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Anomaly Detection for fault analysis in the Proton Synchrotron using Machine Learning

The CERN Proton Synchrotron (PS) is equipped with several RF systems covering a wide range of revolution harmonics (7 to 21, 42, 84) with heterogeneous hardware of different age. Despite a good track record of high availability (over 99%), a degradation observed from 2021 to 2023 highlighted a need for enhanced fault diagnosis of these RF systems. Accurate identification of failure sources is crucial to maintaining optimal performance and high availability, particularly under more demanding beam conditions such as increased intensities. While some faults are easily detected and understood through self-reporting devices, others may cause subtle deterioration that goes unnoticed. To enable more accurate root-cause analysis of faults, we propose machine learning-based anomaly detection models trained on data from both beam and hardware signals. These models could be deployed online to provide early alerts for changing machine states, or they could facilitate post-mortem analyses by identifying the last known normal state prior to a fault.

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