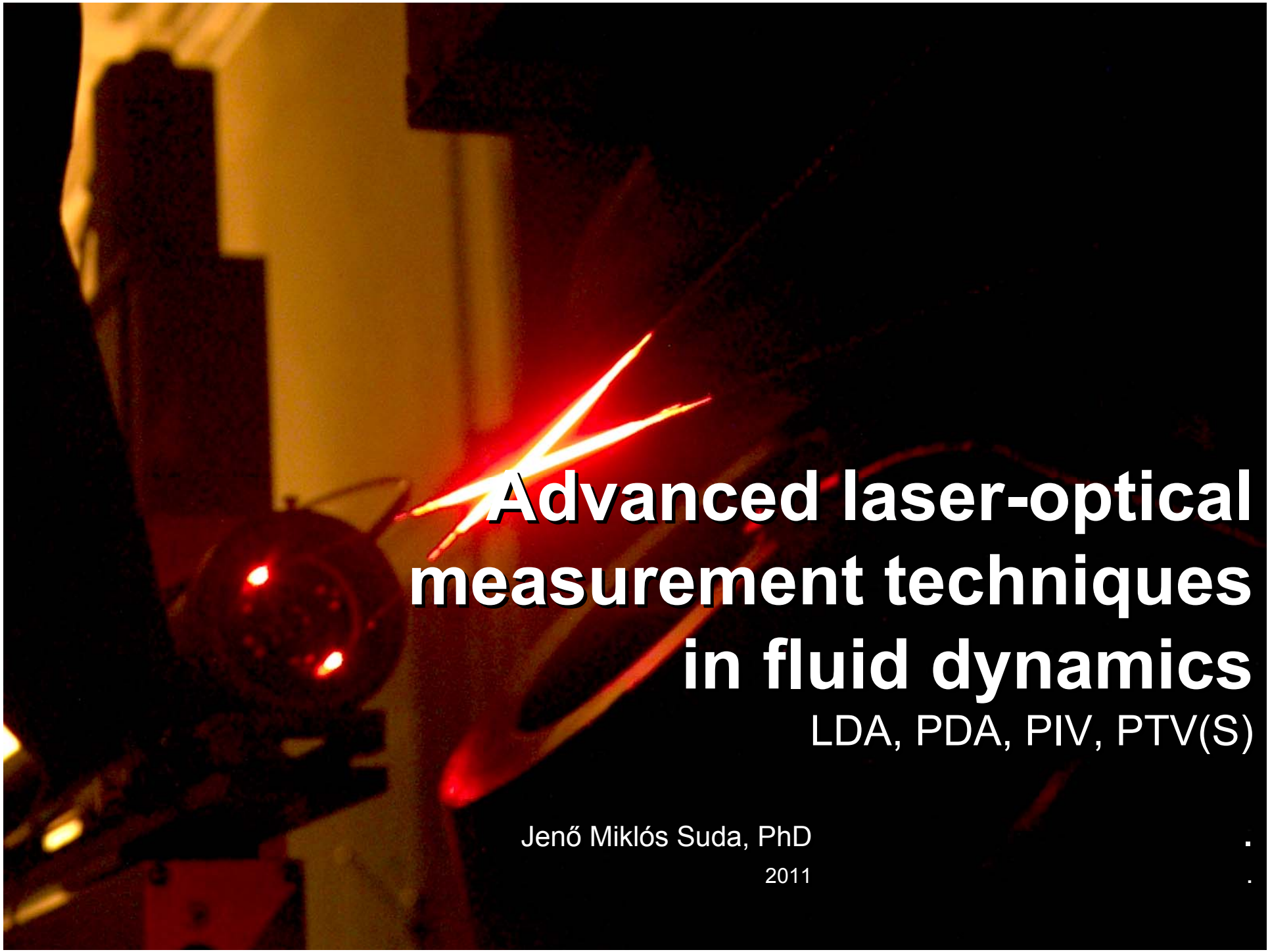


Advanced laser-optical measurement techniques in fluid dynamics

LDA, PDA, PIV, PTV(S)

Jenő Miklós Suda, PhD

2011

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)

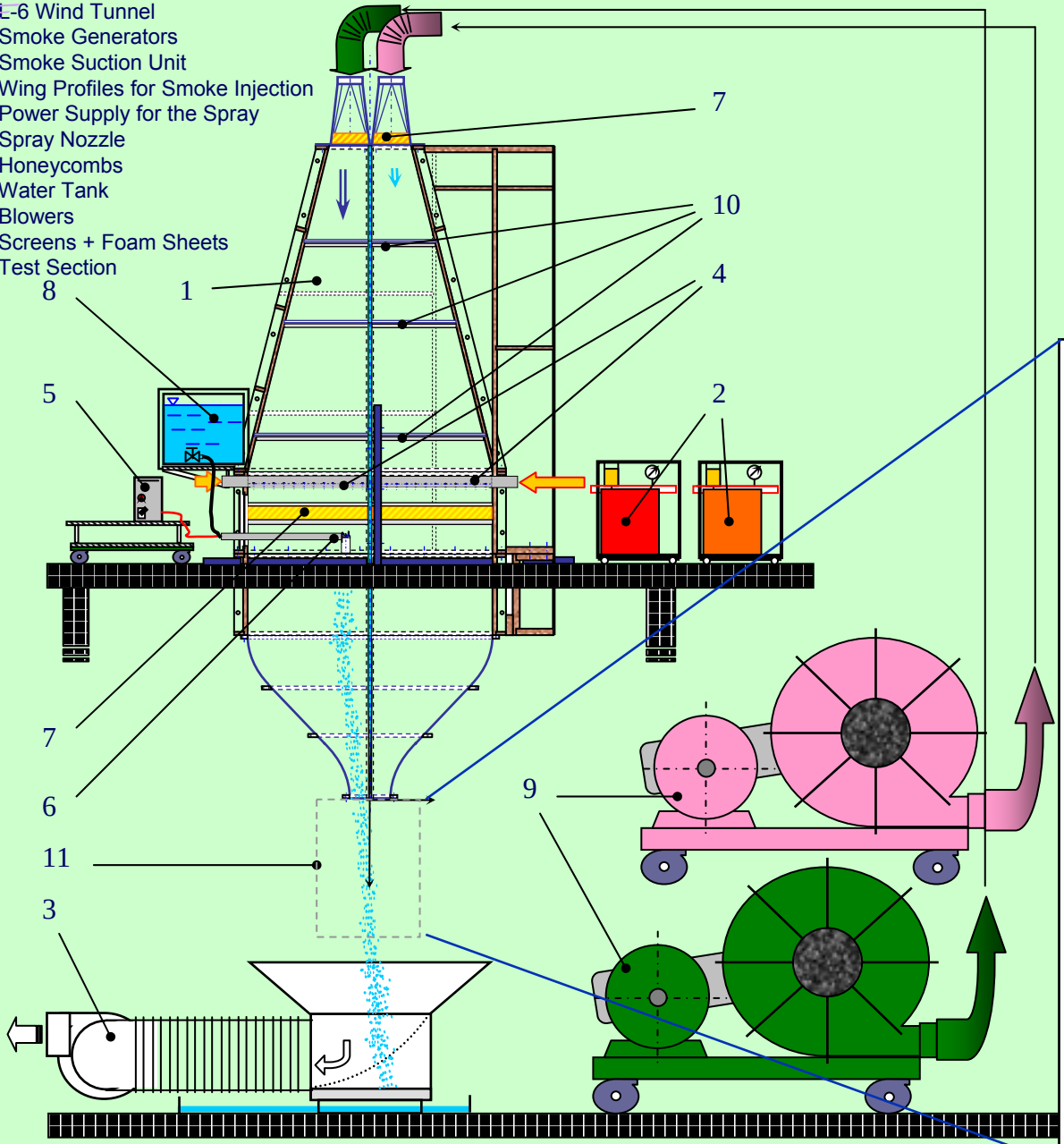
PTV(S) Particle Tracking Velocimetry and Sizing (2D velocity vector component(s), Re-stresses, turbulent characteristics and also particle diameter,size)

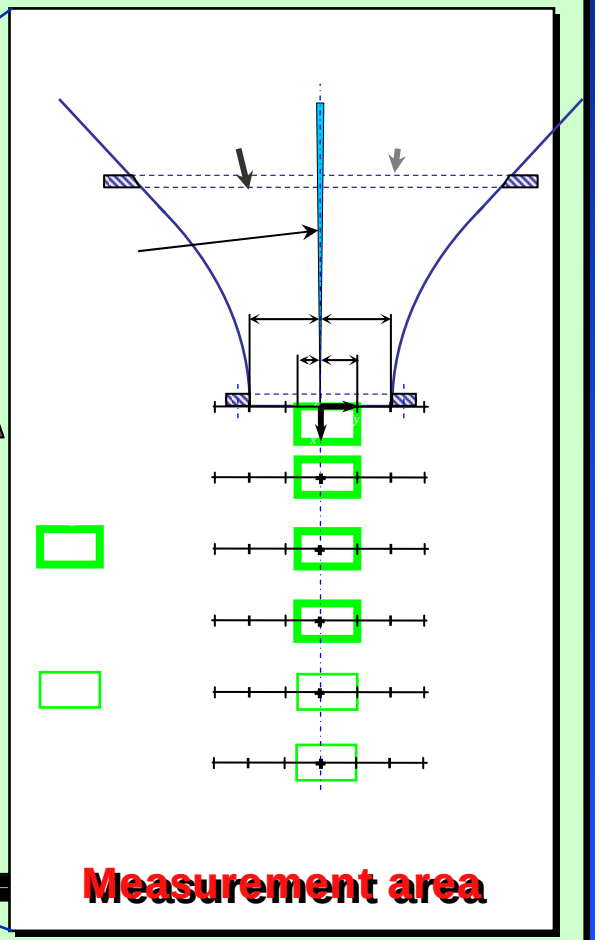
VON KÁRMÁN INSTITUTE FOR FLUID DYNAMICS

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

Set-up
„L-6" twin-jet wind tunnel

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

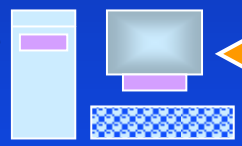




PARTICLE IMAGING VELOCIMETRY

Particle Image Velocimetry PIV

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



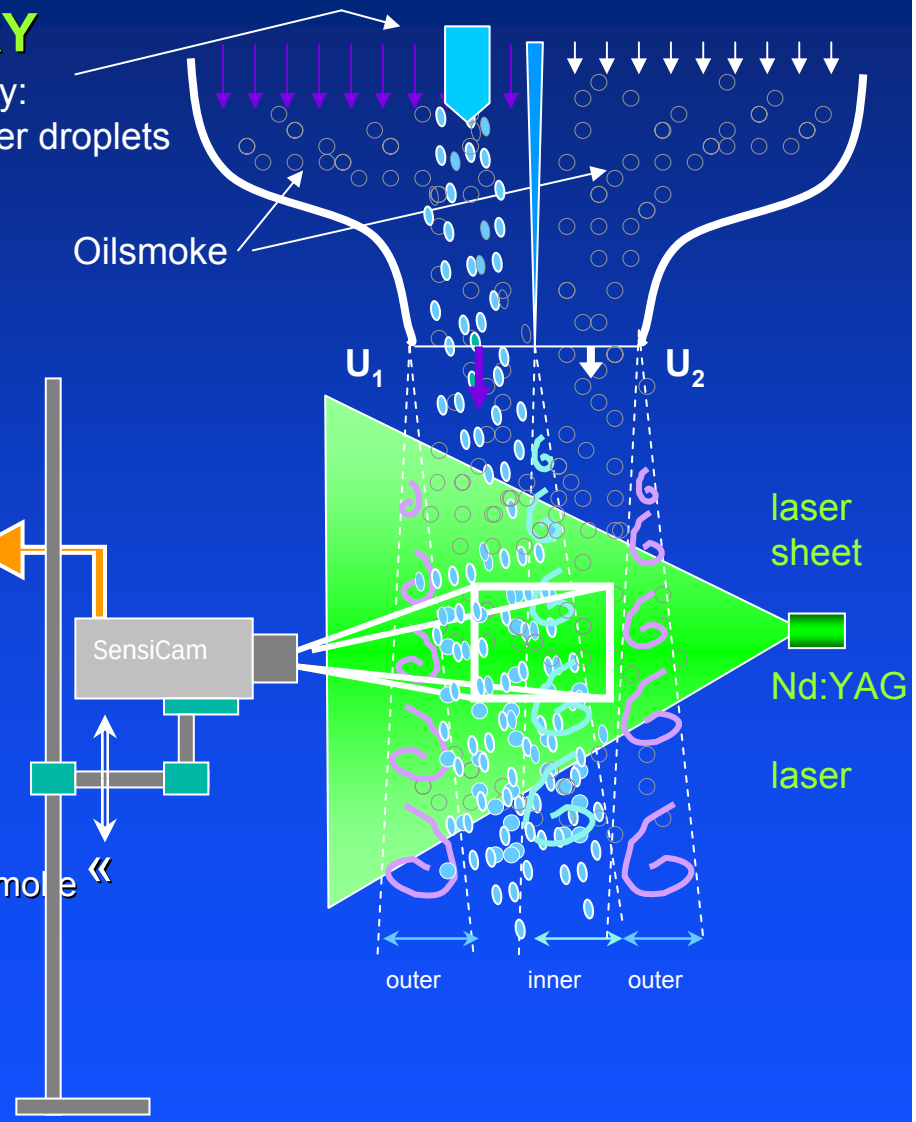
Particle Tracking Velocimetry and Sizing - PTV(S)

For two-phase flow

- Phase discriminatig by image size($d_{oilsmoke}$ « $d_{water\ droplet}$)

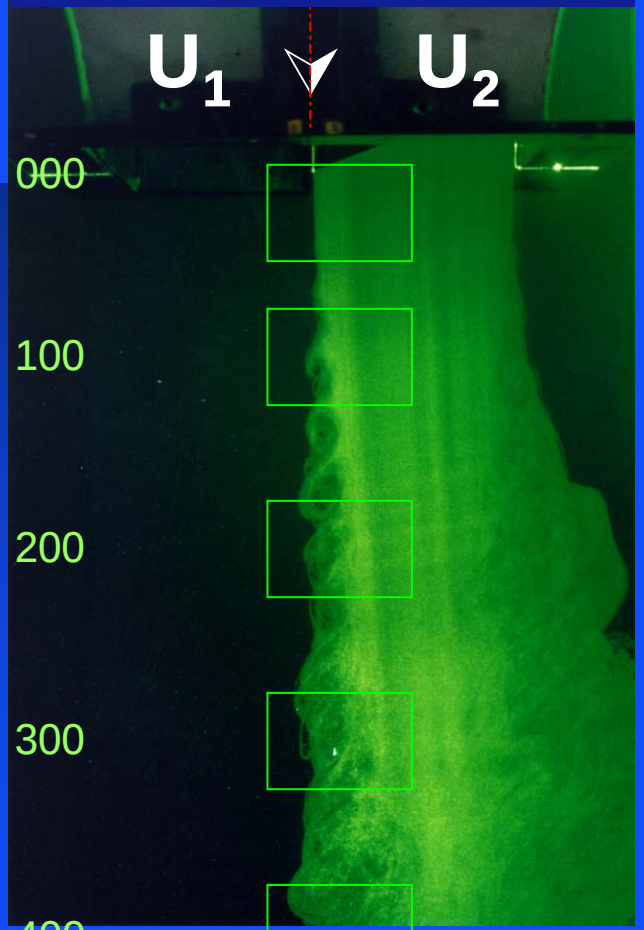
Data processing:

- Matlab, TecPlot, Excel, etc.

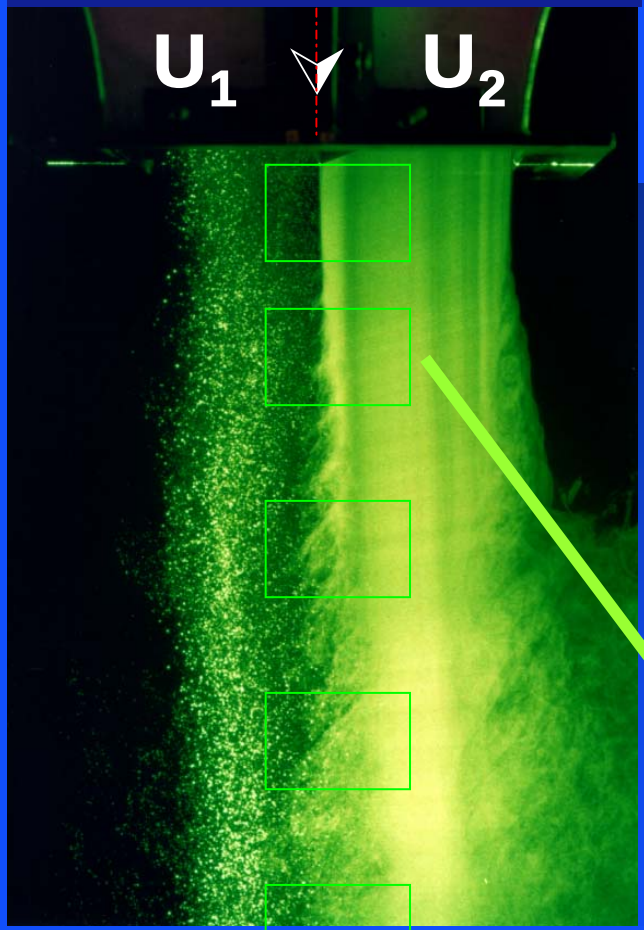


Flow visualization

Single phase flow



Two-phase flow



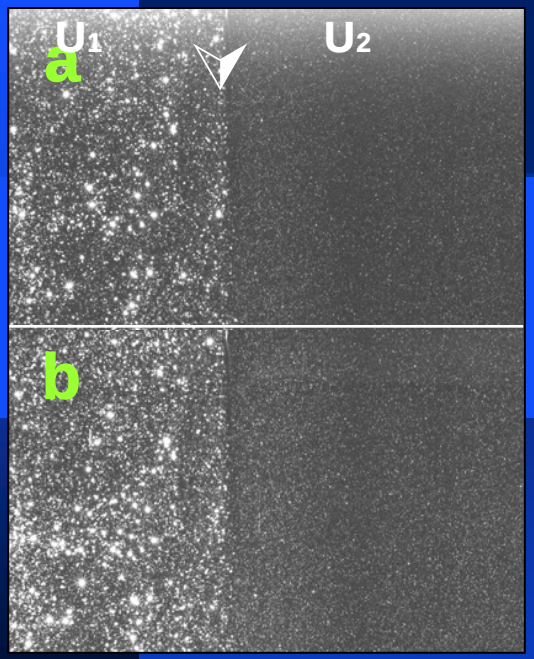
U_1 = 2 m/s
U_2 = 1 m/s

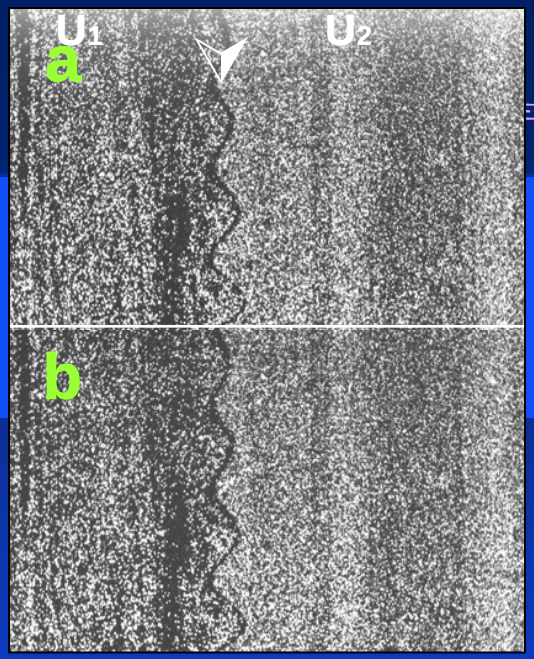
Digital image acquisition

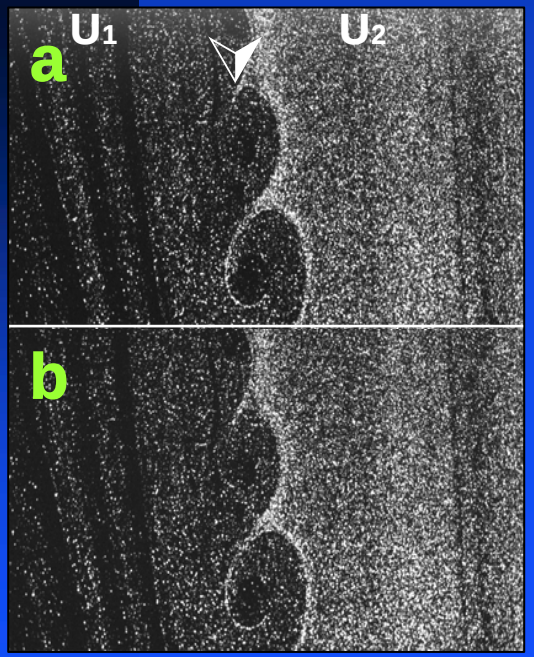
Particle Imaging Velocimetry

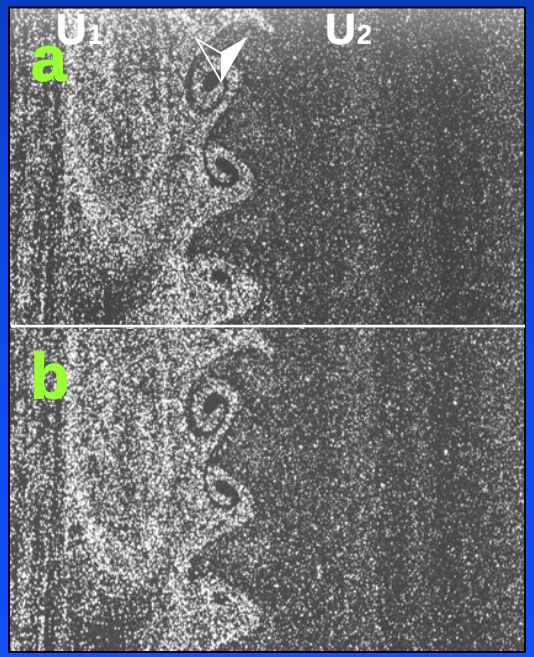
PIV | **PTV(S)**

well defined width of the developing shear layer









VON KÁRMÁN INSTITUTE FOR FLUID DYNAMICS

Succesive images

Δt_{a-b}

displacement

$\Delta x, \Delta y$

velocity vectors

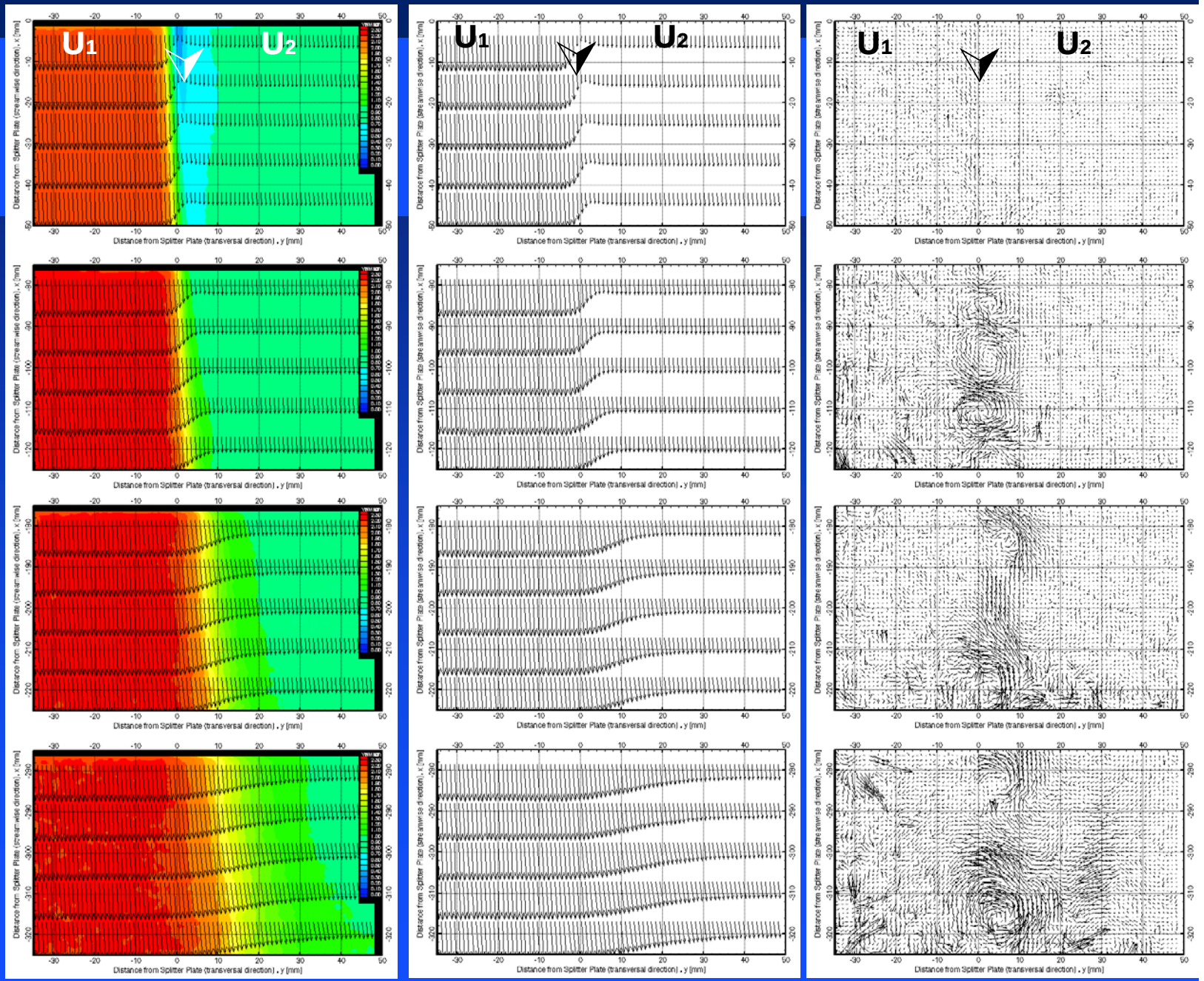
$\underline{V}$

PIV

Particle Image Velocimetry

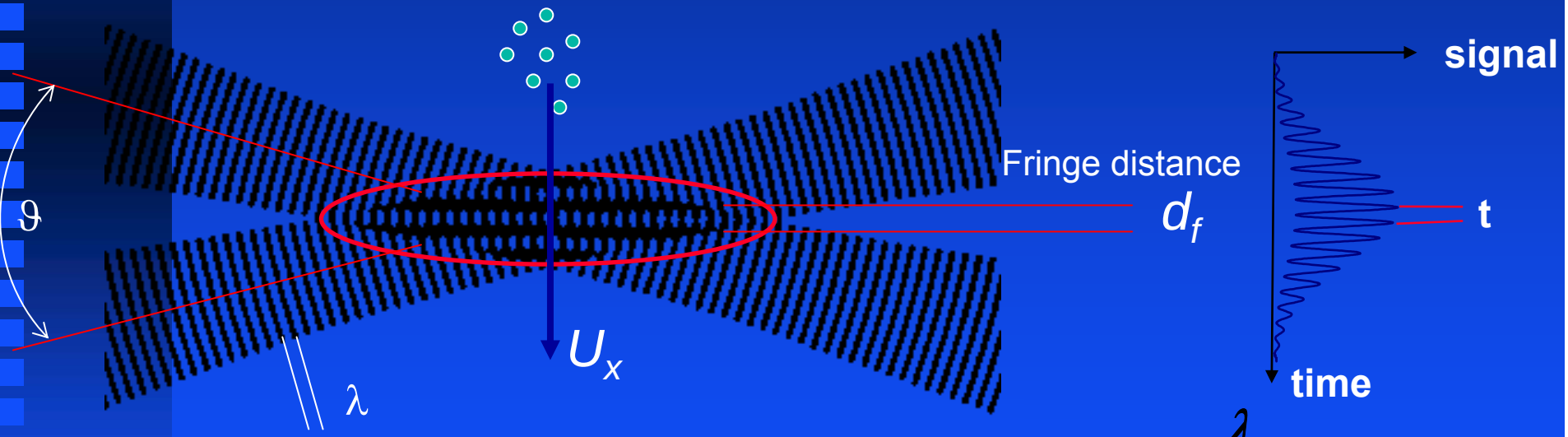
Result

159x95
vectors
/u,v,u',v',T.I.,Ω_z,/



Laser Doppler Anemometer

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



λ wavelength of the laser light

ϑ

f_D Doppler-frequency

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

$$U_x = d_f \cdot f_D$$