Prediction of Superconducting Magnet Quenches with Machine Learning

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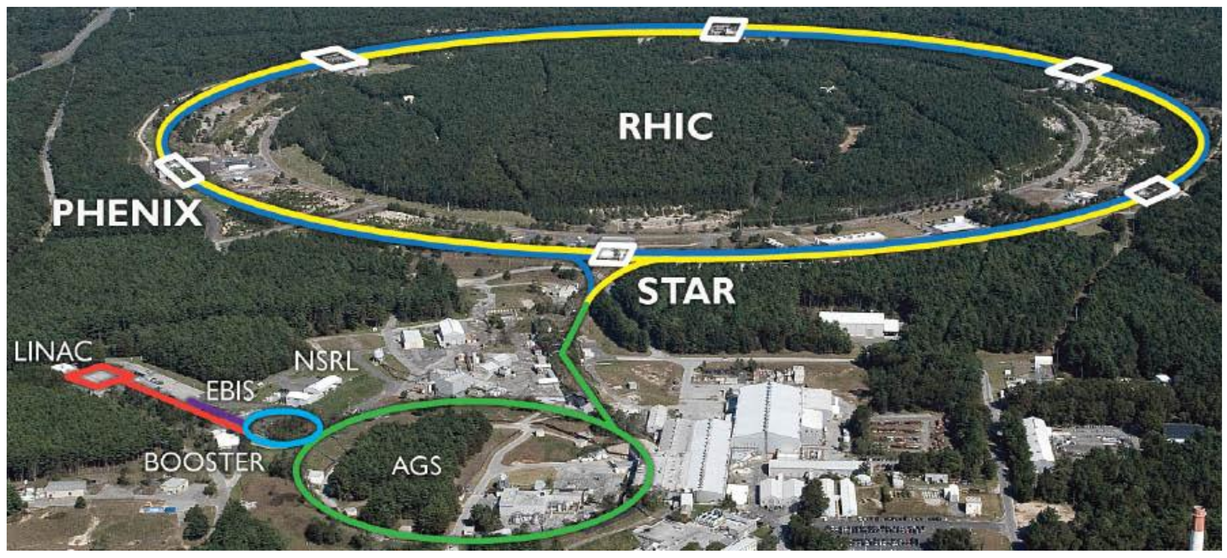
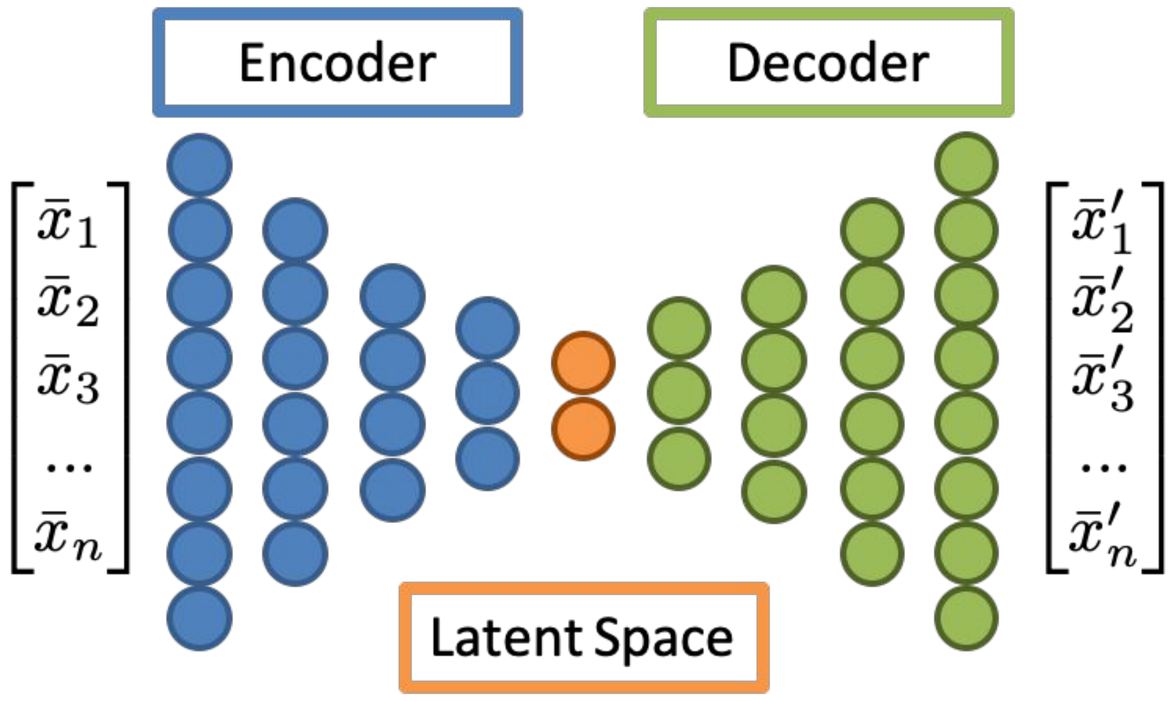
Background

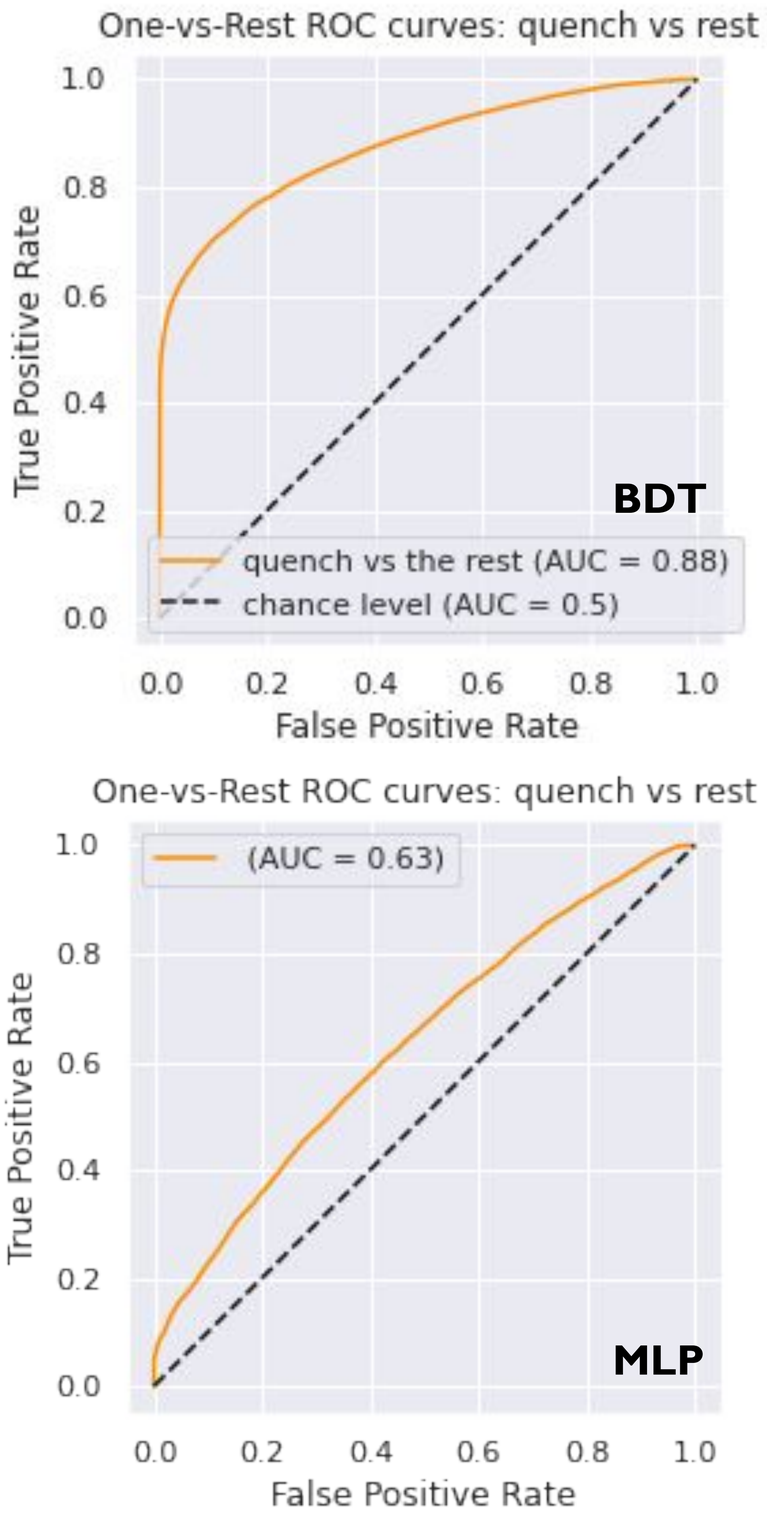
- Quench measurement from the Relativistic Heavy Ion Collider (RHIC) at BNL
  - Parsable power supply (PS) and beam position monitoring (BPM) data from 2009-2022
  - Data is recorded at 720 Hz and 10 kHz for PS and BPM data, respectively
  - Thorough notes detailing precise causes of beam aborts due to the conventional quench protection system
  - Combined into HDF5 files with included metadata for correlation analysis





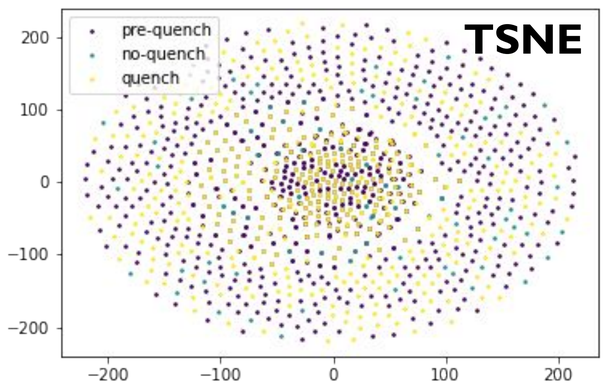
Classification

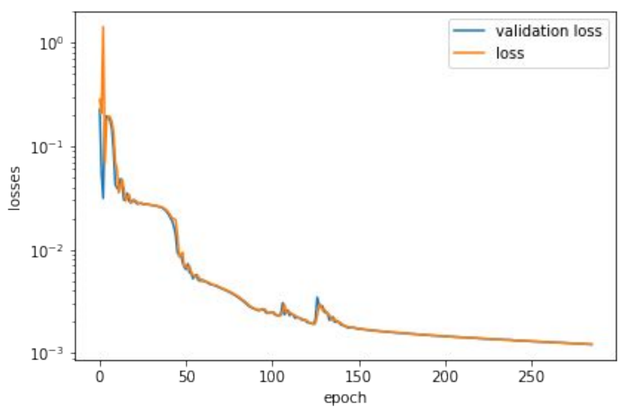
- Magnet quench dataset classification
  - Multi-classification with boosted decision tree (BDT) and custom multi-level perceptron (MLP)
  - Quenches can be uniquely identified by each model for both PS and beam position monitoring (BPM) data
  - Classification tends to perform better on PS data in comparison to BPM data
  - We plan to do further model optimization using the MLP

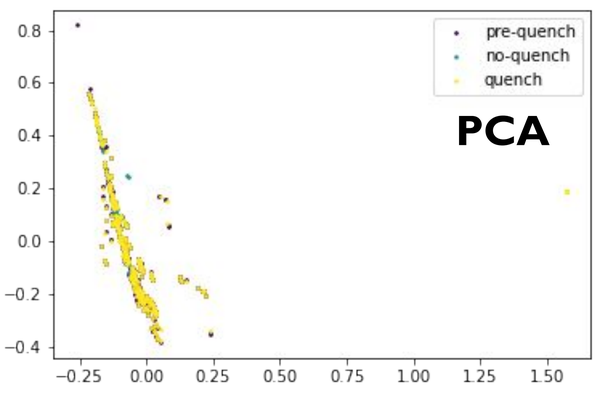


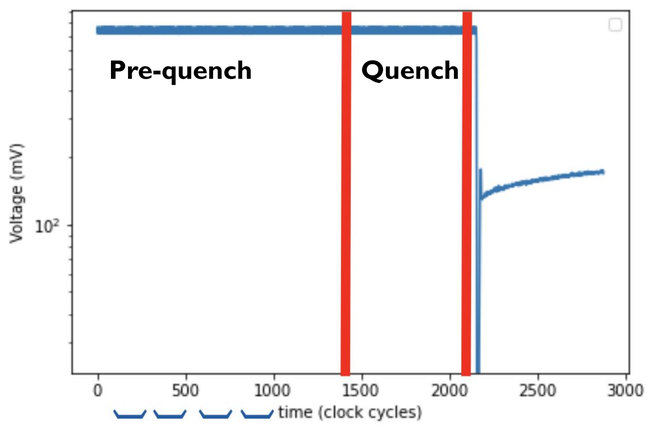
Unsupervised Learning

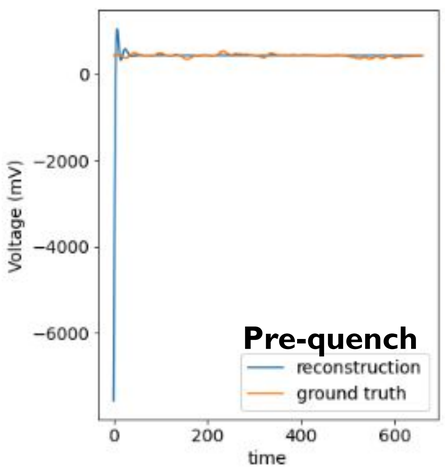
- Precursor identification using a vanilla autoencoder (AE) and a Long short-term memory (LSTM) autoencoder
  - Thorough analysis on PS data, with ongoing work with BPM data
  - Analysis of full range and continuous feed through of time sequence data
- Precursor window Optimization
  - Individual magnet sequences are split into smaller subsets
  - Optimize for large deviation in training/testing reconstruction accuracy
  - PS data is optimized at 660 clock cycles (approximately 1 second)
- Precursor Latent Space
  - Variable distinction between quench and non quench events
  - Using TSNE and PCA for latent space dimensionality reduction
  - Clustering application and optimization could be used to isolate quenches

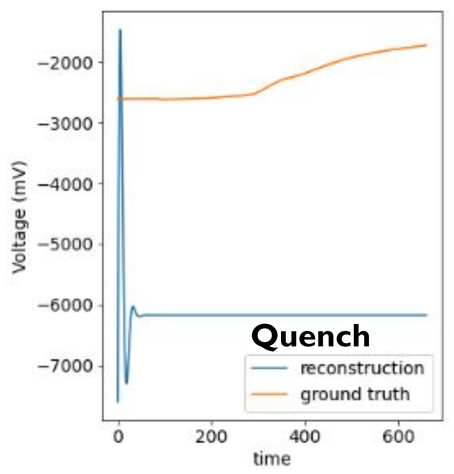












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