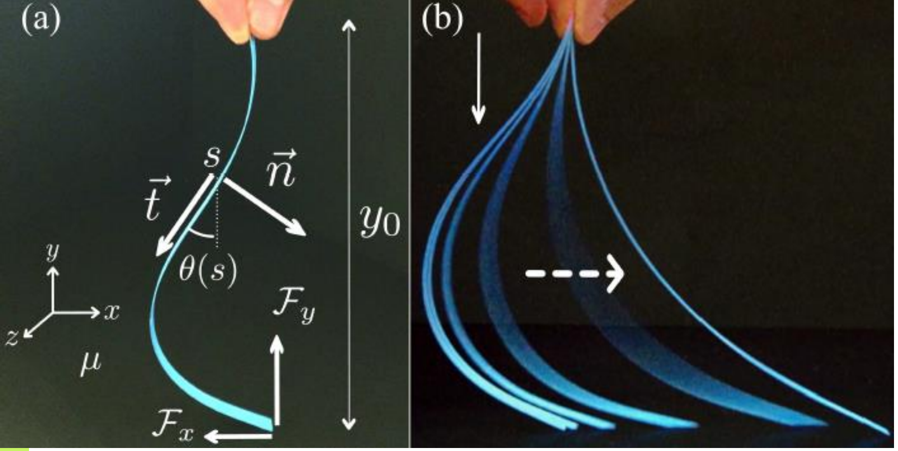
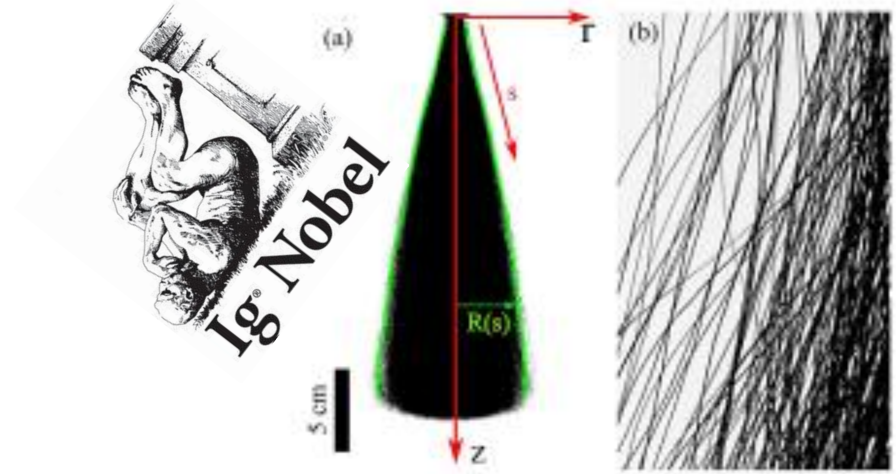
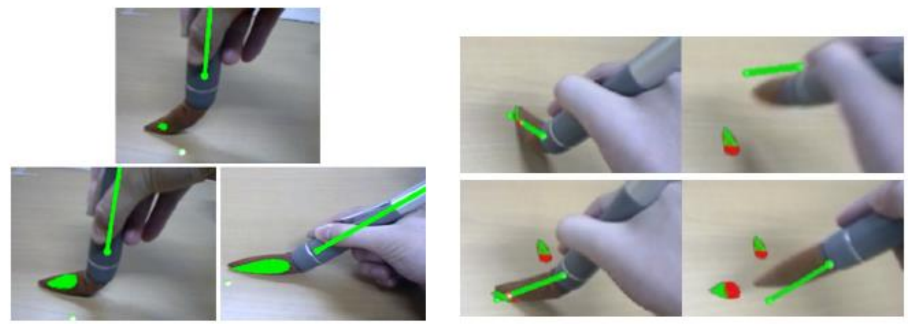

ELEPHANT-ARTISTS



Sano, 2019



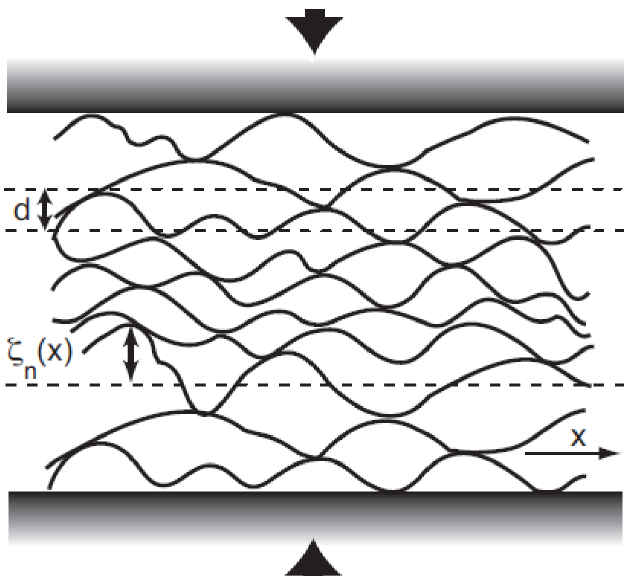
Goldstein, 2012



(a) Changing the shape.

(b) Rotating.

Otsuki, 2010



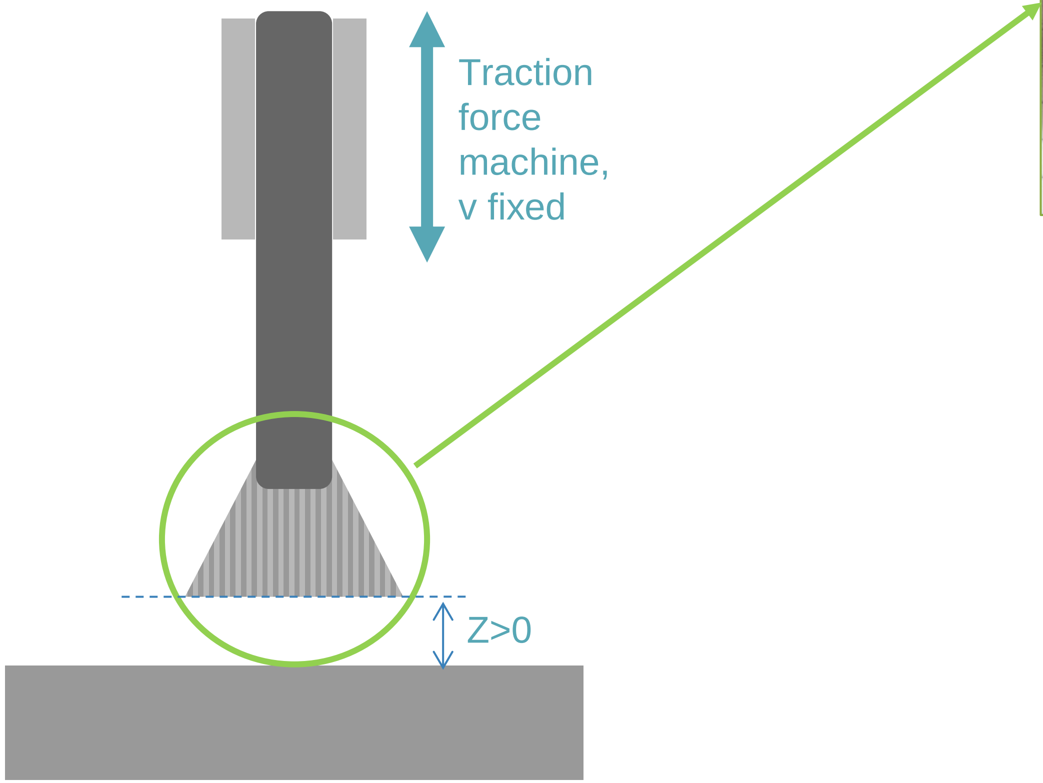
Beckrich, 2003

David, 2011

Compressing a fiber bundle against a rigid surface

Raphaelle Taub – 2nd year PhD Student
Supervisors : Frédéric Restagno, Christophe Poulard
LPS Orsay

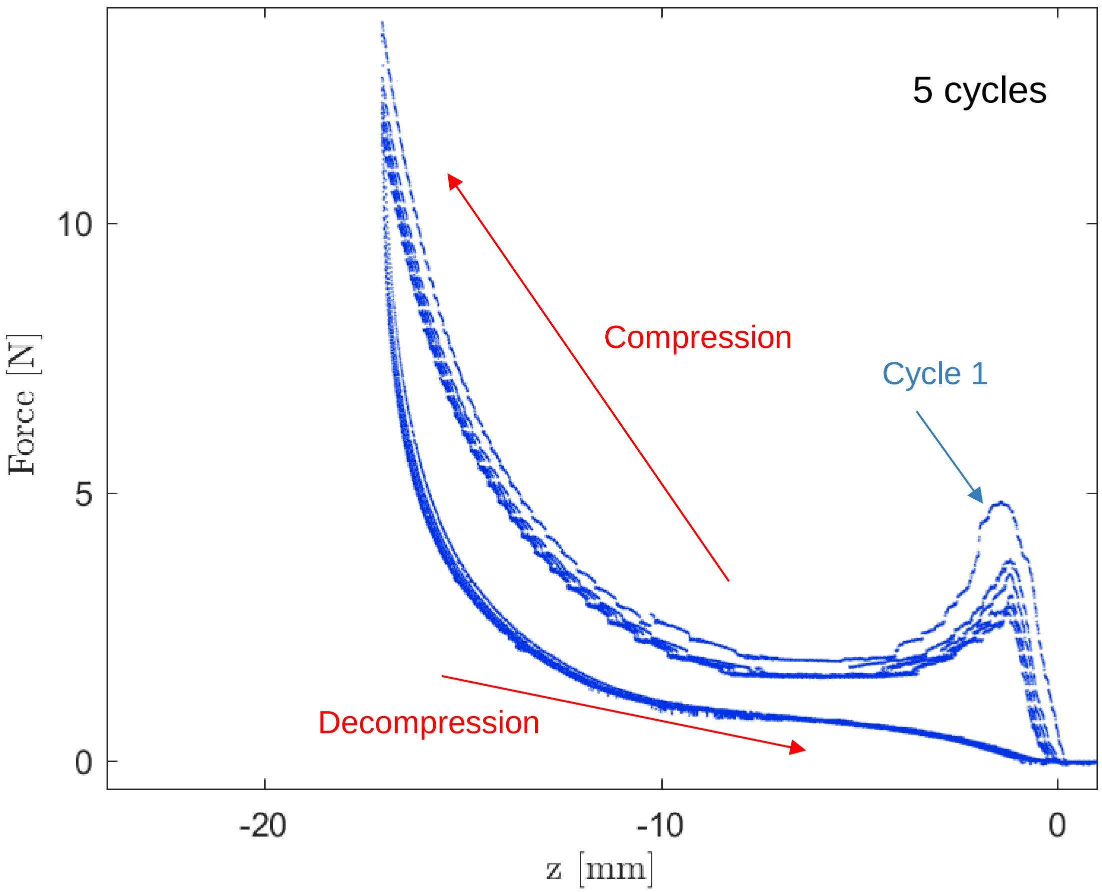
Setup



v = 1 cm/mn
N hairs (around 27000)

1 hair:
d (diameter) : 80-60 microns
L (length) : 3-5 centimeters
E (young modulus) : 3-5 GPa

Variation of the force in the height z

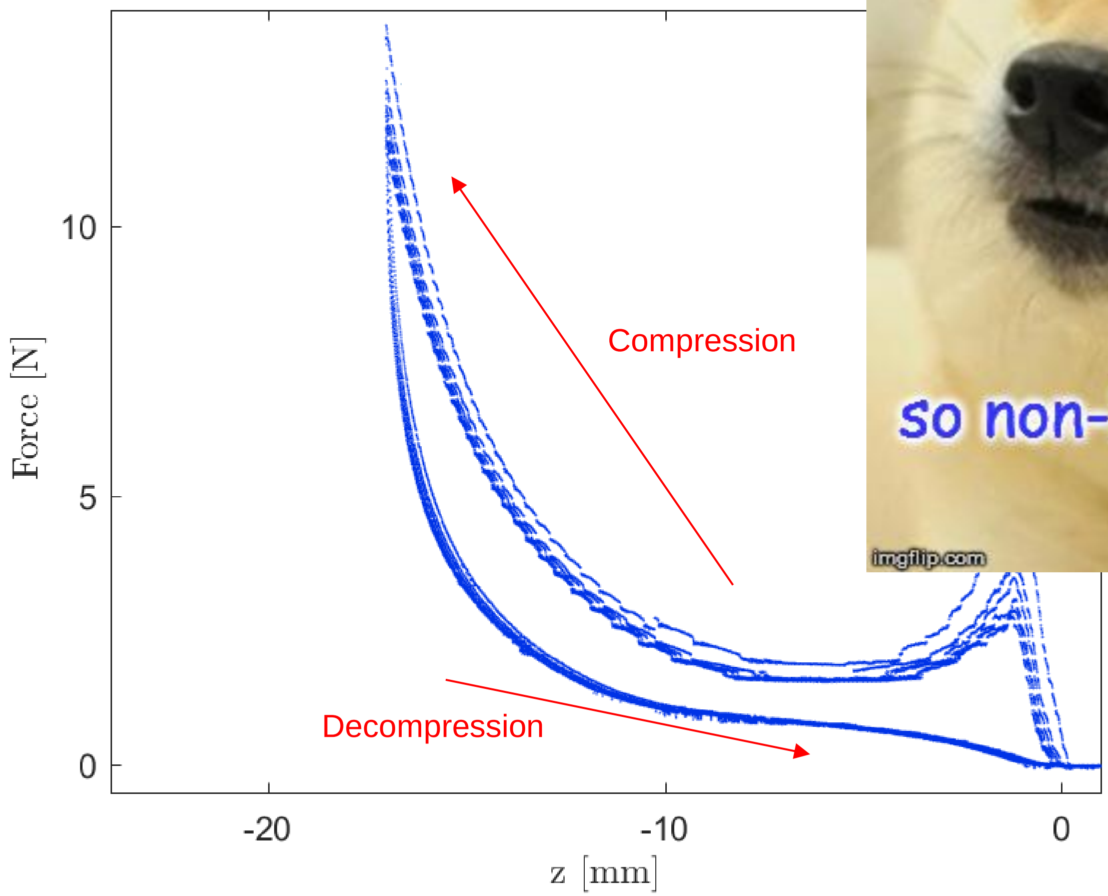


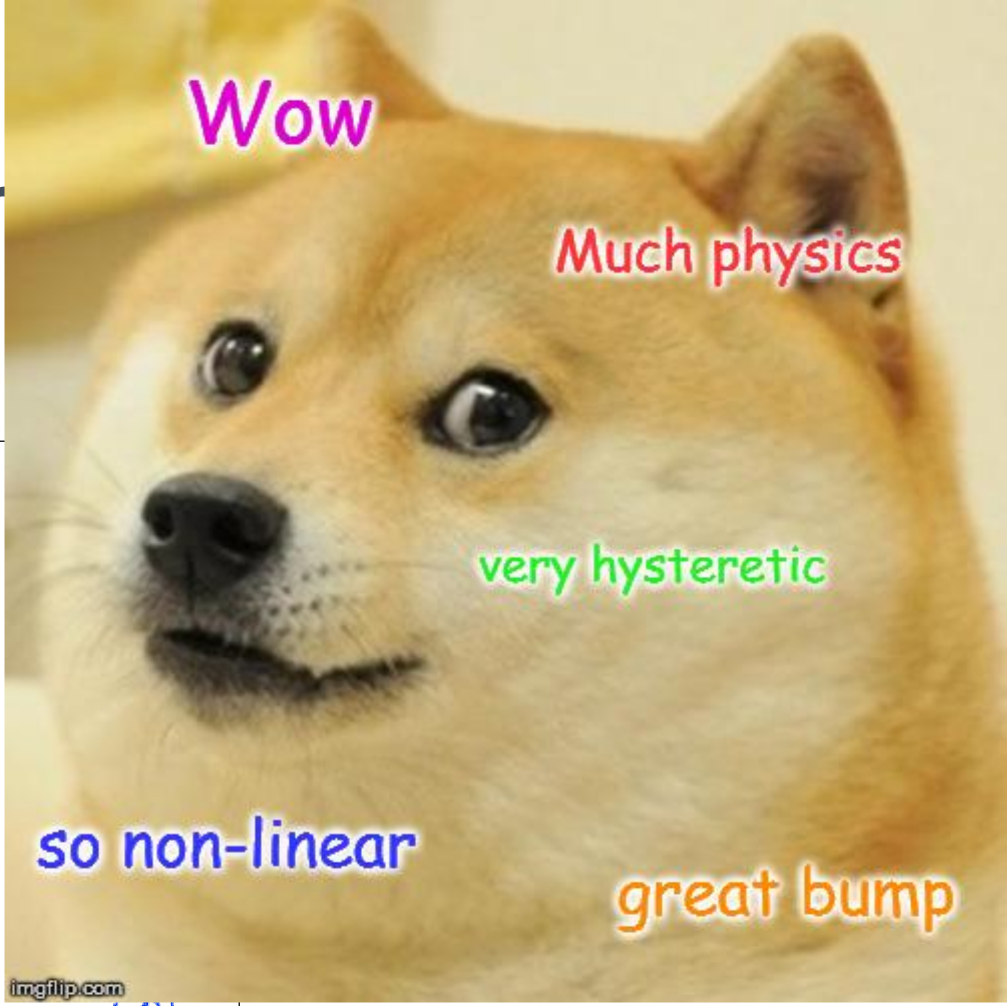
$$F(L, d, N, z, E, \mu)$$

- L: length
- d: diameter
- N: number
- z: distance
- E: Young modulus
- μ: friction coefficient

6 independant variables

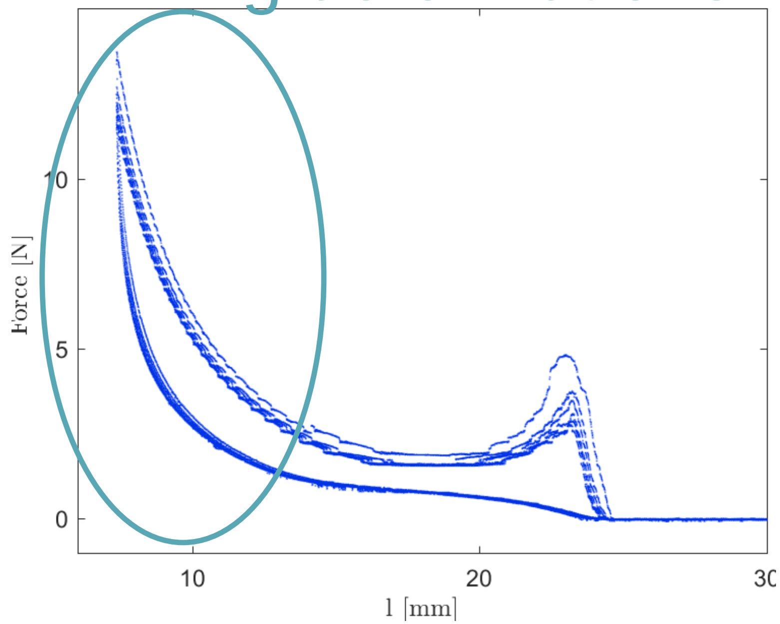
Variation of the for



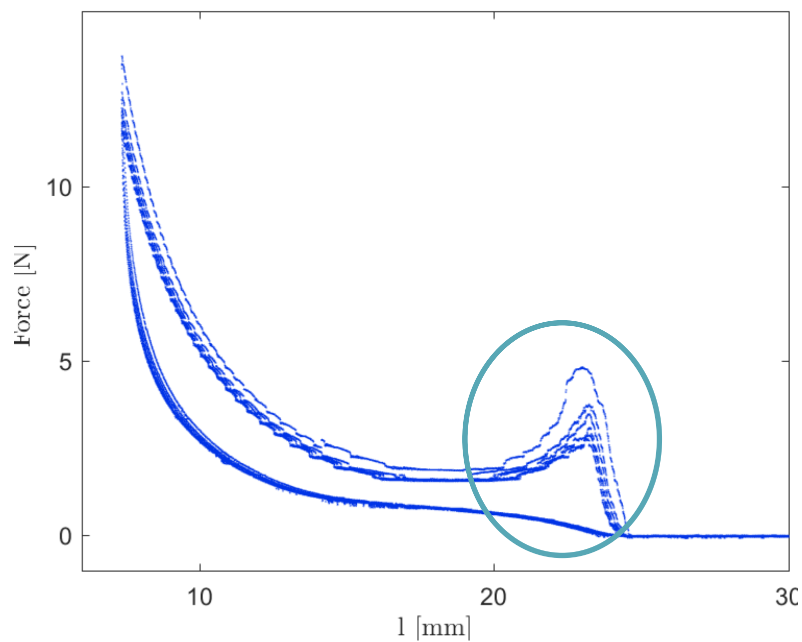


6 independant variables

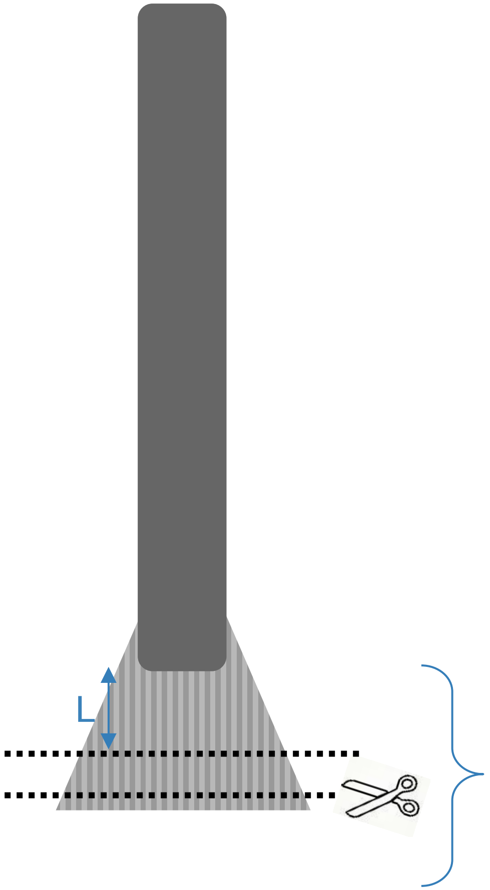
- Big deformations



- Small deformations

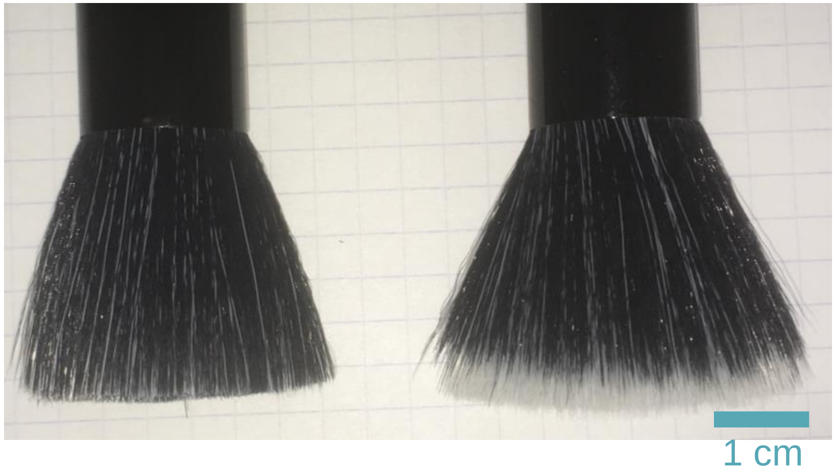


Compressing brushes and varying the fibers' length



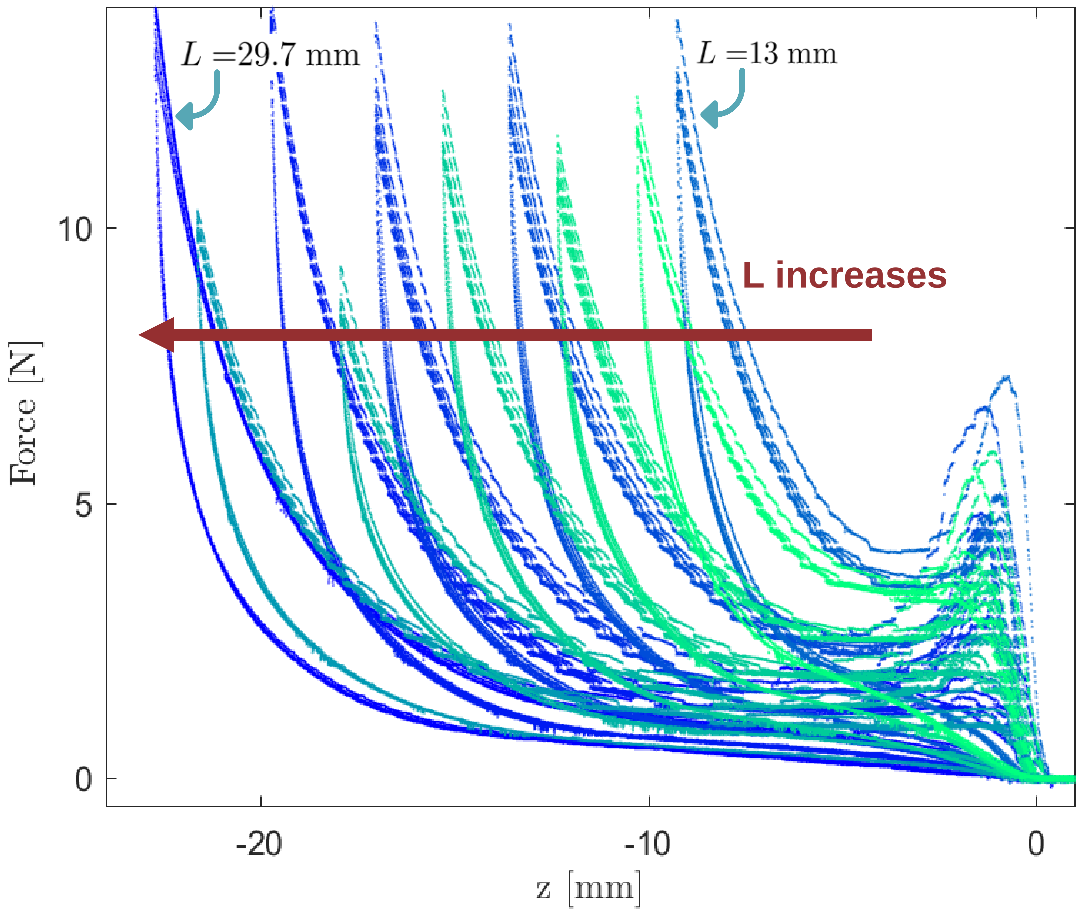
11 cutting planes
2 brushes

Chopped brush Original brush



L varying between
29,7mm and 13mm

Compressing brushes and varying the fibers' length



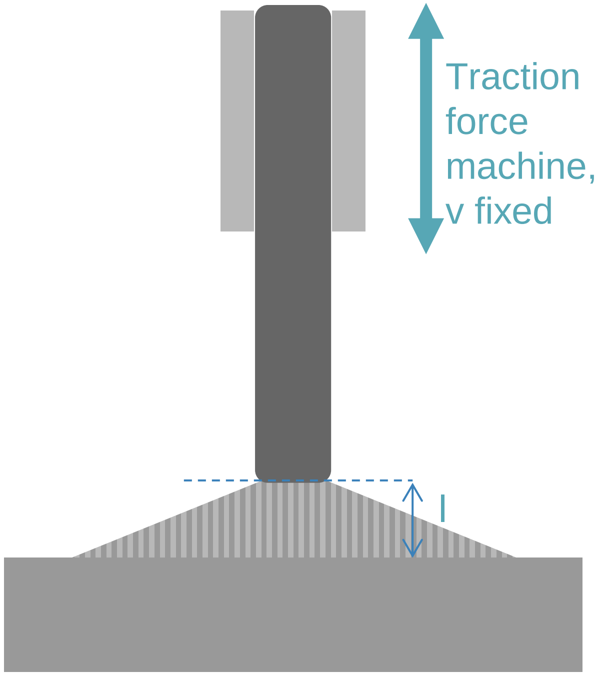
L varying between 29,7mm and 13mm

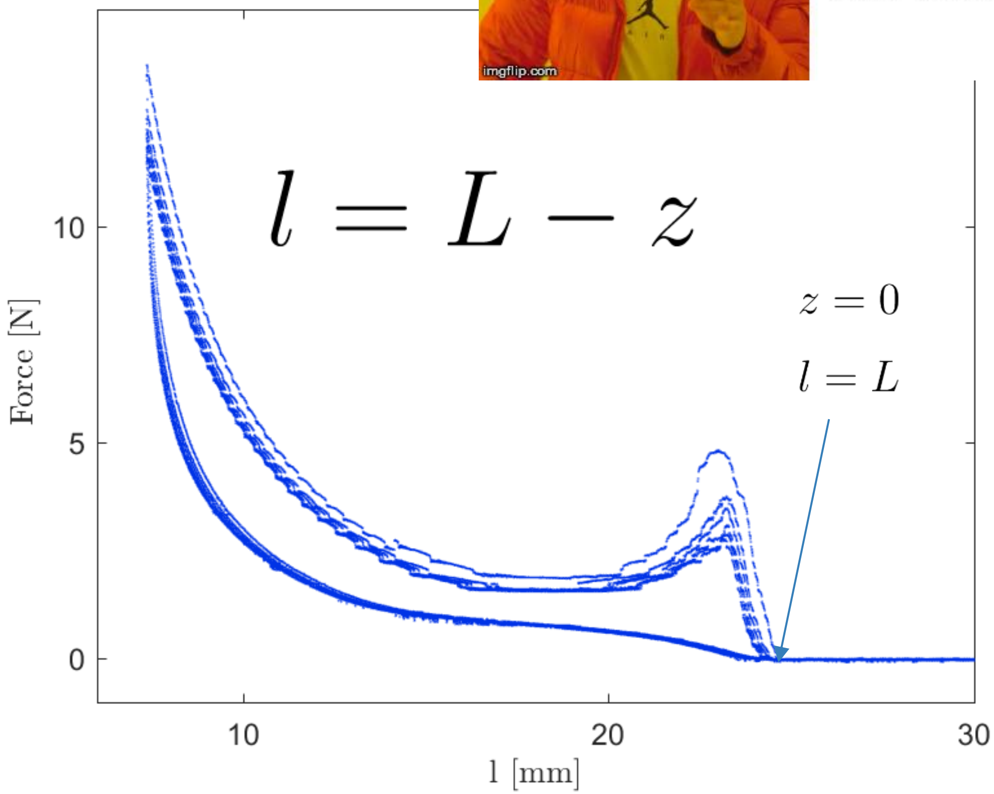
New unit: crushing distance l

- F only depends on l

One notation for one coordinate

Two notations for one coordinate so no one understands





Scaling law model for the force

- With : $E = 3 - 5 \ \mathrm{GPa}$

$$I = 2.9 \ 10^{-18} \ \mathrm{m}^4$$

$$I = \frac{\pi d^4}{64}$$

$$l = L - z$$

distance

Young modulus

$$F(L, d, N, z, E, \mu)$$

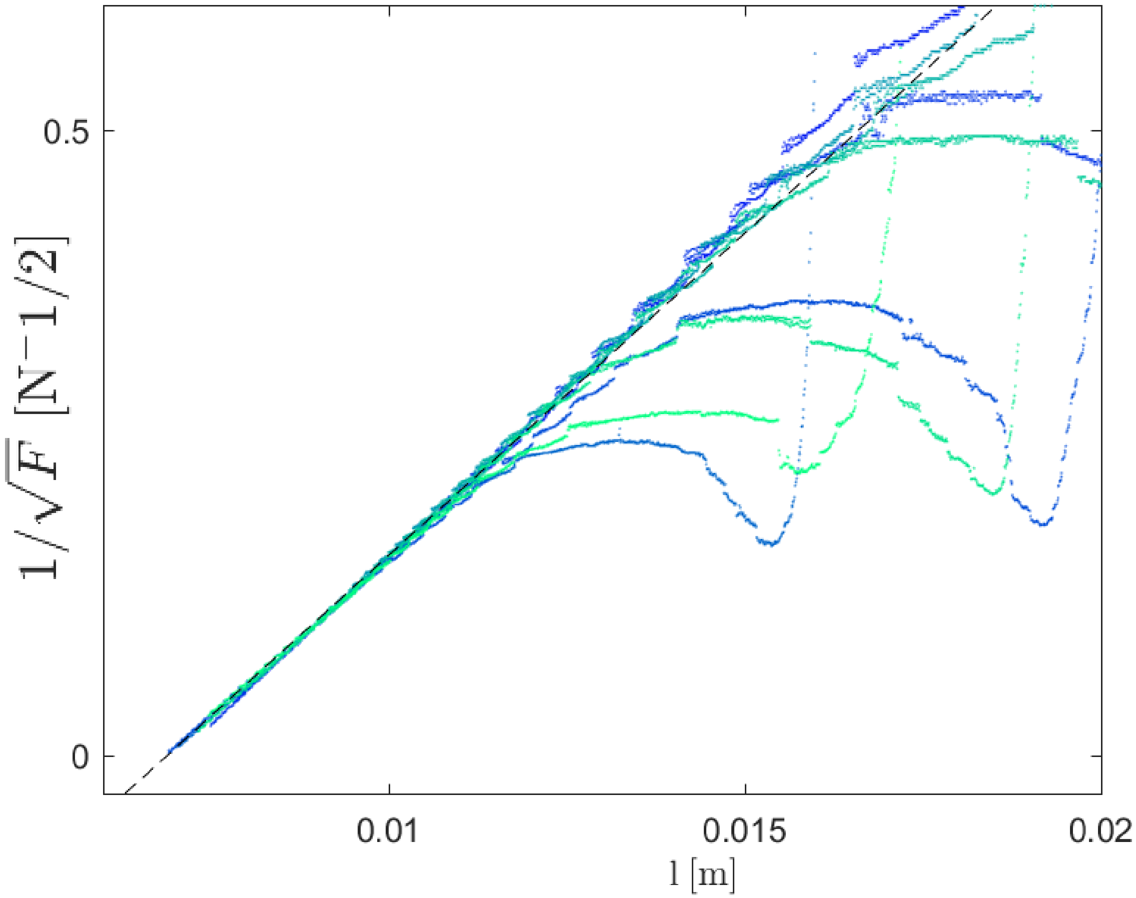
length diameter number friction coefficient

$$F(l, \not{L}, I, N, E, \mu)$$

Scaling law for F

$$F \propto \frac{EI}{l^2}$$

Compressing brushes and varying the fibers' length

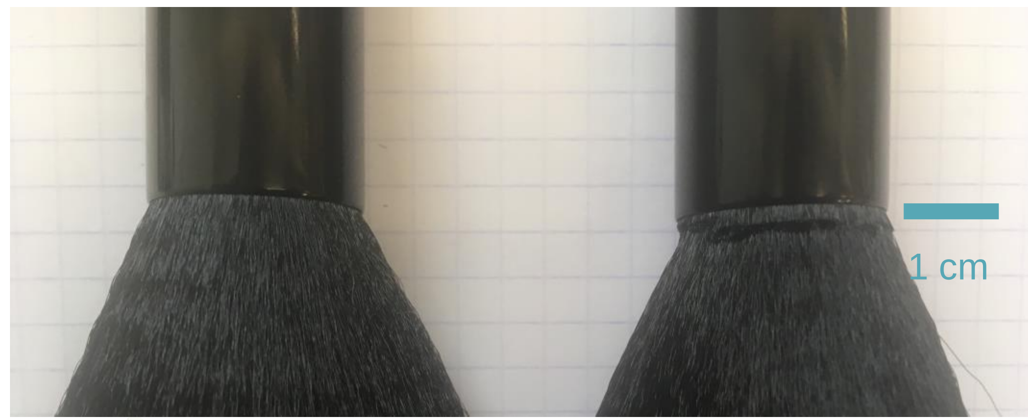


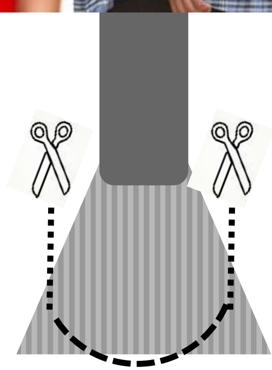
- Mastercurve for every fibers' length

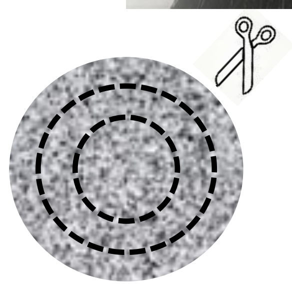
$$F \propto \frac{EI}{l^2}$$

Compressing brushes and varying the number of fibers

$$F(l, I, N, E, \mu)$$





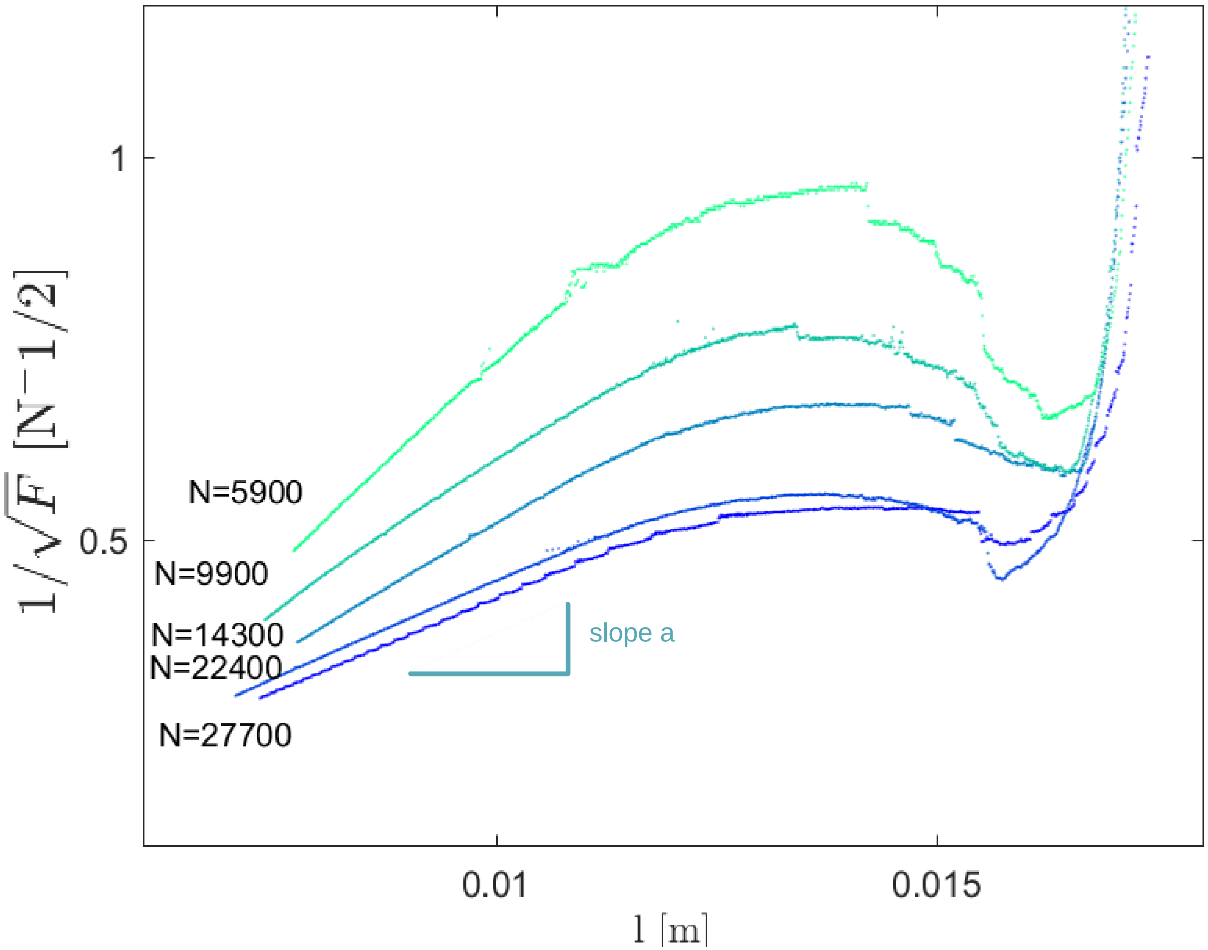


5 cuts

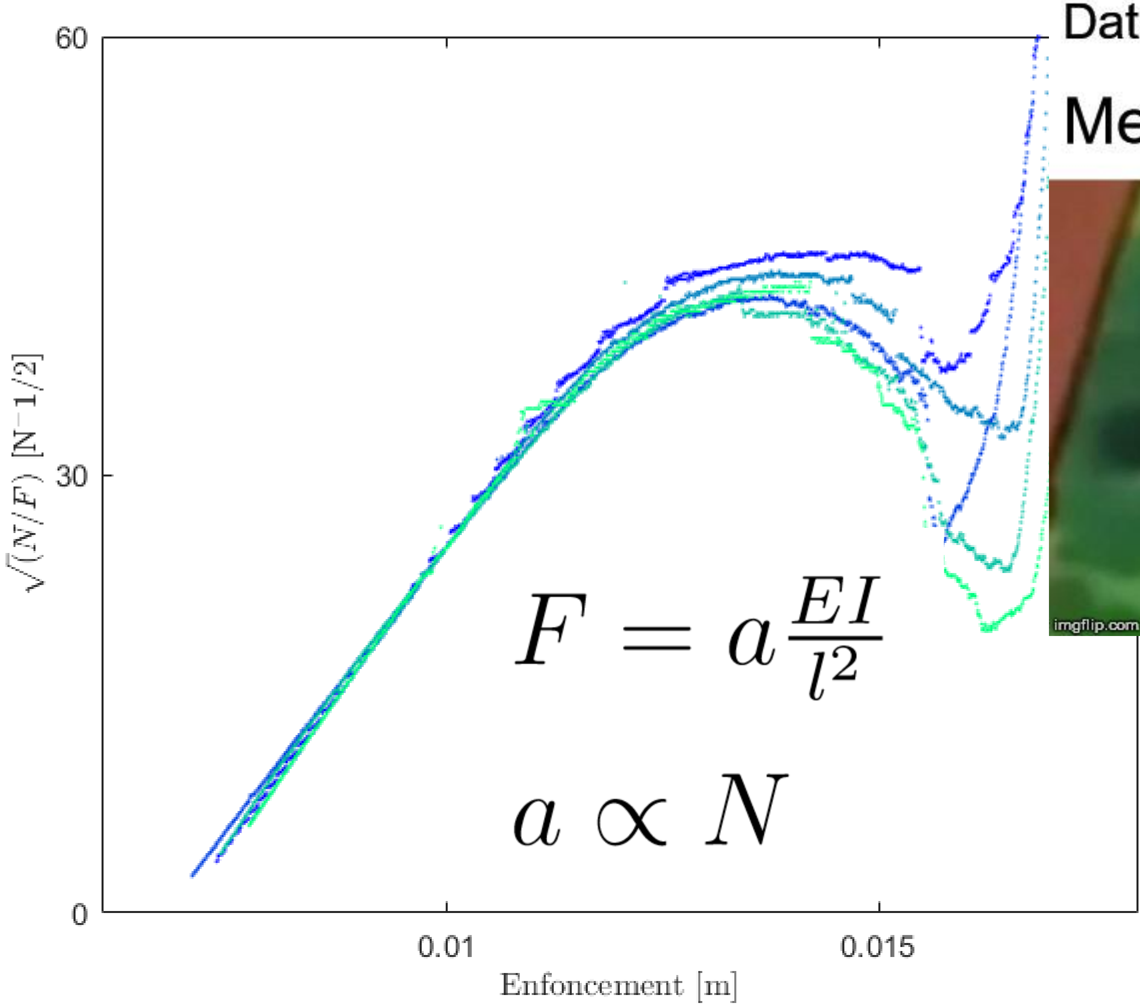
N varying between
27 700 and 5800 fibers

Compressing brushes and varying the number of fibers

$$F = a\frac{EI}{l^2}$$



Compressing brushes and varying the number of fibers



$$F = a\frac{EI}{l^2}$$

$$a \propto N$$

Me: try a new scaling

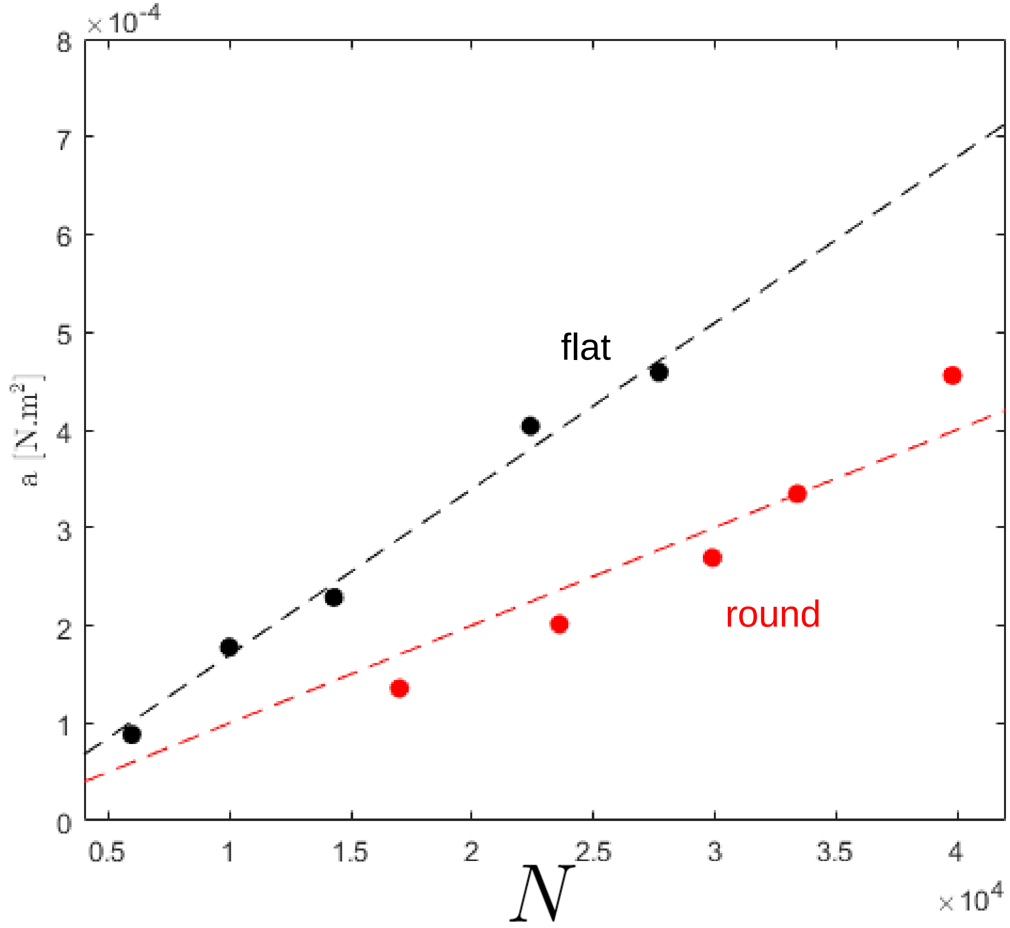
Data: *collapse to a mastercurve*

Me:

l [m]

Types of brushes

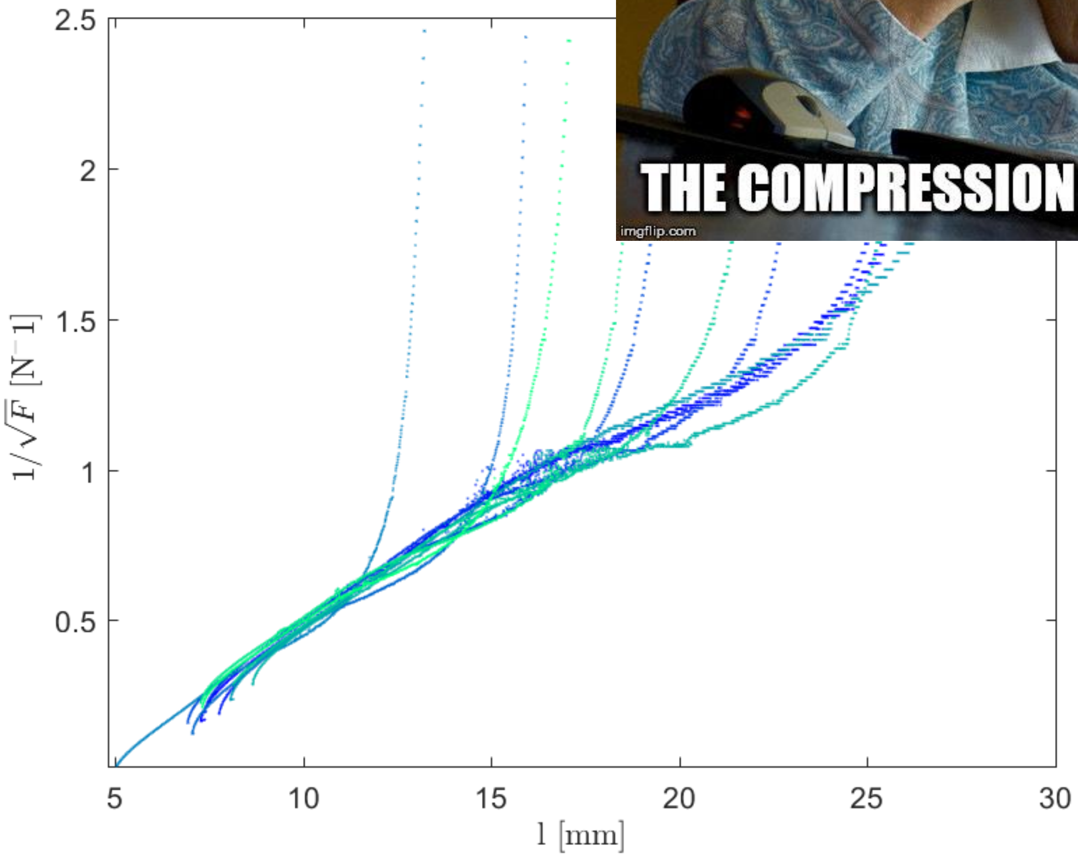
Slope for different number of fibers – round brush



$$a \propto N$$

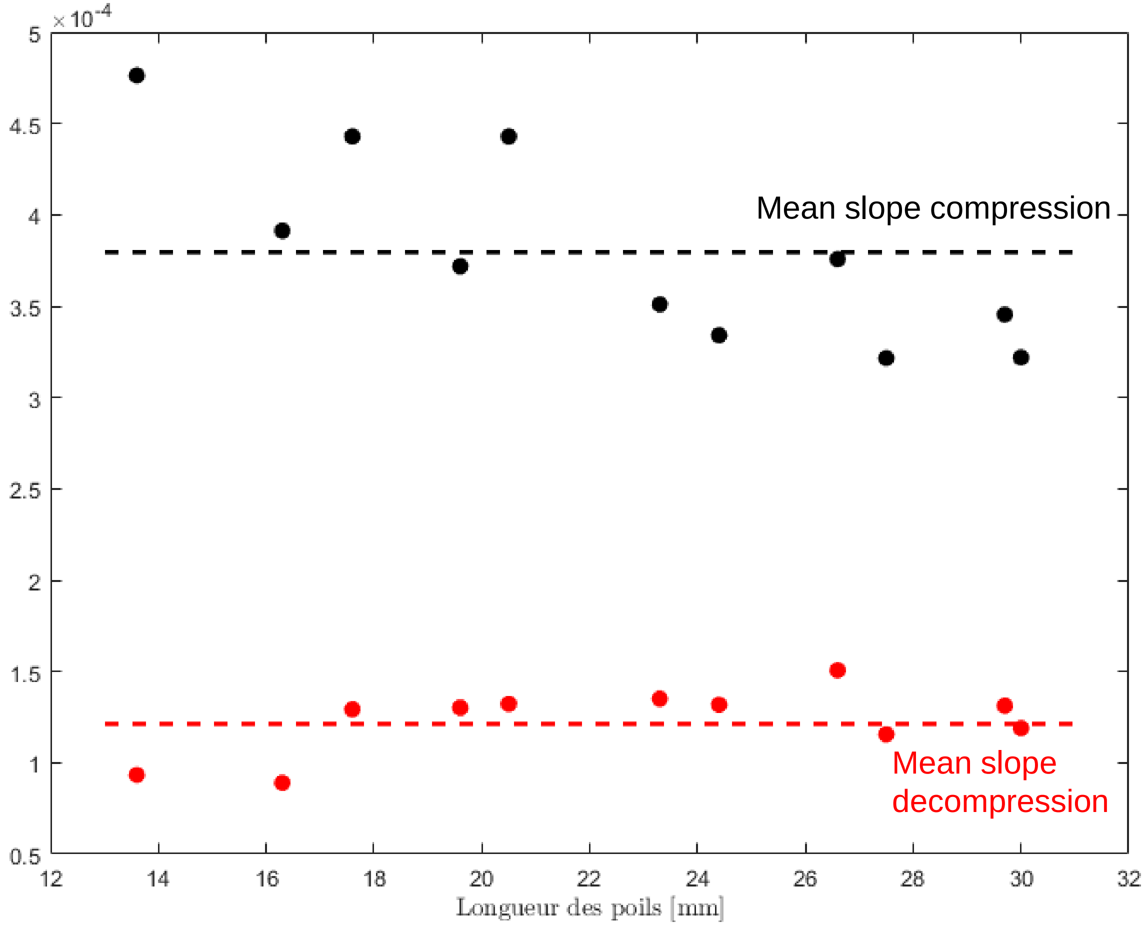
It works for both of our brushes, with different coefficients

Return - decompression



- Mastercurve for every fibers' length

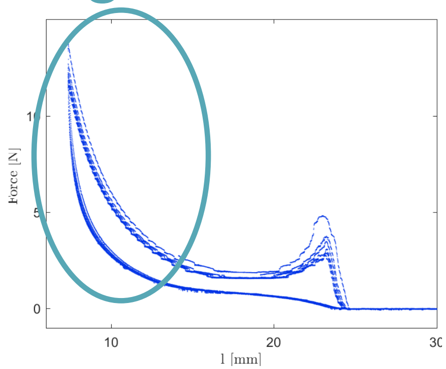
Comparison compression and decompression



- Different prefactor for traction and compression

Conclusion

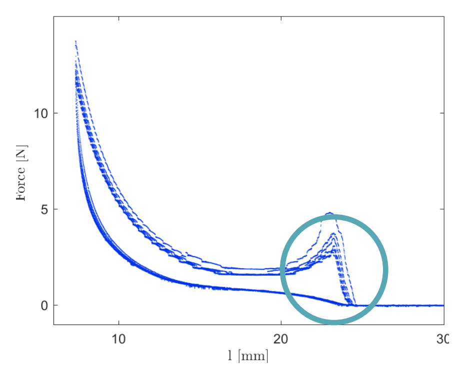
- Big deformations



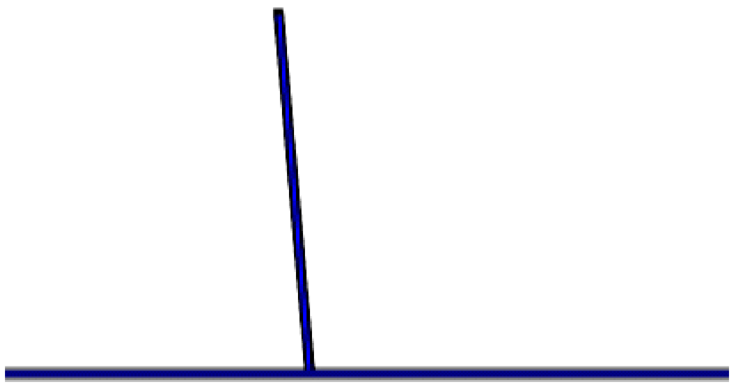
$$F = kN\frac{EI}{l^2}$$

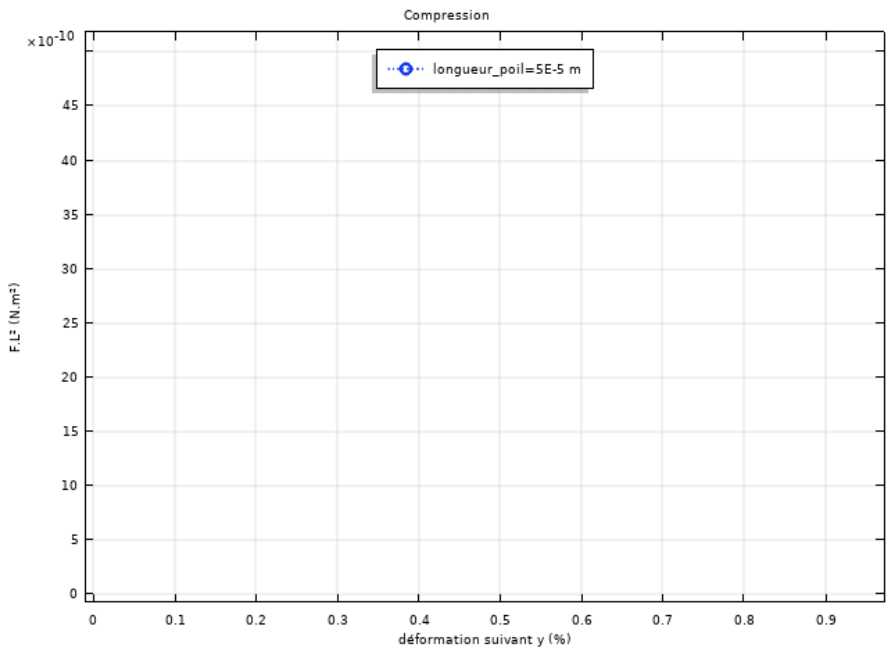
- k is different for compression and decompression
- k does not depend on L

- Small deformations



- Bump at constant ϵ
- But different from single hair experiments



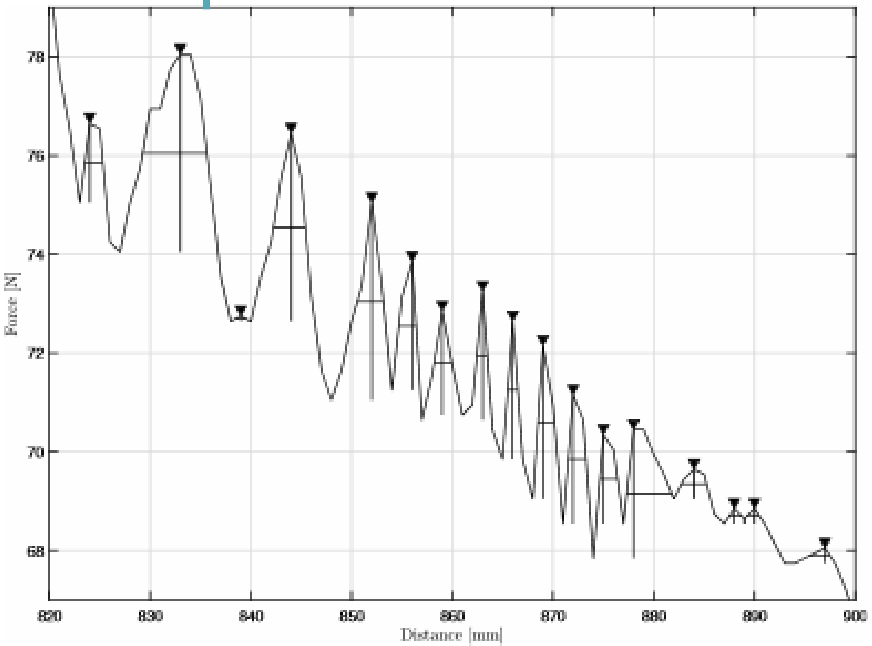


Compression
×10^-10
longueur_poil=5E-5 m
F.L² (N.m²)
45
40
35
30
25
20
15
10
5
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
déformation suivant y (%)

Perspectives

- Interleaving two brushes

- Statistics of the force-displacement curves



Thanks!

Any questions?

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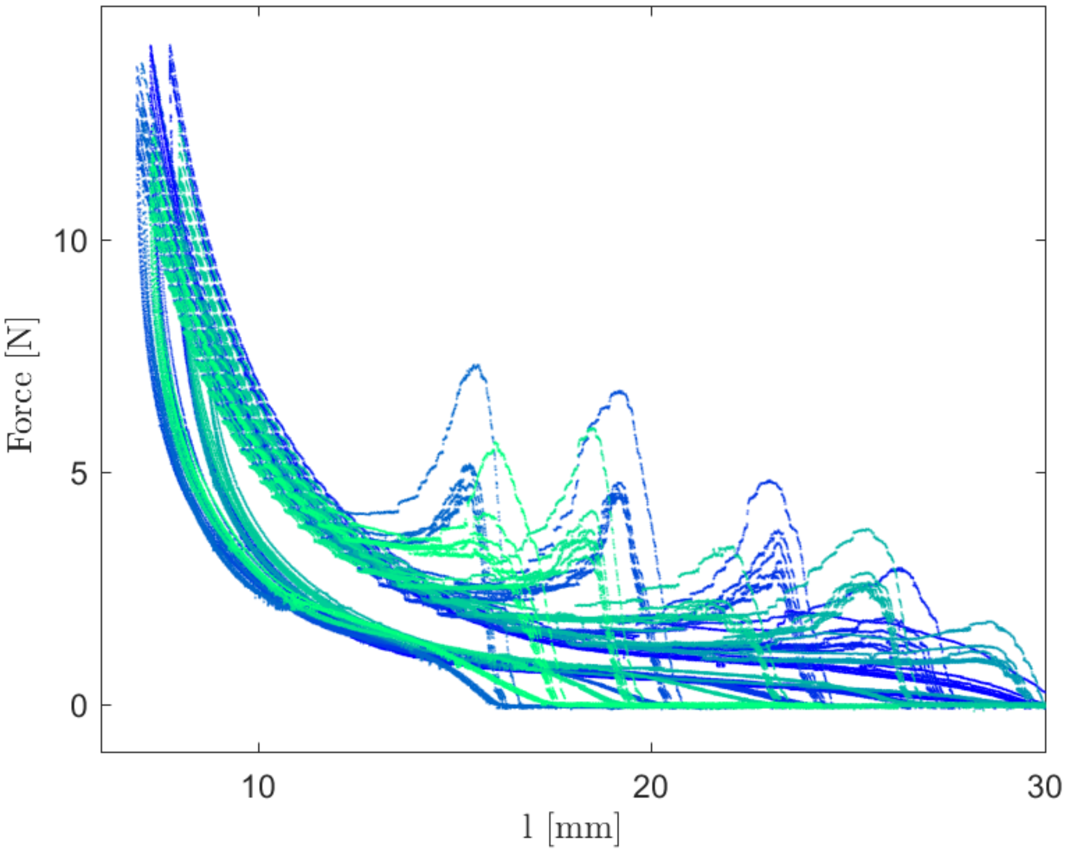
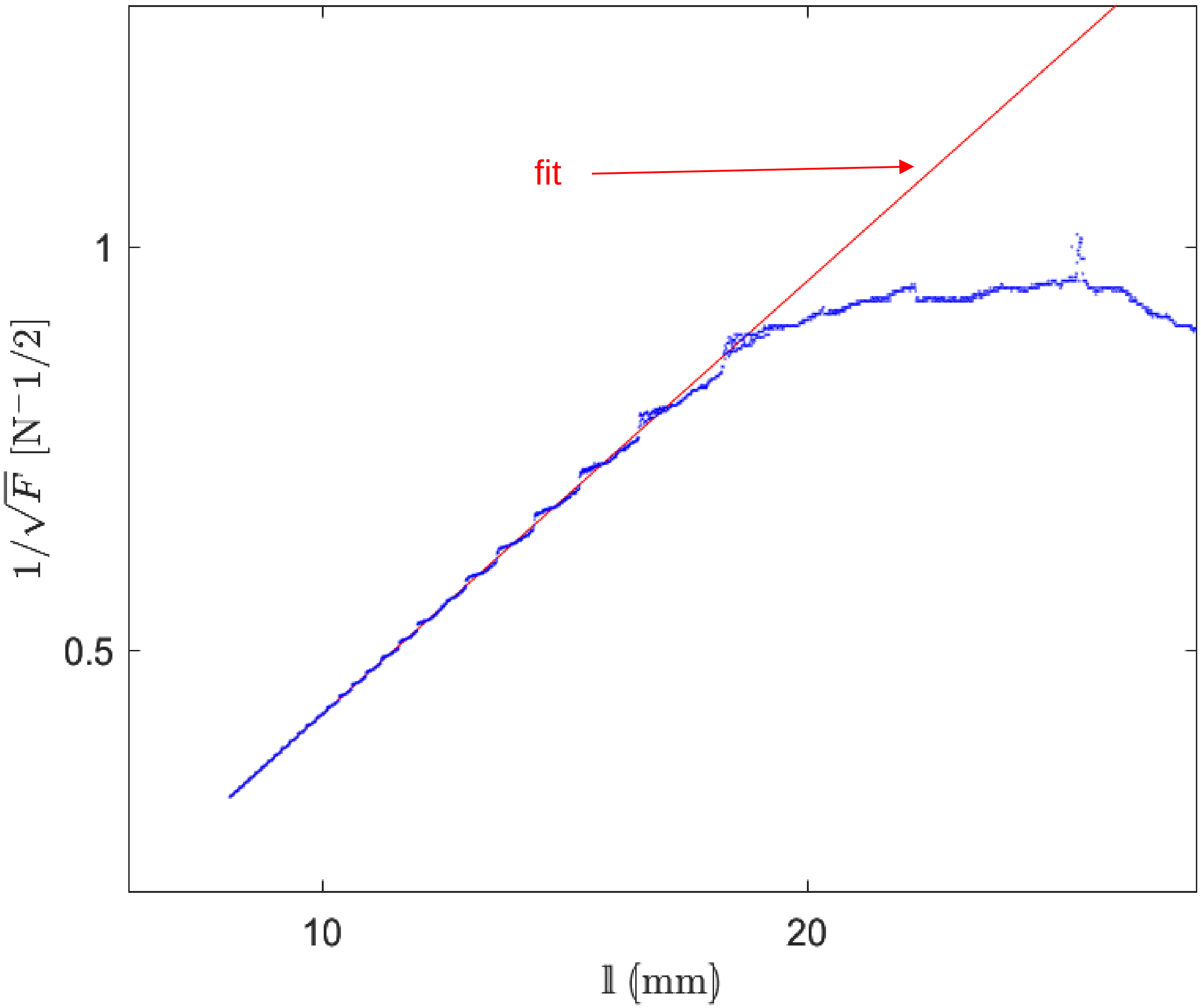
Compressing brushes and varying the fibers’ length



- No dependency in the fibers’ lengths

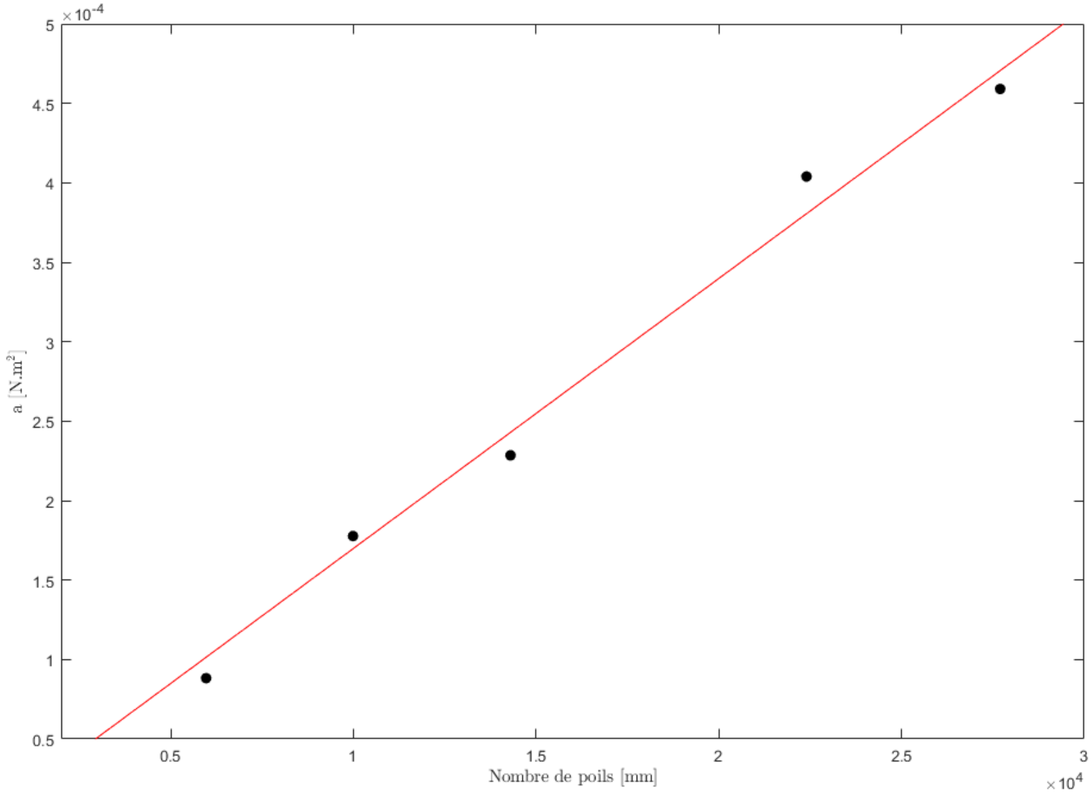
Compression du pinceau – fit



- La force ne dépend que de l’enfoncement

$$F = \frac{EI}{l^2}$$

Slope for different number of fibers – flat brush



$$a \propto N$$

Figure récapitulative sur les pentes et préfacteurs

$$F = kN\frac{EI}{l^2}$$

$$a = kNEI$$

Aller rond : $kEI = 1.001\ 10^{-8}$

Retour rond : $kEI = 5.841\ 10^{-9}$

Aller plat : $kEI = 1.699\ 10^{-8}$

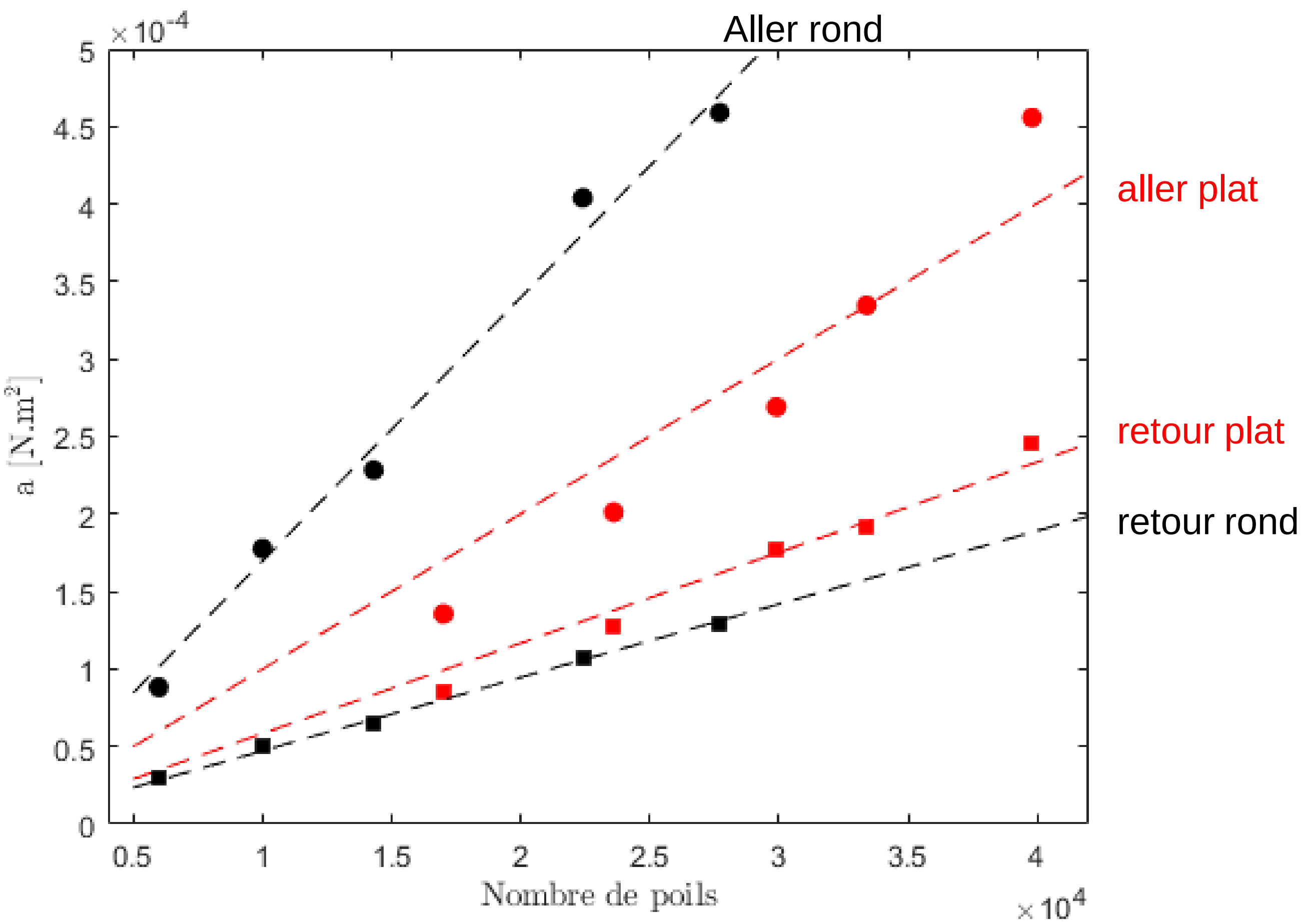
Retour plat : $kEI = 4.73\ 10^{-9}$

Pinceau rond

$$I = 2.9\ 10^{-18}\ \mathrm{m}^4$$

Pinceau plat

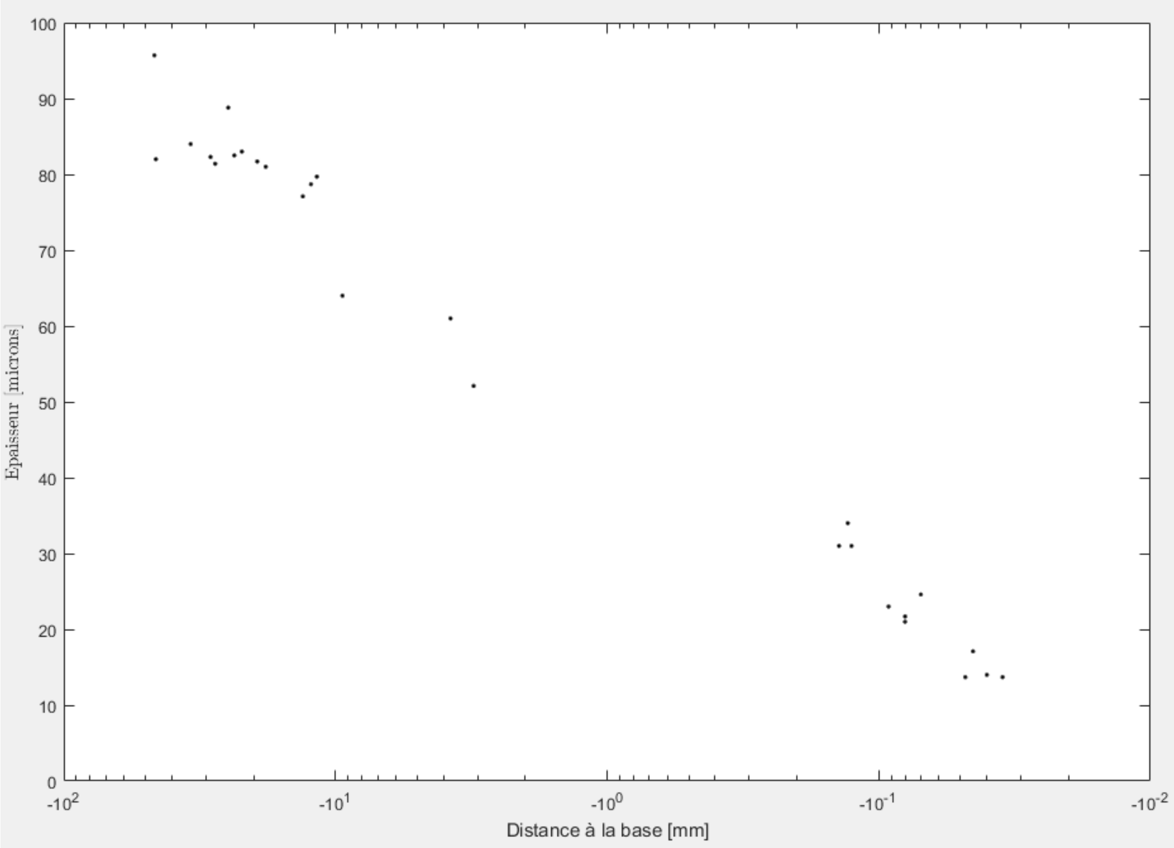
$$I = 2.44\ 10^{-18}\ \mathrm{m}^4$$



Caractéristiques des poils

- Diamètre varie le long du poil,
- Module d'Young : 3 à 5 GPa pour des poils en polyamide,
- Longueur : 2 à 5 cm
- Nombre de poils : 27700 (mesure pesée) à 37600 (mesure géométrique)

Diamètre d'un poil en fonction de la distance à la base



Questions en suspens

$$F = kN\frac{EI}{l^2}$$

- Pourquoi le préfacteur k est différent à l'aller et au retour ? Est-ce qu'il est possible d'avoir une prédiction théorique pour k (il est proche de 1 à l'aller) ?

- Est-ce qu'il est possible d'avoir un modèle qui fitte mieux les données des très grandes déformations, et qui explique donc l'hystérésis ?

- D'où vient le décalage sur le snap entre les expériences à poil unique et les expériences avec les pinceaux ?