Near Optimal Detection of Cyclotron Radiation with Deep Learning for the Project 8 Collaboration

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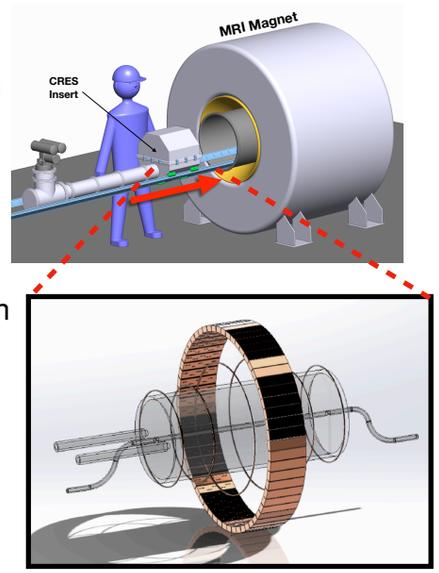
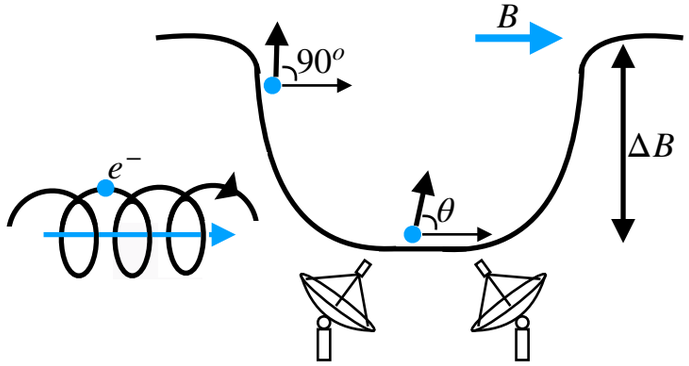
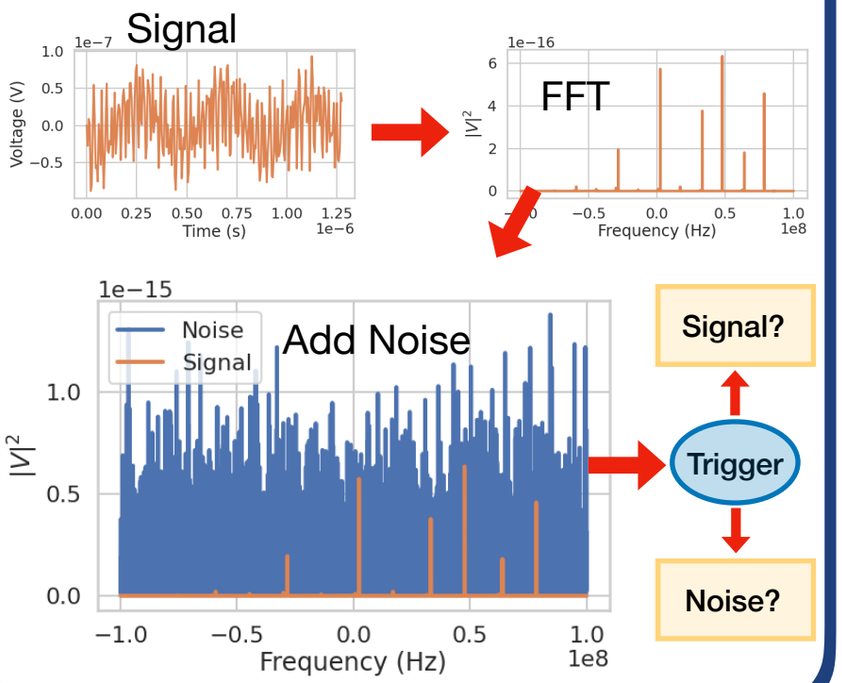
- Project 8 aims to measure the neutrino mass with a 40 meV sensitivity using Tritium beta-decay spectroscopy.
- Next generation detector technology based on detection of cyclotron radiation from individual electrons (CRES) [1].
- Progressing towards first ever free-space CRES experiment.

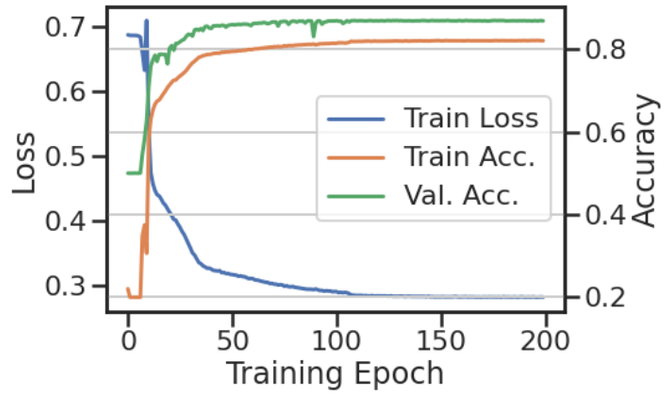




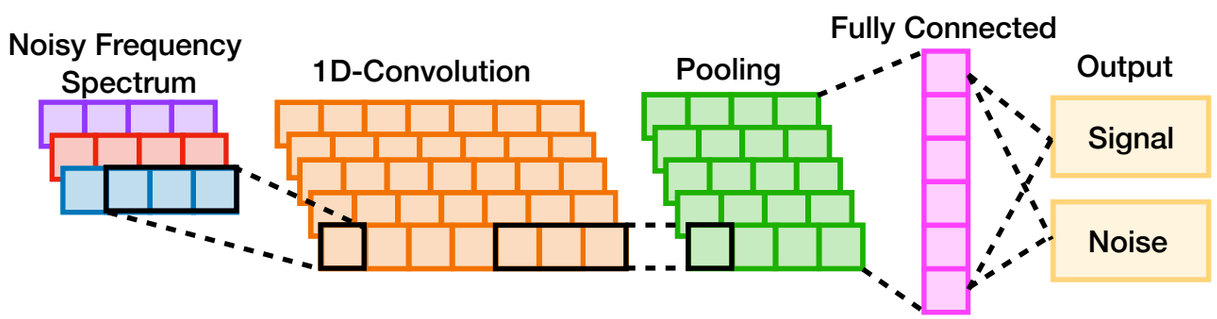
- Locust RF simulation software, developed by Project 8, used to model magnetic trap, antenna array as well as RF detection [2].
- Electron signals are buried by thermal noise radiation, $T \simeq 10K$, challenging task for triggering.
- Traditional detection methods (matched filter) are computationally intensive due to high dimensionality.



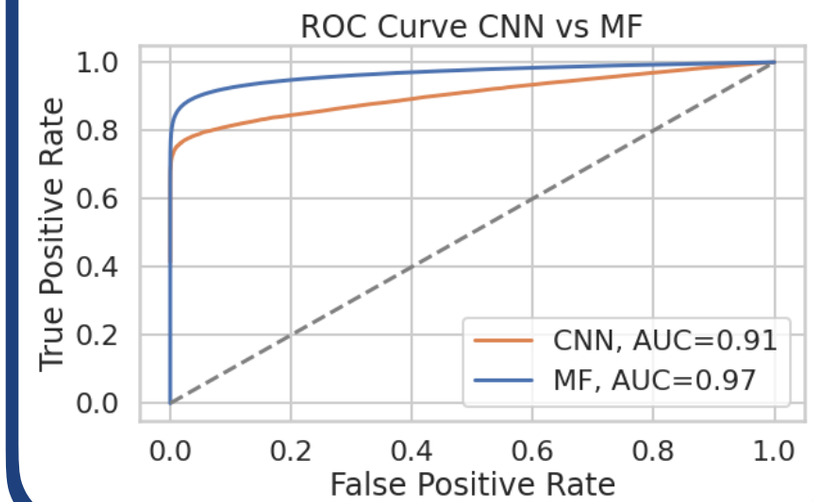
- Develop trigger algorithm using deep-learning techniques: Convolutional Neural Network (CNN).
- Monte-carlo sampling of parameter distributions to generate realistic training data.
- Train CNN on > 200K training signals using GPU acceleration.



- 1-D Convolutional Neural Network (CNN).
- Complex FFT of signal as input.
- Optimized network has 11 total layers.



- Compare CNN with Matched Filter (MF), which is optimal detector with full signal information.
- CNN within 10% of optimal detector, with faster inference.



1. A. Ashtari Esfahani et al 2017 J. Phys. G: Nucl. Part. Phys. 44 054004.
2. A. Ashtari Esfahani et al 2019 New J. Phys. 21 113051.

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