Agricultural spray measurement by high-speed shadow imagery

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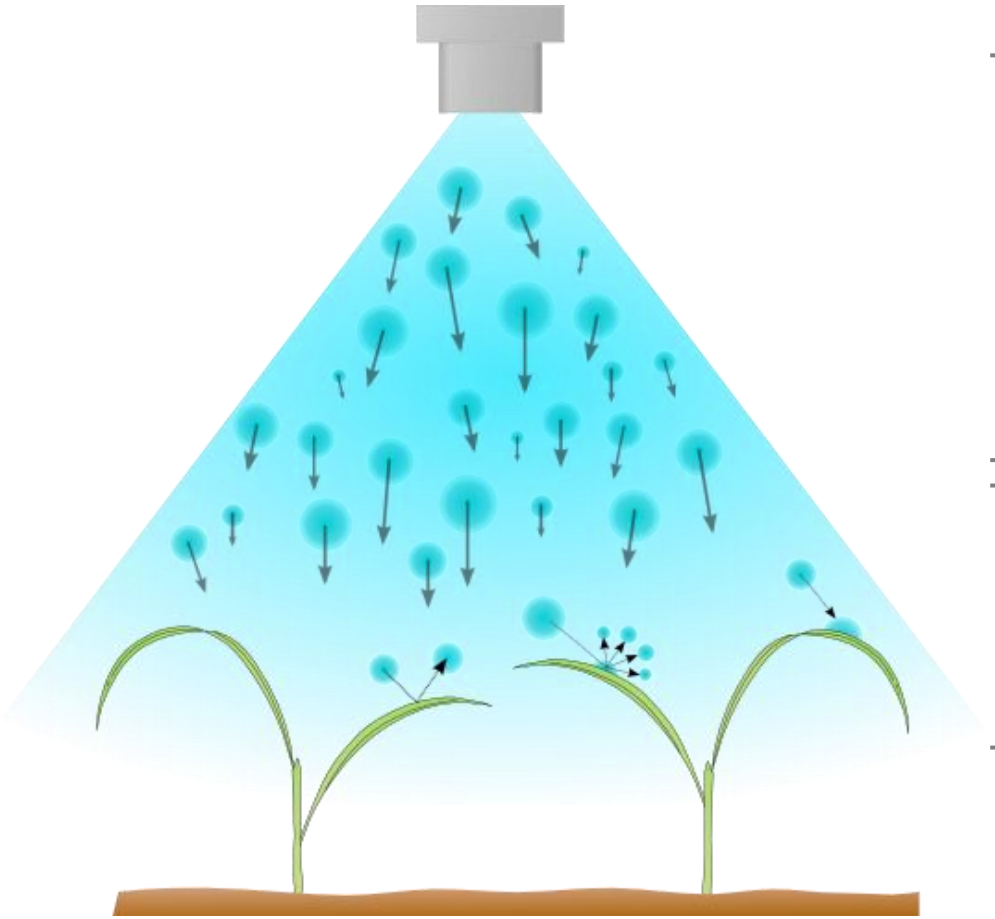
Agricultural spray application



Deposition

From the nozzle to the plant

➔ Effect of the size on droplets driftability

Retention

Droplet impacts on the plant surface

➔ Effect of the droplets energy on the retention

$$We = \frac{\rho v^2 l}{\sigma}$$

Spray characterization techniques

- Laser diffraction spectrometry (LDS)
  - Droplet **size**
- Phase Doppler Anemometry (PDA)
  - Droplet **size and speed**
- Particle/Drop Image Analysis (PDIA)
  - Based on image analysis
  - Droplet **size and speed**

Need coherent light (laser)

➔ High cost

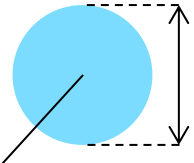
Based on optic theory

➔ Require liquid optical properties

Objective

Development of a versatile, low cost and accurate **spray characterization tool** based on high speed imaging

Method



Velocity (x,y)

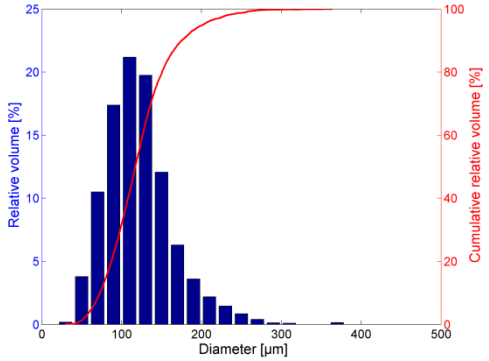
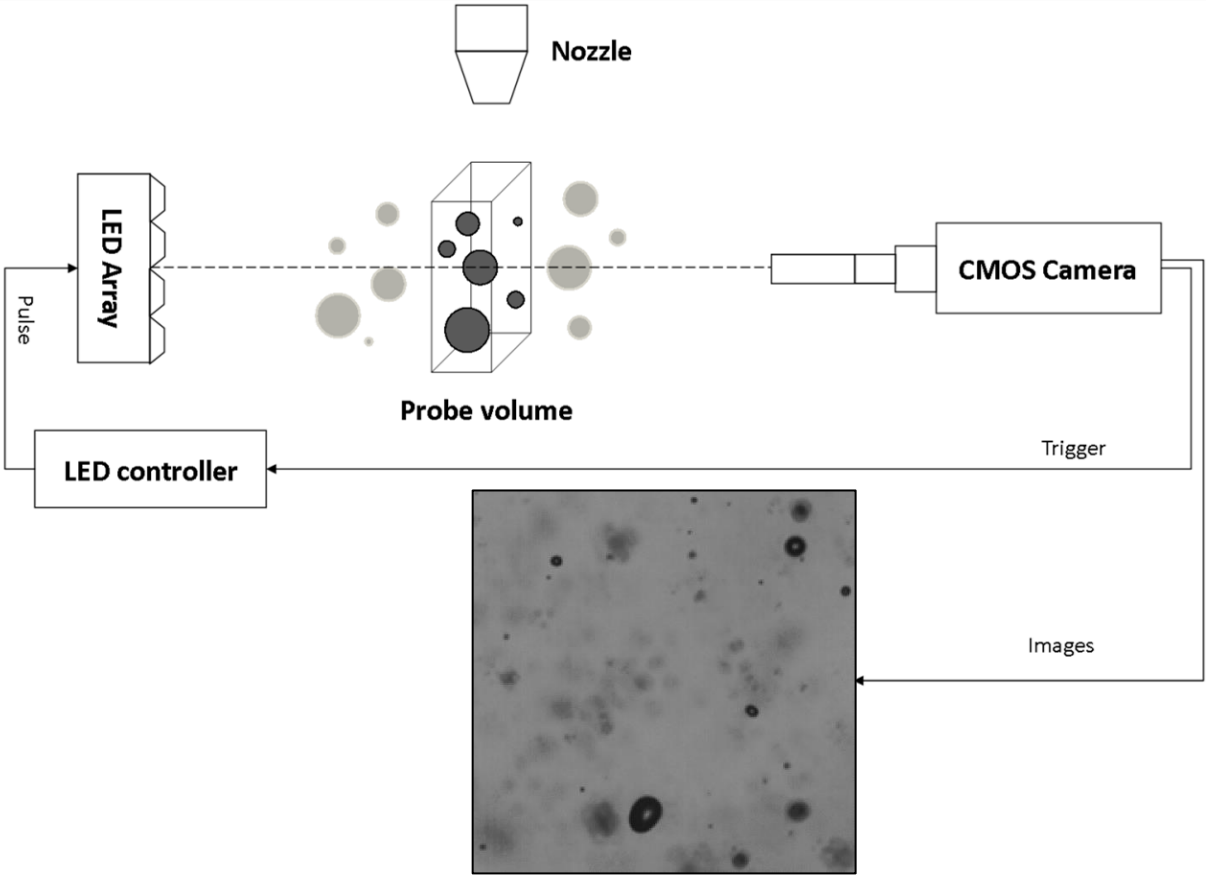


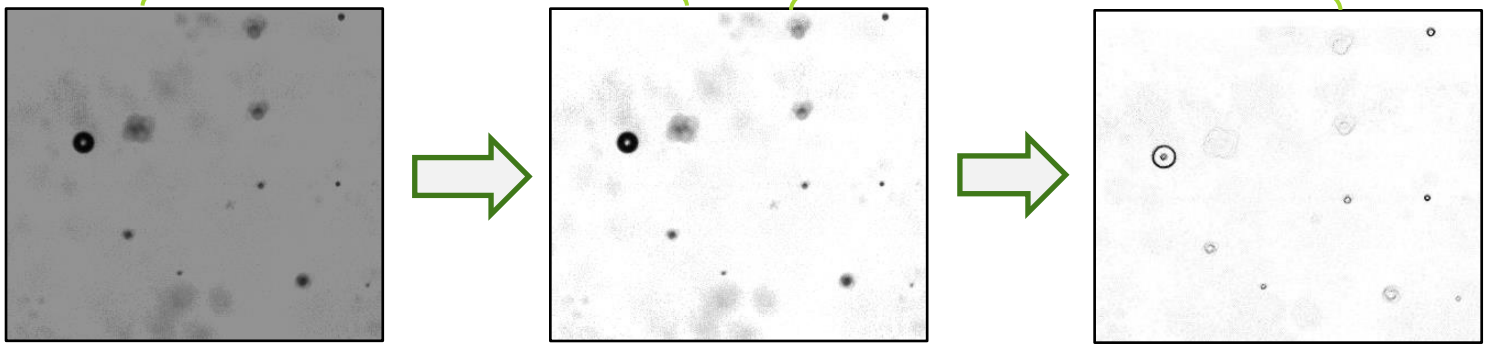
Image acquisition set-up

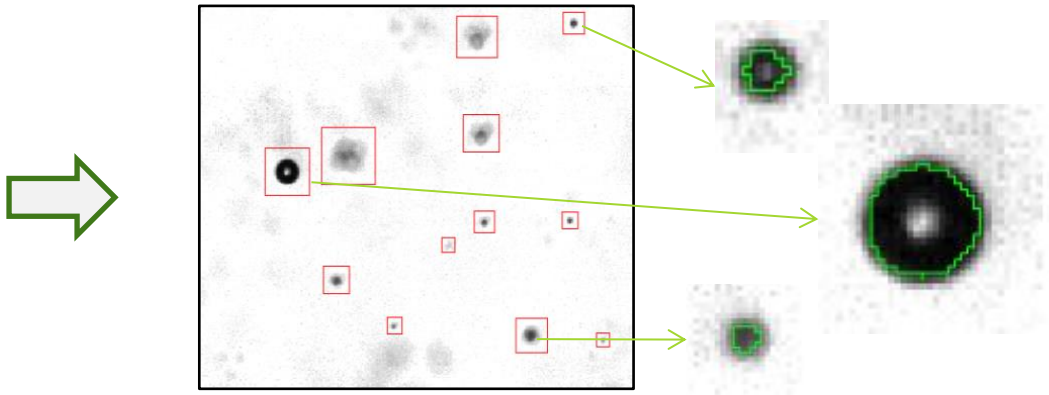


- 8-bit PIV camera
- 72 W LED panel
- Acquisition of picture in PIV mode

Drops localization

Average background subtraction **Gradient computation**

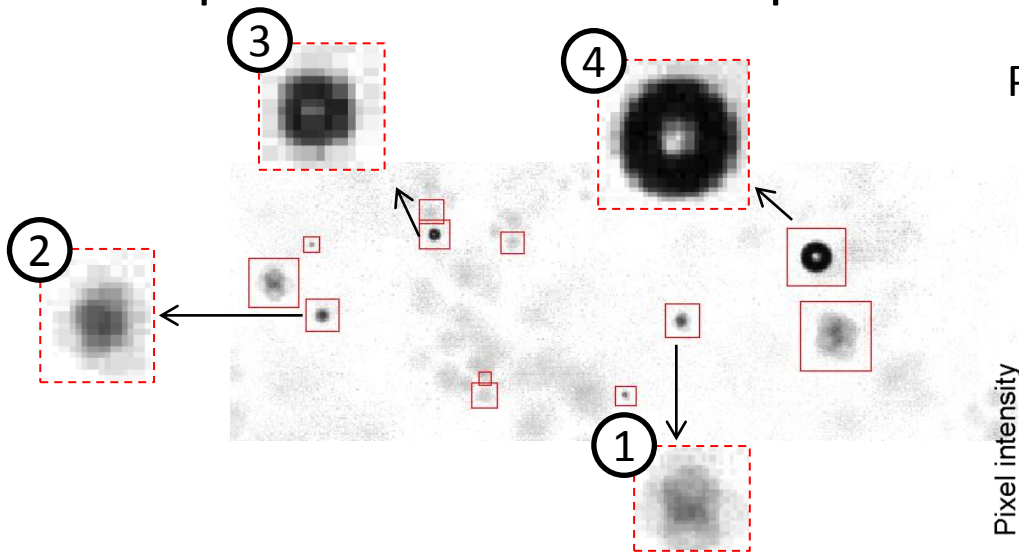




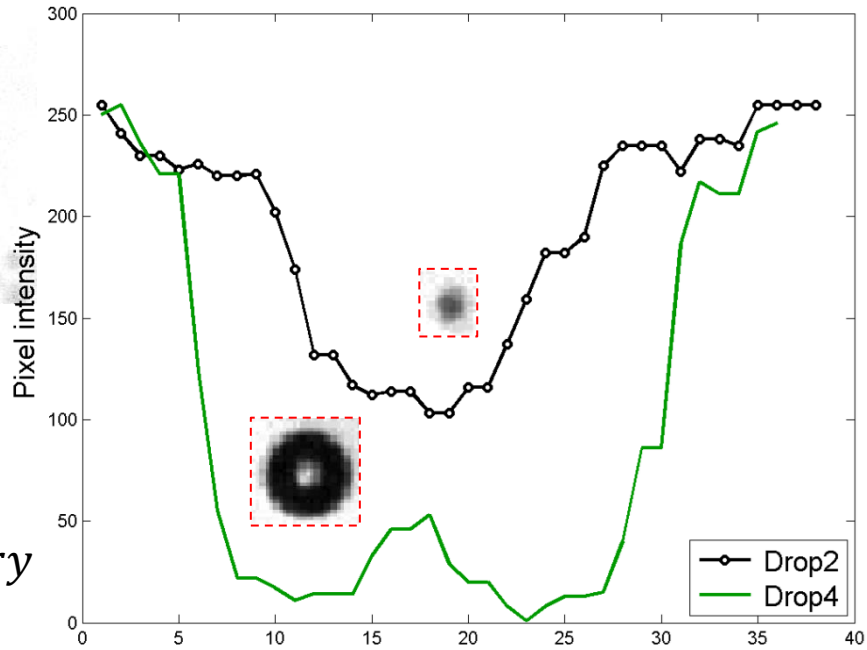
Localization of the drop boundaries by applying a Canny filter

Out of focus drops rejection

- Drop shadow boundaries present various levels of sharpness



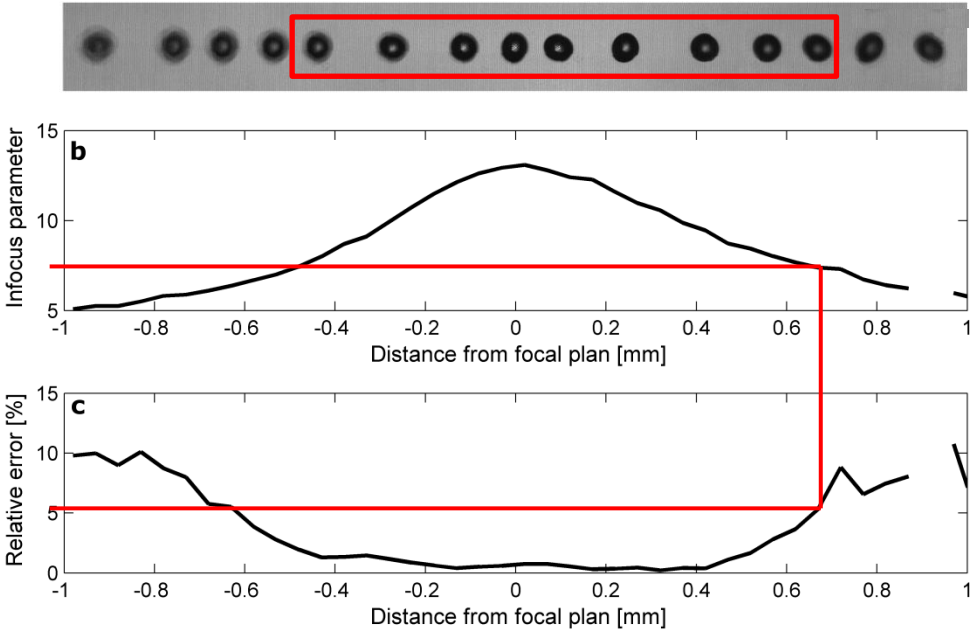
Pixel intensities accross droplet shadows



$$Sharpness \propto Gradient\ intensity\ at\ the\ boundary$$

Out of focus drops rejection

- Determination of focus parameter threshold



Oblique stream of monosized drops

$$Focus\ parameter = \frac{grad_{bound}}{I_{object} - I_{back}}$$

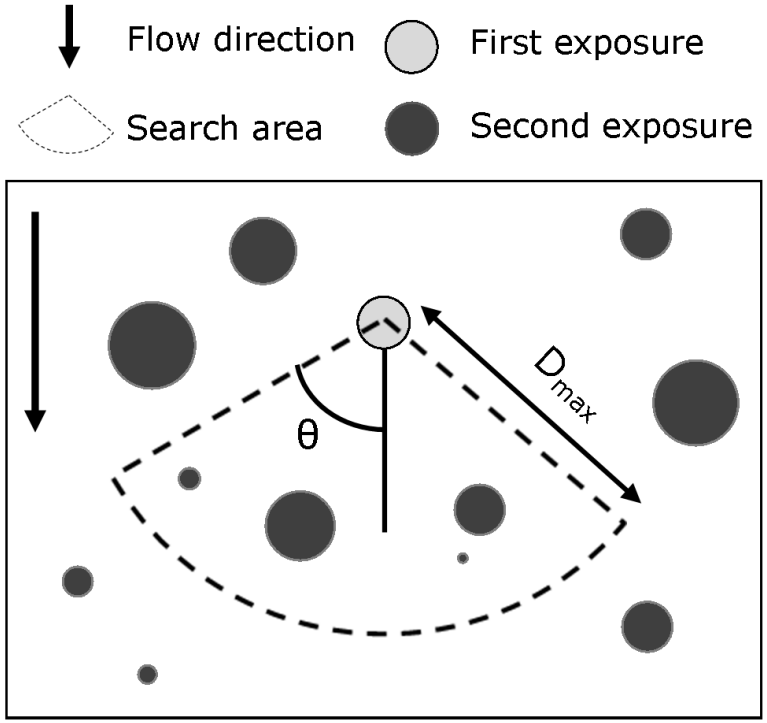
Relative error on drop diameter measurements

Velocity measurement

- Droplet tracking based on:
  - Droplet size
  - Most probable displacement

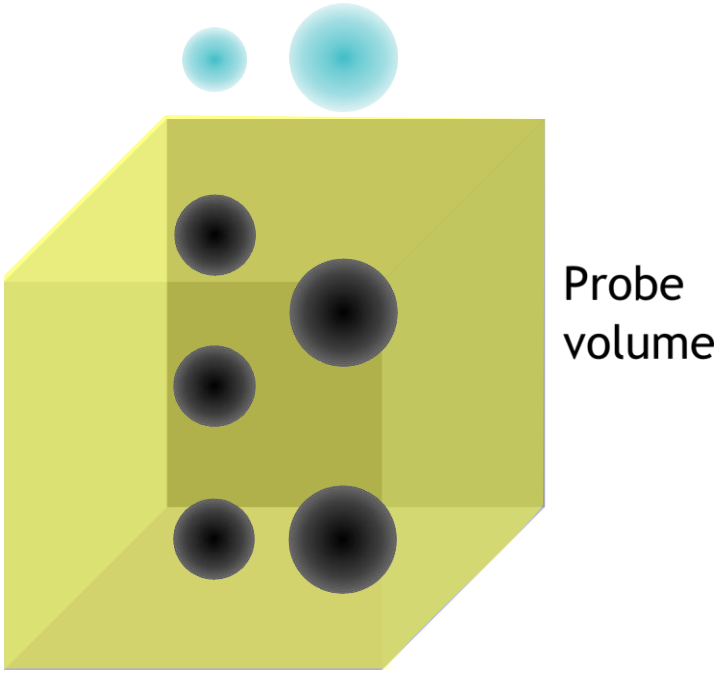
$$D_{max} = v_{max}\,\Delta t$$

θ deviation in respect to the main flow



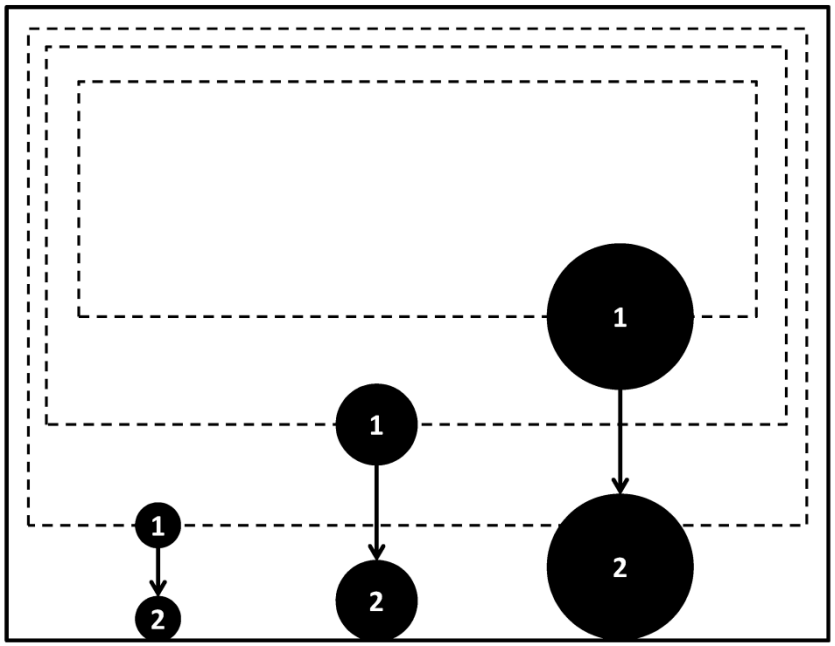
Sampling probality

Residential time



$time \searrow \; when \; v \nearrow$

Size of the probe volume

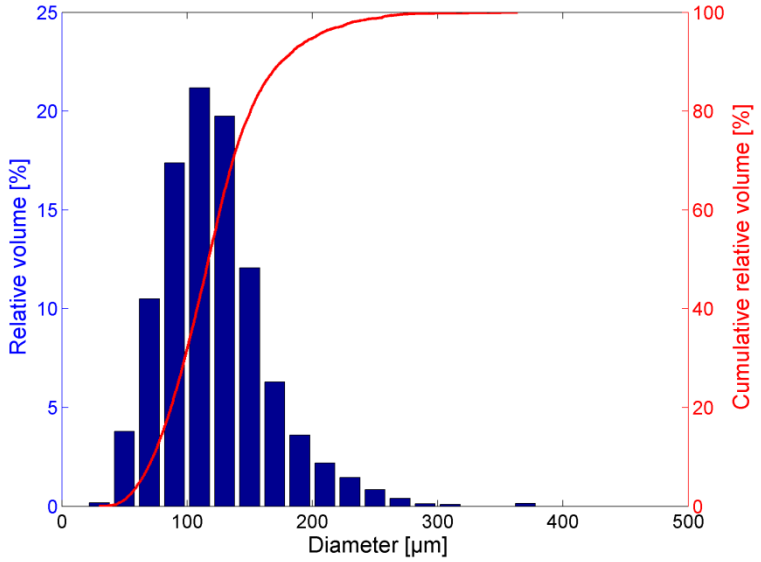


$size \searrow \; when \; d \nearrow$

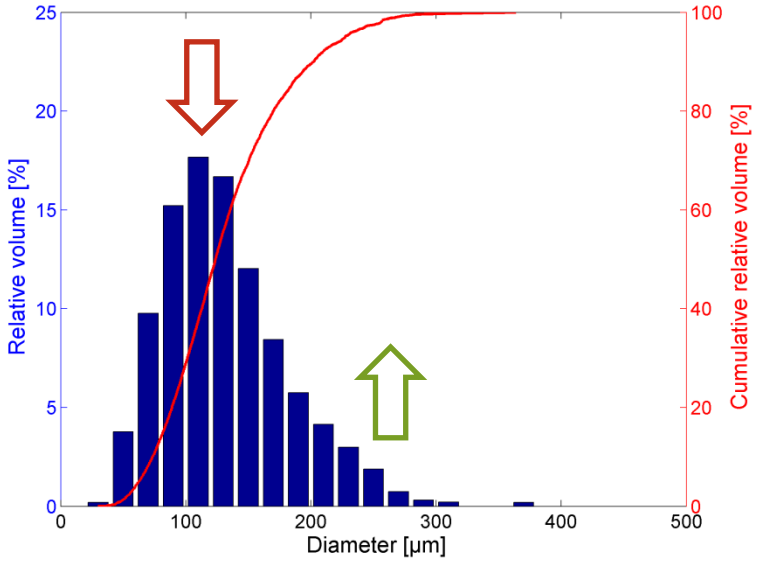
Correction of the drop size distribution

$$Sampling\ probability \propto \frac{PV_{size}}{v_d}$$

$$Correction\ Factor = \frac{v}{(FOV_{cor}\ DOF)}$$

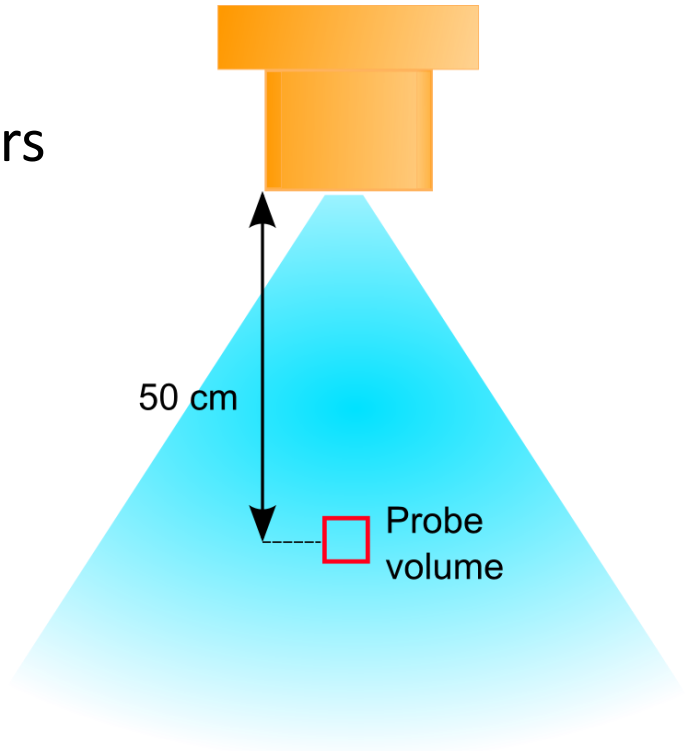


Correction



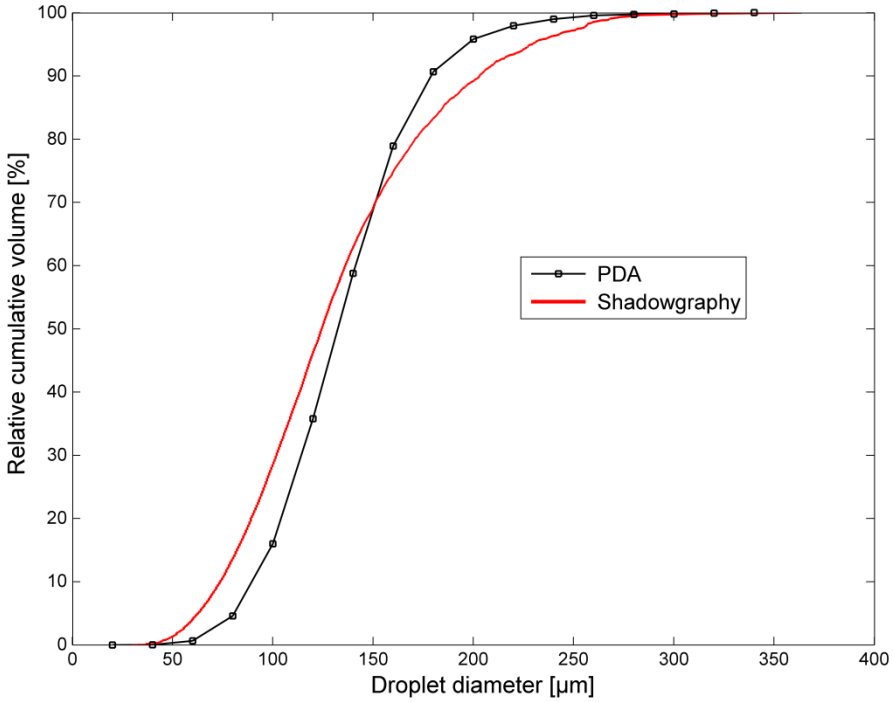
Experiment conditions

- Simultaneous measurements with PDA and shadowgraphy
  - Teejet TP 11001 at 4.5 bars
  - Tap water



Techniques comparison

Drop size distribution



Distribution parameters

	PDA	Shadowgraphy
D_{v10} [µm]	91,5	73,8
D_{v50} [µm]	132,4	124,3
D_{v90} [µm]	178,0	202,1
Relative Span Factor (RSF)	0,665	1,033
Number of drops	71 999	39 815

$$RSF = \frac{Dv_{90} - Dv_{10}}{Dv_{50}}$$

Conclusions

- An image processing method has been presented
- Good agreement between PDA and imagery technique has been found

Further work

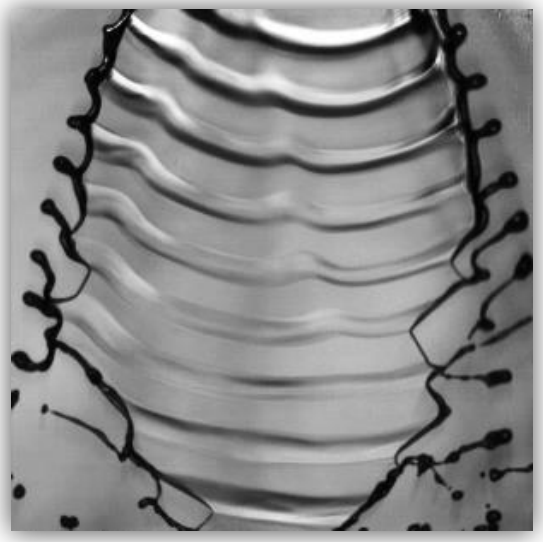
- Assessment of the technique capability for distinguishing the BCPC categories

Thanks for you attention !

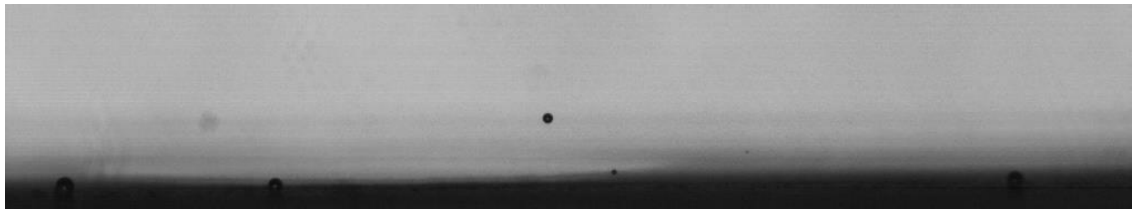
Questions ?

Appendix

Spray formation



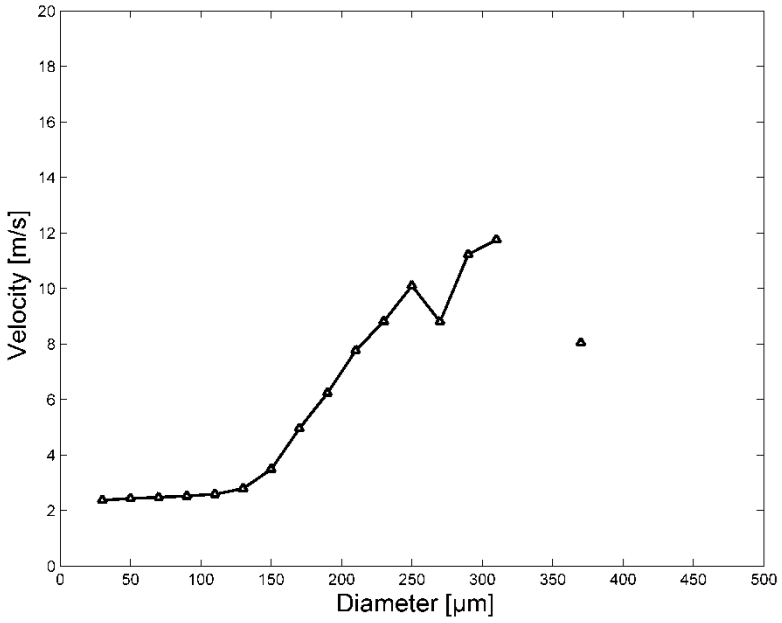
Droplet impacts



Appendix

Correction factor (slide 11)

Average Velocity per class



Drops per class