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Preliminary Findings on the Application of Reinforcement Learning for Real-Time Optimization of Crystal Channelling in the LHC

The Large Hadron Collider (LHC) operates with high intensity proton and heavy ion beams that necessitate a robust collimation system to prevent damage to sensitive equipment along the ring. However, the efficiency of cleaning ion beams is approximately 100 times less efficient than with protons. To address this, bent silicon crystals were implemented to enhance collimation efficiency. The first operational use of crystal-assisted collimation took place during the 2023 lead ion run, achieving the required performance improvements to safely manage high-intensity beams. Despite this success, unwanted crystal rotations were observed, leading to sub-optimal performance. Current understanding attributes these rotations to mechanical deformations caused by energy deposited due to impedance effects, a problem that cannot be addressed until the next long shut-down. In response, a conventional numerical optimiser was employed to monitor and counteract mechanical deformations using data from a series of beam-loss monitors. This challenge lends itself to the application of reinforcement learning (RL) techniques, which can maintain continuous optimal channelling, reduce convergence time, and eventually support the optimisation of crystals across multiple planes simultaneously.

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