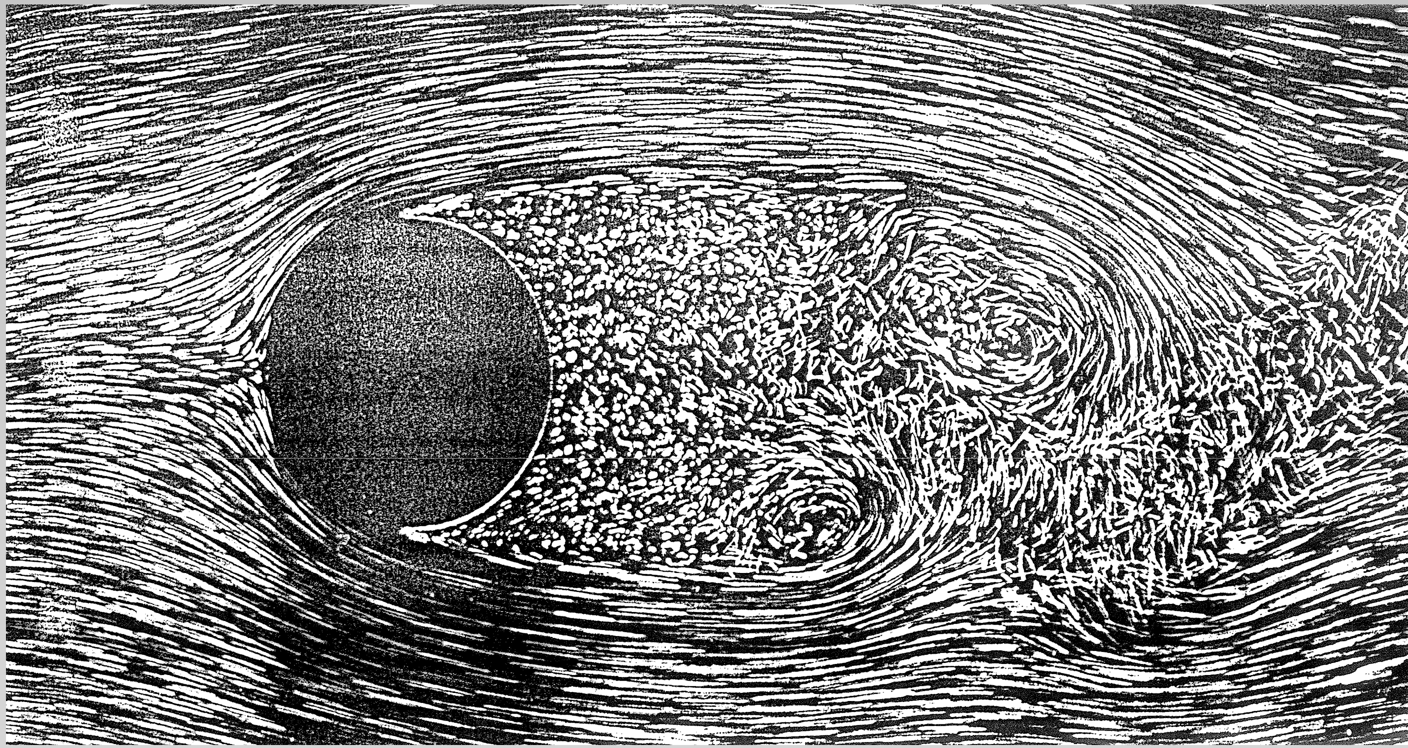
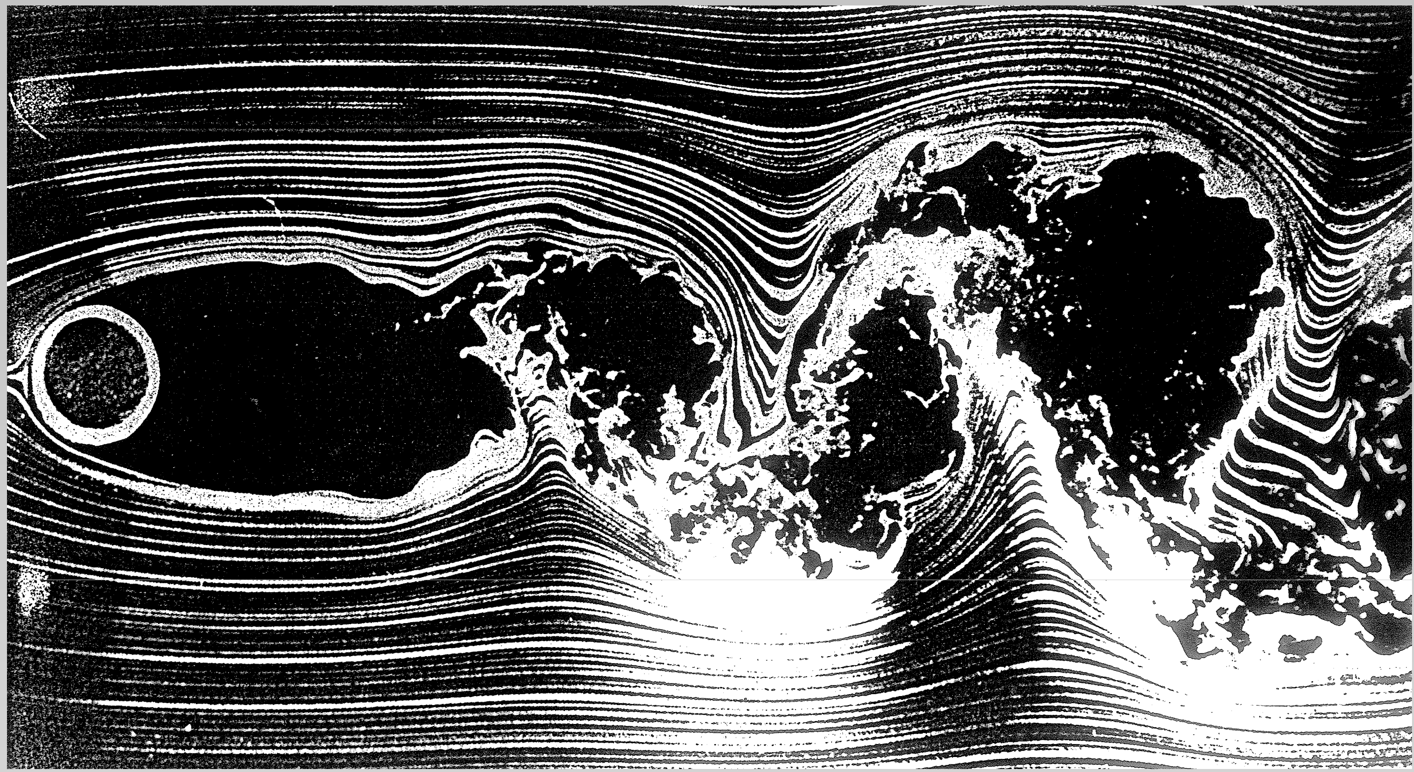
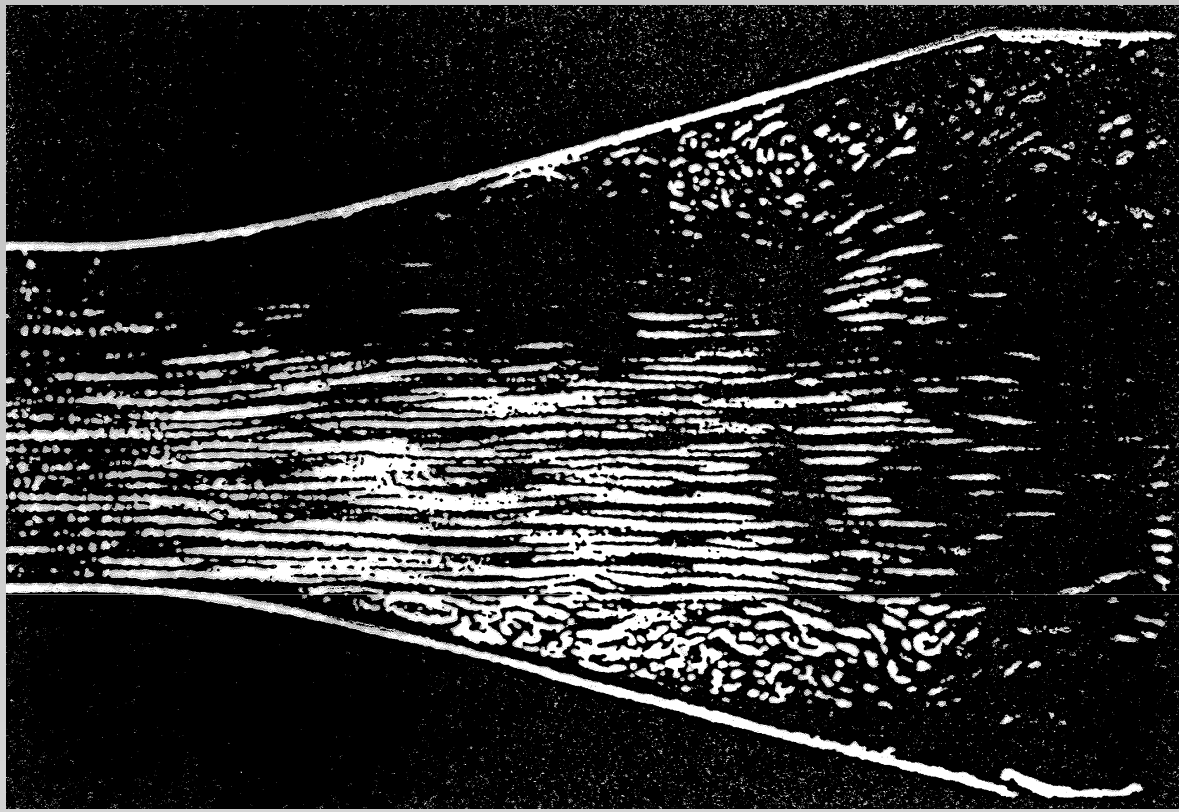
9. Light sheet flow visualisation



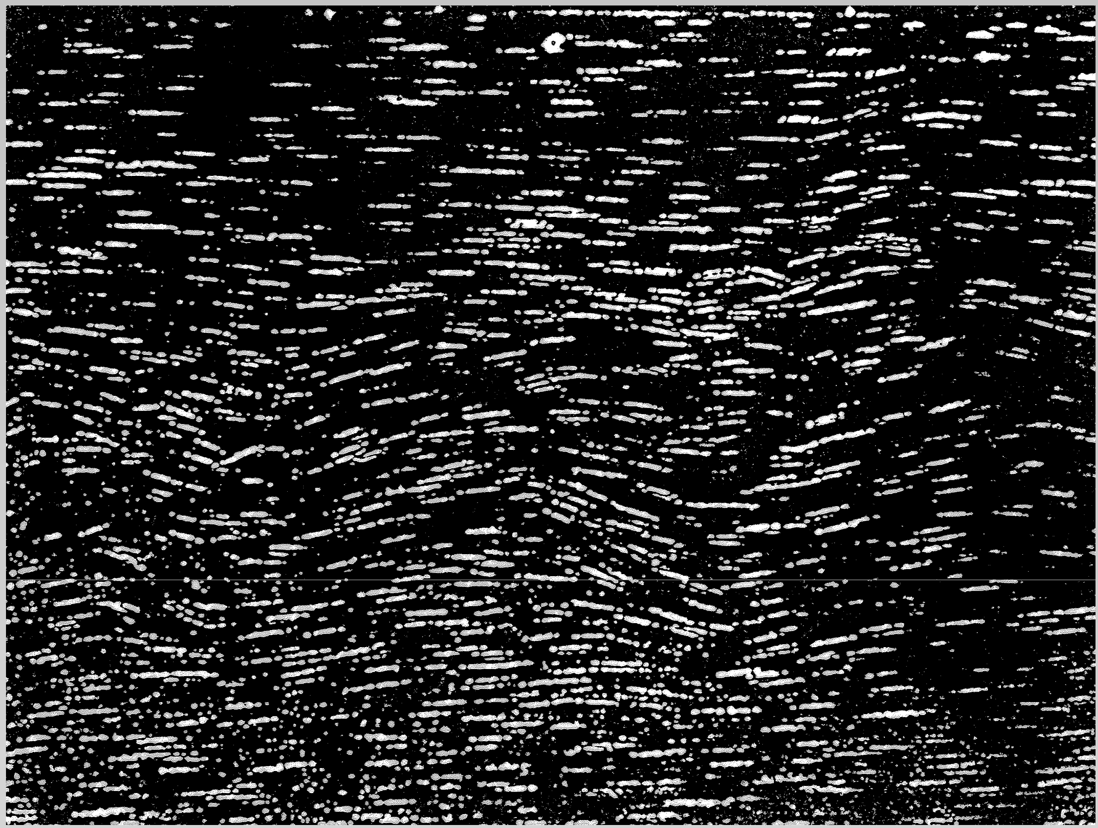
Flow visualised in the vicinity of a cylinder. Re = 2 000. Air bubbles in water. (Van Dyke: An Album of Fluid Motion, Parabolic Press, stanford, California, 1982)



Flow visualised in the vicinity of a cylinder. Re = 10 000. Hydrogene bubbles in water. (Van Dyke: An Album of Fluid Motion, Parabolic Press, Stanford, California, 1982)

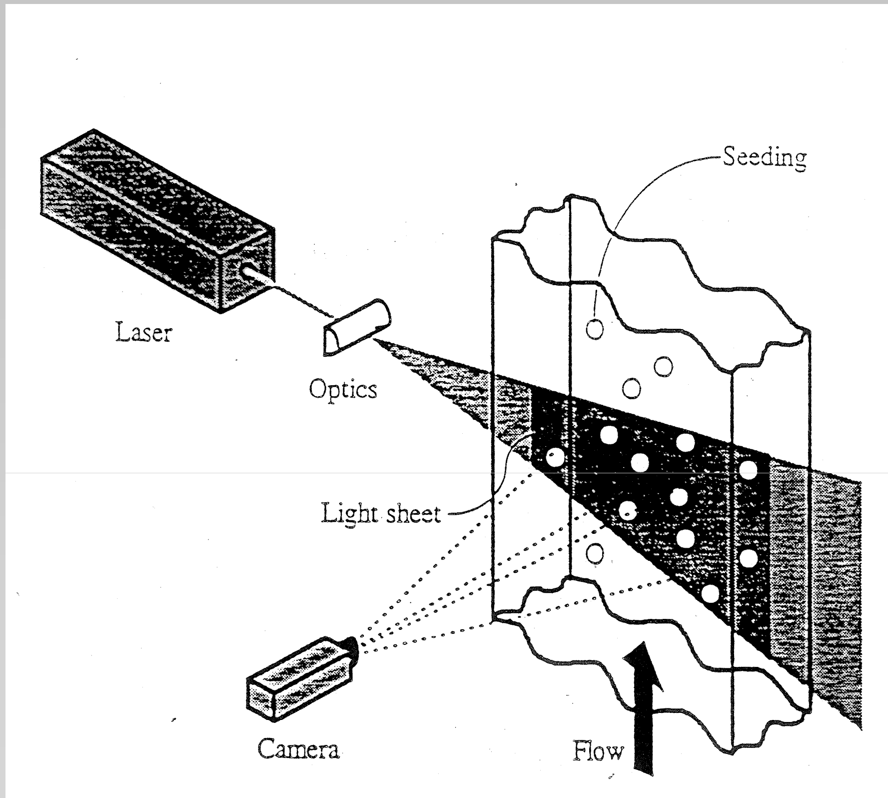


Flow visualised in a diffuser. Air bubbles in water. (Kaufmann, W.: Technische Hydro- und Aeromechanik, Springer Verlag, 1963)

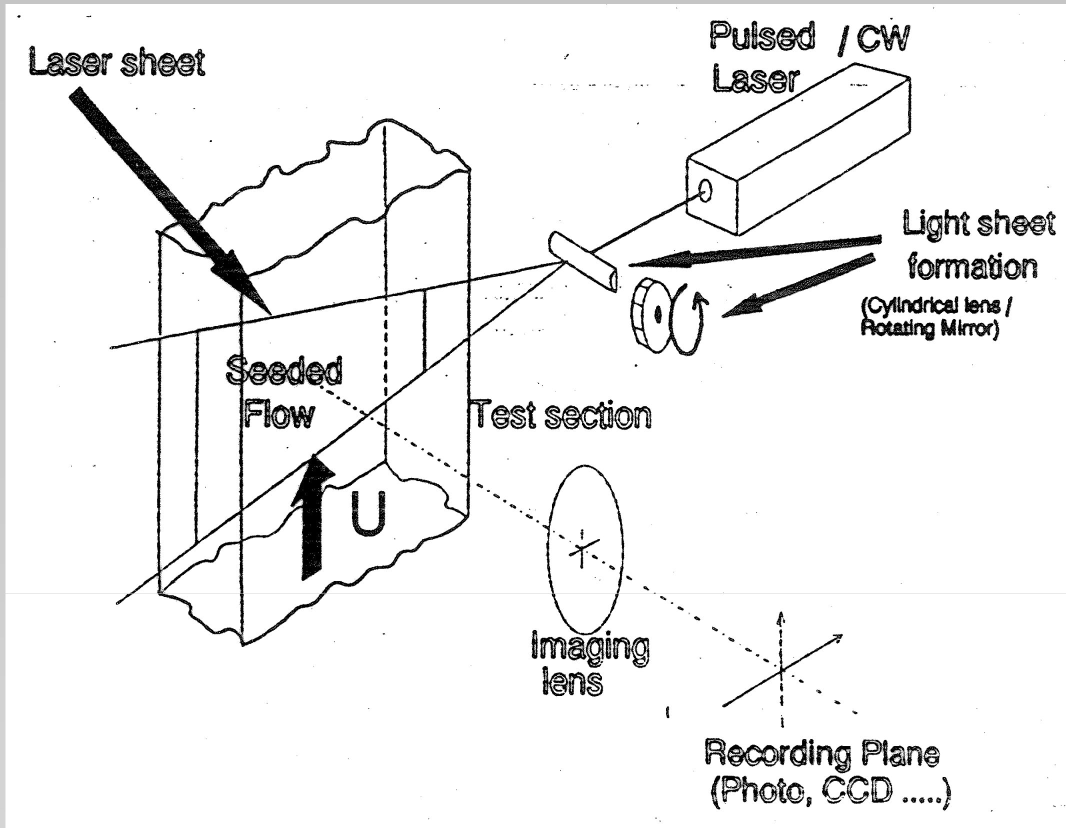


Particle Tracking Velocimetry. Flow downstream of a cylinder.
(Agui, J. C. A., Jimenez, J.: On the Performance of Particle Tracking. J Fluid Mechanics, pp. 447 – 468, 1987)

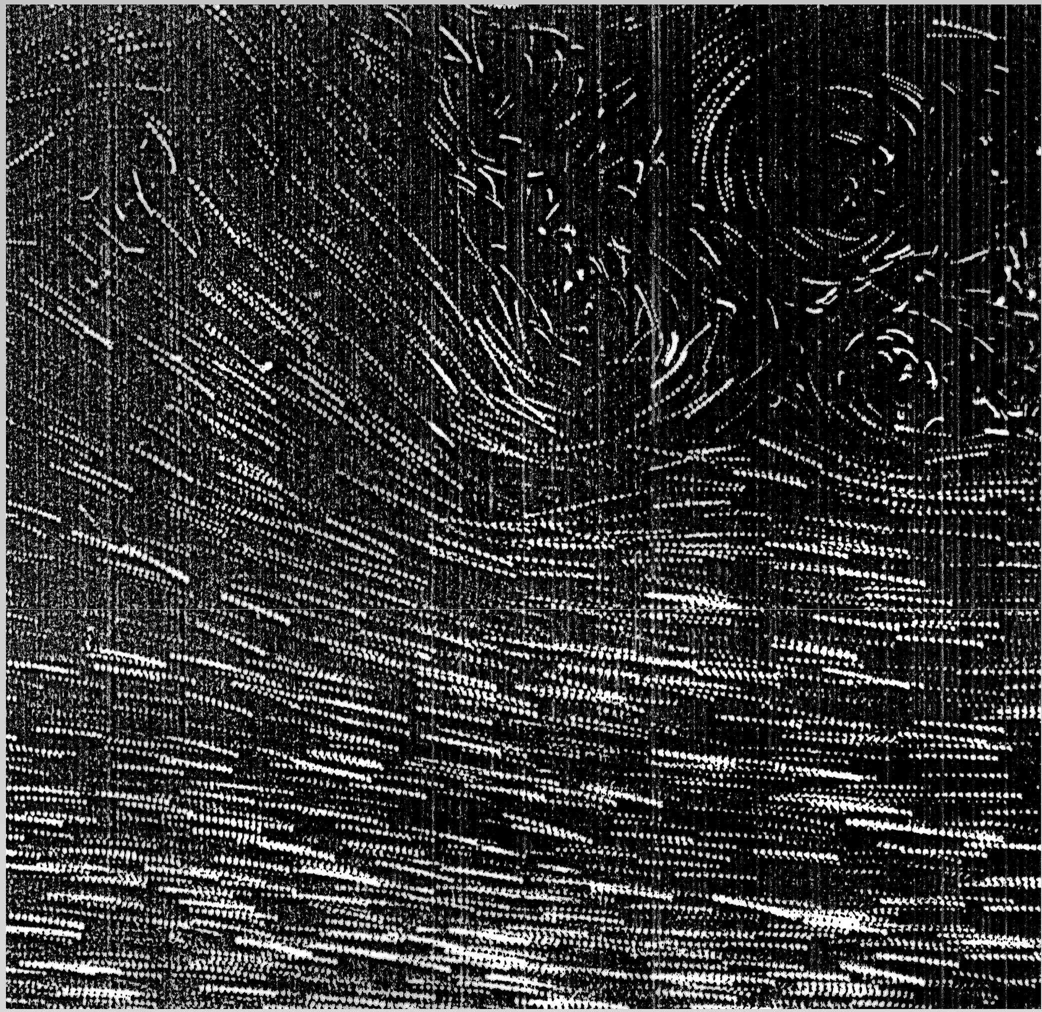
10. Particle Image Velocimetry (PIV)



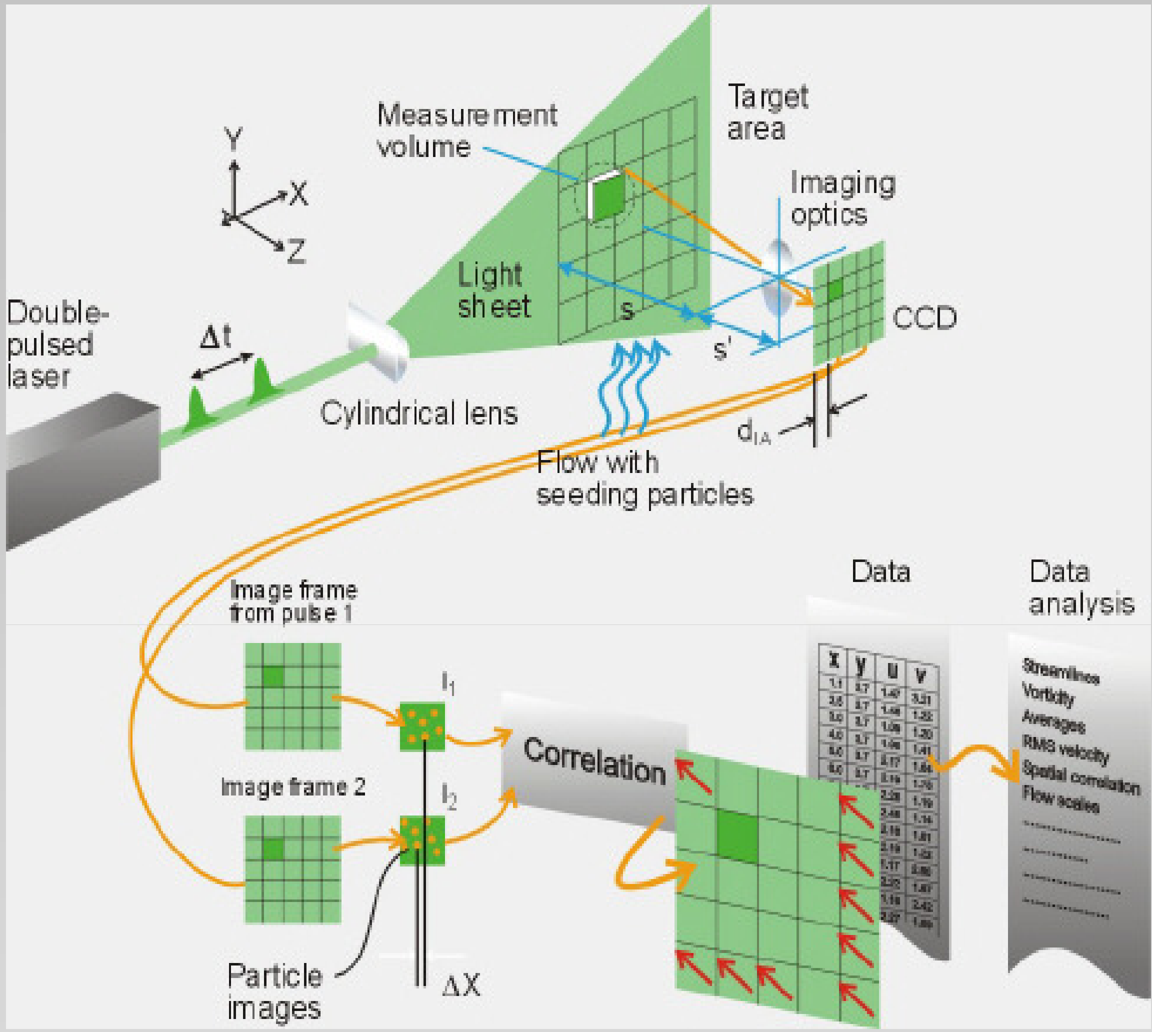
Principle of PIV (Lecture note by Pap, E., Otto-Von-Guericke Universitaet Magdeburg, Institut für Strömungstechnik und Thermodynamik, Lehrstuhl für Strömungsmaschinen)



PIV arrangement with rotating mirror laser sheet generator (Lecture note by Pap, E., Otto-Von-Guericke Universitaet Magdeburg, Institut für Strömungstechnik und Thermodynamik, Lehrstuhl für Strömungsmaschinen)



Typical image originated from multipulse illumination



Summary of PIV http://www.dantecdynamics.com/piv/princip/index.html

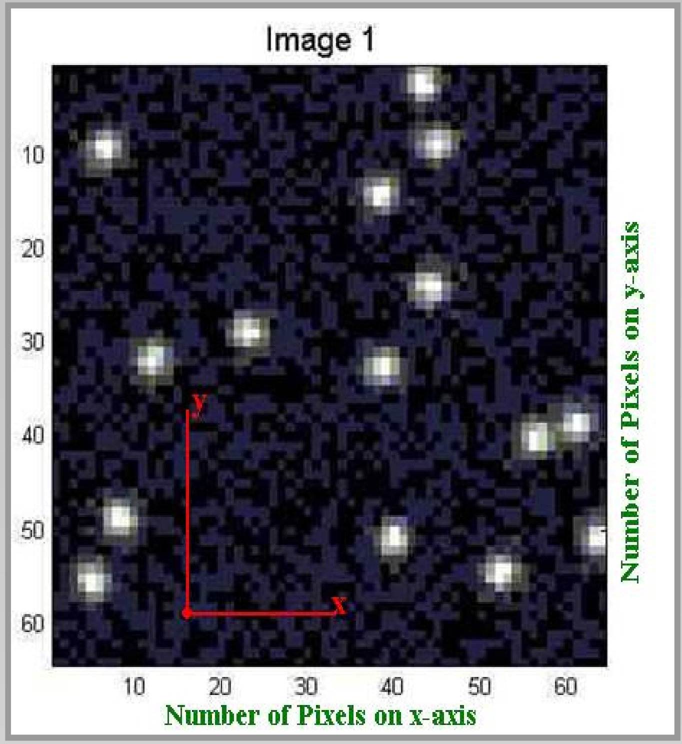


Image 1 at time t1

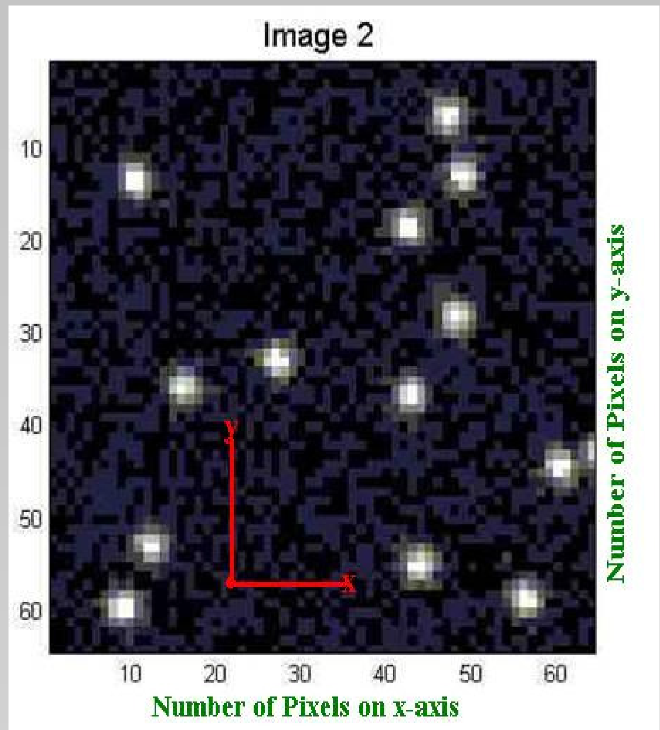
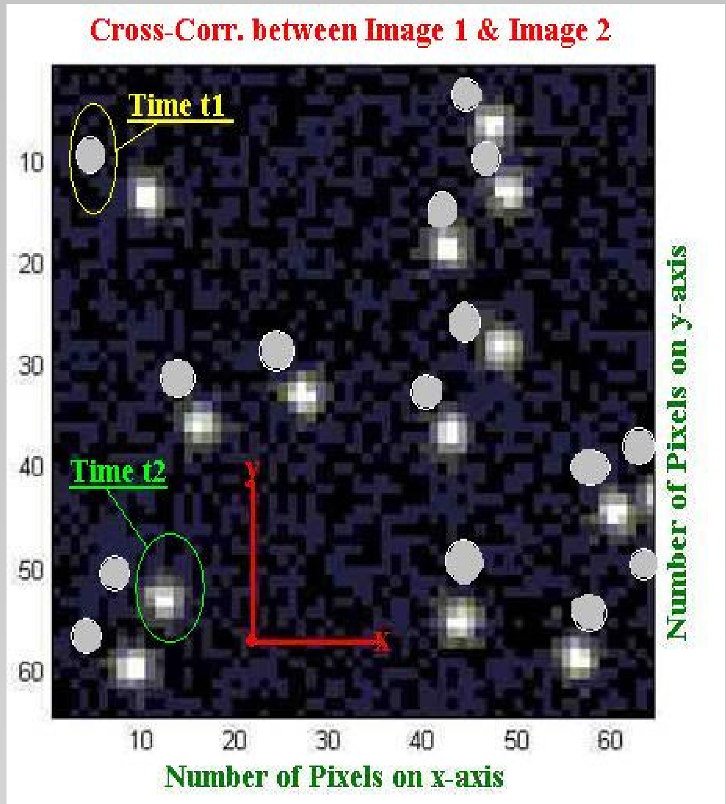


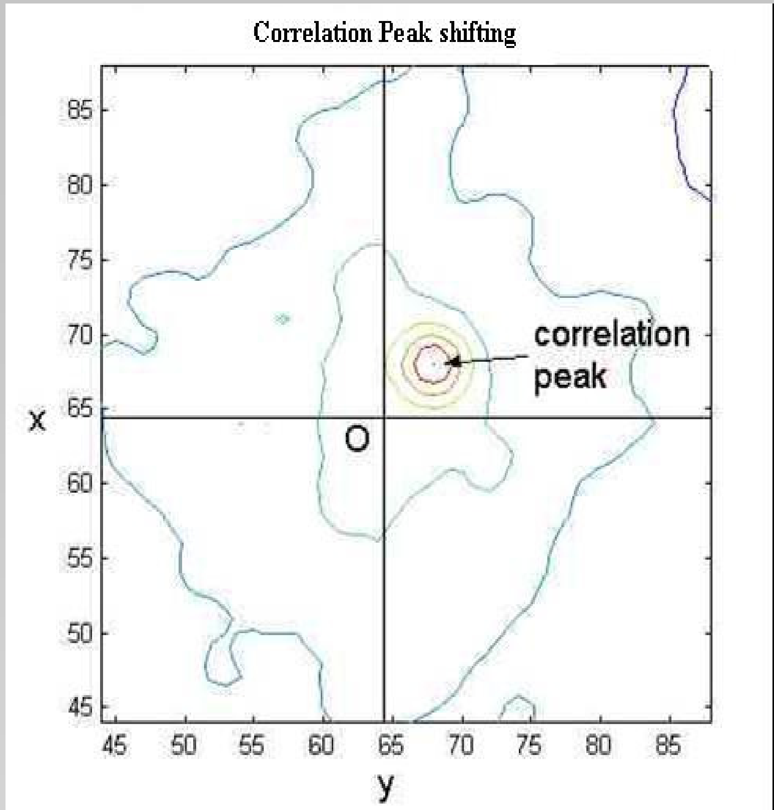
Image 2 at time t2

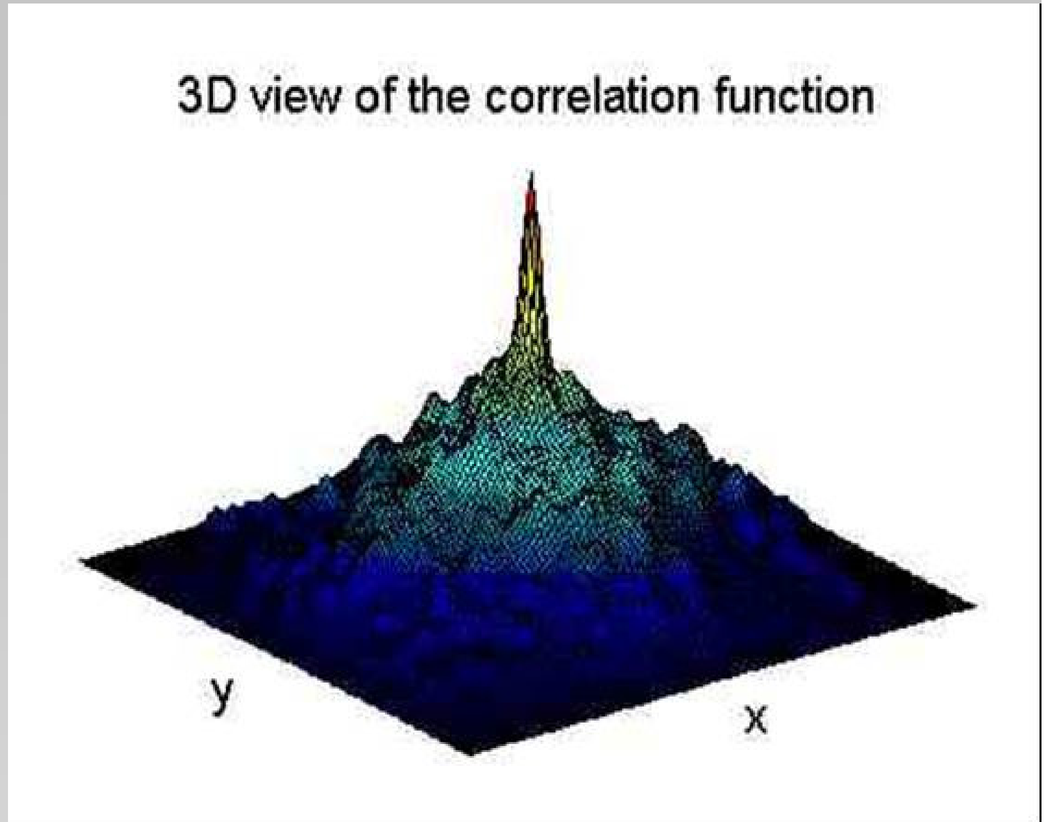
$$\bar{V} = \frac{\bar{\Delta x}}{\Delta t} \qquad \bar{\Delta x} = ?$$

PIV Lecture_Notes, "Particle Image Velocimetry", University of WARWICK, Optical Engineering Laboratory (OEL)



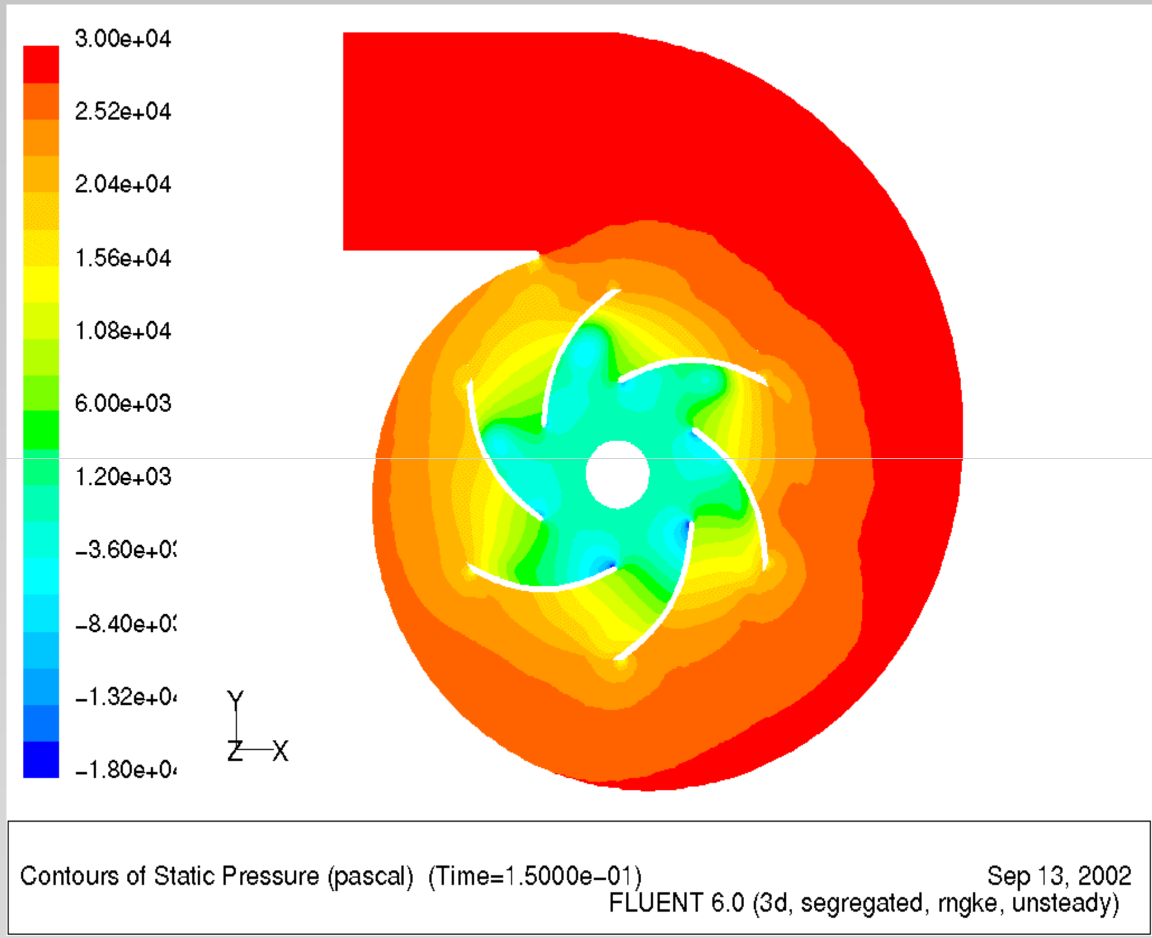
Maximum cross-correlation between Image 1 & Image 2



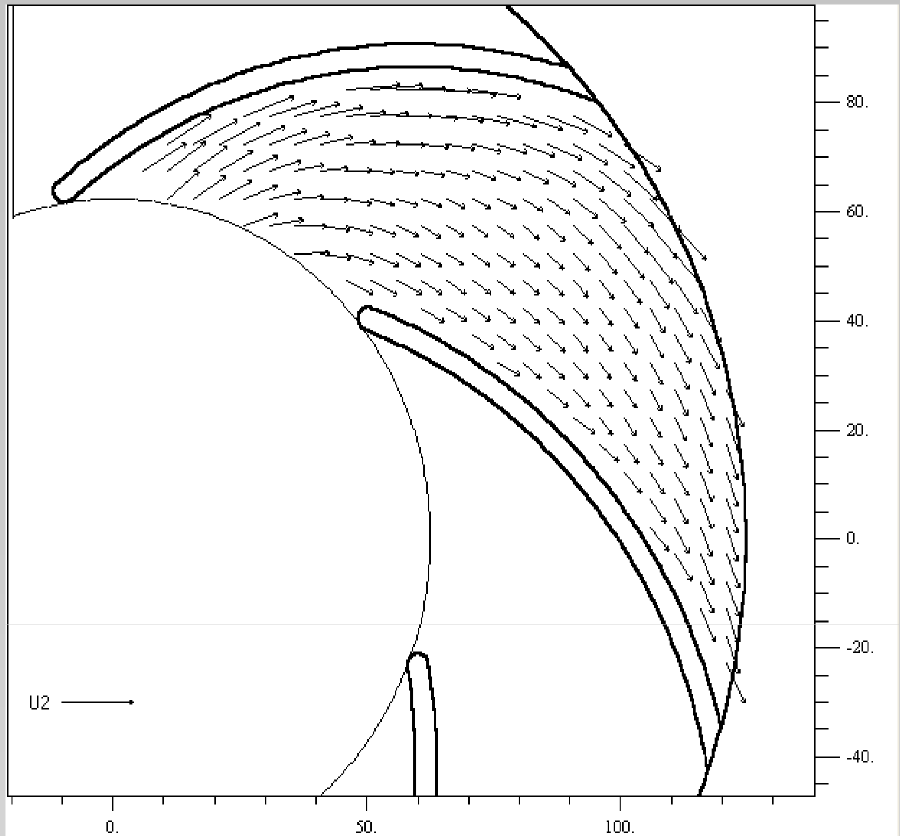


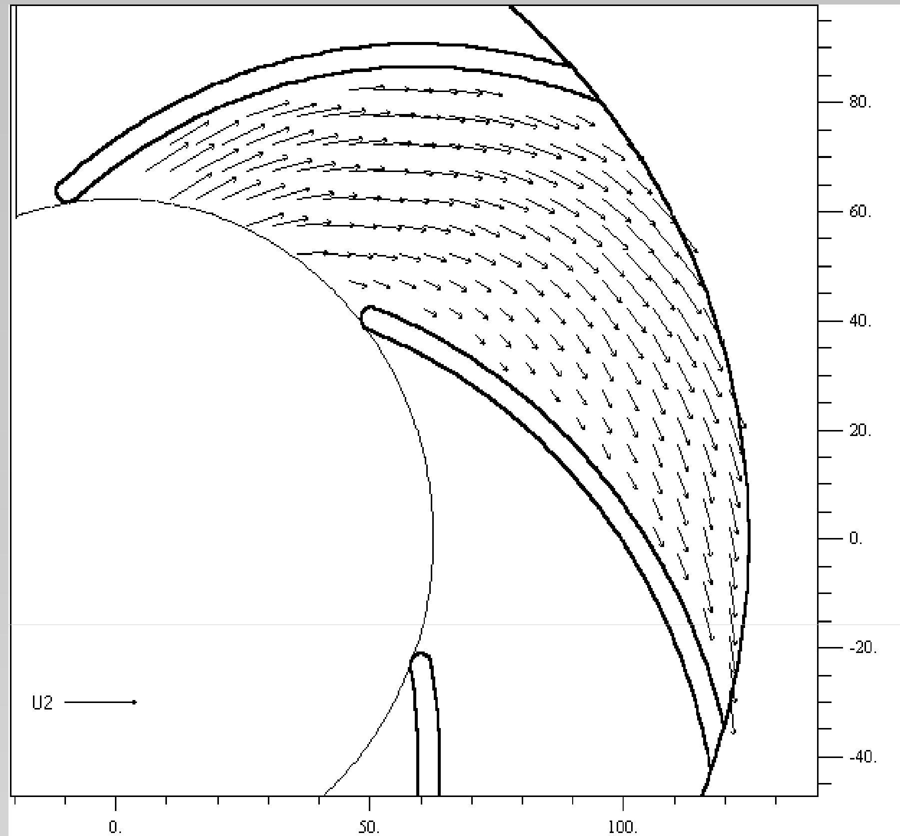
PIV Lecture_Notes, “Particle Image Velocimetry”, University of WARWICK, Optical Engineering Laboratory (OEL)

Radial pump simulation: comparison of simulated flow field and PIV data



DANTEC Measurement Technology





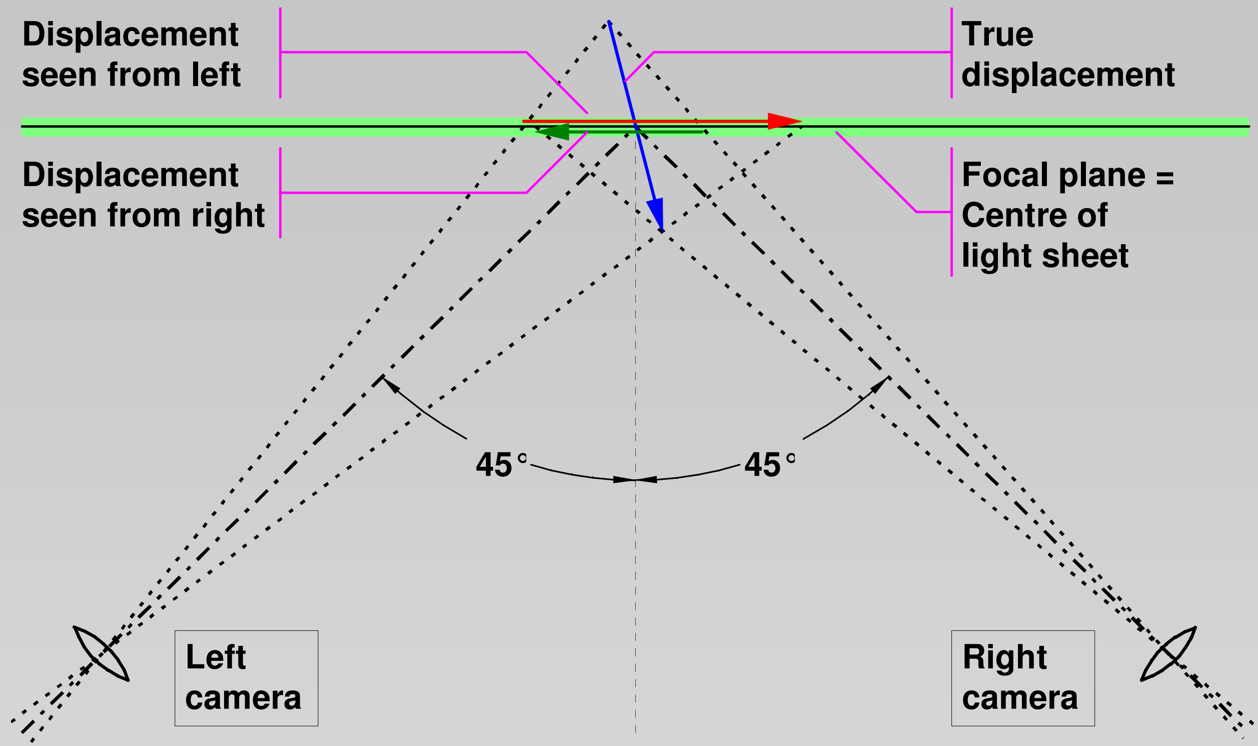
PIV measurement
(Otto-Von-Guericke
Universitaet Magdeburg)

FLUENT simulation
(Dept. of Fluid Mechanics, BME)

FlowManager 3D-PIV
(Stereo PIV)

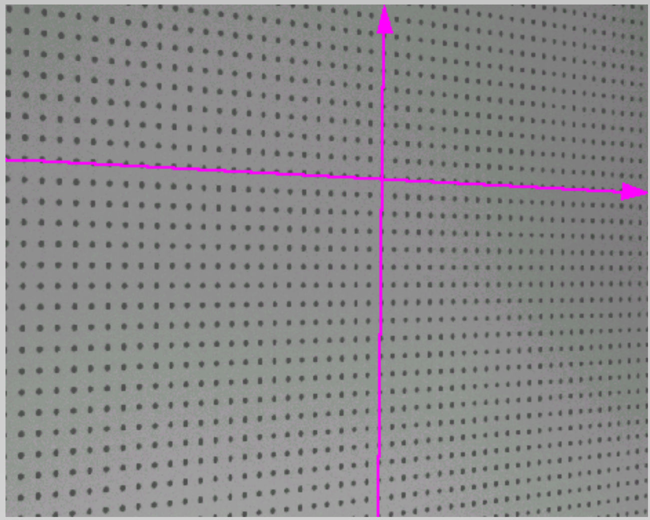
- **Theory of stereoscopic PIV**
- **Dantec 3D-PIV software**
- **Application example:**
  3D-PIV in an automotive wind tunnel
  (used as example through the slide show)

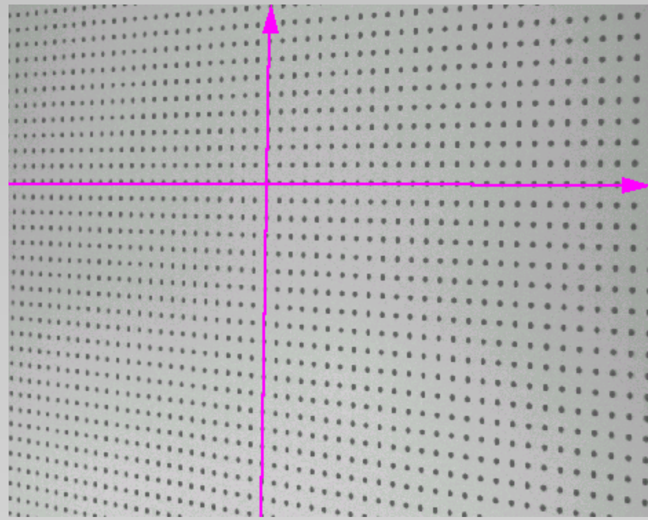
Fundamentals of stereo vision



True 3D displacement (ΔX,ΔY,ΔZ) is estimated from a pair of 2D displacements (Δx,Δy) as seen from left and right camera respectively

Camera calibration





Images of a calibration target are recorded.

The target contains calibration markers in known positions.

Comparing known marker positions with corresponding marker positions on each camera image, model parameters are adjusted to give the best possible fit.

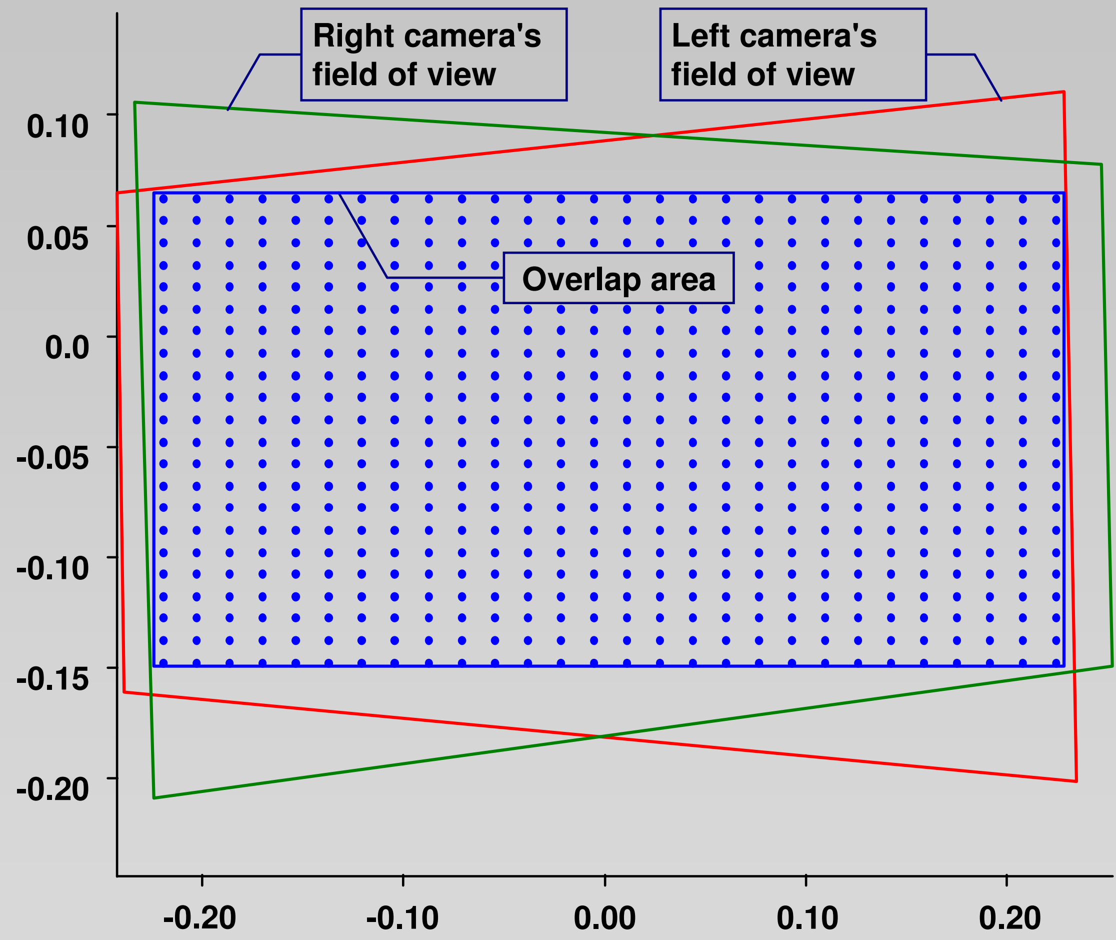
Overlapping fields of view

3D evaluation is possible only within the area covered by both cameras.

Due to perspective distortion each camera covers a trapezoidal region of the light sheet.

Careful alignment is required to maximize the overlap area.

Interrogation grid is chosen to match the spatial resolution.



DANTEC Measurement Technology

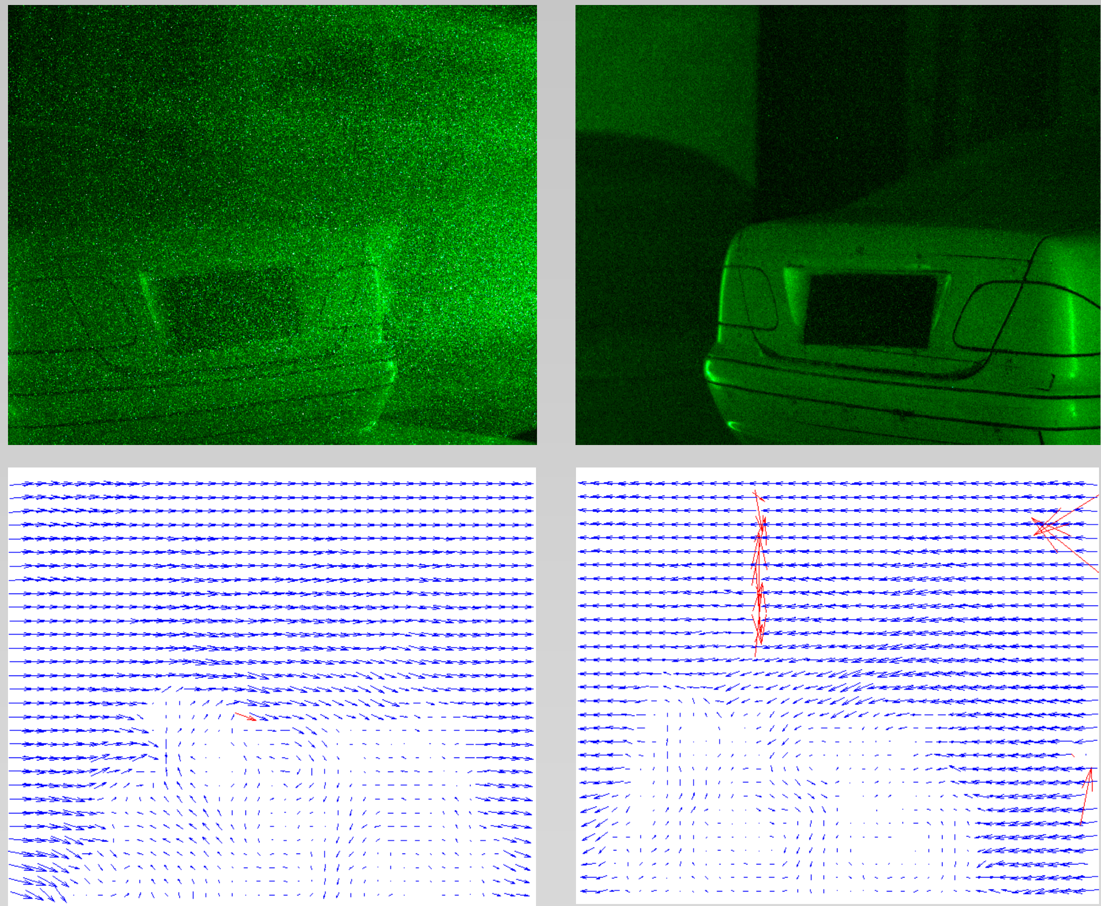
Left / Right 2D vector maps

Left & Right camera images are recorded simultaneously.

Conventional PIV processing produce 2D vector maps representing the flow field as seen from left & right.

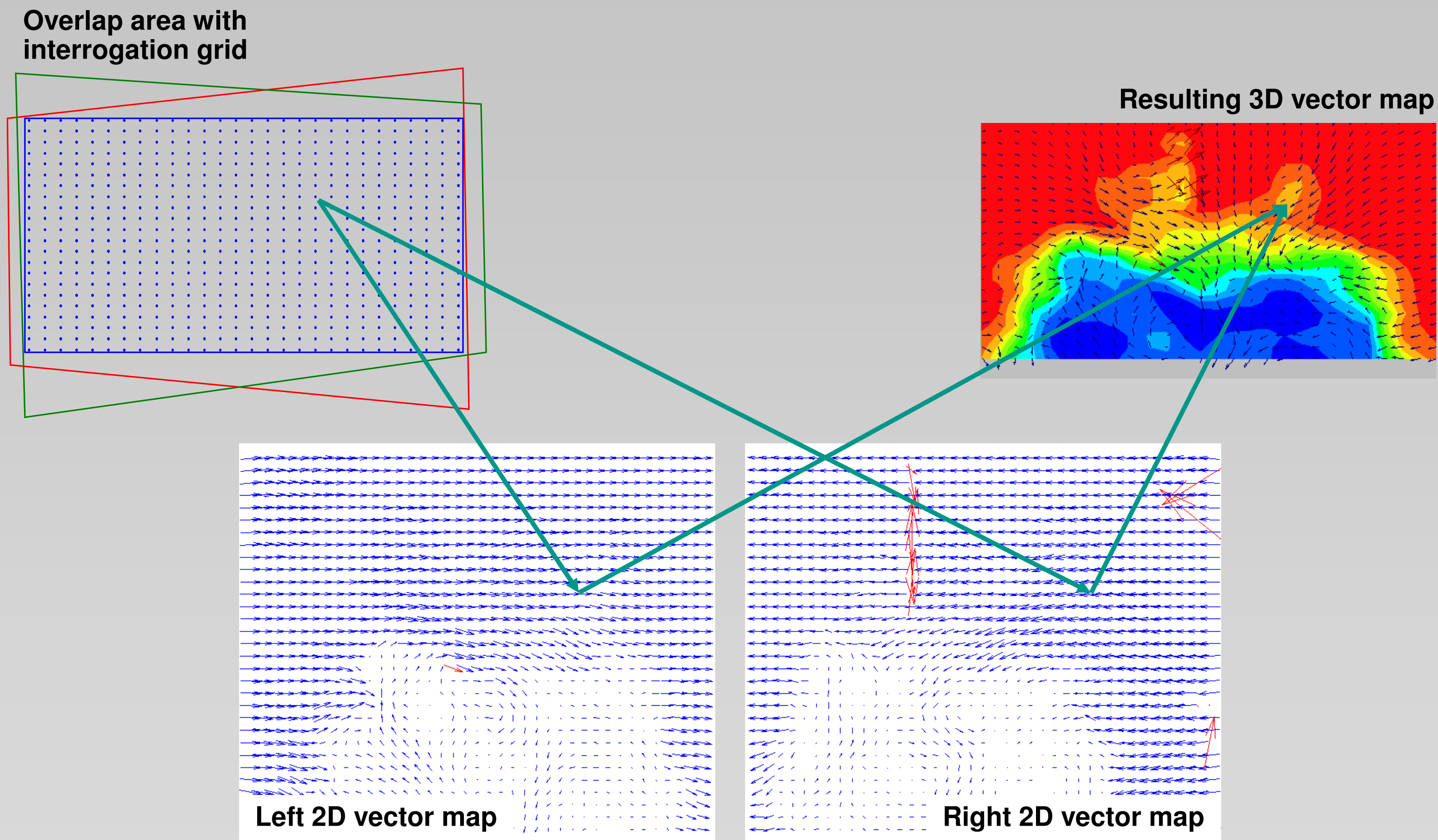
The vector maps are re-sampled in points corresponding to the interrogation grid.

Combining left / right results, 3D velocities are estimated.



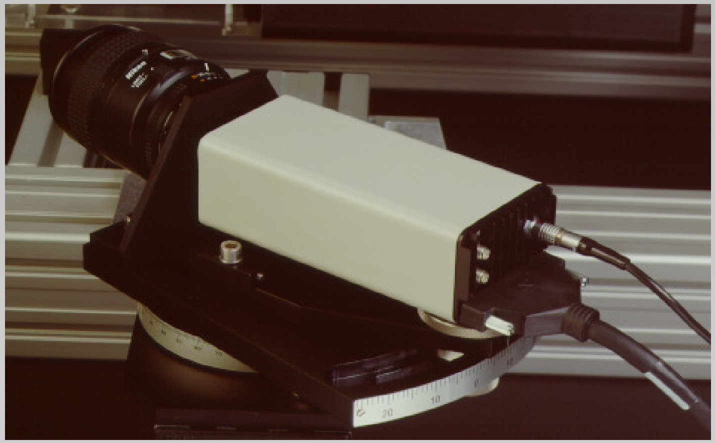
DANTEC Measurement Technology

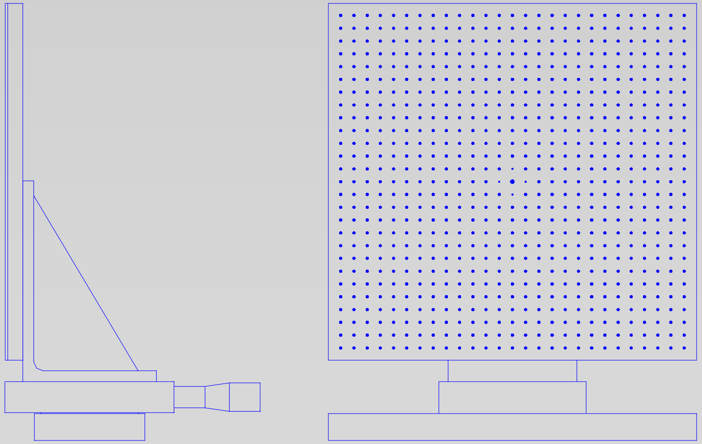
3D reconstruction



Dantec 3D-PIV system components

- Seeding
- PIV-Laser
  (Double-cavity Nd:Yag)
- Light guiding arm &
  Lightsheet optics
- 2 cameras on stereo mounts
- FlowMap PIV-processor with
  two camera input
- Calibration target on a traverse
- FlowManager PIV software
- FlowManager 3D-PIV option

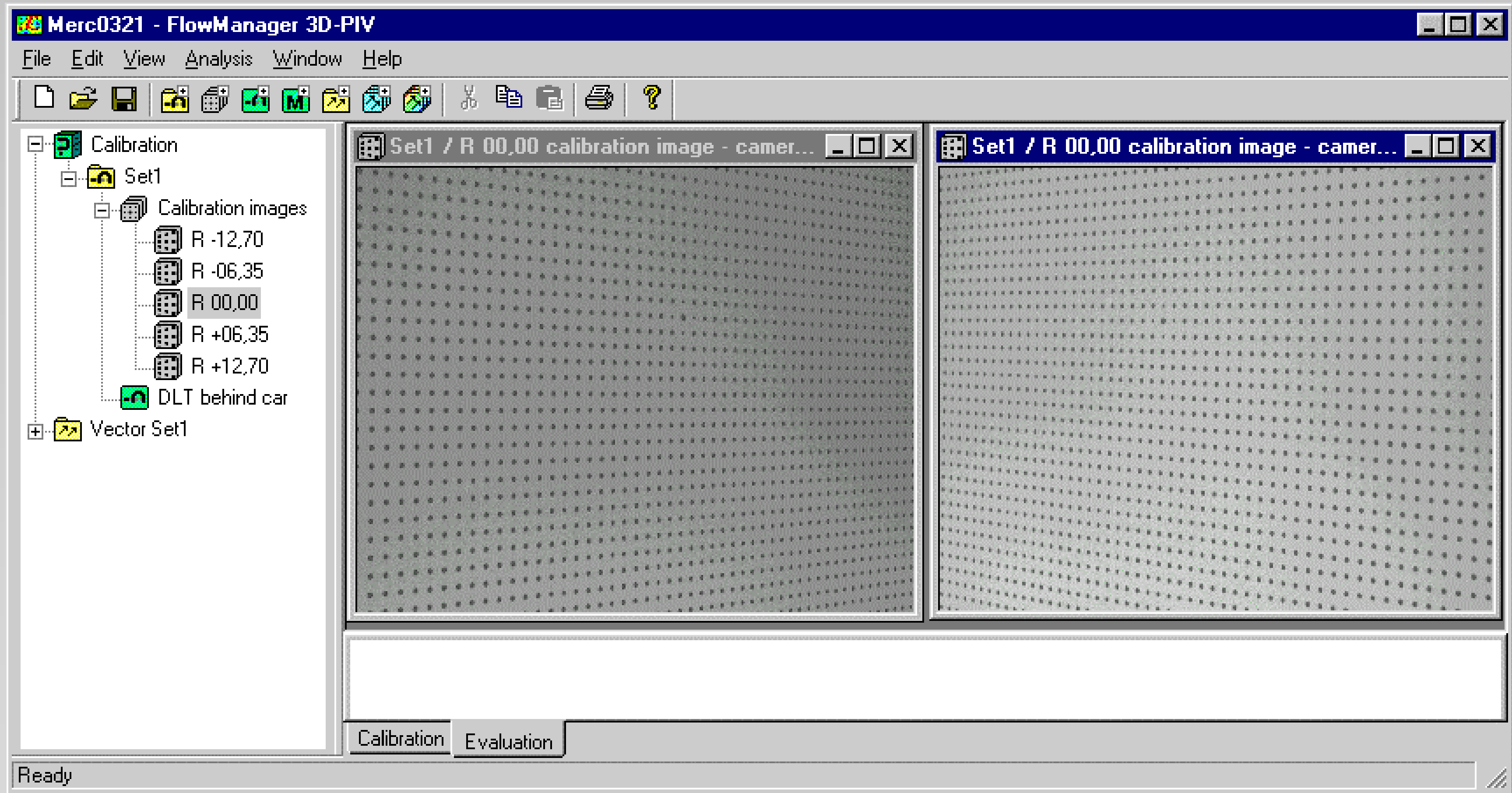




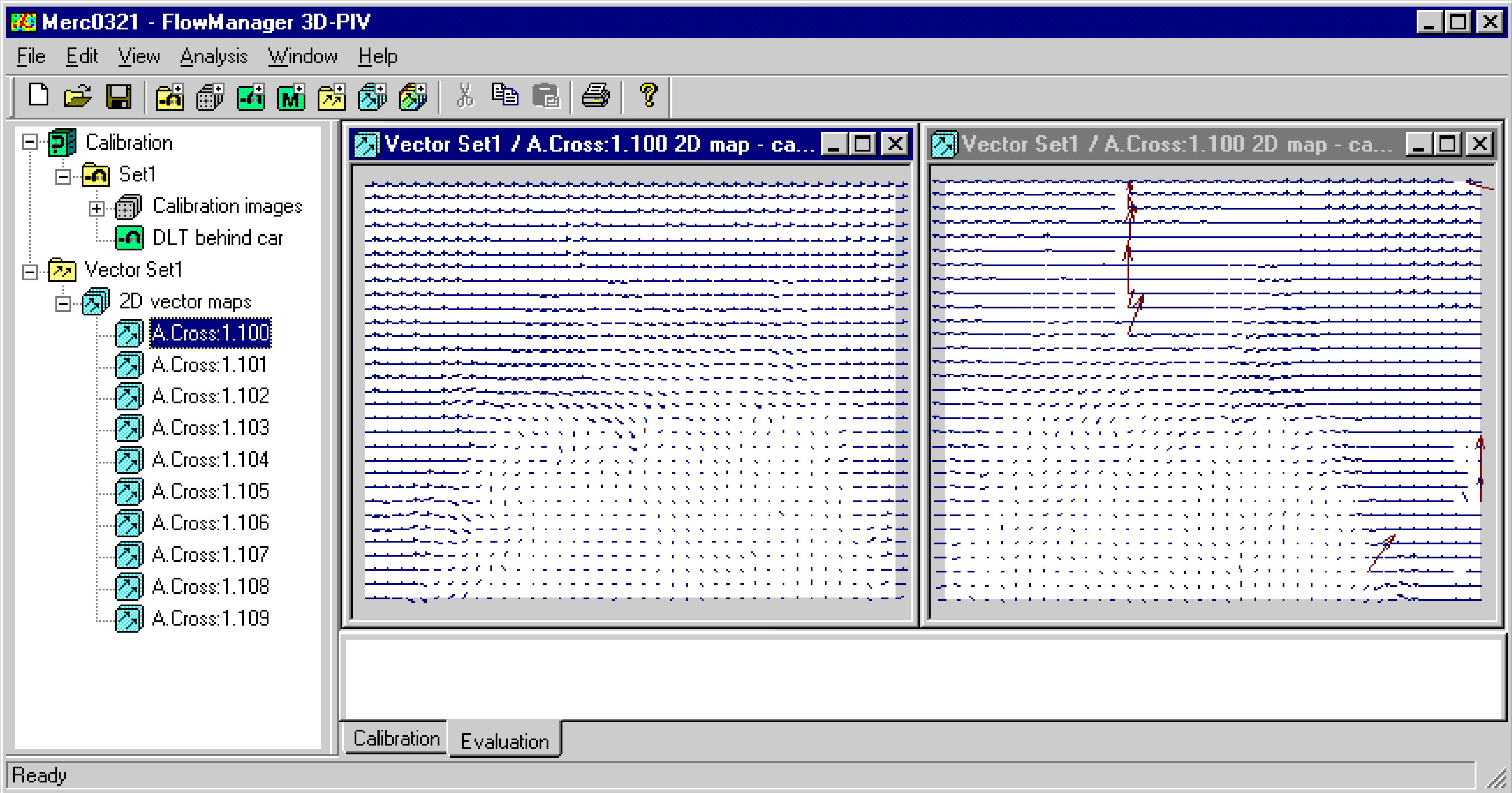
Recipe for a 3D-PIV experiment

- Record calibration images in the desired measuring position (Target and traverse defines the co-ordinate system!)
- Align the lightsheet with the calibration target
- Record calibration images using both cameras
- Record simultaneous 2D-PIV vector maps using both cameras
- Calibration images and vector maps is read into FlowManager
- Perform camera calibration based on the calibration images
- Calculate 3D vectors based on the two 2D PIV vector maps and the camera calibration

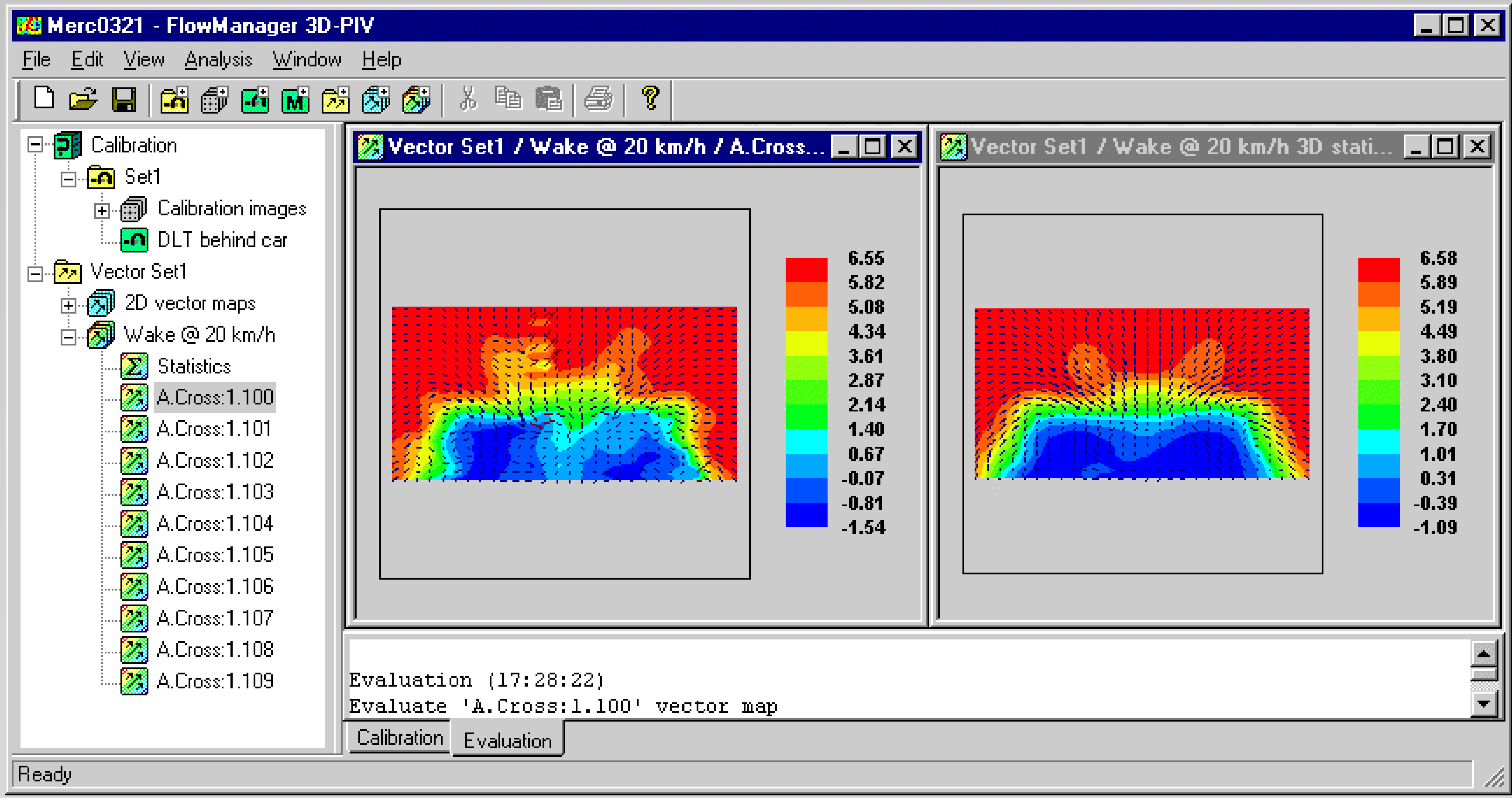
Camera calibration



Importing 2D vector maps



3D evaluation & statistics



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Measurement Technology