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# Non-interfering MC processes for CMS offshell $H \rightarrow ZZ$ analysis

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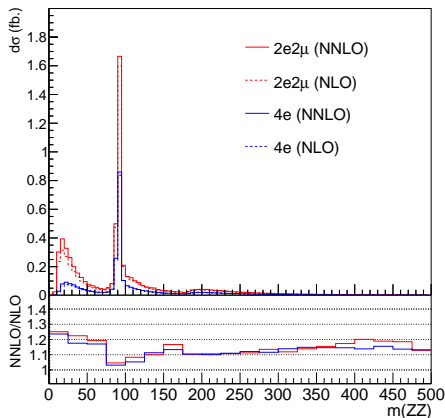
Nicolas Postiau, for the  $H \rightarrow ZZ$  groups

HXSWG Offshell Interpretations TH Uncertainties Meeting  
April 9, 2020

# List of MC processes for the CMS $H \rightarrow ZZ \rightarrow 2l2\nu/4l$ analyses, for the signal region

$q\bar{q} \rightarrow ZZ \rightarrow 2l2\nu, 4l$ ;  $q\bar{q}' \rightarrow W^\pm Z \rightarrow 3l\nu, 2l2q$ : POWHEG samples

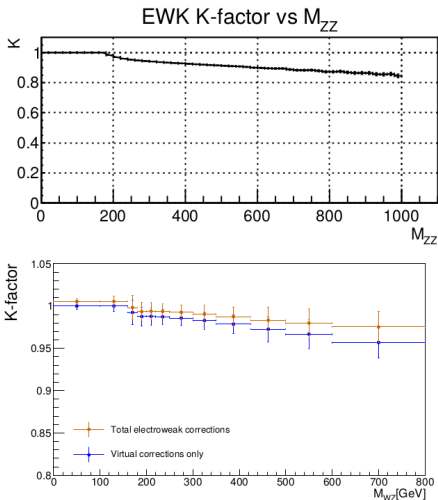
- Generated at NLO QCD.
- Apply NNLO QCD corrections for  $q\bar{q} \rightarrow ZZ$  (1507.06257).



# List of MC processes for the CMS $H \rightarrow ZZ \rightarrow 2\ell 2\nu/4\ell$ analyses, for the signal region

- For  $q\bar{q} \rightarrow ZZ$  and  $q\bar{q}' \rightarrow W^\pm Z$ : Apply **electroweak corrections**:
  - ▶ Virtual corrections for  $ZZ$  and  $WZ$  as function of kinematic variables  $\hat{s}$  and  $\hat{t}$ ; given by the authors of [1305.5402](#) and [1401.3964](#).
  - ▶ Photon-induced contribution for  $WZ$ , estimated using [LUXqed](#).
  - ▶ Uncertainty on virtual corrections (photon-induced uncertainty is negligible): account for the fact that we assume that EW and QCD corrections factorize. 2 separate cases based on the value of 
$$\rho \equiv \frac{\left| \sum_{i=1}^4 \vec{p}_T^i \right|}{\sum_{i=1}^4 |\vec{p}_T^i|} \quad (i \equiv \text{index of lepton from } VV \text{ decay}):$$
    - ★ If  $\rho < 0.3$ , uncertainty =  $\delta_{EW} \times \delta_{QCD,NLO}$ .
    - ★ If  $\rho \geq 0.3$ , take 100% of the EW corrections value ( $\delta_{EW}$ ).
    - ★ Very conservative; open to suggestions!
  - ▶ Recipe is the same as for the published analyses: [HIG-17-012](#) for high-mass search (in 3 channels combined) and [HIG-18-002](#) for width and off-shell cross section (in  $4\ell$ ).
  - ▶ See plots on next slide.

# Electroweak corrections plots



Top:  $ZZ$  electroweak corrections as function of (generated)  $m_{ZZ}$ .  
Bottom:  $WZ$  electroweak corrections.

# Additional background samples for the $H \rightarrow ZZ \rightarrow 2\ell 2\nu$ analysis

- $q\bar{q} \rightarrow ZZ \rightarrow 2\ell 2q$ : from aMC@NLO (minor contribution)
- MC processes contributing to the  $\gamma$  + jets control region (to estimate the DY background):
  - ▶  $Z\gamma \rightarrow 2\nu\gamma$ ,  $Z\gamma \rightarrow 2\ell\gamma$ ,  $W\gamma \rightarrow \ell\nu\gamma$ : aMC@NLO samples
    - ★ NLO samples, no additional corrections applied.
  - ▶  $W$  + jets: MadGraph LO sample + separate  $H_T$  binned samples at high  $H_T$  (apply MLM matching prescription, which avoids double counting)
    - ★ Rescaling to NNLO cross section.
  - ▶  $\gamma$  + jets,  $t\gamma$ ,  $tt\gamma$ , QCD: MC samples used only for reference.
- top (single top,  $t\bar{t}$ ,  $TTW$ ,  $TTZ$ ),  $WW$ ,  $W$  + jets, rare processes (triboson)  $\rightarrow$  MC samples used only for reference, estimation is data-driven (with  $e\mu$  selection). (See [HIG-17-012](#).)