Jet background fluctuations in TennGen and Angantyr

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1. Abstract

We study the measurements of the background by the ALICE collaboration [1] in TennGen (a data-driven random background generator) and PYTHIA Angantyr simulations of Pb+Pb collisions. The standard deviation of the energy in random cones in TennGen is approximately in agreement with the form predicted in the ALICE paper, with deviations of 1–6%. The standard deviation of energy in random cones in Angantyr exceeds the same predictions by approximately 40%. Deviations in both models can be explained by the assumption that the single particle $d^2N/dydp_T$ is a Gamma distribution in the derivation of the prediction. This indicates that model comparisons are potentially sensitive to the treatment of the background. This work has been submitted for publication [2].

2. Models

No reconstruction efficiency correction in [1]→ parameterized p_T-dependent efficiency roughly matching ALICE efficiency in [3]

2.1 TennGen

For N_{ch} from [4]. Even n ψ_n at $\phi = 0$, odd n at random ϕ.

- Throw random p_T from Blast Wave [5] fit to [6].
- Use that p_T to determine v_n from fits to [7]. v_1 roughly matches [8, 9, 10].
- Throw random ϕ from azimuthal distribution with those v_n.
- Throw random η from flat distribution within $-0.9 < \eta < 0.9$

2.2 PYTHIA Angantyr

PYTHIA Angantyr [11] is a Monte Carlo model for heavy ion collisions included in PYTHIA 8[11, 12].

- superposition of nucleon-nucleon collisions and including inelastic collisions, single-diffractive, double-diffractive, and absorptive collisions w/fluctuating radii
- No flow, no jet quenching
- Used with default parameters, $20 \cdot 10^3$ min bias 2.76 TeV Pb+Pb collisions, 200 GeV Au+Au collisions.
- Used the centrality class implemented in Rivet [13]

3. Background density ρ

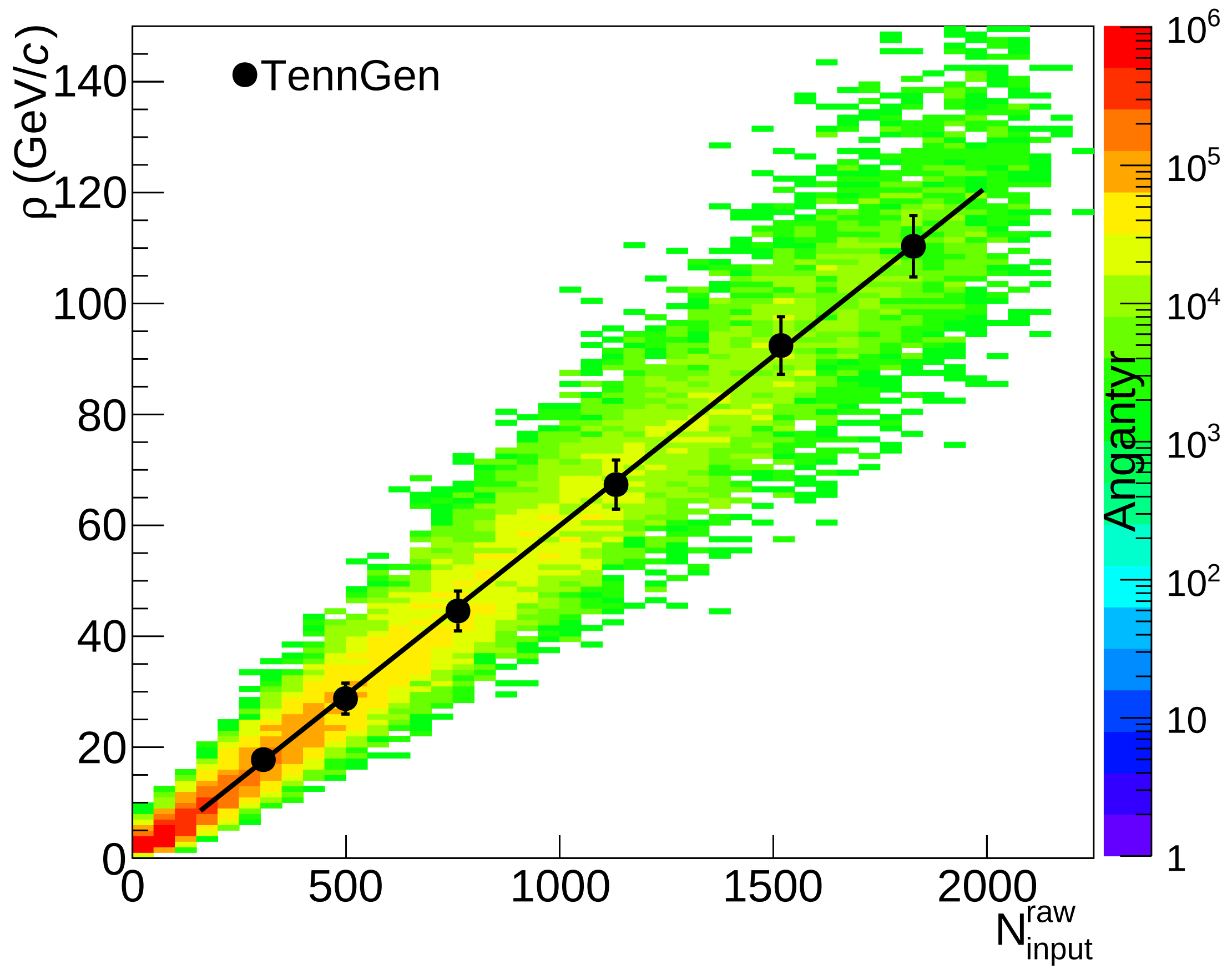

Figure 1: *Median event by event ρ vs. N^{raw}_{input} for TennGen and Angantyr Pb+Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV. The line is from the fit of a straight line to Angantyr.*

- Run k_T jet finder
- For Angantyr, throw out two leading jet candidates
- Find median p/A

4. $\delta p_T = p_T^{reco} - A_{cone}\rho$ width distribution

- Assume Gamma distribution $\frac{d^2N}{dydp_T} \propto \frac{k}{\Gamma(p)}(kp_T)^{p-1}e^{-kp_T}$ [14, 1]
- Fit δp_T distribution in fig. 2 → width.
- No flow:

$$\sigma_{\delta p_T} = \sqrt{N\sigma^2_{p_T} + N\langle p_T\rangle^2}. \tag{1}$$

- With flow:

$$\sigma_{\delta p_T} = \sqrt{N\sigma^2_{p_T} + (N + N^2\sum_{n=1}^{\infty} v_n^2)\langle p_T\rangle^2}. \tag{2}$$

assuming v_n constant and uncorrelated with each other.

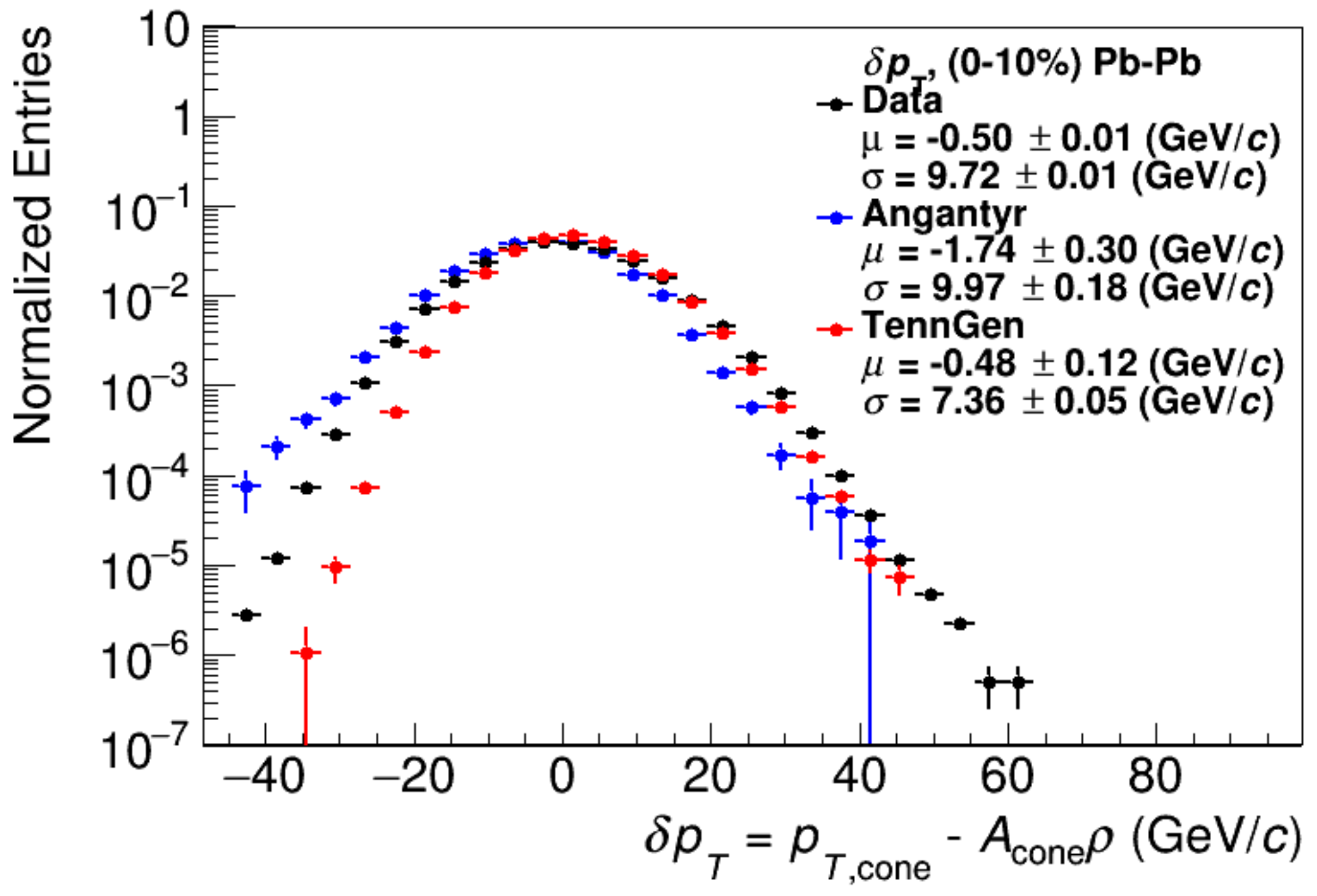

Figure 2: *Comparison of TennGen and Angantyr to 0–10% central Pb+Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV data from [1].*

5. δp_T Widths

5.1 TennGen

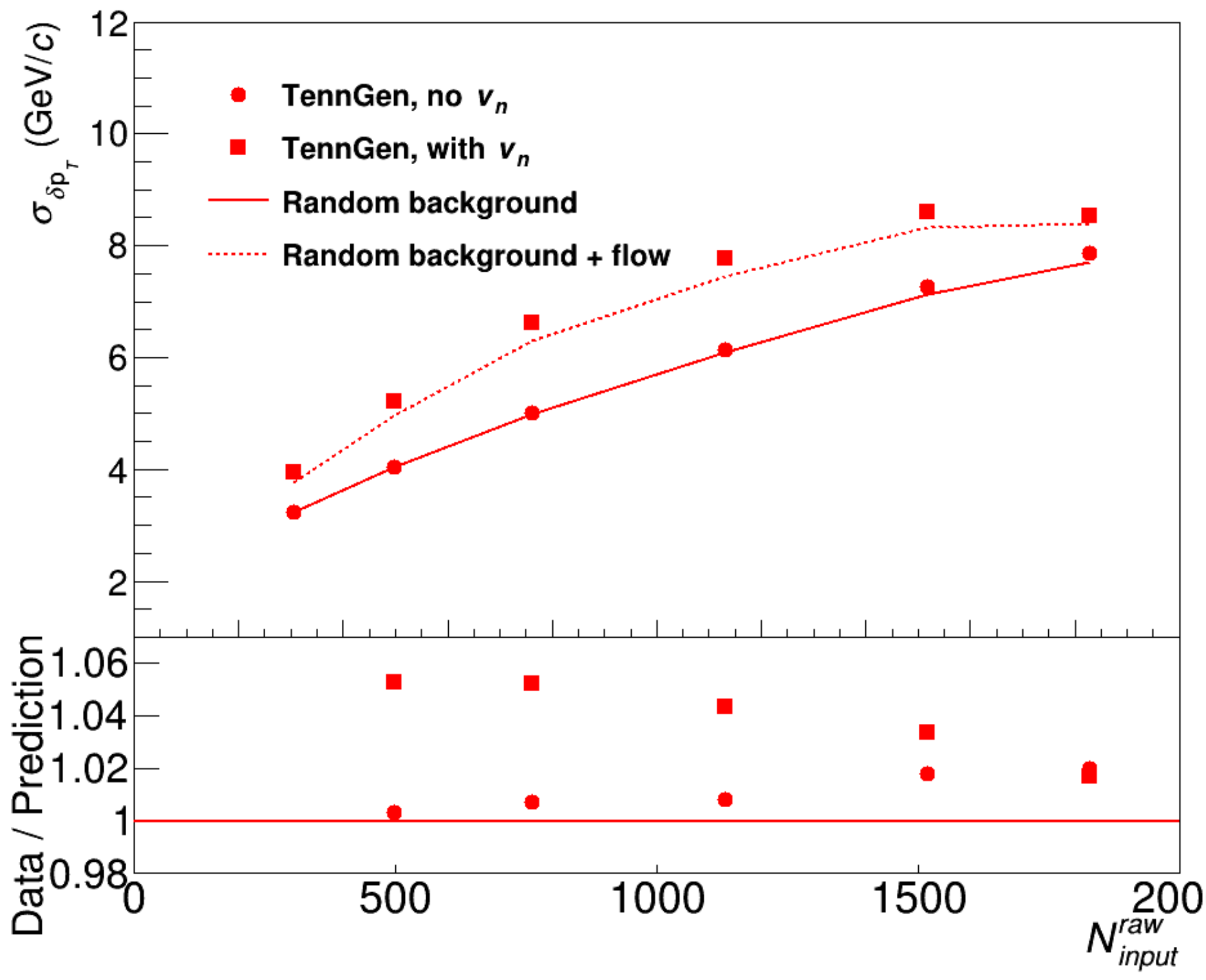

Figure 3: *Comparison of the δp_T distribution's width in TennGen with v_n =0 compared to eq. 1 and non-zero v_n compared to eq. 2.*

- Deviations of 1–2% without flow due to deviations in $\frac{d^2N}{dydp_T}$ from Gamma distribution.
- Deviations of up to 6% due to momentum dependence of flow, correlations between different terms.

5.2 Angantyr

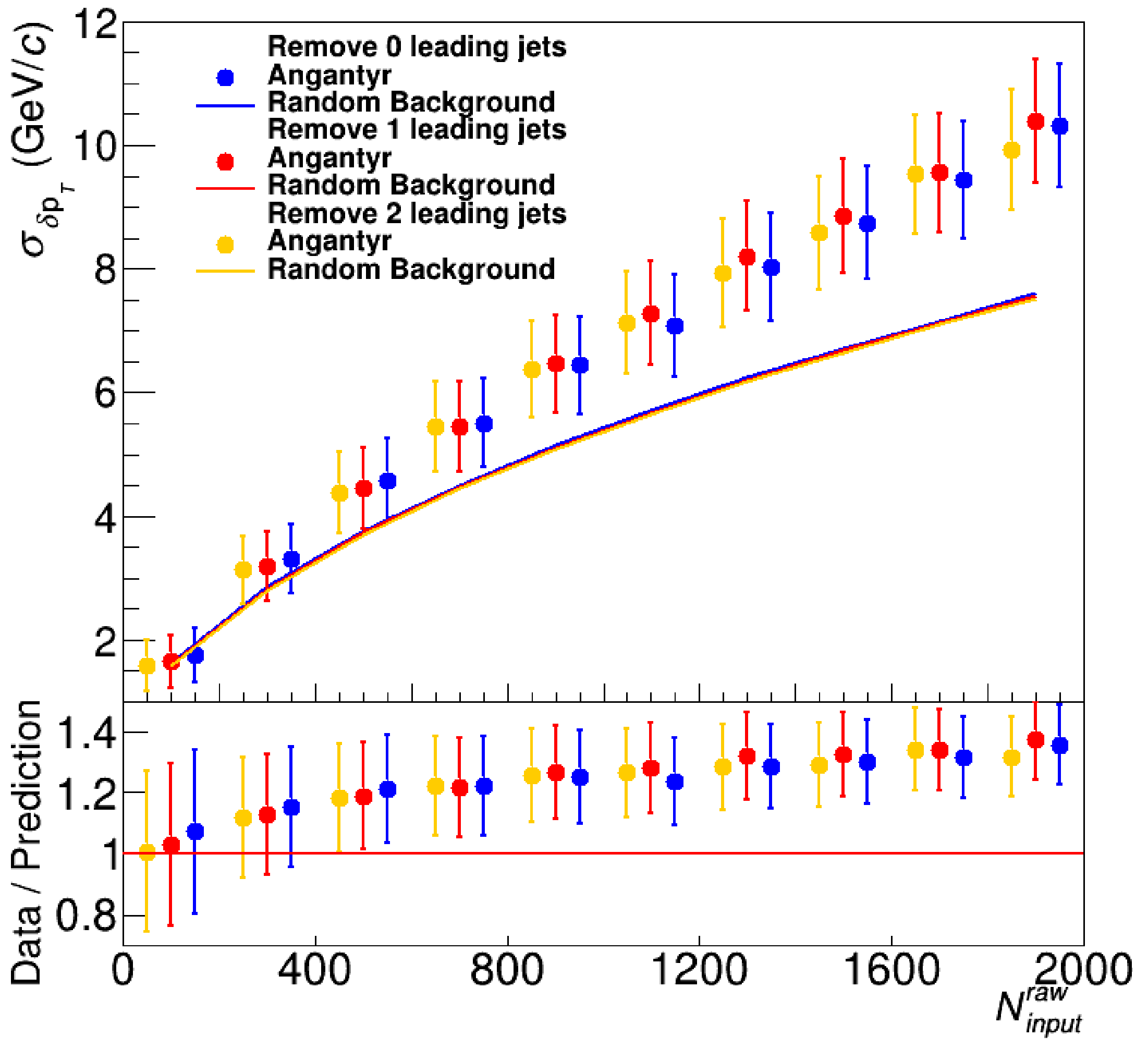

Figure 4: *Comparison of the δp_T distribution's width in Angantyr for Pb+Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV with eq. 1 with zero, one, and two leading jets omitted from the sample.*

- Up to 40% deviations from random distribution predicted by eq. 1.
- Not significantly reduced by excluding jets

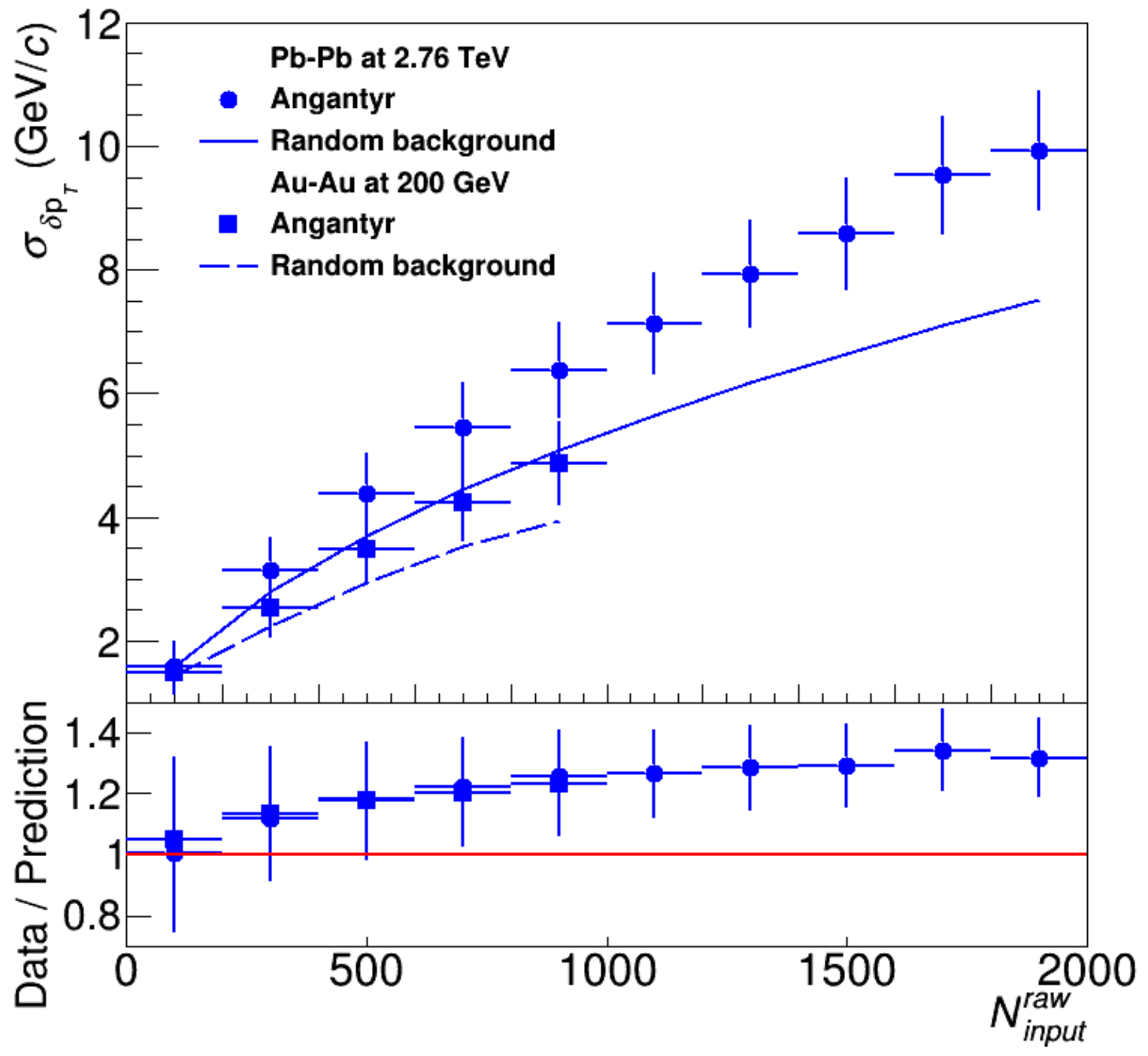

Figure 5: *Comparison of the δp_T distribution's width in Angantyr for Au+Au collisions at $\sqrt{s_{\rm NN}}$ = 200 GeV and Pb+Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV compared to eq. 1.*

- Fewer jets expected at RHIC energies
- Little collision energy dependence → deviations not likely from jets!

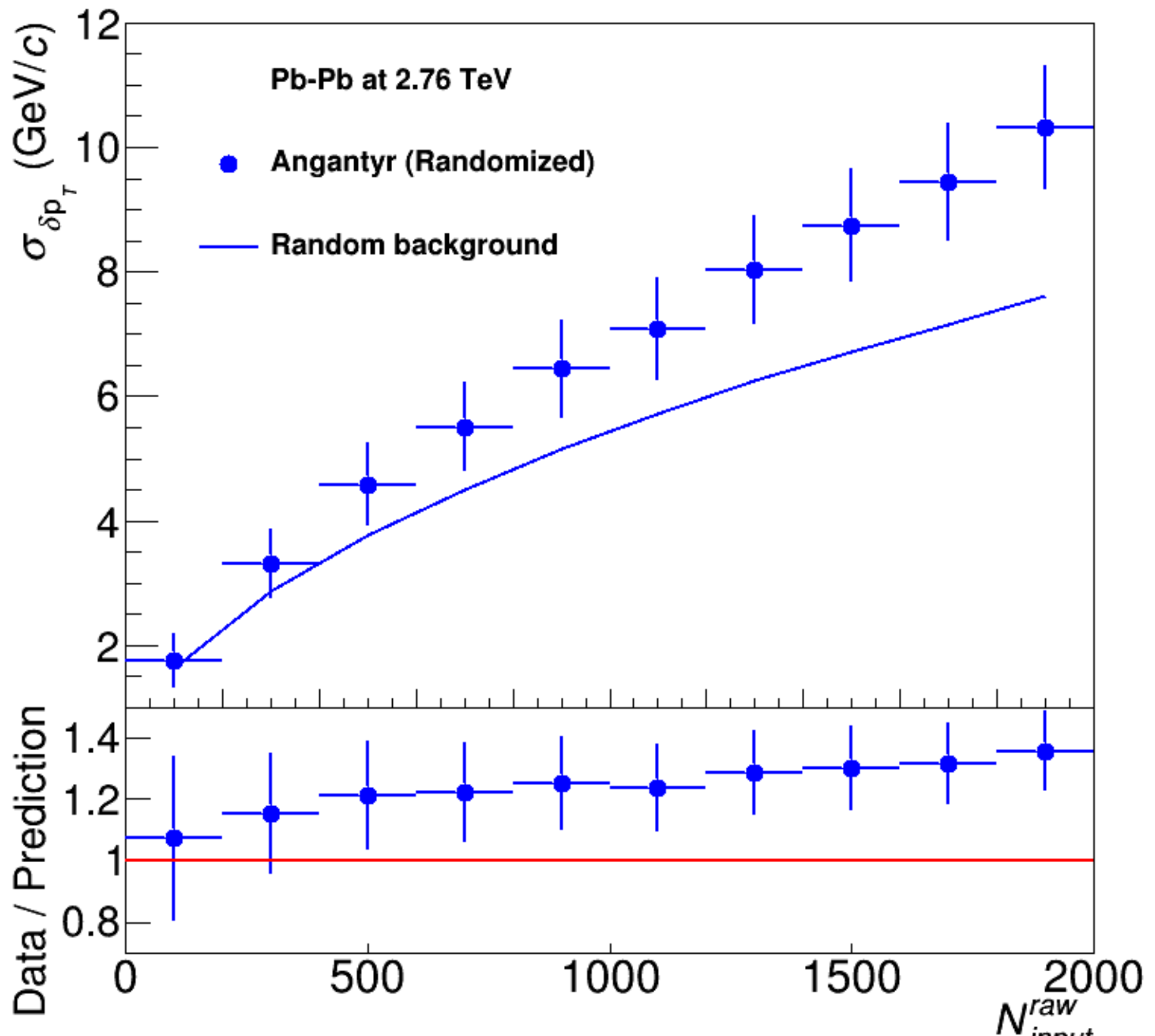

Figure 6: *Comparison of the δp_T distribution's width in Angantyr for Pb+Pb collisions at $\sqrt{s_{\rm NN}}$ = 2.76 TeV with tracks with randomized azimuthal angles compared to eq. 1.*

- Deviations persist when correlations broken by randomly distributing particles → caused by deviations of spectrum from Gamma distribution.

6. Conclusions

- These studies broadly support conclusions in [1] that background is dominantly random fluctuations.
- Effects of up to 6% from shape of the spectrum, flow modulations
- Flow, spectral shape can lead to large deviations from eq. 1, 2in models
- Important to implement background subtraction technique applied in data to models → See "Implementation of heavy ion measurements in Rivet [15]!"

7. Acknowledgements

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