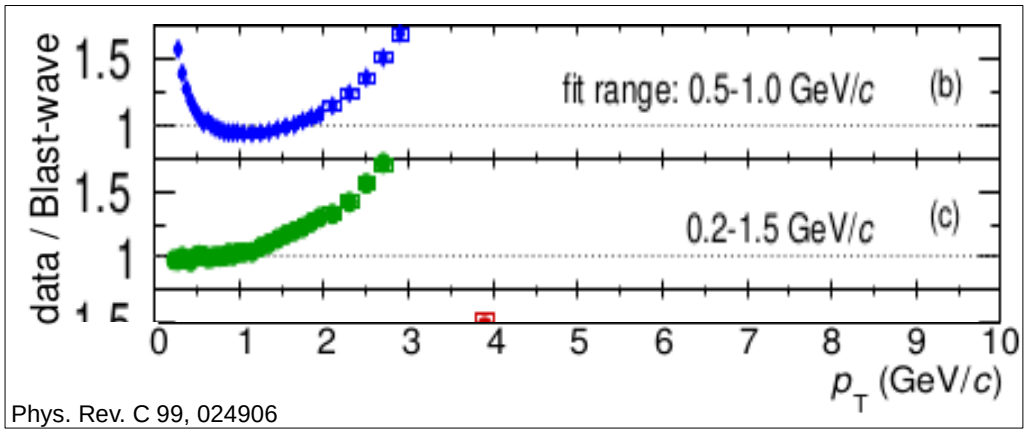
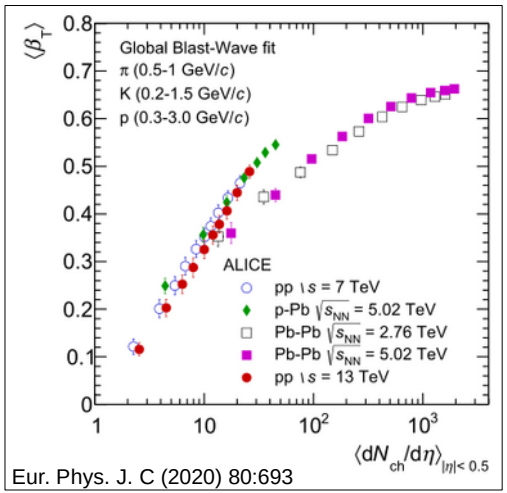
Issues:



Phys. Rev. C 99, 024906



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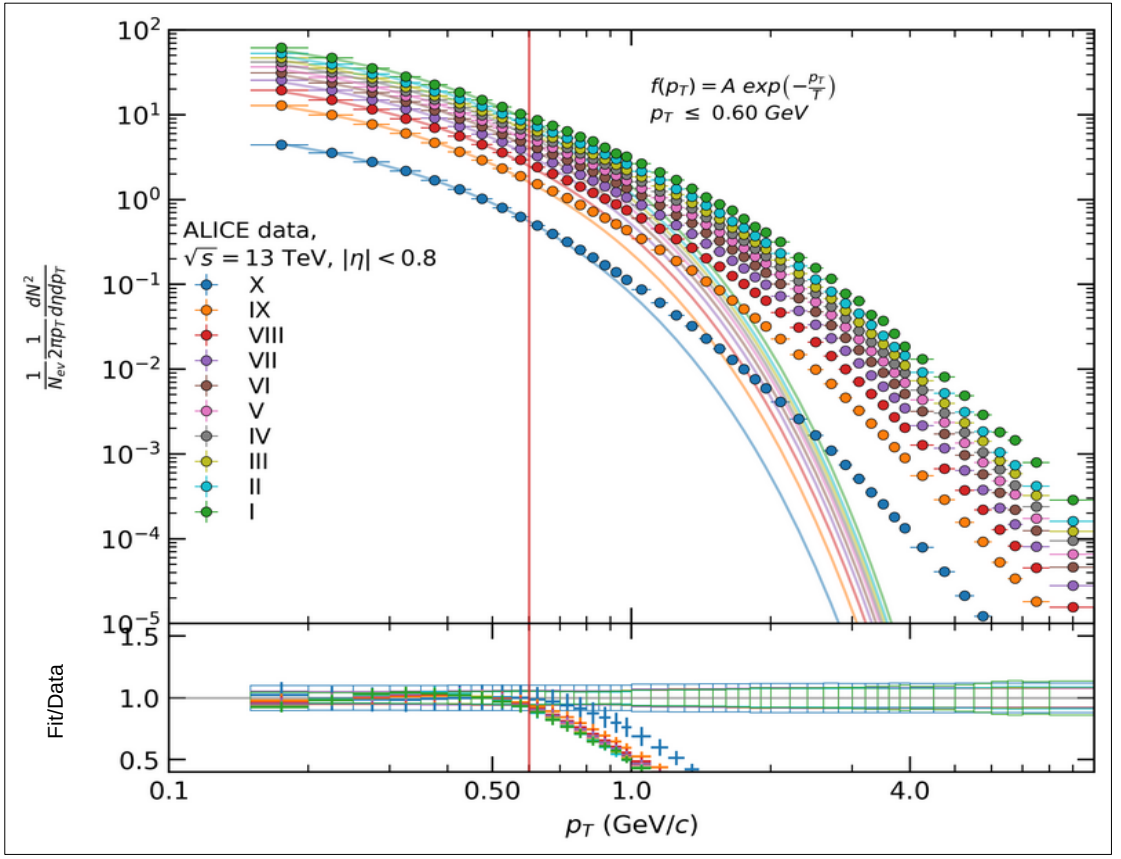
Systematic study of fit ranges

- Systems:
  - 5.02 TeV, 13 TeV (pp→ ch)
- p_T ranges:
  - 0.15 GeV ≤ p_T ≤ **p_0**
  - **p_0** in [0.4, 3.0], dp_T = 0.05
- Fit functions:
  - Most simple Boltzmann

$$f(p_T) = A \exp\left(-\frac{p_T}{T}\right)$$

  - Most simple Tsallis

$$f(p_T) = A\left(1 + p_T \frac{q-1}{T}\right)^{-\frac{q}{q-1}}$$



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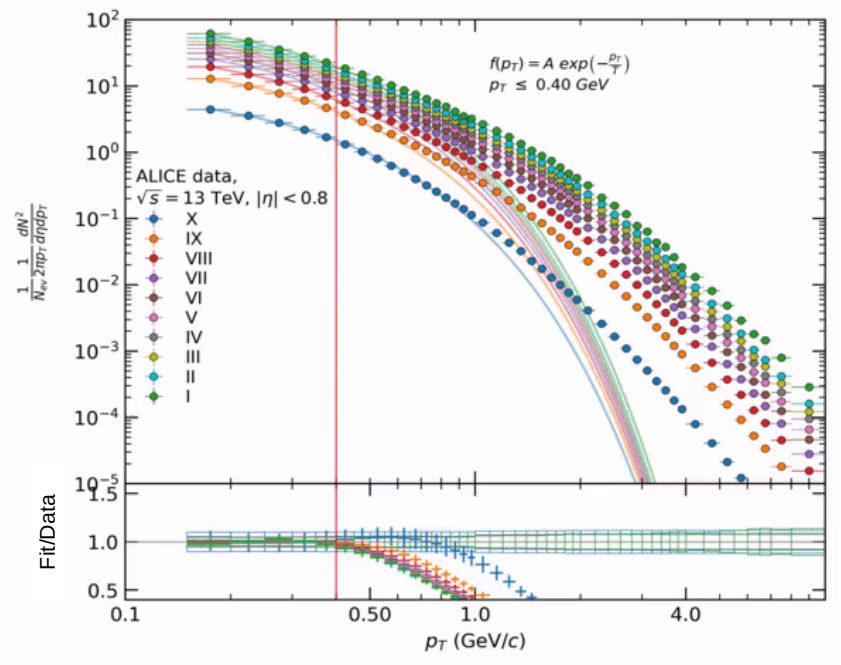

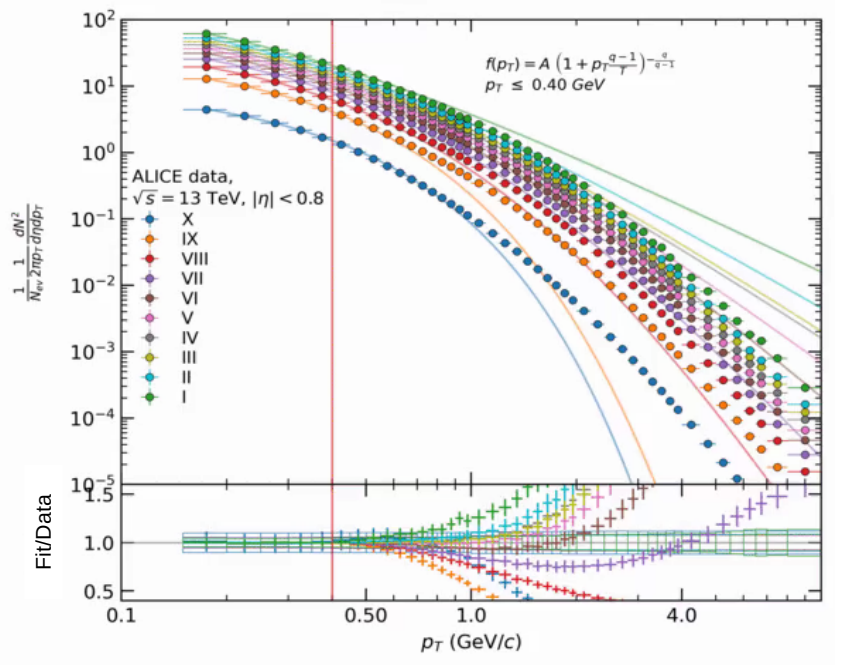

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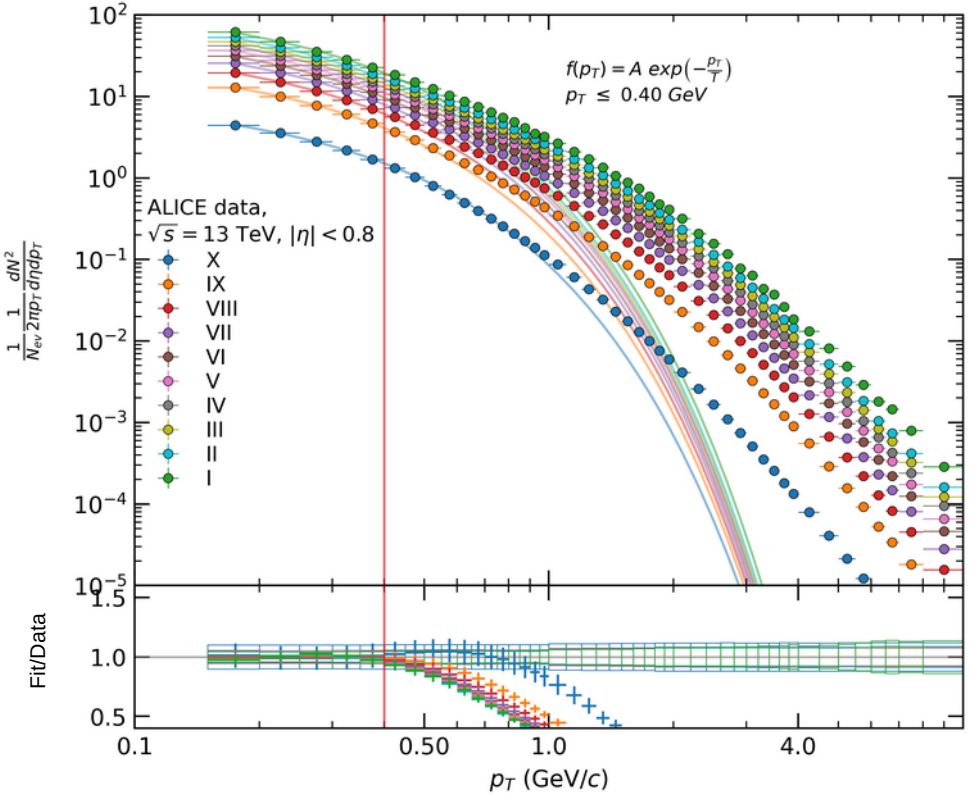

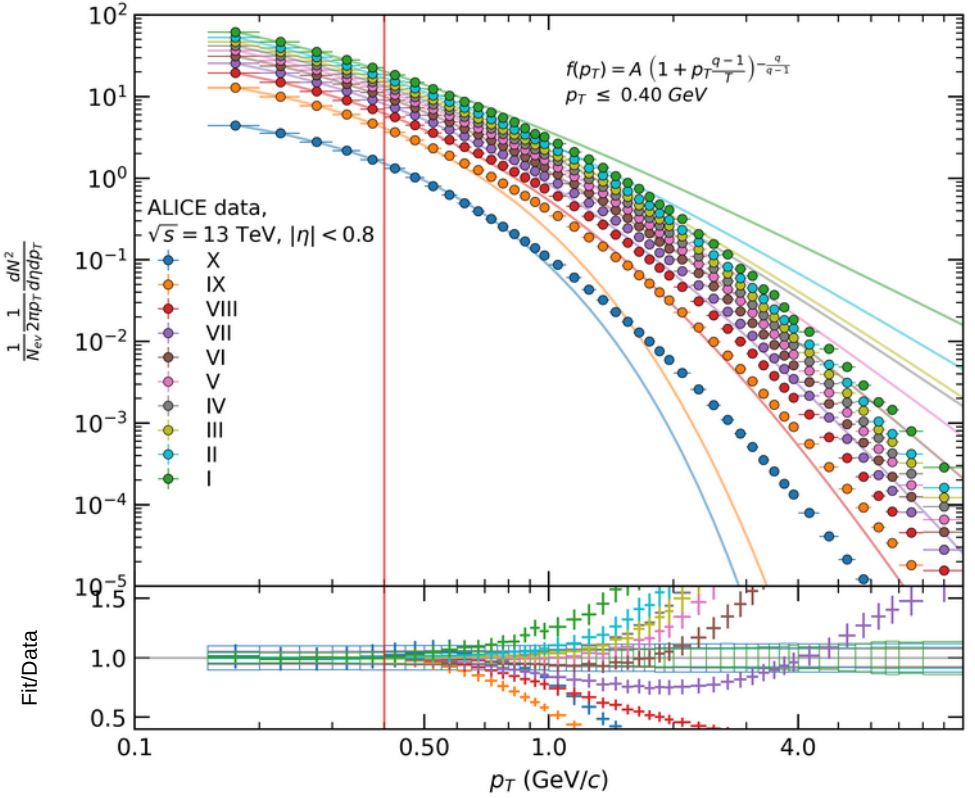

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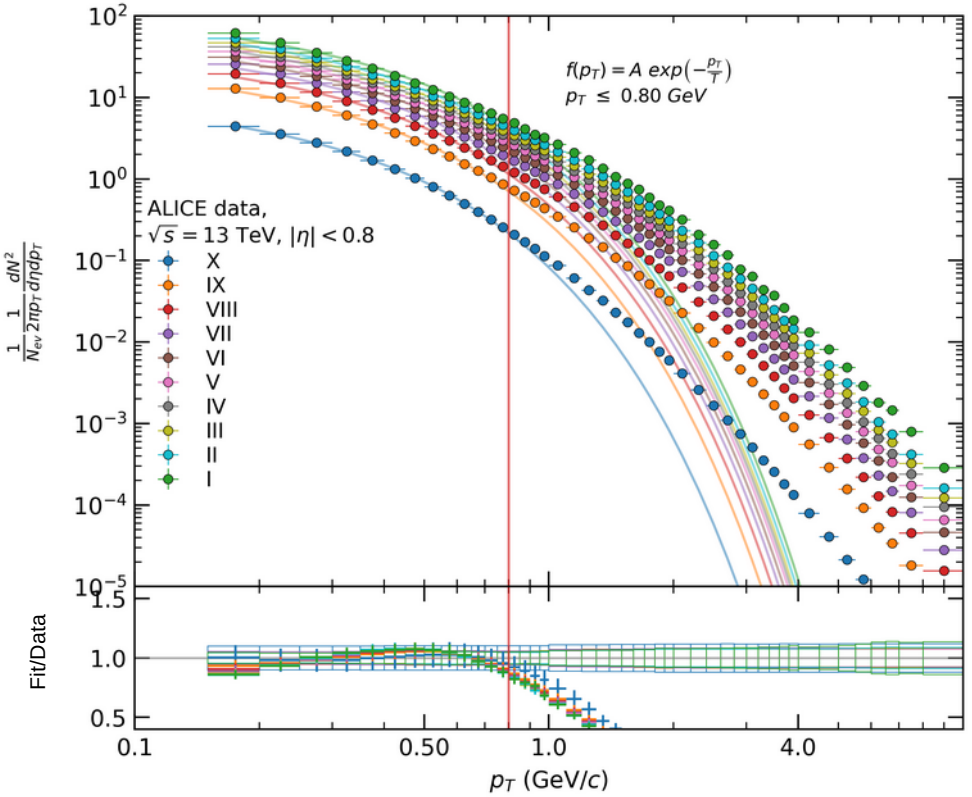

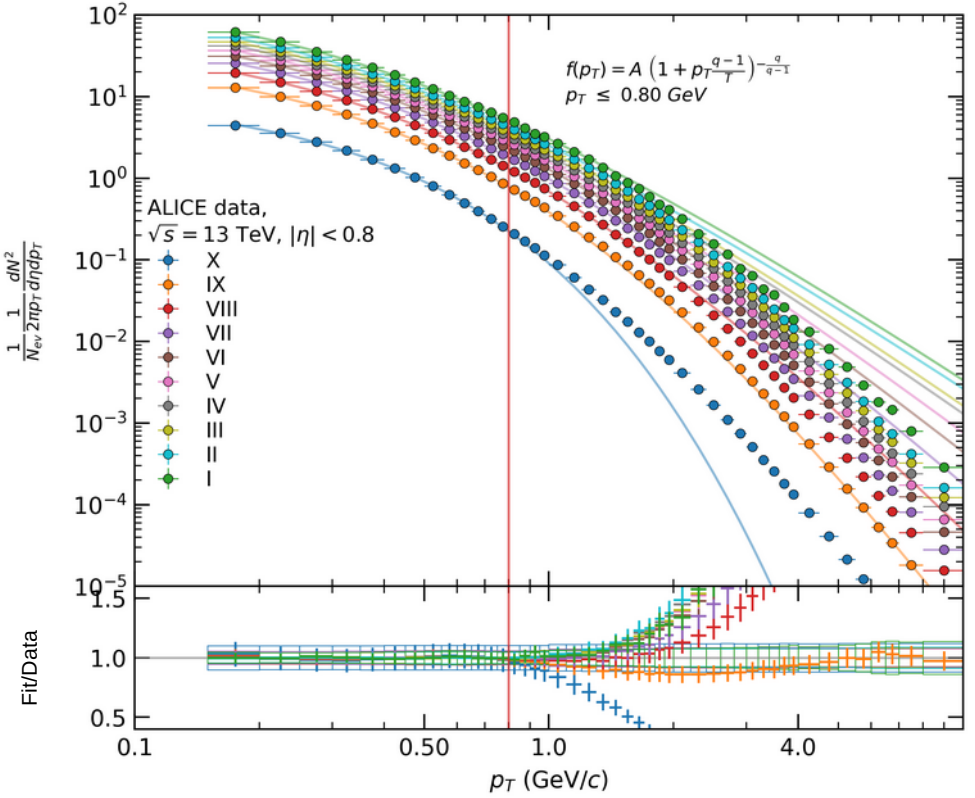

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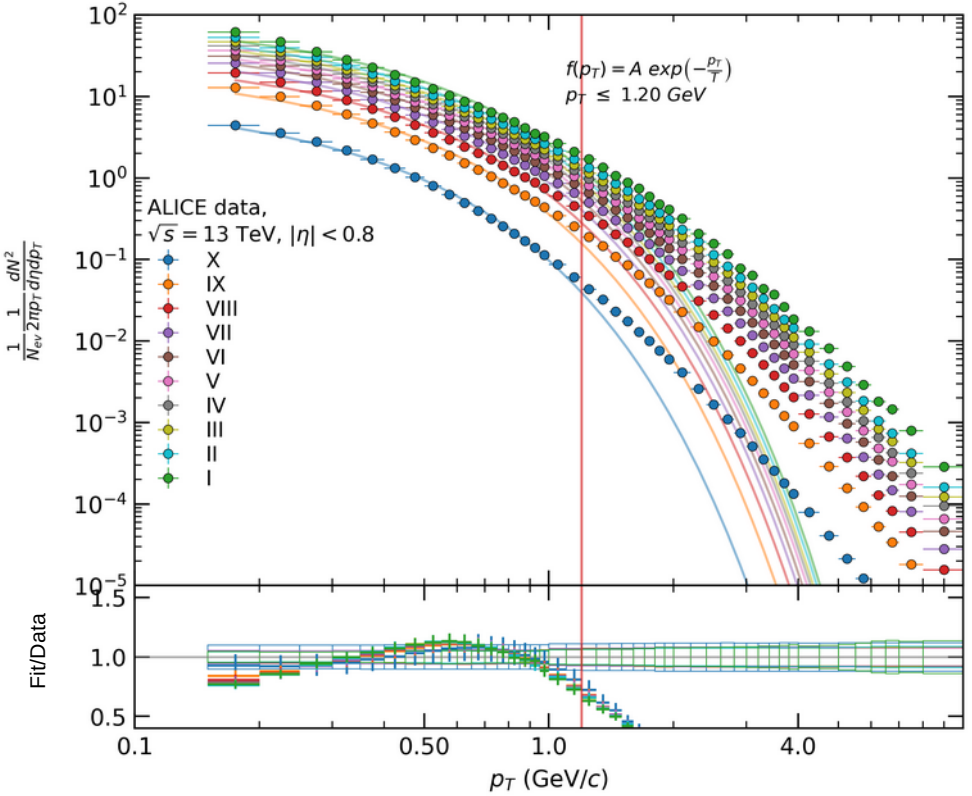

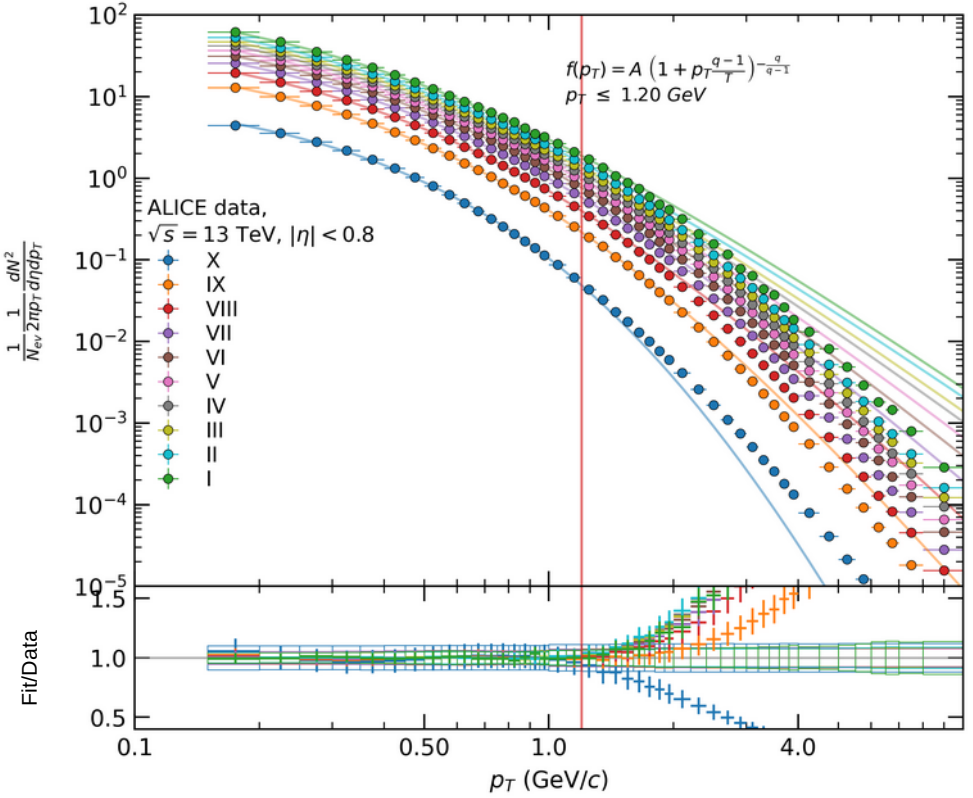

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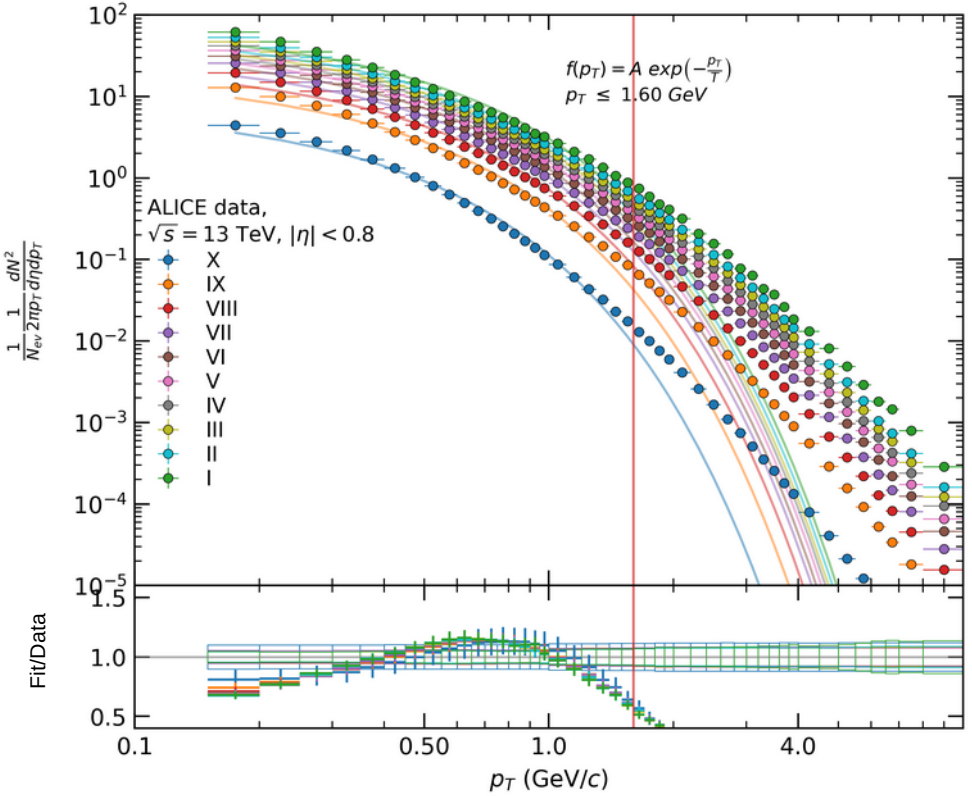

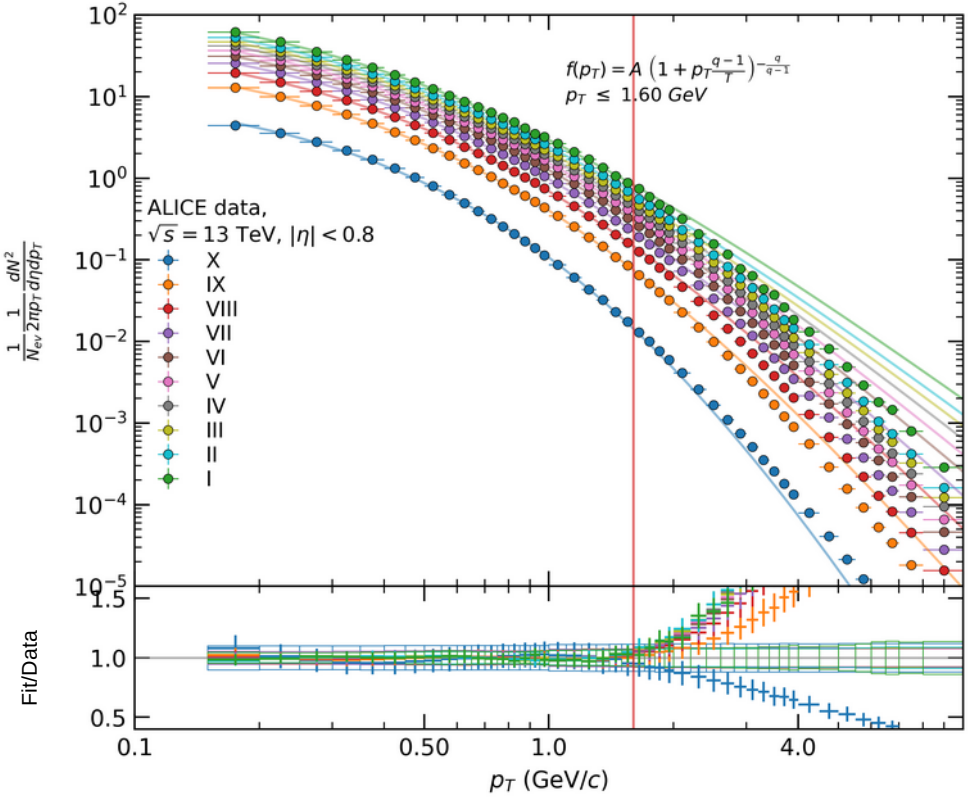

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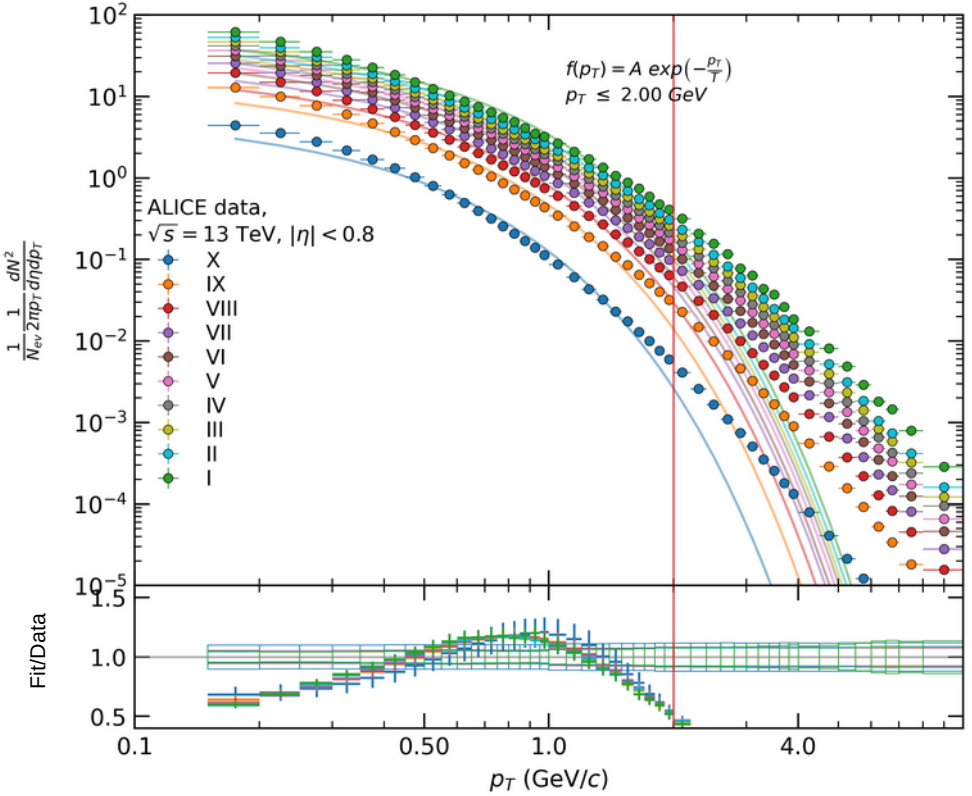

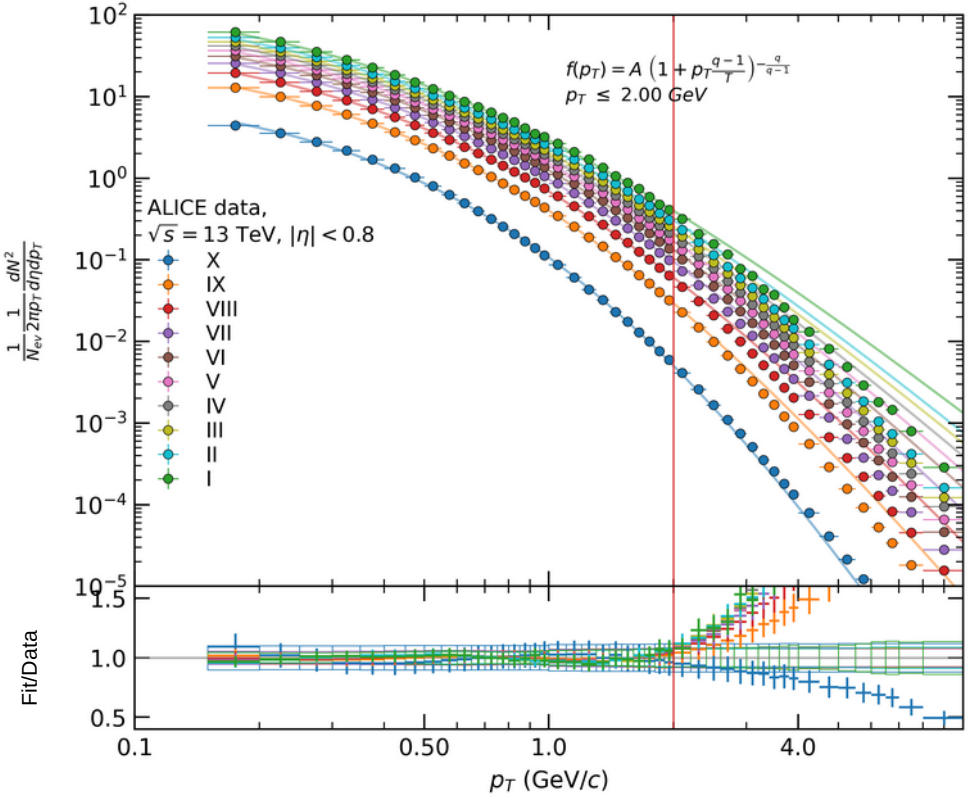

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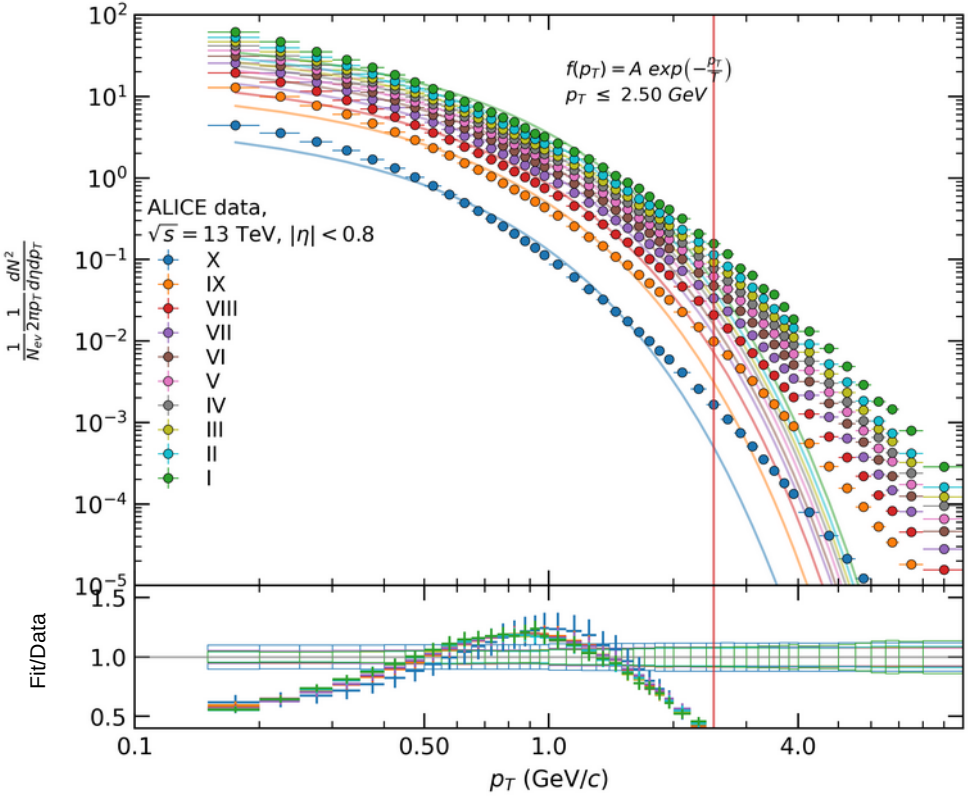

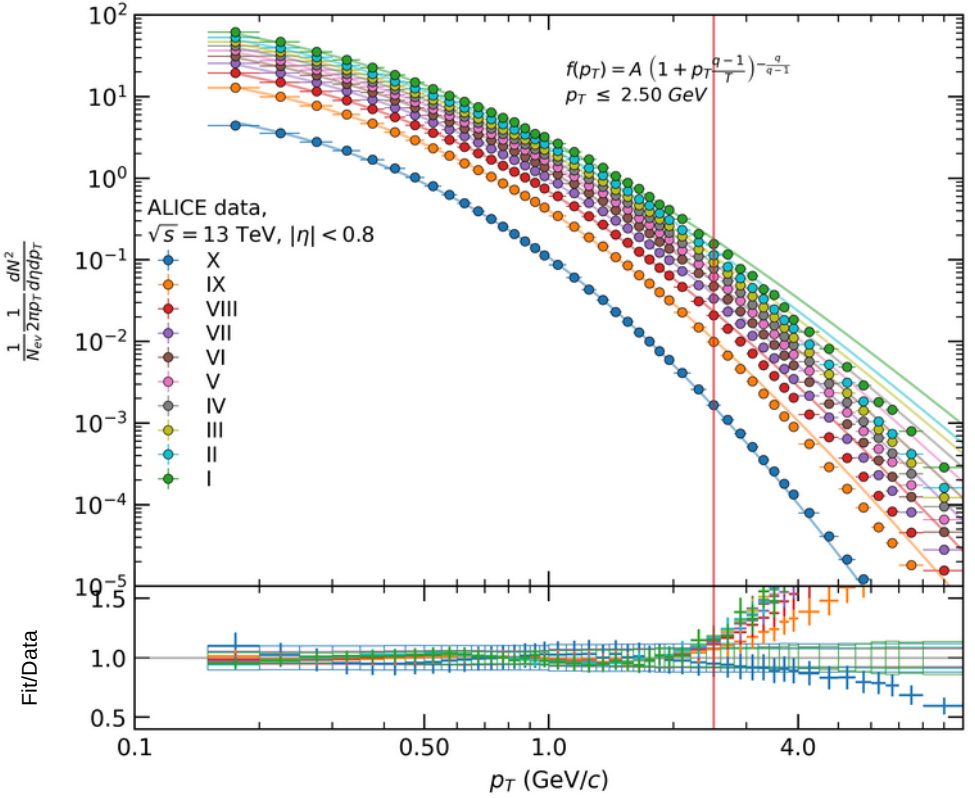

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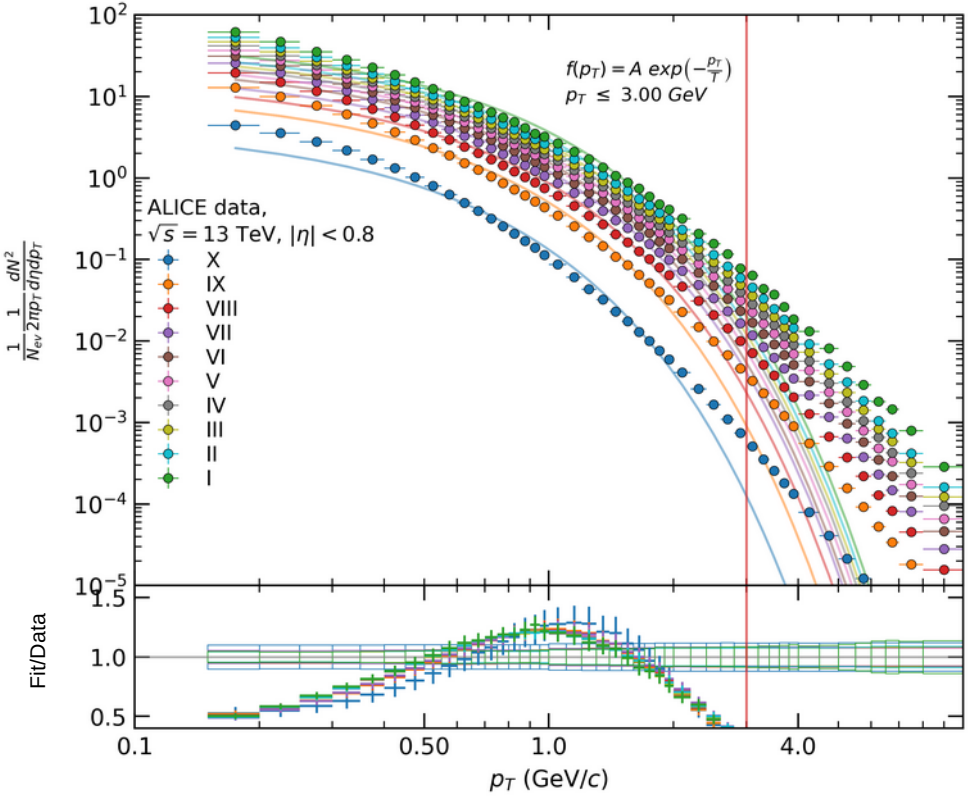

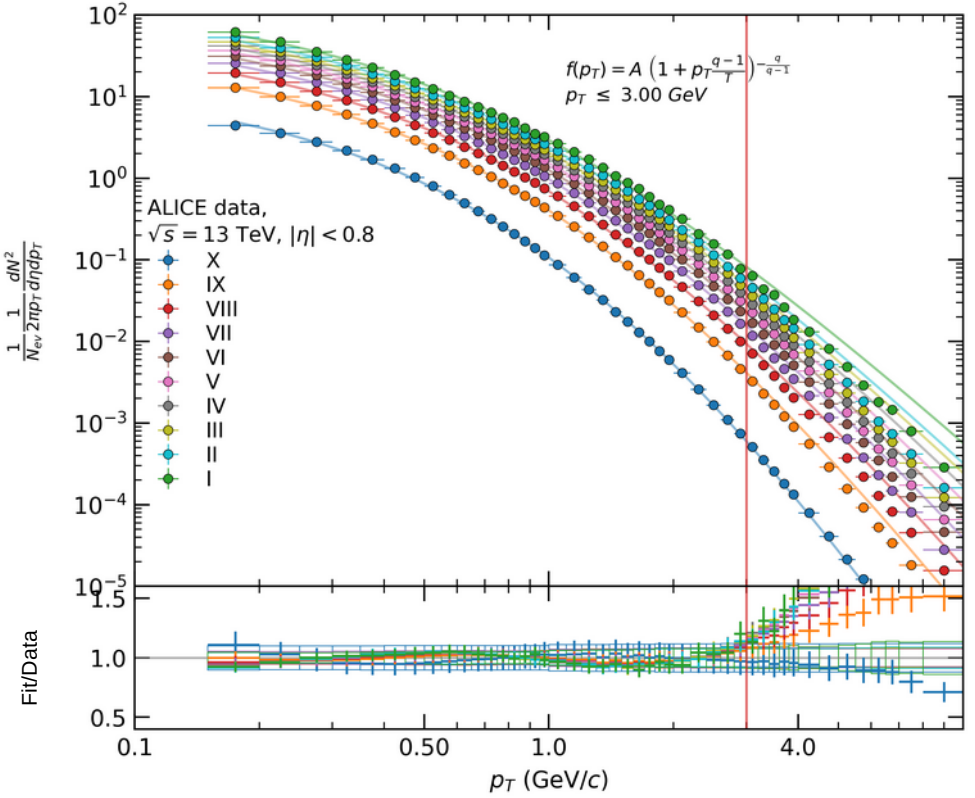

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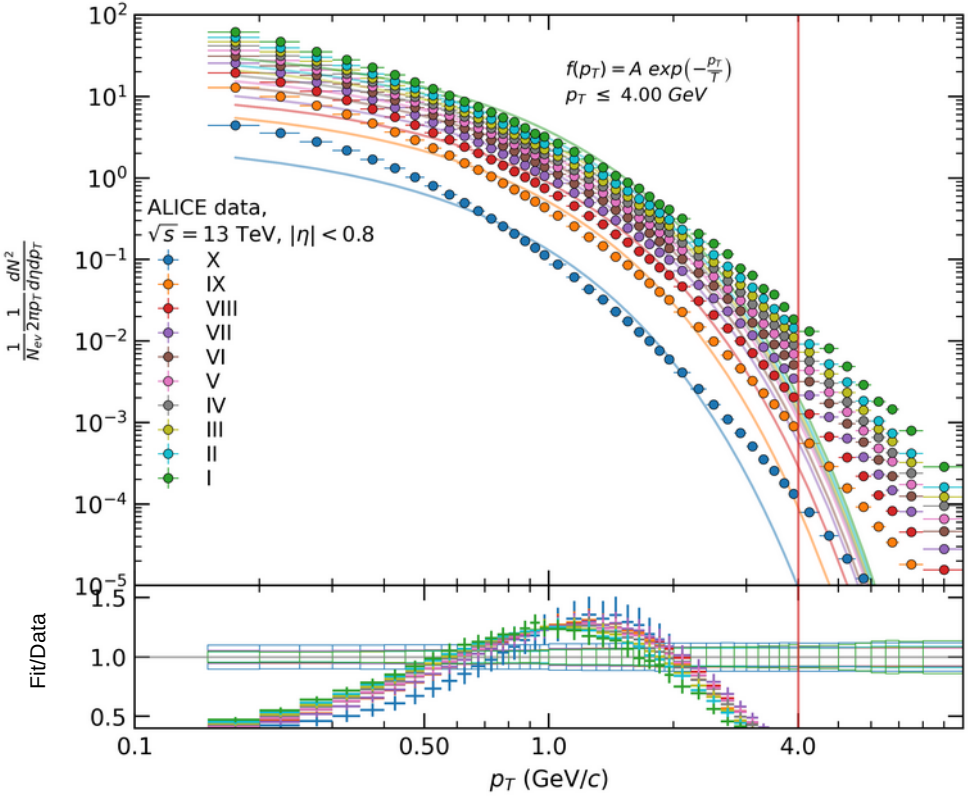

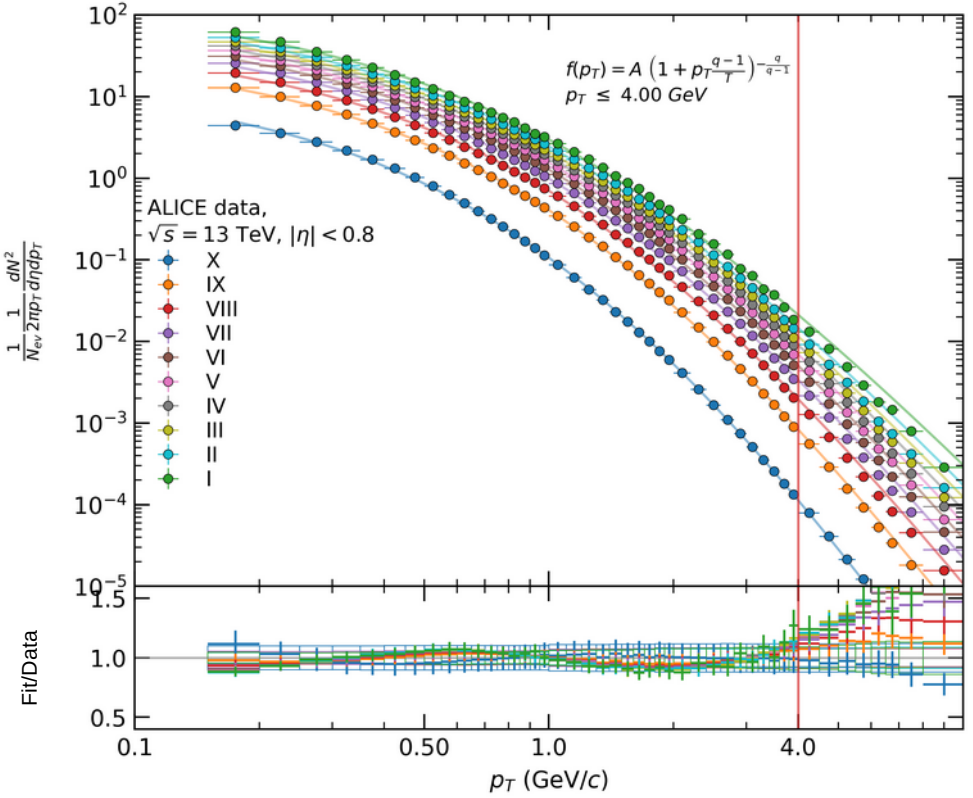

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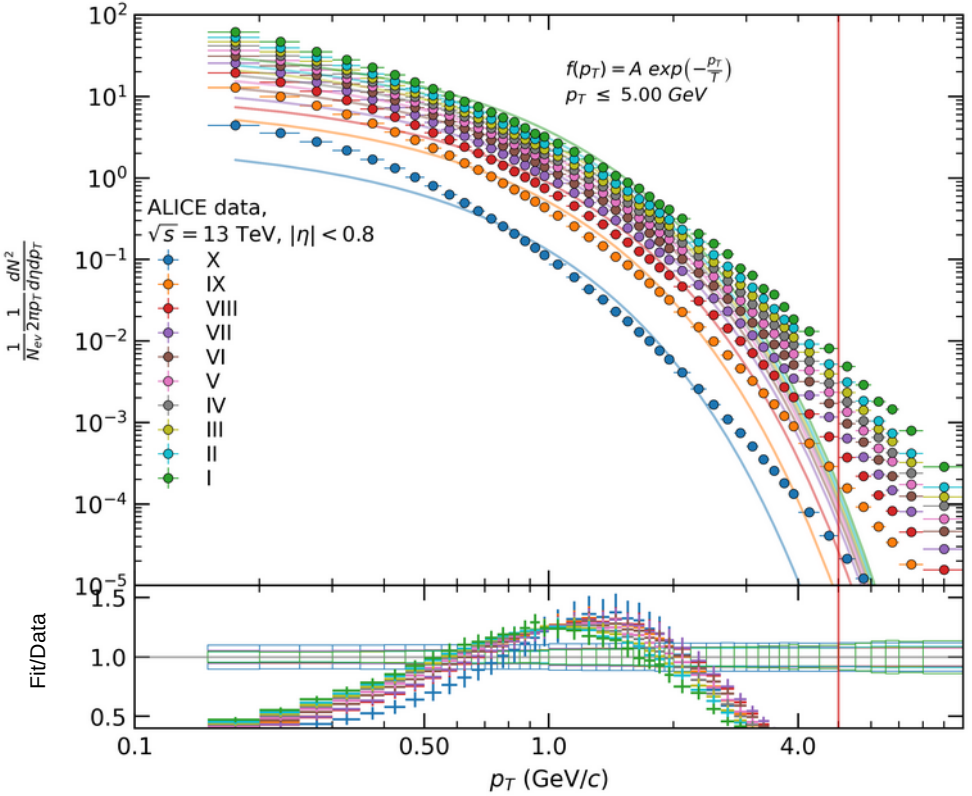

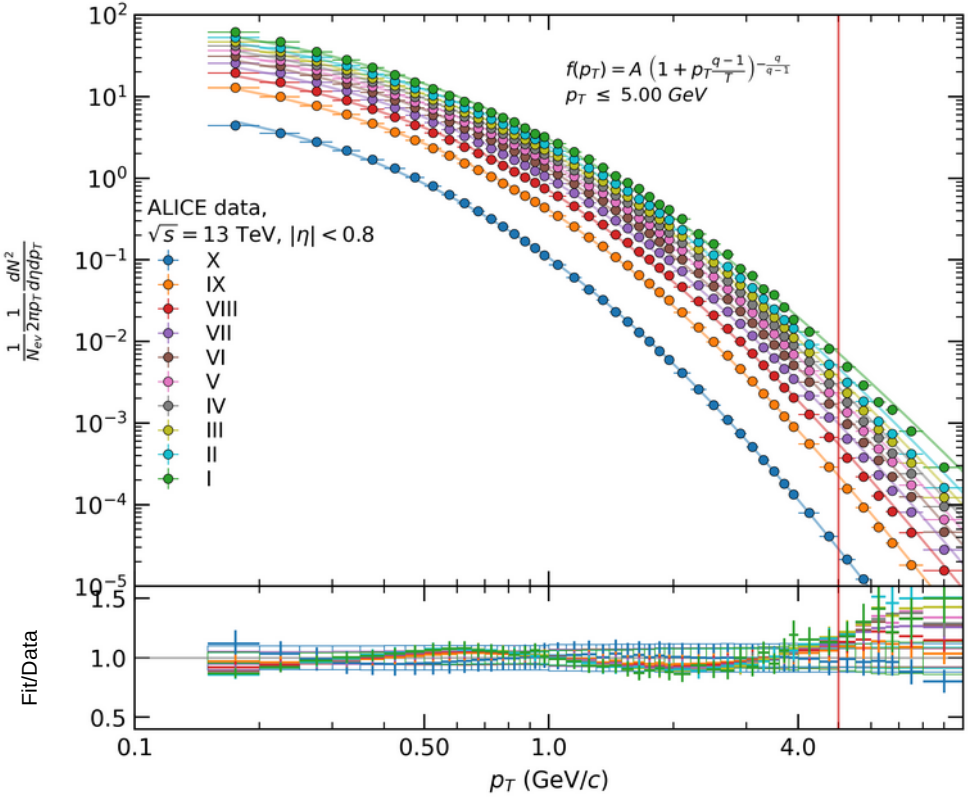

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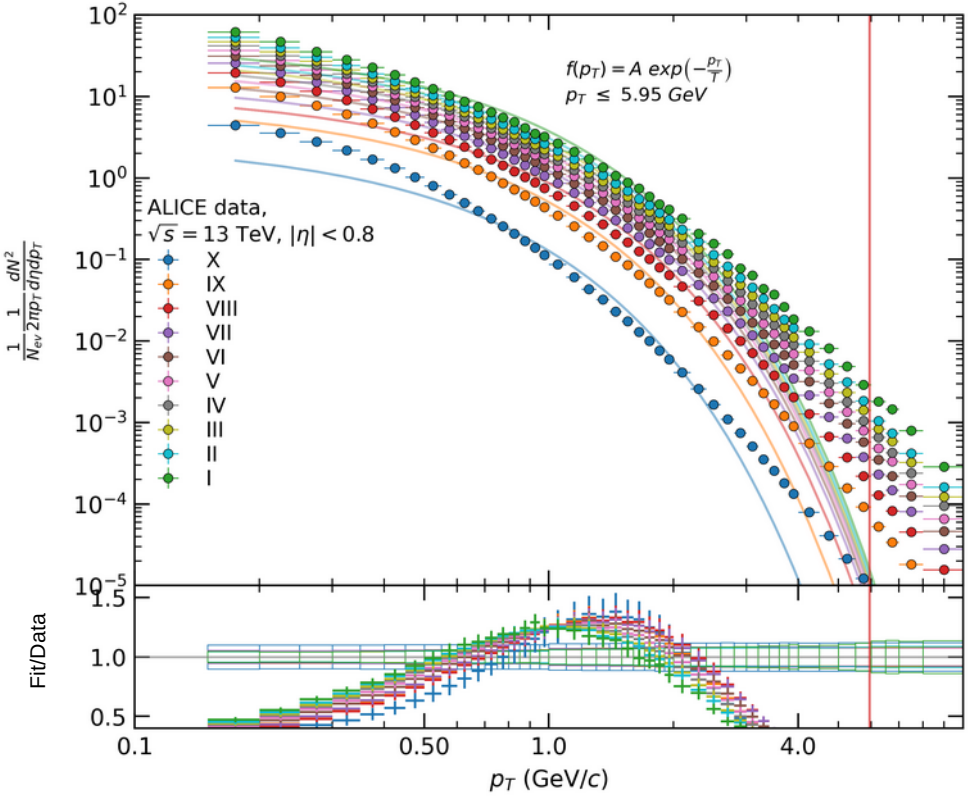
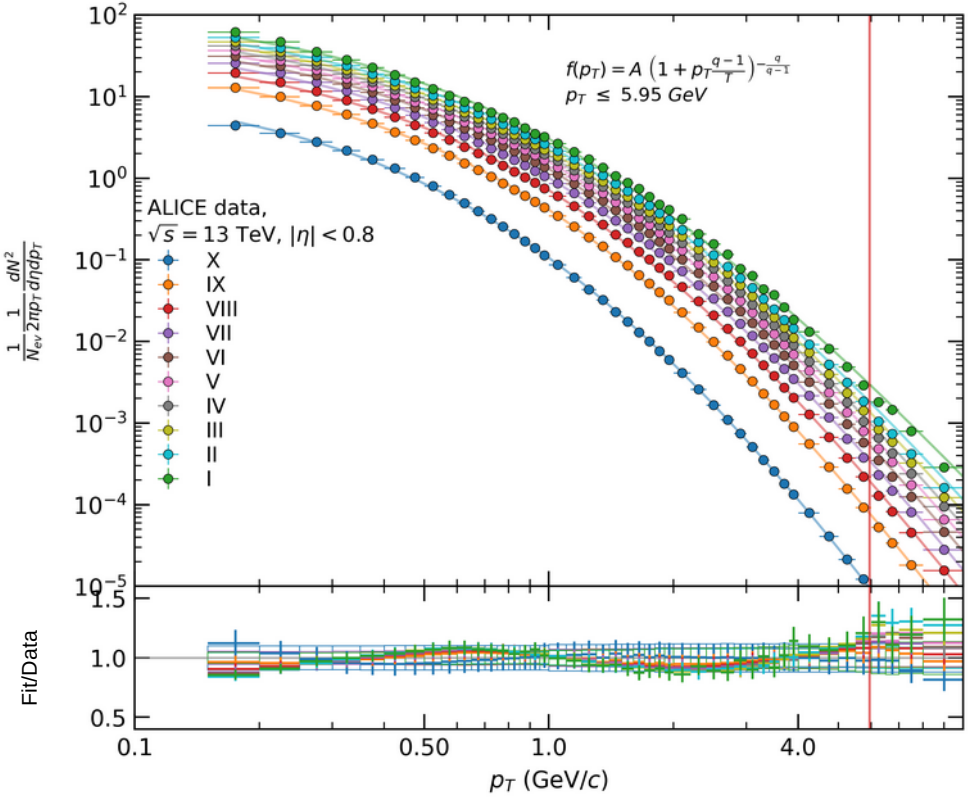
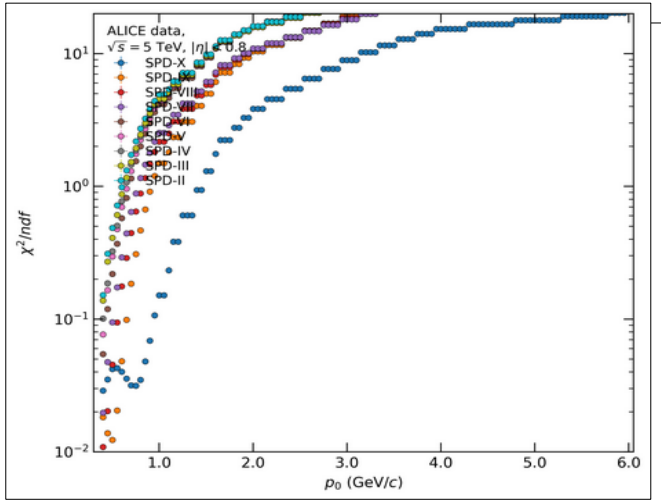
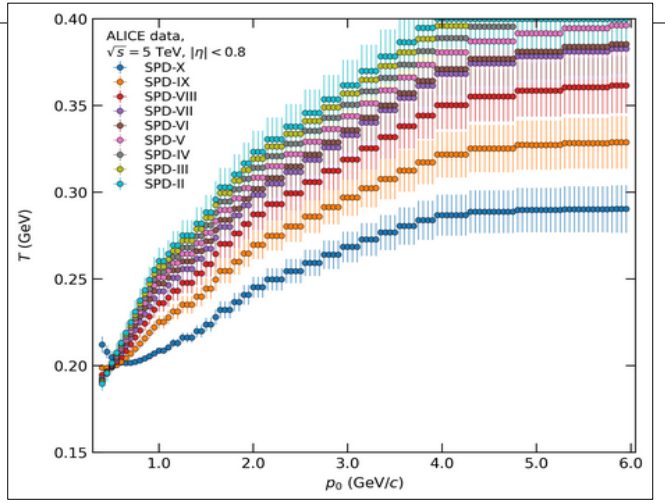
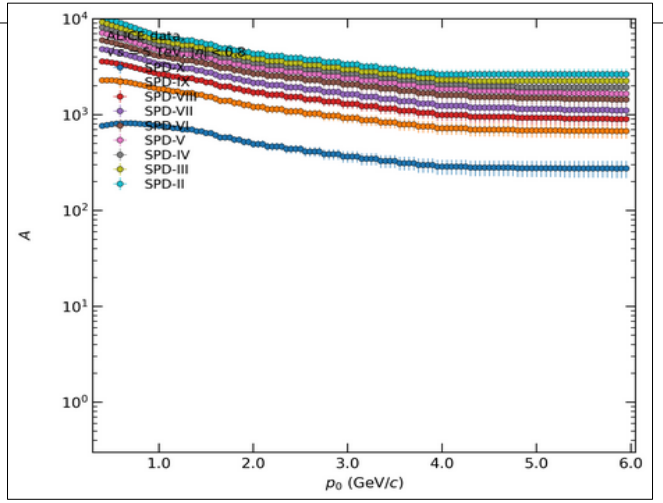


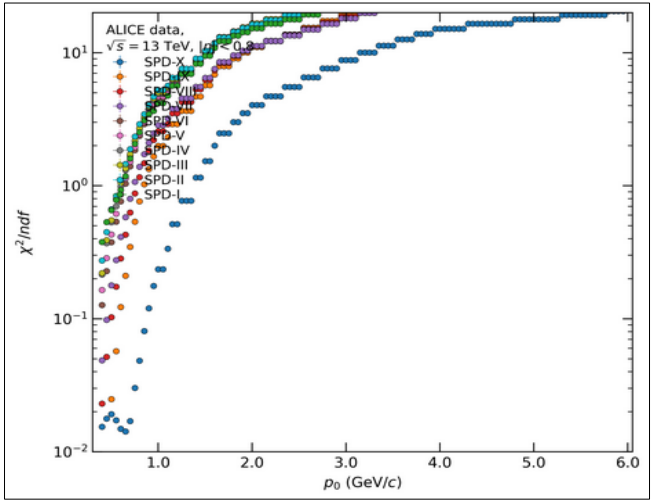


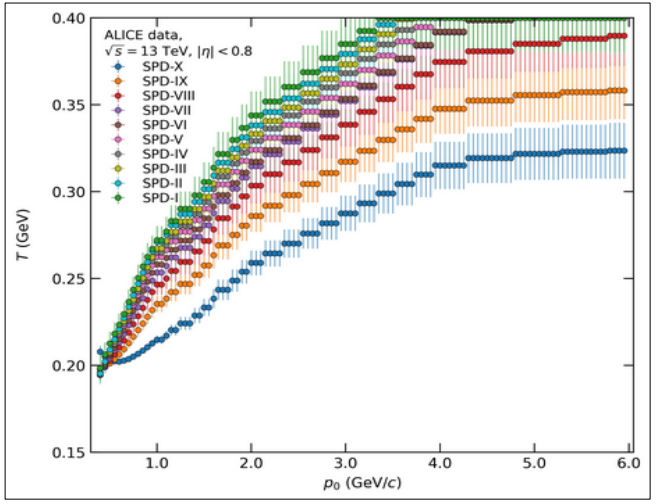
Results - Boltzmann

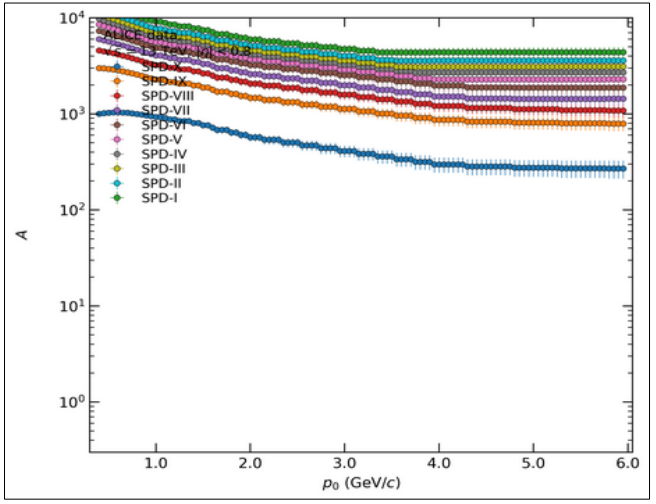




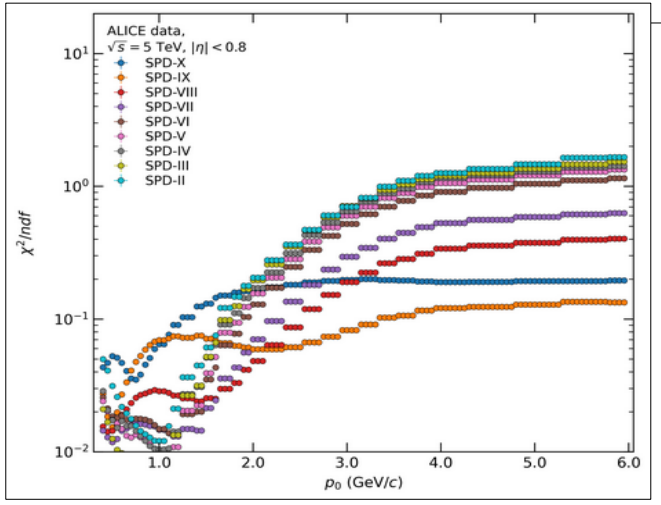


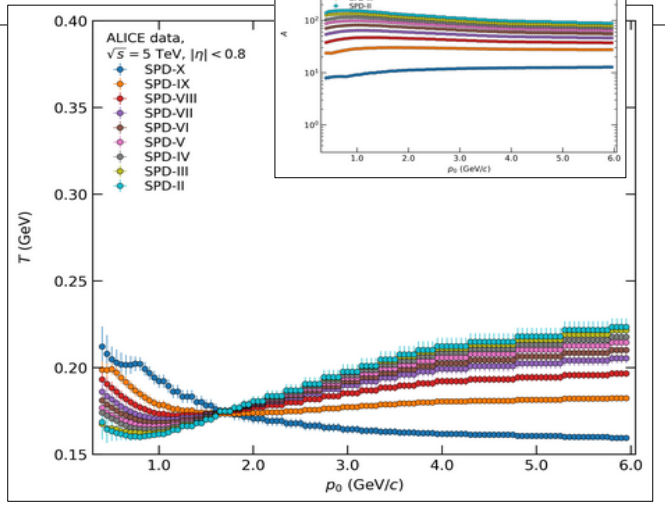


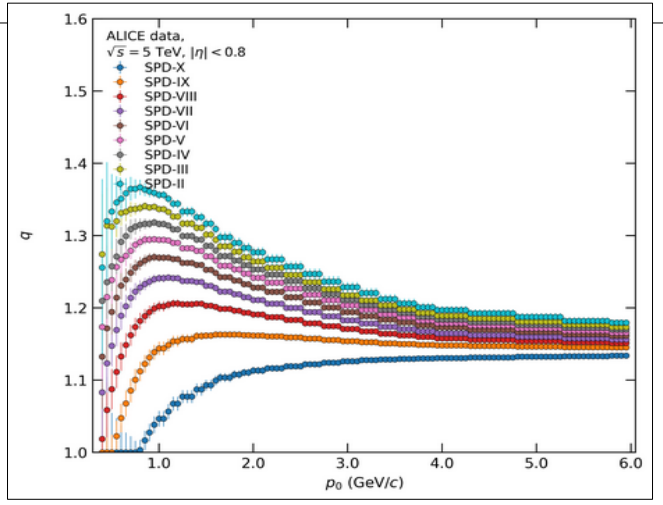


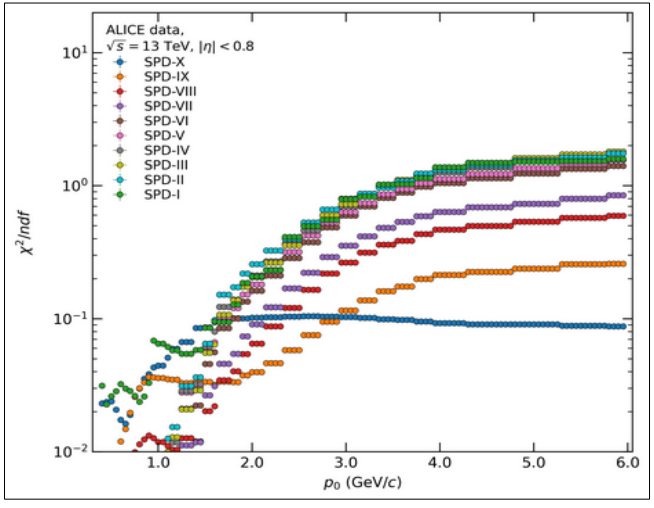


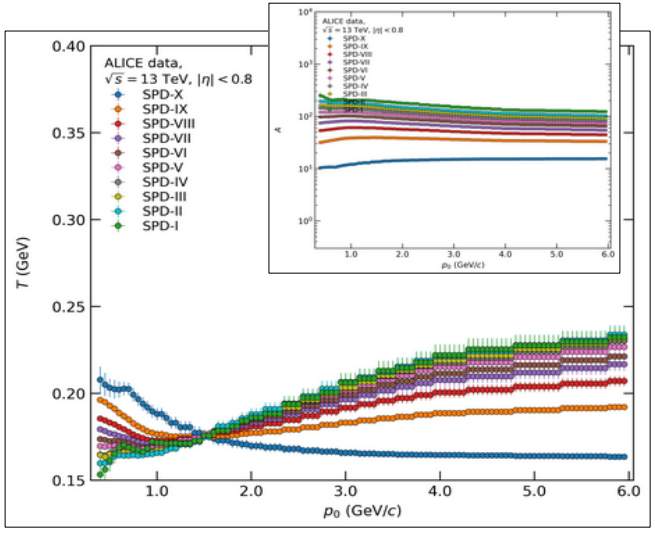
Results - Tsallis

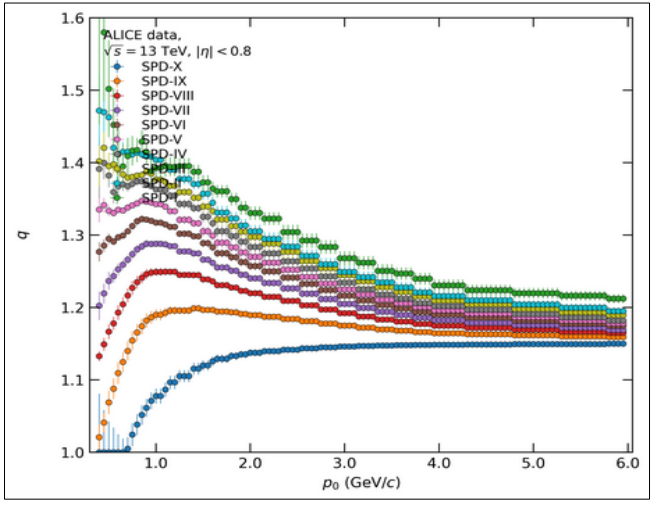












But the ***temperature*** is related to the mean transverse momentum...

And to collective flow properties...

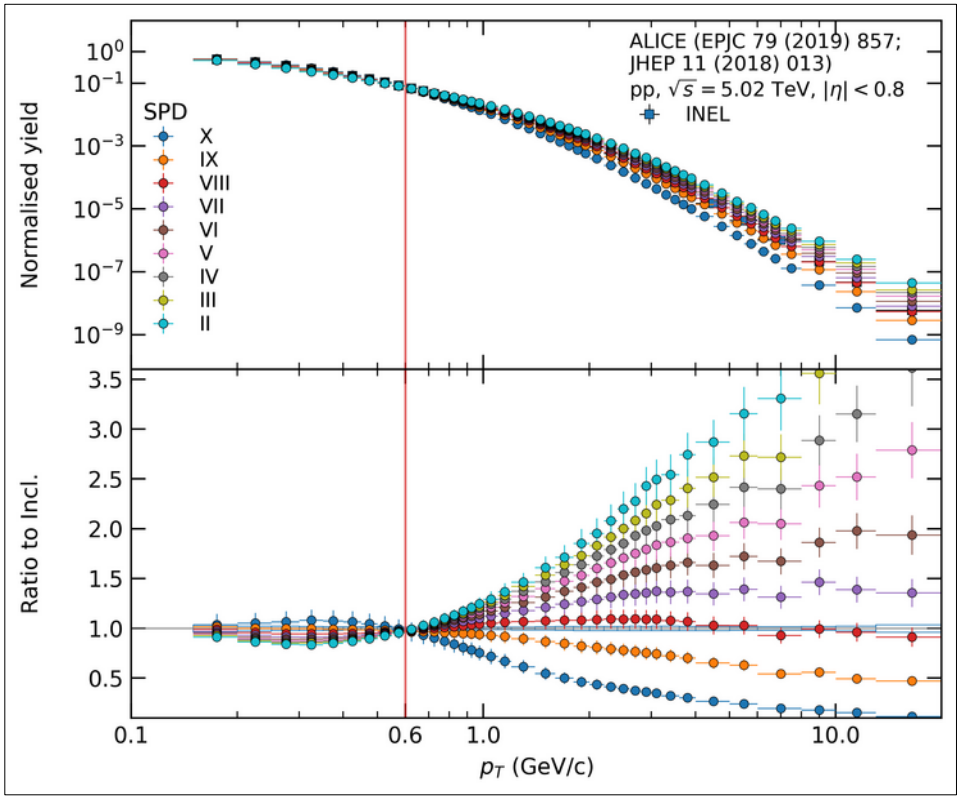
And to entropy density...

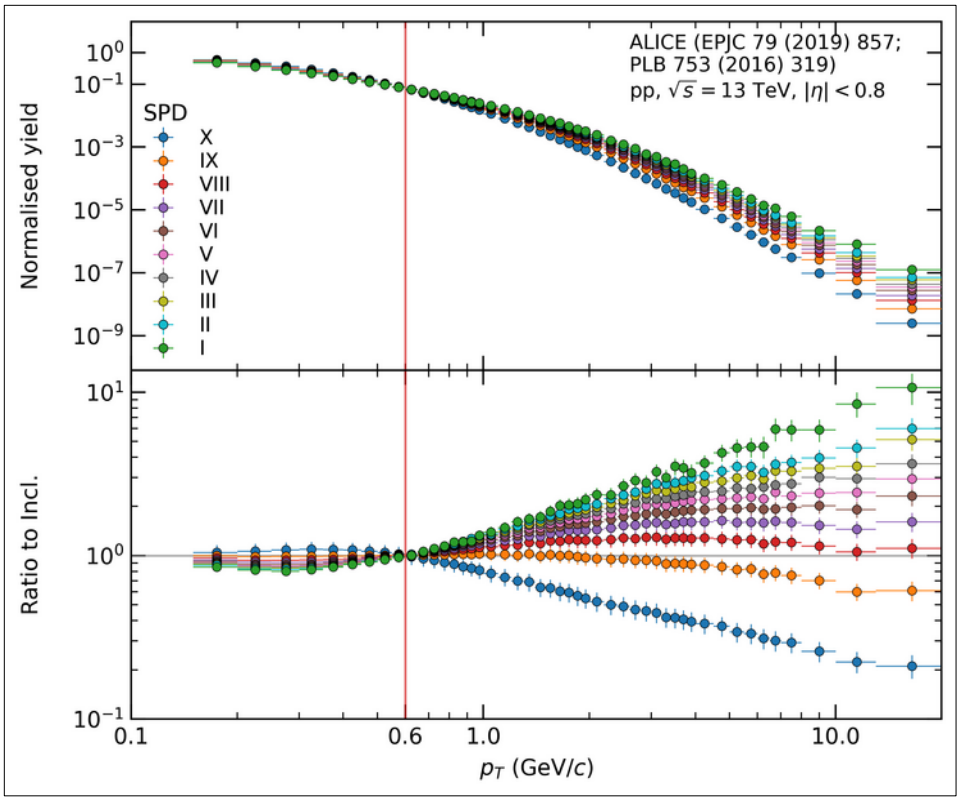
And to viscosity...

...

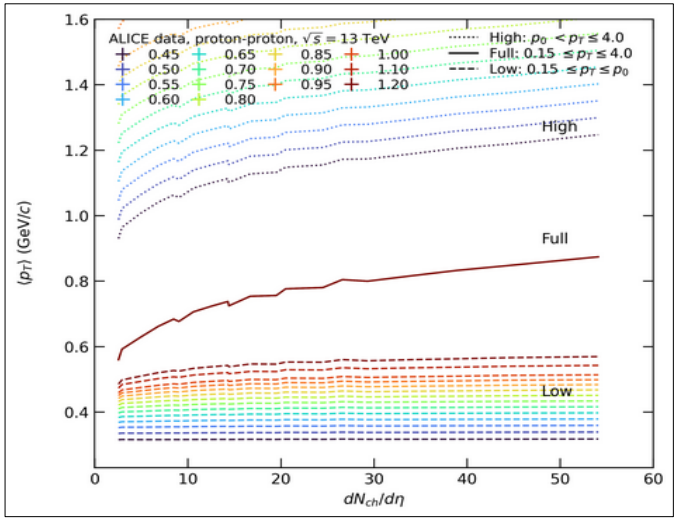
Normalized yields and event multiplicity

Charged hadrons: common crossing for all LHC energies → hint for soft limit?

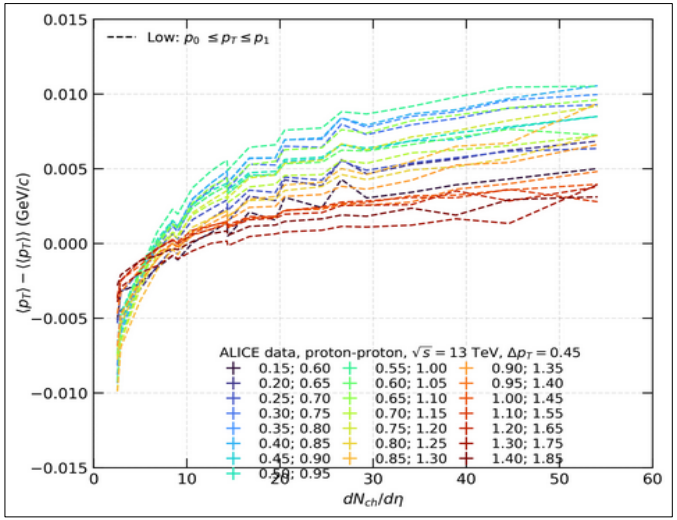




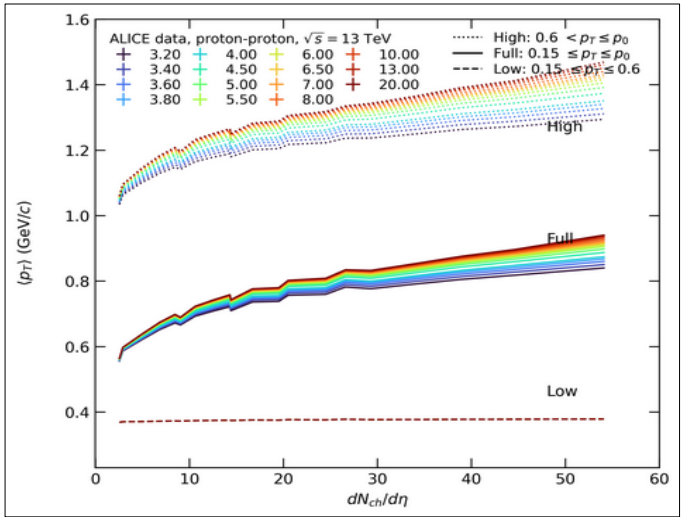
Various mean p_T limits w.r.t. multiplicity



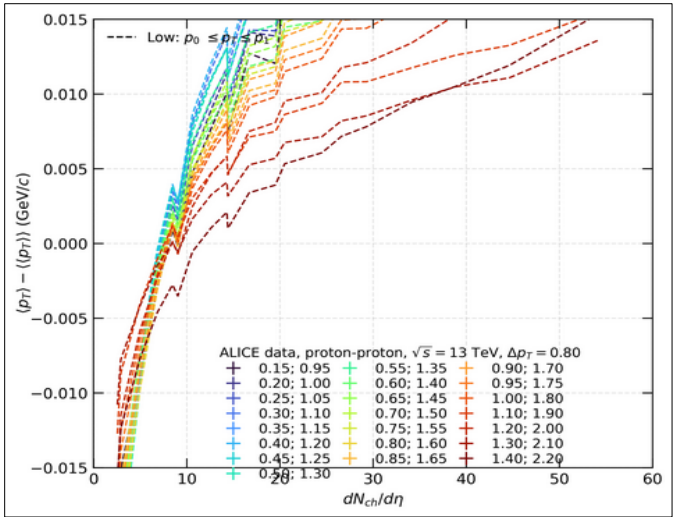
Soft/hard limit separation



Sensitivity of the soft part on the integration limits



High-p_T limit



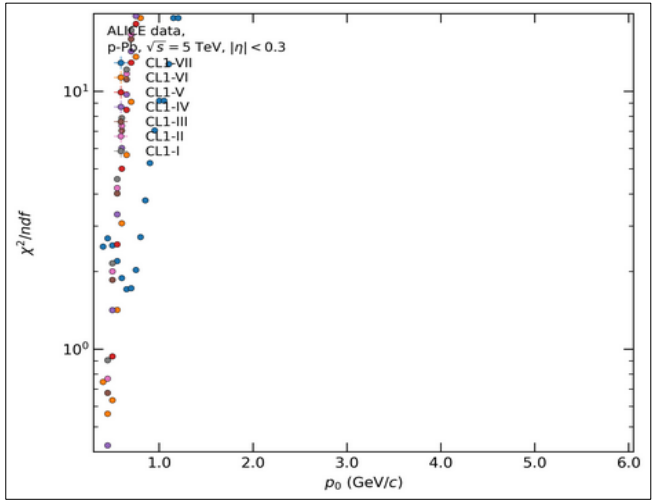
Summary

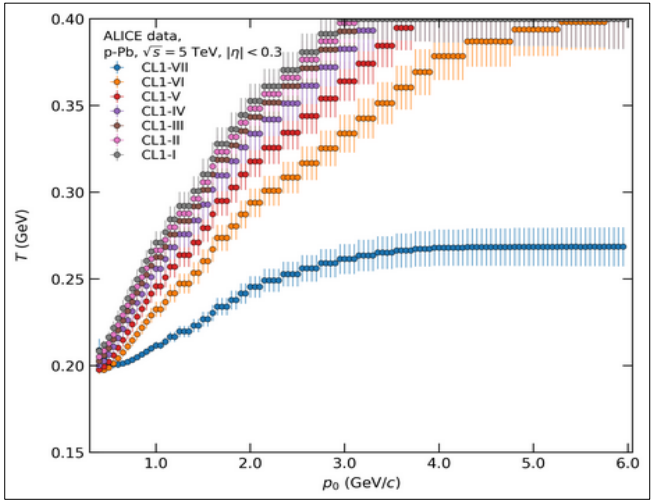
- The mean of the distributions can be **ill defined** (not to mention the extrapolations)
- The exponential-like Blast-wave fits (and the extracted flow properties) can be **ill defined**
- The extracted temperature (and therefore many other quantities) **strongly depends** on the applied definitions
- The soft/hard limit is controversial and question of interpretation

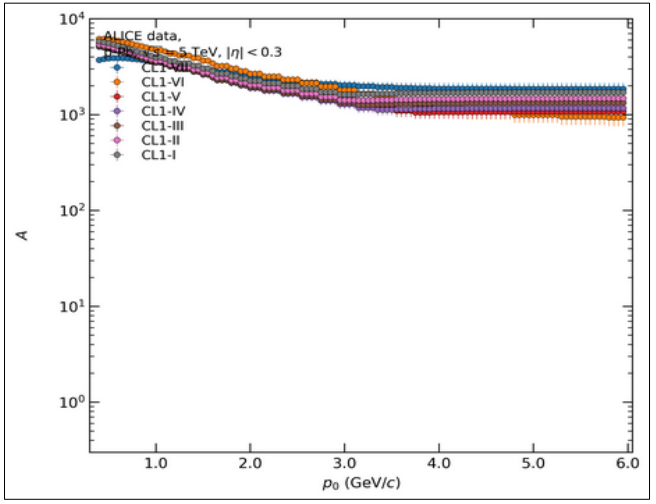
Thank you for your attention!

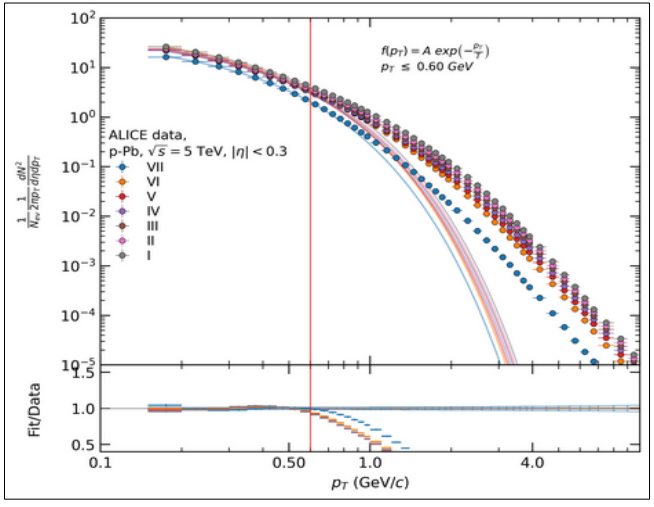
The research was supported by OTKA K135515, 2021-4.1.2-NEMZ_KI-2024-00031, 2021-4.1.2-NEMZ_KI-2024-00033, the **Wigner Scientific Computating Laboratory** (former Wigner GPU Laboratory).

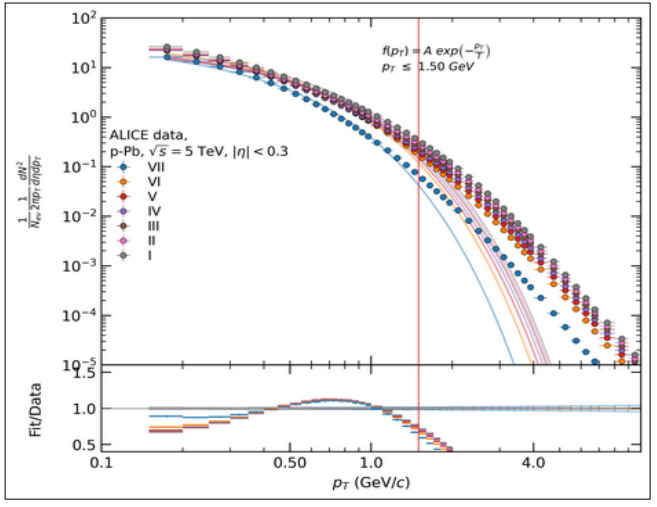
Results – p-Pb, Boltzmann

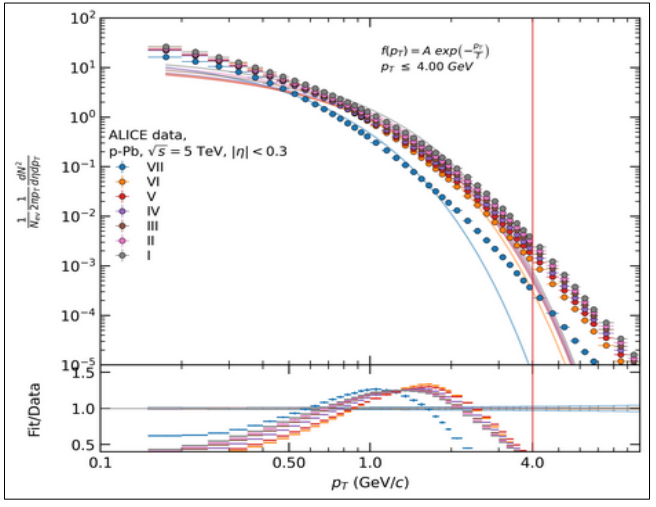












Results – p-Pb, Tsallis