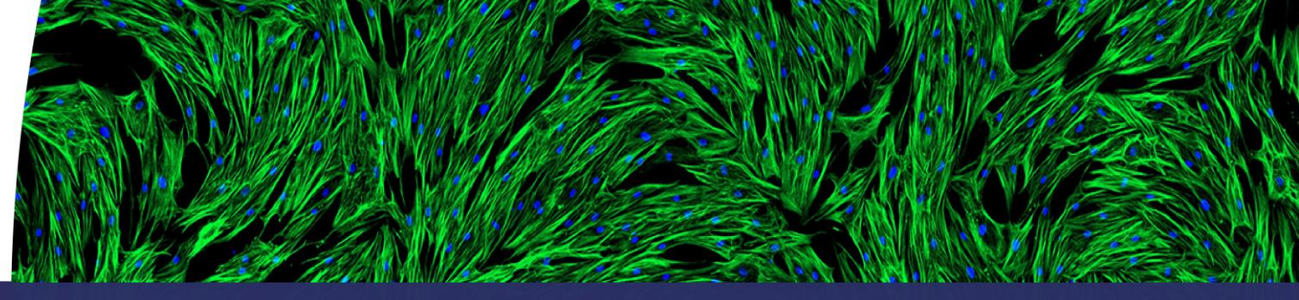
stemNICHE
Engineering Bone Marrow for Discovery



Chemo-mechanical characterisation of engineered bone marrow niches using correlative Brillouin and Raman spectroscopy

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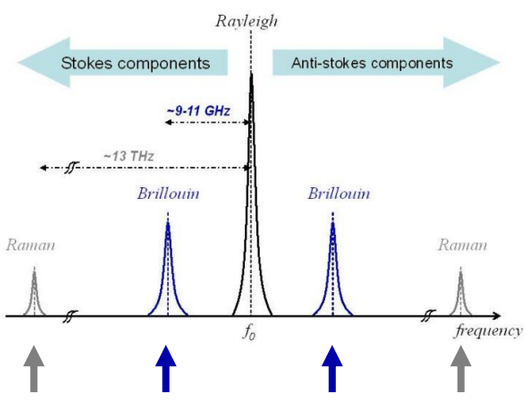
INTRODUCTION AND BACKGROUND

CORRELATIVE BRILLOUIN-RAMAN SPECTROSCOPY



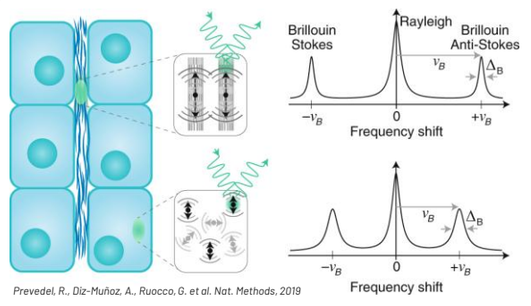
Light–matter interaction, different spectral windows

GHz (Brillouin) + THz (Raman)

No spectral overlap → correlative measurements

Label-free, non-destructive chemo-mechanical imaging

Real-time monitoring of dynamic biological processes



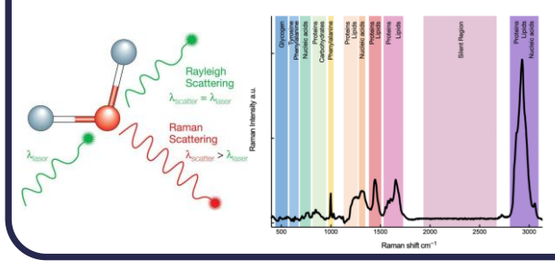
Prevedel, R., Diz-Muñoz, A., Ruocco, G. et al. Nat. Methods, 2019

Brillouin spectroscopy

Light -> acoustic phonons

Mechanics

- Elasticity and viscosity
- Cell-environment interaction



Raman spectroscopy

Light -> molecular vibrations

Biochemistry

- Molecular composition
- Metabolic state
- Chemical fingerprint

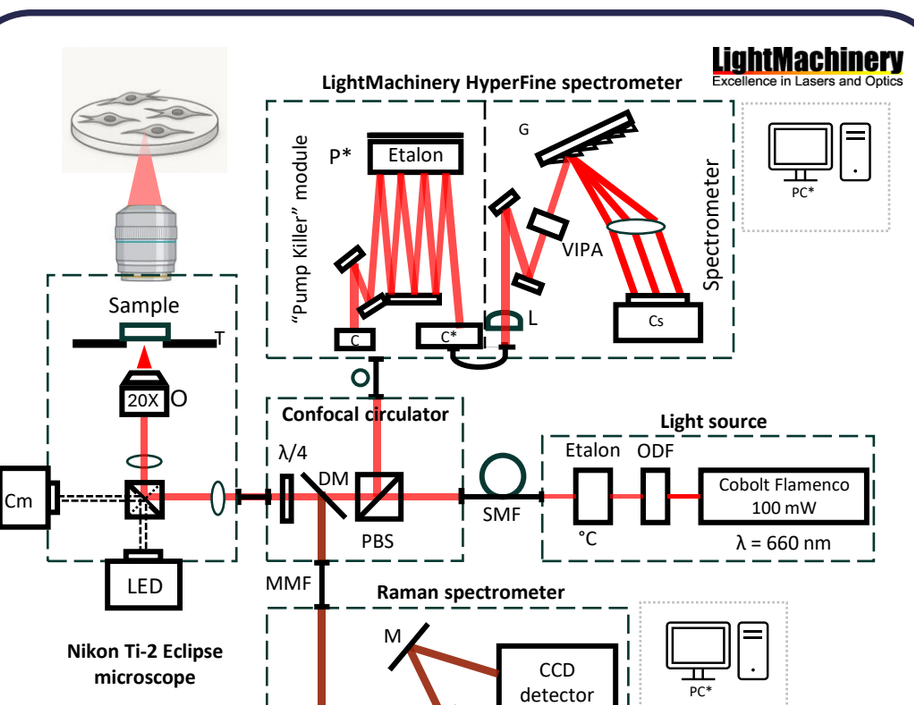
METHODS

CORRELATIVE BRILLOUIN-RAMAN PLATFORM

LightMachinery Brillouin microscope and Horiba iHR320 Raman spectrometer mounted on an inverted Nikon Ti-2 microscope

Technical parameters:

- Single 660 nm CW laser (Cobolt Flamenco) used for both modalities
- Fibre-coupled confocal-style geometry for optical sectioning
- Brillouin (GHz) and Raman (THz) signals separated by a dichroic mirror and directed to dedicated spectrometers
- 20x air objective (NA 0.45) for niche-scale measurements
- Brillouin spectral resolution: 0.5 GHz (~0.7 pm)

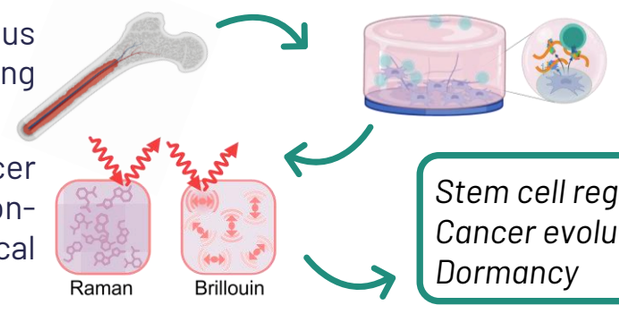


Combined platform enables correlated mechanical, biochemical and morphological characterisation of engineered bone marrow niches.

MOTIVATION

Bone marrow function depends on continuous interactions between cells and their surrounding microenvironment.

To understand stem cell regulation, cancer progression and dormancy, we require non-invasive tools capable of tracking both mechanical and biochemical niche remodelling over time.

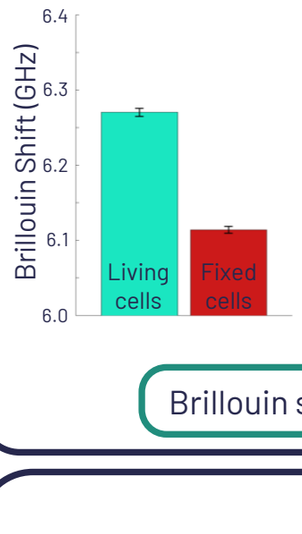


Stem cell regulation
Cancer evolution
Dormancy

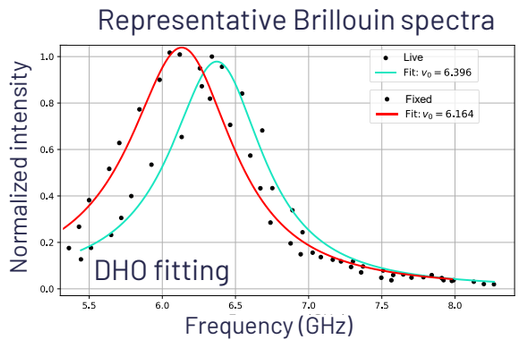
RESULTS

MEASUREMENT OPTIMISATION

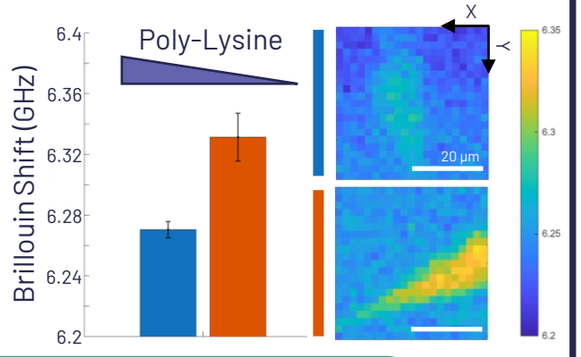
Effect of PFA fixation on Brillouin shift



Representative Brillouin spectra



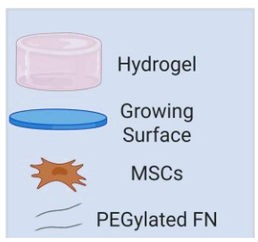
Surface adhesion affects Brillouin shift



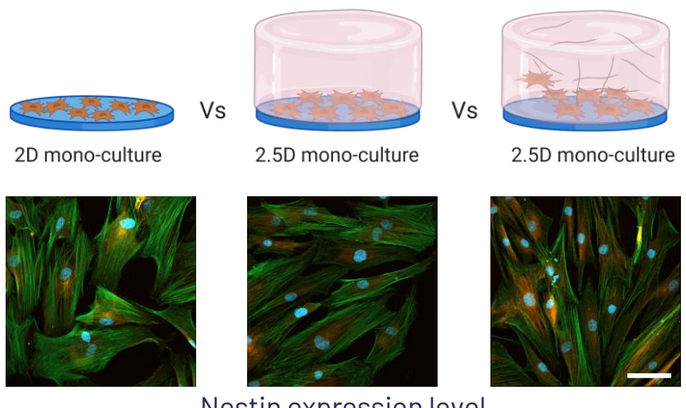
Brillouin shift values sensitive to the state of the cells and culture conditions

ENGINEERED BONE MARROW NICHE

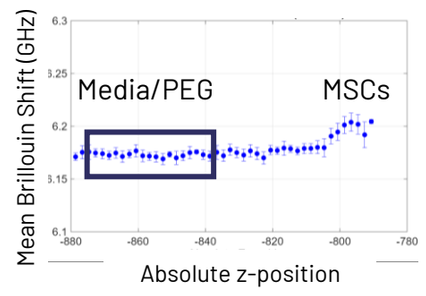
Biophysical characterisation of the 2.5D system with Brillouin microscopy

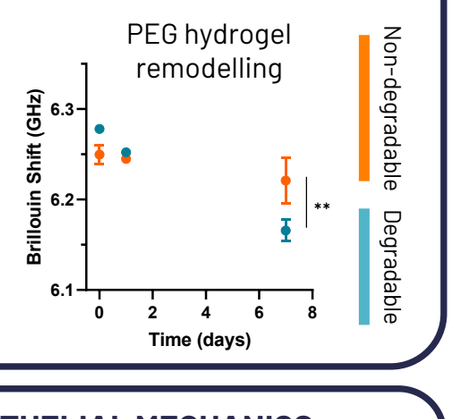


DAPI
F-Actin
Nestin



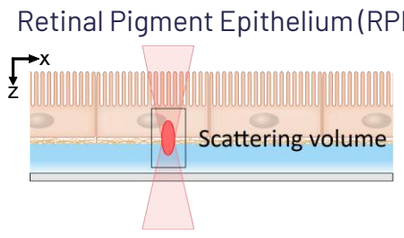
Axial Brillouin scan: mechanics of the environment

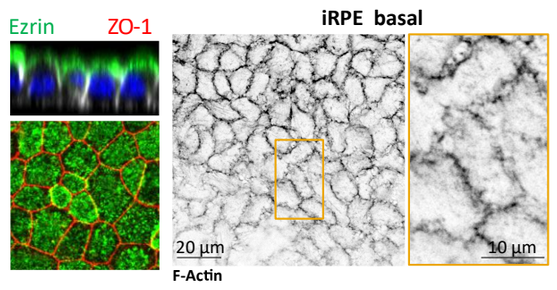


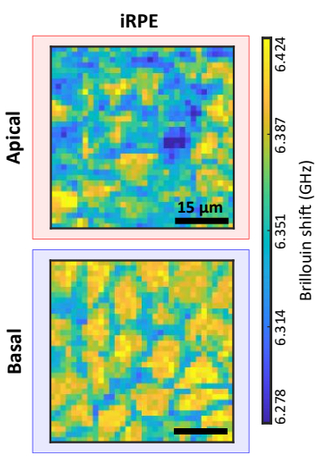


BRILLOUIN MICROSCOPY SPATIALLY RESOLVES RETINAL EPITHELIAL MECHANICS

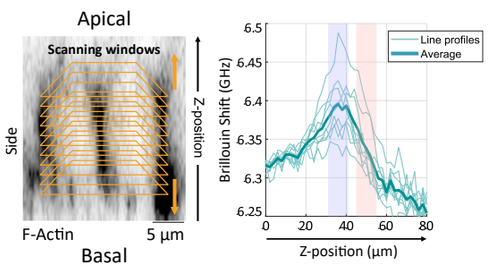
Retinal Pigment Epithelium (RPE)



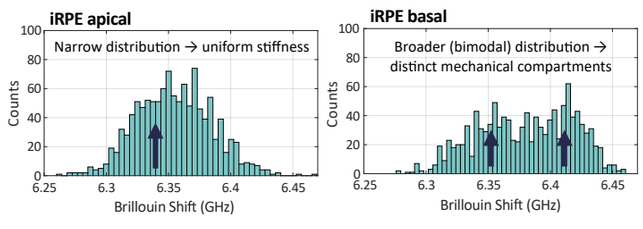




Basal stiffness dominates



Dual population at the basal side



Piskova T., **Kozyrina A. N.**, **Astrauskaitė G.**, Mabrouk M. E., Schepl S., Yam L. S., Ravithas R., Wagner W., **Vassalli M.**, Di Russo J., *Nat. Com.2026*

KEY OUTCOMES

- Established Brillouin microscopy as a mechanical readout for engineered bone marrow niches
- Optimised hydrogel and niche-on-chip platforms
- Captured cell-driven environmental remodelling
- Established a foundation for correlative Brillouin–Raman measurements

Current status

- Brillouin platform established
- Raman integration in process

REFERENCES

Prevedel R., Diz-Muñoz A., Ruocco G. et al. Nat. Methods, 2019
Caponi S., Fioretto D., and Mattarelli M., Opt. Lett., 2020
Passeri A. A., Morena F., et. al. ACS Photonics, 2025
Piskova T., Kozyrina A.N., Astrauskaitė G., et. al, Nat. Com., 2026

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