

**Advanced laser-optical  
measurement techniques  
in fluid dynamics**  
LDA, PDA, PIV, PTV(S)

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# Laser-optical measurement techniques

- LDA** Laser Doppler Anemometer (velocity vector component(s), Reynolds-stresses, turbulent characteristics)
- PDA** Phase Doppler Anemometer (velocity vector component(s), Re-stresses, turbulent characteristics and also particle diameter)
- PIV** Particle Image Velocimetry (2D/3D velocity vector field, Re-stresses, turb. characteristics)
- PTV(S)** Particle Tracking Velocimetry and Sizing (2D velocity vector component(s), Re-stresses, turbulent characteristics and also particle diameter, size)

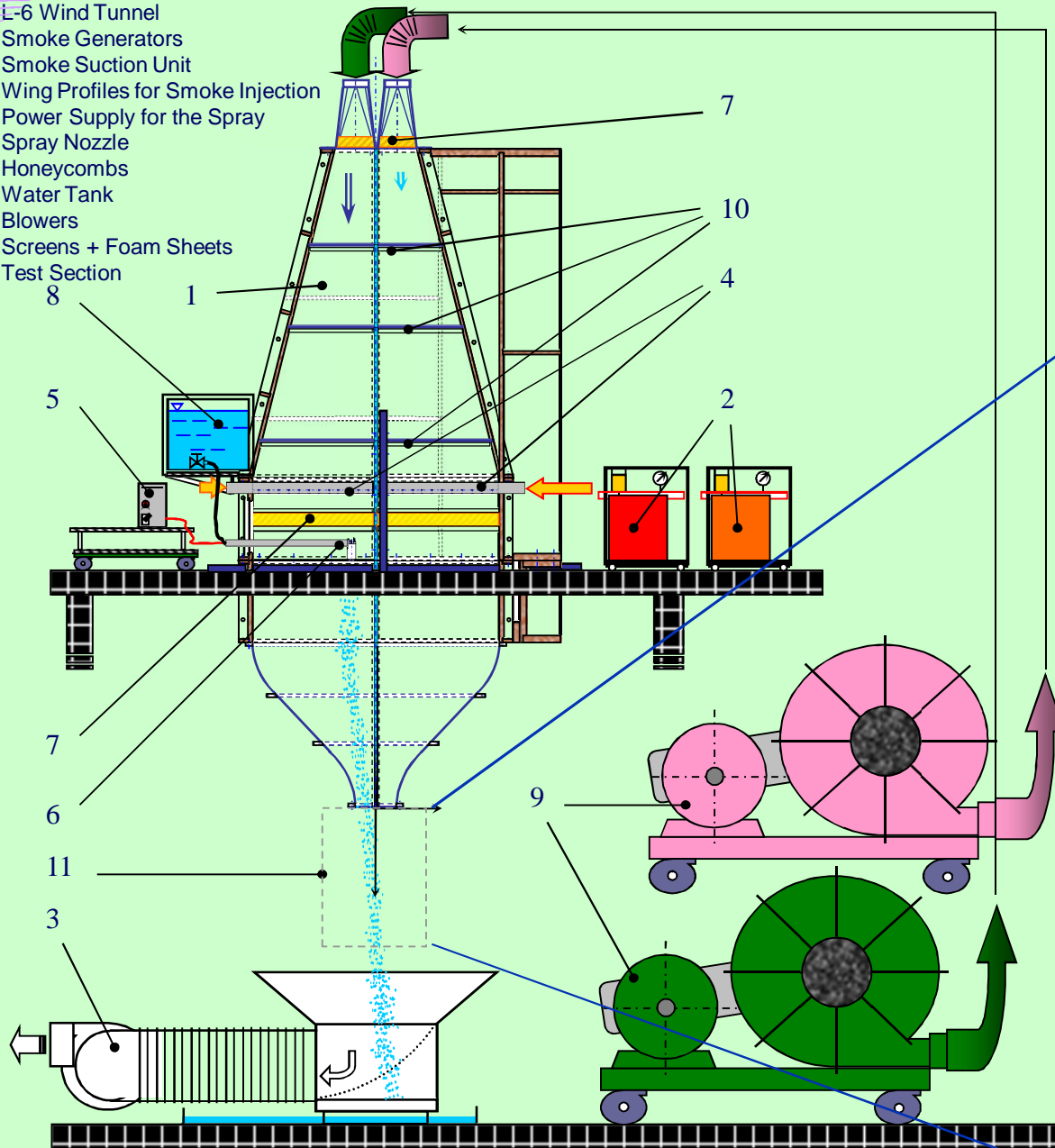


VON KÁRMÁN INSTITUTE FOR FLUID DYNAMICS

**Measurements performed at the Von Kármán Institute for Fluid Dynamics (BELGIUM) in course of a Diploma Course 1999-2000**

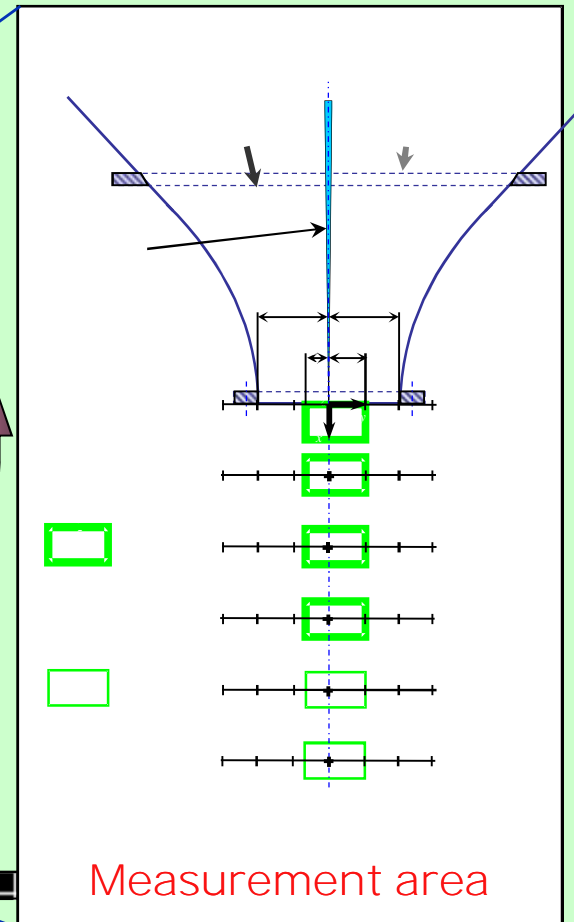


- 1 L-6 Wind Tunnel
- 2 Smoke Generators
- 3 Smoke Suction Unit
- 4 Wing Profiles for Smoke Injection
- 5 Power Supply for the Spray
- 6 Spray Nozzle
- 7 Honeycombs
- 8 Water Tank
- 9 Blowers
- 10 Screens + Foam Sheets
- 11 Test Section



# Set-up

„L-6“ twin-jet  
wind tunnel





## PARTICLE IMAGING VELOCIMETRY

### Particle Image Velocimetry PIV

- CCD
  - ◆ image 1280×768 pixel ( $\approx 85 \times 50$  mm)
- Nd:YAG impulse laser /6W, 0-20 Hz/
- 3D positioning
- SensiCam imaging software

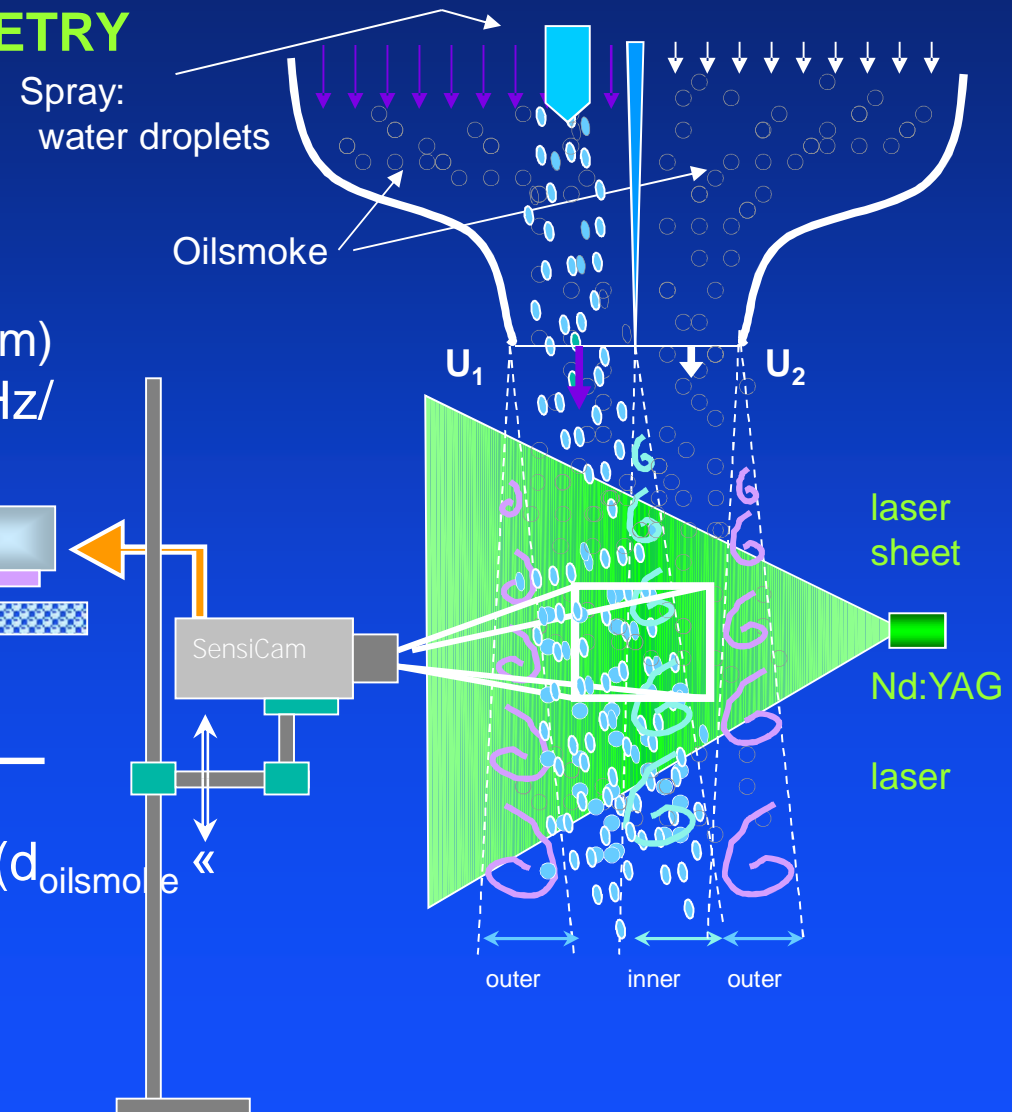
### Particle Tracking Velocimetry and Sizing - PTV(S)

For two-phase flow

- Phase discrimination by image size ( $d_{\text{oil smoke}} \ll d_{\text{water droplet}}$ )

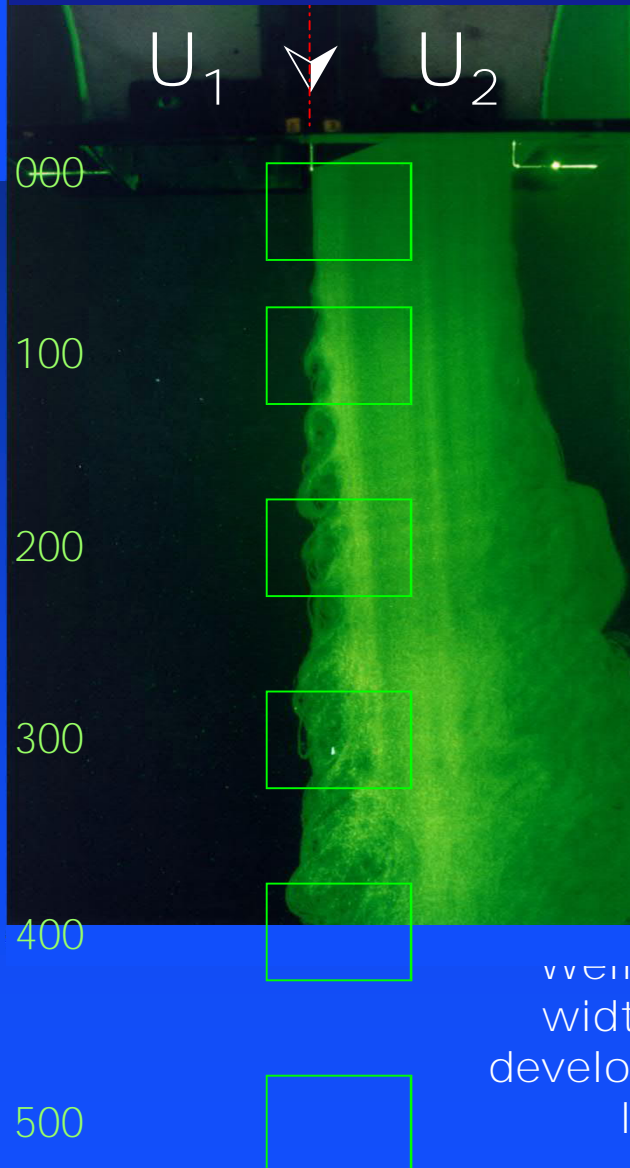
**Data processing:**

- Matlab, TecPlot, Excel, etc.

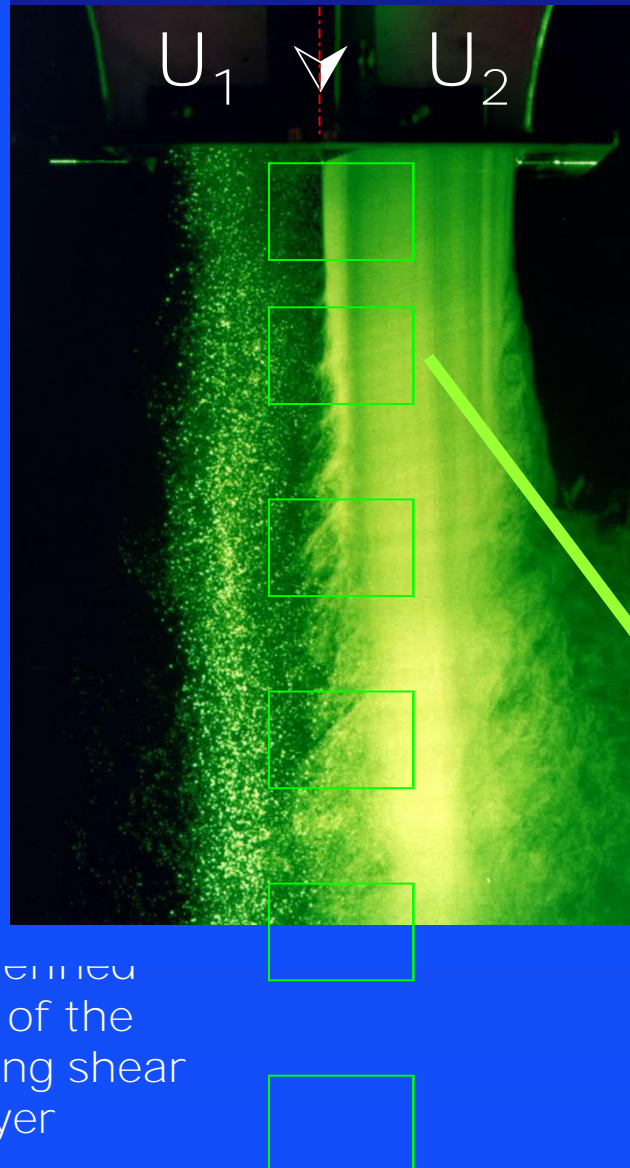




## Single phase flow



## Two-phase flow



Flow  
visualization

$$U_1 = 2 \text{ m/s}$$
$$U_2 = 1 \text{ m/s}$$

Digital image  
acquisition

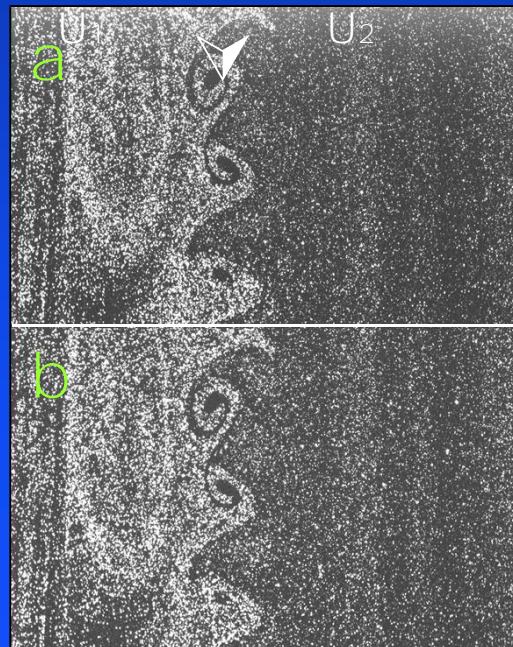
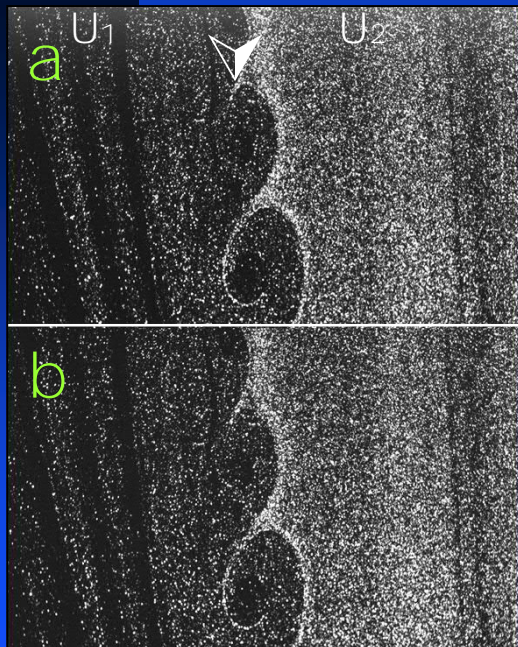
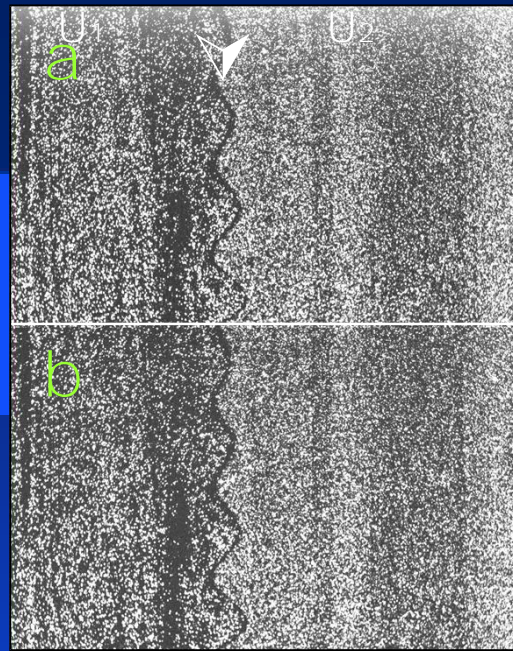
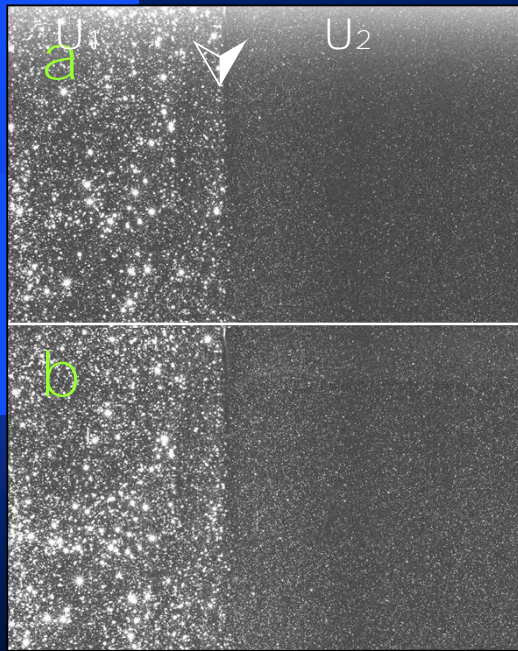
Particle  
Imaging  
Velocimetry

PIV

PTV(S)

well defined  
width of the  
developing shear  
layer





Successive  
images

$\Delta t_{a-b}$

displacement

$\Delta x, \Delta y$

velocity vectors

$\underline{v}$





# PIV

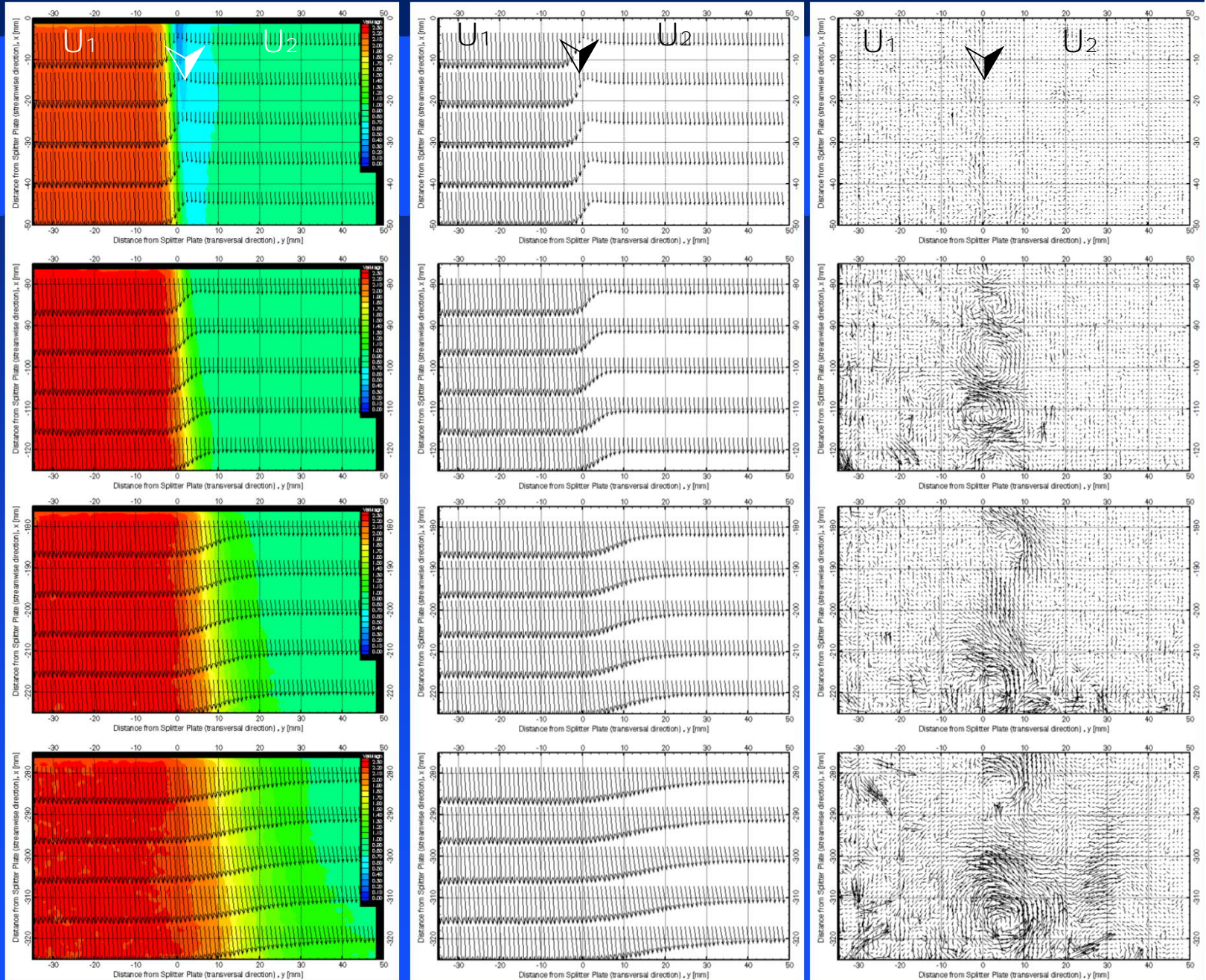
Particle Image Velocimetry

## Result

159x95

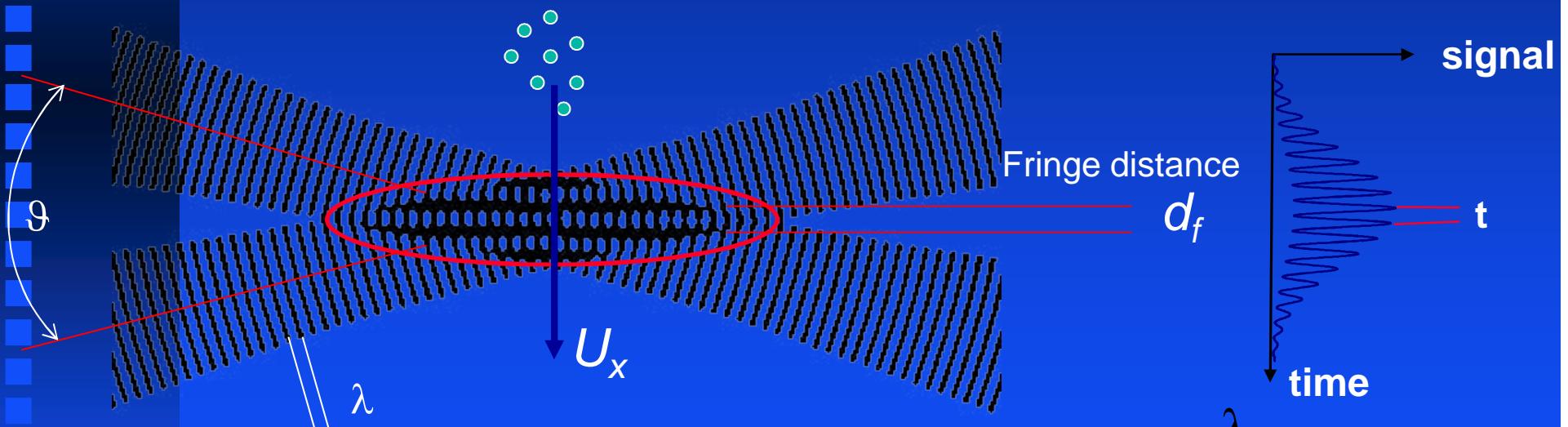
vectors

$u, v, u', v', T.I., \Omega_z,$



# Laser Doppler Anemometer

- Probe volume: laser beams crossing: ellipsoid
- Tracer / seeding problematic



$\lambda$  wavelength of the laser light

$\vartheta$

$f_D$  Doppler-frequency

$$d_f = \frac{\lambda}{2 \sin(\vartheta/2)}$$

$$U_x = d_f \cdot f_D$$