Measurement of Non-Exclusive Dimuon Pairs Produced via γγ Scattering in Pb+Pb Collisions at $\sqrt{s_{NN}}$ = 5.02 TeV with the ATLAS Detector

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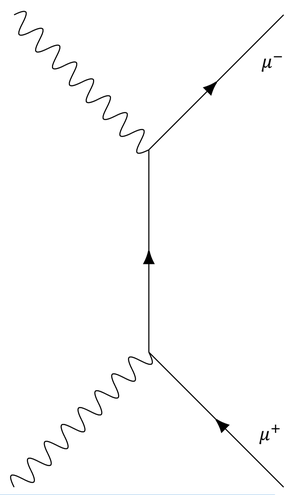
Introduction

- The intense electromagnetic field surrounding a highly charged, relativistic nucleus in Pb+Pb collisions provides an intense flux of quasi-real photons.
- The collisions between these photons (γγ) have been measured in ultra-peripheral collisons. A Feynman diagram of this process is shown below.
- In Pb+Pb collisions with a hadronic component, dimuon pairs produced via γγ scattering are still present and provide a potential electromagnetic probe of the Quark-Gluon plasma.



Methodology

Relevant Analysis Definitions

- Acoplanarity: Relative angular deflection of the dimuon pair

$$\alpha \equiv 1 - |\Delta\phi|/\pi$$

- Asymmetry: Transverse momentum imbalance of the dimuon pair

$$A \equiv (p_{T1} - p_{T2})/(p_{T1} + p_{T2})$$

- $k_\perp$: Relative momentum deflection of the dimuon pair

$$k_\perp \equiv (p_{T1} + p_{T2})\,|(\pi - \Delta\phi)|/2 = \pi\alpha\bar{p}_T$$

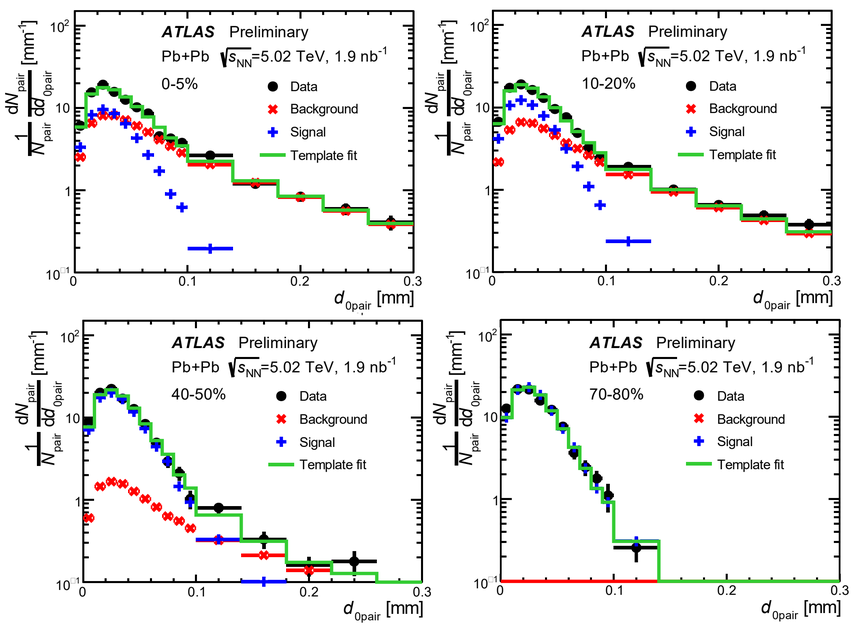
- d_{0pair}: Quadrature sum of muon impact parameters in transverse plane

$$d_{0pair} \equiv \sqrt{d_{01}^2 + d_{02}^2}$$

- Signal region definition:

$$\alpha < 0.08, A < 0.12, d_{0pair} < 0.3\ mm$$

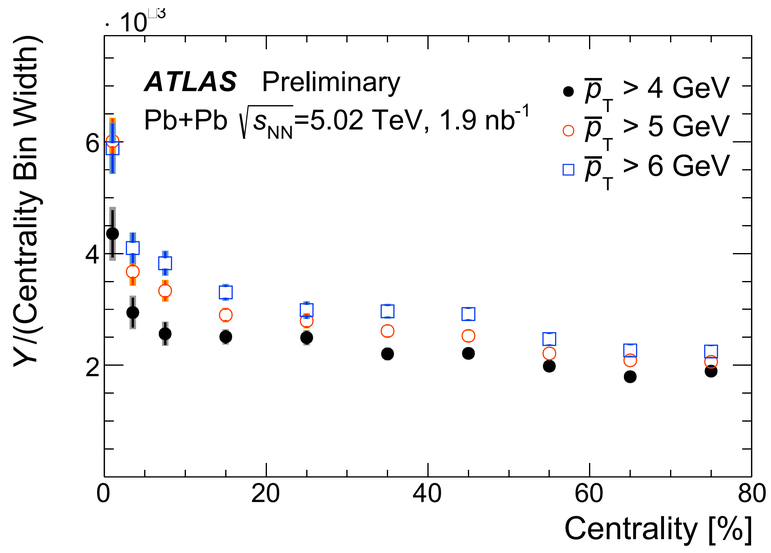
Template Fits of the Background



- A template fit to d_{0pair} is used to extract the heavy flavor muon background.
- The signal template is built using:
  - Monte Carlo simulation (Analysis default)
  - Ultra-peripheral reference (Cross-check)

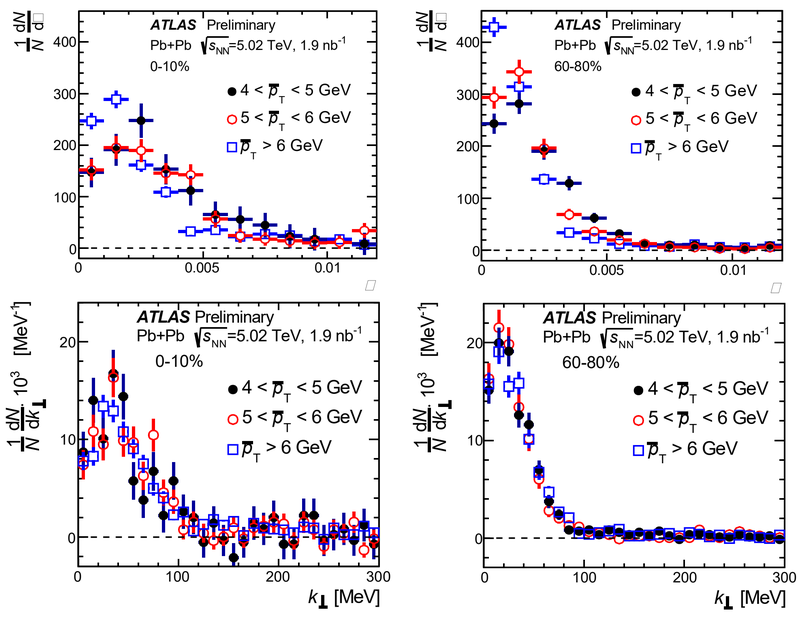
Results

Normalized Dimuon Yields



- The normalized dimuon yields from γγ scattering increase systematically from peripheral to central collisions.
- For lower-p_T muon pairs, the pairs from UPC events make up a largerer fraction of the total pairs.

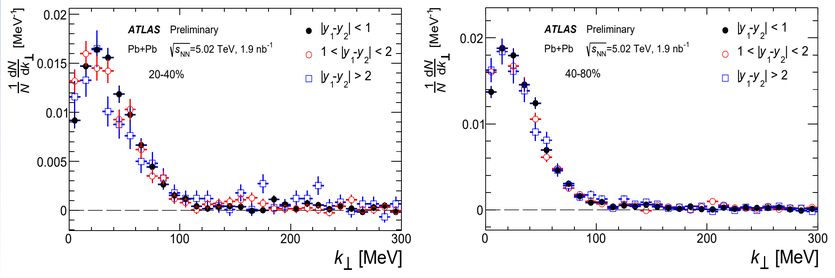
p_T Dependence of $k_\perp$ vs. α



- The $k_\perp$ variable gives consistent results across muon p_T ranges, while α does not.
- This behavior supports the use of $k_\perp$ as a more natural descriptor of modifications to the distribution with centrality.

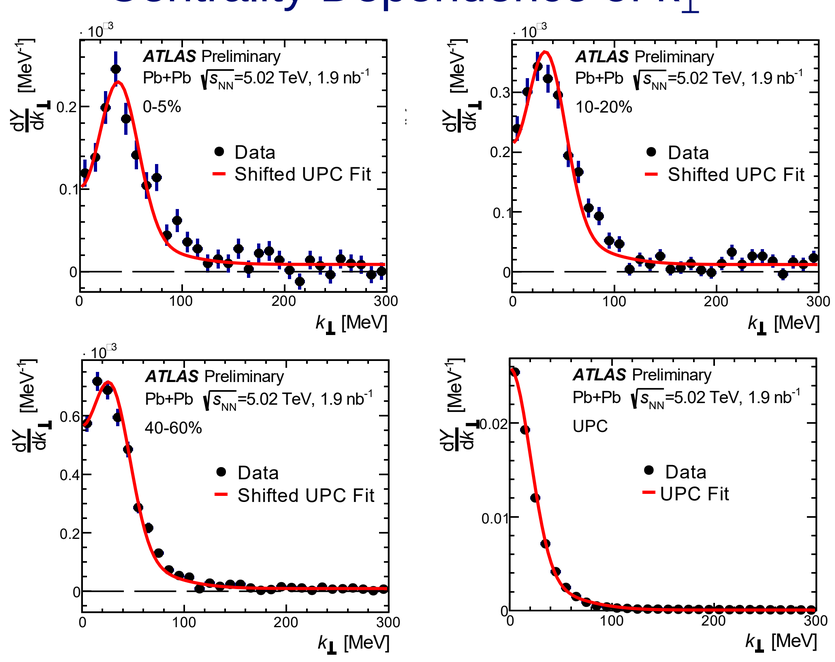
Δy Dependence of $k_\perp$

- The difference in rapidity of the two muons in the pair is potentially sensitive to different models of muon deflection.

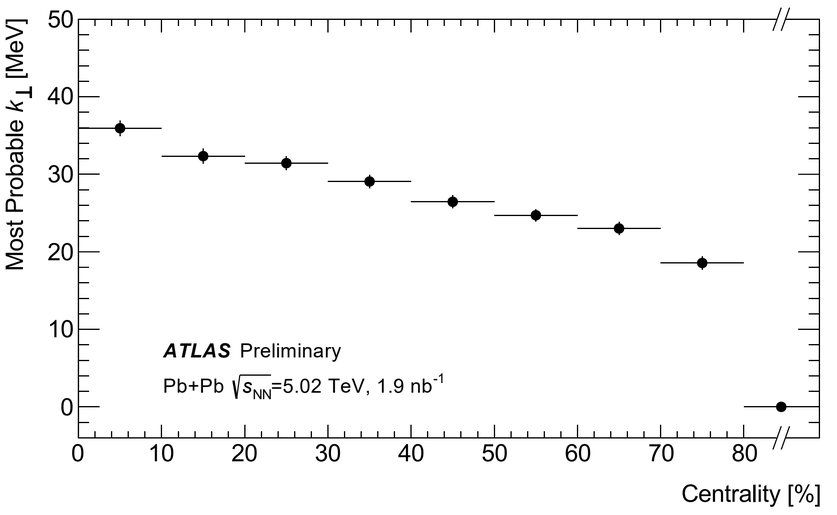


- No dependence on Δy is observed.

Centrality Dependence of $k_\perp$



- The most probable $k_\perp$ value is determined via a shifted, symmetrized fit of the UPC template.
- This peak is observed to shift significantly from peripheral to central collisions.



- The most probable $k_\perp$ value increases to 36 ± 1 (stat + syst) MeV in the 0-5% centrality interval.
- The shift is 0 (by construction) for UPC events and 19 ± 1 (stat + syst) MeV in the most peripheral centrality interval, demonstrating a statistically significant trend.

Conclusions

- The yield of dimuons produced via γγ scattering appears to increase slightly with collision centrality.
- A new feature of the α / $k_\perp$ distributions visible with increased statistics demonstrates that yields are suppressed slightly at small α / $k_\perp$.
- The most probable α / $k_\perp$ value varies with centrality, where more central collisions have a larger peak in the distribution of muon deflections.

Acknowledgment

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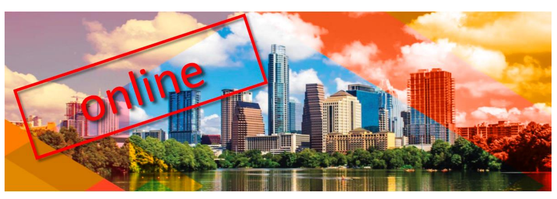

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