Direct photon HBT correlations in pp and Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

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Introduction to direct photon HBT correlations

Measurement: $\gamma\gamma$ with PCM-PHOS in pp and Pb–Pb collisions at 5.02 TeV.

Analysis overview:
HBT interferometry probes the space-time dimensions of the emitting source by two-particle correlations, measured as a function of Q_{inv} for an average pair momentum interval k_T. A potential Bose-Einstein correlation signal produces a peak at small Q_{inv}, depending on the properties of the source.

General analysis strategy:

- Reconstruct photons: PCM and PHOS (see next slide)
- Calculate the pair observable $Q_{\mathrm{inv}}(\mathrm{GeV}/c)$ for same-event pairs (A) and pairs from event-mixing (B)
- Calculate the correlation function $C(Q_{\mathrm{inv}}) = A(Q_{\mathrm{inv}})\ /\ B(Q_{\mathrm{inv}})$
- Fit the results

$$C(Q_{\mathrm{inv}}) = 1 + \lambda_{\mathrm{inv}} exp(-R_{\mathrm{inv}}^2 Q_{inv}^2) \tag{1}$$

- Extract the direct photon excess

$$r_\gamma = \frac{N_{\mathrm{dir}}}{N_{\mathrm{inc}}} = \sqrt{2\lambda} = \sqrt{8\lambda_{\mathrm{inv}} k_T R_O/\sqrt{\pi}\mathrm{Erf}(2k_T R_O)}, \tag{2}$$

where R_{inv} is the source size fit parameter, λ and λ_{inv} are the correlation strength, and R_O the *out* radius component of the source.

Photon reconstruction in ALICE with PCM and PHOS

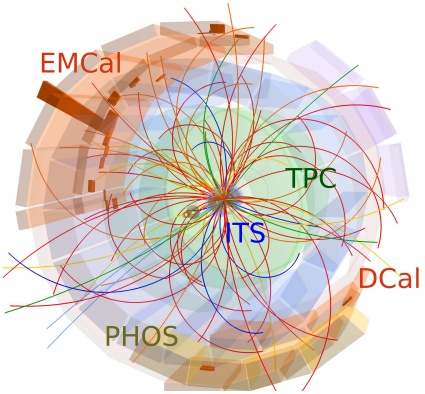
Photon Conversion Method (PCM)

- e^+e^- reconstructed in the ITS and TPC
- $|\eta| < 0.9$ and $0^\circ < \varphi < 360^\circ$
- $E_\gamma > 100$ MeV, $E_{\pi^0} > 300$ MeV
- conversion probability $\sim 8.5\%$

PHOS calorimeter

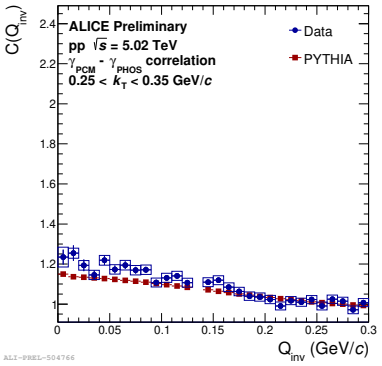
- $PbWO_4$ crystals (cell size 2.2 cm x 2.2 cm, at 4.6 m)
- $|\eta| < 0.12$ and $250^\circ < \varphi < 320^\circ$
- $E_\gamma > 200$ MeV, $E_{\pi^0} > 400$ MeV

The $\gamma_{\mathrm{PCM}}\gamma_{\mathrm{PHOS}}$ correlation allows for near zero opening angles!

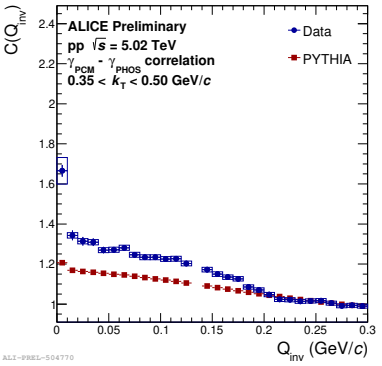


$\gamma\gamma$ correlations in pp collisions at $\sqrt{s} = 5.02$ TeV

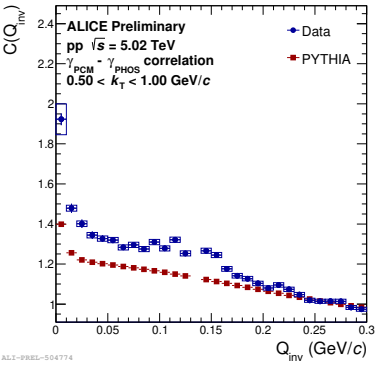
$0.25 < k_T < 0.35$ GeV/c



$0.35 < k_T < 0.50$ GeV/c



$0.5 < k_T < 1.0$ GeV/c

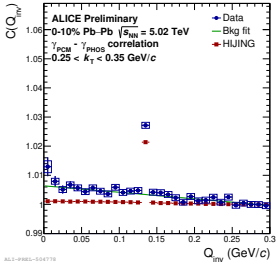


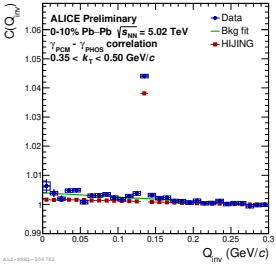
- Slope increases with the k_T bin, most likely related to the correlations within the parton shower.
- No HBT-like signal observed, but data shows a larger correlation than what is predicted by PYTHIA, and increases for k_T.

$\gamma\gamma$ correlations in Pb–Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 5.02$ TeV

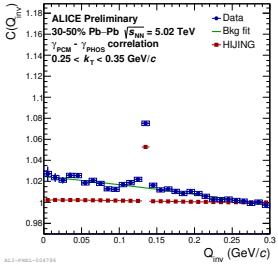
$0.25 < k_T < 0.35$ GeV/c | $0.35 < k_T < 0.50$ GeV/c

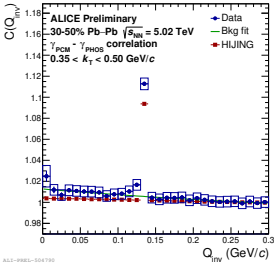
0-10%





30-50%





- Small hint of an HBT-like effect at lower Q_{inv}.
- λ_{inv} not significantly different from zero.

Extracted λ_{inv} values