Electroweak production of events with a Z boson and two jets with CMS

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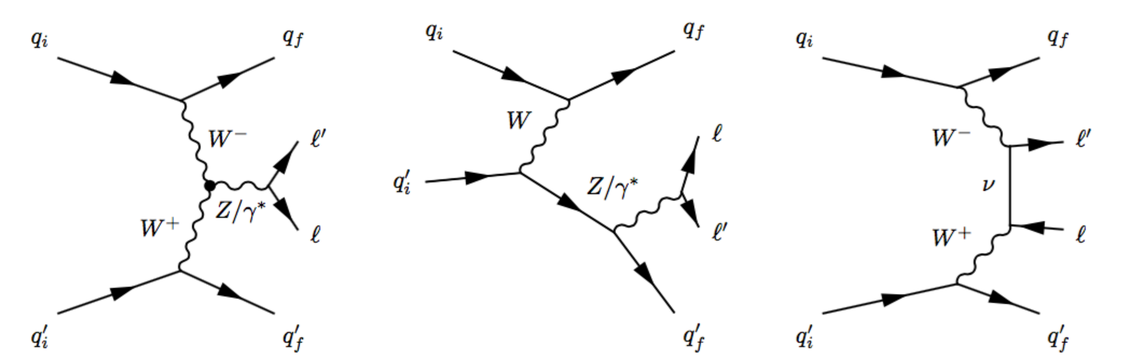
Introduction

- The pure electroweak production of the *lljj* final state in pp collisions at LHC includes production via VBF process, with a very distinct experimental signature of two energetic hadronic jets in the forward and backward regions.
- The study of the VBF production of the Z boson is an important benchmark to cross check and validate other VBF productions as Higgs bosons.
- Isolating a signal-pure sample of events allows to probe their additional hadronic activity. This can shed light on the modelling of additional parton radiation important for signal selection.
- Indirect search for new physics can be performed in this final state as the investigation of anomalous trilinear gauge couplings.

VBF Event Properties

Large negative interference between EW processes:



VBF ***bremsstrahlung*** ***multi-peripheral***

Analysis aims to select 'VBF-like' events:

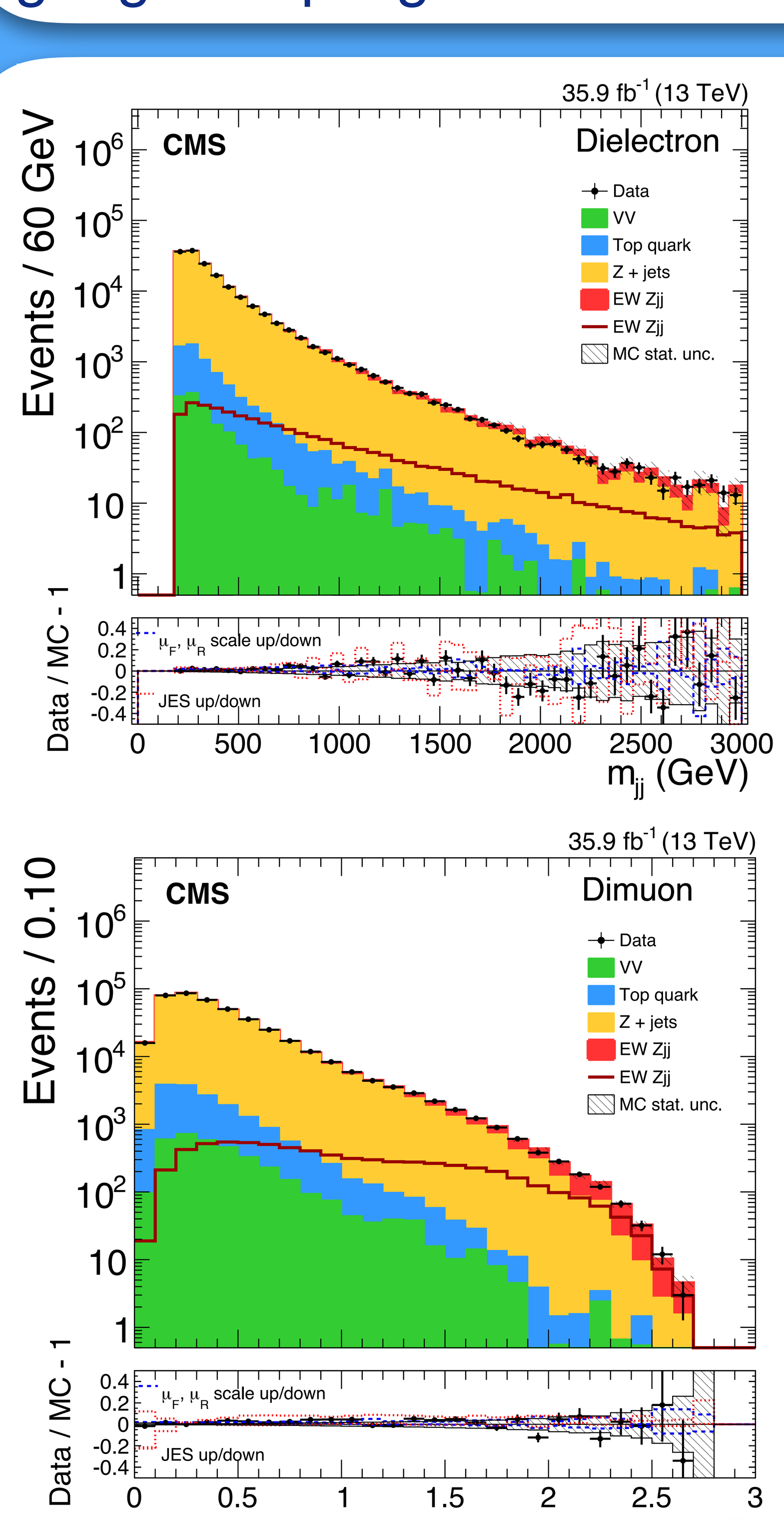
- Central leptonic Z decay associated with 2 energetic forward-backward light-quark jets
- Large $\Delta\eta$ separation between the jets and large invariant dijet mass M_{jj}
- Colour exchange suppression is also expected between the tagging quark jets

Analysis strategy

- Select EW Zjj events
- use MVA methods to discriminate S/B
- Extract the signal and BG x-sec
- Study hadronic activity in signal region
- Perform search for anomalous trilinear gauge couplings (ATGC)

Signal and Background simulation:

- **Signal** events are simulated at LO, MADGRAPH5_aMC@NLO
- Signal is defined in $p_T(j)>25$ GeV, $m(jj)>120$ GeV, $m(ll)>50$ GeV
- **Main DY BG** is simulated at NLO with ≤ 3 partons and at LO with ≤ 4 partons with MADGRAPH5_aMC@NLO
- Cross-section is normalized to NNLO computed with FEWZ
- **Interference** (EW Zjj &DY Zjj) simulated at LO MADGRAPH5_aMC@NLO



Signal extraction

Several discriminating variables are combined and used to train a MVA(**BDT**) to separate EW Zjj signal from DY BG. Discriminating variables make use of distinct topological characteristics of the signal. DY LO simulation is used to train the MVA while an independent NLO sample is used to extract the final results

- M_{jj} , $\Delta\eta_{jj}$
- $p_T(jj)$
- $z^*(Z)$, $R(p_T^{hard})$
- q/g discriminator

$$z^* = \frac{1}{\Delta y_{jj}}\left(y(Z) - \frac{y(j_1)+y(j_2)}{2}\right)$$

$$R(p_T^{hard}) = \frac{|\vec{p}_T(j_1)+\vec{p}_T(j_2)+\vec{p}_T(Z)|}{p_T(j_1)+p_T(j_2)+p_T(Z)}$$

Results

Binned maximum likelihood is used to fit the BDT shape and extract the signal strength. Interference between EW Zjj and DY Zjj is taken into account.

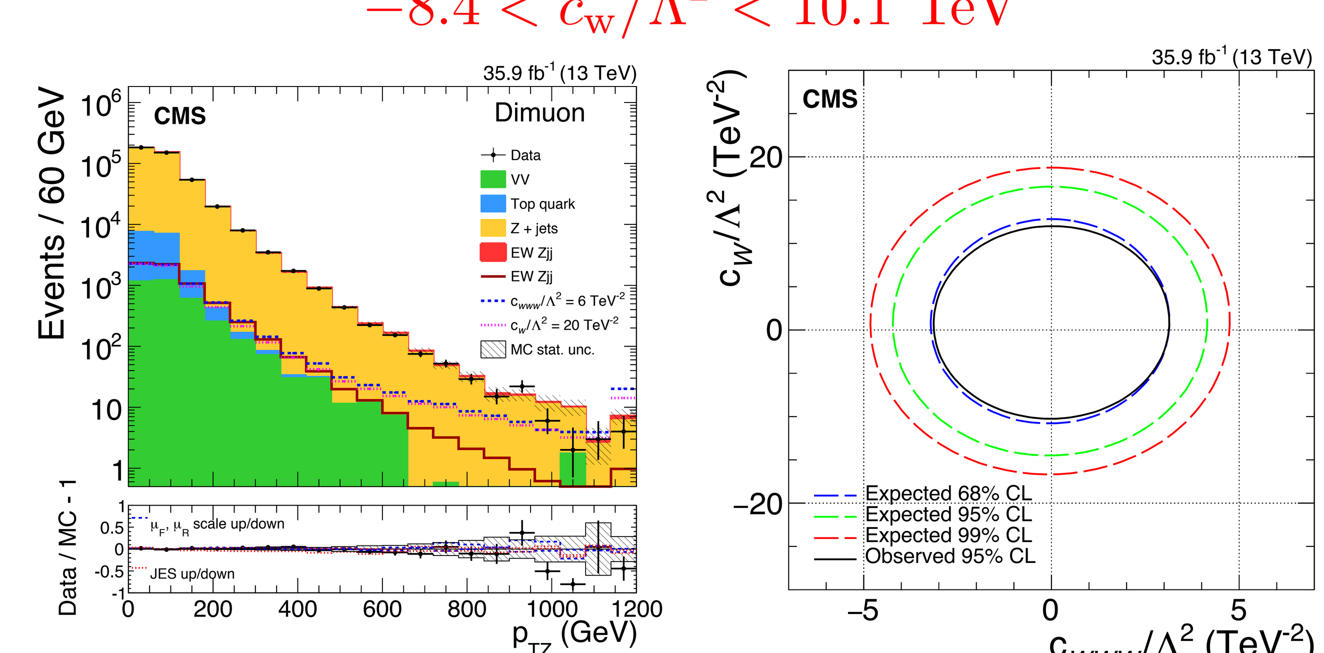
$\sigma(EW\ lljj) = 552 \pm 19(stat) \pm 55(syst) fb$ **10% precision**

$\sigma_{LO}(EW\ lljj) = 543^{+7}_{-9}(QCD\ scale)^{+22}_{-22}(PDF) fb$

Limits on ATGC parameters are set(EFT and effective Lagrangian parametrizations). **The most stringent constraints on c_{WWW} to date.**

@ 95% CL $-2.6 < c_{WWW}/\Lambda^2 < 2.6\ \mathrm{TeV}^{-2}$

$-8.4 < c_W/\Lambda^2 < 10.1\ \mathrm{TeV}^{-2}$

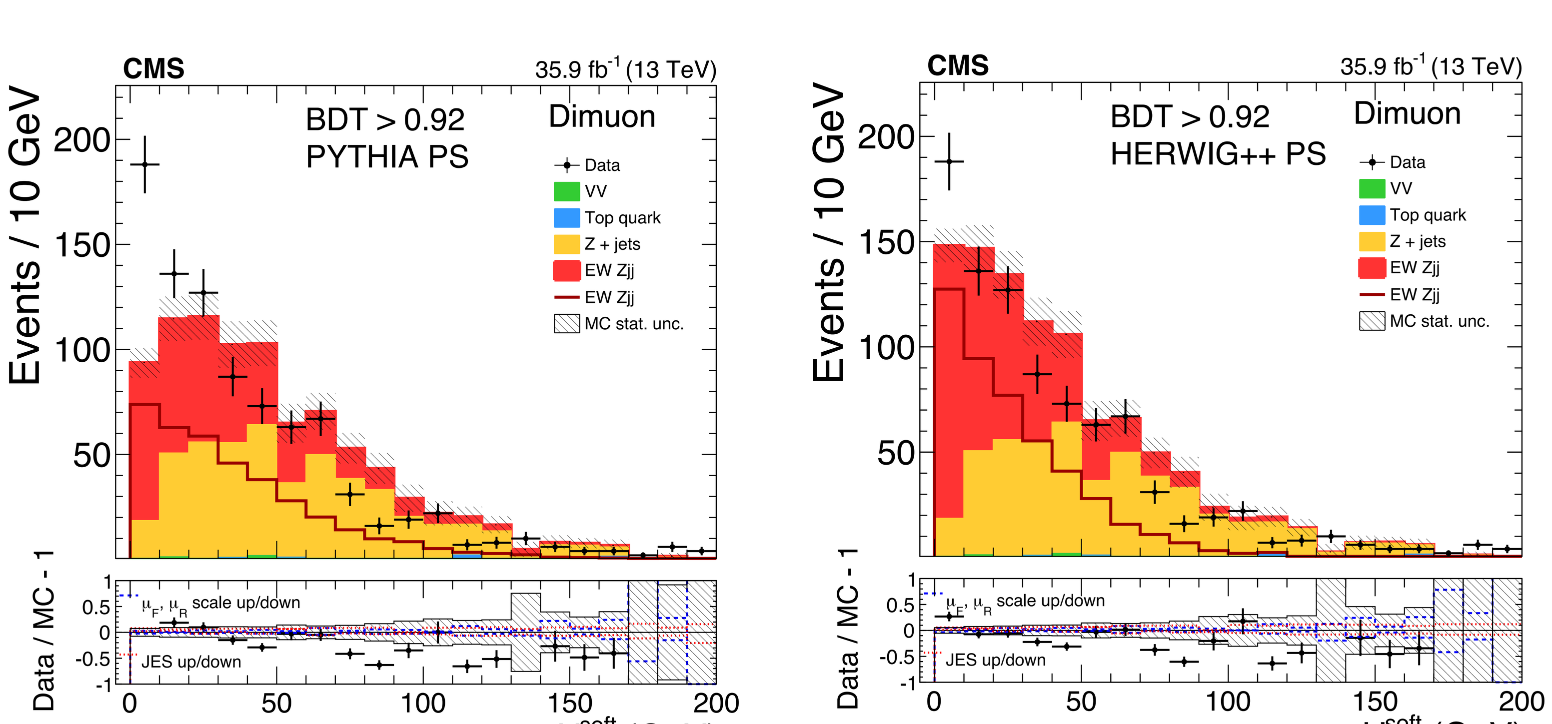


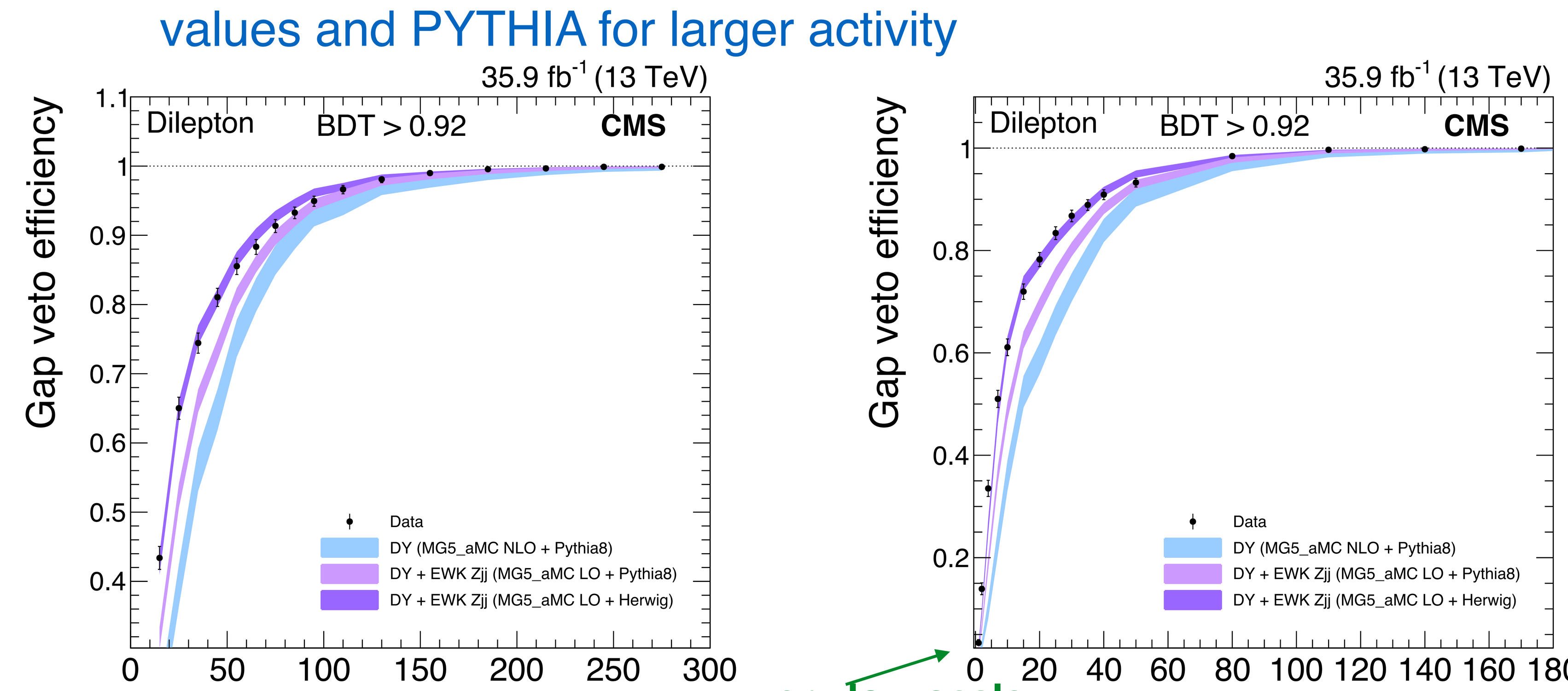
Hadronic activity

Significant suppression of hadronic activity is expected in rapidity gap due to signal pure EW origin

- Activity of jets with $p_T>15$ GeV and soft track-jets with $p_T>1$ GeV is studied
- Study efficiency of a gap activity veto(fraction of events with measured gap activity below some threshold) for different gap activity observables

- Good agreement is found between data and QCD predictions with either the PYTHIA or HERWIG++ PS models
- Data seem to prefer HERWIG+ PS model at low gap activity values and PYTHIA for larger activity





References

1. *Electroweak production of two jets in association with a Z boson in proton-proton collisions at √s = 13 TeV, CMS Collaboration,* ***CMS PAS SMP-16-018, arXiv:1712.09814****, submitted to* ***Eur. Phys. J. C***