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Data processing to improving the signal of one-dimensional neutron images at Sandia's Z Pulsed Power Facility

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A one-dimensional imager of neutrons (ODIN) is being used to image neutrons emitted from a line source created in Magnetized Liner Inertial Fusion (MagLIF) experiments on the Z facility. MagLIF experiments produce DD total neutron yields that range from ~1 x 10^{12} to ~1 x 10^{13}. The neutrons which pass through a 100-mm thick tungsten rolled-edge slit are imaged on multiple CR39 pieces used as detectors and held in alignment with pins though each piece. Each CR39 piece is etched and scanned with a microscope and the images recorded. The observed tracks are then re-binned to ODIN resolution (~500 μm). The binned data are then integrated to produce an axial profile of neutron data. New data analysis techniques have been developed to integrate multiple CR39 scans to increase signal to noise ratio. A key part of this process is correcting rotated or shifted data points that may be present from misalignments during the scanning process. Accurate accumulation of CR39 scans provide an increase in statistical accuracy of the axial profile, especially for lower yield experiments.

- Neutron imaging of Magnetized Liner Inertial Fusion (MagLIF) shots on Z facility
- D-D neutron yields range from ~1 x 10^{12} (low yield) to ~1 x 10^{13} (high yield)
- CR-39 used for its resilience in extreme environments, and x-ray insensitivity
- Individual CR-39 pieces scanned front and back to detect tracks from neutron interactions
- CR-39 pieces in alignment contain individual data from implosions which can be accumulated to increase statistics

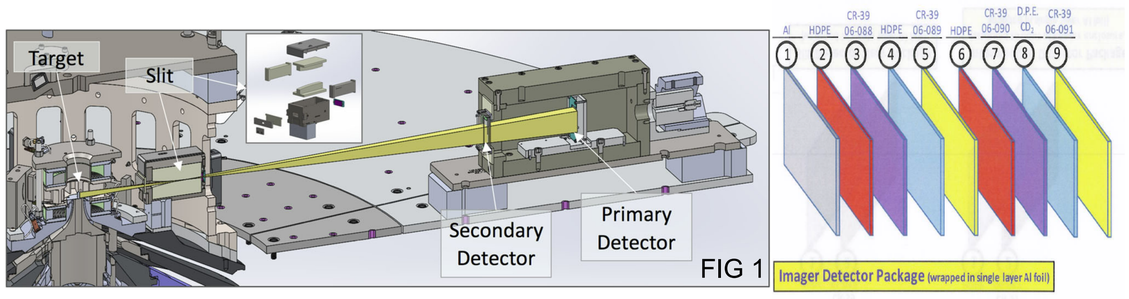


FIG 1

- CR-39 scanned at microscope resolution, then rebinned to ODIN resolution
- Each row of pixels is integrated to get the axial profile of neutron data

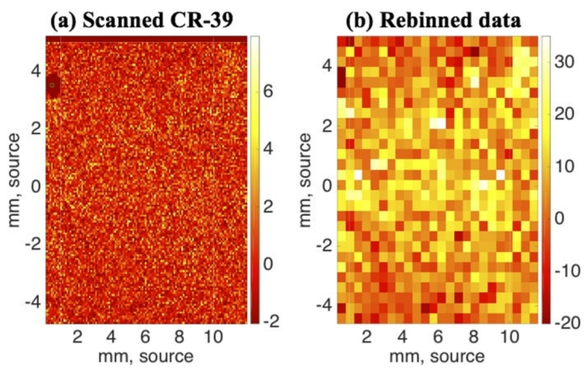


FIG 2

- Axial profile compared to x-ray data for two reasons:
  - X-ray data has been looked at and measured accurately for some time
  - The x-ray and neutron emission profiles share many features

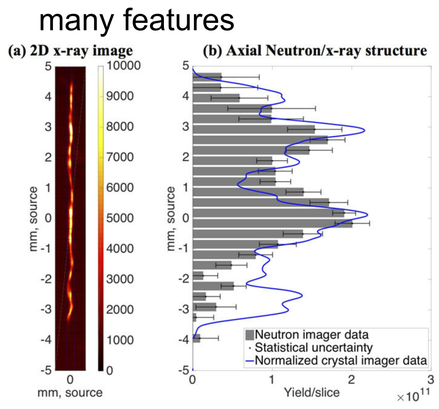
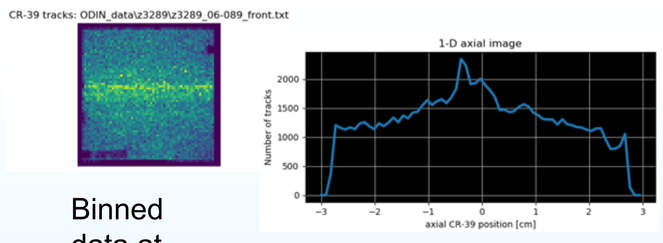


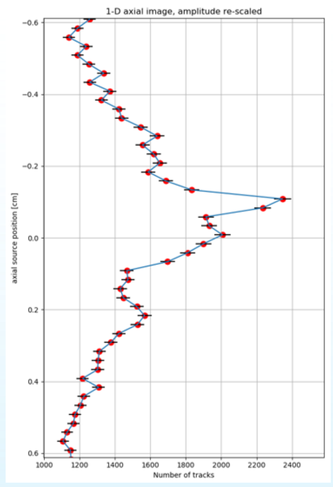
FIG 3

- Take existing data analysis tool and implement the following capabilities:
  - Integrate data from multiple CR-39 scans (both front and back)
  - Correctly align CR-39 data by X, Y, or rotational shifts of data
- This should increase signal to noise ratios by a factor of 2n, where n is the number of CR-39 pieces, and provide a more accurate axial image of target neutron emission



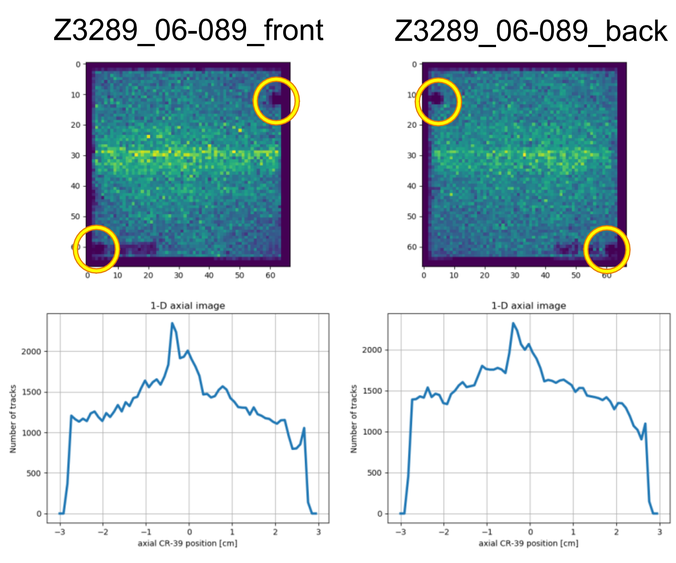
Binned data at ODIN resolution

Integrated axial neutron data

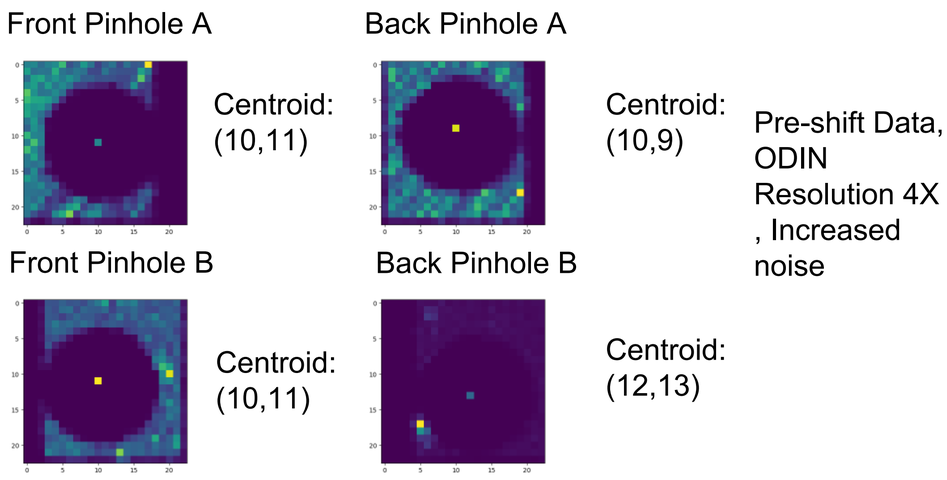


Axial neutron profile rescaled to target size

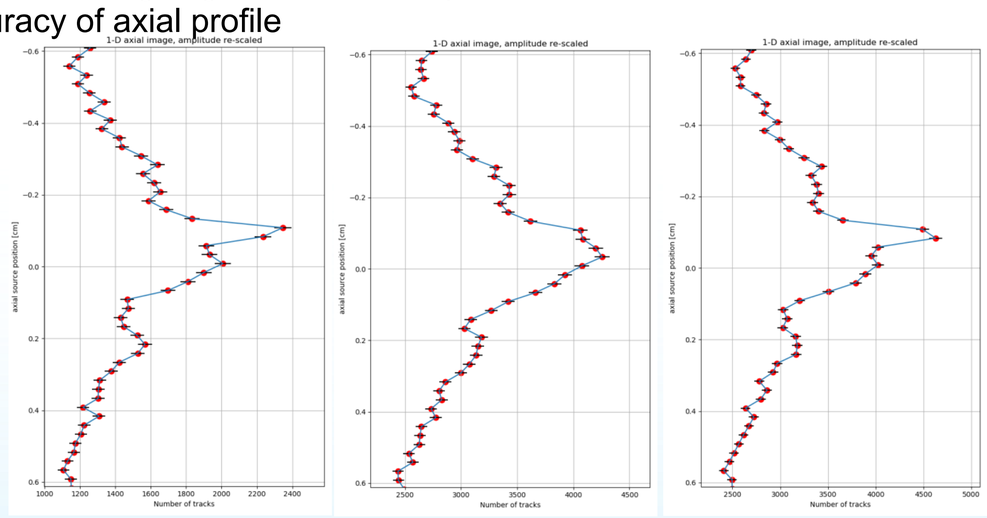
- Microscope scans have some human error in the placement of CR-39 pieces
- Pinholes are absolute positions where CR-39 was held in place during MagLIF sho
- Integration of data needs to be aligned correctly



- Higher resolution binning of data, and increasing noise allowance can be used to see pinhole locations clearly
- Centroid detected with OpenCV
- Shifts in X,Y directions are inadequate, rotational shifts are needed



- Incorrect alignment can result in smearing of axial image data
- Accurate realigning of CR-39 data provides an increase in statistical accuracy of axial profile



Single Front scan

Front and Back scan incorrectly aligned by 0.2 cm in Y direction

Front and Back scan correctly aligned

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FIG. 1, 2, 3: David J. Ampleford, Carlos L. Ruiz, David N. Fittinghoff, Jeremy D. Vaughan, Kelly Hahn, Brandon Lahmann, Maria Gatu-Johnson, Johan Frenje, Richard Petrasso, Christopher R. Ball, Andrew J. Maurer, Patrick F. Knapp, Adam J. Harvey-Thompson, John Fisher, Perry Alberto, Jose A. Torres, Gary Cooper, Brent Jones, Gregory A. Rochau, and Mark J. May , "One dimensional imager of neutrons on the Z machine", Review of Scientific Instruments 89, 10I132 (2018) https://doi.org/10.1063/1.5038118