CMS intensifies search for new physics, closes in on H(125) at 13 TeV

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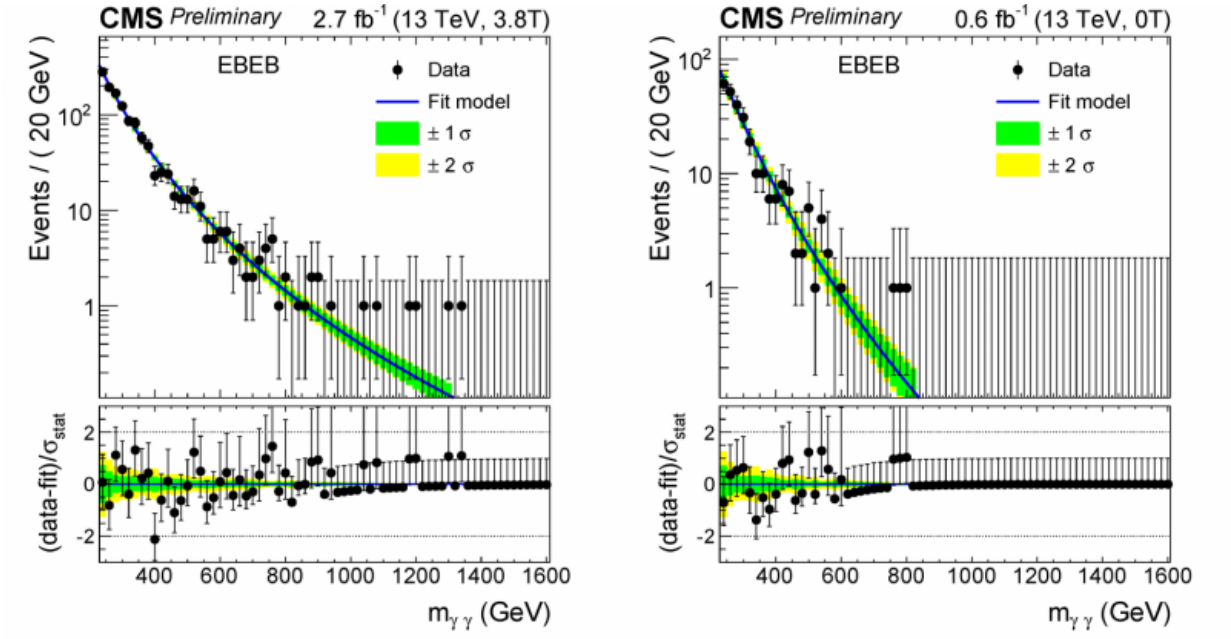

Figure 1: Invariant mass of photon pairs reconstructed in the central region of CMS collected in 2.7fb^{-1} of 3.8 T data (left) and 0.6fb^{-1} of 0 T data (right). Results of simultaneous parametric fits to the data, with uncertainty bands, are also shown.

The Rencontres de Moriond – Electroweak (Moriond EW) takes place this week in La Thuile, Aosta Valley, Italy, where the CMS Collaboration will present more than 30 new results approved since the December 15 seminar at CERN. First measurements of the 125 GeV

Higgs boson in 13 TeV data are presented, as well as an updated search for diphoton resonances; new searches for supersymmetric particles; tt resonances; and dark matter. In addition, CMS continues to exploit the Run 1 data with new precision measurements of Standard Model (SM) processes, including a preliminary estimate of the uncertainty achievable on the W boson mass.

Since Run 2 began, CMS has been working hard to calibrate and characterize the data collected. A new precision measurement of the recorded luminosity is being released this week, following a painstaking effort to calibrate the various luminometers using data taken during special LHC runs, the so-called "Van der Meer scans". The total uncertainty on the luminosity collected in 2015 (up to 2.7fb^{-1} with the solenoid at 3.8 T) is determined to be 2.7%, which is already comparable to the precision achieved at the end of Run 1. Identification of jets containing bottom quarks is a critical component in many searches and measurements performed by CMS. Preliminary calibration results including measurements of the identification efficiency of jets containing heavy or light quarks, as well as studies of b-jet identification algorithms applied to boosted topologies in multijet and tt events, have been finalized and used in the new results shown at Moriond EW.

In December, CMS presented a large number of first searches for new physics in the 13 TeV data, with results including a small excess above background in the diphoton channel near a mass of 750 GeV. Since then, CMS has reanalyzed the data using final calibrations obtained from the 2015 dataset, also including 0.6fb^{-1} of additional data collected while the solenoid was switched off. With these improvements, the sensitivity of the diphoton search increases by 20% relative to the previous result. Figure 1 shows the diphoton mass spectrum in the central region of CMS, separately for the field-on and field-off data. From a fit to the combined data over the range 500-4500 GeV, the largest excess is observed for a resonance of width $\Gamma/m = 1.4\times10^{-2}$ at a mass of 760 GeV,

corresponding to a local significance of 2.8-2.9σ depending on the spin hypothesis (0 or 2). The search at 13 TeV is also combined with results of similar searches in the 8 TeV data, yielding a local significance of 3.4σ for a mass of 750 GeV under the narrow width assumption ($\Gamma/m = 1.4\times10^{-2}$). More data is needed to determine the nature of this excess.

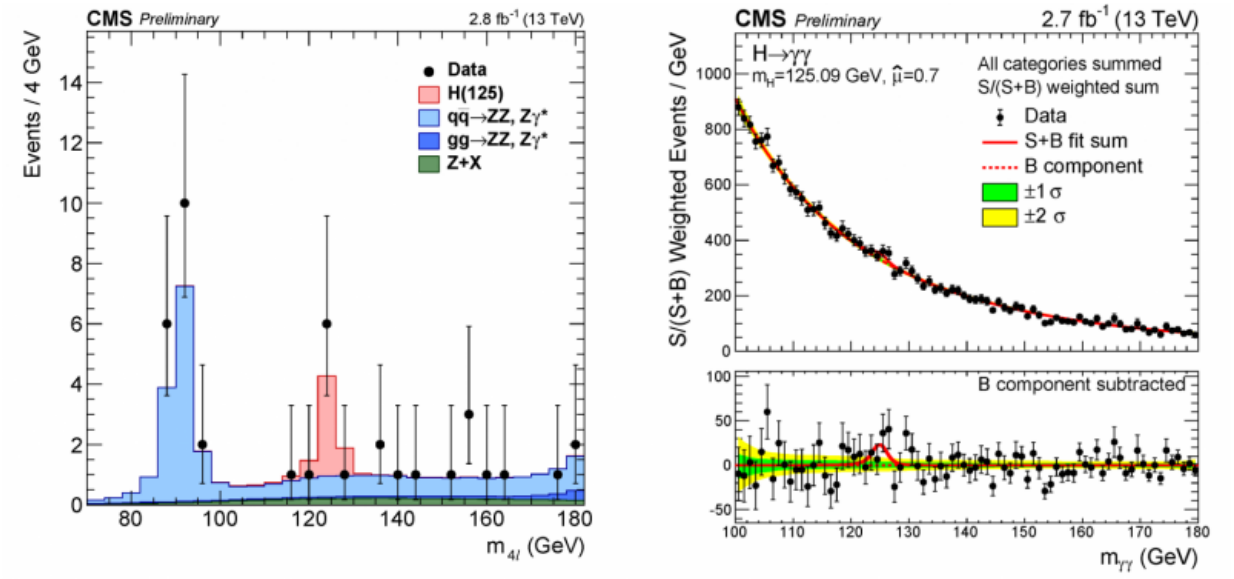

Figure 2: Invariant mass spectrum in the four-lepton (left) and two-photon (right) samples.

The search for physics beyond the SM is intensifying in CMS, with almost 20 new results presented for the first time at Moriond EW. These include six new results hunting for supersymmetric particles, including first limits on top-squark production at 13 TeV. Extended searches based on the results shown in December, including additional simplified model interpretations, as well as new results from searches in final states with leptons are also presented.

CMS remains on the lookout for dark matter produced at the LHC, presenting a new result searching for excesses in events containing bottom quarks that could arise from dark matter produced in association with bb or tt pairs. Searches for second generation leptoquarks and resonances decaying to tt pairs in 13 TeV data are presented for the first time at Moriond EW. Finally, eight new results are presented on the hunt for exotic Higgs bosons or non-standard decays of H(125), including five analyses reporting first searches at 13 TeV. The latter include a search for 'invisible' Higgs decays in the Z(ll)H channel, resonant and non-resonant di-Higgs production in the bbττ final state, and a search for high-mass Higgs bosons decaying in the Z(ll)Z(νν) channel. No significant signals are observed in any of these searches and limits are placed on various new physics models, which in some cases already exceed those achieved in Run 1.

Studying in detail the properties of the 125 GeV Higgs boson, which commences with establishing its decays in 13 TeV data, is one of the highest priorities of CMS. Measurements in the high-resolution channels, where the Higgs decays to two photons or two Z bosons, are presented for the first time at Moriond EW. In the 'golden' channel with $H \rightarrow ZZ \rightarrow 4$ leptons, CMS observes 8 events in the mass region 118 $^{+0.25}_{-0.22}$ background events are expected. The signal strength at the world average mass of 125.09 GeV is measured to be $\mu \equiv \sigma/\sigma SM = 0.82^{+0.57}_{-0.42}$, corresponding to an observed (expected) local significance of 2.5 (3.4) σ. In the diphoton channel (Fig. 2, right) at the world average mass CMS observes a local significance of about 1.7σ, where 2.7σ was expected. The signal strength is measured to be $\mu = 0.73^{+0.46}_{-0.45}$. Both channels are consistent with the Standard Model expectation and provide the initial sightings of the Higgs boson at 13 TeV.

In Run 1, CMS observed a ~2σ excess (relative to the SM prediction) of events where the Higgs boson is produced in association with top quarks (ttH). While still compatible with the SM, such an excess could indicate

contributions to Higgs production from new particles or interactions. Among the various ways the Higgs boson is produced at the LHC, the ttH channel receives the largest cross section increase from the boost in centre-of-mass energy to 13 TeV; investigating this anomaly in the new data was one of the top early priorities of the CMS Higgs analyses. At Moriond EW, a first look at ttH is presented in two decay channels, where the Higgs decays to bottom quarks or in multilepton final states that include WW, ZZ, and ττ decay modes. Within the limited precision of the early data, the results are consistent with the SM expectation and yield upper limits on the signal strength in the range μ=2.6-3.5.

The SM itself remains under intense scrutiny, with CMS presenting nine new results on a mix of Run 1 and Run 2 data. Notable among these is a first estimate of the uncertainty achievable on the W boson mass, m_W, which in electroweak theory is intimately connected to the masses of the top quark, m_t, and the Higgs boson, m_H. A precise measurement of m_W is a key test of the Higgs mechanism, and any deviation in the expected correlation with m_t and m_H could be a sign of new physics. The current best measurement of m_W comes from the CDF experiment and amounts to 19 MeV. As a first step on the path toward a measurement, CMS has employed a technique to estimate the achievable precision from $Z \rightarrow \mu\mu$ events where one muon is removed, mimicking $W \rightarrow \mu\nu$ decays. The analysis involves tour-de-force estimates of various detector effects, including a precision of 0.01% on the impact of the muon momentum scale on mW. In the end, CMS achieves an uncertainty of ±35 (stat)±30 (syst) MeV on the "W-like" Z boson mass using data collected in 2011. Additional SM results on the top quark are presented, including a first look at the ttZ process, where a Z boson is produced in association with a top quark pair, and several new measurements of the top quark mass using pure leptonic information, single-top events or final states including J/ψ mesons.

Provided by CERN