Search for low mass Higgs in CMS

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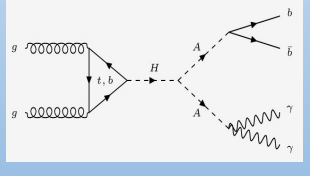
Motivation behind our analysis

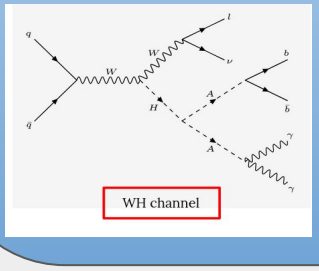
- **N**ext-to-**M**inimal **S**upersymmetric **S**tandard **M**odel **(NMSSM)** ⇨ an extension of MSSM with an additional Higgs singlet
- Two Higgs doublet (H_u, H_d) + A Higgs singlet (S)
- **Total 7 Higgs** ⇨ CP even H_1, H_2, H_3; CP odd A_1, A_2, & charged Higgs $H^{\pm}$
- Among the CP even Higgs, either H_1 or H_2 can be SM like. If H_2 is SM like, H_1 can be lighter than H_2
- The lightest CP odd A_1 can be also lighter than H_2 in a certain region of parameter space
- So, the mass of H_1 and A_1 (non-SM like) can be lighter than H_2 (SM like). These are basically the "**light**" Higgs. Both H_1 and A_1 are dominantly singlet like.
- As said earlier, non-SM like Higgs (A_1) can be singlet dominated.
- It has very suppressed coupling with SM particles (fermions & gauge bosons).
- So, along with dominant bb decay mode, $A_1 \rightarrow \gamma\gamma$ branching ratio (BR) can be also very large (10-80 %) for a certain parameter space. [M.Guchait, Jacky Kumar 1608.05693]
- **Our analysis channel: $H \rightarrow AA \rightarrow bb\gamma\gamma$** (20 GeV < M_A < 60 GeV).

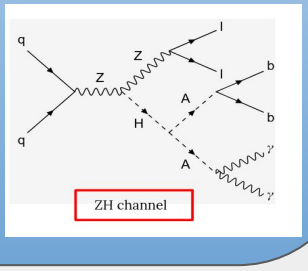
Run-II analysis with VH (V=W/Z) channel

- Targeting **ggH channel** ⇨ quite challenging in Run-II
- Currently used diphoton trigger: **HLT_Diphoton30_18_R9IdL_AND_HE_AND_IsoCaloId_NoPixelVeto_Mass55**
- **Not very useful for our study**
- New HLT paths proposed: **HLT_Diphoton[18_12, 20_14]_eta1p5 with no invariant mass cut**



For Run-II ⇨ VH (V=W/Z) channel using leptonic trigger





Analysis strategy

WH channel

W → eν, EGamma (UL 2018)
W → μν, Single Muon (UL 2018)

Dominant bkg ⇨

Sample	X-sec (pb)
TTGJets	4.078
DYJetsToLL	5343
TTTo2L2Nu	88.29
TTToSemiLeptonic	365.34

Event Selection ⇨

- HLT-Ele32 trigger
- HLT-IsoMu24 trigger

- Only 1 e or μ
- At least 2 b-jets passing DeepJet Med WP
- At least 2 γ
- ΔR (l,γ) > 0.4

* Events are vetoed with additional leptons with loose-id to make analysis orthogonal with ZH

ZH channel

Z → ee, EGamma (UL 2018)
Z → μμ, Double Muon (UL 2018)

Dominant bkg ⇨

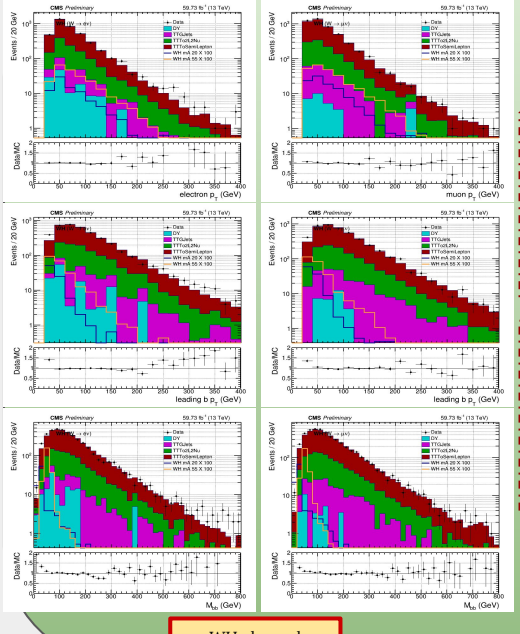
Sample	X-sec (pb)
TTGJets	4.078
DYJetsToLL	5343
TTTo2L2Nu	88.29
TTToSemiLeptonic	365.34

Event Selection ⇨

- HLT-Ele23_Ele12 trigger
- HLT-Mu17_Mu8 trigger

- At least 2 e or μ
- At least 2 b-jets passing DeepJet Med WP
- At least 2 γ
- ΔR (l,γ) > 0.4

Data-MC comparison



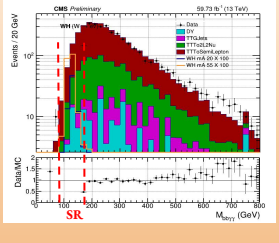
Factors considered:

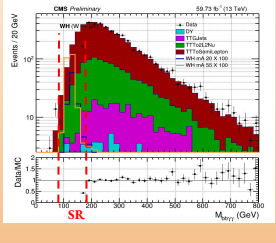
- ★ JEC
- ★ JER
- ★ Trigger SF
- ★ b-tagging SF
- ★ Photon ID
- ★ PU ID
- ★ Lepton ID

➢ **Bkg normalized by:** Cross section x Lumi (2018)
➢ **Signal normalized by:** Cross section (WH) x Br(W→eν)/Br(W→μν) x Lumi (2018)

WH channel

Choice of signal region (SR) & control region (CR)





➢ Preferred choice of signal region (SR), **80 < $m_{bb\gamma\gamma}$ < 170 GeV** reduces significant amount of background without loosing signal contribution.
➢ Choice is based on significance and purity study.
➢ Primary selection of CR (orthogonal to SR): **$m_{bb\gamma\gamma}$ < 80 GeV or $m_{bb\gamma\gamma}$ > 170 GeV.**

Current status & future plans

- WH & ZH channel are being studied, overall good Data-MC agreement found.
- SR has been chosen based on **80 < $m_{bb\gamma\gamma}$ < 170 GeV.**
- Primary CR has been chosen which is **orthogonal to SR.**
- Now we are concentrating on the bkg estimation.
- We are also planning to perform the analysis in MVA method.
- We are merging 2016 & 2017 with 2018, full Run-II analysis is ongoing.