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

Benjamin Gilbert on behalf of the ATLAS Collaboration
CONF Note: ATLAS-CONF-2019-051

Introduction

- The electromagnetic field surrounding a charged, relativistic nucleus in Pb+Pb collisions provides a flux of quasi-real photons described by the equivalent photon approximation (EPA).
- The collisions between these photons and other nuclei (γA) and other co-moving photons (γγ) have been measured in ultra-peripheral collisions.
- Recent theoretical developments predict these results via QED interference effects and a generalized EPA for quantum mechanical systems.
- This measurement could help distinguish between these mechanisms and search for interactions with the nuclear medium.

Methodology

Relevant Analysis Definitions

- Acoplanarity: Relative angular deflection of the dimuon pair

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

- Asymmetry: Transverse momentum imbalance of the dimuon pair

$$A \equiv (p_{T_1} - p_{T_2})/(p_{T_1} + p_{T_2})$$

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

$$k_\perp \equiv (p_{T_1} + p_{T_2})|\pi - \Delta\varphi|/2 = \pi\alpha\bar{p}_T$$

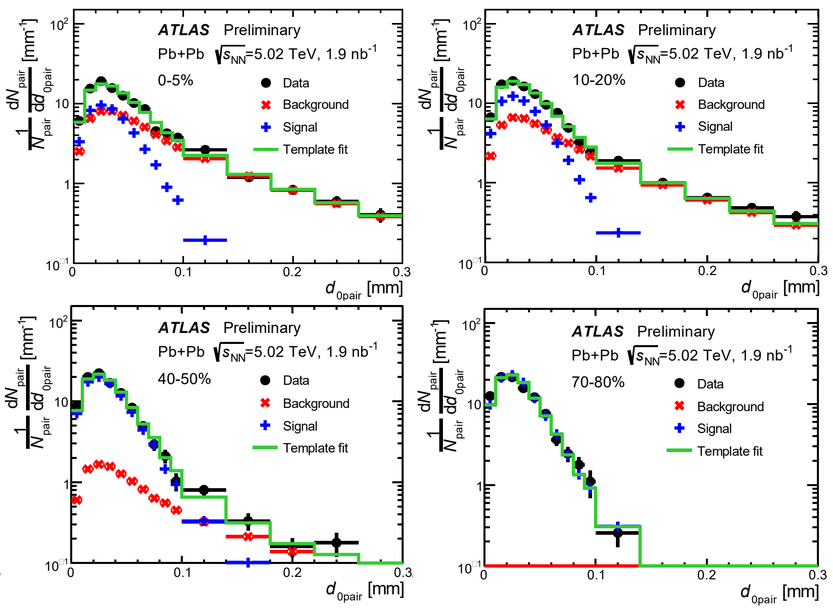
- d_{0pair}: Quadrature sum of muon impact parameters in transverse plane

$$d_{0pair} = \sqrt{d_{0_1}^2 + d_{0_2}^2}$$

- Signal region (z_0 is longitudinal d_0):

$$\alpha < 0.012, A < 0.08$$
$$d_{0pair} < 0.1\ mm, z_{0pair} < 0.2\ mm$$

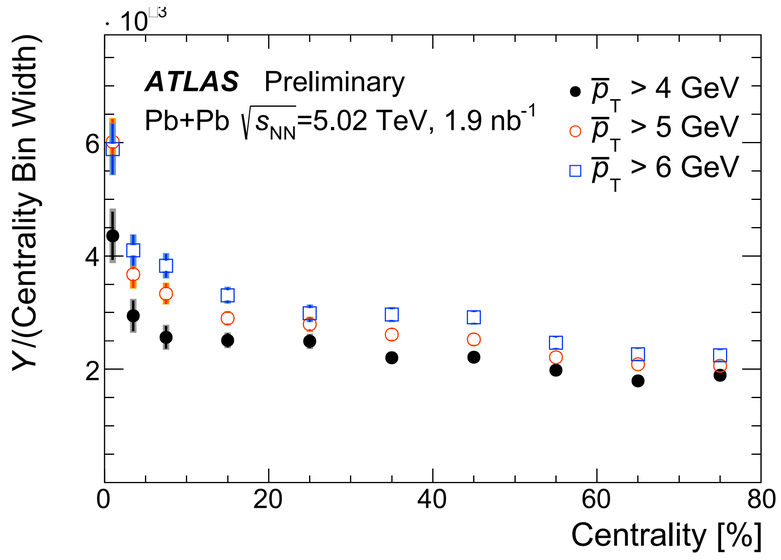
Template Fits of the Background



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

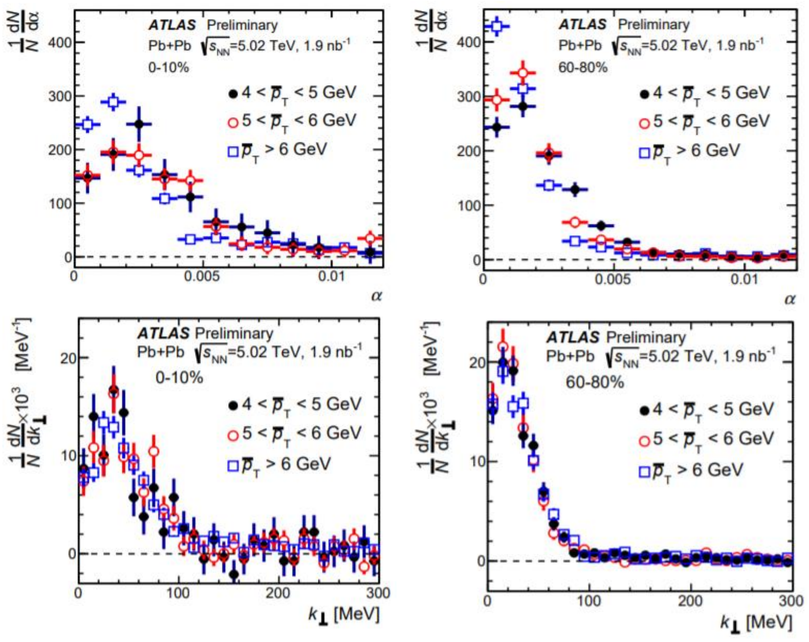
Results

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 larger fraction of the total pairs.

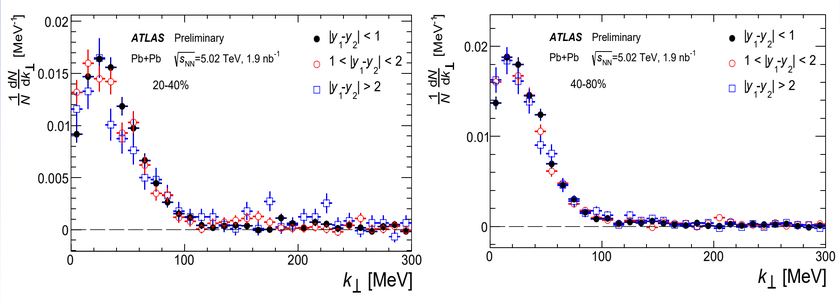
p_T Dependence of $k_\perp$ vs. α



- 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.

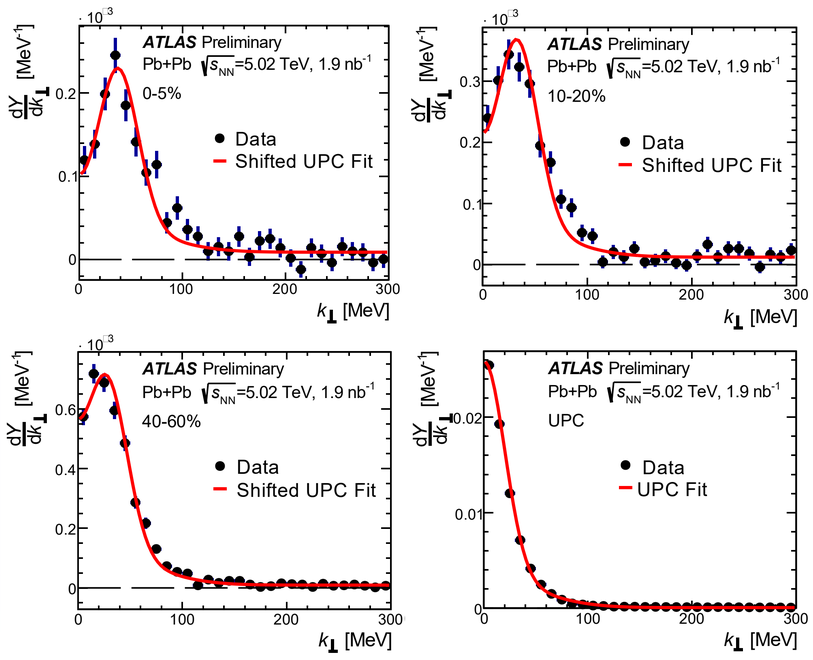
Δy Dependence of $k_\perp$

- Deflection due to magnetic fields in the QGP is predicted to be highly dependent on the dimuon rapidity difference.

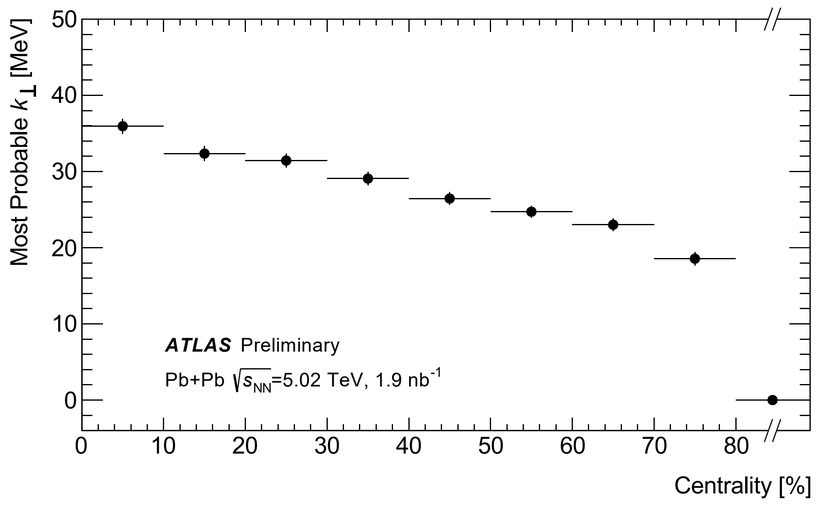


- No dependence on Δy is observed.

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.
- With increased statistics, the α / $k_\perp$ distributions demonstrate that dimuon yields are suppressed at small α / $k_\perp$.
- The most probable α / $k_\perp$ value varies with centrality, where more central collisions have larger most probable deflections.
- The data qualitiatively matches recent theoretical calculations, but more direct comparisons are needed.

Acknowledgment

- Support: The United States Department of Energy Grant DOE-FG02-86ER-40281

IS2021 The VI^th International Conference on the INITIAL STAGES OF HIGH-ENERGY NUCLEAR COLLISIONS

Initial Stages
January 10-15
Rehovot, Israel
(Online only)

COLUMBIA UNIVERSITY IN THE CITY OF NEW YORK

ATLAS EXPERIMENT