CMS Diphotons (and other things at 750 GeV)

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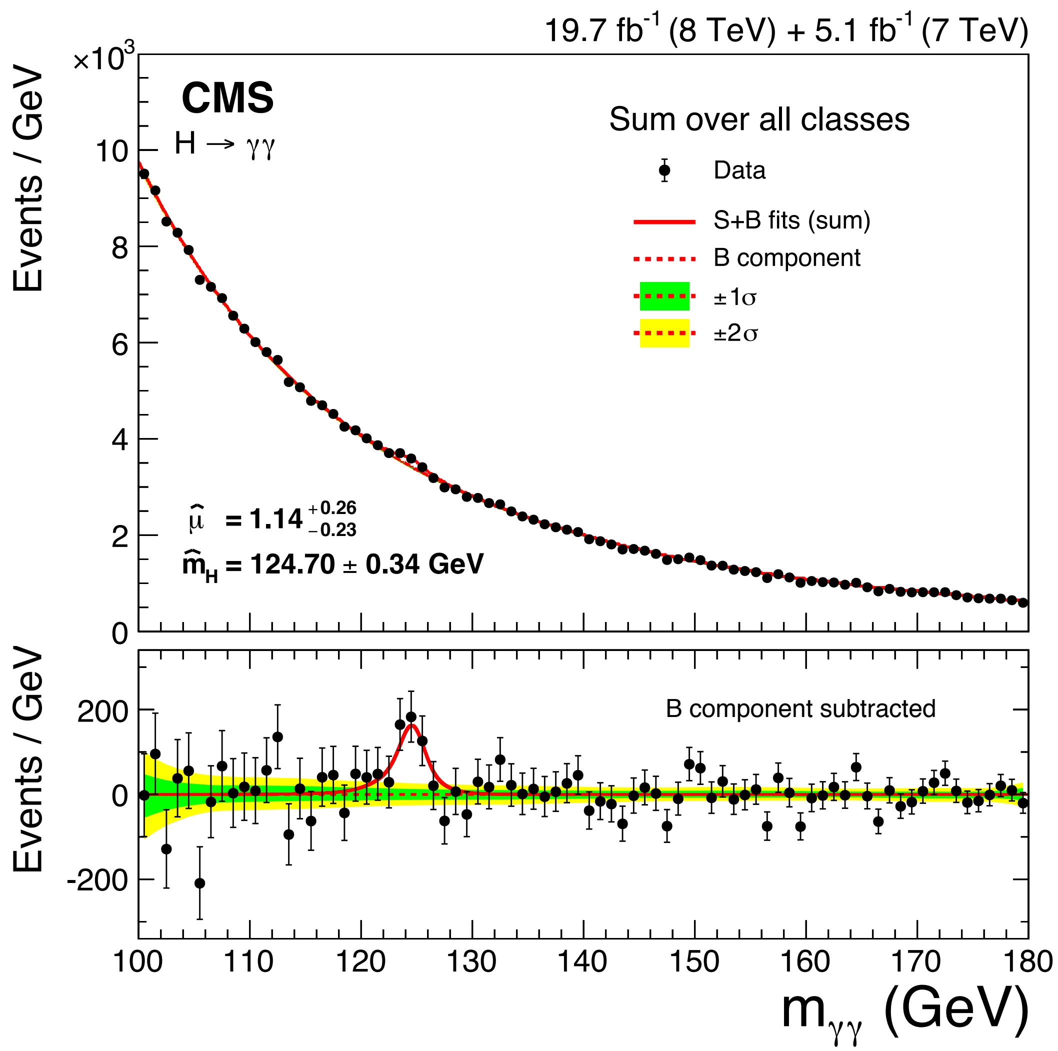
Motivation

[HIG-13-001]

- (Diphoton) resonances are an inherently powerful way of discovering new states
  - Two free, model independent, parameters: mass and width (and spin)
  - Whether or not a new particle fits within a well motivated scheme is a (good) problem for theorists



STRATEGY

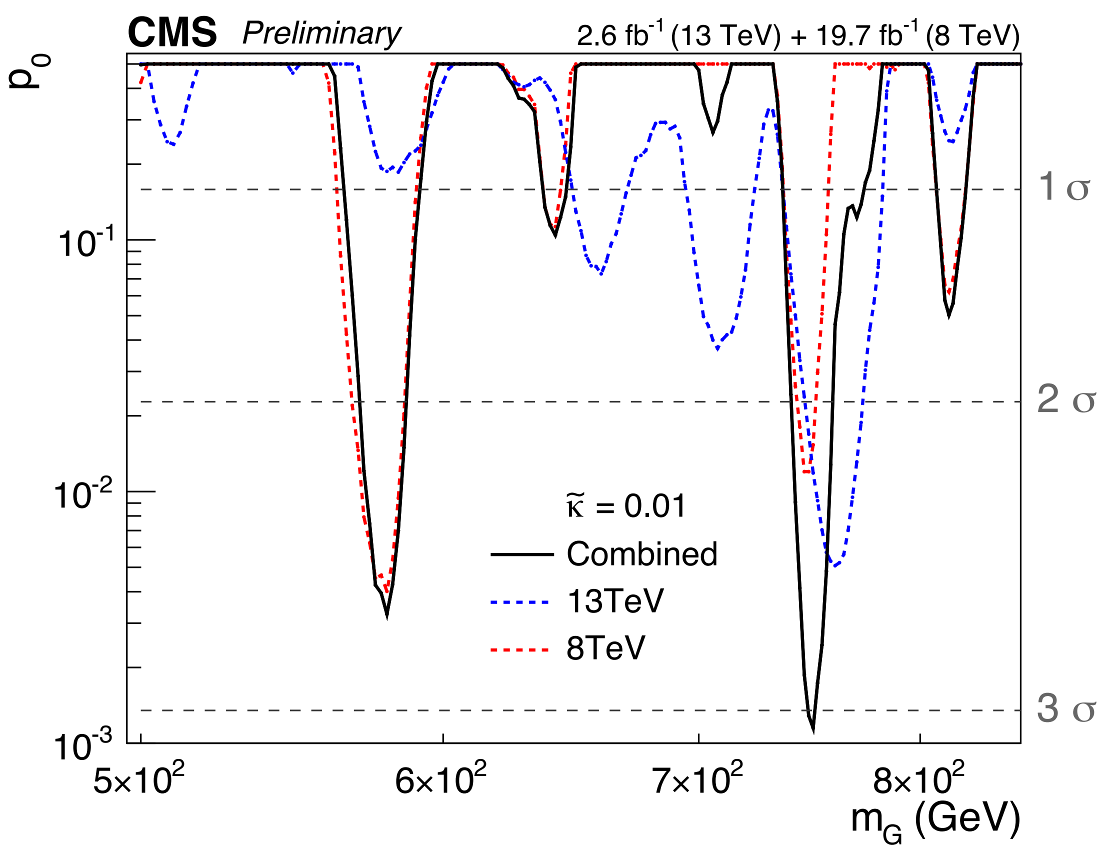
- Select diphoton pairs and search for a local excess of events in the invariant mass spectrum
  - split events between where the two photons are located: “barrel-barrel” and “barrel-endcap”
- Measure energy scale, resolution and efficiency in data
  - $Z \to ee$ and $Z \to \ell\ell\gamma$ are the primary control channels for photons
- Fit background mass spectrum directly in the data
  - bias tests performed to ensure that type-I and type-II errors are under control
  - Background composition from all sources is assumed to be **smoothly falling**
    - dominated by SM diphoton production and x-checked with MC predictions

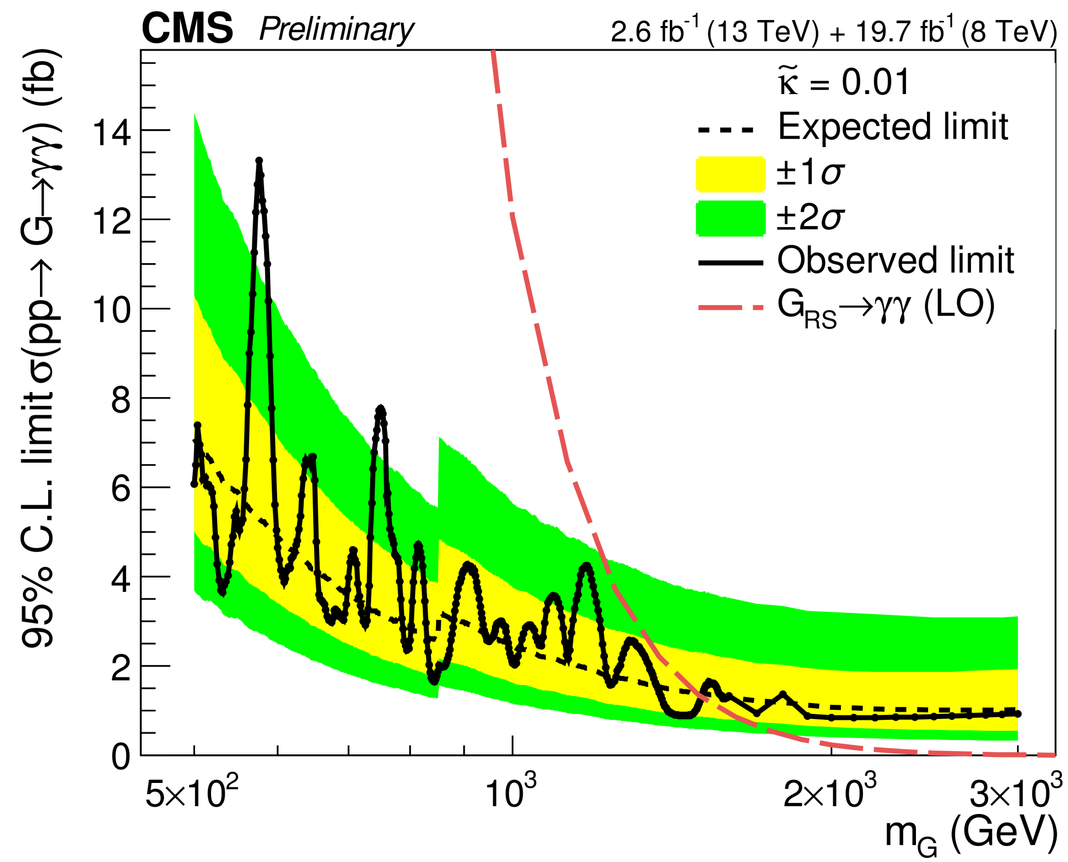
DIPHOTONS AT CMS

[EXO-15-004]

December 2015 Jamboree Result

8+13 TeV Combination

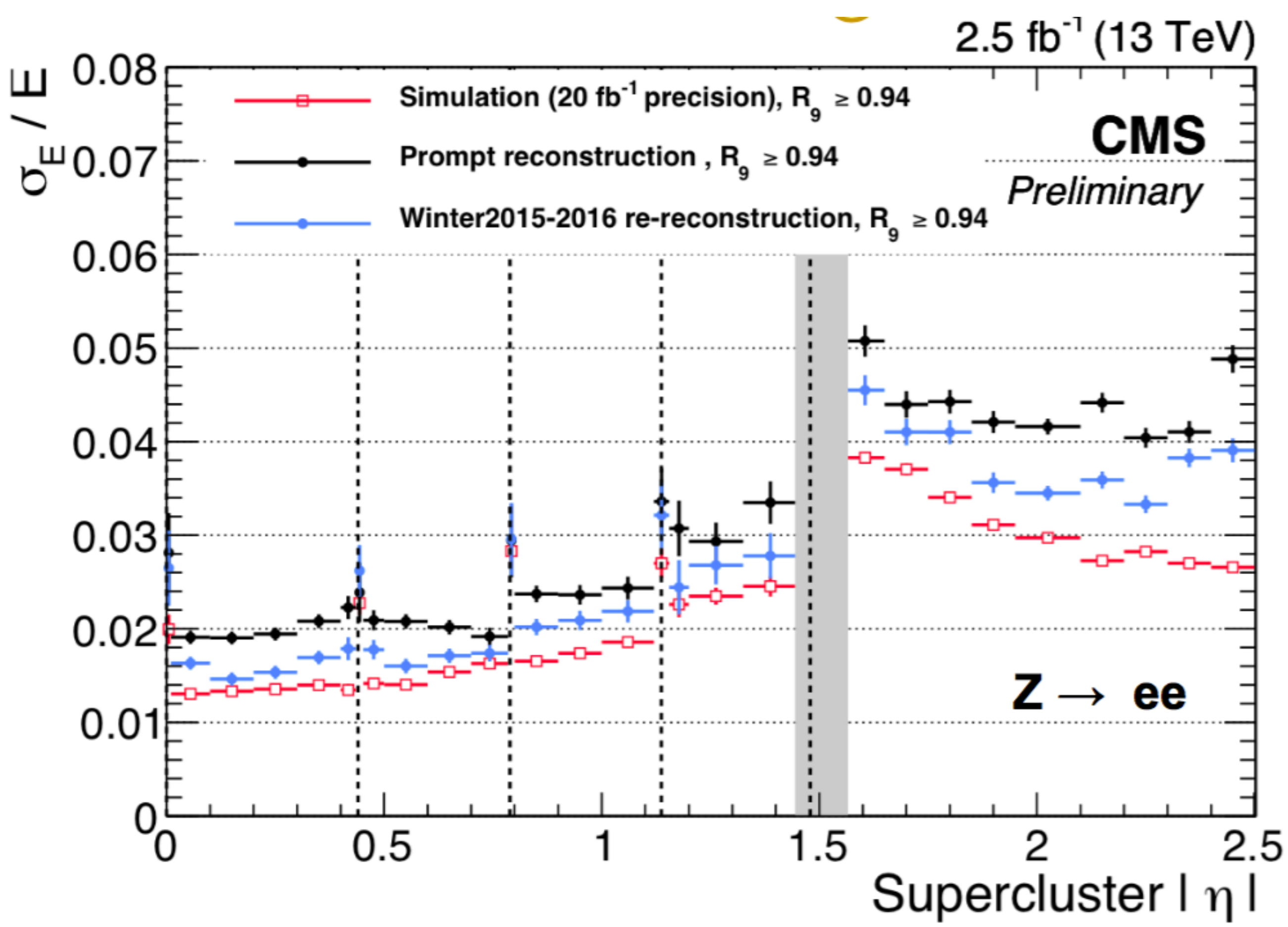


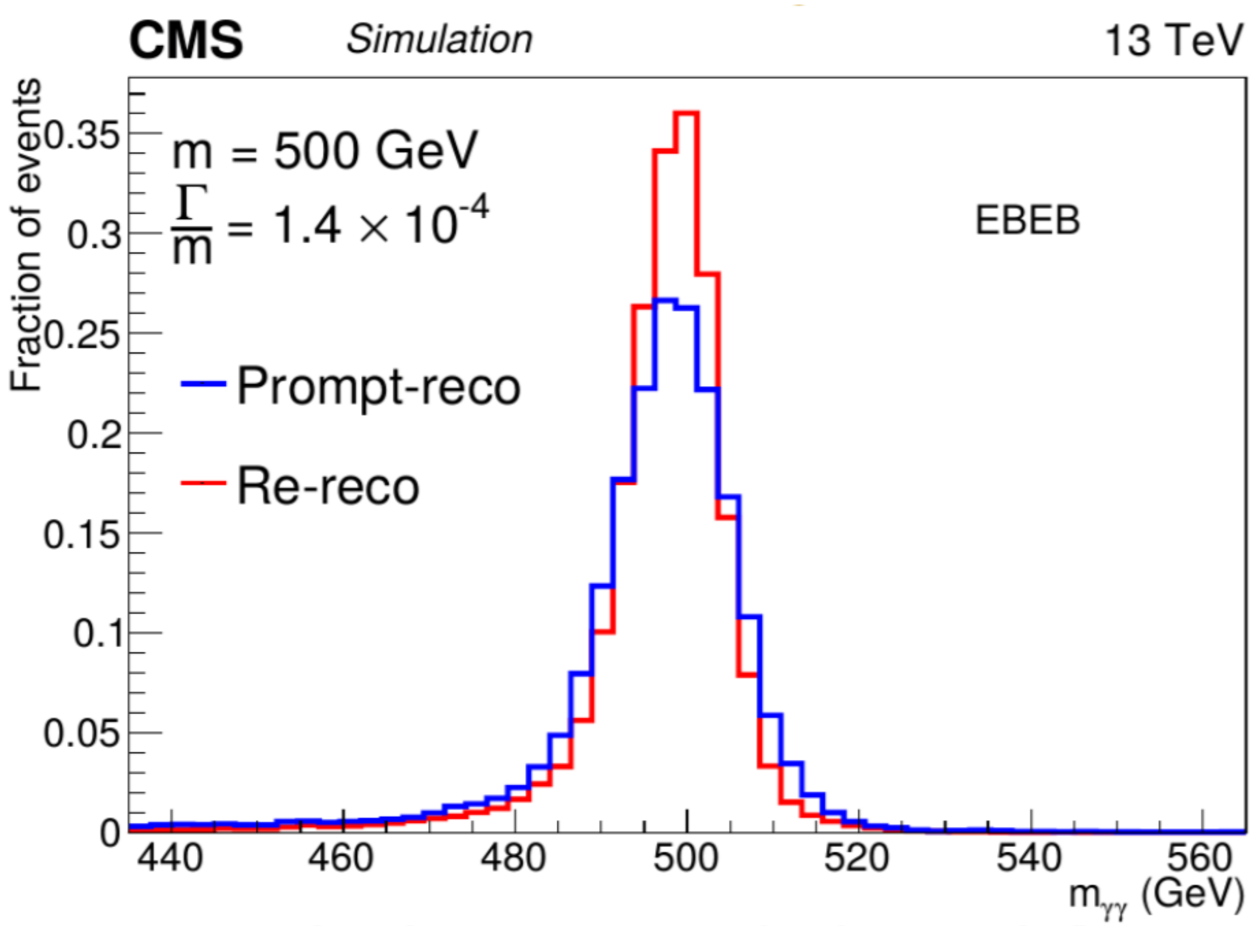


- Status update of December 2015 result (shown above)
  - Added B=0T dataset
    - additional luminosity of 0.6/fb
  - Re-reconstruction of data with latest ECAL calibration

CHANNEL-BY-CHANNEL CALIBRATION

- Reprocessed dataset with new calibration obtained from the 2015 run
  - mass resolution improved 30%

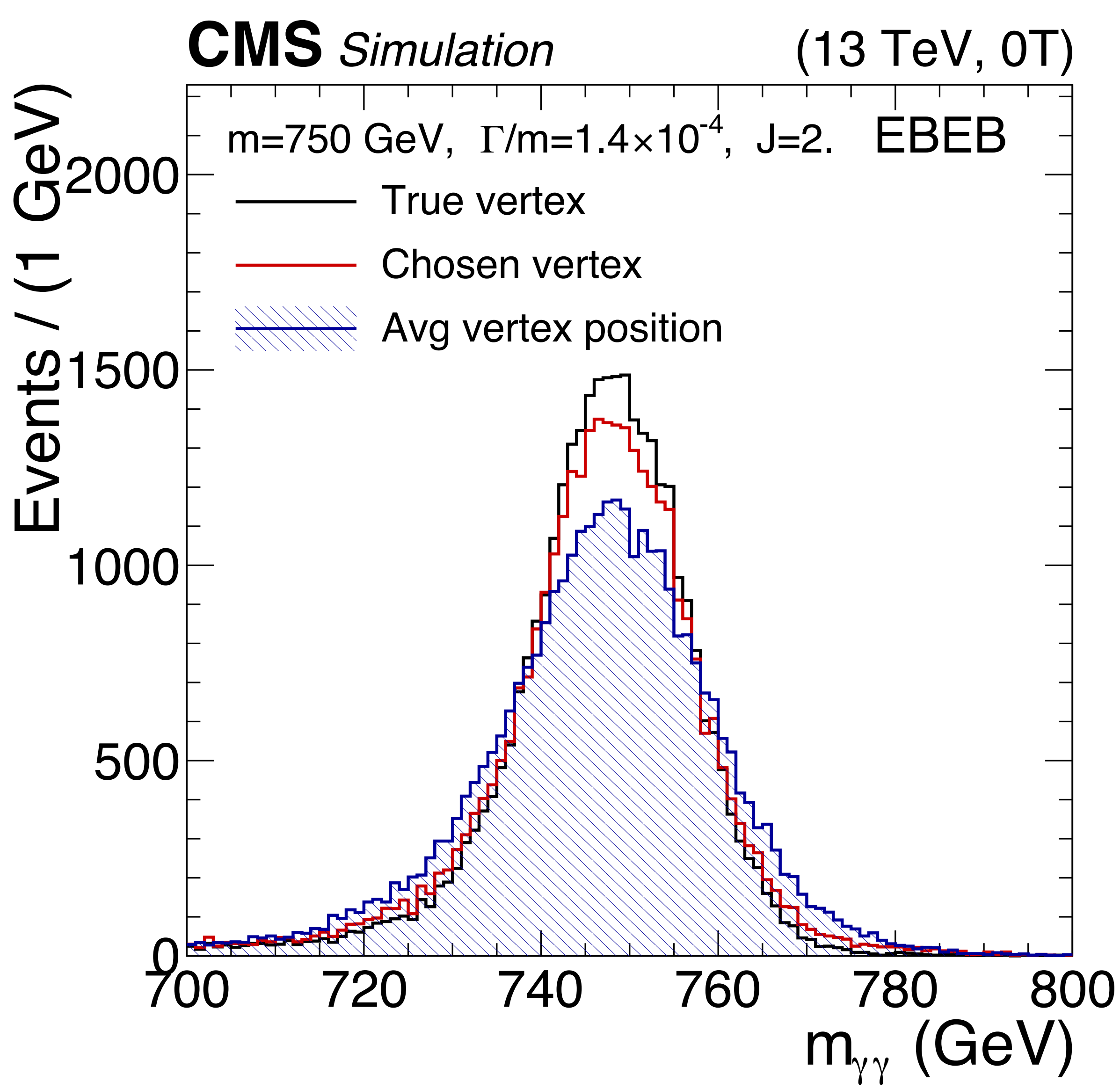




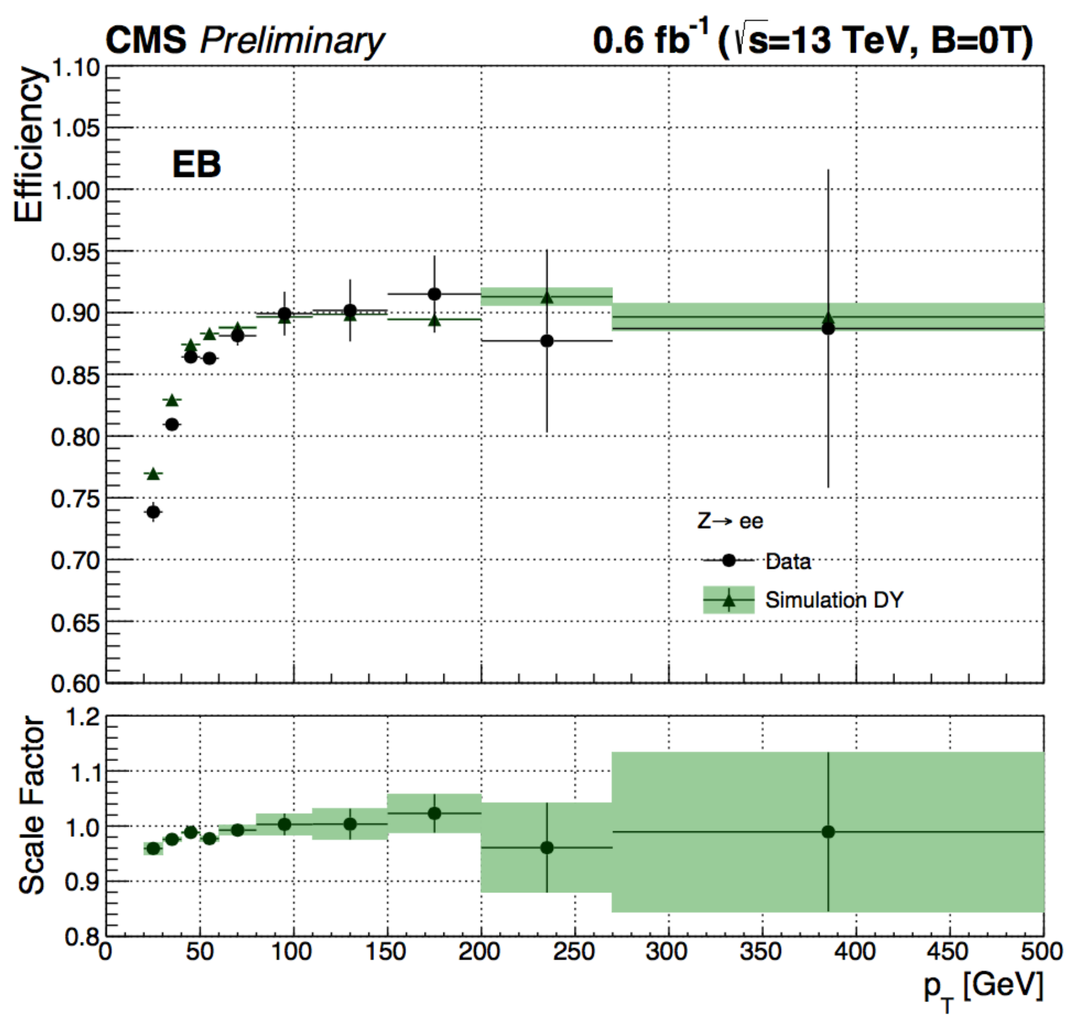
0T RECONSTRUCTION

[EXO-16-018]

- Dedicated 0T vertex ID
  - Vertex selected with the highest track multiplicity



- Dedicated 0T photon ID
  - charged track multiplicity<4
  - use shower shape along **phi direction** (as well as eta)
  - e veto: # of missing hits > 1



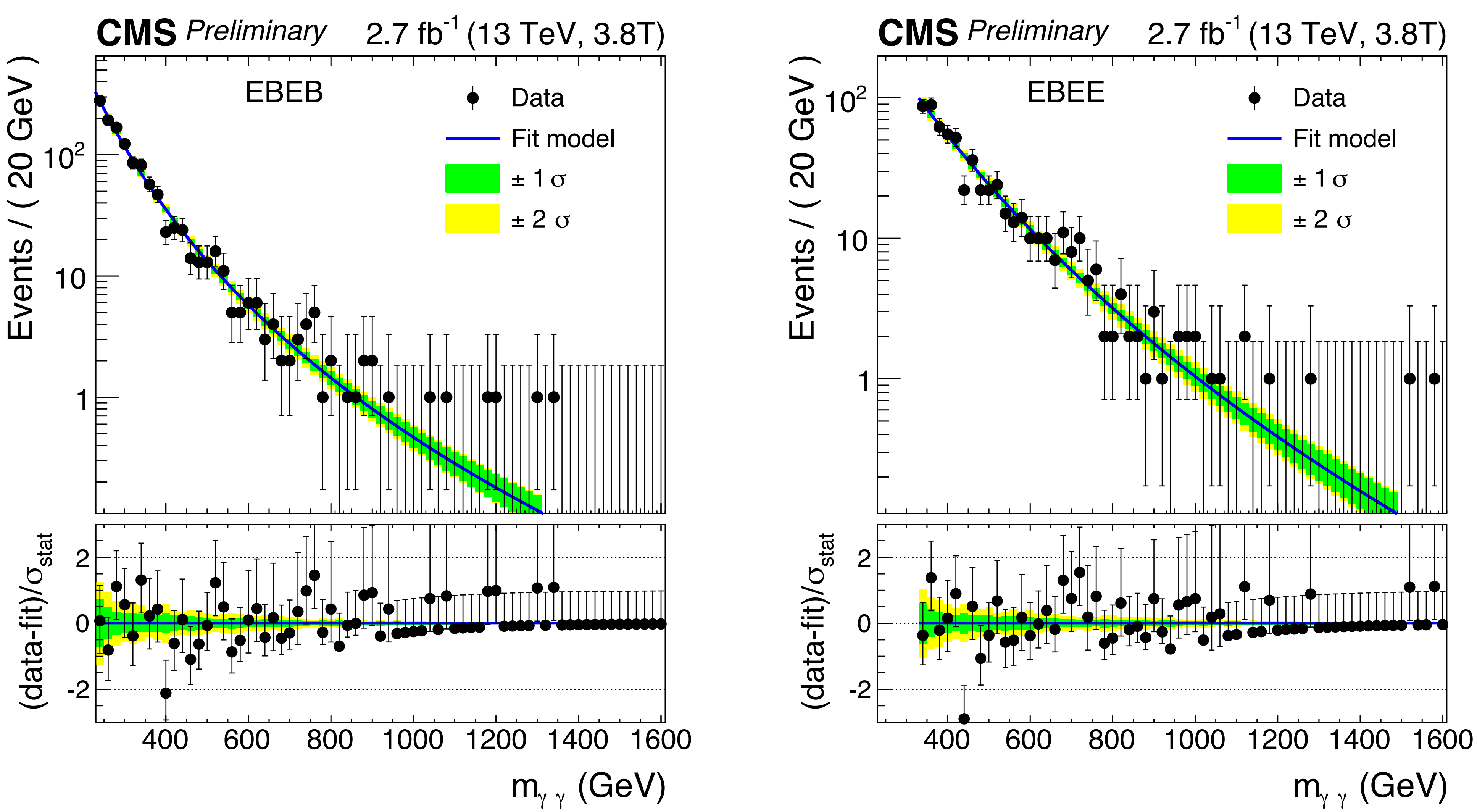
RE-PROCESSED 3.8T DATA

[EXO-16-018]

- Improved calibration yields 10% greater sensitivity
  - Fit background directly to the data using parameterization:

$$f(m_{\gamma\gamma}) = m_{\gamma\gamma}^{a+b\log m_{\gamma\gamma}}$$

Diphoton spectrum at 3.8 Tesla (13 TeV)

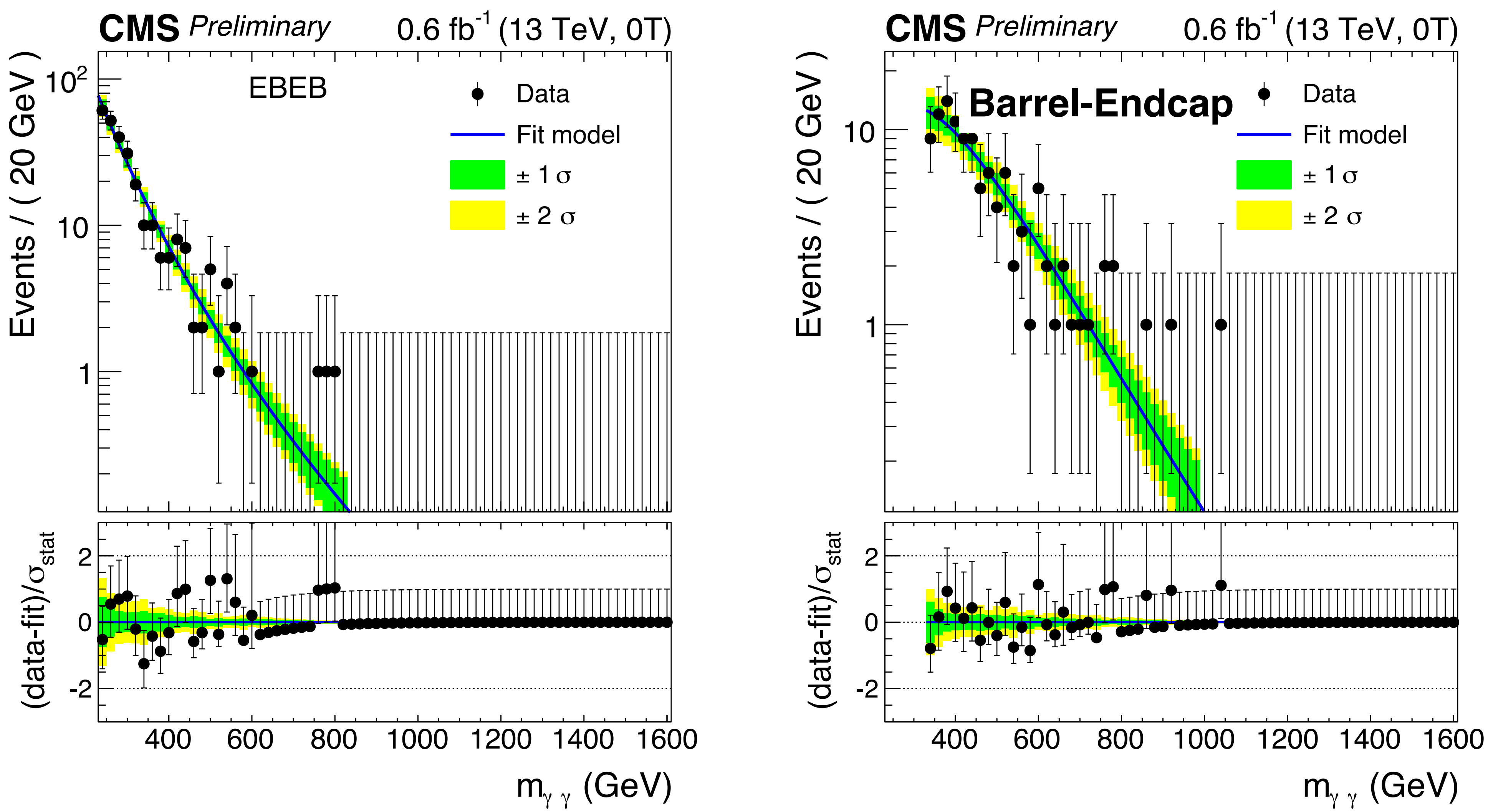


0T Data

[EXO-16-018]

- Without the magnetic field, we need new algorithms for vertex selection and photon identification
  - Correct vertex assignment is ~60% at 0T (~90% at 3.8T)
  - Comparable photon efficiency: 85% (90%) at 0T (3.8T) per γ in barrel

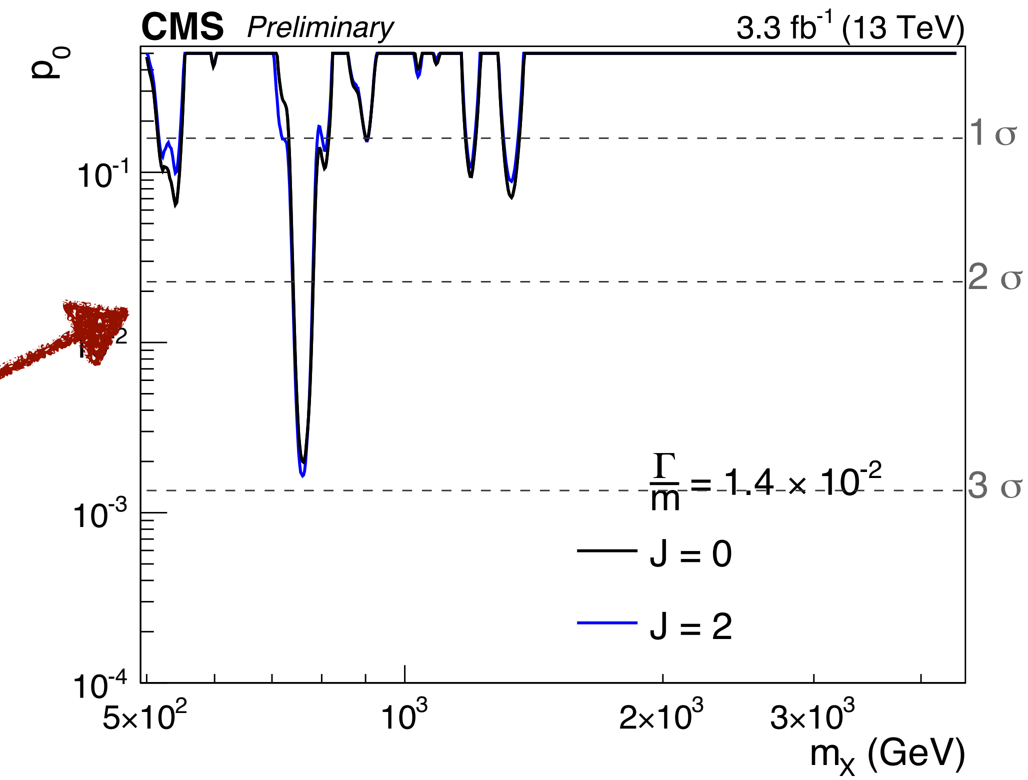
Diphoton spectrum at 0 Tesla (13 TeV)

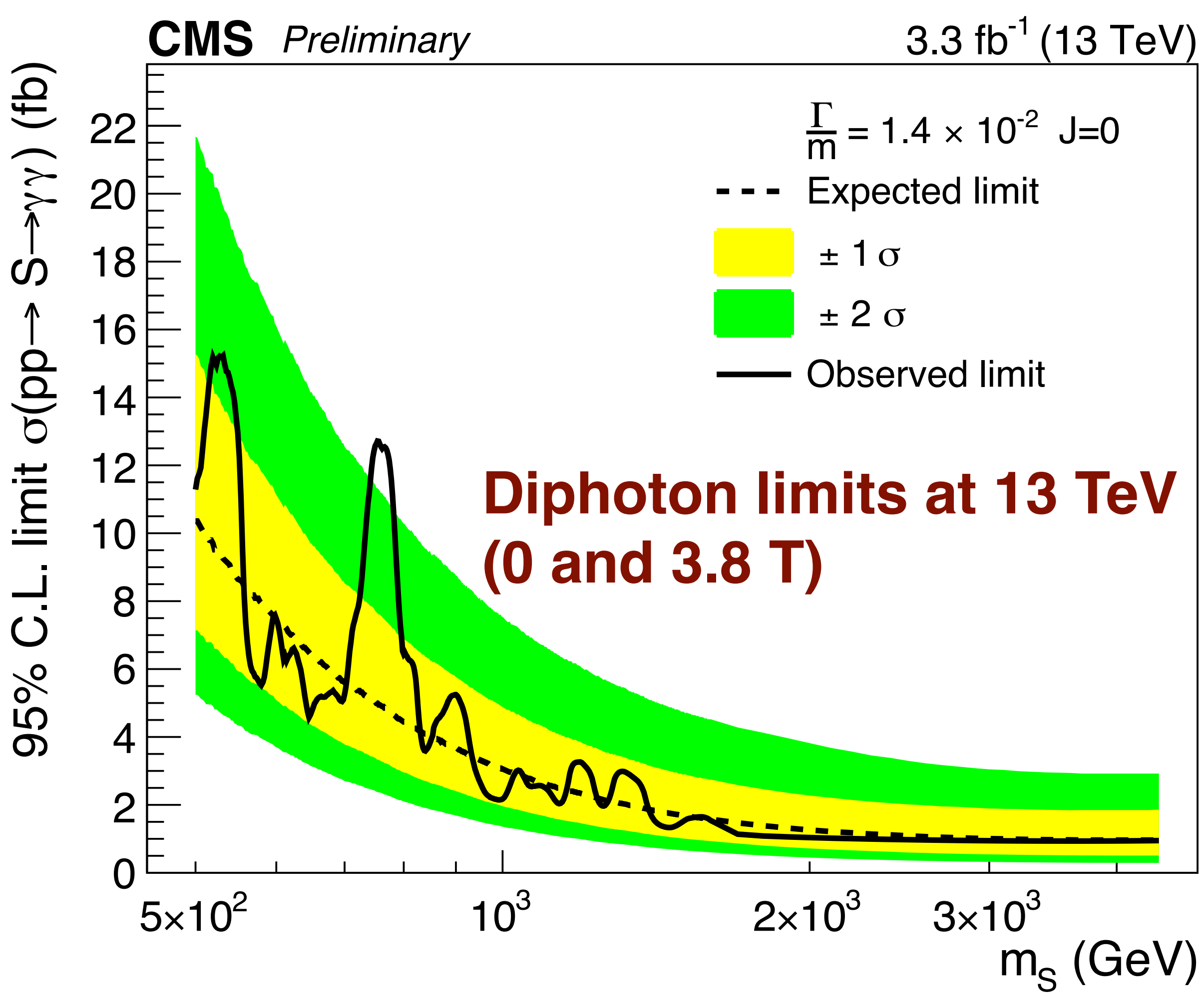


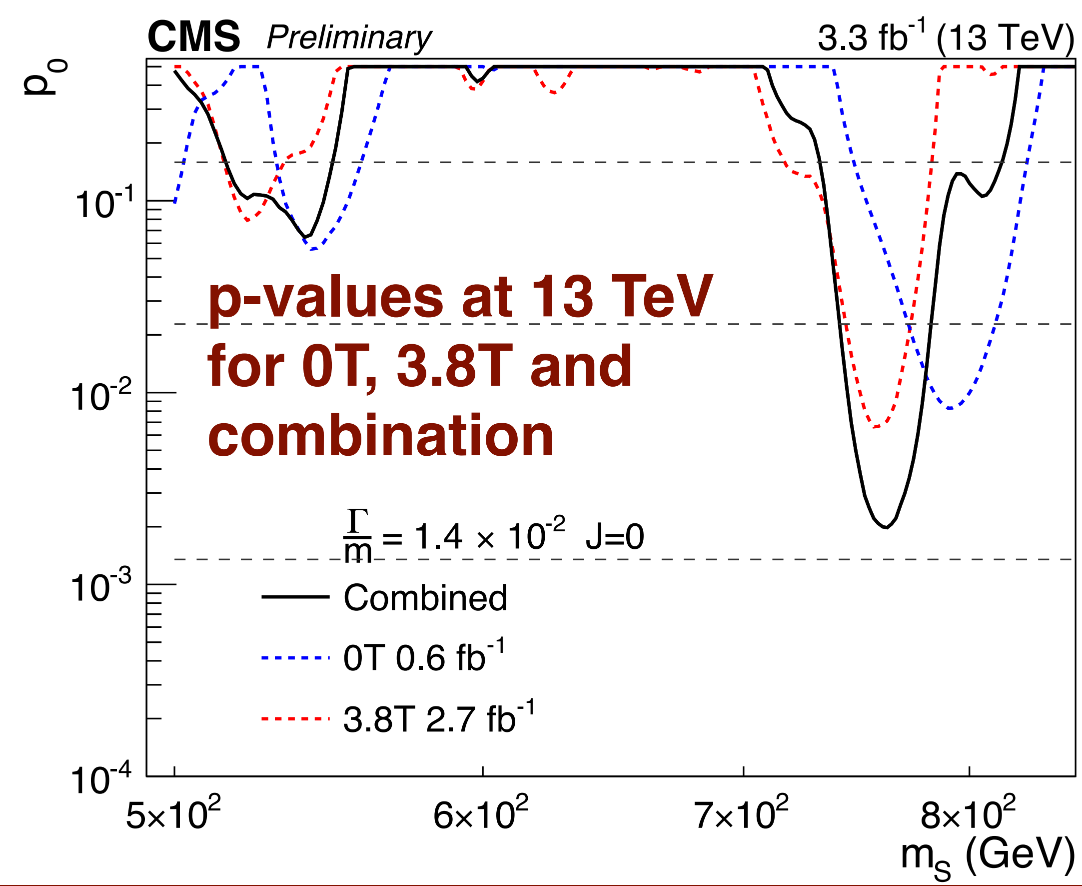
13 TeV Results

[EXO-16-018]

- Limits set on a three different widths
  - Γ/M=1.4×10^{-4}, 1.4×10^{-2}, 5.6×10^{-2}
- Both spin-0 and spin-2 hypotheses
  - limits and p-values very similar



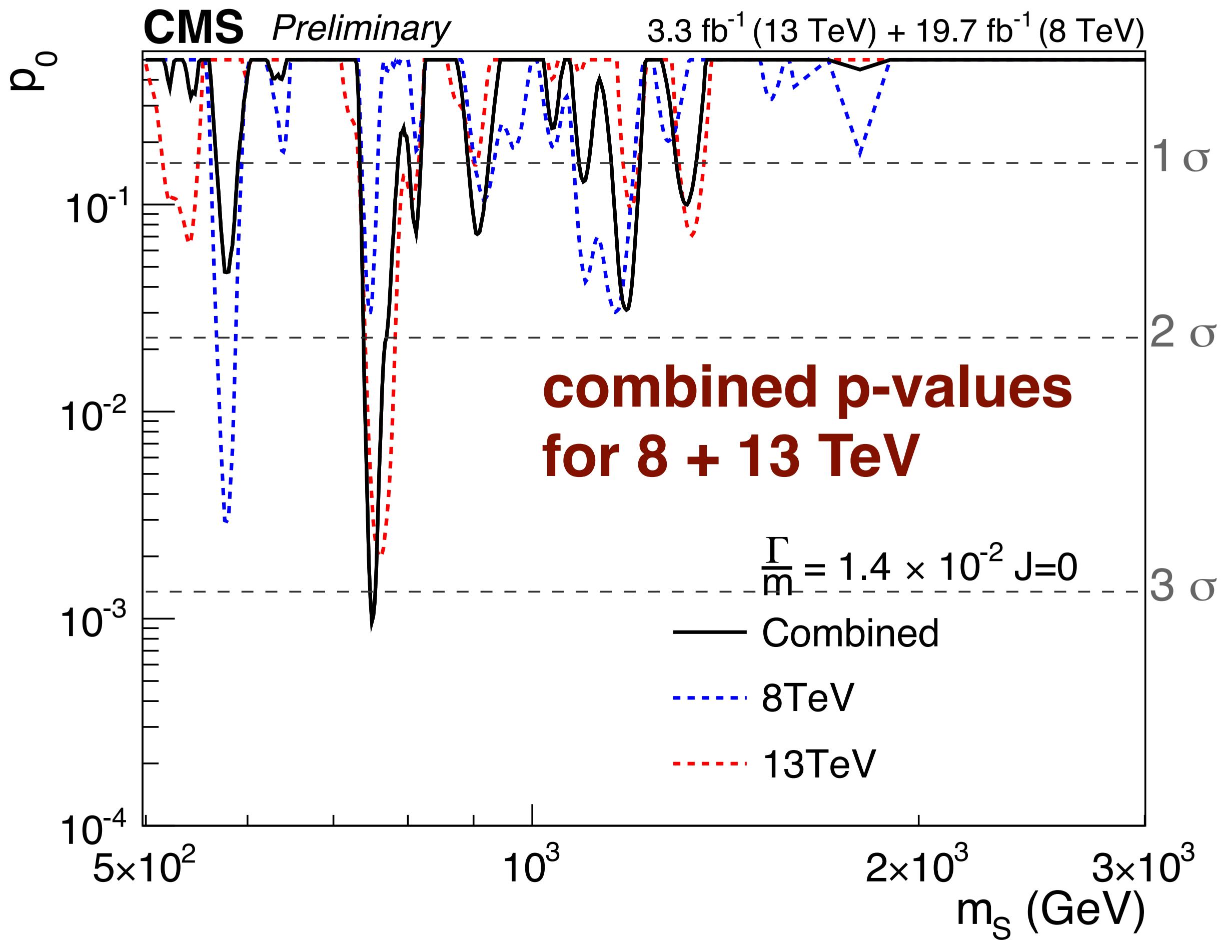


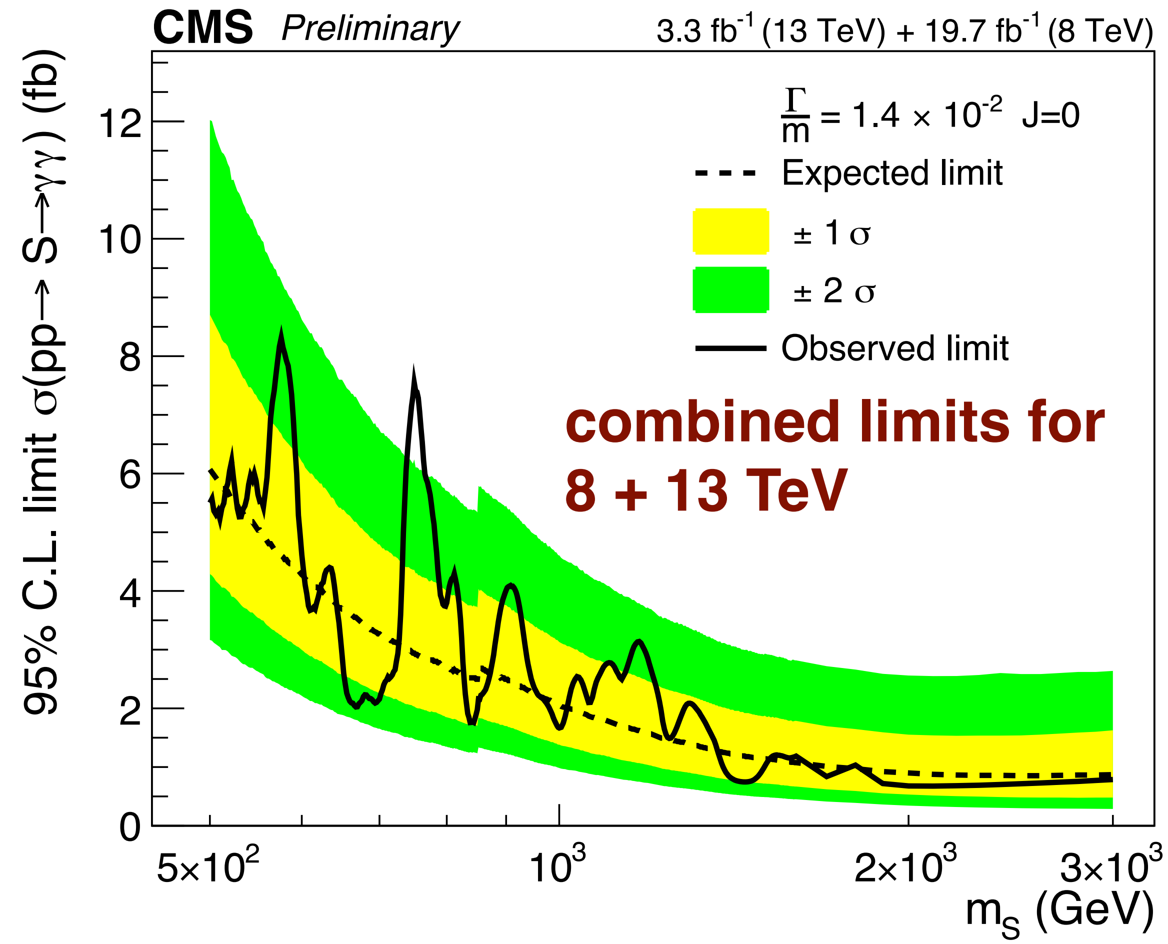


COMBINATION WITH 8 TEV

[EXO-16-018]

- Combined 8 TeV + 13 TeV results
  - Largest excess is observed for **750 GeV, spin-0, narrow width**
    - local significance of 3.4σ, 1.6σ after look-elsewhere effect

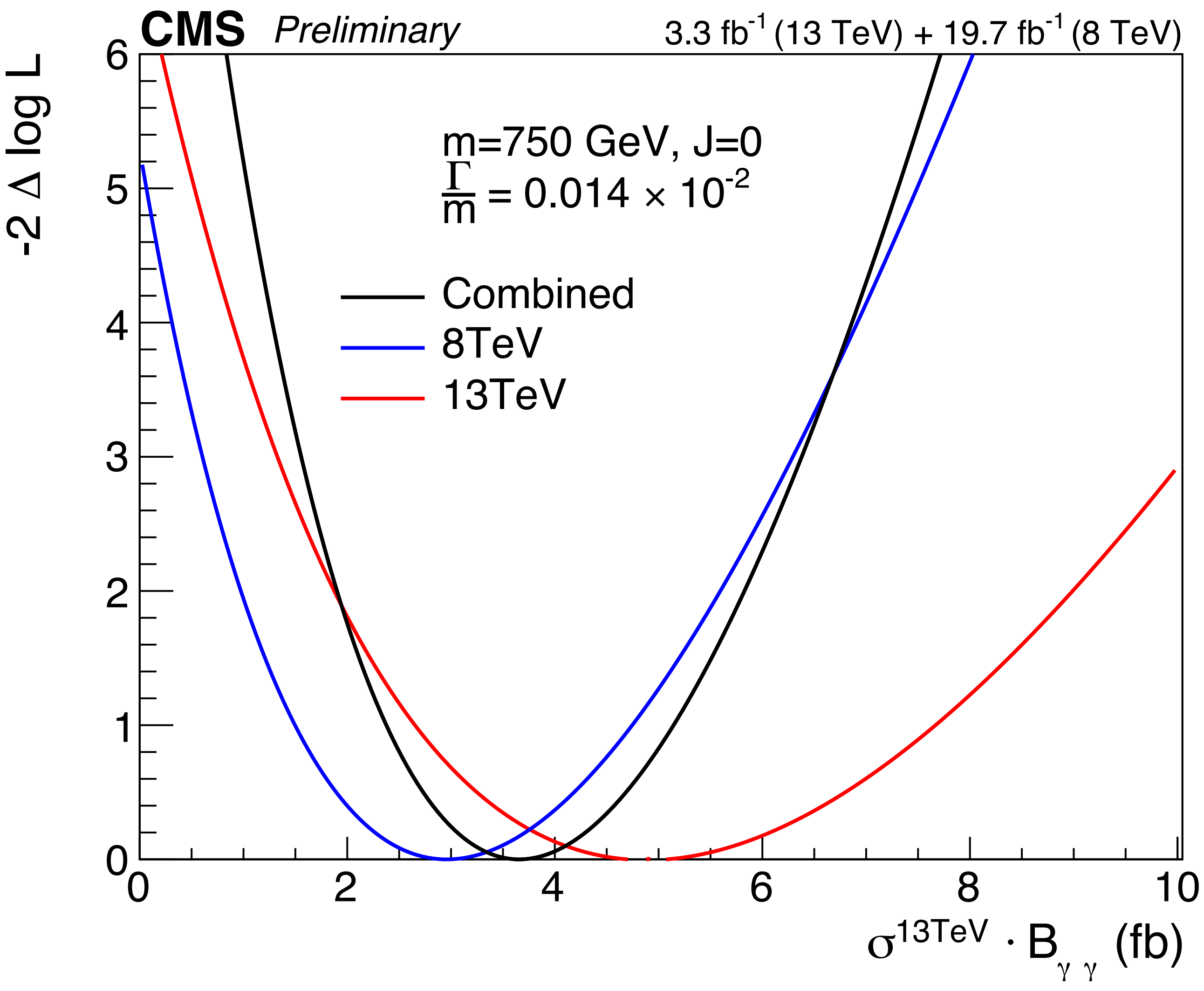


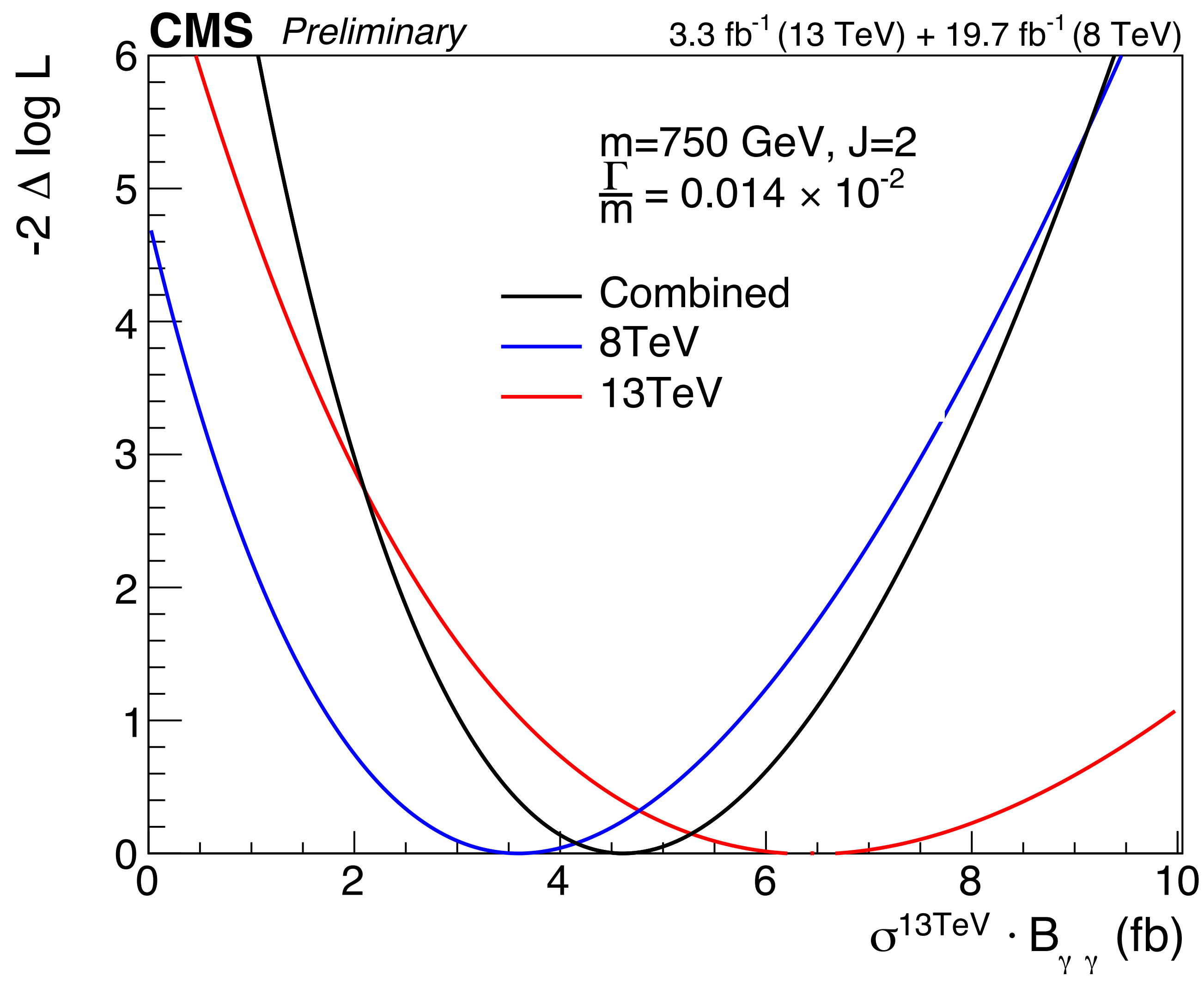


- Dec '15 result: largest excess at 760 GeV for $\Gamma/M=1.4\times10^{-2}$
  - local significance of ~3σ, <1.7σ after look-elsewhere effect

Best Fit X-section

[EXO-16-018]





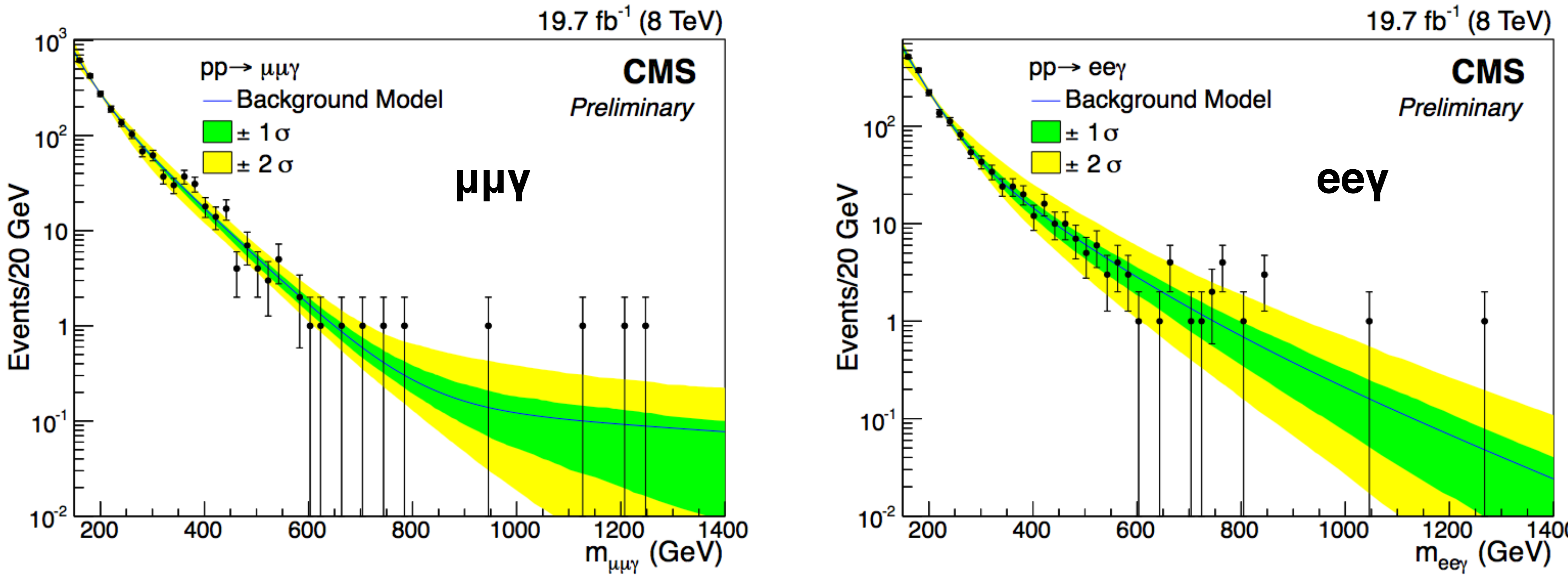
8 TeV Z+gamma Resonances

[HIG-16-014]

- Search for Z(ee or μμ)+photon resonance
  - modified isolation cone for high p_T leptons
  - suppress backgrounds with: $p_{\mathrm{T}}(\gamma) > \frac{40}{150} \cdot m_{Z\gamma}$
- Fit background directly to a smoothly falling function

$$f(m_{Z\gamma}) = m_{Z\gamma}^{a+b\log m_{Z\gamma}}$$

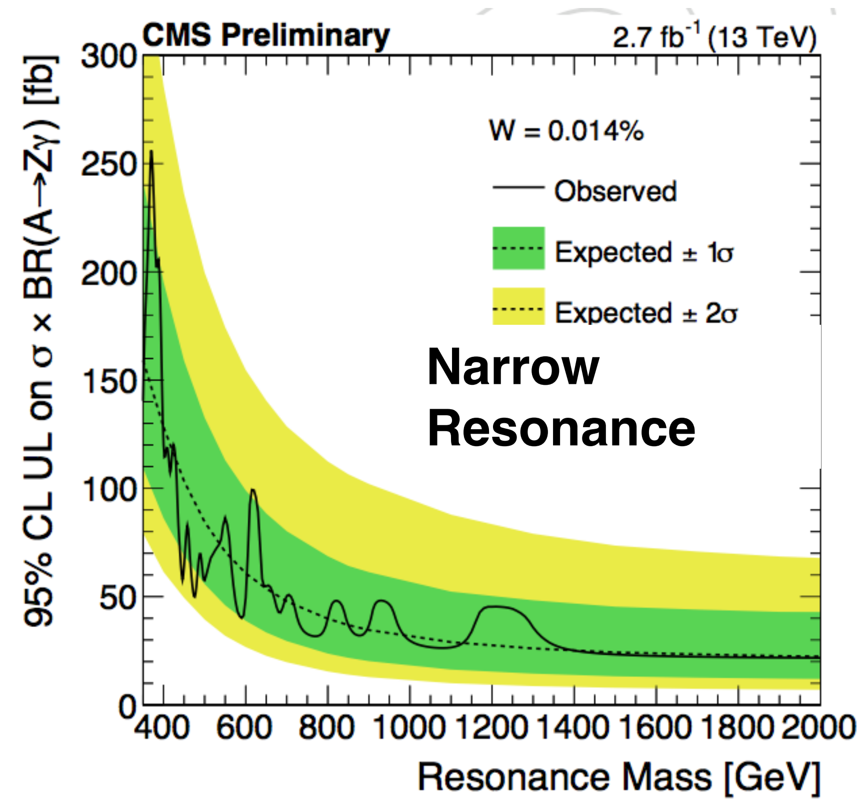
  - signal is fit to a crystal ball

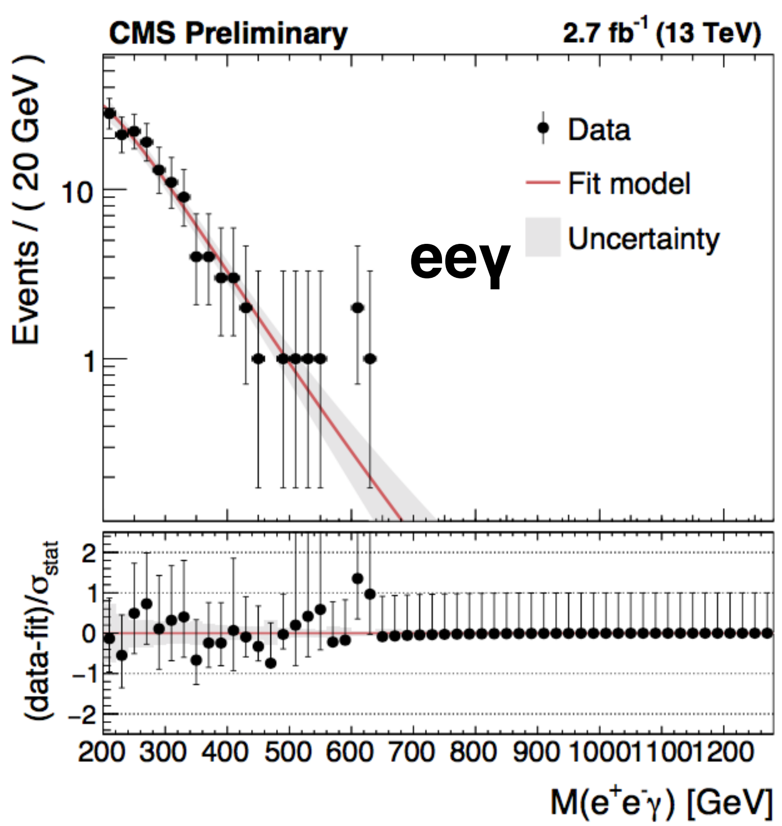


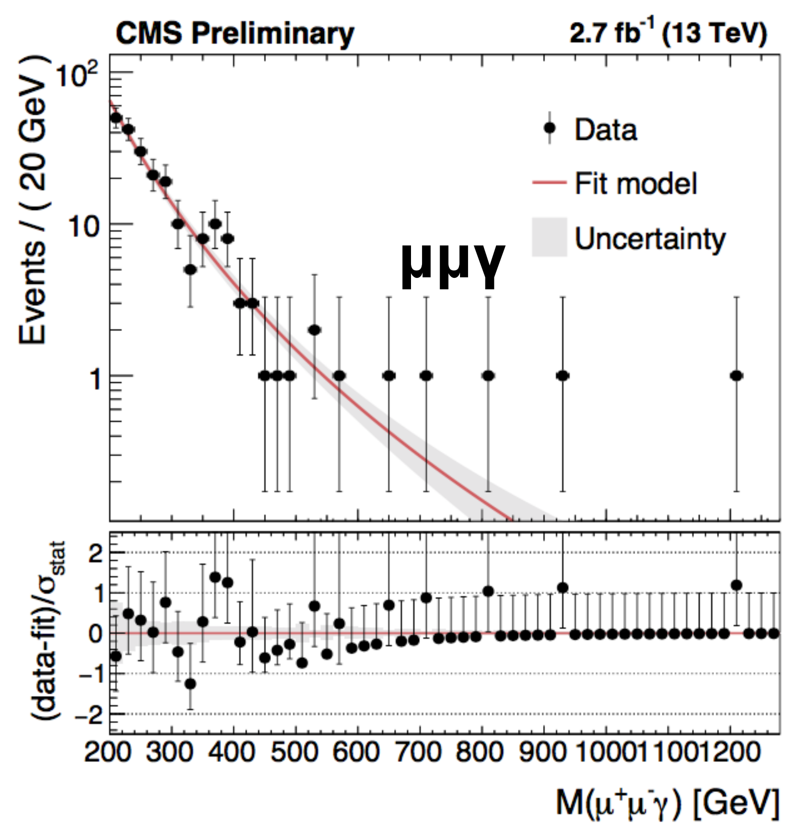
13 TeV Z+gamma Resonances

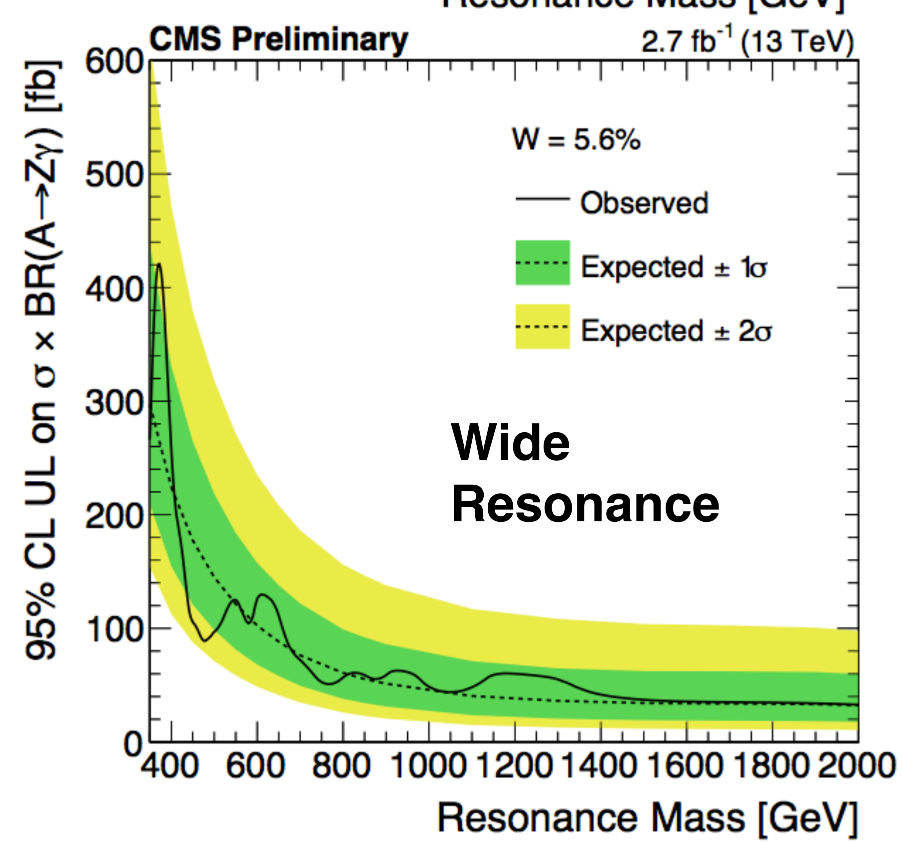
[EXO-16-019]

- Similar strategy to 8 TeV analysis
  - Considers both narrow and wide resonances
  - Upper limit on σ·BR(A→Zγ) at 750 GeV
    - 13 TeV: ~30 fb (narrow resonance)
    - 8 TeV: ~6 fb (narrow resonance)





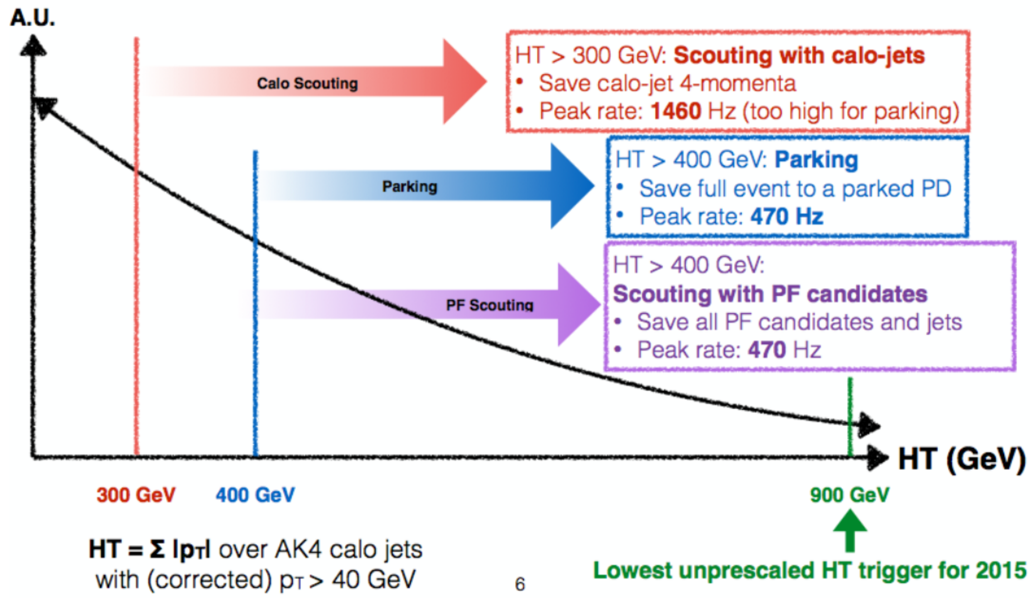


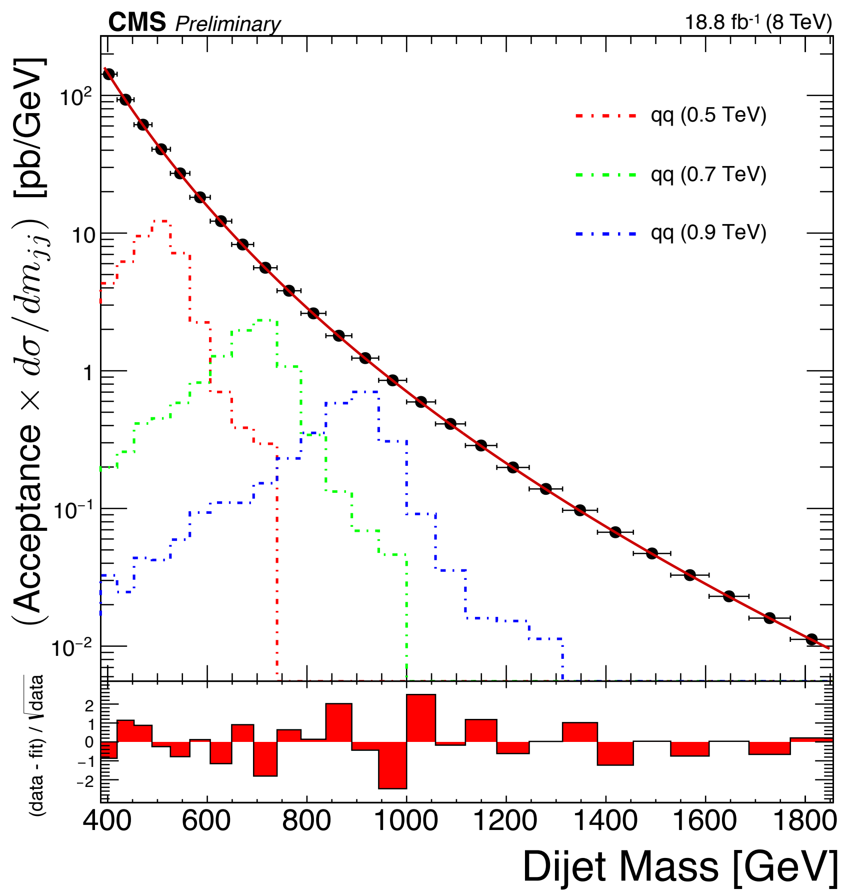


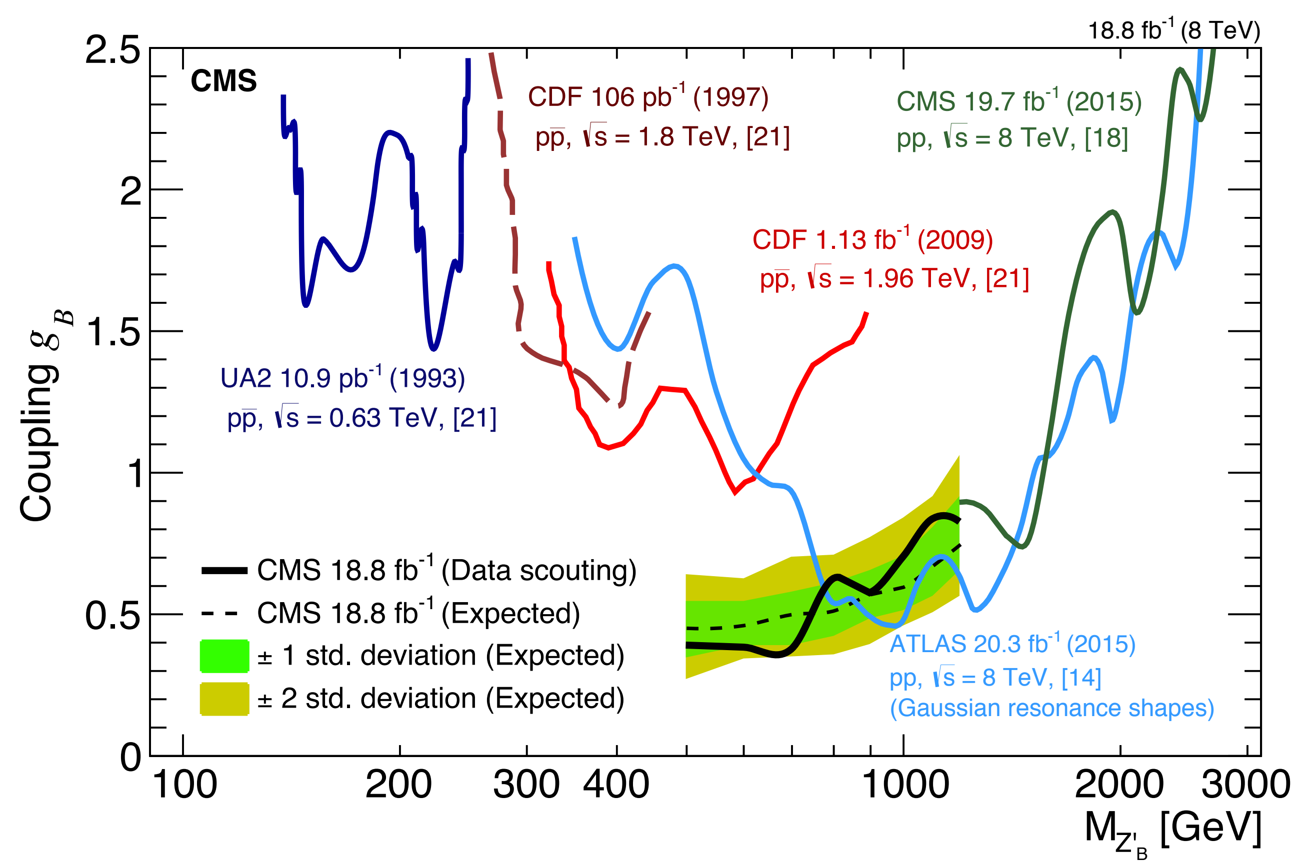
DATA SCOUTING/PARKING

[EXO-14-005]

- CMS has capacity to record dijet events down to 500 GeV without prescaling penalty
- Scouting particle flow HT dataset
  - Record PF information for events with HT > 450 GeV
  - Full event content is **also parked**
    - Can be processed if bump is found







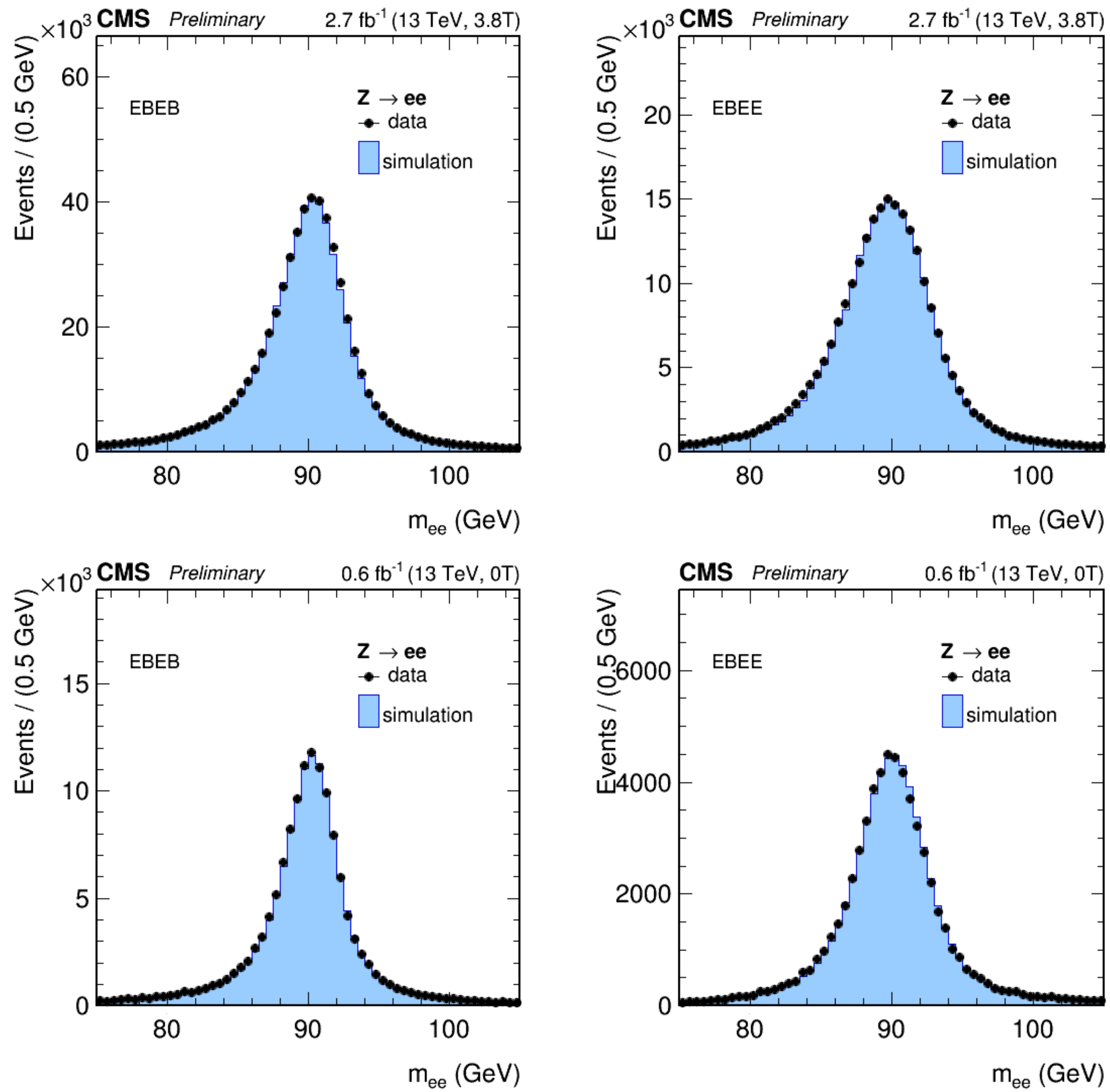
CONCLUSIONS

- A lot more data needs to be taken before we can make any definitive statements about the 750 GeV excess
  - Many channels are available to help categorize the excess should it become significant
  - Don't forget that the 8 TeV dataset plays a role, too
    - even assuming gg-fusion, the 8 TeV dataset is the larger one
- Should the machine perform to expectation, we should know a lot more by the end of the year

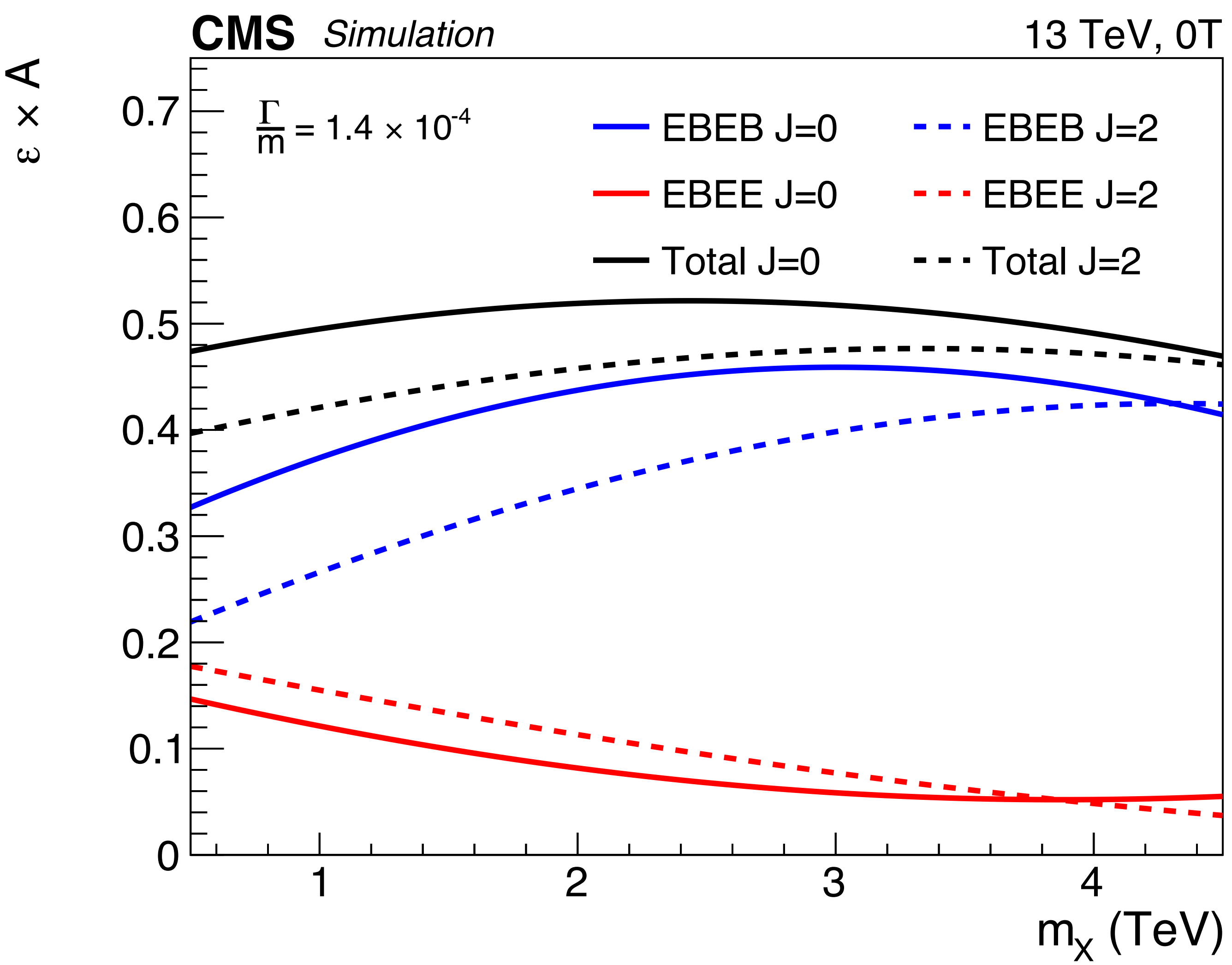
Backup

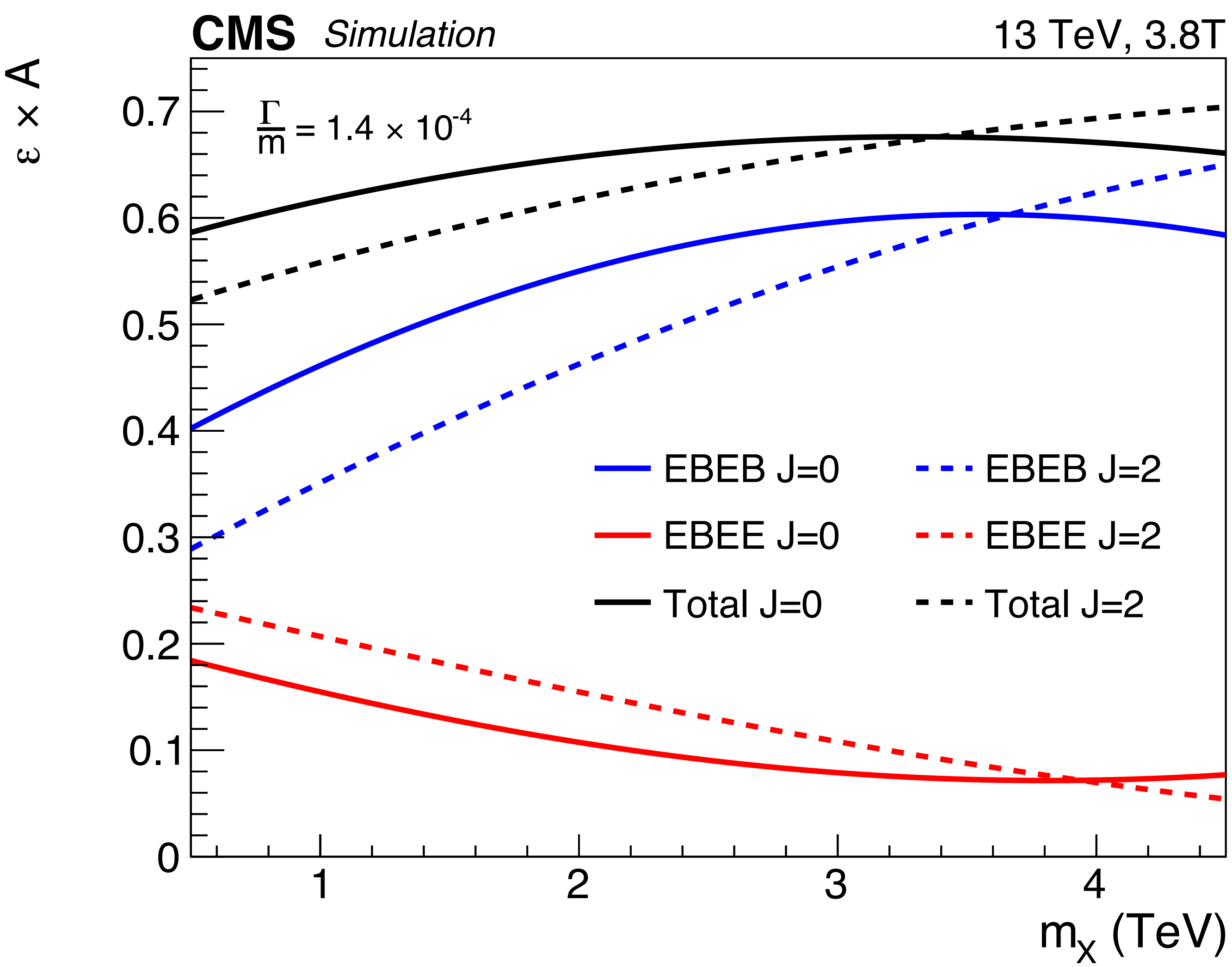
Energy Regression

- Simultaneously adjust energy scale and resolution of electron candidates as a function of the pseudo-rapidity and cluster shape of the candidates.
  - Same procedure as for 3.8T but no binning in cluster shape (no radiative losses)
    - Mass scale is shifted by ~1% between 3.8T and 0T

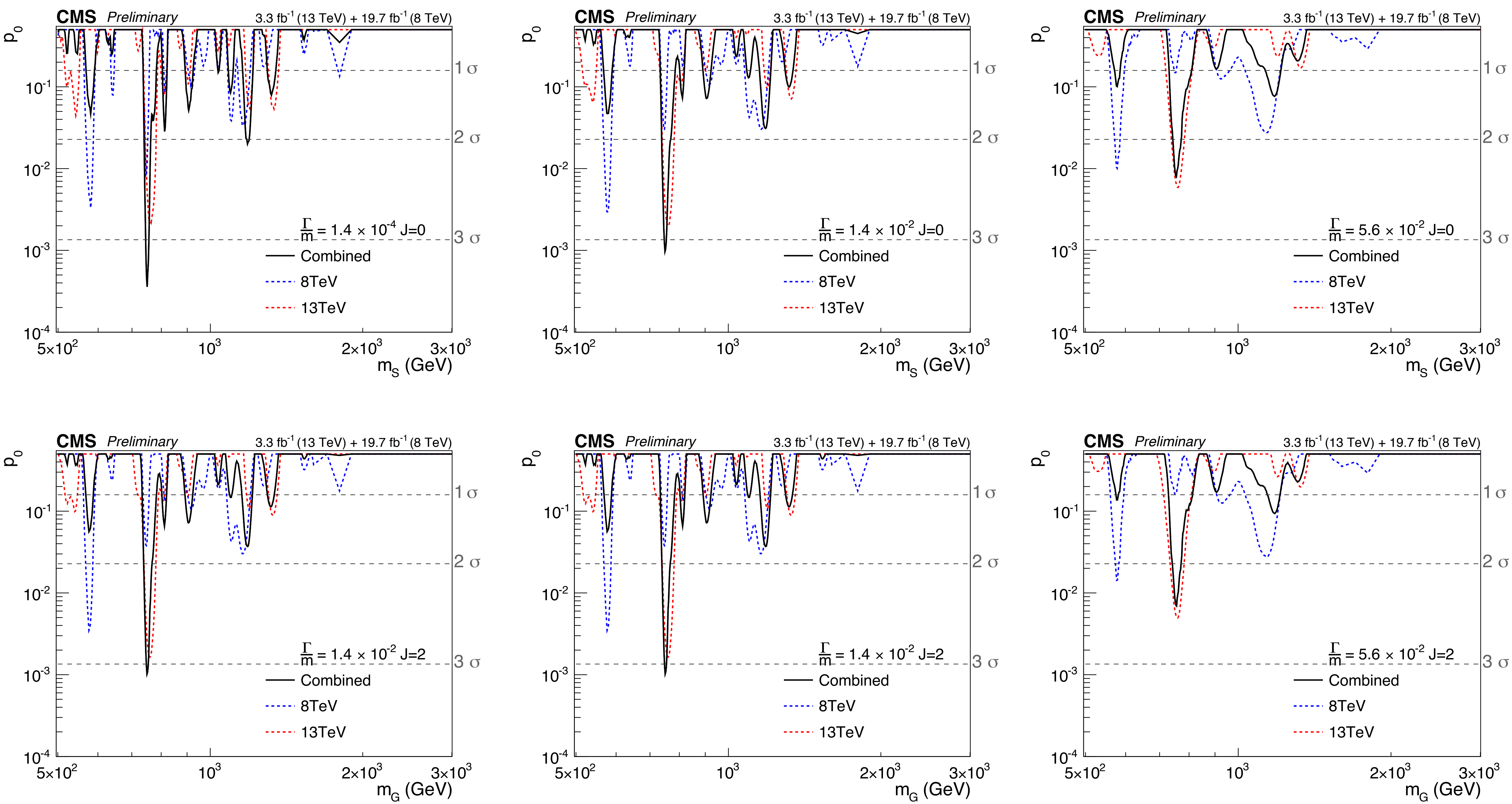


ACCEPTANCE

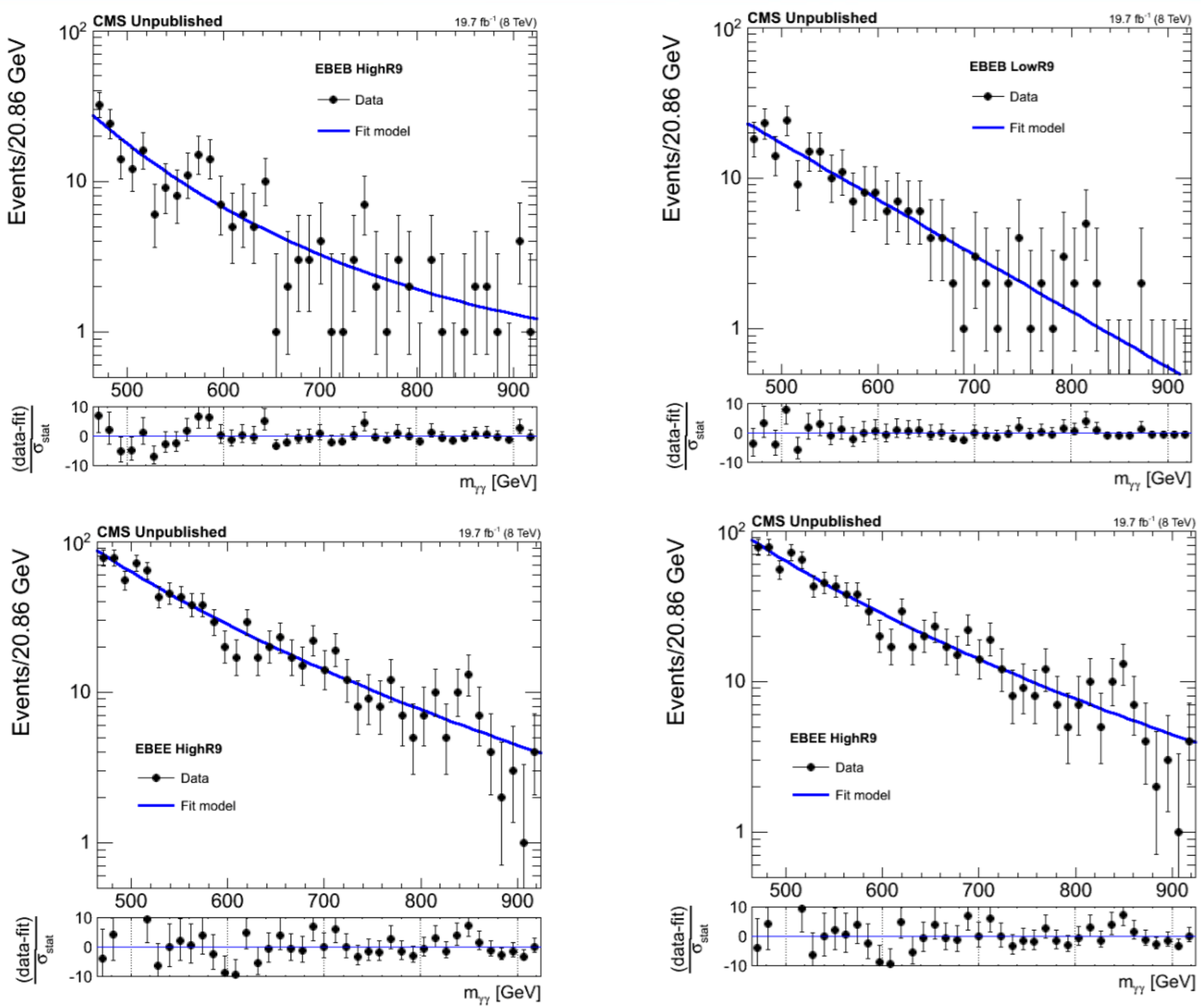

CMS Simulation
13 TeV, 0T
ε × A
Γ/m = 1.4 × 10^-4
EBEB J=0
EBEB J=2
EBEE J=0
EBEE J=2
Total J=0
Total J=2
m_X (TeV)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1
2
3
4


CMS Simulation
13 TeV, 3.8T
ε × A
Γ/m = 1.4 × 10^-4
EBEB J=0
EBEB J=2
EBEE J=0
EBEE J=2
Total J=0
Total J=2
m_X (TeV)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
1
2
3
4

8+13 TeV p-Values



8 TeV Data


CMS Unpublished
19.7 fb⁻¹ (8 TeV)
EBEB HighR9
Data
Fit model
Events/20.86 GeV
(data-fit)/σstat
mγγ [GeV]
EBEB LowR9
EBEE HighR9