Broadband MIR Sources for Spectroscopy

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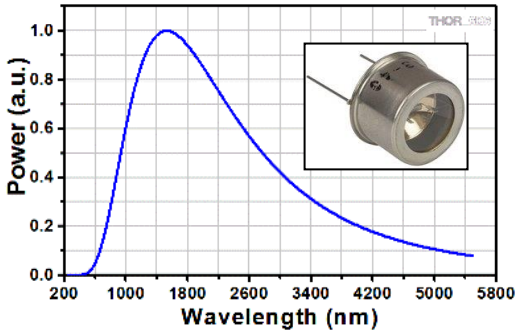
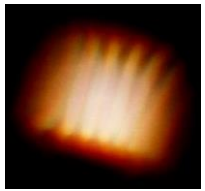
Sources of Broadband MIR Radiation for Spectroscopy

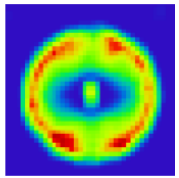
Thermal Source (Lamp/Globar)



- Compact
- Low cost
- Poor beam quality
- Low brightness



Collimated Lamp Beam



Collimated Globar Beam

Synchrotron

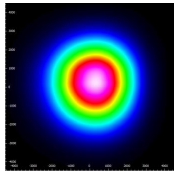
- Higher brightness than thermal source (~ 100X).
- Spatially coherent beam.
- High operating cost.
- Not portable; incompatible with many applications.

Broadband Lasers

Supercontinuum Laser

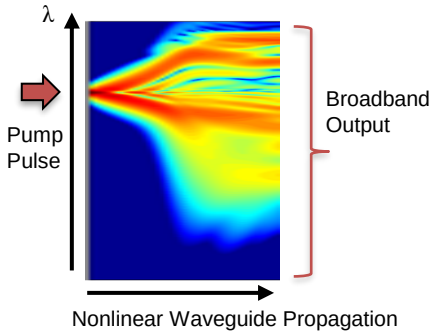
Quantum Cascade Laser

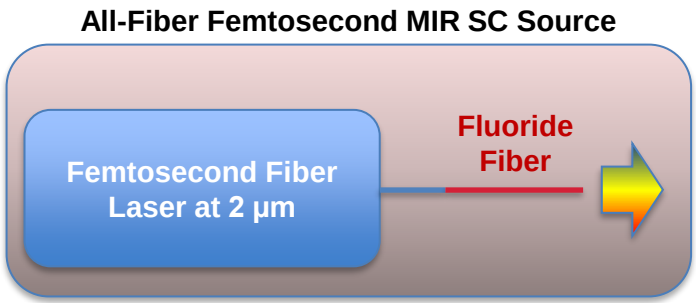
- Compact and portable.
- Comparable or better brightness compared to synchrotrons.
- Single-mode laser beam properties.
- Fiber delivery.

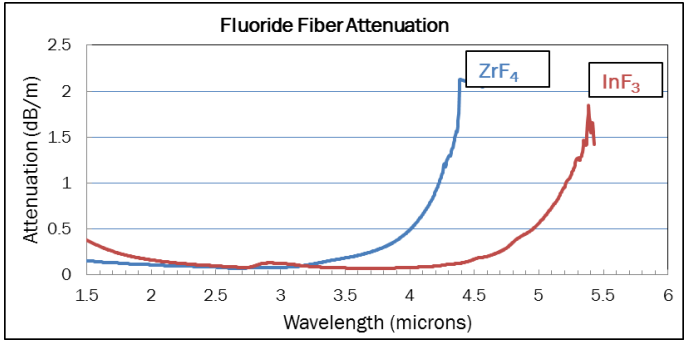


Supercontinuum Output Beam

Thorlabs' Femtosecond MIR Supercontinuum Laser







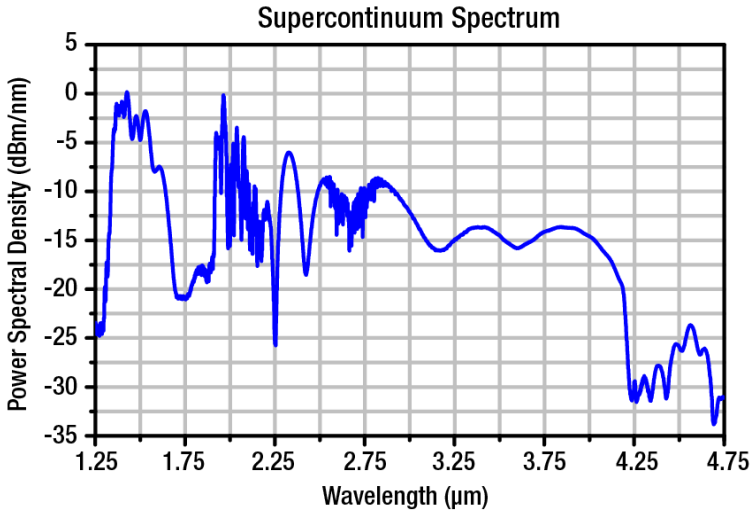
- Supercontinuum (SC) is generated by propagating a pulsed laser through a nonlinear waveguide (e.g. fiber) to spectrally broaden the pulse.
- SC sources have high brightness and single-mode laser beam quality.
- Thorlabs' MIR SC source:
  - Femtosecond architecture to minimize spectral noise.
  - Pumped using a Tm-doped fiber laser at 2-µm, developed and manufactured by Thorlabs.
  - Soft-glass (fluoride) MIR fiber with transmission out to 5.5 µm enables covering a significant portion of the MIR region.
  - In-house draw process allows accurate control of fiber geometry to engineer fiber dispersion (key to femtosecond architecture).

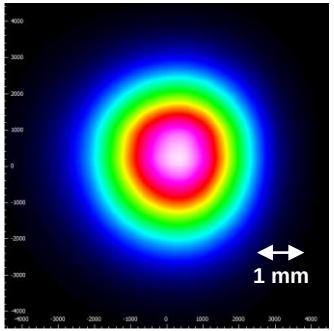
Thorlabs' Femtosecond MIR Supercontinuum Laser

Specification	Value
Wavelength Range	1.3 – 4.5 µm
Output Power	300 mW (Minimum)
Relative Intensity Noise	< 0.03 % (10 Hz – 1 MHz)
Repetition Rate	50 MHz
Beam Output	Collimated; Single Spatial Mode
Beam Size (Approx.)	Ø5.5 mm (1/e²)

PRISM AWARDS WINNER

SC4500

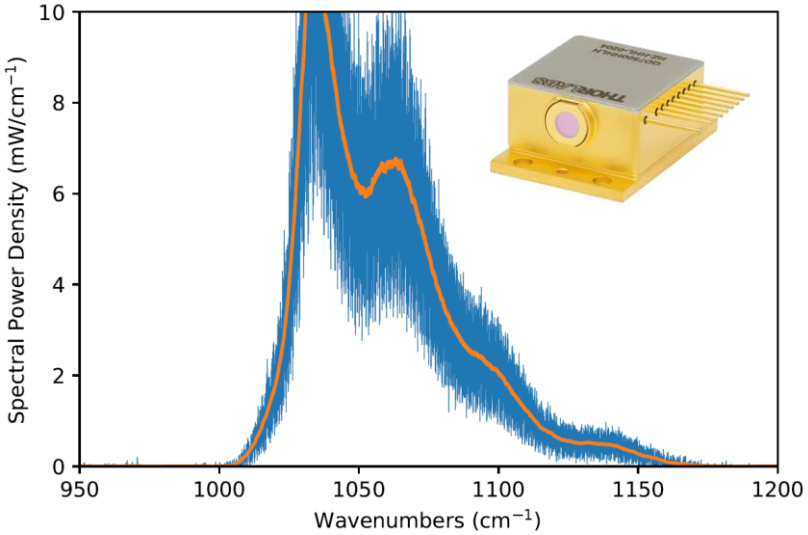


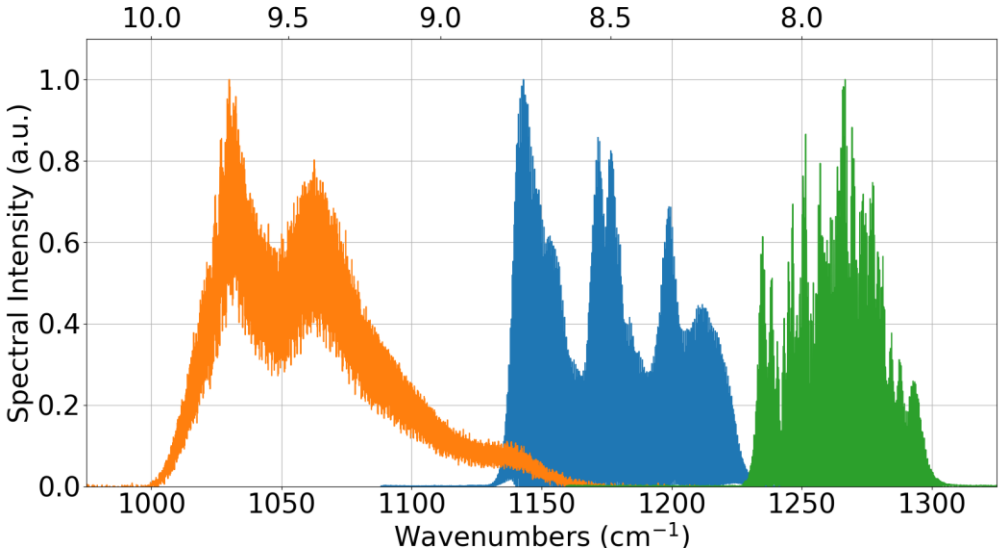


SC4500 Beam Properties:

- Diameter = 5.5 mm
- Circularity > 97%
- M^2 = 1.11

Broadband Quantum Cascade Lasers (QCLs)





- QCLs are semiconductor lasers with power levels exceeding 1 W and single-mode output beam quality.
- As the emission wavelengths of QCLs are determined primarily by *layer thicknesses* rather than material composition, a broad range of wavelengths is accessible (3.8->12µm)
- Active regions designed for emission at different wavelengths can be cascaded, allowing for high spectral power density over 80-150 cm^{-1} (e.g. 0.8-1.5µm around 10µm)
- Three compact (40x35x19mm) lasers can cover >2µm with spectral power density ~1-10mW/cm^{-1}

QCL comb spectroscopy – Eliminating the FTIR

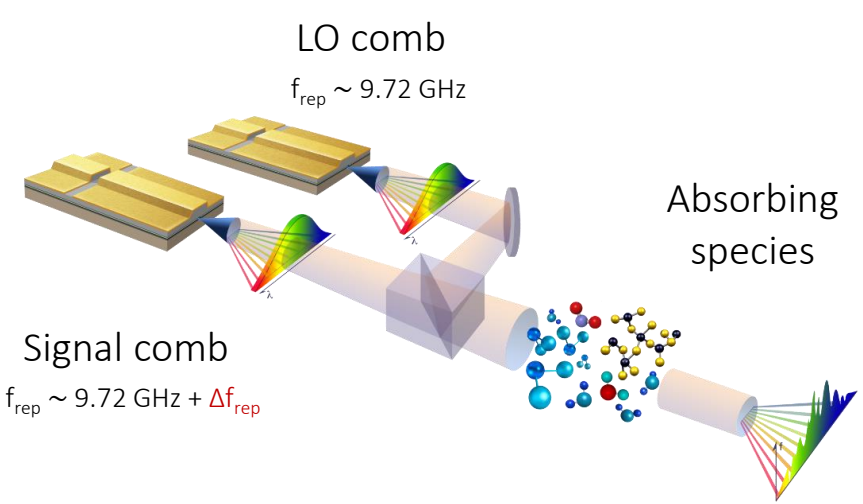
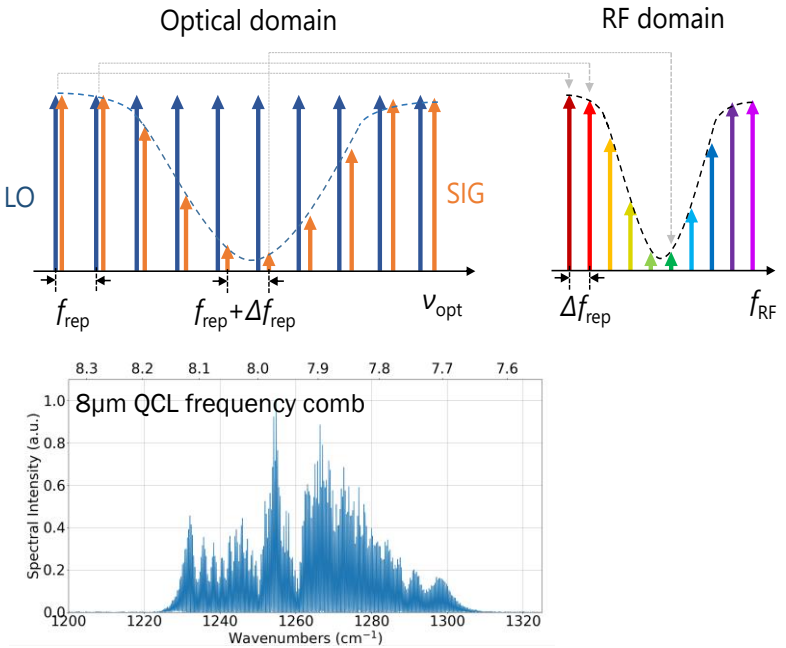


Image source: Dr. Mahmood Bagheri at JPL



- Non-linearities in the QCL cavity can be exploited to tailor the QCL emission to be in multiple *phase-locked* optical modes
- The beating between these modes can be detected *electrically*, with minimal optical elements and NO moving parts

Partnership Opportunities

- Thorlabs' Broadband MIR Laser Portfolio:
  - **Supercontinuum Lasers (fiber based)**
  - **Quantum Cascade Lasers (semiconductor based)**
  - Vertically integrated from laser material development through system integration.
- Opportunities to collaborate with the photonics industry:
  - Explore new spectroscopy applications where broadband lasers can offer significant performance advantage over traditionally used thermal sources.
    - Open-path gas analyzers → improved range and sensitivity due to low-divergence laser beam
    - Hyperspectral infrared microscopy → improved resolution and faster measurements
    - Near-field imaging systems → improved throughput due to higher brightness and better beam quality
    - Dual-comb spectroscopy systems without FTIR → faster measurement time; improved system complexity and size
  - Optimize laser source properties for specific applications.
    - Full access to material development process
    - Ability to tailor device properties
    - System integration for specific foot-print or architecture