

An Essay Concerning Human Misunderstanding: Why It Cannot Be Inferred From Empirically Acquired Information That The Higgs Boson Has Been Observed

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Abstract

A key step towards an understanding of nature is understanding what can be inferred from empirically acquired information. In that context, this essay critically analyzes last years claim that a new boson has been observed with the CMS experiment at the LHC—a claim that was followed up on in 2013 with the announcement that the newly observed particle is indeed a Higgs boson. It is argued that it is neither the case that the new boson has been observed directly, nor that the contended claim can be deduced from the research result. The response of the CMS collaboration to this criticism is presented, and countered with a final argument. The conclusion is then that the claim that the boson has been observed is an overstatement, and thus concerns rhetoric outside the framework of scientific discourse.



Figure 1: Poster shown at the press conference at CERN on 7-4-2012. Source: *CERN Document Server*

Understanding empirically acquired information is important for understanding physics, since experiment determines what is true and what not in physics. A key step in the process towards understanding physics is accurately formulating the empirical findings in the language of physics and correctly inferring what that means for our understanding of nature. Rather than treating the gen-

eral process of inference involved, this essay provides an example of how *not* to proceed by critically analyzing a recent major claim in physics—this automatically touches on general aspects of inference in physics.

In the press conference at CERN on July 4, 2012, the CMS collaboration made the preliminary results public of its search for the Higgs boson. During that press conference the following claim was made, live before a worldwide audience: “we have observed a new boson”, see fig. 1. In the subsequent press release, CERN director Heuer was quoted saying: “we have reached a milestone in our understanding of nature” [1]. In the journal paper [2], in which the preliminary results of the CMS collaboration are published, the aforementioned claim is reiterated: “observation of a new boson” is claimed in the title. In the recent press release by CERN, it is claimed that the newly observed boson is indeed a Higgs boson [3].

Now what is *not* contended is that the CMS collaboration has observed a significant bump above background in the invariant di-photon mass spectrum at 125 GeV, and a significant excess

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of events in the ZZ invariant mass spectrum at the same mass: without a doubt, this is a correct formulation of the output of the measurement equipment in the language of quantum physics. The subject of the critical analysis below is the conclusion that is drawn from there: the claim that the boson *itself* has been observed. And the CMS collaboration does make precisely that claim: see once more fig. 1 and [2]. That is the main claim that has caused all the recent excitement—not to say mass hysteria—among physicists and the general public.

Analyzing, the first point is that it is not possible, not even in principle, to observe a boson, or any other elementary particle (electron, photon, quark, etc.) for that matter. The present-day measurement equipment can, namely, only measure real-valued properties of microsystems like charge, position, momentum, mass, etc.: we can, thus, observe *properties* of an elementary particle, but we cannot observe the elementary particle *itself*. So in particular, if a microsystem consists of one Higgs boson, then we can observe properties of the microsystem that according to theory correspond to properties of the Higgs boson (or of its decay products) like position and mass, but we cannot observe the Higgs boson itself. From this alone it already follows that it is preposterous to claim that a (Higgs) boson has been observed.

The second point is that it is also not the case that the contended claim logically follows from the measurement output. It is well known from scientific literature that the relation between general theory and concrete prediction has the logical form of an if-then statement, cf. e.g. [4]. To spell it out, in the present case we have: *if* the Higgs boson exist, *then* in that in that and that experiment a (combined) mass of 125 GeV will be observed. But the reverse is not valid! Period! From an observation of the predicted mass it can thus *not* be inferred that the Higgs boson itself has been observed, just like it cannot be inferred from an observation of an imprint of a hoof that a unicorn has been observed. Such a conclusion is a logical fallacy—the inference $A \Rightarrow B, B \vdash A$ is not valid!

A third point is that there are no “higher principles” that justify the contended claim. It is, for example, not a matter of majority consensus: it is not the case that the Higgs boson has been observed *because* the majority holds the opinion that the Higgs boson has been observed. It is, thus, important to distinguish a *proof* of the existence of the Higgs boson from an *acceptance* of the existence of the Higgs boson: the latter is largely a social matter, as Kuhn argued in the 1970’s. So although it remains unproven, one can accept

the assumption that the Higgs boson exist, e.g. because the Higgs mechanism is the best available explanation for the obtained empirical data.

The inevitable conclusion is then that the contended claim of the CMS collaboration that a new boson (or a Higgs boson) has been observed is an *overstatement*. To the defense of the CMS collaboration one might say that it has become a convention in modern particle physics to claim the observation of an unstable particle when in fact only the predicted properties of the predicted decay products have been observed: physicists thus *know* that the claim “a new boson has been observed” actually means that only traces of the boson have been observed¹. But there are two major arguments that invalidate this point of view:

- (i) it is of course ludicrous to use the words “we have observed a new boson” when one intends to say that one hasn’t observed a new boson but only traces thereof. Calling on a convention is then no justification: it rather casts doubt on the convention!
- (ii) even if *physicists* know how to read such a claim, uttering the words “we have observed a new boson” when such is not the case is close to scientific misconduct as it gives rise to misinterpretations of the research results by the general public—the general public, namely, takes the claim literally and absolutely believes that the boson *itself* has been observed.

All in all, what we have here is that the measurement equipment has detected, with a significance of 5σ , properties of a microsystem that correspond to properties of decay products of the Higgs boson as predicted by the Standard Model: the only substantial conclusion that then can be drawn is that the the Standard Model, including the Higgs hypothesis, has been found to be *correct* by the CMS experiment at the LHC—this conclusion is, namely, warranted by the definition of ‘correctness’ in the EPR paper [5]. While this conclusion may lead to a wide acceptance of the assumption that the Higgs boson exists—as mentioned above, such is largely a social matter—the bottom line here is that the recent claim that the Higgs boson has already been observed is untenable. It is, thus, way too early to say that “only the most curmudgeonly will not believe that they have found [the Higgs boson]”, as Carroll put it in [6]. It is quite the other way around: while the results add further justification for the belief in the existence of the Higgs boson, only those who are out of touch with the scientific method claim that they have already observed it.

¹This is thus the reply of the CMS collaboration to the present criticism, as communicated anonymously.

References

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