Search for SM $H \to \mu\mu$ at CMS

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Bundesministerium
für Bildung
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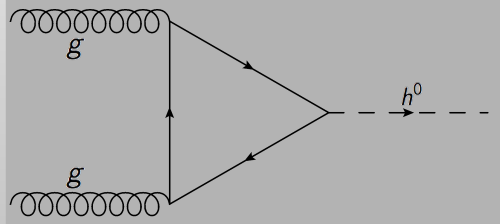
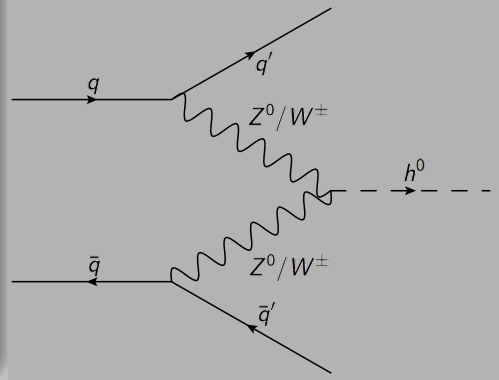
signal topology

Gluon Gluon Fusion



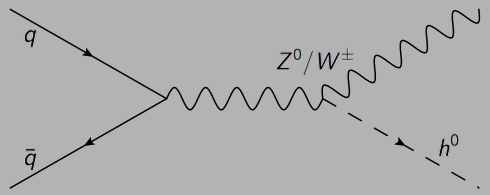
- high cross section
- two isolated muons
- low $\not{E}_T$
- no additional jets

Vector Boson Fusion



- lower cross section
- two isolated muons
- low $\not{E}_T$
- two jets in forward region

associated production

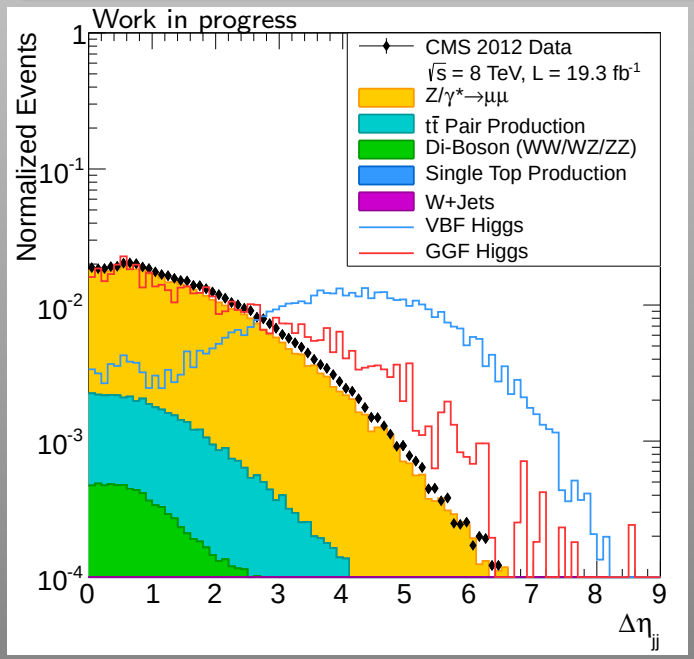


- very low cross section
- boson in the final state can offer additional leptons for separation
- statistics to low at this point

VBF Optimization

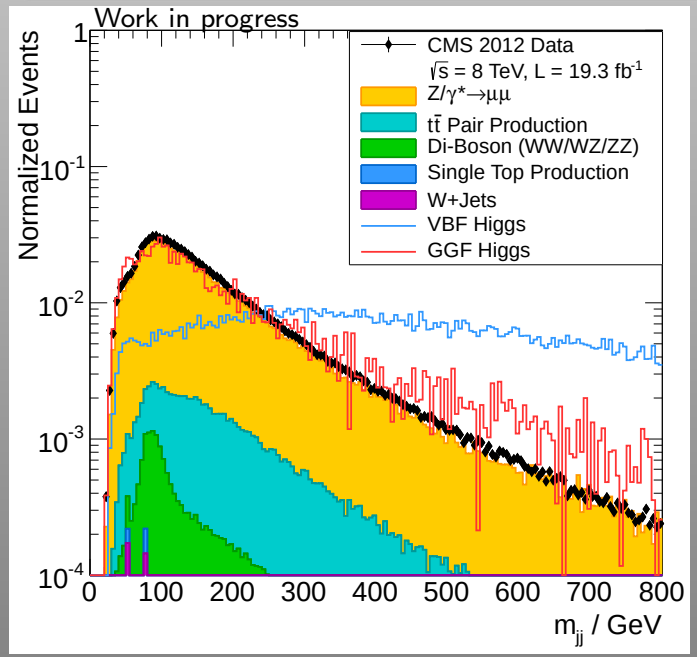
di-jet preselection

- $p_T > 40(30)$ GeV, $|\eta| < 4.7$
- loose CMS jet ID
- tight Pile-Up ID (MVA)
- $\not{E}_T < 40$ GeV
- jet corrections applied

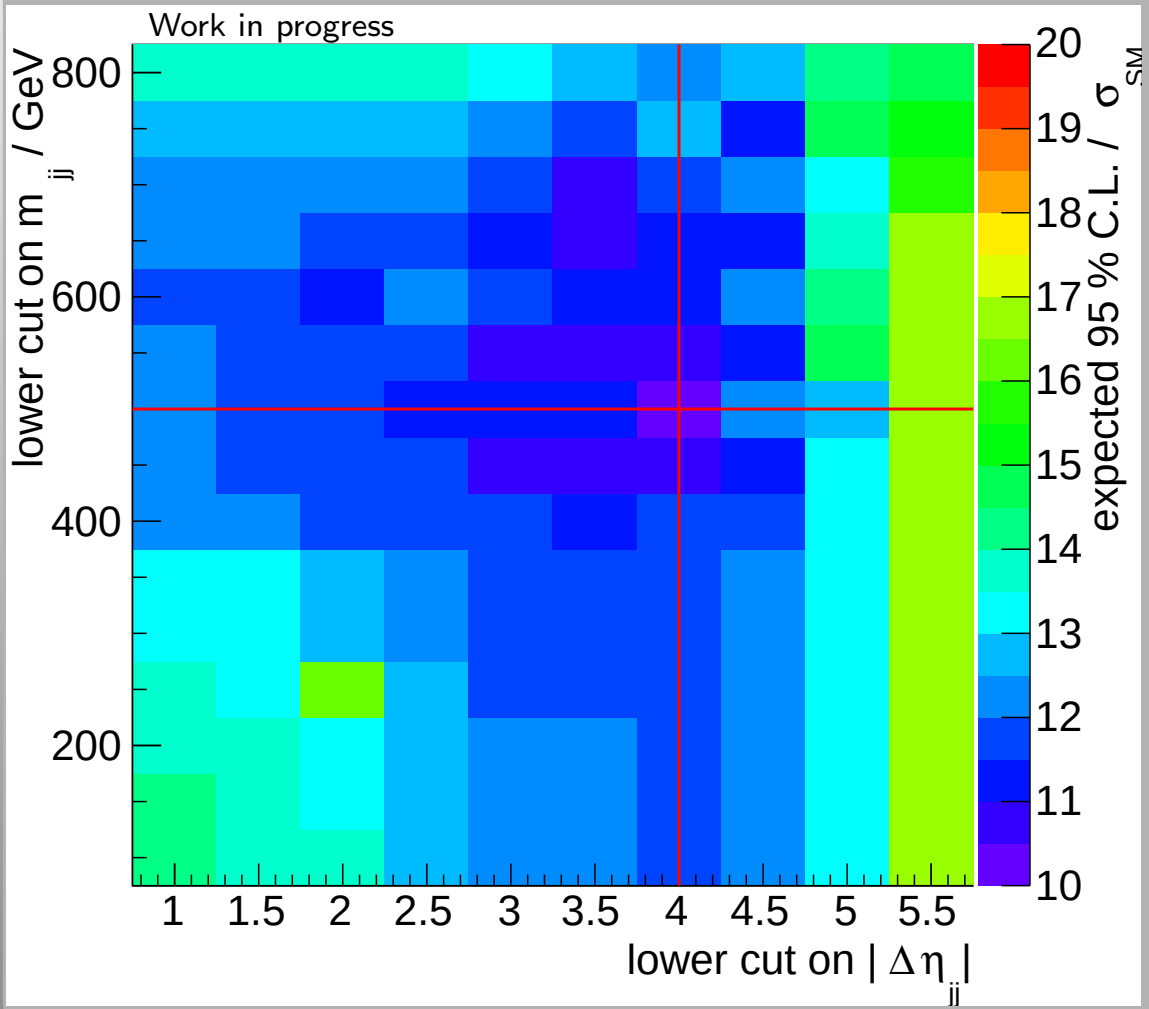


VBF Optimization

- signal sensitivity in the VBF selection optimized
- separation of the two jets ($\Delta\eta$) and
- invariant di-jet mass cuts are varied

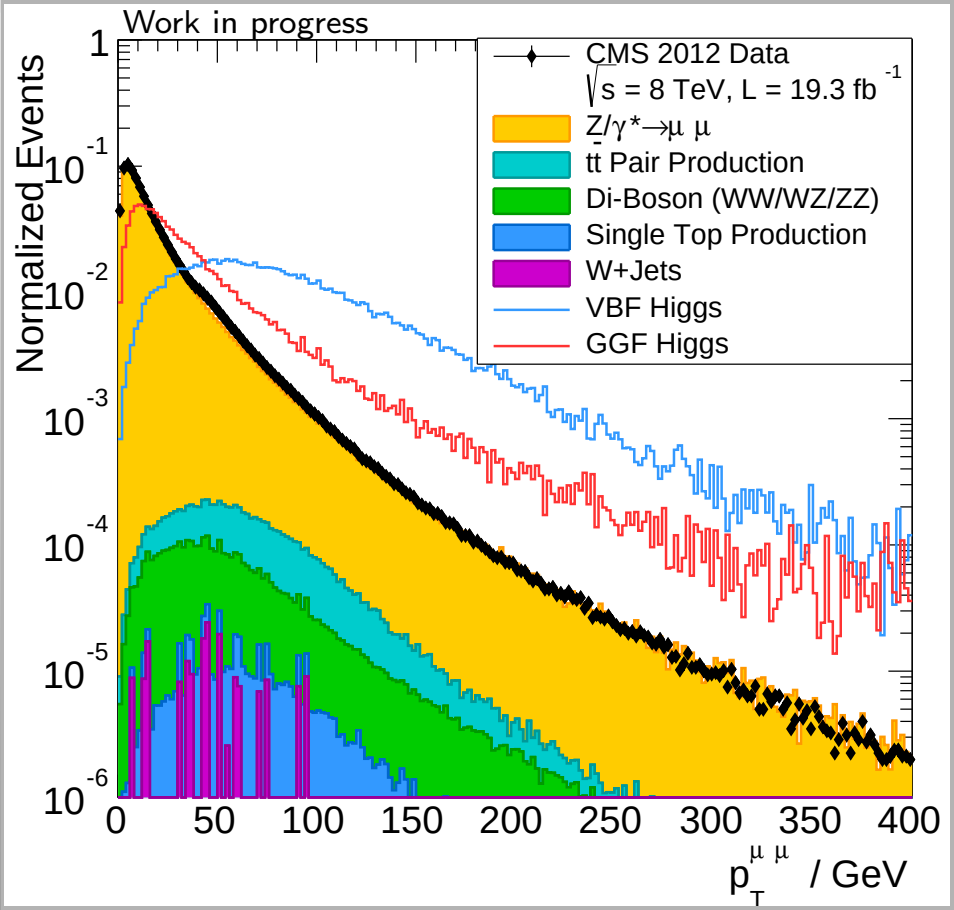


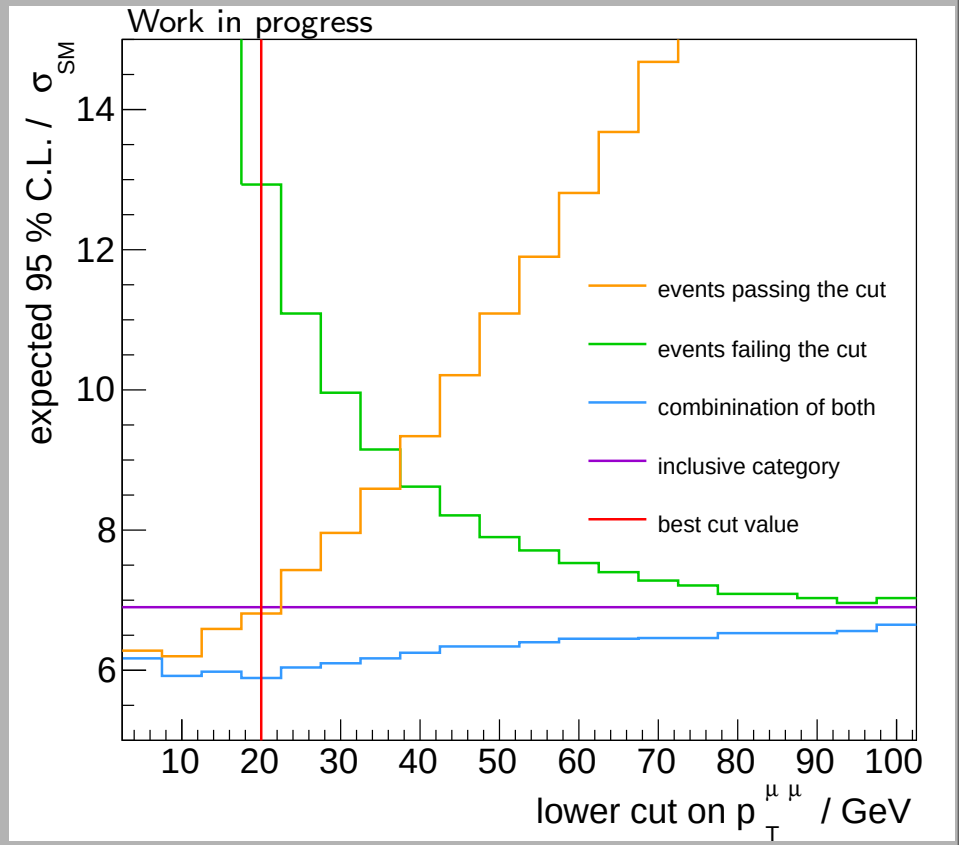
VBF Optimization



- cuts are scanned in 2-D
- expected exclusion limit is calculated as measure of sensitivity
- lowest expected limit for $m_{jj} > 500$ GeV and $|\Delta\eta| > 4$
- events passing the di-jet preselection but failing the optimized cuts are recovered in a separate category

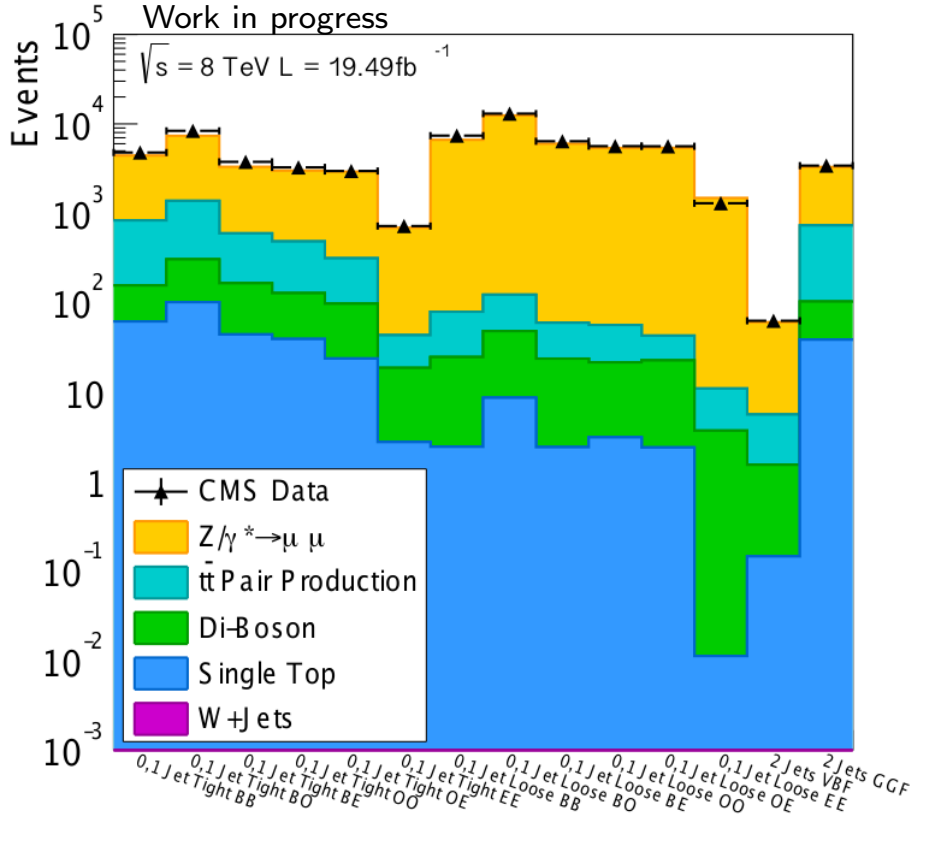
Non-VBF Optimization



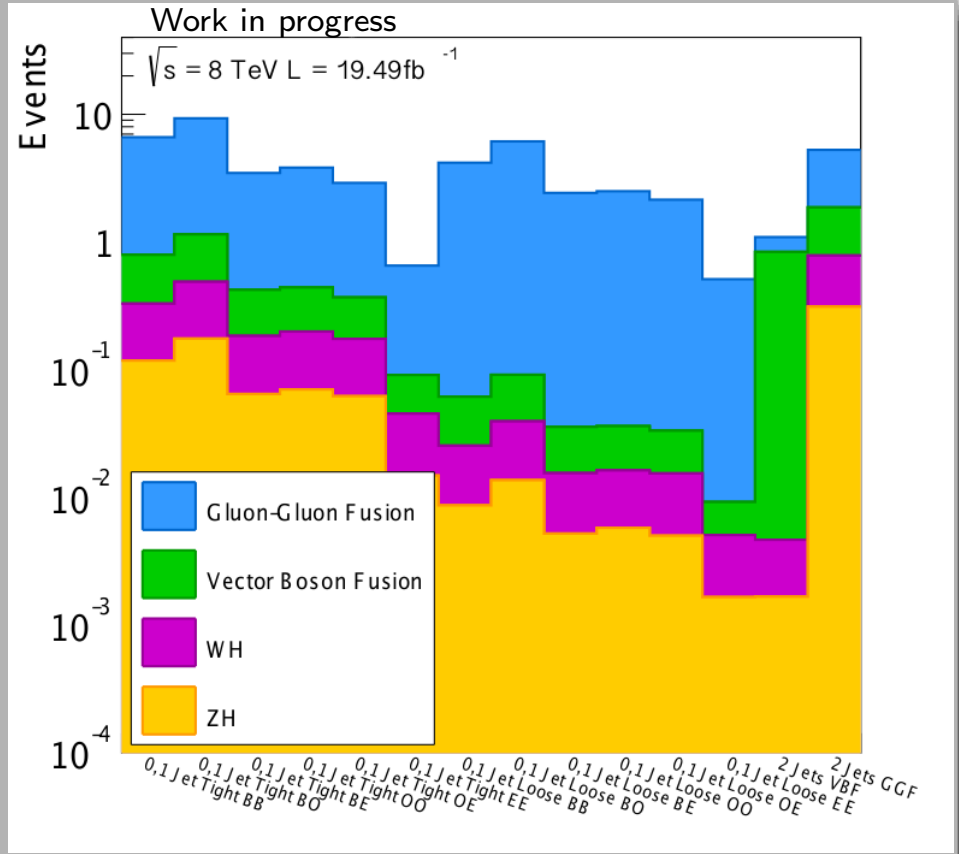


- enhanced sensitvity for events failing the VBF selection by splitting according to their dimuon transverse momentum
- the split is optimized with the expected exclusion limit of the combination
- further gain ($\approx 5\%$) by a split in geometric categories for the muons

Summary Categorization



background composition

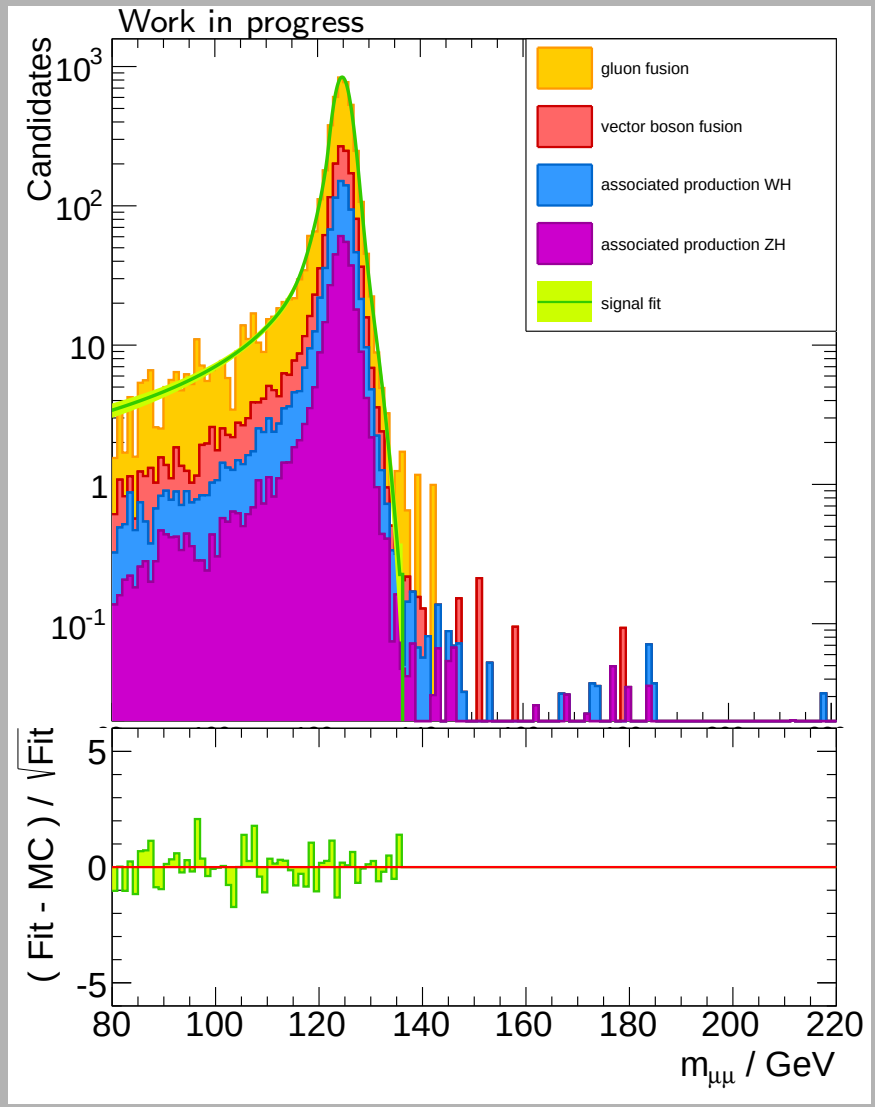


expected signal composition

- optimized VBF category gives best signal to background ratio
- Non VBF categories have poor S to B ratio but gain leverage due to higher statistics

Signal Fit

- signal hypothesis consists of linear combination of a Gaussian and a crystal ball shape
- signal hypothesis is fitted to MC Simulation at each point and category
- shape is interpolated between generated mass points
- parameters are fixed for final fit

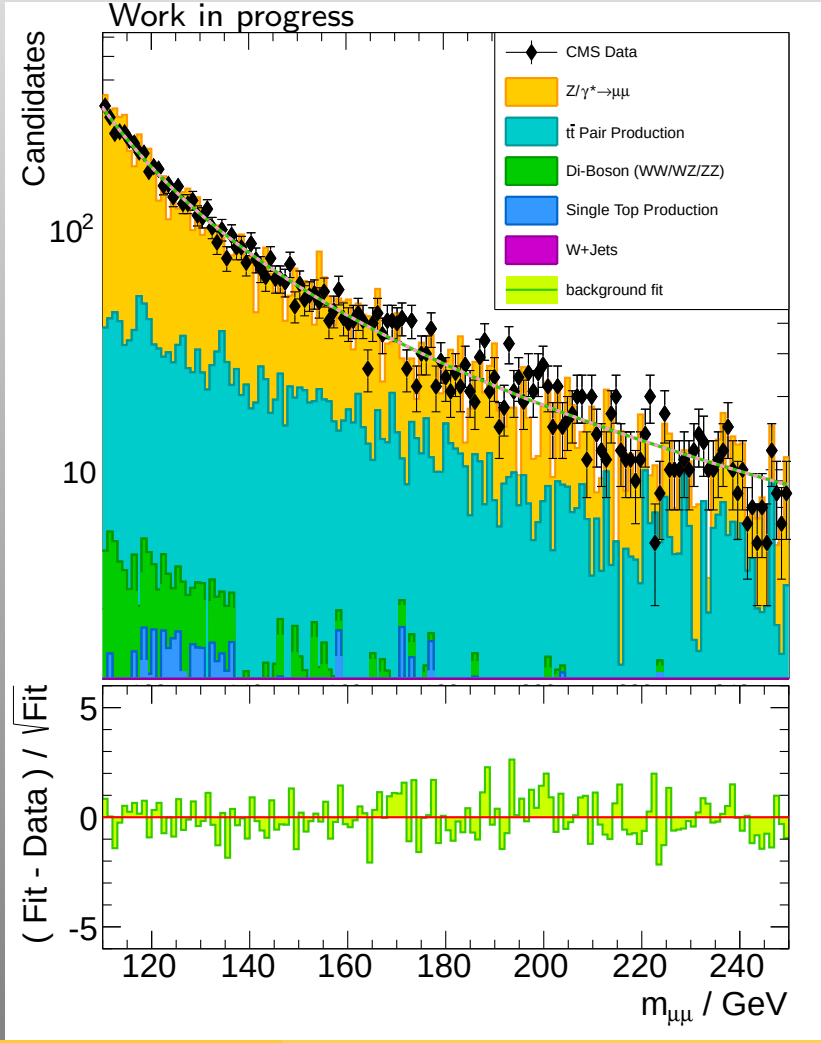


combined fit to data

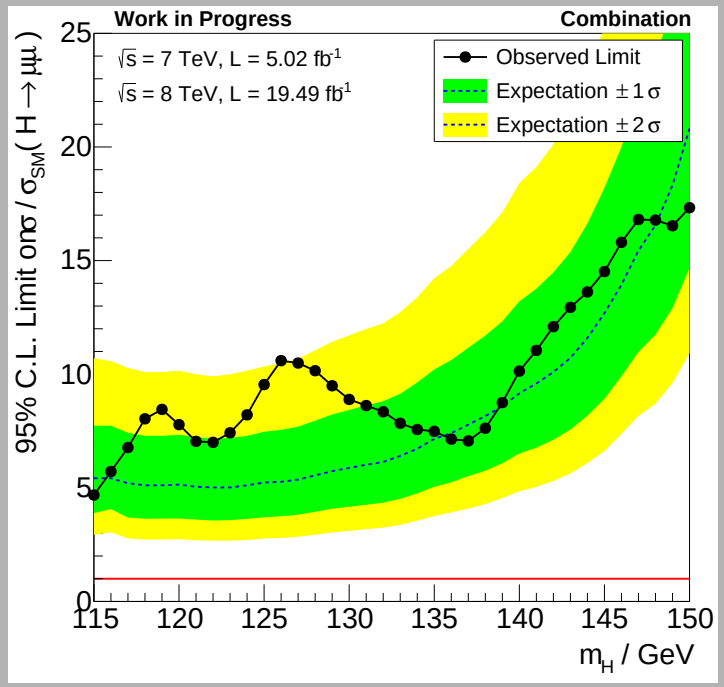
$$f(m) = e^{-\lambda \cdot m}\left(\alpha \frac{\Gamma}{(m_Z - m_{\mu\mu})^2 + \Gamma^2/4} + \frac{1-\alpha}{m^2}\right)$$

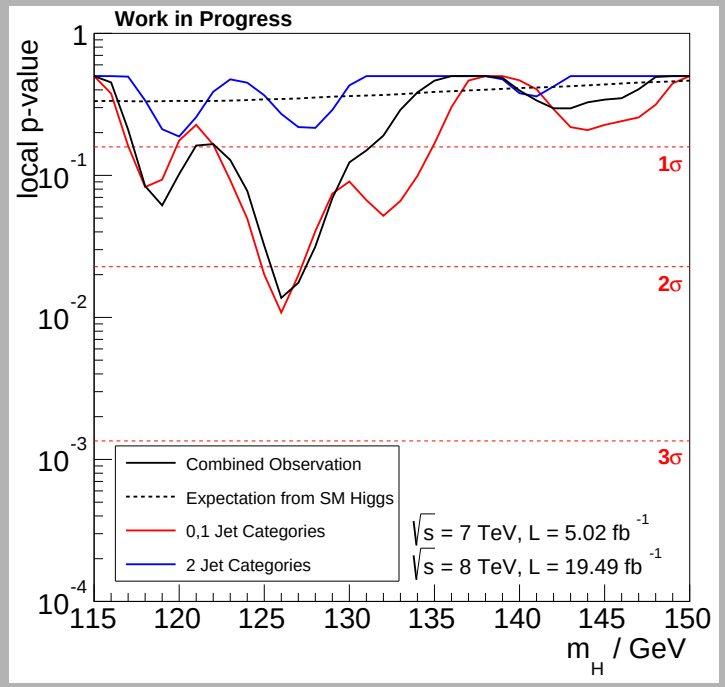
background hypothesis:

- unbinned likelihood fit of $s + b$ hypothesis to data in each category
- signal strength and background parameters are free
- signal and background shapes used in limit calculation:
- fit systematics and normalization treated as nuisance parameters
- additional systematics on signal simulation considered
- correlation of systematics between categories and data-sets considered



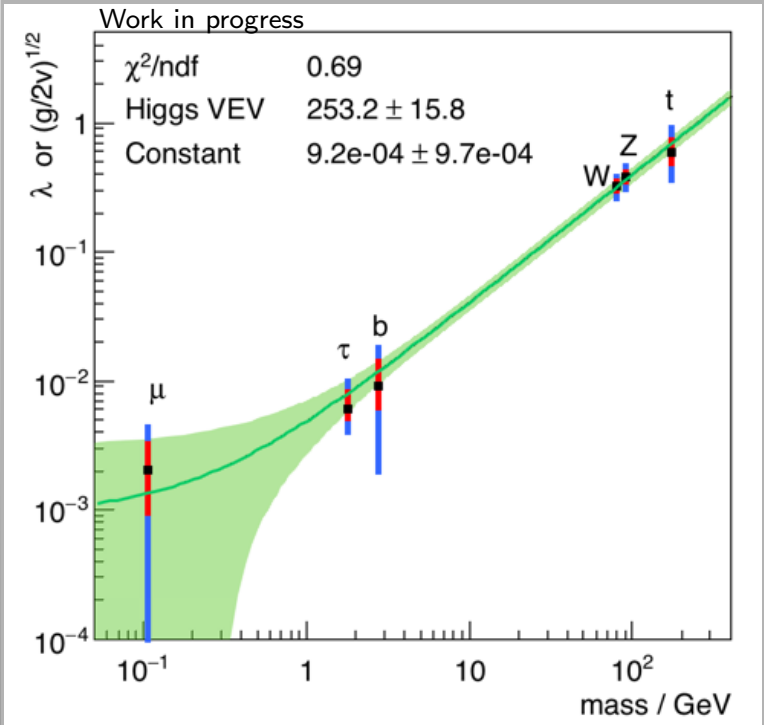
limits and p-values





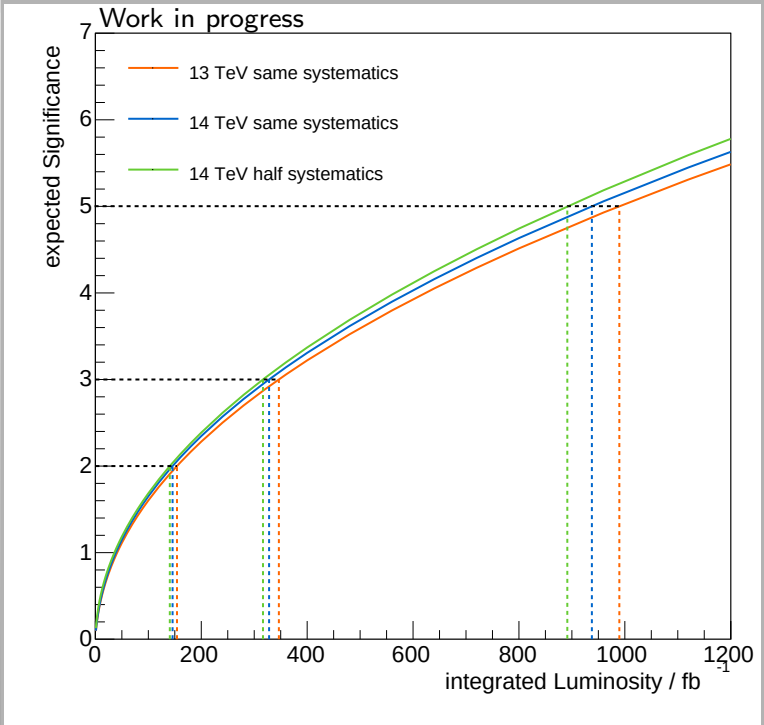
- statistically limited
- expected (observed) limit for a 125 GeV Higgs at $5.23^{+2.23}_{-1.53}$ (9.54) for the combination of 7 and 8 TeV
- excess around 125 GeV dominantly from two NonVBF categories resulting in a local significance of $\approx 2.2\sigma$

Fit to the data



- maximum likelihood fit to the data perfomed gives a best fit at $4.80^{+2.75}_{-2.56}$ times the standard model expectation
- within uncertainties consistent with SM predictions
- combined with the results of the other CMS analyses the coupling scan be fitted versus the mass
- a linear fit is consistent with the predictions of the SM as well
- it is to early to say if the excess in the dimuon channel is real

prospects for higher energies



- datacards are modified to estimate reach for higher energies
- increased cross sections are considered
- same selection efficiencies are considered
- for 14 TeV a scenario with the same systematics and with 50% less systematics are calculated

$\sqrt{s}$	assumed systematics	integrated luminosity neccesarry for 95% C.L. excl.	3σ evid.	5σ disc.
13 TeV	same as 8 TeV	$154.1 fb^{-1}$	$346.6 fb^{-1}$	$989.6 fb^{-1}$
14 TeV	same as 8 TeV	$145.8 fb^{-1}$	$328.1 fb^{-1}$	$937.8 fb^{-1}$
14 TeV	50% less than 8 TeV	$140.6 fb^{-1}$	$316.6 fb^{-1}$	$892.6 fb^{-1}$

Summary

SM Higgs

- full luminosity (24.84 fb^{-1}) utilized for analysis
- 14 categories focusing on VBF and GGF
- combined sensitivity of 5.23 times SM is achieved
- fluctuations in two categories lead to an excess around 125 GeV
- maximum likelihood fit shows consistency with the SM
- several hundred fb^{-1} of Run II data needed to get a clearer picture
- analysis public as CMS HIG-13-007 on arxiv and PLB

BACK UP

Source of the excess