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SLD modeling at onera

Experimental studies on the SLD splashing

P. Berthoumieu and D. Guffond

The droplet splashing is related to the Reynols number at the impact ($Re = \rho V d/\nu$) and the Ohnesorge number

$$\mathrm{Oh} = \mu / \sqrt{\rho \sigma d}$$

with μ water viscosity,, ρ water density, σ the liquid-air surface tension, And d the droplet diameter .

$$K = \mathrm{Oh}\, Re^{1,25} .$$

The splashing occurs if K is greater than 57,7

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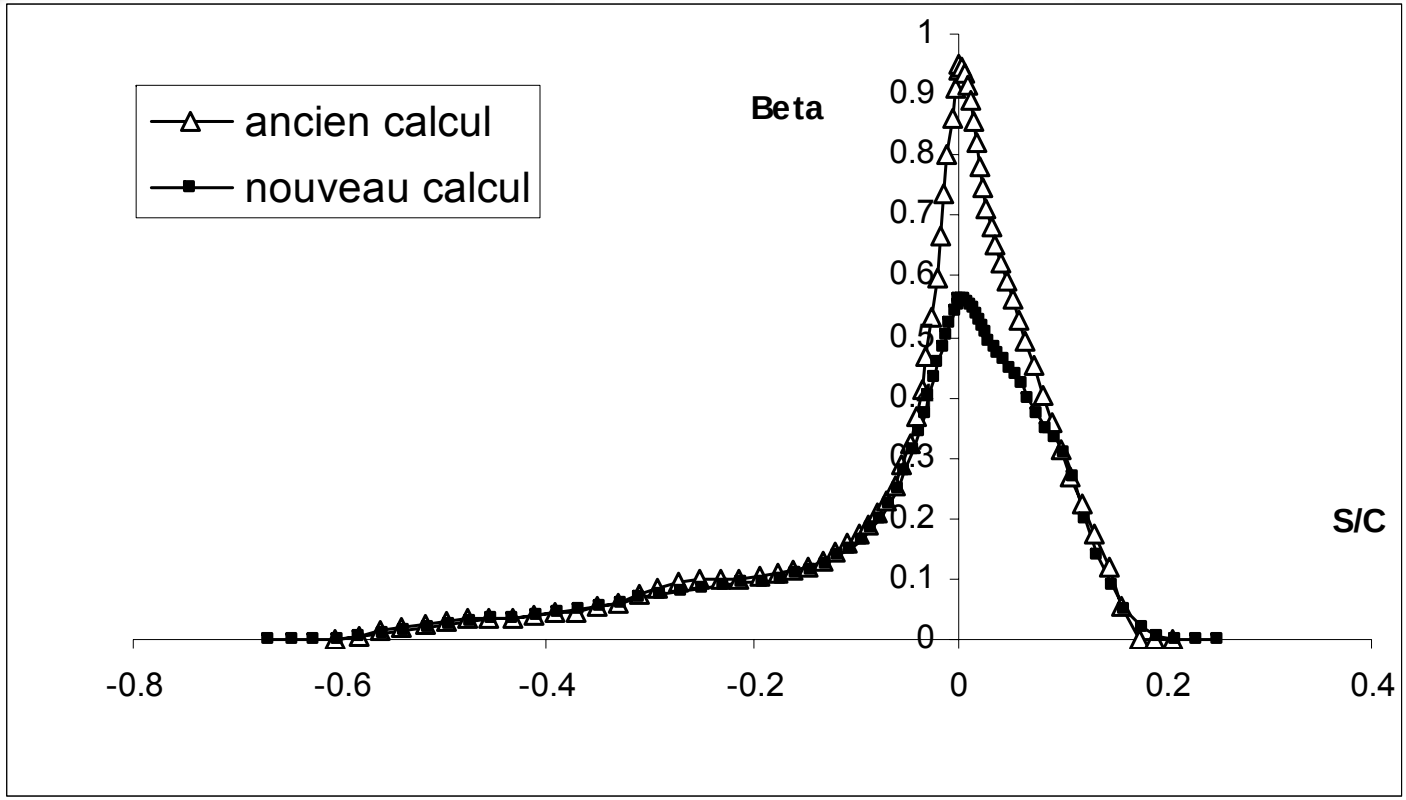
SLD Icing

Empirical formula

$$\beta\ new = \beta\ \text{old}\sqrt{\frac{57{,}7}{\text{K}}}$$



Local catch efficiency for 200 μm droplet diameter

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Experimental studies on the SLD splashing

- Laboratory experiment
  - Perfecting the PAG experiment
  - Temperature influence
  - Weber influence (dimension, velocity)

- Test in the PAG wind tunnel
  - Impact of calibrated droplets
  - Impact visualizations
  - Dimension – velocities measurement

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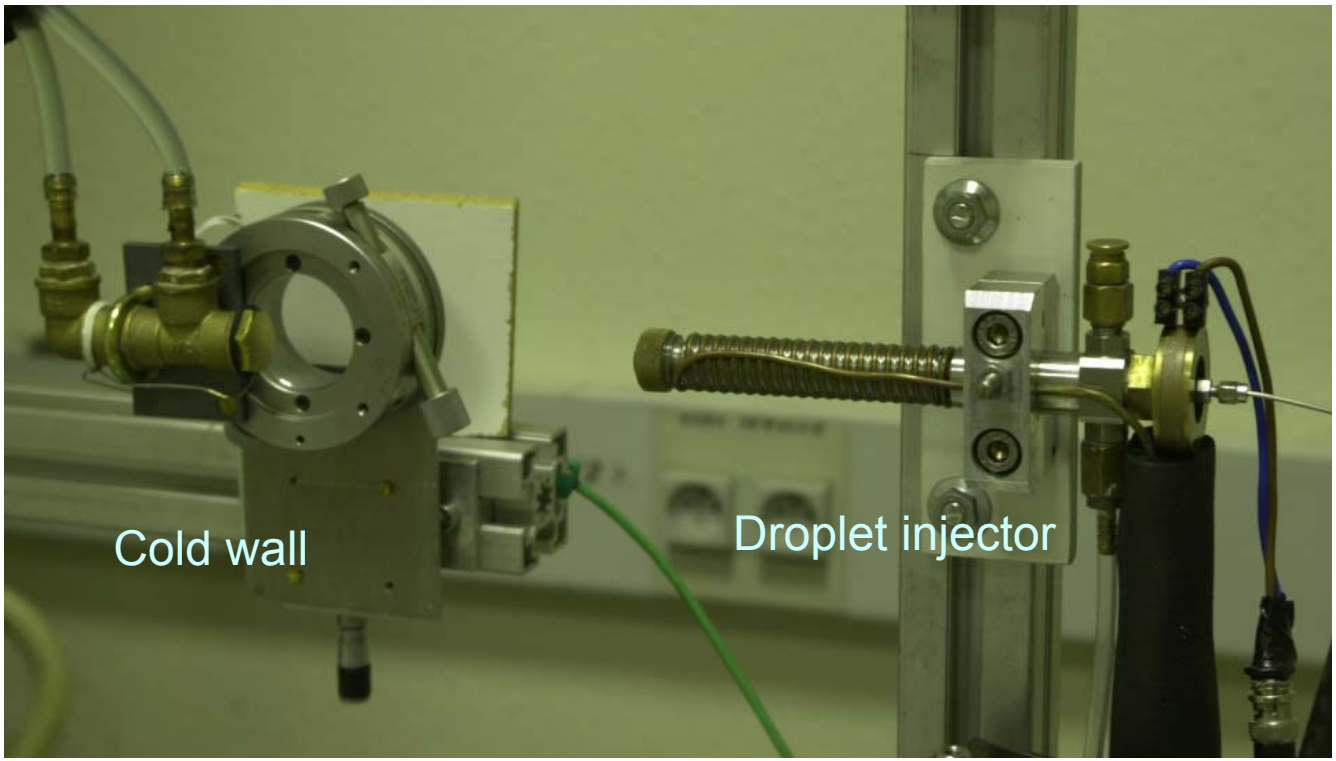
Laboratory experiment



- Horizontal injection
- Injector cooling

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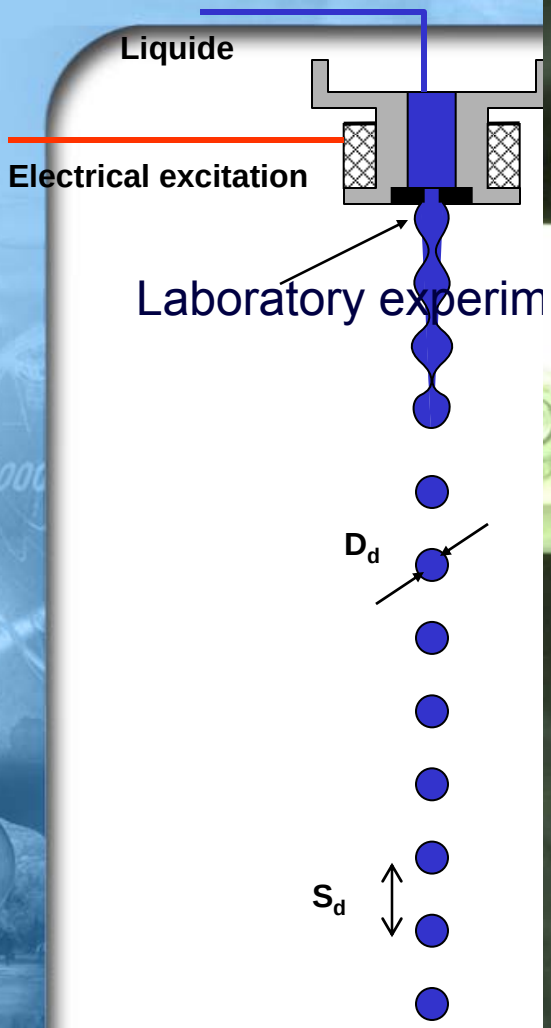
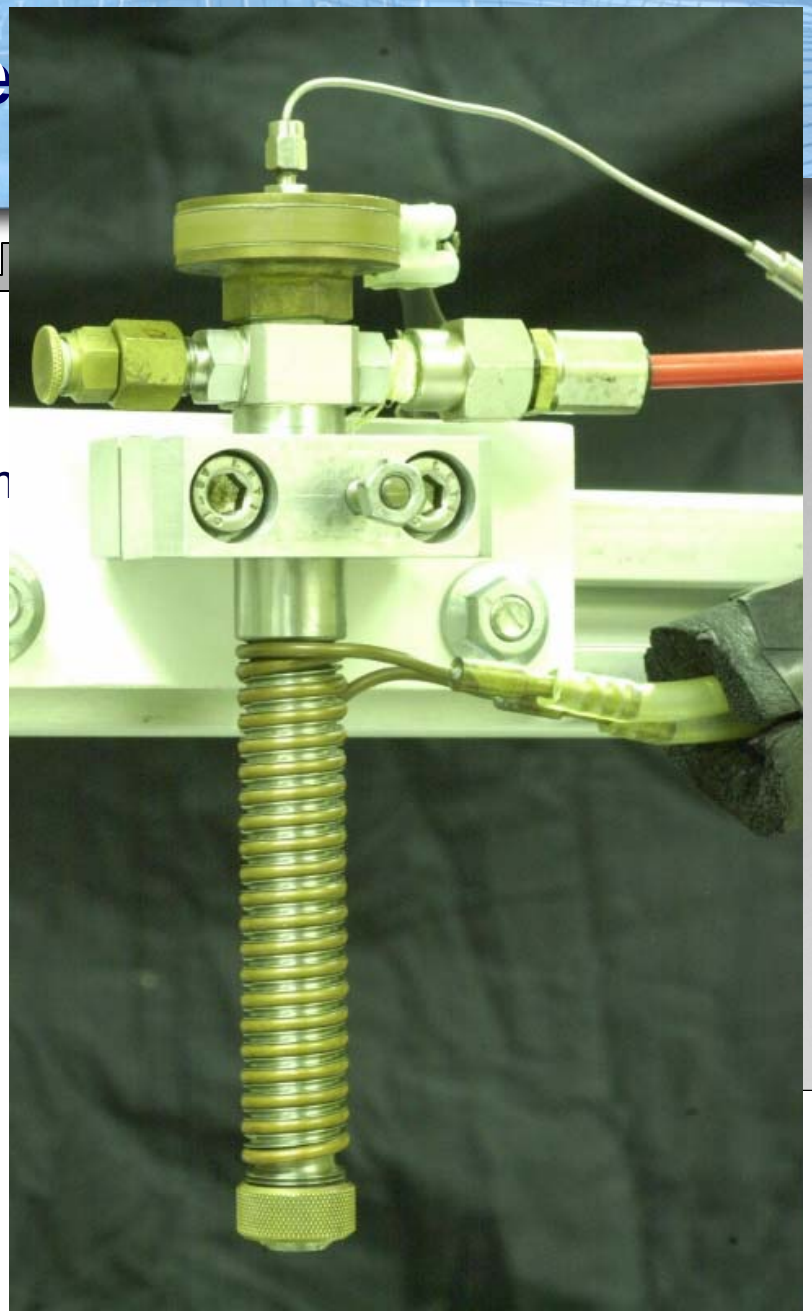
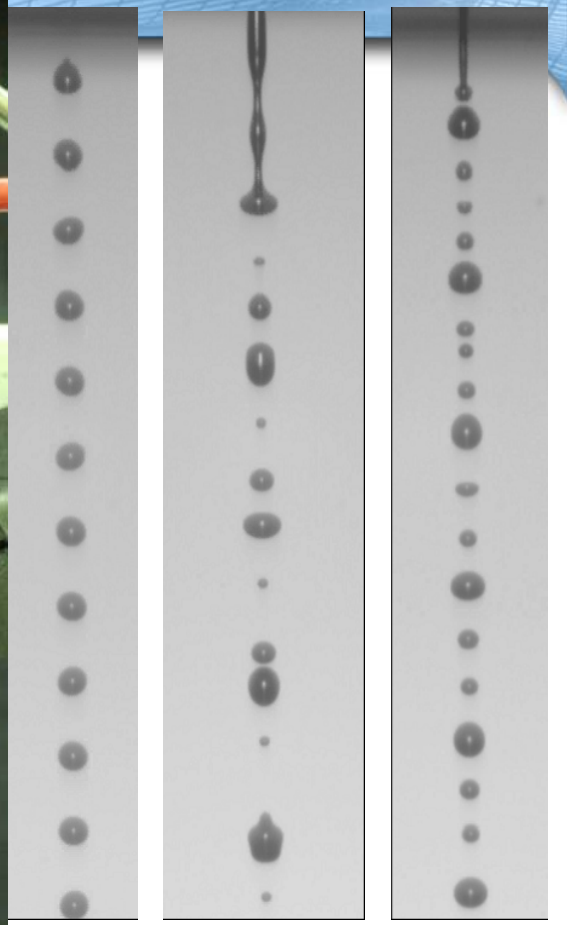
Droplets gene







Droplets chain

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Laboratory experiment

- Parameters
  - Droplet size : 200 µm and 300 µm
  - Droplet velocity : 6 to 11 m/s
  - Impact angle : 30° to 90°
  - Wall temperature : -20 °C, -15 °C, -8 °C, +0.5°C
  - Water temperature : -3.3 °C à 0.3 °C

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Laboratory tests

- Possibility to inject droplets at a low temperature
- Great influence of the wall temperature
- Great influence of the droplet temperature
- Low influence of the impact angle
- The splashing occurs with the velocity reasing

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Experimental studies on the SLD splashing

- Laboratory experiment
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  - Weber influence (dimension, velocity)

- Test in the PAG wind tunnel
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  - Dimension – velocities measurement

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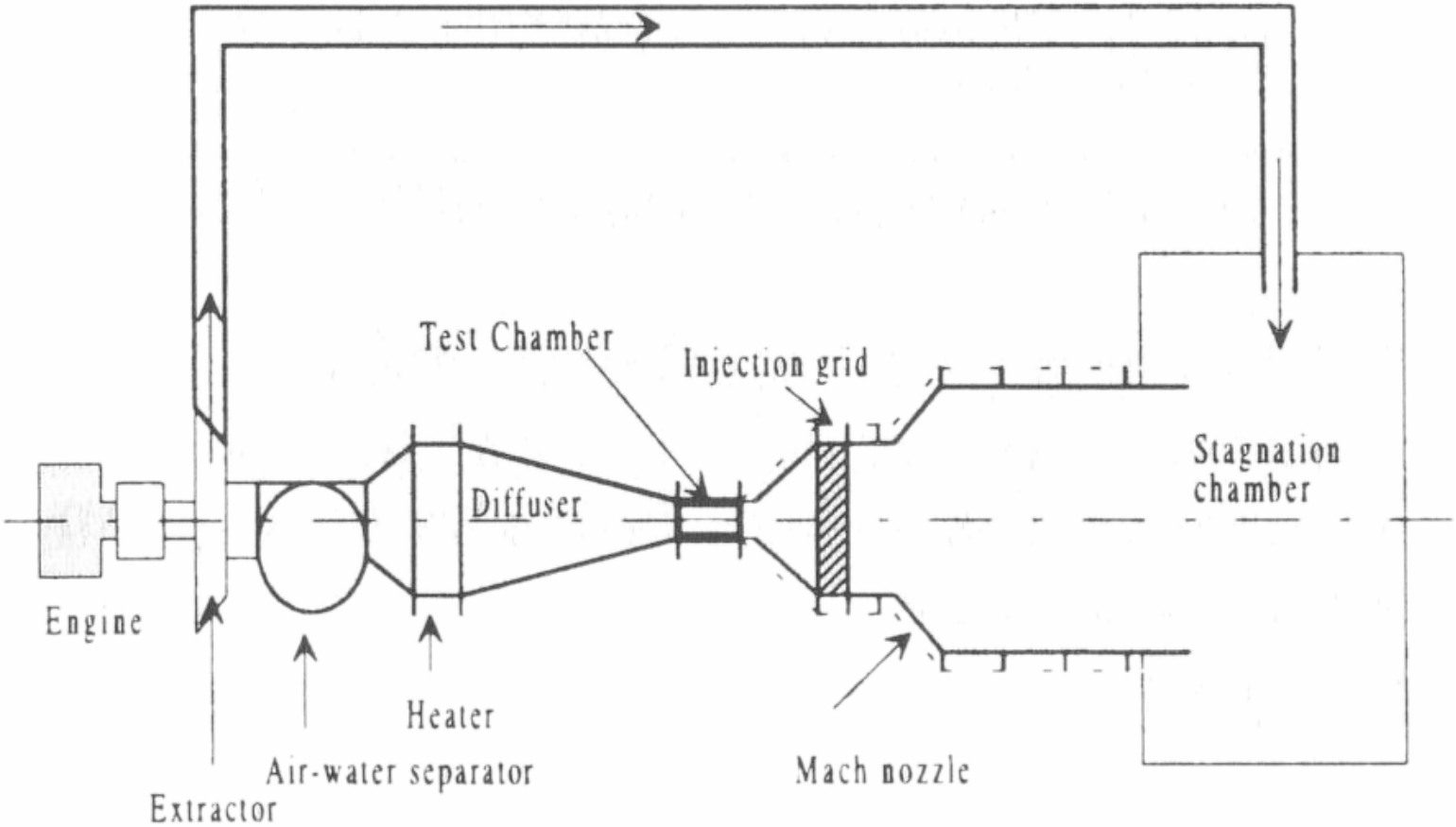
Test in the PAG



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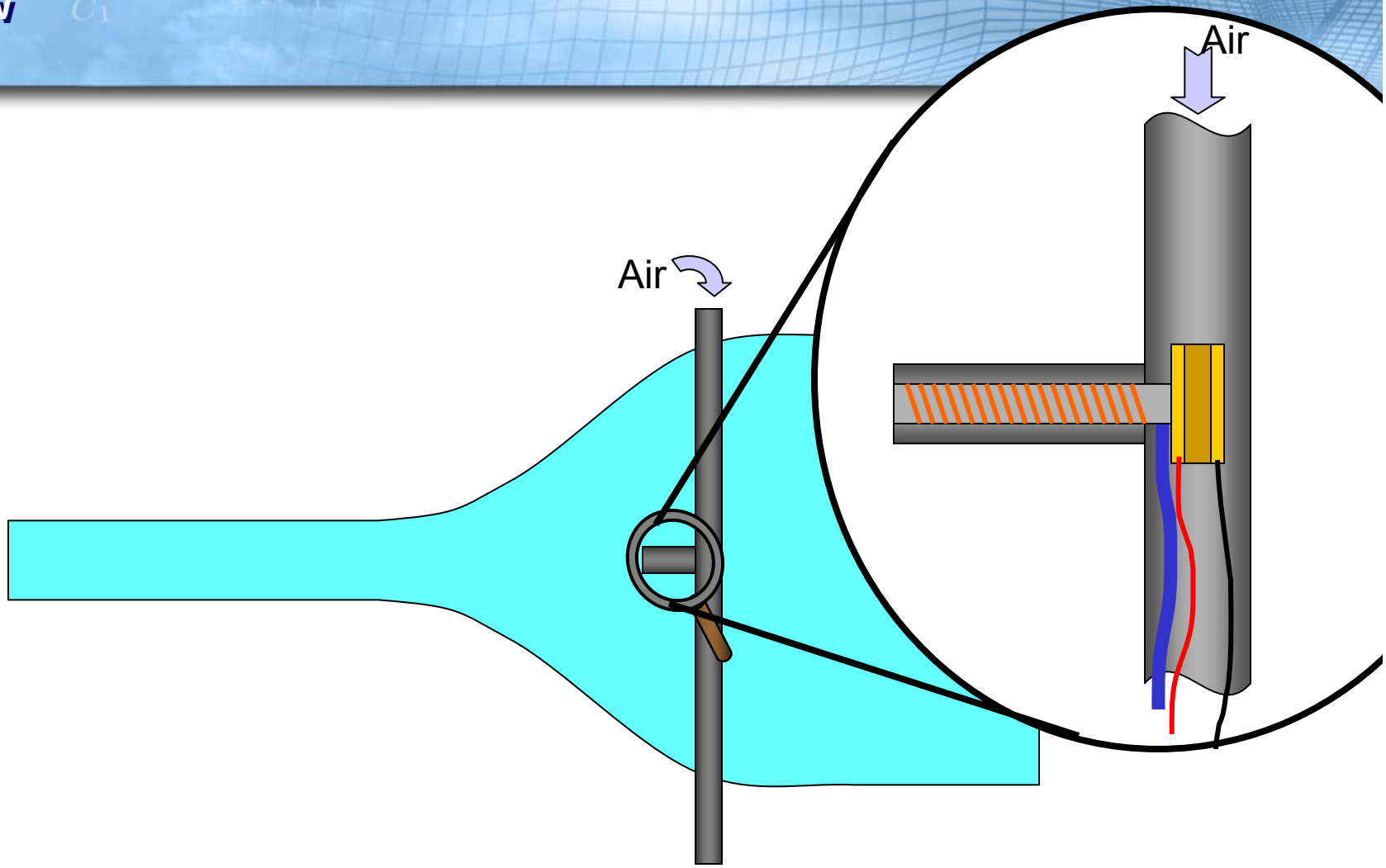
Test in the PAG – injector set-up

top view



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Test in the PAG – general view

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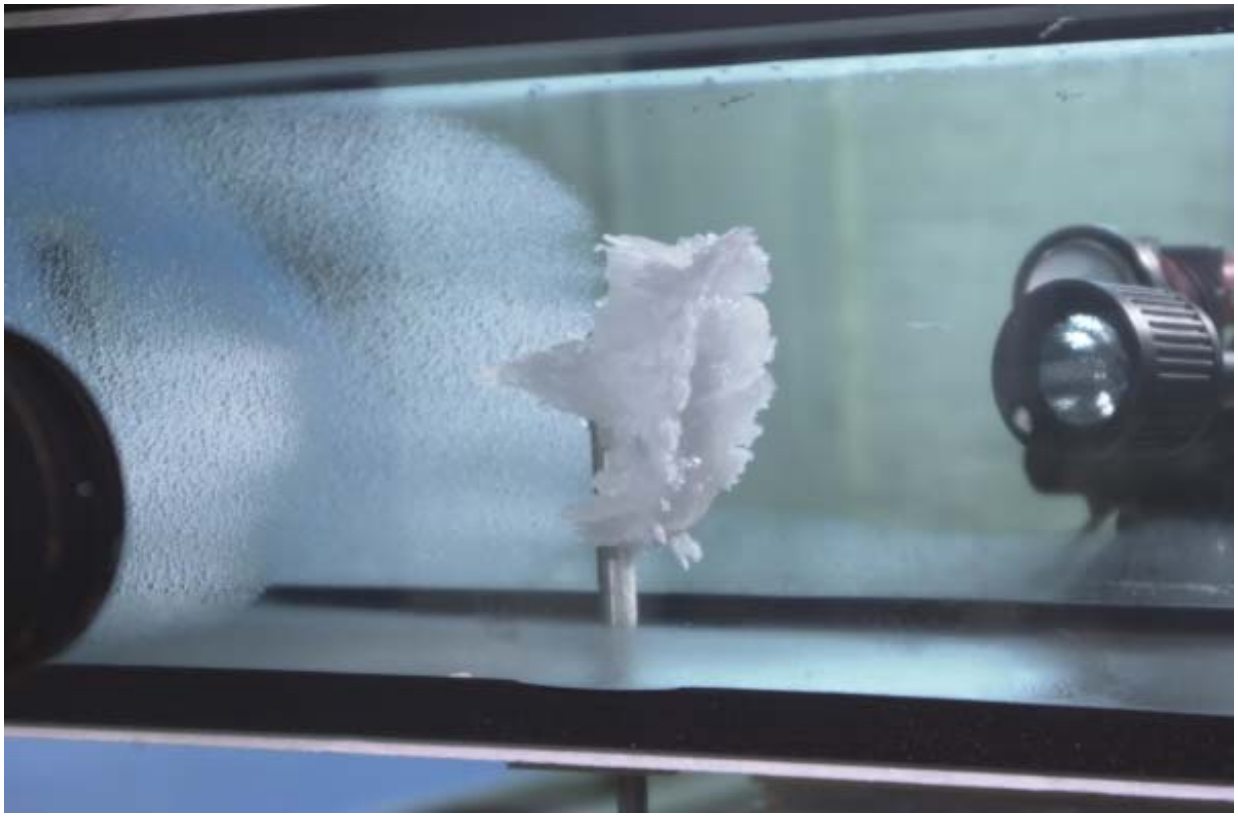
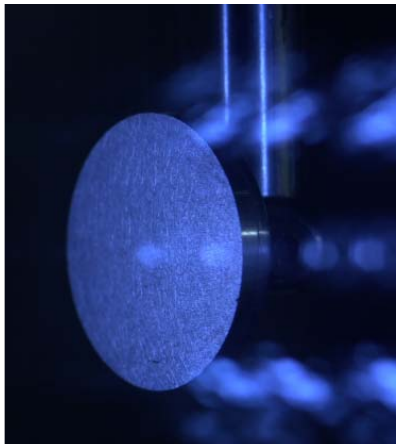
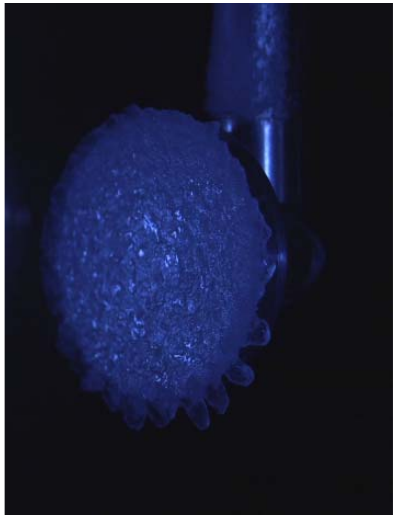
Test in the PAG– test target







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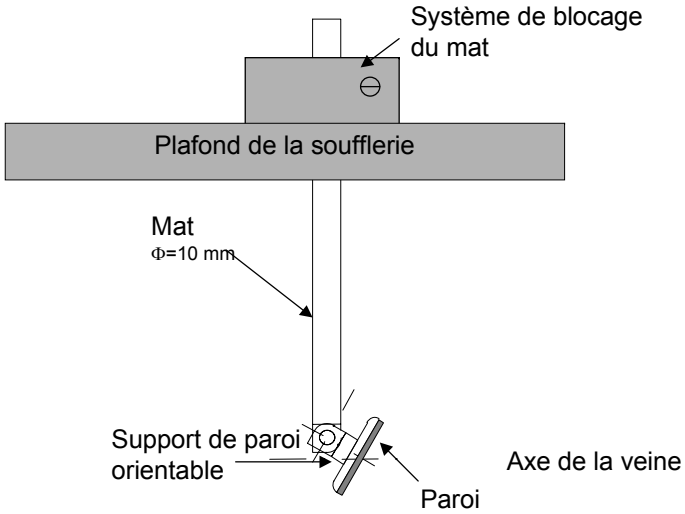
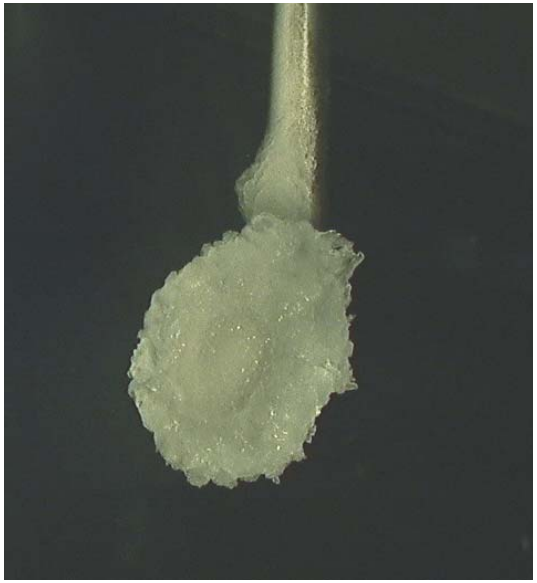
First target test





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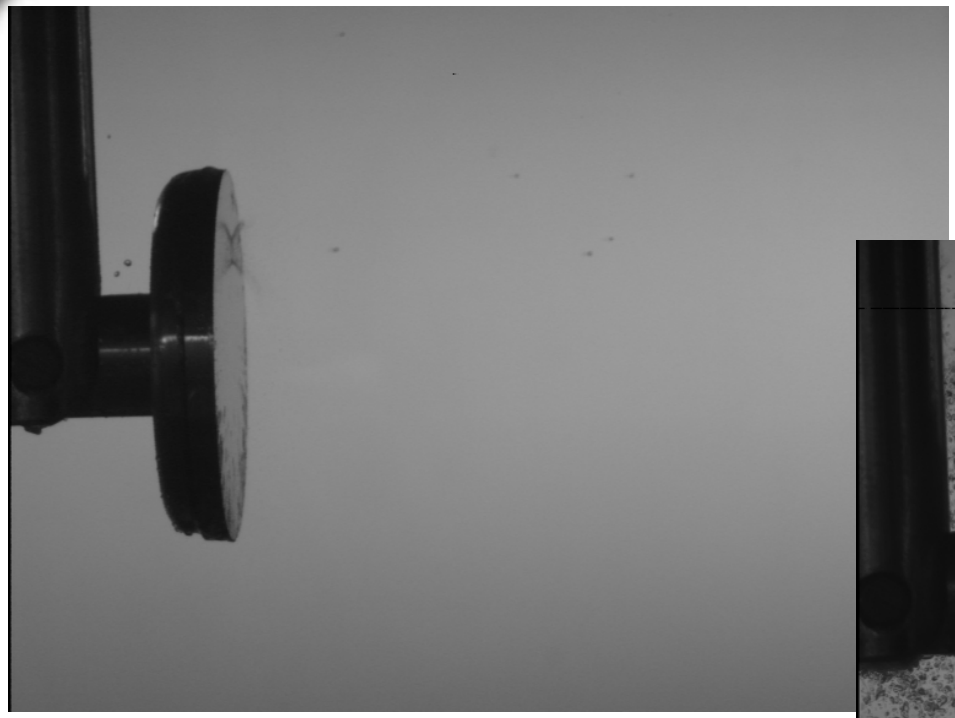
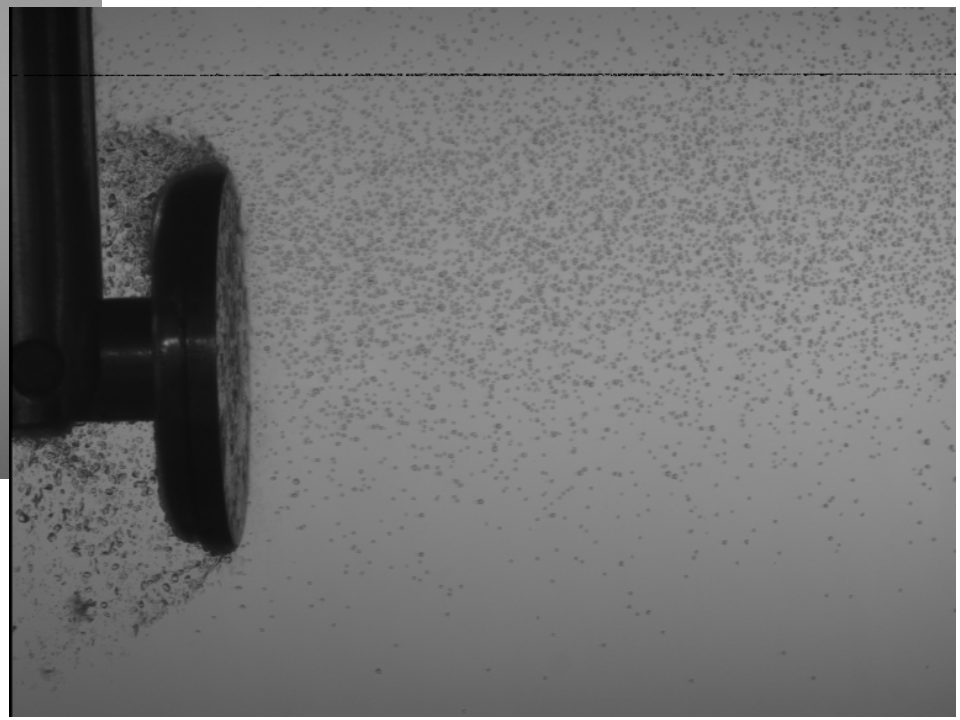
Droplet localization

Uair = 80 m/s



Instantaneous picture

1 000 pictures accumulation



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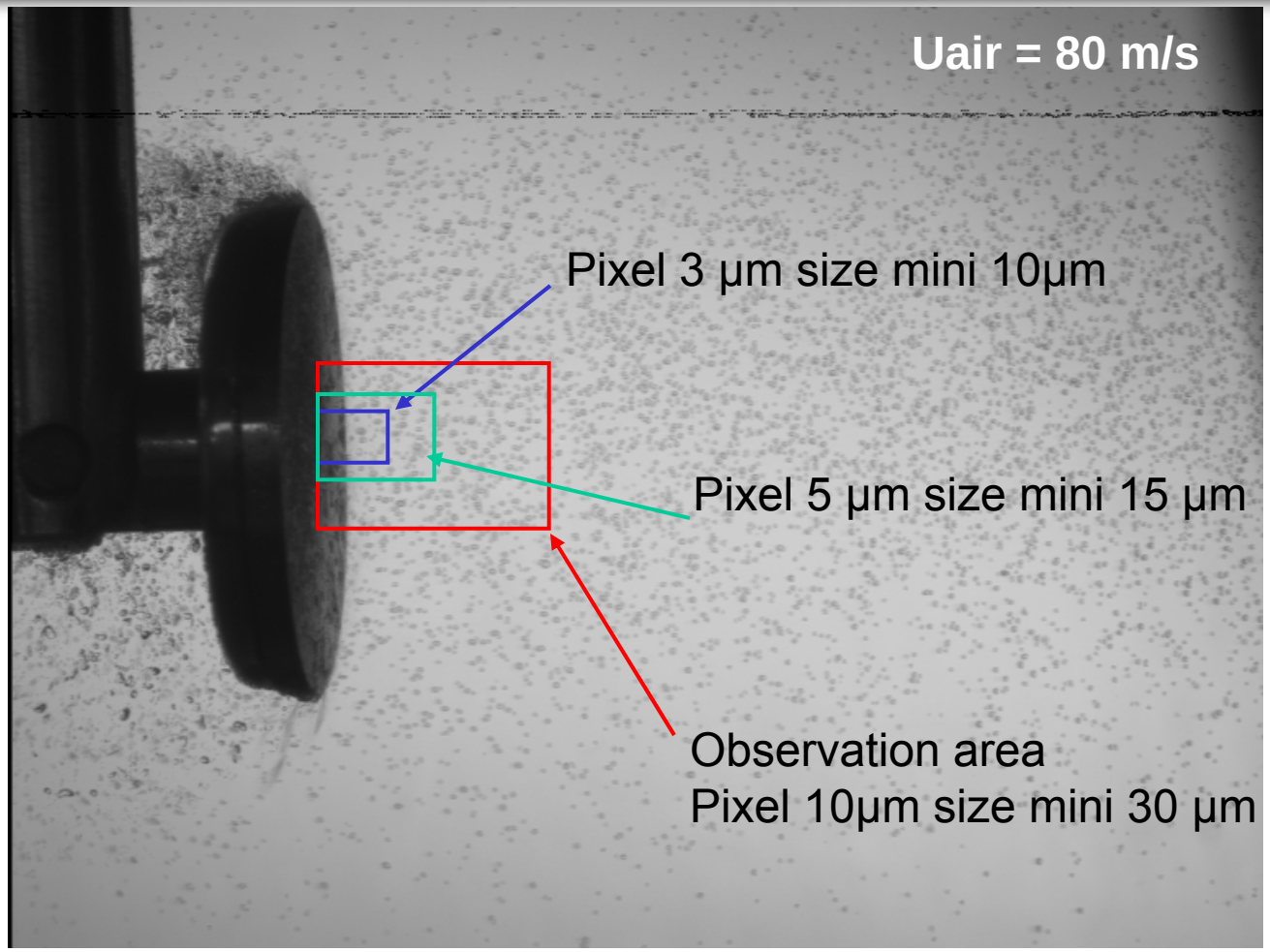
Particle size analysis at impact



1 000 pictures accumulation

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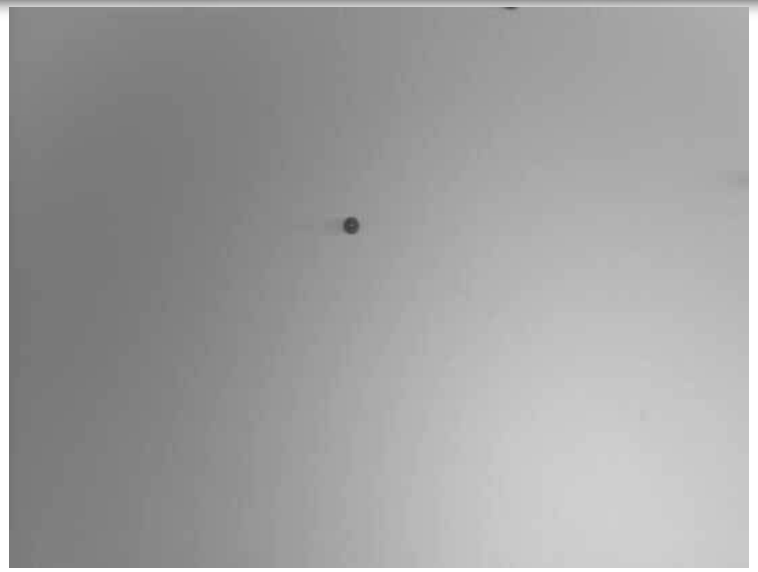
Dimension and velocity measurements

Droplet dimension

Pictures obtained with stroboscopic lighting;



Droplet area
=> Diameter

Droplet velocity

Pictures obtained with continuous lighting
Controlled duration

Line length

=> Droplet velocity

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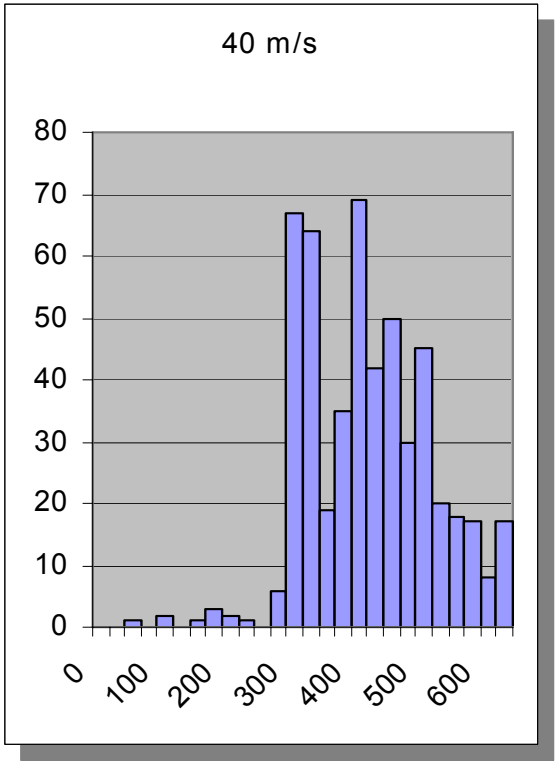
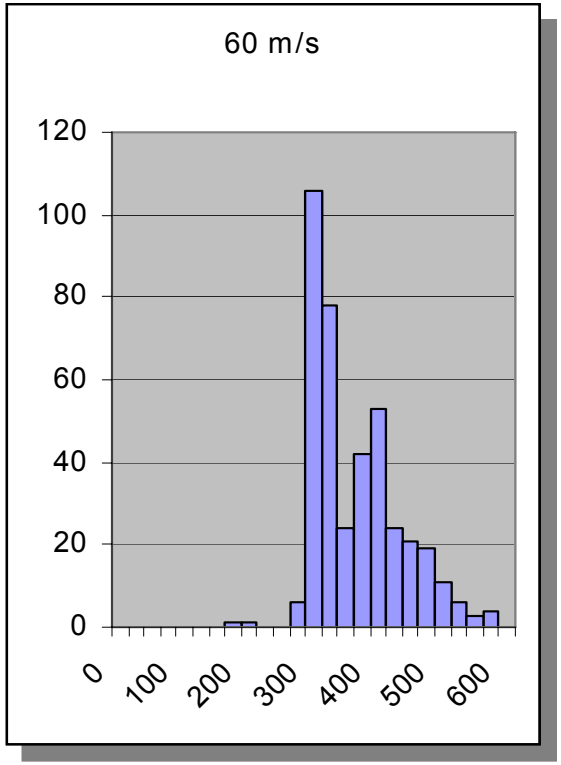
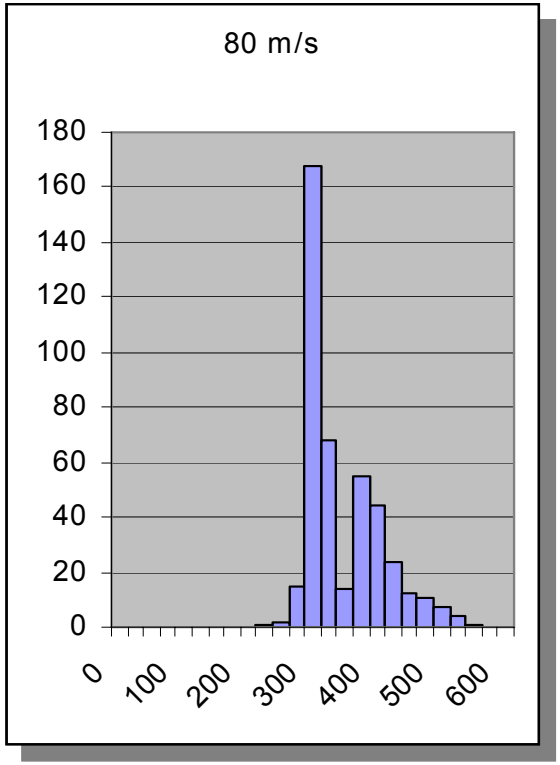
Dimension histogram before the impact

Initial diameter : 320 µm

Temperature -10°C







Air velocity : 40 m/s
D_{10} : 403 µm
D_{VM} : 472 µm

Air velocity : 60 m/s
D_{10} : 354 µm
D_{VM} : 390 µm

Air velocity : 80 m/s
D_{10} : 333 µm
D_{VM} : 368 µm

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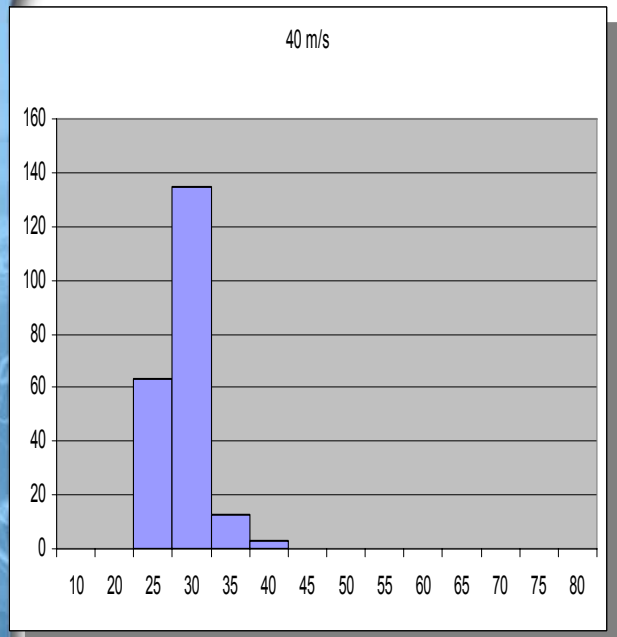
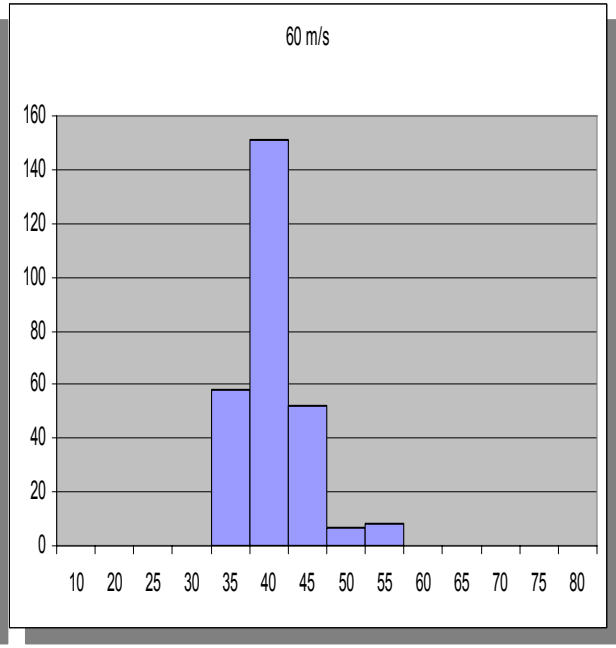
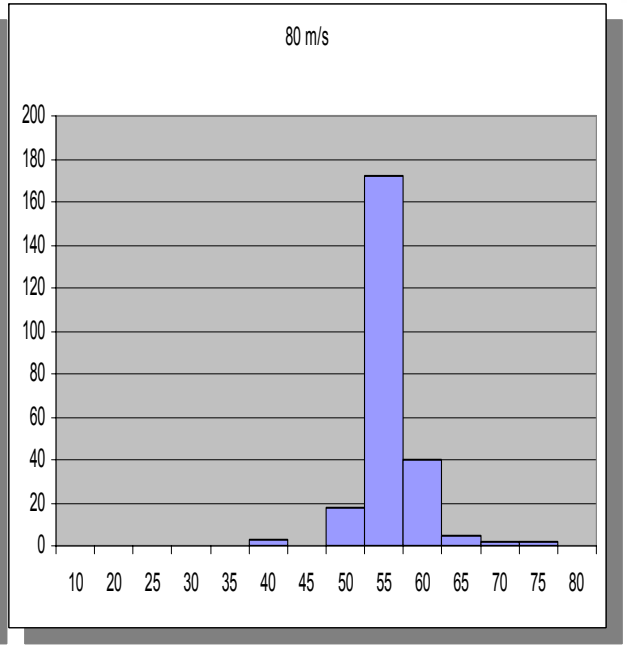
Velocity measurement

Initial diameter : 320 µm

Temperature -10°C







Air velocity : 40 m/s
Ug : 32 m/s
We : 6 600

Air velocity : 60 m/s
Ug : 45 m/s
We : 8 100

Air velocity : 80 m/s
Ug : 59 m/s
We : 14 700

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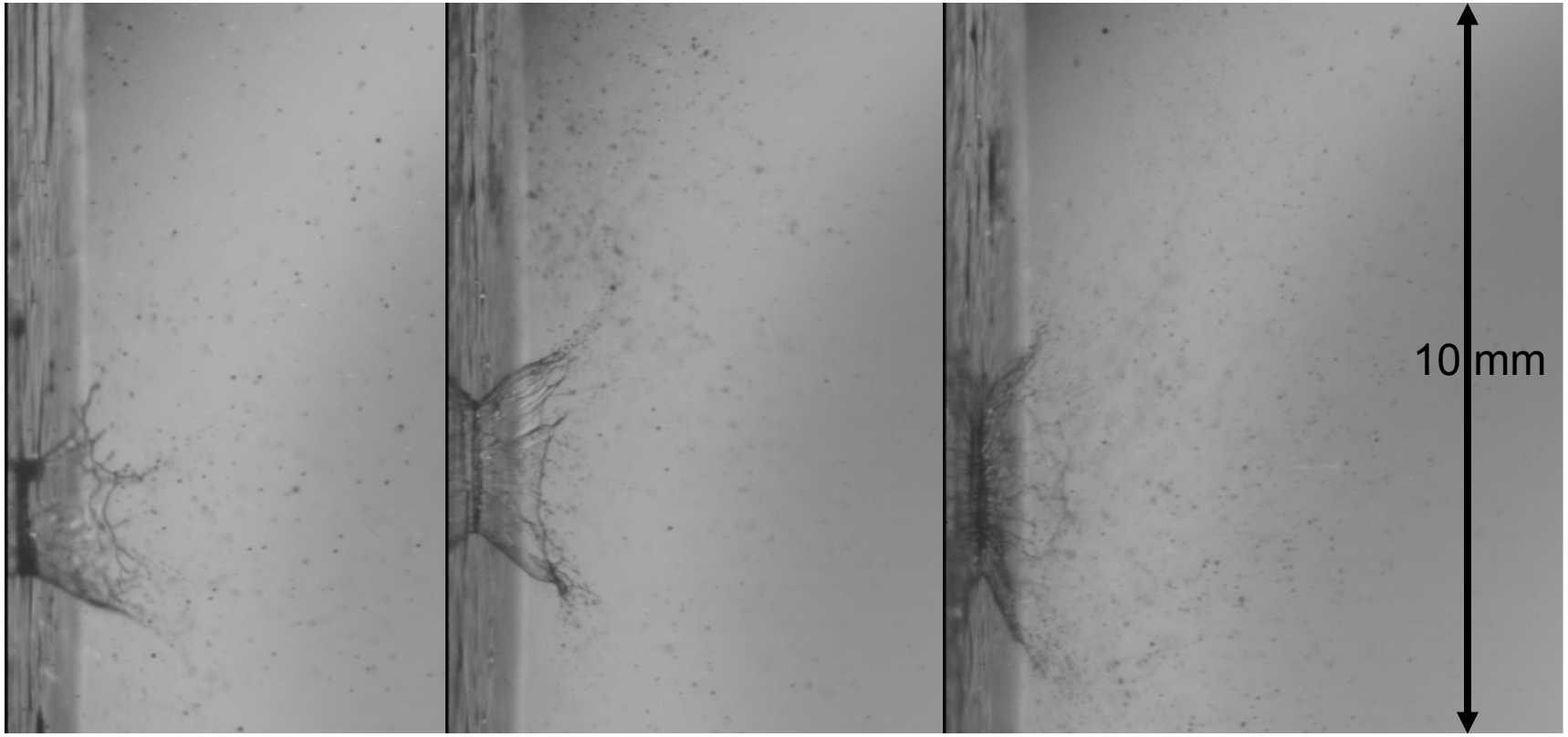
Comparaisons

Impact velocity



Air 40 m/s | Air 60 m/s | Air 80 m/s

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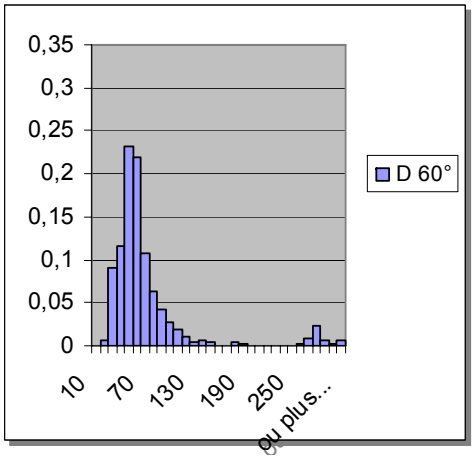
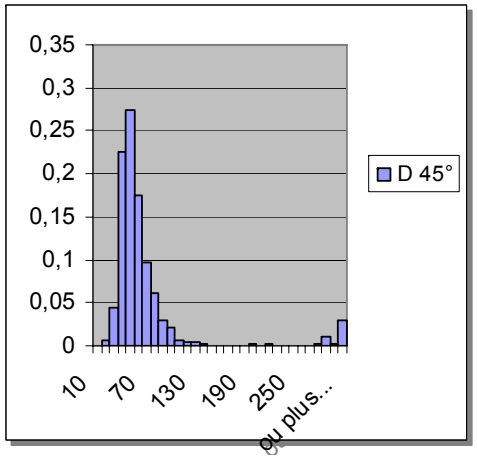
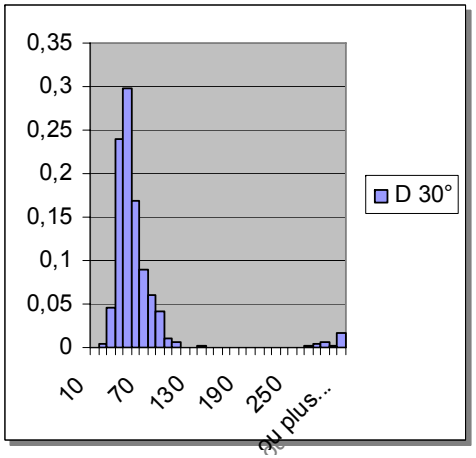
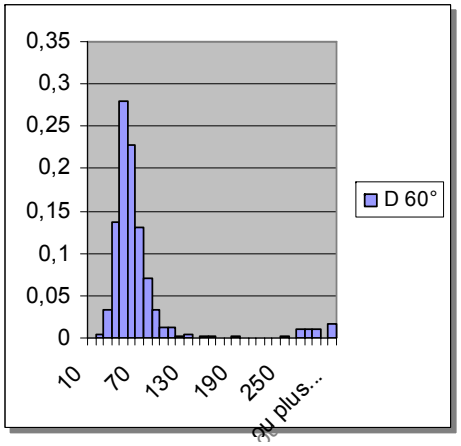
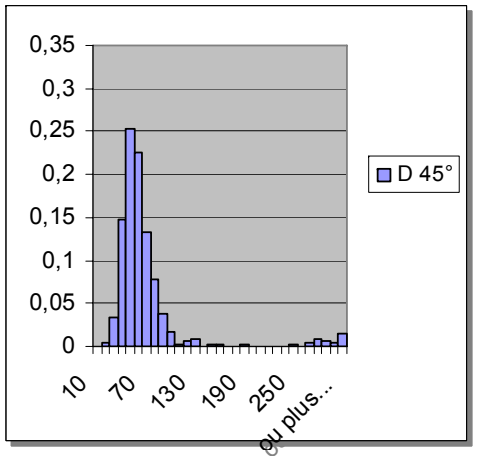
Particle size analysis after impact air 80 m/s – init Diam 320 µm

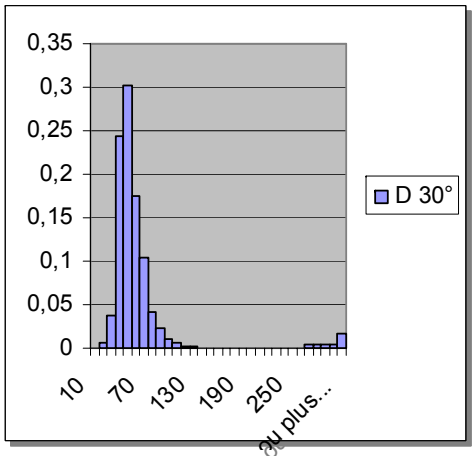












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particle size analysis after impact - Bilan

	80 m/s		60 m/s	
	D10	DVM	D10	DVM
90°	56	72	65	96
75°	58	81		
60°	55	84		
60°	54	53		
45°	51	50		
45°	55	74		
30°	50	68		
30°	49	65		

Not enough droplet for a reliable result

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Impact on a profil

Orifice 150 µm

60 m/s 80 m/s 100 m/s

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Conclusion

- Particle size analysis after impact
  - Difficulties due to the poor number of data
    - Increasing of the data capture frequency
    - Improvement of the optical components
    - Larger target
- Temperature effect on the splashing
    - If low effect, test will be conduct in laboratory
- Ice growth
    - Results to be validate
    - Possibility to determine an ice growth rate

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Conclusion

- Quantify and validate the formula used to modify the b value
- Introduce the droplet re-emission
- Open : introduce the droplet breaking up ?

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