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Cryogenic Current Comparators: Status and Challenges

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DC operation, non-destructive measurement, high sensitivity and direct traceability to the unit ampere are the advantages of CCCs. SQUIDs, superconducting shielding currents and low-temperature flux concentrators made of soft magnetic nanocrystalline alloys allow single cur-rent pulses resolution below 1 nApp and frequency bandwidth from DC of up to 2 MHz De-pending on the application, the DC value can be defined by a time constant (ranging from days to minutes) through analog filters in front of the SQUIDs. Similarly, the upper cutoff fre-quency (commonly between 1 to 100 kHz) can be limited, which supports system stability. A breakthrough in magnetic shielding was achieved through the transition from massive Nb to thin Pb foils. The use of two pickup coils and up to 3 SQUIDs per CCC sensor further im-proved the interference resistance and dynamic range. The revision of the FAIR cryostat now allows more than six months service life of the CCC system. Based on comparative meas-urements in the beam, the Pb-DualcoreCCC-xD was qualified as the standard for the FAIR installations. Currently, the beam pipe of the first FAIR prototype cryostat is being upgraded from 125 mm to 150 mm for permanent installation in the HEBT tunnel. The manufacturing of a second FAIR cryostat has started. In parallel, the manufacturing of a second Pb-DCCC-xD is taking place in Jena. For special experiments at a beamline diameter of 40 mm, a complete DCCC system without a re-liquefier is now also available in Jena, with a service life time of up to 10 days.
As part of a BMFTR project started in 2024, dedicated to digital signal processing, the three data channels generated at the DCCC are optimized and filtered for application of the device in a spill optimization feedback system. Particularly challenging is the development of a very short CCC system specifically for the CRYRING@ESR as part of another BMFTR project that started this year. The second CCC installation planned at CERN, now in the North Area at TT20 from the Super Proton Synchrotron, will also explore new approaches regarding cryogenics.

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