VISIONLAB

Multiscale Imaging in Cancer Research

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10/5/2016

UNIVERSITY OF CAMBRIDGE

CANCER RESEARCH UK | CAMBRIDGE INSTITUTE

CRUK & EPSRC Cancer Imaging Centre in Cambridge and Manchester

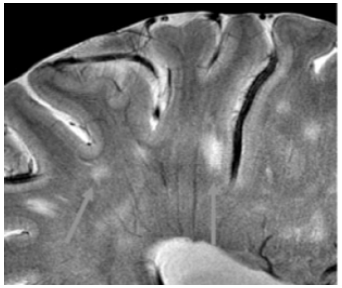
CANCER RESEARCH UK

MRC Medical Research Council

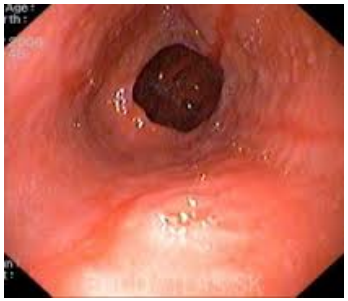
SEVENTH FRAMEWORK PROGRAMME

EPSRC Pioneering research and skills

CAMBRIDGE Cancer CENTRE



Radiowave
> 1 m

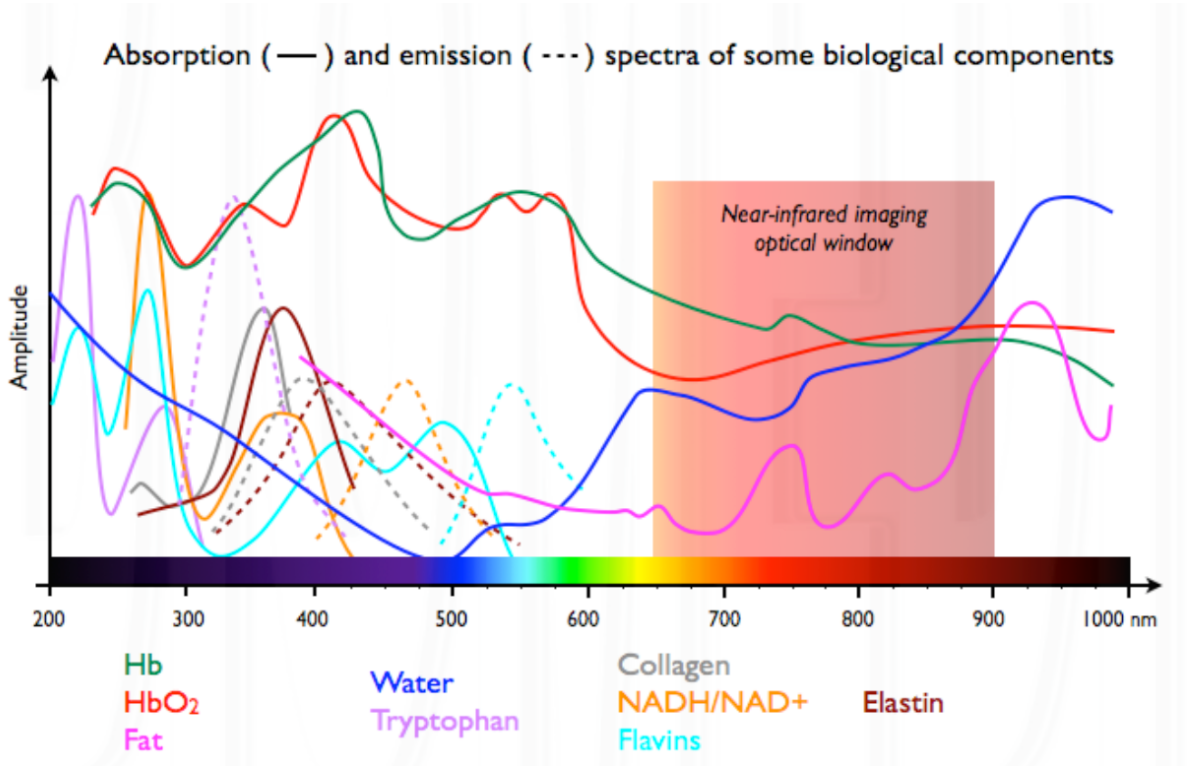


Visible/NIR
400 – 1,000 nm

X-ray
10^{-8} – 10^{-11} m

Gamma
< 10^{-11} m

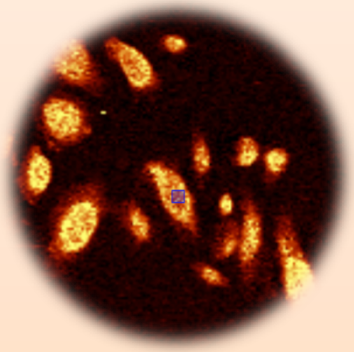
Optical imaging gives high intrinsic contrast for understanding cancer metabolism



- **Penetration depth is limited**
- **Current imaging techniques lack multiplexing**

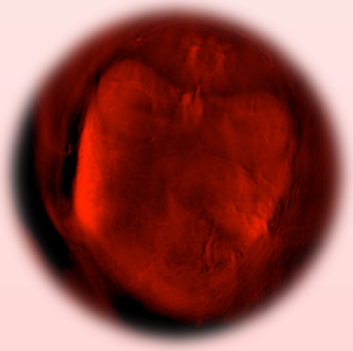
Image from C. Berger http://www.biomedima.org/en/links?modality=5&slide=362

Microscopy



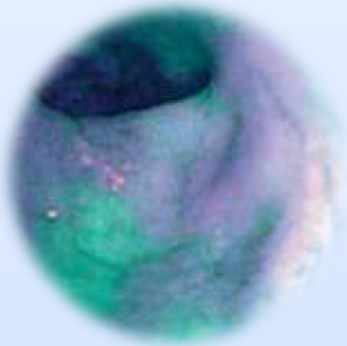
In vitro

Macroscopy



In vivo

Endoscopy



Translational

Interactions of light and tissue (experimental and theoretical)

Technology innovation and instrument development

Understanding the role of oxygen in cancer

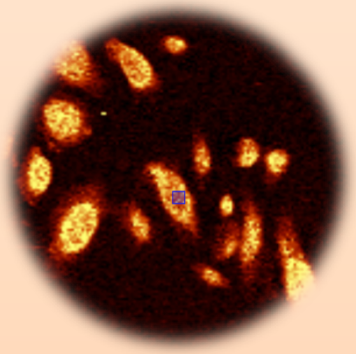
Technical Validation: Phantom trials

Biological Validation: Preclinical trials (cells & mice)

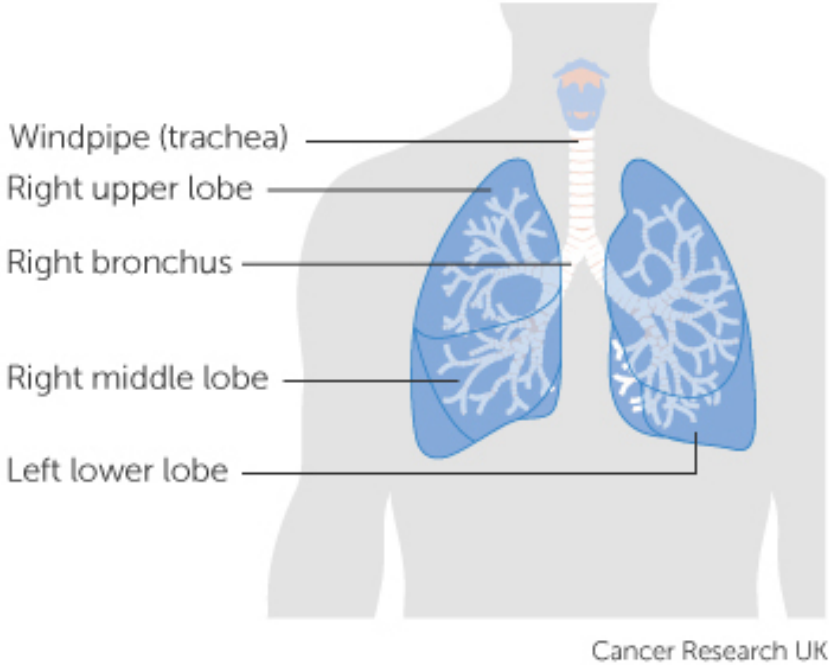
Biological Validation: Clinical trials (patients)

Lung cancer is a major cause of cancer death related to smoking

Microscopy

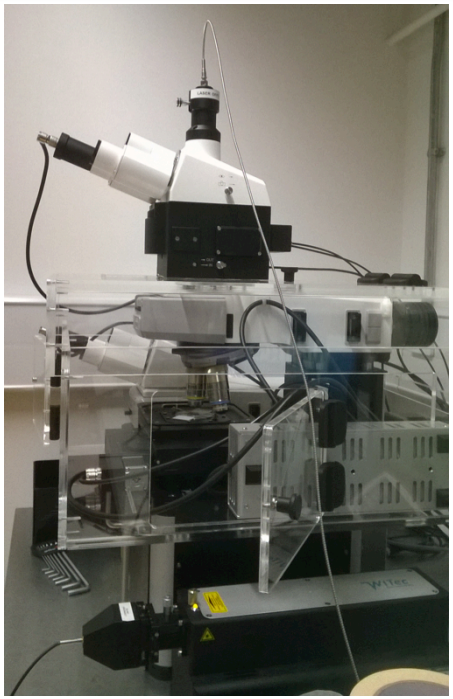


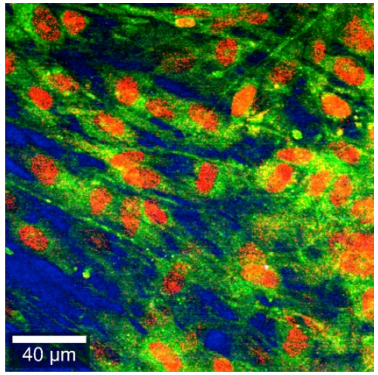
In vitro



Number of new cases per year

Number surviving after 10 years



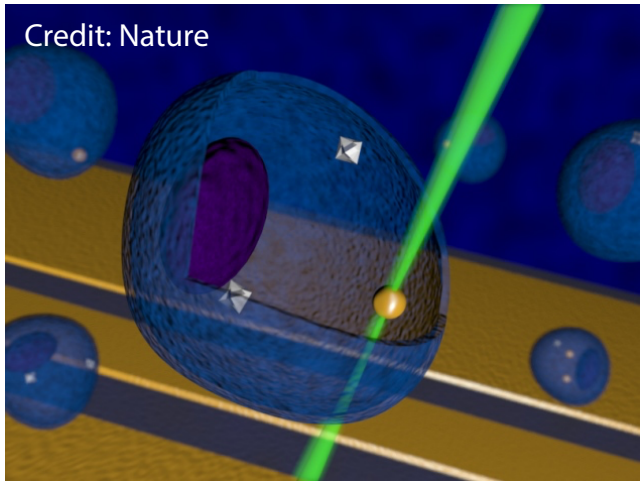


Label free live cell imaging of oxidative stress with Raman spectroscopy

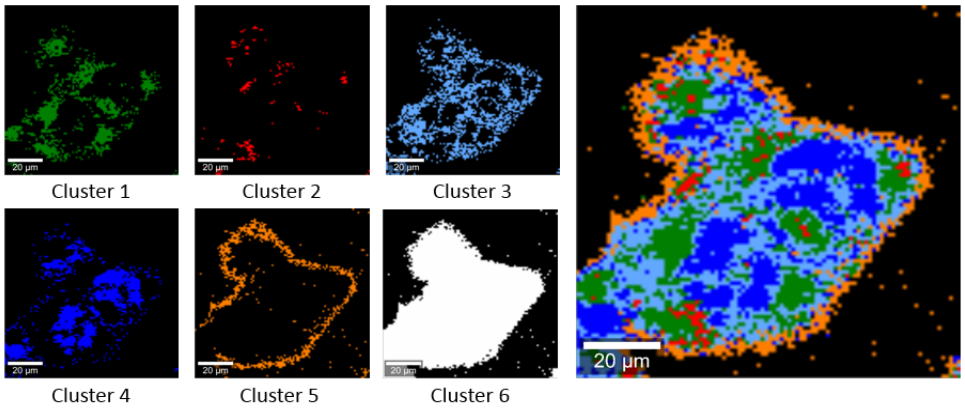
Collaboration with:

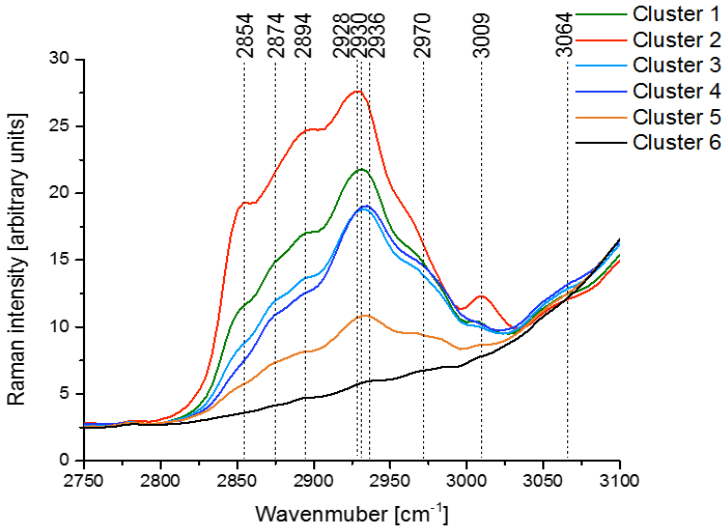
Prof. Bruce Ponder (Oncology)
and
Dr Robert Rintoul (Papworth)

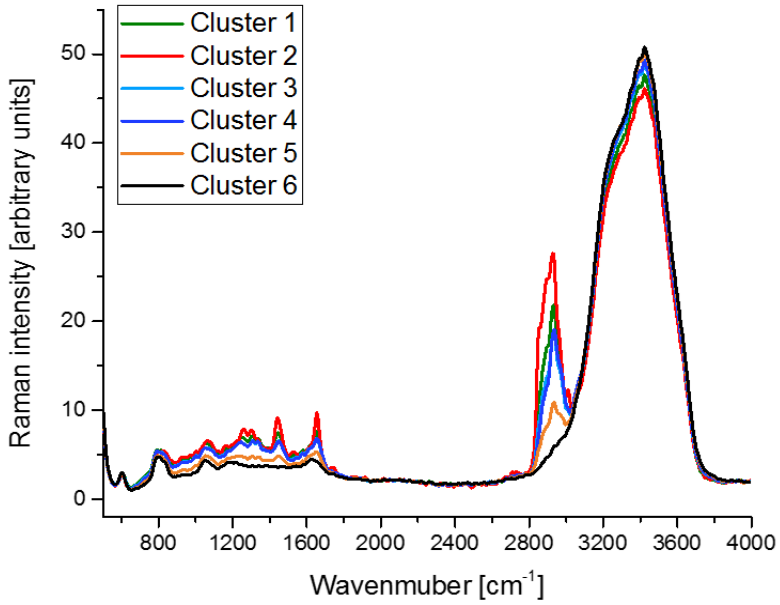
Intracellular sensing



Raman spectroscopy enables spectral identification of cancer cells

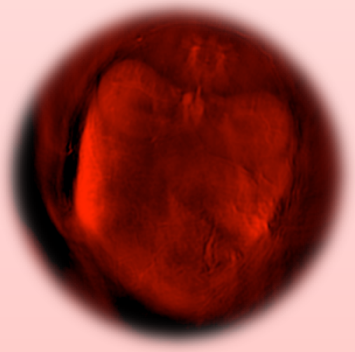






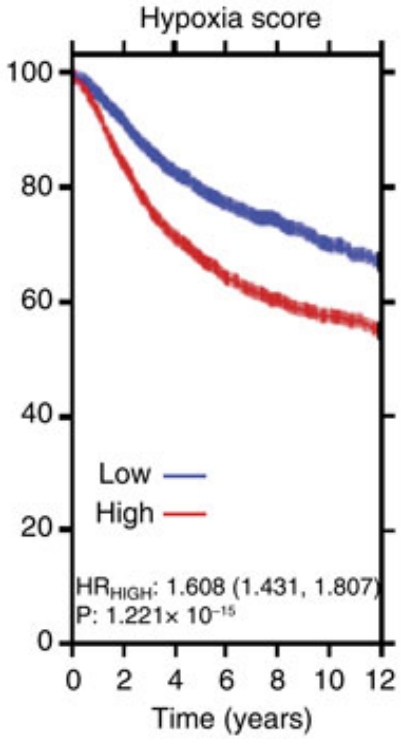
Surmacki *et al* (2016) *In preparation*

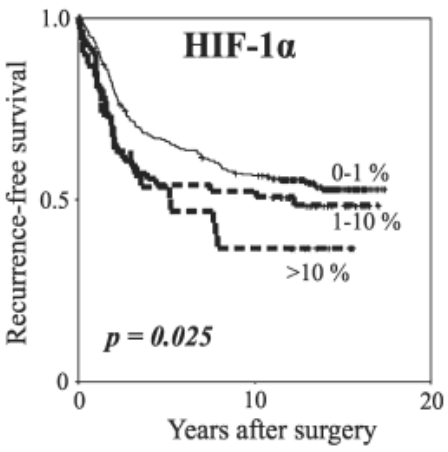
Macroscopy

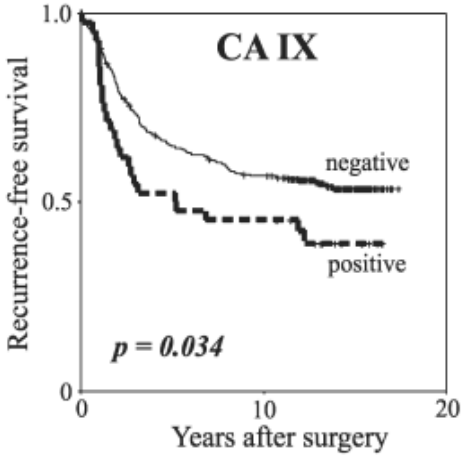


In vivo

Prognosis of cancers in hormone sensitive tissues is linked to hypoxia

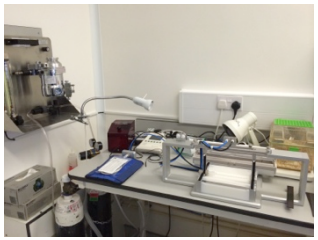


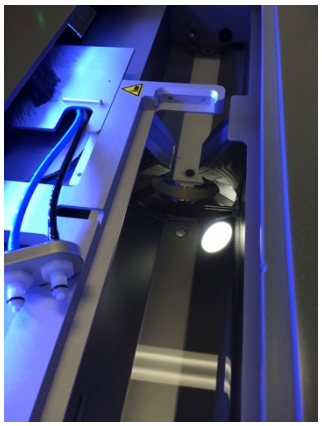




Van de Beucken *et al* (2014) *Nat Comm* **5** 5203; Lundgren *et al* (2007) *Cell Mol Life Sci* **64** 3233-3247.

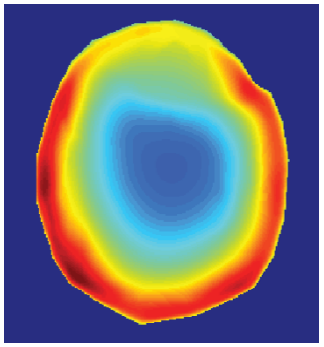
Imaging blood oxygenation and tissue hypoxia with optoacoustic tomography

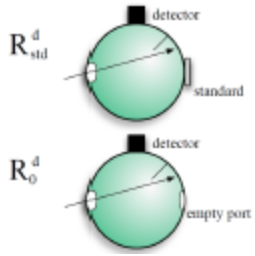


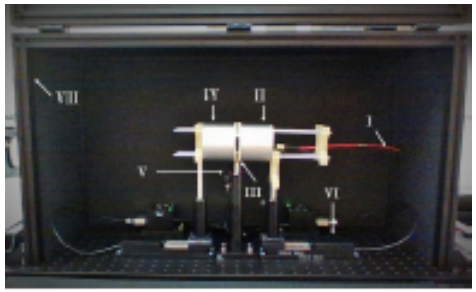


Collaboration with
Dept of Radiology:

Prof. Fiona Gilbert
and
Dr Oshaani Abeyakoon

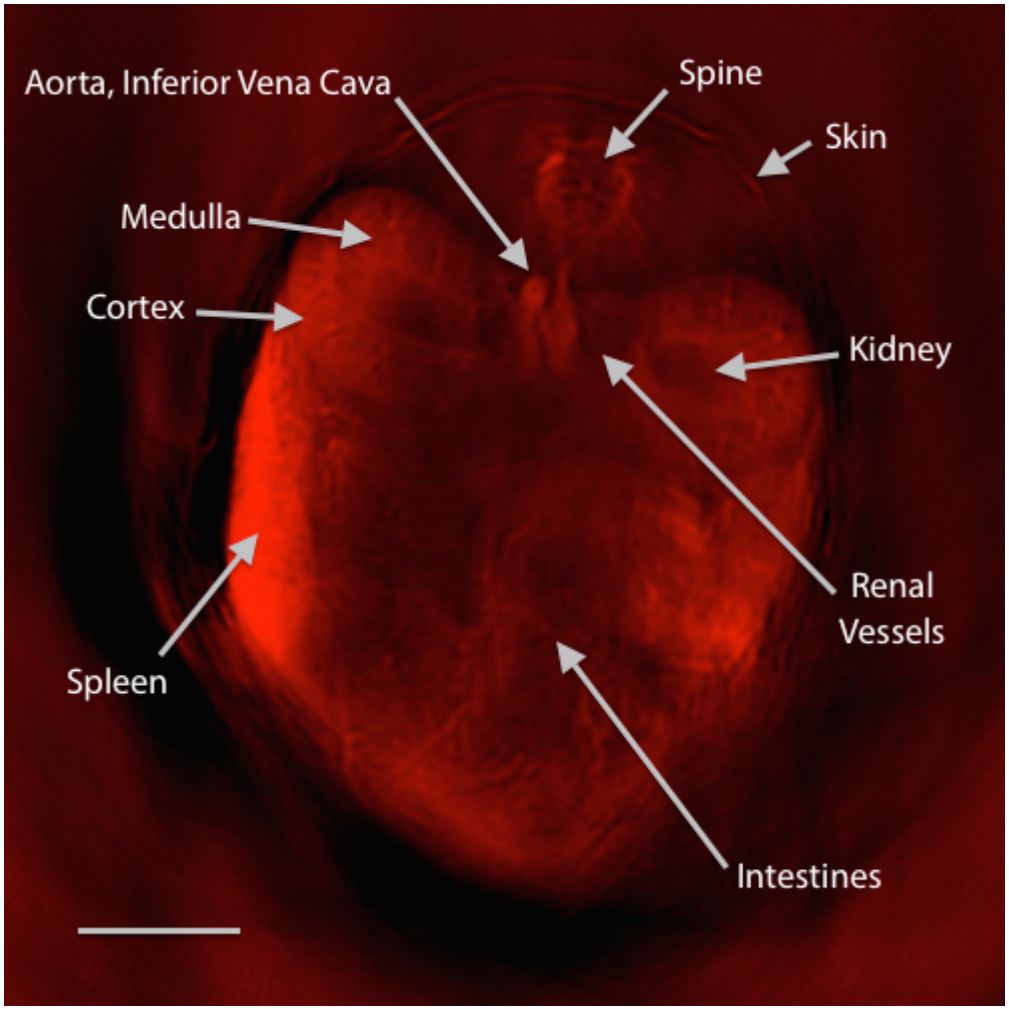




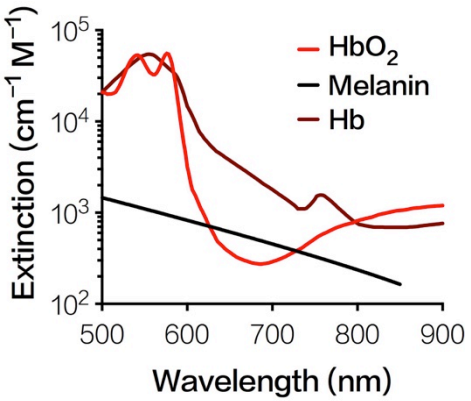


Understanding and compensating tissue optical properties

Optoacoustic tomography enables deep tissue imaging of optical absorption

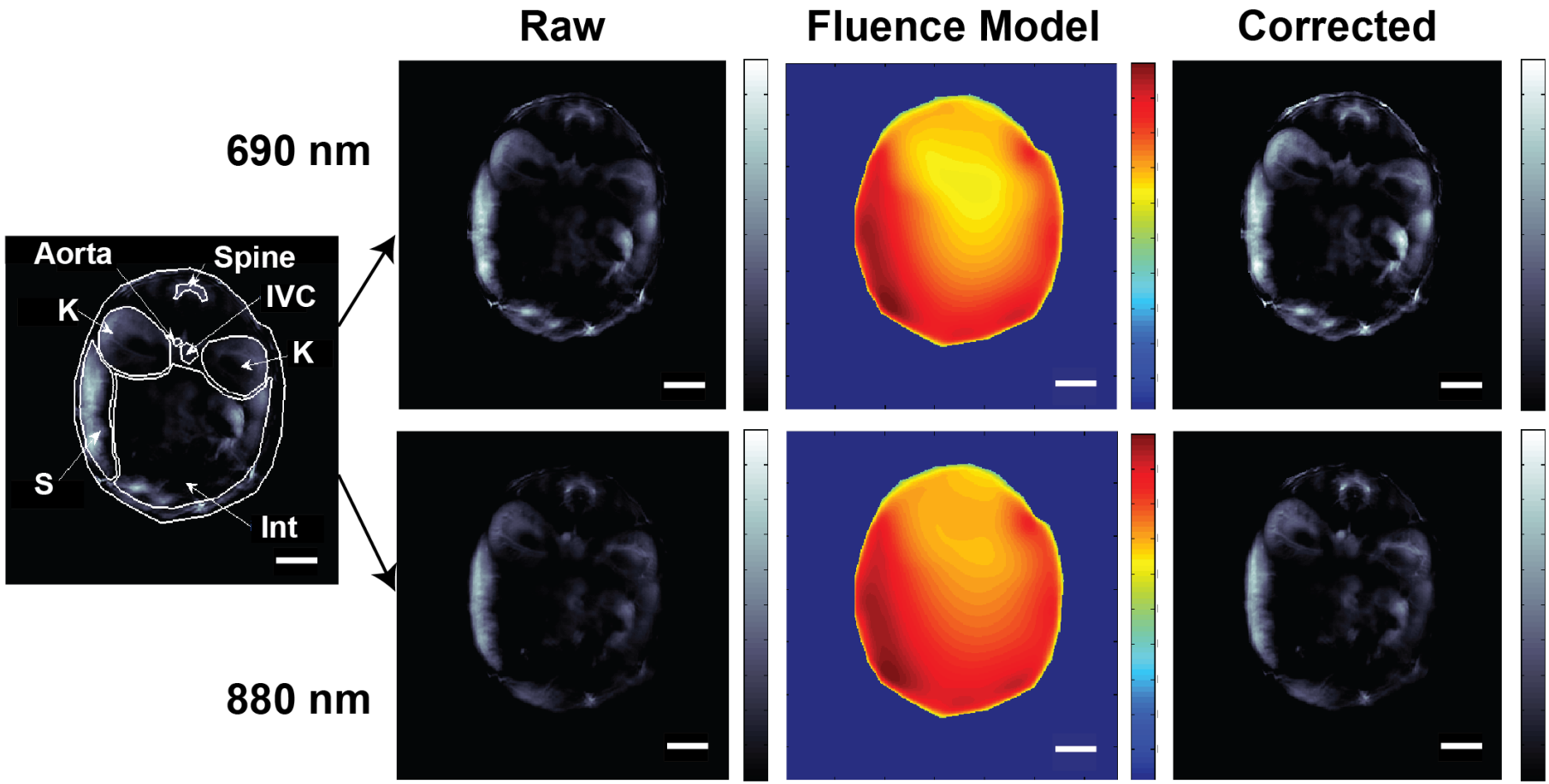


- Pulsed laser light excites tissue in NIR range
- Resulting ultrasound wave detected
- Increases penetration depth up to ~3 cm
- Spatial resolution ~ 150µm
- Temporal resolution ~ 10fps



Oxyhaemoglobin weighted slice through the kidney. Scale 3 mm.

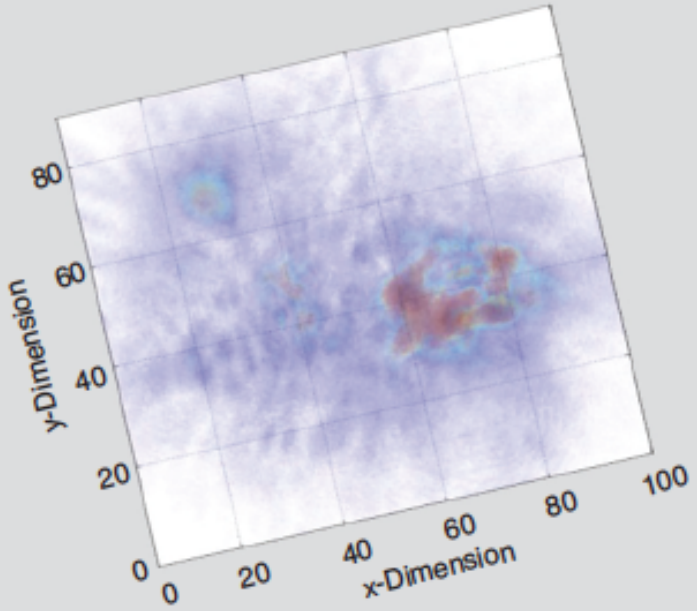
Applying light fluence corrections to *in vivo* improves the visibility of deep tissue structures



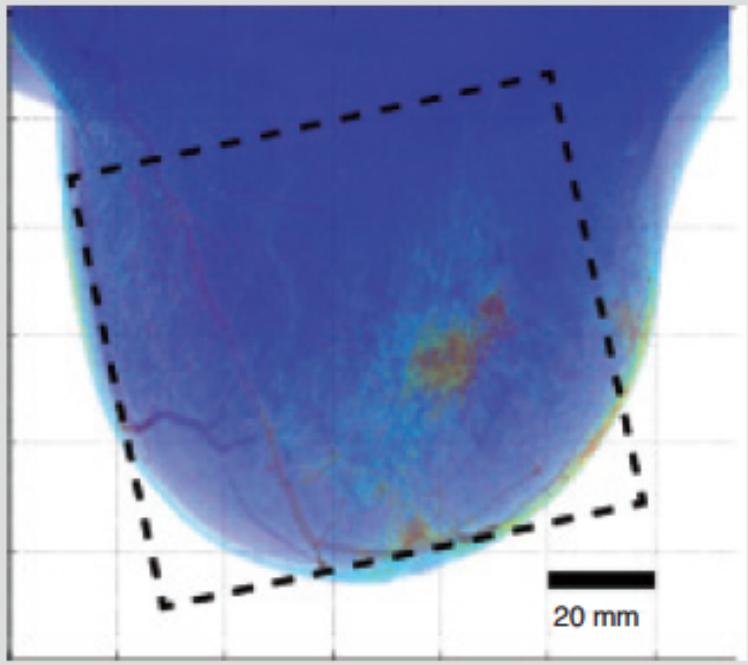
Brochu *et al* (2016) *In revision*; Joseph *et al* (2016) *In submission*.

Clinical trials in breast cancer are underway worldwide and starting in Cambridge

Heijblom *et al* (2015) *IEEE Pulse* May/June 44



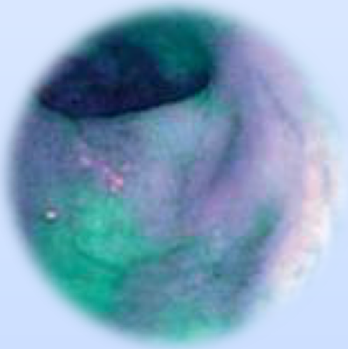
(a) PA Image



(b) MR Image

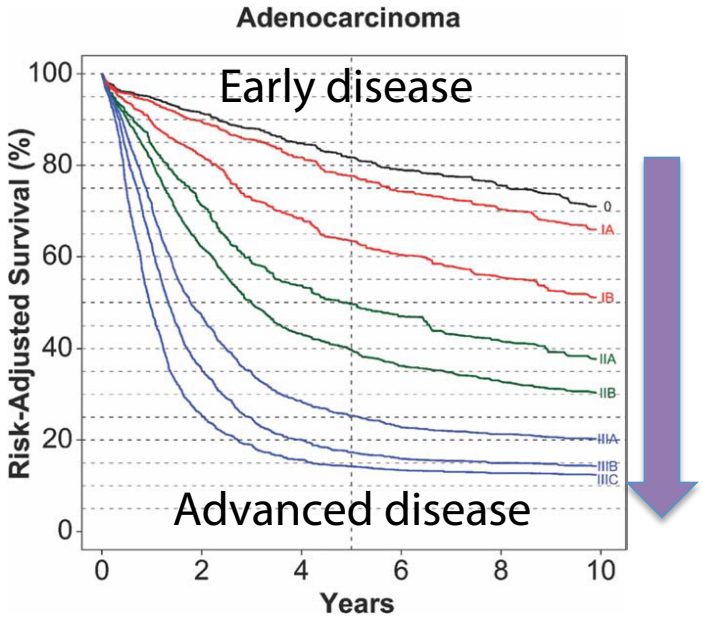
- Healthy volunteer study to confirm normal fluctuations in breast vascular density and oxygenation
- Breast cancer staging will assess prognostic potential compared to standard of care imaging

Endoscopy



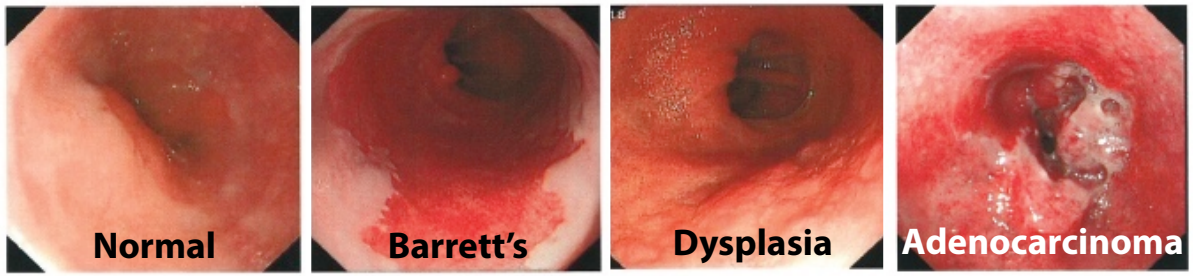
Translational

Barrett's patients undergo surveillance to improve early detection



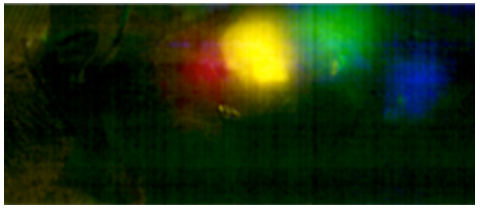
Standard of care:

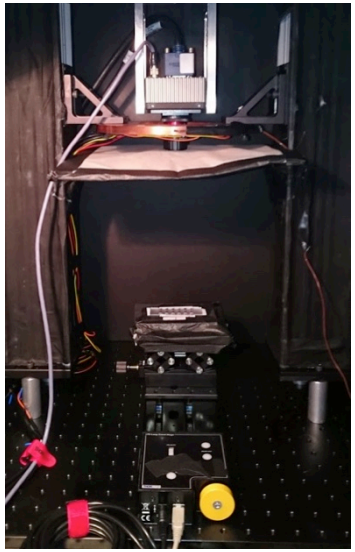
- White Light Endoscopy
- Seattle Protocol Biopsy



Images courtesy Prof. R Fitzgerald

Hyperspectral imaging for multiplexed fluorescence detection

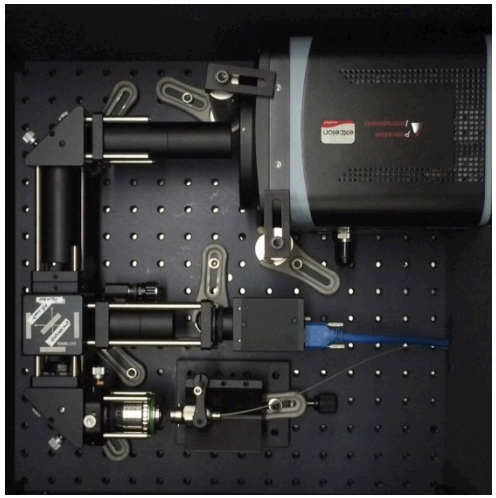


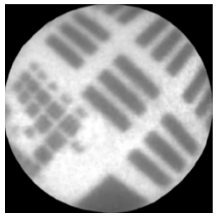


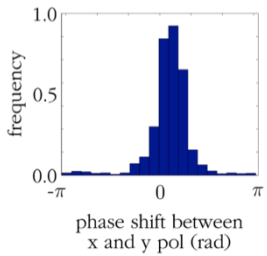
Collaboration with
MRC Cancer Unit:

Prof. Rebecca Fitzgerald
and
Dr Massi di Pietro

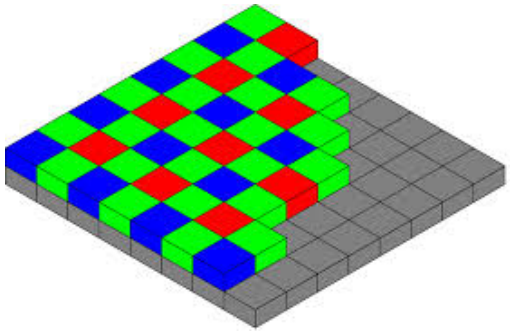
Near infrared and coherent endoscopy for early cancer detection

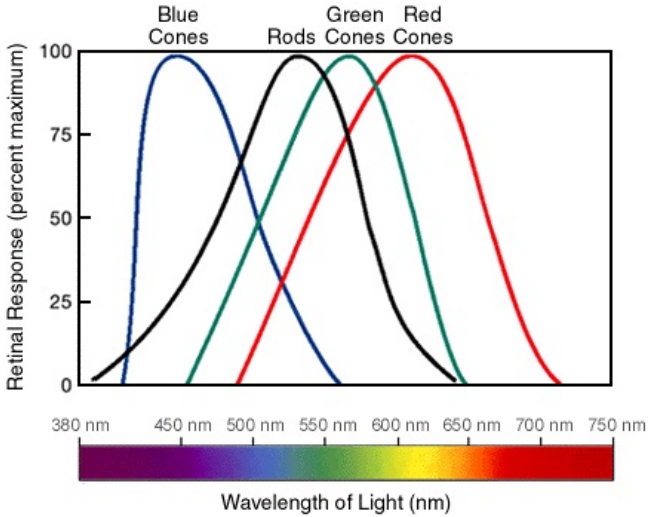






The use of light in endoscopy measures only amplitude





Images from Wikimedia Commons

Spectral imaging can resolve information from absorption and fluorescence emission

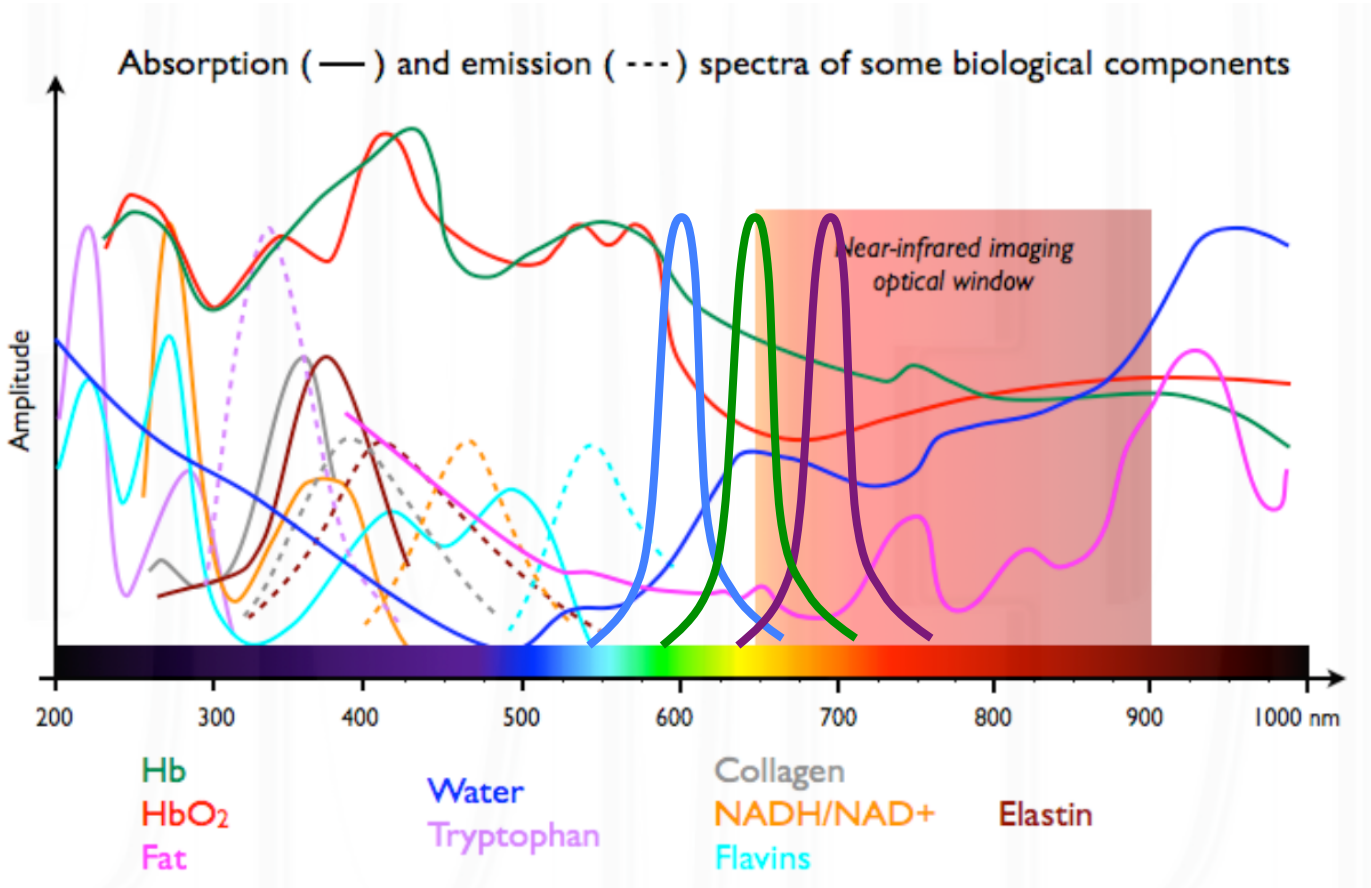
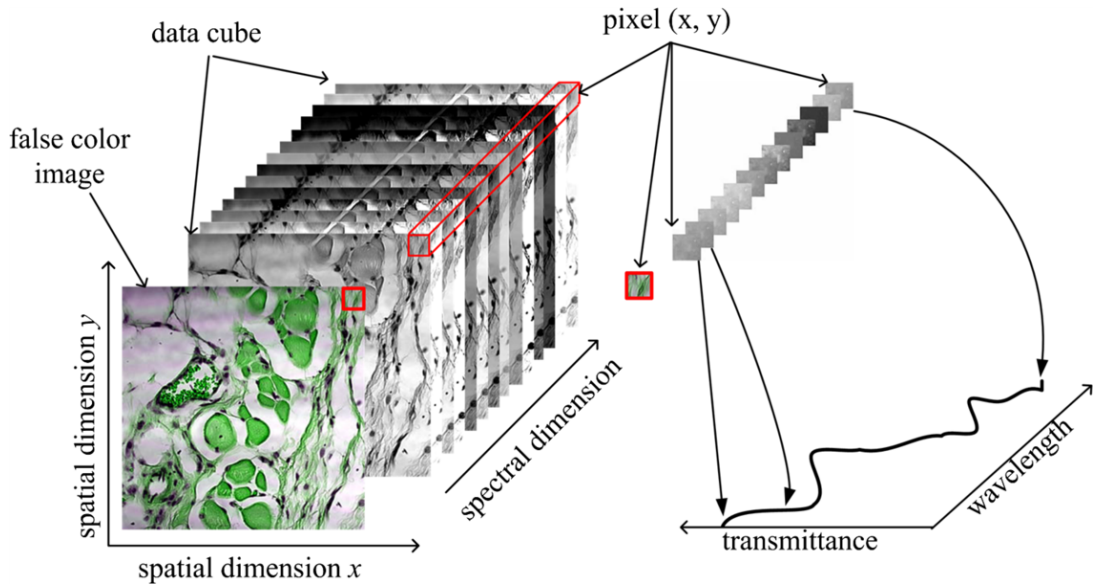
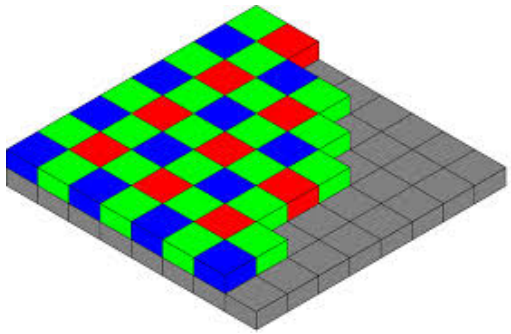
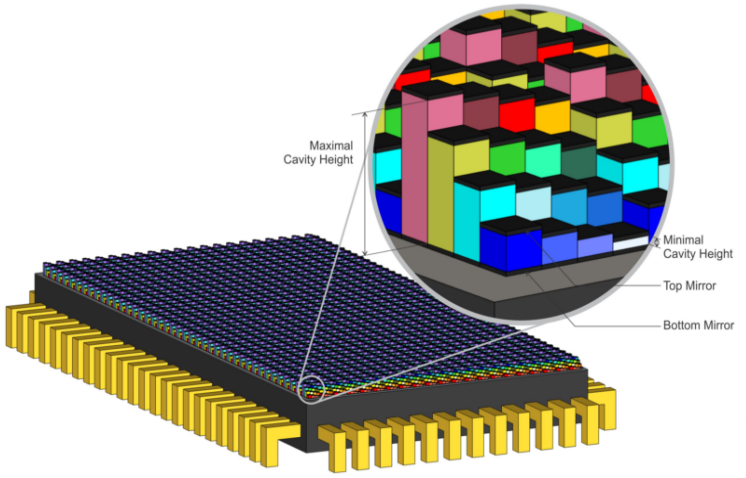


Image from C. Berger http://www.biomedima.org/en/links?modality=5&slide=362

Hyperspectral imaging combines both spatial and spectral information

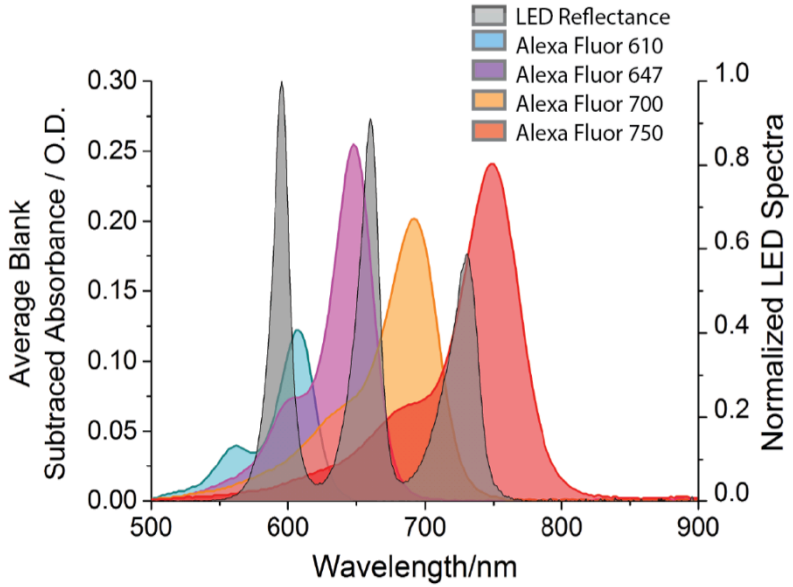


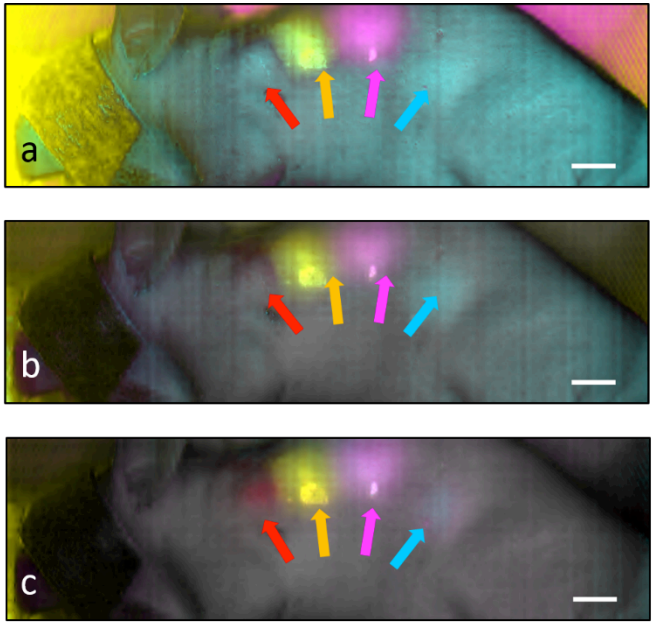




Li Q *et al* (2013) *J Biomed Opt* 18 (10):100901

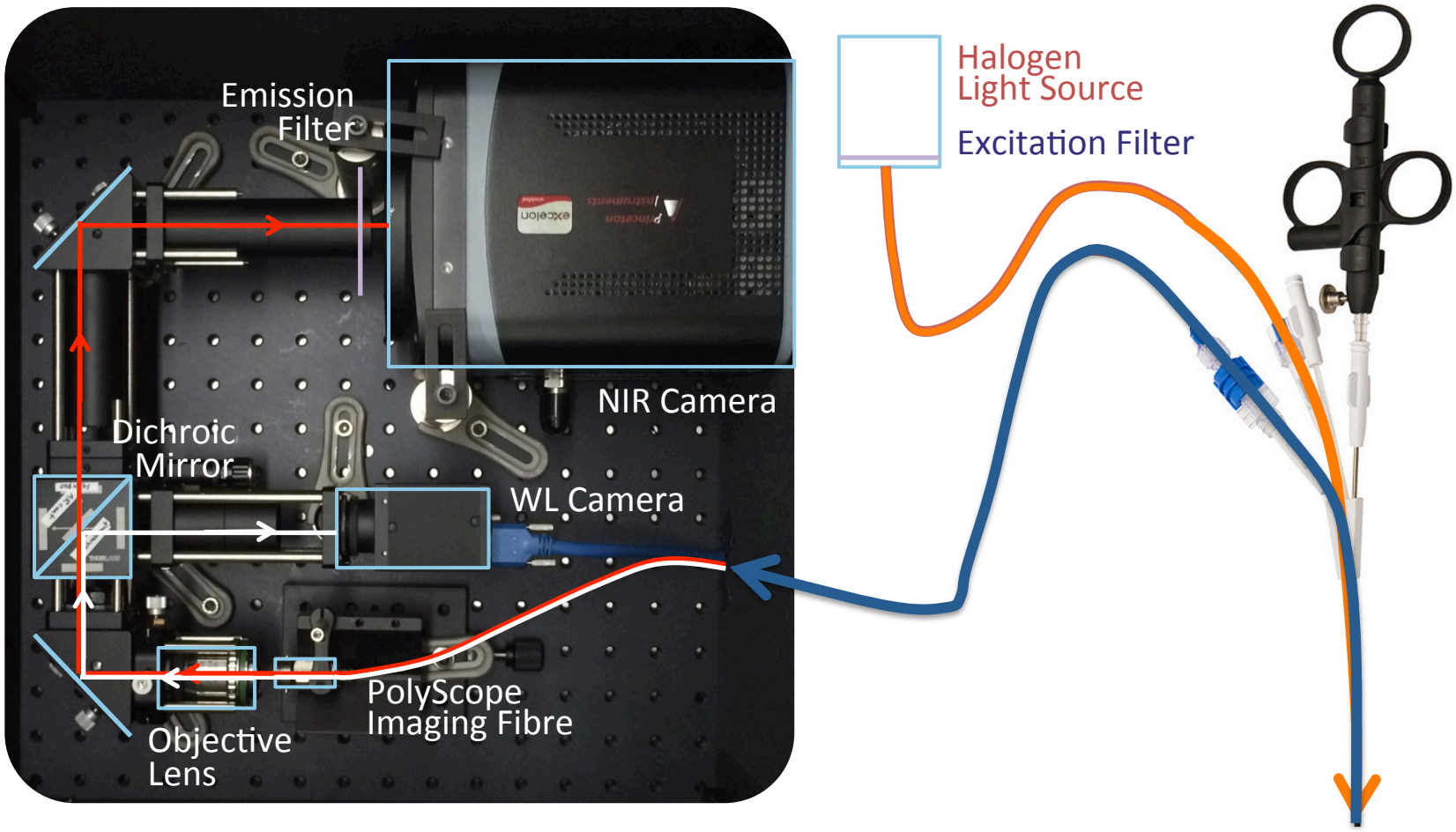
Initial data indicates that we can easily resolve at least four sources of fluorescence *in vivo*





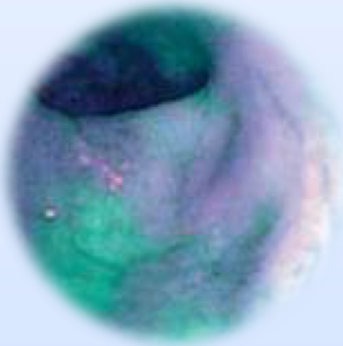
Luthman *et al* (2016) in preparation

We are using a generic platform for testing novel endoscopic technologies



Waterhouse *et al* (2016) In submission

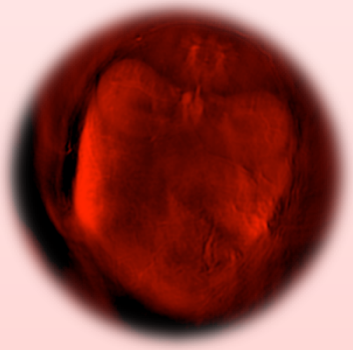
Endoscopy



Translational



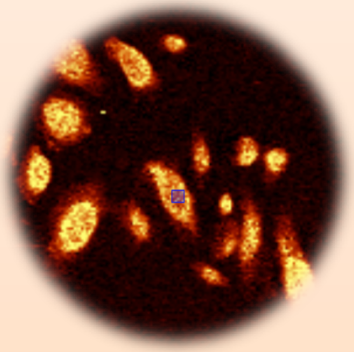

Macroscopy



In vivo



Microscopy



In vitro



Acknowledgements

The Bohndiek Lab

Dr Joanna Brunker
Dr James Joseph
Dr Isabel Quiros-Gonzalez
Dr Jakub Surmacki
Siri Luthman
Michal Tomaszewski
Dale Waterhouse
Ben Woodhams
Judith Weber

Visitors

Dr Frederic Brochu (@HEP)

Lung Cancer
Prof. Bruce Ponder
Dr Robert Rintoul

Breast Cancer
Prof. Fiona Gilbert
Dr Oshi Abeyakoon

Oesophageal Cancer
Prof. Rebecca Fitzgerald
Dr Massi di Pietro

CRUK CI @ Cam
Prof. Kevin Brindle
Dr Andre Neves

Engineering @ Cam
Prof. Tim Wilkinson
Dr George Gordon

iThera Medical
Stefan Morscher
Christian Wiest

CRUK & EPSRC Cancer Imaging Centre in Cambridge and Manchester
CANCER RESEARCH UK
MRC Medical Research Council
SEVENTH FRAMEWORK PROGRAMME
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