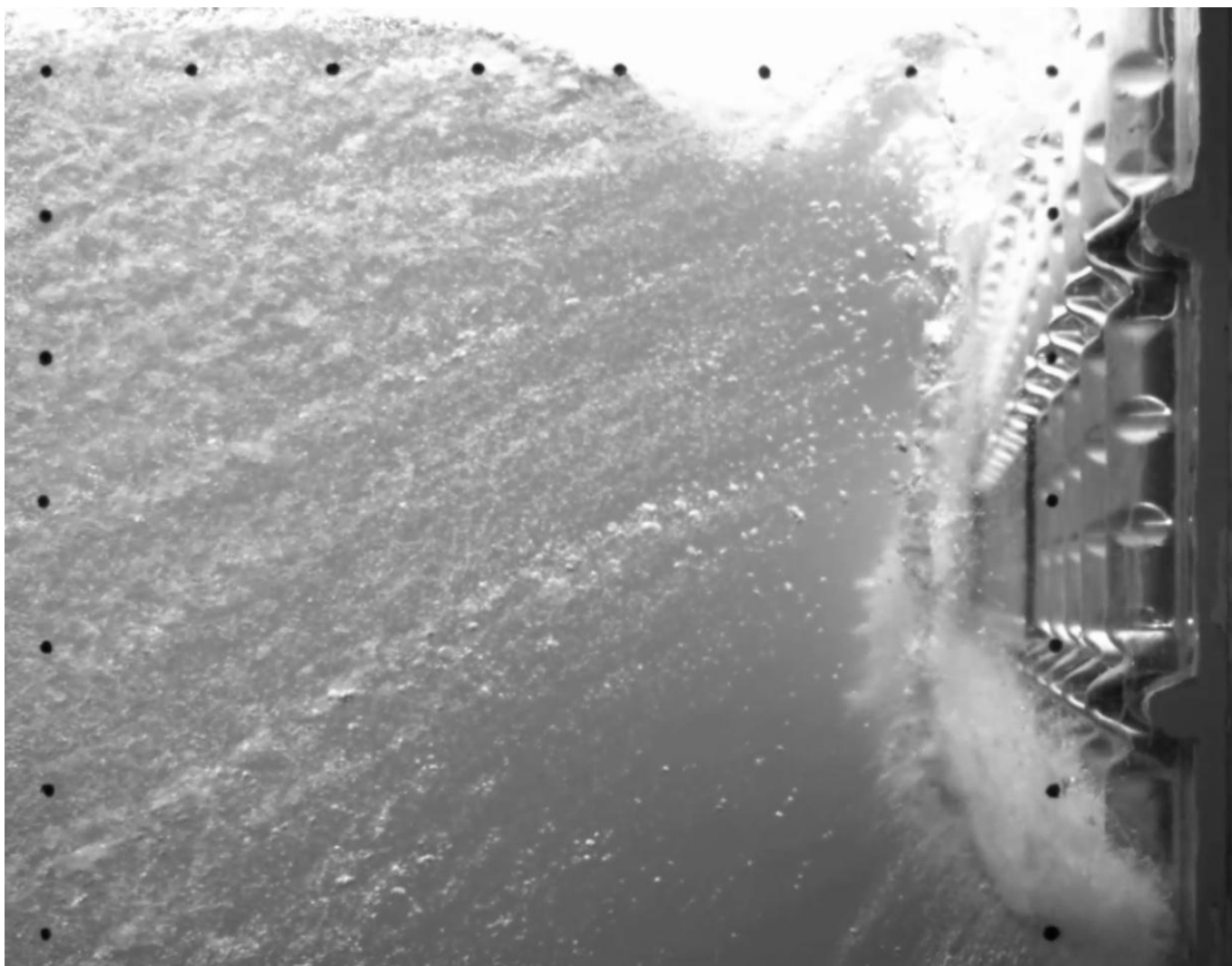


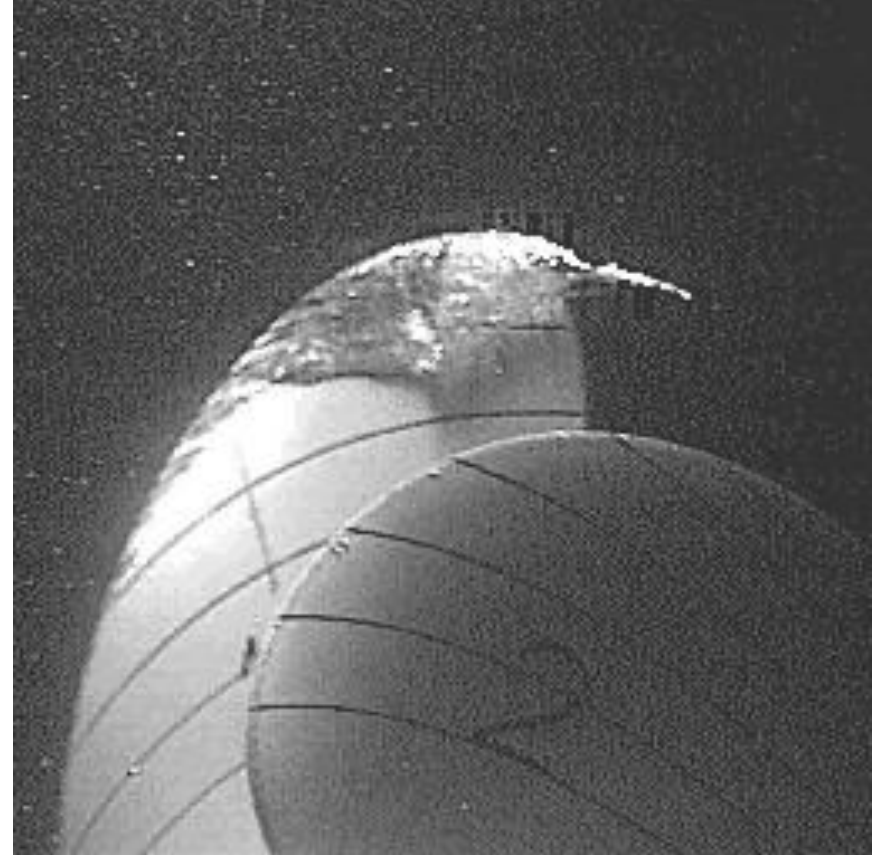
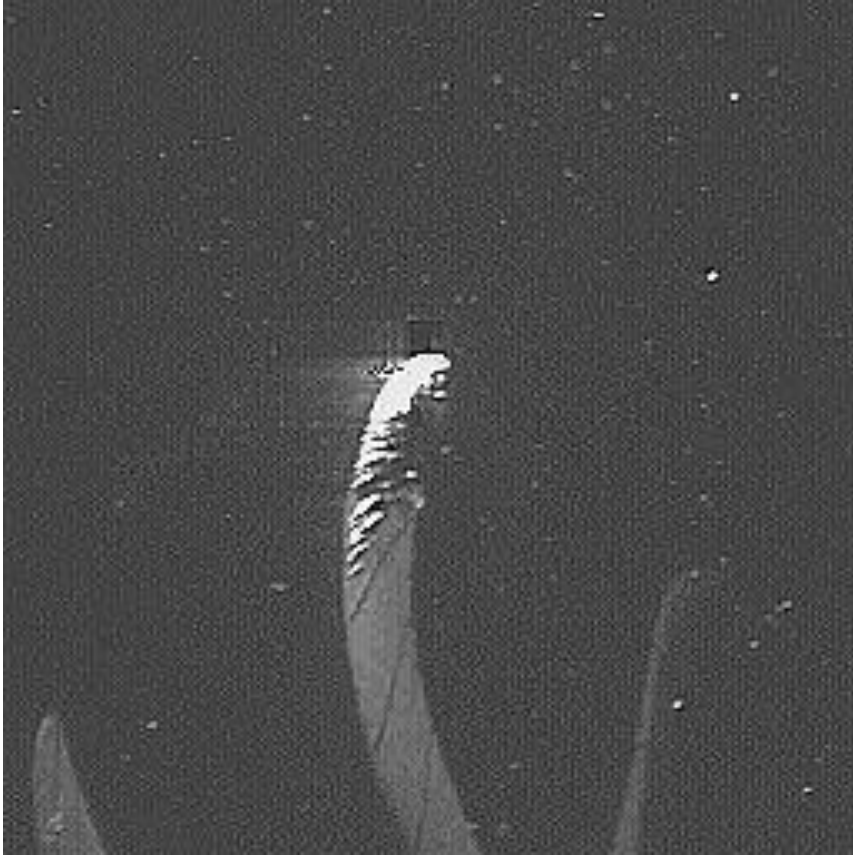
The main title of the presentation is "Measurements of bubbles in the wake of a ship model". It is centered on the slide and written in a large, bold, dark blue, italicized sans-serif font.

Miloš Birvalski, Martijn van Rijsbergen

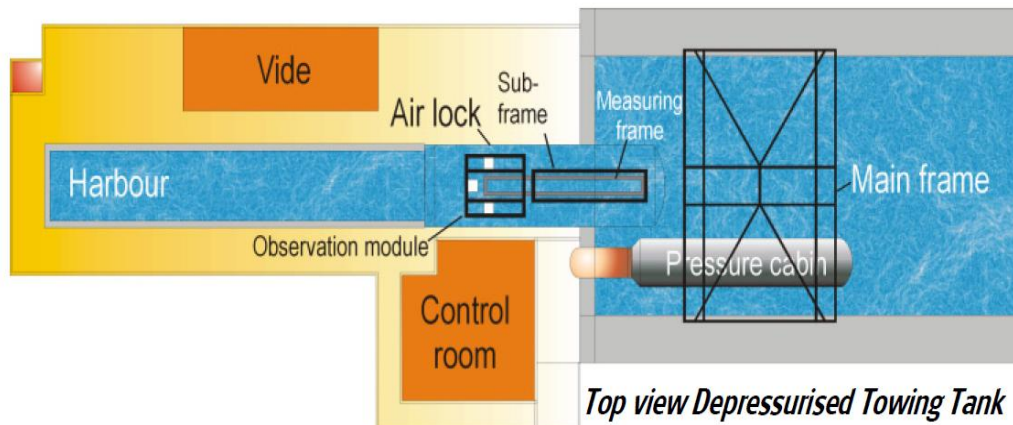
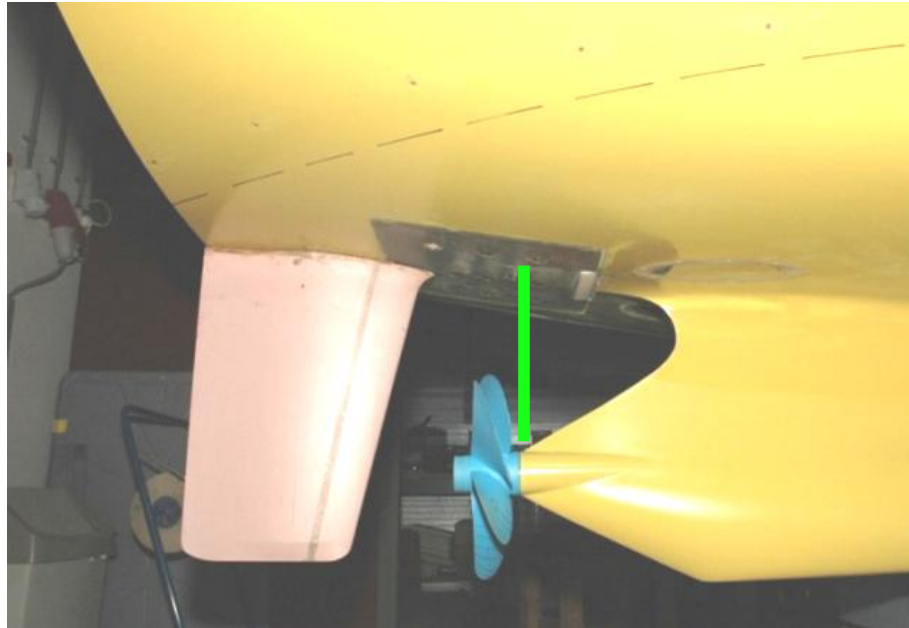
SLOSHING OF LNG: SLOSHEL/SLING



PROPELLER CAVITATION



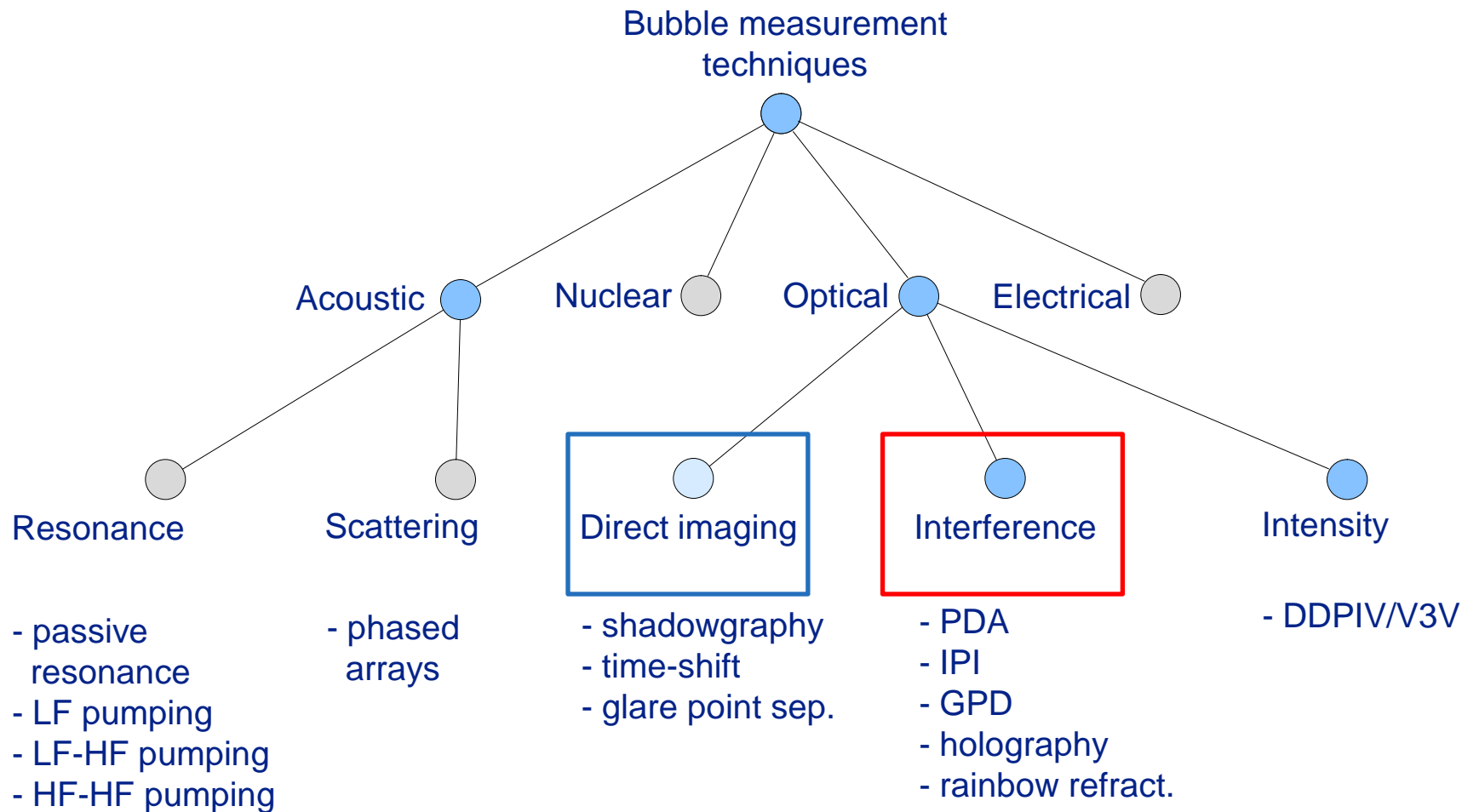
SYSTEM REQUIREMENTS



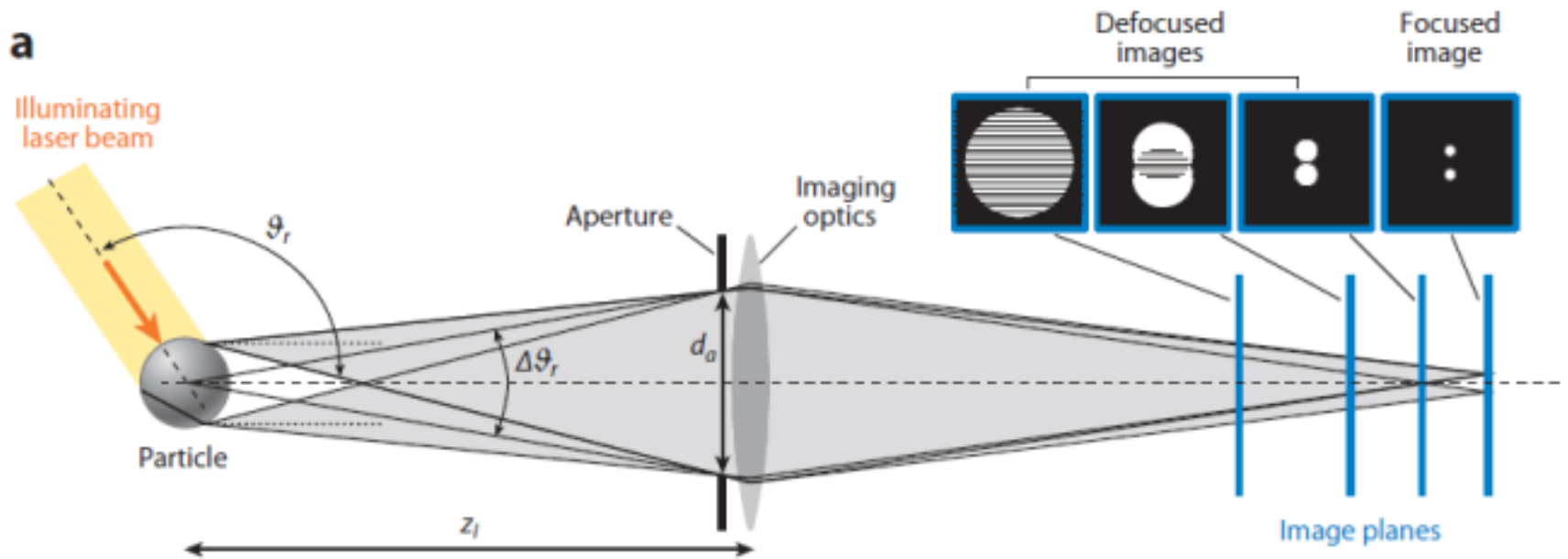
PRESENTATION OVERVIEW

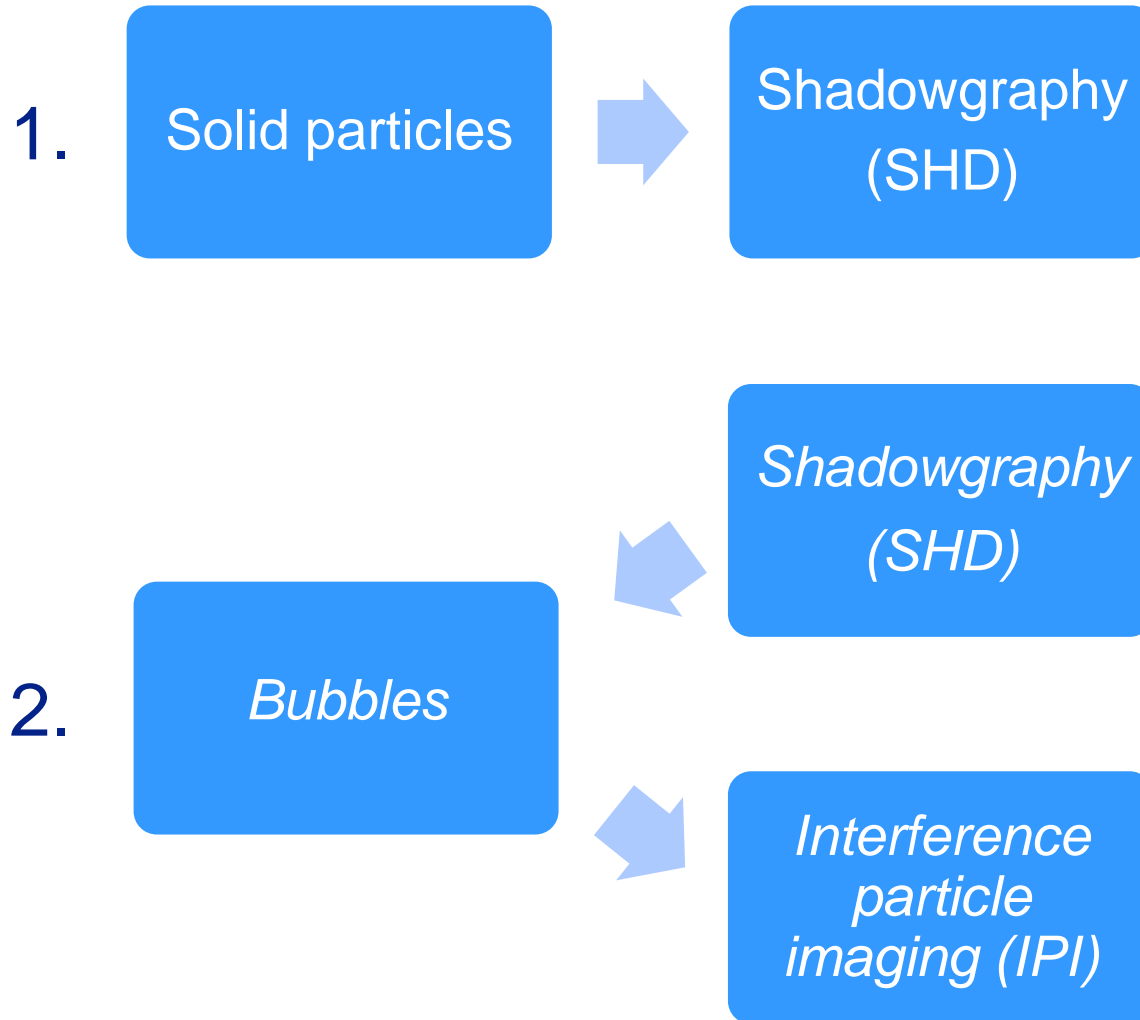
- Background
- Techniques overview
- Techniques validation
- Application results
- Future work

TECHNIQUES OVERVIEW

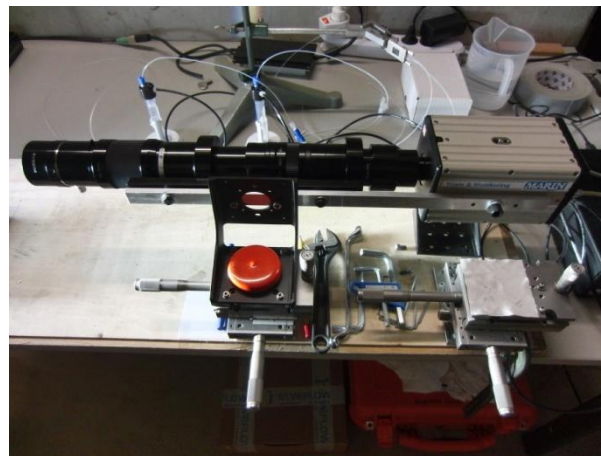
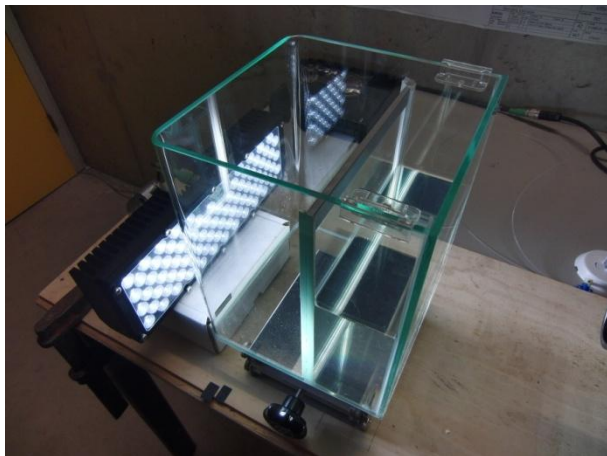


OPTICAL TECHNIQUES: INTERFERENCE

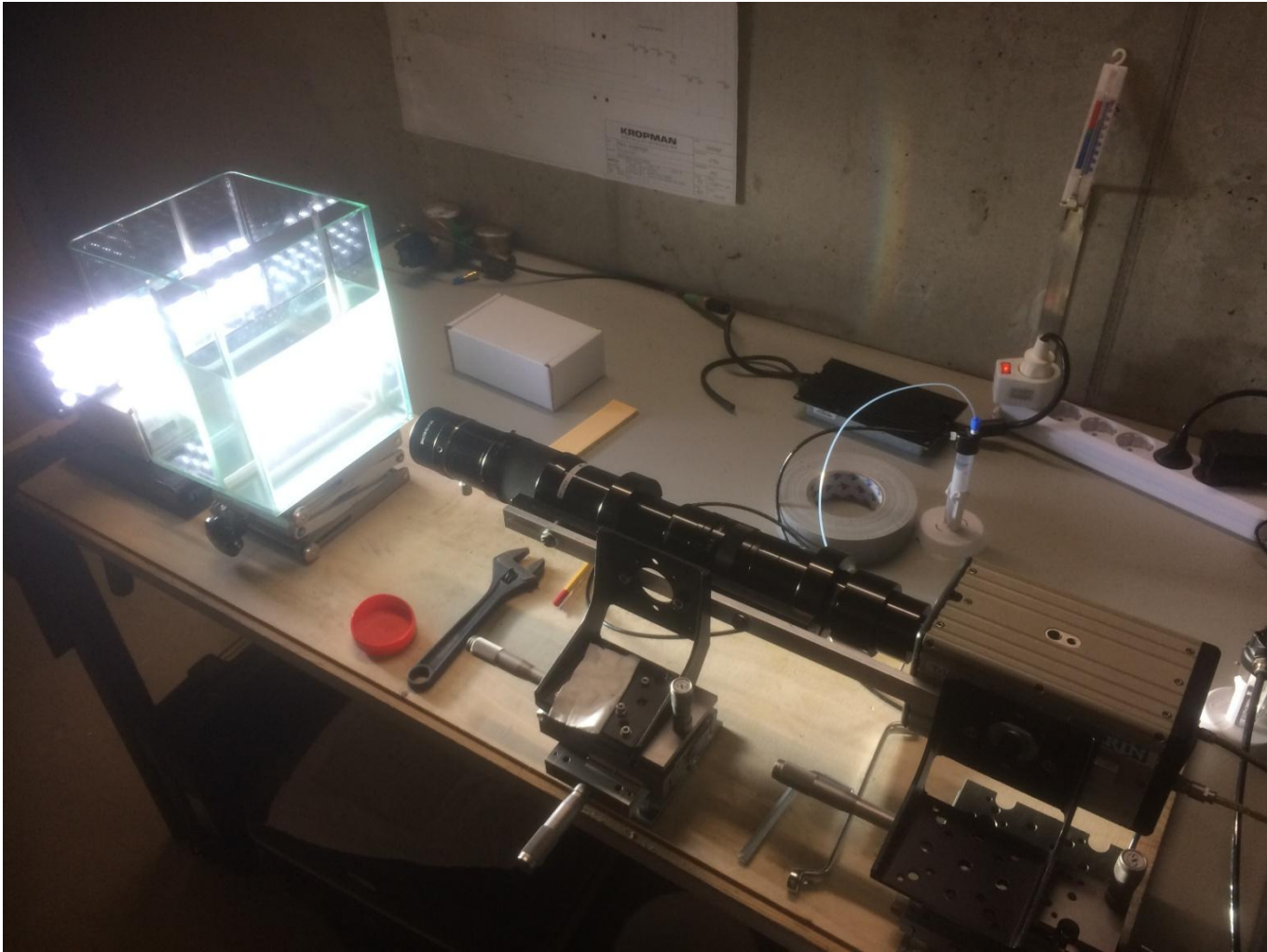




SHADOWGRAPHY VALIDATION: EQUIPMENT

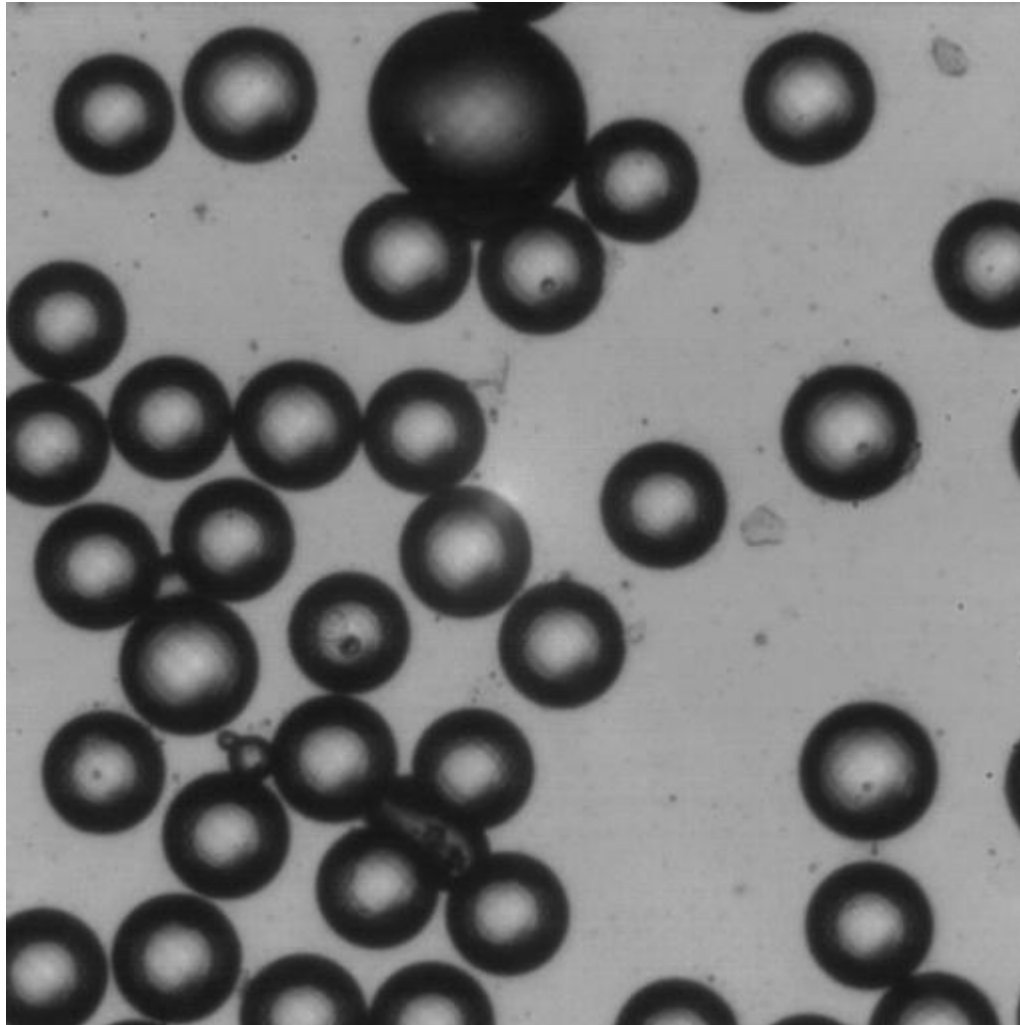


SHADOWGRAPHY VALIDATION: SOLID PARTICLES



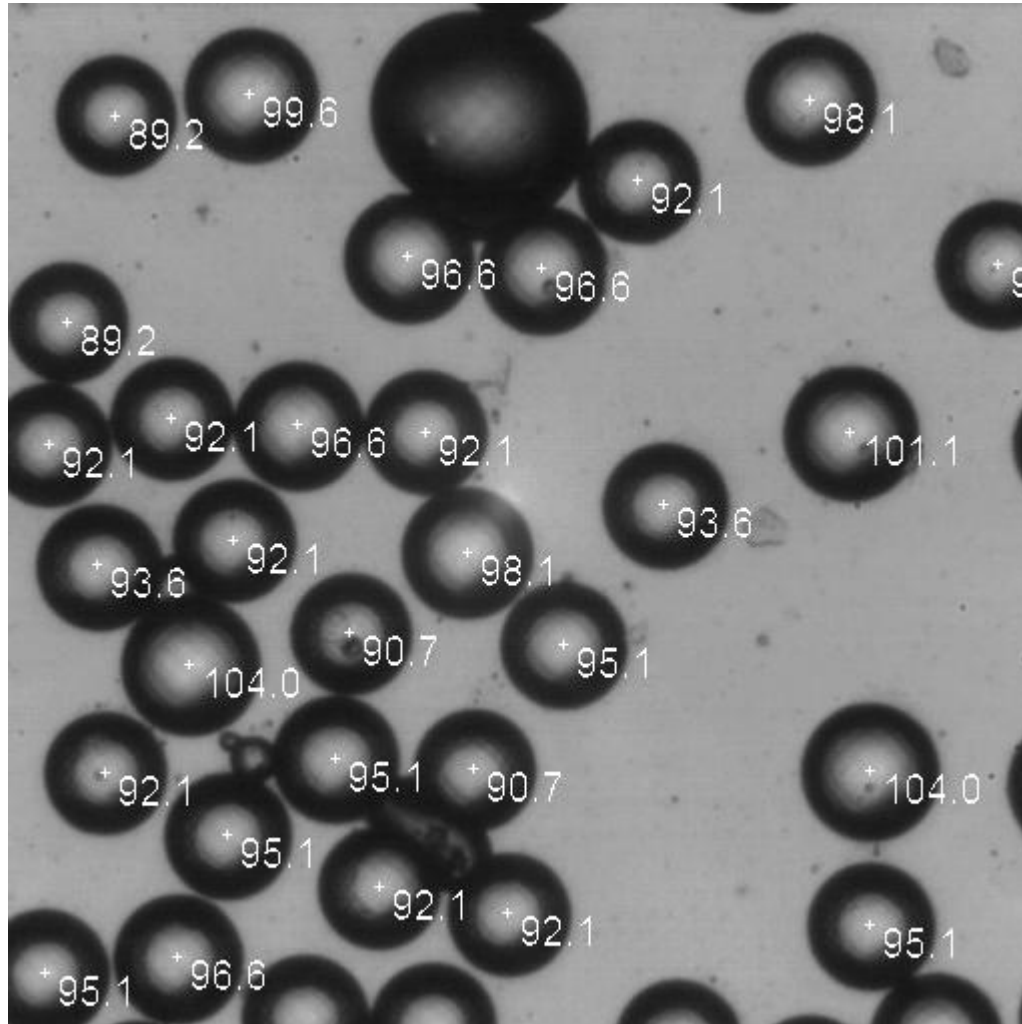
SHADOWGRAPHY VALIDATION: SOLID PARTICLES

- PMMA, 90-106 μm (>90% in range)



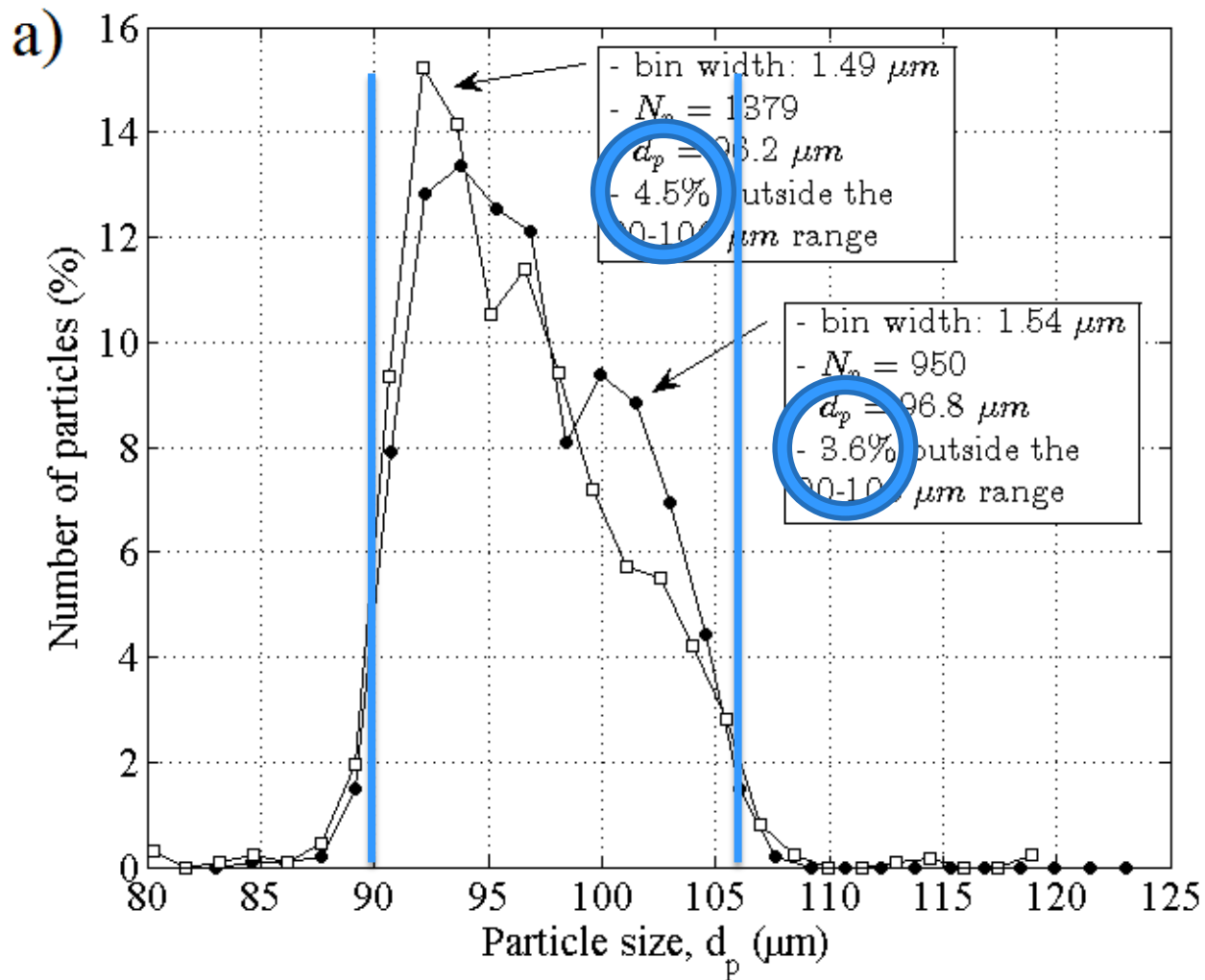
SHADOWGRAPHY VALIDATION: SOLID PARTICLES

- PMMA, 90-106 μm (>90% in range)

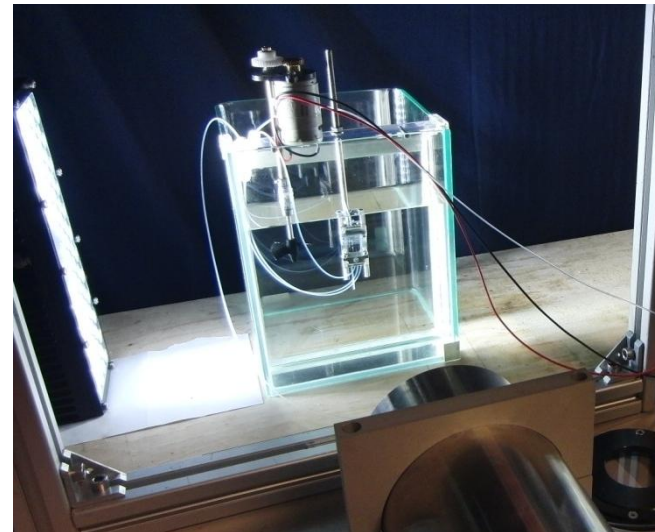
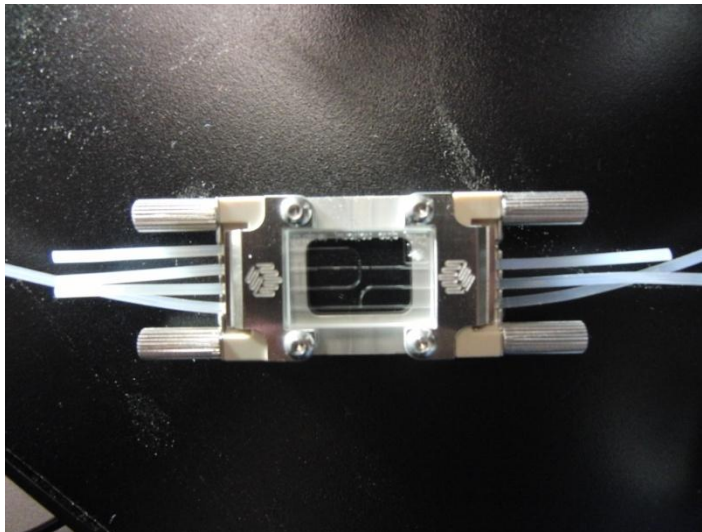
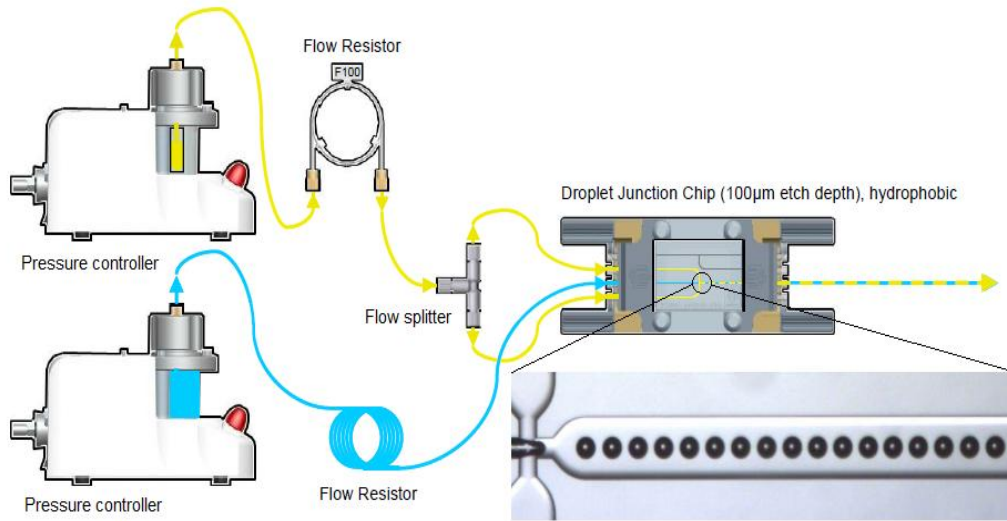


SHADOWGRAPHY VALIDATION: SOLID PARTICLES

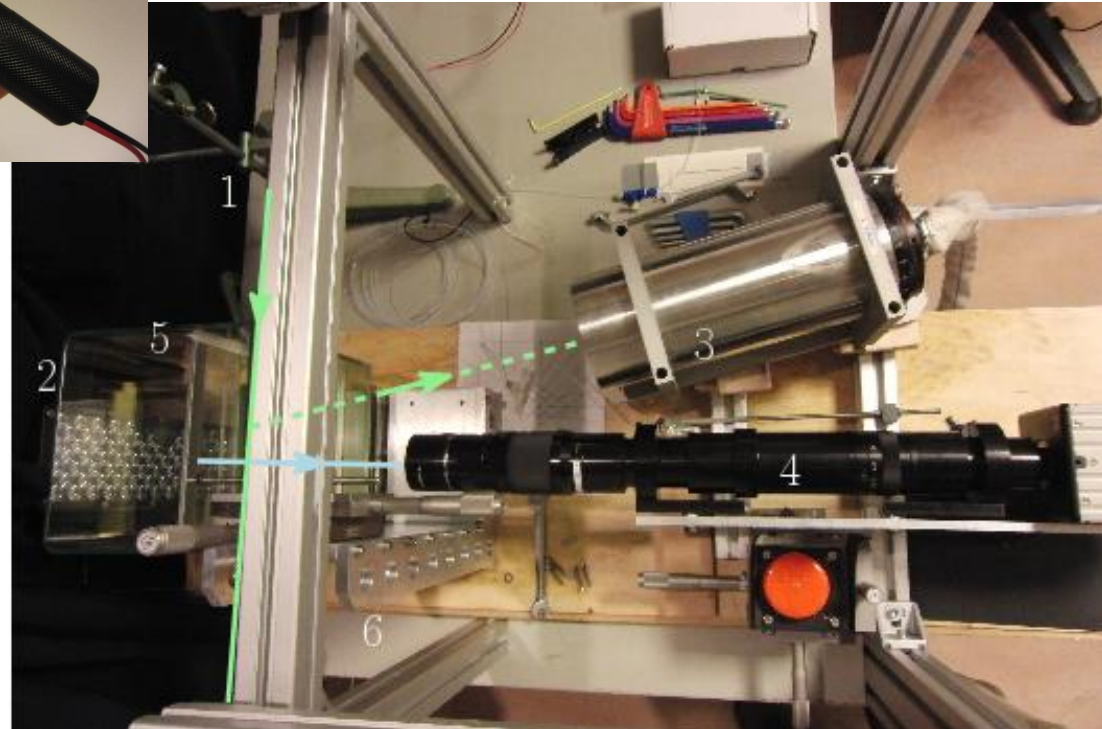
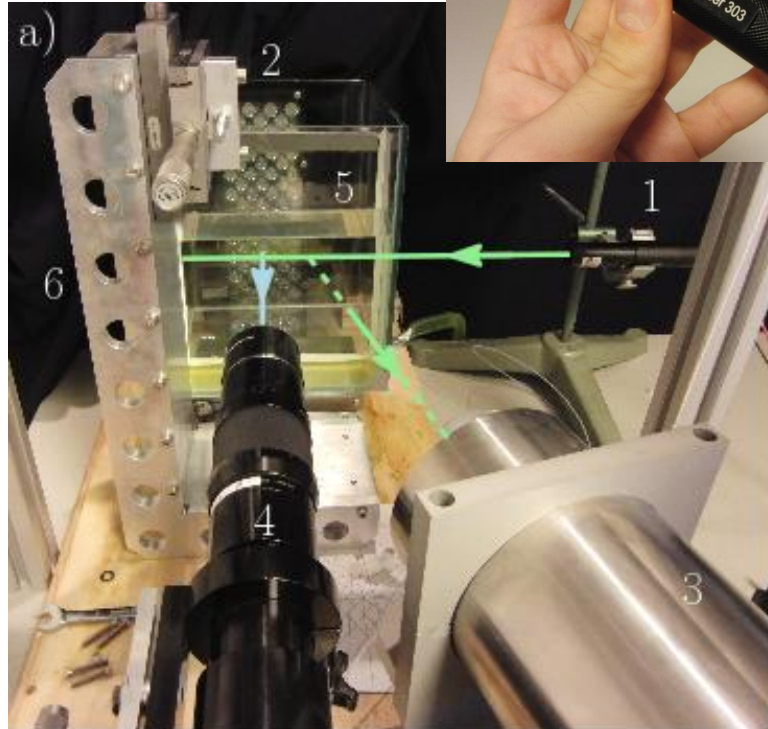
- PMMA, 90-106 μm (>90% in range)



IPI VALIDATION: EQUIPMENT

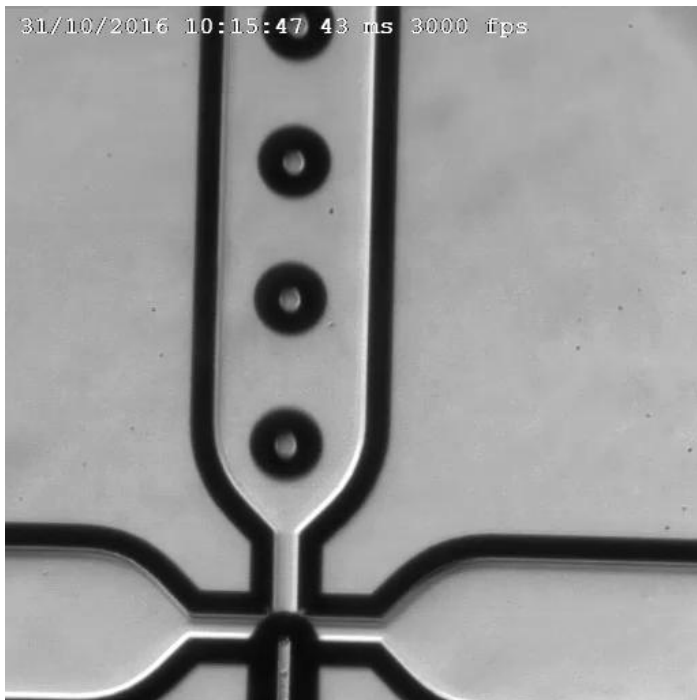


IPI VALIDATION: TEST SETUP

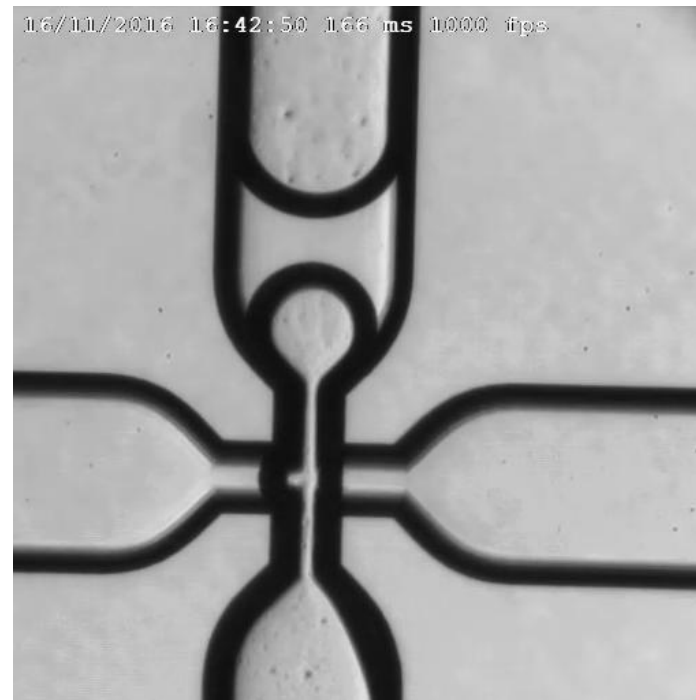


IPI VALIDATION: BUBBLE PRODUCTION

~100 μm

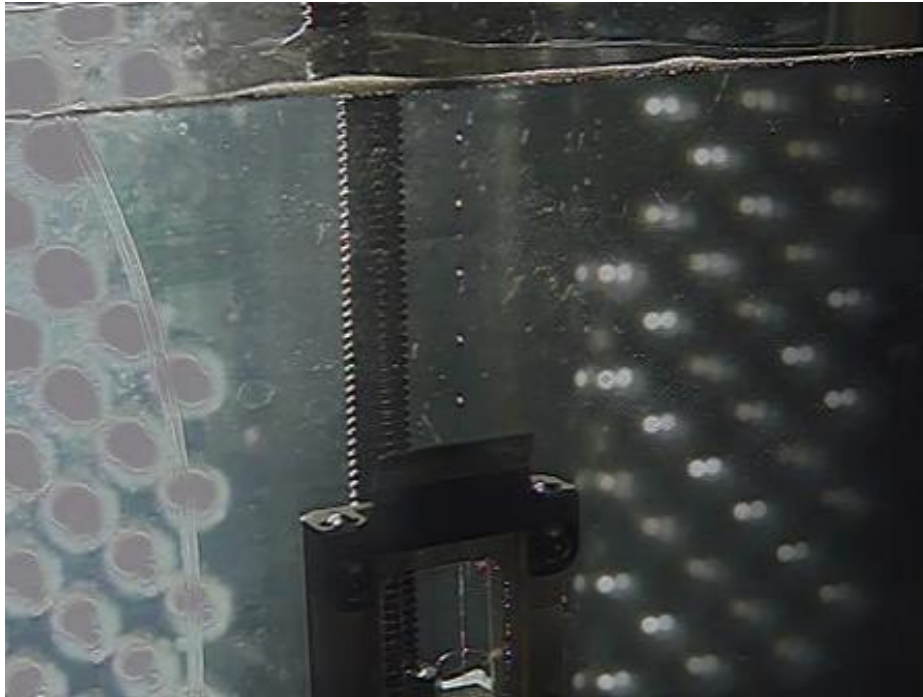


~300 μm

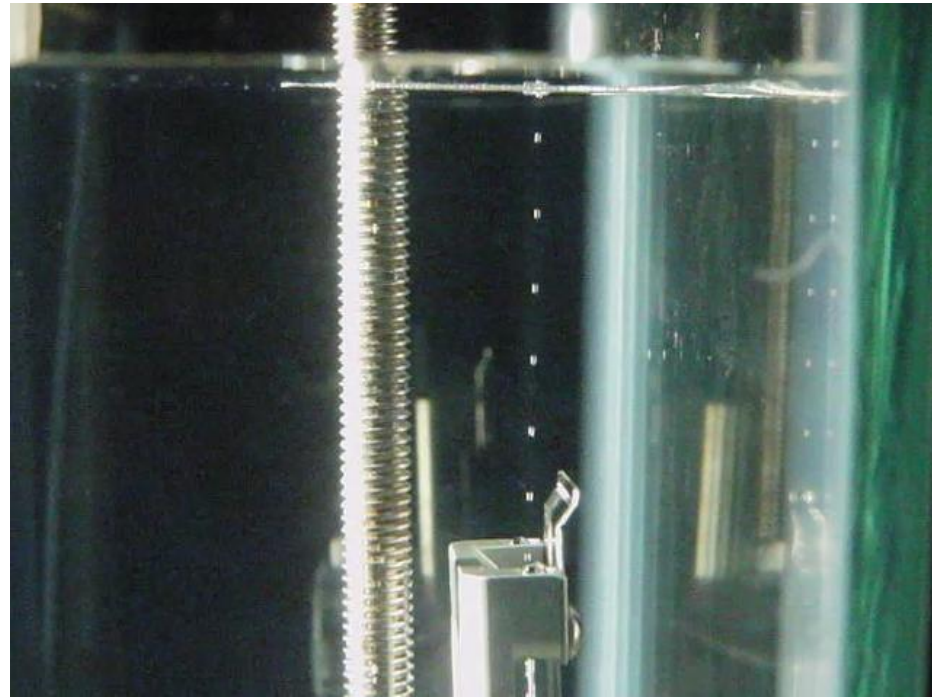


IPI VALIDATION: BUBBLE PRODUCTION

~300 μm



~300 μm

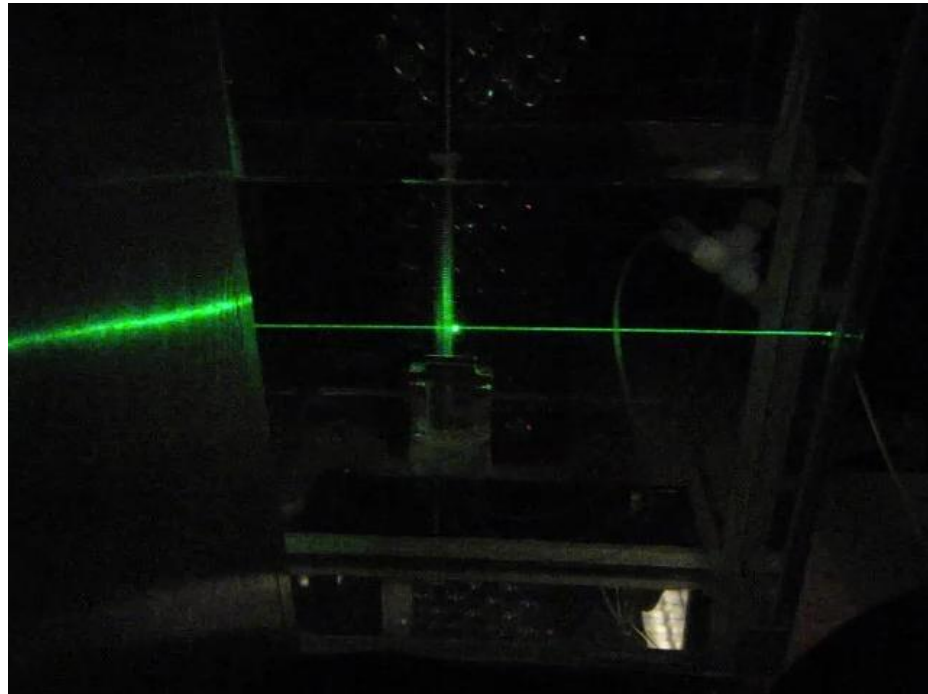
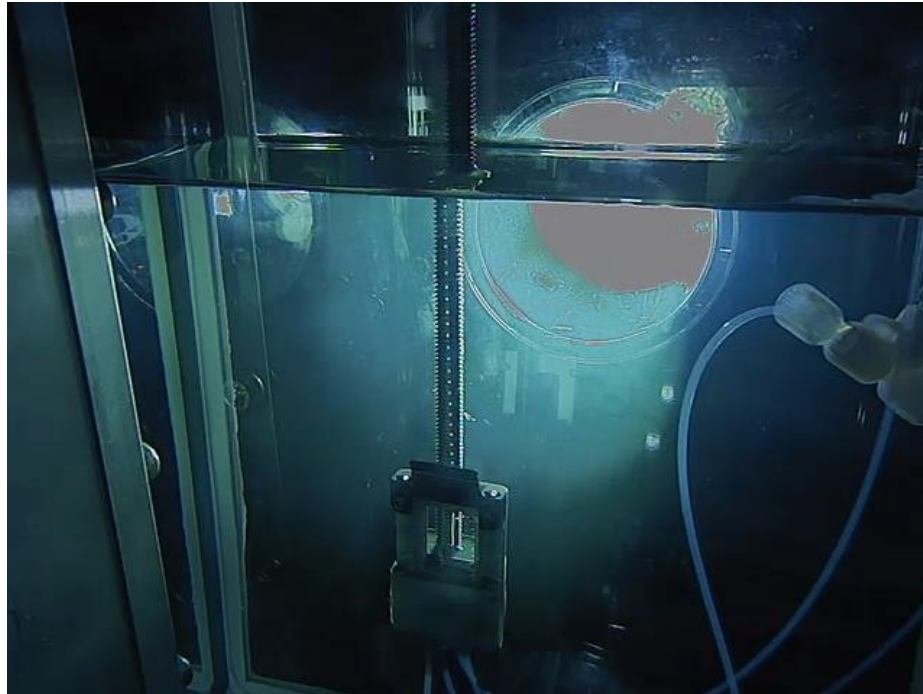


≡ 240 fps



IPI VALIDATION: IPI

IPI

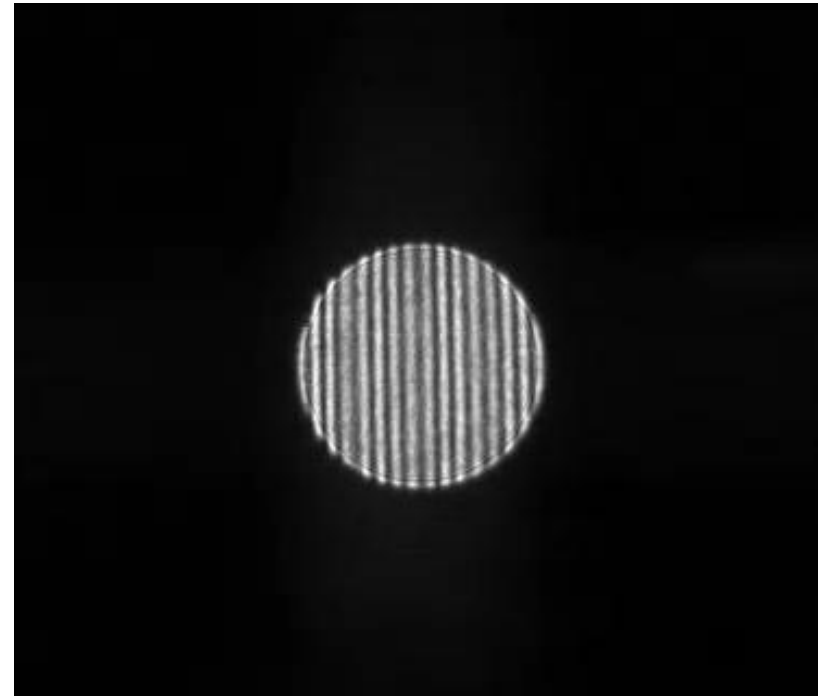


IPI VALIDATION: SHD & IPI

SHD

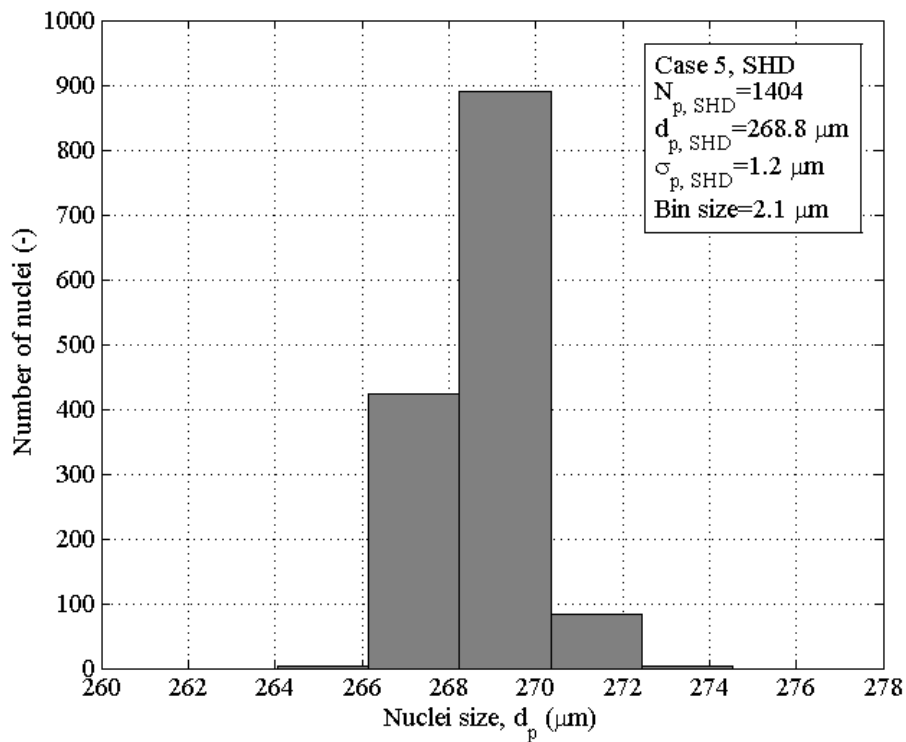


IPI

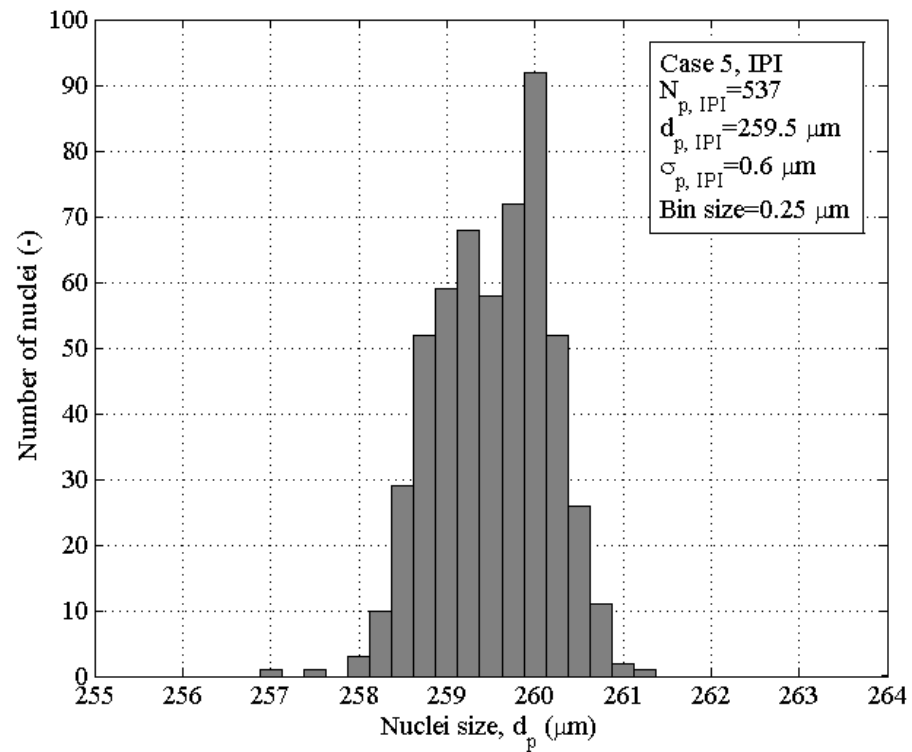


IPI VALIDATION: CASE 5

SHD



IPI

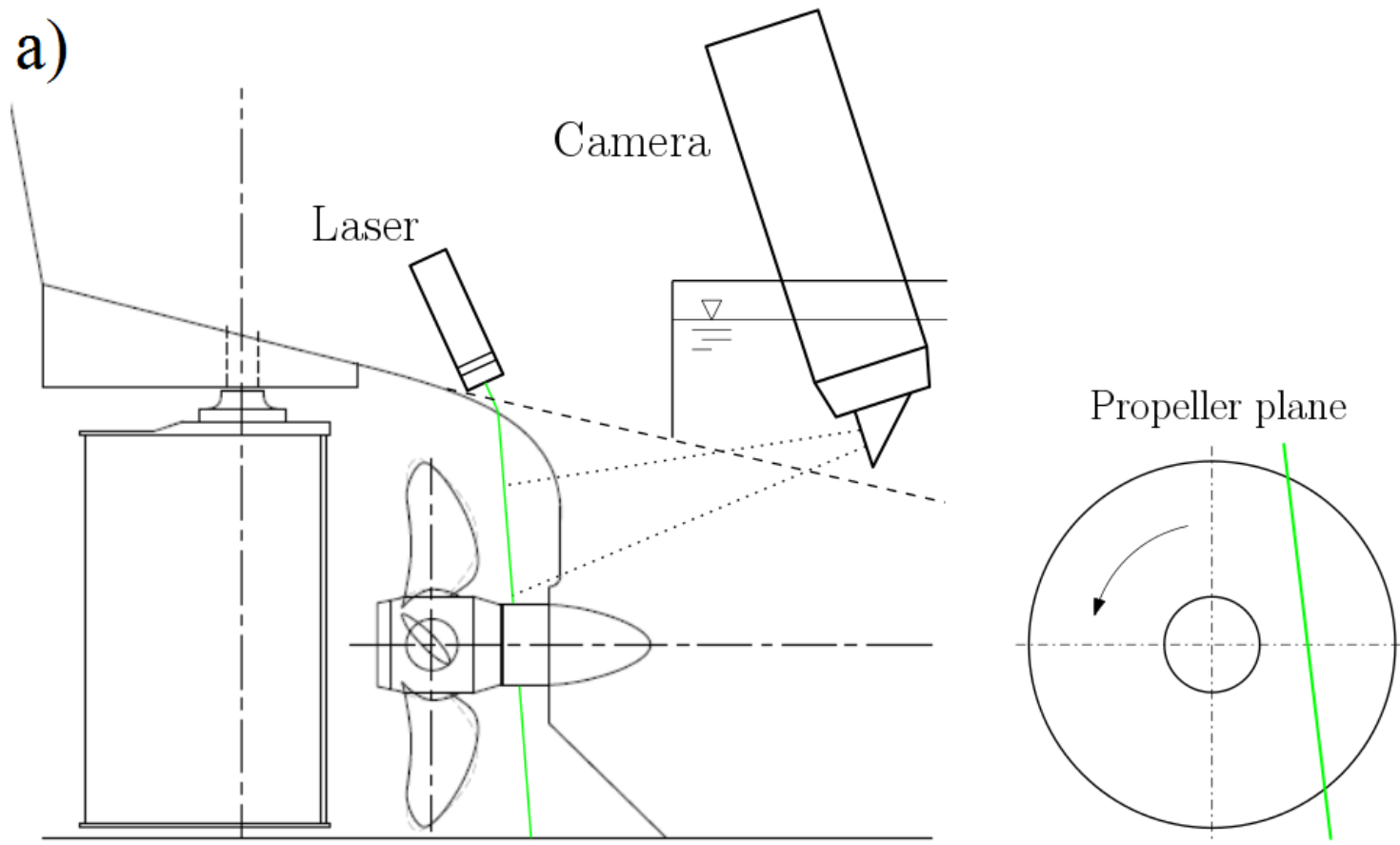


IPI VALIDATION: SIZE MEASUREMENT SUMMARY

Case	IPI			Shadowgraphy			
	Bubble diameter (μm)	St. dev. of diameter (μm)	No. of bubbles (-)	Bubble diameter (μm)	St. dev. of diameter (μm)	No. of bubbles (-)	Error in diameter (%)
1	233.2	0.6	1236	242	0	1	-3.6
2	250.7	0.6	1061	262	0	1	-4.3
3	254.3	0.6	762	264	0	1	-3.7
4	258.3	0.6	921	267.5	1	1376	-3.4
5	259.5	0.6	537	268.8	1.2	1404	-3.5
6	262.5	1.1	877	276.3	1.1	1259	-3.5
7	261.7	1.6	841	275.1	1.2	431	-4.9
8	268.5	0.4	838	277	1.1	820	-3.1
9	279.2	0.8	744	287.5	2.3	708	-3.9

Mean error: -3.8

MODEL TESTS: SCHEME



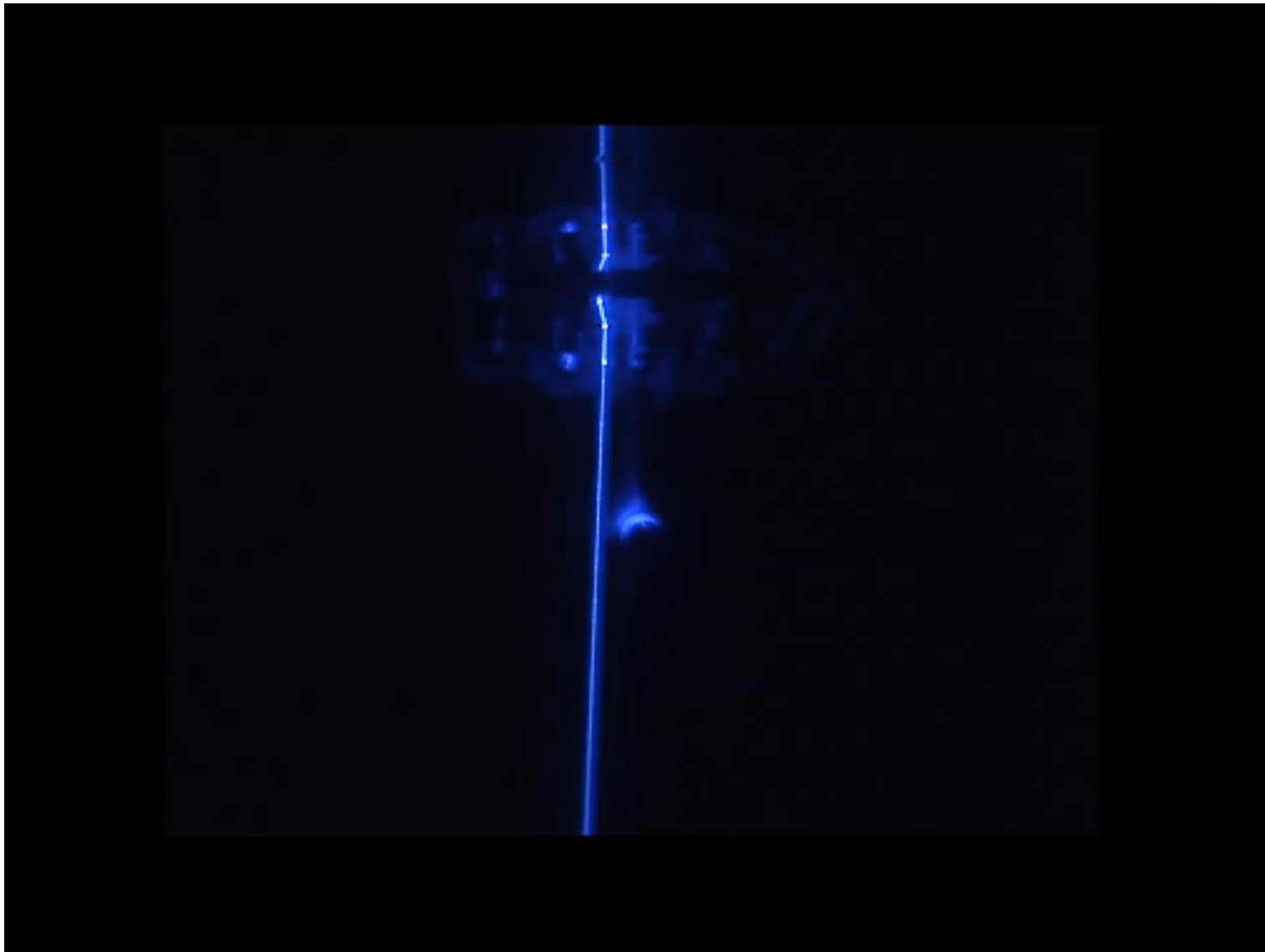
MODEL TESTS: VIDEOS

DWB 1/2

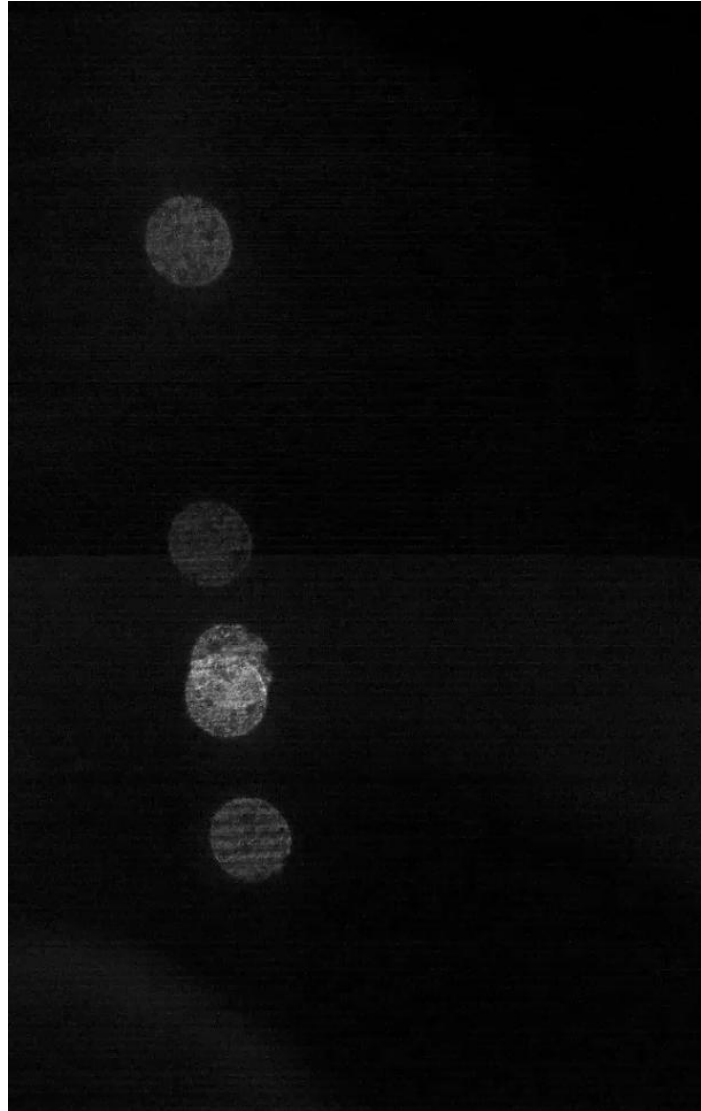


MODEL TESTS: VIDEOS

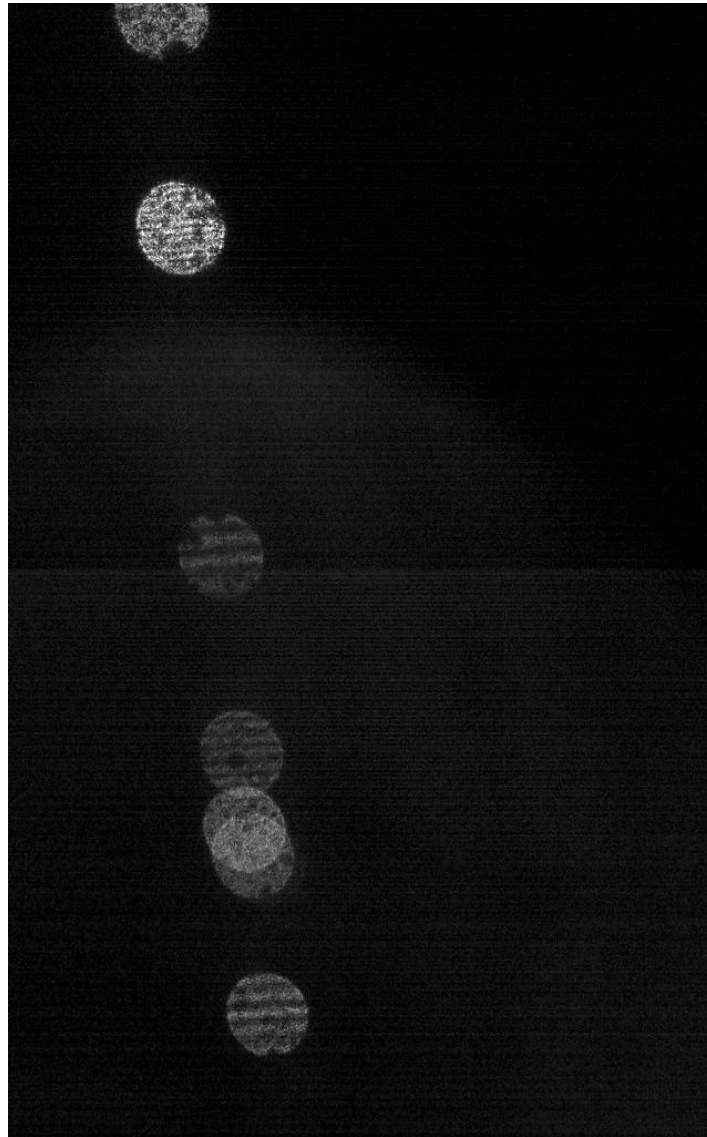
DWB 2/2



MODEL TESTS: RAW DATA VIDEO



MODEL TESTS: RAW DATA

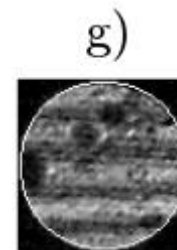
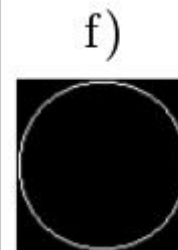
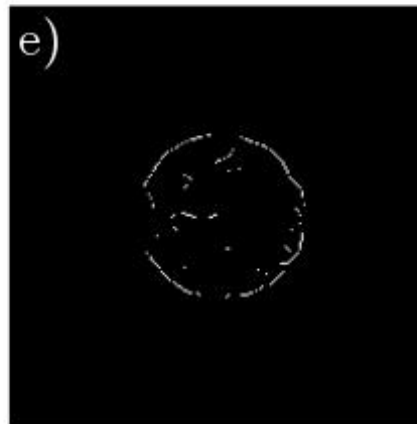
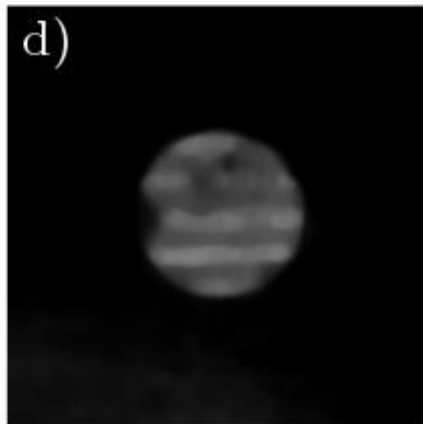
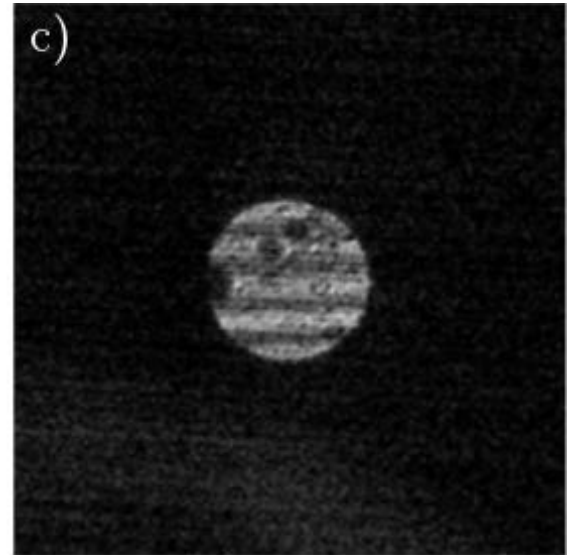
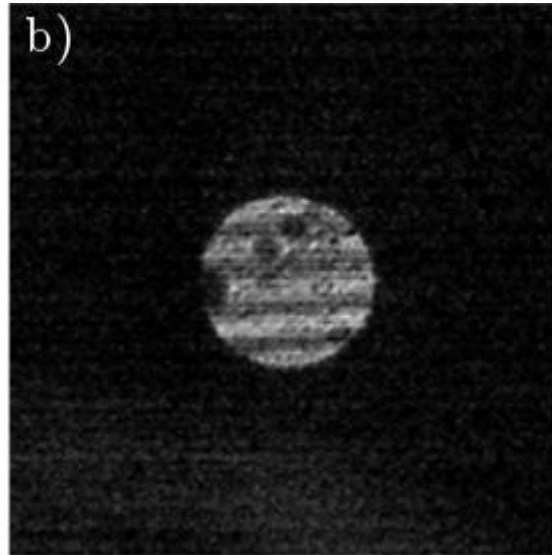
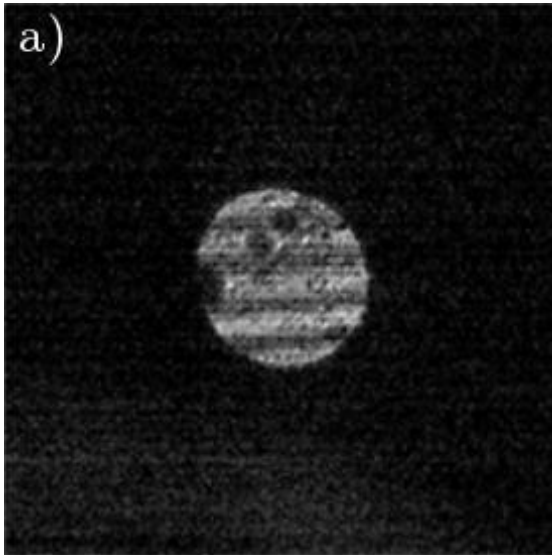


raw image

MODEL TESTS: DATA PROCESSING

shear & scale

rotate



background
subtraction
&
smoothing

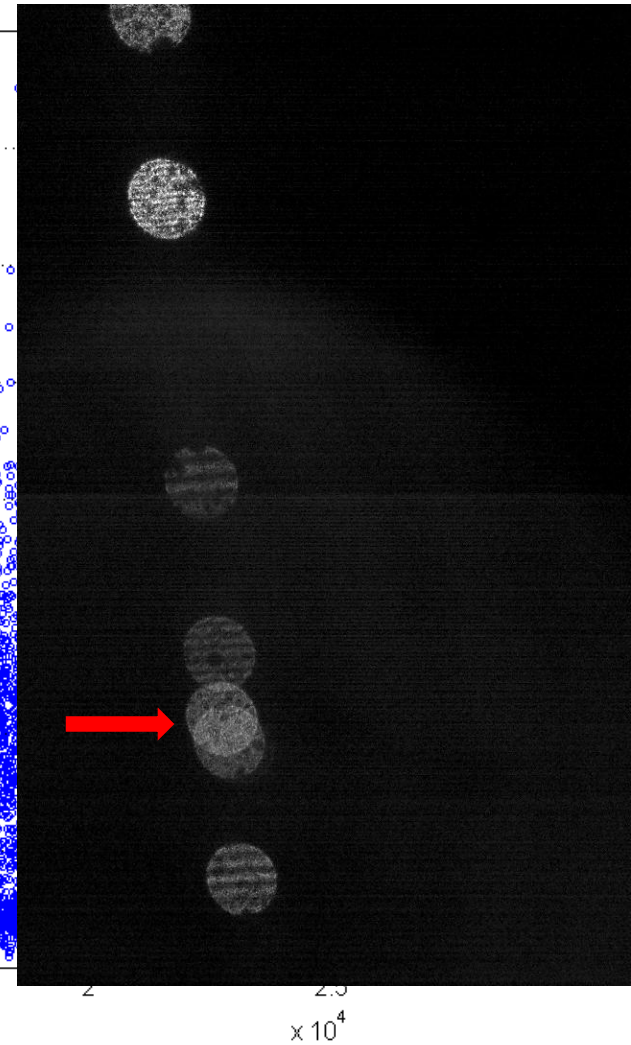
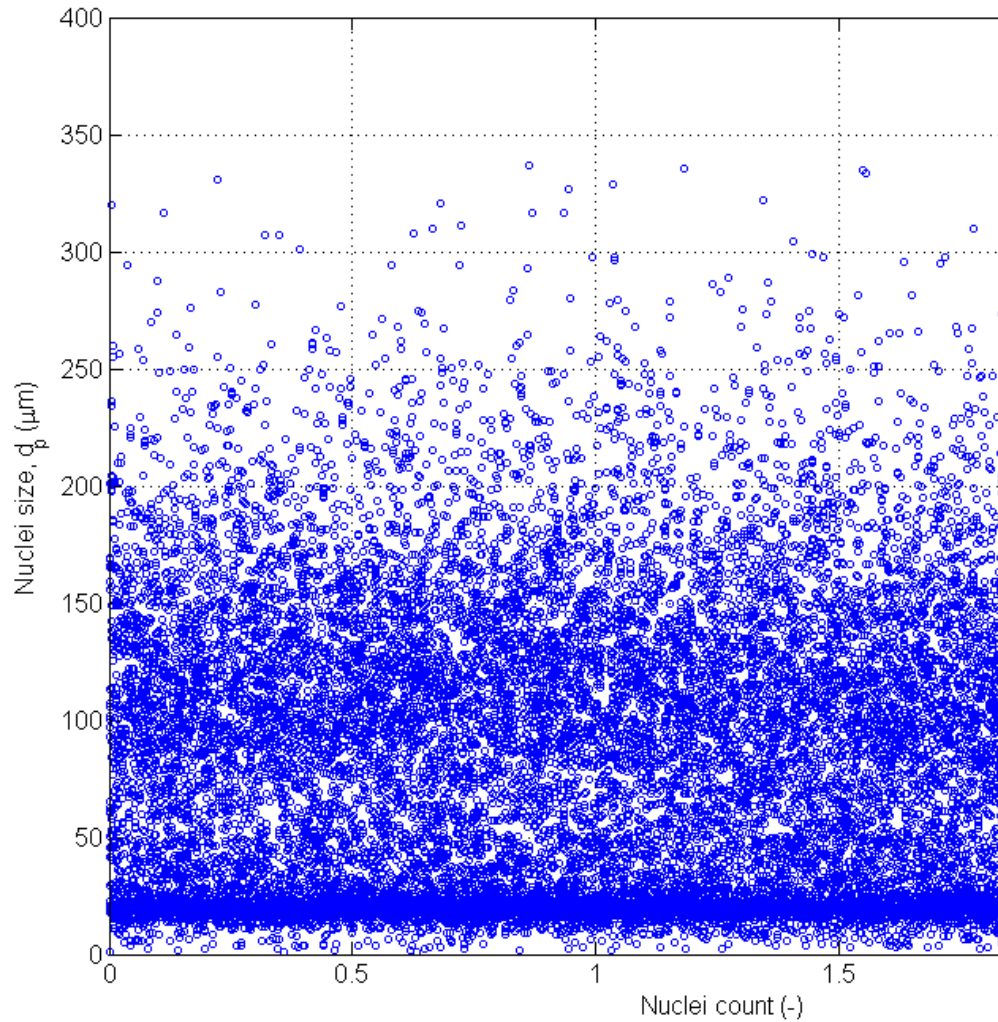
Hough transform

edge detection



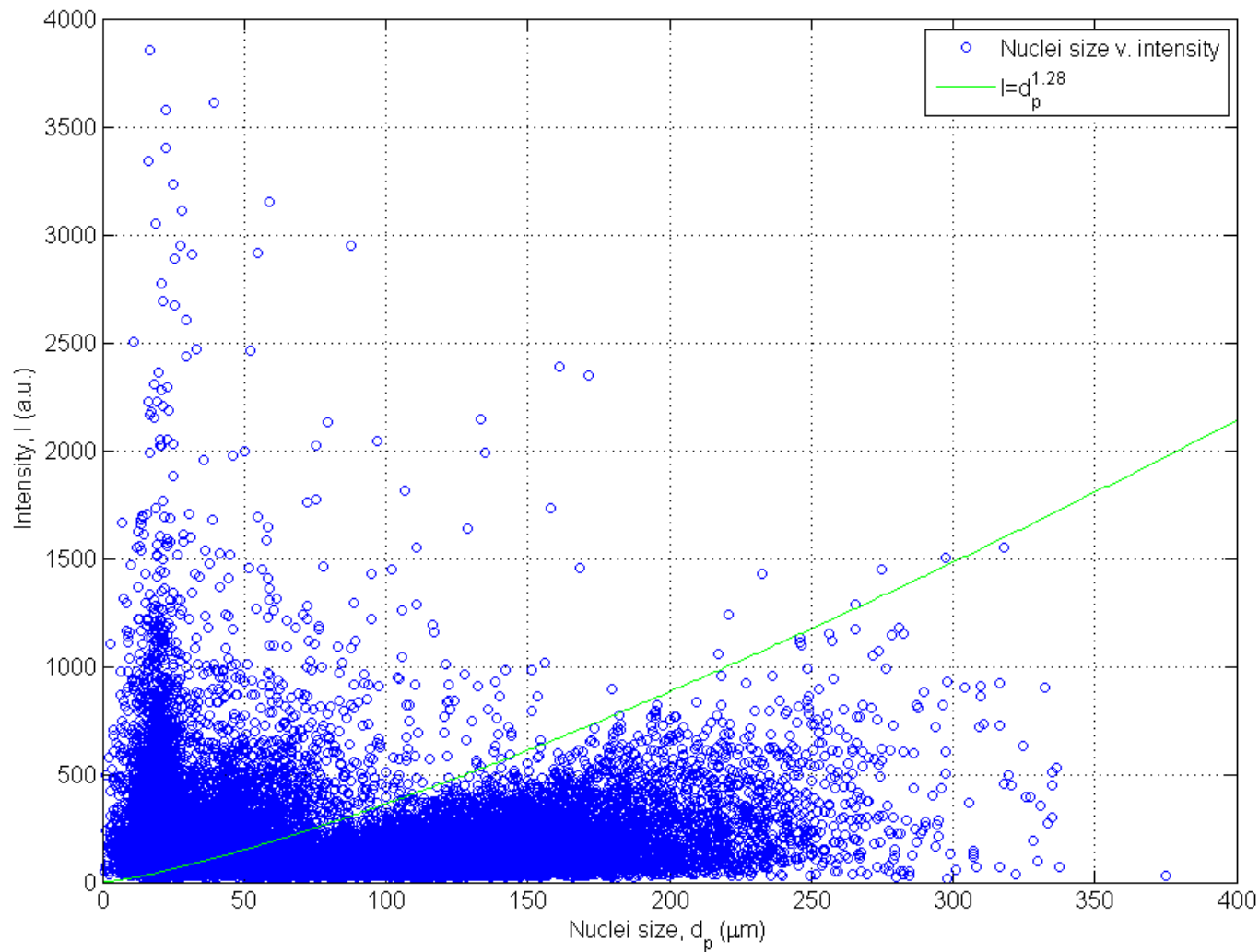
MODEL TESTS: RESULTS

$p=38$ mbar, $I=0.255$ A



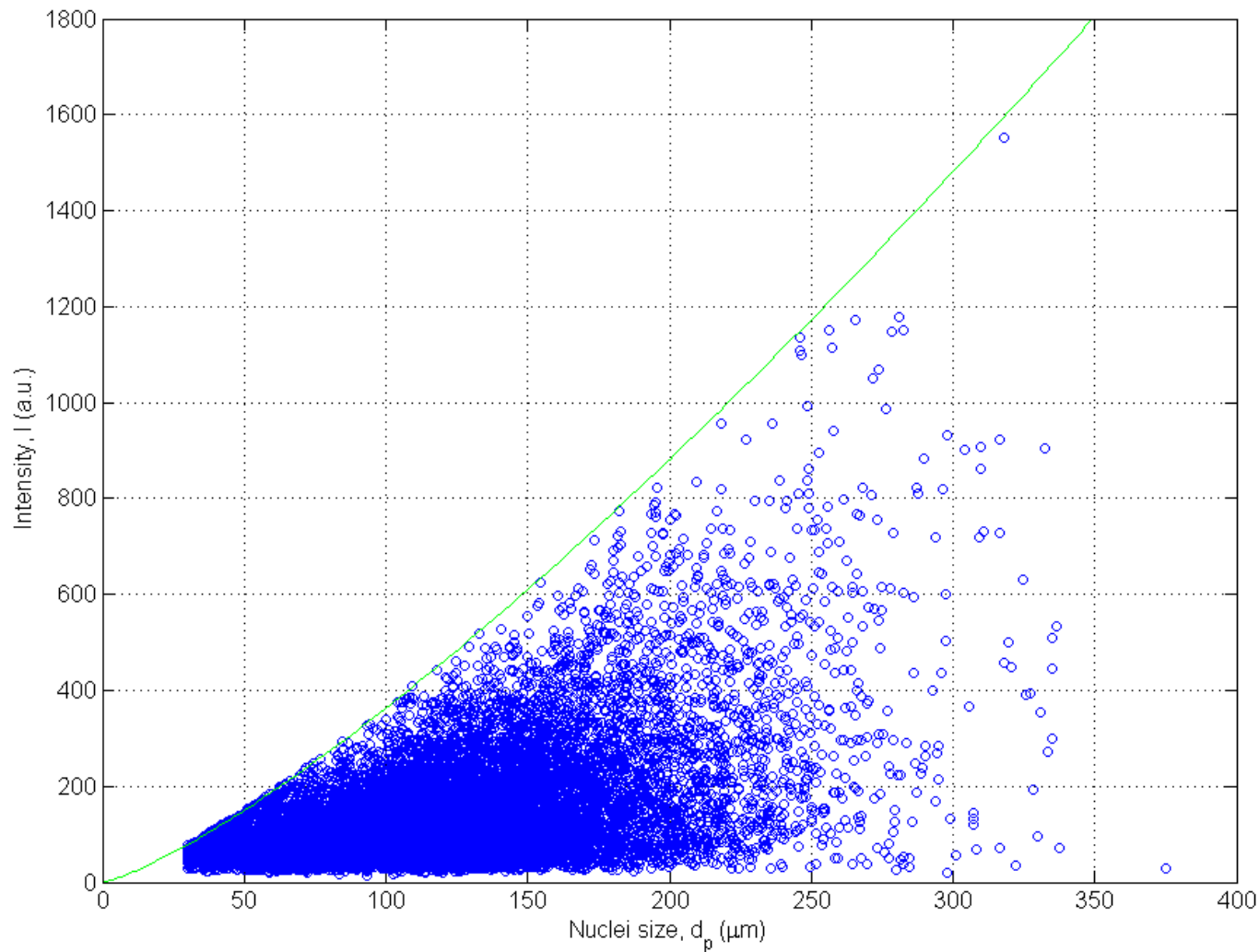
MODEL TESTS: RESULTS

$p=38$ mbar, $I=0.255$ A



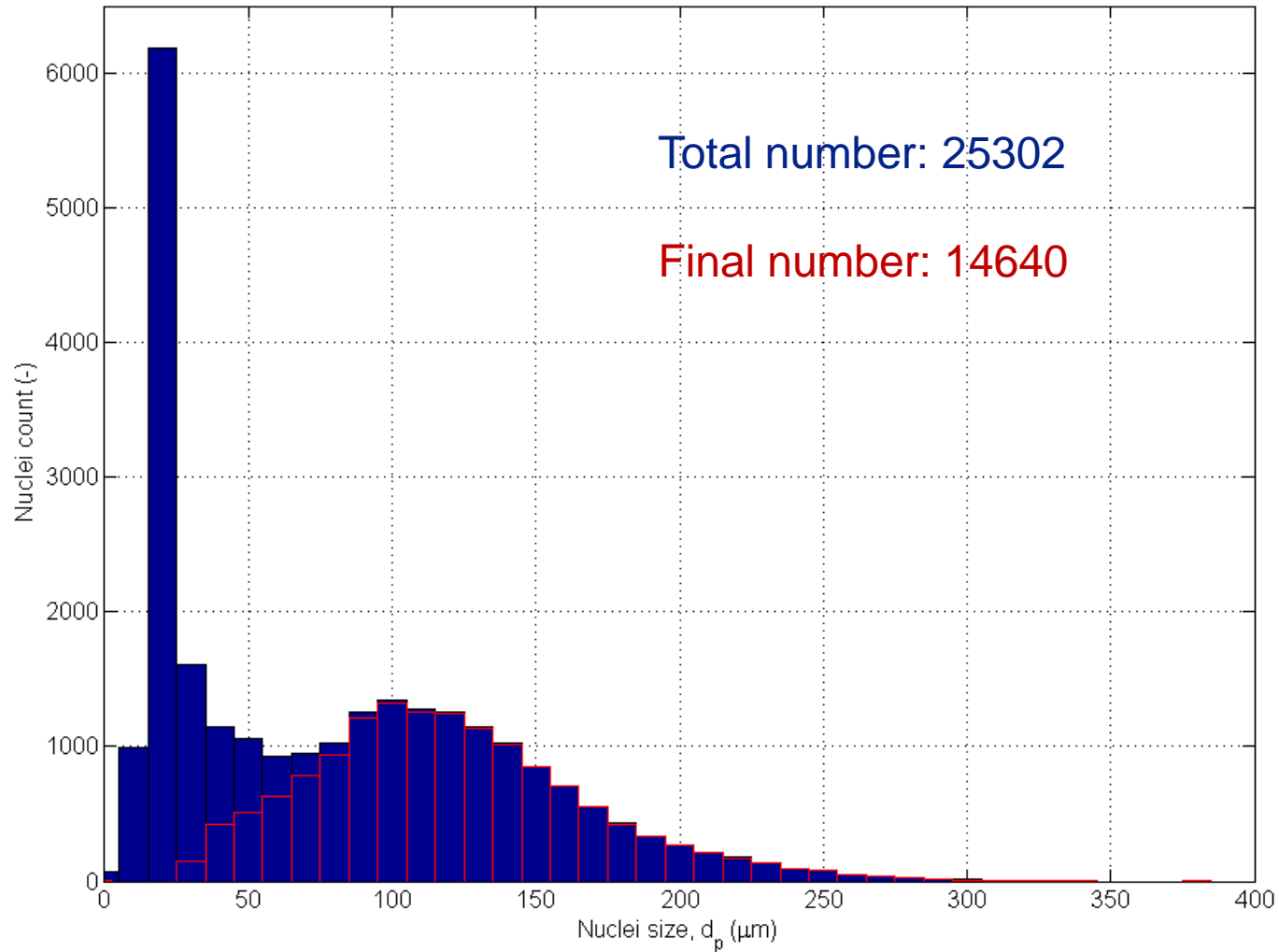
MODEL TESTS: RESULTS

$p=38$ mbar, $I=0.255$ A



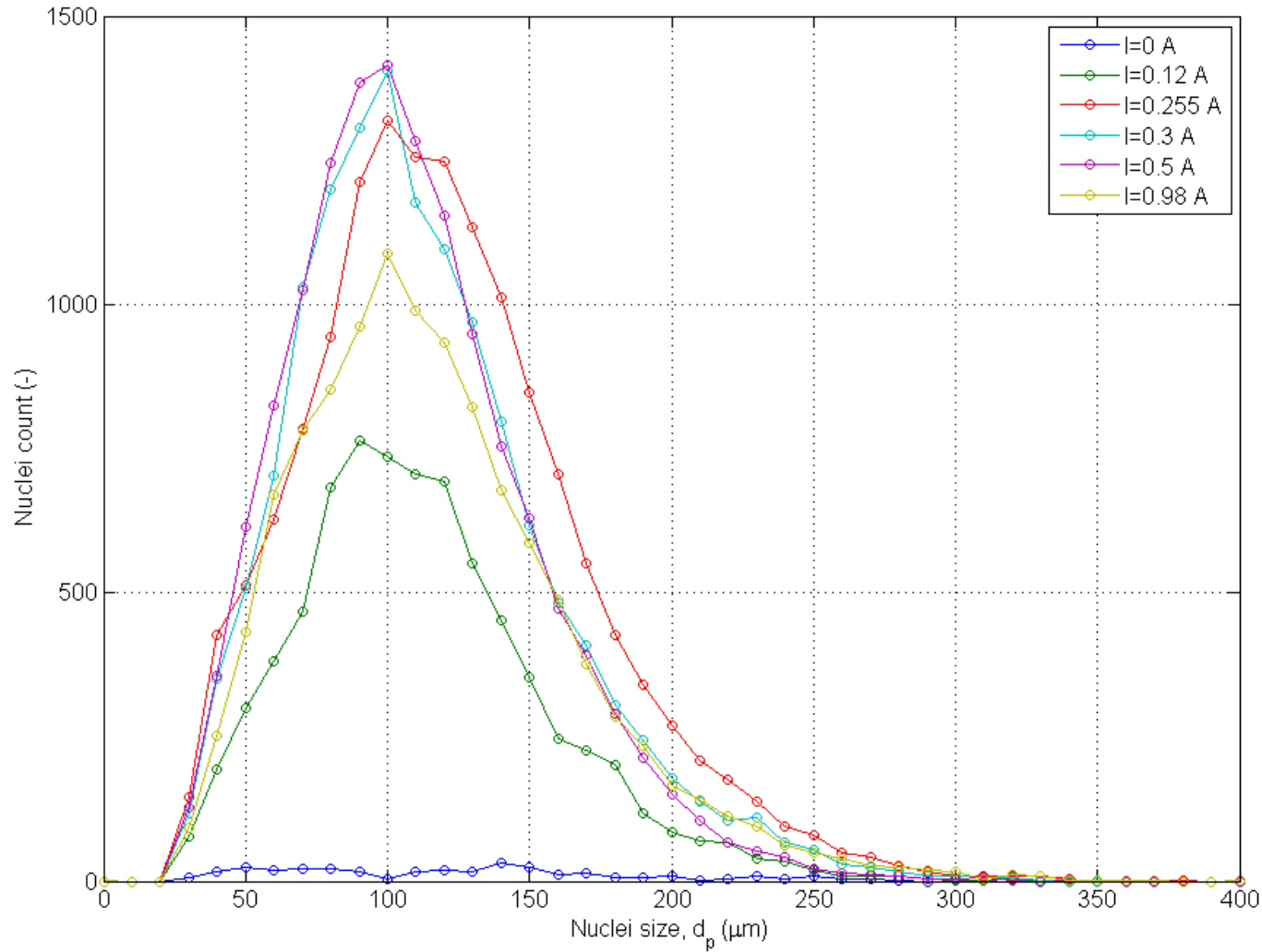
MODEL TESTS: RESULTS

$p=38$ mbar, $I=0.255$ A



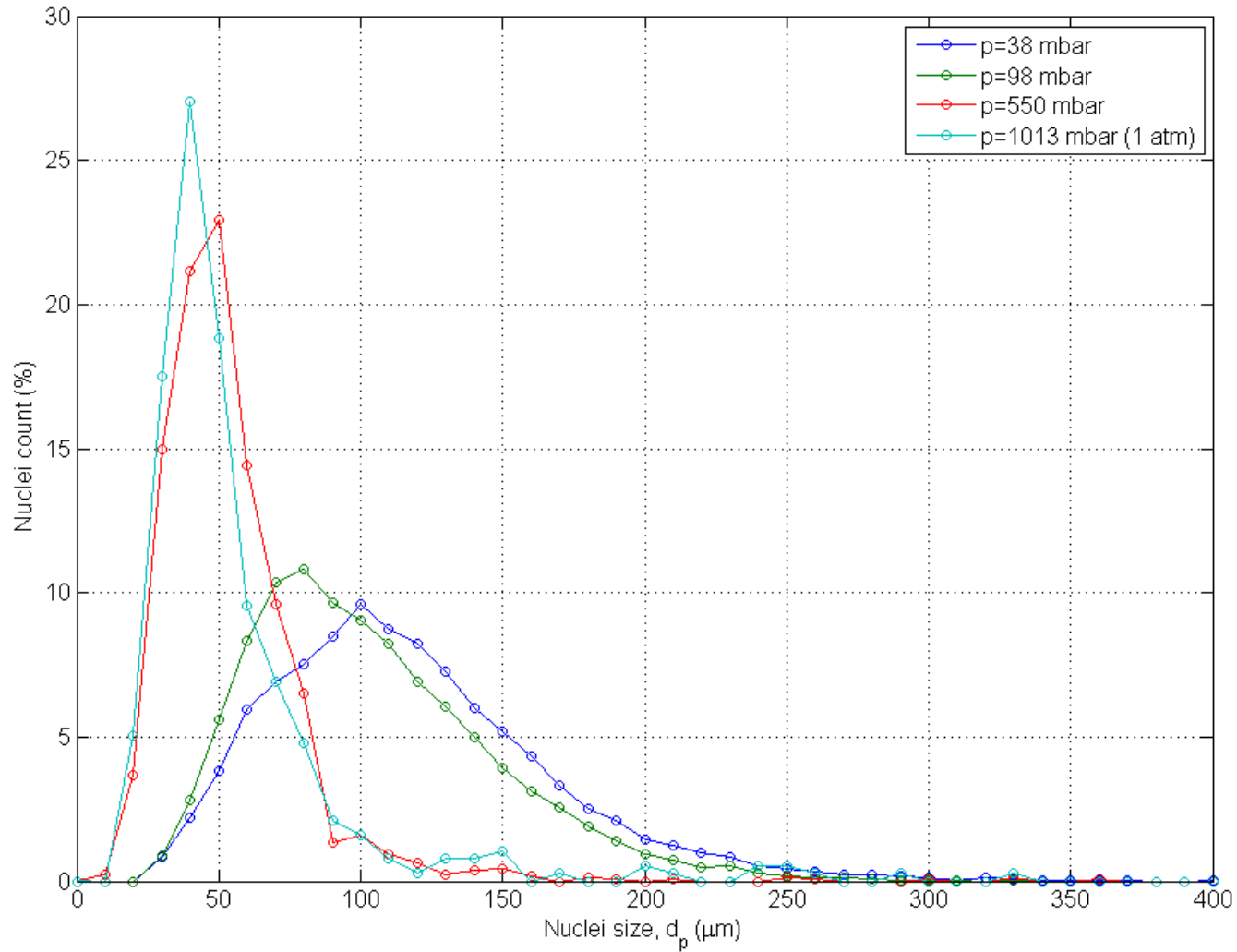
MODEL TESTS: RESULTS

$p=38$ mbar



MODEL TESTS: RESULTS

I=0.98 A



FUTURE WORK

- Further develop concentration calibration method
- Increase processing speed
- Investigate solids/bubbles separation
- Develop IPI for full scale

THANK YOU!

- All questions and suggestions are welcome.

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- *+31 317 49 36 01*
- *m.birvalski@marin.nl*