# Compact femtosecond optical parametric oscillator with an intracavity fibre coupled retroreflector

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## OBJECTIVE

We aim to demonstrate the first optical parametric oscillator to incorporate an intracavity fibre retroreflector. The ultra-compact design based on MgO:PPLN pumped by a Kerr-lens-mode-locked Ti:sapphire laser, will provide broad, continuous and rapid near-infrared tuning with transform limited pulses.

## BACKGROUND

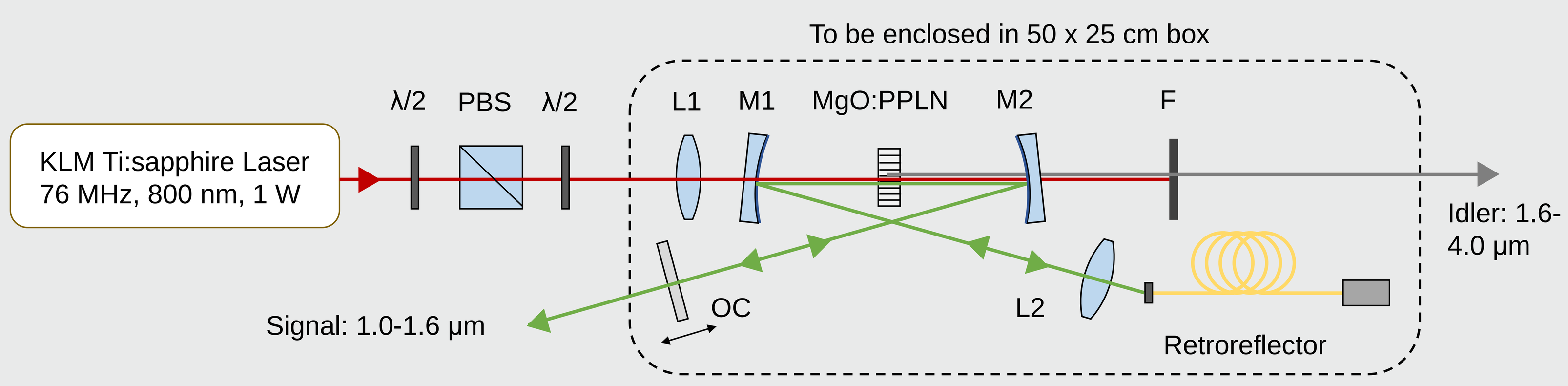
### Motivation

Femtosecond transform limited pulses in the near-infrared are of great interest for use in pump-probe spectroscopy of ultrafast biological and material processes. Femtosecond OPOs are the dominant source for generating tunable pulsed light at these wavelengths, however the cavity synchronisation requirement leads to bulky devices. Additionally, a dispersion compensating element such as a prism pair is required to prevent pulse broadening in the nonlinear crystal. The well-established low threshold MgO:PPLN OPO is a suitable starting position from which to advance to more compact OPO designs.

### Approach

- Ti:sapphire laser providing 1 W average power in pulses of 130 fs at 76MHz
- Build fractional length cavity (1/4 length, 304 MHz), and replace OPO mirror with single mode fused silica fibre retroreflector
- Custom design fibre to compensate for cavity group velocity dispersion (GVD)

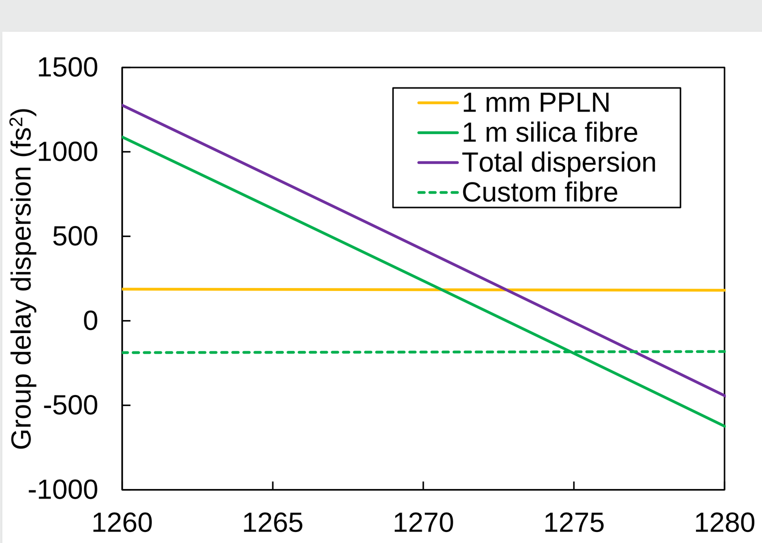
## EXPERIMENTAL SETUP AND FIBRE CHOICE



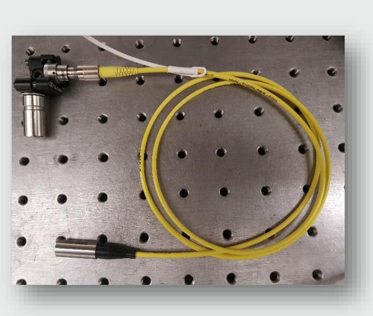

Pump power is adjusted using a pair of half-wave plates and a polarising beamsplitter. L1: f = 75 mm to the beam to a waist radius of $w_0$~25 μm in the centre of the 1-mm crystal. Mirrors M1 and M2: r = 100 mm; highly reflecting for signal, highly transmitting for pump and idler (singly resonant operation). Fibre coupling lens L2: f = 11 mm chosen to maximise coupling efficiency for the intracavity signal into the Ø9.2 μm fibre.

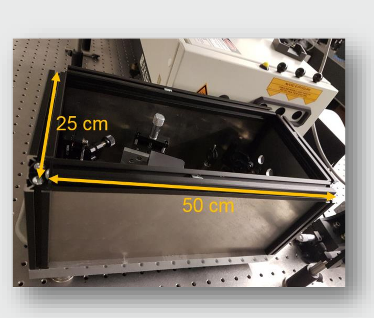
### Fibre calculations

The fibre and coupling lens were selected for single mode operation at wavelength $\lambda$ using the equations below, where $M$ is number of fibre modes, $a$ is core radius and $NA$ is numerical aperture. For a 1 m fused silica fibre (shown below) dispersion is only small around 1275 nm, therefore a custom fibre will be developed to maintain transform limited pulses.



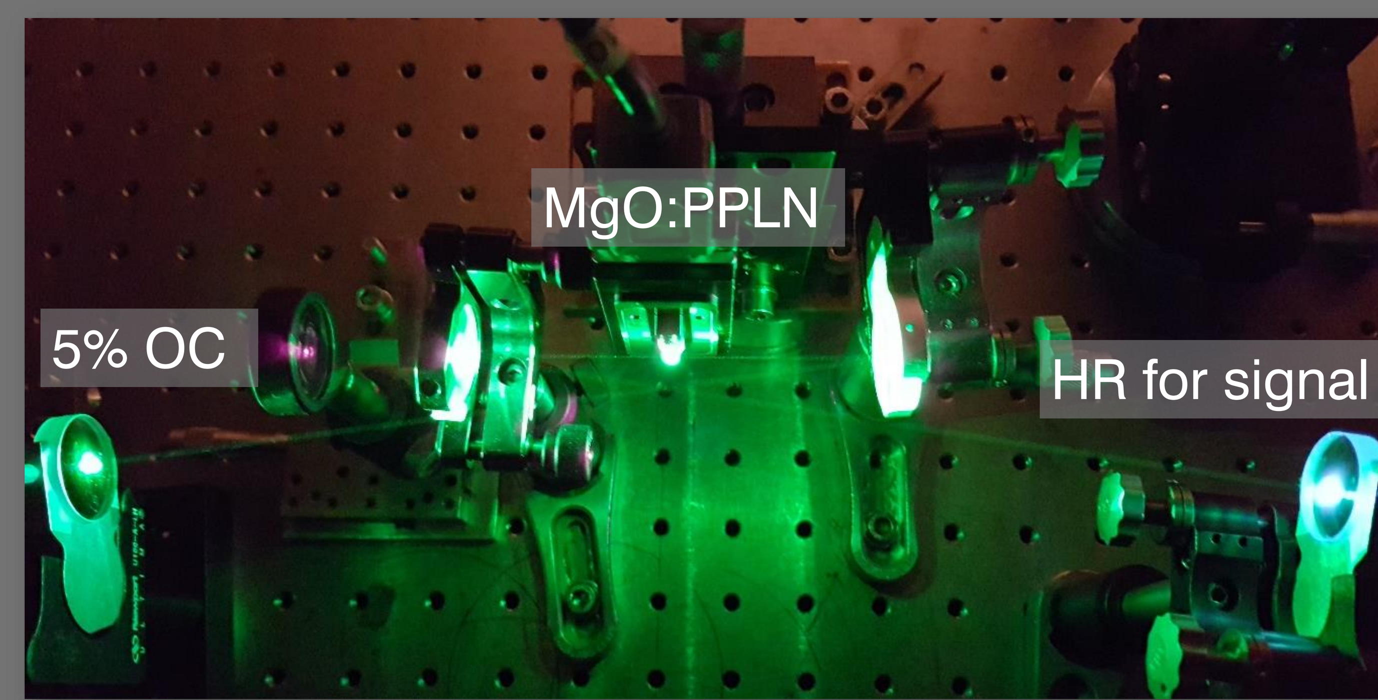

$$V = \frac{2\pi a}{\lambda} NA \qquad M \approx \frac{V^2}{2}$$

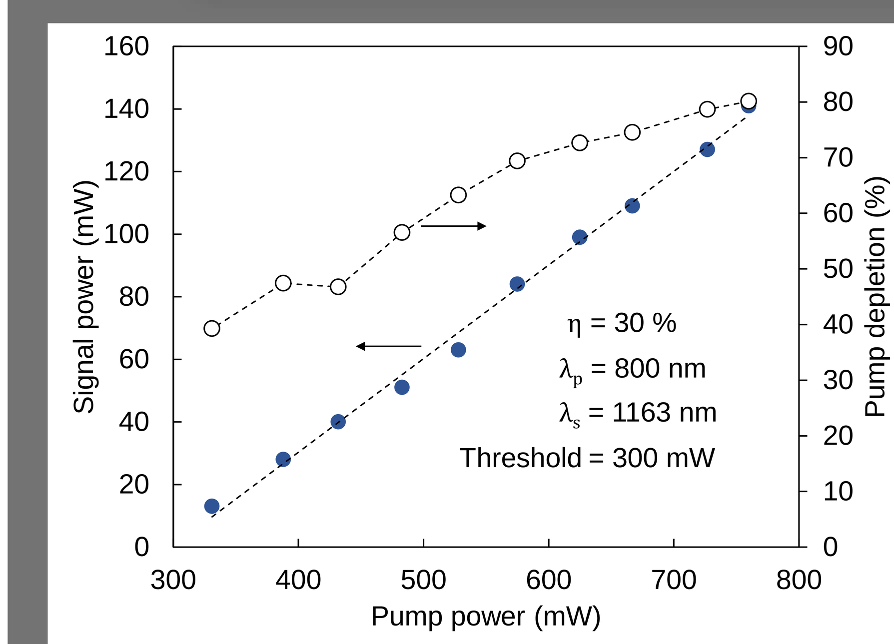


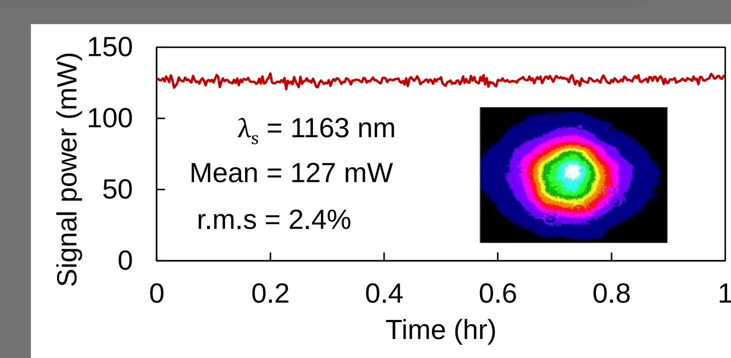



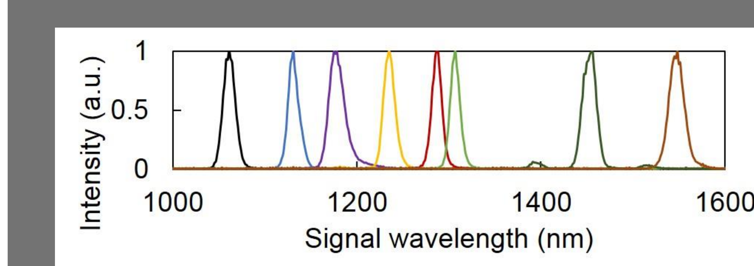
Retroreflector and OPO box

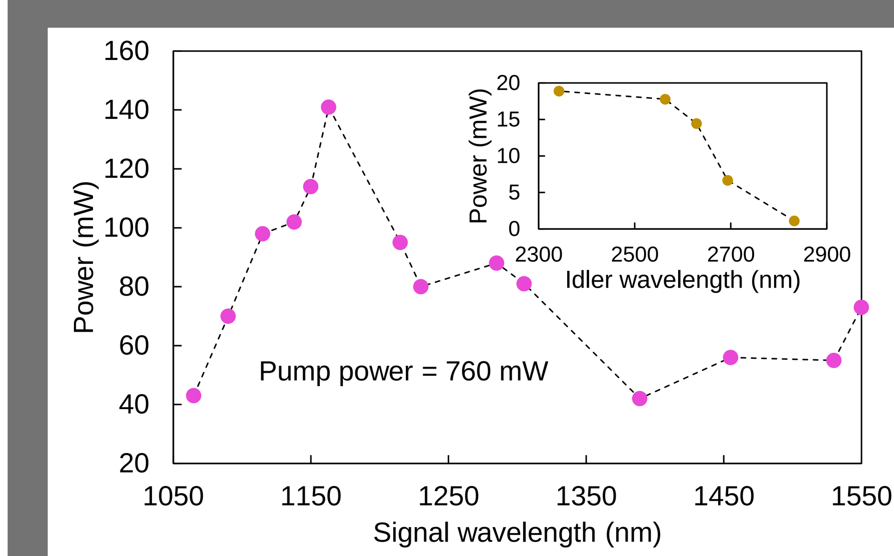
## RESULTS SO FAR: 304 MHz cavity




Clockwise: Power spectrum (non-optimised idler collection), power scaling, lab arrangement, power stability, signal beam profile and spectrum.

### Following stages

- Replace high reflecting mirror with chosen single mode fibre retroreflector and characterise pulses
- Design a custom fibre to compensate for intracavity dispersion

## PUBLICATIONS AND COLLABORATIONS

### Expected publications

1. "First optical parametric oscillator incorporating an intracavity fibre coupled retroreflector"
2. "Dispersion compensated pulse generation from a fibre coupled optical parametric oscillator"

### Secondments

1. Lund: Mid-infrared combustion spectroscopy (M26)
2. DTU: Mid-infrared upconversion imaging (M28)

### Proposed collaboration

ICFO/Radi/DTU: Mid-infrared upconversion imaging using femtosecond optical parametric oscillator source (M27)

## ACKNOWLEDGMENTS

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