A Fundemental Study on Photon Isolation

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In Quantum Electrodynamics (QED), splitting refers to a process where a high-energy particle emits or dacays a daughter particle and undergoes a change in its state.

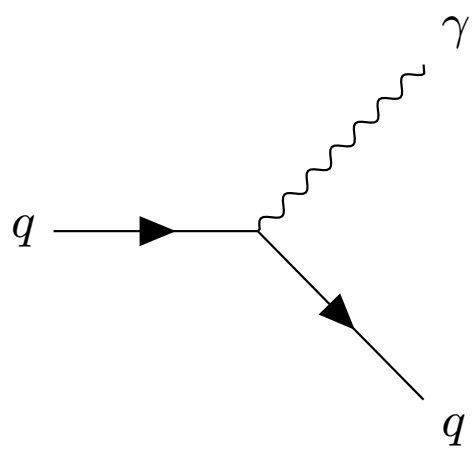


Figure: Feynman diagram for $q \to q\gamma$.

Here we are interested in $q \to q\gamma$ process.
The probability for a quark to radiate a photon with some angle θ_γ and momentum fraction z_γ is given by:

$$\mathrm{d}P_{q\to q\gamma} = \frac{\alpha_e e^2}{2\pi}\frac{\mathrm{d}\theta_\gamma}{\theta_\gamma}P(z_\gamma)\mathrm{d}z_\gamma,$$

$$P(z) = \left(\frac{1+(1-z)^2}{z}\right)_{(1)}^{+},$$

Jet grooming refers to a set of techniques used to improve the reconstruction and analysis of jets. Jets can be affected by various effects, such as soft radiation and pileup, which can lead to a broader or less well-defined jet structure. Grooming methods help mitigate these effects and enhance the precision of jet measurements.

Soft Drop is a grooming algorithm that involves recursively declustering a jet into two subjets and rejecting the subjet with the lower momentum if certain conditions are not met.
Soft drop declustering is used to identify hard subjets within a jet that satisfy the condition:

$$\frac{\min(p_{T1}, p_{T2})}{p_{T1} + p_{T2}} \geq z_{\text{cut}} \left(\frac{R_{12}}{R_0}\right)^{\beta}, \tag{2}$$

The photon isolation procedure is a combination of soft drop declustering and soft drop isolation.

- $R = 0.4$, ankt-k_T algorithm
- soft drop declustering: $z_{\text{cut}} = 0.1$, $\beta = 0$, $R_0 = R = 0.4$
- soft drop isolation: $z_{\text{cut}} = 0.1$, $\beta = 2$, $R_0 = R_{12}/2$

z_{iso}

Isolated photon momentum sharing:

$$z_{\mathrm{iso}} = \frac{p_{T\gamma-\mathrm{sub}}}{p_{T\gamma-\mathrm{sub}} + p_{T\mathrm{had}-\mathrm{sub}}}. \tag{3}$$

θ

θ denotes the angular distance between two objects in the $\eta - \phi$ plane,

$$\Delta R_{12} = \sqrt{(\Delta\eta)^2 + (\Delta\phi)^2}. \tag{4}$$

For event selection, we require $p_{T\text{jet}} > 350$ GeV as a defult setting.

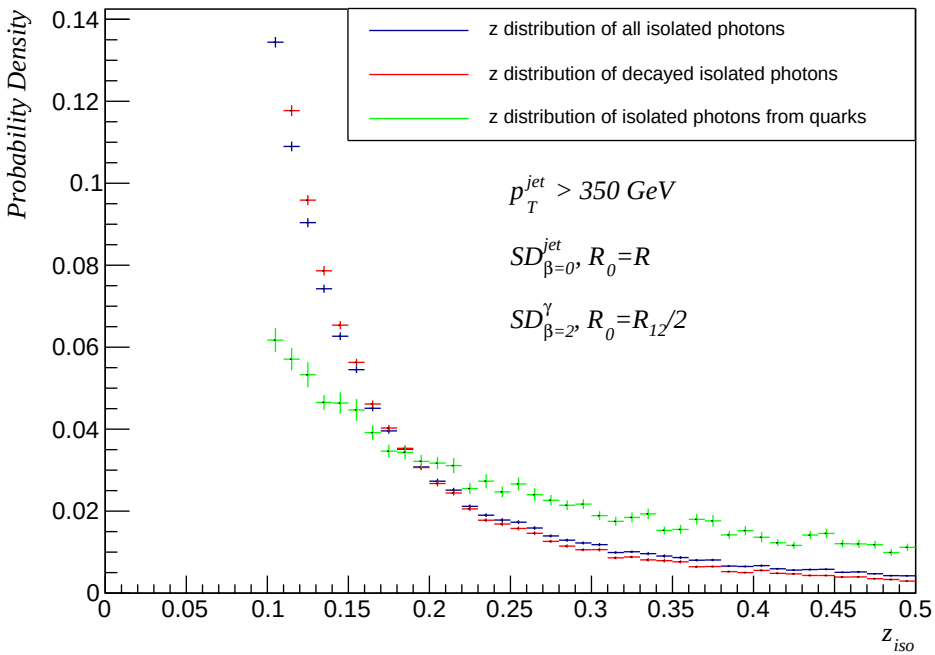
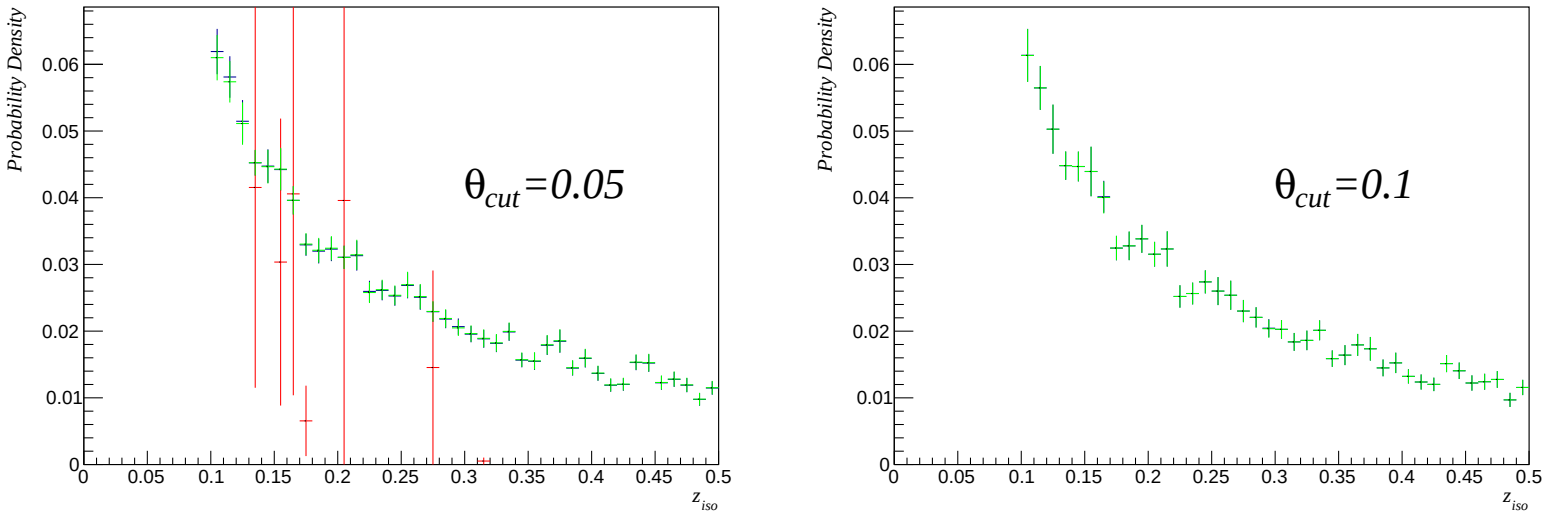


Figure: All isolated photons without θ_{cut}

Here we show the z distribution of all isolated photons ($p_{T\text{jet}} > 350$ GeV).



(a) (b)

Figure: z distribution with θ_{cut}

Here we set a θ_{cut} to be 0.05. And when increase the θ_{cut} to 0.1, there are no splittings from meson decay.

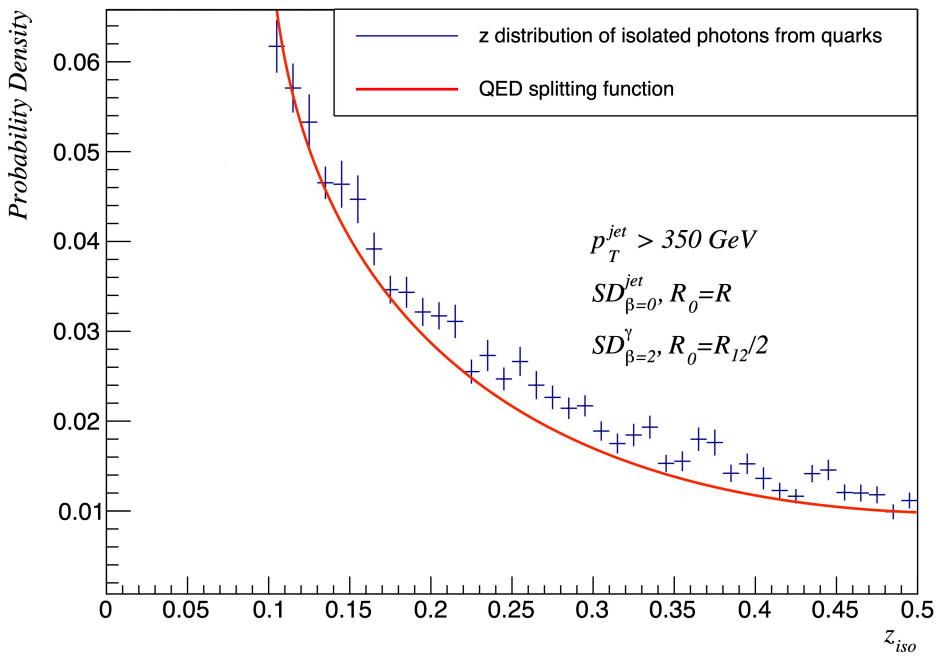


Figure: QED splitting function and isolated photons from quarks

Here we plot the QED splitting function with z distribution of quark photons.