Vector boson associated with jets in CMS

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Introduction

- W and Z bosons are produced at high rate at the LHC in collisions with different center of mass energies (7, 8 and 13 TeV)
- Processes involving production of Z or W boson in association with jets are an important part of the LHC physics program:
  - provide fundamental tests of quantum chromodynamics (QCD)
  - important for understanding and modelling QCD interactions
  - essential to improve theoretical predictions and MC generator techniques
  - constrain the parton distribution functions (PDFs)
  - important background to many Standard Model processes as well as to searches for physics beyond the SM
- W and Z bosons are reconstructed via leptonic final states that are the cleanest final states experimentally

- **The most recent V + jets results from CMS collaboration are presented in this talk**

Z + jets differential measurements

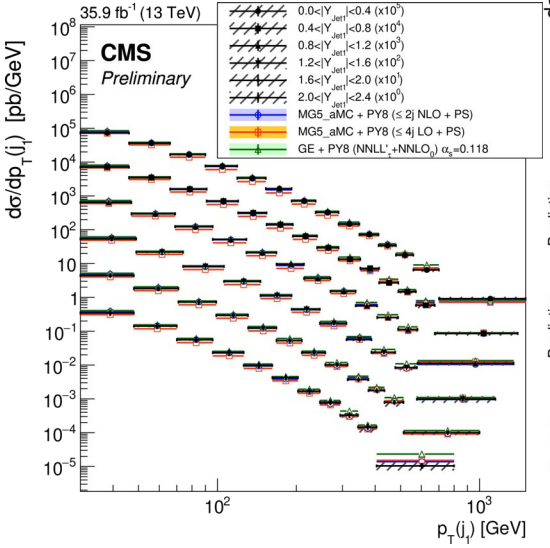
- Measurement of differential cross sections as a function of the:
  - double differential p_T and |y| of Z and jets
  - exclusive and inclusive jet multiplicities (up to 8 jets)
  - jet p_T and |y| of 5 jets
  - dijet invariant mass.

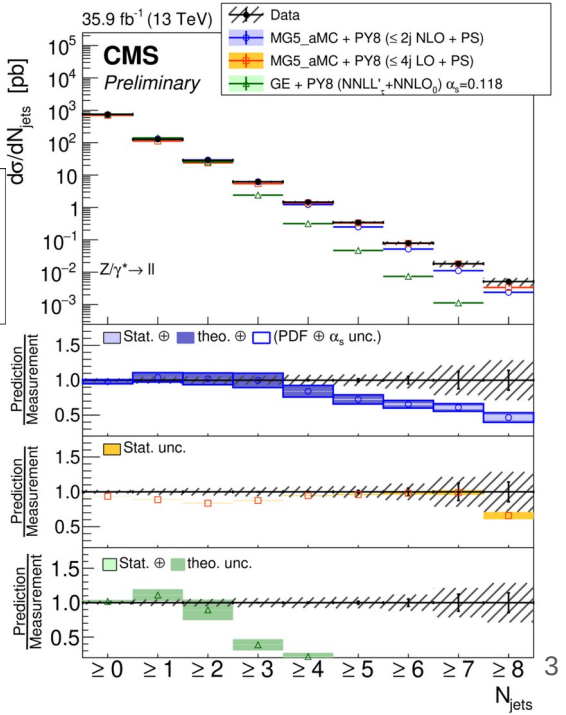
13 TeV, 35.9 fb^{-1}

CMS-SMP-19-009
Submitted to Phys. Rev. D

- Results include **electron and muon channels combined**

- Measured differential cross sections are **within the experimental and theoretical uncertainties** of the expectations from theory
- Deviations are observed for jet multiplicities higher than 3
- The **GENEVA** generator – steeper spectrum, because of the lack of hard jets at ME level beyond two





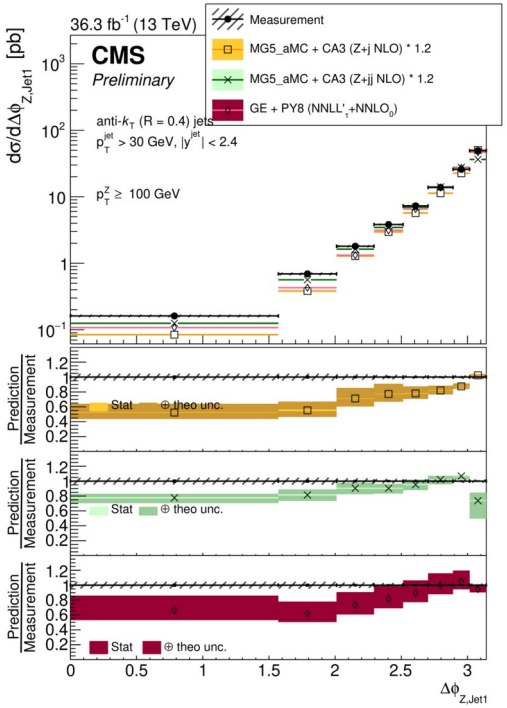
Z + jets azimuthal correlations

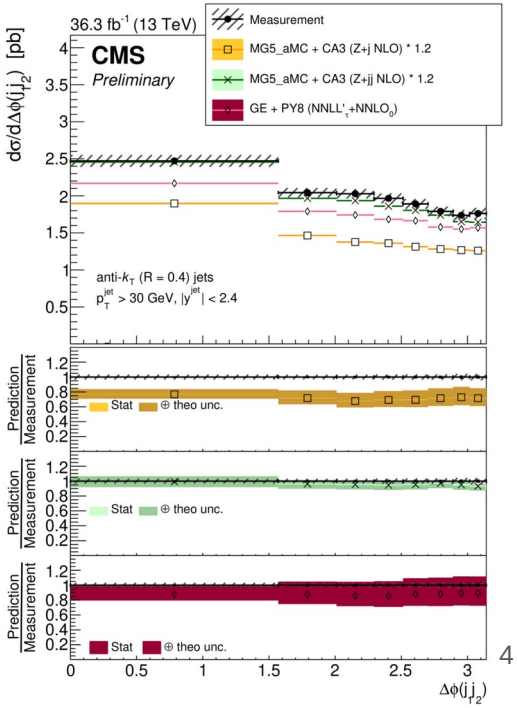
- Measurement of the multiplicity of jets, azimuthal correlation between the Z boson and the leading jet, and the correlation between the two leading jets
- Results include **electron and muon channel combined**
- Measurement performed in different Z p_T regions:
  - ✓p_T (Z) < 10 GeV
  - ✓30 < p_T (Z) < 50 GeV
  - ✓p_T (Z) > 100 GeV

13 TeV, 35.9 fb^{-1}

CMS-PAS-SMP-21-003

- The **best description** is from **GENEVA NNLO**
  - matrix elements at NNLO for Z production
  - NNLL' resummation
  - parton shower and MPI from PYTHIA8
- **MG5_AMC+CASCADE3 (Z ≤ 3j LO)** using parton branching -TMD parton densities and parton shower with merging of jet multiplicities – **good agreement** in the regions where MPI is negligible





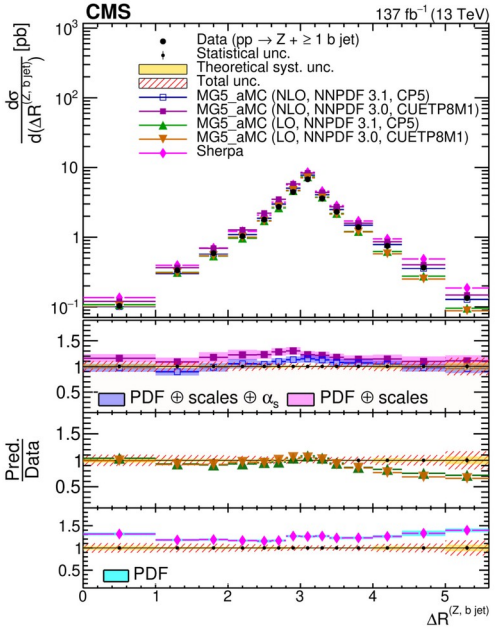
Z + b jets

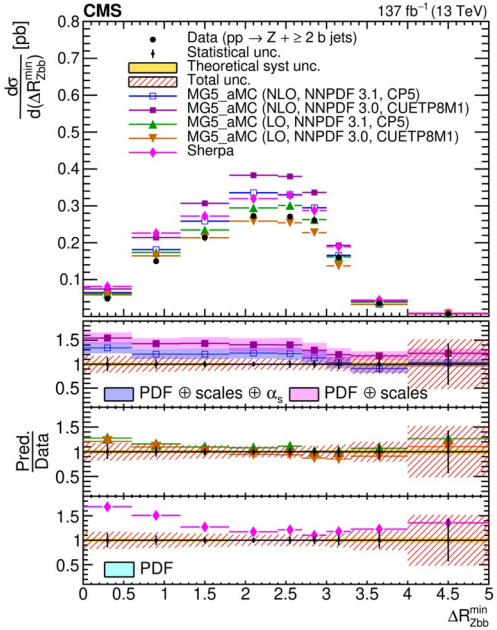
- Measurement of differential cross sections as a function of the:
  - p_T of the Z boson and the two highest p_T b jets
  - absolute pseudorapidity of the b jets
  - angular correlations between the Z boson and the b jets
  - the b jets invariant mass of the two b jets
  - minimum separation between the Z boson and the two b jets
  - invariant mass of the Z boson and the two b jets
  - angular separation between two b jets
  - asymmetry of the Z + ≥ 2 b jets system
- Measurement of integrated cross section ratios of Z + ≥ 2 b jets to Z + ≥ 1 b jet

13 TeV, 137 fb^{-1}

[Phys. Rev. D 105 (2022) 092014]

- **SHERPA** simulation overestimates the measured integrated cross section but it provides a **good description of the shapes** of various kinematic observables
- The **MG5 aMC (LO)** and **MG5 aMC (NLO)** describe the fiducial cross section better but do not completely describe the shapes of the kinematic observables.





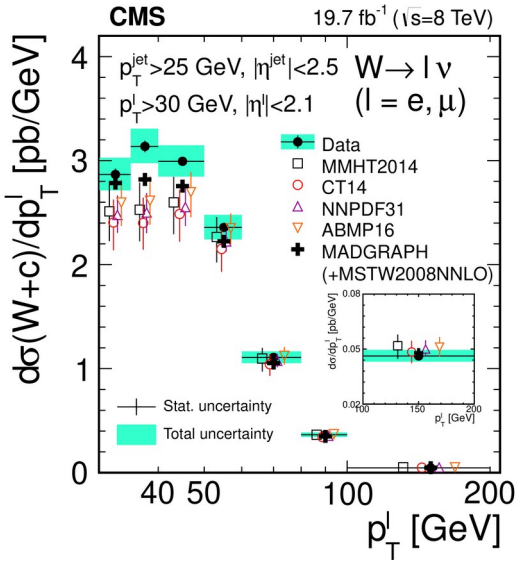
W + c jets

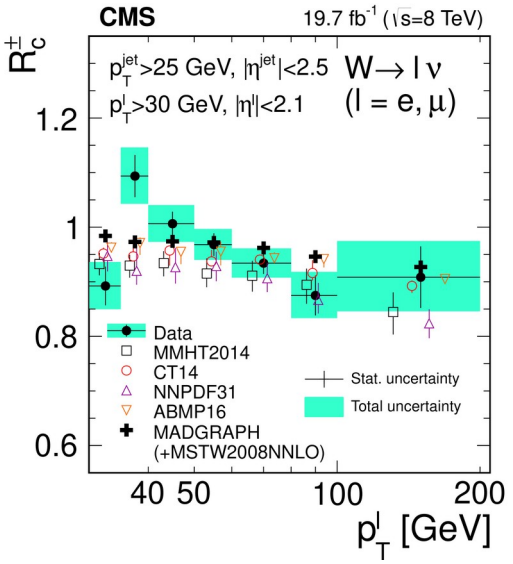
- Inclusive and differential cross section measured as functions of the pseudorapidity and of the transverse momentum of the lepton from the W boson decay
- The ratio of the cross sections of $W^+ + c$ and $W^- + c$ is also measured

8 TeV, 19.7 fb^{-1}

CMS-SMP-18-013
Submitted to Eur. Phys. J.C

- Comparison with the **MADGRAPHMC** normalized to the NNLO cross section predictions from FEWZ - **consistent within uncertainties**
- A **fair agreement** is seen in the differential cross section for analytical calculations from the **MCFM** program using different NLO PDF sets.
- **Strange quark distribution** and the **strangeness suppression factor** – **show agreement** with earlier CMS results and other NLO PDF sets

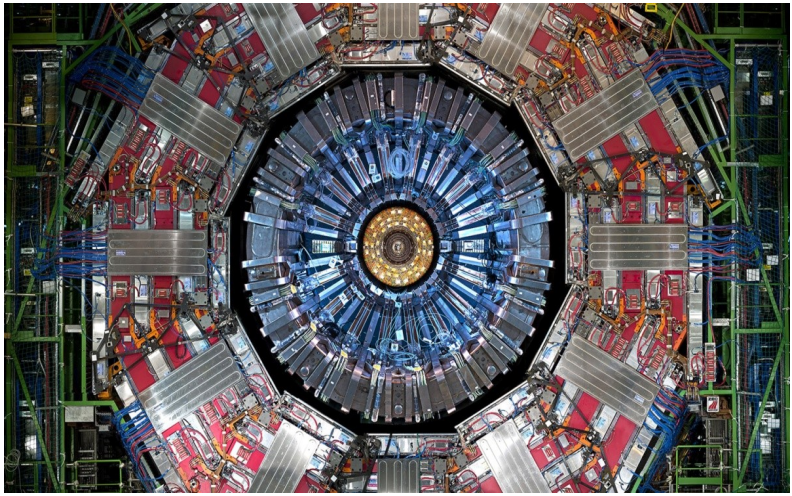




New preliminary results W + c at 13 TeV
CMS-PAS-21-005

Summary

- Latest V + jets CMS results presented
- Measurements are compared with different theoretical predictions up to NNLO precision with different matrix element and parton shower models
  - overall good agreement is observed for several angular and kinematical observables



- More results on Inclusive vector bosons results in CMS – talk by Itana Bubanja
- Full list of analysis V + jets results from CMS collaboration: https://cms-results.web.cern.ch/cms-results/public-results/publications/SMP/index.html