Measuring the mass of the W boson: a portrait of a complex measurement at the Large Hadron Collider

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The standard model of particle physics (SM) is an enormously successful theory that accurately describes phenomena from subatomic to cosmological scales. Despite its success, the SM is considered incomplete, as it does not explain certain experimentally observed phenomena, such as the existence of dark matter or the asymmetry of matter and antimatter in the universe. While the SM does not provide explanations for such phenomena, it makes precise predictions about how new particles would interact with known matter. If such particles exist, they would subtly modify experimental parameters, making precise measurements an indirect search for physics beyond the SM. The W and Z bosons, which mediate the weak nuclear force responsible for many radioactive decays, have an important role in the SM, as many hypothetical new particles would be expected to interact with the W and Z bosons. While the mass of the Z boson is known to the remarkable precision of nearly 20 parts per million, due to the difficulty of its measurement, the mass of W boson is known much less precisely. Furthermore, the most precise measurement of the W boson mass, performed at Fermilab Tevatron in 2022, is in significant tension with the standard model expectation. Recently, the CMS Collaboration at the Large Hadron Collider has performed its first measurement of the W boson mass. This new, precise W boson mass measurement is in agreement with the SM prediction and in tension with the measurement of the CDF Collaboration. I will discuss the measurement procedure and the experimental and theoretical advancements that enabled this striking result.