First-ever collisions of oxygen at the Large Hadron Collider

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In the LHC tunnel. Credit: CERN

The Large Hadron Collider (LHC) gets a breath of fresh air as it collides beams of protons and oxygen ions for the very first time. Oxygen–oxygen and neon–neon collisions are also on the menu of the next few days.

From 29 June to 9 July, the LHC will switch to special operations: two days of proton–oxygen ion collisions, followed by—additional firsts—two days of oxygen–oxygen collisions and one day of neon–neon collisions, with several days of machine set-up and commissioning in between.

This campaign will cover a wide range of research, from the study of cosmic rays to the strong force and quark–gluon plasma, and the LHC experiments are already looking forward to a great harvest of new data.

It is not only the start of a vibrant campaign, but also the end of a long and meticulous process that began in the accelerator complex in mid-April (and as early as 2019 in the case of the initial feasibility studies). Each machine had to be specially configured for operation with oxygen and neon ions, which are produced in Linac3 before being injected into the Low-Energy Ion Ring (LEIR), the Proton Synchrotron (PS), the Super Proton Synchrotron (SPS) (which will also send oxygen beams to the fixed-target experiments in the North Area) and finally the LHC.

"The current operating mode, in which a beam of protons collides with a beam of oxygen ions, is the most challenging," points out Roderik Bruce, an LHC ion specialist. "This is because the electromagnetic field inside the accelerator affects protons and oxygen ions differently, due to their different charge-to-mass ratios. In other words, without corrections the two beams would collide in different places at each turn."

To overcome this problem, the engineers are carefully adjusting the frequency of revolution and the momentum of each beam, so that the collisions take place right at the heart of the LHC's four main experiments: ALICE, ATLAS, CMS and LHCb.

But these four experiments are not the only ones to be involved in this special campaign. Last week, the LHCf experiment, which studies cosmic rays using the small-angle particles created during collisions, installed a detector along the LHC beamline, 140 meters from the ATLAS experiment's collision point, which it will use for proton–oxygen run. This detector will later be removed and replaced by a calorimeter, which will provide additional data during the oxygen–oxygen and neon–neon collisions.

This campaign is also an opportunity to continue to test crystal collimation. This is a crucial upgrade of the LHC collimation system to mitigate the problem of ion beam halos (halos of particles that stray from the beams' orbit). The conventional collimation system at the LHC is less efficient with ion beams, so some crystal collimators will be inserted for testing right before the oxygen–oxygen and neon–neon runs begin.

After several hours in the accelerator, the oxygen beams might have to be ejected because of "beam pollution." "This is a problem that we don't face with proton beams, but with oxygen we experience what's called the transmutation effect," explains Roderik Bruce.

"Each collision creates secondary particles of the same charge-to-mass ratio as oxygen ions, polluting the beam and potentially making it complicated to analyze collisions. So, at some point, we might need to eject the beam and inject a new beam of pure oxygen, but the degree of transmutation is not yet known. The data analysis will tell us."

Provided by CERN