Search for new VW diboson resonances in semileptonic final states at $\sqrt{s} = 13$ TeV

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Introduction

- **Search for massive resonances** decaying into a pair of vector (V) bosons, with V = W,Z boson, in the $\ell\nu q\bar{q}$ final state, where ℓ =e,μ.
- **Targets**: models which aim to explain open questions of the standard model (SM), e.g. integration of gravity using extra dimensions.
- These models usually predict the existence of heavy particles that decay to pairs of bosons.

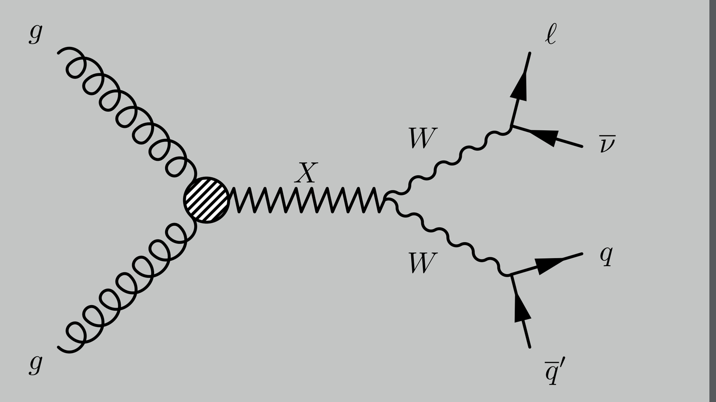

Figure 1: Feynman diagram for a X→VW process.

- **Examples**:
  - Spin-2 bulk scenario, Randall-Sundrum Warped Extra Dimensions model [2]
  - Composite heavy vector triplet (HVT) model [3], predicting spin-1 particles.

Data samples

- Analysis based on proton-proton collision data at $\sqrt{s} = 13$ TeV collected by the CMS experiment at the CERN Large Hadron Colllider during 2015.
- **Integrated luminosity: 2.2 fb^{-1}**.
- **Signal**: **X → VW → $\ell\nu q\bar{q}$, with X = Bulk graviton/W'**, in the mass range [**0.8** − **4.0**] TeV
- **Backgrounds**:
  - **W+jets** → dominant one, estimated from data
  - **$t\bar{t}$**, **single top**, **VW** → estimated from simulation.

Event reconstruction and analysis strategy

- **Reconstruction of the full event**, to search for a local excess in the diboson invariant mass spectrum.
- **Leptonically decaying W bosons** reconstructed by identifying isolated high-momentum leptons.
- **Measured missing transverse energy (E_T)** used to estimate the neutrino longitudinal momentum, by imposing the constraint $M_{\ell\nu} = M_W$.
- **High boosted regime**: quarks coming from the hadronically decaying vector boson very collimated, reconstructed as a single jet.
- **Information from jet substructure** used to identify these jets.
- Two main observables:
  - M_J: mass of the merged jet. Events split according their M_J value in:
    - **Signal region (SR)** [**65 − 105 GeV**]
    - **Sideband region (SB)** (**[40 − 65] and [135 − 150 GeV]**), for the estimation of the background.
  - M_{VW}: four-body invariant mass, used for the final limit computation.

Background estimation: normalization

- **Normalization of the W+jets background in the signal region determined from a fit to the M_J distribution** in the lower and upper sidebands of the observed data (Fig. 2).
- Analytical form of the fit function chosen from simulation studies.
- Contribution of the other backgrounds estimated from the simulation, **corrected with scale factors extracted from data in control regions**.

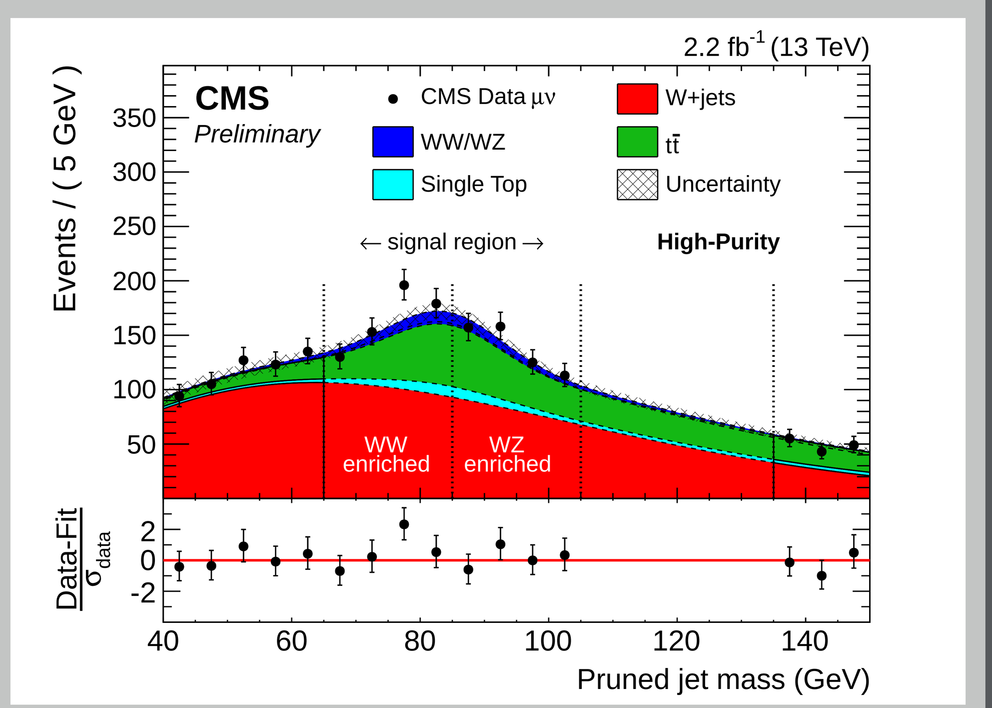

Figure 2: Distribution of the pruned jet mass M_J in the muon channel.

Background estimation: shape

- **Step 1**: extract $F^{W+jets}_{DATA,SB}(M_{VW})$, i.e. the W+jets M_{VW} distribution in the lower sideband region, from a fit on the observed M_{VW} distribution in data, correcting for the presence of minor backgrounds.
- **Step 2**: derive the transfer function $\alpha_{MC}(M_{VW})$ from W+jets simulation:

$$\alpha_{MC}(M_{VW}) = \frac{F^{W+jets}_{MC,SR}(M_{VW})}{F^{W+jets}_{MC,SB}(M_{VW})}, \quad (1)$$

$F(M_{VW})$ = probability density function used to describe the M_{VW} spectrum in the different regions.

- **Step 3**: extract shape of the M_{VW} distribution of the W+jets background in the signal region, by rescaling $F^{W+jets}_{DATA,SB}(M_{VW})$ by $\alpha_{MC}(M_{VW})$. Then add the minor backgrounds to the W+jets background to obtain the total SM prediction in the signal region (Fig. 3).

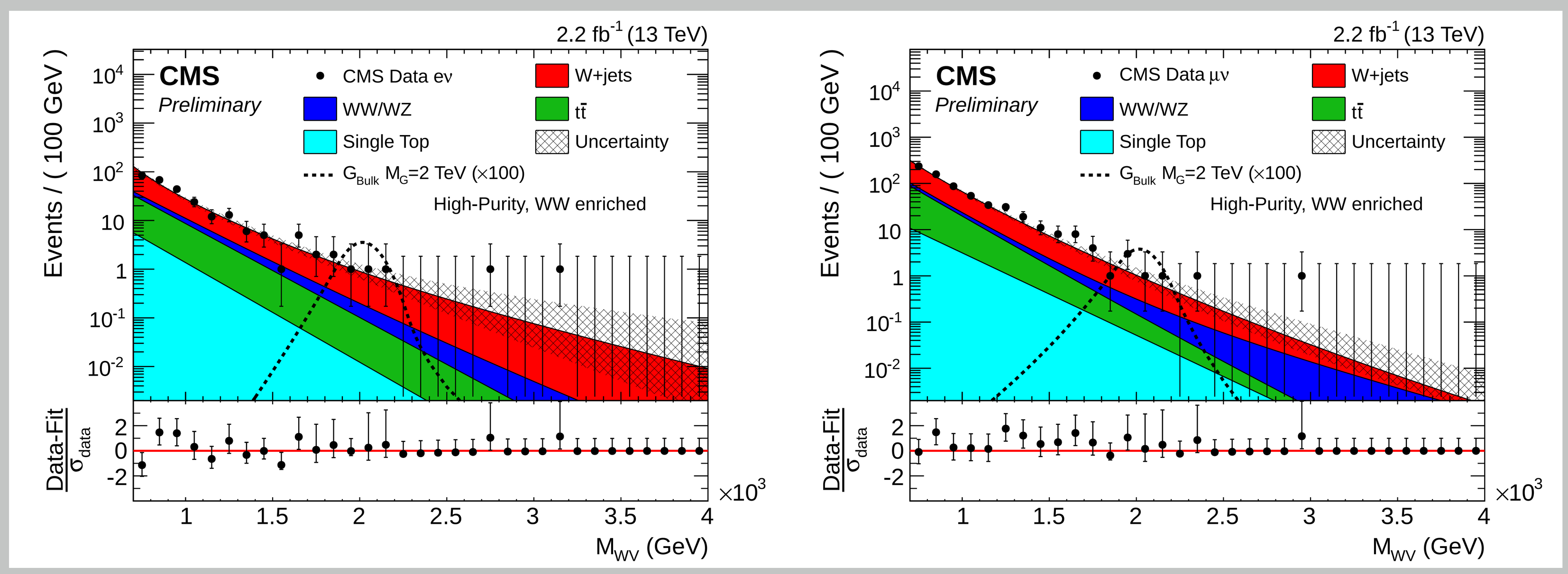

Figure 3: Examples of the final observed M_{VW} distributions in the signal region. Left: electron channel, right: muon channel.

Statistical interpretation

- Compare M_{VW} distribution observed in data with SM background prediction
- **Exclusion limits in the context of bulk graviton model and HVT model B scenario.** Combination with another channel (**X → VV**)
- Assumption: narrow-width approximation

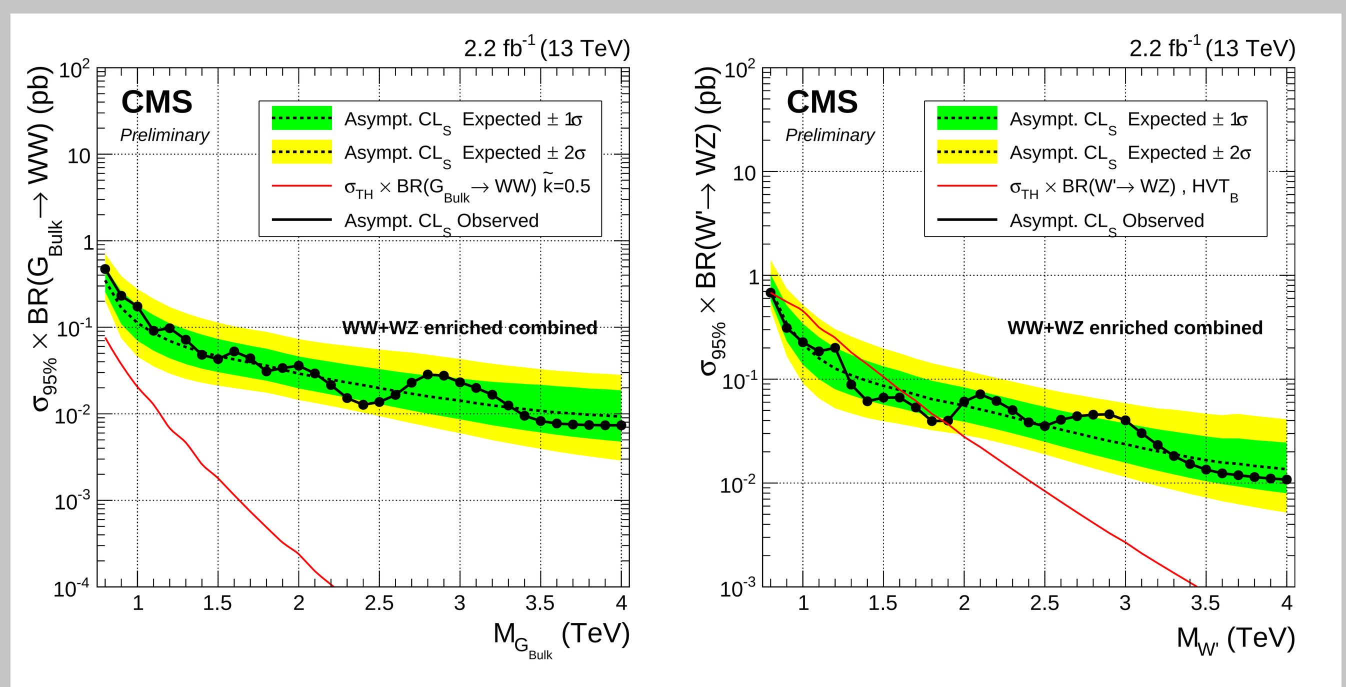

Figure 4: Left: Observed (black solid) and expected (black dashed) 95% CL upper limits on graviton production cross section × branching fraction of G→WW. Right: Observed (black solid) and expected (black dashed) 95% CL upper limits on HVT model B W' production cross section × branching fraction of W'→WZ.

Conclusion

- Search for new resonances decaying to WW or WZ
- **No evidence for a signal is found**
- Results interpreted as upper limit on the production cross section for bulk graviton and HVT models.

References

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