Cosmic Ray Mysteries and Collider Neutrinos

Camila Machado · Follow

3 min read · Sep 21

The FASER experiment, installed in an abandoned tunnel at the LHC, detected collider neutrinos for the first time. Last month, at the International Cosmic Ray Conference in Japan, researchers discussed how this will help to uncover cosmic ray puzzles.

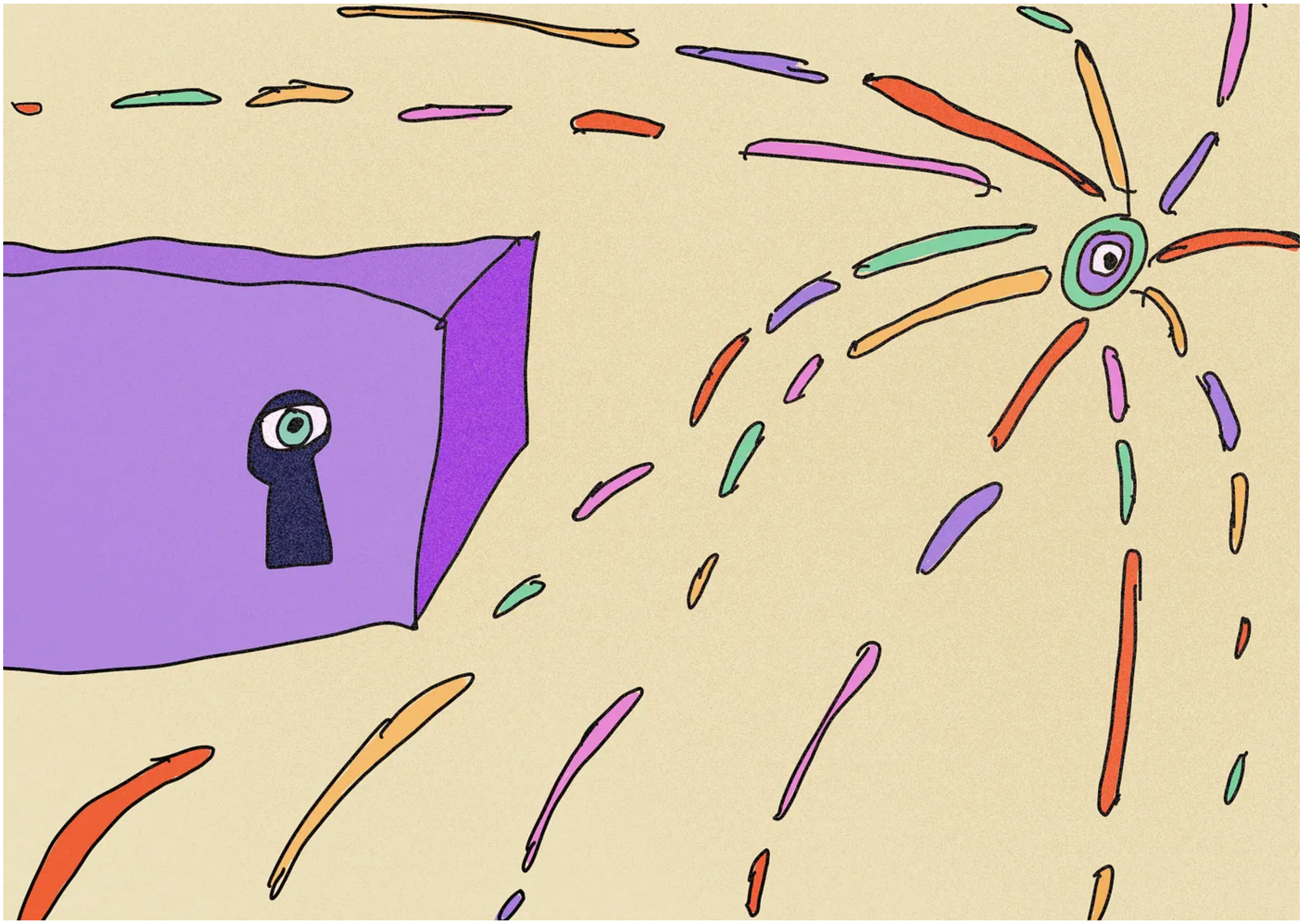

Illustration: Camila Machado

A forgotten little room, 300 ft underground. Nobody was there for more than a decade. No human life around. Nearby, there is just a tunnel where particles are accelerated close to the speed of light. It sounds like a sci-fi-horror movie, but this story has no blood. It just describes the perfect location to place the ForwArd Search ExpeRiment (FASER). “We came and took this forgotten place that was never meant to host an experiment,” said Felix Kling, one of FASER’s co-founders. In this lost room, FASER could do what other detectors in particle colliders couldn’t: for the first time, detect neutrinos directly.

The FASER’s central idea was to help with a ‘weakness’ of the Large Hadron

Collider (LHC) experiments. Neutral particles like neutrinos don't carry an electric charge and usually escape the main LHC detectors. Instead of moving in a circular direction, they go off a tangent, moving in what is called the forward region. The researchers noticed the potential to place a detector there. They were lucky to find in this precise spot an abandoned room used decades ago in a predecessor collider to the LHC, the Large-Electron-Positron (LEP) collider.

Neutrinos also pose an extra challenge: they rarely interact with matter, typically requiring detectors covering an extensive area. But, FASER's size is very modest compared to other LHC detectors. "It is like a suitcase filled with the heaviest metal we know, tungsten," said Kling. But don't get befouled by the size. Considering the entire time LHC will operate (at least a decade), it could only observe around a hundred neutrinos. In a Physics Review Letters publication, FASER's collaboration announced that they measured more than that in just a few months.

These are the first neutrinos ever detected in a particle collider. "It's pretty exciting to get this first look, but it's the first step." said Professor Mary Hall Reno, neutrino specialist from the Department of Physics and Astronomy of the University of Iowa, "These next couple of years, they're going to be analyzing data to get real cross-sections and measurements of the [neutrino] flux. By understanding what that flux is, we're going to understand better some features of the proton structure".

A better understanding of neutrino production can also have implications for astroparticle physics. A long outstanding problem is the so-called muon puzzle. Cosmic rays are highly energetic particles coming from outside our

Solar system and reaching the Earth’s surface. The muon puzzle concerns the discrepancy between the theory prediction and the observation of how many muons (a particle similar to the electron but more massive) hit the ground.

The muon production relates to the neutrino flux and involves calculating things in a regime where the theory breaks. In this case, having more data will help to build a better theoretical model to understand the observations. Another challenge is to figure out the source of cosmic rays. FASER’s neutrino flux measurements will also help trace back the particle shower observed on Earth and identify if the source is supernovas, black holes, or another extragalactic energy burst.

This year, Japan's International Cosmic Ray Conference reunited researchers from the Collider and Astrophysics communities, including Kling and Reno. “People understand that nobody has the perfect model, so it’s interesting the extent to which we can get more information from the collider experiment.”, added Professor Reno. “These high-energy neutrinos are totally pushing the limit on where we’ve searched for physics before.”

Particle Physics Lhc