

# ATLAS proton–proton collision data analysis

## Z and W Boson Reconstruction

### Overview

This analysis uses reconstructed leptons, missing transverse energy (MET), and jets to study standard electroweak processes in proton–proton collision data. The event selection and kinematic reconstruction are performed using Python with Awkward Arrays and vector-based four-vector algebra.

### Z Boson Invariant Mass

Events containing exactly two same-flavour, opposite-sign leptons are selected to reconstruct the  $Z \rightarrow \ell\ell$  decay channel. The invariant mass is computed from the sum of the two lepton four-vectors:

$$m_{\ell\ell} = \sqrt{(E_1 + E_2)^2 - (\vec{p}_1 + \vec{p}_2)^2}. \quad (1)$$

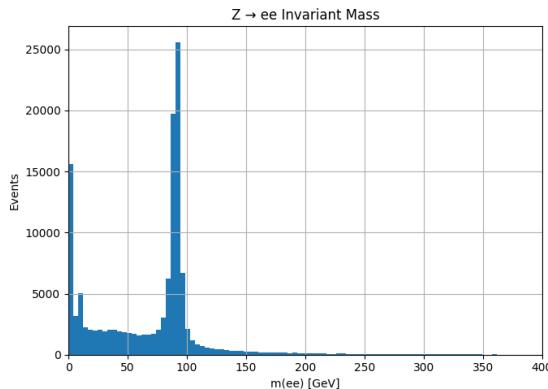


Figure 1: Invariant mass distribution of opposite-sign, electron pairs.

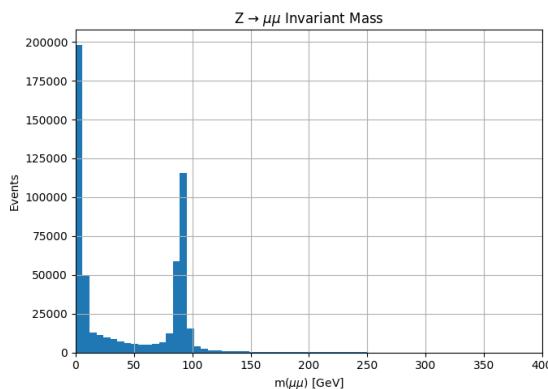


Figure 2: Invariant mass distribution of opposite-sign, muon pairs.

The resulting histogram shows a clear resonance peak near  $m_Z \approx 91$  GeV, indicating correct reconstruction and calibration of the lepton kinematics.

### W Boson Transverse Mass

For the  $W \rightarrow \ell\nu$  channel, events with exactly one lepton are selected. The transverse mass is calculated using:

$$M_T = \sqrt{2p_T^\ell E_T^{\text{miss}} (1 - \cos \Delta\phi)}, \quad (2)$$

where  $\Delta\phi$  is the azimuthal separation between the lepton and MET.

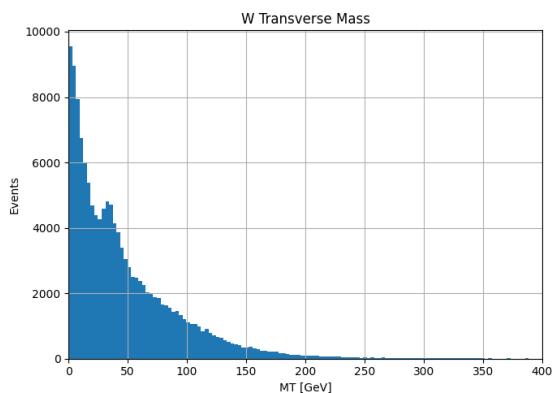


Figure 3: Transverse mass distribution of single-lepton events with missing transverse energy.

The transverse mass distribution exhibits the characteristic Jacobian edge near the  $\approx 30$  GeV.

### Jet Kinematics

Jets reconstructed in the event are used to study hadronic activity. The leading jet transverse momentum ( $p_T$ ) distribution decreases steeply with  $p_T$ , consistent with expectations from QCD jet production.

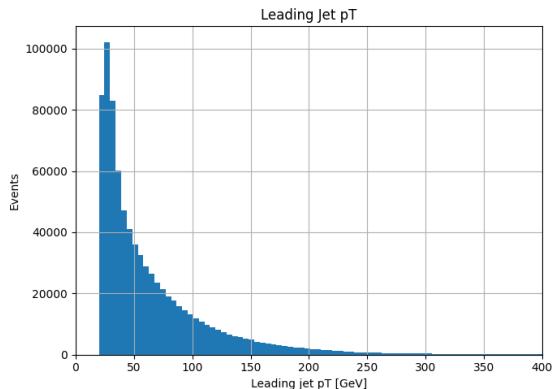


Figure 4: Transverse momentum distribution of the leading jet in each event.

Such distributions are useful for validating jet reconstruction and event topology.

## Conclusion

The reconstructed invariant mass and transverse mass spectra show the expected features of  $Z$  and  $W$  boson production. These results confirm the correctness of the object definitions, event selections, and kinematic calculations used in the analysis framework.