Measurement of jet performance in proton-lead collisions in the ATLAS experiment

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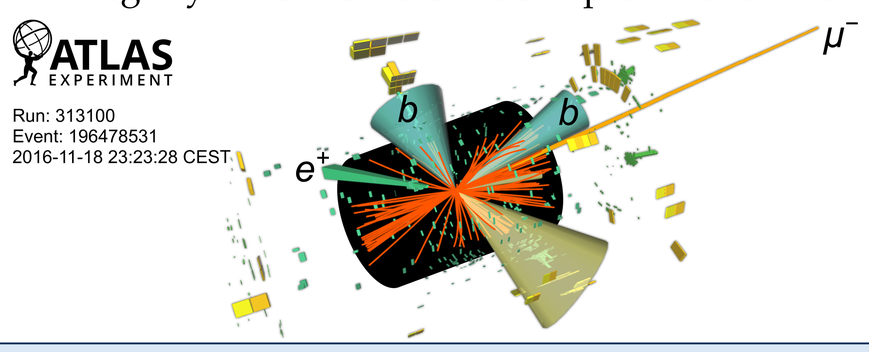
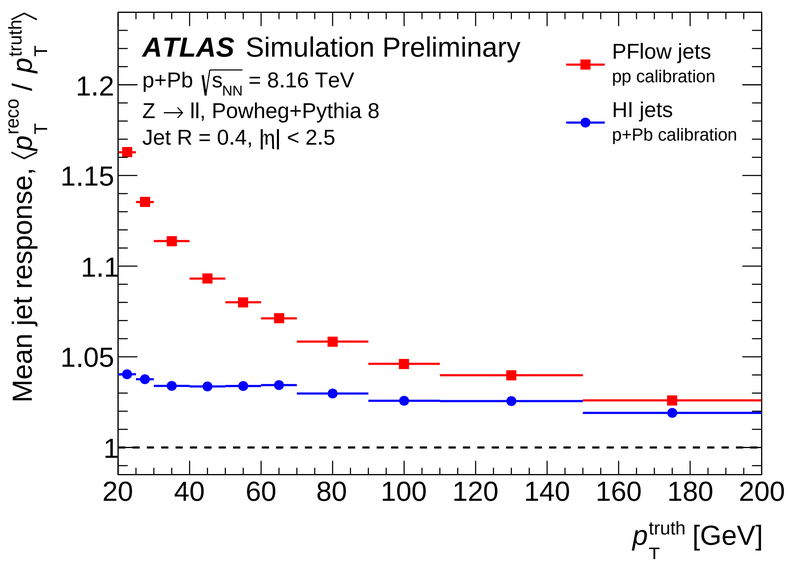
1 Introduction

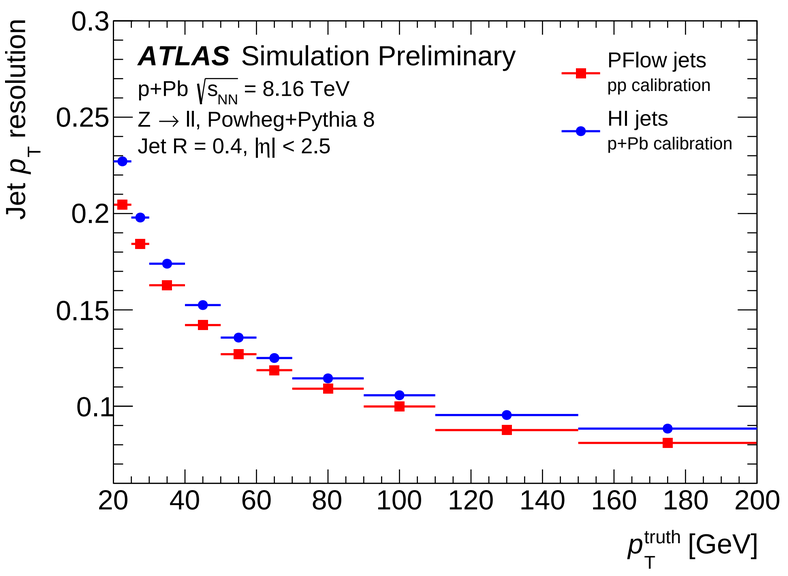
- The studies are a key input to the ongoing $t\bar{t}$ analysis in p+Pb collisions, which uses particle flow jets for b-tagging and heavy ion jets for kinematics.
- The **particle flow (PFlow) jets** combine measurements from the inner detector and the calorimeter, and use high-pileup pp calibration [1].
- The **heavy ion (HI) jets** include the underlying event subtraction and use a dedicated p+Pb calibration.
- Jet performance in the ATLAS experiment is studied using two alternative methods: **truth** and **Z-jet balance**.
- The analysis uses p+Pb data collected at $\sqrt{s_{\mathrm{NN}}} = 8.16$ TeV in 2016 with an integrated luminosity of 165 nb^{-1} and Powheg+Pythia 8 Monte Carlo samples with data overlay.



2 Truth method

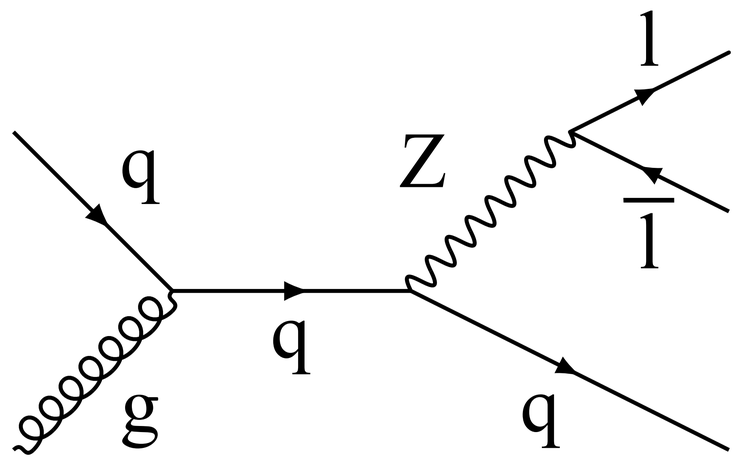
- The **truth method** compares reconstructed jets with corresponding truth jets from Monte Carlo simulation.
- Reconstructed jets are **geometrically matched** to truth jets by imposing a criterion on the distance, $\Delta R < 0.4$.
- The **mean jet response** is estimated as the mean of a Gaussian function fitted to the jet p_{T} response $p_{\mathrm{T}}^{\mathrm{reco}}/p_{\mathrm{T}}^{\mathrm{truth}}$.
- The **jet p_{T} resolution** is derived as the ratio of the standard deviation over the mean of the same Gaussian fit.
- The mean jet response above unity originates from a **quark-dominated composition** of $Z \to \ell\ell$ events and additionally from the **underlying event** for PFlow jets.





3 Z-jet balance method

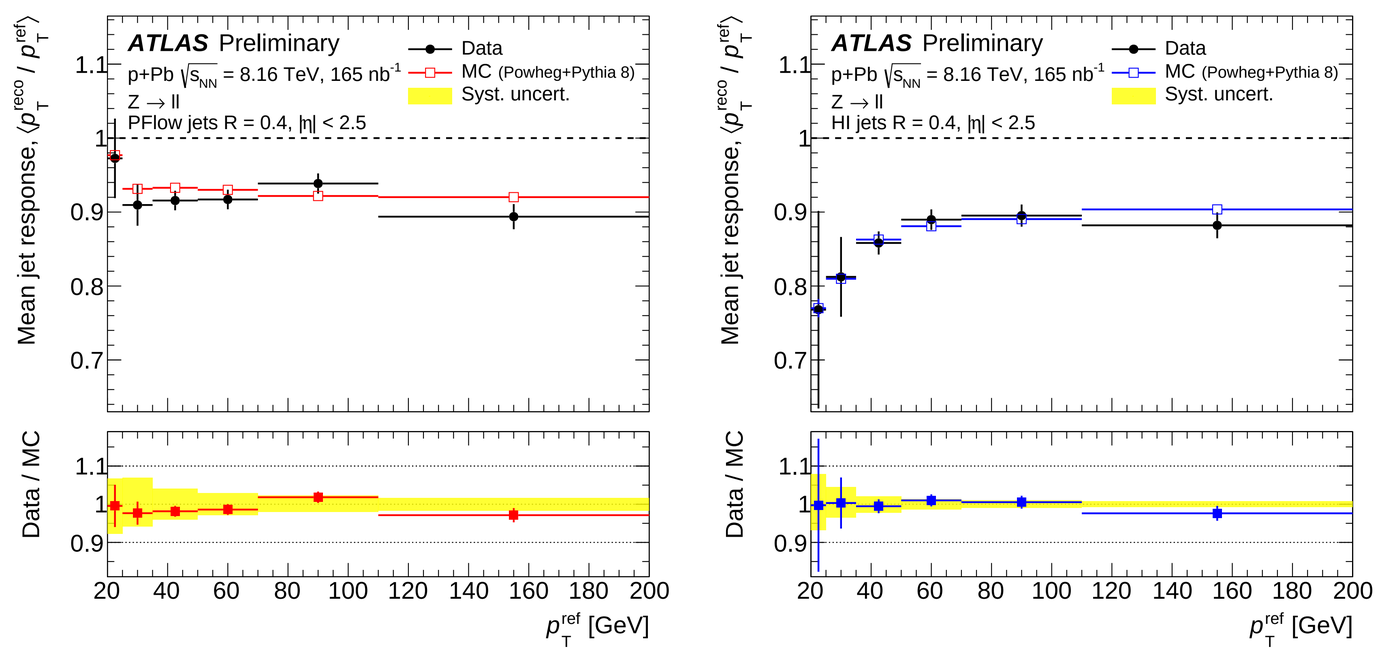
- The jet p_{T} scale and resolution can be evaluated using the **Z-jet momentum balance**.
- The same algorithm can be used in both data and Monte Carlo simulation.
- The method uses jets recoiling against a Z boson, which decay to electron or muon pairs.
- $|\Delta\phi(\mathrm{Z}, \mathrm{jet})| > 2.8$ cut is imposed to ensure the **back-to-back emission** of the Z boson and the jet.



- The **reference transverse momentum $p_{\mathrm{T}}^{\mathrm{ref}}$** is the projection of the Z boson transverse momentum $p_{\mathrm{T}}^{\mathrm{Z}}$ along the jet axis, given by the formula $p_{\mathrm{T}}^{\mathrm{ref}} = p_{\mathrm{T}}^{\mathrm{Z}} |\cos\Delta\phi(\mathrm{Z}, \mathrm{jet})|$.

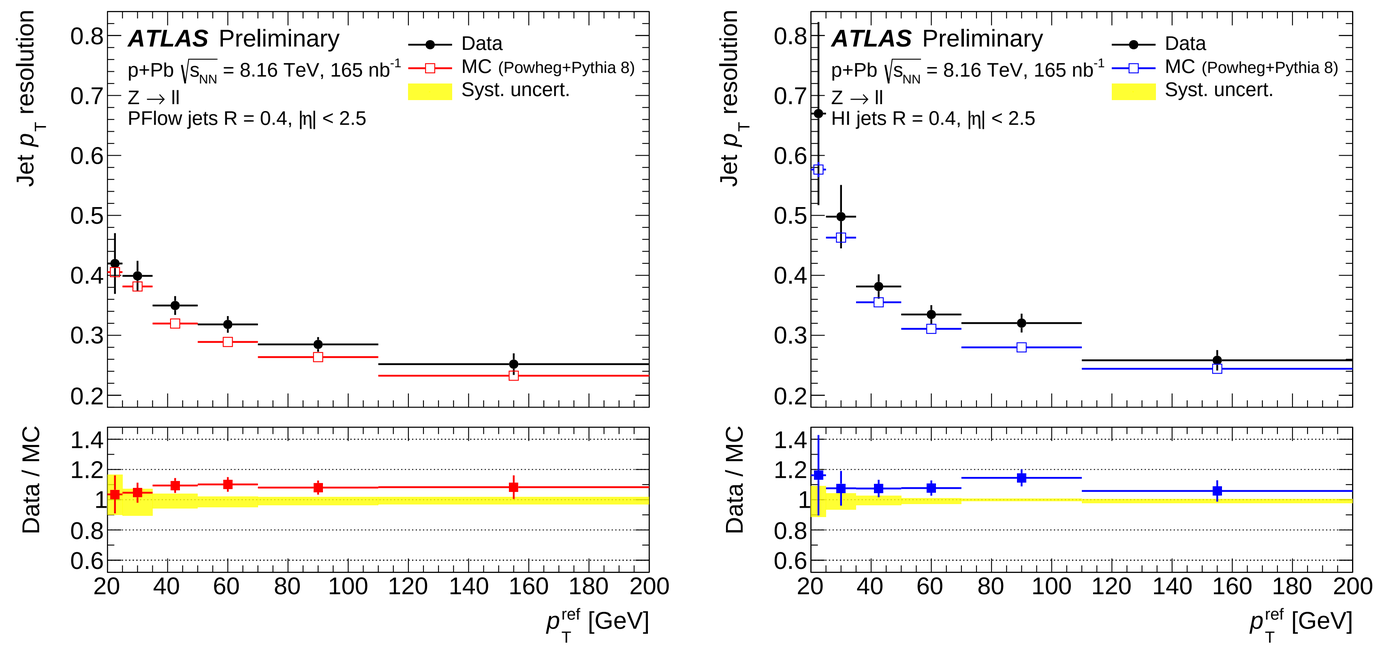
3.1 Z-jet balance: jet p_{T} scale

- The **jet p_{T} scale** is obtained as the mean jet response, defined as a ratio of reconstructed and reference transverse momenta $p_{\mathrm{T}}^{\mathrm{reco}}/p_{\mathrm{T}}^{\mathrm{ref}}$.
- Higher jet p_{T} scale for PFlow jets comes from the **underlying event** in p+Pb.
- The HI jet reconstruction includes the **underlying event subtraction**.



3.2 Z-jet balance: jet p_{T} resolution

- The **jet p_{T} resolution** is evaluated as the ratio of the standard deviation over the mean of the jet p_{T} response.
- The jet resolution determines the amount of **fluctuation** in the jet p_{T} response.
- Worse resolution comes from **intrinsic broadening** due to physics of $Z \to \ell\ell$ decays.



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References

[1] ATLAS Collaboration, Eur. Phys. J. C 81 (2021) 689
[2] ATLAS Collaboration, JETM-2023-001