Non-invasive intensity measurements of low energy beams demonstrated for the first time

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A precise measurement of absolute beam intensity is a key parameter to monitor any losses in a beam and to calibrate the absolute number of particles delivered to the experiments.

However, this type of measurement is very challenging with traditional beam current diagnostics when it comes to low-energy, low-intensity beams due to the very low signal levels. Particle accelerator experts from the University of Liverpool have now experimentally demonstrated a new type of monitor in a collaboration with CERN, the GSI Helmholtz Centre for Heavy Ion Research and Friedrich Schiller University and Helmholtz Institute Jena.

A paper just published in *Superconducting Science and Technology* documents the challenges of implementation and first beam measurements. These are the first-ever measurements of this type performed in a synchrotron using both coasting and short-bunched beams.

The Antiproton Decelerator (AD) is a synchrotron that provides low-energy antiprotons for studies of antimatter. These studies rely on creating antimatter atoms (such as anti-hydrogen) and using them as probes for the most fundamental symmetries in nature such as the invariance of CPT, or of the gravitational acceleration on matter and antimatter.

A precise measurement of the beam intensity in the AD is essential to

monitor any losses during the deceleration and cooling phases of the AD cycle, and to calibrate the absolute number of particles delivered to the experiments. However, this is very challenging with traditional beam current diagnostics due to the low intensity of the antiproton beam, which is of the order of only 10 million particles, corresponding to beam currents as low as a few hundred nano-amperes. To cope with this, a Cryogenic Current Comparator (CCC) based on a superconducting quantum interference device (SQUID) was developed and installed in the AD, in a collaboration between accelerator experts from the University of Liverpool and CERN, the GSI Helmholtz Centre for Heavy Ion Research, Friedrich Schiller University and the Helmholtz Institute Jena.

Previous incarnations of CCCs for accelerators suffered from issues concerning sensitivity to mechanical vibrations and electromagnetic perturbations. Furthermore, these setups were used for measuring slow beams, usually from transfer lines of accelerators, and were unable to measure short bunched beams presenting fast current variations. In order to measure the beam current and intensity throughout the cycle of a synchrotron machine such as the AD, the CCC needed to be adapted to cope with the fast signals of bunched beams.

In an open access paper just published in the IOP *Superconducting Science and Technology* journal, Miguel Fernandes and co-authors describe the challenges of implementation and first beam measurements. These are the first-ever CCC beam current measurements performed in a synchrotron using both coasting and short bunched beams. The paper demonstrates the exciting prospects of this new type of beam diagnostics device.

More information: M Fernandes et al. Non-perturbative measurement of low-intensity charged particle beams, *Superconductor Science and Technology* (2017). DOI: 10.1088/0953-2048/30/1/015001