A SNAPSHOT OF SINGLE PHOTON APPLICATIONS

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Fraunhofer CAP's current status and positioning

- Fraunhofer UK/CAP founded in 2012 as an IRTO partnered with University of Strathclyde and Fraunhofer IAF
- *'Laser and Laser Systems'* Business Unit

  'Quantum Technology' Business Unit
  - Scientific lasers for sensing, imaging, metrology, comms…
- **106 funded company partners** from SMEs to multi-nationals
- Prominent position in Quantum Technology, LIDAR and stand-off chemical and environmental sensing

Industry (UK)

Fraunhofer CAP

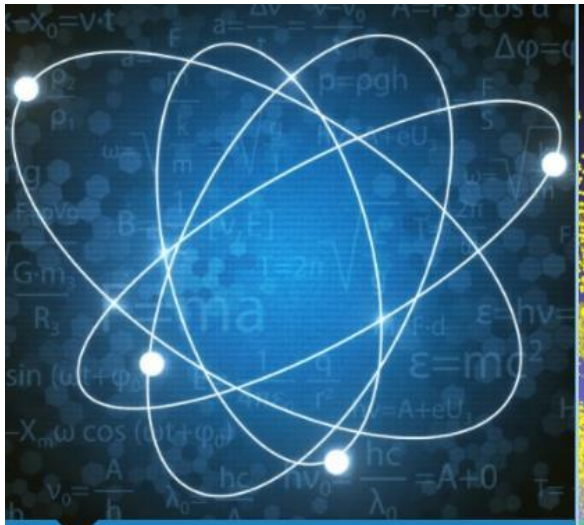
Professional R&D services for industry

University

University of Strathclyde Glasgow

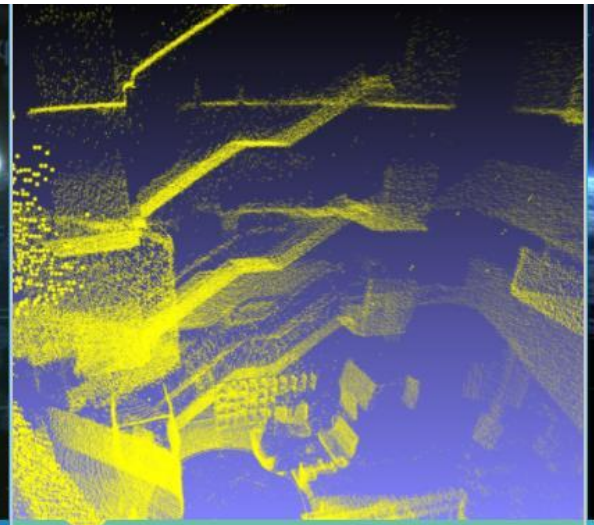
INSTITUTE OF PHOTONICS

Quantum technology themes



Quantum Sensing

- 28 projects
- Atom sensors
- Clocks

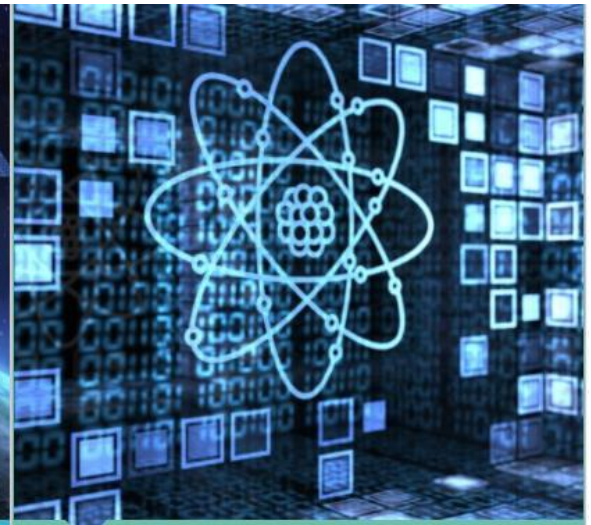


Quantum imaging LiDAR and spectroscopy

- 13 projects
- Time-gated SPADs
- Spectroscopy

Quantum Communications

- 9 projects
- QKD links
- QKD components

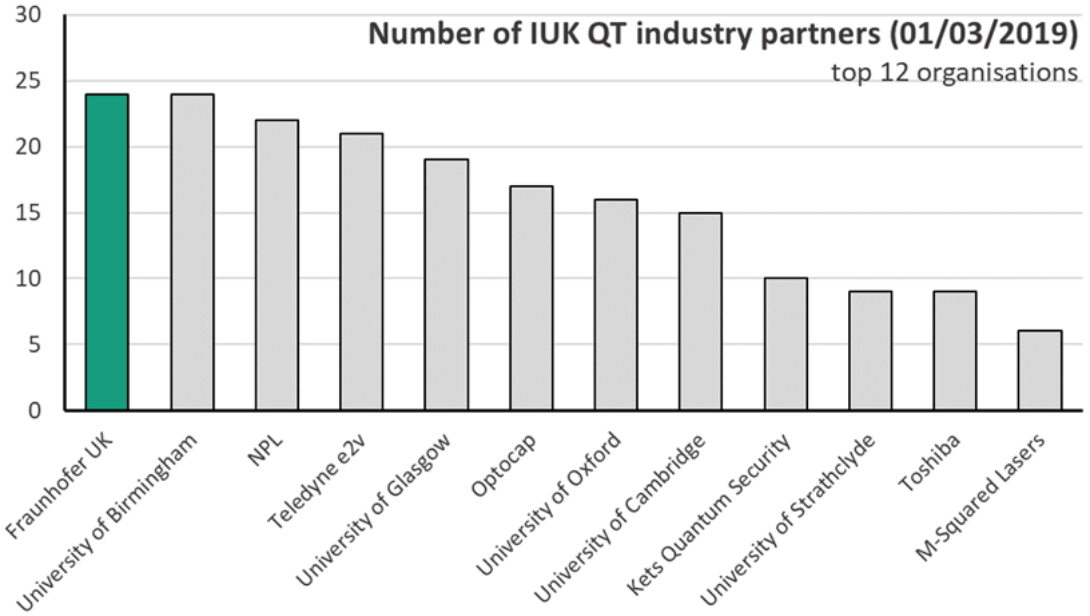


Quantum Computing

- 8 projects
- Trapped-ions
- NV Centres
- Photonics approach

Positioning in QT

- Fh-CAP supports a wide range of industry partners
  - Introducing new industry into IUK programme
- Fh-CAP participates in 30% of the IUK QT programme
- Fh-CAP secured a 6% share of the IUK QT funding
- Diversifying portfolio of funding sources

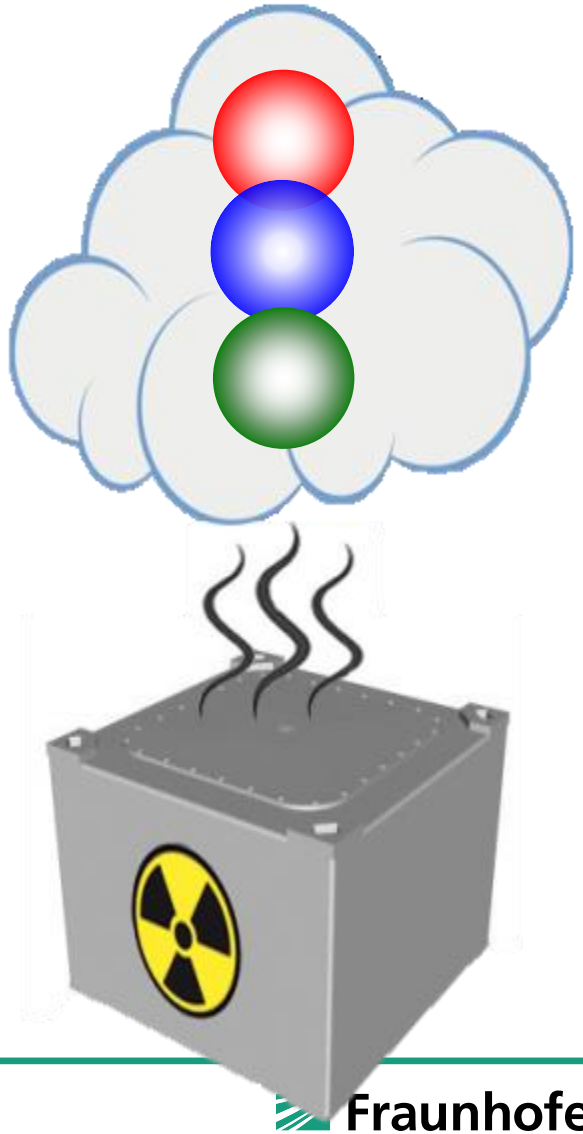


Single photon detection for time-gated Raman Spectroscopy

PHOTON ARRIVAL TIME → **POSITION**

PHOTON COLOUR → **COMPOSITION**

PHOTON NUMBER → **CONCENTRATION**



System overview

RAMAN (10^0)

MIE (~ 10^3)

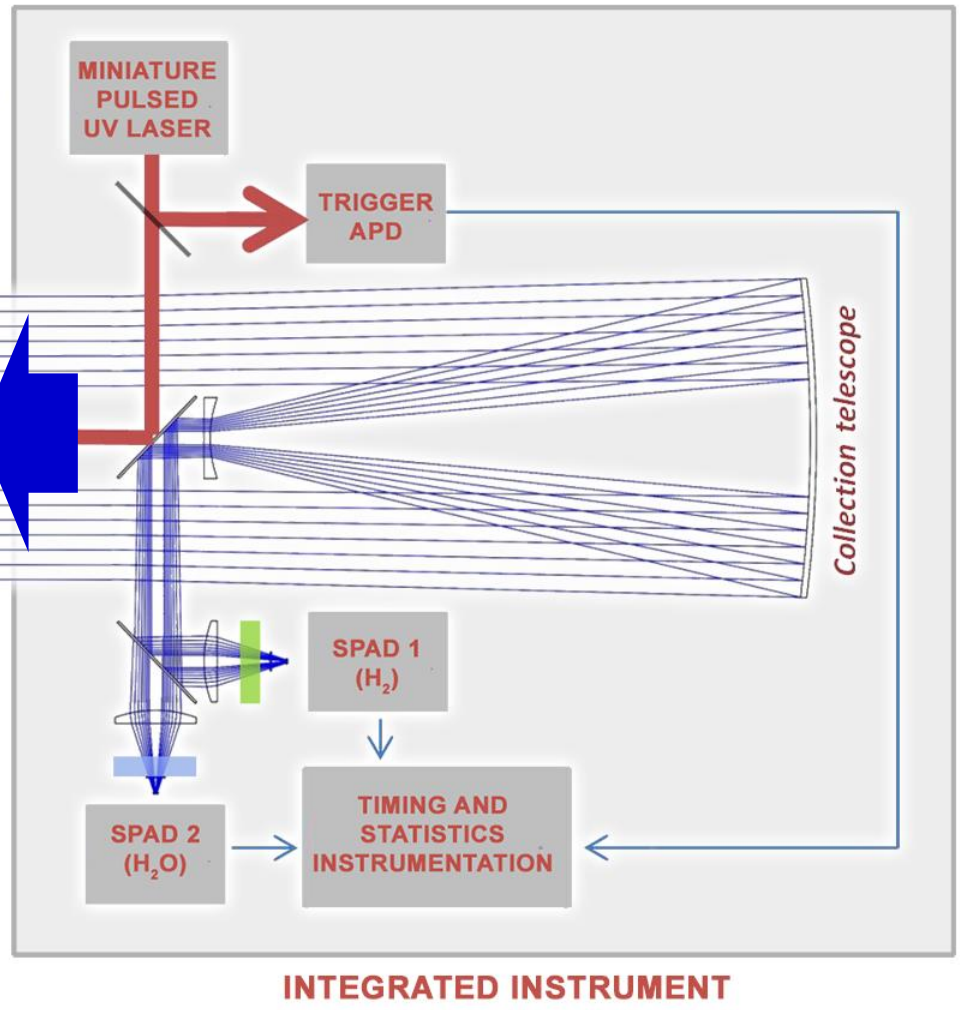
EXCITATION (~ 10^{17})

RAYLEIGH (~10^{11})

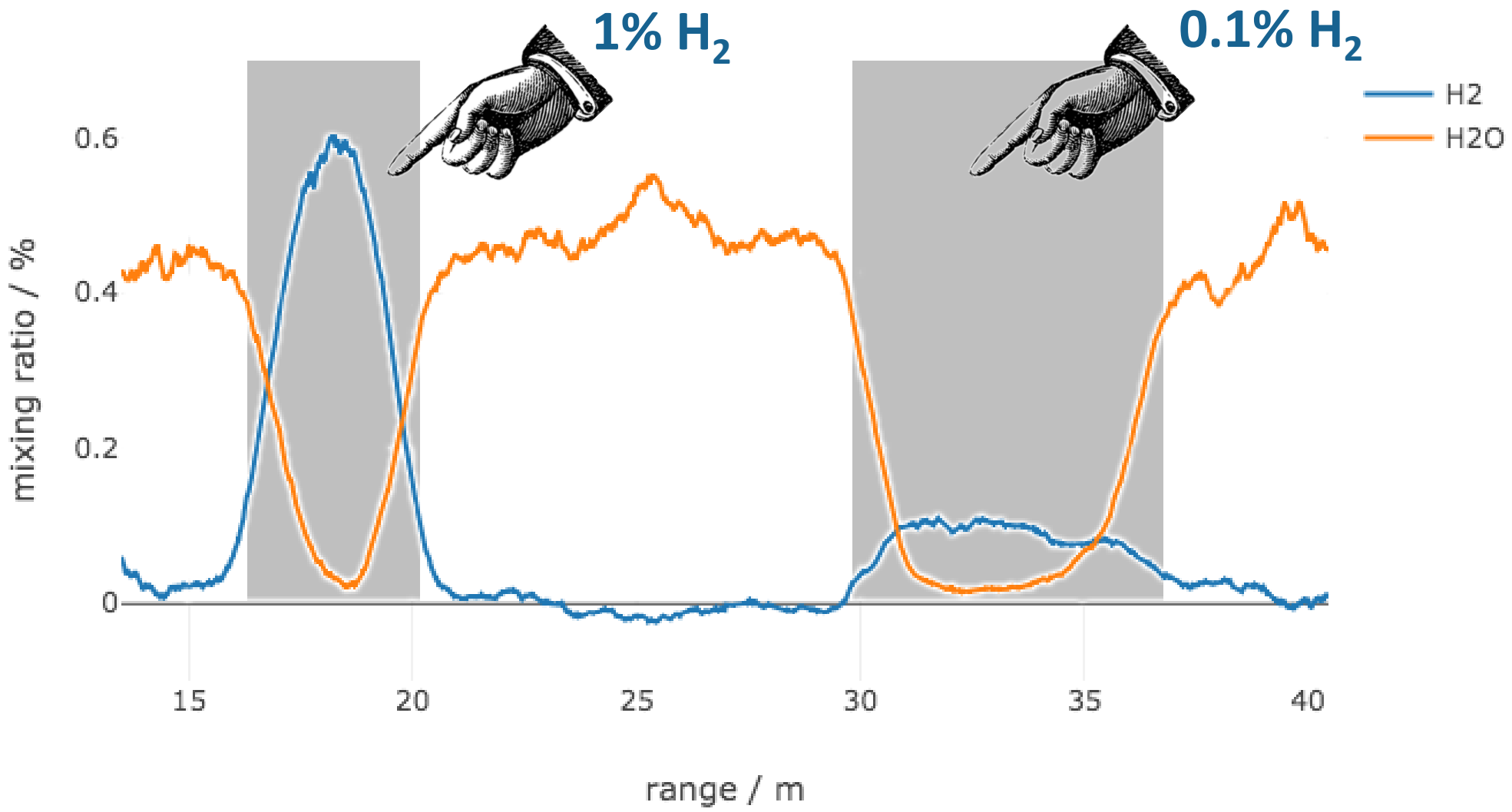
FLUORESCENCE

(Air, ~10^{-1};

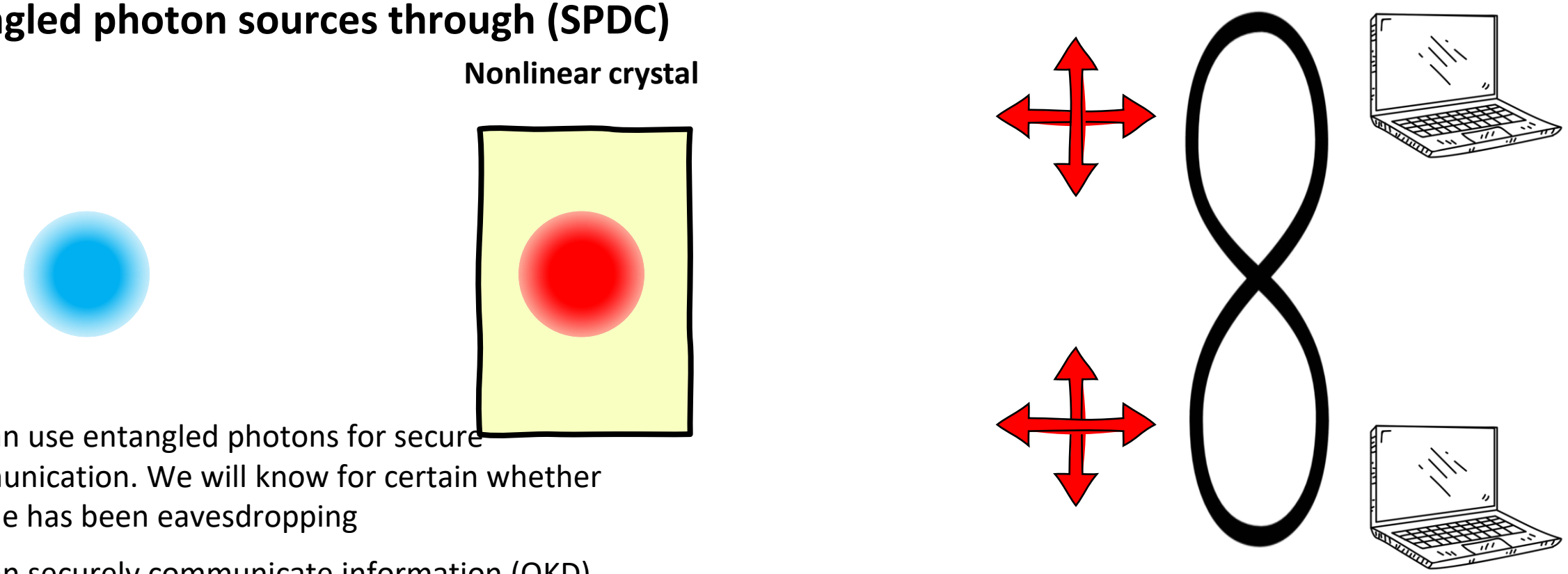
Solid, ~10^6)



‘Looking through’ high concentration clouds



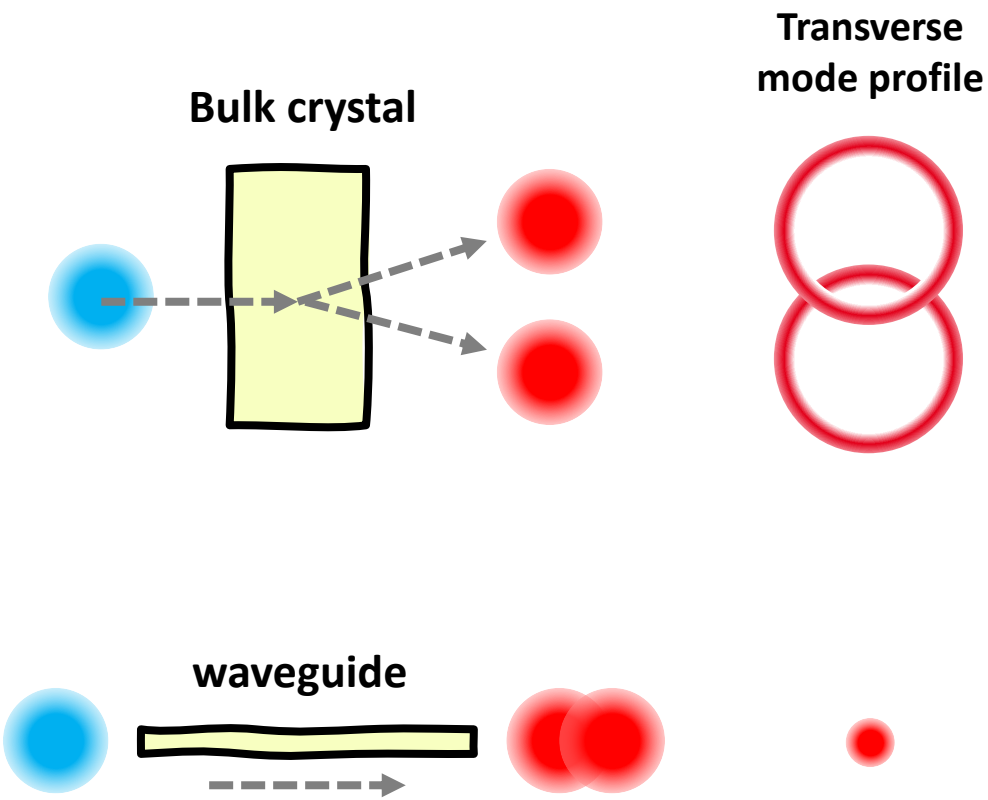
Entangled photon sources through (SPDC)



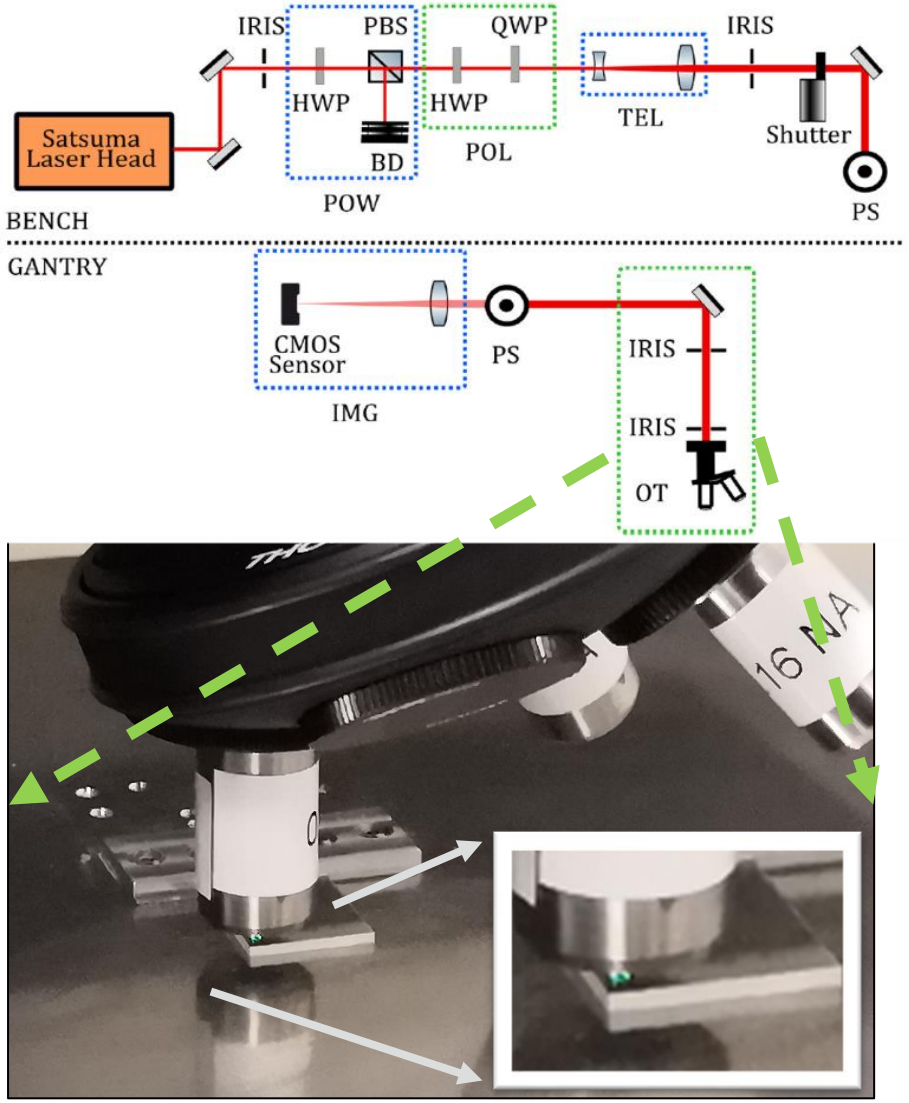
- We can use entangled photons for secure communication. We will know for certain whether anyone has been eavesdropping
- We can securely communicate information (QKD)
  - Protect critical infrastructure
  - Secure our data from decryption
- Sources also have applications in quantum imaging, sensing and lidar.

Integrated sources of quantum light

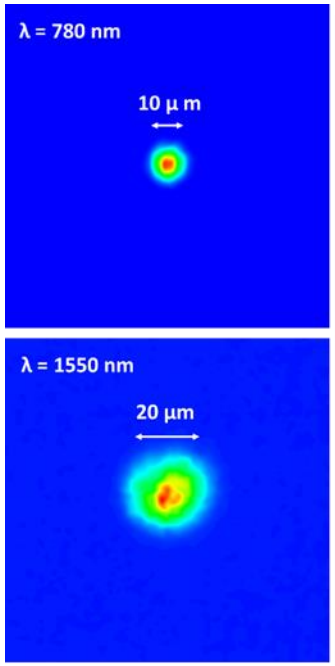
- At Fraunhofer CAP we have a number of programmes of work exploring the use of waveguide-based devices.
- The geometry enables extension of interactions length whilst maintaining high pump intensity.
- Efficient generation into single transverse mode. The collection efficiency is decoupled from the optimal focusing position.
- Possibility for further integration with fibres and lasers for compact sources. We have developed a process with optimised mode-matching to single-mode fibre.
- For high rates of secure key:
  - High pair generation rate is required.
  - low-probability of multi-photon events (e.g. mean photon number < 0.1)

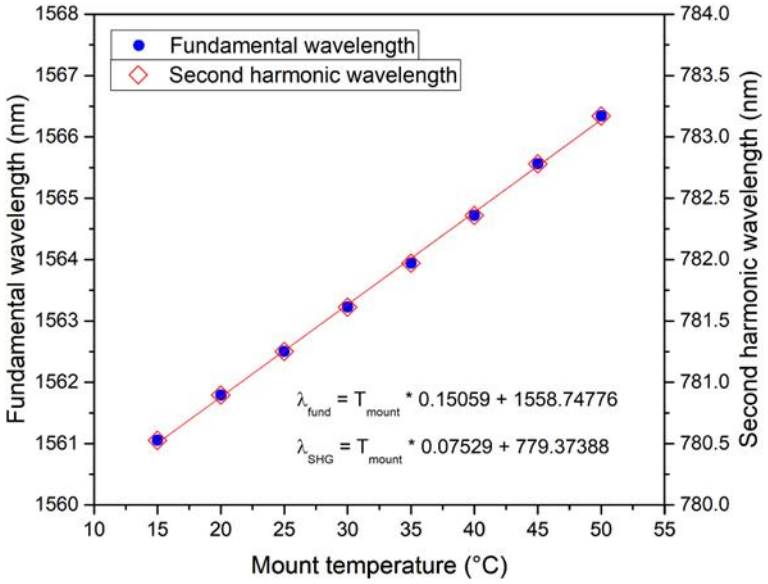


Waveguides in PPLN fabricated by ultrafast laser inscription



- Using ultrafast laser inscription (ULI) we can write low-loss waveguide buried in transparent materials
- We have fabricated waveguides in PPLN that are single-mode at 780 nm and 1560 nm.
- We have confirmed the nonlinear efficiency and phase matching conditions through second-harmonic generation





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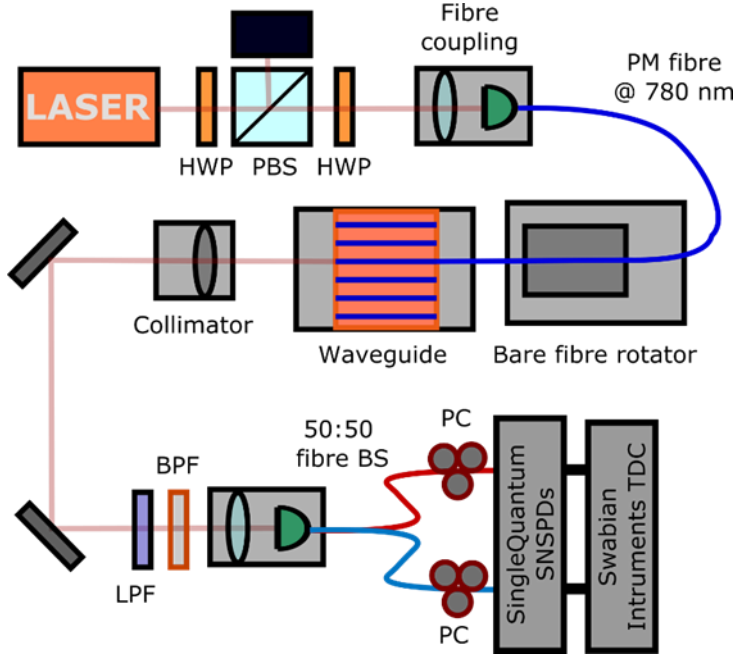
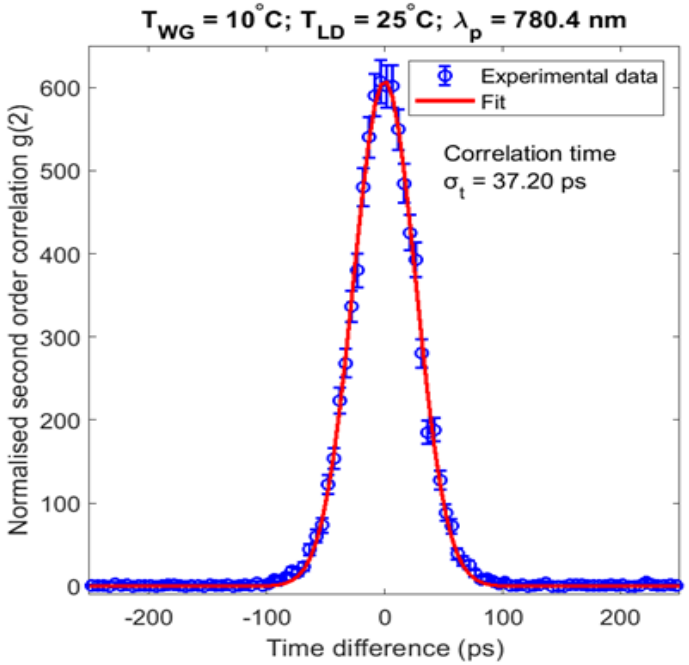
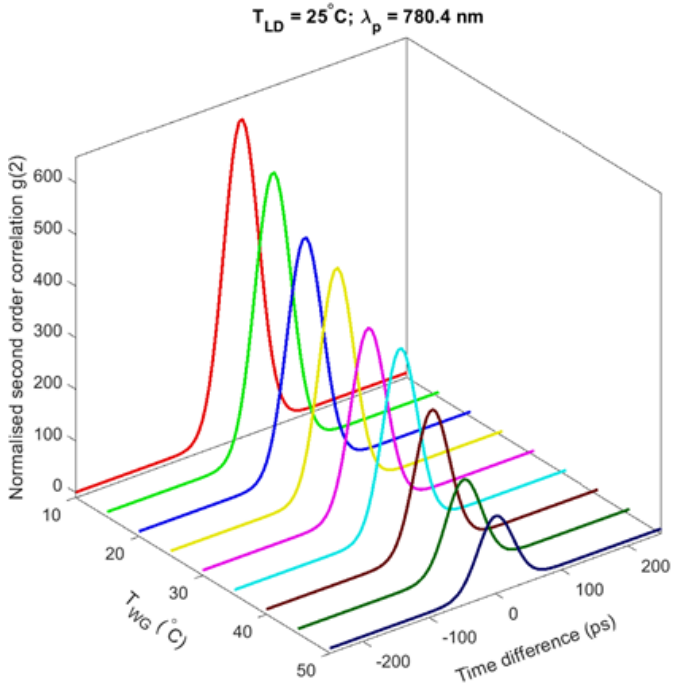
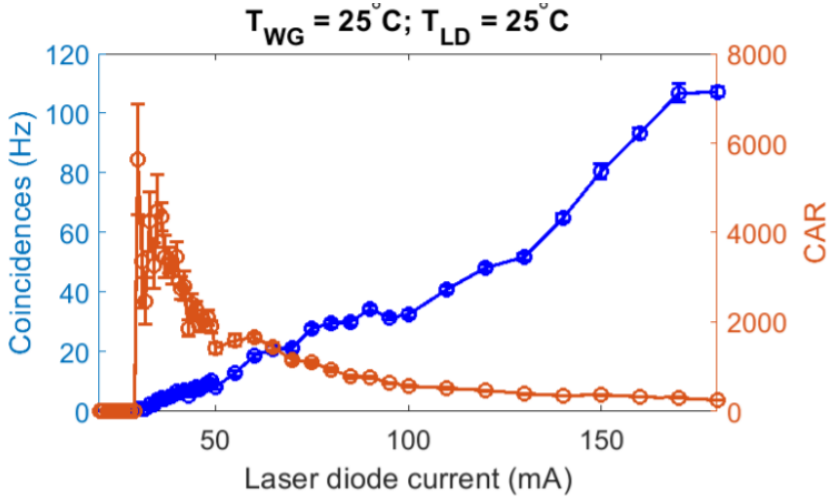
Spontaneous parametric downconversion tests

- Pumping the waveguides with 780 nm light we have demonstrated spontaneous parametric down-converion to 1560 nm
- Using superconducting nanowire detectors we have been able to characterise coincidence to accidental ratios and heralding efficiencies.









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