World Leading Supercontinuum to 4.75 µm

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What is supercontinuum

- Broadband light source – like a lamp or globar

- High brightness – like a laser
- Spatially coherent – like a laser
- Single mode fiber output – like a laser
- Pulsed light source – like a laser

  - **This is why they are nicknamed "white lasers"**

MId-IR Supercontinuum
- Constructed from telecom components
- Covers the entire spectrum

Supercontinuum – How?

- ps-ns
- single pulse -100MHz
- kW peak power
- Single mode
- Preferably fiber laser

- 3-10 µm dia. core
- Length: some meters
- Silica, fluoride or chalcogenide
- Single mode
- Anomalous dispersion

- Ultra broadband
- All colors in one beam
- Single mode
- Short pulsed
- Collimated fiber output

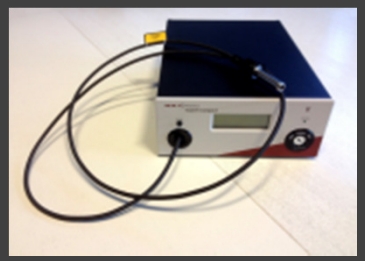
Why Supercontinuum

Positive

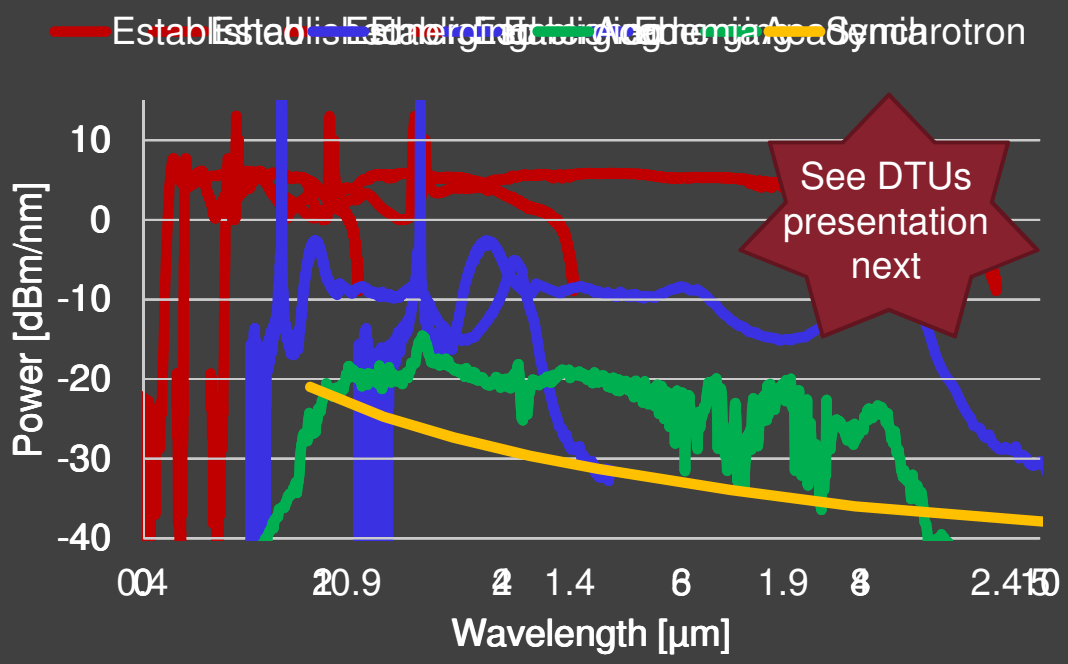
- High brightness
- Nothing except synchrotrons can give wider bandwidth
- Great for acces to multiple absorption lines
- Very flexible system
- Inherently fiber delivered
- Always pulsed

Negative

- Spreading the spectrum means less light in each line
- Filtering has to be done on detection side
- Higher power consumption



Supercontinuum‘s colors

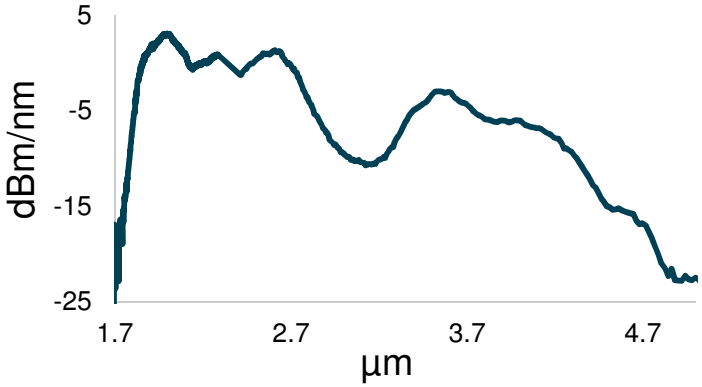


Setting the limit for ZBLAN

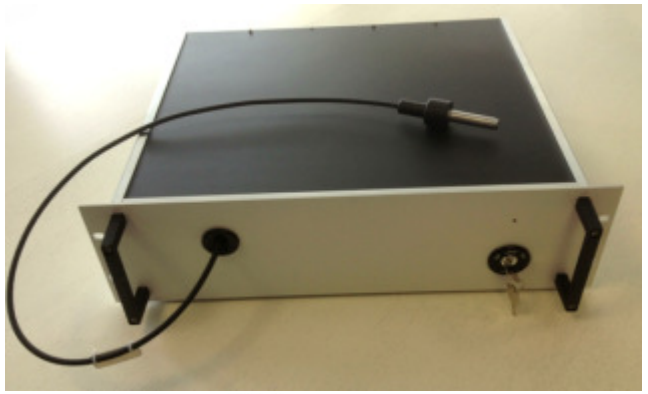
ZBLAN is the most mature soft glass

The limit for ZBLAN SC is often named at 4.3 µm

- In MINERVA NKT has shown that ZBLAN can deliver SC up to 4.75 µm even in a compact source



1200 mW
350 kHz
3ns
1.7-4.75 µm



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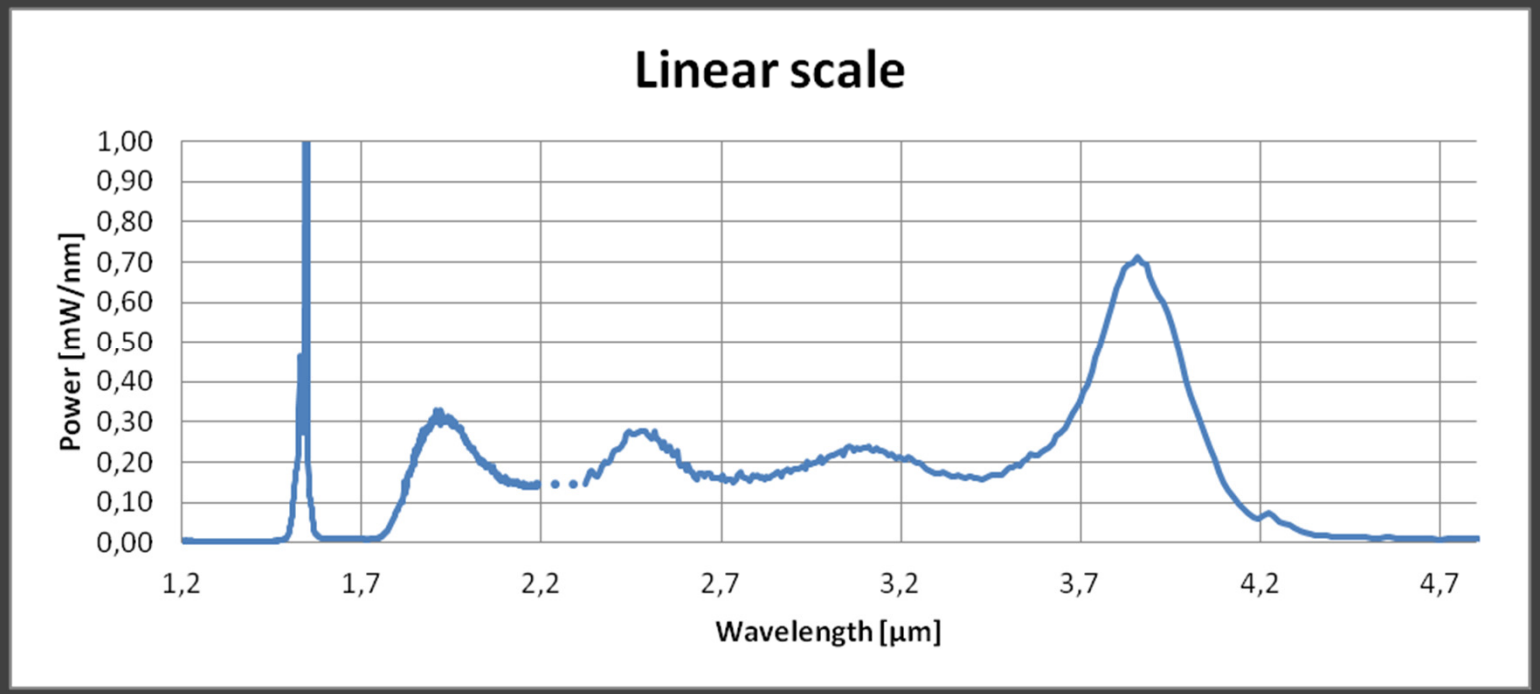
Mid-IR Source generations

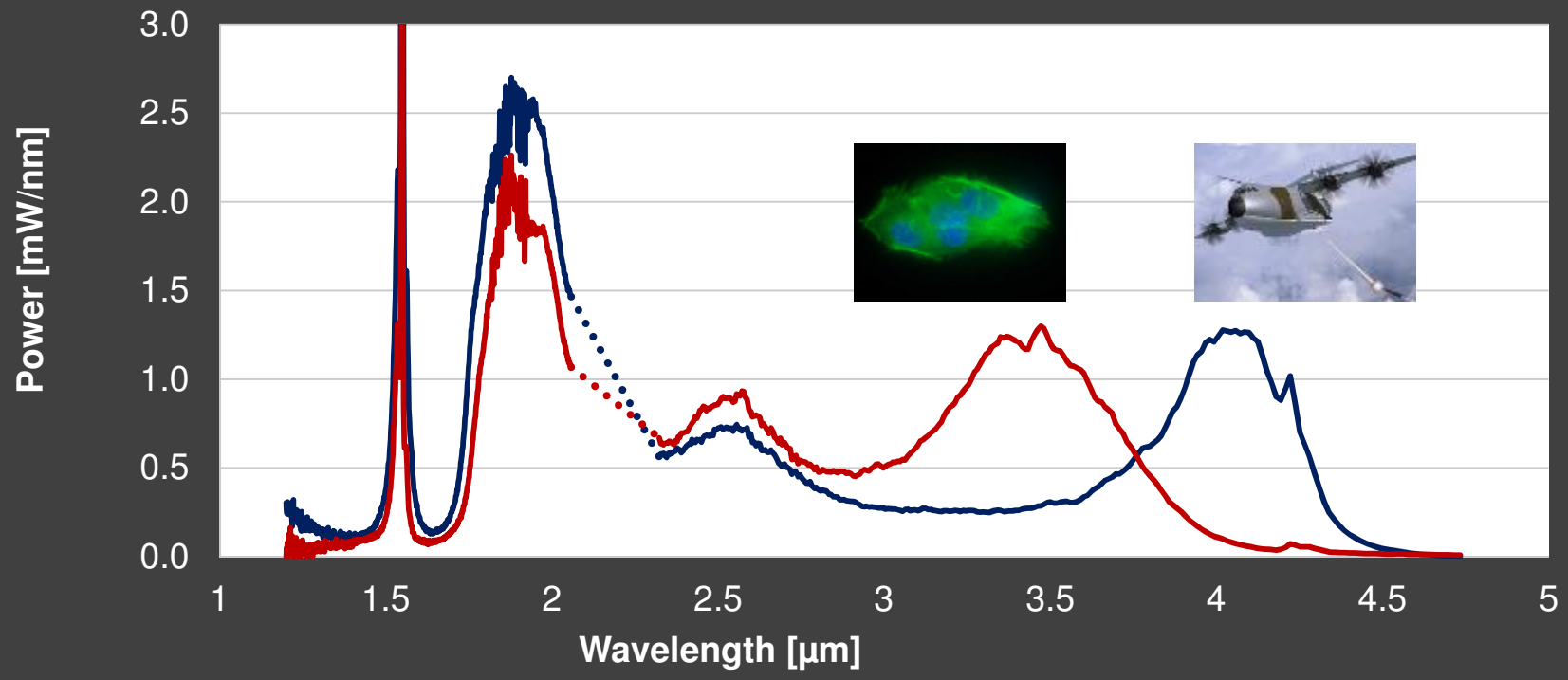
SuperK MIR

- 2.5 MHz
- 1800 – 4200 nm
- Total power > 450 mW
- Single mode fiber delivery
- M^2 < 1.1
- Fiber delivered collimated output
- Room temperature operation
- DEMO source is available now

Power Density curve

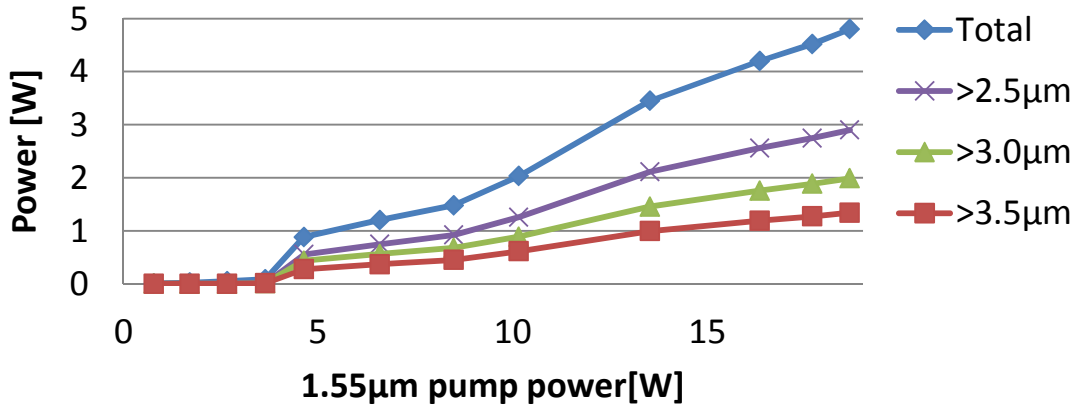


Spectral tailoring

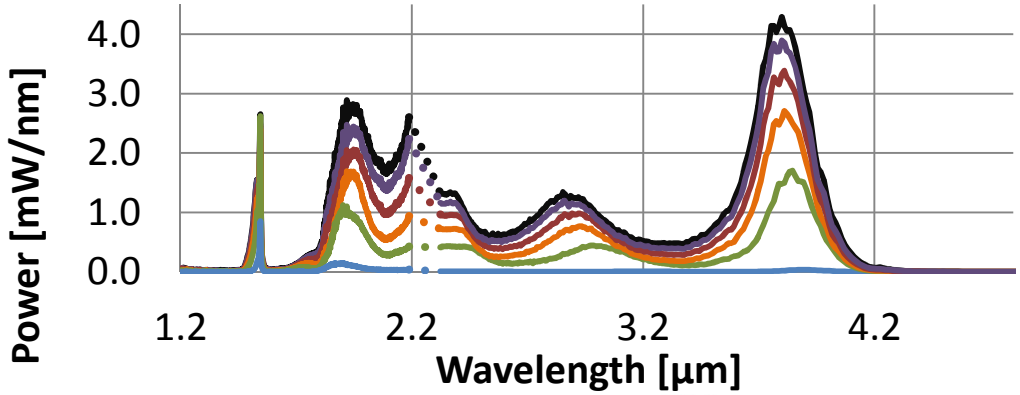


Scaling up the Power

- Total power: 4.8 W
- 60% of power >2.5 µm
- Power >3.5µm: 1.34 W
- Record for power >3.5 µm, at the time



Crystal Fibre • *aero*LASE • Koheras • SuperK



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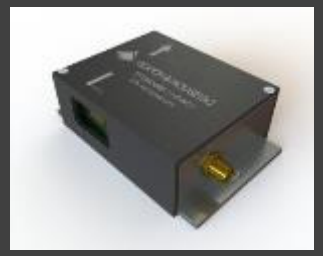
Filtering

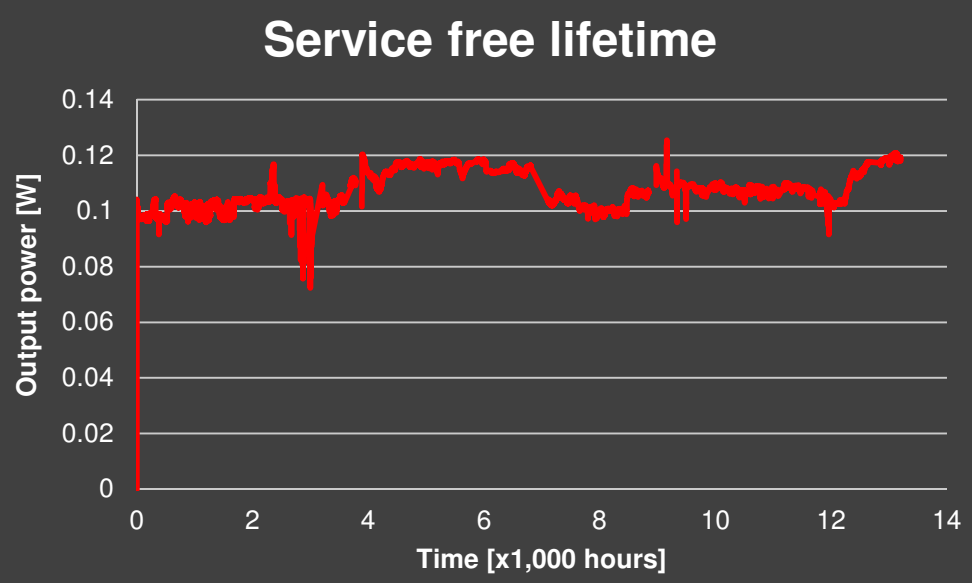
Mid-IR SC has been tested with a number of filtering options

- Monochromators
- Fourier transform spectrometers (FTIRs)
- Acousto optical filters (AOTFs)
- Fabry-Perot micro spectrometers (FPMS)
- Up-conversion detectors



Reliability

- Working with soft glass fiber is challenging.
- In the first 2-3 years of our development this gave reliability problems.
- Now we have demonstrated over 2 years 24-7 operation
- Over 13,000 hours runtime completely service free
- Operation tested at 0-40 ˚C



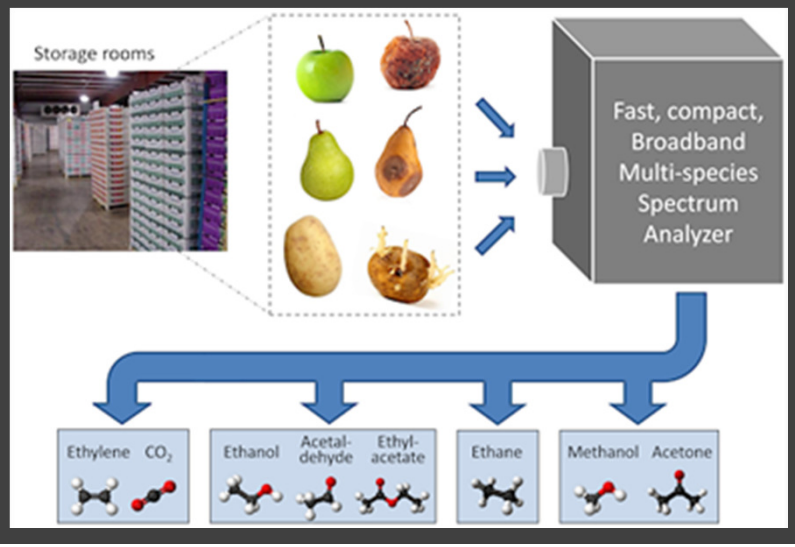
Applications: Storage atmosphere optimization

- SC driven multi-gas spectroscopy to control storage and ripening of potatoes and fruit.
- QCap, InterReg NWE project, will run until December 2019

Interreg North-West Europe

- Aims to detect gasses such as:

  CO_2, O_2, Ethylene, Ethanol, Ethane, Methanol, Acetone, Acetaldehyde, Ethylacetate



Applications: Drone based gas measurement

- SC driven multigas spectroscopy on a drone for pollution monitoring
- H2020 project, FLAIR will run until December 2019
- Target: 8L, 7kg total system
- NKT will develop world's smallest Supercontinuum source

www.h2020flair.eu

Applications in general

- Many diverse scientific applications
- And a few key areas
  - Defence
  - mid-IR tissue/cell analysis
  - Non destructive testing
  - Multi-Gas Spectroscopy

Conclusion

- Supercontinuum sources can provide high brightness over a wider spectrum than any other portable source
- Mid-IR supercontinuum is now becoming a well proven technology
- Sources are commercially available also in mid-IR
- Applications are expected to grow rapidly in the coming years

Questions?

Part of this work has been supported by the European Commission under the Seventh Framework Programme (FP7) under grant agreement No 317803
Other parts of this work has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 732968