

# FINIS

## NEW METHANE DETECTOR TECHNOLOGY FOR POINT-SOURCE DETECTION AND LEAK RATE MEASUREMENTS

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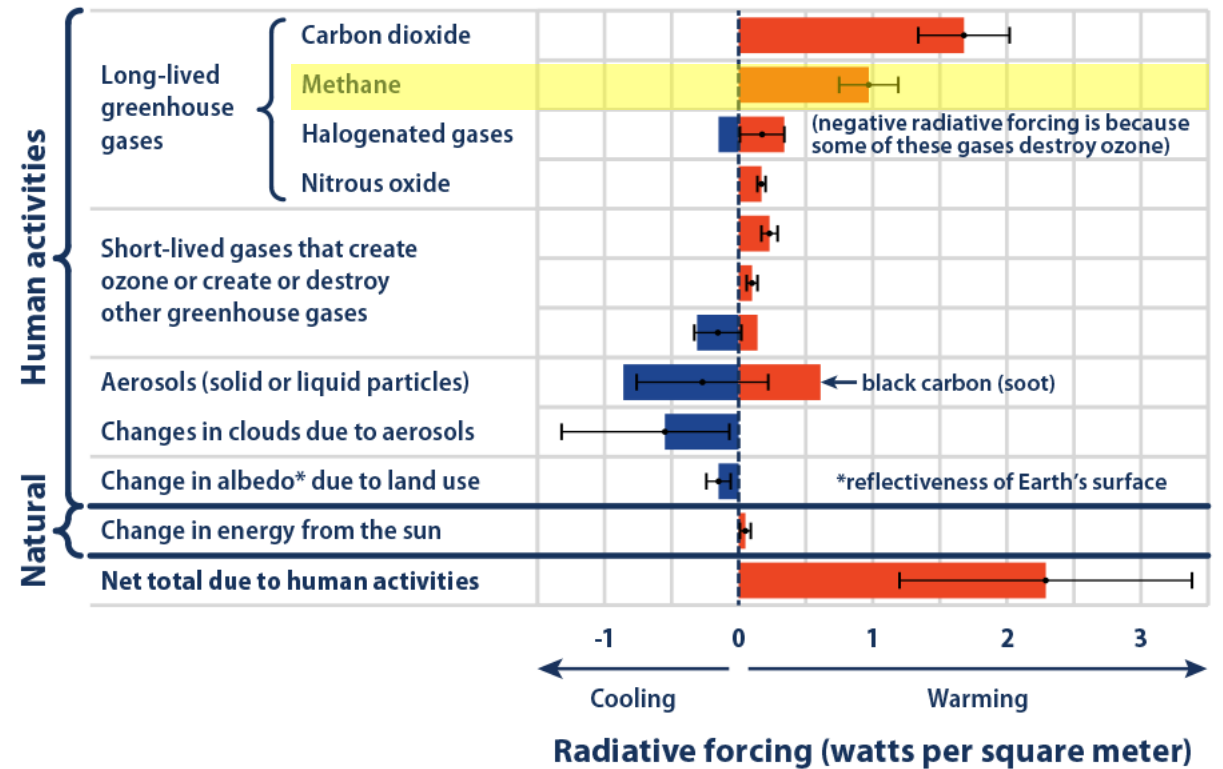
**36<sup>th</sup> Annual Small Satellite Conference**  
**AUGUST 6-11, 2022**



# Introduction

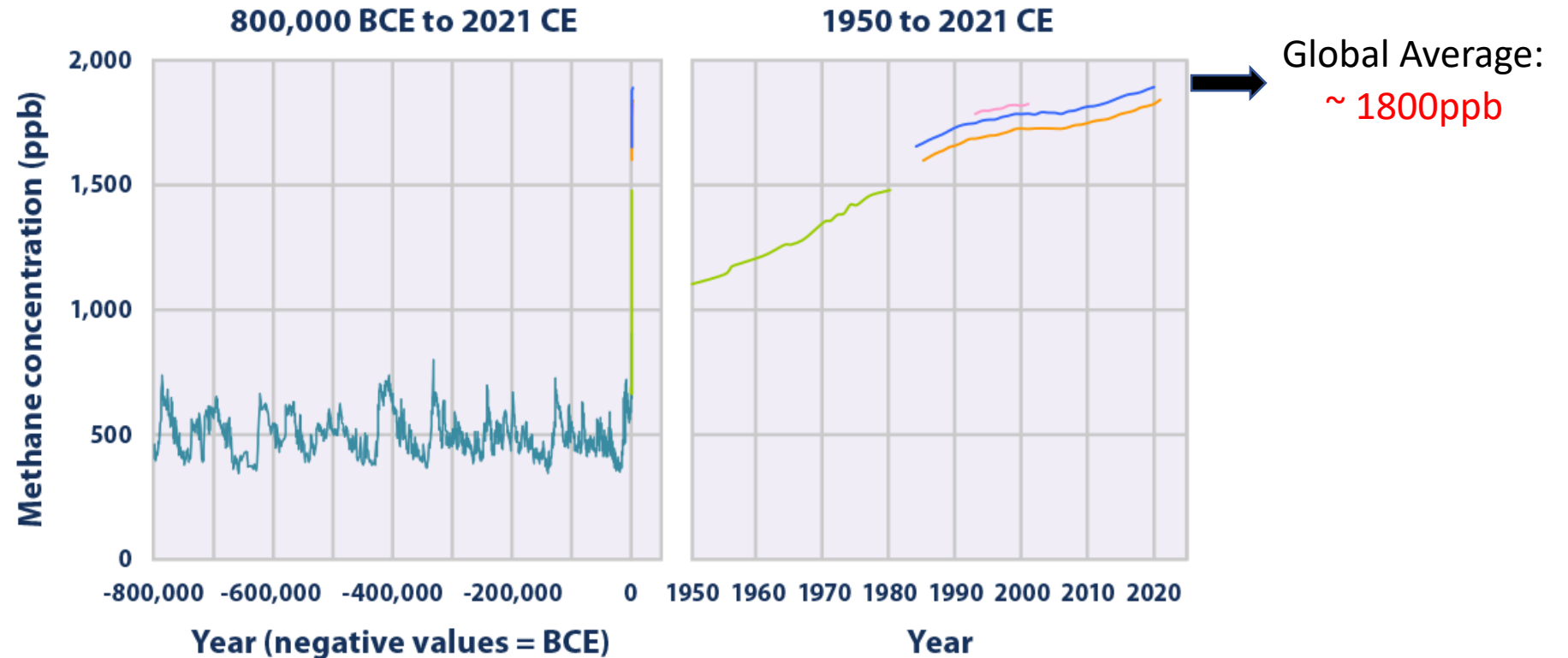
- FINIS stands for **F**ilter **I**ncident **N**arrow-band **I**nfrared **S**pectrometer;
- It is a low power and compact instrument design to detect and measure atmospheric methane concentration onboard small satellites;
- FINIS uses a tilted narrow-band filter to disperse the light and generate the methane absorption feature of the outgoing radiation reflected by the Earth's surface;
- FINIS's novel design is patented by USU;
- FINIS will be tested on the upcoming ACMES mission, which was selected in 2021 as part of the NASA In-space Validation of Earth Science Technologies (InVEST) program.

# Why do we care about Methane?



Source: IPCC (Intergovernmental Panel on Climate Change). 2013. Climate change 2013: The physical science basis. Working Group I contribution to the IPCC Fifth Assessment Report. Cambridge, United Kingdom: Cambridge University Press.

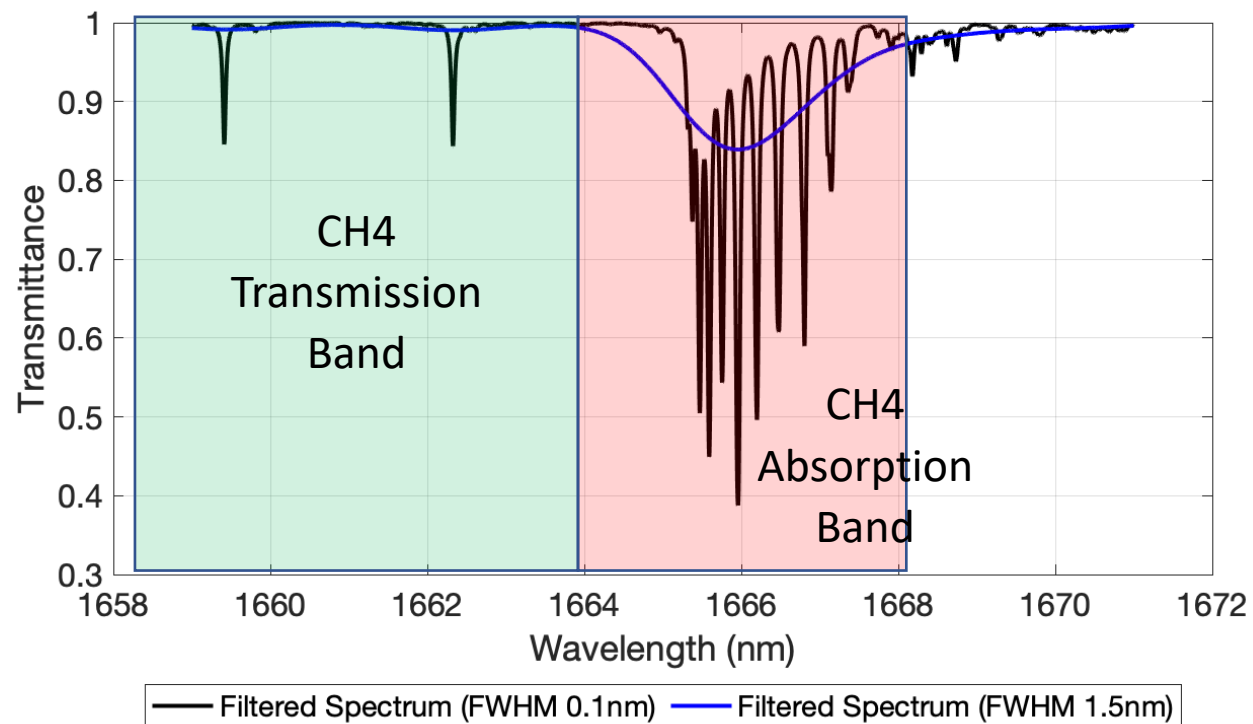
# Global Atmospheric Concentrations of Methane Over Time



Source: United States Environmental Protections Agency, EPA

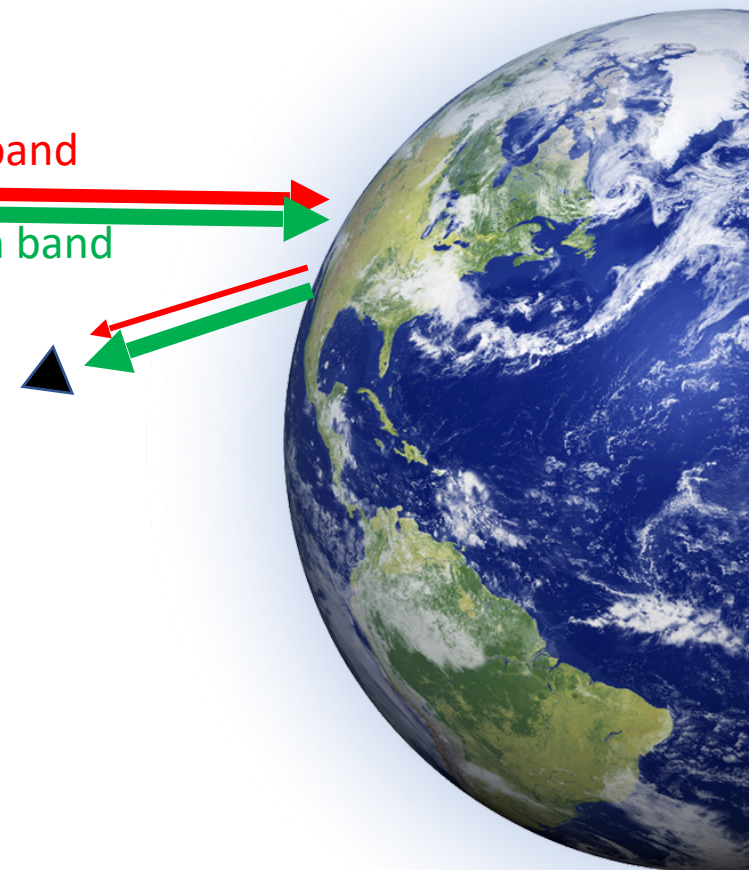


# Methane – Transmittance (SWIR)

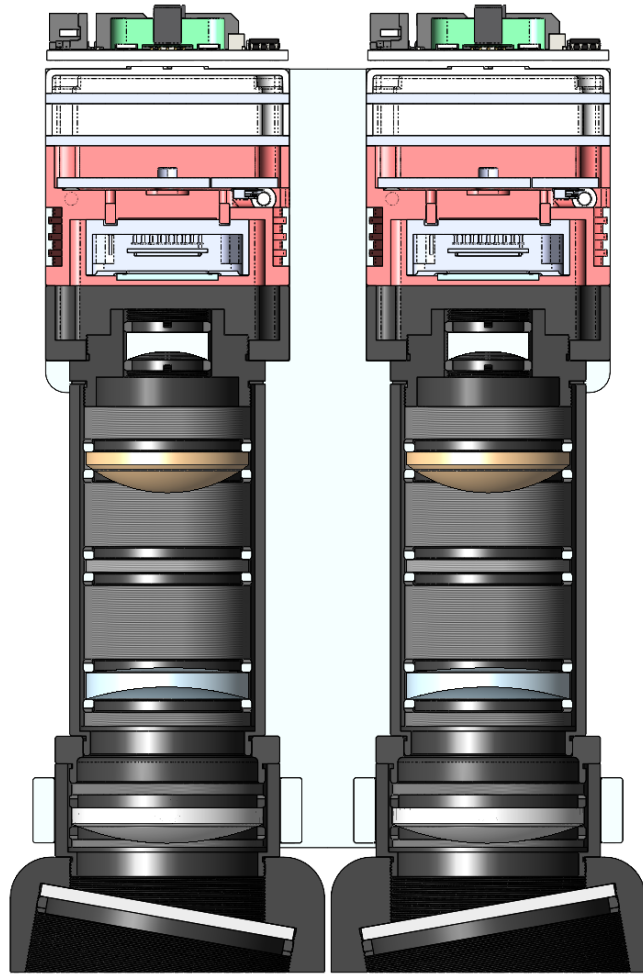


Absorption band

Transmission band



# FINIS – Instrument Overview



SWIR  
Cameras

Telescope  
Optics

Tilted Narrow-band  
Interference Filter

FWHM=1.5nm

Dimensions:  
15 x 10 x 6 cm

## FINIS

Mass:  
700 g  
Power:  
5W  
GSD:  
140m  
Swath:  
90km

## SCIAMACHY

Mass:  
198 kg  
Power:  
122W  
GSD:  
30km  
Swath:  
1000km

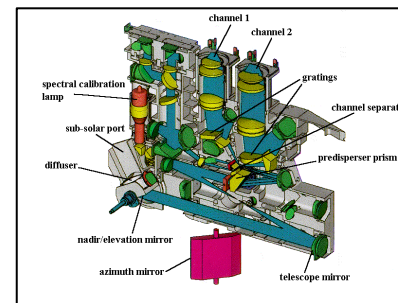
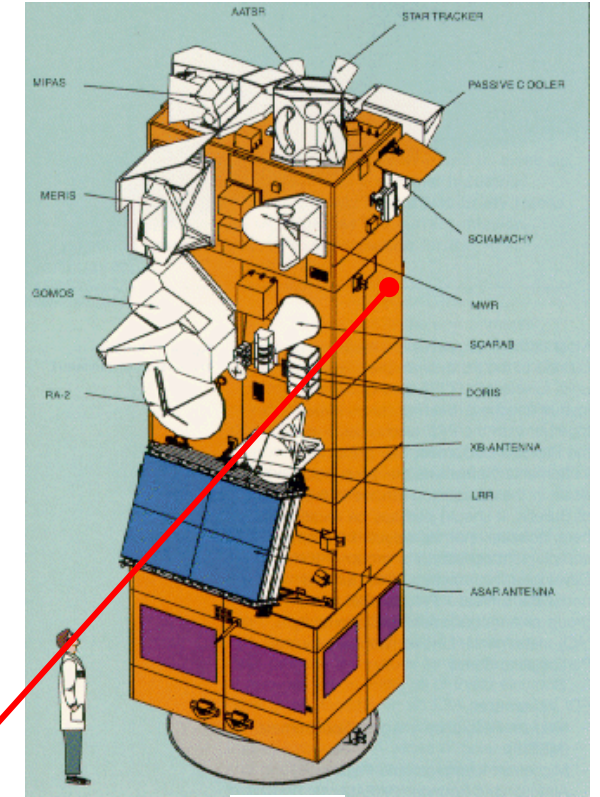
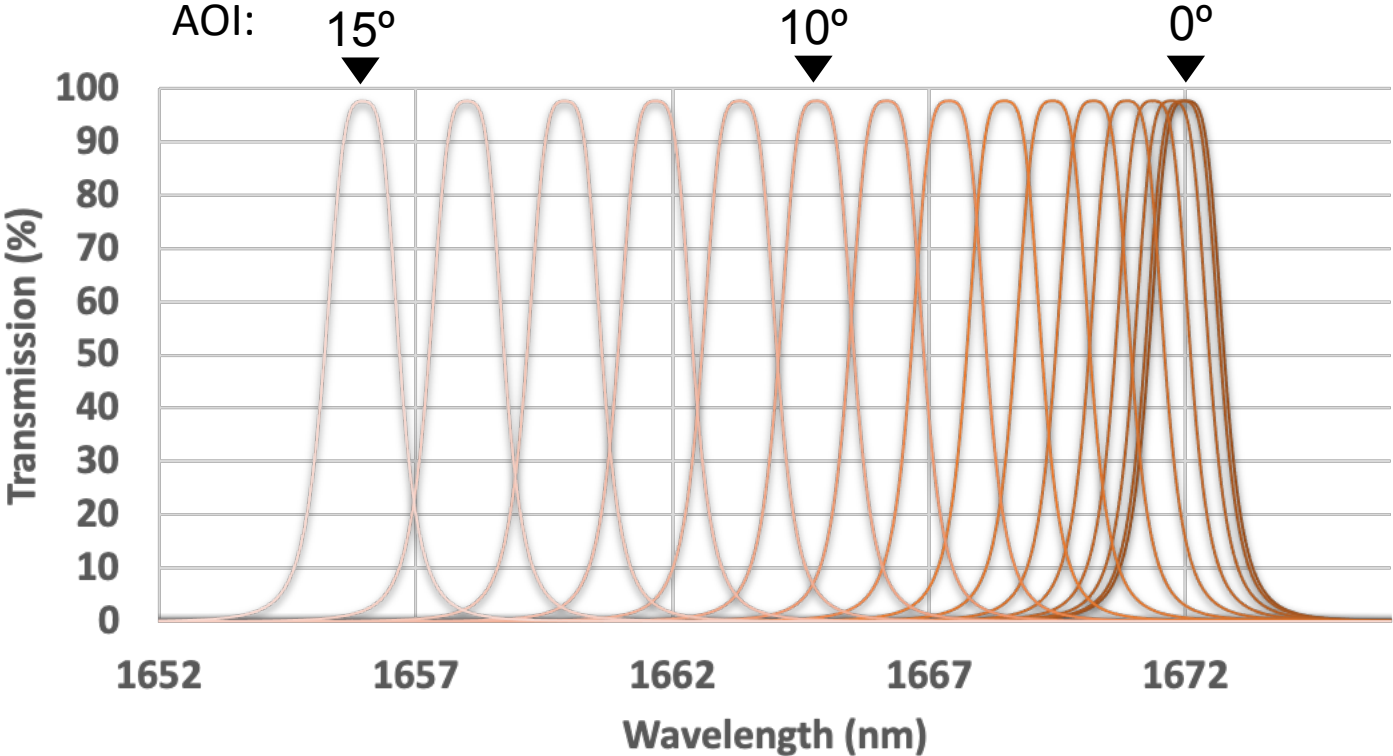


image credit: University of Bremen

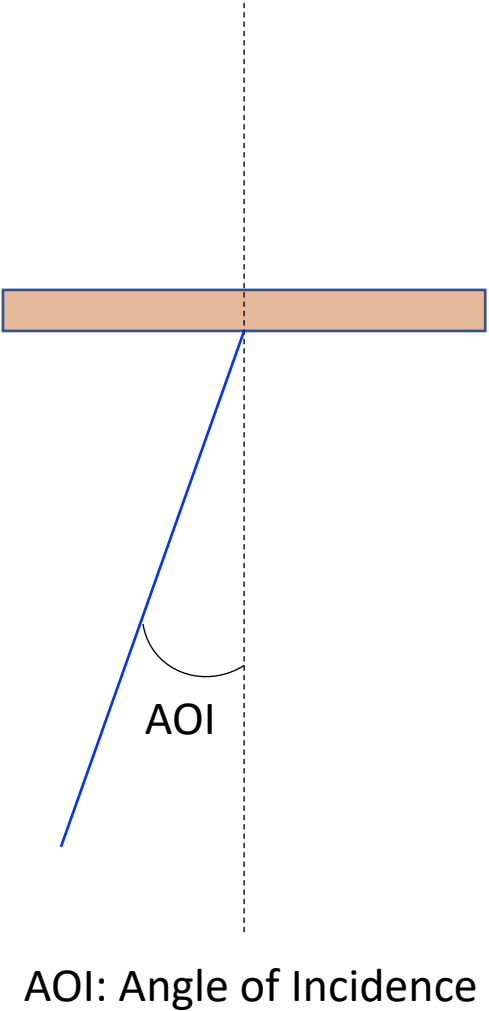


ENVISAT

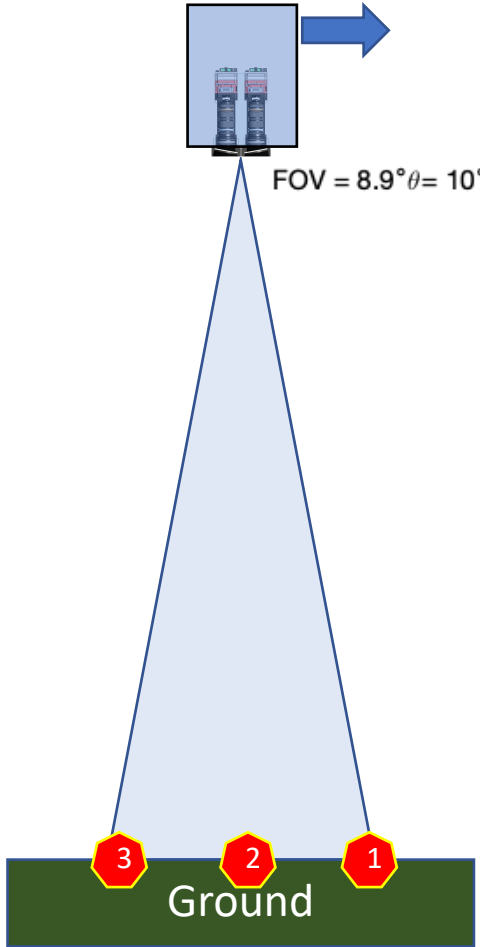
# Interference filters at different AOI's



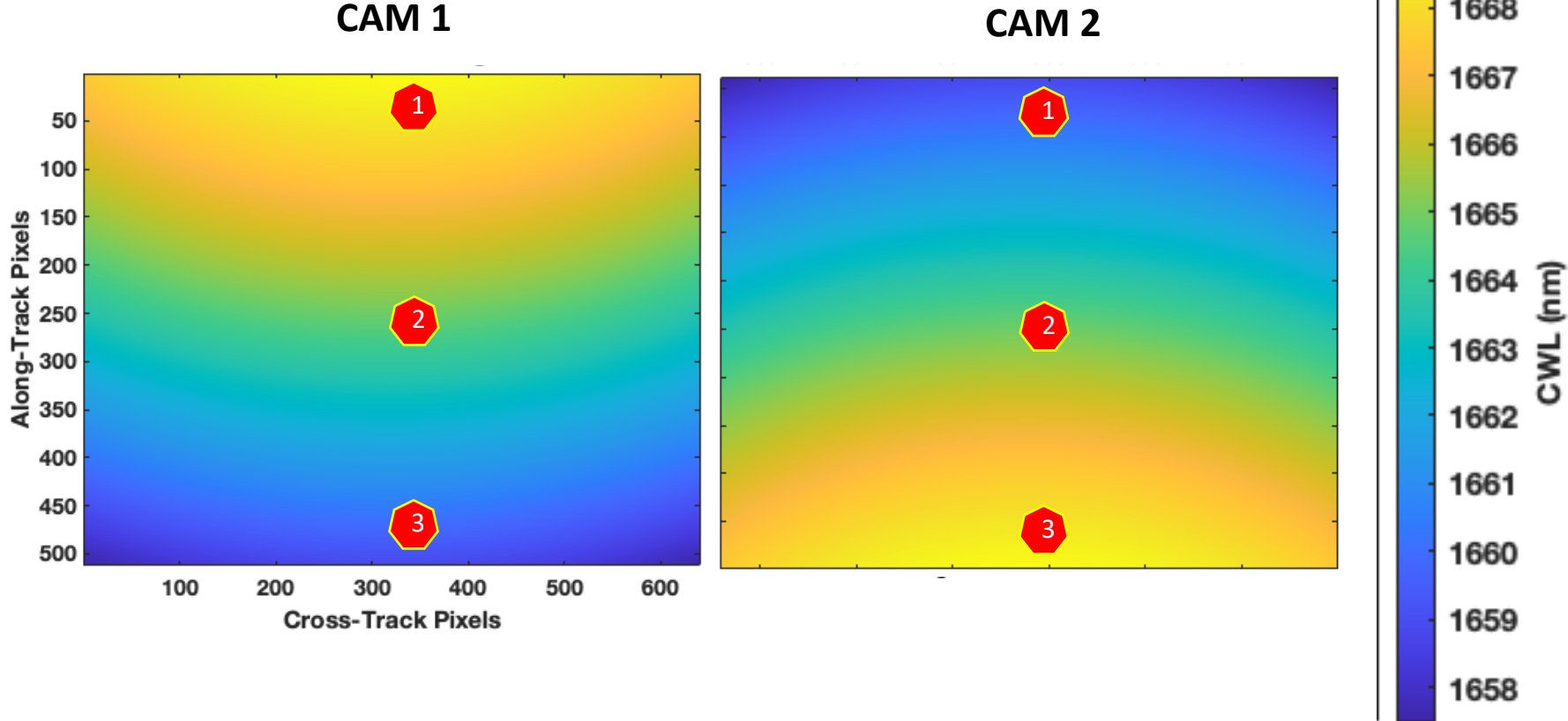
CWL<sub>0</sub> = 1672 nm  
FWHM = 1.5 nm



# Interference filters at different AOI's

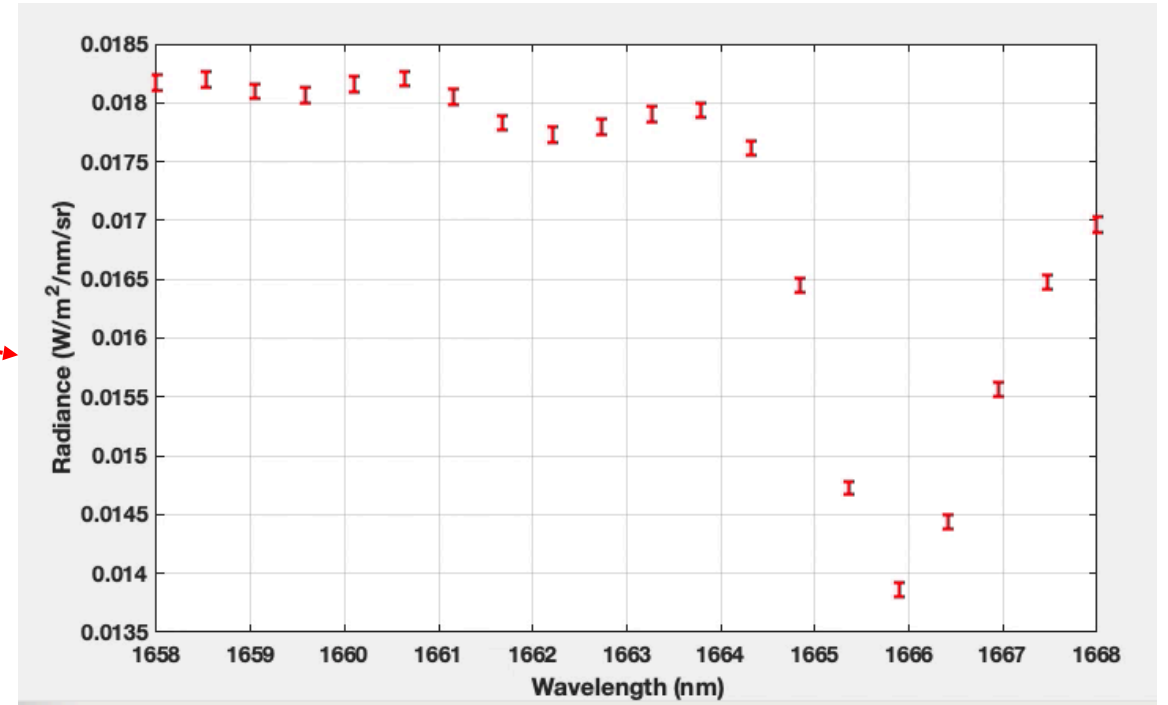
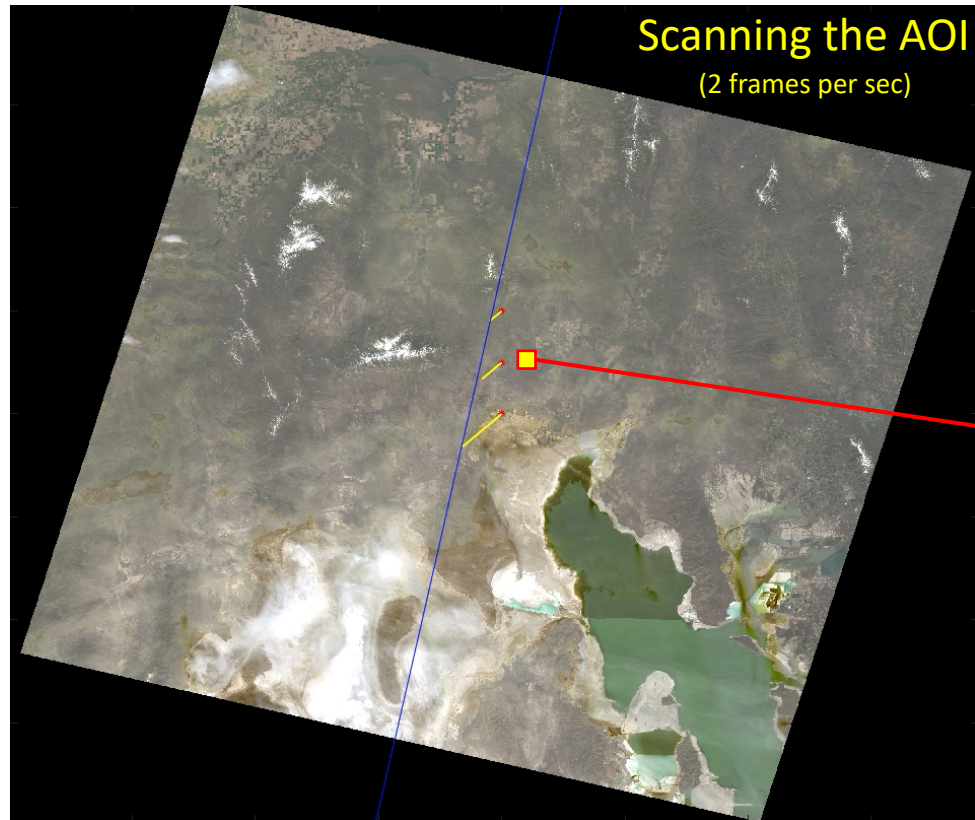


CENTER WAVELENGTH ACROSS THE TWO FPA'S

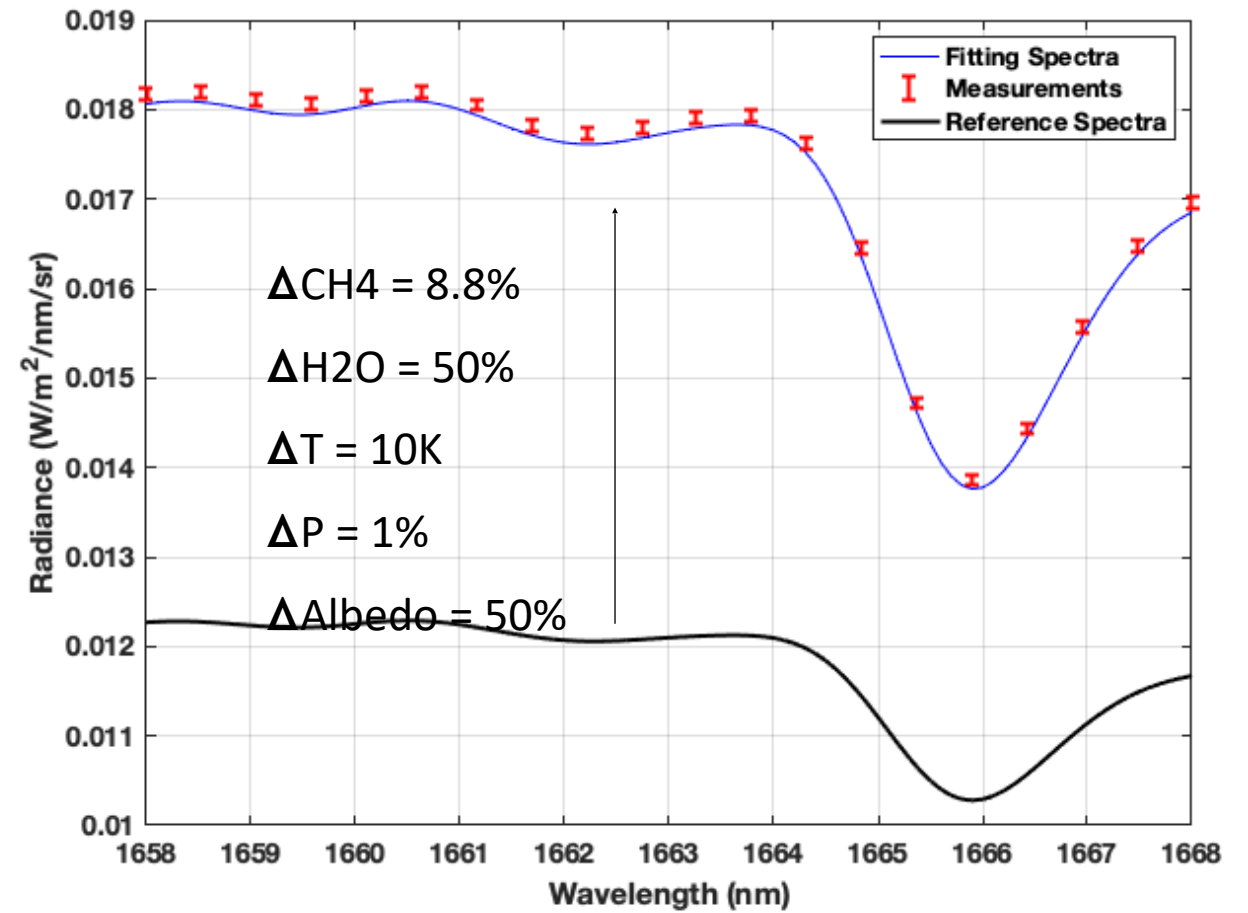
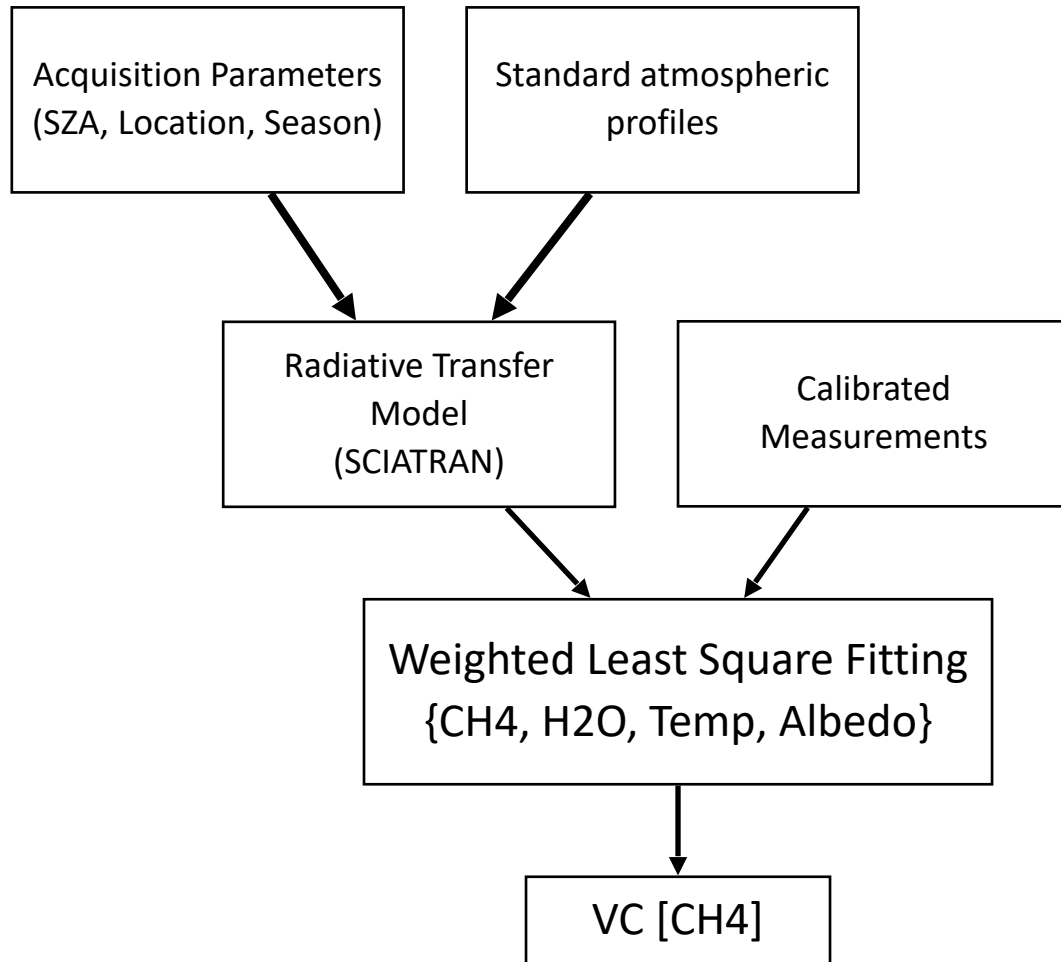




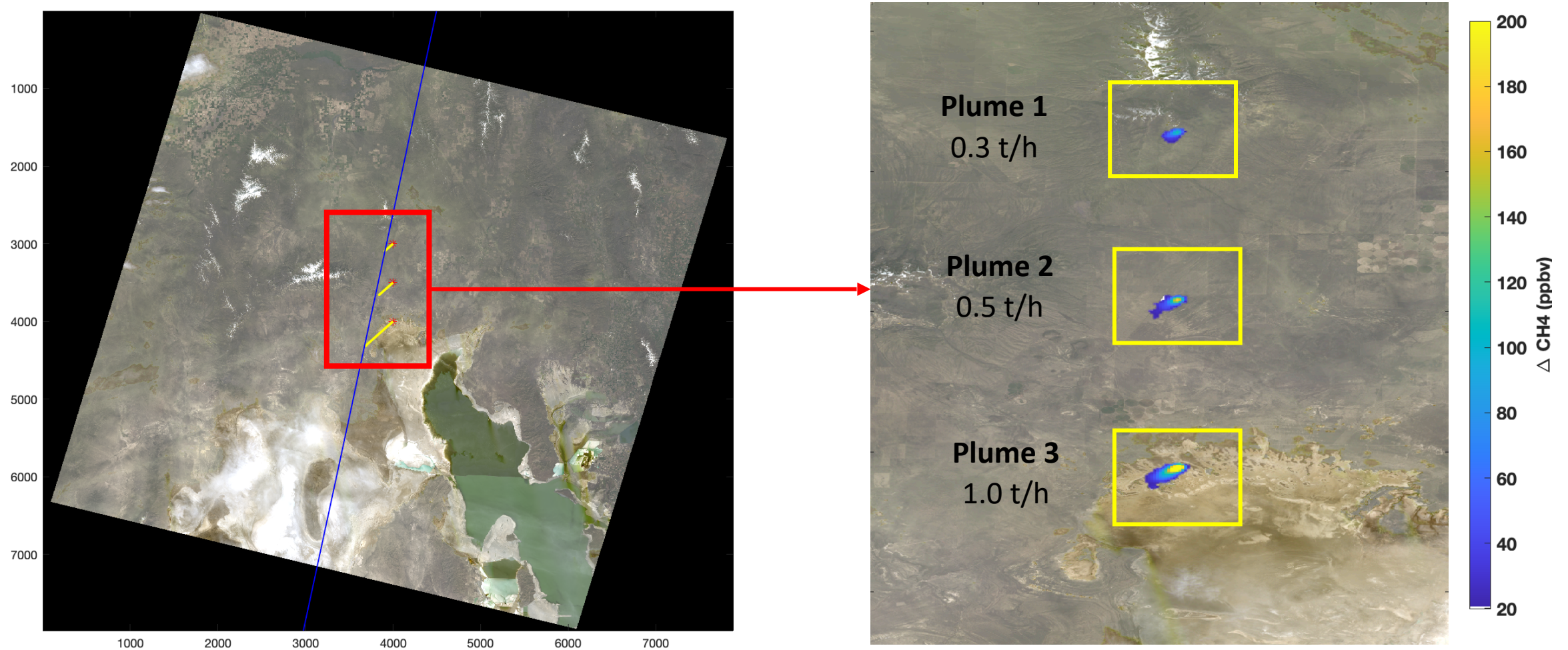
# Spectrum Acquisition



# Retrieval technique: WFM-DOAS

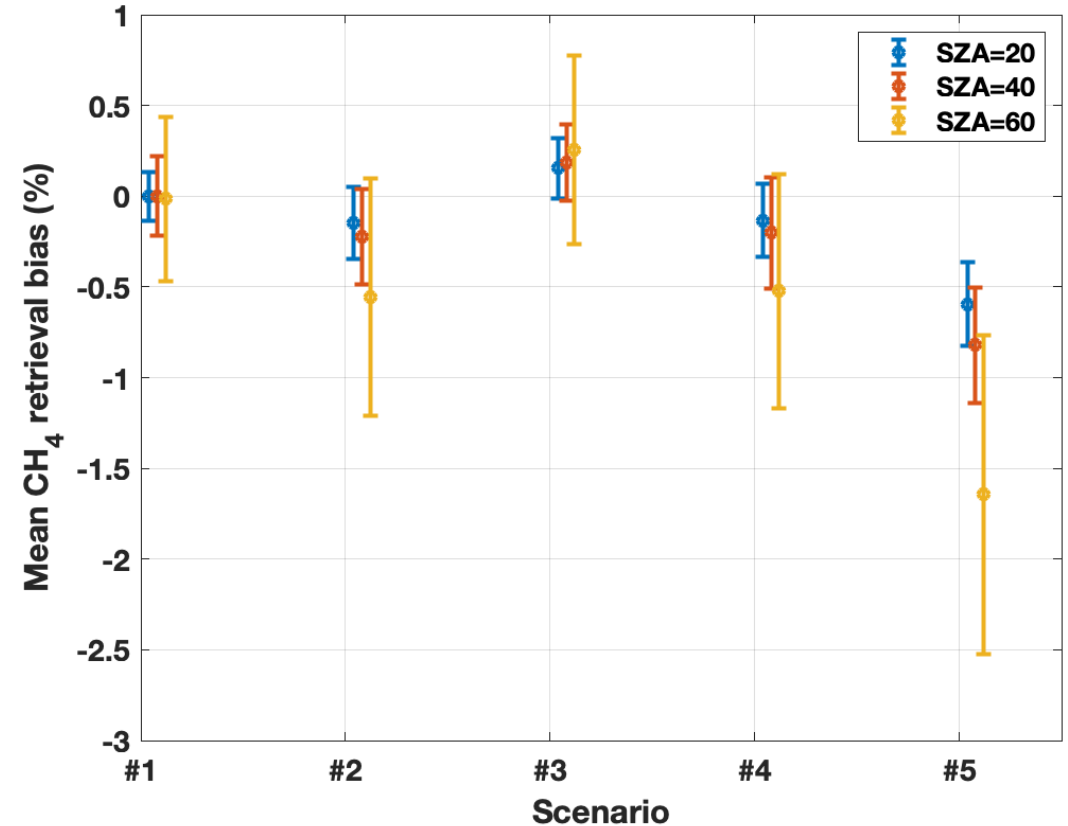


# Point source detection and leak rate measurement



# Performance Estimation

	Scenarios				
	1	2	3	4	5
<b>CH<sub>4</sub></b>	0%	+10%	+10%	+10%	-10%
<b>H<sub>2</sub>O</b>	0%	+50%	+50%	+50%	+50%
<b>CO<sub>2</sub></b>	0%	+10%	+10%	+10%	+10%
<b>AOD</b>	0%	+100%	+100%	+200%	+100%
<b>Press</b>	0%	-10%	-10%	-10%	-10%
<b>Temp</b>	0K	20K	-20K	+20K	+20K



For SZA<40°, the bias for the CH<sub>4</sub> vertical columns retrieval is expected to be less than 1% (~ 18 ppb)



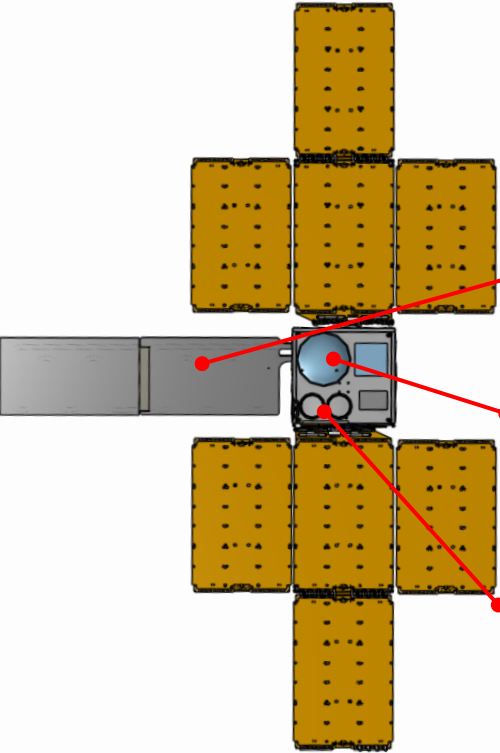
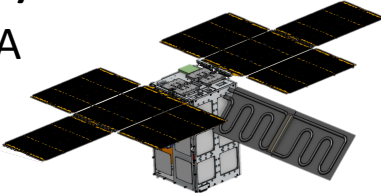
# Flight test and validation concept

## ACMES Mission (2025)

Funded by ESTO/NASA

SSO orbit @550km

Lifetime > 2yrs



**ATA (USU)**  
Active Thermal Architecture

**HiTy (UH)**  
Cryocooled Hyperspectral Thermal Imager

**FINIS (USU)**  
Filter Incidence Narrowband Infrared Spectrometer

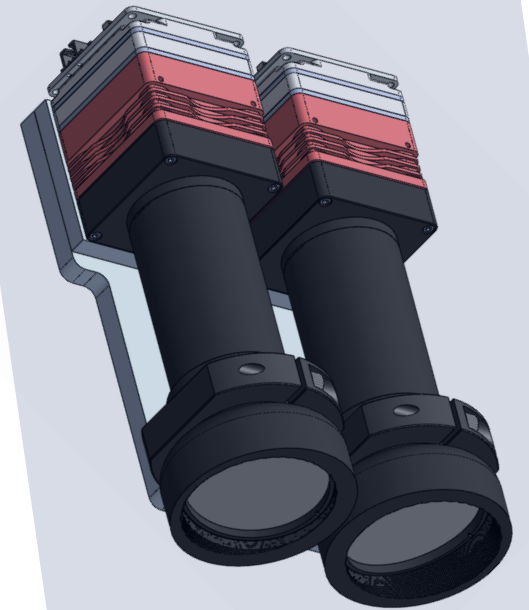
**PLAID (USU)**  
Planer Langmuir/Impedance Diagnostic



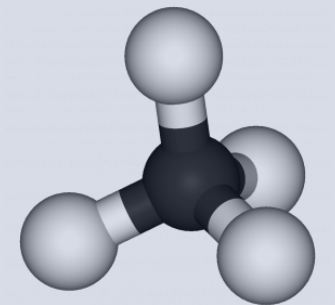
**Total Carbon Column Observation Network**

# Conclusion

- FINIS presents an innovative concept for measuring the atmospheric column density of methane using a compact, robust, and relatively inexpensive instrument.
- The tilted narrow-band interference filter provides a sufficiently wide spectrum range that covers the methane absorption and transmission bands around the  $1.66\mu\text{m}$ .
- FINIS development adds another possibility to further expand the use of CubeSats on the important mission of monitoring greenhouse gas emissions worldwide.
- Once validated in space, this instrument technology will be available for its use in CubeSat constellations, which will be able to provide frequent high accuracy methane measurements with medium spatial resolution, necessary to detect point source leaks and measure emissions rates on local and regional scales.



FINIS

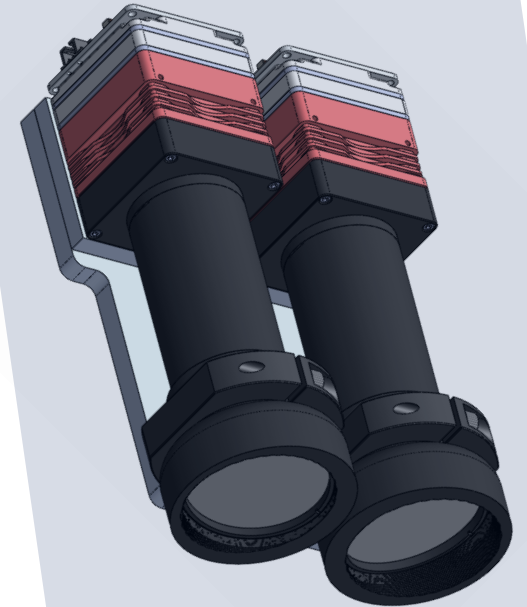


# Thank you!



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Stay in touch:



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