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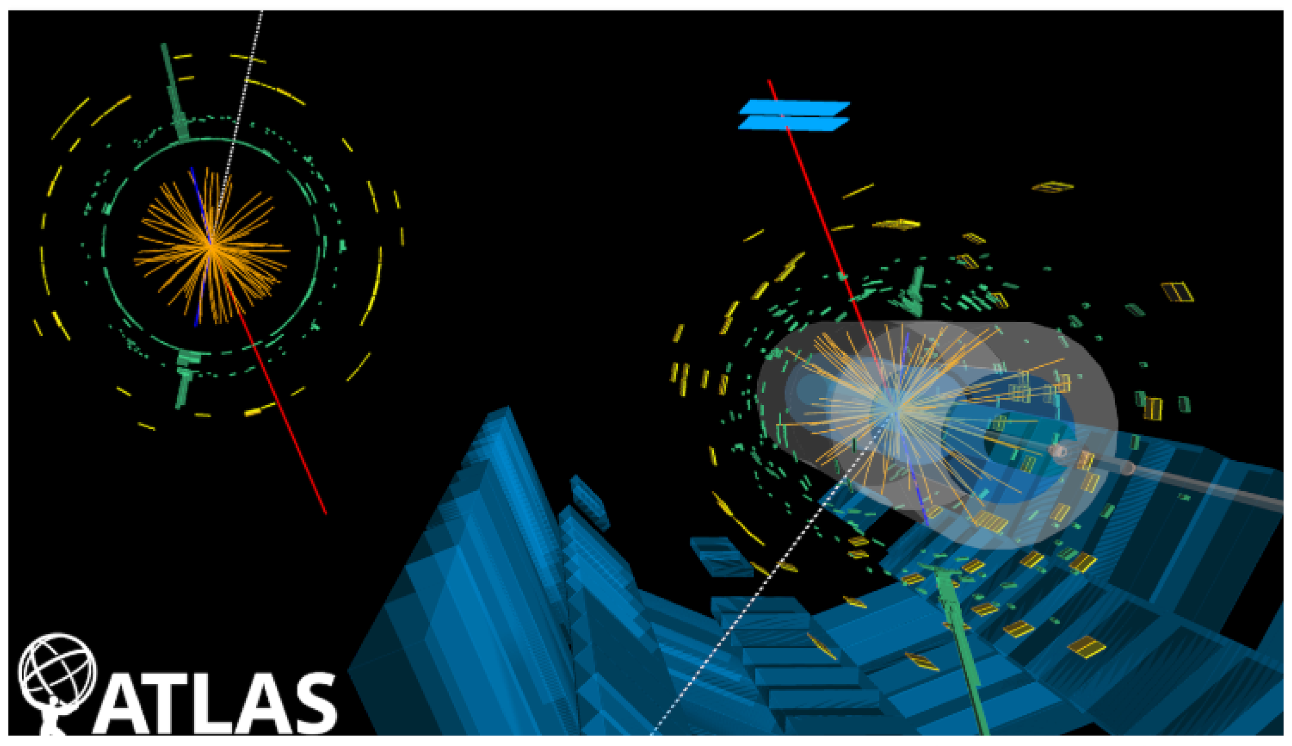
ATLAS reports first observation of WWW production

The ATLAS collaboration announces the first observation of WWW production: the simultaneous creation of three massive W bosons in high-energy LHC collisions

26 JULY, 2021



Today, at the EPS-HEP Conference 2021, the ATLAS collaboration announced the first observation of a rare process: the simultaneous production of three W bosons.

As a carrier of the electroweak force, the W boson plays a crucial role in testing the Standard Model of particle physics. Though discovered nearly four decades ago, the W boson continues to provide physicists with new avenues for exploration.

ATLAS researchers analysed the full LHC Run-2 dataset, recorded by the detector between 2015 and 2018, to observe the WWW process with a statistical significance of 8.2 standard deviations – well above the 5 standard-deviation threshold needed to declare observation. This result follows an earlier observation by the CMS collaboration of inclusive three weak boson production.

Achieving this level of precision was no mean feat. Physicists analysed around 20 billion collision events recorded and pre-filtered by the ATLAS experiment in their search for just a few hundred events expected from the WWW process.

As one of the heaviest known elementary particles, the W boson is able to decay in several different ways. The ATLAS physicists focused their search on the four WWW decay modes that have the best discovery potential due to their reduced number of background events. In three of these modes, two W bosons decay into charged leptons (electrons or muons), carrying the same positive or negative charge, and neutrinos, while the third W boson decays into a pair of light quarks. In the fourth decay mode, all three W bosons decay into a charged lepton and a neutrino.

To pick out the WWW signal from the large number of background events, researchers used a machine-learning technique called Boosted Decision Trees (BDTs). BDTs can be trained to identify specific signals in the ATLAS detector, spotting small – but key – differences between the predicted event properties. The improved separation between signal and background provided by the BDTs – along with the massive dataset provided by Run 2 of the LHC – enhanced the precision of the overall measurement and enabled the first observation of WWW production.

This exciting measurement also allows physicists to look for hints of new interactions that might exist beyond the current energy reach of the LHC. In particular, physicists can use the WWW production process to study the *quartic gauge boson coupling* – where two W bosons scatter off each other – a key property of the Standard Model. New particles could alter the quartic gauge boson coupling through quantum effects, modifying the

CONF-2021-039)

- EPS2021 presentation by Jessica Metcalfe: Measurements of multi-boson production at ATLAS
- CMS Collaboration: Observation of the production of three massive gauge bosons at 13 TeV (arXiv: 2006.11191)

ATLAS EPS-HEP W boson

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