Measurement of the cross section for inclusive isolated-photon production in pp collisions at 13 TeV

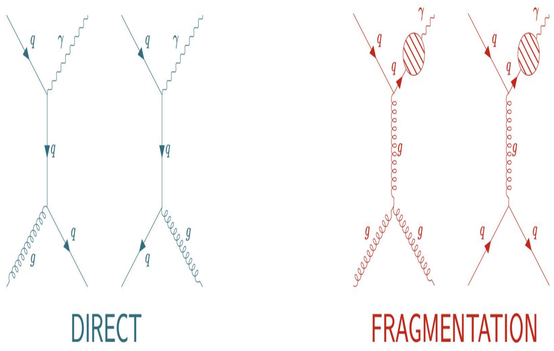
Souad Batlamous on behalf of the ATLAS Collaboration

Universidad Autónoma de Madrid, Spain

Project PID2021-122738OB-I00 funded by MCIN /AEI/ 10.13039/501100011033 / FEDER, UE

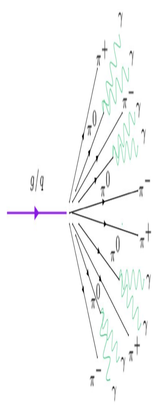
Introduction and motivation

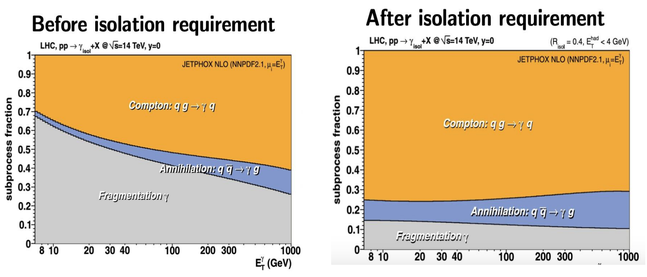
- The measurements of inclusive isolated-photon cross sections performed by ATLAS at 13 TeV using 139 fb^{-1}
  - Important measurement for test of pQCD
  - Constraints on the PDF (especially for gluon-PDF)
  - useful to develop pQCD calculations and tune MC models
- The production of high-Pt prompt photons proceeds via two mechanisms: (Prompt photons: photons not coming from hadron decays)
  - **Direct Process:** Photons originate directly from hard interaction
  - **Fragmentation process:** photons are produced when high pT parton fragments



Isolation requirements

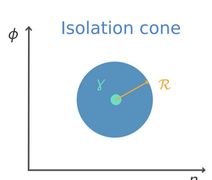
- Photons are copiously produced inside jets due to neutral meson decays such as π_0 and η into photons
  - Essential to require isolation to study prompt photons in hadron colliders
  - Suppresses thecontribution of photons produced in side jets and reduces the contribution from fragmentation photon processes





Fixed-cone isolation requirement is applied:

$$E_{\mathrm{T}}^{\mathrm{iso}} \equiv \sum_{\cdot} E_{\mathrm{T}}^{\mathrm{i}} < E_{\mathrm{T}}^{\mathrm{max}}$$

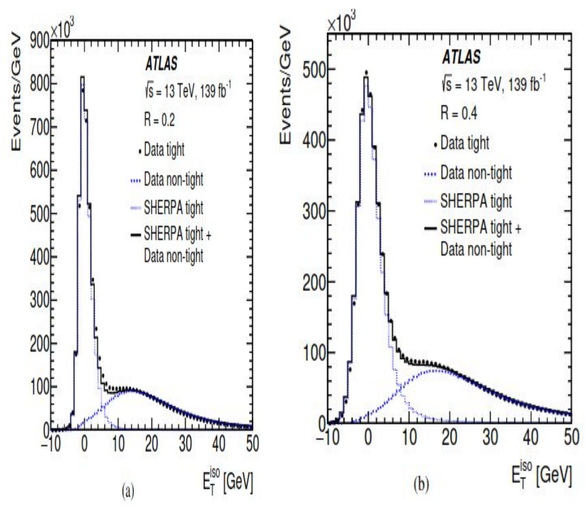


Photon isolation

- The isolation transverse energy E_T^{iso} is computed from topological clusters of calorimeter cells within a cone of radius R = 0.4 orR = 0.2 in the η − φ plane around the photon candidate
- **Correction applied for E_T^{iso}**
  - corrected for the photon energy leakage out of the photon cluster cells
  - underlying event (UE) and pile-up contributions to E_T^{iso} using the jet-area method
  - Clear signal observed after applying tight and isolation requirements
- A photon candidate is considered isolated if

$$E_{\mathrm{T}}^{\mathrm{iso}} < E_{\mathrm{T,cut}}^{\mathrm{iso}} = 4.2 \times 10^{-3} \times E_{\mathrm{T}}^{\gamma} + 4.8\ \mathrm{GeV}$$

➡ Residual background is still expected even after tight identification and isolation requirements



Event selection

Measurement of the inclusive isolated-photon cross section in pp collisions at √s = 13 TeV using the full Run-2 data

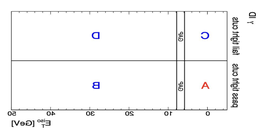
- The $d\sigma/dE^{\gamma}_{T}$ were measured as a function of E_T^{γ} in six $|\eta^{\gamma}|$ regions:
  - **[0.0, 0.6, 0.8, 1.37; 1.56, 1.81, 2.01, 2.37]**
- E_T^{γ} > 250 GeV and $|\eta^{\gamma}|$ < 2.37 (excluding 1.37 < $|\eta^{\gamma}|$ < 1.56)
- Tight identification and isolation:

$$E_{\mathrm{T,cut}}^{\mathrm{iso}} = 4.2 \times 10^{-3} \times E_{\mathrm{T}}^{\gamma} + 4.8\ \mathrm{GeV}$$

- $d\sigma/dE^{\gamma}_{T}$ measured for two γ-isolation cone sizes: R = 0.2 and R = 0.4

Background subtraction

- **Residual background contribution from jets misidentified as photons:**
  - A data-driven background subtraction method is used to avoid dependence on detailed simulations of background processes
  - 2D-sideband method is used in on the γ_{ID} vs E_T^{iso} plane and corrected for signal leakage
  - Leading loose' photon is classified into one of the four regions in the plane
  - γ_{ID} vs E_T^{iso} plane are assumed to be uncorrelated for the background



  - Region A is the signal region;
  - B, C and D is background control regions in each E^{γ}_{T} and η^{γ} bin measured

- The signal yield (Nsig) in region A is extracted with:

$$N_{\mathrm{A}}^{\mathrm{sig}} = N_{\mathrm{A}} - R^{\mathrm{bg}} \frac{(N_{\mathrm{B}} - \epsilon_{\mathrm{B}} N_{\mathrm{A}}^{\mathrm{sig}})(N_{\mathrm{C}} - \epsilon_{\mathrm{C}} N_{\mathrm{A}}^{\mathrm{sig}})}{(N_{\mathrm{D}} - \epsilon_{\mathrm{D}} N_{\mathrm{A}}^{\mathrm{sig}})}.$$

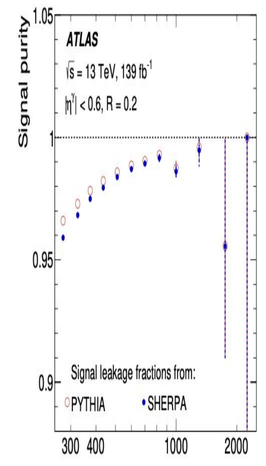
No correlation between γ_{ID} and $E_{\mathrm{T}}^{\mathrm{iso}}$ is assumed for background events: $R^{\mathrm{bg}} \equiv \frac{N_{\mathrm{A}}^{\mathrm{bg}} N_{\mathrm{D}}^{\mathrm{bg}}}{N_{\mathrm{B}}^{\mathrm{bg}} N_{\mathrm{C}}^{\mathrm{bg}}} = 1.$

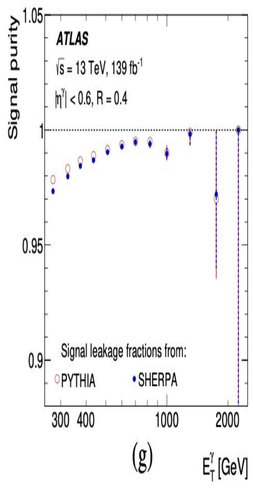
Signal leakage fractions (ϵ_K) from MC: $\epsilon_K = N_K^{\mathrm{sig}}/N_A^{\mathrm{sig}}.$

Signal Purity

- Background subtracted with the ABCD method using signal leakage fractions
- The signal purity was calculated using

$$P = \frac{N_{\mathrm{A}}^{\mathrm{sig}}(i)}{N_{\mathrm{A}}(i)}.$$

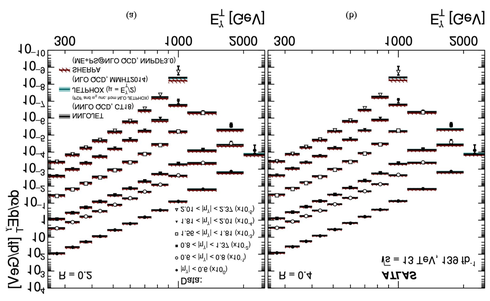




the measured signal purity is Greater than 90% and slightly higher for R = 0.4 compared to R = 0.2

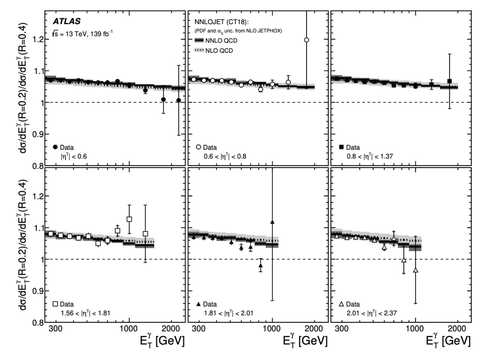
Inclusive isolated photon production

- Measurement of dσ/dEγ in six regions of $|\eta^{\gamma}|$ for $|\eta^{\gamma}|$< 2.37
  - The form of the differential cross-section $d\sigma/dE^{\gamma}_{T}$ is consistent across various regions and radii
  - The normalization of the differential cross-section $d\sigma/dE^{\gamma}_{T}$ for R=0.2 is higher compared to R=0.4
- NLO pQCD predictions and NNLO pQCD predictions compared to measurements for two different R values.



Good description of the data by NLO and NNLO QCD in most of the phase space

Ratio of differential cross sections



➢ **Good descriptionof the data by NNLO pQCD**

Conclusion

- Measurements of cross section for inclusive photon production in pp collision at s = 13 TeV
- The inclusive photon cross section was measured in more $|\eta^{\gamma}|$ regions and for different γ-isolation cone R, providing more experimental information on isolation
- NLO and NNLO pQCD predictions match differential cross-section data within uncertainties.

Reference

ATLAS Collaboration, **JHEP 03 (2020) 179**. DOI: 10.1007/JHEP03(2020)179