Higgs and SUSY at the LHC

Jack Gunion
U.C. Davis

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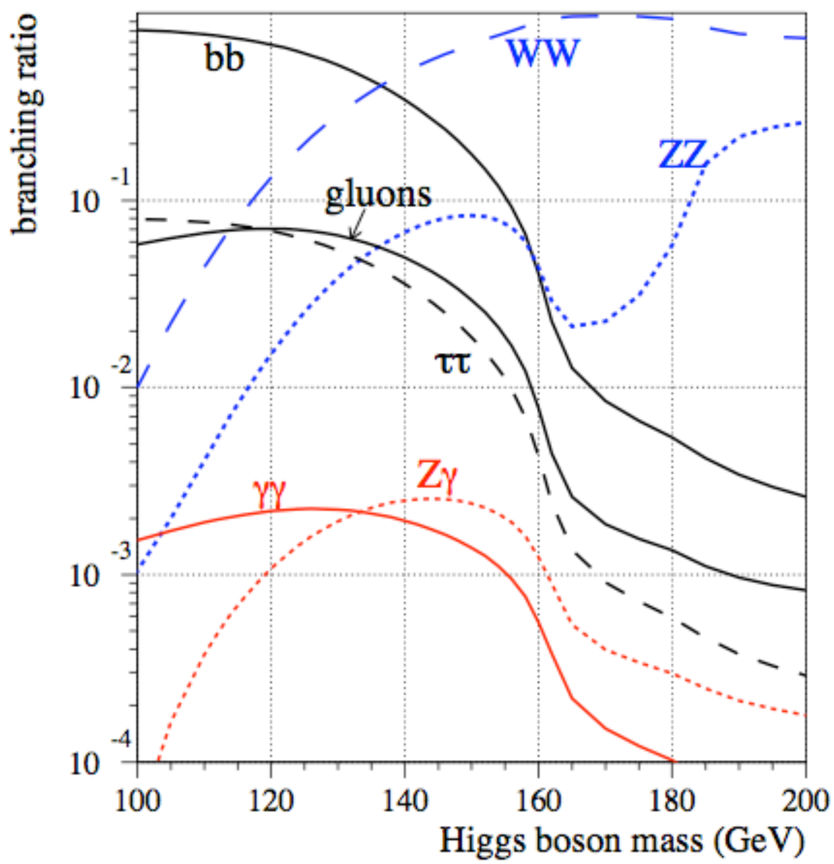
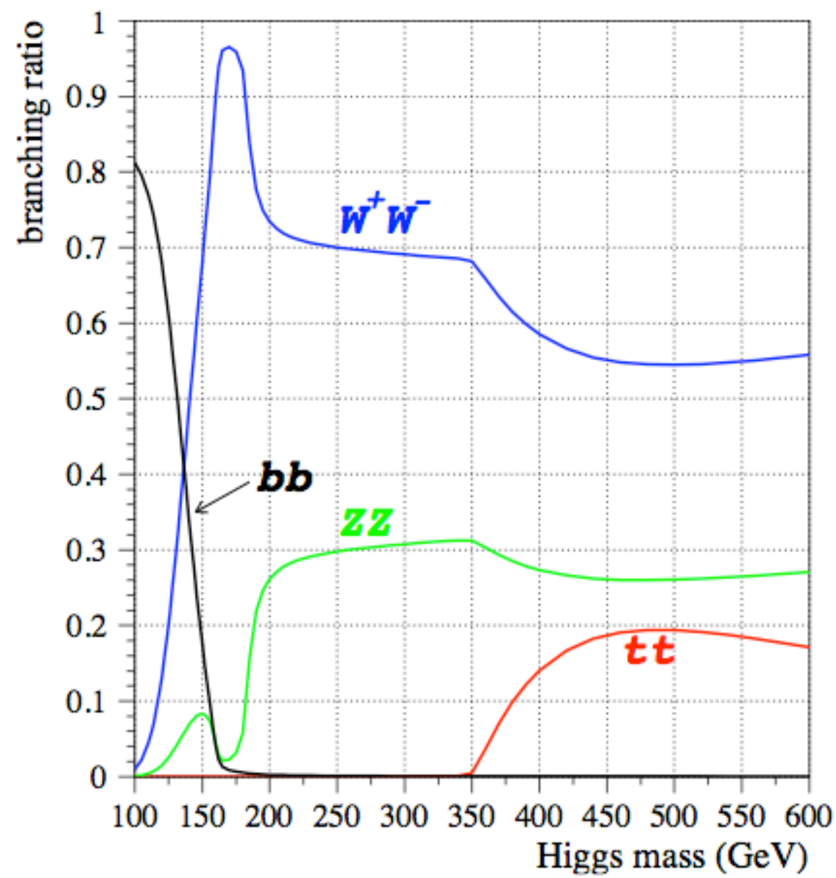
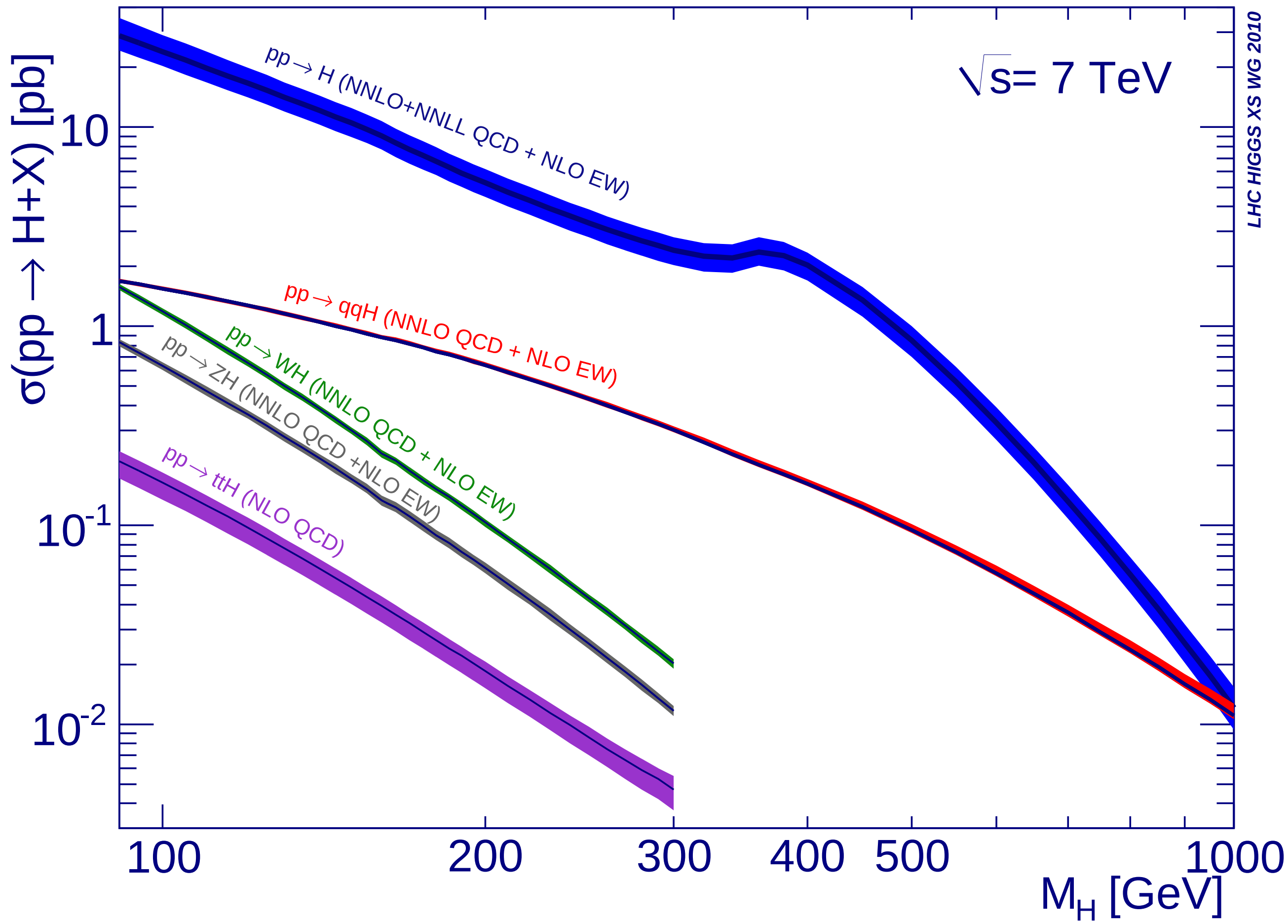
Higgs

Let us review again the SM Higgs branching ratios and cross sections to remind ourselves of the important channels.







A reminder: the number of events in a given channel X is given by

$$N_X = L(\mathrm{~fb}^{-1}) \times \sigma(\mathrm{~fb}) \times B(X), \quad (1)$$

where the integrated luminosity analyzed for ATLAS and CMS (each) is of order $1-2\ \mathrm{fb}^{-1}$ depending upon the channel. Note: $1\ \mathrm{pb} = 1000\ \mathrm{fb}^{-1}$.

So, what do they see?

- **First of all, there are lots of backgrounds.**

  In some cases, the backgrounds can be measured in regions away from a potential Higgs signal region and then extrapolated into the signal region.

  This is easy for the $h_{\rm SM} \to \gamma\gamma$ final state, but hard for example for the $h_{\rm SM} \to WW \to \ell\nu\ell\nu$ final state.

  In the latter case, they have to rely fairly heavily on a Monte Carlo simulation of the SM background since the signal is spread out in any observable, in particular $M_{\ell\ell}$, because of the missing energy associated with the neutrinos.

- **They must determine if there is any excess above the backgrounds.**

  In the $\gamma\gamma$ case, they look for a tiny peak (with width of order the experimental resolution, $\sim 2~{\rm GeV}$) above the background.

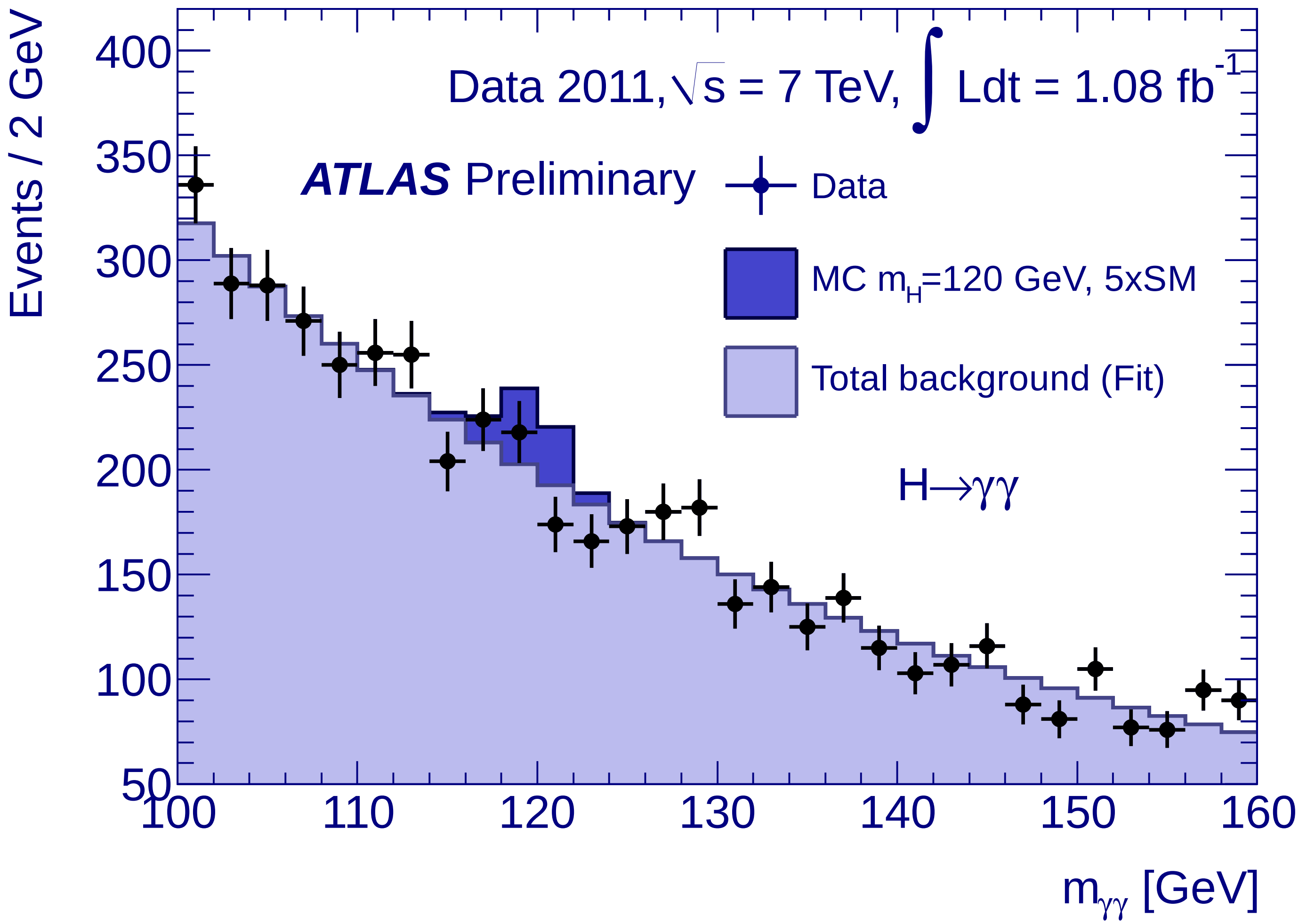
  In the $\ell\nu\ell\nu$ case, they are looking for a broad excess in $M_{\ell\ell}$.

- Should they see such an excess they have to compare to what they would expect for a Higgs of a given mass and then test what Higgs mass gives the best fit.
- In general, there will be a range of Higgs masses for which a reasonable fit is obtained.

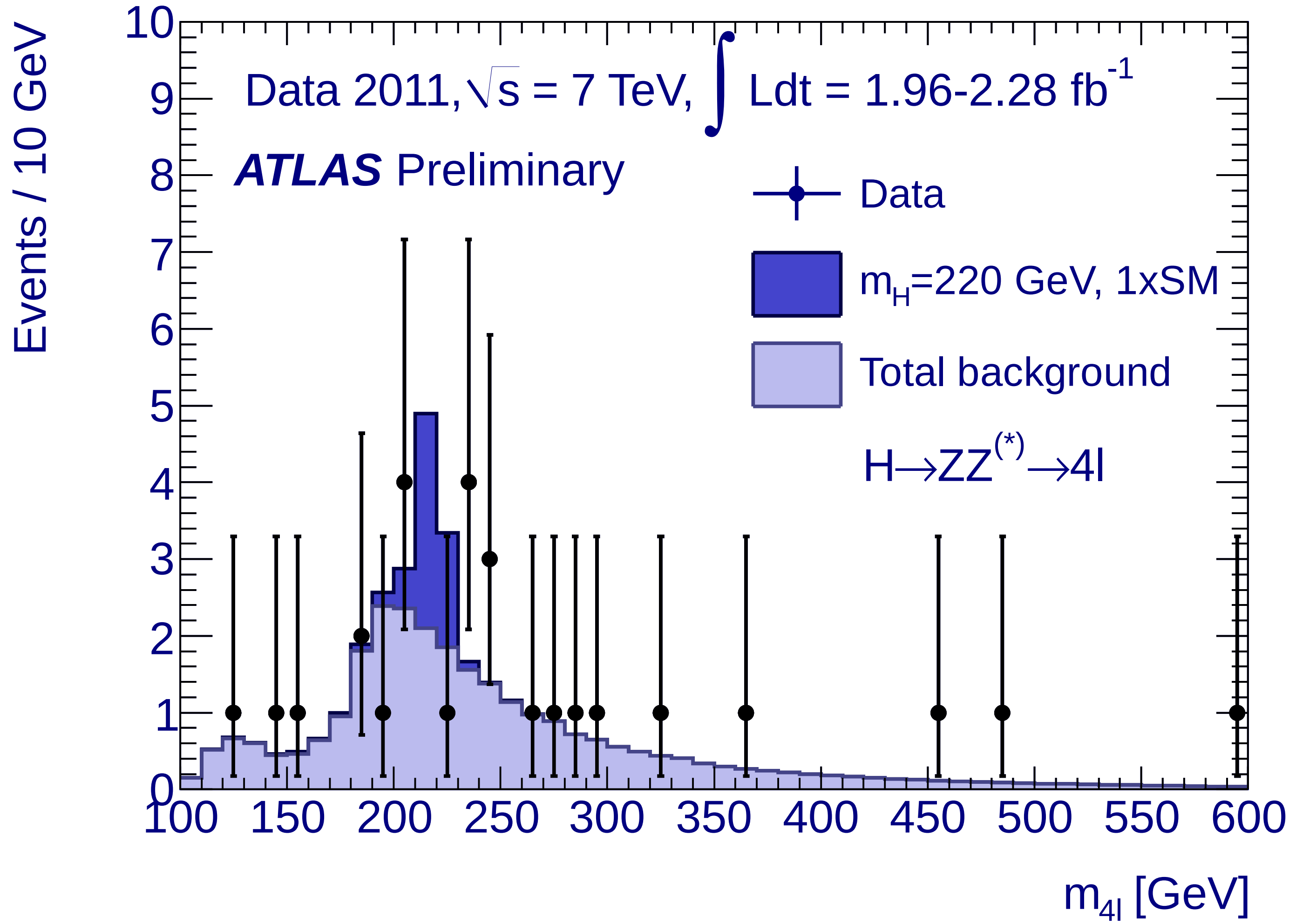
- If an excess is seen, one must then they typically compute two probabilities:
  - The probability that this excess is consistent with a statistical fluctuation of the SM background(s), often labelled p_0.
  - The probability that the excess is consistent with the presence of a SM Higgs of a given mass.

- In assessing the importance of any excess they must also consider the "look elsewhere effect" (LLE) which refers to the fact that statistically speaking a deviation from the SM background has equal probability to occur "anywhere".

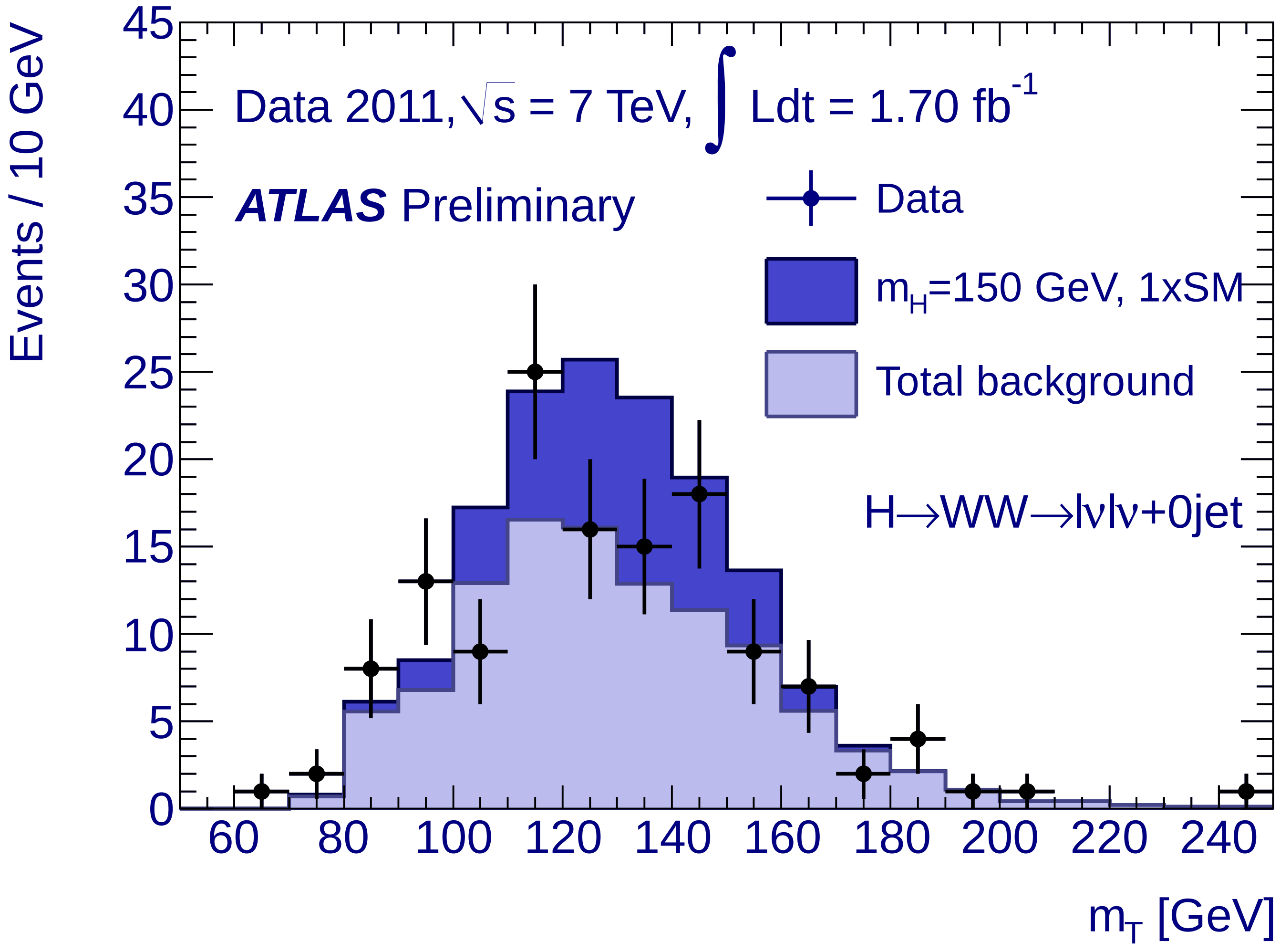
  It is easiest to think of this in the $\gamma\gamma$ case, where a tiny peak that one might be tempted to associate with a Higgs signal could pop up at any $M_{\gamma\gamma}$ as a statistical flucuation.



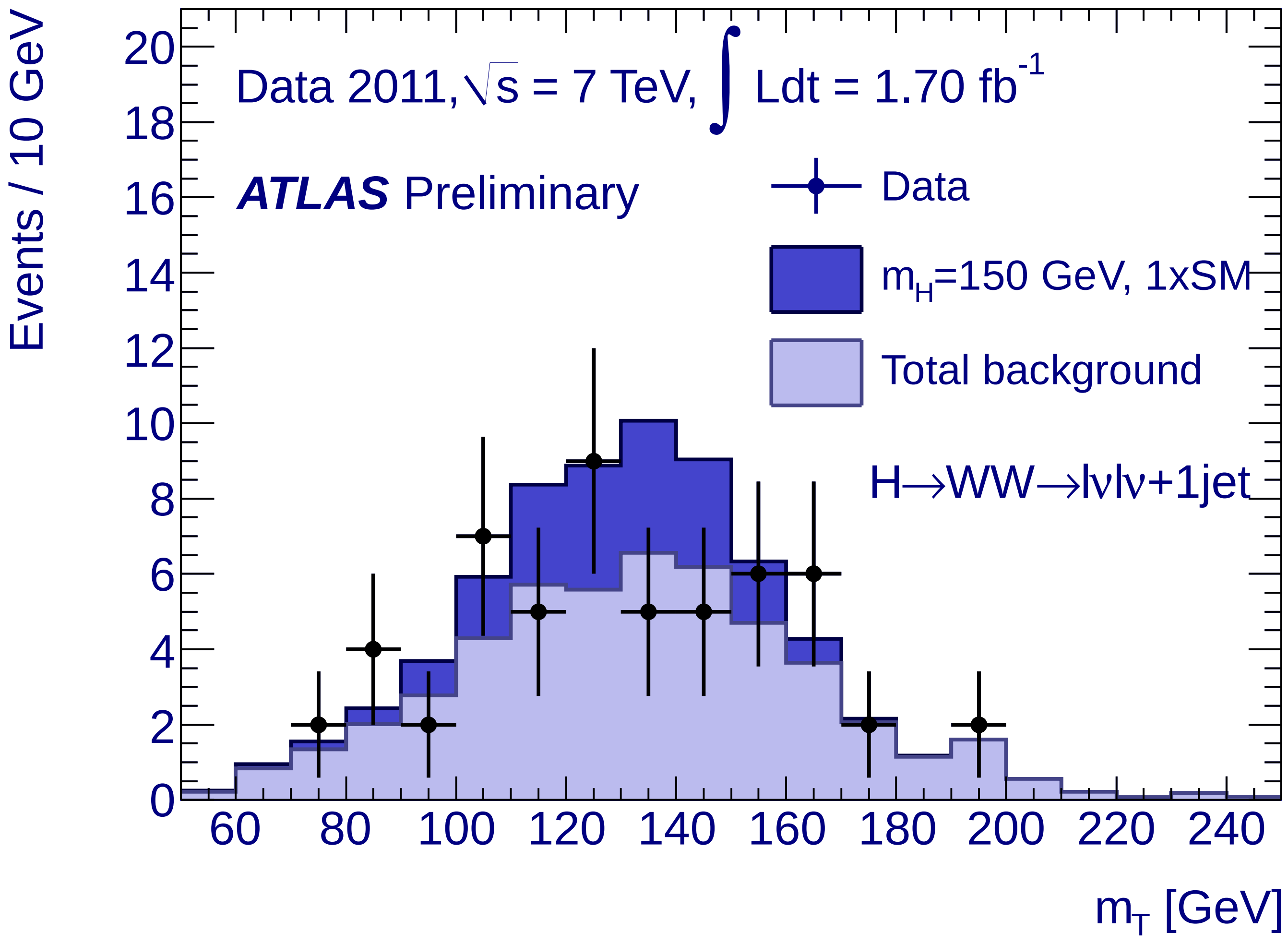
Note scale factor of $5 \times SM$.



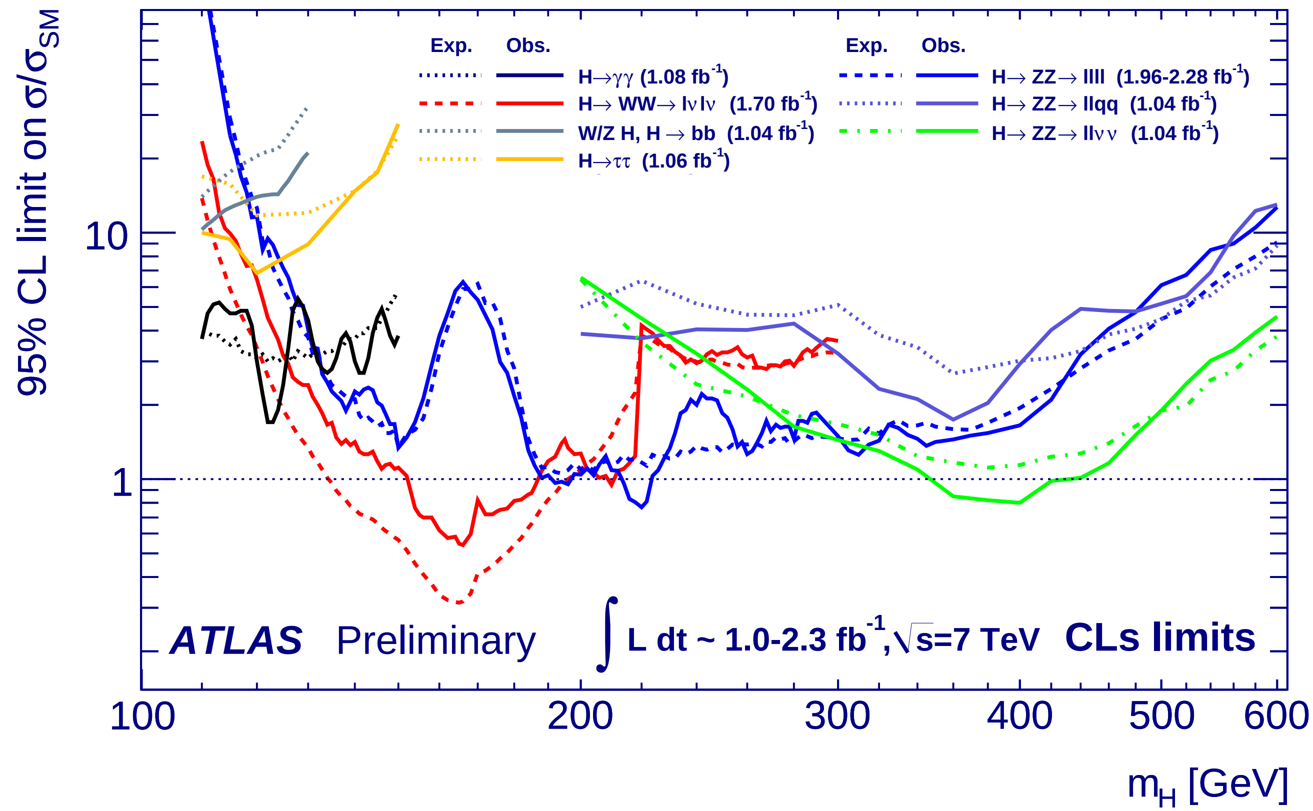
Note scale factor of $1 \times SM$.



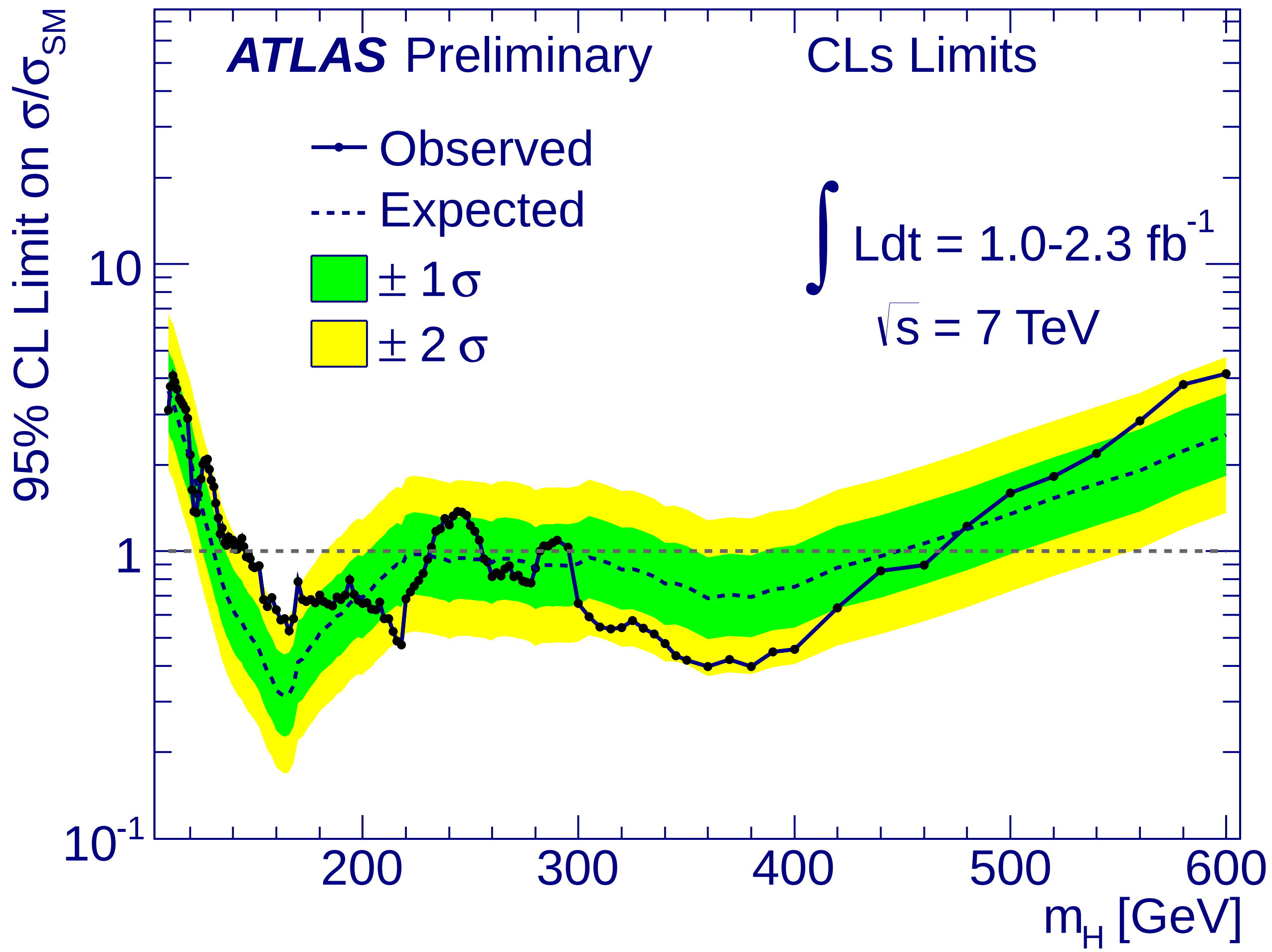
Note scale factor of $1 \times SM$.



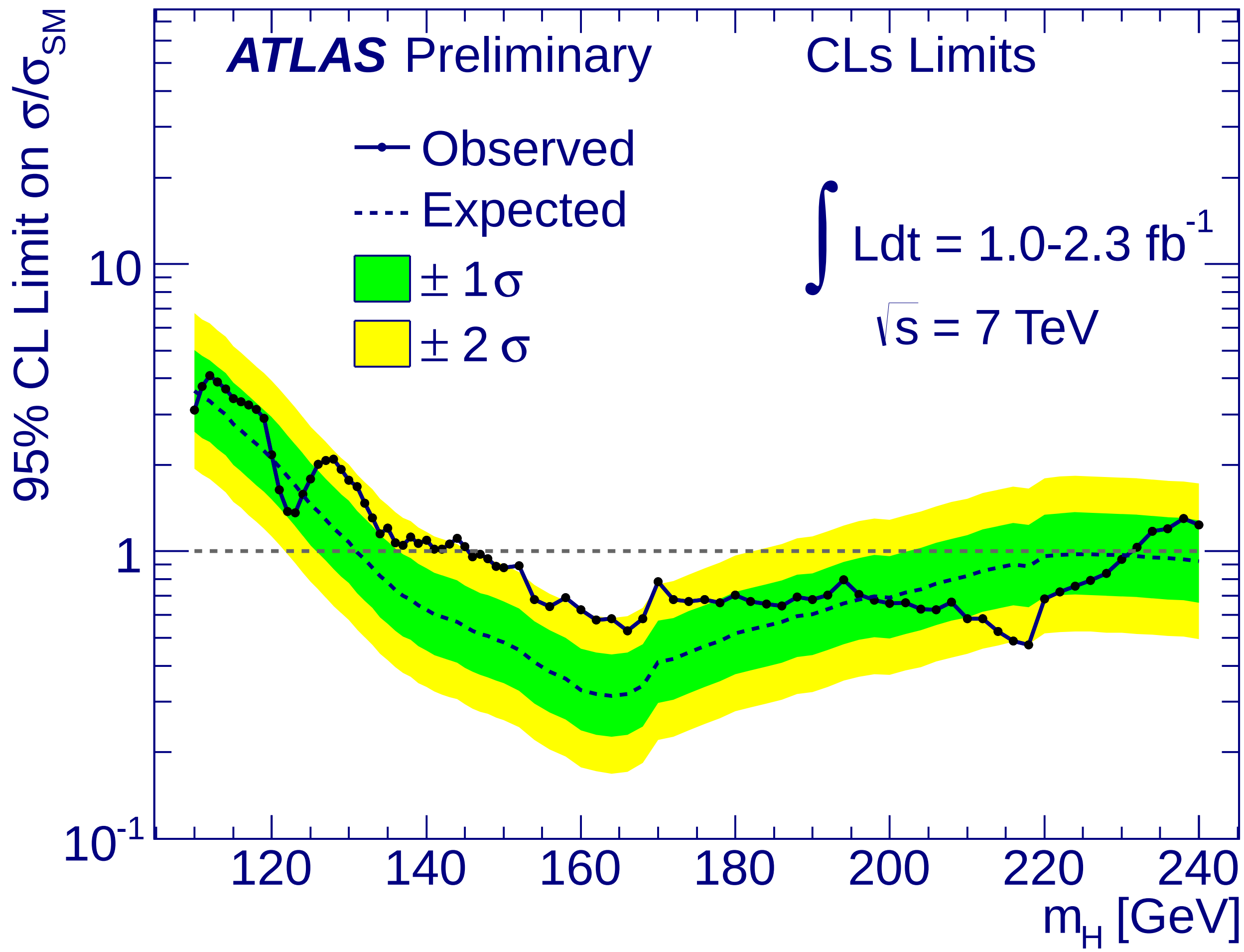
Note scale factor of $1 \times SM$.



All the channels are shown individually.

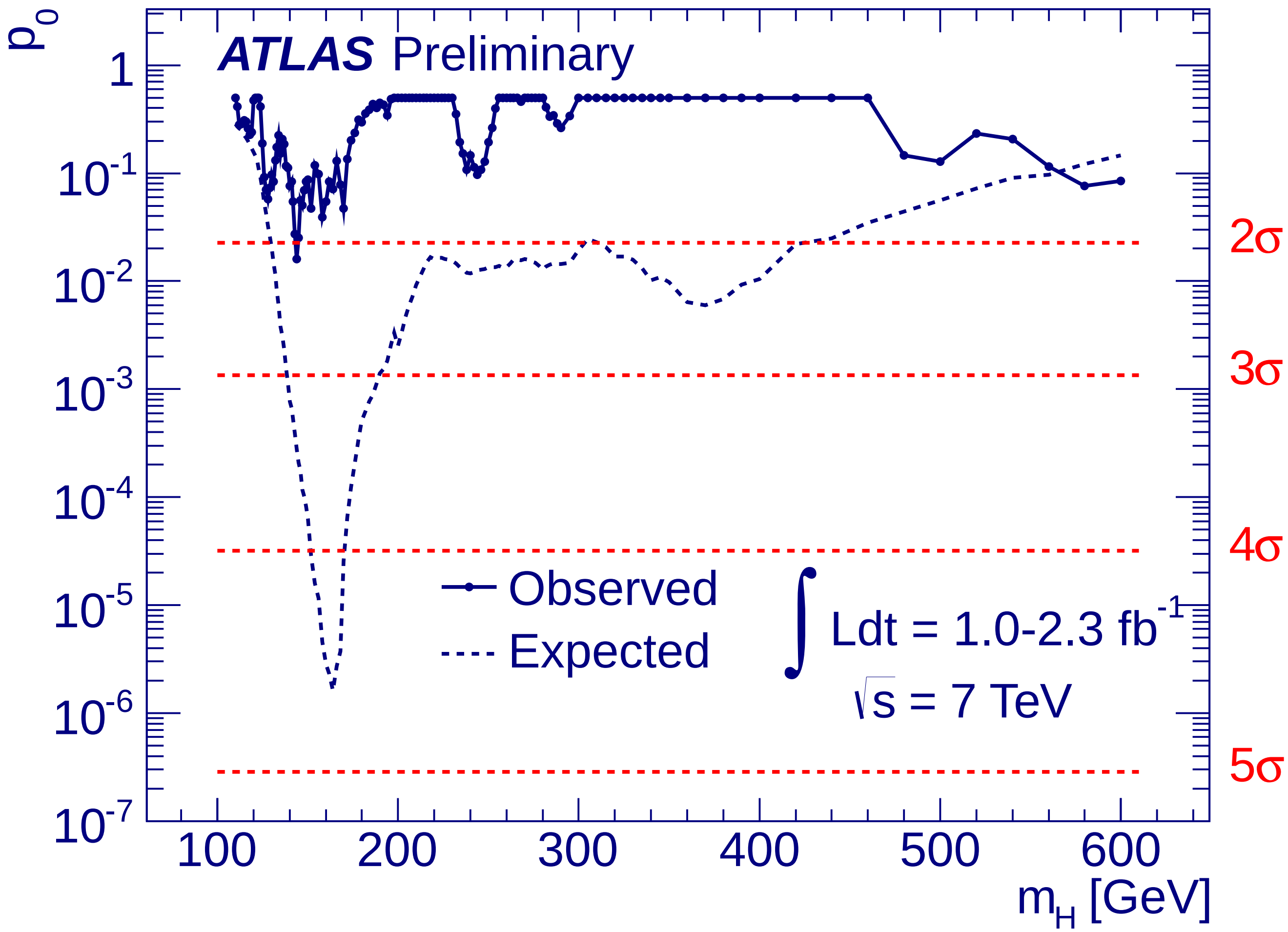


All the channels are combined (assuming SM weight for each).

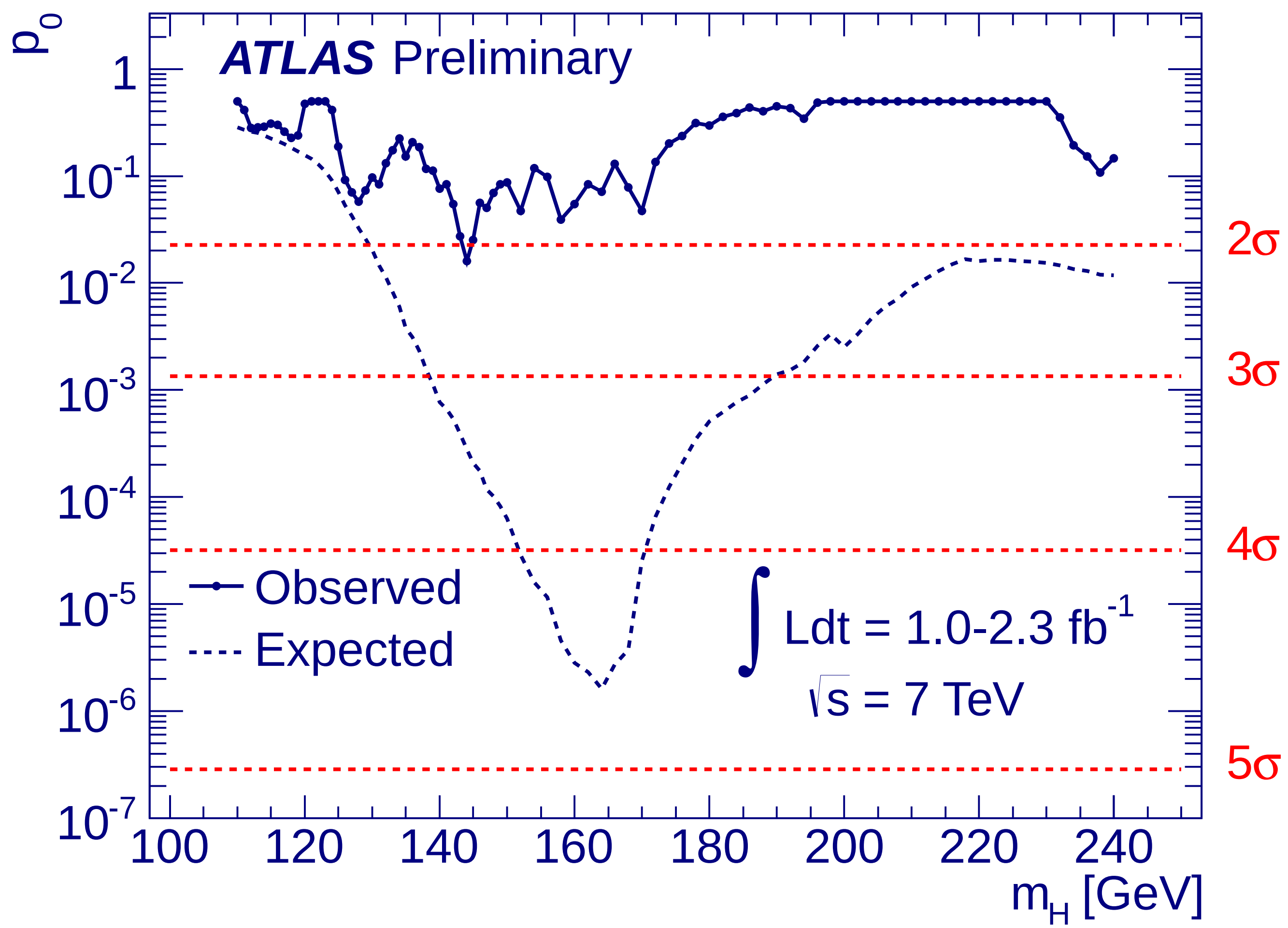


All the channels are combined (assuming SM weight for each).

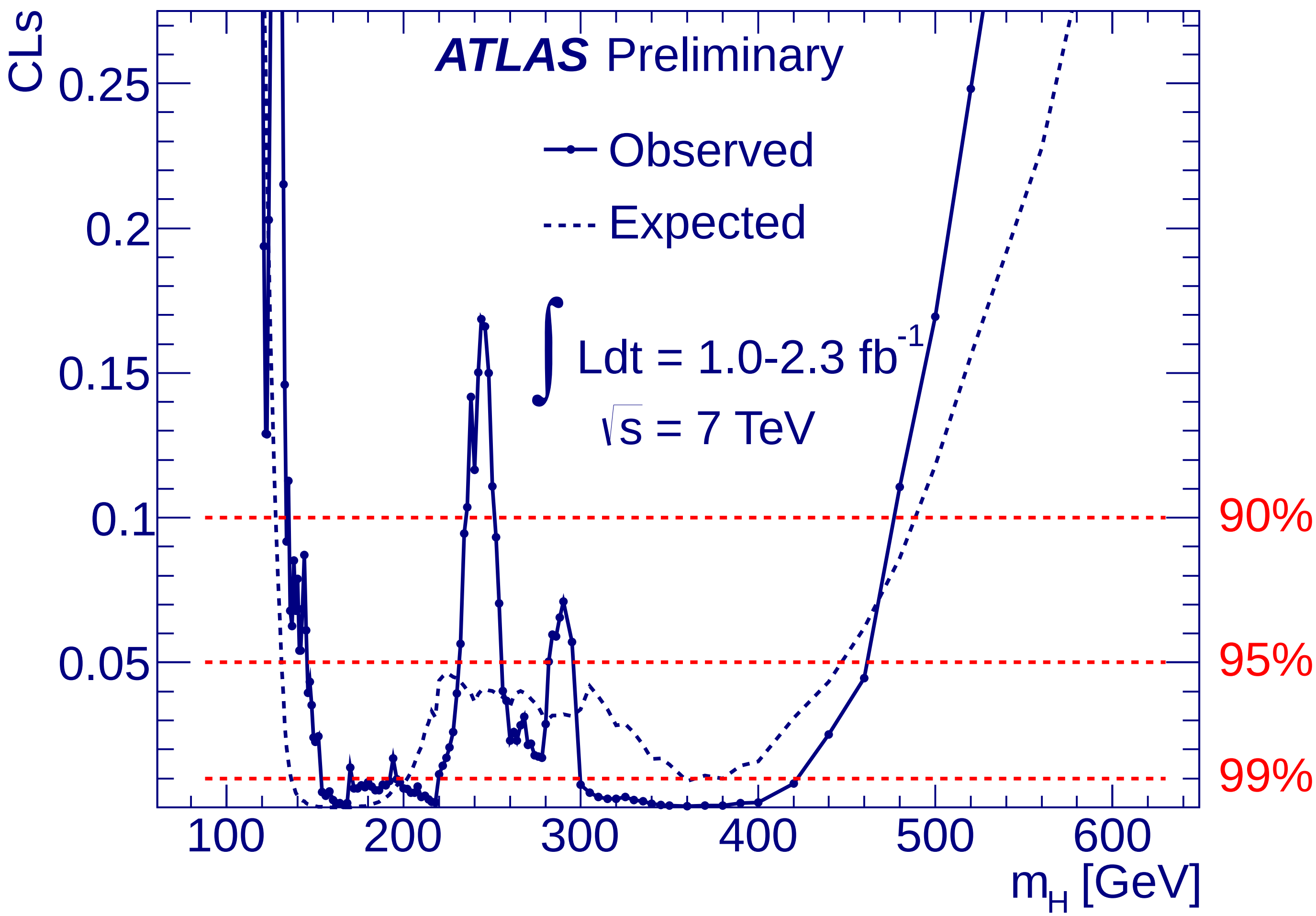
In the following two figures, ATLAS plots the consistency of the observed results with the background-only hypothesis, p_0. The noticeable excesses at 127 GeV, 144 GeV and 245 GeV reported in any earlier analysis are less significant but still present. The dashed line shows the median expected significance in the hypothesis of a Standard Model Higgs boson production signal. The four horizontal dashed lines indicate the p-values corresponding to significances of 2σ, 3σ and 5σ.



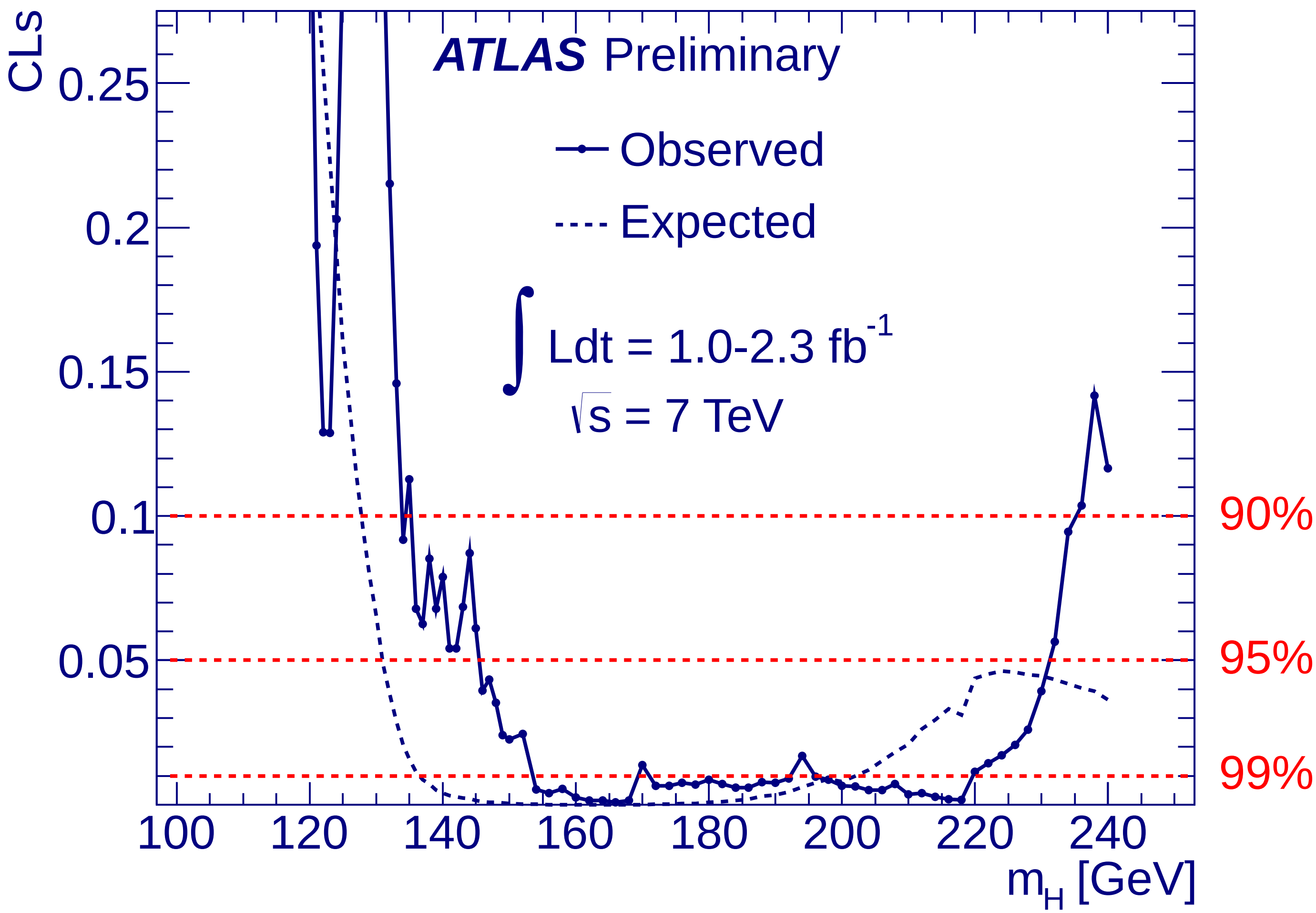
All the channels are combined (assuming SM weight for each).



All the channels are combined (assuming SM weight for each).



The value of the combined CL_s for $\mu = 1$ (testing the Standard Model Higgs boson hypothesis) as a function of $m_{h_{\rm SM}}$ in the full mass range of the analysis. By definition, the regions with $CL_S < \alpha$ are considered excluded at the $(1-\alpha)CL$ or stronger.



As in previous figure but for low mass range.

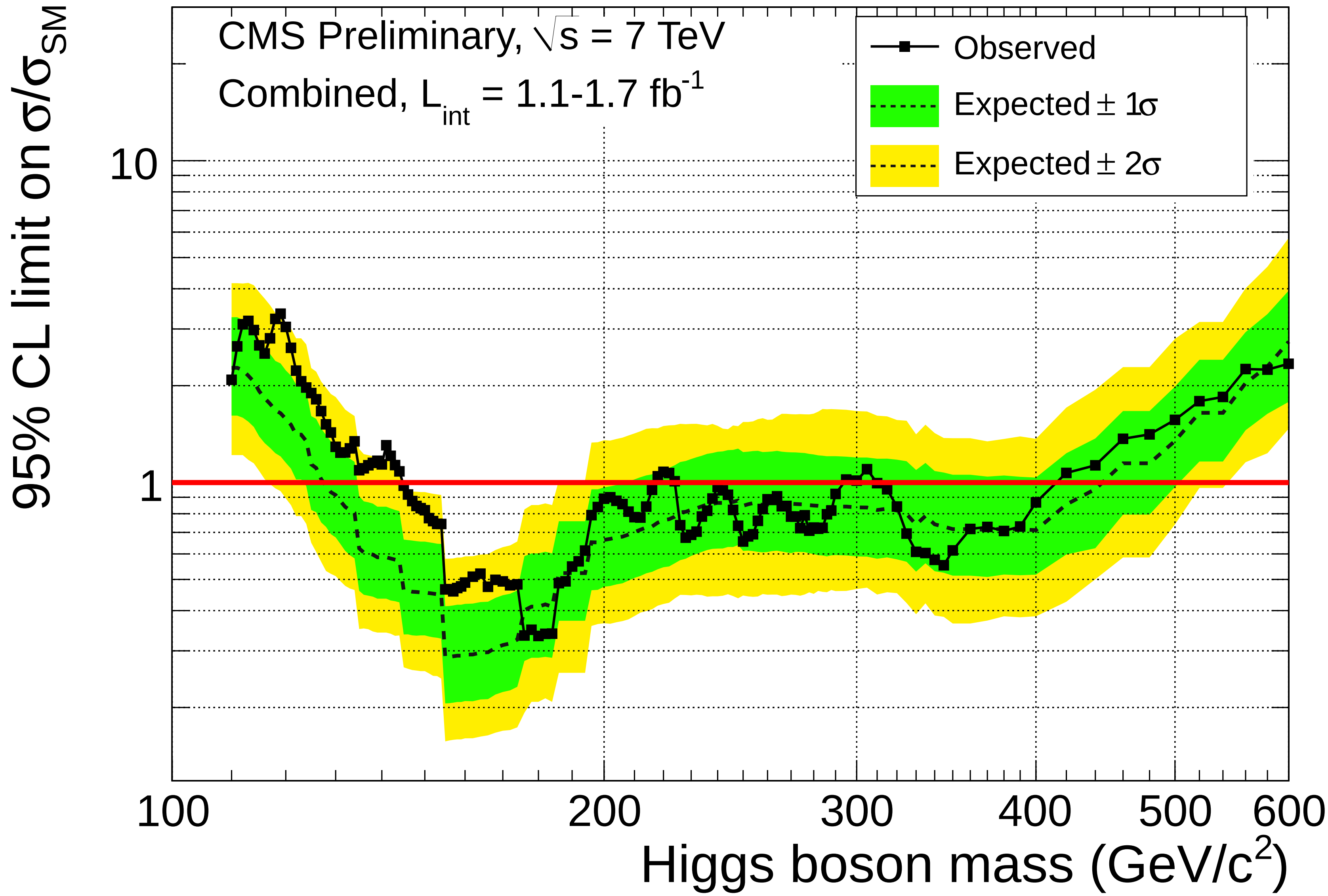


Figure 1: **CMS limits on a SM-like Higgs. Excess of $\sim 0.5 \times SM$ can be accommodated at $m_h \sim 140$ GeV. Excess of $\sim 1 \times SM$ can be accommodated at $m_h \sim 120$ GeV, where ATLAS has a dip.**