

## A detailed ML example: SPS spill quality control

The CERN Super Proton Synchrotron offers slow-extracted, high-intensity proton beams at 400 GeV/c for 3 fixed targets in the CERN North Area hall with a spill length of about 5 s. Various effects are detrimental to the spill quality due to the nature of slow extraction. Some of these spill deterioration sources have been successfully tackled in recent years and for others, projects are ongoing to find solutions (i.e. hysteresis compensation). Continuous compensation of intensity fluctuations at  $n \times 50$  Hz from power converter ripples has however been particularly difficult. During the 2023 SPS proton run, the deployment of two techniques - "Empty-Bucket Channelling" and active control with Adaptive Bayesian Optimisation - finally sufficiently suppressed intensity modulations at these frequencies. This paper will focus on Adaptive Bayesian Optimisation for  $n \times 50$  Hz control. The chosen algorithm will be discussed and implementation details in the CERN control system will be given. Finally the 2023 results will be presented and next steps summarised.

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