Article

Moriond 2012 Higgs Summary

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Abstract

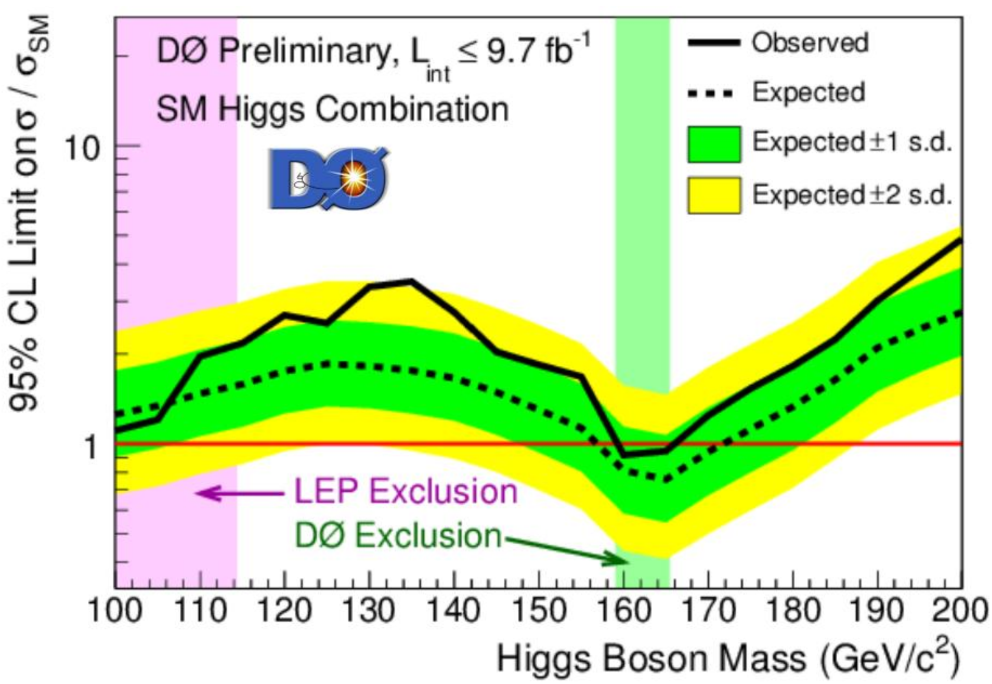
The title of this article is "Moriond 2012 Higgs Summary" or perhaps I should be calling it the "Brout-Englert-Higgs" Summary or even the "SM scalar boson" Summary. These were the titles diplomatically chosen by the speakers in the presence of François Englert who gave the opening talk for the session, but the particle is still symbolised by just the letter H. The Moriond meeting has seen another small step forward in the search for the missing boson with new data coming from the Tevatron and LHC experiments. Now that all the plots are available online it's a good time to pick out a few highlights and see what they are telling us.

Key Words: Moriond 2012, Higgs combinations, Tevatron, CERN, LHC, ATLAS, CMS.

March 8, 2012: Moriond 2012 Higgs Summary

Tevatron

I showed the Tevatron combined plot yesterday with its comforting 2.2 sigma excess from 115 GeV to 135 GeV. Here are the individual plots from CDF and D0



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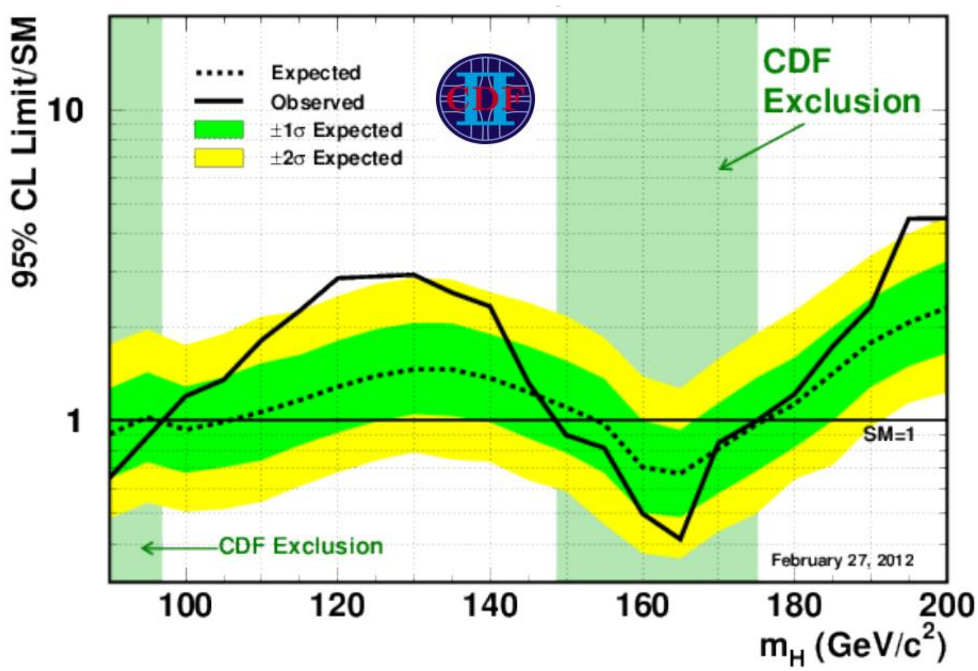
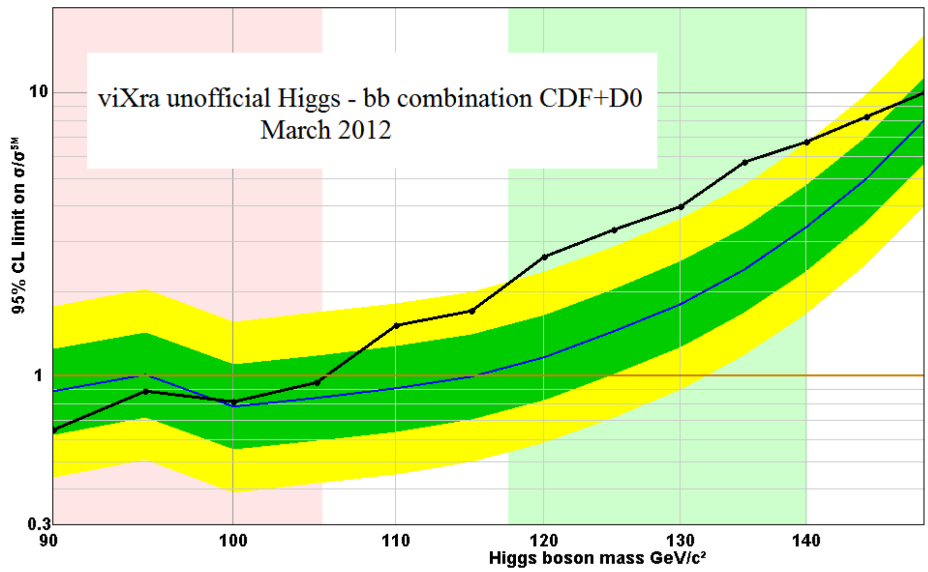
Note: This report is adopted from http://blog.vixra.org/2012/03/08/moriond-2012-higgs-summary/



These are comfortably consistent with a Higgs between 115 GeV and 135 GeV and could accommodate a wider range. 2.2 Sigma is not a high significance level but in conjunction with results from the LHC it is a nice independent confirmation of what they are seeing.

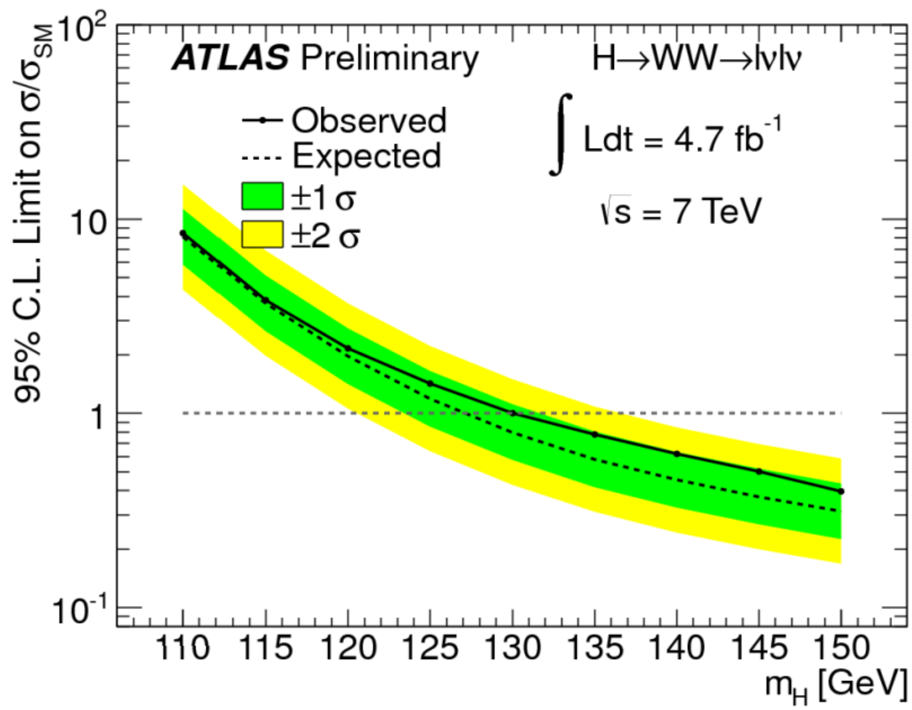
There is one further point to make about this result that is very important and so far overlooked. The Tevatron is getting its signal from the bb channel. Below is my unofficial combination for the decay channel to two bottom quarks alone. CDF and D0 were able to get a lot more information out of this channel than previously by improving their algorithm for identifying the hadronic jets coming from these decay products. It is not an easy business and results in a widely spread excess as seen here.

What makes this especially interesting is that this shows the Higgs decaying to two spin-half fermions. The LHC has so far only had tentative signals in the diphton, WW and ZZ channels which are all spin one products. Spin in conserved in the decay process so a scalar boson with its spin of zero can decay into two particles of equal spin orientated in opposite polarisations so that the total spin cancels out. the experiments cannot measure the orientation of the spin so if they see two photons (or W or Z bosons) they can only say that the spin of the original particle was zero or two. Someone wanting to be argumentative could say that the particle being discovered is a graviton like spin two boson. However, if we take the Tevatron excess to be a signal of the same particle then we also know it can decay into two spin half fermions. That would indicate a particle of spin zero or spin one. Putting the two results together we know that it can only be spin zero which is a nice confirmation for the theory of the Higgs mechanism. It will be a long time before the LHC can get a similar result from the bb channel so this observation makes the Tevatron result much more than just a small confirmation.



ATLAS

Following the Tevatron presentations ATLAS was next up to present. After the major update in December they still had a number of channels to update to use the full 5/fb of data collected in 2011. This included H -> ττ, H -> bb, H-> WW -> lνlν, WW -> lνqq, ZZ -> llqq and ZZ -> llνν. Of these only the first three are relevant to the low mass scale of interest. The H -> ττ, H -> bb do not have much sensitivity yet so no excess was expected there. This leaves only the H-> WW -> lνlν channel to be of any real interest. Here is what it looks like at low mass.



There is not much excess in this plot so the effect of updating it is to drop the combined excess for ATLAS at 125 GeV from 3.5 sigma previously to 2,5 sigma now. Here is what it looks like. Some media outlets such as New Scientist are reporting this as a "fading" signal. There are two points that need to be made to mitigate here.

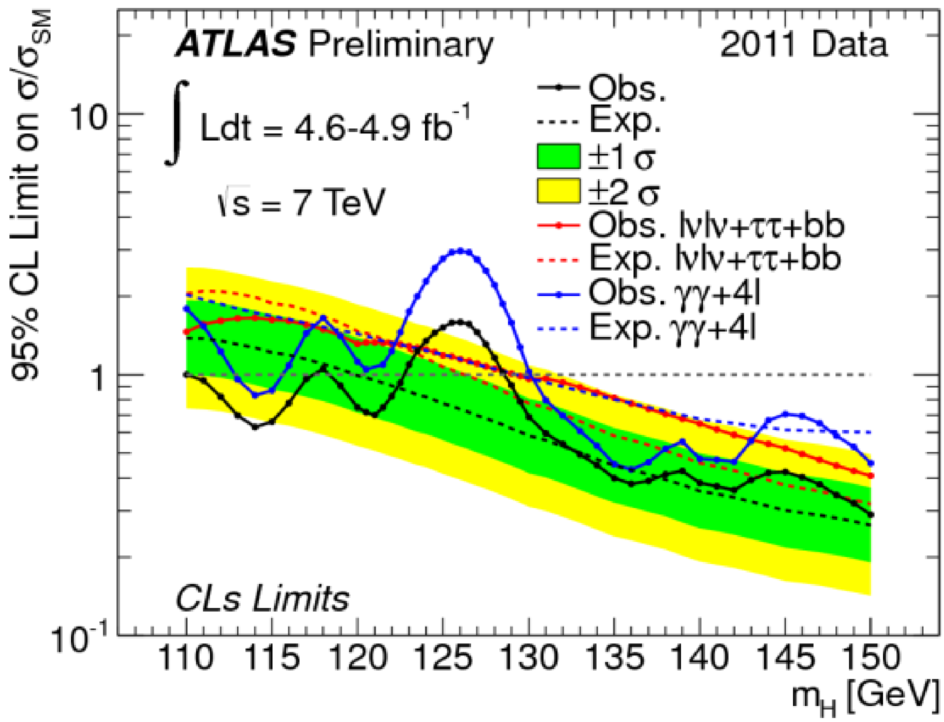
Firstly, the WW channel has very low mass resolution made worse in the latter part of the run by increasing event pile-up. We should only expect a broad excess in this plot rather than a nice peak indicating the mass of the Higgs boson. Let me quote again something I said about this back in September last year.

"*Our expectation is that as more data comes in a sharp peak (or two) will emerge somewhere in the low mass region to reveal where the Higgs is. However, the plot is dominated by the WW channel over most of this range and the WW channel has low resolution. This is because it uses missing energy observations to construct the underlying mass of the events. The W's decay into neutrinos which can never be detected directly. The result is that the Higgs appears as a broad excess in the WW channel and you can't locate it well. The WW channel is great for excluding large ranges of the mass spectrum, but it is not good for pinpointing a low mass Higgs that has a narrow width.*

Furthermore, the situation will not improve as more data is added. The WW channel will always remain low resolution and it will always dominate the combination plot. Sadly the Tevatron data has the same problem. It is dominated by WW and bb channels with neutrinos in each case. In fact the detectors themselves have poorer resolution and even the digamma and ZZ channels are only ever plotted at 5 GeV intervals for the Tevatron. So what should we do? if some data could be making the plot worse the best thing is to remove it and see what we get."

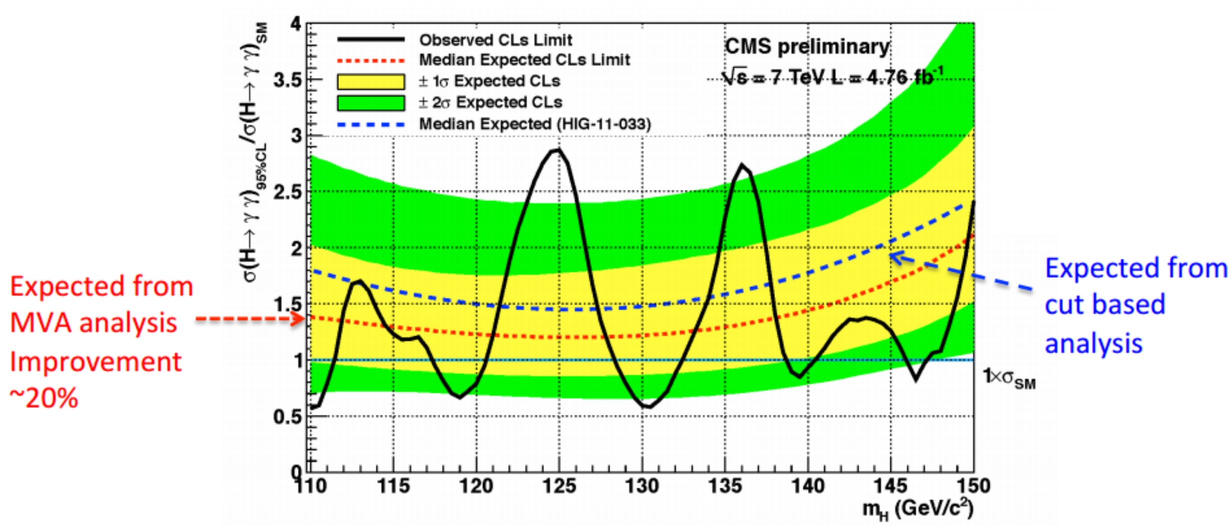
In other words the WW channel does not help the combination and is best left out, but they would not want to be accused of cherry picking so it stays. They have however given us this complicated version of the plot that shows separates the low resolution and high-resolution channels for just this reason.

My second point is that the current excess in the diphoton channel is actually a little larger than the standard model predicts. This can be accounted for as a statistical fluctuation, but likewise the deficit in the WW channel is consistent with a normal fluctuation in the opposite direction. In fact the combination with its now weakened excess is now closer to what the standard model predicts and we should be happier!

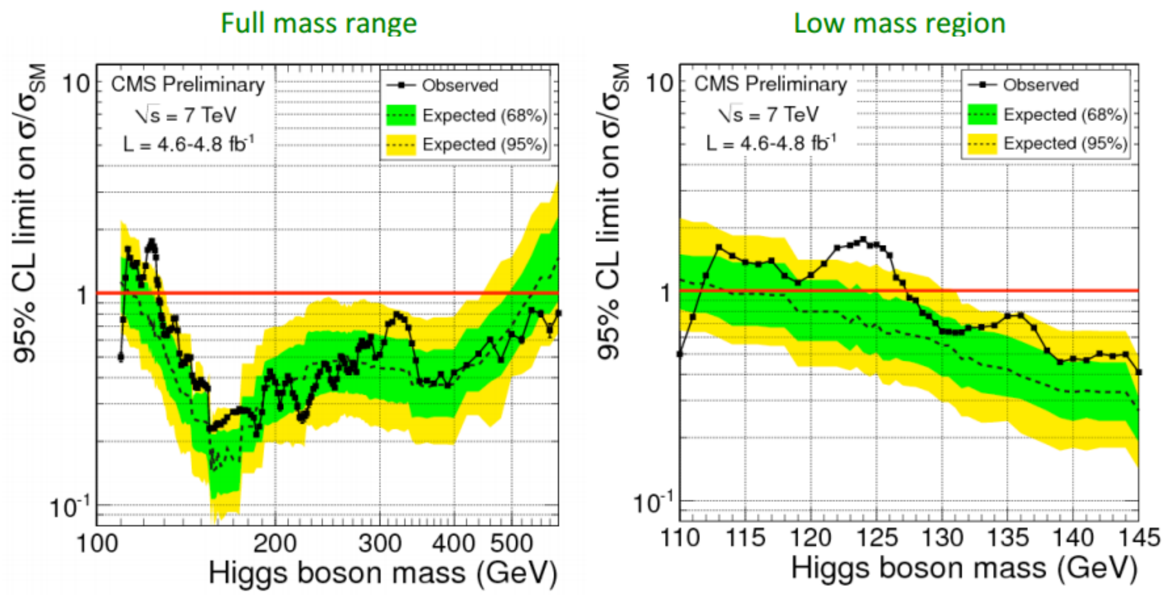


CMS

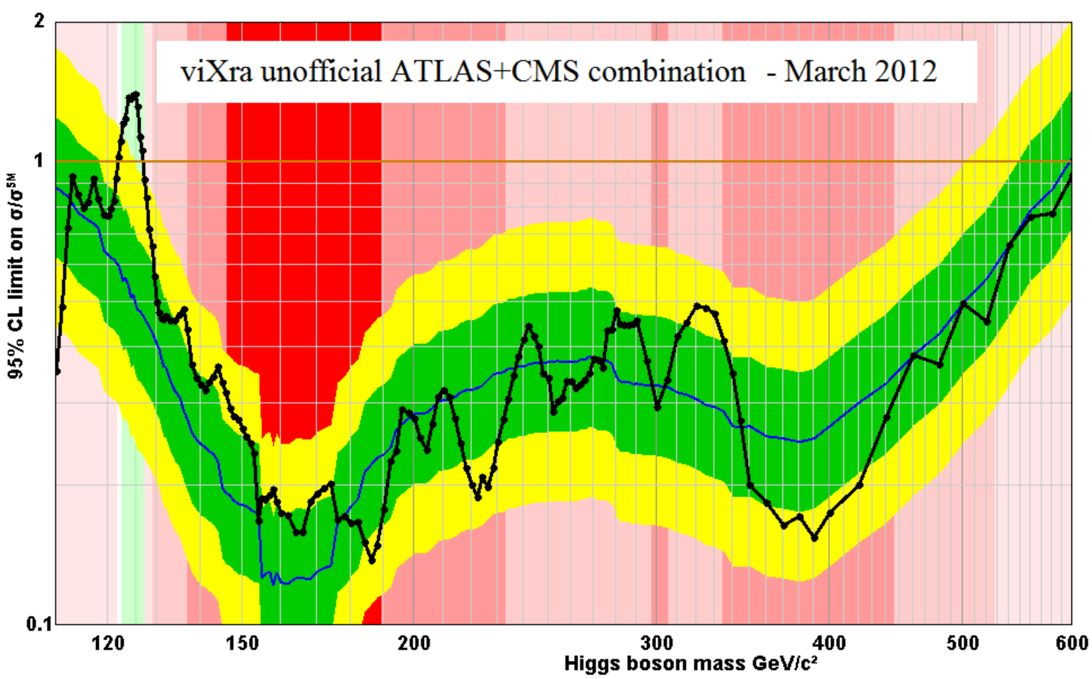
CMS had already updated all their channels with all the available data last month so we did not expect much new from them. Nevertheless they have carried out an MVA analysis of the important diphoton channel to get more out of it. The result is this new plot



They even managed to find some completely new channels such as WH-> WWW. The result is yet another new CMS combination.

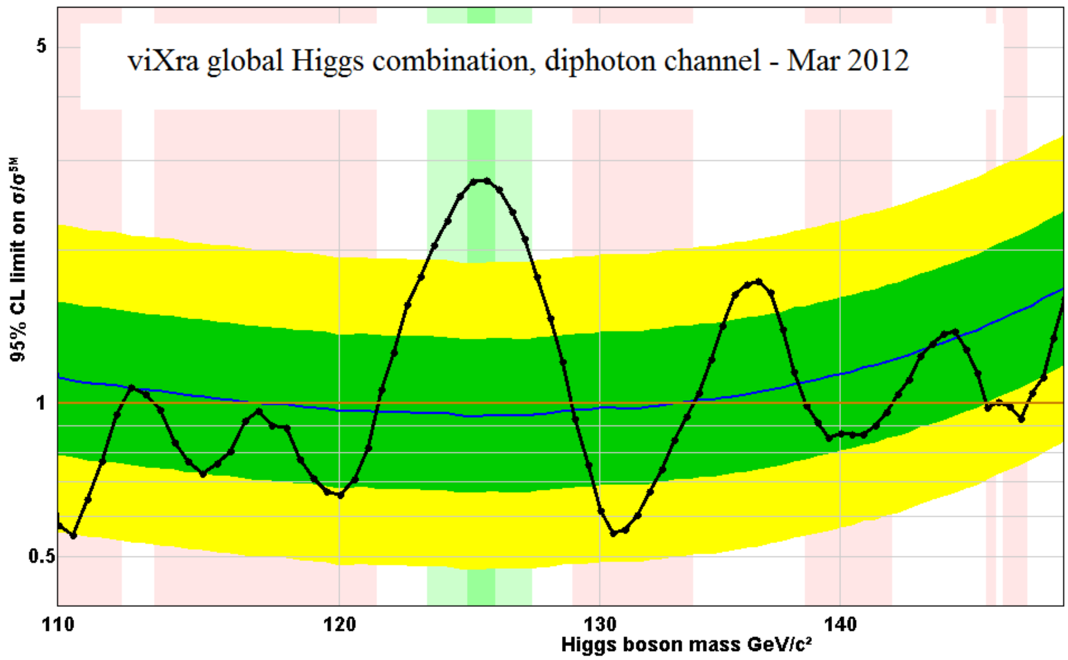


All this means I now owe you a new combination for ATLAS+ CMS and here it is

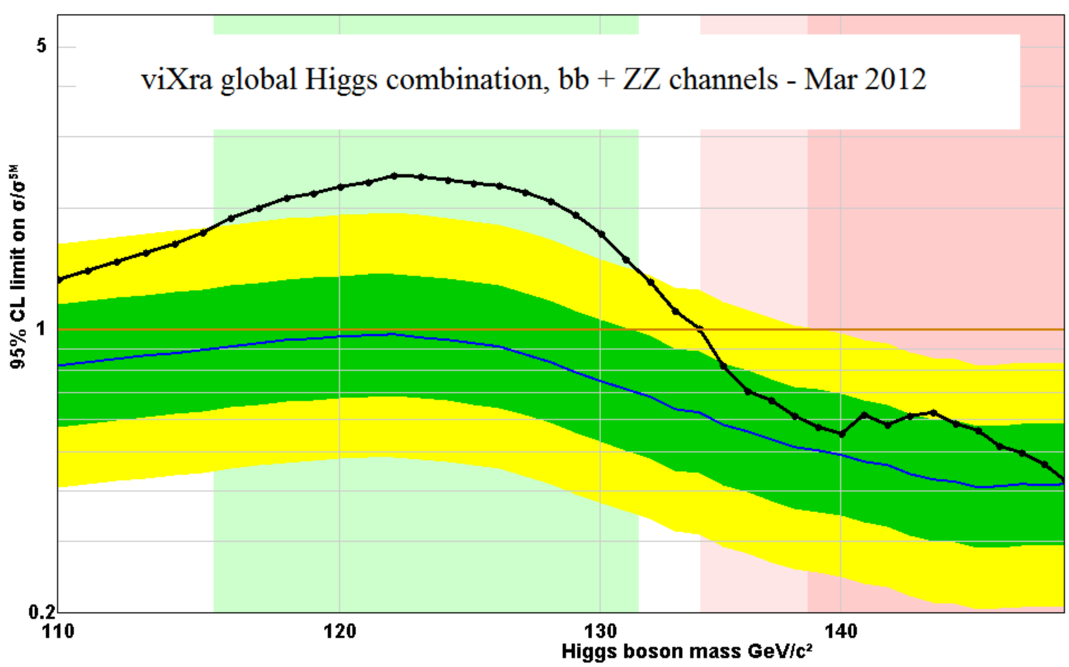


This now excludes the full range of masses except a narrow window from 122 GeV to 128 GeV. This is a remarkable achievement when you consider that at Moriond 2011 a year ago the LHC could tell us essentially nothing about the Higgs boson.

The best evidence we now have for the existence of the Higgs boson still comes from the diphoton channel. Combining all four experiments it now looks like this

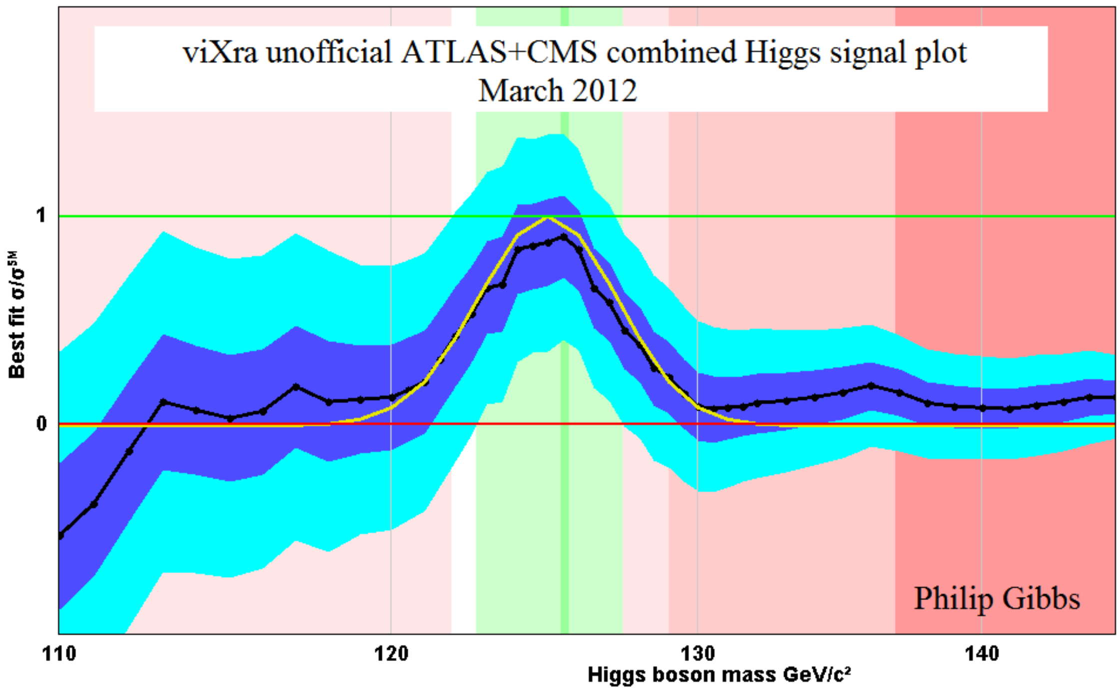


Some people have said that it is really only this channel that supports the case for the Higgs boson at 125 GeV but that is no longer the case. Here is what you get if you combine just the bb and ZZ channels globally



There is still a long way to go but I certainly think the case for a standard model Higgs boson at around 125 GeV now looks good. Even the outside possibility for something more at a lower mass below 120GeV has now faded with the LHC combination excluding that region. It remains hard to get a combination that combines to give an overall significance above the crucial 4 sigma level and we may have to wait some time for that.

Finally I leave you with this impressive plot of the combined Higgs signal from ATLAS and CMS.



References

1. http://blog.vixra.org/2012/03/08/moriond-2012-higgs-summary/