Mini tutorial for limit setting tool

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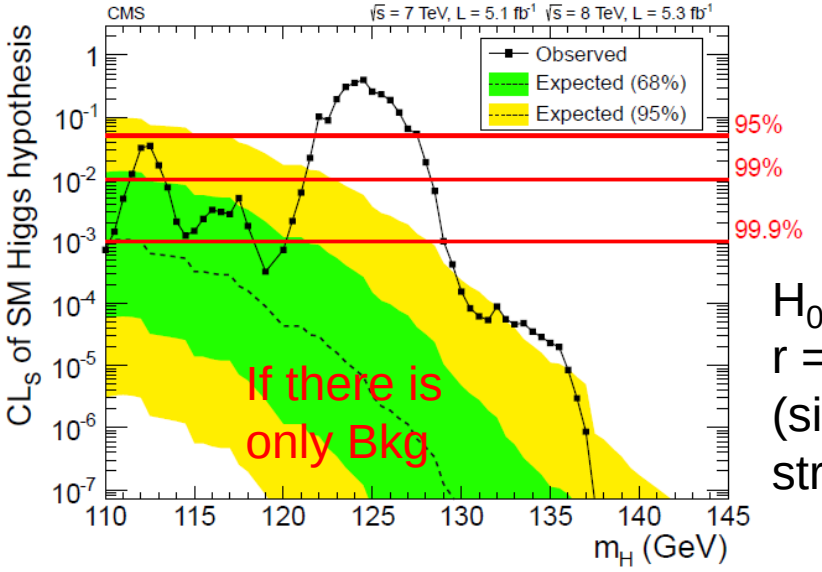
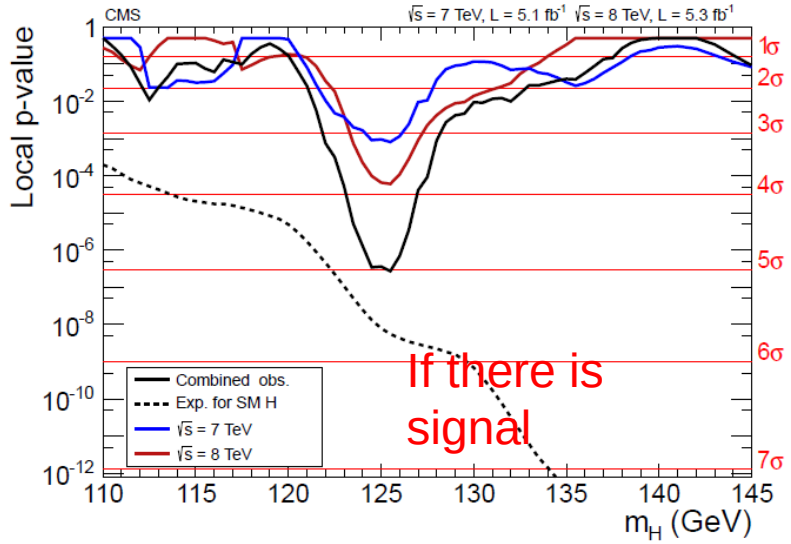
Basics idea

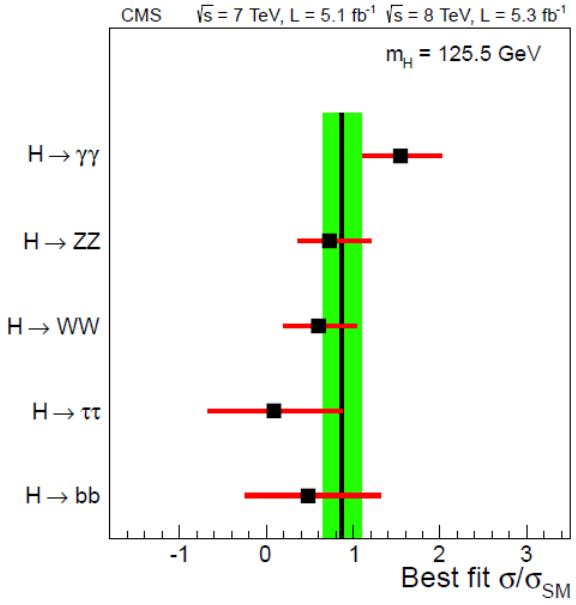
- **Exclusion limits**
  - Test H_0 = s+b
  - Try to disprove it
  - Can't disprove at 125 mH !
- **Claim for a discovery**
  - Test H_0 = b
  - Try to disprove "background only"
- **We found it !**
  - Fit with signal and background to find signal strength



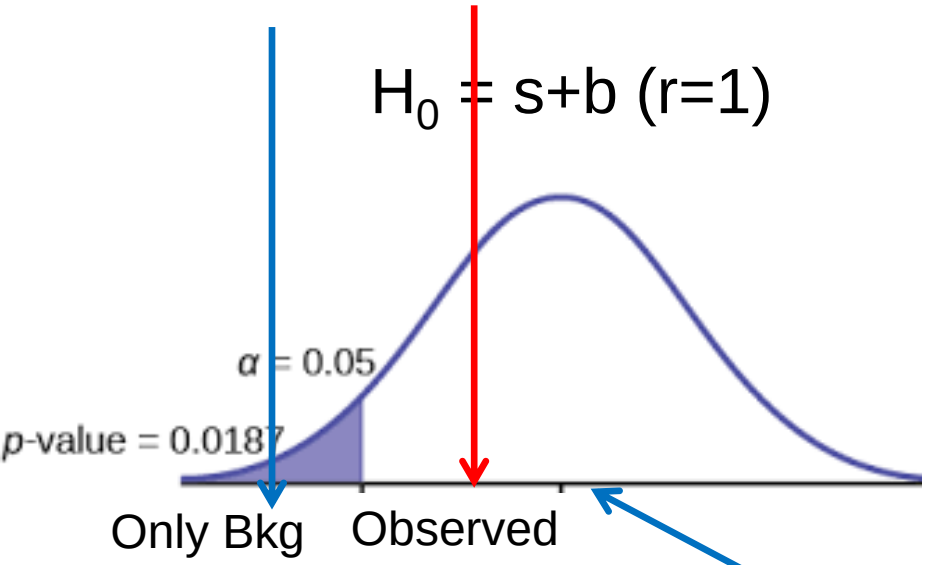
H_0 = s+b , r =1 (signal strength)

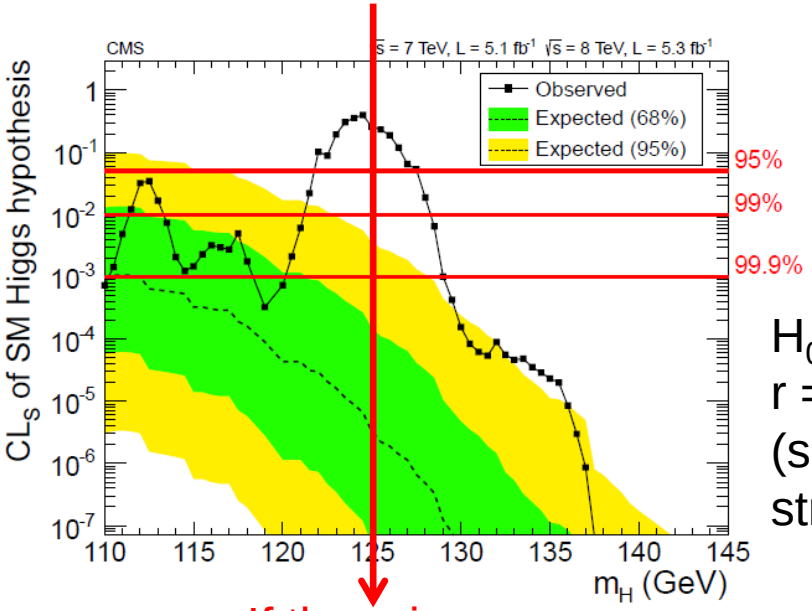
H_0 = b





What are Exclusion limits





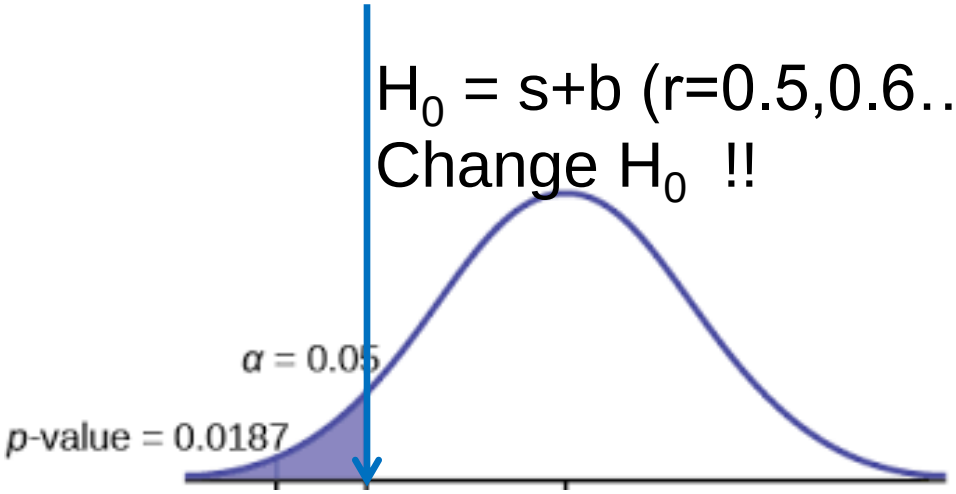
H_0 = S+b , r =1 (signal strength)

If there is only Bkg

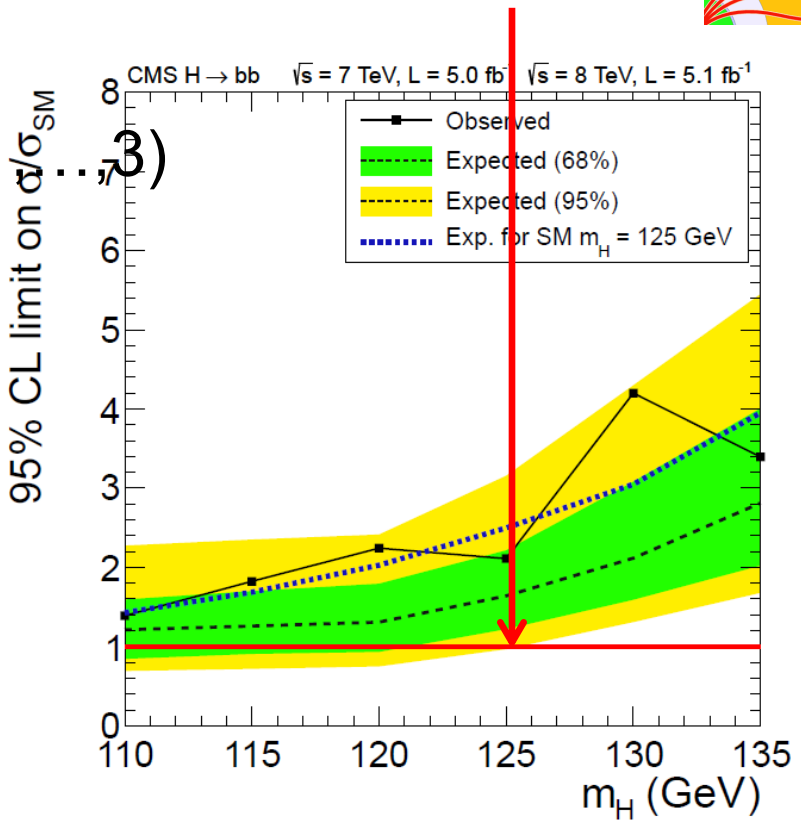
Can't exclude the S+B from our observation!

if Bkg only is here, there is no sensitivity

What are Exclusion limits

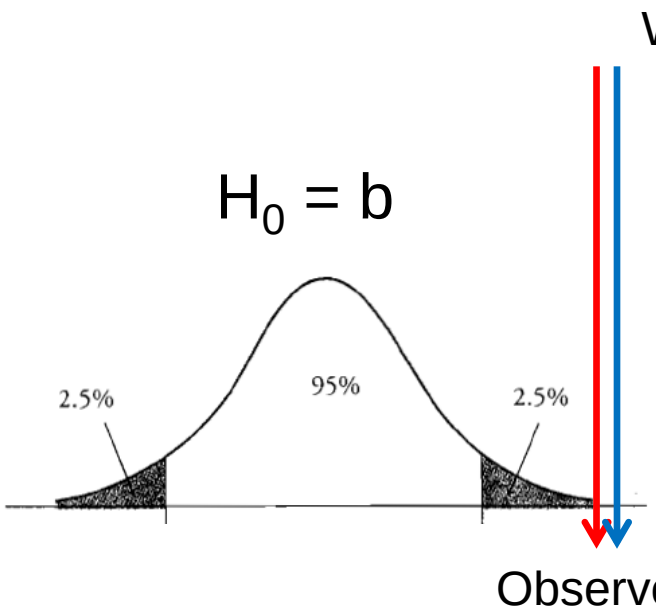


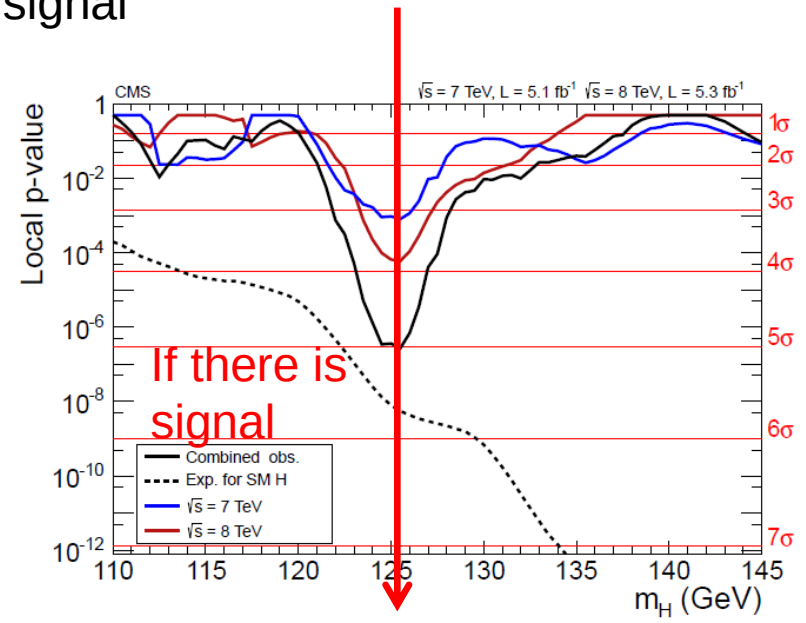
Observed and Only Bkg



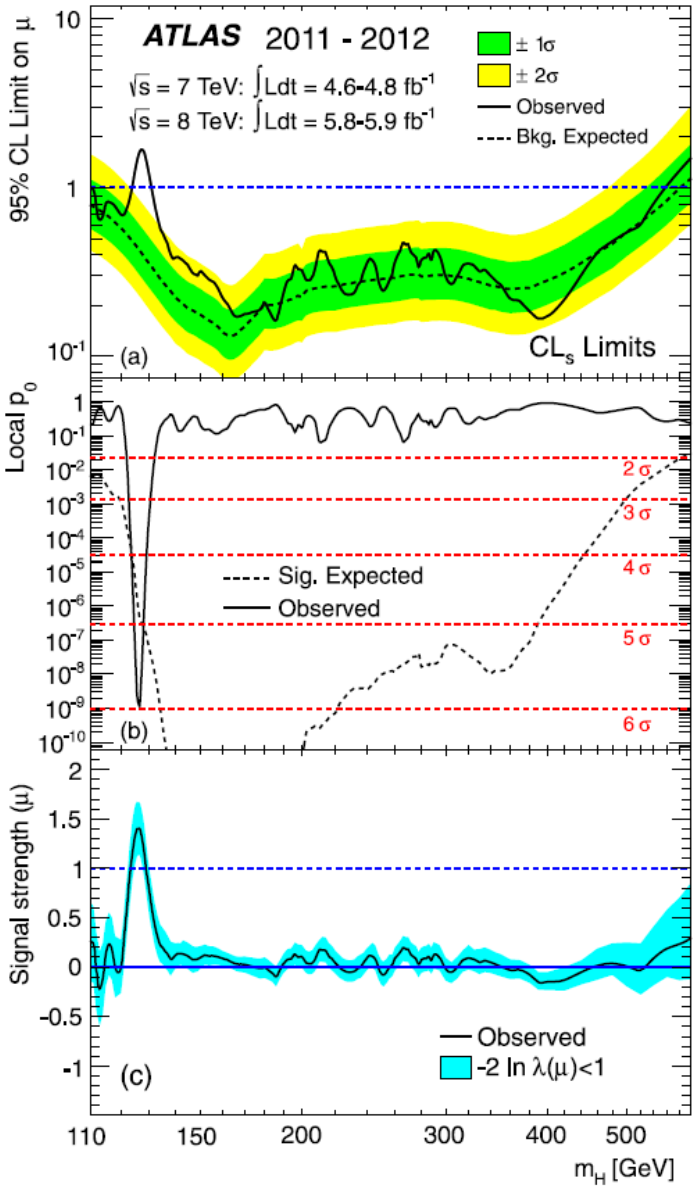
For CMS H->bb
At 125 GeV
Bkg only r =1.5
Data r = 2
No sensitivity!

Make a discovery





3 steps of a discovery from ATLAS



Setup the tool

- **https://twiki.cern.ch/twiki/bin/view/CMS/SWGuideHiggsAnalysisCombinedLimit**

SLC6 release

Setting up the environment (once)

```
setenv SCRAM_ARCH slc6_amd64_gcc481
cmsrel CMSSW_7_1_5 ### must be a 7_1_X release  >= 7_1_5;  (7.0.X and 7.2.X are NOT supported either)
cd CMSSW_7_1_5/src
cmsenv
git clone https://github.com/cms-analysis/HiggsAnalysis-CombinedLimit.git HiggsAnalysis/CombinedLimit
```

- if you get errors related to ZLIB when doing the git clone, try instead doing the git clone before the cmsenv
- when running with the HybridNew calculator, you can safely ignore the following warning from RooFit

  `WARNING:Eval -- RooStatsUtils::MakeNuisancePdf - no constraints found on nuisance parameters in the input model`

Updating to a tag (both the first time and whenever there are updates)

```
cd HiggsAnalysis/CombinedLimit
git fetch origin
git checkout v5.0.1
scramv1 b clean; scramv1 b # always make a clean build, as scram doesn't always see updates to src/LinkDef.h
```

Configuration file

- **combine -M Asymptotic realistic-counting-experiment.txt**

```
# Simple counting experiment, with one signal and a few background processes
# Simplified version of the 35/pb H->WW analysis for mH = 160 GeV
imax 1  number of channels
jmax 3  number of backgrounds
kmax 5  number of nuisance parameters (sources of systematical uncertainties)
------------
# we have just one channel, in which we observe 0 events
bin 1
observation 0
------------
```

Configuration file

```
# now we list the expected events for signal and all backgrounds in that bin
# the second 'process' line must have a positive number for backgrounds, and 0 for signal
# then we list the independent sources of uncertainties, and give their effect (syst. error)
# on each process and bin
bin                 1          1          1          1
process             ggH        qqWW       ggWW       others
process             0          1          2          3
rate                1.47       0.63       0.06       0.22
------------
lumi    lnN         1.11       -          1.11       -          lumi affects both signal and gg->WW (mc-driven).

xs_ggH  lnN         1.16       -          -          -          gg->H cross section + signal efficiency + other minor ones

WW_norm gmN 4       -          0.16       -          -          WW estimate of 0.64 comes from sidebands: 4 events in sideband times  0.16 (=> ~50% statistical uncertainty)

xs_ggWW lnN         -          -          1.50       -          50% uncertainty on gg->WW cross section

bg_others lnN       -          -          -          1.30       30% uncertainty on the rest of the backgrounds
```

lnN stands for Log-normal, which is the recommended choice for multiplicative corrections
gmN stands for Gamma, and is the recommended choice for the statistical uncertainty
on a background coming from the number of events in a control region or in a MC sample with limited statistics