Studies of medium induced modification of jets using photon-tagged jets with the CMS detector

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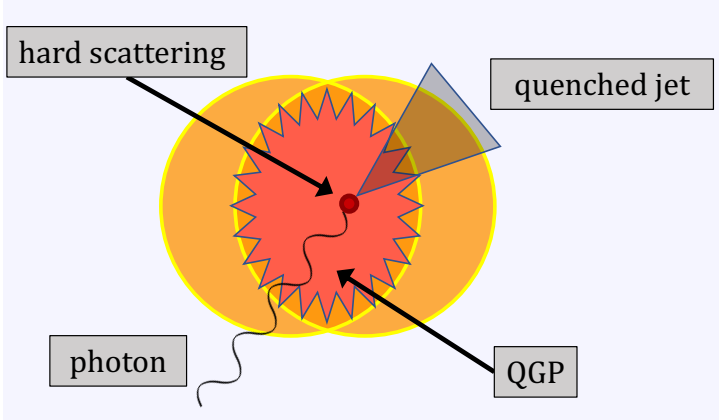
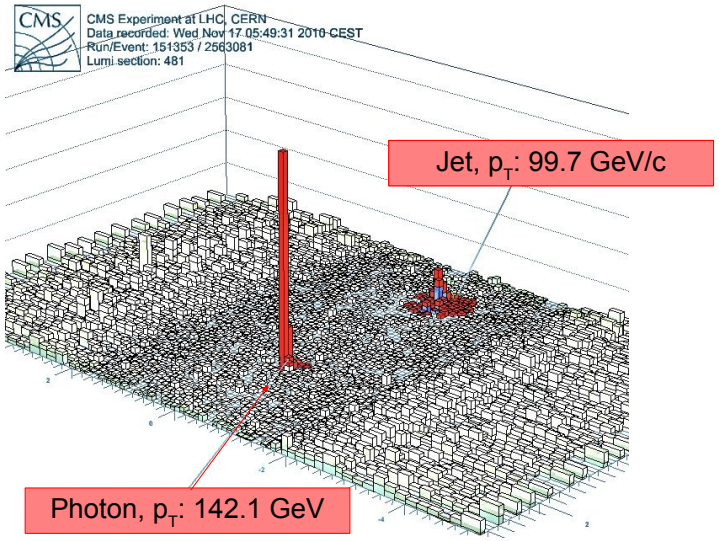
Introduction

- After heavy ions collide, Quark Gluon Plasma (QGP) is formed.
- Jet quenching: hard scattered partons lose energy by interaction with QGP.
- Photons do not interact strongly with QGP: can tag initial p_{T} of the recoil partons.



HI Collision



Analysis Procedure for Photon R_{AA}

Photon selections:

- Selected online by L1+HLT triggers.
- $25 < E_T^{\gamma} < 200$ GeV and $|\eta| < 1.44$
- Reject if too close (difference in η or $\phi < 0.03$) to $e^{\pm}$ candidate track with $p_T^e > 10$ GeV/c.

Isolation selections:

- $E_{\mathrm{HCal}}/E_{\mathrm{ECal}} < 0.1$.
- Shower shape $\sigma_{\eta\eta} < 0.01$.
- Isolation variable $I = \sum_{\Delta R \leq 0.4} E < 1$ GeV.

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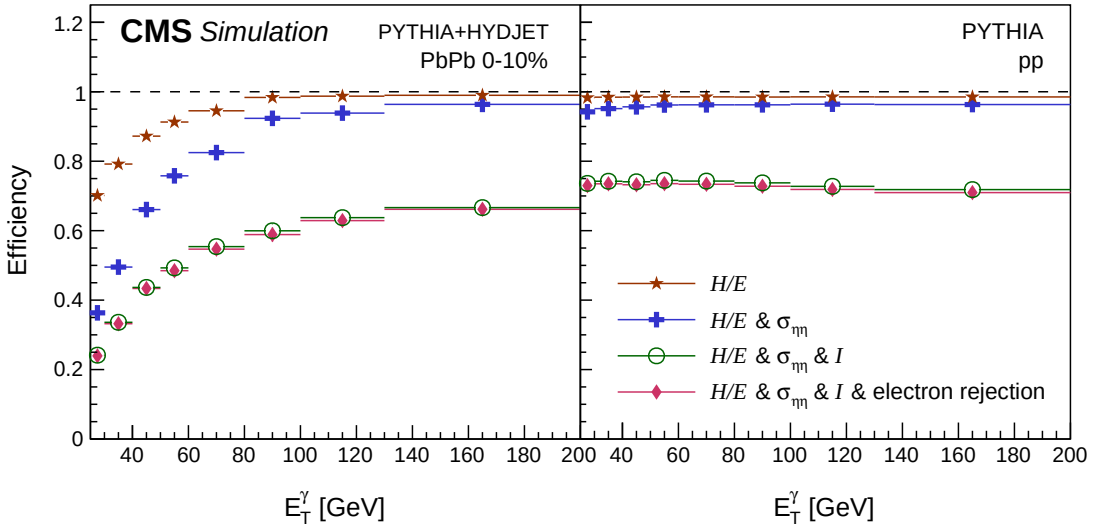
Selection Efficiency



Efficiency corrections:

photon reconstruction, selection, trigger.

$$N^{\gamma}_{\mathrm{corrected}} = \frac{N^{\gamma}_{\mathrm{raw}} P}{\epsilon}.$$

Results unfolded to correct for detector resolution.

Analysis Procedure (cont.) and Photon R_{AA} Results

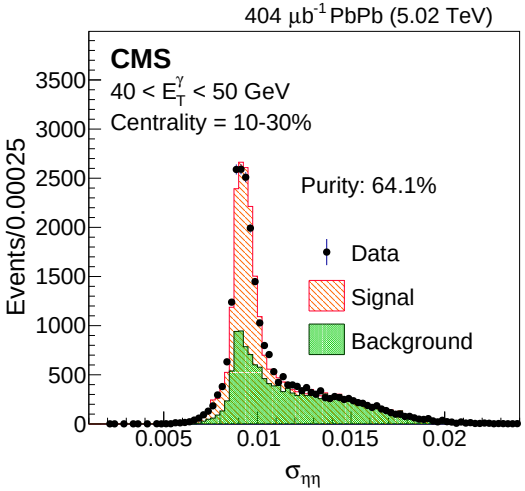
Purity subtraction:

- Dominant background: neutral meson decays, mostly with larger width $\sigma_{\eta\eta} = \sqrt{(\sum_i^{5\times5} w_i(\eta_i - \eta_{5\times5})^2)/(\sum_i^{5\times5} w_i)}$, $w_i = \max(0, 4.7 + \ln \frac{E_i}{E_{5\times5}})$
- Use template fit method to estimate purity and subtract decay photon bkg.

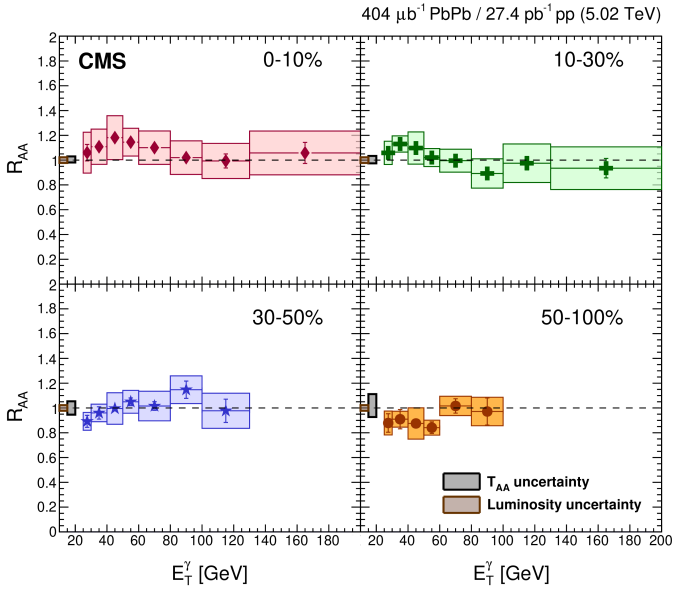
Photon R_{AA} Results:

- $R_{\mathrm{AA}} = \frac{1}{<T_{\mathrm{AA}}>} \frac{1}{N_{\mathrm{MB}}} \frac{d^2 N^{\gamma}_{\mathrm{PbPb}}/dE^{\gamma}_{\mathrm{T}} d\eta}{d^2 \sigma^{\gamma}_{pp}/dE^{\gamma}_{\mathrm{T}} d\eta}$
- Photon production in PbPb collisions and in *pp* collisions are consistent: do not interact significantly with QGP.
- Isolated photons can be used to tag initial transverse momentum of the associated parton.

Purity Template Fit



Isolated Photon R_{AA}



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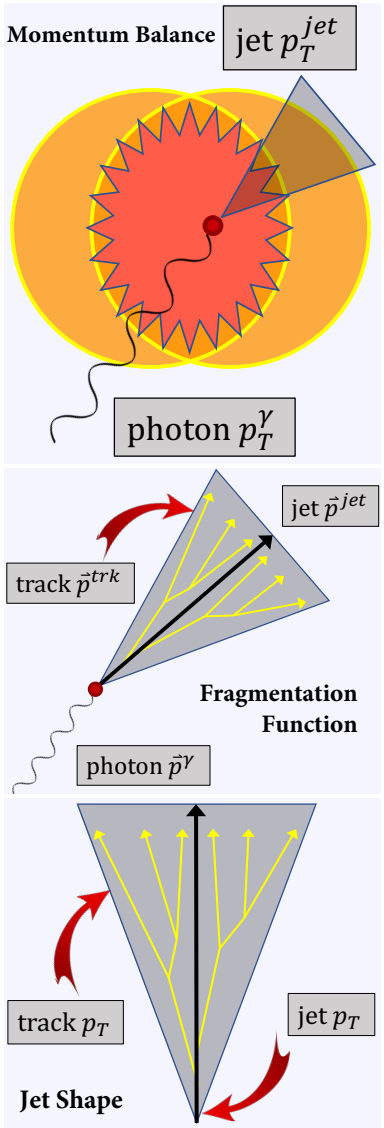
Analysis Procedure for Photon-Jet Analyses

Observables:

- Momentum balance: $x_{\mathrm{jet},\gamma} = p_{\mathrm{T}}^{\mathrm{jet}} / p_{\mathrm{T}}^{\gamma}$.
- Fragmentation function: $\xi^{\mathrm{jet}} = \ln \frac{|\vec{p}^{\mathrm{jet}}|^2}{\vec{p}^{\mathrm{trk}} \cdot \vec{p}^{\mathrm{jet}}}$
- Jet shape: $\rho(r) = \frac{1}{\delta r} \frac{\sum_{\mathrm{jets}} \sum_{r_a < r < r_b} p_{\mathrm{T}}^{\mathrm{trk}} / p_{\mathrm{T}}^{\mathrm{jet}}}{\sum_{\mathrm{jets}} \sum_{0 < r < r_f} p_{\mathrm{T}}^{\mathrm{trk}} / p_{\mathrm{T}}^{\mathrm{jet}}}$

Analysis procedure:

- $p_T^{\gamma} > 40$ GeV and $|\eta| < 1.44$.
- Momentum Imbalance: Select $p_T^{\mathrm{jet}} > 30$ GeV and $\Delta\phi_{j\gamma} > 7\pi/8$.
- Cluster anti-k_{T} $R = 0.3$ jets.
- Subtract underlying events for PbPb collisions.
- Photon isolation variable $I = \sum_{\Delta R \leq 0.4} E < 1$ GeV.
- Reject the photon candidate if too close to $e^{\pm}$ candidate track with $p_T^e > 10$ GeV/c.
- Purity subtraction to remove decay photons.
- Subtract combinatorial jet background with mixed event background subtraction using MB events.



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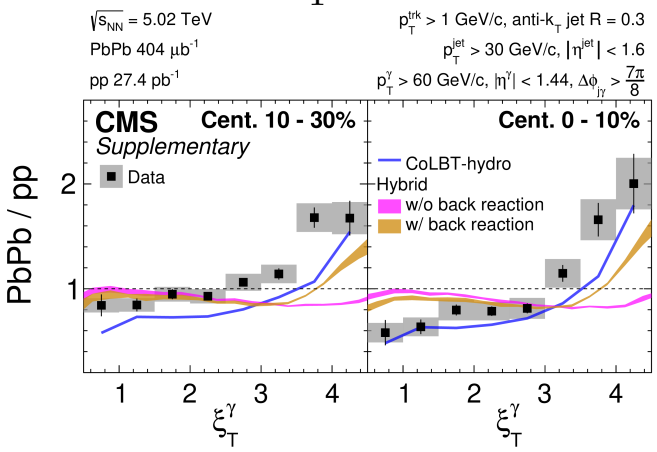
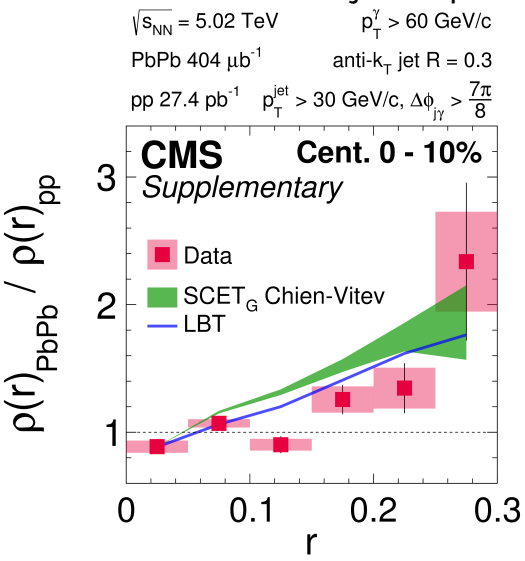
Results

- Mean and yield for $x_{j\gamma}$ shift to lower values in PbPb: overall jet energy loss.
- Central PbPb events show:
  ◊ Depletion of high p_{T} particles: evidence of jet quenching.
  ◊ Excess of low p_{T} particles: Medium response? Higher p_{T} particles losing energy?
- Small relative modification of jet core and enhancement of particles away from jet axis: evidence of broadening.
- Theoretical models agree with data well.
- Future plan: other photon-jet observables such as $\Delta\phi_{j\gamma}$ and jet-axis decorrelation δ_{jj}.
- See slides by Molly Taylor on April 6th for more details.

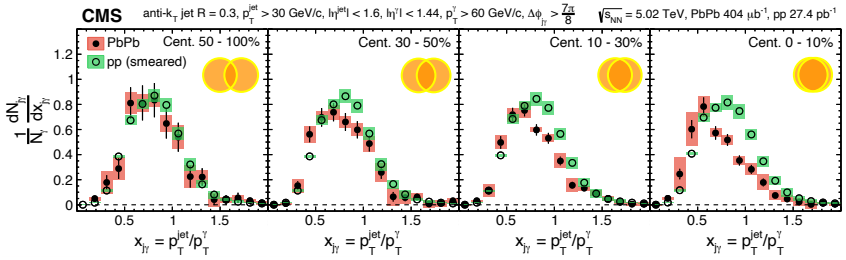
Ratios of $\xi_{\mathrm{T}}^{\gamma}$ distributions

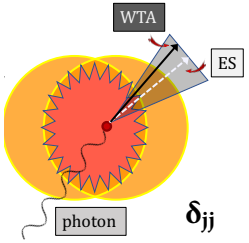


Ratios of differential jet shape



Centrality dependence of $x_{j\gamma}$





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