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# Measurement of Z boson production in association with jets at ATLAS

Z + jets production at the Large Hadron Collider (LHC) allows for precision measurements and provides important tests of perturbative QCD and help probe the proton structure. In addition, Z + jets are irreducible backgrounds in Higgs boson measurements and in physics searches beyond the Standard Model.

## Z + high $p_T$ jets at 13 TeV

**ATLAS-CONF-2021-033**

First cross-section measurement of the production of a Z boson in association with high transverse momentum ($p_T$) jets using **full Run 2** data with $\mathcal{L}$ **= 139 fb$^{-1}$**.

Focuses on a high-$p_T$ selection to enhance and study ***collinear*** and ***back-to-back*** Z boson emissions. High-$p_T$ selection requires leading jet transverse momentum above 500 GeV and enhances the emission of **on-shell** Z bosons.

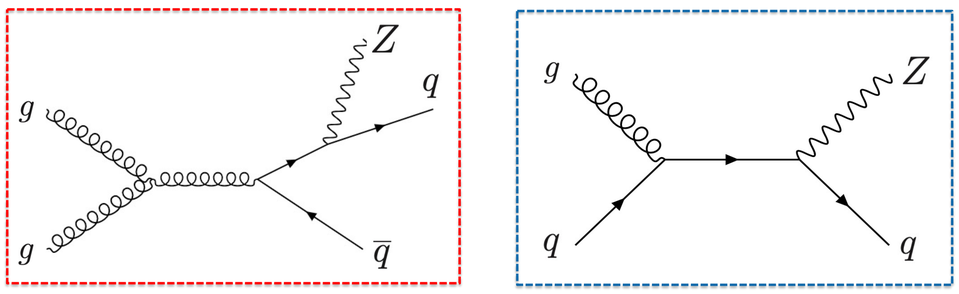



Figure 1: Leading Feynman diagrams for *collinear* Z + 2 jets (left) and *back-to-back* Z + 1 jet (right) emissions.

### Event Selection

Z boson:

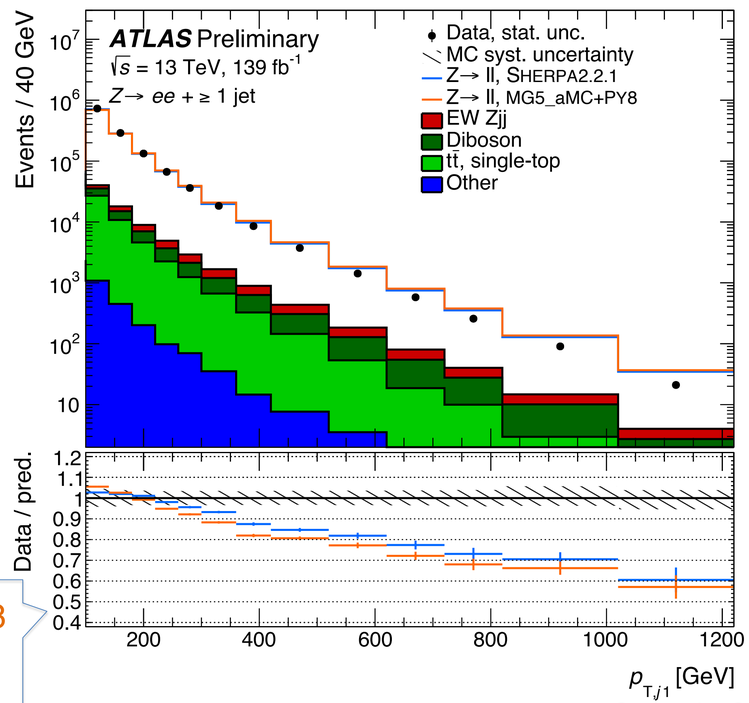
- 2 opposite charge leptons
- $71 < M_{\ell\ell} < 111$ GeV

Leptons:

- $p_T > 25$ GeV
- $|\eta| < 2.5$

Jets:

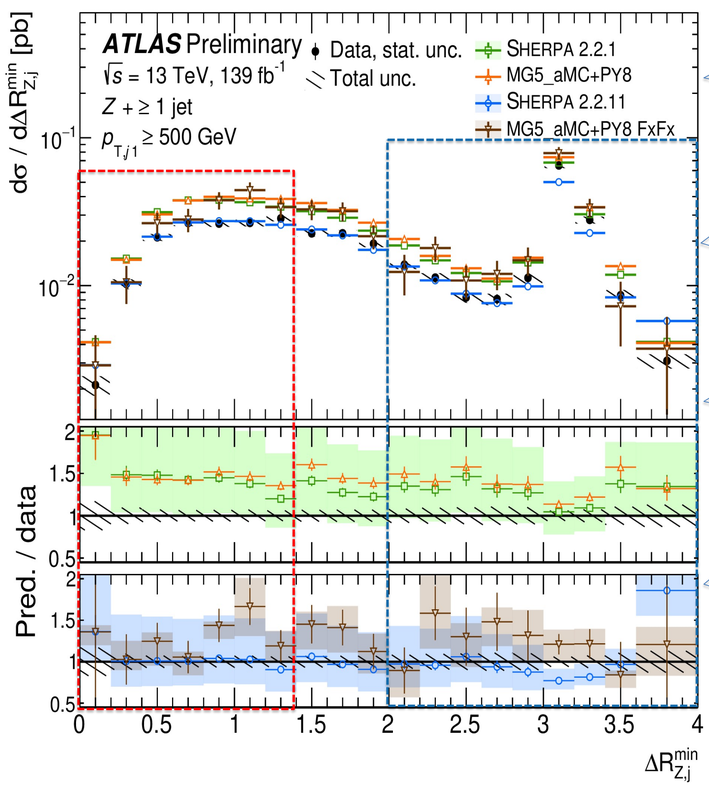
- Anti-kt R = 0.4
- $p_T > 100$ GeV
- $|y| < 2.5$




Sherpa2.2.1 and MG5_aMC+Py8 **overpredict data** as jet $p_T$ increases above 200 GeV.

Figure 2: Detector level data and Monte Carlo (MC) comparison of leading jet $p_T$.

### Results




Sherpa2.2.1 and MG5_aMC+Py8 MC **overpredict data**.

State-of-the-art Sherpa2.2.11 and MG5_aMC+Py8 FxFx **agree with data** within uncertainties.

***Back-to-back*** Z + 1 jet emission populate the peak at $\Delta R_{Z,j}^{min} \approx \pi$.

***Collinear*** Z + jets emission populate collinear region at $\Delta R_{Z,j}^{min} \leq 1.4$.

Many differential cross sections measured separately for different observables in inclusive, high-$p_T$, ***collinear*** and ***back-to-back*** regions.

Figure 3: Differential cross section as a function of angular distance between the Z boson and closest jet in the high-$p_T$ region: $p_T$(lead jet) > 500 GeV. $\Delta R = \sqrt{\Delta y^2 + \Delta\phi^2}$

## Z + b-jets at 13 TeV

**JHEP 07 (2020) 044**

Measurement of the production cross section of a Z boson in association with b-jets using **partial Run 2** data with $\mathcal{L}$ **= 35.6 fb$^{-1}$**.

Z + 1 b-jet measurements probe the proton composition through the b-quark parton probability function (PDF). MC predictions are sensitive to number of quarks in the PDF, called the flavour number scheme (FNS).

Z + 2 b-jets is sensitive to gluon splitting and Z boson emission from di-jet events.

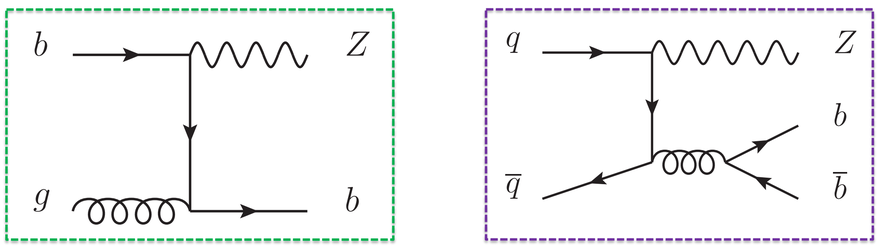
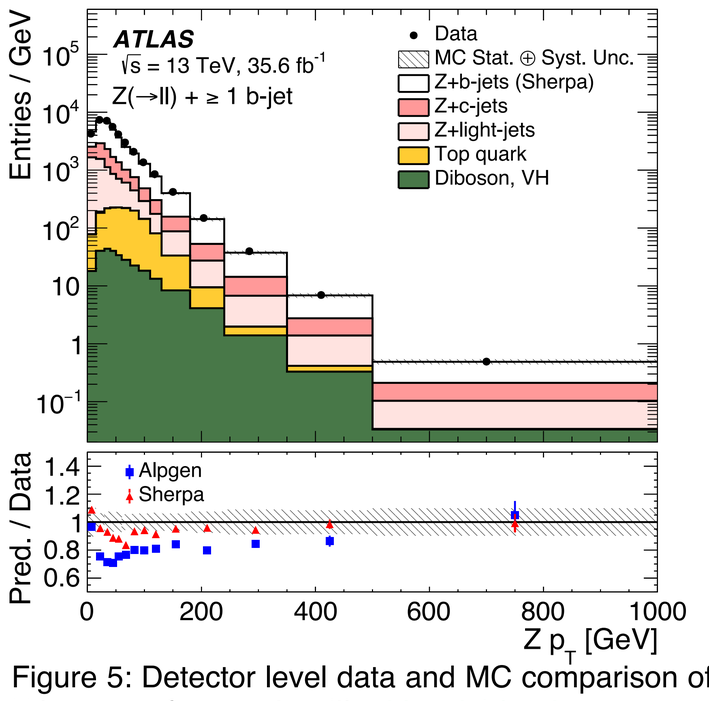



Figure 4: Leading Feynman diagrams for Z + 1 b-jet (left) and Z + 2 b-jets (right) emissions.

### Event Selection




Z boson:

- 2 opposite charge leptons
- $76 < M_{\ell\ell} < 106$ GeV

Leptons:

- $p_T > 27$ GeV
- $|\eta| < 2.5$

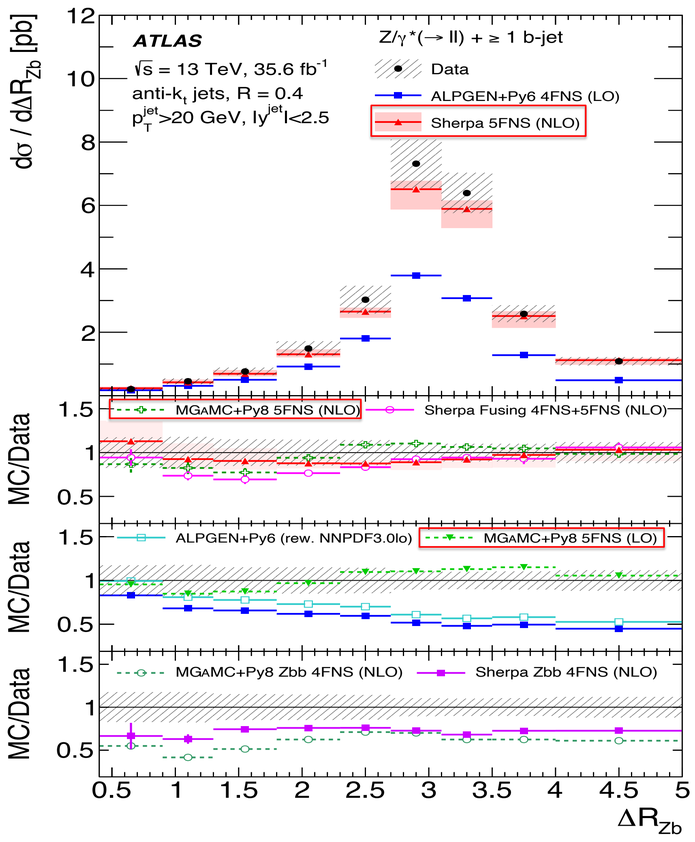
b-jets:

- Anti-kt R = 0.4
- $p_T > 20$ GeV
- $|y| < 2.5$

Leading backgrounds are Z boson + c jets and light-jets. Normalizations estimated with maximum likelihood fit to data in flavour sensitive distributions.

Figure 5: Detector level data and MC comparison of Z-boson $p_T$ for events with at least 1 b-jet.

### Results




MC which include the b-quark in the PDF (5FNS) show **best** description of data.

4FNS excludes b-quark from the initial state of MC predictions.

Back-to-back peak **well modelled** $\Delta R_{Zb} \approx \pi$.

4FNS+5FNS Sherpa fusing setup works well without major issues. No benefit in $\Delta R_{Zb}$.

Both ALPGEN+Py6 predictions **underestimates data**.

Z + 2 b-jets MC (Zbb) **models the shape** correctly.

Important measurements serving as inputs to improve theoretical predictions and MC generators.

Figure 6: Differential cross section as a function of angular distance between the Z boson and the leading b-jet in events with at least 1 b-jet.

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ATLAS EXPERIMENT