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Supplemental material: Measurement of isolated prompt photon production in pp and p–Pb collisions at the LHC

ALICE Collaboration*

Abstract

This note provides supplementary material for the paper "Measurement of isolated prompt photon production in pp and p–Pb collisions". In particular, figures related to the measurement in pp collisions at $\sqrt{s} = 5.02\,\text{TeV}$ are presented, which has been performed using a purity estimation with the template fitting technique. We demonstrate that the measurement is consistent with previously published results in the same collision system using a purity estimation with the ABCD method. This additional study using the template fit for purity estimation allows cancelling systematic uncertainties in the nuclear modification factor R_{pA}, which uses p–Pb data with purities obtained using the template fitting approach.

*See Appendix A for the list of collaboration members

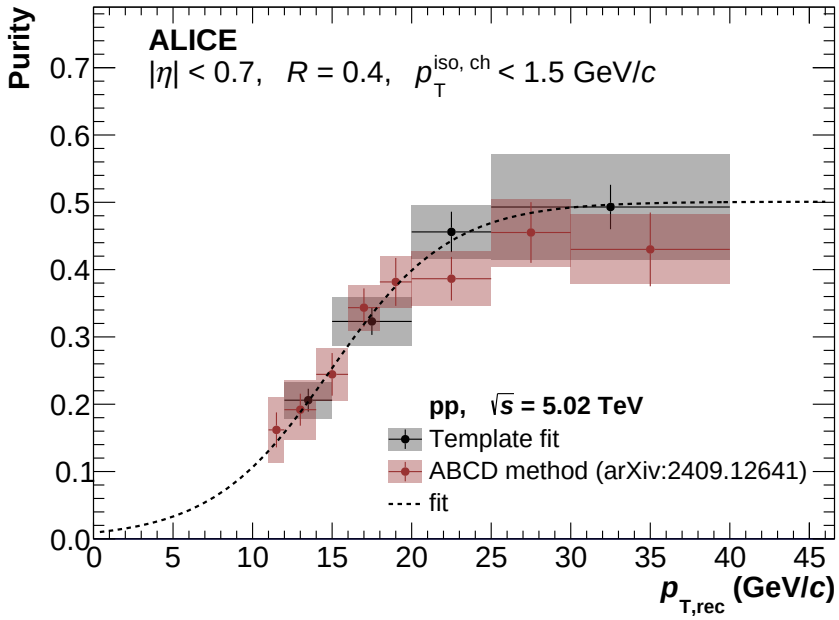

Fig. 1: Isolated prompt photon purity in pp collisions at $\sqrt{s} = 5.02\,\text{TeV}$ obtained using the ABCD method from Ref. [2], as well as the template fitting approach. The purity obtained using the template fitting method is used for the pp reference in Ref. [1] to allow for the cancellation of systematic uncertainties when calculating the nuclear modification factor R_{pA}.

In this note, supplementary material for the paper "Measurement of isolated prompt photon production in pp and p–Pb collisions" [1], which presents the isolated prompt photon production cross section in pp collisions at $\sqrt{s} = 8\,\text{TeV}$, as well as the cross section in p–Pb collisions at $\sqrt{s_{\text{NN}}} = 5.02$ and $8.16\,\text{TeV}$, is provided. Furthermore, the nuclear modification factor (R_{pA}) is presented in Ref. [1] for both collision energies. The prompt photon production cross section in pp collisions at $\sqrt{s} = 5.02\,\text{TeV}$ has been previously published in Ref. [2], where the prompt photon purities were determined using the ABCD method. To allow for the cancellation of systematic uncertainties between the pp and p–Pb data at $\sqrt{s} = 5.02\,\text{TeV}$ for the R_{pA} presented in Ref. [1], the analysis in pp collisions is also performed using the template fitting approach, in line with the analysis for the corresponding p–Pb data. In addition, only the EMCal detector is used for the measurement in pp and p–Pb collisions at $\sqrt{s} = 5.02\,\text{TeV}$ in Ref. [1], whereas Ref. [2] also utilizes the DCal detector. In this note, additional material related to this measurement is presented that showcases the consistency of the ABCD method and the template fitting approach to obtain the prompt photon purity. The measurement is performed using the same selections and techniques used for the measurement in p–Pb collisions at $\sqrt{s_{\text{NN}}} = 5.02\,\text{TeV}$ [1].

Figure 1 shows the isolated prompt photon purity obtained using the ABCD method [2], as well as the template fitting approach [1, 3]. Both methods yield consistent purities within the experimental uncertainties. A slightly finer binning in transverse momentum is achieved using the ABCD method. This is expected, as the ABCD method utilises integrated distributions in the signal and background regions to determine the purity, whereas the template fitting approach is sensitive to the distribution of the shower shape variable σ^2_{long} within a given region.

Figure 2 shows the comparison of the isolated prompt photon cross sections obtained using the template fitting approach and the ABCD method [2] using a charged-only isolation of $p_{\text{T}}^{\text{iso, ch}} < 1.5\,\text{GeV}/c$ in a cone of $R = 0.4$. The systematic uncertainties shown for the cross section obtained with the template fitting approach are given in Table 1. Both cross sections are shown as the ratio with respect to JETPHOX perturbative QCD (pQCD) calculations at the next-to-leading order (NLO) [4]. The calculations are performed using the NNPDF4.0 [5] proton parton distribution functions to describe the incoming projectiles

Table 1: Systematic uncertainty sources of the isolated prompt photon inclusive production cross section in pp collisions at $\sqrt{s_{\rm NN}} = 5.02\,\text{TeV}$, where the purity was evaluated using the template fit method. Ranges indicate the uncertainty in the lowest (first value) and highest (second value) covered $p_{\rm T}$ interval.

Name	Rel. uncertainty
Photon purity	16.0 – 11.0%
Trigger mimicking	8.3%
UE estimation	2.0%
$\sigma^2_{\rm long}$ signal range	1.0 – 6.0%
CPV	-
Energy scale	2.0%
Material budget	2.1%
Total	18.4 – 15.4%

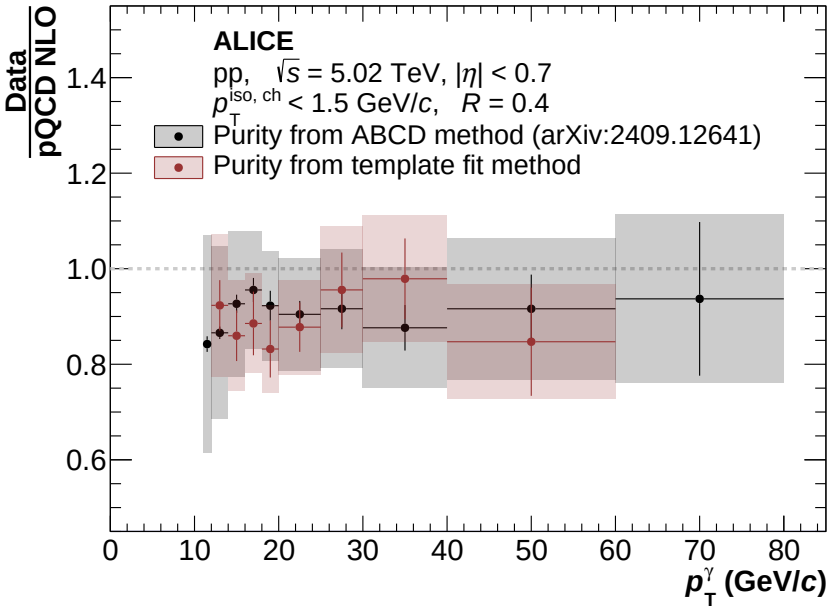

Fig. 2: Comparison of the isolated prompt photon production cross section in pp collisions at $\sqrt{s} = 5.02\,\text{TeV}$ obtained using two different techniques to estimate the prompt photon purity. Both cross sections are shown with respect to JETPHOX pQCD calculations [4] at NLO, as outlined in the text. The result using the ABCD method has been presented in Ref. [2], whereas the results obtained using the template fit are used for the $R_{\rm pA}$ in order to allow for the cancellation of systematic uncertainties.

and the BFG II [6] fragmentation function to describe the fragmentation photon contribution to the cross section. The renormalisation scale μ_R, factorisation scale μ, and fragmentation scale μ_F are chosen to coincide with the photon $p_{\rm T}$. A full (charged+neutral) isolation of $p_{\rm T}^{\rm iso} < 2\,\text{GeV}/c$ in a cone of $R = 0.4$ is required. This higher threshold is chosen to allow for a direct comparison with the lower charged-only isolation criterion used in the measurement and has been determined using the neutral energy fraction in the isolation cone observed in PYTHIA 8 [7] simulations. Good agreement between the cross sections obtained using the two different techniques to estimate the prompt photon purity is observed within the experimental uncertainties.

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