Measurement of the Z boson production in association with at least two b jets in pp collisions at $\sqrt{s}$ = 13 TeV with CMS

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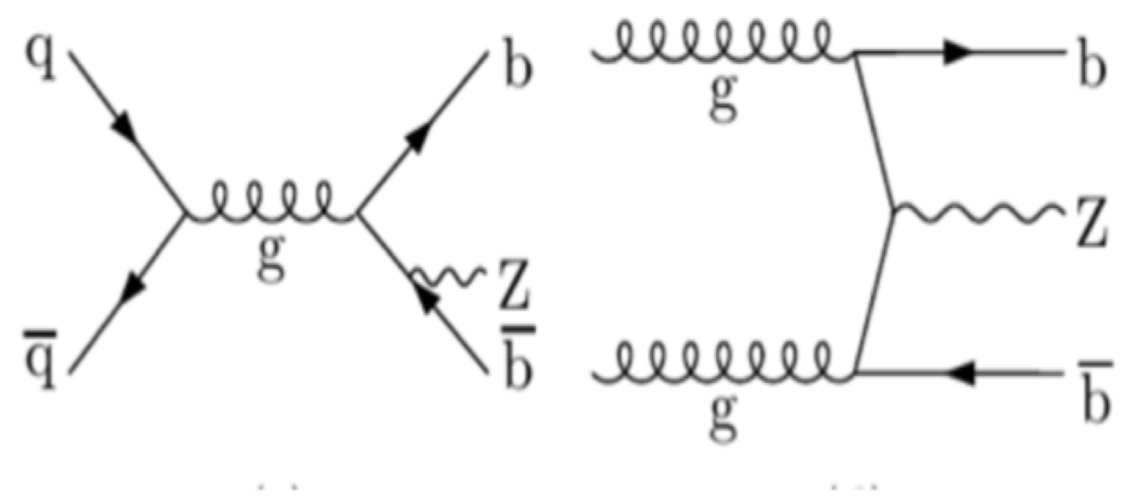
For the CMS Collaboration

Introduction

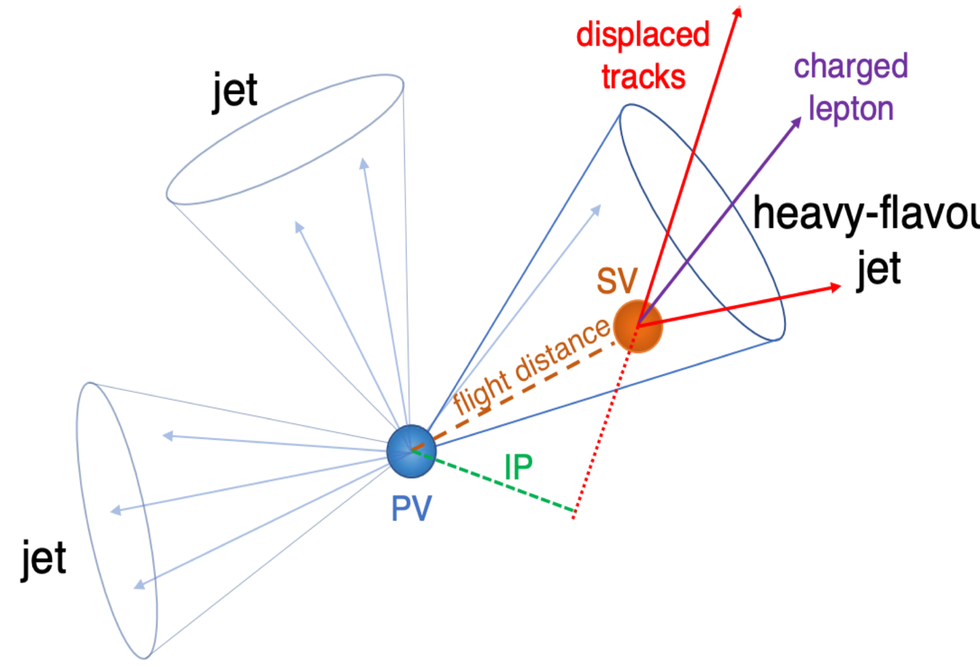
- The Z boson production associated with jets from b quarks provides important tests to perturbative quantum chromodynamics calculations.
- It is also the major background for many physics processes, including Higgs boson production in association with a Z, ZH($H \to b\bar{b}/c\bar{c}$), and searches for new physics phenomena.



Examples of Feynman diagrams of Z+2b production

Overview of the measurement [1]

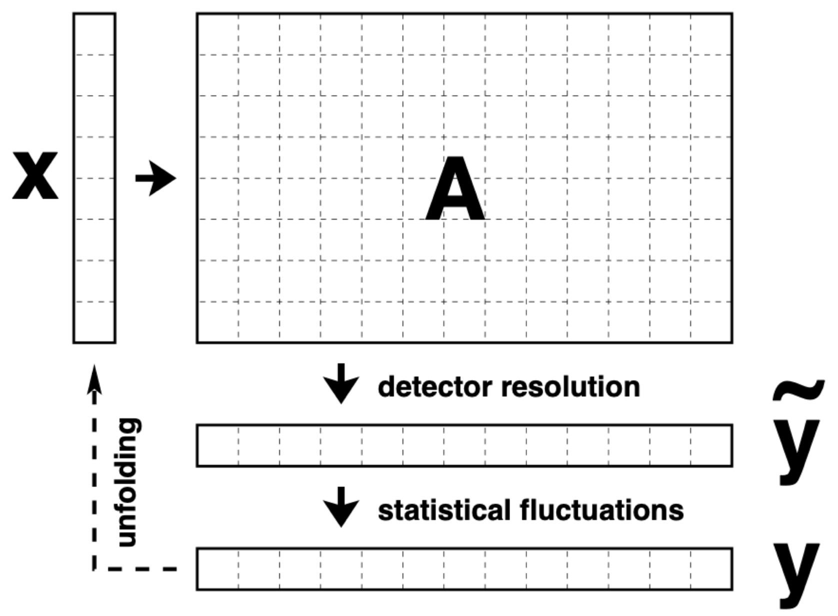
- The cross section is measured in the leptonic decay channel of Z bosons ($Z \to ee$ or $Z \to \mu\mu$) with full Run 2 data (137 pb^{-1}).
- Data collected with a single lepton trigger
- Leptons: leading (sub-leading) lepton p_T > 35 GeV (25 GeV), $|\eta|$ <2.4, isolated.
- Z boson: pair of oppositely charged leptons within Z mass window $71\ \mathrm{GeV} < M_{ll} < 111\ \mathrm{GeV}$.
- Jets: anti-k_T jets, p_T > 30 GeV, $|\eta|$ <2.4.
  jets from pileup events are excluded.
- Missing transverse momentum < 50 GeV → to reduce $t\bar{t}$ background
- b jets: tight tagging requirement (50% b quark tagging efficiency with 0.1% misidentification rate for jets originating from gluons or u, d, s quarks) → to reduce DY + X backgrounds,
  X = light or c jets (jets originated from c quarks).



b jets are tagged based on unique properties of B hadrons inside the jets: relatively long lifetime (~1.5 ps) → secondary vertex displaced from the primary vertex and large invariant mass [2].

Unfolding

- The observed distributions at reconstruction level **y** are unfolded to particle level ones **X** by applying corrections for the detector effects represented by response matrix **A** [3].

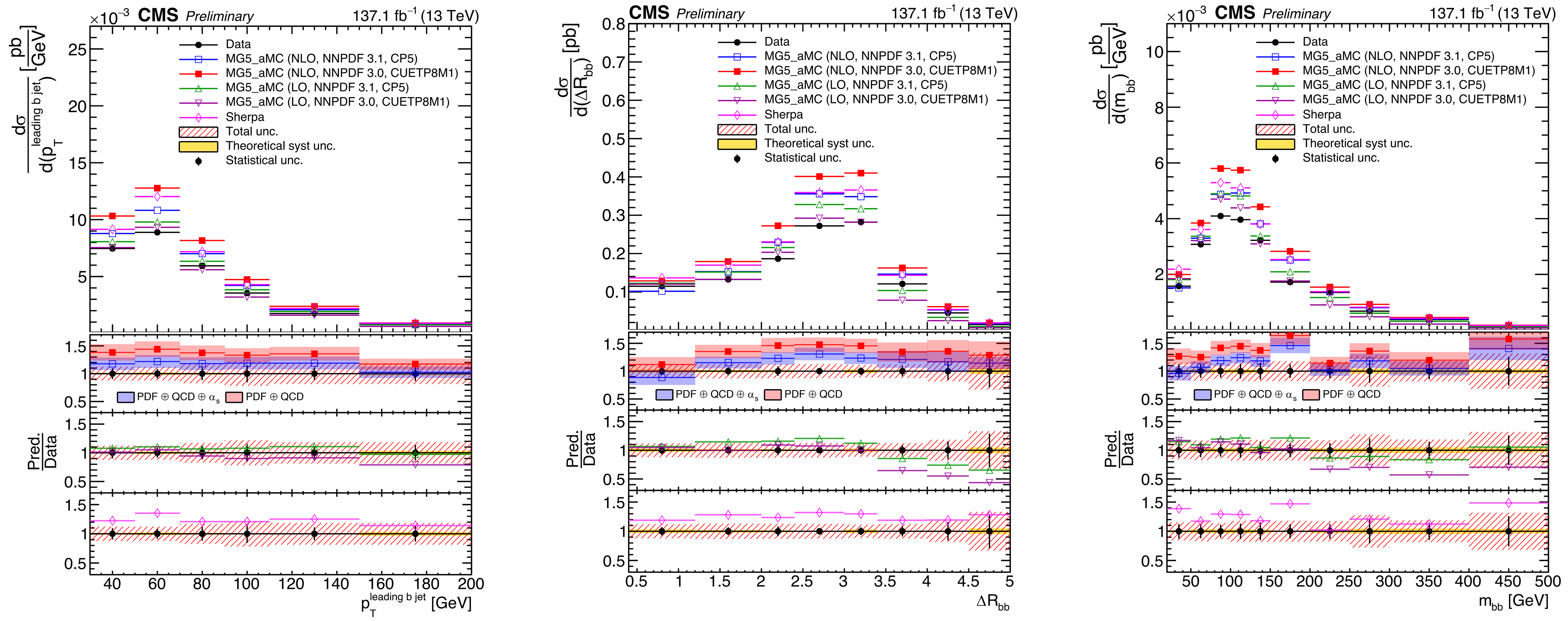


Integrated cross section for Z + $\geq$ 2 b jets in combined channel

Measured	0.65 ± 0.03 (stat) ± 0.07 (syst) ± 0.02 (theo) pb
MG5_aMC (LO) (NNPDF 3.1, CP5)	0.71 pb
MG5_aMC (LO) (NNPDF 3.0, CUETP8M1)	0.63 pb
MG5_aMC (NLO) (NNPDF 3.1, CP5)	0.77 ± 0.07 pb
MG5_aMC (NLO) (NNPDF 3.0, CUETP8M1)	0.90 ± 0.09 pb
SHERPA	0.84 pb

- Uncertainties in the jet and missing transverse momentum measurements as well as b jet tagging contribute significantly to the systematic uncertainty.
- Measured integrated cross section is in good agreement with MADGRAPH5_aMC@NLO (MG5_aMC) simulations calculated at LO.
- MG5_aMC at NLO and SHERPA predictions overestimate the measured cross section values.

Unfolded differential cross section distributions



Summary

- MG5_aMC LO predicted rates agree better with data, while MG5_aMC NLO and SHERPA overestimate the data rate.
- In differential cross sections, the shape of data distributions are well described by MG5_aMC at NLO and SHERPA.

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References

[1] The CMS Collaboration, "Measurement of Z+b jets cross section in proton-proton collisions at $\sqrt{s}$ = 13 TeV", PAS SMP-20-015 (2021)
[2] CMS Collaboration, "Identification of heavy-flavour jets with the CMS detector in pp collisions at 13 TeV" , JINST 13 (2018) P05011
[3] S. Schmitt, "TUnfold: an algorithm for correcting migration effects in high energy physics", JINST 7 (2012) T10003