
# Search for a standard model-like Higgs boson in the mass range between 70 and 110 GeV in the diphoton final state in proton-proton collisions with CMS at √s=13 TeV

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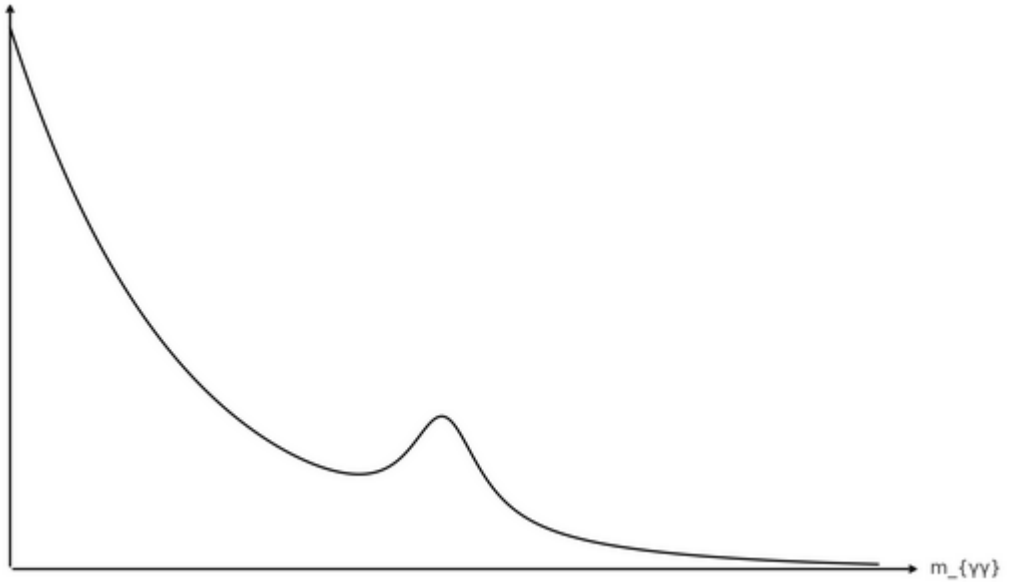
# Outline

Results based on
Phys. Lett. B 860 (2025) 139067

- Motivation for low mass diphoton resonance searches
- Analysis Strategy
- Signal and Background modeling
- Full Run 2 Results
- Summary



# Motivation

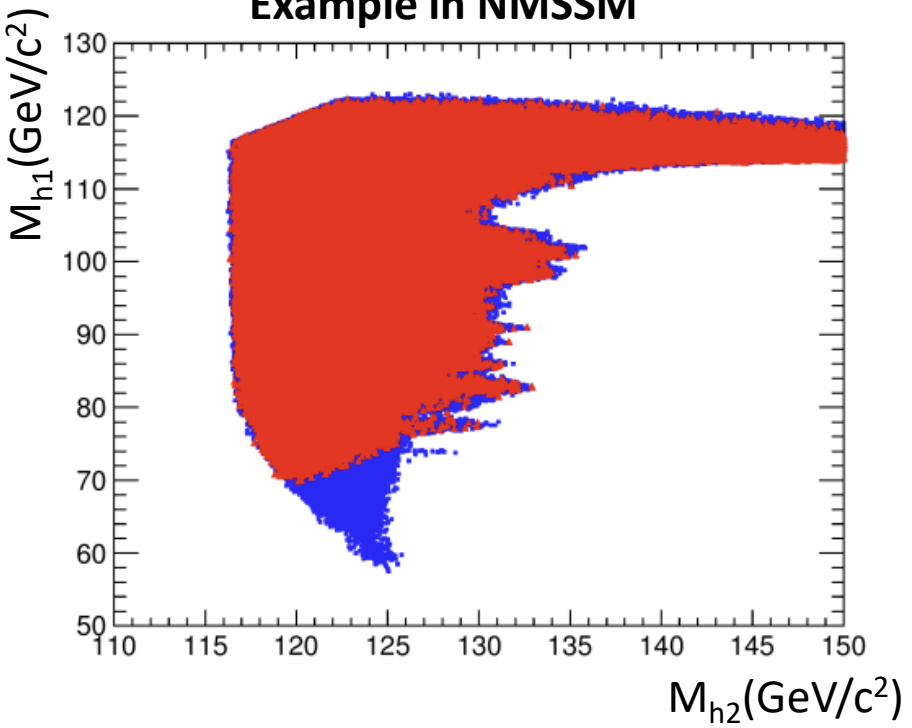
**Theoretical Motivation :** Many BSM models allow the existence of a low mass resonance with m < 125 GeV, lower than the Higgs boson discovered in 2012

Blue : Case I = $\Omega h^2 < 0.1102$
Red : Case II = $0.1102 < \Omega h^2 < 0.1272$

Where $\Omega h^2$ is the relic density

**In this model, even after tighter cosmological constraints, a second Higgs boson with 70 GeV<$M_{h1}$<120 GeV is still allowed in the case of $M_{h2}$~125 GeV**

**Example in NMSSM**




$h_1$ : lightest NMSSM scalar Higgs boson

$h_2$ : Next to lightest scalar Higgs boson (with a mass around 125 geV)

J. Fan et. al
2014 *Chinese Phys. C* **38** 073101

# Analysis Strategy

**Full Run2 data**

- Corresponding luminosity 132 fb-1

**Main production modes included in signal model**

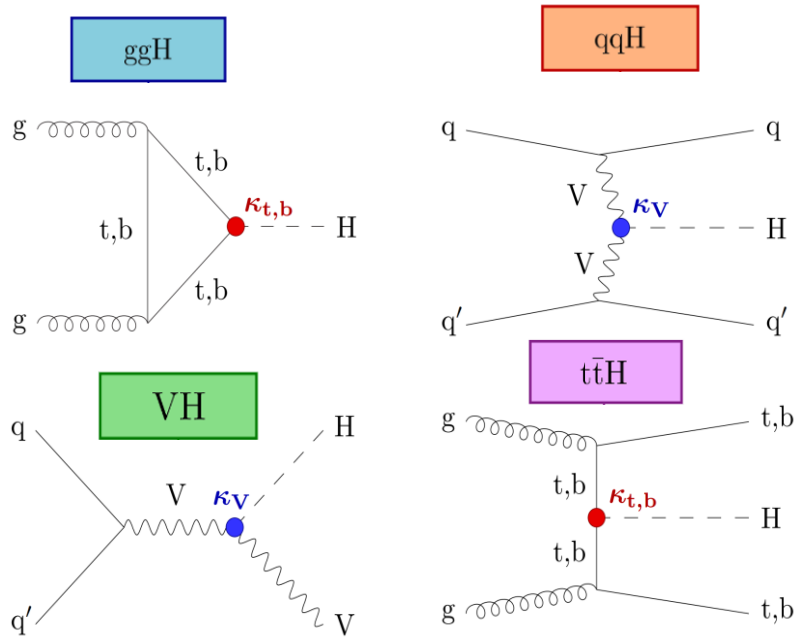
- ggH, VBF, VH, and ttH
- Relative branching fractions of the different production modes assumed to be the same as in the SM

**Extract signal events by fitting to the diphoton invariant mass**

- Signal search region: 70-110 GeV
- Background fitting range: 65-120 GeV

**Background components**

- Irreducible direct γγ production
- Reducible γ+jet,jet+jet, Drell-Yan (DY) Z→ee events



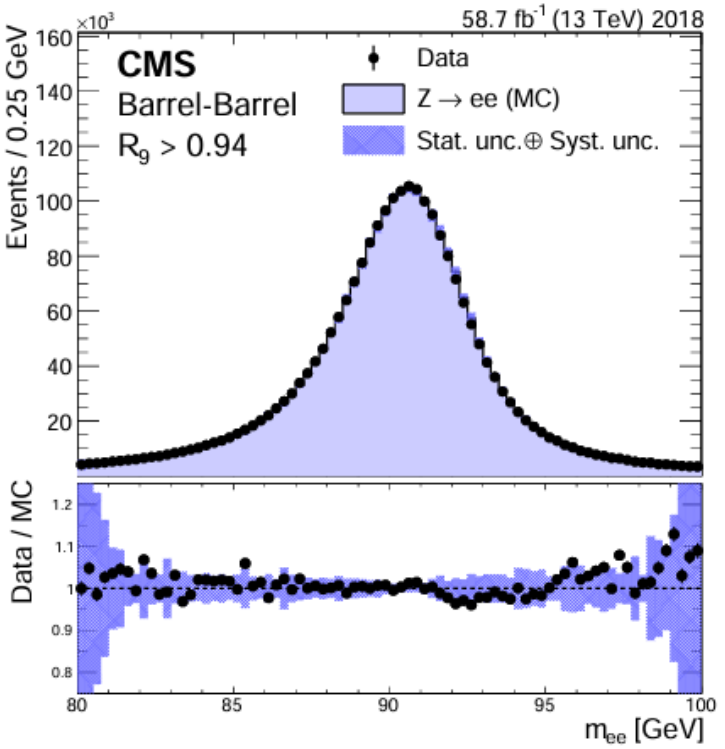
# Analysis Strategy

Share many elements from the SM H-> γγ Run 2 analysis

- Photon reconstruction and correction
- Vertex ID
- Signal and Background modeling techniques

Dedicated optimizations for low mass H->γγ full Run 2

- New dedicated triggers and dedicated pre-selections
  - Stricter isolation and shower shape requirements, allowing photon pt requirements of {30, 18} GeV and little mass requirement
- Reoptimized photon ID
- Diphoton candidate BDT classifier using kinematic variables retrained for low-mass case
- Dedicated VBF event class in 2017 & 2018
- Data reanalyzed with improved calibration for 2016
- Reinforced DY suppression strategy

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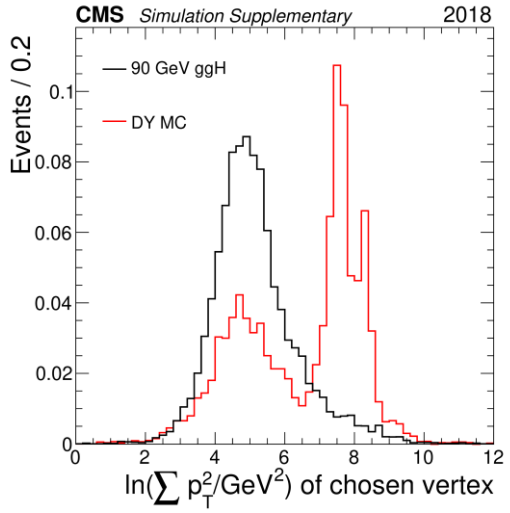
# Analysis Strategy : DY suppression

- **Electron-veto without pixel detector hits**
  - Already used in the analysis of 2016 data combined with 2012 *PLB 793 (2019) 320*
- **Additional selections :**
  - Rejection of photon candidates also reconstructed as electrons
  - $\log(\Sigma p_T^2) <= 0.016 * p_T^{\gamma\gamma} + 6.0$ : Maximum value of $\log \Sigma p_T^2$

- **Classification based on diphoton candidate BDT :**
  - 3 inclusive event classes for 2016
  - 3 inclusive event classes + 1 class targeting VBF process for 2017 and 2018

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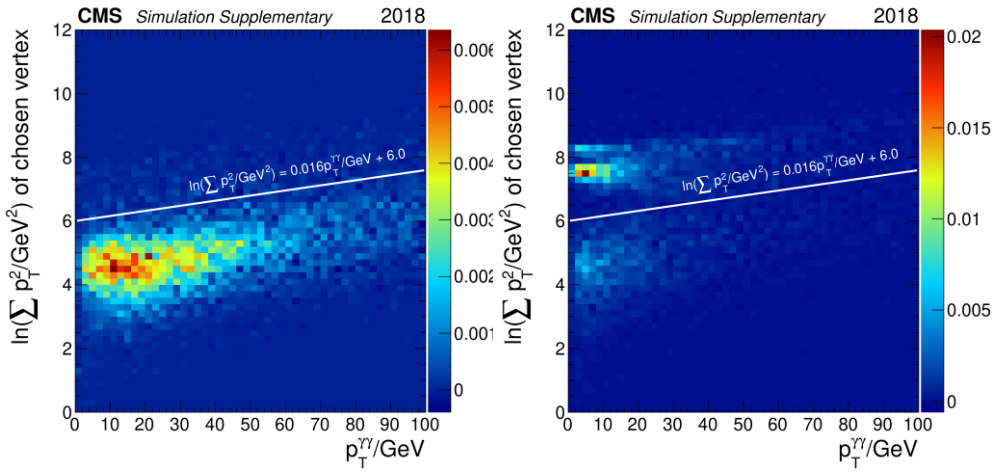
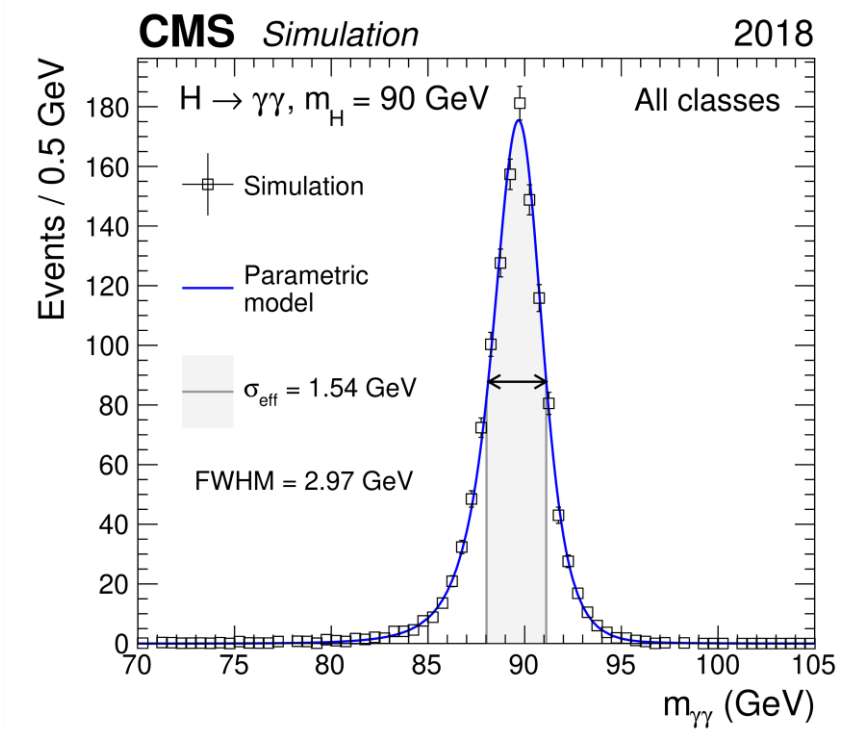


# Signal modeling

- A parametric model corresponding to a sum of Gaussians is used to model the signal
- All production modes (ggH, VBF, WH, ZH, ttH) from 70 GeV to 110GeV with a 5 GeV granularity
- Different production modes weighted by SM-like Higgs boson cross sections evaluated at $70 < m_H < 110$



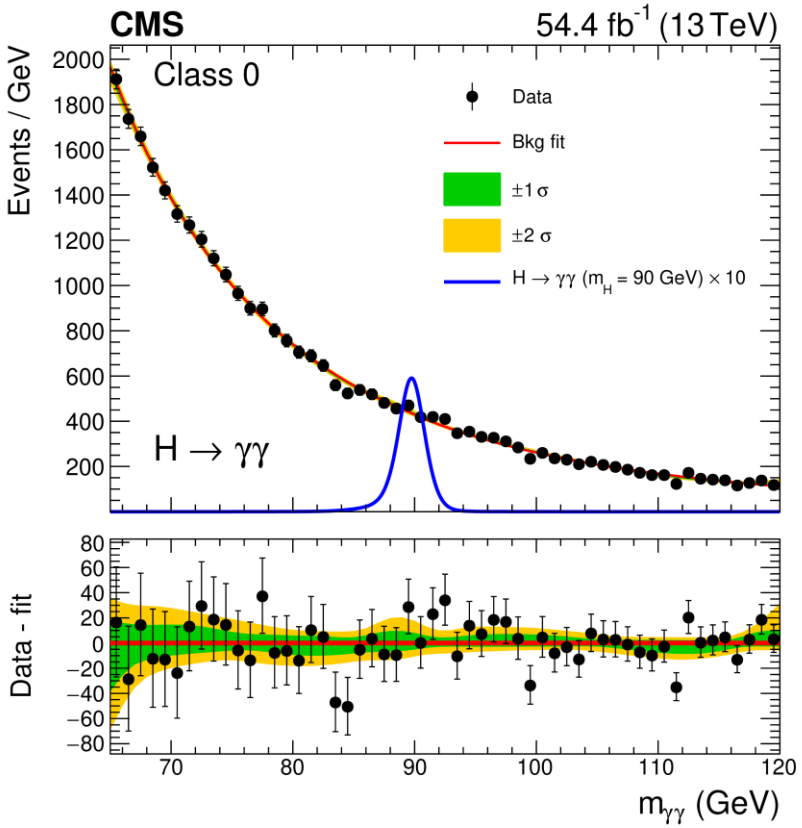
# Background modeling

**Relic Drell-Yan Z->ee contribution :**

- Estimated by fitting doubly-misidentified MC Drell-Yan events with a double-sided Crystal Ball (DCB) function + an exponential

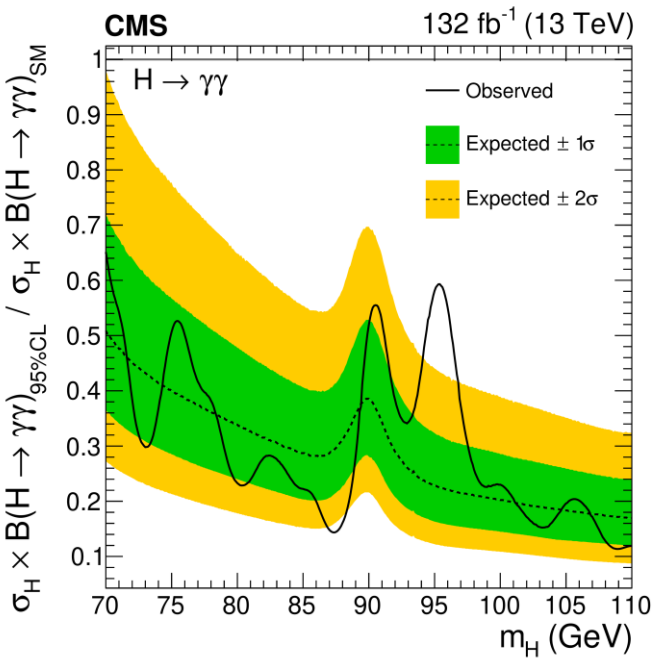
**Total background model**

- Built from fit to the diphoton mass spectrum (65-120 GeV) of data
- Sum of two components using the 'envelope' (discrete profiling) method
  - Continuous analytic functions from four families (Power law, Exponential, Laurent, Bernstein) for the continuum background
  - DCB+exponential (normalization floating) function for Z→ee contribution
- Envelope method chooses function orders and estimates associated systematic uncertainties

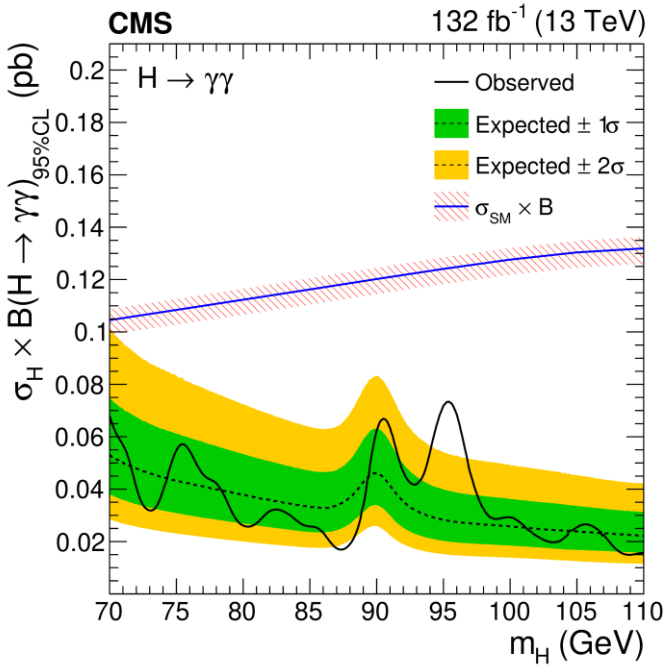


# Full Run 2 Results : inclusive limit

**95% CL upper limits on σ×BR normalized to SM prediction**



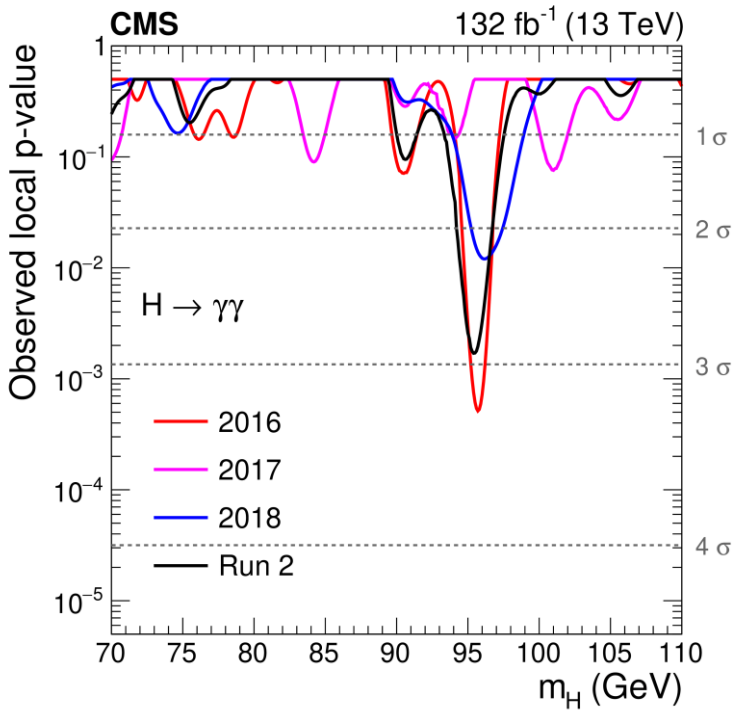

**Absolute 95% CL upper limits on *σ×BR***



# Full Run 2 results : inclusive significance

**Observed p-values for 2016,2017,2018 and the combination**

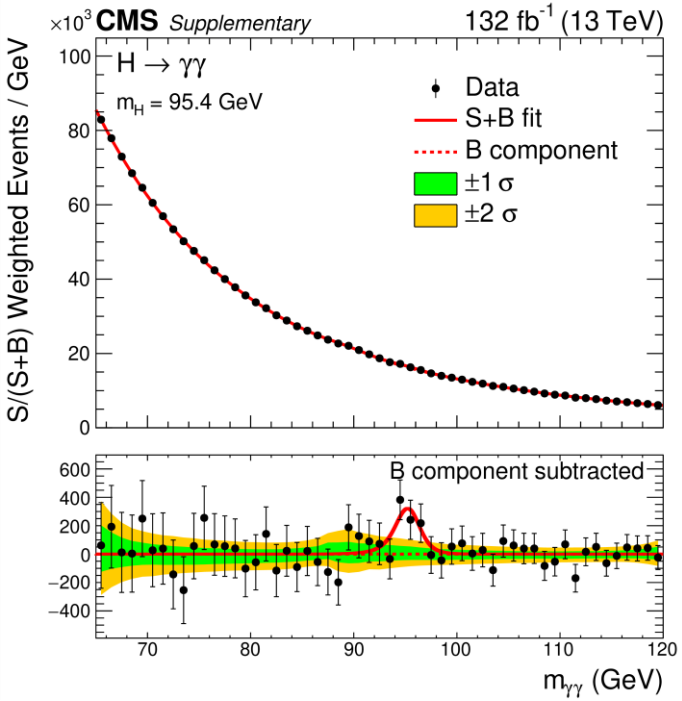
Modest excess with ~2.9σ local (1.3σ global) significance at $m_{\gamma\gamma}$ = 95.4 GeV




**$m_{\gamma\gamma}$ distribution with Signal+Background model fit**

The mass hypothesis here is $m_H$ = 95.4 GeV

Each event is weighted by the ratio S/(S+B) for its event class



# Summary

Results of search for a standard model-like Higgs boson in the mass range between 70 and 110 GeV in the diphoton final state at 13 TeV with full Run 2 data has been presented

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No evidence for the existence of a new Higgs Boson so far :
At 95.4 GeV, for all the classes and combined production modes

- Local excess significance : 2.9σ.
- Global excess significance : 1.3σ

# Thanks for your attention !