# Three-dimensional macromolecule orientation by means of infrared (IR) imaging and its significance in cancer microenvironment

Macromolecular 3D orientation is a desirable experimental characteristic for any complex system and can provide important insight in biomedical studies, e.g. breast cancer[1], or in material sciences, e.g. liquid crystals or polymers[2]. The tumor microenvironment is being revealed as a crucial biological response mechanism which in some cases aides and in some worsens the disease outcome, as for example in pancreatic cancer. However, there is a limited number of techniques at the microscale capable of delivering not only three-dimensionally resolved images of samples, but offering also information about 3D orientation of macromolecules.

Polarization-controlled IR absorption is one of them and can provide in-plane orientation function[2] of a macromolecule. This capability has been around for decades, however, it is the recent advance in imaging technology[3] that offers enough acquisition speed to attempt to tackle this problem at a proper scale. Tissue microarrays (TMA) allow a reasonable biological variability scale sampling and IR histopathological imaging has been recently developed for several diseases and cancer types.

**The goal of this project is to use polarization dependent IR imaging to improve such histopathological models with the addition of 3D macromolecular orientation calculated from rigorous mathematical models.** This information can then be used to characterize tumor microenvironment of pancreatic and breast cancers – two types of cancer that are strongly influenced by the extracellular matrix (ECM). **The idea is to use IR imaging approach as spatial organization of ECM plays a major role in such systems. No study in the past has been able to tackle the scale of what changes may occur in the ECM surrounding these cancers and this project aims to fill in this gap.**

**Therefore, the project will provide new information about orientation behavior of all tissue constituents in the context of breast and pancreatic cancers in a spatially resolved manner on dozens of patients scale. It proposes a unique approach using new theoretical models on an unprecedented scale.**

## Literature:


1. Ambekar, R., Lau, T.-Y., Walsh, M., Bhargava, R. & Toussaint, K. C. Quantifying collagen structure in breast biopsies using second-harmonic generation imaging. *Biomed. Opt. Express* **3,** 2021 (2012).

2. Wrobel, T. P., Mukherjee, P. & Bhargava, R. Rapid visualization of macromolecular orientation by discrete frequency mid-infrared spectroscopic imaging. *Analyst* **142,** (2017).

3. Wrobel, T. P. & Bhargava, R. Infrared Spectroscopic Imaging Advances as an Analytical Technology for Biomedical Sciences. *Anal. Chem.* **90,** 1444–1463 (2018).