**Title:** Shedding light on the invisible Higgs



**Image caption:** Some of the Higgs boson’s decay modes may be invisible to detectors, but that doesn’t mean we can’t see them.

**Main text:**

There are basically two types of detectors used in collider experiments: [trackers](http://www.fnal.gov/pub/today/archive/archive_2015/today15-03-19.html), which are sensitive to any particles that interact [electromagnetically](http://www.fnal.gov/pub/today/archive_2013/today13-03-29.html), and [calorimeters](http://www.fnal.gov/pub/today/archive/archive_2015/today15-04-02.html), which are sensitive to any particles that interact electromagnetically or through the [strong force](http://www.fnal.gov/pub/today/archive_2013/today13-04-12.html). That’s only two of the four forces — there’s also the [weak force](http://www.fnal.gov/pub/today/archive_2013/today13-04-26.html) and [gravity](http://www.fnal.gov/pub/today/archive_2013/today13-05-10.html). Anything that interacts exclusively through the latter two forces would be invisible.

This is not a speculative point. Neutrinos are effectively invisible in collider experiments. Even [specialized neutrino detectors](http://www.fnal.gov/pub/today/archive/archive_2014/today14-10-09.html) can only detect a small fraction of the neutrinos that pass through them. Dark matter is known purely through its gravitational effect on galaxies; No one even knows if it interacts via the weak force as well. Invisible particles could be slipping through detectors at the LHC right now.

But if you can’t see them, how can you find them? Fortunately, physicists have developed a few tricks, mostly involving conservation laws. For instance, conservation of charge forces some particles and antiparticles to be produced in pairs, and one may be detected while the other decays invisibly. [Conservation of momentum](http://www.fnal.gov/pub/today/archive/archive_2014/today14-12-05.html) requires particles to be produced symmetrically around the beamline; If the observed distribution is highly asymmetric, that’s an indication of an unseen particle.

In a [recent study](http://arxiv.org/abs/1507.00359), CMS physicists used the latter technique to determine how often Higgs bosons decay into invisible particles and also a photon. This is interesting because Higgs bosons have only been observed in a few of their predicted decay modes — the rest could be wildly different from expectations. In particular, Higgs bosons could interact with new phenomena like dark matter or supersymmetry, and most of these particles would be invisible. One of the ways supersymmetry [might be hiding](http://www.fnal.gov/pub/today/archive/archive_2015/today15-01-16.html) is by decaying into gravitinos (gravity only), neutralinos (gravity and weak only) and a visible photon.

Through this analysis, the mostly invisible signature has been partially ruled out: At most 7 to 13% of Higgs bosons might decay this way, if any at all. Before the measurement, it could have been as much as 57%. That’s a lot for one bite!