Patched roughness in highly turbulent Taylor-Couette flow

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Turbulence

- Irregular
- Seemingly random
- Chaotic

Taylor-Couette Flow

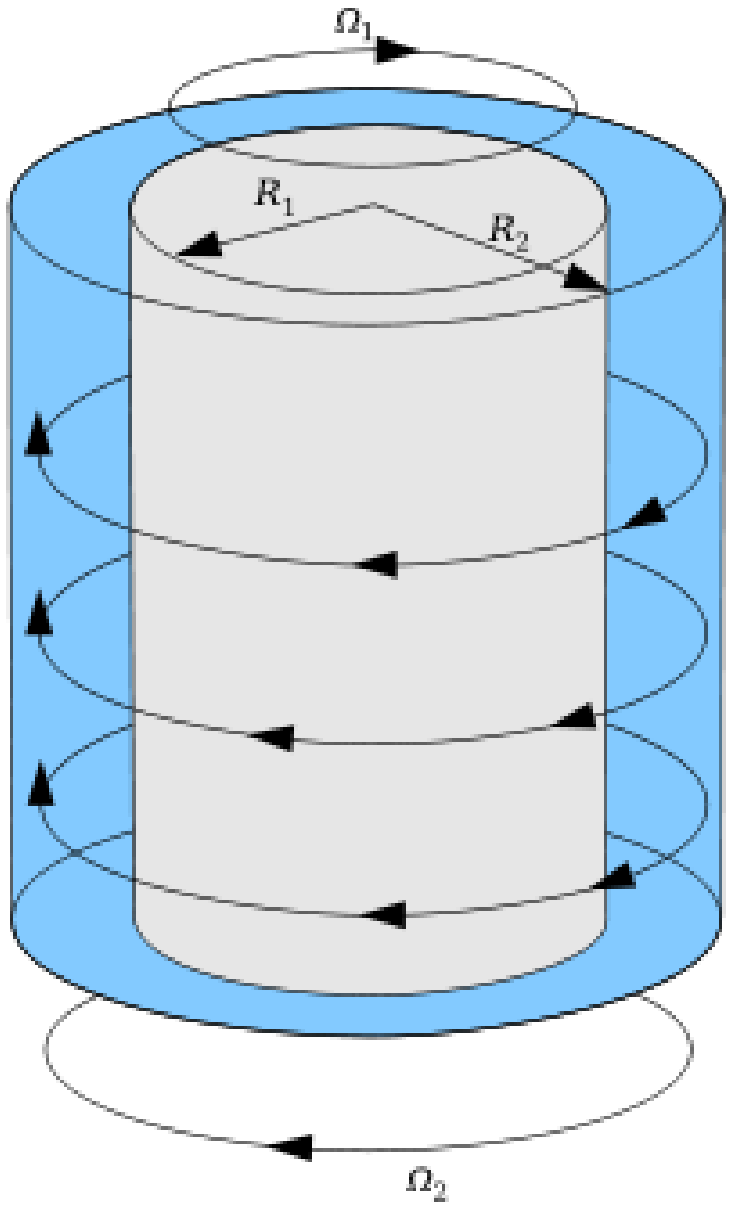
- Fluid flow between two coaxial cylinders
- Important parameters:

$$a = -\frac{\Omega_2}{\Omega_1}$$

$$Ta = \frac{centrifugal\ forces}{viscous\ forces}$$

$$= \frac{1}{4}\left(\frac{1+\eta}{2\sqrt{\eta}}\right)^4 \left(\frac{R_2^2 - R_1^2}{\nu}\right)^2 (\Omega_1 - \Omega_2)^2$$

where $\eta = \frac{R_1}{R_2}$



Twente Turbulent Taylor-Couette (T^3C)

~1m

~0.56m

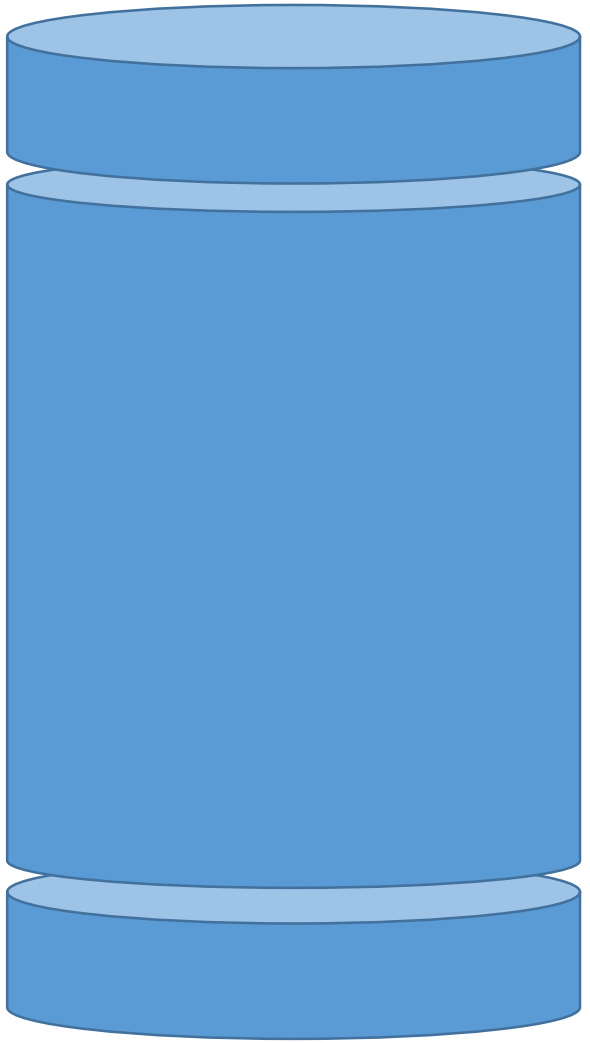
$\eta = 0.716$

Maximum rotation frequency:
20Hz

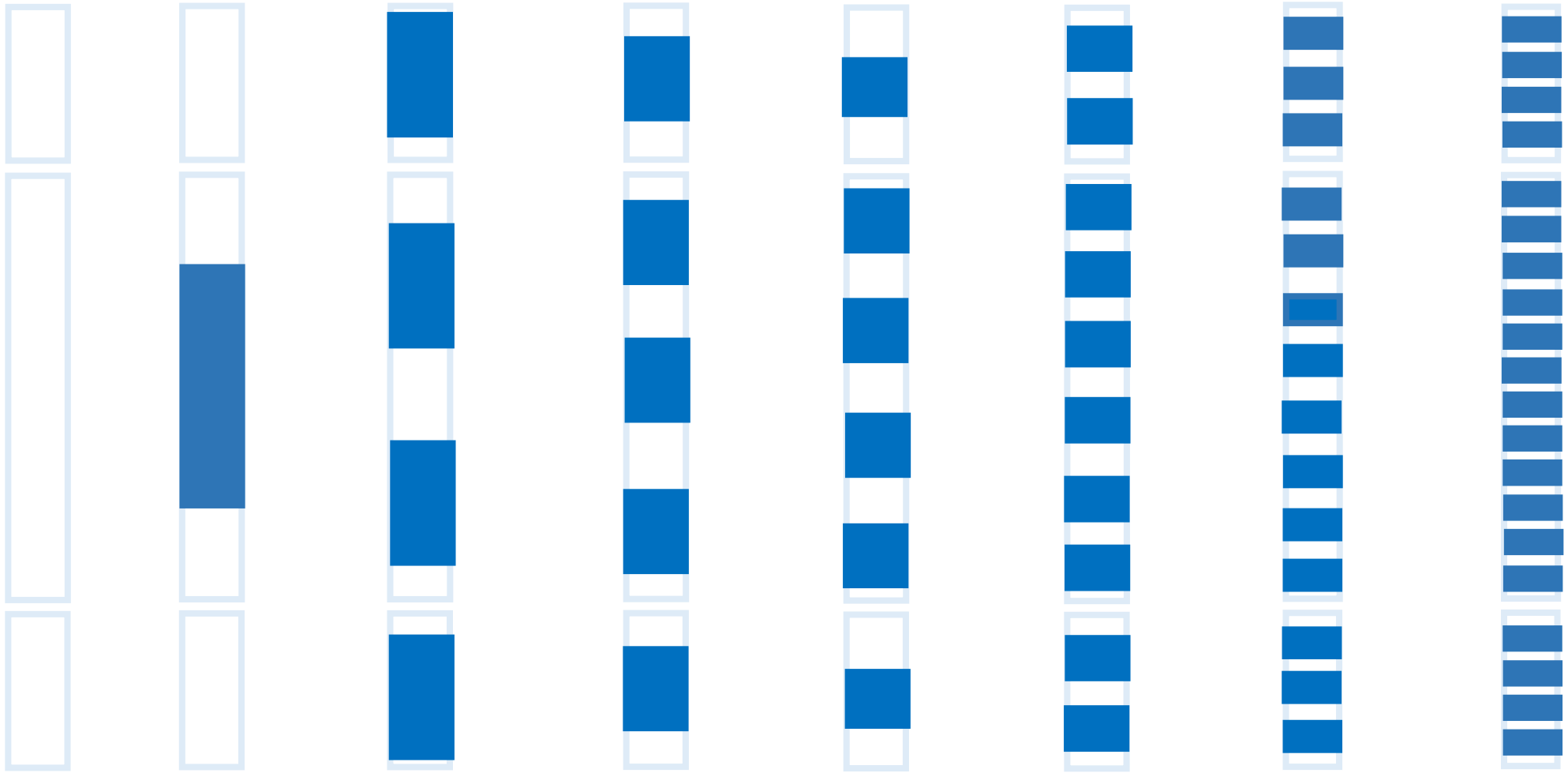
Torque and Temperature sensors

What we want to study

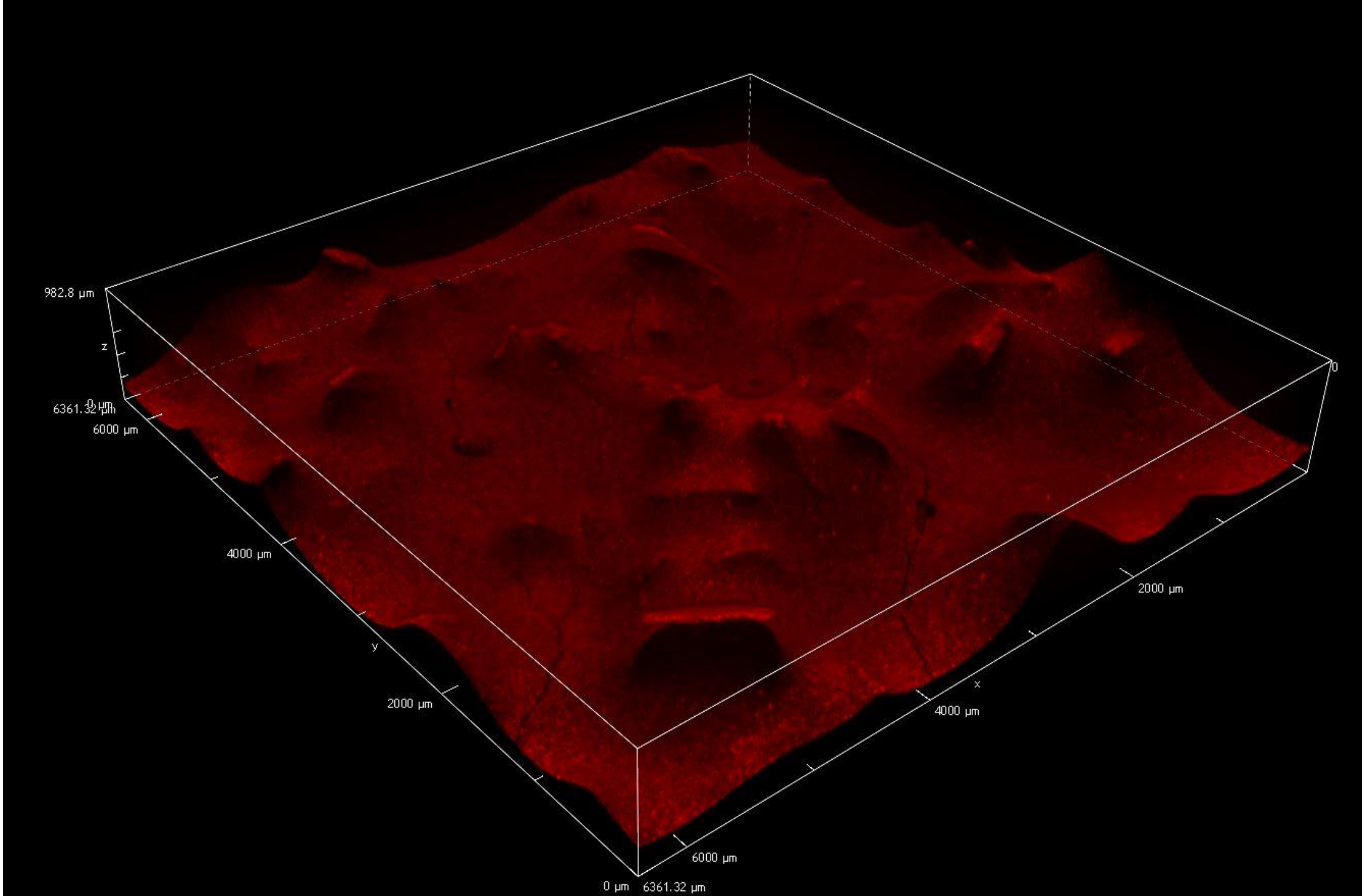
- Infinitely long TC facility with periodic roughness pattern of different period
- Inner cylinder
  - Finite
  - Top and bottom plates
  - Composed of three parts



What we want to study



- Roughness coverage on the middle cylinder is kept constant ~56%

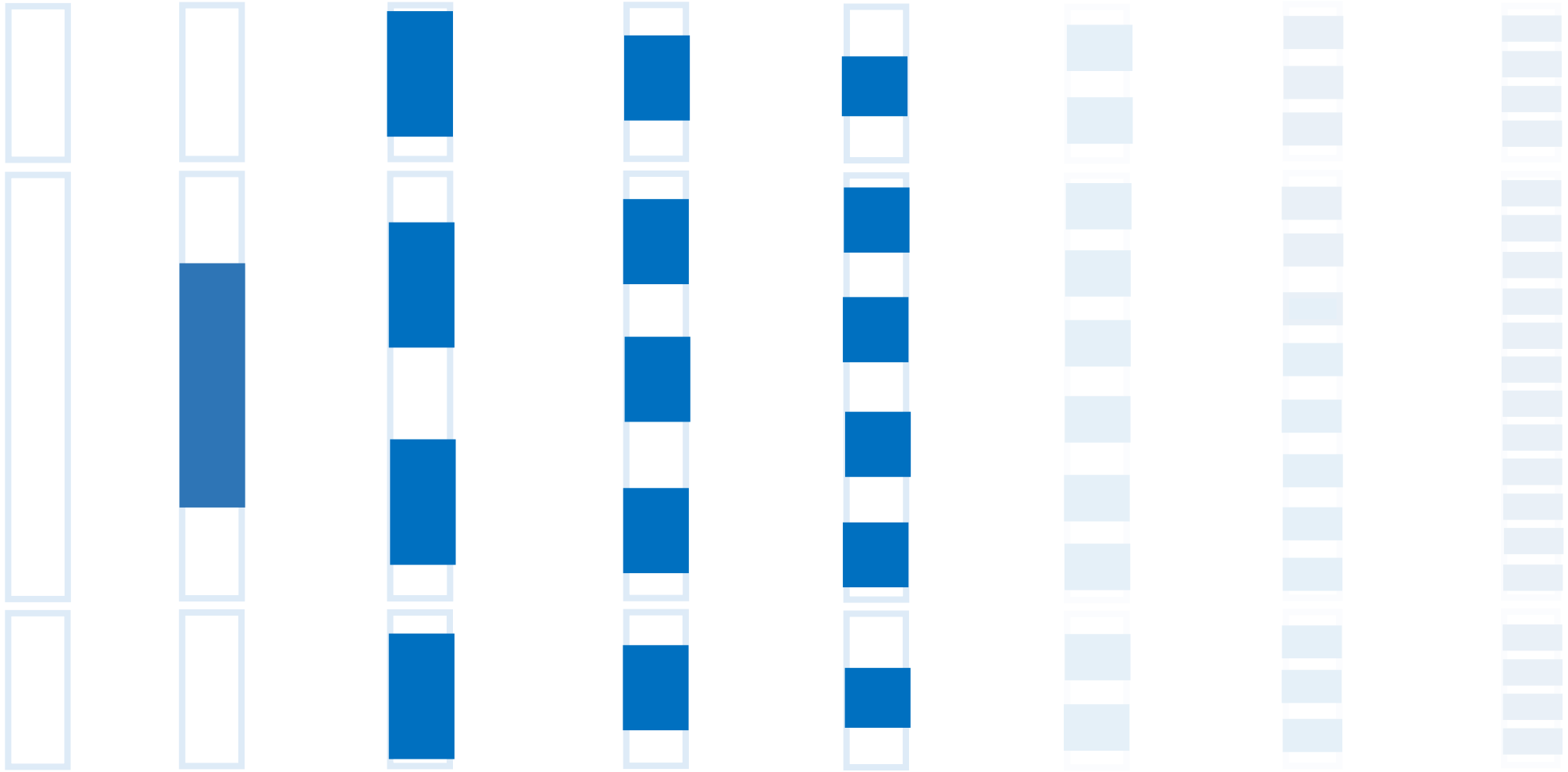

982.8 µm
z
0 µm
6361.32 µm
6000 µm
4000 µm
y
2000 µm
0 µm
6361.32 µm
6000 µm
4000 µm
x
2000 µm
0

What we measured

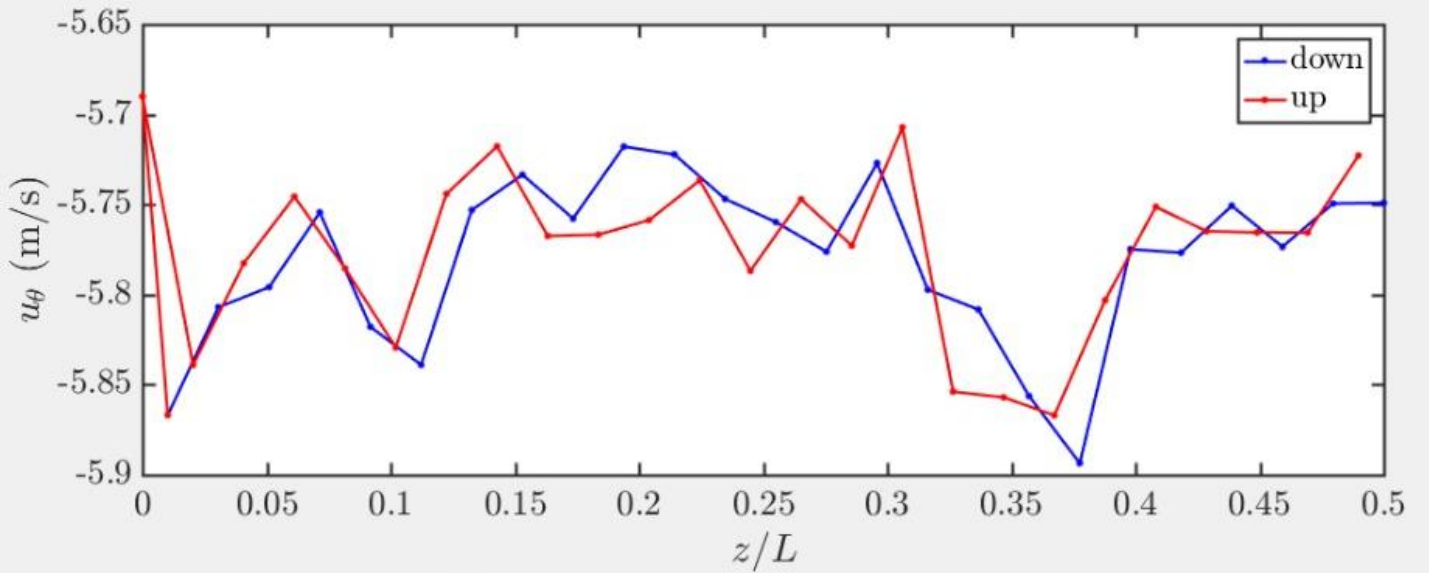
- Nusselt number
  - Angular velocity flux
  - Non-dimensional torque

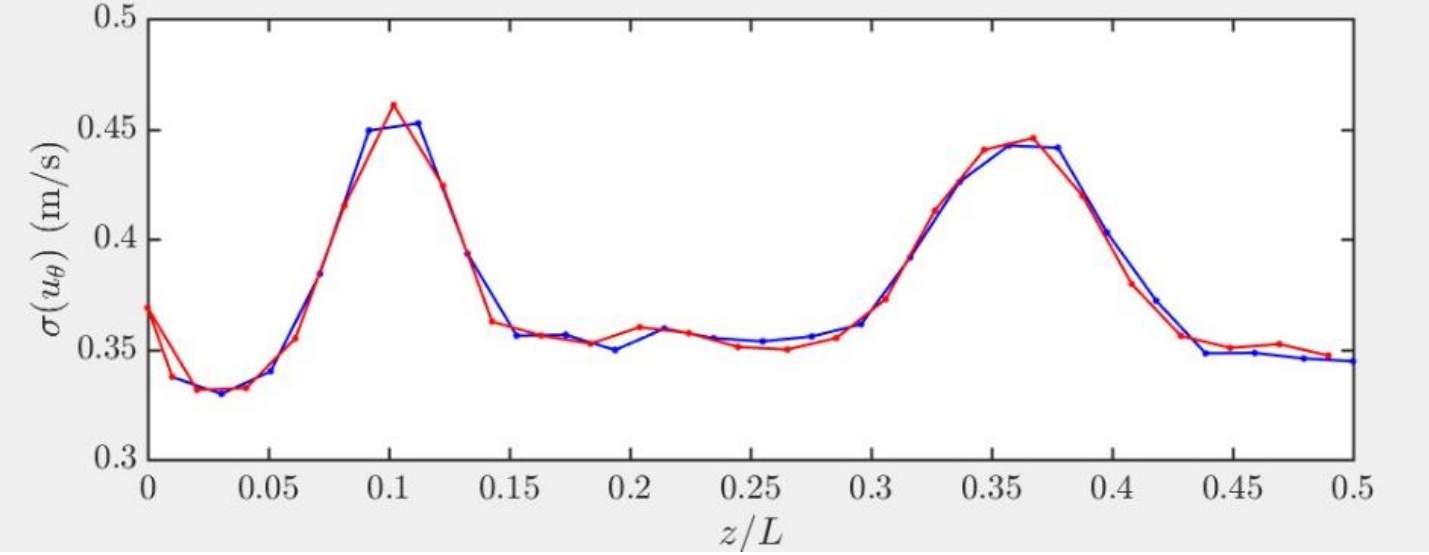
- Velocity Profile
  - Laser Doppler Anemometer (LDA)
    vertical profile of velocity in $\hat{\theta}$ and $\hat{z}$ direction
  - Particle Image Velocimetry (PIV)
    2D velocity field at fixed height ($\hat{\theta}$ and $\hat{r}$ direction)

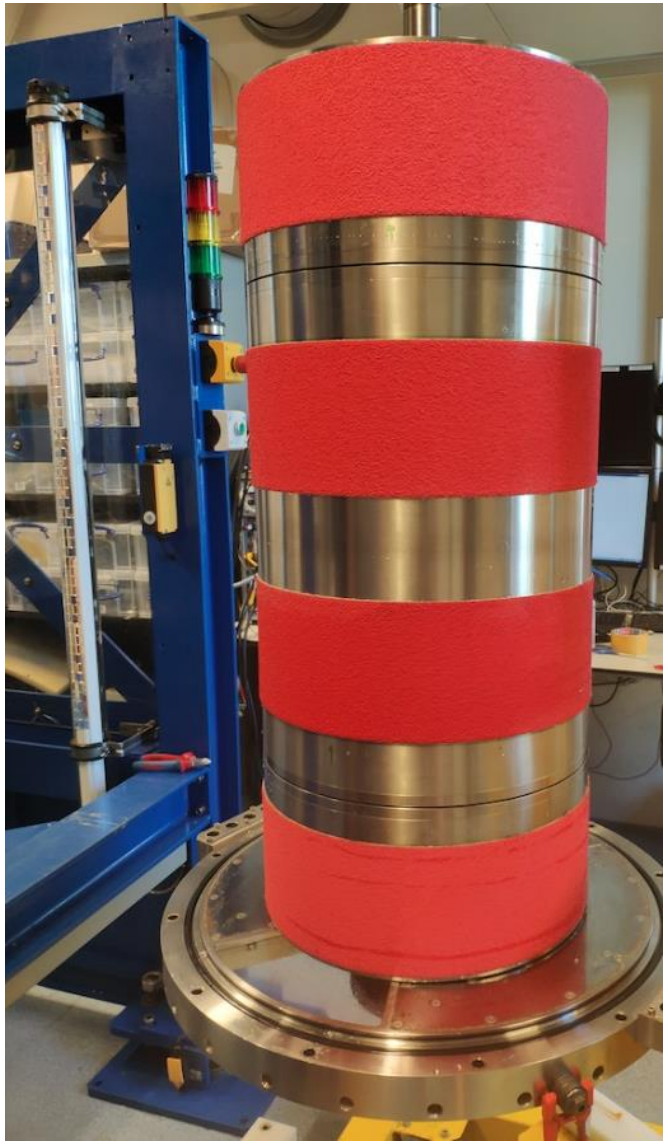
The Project is still ongoing.....



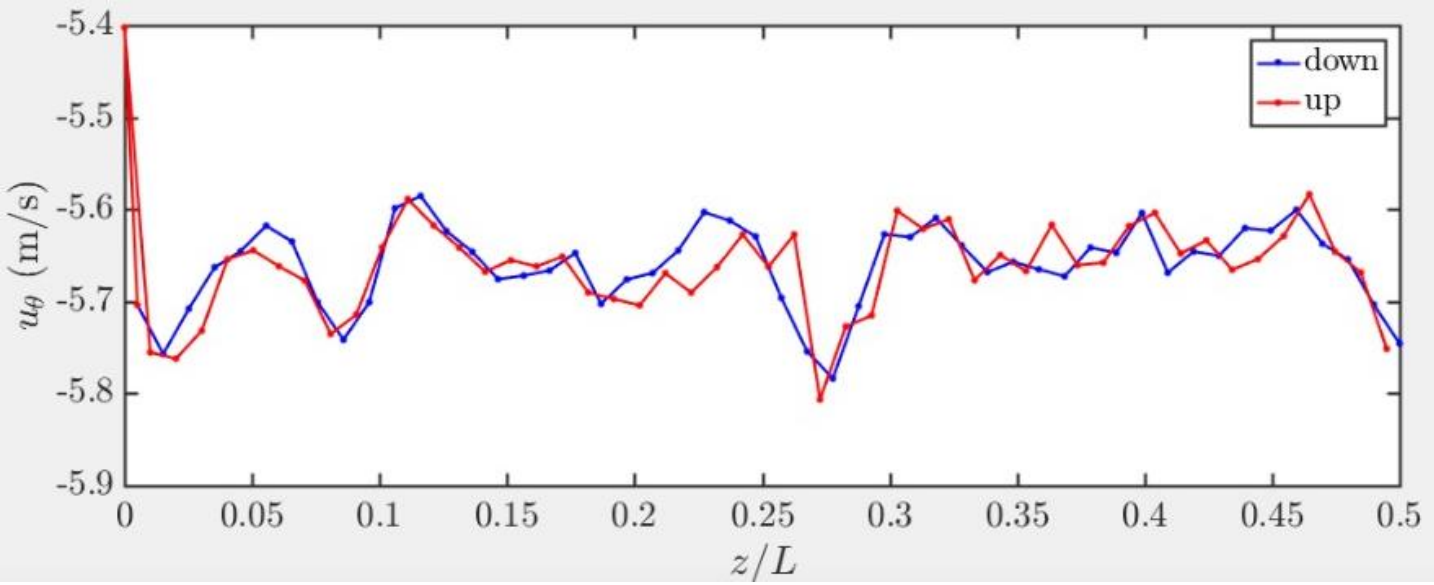
Results

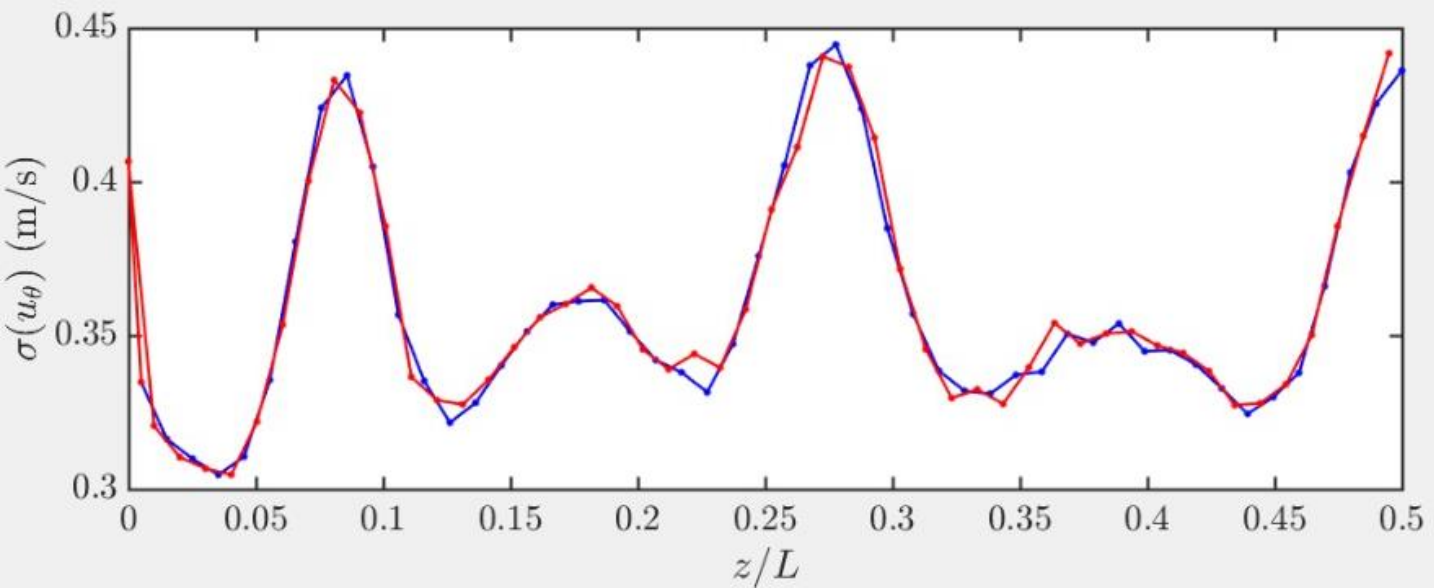


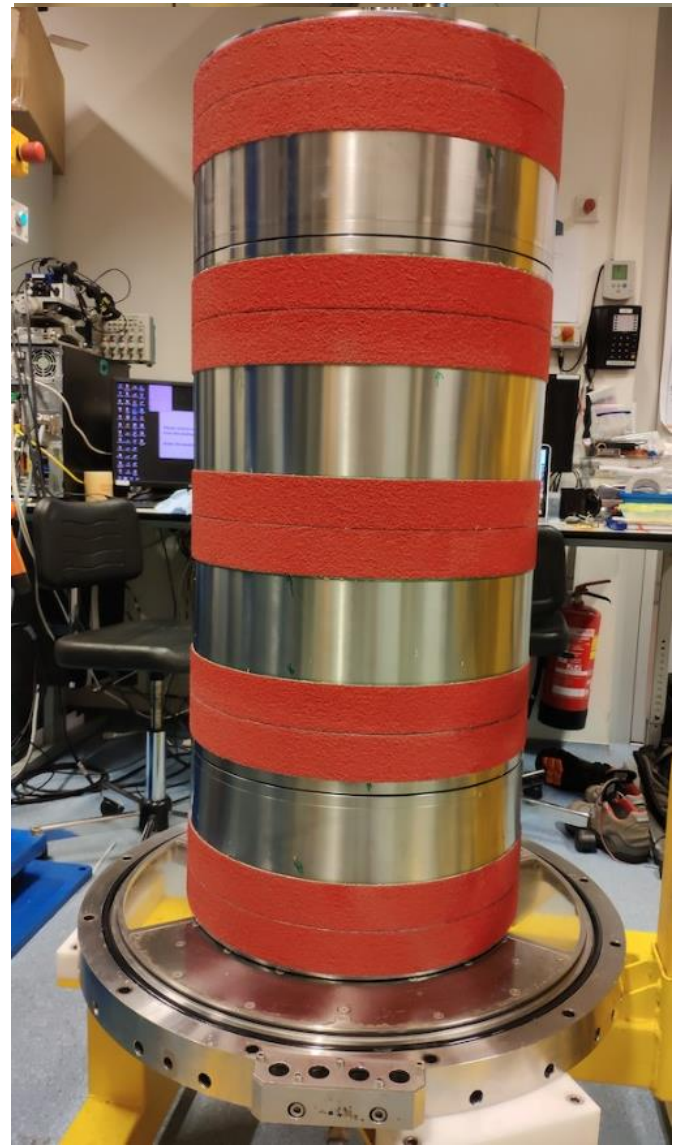




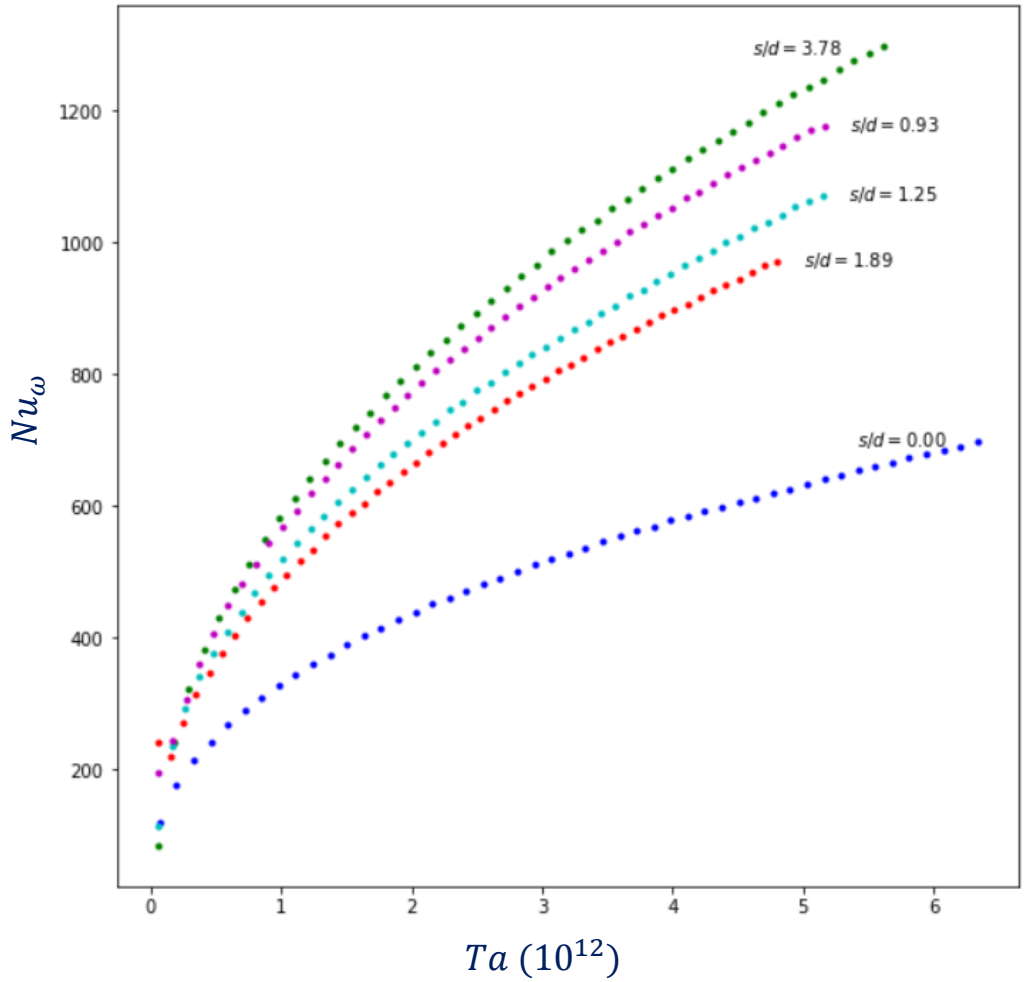
Results

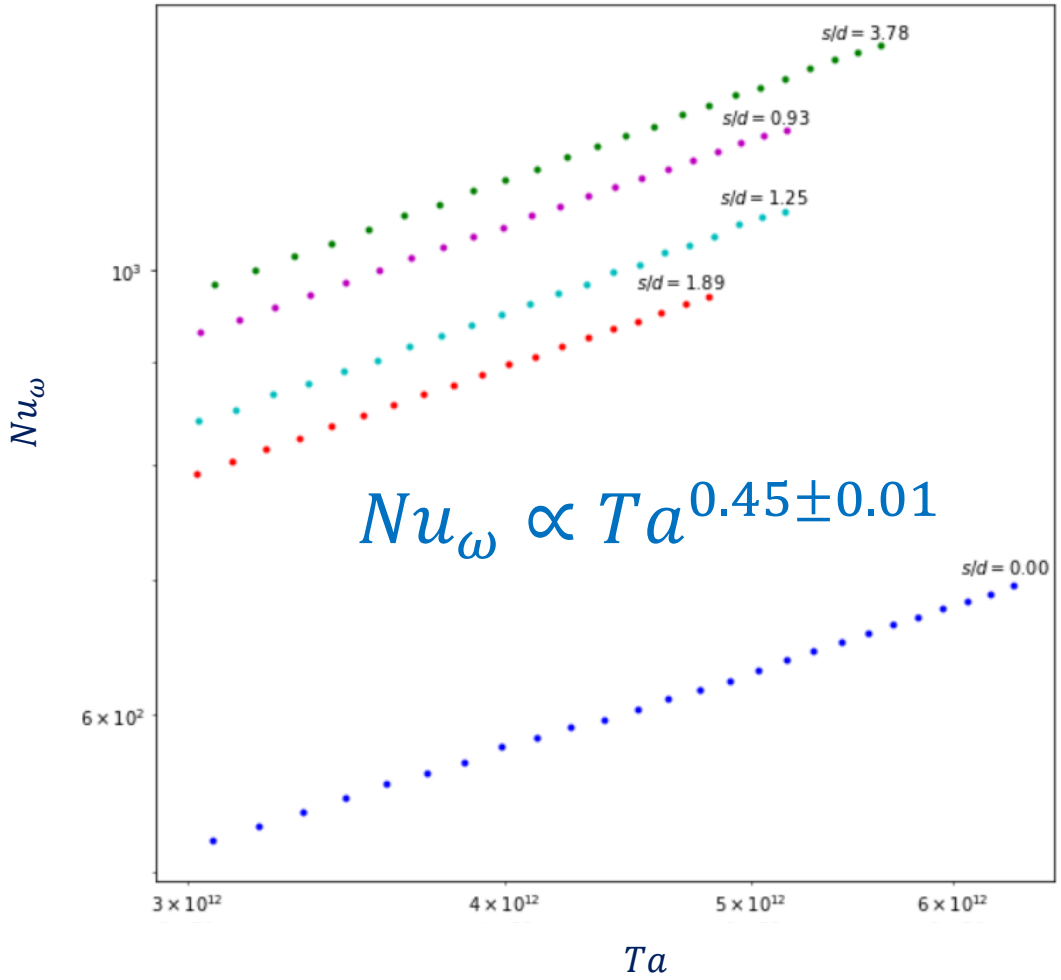




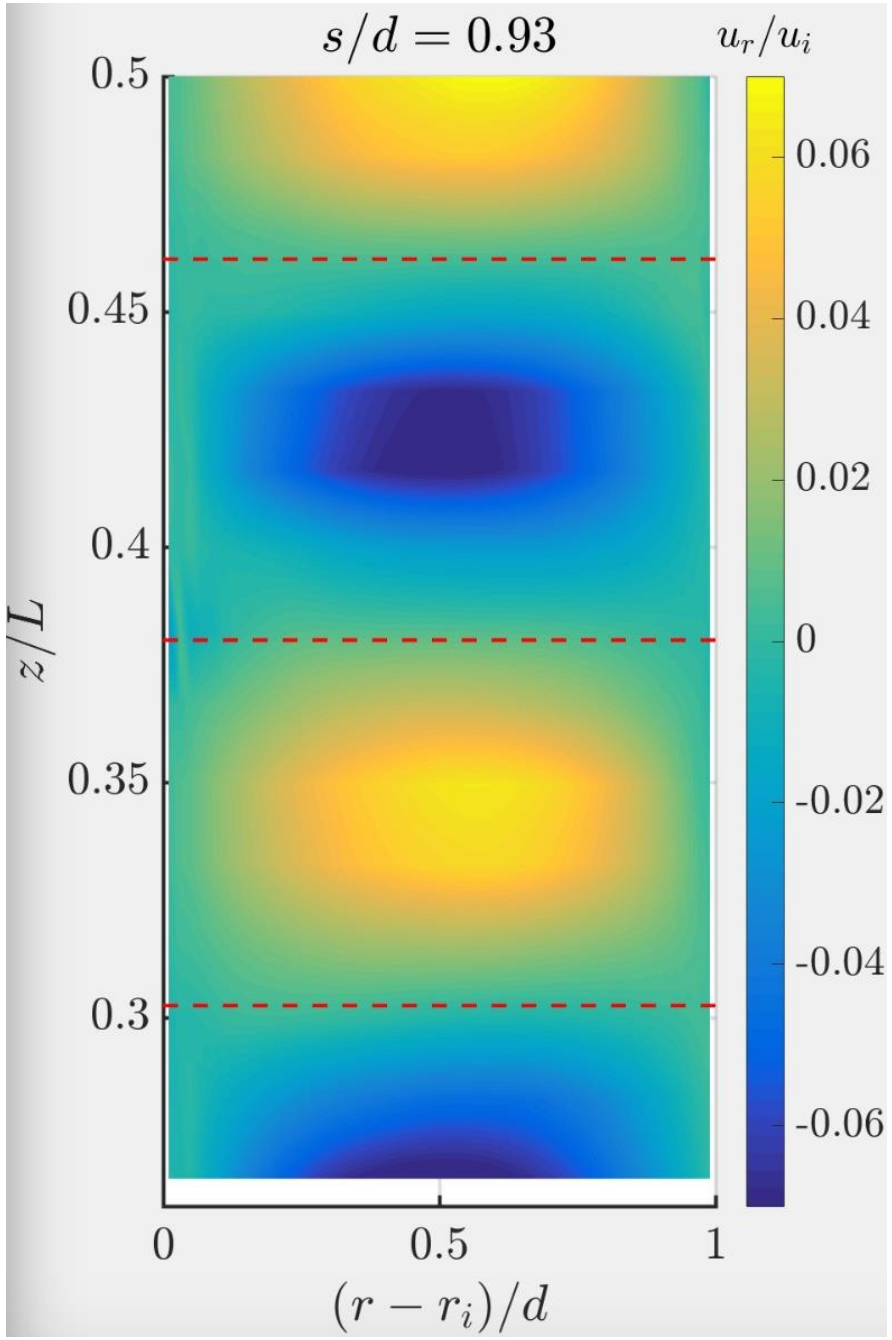


Results

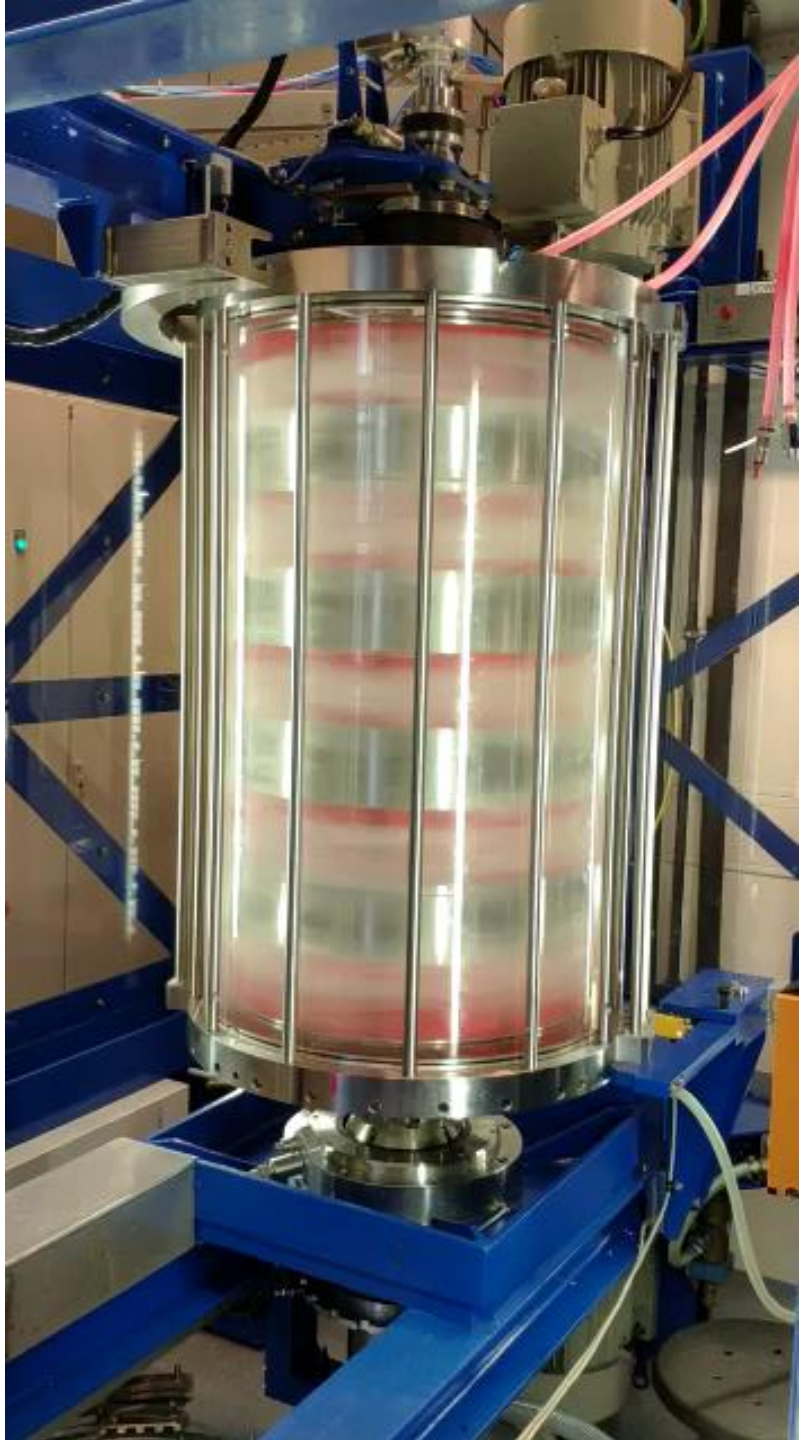

s/d = 3.78
s/d = 0.93
s/d = 1.25
s/d = 1.89
s/d = 0.00
1200
1000
800
600
400
200
0
1
2
3
4
5
6
Nu_ω
$Ta\ (10^{12})$


s/d = 3.78
s/d = 0.93
s/d = 1.25
s/d = 1.89
s/d = 0.00
10^3
6×10^2
3×10^{12}
4×10^{12}
5×10^{12}
6×10^{12}
Nu_ω
Ta
$Nu_\omega \propto Ta^{0.45 \pm 0.01}$

Results


$s/d = 0.93$
u_r/u_i
0.5
0.45
0.4
0.35
0.3
z/L
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
0
0.5
1
$(r - r_i)/d$

Results



Questions?!

☺ Thank you for paying attention ☺