Non-rigid alignment of preoperative MRI, fMRI, DT-MRI, with intra-operative MRI for enhanced visualization and navigation in image-guided neurosurgery

- Brain tumor resection relies on brain visualizations to display seriously compromised brain shift, which inevitably occurs during the course of the operation, significantly degrading the precise alignment between the pre-operative MR data and the intra-operative shape of the brain.
- Deep Brain Stimulation (DBS) surgery makes use of stereotactic systems and image guidance to accurately place electrode leads, as well as intra-operative imaging to survey the location of the lead and guide the surgery.

Using Machine Learning for Particle Track Identification in the CLAS12 Detector

- Tracking takes most of track reconstruction time
- Computationally intensive (combinatorics)
- Delegate tracking to a machine learning model
- Classify tracks with machine learning
- Fit only those with highest probability of being valid
- Mitigates the cost of track fitting
- Much fewer candidates to examine
- 25% speedup
- $5\text{\,MM} year

Denoising Drift Chambers in CLAS12 using Convolutional Auto-Encoders

- Denoise used Auto Encoder (AE) and then perform tracking with ML
- Denoising with AE maintains samples with higher efficiency
- $\sim$ 35% more events in normal operation (45nA)
- The higher impact expected in the future
- Almost double the output when 100nA is possible

Charged Particle Reconstruction in CLAS12 using Machine Learning

- Use machine learning to directly infer physics parameters
- Parameters include momentum, polar and azimuthal angles
- Conventional methods use Hit-Based reconstruction
- Takes about 380-420 ms per event
- Using machine learning takes about 4 ms per event
- $\sim$ 100 times faster than conventional
- Same accuracy

Putting It All Together: Medical and Physical Sciences

- Electromagnetic potential solution for 18-B143 (left), 614 (right)
- There appear to be a larger region of weak proton overlap that may change the size of the 18-B143 protein compared to the original 514-614 area.