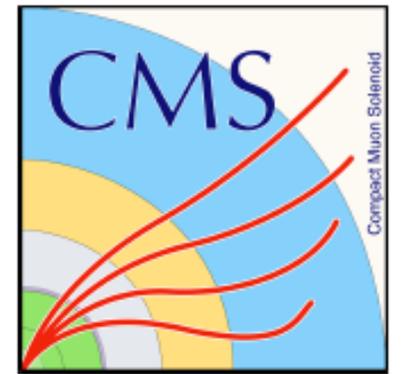




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# Measurements of Higgs production and search for an additional SM-like Higgs boson in the diphoton decay channel with the CMS detector

**Summary**  
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**IHEP CAS, Beijing**

On behalf of the CMS Collaboration

**Higgs 2021, 18 Oct. - 22 Oct.**

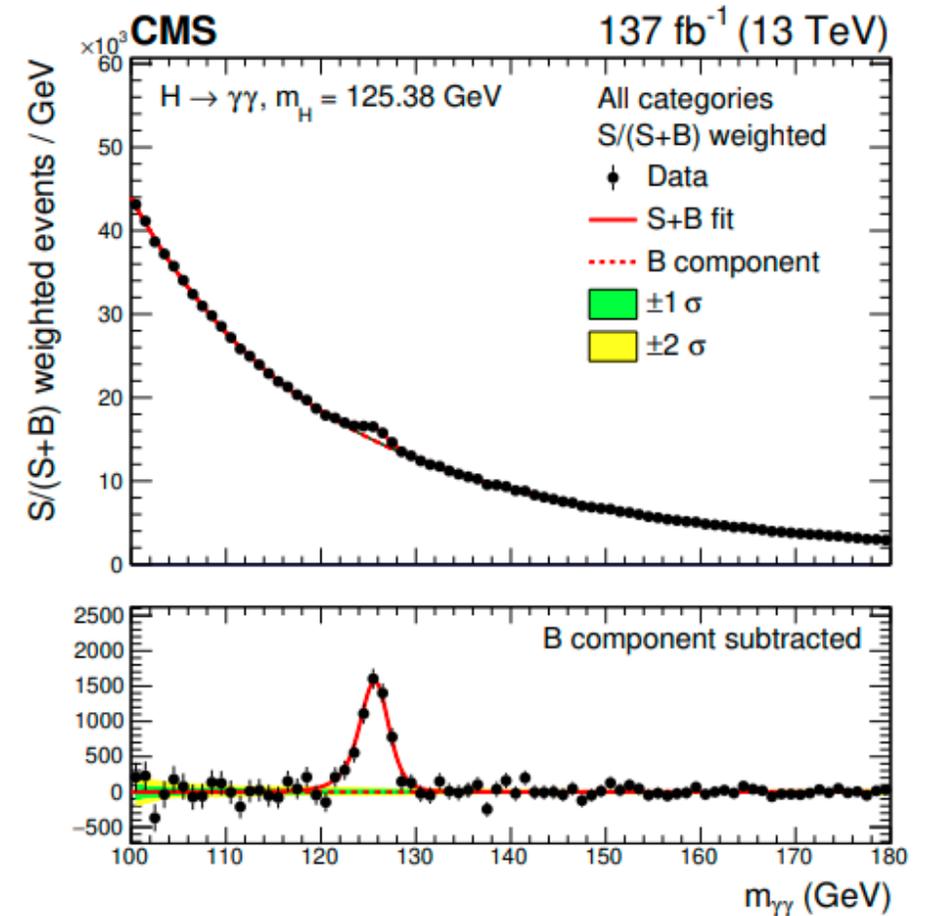
**Stony Brook University, New York, US**

# Measurements of Higgs boson production cross-sections and couplings in the diphoton decay channel at 13 TeV

# Introduction & Analysis Strategy

## STXS Framework:

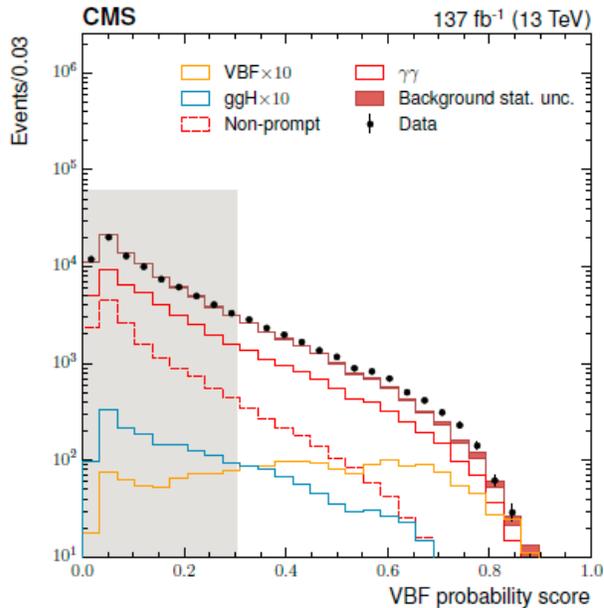
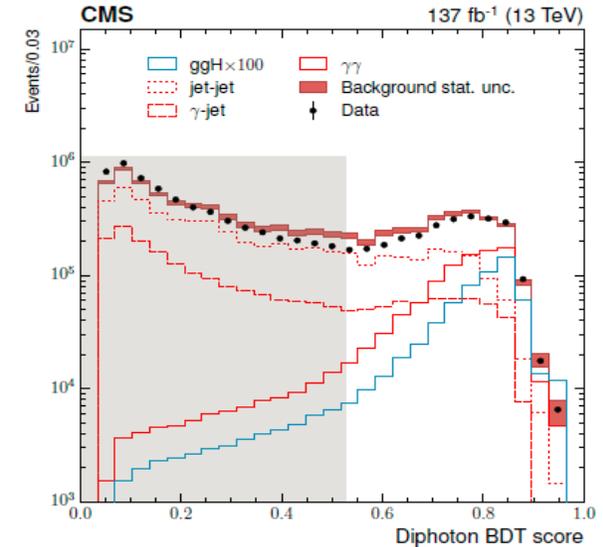
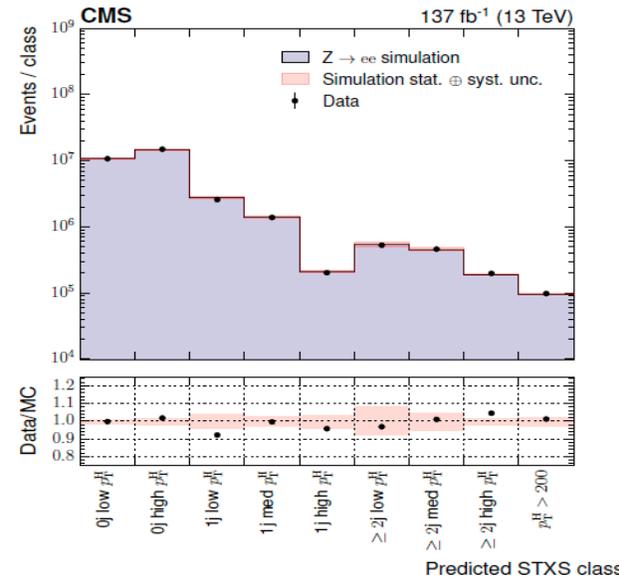
- STXS provides a framework for making measurements in increasingly finer bins of the Higgs boson phase space
- Maximize experimental sensitivity
- Less dependence of measurements on theory
- BSM physics is isolated in a separate bin
  
- Analysis is targeting ggH, qqH (VBF and VH hadronic), ttH and tH, VH leptonic Stage 1.2 STXS bins
- In each production mode categories are defined to **target as many STXS bins as possible**



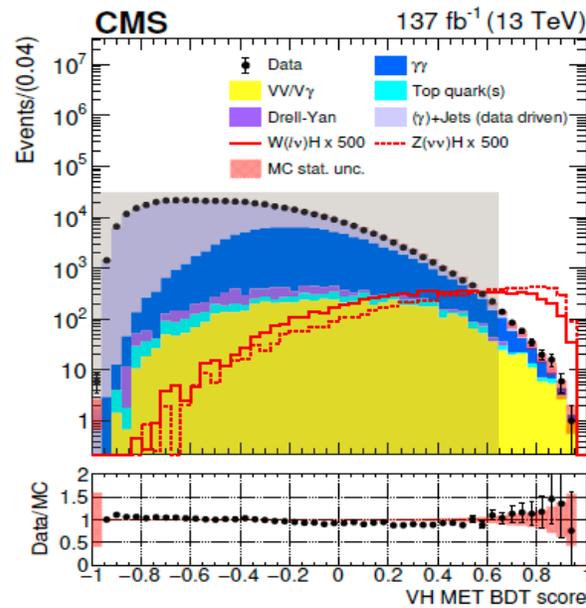
- Simultaneous fit to the diphoton invariant mass distributions: Background determined from data

# ggH event categorization and other production modes

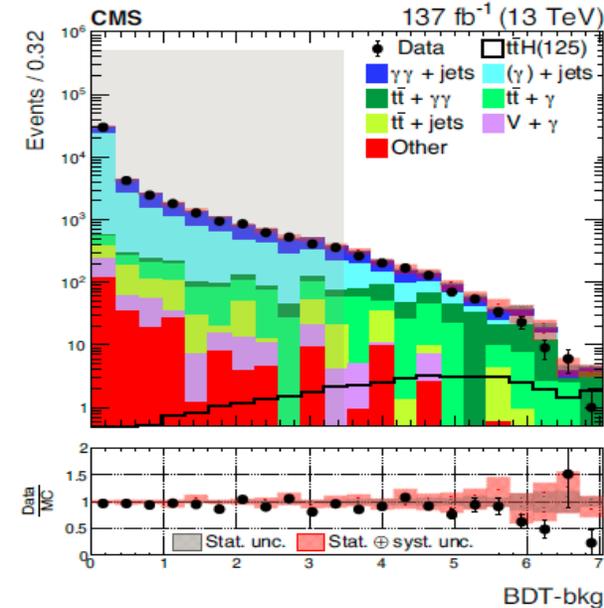
- Use a multi-class BDT (9 Classes): Predicts the probability that an event belongs to a given ggH STXS bin
- After ggH BDT classification, events are divided into analysis categories using the diphoton BDT
- Data-driven estimation of key backgrounds for MVA training i.e. **VBF, VH MET, ttH Hadronic**



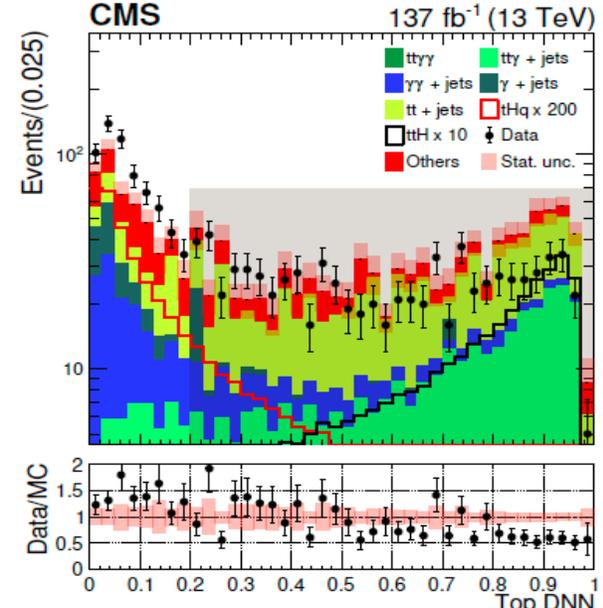
**VBF**



**VH MET**



**ttH Hadronic**



**tHq Leptonic**

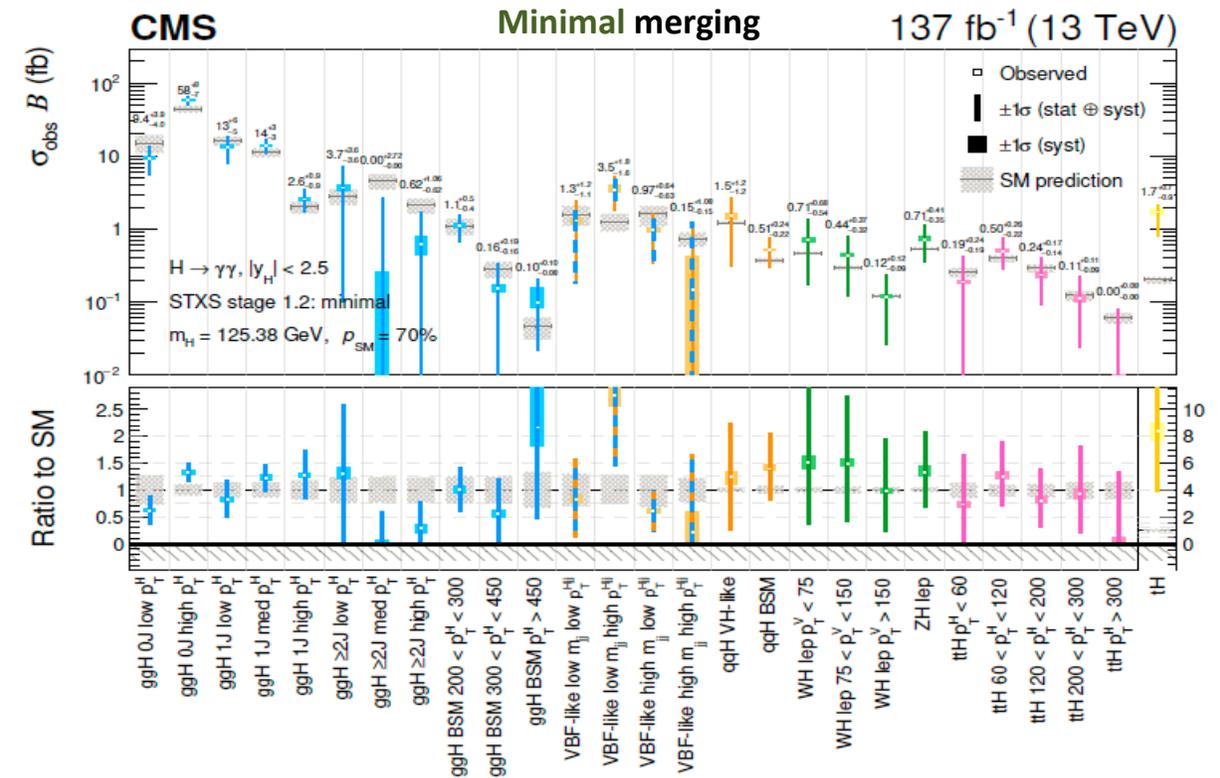
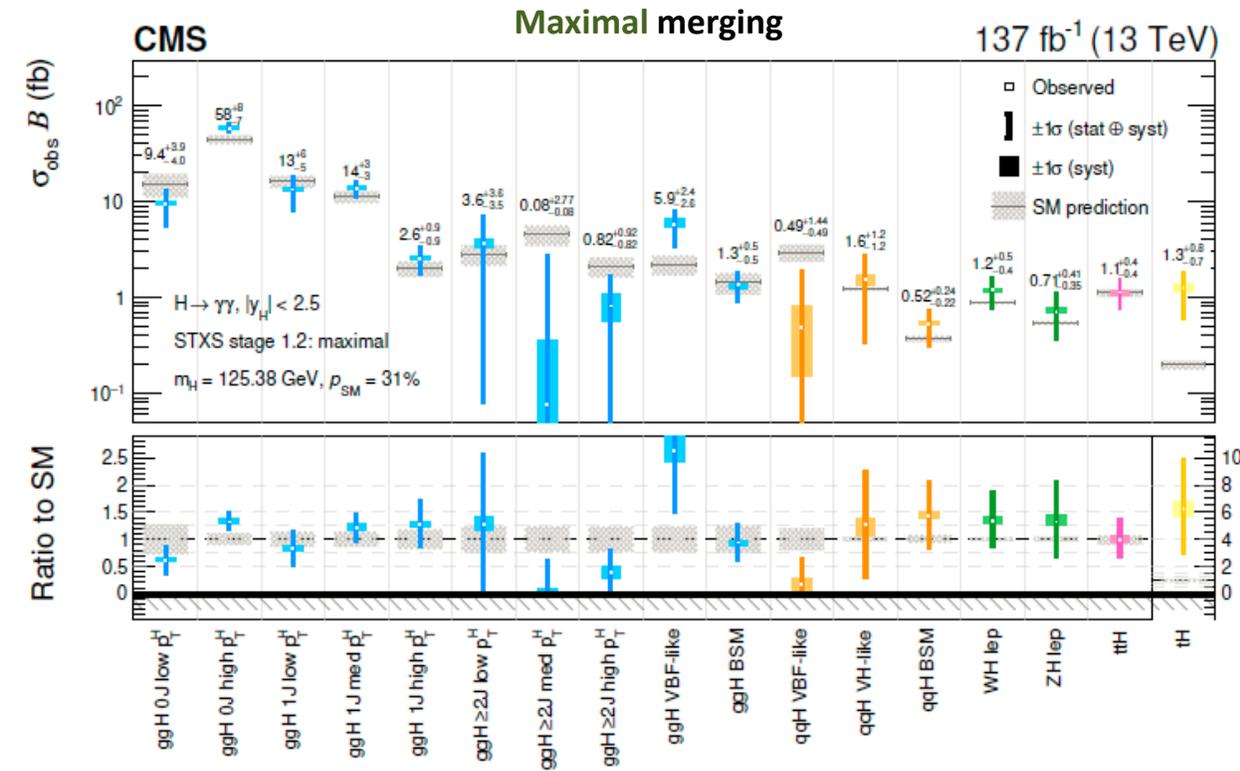
# Merging Scenarios

## ➤ “Maximal” merging scenario (17 Parameters)

- STXS bins are merged until their expected uncertainty is less than **150%** of the SM prediction
- Measurement of **ttH** and **tH** simultaneously

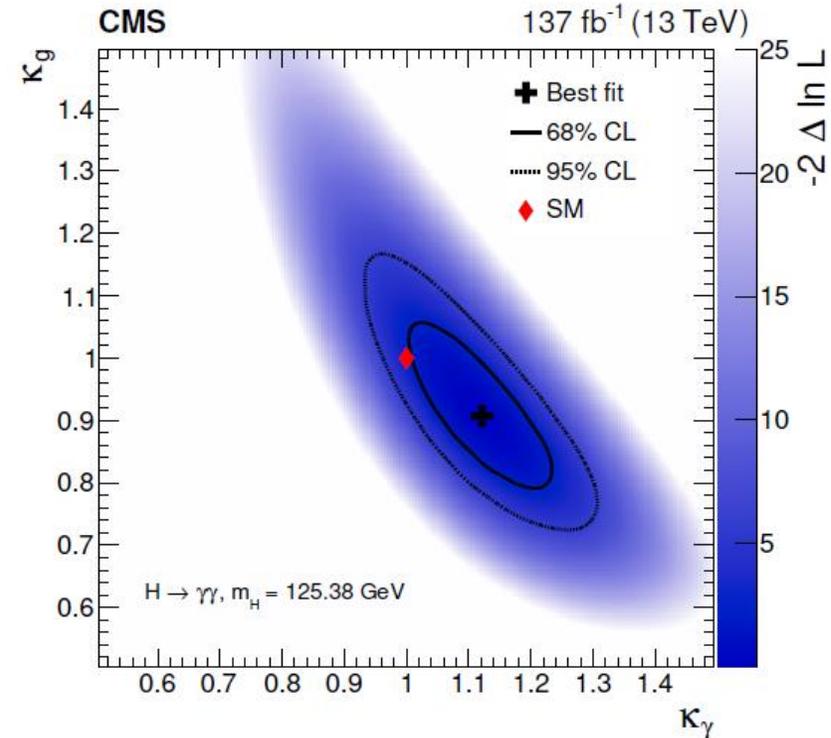
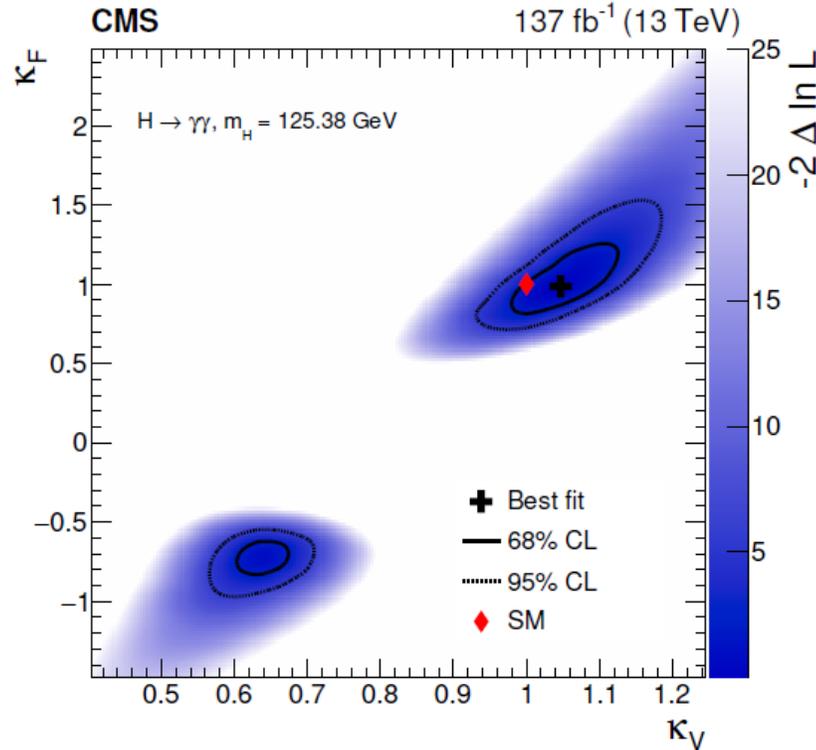
## ➤ “Minimal” merging scenario (27 Parameters)

- Merges as few bins as possible that parameters do not become too anti-correlated, meaning values of less than around 90%
- Measurement with additional stage 1.2 splitting (**ttH** and **ggH BSM**)



# Coupling Modifiers

- The  $\kappa$ -framework defines coupling modifiers to directly parametrize deviations from the SM expectation in the couplings of the Higgs boson to other particles



- **Resolved  $\kappa$  model:** The scaling factors of loops present in Higgs boson production and decay are resolved into their SM components, in terms of the other parameters
- Exclude negative  $\kappa_f$  with **0.5 (2.4)  $\sigma$**  confidence

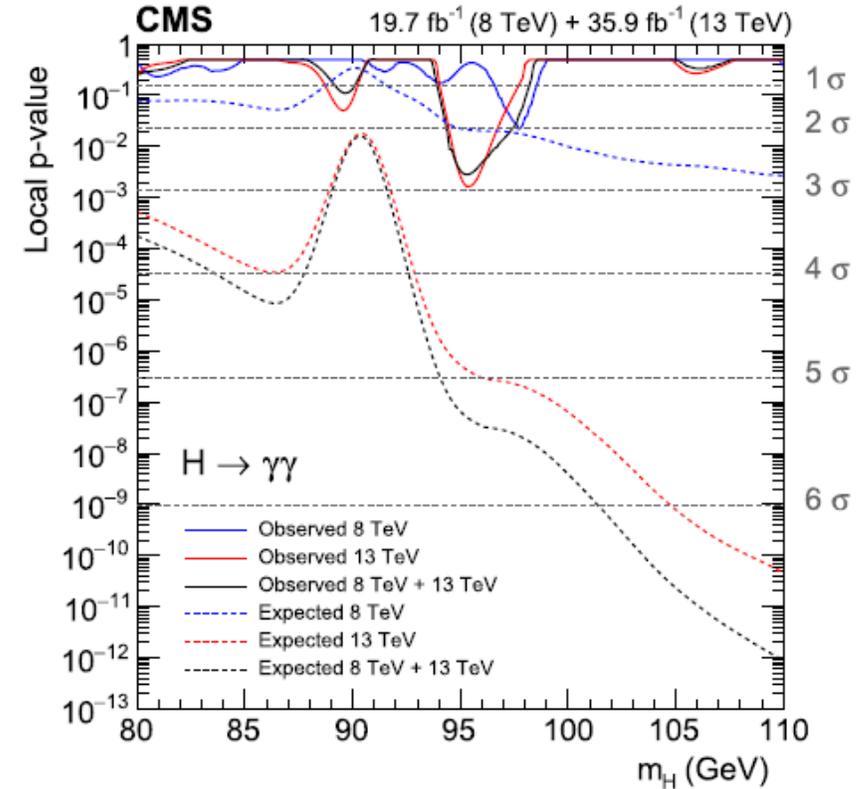
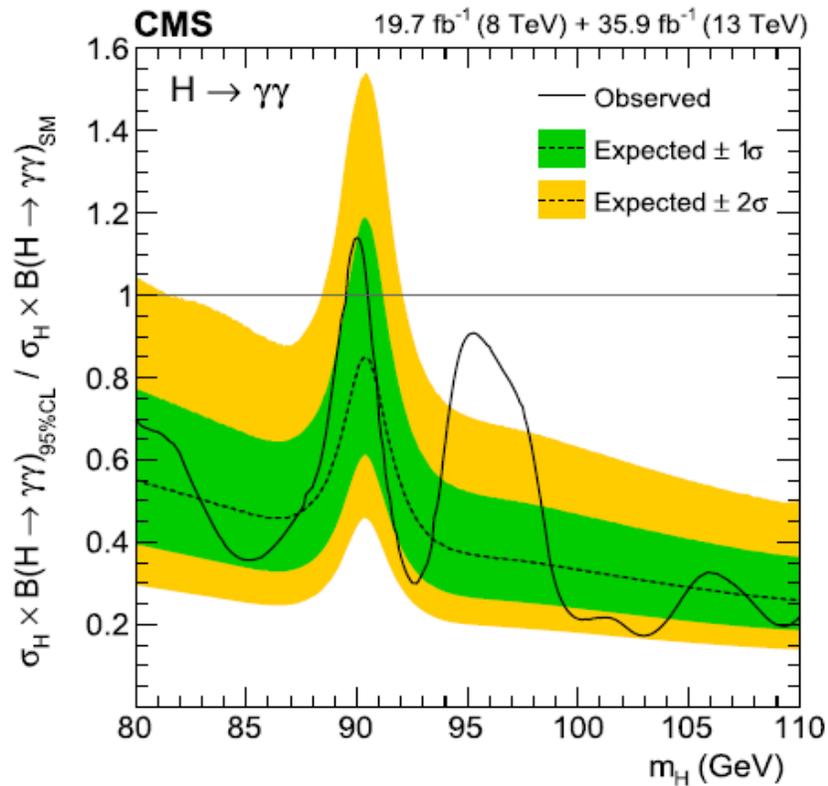
- **Unresolved  $\kappa$  model:** Used to parameterize deviations in  $ggH$  and  $H \rightarrow \gamma\gamma$  loops using effective coupling modifiers ( $\kappa_g, \kappa_\gamma$ )
- The  $g$  and  $\gamma$  parameters are particularly sensitive to additional BSM states, that contribute towards the rate of Higgs boson production and decay via loop processes

# Search for an additional SM-like Higgs boson in the diphoton decay channel (2012+2016)

- The major difference in **low-mass** is the **Relic DY** as compared to standard  **$H \rightarrow \gamma\gamma$**
- In low-mass: standard  **$H \rightarrow \gamma\gamma$**  4 Untagged event classes -> Low-mass 3 Untagged classes (2016) by merging class0 and class1 in standard  **$H \rightarrow \gamma\gamma$** , to be the class0 in **LM**

# Results (2012+2016)

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- Limit on  $\sigma \times BR (H \rightarrow \gamma\gamma)$  normalized to that of SM.
  - ✓ Min. (Max.) limit: **0.17 (1.13) pb** at  $m_H = 103.0 (90.0) \text{ GeV}$
- Observed significance:
  - ✓ **8 TeV:  $\sim 2.0 \sigma$  local significance at  $m_H = 97.6 \text{ GeV}$**
  - ✓ **13 TeV:  $\sim 2.9 \sigma$  local (**1.47  $\sigma$  global**) significance at  $m_H = 95.3 \text{ GeV}$**
  - ✓ **8 TeV + 13 TeV:  $\sim 2.8 \sigma$  local (**1.3  $\sigma$  global**) significance at  $m_H = 95.3 \text{ GeV}$**
- Need more data to ascertain the origin of this excess.

# Summary and Conclusion

- Two different measurements are performed within the simplified template cross section framework, in which **17** and **27** independent kinematic regions are measured simultaneously
  - Measurements of the Higgs boson's couplings to vector bosons and to fermions, are also in agreement with the SM expectations
- 
- No evidence for the moment has been found for the presence of BSM Higgs bosons
  - Looking forward to new results with **Full Run II** data (**Ongoing...**)

Thanks