Courant's Marateck describes math theory behind Higgs boson finding

January 4 2013, by James Devitt

Lost in the exhilaration surrounding this summer's presumed discovery of the Higgs boson, the subatomic particle that is a building block of the universe, were the theoretical clues that led to the breakthrough.

In an article that appeared last summer in the *Notices of the* American Mathematical Society, Samuel Marateck, a senior lecturer at NYU's Courant Institute of Mathematical Sciences, unpacks scholarship dating back to the era following World War I that provided the scientific foundation for the search.

For some time, physicists have been searching for the Higgs boson, the only particle of the Standard Model of Particle Physics that scientists had yet to detect. The Standard Model of Particle Physics describes the universe in terms of its fundamental particles and the forces between them.

The hunt was primarily conducted in the Large Hadron Collider (LHC), located at the CERN laboratory near Geneva, Switzerland. But mathematical physicists had, decades ago, laid a theoretical groundwork that ultimately gave physicists clues of where and how to look.

The initial, formal underpinning, Marateck writes, was the Yang-Mills theory, formulated in 1954. Chen Ning Yang and Robert Mills invented what was then a new type of particle field strength based on the electro-magnetic one—a contribution that would allow physicists to obtain a calculable result in future analyses.

However, the Yang-Mills theory had a significant shortcoming. The particles it hypothesized had to have zero mass—that is, they must be weightless. These hypothesized particles belong to the particle family called bosons, and the only zero-mass bosons are photons. Given the theory's limitations, it lay dormant for a decade, Marateck explains, until others found a way to give these bosons mass.

Three different research teams working independently in the 1960s updated Yang-Mills by devising a theory that not only imparted mass to bosons, but also hypothesized a new particle. This particle became known as the Higgs boson, named after Peter Higgs, one of these researchers. The addition by Higgs and others offered a way to explain why atoms have weight.

The apparent discovery of the Higgs boson should now provide fundamental insights into why particles have mass. It has been dubbed the "God particle" because it is associated with an energy field that gives other particles their mass, or resistance.

Provided by New York University