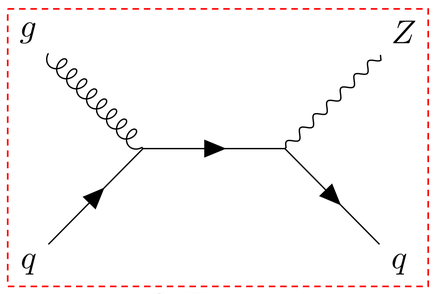
ISMD2022 · Scotland, 1 - 5 August 2022

Measurement of Z boson production in association with high-transverse-momentum jets in *pp* collisions at 13 TeV using full Run-2 data at ATLAS

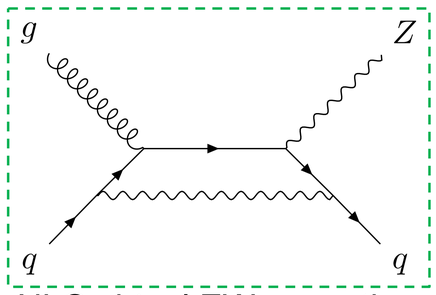
arXiv:2202.02597 · STDM-2018-49

Introduction

- First ever Z + high-p_T jets measurement using the **full Run-2** dataset of $\mathcal{L} = 139\ \mathbf{fb^{-1}}$.
- Measurements unfolded to fiducial phase space.
- High-p_T jet and Z phase spaces sensitive to **NLO QCD and EW corrections**.

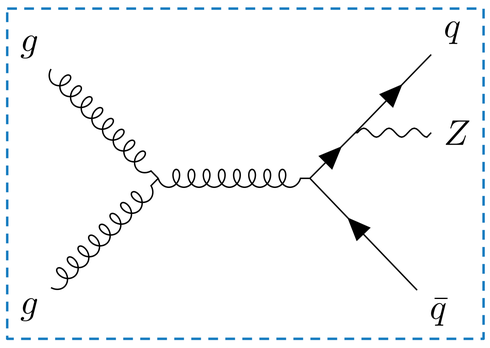


LO Z + 1 jet



NLO virtual EW correction

NLO virtual EW corrections to Z + 1 jet have impact of up to -20% for large $p_T(Z)$



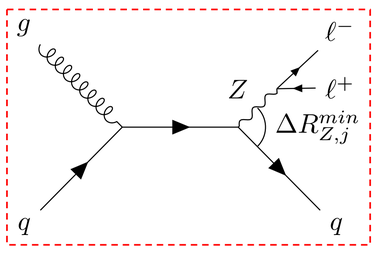
Collinear emission of on-shell Z boson: real EW correction

Real EW correction to dijet production enhanced by $\ln^2(\frac{p_T(jet)}{m_Z})$ vs real QCD corrections to Z + 1 jet

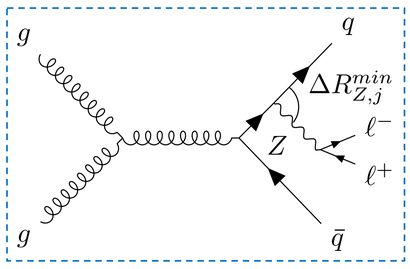
Event Selection

- Final state:
  → $Z + \geq 1$ jet.
  → On-shell Z boson decaying into charged leptons: e^+e^- or $\mu^+\mu^-$.
  → Only jets with $p_{\mathrm{T}} \geq 100\ \mathrm{GeV}$.
- *High-p_T* region defined with: $p_{\mathrm{T}}(j_1) \geq 500\ \mathrm{GeV}$.

- Use $\Delta R_{Z,jet}^{min} = \sqrt{\Delta y^2 + \Delta\phi^2}$ to study enhanced topologies:
  → **Back-to-back** Z + 1 jet hard-scatter.
  → **Collinear** Z boson emission.



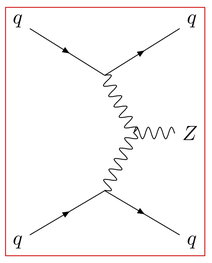
Back-to-back Z+1 jet
$\Delta R_{Z,jet}^{min} \geq 2.0$



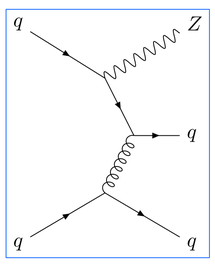
Collinear Z + 2 jets
$\Delta R_{Z,jet}^{min} \leq 1.4$

Background Estimation

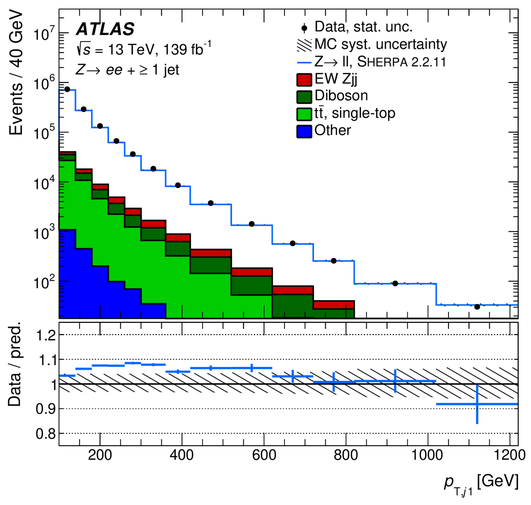
- EW produced Z + 2 jets treated as **background**.



EW Z + 2 jets



Strong Z + 2 jets

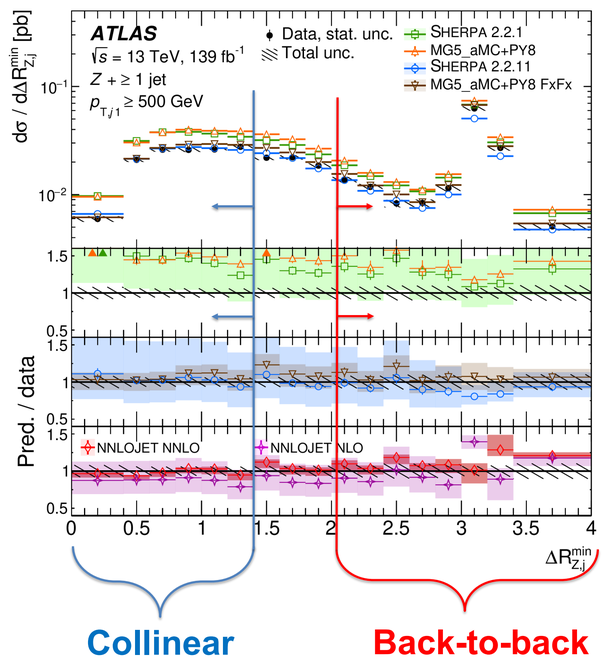


- Monte-Carlo generators to model dominant backgrounds: diboson and EW Z + 2 jets.
- Data-driven method to estimate dominant $t\bar{t}$ background using $e\mu$ control region data.

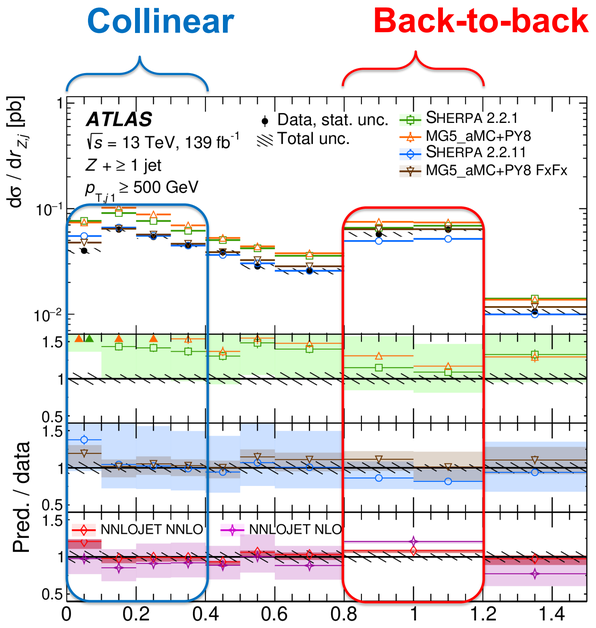
Dominant backgrounds:
→ 2% - 6% $t\bar{t}$
→ 2% - 5% Diboson
→ 1% - 5% EW Z + 2 jets

Results

- Fiducial cross sections compared against theoretical predictions and fixed-order calculations from NNLOjet.
- Only Sherpa2.2.11 includes NLO virtual EW corrections.



- Low $\Delta R_{Z,jet}^{min}$ populated by **collinear** events.
- **Back-to-back** events in peak at $\Delta R_{Z,jet}^{min} = \pi$.
- All predictions **consistent with data** within errors.
- Sherpa2.2.1 and Sherpa2.2.11 imprecise with uncertainties reaching 50%.



$$r_{Z,j} = \frac{p_{\mathrm{T}}(Z)}{p_{\mathrm{T}}(closest\ jet)}$$

- Sherpa2.2.1 and MG5_aMC+Py8 **overestimate events** of collinear Z boson emission.
- Back-to-back events generally **well modelled**.
- MG5_aMC+Py8 FxFx very precise and **describes data** in full range of distributions.

- State-of-the-art MC generators Sherpa2.2.11 and MG5_aMC+Py8 FxFx **outperform previous versions** of Sherpa2.2.1 and leading order MadGraph.
- NNLOjet @ NNLO most precise prediction.
- Collinear emissions have large effect in *high-p_T* region.
- NLO virtual EW corrections have 10% - 20% impact on events with $p_{\mathrm{T}}(jet) \geq 500\ \mathrm{GeV}$.
- QCD scale uncertainties very large: several 10s of %.

Carleton University
Alexandre Laurier · Carleton University · Canada
On behalf of the ATLAS collaboration
ATLAS EXPERIMENT