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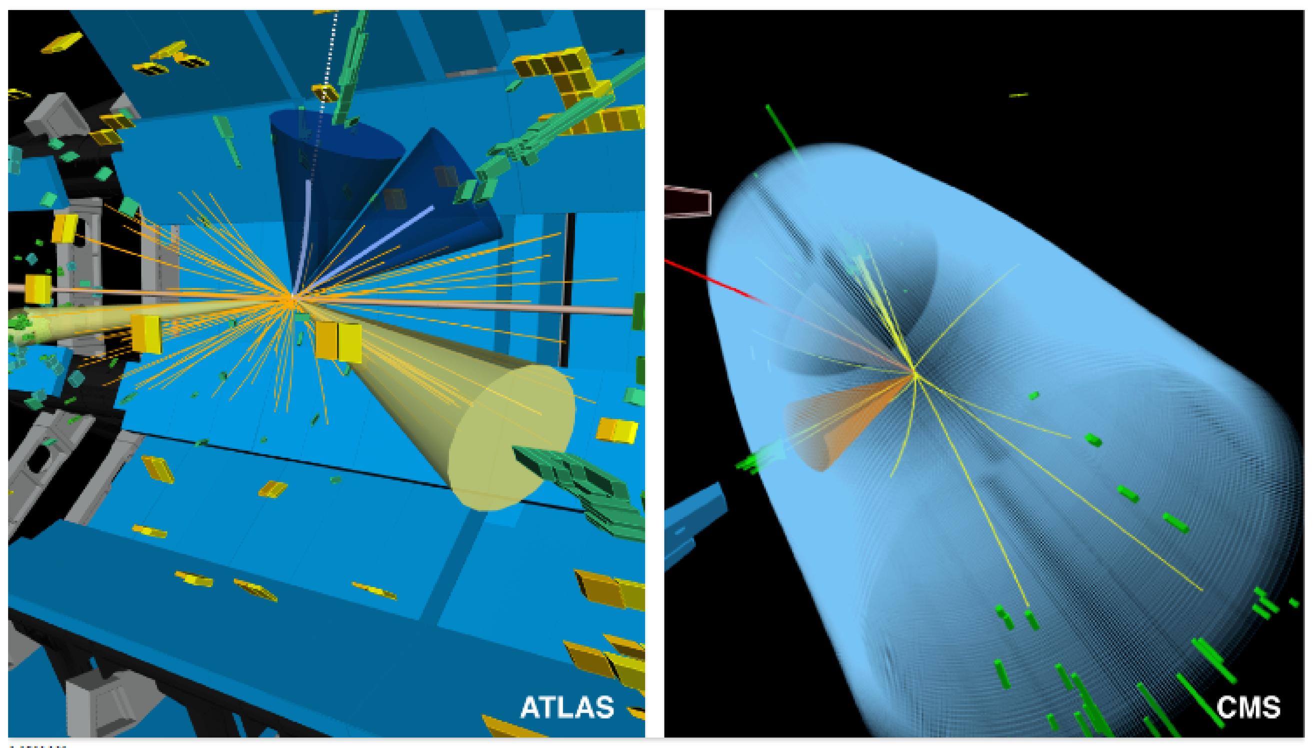
Searching for matter–antimatter asymmetry with the Higgs boson

The ATLAS and CMS collaborations have searched for matter–antimatter asymmetry in the interaction between the Higgs boson and the tau lepton

23 JUNE, 2022 | By Ana Lopes



The Standard Model of particle physics – the theory that best describes the building blocks of matter and their interactions – includes sources of CP asymmetry, and some of these sources have been confirmed in experiments. However, these Standard Model sources collectively generate an amount of CP asymmetry that is far too small to account for the matter–antimatter imbalance in the universe, prompting physicists to look for new sources of CP asymmetry.

In two recent independent investigations, the international ATLAS and CMS collaborations at the Large Hadron Collider (LHC) turned to the Higgs boson that they discovered ten years ago to see if this unique particle hides a new, unknown source of CP asymmetry.

The ATLAS and CMS teams had previously searched for – and found no signs of – CP asymmetry in the interactions of the Higgs boson with other bosons as well as with the heaviest known fundamental particle, the top quark. In their latest studies, ATLAS and CMS searched for this asymmetry in the interaction between the Higgs boson and the tau lepton, a heavier version of the electron.

To search for this asymmetry, ATLAS and CMS first looked for Higgs bosons transforming, or "decaying", into pairs of tau leptons in proton–proton collision data recorded by the experiments during the second run of the LHC (2015–2018). They then analysed this decay's motion, or "kinematics", which depends on an angle, called the mixing angle, that quantifies the amount of CP asymmetry in the interaction between the Higgs boson and the tau lepton.

In the Standard Model, the mixing angle is zero and thus the interaction is CP symmetric, meaning that it remains the same under a transformation that swaps a particle with the mirror image of its antiparticle. In theories that extend the Standard Model, however, the angle may deviate from zero and the interaction may be partially or fully CP asymmetric depending on the angle; an angle of -90 or +90 degrees corresponds to a fully CP-asymmetric interaction, whereas any angle in between, except 0 degrees, corresponds to a partially CP-asymmetric interaction.

After analysing their samples of Higgs boson decays into tau leptons, the ATLAS team obtained a mixing angle of 9 ± 16 degrees and the CMS team -1 ± 19 degrees, both of which exclude a fully CP-asymmetric Higgs boson–tau lepton interaction with a statistical significance of about three standard deviations.

The results are consistent with the Standard Model within the present measurement precision. More data will

ATLAS CMS CP violation Higgs boson

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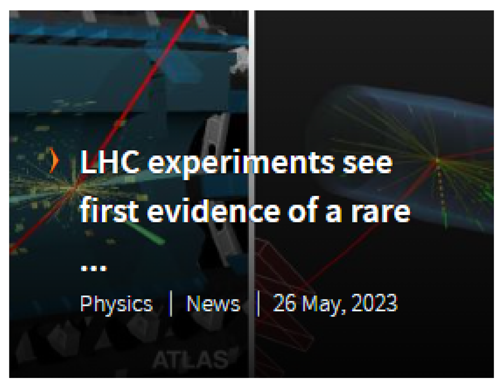

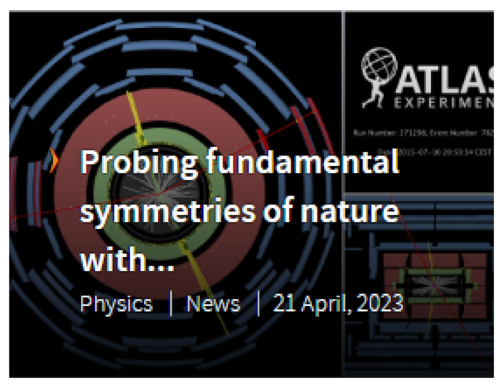

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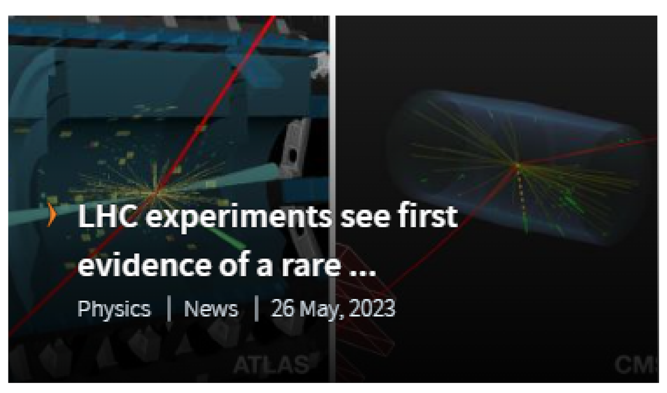

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