



# Coastal & Offshore Modelling Symposium

COMS2026



## Flume Confinement Effects on Near-Bed Flow and Scour Around Floating Offshore Wind Anchors

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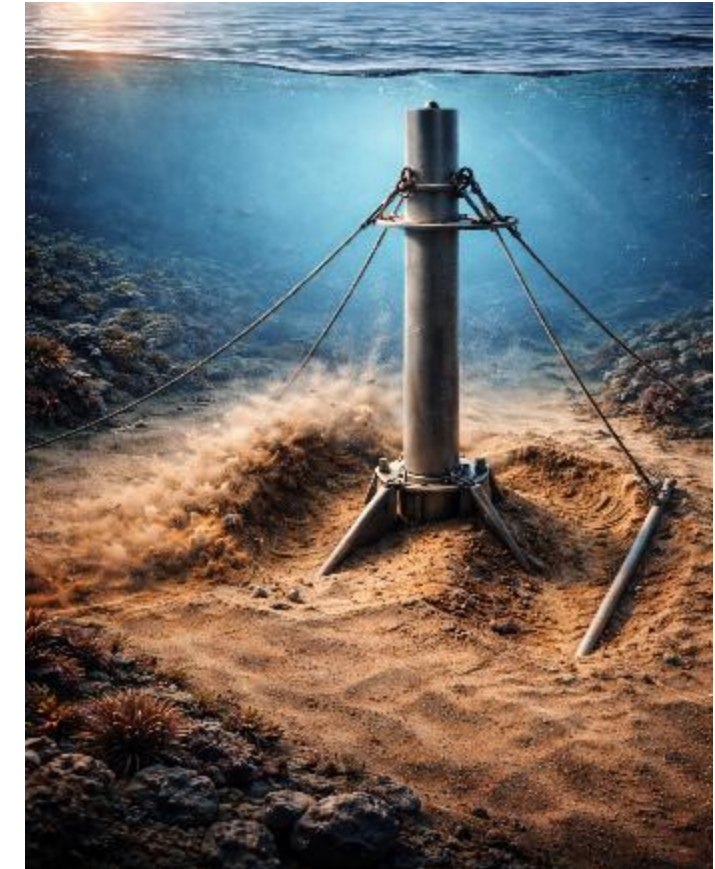
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## Floating Offshore Wind Anchors and Seabed Interaction

- Floating offshore wind farms operate in deeper, more energetic waters where anchors control system stability.
- Seabed scour around anchors can erode support and reduce long-term holding capacity, especially in sandy beds.
- Understanding flow–seabed interaction is essential for reliable design of floating offshore wind foundations.

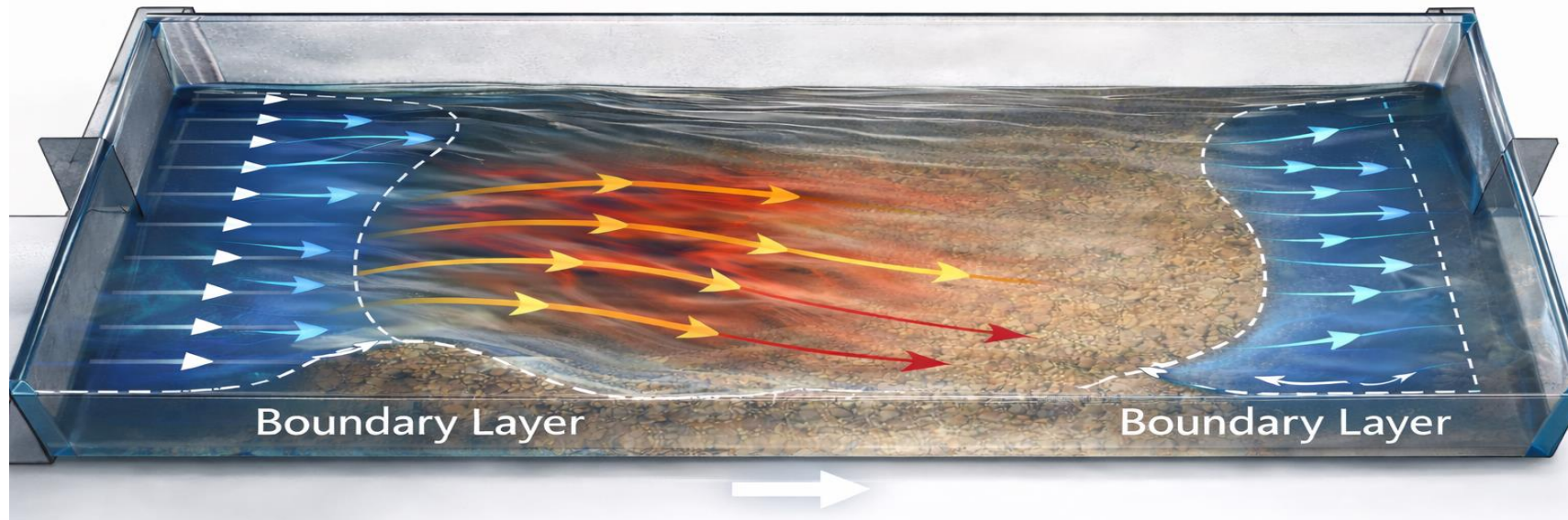




## Confinement as a Hidden Experimental Variable

Laboratory flume geometry itself distorts the flow field in ways not always recognized

- Narrow test sections → sidewalls restrict turbulence
- Velocity development modified across channel
- Near-bed flow behavior fundamentally altered
- Scour patterns differ from true open-channel conditions



## Research Objectives

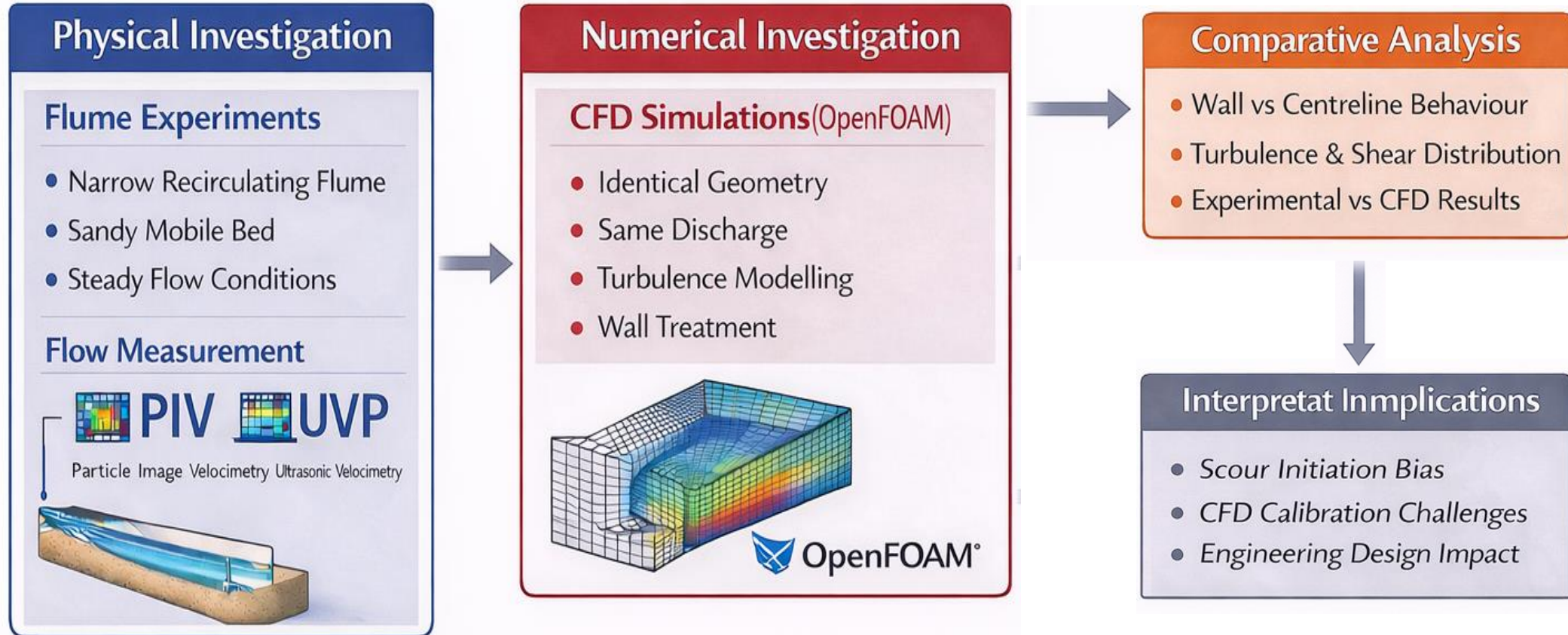
**Quantify wall-boundary effect on near-bed flow and turbulence in narrow flume**

**Link confinement to the onset and pattern of anchor scour**

**Validate CFD predictions against PIV and UVP measurements**

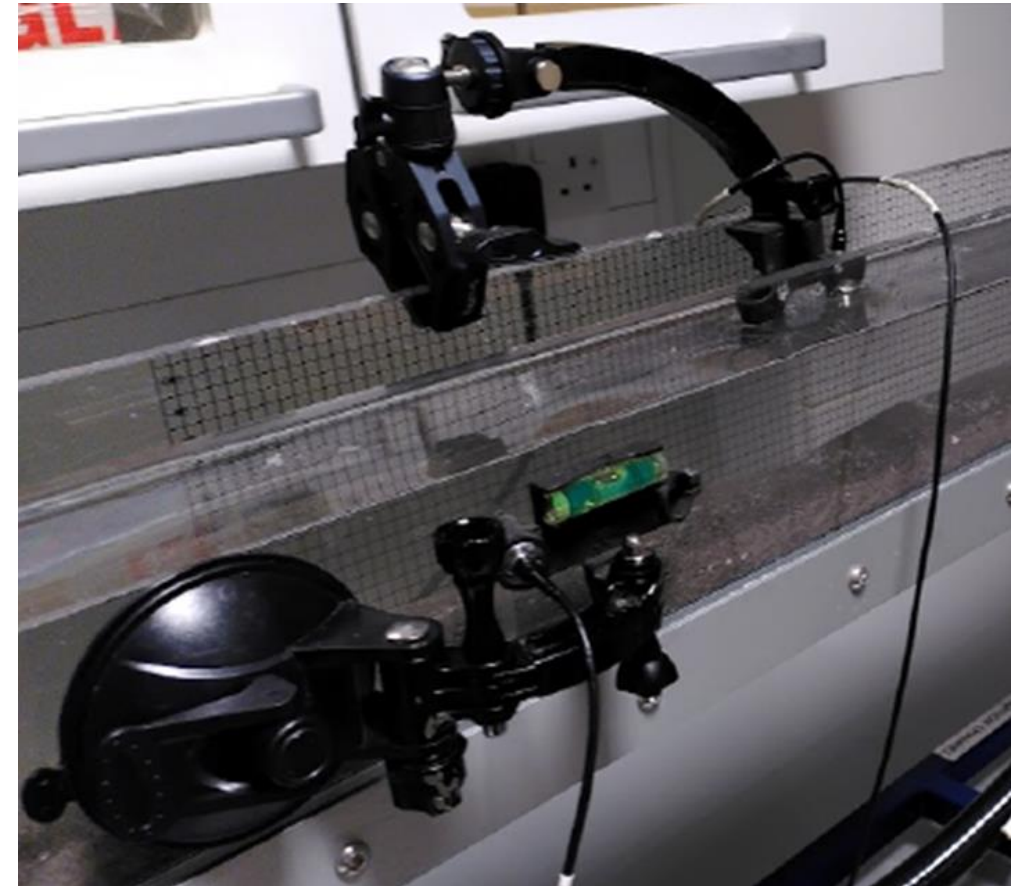
**Develop scaling guidelines that correct for confinement bias when using narrow-flume results for anchor design**

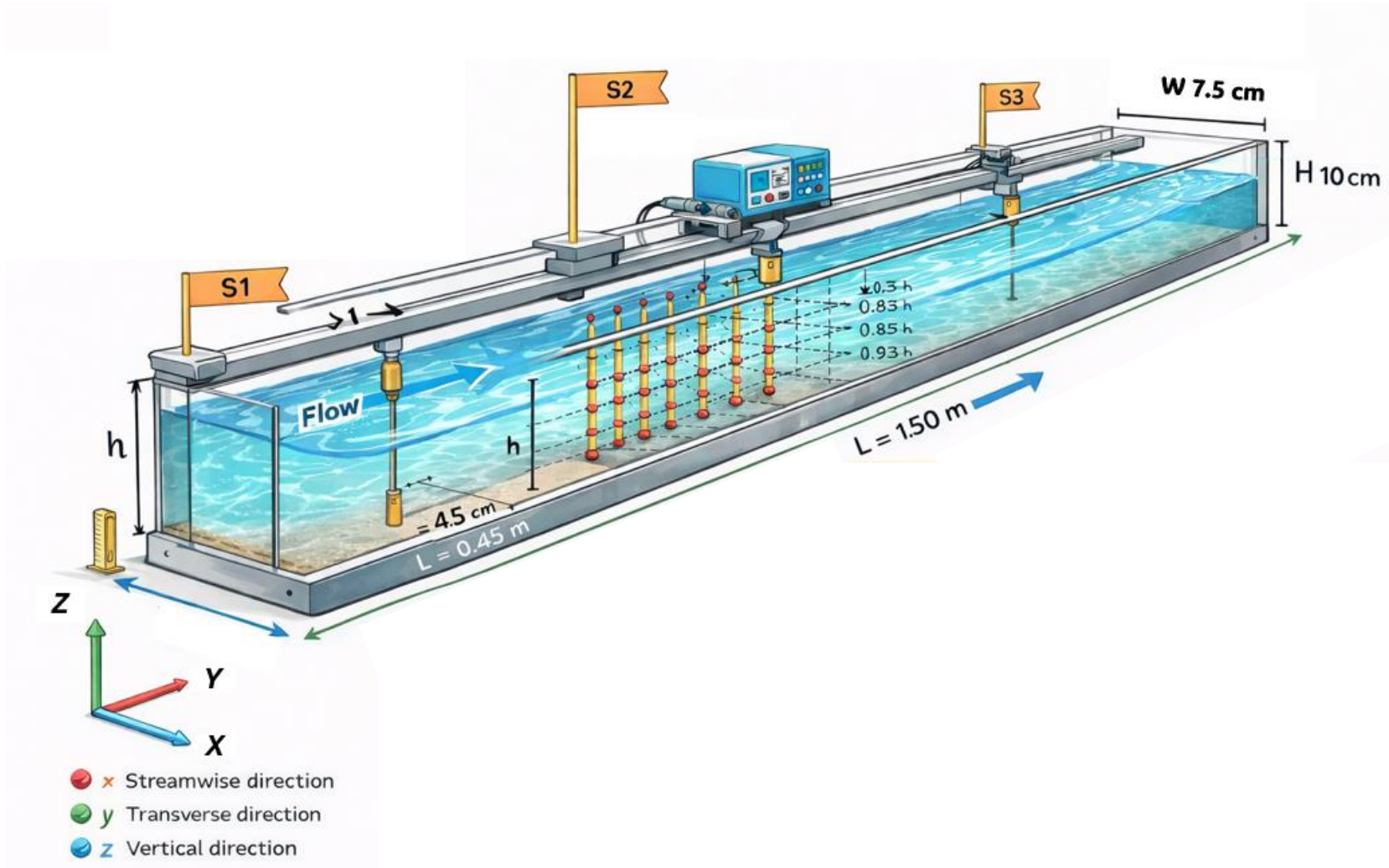
## Research Framework



## Ultrasonic Doppler Velocimeter / Velocity Profiler (UVP/UDV)

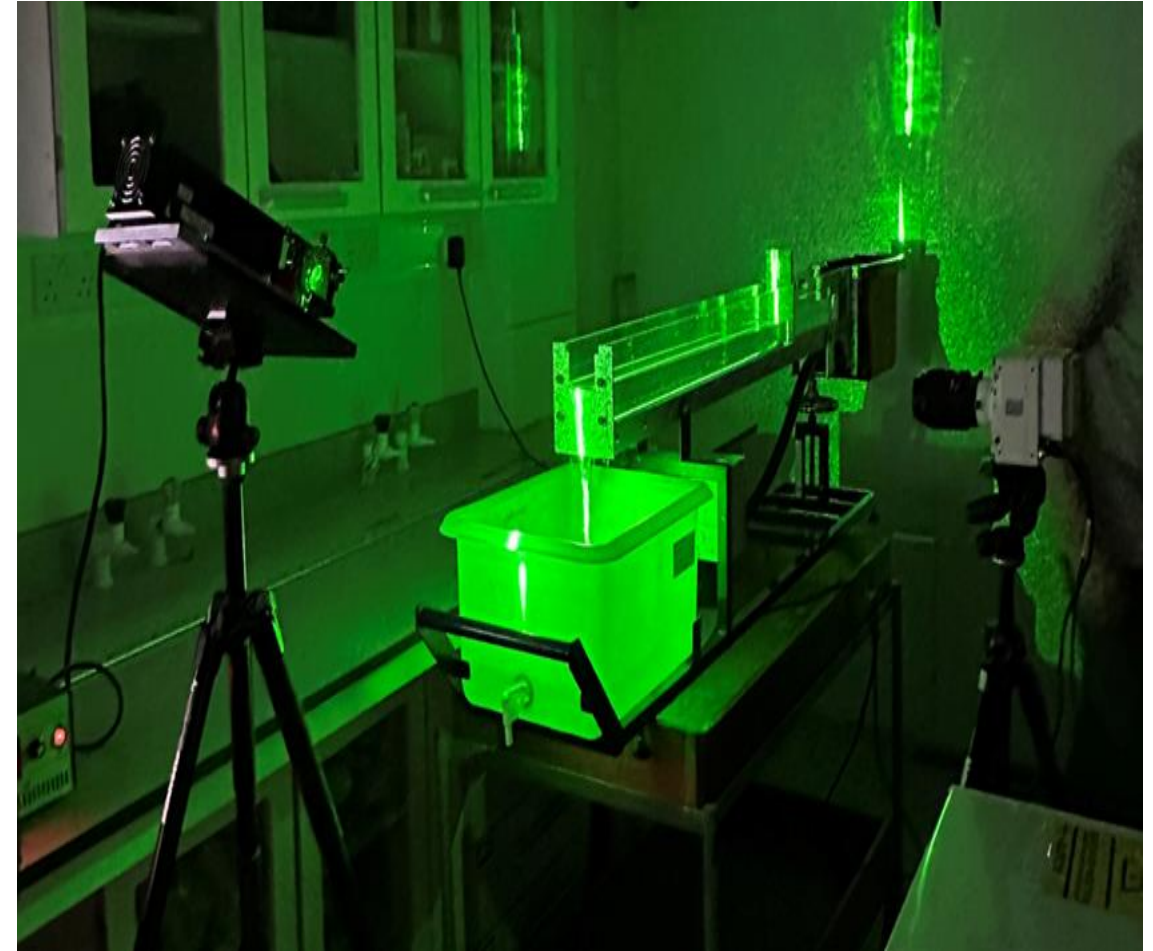
- UVP used alongside PIV to obtain streamwise velocity  $U$  profiles across the flume width at selected vertical positions.
- Measurements acquired with 3 MHz UBERTONE probes mounted on the sidewall or above the flume, with the acoustic beam directed downward into the flow.
- Time-averaged profiles obtained by averaging several minutes of data, with settings optimized for near-bed and near-surface zones where PIV is less reliable.
- An overlap region (around mid-depth) used to compare UVP and PIV, assess uncertainty, and check consistency; data affected by acoustic near-field or surface interference were discarded.

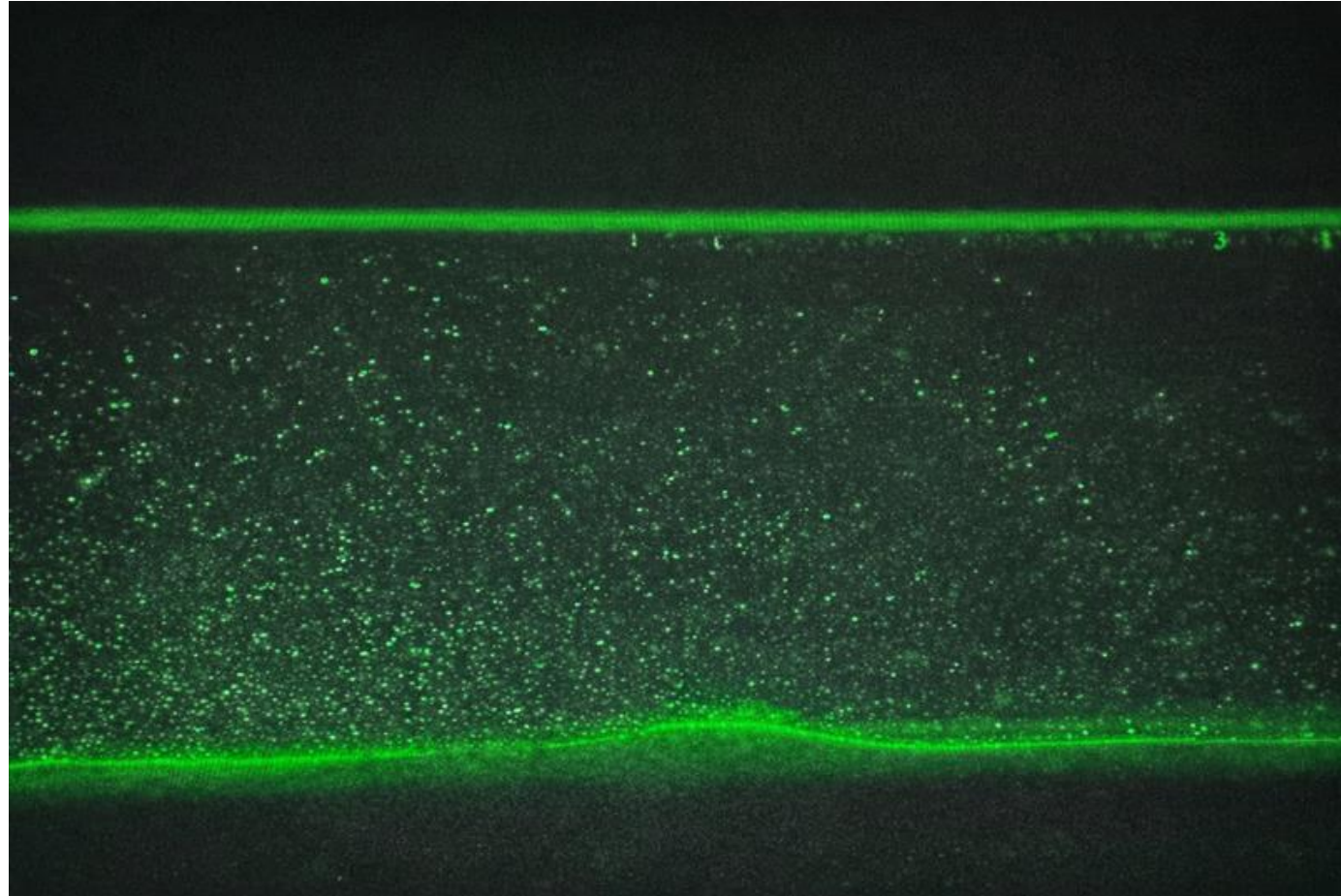




## Particle Image Velocimetry (PIV)

- Two-component planar PIV measuring  $V$  and  $W$  in the  $x$ - $z$  plane at a selected cross-section.
- Flow seeded with tracers and illuminated by a 2 W, 532 nm continuous-wave laser sheet through the sidewall.
- High-speed Phantom camera normal to the sheet; images calibrated with a target of known dimensions.
- Processed using pre-processing and multi-pass cross-correlation to obtain mean velocity fields and turbulence statistics.

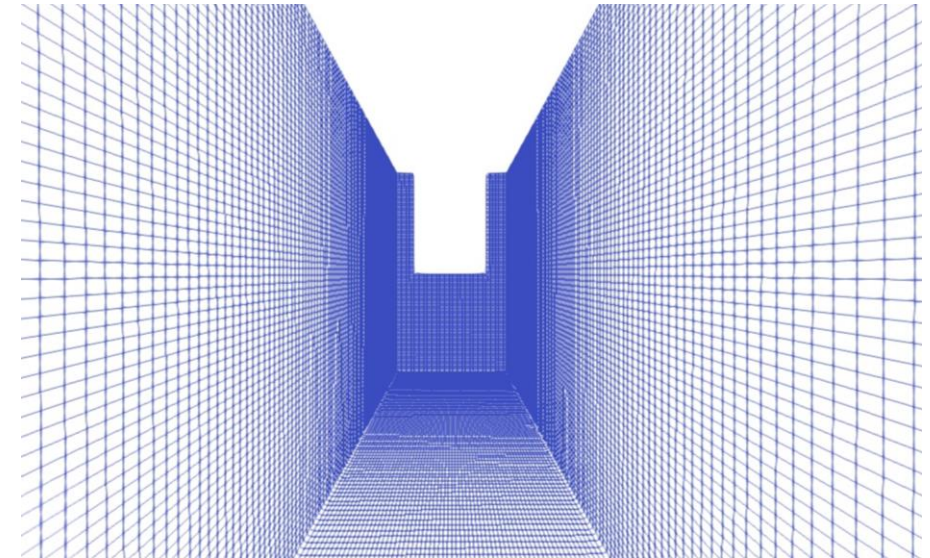


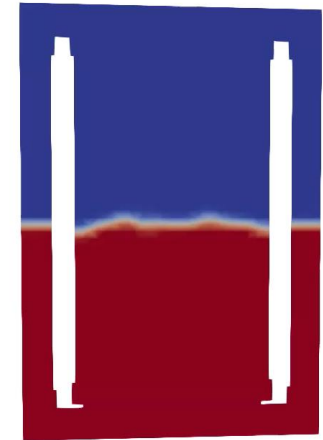
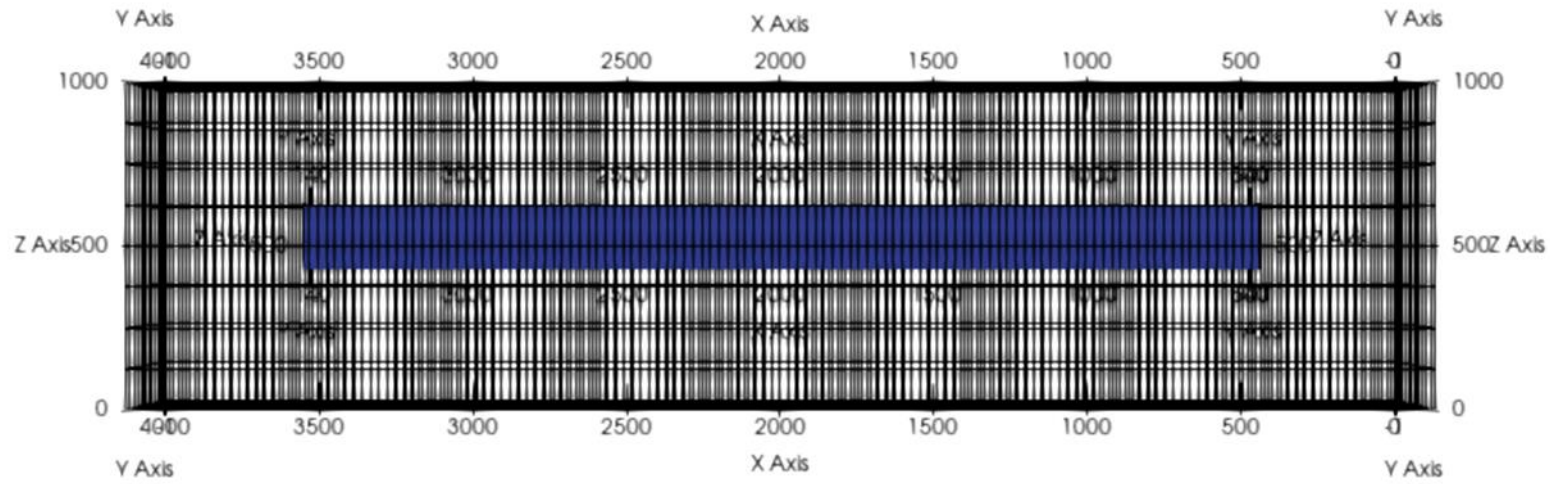
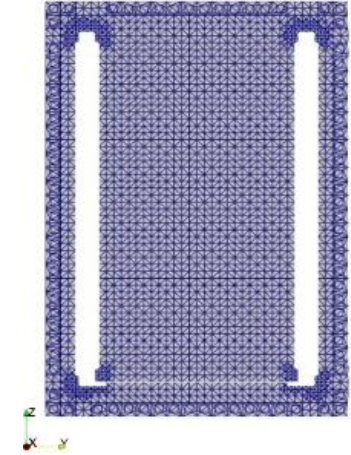
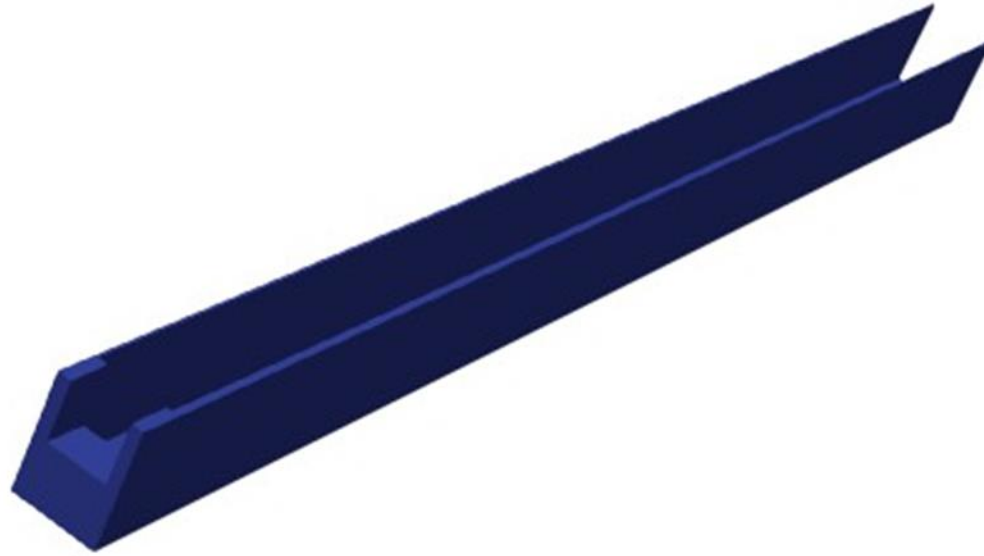


Raw PIV image showing tracer particle distribution within the measurement plane illuminated by a laser sheet

## Numerical Modeling Approach

- Three-dimensional CFD model of the laboratory flume using a finite-volume solver for incompressible flow, matching  $L = 1.5$  m,  $B = 0.075$  m,  $H = 0.10$  m.
- Mesh generated with a hexahedral background grid using blockMesh, followed by local refinement with snappyHexMesh.
- Refinement box and additional refinement applied near the walls and internal flume surfaces to better resolve boundary layers.
- Near-wall spacing  $\approx 0.5$  mm, giving a mesh of  $\sim 2.5$  million cells.
- Mesh quality indicators (non-orthogonality, skewness, aspect ratio, openness, cell volume range) are within accepted limits, ensuring a watertight and numerically stable grid.





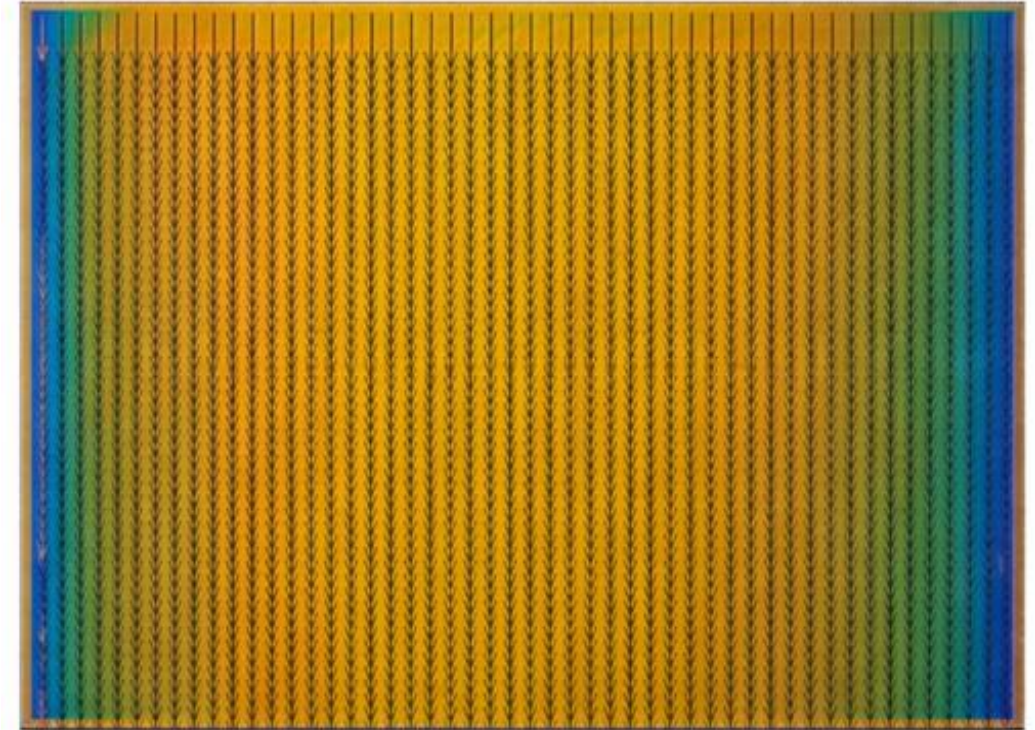
## Confinement Bias & Analysis Framework

- Confinement bias is defined relative to a central, quasi-unconfined region where sidewall effects are minimal.
- At each elevation, local streamwise velocity and turbulence intensity are compared to this reference across the width.
- Lateral profiles at fixed heights map how strong and how wide the sidewall influence is.
- The framework is applied to experimental velocity fields and will be extended to quantify impacts on velocity profiles, secondary currents, and near-bed shear stress.

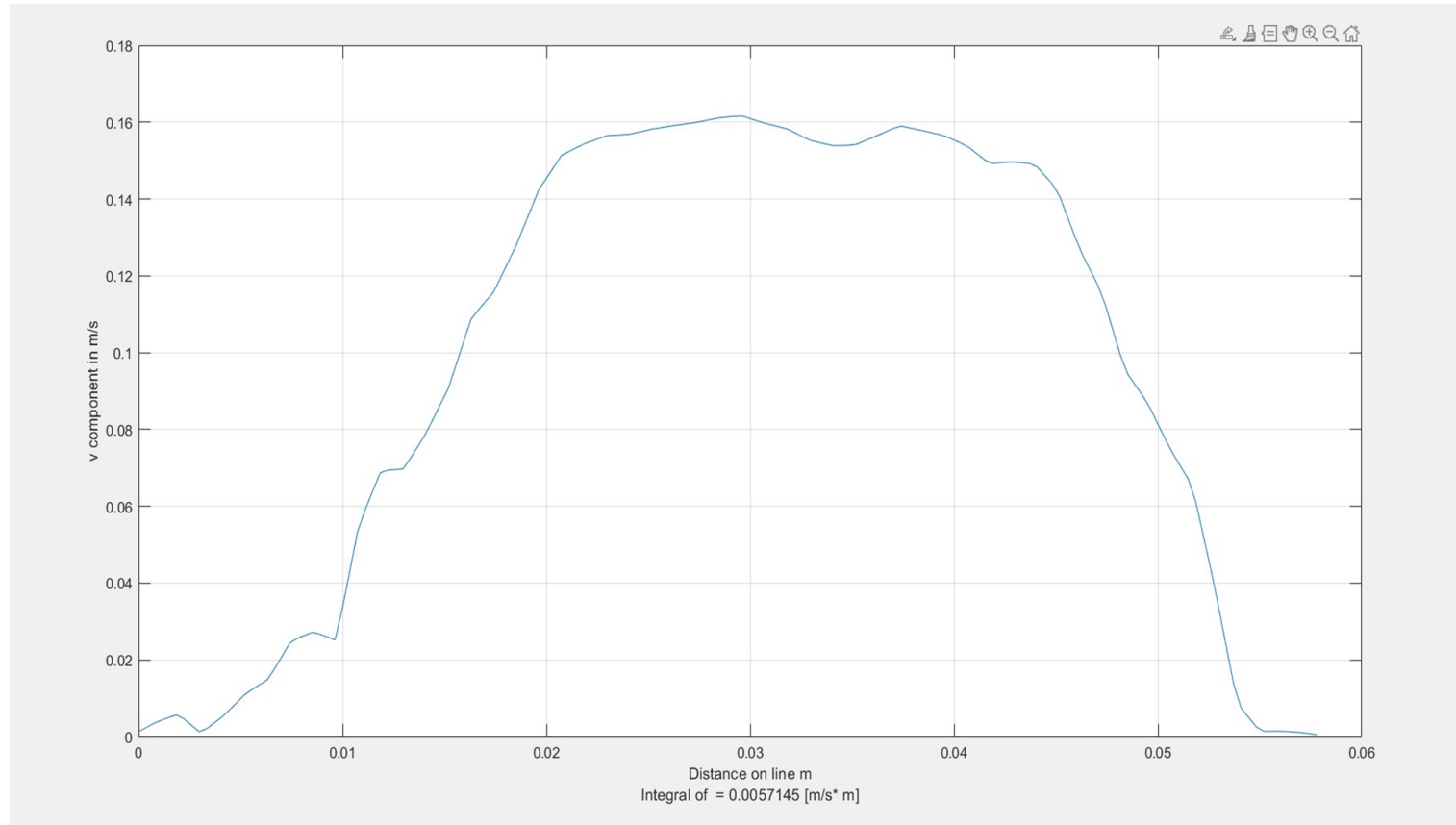


## Preliminary Results

- PIV shows a strong lateral variation of streamwise velocity, with a maximum at the centreline and lower values near the sidewalls, consistent with sidewall boundary layers and narrow-channel secondary flows.
- UVP profiles have a similar shape and agree well with PIV in the overlap region, confirming both methods capture confinement effects reliably.
- CFD currently resolves bulk flow and the air–water interface but under-resolves near-wall boundary layers; future mesh refinement and unsteady simulations (targeting  $y^+ \approx 1$  (will improve sidewall resolution and support detailed confinement-bias analysis.



Initial streamwise (x-direction) PIV velocity field, showing lateral gradients across the flume with reduced velocities near sidewalls and higher velocities centrally



Velocity profile of the  $V$  component along a transverse line across the channel, showing near-zero speeds at the boundaries and a peak ( $\sim 0.16$  m/s) in the center



Sample output from the CFD simulation showing water (in red) and air (in blue).



## Conclusions

- This study proposes a systematic framework to quantify confinement bias in narrow flume experiments relevant to offshore anchor scour.
- Validated PIV and UVP methodologies capture sidewall effects across the full flume width, and are complemented by a 3D CFD model of the laboratory flume.
- Together, these tools provide a consistent basis for interpreting near-bed flow and turbulence under confined conditions and for improving the reliability of laboratory–CFD comparisons.

## Future Work

- Analyze the full PIV–UVP datasets together with more advanced CFD simulations to quantify confinement bias for different flume aspect ratios (B/H).
- Characterize sidewall effects on velocity profiles, secondary currents, and near-bed shear stress using classical open-channel benchmarks and tailored metrics.
- Determine quasi-unconfined core regions and develop quantitative thresholds for when narrow-flume hydraulics remain reliable for sediment mobility and offshore scour predictions, including refined uncertainty bounds.

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**Thank for the listening!**  
**Question?**