Preliminary results of antiproton experiment may provide clues in search for dark matter

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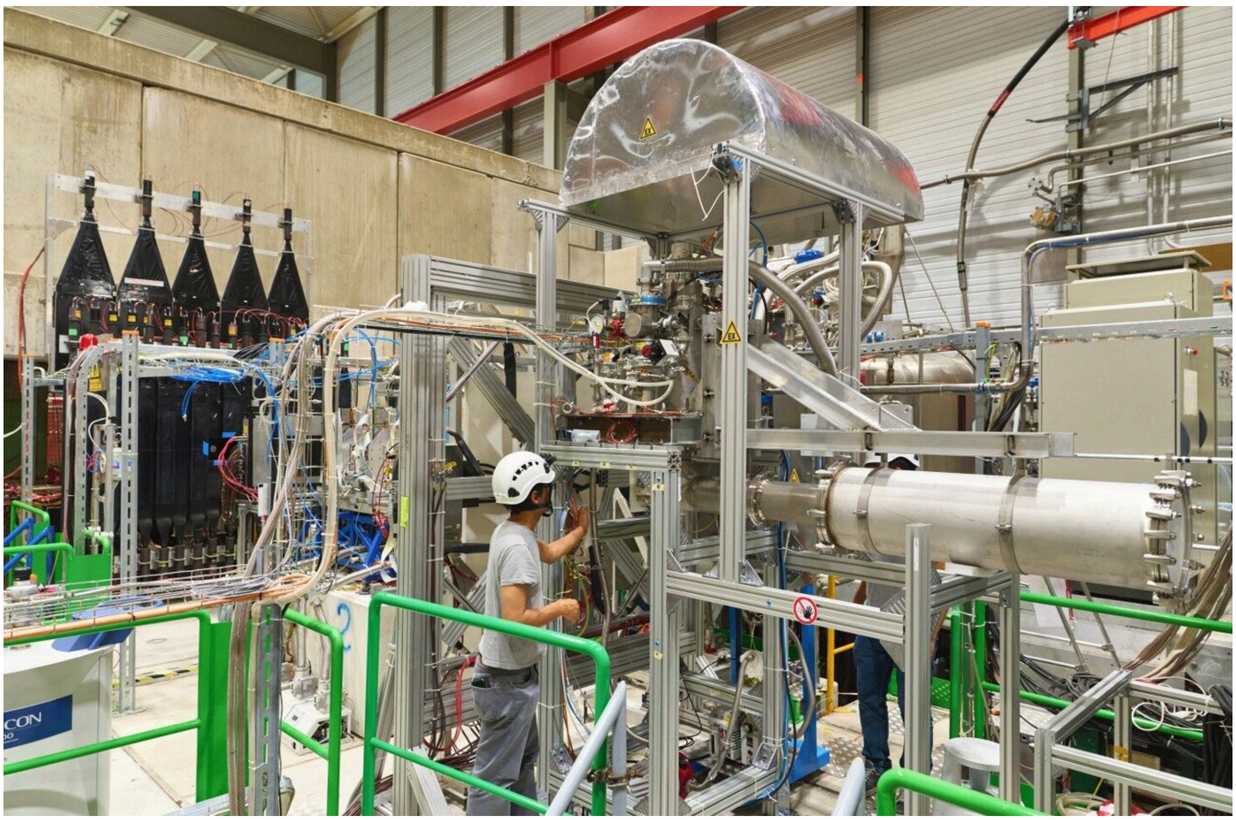

The AMBER experiment in CERN's North Area. Credit: CERN

Last week, at the biennial ICHEP conference, the AMBER experiment presented results from its first data-taking period. Taken in 2023, these results show preliminary plots of the antiproton's production cross section—the probability that antiprotons are produced when a beam of protons interacts with a helium target. Knowing more about how antiprotons are produced will help improve the sensitivity of searches for dark matter.

While physicists can observe the effect of dark matter on the universe, they still cannot "see" it directly, as it does not react with the electromagnetic force. This means they still do not know what it is, despite the fact that it accounts for about a quarter of the universe's mass. Space-based experiments like AMS look for clues about dark matter by collecting data on cosmic rays—high-energy particles from outer space that hit the Earth's atmosphere.

Among the cosmic rays that AMS studies are antiprotons, which do not originate from primary cosmic rays (caused by stars or other astrophysical phenomena) but are produced when primary cosmic rays interact with the interstellar medium.

Recently, AMS found that some of the numbers that they have observed of antiproton cosmic rays are in excess of the prediction. This excess may be due to statistical uncertainty or it could be from an unknown source, such as dark matter. This has led physicists to believe that some antiprotons may be produced by dark matter.

This is where AMBER comes in. "If you have a standard way of producing an antiproton and you want to disentangle this standard way from an exotic way, you need to know its standard production very well," says Davide Giordano, a researcher with the AMBER experiment. "By studying its production, we are reducing the uncertainty about the expected background of antiprotons in space. If there is any exotic signal, we will be more sensitive to it."

Located where the former COMPASS experiment used to be, AMBER is a new facility that uses a secondary beam from the SPS and fires it at an interchangeable fixed target in CERN's North Area. The first phase of its physics program consists of three experiments: the study of the antimatter production cross section, the measurement of the proton radius and the use of particular physics processes to study how hadrons get their mass.

For last year's data taking, the target was liquid helium, and the resulting particle tracks were recorded by its spectrometer. "One of the most common reactions that produce antiprotons in space is the reaction between protons and helium," states Giordano. "Before AMBER, there was no experimental data on this reaction in the energy range relevant to AMS."

Although preliminary, the results presented at ICHEP showed that AMBER is in good shape, with very low statistical uncertainties. "We've already taken data in 2024 using hydrogen and deuterium as our targets," said Giordano.

AMBER hopes to use the hydrogen data to study proton—proton collisions, the most common reaction behind the production of antiprotons in space. The deuterium data will allow physicists to compare the rate of antiproton production in proton—proton collisions with that of proton—neutron collisions, and thus to investigate the poorly known production asymmetry.

AMBER joins a number of experiments that are helping AMS in its cosmic-ray data collection.

Provided by CERN

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