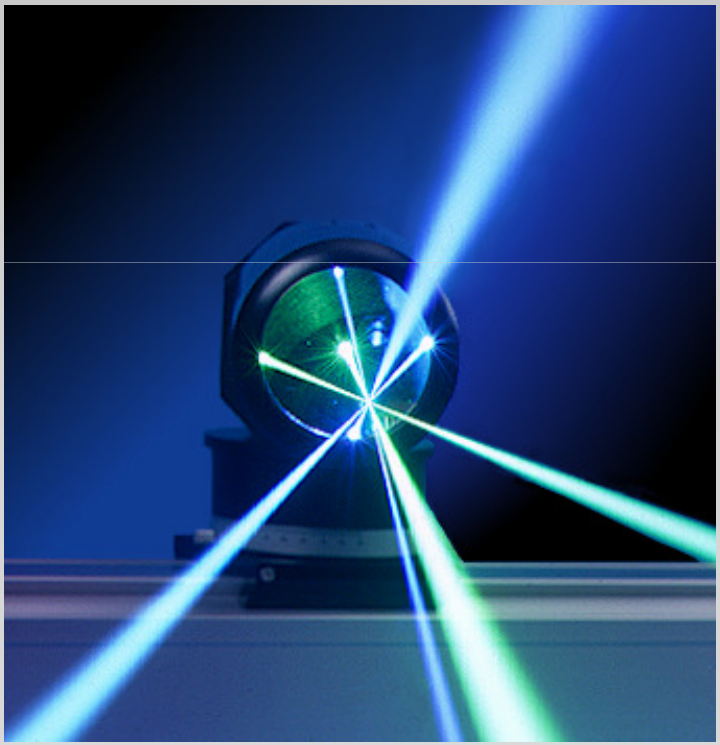
6. Laser Doppler Anemometry

Introduction to principles and applications



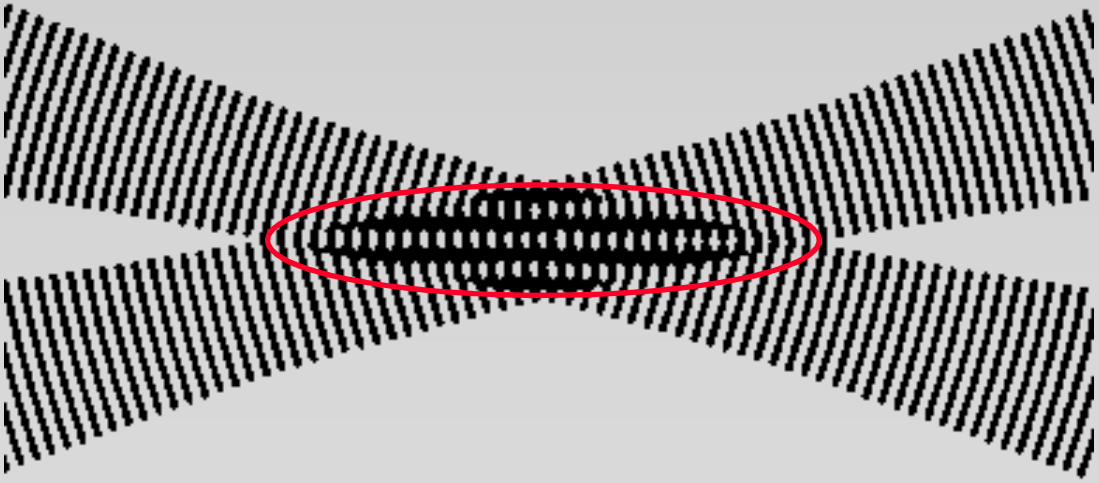
DANTEC
Measurement Technology

Characteristics of LDA

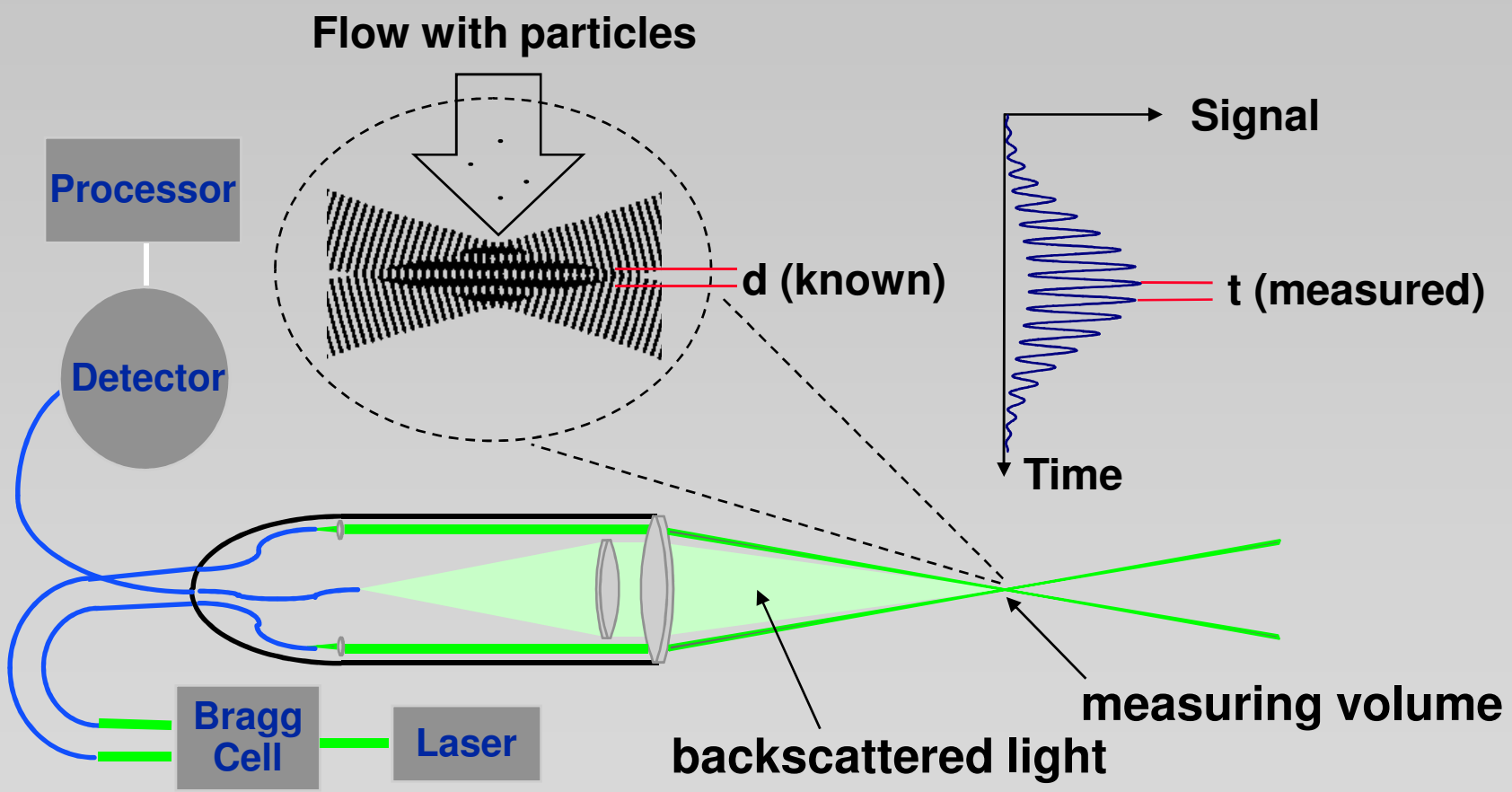
- Velocity measurements in Fluid Dynamics (gas, liquid)
- Up to 3 velocity components (3 beam pairs)
- Non-intrusive measurements (optical technique)
- Absolute measurement technique (no calibration required)
- Very high accuracy
- Very high spatial resolution due to small measurement volume
- Tracer particles (seeding) are required

LDA - Fringe Model

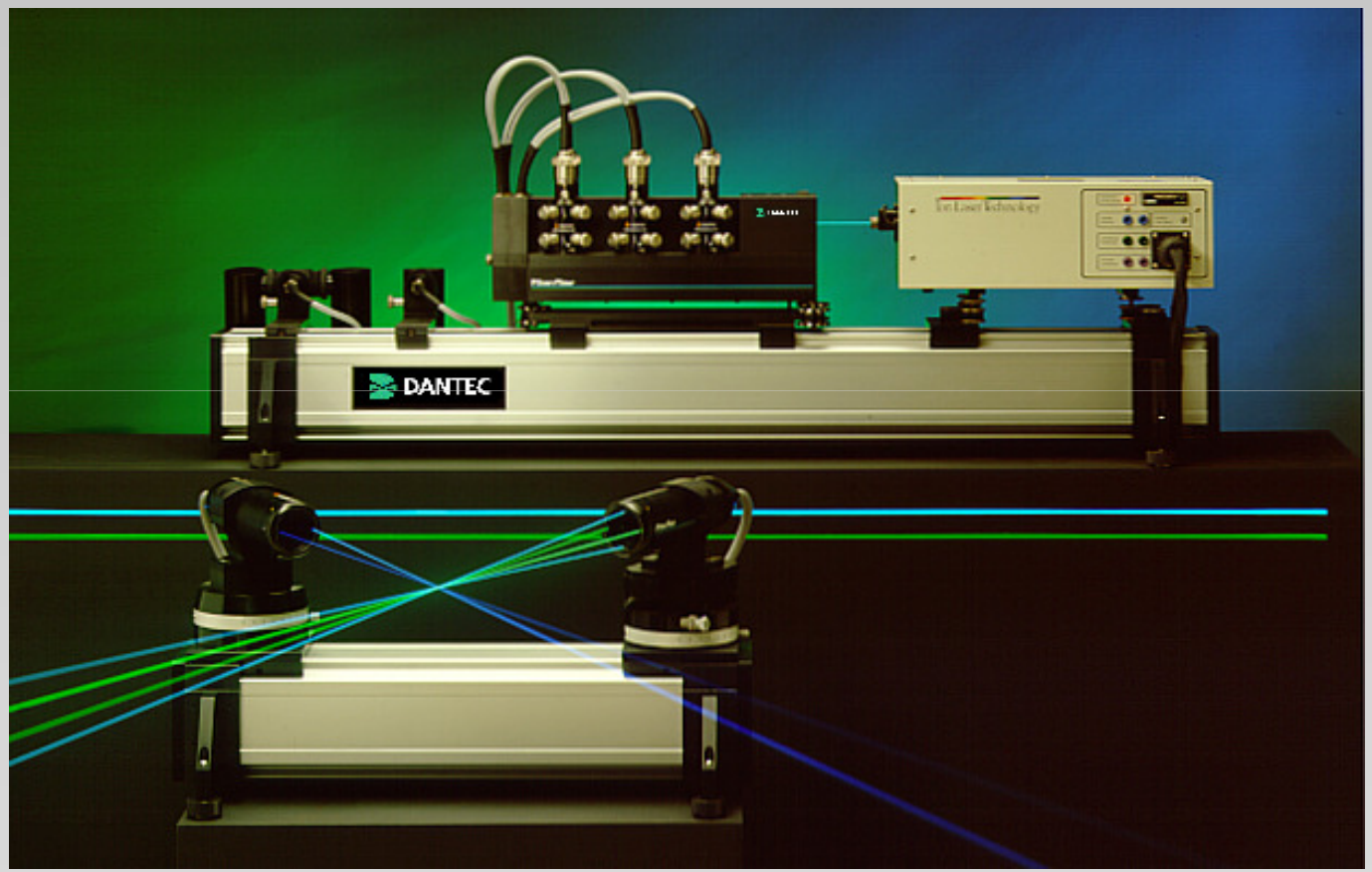
- Focused Laser beams intersect and form the measurement volume
- Interference in the plane of intersection
- Pattern of bright and dark stripes/planes



Velocity = distance/time



LDA Fibre Optical System



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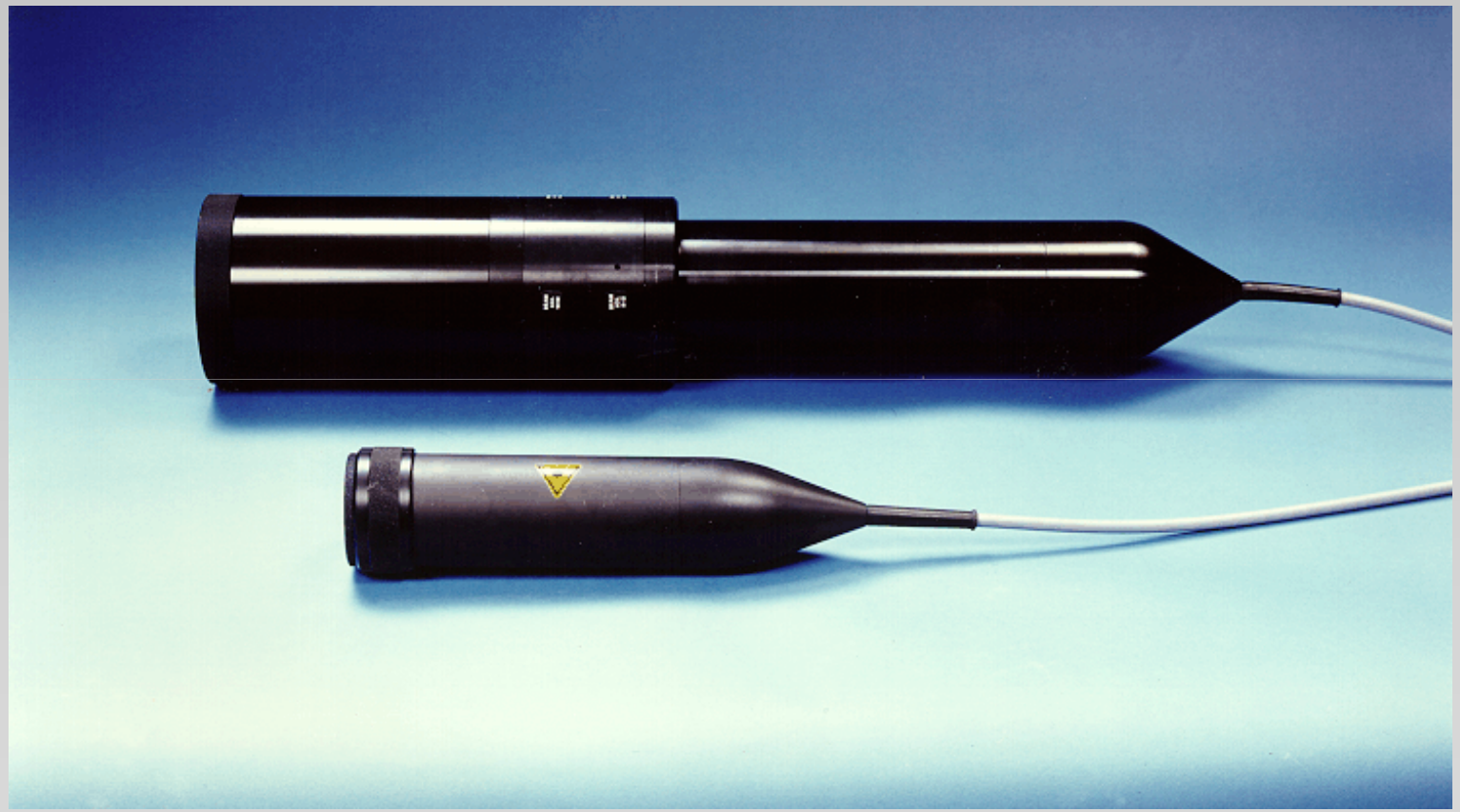
Measurement Technology

60 mm and 85 mm *FiberFlow* probes



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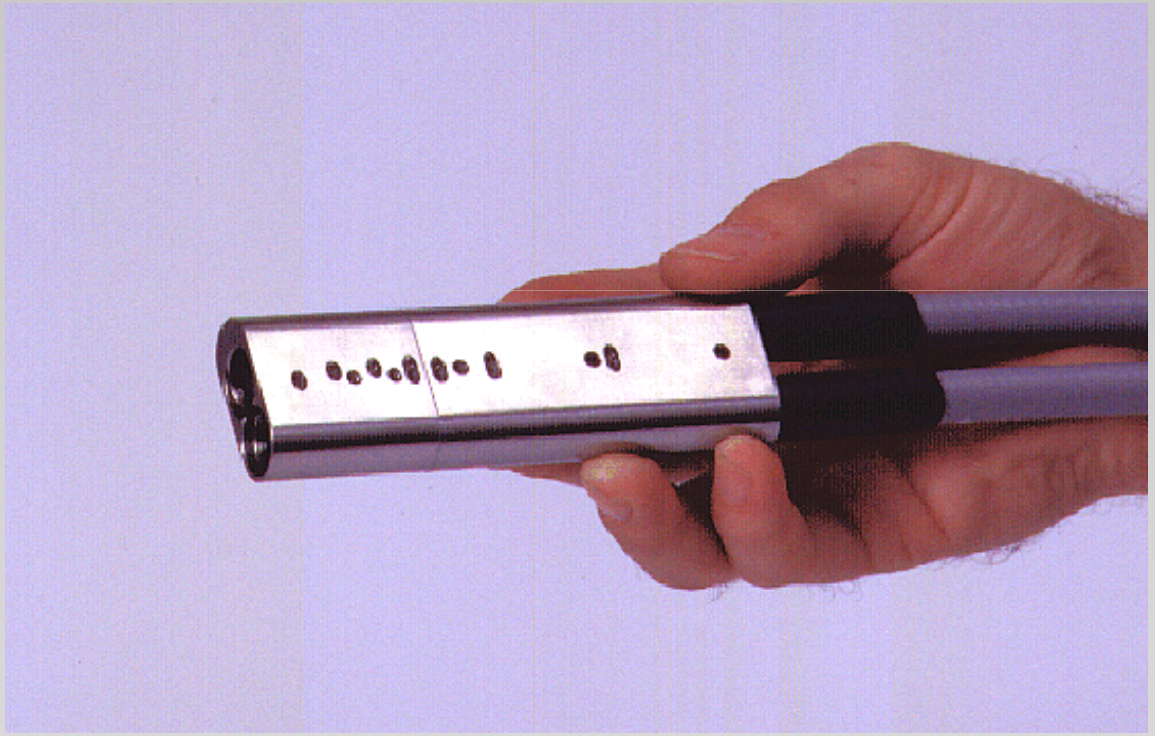
Measurement Technology

The small integrated 3D *FiberFlow* probe



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Measurement Technology

Measurement of air flow around a helicopter rotor model in a wind tunnel

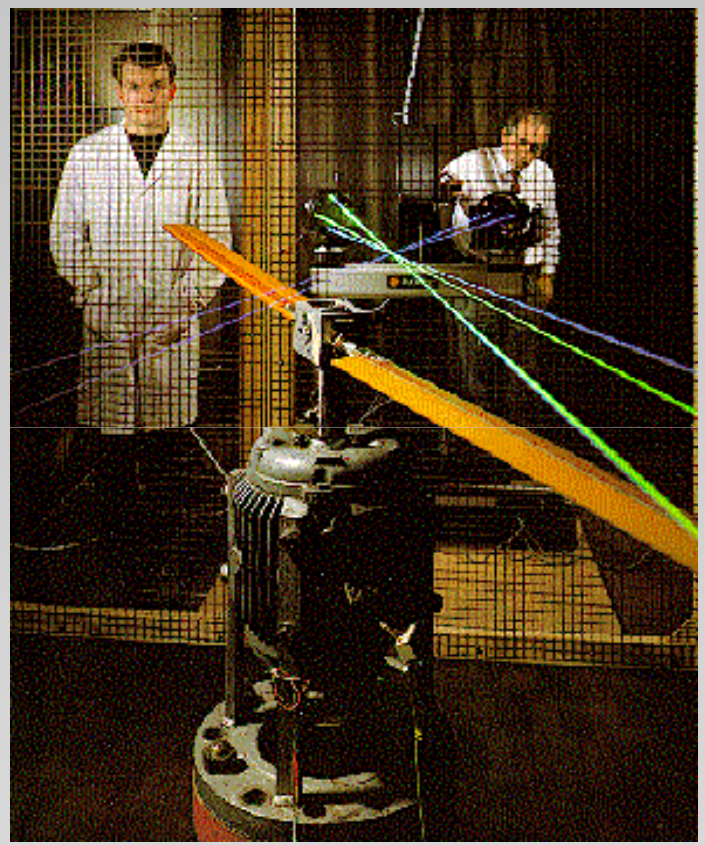

Photo courtesy of University of Bristol, UK

DANTEC
Measurement Technology

Measurement of water flow inside a pump model

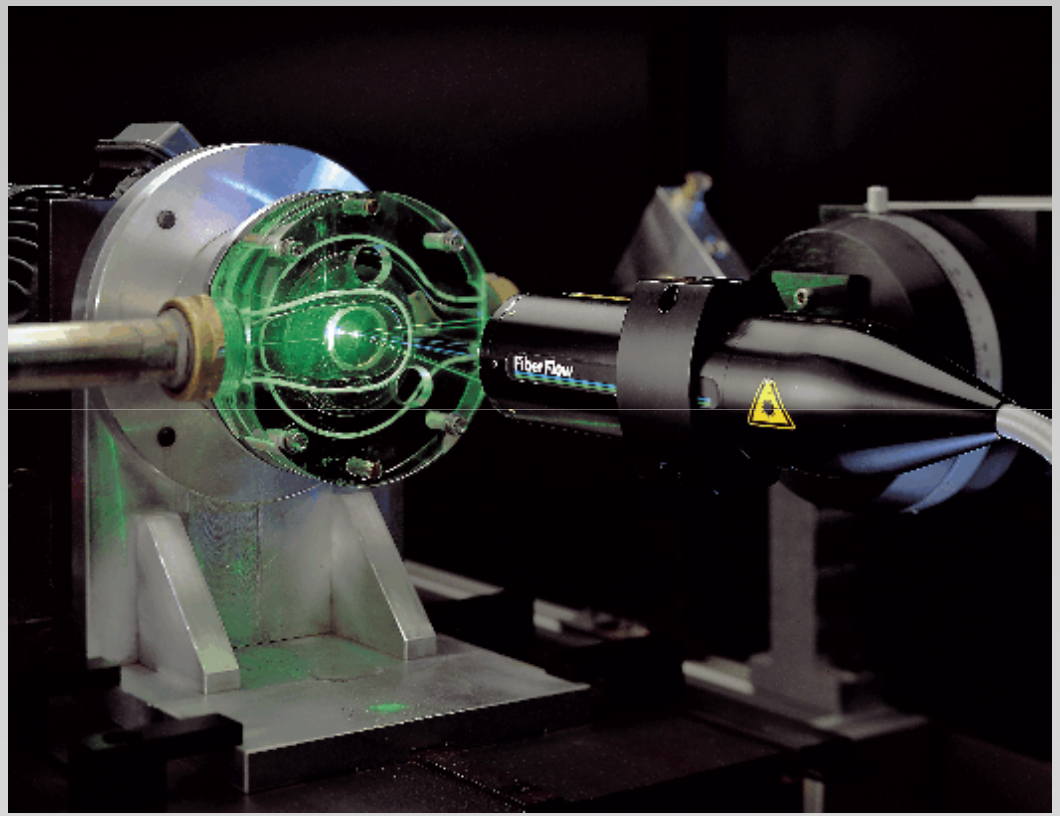

Photo courtesy of Grundfos A/S, DK

DANTEC
Measurement Technology

Measurement of flow field around a 1:5 scale car model in a wind tunnel

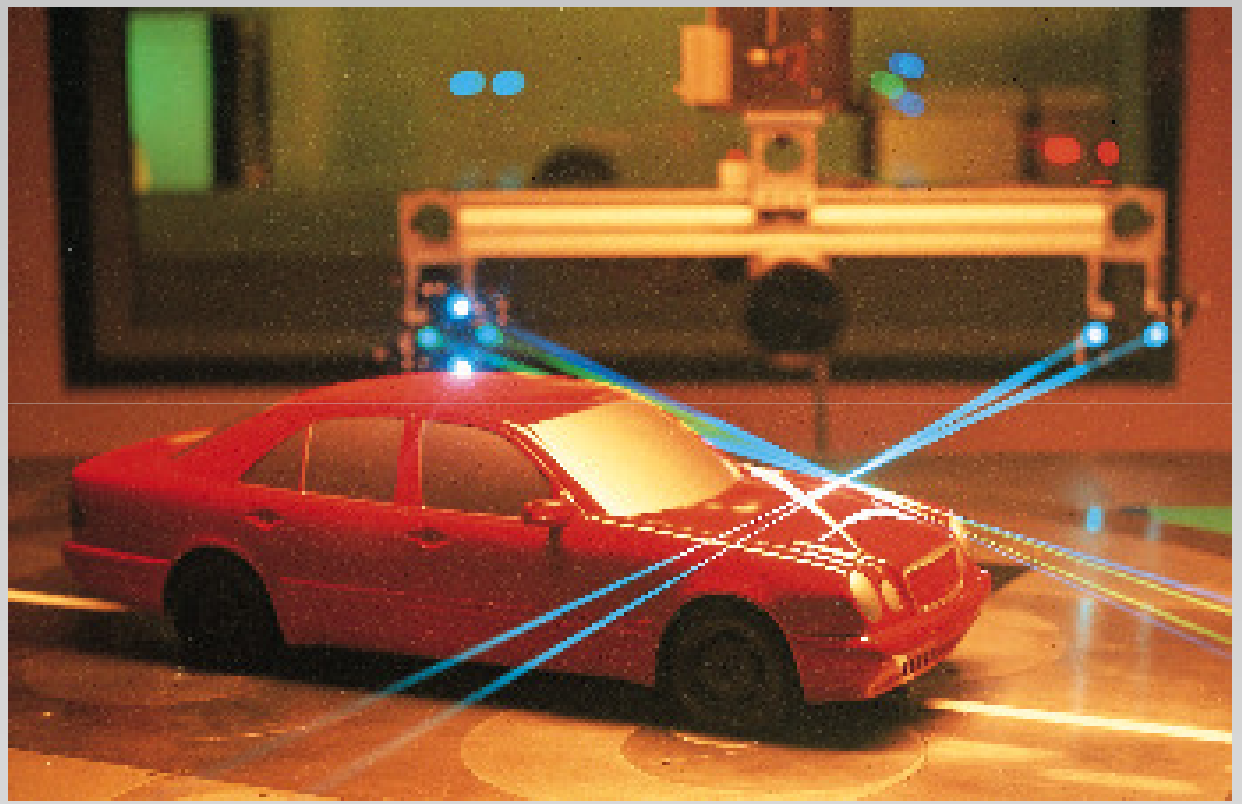

Photo courtesy of Mercedes-Benz, Germany

DANTEC
Measurement Technology

Measurement of wake flow around a ship model in a towing tank

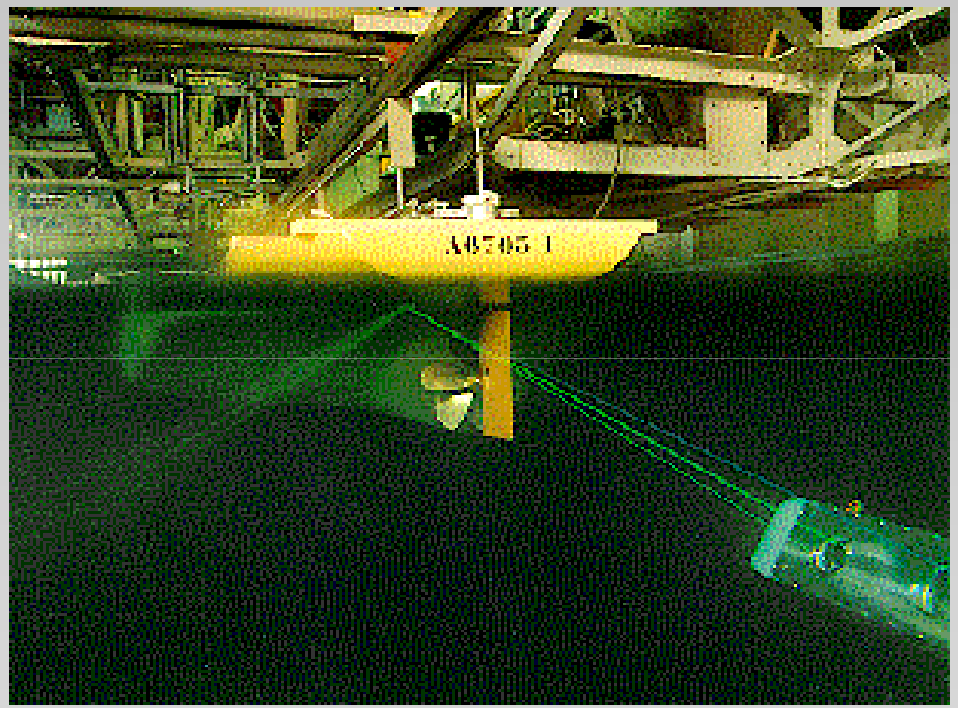

Photo courtesy of Marin, the Netherlands

DANTEC
Measurement Technology

Measurement of air flow field around a ship model in a wind tunnel

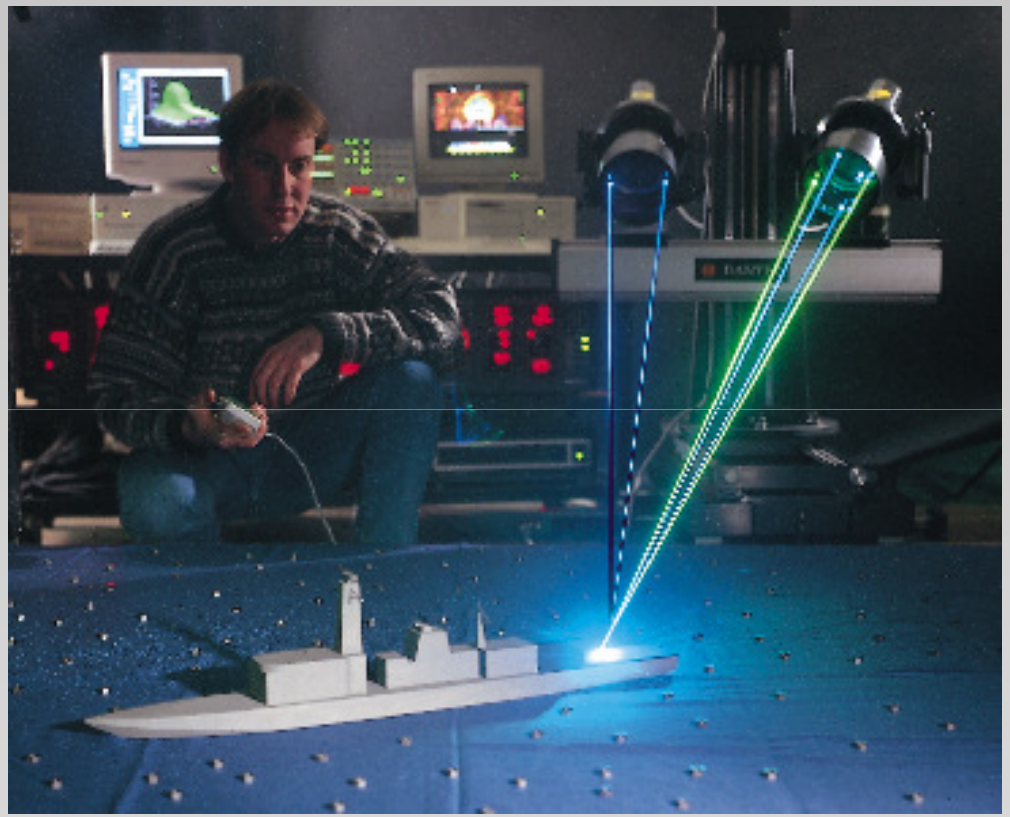

Photo courtesy of University of Bristol, UK

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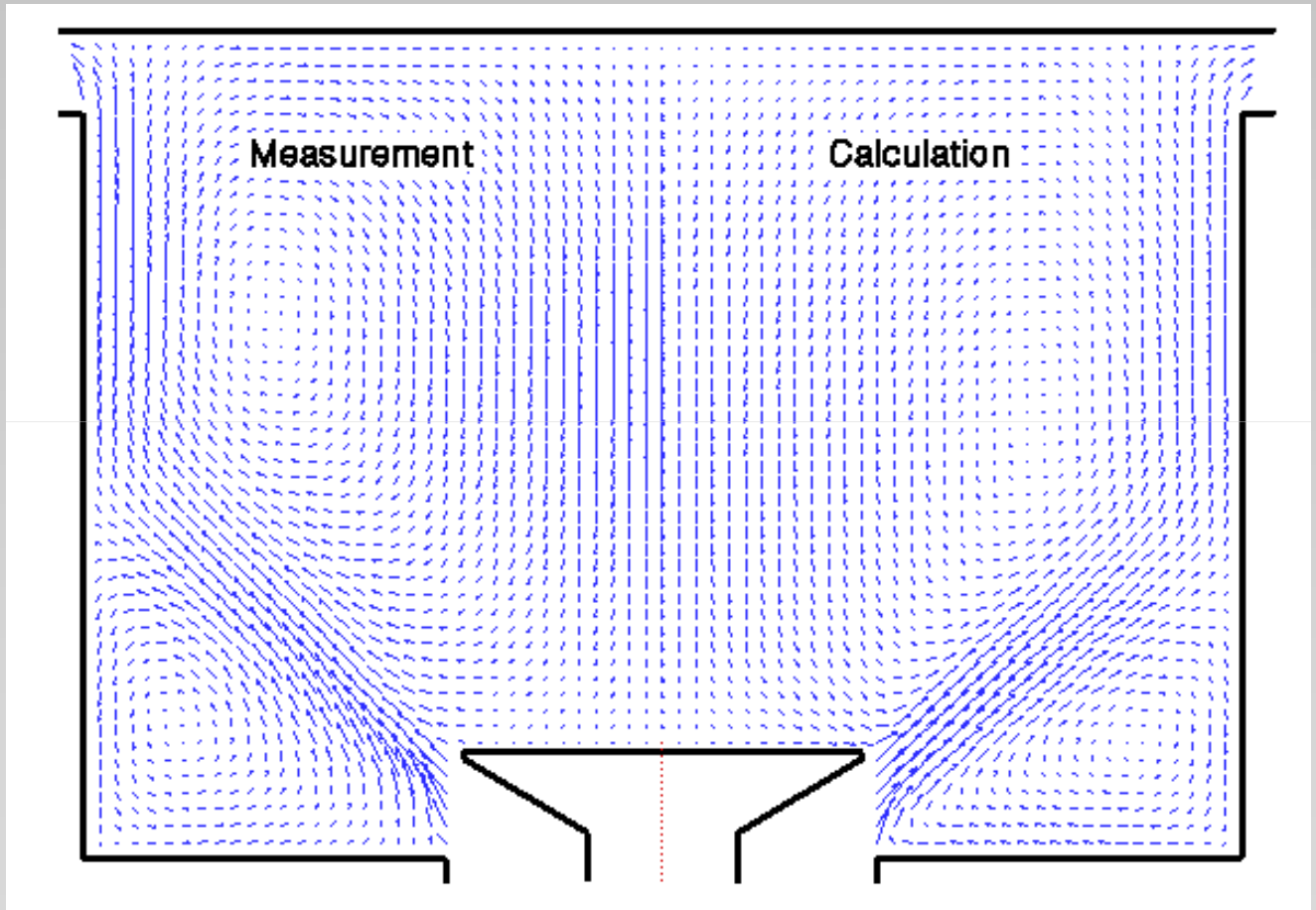
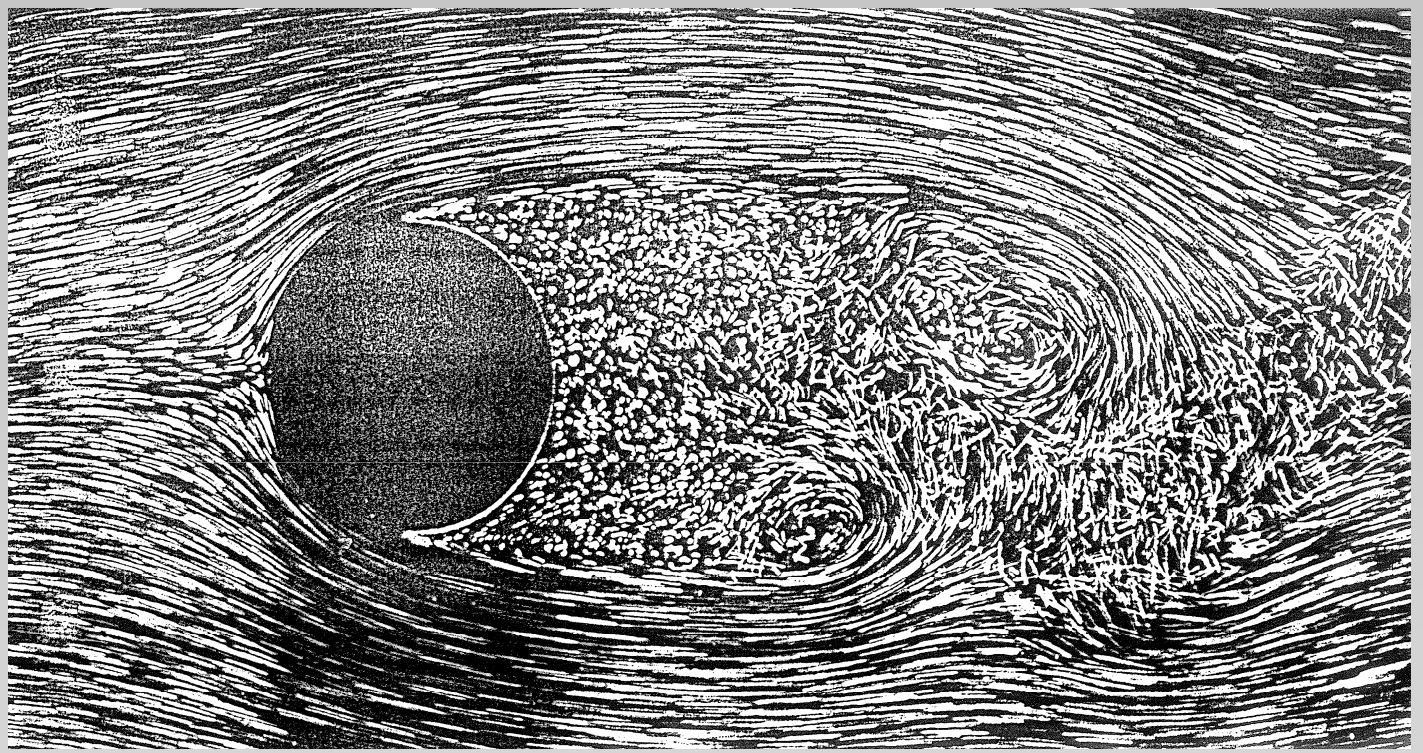
Measurement Technology

Comparison of EFD and CFD results

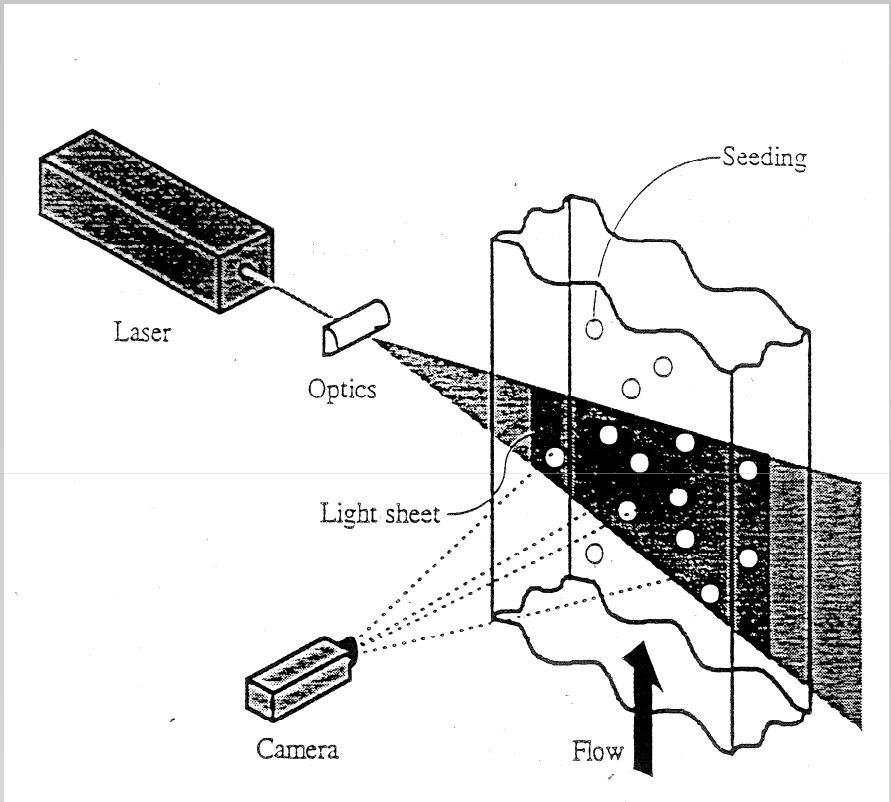


7. Light sheet flow visualisation

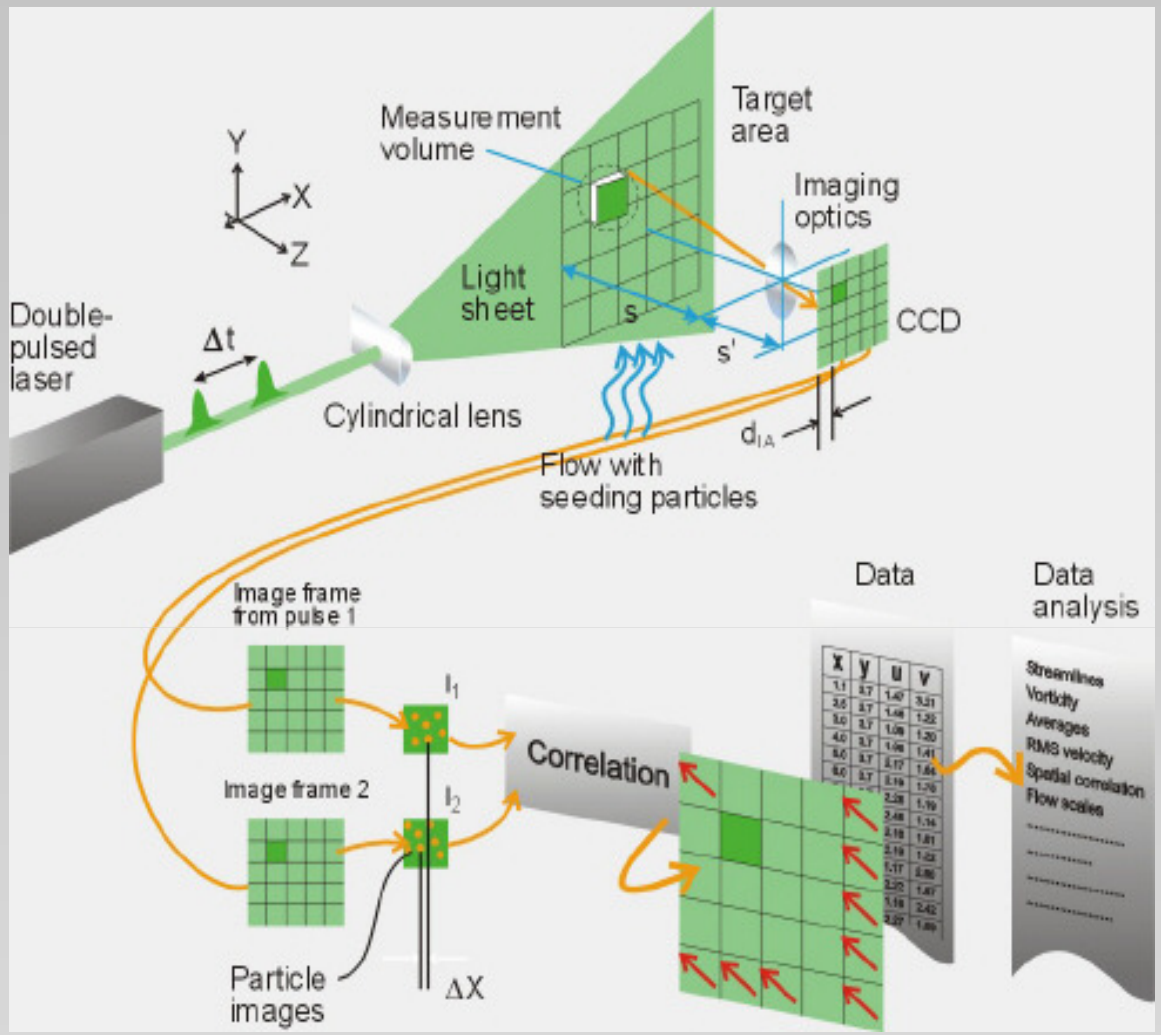


Flow visualised in the vicinity of a cylinder. Re = 2 000. Air bubbles in water. (Van Dyke: An Album of Fluid Motion, Parabolic Press, stanford, California, 1982)

8. 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)



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

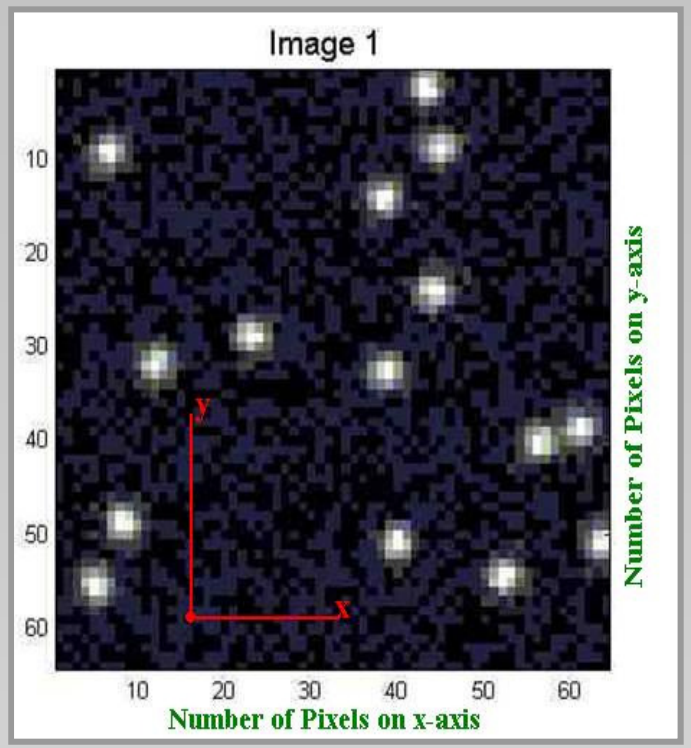


Image 1 at time t1

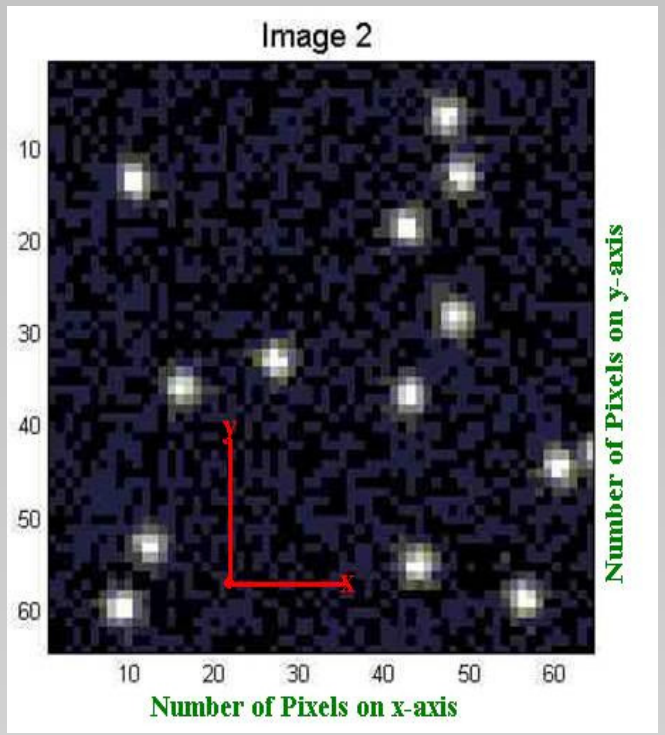
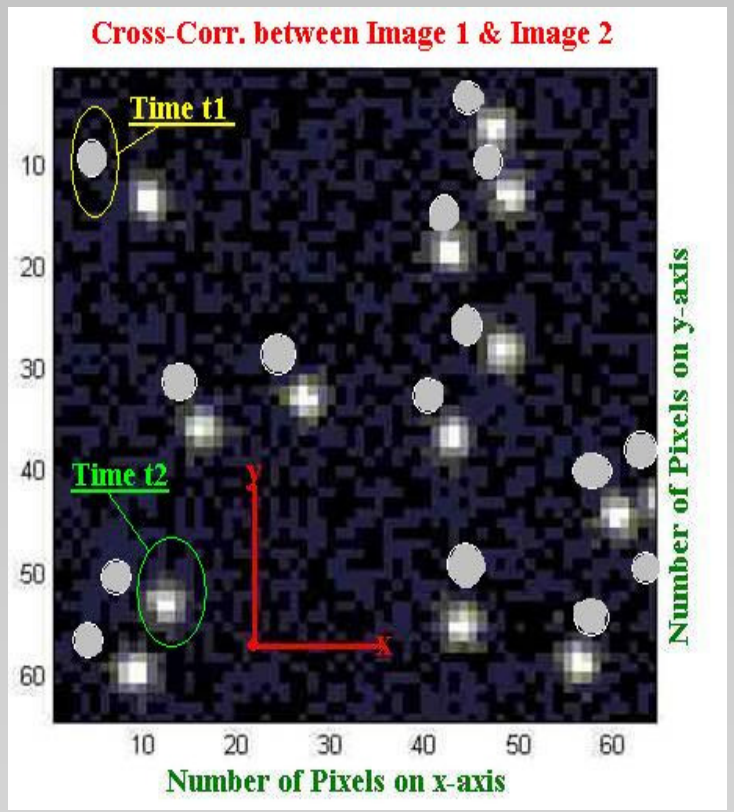


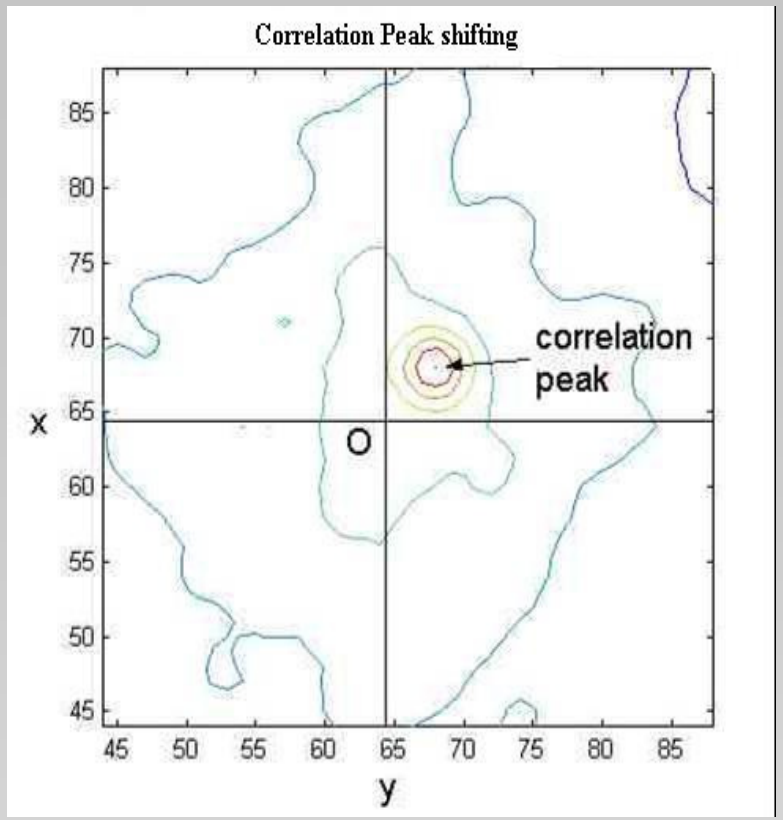
Image 2 at time t2

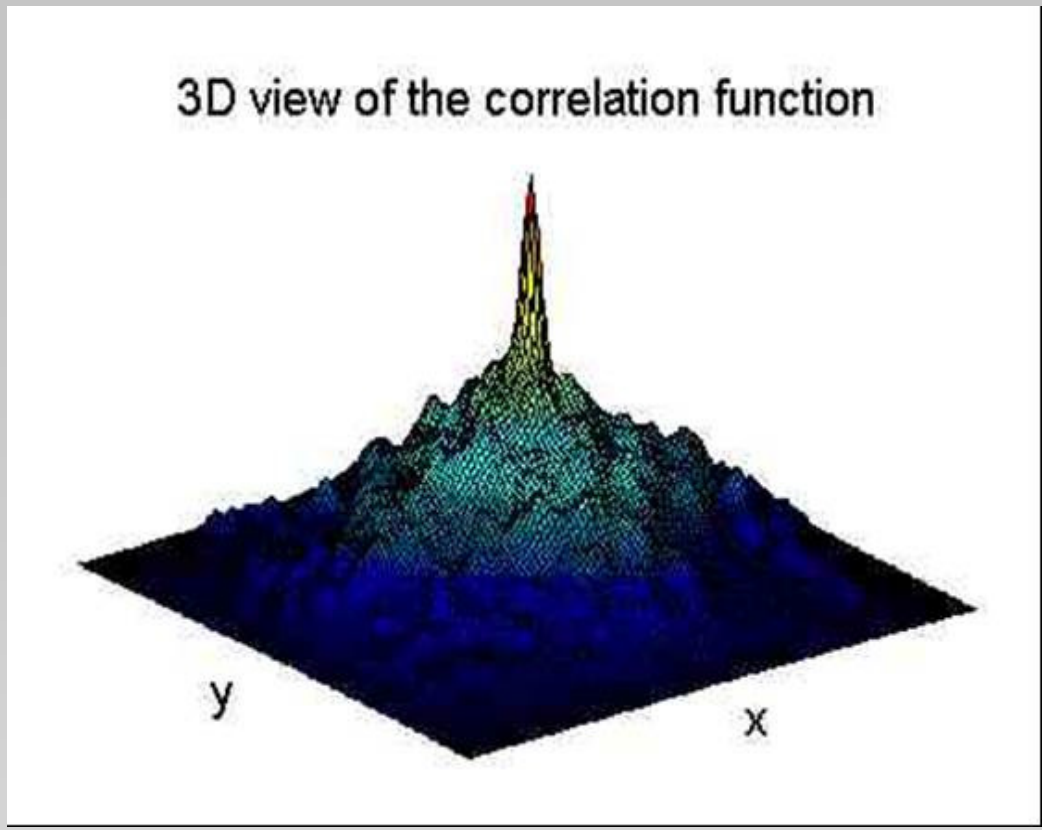
$$\bar{V} = \frac{\bar{\Delta x}}{\Delta t} \qquad \bar{\Delta x} = ?$$

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



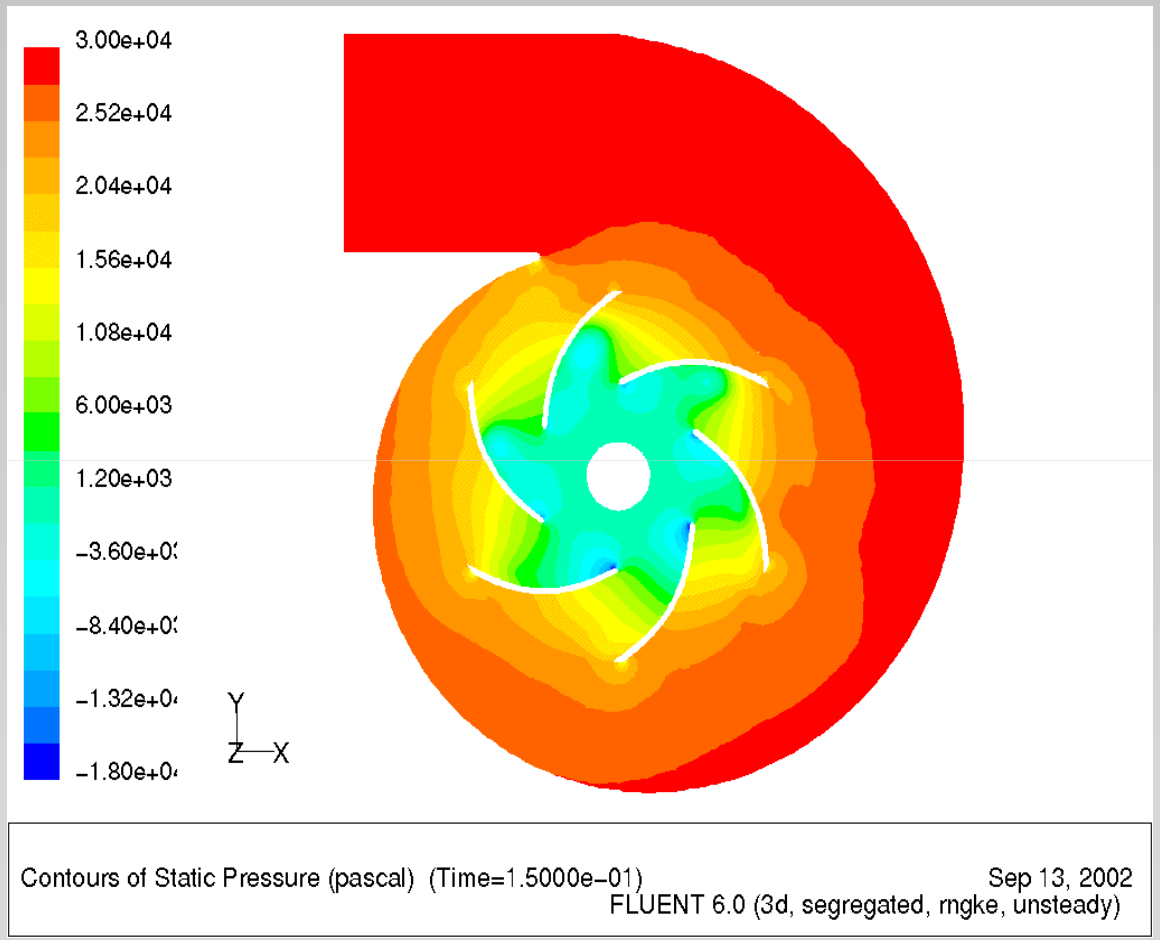
Maximum cross-correlation between Image 1 & Image 2

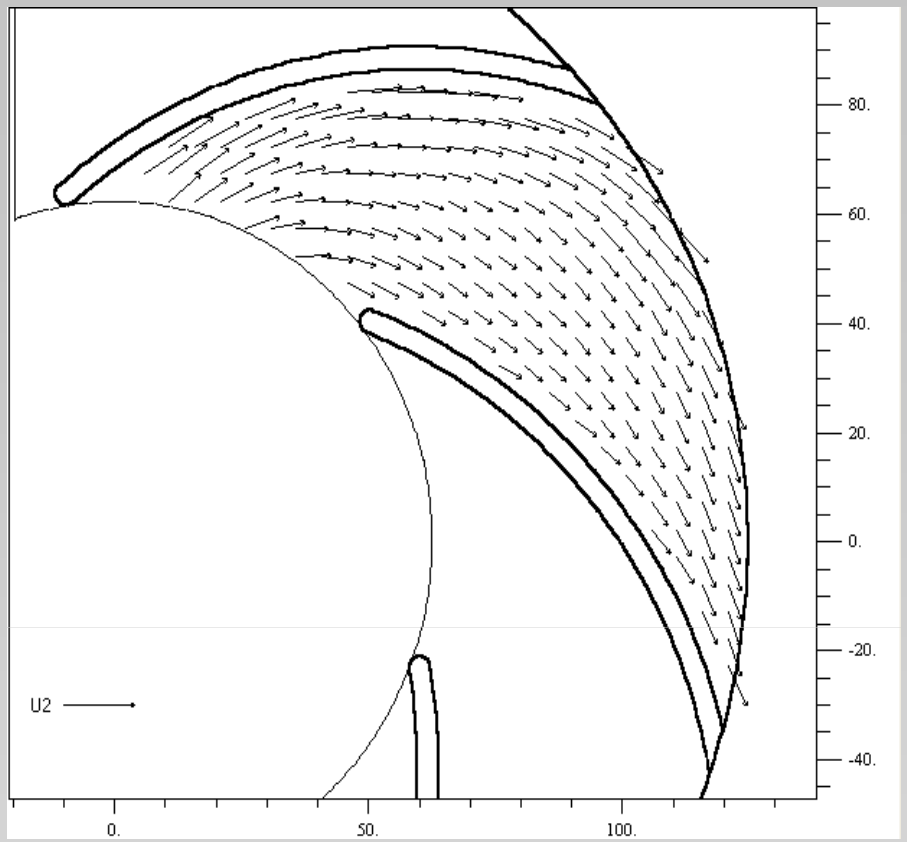


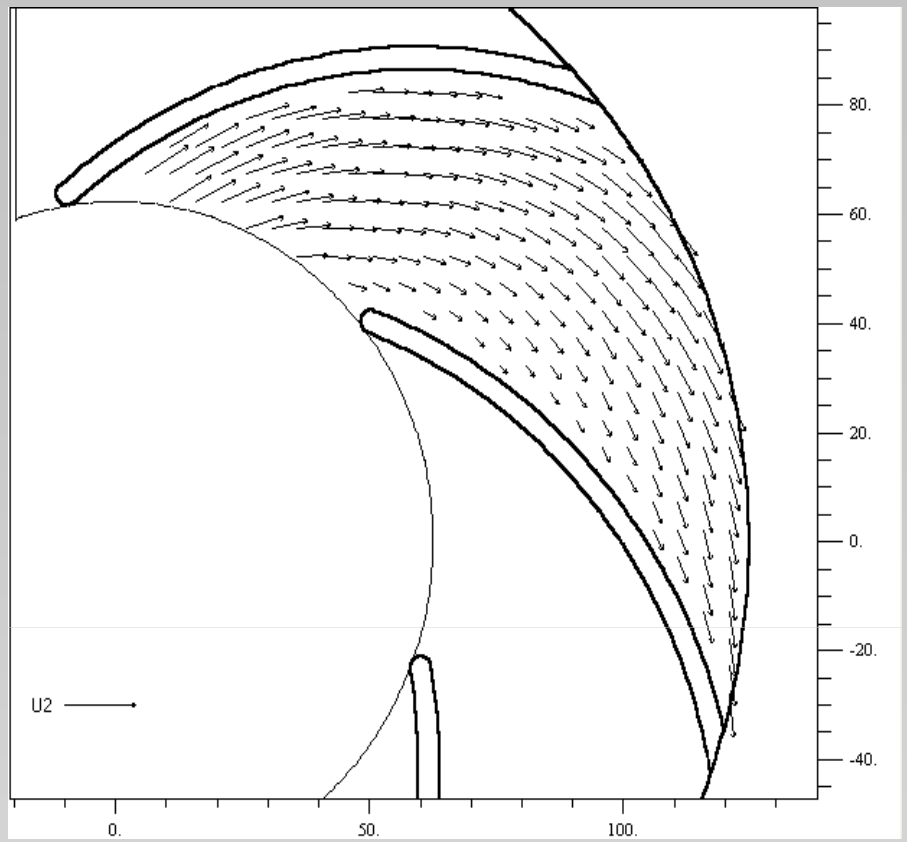


PIV Lecture_Notes, “Particle Image Velocimetry”, University of WARWICK, Optical Engineering Laboratory (OEL)

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







PIV measurement
(Otto-Von-Guericke
Universitaet Magdeburg)

FLUENT simulation
(Dept. of Fluid Mechanics, BME)

DANTEC
Measurement Technology

9. Hot-Wire Anemometry

- **Purpose:**

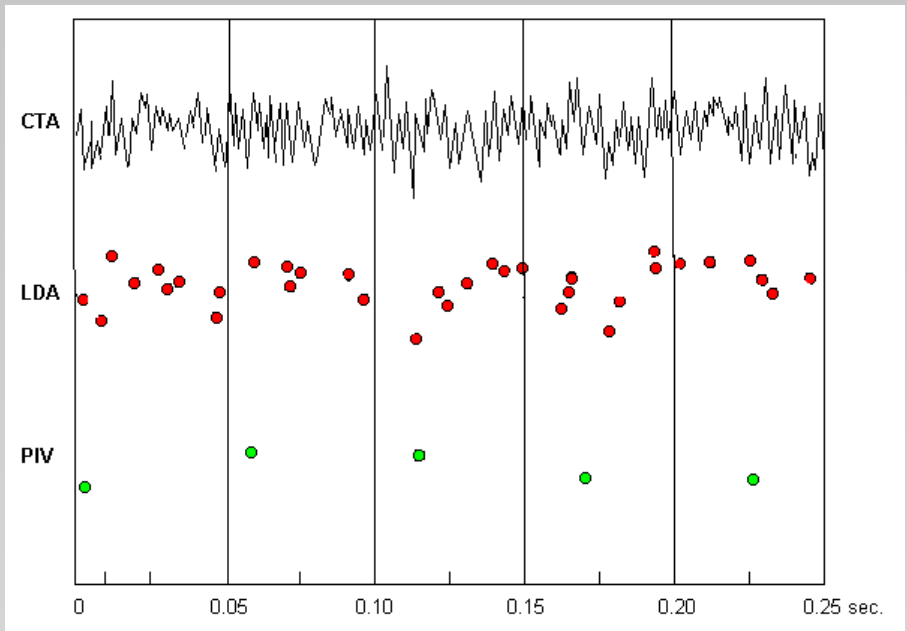
  to measure mean and fluctuating variables in fluid flows (velocity, temperature, etc.): mean velocity, turbulence characteristics

TURBULENCE RESEARCH (LABORATORY)

Anemometer signal output

The thermal anemometer provides an analogue output which represents the velocity in a point. A velocity information is thus available anytime.

Note that LDA signals occur at random, while PIV signals are timed with the frame grapping of illuminated particles.

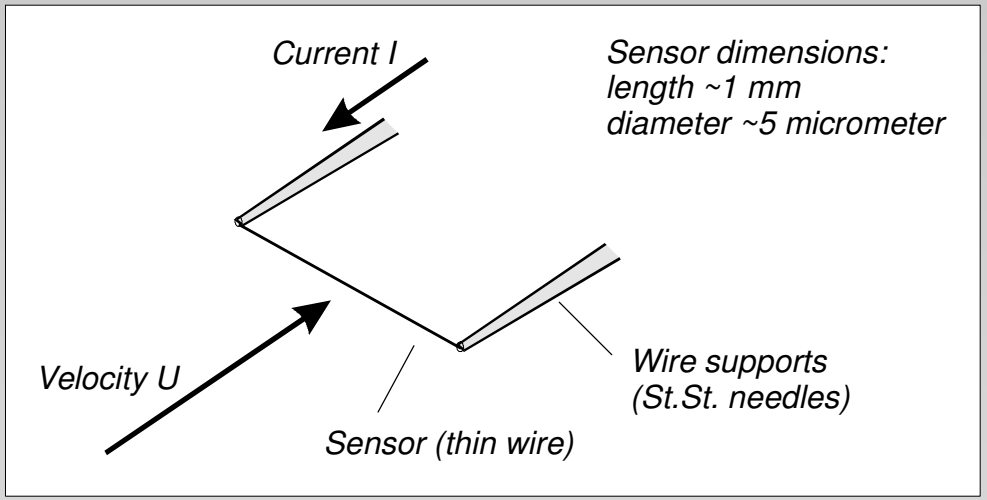


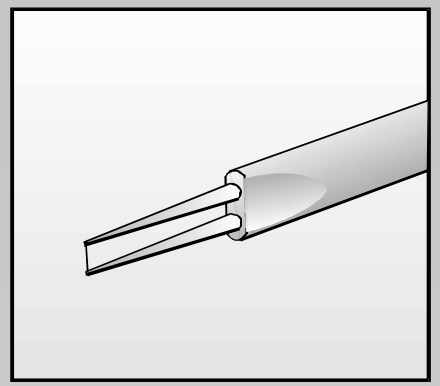
Principles of operation

- **Consider a thin wire mounted to supports and exposed to a velocity *U*.**

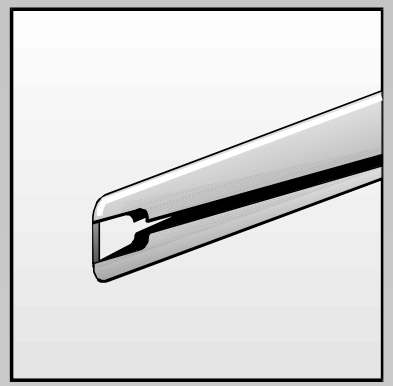
  When a current is passed through wire, heat is generated (I^2R_w). In equilibrium, this must be balanced by heat loss (primarily convective) to the surroundings.

- **If velocity changes, convective heat transfer coefficient will change, wire temperature will change and eventually reach a new equilibrium.**

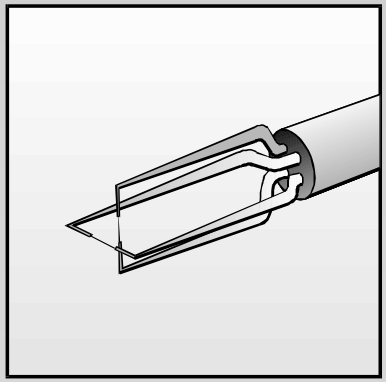




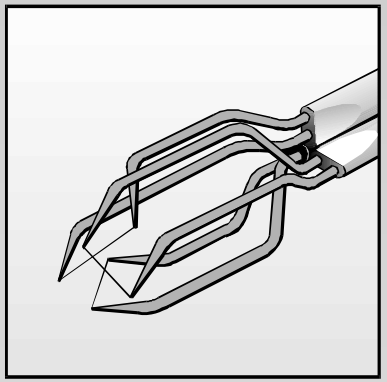
1D



1D film probe



2D X-probe



3D tri-axial probe

Constant Temperature Anemometer CTA

- **Principle:**

  Sensor resistance is kept constant by servo amplifier

- **Advantages:**
  - **Easy to use**
  - **High frequency response**
  - **Low noise**
  - **Accepted standard**

- **Disadvantages:**
  - **More complex circuit**