Contribution ID: **81** Type: **Invited talks**

Enhancing Quench Detection in SRF Cavities at the European XFEL: Machine Learning Approaches and Practical Challenges- 15'+5'

Thursday 10 April 2025 09:50 (20 minutes)

At the European XFEL, detecting anomalies in superconducting cavities is essential for reliable accelerator performance. We began with a model-based fault detection approach focused on residual analysis to identify anomalies. To improve fault discrimination, particularly for quench events, we augmented this system with machine learning (ML) models. Key challenges included the scarcity of labeled data, which we addressed by integrating expert feedback through an optimized labeling process, and the transition to real-time operation, requiring computational and integration adjustments. For the online application, we deployed two servers in the tunnel at one of the 25 stations to detect failures in real-time with a software-based solution. In parallel we pushed the development of an FPGA-based solution, that will allow to counteract on real-time in the future. The resulting detection system delivers reports across various timescales, supporting both immediate responses and long-term maintenance. It will provide new insights to the online data, which was never explored in the past.

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Session Classification: Anomaly Detection and Diagnostics

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