Comparison of calibrations of wind speed meters with a large blockage effect

Euramet project no. 1431

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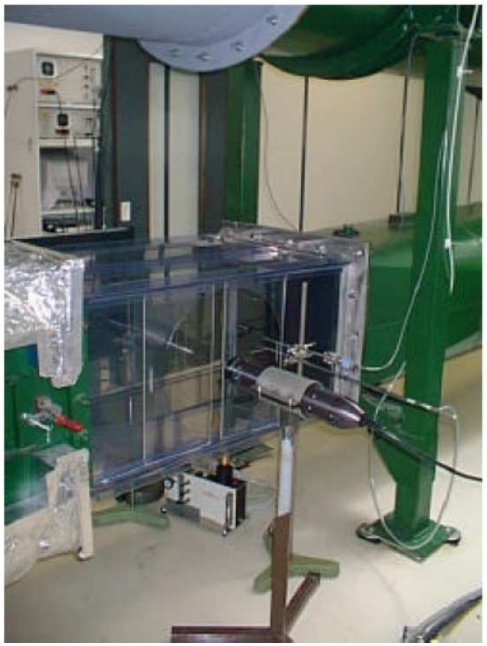
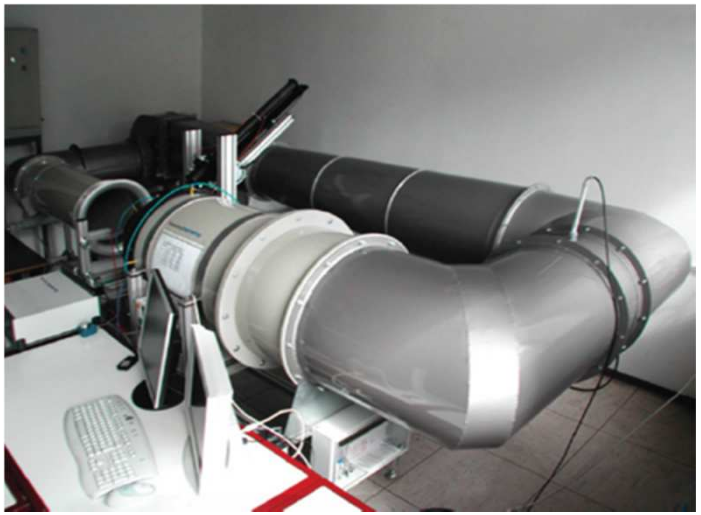
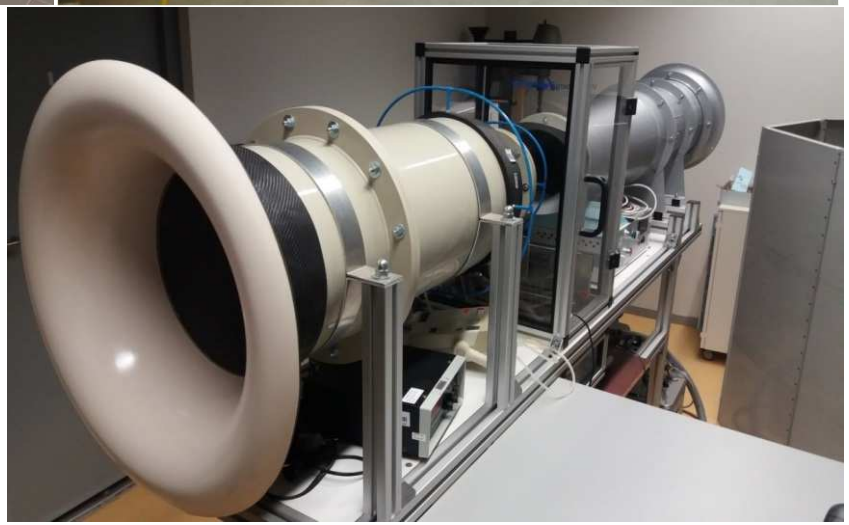
Examples
of wind tunnels
of various types
and sizes used for
calibrations
of anemometers







Goals

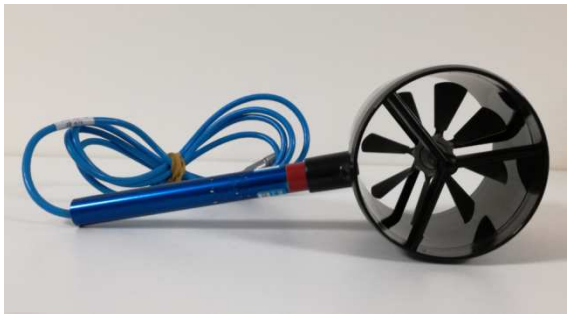
- Investigate effect of boundary conditions in test section of a wind tunnel to indication of larger size vane and cup anemometers for a given reference velocity in area undisturbed by the MUT (blockage effect),
  especially but not only for wind tunnels with open test section

- Investigate effect of flow disturbance in front of large size vane and cup anemometers

- Compare calibration results of European wind-speed laboratories for the large size vane and cup anemometers

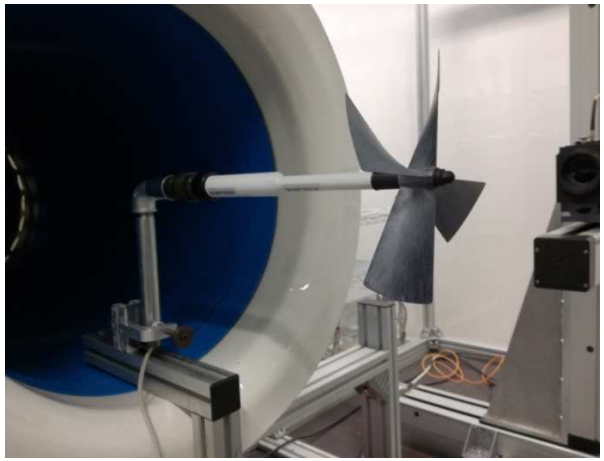
Transfer standards

Schiltknecht MiniAir20
Macro, d = 8.5 cm



Testo 0635 9340
d = 10.8 cm

RM Young Gill Propeller
d = 20 cm



Thies First Class Advanced
d = 24 cm

Vaisala WAA151
d = 18.2 cm

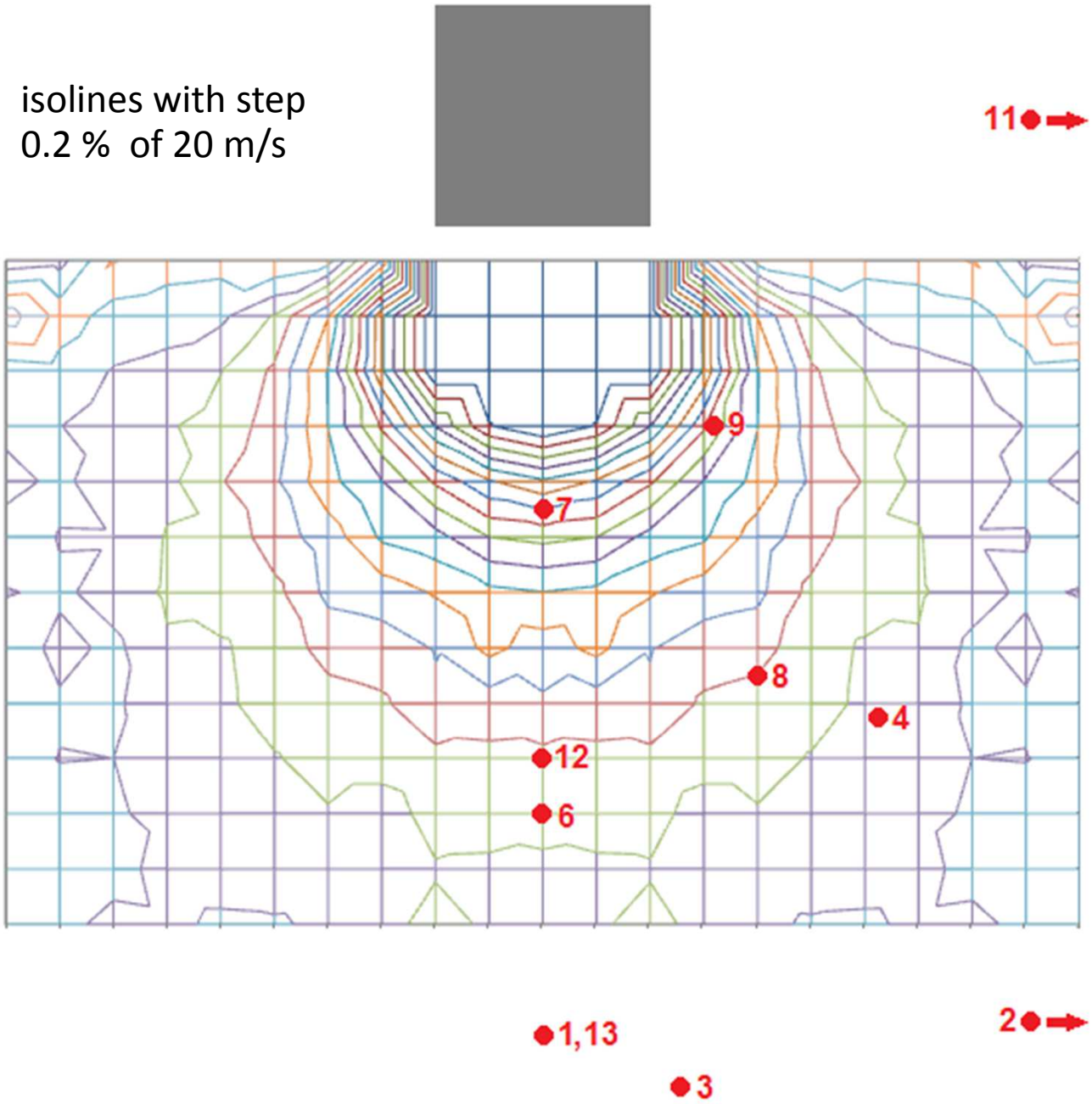
Airflow TA440, d = 0.7 cm

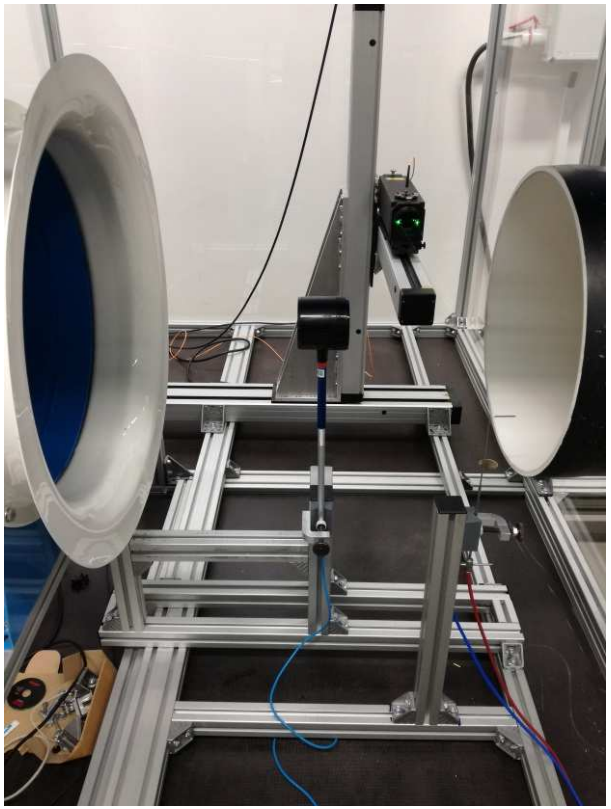
Participants

lab no.	test section type	nozzle shape	nozzle diameter /width (cm)
open or box			
1	open	square	100
2	box	circular	80
3	open	rectang.	50 x 60
4	open	circular	45
5	box	circular	40
6	open	circular	32
7	box	circular	31.5
8	box	circular	25.5
9	open	circular	25.5
10	box	circular	15.2
closed			
11	closed	rectang.	74 x 49
12	closed	square	51
13	closed	square	50
14	closed	circular	40

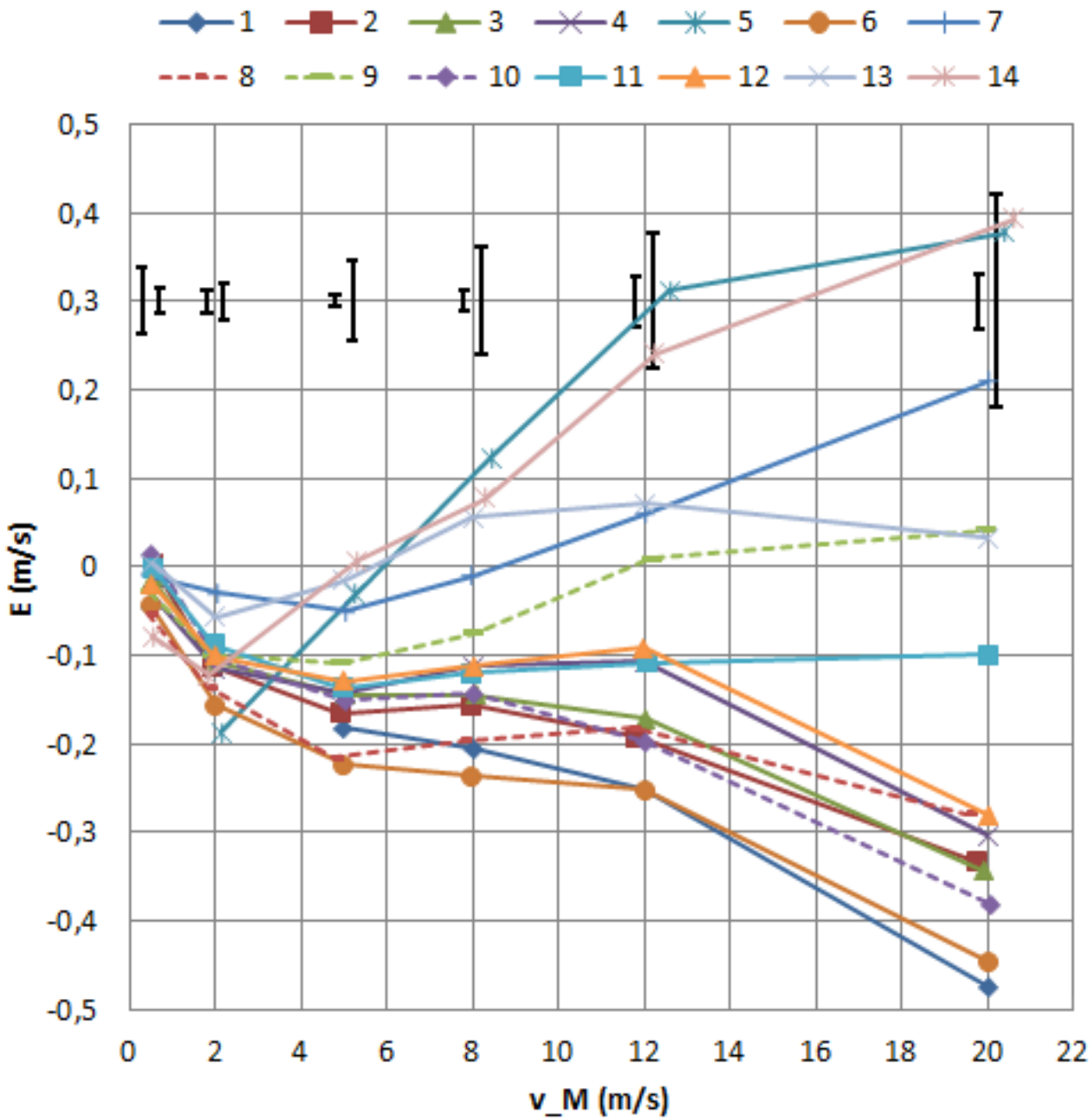
Schiltknecht 8.5 cm vane – velocity field 20 m/s

isolines with step
0.2 % of 20 m/s





Schiltknecht 8.5 cm vane – results

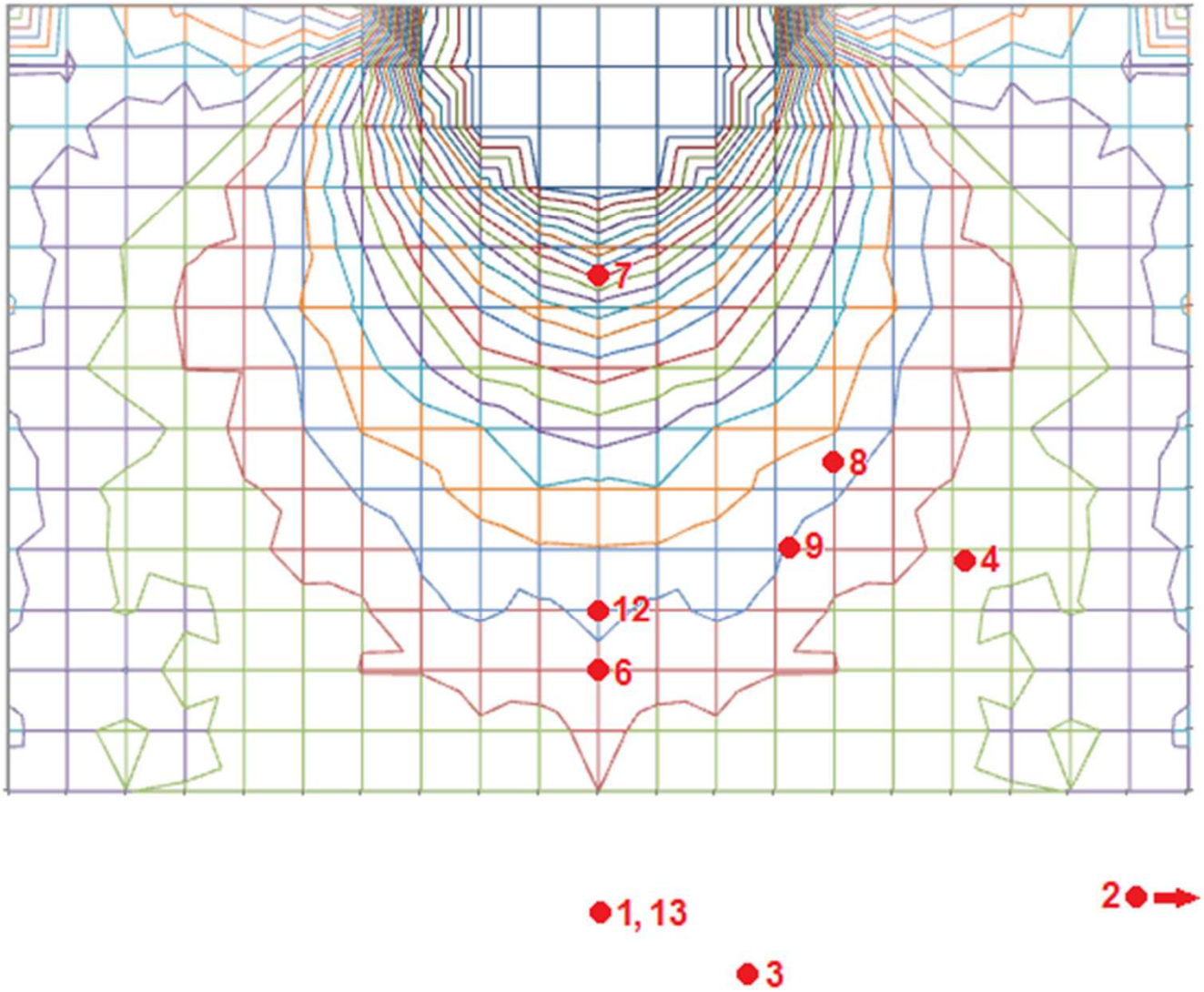


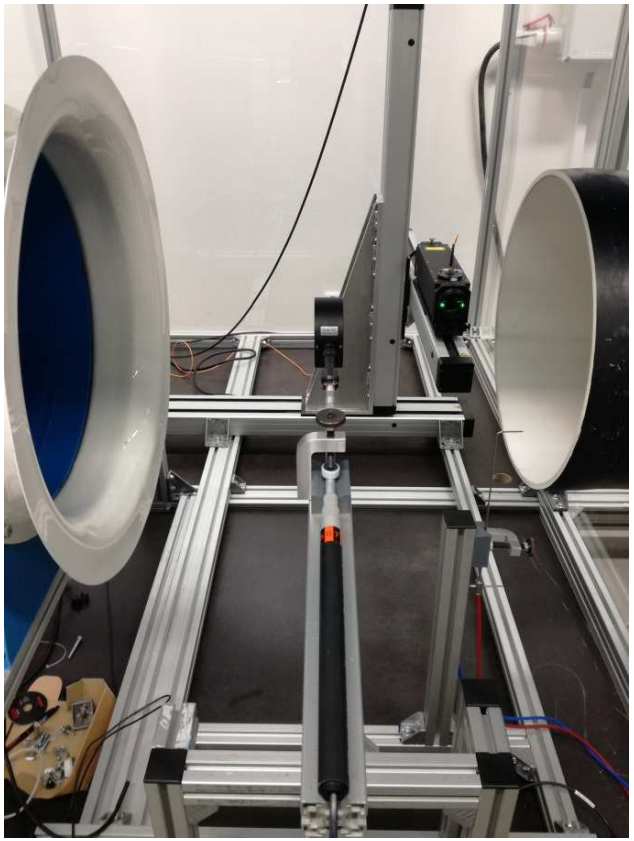
$$En = \frac{E_1 - E_2}{\sqrt{U_1^2 + U_2^2 + D^2}}$$

wt.set	all (14)	large (11)
v (m/s)	% En ≤ 1	
0,5	99	98
2	64	53
5	53	47
8	49	42
12	47	38
20	49	45

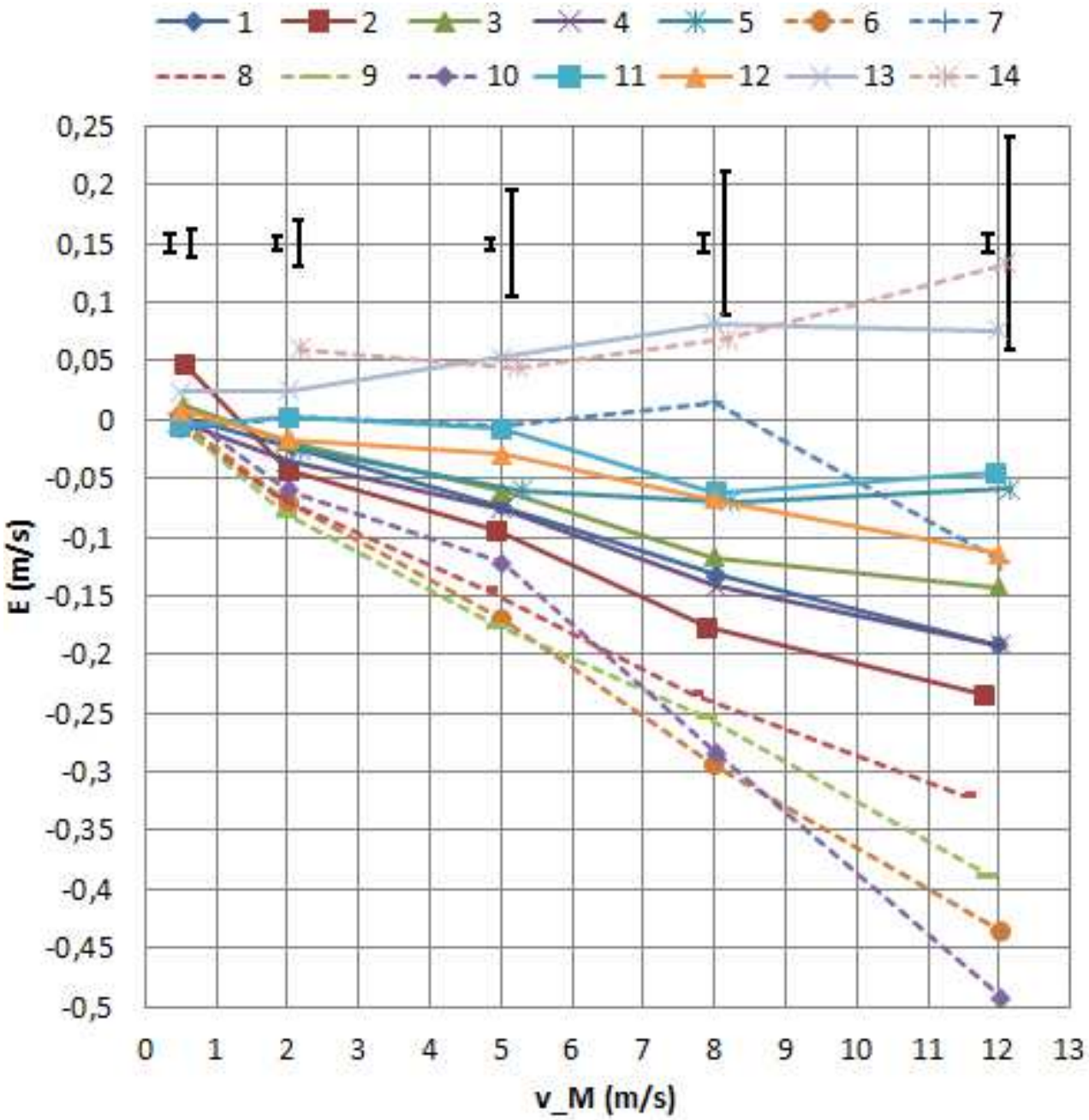
Testo 10 cm vane – velocity field 12 m/s

isolines with step
0.2 % of 12 m/s





Testo 10 cm vane – results

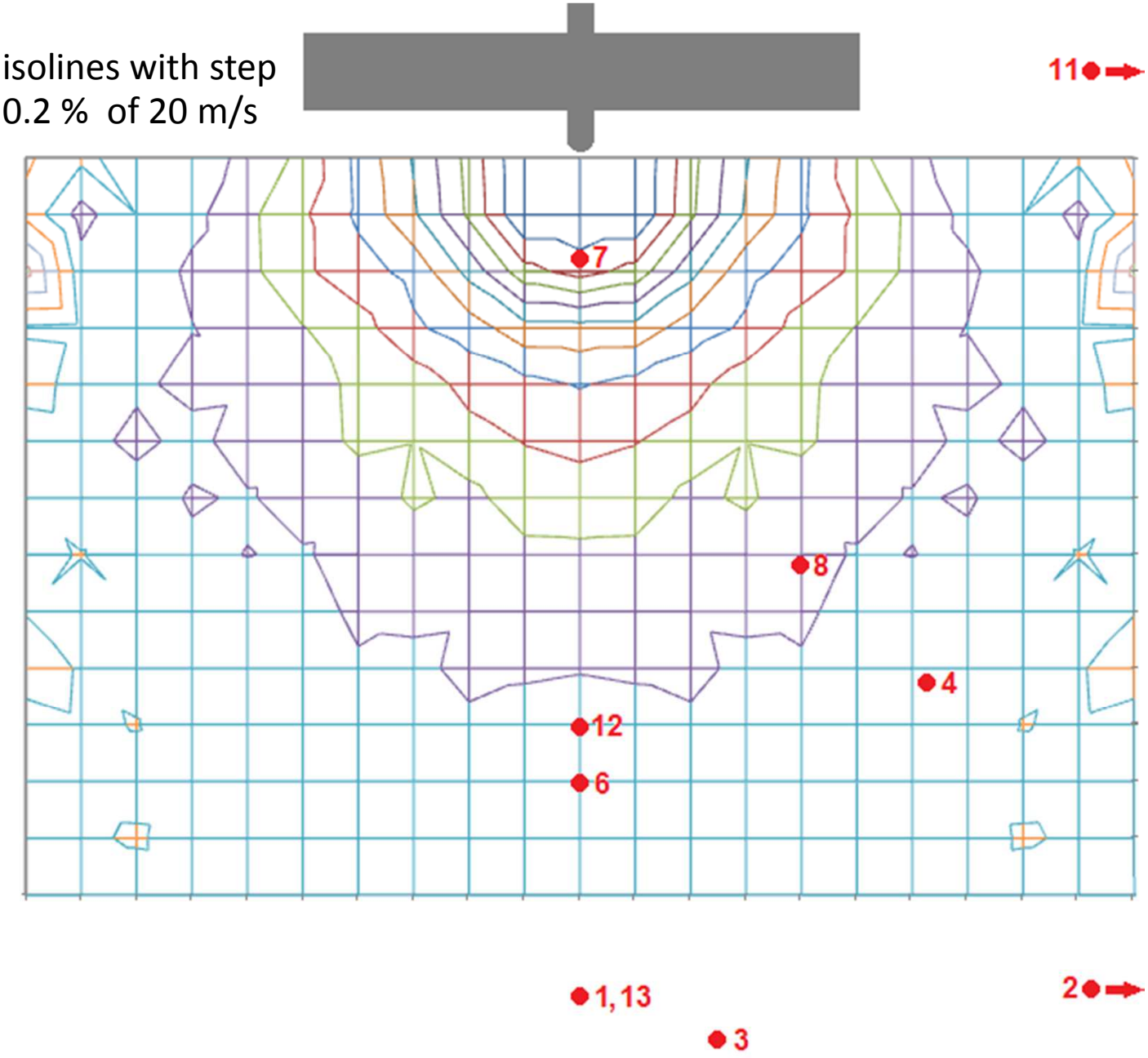


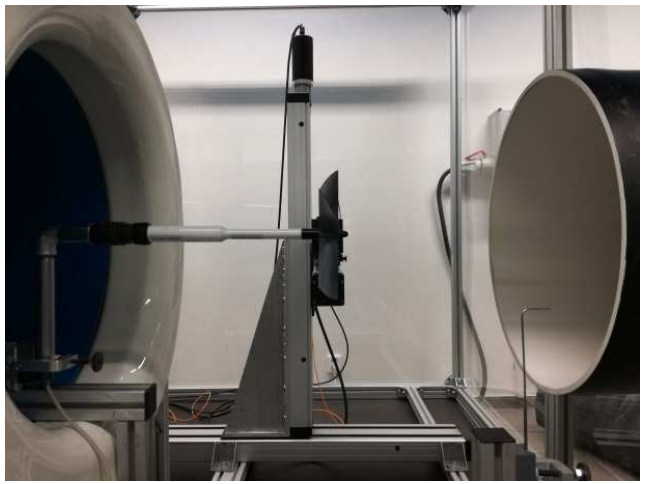
$$En = \frac{E_1 - E_2}{\sqrt{U_1^2 + U_2^2 + D^2}}$$

wt.set	all (14)	large (8)
v (m/s)	% En ≤ 1	
0,5	88	81
2	58	93
5	51	75
8	51	71
12	47	68

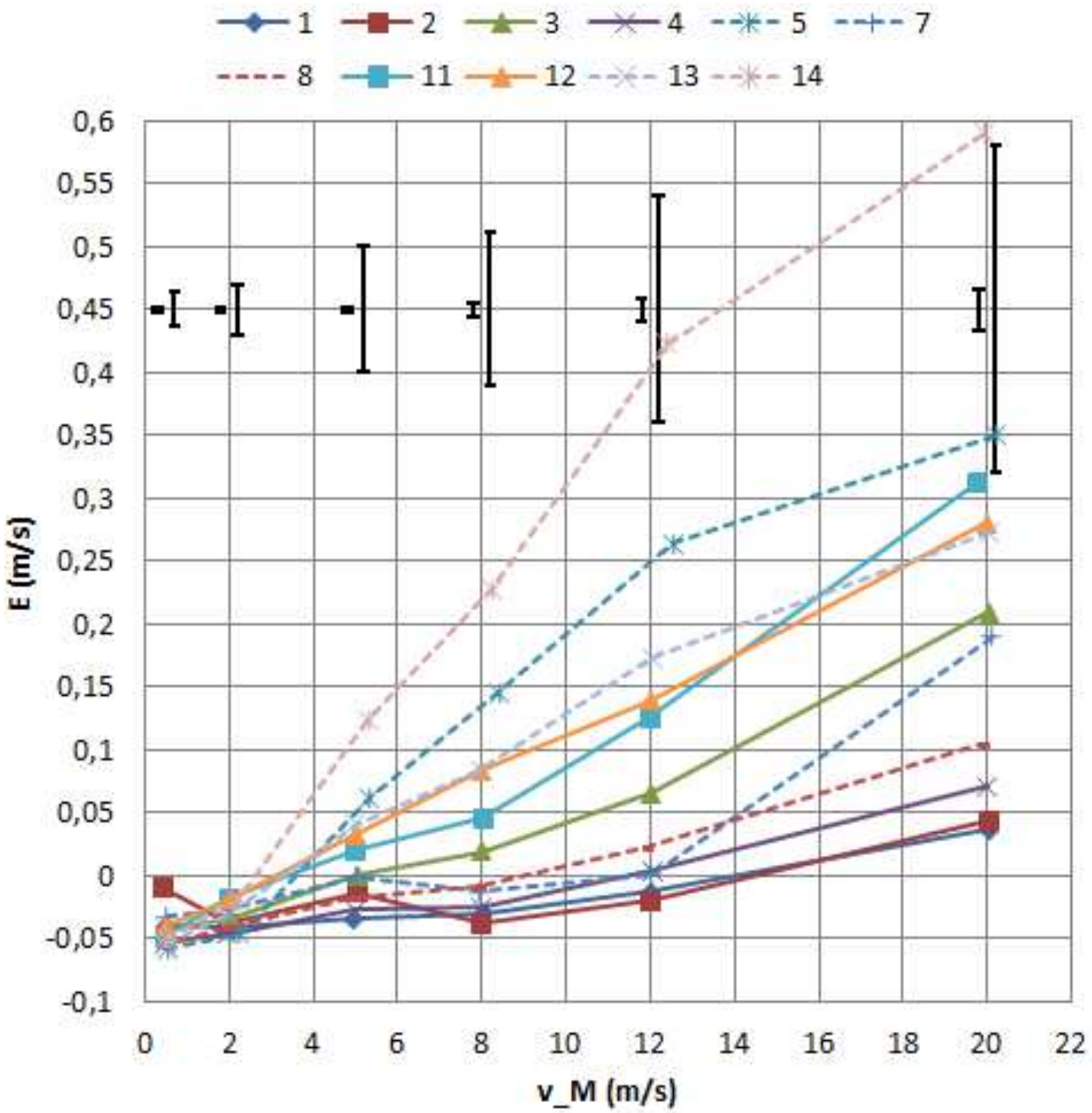
RM Young 20 cm vane – velocity field 20 m/s

isolines with step
0.2 % of 20 m/s





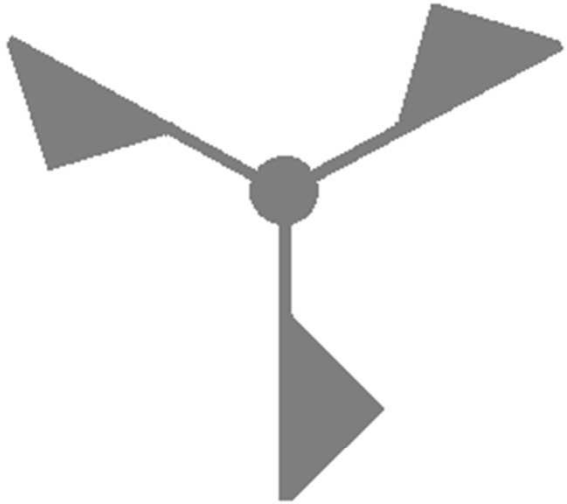
RM Young 20 cm vane – results



$$En = \frac{E_1 - E_2}{\sqrt{U_1^2 + U_2^2 + D^2}}$$

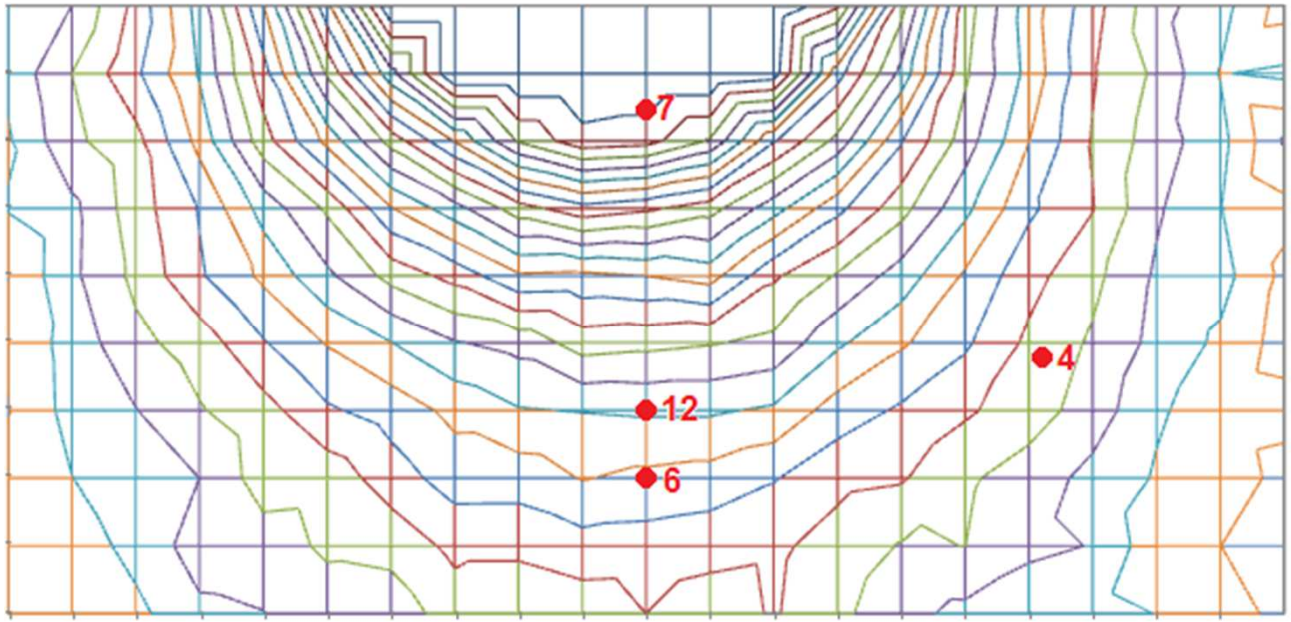
wt.set	all (11)	large (6)
v (m/s)	% En ≤ 1	
0,5	76	73
2	100	100
5	69	93
8	56	80
12	51	87
20	64	80

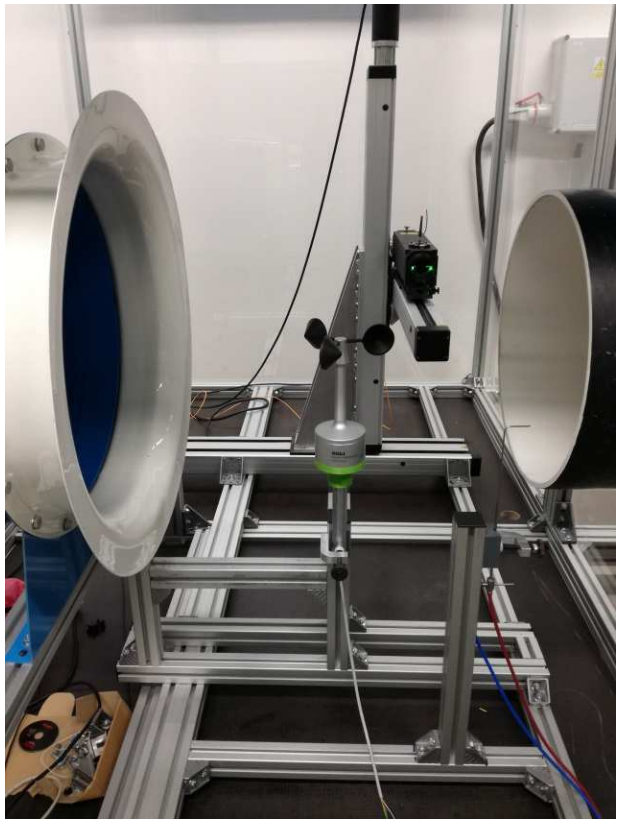
Vaisala 18 cm cup – velocity field 20 m/s - horizontal



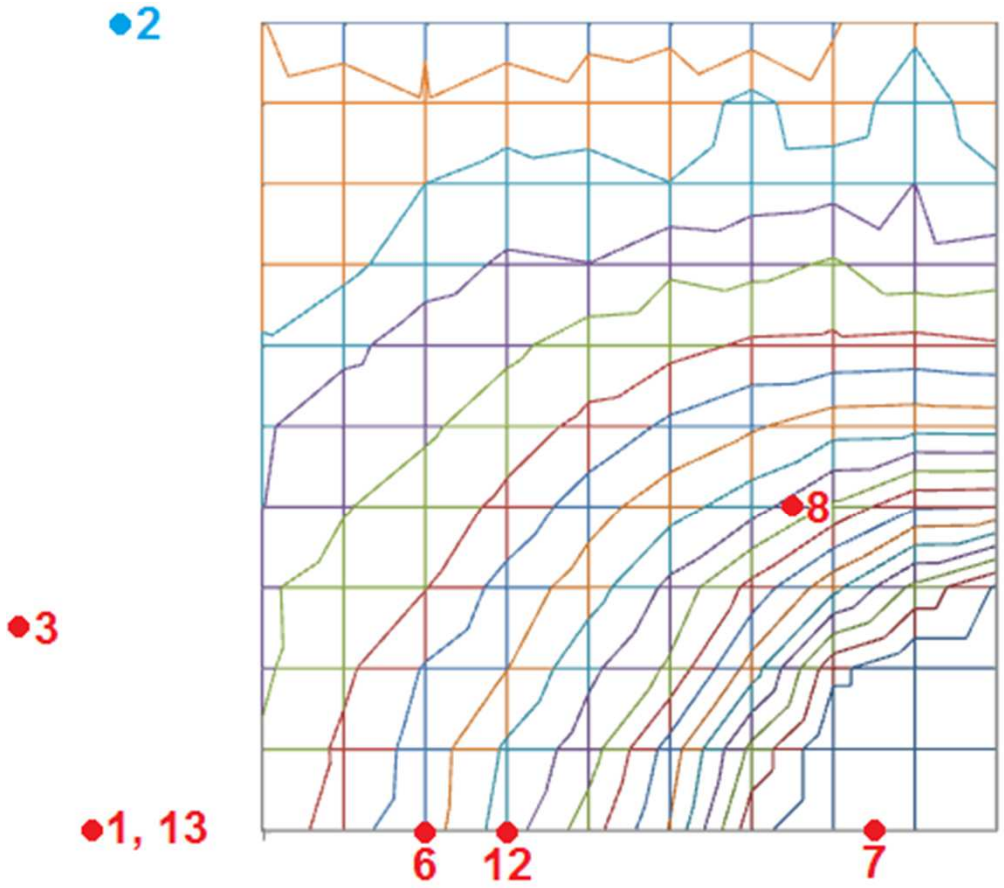
11

isolines with step
0.2 % of 20 m/s



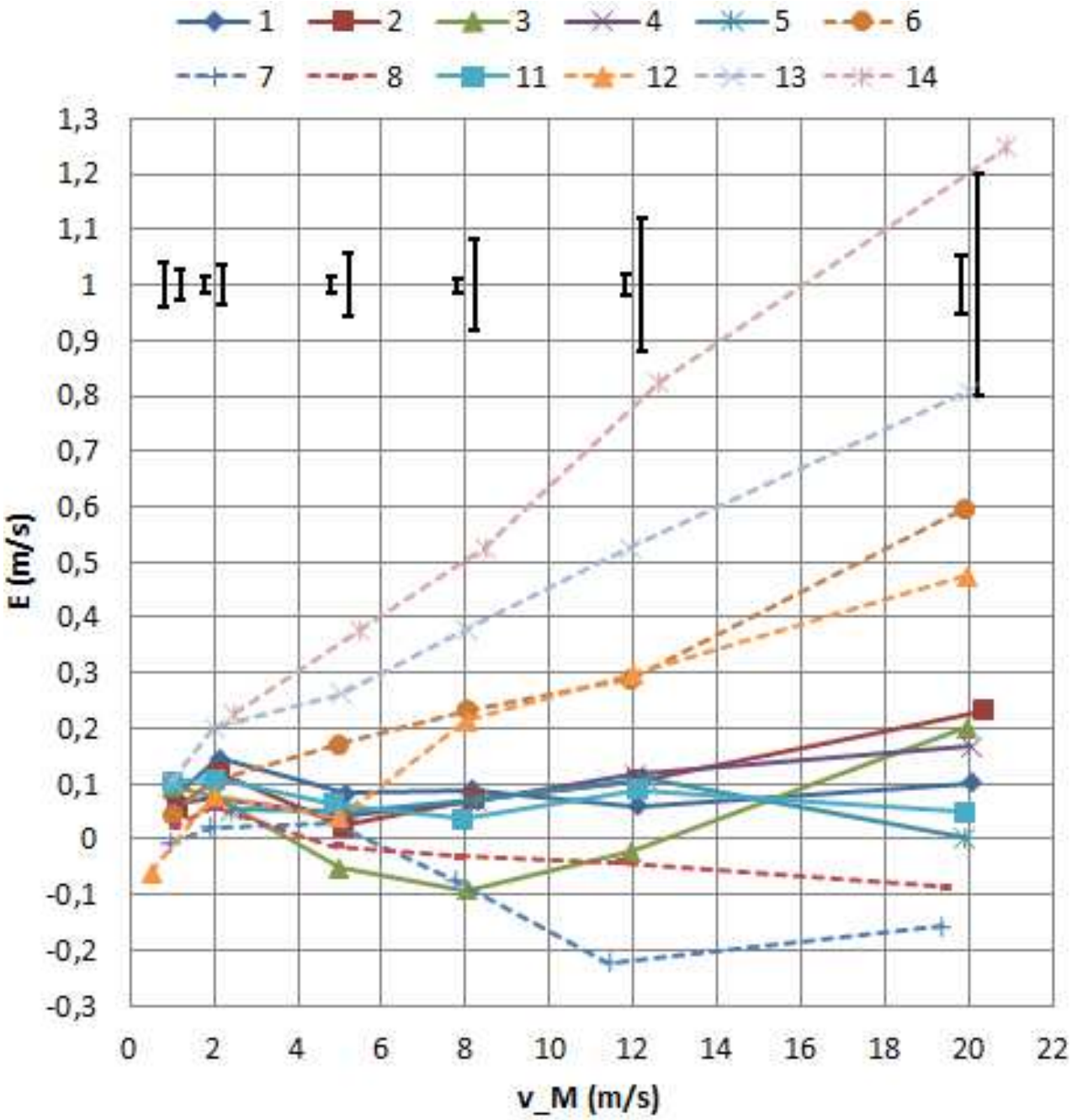


Vaisala 18 cm cup – velocity field 20 m/s - vertical



isolines with step
0.2 % of 20 m/s

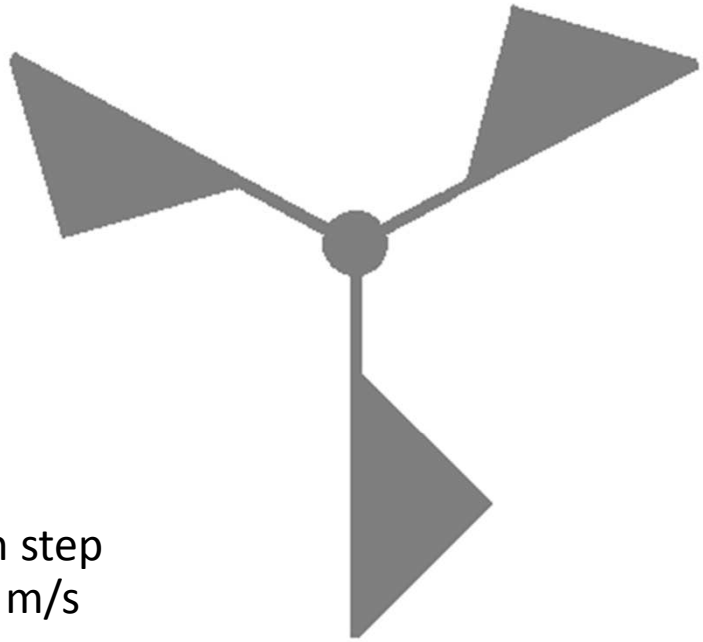
Vaisala 18 cm cup – results



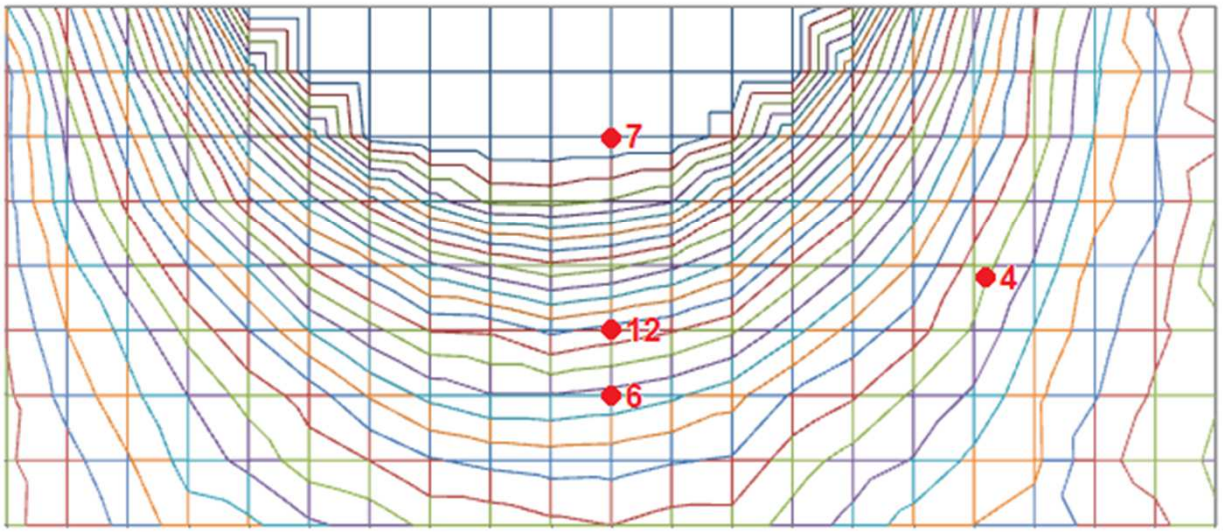
$$En = \frac{E_1 - E_2}{\sqrt{U_1^2 + U_2^2 + D^2}}$$

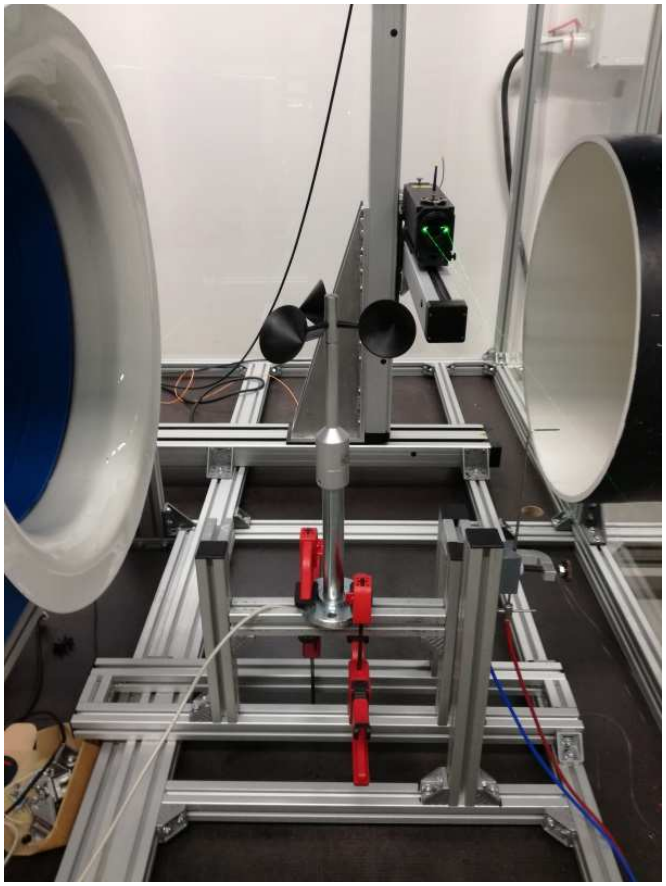
wt.set	all (12)	large (6)
v (m/s)	% En ≤ 1	
1	84	87
2	59	67
5	64	80
8	50	73
12	56	93
20	58	93

Thies 24 cm cup – velocity field 20 m/s - horizontal

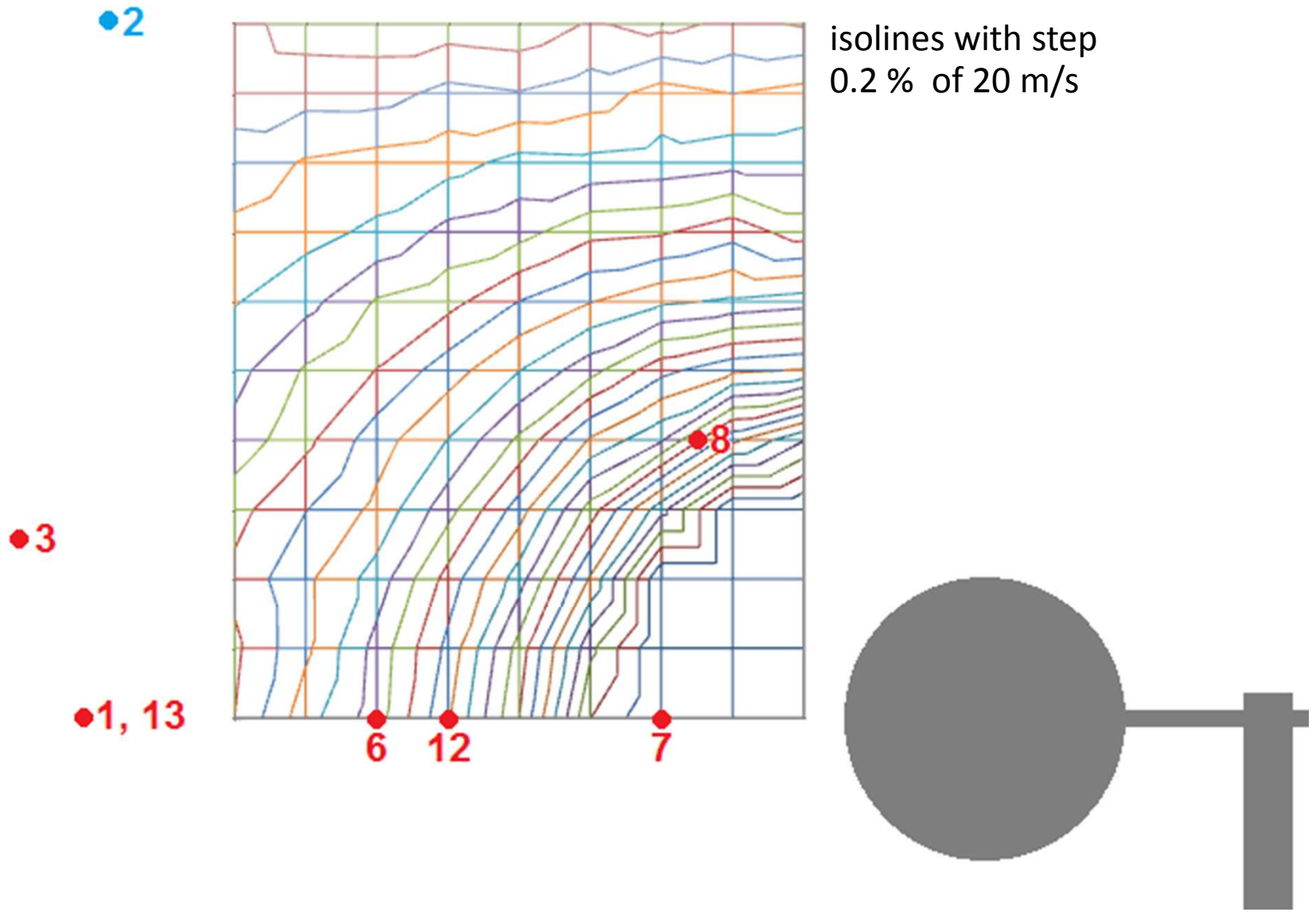


isolines with step
0.2 % of 20 m/s

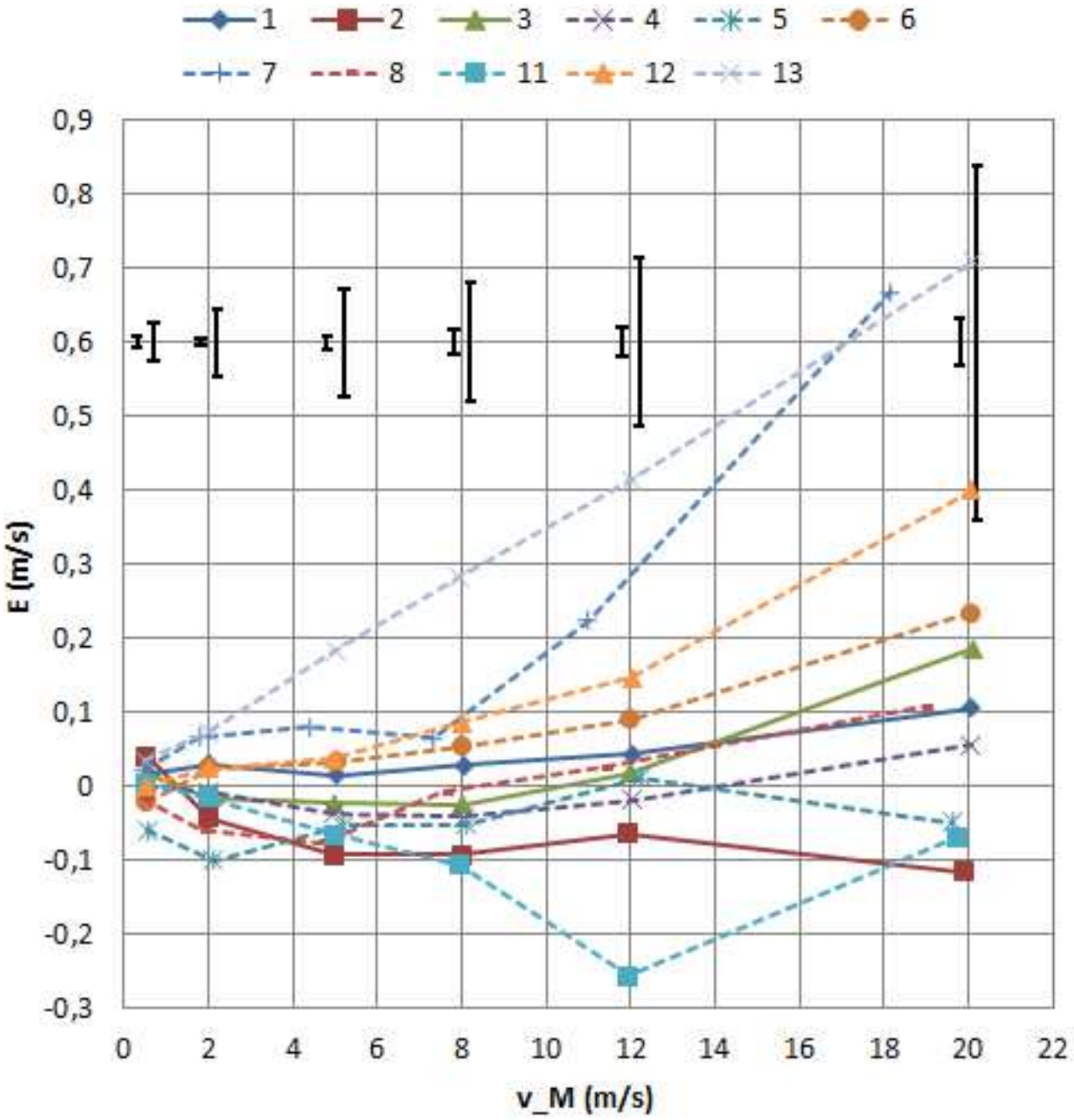




Thies 24 cm cup – velocity field 20 m/s - vertical



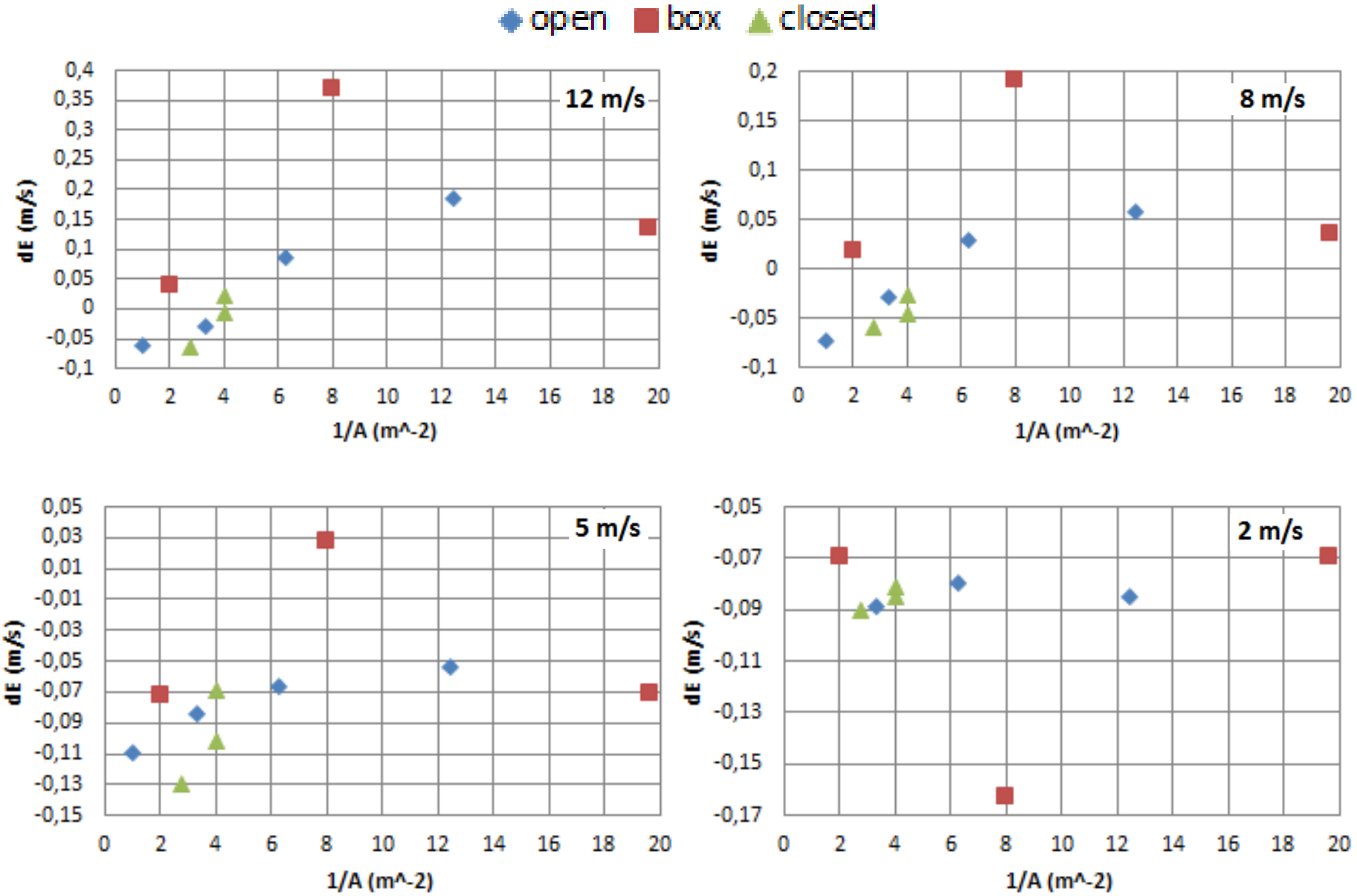
Thies 24 cm cup – results



$$En = \frac{E_1 - E_2}{\sqrt{U_1^2 + U_2^2 + D^2}}$$

wt.set	all (11)	large (3)
v (m/s)	% En ≤ 1	
0,5	69	67
2	62	67
5	73	67
8	75	67
12	69	100
20	67	67

Trends according to test section size and type?



dE = E(Schiltknecht) – E(Testo)

A = area of wind tunnel nozzle

Conclusions and future work

- Flow disturbance in front of cup anemometers is large even in reference meter position of large wind tunels in the project
- Large vane diameter does not mean a large flow disturbance; frame around a vane and density of blades plays role
- The percenatage of En < 1 shows that there is something to be investigated in our uncertainty budgets
- Data to be analyzed to look for trends in MUT error according to wind tunnel size and type; some trends are observable in error difference of 8 cm vane and 10 cm vane
- Additional measurements with small 2.5 cm vane are performed in several wind tunnels to confirm the trends in error differences

Thank you for your and attention!