Isolated γ - hadron correlations in Pb-Pb at $\sqrt{s_{NN}} = 5.02$ TeV - Updates

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ALICE Group Meeting 09/12/2022

Datasets and analysis cuts

Datasets:

- LHC15o pass2, LHC18q+r pass3
- Trigger: Sum of MB+EMCAL
- ***MC***: pp @5.02 TeV PYTHIA embedded in Pb-Pb MB; γ***-jet events*** (LHC20g3d_GJ_anchLHC15o, LHC20g3a_GJ_anchLHC18qr)

Centralities:

- 0-10 %, 10-30 %, 30-50 %, 50-90 %

$z_{\mathrm{T}} = p_{\mathrm{T}}^{hadr} / p_{\mathrm{T}}^{\gamma}$ *intervals*:

- { [0.05-0.1]; [0.1-0.15]; [0.15-0.2]; [0.2-0.4]; [0.4-0.6]; [0.6-0.8]; [0.8-1.0]; [1.0-1.2] }

Purity estimation:

- ABCD method

Shower shape σ_{long}^2:

Only 5x5 cluster (V2 clusterizer)

- γ $0.10 < \sigma_{long}^2 < 0.30$
- Background: $0.40 < \sigma_{long}^2 < 2.00$

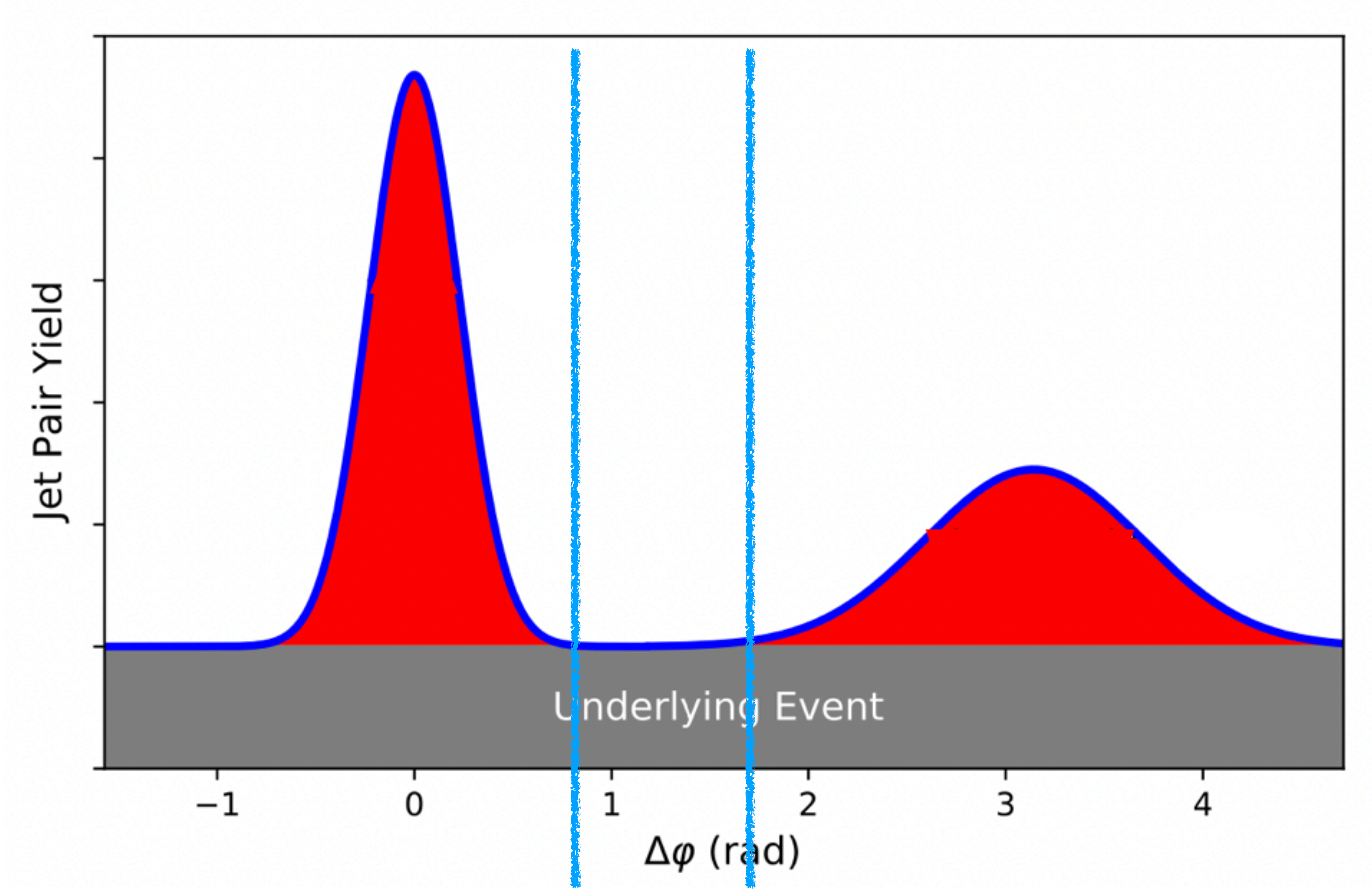
Isolation

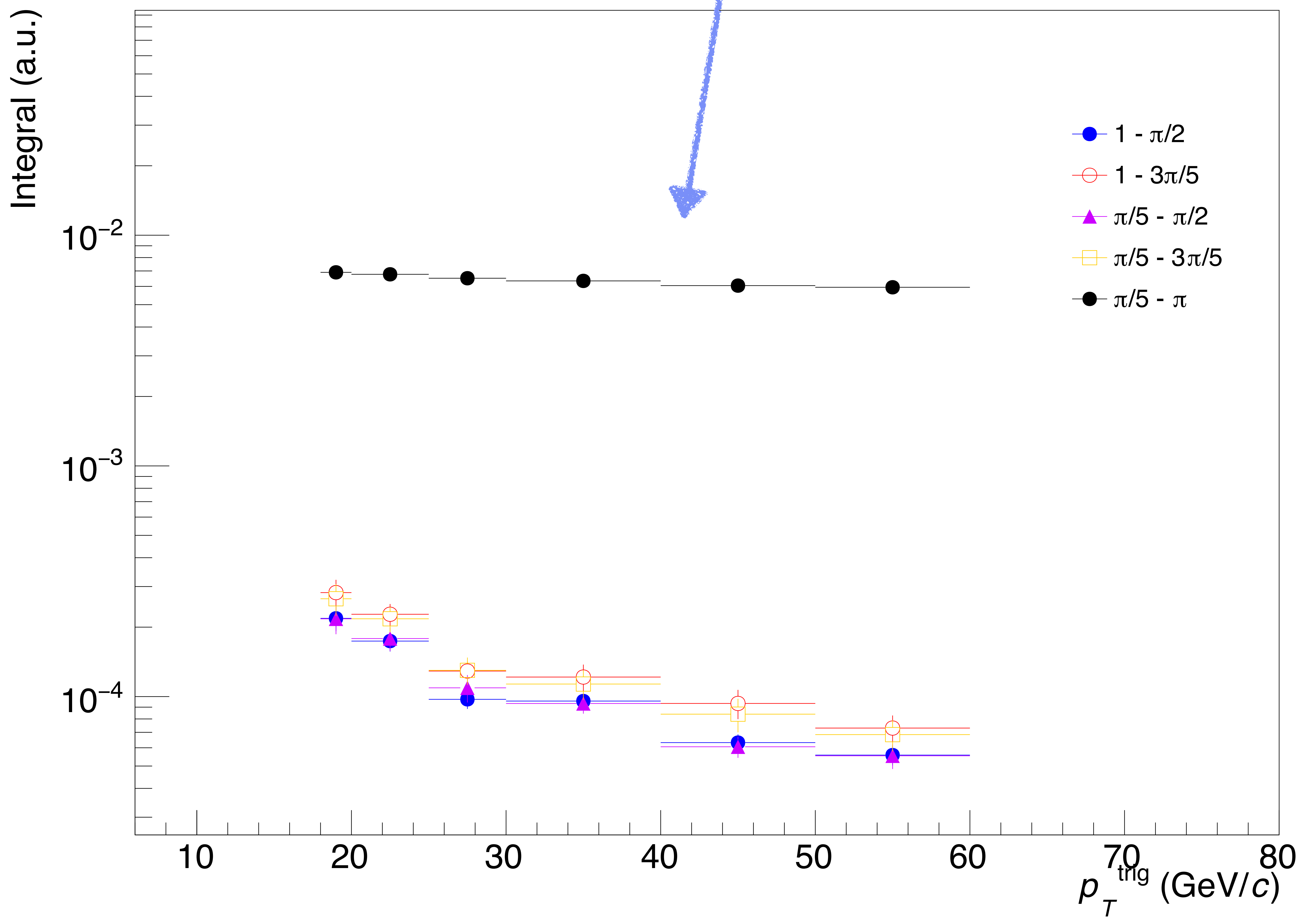
(after UE subtraction with η-band):

- $p_{\mathrm{T}}^{iso} < 2$ GeV$/c$
- $R_{cone} = 0.2$

Definition of ZYAM - Mixed region

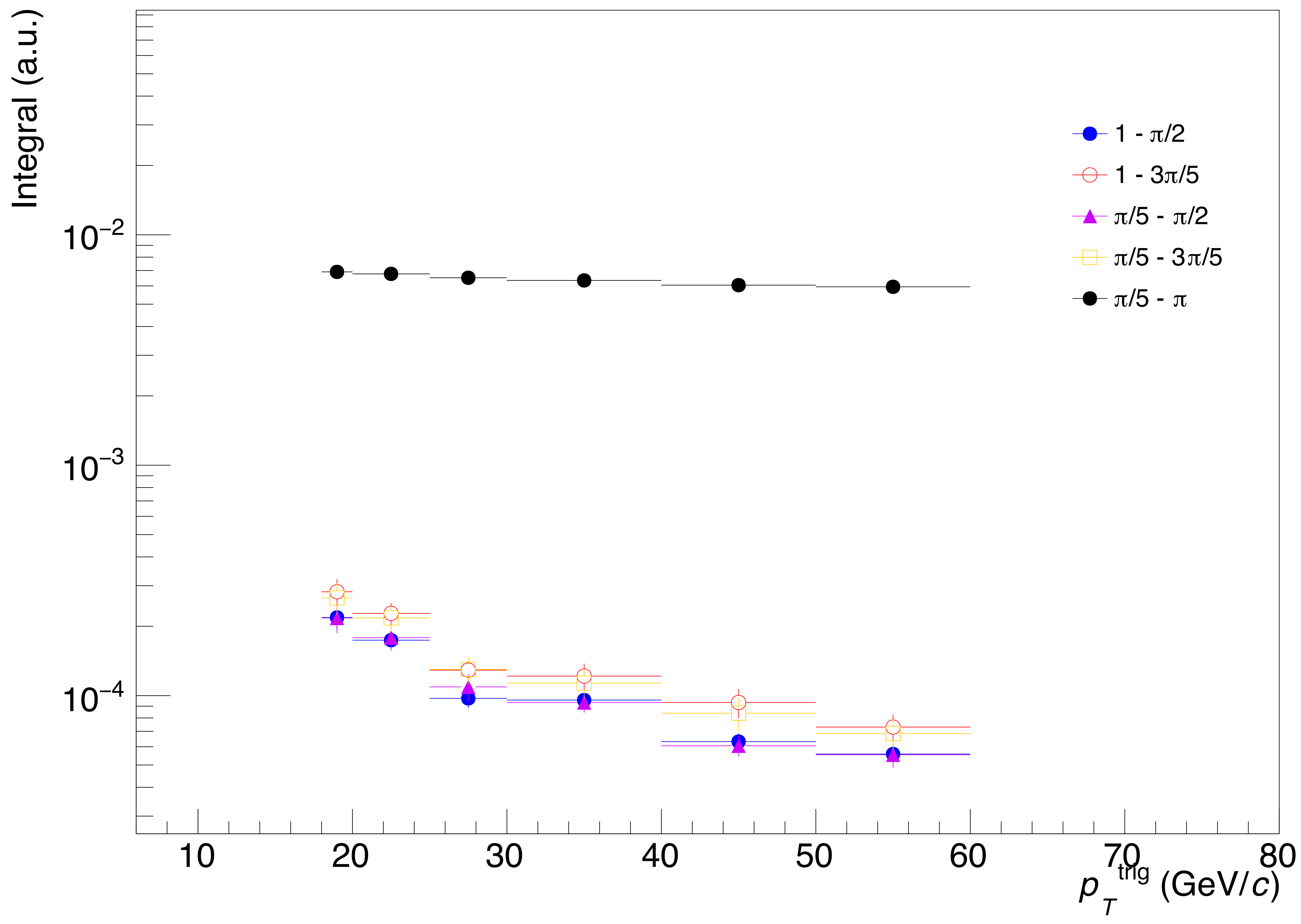
- Careful evaluation of UE region: to exclude away-side or near-side effects.
- Use pure γ*-jet* MC to see a residual of away-side peak (away-side effect)
- $\Delta\varphi$ regions = $\{[1\text{-}\pi/2];[1\text{-}3\pi/5];[\pi/5\text{-}\pi/2];[\pi/5\text{-}3\pi/5];[\pi/5\text{-}\pi]\}$

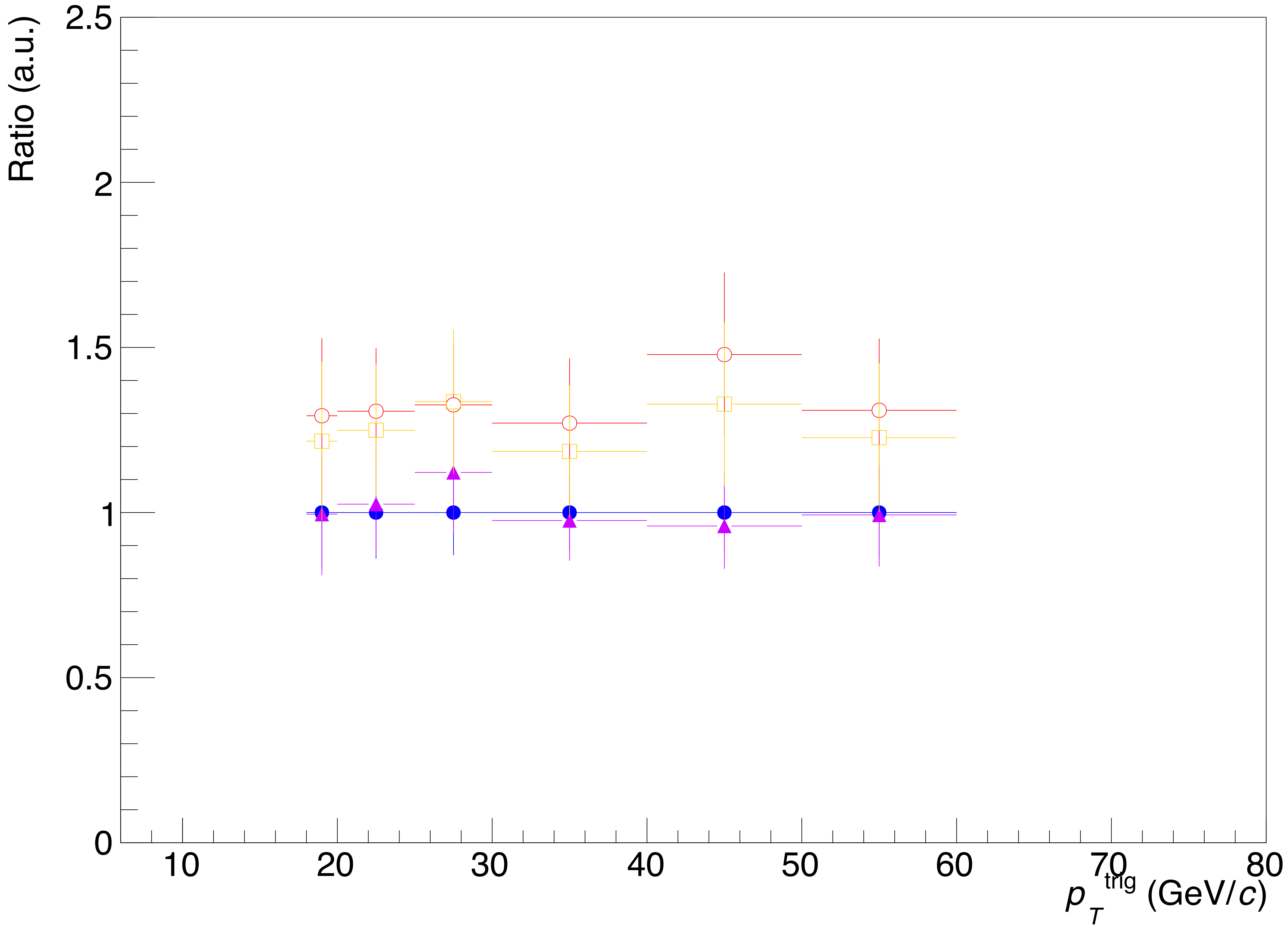




Definition of ZYAM - Mixed region

$\Delta\varphi$ regions = {[1-$\pi/2$];[1-$3\pi/5$];[$\pi/5$-$\pi/2$];[$\pi/5$-$3\pi/5$];[$\pi/5$-π]}





The ranges in red and yellow are still affected by the away-side: EXCLUDED!

The ranges in blue and violet are compatible

Range $\Delta\varphi$ = [1-$\pi/2$] is used.

Analysis flow

Subtraction of UE

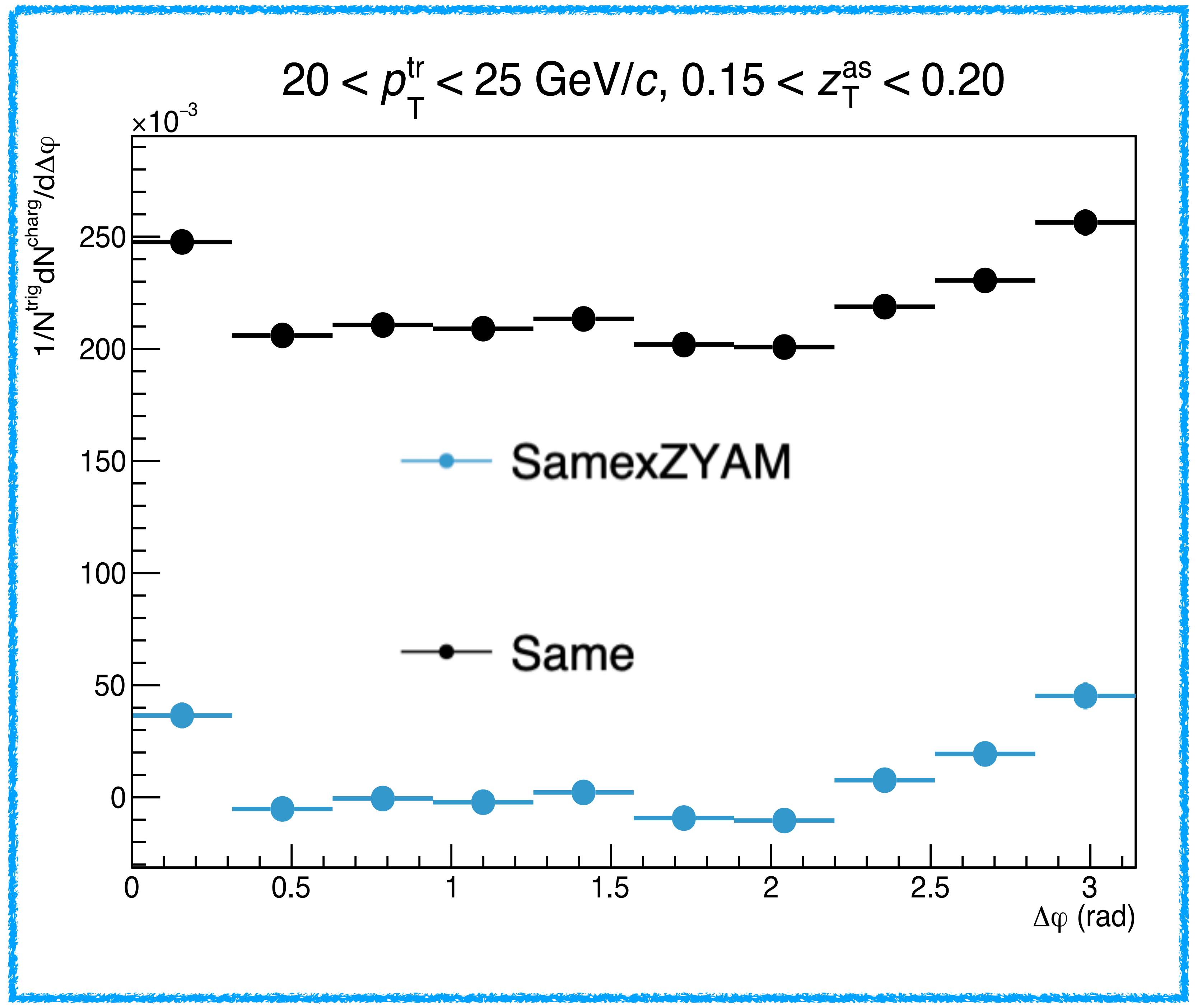
Purity Correction

Efficiency Correction

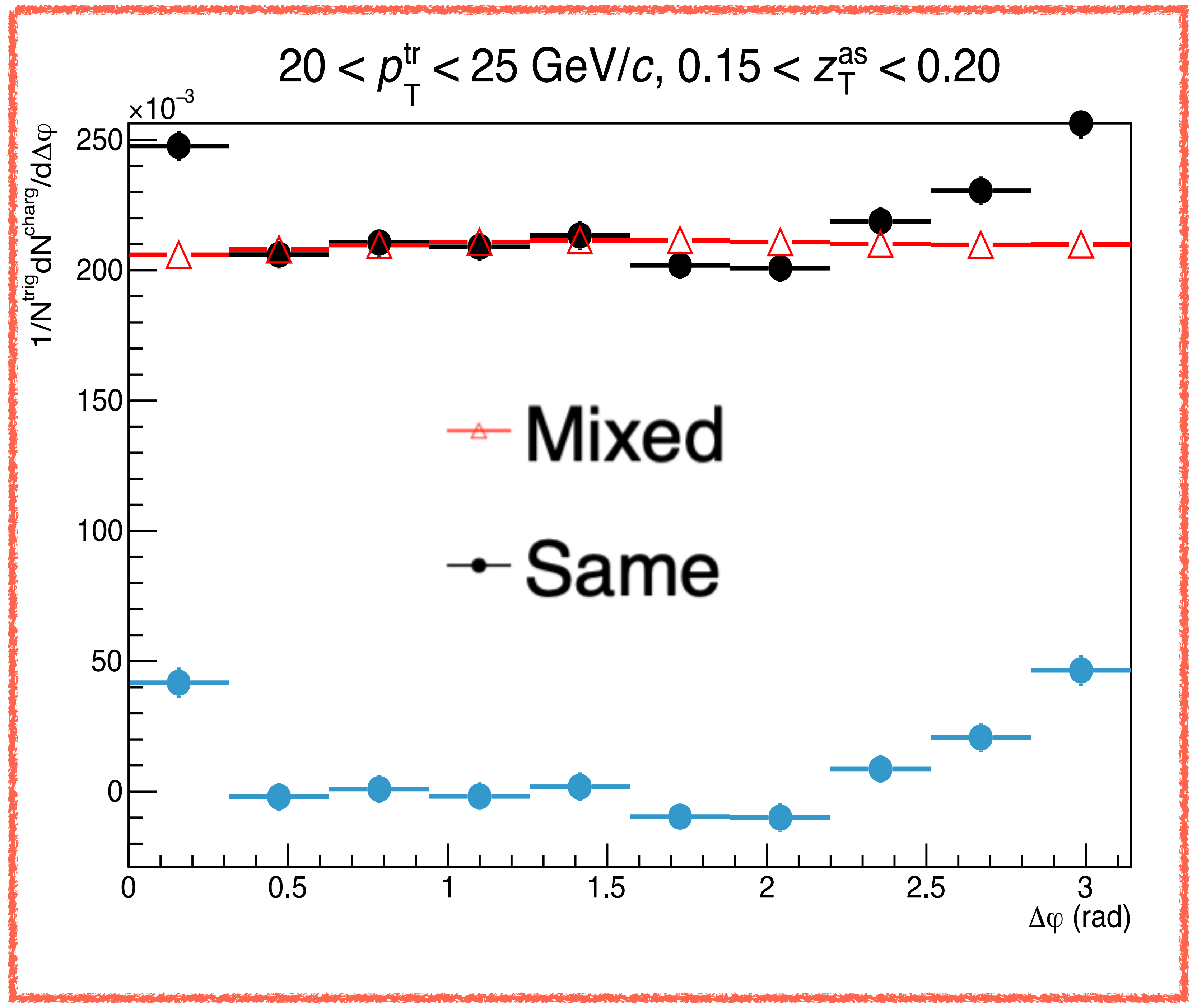
Systematic errors

UE subtraction, ZYAM or Mixed Event

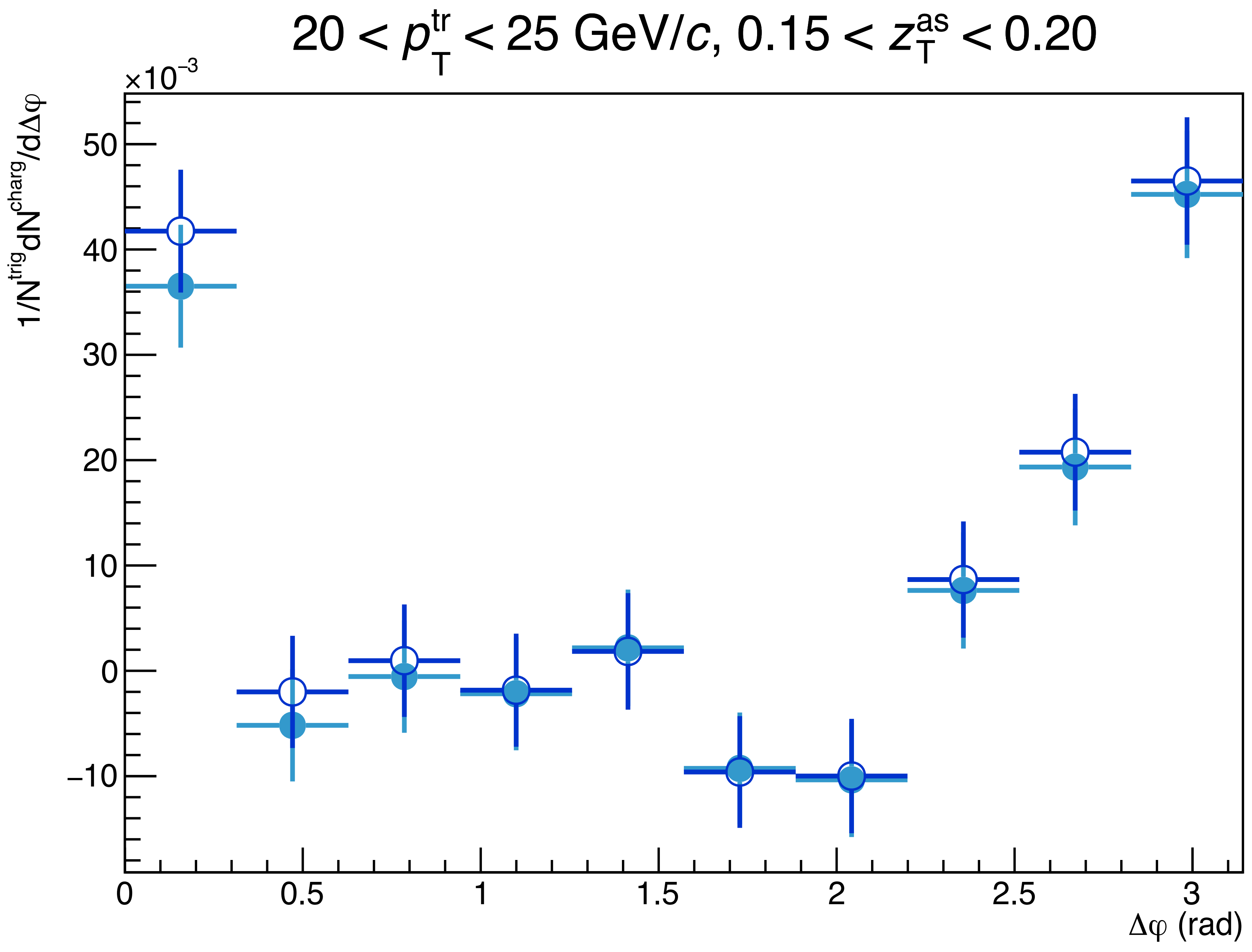
Cent: 30-50%, 20 < p_T^{tr} < 25 GeV/c, Isolation ON, 0.1 < σ^2_{long} < 0.3



ZYAM Method



Mixed Event Method (ME)



Compatibility of ME and ZYAM

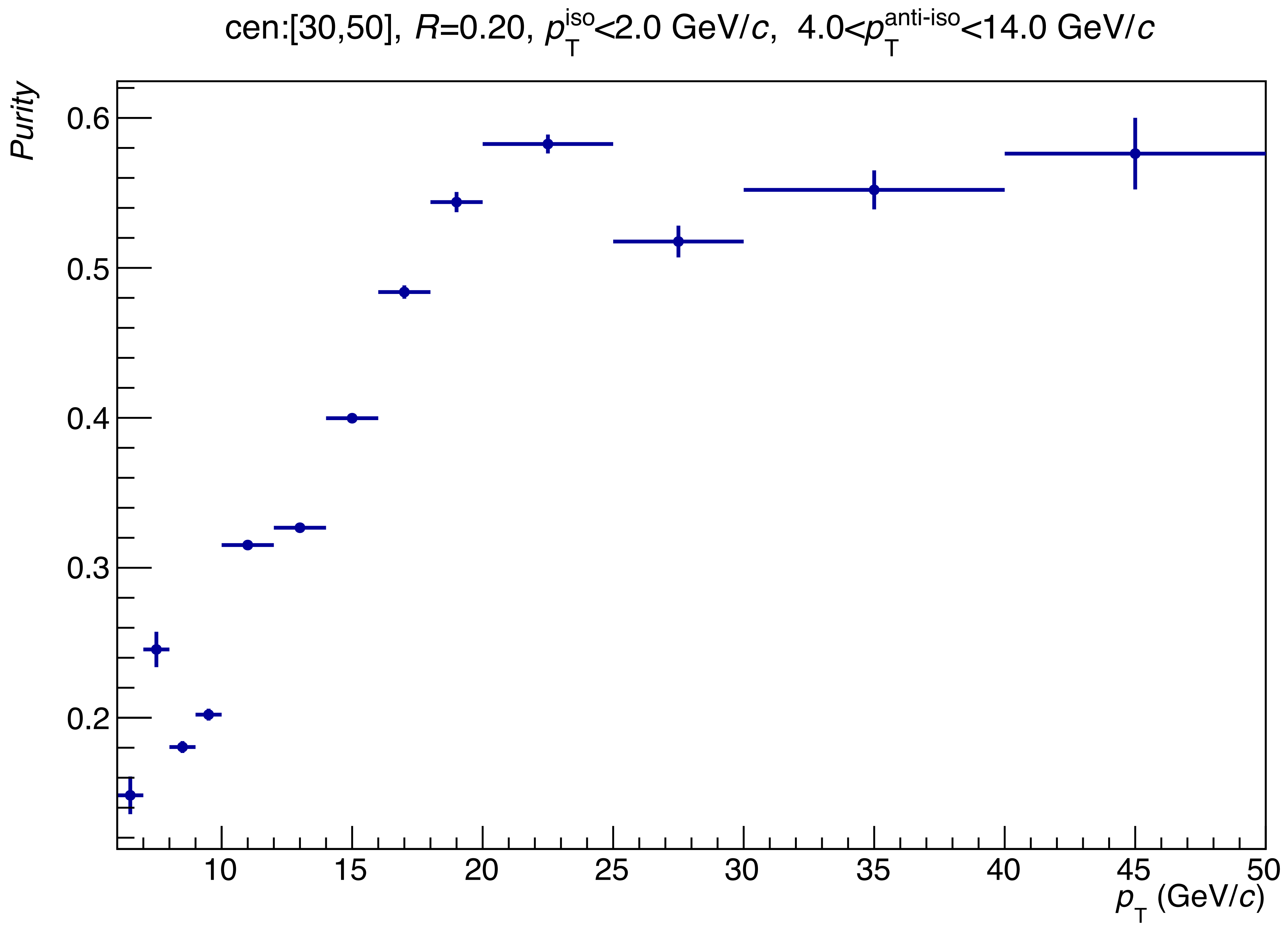
- Mixed event coincides with the uncorrelated of the Same → method works!
- The two methods are compatible!

Purity Correction

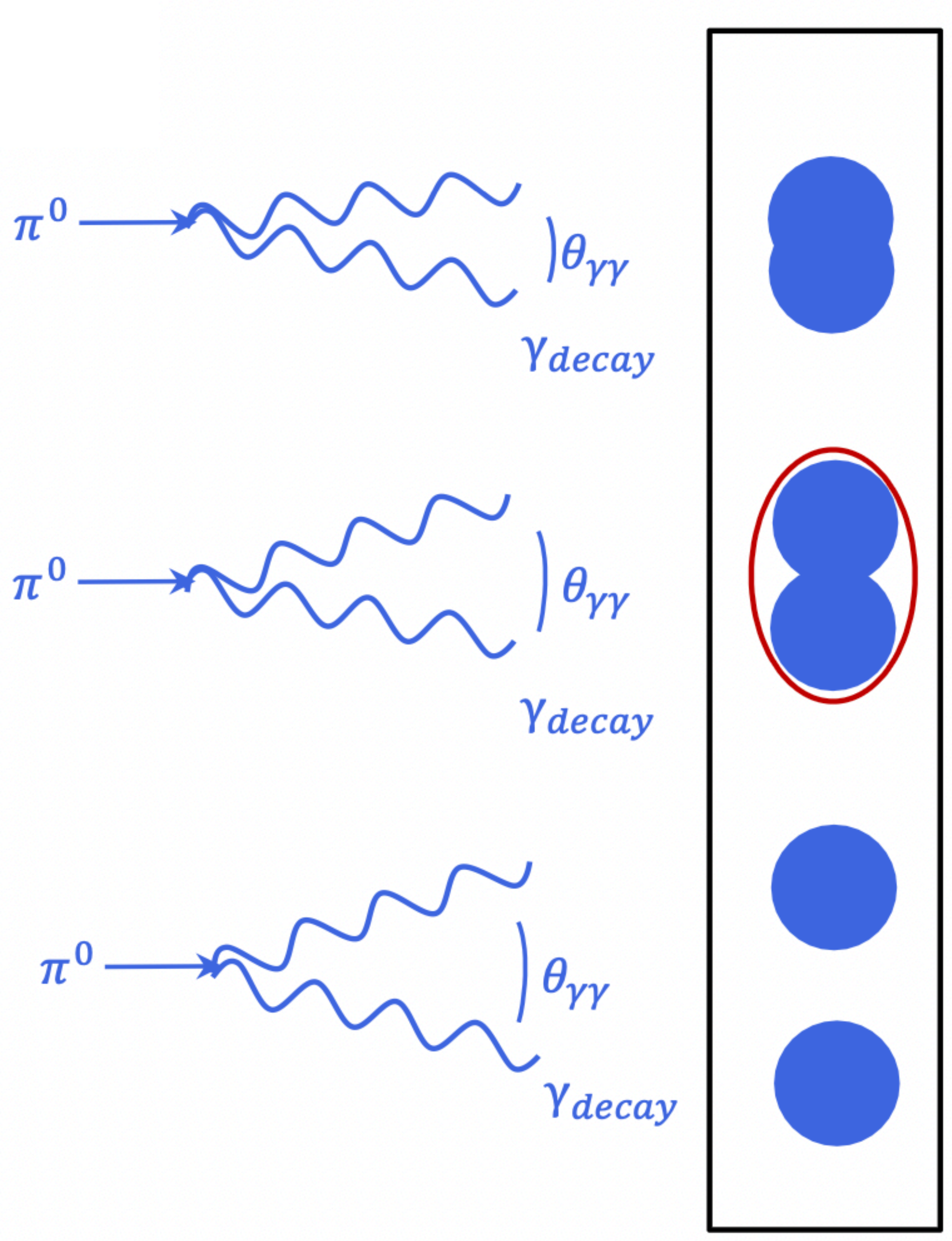
The isolated γ candidate sample ***has to be corrected*** for π^0 accepted = $\text{cluster}^{iso}_{\text{wide}}$

$$\boxed{\gamma^{iso} = \frac{\text{cluster}^{iso}_{\text{narrow}} - (1-P)\,\text{cluster}^{iso}_{\text{wide}}}{P}}$$

Where *P* = *Purity*



ALICE 2022, Internal, Gustavo Conesa's analysis

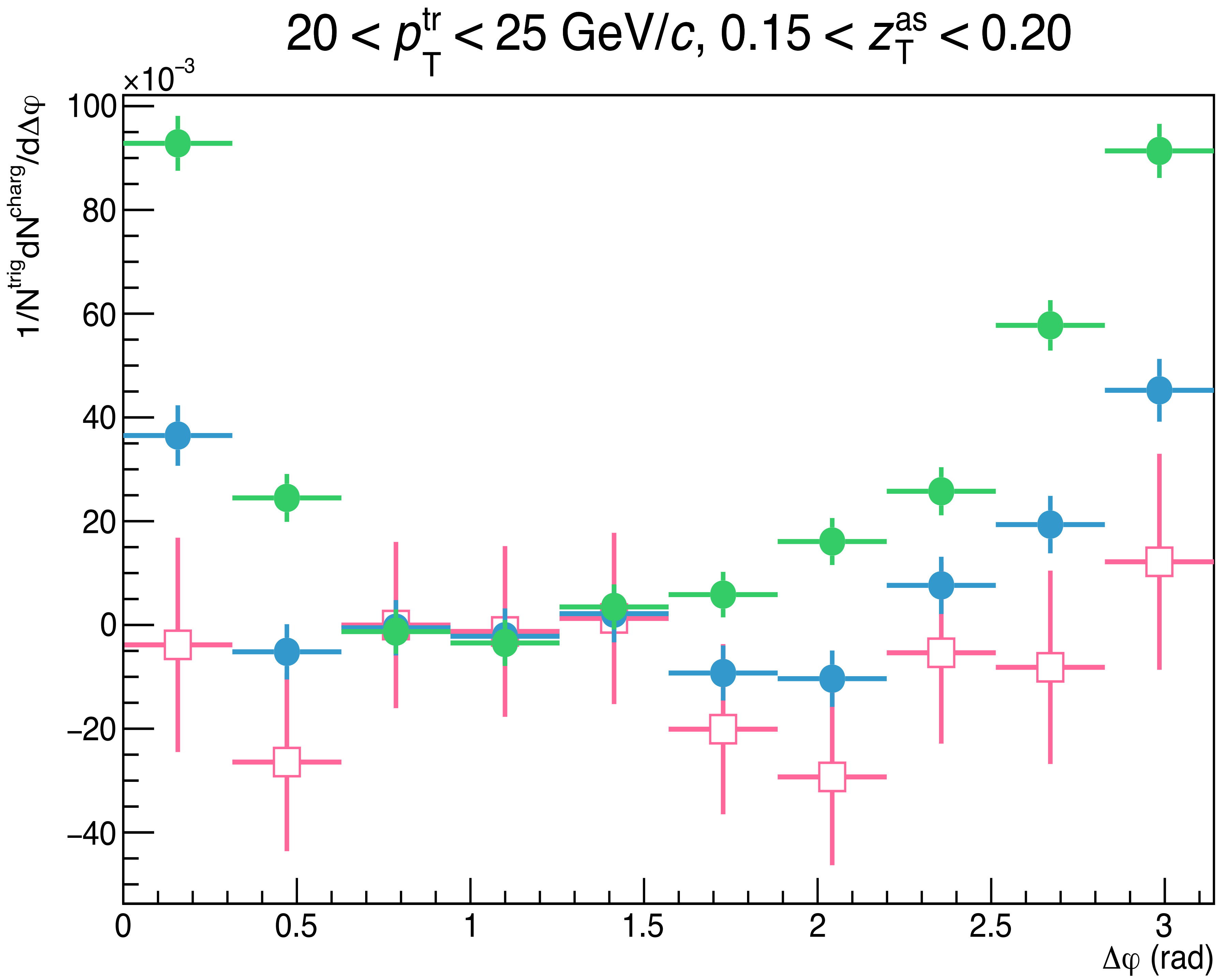


$\text{cluster}^{iso}_{\text{wide}} \rightarrow 0.4 < \sigma^2_{long} < 2.00$

$\text{cluster}^{iso}_{\text{narrow}} \rightarrow 0.1 < \sigma^2_{long} < 0.3$

☑ Purity result not final, but variations not expected to affect much the analysis

Purity Correction



Cent: 30-50%, 20 < p_T^{tr} < 25 GeV/*c*, Isolation ON

$$\gamma^{iso} = \frac{\text{cluster}^{iso}_{\text{narrow}} - (1 - P)\ \text{cluster}^{iso}_{\text{wide}}}{P}$$

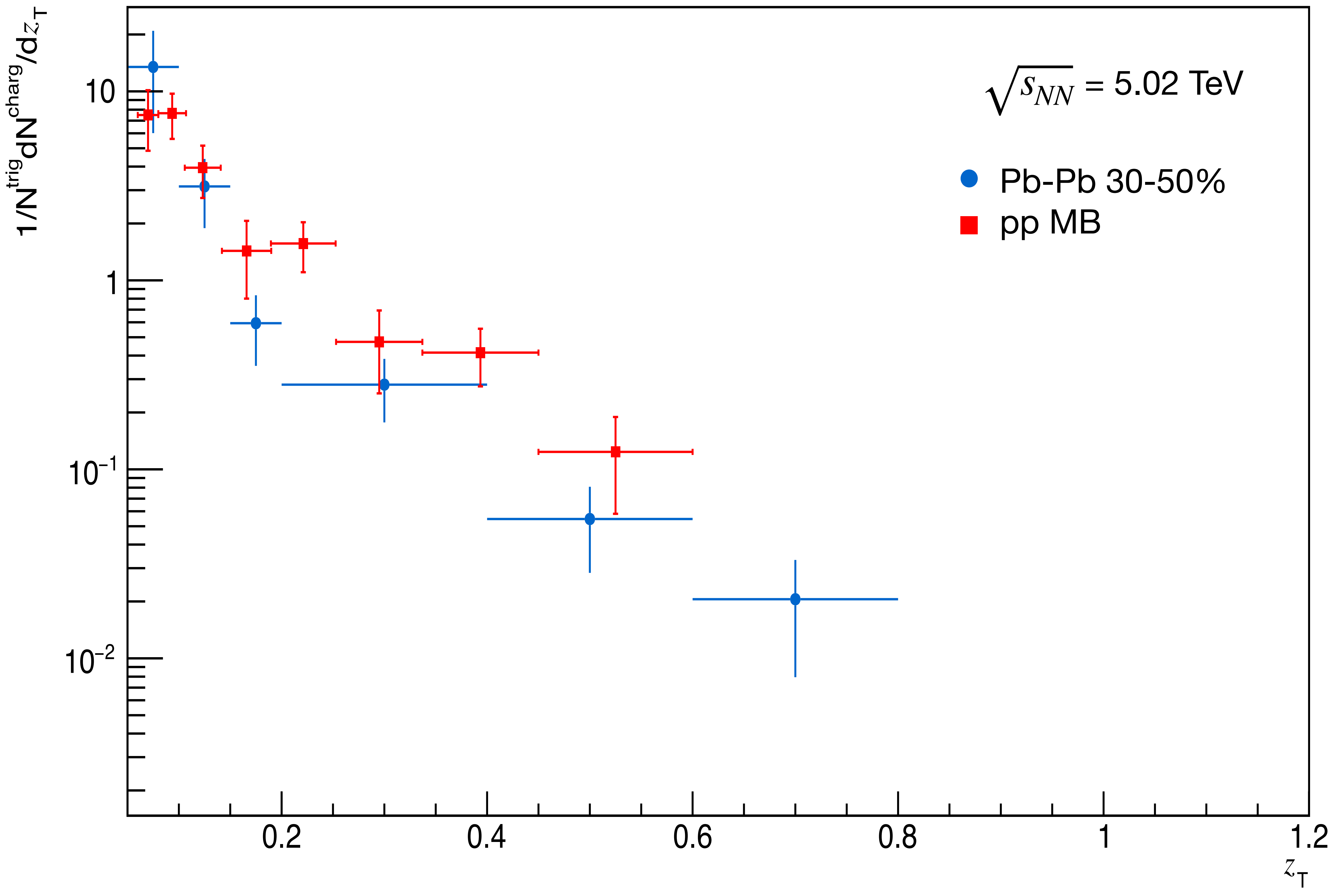
$\text{cluster}^{iso}_{\text{wide}} \rightarrow 0.4 < \sigma^2_{long} < 2.00$

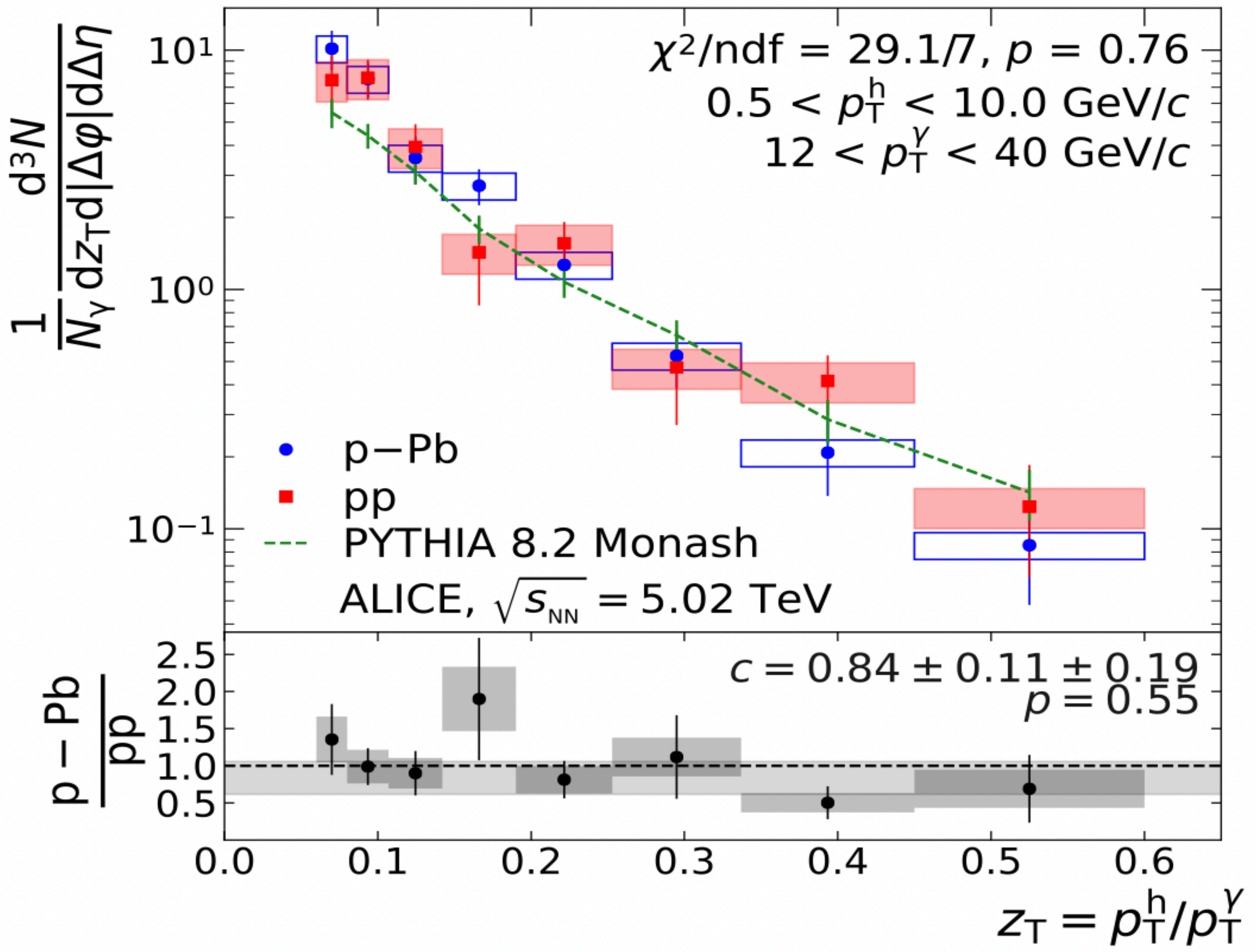
$\text{cluster}^{iso}_{\text{narrow}} \rightarrow 0.1 < \sigma^2_{long} < 0.3$

- Integration of the area around the away-side peak ($2\pi/3 < \Delta\varphi < \pi$) for every z_{T} interval to obtain $1/N^{trig} dN^{ch}/dz_{\text{T}}$ distribution
- Apply Monte Carlo Correction to take into account detector effects

Evaluation of the z_T function

➡ALICE, arXiv:2005.14637





- After Monte Carlo correction, different p_T^{tr} bins are merged
- Visual Comparison with published pp results (Different cuts!)

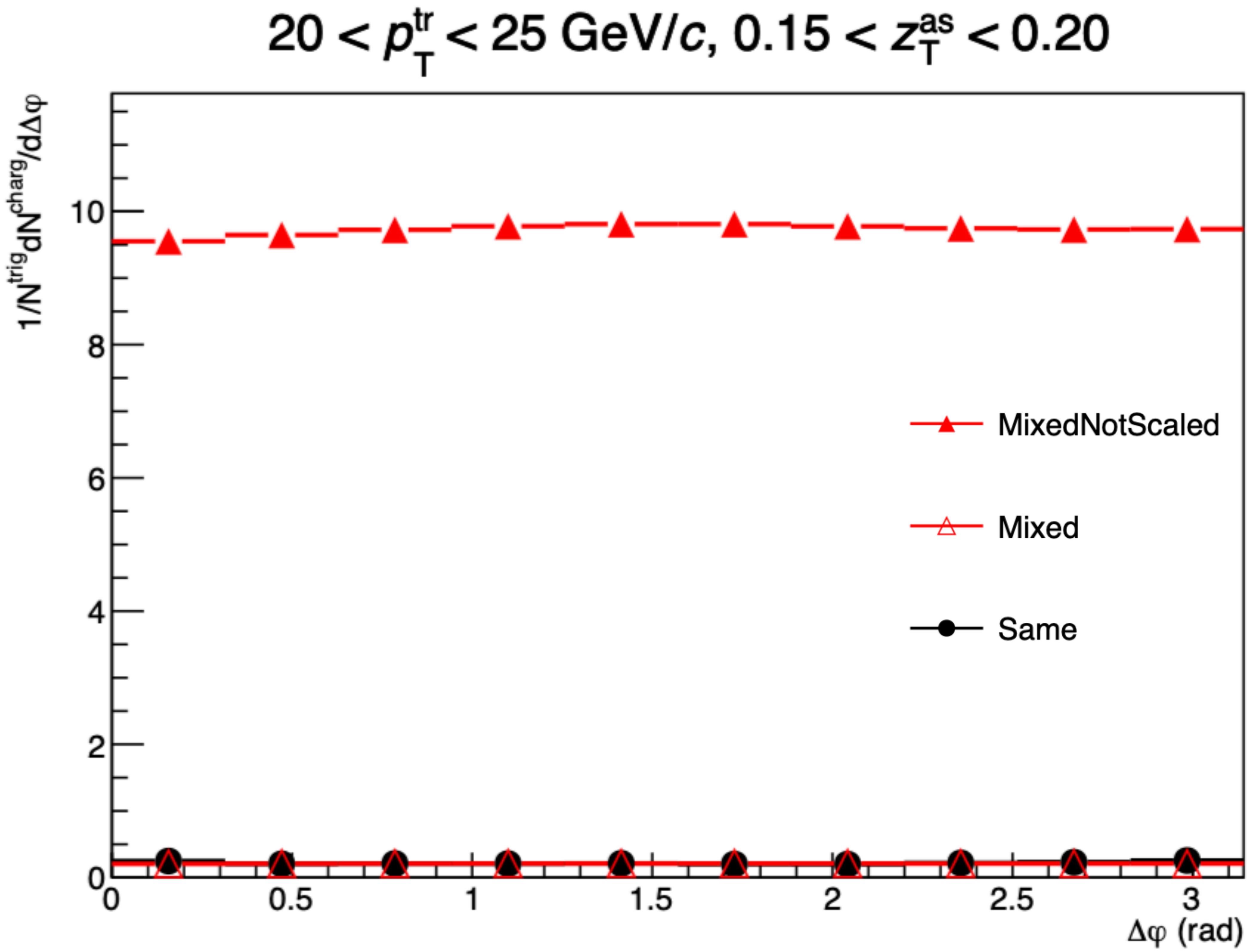
Check Clusters for Same and Mixed event

- Difference between Mixed Event and Same event in correlation distribution functions:

  Necessary to apply a scaling factor

  Similar problem in isolated-γ jet correlations (Ref. PWG-PAG JP 14/11/22 slide 12)

- In isolated γ-jet correlations found a discrepancy between cluster distribution for Mixed and Same



Mixed larger than Same

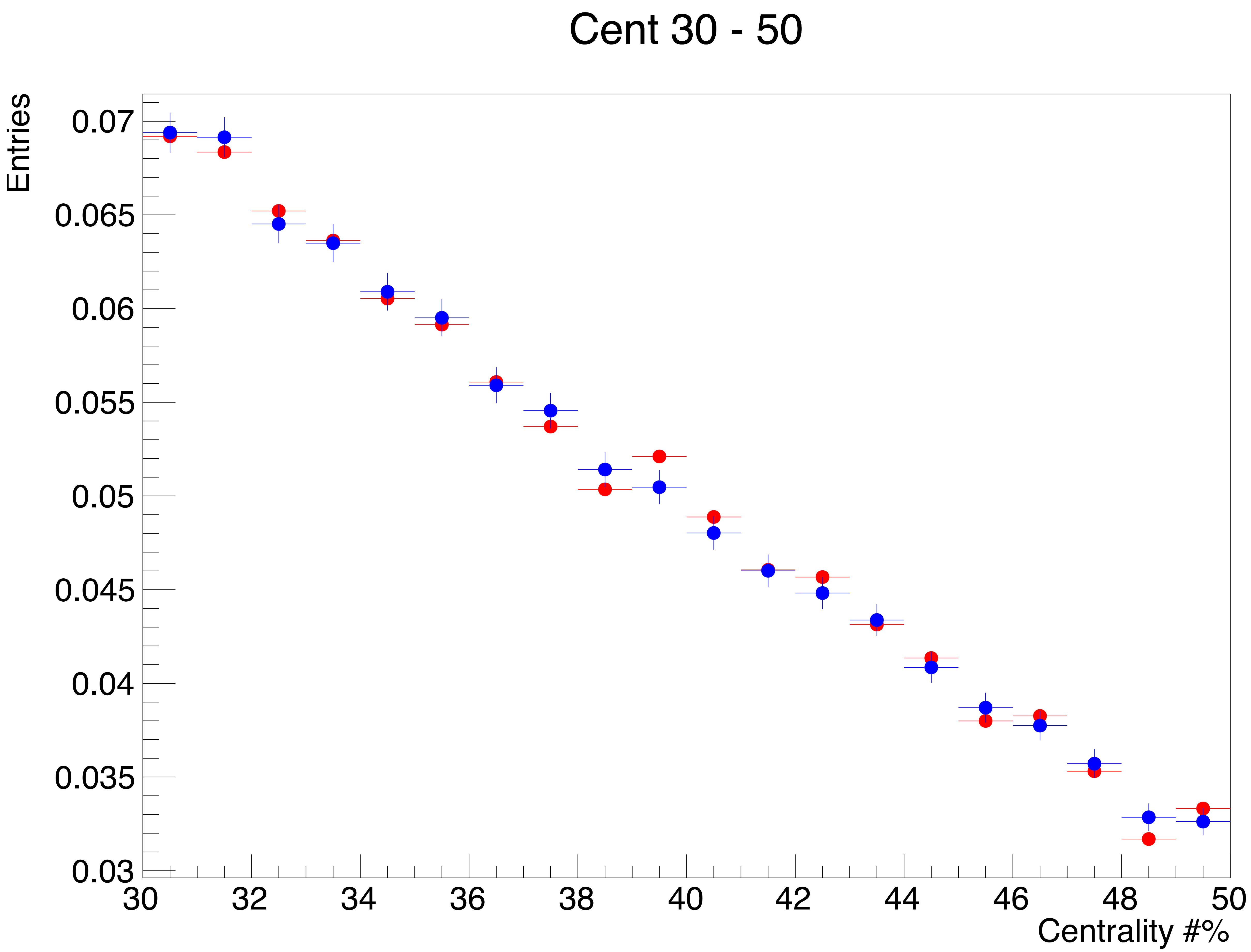
Scaling factor = $\int_1^{\pi/2} \mathrm{Same} / \int_1^{\pi/2} \mathrm{Mix}$

Check Clusters for Same and Mixed event

- Similar problem in isolated γ-jet correlations

  (Ref. PWG-PAG JP 14/11/22 slide 12)

- In isolated γ-jet correlations found a discrepancy between cluster distribution for Mixed and Same
- Check cluster distributions (before correlations) for Same and Mixed for all centralities



Same and Mixed clusters distribution agreed

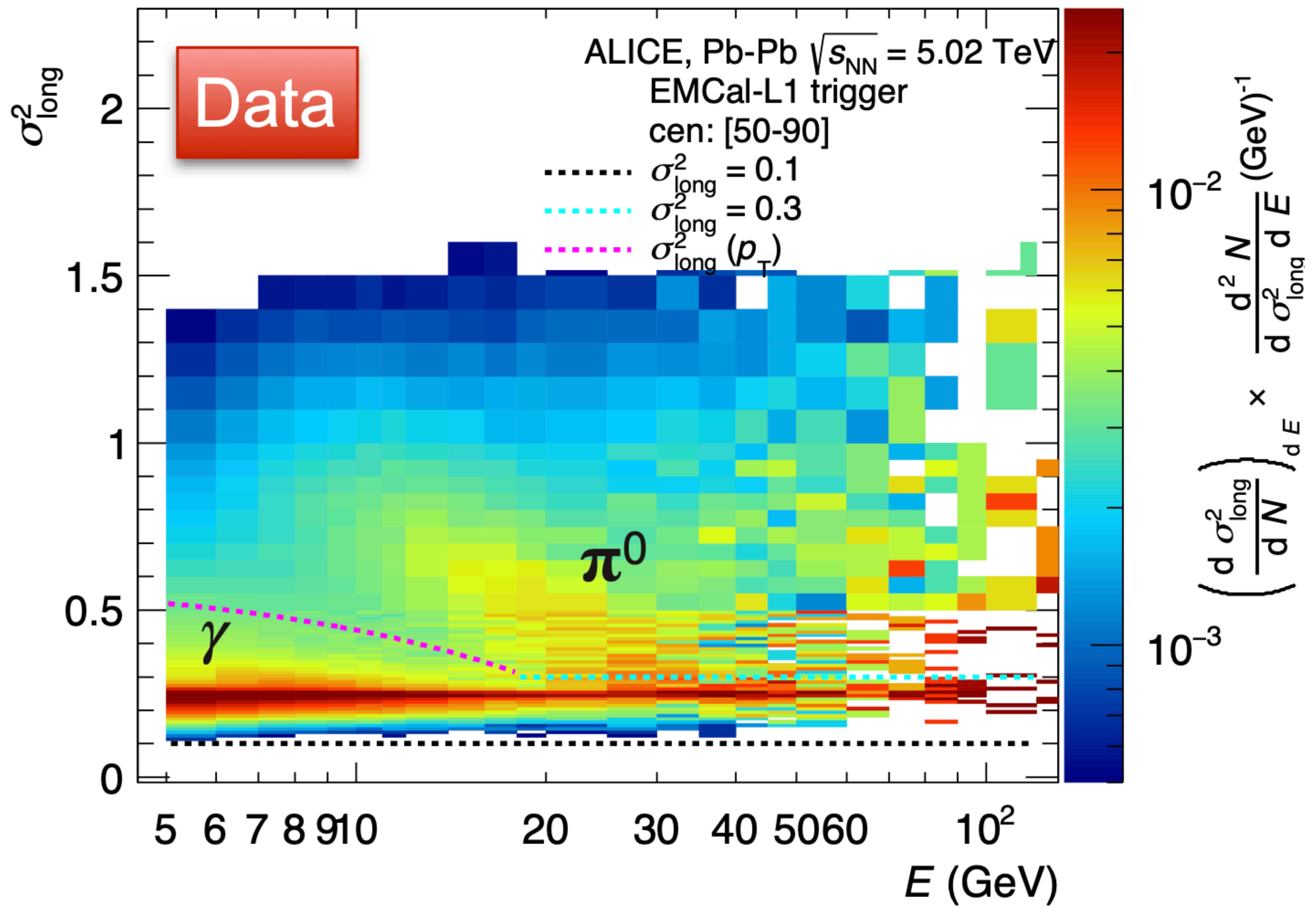
Systematics

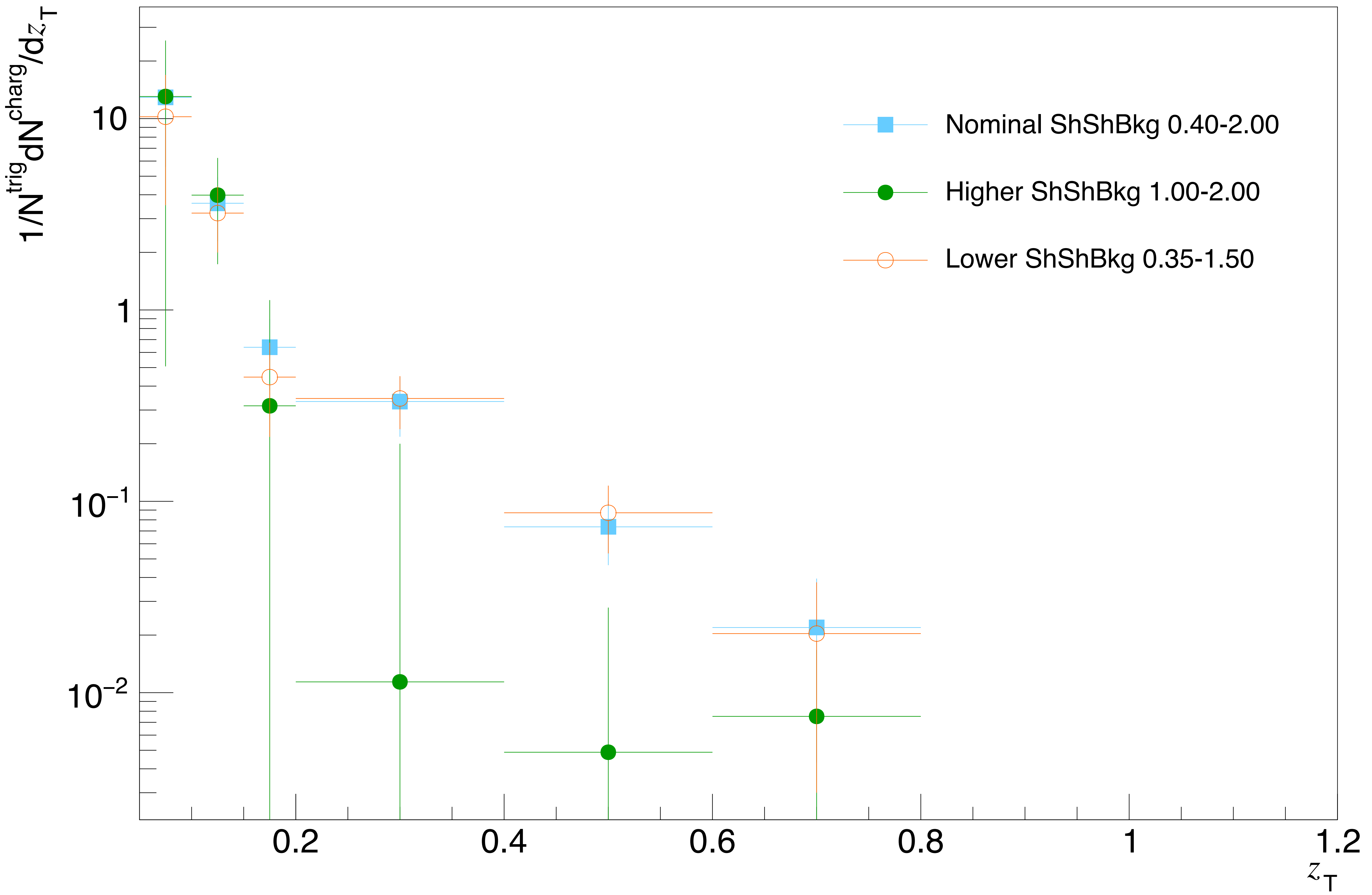
Systematic uncetainties for most sources are estimated using mostly cut variations

- UE estimation uncertainty (ongoing)
- Background σ^2_{long} selection (ongoing)
- Purity
- ΔCentrality cut when pairing events for mixing

- Tracking Performance
- Luminosity
- Trigger
- Photon and vertex reconstruction
- Photon energy scale

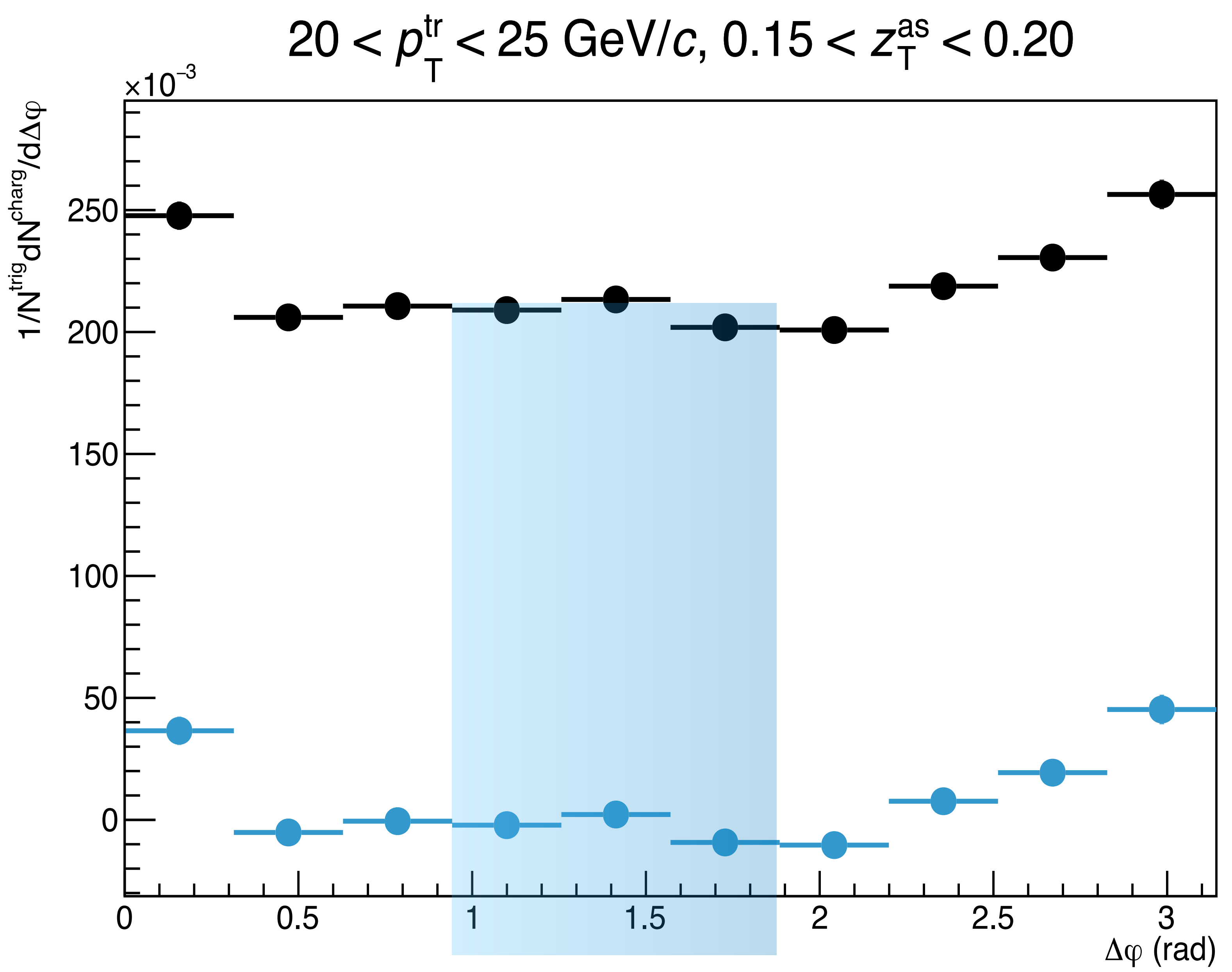
Systematics: Background σ^2_{long} selection





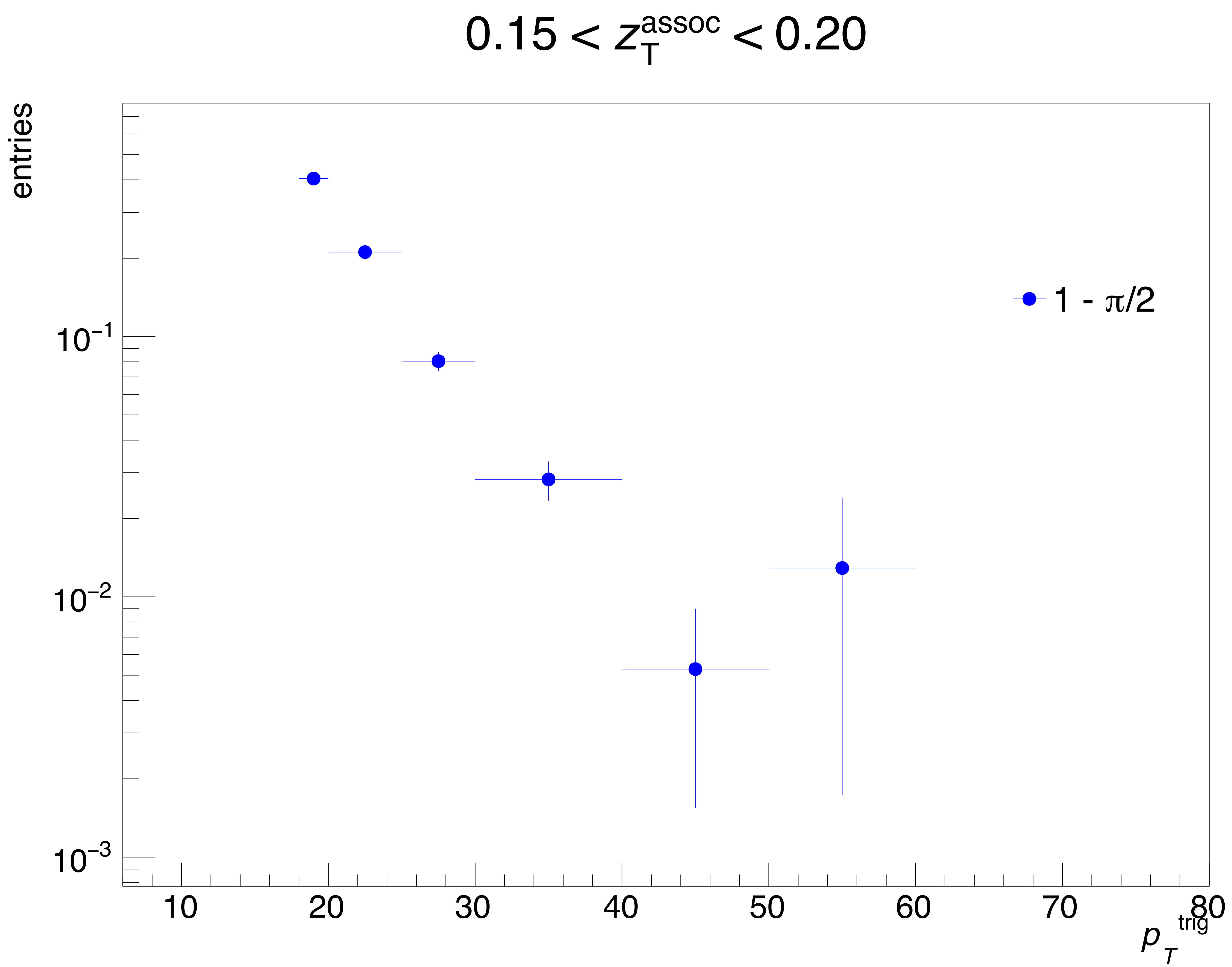
- **ShShBkg 1.00-2.00**: not good description of $\text{cluster}^{iso}_{\text{wide}}$ (π^0)
- **ShShBkg 0.35-1.50** : similar to the nominal one
- Test other shower shape for π^0

Systematics: UE estimation uncertainty (ZYAM)



For every p_T^{tr} bin and every $z_{\mathrm{T}} = p_{\mathrm{T}}^{hadr}/p_{\mathrm{T}}^{\gamma}$ bin:

- Evaluated the Integral for applying ZYAM and its error



- Combined all the p_T^{tr} bins

To do list

- Systematics:
  - “Final” plots for UE systematic
  - Background σ^2_{long} selection (different cuts)
  - Vary ΔCentrality cut when pairing events for mixing
  - …
- Redo analysis with JJlow MC
- Rerun pp analysis to make feasible a comparison

Thank you for the attention!

Evaluation of the z_T function

Cent: 30-50%, 20 < p_T^{tr} < 25 GeV/*c*, Isolation ON, 0.1 < σ^2_{long} < 0.3

- $z_T = p_T^{hadr}/p_T^{\gamma}$ distribution allows to ***access to the parton fragmentation***
- Integration of the area around the away-side peak ($2\pi/3 < \Delta\varphi < \pi$) for every z_T interval to obtain $1/N^{trig}dN^{ch}/dz_T$ distribution

Efficiency Correction

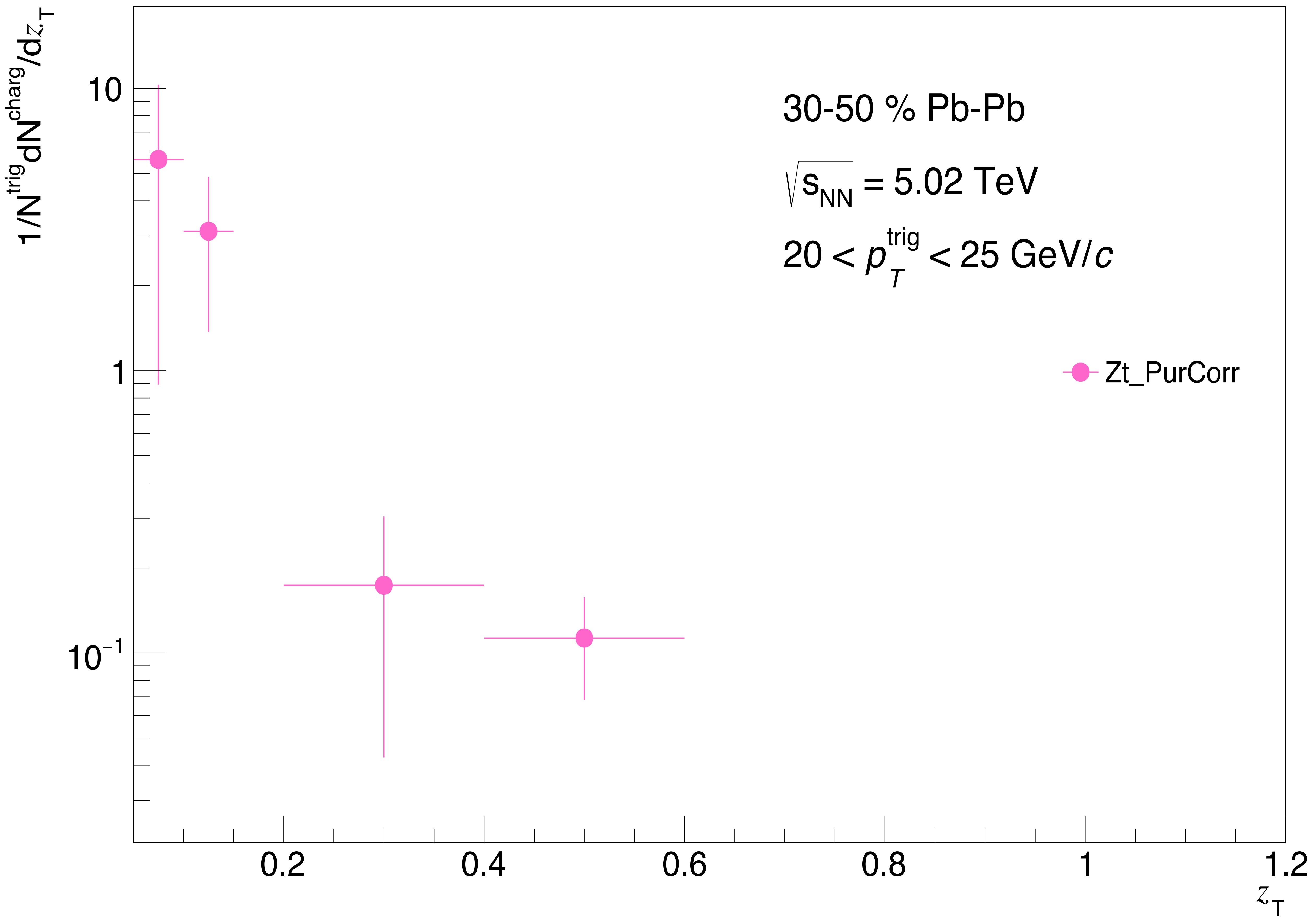
Generated: pure MC of γ^{iso} and of γ^{iso}– hadron correlations

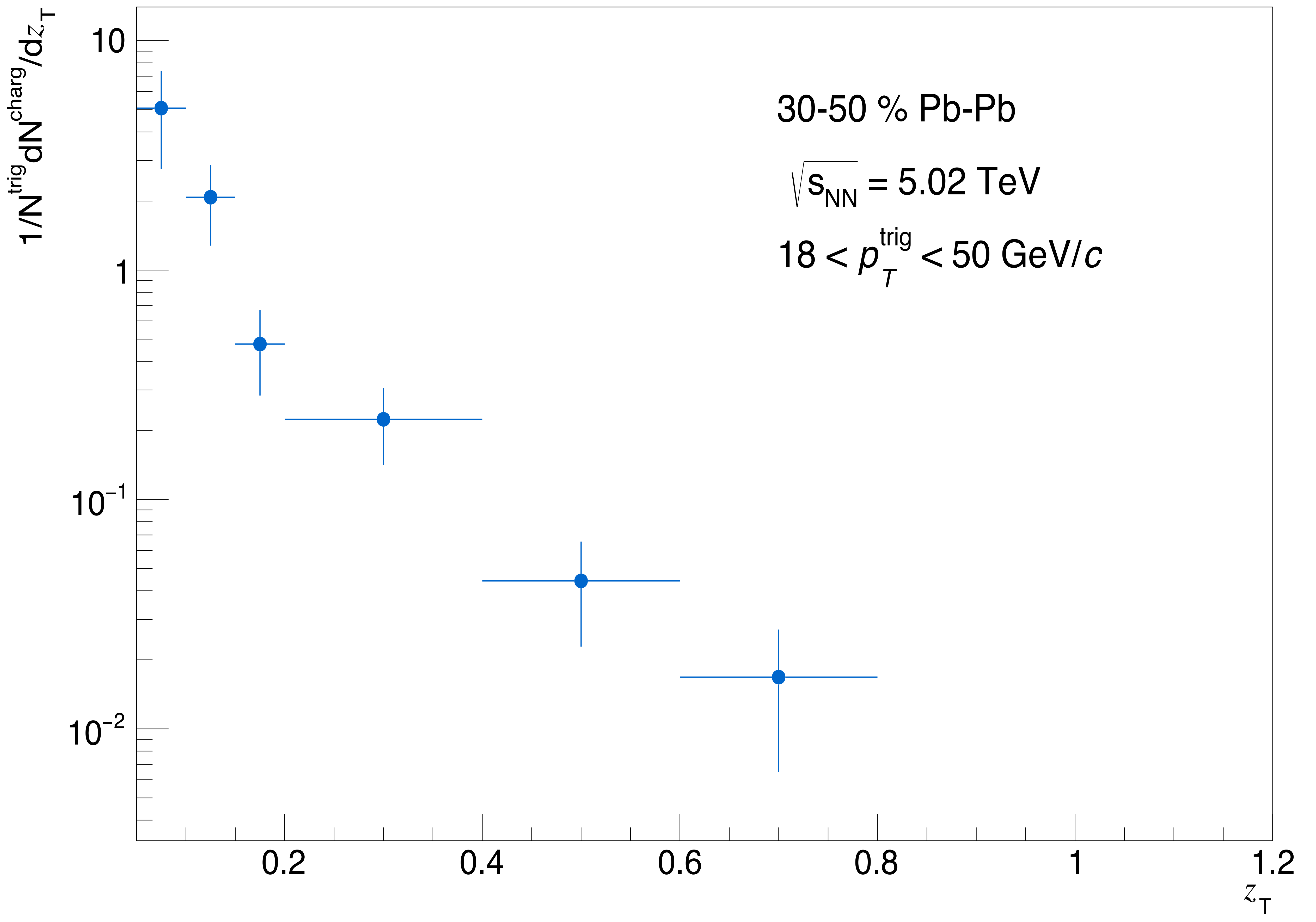
Reconstructed: *embedding* of MinimumBias (MB) data + pure MC

Cent: 30-50%, 20 < p_T^{tr} < 25 GeV/*c*, Isolation ON, 0.1 < σ^2_{long} < 0.3

- The negative values around 0 are related to the isolation
- As before, the integration of the away-side peak is applied to obtain the z_T function

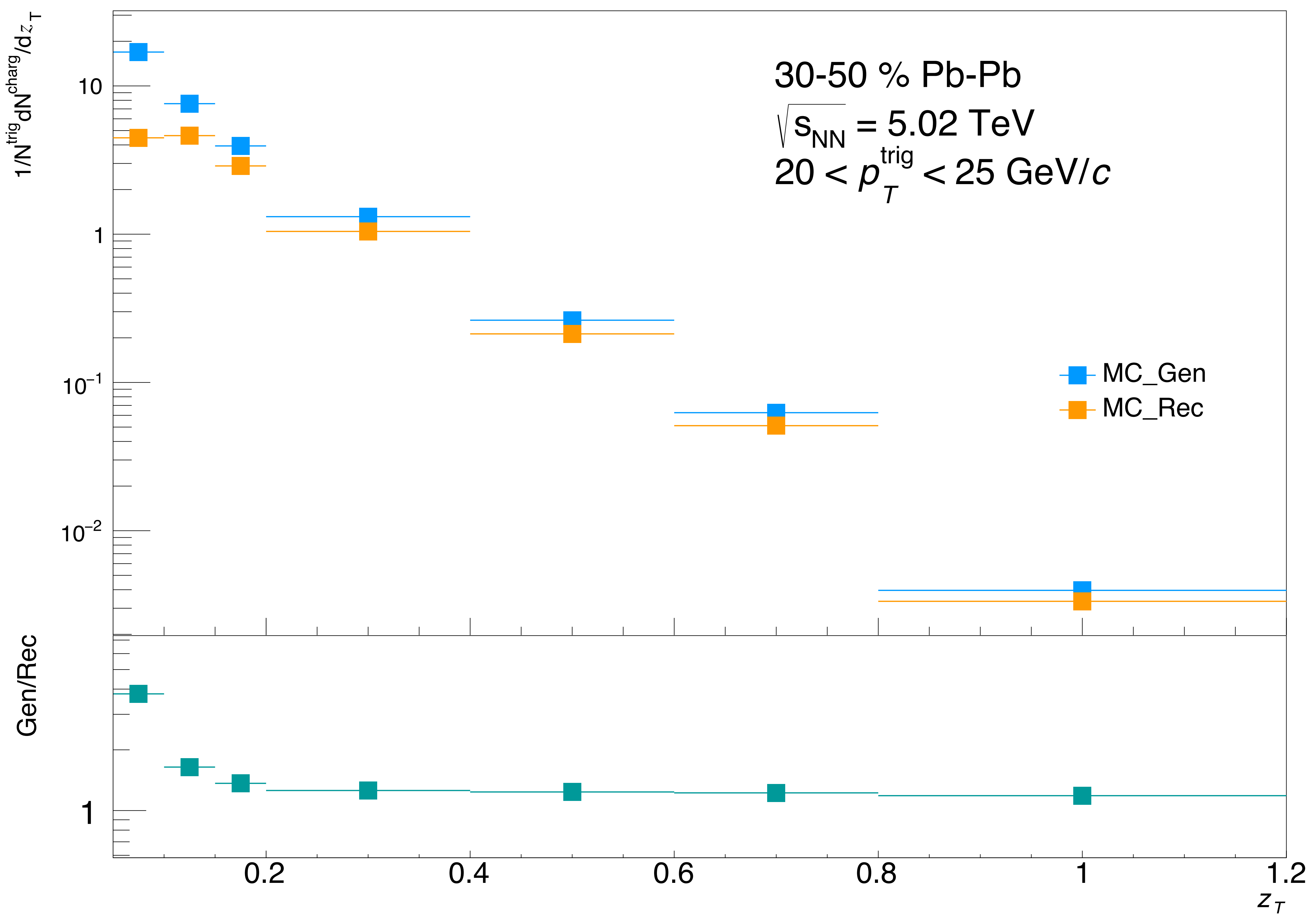
Evaluation of the z_T function

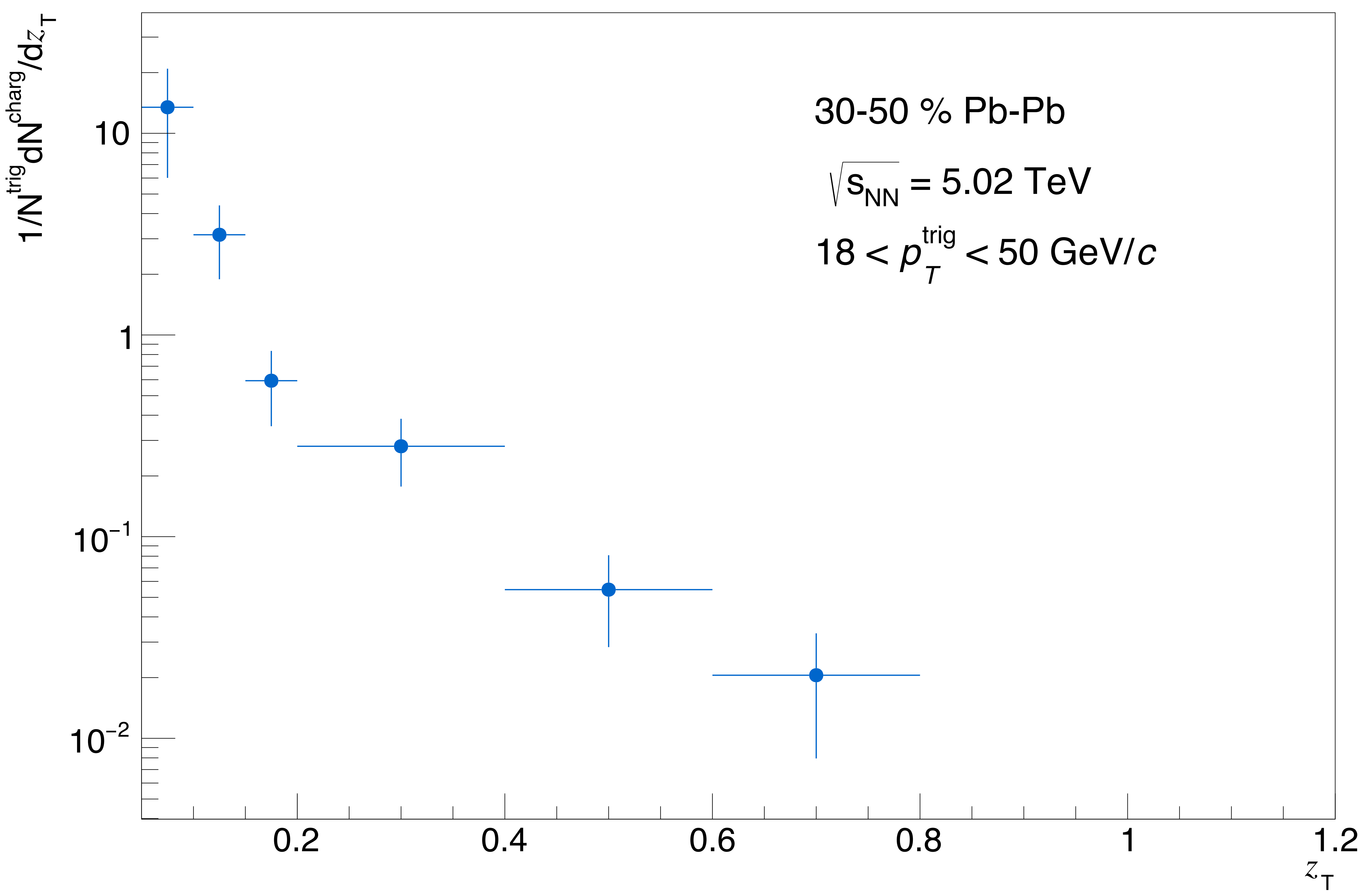




- Clearly lack of statistic. To improve necessary to combine different p_T^{tr} bins
- Next step: ***efficiency correction*** to take into account detector effects
- How? Monte Carlo dataset: ideally generation and reconstruction of γ^{iso}

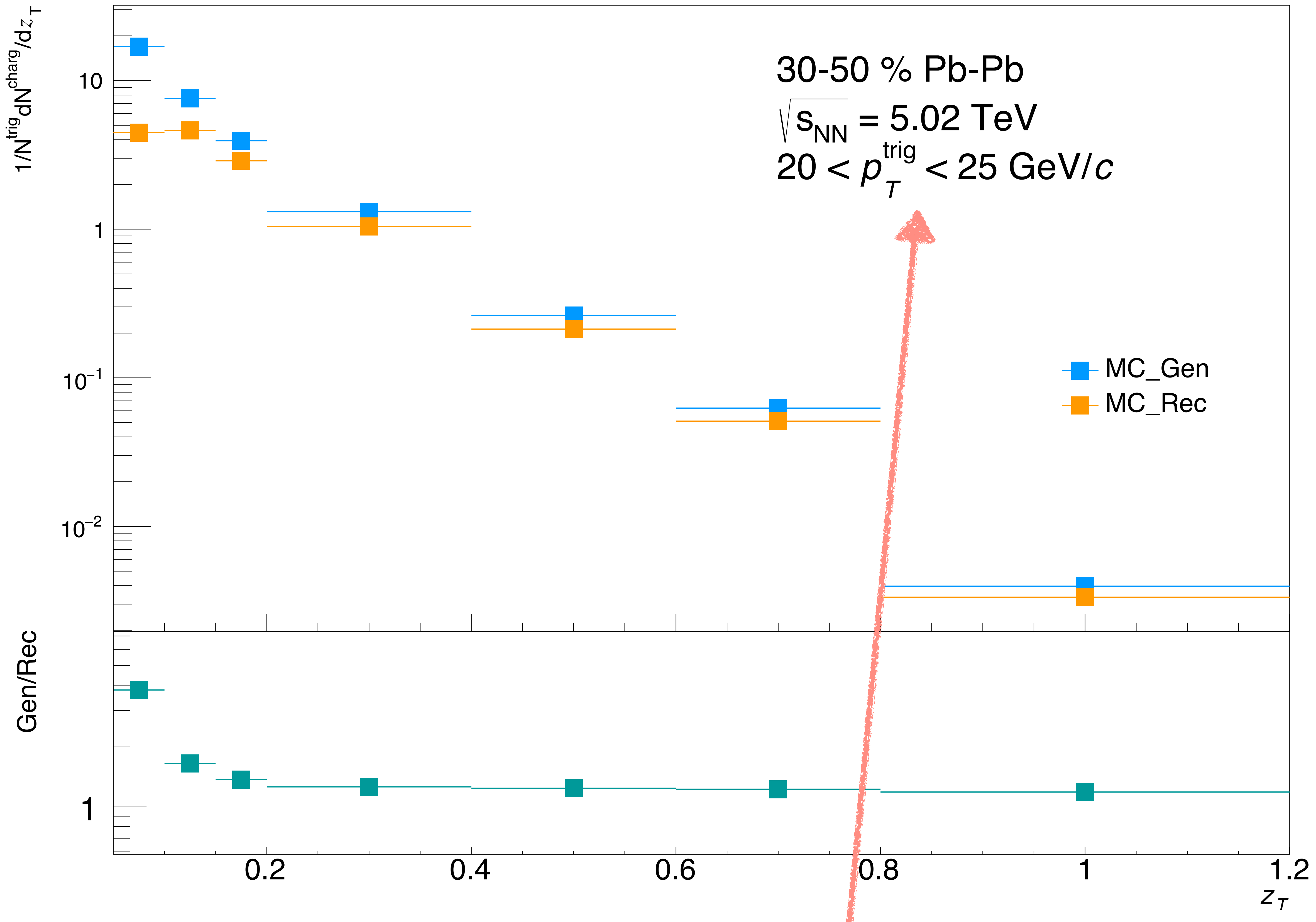
Efficiency correction of the z_T function

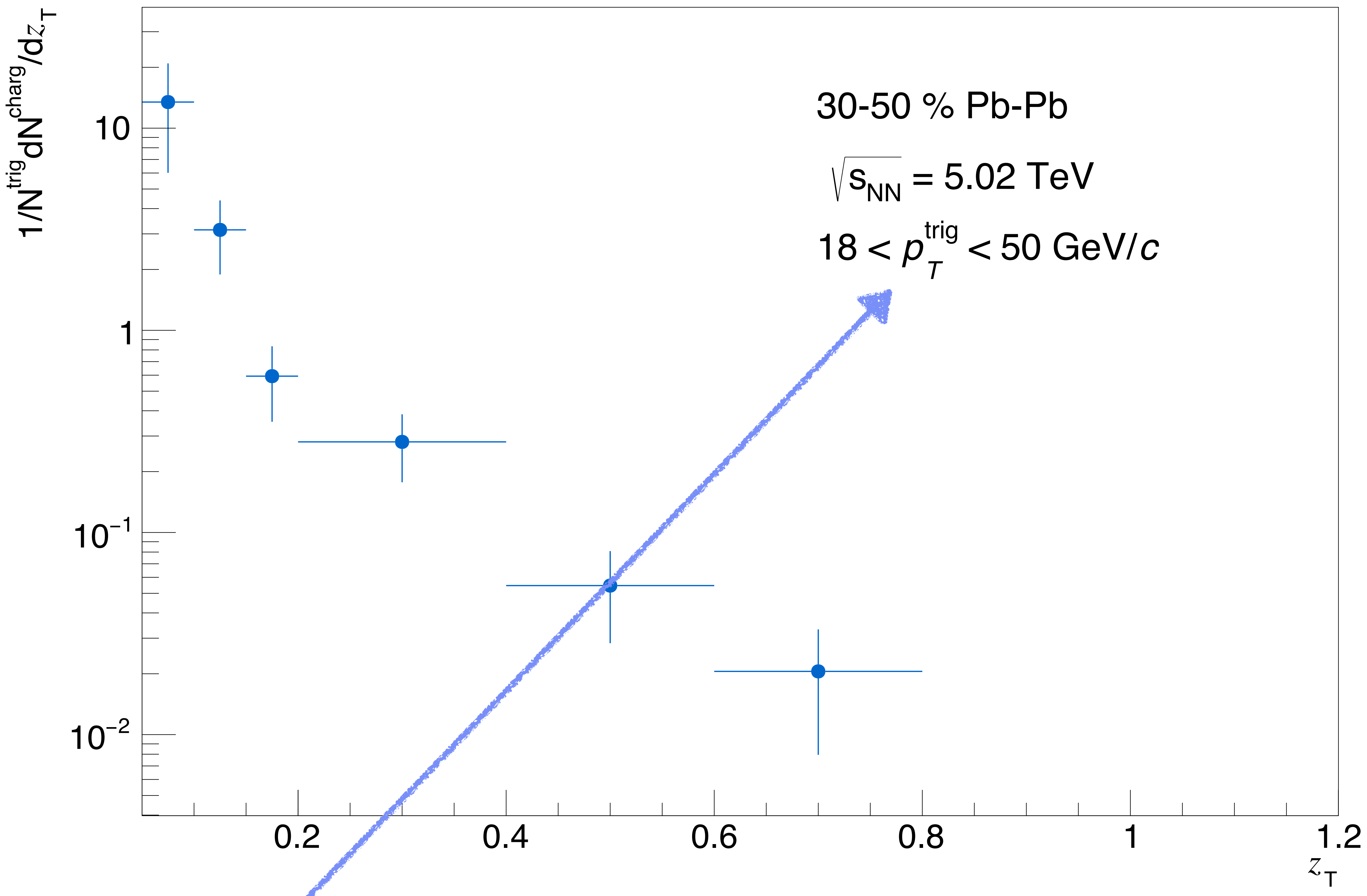




- The z_T function is multiplied by the correction factor (Gen/Rec) → Detector effects taken into account
- Corrections for every p_T^{tr} bin, then different p_T^{tr} bins are merged!

Efficiency correction of the z_T function

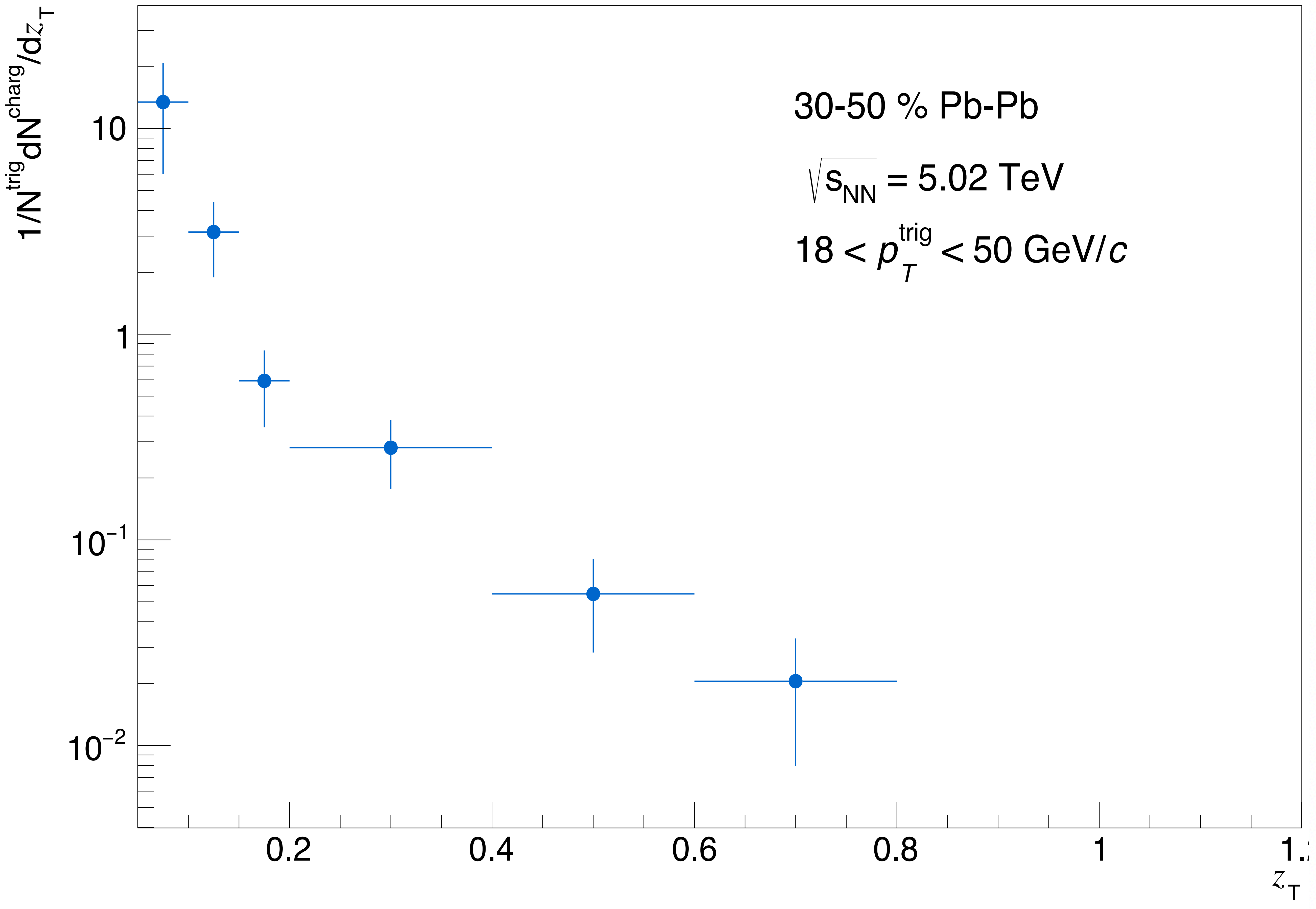


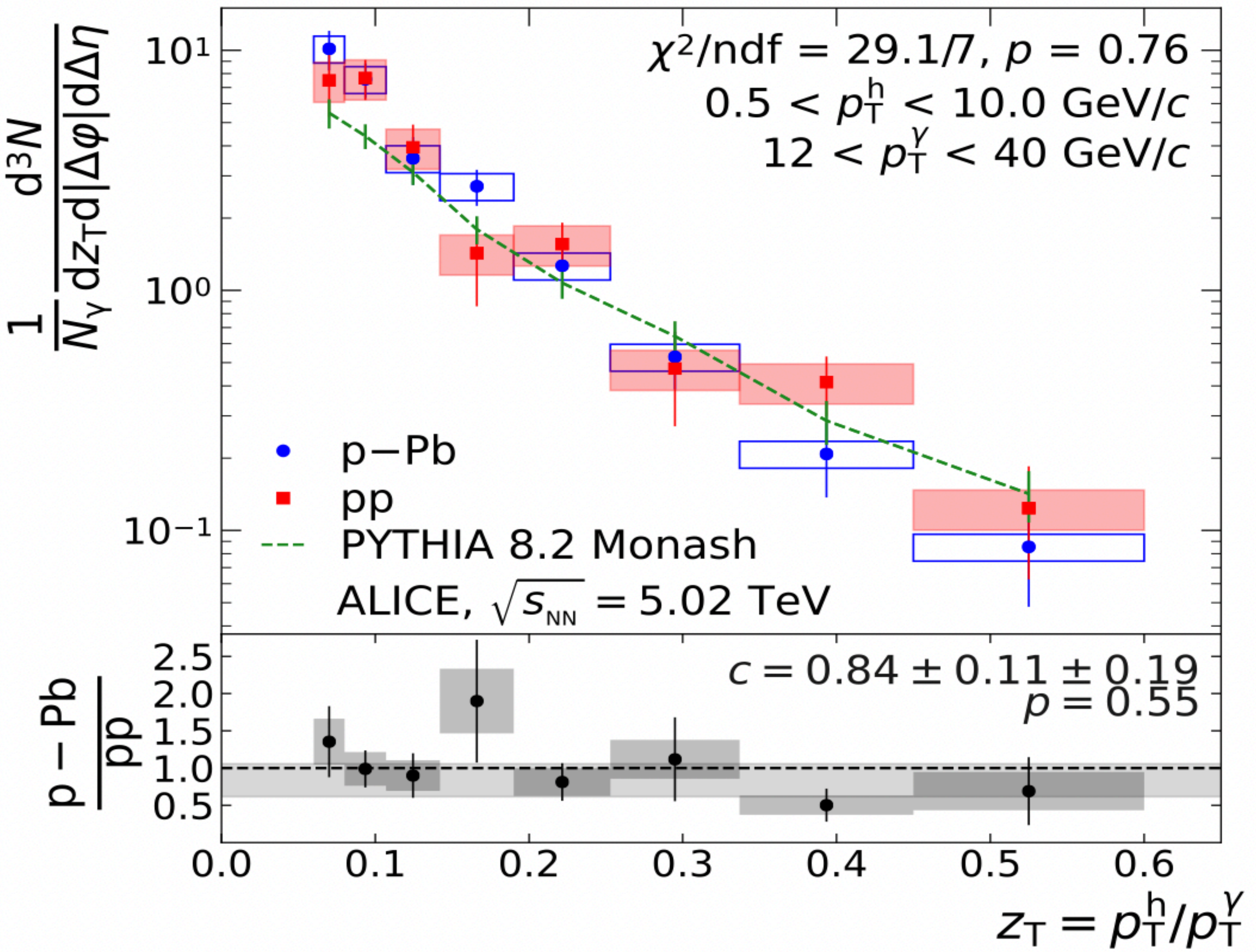


- The z_T function is multiplied by the correction factor (Gen/Rec) → Detector effects taken into account
- Corrections for every p_T^{tr} bin, then different p_T^{tr} bins are combined!

Evaluation of the z_T function

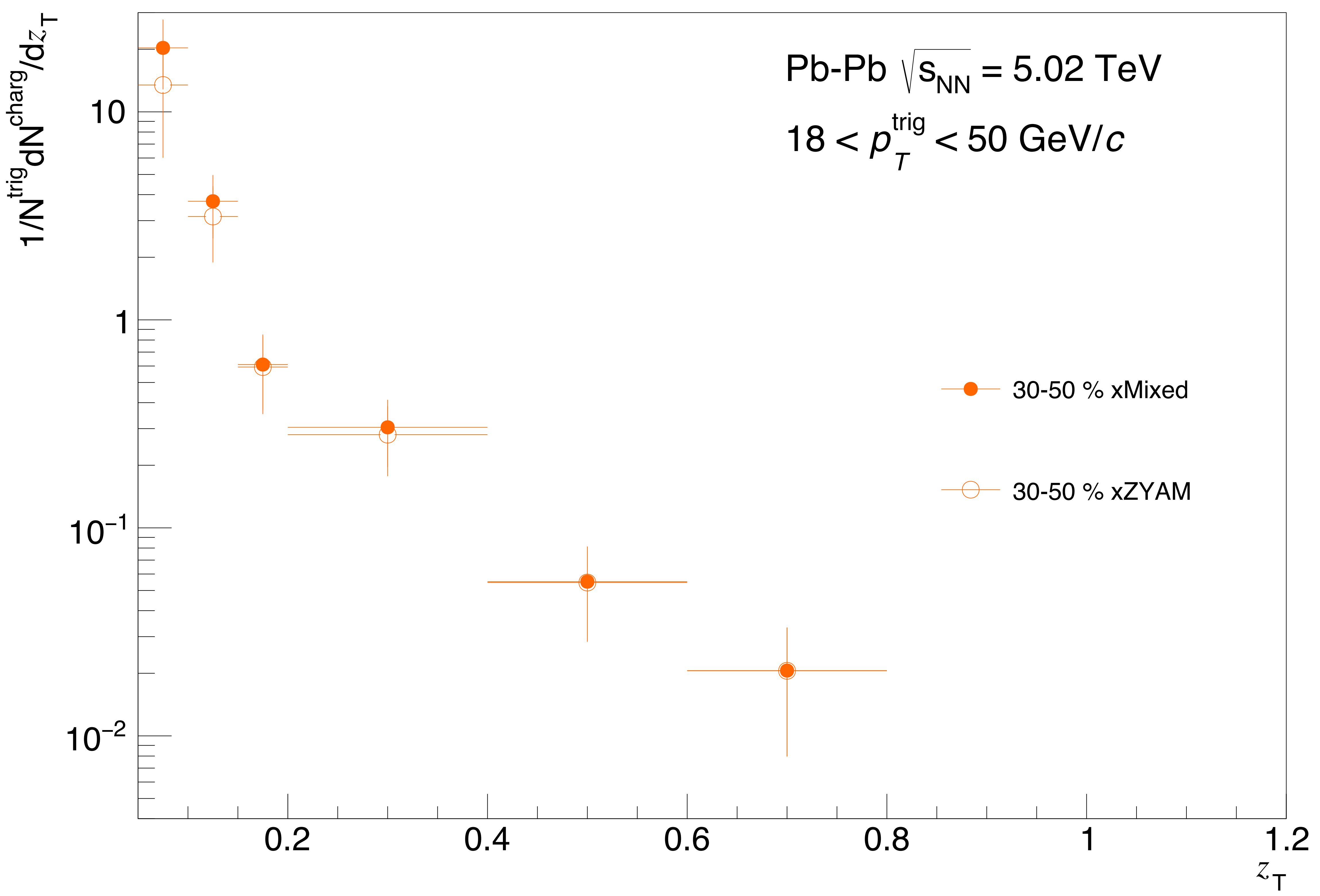
➡ALICE, arXiv:2005.14637

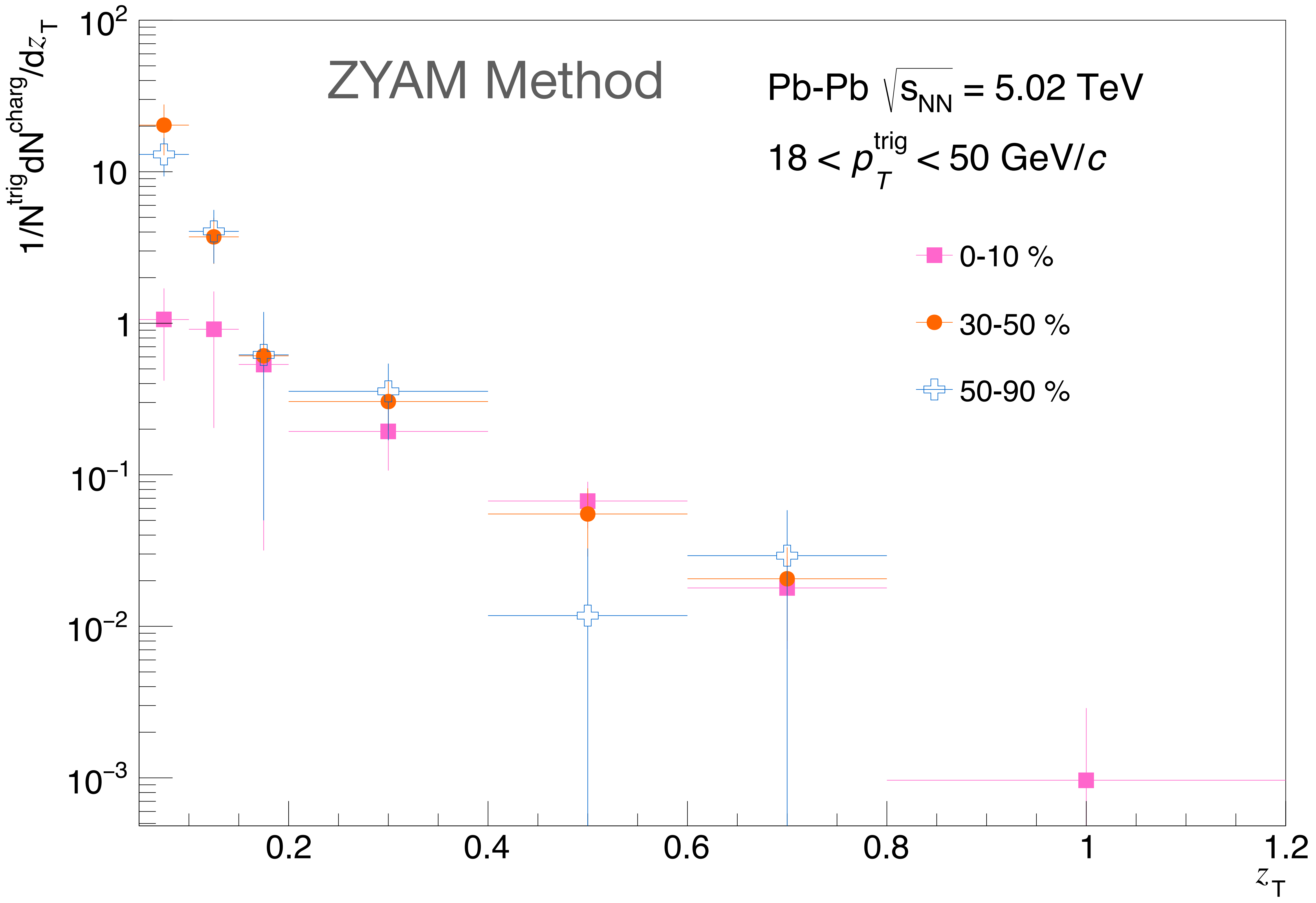




- After Monte Carlo correction, different p_T^{tr} bins are merged
- Comparison with published pp and p-Pb results

z_T function for different methods and centralities



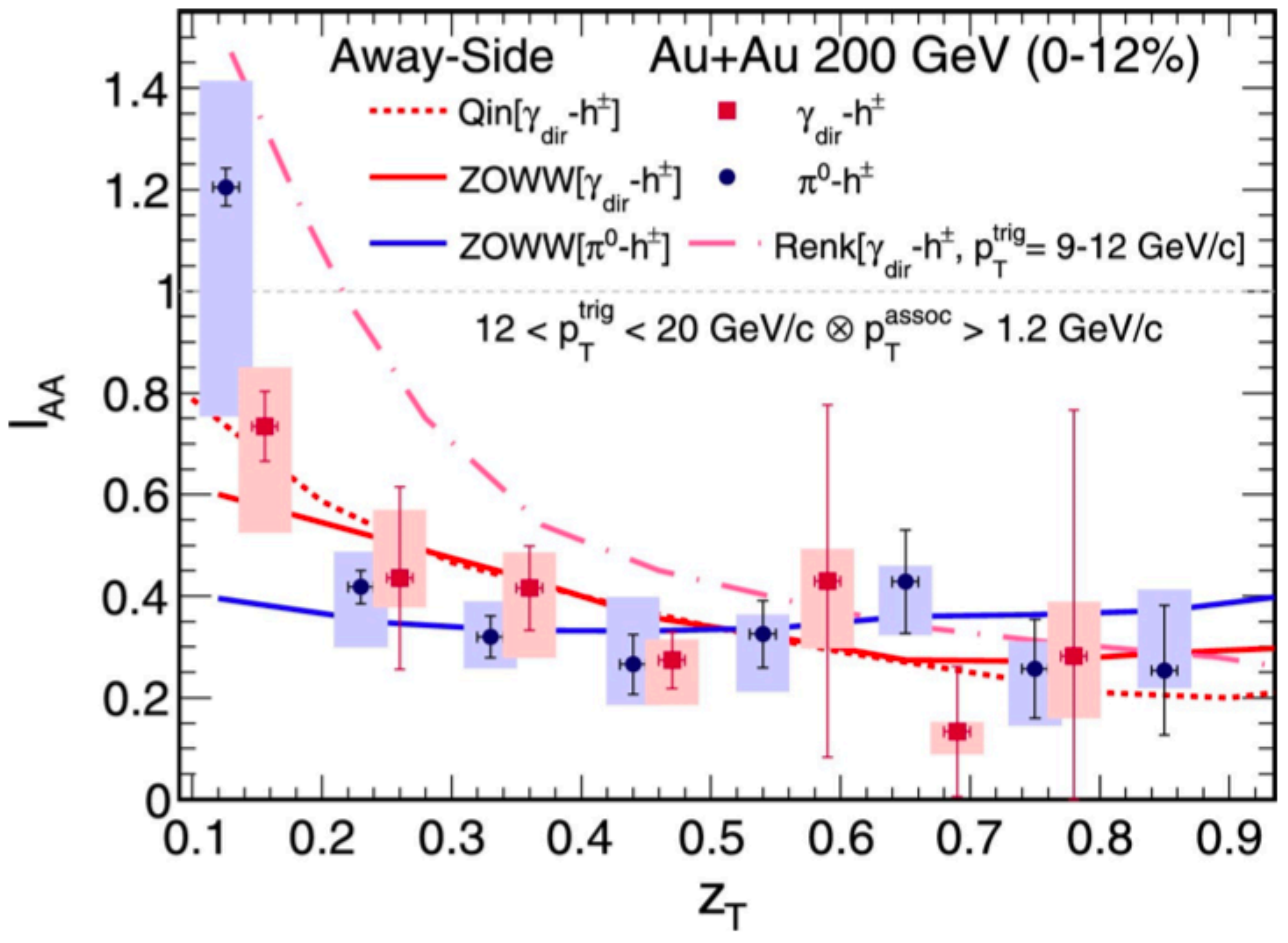


- The two methods are compatible.
- With the mixed event the error bars are a bit reduced.
- Still necessary to investigate the comparison with the different centralities

Backup

γ-hadron correlations

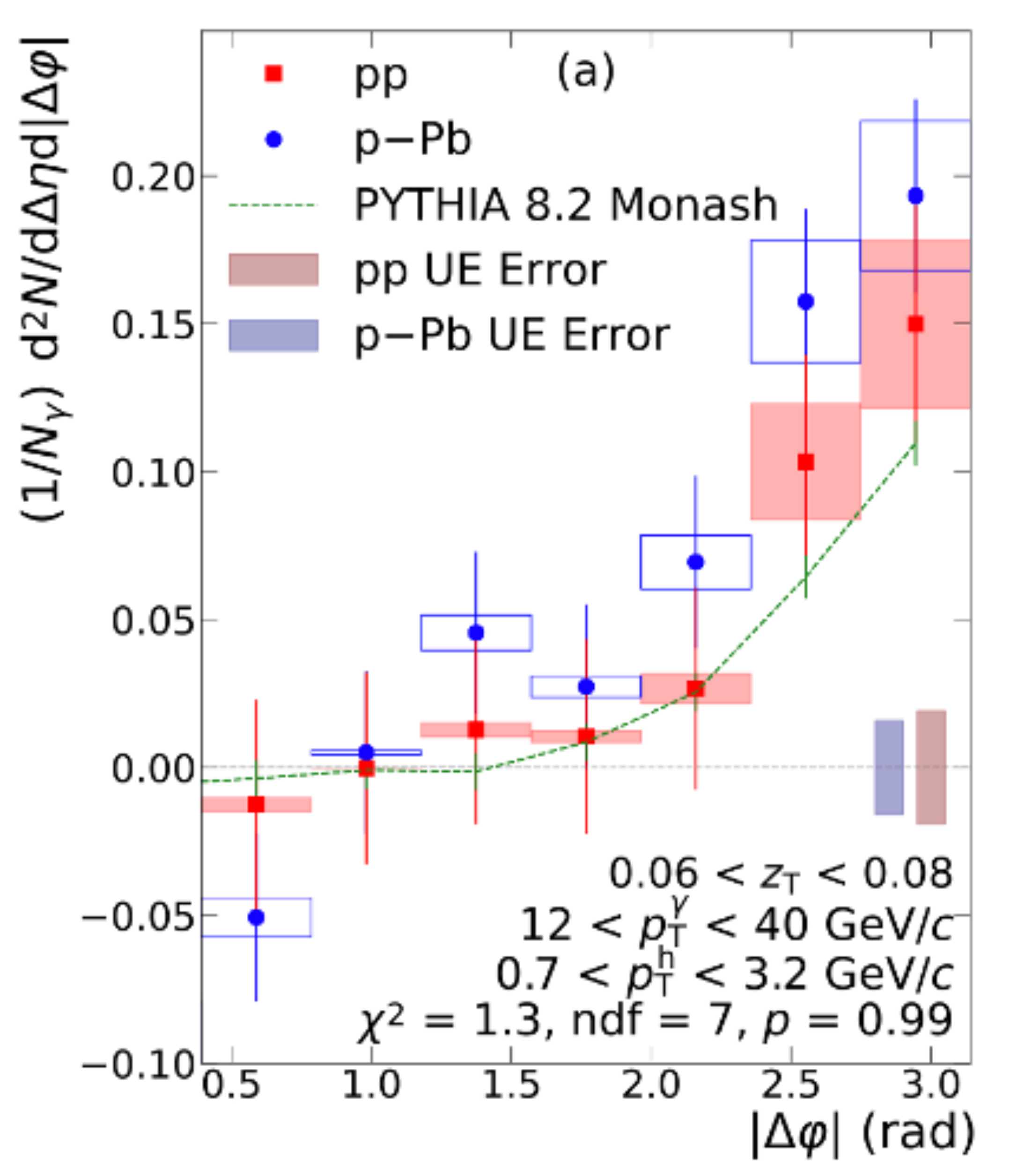
$$\Delta\varphi = (\varphi^{\gamma} - \varphi^{hadr}), \quad z_{\mathrm{T}} = p_{\mathrm{T}}^{hadr}/p_{\mathrm{T}}^{\gamma} \qquad \xi_{\mathrm{T}} = ln(1/z_{\mathrm{T}})$$



➡ *STAR, 2016, arXiv:1610.09568*

From $z_T > 0.2$

Hadrons suppressed in Au-Au wrt pp



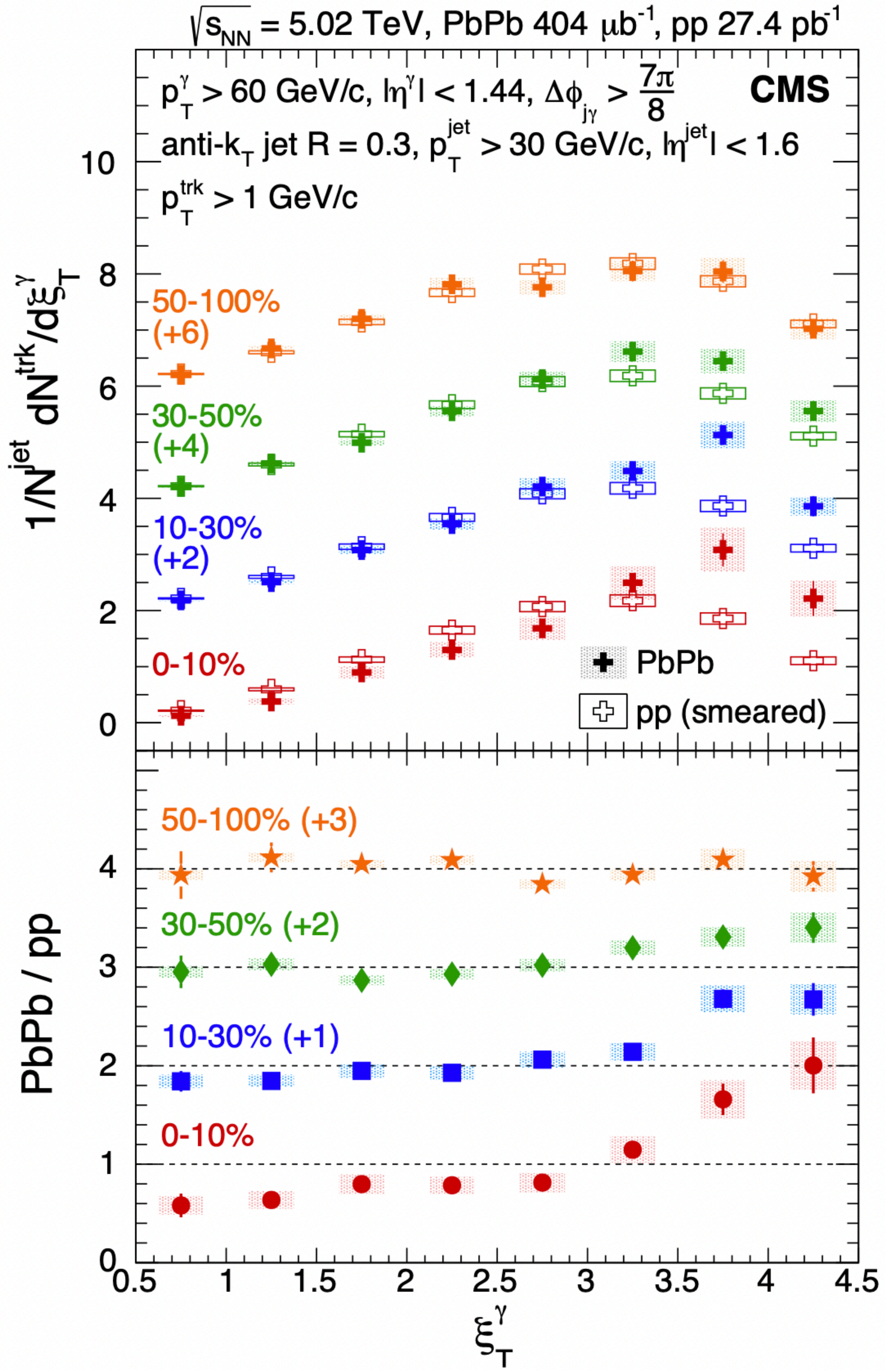
➡ *ALICE, 2020, arXiv:2005.14637*

In pp and p-Pb

Compatible

No modification,

same behaviour



➡ *CMS, 2018, arXiv:1801.04895*

Depletion of high p_{T} particles

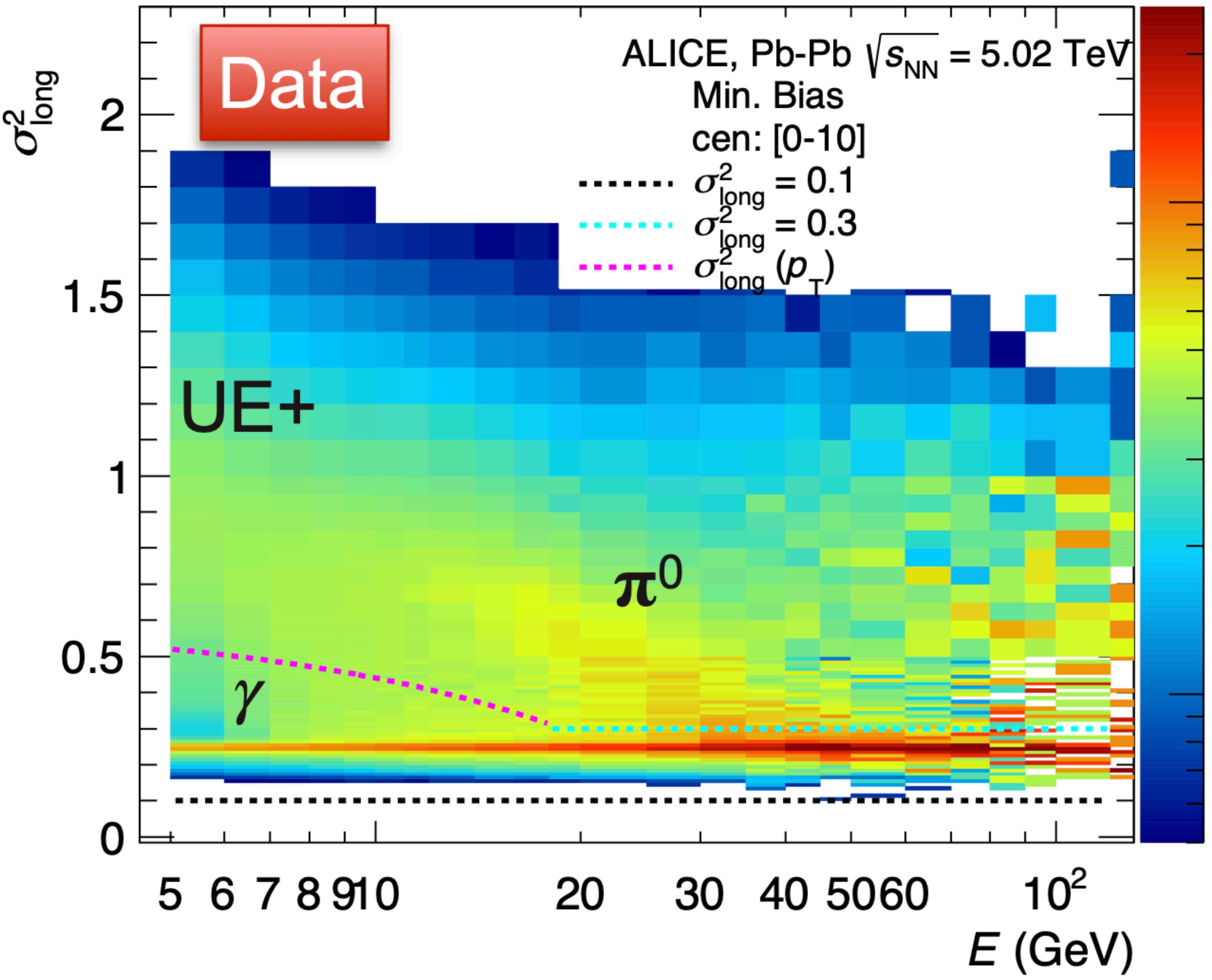
Enhancement of low p_{T} ones

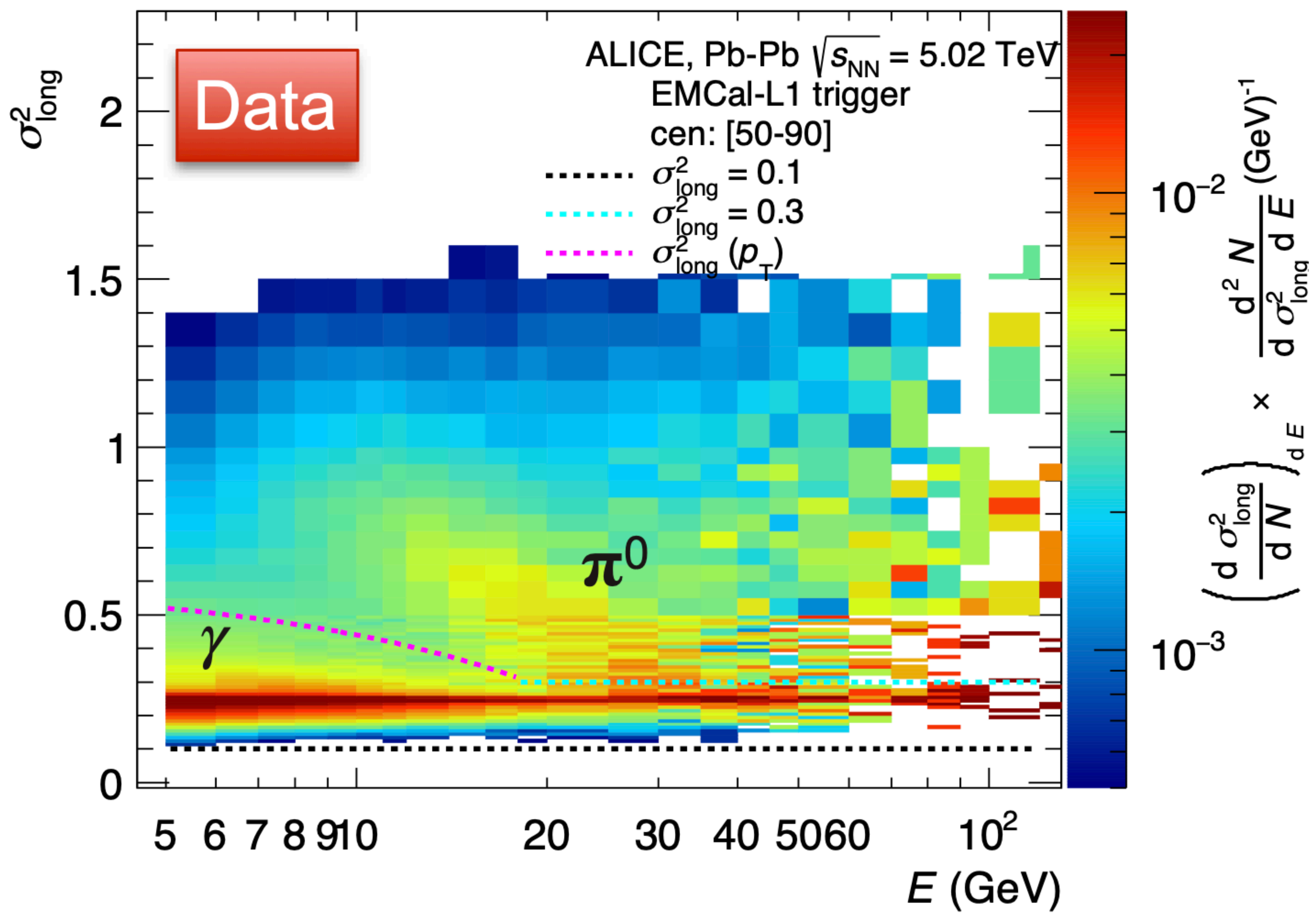
Candidate isolated photons

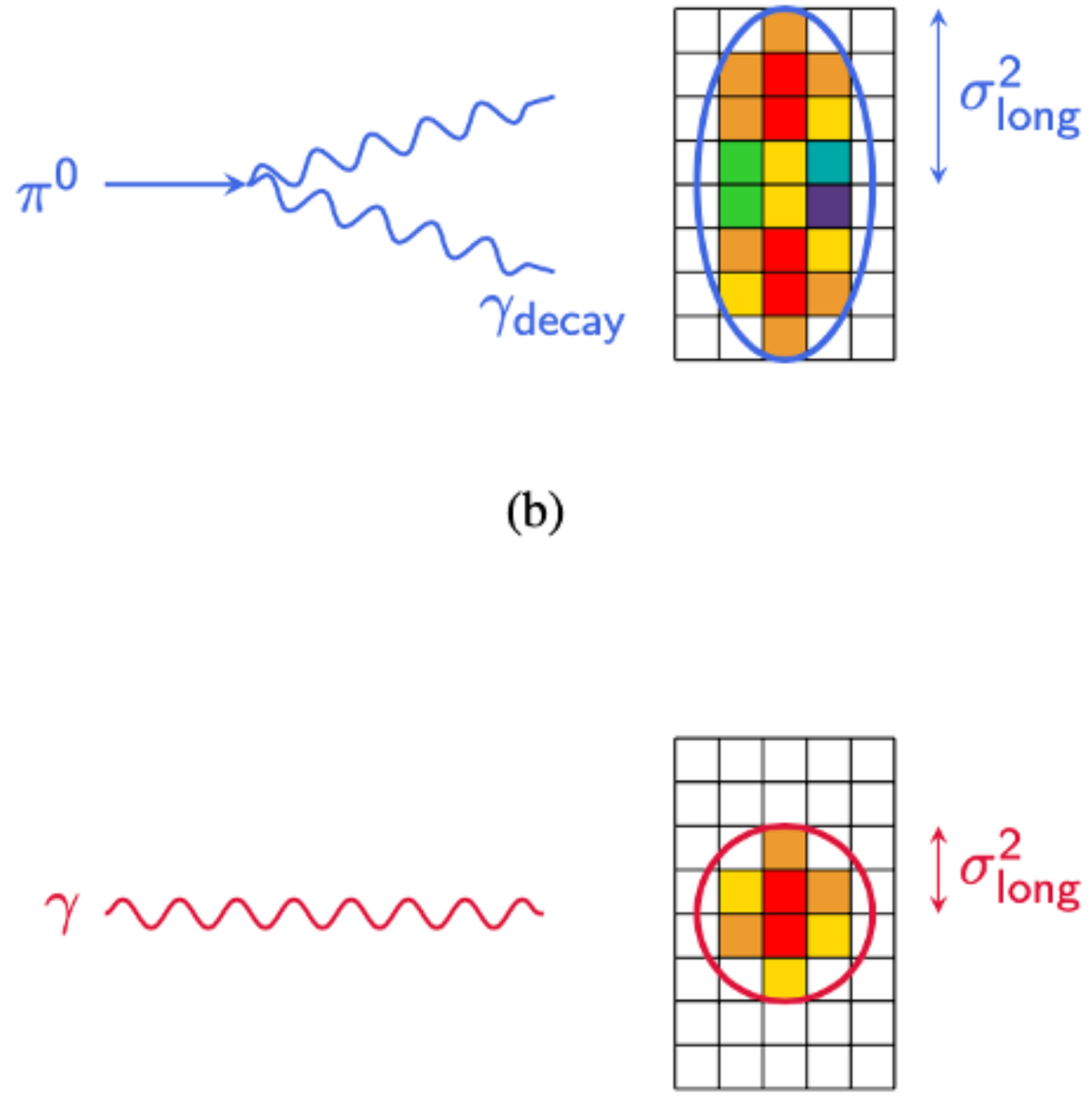
The neutral cluster samples are a mixture of neutral particles.

Photon discrimination with elliptical parametrization: evaluate dispersion of the EM shower.

The semi-major axis σ^2_{long} allows to feature the *type* of photon.







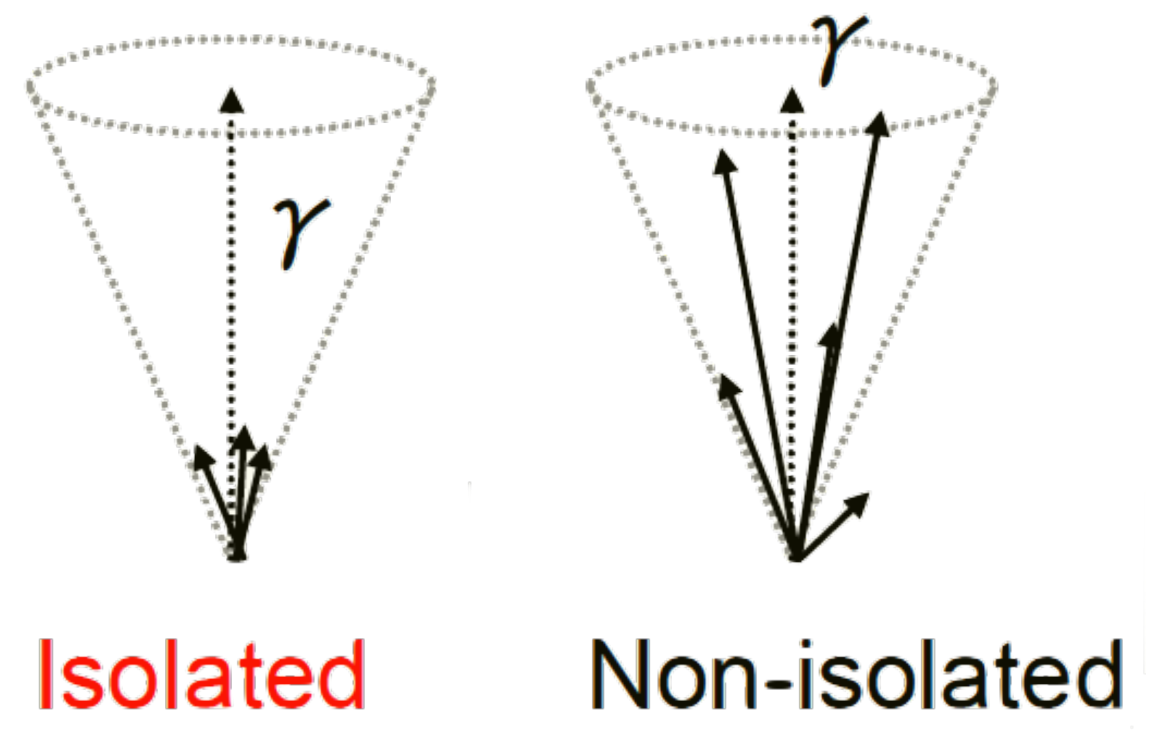
ALICE 2022, Internal, Gustavo's analysis

Isolation method and UE subtraction

Goal: isolate direct photons and reject the largest part of non direct photons

Cone radius around a candidate photon at $(\eta_\gamma, \varphi_\gamma)$:

$$R_{cone} = \sqrt{(\eta - \eta_\gamma)^2 + (\varphi - \varphi_\gamma)^2}$$



In Pb-Pb high multiplicity in final state →subtracting the UE

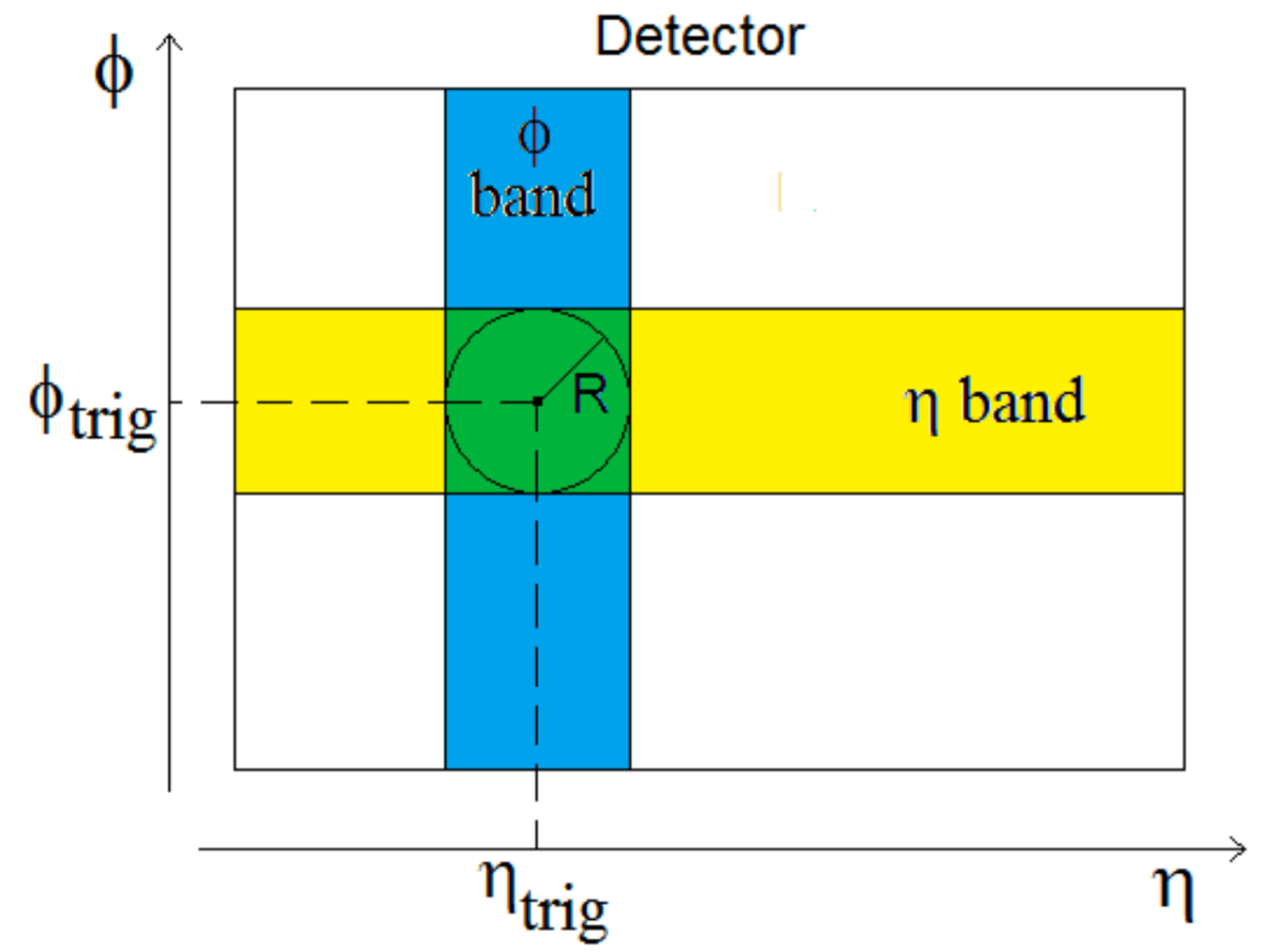
How? METHOD <u>η-φ bands</u>

The contribution of the UE in the cone is ~ $(\Sigma\, p_{\mathrm{T}}^{iso})_{UE} \cdot A_{cone}$

It's removed from the total transverse momentum in the cone

The final condition on p_{T} that defines a isolated γ is :

$$\boxed{\sum_{cone} p_{\mathrm{T}}^{iso} - (\sum_{UE} p_{\mathrm{T}}^{iso})_{in\,cone} = p_{\mathrm{T}}^{iso} < 2\ \mathrm{GeV}/c}$$



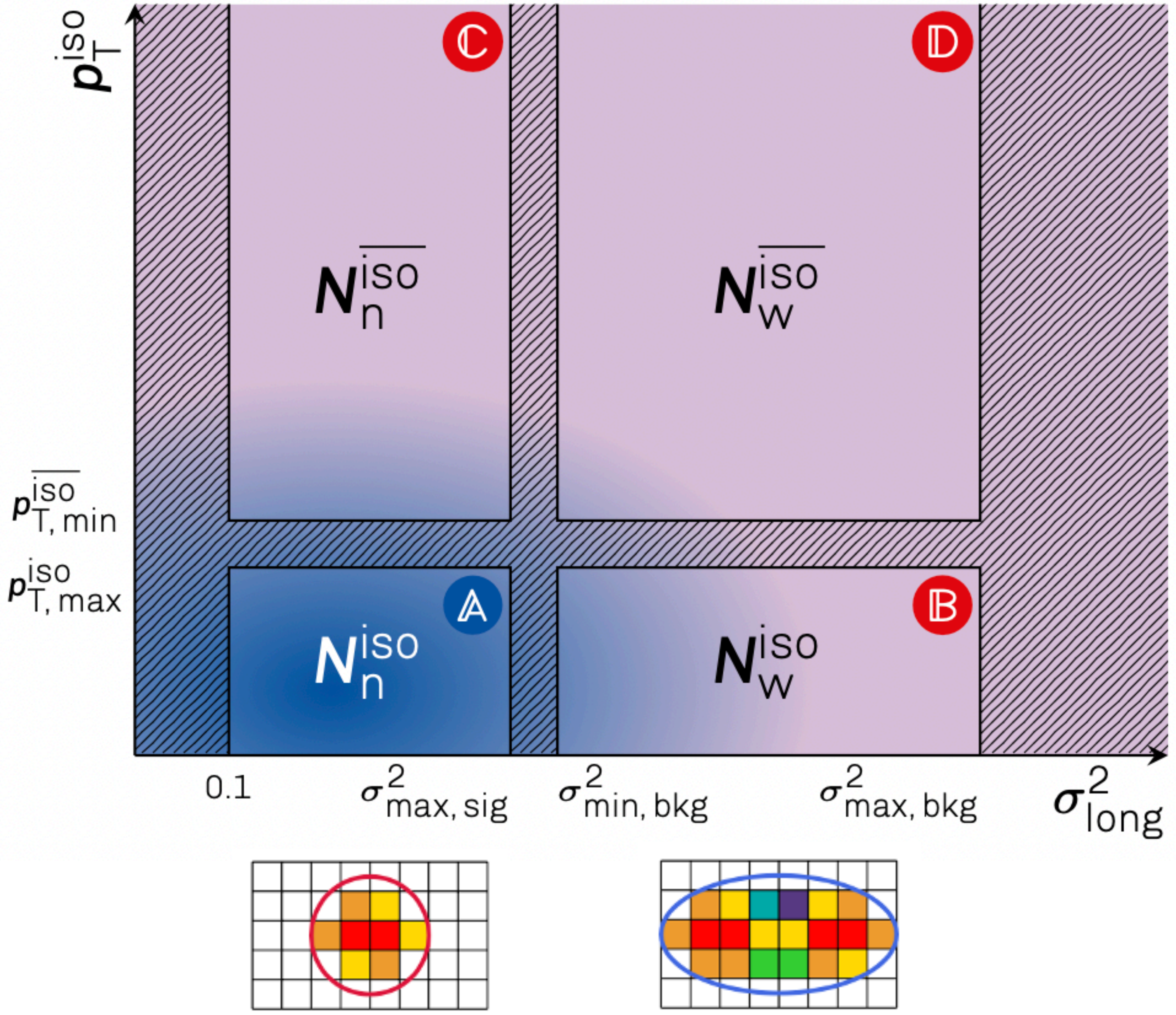
Purity: ABCD method

Divide clusters σ^2_{long}- isolation energy plane into 4 regions ABCD

- A : signal dominated region
- B, C and D : background dominated regions

$\boldsymbol{N} = \boldsymbol{S} + \boldsymbol{B} = \gamma_{direct}$ signal + background

- ***purity*** = ***S/N*** in A region



$$\textit{purity} = \boxed{1 - \left(\frac{N_n^{\overline{iso}} / N_n^{iso}}{N_w^{\overline{iso}} / N_w^{iso}}\right)_{data}} \times \boxed{\left(\frac{B_n^{\overline{iso}} / N_n^{iso}}{N_w^{\overline{iso}} / N_w^{iso}}\right)_{MC}}$$

Data-driven purity

MC correction factor

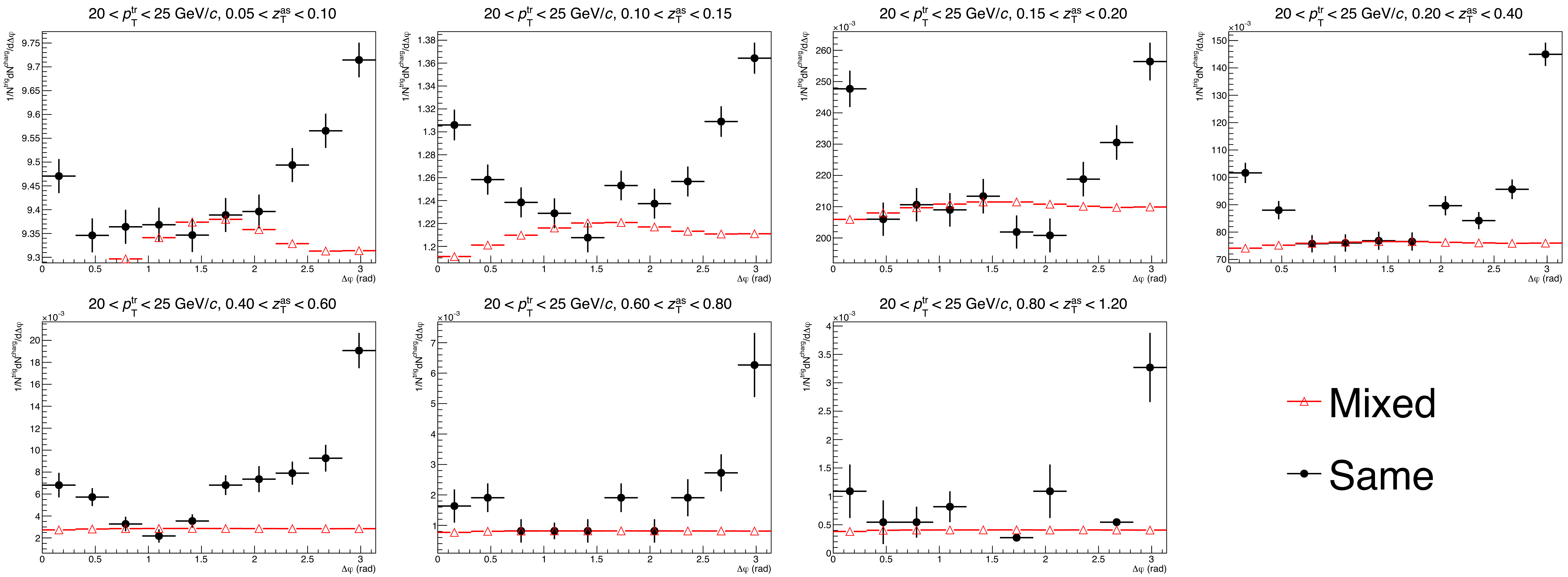
Corrections due to:

B isolation fraction depends on the circularity

S not contained only in A, it spreads over B, C and D regions

UE subtraction, method 1: Mixed Event

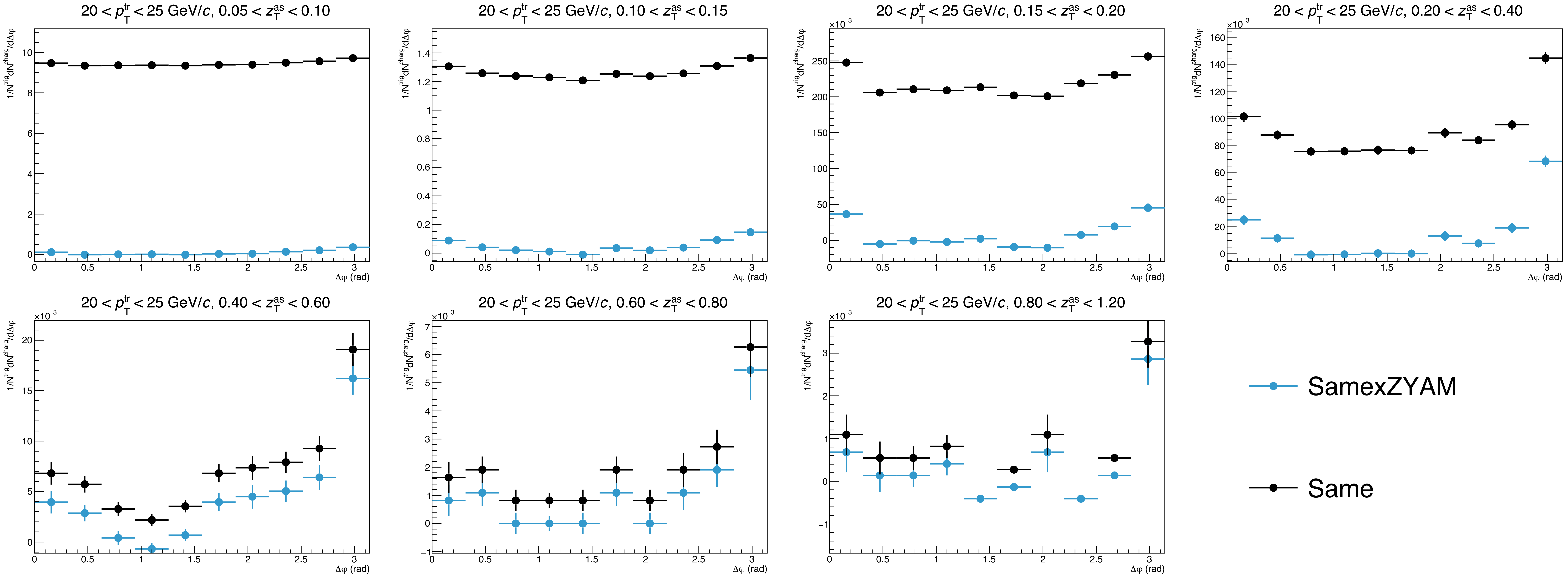
Cent: 30-50%, $20 < p_T^{tr} < 25$ GeV/c, Isolation ON, $0.1 < \sigma^2_{long} < 0.3$



- Mixed event coincides with the uncorrelated of the Same → method works!

UE subtraction, method 2: ZYAM

Cent: 30-50%, 20 < p_T^{tr} < 25 GeV/c, Isolation ON, 0.1 < σ^2_{long} < 0.3

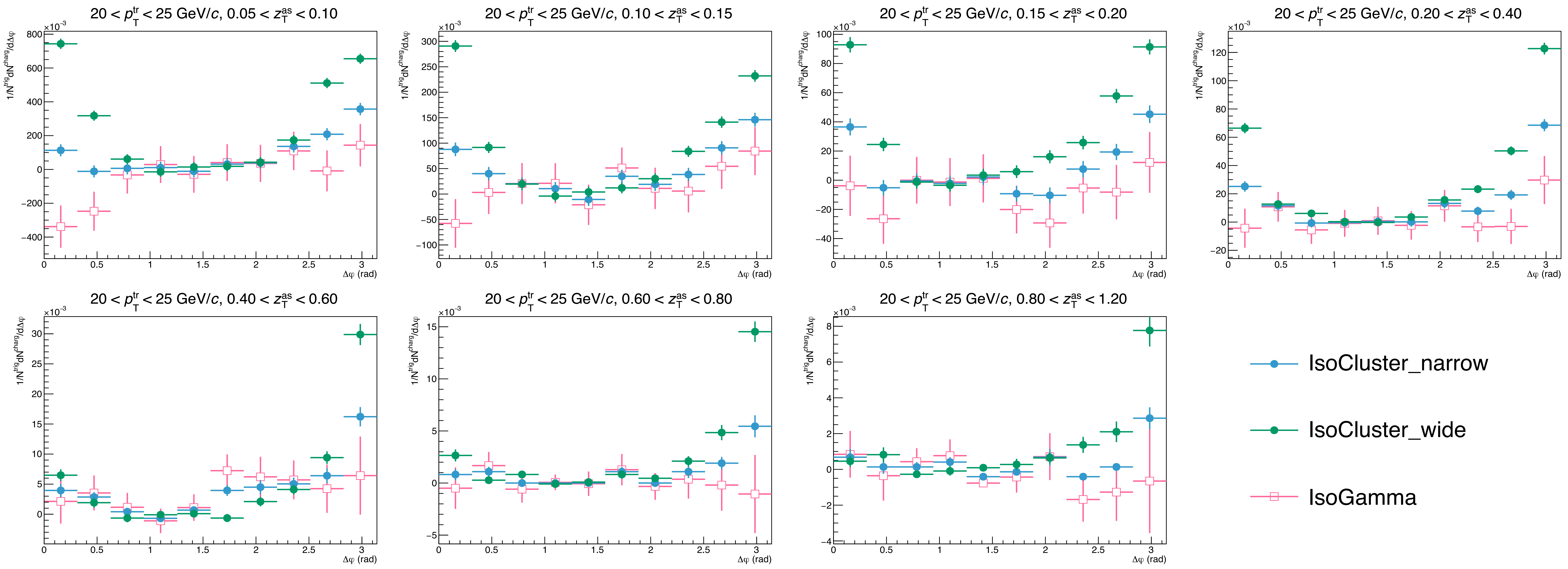


- ZYAM method works!
- It doesn't modify the distributions, but it emerges the predominance of the UE

Purity Correction

$$\text{IsoGamma} = \frac{\text{IsoCluster\_narrow} - (1 - p)\ \text{IsoCluster\_wide}}{p}$$

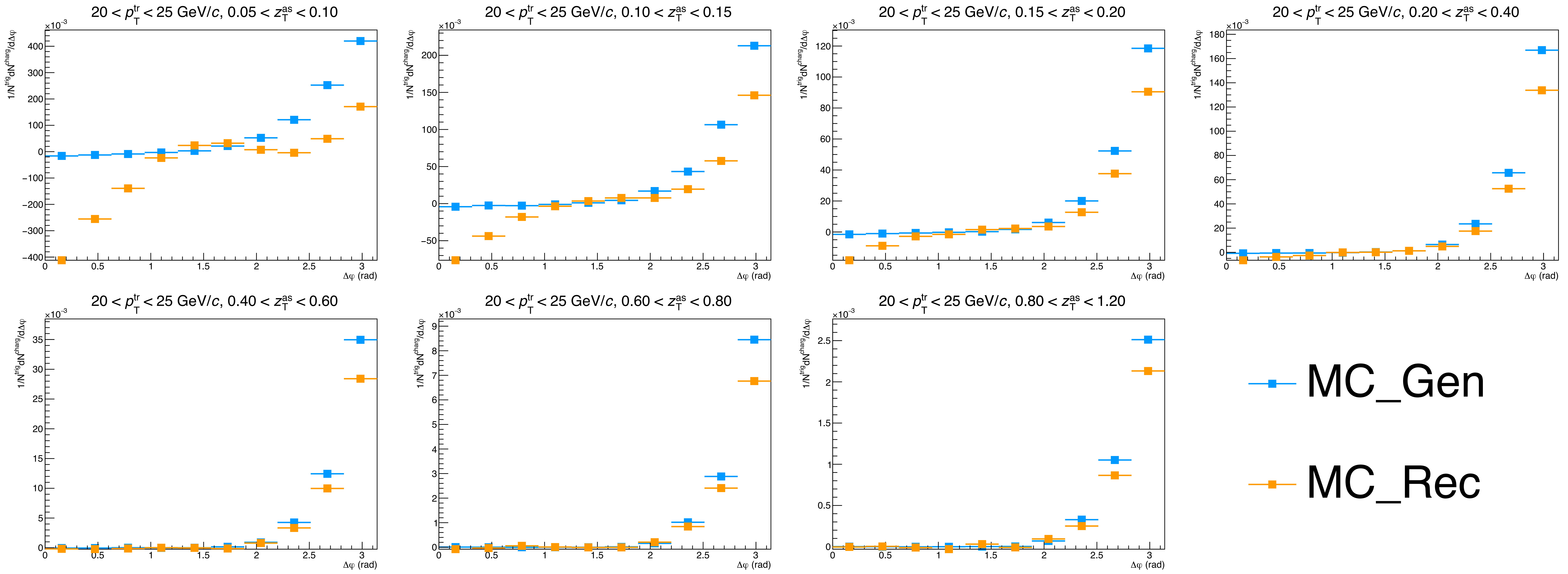
Cent: 30-50%, Isolation ON



- High π^0 contamination, effect on the γ^{iso} azimuthal distribution

Efficiency Correction

Cent: 30-50%, $20 < p_T^{tr} < 25$ GeV/c, Isolation ON, $0.1 < \sigma^2_{long} < 0.3$



- Generated: pure MC of γ^{iso} and of γ^{iso}– hadron correlations
- Reconstructed: *embedding* of MinimumBias (MB) data + pure MC