Scientists discover support for disputed universal truth of particle physics

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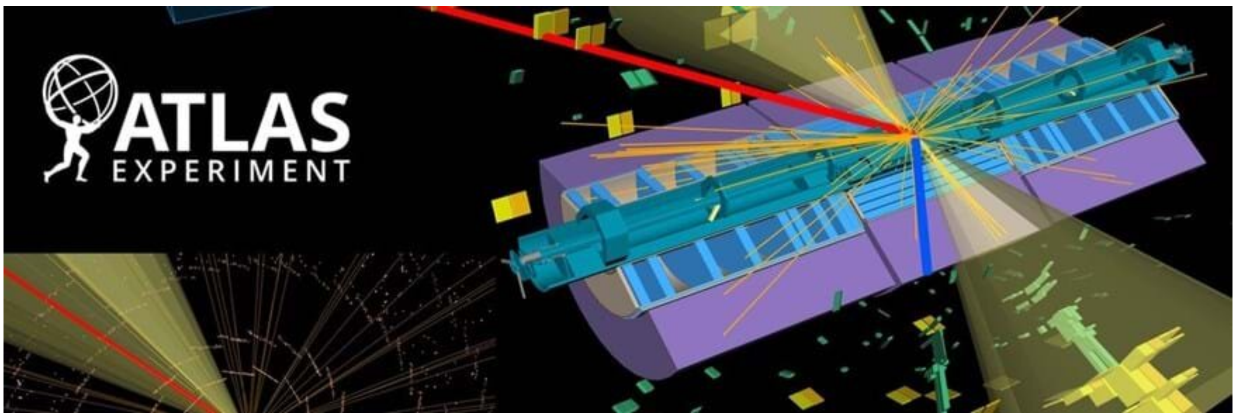

Credit: The Atlas Collaboration

A measurement of a fundamental principle of the standard model of particle physics—lepton flavour universality—captured by the ATLAS detector at the Large Hadron Collider, is reported in a paper published in *Nature Physics*.

The findings supersede the long-standing result from the Large Electron–Positron Collider.

Our understanding of elementary particles—the building blocks of the Universe—and the electromagnetic, weak and strong fundamental forces that act between them, is formulated in the standard model of particle physics. In the theory, electrons, muons and τ leptons represent three varieties (or flavours) of an electrically charged type of elementary particle known as leptons. The standard model assumes that the strength of the couplings between leptons and the particles that mediate the weak force—known as 'W' or 'Z' electroweak gauge bosons—is independent of the lepton flavour. This long-held principle, known as lepton flavour universality, has recently been challenged by experiments at B-factories and at the LHC.

The ATLAS Collaboration—involving a global team of scientists including experts from Lancaster –studied whether this 'universal truth' holds true for the muon and the τ lepton in around half a million proton–proton collisions recorded with the ATLAS detector at the Large Hadron Collider. By examining decays of W bosons into τ leptons and muons and measuring the ratio of their decay rates, the authors were able to conclude that the weak force interacts with both types of lepton in the same way.

This result from the ATLAS Collaboration is the most precise measurement to date, with almost twice the precision obtained from experiments at the Large Hadron Collider's predecessor at CERN—the Large Electron–Positron Collider (LEP).

Lancaster University Physics Professor Guennadi Borissov said: "The measurements at LEP indicated that there may be a difference between the decays to different sorts of leptons. This intriguing hint of deviation from the standard model has been unconfirmed for about 20 years. Although our latest measurements do not back up the result of the LEP, it has been exciting to find a new and remarkably precise way to test this using the power of the Large Hadron Collider, with Lancaster being at the heart of each step of the analysis."

Professor Roger Jones, head of the Lancaster ATLAS group, said: "Tests such as ours of fundamental theoretical assumptions are currently a hot area of research in particle physics. Recent results from the LHCb experiment, and very precise measurements of muons made by the g-2 collaboration (which also has Lancaster physicists in the team) have provided new hints that leptons may not all behave the same way as our theories predict.

"In contrast, new and very precise measurements show that in important ways the leptons really do behave the same way. It will be exciting to see if the hints from other experiments become clear evidence. If so, theories will have to account for our strong evidence for leptons behaving in the same way in the process we have studied and yet behaving differently in other processes."

More information: Test of the universality of τ and μ lepton couplings in W-boson decays with the ATLAS detector, *Nature Physics* (2021). DOI: 10.1038/s41567-021-01236-w

Provided by Lancaster University