

Search for new physics in events with a high-mass photon pair in proton-proton collisions at $\sqrt{s} = 8$ and 13 TeV

—Supplemental Material—

The CMS Collaboration

CERN

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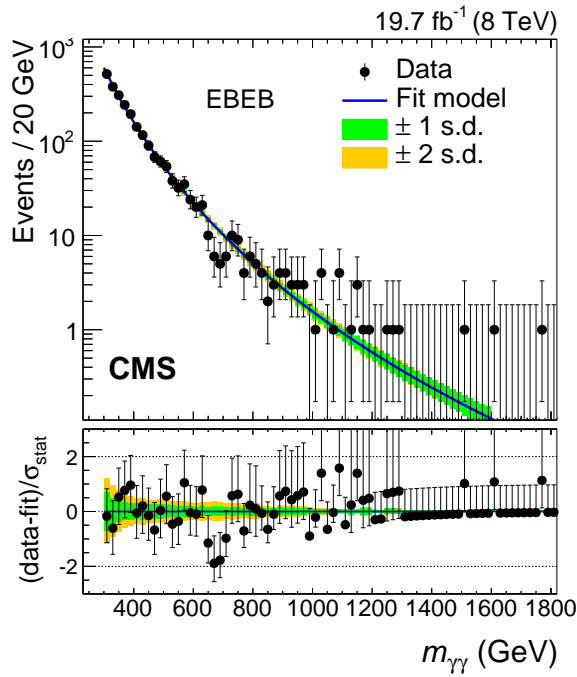


FIG. 1. Observed diphoton invariant mass $m_{\gamma\gamma}$ spectra for the event categories used in the analysis of the 8 TeV data for the $m_X > 850$ GeV search. No event with $m_{\gamma\gamma} > 1800$ GeV is selected in the analysis. The results of a likelihood fit to the background-only hypothesis are also shown. The lower panel shows the difference between the data and fit, divided by the statistical uncertainty in the data points.

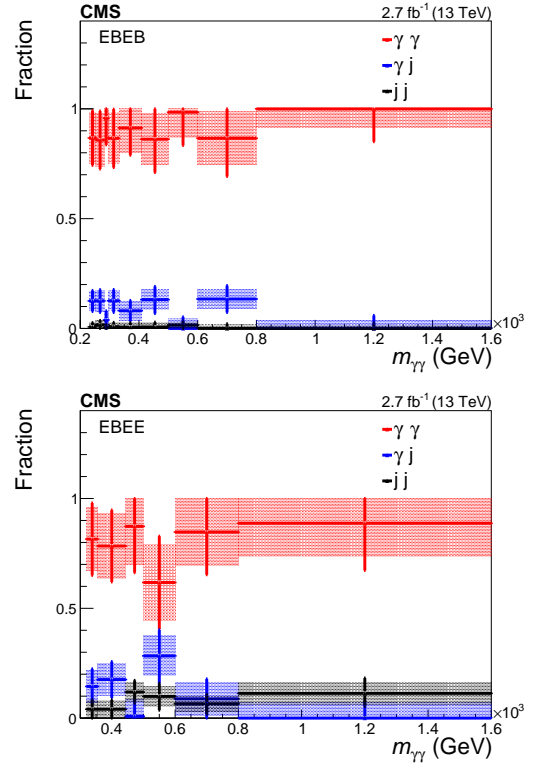


FIG. 2. Measured composition of the background for the 13 TeV analysis at 3.8 T for the (upper) EBEB and (lower) EBEE categories. The method described in Ref. [1] was used to obtain these results. The background corresponds to the direct production of two photons ($\gamma\gamma$), the production of γ + jets events (γj), and the production of multijet events (jj). The shaded error boxes represent the systematic uncertainties associated with the measurement, while the error bars represent the total uncertainties, obtained adding in quadrature statistical and systematic uncertainties.

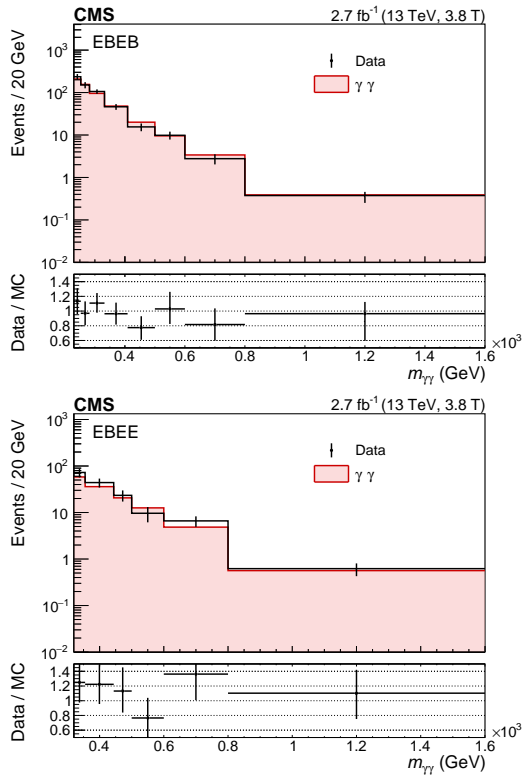


FIG. 3. Comparison between the measured and the predicted invariant mass spectrum of the nonresonant SM $\gamma\gamma$ background for the 13 TeV analysis at 3.8 T for the (upper) EBEB and (lower) EBEE categories. The γ +jets and multi-jet background components are subtracted in data, using the method described in Ref. [1]. The predicted background is obtained correcting the distribution of the events generated with the SHERPA 2.1 [2] generator (where the CMS detector response was simulated using the GEANT4 package [3]) to match the predictions obtained with the 2γ NNLO program [4].

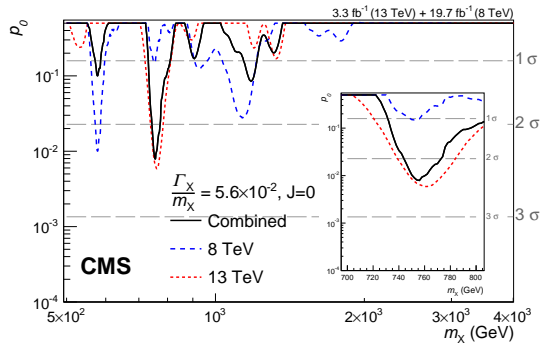


FIG. 4. Observed background-only p -values for spin-0 resonances with $\Gamma_X/m_X = 5.6 \times 10^{-2}$ as a function of the resonance mass m_X from the combined analysis of the 8 and 13 TeV data. The results for the 8 and 13 TeV data sets are also shown separately.

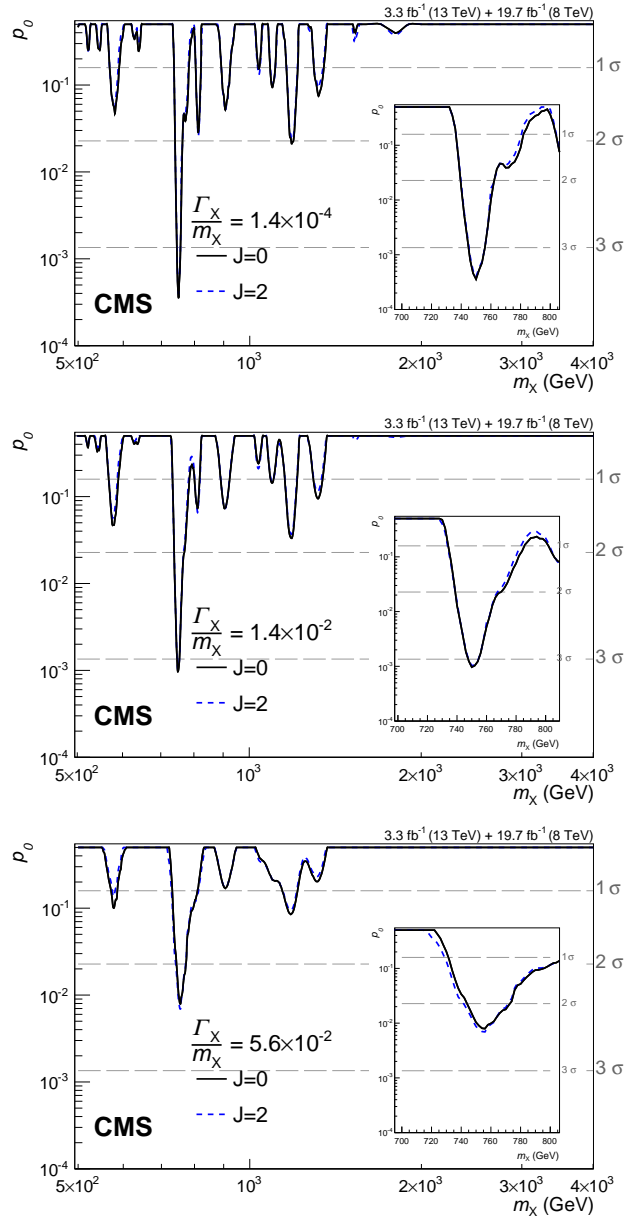


FIG. 5. Observed background-only p -values as a function of the resonance mass m_X from the combined analysis of the 8 and 13 TeV data. Three width hypotheses are shown: (upper) $\Gamma_X/m_X = 1.4 \times 10^{-4}$; (middle) $\Gamma_X/m_X = 1.4 \times 10^{-2}$; (lower) $\Gamma_X/m_X = 5.6 \times 10^{-2}$. In each plot, the results obtained under the RS graviton and scalar hypotheses are shown.

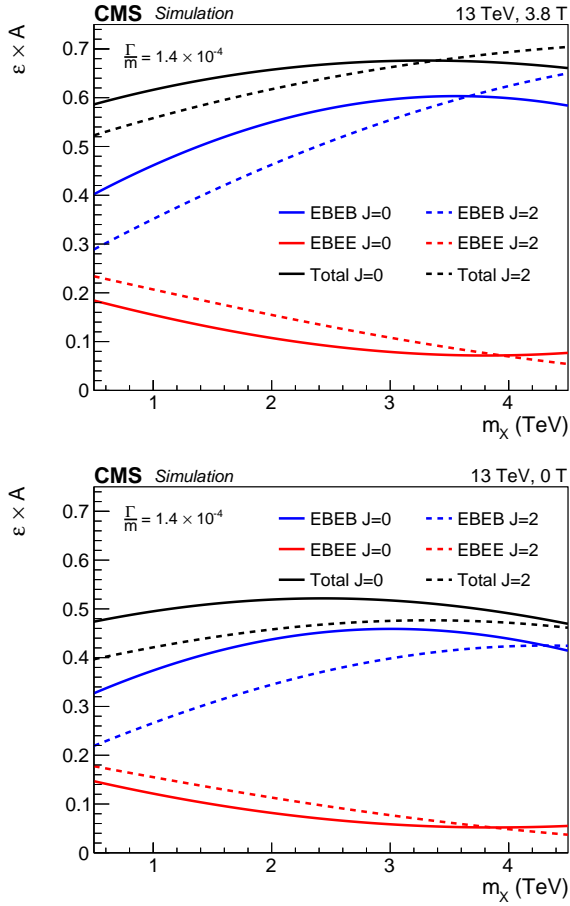


FIG. 6. Fraction of events selected by the analysis categories for $0.5 < m_X < 4.5$ TeV and $\Gamma_X/m_X = 1.4 \times 10^{-4}$. Curves for both spin-0 and RS graviton resonances are shown, in the upper plot for the 3.8 T sample and in the lower one for the 0 T sample.

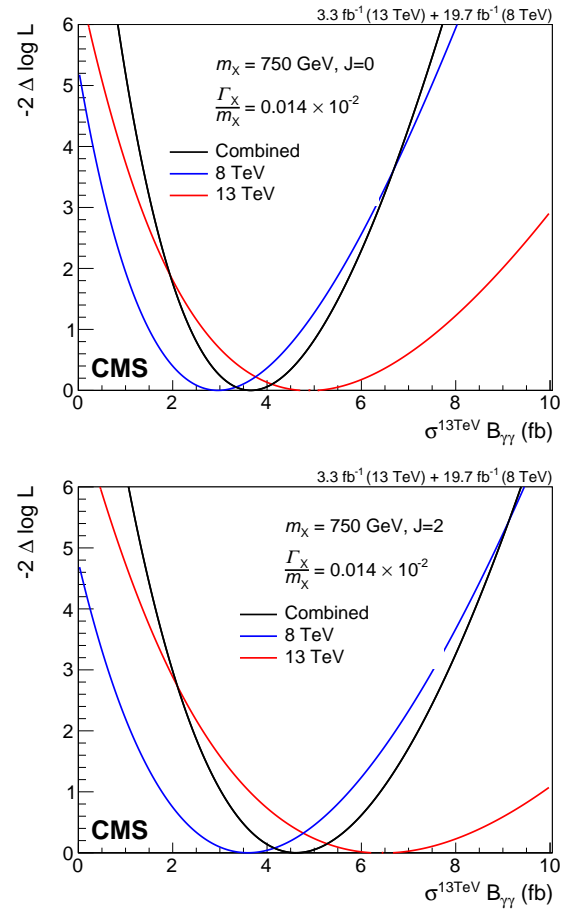


FIG. 7. Likelihood scan for the cross section corresponding to the largest excess in the combined analysis of the 8 and 13 TeV data sets. The upper (lower) plot corresponds to the scalar (RS graviton) signals. The 8 TeV results are scaled by the expected ratio of cross sections in each scenario.

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- [1] CMS Collaboration, “Measurement of differential cross sections for the production of a pair of isolated photons in pp collisions at $\sqrt{s} = 7\text{ TeV}$,” *Eur. Phys. J. C* **74**, 3129 (2014).
- [2] T. Gleisberg, S. Hoeche, F. Krauss, M. Schonherr, S. Schumann, F. Siegert, and J. Winter, “Event generation with SHERPA 1.1,” *J. High Energy Phys.* **02**, 007 (2009).
- [3] S. Agostinelli *et al.* (GEANT4), “GEANT4 — a simulation toolkit,” *Nucl. Instrum. Meth. A* **506**, 250 (2003).
- [4] Stefano Catani, Leandro Cieri, Daniel de Florian, Giancarlo Ferrera, and Massimiliano Grazzini, “Diphoton production at hadron colliders: a fully-differential QCD calculation at NNLO,” *Phys.Rev.Lett.* **108**, 072001 (2012).