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EPS-HEP 2019: A PRIZE FOR THE DISCOVERY OF THE TOP QUARK AND FOR MEASURING ITS PROPERTIES

The European Physical Society (EPS) has awarded the High Energy and Particle Physics Prize 2019 to the CDF and D0 scientific collaborations at the Fermi National Accelerator Laboratory (Fermilab) for the discovery of the top quark and the detailed measurements of its properties. The prize was awarded during the EPS conference that was held in Ghent, Belgium, from 10 to 17 July. It is a recognition that is awarded every two years to one or more people, or to collaborations, that have distinguished themselves for having made an exceptional contribution to high energy and particle physics in the technological, theoretical, or experimental fields.

The discovery of the top quark was jointly announced by the CDF and D0 collaborations in 1995. The two scientific collaborations, in which hundreds of scientists from all over the world participated, managed to measure the mass of the top quark - the last of the six quarks described by particle theory to have escaped observation. They could do so with a high degree of precision thanks to data collected by Fermilab's Tevatron particle accelerator, and they subsequently studied the quark's properties in detail.

CDF is the acronym for the Collider Detector at Fermilab, the laboratory that, at the time, hosted the most powerful particle accelerator in the world, the Tevatron. The latter was a ring in which protons and antiprotons were accelerated up to speeds almost equal to the speed of light in order to make them frontally collide in the detectors.

The first stone of the CDF experiment was laid in April 1982, after having obtained the approval and support of the Department of Energy (DOE) and the National Science Foundation (NSF) in the United States, as well as of the Ministry of Culture and Sport in Japan and INFN in Italy. INFN initially participated alongside the Frascati National Laboratories (LNF) and the Pisa INFN division, later being joined by the Bologna and Padua divisions.

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The collaborations began to collect data in 1985, under competitive pressure from the UA1 and UA2 experiments at CERN, but the first truly interesting data didn't arrive until 1988-89. It was during these years that researchers began to do precision physics. The real shift occurred in the 1990s, when the silicon vertex detector (SVX) was introduced. This was created, in part, thanks to the effective cooperation of INFN and Lawrence Berkeley National Laboratory (LBL) expertise in, respectively, microstrip detectors and integrated electronics. Thanks to the new detector, it was, at that point, possible to measure with very high precision the trajectory of traces of charged particles.

At the same time as the creation of the CDF silicon vertex detector, the construction of a new experiment, D0, began at Tevatron.

Starting from 1992-1993 a period full of CDF measures began. The properties of particles containing bottom quarks and the mass of the W boson were measured with great precision. The W boson was discovered together with the Z boson by the UA1 and UA2 experiments at CERN, a discovery that led to Carlo Rubbia and Simon van Der Meer's winning the Nobel prize. Moreover, the first evidence of the existence of the top quark was obtained in these years, although it had a much higher mass than what was initially hypothesised on the base of indirect measures. The first evidence of the top quark was published by CDF in 1994, and its definitive discovery, with a mass of 175 GeV/c^2, was announced in the spring of 1995.

It took a long time to arrive at this observation because this quark is very heavy and, therefore, a very powerful accelerator was needed to produce it. This particle weighs more than 180 times the mass of the proton. The top quark decays fairly rapidly and, to observe it, you need to study the traces of particles that it leaves behind: these allow researchers to identify it; they are its signature. Furthermore, since the top quark appears just once out of every billion or so collisions, millions of billions of collisions were required to identify it definitively. Its mass, precisely measured, is linked to the mass of the Higgs boson and that of the W boson, and constitutes a milestone in the Standard Model of elementary particles.

As well as the discovery of the top quark, CDF also achieved many important results and recognitions. In 2006, there was another important discovery: the measurement of the oscillations of the strange B meson. In 2008, the prestigious Panofsky prize of the American Physical Society (APS) went to the Italians Aldo Menzione and Luciano Ristori, leaders of projects that were vital for the previous discoveries: the silicon vertex detector (SVX) and the SVT super-processor.

Finally, in 2012, evidence of the existence of the Higgs boson also appears in the data of CDF and D0, after those of ATLAS and CMS.

The data collected by the CDF still continue to be analysed, to take advantage of decades of constant and tenacious work by hundreds of scientists, students, engineers and technicians, who have produced over seven hundred articles and almost as many doctoral theses. ■