Searches for New Physics with di-boson at the CMS

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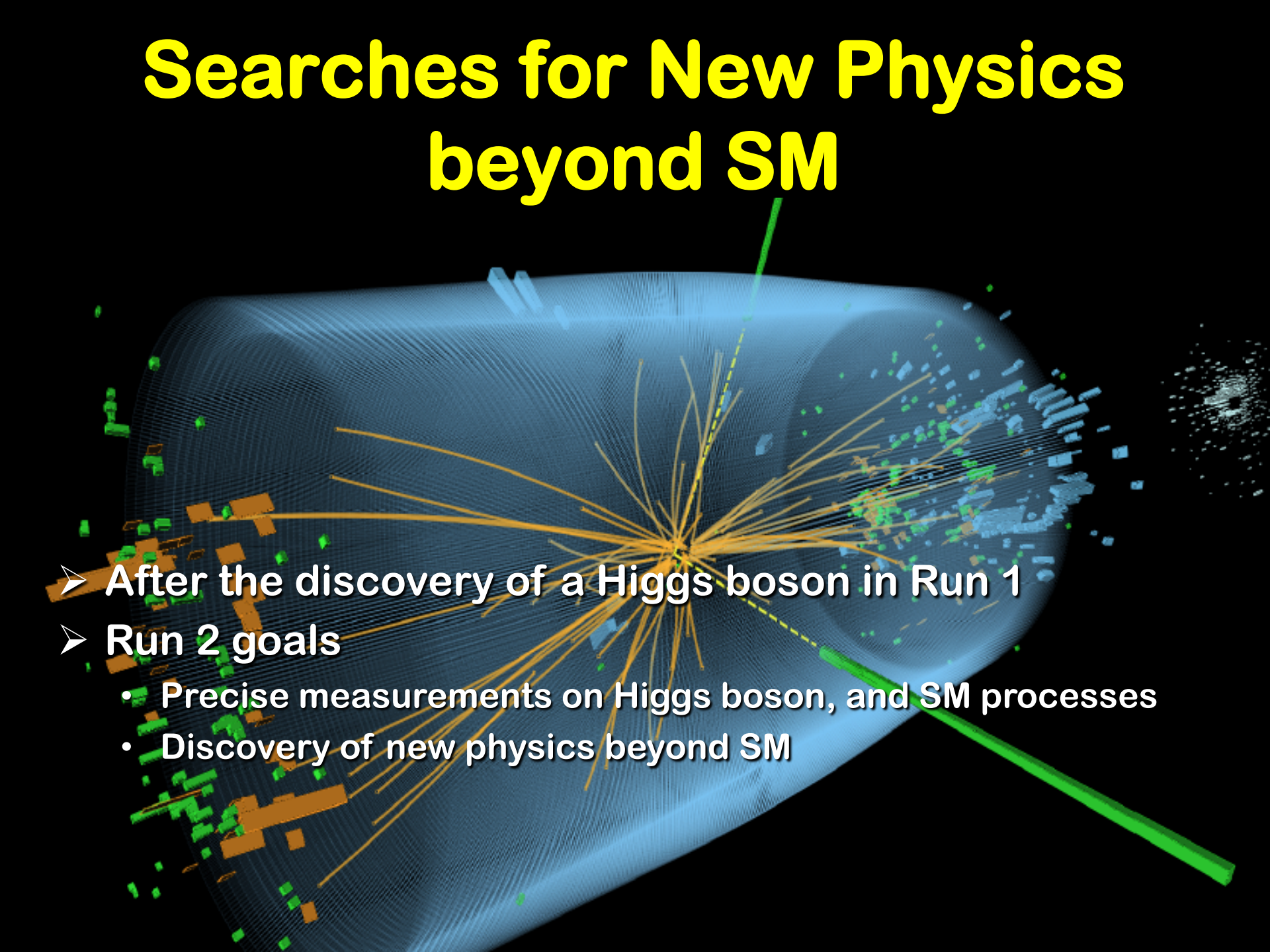
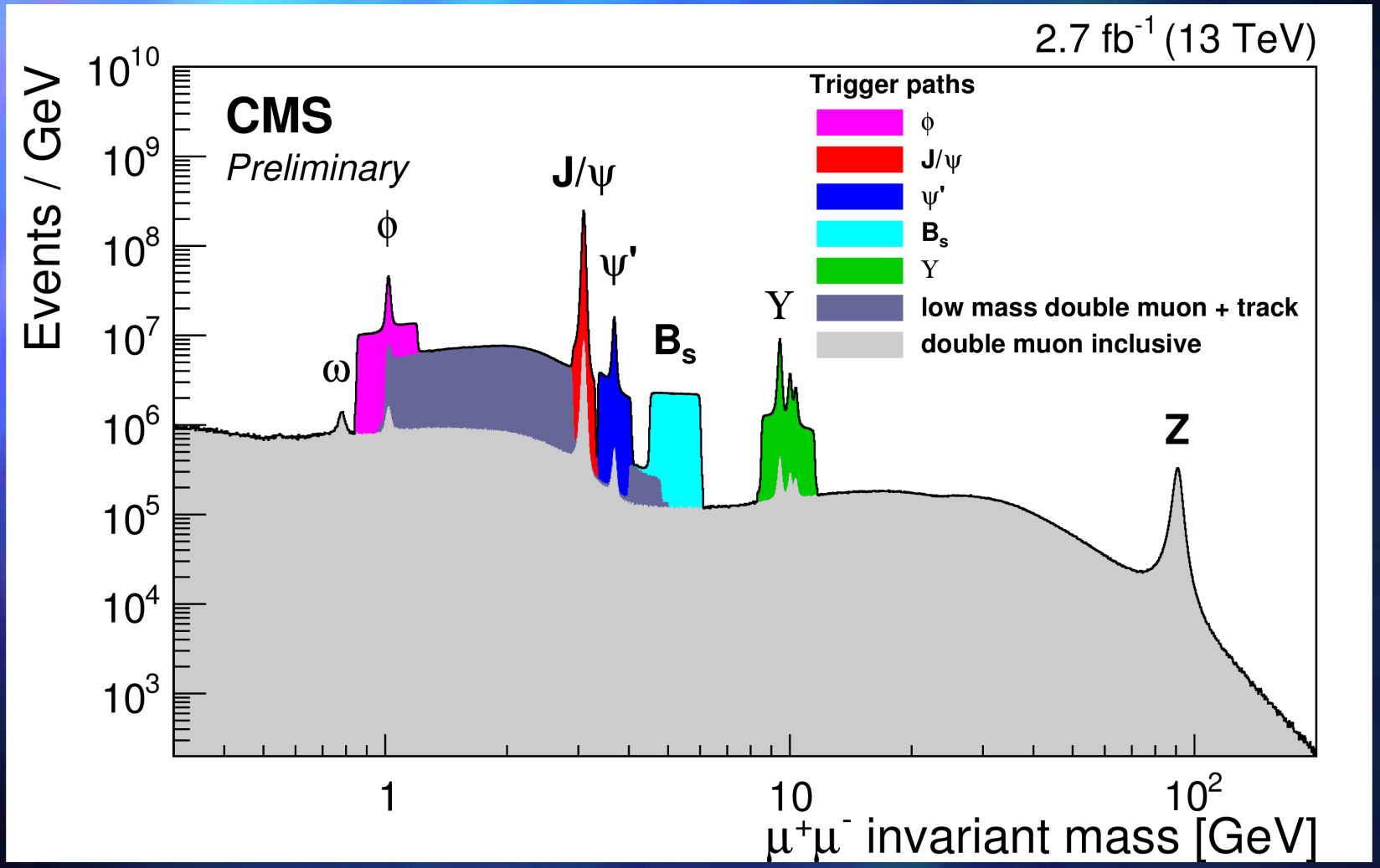
Searches for New Physics beyond SM

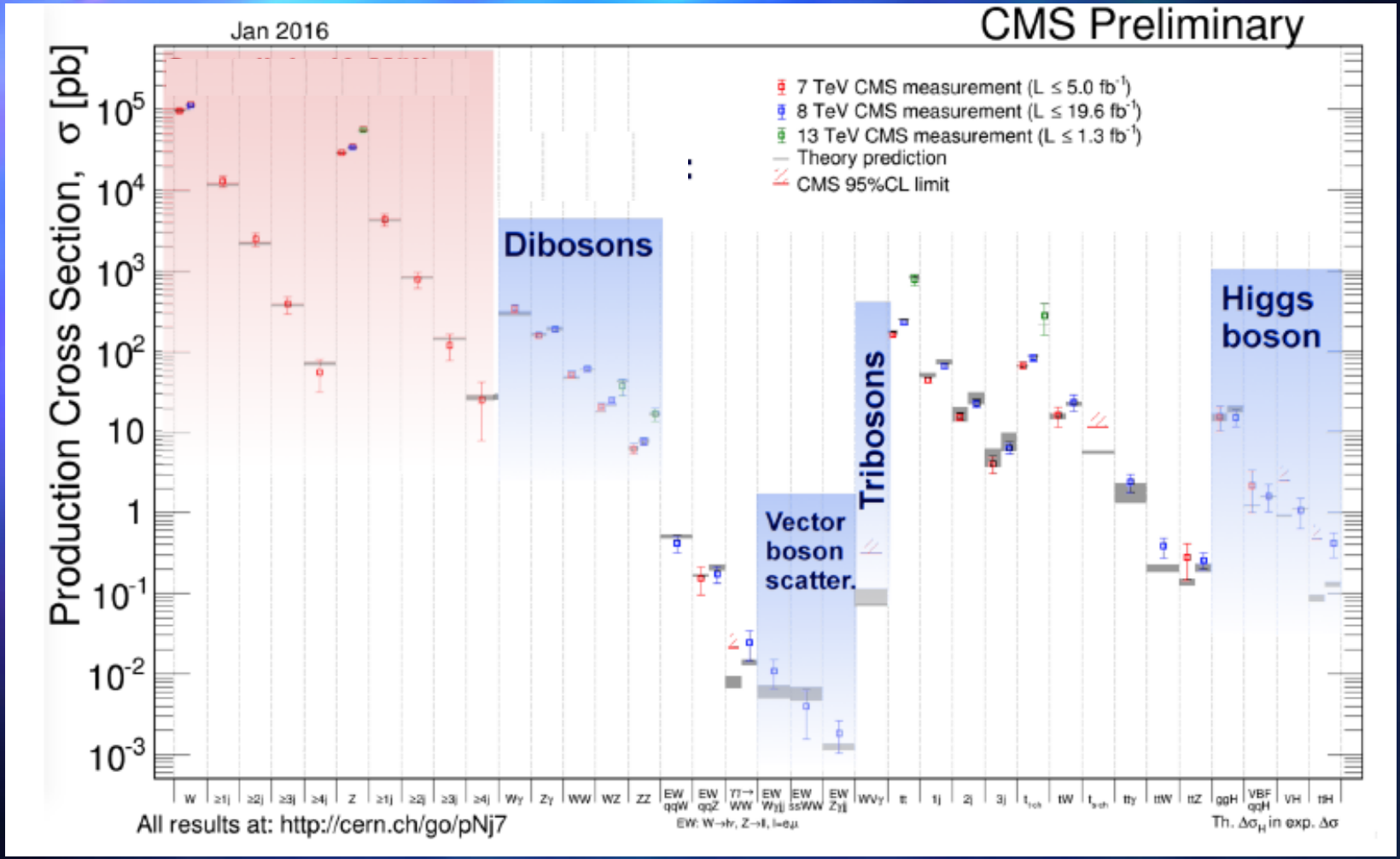


- After the discovery of a Higgs boson in Run 1
- Run 2 goals
  - Precise measurements on Higgs boson, and SM processes
  - Discovery of new physics beyond SM

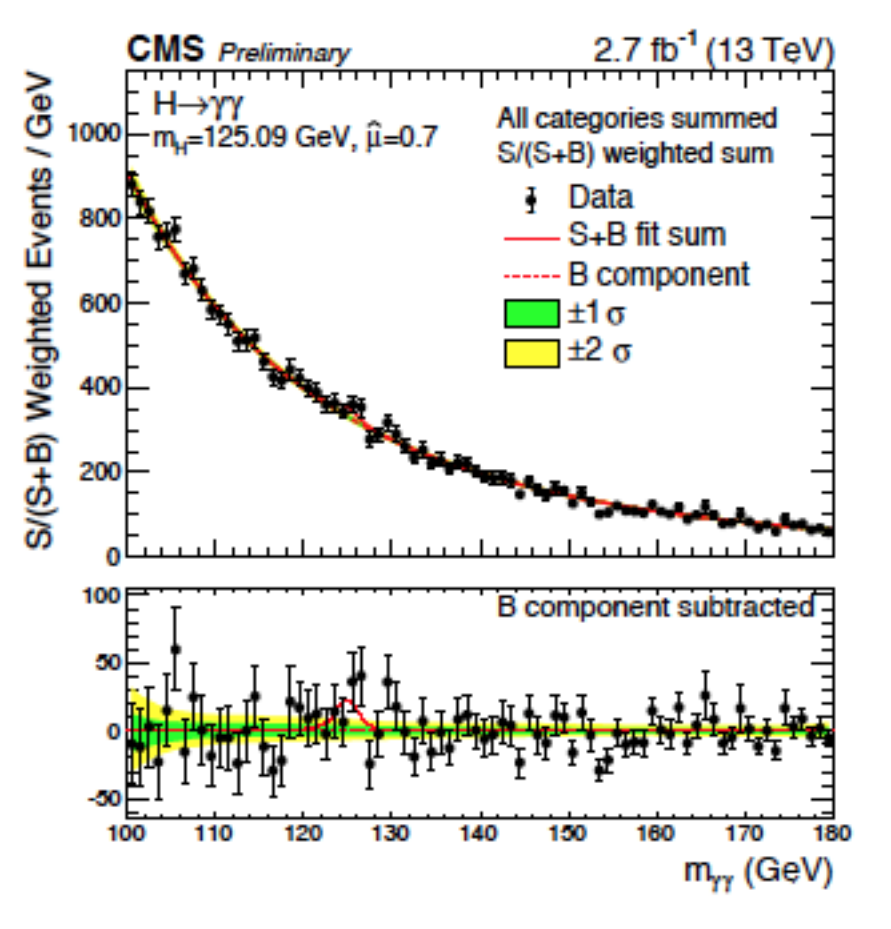
Successful Start at 13 TeV

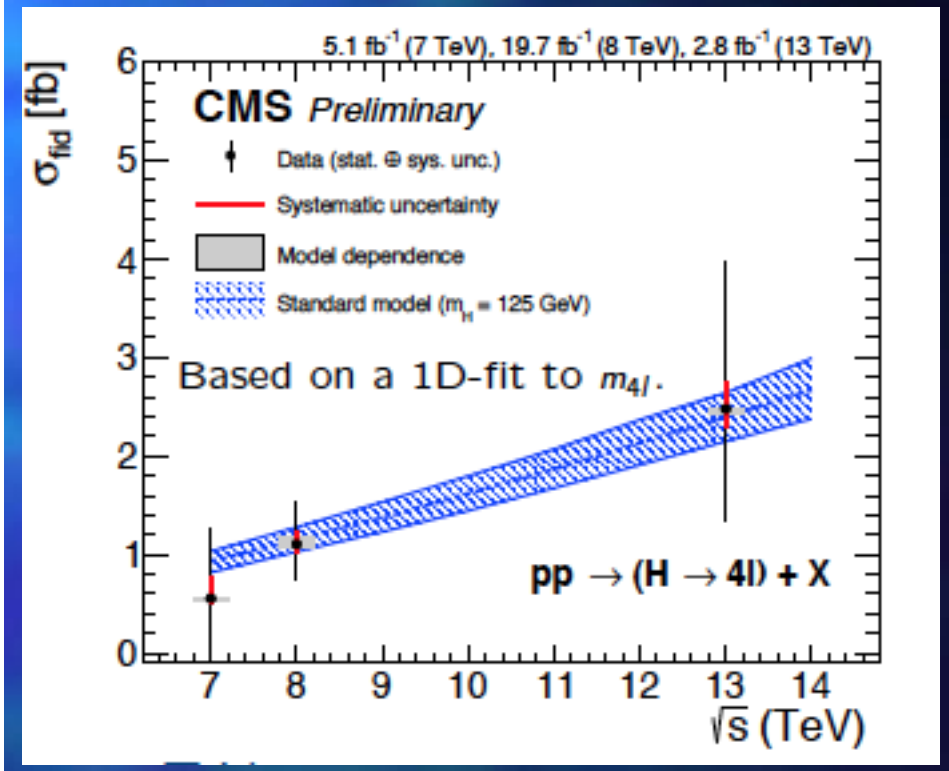


Glory of the SM at 7,8, 13 TeV

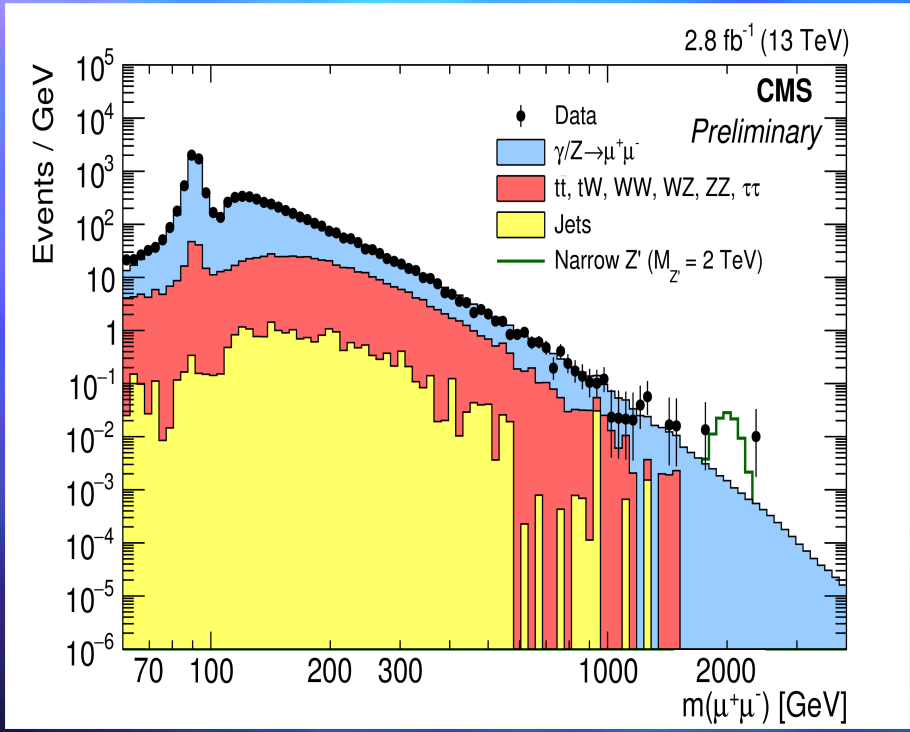


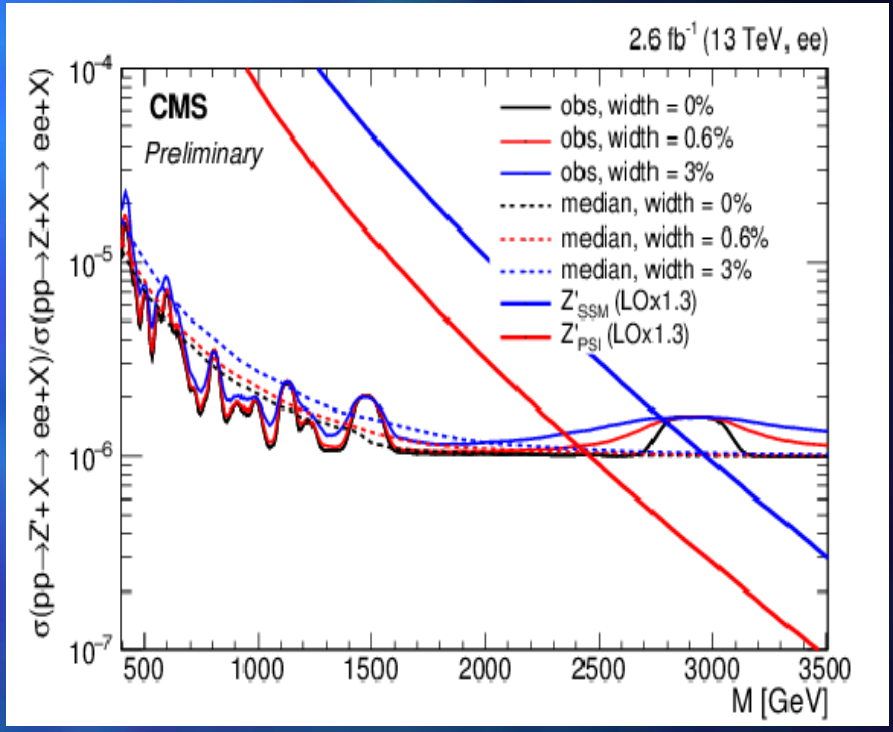
Higgs at 125 GeV



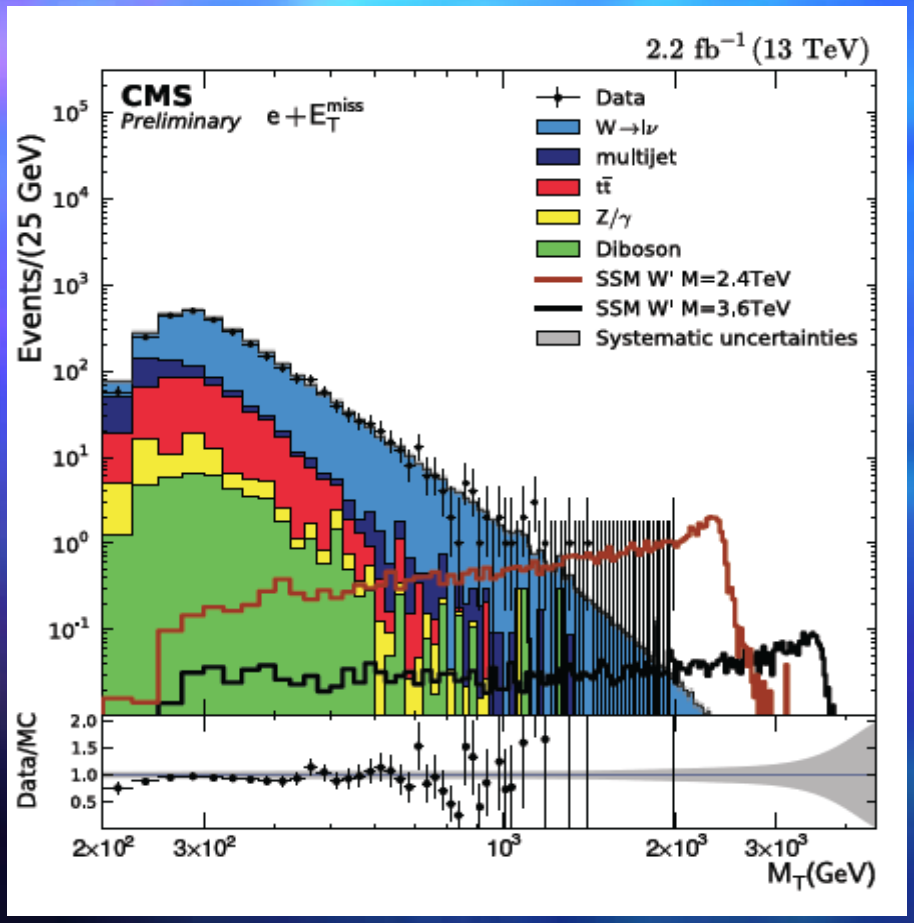


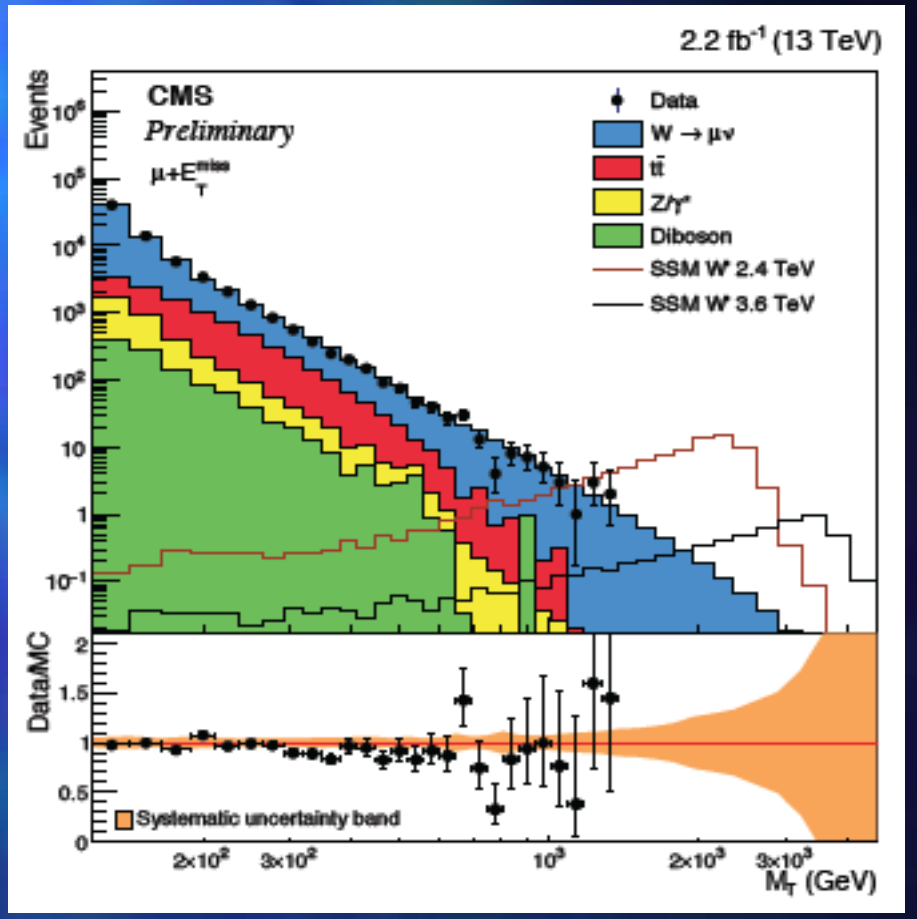
Search in Z’


2.8 fb-1 (13 TeV)
CMS
Preliminary
Data
γ/Z→μ+μ-
tt, tW, WW, WZ, ZZ, ττ
Jets
Narrow Z' (MZ' = 2 TeV)
Events / GeV
m(μ+μ-) [GeV]

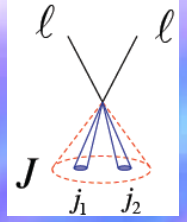

2.6 fb-1 (13 TeV, ee)
CMS
Preliminary
obs, width = 0%
obs, width = 0.6%
obs, width = 3%
median, width = 0%
median, width = 0.6%
median, width = 3%
Z'SSM (LOx1.3)
Z'PSI (LOx1.3)
σ(pp→Z'+X→ ee+X)/σ(pp→Z+X→ ee+X)
M [GeV]

Search in W’

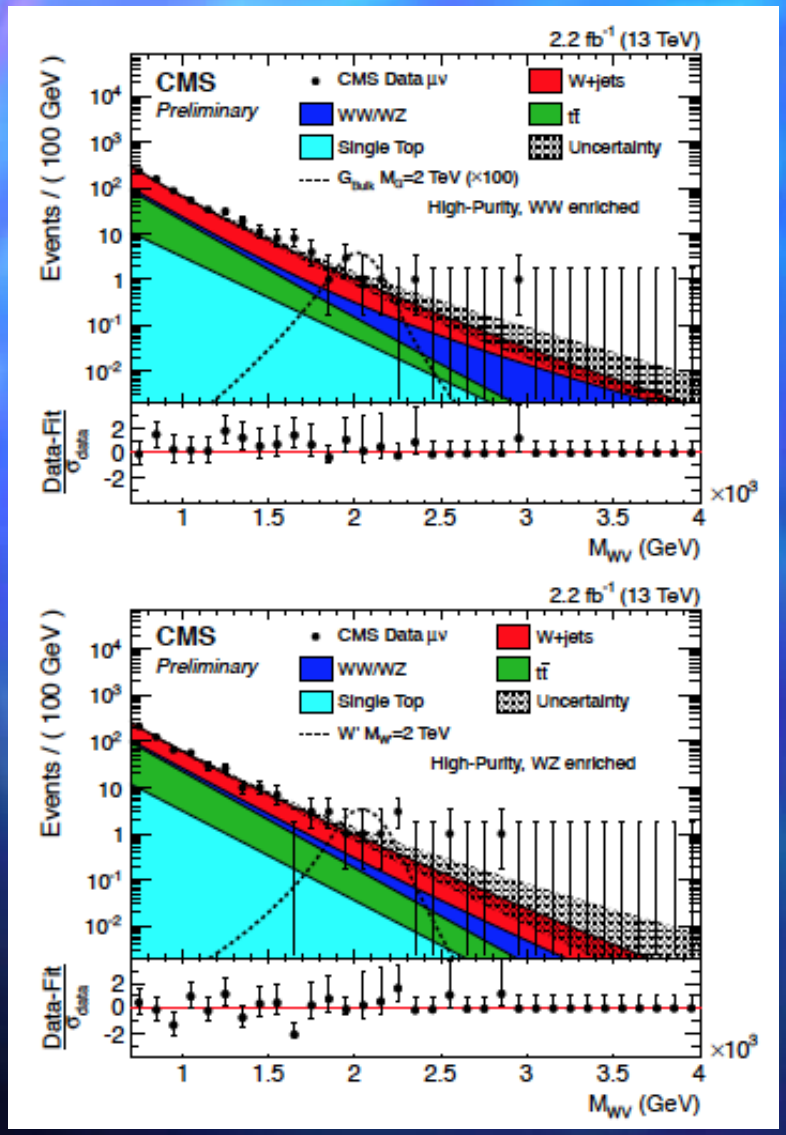




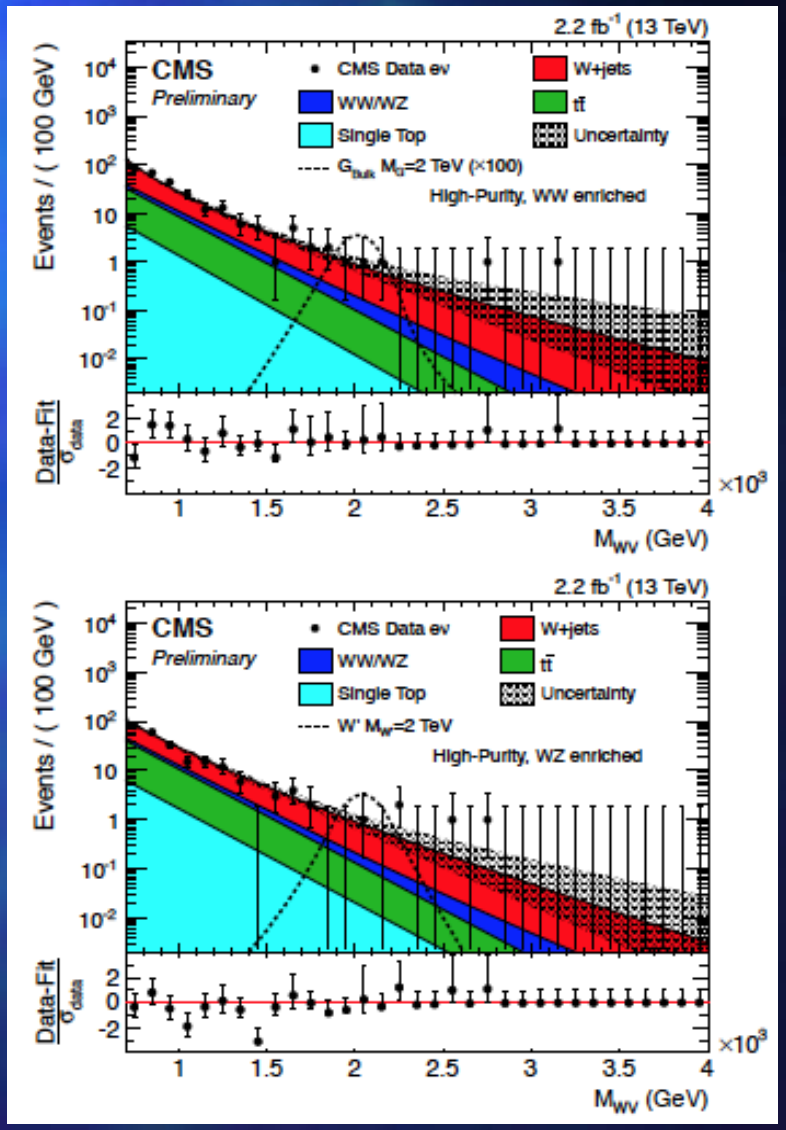
- Exclusion up to 4.4 TeV (95%)



Searches in di-bosons (W,Z)



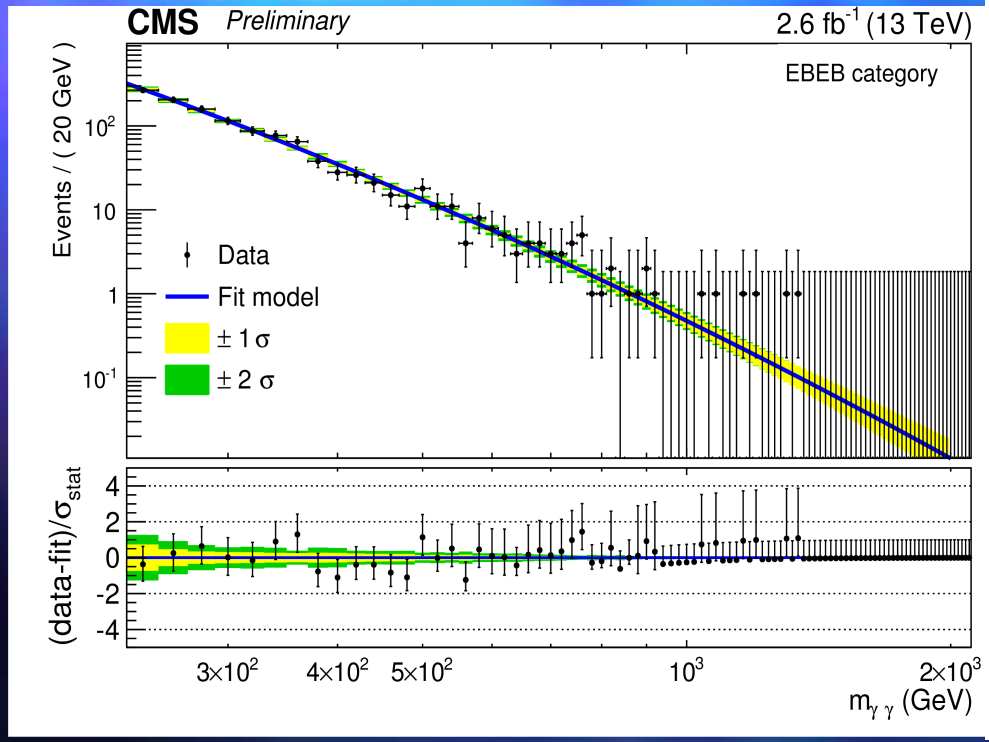
muon

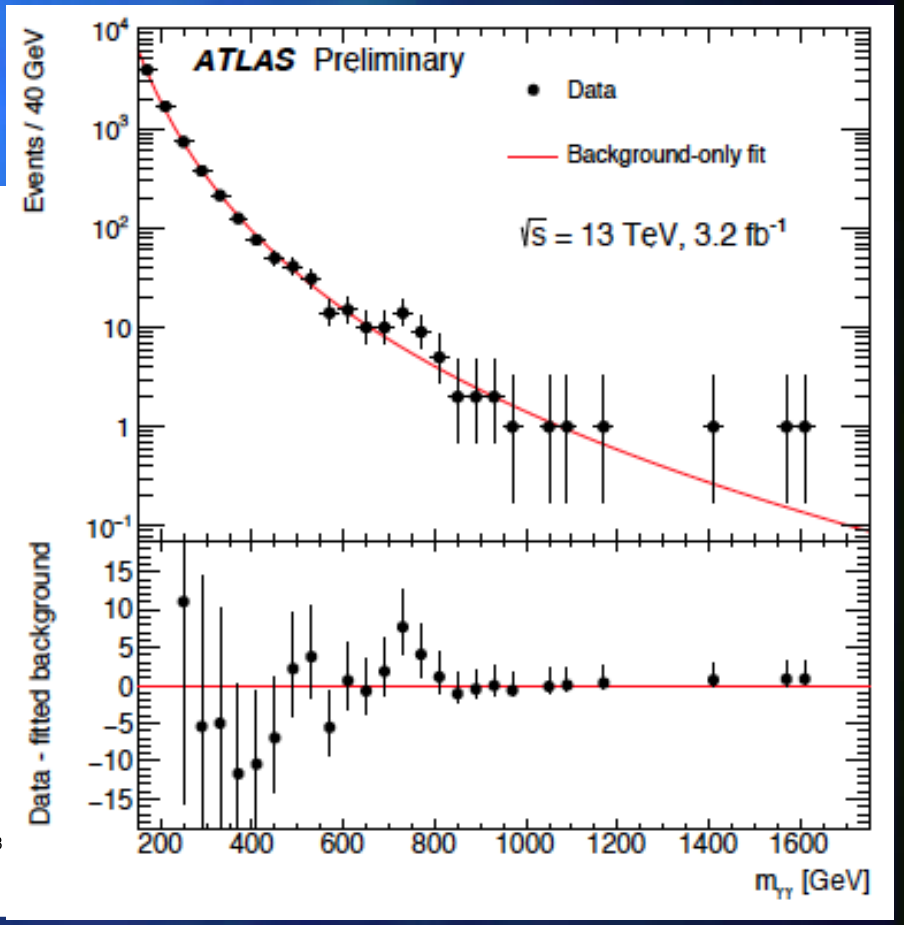


electron

Di-photon at 750 GeV

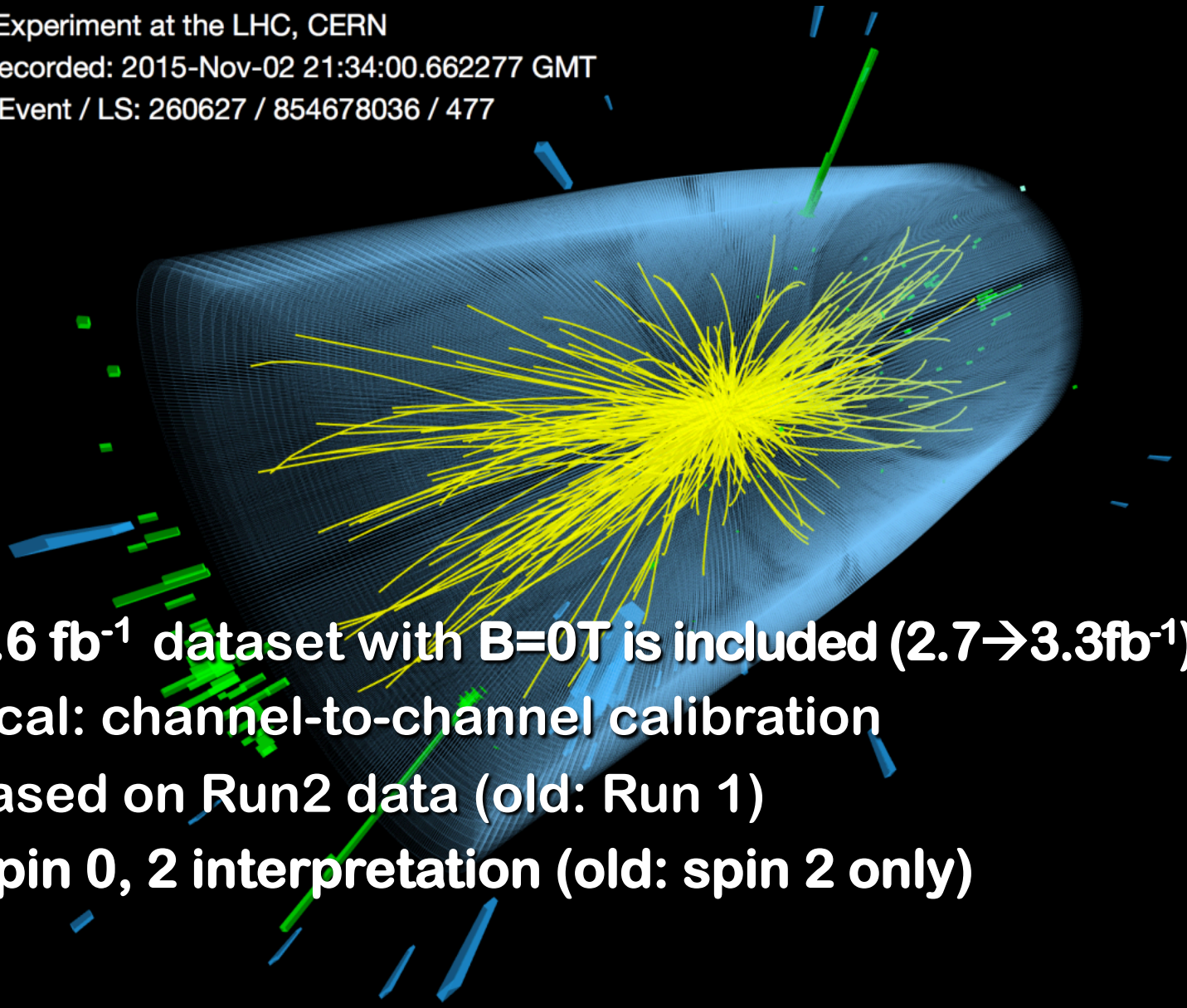
- Announced at Dec. 14, 2015
  - 2.6σ (CMS)
  - 3.6σ (ATLAS)





Update since Dec. 14, 2015

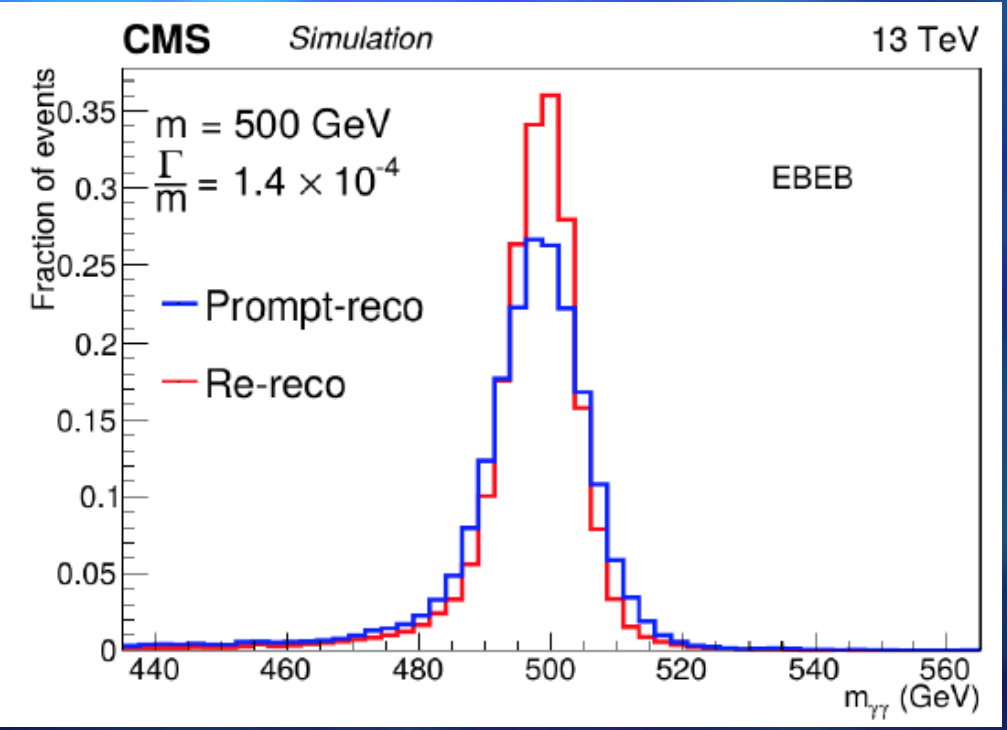
CMS Experiment at the LHC, CERN
Data recorded: 2015-Nov-02 21:34:00.662277 GMT
Run / Event / LS: 260627 / 854678036 / 477



- 0.6 fb^{-1} dataset with B=0T is included (2.7→3.3fb^{-1})
- Ecal: channel-to-channel calibration based on Run2 data (old: Run 1)
- Spin 0, 2 interpretation (old: spin 2 only)

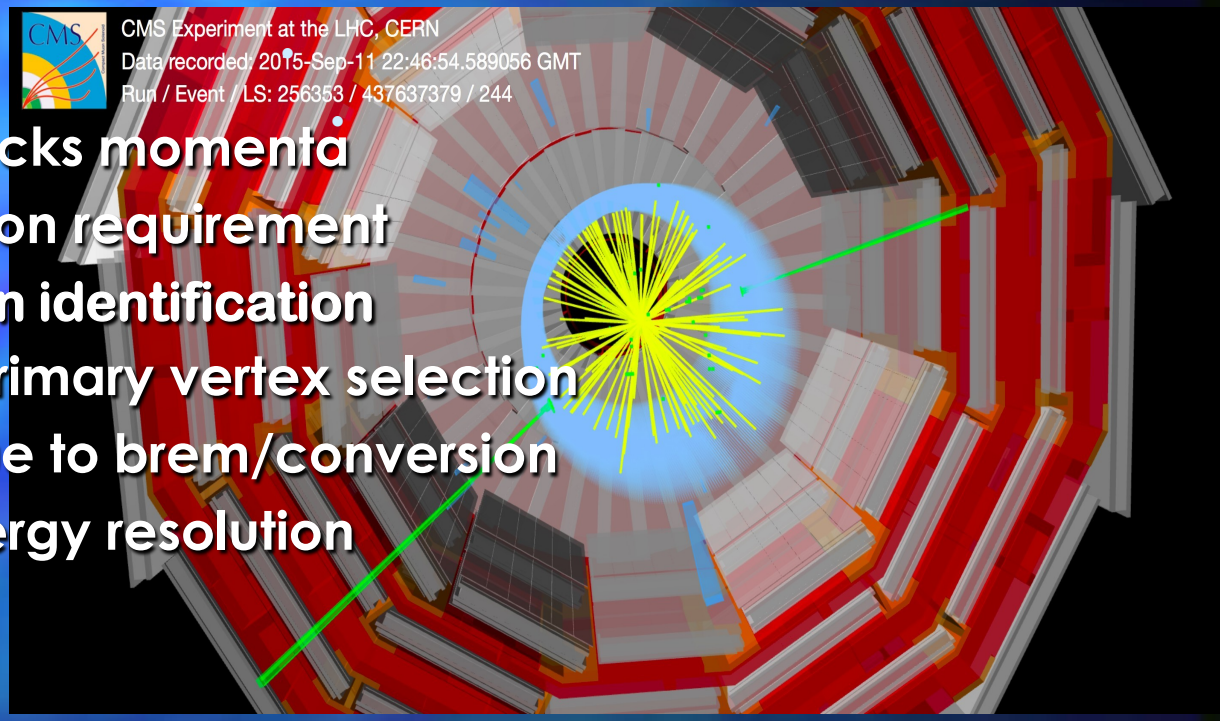
New Energy Calibration

- New channel-to-channel calibration using the 2015 data (old: based on the Run1 data)
  - 30% improvement in mass resolution above 500GeV
  - 10% improvement in analysis sensitivity



Additional data with 0 T?

- 0.6 fb^{-1} dataset with B=0T is included

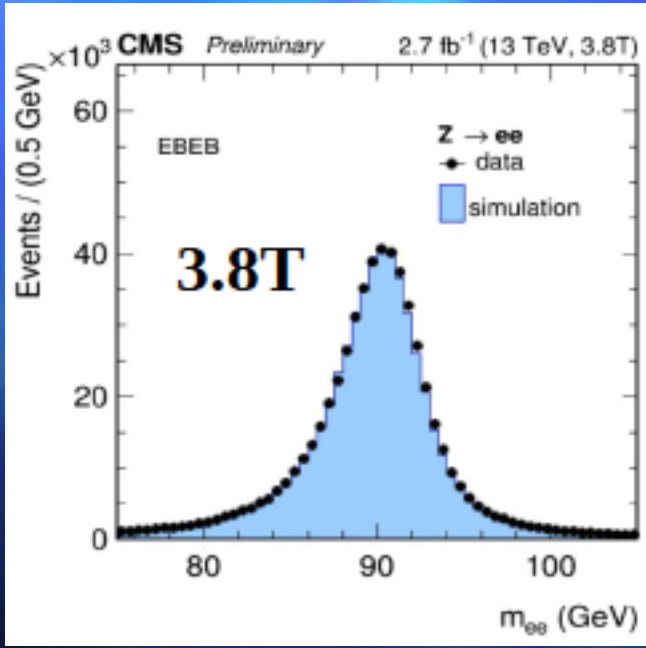


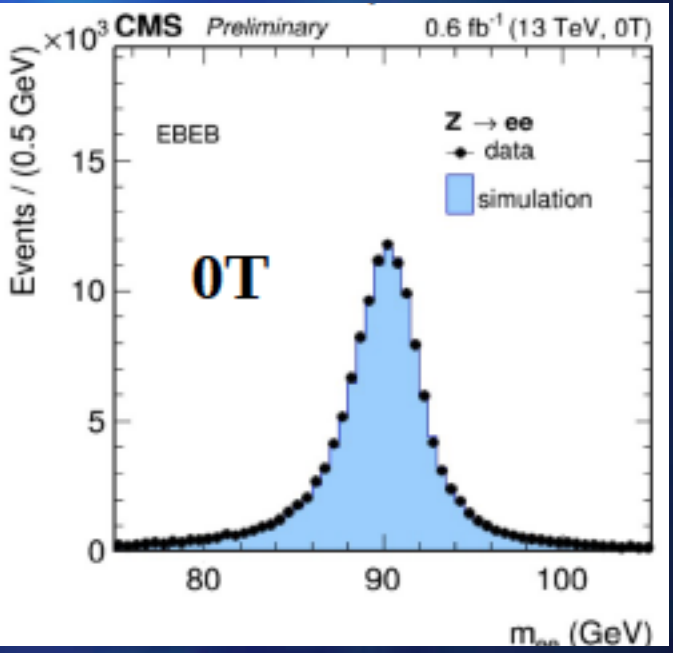
- No information on tracks momenta
  - Hard to use isolation requirement
    → dedicated photon identification
  - Hard to make a primary vertex selection
- No energy spread due to brem/conversion
  - Better intrinsic energy resolution

- 10% improvement on top of the re-calibration

Energy Scale Correction

- Energy stability checked with boosted events up to ~150GeV
- Consistent within 0.5(0.7)% in barrel (Endcaps)
- Dedicated energy scale calibration with 0T Z → ee event



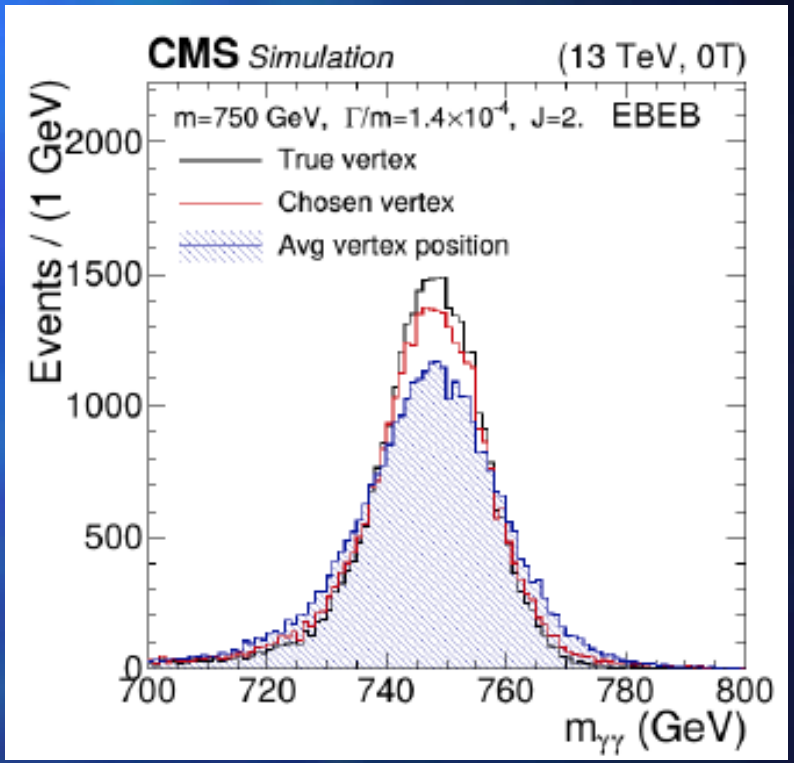


Vertex Identification

- A precise vertex information
  → good mass resolution

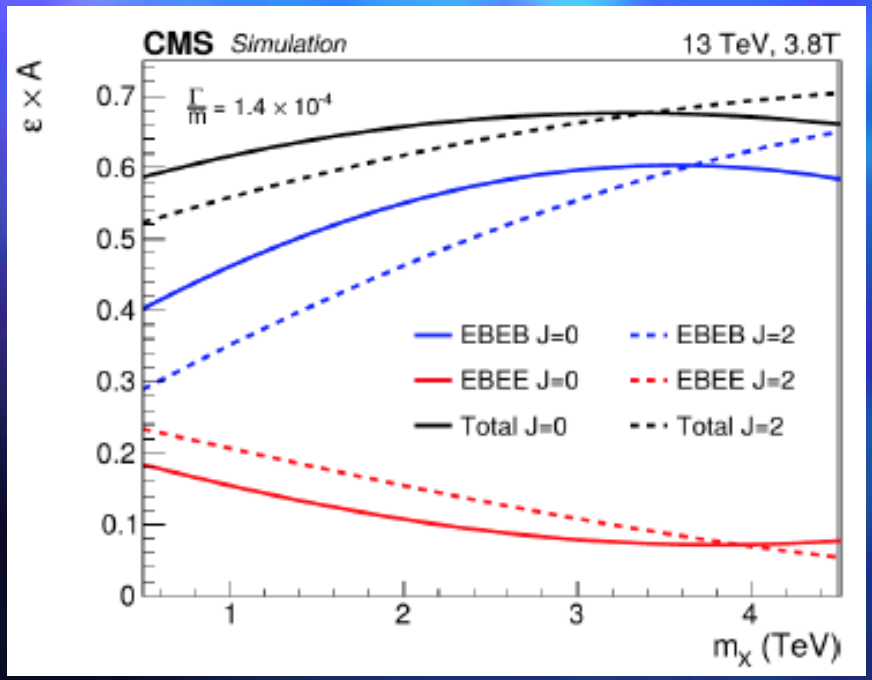
  - B=3.8T: multivariate method using recoil and tracks kinematics, trained for SM H →γγ

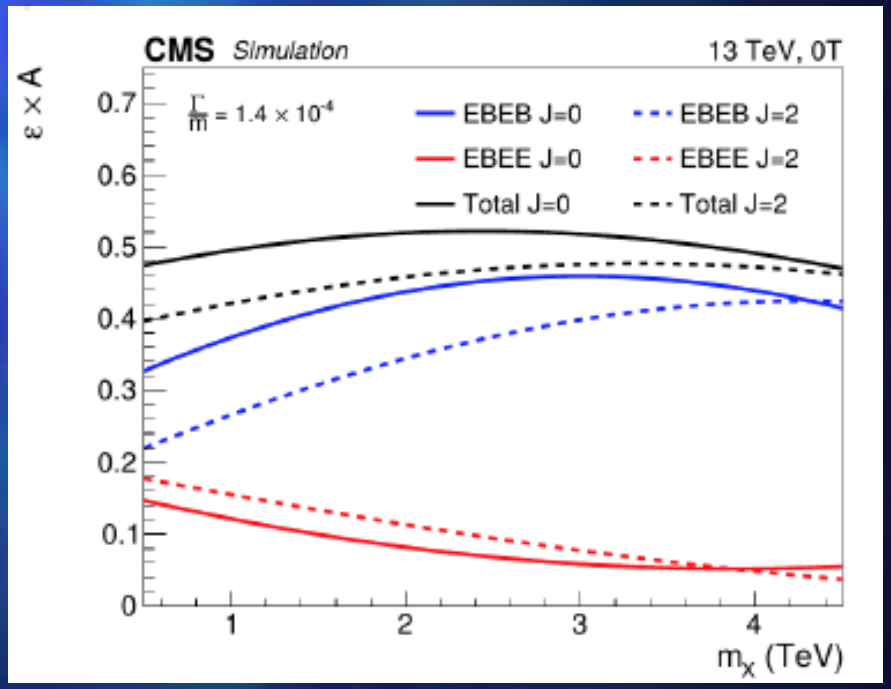
  - B=0T: simpler algorithm based on track-counting vertex with the highest track multiplicity



Di-photon Analysis

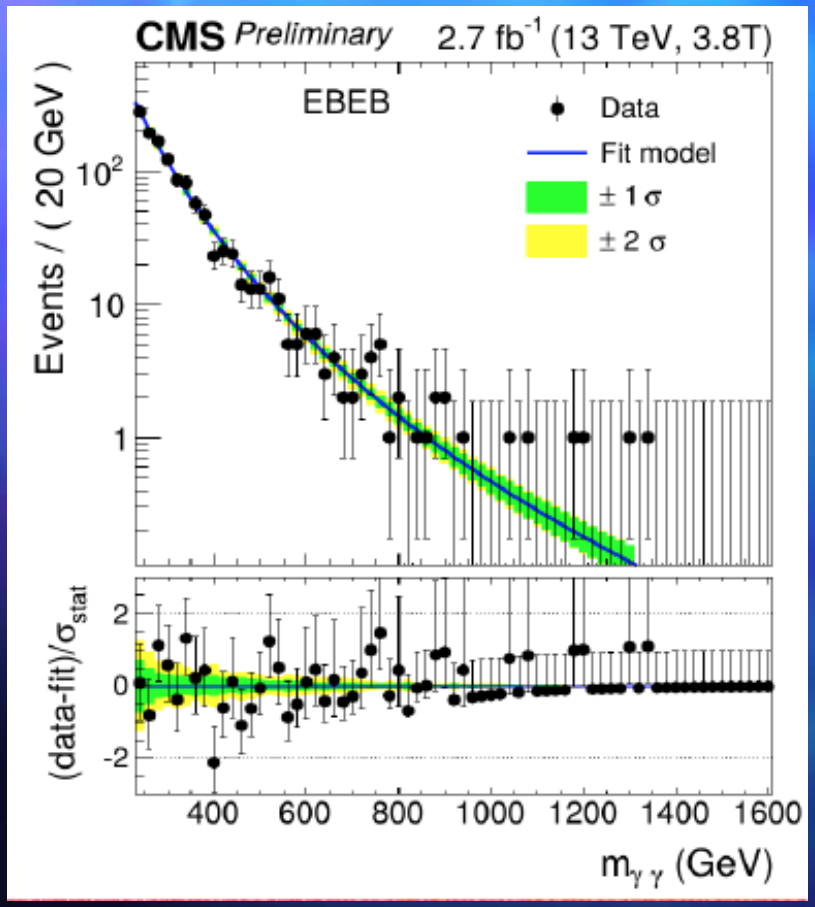
- 4 different categories: (EB-EB, EB-EE) x (3.8 T, 0 T)
- Search region: M > 500 GeV
- Select events with two photons of p_T > 75 GeV
  - ε =90% (3.8T), ε =70-80% (0T)

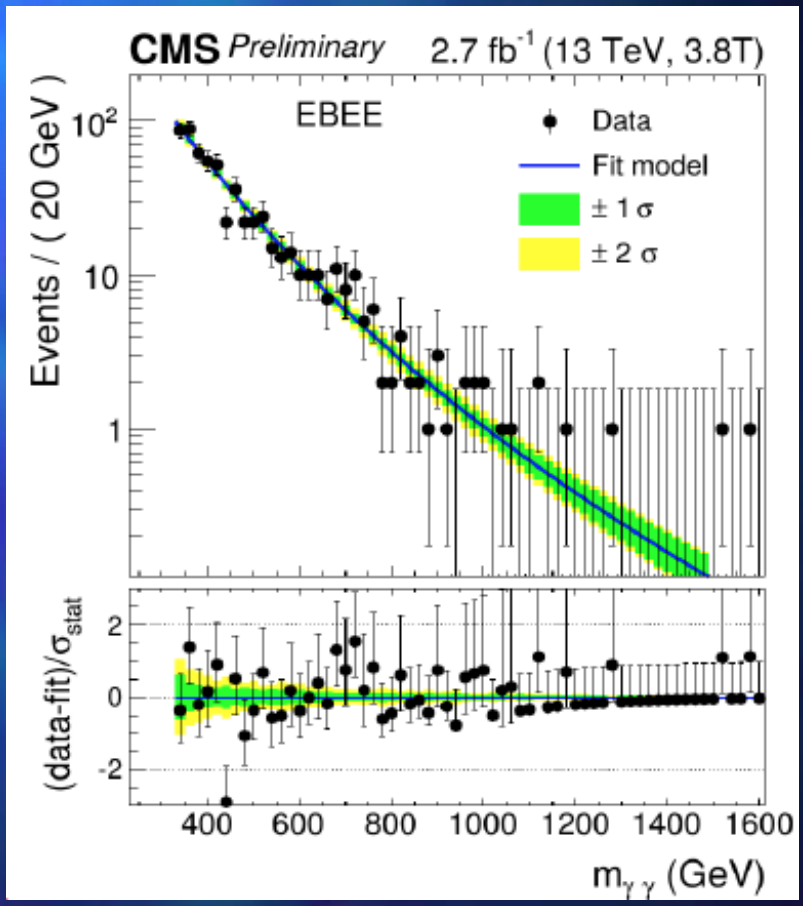




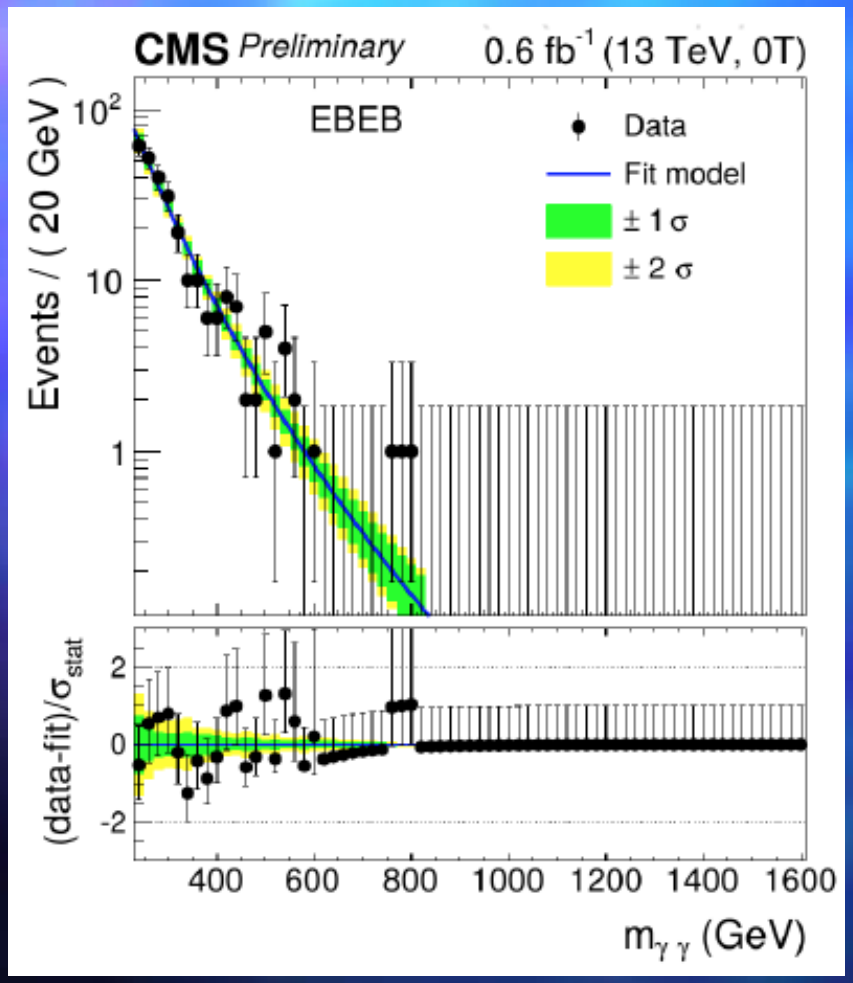
Di-photon mass at 3.8 T

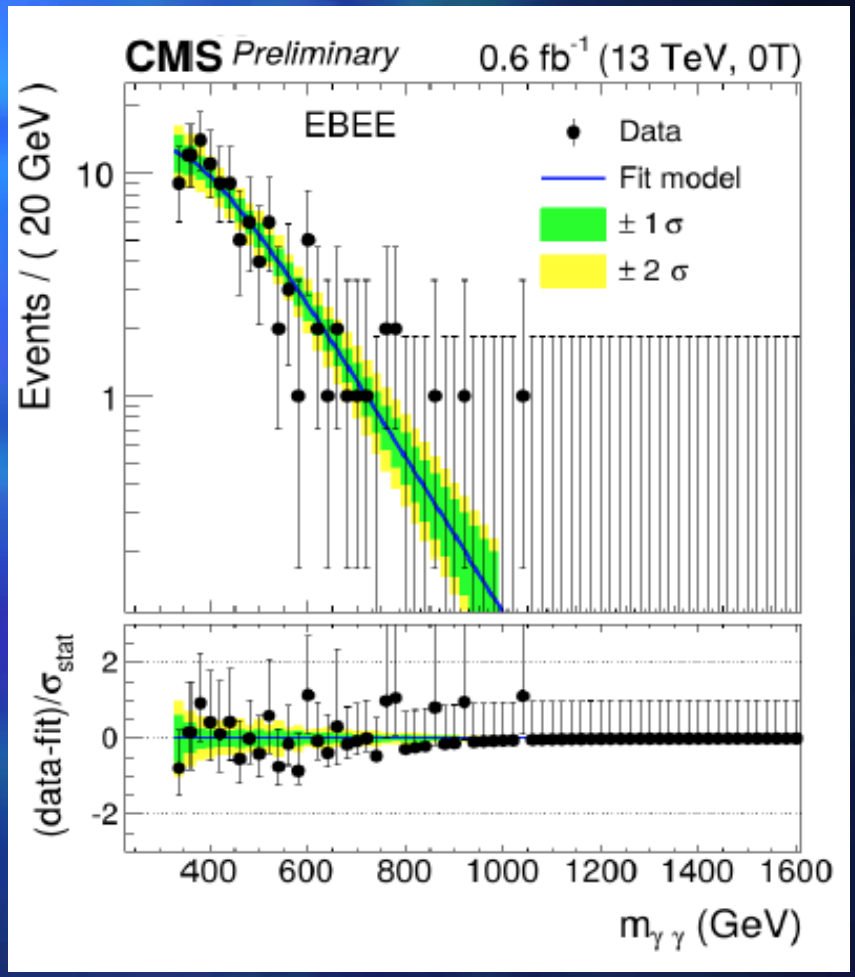
- Fit the mass dist. in 0.5-4.5 TeV using $f(m_{\gamma\gamma}) = m_{\gamma\gamma}^{a+b\cdot\log(m_{\gamma\gamma})}$





Di-photon mass at 0 T

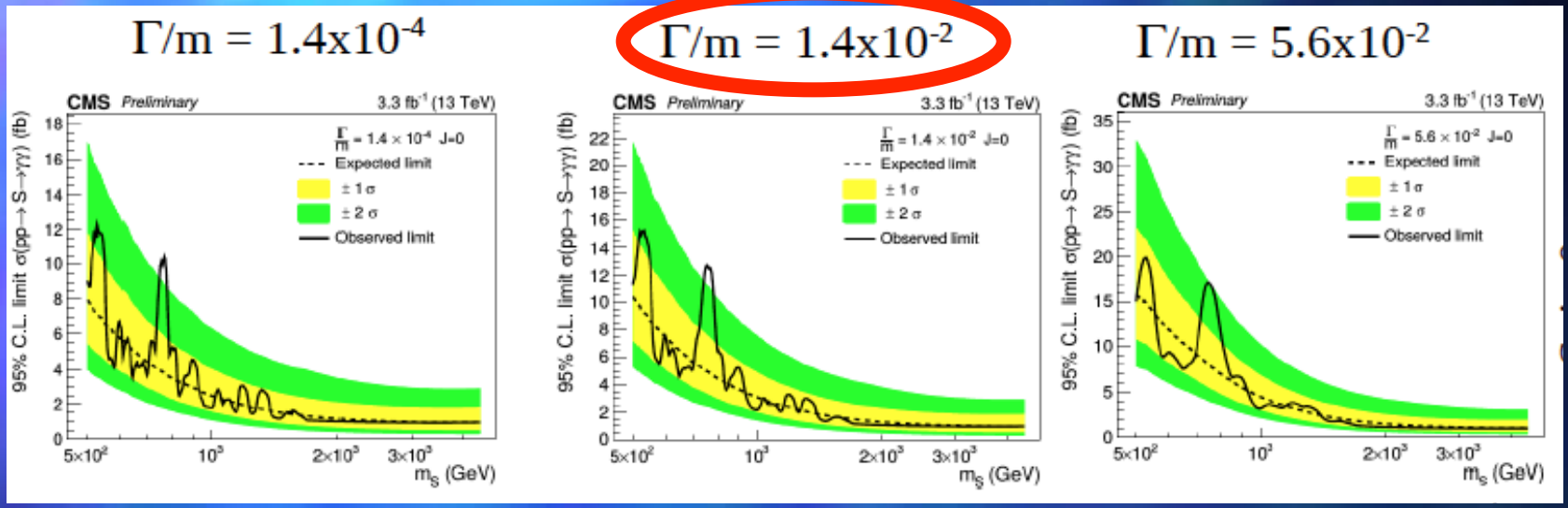


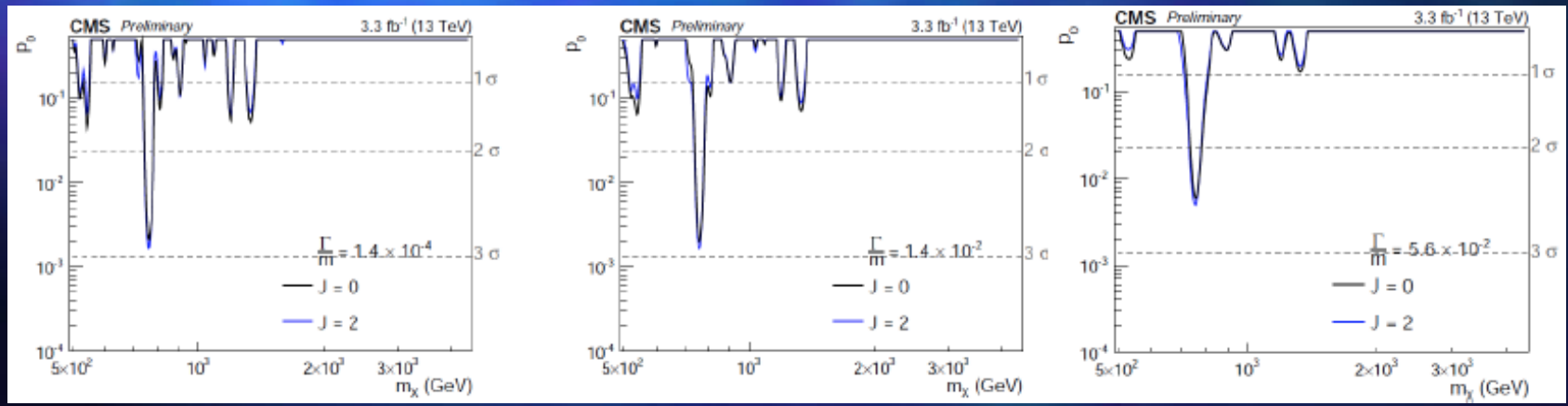


Combined Results

- Spin-0, 2 cases for 3 width hypotheses

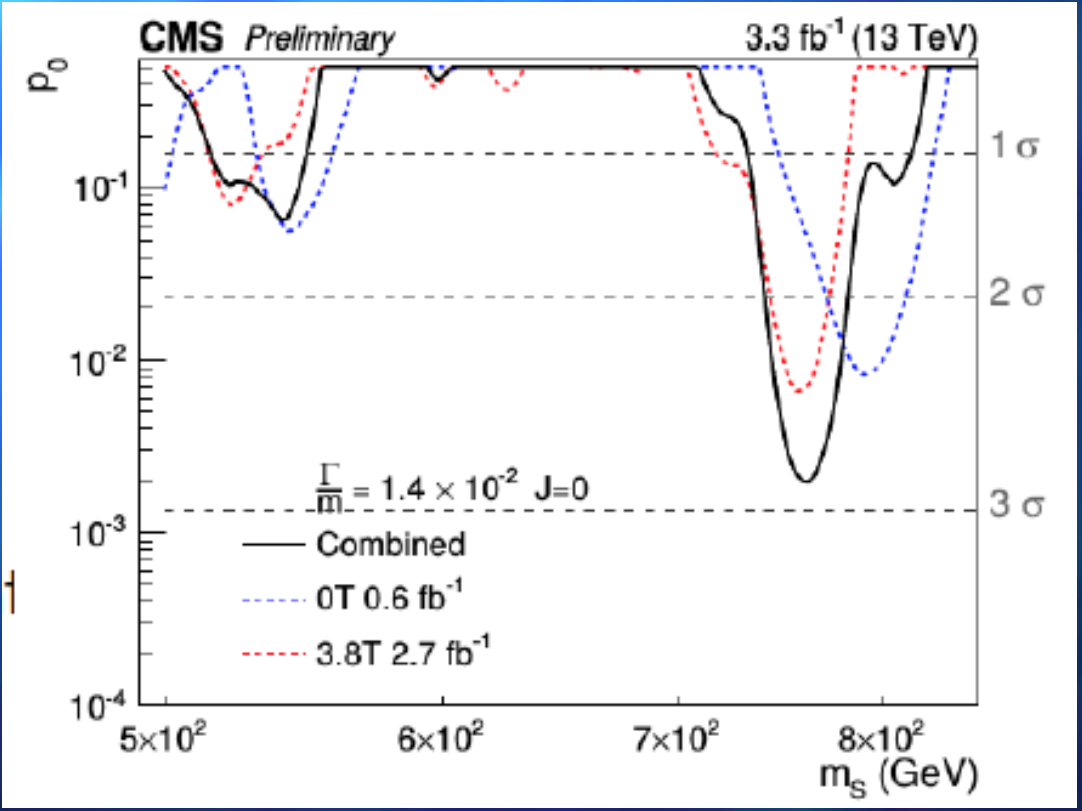
$\Gamma/m = 1.4\times10^{-4}$ | $\Gamma/m = 1.4\times10^{-2}$ | $\Gamma/m = 5.6\times10^{-2}$





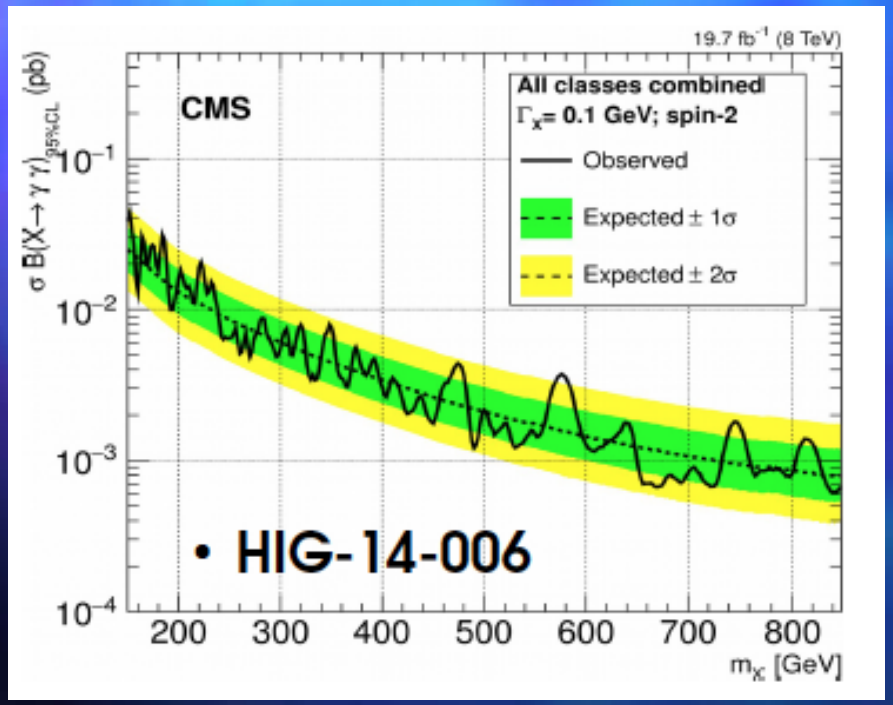
Combined Results

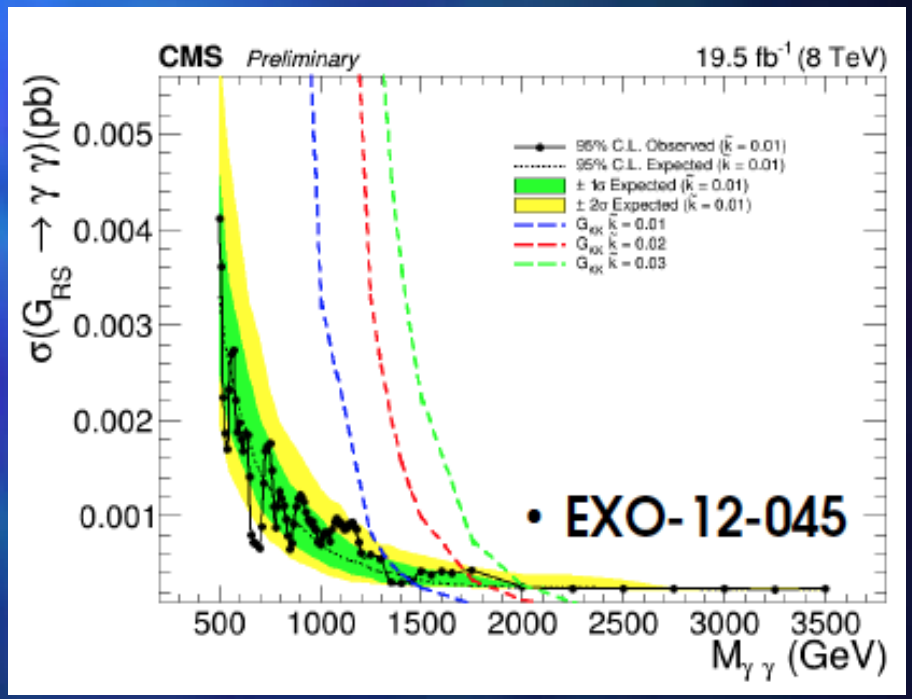
- Largest excess for m = 760GeV with J=0 & $\Gamma/m = 1.4\times10^{-2}$
- 2.8-2.9σ local significance (excess mainly by EBEB events)
- <1σ global" significance including look-else effect



8 & 13 TeV combined analysis

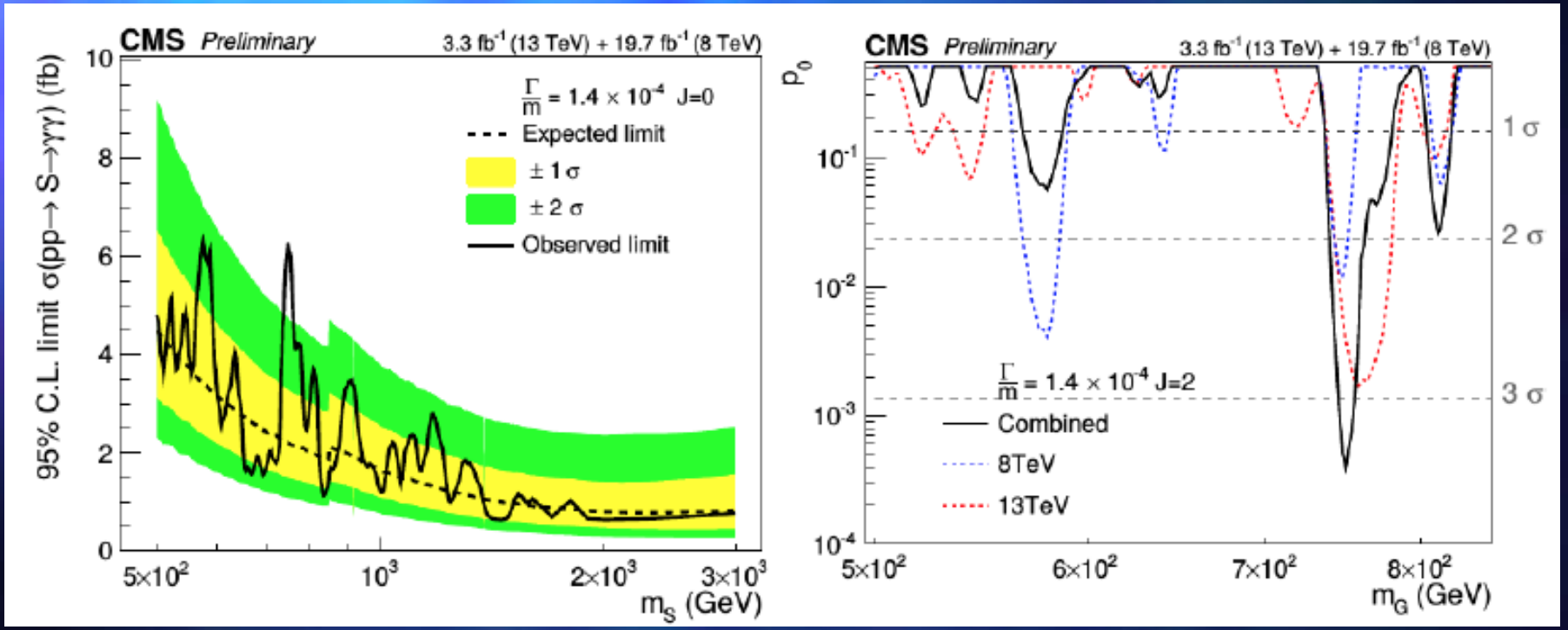
- Two search results at 8 TeV
  - Higgs: [150-850 GeV], HIG-14-006
  - Exotic: [500-3000 Gave], EXO-12-045





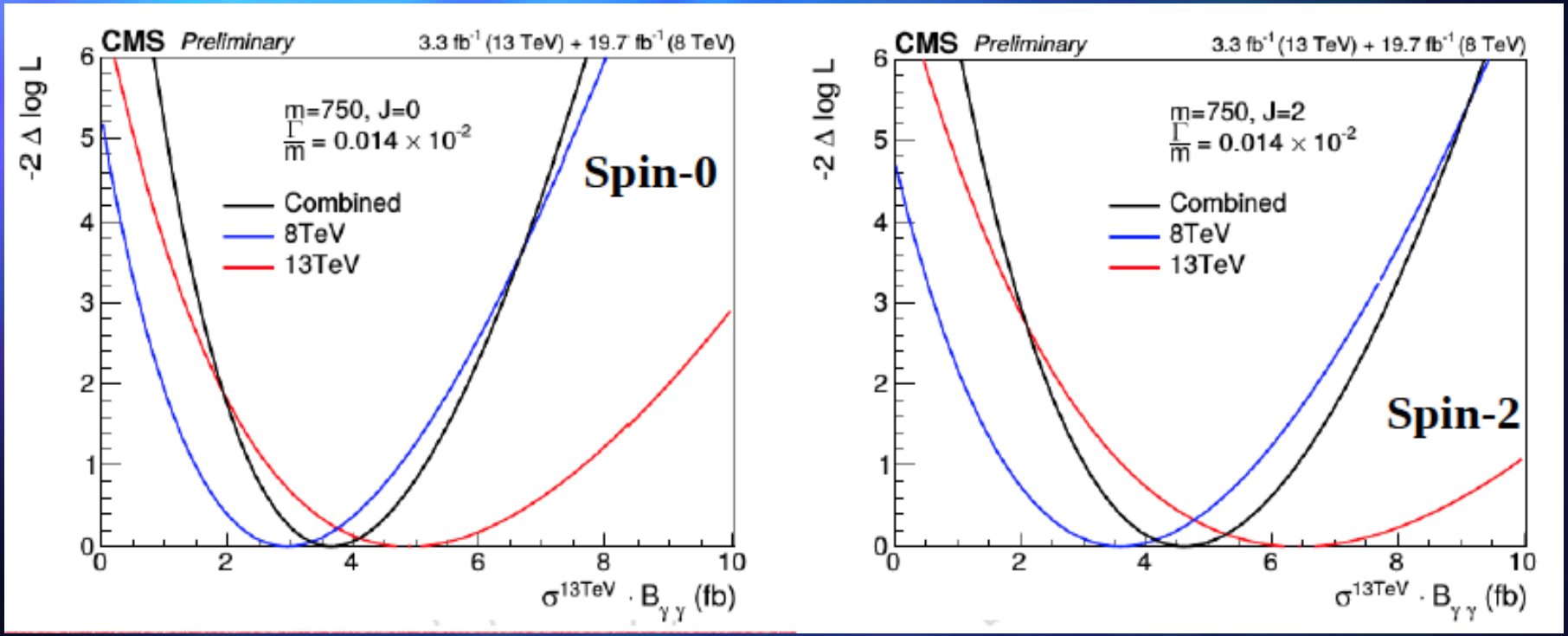
8 & 13 TeV combined results

- Results are normalized to 13 TeV cross section
- Local significance is increased to 3.4 σ (Γ =0.1 GeV, J=2)
- Gloal significance: 1.6σ

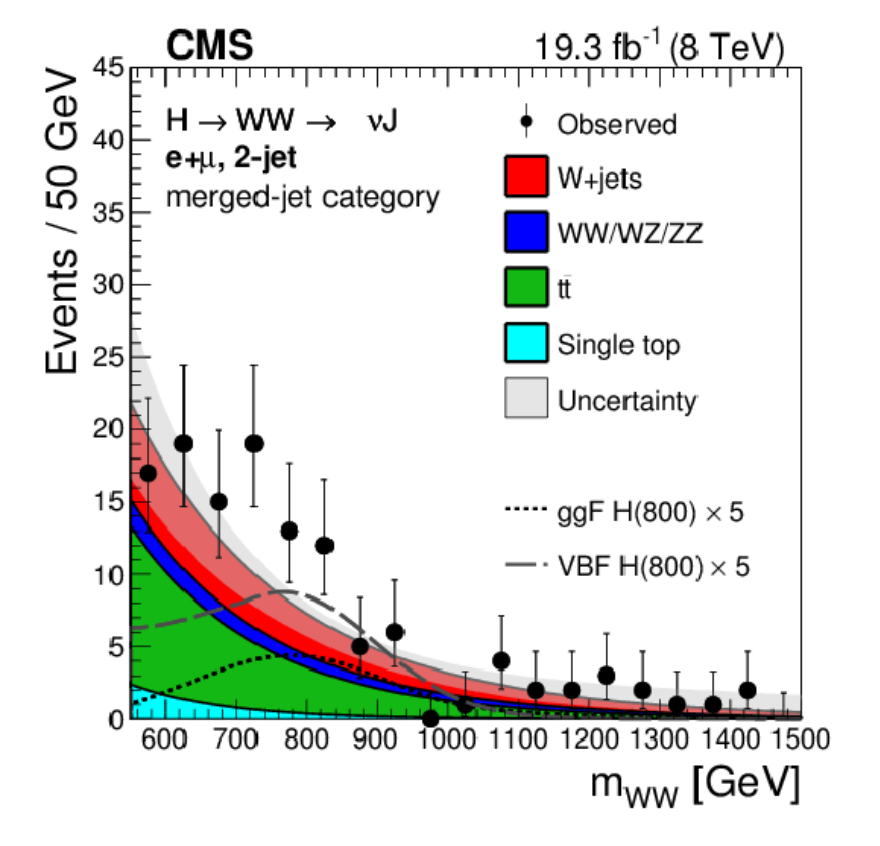


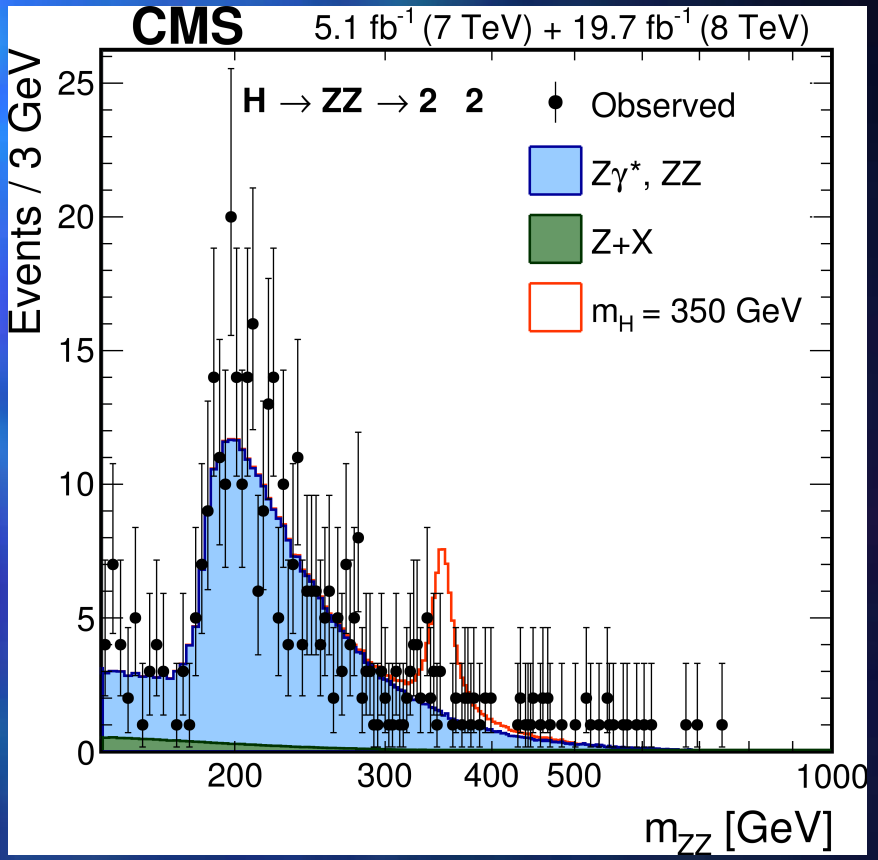
Consistency between 8 and 13 TeV

- Checked through likelihood scan vs equivalent cross section at 750 Gave with narrow-width hypothesis
- Comparable results



H→WW,ZZ at 8 TeV

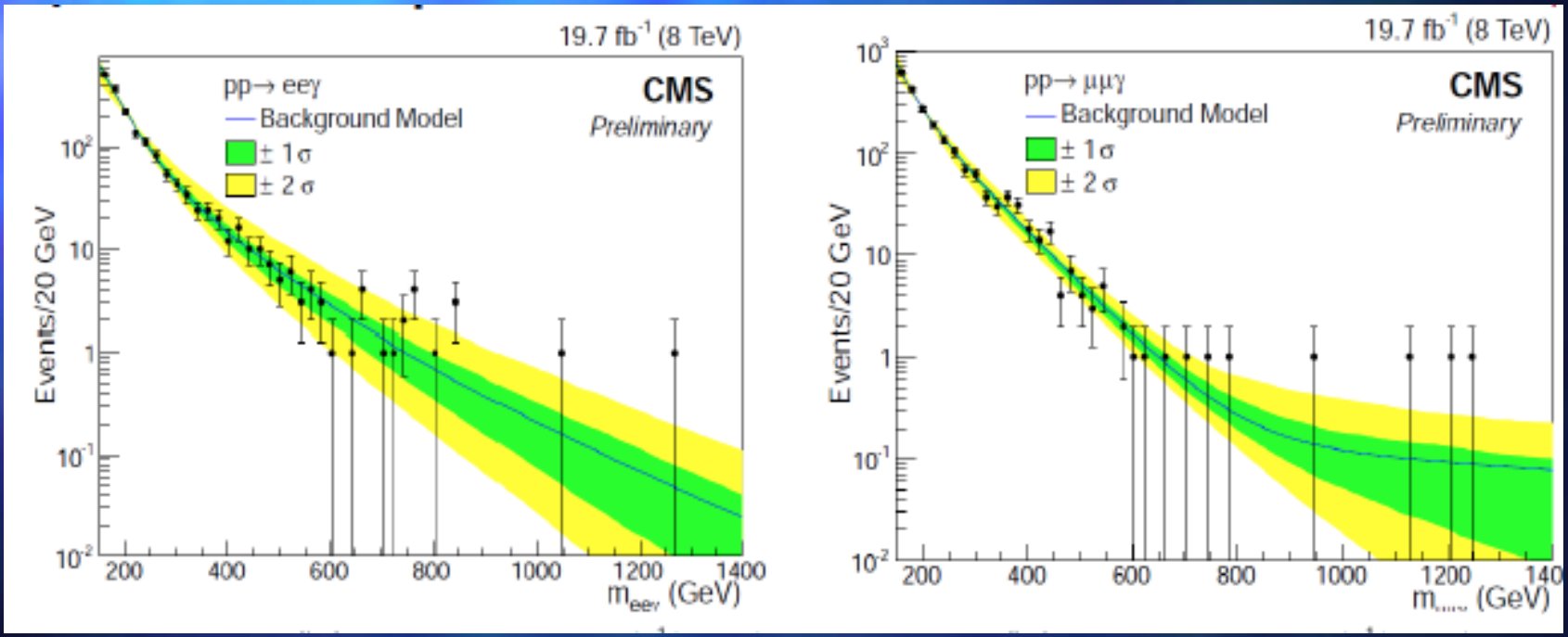




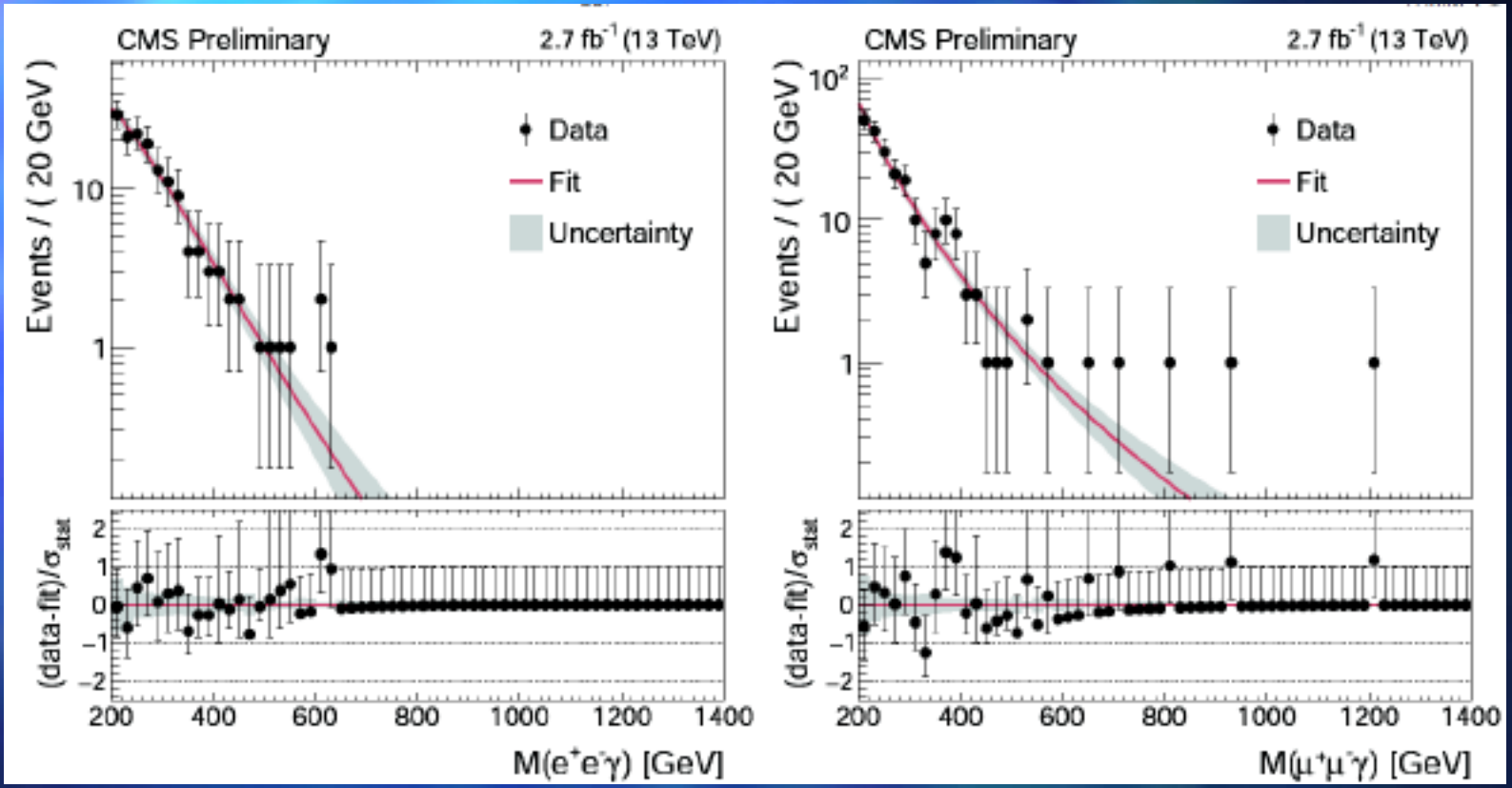
- **2.6σ excess : JHEP 10 (2015) 144**

Search in Z+γ

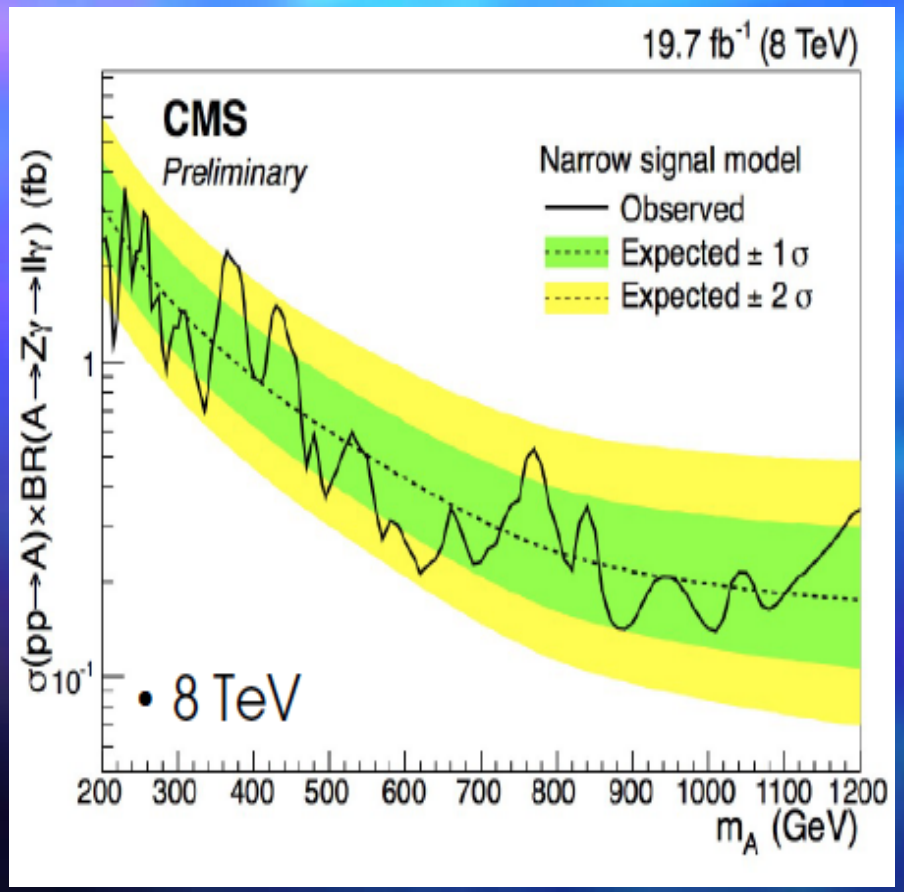
- Search in Z+ γ : disentangle new physics at 750 GeV
- Use di-electron and di-muon channel
- Mass resolution: 1%(ee), 1.4-3%($\mu\mu$)

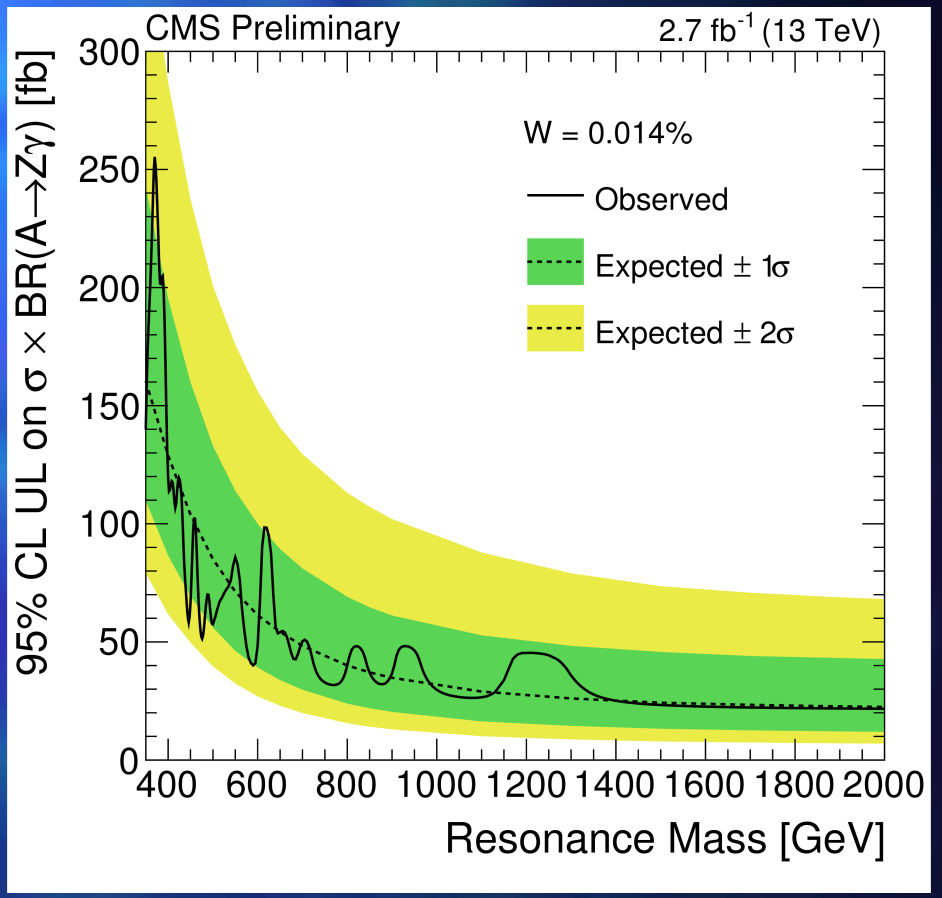


Search in Z+γ


CMS Preliminary
2.7 fb^{-1} (13 TeV)
Data
Fit
Uncertainty
Events / (20 GeV)
(data-fit)/σ_{stat}
M(e$^+$e$^-$γ) [GeV]
CMS Preliminary
2.7 fb^{-1} (13 TeV)
Data
Fit
Uncertainty
Events / (20 GeV)
(data-fit)/σ_{stat}
M(μ$^+$μ$^-$γ) [GeV]

Results from Z+γ





Summary

- After a great success of the Run1, LHC opens another new territory in search for new physics
  - SM at 13 TeV is still valid so far, limited by statistics
  - Many searches from all different angles are underway.

- An interesting excess is shown in di-photon in both experiments based on the 2015 data (3.3fb^{-1})
  - Checks in different channels are underway
  - Eagerly Waiting for more data:
    - Another 5 fb^{-1} for ICHEP16 and ~25 fb^{-1} by 2016