UC Irvine scientists among winners of Breakthrough Prize in Fundamental Physics

$3 million award recognizes research achievements at CERN’s Large Hadron Collider.

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At CERN’s Large Hadron Collider, technicians install the New Small Wheels upgrade at the ATLAS experiment; it’s designed to help trigger and track elementary particles known as muons. UC Irvine researchers led the commissioning of NSW and were among a large group of scientists to win this year’s Breakthrough Prize in Fundamental Physics.

Picture Credit:
Julien Marius Ordan / CERN

Irvine, Calif., April 25, 2025 — Researchers in the University of California, Irvine's Department of Physics & Astronomy were among thousands of scientists from 70 countries to share in the Breakthrough Prize in Fundamental Physics that was announced by the Breakthrough Prize Foundation in early April. The $3 million award honors experimental contributions at CERN's Large Hadron Collider near Geneva, Switzerland, that enabled the study of Higgs boson properties and other key findings in particle physics between 2015 and 2024.

Positioned along the 16.8-mile LHC loop at CERN are numerous instruments designed to detect and analyze particle interactions resulting from the collision of protons that are accelerated through the system. Experiments at CERN have helped scientists gain fundamental knowledge about elementary particles and the nature of matter in the first moments after the Big Bang as well as search for physics beyond the standard model, including dark matter, supersymmetry and hidden dimensions.

Specific projects mentioned in the Breakthrough Prize citation include ATLAS, CMS, ALICE and LHCb. UC Irvine researchers have collaborated with scientists from around the world on ATLAS throughout its design, construction and operation during the LHC's first run, when the Higgs boson was discovered; its second run, the period for which the Breakthrough Prize was awarded; and now during its third run. Involving 6,000 scientists, engineers and students from 250 institutes in 40 nations, ATLAS is an enormous, high-tech, multifaceted particle detector that is 150 feet long, is 80 feet in diameter and weighs 7,700 tons.

"UC Irvine physics and astronomy researchers can be proud of their contributions to the Breakthrough Prize-winning research at CERN's Large Hadron Collider," said Daniel Whiteson, UC Irvine professor of physics and astronomy and chair of the department's communications committee. "Our work has led directly to the important discoveries at the LHC, and it has laid the groundwork for new and more effective research methods in all parts of physics research."

Andrew Lankford, UC Irvine Distinguished Professor of physics and astronomy, became a member of the ATLAS collaboration in 1994. He was joined in 2007 by Professor Anyes Taffard and Whiteson, in 2014 by Associate Professor David Casper, and in 2024 by Assistant Professor Andre Frankenthal. Lankford was the founding

project leader of one of the six detector subprojects of ATLAS during its design, and he served as deputy director of ATLAS from 2009 to 2013, the period during which ATLAS began operation, discovered the Higgs boson (2012) and prepared for Run 2 of the LHC, the period considered by the Breakthrough Prize judges. This is Casper's second Breakthrough Prize in Fundamental Physics; the first was awarded in 2016 to members of the Super-Kamiokande team and other neutrino research groups.

UC Irvine researchers assisted in the design, commissioning and operations of ATLAS Run 2, including leadership roles in key detector components, such as the muon spectrometer and data acquisition and readout systems, which benefit the broad physics program of the experiment. Their work enabled activities ranging from precision measurements in Higgs physics to searches for exotic particles. UC Irvine scientists also contributed to the software and computing infrastructure required to conduct an experiment of such a scale.

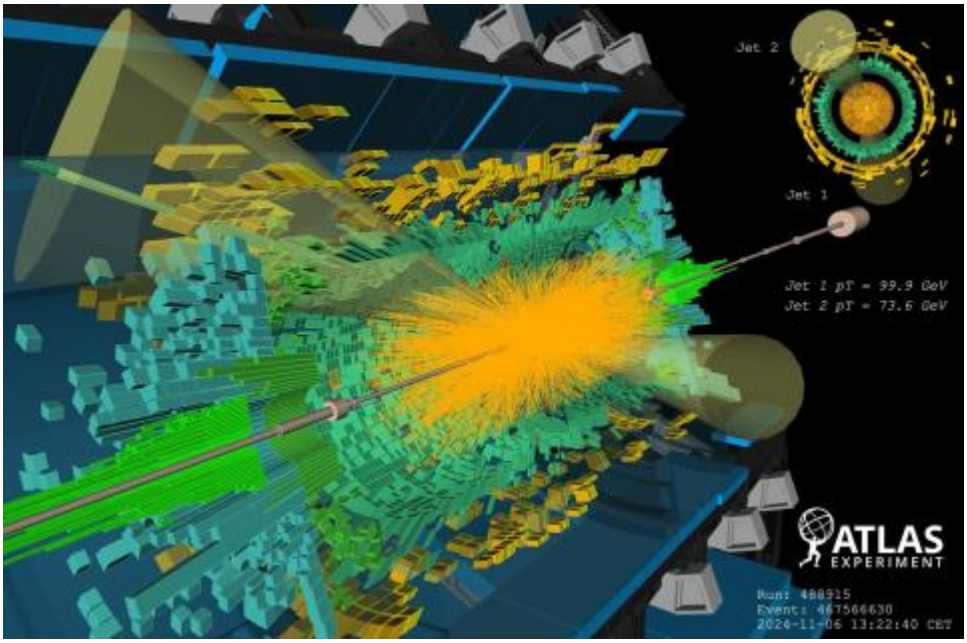
They were among the first to identify the potential for the application of artificial intelligence in LHC experiments, and their influence has resulted in substantial growth in the use of AI in physics simulation and data analysis problems in recent years.

Whiteson and Aishik Ghosh, a UC Irvine postdoctoral scholar in physics and astronomy – in conjunction with researchers from France's Irene Joliot-Curie Laboratory, the University of Massachusetts and Belgium's University of Liege – introduced an AI technique for high-dimensional statistical inference in ATLAS that vastly enhanced scientists' ability to measure the Higgs boson's width, one of the most elusive Higgs properties.

"Higgs width and Higgs self-coupling are considered two of the most important measurements in collider physics because they provide general-purpose information about possible new physics," Ghosh said. "This AI statistical technique we developed, called neural simulation-based inference, is causing a paradigm shift in research done with ATLAS and is being adopted by several other measurement efforts in the experiment."

Taffard, who led the measurement of Higgs self-coupling, said, "By using AI methods, we are able to explore a wider range of event categories and improve the precision of our measurements."

Image



CERN

UC Irvine researchers also contributed to the proposal for dark matter theories and searches with ATLAS. Taffard and Whiteson partnered to devise a method of searching for supersymmetric particles. Taffard and Lankford investigated other unexpected particles in the data that could lead to the discovery of new kinds of physical phenomena.

In addition, Taffard served as data quality co-convener at the start of LHC Run 2, leading a team of physicists to ensure that data was efficiently collected and that all recorded data met the standards required for scientific analysis. She also oversaw enhancements to data acquisition hardware in the ATLAS experiment and has led groups involved in a range of physics studies, including events with two leptons, with two Higgs bosons and with signatures of supersymmetry. Taffard and Lankford led a team on the commissioning of ATLAS New Small Wheels, an upgrade designed for precision triggering and tracking of elementary particles called muons that is now operating during LHC Run 3.

On ATLAS, Casper worked on the search for long-lived exotic particles and the improvement of software to aid in reconstructing such particles from raw detector measurements. He left ATLAS in late 2018 to assume a major role in the development of FASER, a smaller experiment to detect neutrinos produced by particle collisions at the LHC. Casper and Professor Jonathan Feng are currently co-leaders of the FASER collaboration.

Before coming to UC Irvine, Frankenthal was a member of the Compact Muon Solenoid collaboration, also honored by this year's Breakthrough Prize, in which he helped increase the precision and capabilities of a detector that records the paths taken by charged particles involved in collisions by tracking them at different points. He also participated in studies of dark matter and particles that are not predicted by the standard model of particle physics, and he worked on searches for very rare processes that are challenging for other experiments to conduct.

Looking to the future while collecting and analyzing the data of Run 3, UC Irvine researchers are now engaged in major upgrades to the instrumental capabilities of ATLAS for the subsequent data-taking phase, which will commence in 2030 and during which the LHC will record 85 percent of its total dataset. For instance, Taffard is currently contributing to two important data acquisition projects that aim to improve ATLAS's selection of which beam-collision events to study – critical to maximizing the physics reach of ATLAS.

In consultation with the leaders of the experiments, the Breakthrough Prize Foundation will donate 100 percent of the prize funds to the CERN & Society Foundation. The money will be used by the collaborations to offer grants for doctoral students from member institutes to spend research time at CERN, giving them experience working at the forefront of science and new expertise to bring back to their home countries and regions.

About UC Irvine's Brilliant Future campaign: Publicly launched on Oct. 4, 2019, the Brilliant Future campaign aims to raise awareness and support for UC Irvine. By engaging 75,000 alumni and garnering $2 billion in philanthropic investment, UC Irvine seeks to reach new heights of excellence in student success, health and wellness, research and more. The School of Physical Sciences plays a vital role in the success of the campaign. Learn more by visiting https://brilliantfuture.uci.edu/uci-school-of-physical-sciences.

About the University of California, Irvine: Founded in 1965, UC Irvine is a member of the prestigious Association of American Universities and is ranked among the nation's top 10 public universities by *U.S. News & World Report*. The campus has produced five Nobel laureates and is known for its academic achievement, premier research, innovation and anteater mascot. Led by Chancellor Howard Gillman, UC Irvine has more than 36,000 students and offers 224 degree programs. It's located in one of the world's safest and most economically vibrant communities and is

Orange County’s second-largest employer, contributing $7 billion annually to the local economy and $8 billion statewide. For more on UC Irvine, visit www.uci.edu.

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