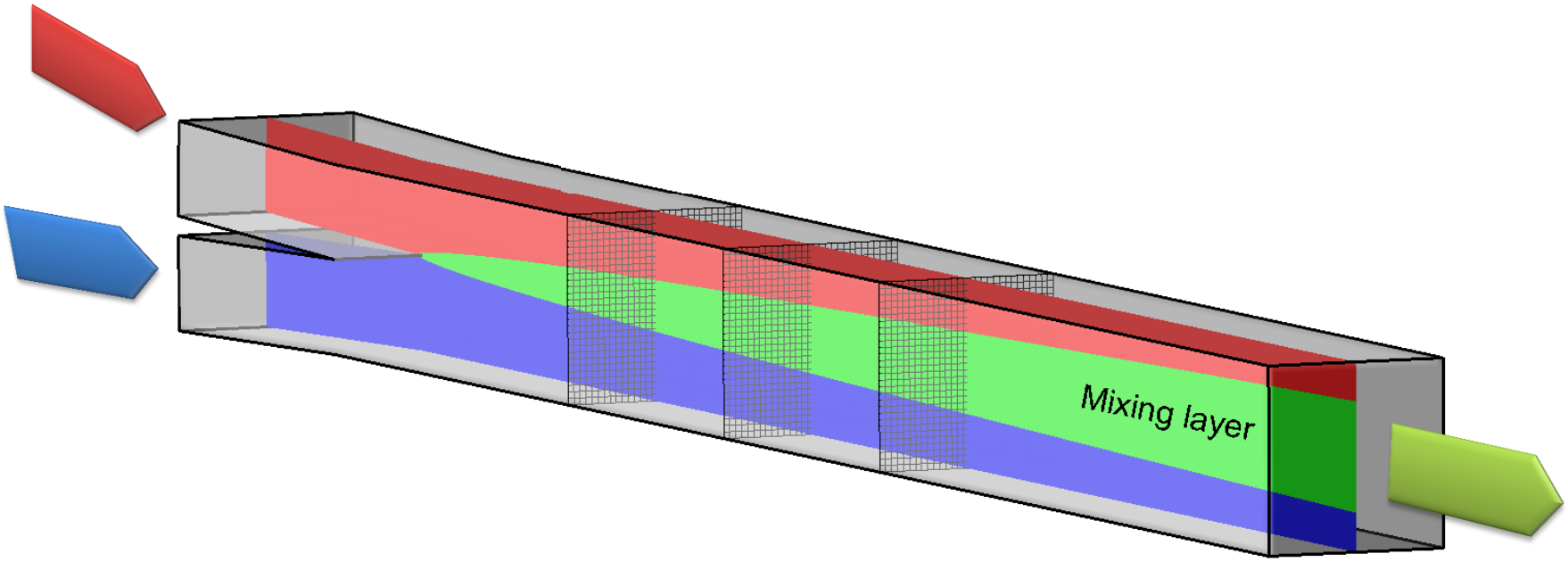
Piotr A. Prusiński, M.Sc., Eng.

Can we trust in CFD results?

Few words on GEMIX benchmark



CFD Benchmarks

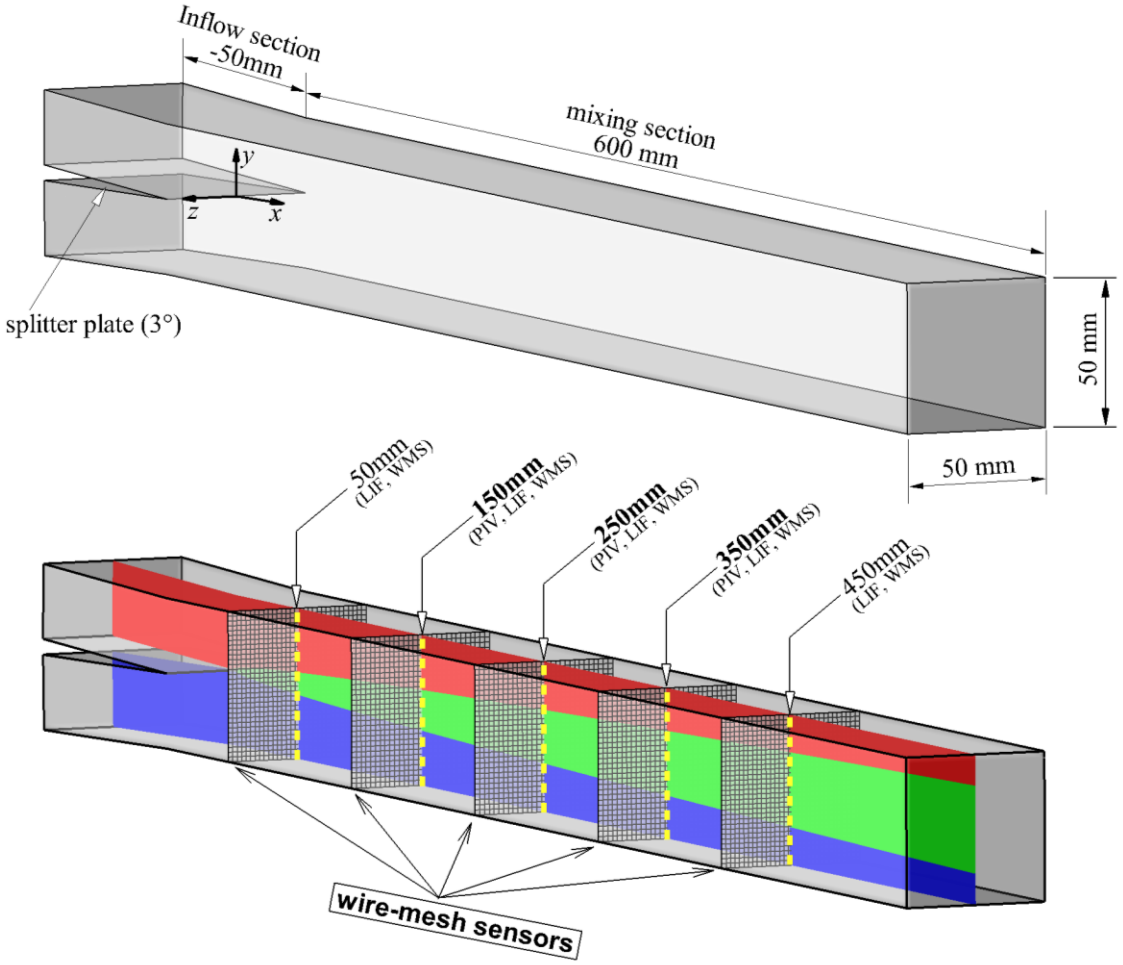
- To quantify the accuracy of CFD results
- Sources of doubts/uncertainties:
  - Fluid domain simplifications
  - Mesh quality (discretization accuratness)
  - Material parameters (mostly ideal concepts)
  - Choice of physics spectrum
  - Choice of turbulence model (and/or its tunning)
  - Solver accuracy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

GEMIX

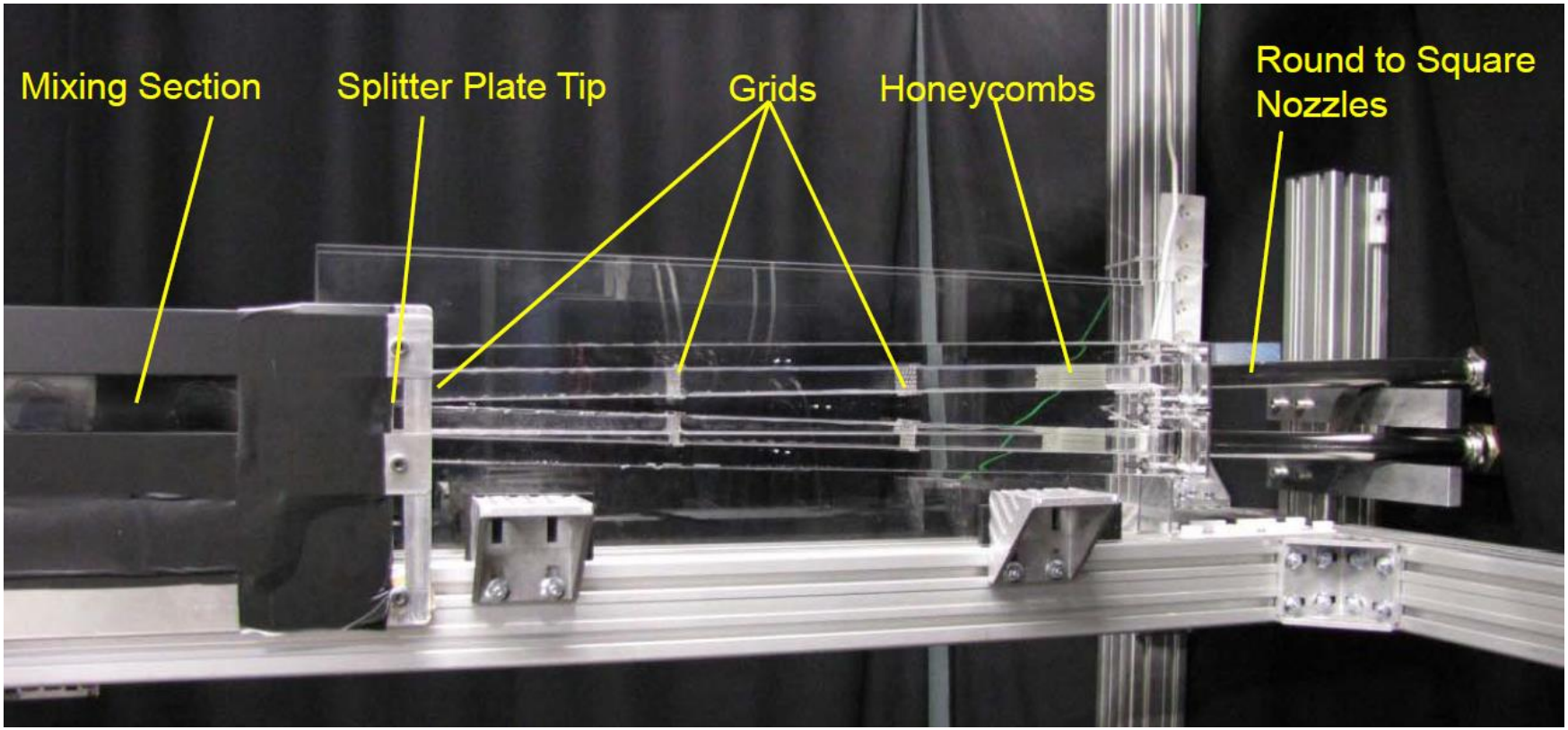
- Benchmark:
  - CFD prediction and Uncertainty Quantification of a GEMIX mixing layer test

- Test facility:
  - GEMIX (**GE**neric **MI**xing e**X**periment), developed at the Paul Scherrer Institute in Switzerland.

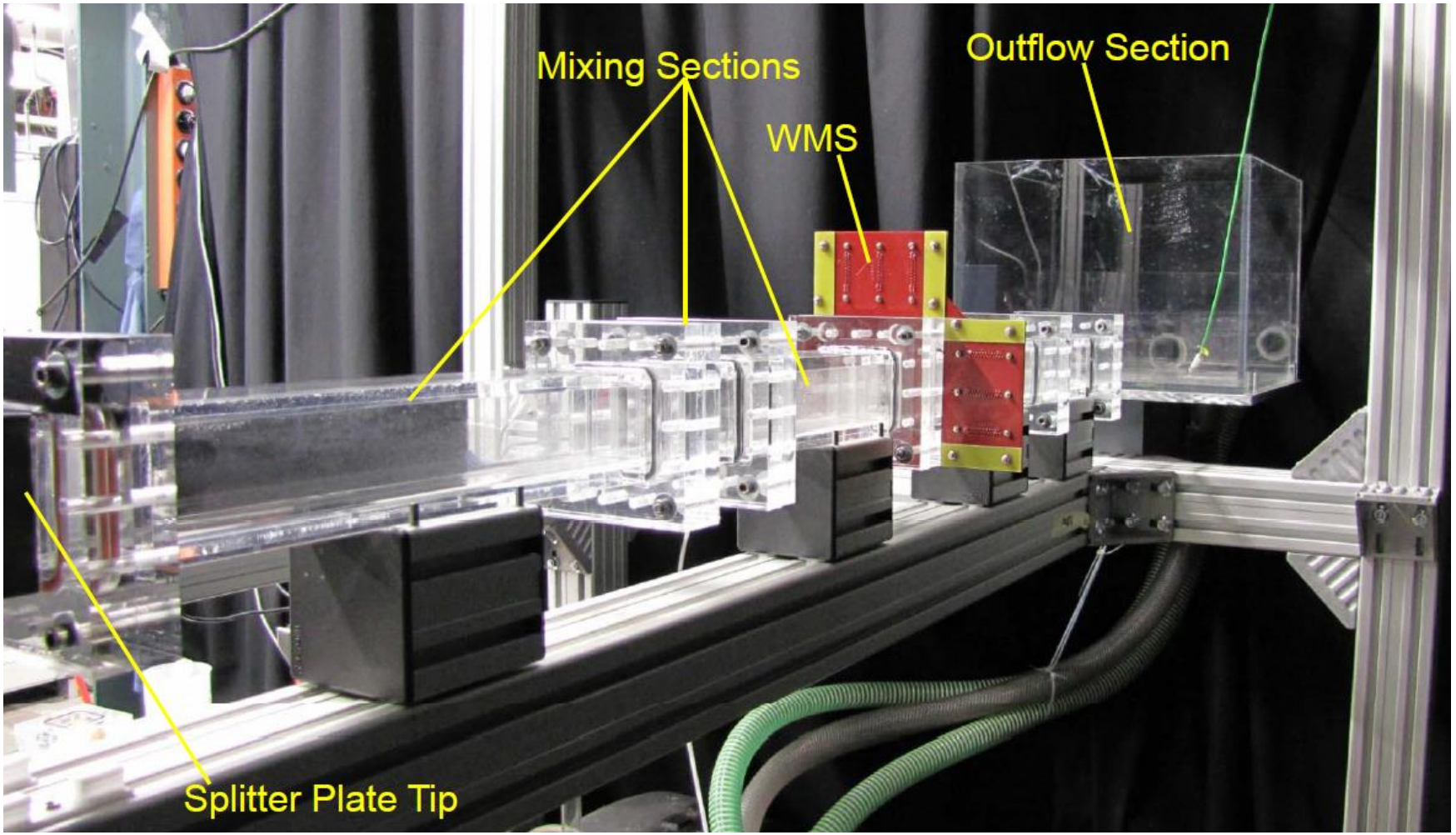
GEMIX – general overview



Experimental setup



Experimental setup



GEMIX experiment matrix

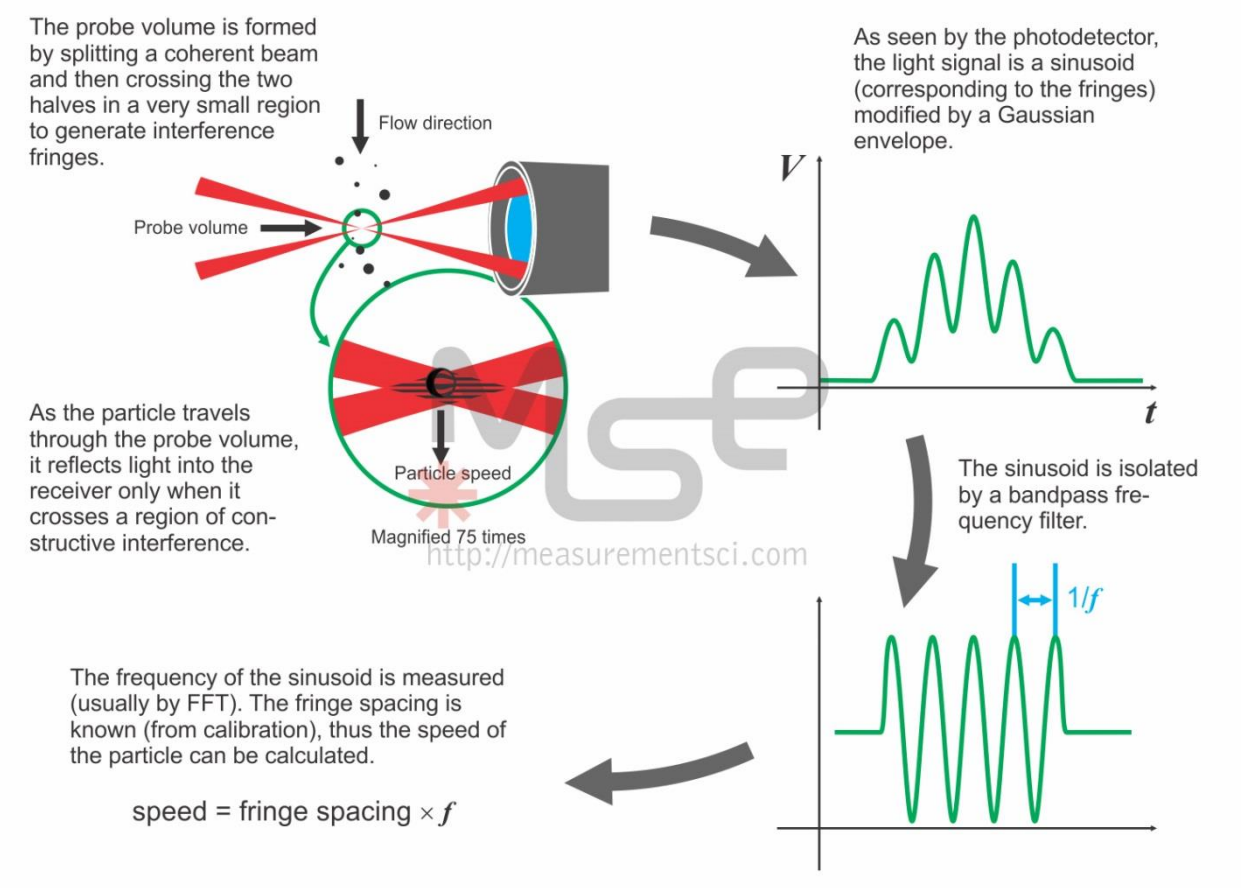
	0.2 m/s	0.4 m/s	0.6 m/s	0.8 m/s	1 m/s	1.2 m/s	Series
Global Re-number	**10000**	**20000**	**30000**	**40000**	**50000**	**60000**	
Δρ=0%	N341	N340	N339	N338	N337	n.a.	20100821A
Δρ=1%	N322	N321	N320	N319	N318	n.a.	20100818
Δρ=3%	N341	N340	N339	N338	N337	n.a.	20100820C
Δρ=5%	N335	N334	N333	N332	N331	n.a.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

Complete data set available

Measurement techniques

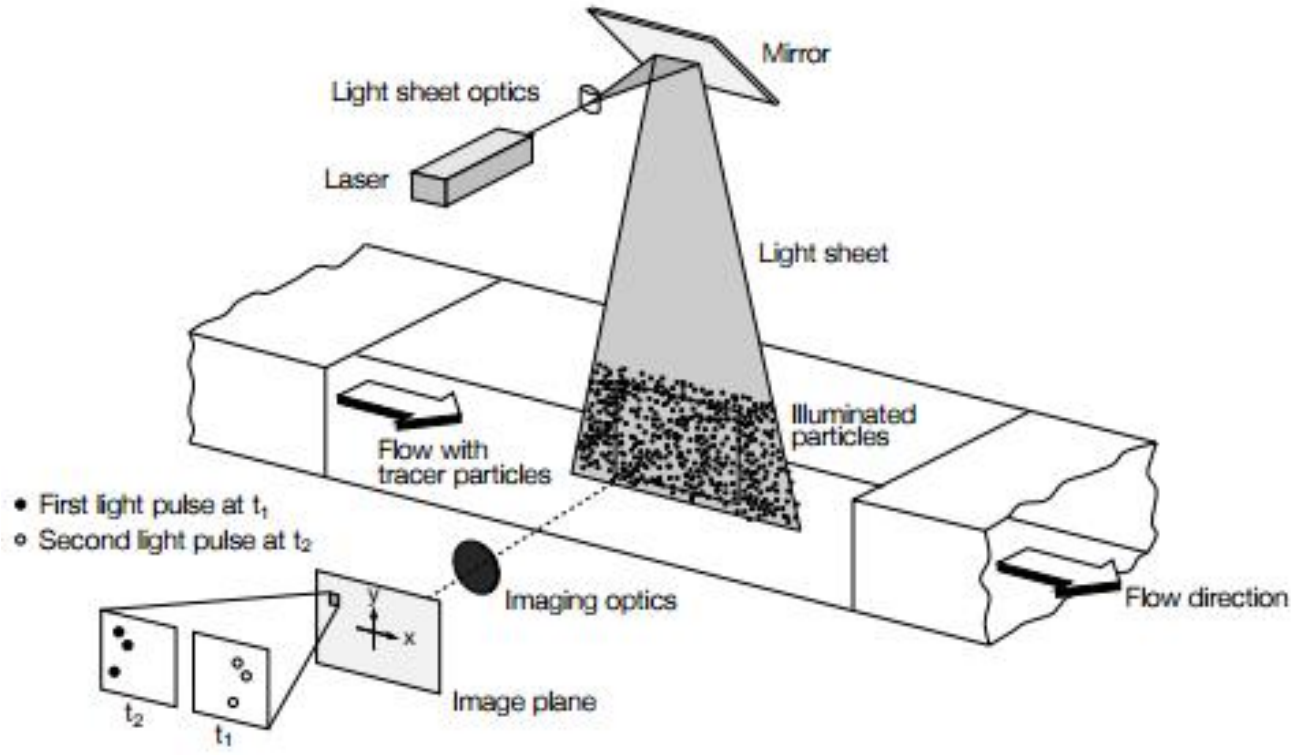
- LDA - Laser Doppler Anemometry
- PIV - Particle Image Velocimetry
- LIF - Laser Induced Fluorescence
- WMS - Wire Mesh Sensors

LDA



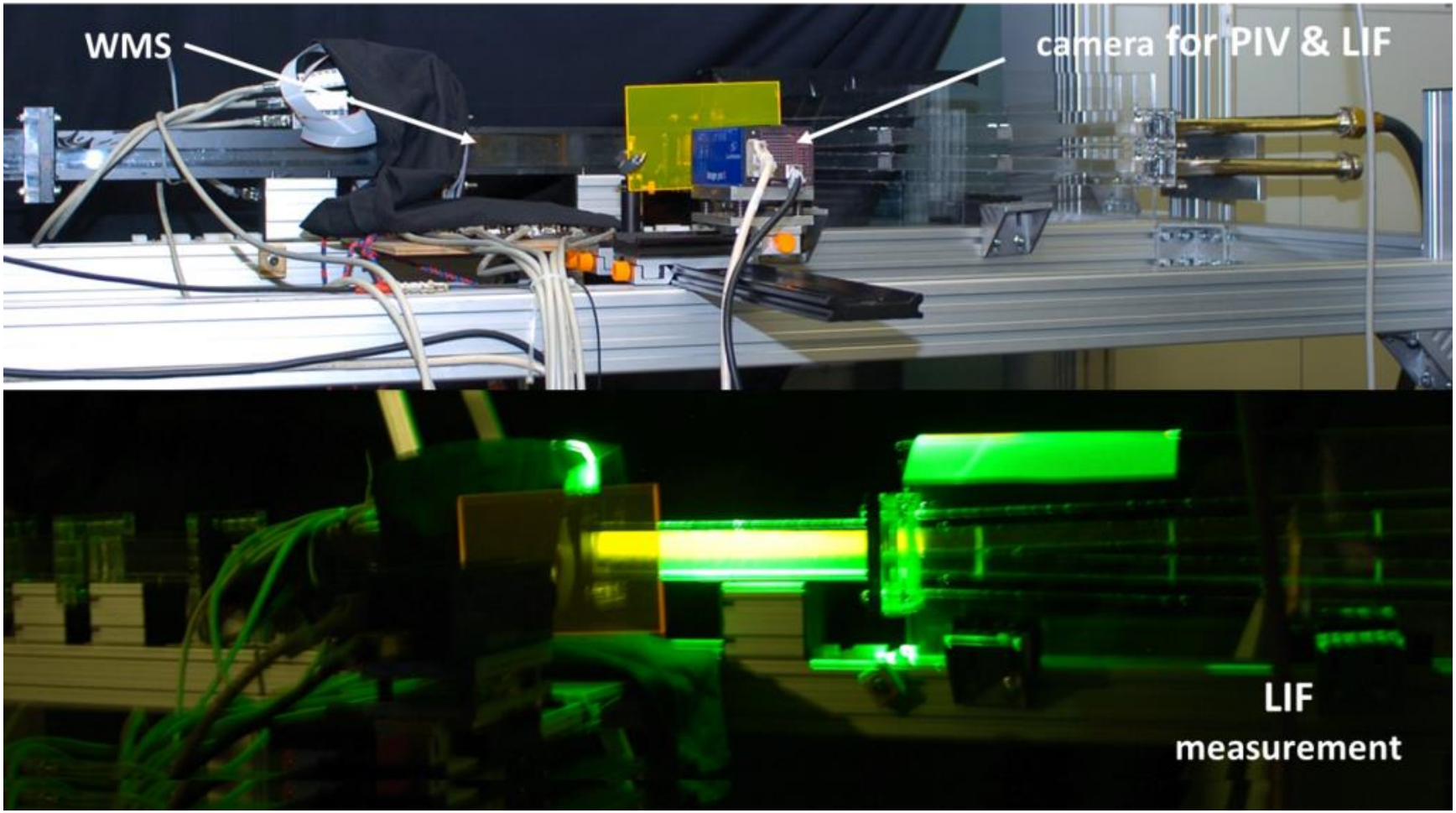
min $5 000 for one velocity component

PIV/LIF

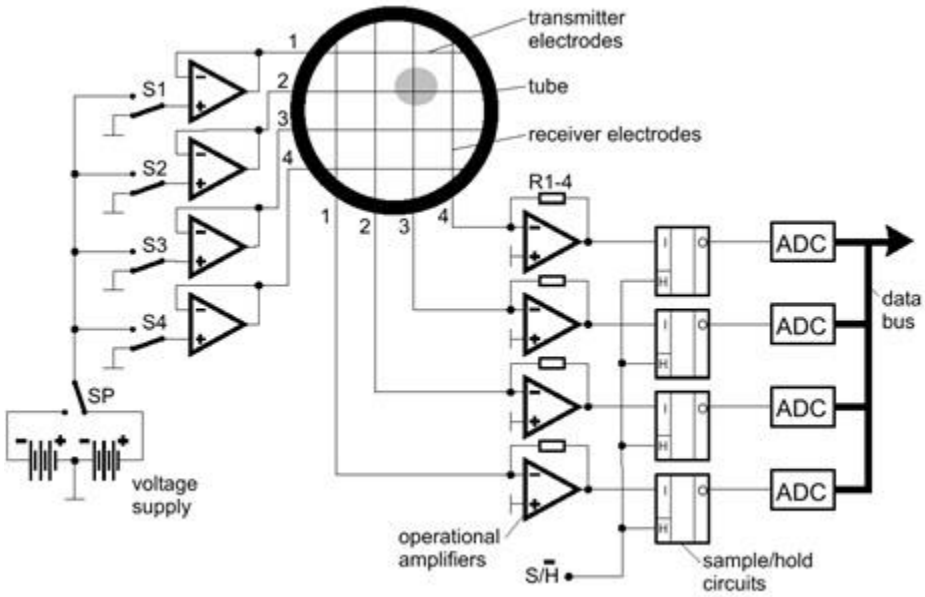


on average $100 000

PIV/LIF



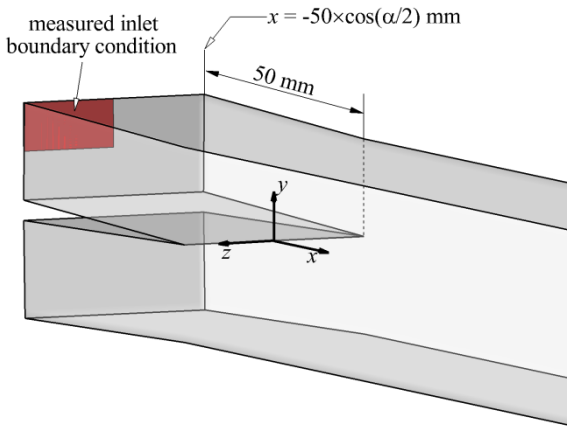
WMS

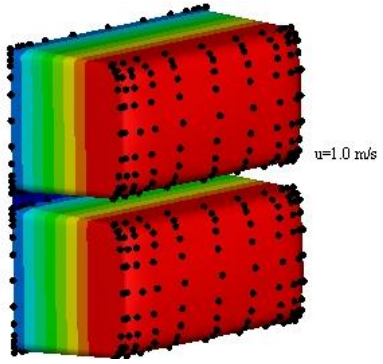

transmitter electrodes
tube
receiver electrodes
R1-4
S1
S2
S3
S4
SP
voltage supply
operational amplifiers
S/H
sample/hold circuits
ADC
ADC
ADC
ADC
data bus

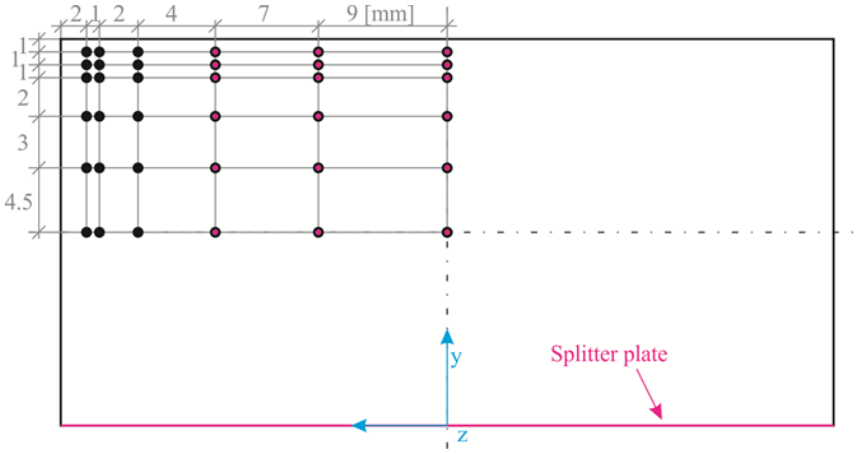
GEMIX Schedule

- 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

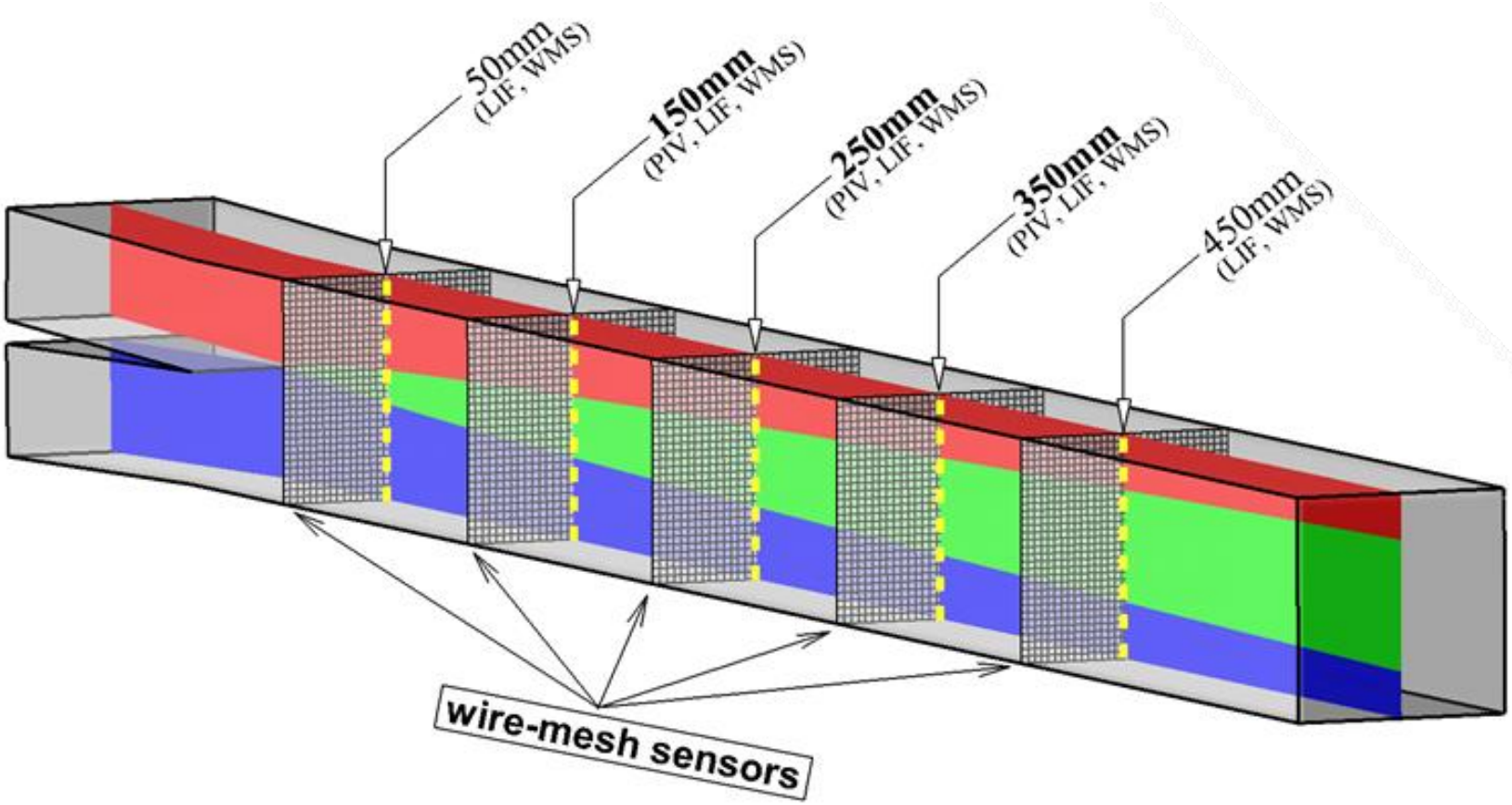
Input


measured inlet
boundary condition
x = -50×cos(α/2) mm
50 mm
y
z
x

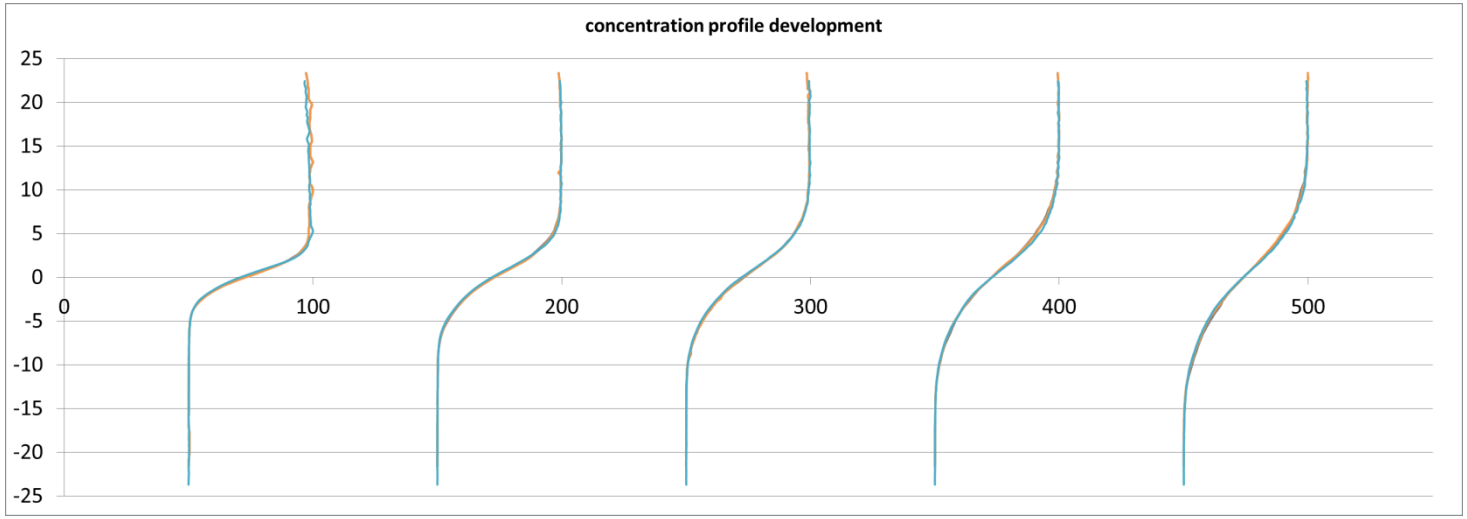

u=1.0 m/s

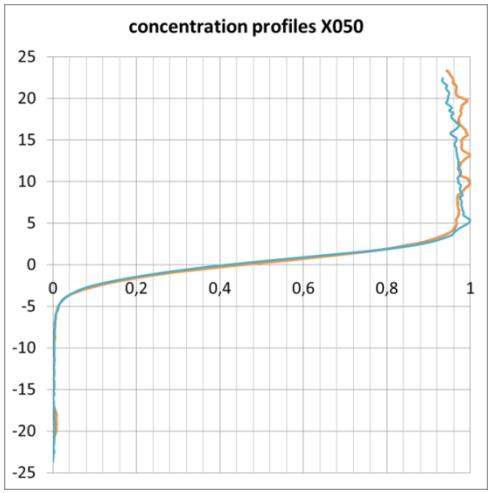

2 1 2 4 7 9 [mm]
1
1
1
2
3
4.5
y
z
Splitter plate

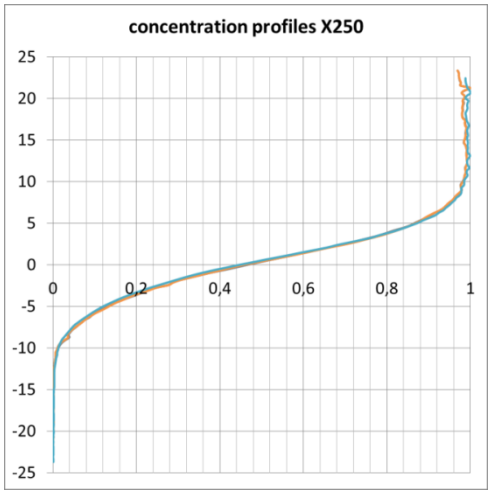
Output

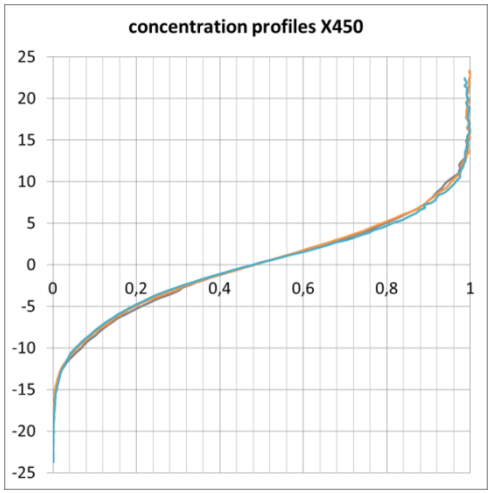

50mm
(LIF, WMS)
150mm
(PIV, LIF, WMS)
250mm
(PIV, LIF, WMS)
350mm
(PIV, LIF, WMS)
450mm
(LIF, WMS)
wire-mesh sensors

Output: concentration

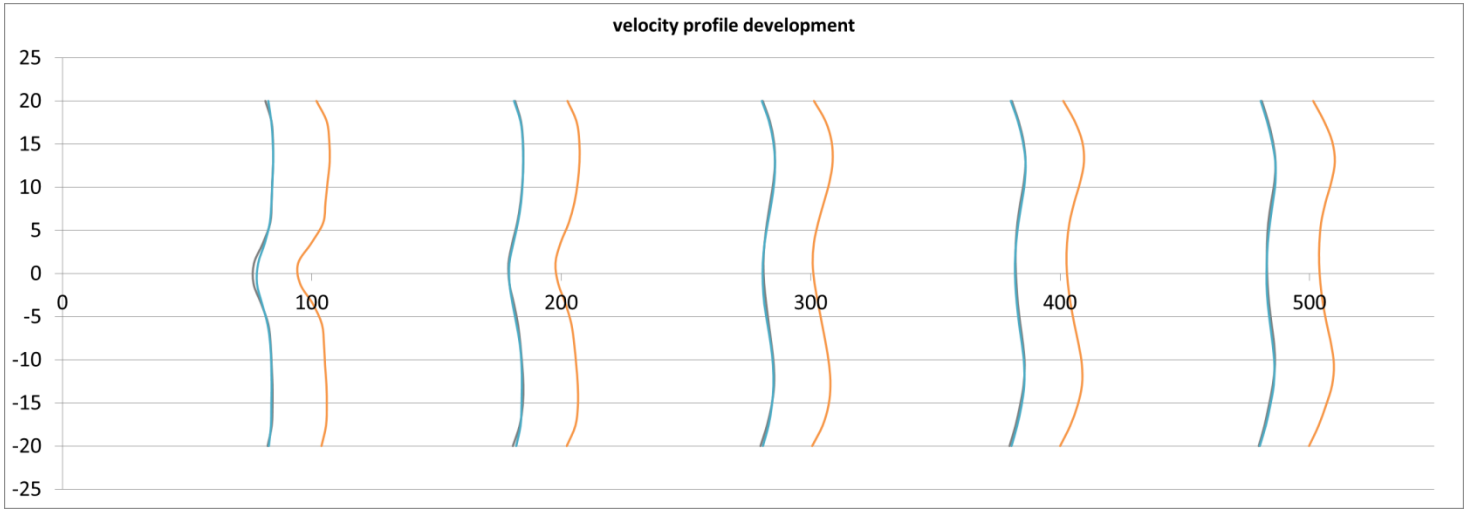


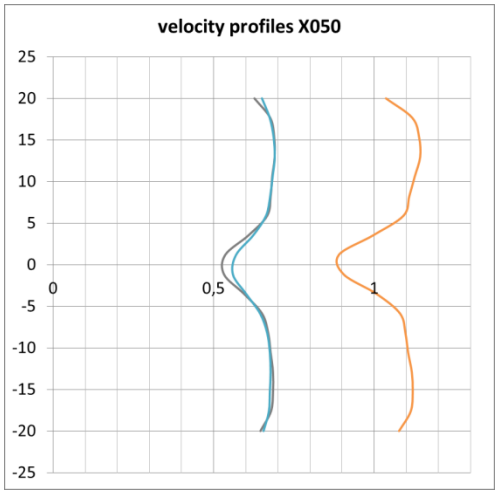


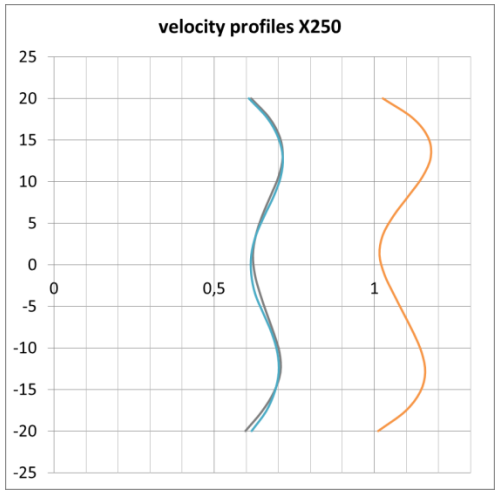


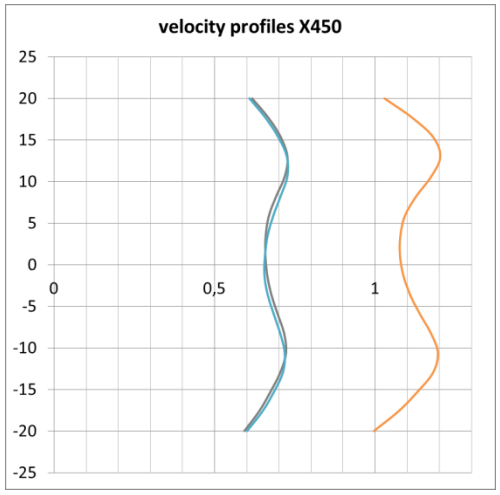


Output: velocities









Input/Output

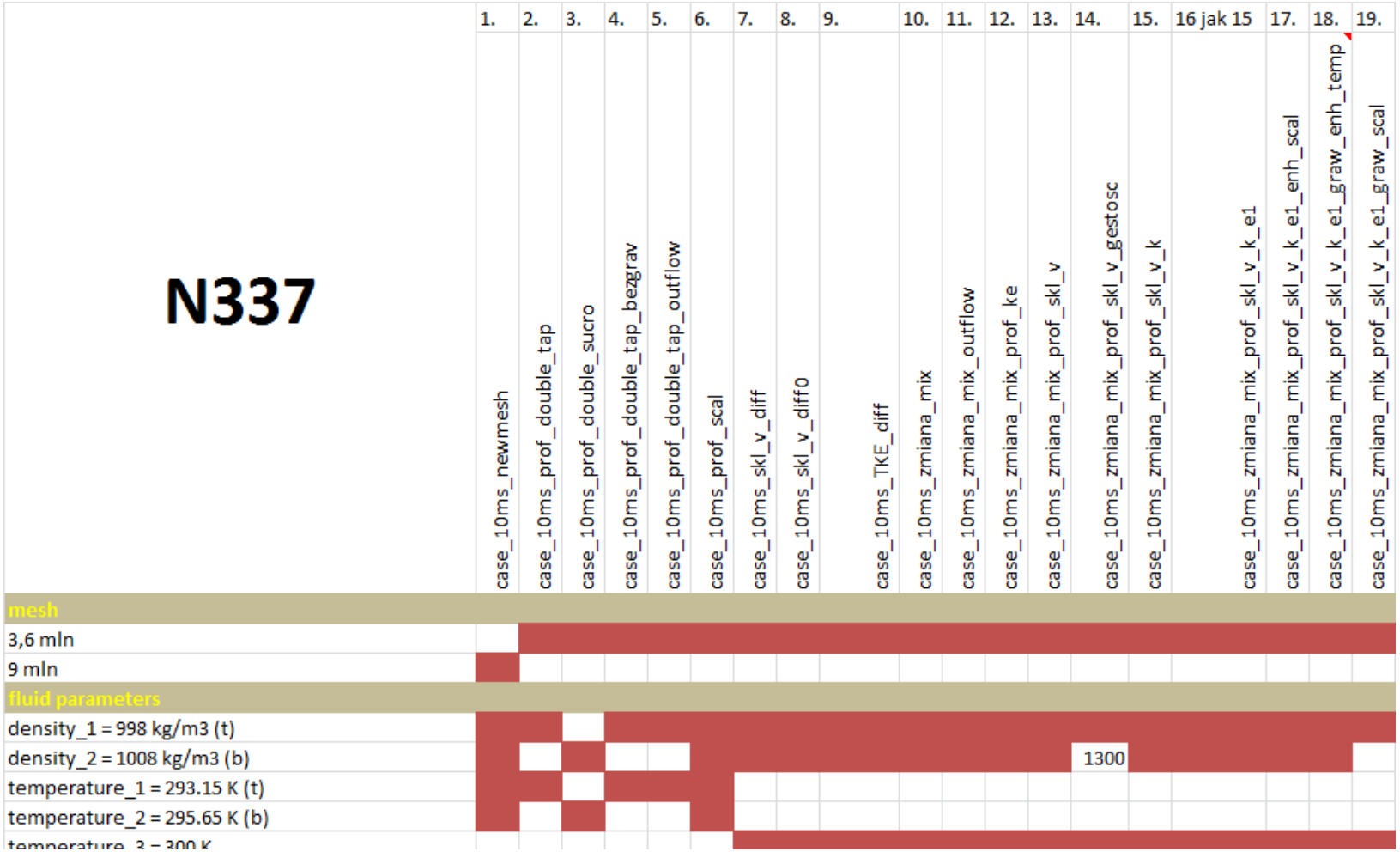
- Input
  - X, Y, Z – coodinates
  - Vx, U_x95, RMSVx, RMSVxUpper, RMSVxLower
  - Vy, U_y95, RMSVy, RMSVyUpper, RMSVyLower
  - Vz, U_z95, RMSVz, RMSVzUpper, RMSVzLower
  - k, kLOWER, kUPPER

- Output

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

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

Matrix of case N337 (1/3)

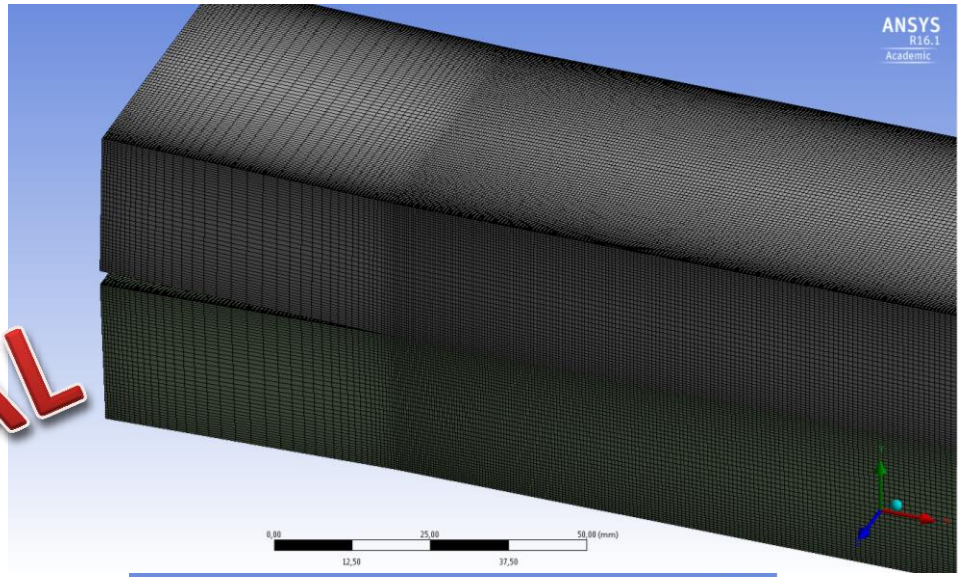


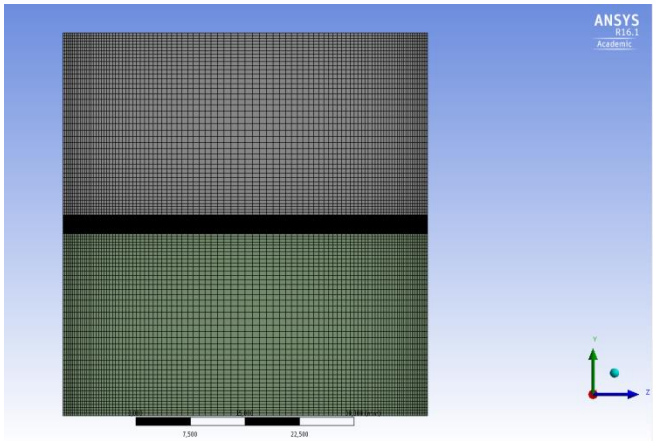
Matrix of case N337 (2/3)

Matrix of case N337 (3/3)

Mesh

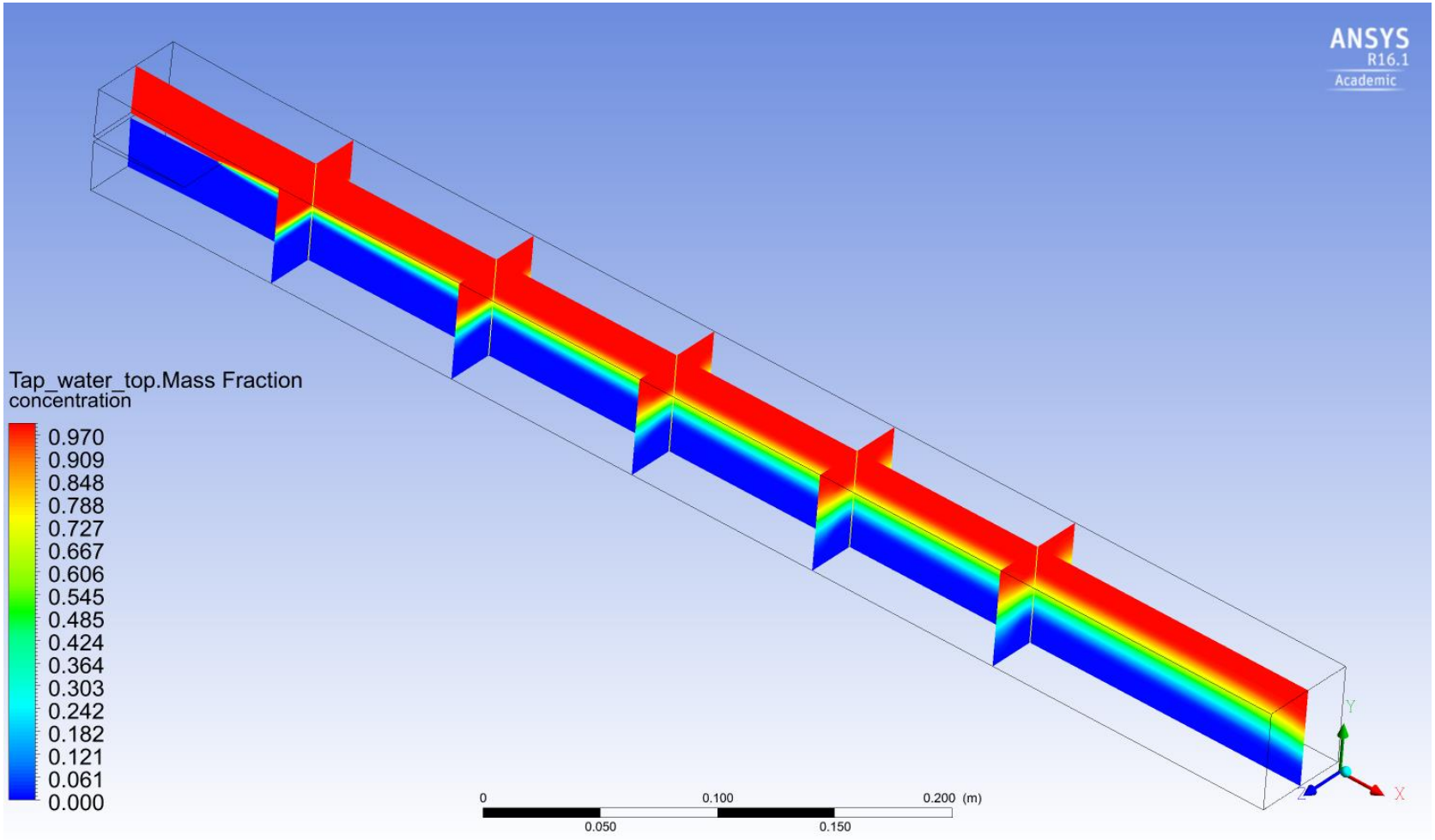
Mesh: 3D hex





CONFIDENTIAL

CFD vs Experiment: concentration



CFD vs Experiment: concentration

Chart 6.

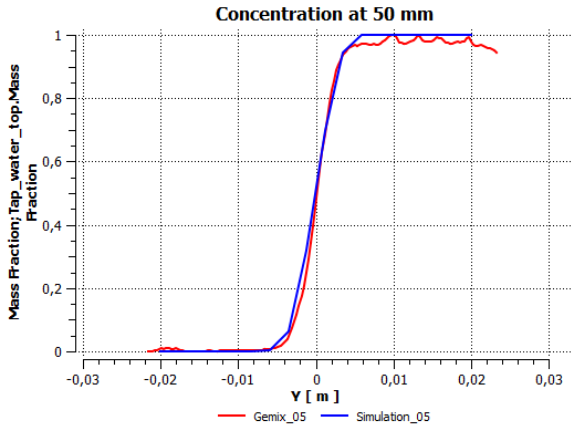


Chart 8.

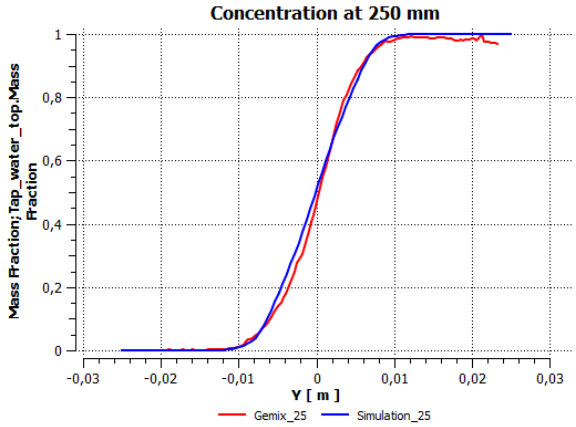


Chart 10.

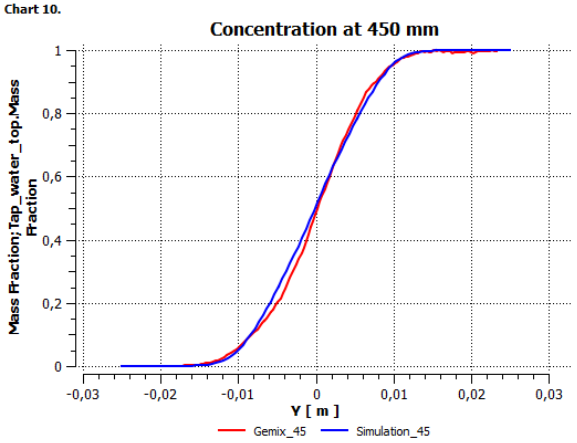


Chart 7.

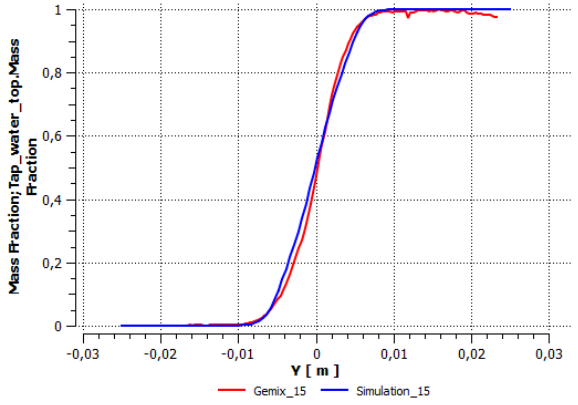
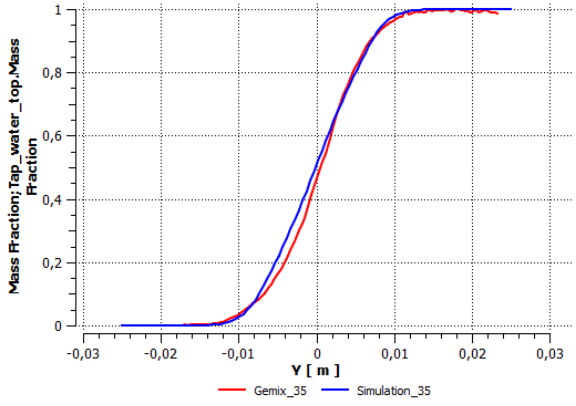
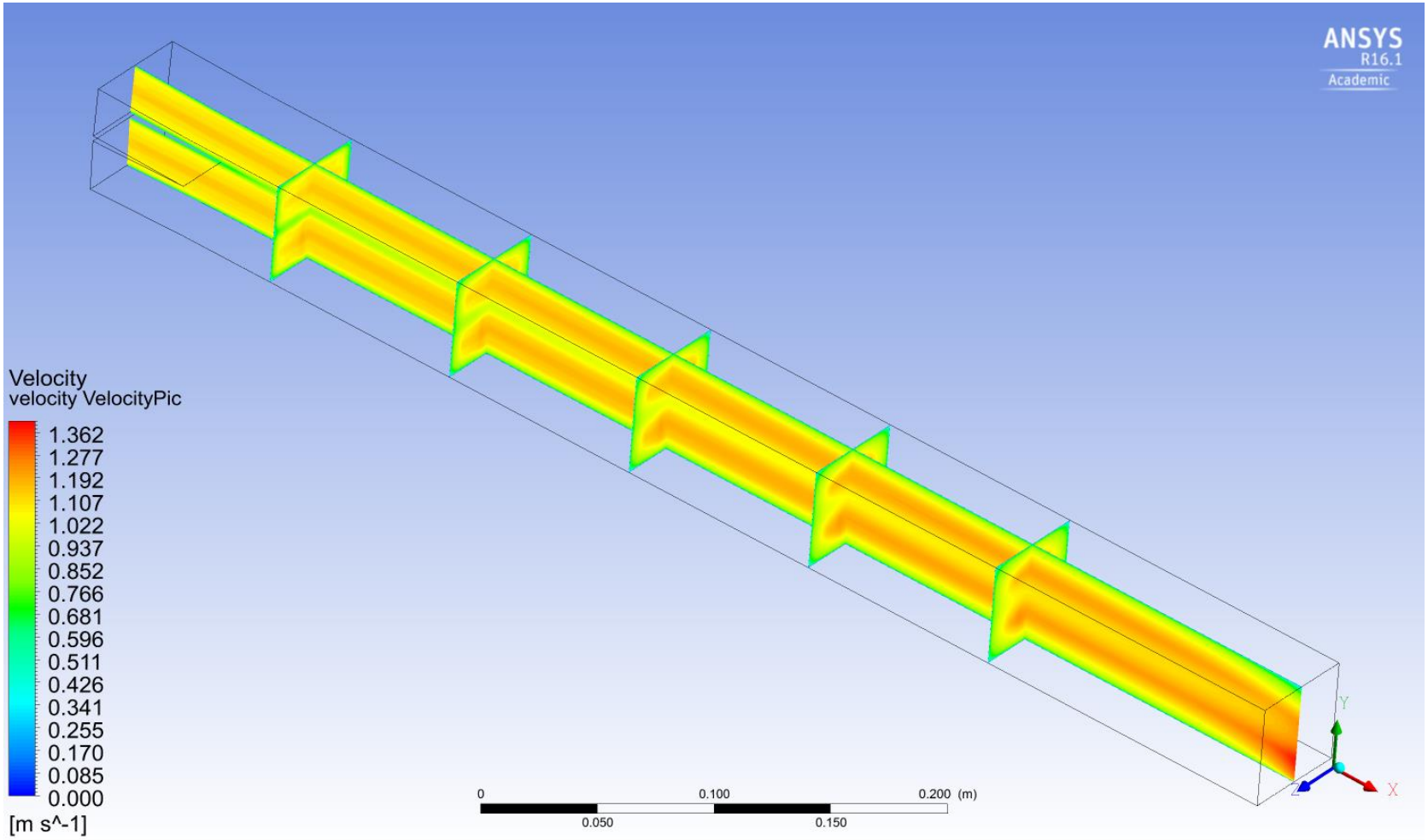


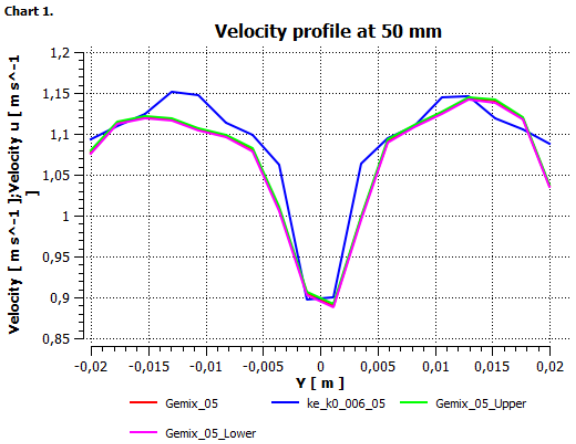
Chart 9.

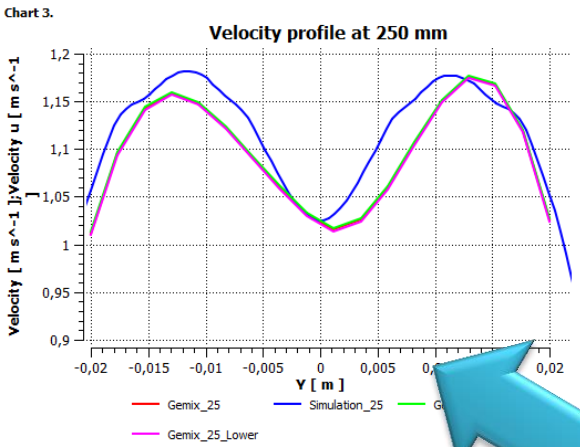


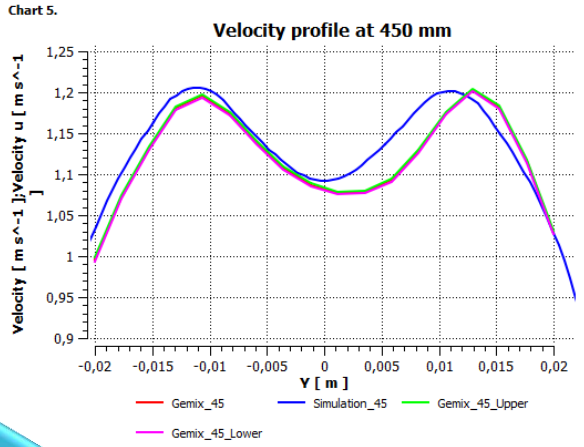
CFD vs Experiment: velocity

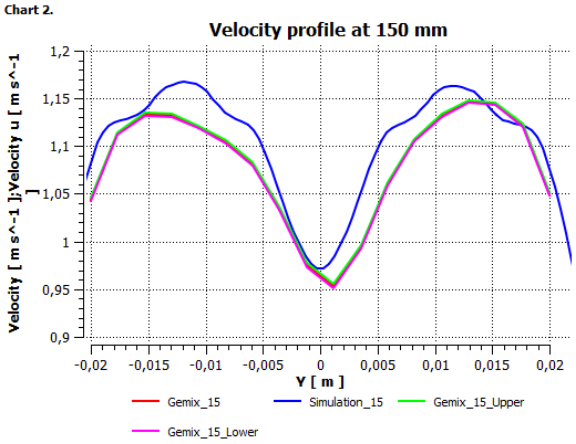


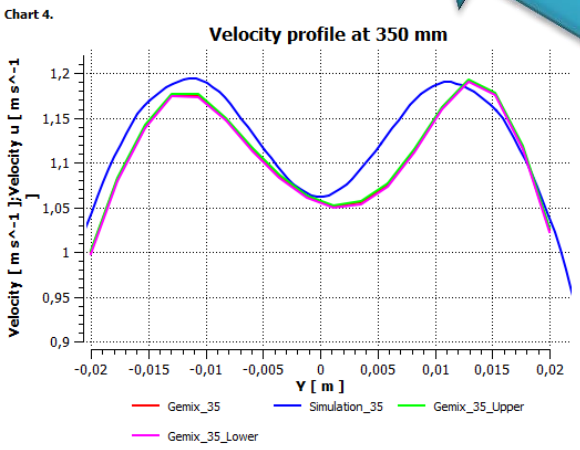
CFD vs Experiment: velocity

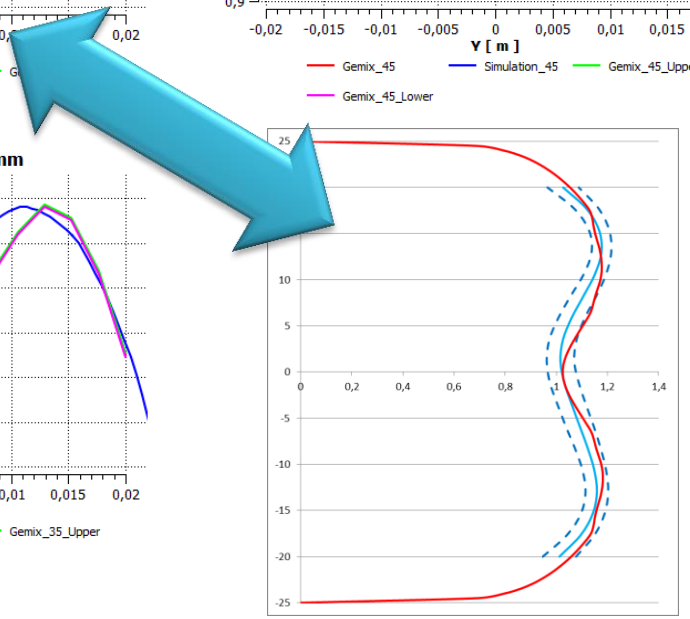












Can we trust in CFD results?

YES, of course!

Thank you…

Any comments?

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