SEARCH FOR A HIGH-MASS SCALAR IN THE $ZZ \to \ell^+\ell^-$+MISSING TRANSVERSE ENERGY FINAL STATE

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SEARCH FOR $H \to ZZ \to \ell^+\ell^-\nu\bar{\nu}$

Characteristics:

- High branching ratio: $BR(ZZ \to 2\ell 2\nu) \sim 6 \times BR(ZZ \to 4\ell)$
- Reduced background at high M_{ZZ}: better control than $ZZ \to 2\ell 2q$

Signal modelling is computed with interference with the SM Higgs for several mass points :

- $gg \to H$
- $qq \to H + 2jets$ (VBF)

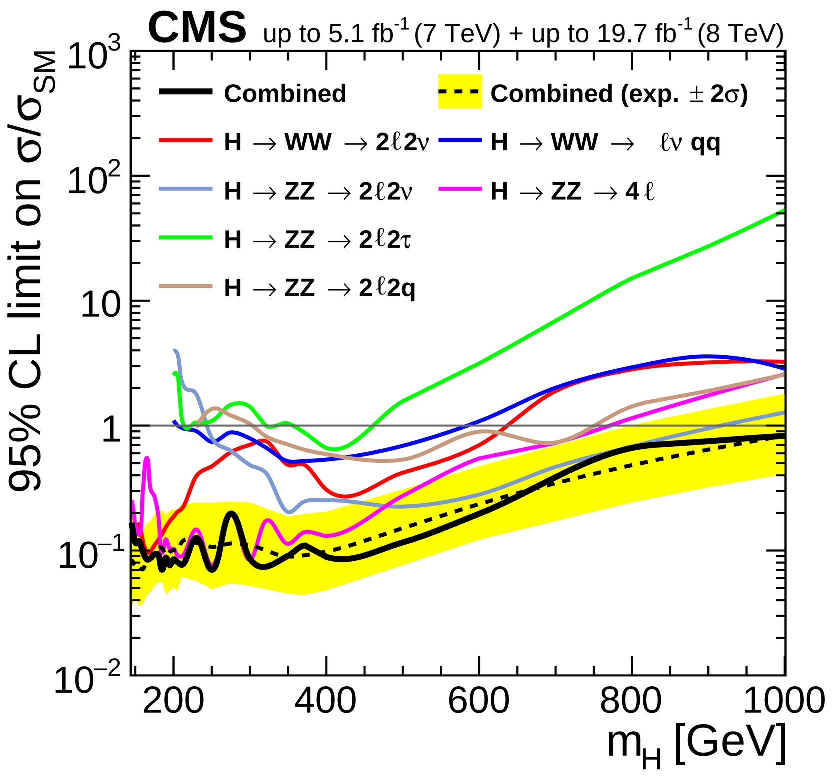
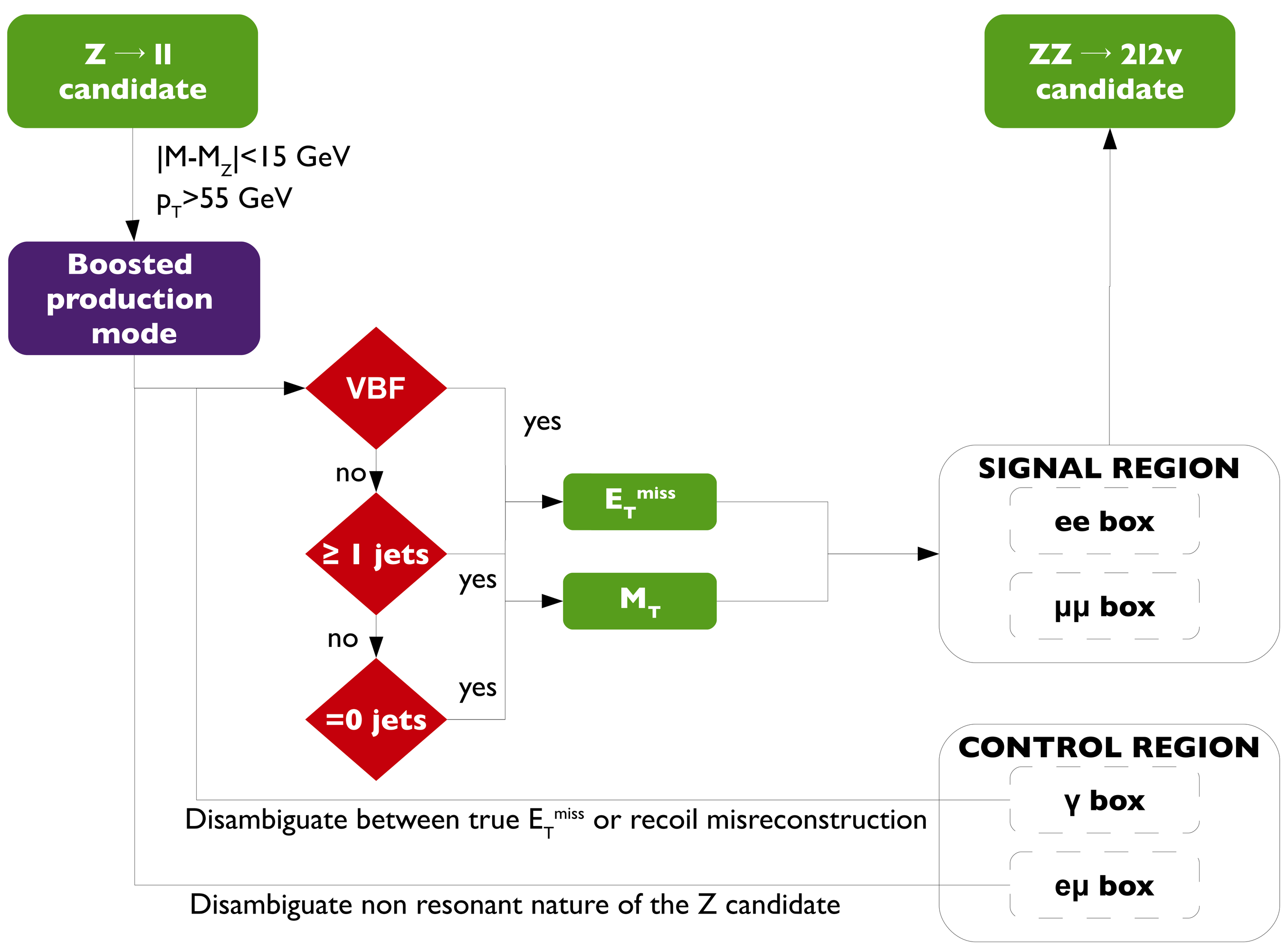


Figure 1: Limits on $H \to VV$ production from run 1 [1]

Search for a narrow resonance in two types of interpretations:

- Extra Singlet Model
- 2 Higgs Doublet Model

EVENT SELECTION



Pre-selection:

- di-lepton trigger
- $\geq 2e$ or $\geq 2\mu$
  - $p_T > 25\,$GeV
  - $|\eta| < 2.5(e)/2.4(\mu)$
  - tight ID
  - tight Iso
  - $|M_{\ell\ell} - 91| < 15\,$GeV
- $p_T^Z > 55\,$GeV
- 3^{rd} lepton veto
- b-tag veto
- $\Delta\phi_{j,\mathrm{MET}} > 0.5$ for $p_T^j > 30\,$GeV

DRELL-YAN BACKGROUND ESTIMATION

We use data driven method to estimate this background. This allows us to take into account the fake MET due to the misreconstruction of jets in Drell-Yan events and to check/correct the simulation. Therefore, we need a process with:

- independent events
- with more statistics

We take $\gamma + jets$ events. To that extend dedicated photon triggers have been set.

An important point of this process is the reweighting of the p_T^γ to match the p_T^Z.

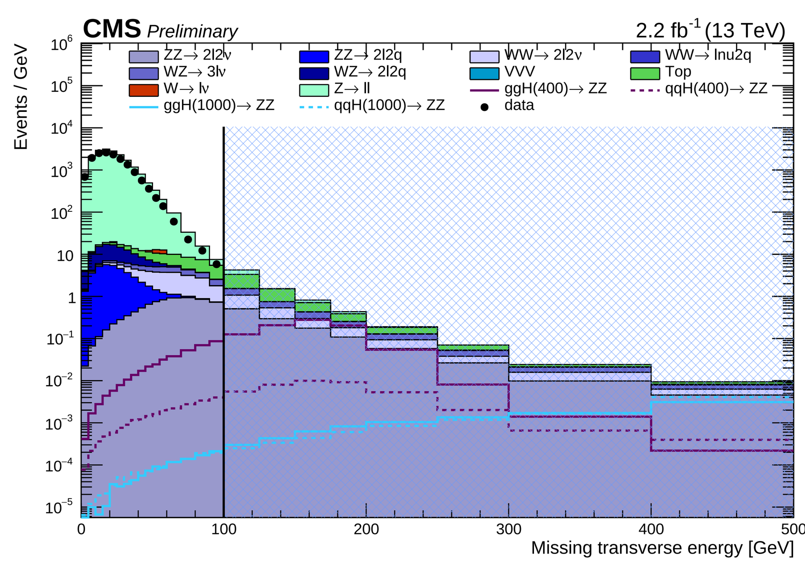


Figure 2: Missing transverse energy. Here the DY background is obtained using only MC prediction [2]

DATA-DRIVEN BACKGROUND ESTIMATION

The non-resonnant di-lepton background is also estimate using data-driven methods, using the $e\mu$ final state.

$$N_{\mu\mu} = \alpha_\mu \times N_{e\mu}, \qquad N_{ee} = \alpha_e \times N_{e\mu}$$

$$\text{with} \quad \alpha_\mu = \frac{N_{\mu\mu}^{SB}}{N_{e\mu}^{SB}}, \qquad \alpha_e = \frac{N_{ee}^{SB}}{N_{e\mu}^{SB}}$$

The N^{SB} are the number of events in a top-enriched sample of e^+e^-, $\mu^+\mu^-$ and $e^\pm\mu^\pm$ where we asked $E_T^{\mathrm{miss}} > 70\,$GeV and b-tagged events.

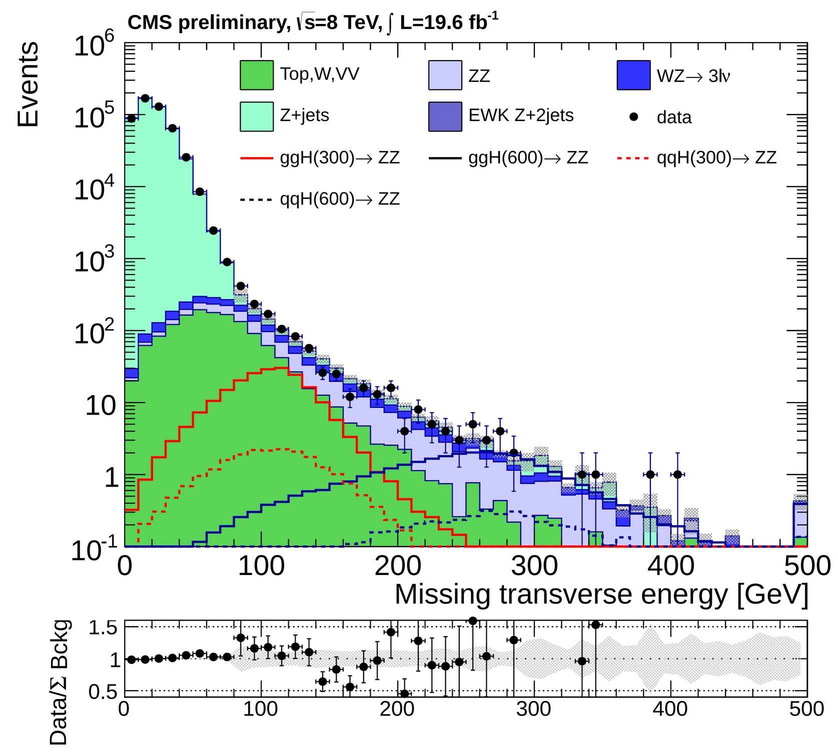


Figure 3: Missing transverse energy with data-driven estimation of the DY background [1]

PRECISE MODELING OF THE ZZ BACKGROUND

The ZZ represents our most important irreducible background. Therefore, precise modelling is done:

- $qq \to ZZ$:
  - NLO electroweak corrections as a function of Mandelstam variables and quark flavors
  - NNLO QCD corrections as a function of M_{ZZ}
- $gg \to ZZ$:
  - NNLO/LO k-Factor as a function of M_{ZZ}

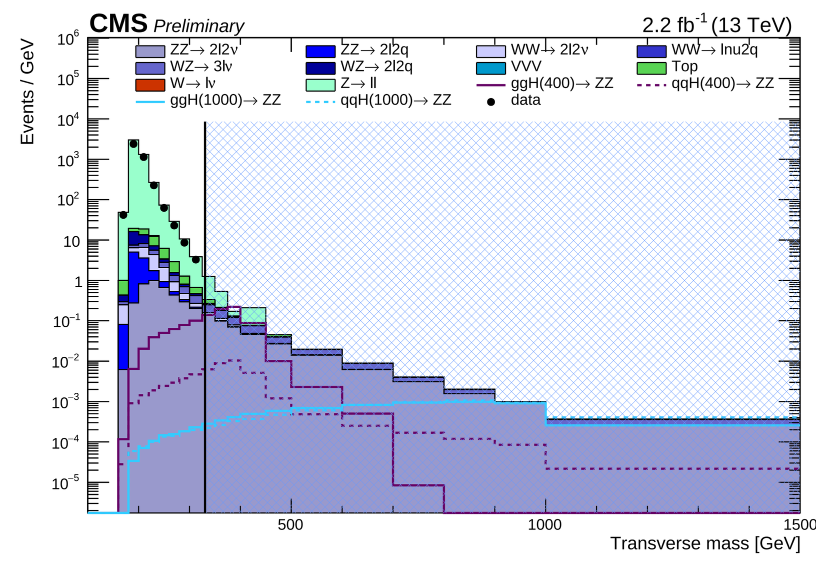


Figure 4: Transverse Mass after event selection [2]

RESULTS AND PROSPECTS

Our first results at 13 TeV are going for approval for Moriond!

As shown on Figure 5, we expect an increase of a factor 5 of the production cross section $pp \to H + X$ in comparison to run 1, at $M_H \sim 1\,TeV$.

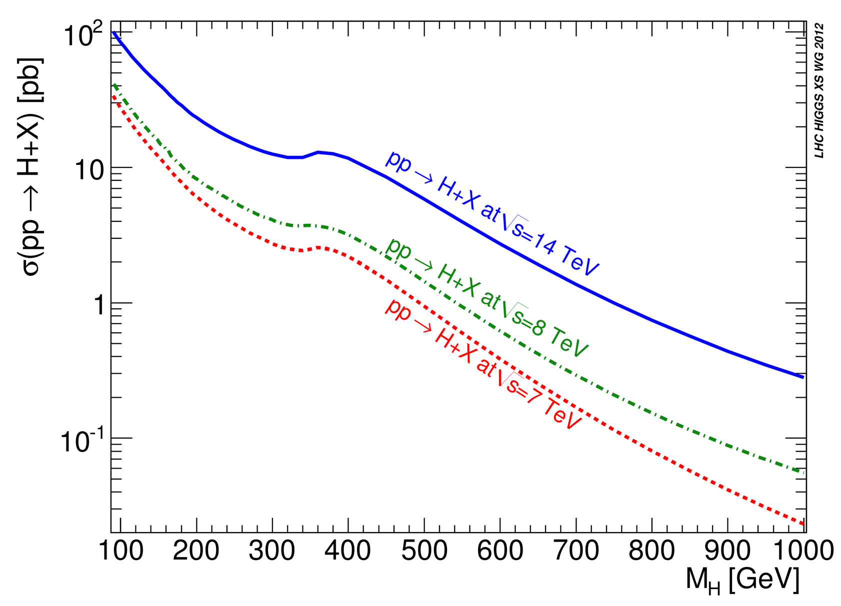


Figure 5: Transverse Mass after event selection [3]

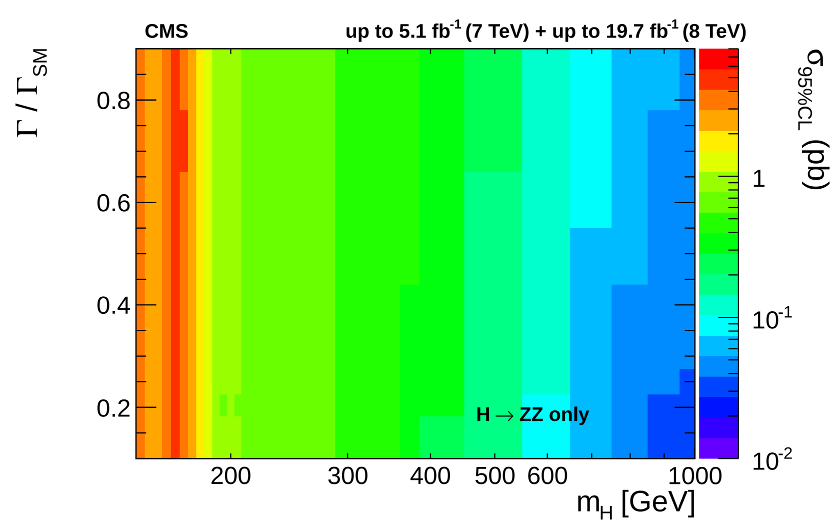


Figure 6: Upper limits at 95% CL on the cross section from run 1, combining all (semi-)leptonic decays of ZZ channel [1].

Figure 6 shows the run 1 upper limits at 95% CL on the cross section for a heavy Higgs boson decaying to a pair of Z bosons as a function of its mass and its width relative to a SM-like Higgs boson. Several interpretations will be considered. In particular, we will look at a simple Extra Singlet Model (like in run 1) and will also introduce 2 Higgs Doublet Models.

REFERENCES

[1] CMS collaboration. Search for a Higgs Boson in the Mass Range from 145 to 1000 GeV Decaying to a Pair of W or Z Bosons. *JHEP*, 10:144, 2015.

[2] *https://twiki.cern.ch/twiki/bin/view/CMS/HiggsZZ2l2nu2015*, 2015.

[3] *https://twiki.cern.ch/twiki/bin/view/LHCPhysics/LHCHXSWG*, 2015.