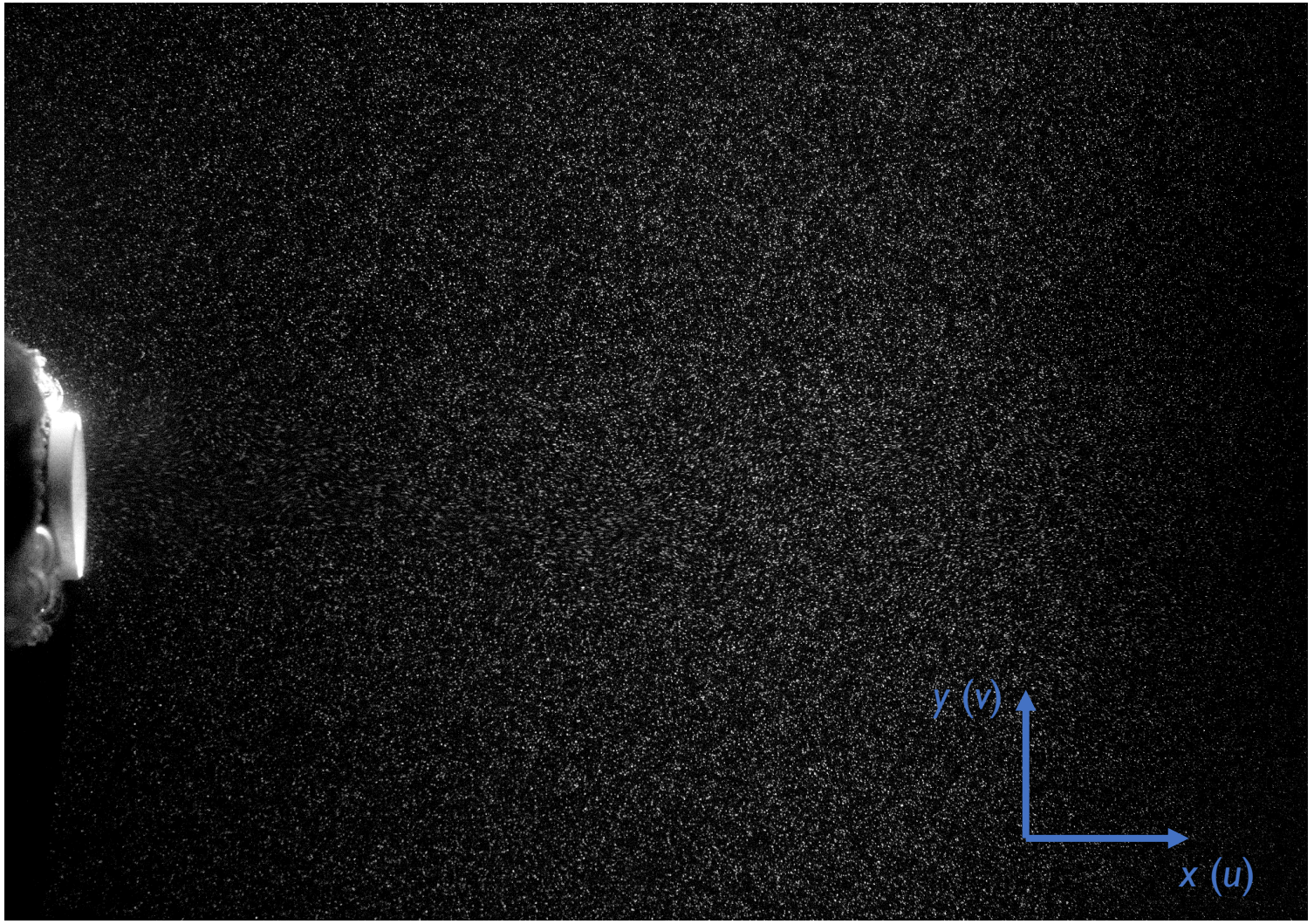
Particle Image Velocimetry (PIV)

MAE 519, Fall 2019

Daniel Ruth, Luc Deike, Baptiste Néel, and Daniel Shaw

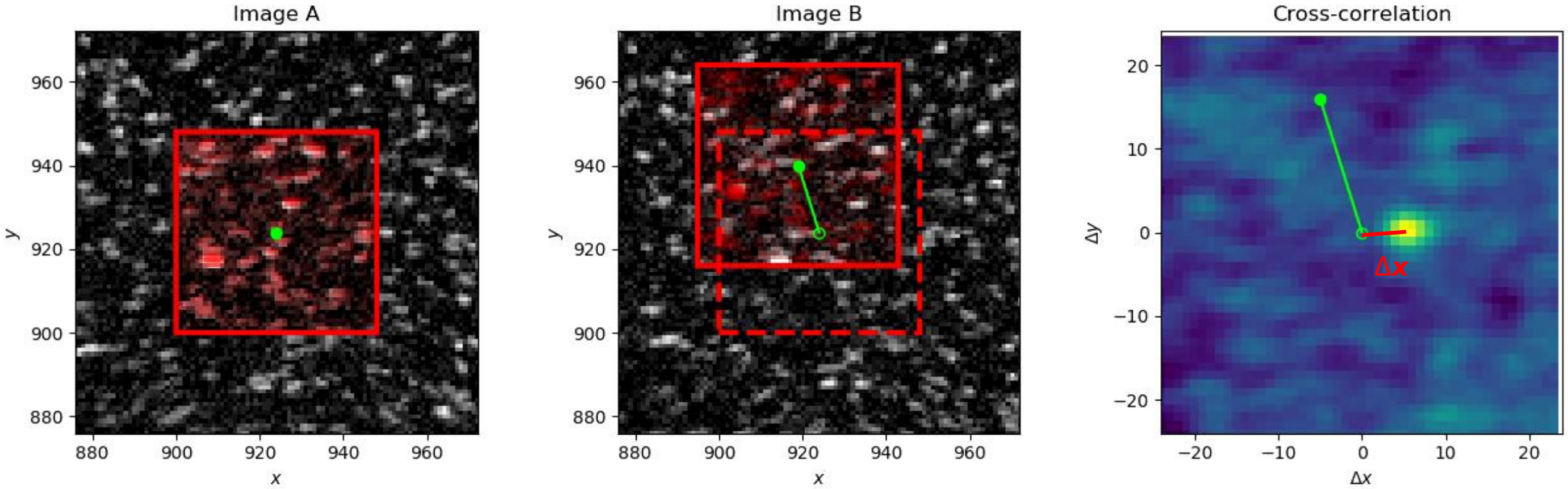
A sheet of particles is illuminated in the flow.



Particles are small and neutrally buoyant so they **follow the flow**.

The motion of the particles reveals **two of the three velocity components** in a **single plane** in the flow.

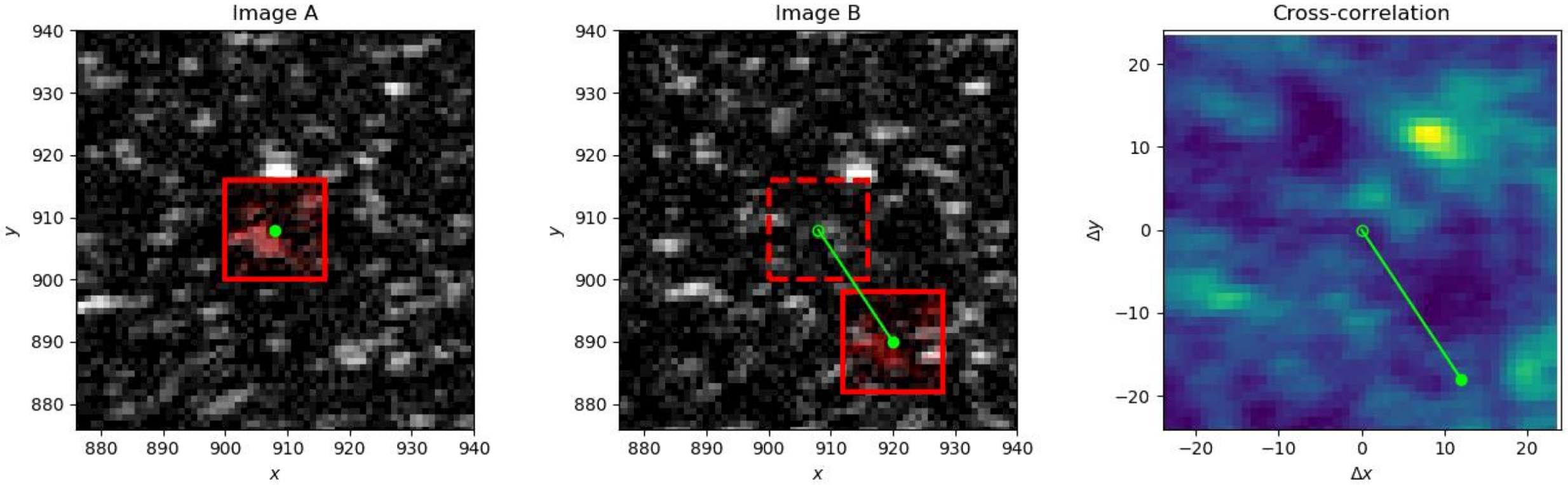
Back-to-back images are correlated to determine the particle displacement between frames.



Compute the velocity in the window as $\boldsymbol{u} = \Delta\boldsymbol{x} / \Delta t$.

PIV calculates an **average velocity** in the interrogation window—it may filter out smaller-scale motions!

Back-to-back images are correlated to determine the particle displacement between frames.



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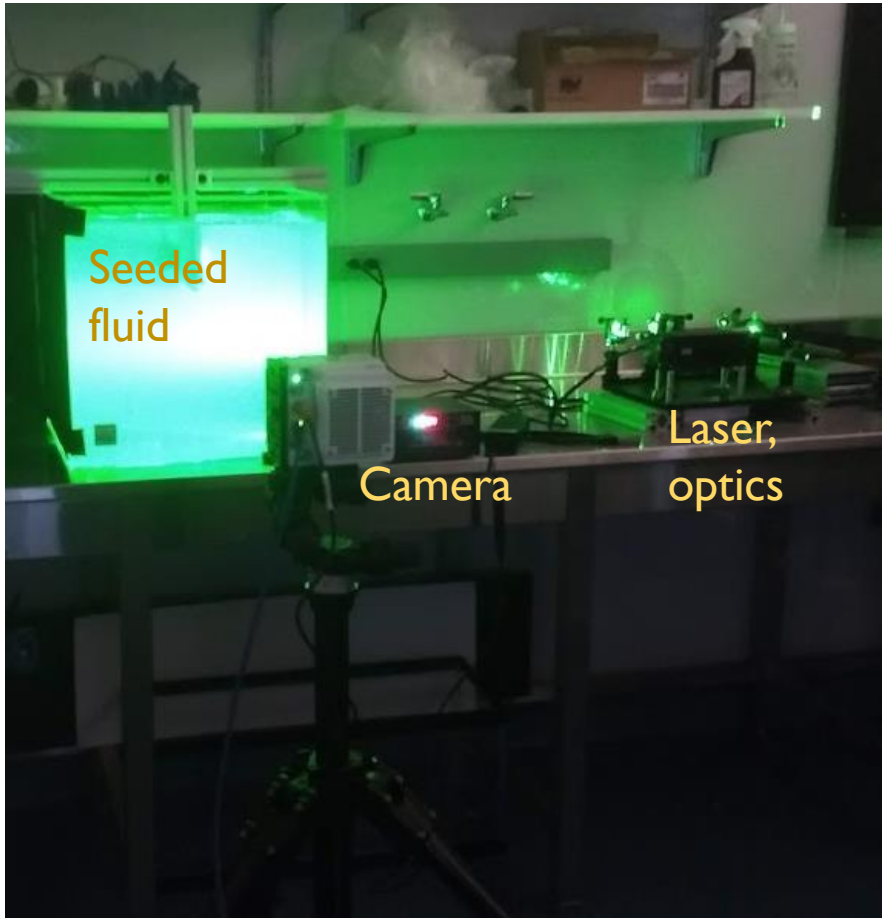
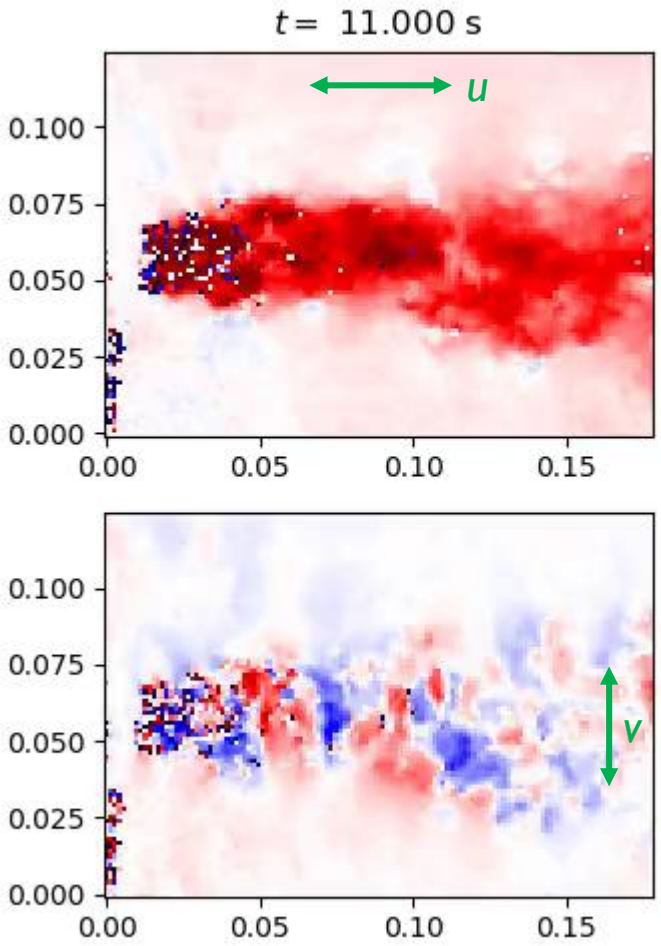
Designing a PIV experiment

- **Camera/optics** → pixel size, a/b frame time separation
- **Laser sheet/seeding** → laser sheet intensity and thickness, seeding material and particle density
- **Processing** → window size, correlation method, filtering



Project: measuring the velocity field in a turbulent water jet



- Take two sets of PIV measurements: **large-scale** view and **small-scale** view
  - Calculate the seeding density, frame rate, etc. requirements for each
  - How do the statistics compare?

- Evaluate with two open-source PIV packages: **OpenPIV** (Python) and **PIVLab** (Matlab)
  - Different approaches to correlating particle displacements; how does this affect the results?

Designing the experiments

Two views: pixel size ~ 100 μm (large-scale), 50 μm (zoomed-in).

Typical velocity is ~ 0.5 m/s.

To determine the **seeding density**:

- Want ~10 particles/PIV window
- Particles are spheres ~ 30 μm in diameter, same density as water
- Window is ~ 32 x 32 pixels^2
- Laser sheet is ~ 0.5 mm thick
- The tank holds 0.08 m^3 of water

To determine the **frame rate**:

- Want particles to move ~ ¼ of the window size between a/b frames

Ken Kriger, Introduction of Particle Image Velocimetry
https://www2.cscamm.umd.edu/programs/trb10/presentations/PIV.pdf

Before lab on Friday

Download/install **software** packages:

- Matlab
- PIVLab 2.20
- Python 3
- OpenPIV-python
- Sample processing code: https://github.com/DeikeLab/MAE519/tree/master/PIV
  (The list of required code is there as well)

Estimate experimental parameters for the two experiments to be conducted, given the guidelines in the previous slide (available on Blackboard).

Complete the **laser safety training**.