SAND2019-2690C

Initial data from the One-Dimensional Imager of Neutrons on Magnetized Liner Inertial Fusion experiments

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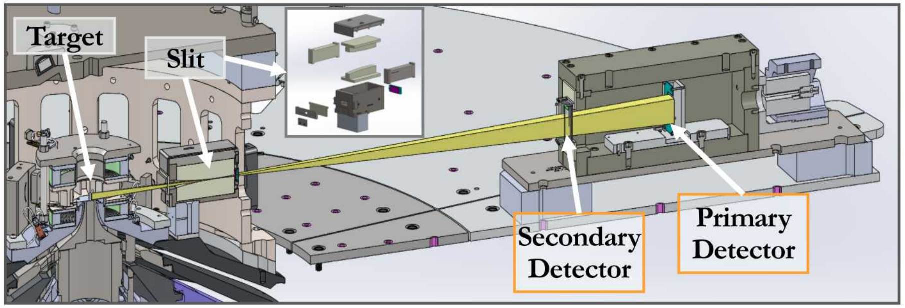
Abstract: We have recently developed a One-Dimensional Imager of Neutrons (ODIN) for Magnetized Liner Inertial Fusion (MagLIF) experiments on Z. When coupled to other diagnostics, including x-ray imaging, we anticipate that locally diagnosing neutron emission will aid in characterizing regions of mix within the target. In this poster we describe the instrument, which consists of a 10-cm thick rolled edge W slit and CR39 detectors. We also show initial data obtained with ODIN and compare to other data from MagLIF experiments.



Slit design

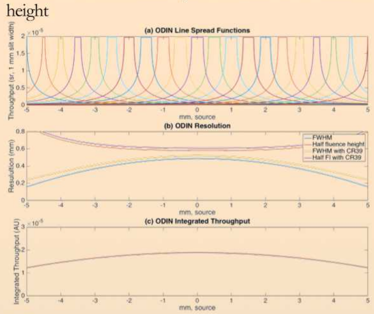
- Aim is to diagnose neutron emission in MagLIF.[1]
- Expected ~3e12 DD neutrons emission region is 10 mm tall, 100 μm diameter, motivating a one-dimensional imager.
- Thick W slit used as imaging element
  - 100 mm provides 1e-2 contrast.
  - High Z slit minimized small angle scattering
- Rolled edge slit design minimizes vignetting
  - 500 mm radius of curvature to view 10-mm tall target.
- Design includes 250-μm, 500-μm, 750-μm slit spacings.

Detector

- CR39 plates were selected as the detector due to low sensitivity to x-rays and Bremsstrahlung radiation.[2]
- A 1 mm thick layer of high density polyethylene (HDPE) was positioned ahead of the CR39.
- Incident neutrons interact with the HDPE producing a proton, which has a much higher efficiency than neutrons in the CR39.
- Two detector magnifications provide confidence in data.

Performance estimates

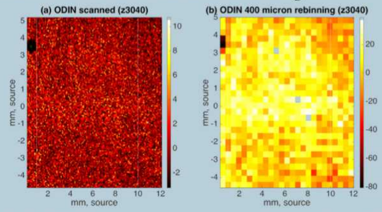
- We have developed an analytic estimate for the performance of ODIN
- Neglecting scattering, we can use the rolled edge geometry and the mean free path of neutrons in tungsten to infer the instrument performance as a function of height



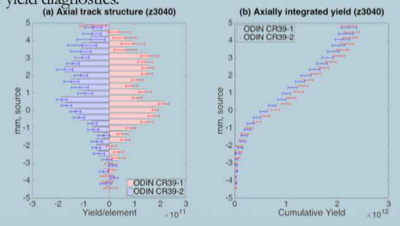
MCNP calculations of small angle scattering are underway.[3,4]

Data analysis[5]

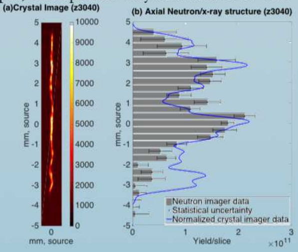
- CR39 plates are etched in NaOH for 5 hours to reveal tracks.
- Data is scanned with a microscope; image processing techniques are used to isolate DD neutron induced tracks.
- Raw data has high noise level, but rebinning at instrument resolution starts to show one-dimensional image.



- Multiple CR39 plates at primary detector location show 1D image.
- We use the standard error in the mean to quantify noise.
- Efficiency estimates used to quantify emissivity; within factor of 2 of yield diagnostics.

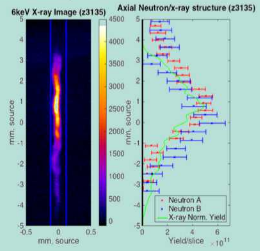


- We can compare 1D neutron image with 1D profile from 6 keV crystal imager.
- Similar shapes; discrepancies may be indicator of mix.



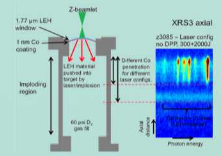
Structure in neutron emission

- Continuity of stagnation region
  - To understand magnetization of the stagnation we assume that there is a continuous column of hot fuel
  - Confirming continuous neutron emission along the length of the column helps evaluate this assumption

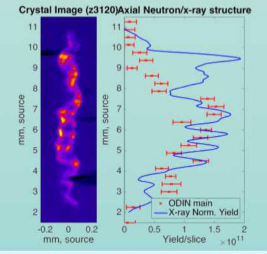


Inferring mix

- Laser induced mix:
  - Previous laser configuration was inferred from spectroscopy to have considerable laser-induced mix



  - An alternative approach to mix diagnosis is to evaluate relative neutron and x-ray emissivities from hot fuel (undoped)



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