

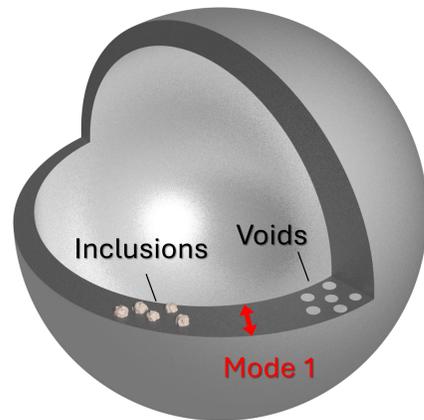
ENHANCING GEOMETRICAL UNIFORMITY OF ABLATOR CAPSULES THROUGH REAL-TIME COATING PROCESS MONITORING

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ABSTRACT

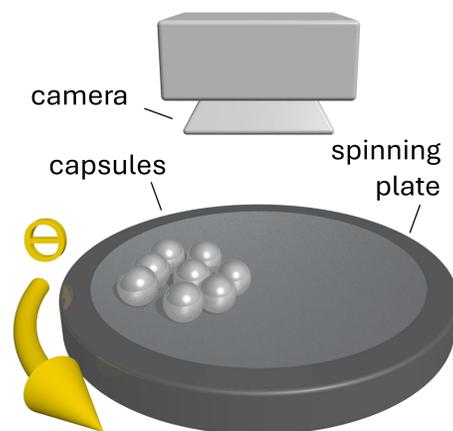
Geometrical uniformity in inertial confinement fusion ablator capsules plays a critical role in successful ignition experiments at the National Ignition Facility. Yet, the mechanism underlying the wall thickness non-uniformity, often referred to as “mode 1”, remains poorly understood. In this work, object tracking is utilized to monitor trajectories of high-density carbon ablators during the



Schematic representation of corner-cut capsule with Mode 1 symmetry, as well as inclusions and voids.

coating process, and their correlation with Mode 1, as well as with the presence of pores and inclusions, is investigated.

METHOD...



Schematic representation of experimental setup.

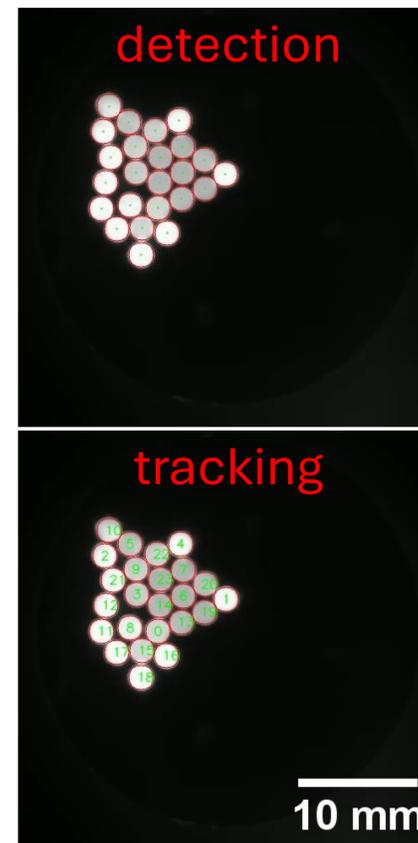
Capsules are placed on a circular plate that rotates at a controlled speed. A camera with a 1440x1080 pixel array is positioned ~500 mm above the plate and yields a pixel size of ~70 μm/pxl or 30 pixel per capsule’s diameter. Motion of capsules are captured with ~100 frames per second acquisition rate.

The study investigates the effect of coating parameters on capsule behavior, focusing on:

- **Number of Capsules:** Understanding how varying quantities impact interactions and dynamics.
- **Rotation Speed of the Plate:** Analyzing how changes in speed affect capsules movement.

...METHOD

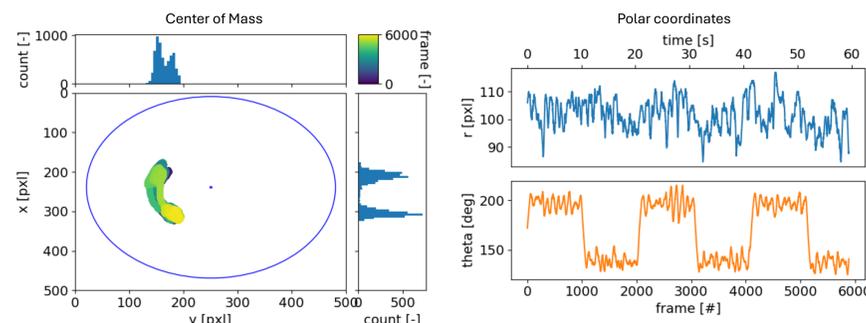
- Capsule detection is performed using YOLOv8 library, which employs **convolutional neural networks** to classify and locate objects.
- The model is trained on a minimum subset of ~27 capsules across ~7 frames.
- Each capsule is assigned an **identification number**, and its positions are tracked throughout the video using a minimal **Euclidean distance tracking technique**.



PRELIMINARY RESULTS...

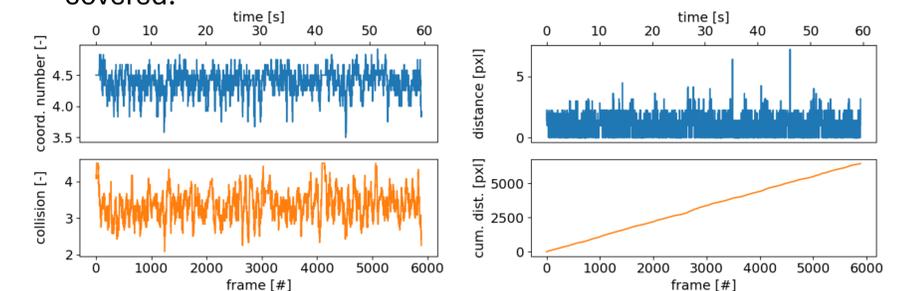
The following graphs illustrate various metrics used to analyze the motion behavior of the capsules.

- The scatter plot shows the **position of the capsule cluster** over time, while histograms reveal the preferred positions.
- polar coordinates highlight the **distances from the center** and **angles** within the plate.

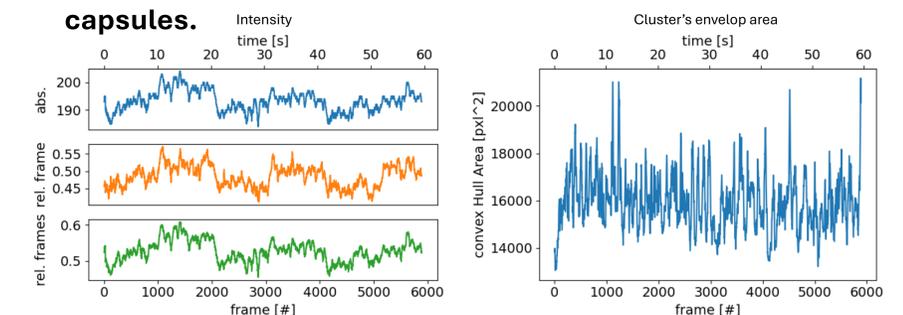


... PRELIMINARY RESULTS

- **Coordination** and **collision numbers** indicate the count of nearest neighbors within x1.5 and x1.1 radius.
- Distance and cumulative distance provide information on the **travel of the cluster** from frame to frame, and the total distance covered.

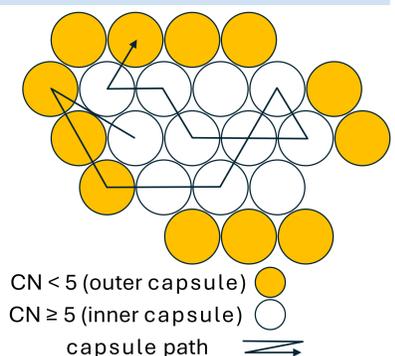


- Intensity fluctuations are monitored to detect shadowing and **thermal effects** that contribute to non-uniform coating.
- The area of the cluster is tracked to assess the **density of the capsules**.



FUTURE WORK

The next phase of the investigation will **focus** into greater detail and evaluate **each capsule** individually. New metrics will be implemented, including those assessing **mixing quality** and **agitation scheme**, by measuring the frequency with which capsule moves from an inner to an outer cluster position.



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