Centre for Nanoscale BioPhotonics
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Multimodal fibre-optic imaging probe for detection of atherosclerotic plaques using fluorescent nanoparticles

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Atherosclerosis

Cardiovascular diseases (CVD)

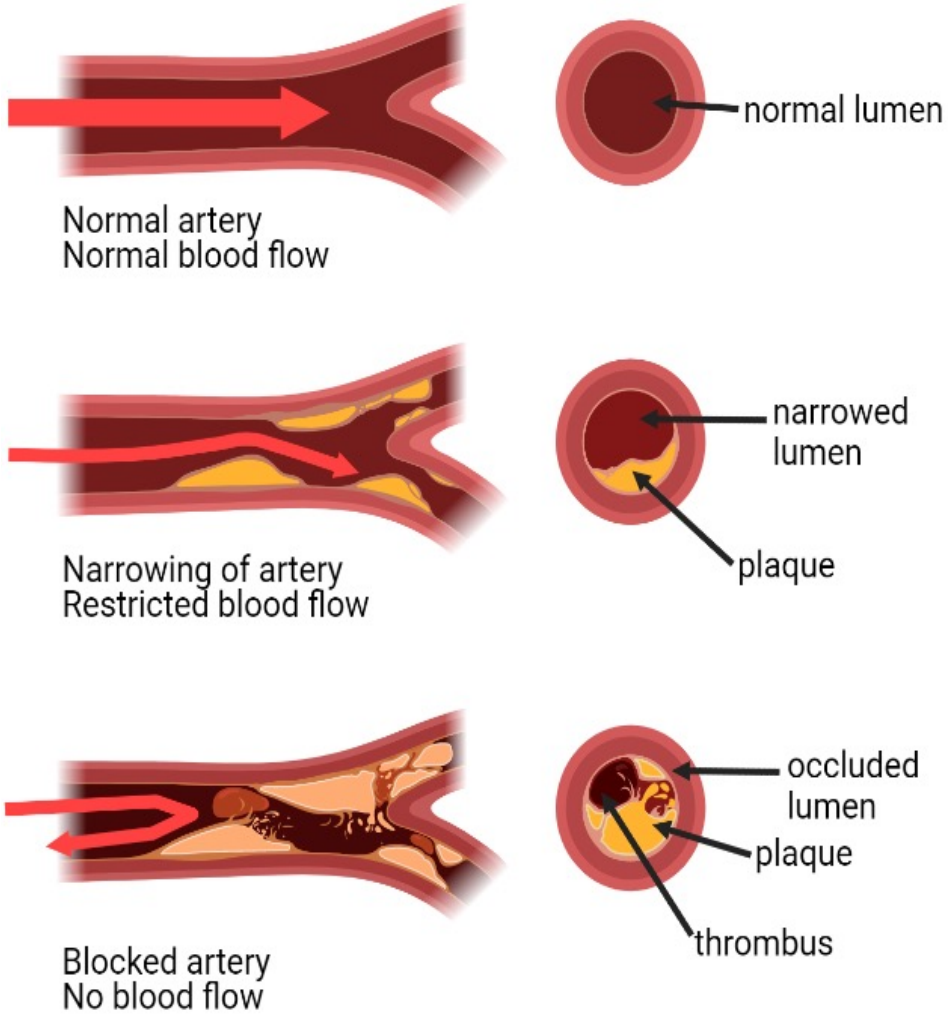
17.9 million deaths from CVD each year

85% caused by atherosclerosis

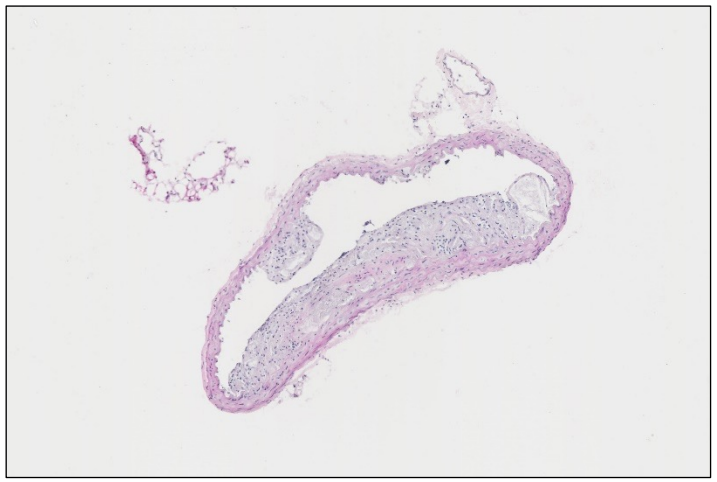
What is atherosclerosis?

Plaque (fatty deposits) build up inside blood vessel wall

- Lead to strokes or heart attacks



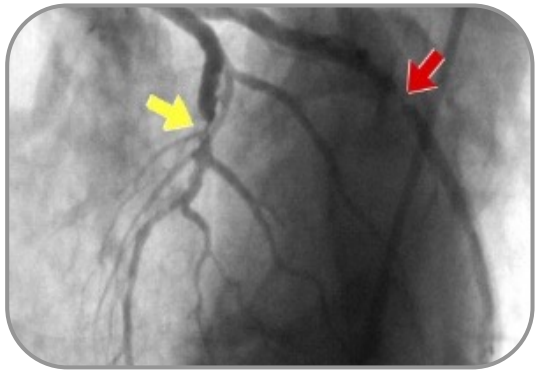
Gold standard vs current imaging techniques



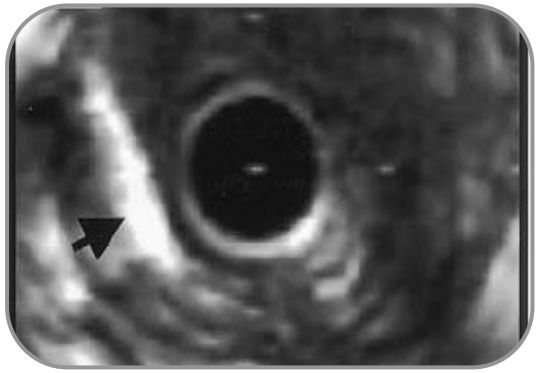
Histology image

vs

Examples of current imaging techniques for atherosclerosis detection



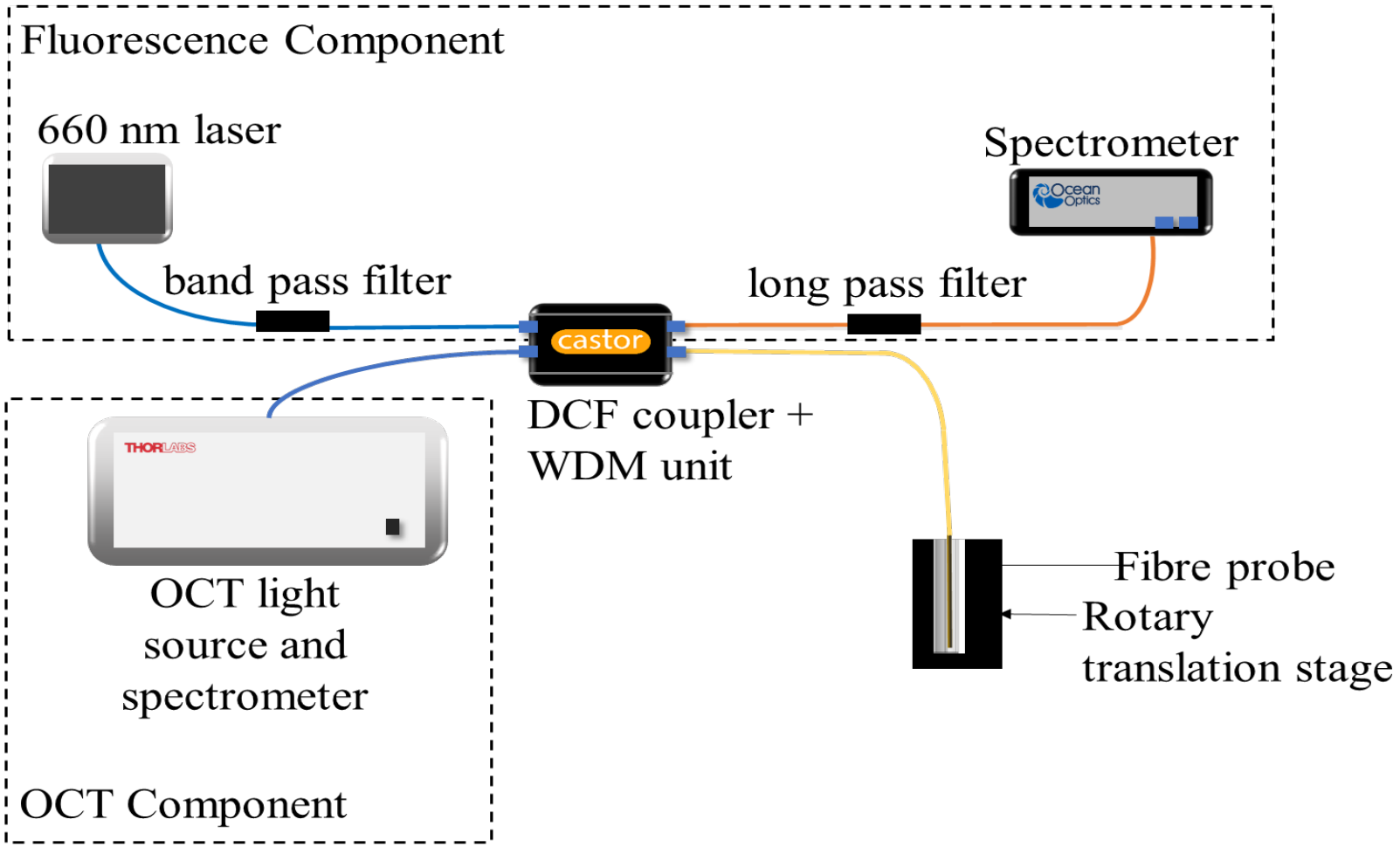
Coronary angiogram showing narrowing of the coronary arteries



IVUS imaging of the coronary artery, black arrow indicating the presence of plaque

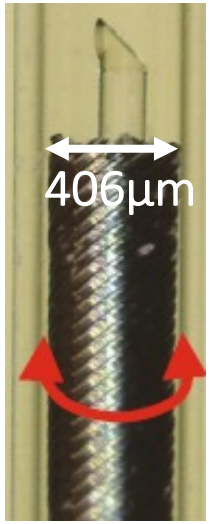
Ibanez et. al, The American Journal of Medicine, 2009
Jang et. al, Journal of the American College of Cardiology, 2002

Optical Coherence Tomography (OCT) + Fluorescence system



OCT -> Structural:
how the plaques look like
Fluorescence -> Molecular:
what is within the plaque

Close up of fibre-optic probe



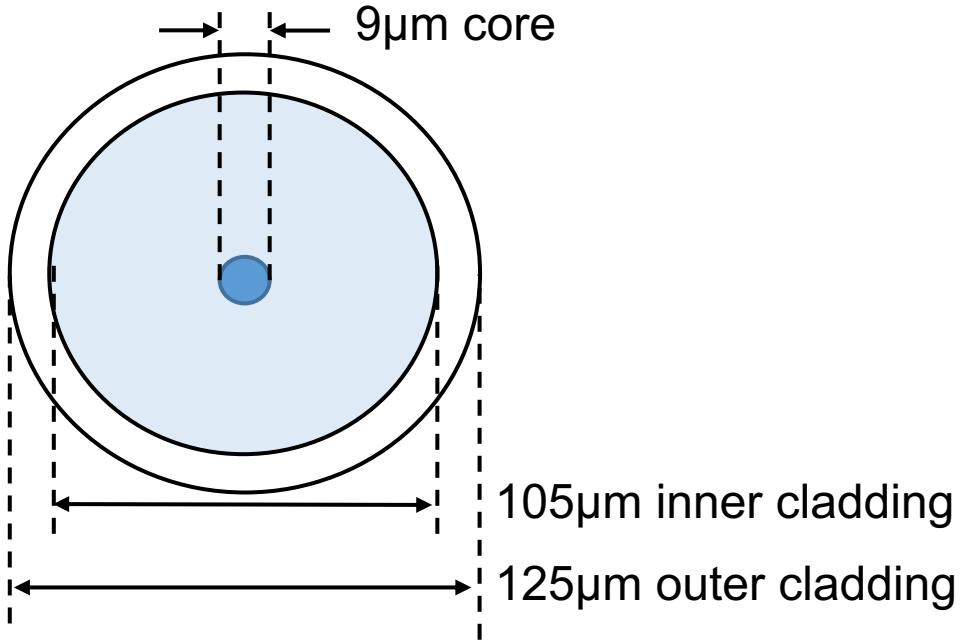
Multimodal imaging – DCF probe

Double-clad fibre (DCF) for simultaneous co-localised

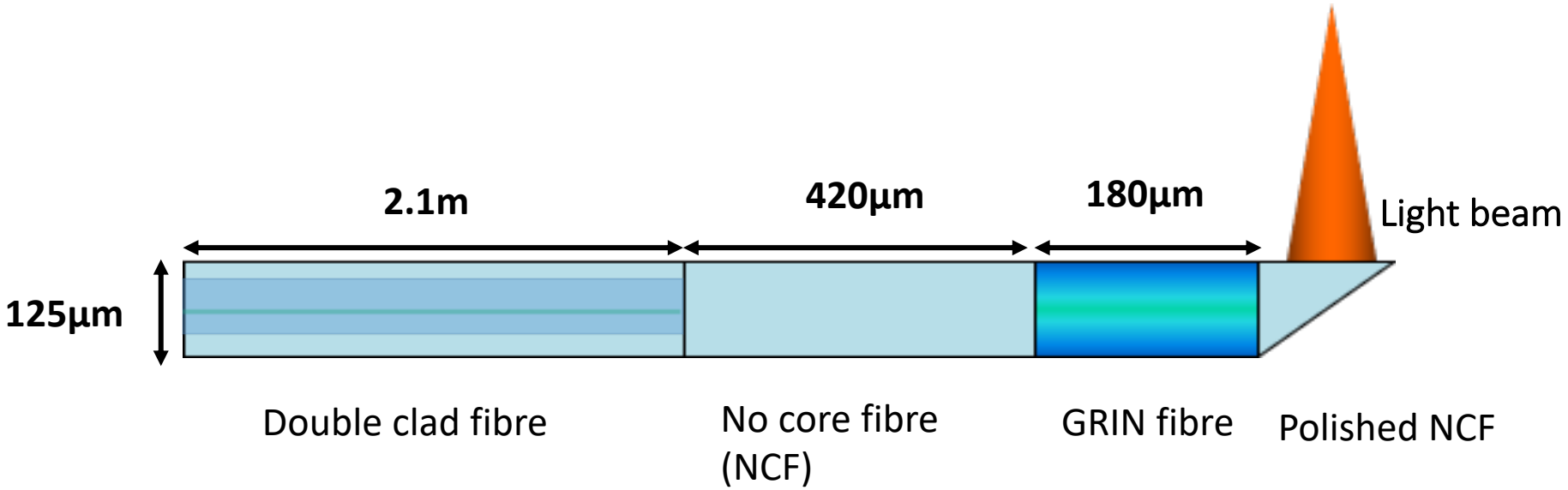
OCT imaging and **fluorescence imaging**

- Fibre core: excitation light emitted, and OCT light emitted and collected
- Fibre inner cladding: fluorescence signal collected

Cross section of Double Clad Fibre



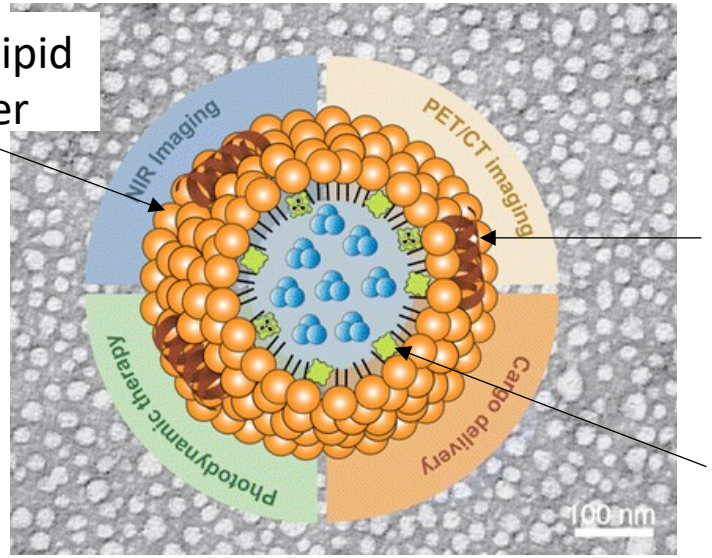
Multimodal imaging – DCF probe

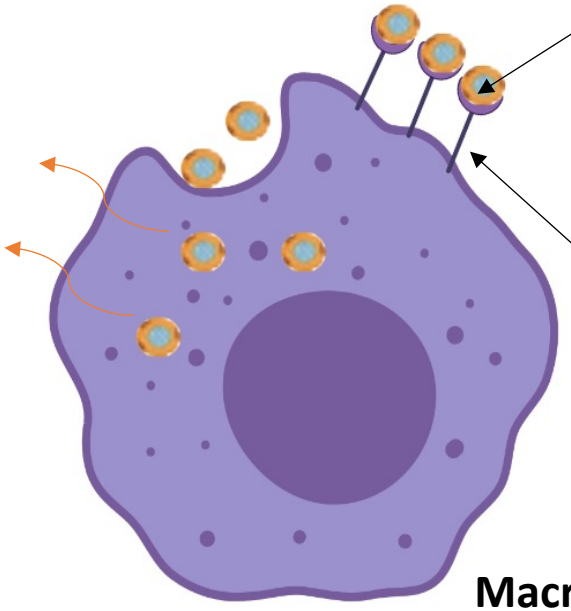


Not to scale

Porphylipoprotein Nanoparticle

Porphylipoprotein



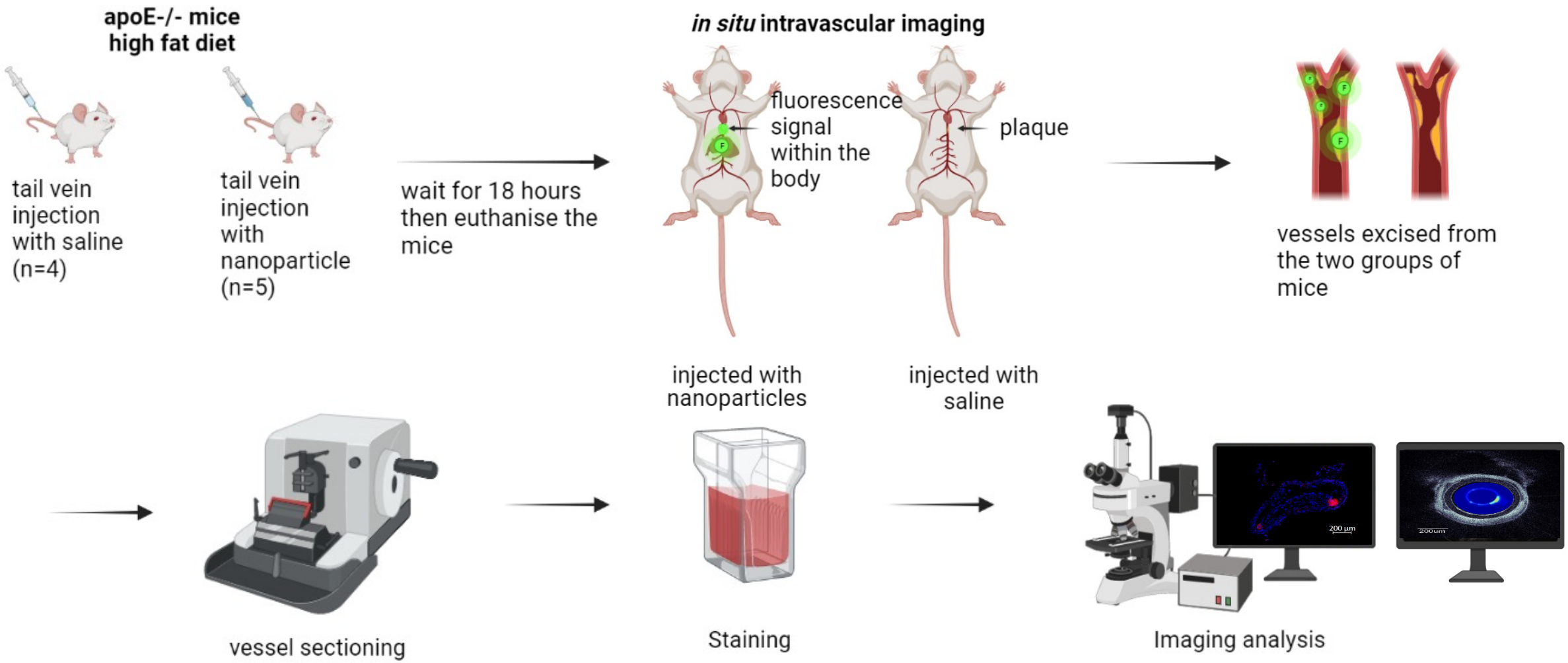


Macrophage: type of white blood cell that engulfs foreign materials

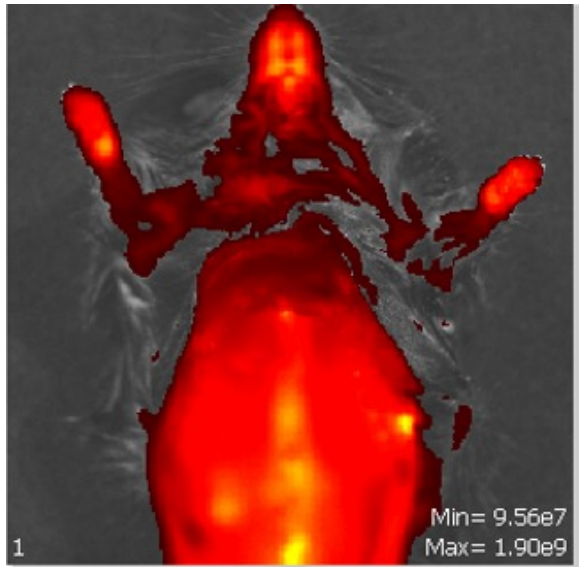
- Nanoparticles are used to make the plaques glow, excited at 660nm
- R4F peptide allows **specific binding to SR-b1 scavenger receptors**, highly expressed on macrophages
- Fluorescence signal emitted by porphyrin molecules

Cui et. al, ACS Nano, 2015

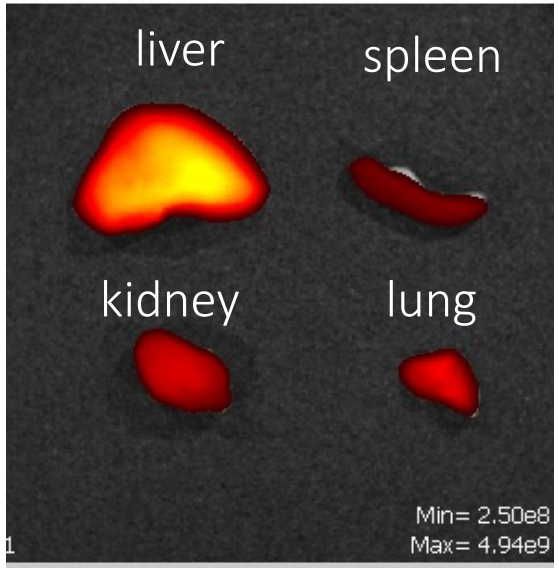
In situ mouse study - Methods



In situ mouse study - Results



IVIS image of upper body of the mouse



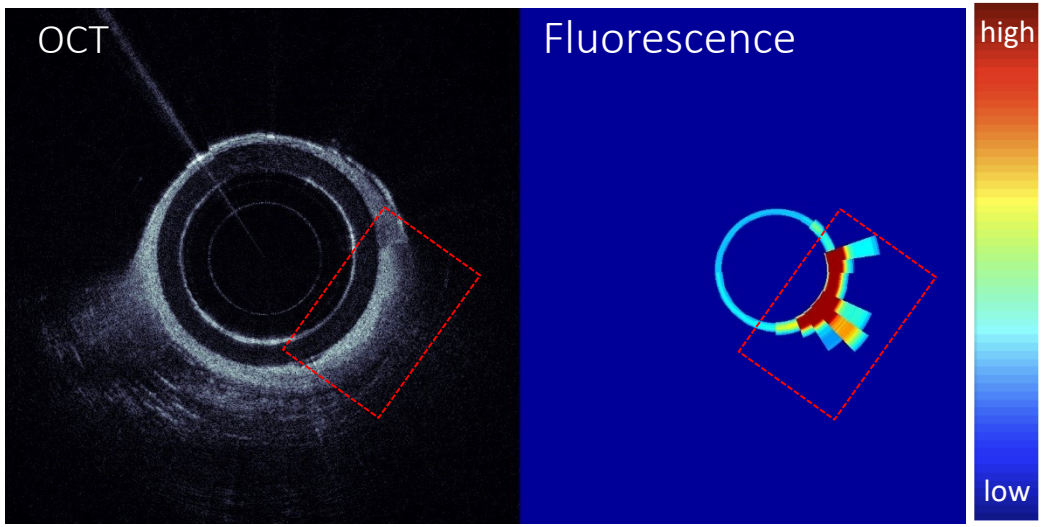
IVIS image of liver, spleen, kidney and lung of the mouse

- Mouse also imaged with In Vivo Imaging System (IVIS) right after being culled, with excitation at 675nm, and emission at 720nm
- High fluorescence observed in liver and down the aorta

In situ mouse study - Results

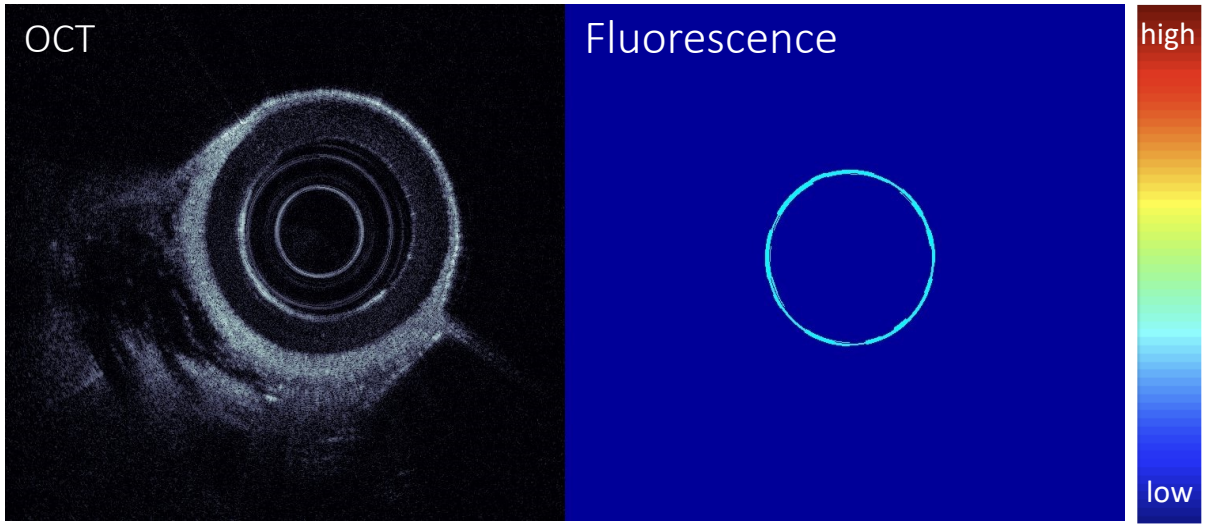
- High fluorescence intensity areas in mice injected with nanoparticles
- No fluorescence observed for control mice

Diseased mouse with nanoparticle injection



Slice 384 – 4.32mm above the incision

Diseased mouse with saline injection

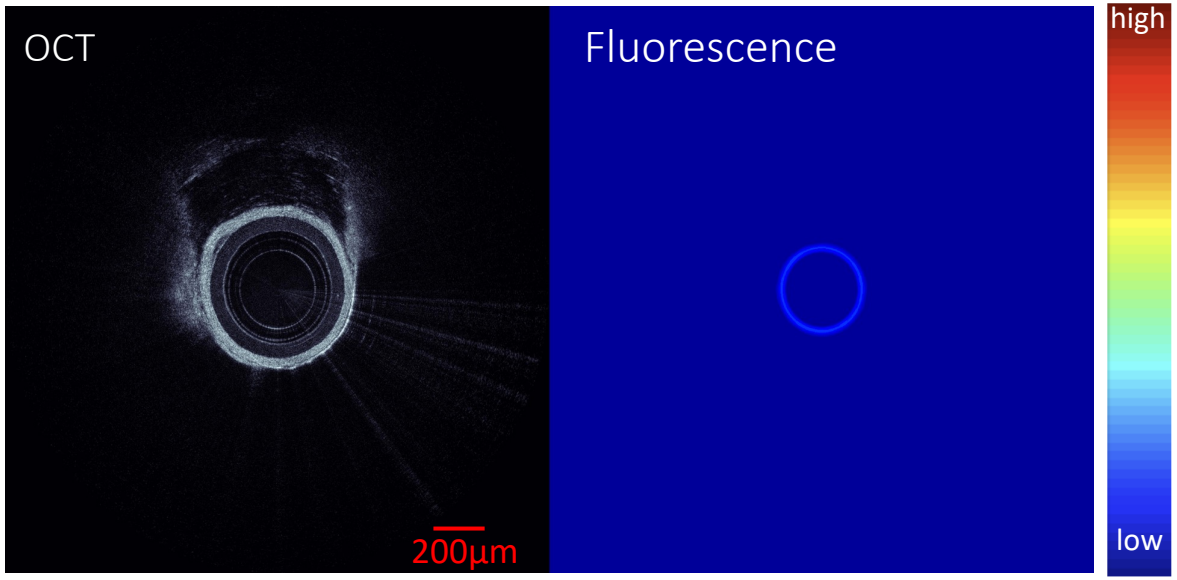


Slice 115 – 9.7mm above the incision

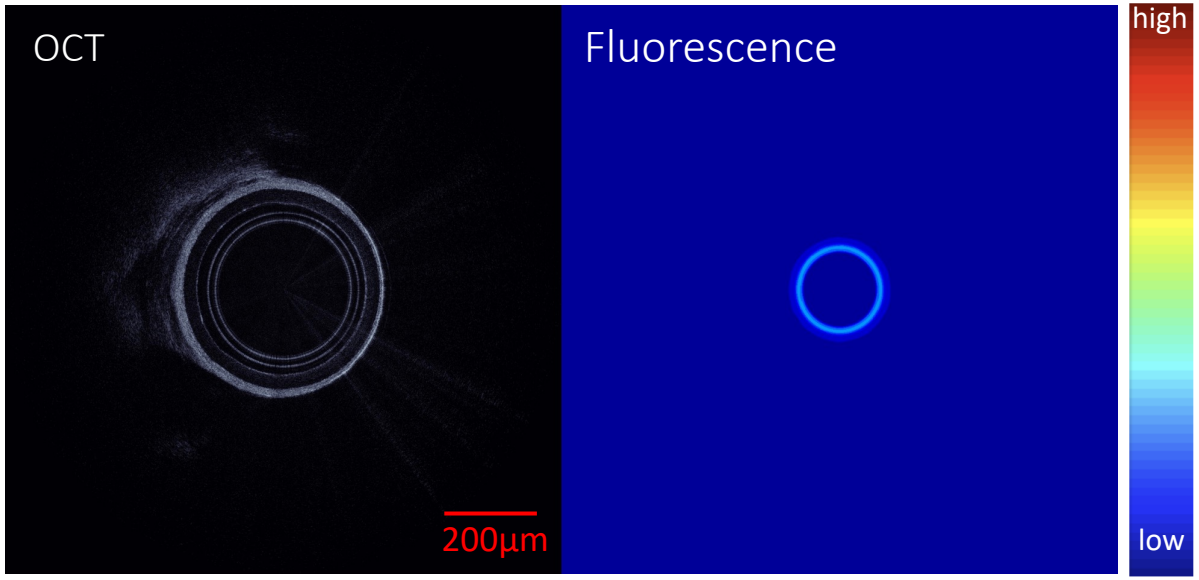
In situ mouse study - Results

- Several high fluorescence intensity areas were found in the descending aorta for mouse injected with nanoparticles
- No fluorescence observed for control mouse in the entire artery

Diseased mouse with nanoparticle injection



Diseased mouse with saline injection



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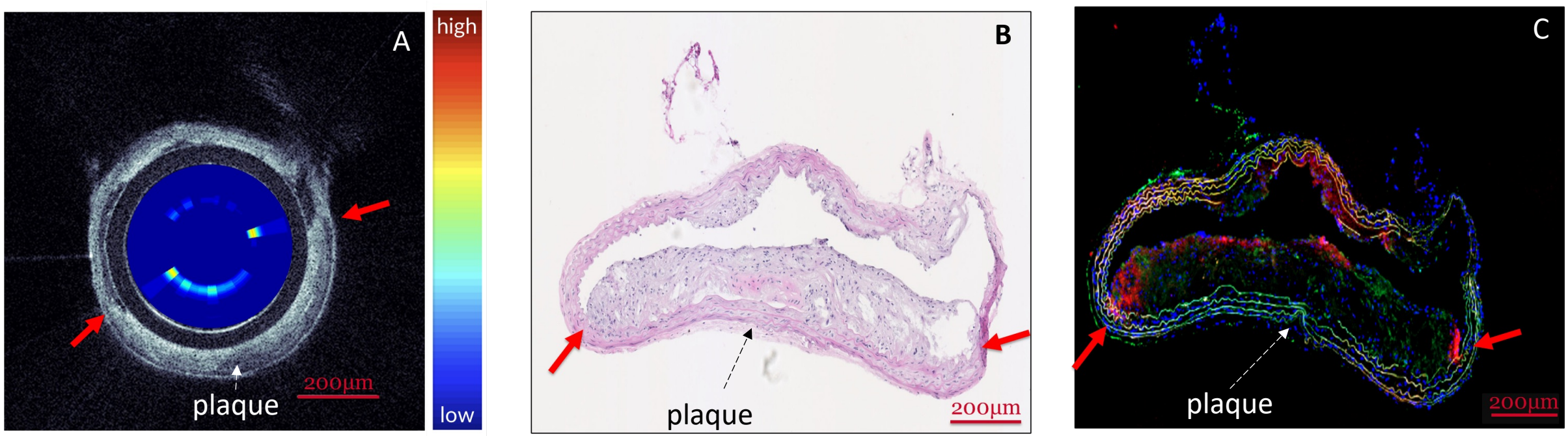
In situ mouse study - Histology



(A) Combined intravascular OCT and Fluorescence images
(B) Corresponding Hematoxylin and Eosin (H&E) staining – general morphology
(C) Corresponding fluorescence microscopy: Cell nuclei (Blue), macrophages (green), nanoparticle fluorescence (red)

Conclusion and Future Works

- Miniaturised fibre-optic probe and fluorescent nanoparticle
- **Structural information** and **additional biomolecular information** of atherosclerotic plaques
- Better delineate plaque and see live macrophages

- Explore the effect of using the nanoparticle in *in vivo* longitudinal mouse study
  - Mice will be kept alive for 12 weeks for the study, with 3 imaging time points

Acknowledgement

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