

# 2021 EPIC Online Technology Meeting on Mid-IR Technologies for Environmental Monitoring

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# H2020 FLAIR project - Airborne Field Test



- **Objectives:** to monitor CH<sub>4</sub> emission from the stack of ships in operation
- Helicopter, flying from near Copenhagen to the north of Denmark, **123 ships over 3 days**

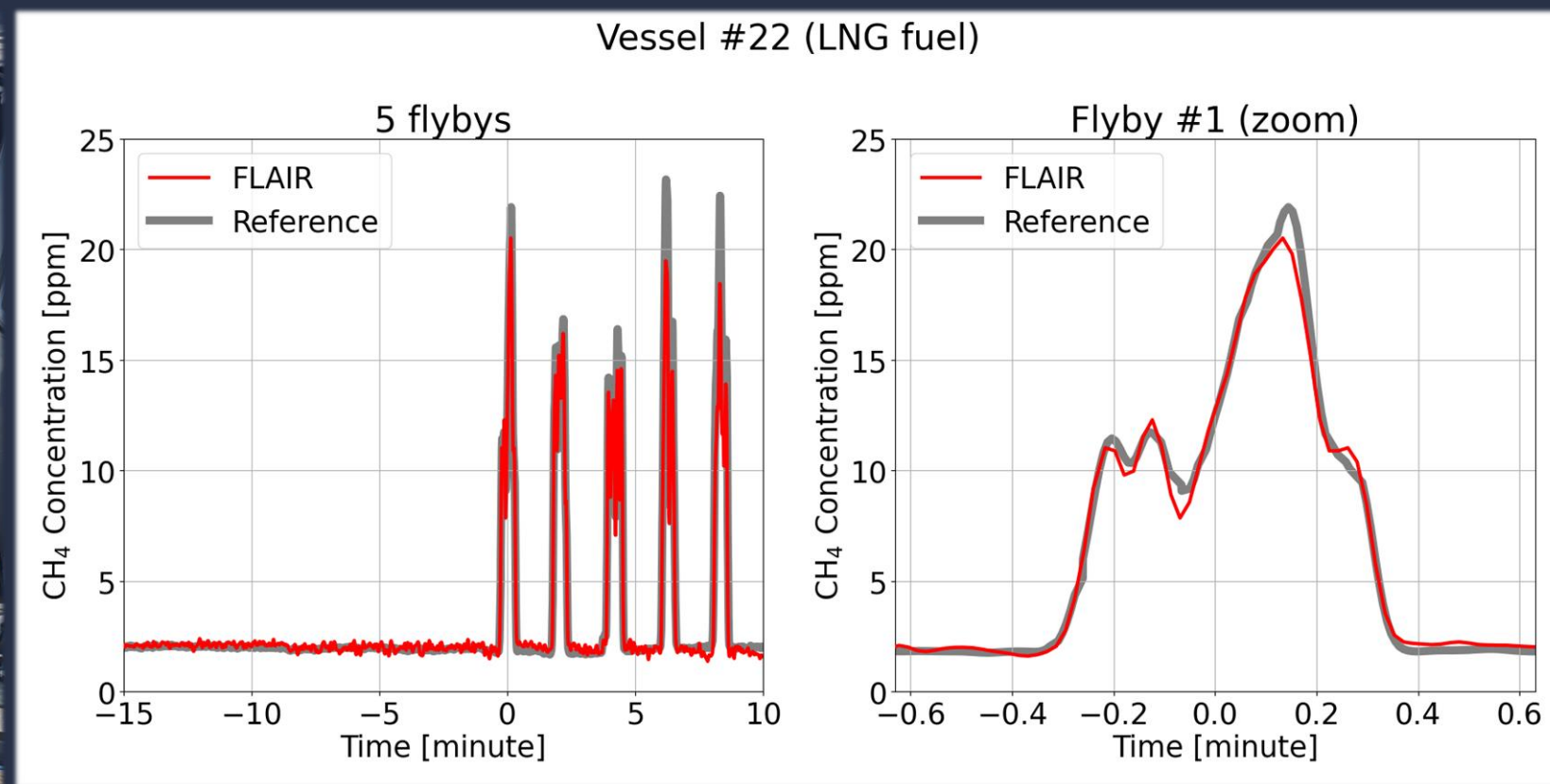


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# H2020 FLAIR project - Airborne Field Test



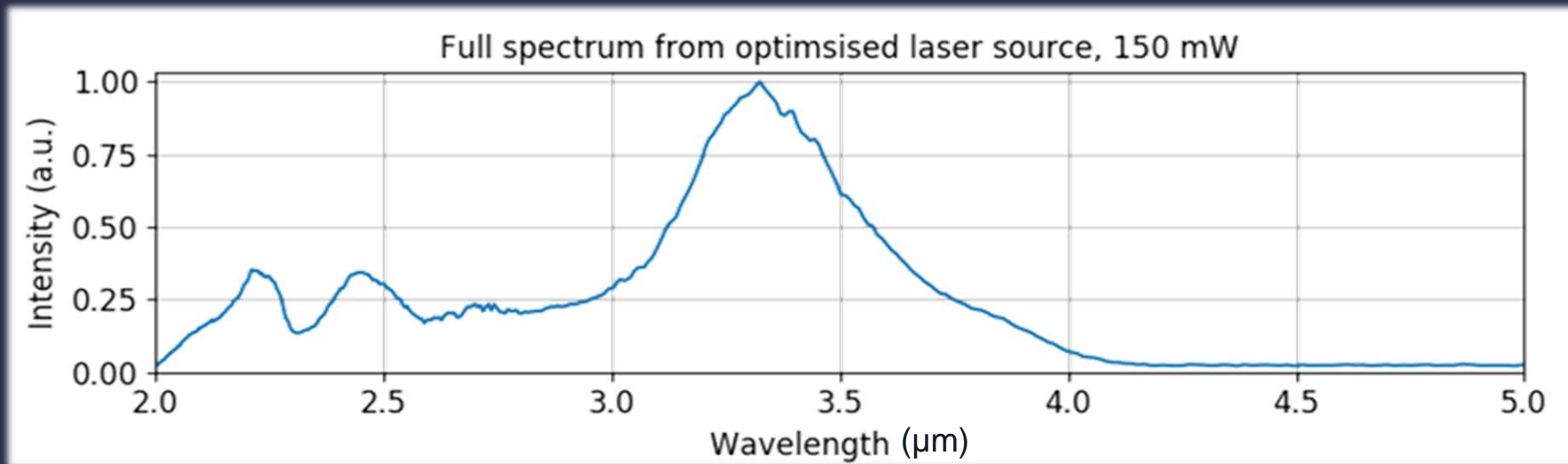
- **Successful measurement** of CH<sub>4</sub> emission from LNG ships
- **Excellent agreement** between FLAIR multispecies sensor and commercial reference systems





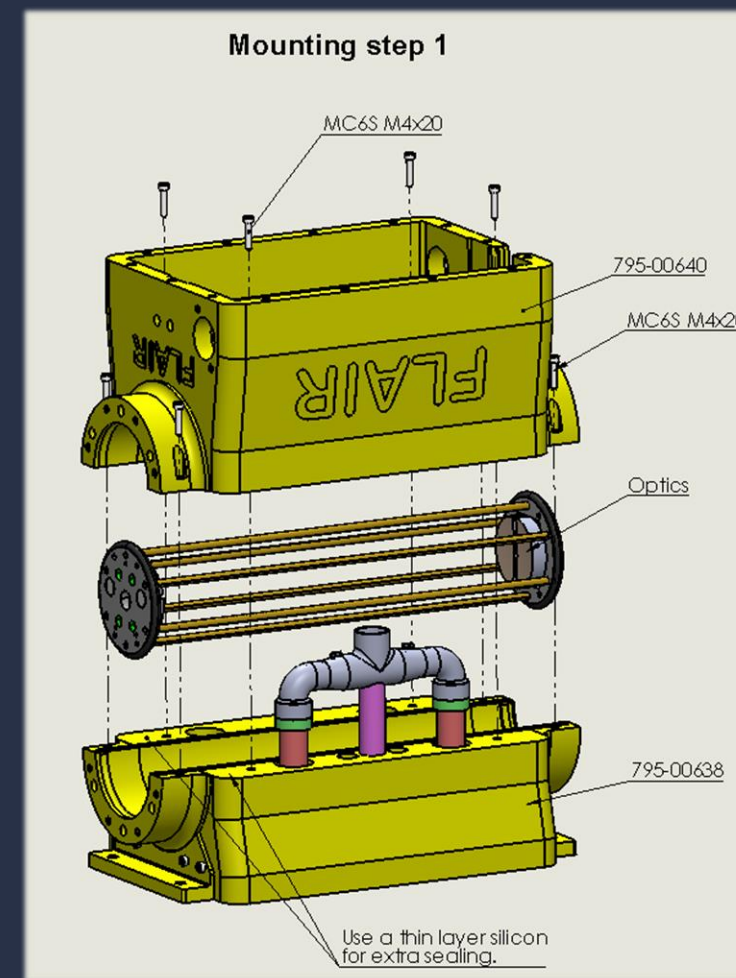
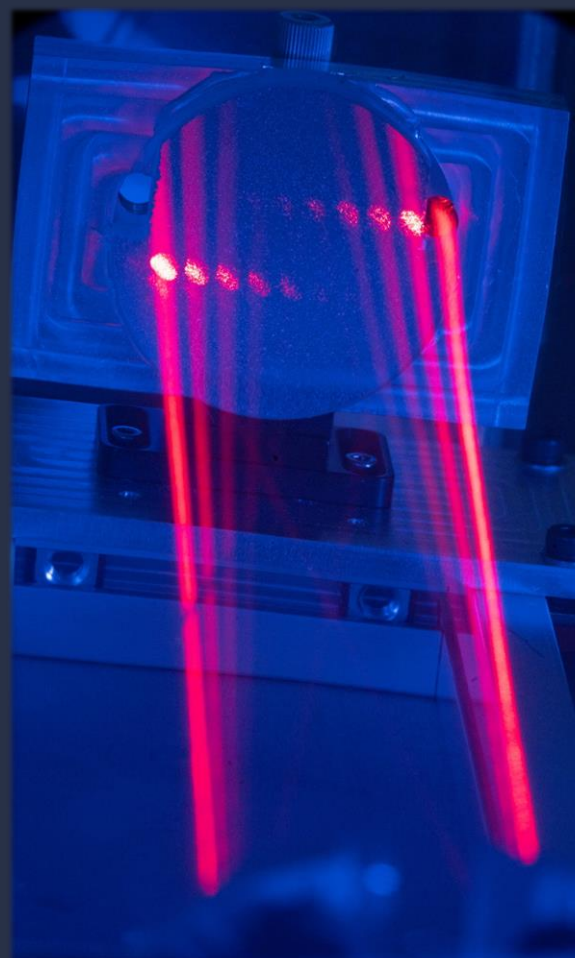
## Laser source (NKT Photonics A/S, Denmark)

- **Supercontinuum** based on ZBLAN fiber, at 200kHz repetition rate, 150 mW
  - >60mW average power, **centered at 3.3 $\mu$ m** (i.e., CH<sub>4</sub>, C<sub>6</sub>H<sub>6</sub>, N<sub>2</sub>O etc)
- Compact (**hand size**): 220 x 150 x 55 mm<sup>3</sup>
- Low power consumption: <12W



# Multi-pass gas cell (SenseAir AB, Sweden)

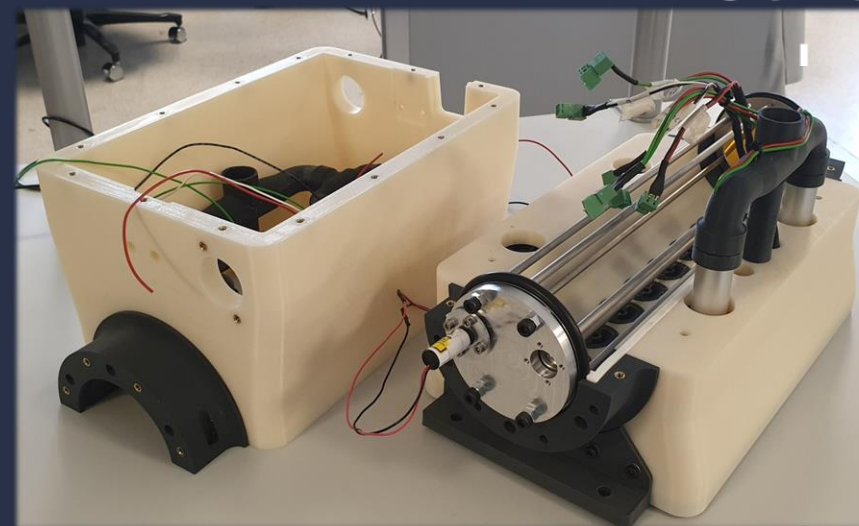
- **12 m optical path length** (physically 0.3 m length)
- Compact: 340 mm long, 80 mm diameter (size of a forearm)
- Packaged in a 3D printed structure for air flow and thermal management



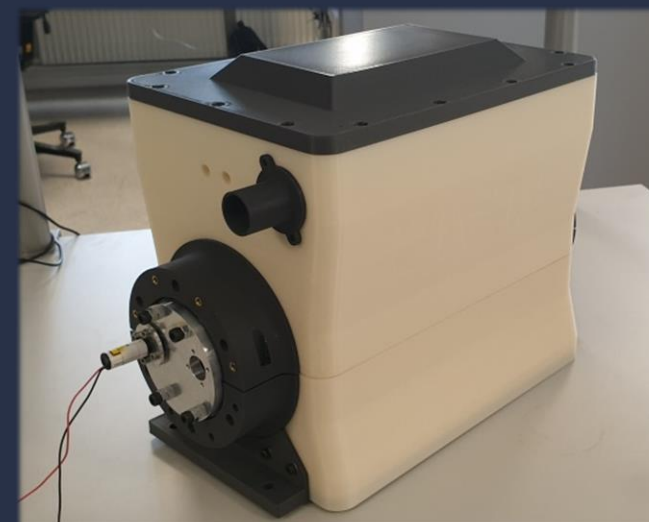
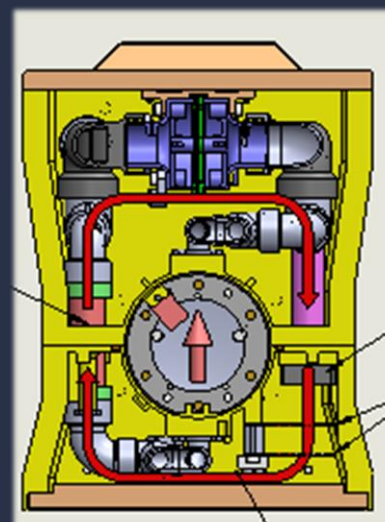
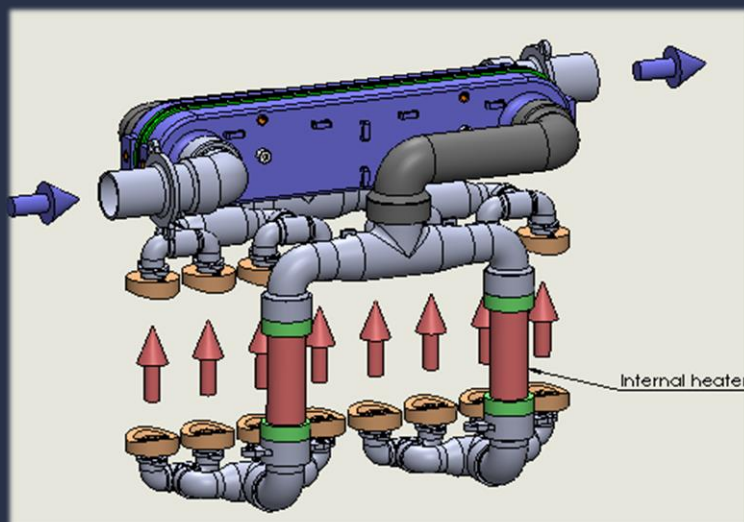
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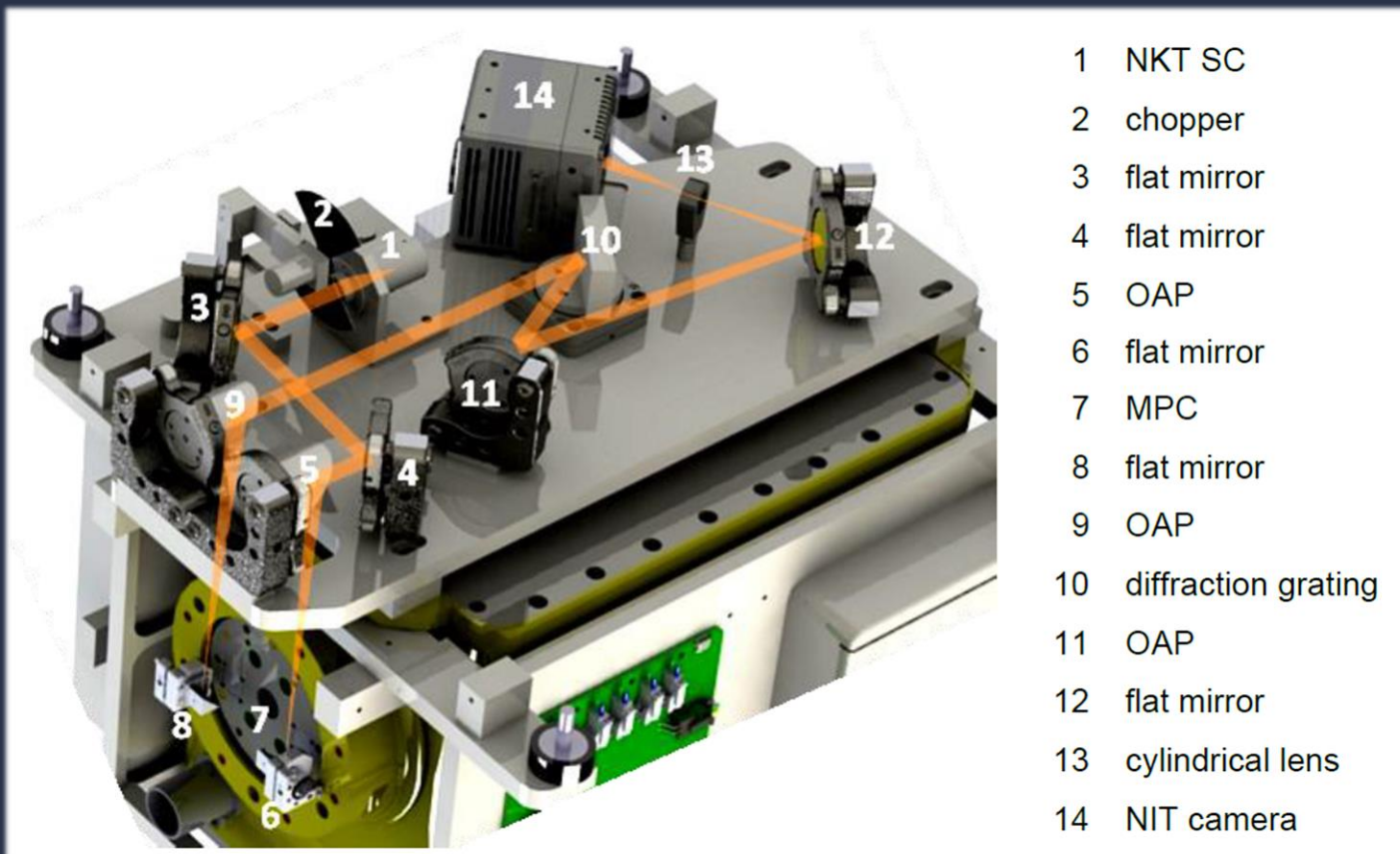




# Design of FLAIR Sensing System

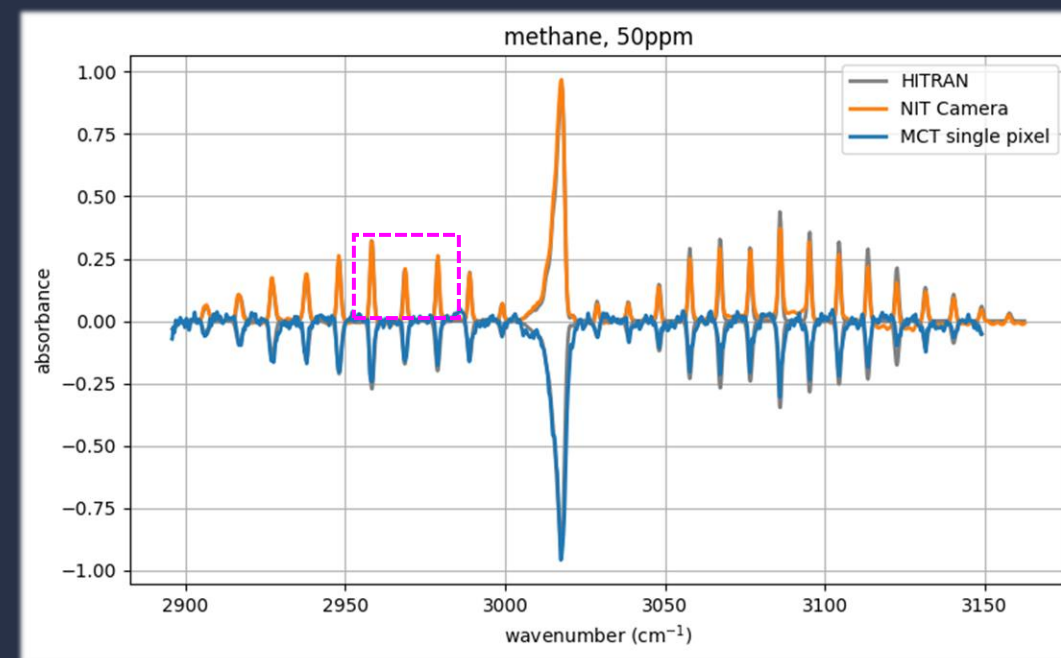


## Spectrometer design (CAD)



35cm  
35cm  
45cm  
16kg

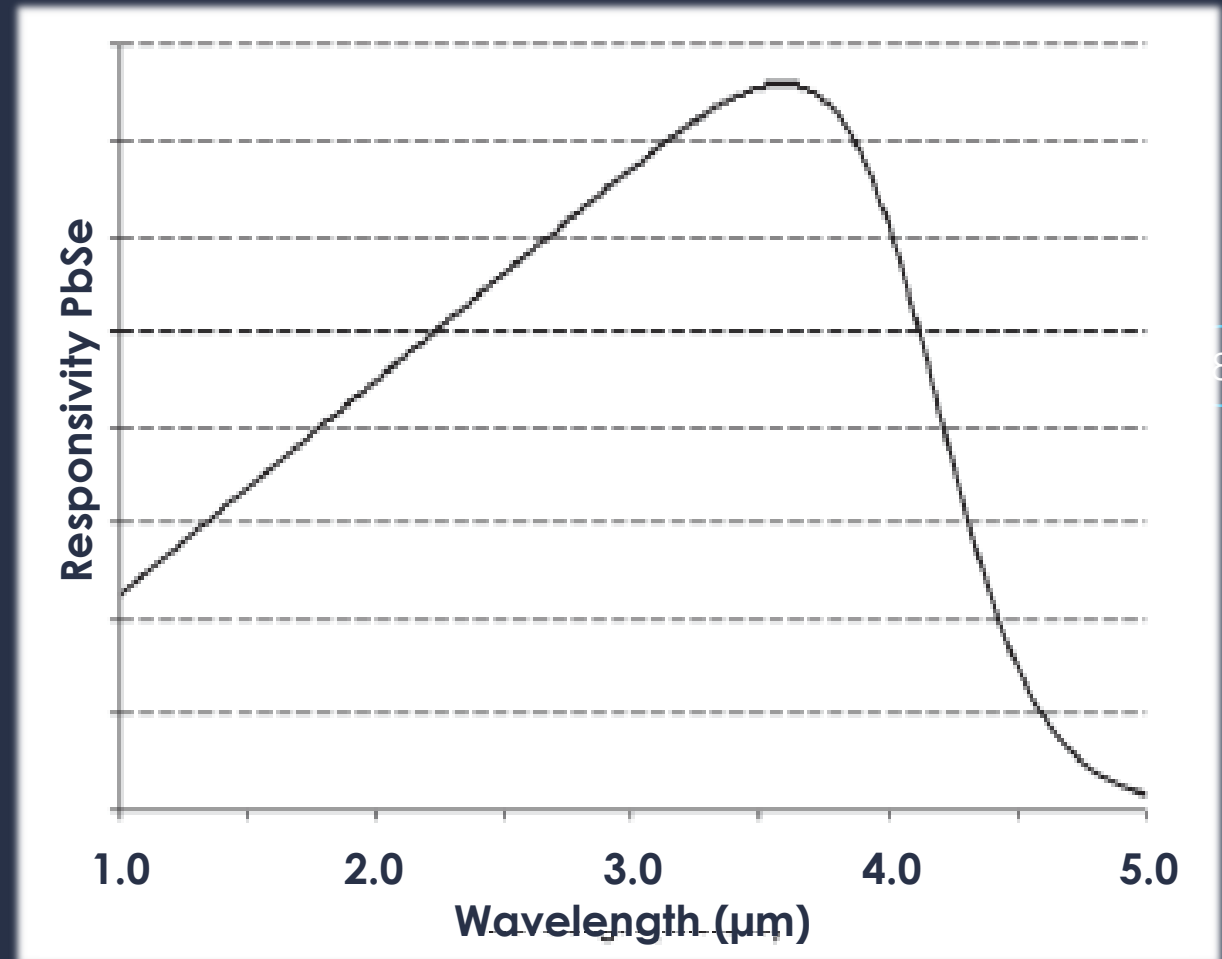
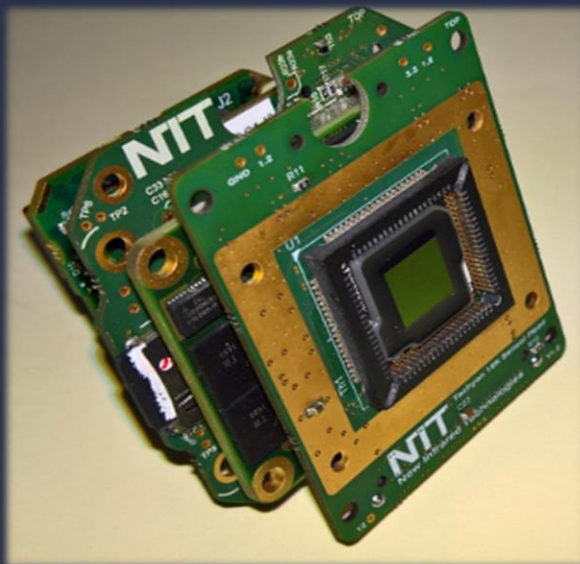
## MCT single pixel detector vs detector matrix



# Infrared Camera (New Infrared Technology SL, Spain)



- **Uncooled** 2D array detector (128x128 pixels) – Tachyon 16k camera
- VPD PbSe on Si-CMOS substrate
- Compact (**fist size**), 66 x 62 x 62 mm<sup>3</sup>
- **Speed**: up to 4000 fps at max
- **Cost-effective**

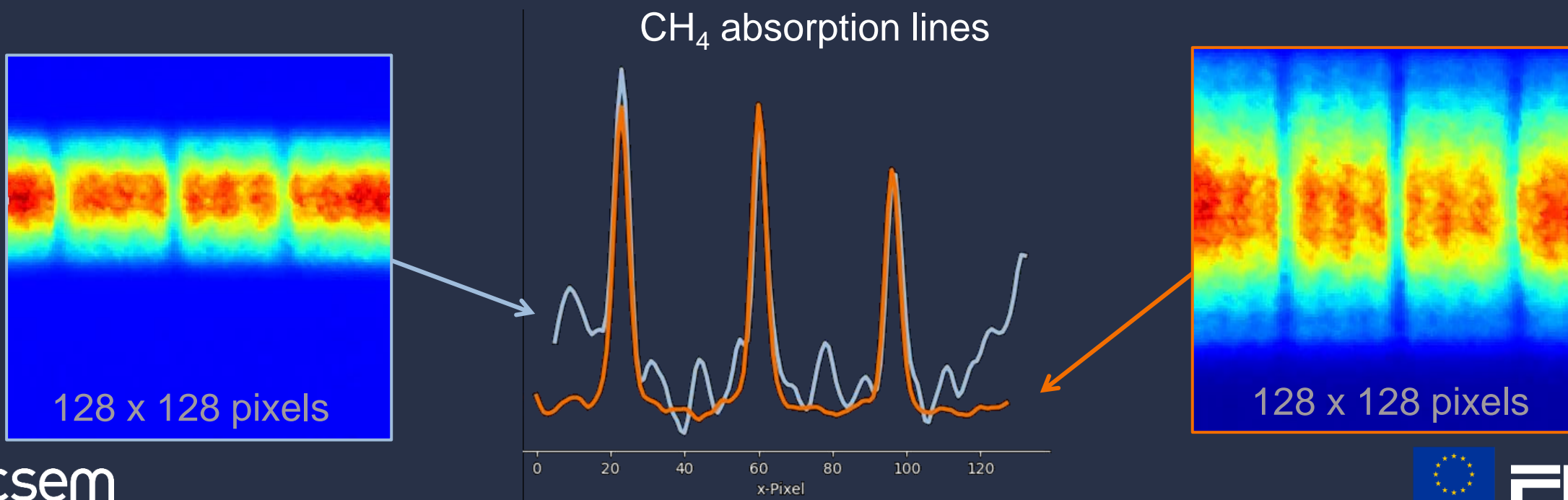
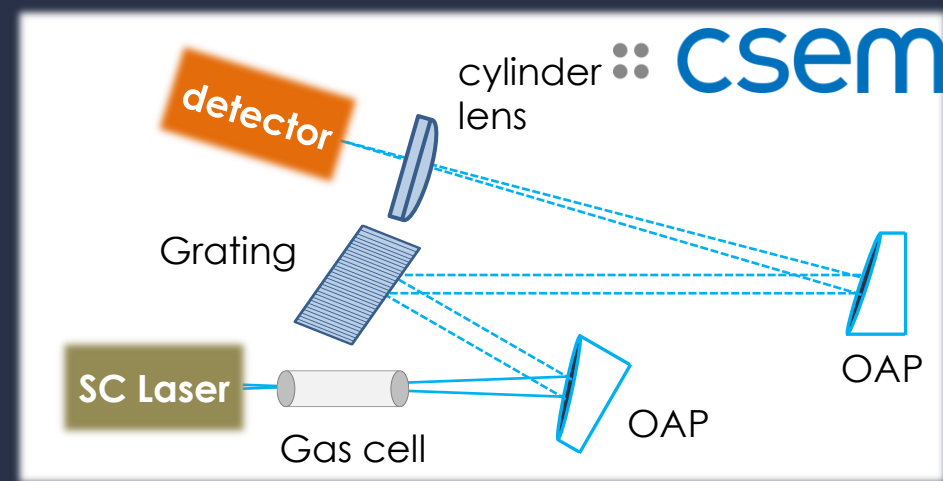


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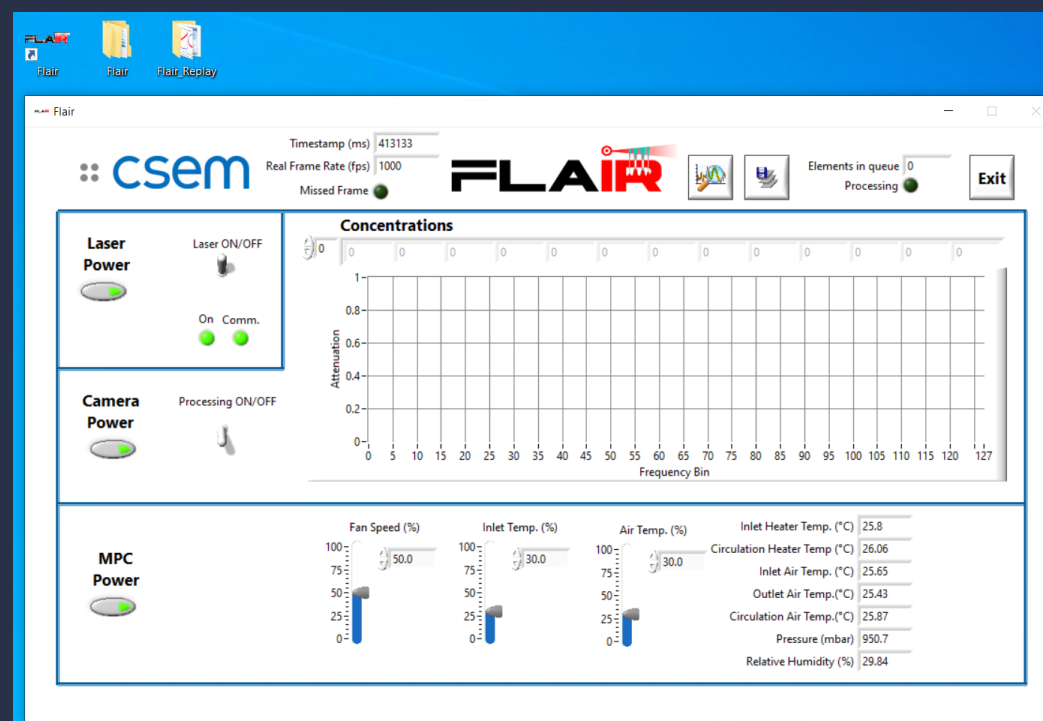
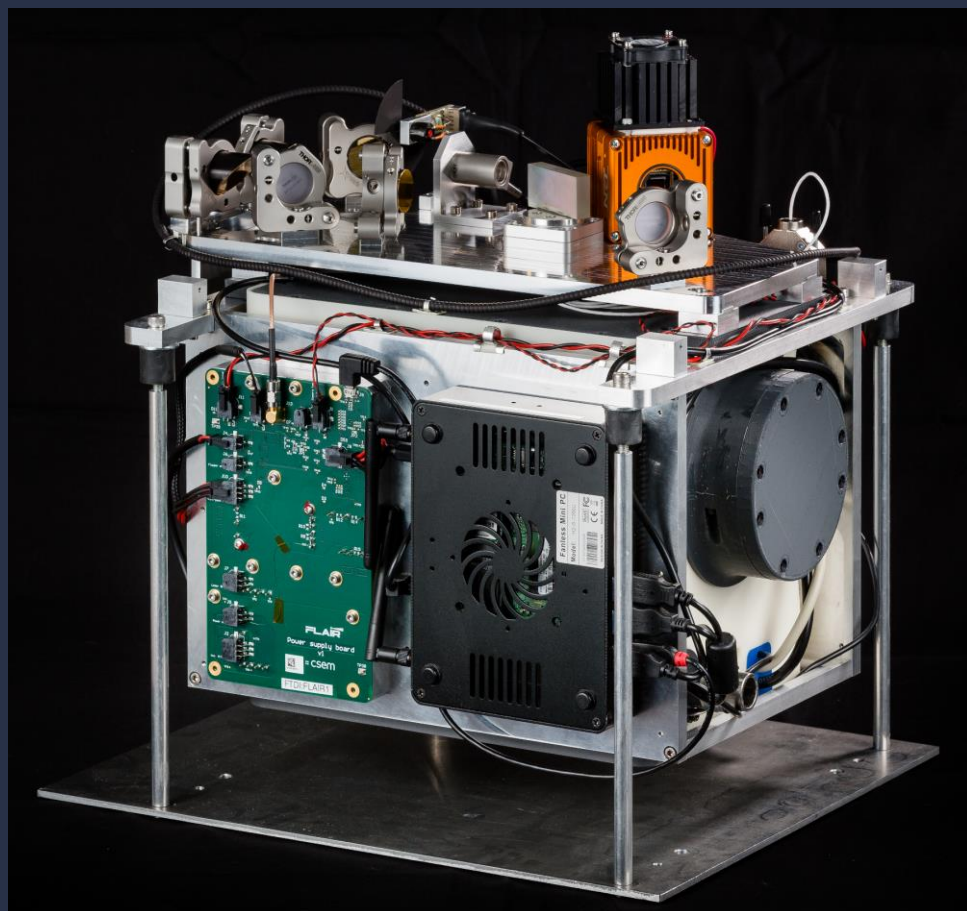
## Increasing SNR on FLAIR system

- Detection limit: **sub-atmospheric background level**
- **Non-uniform gain compensation** (NUC) on each pixel of camera and regular background removal
- **Lock-in** modulation (113 Hz) at 1000 fps
- 1.5 D dispersion, **by spreading the spectrum vertically and averaging** over the row pixels



# Final prototype – ready for takeoff

- **16 kg**, 55 liters (35 x 35 x 45 cm<sup>3</sup>), 9 – 36 VDC, ~80W power consumption
- Remote control and monitoring through 4G network

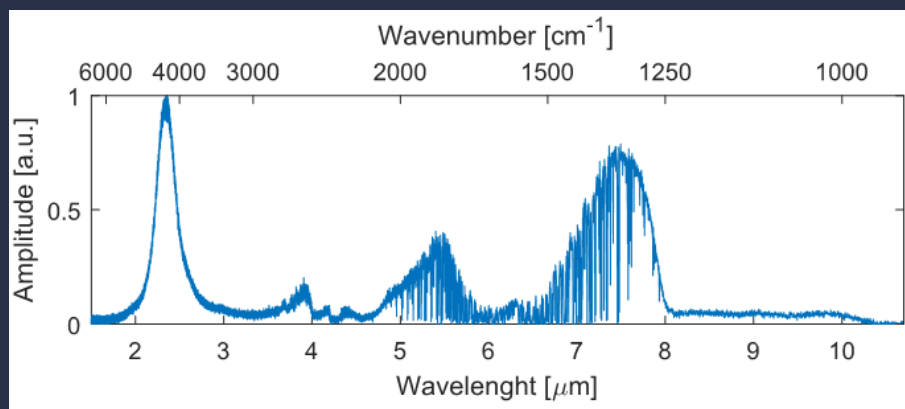


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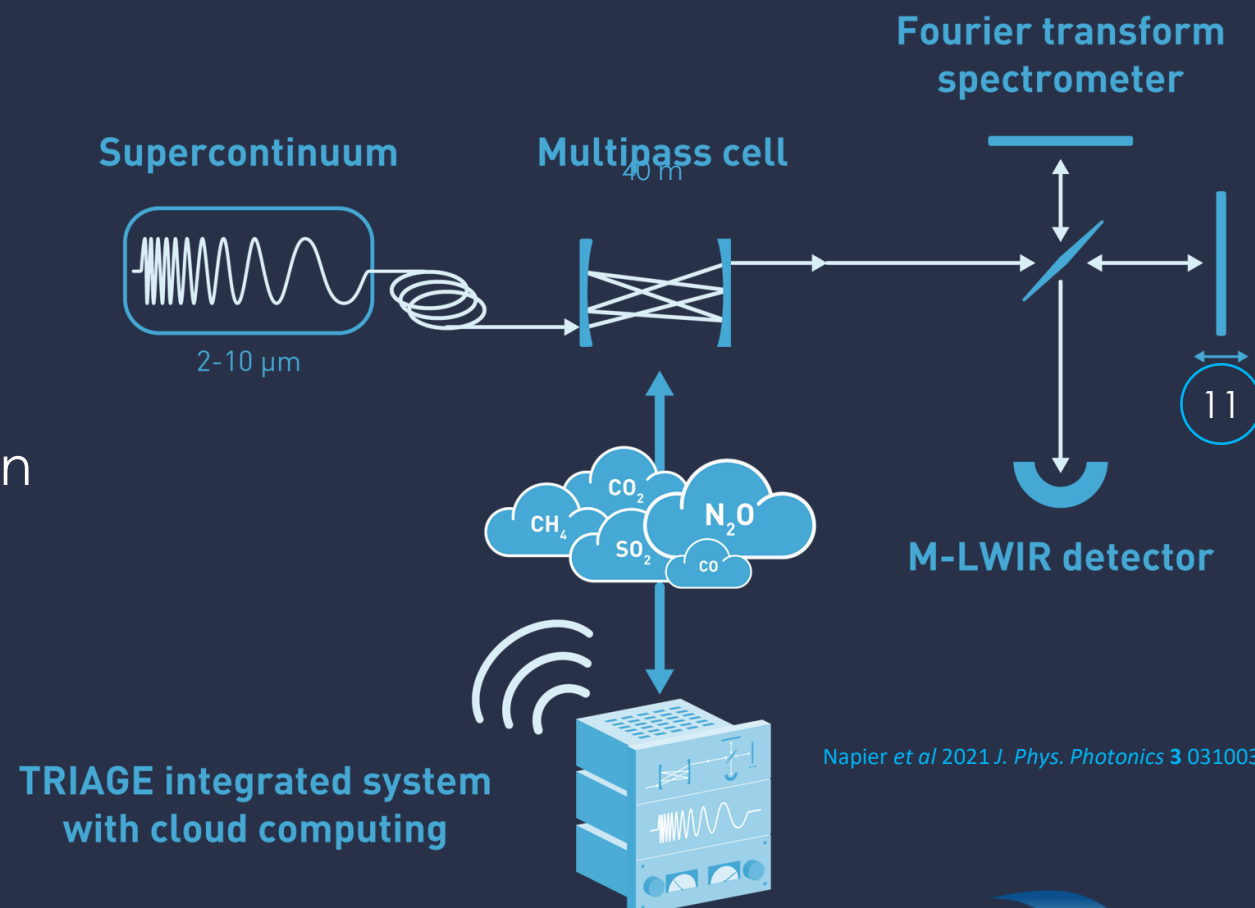
# H2020 – TRIAGE project

- Improved SC source: **2 – 10 μm** wavelength



Abbas et al 2021 Opt. Express 29, 22315-22330

- FTIR spectrometer** with balanced detection
- Machine learning** identification and concentration monitoring of gas species
- Big-Data** techniques for collecting, analysing and sharing data, **cloud computing**
- Environmental and industrial monitoring



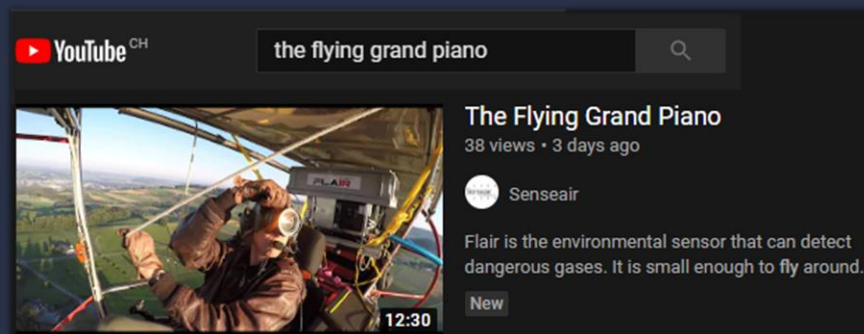
Napier et al 2021 J. Phys. Photonics 3 031003



## The Flying Grand Piano

<https://vimeo.com/507077454>

[https://youtu.be/JTiuh6G0\\_XA](https://youtu.be/JTiuh6G0_XA)



## The Dog & the Eagle

<https://vimeo.com/291061243>

[https://youtu.be/T\\_JUKMY\\_FMY](https://youtu.be/T_JUKMY_FMY)



Thank you for your attention !

