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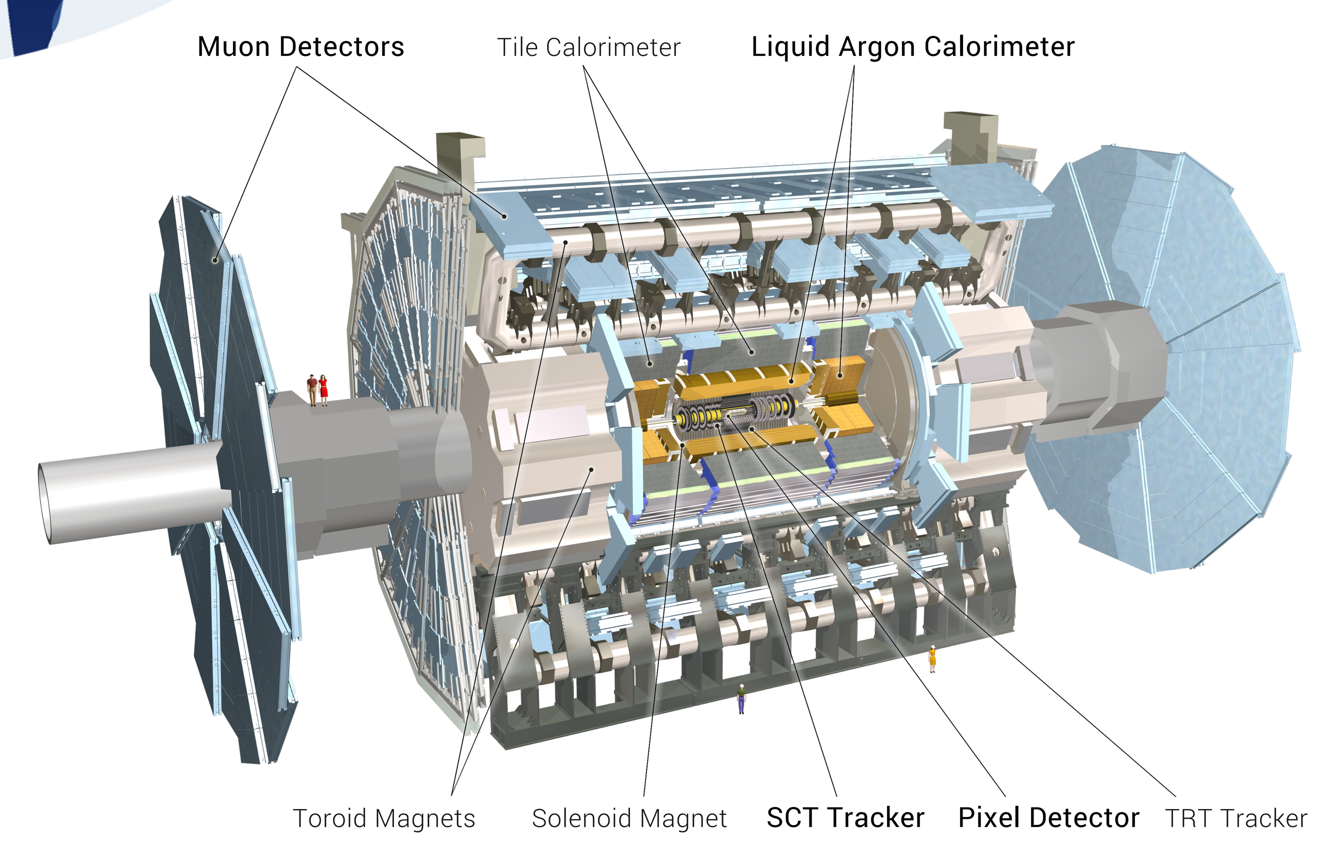
W boson production and the lepton charge asymmetry in lead-lead collisions in the ATLAS experiment



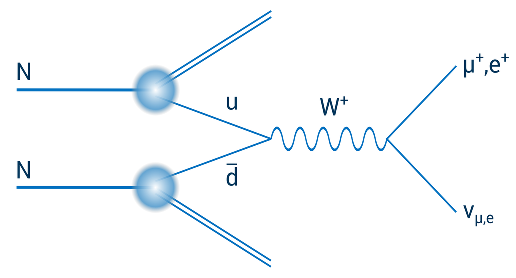
W Boson Production

Electroweak bosons (γ, W, Z) provide additional ways to study partonic energy loss in heavy ion collisions. They do not interact strongly with the medium and therefore can act as standard candles for strongly-interacting processes such as jet-quenching.

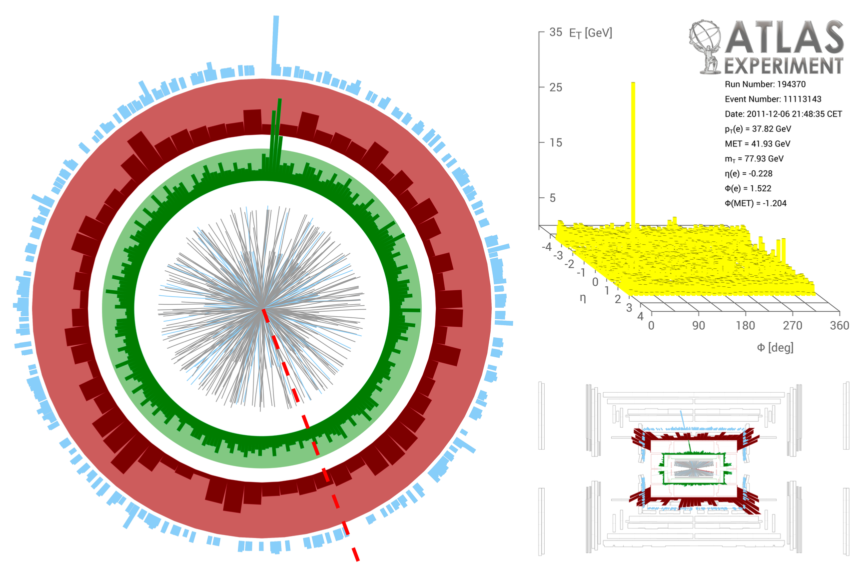
To leading-order, $W^+(W^-)$ bosons are produced by interactions between the u(d) valence quark and $\bar{d}(\bar{u})$ sea quark. This implies that the rapidity of the W boson is primarily determined by the momentum fraction, x, of the incoming partons, providing direct sensitivity to parton distribution functions. Information on the PDF can be extracted by measuring the charge asymmetry as a function of the pseudorapidity of charged leptons produced from W decays.

The charge asymmetry is defined in terms of the differential W boson production yields for W→lν, $dN_{W\pm}/d\eta_l$:

$$A_l = \frac{dN_{W^+\to l^+\nu}/d\eta_l - dN_{W^-\to l^-\nu}/d\eta_l}{dN_{W^+\to l^+\nu}/d\eta_l + dN_{W^-\to l^-\nu}/d\eta_l}$$



Event Selection



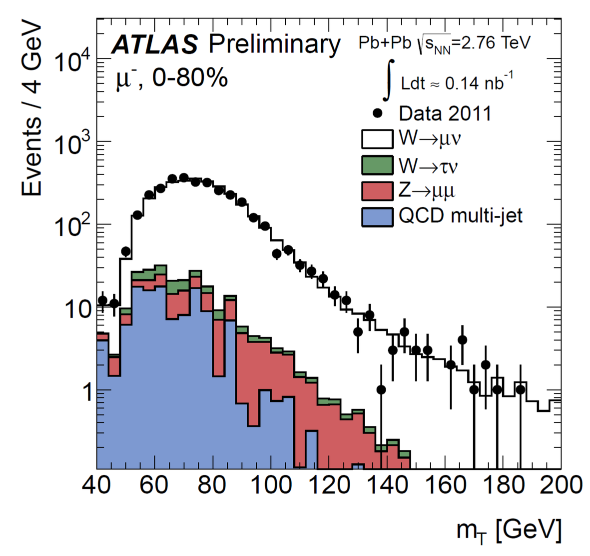
The full 2011 dataset, corresponding to $1.03\cdot10^9$ PbPb events was analysed. Each event was categorised into one of centrality classes defined by the total energy deposit in the FCal detector, which is closely related to <N_{part}> and <N_{coll}>.

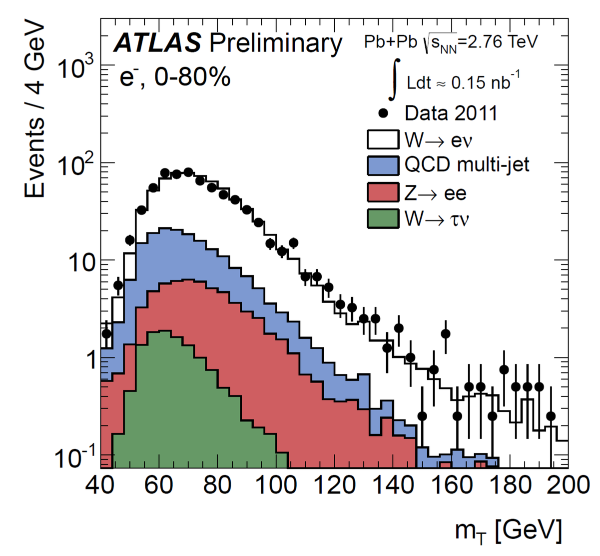
The fiducial kinematic region for this analysis is defined as follows:

- Lepton transverse momentum $p_T^l > 25\ GeV$
- Missing transverse momentum (MET) $p_T^{miss} > 25\ GeV$ which is calculated as negative vector sum of transverse momenta of all tracks in an event, having $p_T > 3$ GeV.
- Transverse mass of the lepton - missing energy system $m_T > 40\ GeV$ defined as $m_T = \sqrt{2p_T^l p_T^{miss}(1-\cos\Delta\phi_{l,p_T^{miss}})}$
- Lepton pseudorapidity $|\eta| < 2.5$

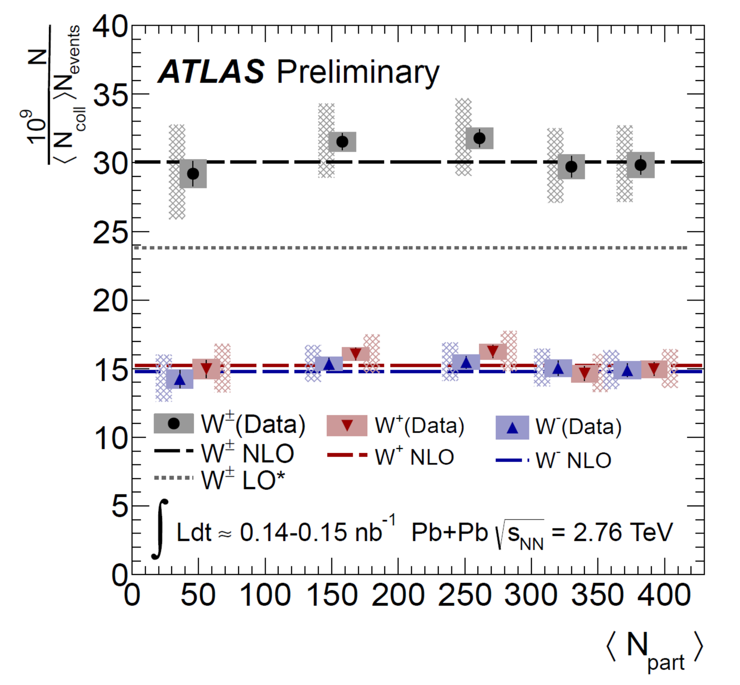
Backgrounds

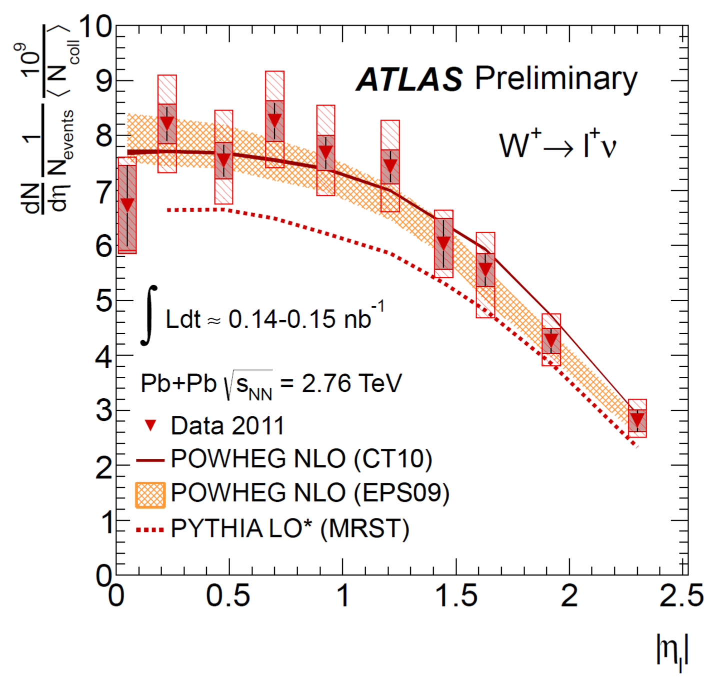
The main background contributions to the W→lν channels come from heavy flavour decays in multi-jet events ('QCD background') and electroweak processes: $Z\to l^+l^-$ events, where one lepton is not reconstructed and W/Z decays to tau(s), which then decays into an electron or muon, respectively. All the background sources are well understood, and their contributions to the selected data samples are well described by Monte Carlo simulation.

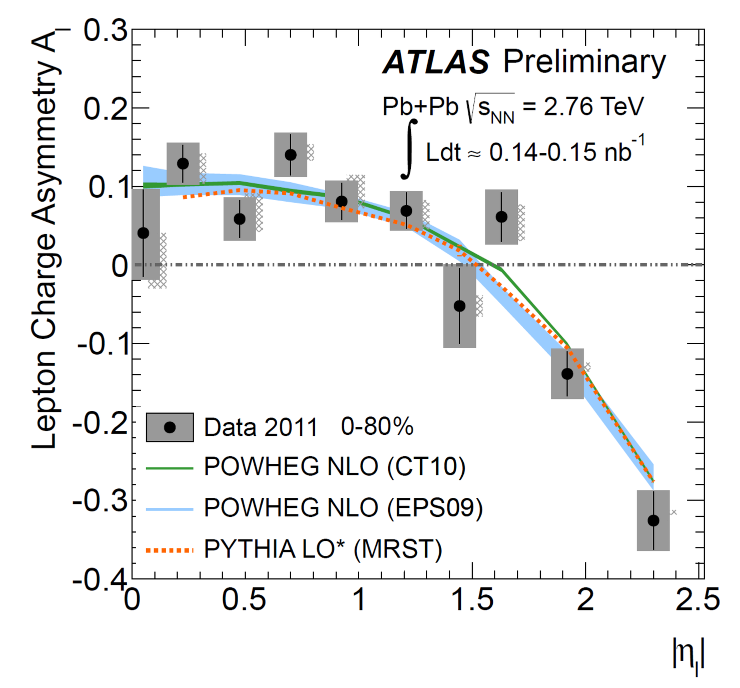


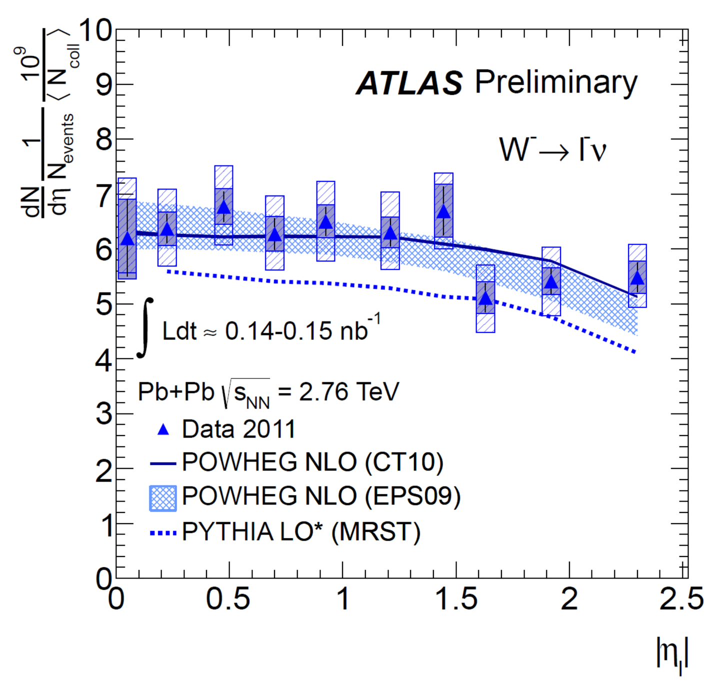


Results









	W^+	W^-	W^+/W^- ratio
W→μν	5900 ± 100 (stat.) ± 86 (syst.)	5700 ± 100 (stat.) ± 83 (syst.)	1.03 ± 0.03 (stat.) ± 0.02 (syst.)
W→eν	5800 ± 150 (stat.) ± 91 (syst.)	5700 ± 150 (stat.) ± 110 (syst.)	1.02 ± 0.04 (stat.) ± 0.01 (syst.)

The ability of electroweak bosons to act as standard candles in a QGP is bolstered by the top left figure. As with other heavy ion electroweak boson measurements, W boson production yields divided by <N_{coll}> are independent of centrality. Thus, when produced in association with jets, the W boson introduces an additional avenue for exploring in-medium modifications – energy loss due to multiple scattering and gluon radiation – to jets.

The η-dependence of W→lν decays may be used to extract information pertaining to nuclear PDFs. This utility is explored in the right figures, presenting centrality-integrated yields, together with theoretical predictions from LO* and NLO PDF sets. The former uses the MRST PDF set, whereas the latter uses the CT10 PDF set, both with and without nuclear corrections (EPS09). Though all sets employ an NLO α_s definition, the LO* fails to adequately describe the data.

Another interesting feature is the sign-change of the charge asymmetry at $|\eta_l|\approx1.5$, which is not observed in pp measurements. Due to the V-A structure, the leptonic W boson decays are not isotropic but rather favor a larger fraction of negatively-charged leptons at forward $|\eta_l|$. Since in PbPb collisions there is a larger number of d valence quarks than in pp collisions, the ratio between the number of $W^+\to l^+\nu$ and $W^-\to l^-\nu$ events decreases, resulting in a sign-change of the asymmetry that can be observed within the $|\eta_l|$ acceptance of the measurement.

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