The Abdus Salam International Centre for Theoretical Physics

ICTP Scientific Fabrication Laboratory
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International Conference on "Scientific Fabrication Laboratories"
October 23-25, 2017., Trieste

Scientific FabLab at the Faculty of Mechanical Engineering University of Belgrade – Support for Experimental Fluid Flow Research

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Hydraulic Machinery and Energy Systems Department

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Contents:

1. INVESTIGATIONS IN PROGRESS:

1. Turbulent swirling flow in pipes, diffusers and jets (experiments in air)
2. Study of the flow in human nasal cavity
3. Flow study in pump impeller and spiral casing
4. Wing tip vortex behaving on the NASA CRM model

Engineering applications:
1. Energy efficiency in pump, fan and compressor systems
2. Energy efficiency in hydropower plants
3. Pump impellers – geometry

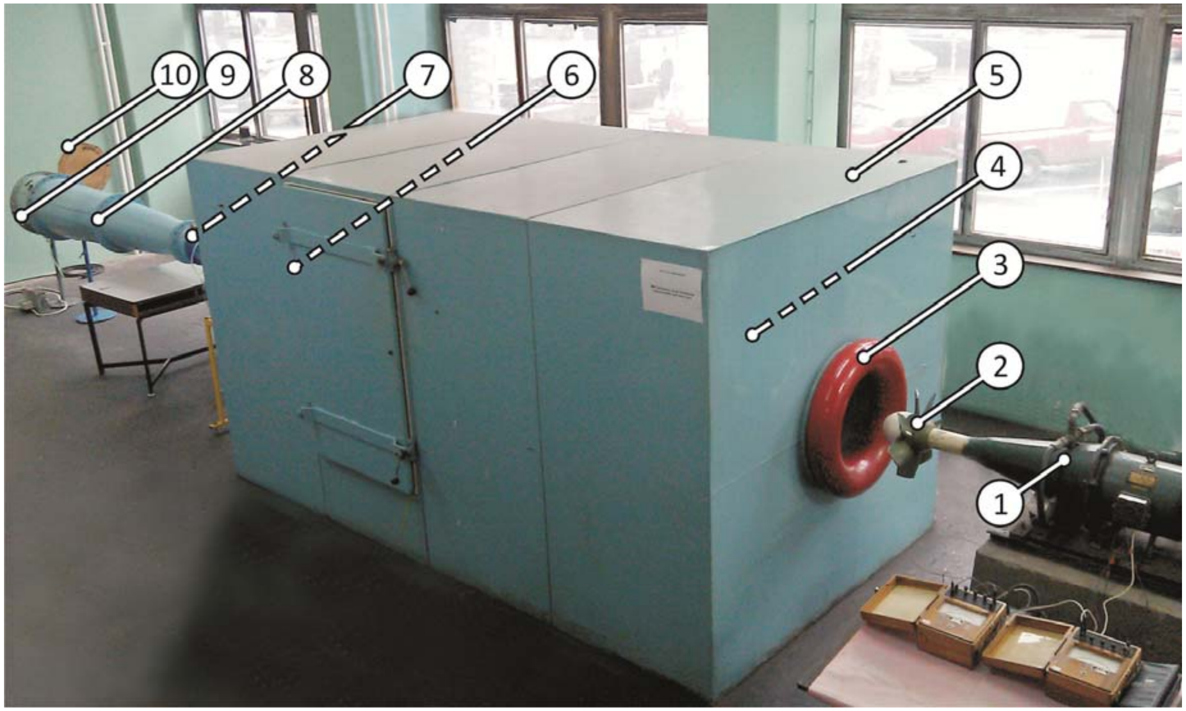
Techniques:
1. Hot wire anemometry – probes and calibration
2. Software for axial turbomachines
3. Development of affordable PIV systems
4. Micro PIV and microchannels
5. Flow visualizations

1. Test rigs in Laboratory

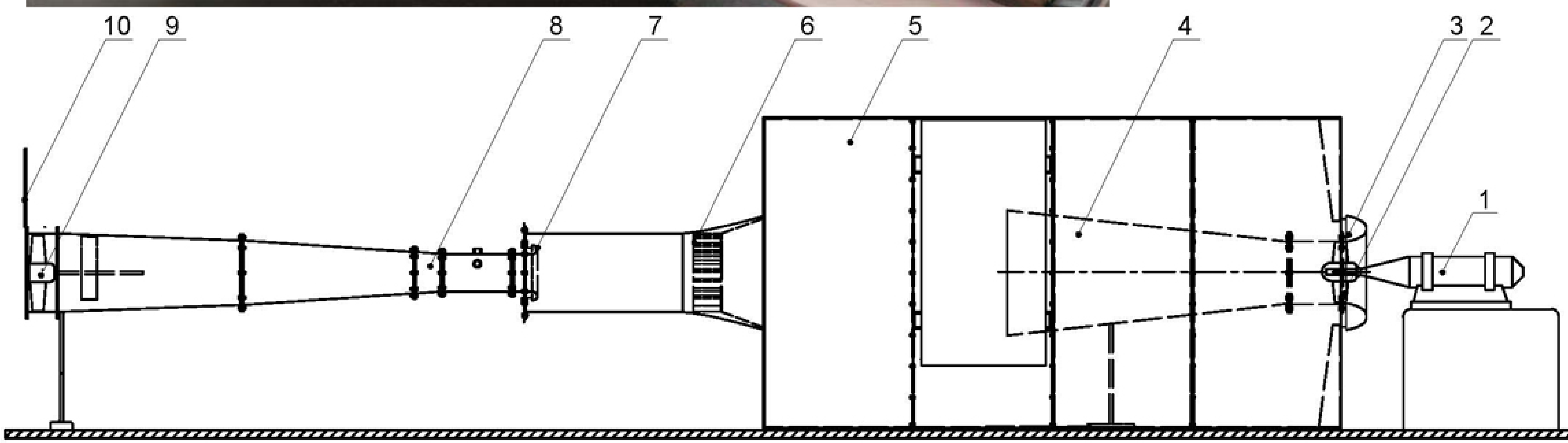
-Test rig for energy and cavitation characteristics of the Francis, Kaplan, Banki, bulb turbines, small hydropower plants, hydraulic pumps and hydro mechanical components
($Q = 0.3\ m^3/s$, $H = 25\ m$).
-Installation for testing fans after international standard ISO 5801 and ISO 5802.
-Installation for testing jet fans.
-Various installations for ventilation components testing.
…
Installations for calibration:
1. Volume flow meters in three ranges up to: 3 l/s, 50 l/s, 200 l/s.
2. Three wind tunnels for anemometers calibration: up to 10 m/s, 36 m/s and 60 m/s.
3. Pressure (primary method) – gas (range: vacuum to 70 bar).
4. Pressure (primary method) – hydraulic (range: till 50 bar).

Test rig for energy and cavitation characteristics of the Francis, Kaplan, Banki, Bulb turbines, small hydropower plants, hydraulic pumps and hydro mechanical components (Q = 0.3 m^3/s, H = 25m).

Test rig for defining energy characteristics of the axial fans (ISO 5801, type A) (by Prof. Dr. Zoran D. Protić†)

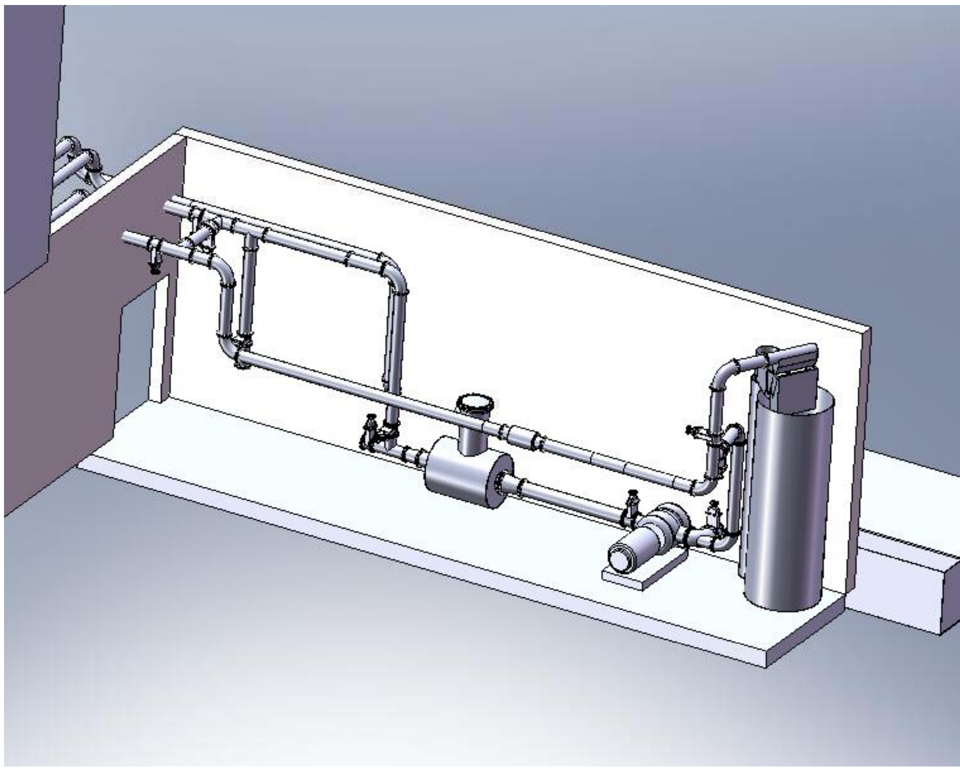


1. DC motor with regulation,
2. axial fan impeller,
3. profiled bell-mouth inlet ,
4. straight conical diffuser,
5. chamber,
6. honey-comb,
7. flow meter (nozzle),
8. pipe,
9. booster fan.



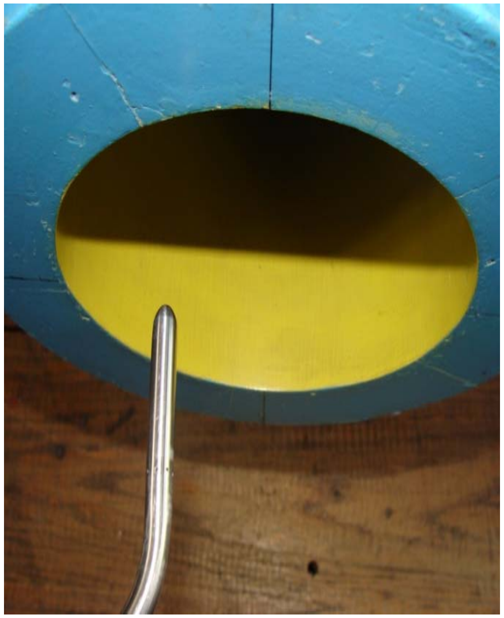
REVERSIBLE JET FAN FOR ECOLOGICAL CONDITION SUSTAIN IN THE TUNNELS

Test rig for hydraulic tests of pumps, turbine models, hydro-mechanical equipment and volumetric flow meters calibration (up to 0.2 m^3/s) (by Prof. Dr. Miroslav H. Benišek)



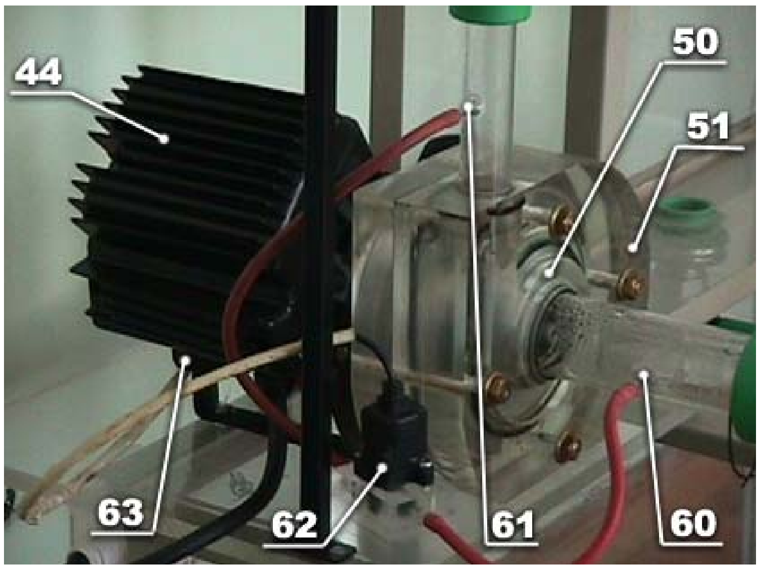
Test rig for volumetric flow meter calibration up to 50 l/s for standard procedure.

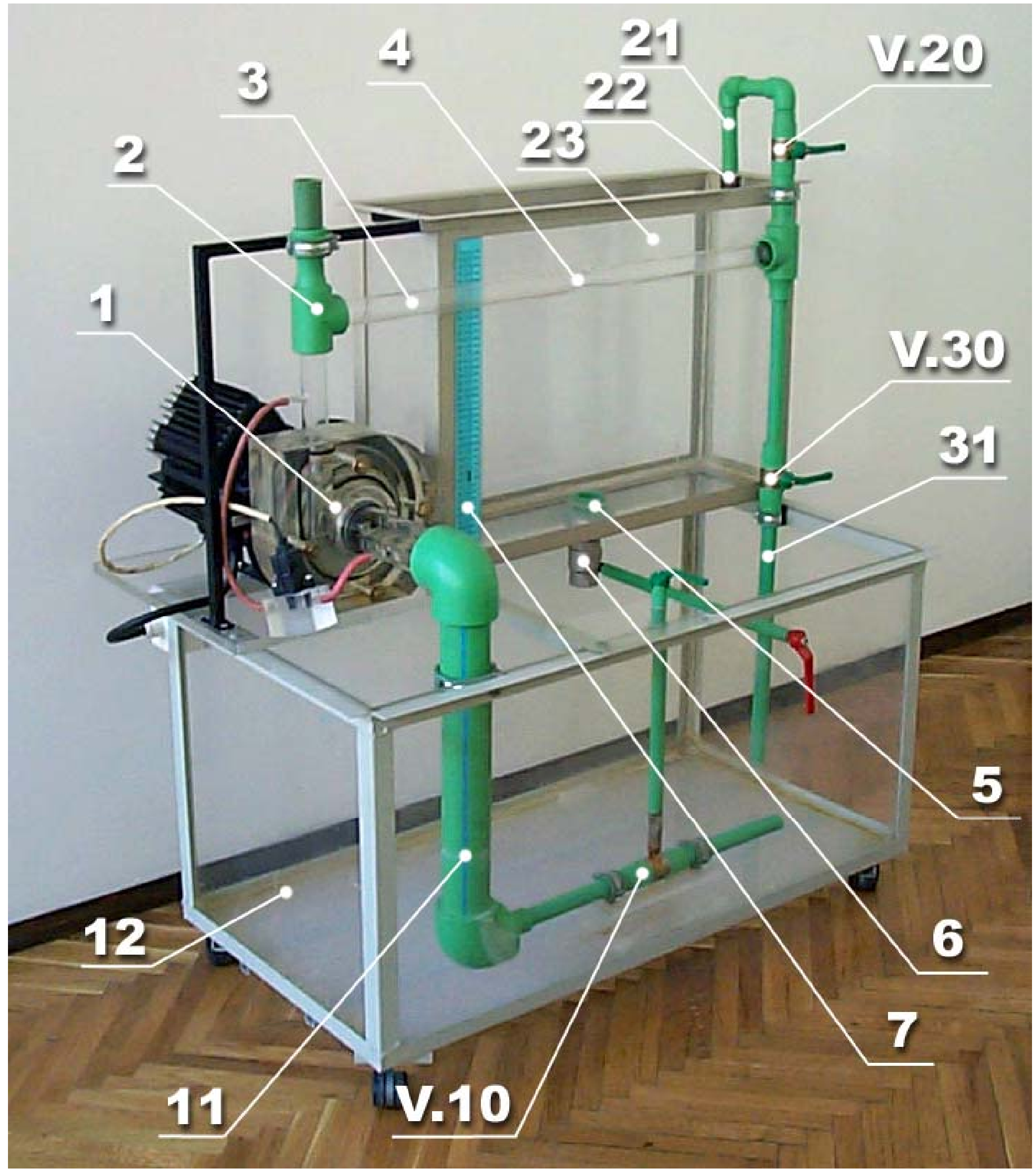
Probe calibration in the air tunnel up to 60m/s.



Probe calibration in the air tunnel up to 36 m/s and 10 m/s.

Original educational installation for flow visualization, determination of pump hydraulic characteristics, variety of pump control possibilities, determination of pipe hydraulic characteristics, volume flow rate calibration, etc.
(by Prof. Dr. Miloš S. Nedeljković)



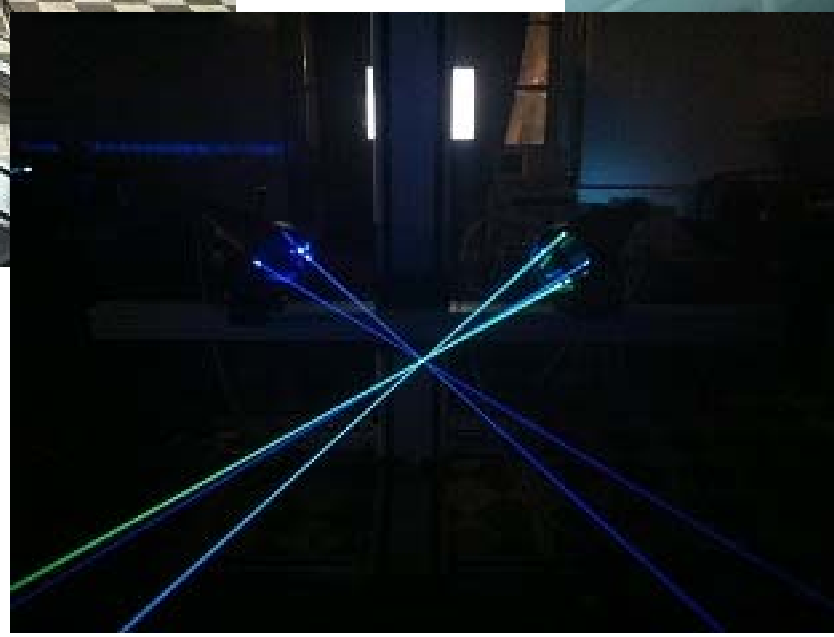


Pressure devices calibration

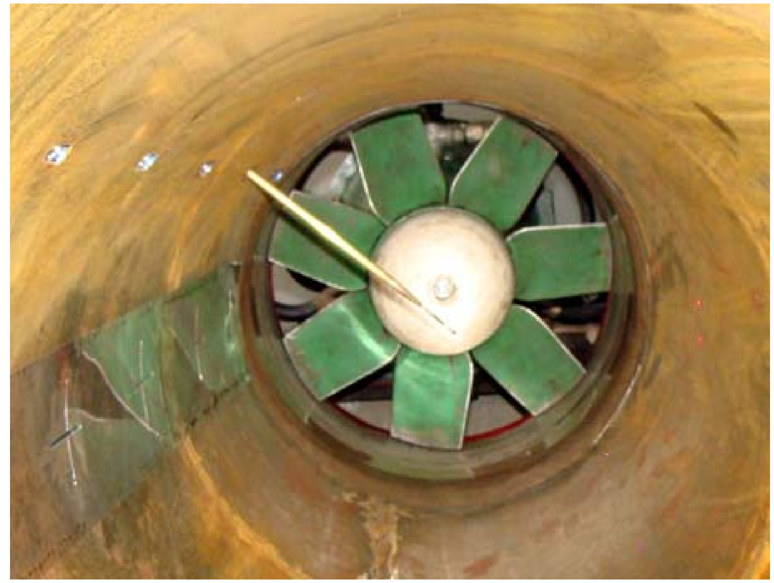
2. Novel measurement techniques in Laboratory

1. Laser Doppler anemometry (3D system)
2. Stereo particle image velocimetry (SPIV)
3. High speed stereo PIV – to be installed in the first half of 2017
4. Micro PIV
5. Hot-wire anemometry
4. Classical and original probes (Pitot, Pitot-Prandtl, Cylindrical, Conrad, ...)

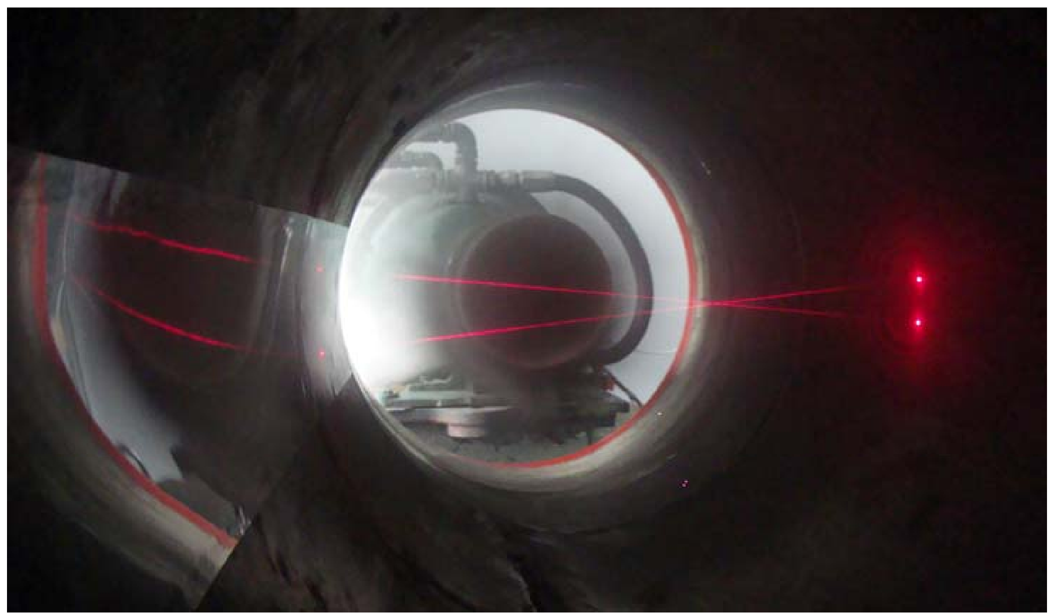
Three-components LDA system – study of the turbulent swirling flow in jets



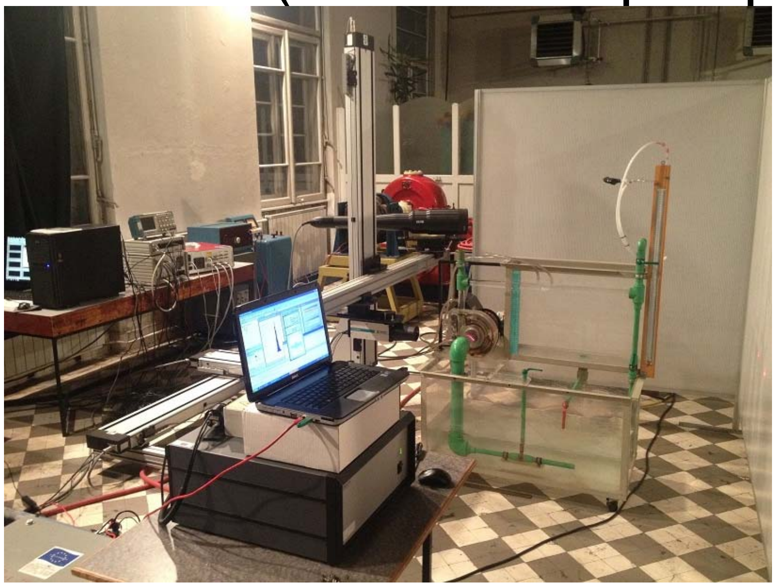
Swirl flow in diffusers

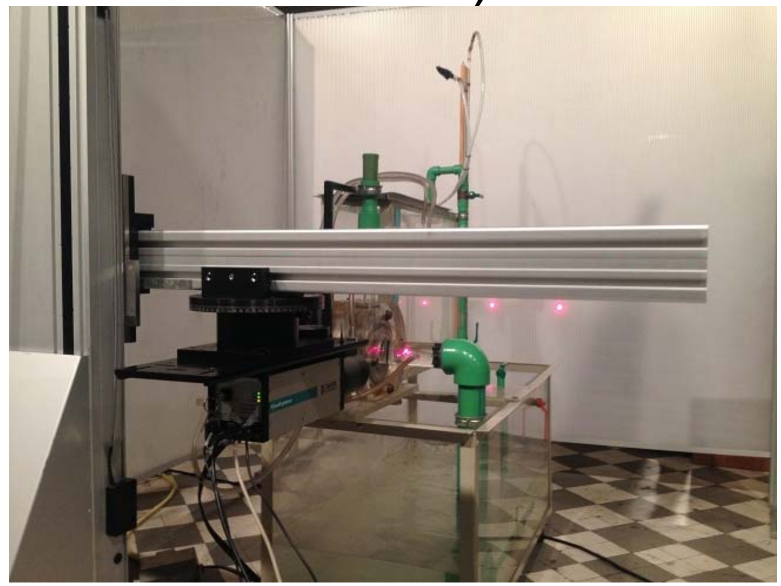


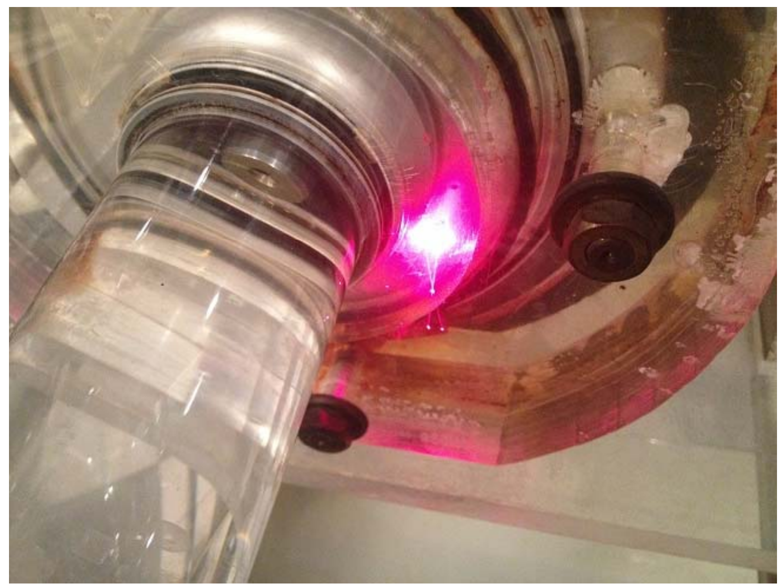
Application of one- and
two-component LDA systems.



Experimental (LDA) investigation in pump impeller spiral casing (in addition: pump inlet mesurements)

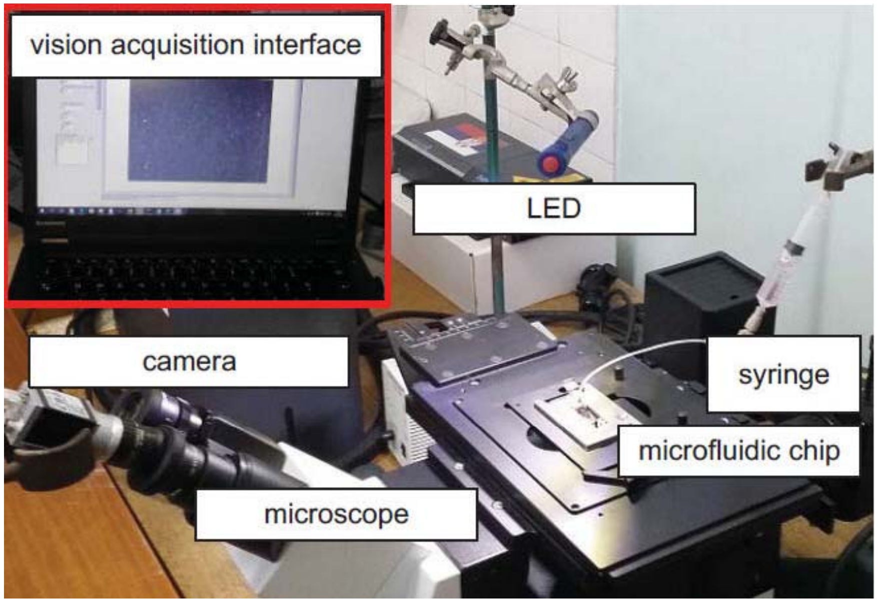




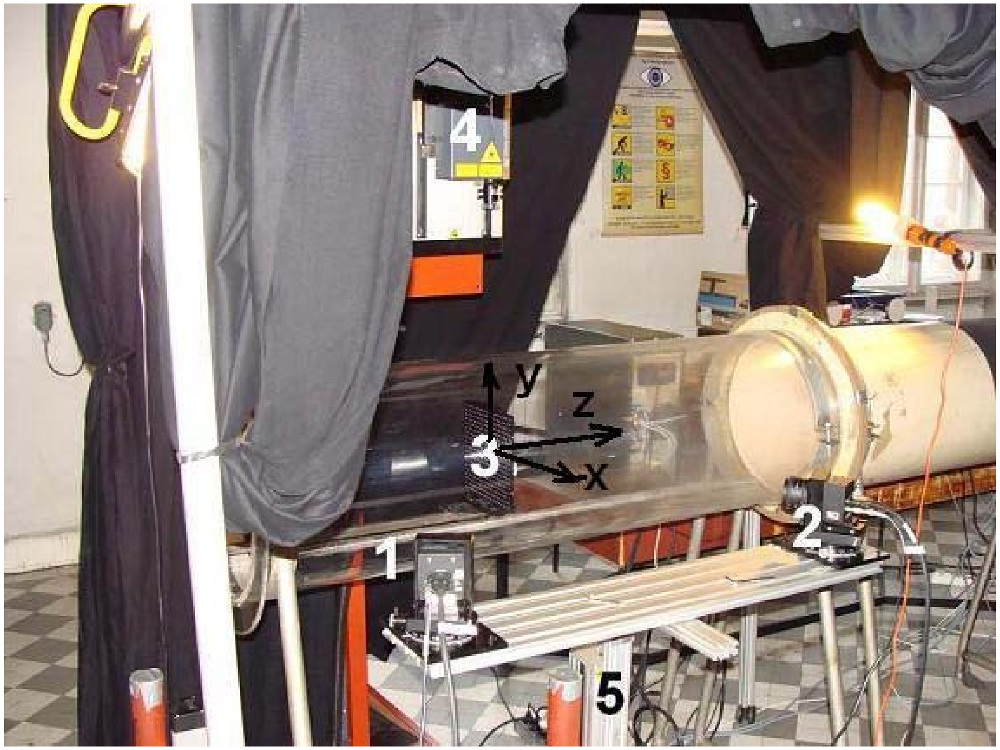


Micro PIV measurements

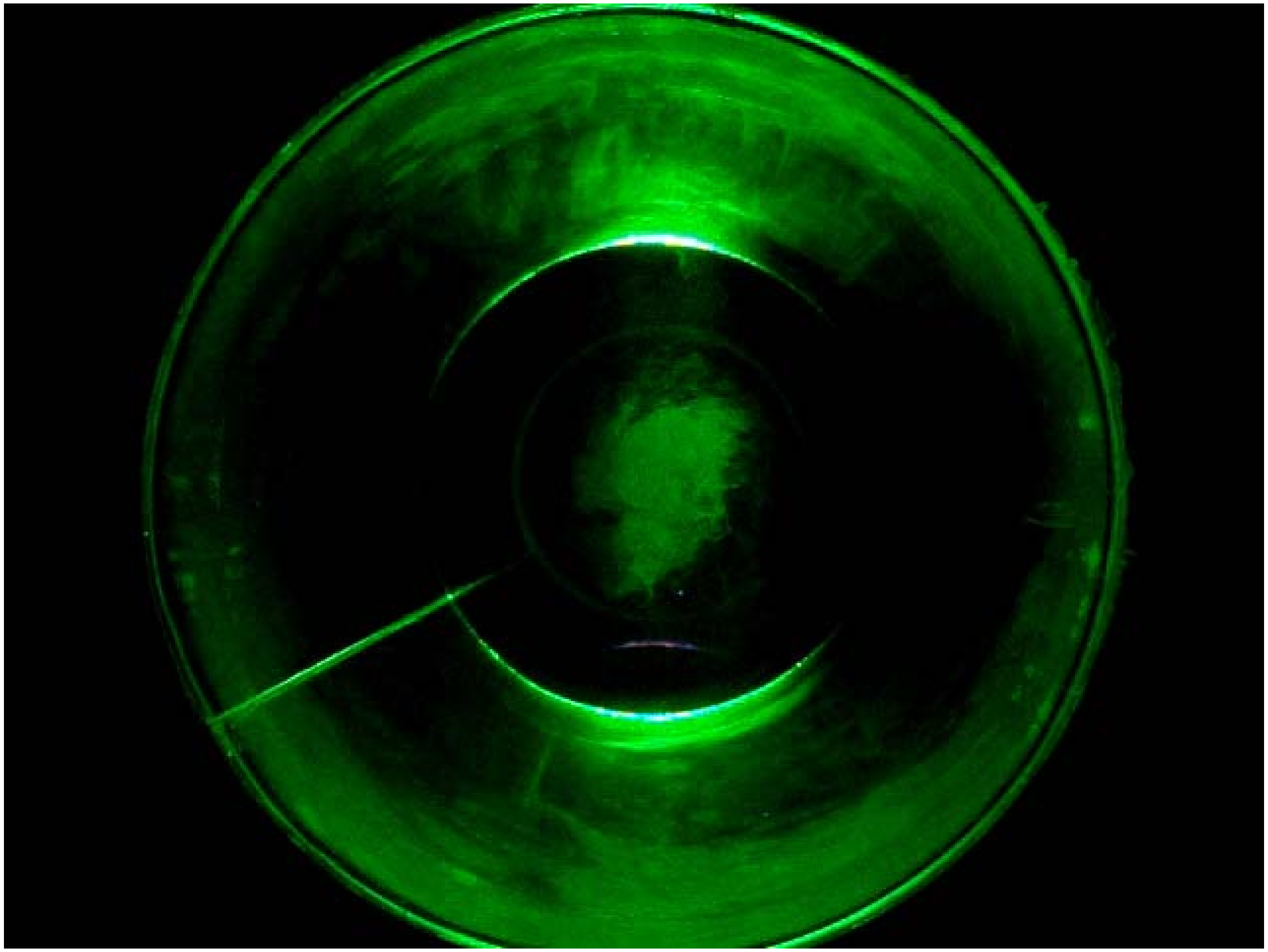
“Do-it-yourself” micro PIV [9]



Investigation of the turbulent swirl flow field in pipe with stereo PIV

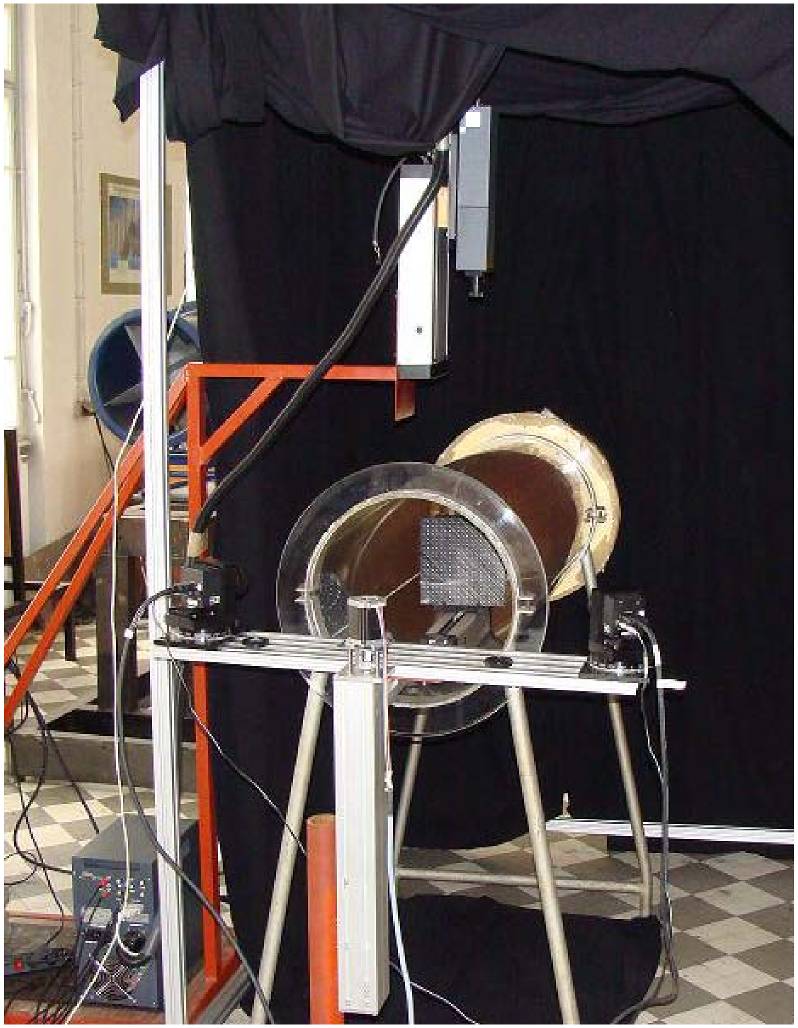


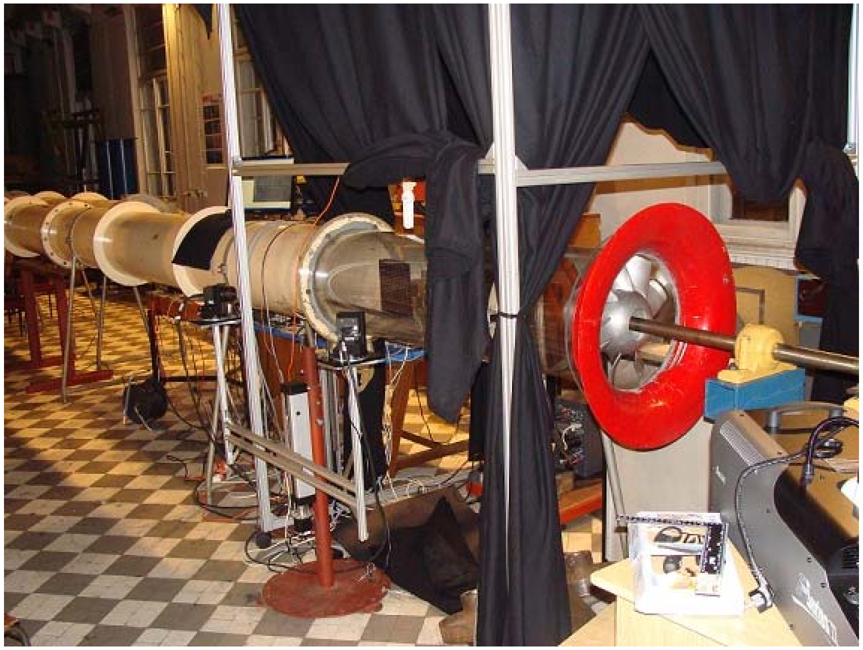
Stereo PIV calibration in the measuring cross-section:
1- left CCD camera, 2- right CCD camera, 3- target, 4- Nd:YAG laser, 5- “П”-camera positioner on the computerized linear guide.

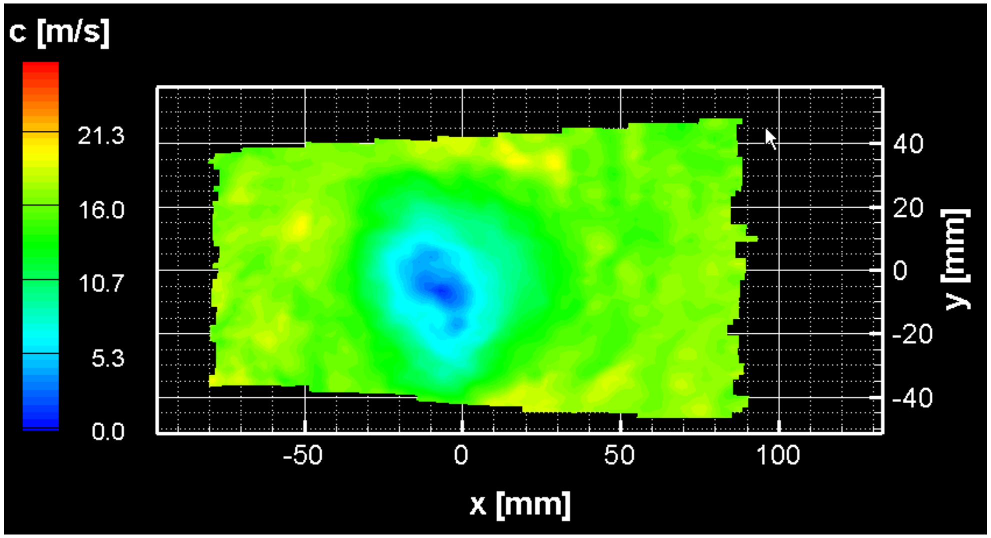


Turbulent swirl flow visualization

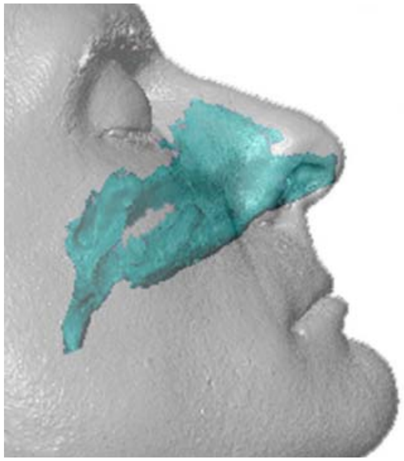
Stereo PIV measurements

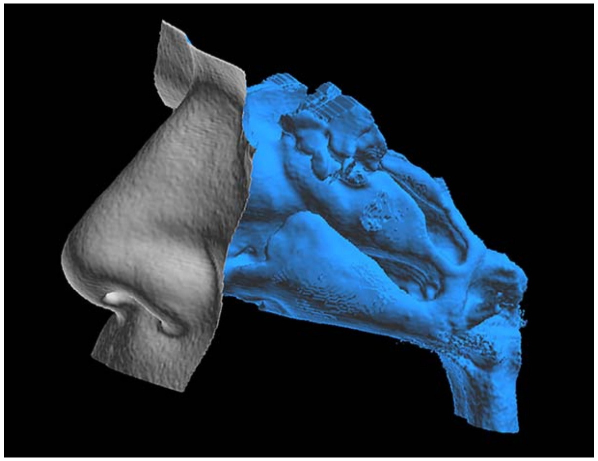


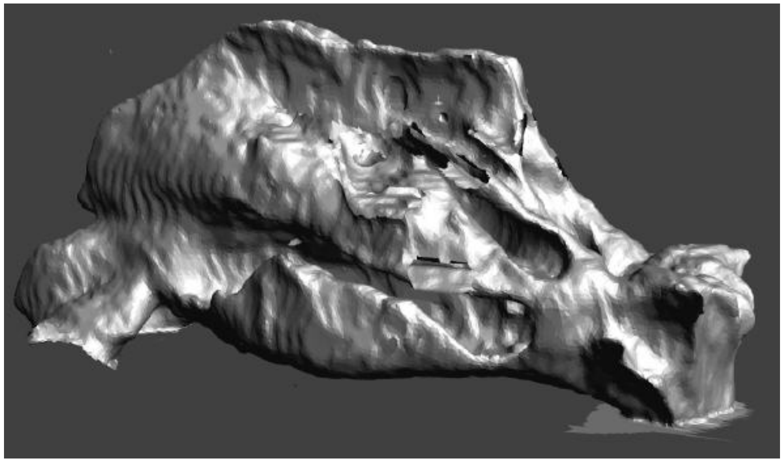




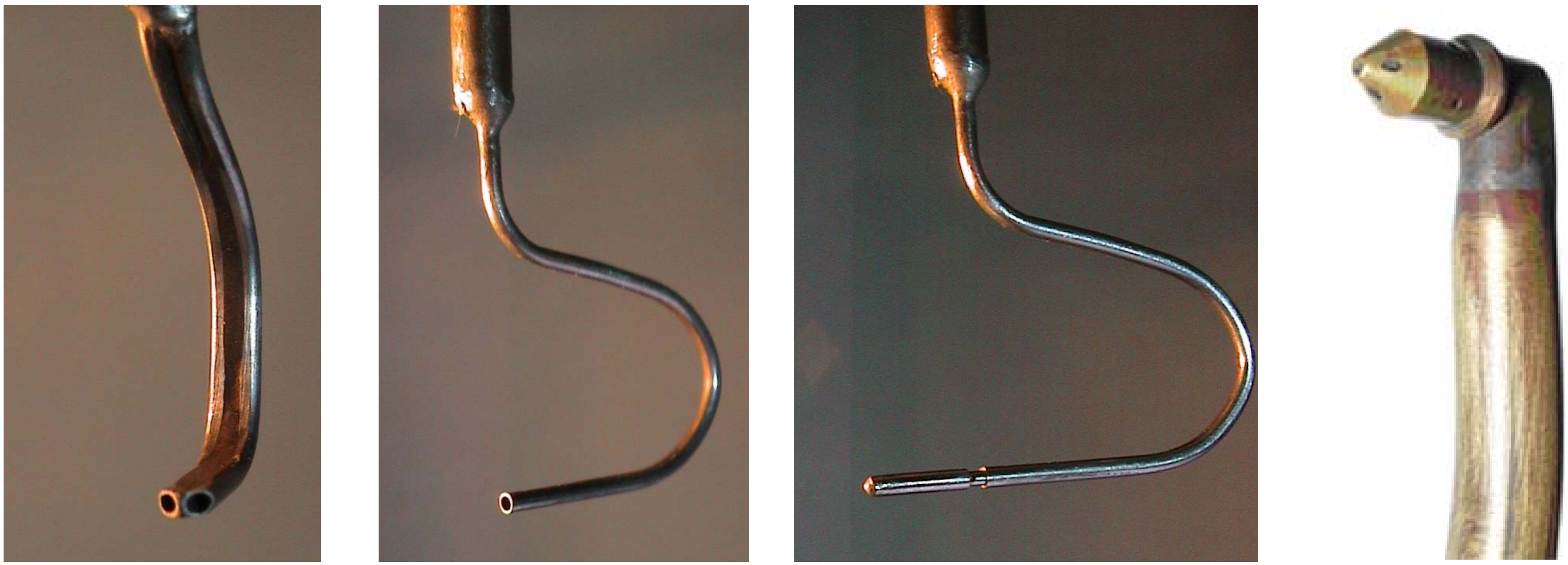
Computational and experimental investigation of the airflow in the human nasal cavity





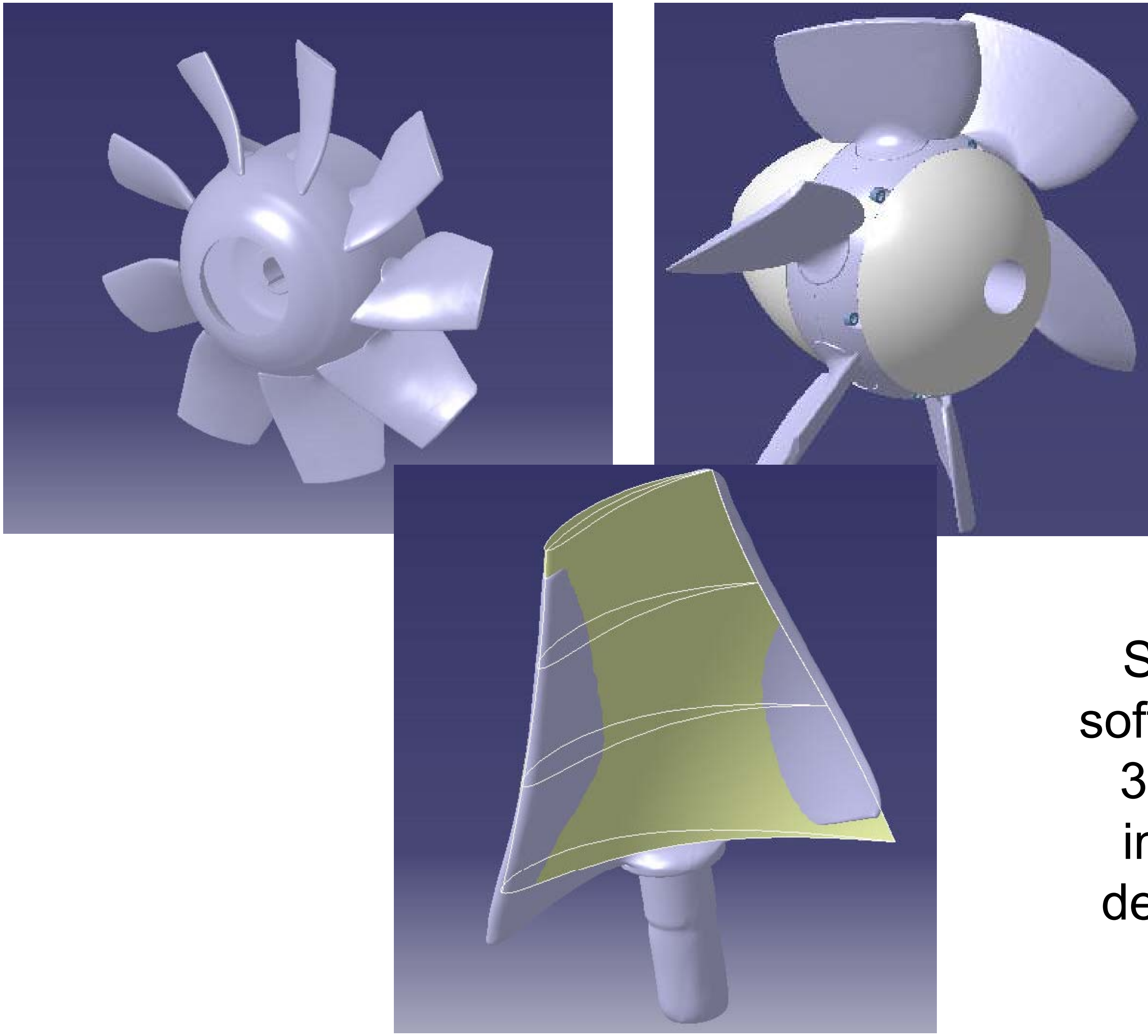


Classical probes



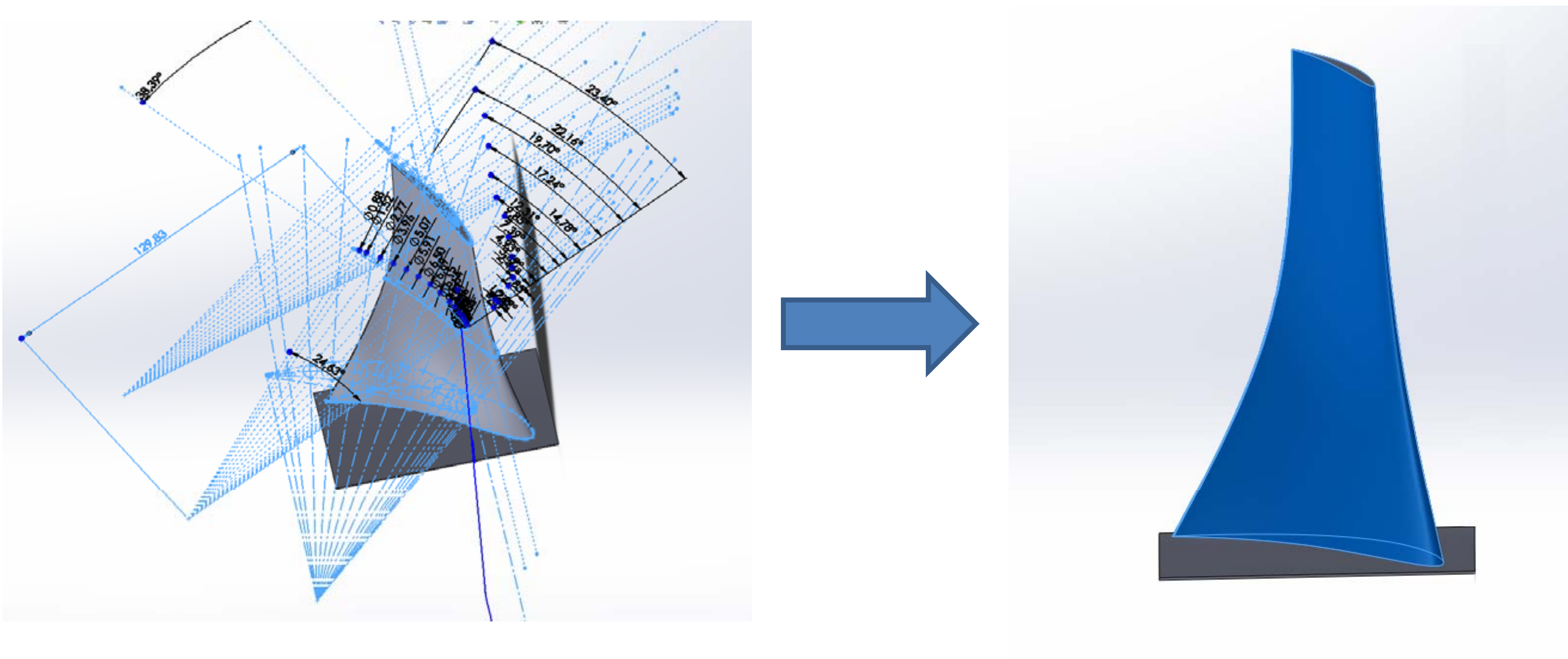
1-Angle probe, Combined Prandtl probe 2-without the sleeve and 3-with attached sleeve, 4-Conrad probe (by Prof. Dr. Miroslav H. Benišek)

3. CAD and production technologies

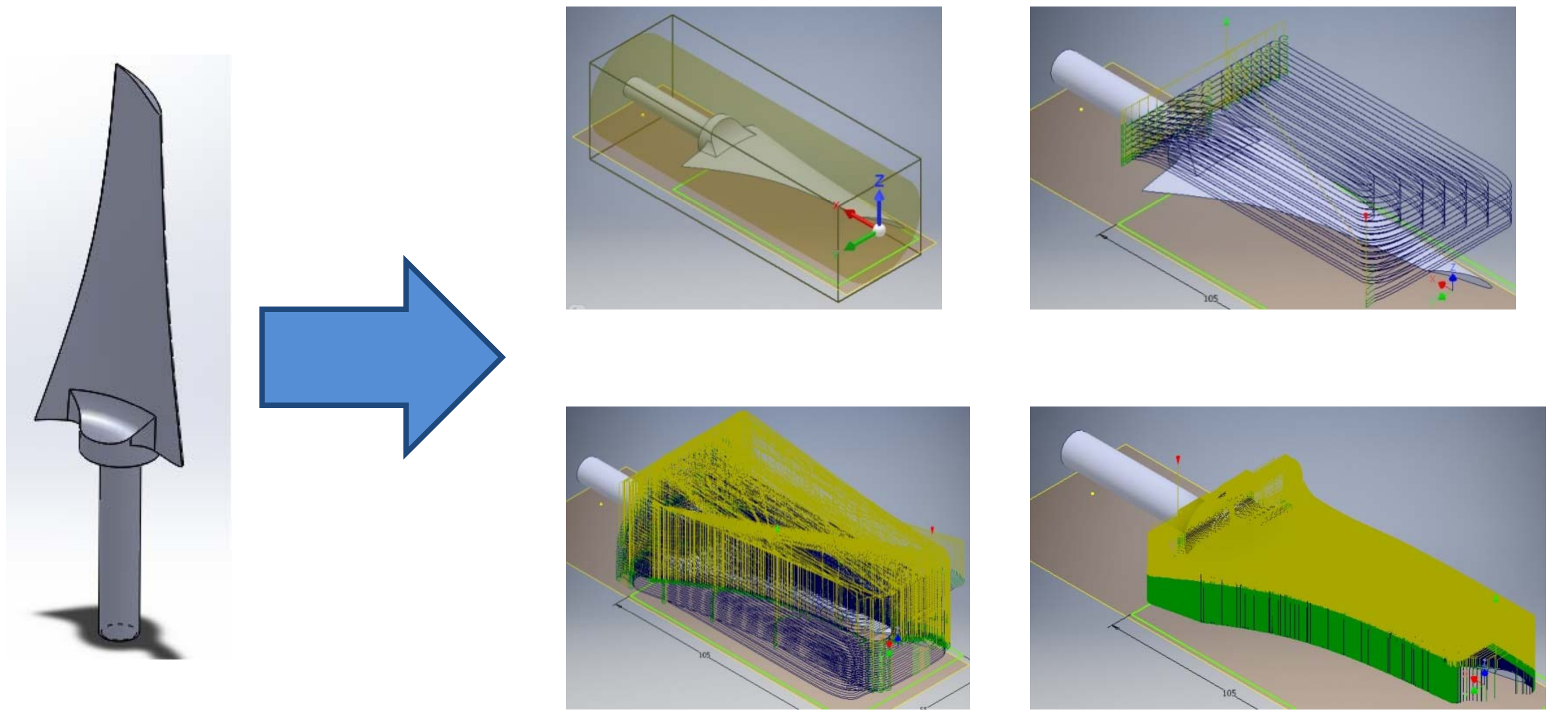


Support software for 3D axial impeller design [7]

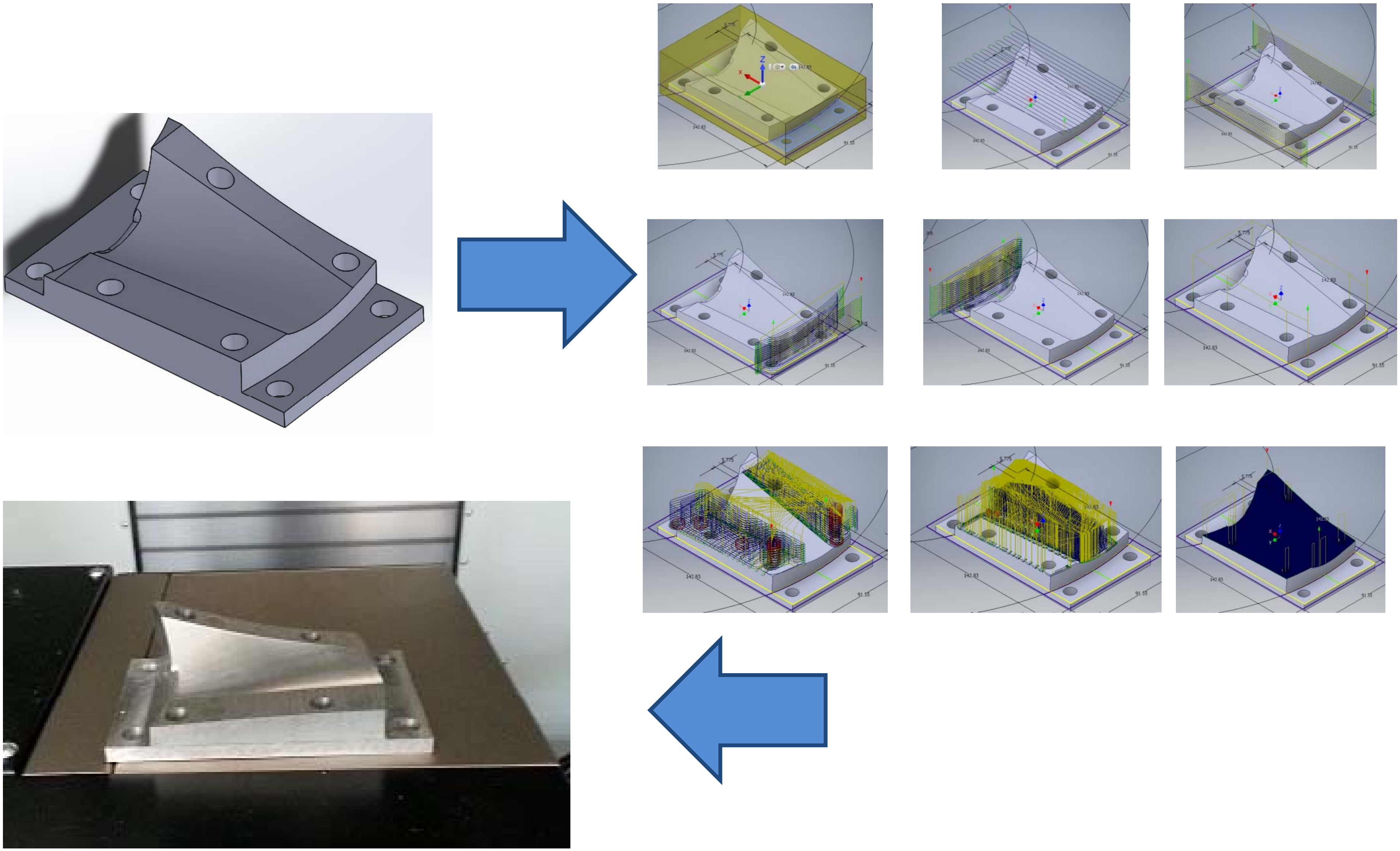
3D CAD model of the axial turbocompressor impeller blade [3]

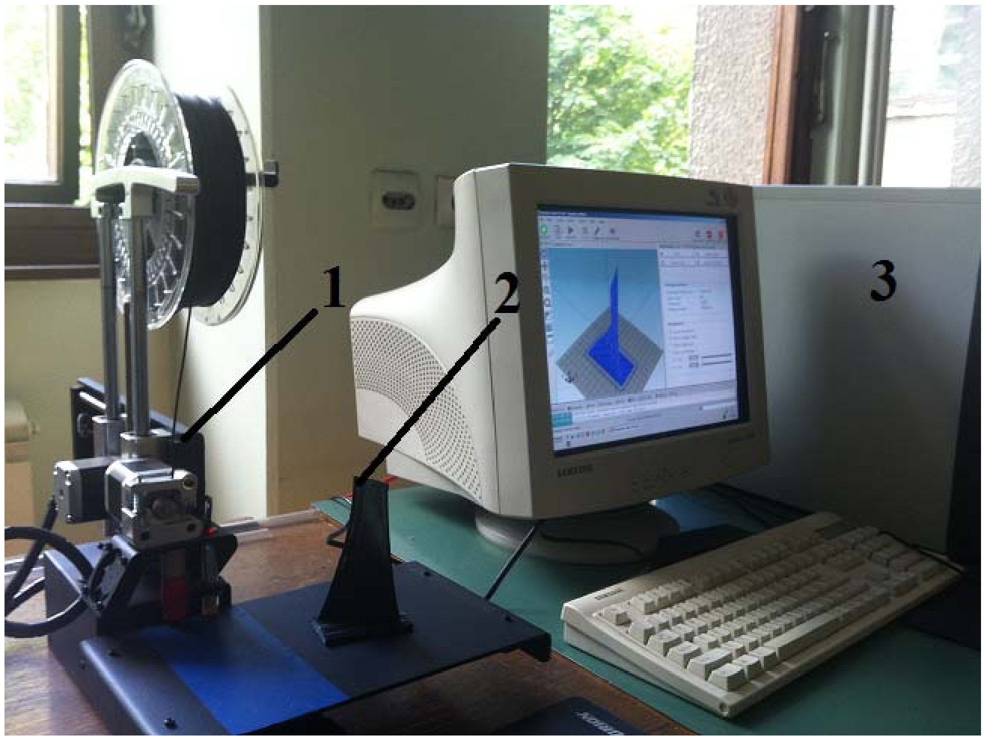


CAM for axial blade impeller [1]



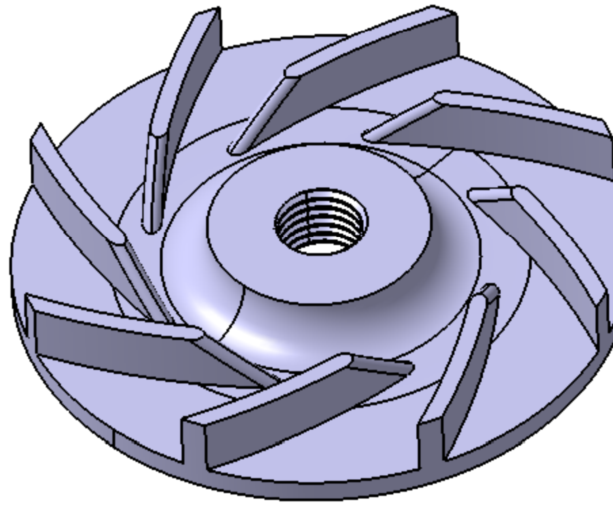
CAM for axial blade impeller mould [1]

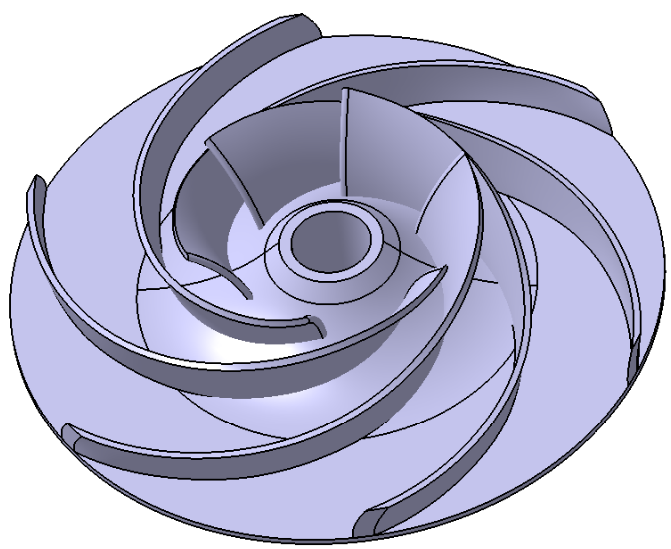




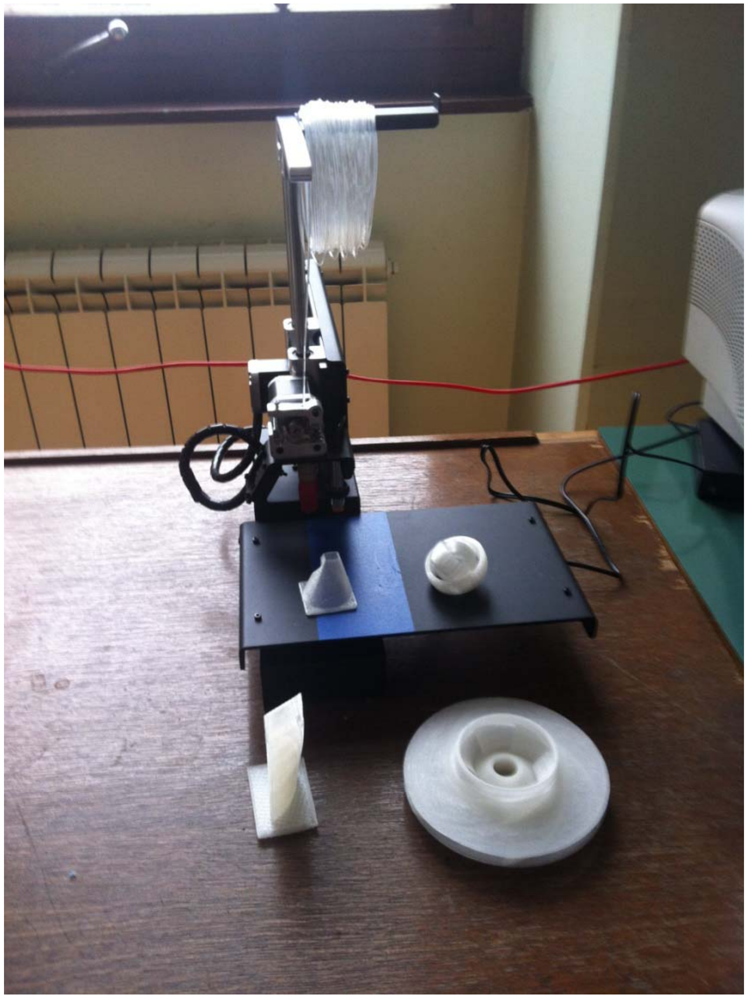
Digital fabrication system: 1-Printrbot Simple, 2-printed impeller blade and 3-personal computer.

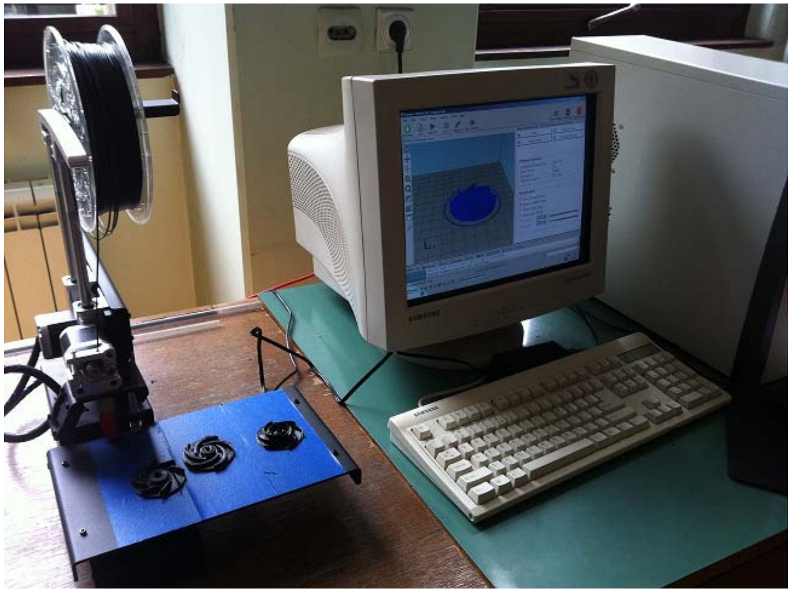
Centrifugal pump impellers

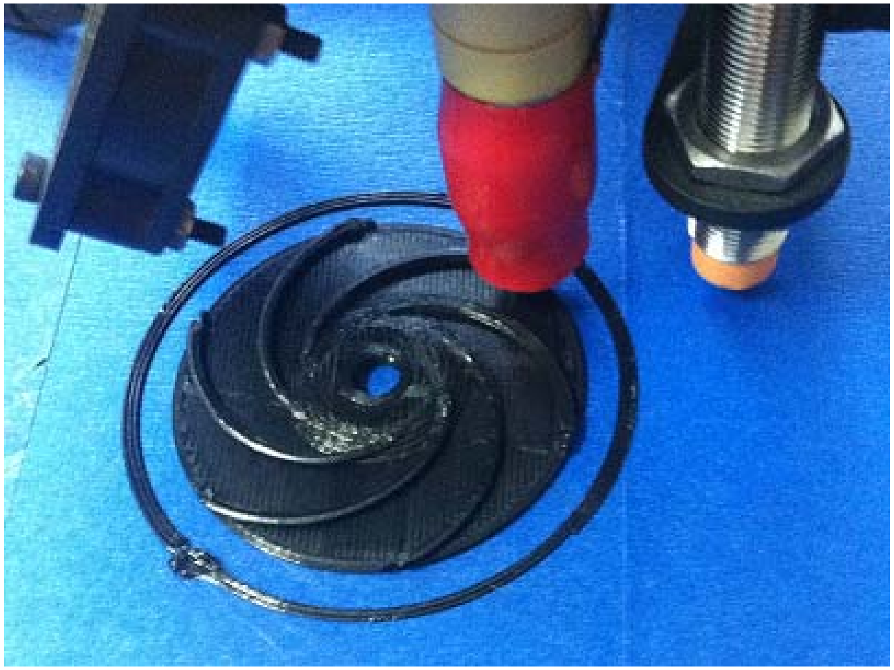




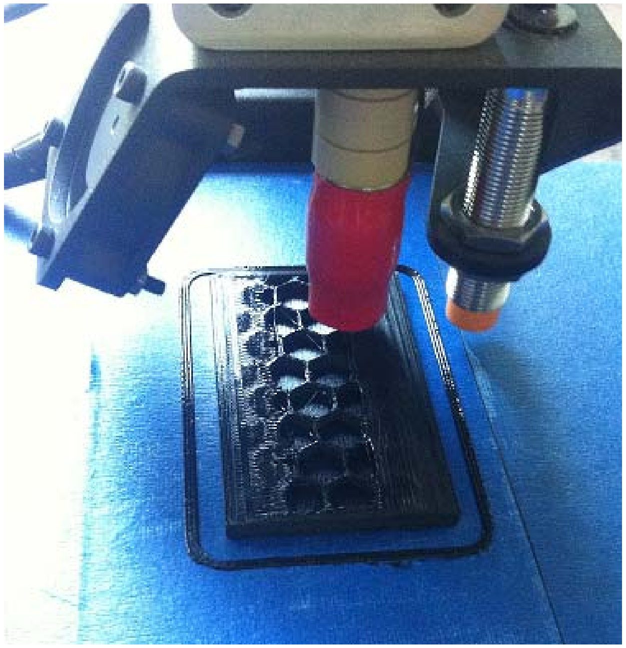
3D printing - printrbot



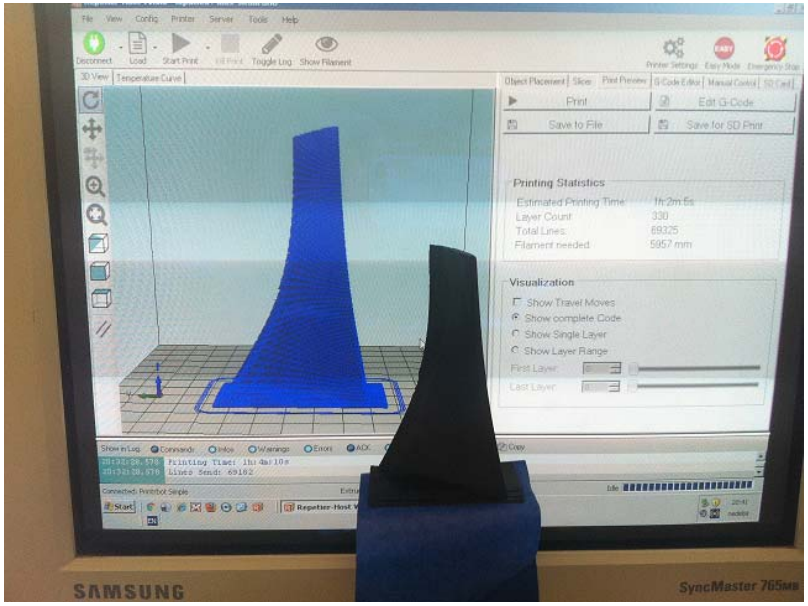




- Estimated printing time was more than doubled - 25 min. and 50 s.
- 34 layers and 26965 lines are generated.
- For this fabrication 1916 mm of filament was used. Here were generated 26962 lines of Gcode, including comments.



Axial blade production

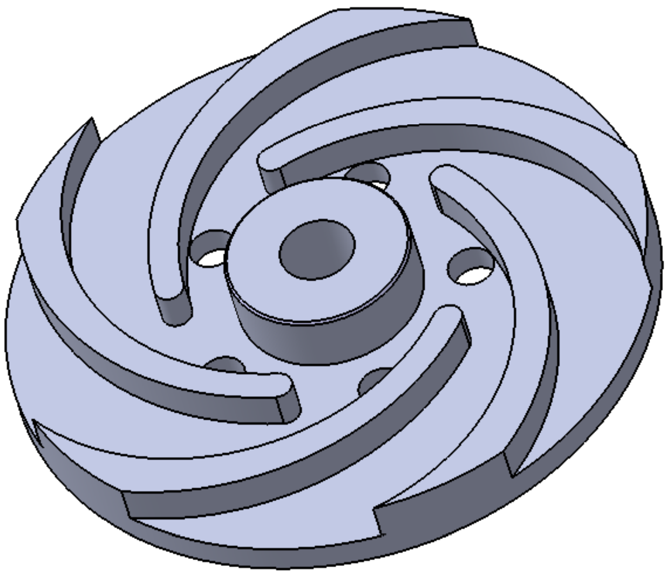


Fill density is 10% and fill pattern is honeycomb.

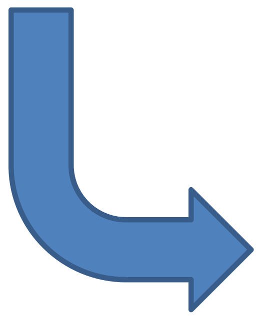
CNC machines

4-axis

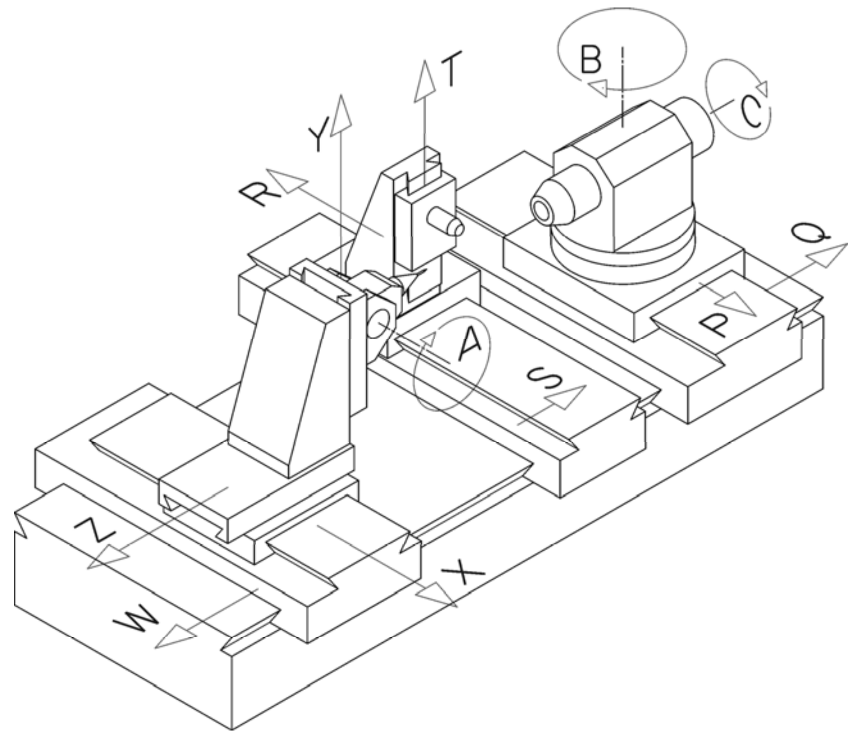
5-axis



CNC machines pump impeller production

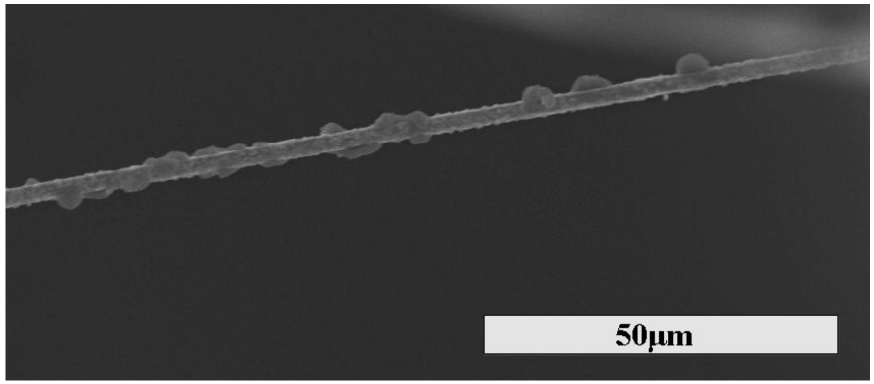


HWA Probe Reparation (patent)

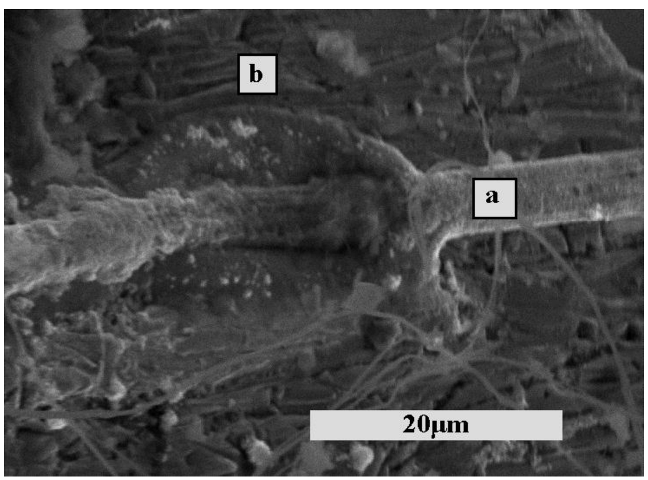


Original device for HWA probe repairing with six rotations and nine translations is presented under stereo microscope with max 180x magnification

Microscopy in HWA – probe reparation

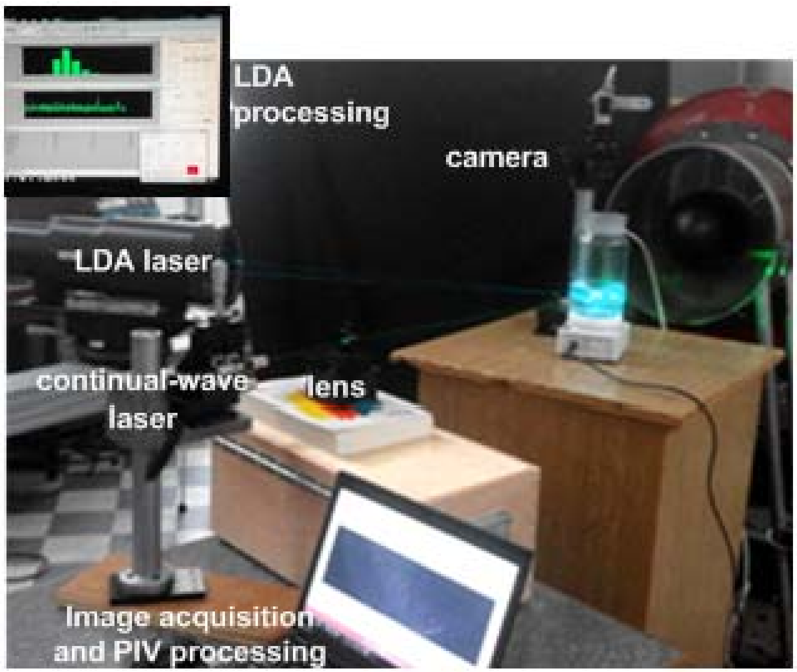


Platinum-rhodium alloy sensor of 2.5µm diameter.
Seen by a Scanning electron microscope (SEM) with **850** magnification

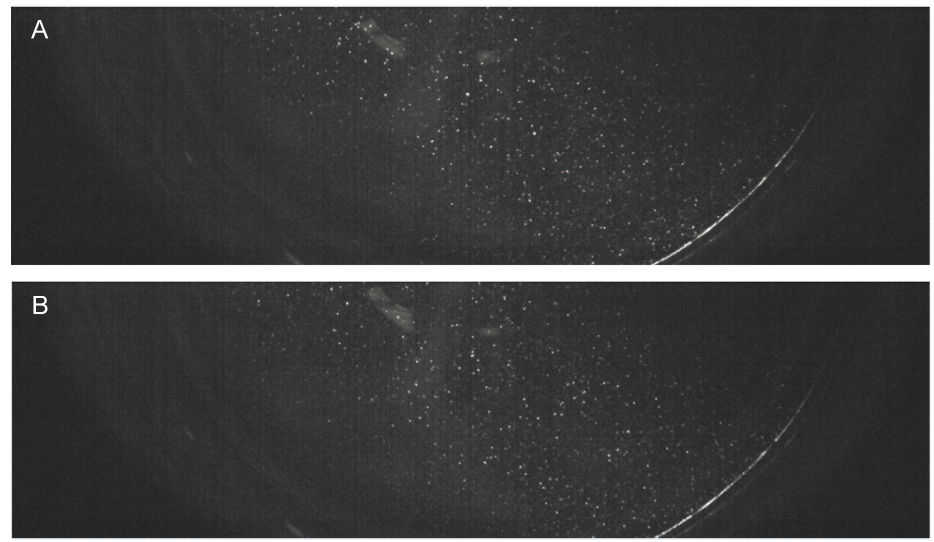


DANTEC 55P12 HW probe
Region of welded joint of platinum-tungsten alloy sensor (5µm diameter) to prong (seen from top by SEM microscope with **1800** magnification.): a-sensor, b-prong.

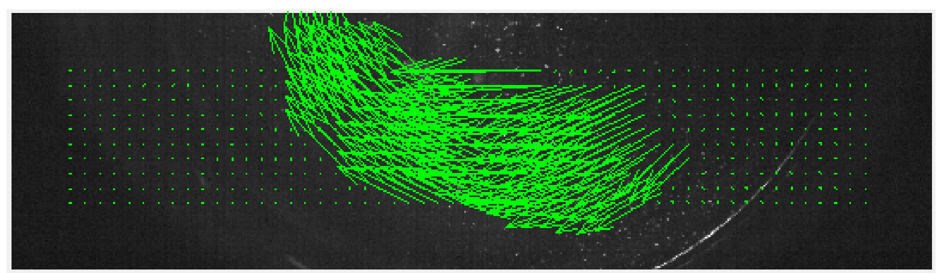
First steps in new affordable PIV measurements [7]



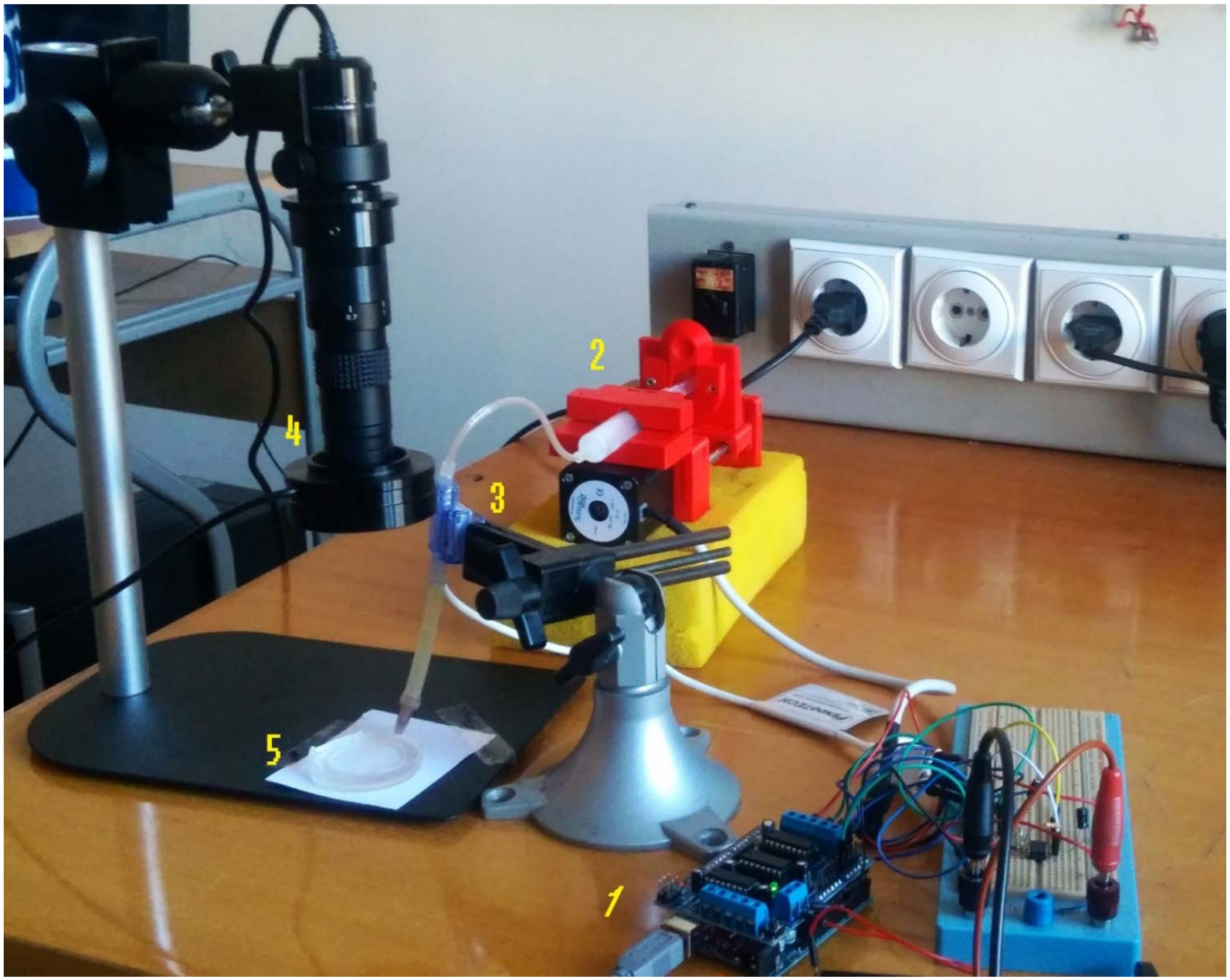
Two successive frames



Vector map of fluid velocity

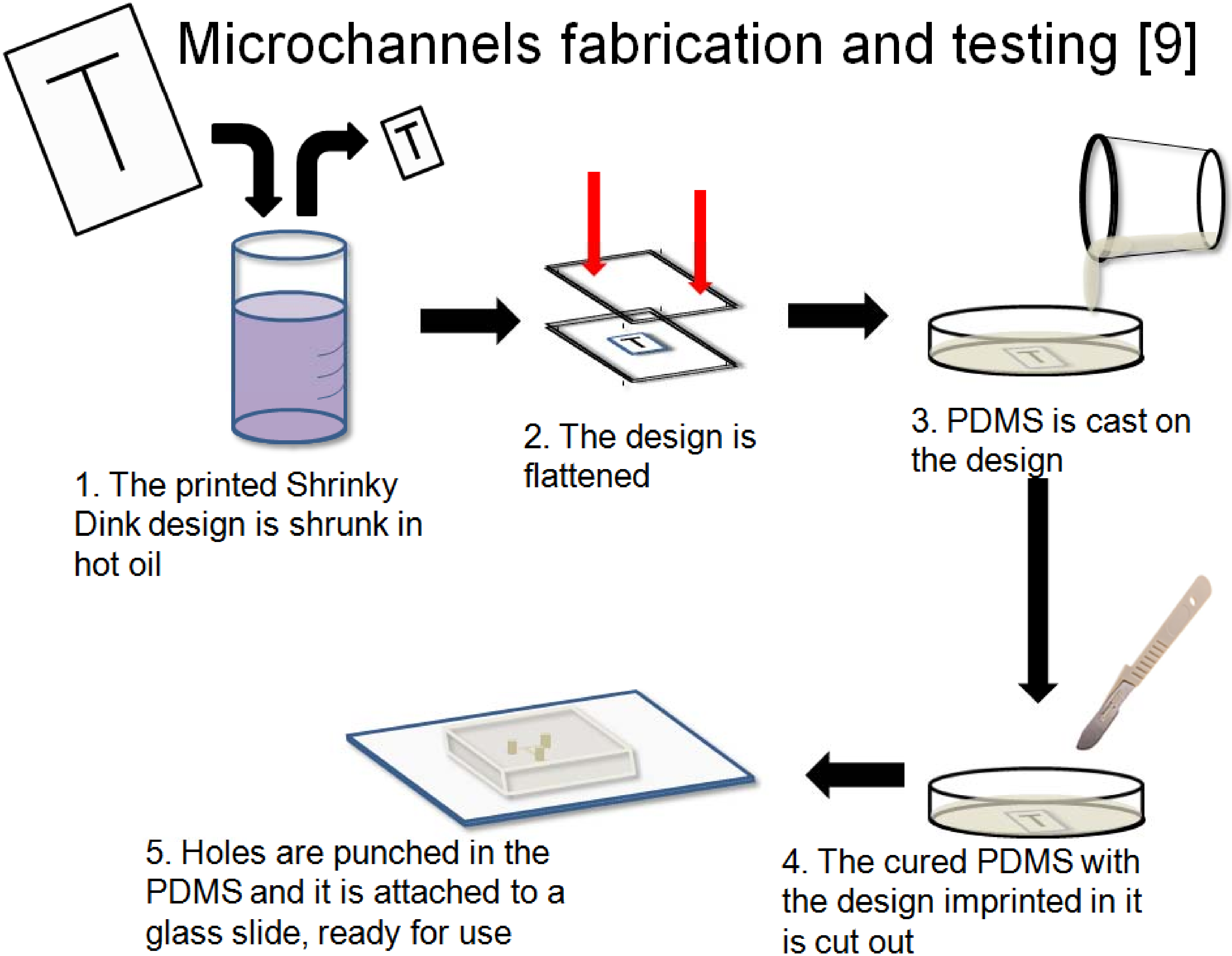


Design and Regulation of the System for Fluid Flow Control in Micro Channels [12]

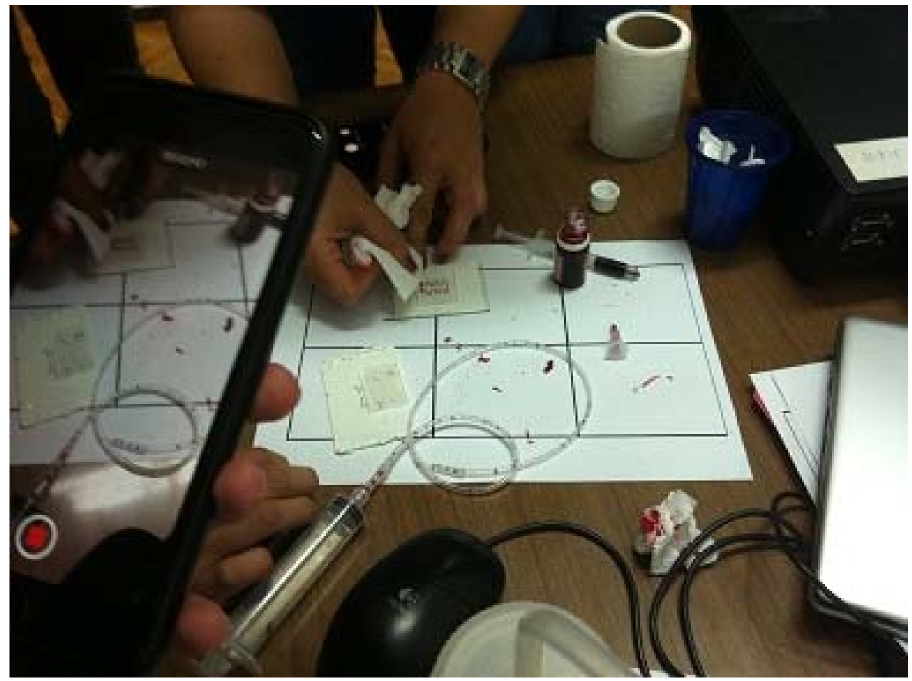


1- Uno microcontroler and Adafruit Motor Shield v0.1 controler for motor
2 -3D printed pump with step motor
3- pressure sensor
4- camera Basler aca-1920 – 50g
4. microchannels

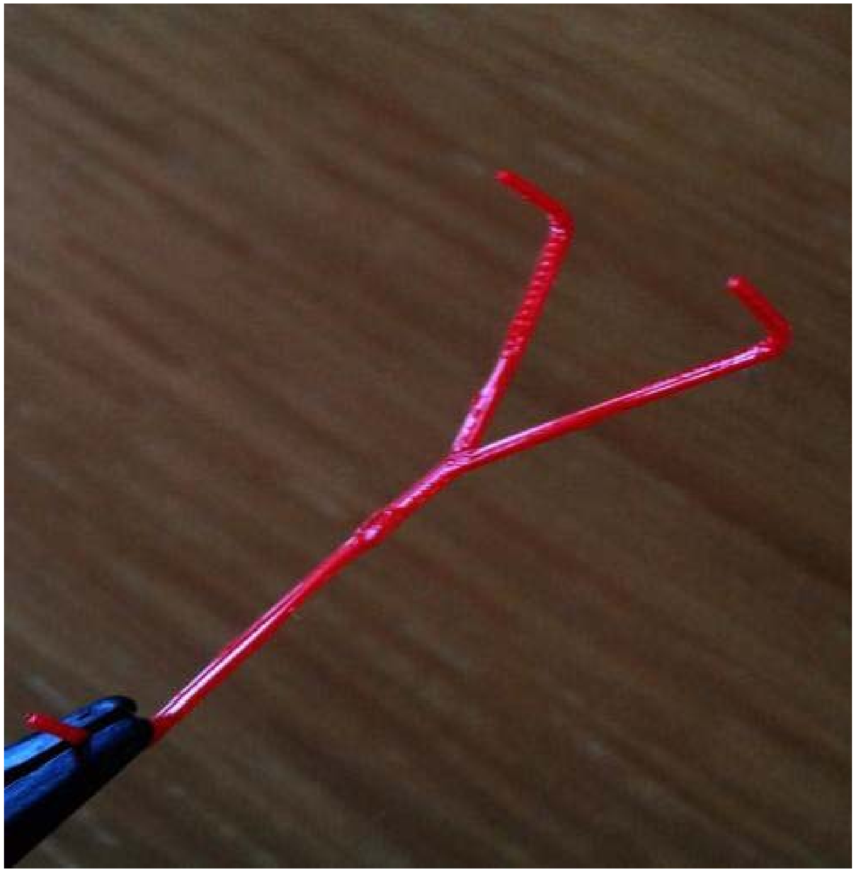
Microchannels fabrication and testing [9]



Microchannels fabrication and testing



Microfabrication of bifurcated microchannels with PDMS and ABS [10]



Example of red ABS bifurcated microstructure [10].

Microfluidic device made as the bifurcated microchannels. Photograph of lateral side of PDMS block [10].

Cooperation with heavy industry, middle and small companies:

- Serbian Energy System (EPS),
- Serbian Oil Industry,
- Serbian Army Forces,
- Water factory plants, Belgrade,
- Water factory plants, Obrenovac,
- Pump factory Jastrebac, Niš,
- Petrochemical Industry, Pančevo,
- Prva Petoletka, Trstenik,
- Holding company Goša-FOM, S. Palanka,
- Corporation Ivo Lola Ribar, Belgrade,
- Lafarge, Beočin,
- Janko Lisjak, Belgrade,
- VATECH, Wien - Belgrade,
- Heimeier, Belgrade,
- Milan Blagojević, Lučani,
- Minel Kotlogradnja, Belgrade,
- Zanus, Valjevo,
- ATB Sever, Subotica,
- Holding RTB-FOD, Bor,
- MIN, Niš,
- Prva Iskra, Barič,
- Tehnika K.B., Belgrade
- Analysis, Belgrade
- …

Concluding remarks:

- Classical and modern measurement, design and production techniques and technologies.
- From ideas to products.
- From macro to micro flows and geometries.
- From laminar to turbulent flows.
- In house codes and measurement techniques.
- Students - from design and simulations to product.
- Workshops for fluid flow study and microchannels.
- Open soft- and hardware.
- Cooperation with universities,institutes, companies and inviduals in Serbia and abroad.

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Thank you for your attention!

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