# SIMPLE AND EFFECTIVE TISSUE ATTENUATION MEASUREMENT


FACULTY OF MECHANICAL ENGINEERING CTU IN PRAGUE

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DIVISION OF PRECISION MECHANICS AND OPTICS

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NOTES

Animals were treated accordingly to Animal Protection and Welfare Act No. 246/1992 Coll. of the Government of the Czech Republic. Samples were obtained as remnants of fresh cadavers.

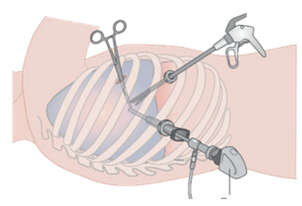
LITERATURE


[1] Parakh Fertility and surgery clinic. Portfolios - Thoracoscopic surgery.
[2] MAYO Clinic, Bronchoscopy.
[3] Haryati, H. et al. Resp. Sci., 4(1), 65-79, 2023.
[4] Ústav zdravotnických informací a statistiky ČR, "Novotvary 2019–2021," ÚZIS ČR, Prague, Czech Republic, 2023.
[5] Office for National Statistics (ONS), "Cancer survival by stage at diagnosis for England (experimental statistics): Adults diagnosed 2012, 2013, and 2014 and followed up to 2015," ONS, Newport, UK, Statistical Bulletin, 2016.
[6] Yang, L. et al. ACM Computing Surveys, 2023, 56.4: 1-39.
[7] Genina, E.A. et al. Bio. Opt. Expr. 10, 1–10, 2019.
[8] Ntombela, L. et al. Heliyon 6:e03602, 2020.
[9] Nilsson, A.M.K. et al. Appl. Opt., 34, 4609–4619, 1995.

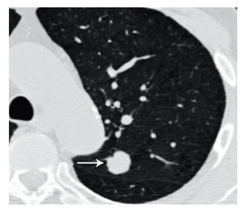

## MOTIVATION

Early detection of lung abnormalities is crucial for improving survival rates. Non- and low-invasive methods, such as optical tissue assessments, offer reduced complications and quicker recovery. Doctors at General University Hospital in Prague propose a novel approach to lung diagnostics. NIR transmissive spectroscopy (light transmission through lung tissue) being the principle. Adding dynamic imaging method to the static before-acquired CT scans, registered spectra help accurately pinpoint nodules locations and determine optimal treatment strategies, using bronchoscope and pleuroscope. Our team is now actively working to develop such instruments set.

*Bronchoscope [1]*



*Pleuroscope [2]*



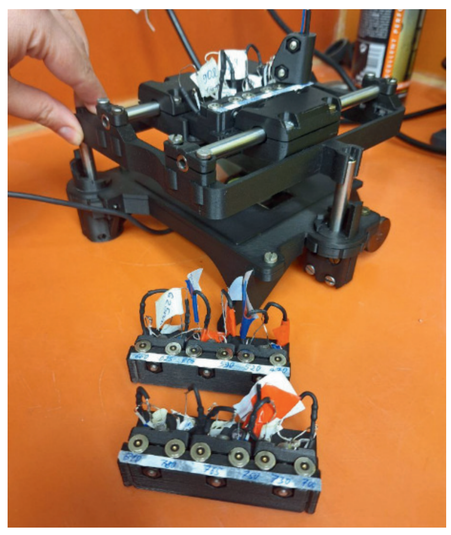
*CT scan of lung [3]*

## LUNG CANCER STATISTICS OF CZECH REPUBLIC

- *Lung cancer - 6600 cases/year (2021)*
- *Lung cancer is death reason of 18,2 % of all cancer cases (2021)*
- *Just 10.5% of lung cancers are diagnosed at stage I [4]*
- *1 year survival rate: 15-19 % stage IV vs. 81-85 % for stage I [5]*

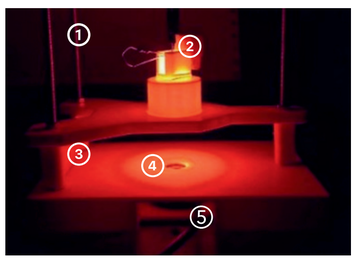
## INTRODUCTION

This study presents a low-cost, mobile, 3D-printed device to measure spectral optical transmittance. The results of such measurements are used to define technical characteristics of developed diagnostic set and to describe the light behaviour in biological tissues. This method provides an alternative to traditional equipment, yielding results consistent with existing literature.



Several cassettes with different wavelengths LEDs slide on the linear guideway, one LED being connected at a time for each slider position.
Height of source position (thickness of the sample) is set by three rotating stage positioners.

*Second design: improved ergonomics and time consumption*



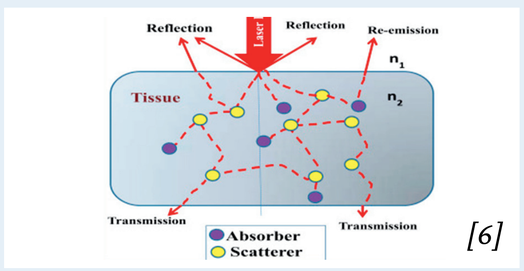

*First assembly design*

1. Threaded rods
2. LED source
3. 3D printed assembly (LED holder, light stage, spacers, sample stage)
4. Sample glass
5. Wattmeter sensor

## THEORY

Tissue structure and composition affects light-tissue interactions:

- Absorption $A, \mu_a$
- Reflection $R$
- Refraction $n$
- Transmission $T$
- Scattering $\mu_s$




[6]

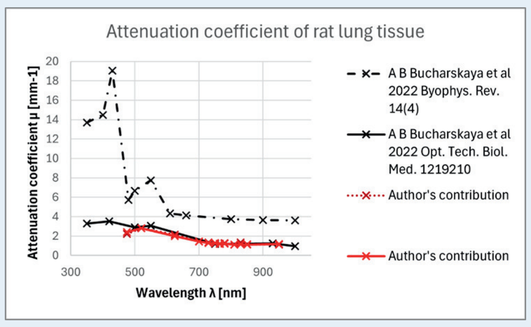
The Radiative Transfer Equation is a golden standard for light in tissue description. However, solutions are sophisticated.
Beer-Lambert Law: deals with attenuation, straightforward, was used for tissue optics [7-9].

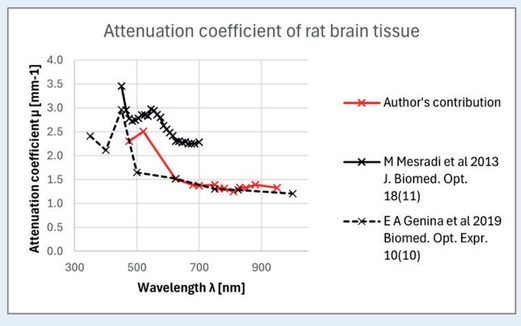
$$I = I_0 e^{-\mu b}$$ *Beer-Lambert law*

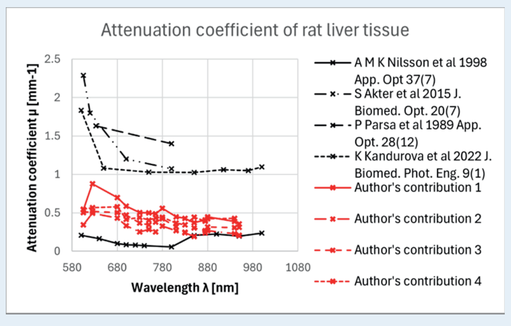
$$\mu = \mu_a + \mu_s$$ *Attenuation in tissue*

$$T = \frac{I}{I_0}$$ *Transmittance*

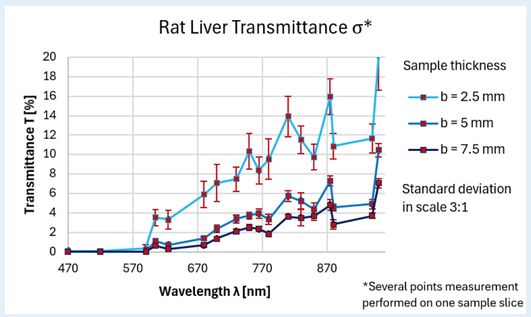
## APPROACH VALIDATION: COMPARISON TO THE LITERATURE ($\mu$)

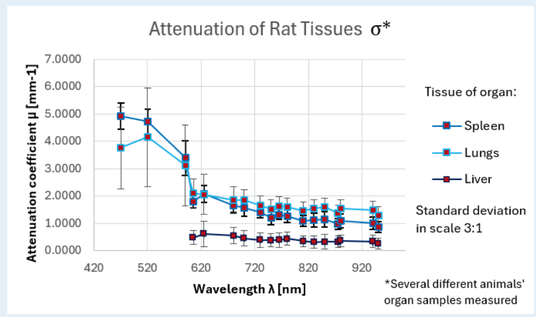


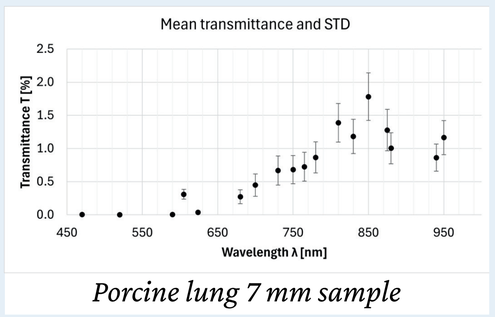




## APPROACH VALIDATION: STATISTICS AND REPEATABILITY

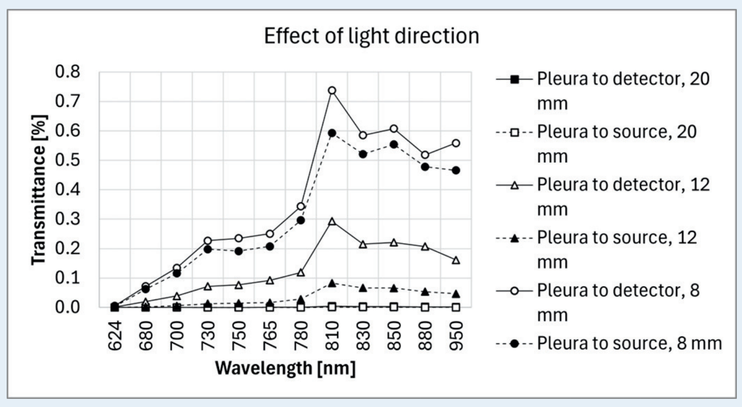


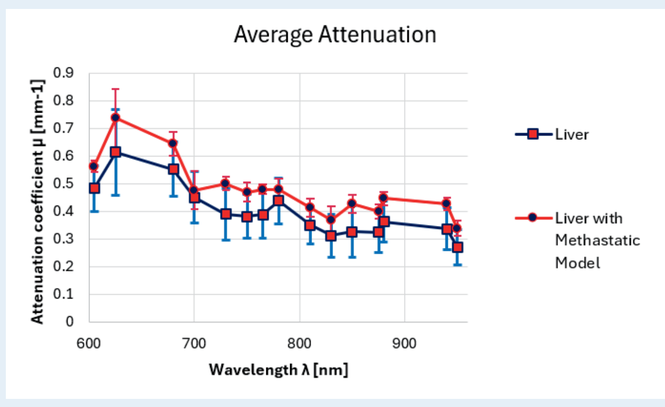




*Porcine lung 7 mm sample*

## LIGHT POSITION EFFECT




## METHASTASIS MODEL REGISTRATION




## SUMMARY

- **3D printed, low-cost, mobile, spectral transmittance measurement assembly** is presented.
- Measurement results and attenuation calculation approach are **validated** through comparison with the literature.
- Measurement results **guide technical characteristics** selection for **low-invasive optical diagnostic tool set**.
- Technical data for the diagnostic set are prescribed

– by higher light penetration for **light position inside** the lung bronchi,
– by **wavelength of the source** corresponding to the maximum values of the porcine lung NIR transmittance,
– by possibility to **register foreign lesion** presence **only in comparison** to the basic healthy tissue spectrum.

- Experiments show highly varying attenuation values for different tissues. Therefore further studies in the project must be performed only with porcine lung material as closest to human.
- Presented **measurement assembly allows** for simple and **trustworthy data collection and** various **analysis for tissue optics** studies **and medical tools development**.