ESTF2020

The GLO (GFCR Limb Occultation) Sensor: A New Sensor Concept for Upper Troposphere and Lower Stratosphere (UTLS) Composition and Transport Studies.

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Program: AIST-18

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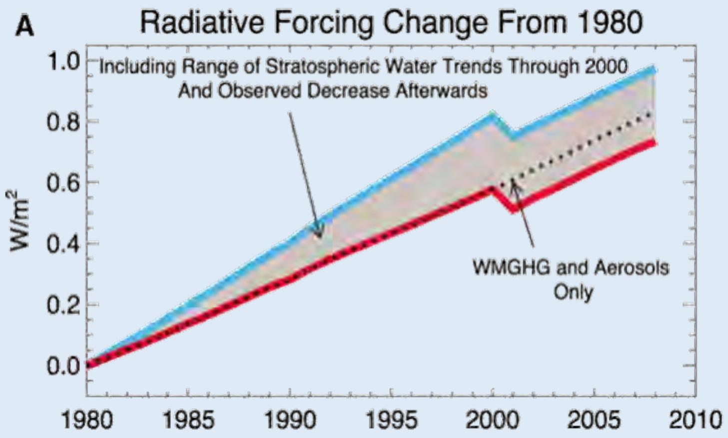
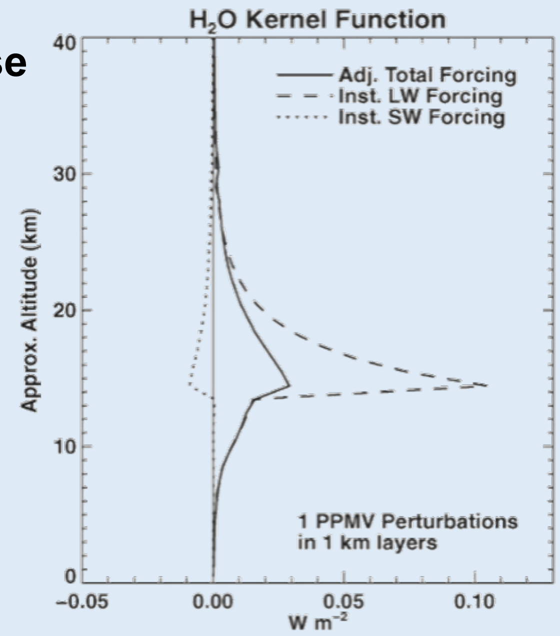
Recent composition changes in the UTLS have significant implications for climate change, but are not understood.

H_2O Trends:
1980-2000: ~0.5 ppmv/decade increase
2000-2001: ~0.5 ppmv decrease

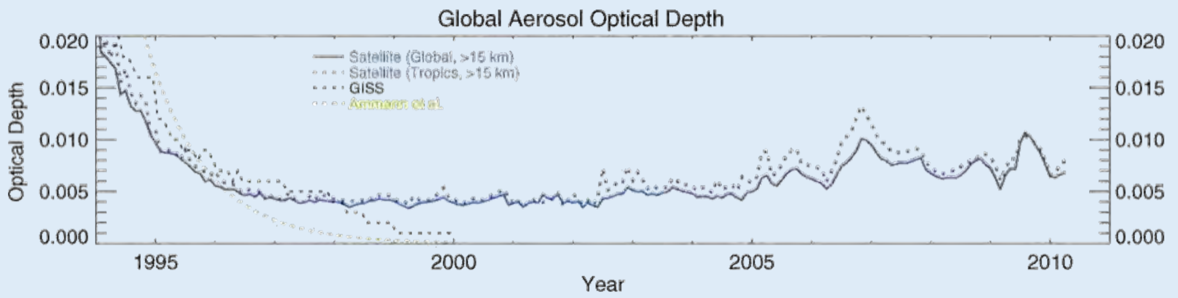




H_2O radiative forcing:
1980-1998: +0.24 Wm^{-2}
CO2 forcing: ~+0.36 Wm^{-2}

1996-2005: -0.098 Wm^{-2}
CO_2 forcing: ~+0.26 Wm^{-2}

Lower Stratosphere Aerosol Trends:
2000-2010: 4-7% per year increase
(Hoffman et al., 2009)



Aerosol radiative forcing: 2000-2010: ~-0.19Wm^{-2}
45% of forcing between trop and 15 km (Ridley et al., 2014)

- **Combined effects resulted in a negative (cooling) radiative forcing of ~80% of the positive CO_2 forcing (warming) during the 2000-2009 period.**
- **The cause of these changes is not well understood: indicative of importance of UTLS transport because the distribution of radiatively active constituents in the UTLS is mainly controlled by stratosphere/troposphere exchange.**

The GLO Instrument Uses Broadband Radiometer and GFCR Channels to Achieve High Vertical Resolution and Precision Solar Occultation Measurements

Top system-level requirements (subset):

- 0.5 km vertical resolution from 600 km orbit
- SNR: 300,000:1 above the atmosphere
- SWaP: 29x16x16cm (O), 5.25 kg (O), 28.2 W (O)

Top level derived requirements (subset):

- Image full sun for pointing knowledge - automated edge detection
- Solar diameter of 211 pixels for signal aggregation (supports SNR and vertical resolution requirements)

9 GFCR Channels

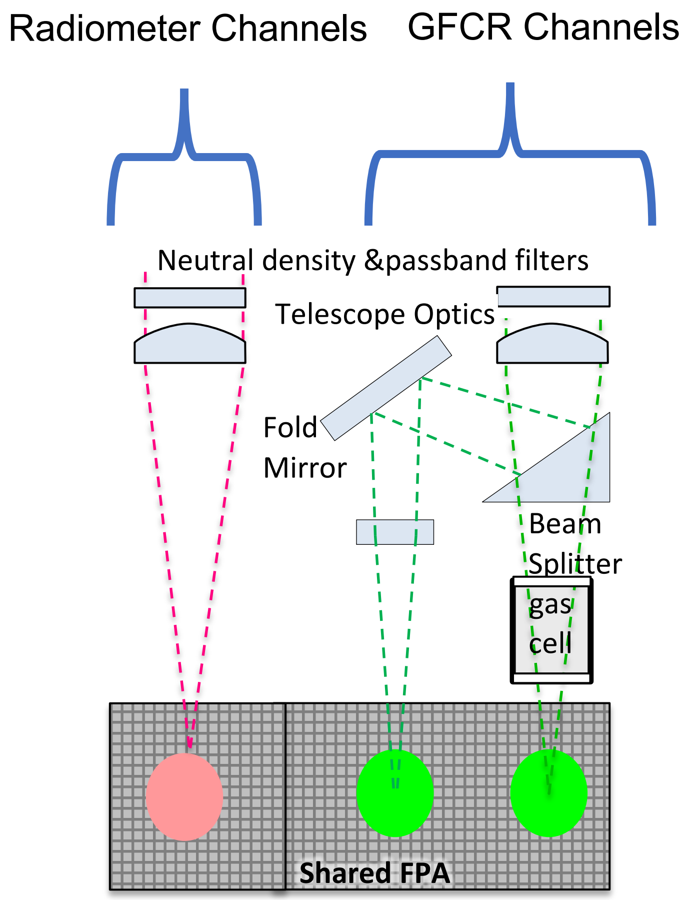
	Channel	λ_0 (μm)	$\Delta\lambda$
Radiatively Active	H_2O	2.503	0.0626
	O_3	2.475	0.0371
	CH_4	2.305	0.0461
	N_2O	3.905	0.0976
Tracers	CO	2.335	0.0537
	HDO	3.710	0.1113
	HCN	3.005	0.0601
	HCl	3.380	0.1014
	HF	2.455	0.0491

5 Single (broadband) Radiometer Channels

Channel	λ_0 (μm)	$\Delta\lambda$
aerosol	0.45	0.0045
aerosol	1.02	0.0102
aerosol	1.556	0.0156
H_2O	2.60	0.052
CO_2 (T)	2.80	0.056

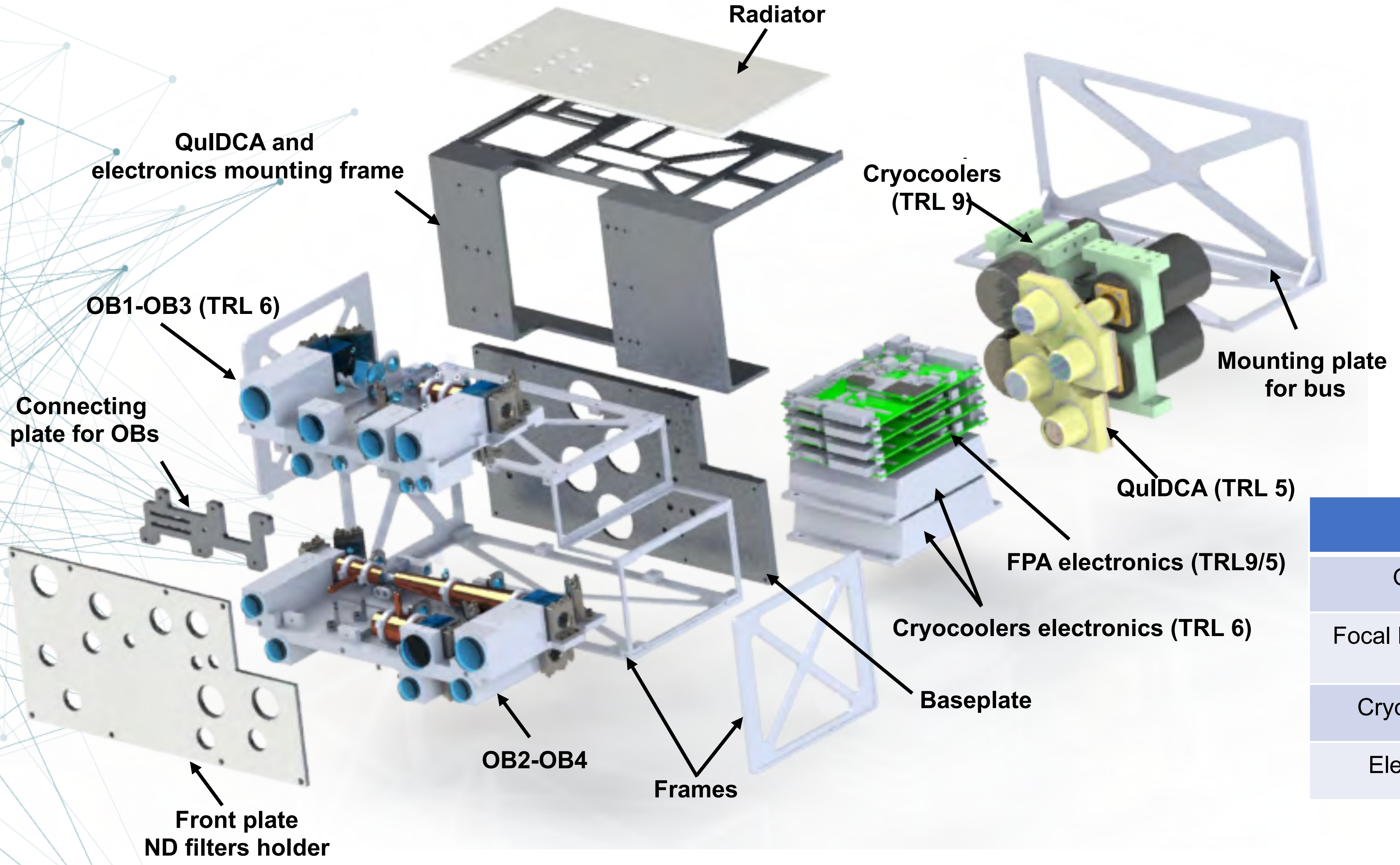
Highlighted wavelengths are also used for aerosol composition & particle properties.

Instrument Approach



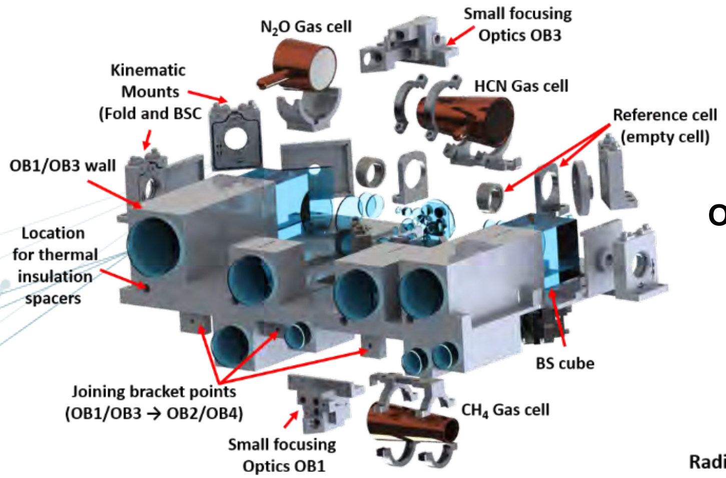
6 images of the sun on each detector.

GLO Design is Complete and Utilizes Heritage Components



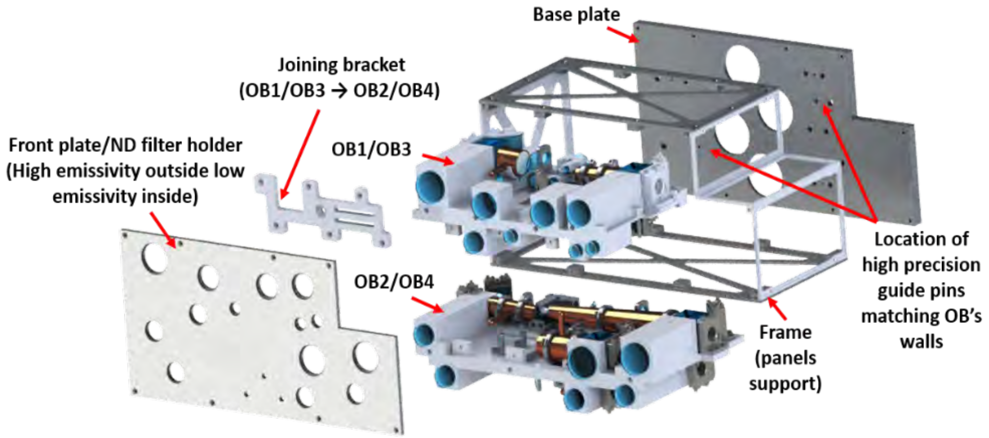
Item	Heritage
Optics	COTS
Focal Plane Array	Lockheed Martin nbn SBF207 FPA
Cryo Coolers	Ricor K508N
Electronics	Xiphos Q7S

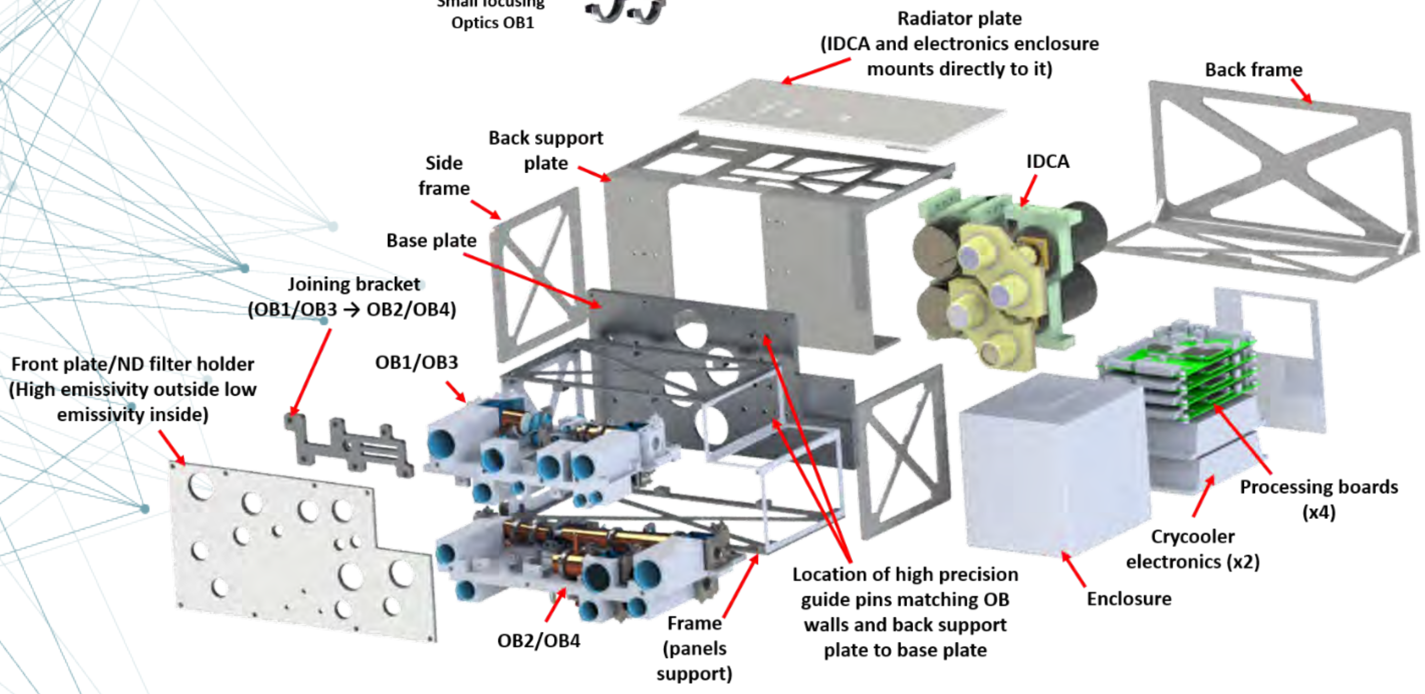
GLO is Designed to be Compact for Constellation Missions and for Straightforward Assembly

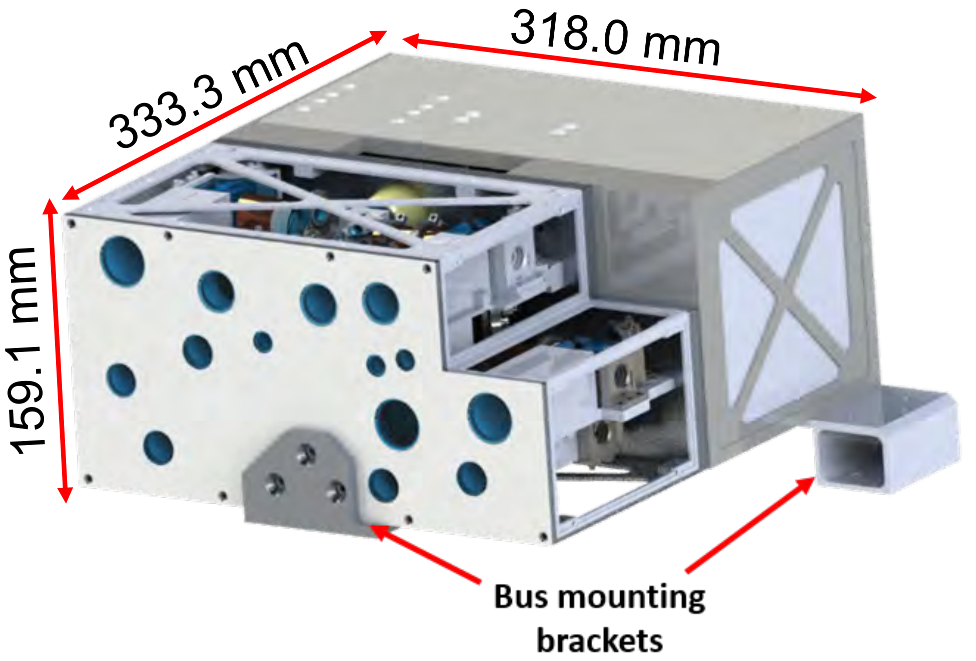


OB1/OB3

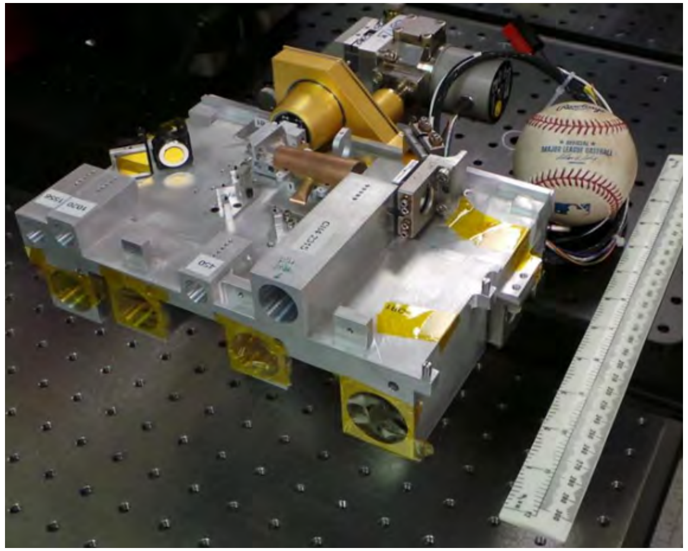
Front end assembly exploded and collapsed







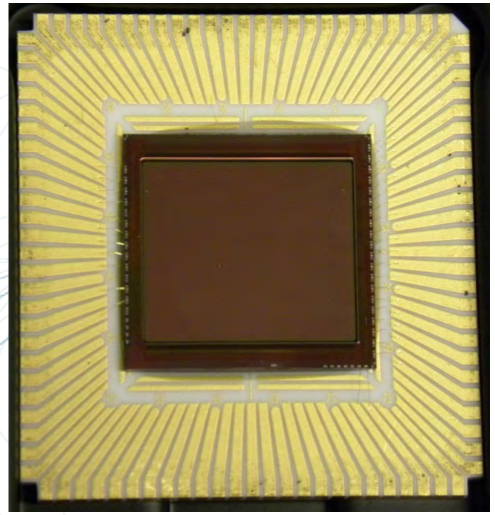
GLO Fabrication is nearly complete and lab testing is underway.



- The NRL team is starting back to work.
- Completion of fabrication should be complete in coming weeks.
- Lab testing will occur this summer to confirm optical performance, SNR, scattered light etc.
- Environmental testing will also be done.
- TRL 6 will be achieved by Fall 2020.
- Ground based occultation column measurements will be obtained, aerosol optical depth compared to Aeronet results.
- A stratospheric balloon flight originally planned for all 2020, but delayed due to COVID-19 is now planned for fall 2021.

Back Up Slides

GLO Enabling Technology



Lockheed Martin nbn
SBF207 Focal Plane Array

Size	1280 x 1024 pixels
Pixel pitch	12 microns
A/D	13 or 14 bit
Frame Rate	99 Hz full frame and 14 bit
Well Depth	2.05 million electrons
ROIC noise	300 electrons (max)
Responsivity	125 electrons/bit
Power	160 mWatts
Integration modes	Snapshot- integrate while or then read
Windowing	608 x 8 in 1 x 4 increments
QE	>80%
Operability	>99.5%
Readout	Direct injection

GLO uses 4 FPAs: 3 with 1.7-4.2 μm, 1 with 0.5-4.2 μm sensitivity (substrate removed)

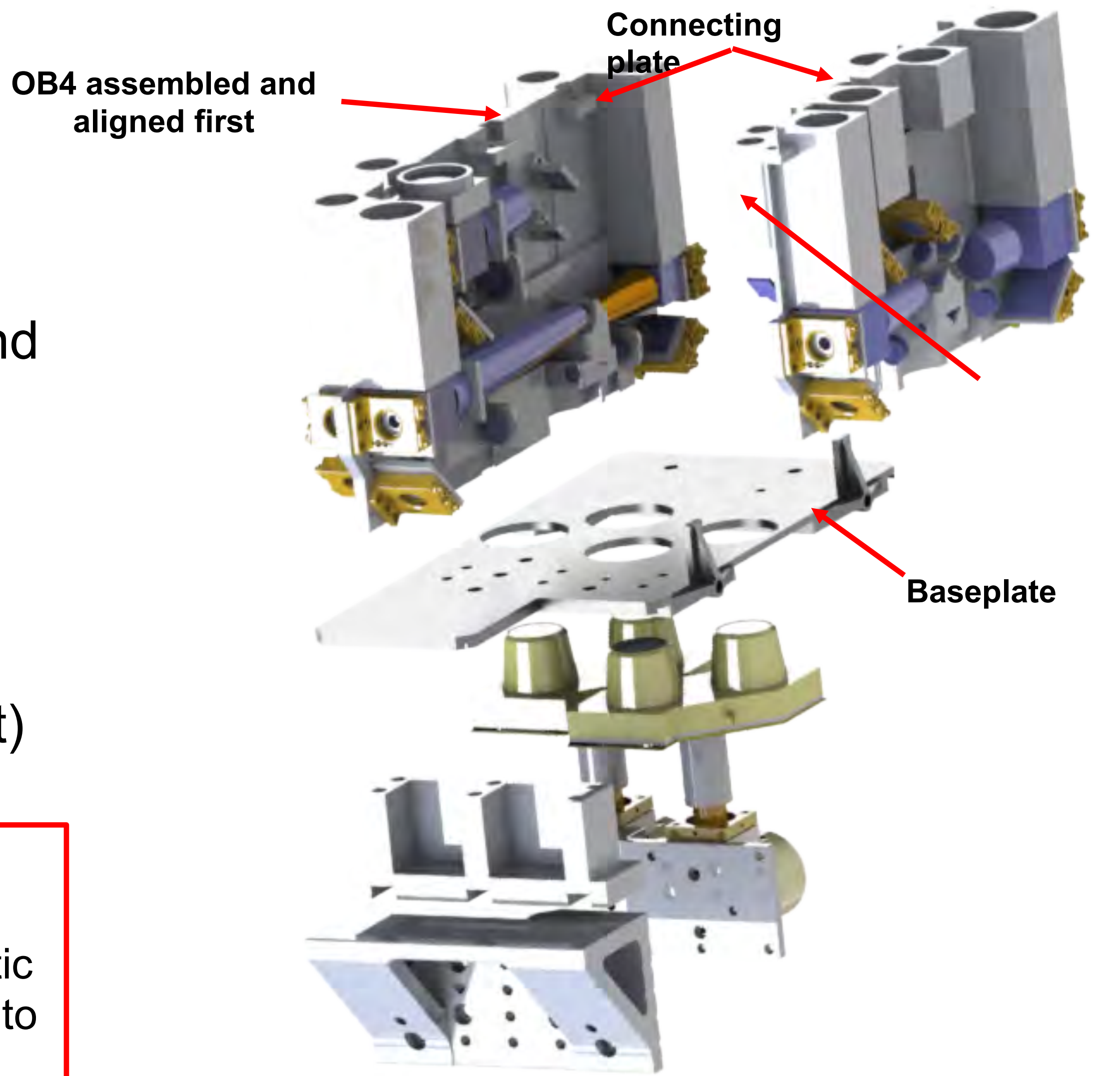
Ricor K508N sterling cycle micro cryocooler

- **Ricor K508N has space heritage**
  - **Prototype uses the (mechanically identical) non-space qualified version of this cooler**
- **GLO uses 2 coolers (each unit cools 2 FPAs) as components of the Integrated Detector and Cooling Assembly (IDCA): operating temperature ~ 150K**

GLO Assembly

Assembly and alignment

- Step 1: Mount IDCA to baseplate
- Step 2: OB4 is the first unit assembled and aligned (Interior OB)
- Step 3: Connecting plate is added
- Step 4: OB1 assembled and aligned (second interior OB).
- Step 5: Continue with OB3
- Step 6: Follow by OB2
- Step 7: Add frames and enclosures
- Step 8: Add ND filter plate
- Step 9: Mount to pan/tilt unit (IIP Instrument)

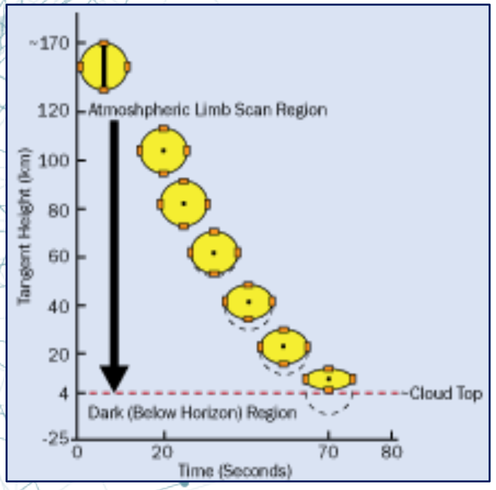


- ➢ The design allows for the OBs to be aligned horizontally with alignment adjustments from top
- ➢ Once all parts are assembled, there is access to kinematic components (including through OBs) for fine tuning prior to locking components

GLO Data Acquisition

In the GLO orbital configuration the sensor does not scan, rather the MicroSat inertially points the sensor optics toward the sun (~0.1^{o} pointing accuracy required).

- GLO uses the solar edge detection algorithm developed and used operationally on SOFIE for 10 years.
- This allows for downlinking only a small subset of the image data and placing only modest communications requirements on the spacecraft.



- 1024x1280 FPA.
- 6 images of the sun on each FPA.
- Solar diameter subtends 211 pixels:
  - From orbit ~125m/pixel
  - From balloon ~21m/pixel
- SOFIE demonstrated solar edge detection to ~1 m (on the limb) from orbit.