Imaging intra-cellular polyethylene wear debris with coherent anti-Stokes Raman scattering spectroscopy

Martin Lee, Alistair Elfick

Institute for Materials and Processes,
The University of Edinburgh,
Edinburgh, UK

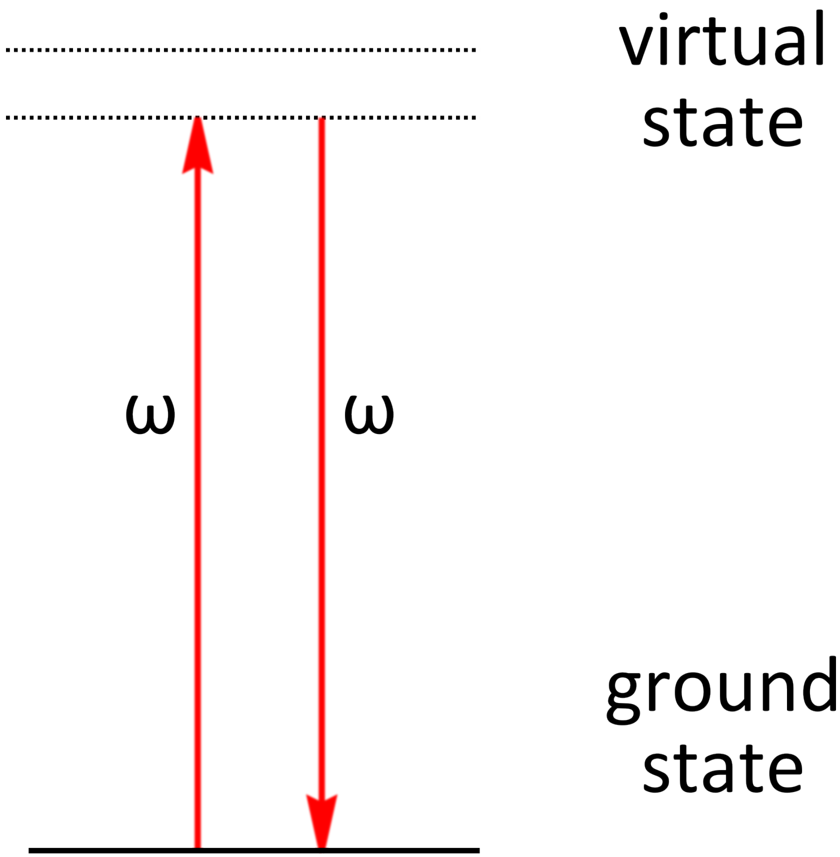
THE UNIVERSITY *of* EDINBURGH

Overview

1. Introduction to Raman
2. Coherent anti-Stokes Raman scattering
3. Our CARS setup
4. Our model system
5. Results
6. Conclusion

THE UNIVERSITY *of* EDINBURGH

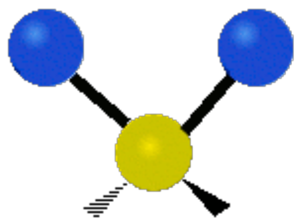
Rayleigh Scattering



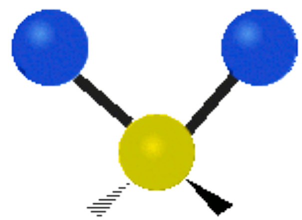
THE UNIVERSITY *of* EDINBURGH

CH_2 Vibrations

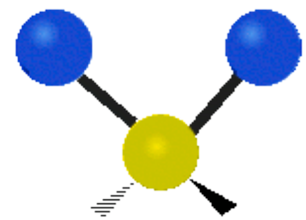
symmetric stretching



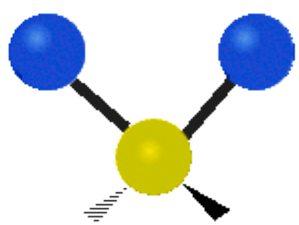
asymmetric stretching



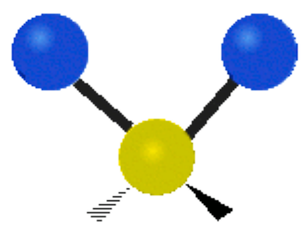
scissoring



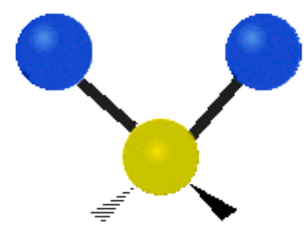
rocking



wagging

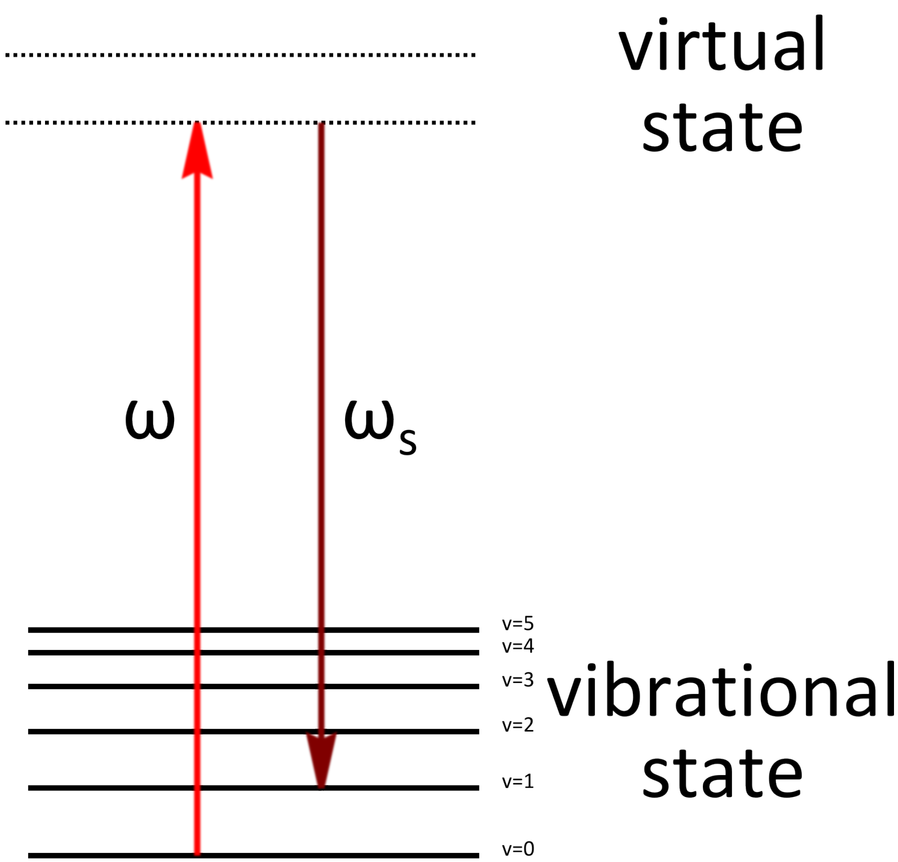


twisting



THE UNIVERSITY *of* EDINBURGH

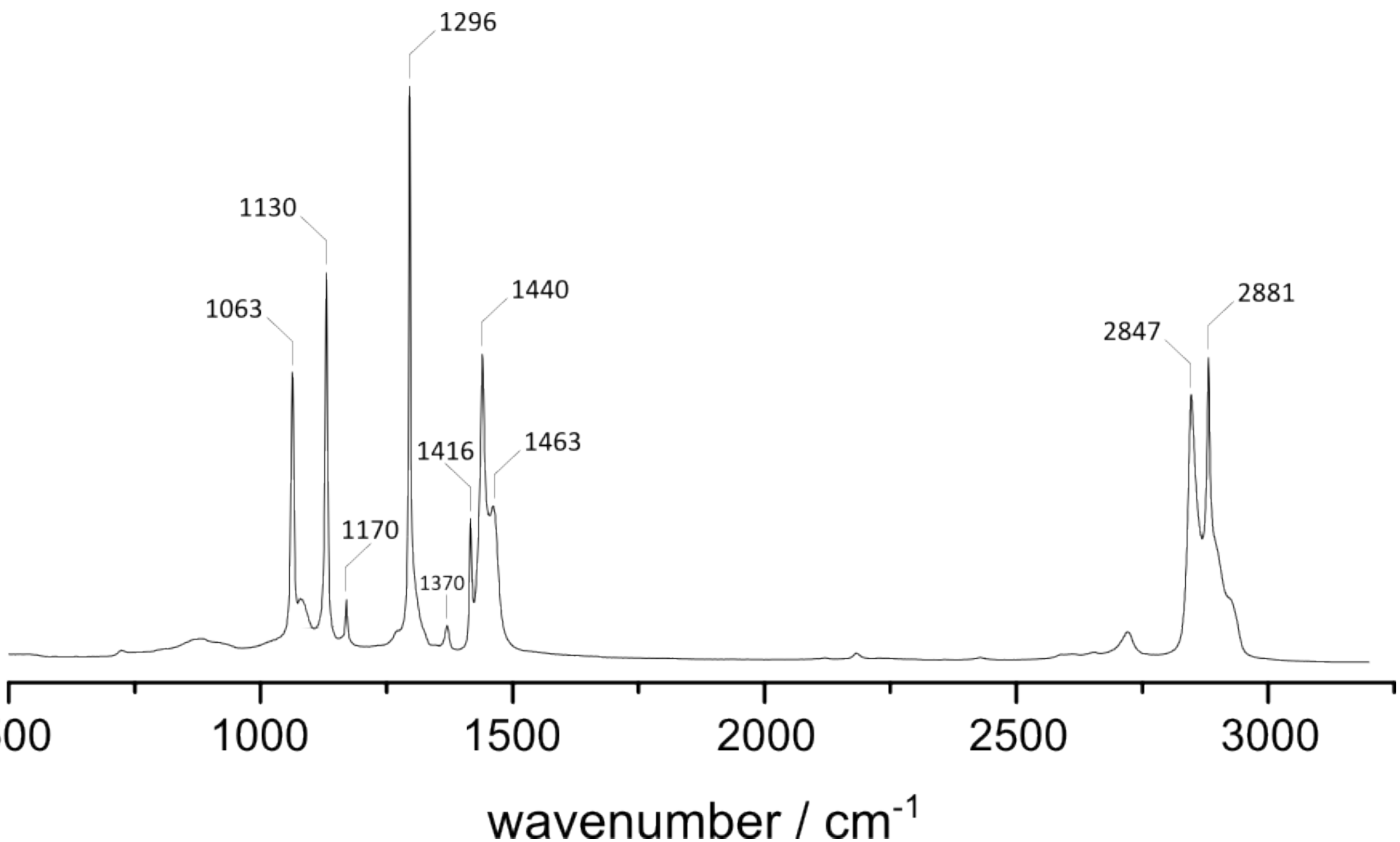
Raman Scattering



1 in 10,000,000 photons

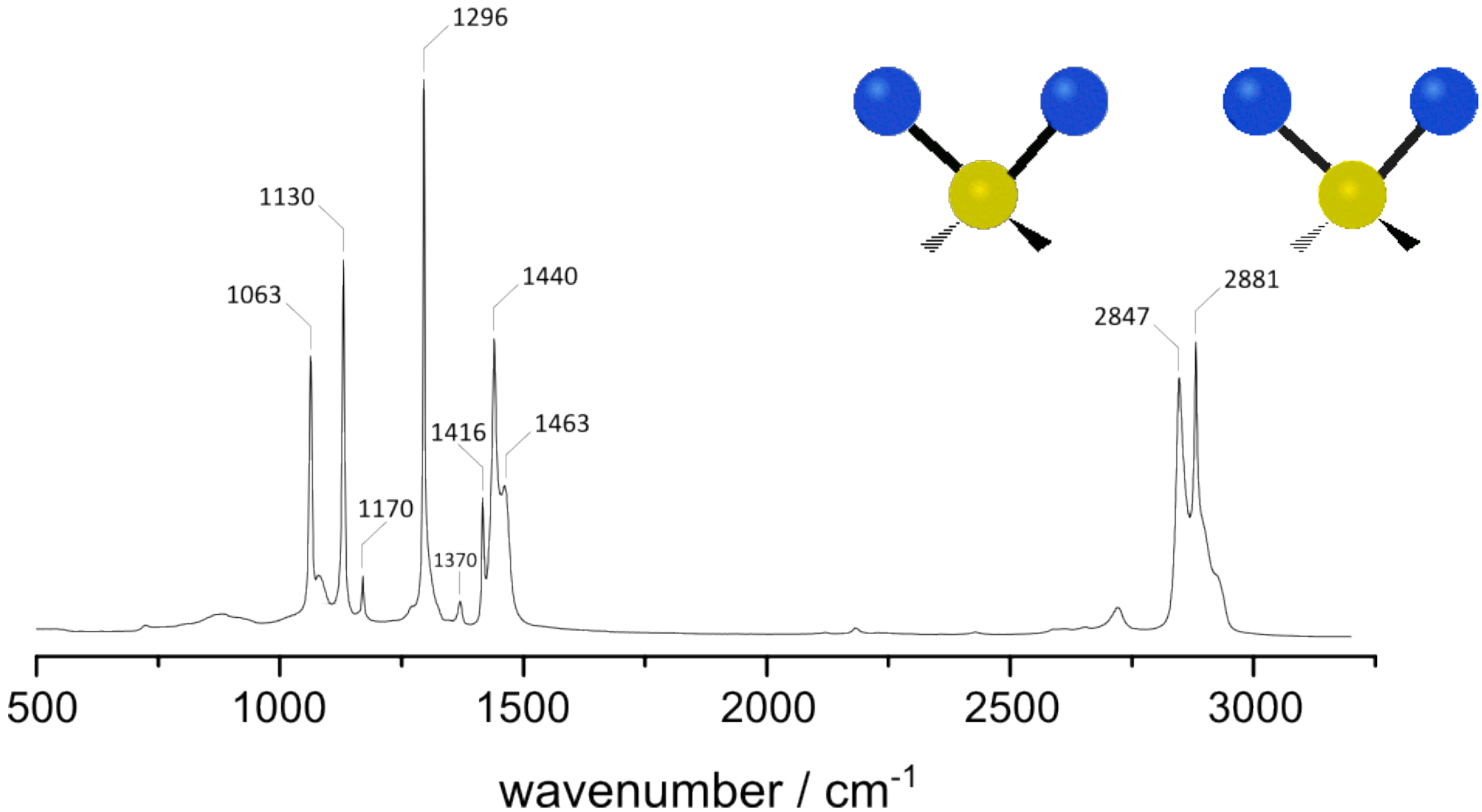
THE UNIVERSITY of EDINBURGH

Raman Spectrum - UHMWPE

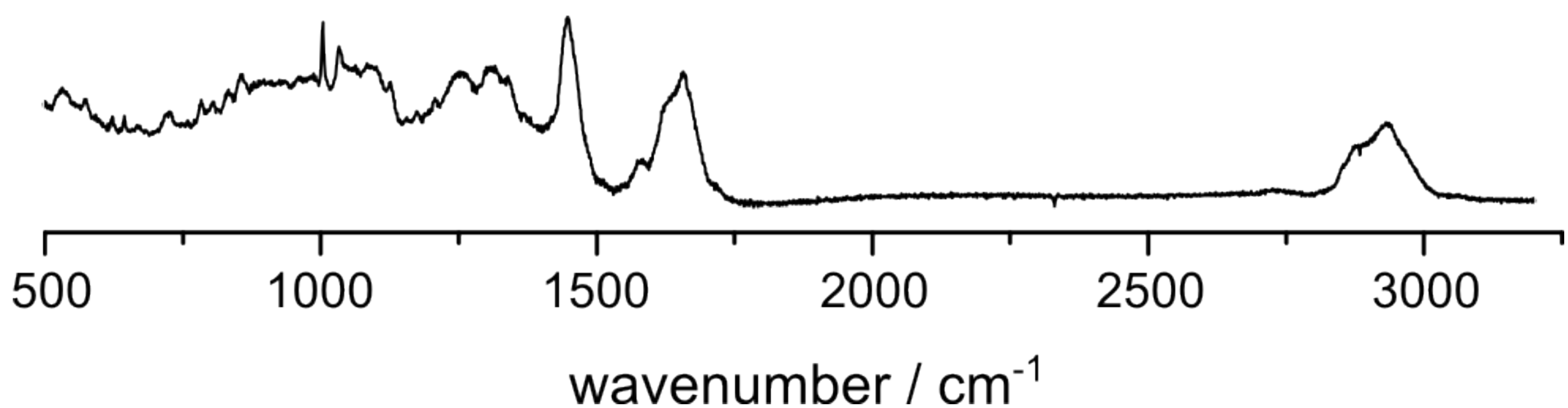


THE UNIVERSITY of EDINBURGH

Raman Spectrum - UHMWPE

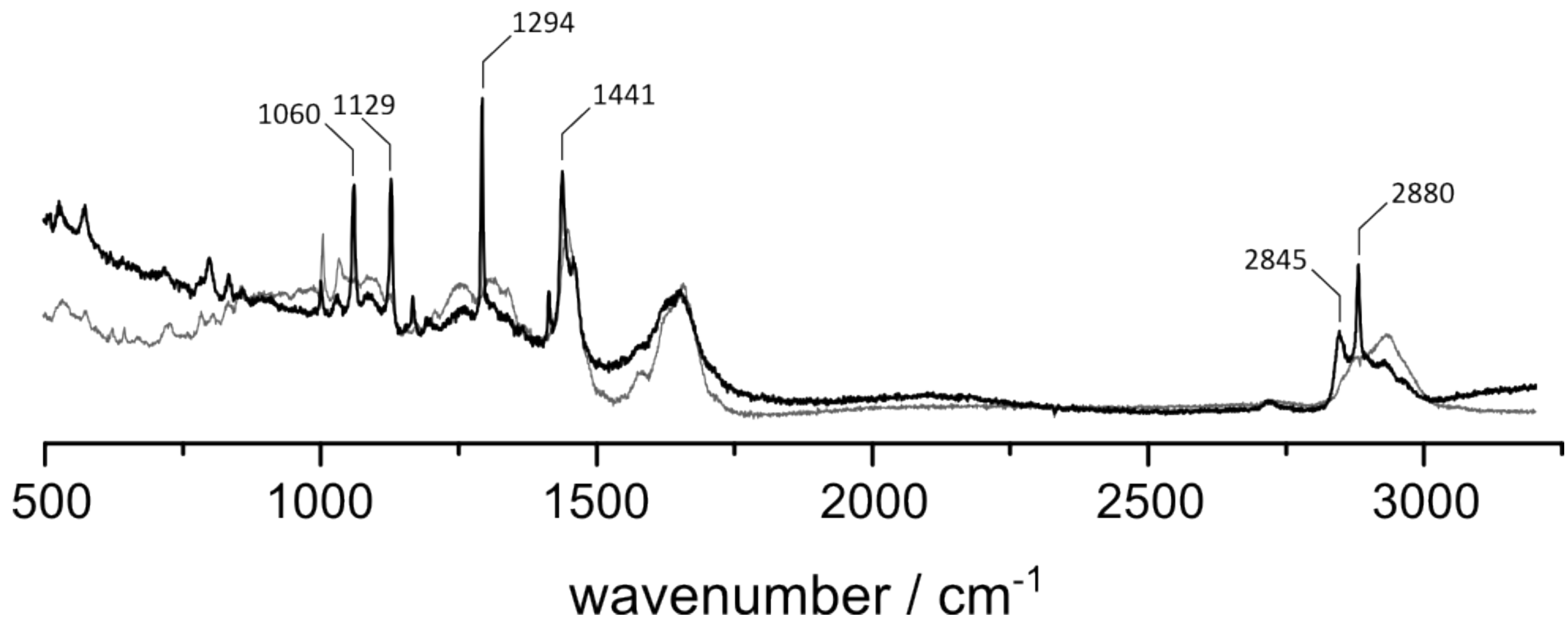


Raman Spectrum – Cell



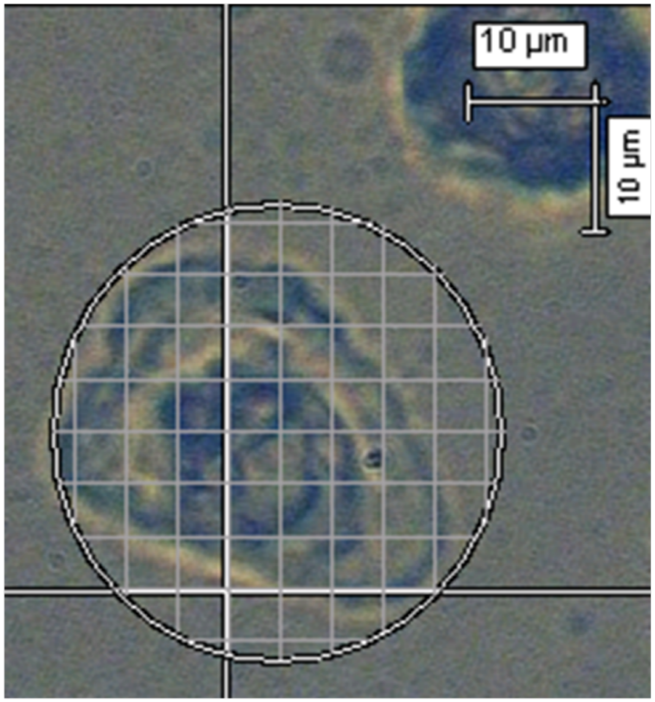
THE UNIVERSITY of EDINBURGH

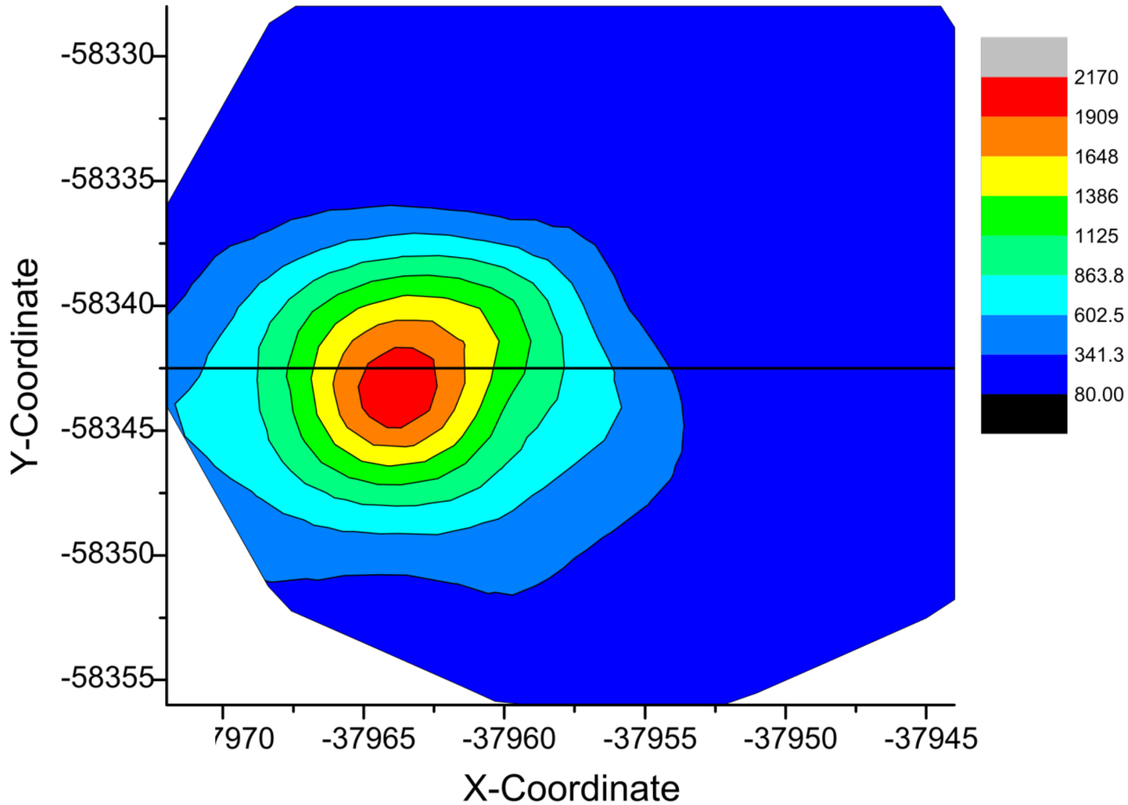
Raman Spectrum – Cell + UHMWPE



THE UNIVERSITY of EDINBURGH

Raman Mapping

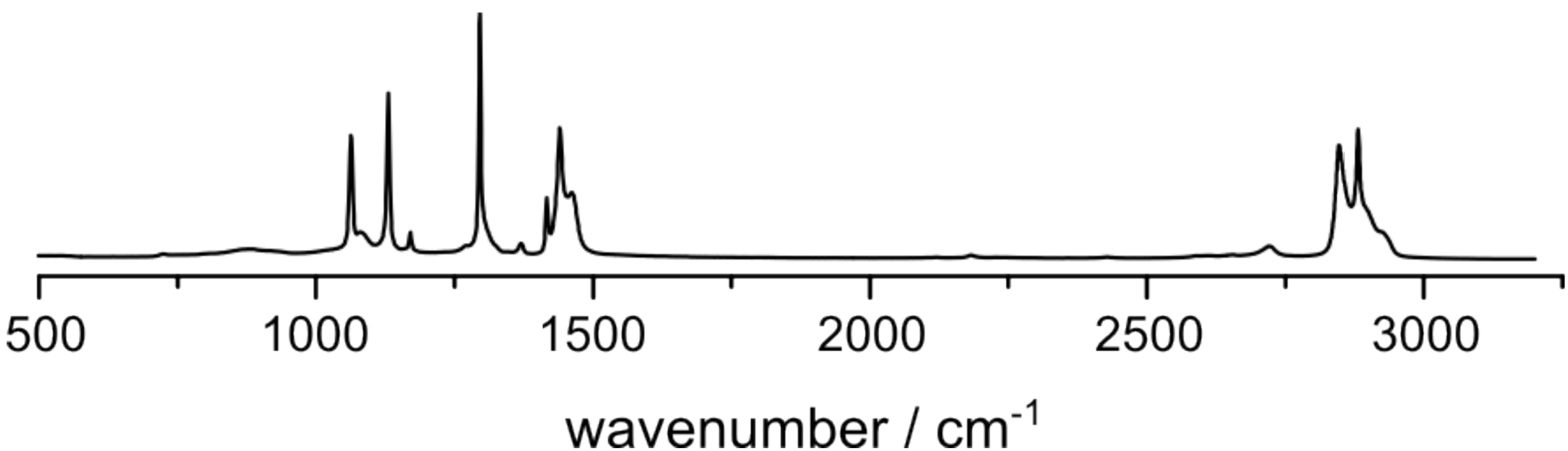




THE UNIVERSITY of EDINBURGH

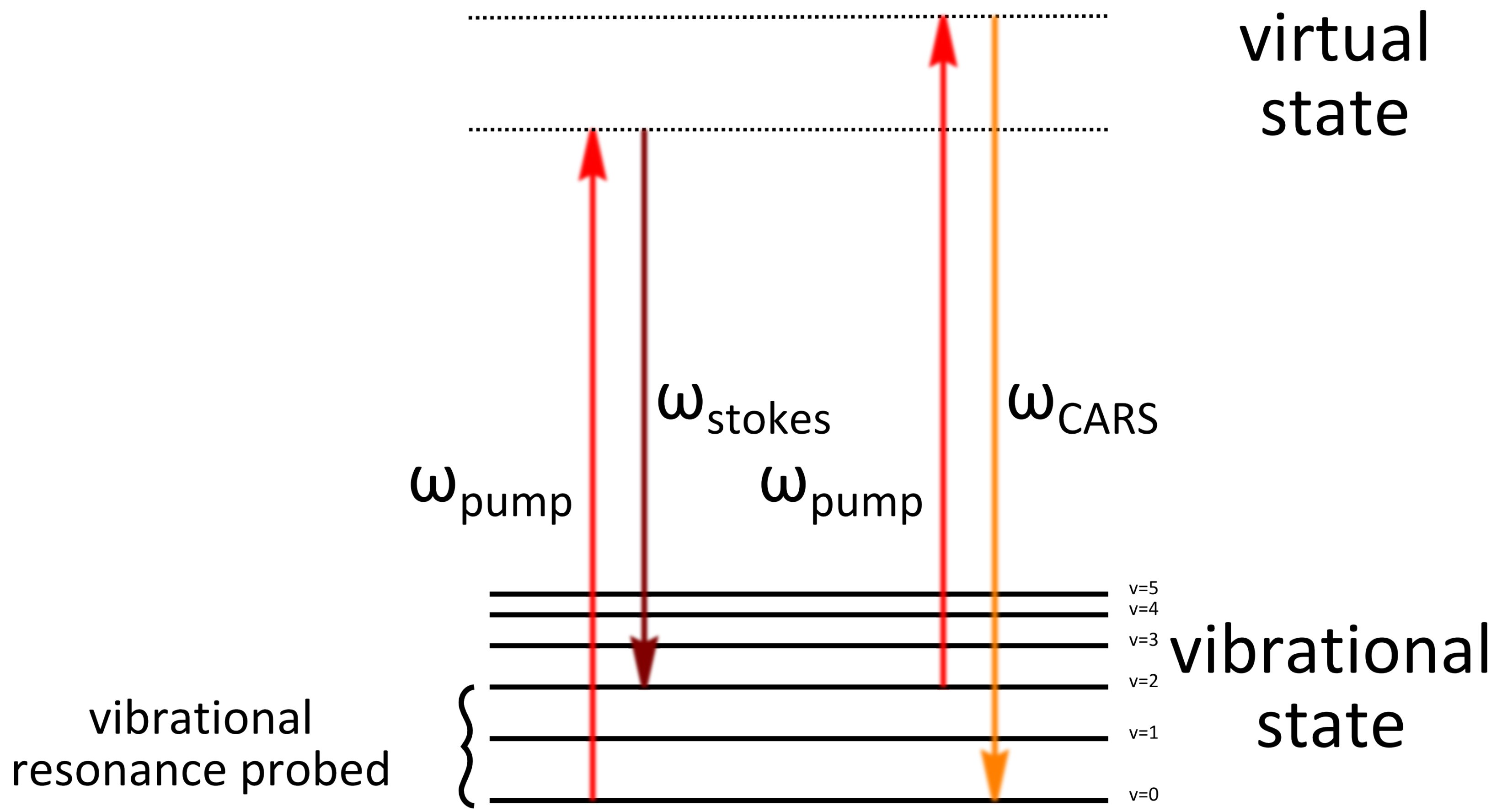
Raman

- optical method
- no label required
- wide spectrum
- slow
- low resolution
- poor 3D information



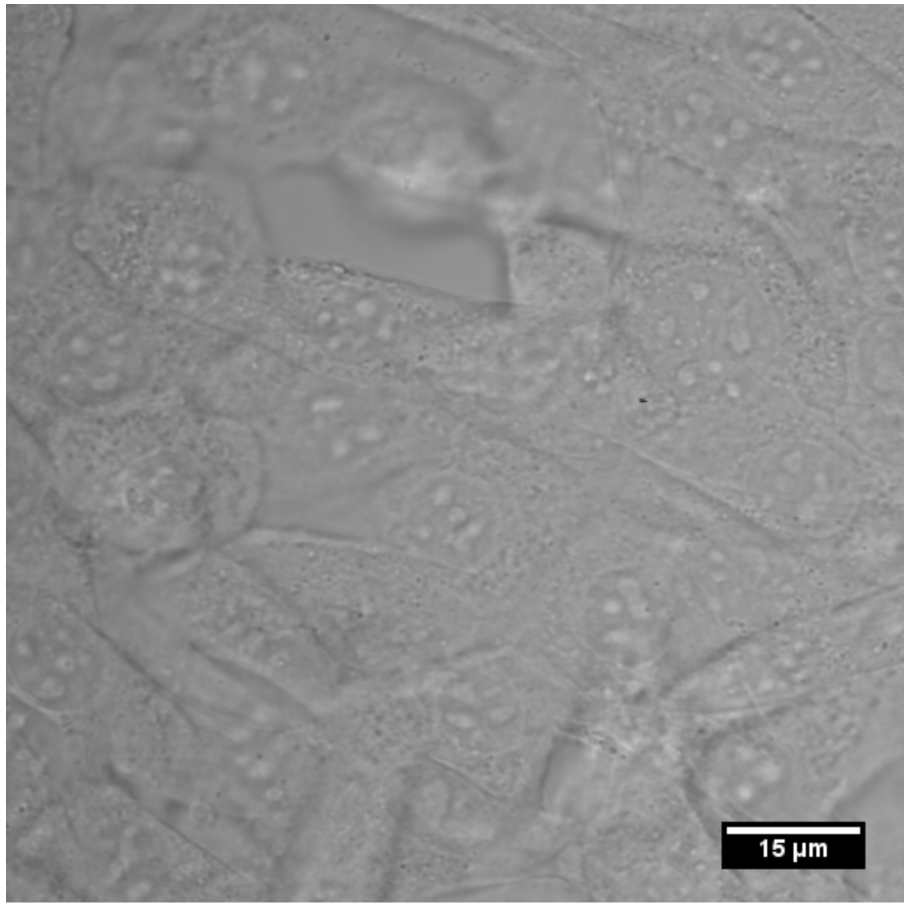
THE UNIVERSITY of EDINBURGH

Coherent anti-Stokes Raman Scattering



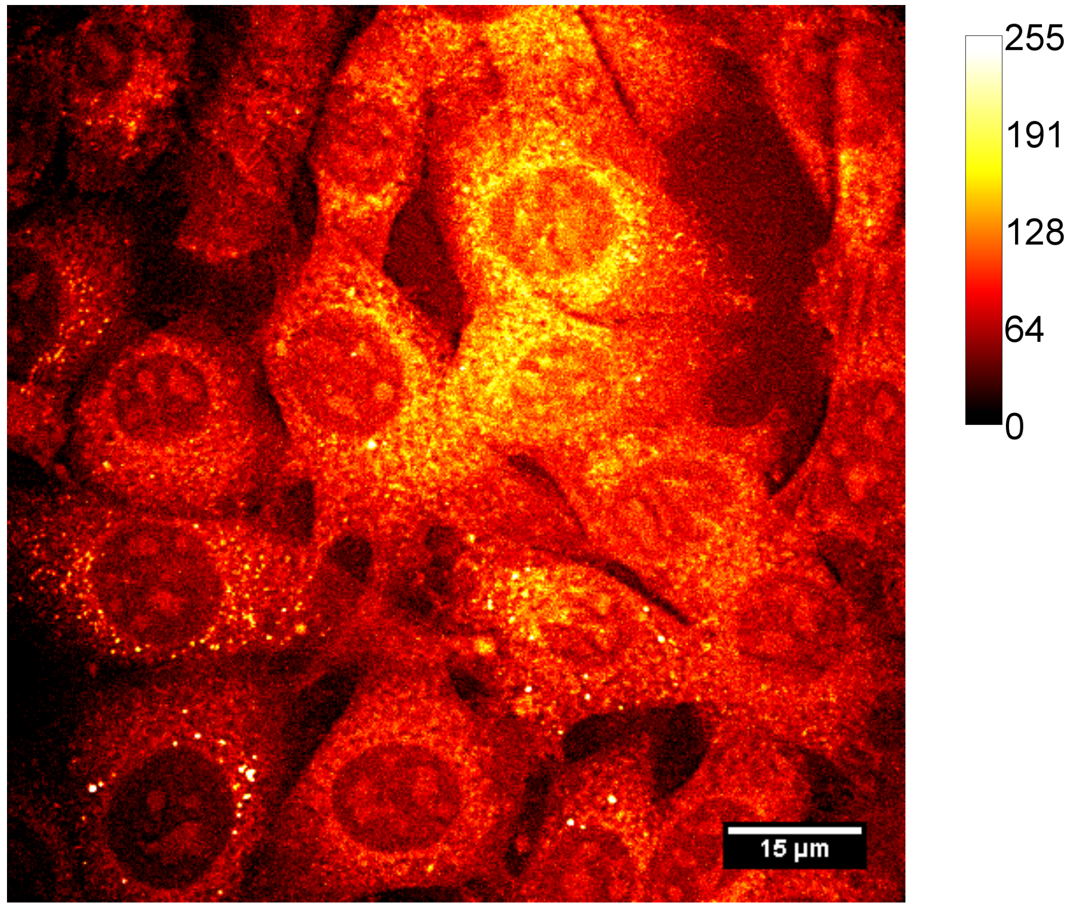
THE UNIVERSITY *of* EDINBURGH

White Light – Refractive Index



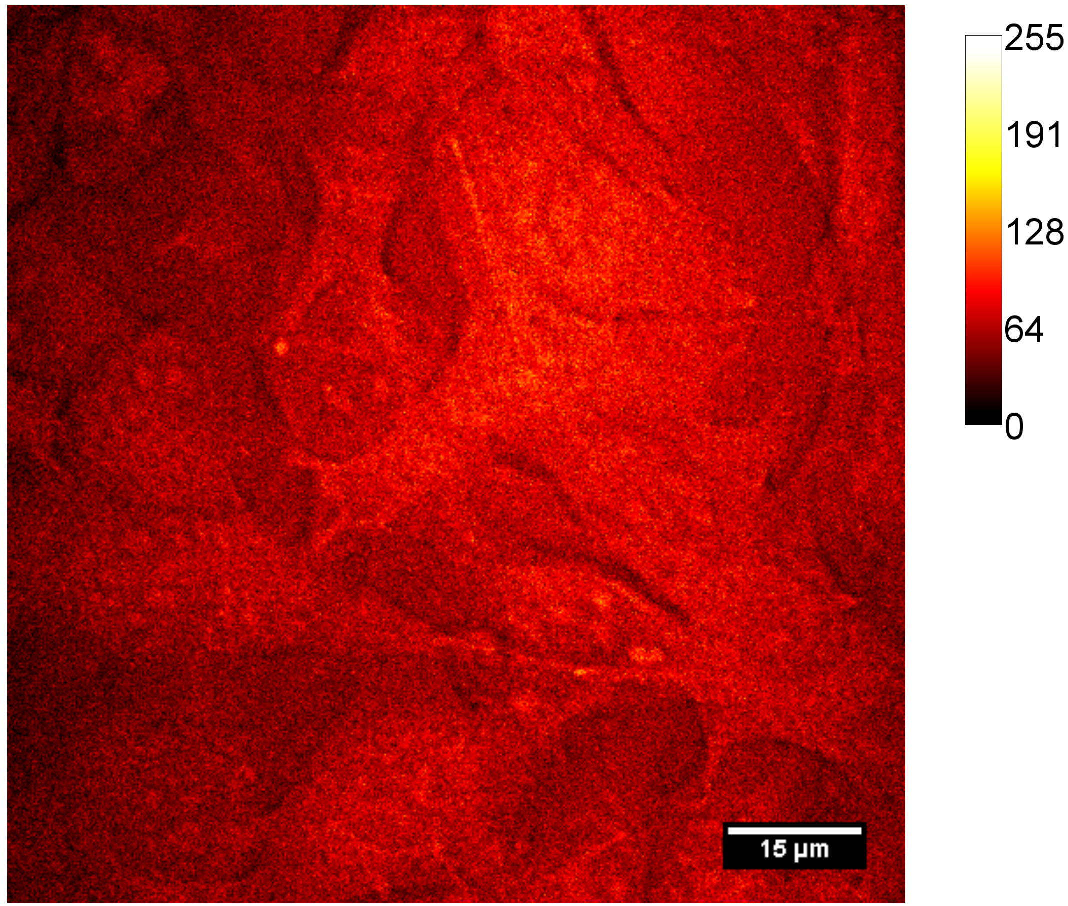
THE UNIVERSITY *of* EDINBURGH

CARS – Chemical Bonds



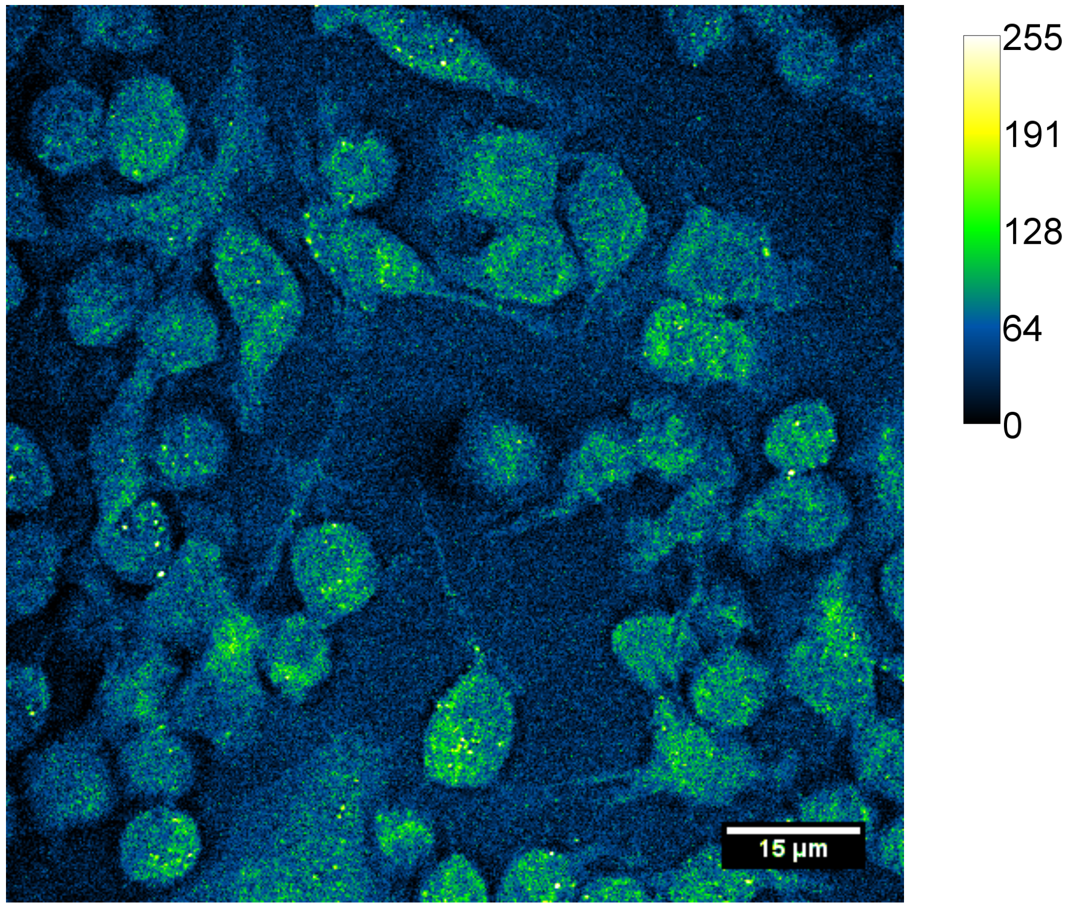
THE UNIVERSITY of EDINBURGH

CARS – 3D Sectioning



THE UNIVERSITY *of* EDINBURGH

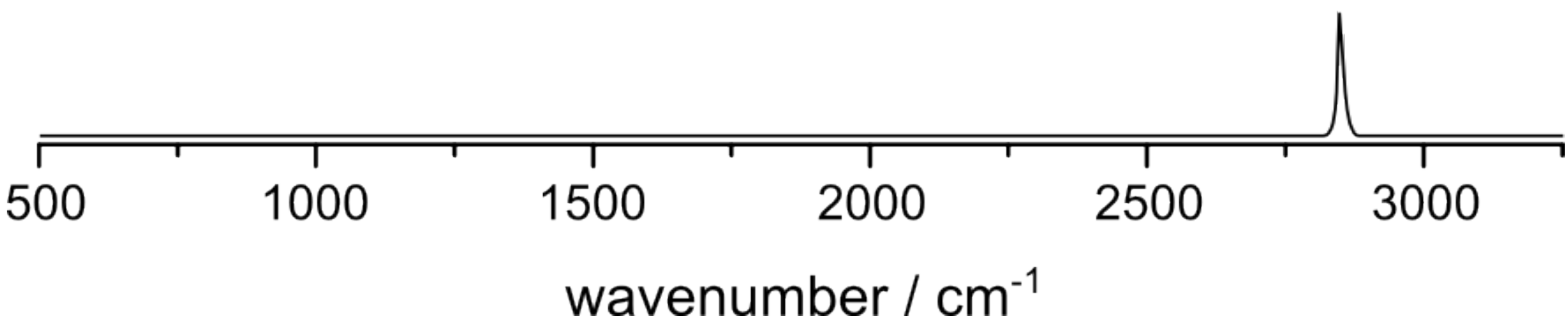
CARS – Living Cells



THE UNIVERSITY *of* EDINBURGH

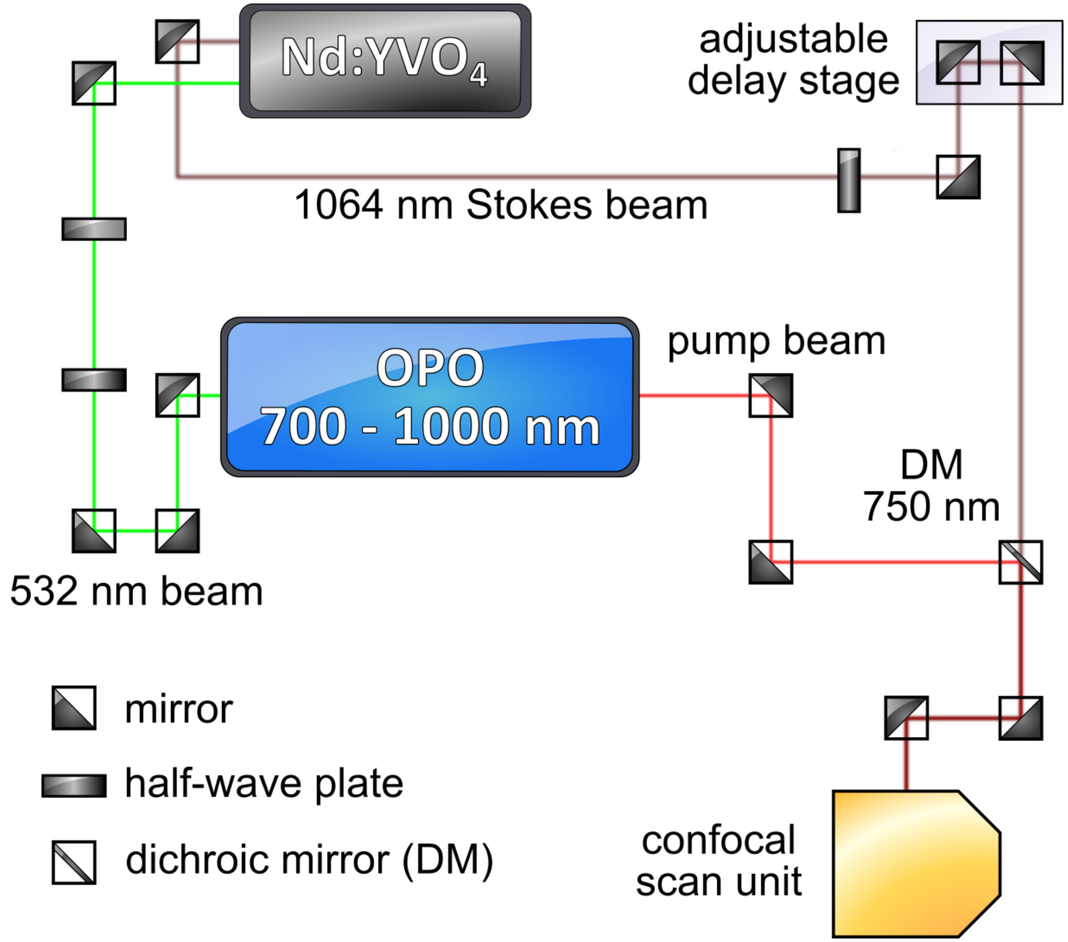
Coherent anti-Stokes Raman

- optical method
- no label required
- narrow spectrum
- fast
- high resolution
- good 3D information



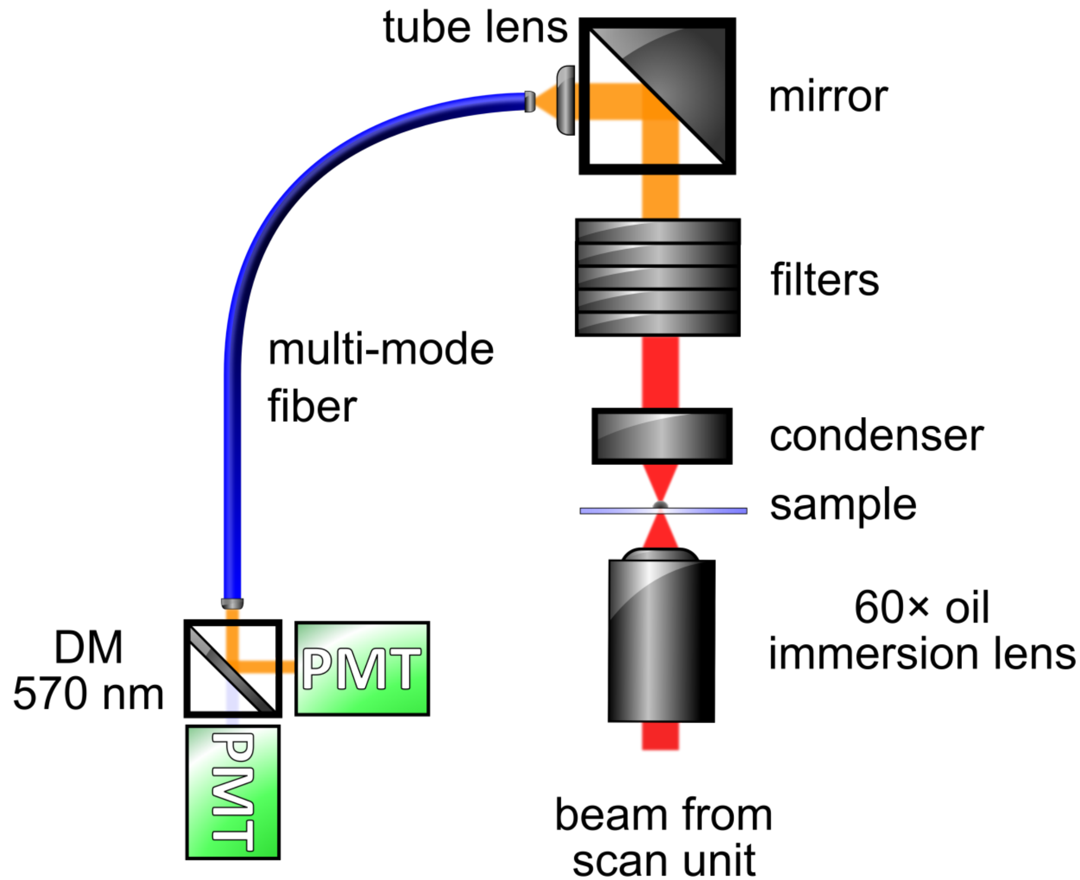
THE UNIVERSITY of EDINBURGH

CARS – Laser Source

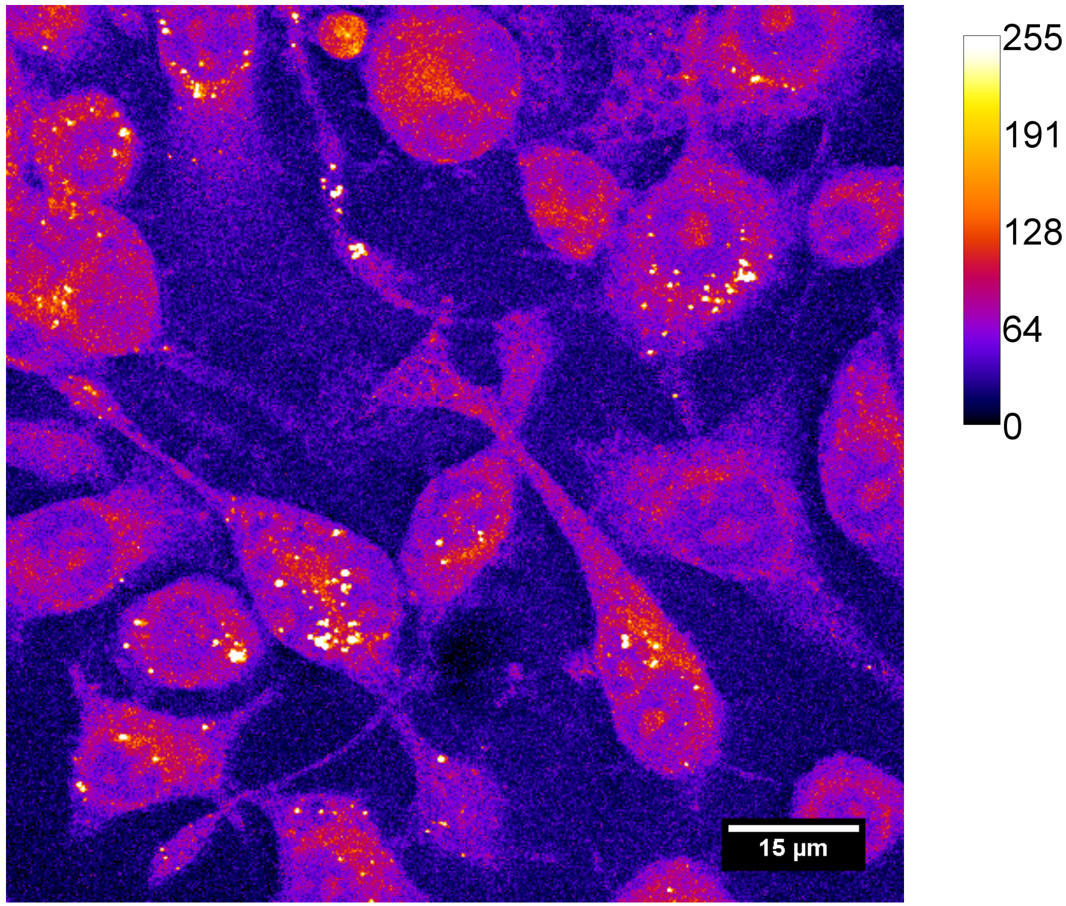


THE UNIVERSITY of EDINBURGH

CARS – Microscope Setup

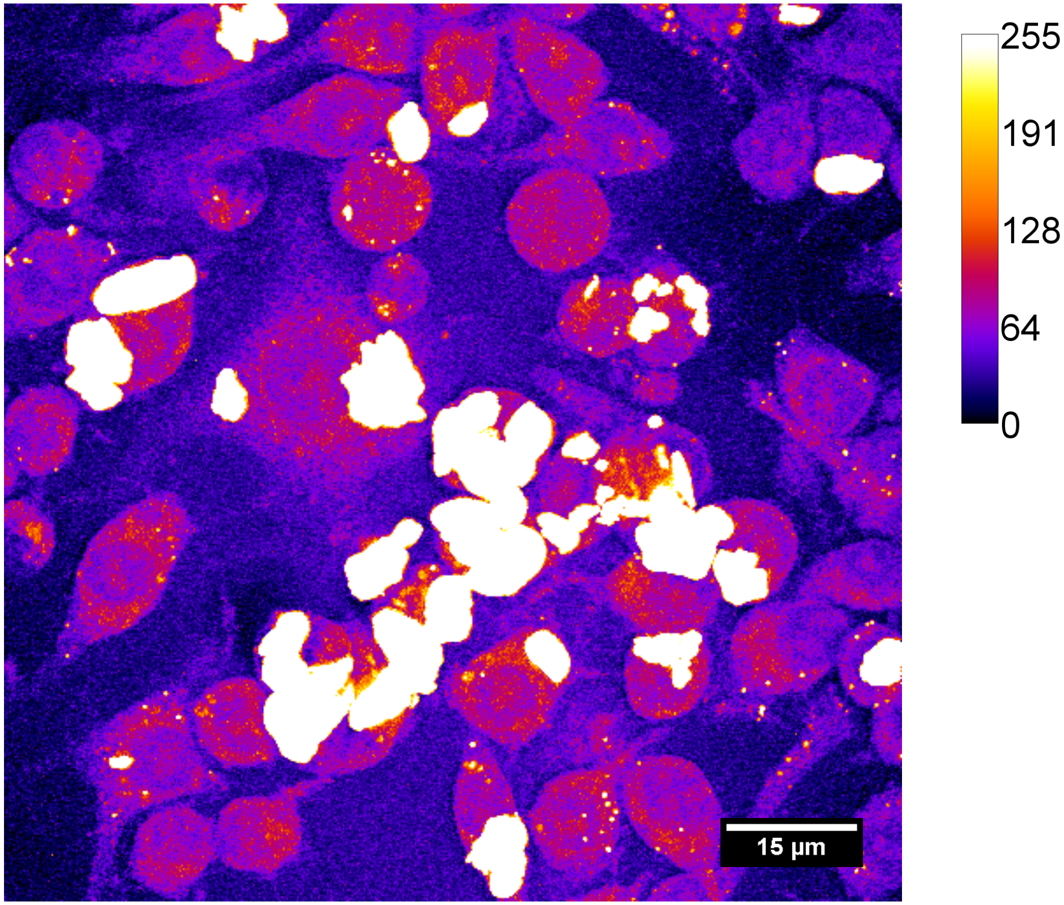


Macrophage Cells



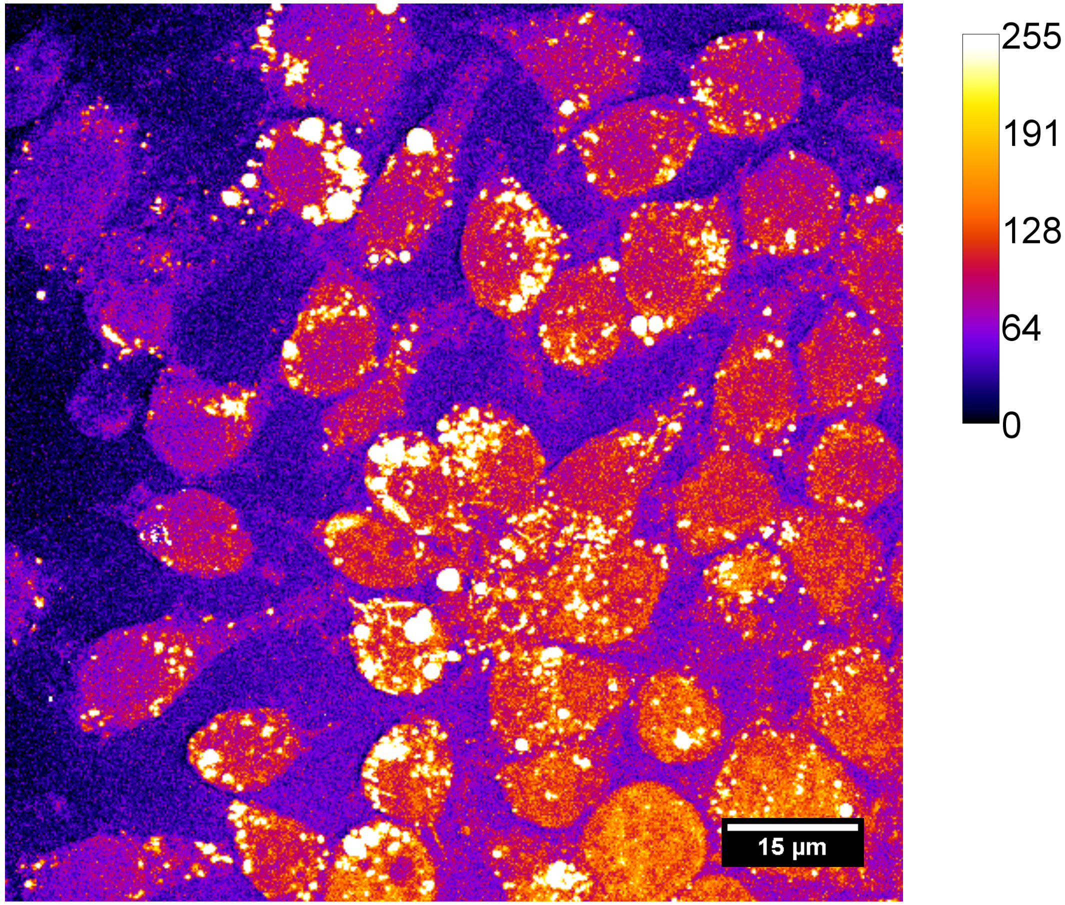
THE UNIVERSITY *of* EDINBURGH

Micronised Polyethylene



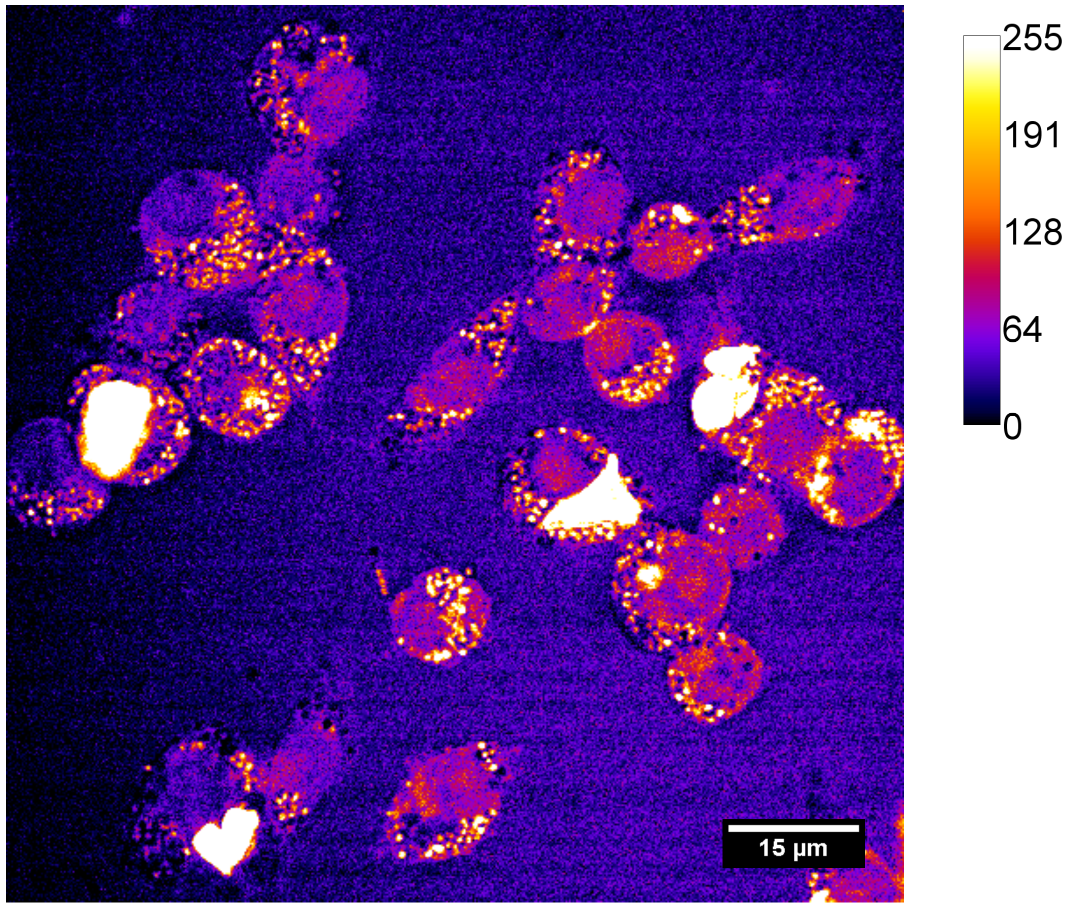
THE UNIVERSITY *of* EDINBURGH

Wear Simulator Debris



THE UNIVERSITY of EDINBURGH

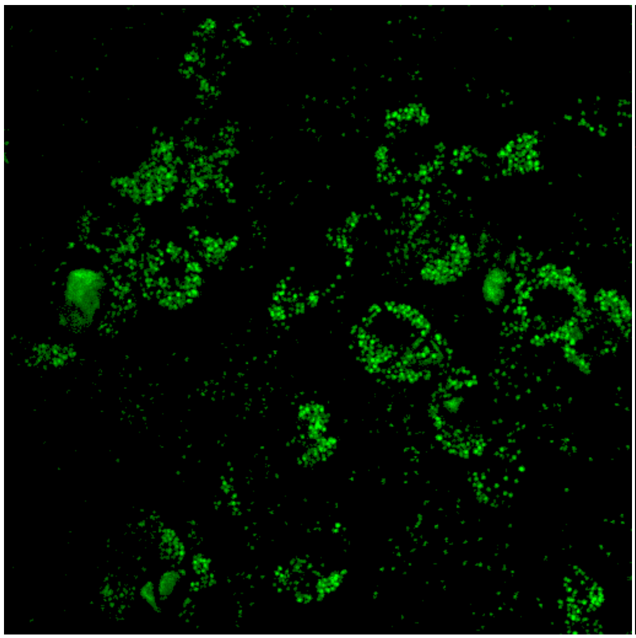
Enhancing Contrast



THE UNIVERSITY of EDINBURGH

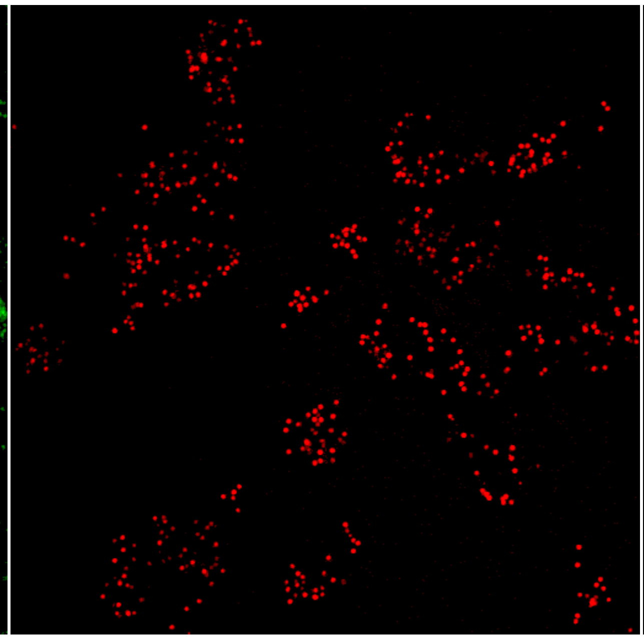
Enhancing Contrast

PMMA



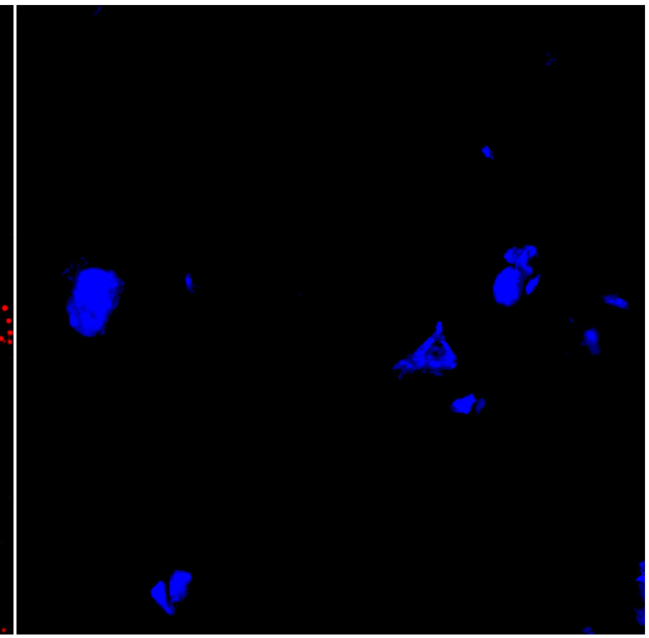
2950 cm^{-1}

Polystyrene



3060 cm^{-1}

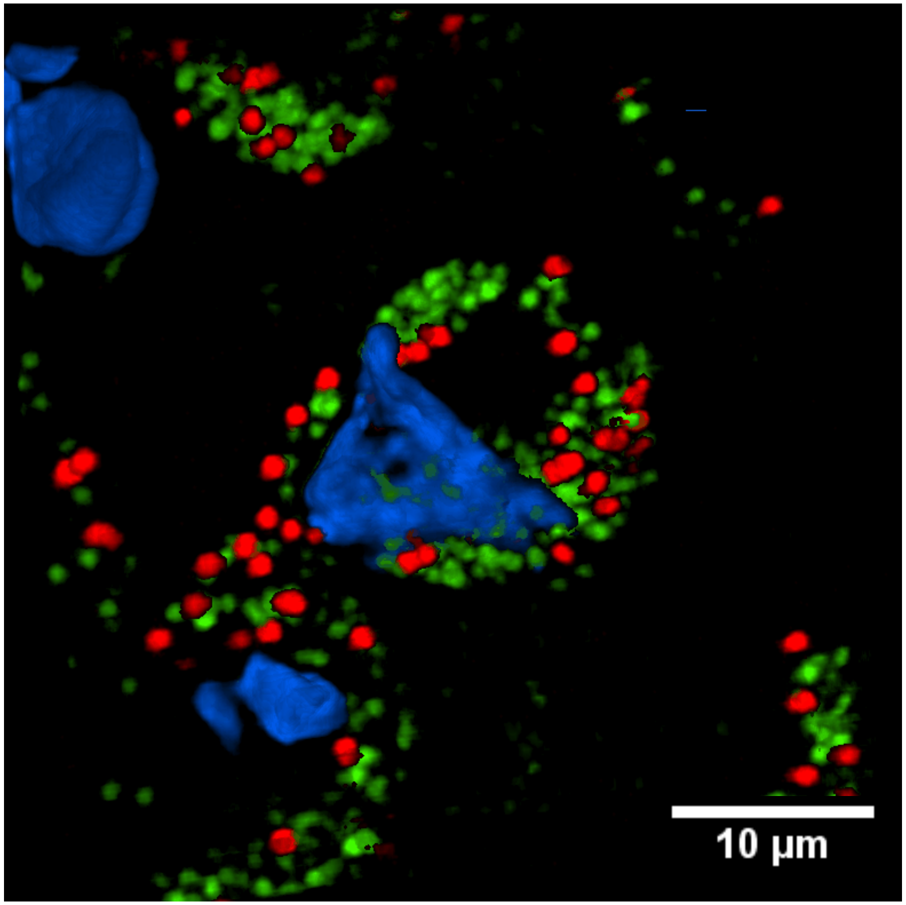
Polyethylene



2850 cm^{-1}

THE UNIVERSITY *of* EDINBURGH

3D Imaging



THE UNIVERSITY *of* EDINBURGH

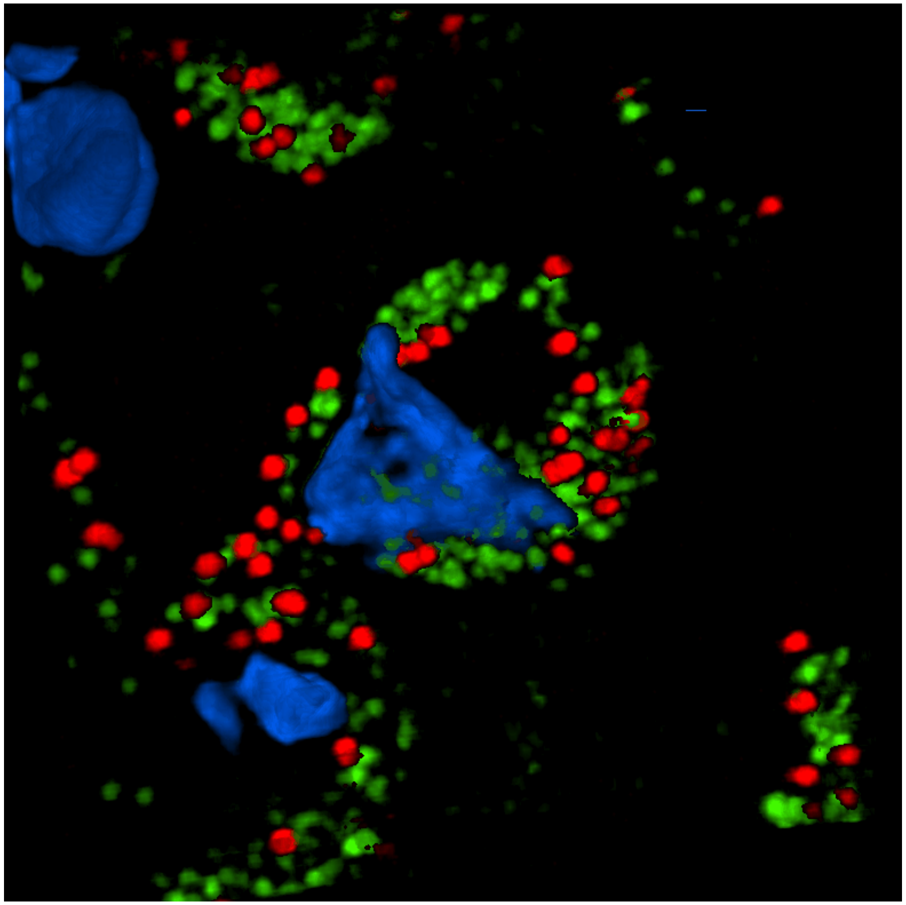
Conclusions

- label free imaging of polyethylene and more
- fast image acquisition on live cells
- good spatial resolution

- improve chemical identity
- work on tissues

Thanks

Engineering and Physical Sciences Research Council



Dr. Alistair Elfick
Vlastimil Srsen

martin.lee@ed.ac.uk
alistair.elfick@ed.ac.uk

THE UNIVERSITY *of* EDINBURGH