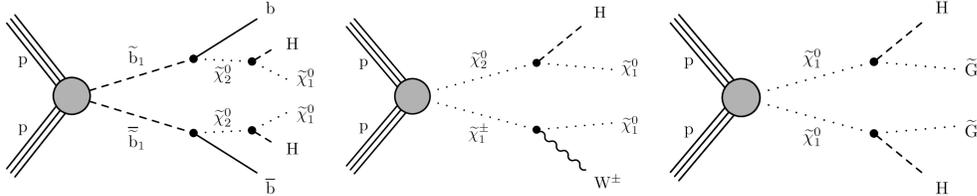


Introduction

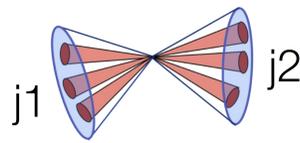
- A wide range of supersymmetry (SUSY) particles decay to Higgs



- $H \rightarrow \gamma\gamma$ is one of the best accessible channels due to suppression of background.
- This search uses LHC proton-proton collision data collected by the CMS experiment at a center-of-mass energy of $\sqrt{S} = 13$ TeV and corresponding to an integrated luminosity of 35.9 fb^{-1} .
- Interpretation: SUSY Strong and EWK production

Razor Variables

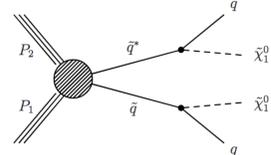
- Higgs candidate and all identified jets are clustered into two **megajets**.
- The razor variables M_R and R^2 are defined in terms of the momenta of the two megajets:



$$M_R \equiv \sqrt{(|\vec{p}^1| + |\vec{p}^2|)^2 - (p_z^1 + p_z^2)^2},$$

$$R^2 \equiv \left(\frac{M_R^T}{M_R}\right)^2, \text{ where } M_R^T \equiv \sqrt{\frac{E_T^{\text{miss}}(p_T^1 + p_T^2) - \vec{p}_T^{\text{miss}} \cdot (\vec{p}_T^1 + \vec{p}_T^2)}{2}}.$$

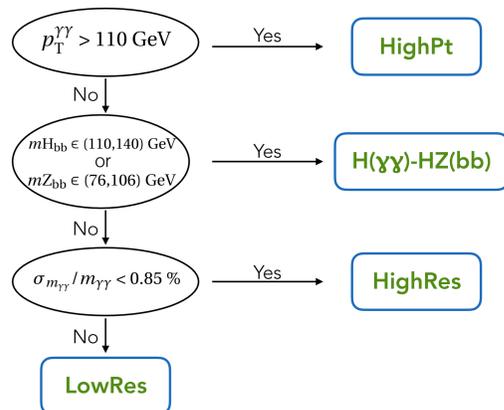
- M_R peaks at characteristic mass scale $M_\Delta \approx (m_{\tilde{q}}^2 - m_{\tilde{\chi}_1^0}^2)/m_{\tilde{q}}$ for SUSY signals, and M_R^T has maximum value at M_Δ .
- R^2 is related to \vec{p}_T^{miss} in the event.
- M_R and R^2 are exponentially falling for standard model (SM) backgrounds like QCD multijet events.
- This also allows us to identify a 2D $M_R - R^2$ region where SUSY signals are enhanced while SM backgrounds are reduced.



Event Selection and Categorization

- At least two photons and one jet:
 - Photons: $|\eta^\gamma| < 1.5$, $p_T^{\gamma 1} > 40$ GeV, $p_T^{\gamma 2} > 25$ GeV
 - Jet: $|\eta^j| < 3.0$, $p_T^j > 30$ GeV

- Select the photon pair that maximizes scalar sum $p_T(p_T^{\gamma 1} + p_T^{\gamma 2})$ as the best Higgs candidate.
- Each event is then put into one of four categories depending on Higgs p_T , presence of hadronic $H \rightarrow b\bar{b}$ or $Z \rightarrow b\bar{b}$ candidate, and diphoton mass resolution.



- Each category is divided into several bins based on razor variables to further enhance S/B.

Background Estimation

- Two broad classes of backgrounds:
 - Resonant backgrounds:
 - SM Higgs is modeled using aMC@NLO Monte Carlo simulation samples.
 - Non-resonant backgrounds:
 - sources: real photon qcd, photon+jets qcd, qcd multijets
 - It is modeled by a functional-form fit to the $M_{\gamma\gamma}$ spectrum within each bin.

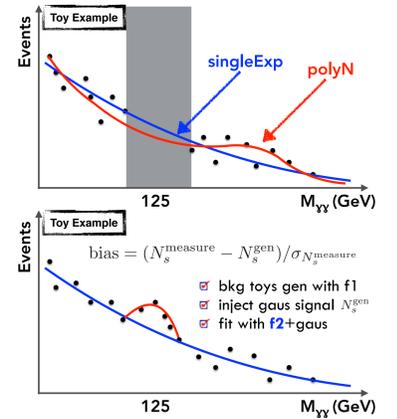
Functional Form Modeling

- First, fit the sideband data with each function candidates and exclude functions with large Akaike Information Criterion (AIC) score:

$$AIC = -2\log(\mathcal{L}) + 2k + \frac{2k(k+1)}{N-k-1}$$

$$\approx -2\log(\mathcal{L}) + 2k$$

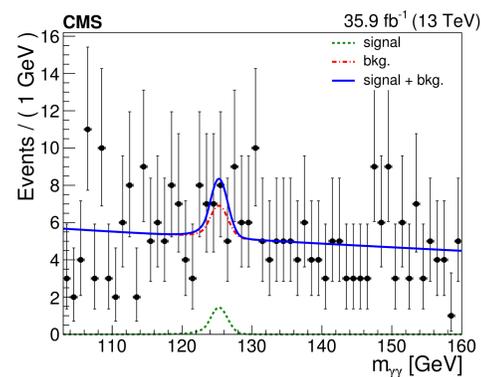
- Then, perform a bias test by toy experiments for each function pairs among the functions that pass AIC test.



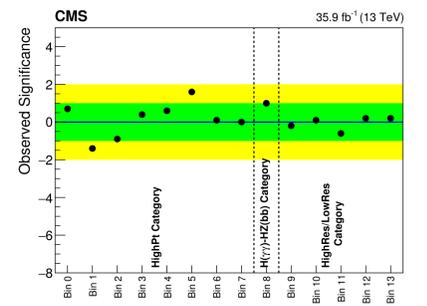
- The final function is chosen with a preferred order among the candidates that pass both AIC and bias test.

Fit Results and Limits on SUSY Masses

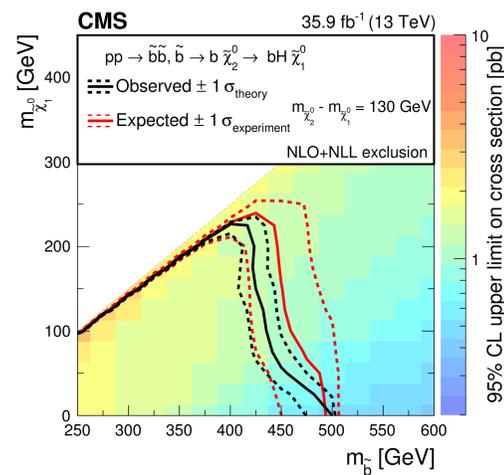
- Dominant systematics are fit uncertainties on the non-resonant background.
- The bin with the largest significance occurs in the HighPt category with $M_R > 600$ GeV and $R^2 > 0.025$.



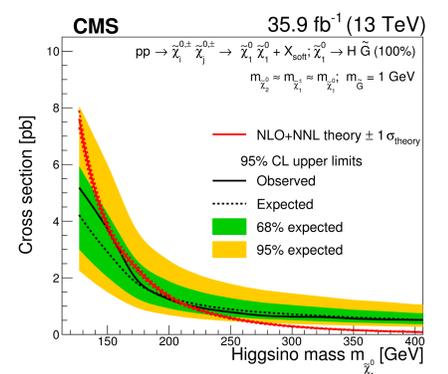
- None of the 14 bins exhibits a deviation from the background expectation larger than two standard deviations.



- We exclude bottom squarks with masses below about 450 GeV for all LSP masses below 250 GeV.



- We exclude charginos with mass below 205 GeV for neutralinos decaying to a Higgs boson and a goldstino LSP (\tilde{G}) with 100% branching fraction.



Summary and Outlook

- Current search is performed with 35.9 fb^{-1} of 13 TeV data.
- Search for anomalous Higgs production from SUSY particle decays performed with doubled luminosity from Run 2 using the razor variables M_R and R^2 is on-going.
- Preparing the next iteration of the analysis; optimization for events containing leptons in addition to the photons.

References: CMS-PAS-SUS-14-017 (Run 1), CMS-PAS-SUS-16-012 (ICHEP 2016), PLB 779 (2018) 166.