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MINES
Saint-Étienne

Jamming/flowing transition of a non brownian suspension

Crossroads of Particle Science and Technology Joint conference

INSPIRING INNOVATION INNOVANTE PAR TRADITION

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Context and objective of this study

- **Pipe blockage : appearance and understanding of the phenomenon**

System and Material	% Solids by Mass	Flow Regime	Top Size Particle (mm)	Major Blockage Problems	Pressure Loss
Osborne Mine thickened tailings	65–78%	Turbulent	2 mm	No	Low
Stab-flo coal transport	61%	Laminar	0.5	Yes	Low
Limestone pipeline	56–60%	Laminar	0.2–0.3	Yes	Low
Paste backfill systems	75–80%	Laminar	0.2–0.5	Varies	High
Kimberley CTP	50–55%	Laminar	1–1.6	No	High

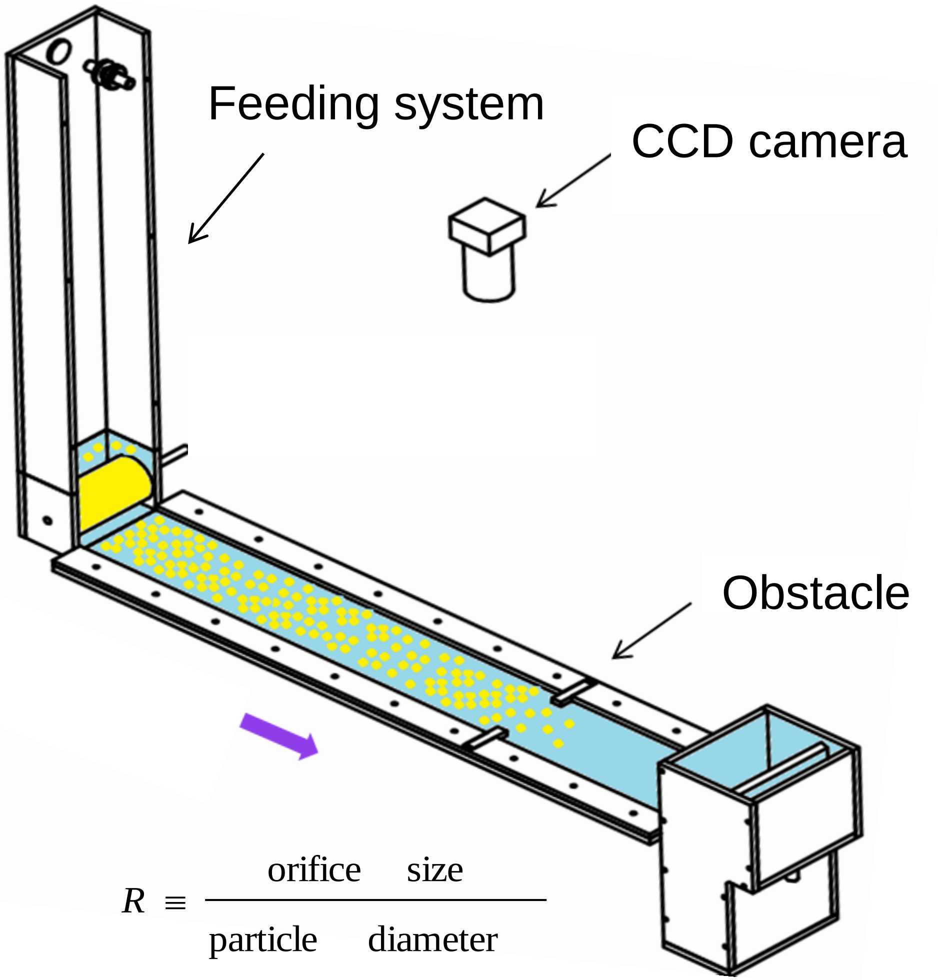
- **Studied case: Jamming induced by an obstacle whose role is to simulate particles attached to the wall**

Experimental device >> Particles characteristics

- Neutrally buoyant : PE in water + glycol
- Size: D = 6 mm
- 2 Morphologies :

Spheres
AR = 1

Squeezed spheres
AR= 0.8



$$R \equiv \frac{\text{orifice size}}{\text{particle diameter}}$$

Experimental device >> Flow characteristic

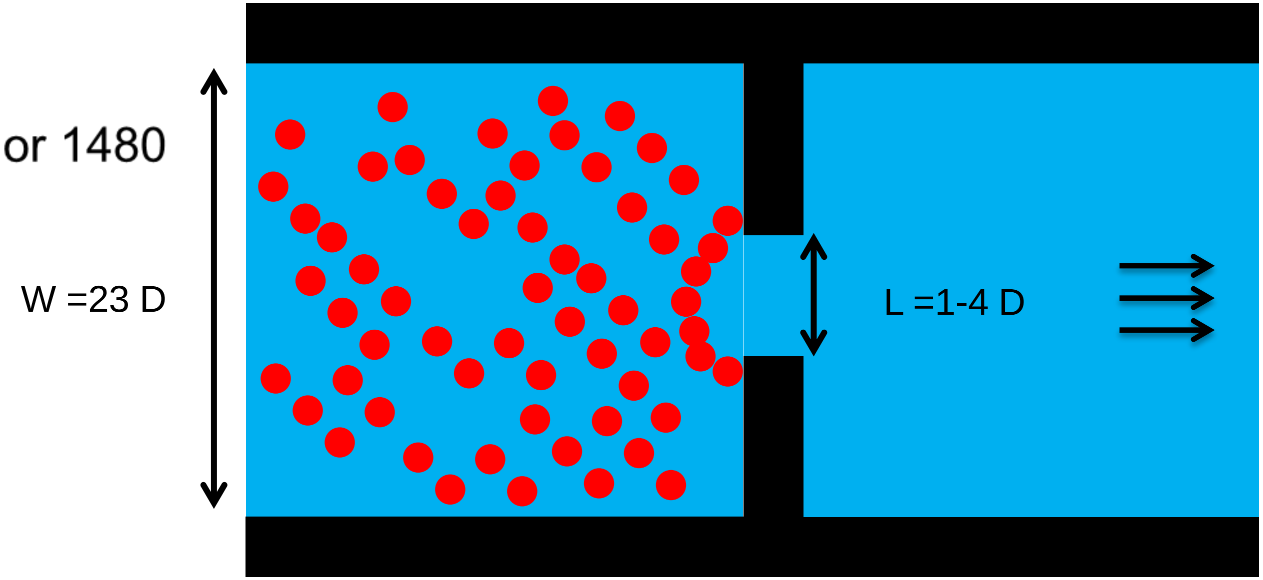
- Laminar: Re = 185, 740 or 1480

- St < 0.015 << 1

$$St = \frac{\rho_p d_p^2 v_f}{18\mu l}$$

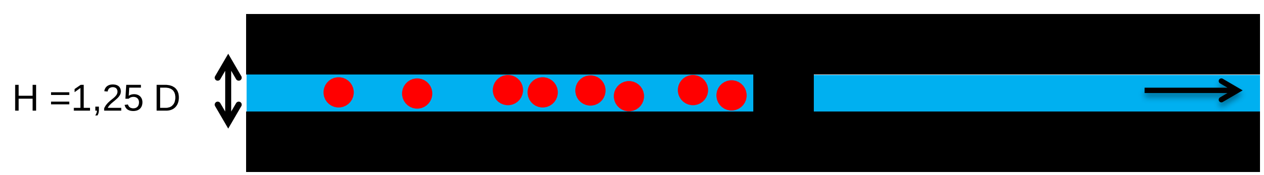
- $Pe > 10^4 >> 1$

$$Pe = \frac{6\pi\mu_f d^3 \dot{\gamma}}{k_B T}$$



Top view

Side view



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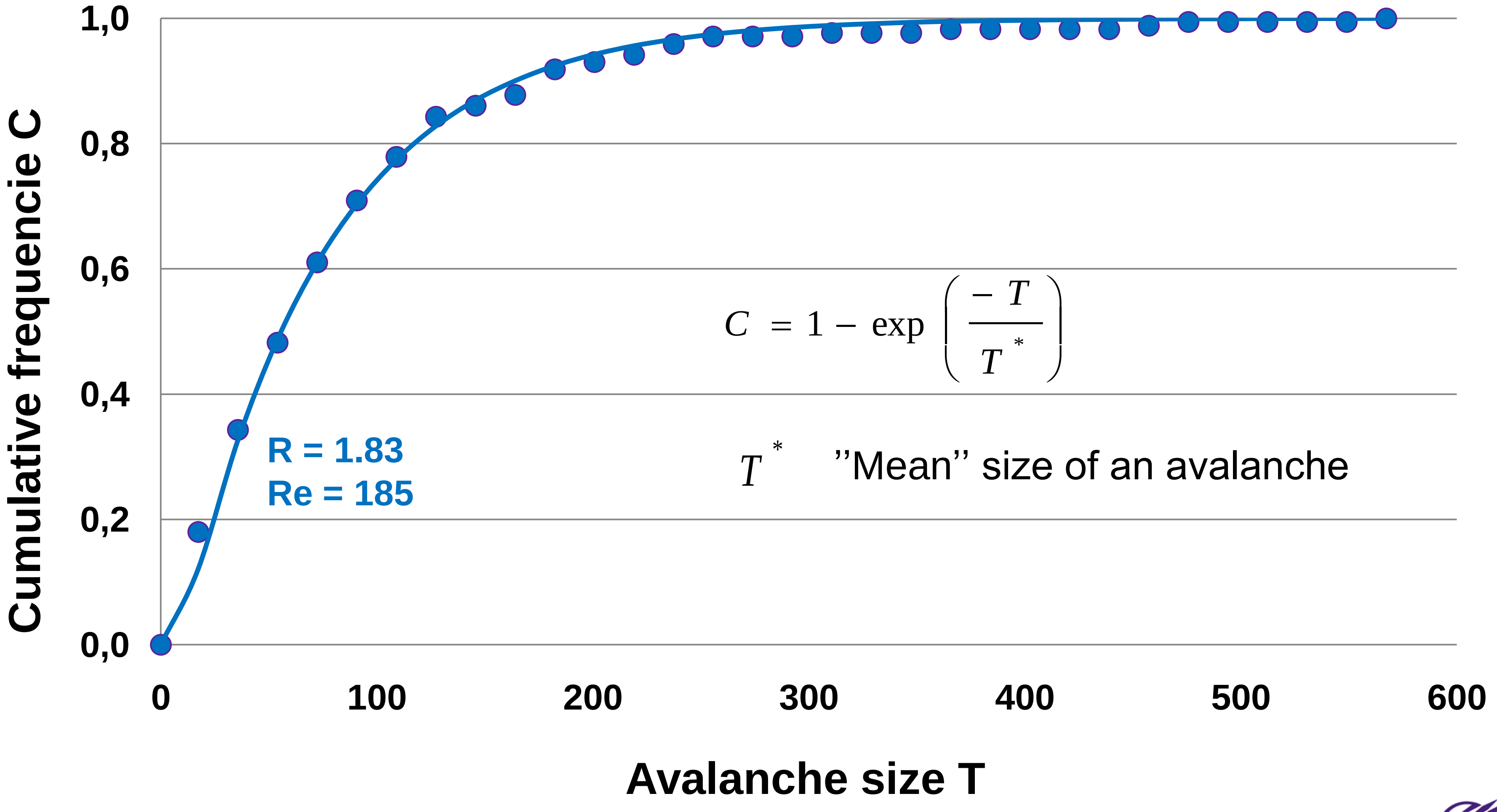
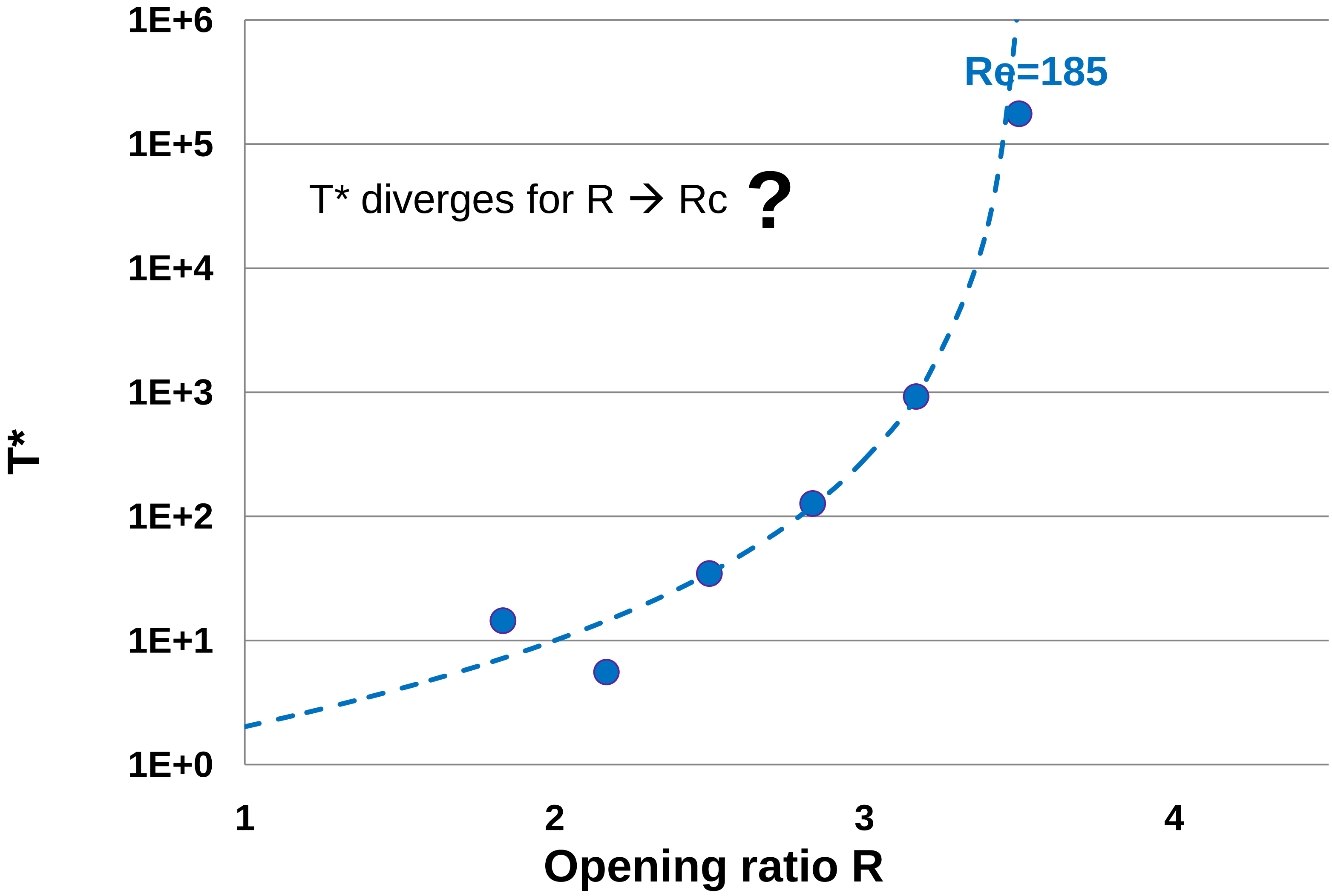
Distribution function



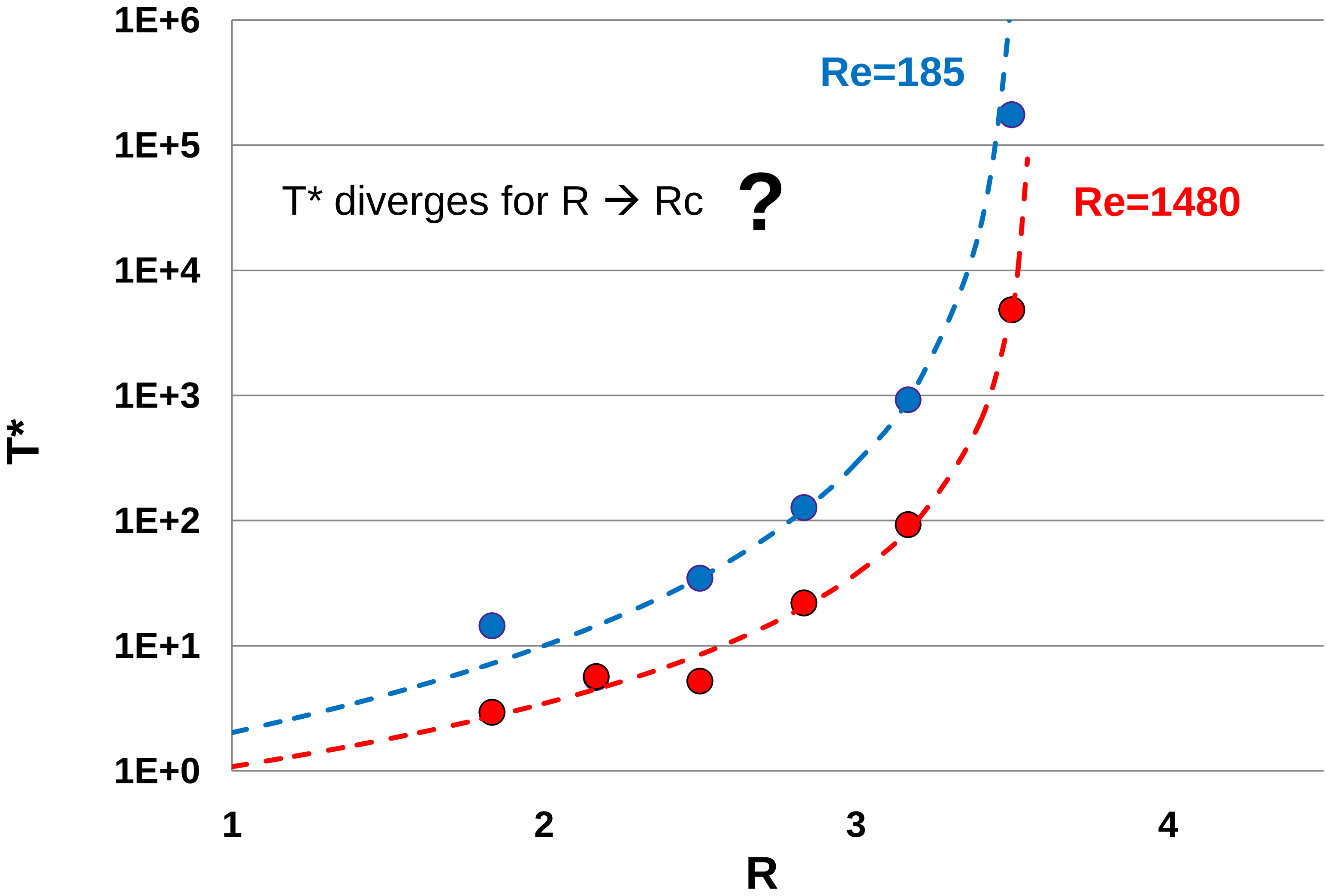
$$C = 1 - \exp\left(\frac{-T}{T^*}\right)$$

T^* "Mean" size of an avalanche

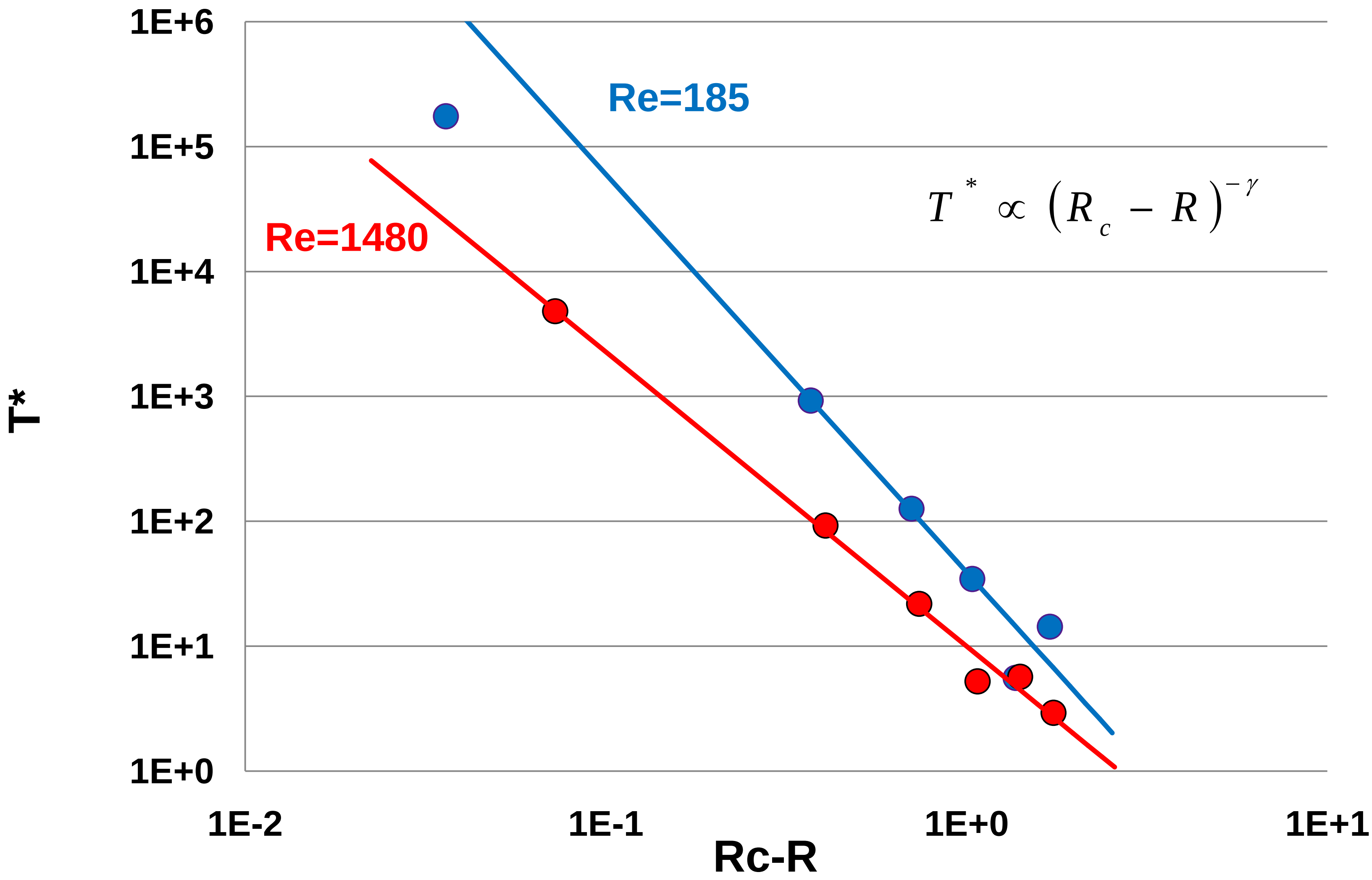
Results for spheres



Results for spheres >> Influence of Re

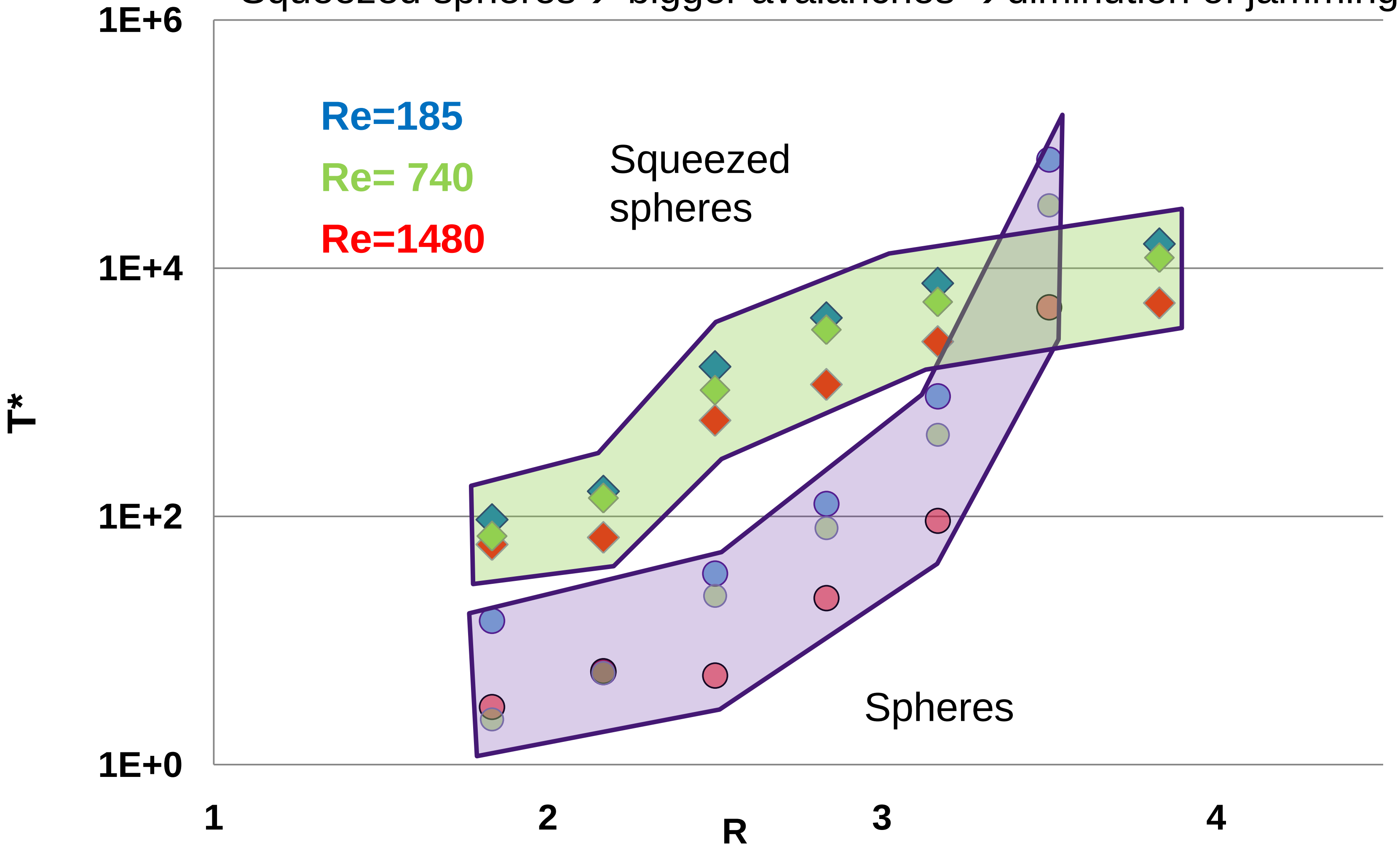


Results for spheres>> Power law divergence

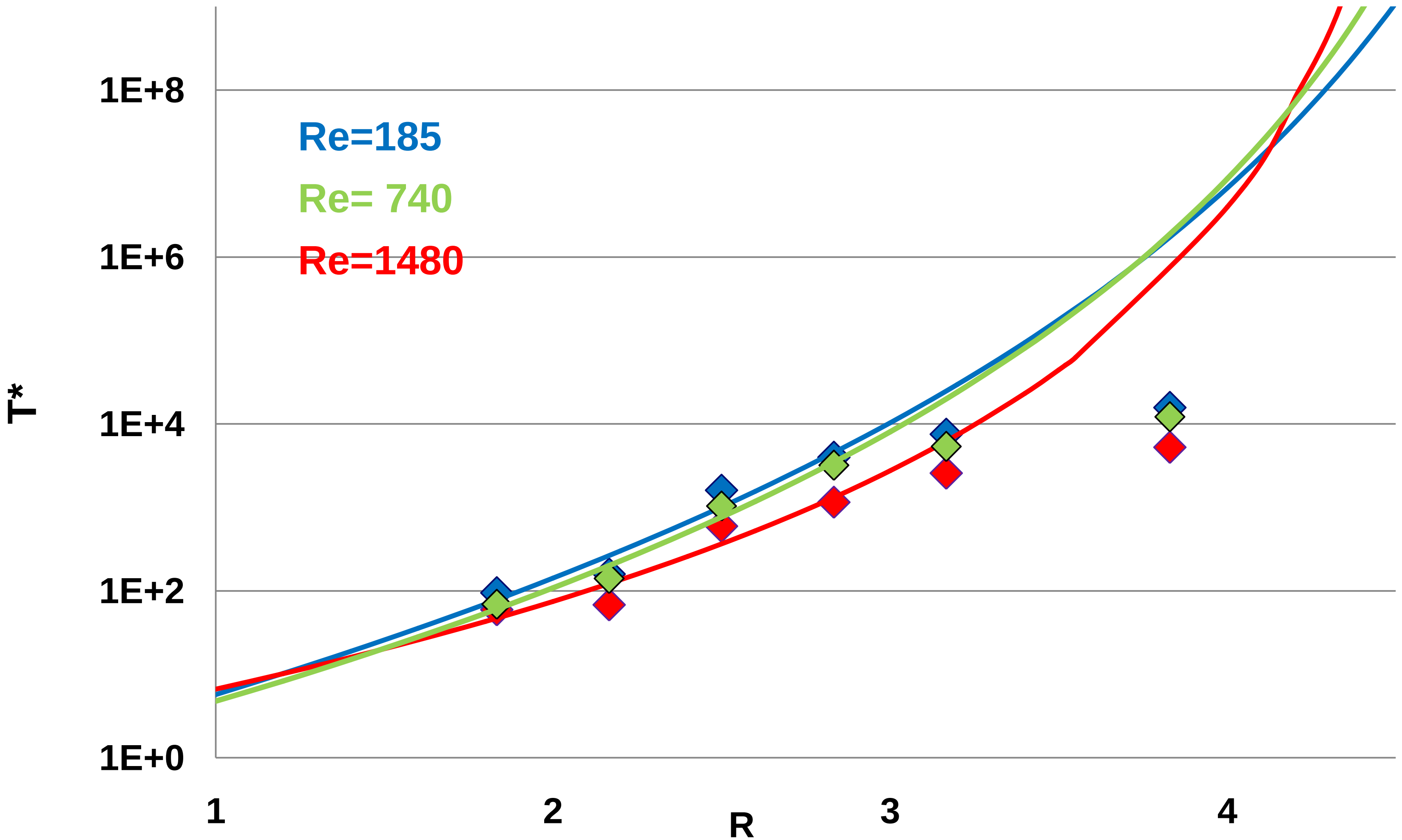


Influence of particles morphology

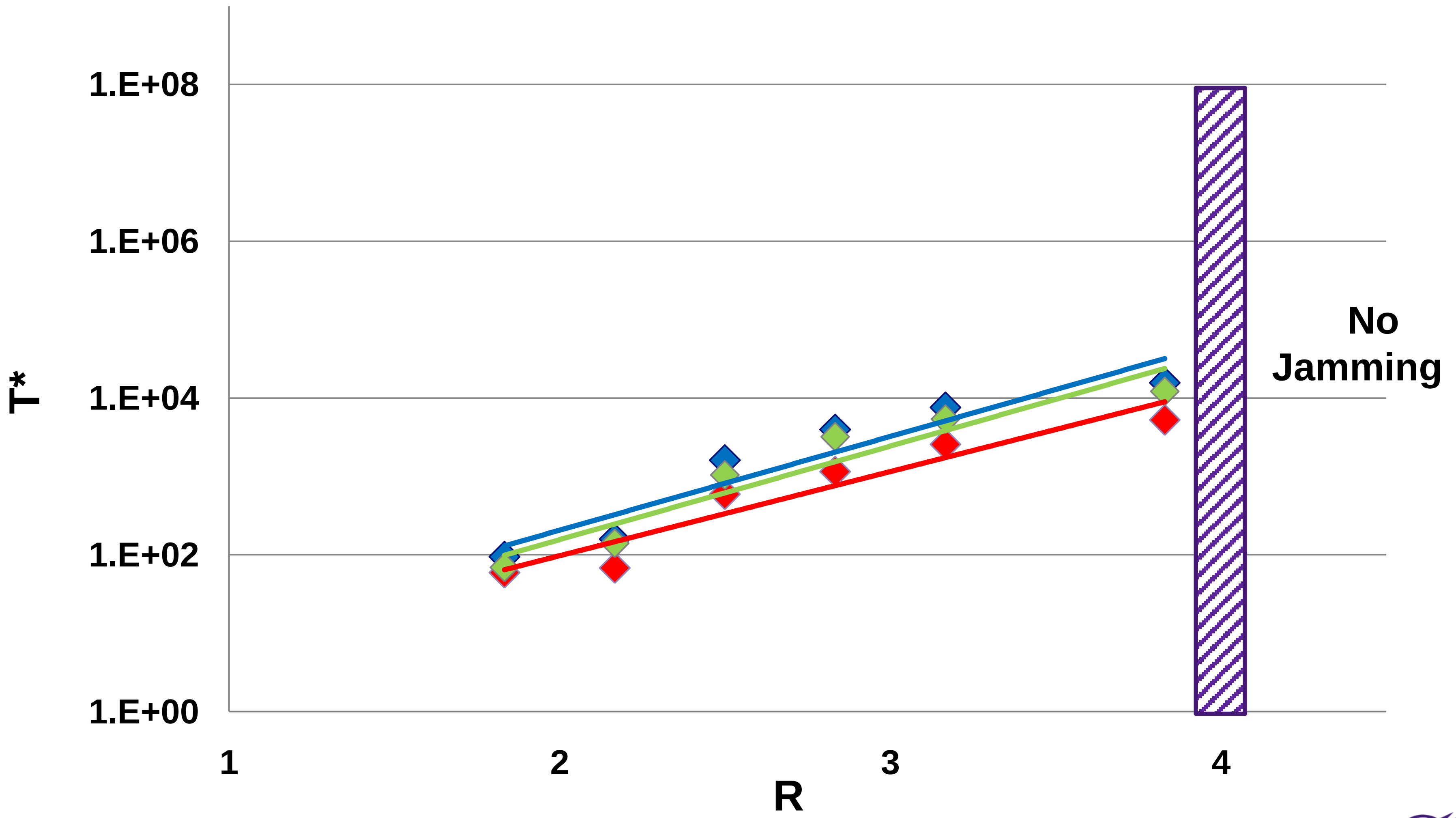
Squeezed spheres→ bigger avalanches →diminution of jamming



Results for squeezed spheres



Results for squeezed spheres >> exponential divergence



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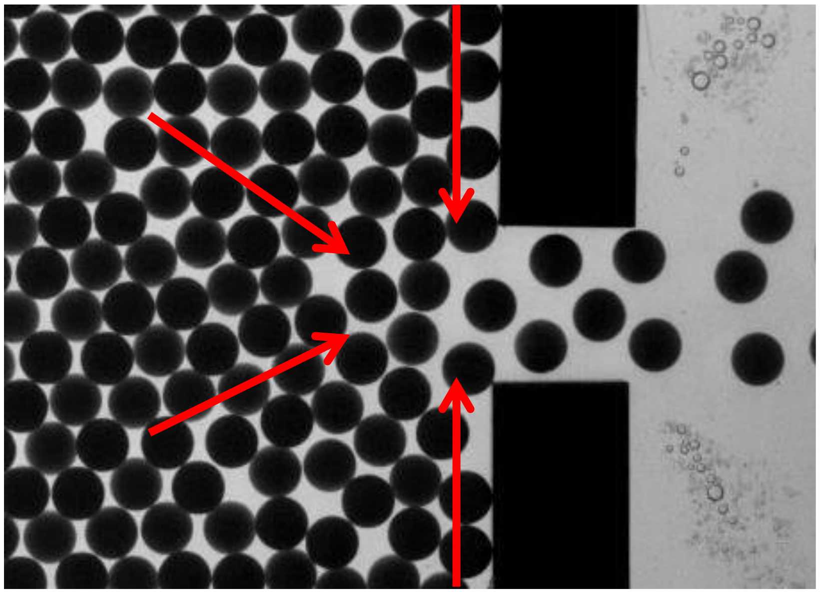
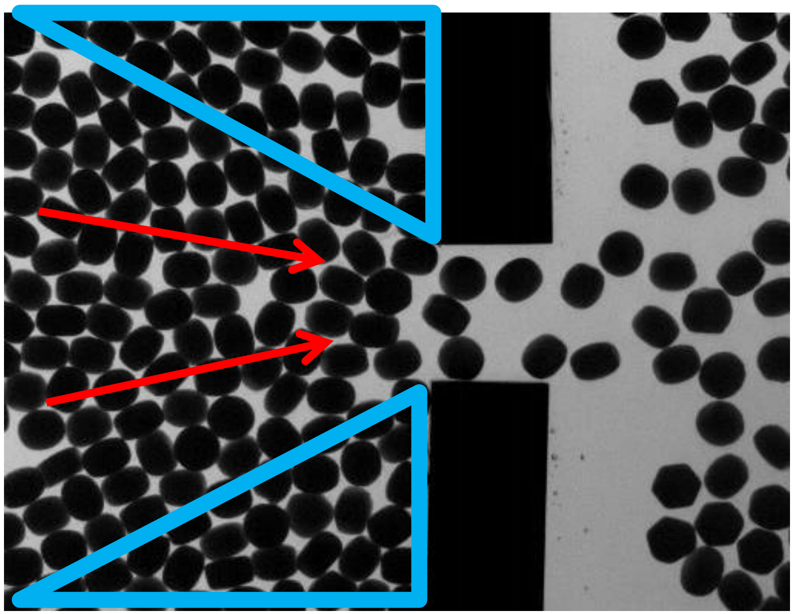
Why are the squeezed spheres avalanches larger ?

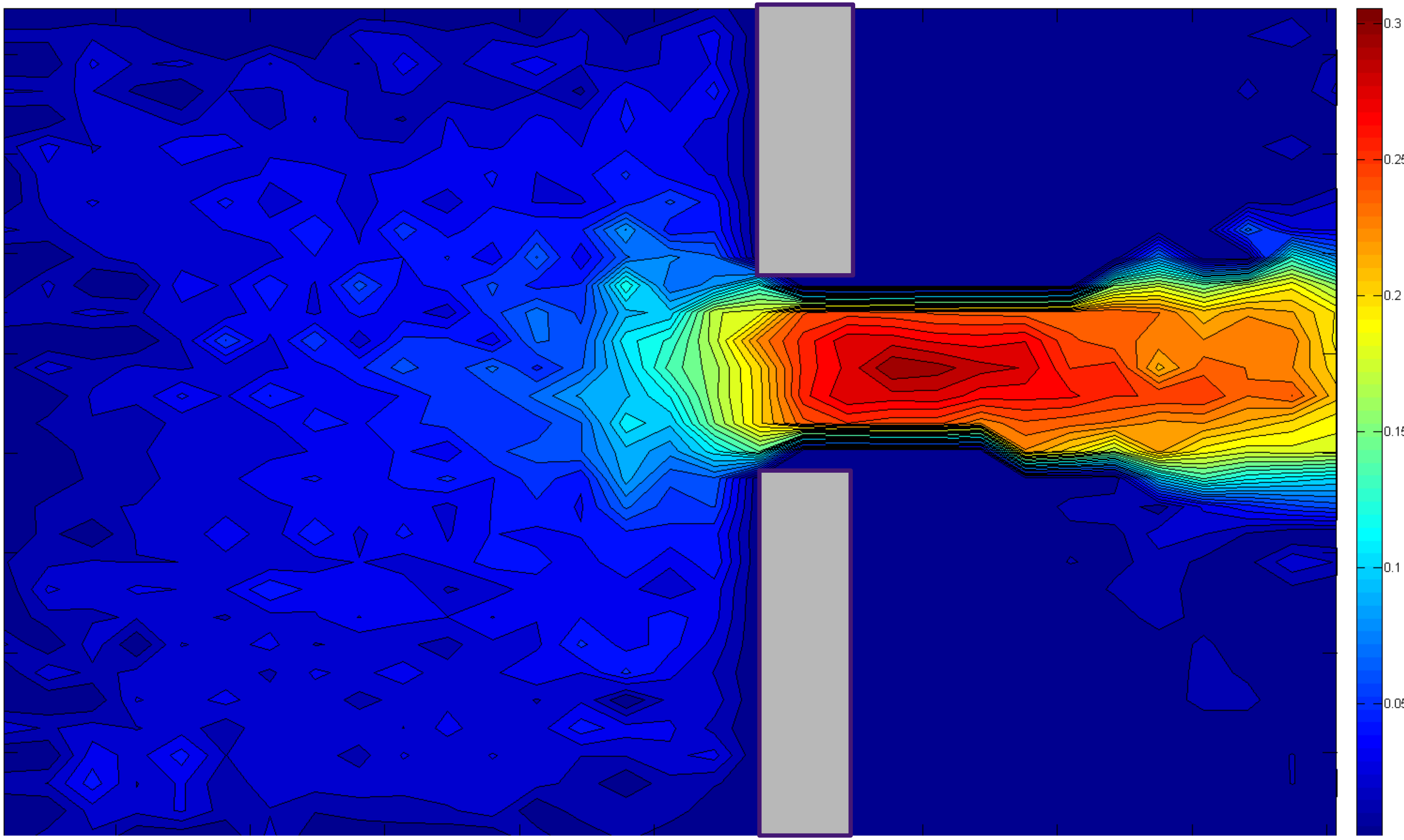


Spheres

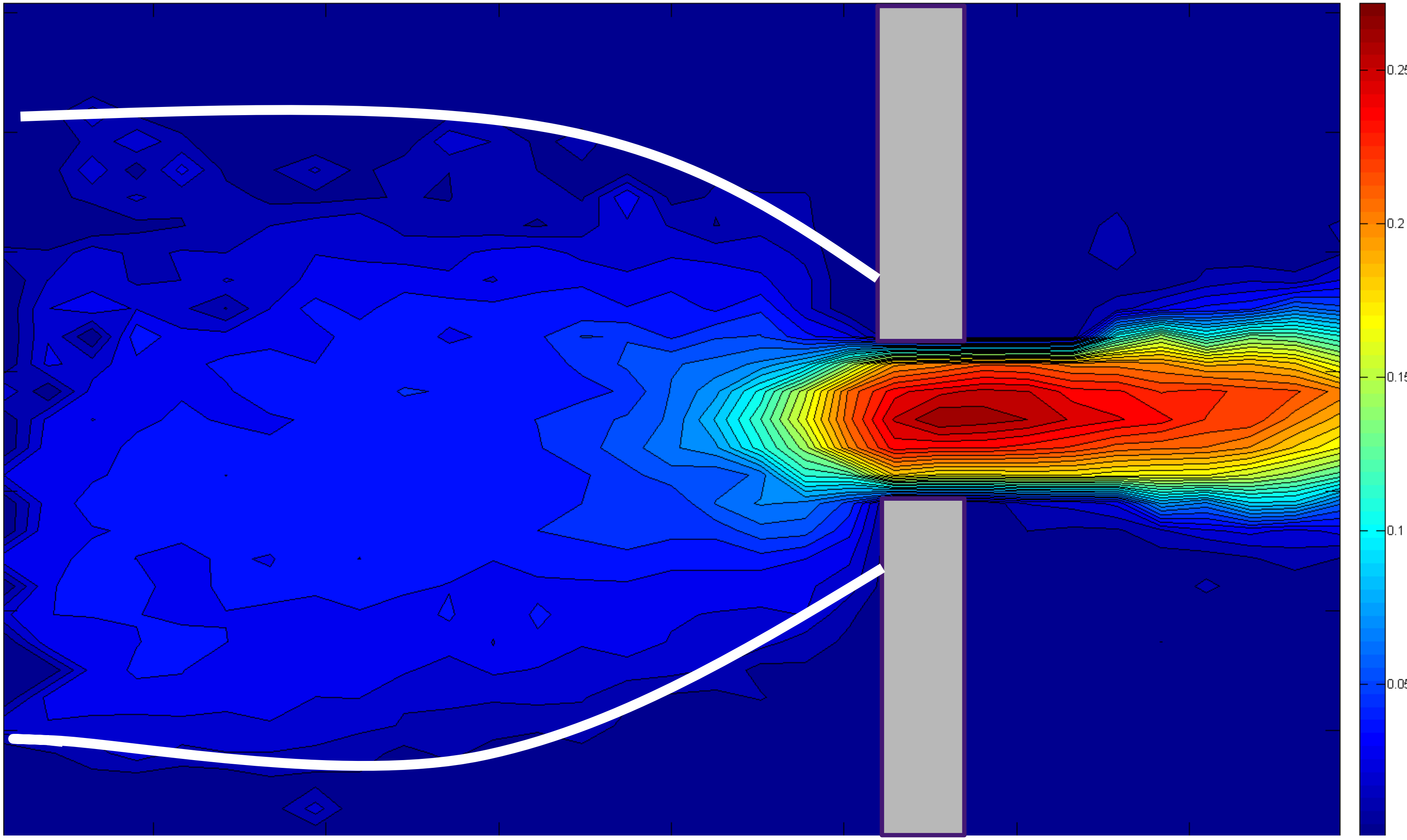


Squeezed spheres

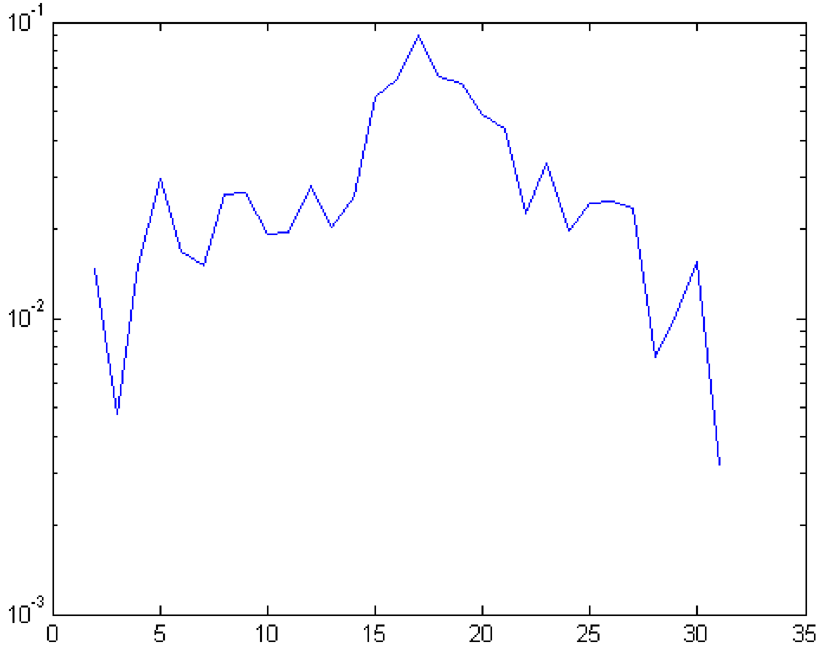
Velocity profil spheres

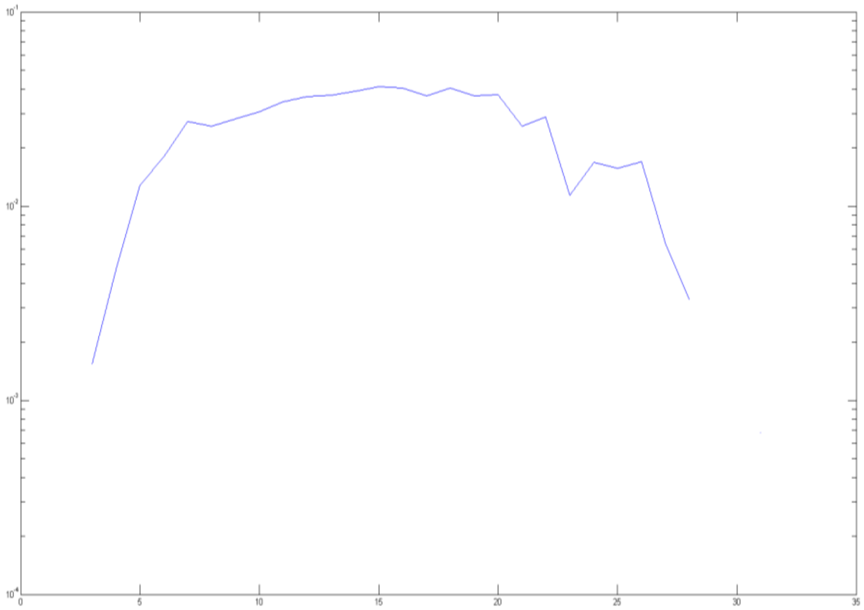


Velocity profil flattened spheres



Vx 100rpm





Conclusions

- **Power law for spheres flow**
- **Exponential law for flattened spheres**
- **High flowrate increase blockage**
- **Morphology : decrease of jamming probability (flat spheres) , observation of dead zones that maintain an unidirectional flow**

Perspectives

- **Studying the interaction strength**
  - Contacts between the particles to generate an attractive force : hydrophobic spray
- **Simulation**
  - CFD coupling / DEM
  - Modelling of hydrodynamic interactions and contacts
- **Second mode: jamming of steady state flow of particles**
- **Study of different grain sizes**
  - 100 µm to 6 mm

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Thank you for your attention

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