ATLAS RESULTS ON DIFFRACTION

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The results of the first detailed explorations of diffractive dissociation processes in pp collisions at 7 TeV of centre-of-mass energies with the ATLAS detector are presented. A study of dijet production with a veto on additional central jet activity is also discussed.

1 Introduction

Also at LHC energies, a substantial fraction of the total cross section of *pp* interactions is due to inelastic diffractive processes. Diffractive processes are not uniquely defined. Theoretically, the diffractive interactions can be defined as interactions where the beam particles emerge intact or dissociated into low-mass states. Another possibility is to call diffractive any interaction mediated by the t-channel exchange of an object having the quantum numbers of the vacuum, the Pomeron, an exchange described via phenomenological models or via models based on QCD.
In general such processes lead to final state particles separated by large rapidity gaps $\Delta\eta$, where the size of the gaps is related to the mass of the dissociative system M_X. In case of single diffraction, $\Delta\eta \propto ln\xi$, where $\xi = M_X^2/s$. However gaps can arise also from Reggeon exchange or from fluctuations in the hadronisation processes, and a special care must be devoted to estimate such processes.
In ATLAS, low-mass diffractive states are not observable, as the detector does not cover the whole available rapidity interval. Samples enriched in diffractive events are selected using the detector Minimum Bias Trigger Scintillators, consisting of two sets of scintillator counters situated on the inner face of the endcap calorimeters in the forward regions of ATLAS. This detector is used to trigger on activity on only one side or both side of the interaction point. Additionally the ATLAS inner detector and calorimeters provide information on particle activity distributions measuring particles for pseudorapidity $|\eta| > 4.9$ corresponding to $M_X > 7$ GeV. A measurement [1], performed using an integrated luminosity of 20.3 μb^{-1} and where the diffractive events were contrained by the ratio of single sided to inclusive events, estimated the fraction of dissociative events in the region $M_X > 15.7$ to be $26.9^{+2.5}_{-1.0}\%$ when the default Donnachie-Landshoff model is used to estimate the detector acceptance [2].

2 Rapidity gap cross section

The diffractive contribution to the inelastic cross-section has been tuned using an integrated luminosity of 7.1 μb^{-1} taken in a single run with a negligible pile-up contamination [3]. In this analysis, the events are studied as a function of the largest forward rapidity gap and compared to models based on Regge phenomenology, assuming different parametrisations for the Pomeron

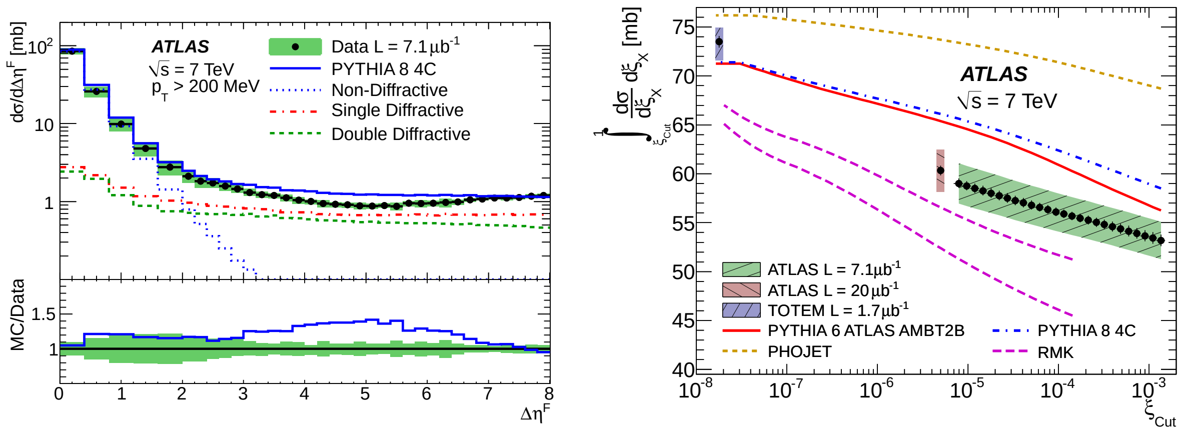

Figure 1: In the left-hand plot, the inelastic cross-section is shown as a function of the forward rapidity gap size ($\Delta\eta^F$) for particles with $p_T > 200$ MeV. The error bars indicate the total uncertainties. The data are compared with PYTHIA8 predictions showing separately the contributions for each component. In the right-hand plot, the inelastic cross-section obtained by integration of the differential cross-section from gap sizes of zero to a variable maximum is shown for $\xi_X < \xi_{Cut}$. The ATLAS results are compared to a TOTEM measurement. The predictions of the default versions of MC models are also presented.

flux. The rapidity gaps are identified by dividing the ATLAS calorimeters and the inner detector into rings in η of size 0.1 and identifying the largest sequential runs of rings without any particle activity in them, starting from the edge of the acceptance ($\eta = \pm 4.9$), of forward rapidity gap size $\Delta\eta^F$. The data are corrected back at the hadron level, were the gaps are defined in the same way, and compared to Monte Carlo (MC) generators. The inelastic cross-section is shown in the left-hand plot of figure 1 as a function of $\Delta\eta^F$ for particles with $p_T > 200$ MeV. The data are compared with PYTHIA8 predictions showing separately the contributions of the non-diffractive, single diffractive and double diffractive components. At small $\Delta\eta^F$, the cross section is dominated by non-diffractive events, exponentially suppressed as $\Delta\eta^F$ increases. For $\Delta\eta^F > 3.5$, the diffractive cross-section for $p_T > 200$ MeV has been measured as $d\sigma/d\Delta\eta^F \simeq 1.0\pm$ mb per unit of rapidity. The comparison over a large range of rapidity between data and MCs allows to tune the relative fraction of the different components in the models.
The right-hand plot of figure 1 shows the measurements of the inelastic cross section obtained by integration of the differential cross section from gap sizes of zero to a variable maximum and excluding the kinematic region with $\xi_X < \xi_{Cut}$. In this way, the data are compared to the predictions avoiding the extrapolation of the cross section at low dissociative masses, where the ATLAS detector has no acceptance. The ATLAS results are compared to a TOTEM measurement [5] integrated over all kinematically accessible ξ_X values.

3 Dijet production with a veto on additional central jet activity

Dijet events that do not contains an additional jet in the rapidity region bounded by the dijet system are a tools to investigate perturbative QCD radiation. These events have been investigated [4] using the full 2010 dataset, corresponding to an integrated luminosity of 37 pb^{-1}. The jets are identified using the anti-k_t algorithm and required to have transverse momentum $p_T > 20$ GeV and rapidity $|y| < 4.4$, ensuring that they are in a region in which the jet energy scale has been validated. Gap events are the events that do not contain an additional jet with p_T above the veto scale Q_0 in the rapidity interval between the boundary jets, with $Q_0 > 20$ GeV. The data are compared to models based on QCD next-to-leading order (NLO) calculations in two limits, large jet transverse momentum and large jet rapidity separation.

In figure 2, the data are compared to HEJ and POWHEG predictions. In the left-hand plot

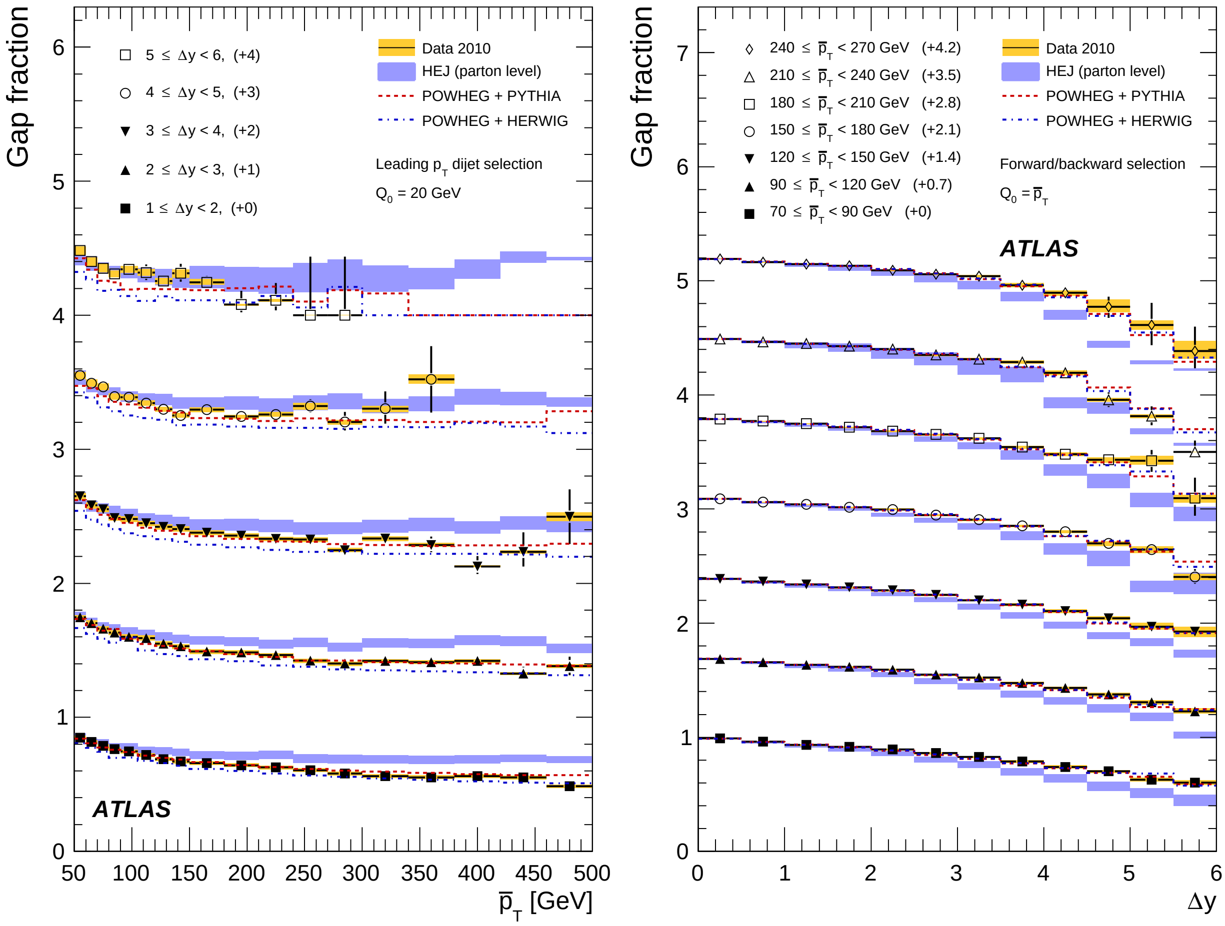

Figure 2: The left-hand plot shows the gap fraction as a function of $\bar{p_T}$ for various Δy slices when the dijet system is defined as the two leading-p_T jets in the event. The left-hand plot shows the gap fraction as a function of Δy for various $\bar{p}_T$ slices whith the dijet system defined as the most forward and the most backward jets in the event. The data are compared to HEJ and POWHEG predictions. The total systematic uncertainty of the data and the theoretical uncertainty of the models are also presented.

the dijet system is defined as the two highest transverse momentum jets in the event and the gap fraction is studied as a function of the mean transverse momentum of the jets, $\bar{p}_T$, to investigate the wide-angle soft gluon radiation in p_T-ordered jet configuration. The right-hand plot shows the gap events as a function of the rapidity separation between jets, Δy, and the dijet system is defined as the most forward and the most backward jets in the event to favour BFKL-like dynamics because the dijet invariant mass is much larger than the transverse momentum of the jets.

HEJ (High Energy Jets) is a parton level event generator for all order description of wide angle emissions of similar p_T. It describes the data well as a function of Δy at low values of $\bar{p}_T$ but predicts too many gap events at large values of $\bar{p}_T$. This means that HEJ calculation is missing higher order QCD effects that become important as $\bar{p}_T$ increases and that are provided by a traditional parton shower approach.

POWHEG provides a full NLO dijet calculation and is interfaced to PYTHIA or HERWIG to supply all-order resummation of soft and collinear emissions using the parton shower approximation. It describes the data well as p_T increases but predicts too much jet activity in the rapidity interval between the boundary jets at large value of Δy, implying that the fixed order plus parton shower approach does not contain higher order QCD effects that become important as Δy increases.

This data can therefore be used to constrain the event generator modelling of QCD radiation between widely separated jets, as discussed also in [6].

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