QUANTIC

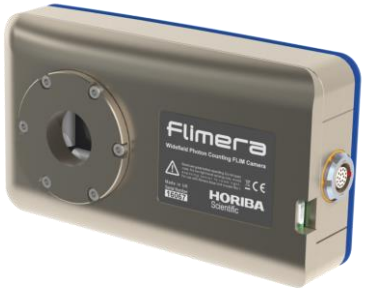
Prof Miles Padgett FRS

DEVELOPING QUANTUM IMAGING TECHNOLOGIES

UK NATIONAL QUANTUM TECHNOLOGIES PROGRAMME


Chromacity
NPL
National Physical Laboratory
TOSHIBA
HORIBA
Scientific
PHOTON FORCE
QLM
PXYL
MIRA TECHNOLOGY PARK
THz
TERAHERTZ
GSS
Gas Sensing Solutions
THALES
bp
JAGUAR
LAND ROVER
LEONARDO
M SQUARED
[dstl]
Fraunhofer UK
QinetiQ
covesion
BAE SYSTEMS
INSPIRED WORK
Gooch & Housego
CLYDE SPACE
ARALIA
IDQ
AIRBUS
optos
e2v
kromek
detect image identify
ipgroup
COMPOUND SEMICONDUCTOR TECHNOLOGIES
CATAPULT
Compound Semiconductor Applications
THE UNIVERSITY of EDINBURGH
University of Glasgow
HERIOT WATT UNIVERSITY
University of Strathclyde Glasgow
University of BRISTOL
Imperial College London
UNIVERSITY OF EXETER
UNIVERSITY OF Southampton

New Products in Collaboration with our Partners



HORIBA Scientific

Sequestim

QLM

PHOTON FORCE

THORLABS

Raycal

How can Quantum Improve Imaging?

Quantum Technology Cameras
Photon Detection

Gated intensified Cameras
- QE ≈ 10%
– $\Delta t \approx 1nS$
- False +ve ≈0.001

Electron Multiplying CCD
- QE ≈ 80%
- Video frame rate
- False +ve ≈0.01

OXFORD INSTRUMENTS | ANDOR

Quantum Technology Cameras
Photon Counting

CMOS camera
- Counts the number of photons in each pixel!

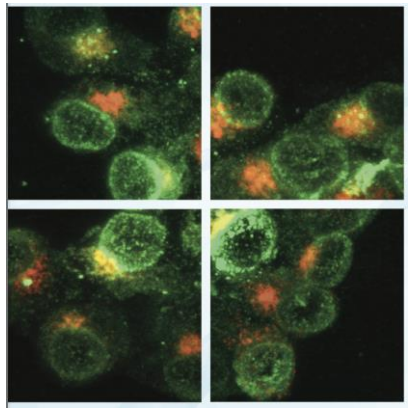
HAMAMATSU
PHOTON IS OUR BUSINESS

Quantum Technology Cameras
Photon Timing

PHOTON FORCE

HORIBA Scientific

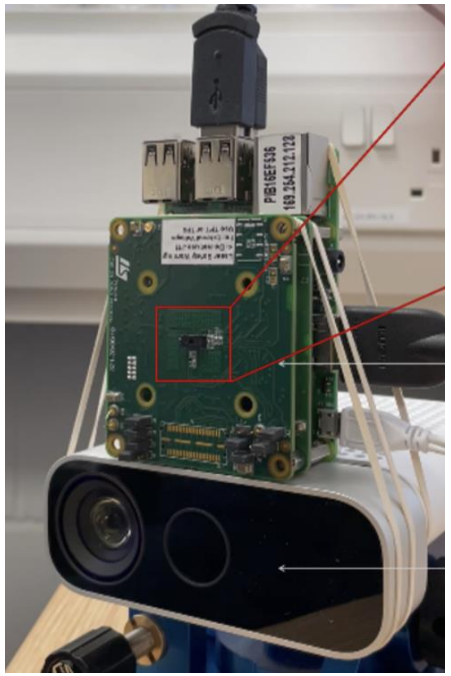
SPAD Cameras
- Measures the arrival time of the first photon at each pixel

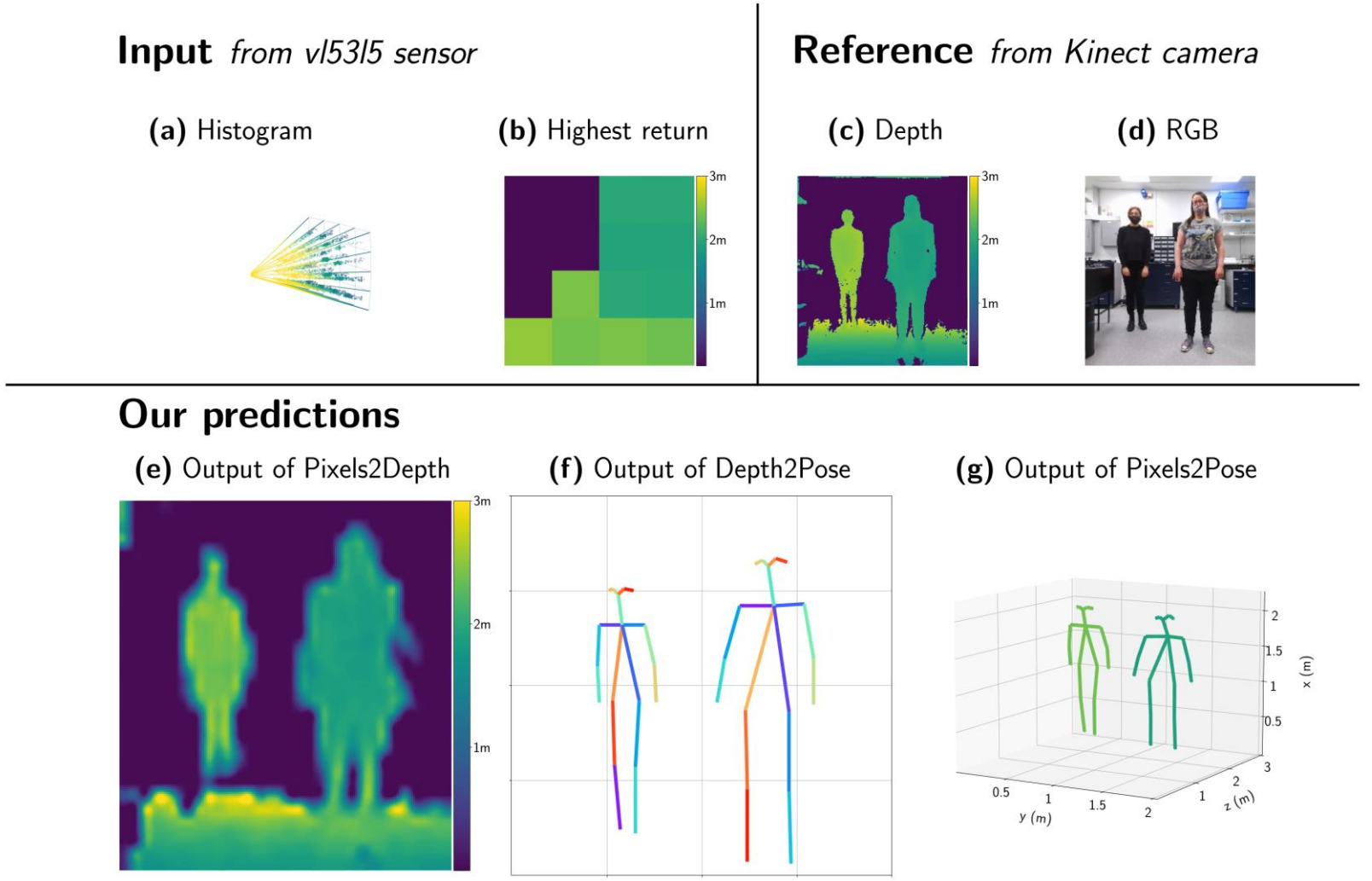


Fluorescence lifetime imaging

Pose estimation from low res data

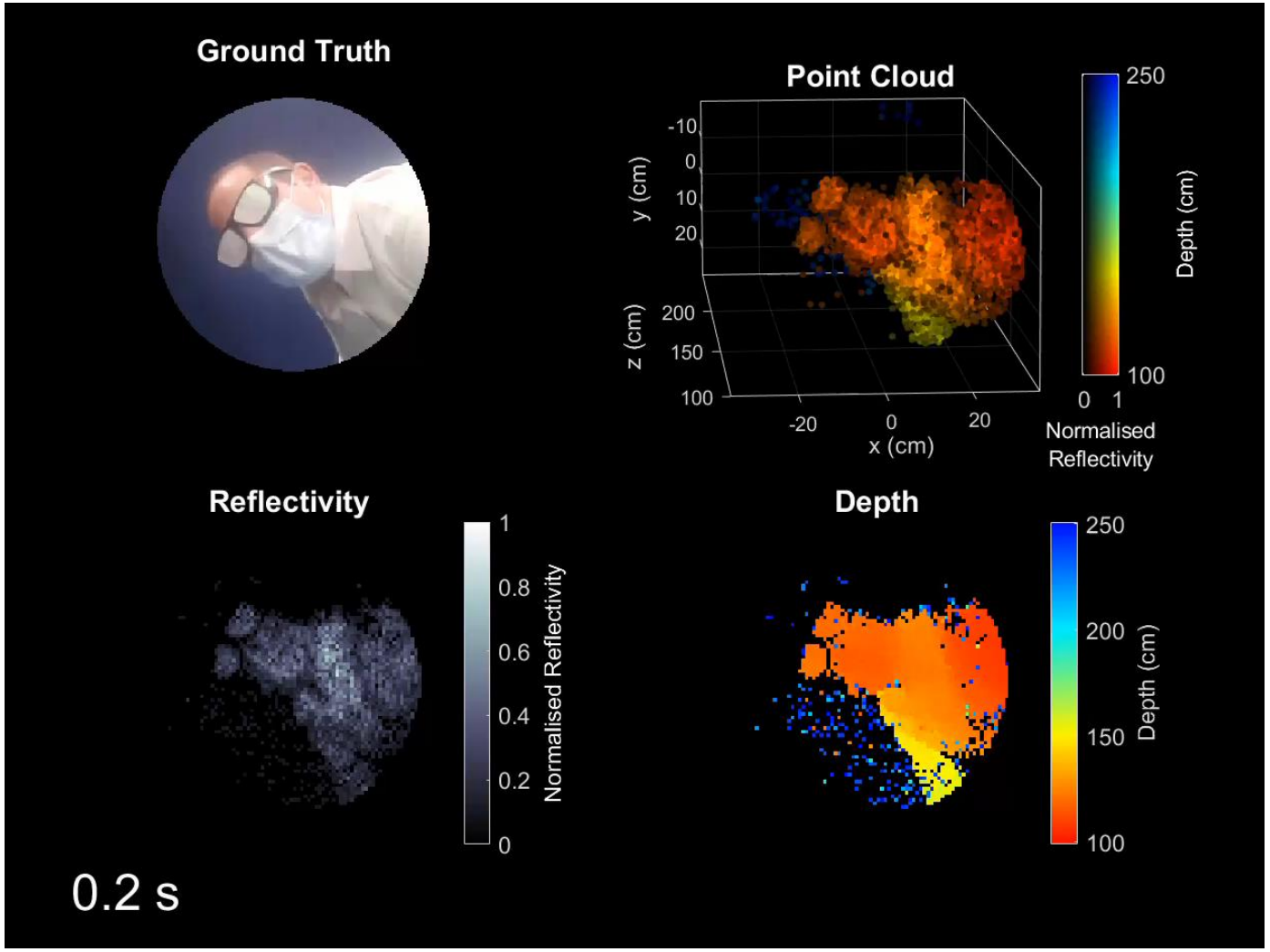
Dr Jonathan Leach

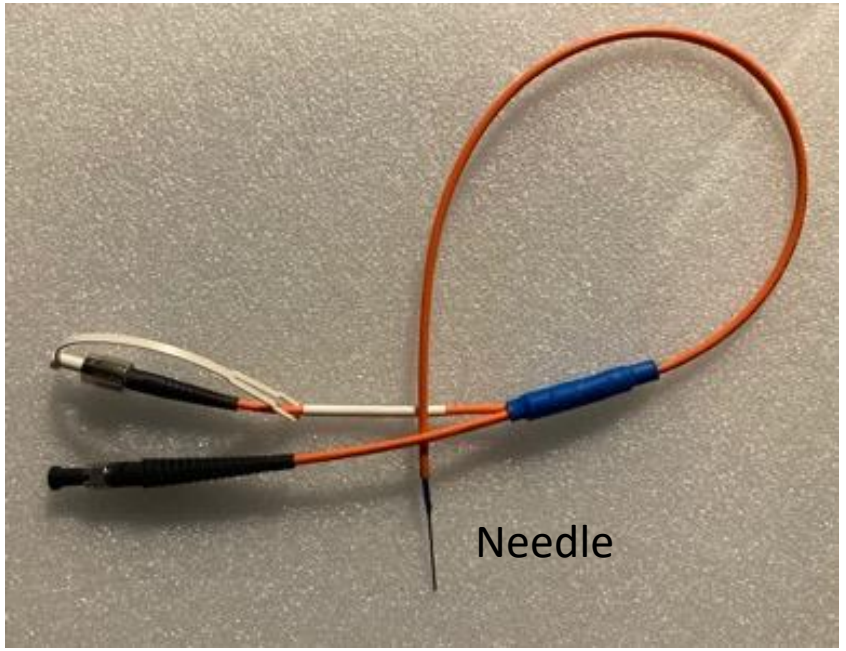


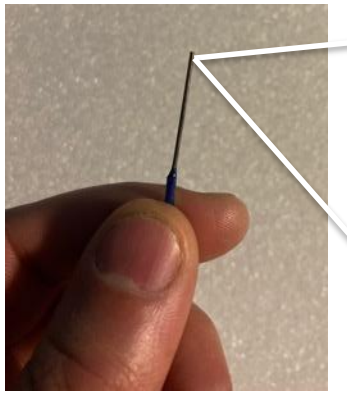


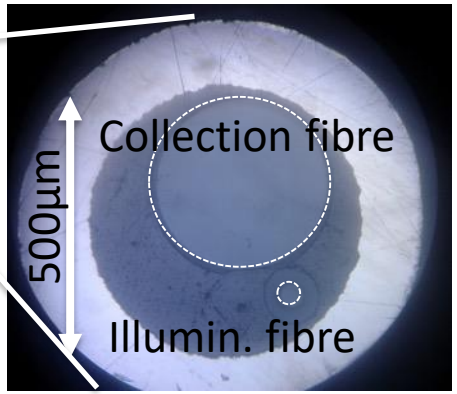
An endoscope the width of a human hair

Prof. Miles Padgett and Dr Simon Mekhail





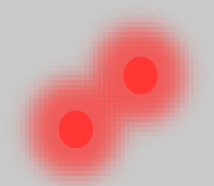





1 x 355 nm UV photon in
(Quantum) Parametric Down-conversion
One photon in two out!
2 x 710 nm infrared photons out

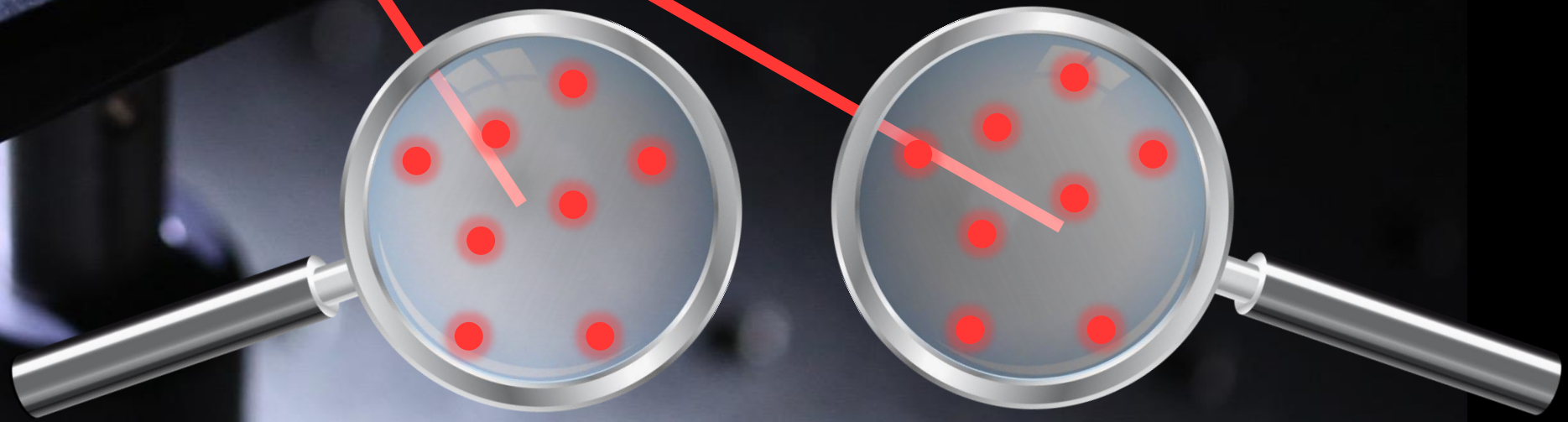
Taking a closer look

Entangled Photons



Correlated in their positions
Anti-correlated in their transverse momenta

These two image patterns are the ≈same

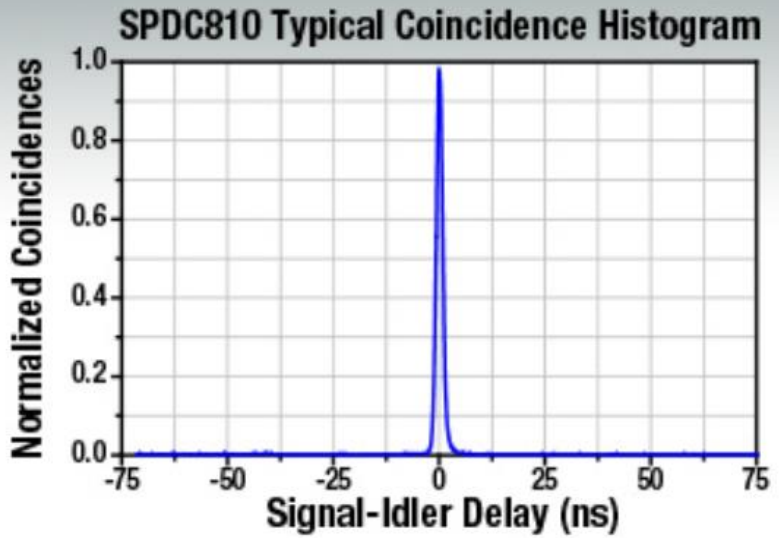


Quantum Source

Prof Jonathan Matthews

- Heralded Single-Photon Source with $g^{(2)}(\tau = 0) < 0.1$
- Photon-Pair Generation at 810 nm
- Integrated 405 nm Pump Laser

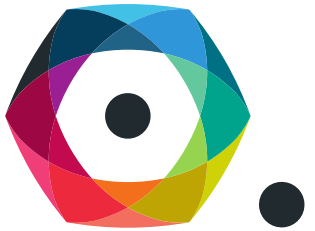
SPDC810
Correlated Photon-Pair Source



A second-order correlation measurement [$g^{(2)}(\tau)$] between signal and idler photons. The peak at $\tau = 0$ confirms the generation of photon pairs. Data is taken at 35 mW.

THORLABS

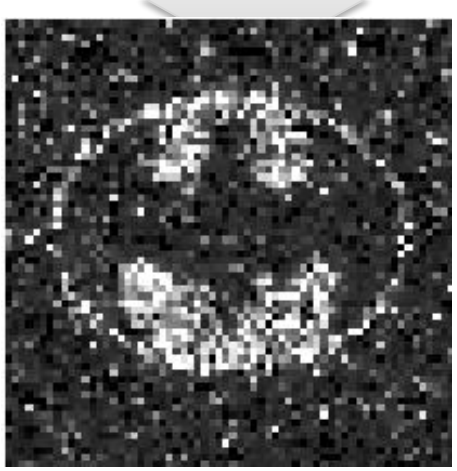
How can correlation be used ?



- Correlation in:
  - Time
  - Energy
  - Position
  - Momentum
  - Polarisation

Correlation in Time

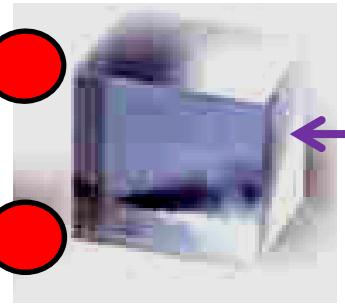
Free running Image



Gated Image

Gated Intensified Camera
(single photon sensitive)

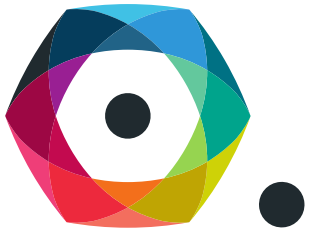
Thermal Light



Down-conversion source

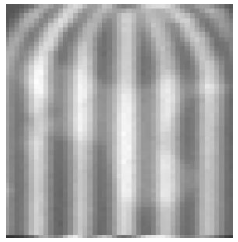
Single photon Detector (SPAD)

Correlation in Position

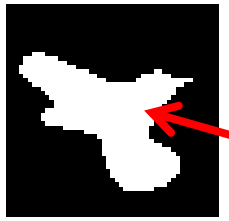


EMCCD Camera
(single photon sensitive)

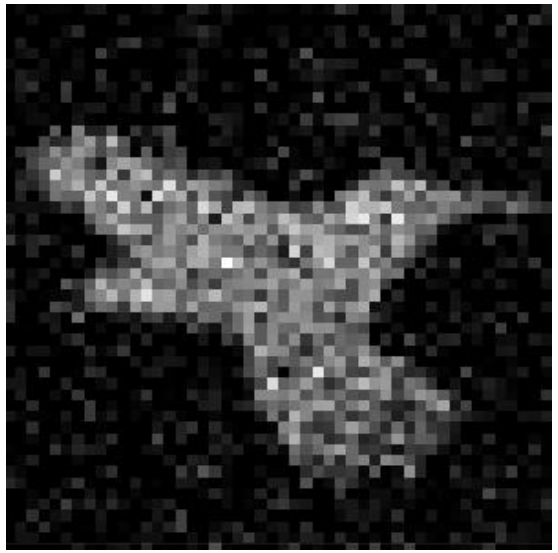
Quantum +
classical image

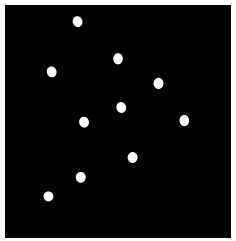


Thermal Light

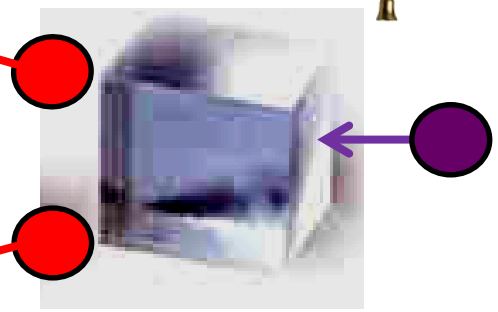


Quantum Image





Quantum
Reference Image

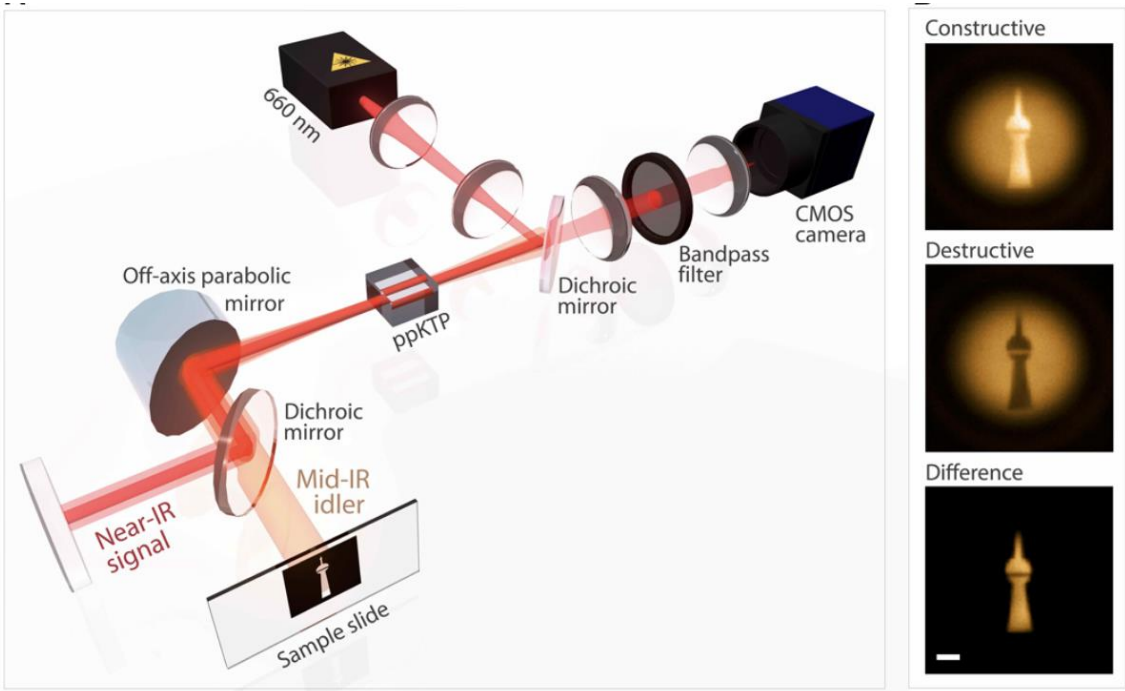


Down-conversion source

Beyond Correlation: Imaging with Undetected Photons

Imaging with undetected photons (illuminate sample in the infra-red but record the image in the visible)

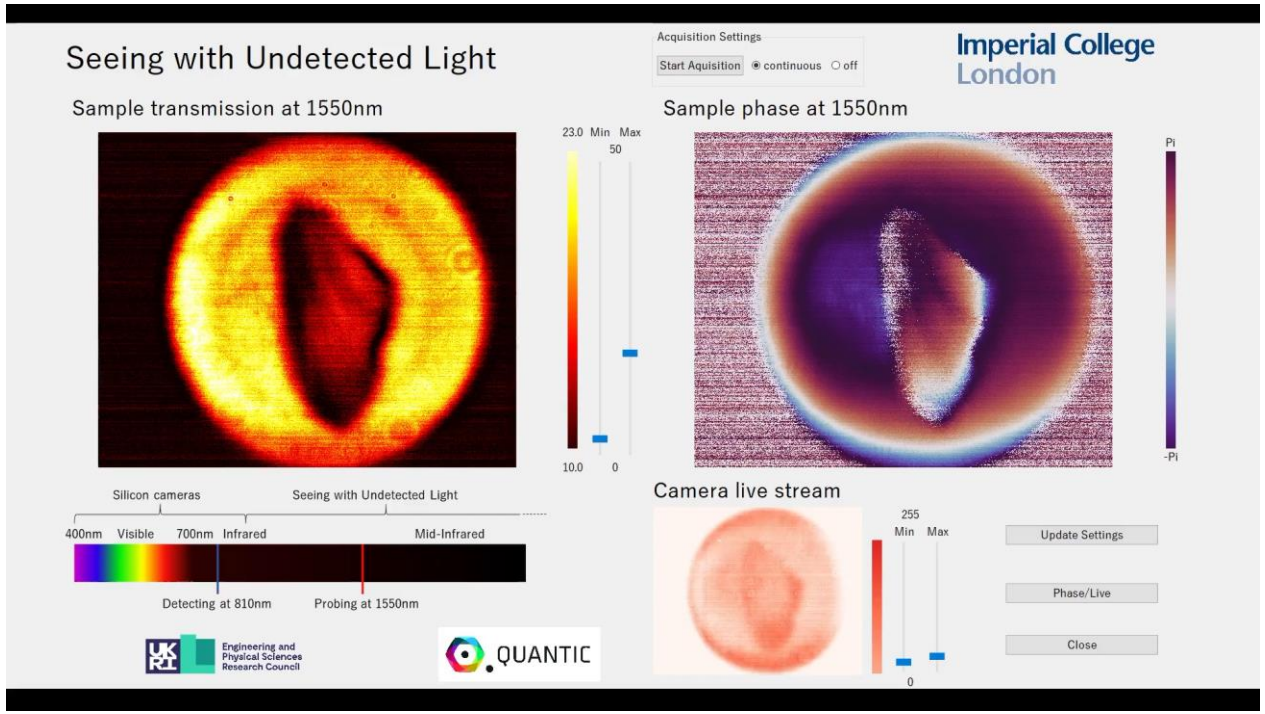
- Zeilinger and co-workers (2014)
- Ramelow and co-workers (2020)
- Phillips and co-workers (2022)
- Fraunhofer (here in the hall) (inc. FTIR!±)

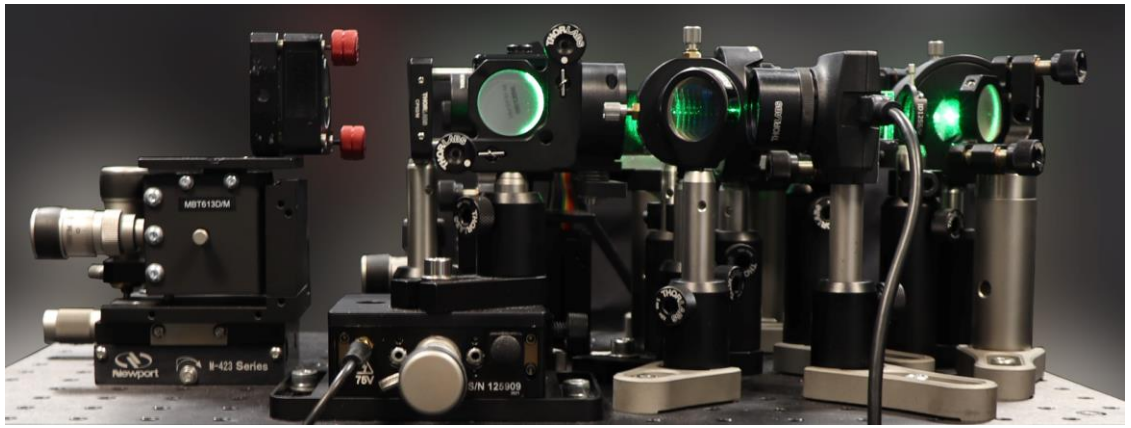


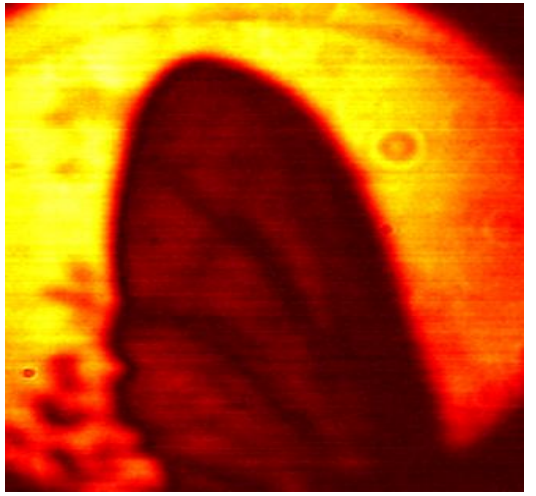
Imperial College London

Imaging without detection

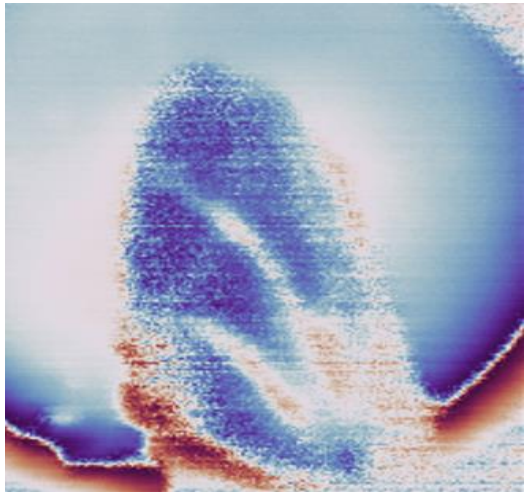
Prof. Chris Phillips and Dr Alex Clark







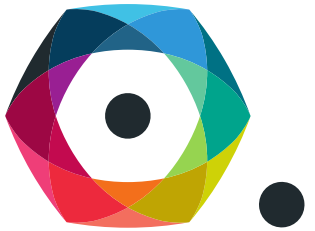
IR Transmission



IR Phase

A compact nonlinear interferometer for infrared imaging while only detecting visible light with 532 nm pump laser, 700 - 820 nm signal photons and 1.5 - 2.5 µm idler photons.

Summary



- Quantum technology Cameras
  - Count and time individual photons
- Quantum (correlated) light sources
  - Correlations between individual photons (≈ perfect reference)
- Beyond correlations
  - Illuminating with undetected photon