Progress Report (May-August, 2022)

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HIG-20-002: Search for additional Higgs Boson in the di-photon final state at CMS (HIG-20-002) with 2016 legacy, 2017, 2018 and Full Run2 combination

- Pre-approved and got green light for re-unblinding for 2017, 2018 and 2017+2018 combination
  - Many check have been performed after the pre-approval and un-blinding talk
  - Later on the analysis was blinded again to update the strategy in order the suppress the relic DY events
  - A series of extensive checks were performed in the past few months leading towards the finalization of strategy for the suppression of relic DY events
  - The final strategy was then presented by "Junquan" in the HIG PAG meeting on (21.06.2022) which was approved by the conveners and gave the GL for re-unblinding

Available on the CMS information server

CMS AN-18-249

CMS Draft Analysis Note

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Search for low mass resonances in the diphoton final state in pp collisions at $\sqrt{s}$ =13 TeV with the 2017 and 2018 dataset

S. Bhattacharya[3], C. Camen[2], E. Chapon[1], G. Chen[1], L. Finco[4], S. Gascon-Shotkin[2], A. Lesauvage[2], M. Lethuillier[2], K. Mondal[3], A. Purohit[3], P. K. Rout[3], A. Syx[2], M. A. Shahzad[1], J. Tao[1], C. Wang[1], J. Wang[1], and S. Zhang[1]

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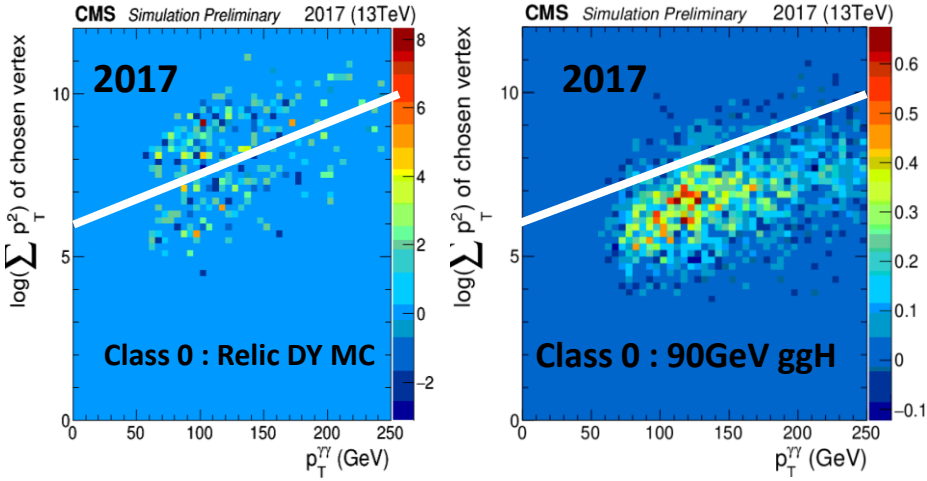
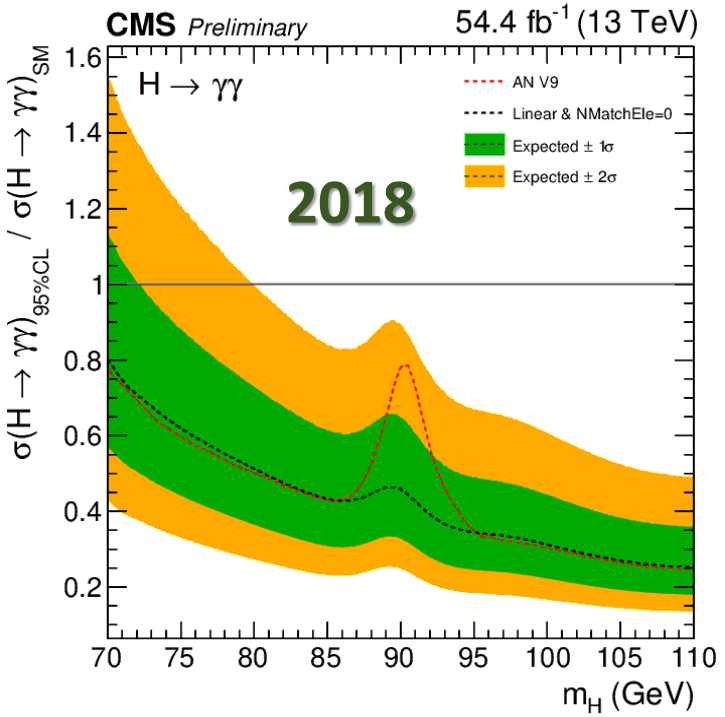
Status of HIG-20-002

➢ Following checks were performed with 2017, 2018 data:

- ➢ $\log(\Sigma pT^2)$ of MVA chosen vertex can be used to suppress the relic DY events
- ➢ Performed studies with a straight cut on $\log(\Sigma pT^2)$
  - **$\log(\Sigma pT^2)$<=7** can kill ~**75% of relic DY** (MC) events but also kill ~50% of the signal events in event class 0 for both 2017 (3untag+1VBF) and 2018 (3Untag), and kill ~**70% of 90GeV signal events with diphoton BDT>0.9** in 2017 (3untag+1VBF)
  - With **$\log(\Sigma pT^2)$<=7**, the expected sensitivity **decreased by ~20%** (except "Z-peak" regions) in 2017 (3Untag+1VBF) and also in 2018 (3Untag)



- ➢ Performed studies with cut on $\log(\Sigma pT^2)$ as a function of diphoton P_T: $\log(\Sigma pT^2) <= 0.016*pT^{\gamma\gamma} + 6.0$, in 2017 with (3Untag+1VBF)
  - Can keep **~95% signal events** in each event class, while kill ~54% DY events in class 0

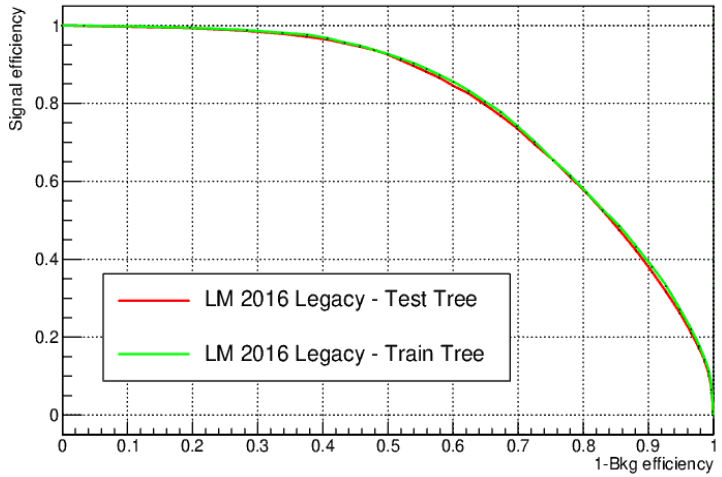


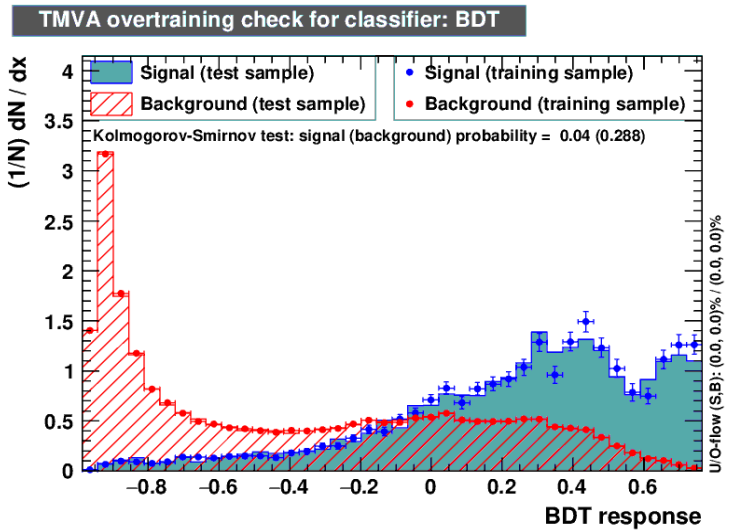
- ➢ **Finalized strategy:** $\log(\Sigma pT^2)$ as a function of diphoton **P_T: $\log(\Sigma pT^2) <= 0.016*pT^{\gamma\gamma} + 6.0$** along with an additional cut **NMacthedEle=0** (for all the three years)

Status of HIG-20-002

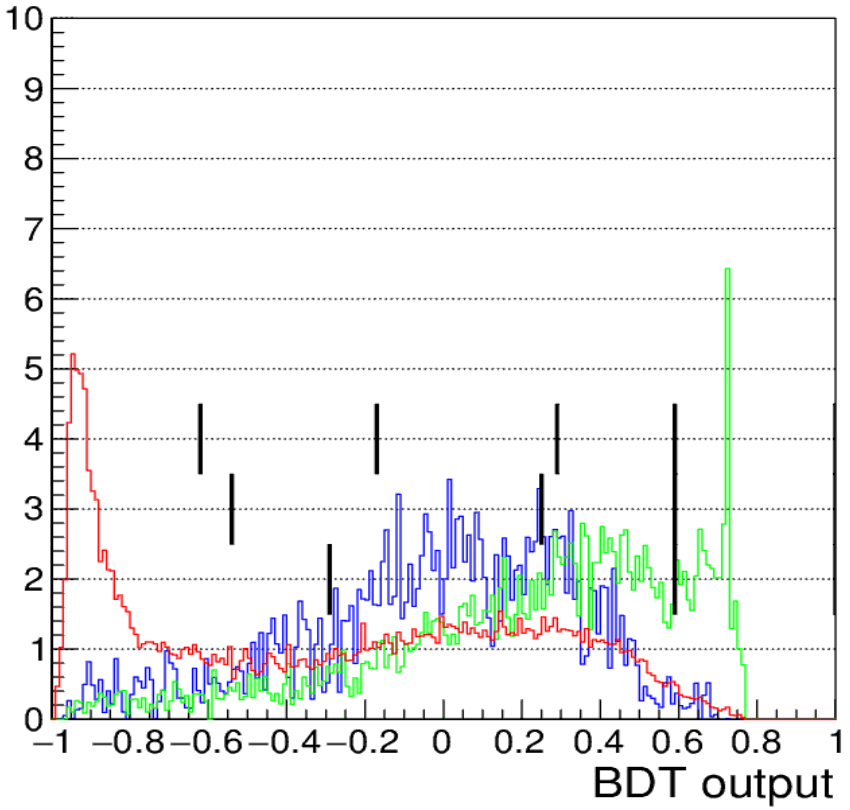
- ✓ 2016 Legacy: The analysis is ongoing with the finalized DY suppression strategy
  - ✓ Retrained diphoton BDT
  - ✓ Redone boundary optimization

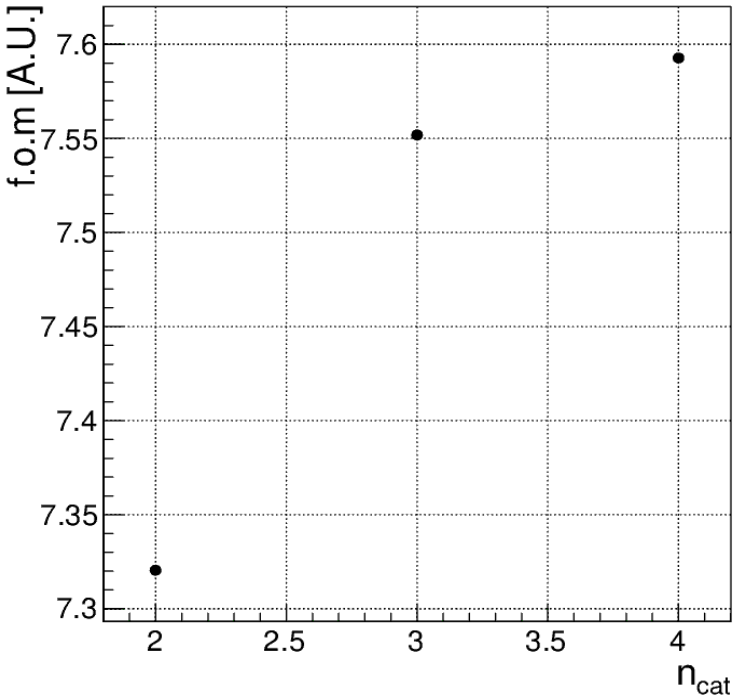
Training Samples = 50 %, Test Samples = 50 %





Signal and Bkg. distribution of LM BDT score





ncat: 2
max: -7.32048
boundaries: 1 0.591 -0.288

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ncat: 3
max: -7.55186
boundaries: 1 0.593 0.246 -0.538

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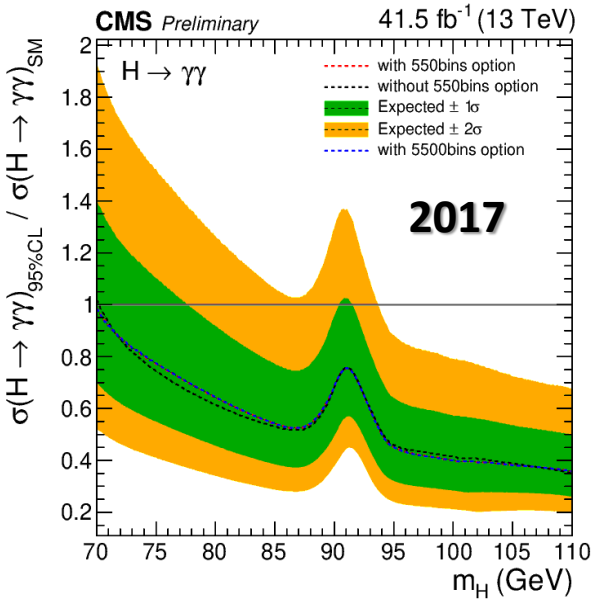
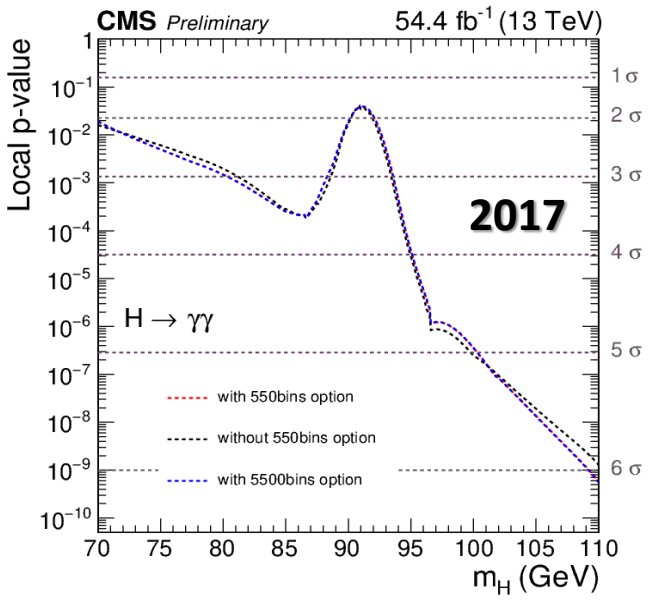
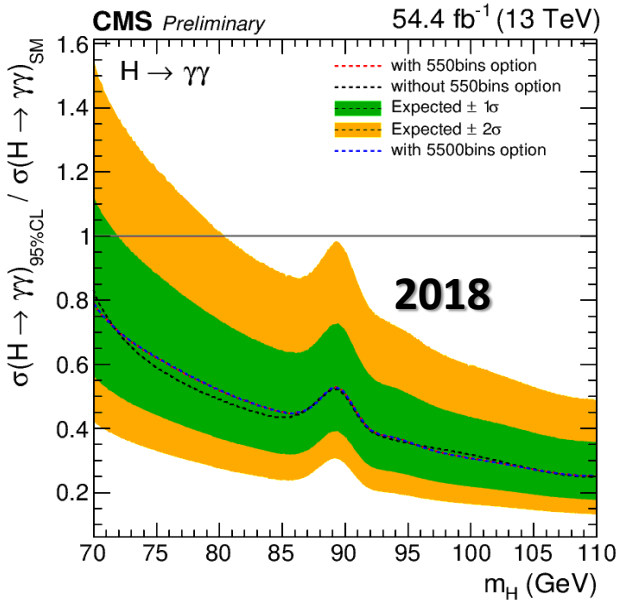
ncat: 4
max: -7.59275
boundaries: 1 0.594 0.286 -0.168 -0.616

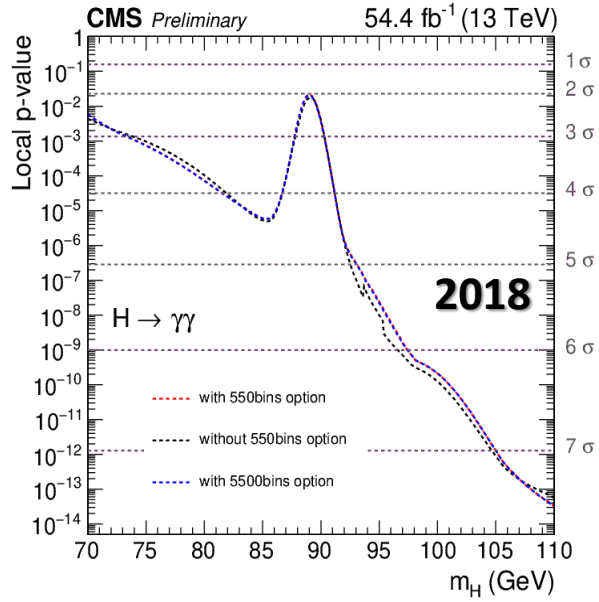
Boundaries of 3 cats: [-0.538, 0.246, 0.593, 1.0]

Status of HIG-20-002

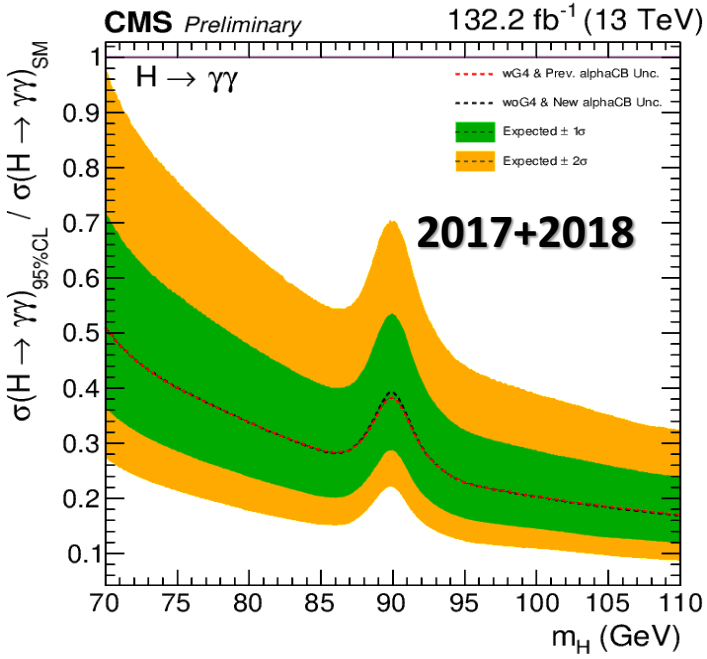


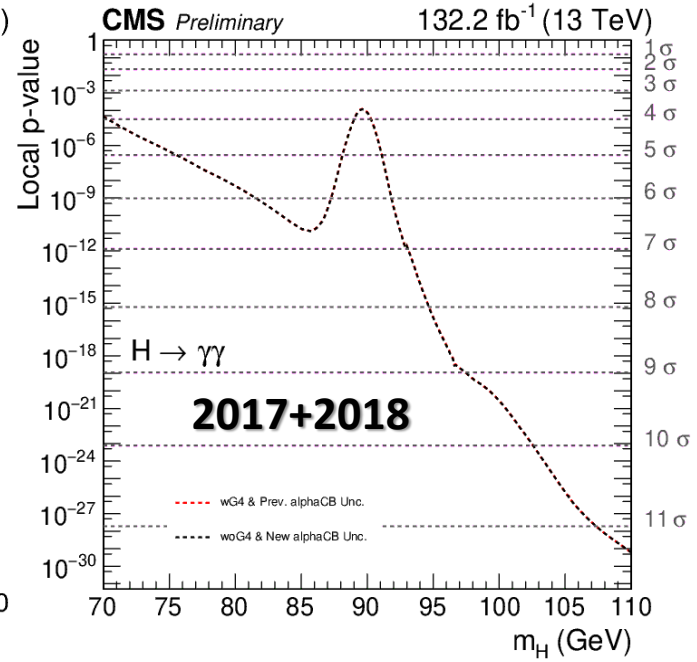




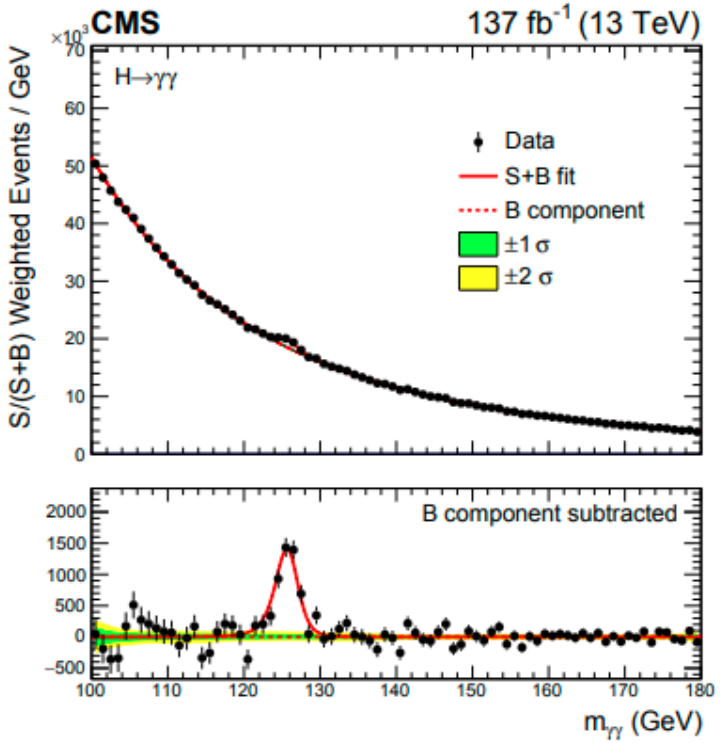


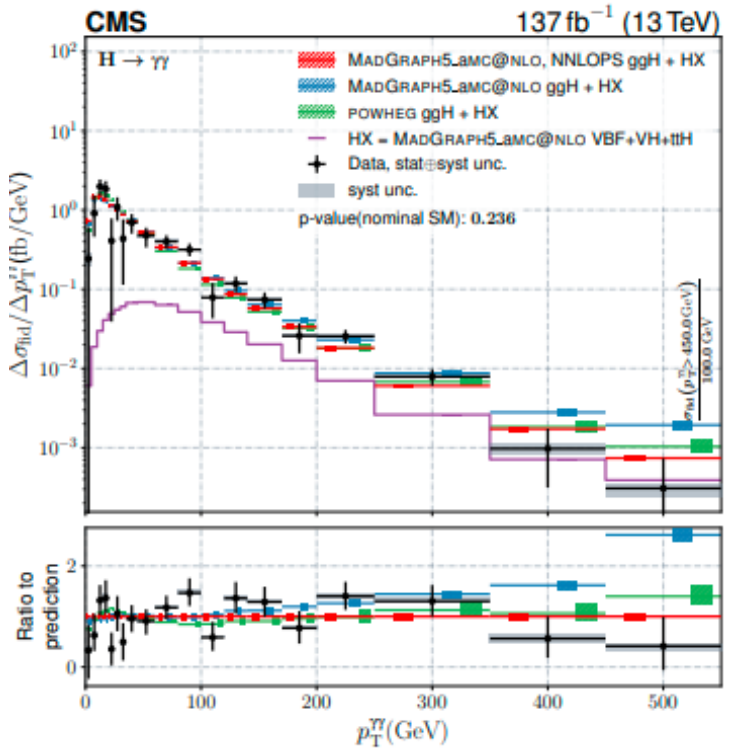
- Some results with the updated/finalized DY suppression strategy
- We will present the re-unblinded results in 2-3 weeks

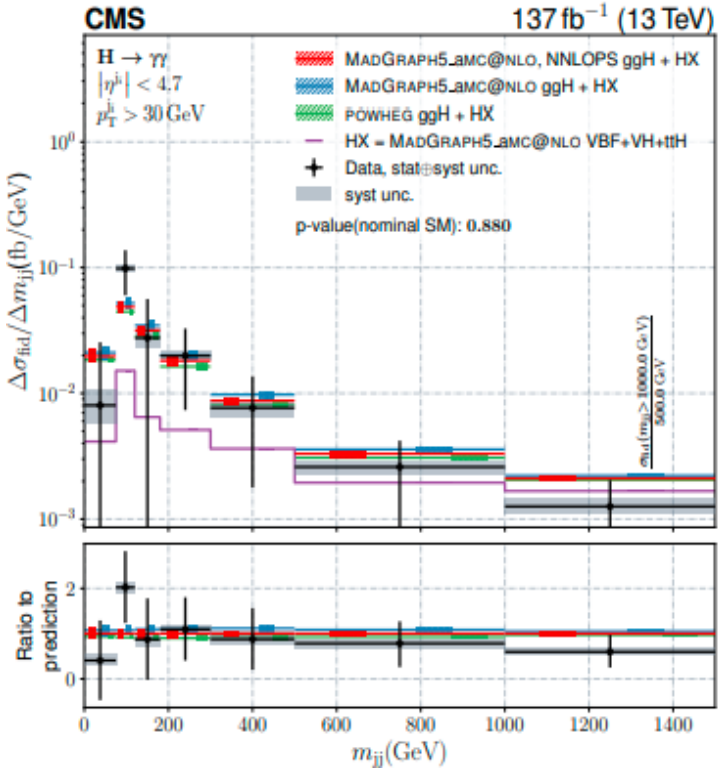




Status of HIG-19-016







- Some results of paper "**Measurement of the Higgs boson inclusive and differential fiducial production cross sections in the diphoton decay channel with pp collisions at 13 TeV**" (HIG-19-016)
- This paper has been submitted to JHEP and uploaded to the arXiv, arXiv:2208.12279, on 25.08.2022
- I contributed in the studies of "**e-veto and data/MC Scale Factors**" for **Ultra-Legacy 2017 data** and presented results in Hγγ meeting (link)

Summary and Ongoing …

- **HIG-20-002: Low mass Higgs → γγ**
  - ✓ The analysis is Preapproved
  - ✓ Got GL Re-unblinding last month
  - ✓ Approval: soon in 1-2 months

- **Higgs properties measurements:**
  - ✓ Fiducial and differential XS (HIG-19-016): Submitted to JHEP
  - ✓ Mass measurements with full Run2 Ultra-Legacy samples: Ongoing

Thanks