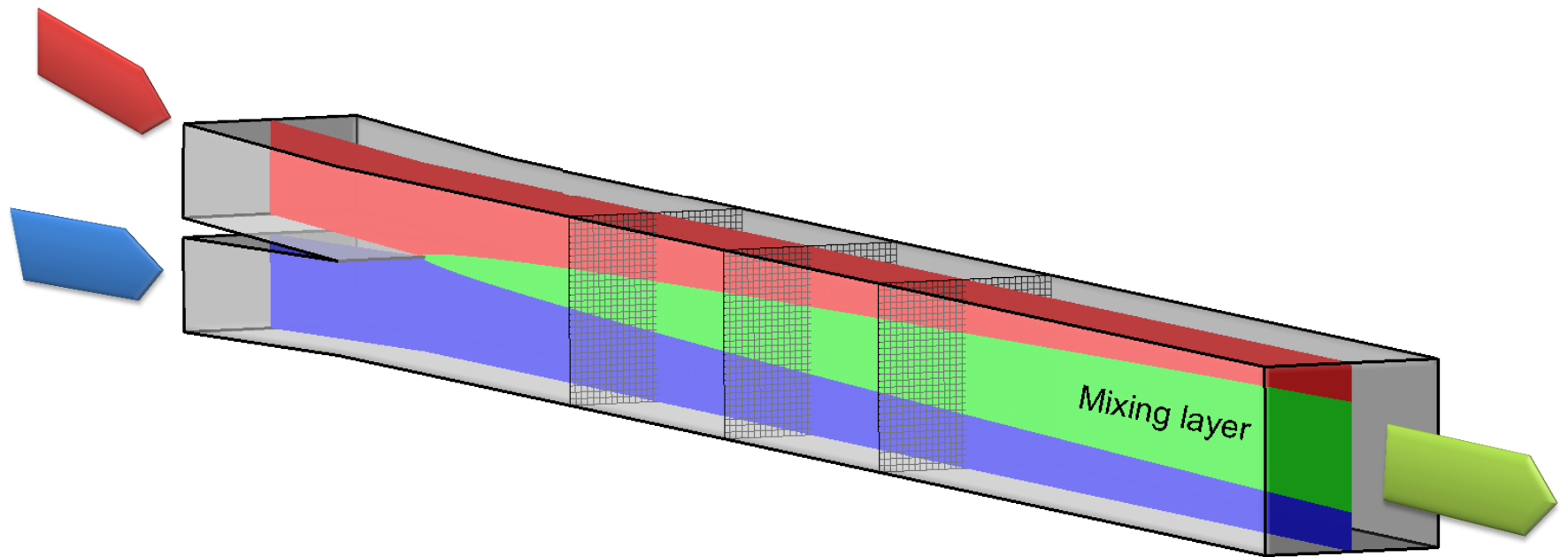


Piotr A. Prusiński, M.Sc., Eng.

Can we trust in CFD results?

Few words on GEMIX benchmark



CFD Benchmarks

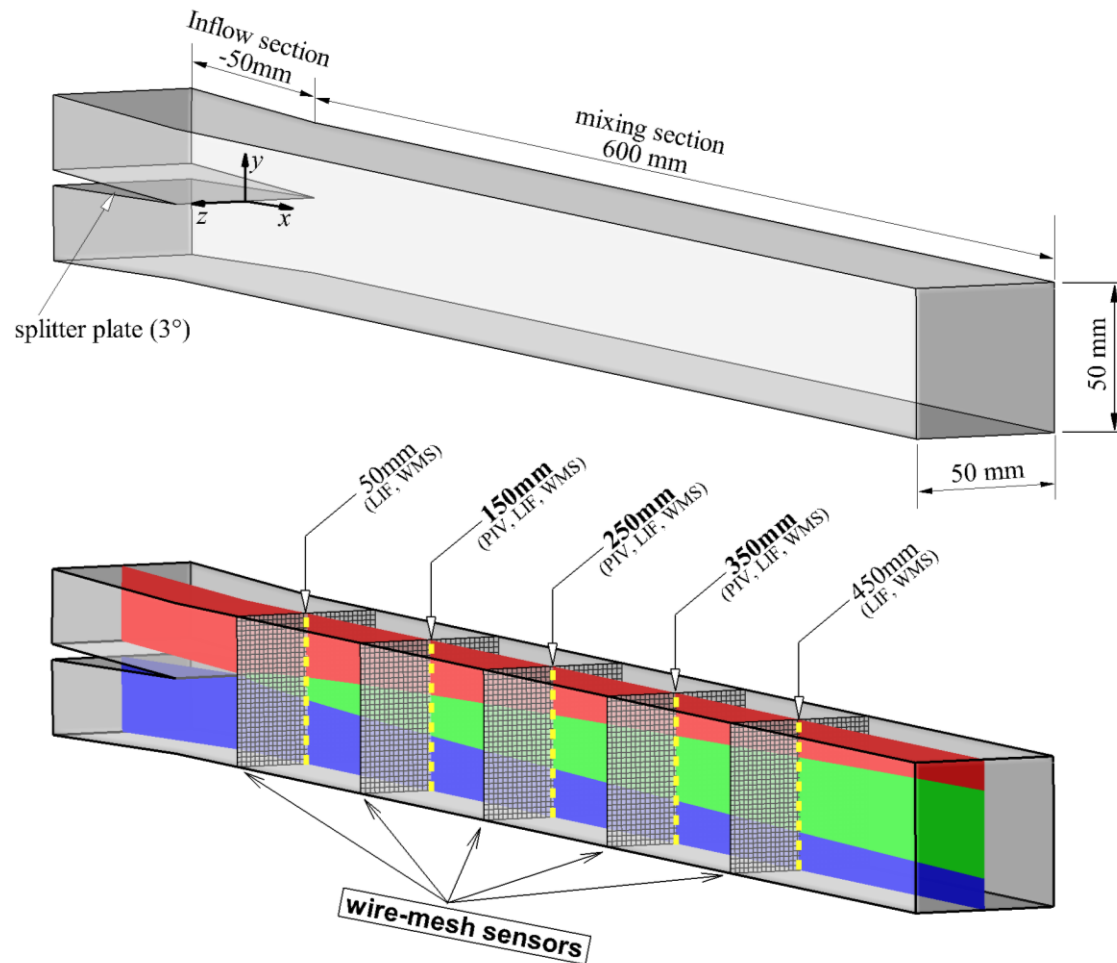
- To quantify the accuracy of CFD results
- Sources of doubts/uncertainties:
 - Fluid domain simplifications
 - Mesh quality (discretization accuratness)
 - Material parameters (mostly ideal concepts)
 - Choice of physics spectrum
 - Choice of turbulence model (and/or its tuning)
 - Solver accuracy
 - ...
 - **Input (I&BC) parameters from real experiment**

GEMIX

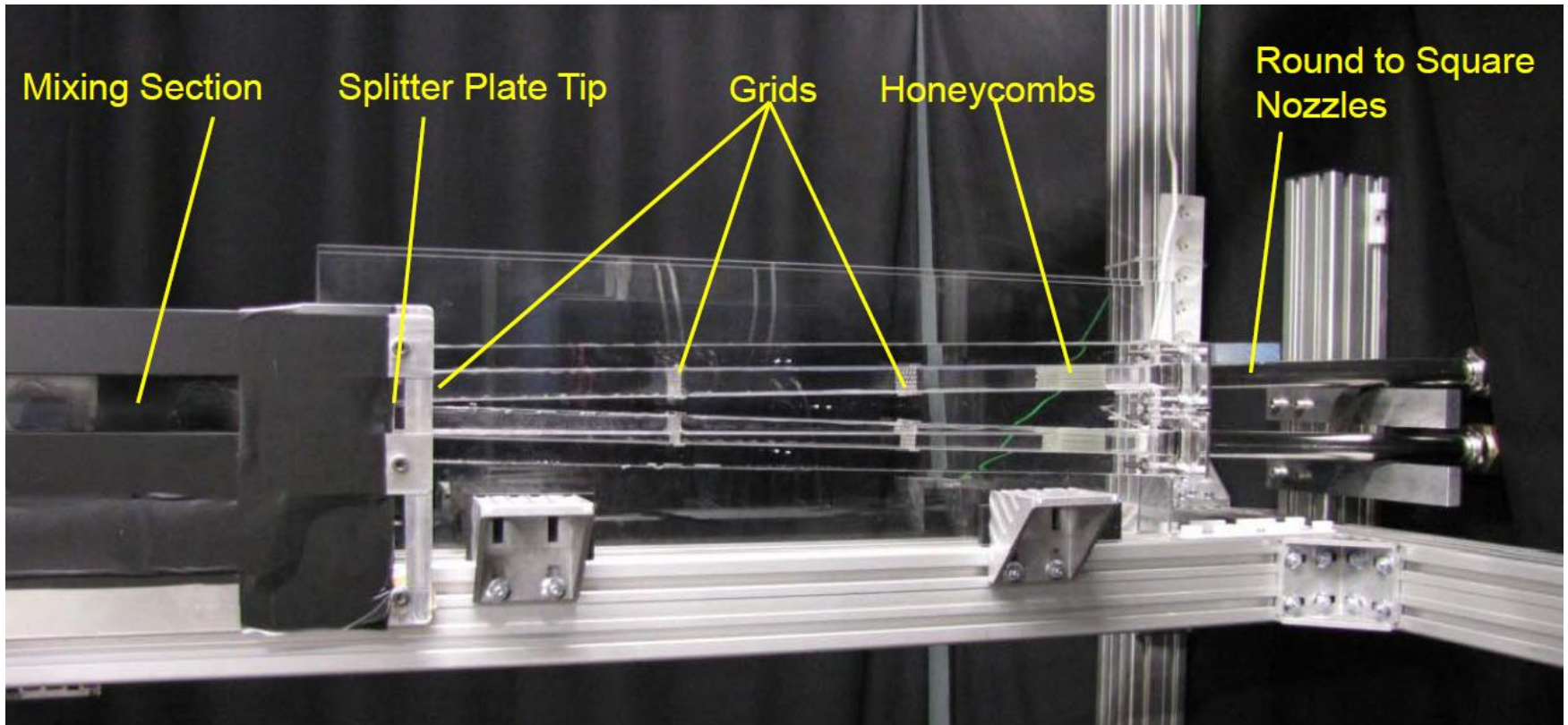


- Benchmark:
 - CFD prediction and Uncertainty Quantification of a GEMIX mixing layer test
- Test facility:
 - GEMIX (**GE**neric **MI**xing **eX**periment), developed at the Paul Scherrer Institute in Switzerland.

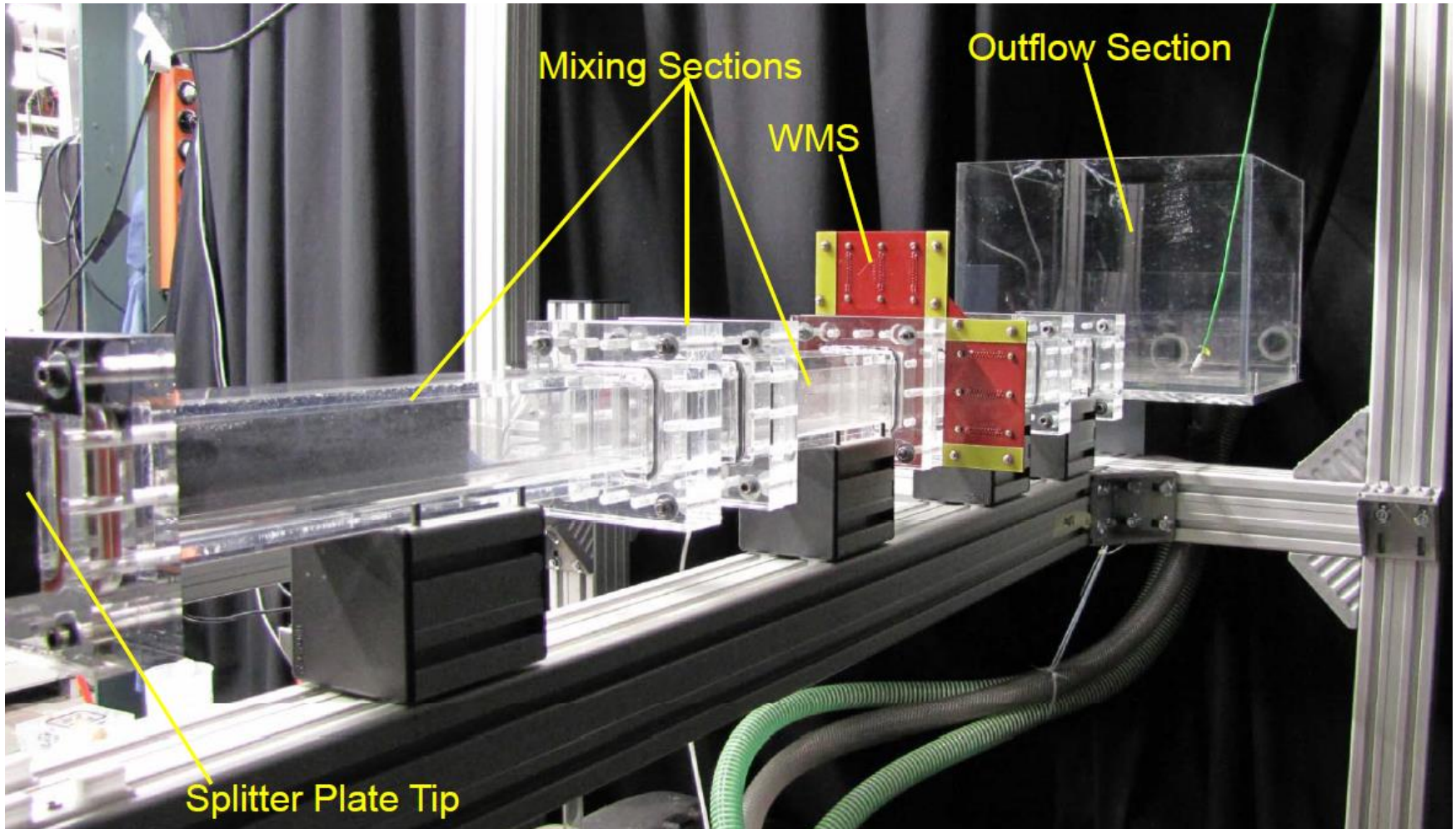
GEMIX – general overview



Experimental setup



Experimental setup



GEMIX experiment matrix

		0.2 m/s	0.4 m/s	0.6 m/s	0.8 m/s	1 m/s	1.2 m/s	Series
	Global Re-number	10000	20000	30000	40000	50000	60000	
Complete data set available	$\Delta p=0\%$	N341	N340	N339	N338	N337	n.a.	20100821A
	$\Delta p=1\%$	N322	N321	N320	N319	N318	n.a.	20100818
	$\Delta p=3\%$	N341	N340	N339	N338	N337	<u>n.a.</u>	20100820C
	$\Delta p=5\%$	N335	N334	N333	N332	N331	n.a.	20100820B
	$\Delta p=10\%$	N329	N328	N327	N326	N325	n.a.	20100820A

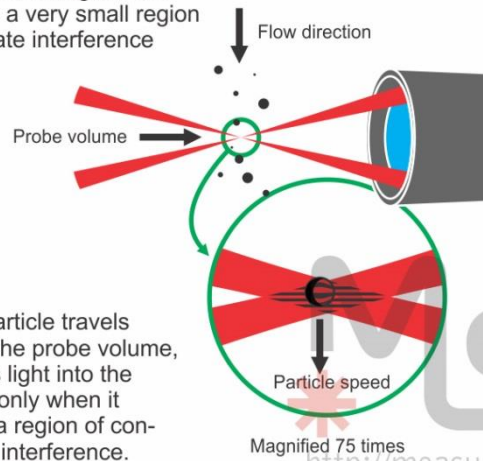
Measurement techniques



- LDA - Laser Doppler Anemometry
- PIV - Particle Image Velocimetry
- LIF - Laser Induced Fluorescence
- WMS - Wire Mesh Sensors

LDA

The probe volume is formed by splitting a coherent beam and then crossing the two halves in a very small region to generate interference fringes.

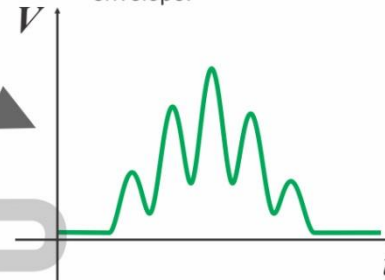


As the particle travels through the probe volume, it reflects light into the receiver only when it crosses a region of constructive interference.

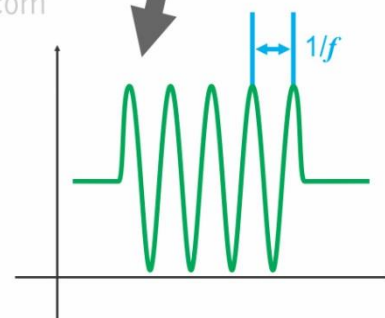
The frequency of the sinusoid is measured (usually by FFT). The fringe spacing is known (from calibration), thus the speed of the particle can be calculated.

$$\text{speed} = \text{fringe spacing} \times f$$

As seen by the photodetector, the light signal is a sinusoid (corresponding to the fringes) modified by a Gaussian envelope.

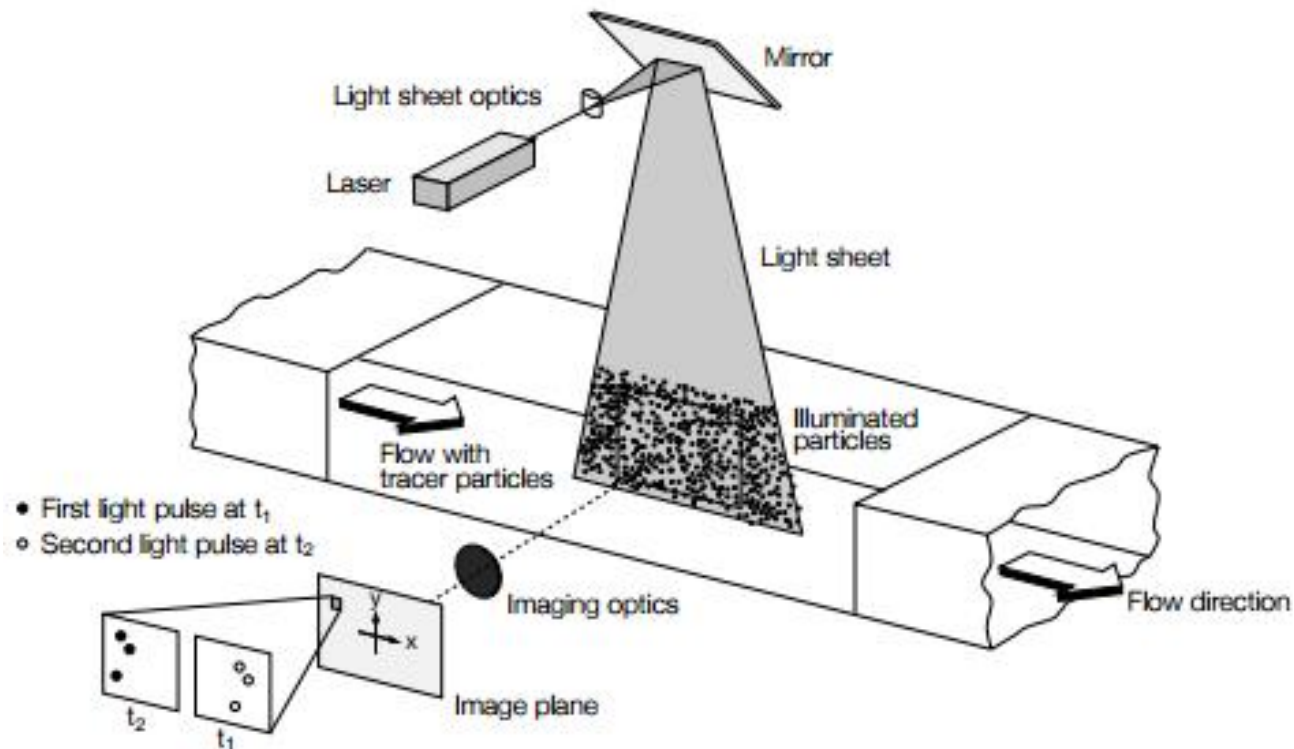


The sinusoid is isolated by a bandpass frequency filter.



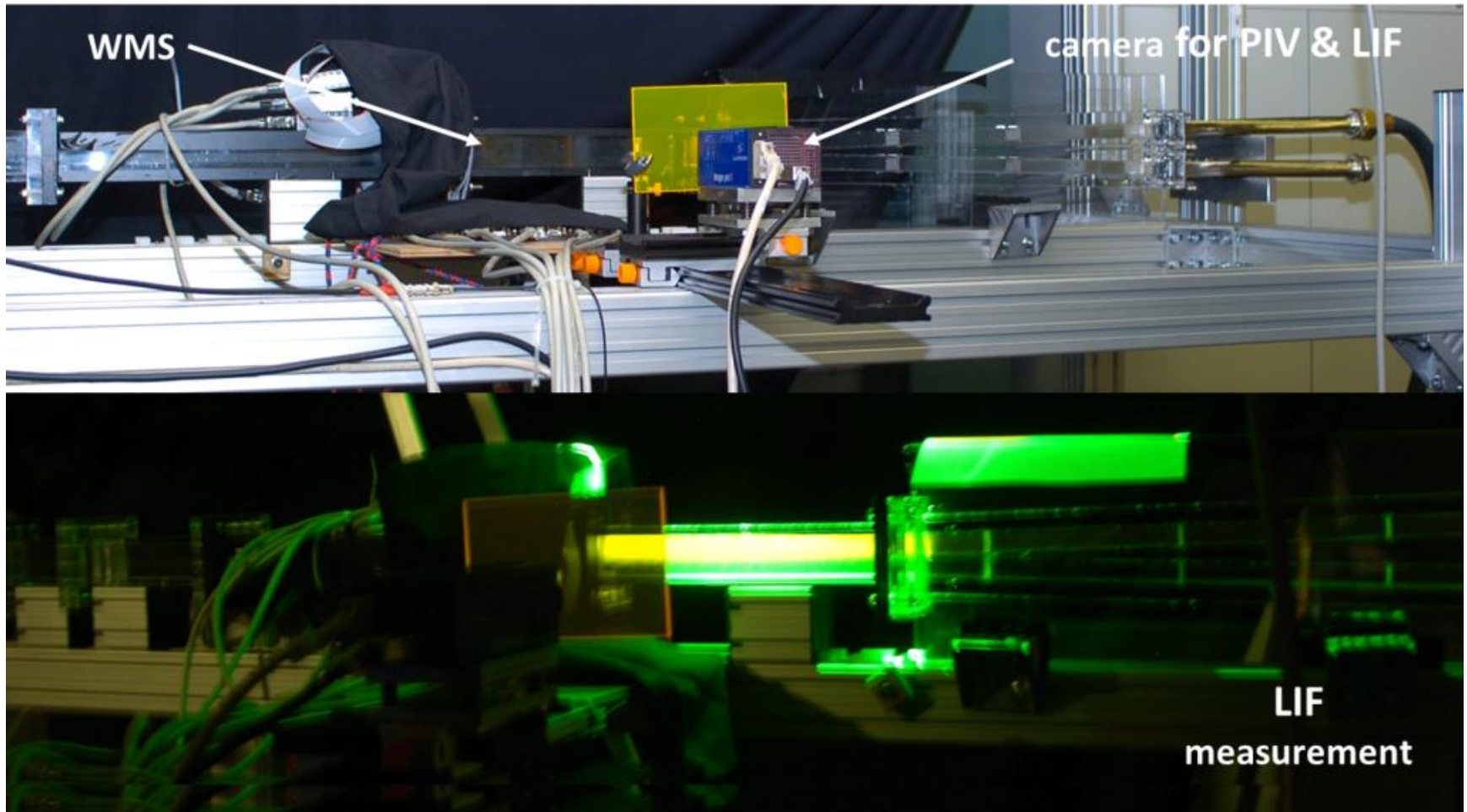
min \$5 000 for one velocity component

PIV/LIF

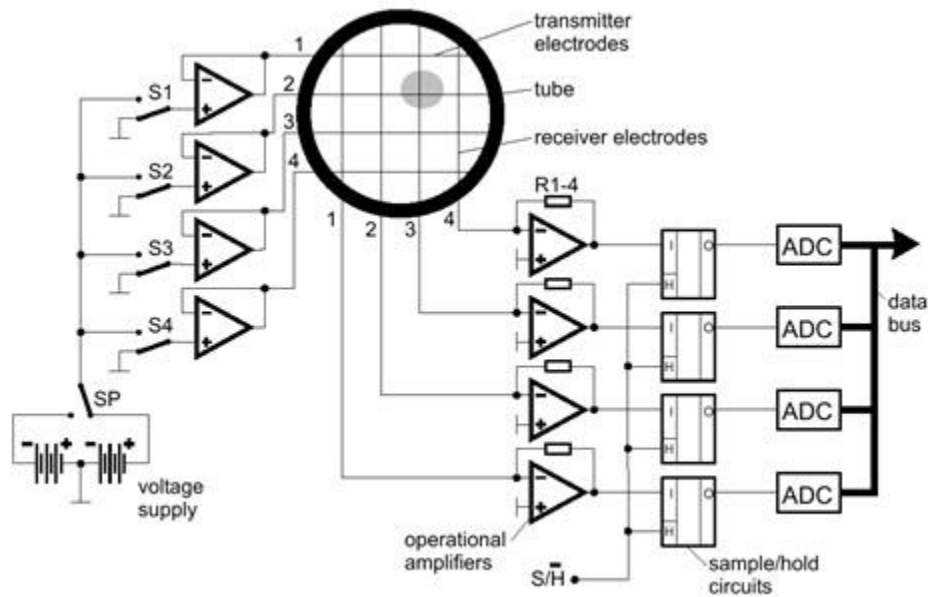


on average \$100 000

PIV/LIF



WMS

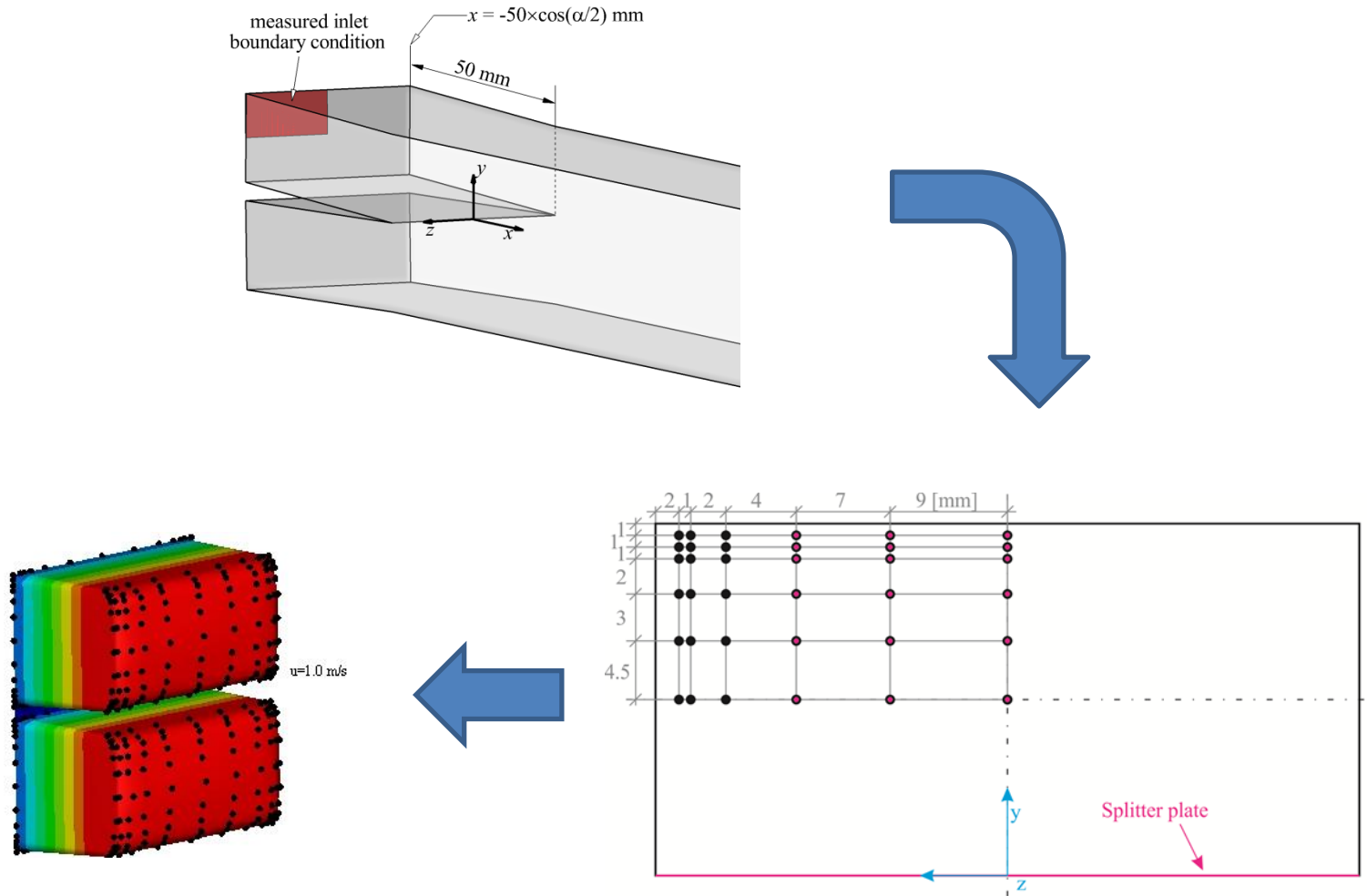


GEMIX Schedule

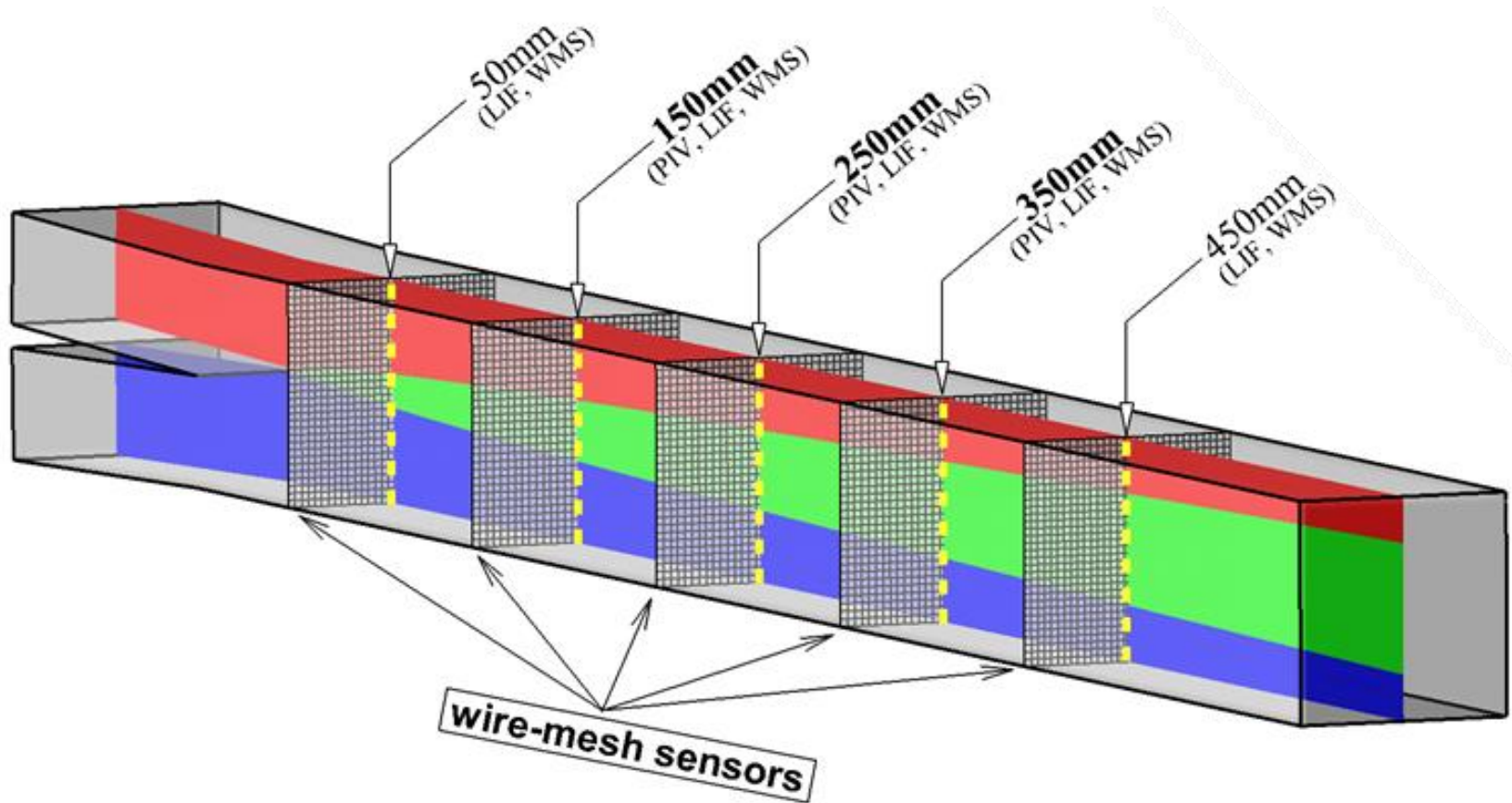


- 30 June 2015 PSI distributes Initial Benchmark Specifications (for Comment)
- 15 Aug. 2015 All participants must have sent any comments/queries on specifications to PSI
- 28 Aug. 2015 PSI issues final specifications
- 30 Sep. 2015 Deadline for registration to the benchmark
- **30 May 2016** All participants must have sent their results to PSI (this is NOT extendable)
- 14 June 2016 Open benchmark meeting and release of test data
- 13 Sept. 2016 PSI presents the benchmark synthesis at CFD4NRS-6 Workshop
- April 2017 Meeting on synthesis of post-test analyses

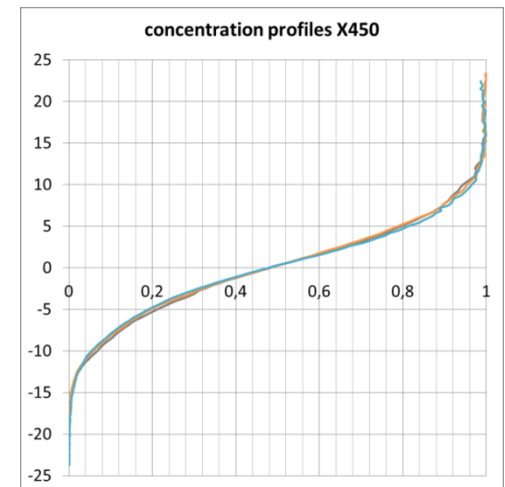
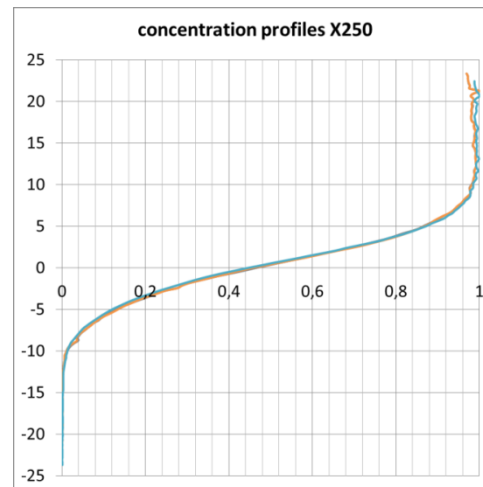
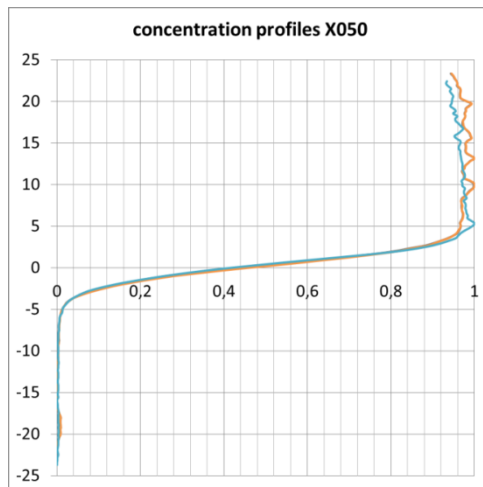
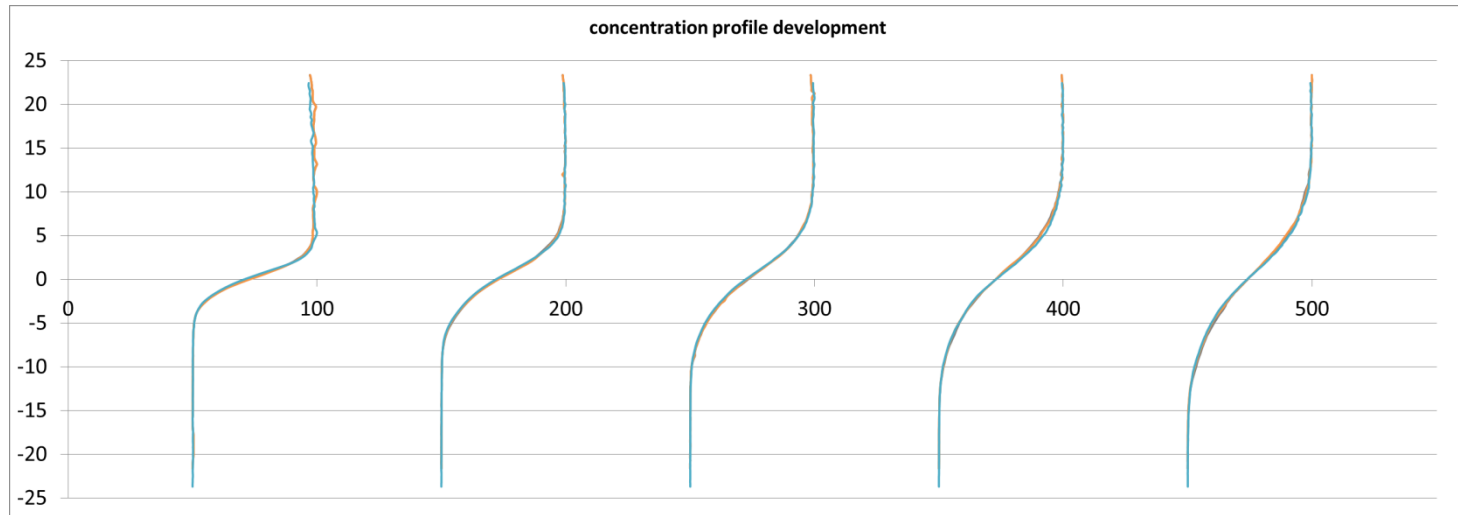
Input



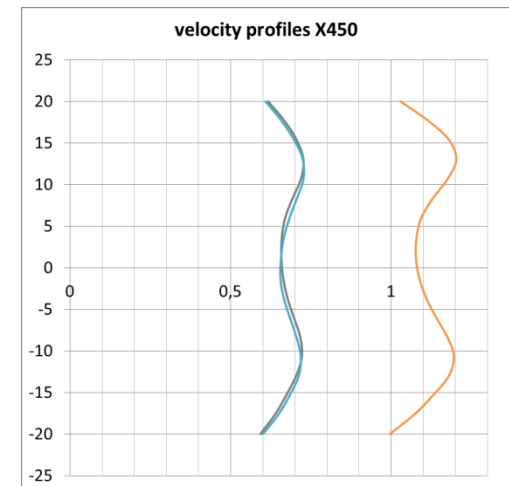
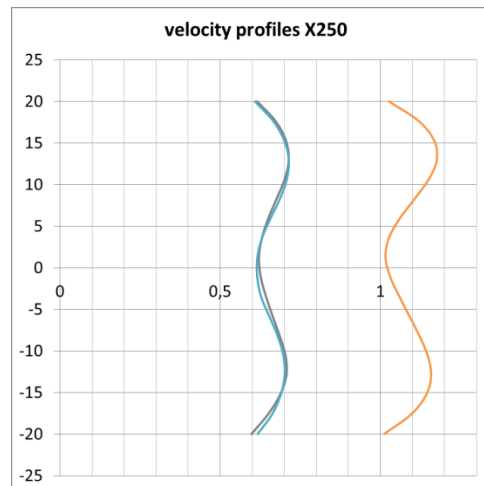
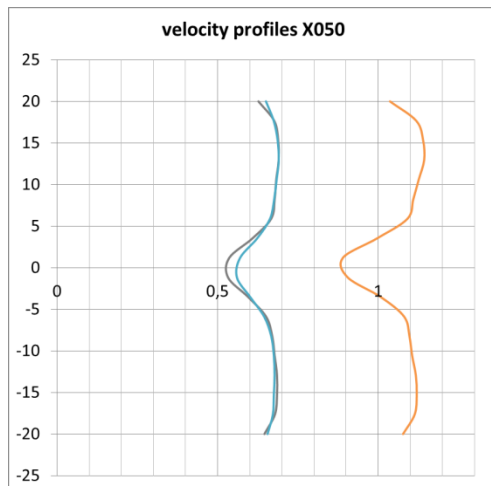
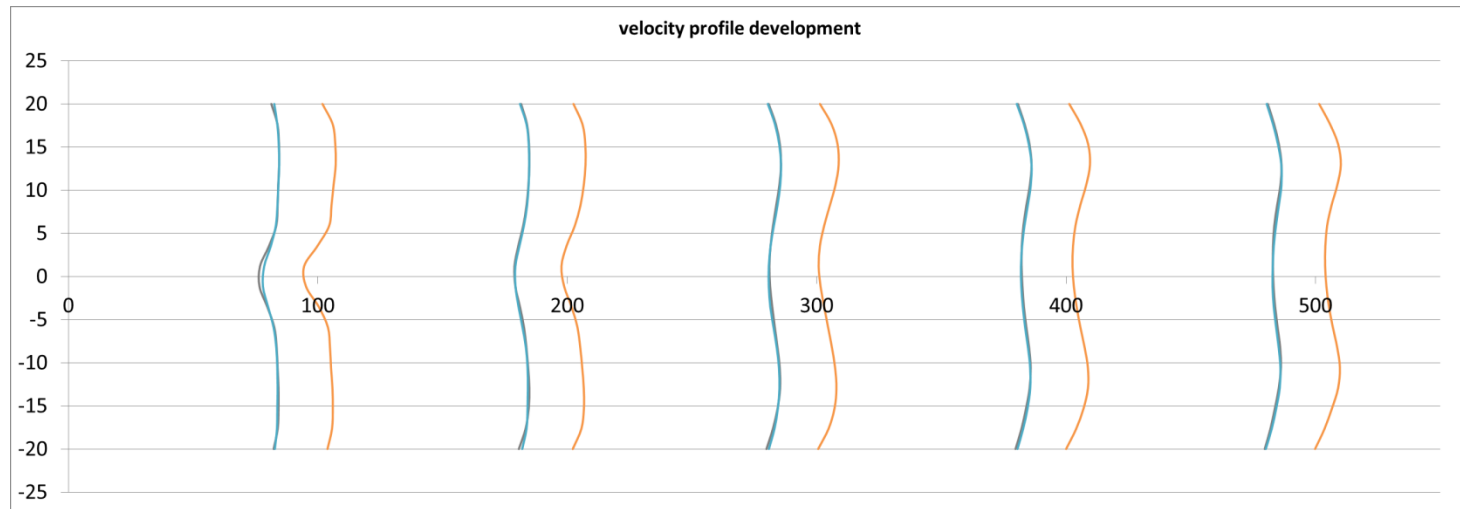
Output



Output: concentration



Output: velocities



Input/Output

- Input

- X, Y, Z – coordinates
- Vx, U_x95, RMSVx, RMSVxUpper, RMSVxLower
- Vy, U_y95, RMSVy, RMSVyUpper, RMSVyLower
- Vz, U_z95, RMSVz, RMSVzUpper, RMSVzLower
- k, kLOWER, kUPPER

- Output

LIF:

- C(Y(X)), C_95, C, C'low, C'high

PIV:

- X, Y – coordinates
- Vx, U_x95, RMSVx, RMSVxLOW, RMSVxUP
- Vy, U_y95, RMSVy, RMSVyLOW, RMSVyUP
- tauxy, tauxyLOW, tauxyUP
- k, kLOW, kUP

Matrix of case N337 (1/3)

N337	1.	case_10ms_newmesh																		
	2.	case_10ms_prof_double_tap																		
	3.	case_10ms_prof_double_sucro																		
	4.	case_10ms_prof_double_tap_bezgrav																		
	5.	case_10ms_prof_double_tap_outflow																		
	6.	case_10ms_prof_scal																		
	7.	case_10ms_skl_v_diff																		
	8.	case_10ms_skl_v_diff0																		
	9.																			
		case_10ms_TKE_diff																		
	10.	case_10ms_zmiana_mix																		
	11.	case_10ms_zmiana_mix_outflow																		
	12.	case_10ms_zmiana_mix_prof_ke																		
	13.	case_10ms_zmiana_mix_prof_skl_v																		
	14.	case_10ms_zmiana_mix_prof_skl_v_gestosc																		
	15.	case_10ms_zmiana_mix_prof_skl_v_k																		
	16 jak 15																			
		case_10ms_zmiana_mix_prof_skl_v_k_e1																		
	17.	case_10ms_zmiana_mix_prof_skl_v_k_e1_enh_scal																		
18.	case_10ms_zmiana_mix_prof_skl_v_k_e1_graw_enh_temp																			
19.	case_10ms_zmiana_mix_prof_skl_v_k_e1_graw_scal																			
mesh																				
3,6 mln																				
9 mln																				
fluid parameters																				
density_1 = 998 kg/m3 (t)																				
density_2 = 1008 kg/m3 (b)																				
temperature_1 = 293.15 K (t)																				
temperature_2 = 295.65 K (b)																				
temperature_3 = 300 K																				

Matrix of case N337 (2/3)



CONFIDENTIAL

Matrix of case N337 (3/3)

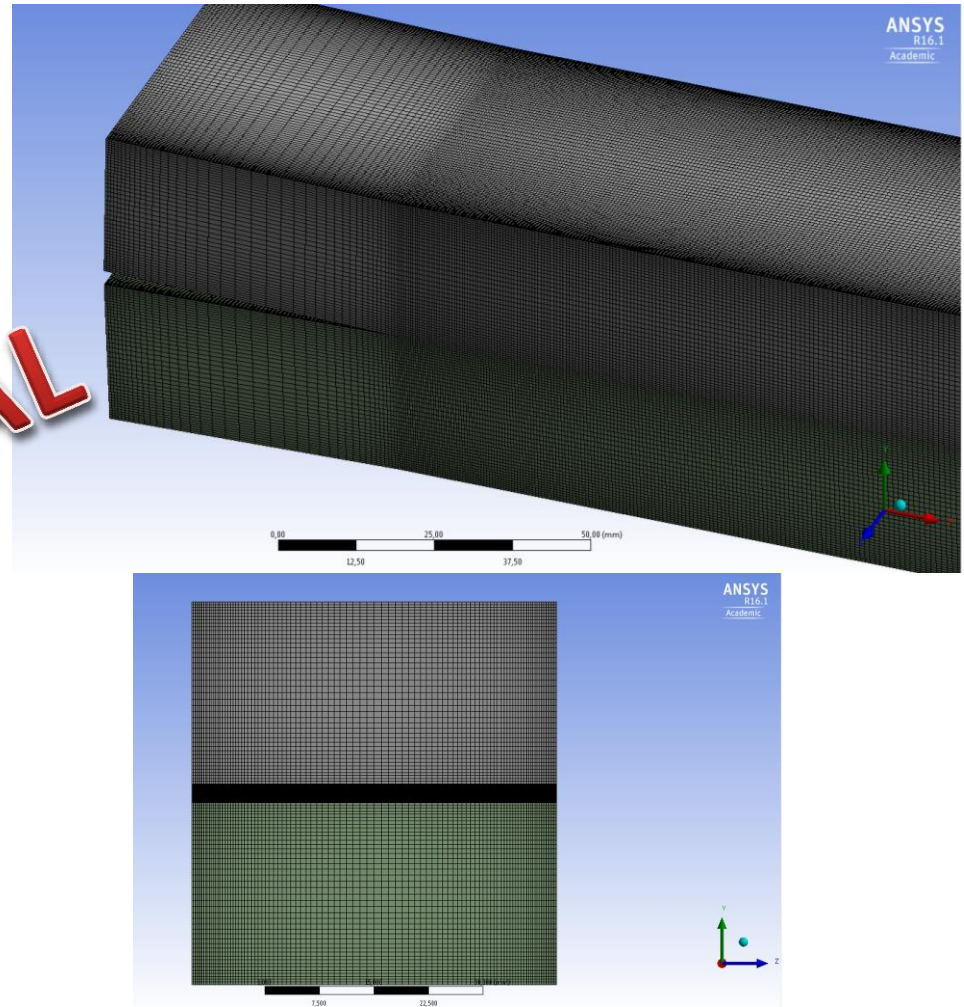


CONFIDENTIAL

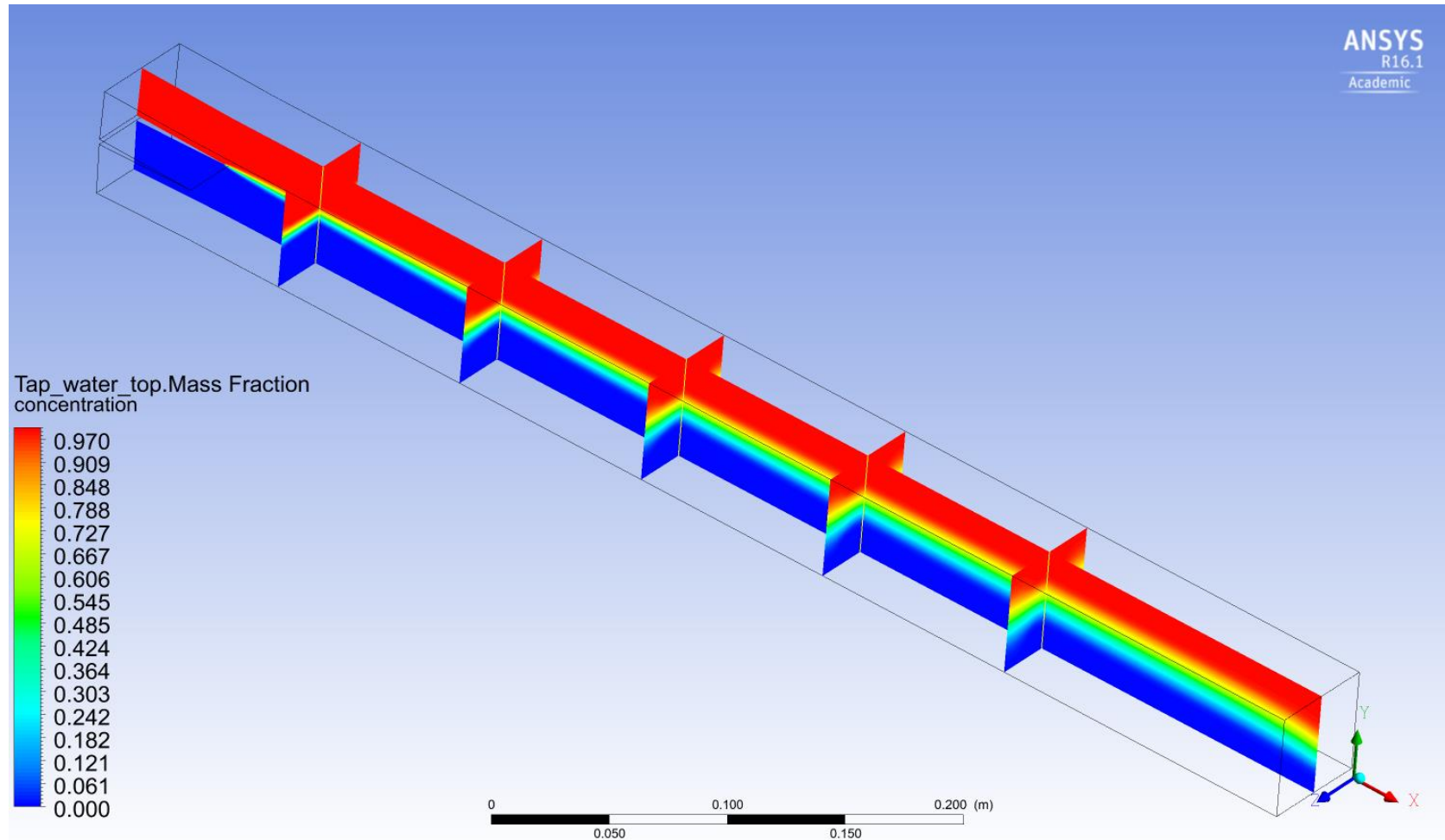
Mesh

Mesh: 3D hex

CONFIDENTIAL



CFD vs Experiment: concentration



CFD vs Experiment: concentration

Chart 6.

Concentration at 50 mm

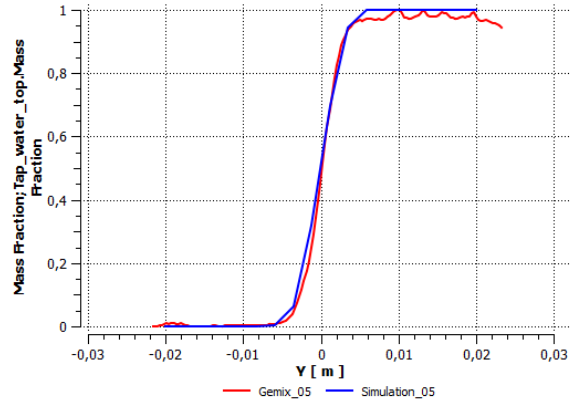


Chart 8.

Concentration at 250 mm

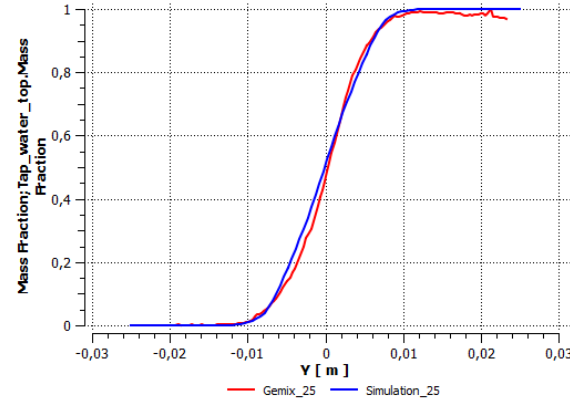


Chart 10.

Concentration at 450 mm

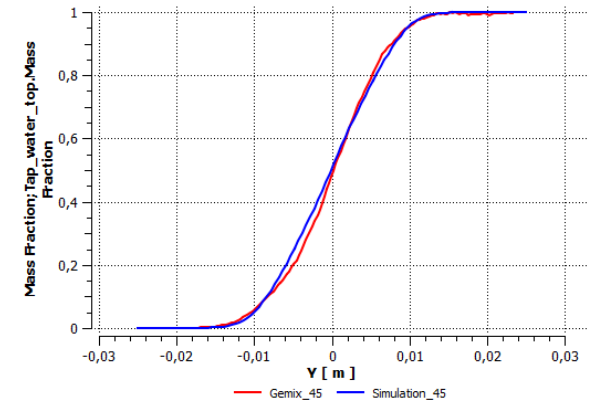


Chart 7.

Concentration at 150 mm

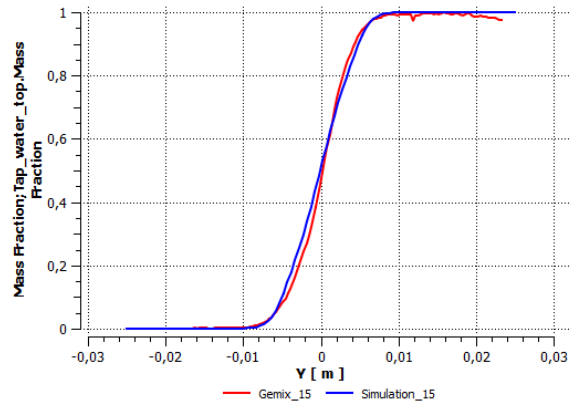
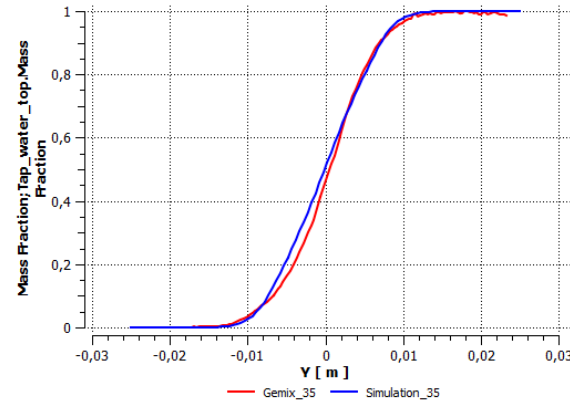
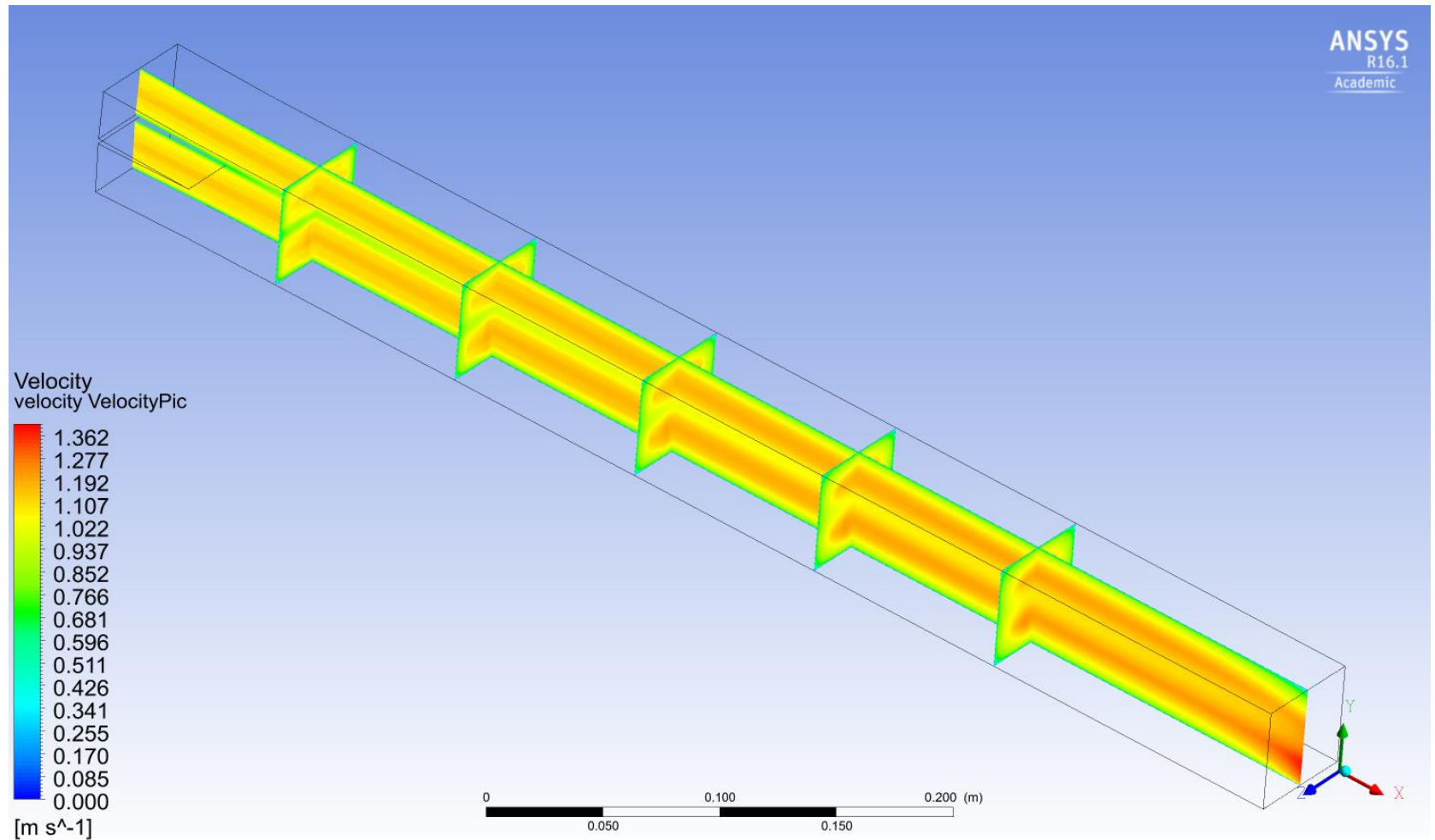


Chart 9.

Concentration at 350 mm



CFD vs Experiment: velocity



CFD vs Experiment: velocity

Chart 1.

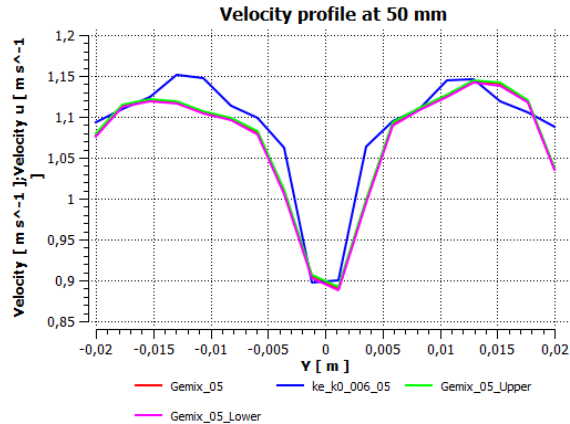


Chart 3.

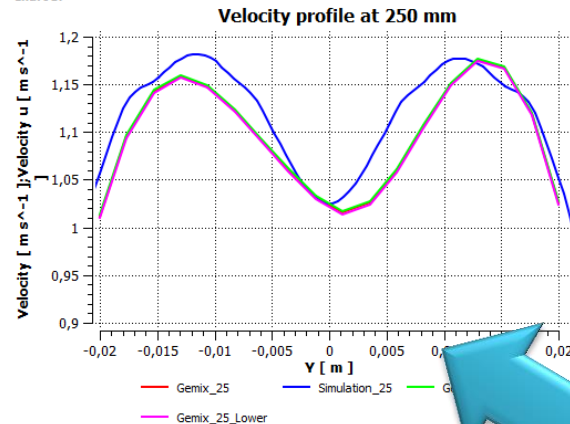


Chart 5.

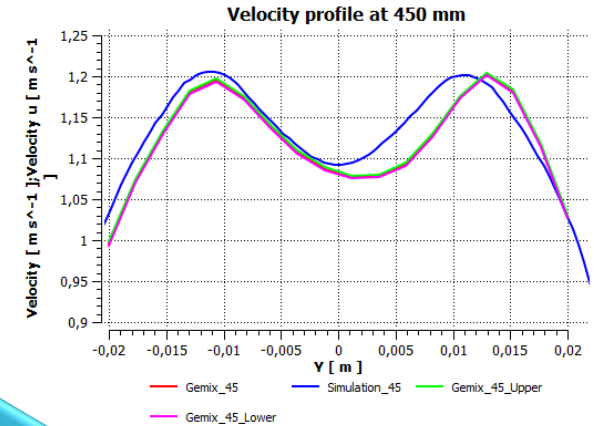


Chart 2.

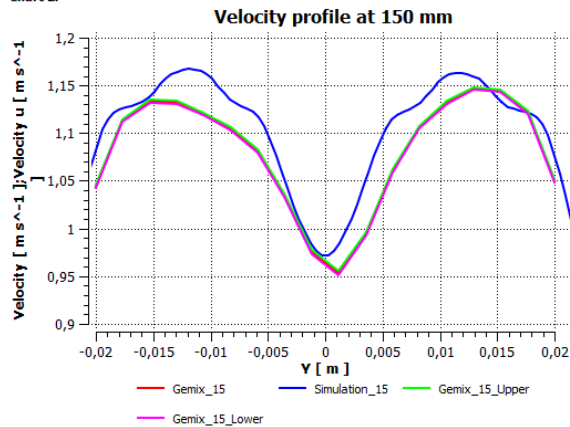
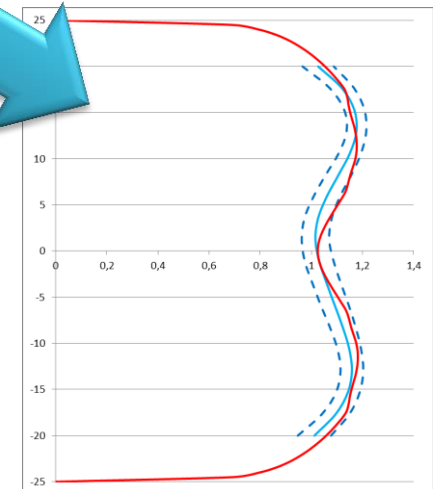
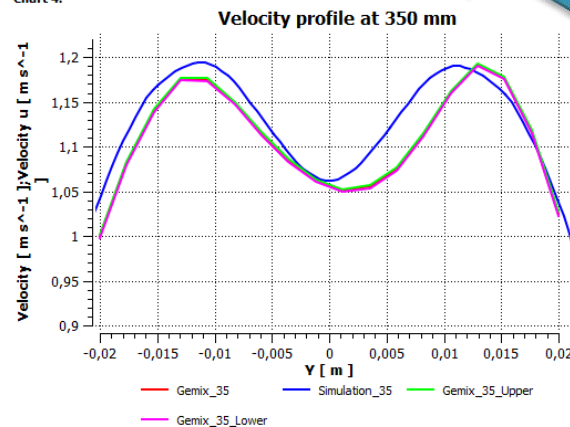


Chart 4.



Can we trust in CFD results?
YES, of course!

Thank you...

Any comments?



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e-mail: piotr.prusinski@ncbj.gov.pl