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C3Po1B-03: How digital twins can help with operator training, an example with ATLAS and CMS detector's cryogenics at CERN

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This paper presents the implementation of a cryogenic process simulator applied to A Toroidal LHC Apparatus (ATLAS) and the Compact Muon Solenoid (CMS) experiments at CERN (European Organisation for Nuclear Research). Building upon the development of a digital twin of the complex LHC accelerator cryogenic system, this work extends its application to the specific needs of the ATLAS and CMS experiments and their dedicated cryogenic systems. These particle large detectors rely on superconducting magnets, each weighting hundreds of tons, which must be maintained at 4.5 K. The cryogenic simulator replicates the helium refrigerators and the proximity system connected to the detectors reproducing real operational case scenarios, enabling cryogenic operator training for both routine and special operations. This digital twin is using identical features as the real infrastructure, integrating multiple layers forming the process control system: the simulation model, Programmable Logic Controllers (PLC), and Supervision Control And Data Acquisition (SCADA) system, that shares data in real time between them. The objectives of this digital twin are threefold: first, to provide a comprehensive off-line training tool for the operators, second to improve the knowledge on the installations and third, to simulate and evaluate the reactions of the cryogenic plants in new scenarios or configuration changes before implementation.

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