



Magnetic Resonance Acoustic Radiation Force Imaging (MR-ARFI) for the estimation of local viscoelasticity and anisotropy

Karine Choquet, Jonathan Vappou, Ounay Ishak, Paolo Cabras, Afshin Gangi, Élodie Breton

► To cite this version:

Karine Choquet, Jonathan Vappou, Ounay Ishak, Paolo Cabras, Afshin Gangi, et al.. Magnetic Resonance Acoustic Radiation Force Imaging (MR-ARFI) for the estimation of local viscoelasticity and anisotropy. ISMRM Workshop on Magnetic Resonance Elastography (ISMRM 2022), Aug 2022, Berlin, Germany. . hal-03926433

HAL Id: hal-03926433

<https://hal.science/hal-03926433>

Submitted on 6 Jan 2023

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial - NoDerivatives 4.0 International License

Magnetic Resonance Acoustic Radiation Force Imaging (MR-ARFI) for the estimation of local viscoelasticity and anisotropy

Karine Choquet¹, Jonathan Vappou¹, Ounay Ishak¹, Paolo Cabras^{1,2}, Afshin Gangi^{1,3}, Elodie Breton¹

¹Université de Strasbourg, CNRS, ICube, UMR 7357, Strasbourg, France

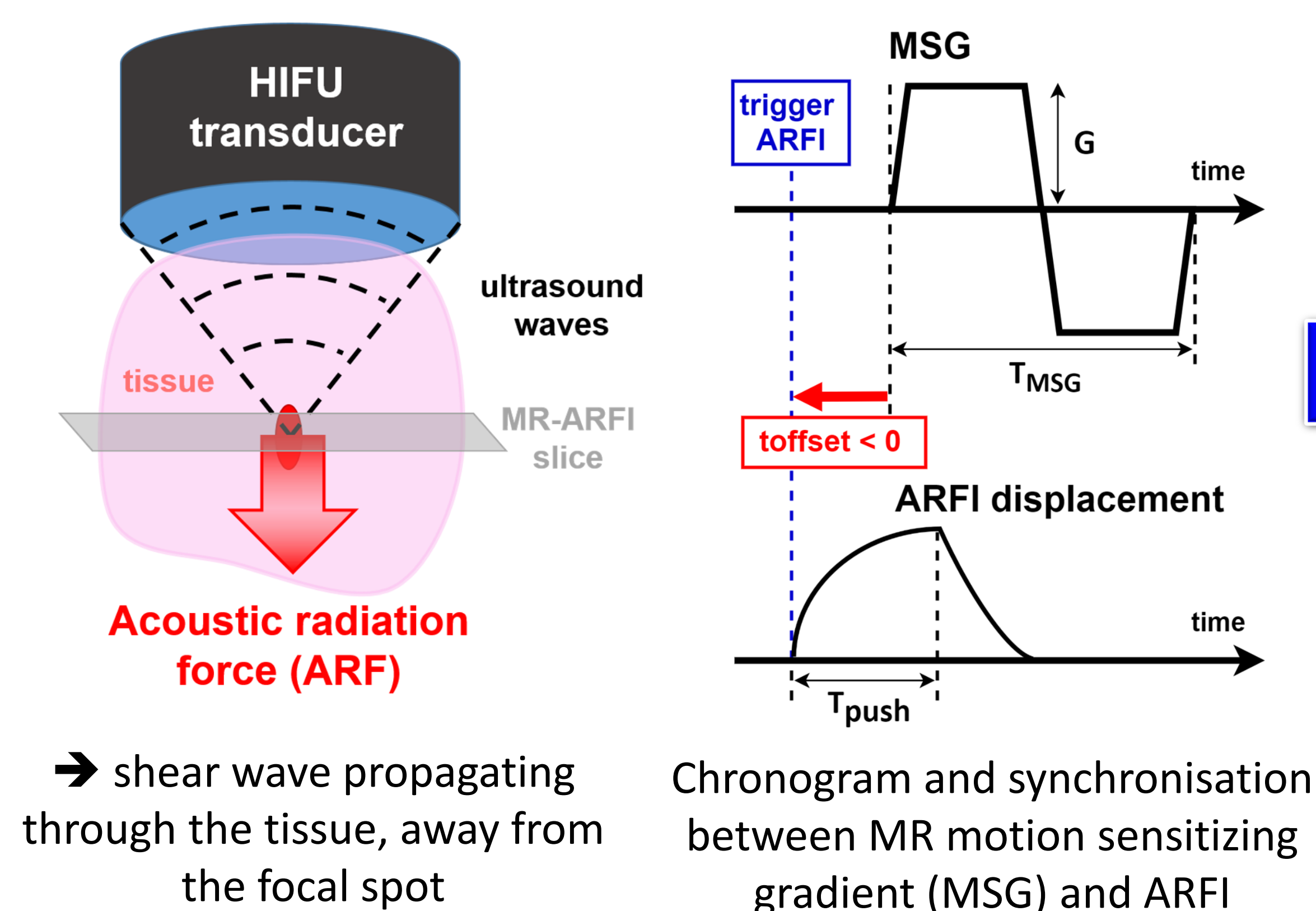
²Image Guided Therapy, Pessac, France

³Department of interventional imaging, Hôpitaux Universitaires de Strasbourg, Strasbourg, France

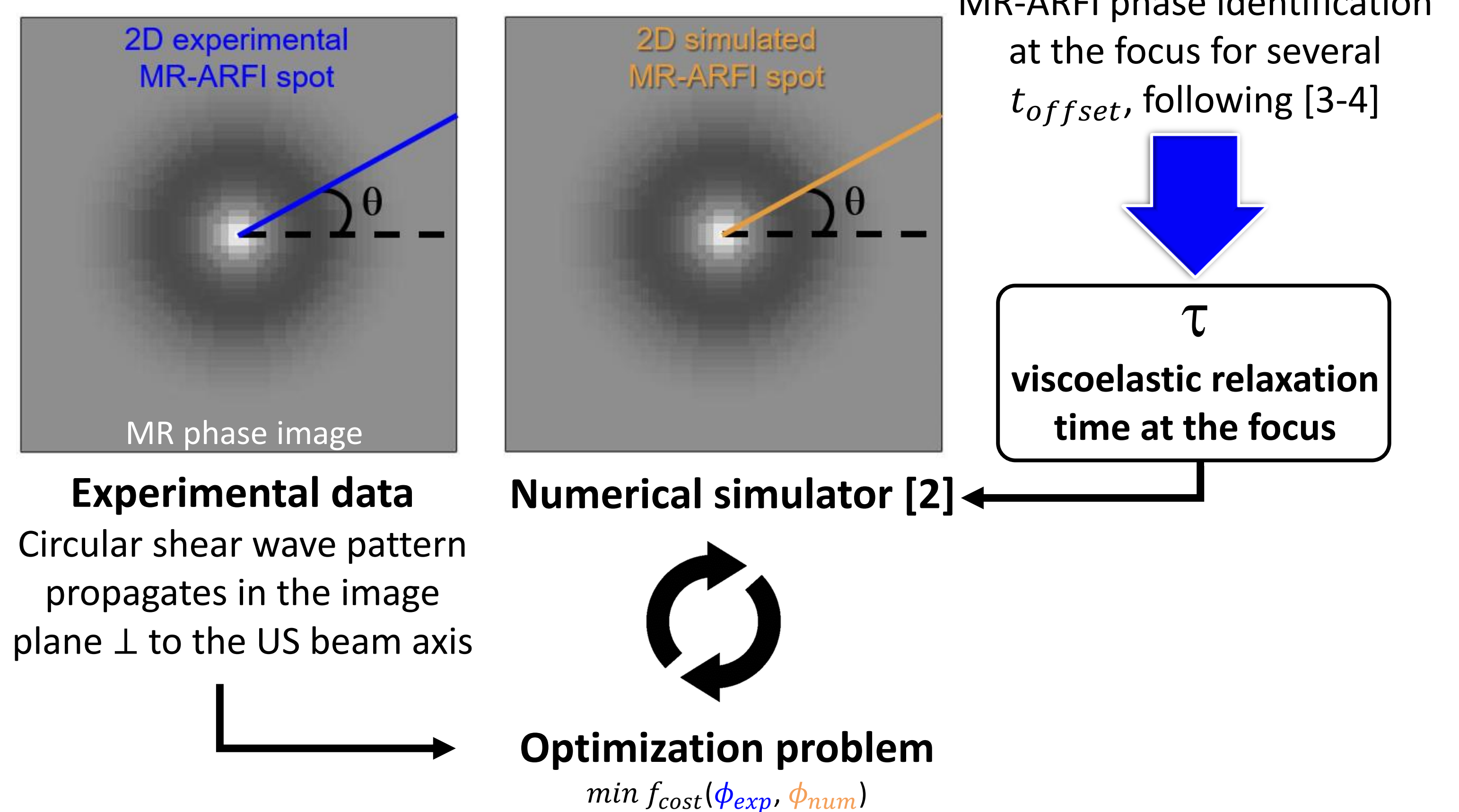
Purpose: To use MR-ARFI [1] as a fast transient elastography method to estimate the **viscoelasticity** and the **anisotropy of soft tissues**

METHOD

1. Generate ARF in tissue & encode tissue displacement

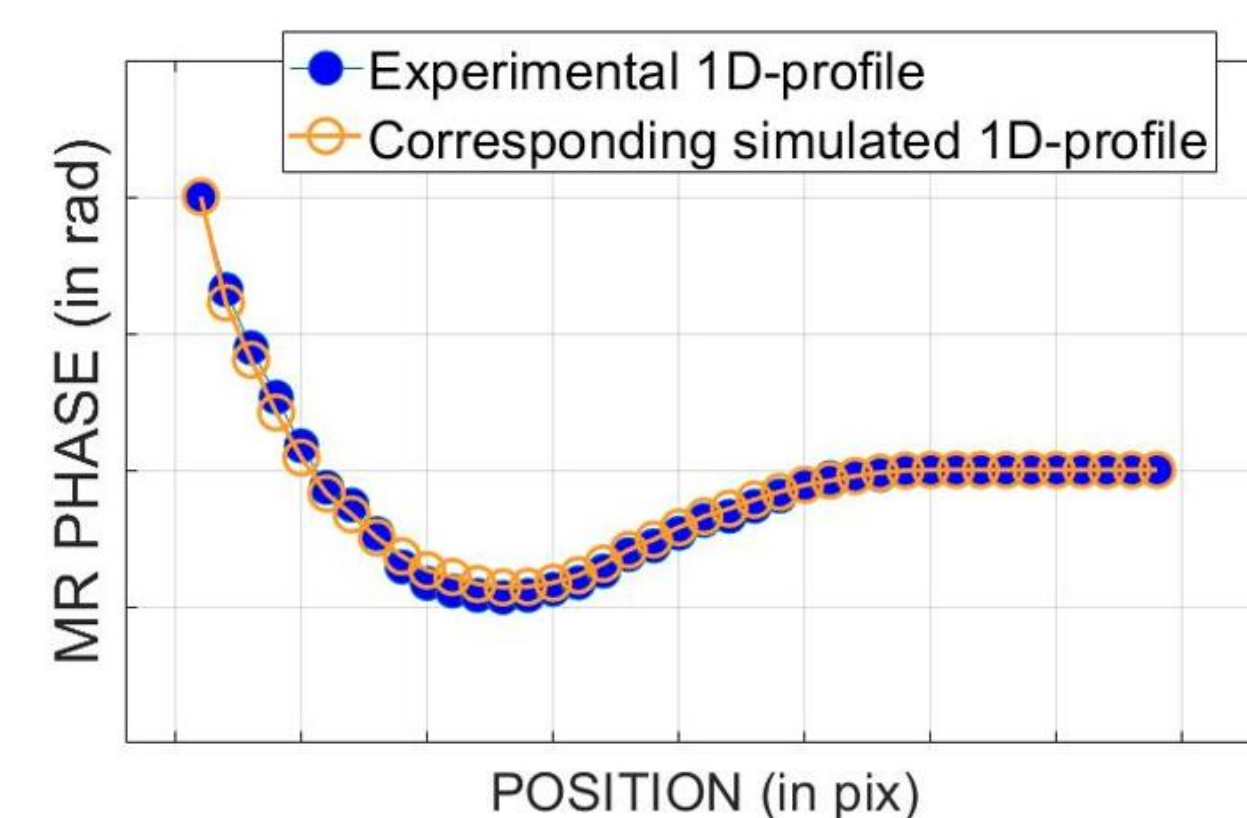


2. Numerical simulation & Fitting process



MAIN ACQUISITION PARAMETERS

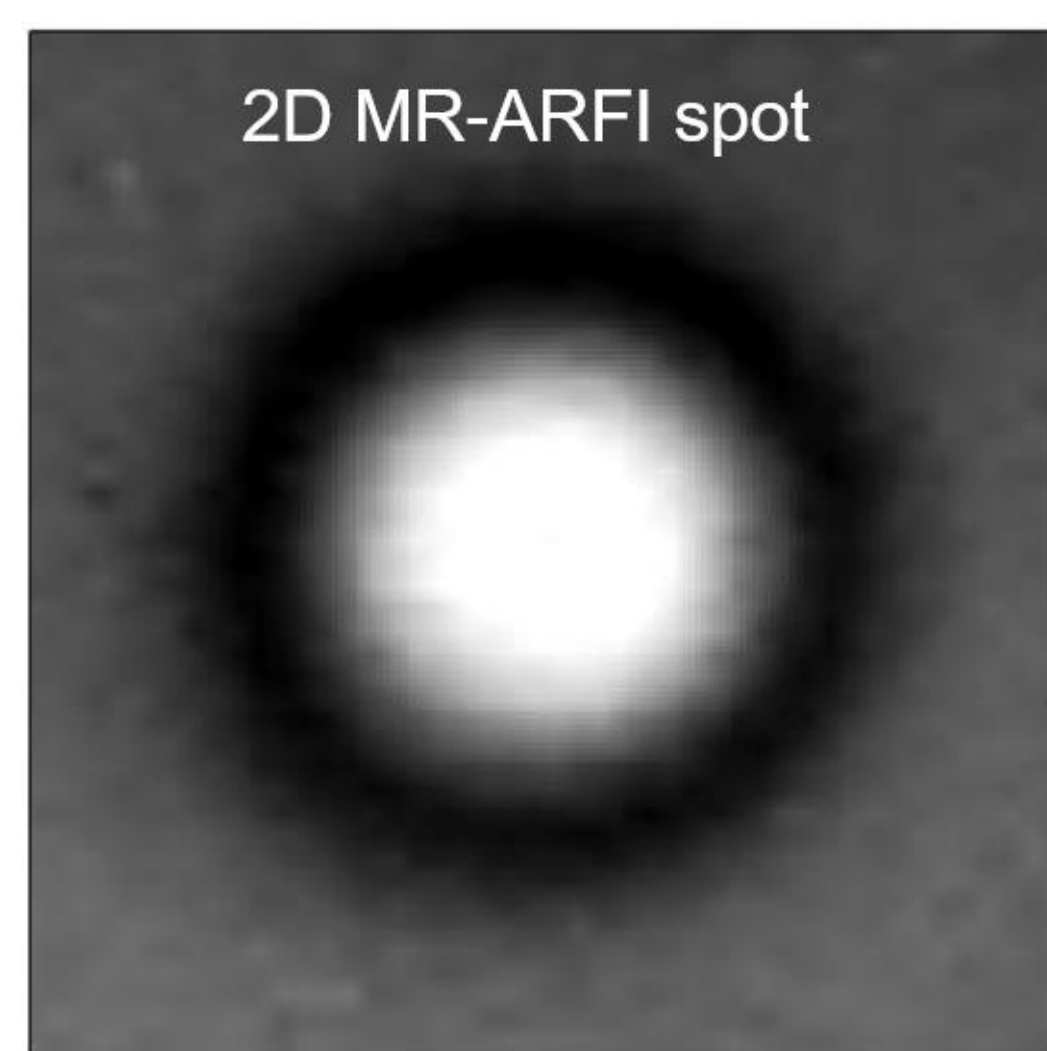
- MRI: B0 = 1.5 T, segmented echo planar imaging (EPI) gradient echo sequence, EPI factor = 37, matrix 128x128, TE/TR = 28/500 ms, acq. time = 4 s, voxel 2x2x6 mm³, T_{MSG} = 10 ms, G = 36 mT/m
- HIFU: 1 MHz 128-elem. spherical transducer, focal length = 6 cm, P_{push} = 200 W acoustic power, T_{push} = 5 ms



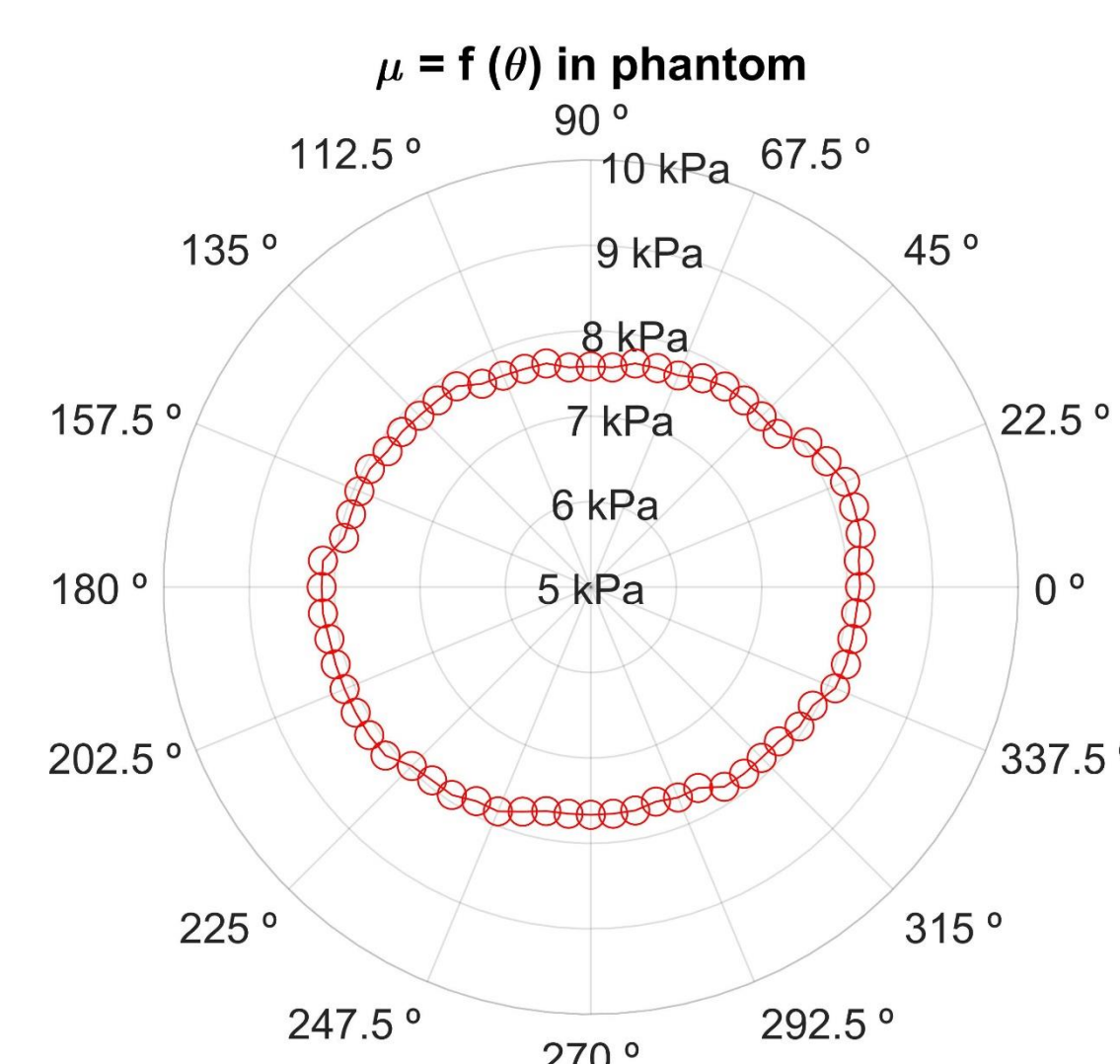
$\mu(\theta)$
shear modulus
polar map

VALIDATION EXPERIMENT

- Homogeneous calibrated gel phantom (model 049, CIRS, USA)



Experimental MR-ARFI pattern in the image plane $\perp$ to the US beam axis

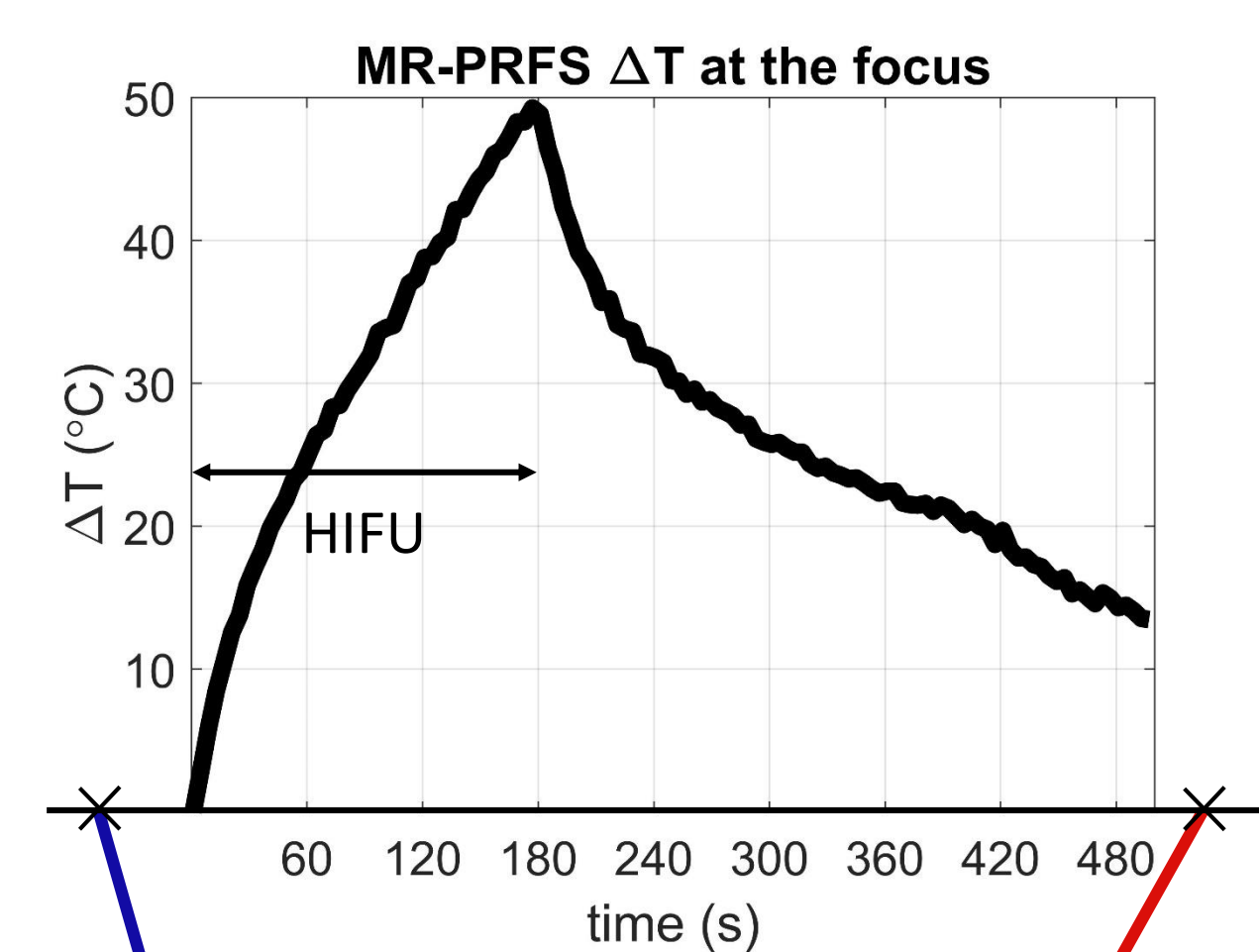


Identified μ polar map ($t_{offset} = -6$ ms)

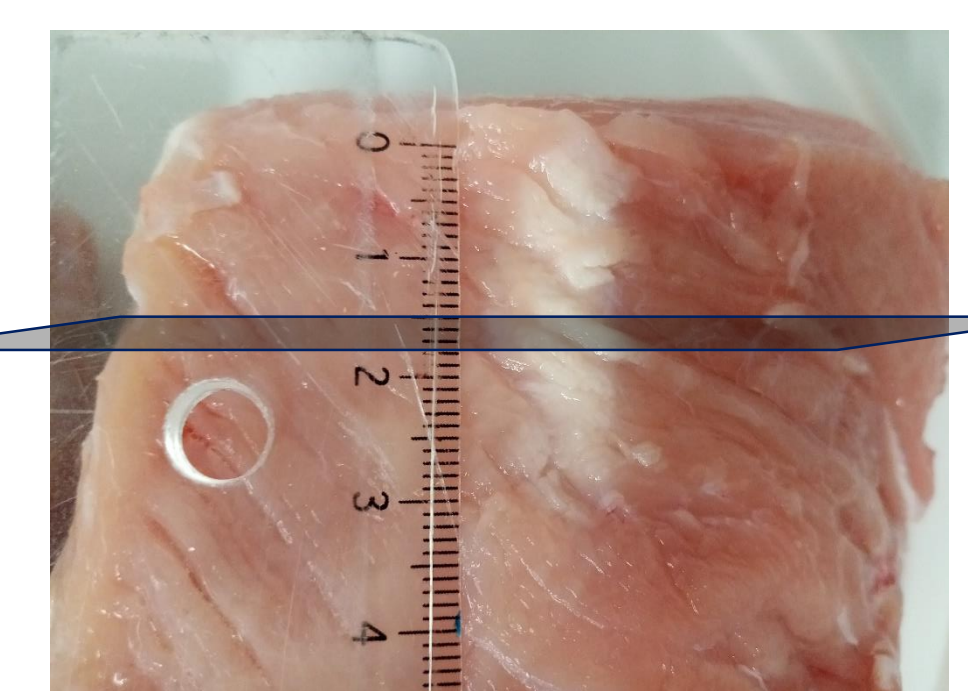
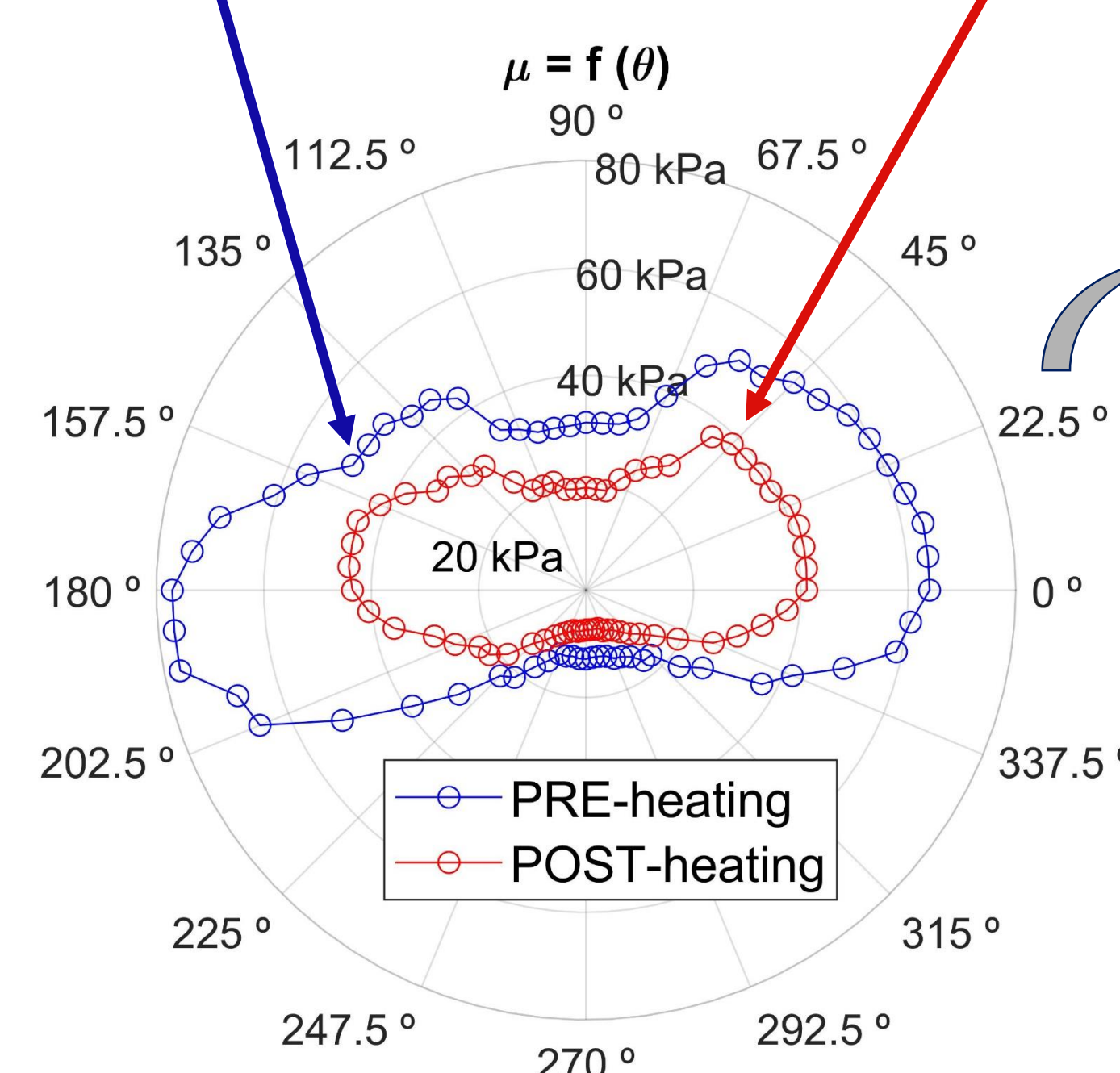
→ Circular μ polar map in isotropic medium

	Datasheet	Proposed approach
τ	N.A.	3.3 ms
μ	5.9 kPa $\pm$ 5%	7.9 kPa $\pm$ 3%

HIFU HEATING EXPERIMENT



- Ex vivo calf muscle tissue
- HIFU during 180 s, spiral trajectory of 7 shots (50 ms each), P_{heating} = 60 W acoustic power
- $\Delta T_{max} \approx +50$ °C



Meat cut in the image plane $\parallel$ to the US beam axis: irregular fiber orientation, consistent with the resulting distorted polar map (left)

CONCLUSIONS & PERSPECTIVES

- The proposed approach allows for local, **quantitative** and **direction-dependent** viscoelasticity measurements.
→ promising localized, biomechanical testing method
- The modification of τ found with HIFU heating calls for a **further refined modeling of viscoelasticity**.
→ extend the method to the monitoring of HIFU ablations

REFERENCES

- [1] McDannold et al, Med Phys, 35-8, 2008 [2] Vappou et al, Phys Med Biol, 63-9, 2018 [3] Kaye et al, Magn Reson Med, 69-3, 2018 [4] Dadakova et al, Magn Reson Med, 79-2, 2018 [5] Wu et al, Magn Reson Med, 45-1, 2001

	pre-HIFU	post-HIFU	Δ
τ	7.5 ms	4.5 ms	-40 %
$\mu(\theta = 0^\circ)$	64 kPa	41 kPa	-36 %
$\mu(\theta = 45^\circ)$	55 kPa	39 kPa	-30 %
$\mu(\theta = 90^\circ)$	31 kPa	19 kPa	-39 %

→ Meat tenderization with HIFU, consistent with literature [5]
→ Anisotropy of muscle tissue