LHCf gears up to probe birth of cosmic-ray showers

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One of the LHCf experiment's two detectors, LHCf Arm2, seen here during installation into a particle absorber that surrounds the LHC's beam pipe. Credit: Lorenzo Bonechi

Cosmic rays are particles from outer space, typically protons, travelling at almost the speed of light. When the most energetic of these particles strike the atmosphere of our planet, they interact with atomic nuclei in the atmosphere and produce cascades of secondary particles that shower down to the Earth's surface. These extensive air showers, as they are known, are similar to the cascades of particles that are created in collisions inside particle colliders such as CERN's Large Hadron Collider (LHC). In the next LHC, run starting in 2021, the smallest of the LHC experiments—the LHCf experiment—is set to probe the first interaction that triggers these cosmic showers.

Observations of extensive air showers are generally interpreted using computer simulations that involve a model of how cosmic rays interact with atomic nuclei in the atmosphere. But different models exist and it's unclear which one is the most appropriate. The LHCf experiment is in an ideal position to test these models and help shed light on cosmic-ray interactions.

In contrast to the main LHC experiments, which measure particles emitted at large angles from the collision line, the LHCf experiment measures particles that fly out in the "forward" direction, that is, at small angles from the collision line. These particles, which carry a large portion of the collision energy, can be used to probe the small angles and high energies at which the predictions from the different models don't match.

Using data from proton–proton LHC collisions at an energy of 13 TeV, LHCf has recently measured how the number of forward photons and neutrons varies with particle energy at previously unexplored high energies. These measurements agree better with some models than others, and they are being factored in by modellers of extensive air showers.

In the next LHC run, LHCf should extend the range of particle energies probed, due to the planned higher collision energy. In addition, and thanks to ongoing upgrade work, the experiment should also increase the number and type of particles that are detected and studied.

What's more, the experiment plans to measure forward particles emitted from collisions of protons with light ions, most likely oxygen ions. The first interactions that trigger extensive air showers in the atmosphere involve mainly light atomic nuclei such as oxygen and nitrogen. LHCf could therefore probe such an interaction in the next run, casting new light on cosmic-ray interaction models at high energies.

Provided by CERN