Jet Shape Observables

Fabio de Moraes Canedo

Jet Shape Observables

- Anti-k_t algorithm
- Jet Quenching
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Recombinantion algorithm IRC-safe defined through the distance in the equqations below for *p=-1.* Essentially the minimum is found of both quantities and then the pair that satisfies it is combined until all distances are above some cut-off.

$$d_{ij} = \min(k_{ti}^{2p}, k_{tj}^{2p}) \frac{\Delta_{ij}^2}{R^2}$$

$$d_{iB} = k_{ti}^{2p}$$

The angular distance is defined by:

$$\Delta_{ij}^2 = (y_i - y_j)^2 + (\phi_i - \phi_j)^2$$

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The algorithm is described by the steps:

1) Take the minimum between the d_{ij} and d_{iB};
2) If the minimum is larger than d_{cut}, stop algorithm;
3) If it is of the first type, cluster the particles together, else, declare the i particle to be part of the beam jet, repeat first step;

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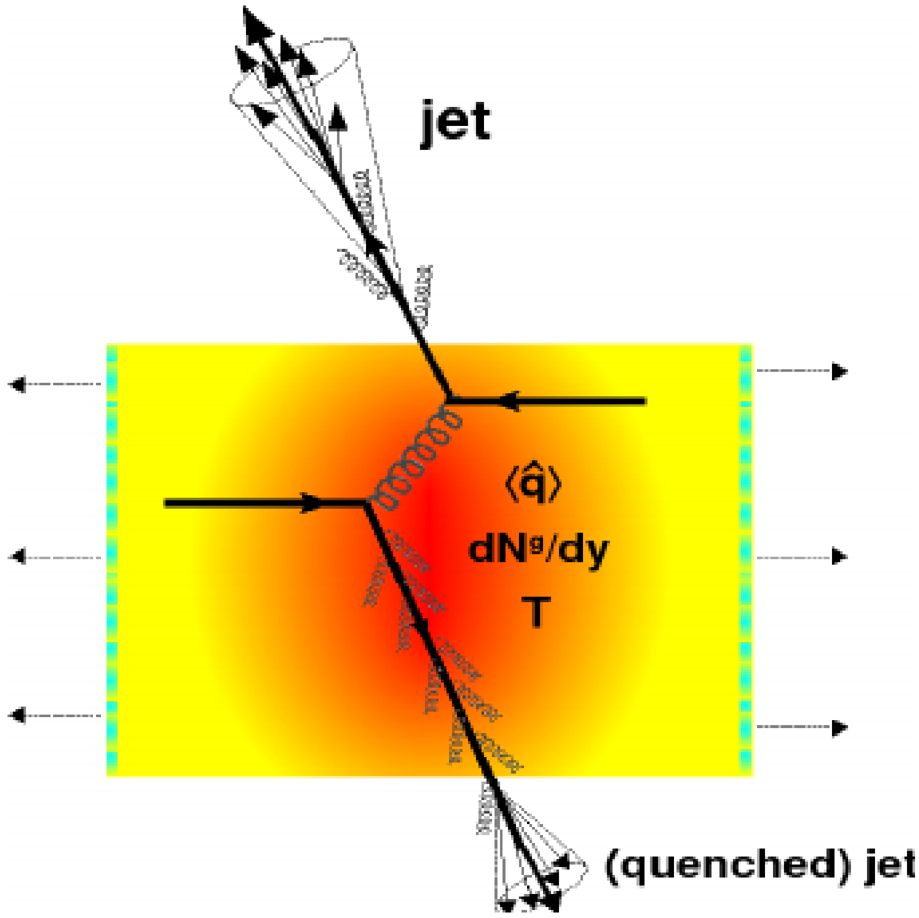
Defined as the effects of partons traversing the hot QGP



d‘ Enterria, D. & Betz, B. High-pT Hadron Suppression and Jet Quenching. in Lecture Notes in Physics 785, 285–339 (2009).

Jet Shape Observables

The energy loss of jets can happen through radiation and collisional processes. The former is described by a parton shower that can be be described probabilistically by the so called Sudakov form factor:

$$\mathcal{S}_a(t_\mathrm{h}, t_\mathrm{c}) = \exp\left\{ - \int\limits_{t_\mathrm{c}}^{t_\mathrm{h}} \frac{\mathrm{d}t}{t} \int\limits_{z_\mathrm{min}}^{z_\mathrm{max}} \mathrm{d}z \sum_b \frac{\alpha_\mathrm{s}(k_\perp^2)}{2\pi} \hat{P}_{ba}(z) \right\}$$

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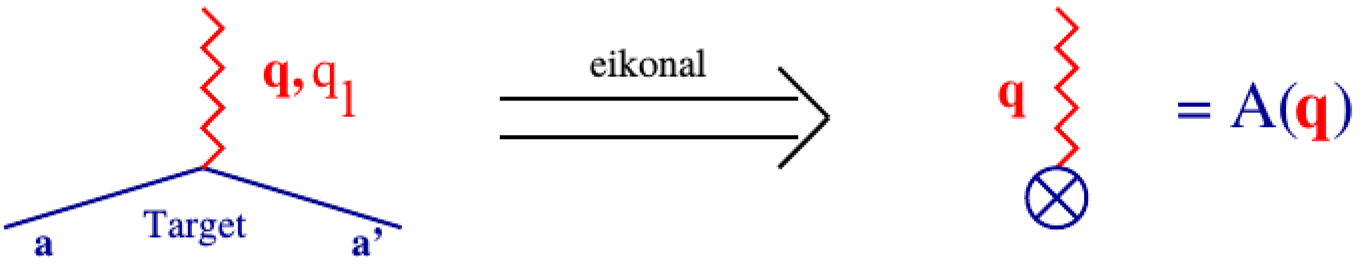
The collisional part can be modelled through the assumption that the parton sees the medium as an ensemble of targets



Collisions might stimulate radiation due to enlargement of available phase space.

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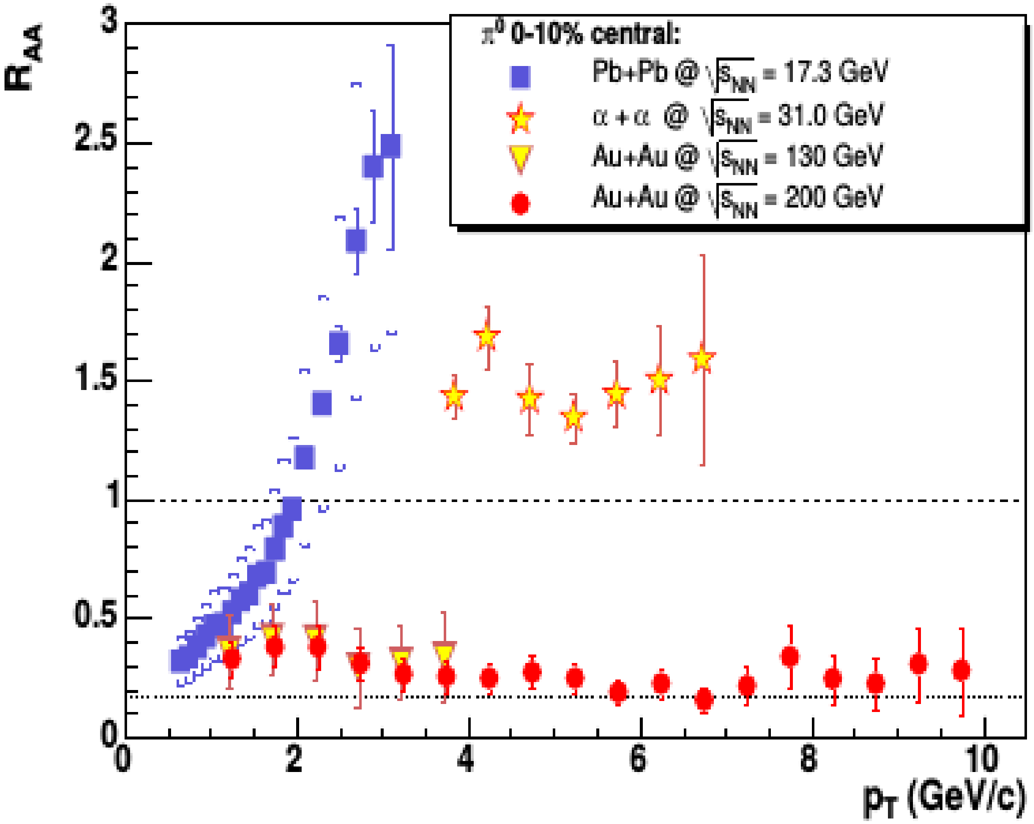
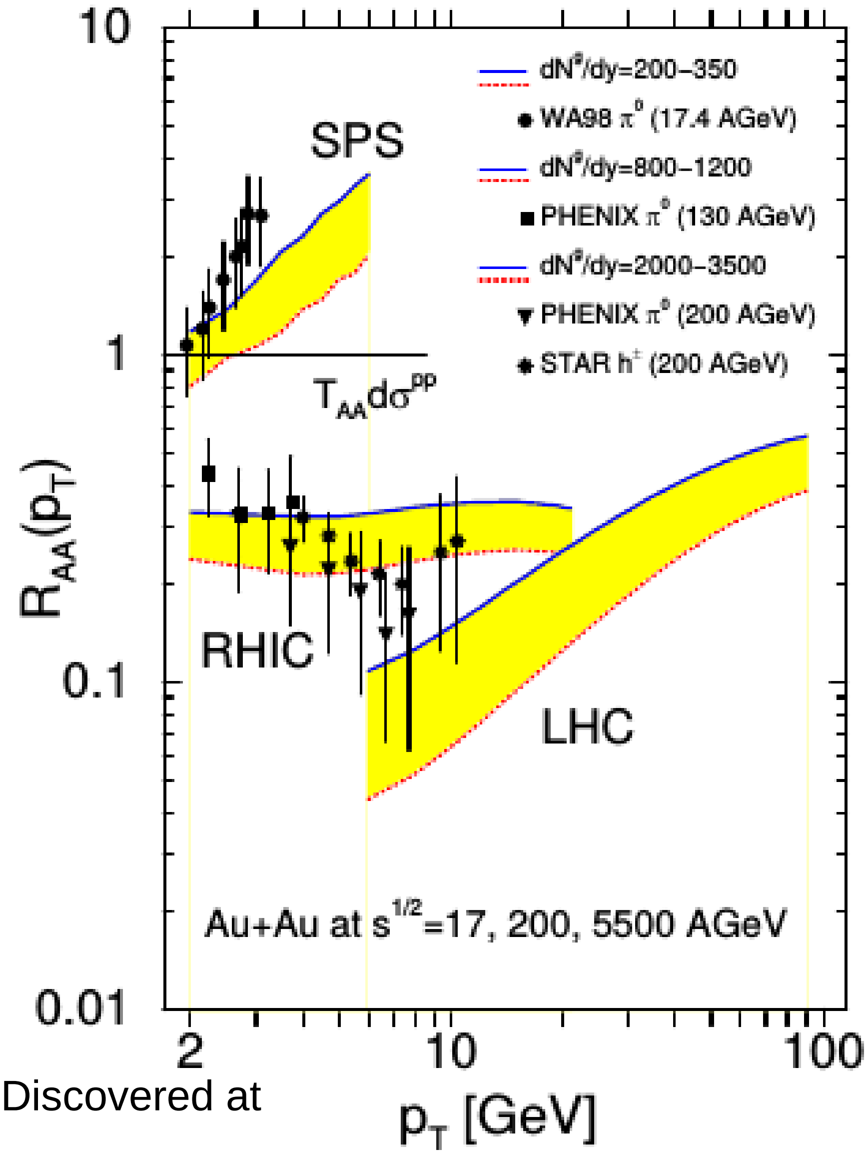
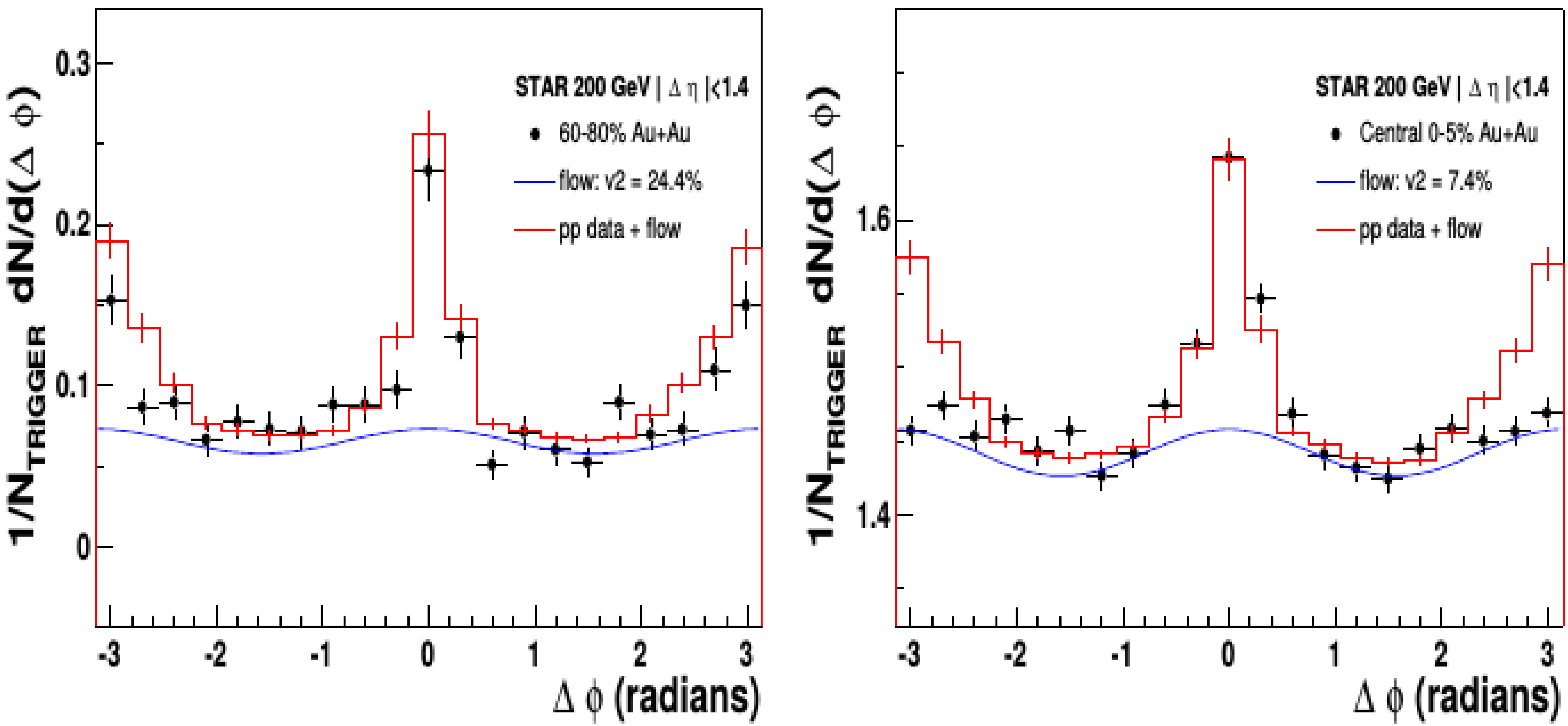




Gyulassy, M. & McLerran, L. New Forms of QCD Matter Discovered at RHIC. Nuclear Physics A 750, 30–63 (2005).

Jet Quenching



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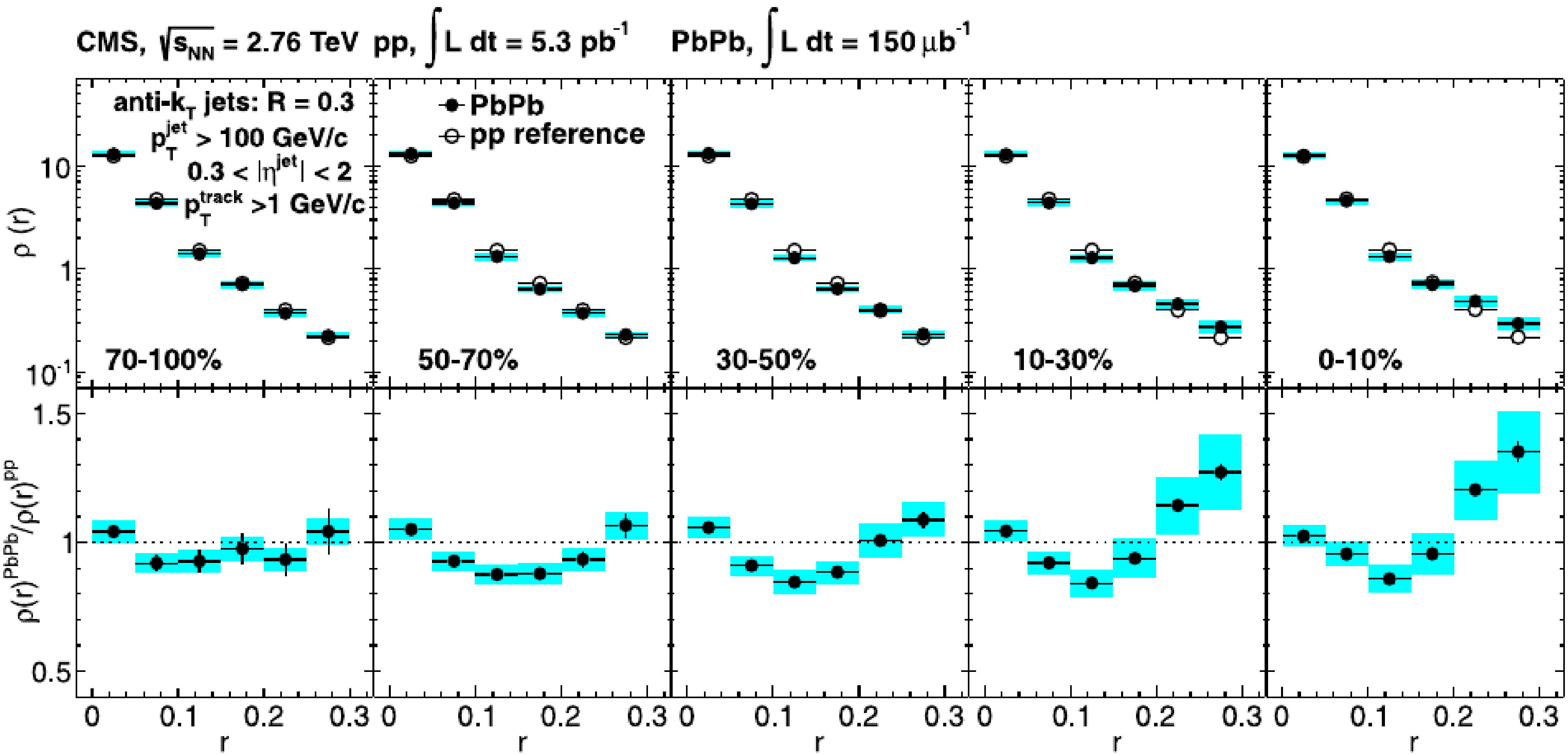
The radial distribution of jet's transverse moment is defined by:

$$\rho(r) = \frac{1}{p_\perp^{\text{jet}}} \sum_{\substack{k \text{ with} \\ \Delta R_{kJ} \in [r, r+\delta r]}} p_\perp^{(k)}$$

Chatrchyan, S. et al. Modification of jet shapes in PbPb collisions at sNN=2.76 TeV. Physics Letters B 730, 243–263 (2014).

Jet Shape Observables



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Jet Shape Observables

The girth, or angularity is defined by:

$$g = \sum_i \frac{p_{\mathrm{T,i}}}{p_{\mathrm{T,jet}}} |\Delta R_i|$$

It is an observable sensitive to jet radial energy profile.

Larkoski, A. J., Thaler, J. & Waalewijn, W. J. Gaining (Mutual) Information about Quark/Gluon Discrimination. Journal of High Energy Physics 2014, (2014).

Elayavalli, R. K. & Zapp, K. C. Medium response in JEWEL and its impact on jet shape observables in heavy ion collisions. Journal of High Energy Physics 2017, (2017).

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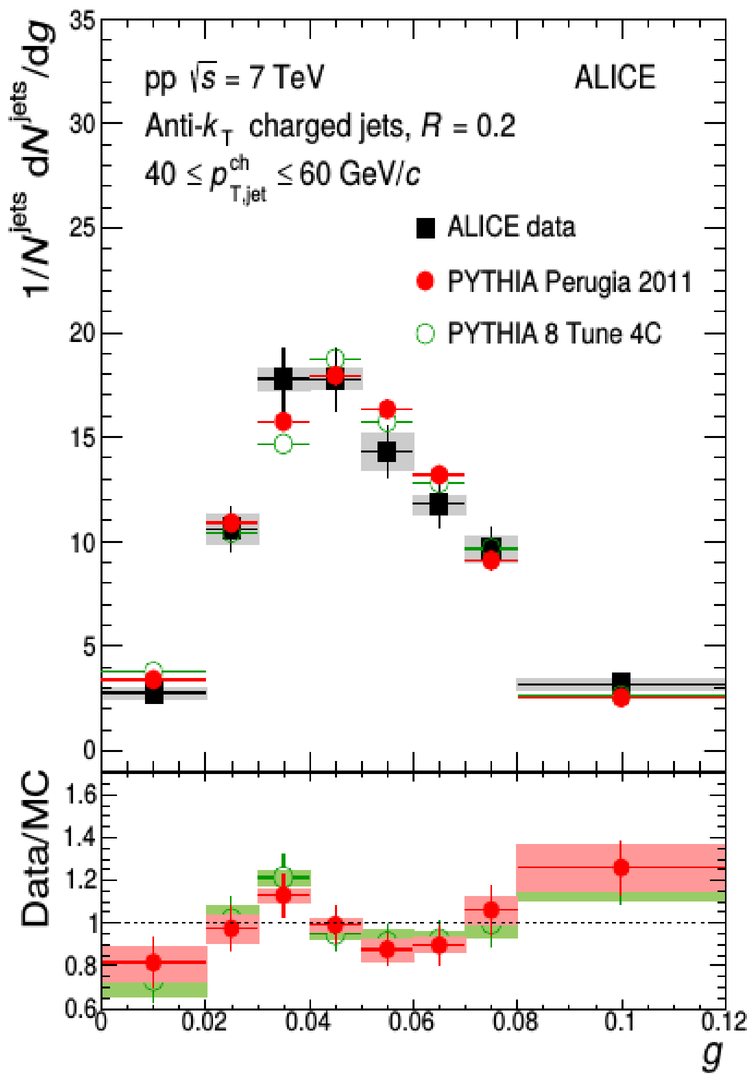

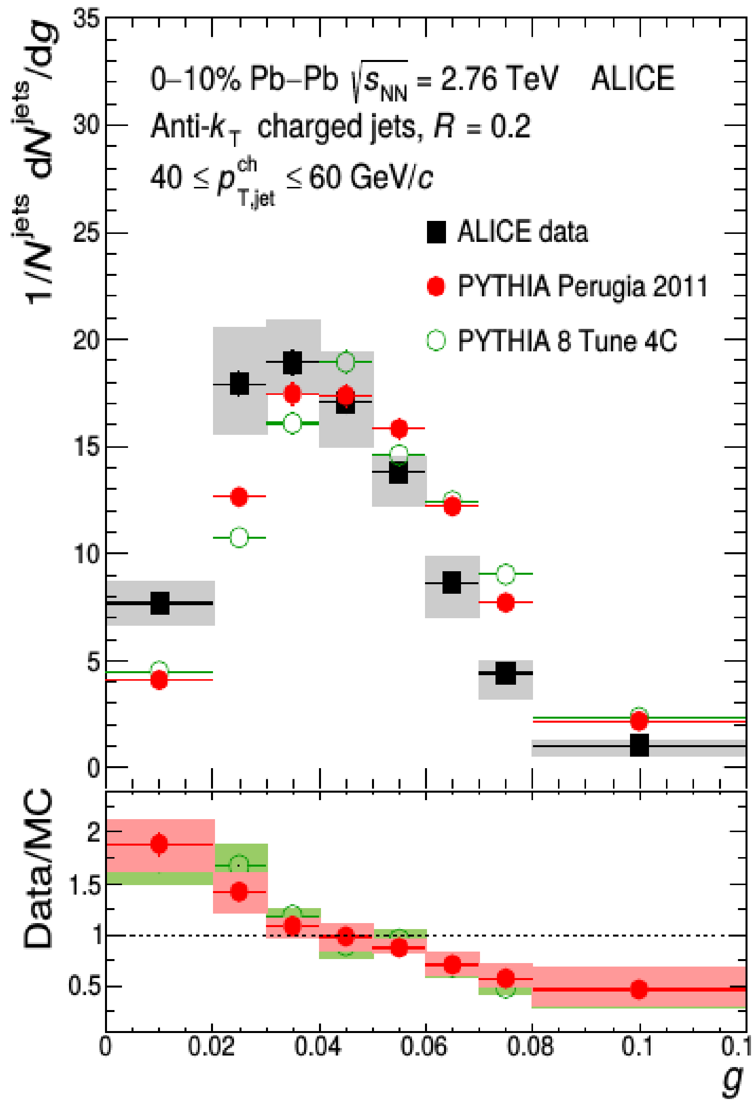

ALICE Collaboration. Medium modification of the shape of small-radius jets in central Pb-Pb collisions at $\sqrt{s_{\mathrm {NN}}} = 2.76\,\rm{TeV}$. arXiv:1807.06854 [hep-ex, physics:nucl-ex] (2018).

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Momentum dispersion is defined as:

$$p_{\mathrm{T}}^{\mathrm{D}} = \frac{\sqrt{\sum_i p_{\mathrm{T,i}}^2}}{\sum_i p_{\mathrm{T,i}}}$$

Connected to how hard or soft a fragmentation is. Few constituents on a jet carrying large fraction of its momentum brings it closer to 1. Otherwise it goes to 0.

Larkoski, A. J., Thaler, J. & Waalewijn, W. J. Gaining (Mutual) Information about Quark/Gluon Discrimination. Journal of High Energy Physics 2014, (2014).

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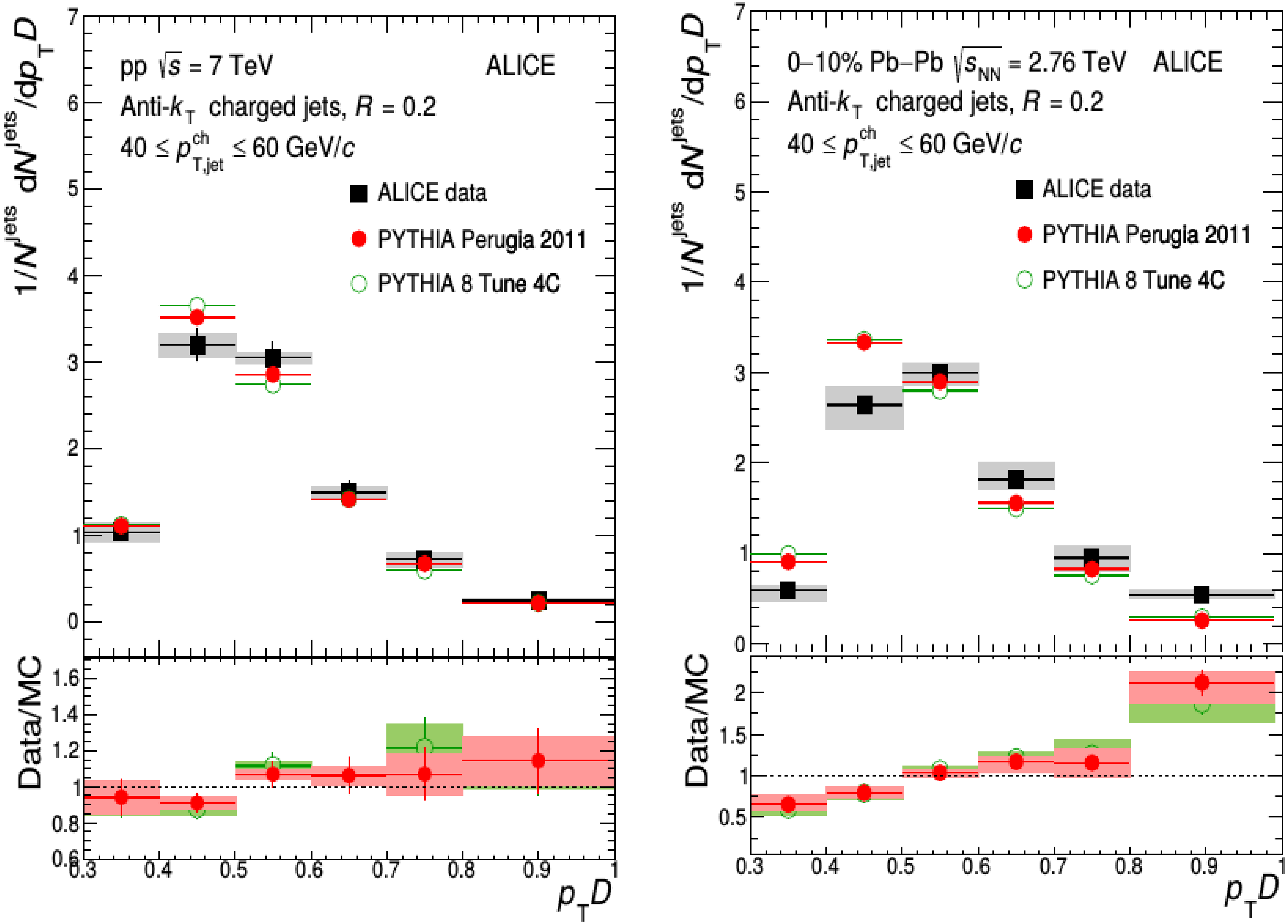

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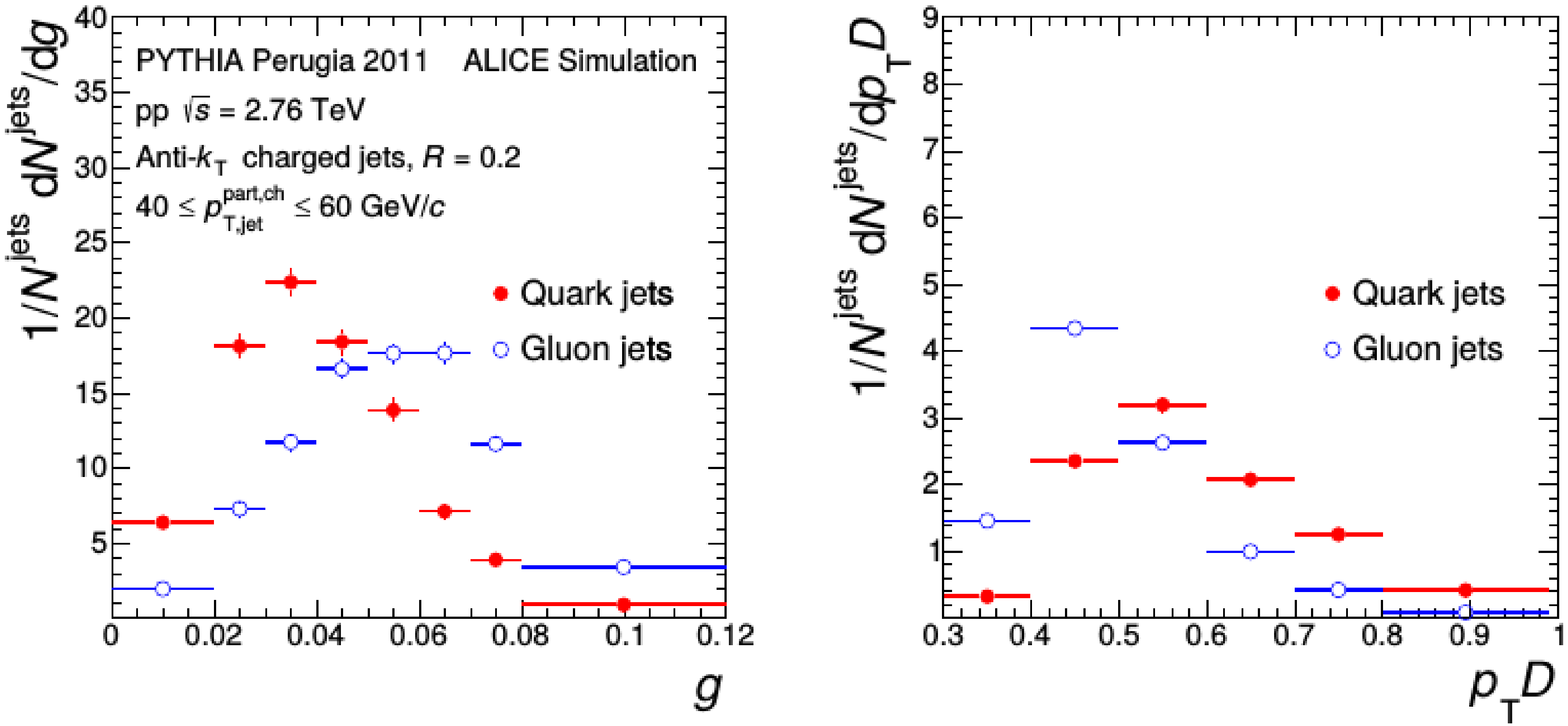

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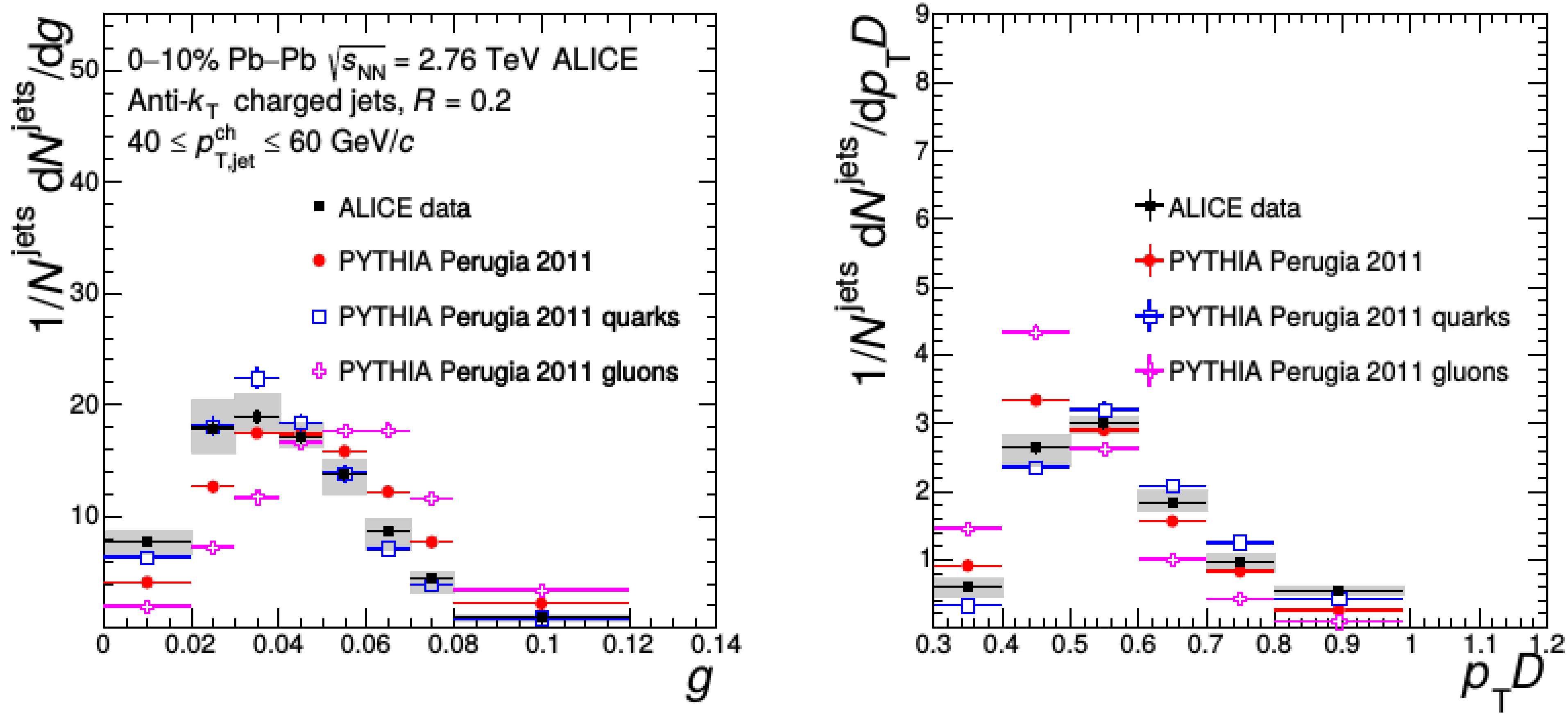

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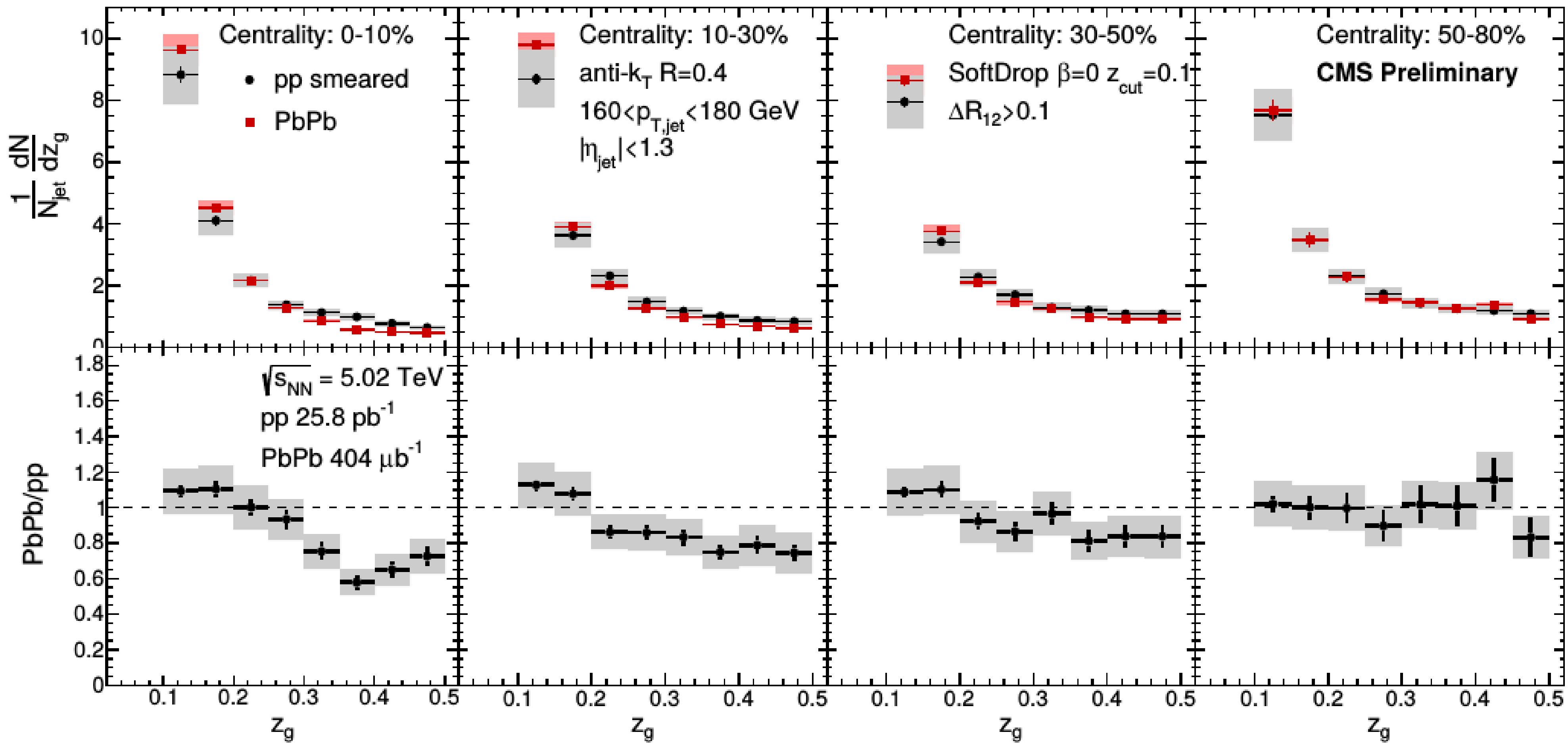
Jet Shape Observables

Groomed shared momentum fraction is related to the first splitting of a parton. In the pp case it is well described by Altarelli-Parisi splitting functions.

$$z_g = \frac{\min(p_{\perp,1}, p_{\perp,2})}{p_{\perp,1} + p_{\perp,2}} > z_{\mathrm{cut}} \left(\frac{\Delta R_{1,2}}{R_J} \right)^{\beta}$$

Larkoski, A. J., Marzani, S. & Thaler, J. Sudakov Safety in Perturbative QCD. Physical Review D 91, (2015).

Jet Shape Observables



Splitting function in pp and PbPb collisions at 5.02 TeV - CERN Document Server. Available at: https://cds.cern.ch/record/2201026?ln=en.

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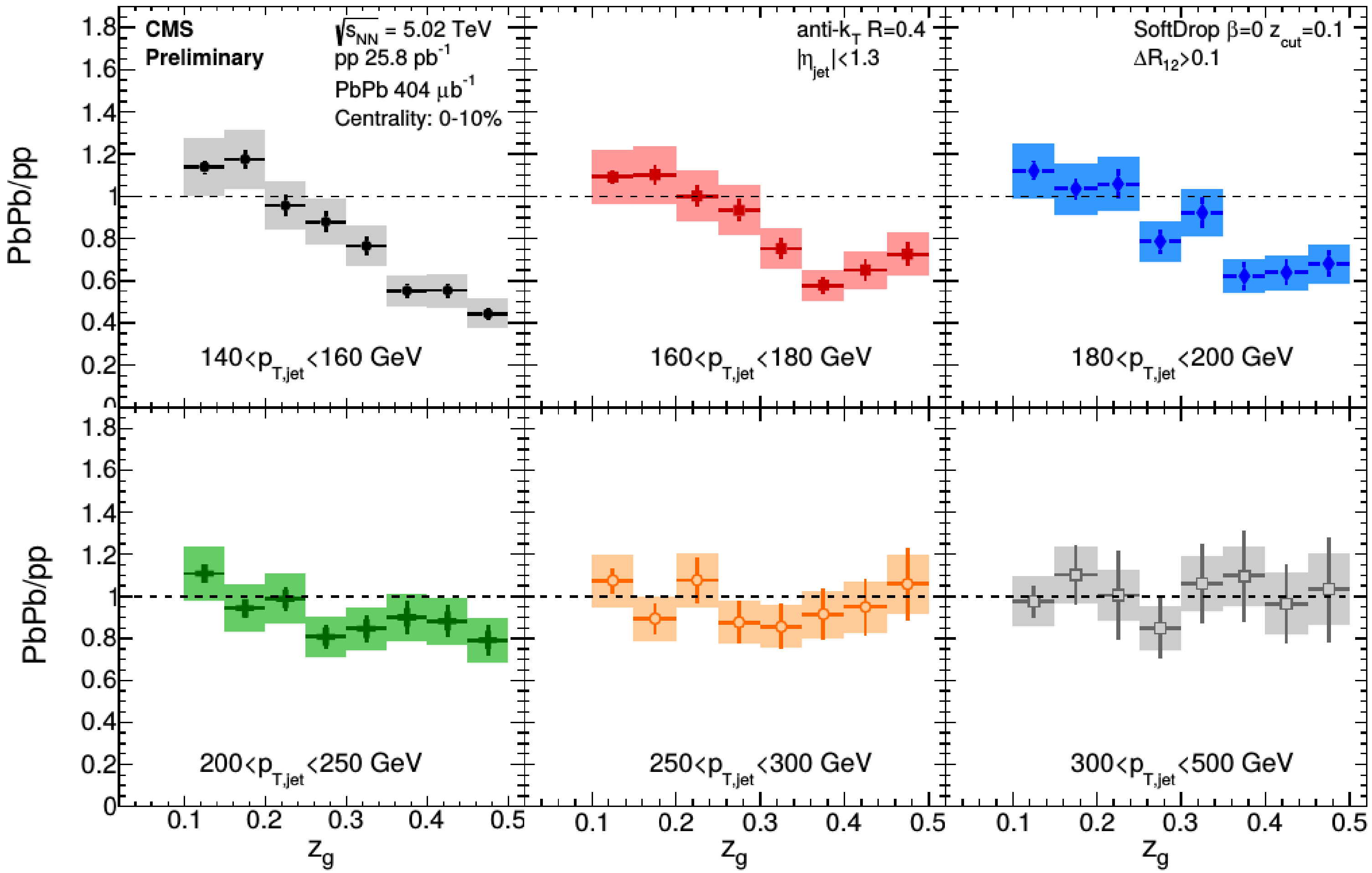

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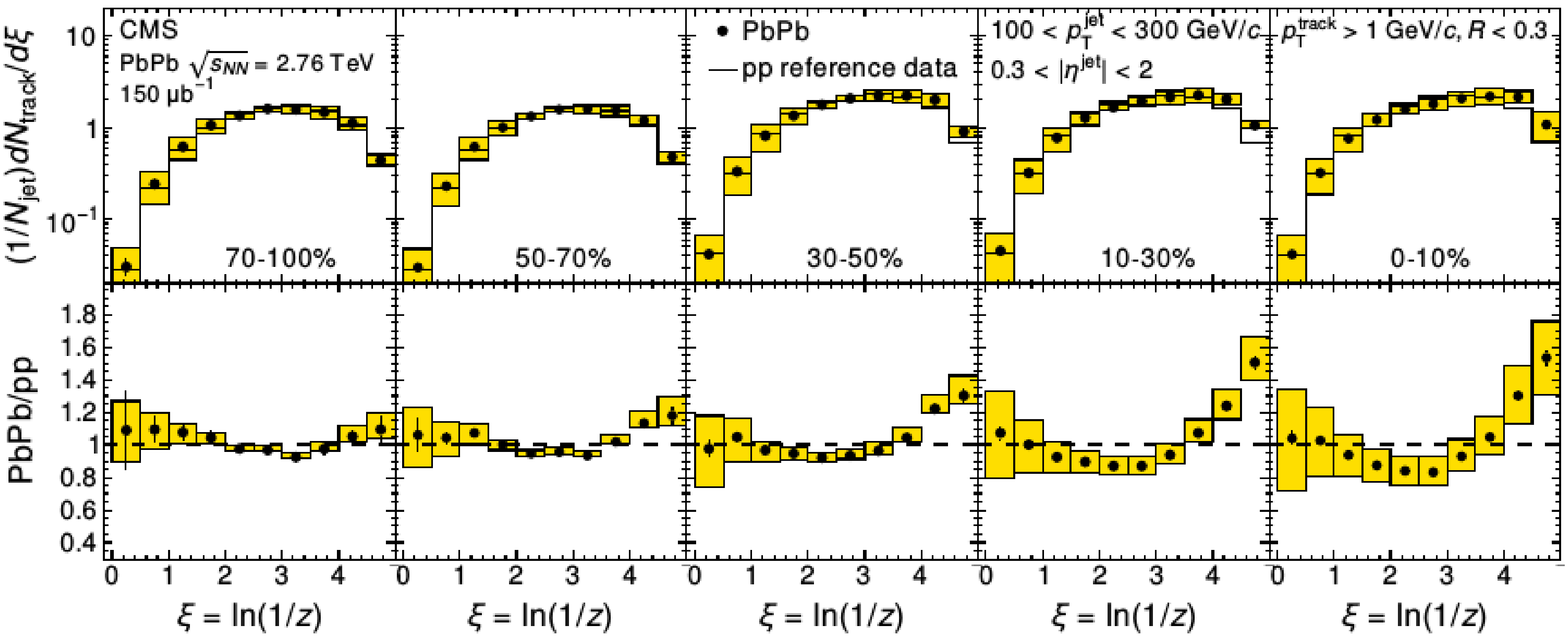
Fragmentation function, is the distribution of the variable z:

$$z = \frac{p_{\parallel}^{\text{track}}}{p^{\text{jet}}}, \quad \xi = \ln \frac{1}{z}$$

Jet Shape Observables



CMS Collaboration. Measurement of jet fragmentation in PbPb and pp collisions at sqrt(s[NN]) = 2.76 TeV. Physical Review C 90, (2014).

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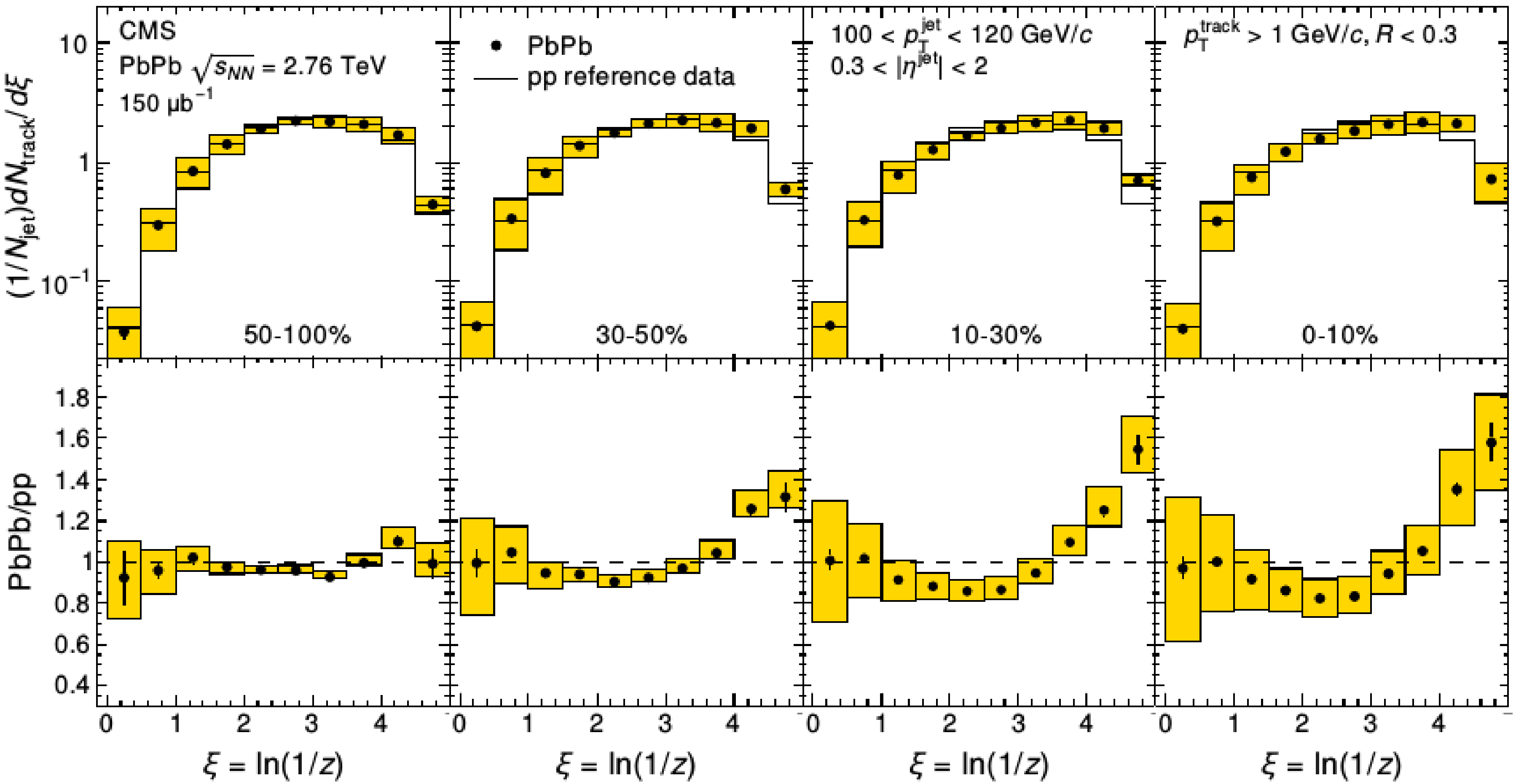

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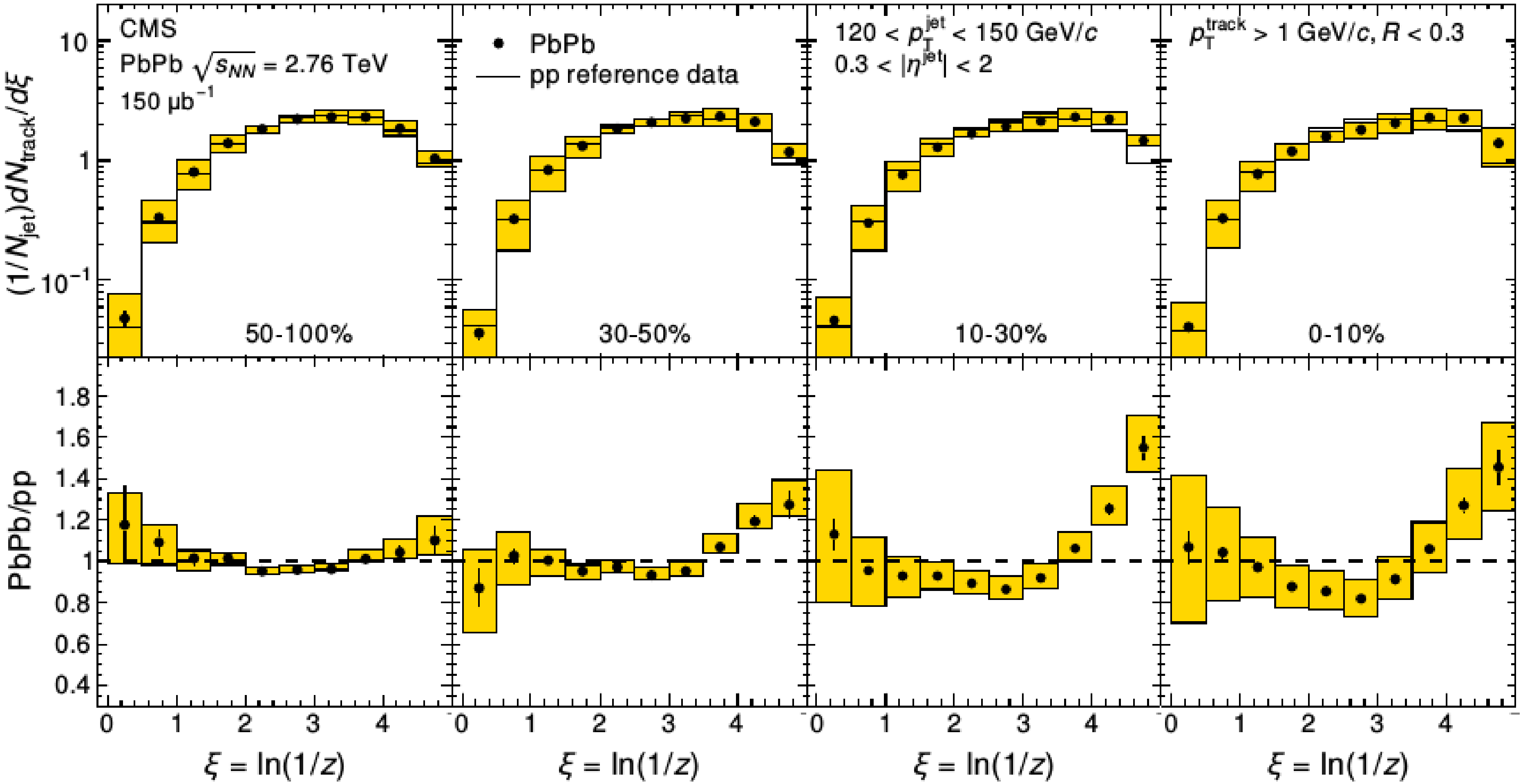

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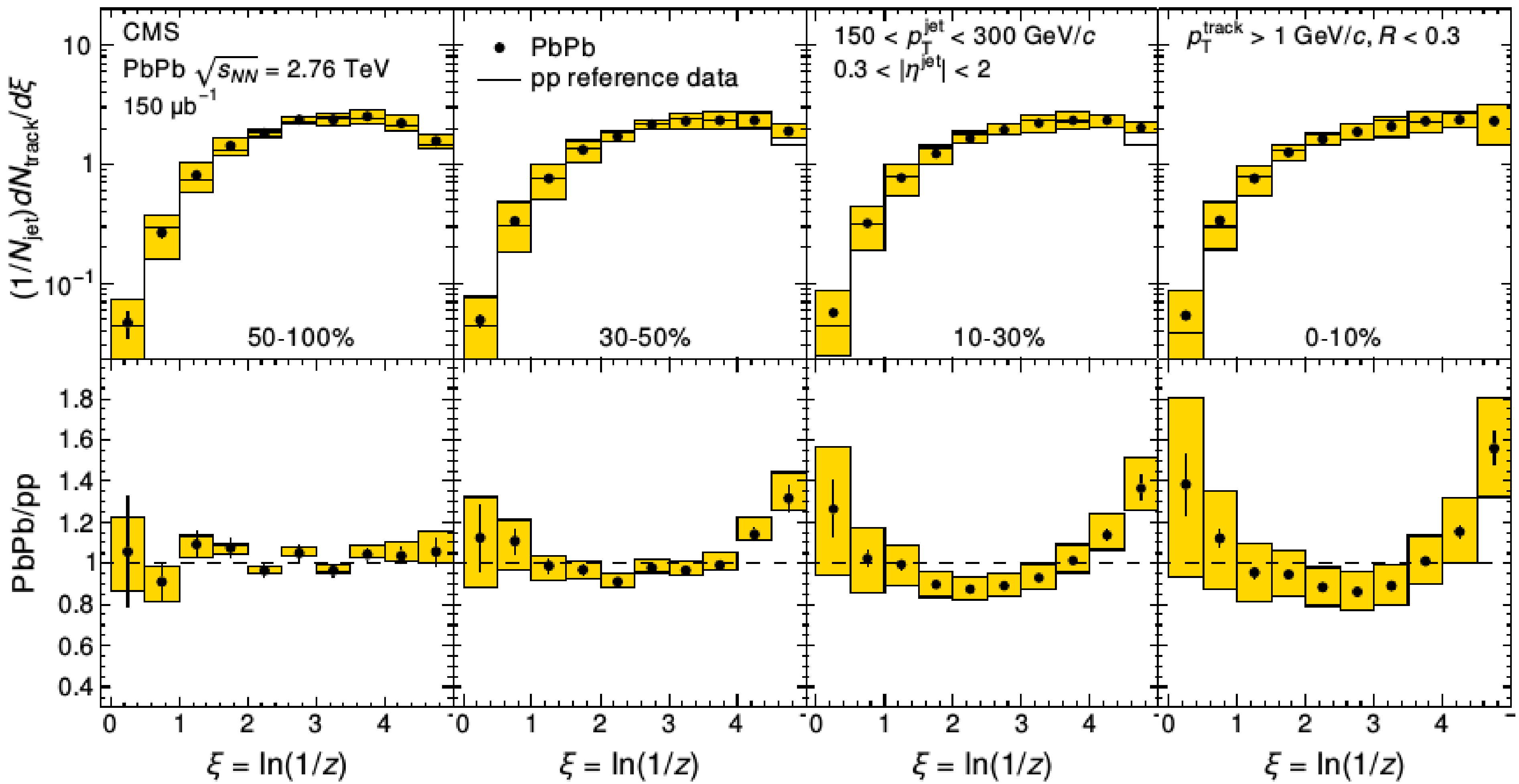

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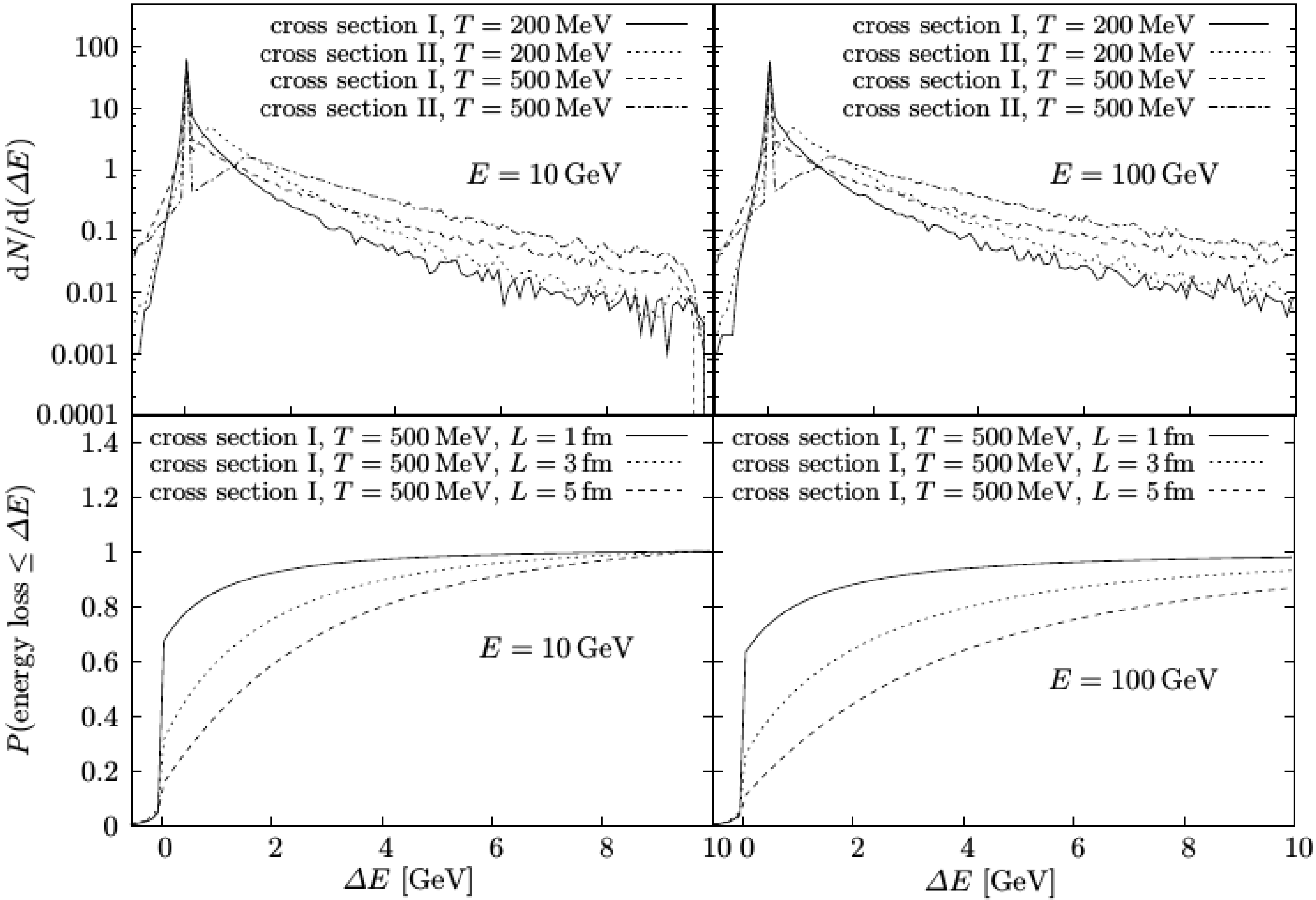

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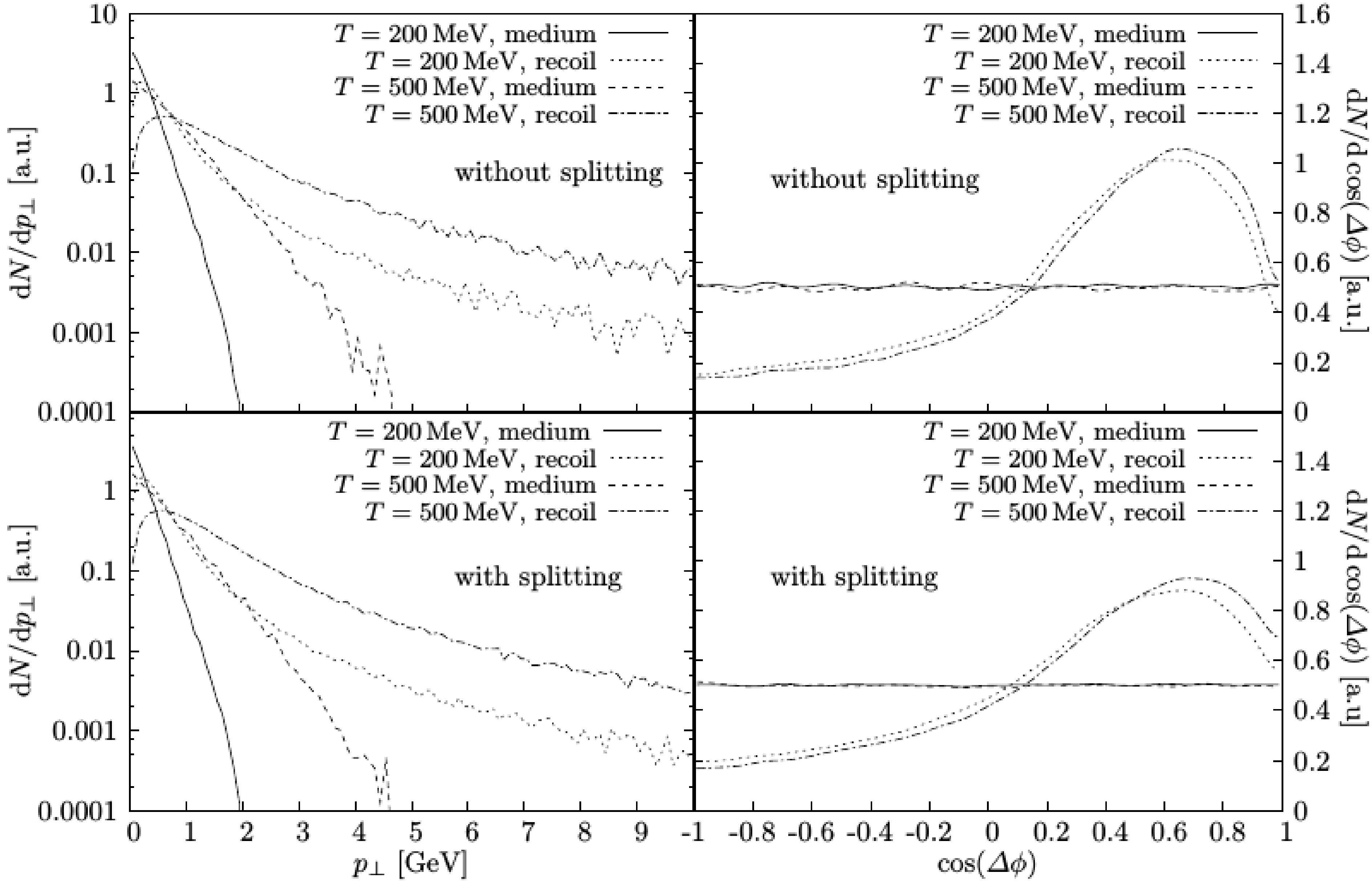

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- It is clear from experimental evidence that interaction of partons with the hot medium modifies its energy loss pattern;
- With higher statistics on future runs, one might expect to extract information about the medium such as transport coefficients and thermalization properties. Also, medium properties might also be extracted from jet shape modifications;