PROCEEDINGS OF SCIENCE

Measurement of high-p_T electron performance in proton-lead collisions in the ATLAS experiment

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Electrons constitute an essential component of final states from the leptonic decay channels of W and Z bosons. Their reconstruction and identification are especially challenging in heavy-ion collisions due to high detector occupancy. Therefore, the evaluation of electron performance is crucial for precision measurements of properties of quark-gluon plasma produced in heavy-ion collisions at the LHC energies. The measurements focus on electron reconstruction, identification, isolation, and trigger performance in p+Pb collisions at $\sqrt{s_{\mathrm{NN}}} = 8.16$ TeV collected by the ATLAS experiment in 2016. The data correspond to a total integrated luminosity of 165 nb^{-1}. The Tag-and-Probe method is applied, which allows for the estimation of electron efficiency independently in data and Monte Carlo (MC) simulation.

The Tenth Annual Conference on Large Hadron Collider Physics - LHCP2022
16-20 May 2022
online

*Speaker

https://pos.sissa.it/

PoS(LHCP2022)314

1. Tag-and-Probe method

The Tag-and-Probe method [1] is well established in the ATLAS experiment [2] to measure electron efficiencies. The total electron efficiency $\varepsilon_{\text{total}}$ can be factorised as a product of four efficiencies, related to electron reconstruction $\varepsilon_{\text{reco}}$, identification ε_{id}, isolation ε_{iso} and trigger $\varepsilon_{\text{trig}}$:

$$\varepsilon_{\text{total}} = \varepsilon_{\text{reco}} \cdot \varepsilon_{\text{id}} \cdot \varepsilon_{\text{iso}} \cdot \varepsilon_{\text{trig}}. \tag{1}$$

The method involves choosing an unbiased electron sample (probe) along with another electron candidate (tag) using strict selection criteria. The events are selected based on the electron pair invariant mass m_{ee} from a $Z \rightarrow e^+e^-$ resonance decay. Figure 1 shows exemplary invariant mass distributions of opposite-sign electron pairs with reconstructed and identified probes. The presented analysis measures electron efficiencies in p+Pb collisions collected with the ATLAS detector in 2016 at a nucleon–nucleon centre-of-mass energy of $\sqrt{s_{\text{NN}}}$ = 8.16 TeV.

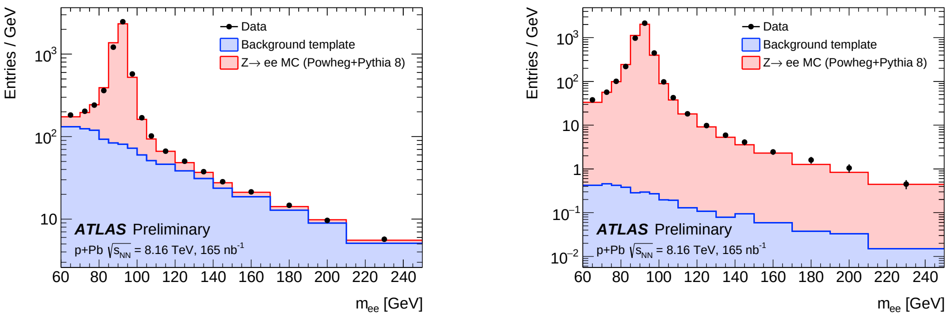

Figure 1: Invariant mass distributions of opposite-sign electron pairs with reconstructed (left) and identified (right) probes in 2016 p+Pb data (points) and in MC simulation for the signal (red) and background (blue) processes [3].

2. Electron reconstruction

Electrons are reconstructed from tracks in the Inner Detector matched with clusters in the electromagnetic (EM) calorimeter. The reconstruction efficiency is defined as the ratio of the number of reconstructed electrons to the number of EM clusters. The efficiency of creating an EM cluster for an electron with transverse energy $E_T > 15$ GeV is measured to be above 99% [4].

Electron reconstruction efficiency as a function of electron transverse energy E_T and pseudorapidity η is presented in Figure 2. The efficiency increases with E_T from 93% at $E_T = 15$ GeV and reaches the plateau for E_T at around 50 GeV with 98%. Efficiency is higher for central electron pseudorapidities and drops to 93% at $|\eta| > 1.37$. Data-to-MC ratios do not show significant deviations from unity.

3. Electron identification

A likelihood electron identification algorithm is used to distinguish signal electrons from background processes. Four identification working points are defined, referred to as Loose, Loose-

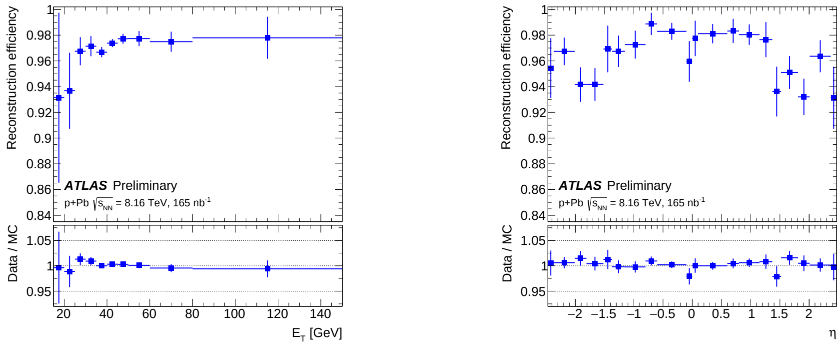

Figure 2: The electron reconstruction efficiency as a function of electron E_T (left) and η (right) evaluated in 2016 p+Pb data. The bottom panels show the data-to-MC ratio. Error bars represent the total uncertainties composed of statistical and systematic components added in quadrature [3].

AndBLayer, Medium and Tight [1]. The identification efficiency is evaluated as the ratio of the number of identified electrons to the number of reconstructed electrons in the $Z \to e^+e^-$ sample.

Figure 3 shows electron identification efficiency as a function of E_T and η for four working points. The efficiency rises with E_T from 82% (68)% for Medium (Tight) at E_T = 15 GeV and reaches the plateau for E_T at around 60 GeV with 92% (87%) for Medium (Tight). Data-to-MC ratios are significantly below unity for $|\eta| > 1$.

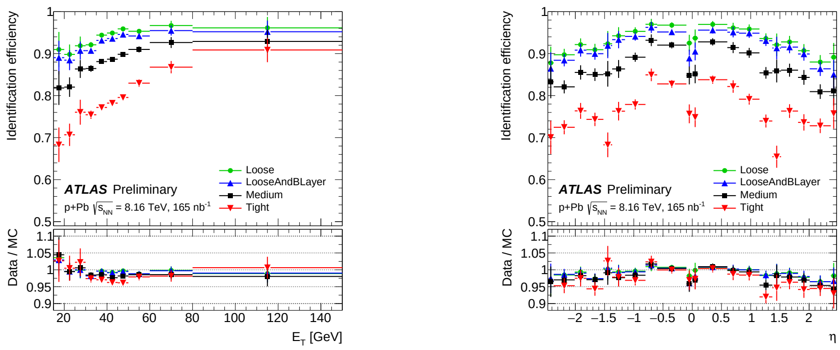

Figure 3: The electron identification efficiency as a function of electron E_T (left) and η (right) evaluated in 2016 p+Pb data for four working points. The bottom panels show the data-to-MC ratios. Error bars represent the total uncertainties composed of statistical and systematic components added in quadrature [3].

4. Electron isolation

In order to further discriminate signal and background electrons, isolation requirements are used. Isolation selections are defined using calorimeter isolation E_T^{cone} and track isolation p_T^{varcone} [1]. The isolation efficiency is determined as the ratio of the number of isolated electron candidates to the number of electron candidates identified as Medium in the $Z \to e^+e^-$ sample.

Figure 4 shows electron isolation efficiency as a function of E_T and η for four working points. The efficiencies range between 65–96% at E_T = 15 GeV for various selections. A deviation from unity up to 8% is found for data-to-MC ratios.

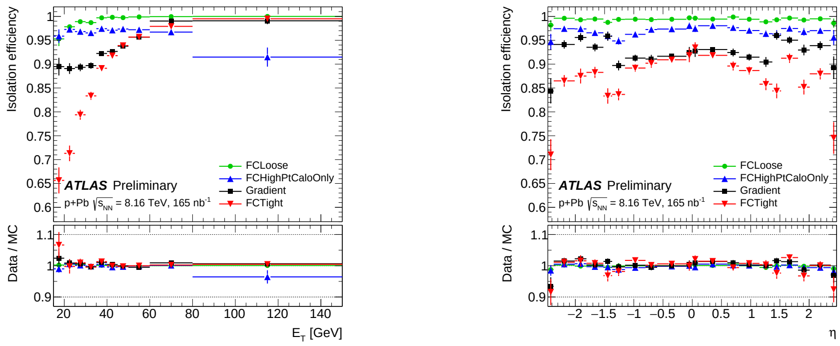

Figure 4: The electron isolation efficiency as a function of electron E_T (left) and η (right) evaluated in 2016 p+Pb data for four working points. The bottom panels show the data-to-MC ratios. Error bars represent the total uncertainties composed of statistical and systematic components added in quadrature [3].

5. Electron trigger

The presented analysis measures the efficiency of a single electron trigger with the E_T threshold of 15 GeV and Loose identification requirements [5]. The trigger efficiency is estimated as the ratio of the number of triggered electron candidates to the number of electron candidates with Medium identification and Gradient isolation criteria in the $Z \to e^+e^-$ sample.

Electron trigger efficiency as a function of electron E_T and η is shown in Figure 5. The efficiency rises with E_T from 82% at E_T = 15 GeV and reaches the plateau at around 40 GeV with 98%. Data-to-MC ratios deviate from unity up to 5% at E_T < 20 GeV, $\eta \approx 0$ and $\eta \approx -1.5$.

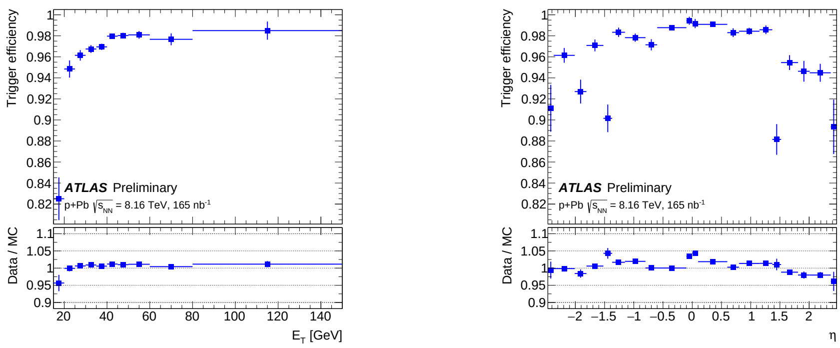

Figure 5: The electron trigger efficiency as a function of electron E_T (left) and η (right) evaluated in 2016 p+Pb data. The bottom panels show the data-to-MC ratio. Error bars represent the total uncertainties composed of statistical and systematic components added in quadrature [3].

6. Conclusion

The electron performance has been studied in p+Pb collisions at $\sqrt{s_{NN}}$ = 8.16 TeV collected by ATLAS in 2016, corresponding to a total integrated luminosity of 165 nb^{-1}. Electron efficiencies have been derived in data and MC simulation. Data-to-MC ratios have been extracted as a function of electron E_T and η. They have been integrated with the ATLAS software for usage as a multiplicative correction to account for mismodelling of the detector in MC simulation in the 2016 p+Pb data set.

7. Acknowledgements

The research was partly supported by the program „Excellence initiative - research university" for the AGH University of Science and Technology, the National Science Centre, Poland, grant 2020/37/B/ST2/01043 and PL-Grid Infrastructure.

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