

Article

Are Unofficial Higgs Combinations Valid? Unofficial Higgs Discovery with 2011 Data and H --> WW Revisited

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Abstract

At the CERN July 4th press conference the Director General Dr. Rolf Heuer warned journalists about unofficial combinations. I agree with what he says. The unofficial combinations are approximate and should be used with caution. It is not just the correlations that are neglected but also it assumes that the statistical errors have a flat normal distribution. The detector collaborations don't provide detailed likelihood data to outsiders. However, all statistical errors tend towards the normal Gaussian as the quantity of data increases (central limit theorem) and in most cases there is enough data for the results to be good, with a few exceptions. Indeed, using the unofficial combination on the 2011 data, I find that the LHC combination jumped from 3.67 sigma to 4.64 sigma while the global combination with all the 2011 data jumped from 4.4 sigma to 5.27 sigma. Even taking into account the error margins for the unofficial combination this means that the global combination has risen to discovery level significance level based on 2011 data alone, an impressive result. Finally, I revisit the Higgs to WW decay.

Key Words: Unofficial, Higgs combination, Higgs discovery, 2011 data, Higgs to WW decay.

A Cube of Higgs Combinations

On July 4, 2012, CERN will announce an important update on their search for the Higgs Boson at the LHC (in case you have just got back from another planet) Expectations are high with some news reports saying they will reach the critical 5 sigma discovery level. Peter Higgs himself has flown over to CERN where he has joined other physicists responsible for the theoretical breakthrough back in 1964 that predicted the Higgs Boson. Sources from within CERN point out that final results will not be ready until today so all prior reports of a discovery can be no more than speculation, we will see tomorrow.

What we do know is that the two experiments that have been searching for the Higgs, CMS and ATLAS will each provide updates including data collected this year at 8 TeV. This could be combined with the results from last years 7 TeV run that were published at the last big update in

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<http://blog.vixra.org/2012/07/03/coming-soon-a-cube-of-higgs-combinations/> ;

<http://blog.vixra.org/2012/07/05/are-unofficial-higgs-combinations-valid/> ;

<http://blog.vixra.org/2012/07/10/global-combination-gives-unofficial-discovery-with-2011-data/> ; and

<http://blog.vixra.org/2012/07/18/h-%E2%86%92-ww-revisited/>

December. We know that they will not attempt to combine the CMS and ATLAS data together because they have stated that they are now aiming for independent discoveries from the two detectors. Whether they can reach that important 5-sigma level will depend on how much data they can prepare in time. The amount of data available is 6/fb to be compared with the 5/fb from last year. The higher energy gives another 15% advantage in the crucial diphoton channel where the Higgs is seen most clearly.

If they can get that data together it adds up to a signal about 55% stronger than last year when they each had about 3 sigma in the diphoton channel, so this year we might expect at least 4.5 sigma, but it is not that simple. Last years signal was stringer than expected. If that was a statistical fluke for both experiments then it should be weaker this year bringing expectations down to more like 4 sigma. On the other hand if the enhancement was due to real physics it will still be there and they may even be lucky with the random quantum fluctuations and get nearer 5 sigma.

There is one last thing they can do to improve the signal. They can combine information from another channel such as the decay of the Higgs to 4 leptons. Last year this did not provide much help and only added about 0.2 sigma, but with higher energies it may just be a little better, perhaps enough to take them over the finish line. In the end it will be the luck of the fluctuations that counts. They have two experiments so two tosses of the coins. One may make it while the other falls short.

Of course the next set of data due out in September will certainly finish the game for both of them but nobody wants to wait for that after all the build-up. If neither experiment makes it individually they will be close enough to say that the combination of the two certainly adds up to an unofficial discovery, even if they do not do that combination immediately, Which ever way you look at it they will be able to spin the conclusion to provide the media with the result they are waiting for.

And if they don't? Here is a ray of hope from an [AP report](#)

“Scientists with access to the new CERN data say it shows with a high degree of certainty that the Higgs boson may already have been glimpsed, and that by unofficially combining the separate results from ATLAS and CMS it can be argued that a discovery is near. Ellis says at least one physicist-blogger has done just that in a credible way.”

That physicist-blogger is of course yours truly. As usual I will be carrying out the full cube of combinations using my unofficial methods as soon as the plots are available. The [viXra combination applet](#) has already been updated with yesterday's new data from the Tevatron. The results will be a little approximate and certainly not endorsed by CERN, but unofficial discovery is at least guaranteed or your money back.

Are Unofficial Higgs Combinations Valid?

The [Unofficial Higgs Combination Tool](#) has now been updated with all the new Higgs plots released in the last few days, including the Tevatron updates and the new 8 TeV data from the LHC. There will probably be more to add on 7th and 9th July from ICHEP. Feel free to play around with it.

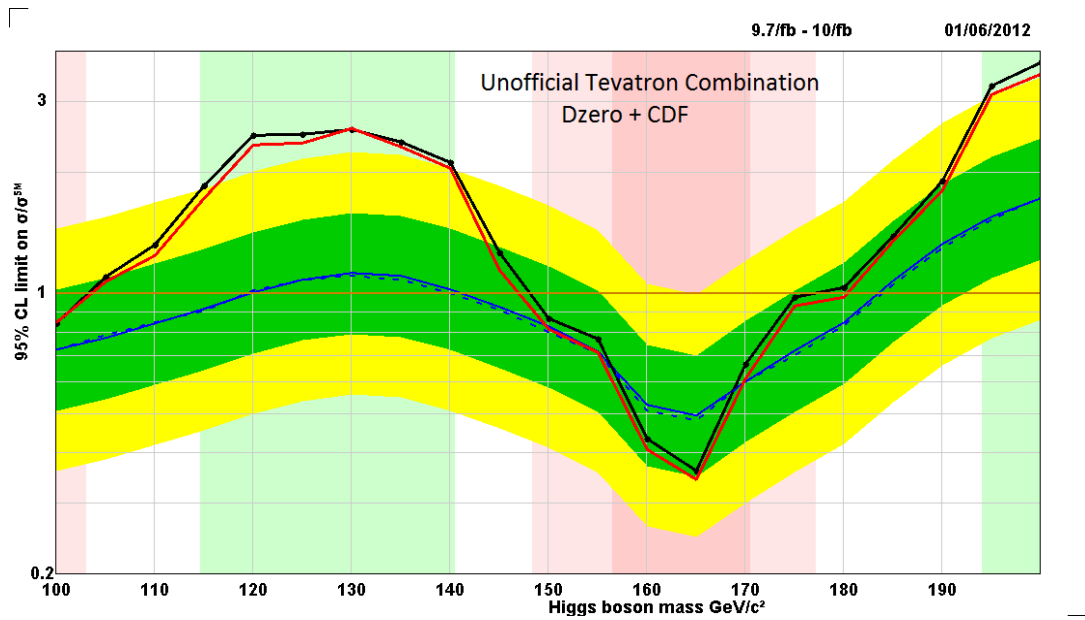
At the CERN press conference yesterday the Director General Dr Rolf Heuer warned journalists about unofficial combinations. What he said exactly was at follows (It is 26:50 in if you are looking on [the recording](#)):

The fact that they [CMS and ATLAS] have not yet combined their results today is that they did not have enough time. We should have shifted the Melbourne conference by 2 weeks or 3 weeks or 4 weeks but that was not possible. You have to stay tuned until at some time they combine their results. Whatever combination you get beforehand is unauthorised and is certainly not valid because you have to take into account the different correlations, one has to be very careful.

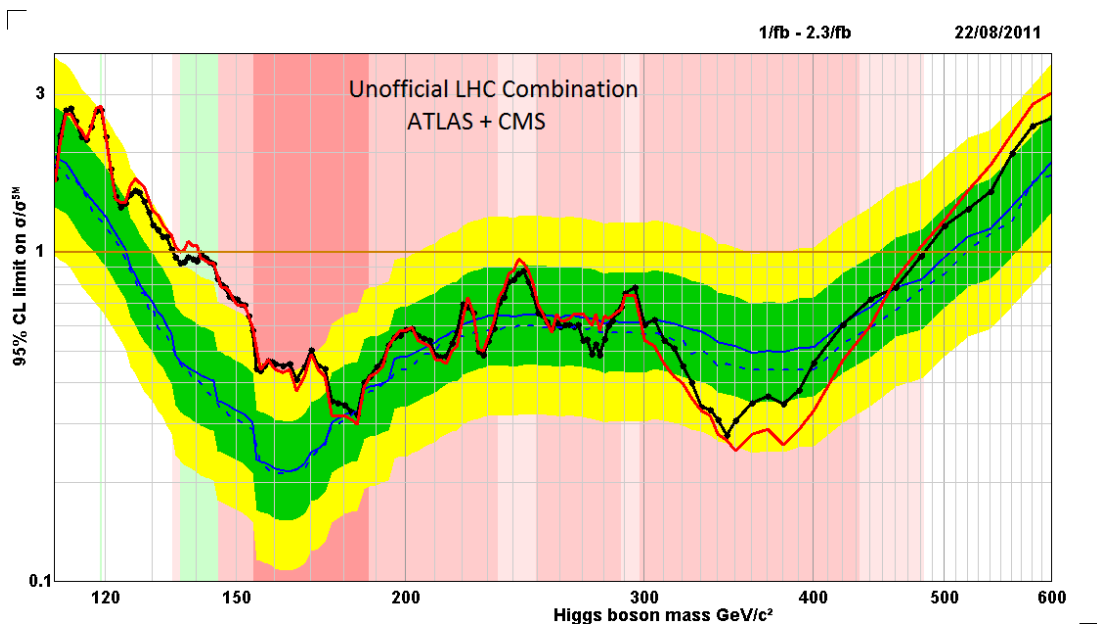
I agree with what he says. The unofficial combinations you find on this blog are approximate and unofficial and should be used with caution. I have always made that clear. It is not just the correlations that are neglected. The quick combination method assumes that the statistical errors have a flat normal distribution and that is not quite correct. The detector collaborations don't provide detailed likelihood data to outsiders so this is the best I can do. Luckily all statistical errors tend towards the normal Gaussian as the quantity of data increases (central limit theorem) and in most cases there is enough data for the results to be good, with a few exceptions.

Whether the combinations are “valid” or not depends on what you are using them for. I don't consider them valid for writing up published results of any kind, but they are good enough as a rough guide to theorists looking for possible signals in the data and there is nothing wrong with showing them at conferences as some eminent theorists have already done, provided they come with appropriate caveats.

I have previously shown some comparisons between official combinations and my unofficial ones to show how accurate they can be (or not). I think it is worth doing a few more now using some of the recent results where the amount of data has increased. In all the plots below the red line is the official result and the black is the unofficial. First up is the latest version of the Tevatron combination compared with an unofficial combination of the updated Dzero and the latest CDF plot that was updated in March. You can click on the plots to get a larger version.

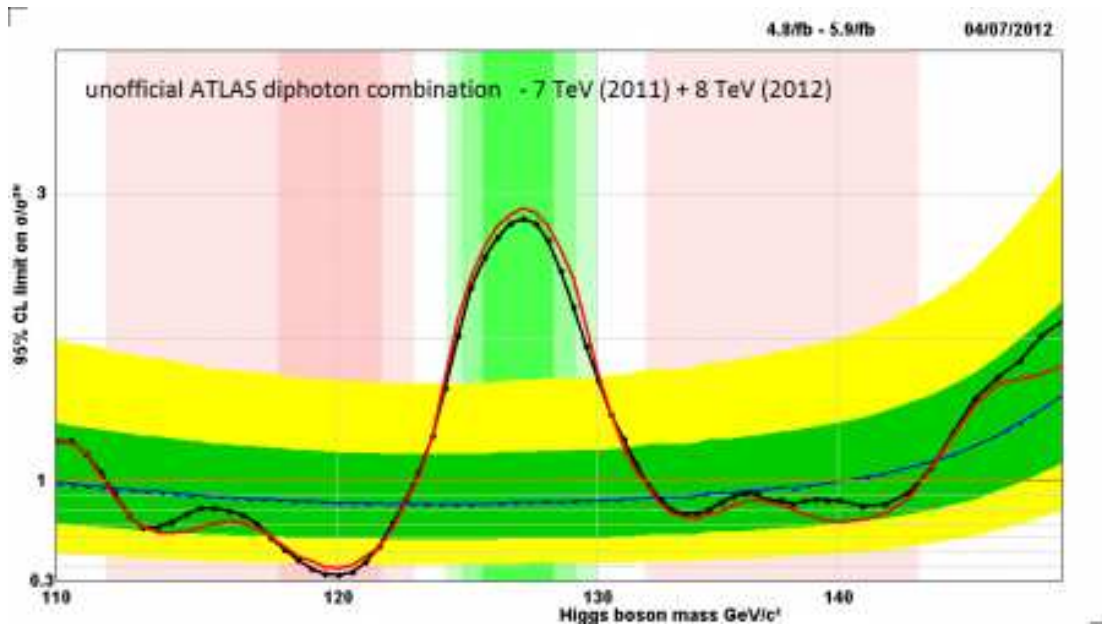


The combinations across all channels have always worked quite well because they use lots of data. The last time that the LHC provided an official combination for ATLAS + CMS was in November when there was only 2.3/fb. here is how it looked next to the unofficial combination that I had done 10 weeks earlier.



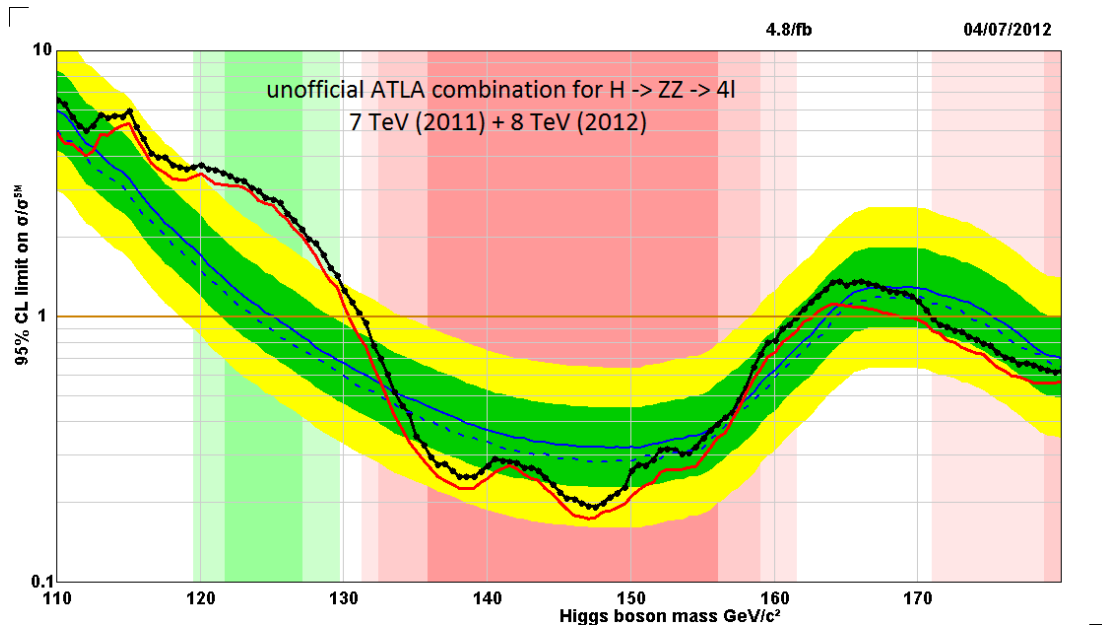
Notice here how the accuracy gets worse at higher energies where there is less data available. Heuer seemed to be implying that there should be another combination due out soon. If so it will be interesting to see if the comparison improves as I would expect.

The combinations for single channels have been less successful in the past, but now they are improving. Here is a reconstruction of the ATLAS combination for 7 TeV + 8 TeV data in the diphoton channel.



But the results don't always come out so well even now. The 4 lepton channel uses very few events in both the signal and the background. Here is the result of a similar combination

(Update: There was an error in the digitisation that I now fixed and it is not so bad now)



The combination across ATLAS and CMS should be better because it involves twice as much data. They should also have twice as much again by the end of the year so by then combination should work OK even in this channel.

If you want to try more the [Higgs combination tool](#) is easy to use and free.

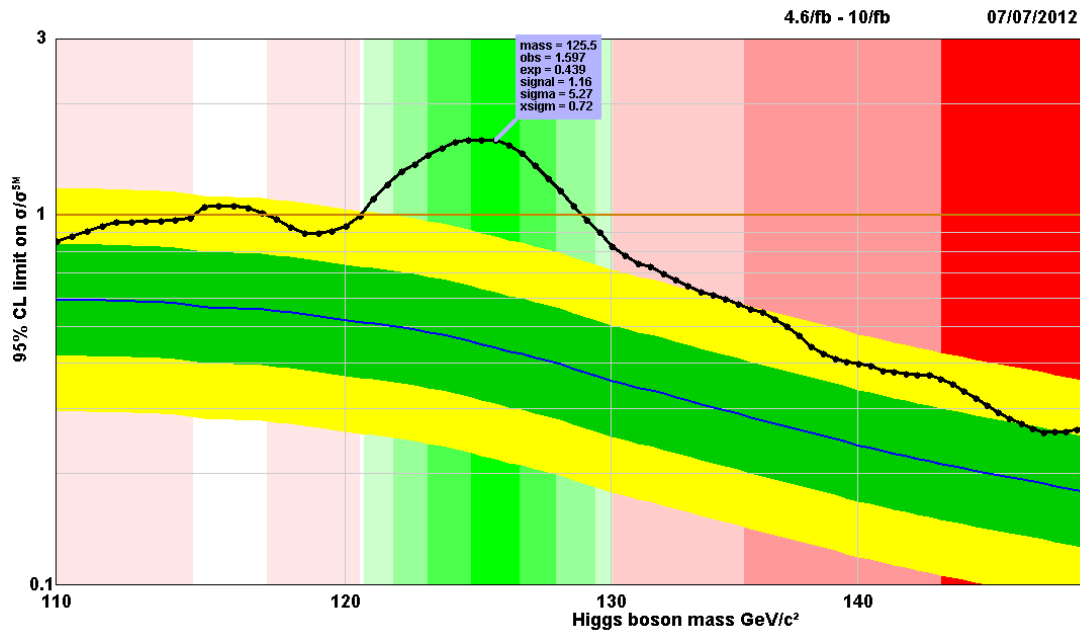
Update: I said that I don't think these combination methods should be used in published papers but other theorists are apparently not as reticent. [arXiv:1207.1347](#) is one example of paper showing a combined signal plot as well as combined channel values and other fits. There conclusion is that everything fits the standard model except that the diphoton rate is 2.5 sigma too high, in agreement with my figure.

Global Combination Gives Unofficial Higgs Discovery with 2011 Data

When ATLAS and CMS first published their results based on 2011 data in December, an unofficial combination of the results gave an excess with significance 3.74 sigma, a long way short of the 5 sigma needed to claim a discovery. Adding the Tevatron results available at that time only made it worse with a drop to 3.69 sigma. In February CMS added some extra diphoton events that pushed the LHC combination up to 4.3 sigma, then at the Moriond conference on March both CMS and ATLAS updated their combinations with the result that the significance dropped to 3.64 sigma. At the same meeting CDF and Dzero presented an update using the full dataset from the Tevatron. This time the combination with the Tevatron data improved the result pushing the significance back up to 4.25 sigma.

With all the data in use it looked like new data from the 2012 LHC run would be needed to reach discovery significance. Three days before the ICHEP conference the Tevatron collaborations presented updated combinations using some updated analysis from Dzero. This pushed the significance of the global combination up to 4.39 sigma. Then of course ATLAS and CMS added their 2012 data to reach 5.0 sigma individually with the combination reaching an impressive 7.45 sigma.

Later when the data was published as analysis notes more detail was given including data for the diphoton and 4 lepton data at 7 TeV. These had been updated yet again with ATLAS improving their analysis technique and CMS finding an extra 0.33/fb of 2011 data. Using these new unofficial combination for the 2011 data can be generated and the result is dramatic. The LHC combination jumped from 3.67 sigma to 4.64 sigma while the global combination with all the 2011 data jumped from 4.4 sigma to 5.27 sigma. Even taking into account the error margins for the unofficial combination this means that the global combination has risen to discovery level significance level based on 2011 data alone, an impressive result.



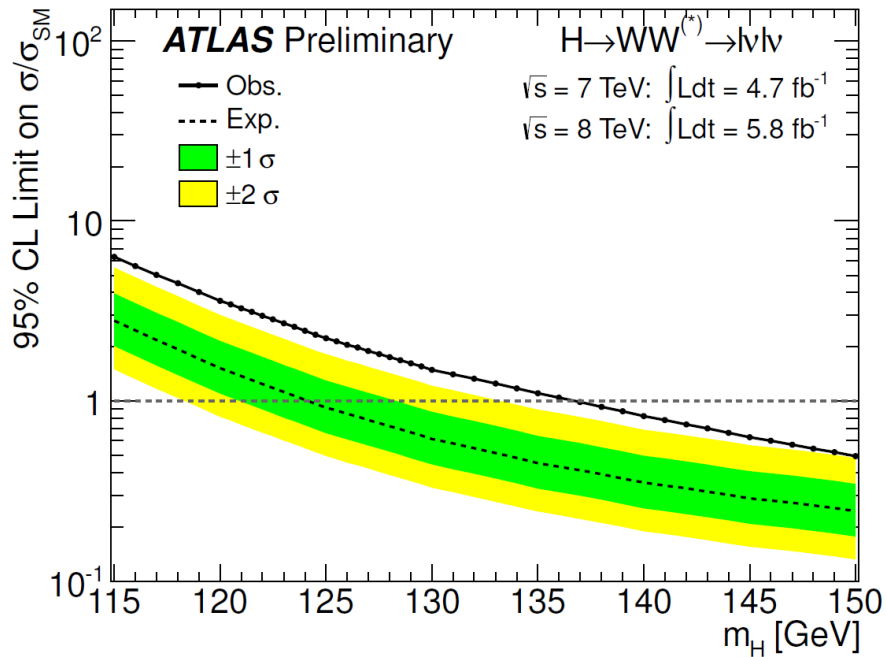
So where did this increase of nearly 1 sigma from the 2011 data come from? Looking at the individual contributions, the CMS combination increased by 0.35 sigma and the ATLAS combination increased by 0.85 sigma. Of course all these results are approximate, unofficial and not endorsed by the experiments.

You can generate all the combinations here using the [unofficial Higgs combination tool](#).

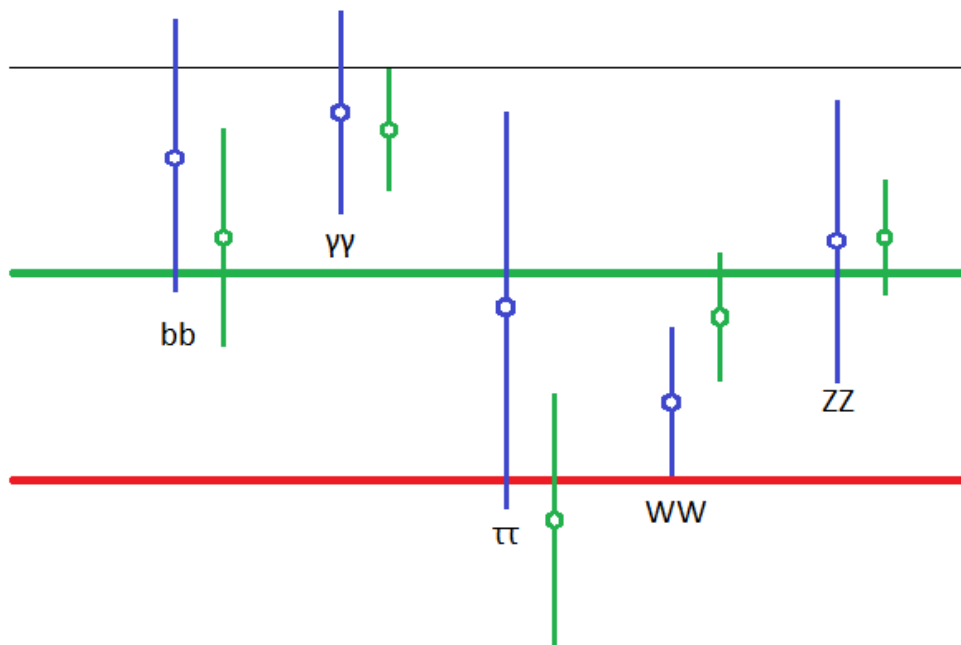
H → WW Revisited

Before the independence day and ICHEP Higgs discovery I [raised a question](#) about the Higgs decay to WW channel. In the early days it had shown a broad excess, but this had then faded to the point where it was consistent with no Higgs anywhere rather than the signal seen in some other channels. I asked how well we could trust these results.

The deficit was especially noticeable from ATLAS with CMS showing a less significantly low event count. Today at the [Higgs Hunting workshop](#) ATLAS have released an update for their WW channel at low mass with a combination of 7 TeV and 8 TeV data. Now they once again have a broad excess signal more consistent with a boson in the low mass range. There is also a [conference note](#) giving all the details.



Using unofficial combinations I can now update the plot that shows the size of the signal in each channel. Here it is with the earlier results from 2011 shown in blue and the updated versions in green. This is a global combination with the Tevatron data helping in the bb channel.



Higgs signal at 125 GeV using global combination of data up to Dec 2011 (in blue) and June 2012 (in green).

The diphoton channel stills shows an excess while the ditau now has a deficit. Others are really in line with the standard model Higgs. In any case there is not yet enough data to draw any conclusions but that is no reason to not speculate about what might explain the results if they hold up.

References

1. <http://blog.vixra.org/2012/07/03/coming-soon-a-cube-of-higgs-combinations/>
2. <http://blog.vixra.org/2012/07/05/are-unofficial-higgs-combinations-valid/>
1. <http://blog.vixra.org/2012/07/10/global-combination-gives-unofficial-discovery-with-2011-data/>
2. <http://blog.vixra.org/2012/07/18/h-%E2%86%92-ww-revisited/>