Measurements of EW production of a W boson in association with 2 jets

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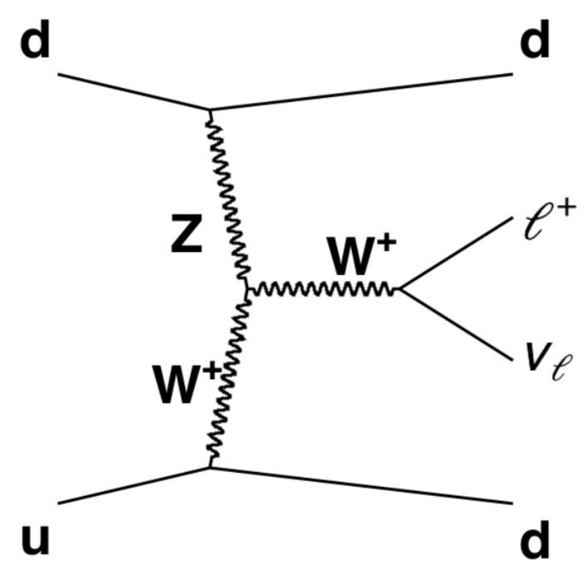
Previous analysis: SMP-17-011

What's VBF ?

- It occurs when a W and a Z (or γ), irradiated by the initial quarks, merge together. The poster focuses on a W in the final state, namely VBF - W.
- VBF - W is the most abundant VBF production: $\sigma_{VBF-W} \sim 10\sigma_{VBF-Z}$

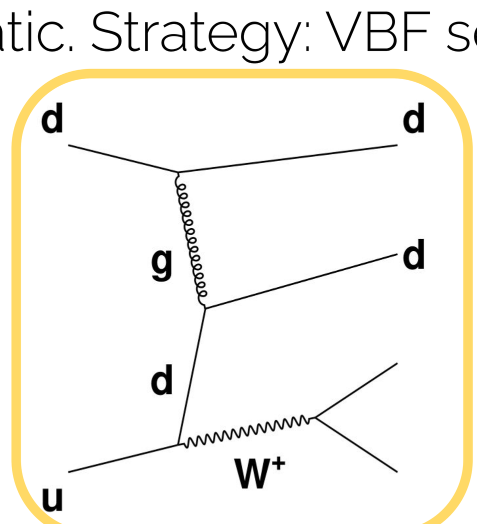


Why VBF - V?

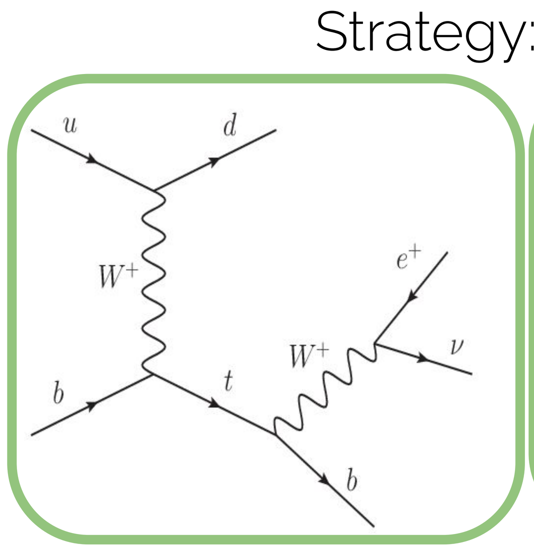
- Test of the SM gauge sector, **complementary** to Higgs boson measurements.
- Sensitive to new (BSM) physics: **aTGC, EFT**

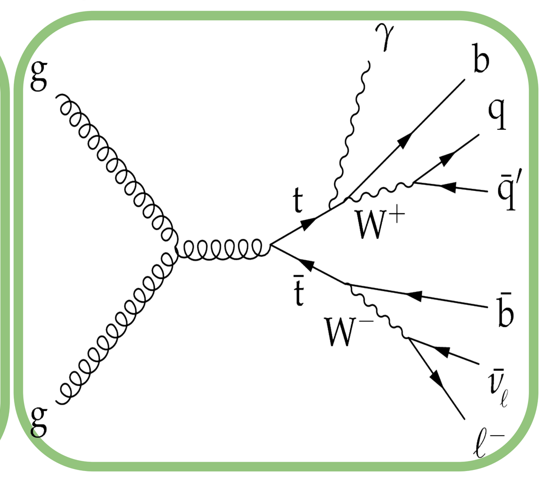
Main Backgrounds

W+Jets: Strong interaction between the initial state quarks. Same final state, but different kinematic. Strategy: VBF selections.

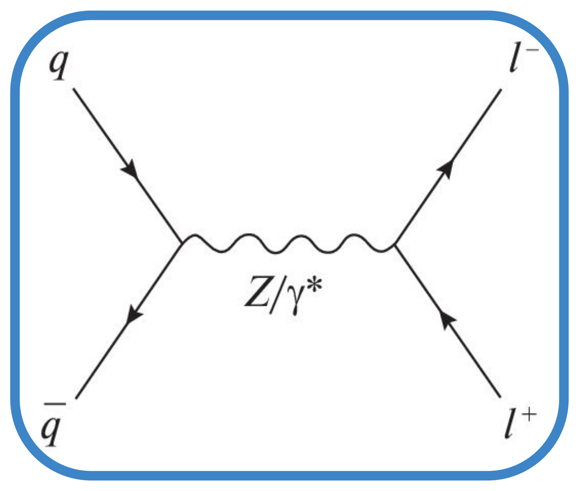


Single (double) top: Single: s & t- channel. Double: one W decaying leptonically. Strategy: b jets veto.

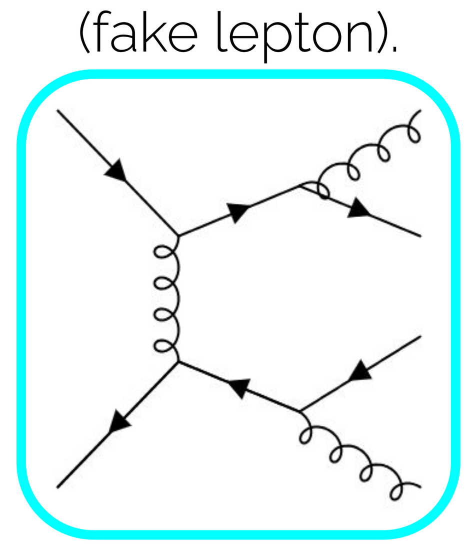




Drell-Yan: One lepton not reconstructed (or out the acceptance). Strategy: VBF selections.



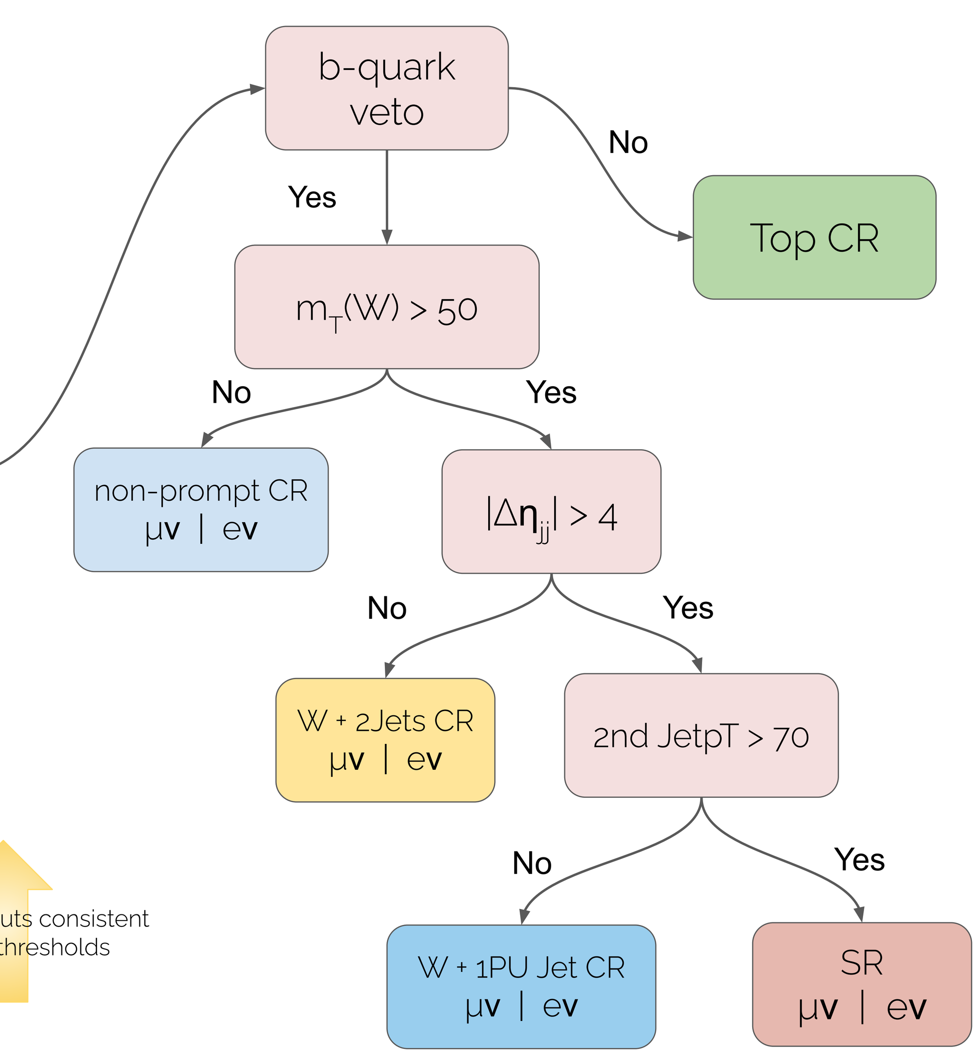
Non-prompt: Mainly multijet with 1 jet misidentified as lepton (fake lepton).



Analysis Strategy

Common preselections:
- $p_T^{l1} > 25$ GeV
- $|\eta_{l1}| < 2$
- $p_T^{l2} < 15$ GeV (veto)
- At least 2 jets with $p_T > 30$ GeV and $|\eta_j| < 4.7$
- $p_T^{j1} > 40$ GeV
- **$m_{jj} > 400$ GeV**
- **$|\Delta\eta_{jj}| > 2$**

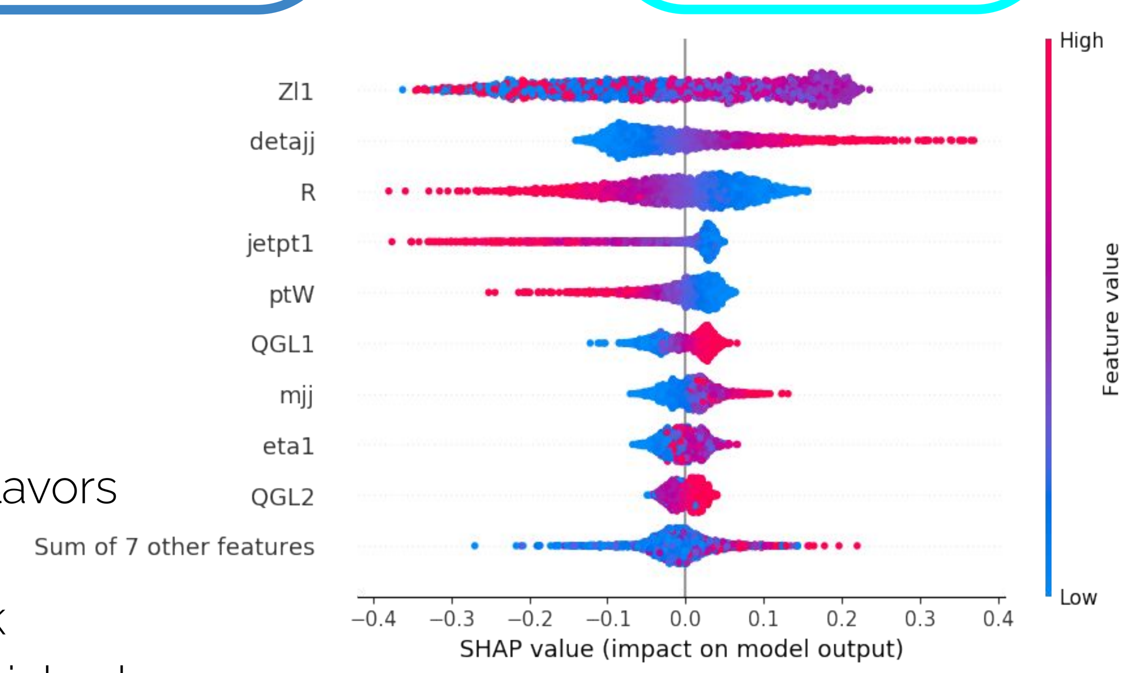
• Additional cuts consistent with HLT thresholds

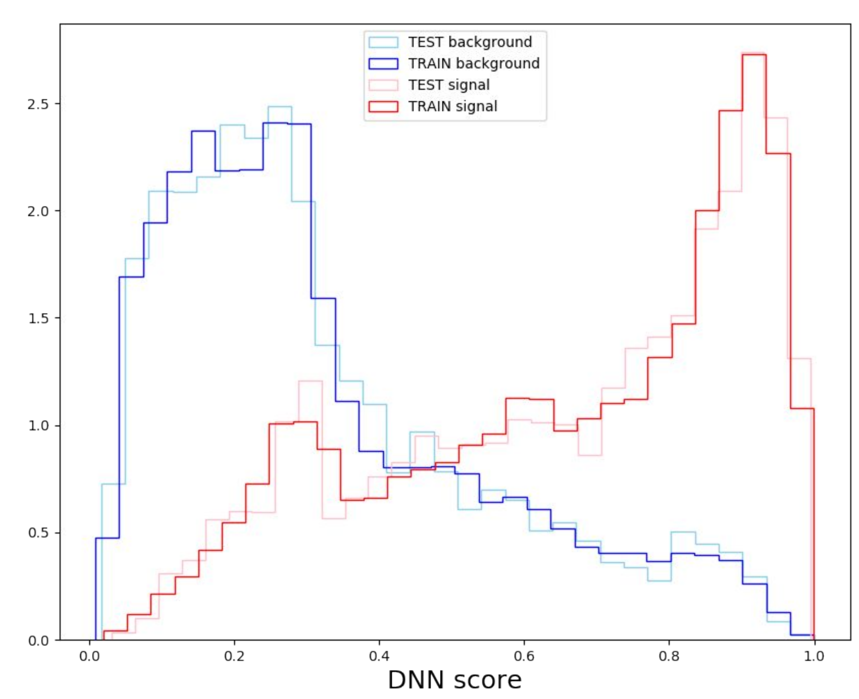


Deep Neural Network

To increase sensitivity (+15%) in SR:

- 1 unique model: implemented for both the lepton flavors
- Training samples: Dataset from SRs. 60k training, 20k splitted in test & validation. 24% enriched in signal
- Architecture: 3 hidden layers with (64,64,64) neurons
- Set of training variables: 10 physical-meaningful training variables





Signal extraction

$$\mathcal{L}(\vec{n} \mid \mu, \theta) = p(\theta) \cdot \prod_{i=1}^{N} Poisson(n_i \mid \mu \cdot s_i(\theta) + b_i(\theta))$$

Systematic uncertainties are treated as **nuisances**

(blind analysis) data = MC

- Combined binned maximum likelihood fit of the **DNN output** distribution in SR with signal and background templates
- Signal region: 10-bins DNN output distribution
- Top, W+2jets, W+1PU jet CRs are used as single-bin regions to constrain the normalization of their own processes

Effective Field Theory

- Basic idea is that SM is low-energy limit of a complete theory
- Up to an energy of Λ (≈ 1 TeV) it is possible to expand the SM Lagrangian:

$$\mathscr{L}_{EFTSM} = \mathscr{L}_{SM} + \frac{1}{\Lambda}\sum_i c_i Q_i^{(5)} + \frac{1}{\Lambda^2}\sum_i c_i Q_i^{(6)} + \mathcal{O}\left(\frac{1}{\Lambda^3}\right)$$

No L-conserving **(removed)**

Dimension-six terms:
c_i Wilson coefficients
Q_i gauge-invariant operators

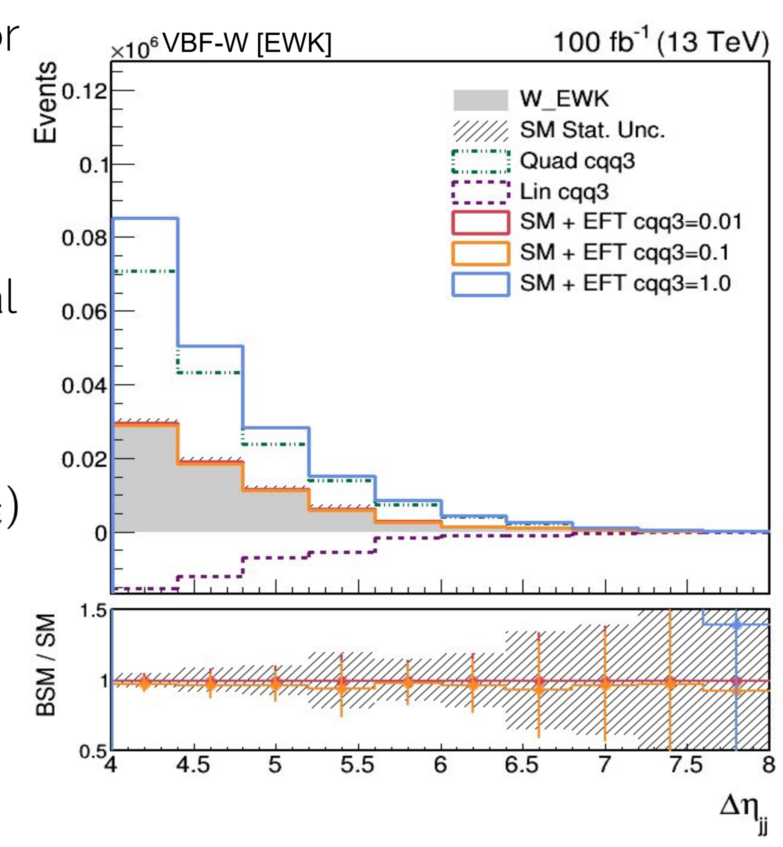
- Work in the "Warsaw Basis": 59 linearly independent operators L & B-conserving
- The main goal is to extract limits on the Wilson coefficient for each operator
- For the time being, the study is carried out only at parton level (no detector effect)

Likelihood inputs

- Showering, hadronization and detector effects are not taken into account
- Statistics and luminosity are the only uncertainties considered
- log likelihood ratio is used as statistical discriminator:

$$q(c_i) = -2\log\frac{\mathcal{L}(data \mid H_1(c_i))}{\mathcal{L}(data \mid H_0)} = -2\Delta\log\mathcal{L}(c_i)$$

- q = 1 → 68% CL (1σ)
- q = 3.84 → 95% CL (2σ)



Results

At most 2 Wilson Coefficients are free to float, all the others are set to their SM value

$$N \propto |\mathcal{A}_{EFTSM}|^2 = |\mathcal{A}_{SM}|^2 + \frac{1}{\Lambda^2}\sum_i 2c_i Re(\mathcal{A}_{SM}\mathcal{A}_i^*) + \frac{1}{\Lambda^4}\sum_i c_i^2|\mathcal{A}_i|^2 + \frac{1}{\Lambda^4}\sum_{i>j} c_i c_j Re(\mathcal{A}_i\mathcal{A}_j^*)$$

SM, Linear, Quad, Mixed