PHOTON-TAGGED JET SUBSTRUCTURE IN PP AND PBPB COLLISIONS AT 5.02 TEV WITH CMS

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Opportunities and Challenges with Jets at LHC and beyond
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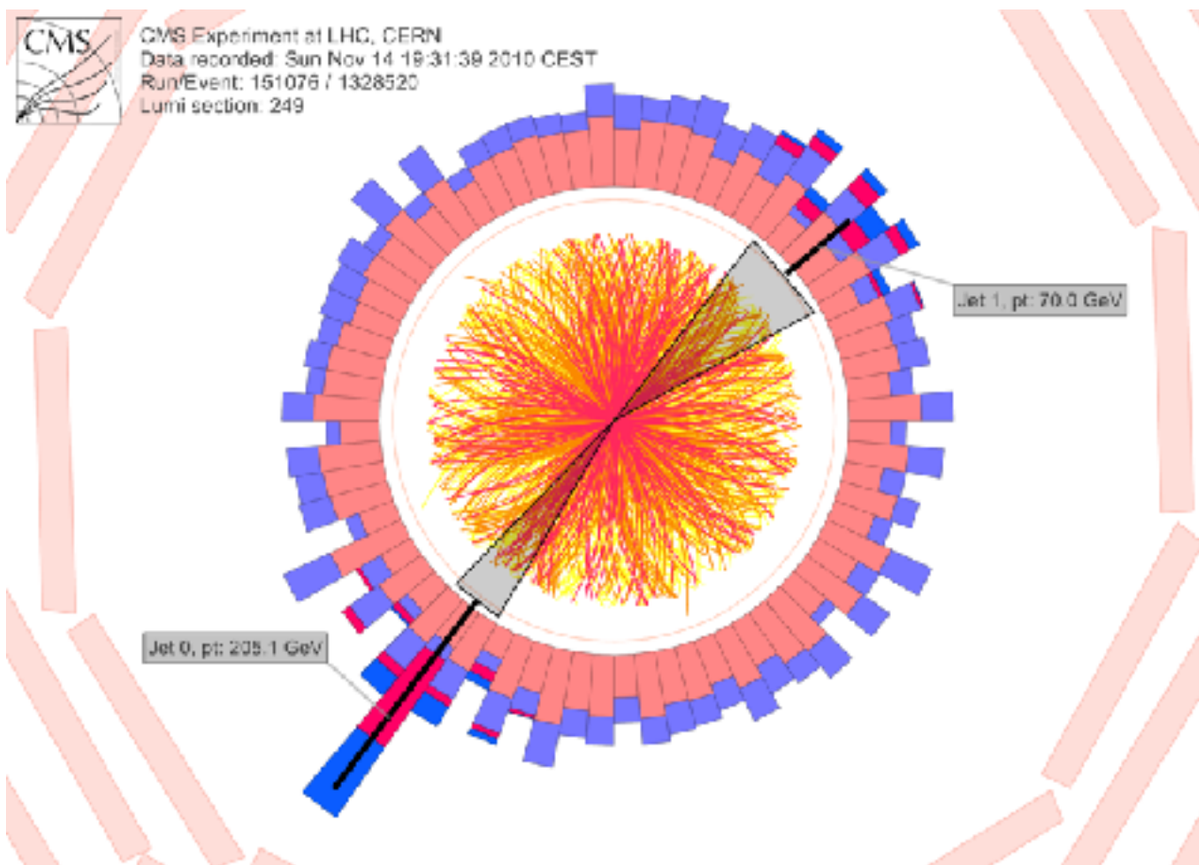
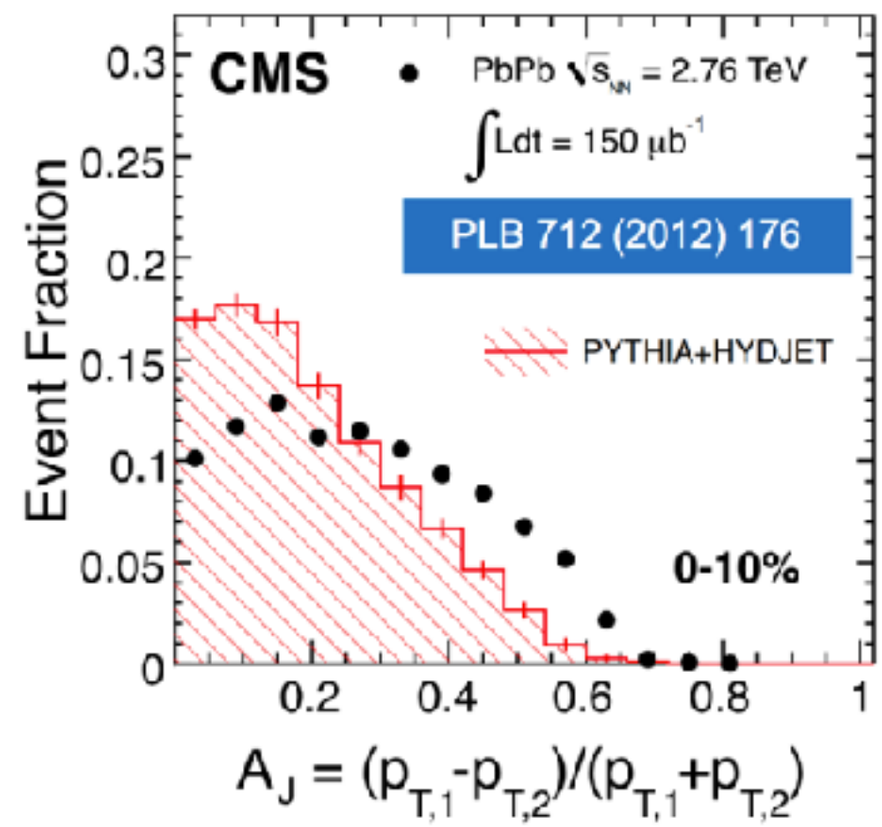
ENERGY LOSS IN DIJET EVENTS

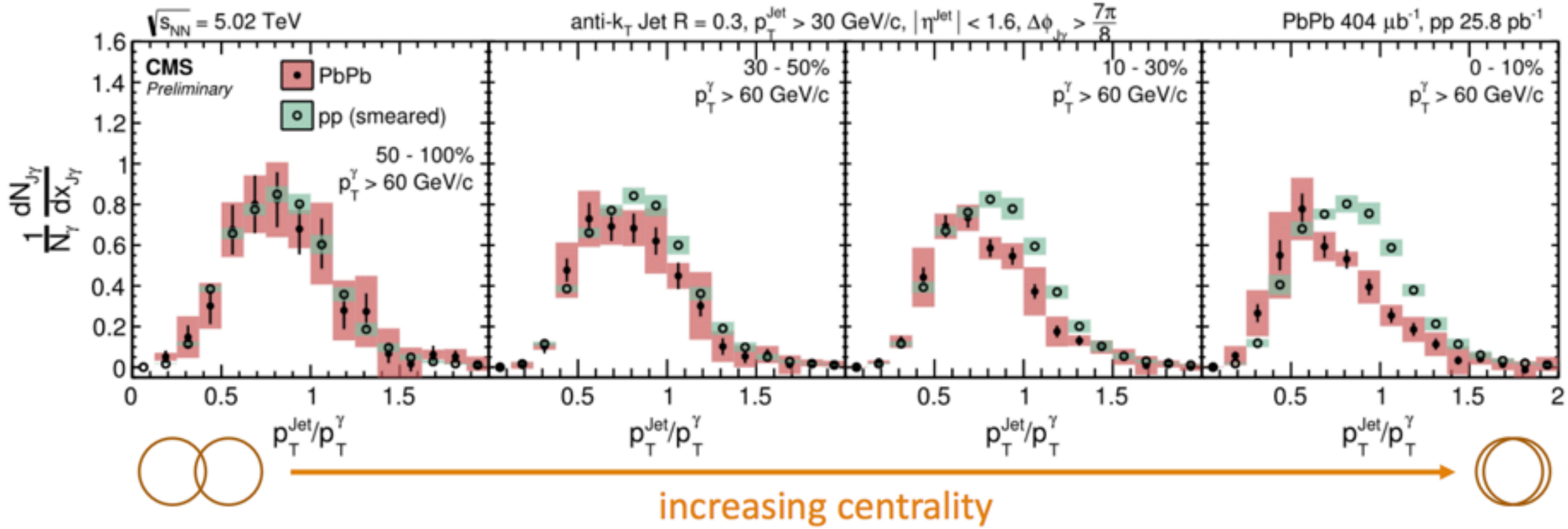
- Jet quenching is a characteristic feature of the QGP
  - Observed through measurements of jet energy loss in dijet systems
- Caveat: both jets are modified when passing through the medium





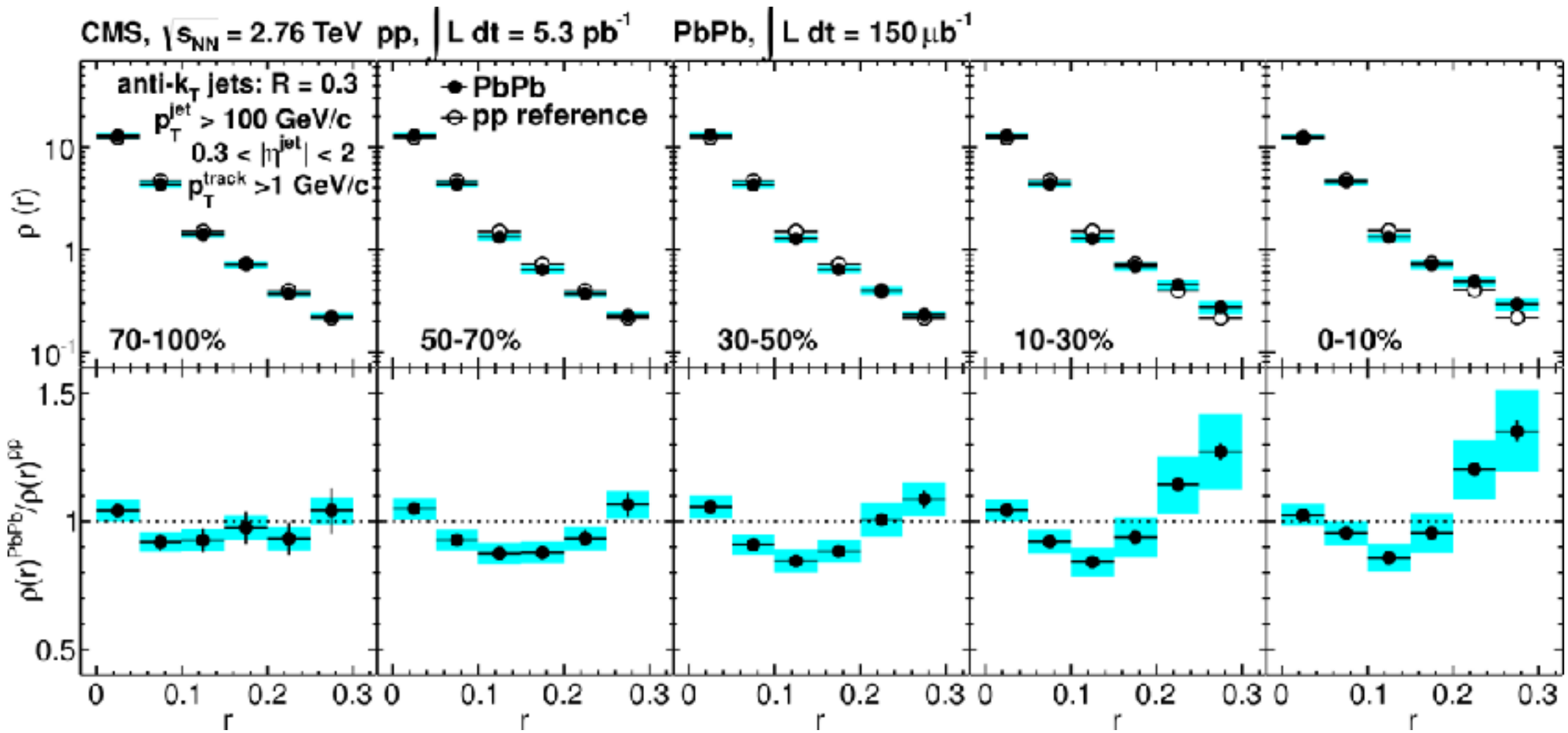
ENERGY LOSS IN PHOTON-JET EVENTS

- Photons, being colourless, do not interact with the medium
  - Clean tag of the initial energy
  - Better handle on the quark/gluon jet ratio
- Measurements with photon-jet and Z-jet events show clear evidence for in-medium energy loss



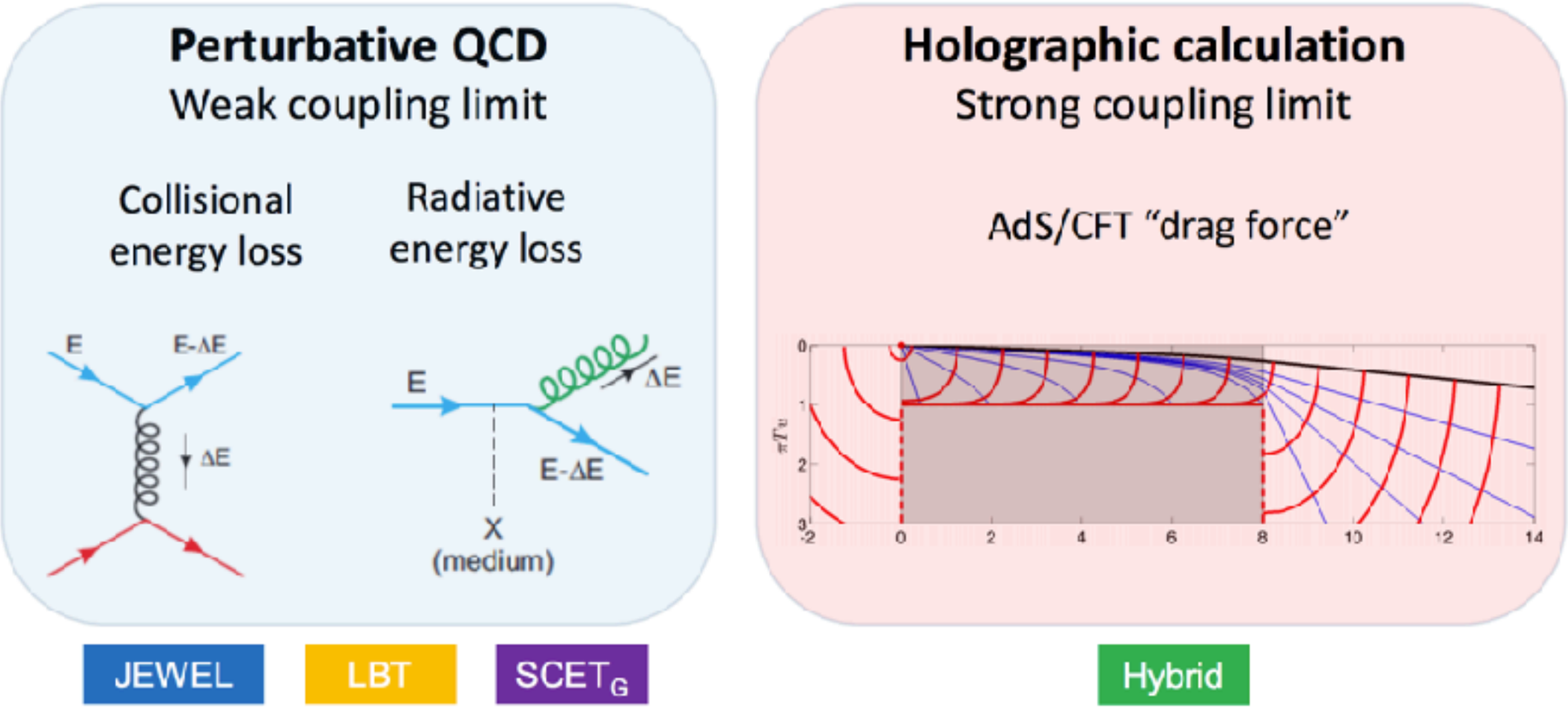
PHOTON-TAGGED JET SUBSTRUCTURE

- Where does the quenched jet energy go?
  - Jet substructure measurements can help answer this



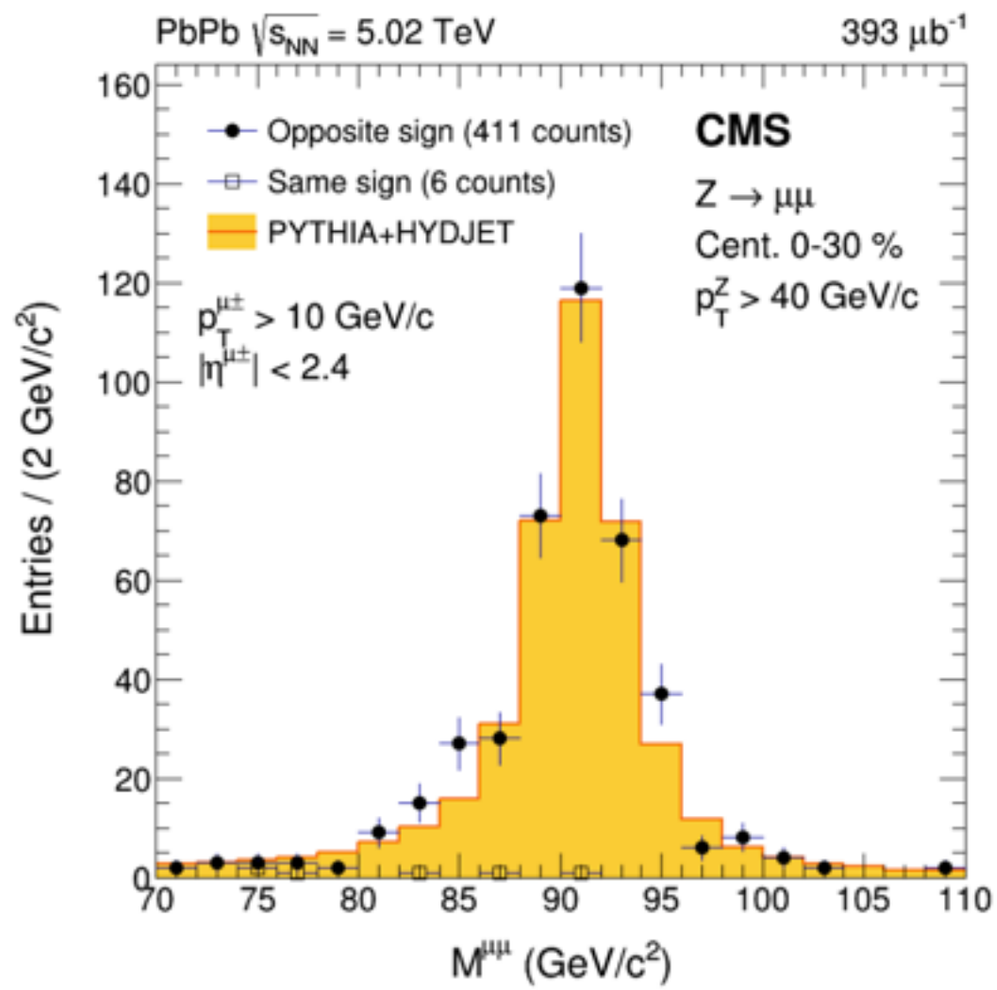
ENERGY LOSS MECHANISMS

- Various models exist with different approaches to modelling the energy loss



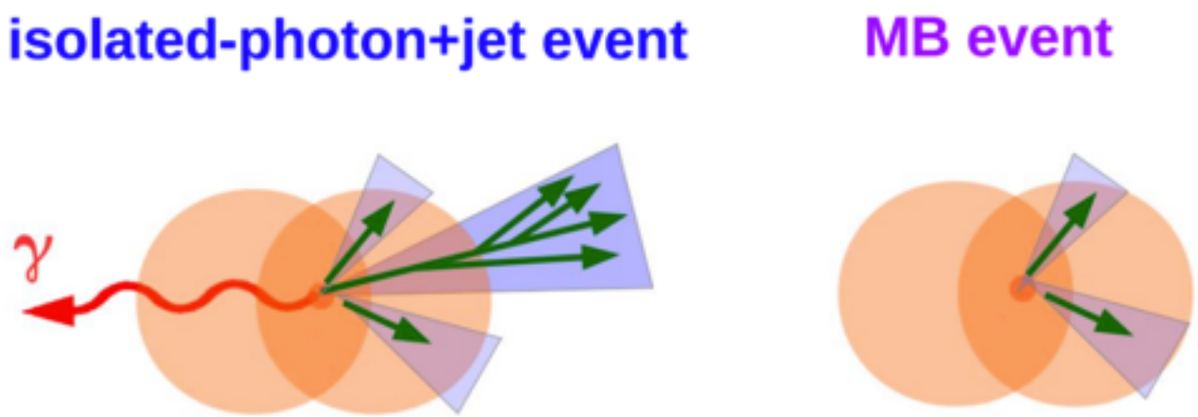
ANALYSIS TECHNIQUE

- Reconstruct photons, tracks, jets
- Correlate selected photons with all jets (back-to-back with the photon) within the event (inclusive jet measurement)
- Subtract backgrounds
  - Underlying event
  - Neutral meson decays
- Smear jet resolutions/Correct for resolution effects
  - Necessary for proper comparison



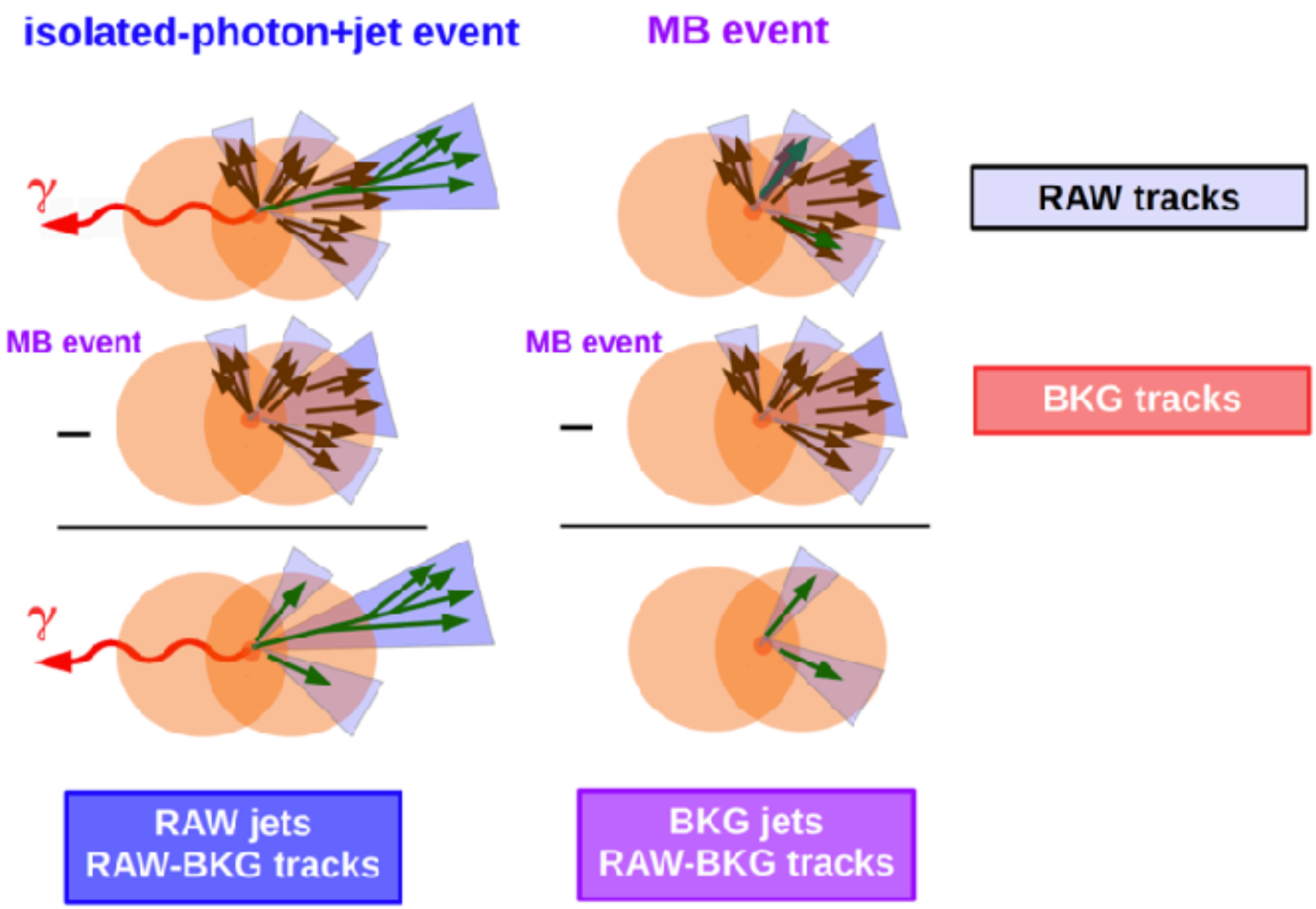
BACKGROUND SUBTRACTION (EVENT MIXING)

- Tracks from the underlying event are uncorrelated with the photon
  - Estimate contribution of underlying event by embedding the photon into minimum bias (MB) events
  - Select MB events with similar event characteristics
    - Centrality, primary vertex position, event plane angle



BACKGROUND SUBTRACTION (EVENT MIXING…)

- Contributions from background tracks (UE) and background jets (fake jets) must be subtracted



BACKGROUND SUBTRACTION (EVENT MIXING……)

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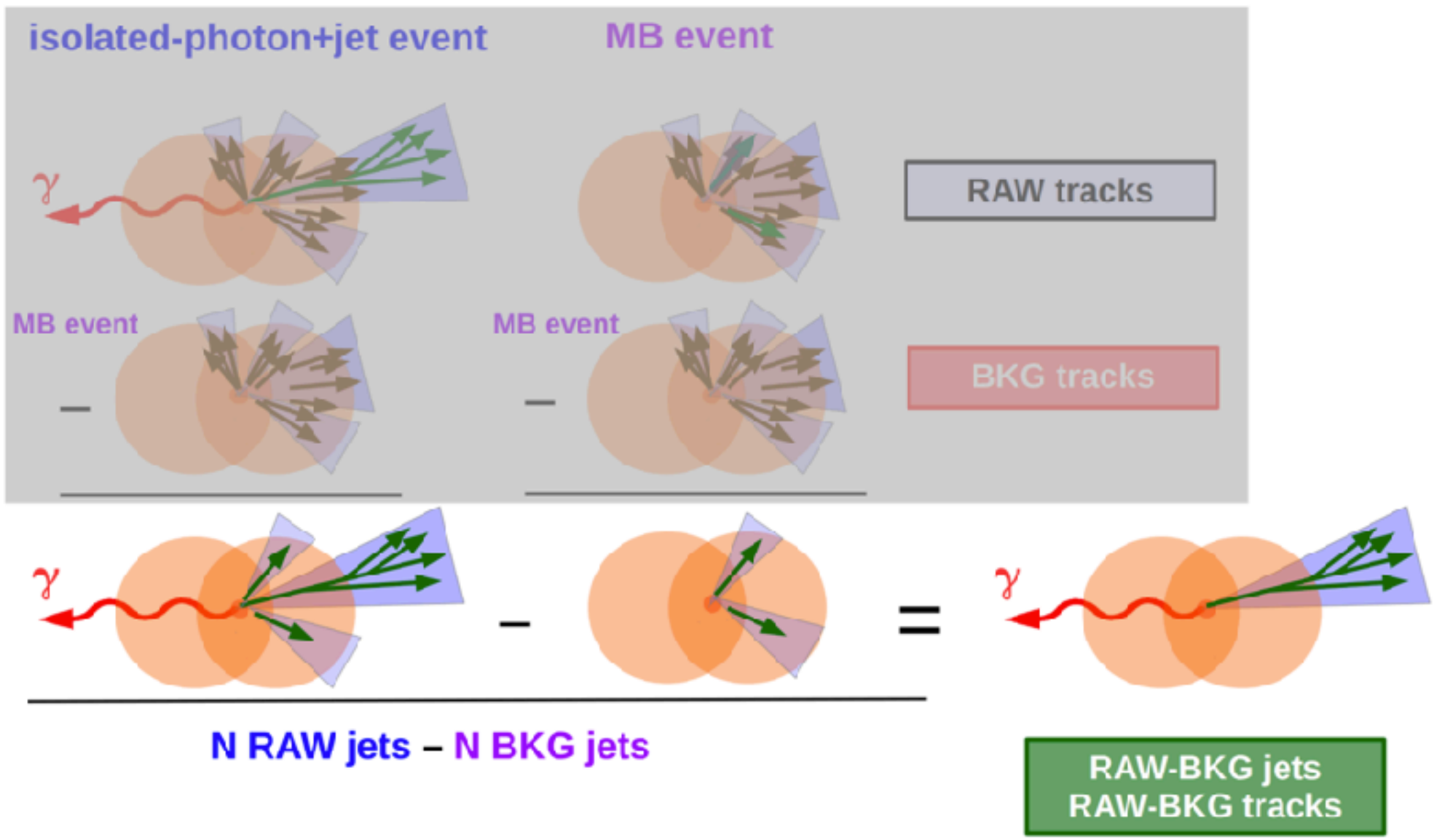
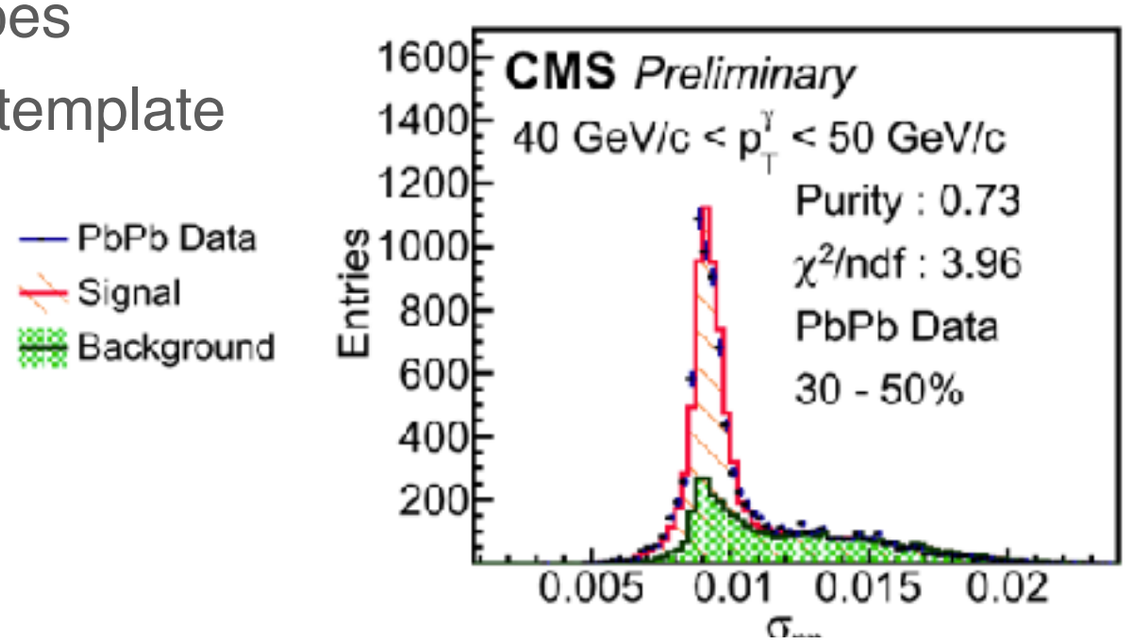
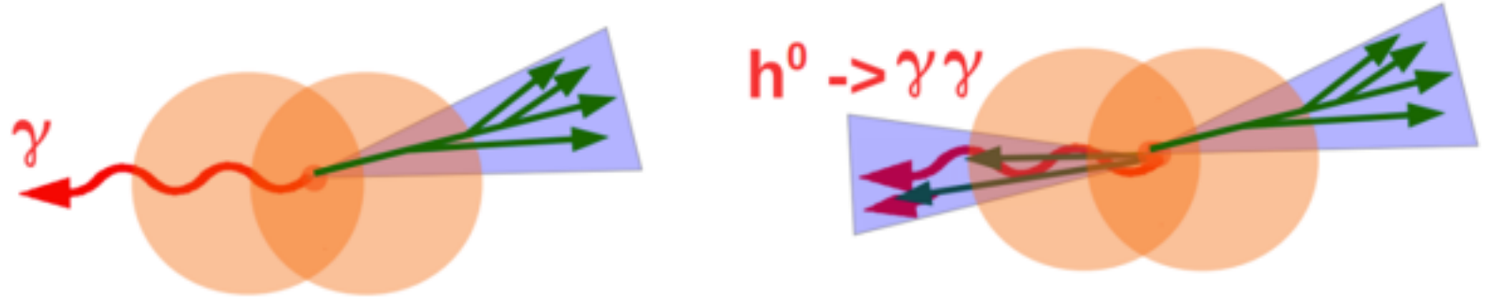


BACKGROUND SUBTRACTION (NEUTRAL MESON DECAY)

- Photons produced from neutral meson decays mimic direct photons
  - Generally have wider shower shapes
  - Estimated and subtracted using a template fitting method
    - Signal template from simulation
    - Background template from data

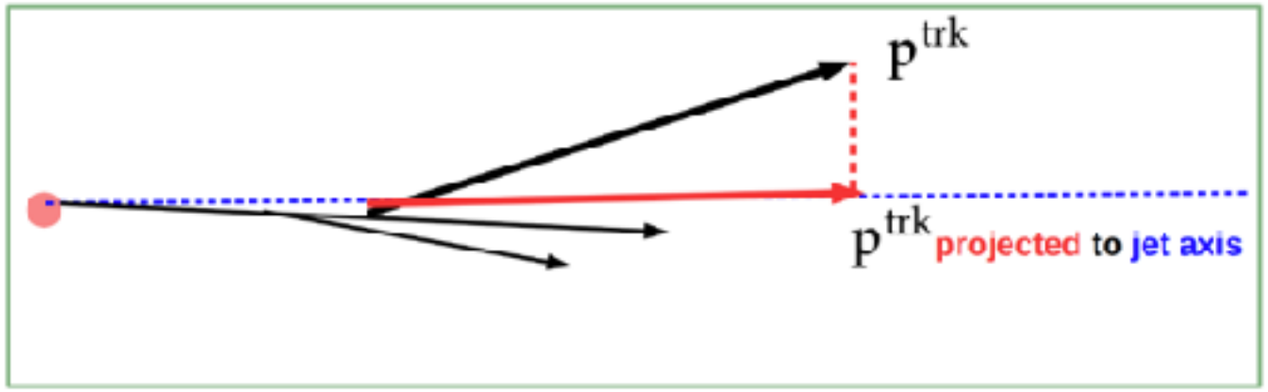




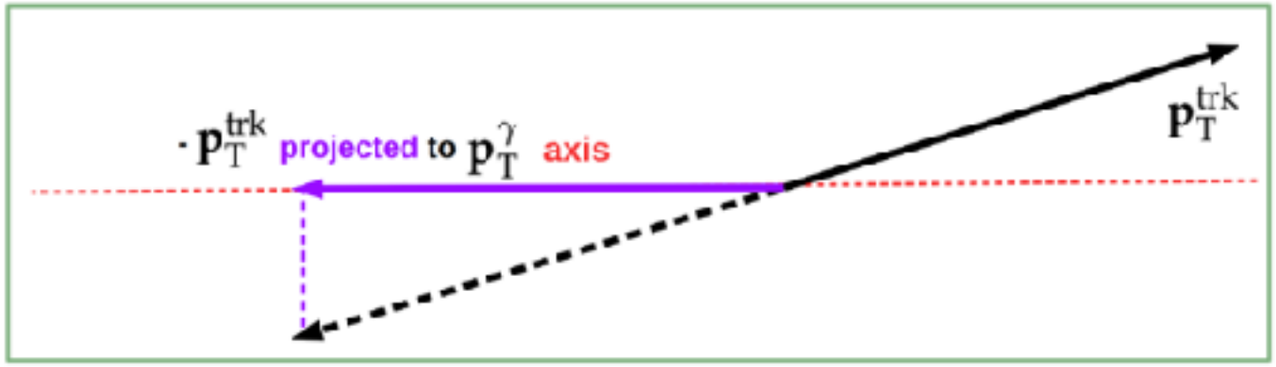
$$\text{Final result} = \frac{1}{\text{purity}} \times \text{Observable from all photon candidates} - \frac{1 - \text{purity}}{\text{purity}} \times \text{Observable from sideband photons}$$

OBSERVABLES (JET FRAGMENTATION FUNCTION)

- Jet fragmentation function
  - $\xi^{jet} = \ln \frac{|\mathbf{p}^{jet}|^2}{\mathbf{p}^{trk} \cdot \mathbf{p}^{jet}}$
  - Distribution of jet momentum parallel to the jet axis
    - Sensitive to hadronisation

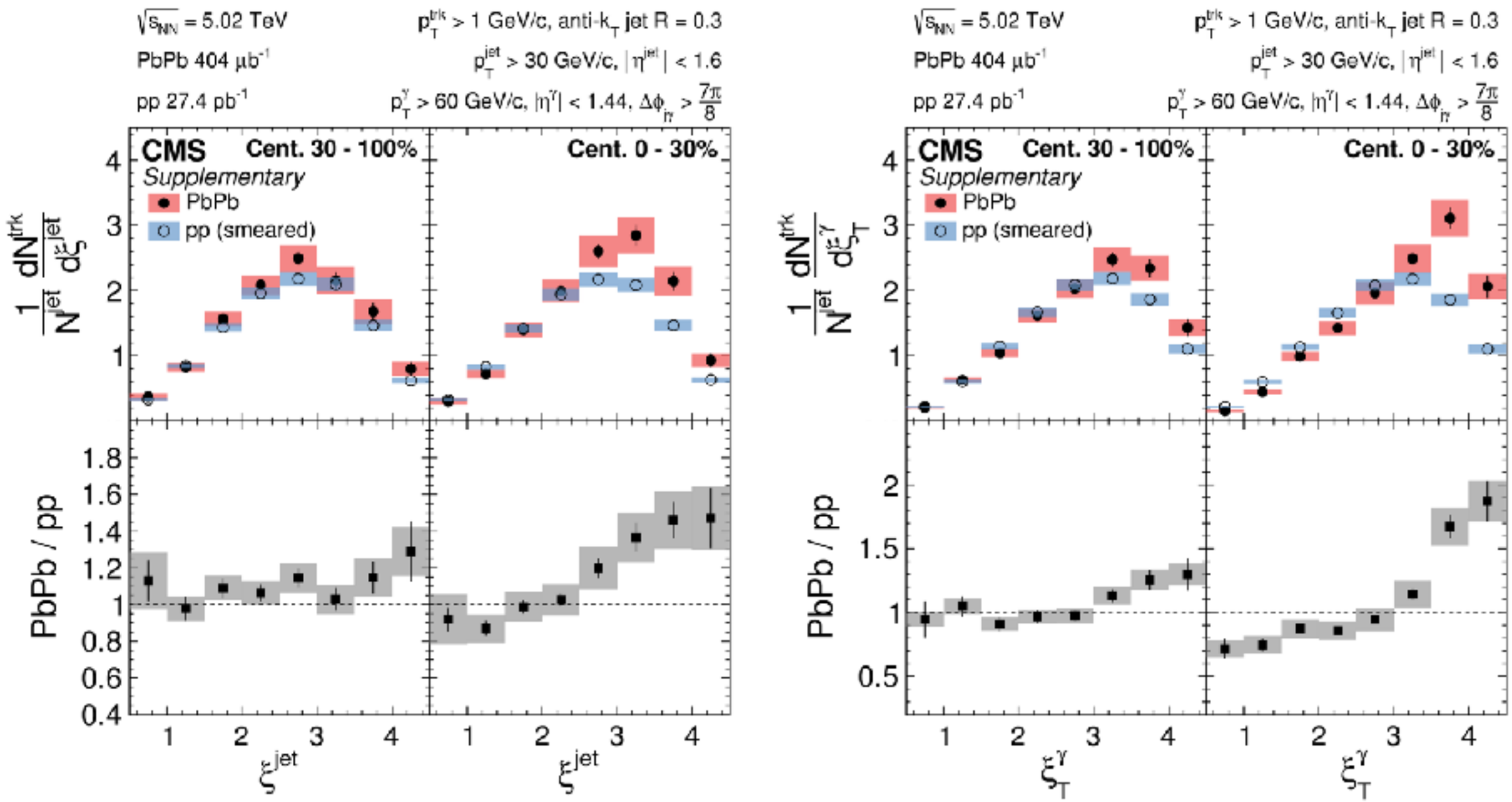


- Can also be calculated with respect to photon momentum
  - $\xi_T^{\gamma} = \ln \frac{-|\mathbf{p}_T^{\gamma}|^2}{\mathbf{p}_T^{trk} \cdot \mathbf{p}_T^{\gamma}}$
  - Momentum conservation is valid only in transverse direction



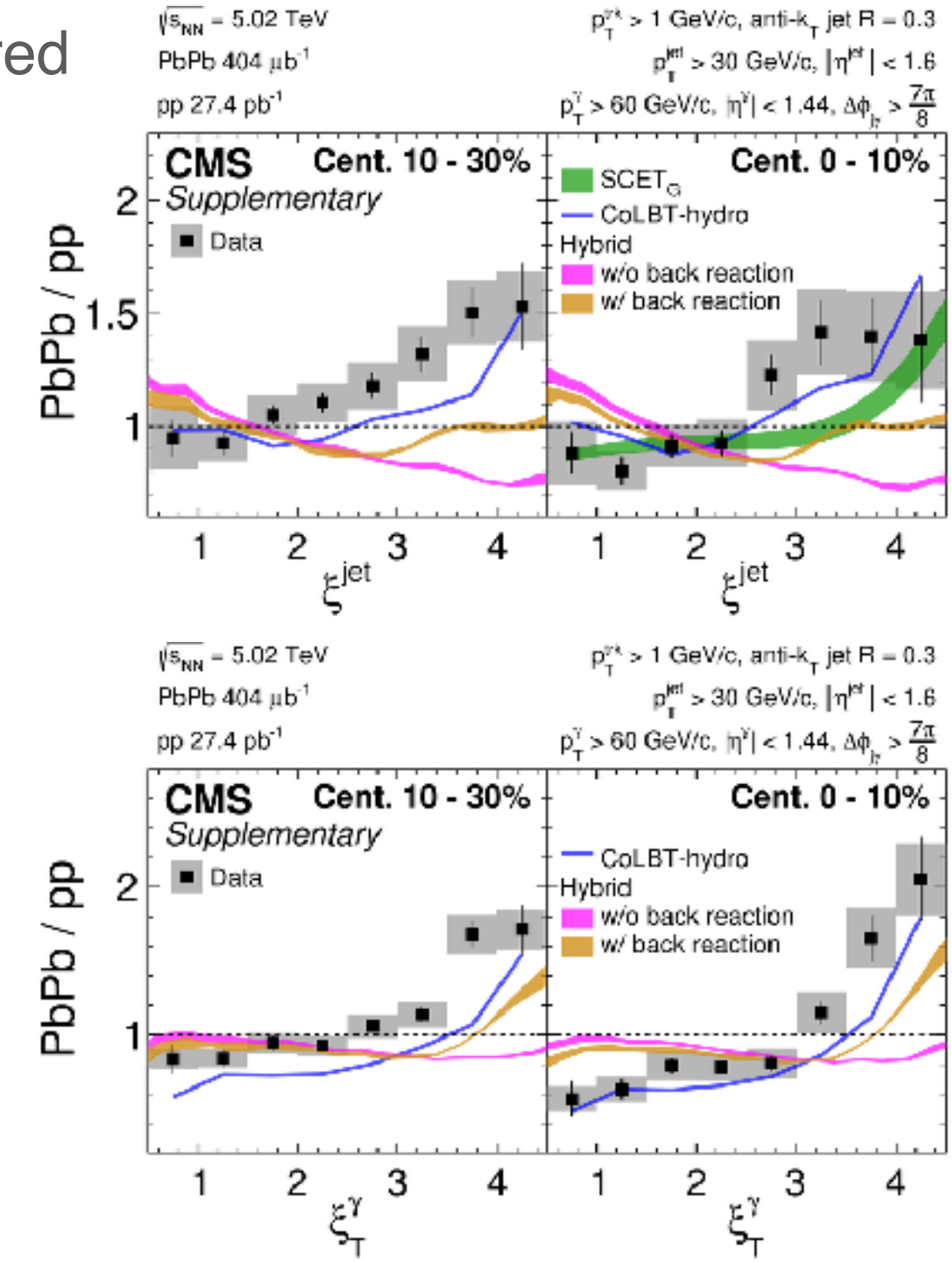
RESULTS (JET FRAGMENTATION FUNCTION)

- Enhancement of low-pT particles, depletion of high-pT particles



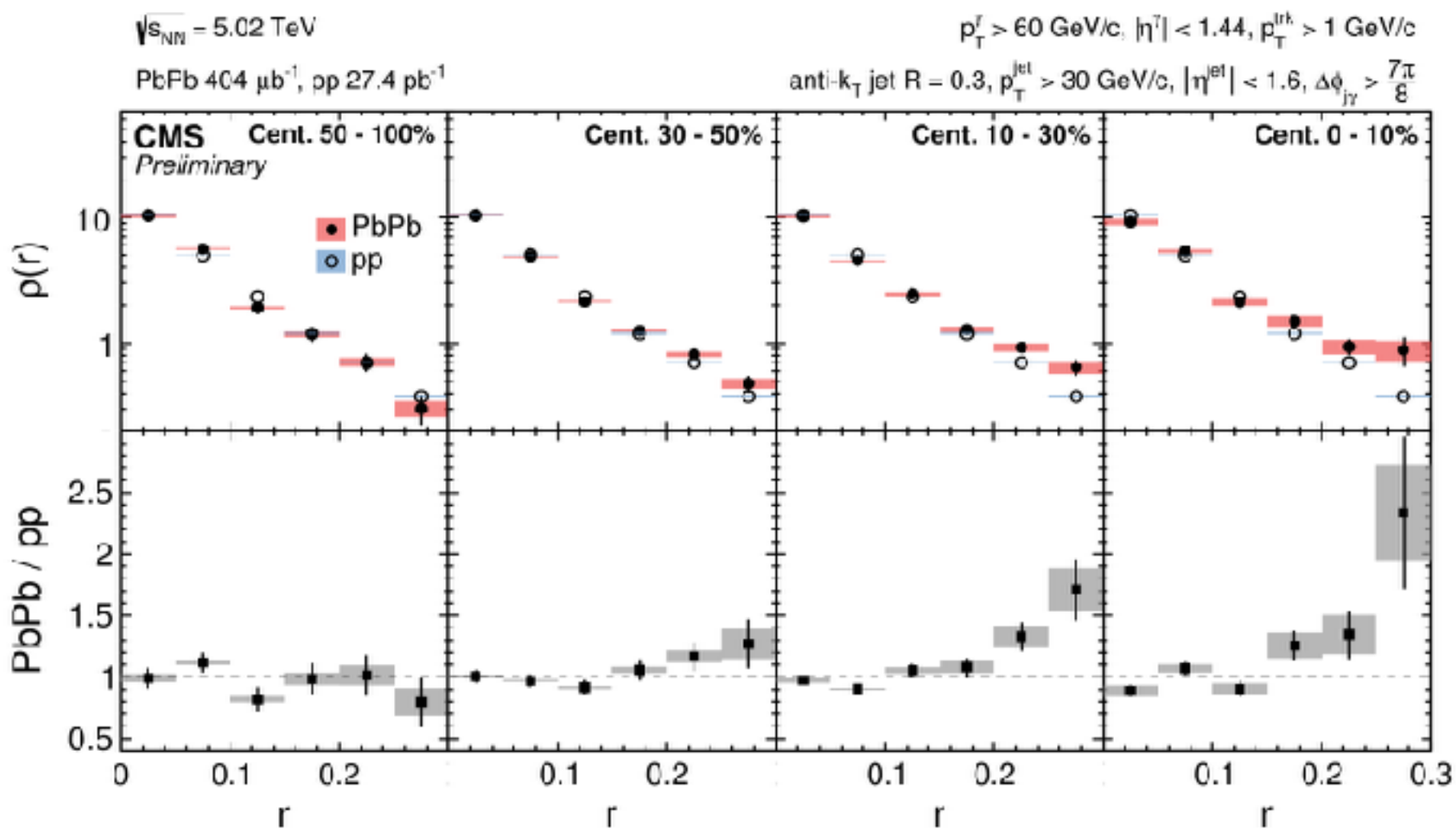
THEORY COMPARISON (JET FRAGMENTATION FUNCTION)

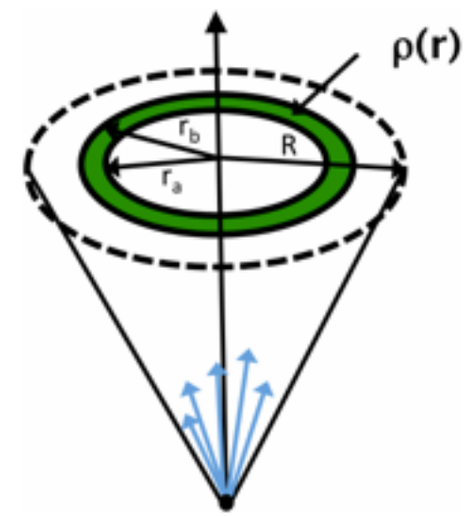
- Stronger modification for ξ_T^{γ} compared to ξ^{jet}
  - Jet energy quenched
- $SCET_G$/CoLBT-hydro describes trend in both observables
- Enhancement at large ξ (low-p_T particles) is underestimated in all models



OBSERVABLES (JET SHAPE)

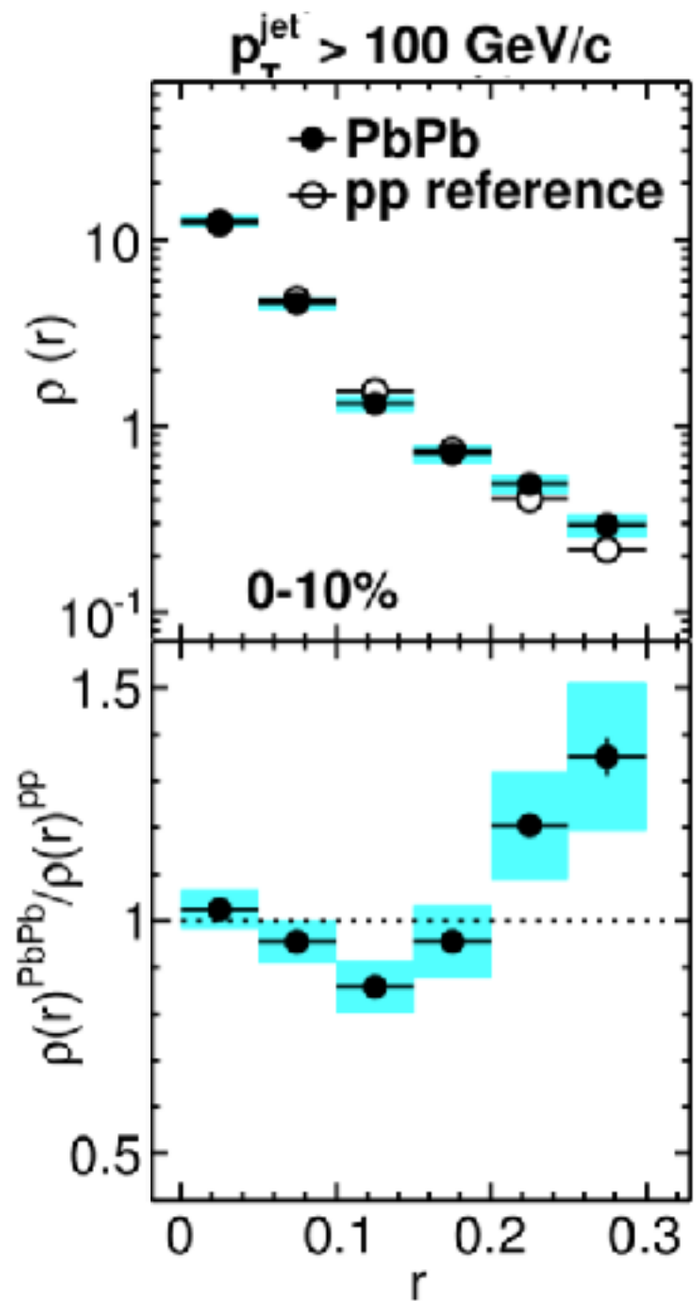
- Distribution of jet energy in transverse direction with respect to jet axis
  - Complementary information to jet fragmentation function
- $$\rho(r) = \frac{1}{\delta r} \frac{\sum_{\text{jets}} \sum_{\text{trk}\in[r_a, r_b)} (p_T^{\text{trk}} / p_T^{\text{jet}})}{\sum_{\text{jets}} \sum_{\text{trk}\in[0, r_f)} (p_T^{\text{trk}} / p_T^{\text{jet}})}$$

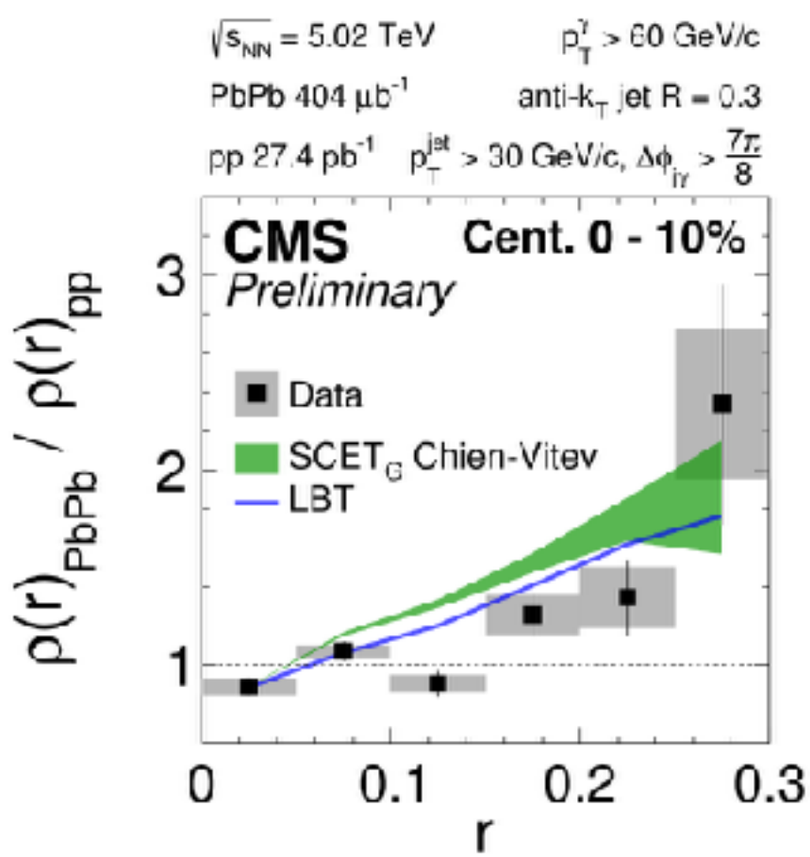




RESULTS (JET SHAPE)

- Comparison to inclusive jet shapes
  - No depletion at intermediate r
    - Increased quark/gluon ratio
    - Lower jet p_T threshold - jets lose more energy
- Comparison to theory models
  - $SCET_G$/LBT describes trend





SUMMARY

- Photon-tagged measurements constrain initial parton kinematics and flavour
- Photon-tagged jet fragmentation functions:
  - Depletion of high-p_T particles and excess of low-p_T particles within the jet
- Photon-tagged jet shapes:
  - Larger amount of jet energy found at larger radial distances from the jet axis