Sedimentation of particles in drilling fluids

PIRE Project annual review
Trust III - Drilling fluids

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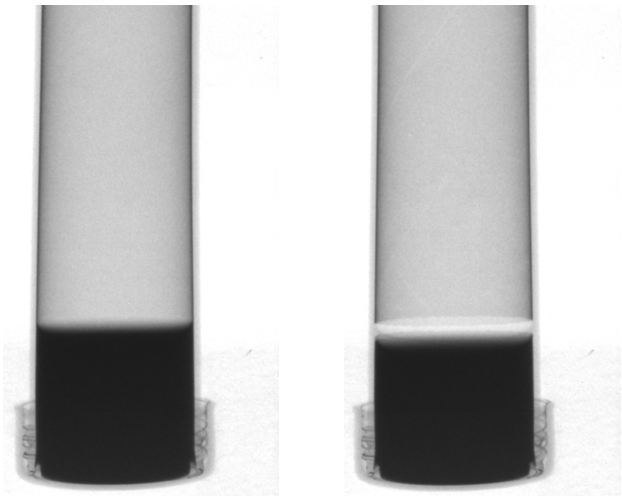
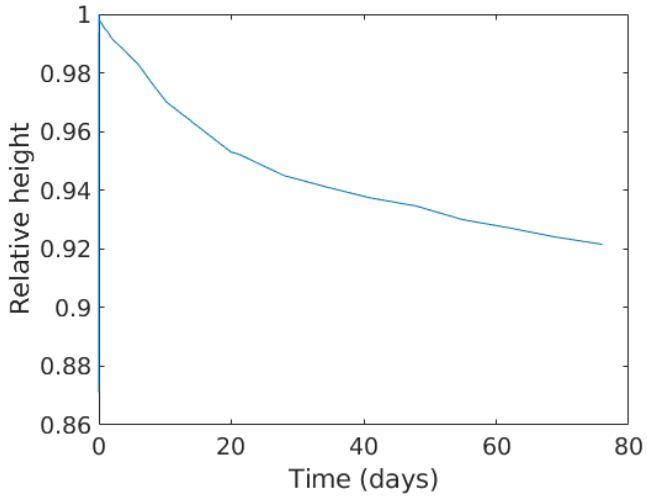
Plan

Fluid at rest: X-rays results

1 h **28 days**





- From 1 h after the tube is shaken, height of the interface decreases with time.
- After several days, a layer of liquid appears at the top of the drilling fluid.
- Compare with Santos et al. *J. Petrol. Sci. Eng.* (2018) : 80% of the initial height after one month.

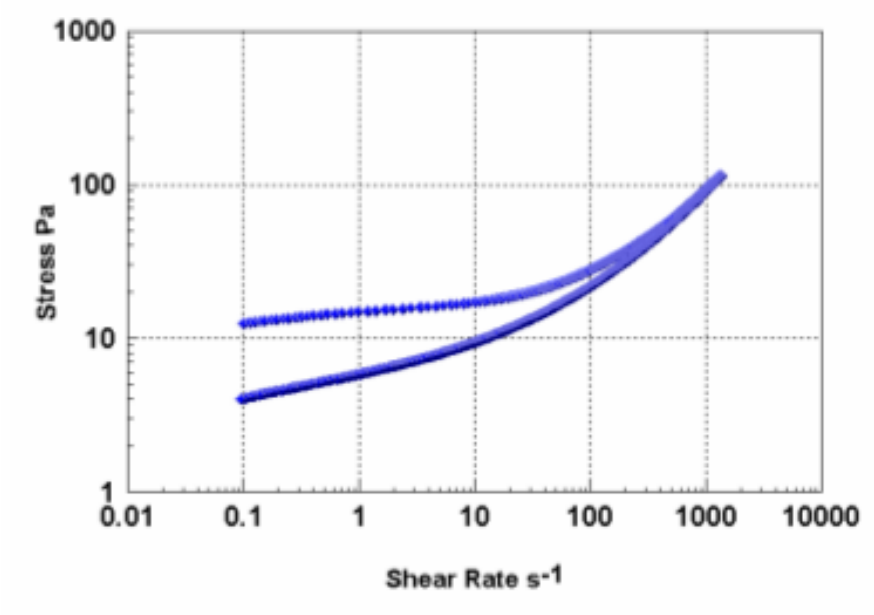
Fluid at rest: Perspectives

- Rheology of the different phases
- X-rays with model fluids:
  - Newtonian
  - Emulsions
  - Emulsion + nanoparticles

Plan

Sedimentation under shear: objectives

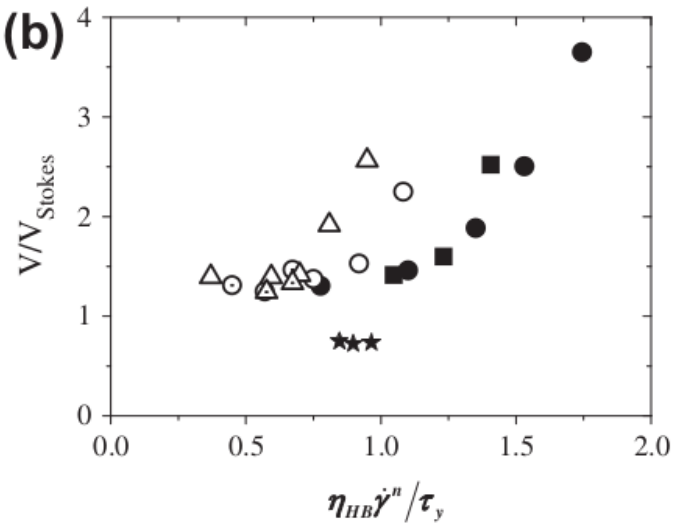
- How is sedimentation velocity affected by ...
  - ... fluid composition
    - Liquid droplets stabilized with surfactants
    - Thickeners: clay, polymers
  - ... rheological properties
    - Yield stress
    - Thixotropy



Jachnik (2003) *Ann. T. Nord. Rheol. Soc.*

Sedimentation under shear: objectives

- Ovarlez et al. (2012), *J. non-Newton. Fluid*
  - Yield stress fluids
  - Wide gap Couette
  - MRI



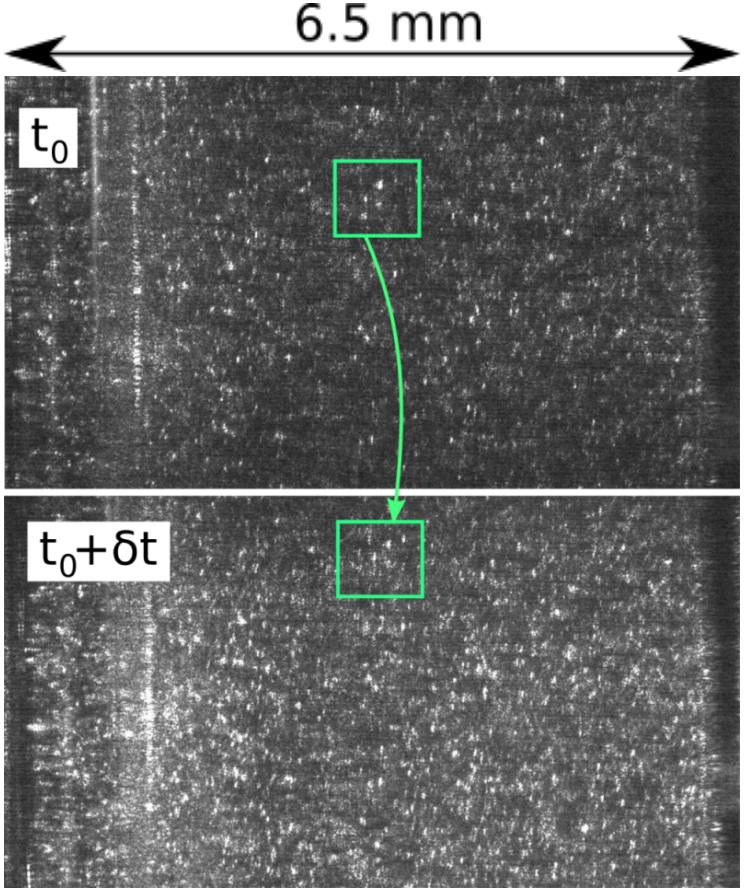
- Some objectives
  - Higher shear rates
  - Effect of emulsion droplet size on sedimentation
  - Transient flow
- Need to install experimental setup
  - Rheometer
  - PIV

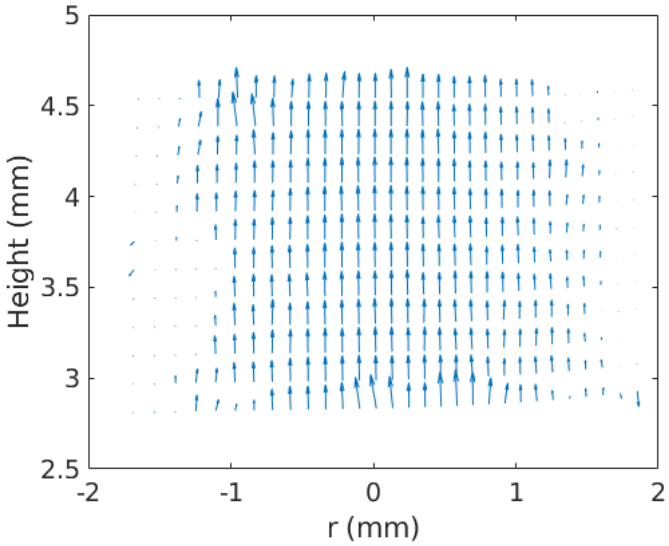
Methods: PIV (Particle image velocimetry)

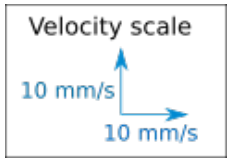
- Transparent fluid
- Particles
  - Passive $\Rightarrow$ velocity field of the flow
  - Active $\Rightarrow$ particle sedimentation
- Lighten a plane or a volume with a laser
- Cross correlation of two images

Methods: PIV (Particle image velocimetry)

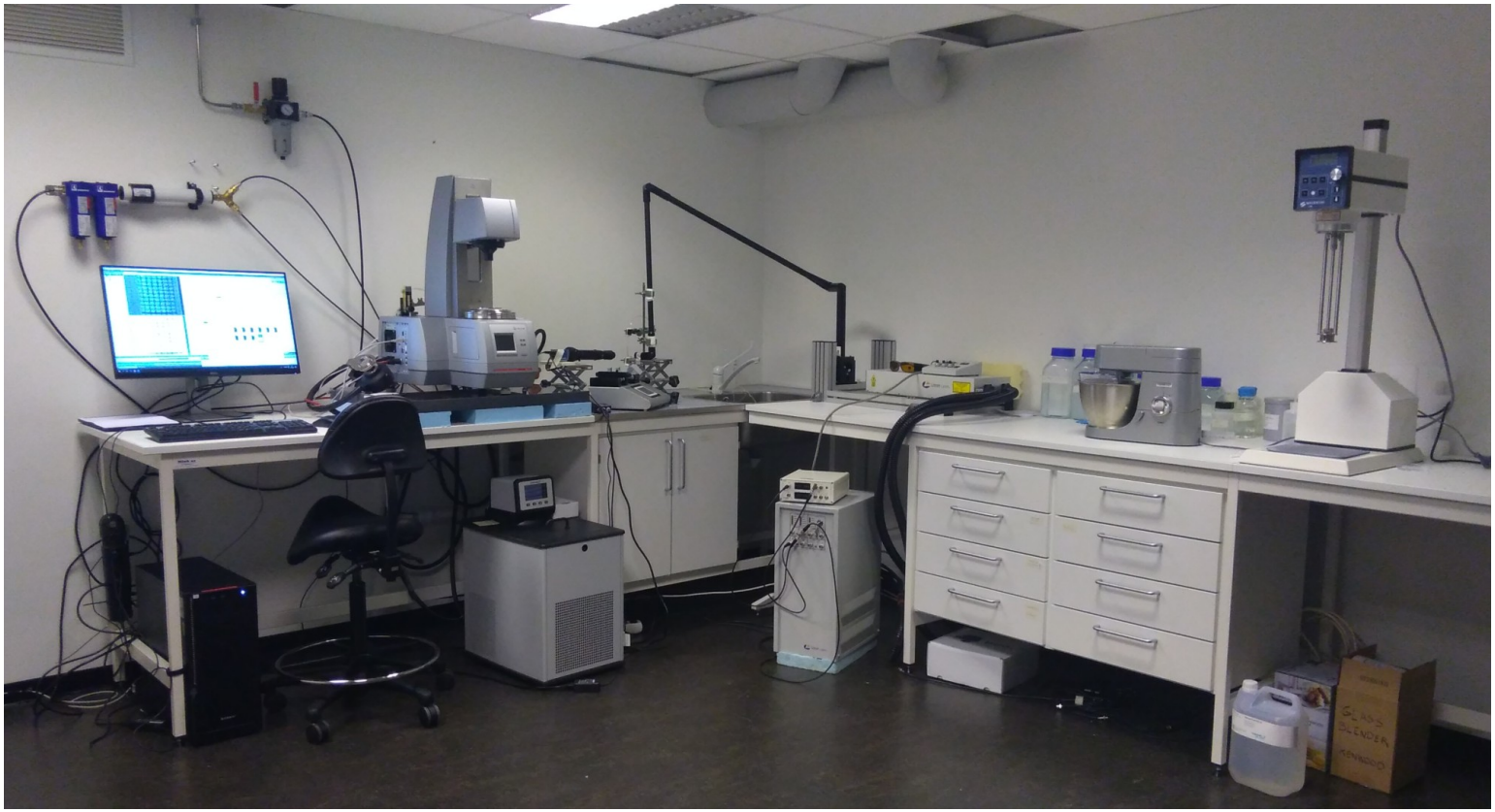
Example: passive particles in vertical pipe, upward flow







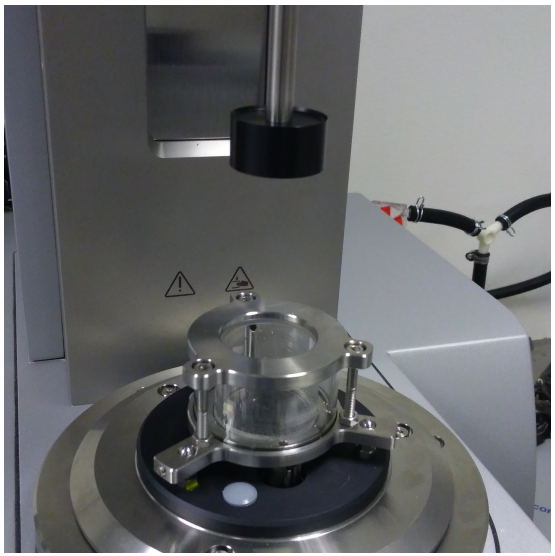
PIV setup: Laboratory

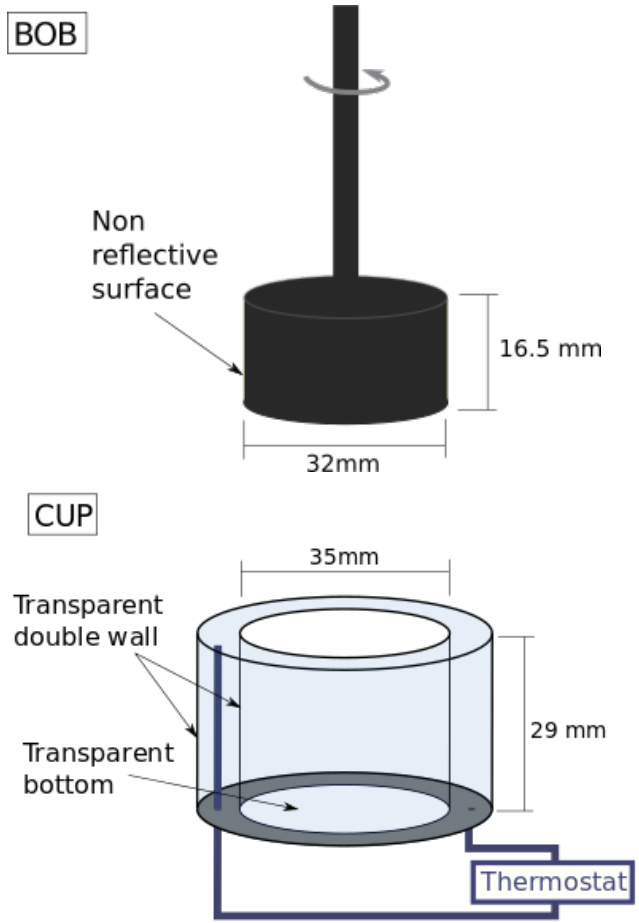


PIV setup in rheometer

Rheometer Anton Paar *MRC 702 TDR* with PIV cell *C-LTD 70/PIV*

- Couette cell
- Transparent walls
- Temperature regulation
- Gap 1.5 mm





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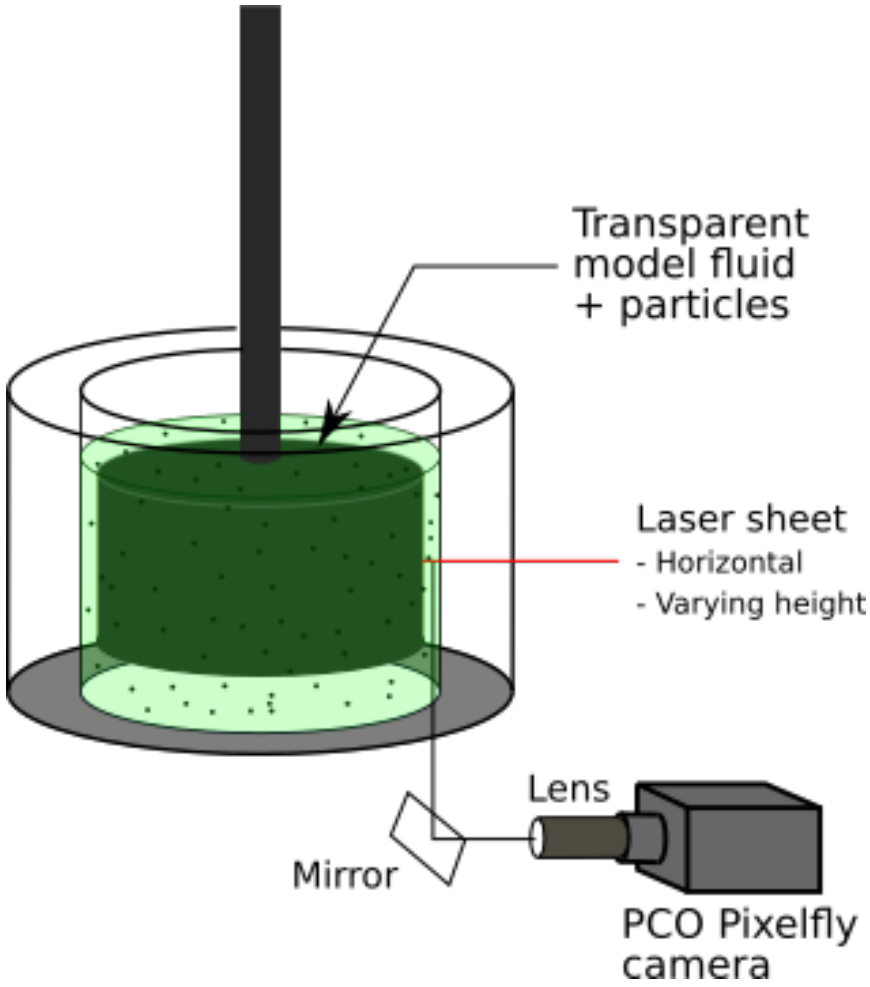
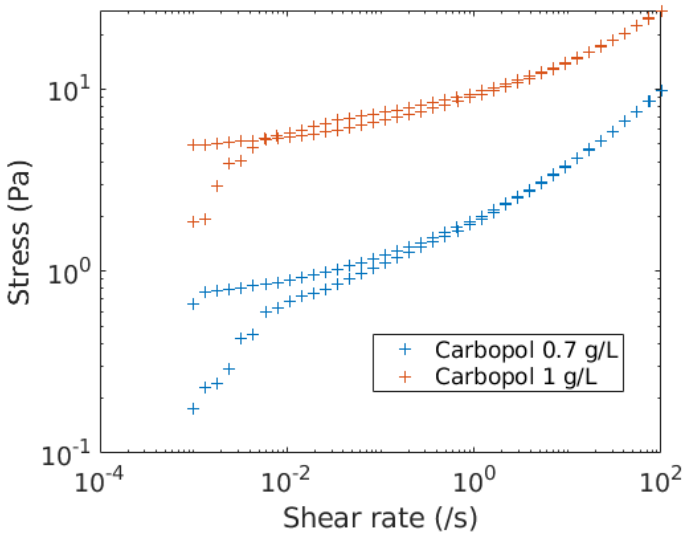
PIV setup in rheometer

- Field of view: 1 mm-6.5 mm
- Camera resolution: 6.45 μm
- Time interval: 1 μs ... 60 s

$\Rightarrow$ Velocity up to 6 m/s, i.e. shear rates up to 4000 s^{-1}.

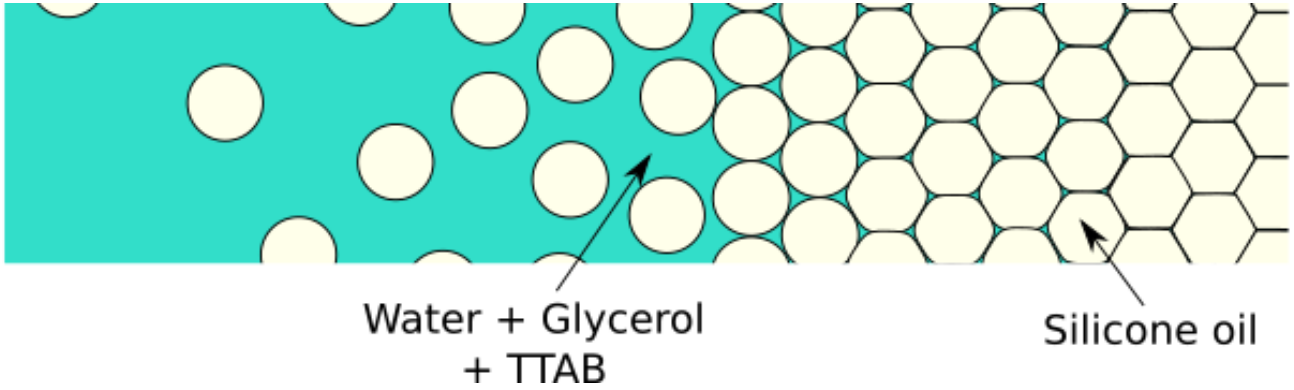


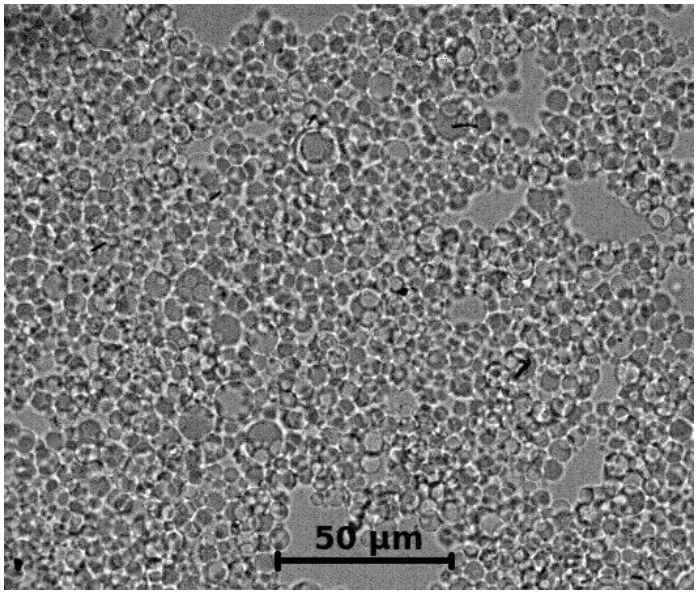
Model fluids: Carbopol 940



Concentration (g/L)	Spread test Yield stress
5	$>$ 100 Pa
1.5	96 Pa
1	13 Pa
0.7	6 Pa

Model fluids: transparent emulsions

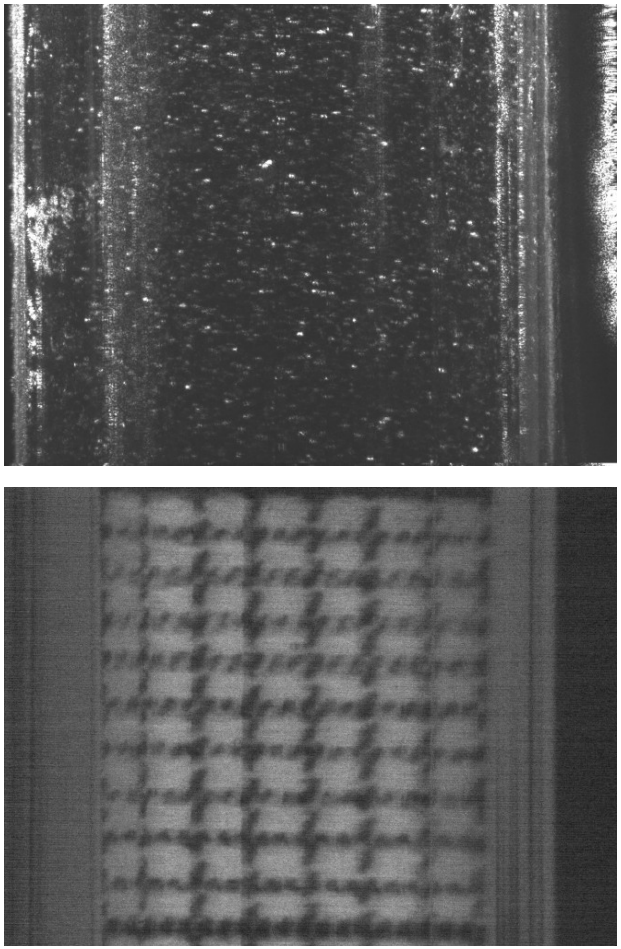




Yield stress depends on

- Droplet size
- Droplet concentration

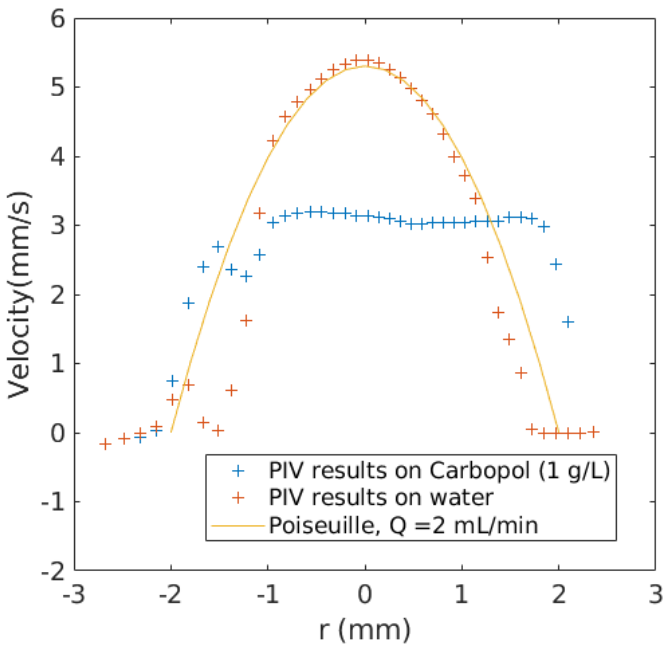
PIV in a 4mm diameter tube



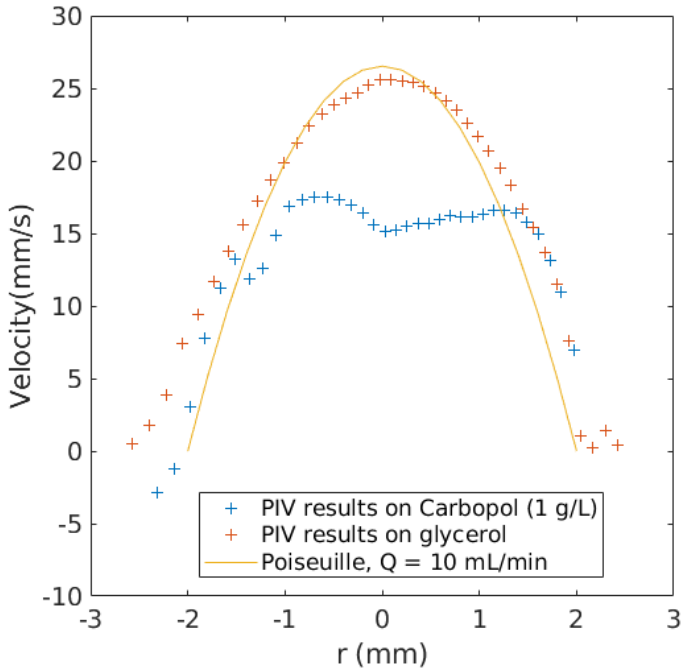
- With 5 μm seeding particles
- Average on 50 image pairs
- Calibration grid to take into account the image deformations due to the camera and the tube

PIV in a 4mm diameter tube

- Field of view 6.5mm
- Q=2 mL/min
- Re $\sim$ 1 for water

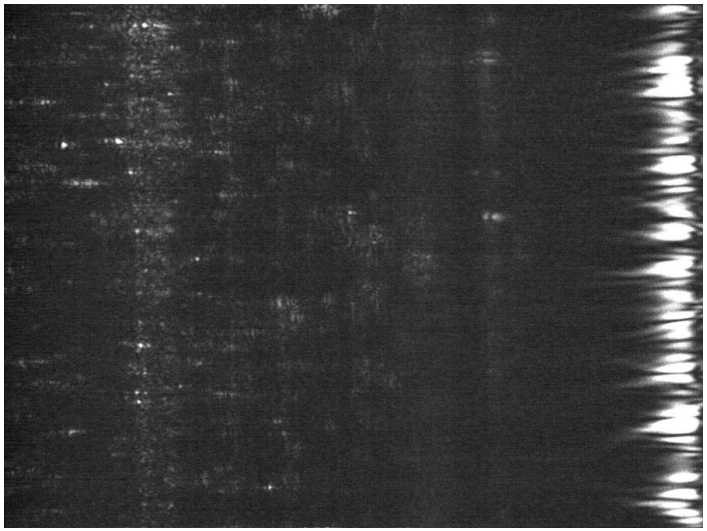


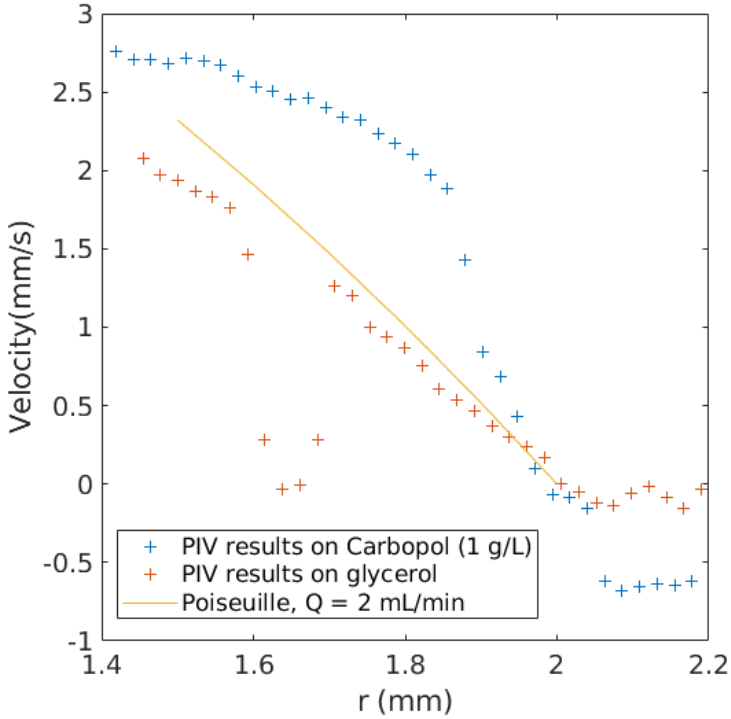
- Field of view 6.5mm
- Results, Q=10 mL/min
- Re $\sim$ 0.1 for glycerol



PIV in a 4mm diameter tube

- Field of view 1mm
- Q= 2 mL/min
- Re $\sim$ 0.01 for glycerol





Thank you for your attention

Any questions / comments ?