Measurement of inclusive, boson-tagged, and heavy-flavor-tagged jet energy loss in PbPb collisions at $\sqrt{s_{NN}}$=5 TeV with CMS detector

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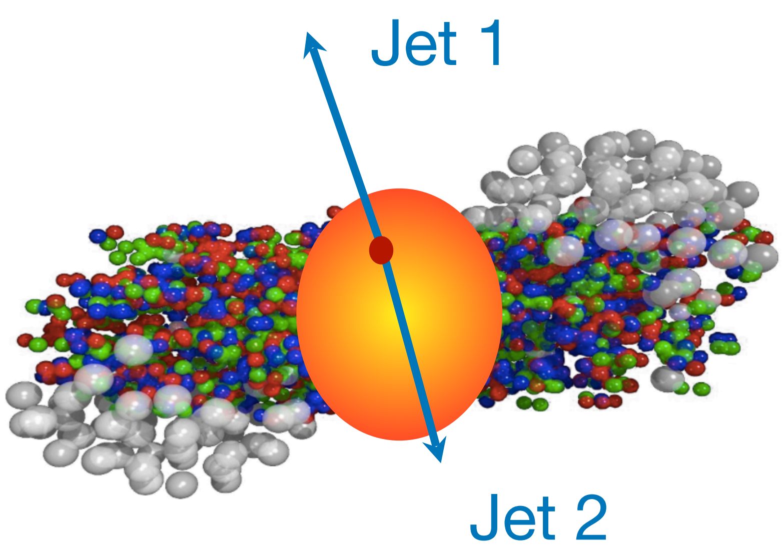
Introduction

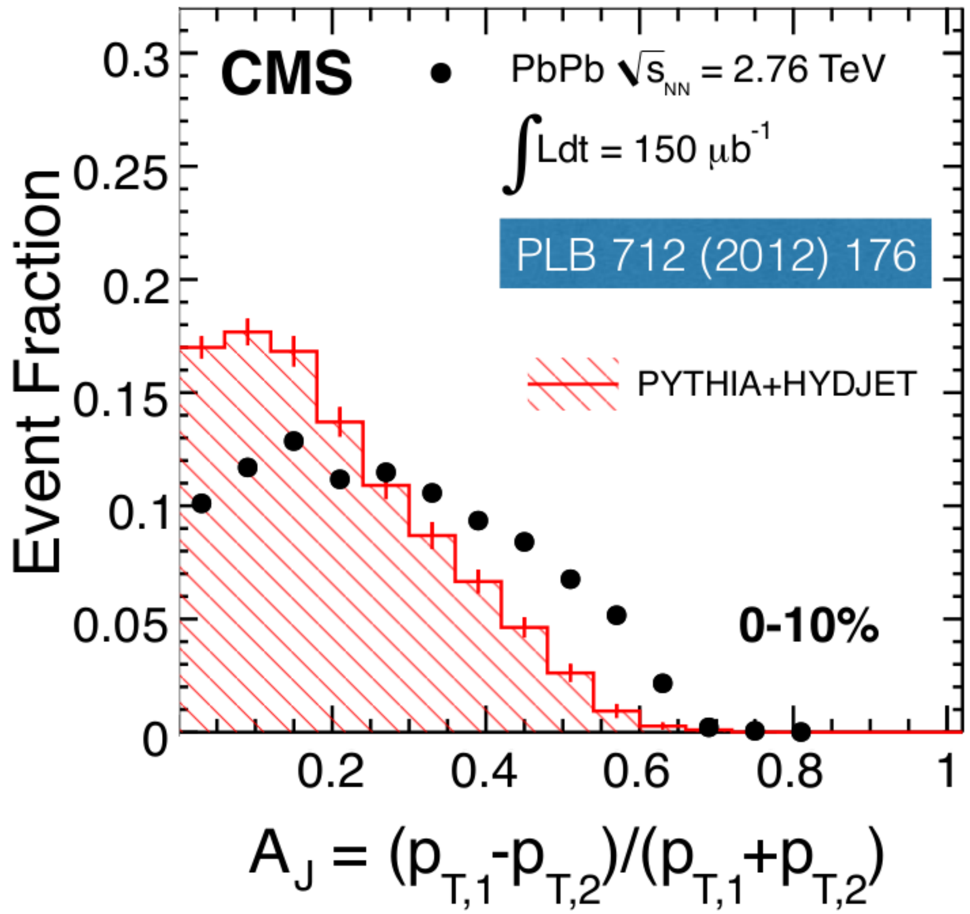
- Jet tomography is an established experimental tool for relativistic Heavy Ion studies to answer what happens if partons traverse a high energy density colored medium?
- Jet, di-jet and boson-tagged jets allow to study:

✓ Jet-medium interactions

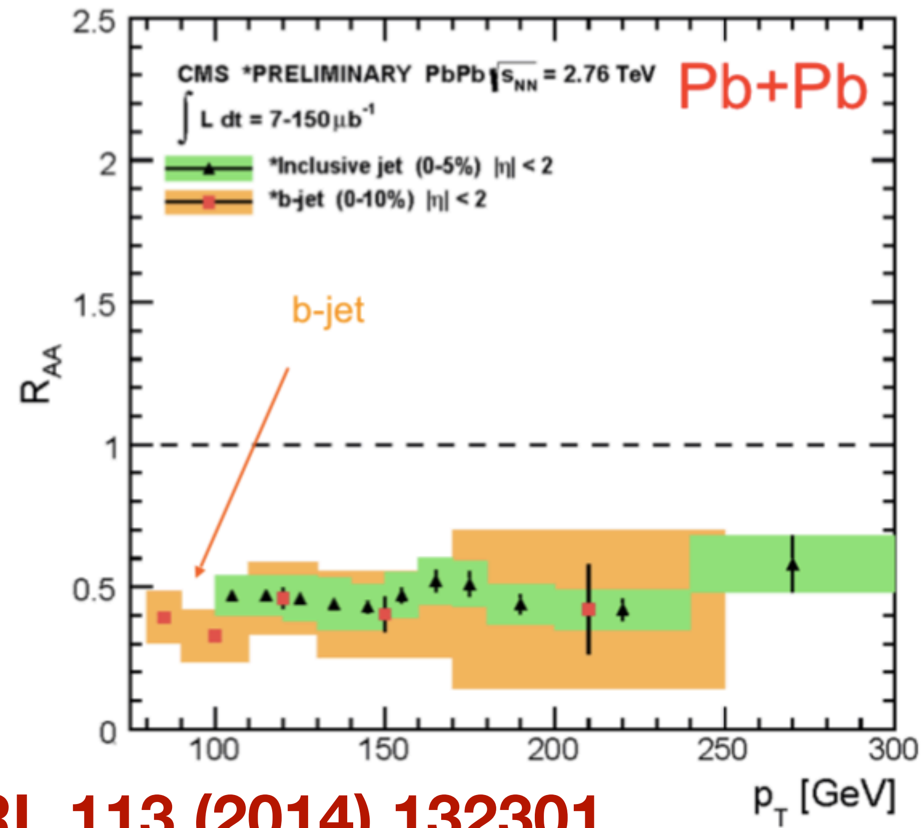
✓ Flavor dependence of parton-medium coupling

✓ In-medium fragmentation/ hadronization





Jet Quenching



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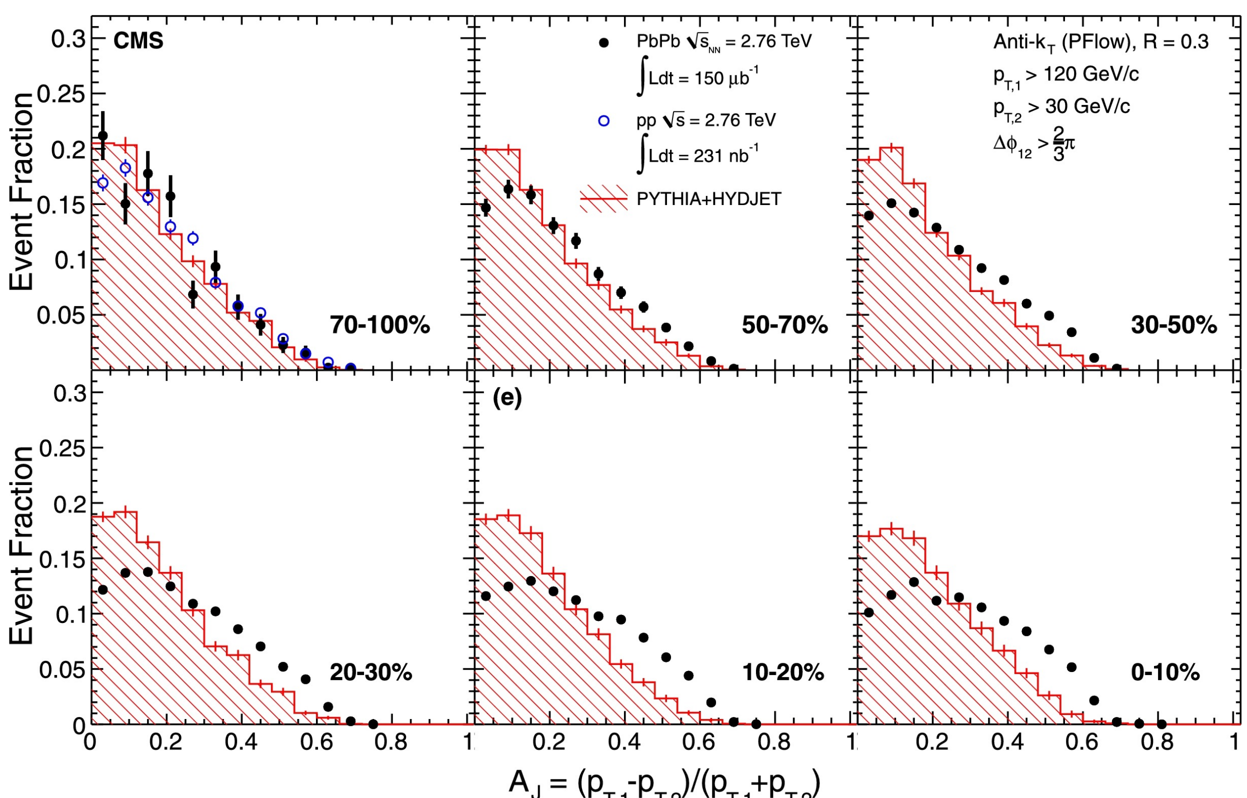

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$$R_{AA}(p_T) = \frac{d^2N^{AA}/dp_T d\eta}{T_{AA} d^2\sigma^{NN}/dp_T d\eta}$$

Jet R_{AA}:

Strong suppression

No appreciable p_T dependence

Di-jet A_J

Centrality-dependent increase in the fraction of dijets with substantial energy imbalance

b-jet suppression:

Similar level of suppression for high p_T jets (p_T> 80 GeV)

What about flavor dependence?

Better understand jet energy loss: compare jets from different partons.

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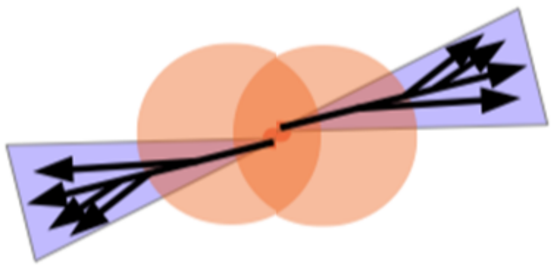
Understanding the flavor effects

Constrains on the energy loss scenarios could be added by comparing energy redistribution patterns for inclusive jets, γ + jet and Z-boson + jet



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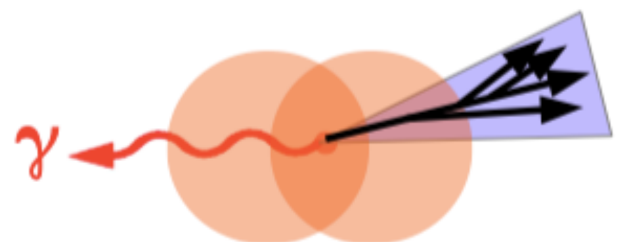

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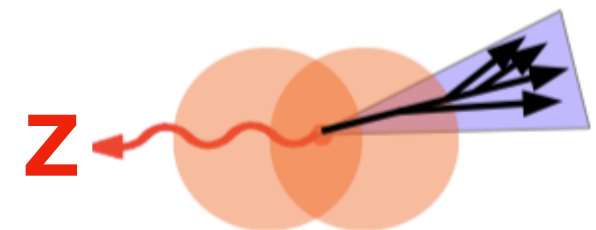

Inclusive jets

- All initial states involved
- A mix of gluon and quark jets

γ +jet

- Good control of initial parton energy
- Larger fraction of quark jets tagged

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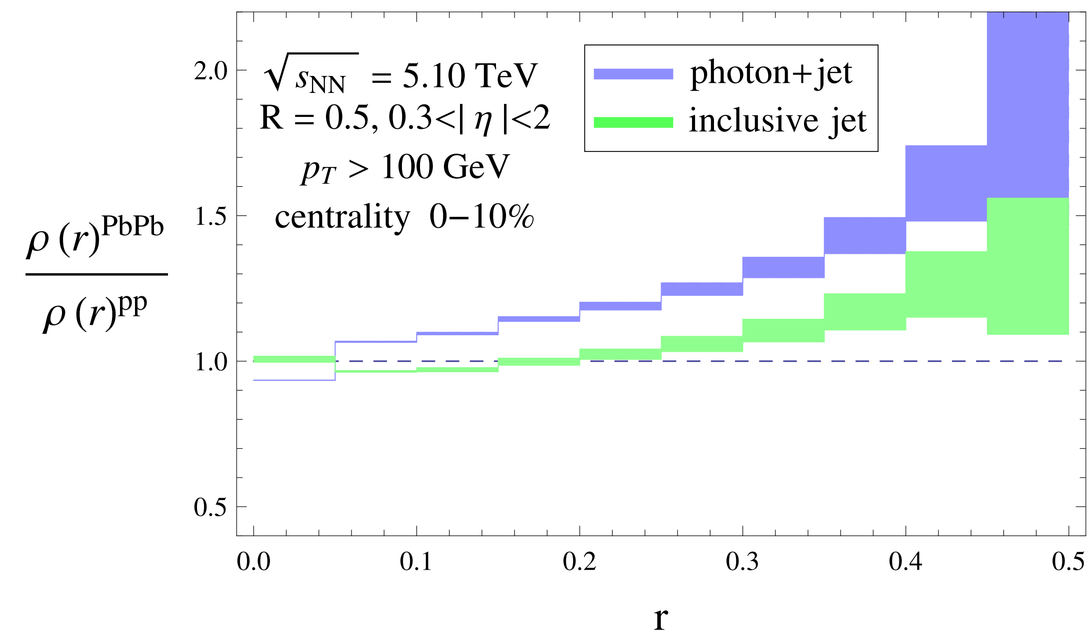
Z +jet

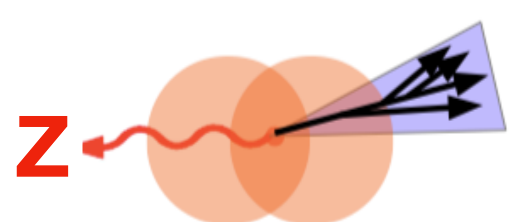
- Great control of initial parton energy+no contamination.

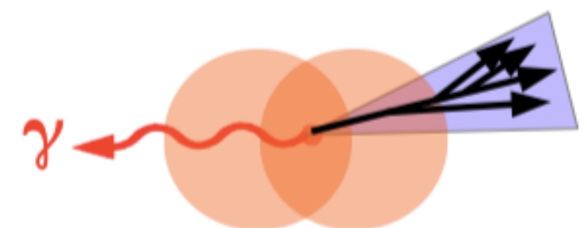


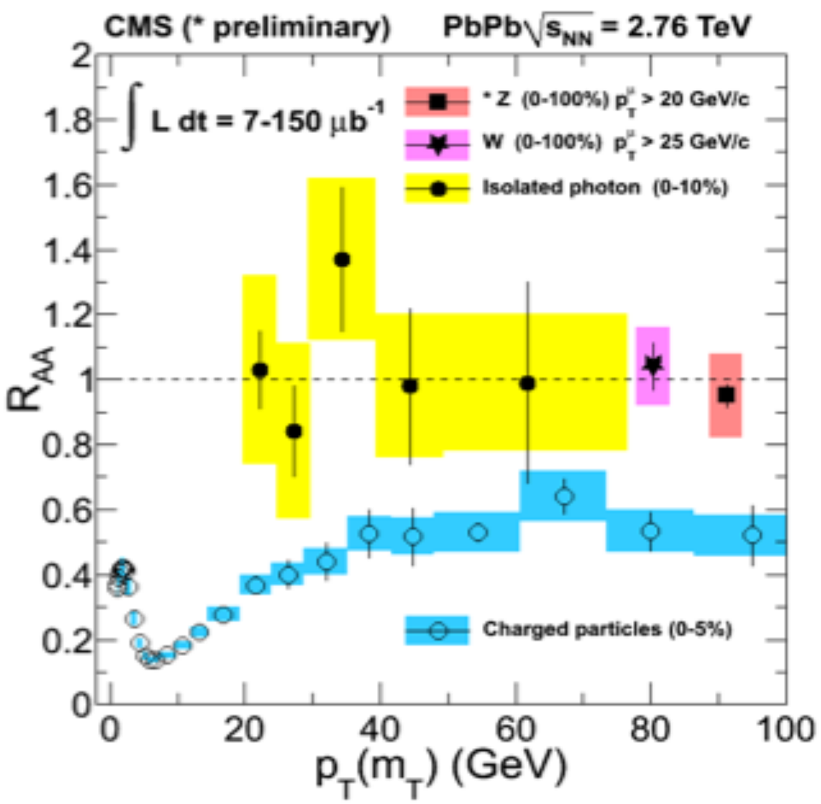
arXiv:1711.09905

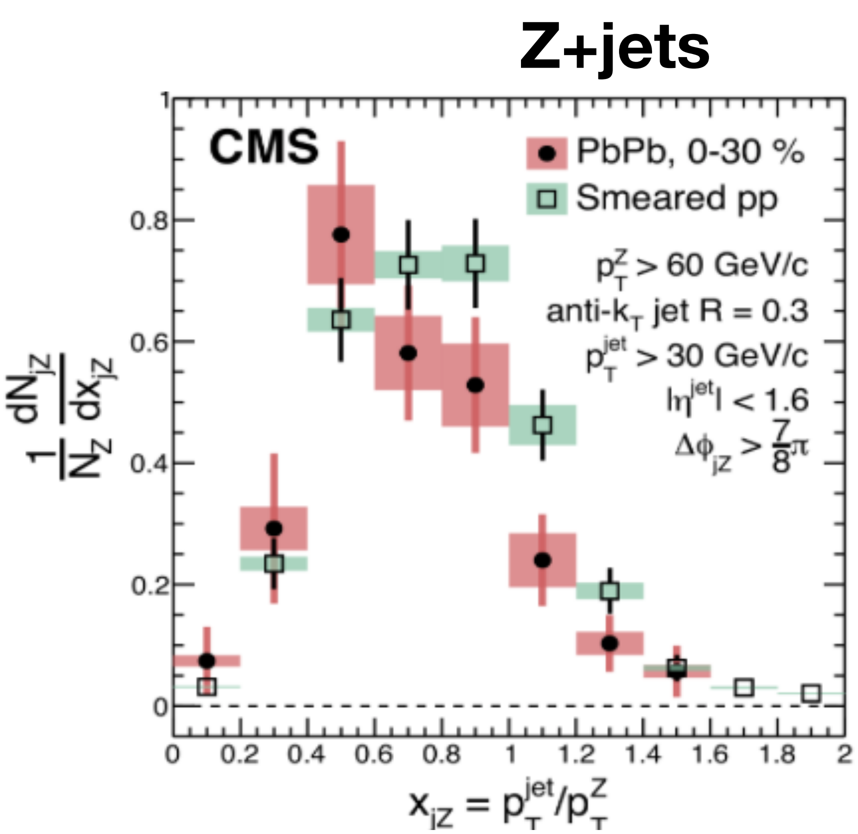
Jet quenching with boson+jets

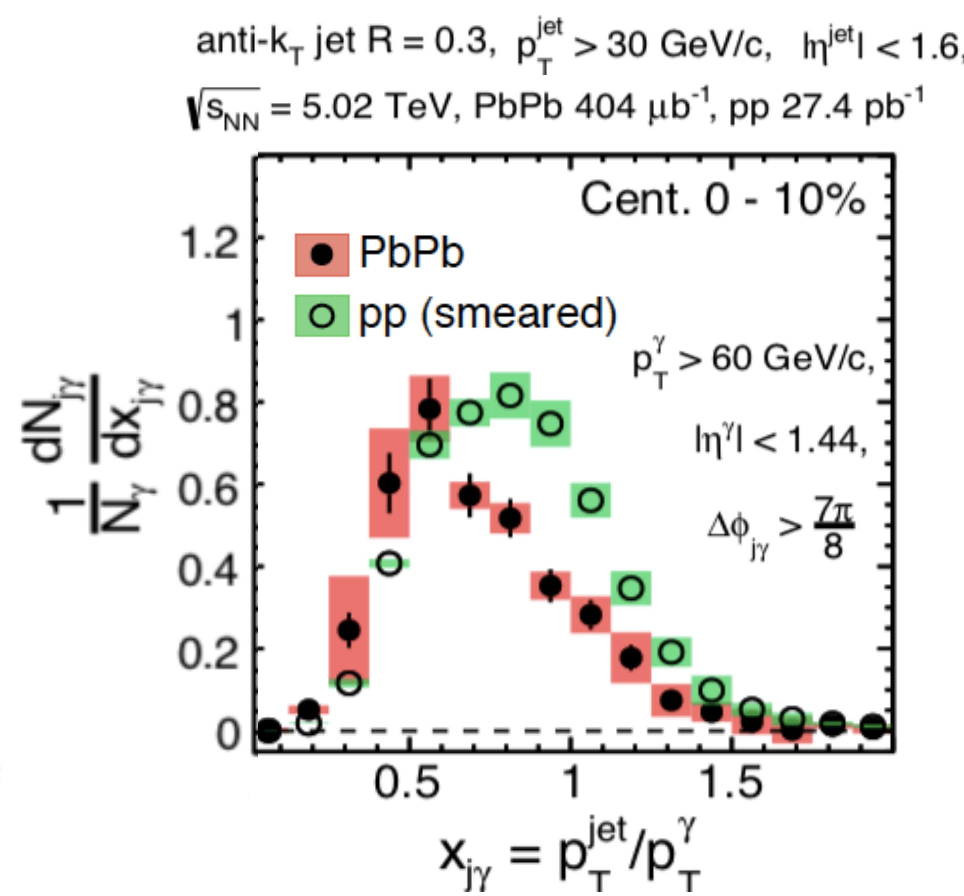
- Boson energy provides a measure of initial parton energy unbiased by the jet quenching effects











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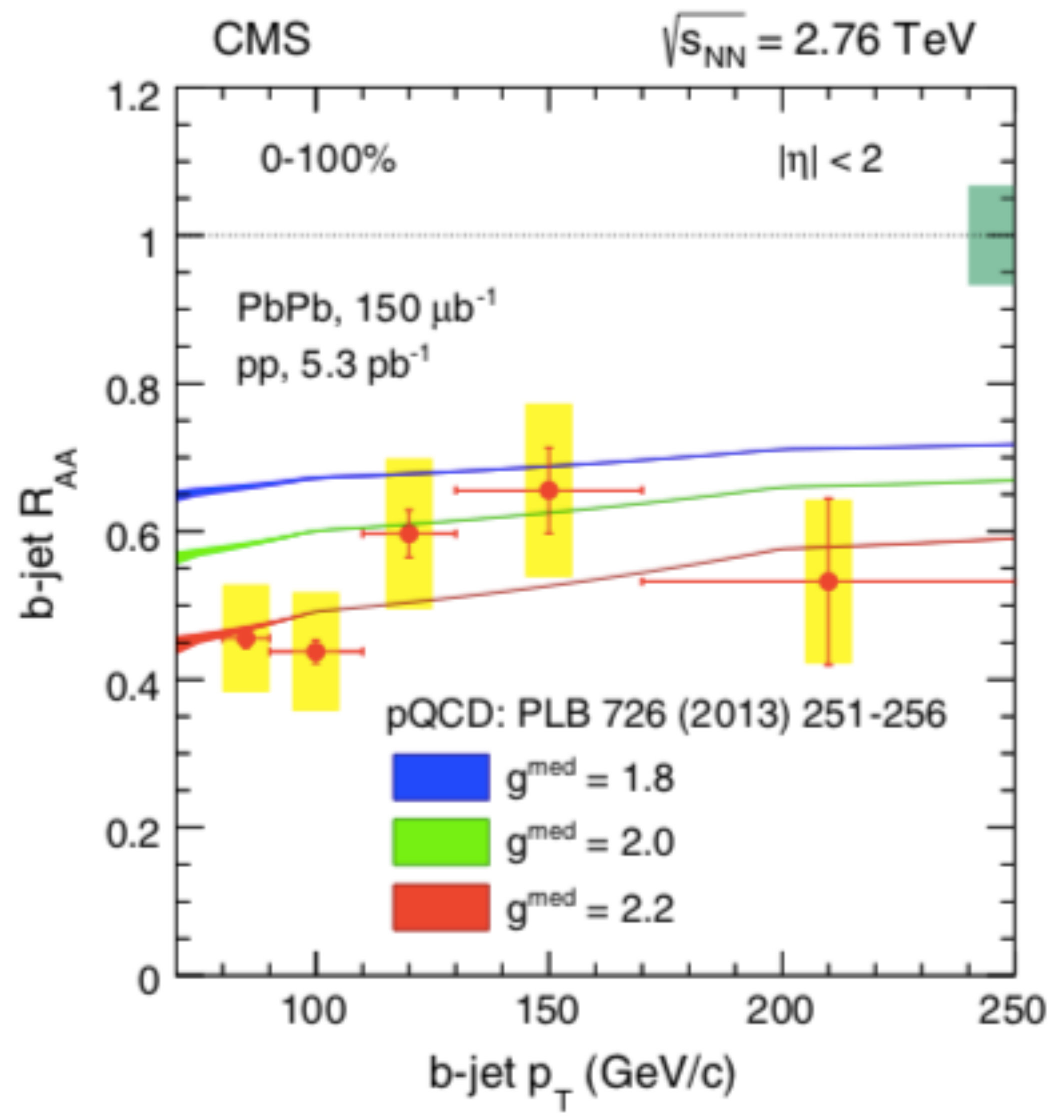
- Significant jet imbalance observed Z+jet and γ+jet.

Jet quenching with b-tagged jets

- A building block to the parton mass hierarchy in the jet energy loss.
- The source of b-jets: quarks jets from primary production (FCR+FEX) and the jets splitting from a gluon jets.



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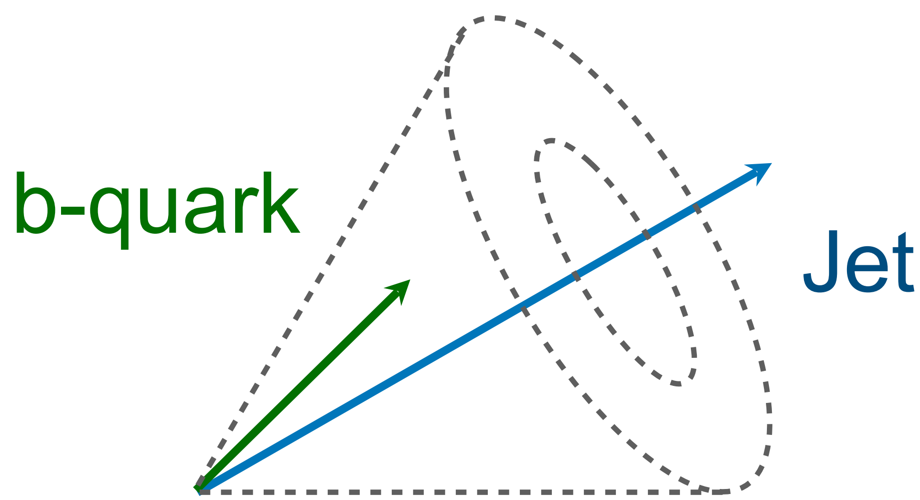

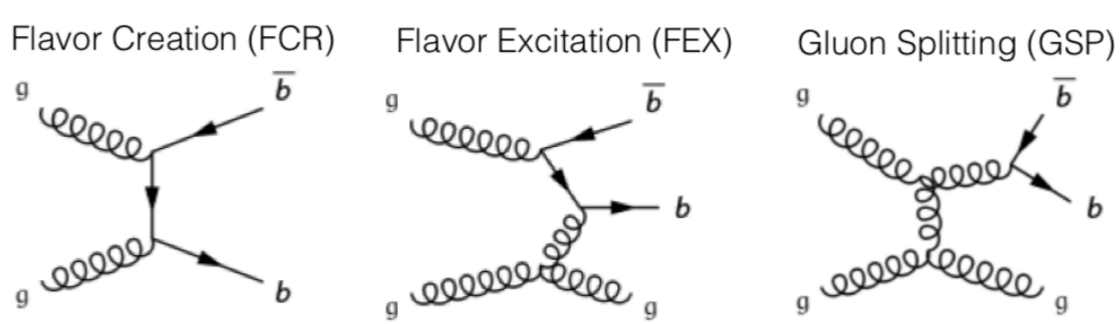

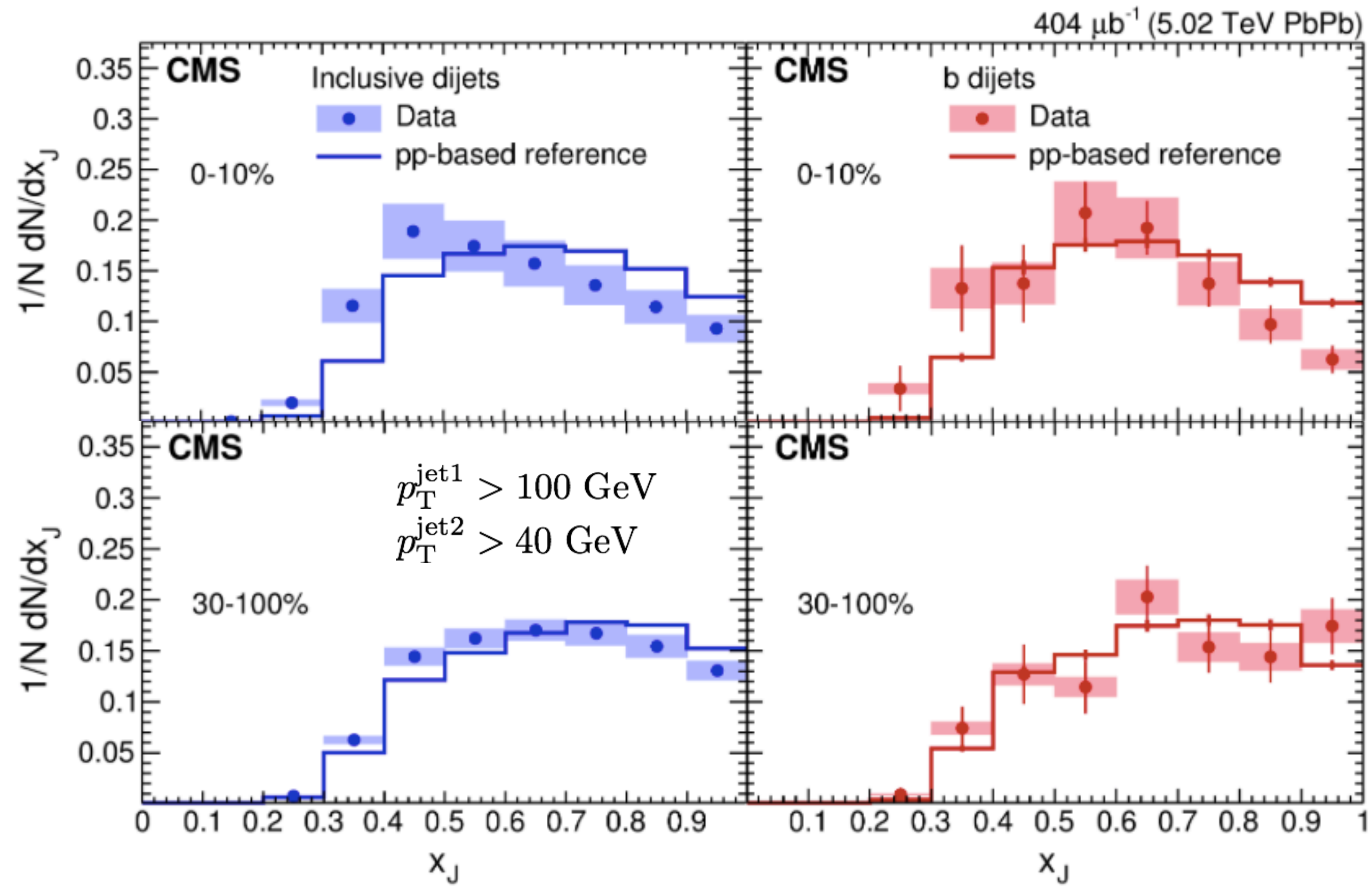

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- b dijet asymmetry is similar to the inclusive jet case.

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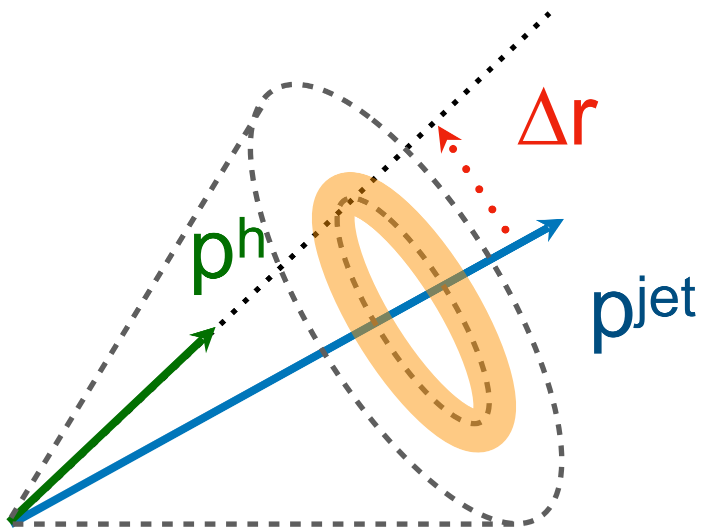
Where does the energy go?

- To better understand the details of jet energy loss, detailed studies of energy distribution of jet constituents



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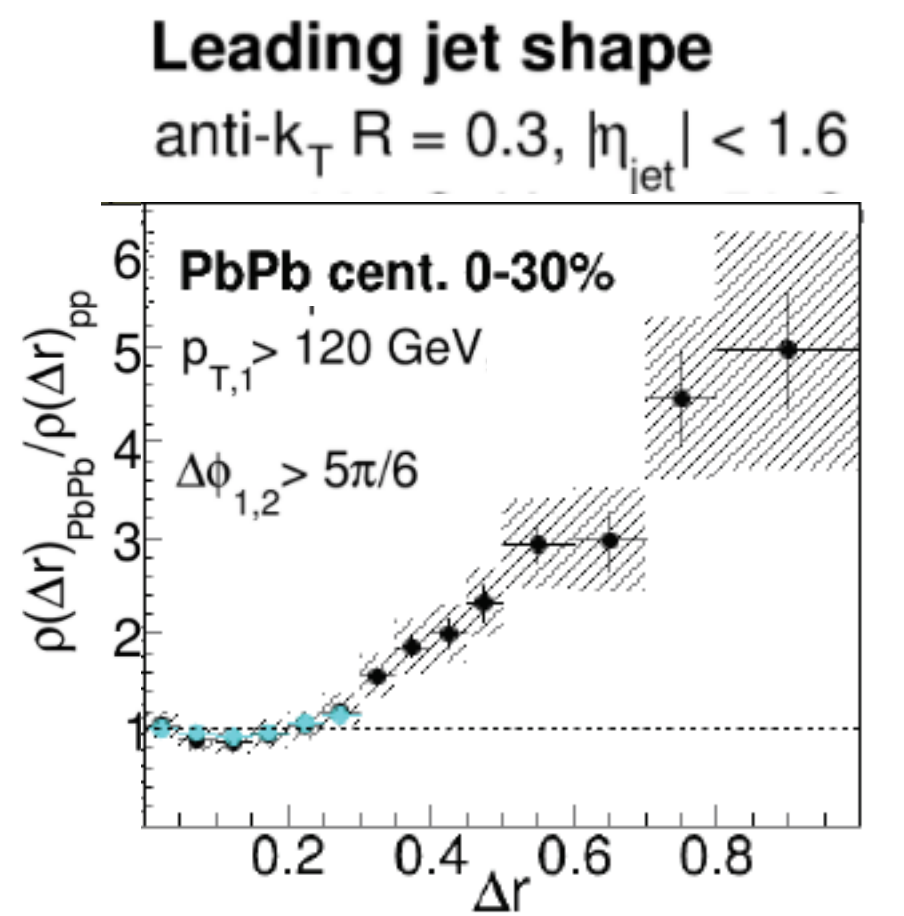
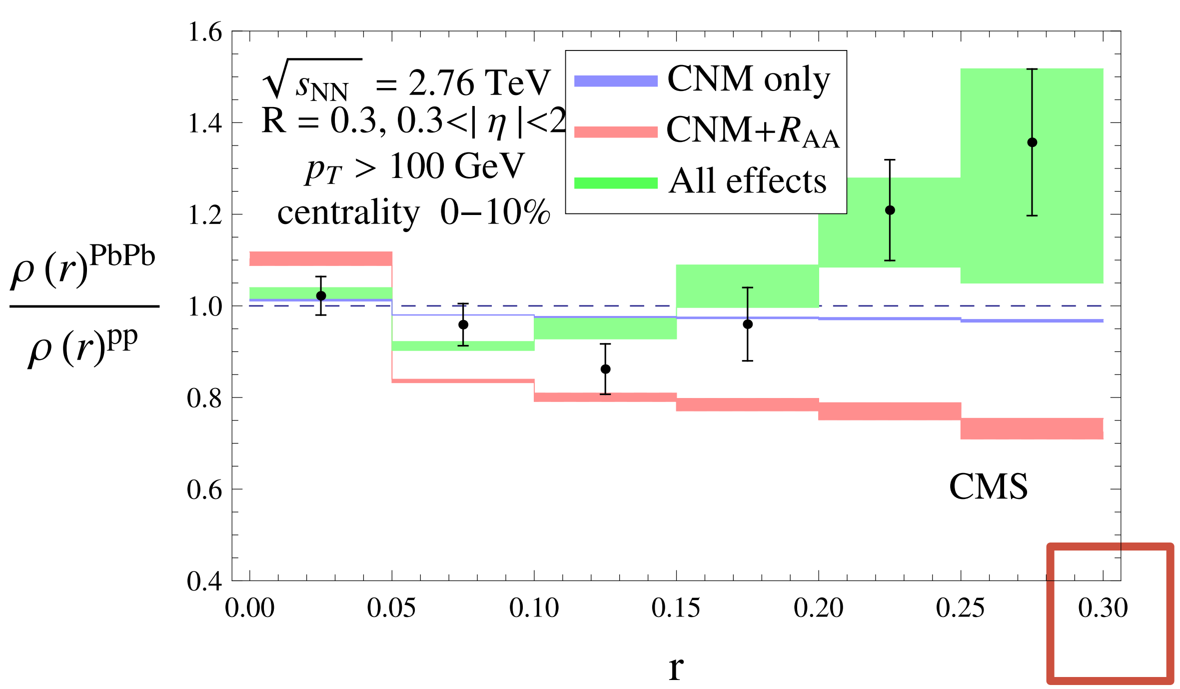


$$\Delta r = \sqrt{(\eta_{\mathrm{jet}} - \eta_{\mathrm{track}})^2 + (\phi_{\mathrm{jet}} - \phi_{\mathrm{track}})^2}$$



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arXiv:1711.09905

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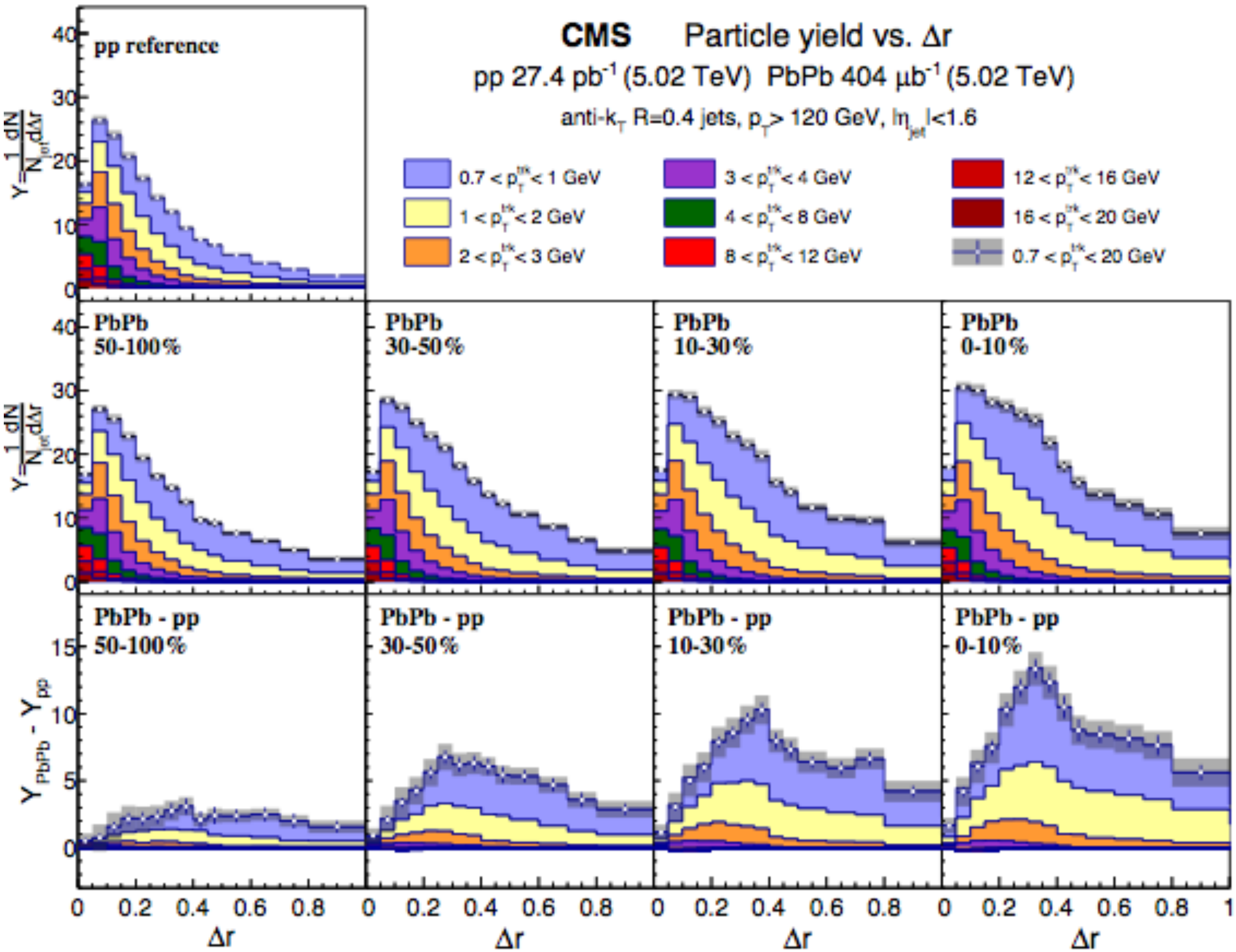
Inclusive jet particle yield



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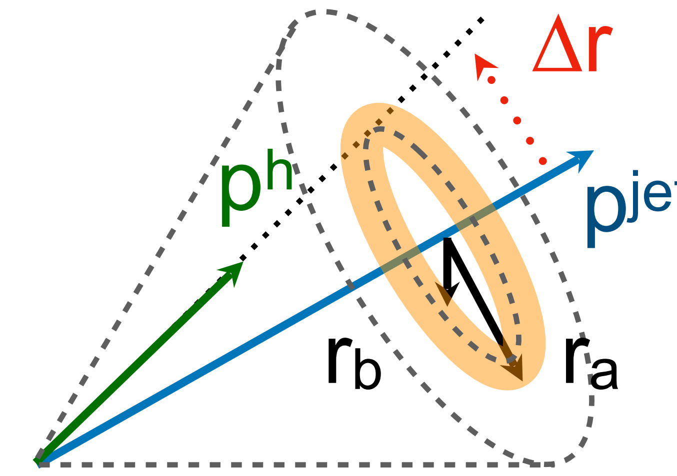

The jet fragmentation pattern is modified

- correlated yield in the soft particle yield enhanced;
- the high p_T particle yield depleted.

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Inclusive jet radial momentum distribution

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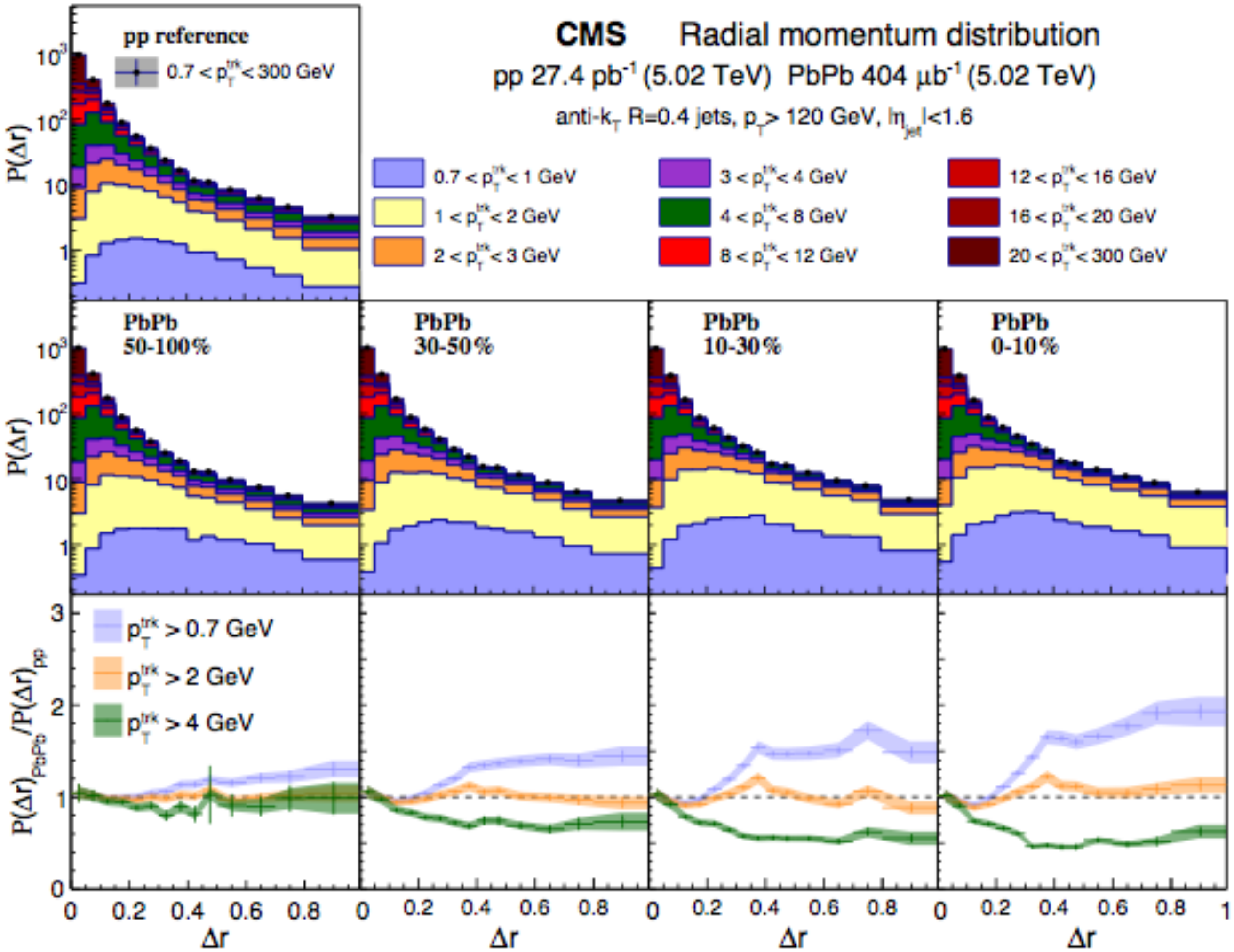
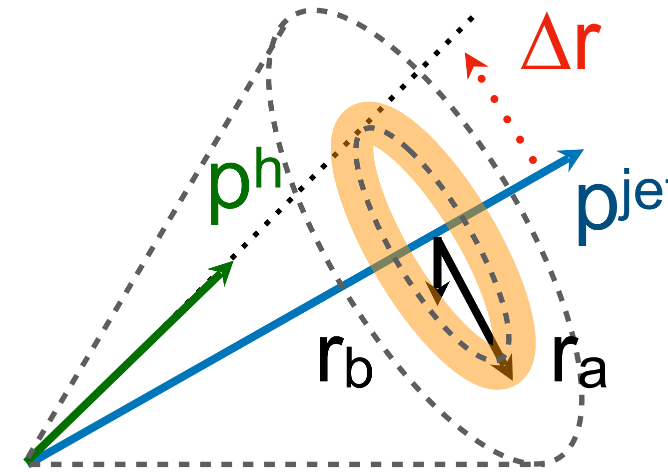
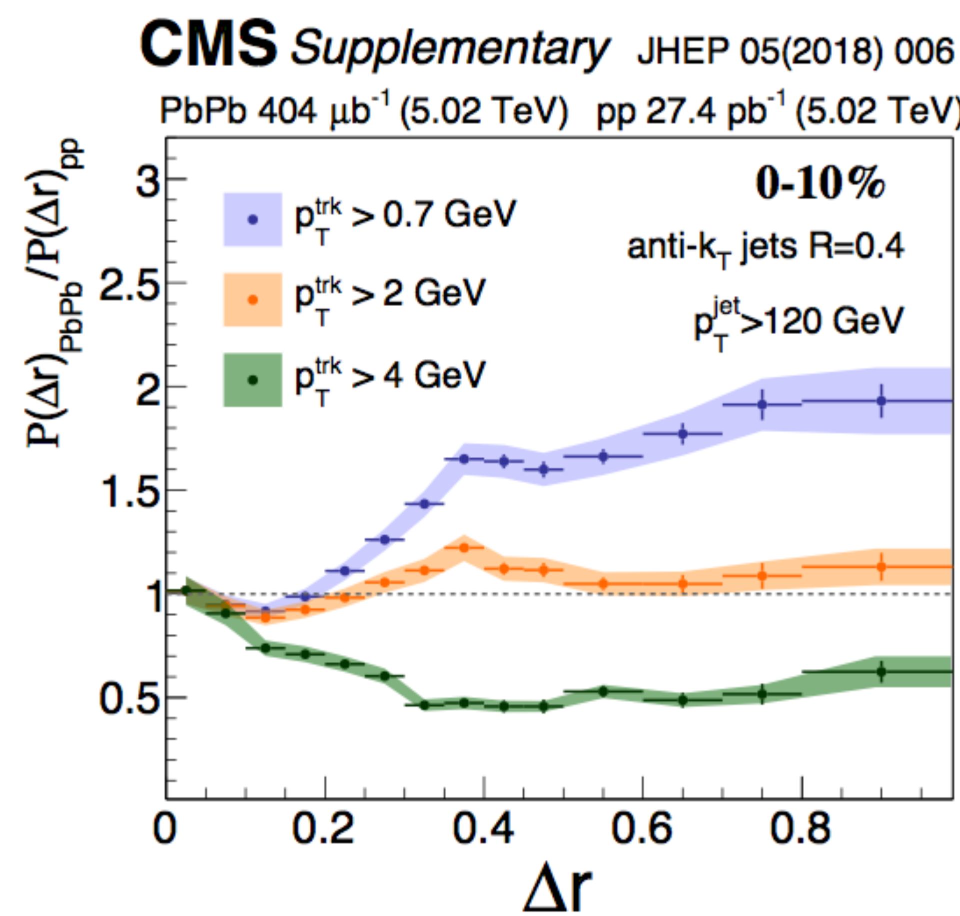




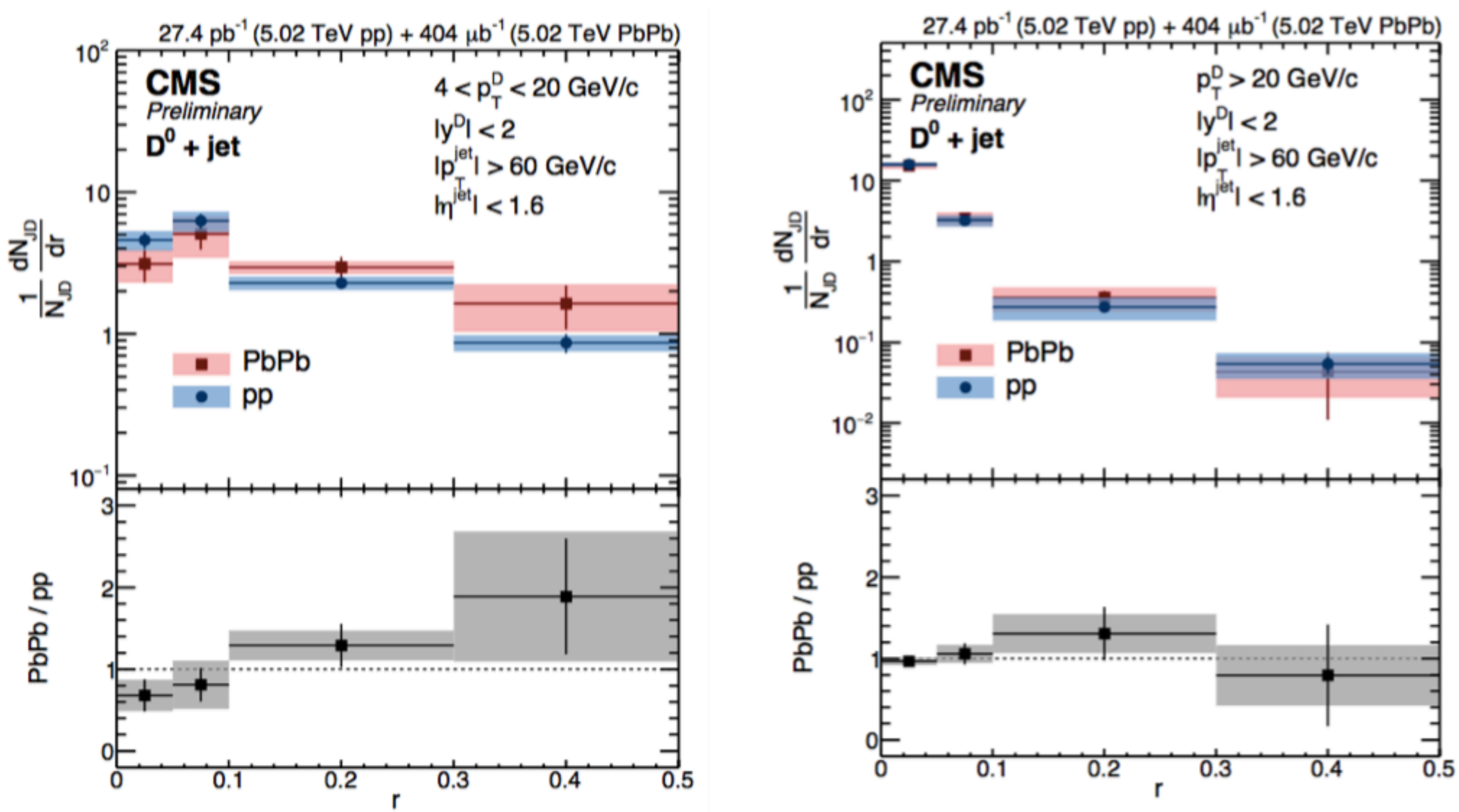


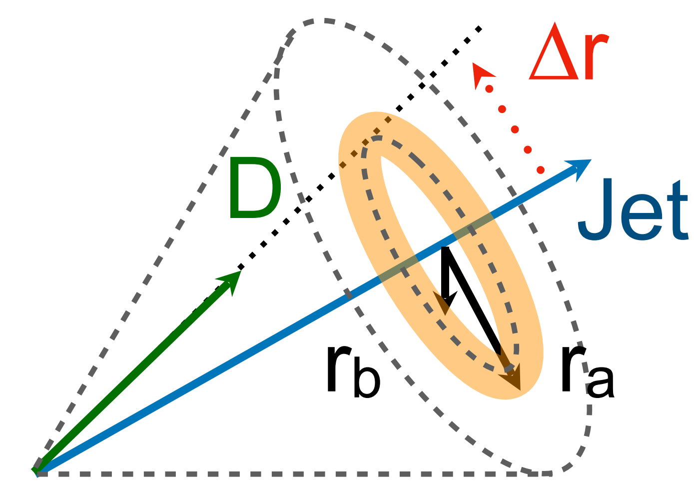
$$P(\Delta r) = \frac{1}{\delta r}\frac{1}{N_{\rm jet}}\sum_{\rm jets}\left\{\sum_{{\rm tracks}\in(r_a,r_b)} p_T^{\rm trk}\right\}$$

- Jet energy is redistributed towards softer fragments and large radii

D^0 meson yield profile in jets

- A hint of the low p_T D^0 enhancement at large angle.
- Provide constraints on the heavy-flavor energy loss.





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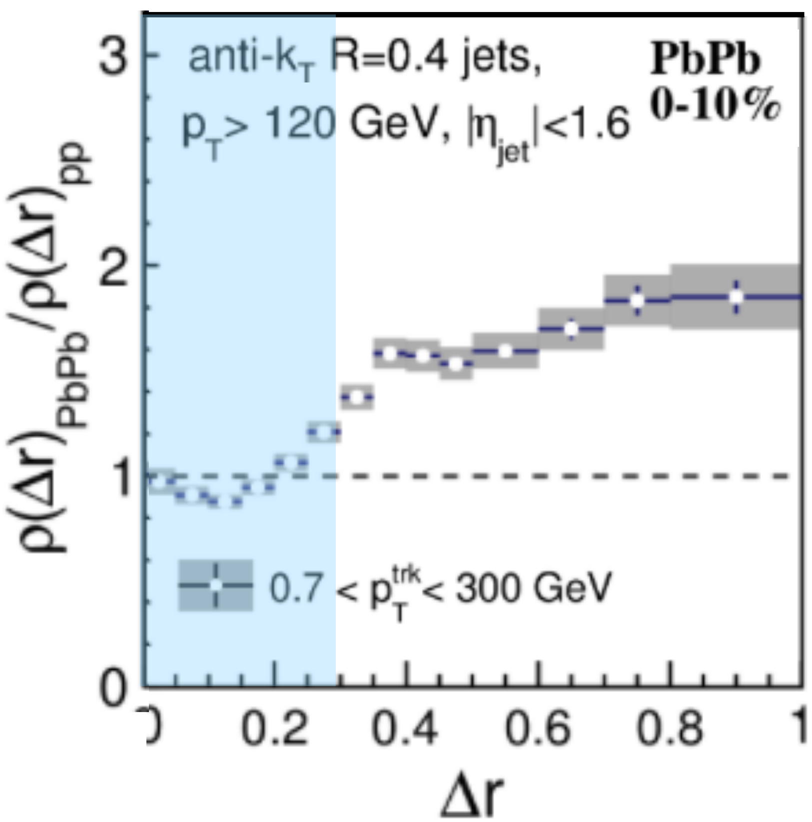
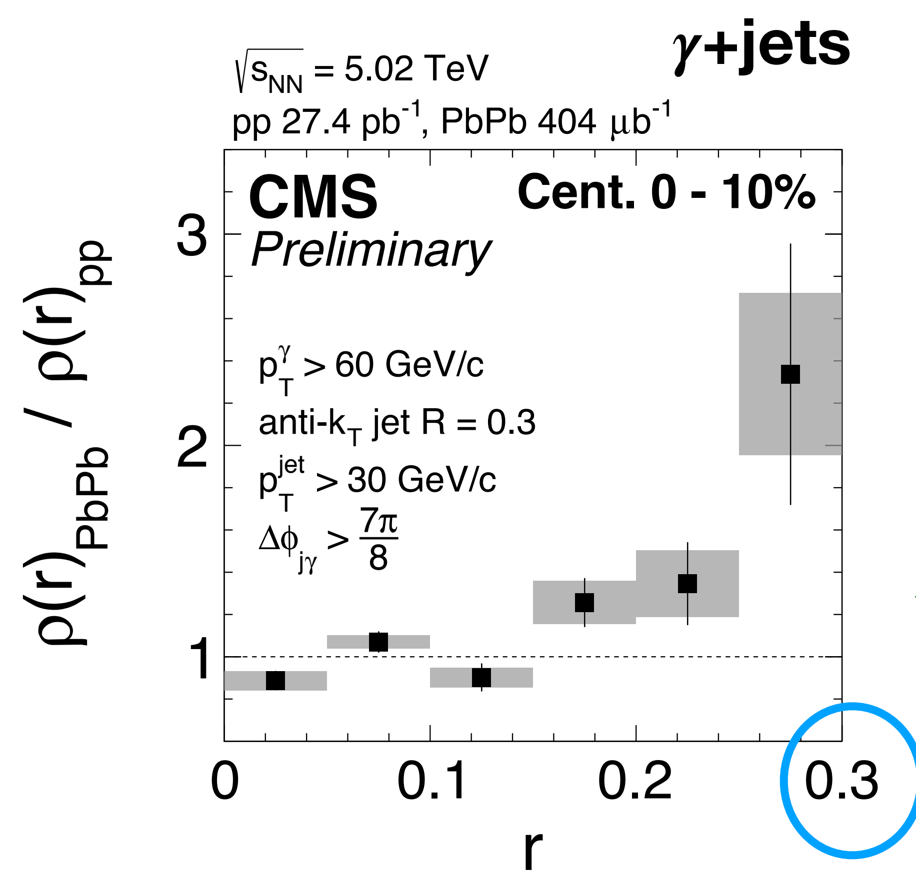
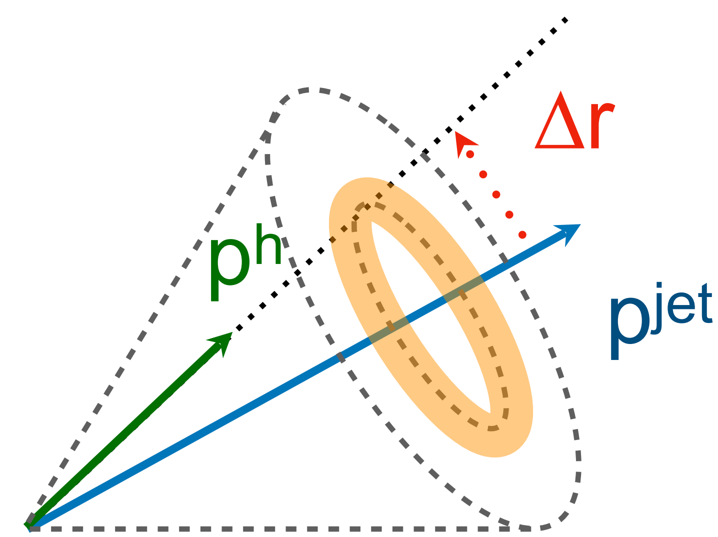
inclusive jets vs. γ +jets

- Jet shape results for γ +jets show similar pattern with inclusive jet shapes:
  Central PbPb – energy redistributed towards larger radii

inclusive jets (5.02 TeV)







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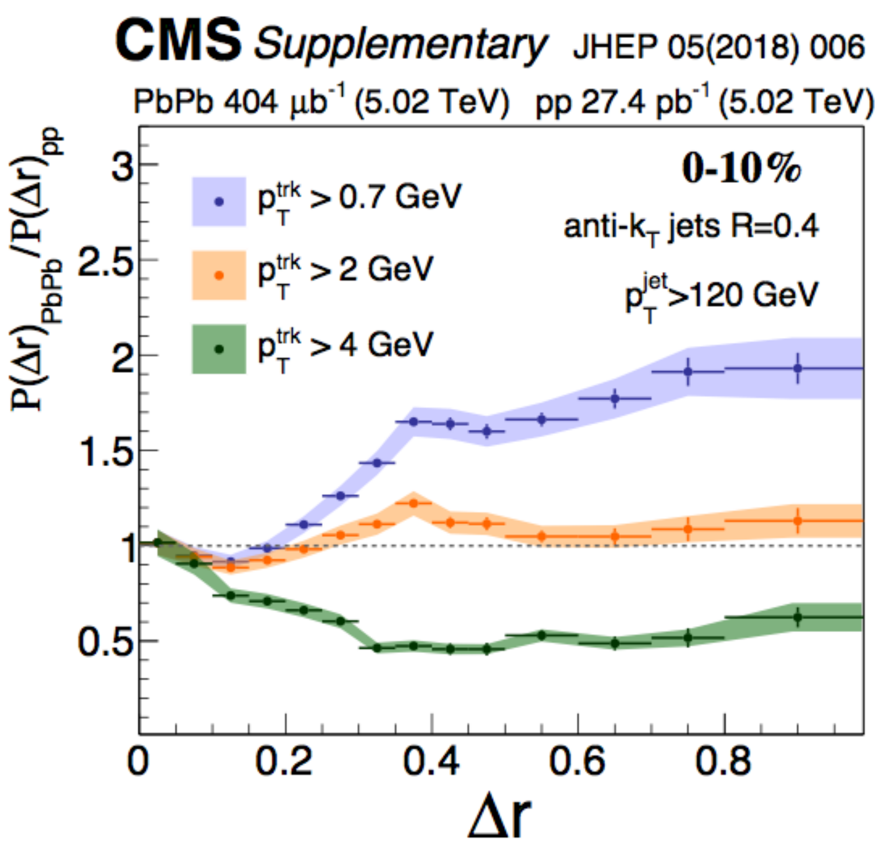
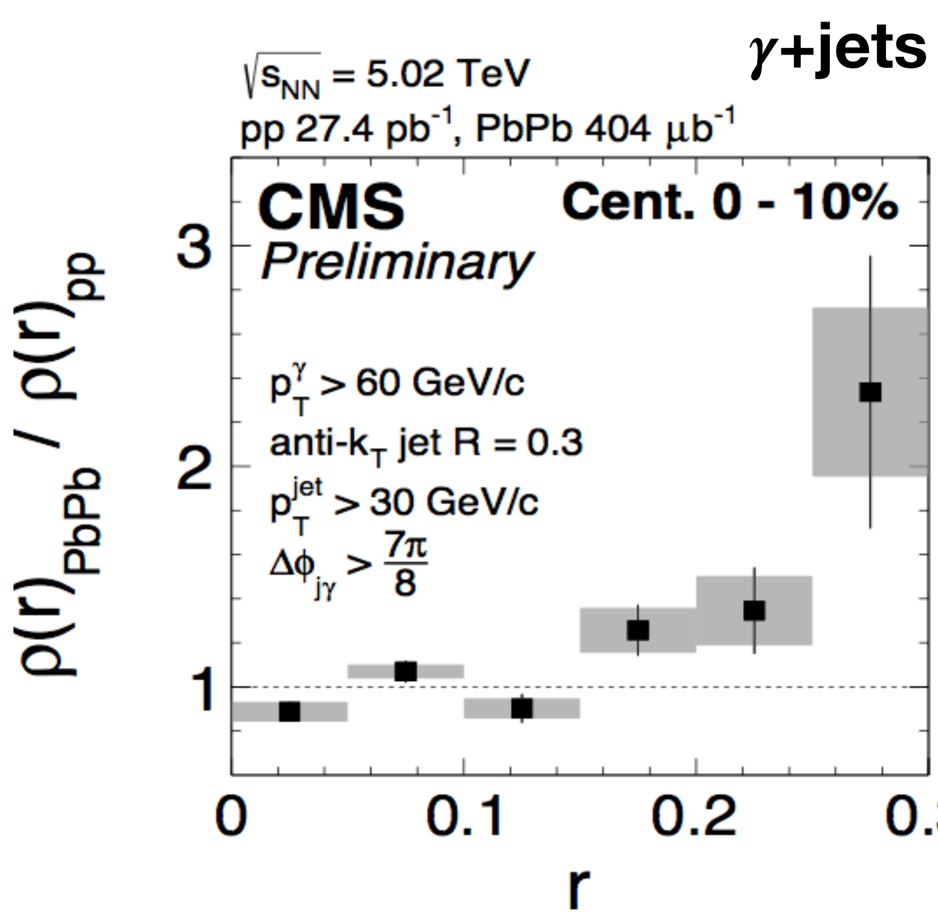
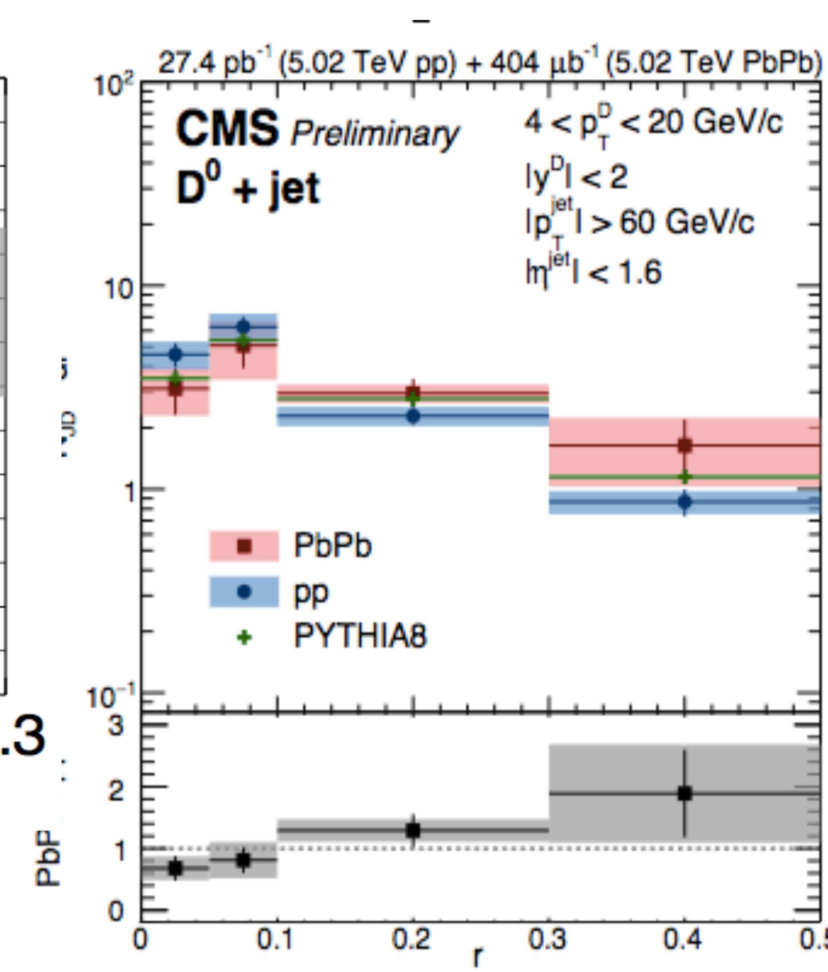
Summary

- Common general trend:
  redistribution of energy from small angles (jet core) to the larger radii.
- Comparative analysis of the **inclusive jets** and **boson-tagged jets** help to understand the difference in quark vs. gluon energy loss mechanism.
- New constraints on flavor-dependent aspects of energy loss and medium response







The work of the UIC group is supported by US DoE-NP

Back up

isolated photon + jets

Jets

Jet Reconstruction

- Anti-k_t calorimeter jets, R = 0.4
- **PbPb:** pile-up UE subtraction
- **pp:** no UE subtraction for jet energy determination

Inclusive Jet Selection

- $p_T > 120$ GeV
- $|\eta| < 1.6$
- May include multiple jets from one event

Tracks

Track Reconstruction:

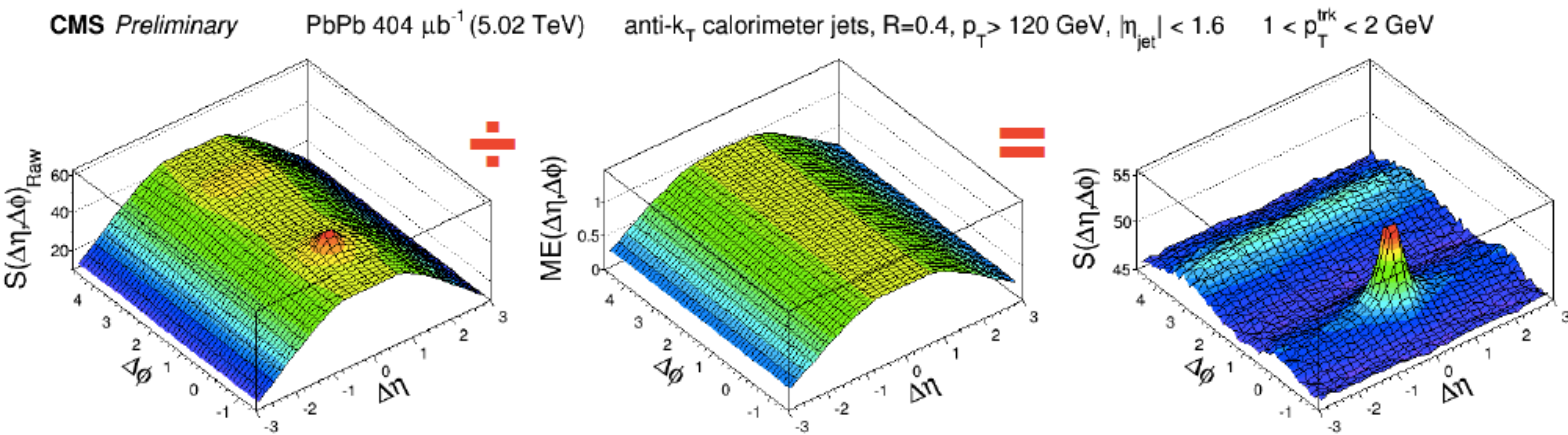
- **PbPb:** heavy ion reconstruction, $p_T > 0.4$ GeV
- **pp:** pp reconstruction, $p_T > 0.2$ GeV
- Corrected for efficiency etc. as a function of η, φ, p_T, and centrality

Track Selection:

- $0.7 < p_T < 300$ GeV
- $|\eta| < 2.4$

isolated photon + jets

- Finite jet and track acceptances result in trapezoidal geometry
- Correct for this pair acceptance effect with a mixed-event correction:
  - Jets from sample
  - Tracks from a minimum-bias event matched on centrality and v_z



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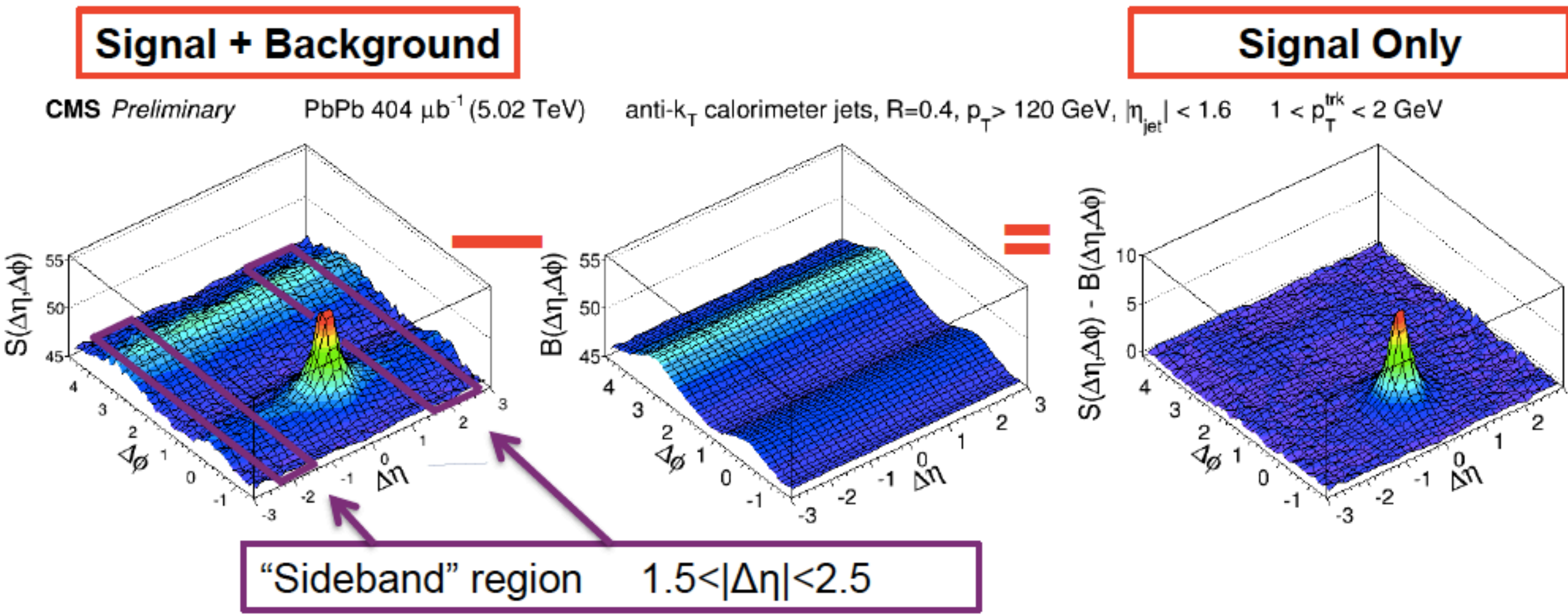
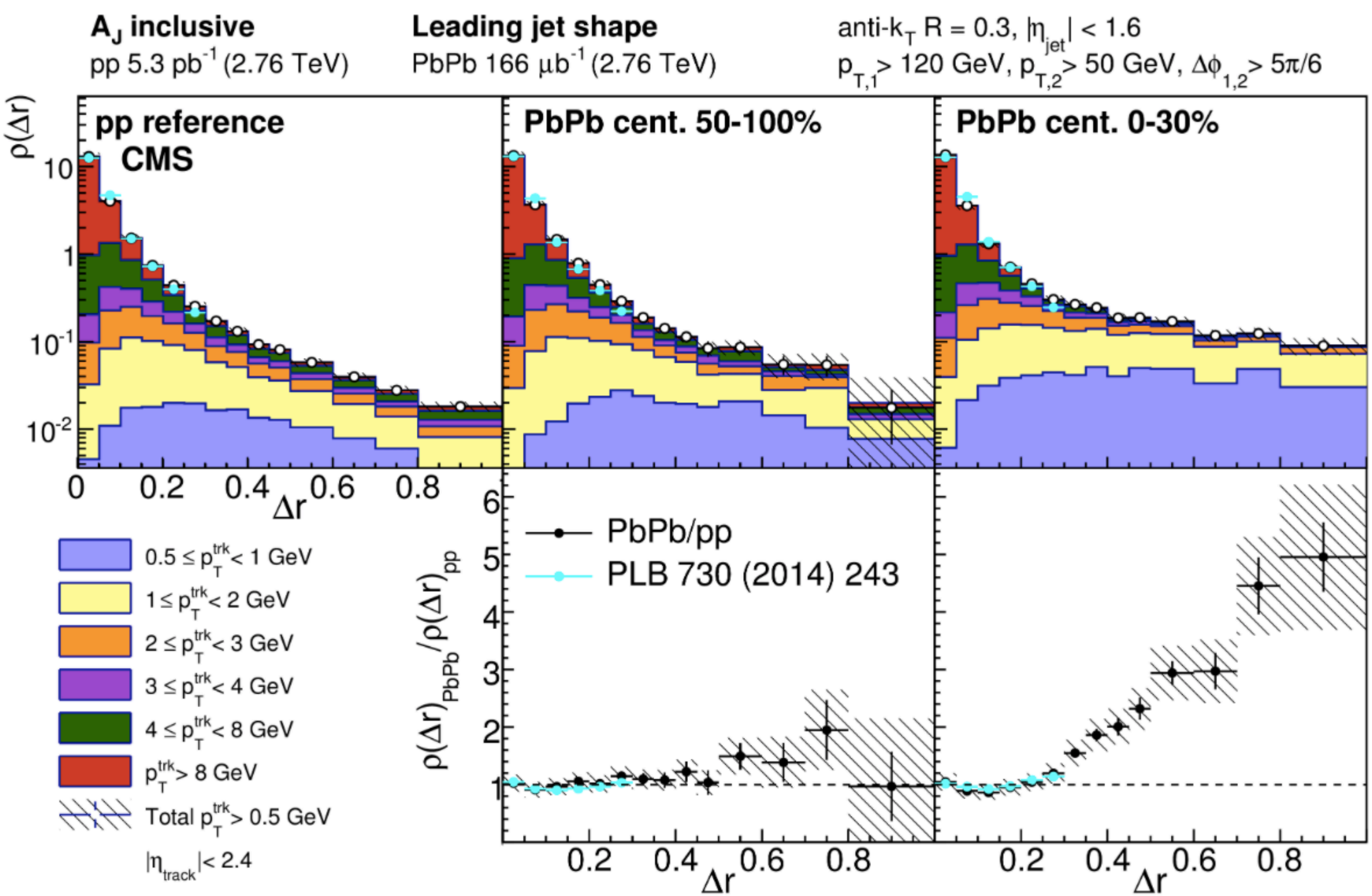
isolated photon + jets

- Project background (measured on 1.5<|Δη|<2.5) into Δφ
- Propagate this background distribution in 2D
- Subtract from background from signal to yield isolated jet peak



- Finally: apply two MC-based corrections for jet reconstruction biases

Dijet shapes in 2.76 TeV



PLB: Inclusive jets, pT > 120 GeV

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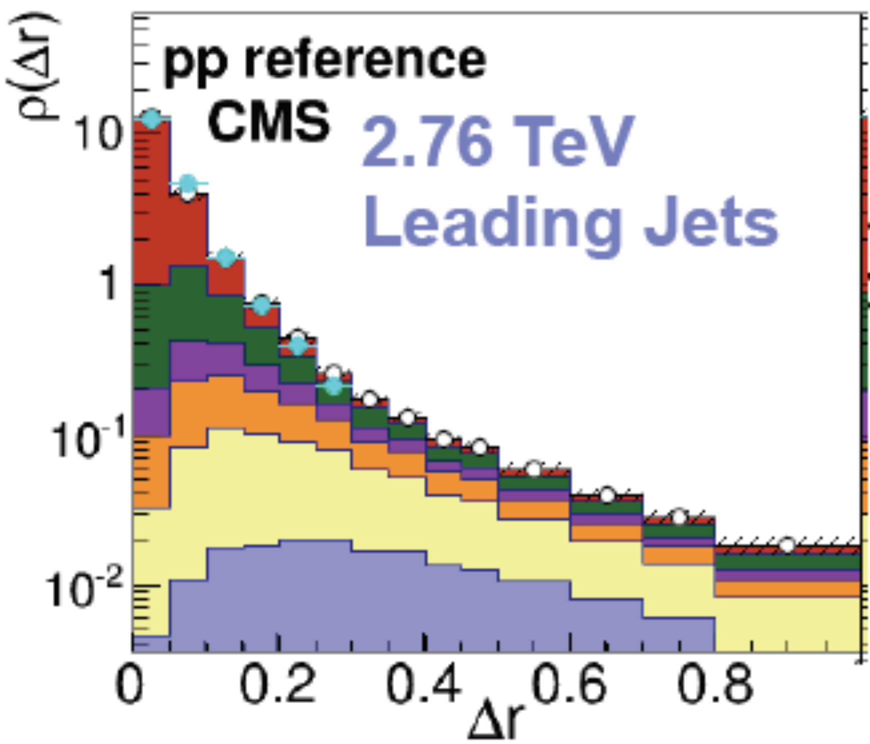
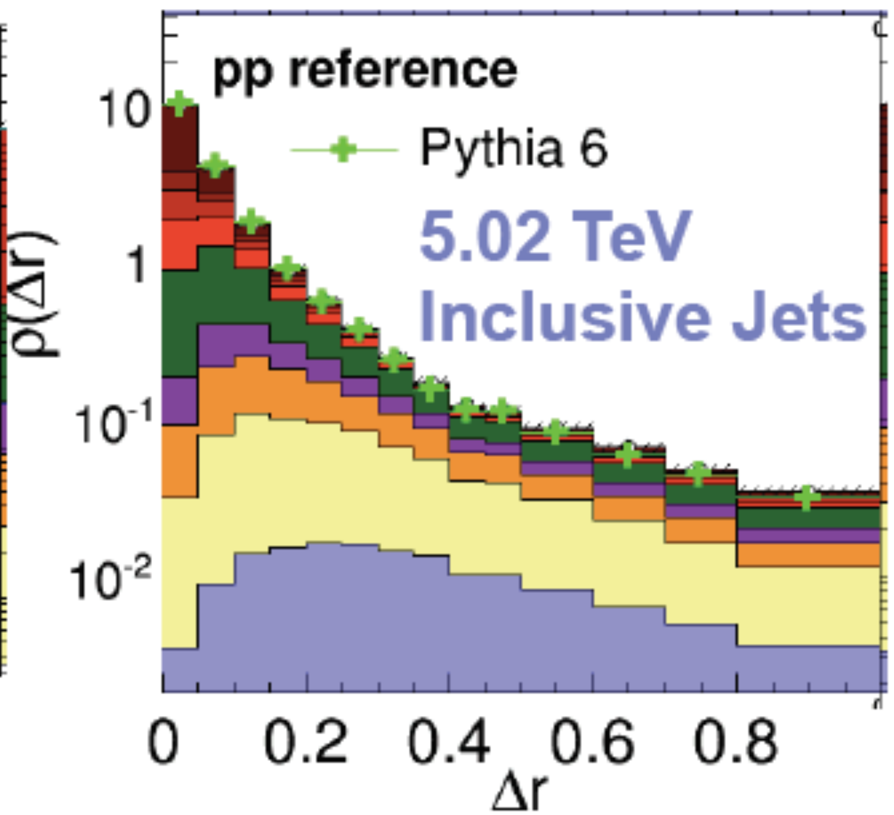
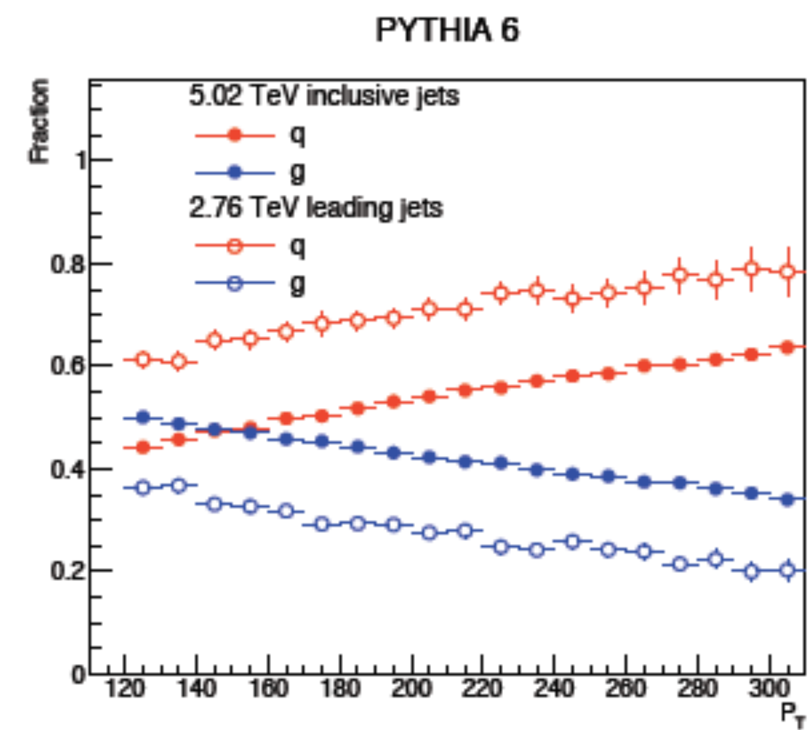
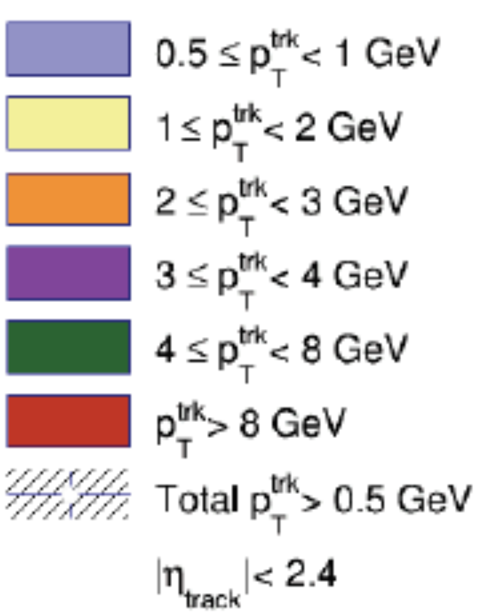
Inclusive jet shapes









pp jet shapes are significantly broader and softer at 5.02 TeV

- 2.76 TeV Leading Jets: 64.0% Quark Jets, 33.4% Gluon Jets
- 5.02 TeV Inclusive Jets: 47.4 % Quark Jets, 47.6% Gluon Jets

In modification measurements:

- PbPb – pp differences are similar at 5.02 and 2.76 TeV
- Difference in jet shape ratio can be accounted for by differences in pp reference jet shape

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