Development of an elastography bench for MR exam of small samples

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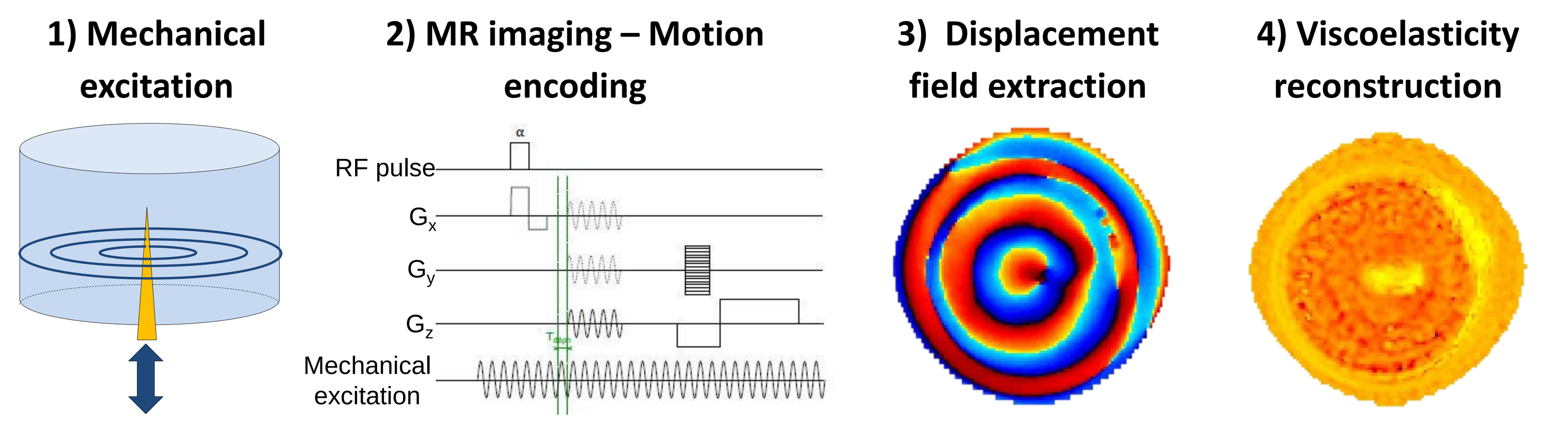
Introduction

Extraction of biomechanical parameters for small samples via Magnetic Resonance Elastography (MRE):



Need of: - Wave amplitude > µm
- High signal to noise ratio (SNR) with high resolution
- Low cost and handy design

Methods

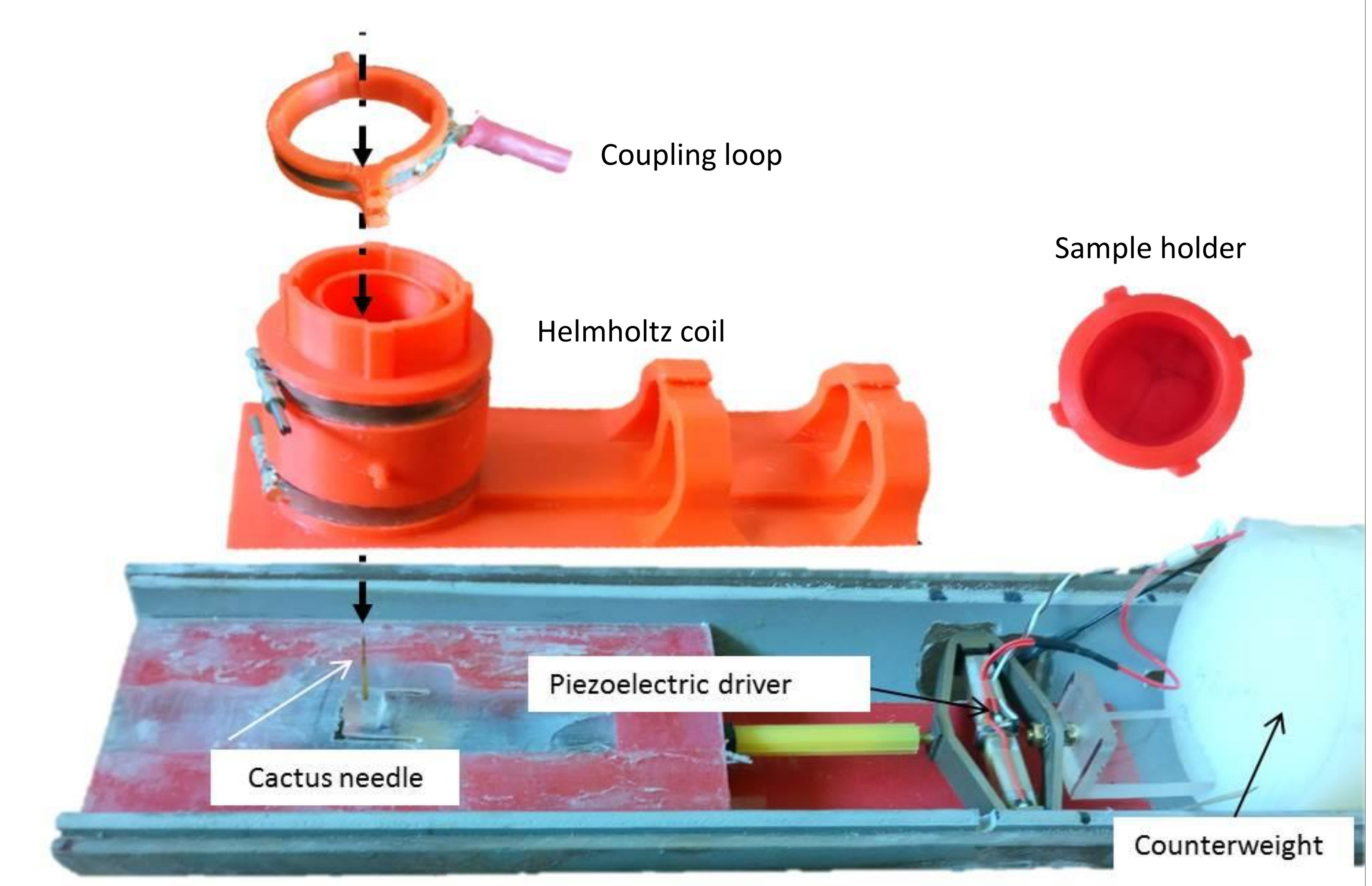


Figure 1. 3D-printed device on top of a classical elastography setup:
- Helmholtz coil (Ø = 36 mm):
  Tuning: capacity trimmers
  Matching: Coupling loop (inductive coupling)
- Sample holder gliding into the coil

Acquisition on a Bruker 4.7 T scanner for fibrin and agarose 1,5% gels and an *ex vivo* rat brain:

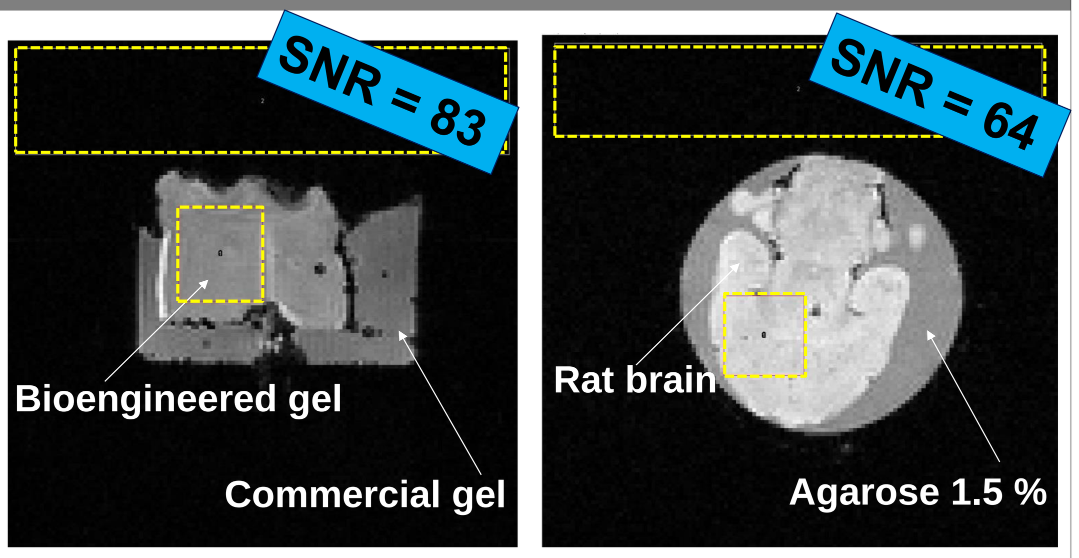
Acquisition parameters	FLASH 3D	Turbo spin echo (MRE)
TR/TE (ms)	15/6	2000/18 - 24
Voxel size (mm)	0.312x0.312x0.625	0.312x0.312x0.625
FOV (mm)	40 x 40	40 x 40
Flip angle (°)	15	X
Reception bandwidth (kHz)	50	50
Acquisition time (min)	2	17
Excitation frequency (Hz)	X	600 – 1000

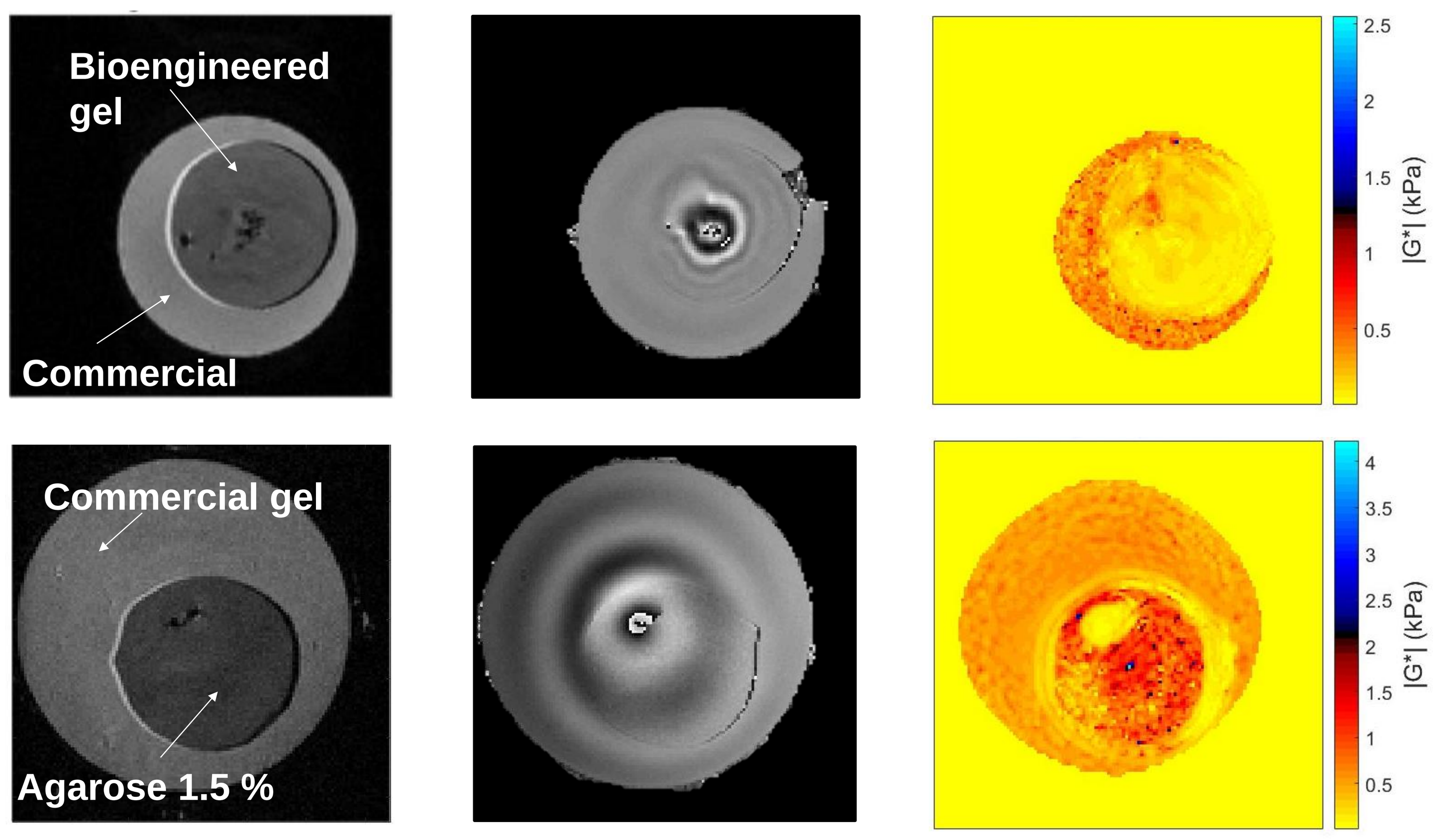
Table 1. Acquisition parameters for an anatomical (FLASH) sequence and a conventional spin echo based elastography sequence

Results

Figure 2. SNR worked out on central slices of a FLASH sequence for a bioengineered gel and a rat brain:

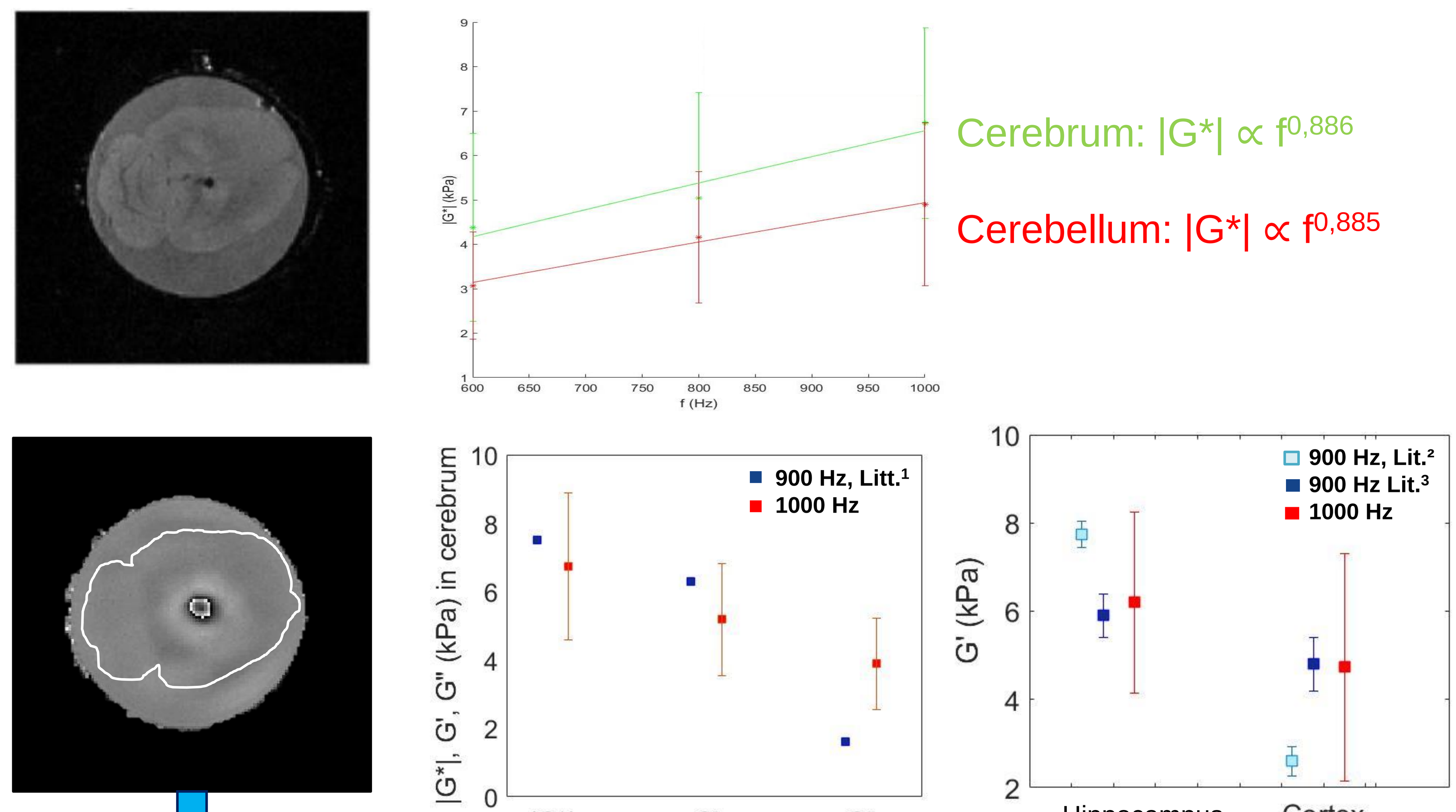
$SNR_{gel} = 83$
$SNR_{brain} = 64$





Visible propagation + Clear difference in |G*| for gels

Figure 3. Magnitude, phase and reconstructed magnitude of the complex shear modulus |G*| obtained by MRE at 600 Hz for the bioengineered gel and an 1.5% agarose gel, both embedded in a commercial gel. Total displacement magnitude <A> was 3.8 µm for the first gel and 25.5 µm for the agarose gel after bench improvement. |G*| = 1.4± 0.5 and 7.3 ± 3.9 kPa, respectively.



<A> = 5.6 µm

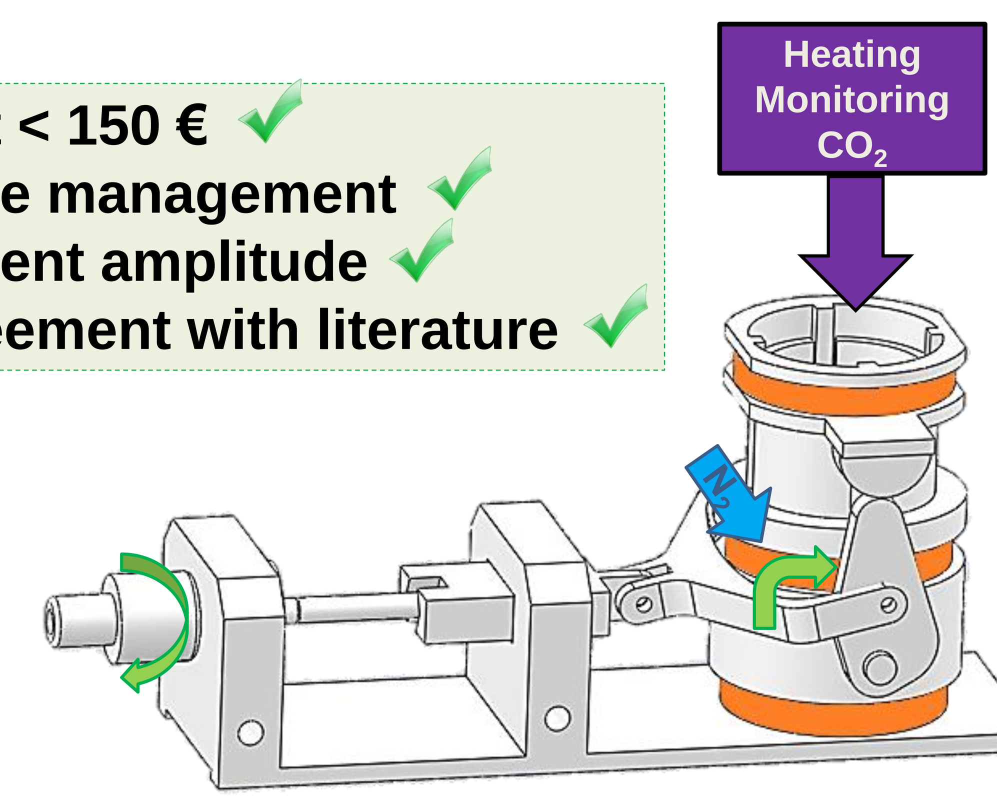
$|G^*|_{cerebrum} > |G^*|_{cerebellum}$ Similar dispersion

$G'_{hippocampus} > G'_{cortex}$

Figure 4. Magnitude and phase images of a fresh *ex vivo* rat brain for an excitation frequency of 600 Hz. Comparison of extracted biomechanical parameters G' (conservation modulus), G" (loss modulus) and |G*| with literature data

Discussion and Conclusion

Cost < 150 € ✓
Easy sample management ✓
Displacement amplitude ✓
Brain data in agreement with literature ✓



Planned improvements, in order to enable:
- **imaging of samples containing living cells: heating and its monitoring + gas arrival**
- **further improvement the SNR: N_2 arrival for coil cooling**
- **easier matching: lever system for the coupling loop.**

Perspectives: *ex vivo* acquisitions on rodent brains with neurological lesions (fibrillar aggregates of proteins, demyelination).

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References: (1) Millward *et al*., NMR Biomed., vol 28 2015. (2) Munder *et al*., J. Magn. Reson. Imaging, 2017. (3) Boulet *et al*., J. Neurosci. Methods, vol 201, 2011.

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