Higgs bosons as a portal to beyond the Standard Model

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Successes and drawbacks of the Standard Model

The Standard Model is a very successful theory — many people have expected it to break down earlier

- Precision tests: Magnetic moments of leptons, lifetimes and branching ratios of particles
- Electroweak tests: SU(2)×U(1) symmetry confirmed to 0.1% level
- Flavor physics tests: The unitarity of the CKM matrix tested to 0.1% level
- CP-violation tests: All observed CP-violating reactions can be explained by a single parameter (the phase of the CKM matrix)

But: Neutrino masses, cold dark matter, the amount of matter-antimatter asymmetry in the Universe, the metastability of the SM scalar potential and the smallness of the electroweak scale to the assumed scale of quantum gravity require or suggest that the SM must be extended

How can the Higgs reveal new physics?

1. If a new particle has the same quantum numbers, the particle can mix with the Higgs $\Rightarrow$ modified production and decay probabilities
2. If the new particle couples to the Higgs and is light enough, the Higgs may decay to it and limits can be drawn even if the decay products are not seen or are lost in backgrounds
3. If the new particle is heavy (but $\lesssim 1$ TeV) but couples to the Higgs and some other SM particles, it can modify the production and decay properties of the Higgs, especially the loop-mediated processes $gg \to h$, $h \to \gamma\gamma$ and $h \to Z\gamma$

The Higgs boson is a promising portal to new physics, since it couples more strongly to heavy particles which get their mass from this Higgs. Full utilization will need increasing precision in both experiment and theory.