Instituto de Ciencias Nucleares UNAM

ALICE

Analysis Update: p_{T} spectra as a function of R_{T} for pp, pPb and PbPb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV¶

Tutor: Dr. Antonio Ortiz Velásquez

Luz Elena Tiscareño Montoya
Paola Vargas Torres

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Objective

- The measurement of the charged-particle production as a function of multiplicity in transverse region in pp, p–Pb and Pb–Pb collisions at $\sqrt{s_{\rm NN}} = 5.02$ TeV. We use an unfolding technique to correct for detector effects the correlation between the transverse momentum ($p_{\rm T}$) spectra and the charged particle multiplicities in the transverse region.

Tracking efficiency

The tracking efficiency is the result of the reconstructed primary particles over generated primary particles.

$$\varepsilon(p_{\rm T}) = \frac{N^{\rm MC}_{\rm prim,rec}(p_{\rm T})}{N^{\rm MC}_{\rm prim,gen}(p_{\rm T})}$$

The ”real” tracking efficiency for each particle species is a convolution of the particles decay probability and detector effects.

The rest tracking efficiency is given by the weighted sum of the rest bulk particle tracking efficiencies:

$$\varepsilon_{rest}(p_{\rm T}) = \sum_{\rm i=e,\mu,\Omega,\Xi} \frac{N^{\rm MC}_{\rm i}(p_{\rm T})}{N^{\rm MC}_{\rm rest}(p_{\rm T})}\varepsilon_i$$

Particle composition

The relative single-particle abundances in Monte Carlo differ from data.

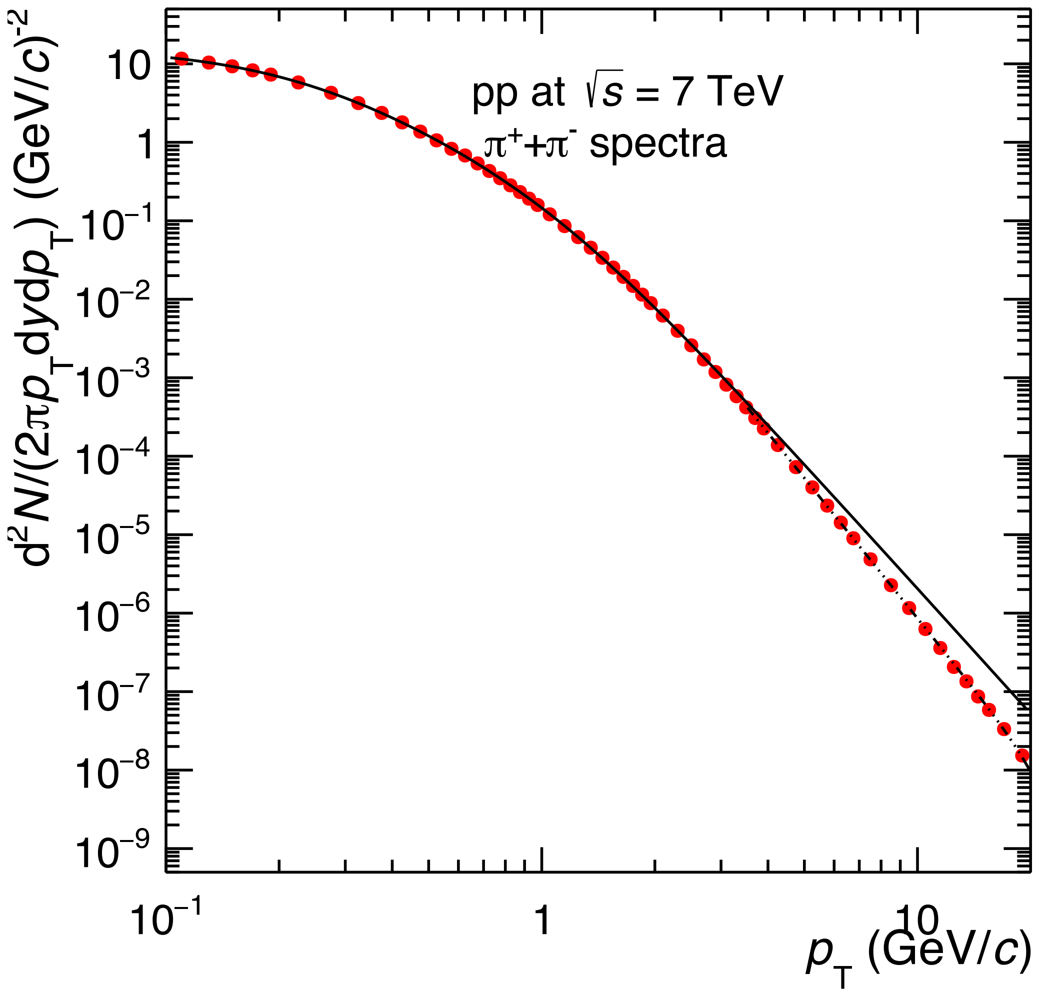
For that reason the tracking efficiency is reweighed with measured particle composition.

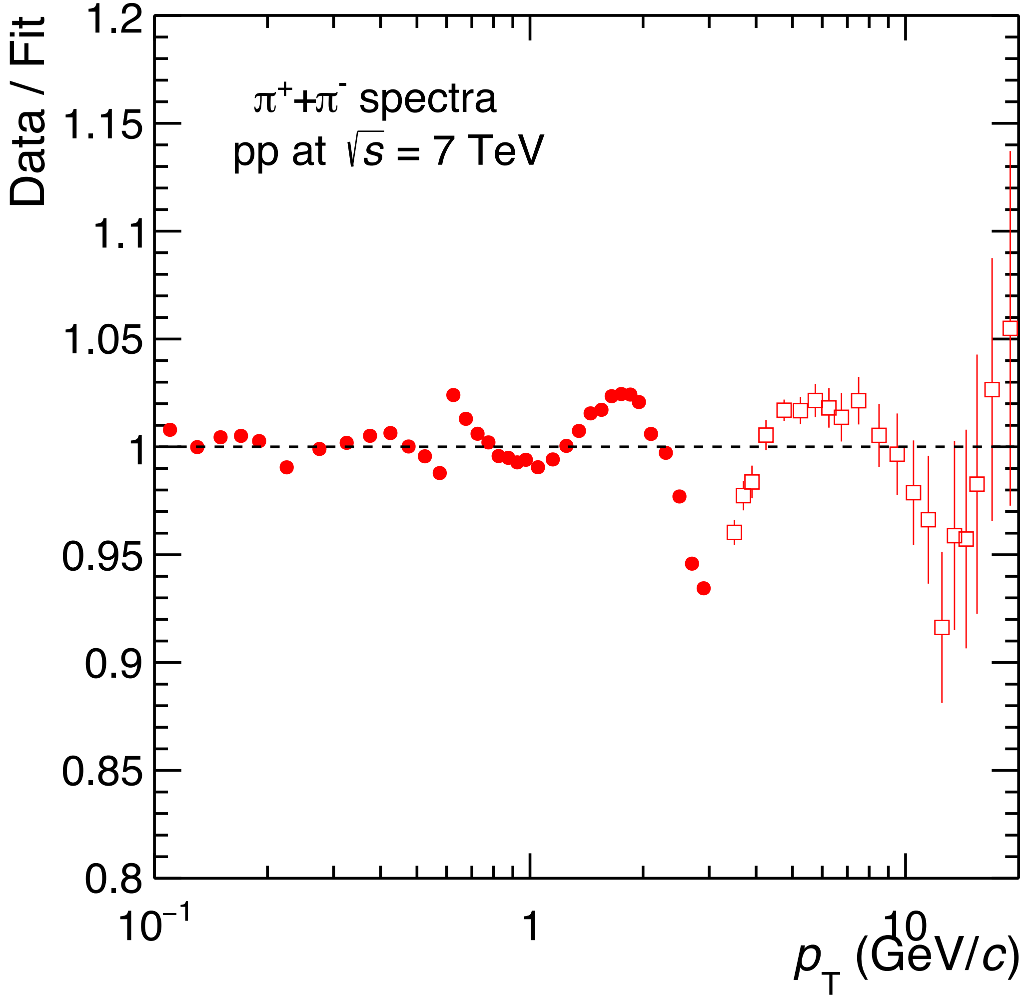
The single-particle spectra

The measured single-particle spectra in pp and pPb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV are shown in the next figures:

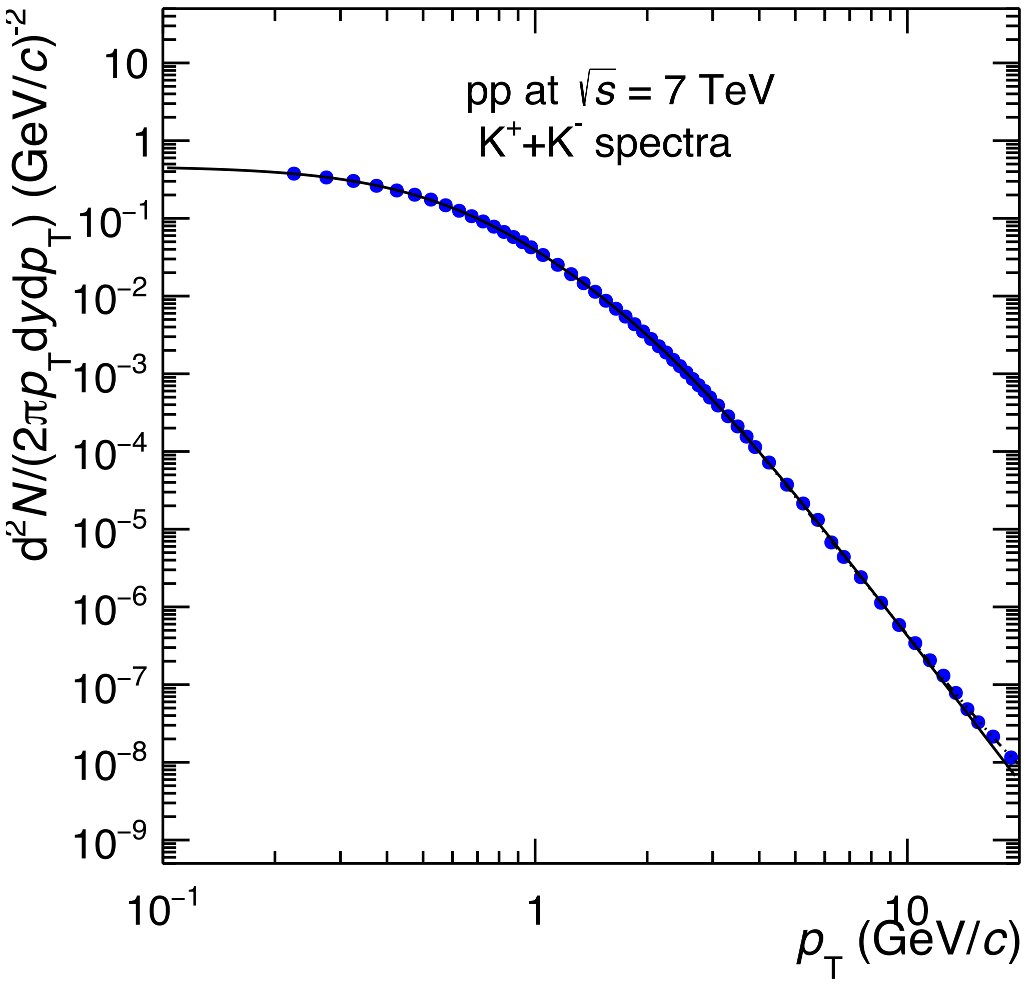
- ✦ considering a fit for low-p_{T} because the spectra does not cover the full transverse-momentum range.
- ✦ shown also a power law to $p_{\mathrm{T}} > 3.5$ GeV.

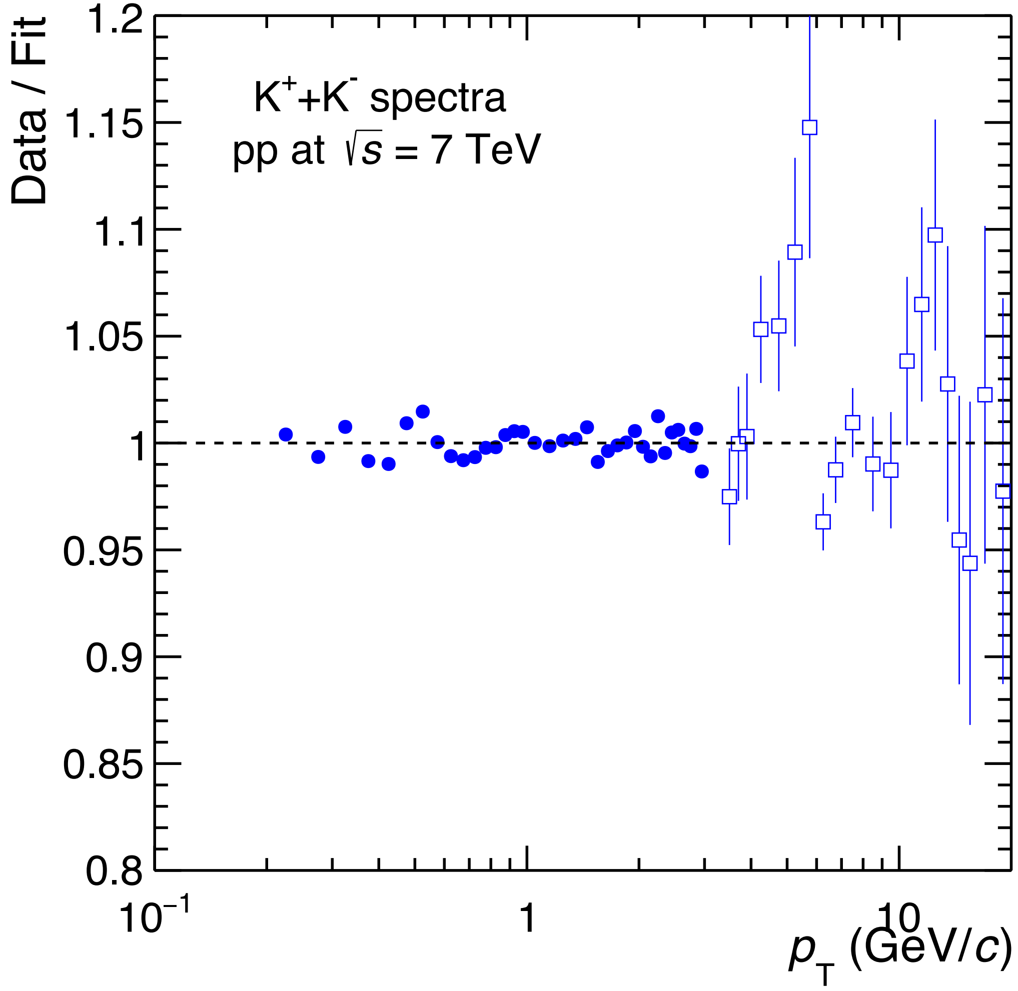
The single-particle spectra



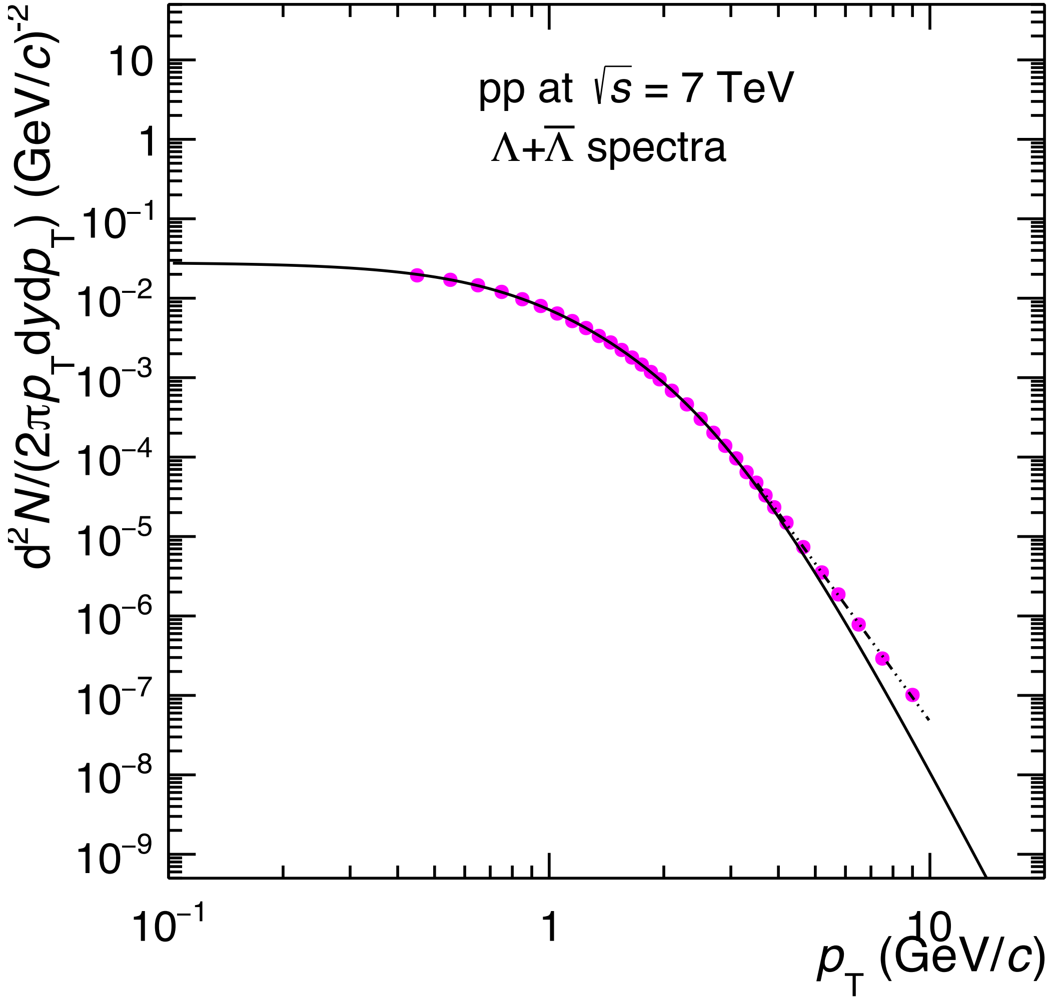


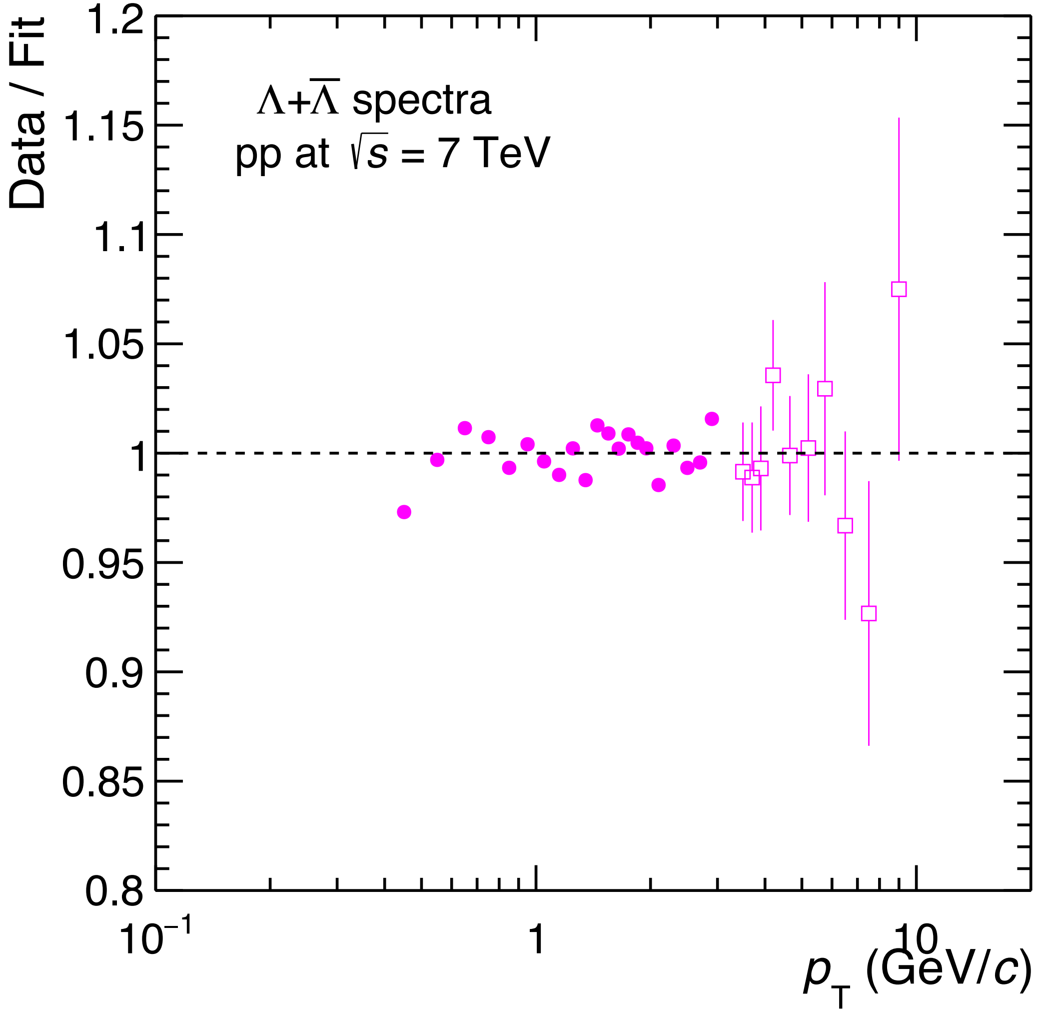
The single-particle spectra



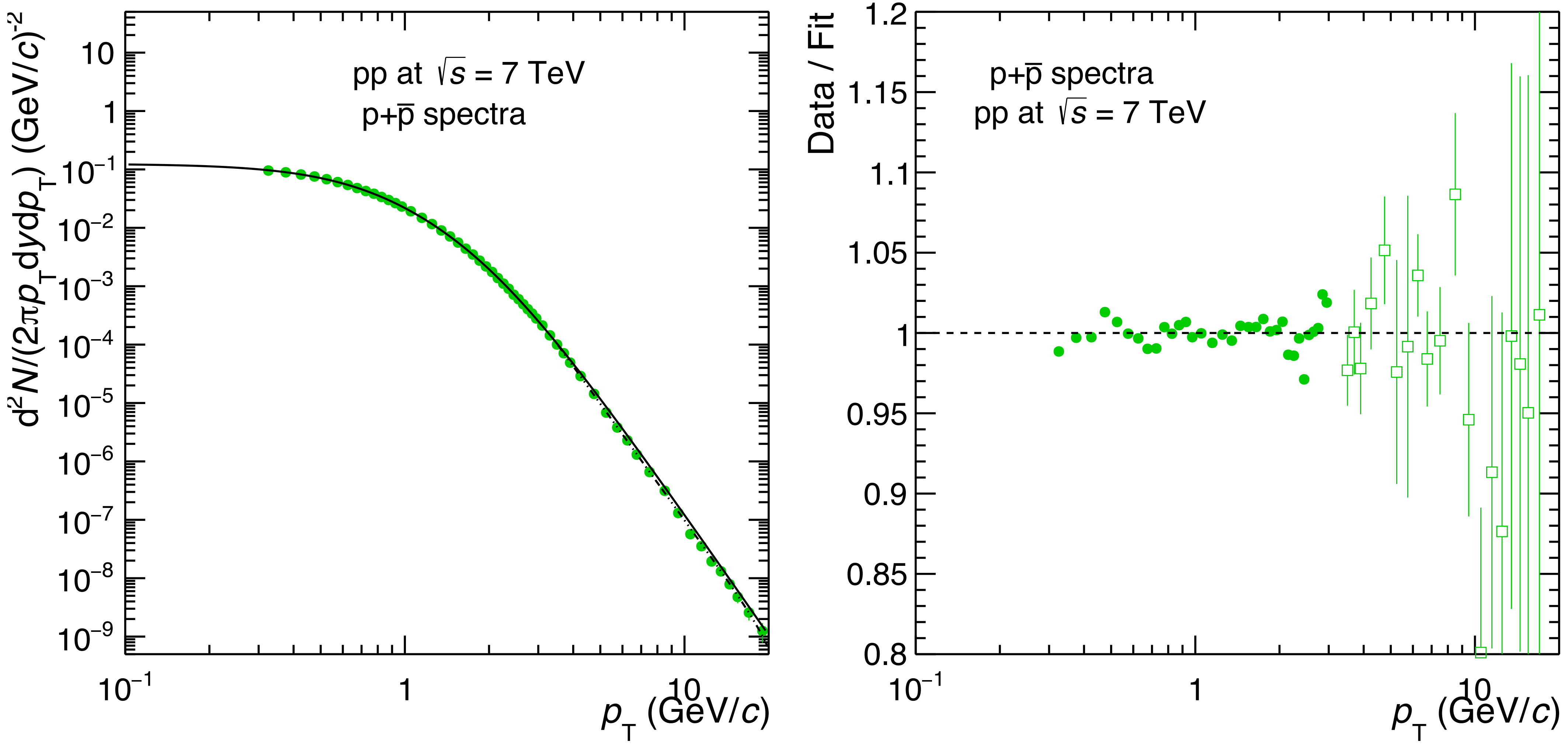


The single-particle spectra





The single-particle spectra



Construction of Σ^{+} and Σ^{-} spectra

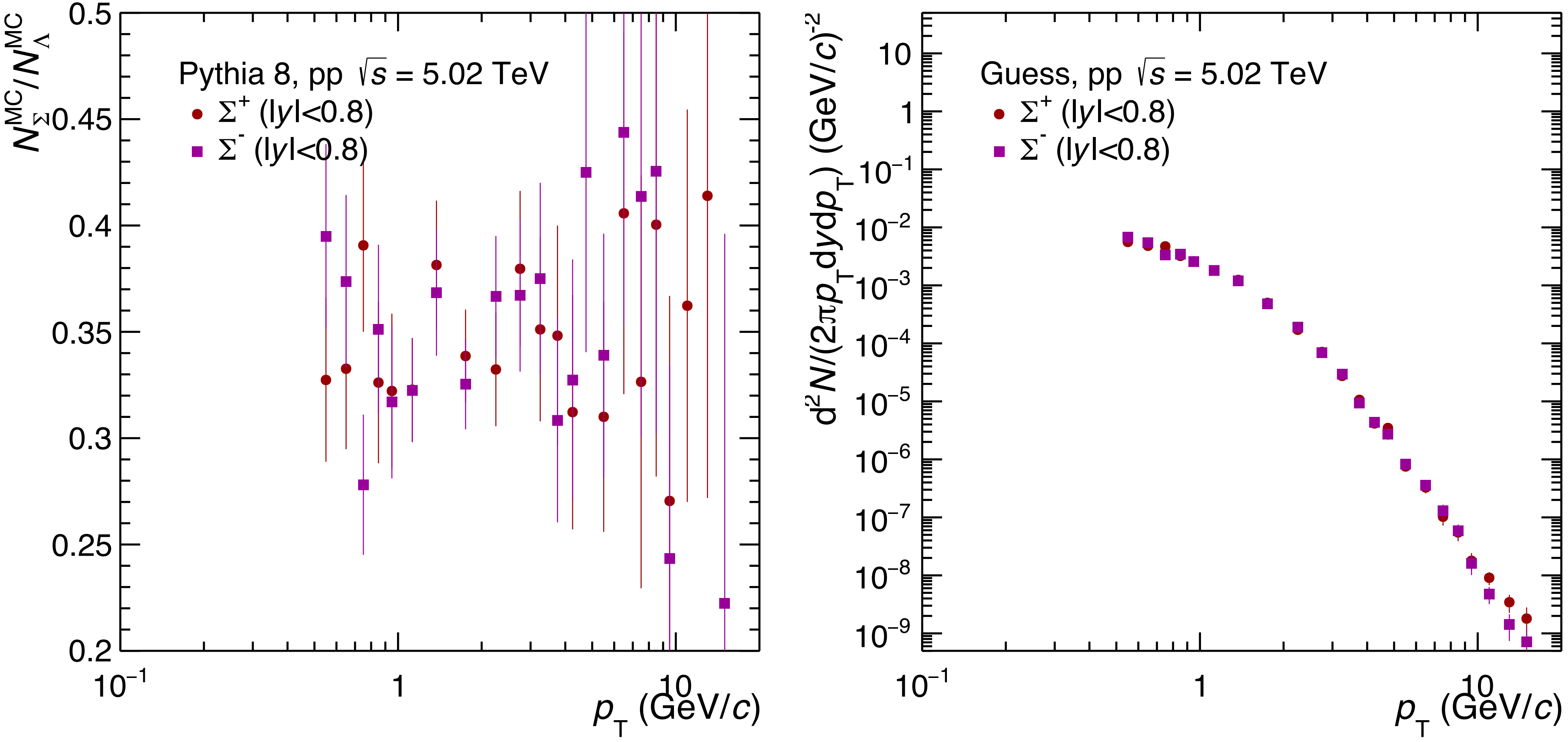
Since there is no measurement of Σ+ and Σ- particles as well as their corresponding antiparticles, their similarity in composition with Λ is exploited to construct a realistic Σ+ and Σ-spectrum.

$$\Sigma^{+}(uus) \qquad \Sigma^{-}(dds) \qquad \Lambda(uds)$$

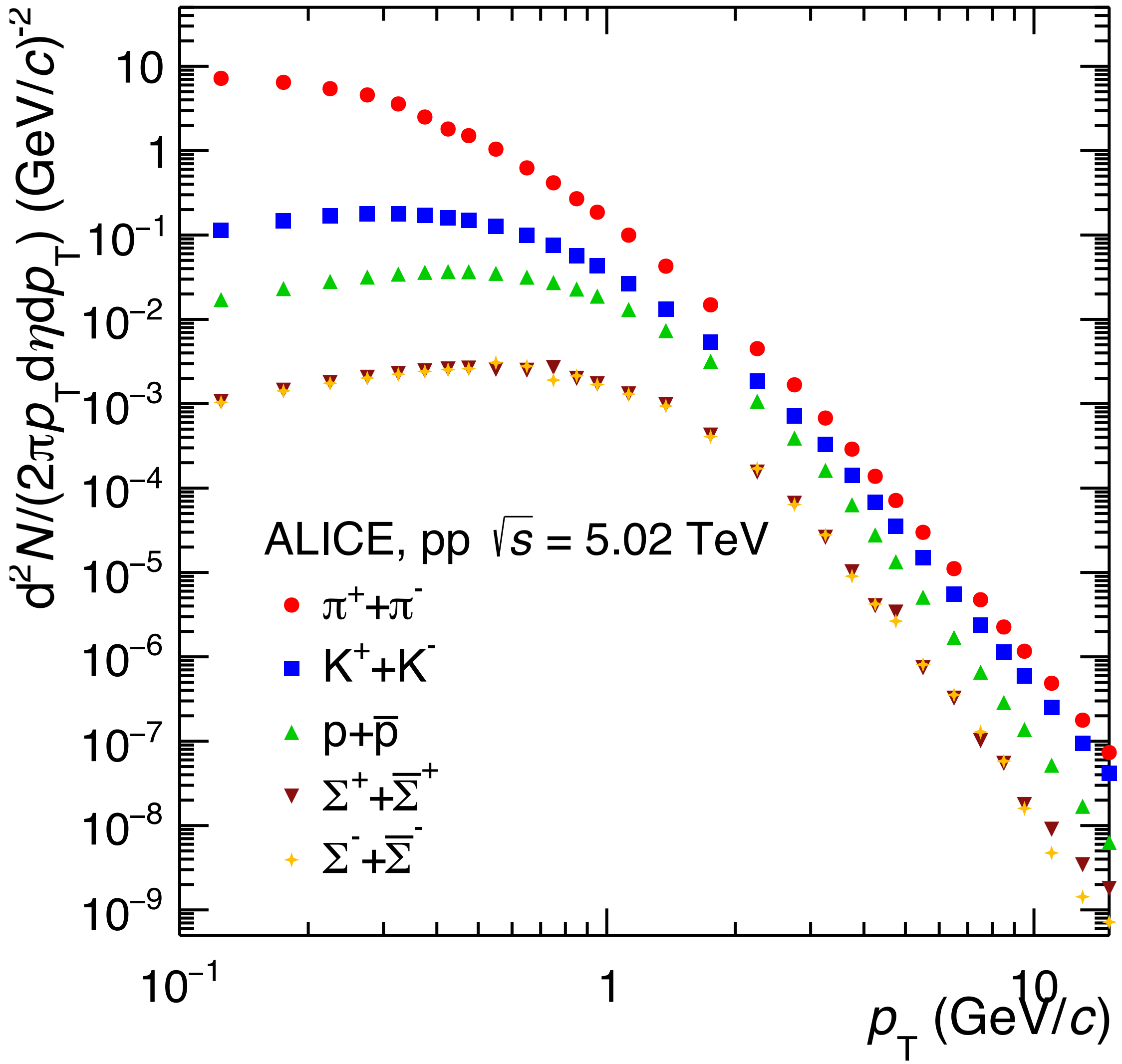
The procedure uses the following formula:

$$N^{const}_{\Sigma^{+/-}}(p_{\mathrm{T}}) = \frac{N^{\mathrm{MC}}_{\Sigma^{+/-}}(p_{\mathrm{T}})}{N^{\mathrm{MC}}_{\Lambda}(p_{\mathrm{T}})} N^{\mathrm{mes}}_{\Lambda}(p_{\mathrm{T}})$$

Construction of Σ^+ and Σ^- spectra



The single-particle spectra



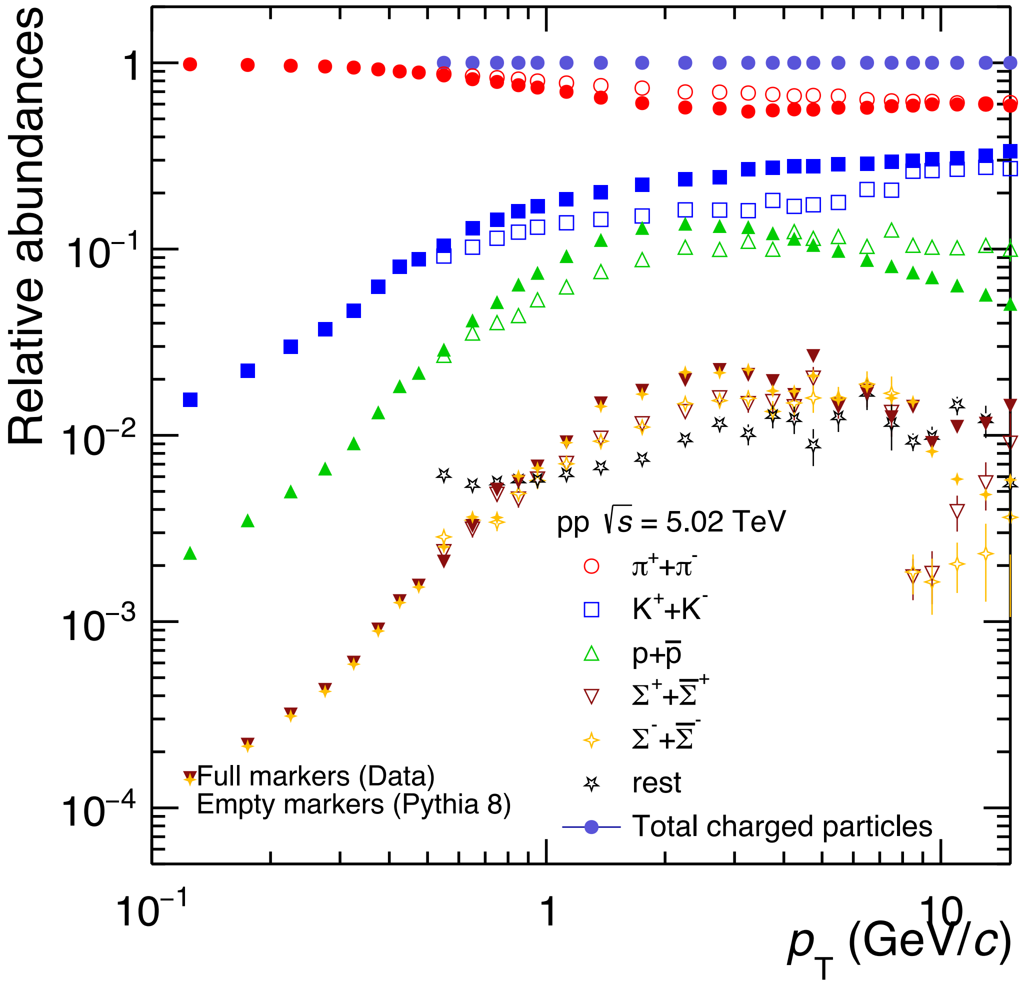
Relative abundances

The particle composition is dominated by π's, K's, p's and Σ's however the bulk of rest particles contains e's, μ's, Ω's and Ξ's.

The relative fractions of all particle species can be calculated by

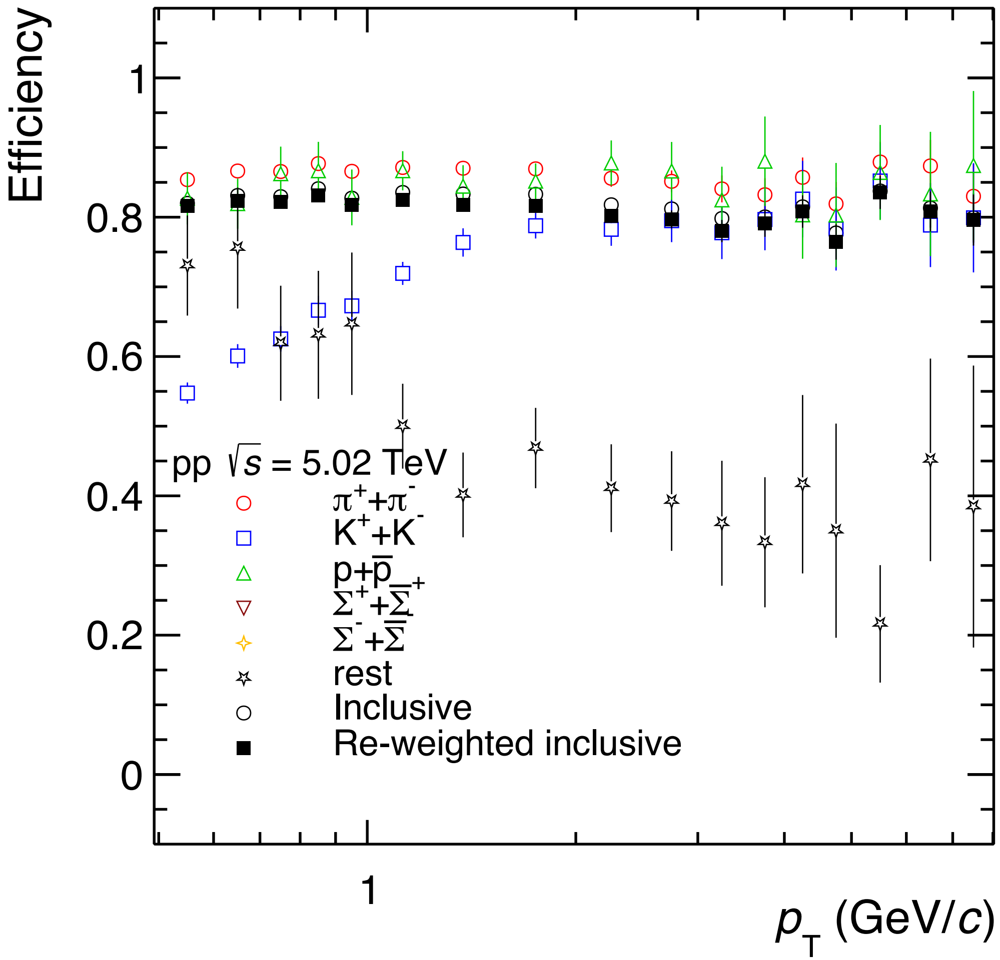
$$f_i = \frac{N_i}{\sum_{j=\pi,K,p,\Sigma,rest} N_j}$$

Relative abundances



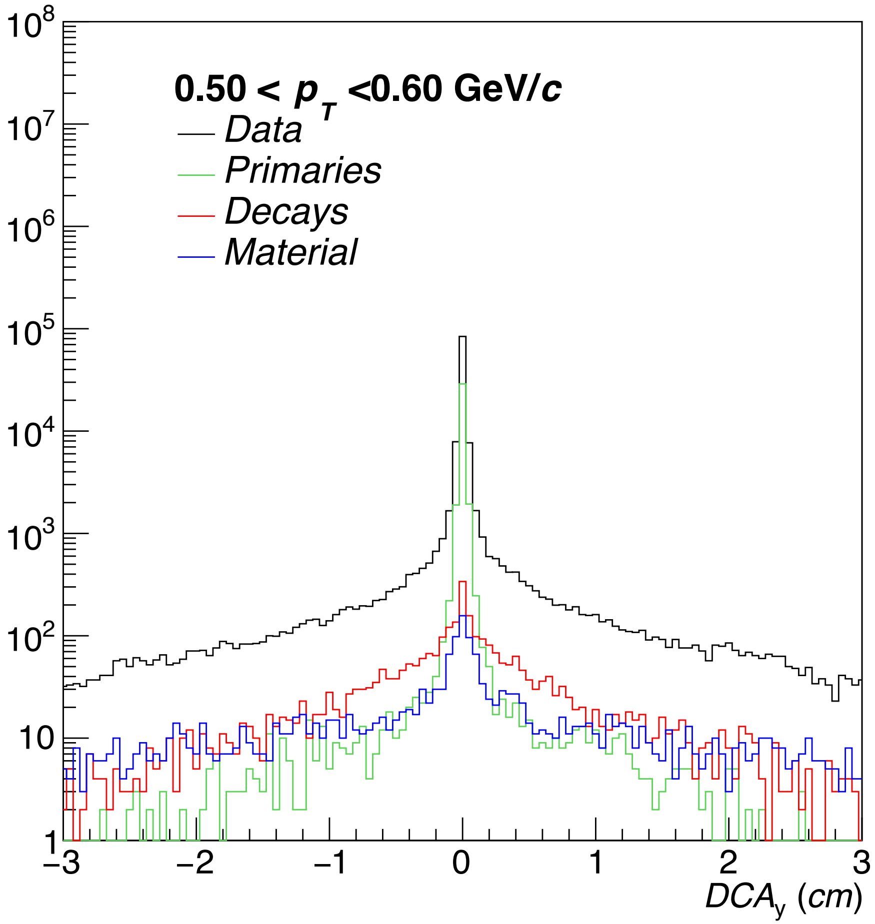
Measured relative particle fractions as well as the ones predicted by the PYTHIA 8 event generator

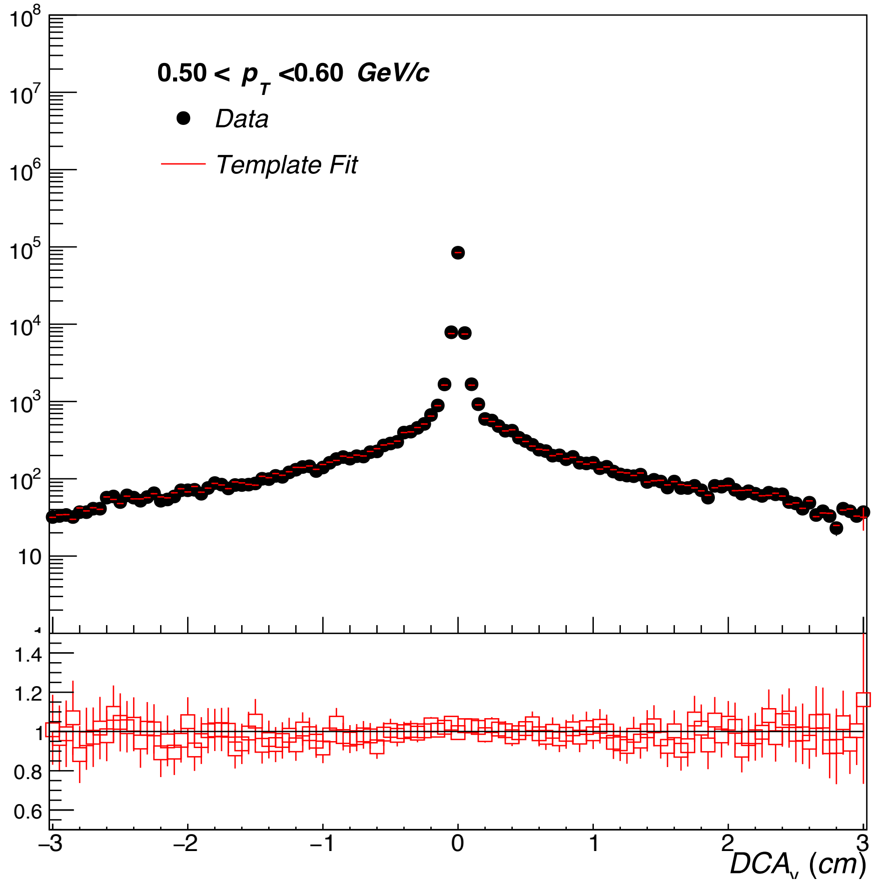
Efficiency



Data driven-tracking efficiency as well as the ones from MC

Correction by secondaries





The DCAxy distributions for different p_T bins, indicated in each frame

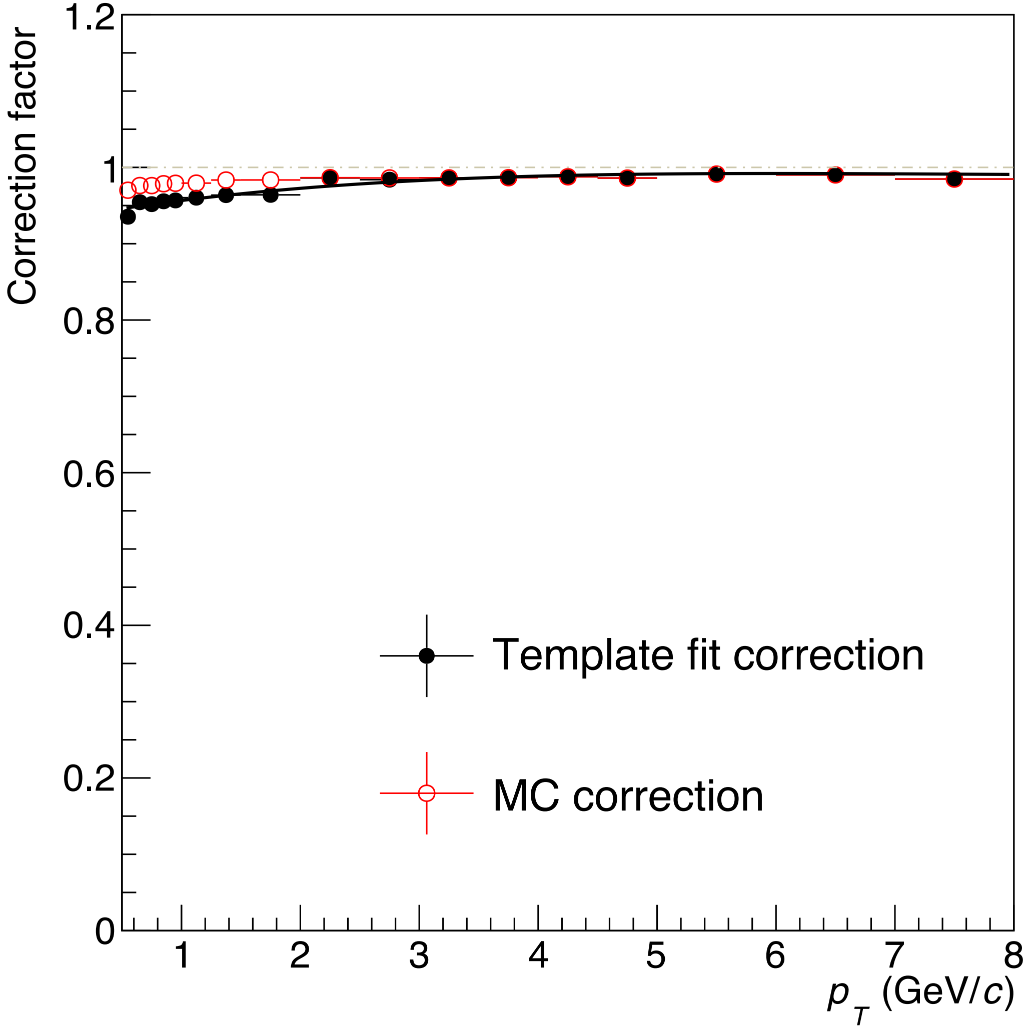
Correction factor for secondary contamination

Once the multi template function is fitted to the data, the contamination from secondary particles is obtained from the DCA distribution after restricting the DCA interval following the p_{T}-dependent cut where it is used the next function:

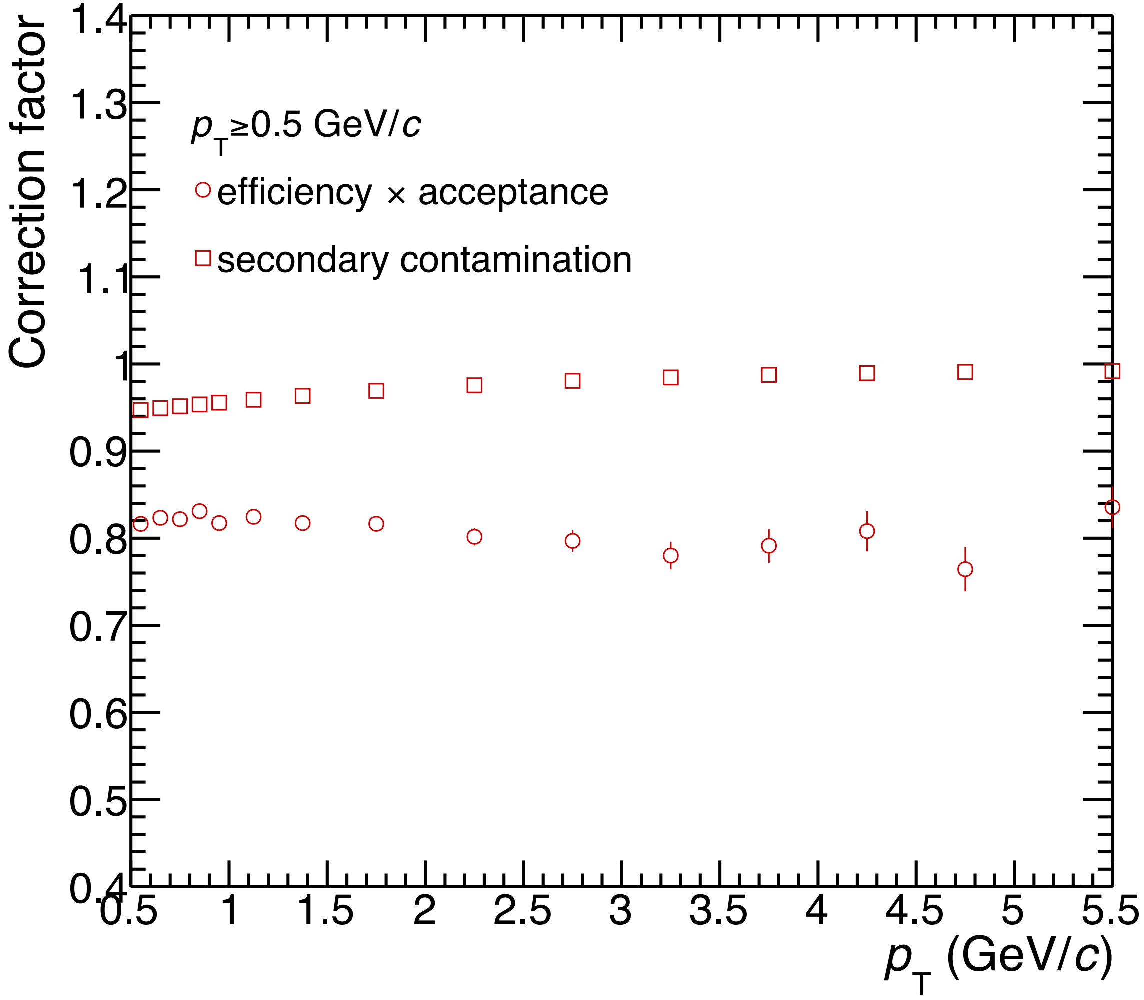
$$max(p_{\mathrm{T}}) = 0.0105 + 0.0350 p_{\mathrm{T}}^{-1.1}$$

After the DCA distribution was restricted it was obtained the contribution for secondary contamination from the sum of the contribution of weak decays and interaction with the detector material.

Correction factor

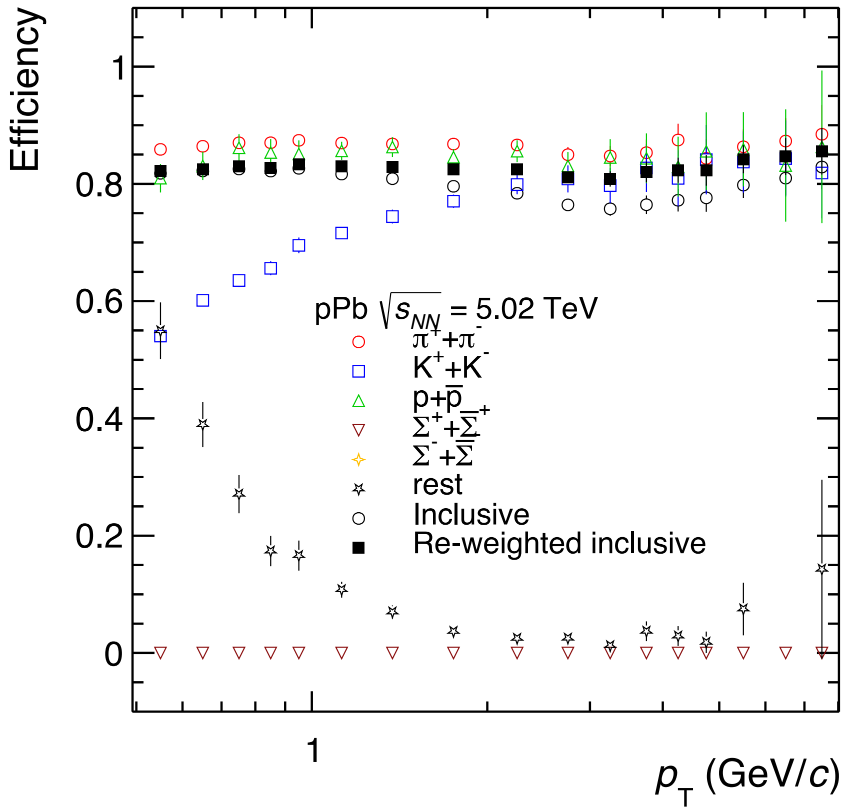


Corrections

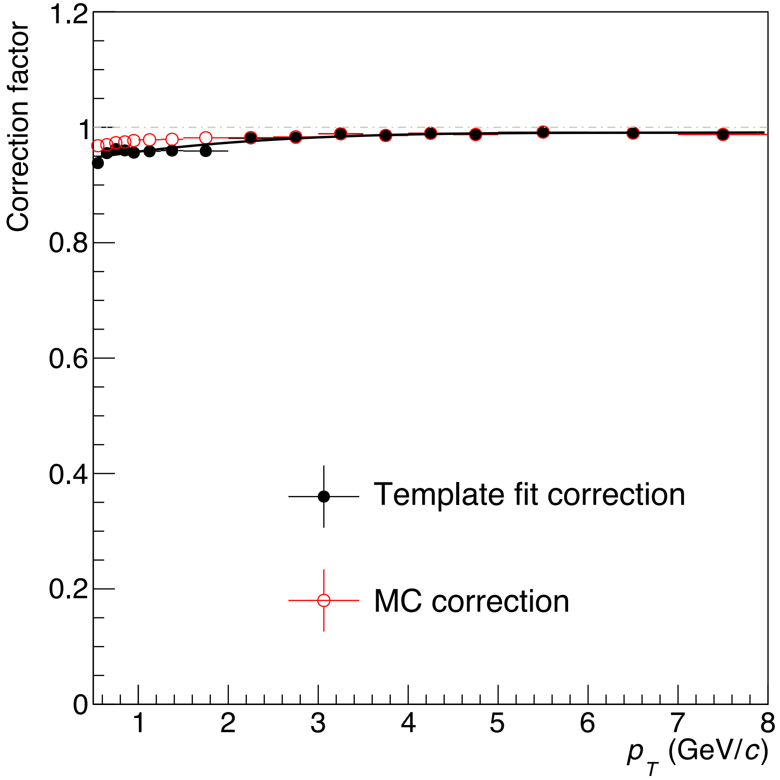


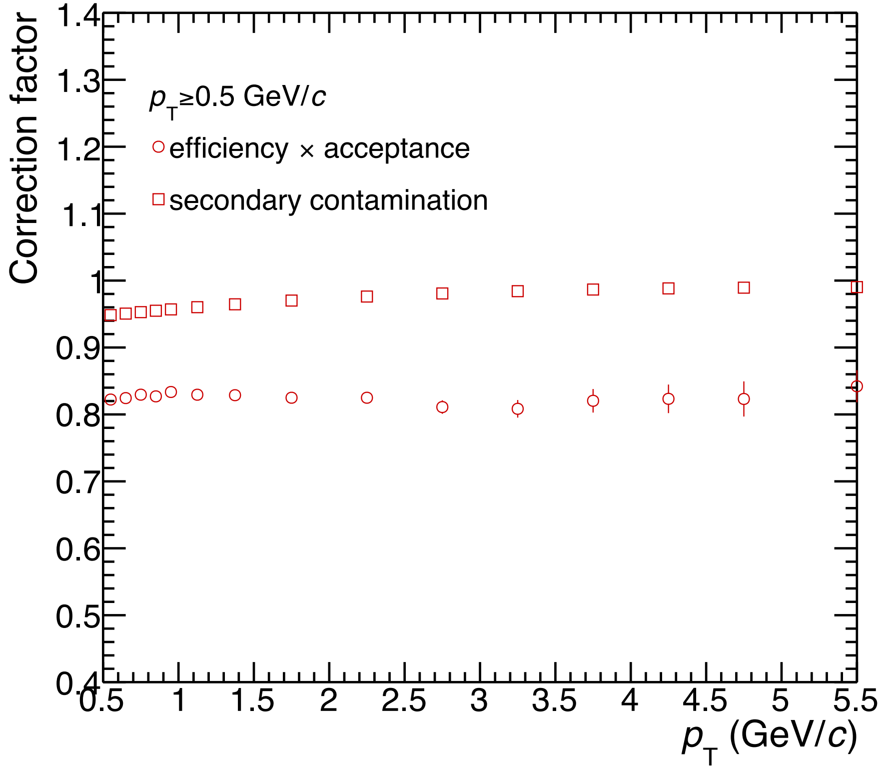
Corrections (pPb)

Efficiency: Data driven-tracking efficiency as well as the ones from MC



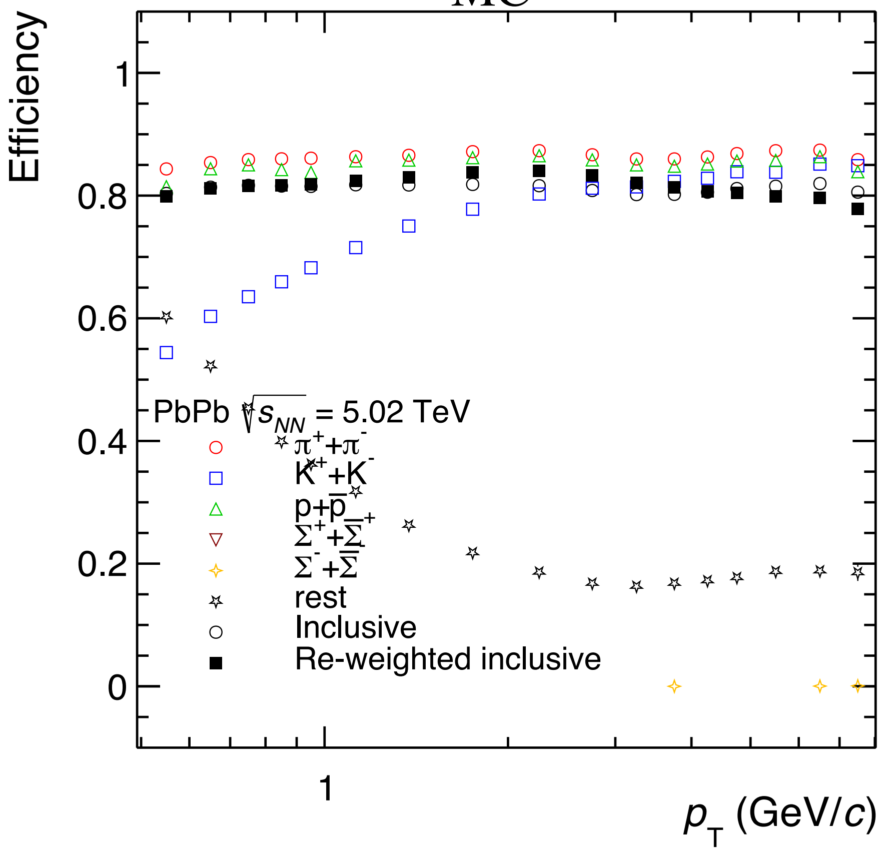
Correction factor: Secondary contamination from different sources such as weak decays and material interactions



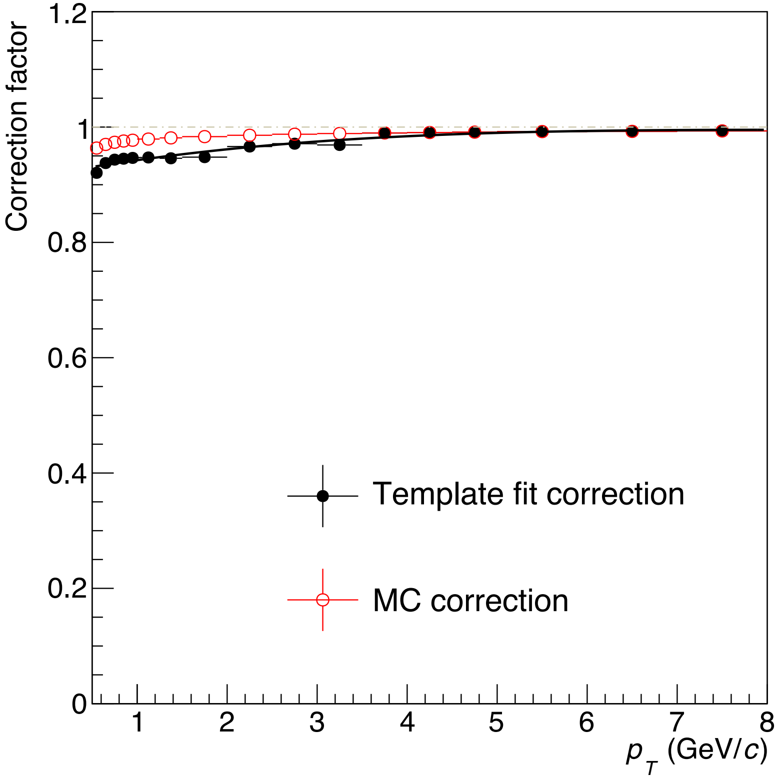


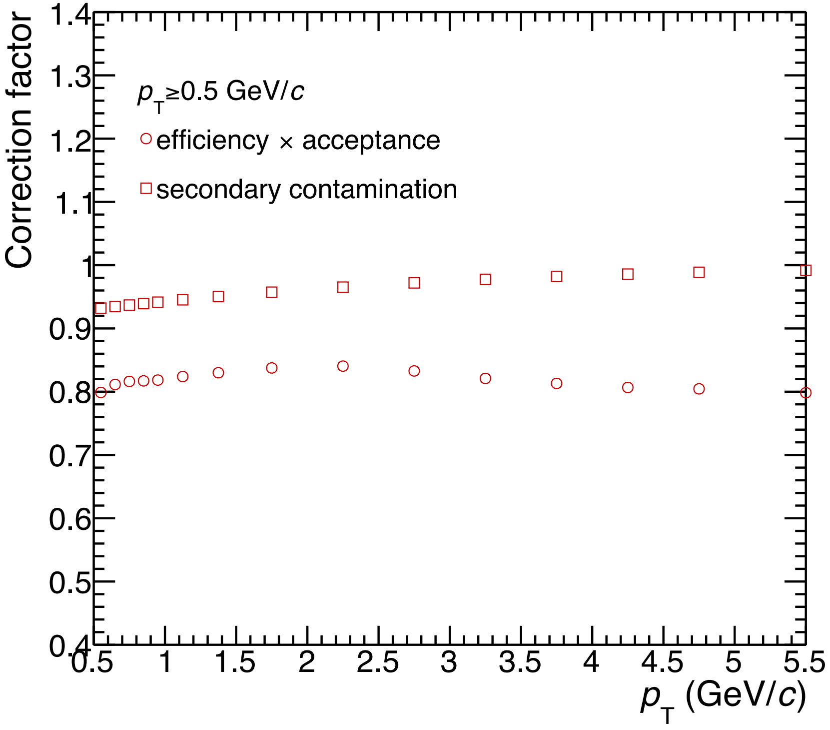
Corrections (PbPb)

Efficiency: Data driven-tracking efficiency as well as the ones from MC



Correction factor: Secondary contamination from different sources such weak decays and material interactions





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1D Unfolding of distributions $N_{\mathrm{ch}}^{\mathrm{TS}}$

Purpose: To obtain a better estimate of the true distribution of the multiplicity of charged particles from the development of experimental distributions.

$N_{\mathrm{ch,true}}^{\mathrm{TS}}$: True multiplicity in the Transverse region.
$N_{\mathrm{acc}}^{\mathrm{TS}}$: Multiplicity distribution of measured events in the Transverse region.
$P(N_{\mathrm{acc}}^{\mathrm{TS}} \,|\, N_{\mathrm{ch,true}}^{\mathrm{TS}})$: Multiplicity response matrix.

$$P(N_{\mathrm{ch,true}}^{\mathrm{TS}} \,|\, N_{\mathrm{acc}}^{\mathrm{TS}}) = \frac{P(N_{\mathrm{acc}}^{\mathrm{TS}} \,|\, N_{\mathrm{ch,true}}^{\mathrm{TS}}) P(N_{\mathrm{ch,true}}^{\mathrm{TS}})}{\sum_{N_{\mathrm{ch,true}}^{\mathrm{TS}\prime}} P(N_{\mathrm{acc}}^{\mathrm{TS}} \,|\, N_{\mathrm{ch,true}}^{\mathrm{TS}\prime}) P(N_{\mathrm{ch,true}}^{\mathrm{TS}\prime})}$$

$$P_0(N_{\mathrm{ch,true}}^{\mathrm{TS}})$$

Initial guess

$$P(N_{\mathrm{ch,true}}^{\mathrm{TS}} \,|\, N_{\mathrm{acc}}^{\mathrm{TS}}) = \frac{P(N_{\mathrm{acc}}^{\mathrm{TS}} \,|\, N_{\mathrm{ch,true}}^{\mathrm{TS}}) P(N_{\mathrm{ch,true}}^{\mathrm{TS}})}{P(N_{\mathrm{acc}}^{\mathrm{TS}})}$$

Bayes' Theorem

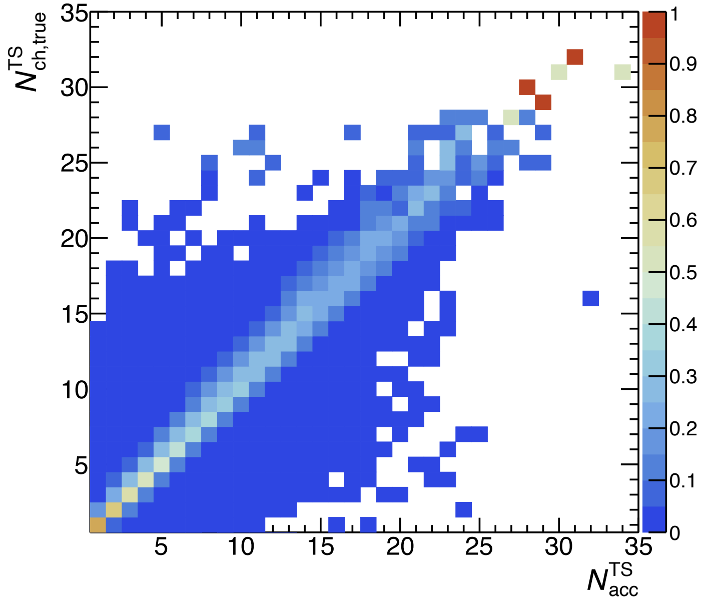
While$(\chi_i^2 < 1)$

$$\hat{P}(N_{\mathrm{ch,true}}^{\mathrm{TS}}) = \frac{\hat{n}_{\mathrm{evt}}(N_{\mathrm{ch,true}}^{\mathrm{TS}})}{\sum_{N_{\mathrm{ch,true}}^{\mathrm{TS}\prime}} \hat{n}_{\mathrm{evt}}(N_{\mathrm{ch,true}}^{\mathrm{TS}\prime})}$$

$$\hat{n}_{\mathrm{evt}}(N_{\mathrm{ch,true}}^{\mathrm{TS}}) = \frac{1}{\varepsilon(N_{\mathrm{ch,true}}^{\mathrm{TS}})} \sum_{N_{\mathrm{acc}}^{\mathrm{TS}}} P(N_{\mathrm{ch,true}}^{\mathrm{TS}} \,|\, N_{\mathrm{acc}}^{\mathrm{TS}})\, n_{\mathrm{evt}}(N_{\mathrm{acc}}^{\mathrm{TS}})$$

Unfolded multiplicity distribution

Measured multiplicity distribution



Smearing matrix $P(N_{\mathrm{ch,true}}^{\mathrm{TS}} \,|\, N_{\mathrm{acc}}^{\mathrm{TS}})$

2D Unfolding of p_{T} spectra

First: NS, AS

(Smearing matrix $P(N^{\mathrm{TS}}_{\mathrm{ch,true}} \,|\, N^{\mathrm{TS}}_{\mathrm{acc}})$)

TS

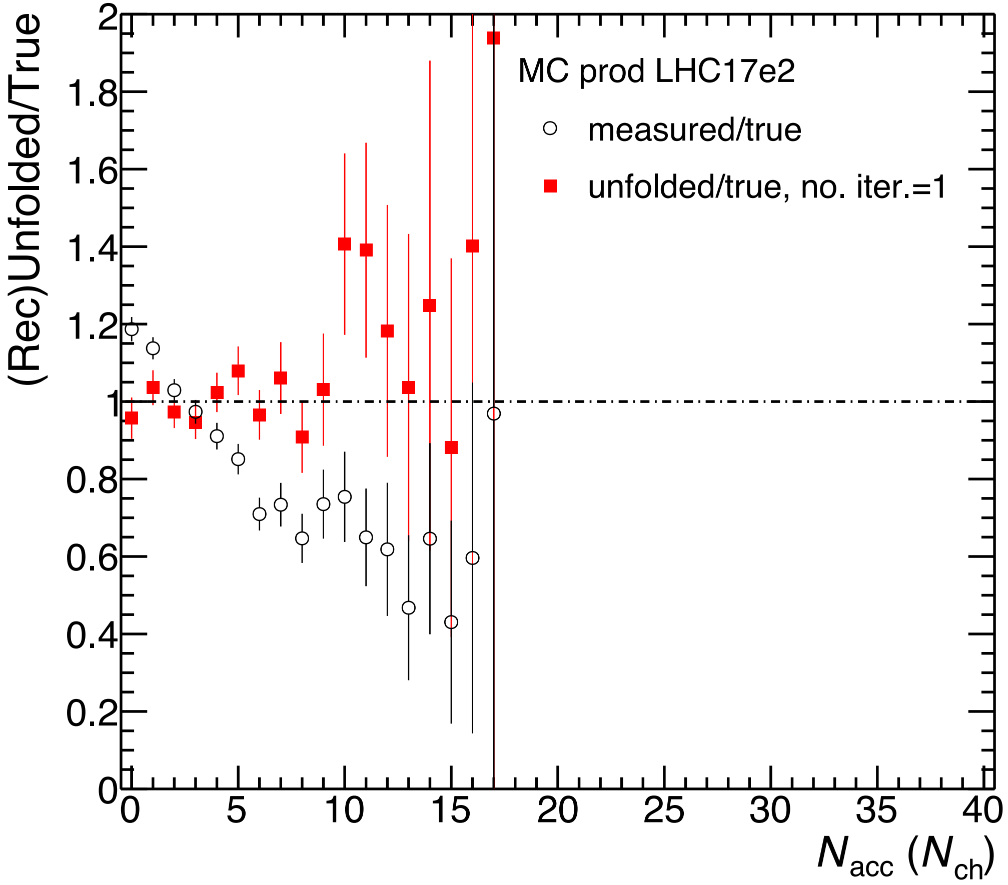
(Multiplicity response matrix, $P(N^{\mathrm{TS}}_{\mathrm{acc}} \,|\, N^{\mathrm{TS}}_{\mathrm{ch,true}})$)

× (Weight of the number of measured particles)

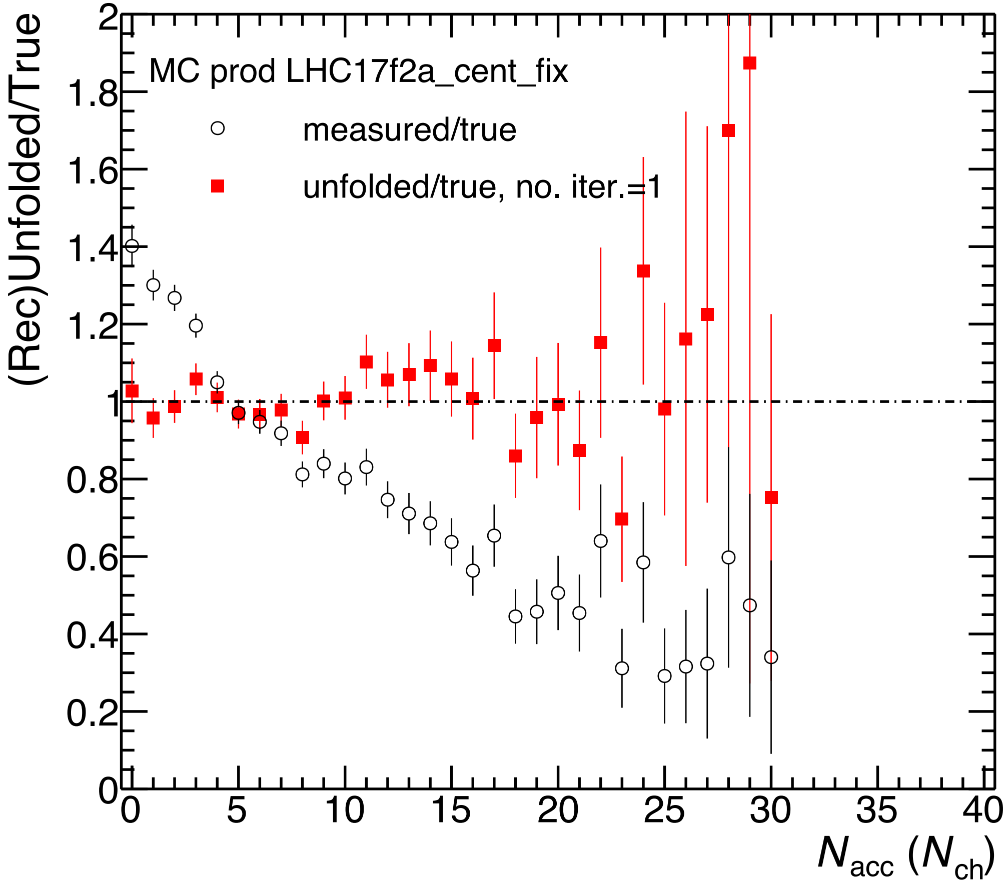
Second: Apply the tracking efficiency and secondary particle contamination

MC Closure test

Updated results (pp)

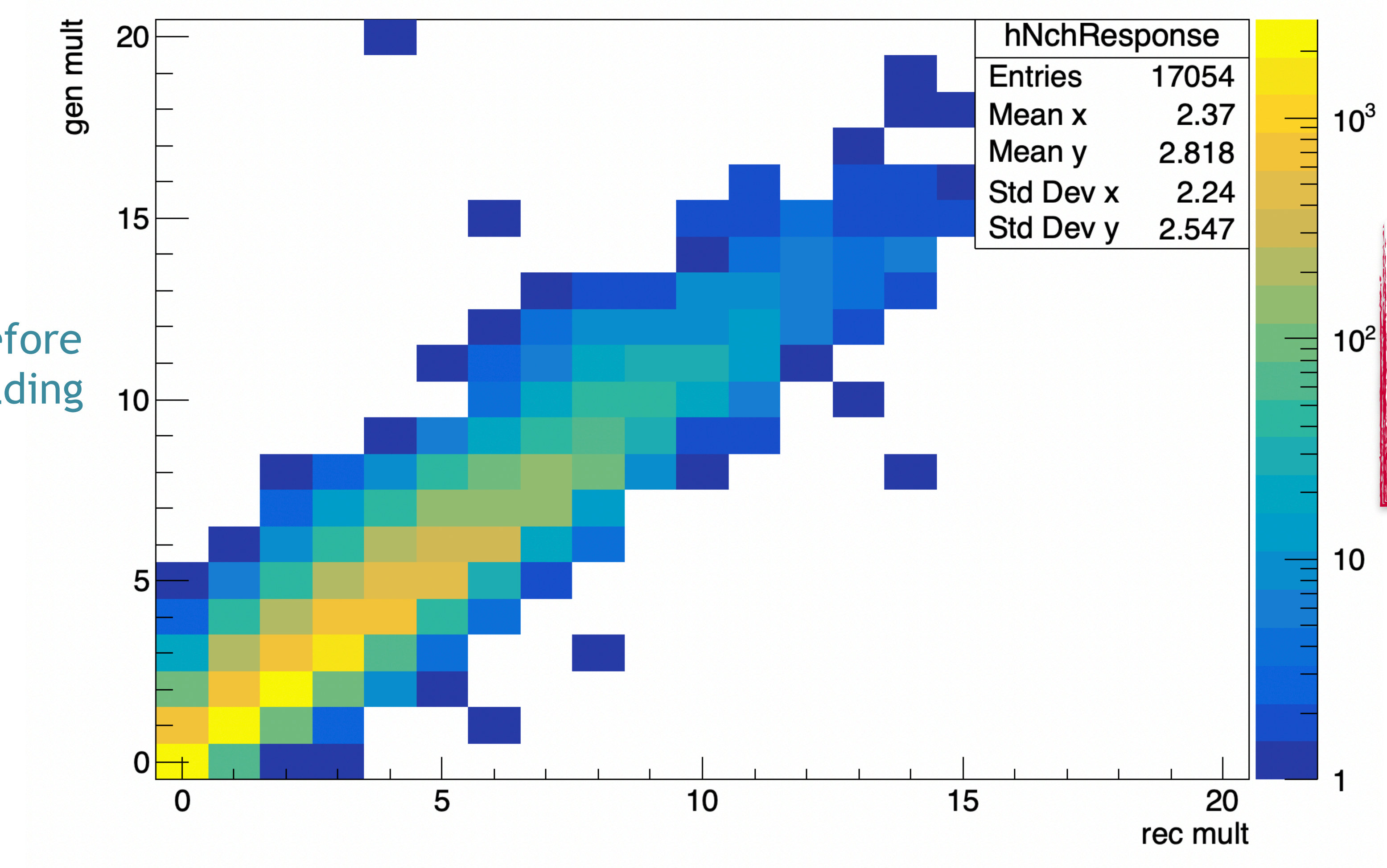


Updated results (pPb)



Response matrix

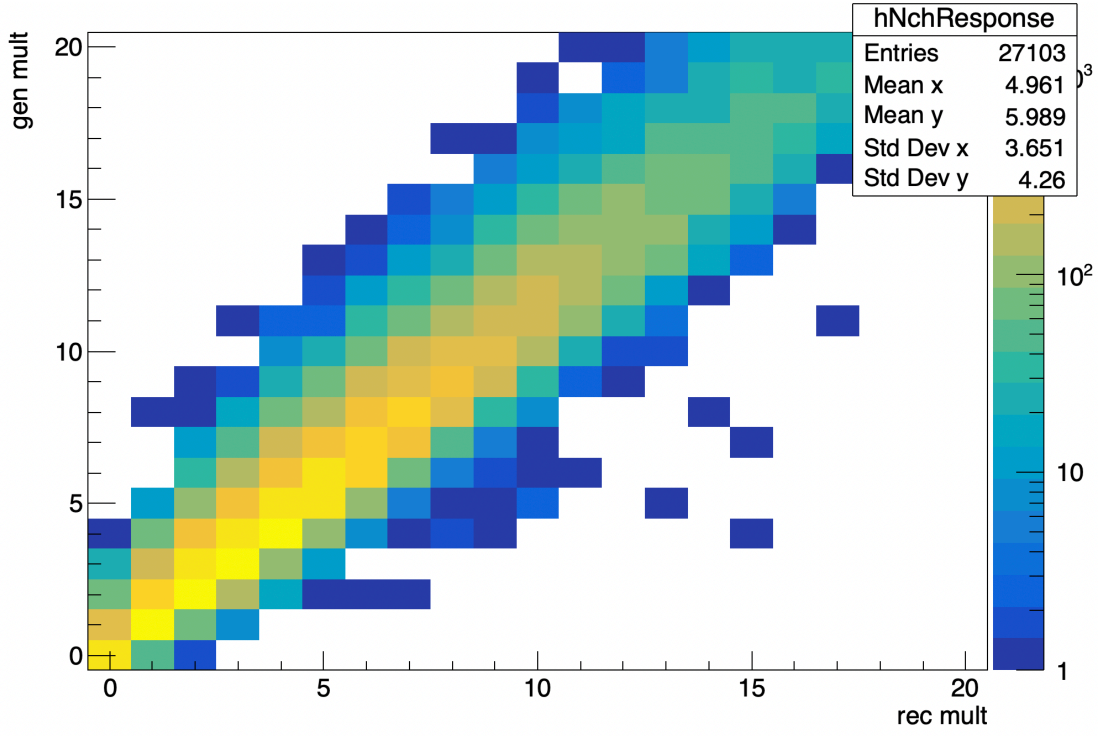
Obtained before the 1D unfolding (pp)



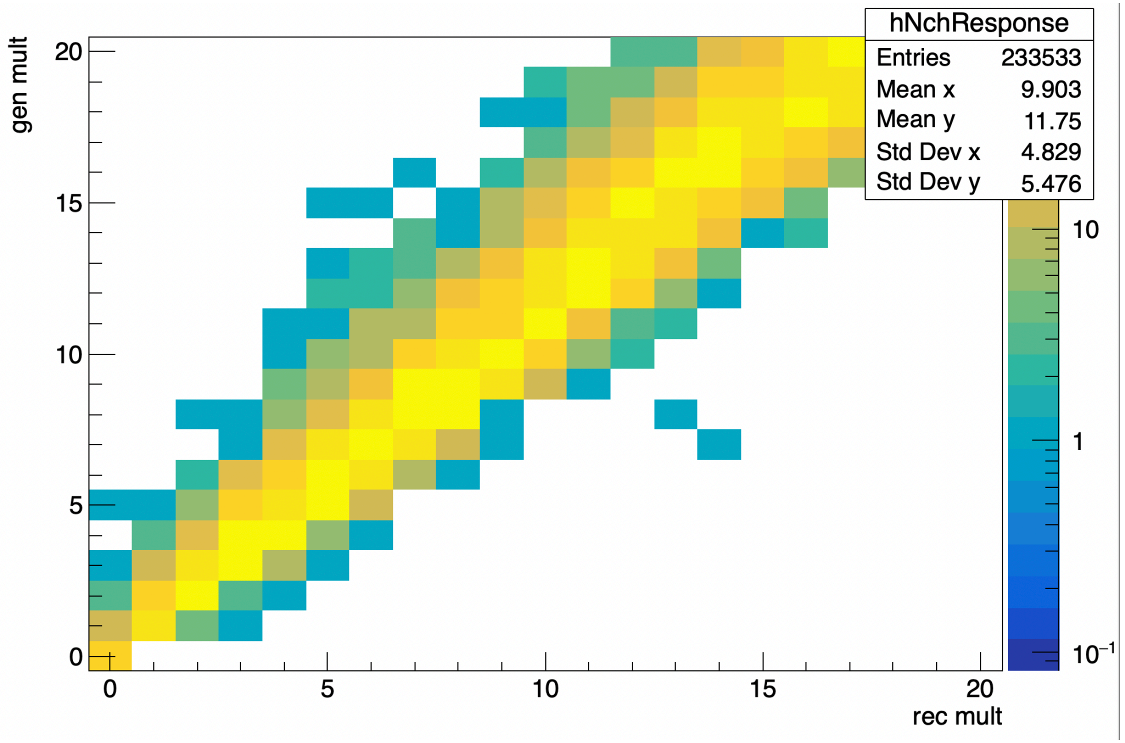
The main problem was that we were observing more particles generated than reconstructed.

Response matrix

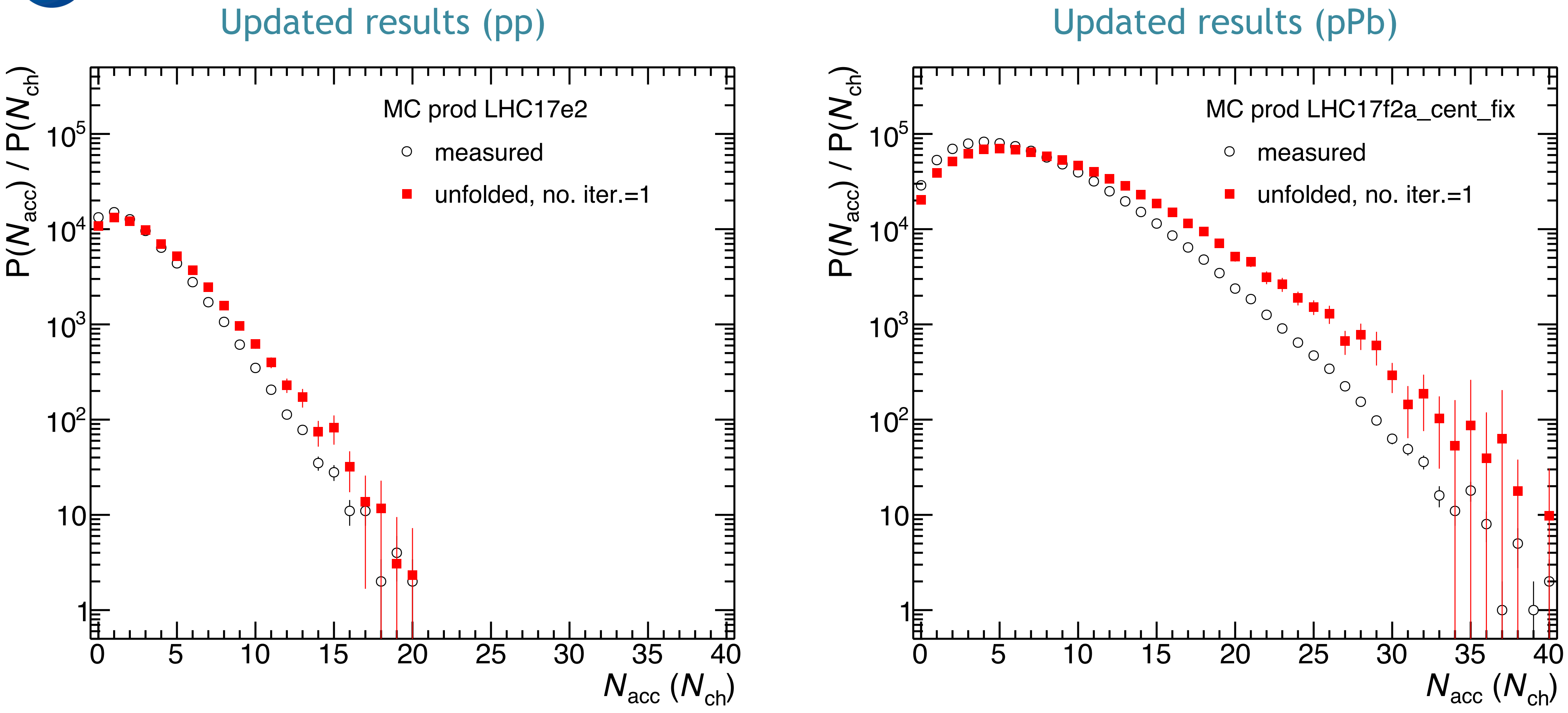
Obtained before the 1D unfolding (pPb)



Obtained before the 1D unfolding (PbPb)

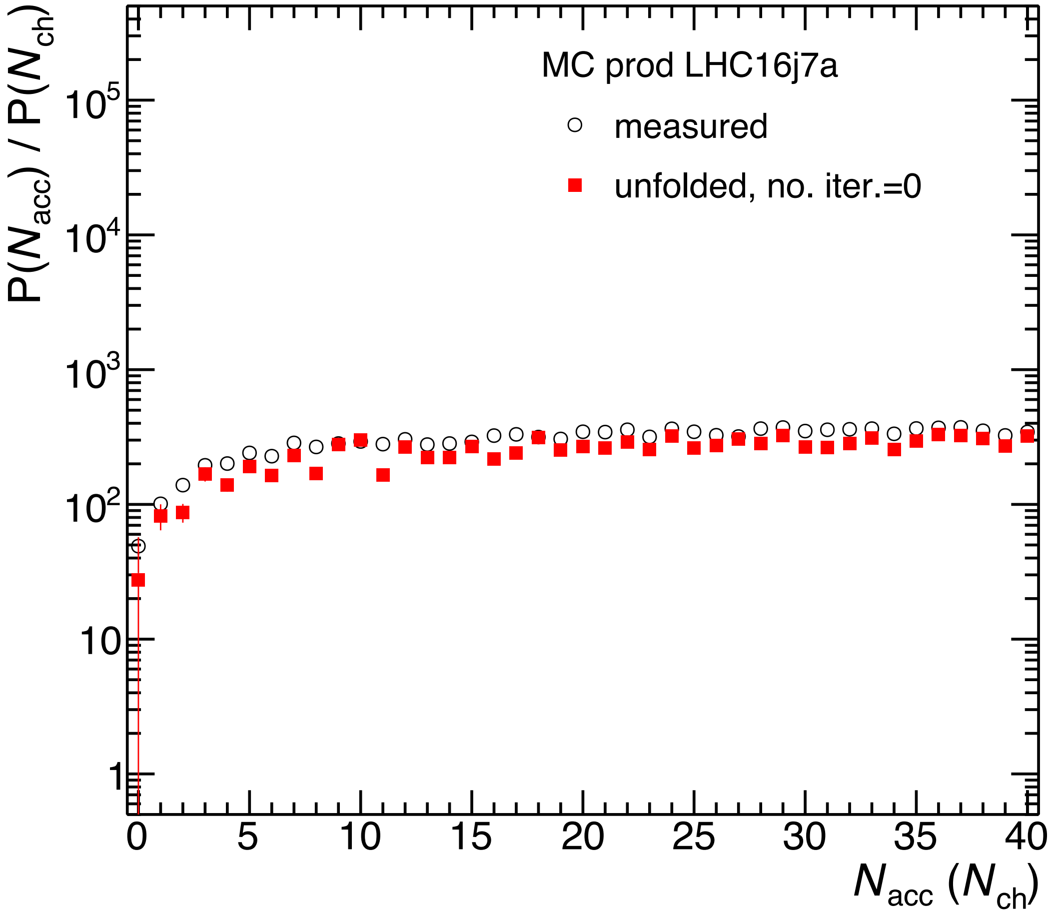


1D Distribution



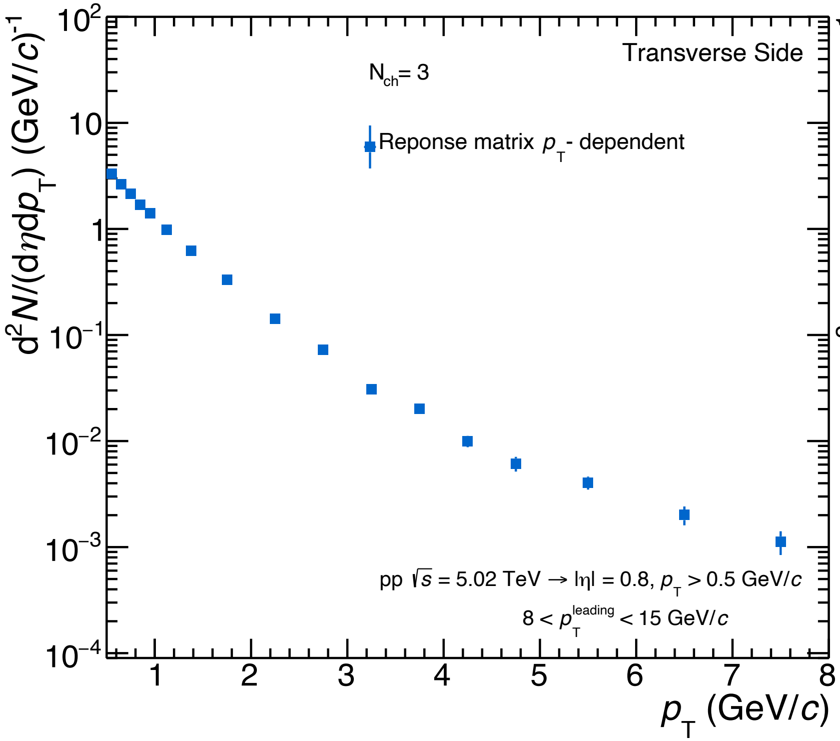
1D Distribution

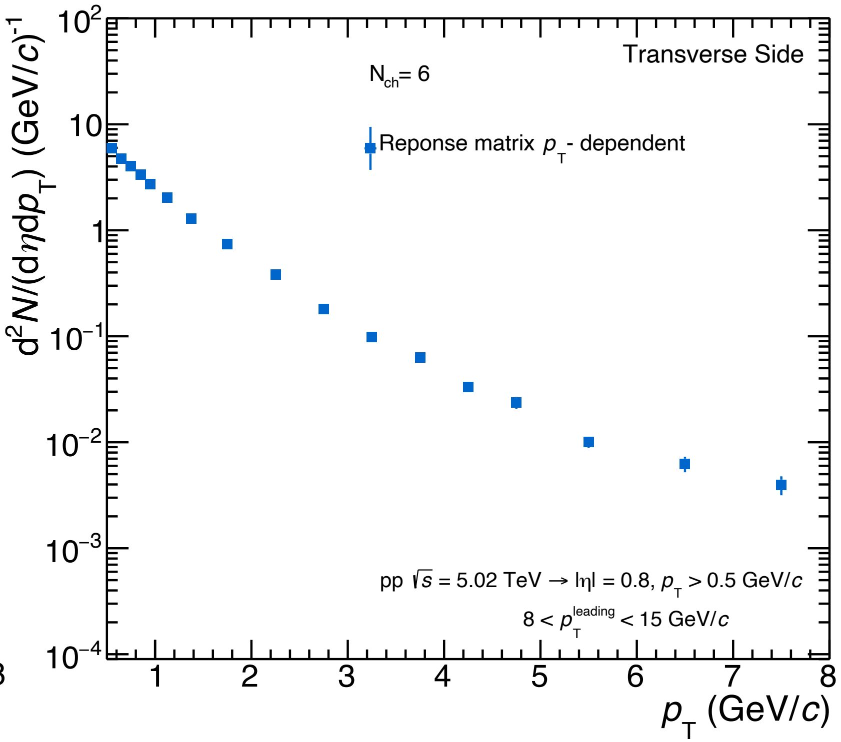
Updated results (PbPb)

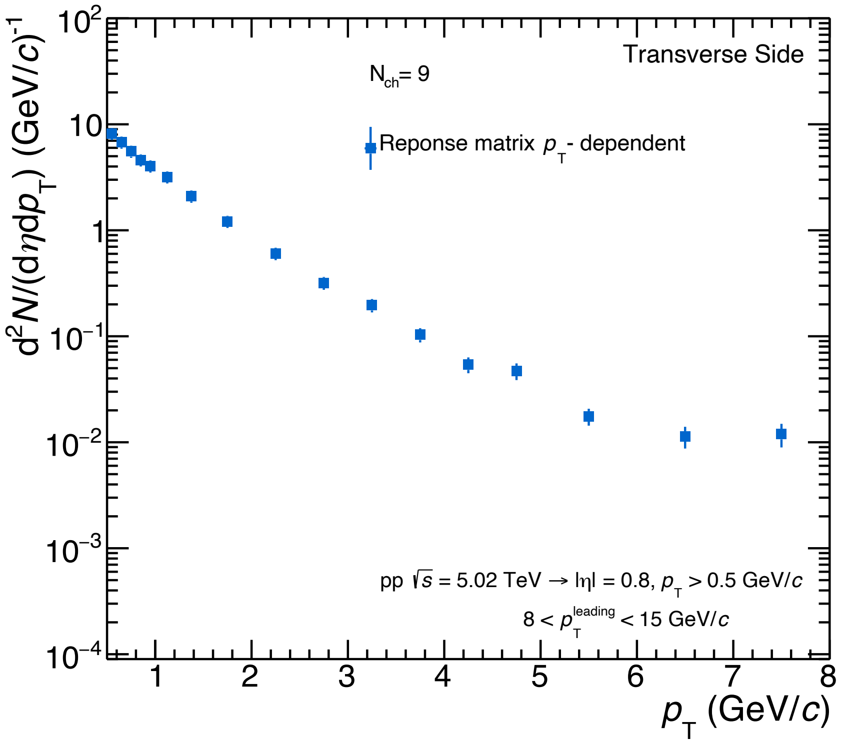


Invariant Yield (pp)

Obtained by the 1D and 2D unfolding

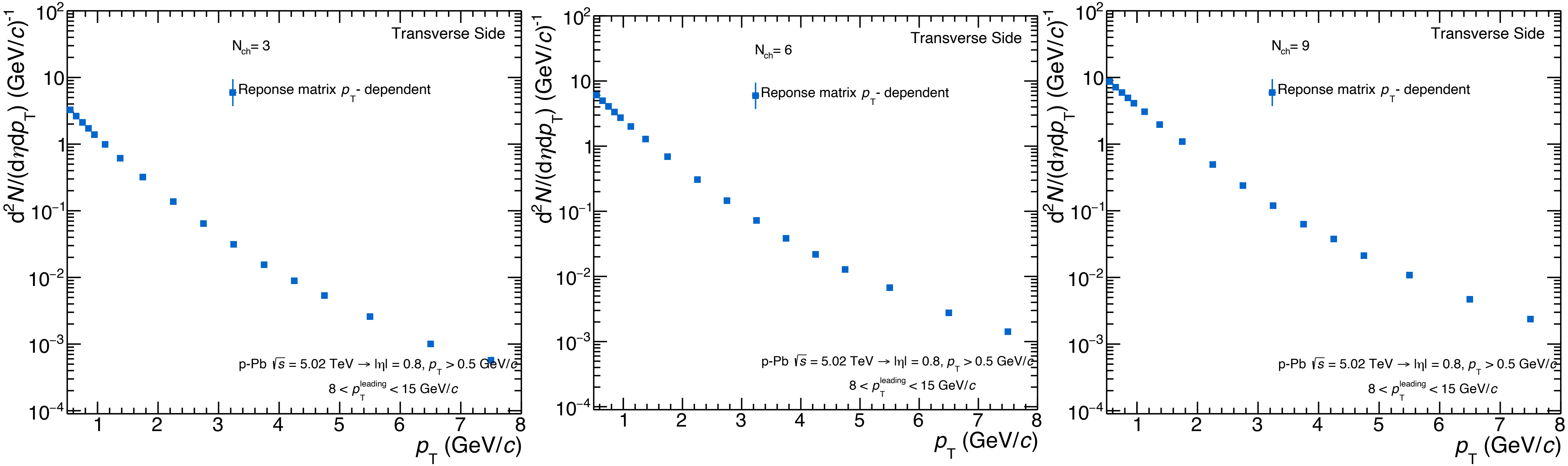






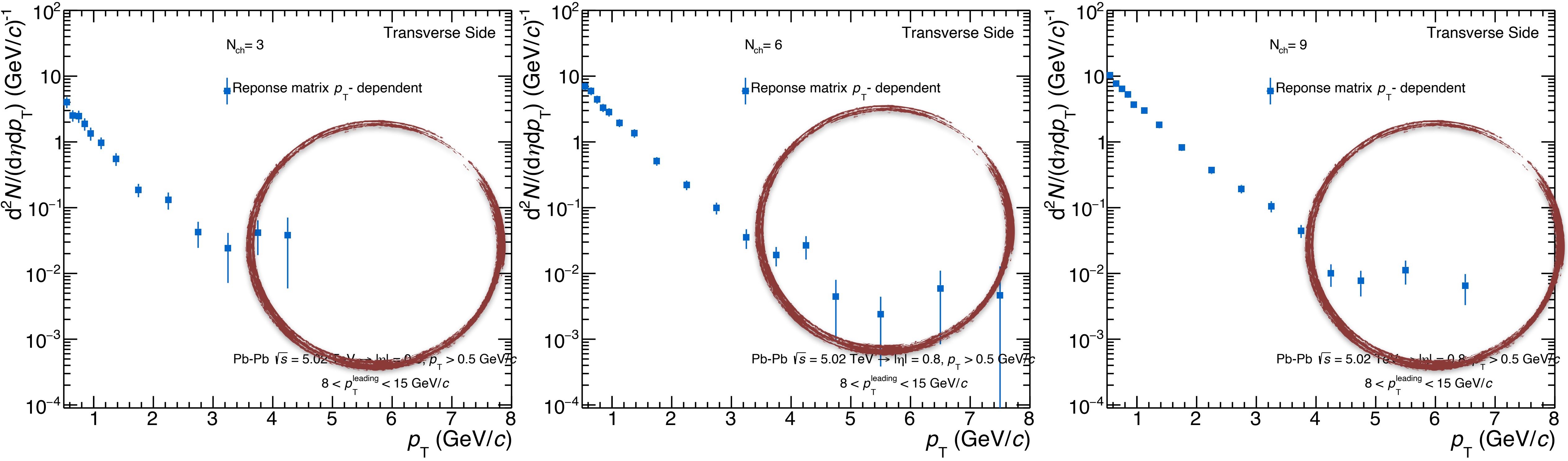
Invariant Yield (pPb)

Obtained by the 1D and 2D unfolding



Invariant Yield (PbPb)

Obtained by the 1D and 2D unfolding

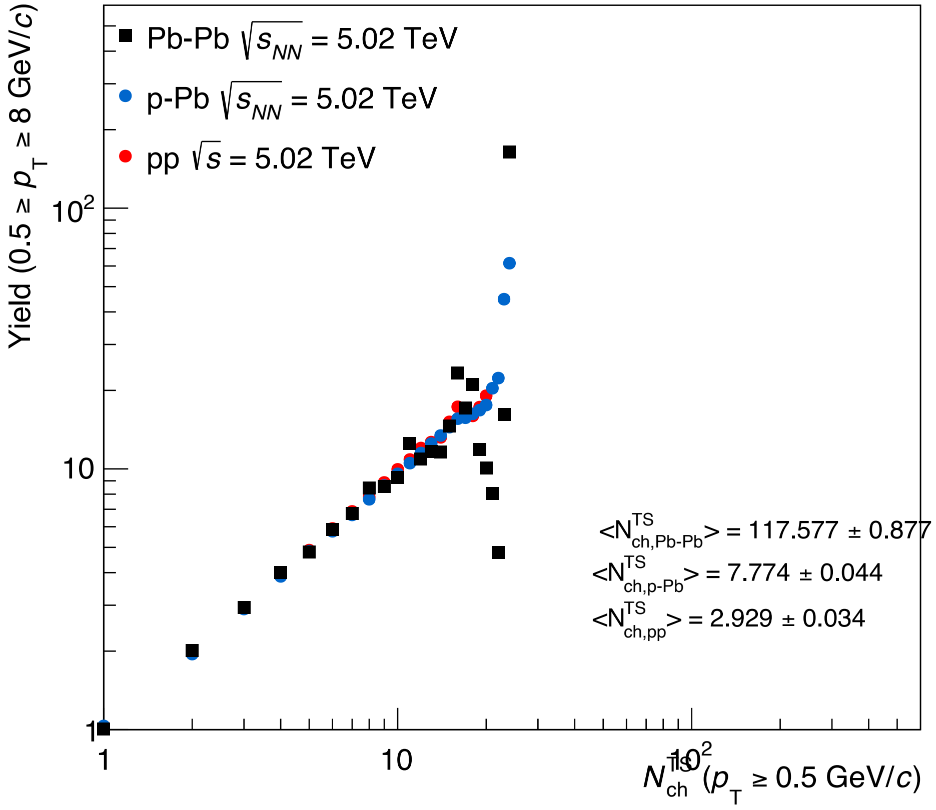


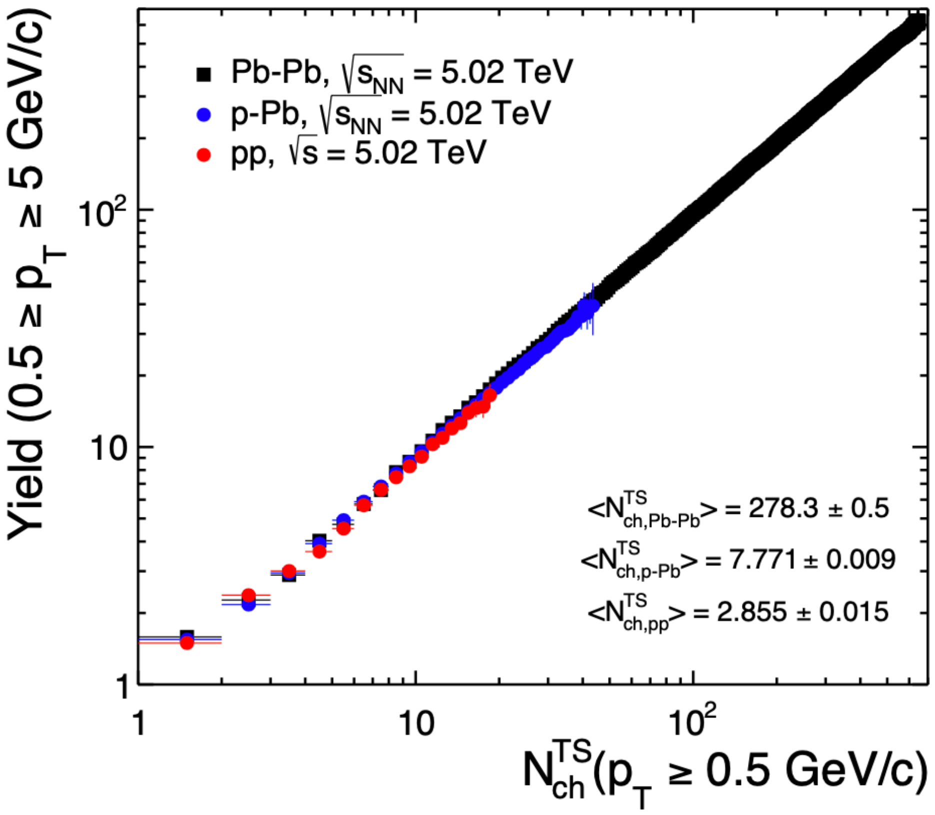
Fully corrected integrated yield

Analysis note

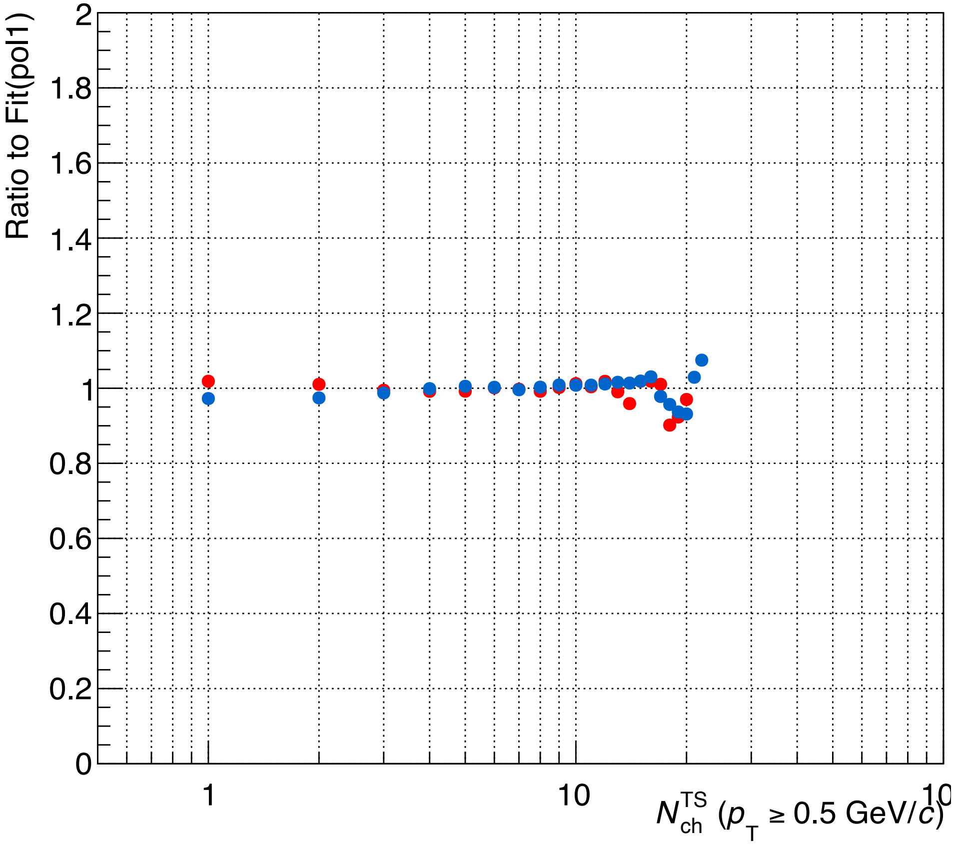
Fully corrected integrated yield as a function of N_{ch}^{TS} for pp collision system in the transverse side.

$$\int \frac{d^2N}{d\eta dp_T} d\eta dp_T = N_{ch}^{TS}$$

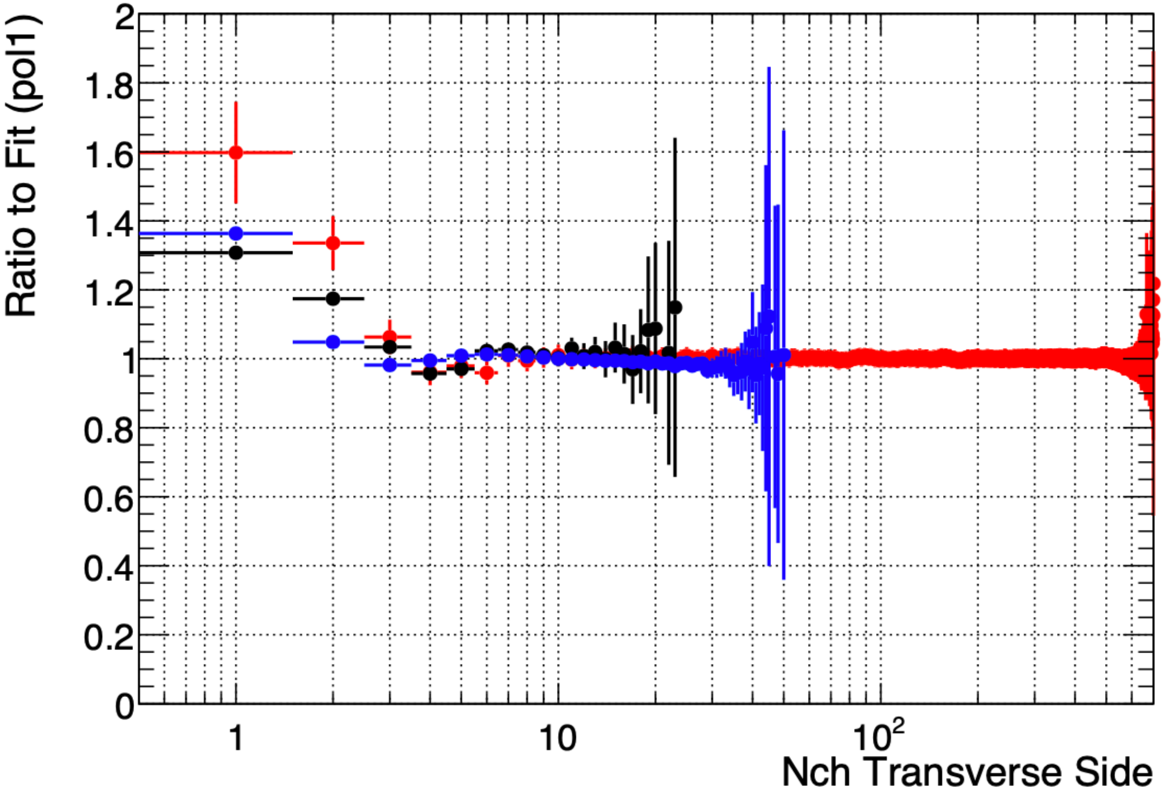




Deviation from the linear trend of integrated yield as a function of N^{TS}



Analysis note



Next step

- To obtain the fully corrected integrated yield as a function of $N_{\rm ch}^{\rm TS}$ to p-Pb and Pb-Pb collision systems.
- To obtain $p_{\rm T}$ spectra for different topological regions for different $R_{\rm T}$-bins in pp, p-Pb and Pb-Pb collisions.

Thank you