Chromacity

Discover more

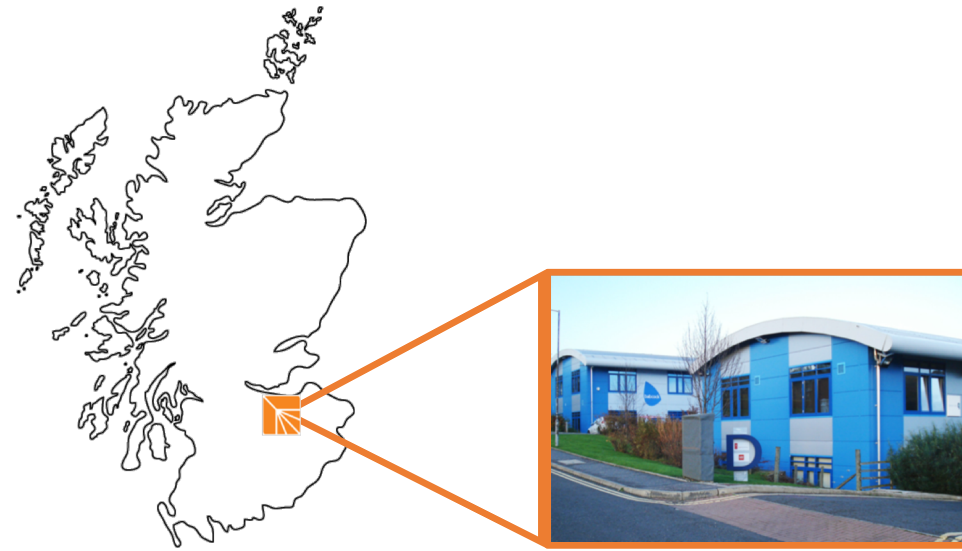
Ytterbium Based Lasers Sources And OPOs For Quantum Technologies: Latest Capabilities

Dr Christopher G. Leburn, Founder & Director

Rochester Institute of Technology
Photonics for Quantum – 23rd January 2019

Chromacity – Introduction

- Founded in 2013, based in Edinburgh, Scotland.
- Venture capital backed.
- Chromacity design and manufacture ultrafast lasers for industrial and fundamental research markets.
- Recognised leaders in innovation in near and mid infra-red laser development.
- Specialize in Optical Parametric Oscillator (OPO) designs.
- Technical capability to design and build custom lasers that operate at unusual wavelengths.
- Patented Technology



Chromacity – Product Range

Ytterbium fibre-based ultrafast laser delivering > 2.5 W output at 1040 nm with 100 MHz repetition rate.

Chromacity 1040 ultrafast laser source
New Product Launch – Chromacity 520 femtosecond laser

The Chromacity OPO and FIR deliver light across the near and mid-IR (1.4 μm - 12 μm).

Chromacity OPO 1.4 – 4.2 μm
Chromacity FIR 5-12 μm
Both pumped by an integrated Chromacity 1040

Ultrafast laser delivering up to 50 mW output at 1280 nm with 100 MHz repetition rate

Ultrashort pulse generation at 1280nm
Semiconductor fault analysis

Chromacity 1040

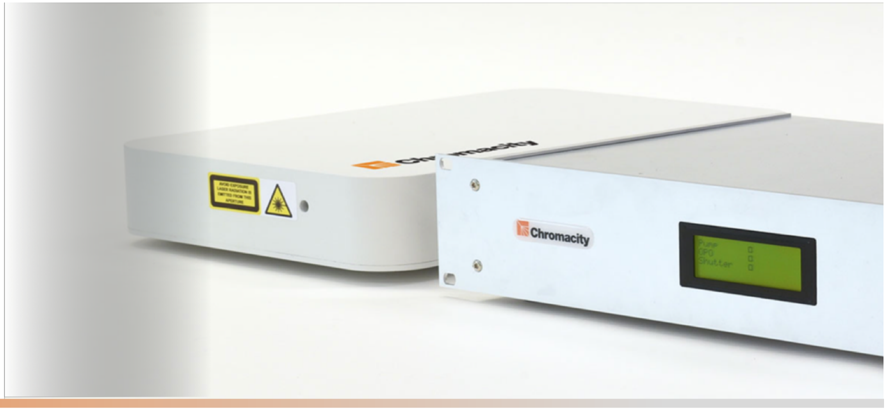
Femtosecond laser source

- Average power: > 2.5 W
- Wavelength: 1040 nm
- 15-40 nm bandwidth
- 100 MHz repetition rate.
- Pulse width factory set from 130 fs – 3 ps.
- Linearly polarized free-space output
- M^2 <1.2 with ~1 mm beam diameter

Chromacity

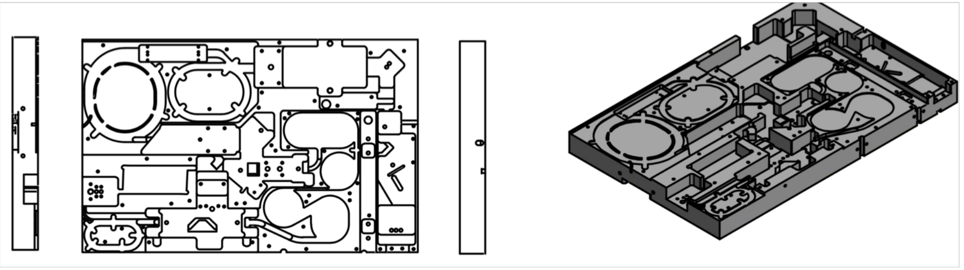
Chromacity 1040

Femtosecond laser source



- Average power: > 2.5 W
- Wavelength: 1040 nm
- 15-40 nm bandwidth
- 100 MHz repetition rate.
- Pulse width factory set from 130 fs – 3 ps.
- Linearly polarized free-space output
- M^2 <1.2 with ~1 mm beam diameter

- Part fiber, part free space
- High gain in fiber
- Ability to manage dispersion
- High efficiency (due to core IP)

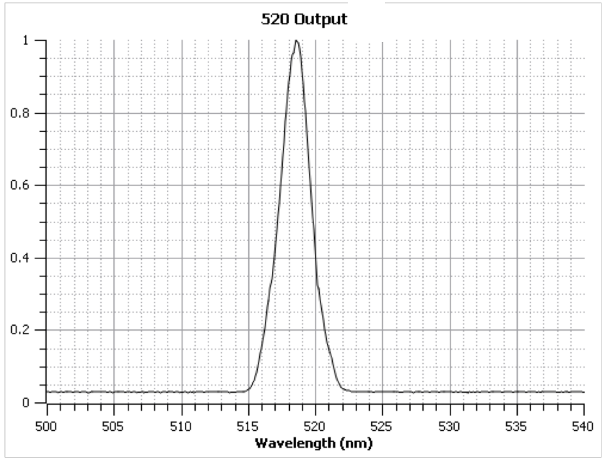


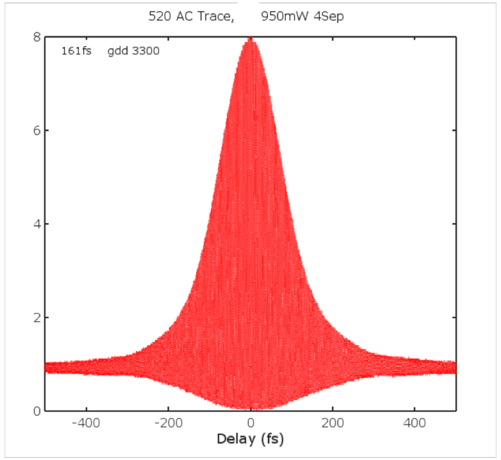
Chromacity

Chromacity 520 & THG

Femtosecond laser source

- Significant expertise in non-linear optics
- Now have a 520n nm source
- Average power of up to 1 W
- Pulse duration ~120 fs
- 100 MHz repetition rate.
- Linearly polarized free-space output
- M^2 <1.2 with ~1 mm beam diameter
- Also provides 1040 nm output





Chromacity

Chromacity 520 & THG

Femtosecond laser source

- Significant expertise in non-linear optics
- Now have a 520n nm source
- Average power of up to 1 W
- Pulse duration ~120 fs
- 100 MHz repetition rate.
- Linearly polarized free-space output
- M^2 <1.2 with ~1 mm beam diameter
- Also provides 1040 nm output

- Third harmonic generation can be provided
- Wavelength: 347 nm
- Output powers now in excess of 400 mW

Chromacity

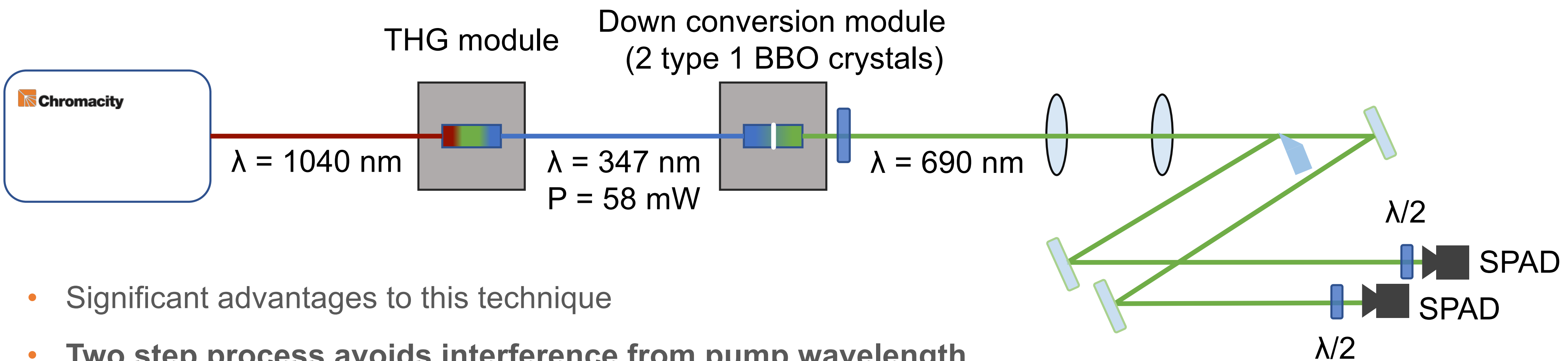
Photon pair counting

Working with Prof. Daniele Faccio

His research is pushing towards quantum imaging

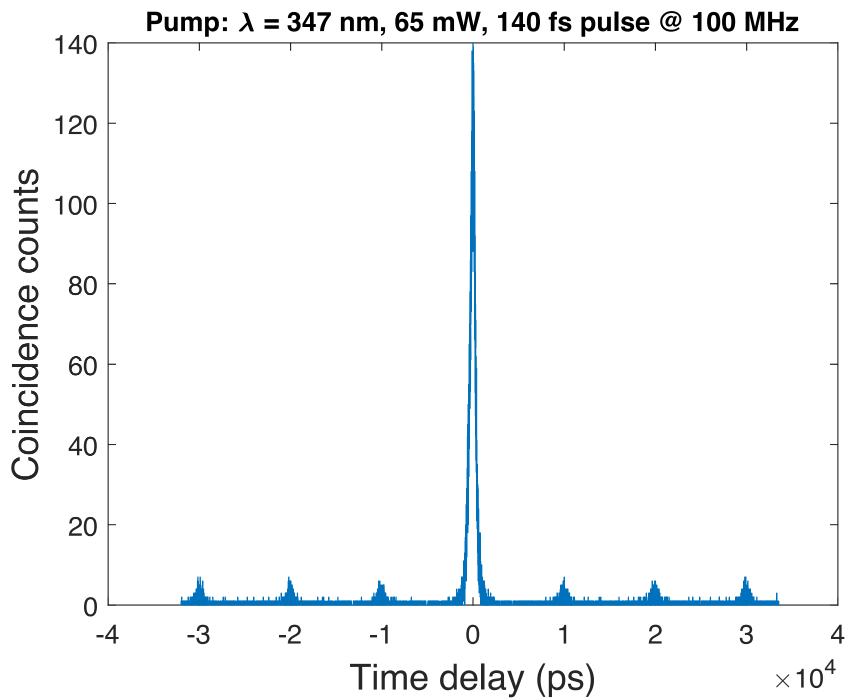
He is looking to generate entangled photons as part of his research themes

Photon pair counting



- Significant advantages to this technique
- **Two step process avoids interference from pump wavelength**
- **Peak of detection efficiency for APD is close to 690nm**

Photon pair counting



- 0 = coincidences within the same laser pulse.
- Peaks at other delays correspond to coincidences between one pulse and the next, which correspond to “accidentals”.
- The contrast between these two peaks is the “coincidence to accidentals ration” CAR.
- CAR that is of order ~100.
- Next steps – HOM measurement - to demonstrate generation of quantum signatures.

Chromacity

University of Glasgow

Generation and Detection of Down-converted Photon Pairs at 2.080 μm

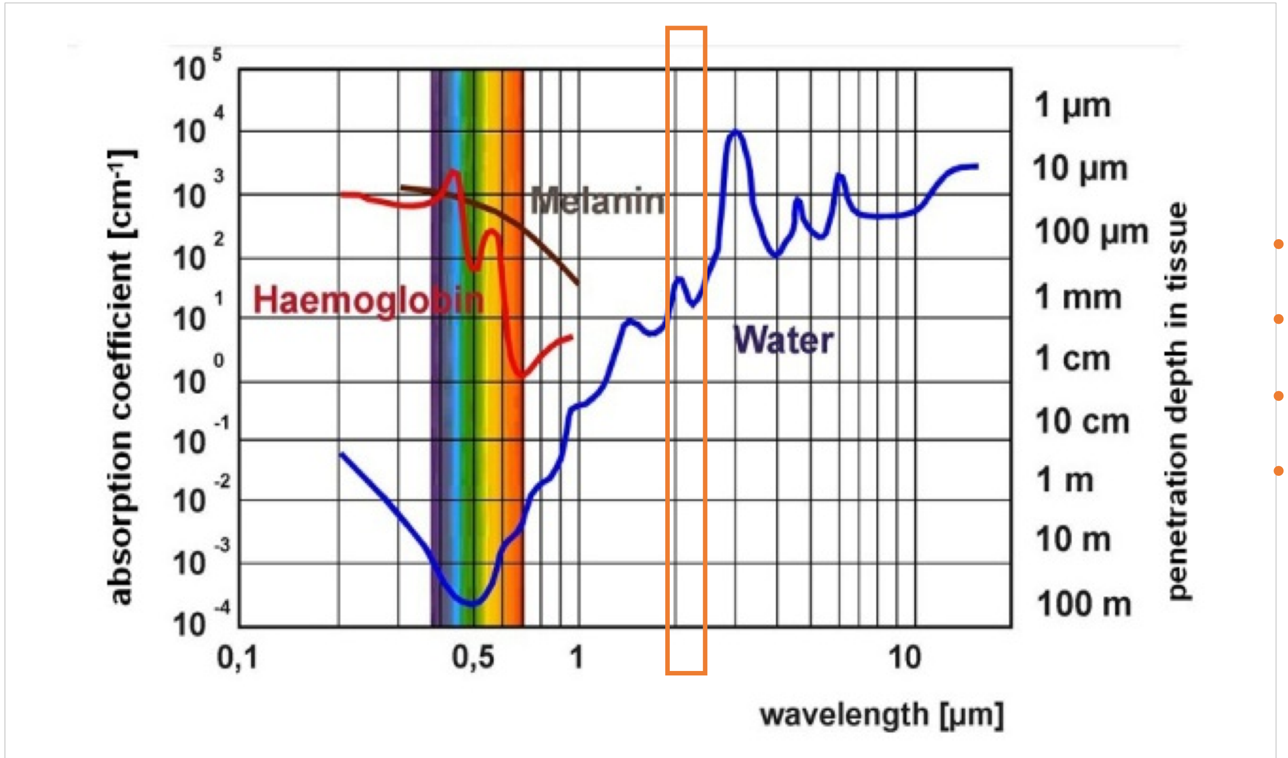
Working with Dr Matteo Clerici

His motivation revolves around the the fact that there is a strain on current radio frequency based satellite communications

Quantum optical technologies are being considered as an alternative to improve free-space communication systems

These utilise fundamental properties of quantum mechanics: indeterminacy, superposition, entanglement, uncertainty etc.

Generation and Detection of Down-converted Photon Pairs at 2.080 µm

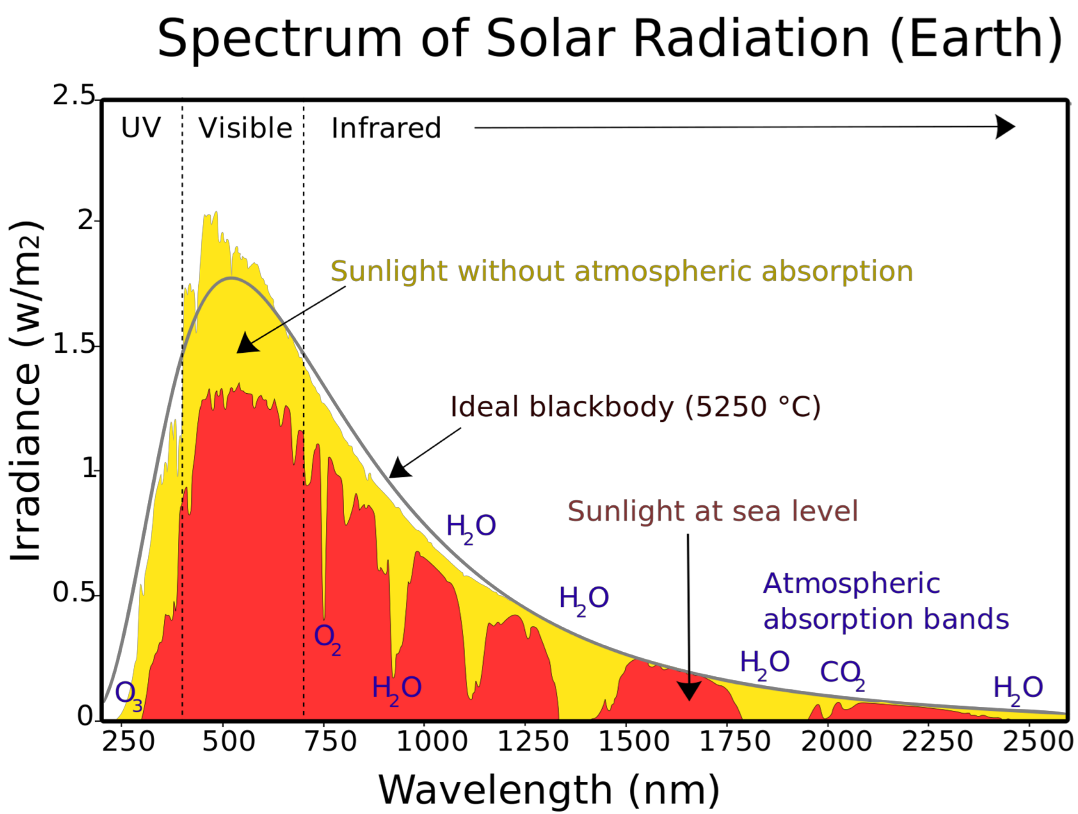


- Demand for 2µm sources in fields such as:
- Medical surgery ~ strong water absorption
- LIDAR ~ “eye safe” wavelength range
- Atmospheric sensing ~ absorption lines for atmospheric gases (e.g. CO2, H2O, N2O)

Chromacity

University of Glasgow

Generation and Detection of Down-converted Photon Pairs at 2.080 μm

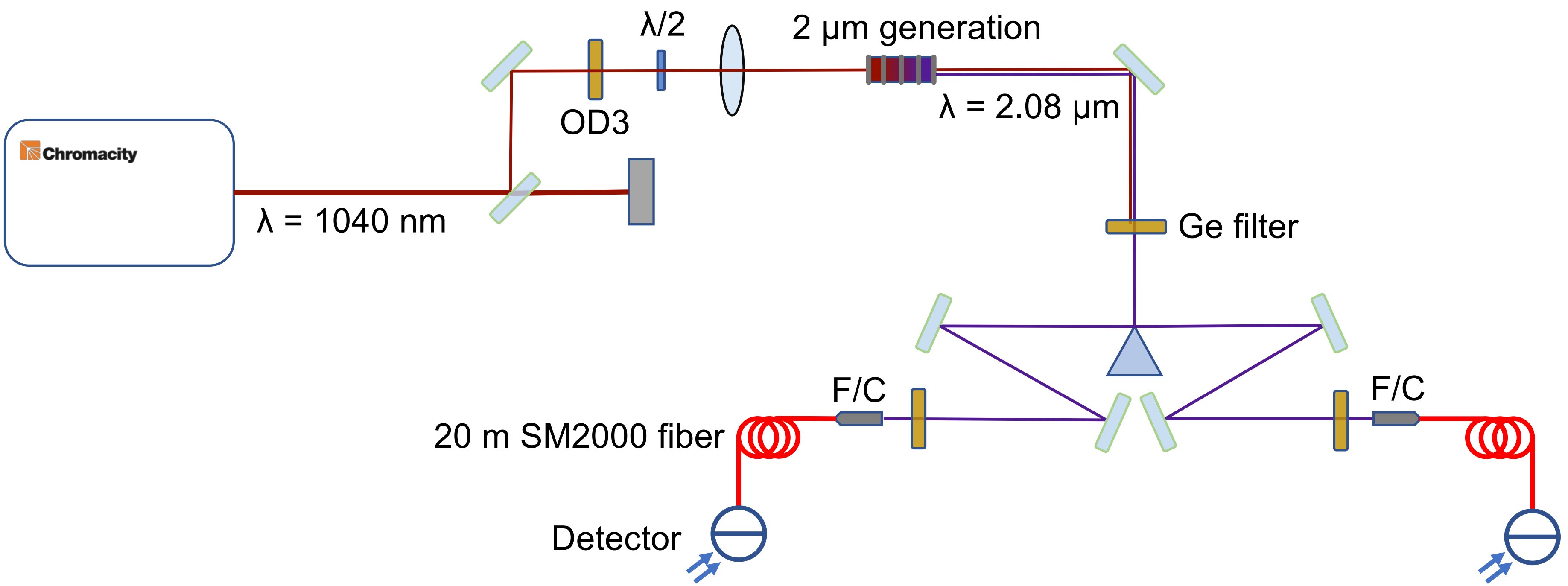


- Ground-to-satellite quantum communications ~ atmospheric transparency window at 2μm
- Solar blackbody radiation at telecom wavelengths reduced by half
- Free-space QKD ~ complications in implementing these systems in urban areas (higher concentration of aerosols, scatters shorter wavelengths)
- However there are challenges……..
- Polarisation maintaining fibers at 2μm
- High efficiency single photon detectors at 2μm

Chromacity

University of Glasgow

Generation and Detection of Down-converted Photon Pairs at 2.080 µm



Chromacity

University of Glasgow

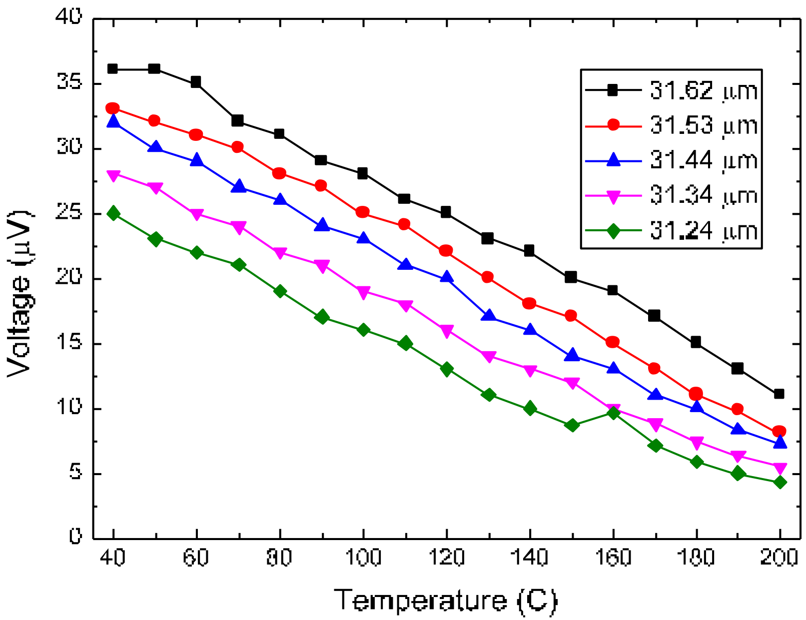
Generation and Detection of Down-converted Photon Pairs at 2.080 μm

- Detection via superconducting nanowire single-photon detector (SNSPD) optimised for radiation at 1560 nm.
- System detection efficiency of ~10^{-5} at 2 μm.
- The generated photons at 2 μm are coupled to SM2000 fibres and routed to the SNSPDs
- SNSPD operates at < 3K.

Chromacity

University of Glasgow

Generation and Detection of Down-converted Photon Pairs at 2.080 μm

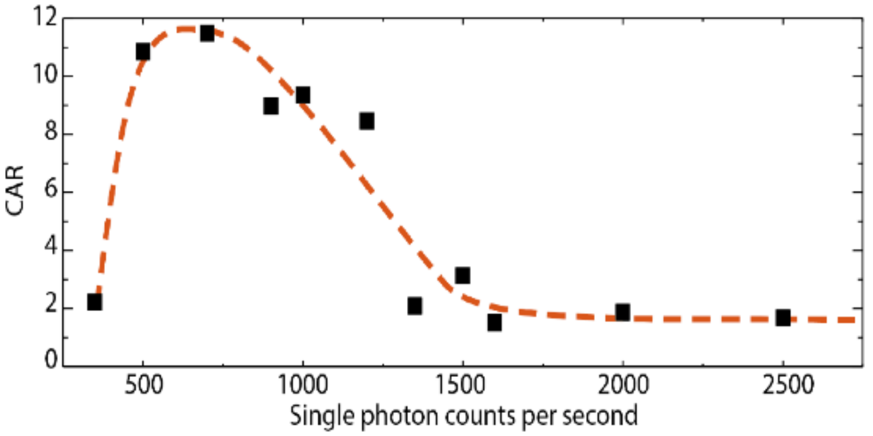


- 1 mm long magnesium-doped periodically-poled lithium-niobate crystal (MgO:PPLN) crystal with 31.62 μm poling period at a temperature of 40ºC.
- Characterization using InGaAs detectors

Chromacity covesion University of Glasgow

Generation and Detection of Down-converted Photon Pairs at 2.080 μm

- For the first-time, they have generated and detected correlated photon pairs at 2 μm with maximum CAR ~ 11.5.
- These sources suotable for daylight free-space QKD in a spectral region with high atmospheric transparency & low solar background.
- Further improvements will be made with improved SNSPD/optical component technology at longer wavelengths as well as minimization of coupling losses

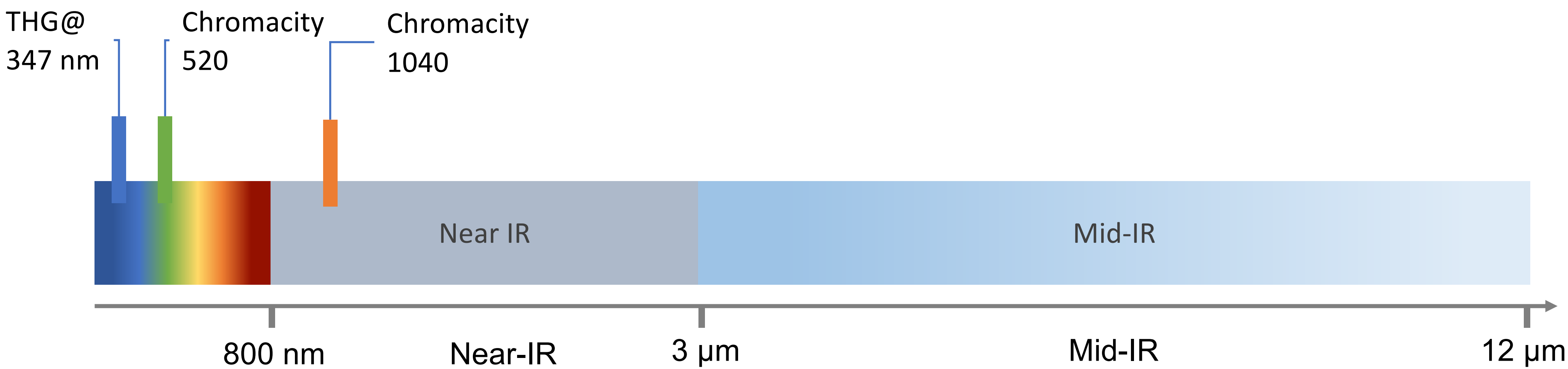


- Future work:
  - HOM interference at 2 μm
  - Hyperentanglement at 2 μm
  - Free space QKD

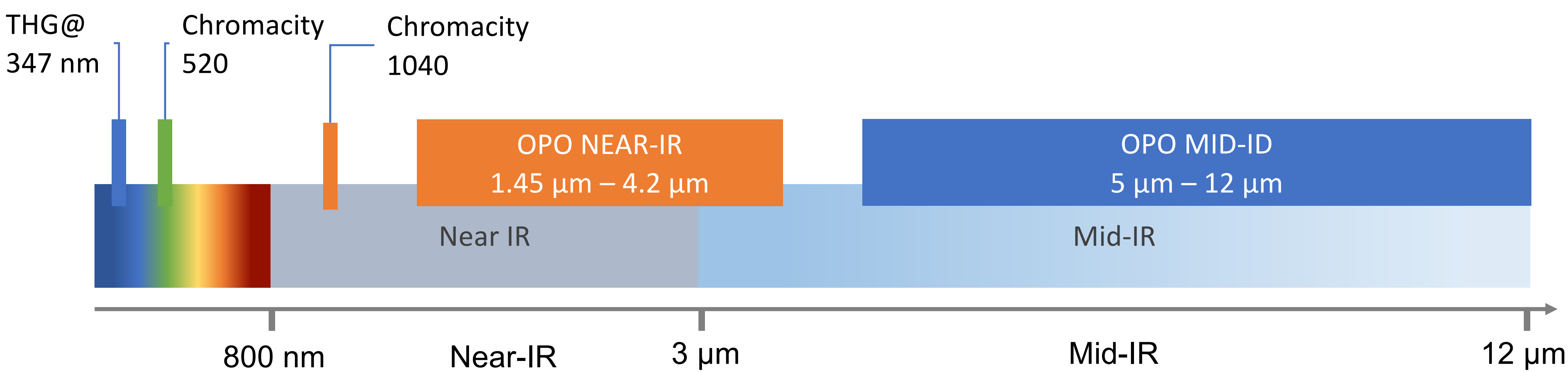
Chromacity

University of Glasgow

Chromacity – Product Range



Chromacity – Product Range



Chromacity

Chromacity OPO / Chromacity FIR

Near-Infrared and mid-Infrared OPOs

The Chromacity OPO provides tunable output from 1.4 - 4.2 µm.

Underlying OPO architecture is able to work with a range of existing non-linear crystals.

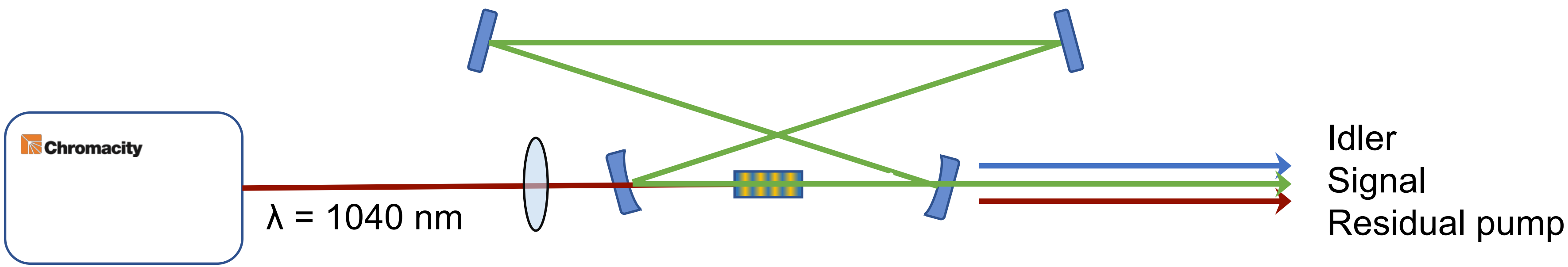
- Delivers light from 1.4 µm – 4.2 µm
- Typically 1-5 ps output at 100 MHz
- Signal 1.4 µm - 1.9 µm up to 1.5 W
- Idler 2.3 µm – 4 µm up to 350 mW (near IR)
- Pumped by an integrated Chromacity 1040
- Residual pump up to 500 mW

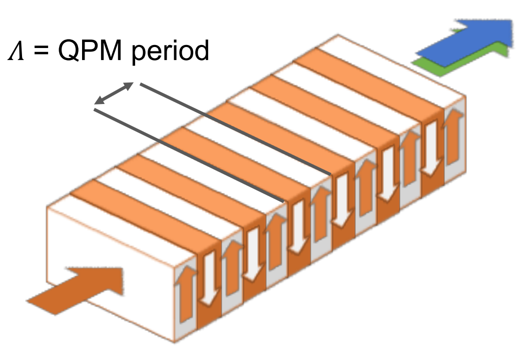
The Chromacity FIR is the world's first commercial mid-infrared OPO

Pumped by an integrated Chromacity 1040 is available in different variants depending on customer requirements

- Delivers light from 5 µm - 12 µm in discrete broadband spectra
- ~100mW at 5 µm
- ~10 mW at 12 µm
- Pumped by an integrated Chromacity 1040
- Residual pump up to 500 mW available

Chromacity OPO-CX
Femtosecond laser source

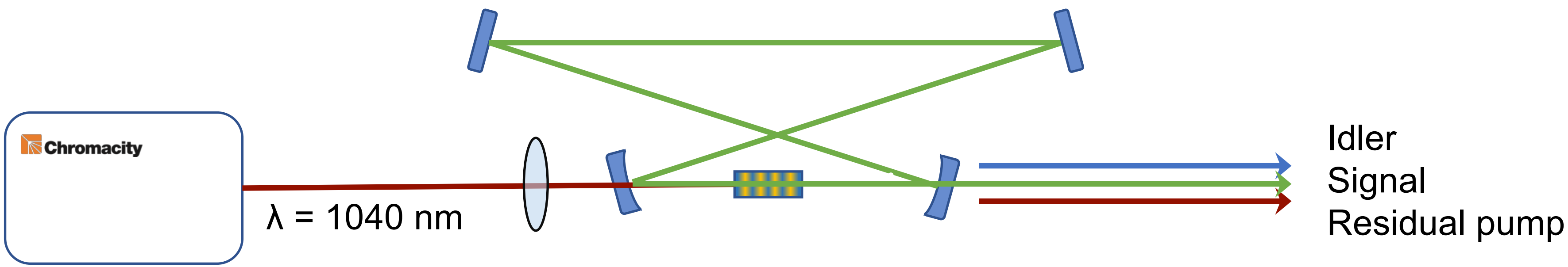


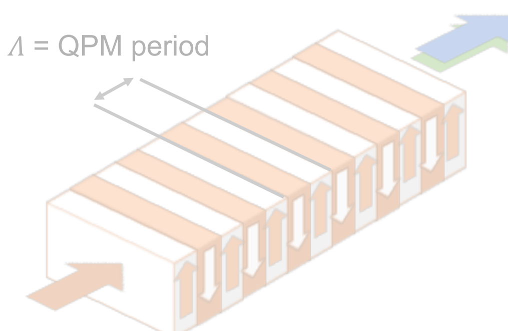


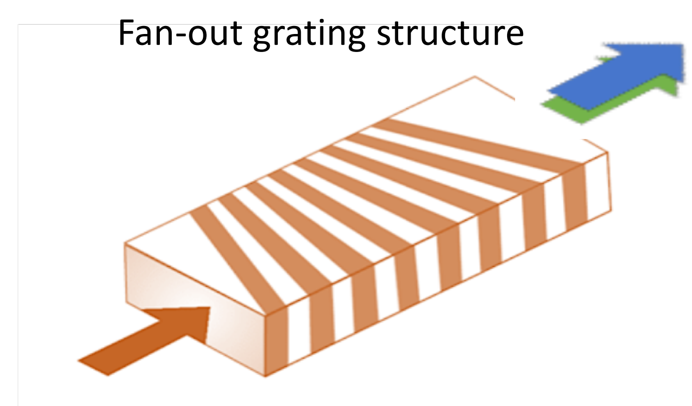
Chromacity

Chromacity OPO-CX

Femtosecond laser source



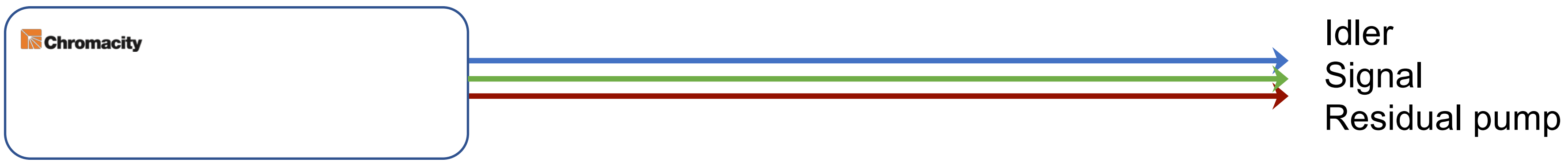




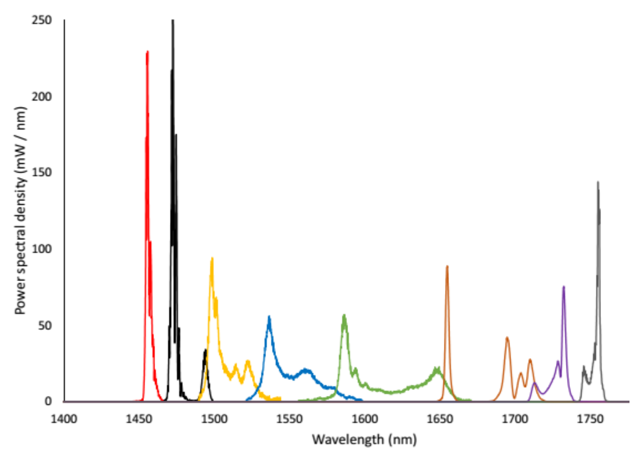
Chromacity

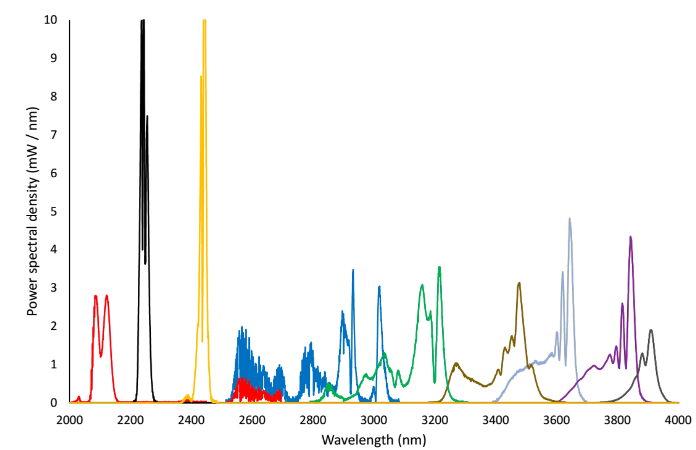
Chromacity OPO-CX

Femtosecond laser source

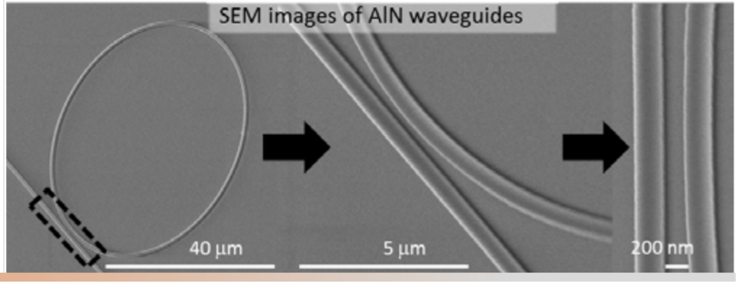


- Incorporate the 1040 pump and OPO cavity onto one unit
- Machined from a single aluminium block to improve stability/reliability
- Air cooled
- All this keeps costs down
- Signal 1.4 µm - 1.9 µm up to 1.5 W
- Idler 2.3 µm – 4 µm up to 350 mW



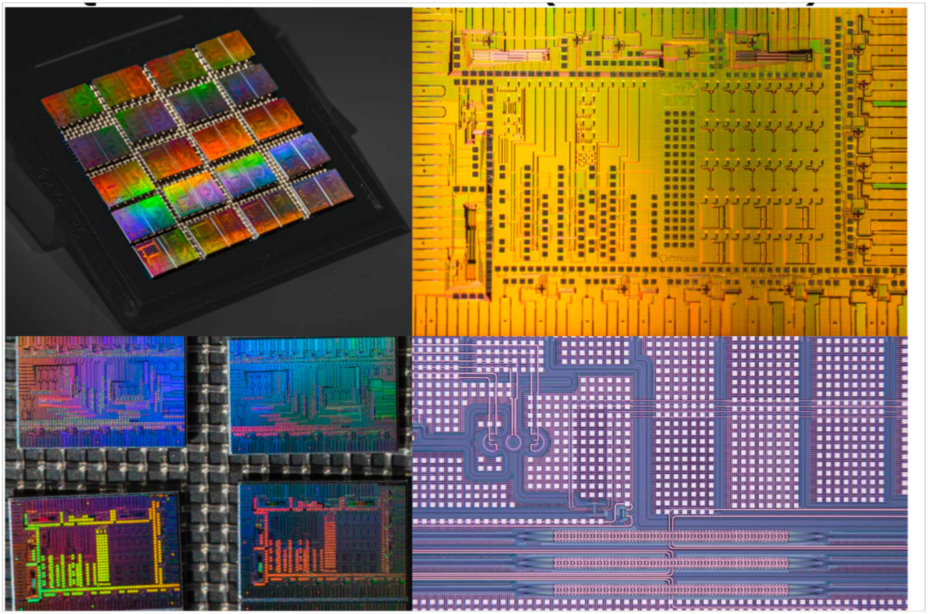


Chromacity



Quantum Photon Sources & Photonic Circuits

- Michael Fanto has recently taken delivery of a Chromacity OPO-CX to interrogate next generation integrated circuits.
- Quantum information processing relies on photon interference and requires qubits to be identical in order to perfectly interfere.
- He is investigating integrated waveguides in a number of different compound semiconductors
- The Chromacity OPO allows him to interrogate in the near/mid IR (beyond standard telecoms wavelengths) and into the UV by using the output of our source to generate THG.

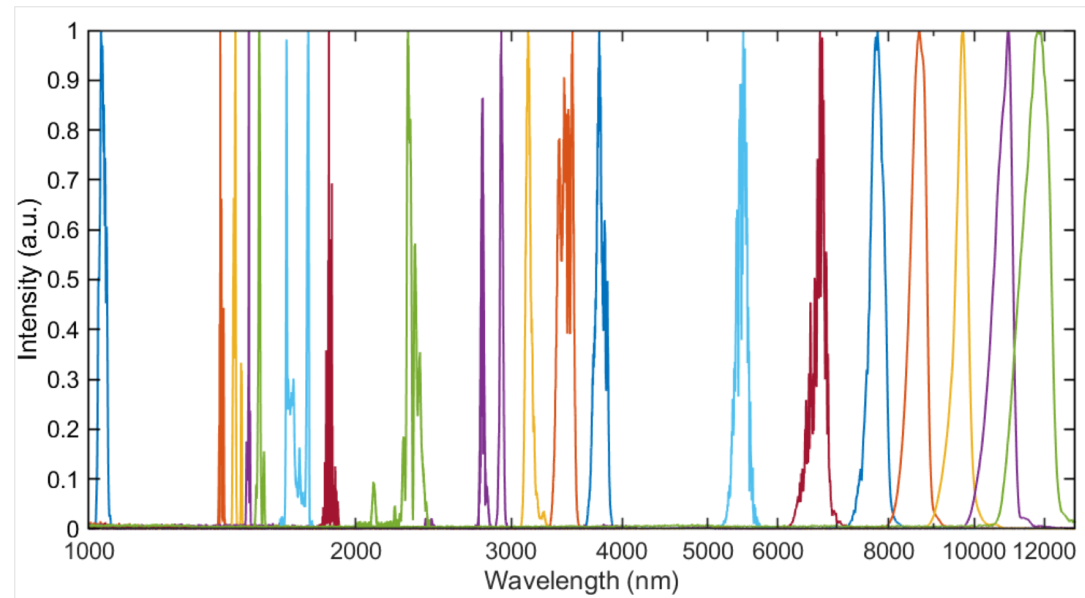


Chromacity

U.S. AIR FORCE

Summary

- Chromacity has a range of systems that cover the near & mid-IR as well as 520 nm and 347 nm.
- The team has significant expertise in ultrafast lasers, OPOs and non-linear optics.
- We are keen to engage with the Quantum Optics/Comms community.



Chromacity

Chromacity

Dr Christopher G. Leburn, Founder & Director
c.g.leburn@chromacitylasers.com

Rochester Institute of Technology
Photonics for Quantum – 23rd January 2019