Plano-concave optical sensing for brain imaging

For more informations of fabrication and evaluation of plano-concave sensing

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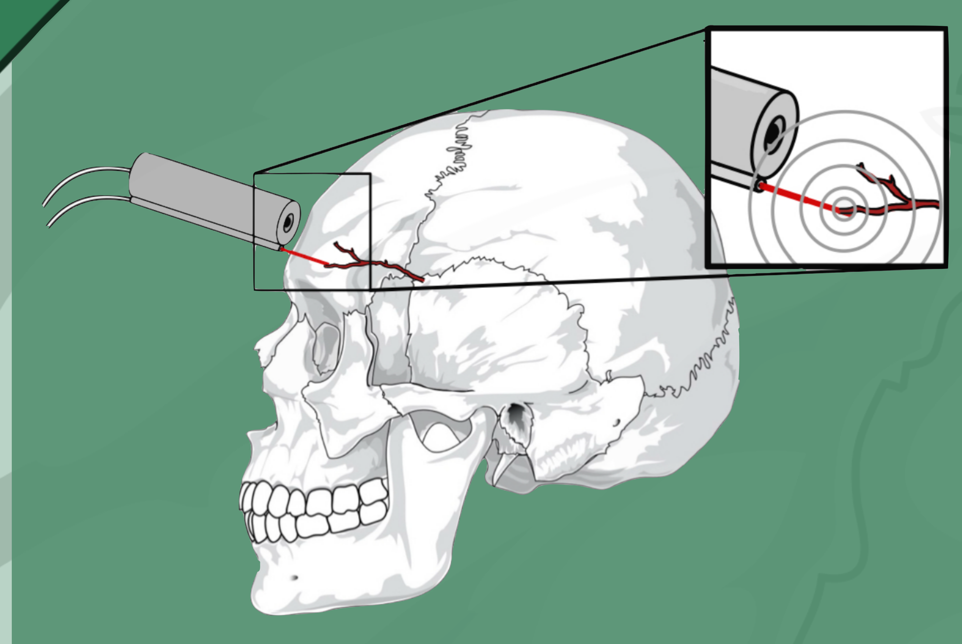
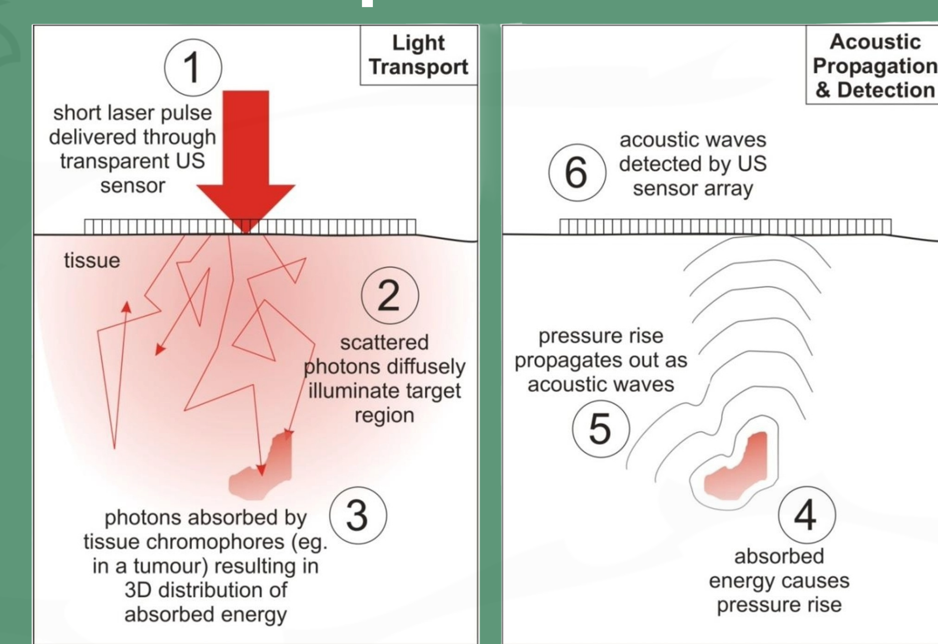
Aim of the project



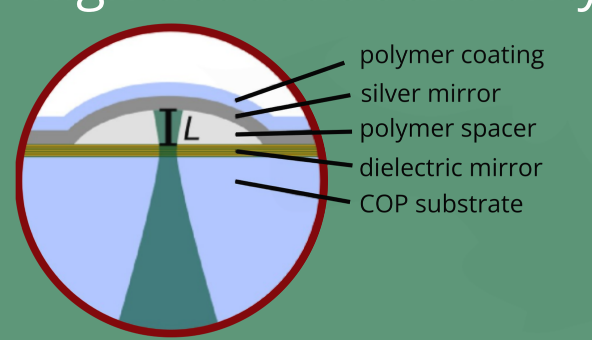
What is photoacoustics?



Laufer, J. et. al.

Demands for optical sensors

1 small sensors
2 wide frequency range
3 high acoustic sensitvity

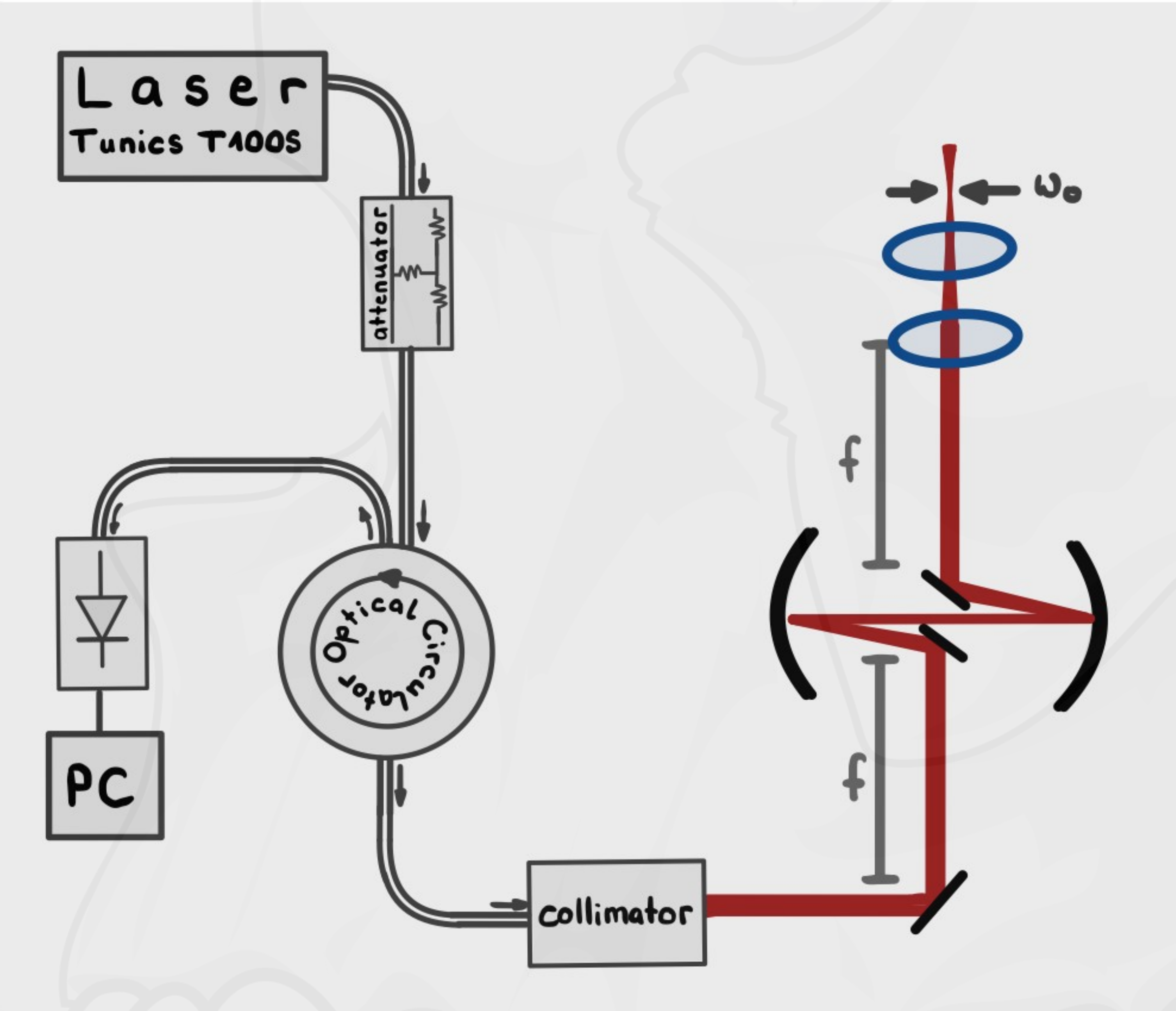


Kirchner, T. et. al., Photoacoustics (2023)

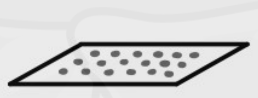
Research Questions

- What influence does the beam waist have on the sensitivity of plano-concave optical sensors?
- Which properties of the sensors result in the highest sensitivity?
- Which sensors are suitable for transcranial photoacoustic?

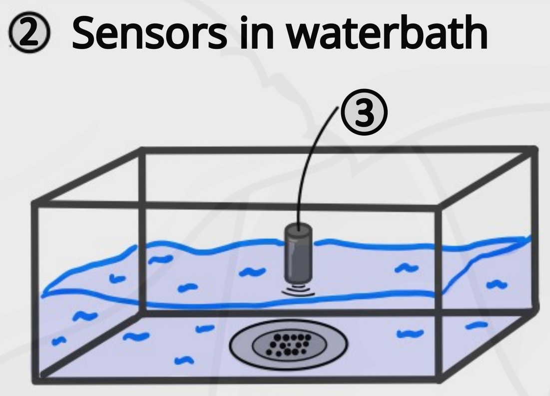
Method / Experimental setup



① Calibration - dot target



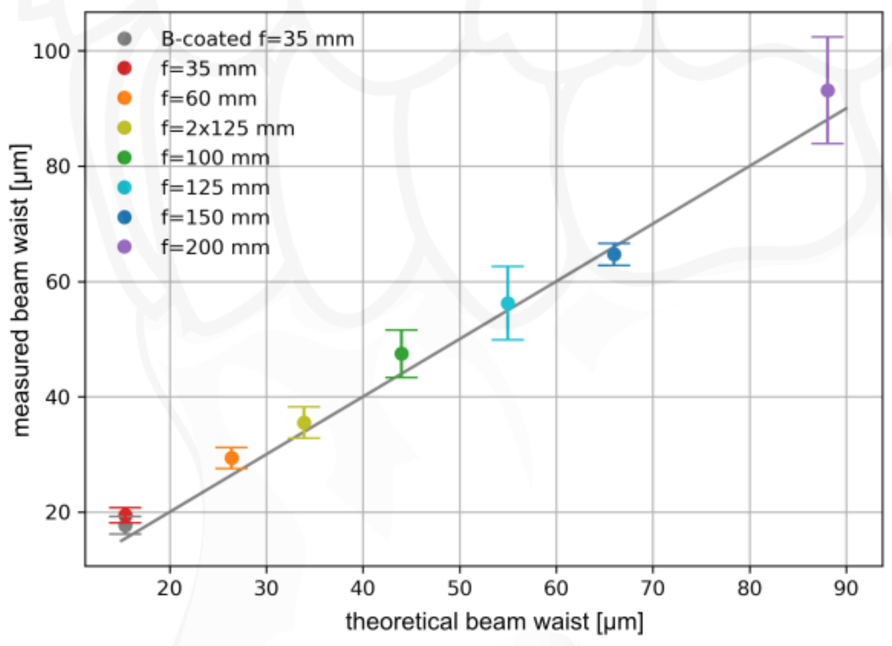
② Sensors in waterbath



Measurement

1 calibration with dot target to find beam waist ω
2 place sensors in waterbath in beam waist, measure intensity
3 put ultrasound transducer, measure NEP and sensitivity

Calibration of experimental setup



- beam widths can be measured with edge of dot target
- experimental setup can be calibrated with the inverse knife-edge-method

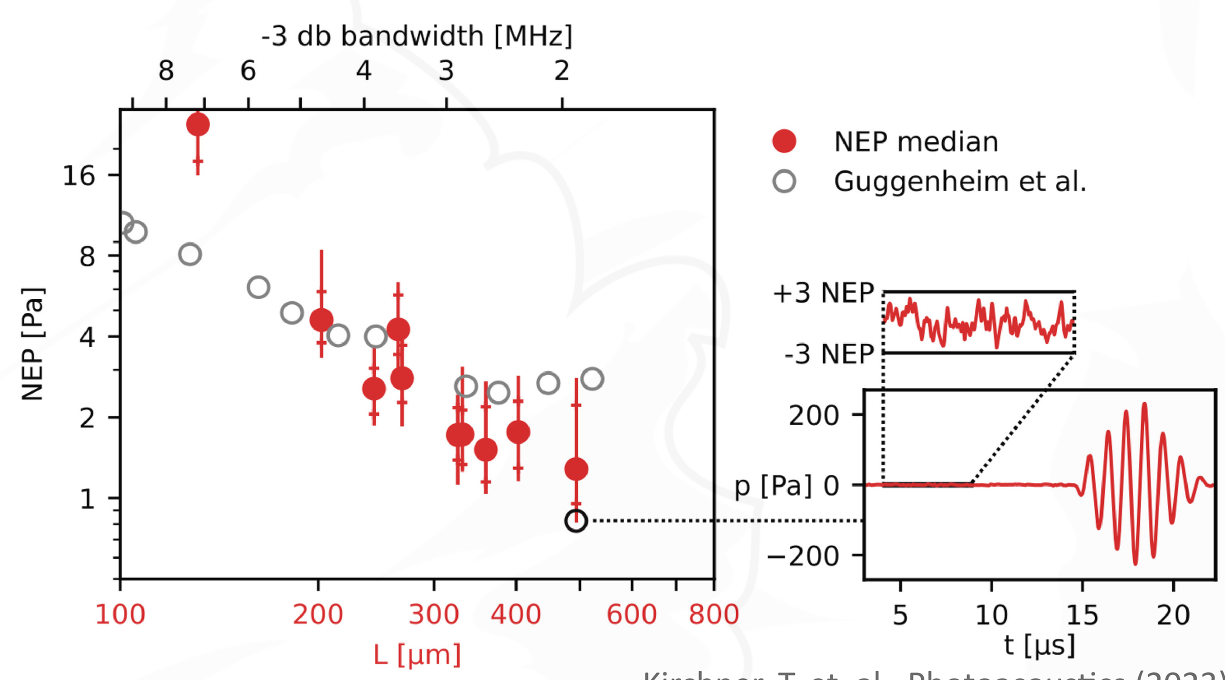
Results

Characterisation

- noise-equivalent pressure:

$$\text{NEP} = \frac{\sigma}{S_{max}} \cdot p$$

- larger sensors show higher sensitivity



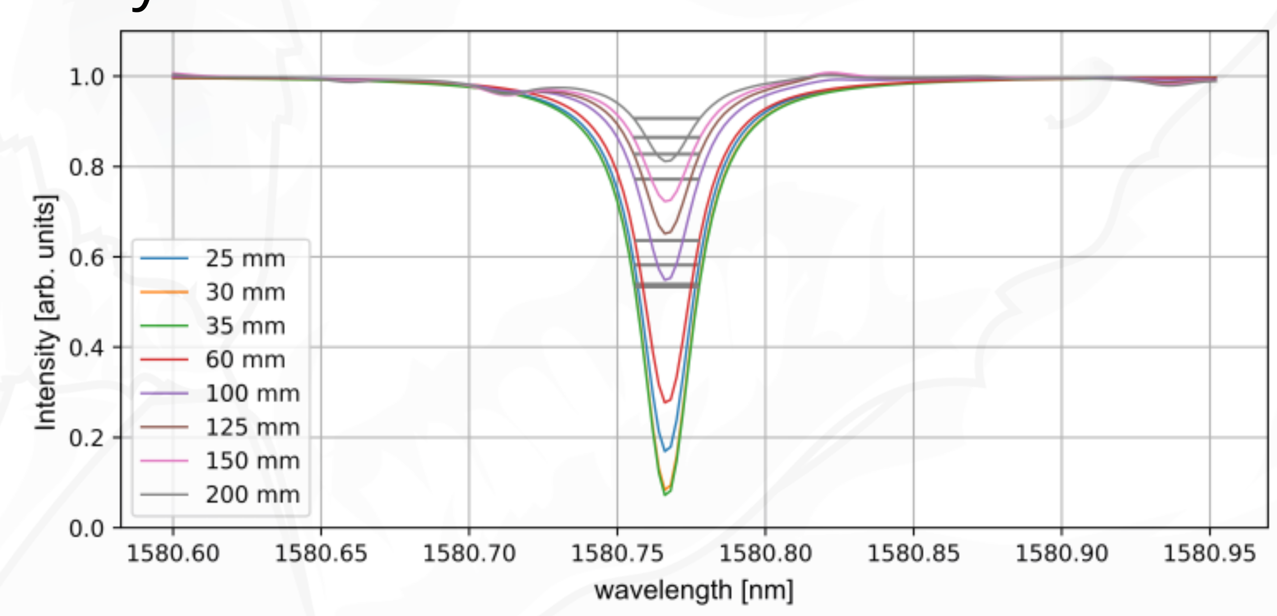
Kirchner, T. et. al., Photoacoustics (2023)

- better NEP in comparism to Guggenheim et. al. [1] could be explainable by optical and mechanical properties

Simulation - influence of beam waist on sensitivity

- existence of one beam waist with highest sensitivity
- depends on reflectivity and radius of curvature of every sensor
- Interferometer transfer function:

$$\text{ITF}(\lambda) = \frac{I_{out}(\lambda)}{I_{in}(\lambda)}$$



code adapted from Guggemheim, J. et. al. [2]

Summary

- beam waists have an influence on the sensitivity of plano-concave optical sensors: each sensor has a specific beam waist with its highest sensitivity
- optical sensors should not be to small
- highest sensitivity is achieved with sensors with a bandwidth of approx. 1.9 MHz

Literatur:
[1] Guggenheim et. al., Ultrasensitive plano-concave optical microresonators for ultrasound sensing, Nature Photonics 11, 714-719 (2017)
[2] Guggenheim et. al., ABCD transfer matrix model of Gaussian beam propagation in plano-concave optical microresonators ultrasound sensing, Optics express 31, 16523-16534 (2023)

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