CMS

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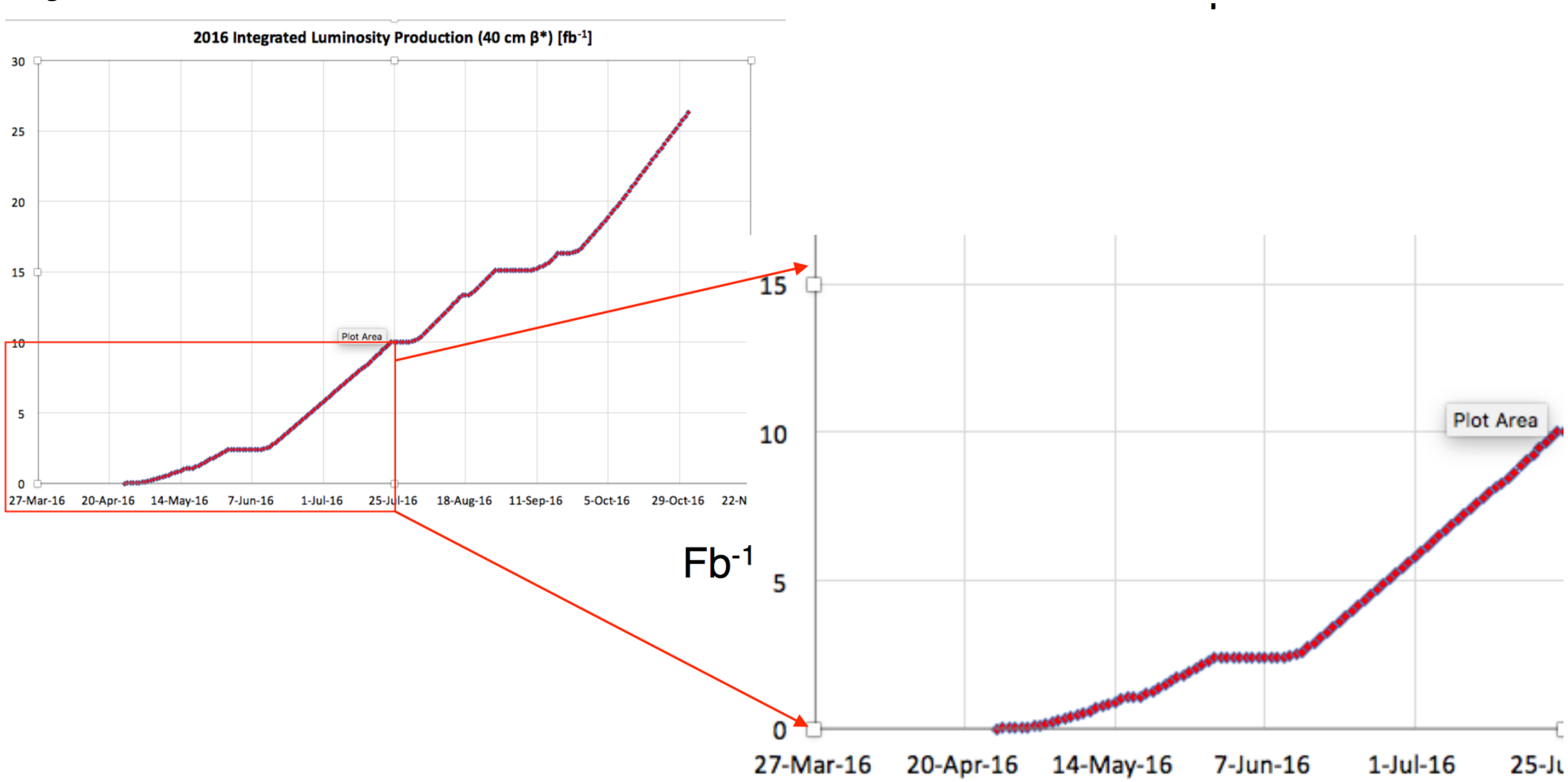
OF NEW JERSEY

OUTLINE

- 750 GeV
- Long-Lived Searches
- Data Scouting and Data Parking

Status of LHC and CMS

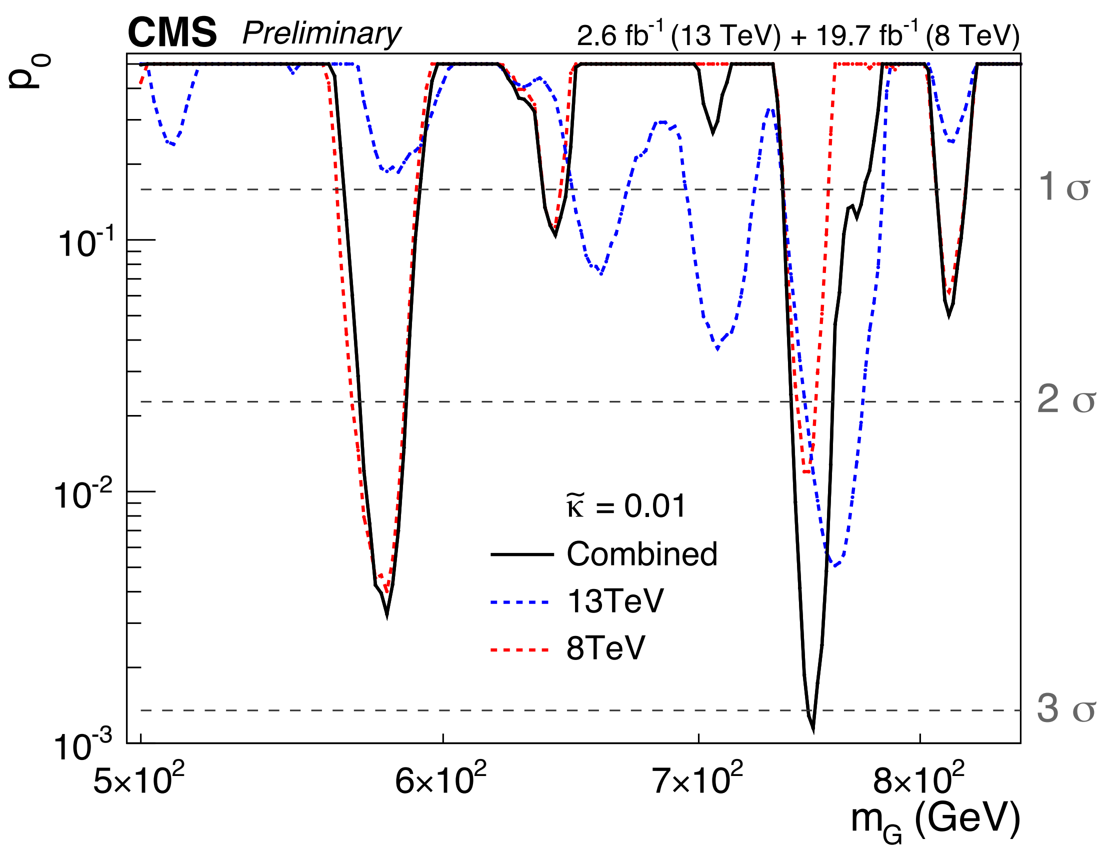
- The cold box cleanup has been a success:
  - the new elements performing much better that before; cleaning (to the best one can tell) complete; the magnet reached 3.8T Thursday noontime
- LHC is performing very well, and may exceed expectations for the year

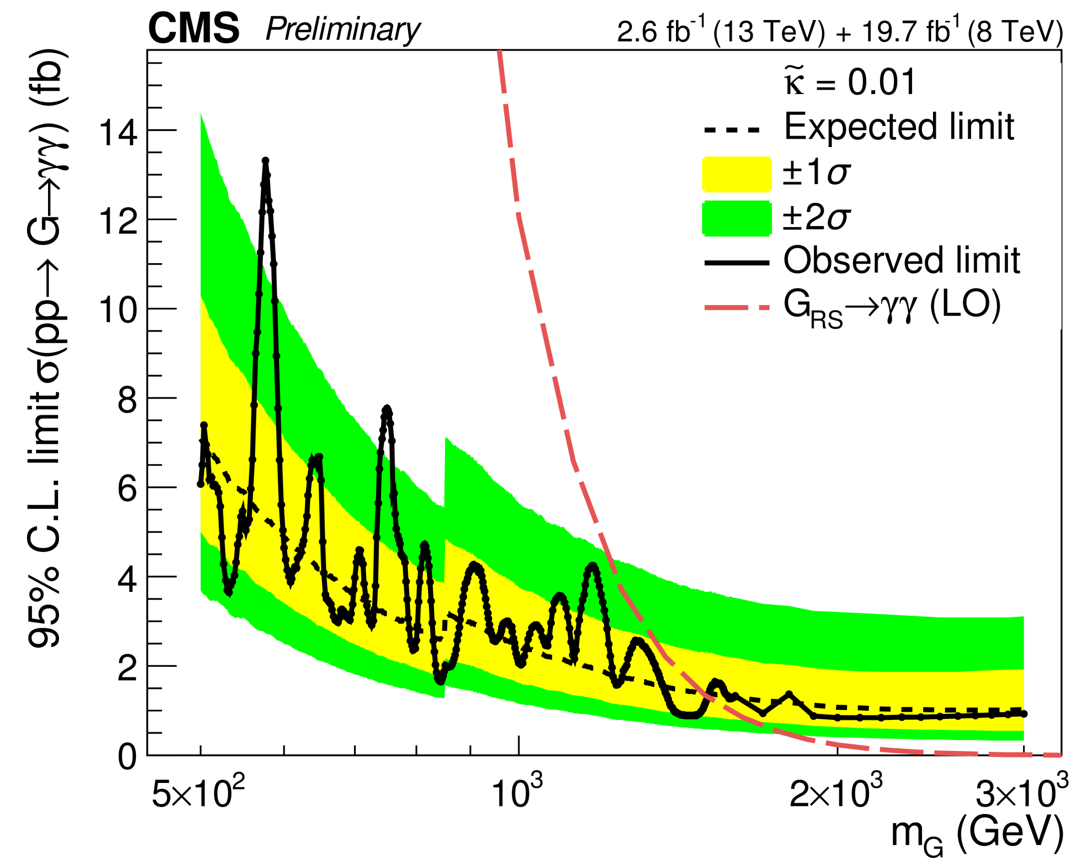


Diphotons at CMS

December 2015 Jamboree Result

8+13 TeV Combination





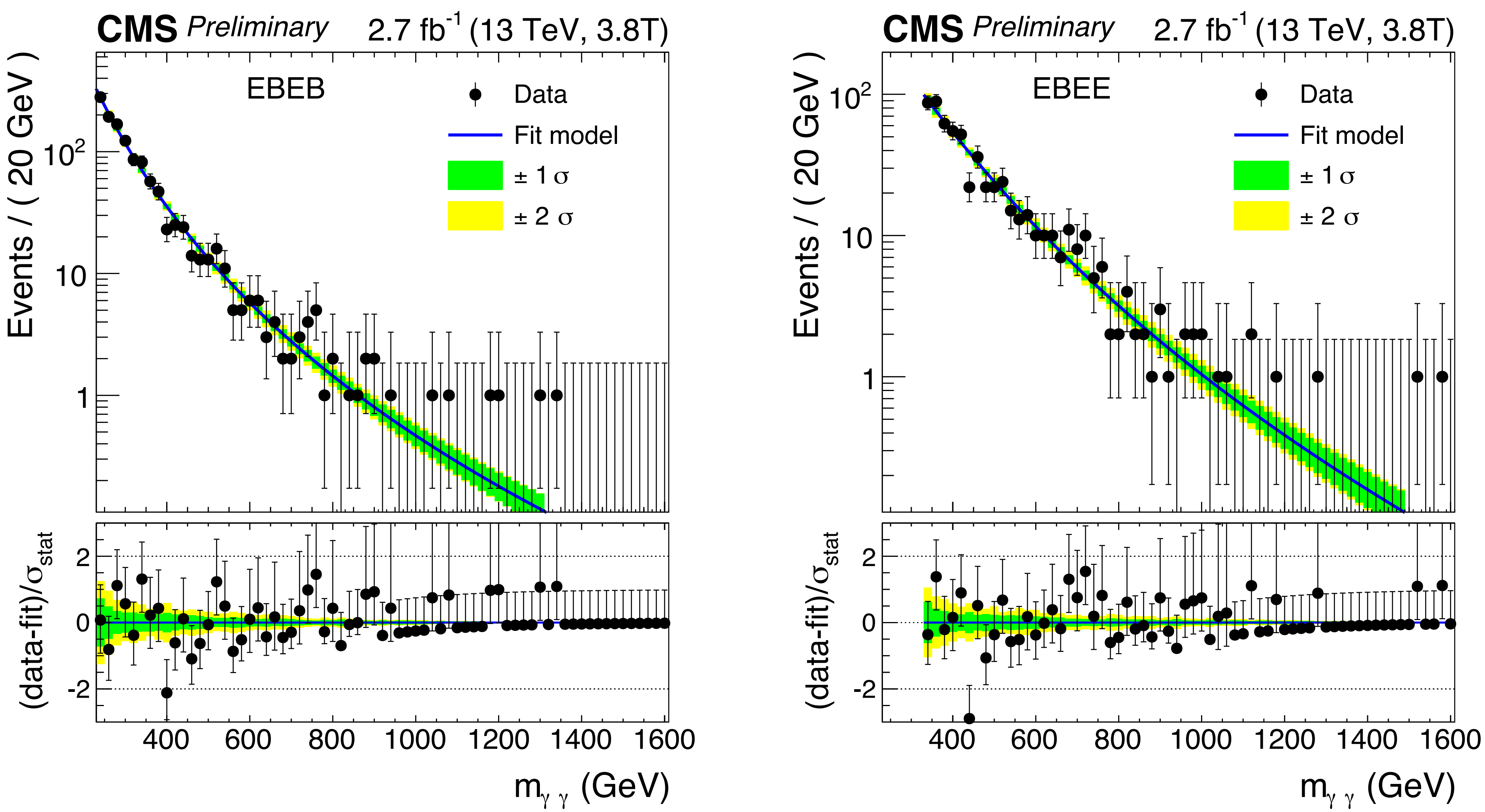
- Status update of December 2015 result (shown above)
  - Added B=0T dataset
    - additional luminosity of 0.6/fb
  - Re-reconstruction of data with latest ECAL calibration
    - mass resolution improved 30%

RE-PROCESSED 3.8T DATA

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

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

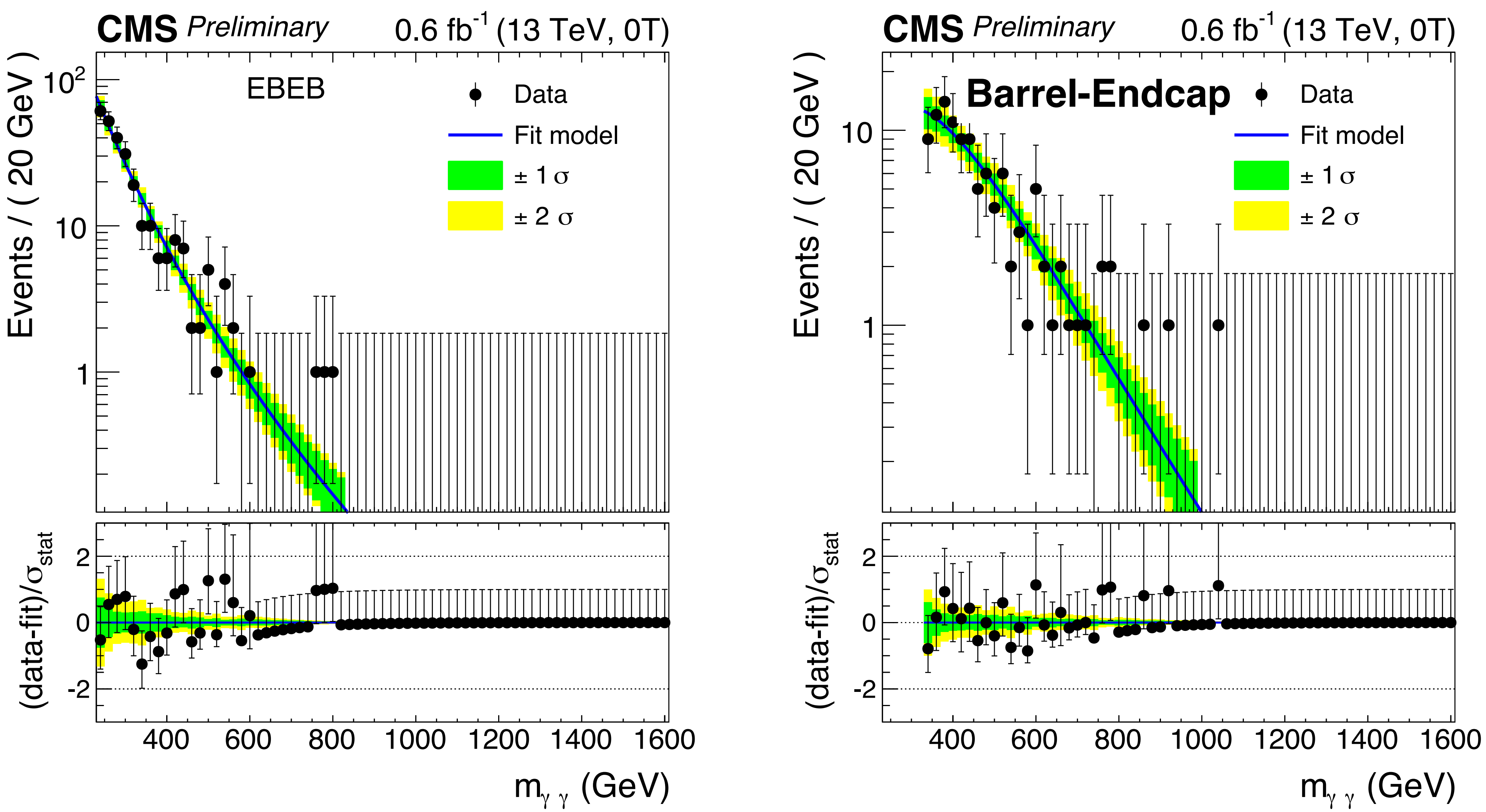
Diphoton spectrum at 3.8 Tesla (13 TeV)



0T DATA

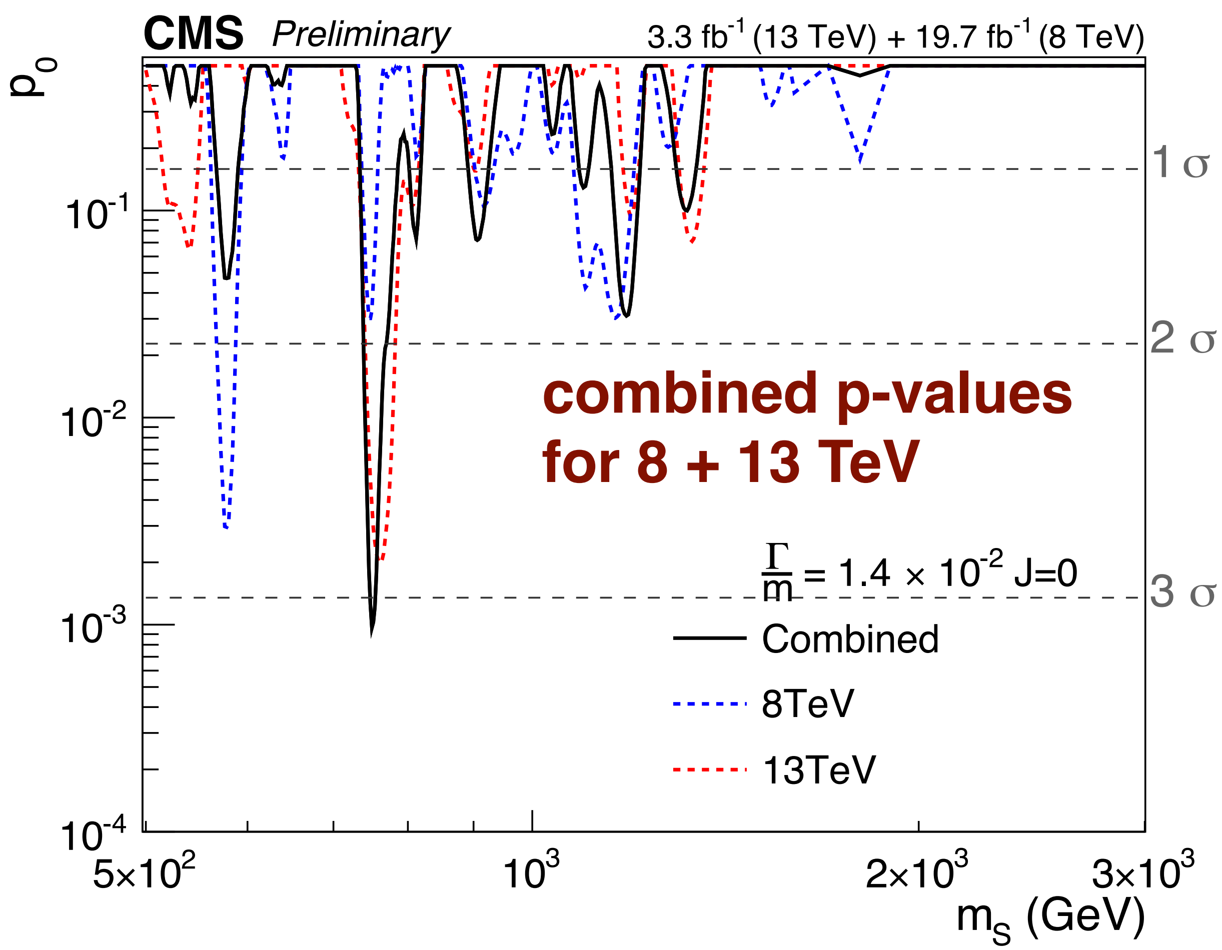
- Without the magnetic field, we need new algorithms for vertex selection and photon identification
  - Correct vertex assignment is ~60% at 0T (~90% at 3.8T)
  - Comparable photon efficiency: 85% (90%) at 0T (3.8T) per γ in barrel

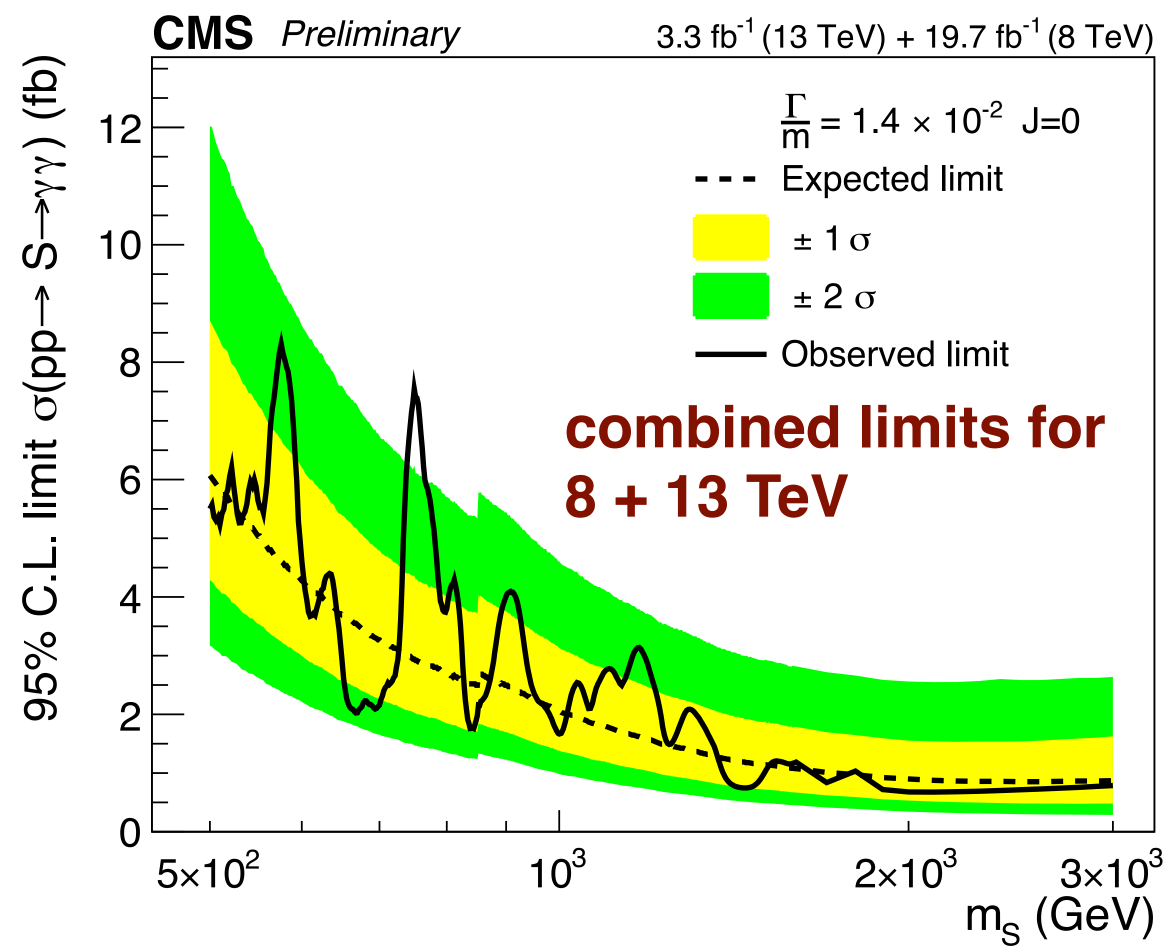
Diphoton spectrum at 0 Tesla (13 TeV)



COMBINATION WITH 8 TEV

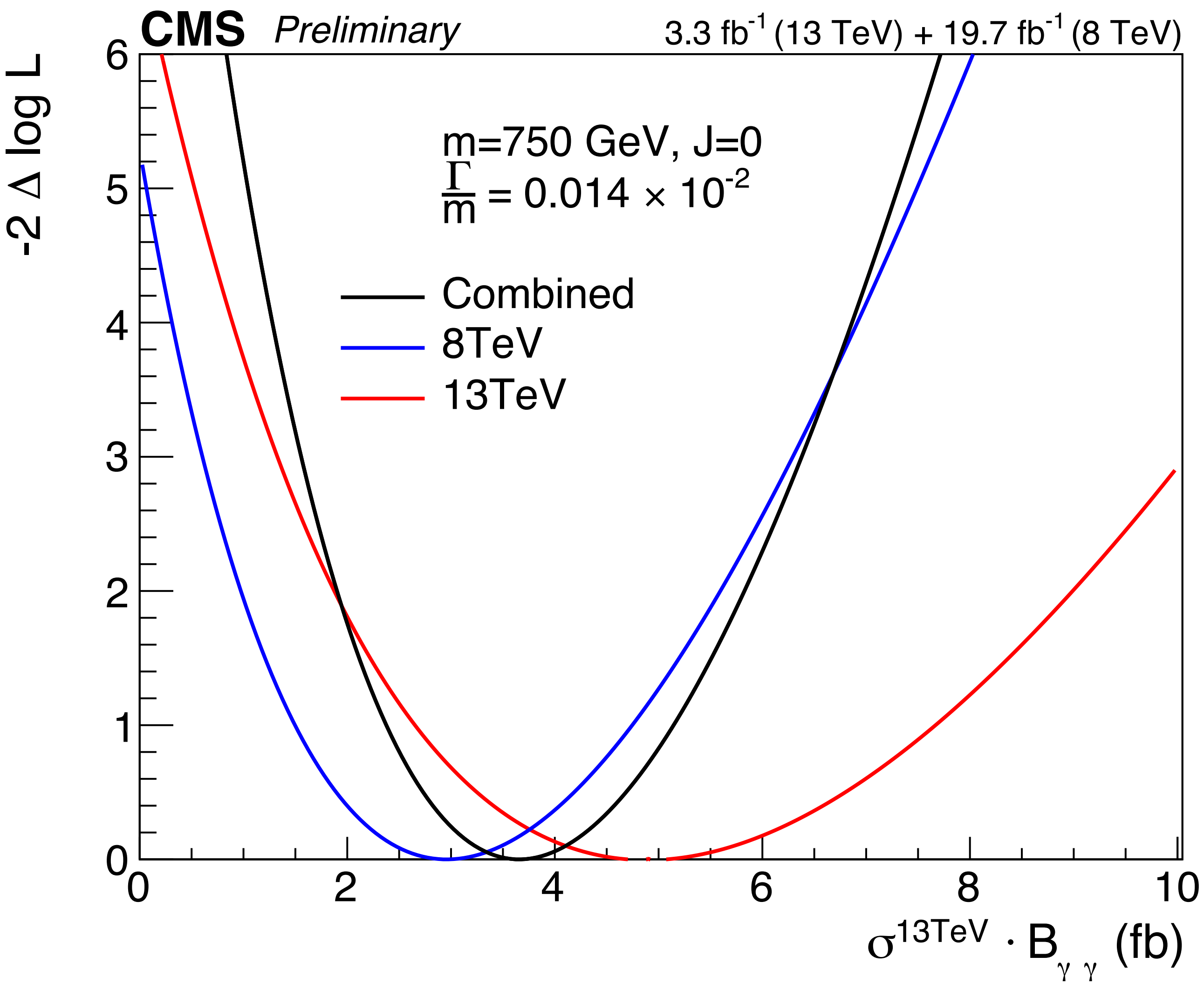
- Combined 8 TeV + 13 TeV results
  - Largest excess is observed for **750 GeV, spin-0, narrow width**
    - local significance of 3.4σ, 1.6σ after look-elsewhere effect

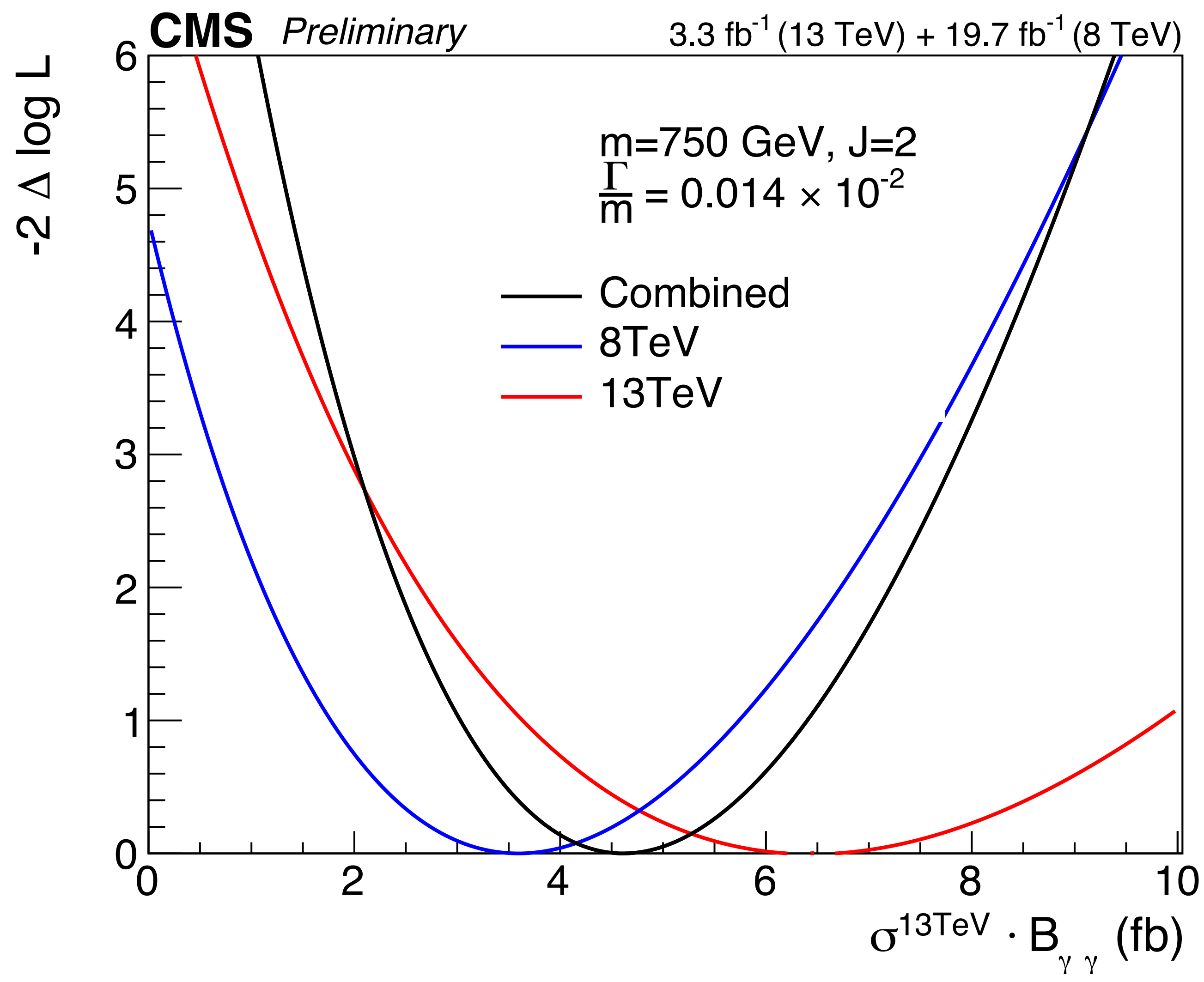




- Dec ’15 result: largest excess at 760 GeV for $\Gamma/M=1.4\text{x}10^{-2}$
  - local significance of ~3σ, <1.7σ after look-elsewhere effect

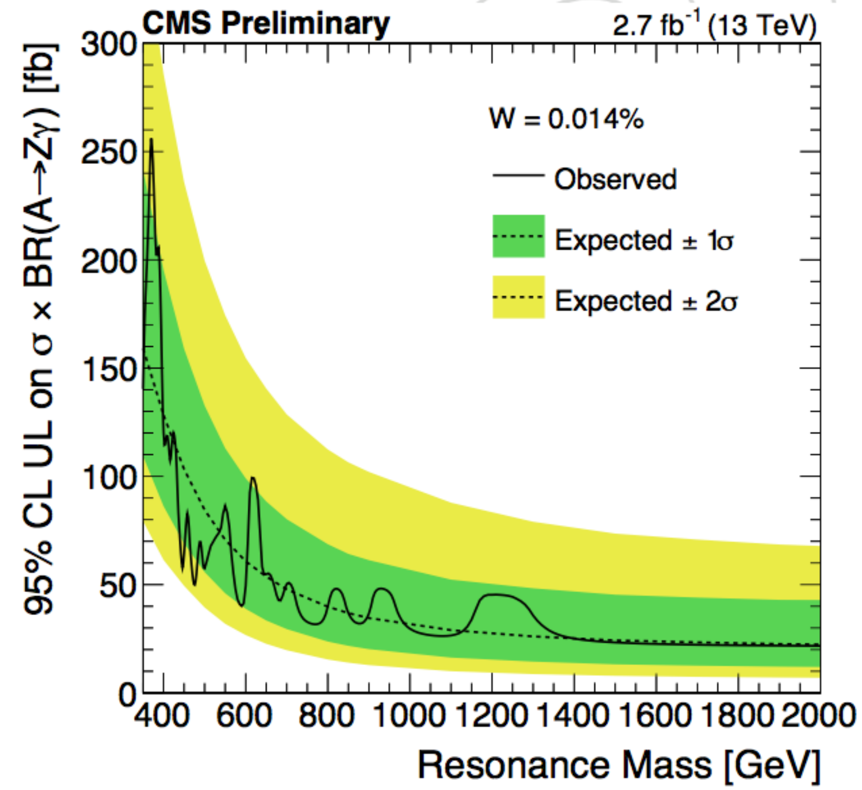
BEST FIT X-SECTION

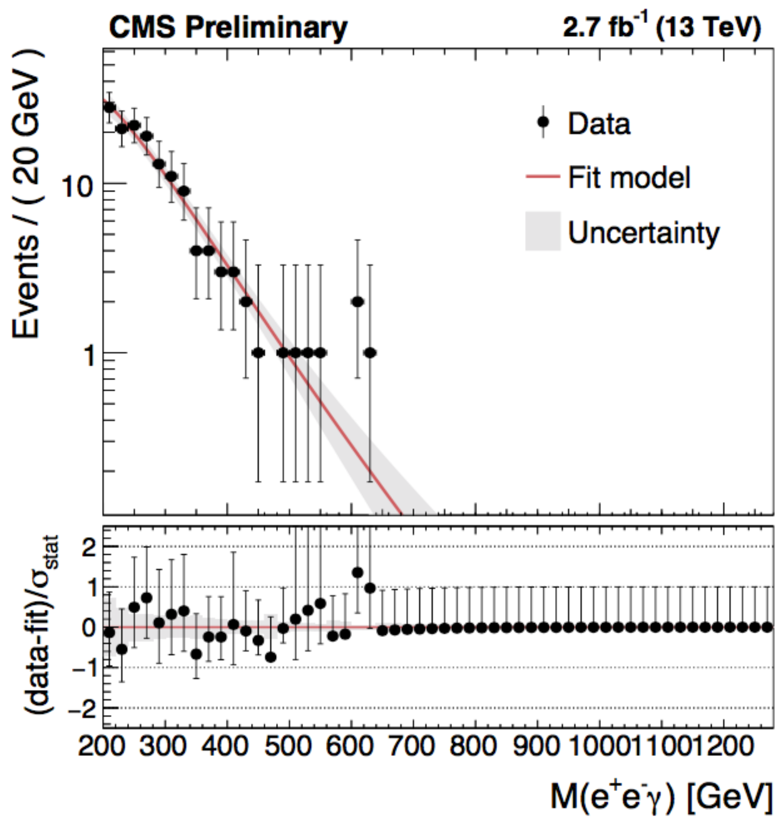


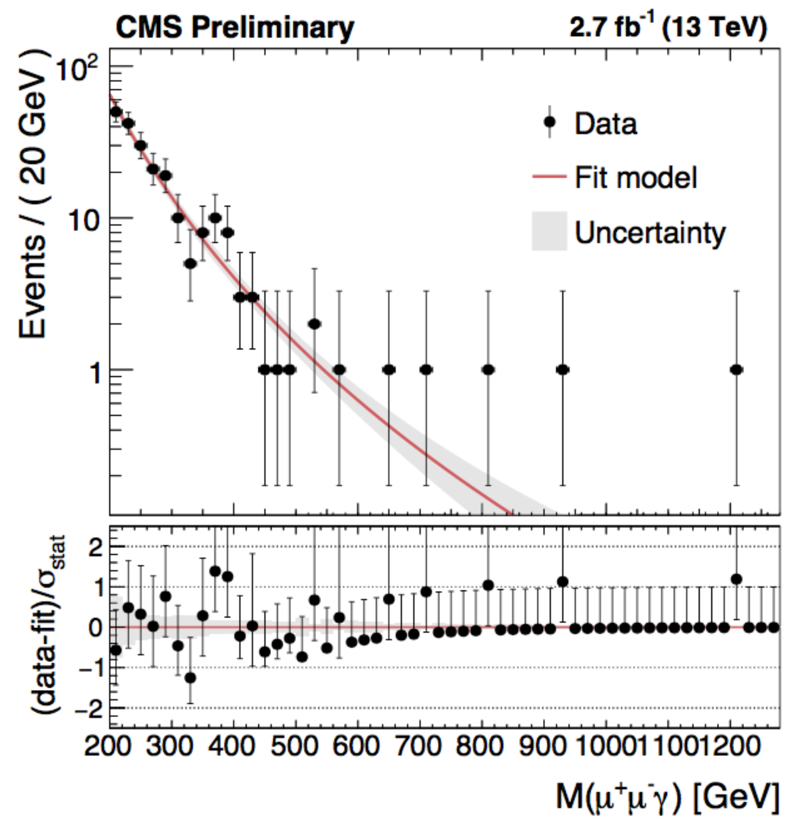


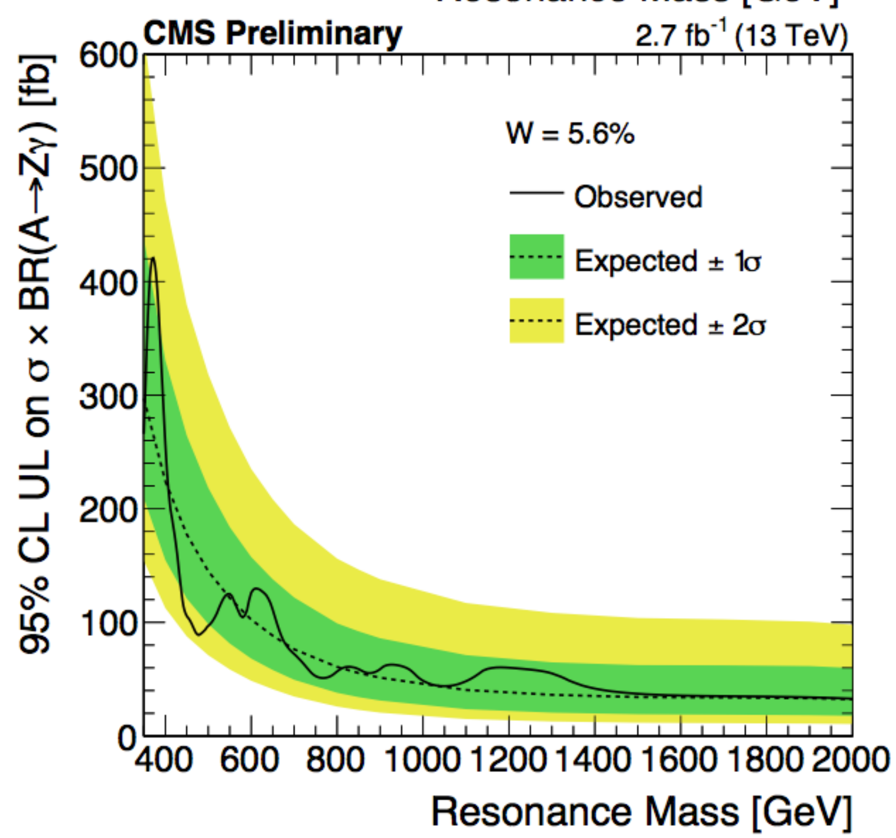
13 TeV Z+gamma Resonances

- Considers both narrow and wide resonances
  - suppress backgrounds: $p_{\mathrm{T}}(\gamma) > \frac{40}{150} \cdot m_{Z\gamma}$
  - Upper limit on σ·BR(A→Zγ) at 750 GeV
    - 13 TeV: ~30 fb (narrow resonance)
    - 8 TeV: ~6 fb (narrow resonance)



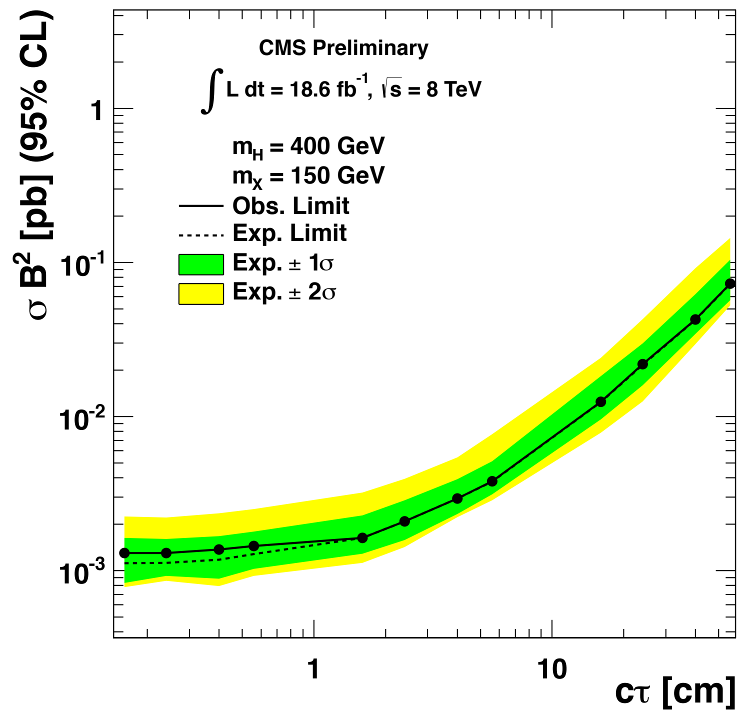


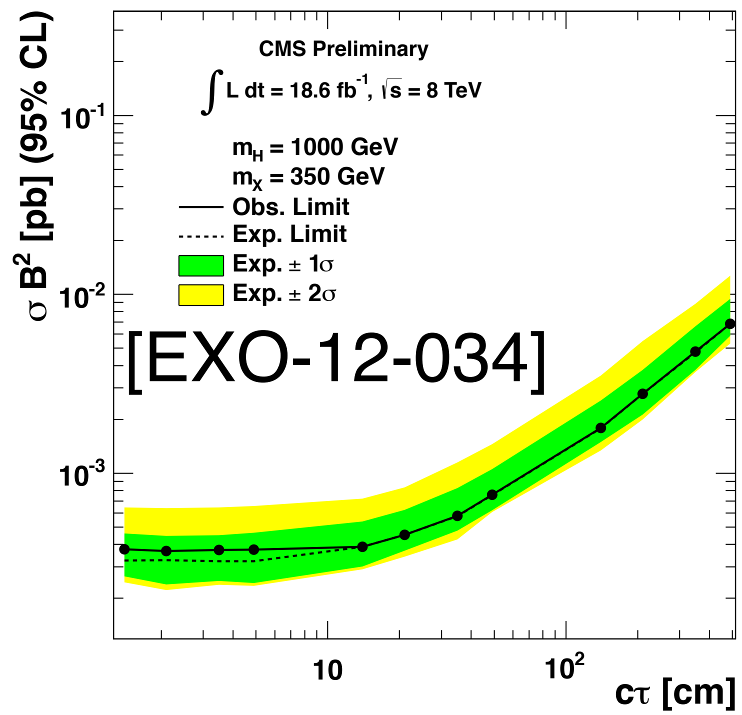




Run I Displaced Dijet Search

- Baseline signature
  - H→2X; X→dijets (udscb)
  - where X is long-lived, neutral, spin-0 particle decaying inside the tracker volume
- Selection
  - Scalar sum of the jets transverse momenta H_T > 300 GeV
  - **≥2** jets (p_T>60 GeV, $|\eta| < 2$) with small number of prompt tracks and prompt energy fraction
  - both jets reconstruct to a **single, displaced vertex**
    - likelihood discriminant determines quality of the vertex and promptness of the jets
- Final result: ~fb xs·BR limits for ~mm cτ

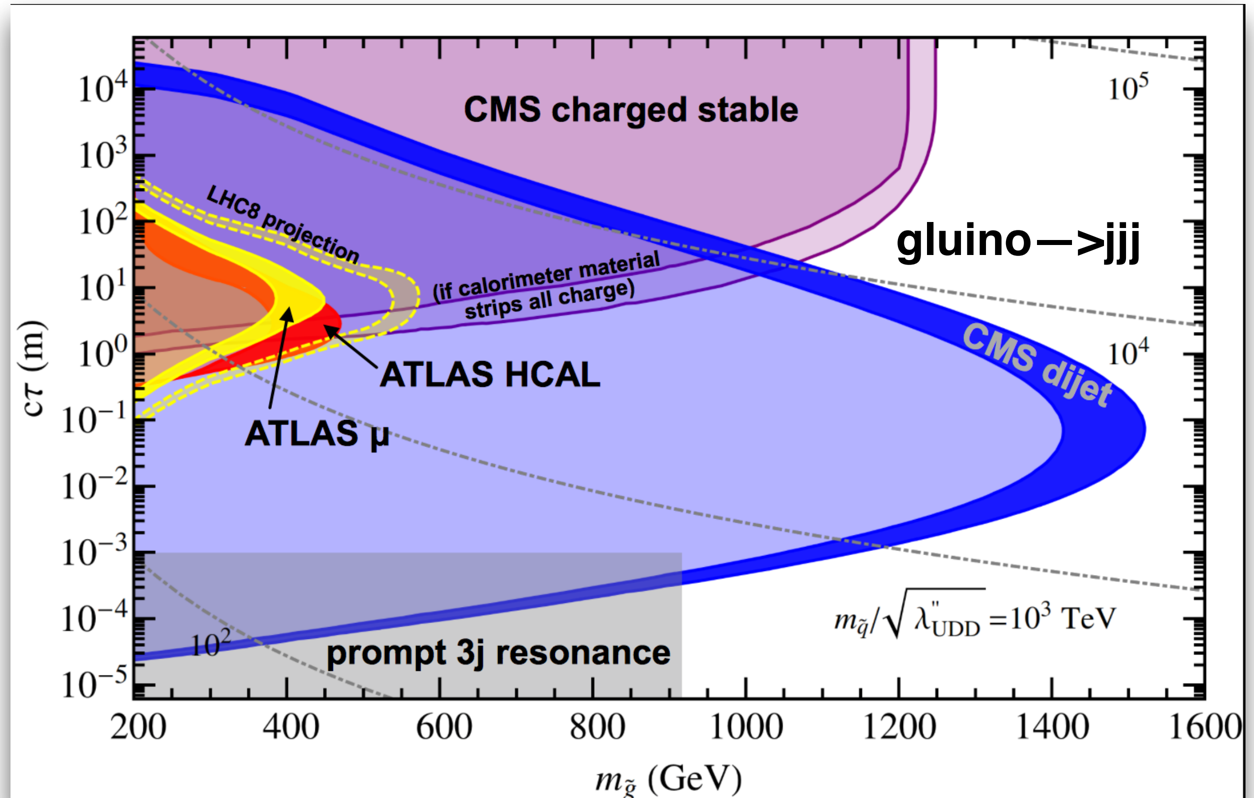


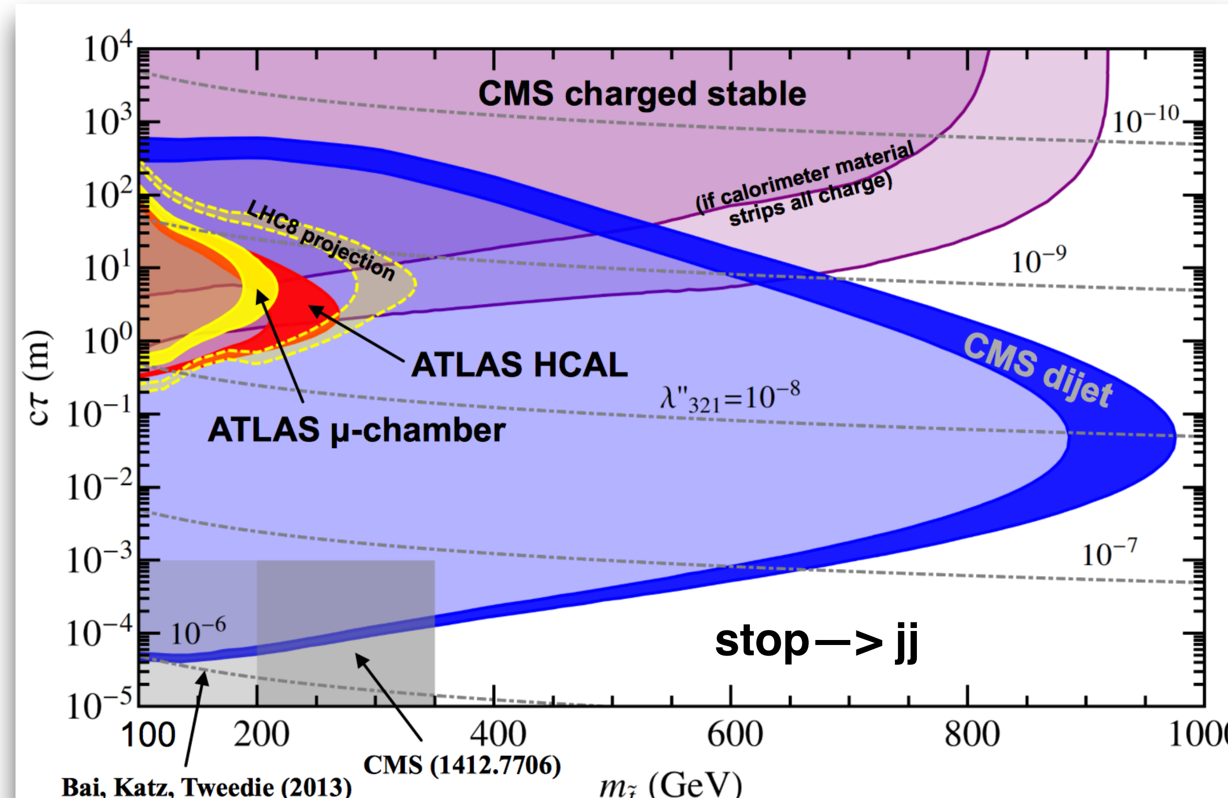


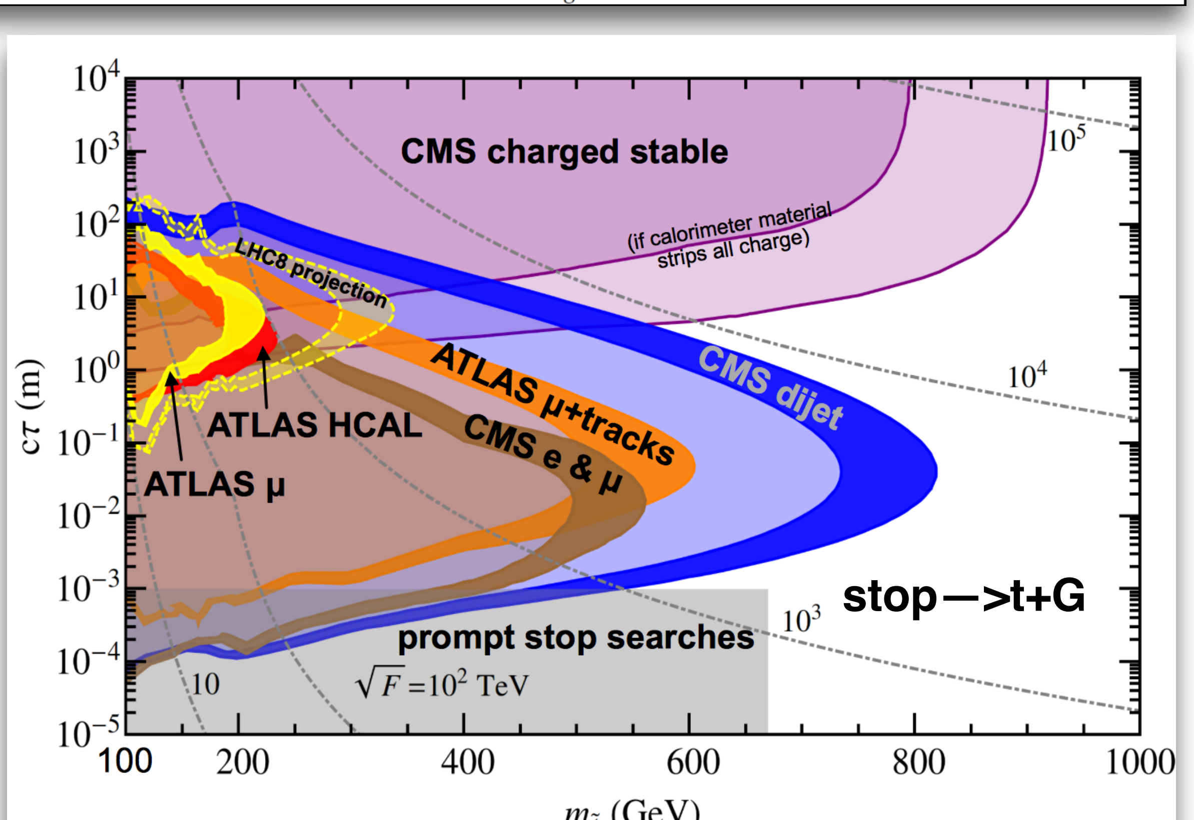
Run I Displaced Dijet Search

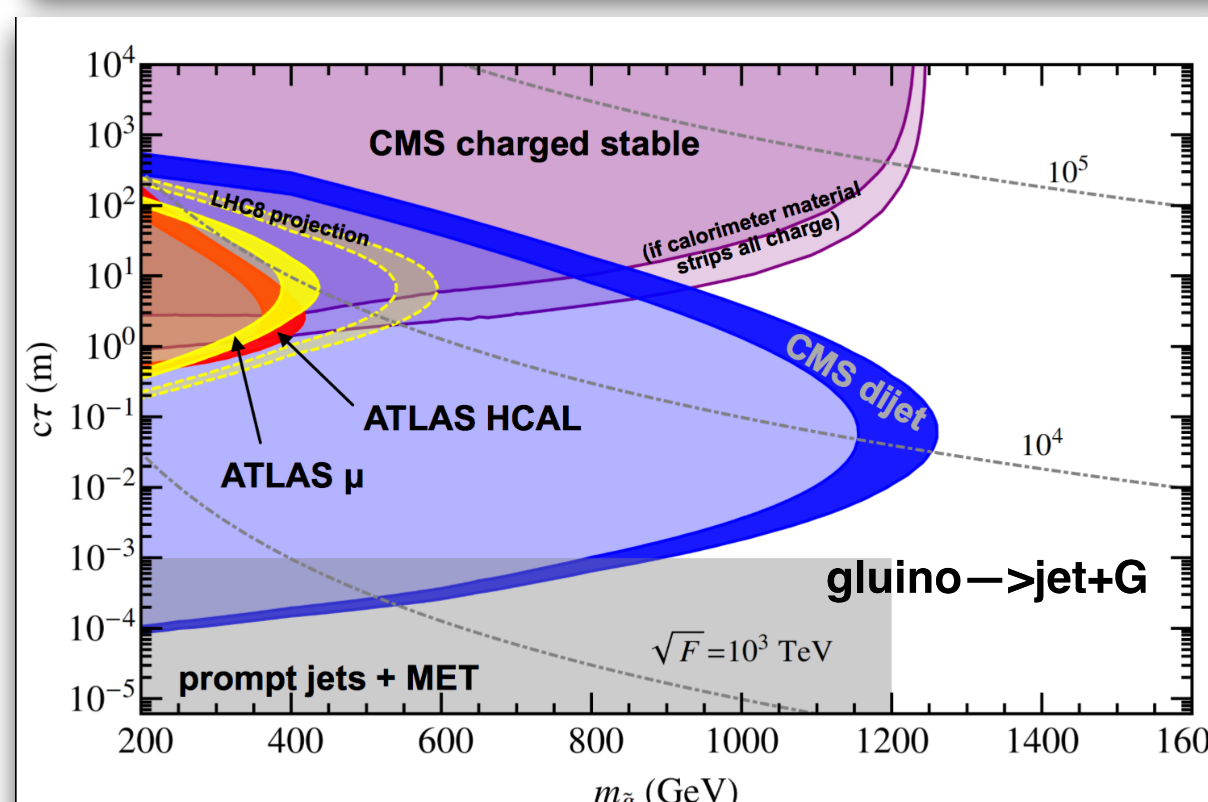
- Why focus on displaced dijet search (EXO-12-038)?
  - It is a powerful search
    - covers many important models involving long-lived objects
    - It has sensitivity to a wide range of lifetimes ctau from 1mm to 1m
  - It takes a minimalistic approach
    - Two "jets" with a common displaced vertex and little prompt energy
    - H_T>300 GeV
  - ~0 backgrounds
    - Essentially a rate limited search: Improvements must be directed towards improving acceptance, not further reducing background

SENSITIVITY







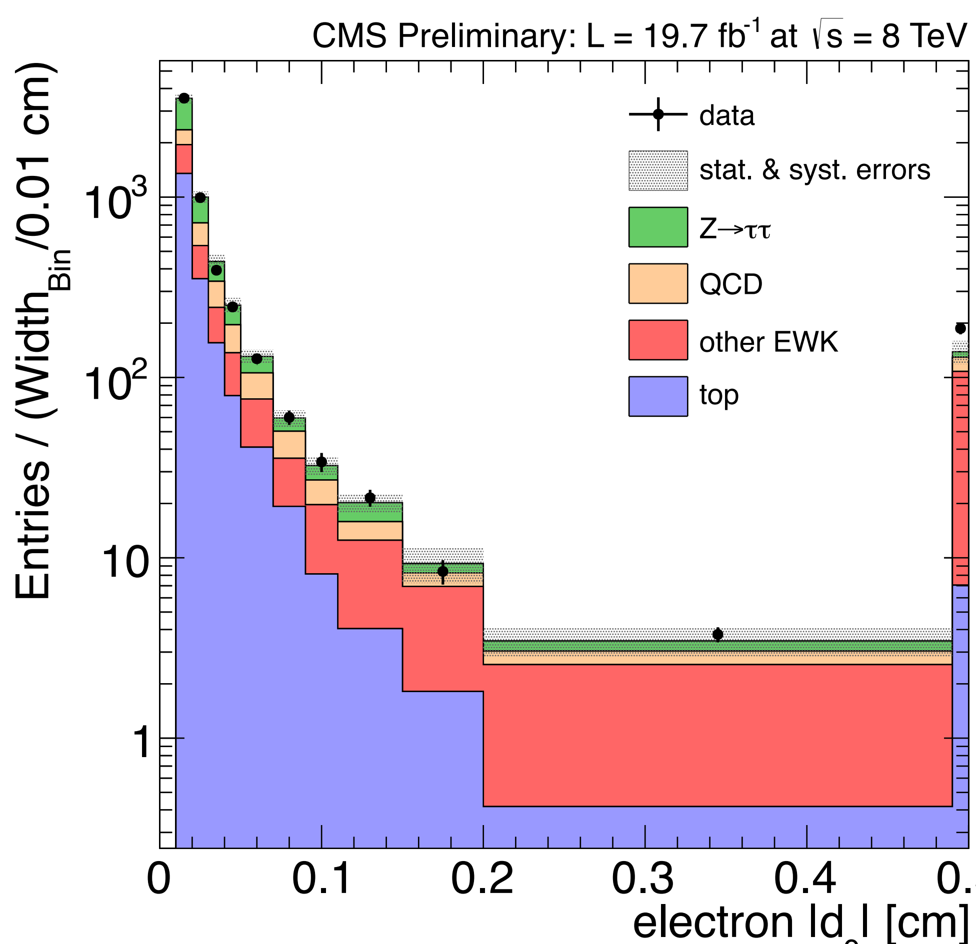


Displaced Dijet Coverage

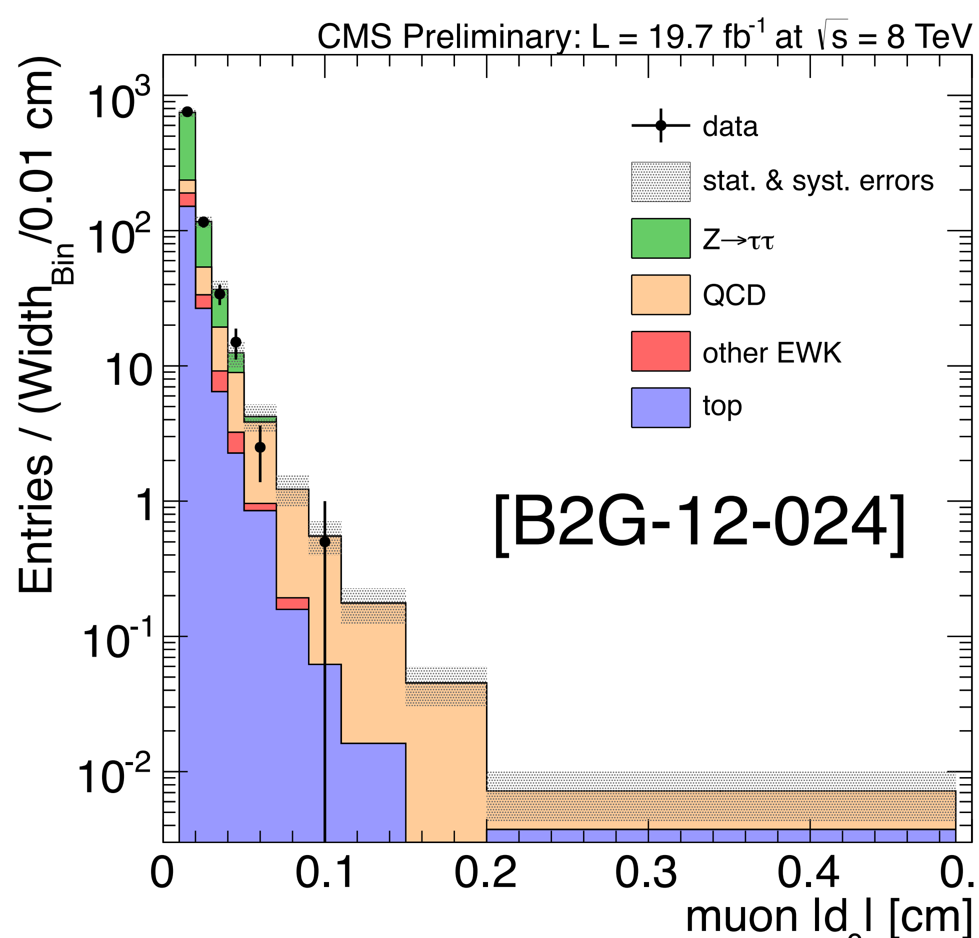
- Again, this single analysis is transparently very powerful
  - Still, there are places that it lacks coverage
    - it requires two, separated jets from the same vertex
    - H_T>300 GeV
    - reduced sensitivity for lifetimes below 1 mm and above 1 m
- Model dependent improvements by considering different triggers targeting associated production
  - single lepton, dilepton, VBF, MET, etc.
  - LL analyses typically have data-driven methods for the backgrounds (ABCD, etc.) so adapting to different triggers is very easy
- We are also pursuing other analyses that target:
  - shorter lifetimes, longer lifetimes (trackless jets), single displaced jets, looser displaced jet selection, etc.

Slightly Displaced Leptons

- Look for two isolated, opposite-sign, opposite-flavor leptons
  - require 2D impact parameters **between 0.05 cm and 2.0 cm**
    - Does **not require** that the two leptons originate from a common vertex
  - Dominant backgrounds: $Z \rightarrow \tau\tau$ and QCD
    - Check (below) that leptons with moderate displacements are still well-reconstructed



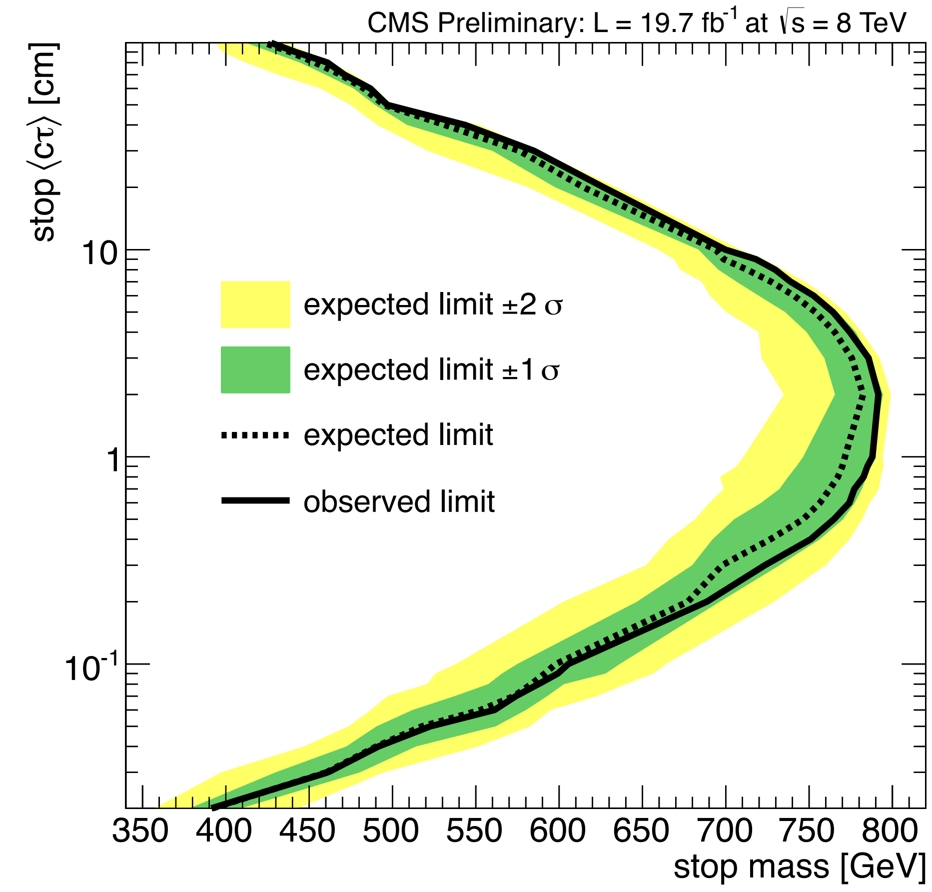
non-prompt e and prompt u



non-prompt u and prompt e

Slightly Displaced Leptons

- QCD background estimated with "ABCD" method
  - Opposite Sign v. Same Sign and Isolated v. Non-Isolated
- Three non-overlapping signal regions based on the minimum lepton d0



Event Source	$0.02\ \text{cm} < \lvert d_0 \rvert < 0.05\ \text{cm}$	$0.05\ \text{cm} < \lvert d_0 \rvert < 0.1\ \text{cm}$	$\lvert d_0 \rvert > 0.1\ \text{cm}$
other EWK	$0.65 \pm 0.13 \pm 0.08$	$(0.89 \pm 0.53 \pm 0.11) \times 10^{-2}$	$< (89 \pm 53 \pm 11) \times 10^{-4}$
top	$0.767 \pm 0.038 \pm 0.061$	$(1.25 \pm 0.26 \pm 0.10) \times 10^{-2}$	$(2.4 \pm 1.3 \pm 0.2) \times 10^{-4}$
$Z \to \tau\tau$	$3.93 \pm 0.42 \pm 0.32$	$(0.73 \pm 0.73 \pm 0.06) \times 10^{-2}$	$< (73 \pm 73 \pm 6) \times 10^{-4}$
QCD	$12.7 \pm 0.2 \pm 3.8$	$(98 \pm 6 \pm 30) \times 10^{-2}$	$(340 \pm 110 \pm 100) \times 10^{-4}$
Total expected background	$18.0 \pm 0.5 \pm 3.8$	$1.01 \pm 0.06 \pm 0.30$	$0.051 \pm 0.015 \pm 0.010$
Observation	19	0	0
$pp \to \tilde{t}_1 \tilde{t}_1^*$			
$M = 500$ GeV, $\langle c\tau \rangle = 1$ mm	$30.1 \pm 0.7 \pm 1.1$	$6.54 \pm 0.34 \pm 0.24$	$1.34 \pm 0.15 \pm 0.05$
$M = 500$ GeV, $\langle c\tau \rangle = 1$ cm	$35.3 \pm 0.8 \pm 1.3$	$30.3 \pm 0.7 \pm 1.1$	$51.3 \pm 1.0 \pm 1.9$
$M = 500$ GeV, $\langle c\tau \rangle = 10$ cm	$4.73 \pm 0.30 \pm 0.17$	$5.57 \pm 0.32 \pm 0.20$	$26.27 \pm 0.70 \pm 0.93$

Some Extensions

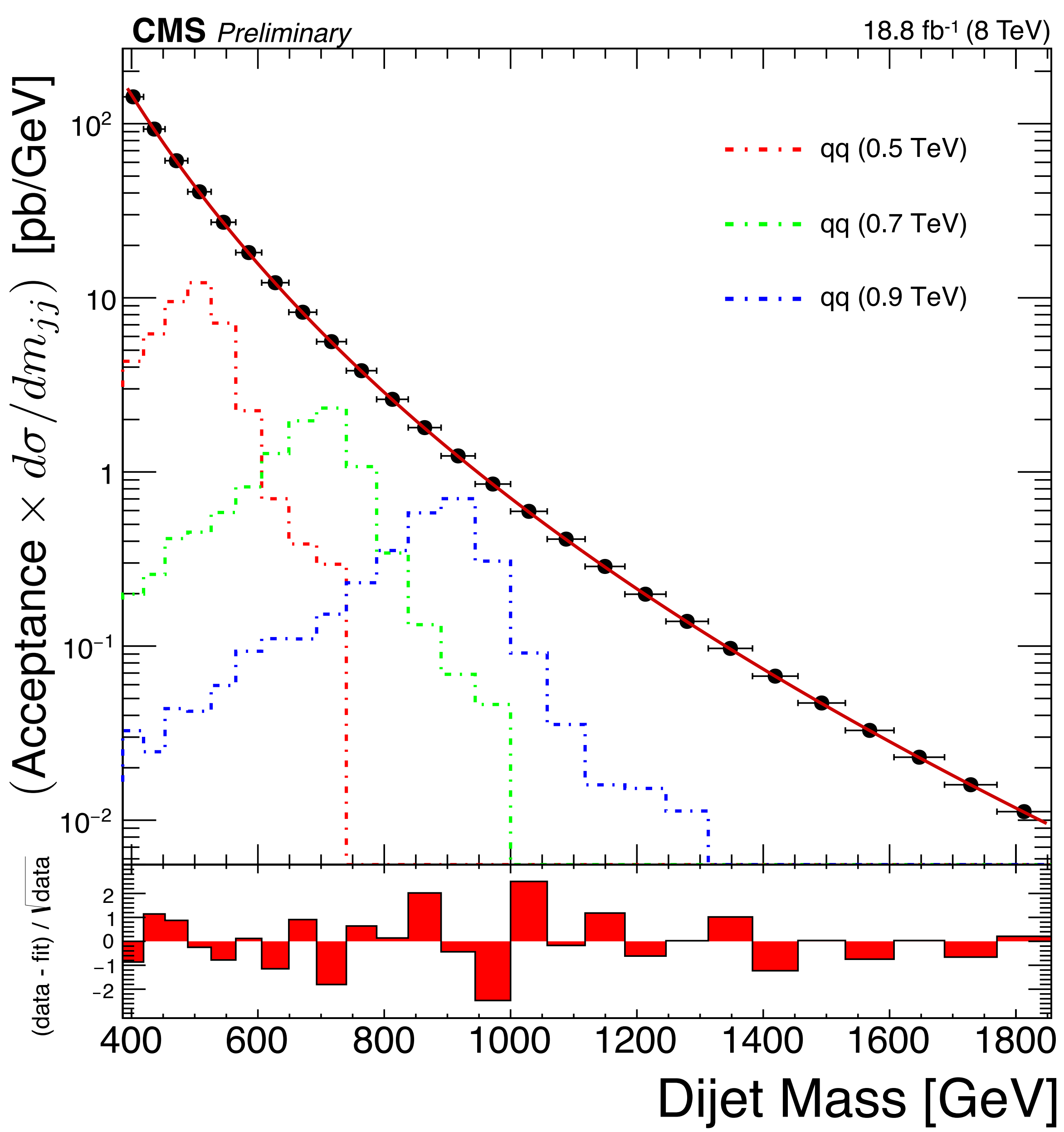
- displaced lepton analyses
  - plan to add taus to the list of displaced leptons (vertexed and non-vertexed) we look for
    - Probably it's simplest to start with mixed leptonic and hadronic modes to deal with trigger selection
  - look for displaced dileptons with m_{ll}<20 GeV
    - $h(125) \to XX \to (\tau\tau)(\tau\tau)$ is especially important for M_X<10 GeV
    - still important for other leptonic modes too
    - non-prompt "onia" are the obvious difficulty here
- Lesson for displaced photon analyses
  - Don't just look for displaced photons associated with jets+MET
    - photon pointing at CMS is tricky (ATLAS has a competitive advantage here)

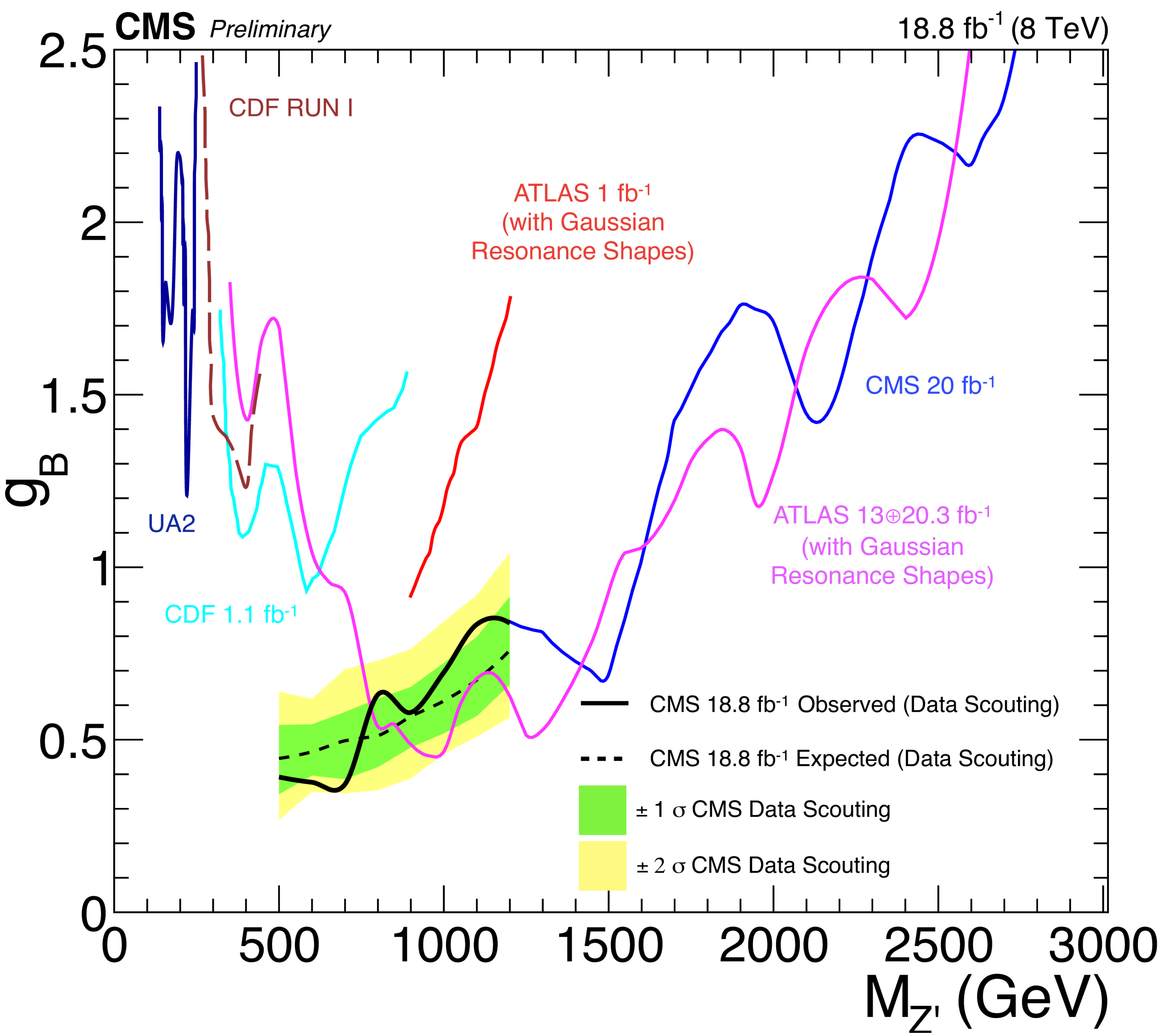
Scouting and Parking

- Data Scouting
  - HLT processes event rate of 100 kHz from L1 trigger
    - time optimized event reconstruction based on “offline” software
  - Ultimately, the limiting factor is **(event size) x (rate)**
  - Can write a substantially reduced dataset to tape at >kHz rate
    - for instance, keep just four vectors of electrons, muons, jets, etc.
    - we considerable flexibility for what is stored
      - nearly everything available in standard reconstruction can be recorded
      - but what we can do with tracking also has limitations…
- Data Parking (aka “delayed dataset”)
  - Can write up to 1000 Hz of data
    - O(300 Hz) is processed promptly and ready for analyzers to study within days
    - The rest may never be processed, but can be used as a backup in case something is observed in the scouting

Dijet Scouting Data in 2012

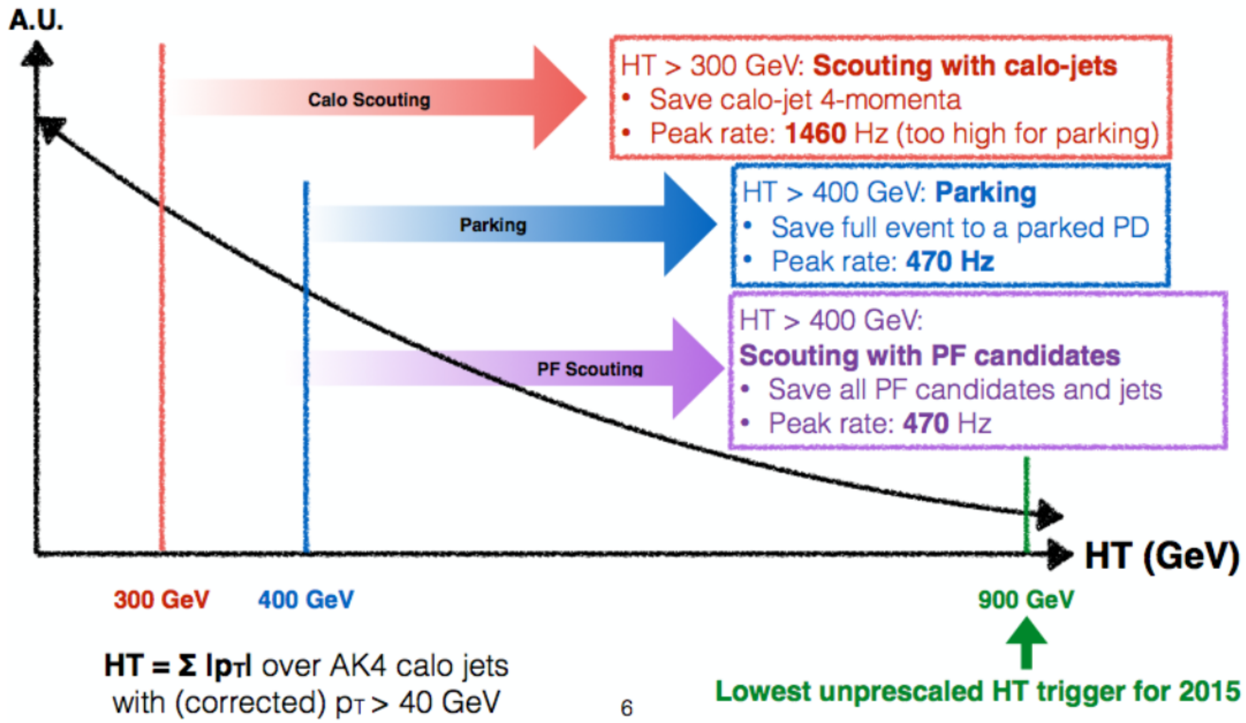
- Standard dijet bump hunt can access resonances as low as 500 GeV in 2012





DATA SCOUTING IN 2015

- Scouting CaloHT dataset: collected data starting October 1 (**1.8/fb**)
  - Events with **HT > 250 GeV**
- Scouting PFHT dataset: collected data starting October 1 (**1.8/fb**)
  - Events with **HT > 450 GeV**
  - Full event content is **parked**
- Scouting PFMuons dataset: collected data starting October 20 (**830/pb**)
  - Events with two muons having **pT > 3 GeV** and **$m_{\mu\mu}$ > 10 GeV**
  - Full event content is **parked**

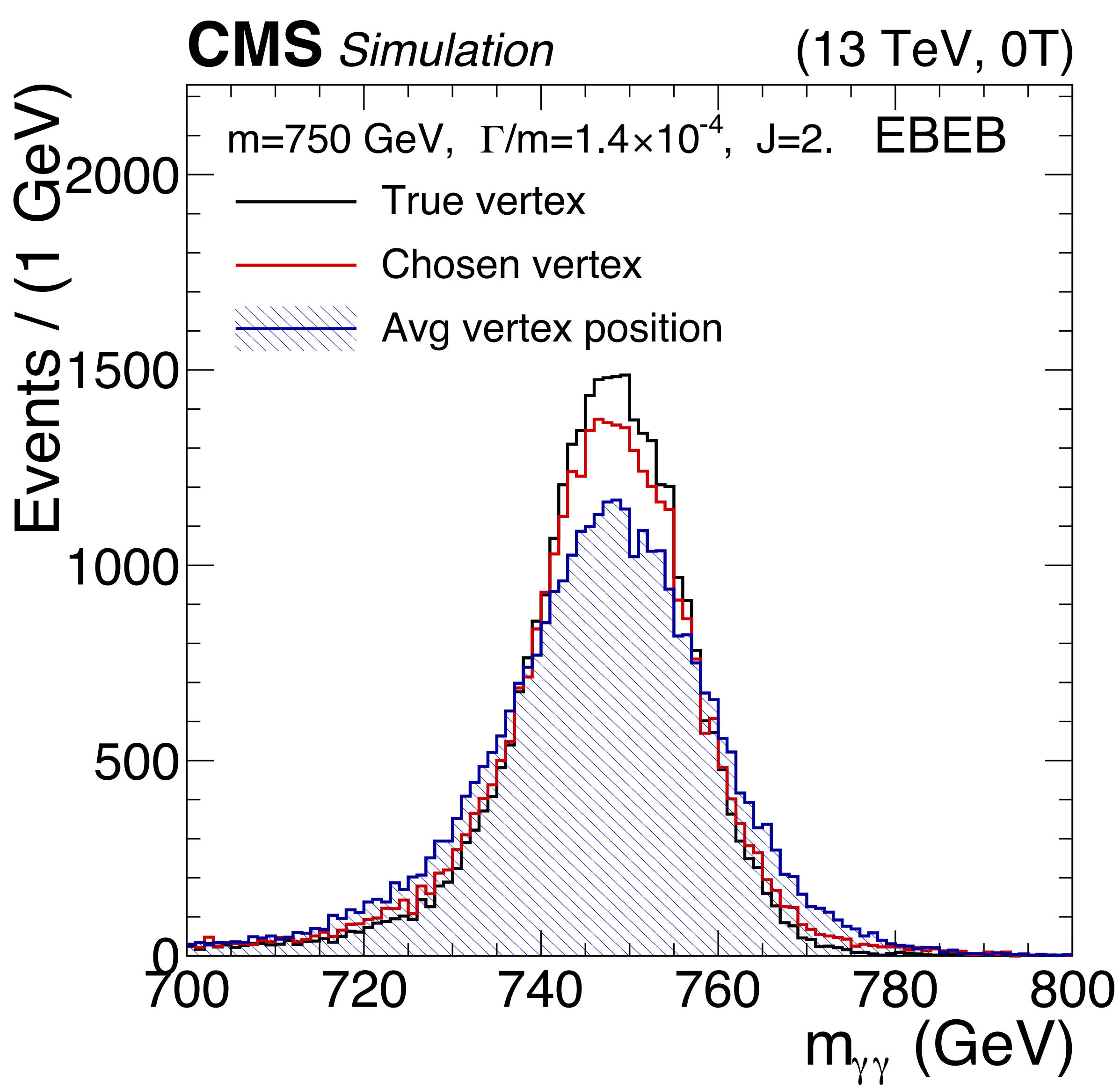


FURTHER IMPROVEMENTS FOR 2016

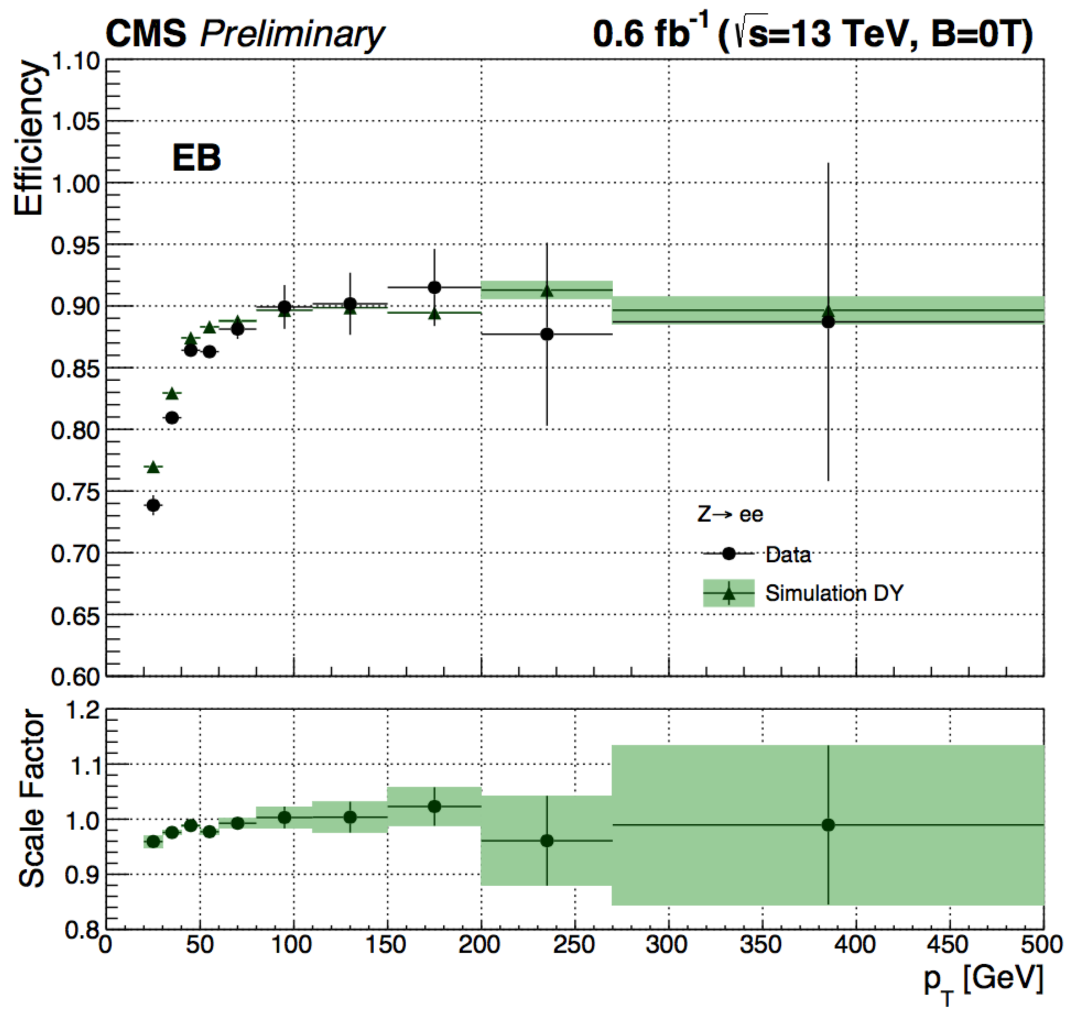
- Reduced thresholds
  - HT>410 GeV scouting trigger with PF information and matching parked dataset
  - Reduce DoubleMu invariant mass to 0 GeV for scouting (10 GeV still for parked dataset)
- Would like to expand / improve b-tag in scouting:
  - Timing study indicates that b-tagging can be added to the calo scouting event content
- R&D towards a fast PU ID for calo jets
- Any other good ideas?

Backup

- 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



8+13 TeV p-Values