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Rheology of a granular medium mixed with flexible fibers (vane geometry)

L Wierzhalek, B Darbois-Textier, Georges Gauthier

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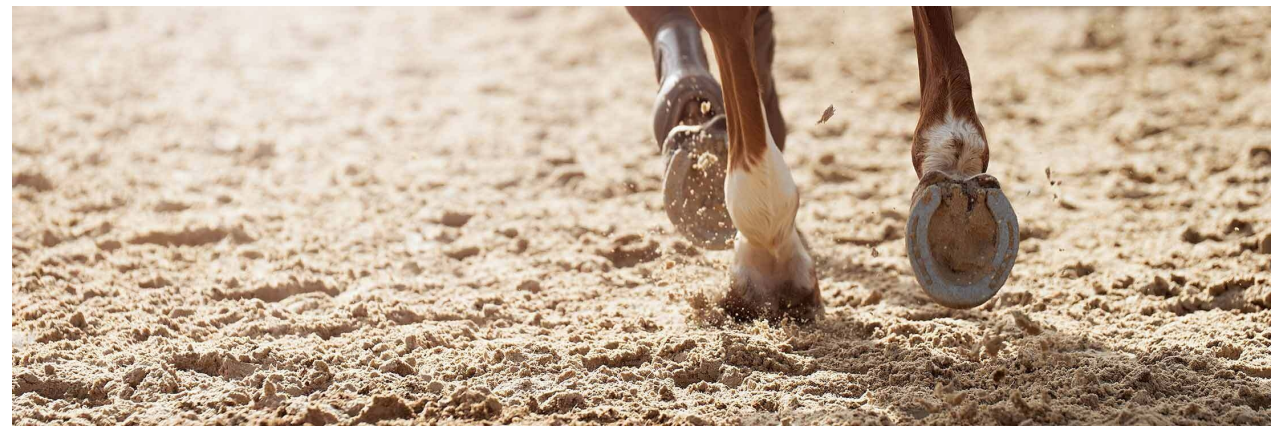
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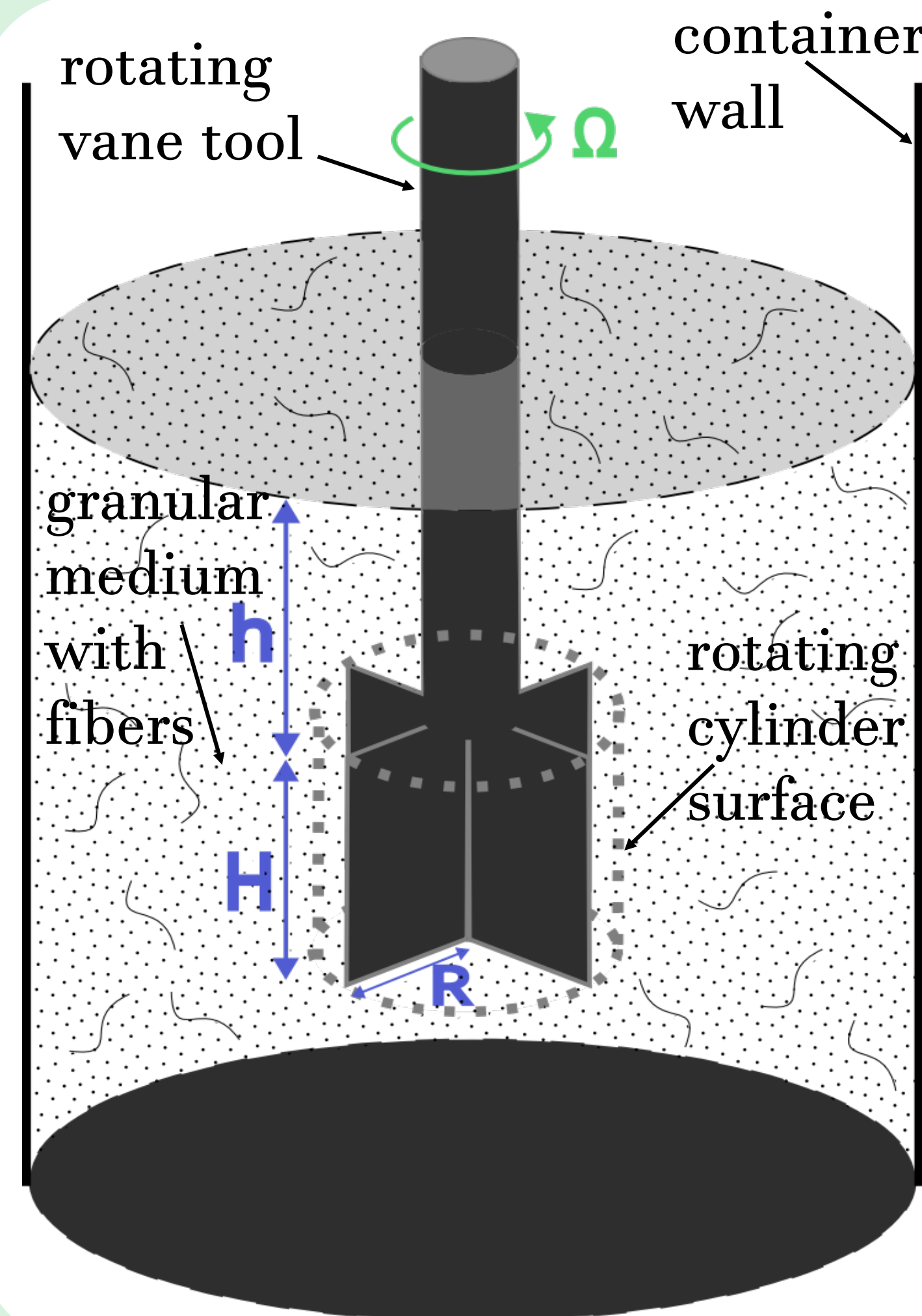
HAL Authorization

Rheology of a granular medium mixed with flexible fibers

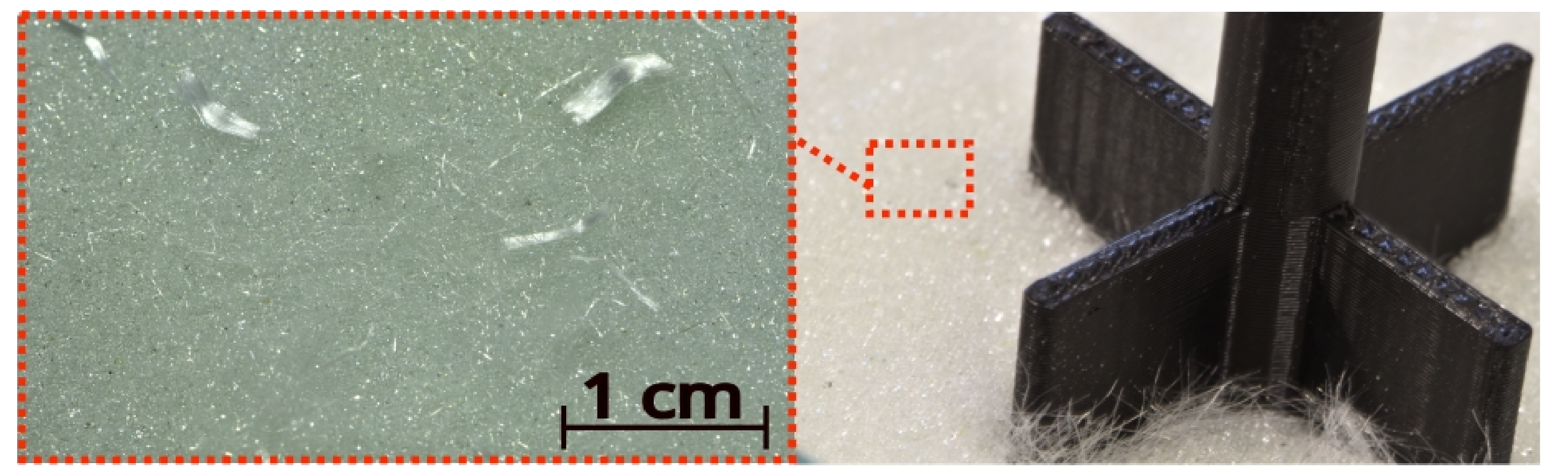
CONTEXT



Concrete mixed to fibers to strengthen the medium, and sand mixed to fibers in horse riding context



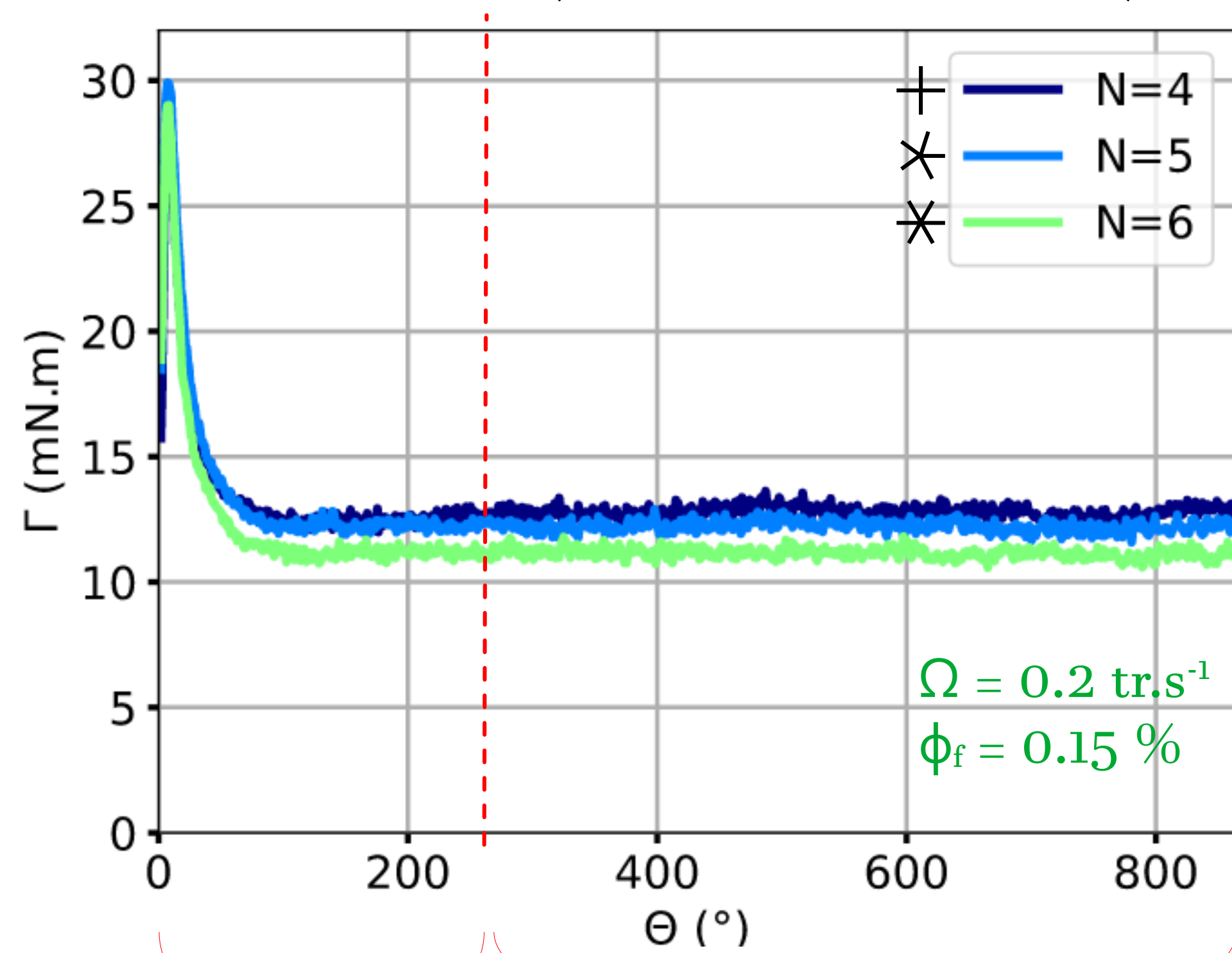
EXPERIMENTAL SET-UP



- Glass beads : Diameter $d = 300 \mu\text{m}$
- Polypropylene fibers : Young Modulus = 1.3 GPa
Length $L = 6 \text{ mm}$
Diameter $D = 30 - 100 \mu\text{m}$
Aspect ratio $r = L/D = 200 - 60$

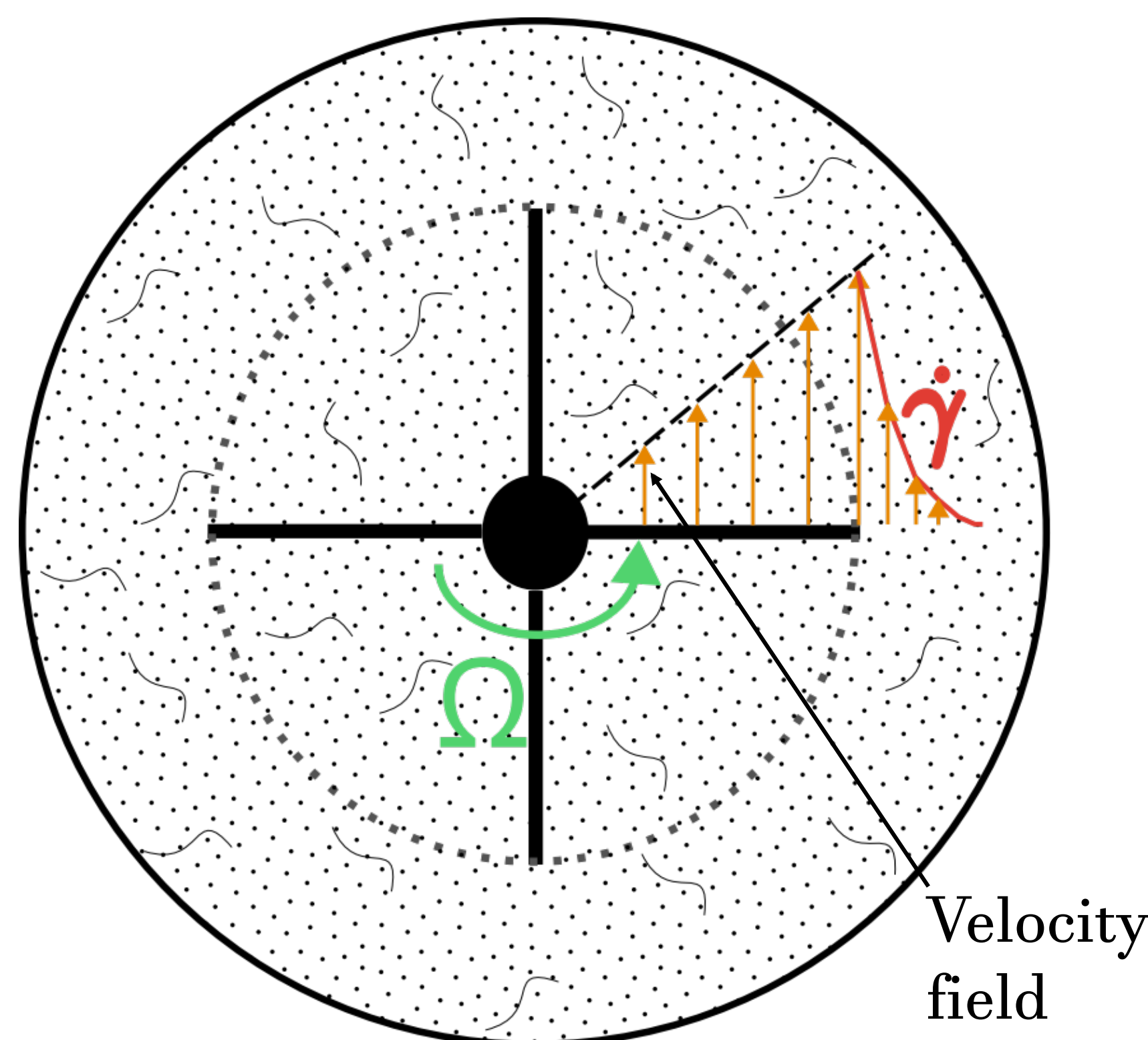
MEASUREMENT AND MODEL

- The torque measured by the rheometer with fixed rotation speed and given volumic fraction is the following one ($N =$ number of blades) :



Transient regime

Stationary regime



$$\text{Inertial number : } I = \frac{\dot{\gamma}d}{\sqrt{P/\rho}}$$

$$\text{Hydrostatic pressure : } P \sim \rho_{eff}gh$$

- In the stationary regime, the torque measured is equivalent to the torque exerted on a cylinder :

$$\Gamma_{side} = \mu\pi R^2 \rho_{eff}g(H^2 + 2Hh)$$

$$\Gamma_{bot} = \mu \frac{2\pi}{3} R^3 \rho_{eff}g(H + h)$$

$$\Gamma_{th} = \Gamma_{side} + \Gamma_{bot} \quad \text{Daniel R.C, et al. PT (2008)}$$

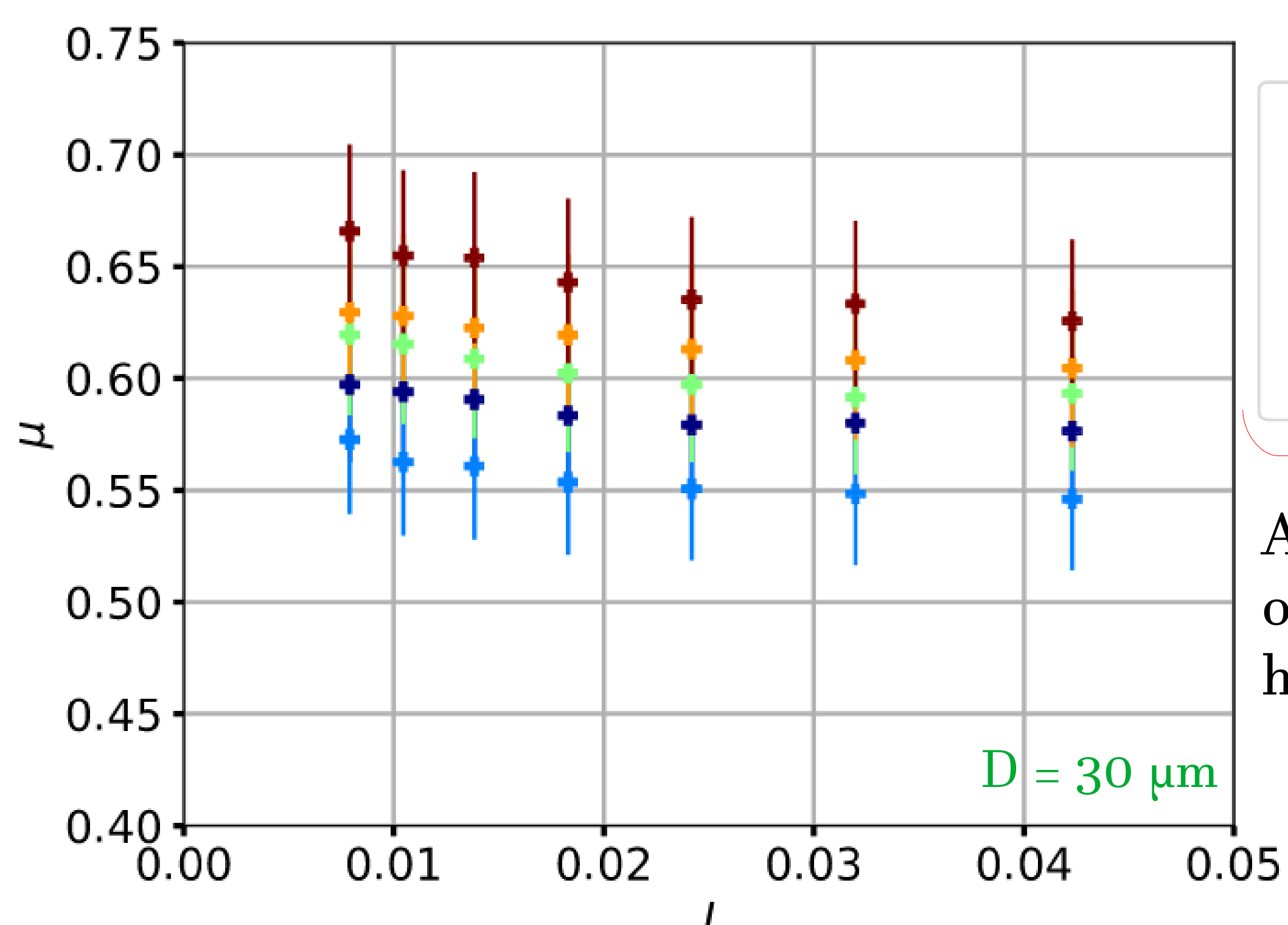
$$\widetilde{\Gamma}_{th} = \mu \Gamma_{th}$$

$$\frac{\Gamma_{exp}}{\widetilde{\Gamma}_{th}} = \mu$$

- From the torque measured in the stationary regime, one can deduce the effective friction coefficient μ of the fibers granular mixture

RHEOLOGY

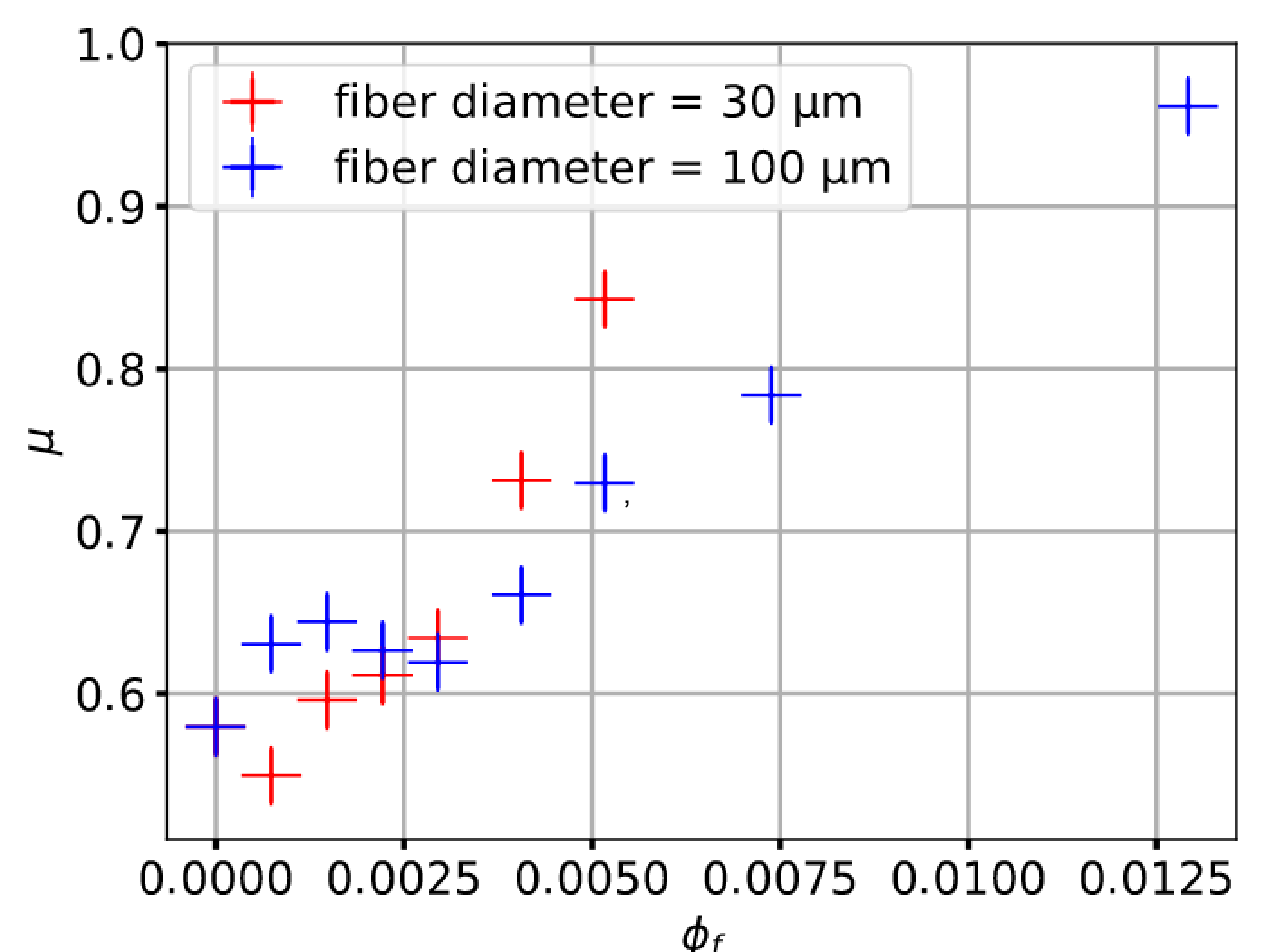
- One can observe the effect of the volumic fraction of fiber and the rigidity of the fibers on the effective friction coefficient of the mixture :



- The higher the volumic fraction of fibers, the higher μ

- For ϕ_f fixed, μ is constant in the range of inertial number explored

Above these volumic fraction of fibers, the medium is not homogeneous anymore



- The stiffer fibers, the higher increase of μ with volumic fraction ϕ_f

CONCLUSION AND PERSPECTIVES

- Low volumic fraction of fibers induces a clear increase of μ for the mixture
- Stiffness of fibers plays a role in the evolution of μ with the volumic fraction of fibers

- Test different lengths of fibers and more fibers with different stiffness
- More complex flow configurations like inclined plan or rotating drum