A detailed map of Higgs boson interactions by the ATLAS experiment ten years after the discovery

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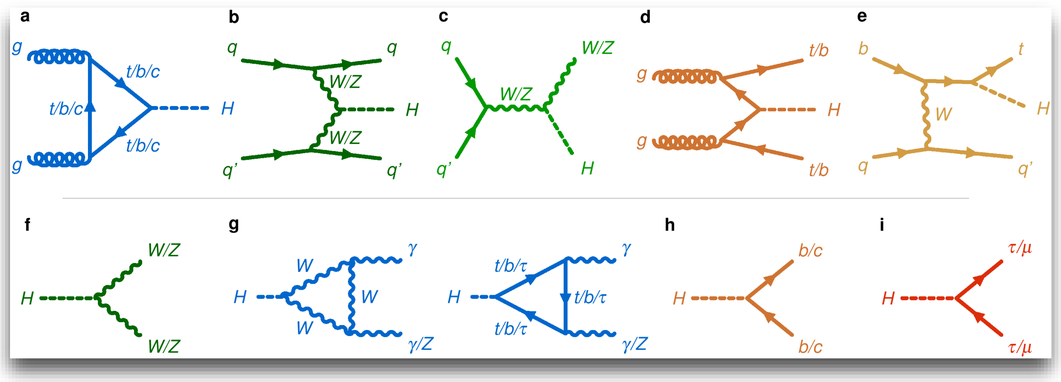
Abstract:
One of the central features of the Standard Model is a field that permeates all of space and interacts with fundamental particles. The quantum excitation of this field, known as Higgs field, manifests itself as the Higgs boson, the only fundamental particle with no spin. Since the discovery of a particle with properties consistent with the Higgs boson, more than 30 times as many Higgs bosons have been recorded by the ATLAS experiment, allowing much more precise measurements and new tests of the theory. Here, we report the measurement of the interactions between Higgs boson and unprecedented kinds of elementary particles. These tests reveal that the Higgs boson discovered ten years ago is remarkably consistent with the predictions of the theory and provide stringent constraints on many models of new phenomena beyond the Standard Model.

Input measurements:

Interactions with gluons, photons, and W and Z bosons – the carriers of the strong, electromagnetic, and weak forces – are studied in detail. Interactions with three third-generation matter particles (b t quarks, and τ lepton) are well measured and indications of interactions with a second-generation particle μ are emerging.

VBF $\rightarrow H\bar{b}b$ channel is one of the most updated measurements included in this combination. Due to its sensitivity on the interactions between Higgs boson and W/Z bosons and b quark, the related measurements could be improved.



Cross section and coupling measurements:

The total cross section of Higgs production modes ggF, VBF, WH, ZH, ttH and tH in each $H \rightarrow \gamma\gamma$, $H \rightarrow ZZ*$, $H \rightarrow WW*$, $H \rightarrow \tau\tau$, $H \rightarrow \mu\mu$, $H \rightarrow b\bar{b}$ decay are measured respectively. The production modes are properly merged in some decay due to the limited sensitivity.

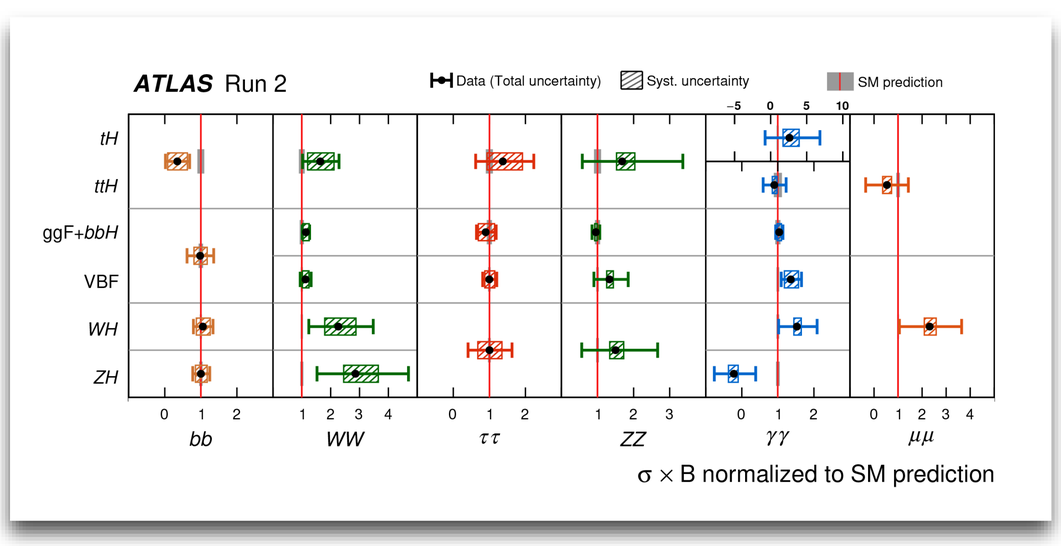


Figure 2

Ratio of observed rate to predicted SM event rate for different combinations of Higgs boson production and decay processes are shown in Figure 2. The horizontal bar on each point denotes the 68% confidence interval. The narrow grey bands indicate the theory uncertainties in the SM cross-section times the branching fraction predictions. The p-value for compatibility of the measurement and the SM prediction is 72%.

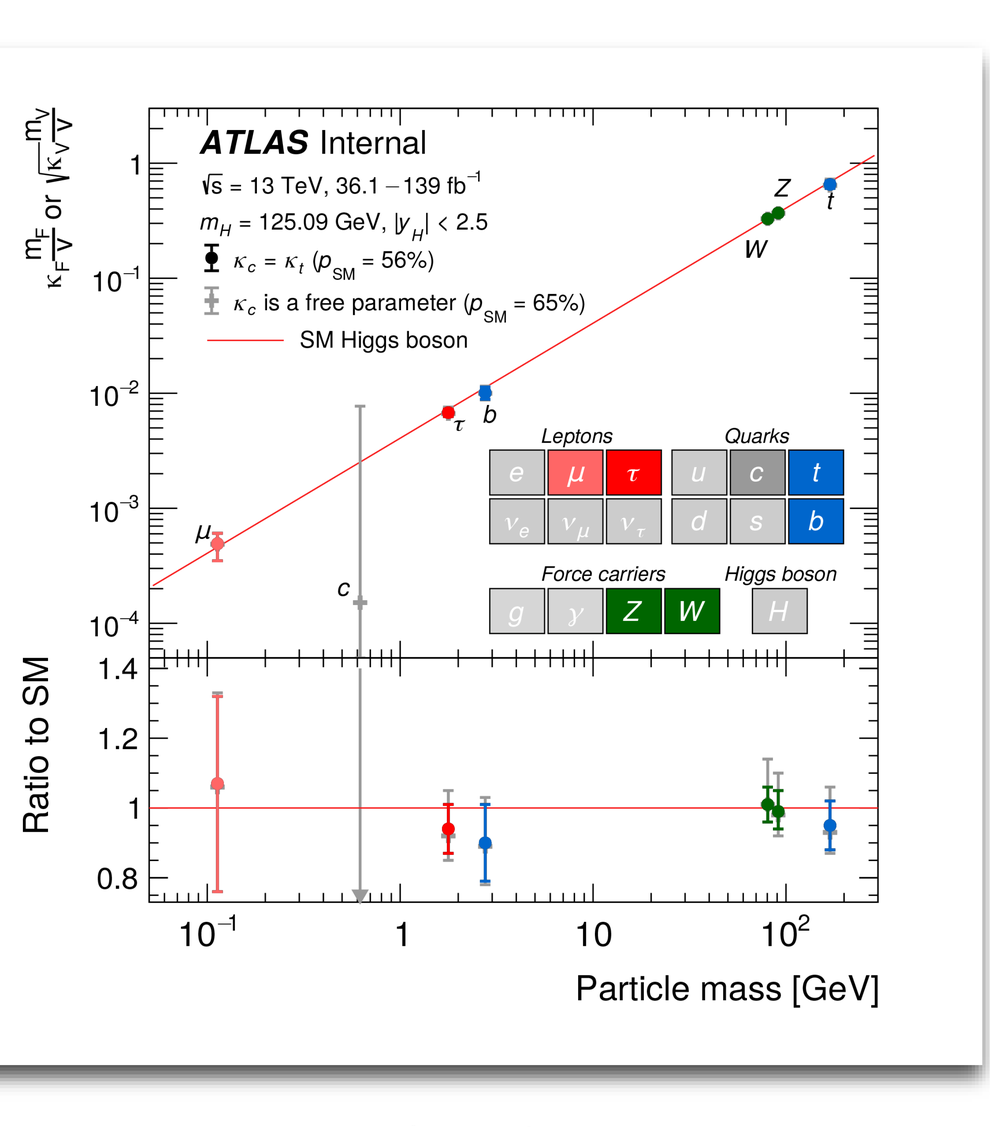


Figure 3

Reduced Higgs boson coupling strength modifiers and their uncertainties. They are defined as κFmF/vev for fermions and $\sqrt{\kappa VmV}$/vev for vector bosons as a function of their masses mF and mV. Loop-induced processes are assumed to have the SM structure, and Higgs boson decays to non-SM particles are not allowed. The p-values for compatibility of the combined measurement and the SM prediction are 56% and 65% for the respective scenarios.

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