RadiaSoft: Projects, Sirepo, and Jupyter

November 2, 2022

3rd ICFA Machine Learning Workshop

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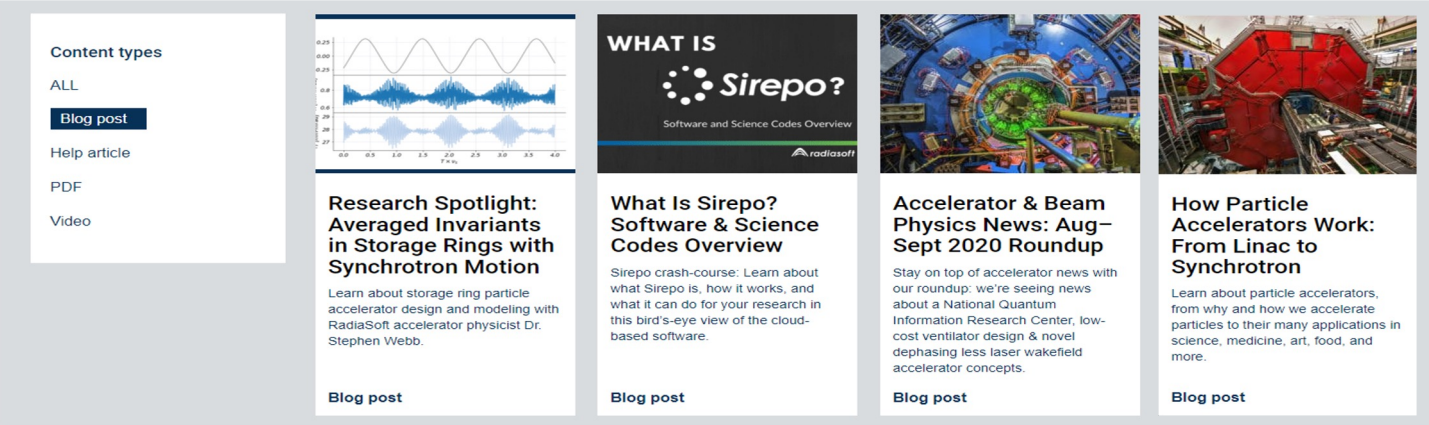

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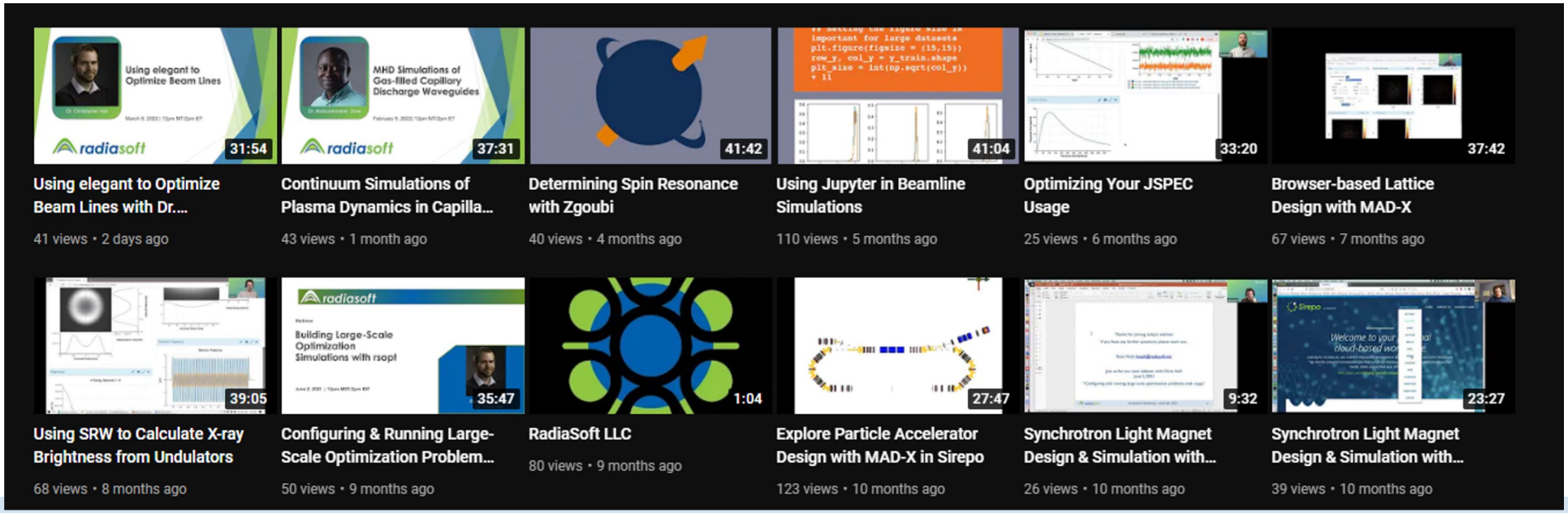

Sirepo supported codes and apps

Command line & ML

jupyterhub

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Neutron Transport

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Vacuum nanoelectronics

WARP

Accelerators

elegant

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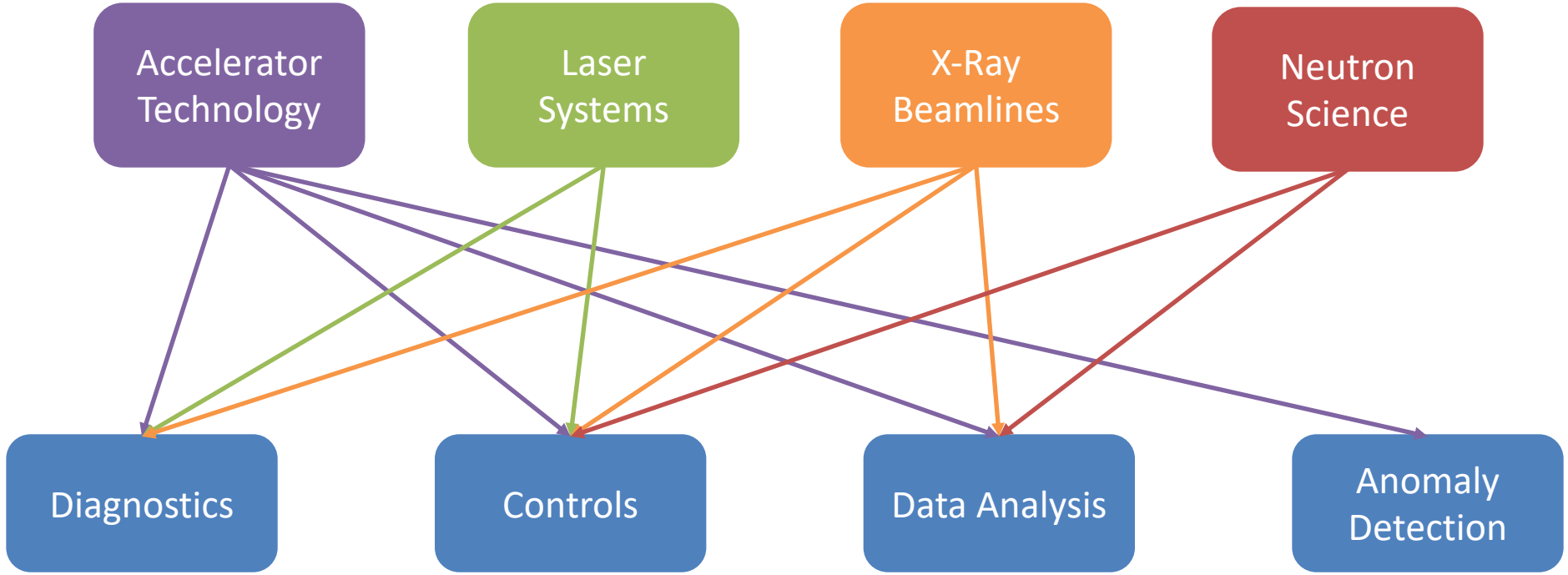
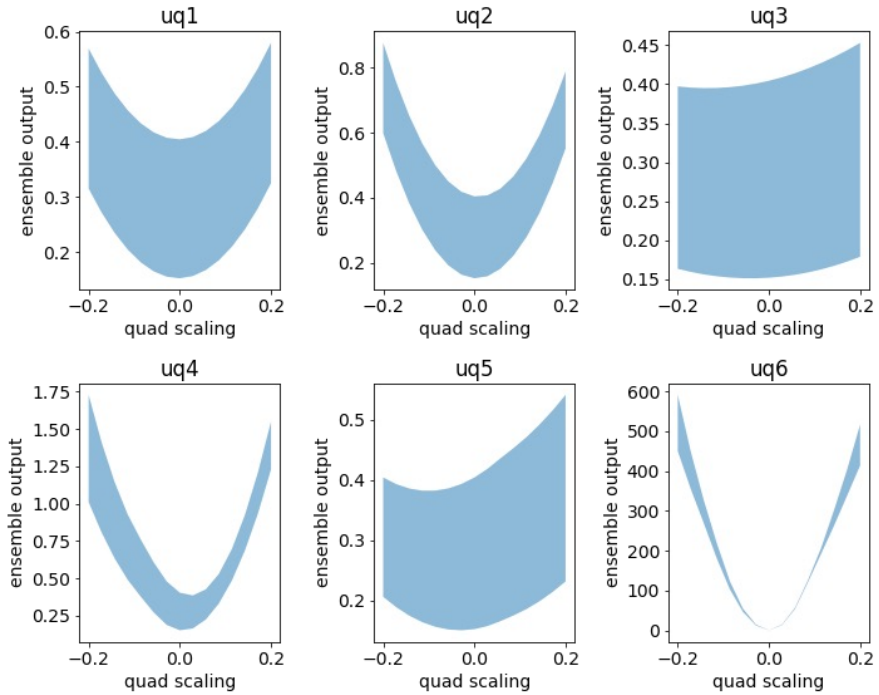
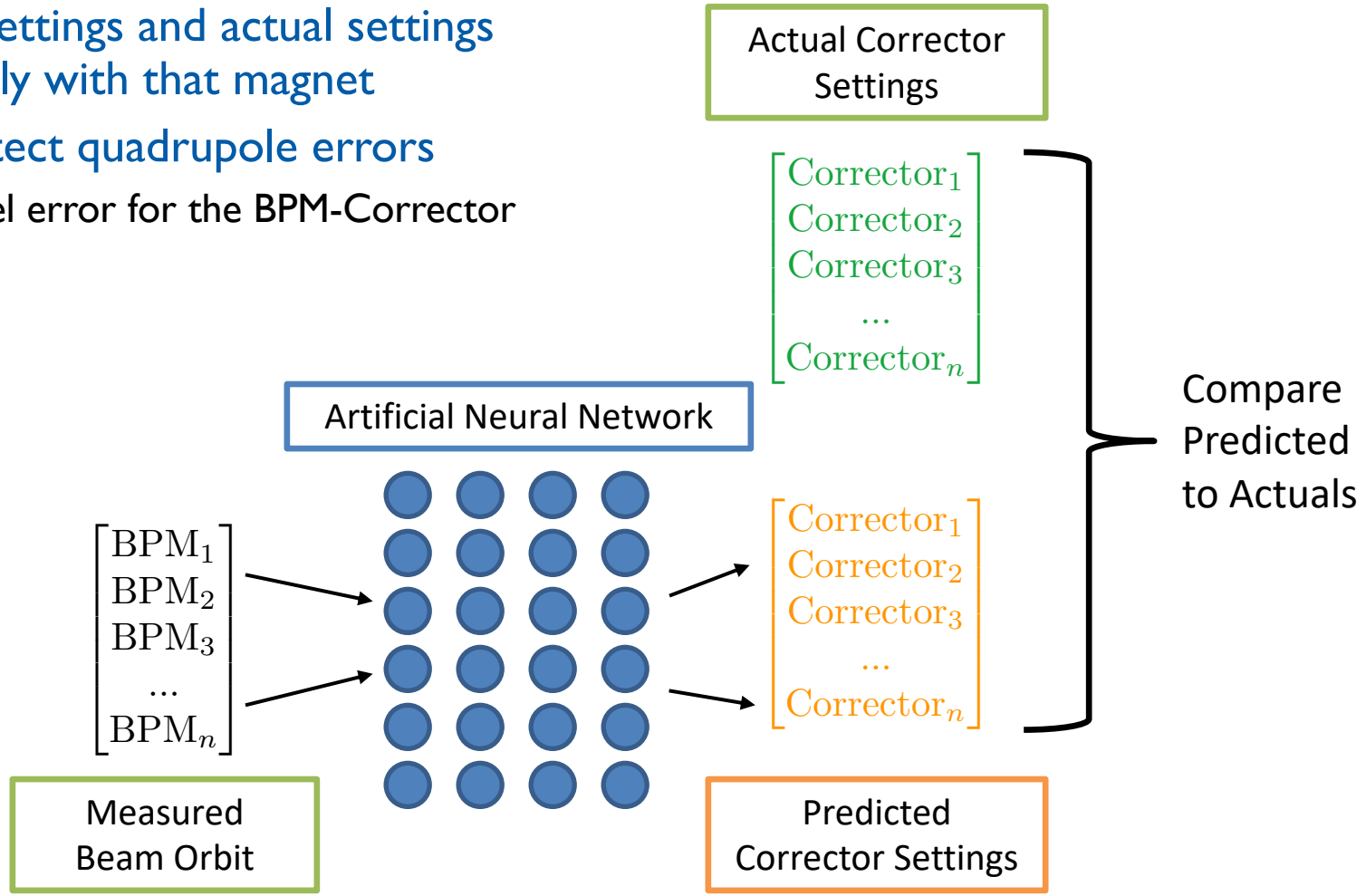


Inverse Models for Tuning and Diagnostics

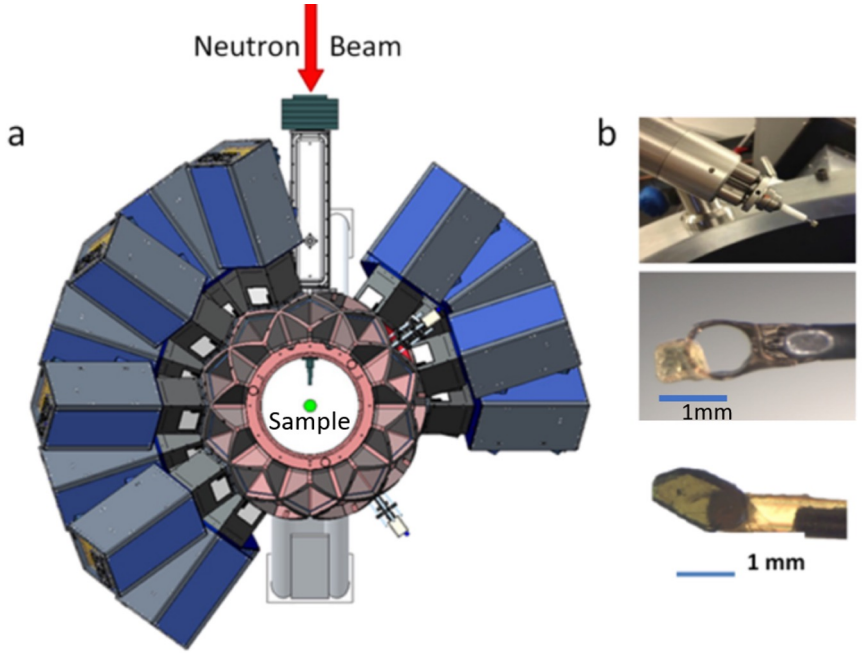
- Train model to predict settings from readings
- Direct comparison between predicted settings and actual settings informs operations of a potential anomaly with that magnet
- For BPM-Corrector models one can detect quadrupole errors
  - Tuning the quadrupoles as a function model error for the BPM-Corrector model

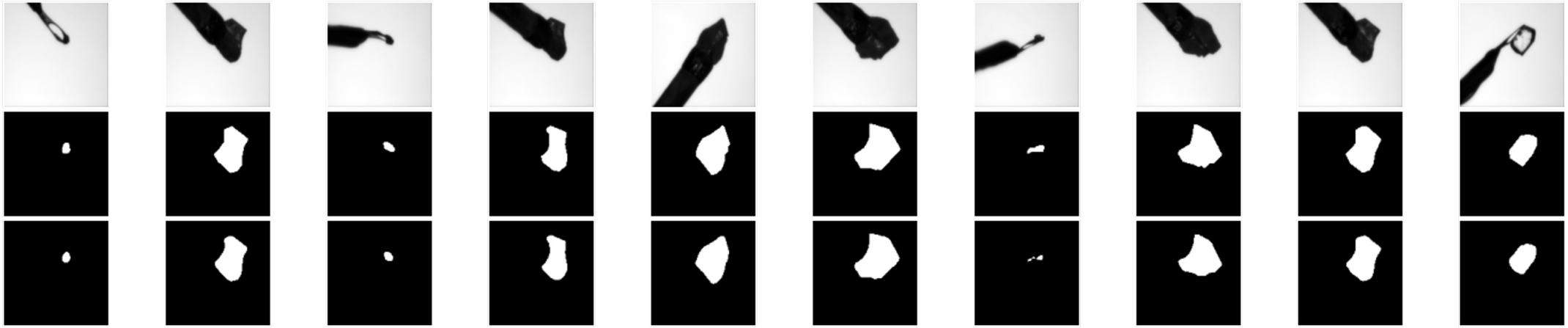




Computer Vision: Sample Identification

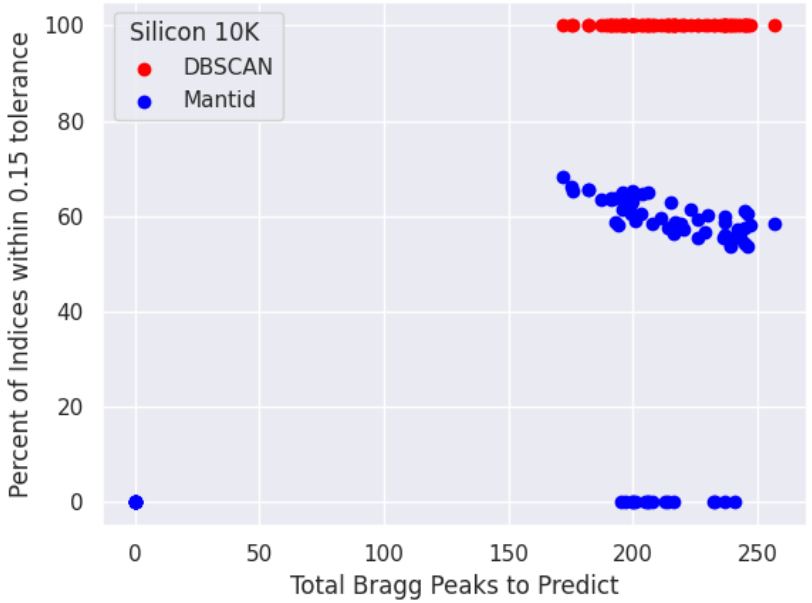
- Right: sample and detector area is shown as viewed from above the instrument.
- Bottom: examples images obtained from the experiment.
  - lower plots show binary image masks created around the sample.
  - for images with no sample the mask is empty
  - Bottom is the neural network prediction
- See Morgan's Poster

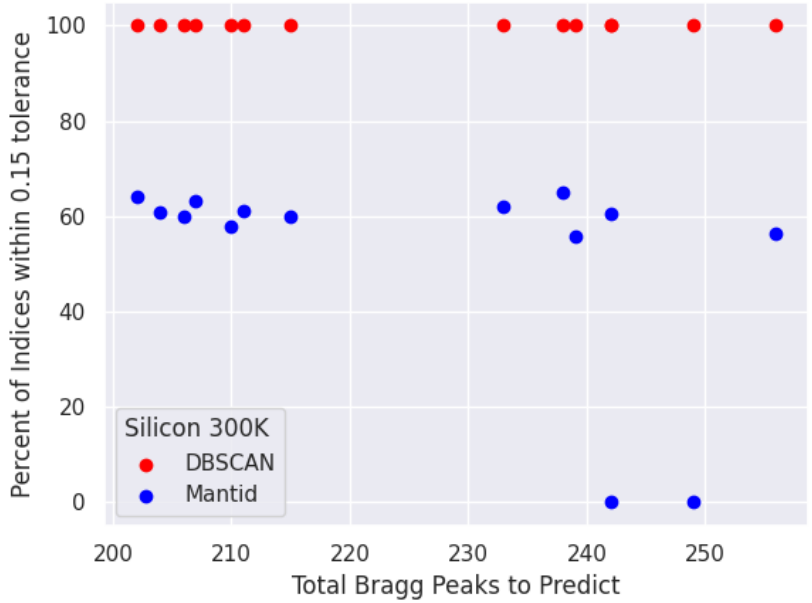




Feature Identification using Clustering

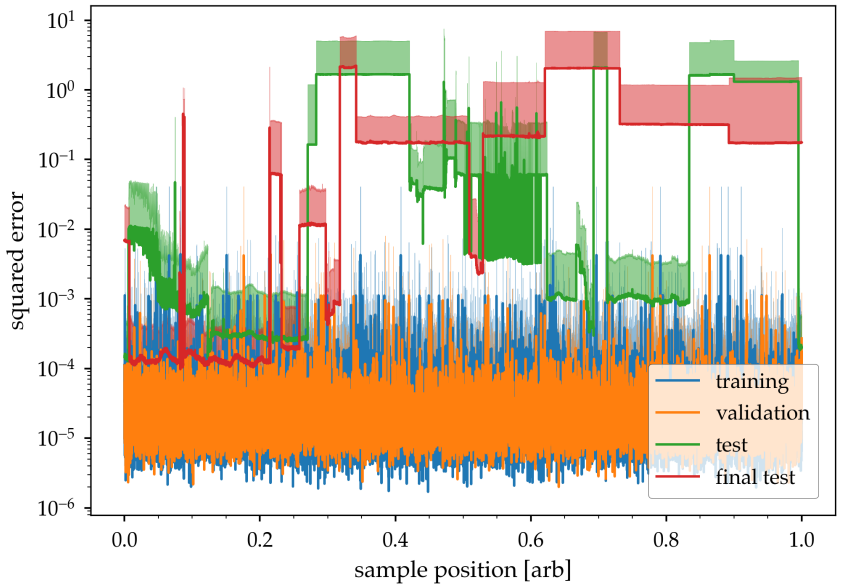
- The feature of primary interest in TOPAZ data is Bragg peaks
  - These are periodic regions in which contain a very high number of neutrons relative to their surroundings
    - They are very useful in inferring the periodic arrangement of atoms and elements in highly ordered samples
  - Bragg peaks are detectable in voxel data by identifying clusters that exceed a threshold
  - The periodicity of Bragg peaks can be determined by finding lines that pass through multiple peaks and measuring the distance between peaks in different dimensions

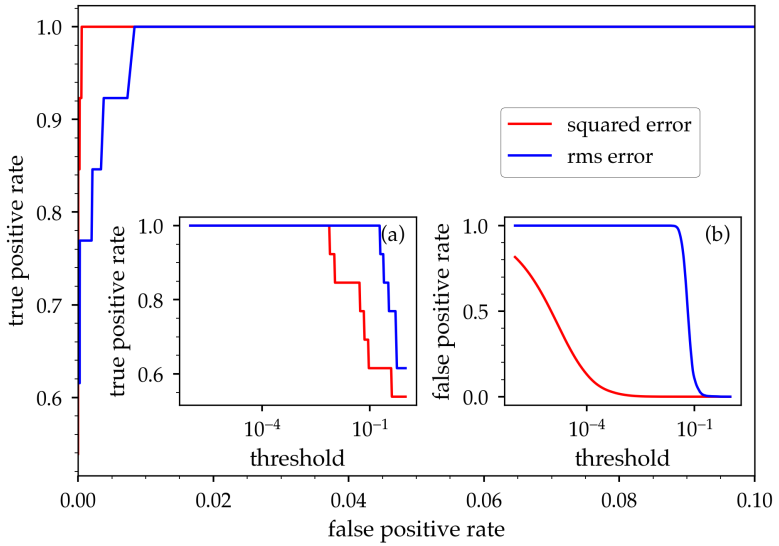


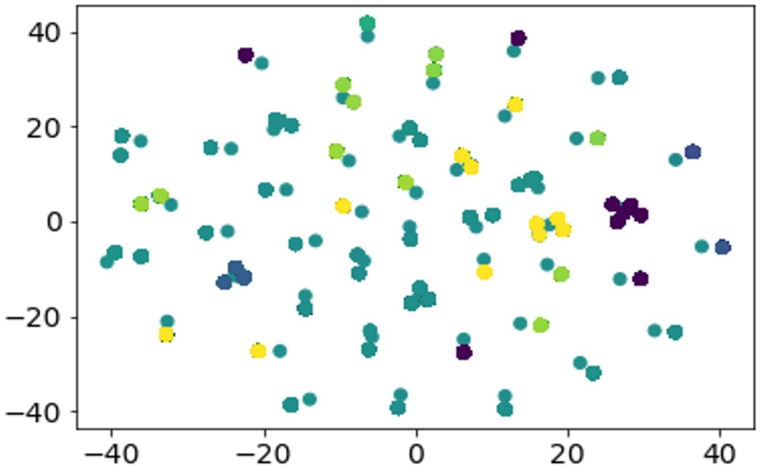


Anomaly Detection: Magnet Quench and Fault Prediction

- Autoencoders for identification of power supply faults in the APS
  - Region of convergence plot for the RMS error and squared error evaluation metrics.
  - Inset a) true positive rate as a function of the error threshold
  - inset b) shows the false positive rate as function of the error threshold.
- Autoencoders for quench classification
  - Below: Latent space plot colored by quench type
    - Not quench: -1, snake: 0, main: 1, rotator: 2, unknown: 3, quad quench: 4
  - See Josh's poster



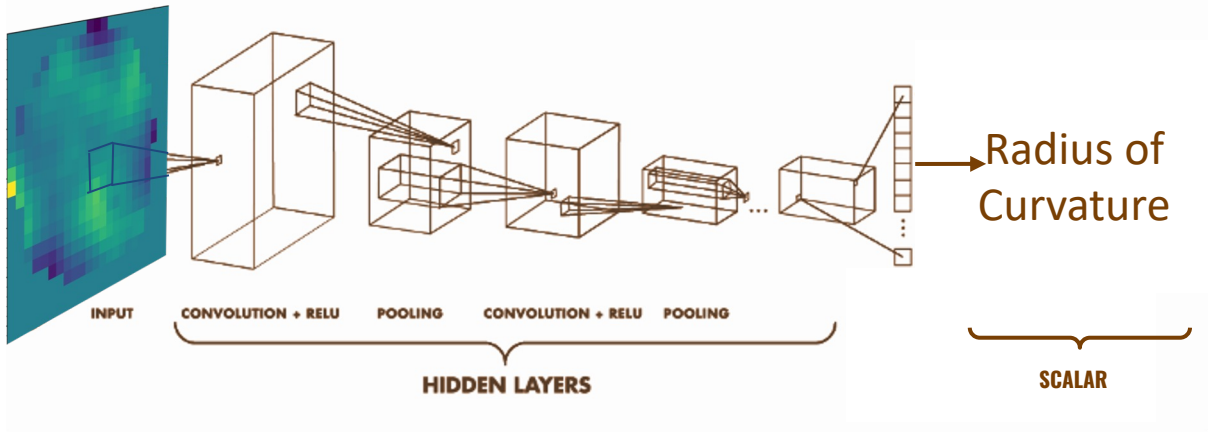




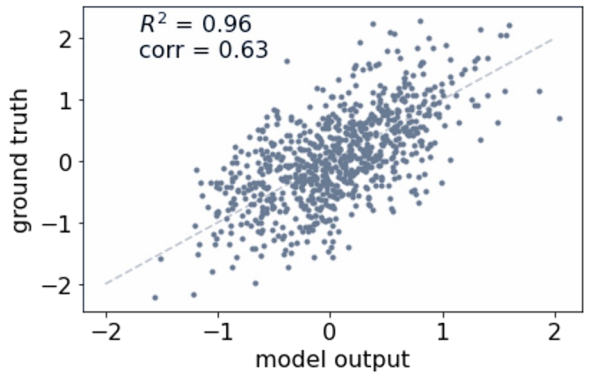
Neural Networks Improved Laser Diagnostics

- Exploring convolutional neural networks and feed-forward neural networks for mapping datasets

Convolutional Neural Network

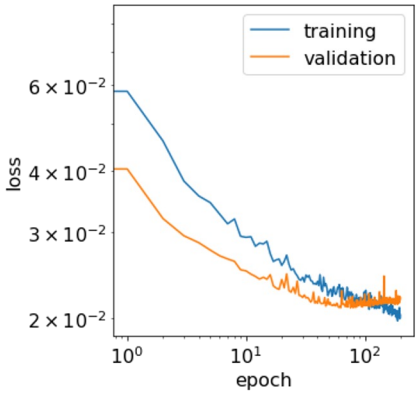


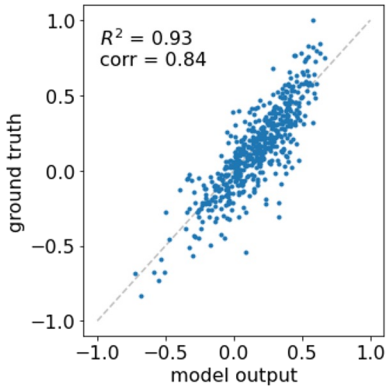
- Use differenced images from Thorlabs sensor to learn relationship to the HASO sensor
- Convolutional neural networks identify spatially correlated features in the image
  - Exploring architectures with 2 convolutional layers



Feed-forward Neural Network

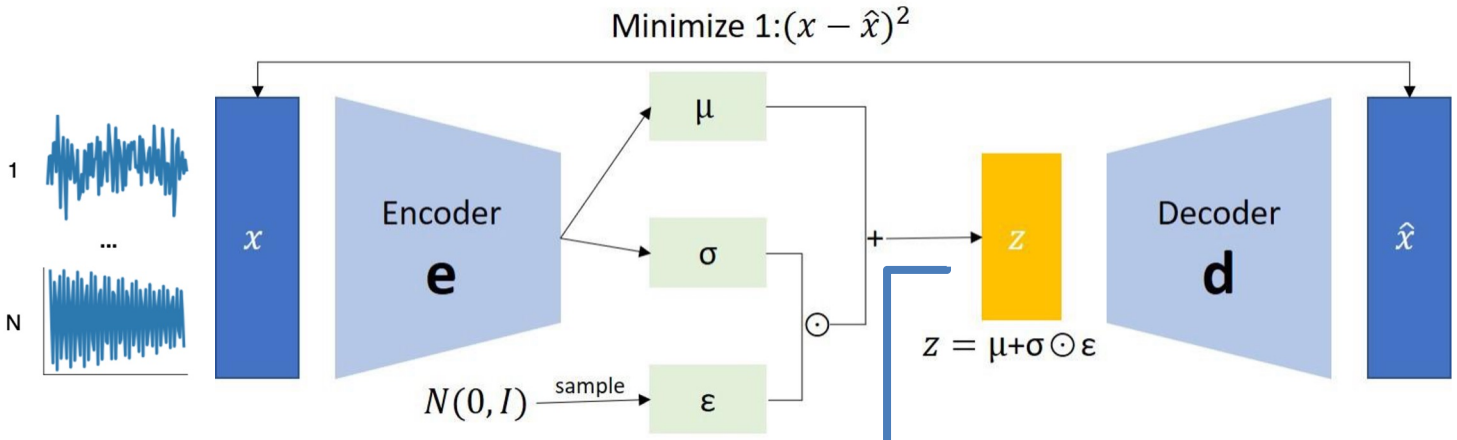
- FFNNs do not preserve complete spatial orientation of the input image
  - May improve identification of global parameters
  - Permits the inclusion of scalar inputs to augment image data
- Pre-processing routines can further enhance inputs

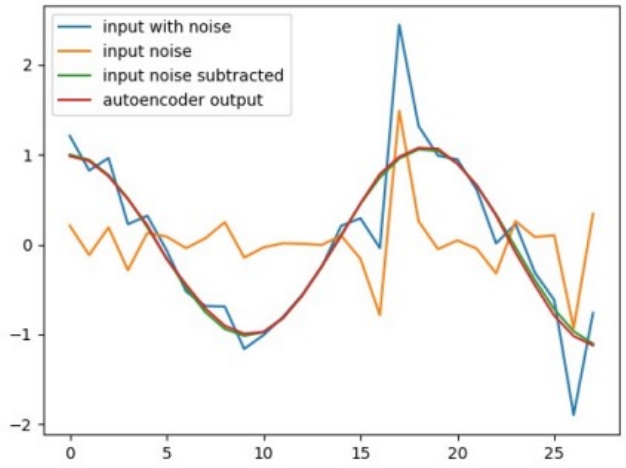


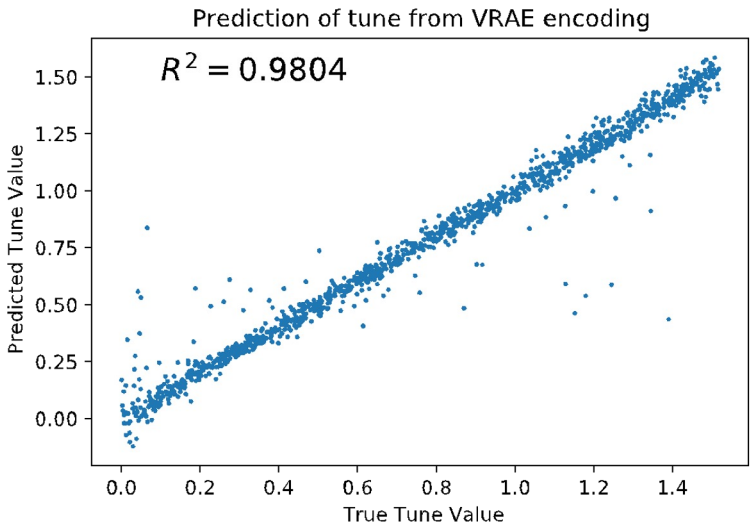


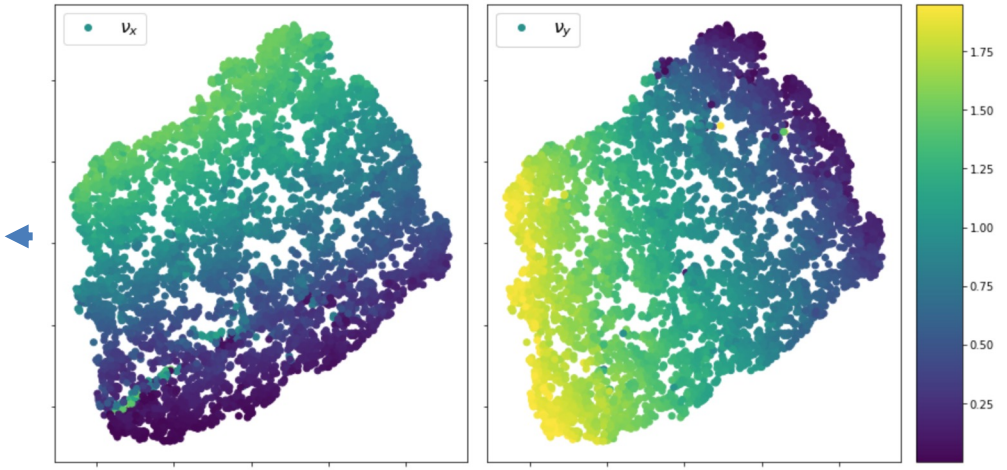
Variational Autoencoders for Diagnostics and Noise Reduction

- Variational autoencoders seek to learn a smooth, regular encoding of data in the latent space
- VAE trained on noisy BPM data
- MLP model used to extract the tunes from the latent space









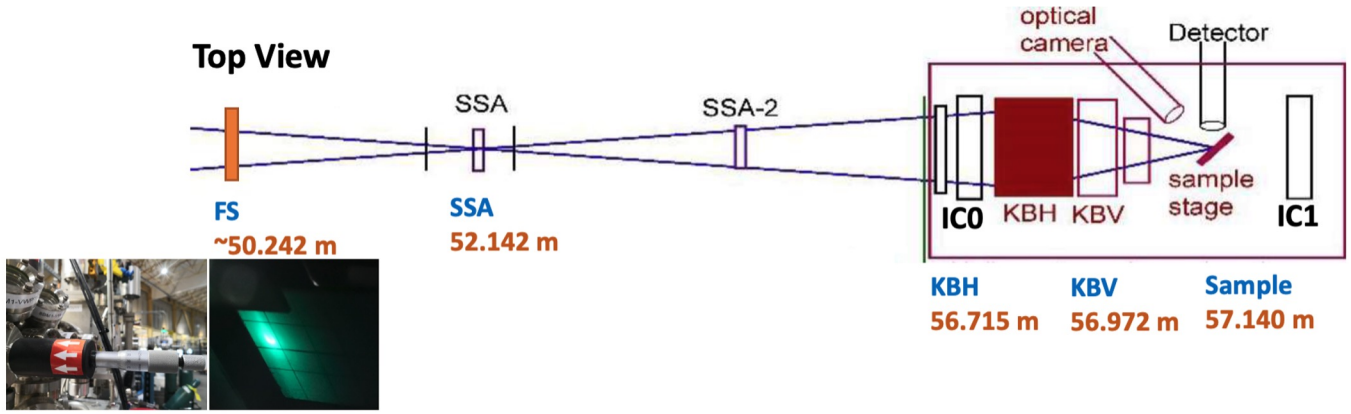
ML for Beam Size Predictions at the TES Beamline

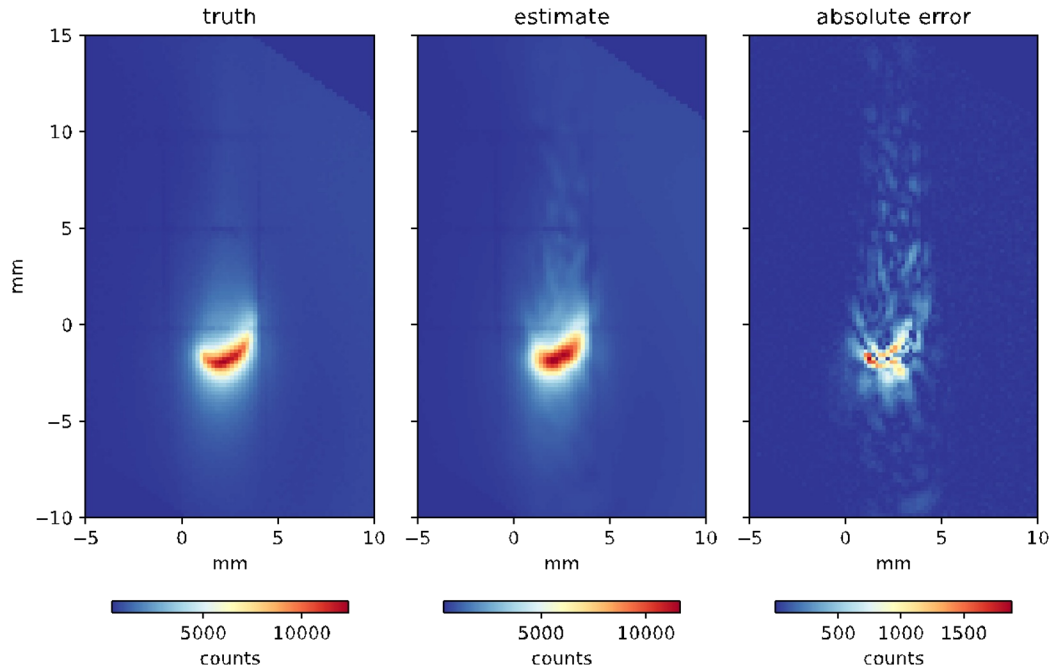
Inputs:

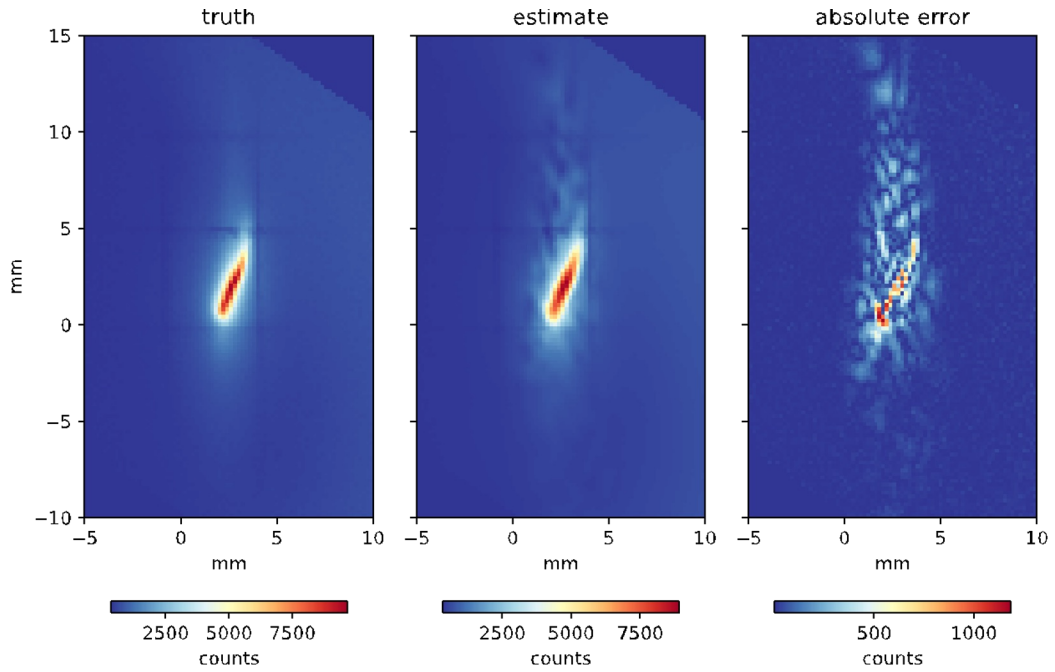
- Four motor positions for adjusting alignment mirrors

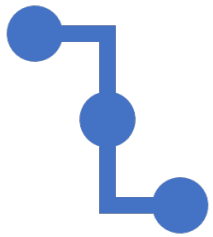
Outputs:

- Beam images









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