The Discovery of What?
Ten Questions About the Higgs to the Particle Physics Community

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Abstract

2012 seems to become a year to be celebrated in the high energy physics community. "As a layman, I would say we have it!" said CERN director general Rolf-Dieter Heuer at the press conference on July 4, 2012, announcing the discovery of a footprint of 'something' in the LHC proton collision data. Evidently, such a short statement was necessary because the expert's account of the discovery is a long story to tell. As physicists, we are seeking something in between. We would be curious if there are discussions in the community along our questions; in any case, they don't seem to have got outside so far. Therefore, we would like to invite a broader communication between the particle physics community and the rest of physics.

What were the predictions? Our impression was that the Higgs signal was searched for in every energy region and eventually found in the only one not excluded before. Was there any theoretical prediction of its mass earlier than 2011?

Two photons. So what? The first and most important evidence is an excess of photon pairs. Virtually every particle-antiparticle pair created by the collisions decays into two photons. How can one read from this any characteristic of such a peculiar and unique process the Higgs mechanism is claimed to be?

Is this a triumph of the standard model? It seems that at least some branching ratios (decay probabilities to various particles) do not match the expected values, and a tentative explanation in terms of a 'non-standard' Higgs was given. Is such a non-standard Higgs still a triumph of the standard model? Or the triumph of a non-standard standard model yet to be developed? Or is such a failure of the predictions just an additional result to celebrate, namely 'tantalizing hints to new physics?

How is radiation damping controlled? A high-energy collision of protons, as for all charged particles, implies that enormous (negative) accelerations must occur. Accelerated charges necessarily loose energy due to radiated photons. However, a complete theory at what wavelength, rate and direction these photons are emitted by accelerated charges, just doesn't exist. This is a sad, but elementary consequence of electrodynamics being inconsistent.[1] How does one, in an experimentally unprecendented situation, reliably model the amount of radiated photons, if there is no theory for it at hand?

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[1] See, e.g. Feynman Lectures II, chap. 28; Landau-Lifshitz II, par. 75.

How do you remove a background of one trillion pairs? To repeat an analogy used by Rolf-Dieter Heuer, identifying the Higgs corresponds to finding a needle in a needlestack. Thus, for every single signal in the two-photon channel, one trillion other pairs must be assigned uniquely to all other processes involved. Recently, physicists disagreed about the size of the proton.[2] Is it reasonable to claim that 600 million collisions per second can be modelled to such an incredible accuracy?

Is the lifetime of the Higgs irrelevant? The standard model predicts the lifetime of the Higgs to be $1.56 \cdot 10^{-22}s$. However, the photon excess at 125 GeV has an approximate width of about 8 GeV. According to Heisenbergs uncertainty relation, this is also consistent with a lifetime a few hundred times shorter. Is this missing piece of evidence really irrelevant ? We are concerned about this point since a particle with lifetime in the order of $10^{-25}s$ (incidentally, the top quark is assumed to have such a short lifetime) could not even leave the collision point. How can one claim to know precisely what's going on there?

Is this an explanation of masses? It is often stated that the discovery of the Higgs boson would explain an old riddle of masses. Indeed, Einstein, Dirac and Feynman wondered why the proton is 1836 times heavier than the electron. If the answer should be 'because it couples 1836 times stronger to the Higgs field',[3] where precisely lies the epistomological insight?

How many numbers are in the game? A basic tool in scientific methodology is to compare the number of independent results with the number of parameters needed to describe it (a meaningful theory should have fewer of the latter). Are all the branching ratios truely independent? Is there an overview of how many independent measurements are generated by the LHC results and how many parameters are used for the description?

What are the model-independent results? If the results of the LHC should confirm the standard model, it seems to be a fair idea not presupposing the validity of the standard model. The advance of mercury's perihelion existed before general relativity was developed. The Lamb shift of the hydrogen atom is a result that can be stated without the language of QED that explains it. How can the results of the LHC be formulated *without* relying on the standard model with all its particles?

Why not public data? The scientific method relies on reproducibiliy of results. We appreciate that the instrument experts apply their corrections and calibrations to the raw data. But we miss a publicly available dataset that simply says how much energy, at a given time and location in a specified detector, was deposited. Why does an experiment with huge resources not provide public access to such model-independent results?

These questions came to our mind because we would consider it somehow unsatisfactory if the existing signal is one day declared as a Higgs particle because "there are no reasonable alternatives that explain it". We apologize if some of our questions seem too general or a bit naive, though we believe that answers should exist which are comprehensible for non-expert physicists.

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[2]R.Pohl et.al., The size of the proton. Nature 466, 213 (2010)

[3]Distinguishing quark and gluon masses does not change the underlying problem.