Towards measurment of direct photons via external conversions in high multiplicity pp collisions at 13 TeV

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A Large Ion Collider Experiment (ALICE) at the CERN, LHC is dedicated to the study of Quark Gluon Plasma (QGP), a strongly interacting QCD medium. The study of the QGP was mainly performed by using relativistic heavy ion collisions. The collective behavior of hadronic particles has been observed in high multiplicity pp and p-Pb collisions at the LHC.[1)] These observations could be indicating the formation of thermalized systems such as the QGP, even in small systems.[2)] A direct photon is an ideal probe to study such thermalized systems due to its penetrating nature. In this study, we aim to measure direct photons produced in high multiplicity pp collisions at $\sqrt{s}$ =13 TeV.

In the ALICE experiment, we measure direct photons in two ways, via a calorimeter or via the measurement of photon conversions (external conversions). The latter allows us to measure very low transverse momentum p_{T} photons. The main tracking system[3)] of the ALICE detector consists of the Inner Tracking System (ITS), the Time Projection Chamber (TPC), and the Time of Flight (TOF). Direct photons will convert into dielectrons in the material of the ITS and TPC, and leave two tracks. For multiplicity estimation, V0 detectors, which are made of two arrays of scintillation counters are used and they are set on both sides of the ALICE interaction point.

Photons are produced in several stages during the time-space evolution of the QGP and there are mainly two groups: direct photons and decay photons. The former originates from quark-anti-quark annihilation and the QCD Compton scattering, and the latter comes from particle decay such as $\pi^0 \to \gamma\gamma$. It is difficult to measure direct photons separately, since there is huge background from decay photons. Therefore, we measure all the emitted photons(inclusive photons) and decay photons. The invariant yield of direct photons $\gamma_{\mathrm{dir}}(p_{\mathrm{T}})$ can be expressed in terms of the inclusive photons $\gamma_{\mathrm{inc}}(p_{\mathrm{T}})$ and that of decay photons $\gamma_{\mathrm{dec}}(p_{\mathrm{T}})$:

$$\gamma_{\mathrm{dir}}(p_{\mathrm{T}}) = \gamma_{\mathrm{inc}}(p_{\mathrm{T}}) - \gamma_{\mathrm{dec}}(p_{\mathrm{T}}) \quad (1)$$

$$= (1 - \frac{\gamma_{\mathrm{dec}}(p_{\mathrm{T}})}{\gamma_{\mathrm{inc}}(p_{\mathrm{T}})}) \cdot \gamma_{\mathrm{inc}}(p_{\mathrm{T}}) \quad (2)$$

$$= (1 - R_{\gamma}^{-1}(p_{\mathrm{T}})) \cdot \gamma_{\mathrm{inc}}(p_{\mathrm{T}}), \quad (3)$$

where the fraction of inclusive photons above decay photons $R_{\gamma}(p_{\mathrm{T}})$ is called the direct photon fraction. If $R_{\gamma}(p_{\mathrm{T}})$ is larger than unity, direct photons are produced in the collision. The fraction can be calculated from the decay photon spectrum. The major source of decay photons are π^0 and η , and other sources are calculated by using m_{T} scaling based on these neutral meson's p_{T} spectra. Therefore, the determination of the p_{T} spectra of neutral meson is very importatnt.

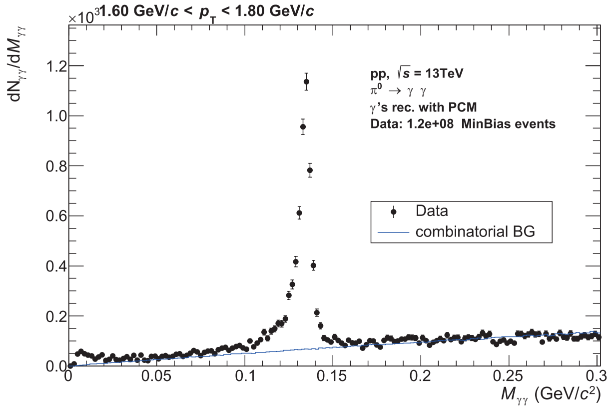

Fig. 1. Invariant mass distribution of reconstructed photon pairs $M_{\gamma\gamma}$

In this paper, we report the status of neutral meson analysis. In 2015, ALICE successfully collected over 400M events which correspond to 0.007 pb^{-1} in $\sqrt{s}$ =13 TeV pp collisions with minimum bias (MB) trigger and we used this data sample. The first step of the analysis is to find photons with the V^0 reconstruction method. The V^0 is the secondary vertex from unknown particle decays such as $\Lambda^0, \overline{\Lambda^0}, K_s^0, \gamma$. In order to select pure photon samples from V^0 particles, several cuts such as particle identification cuts, a 2D cut for dielectrons and a cut using the Armenteros-Podolanski plot[4)] were applied. Figure 1 shows the invariant mass spectrum of reconstructed photon candidates which are from external conversion pairs. The blue line is the combinatorial background(BG), which is calculated using the event mixing technique, in which photons are taken from different events and combined to form pairs. On top of the BG, a clear peak can be seen for π^0 mass 0.135 GeV/c^2. Subtraction of BG and evaluation of the invariant raw yield of π^0 are work in progress. Not only the raw yield of π^0, but also that of η will be calculated and eventually, we will evaluate the invariant cross section. Moreover, we will carry out an analysis focused on high multiplicity events.

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References

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