

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

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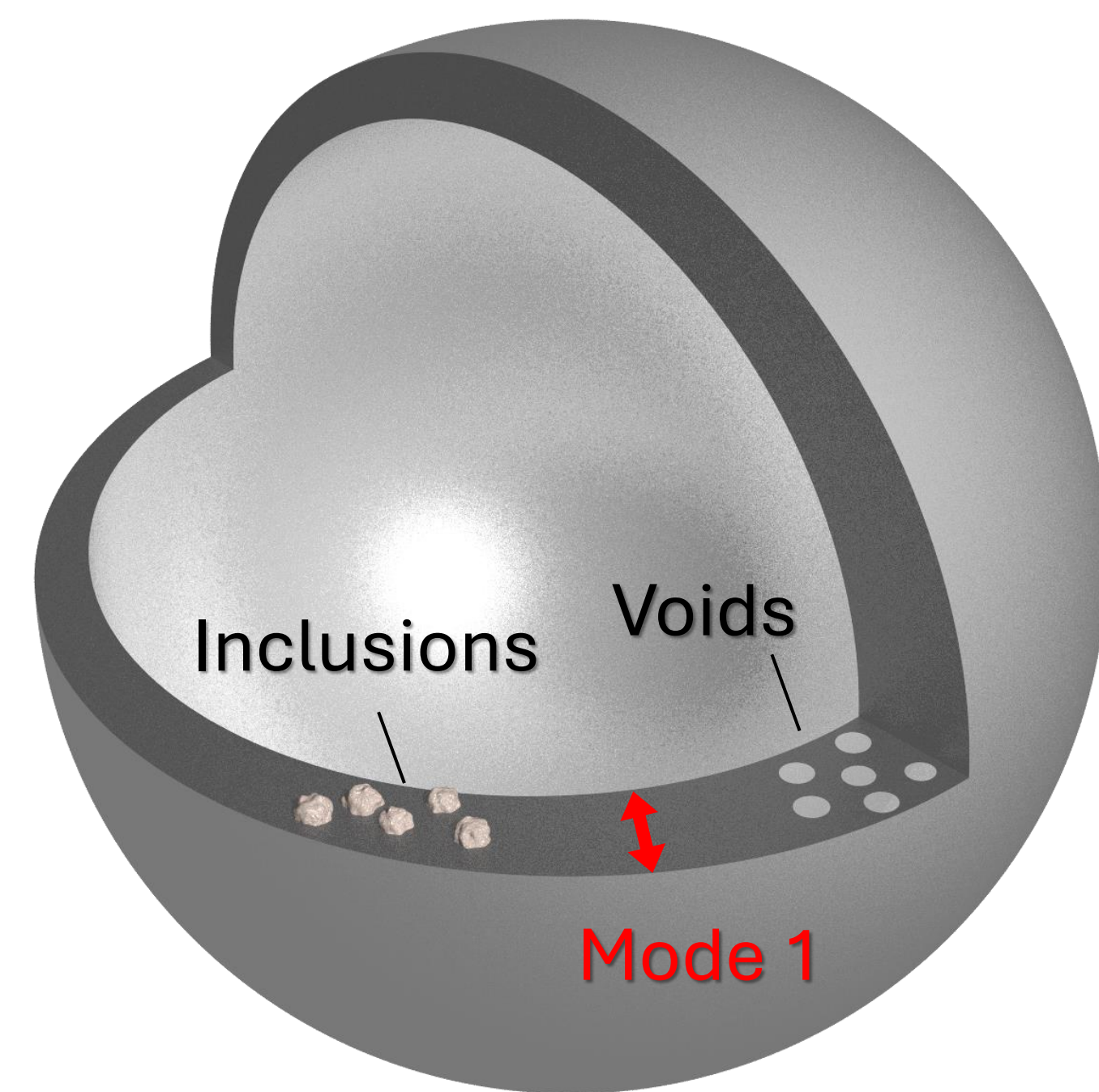
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ABSTRACT

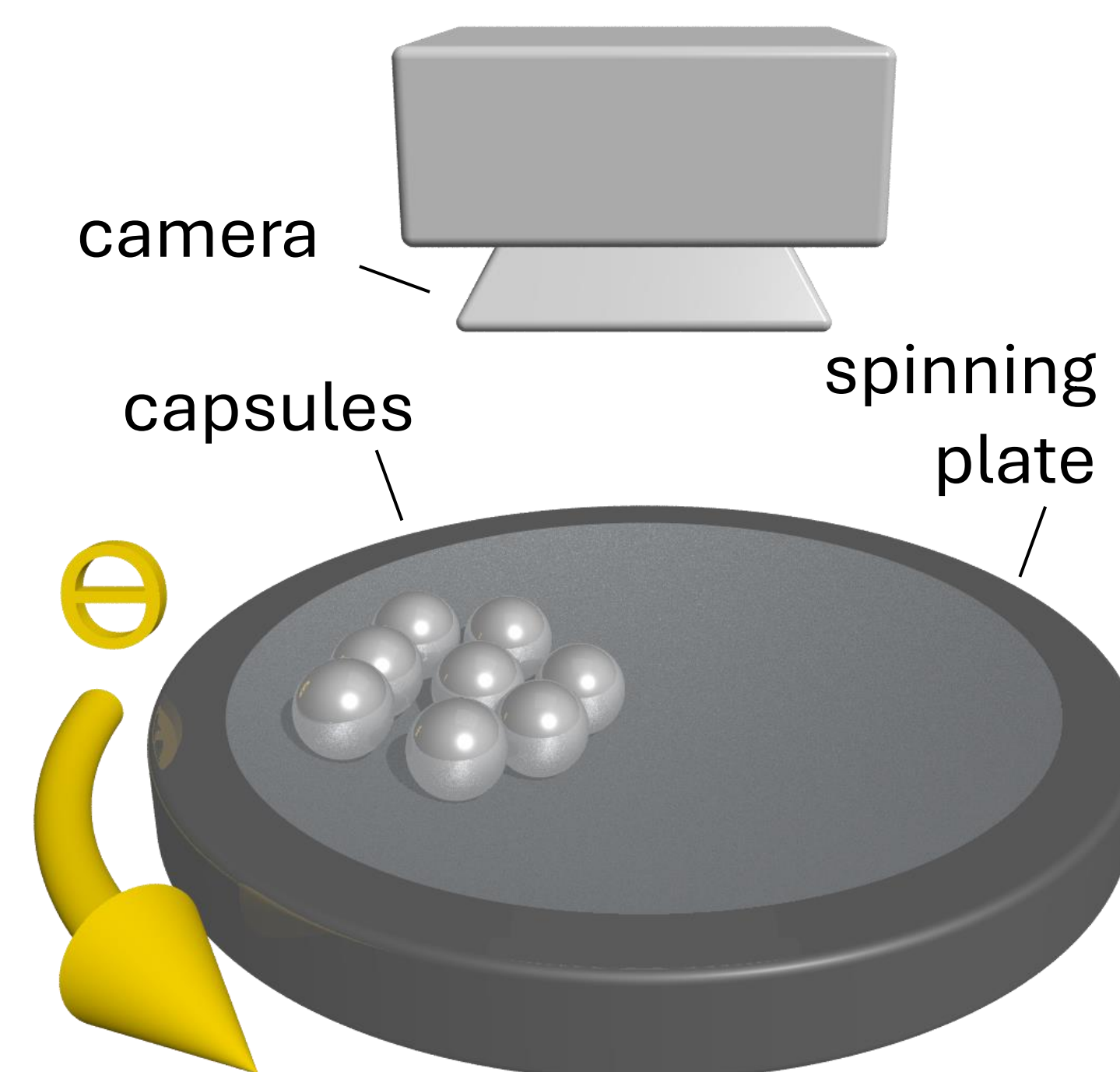
Geometrical uniformity in inertial confinement fusion ablator capsules plays a critical role in successful ignition experiments at the National Ignition Facility. Yet, the mechanism underlying the wall thickness non-uniformity, often referred to as “mode 1”, remains poorly understood. In this work, object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

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



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

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 $\mu\text{m}/\text{pxl}$ 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

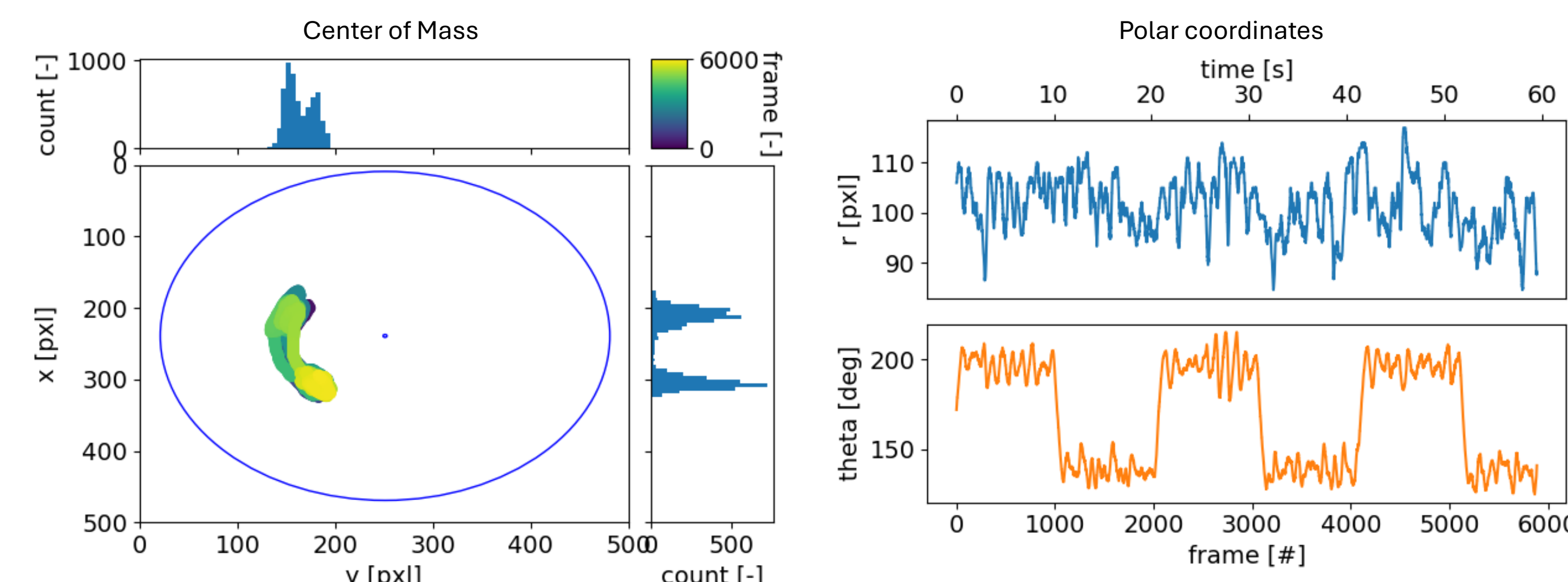
- Capsule detection is performed using YOLOv8 library, which employs **convolutional neural networks** to classify and locate objects.
- The model is trained on a minimum subset of ~27 capsules across ~7 frames.
- Each capsule is assigned an **identification number**, and its positions are tracked throughout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



PRELIMINARY RESULTS...

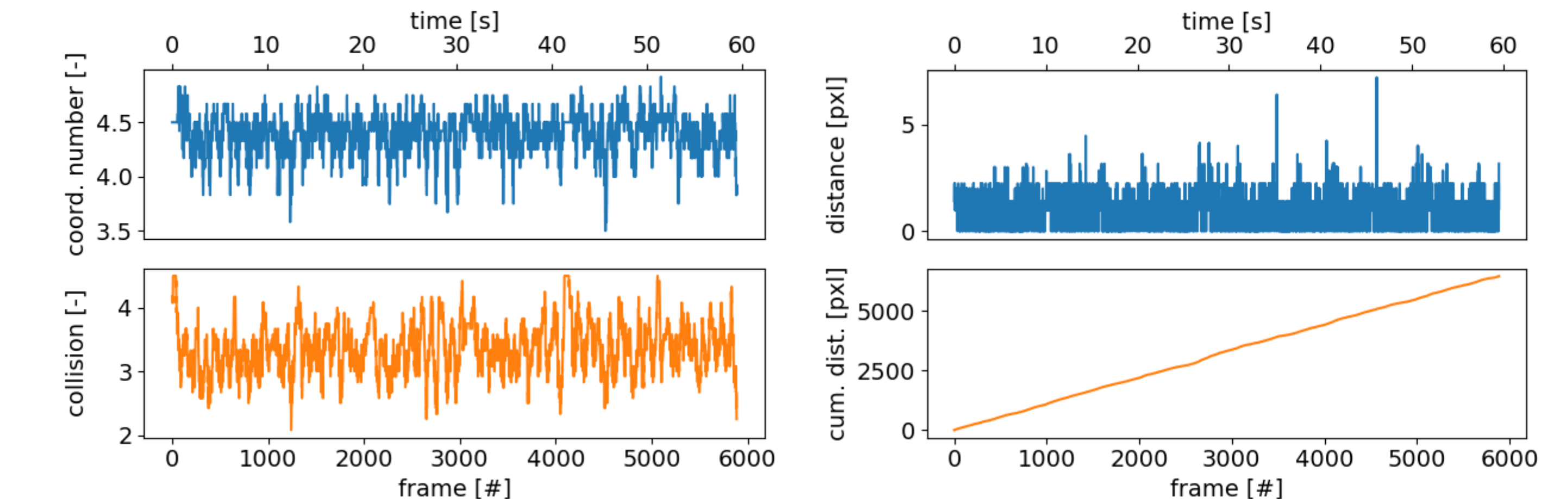
The following graphs illustrate various metrics used to analyze the motion behavior of the capsules.

- 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.

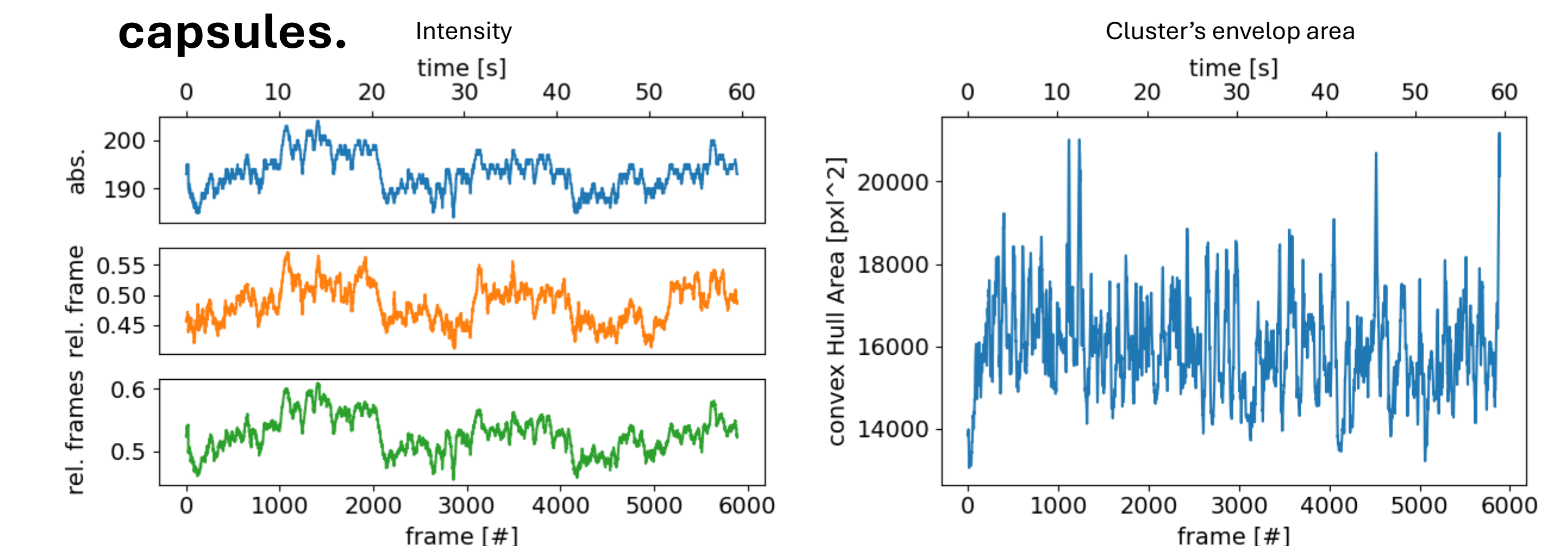


... PRELIMINARY RESULTS

- **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.

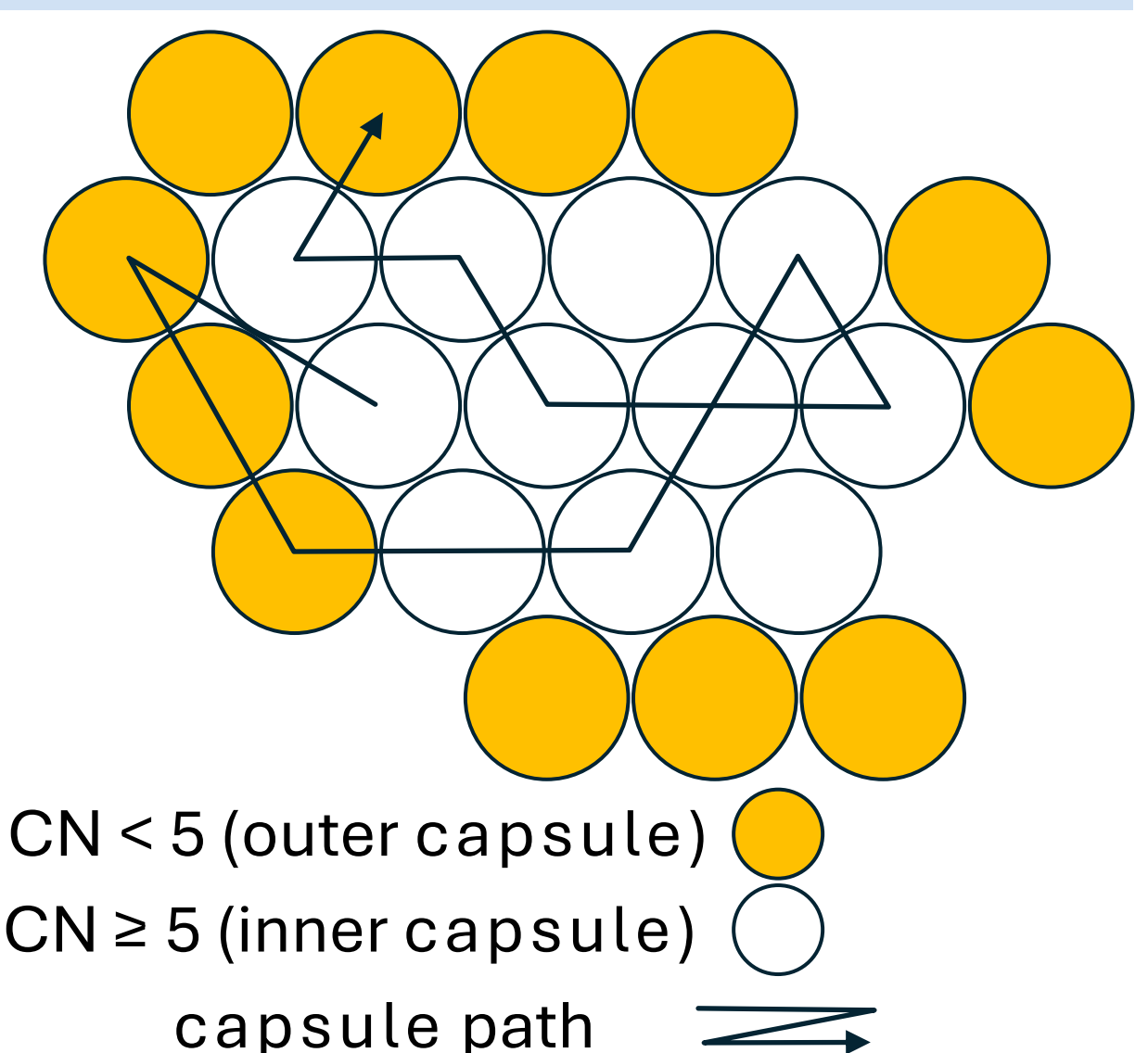


- Intensity fluctuations are monitored to detect shadowing and **thermal effects** that contribute to non-uniform coating.
- The area of the cluster is tracked to assess the **density of the capsules**.



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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