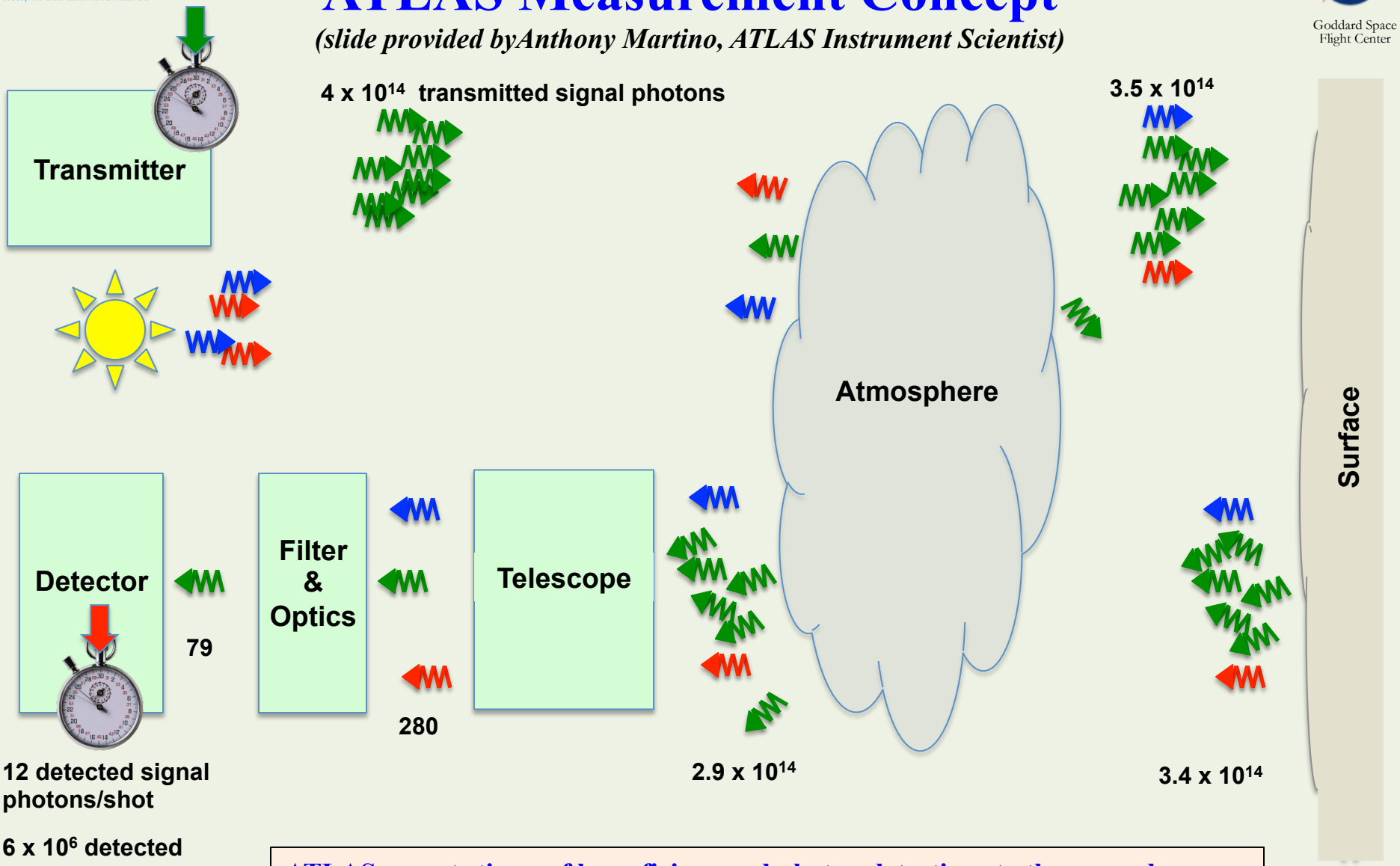
Space Qualification of the Optical Filter Assemblies for the ICESat-2/ATLAS Instrument

Elisavet Troupaki*, Zachary Denny, Stewart Wu, Heather Bradshaw, Kevin Smith, Judy Hults, Luis Ramos-Izquierdo, William Cook

* elisavet.troupaki-1@nasa.gov

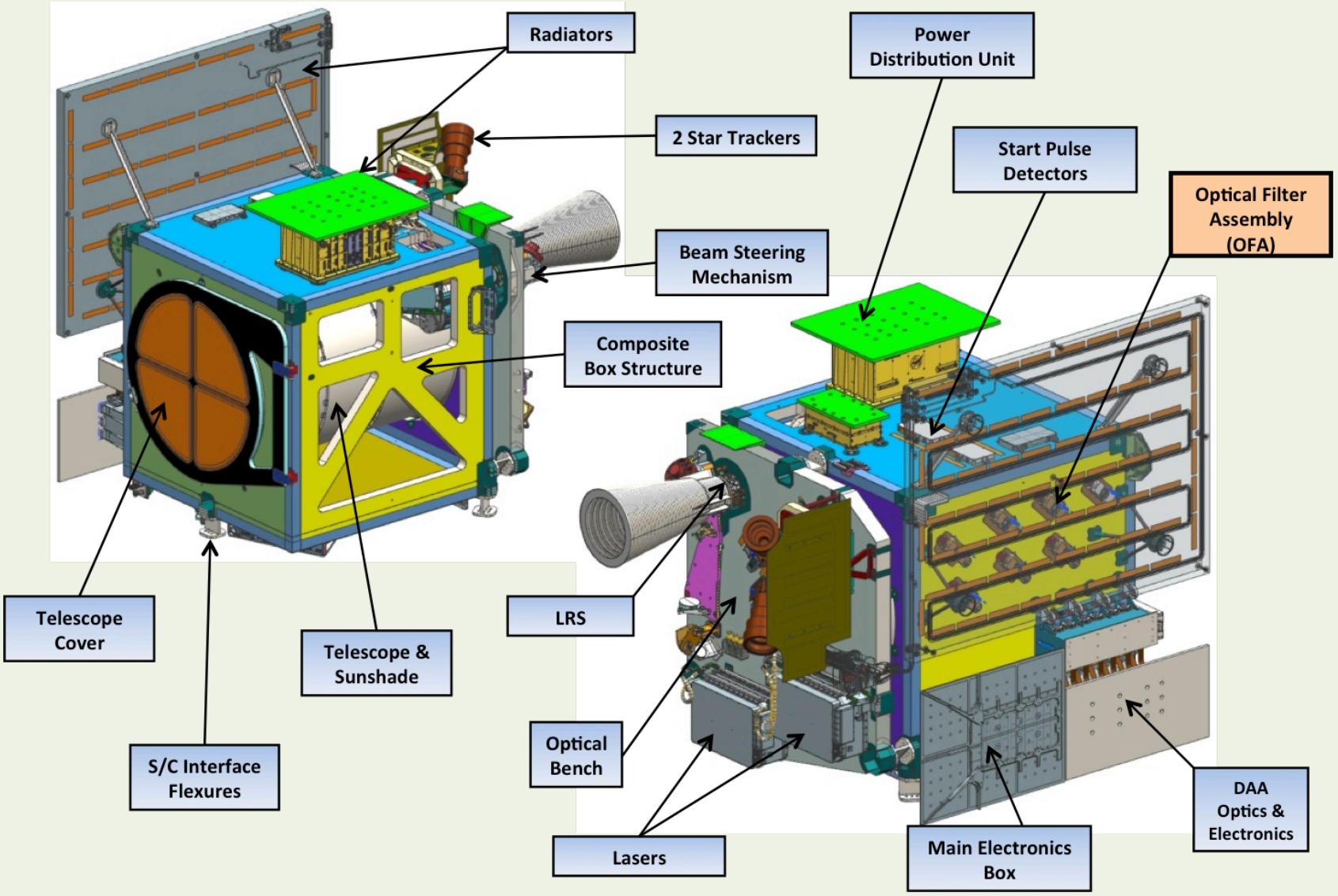
ATLAS Measurement Concept

(slide provided byAnthony Martino, ATLAS Instrument Scientist)

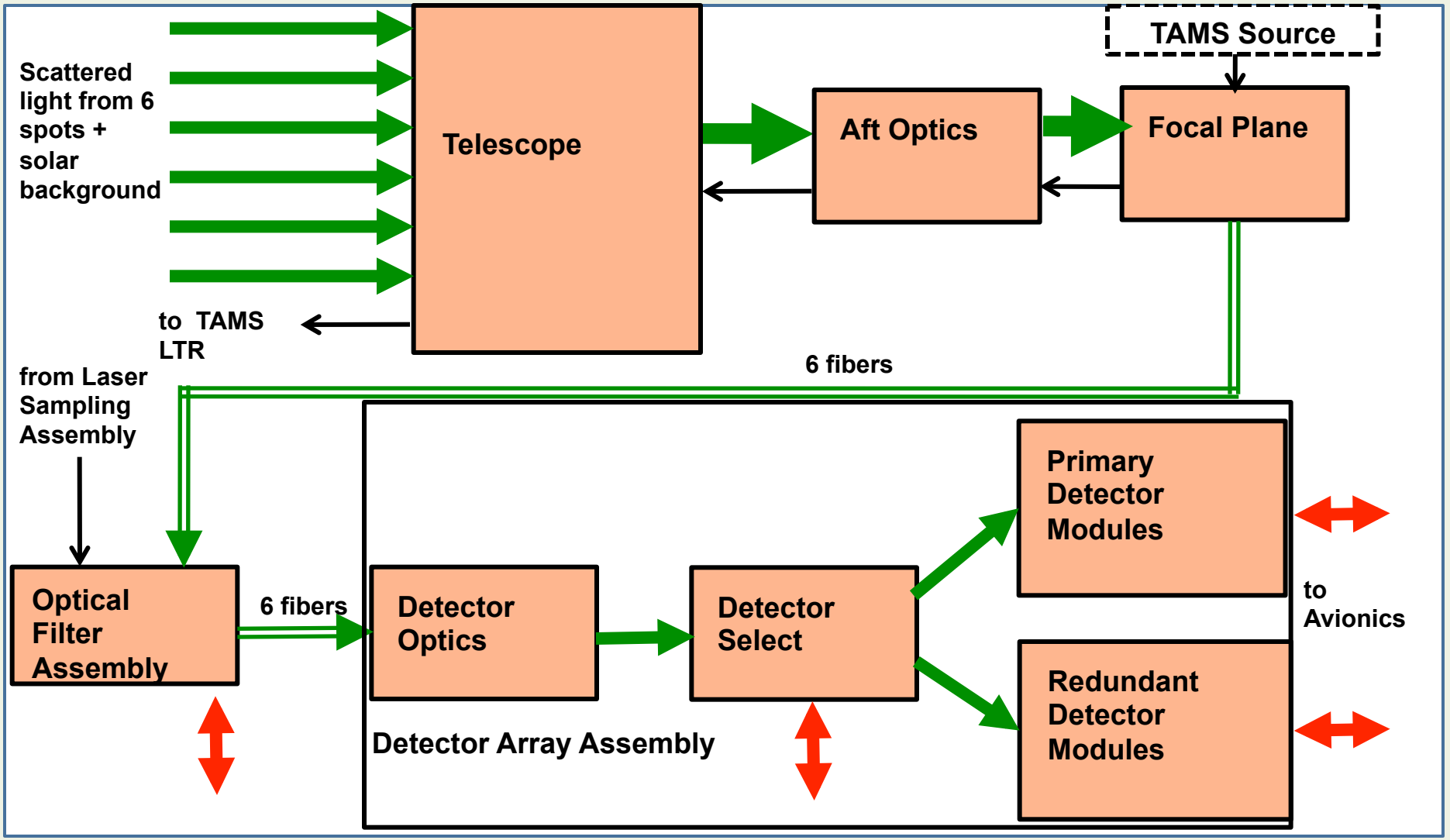


ATLAS reports times of laser firings and photon detections to the ground.
Range and surface elevation are computed by data processing on the ground.

Advanced Topographic Laser Altimeter System

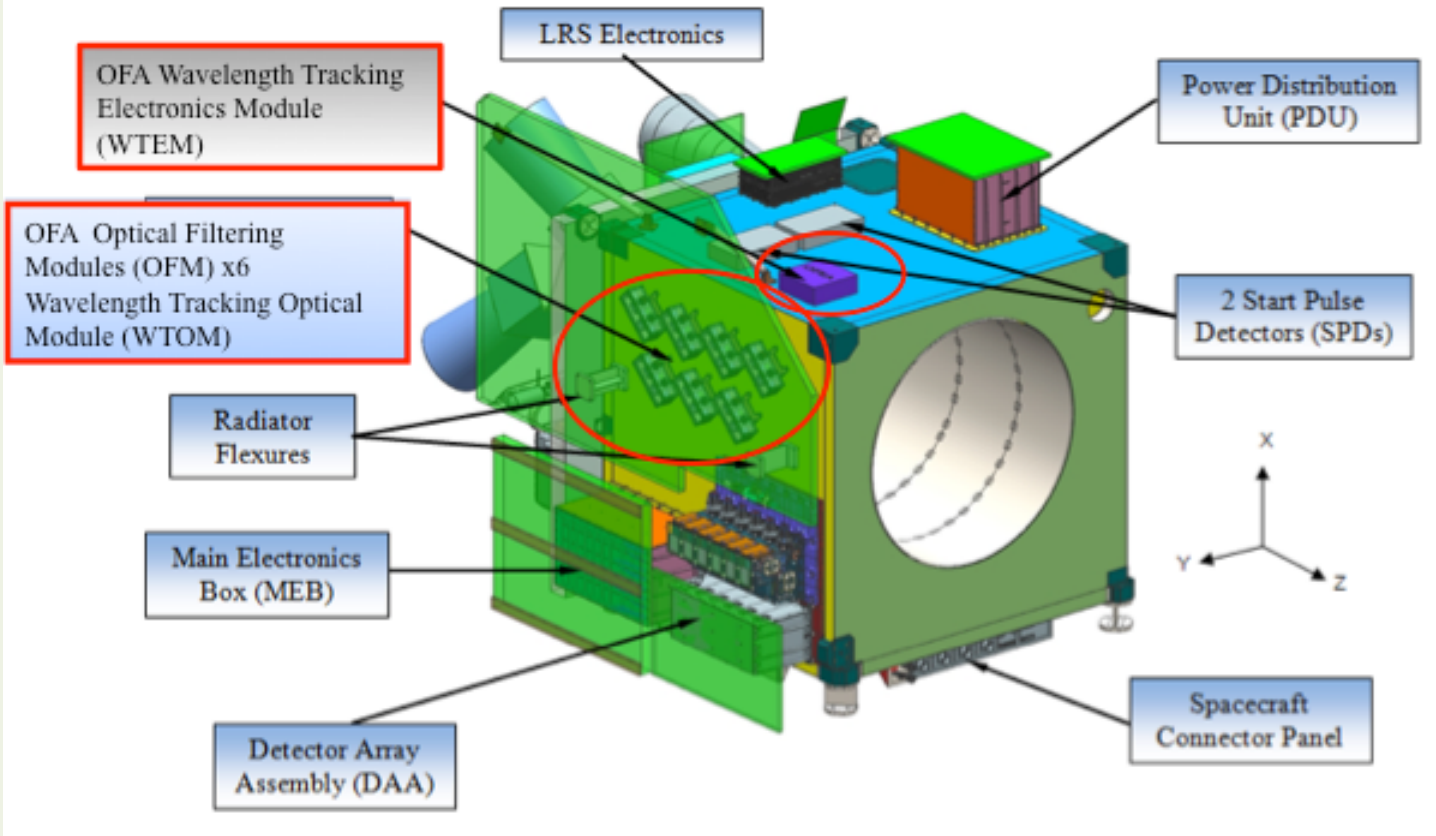


ATLAS Receiver Diagram



The Receiver collects light from the target, filters out most of the solar background, and generates electrical signals corresponding to the arrival of individual photons in each of the 6 spots.

ATLAS Optical Filter Assembly



The ATLAS OFA shall:

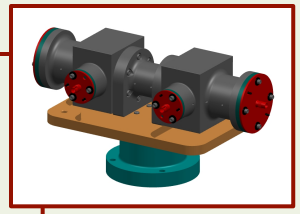
✓ **remove background solar radiation from collected signal while transmitting the laser light to the detectors**

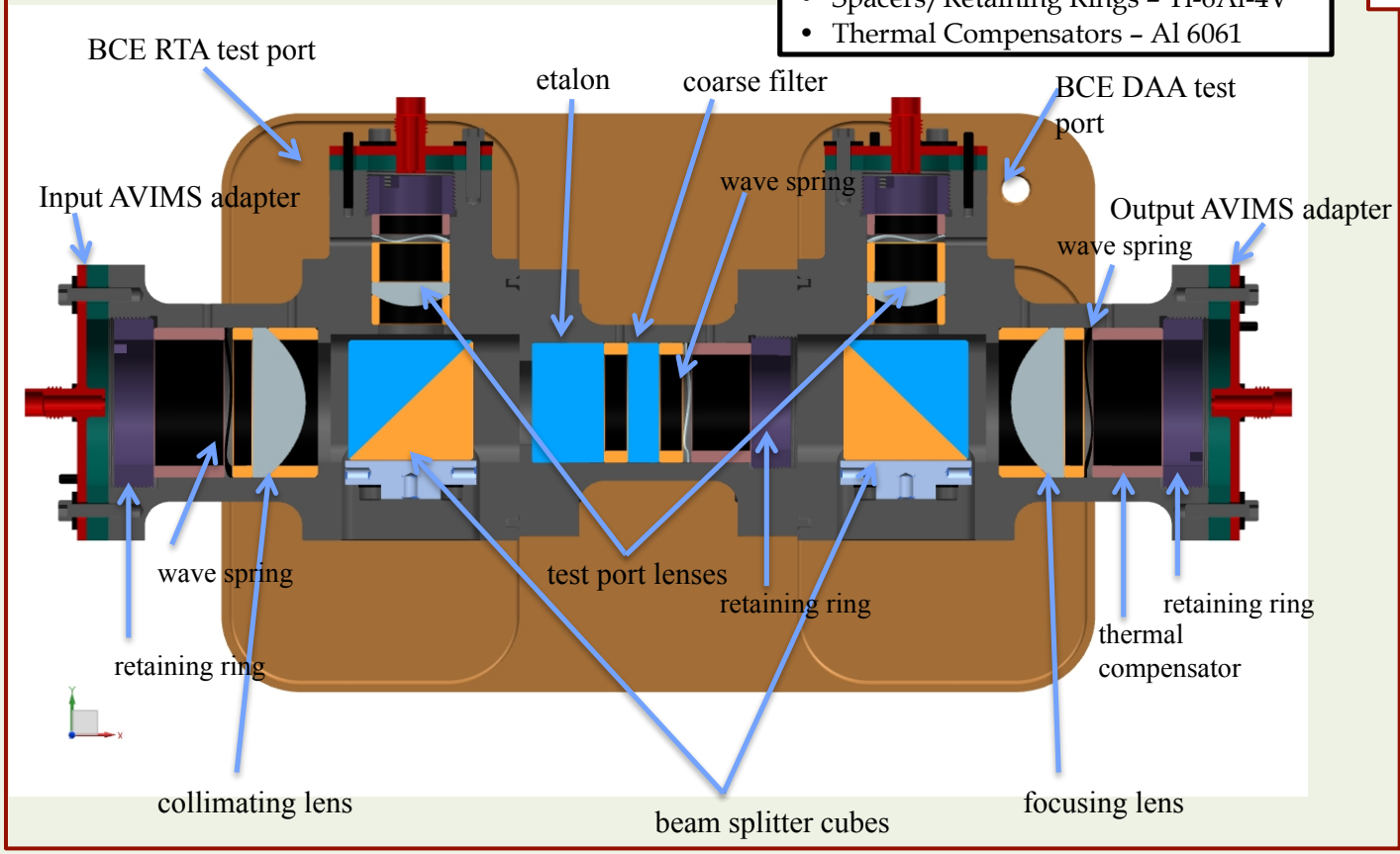
✓ **provide the means to monitor the etalon tuning to the laser wavelength**

ATLAS Optical Filtering Modules

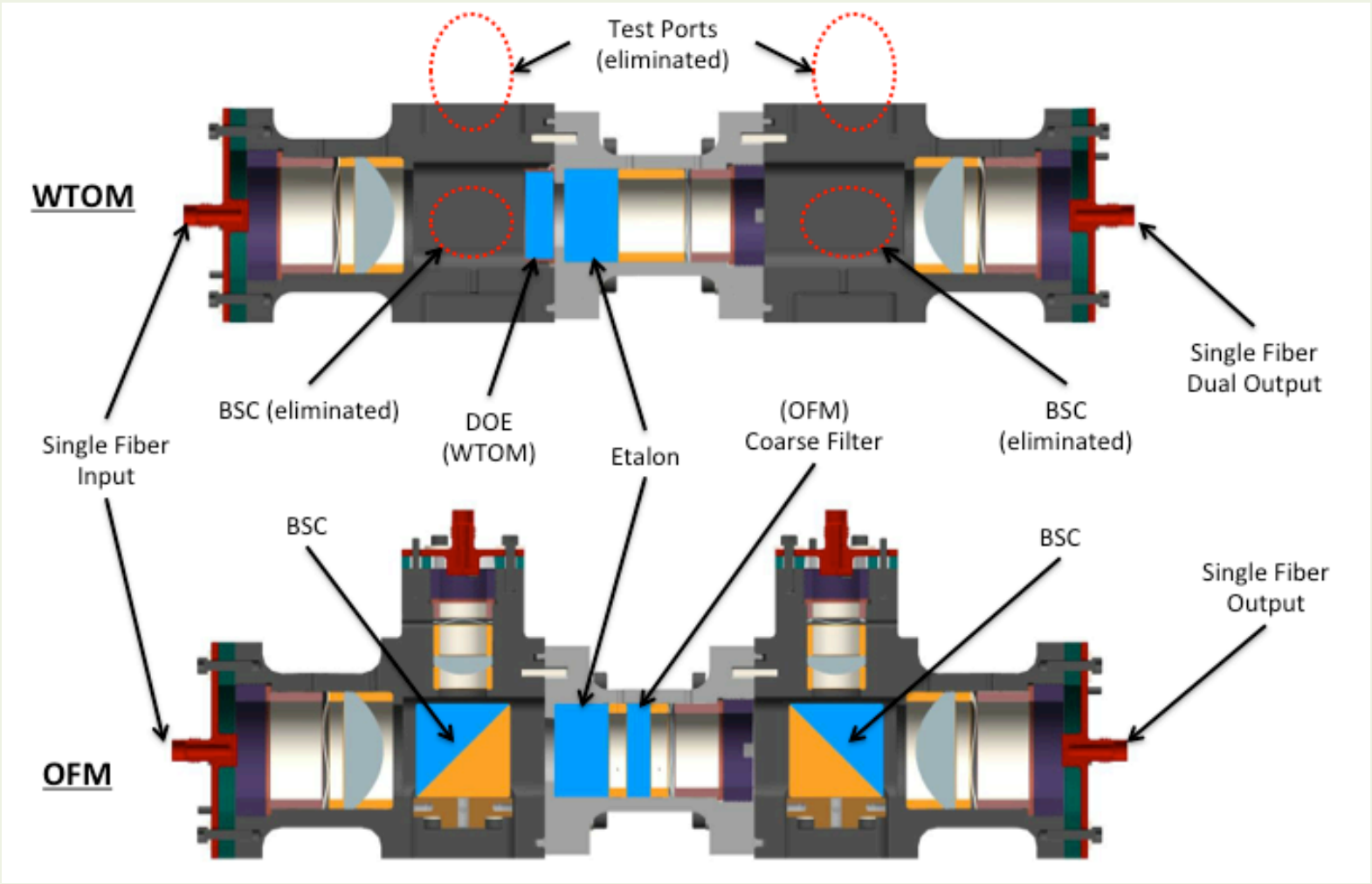
Envelope: 7.67″ x 3.76″ x 2.44″

Materials
- Optics: Fused Silica
- Body: Ti-6Al-4V
- Spacers/Retaining Rings – Ti-6Al-4V
- Thermal Compensators – Al 6061





ATLAS Wavelength Tracking Optical Module



Optical Performance (filters)

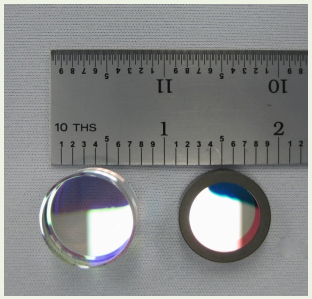
Goddard Space Flight Center

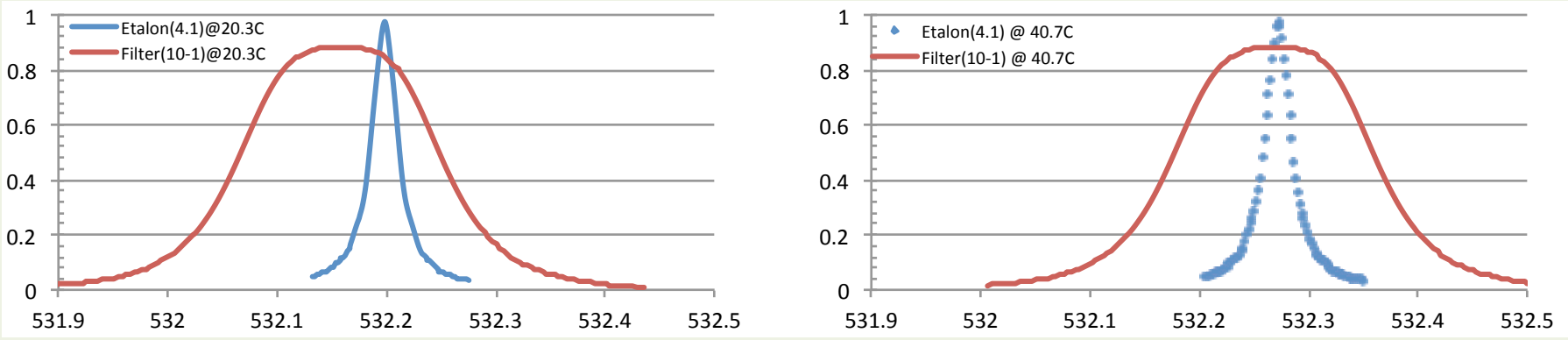
Measured performance of the 18 flight etalon filters

Parameter	Specification	Performance
Center Wavelength	532.272 nm +/- 0.012nm in vacuum, at 40°C	532.264 nm – 532.283 nm
Free Spectral Range	300 +/- 3pm	297.6 pm - 299.9 pm
Passband full width	30 +/- 2 pm at 50% of measured peak transmission	27.73 pm - 28.80 pm
Peak transmission	> 90%	96.01% - 98.20%

Measured performance of the 20 flight blocking (coarse) filters

Parameter	Specification	Performance
Center Wavelength	532.272 nm +/- 0.040nm, at 40°C, in vacuum	532.245 nm – 532.285 nm
FWHM	200 +/- 40 pm	184.0 pm – 195.7 pm
Peak transmission	>80%	82.2% - 90.3%
Out-of-band blocking	OD5 from 250nm to 950nm	OD5 or better



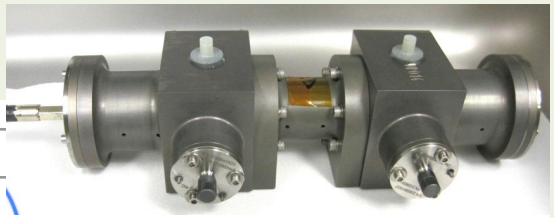


Etalon and filter transmission vs. wavelength at room temperature (left) and at mission operating temperature (right)

Optical Performance (filter assemblies)

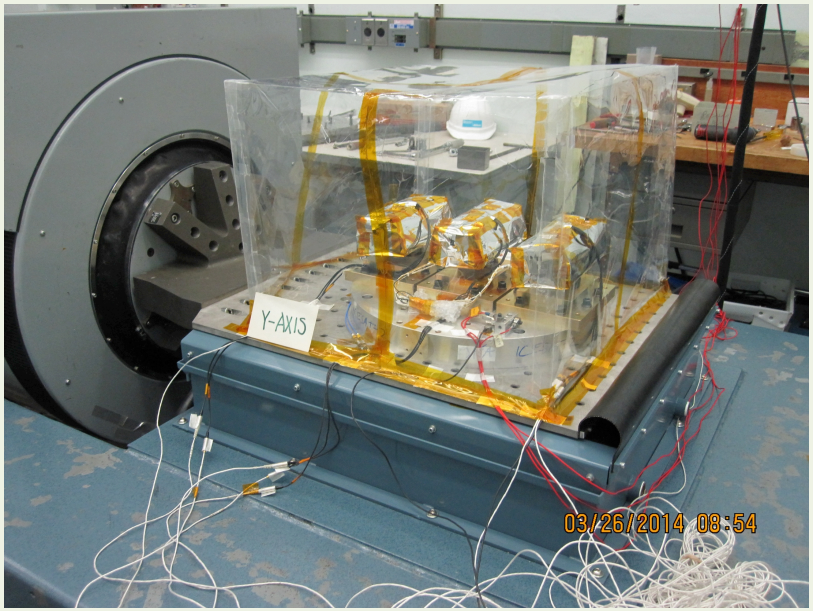
Goddard Space Flight Center

Estimated and measured optical throughput of OFM #A



Parameter	Requirement	Performance
Optical transmission	64.4%	71.2% - 78.7% (lab single-mode tunable 532nm laser);
Bandwidth (FWHM)	30 ± 3 pm	31.04 – 32.35 pm
Center wavelength (vacuum)	532.272nm	532.272 nm, at nominal operating temperature
Wavelength tunability	greater than ± 15pm	greater than 25pm
Solar background rejection	transmittance of no more than 8.5E-5% integrated across the solar spectrum	3.7E-5% - 8.5E-5% broadband transmission between 250nm and 950nm
Light tightness	Stray light events of no more than 2KHz light	<500Hz (lab)

Vibration Testing

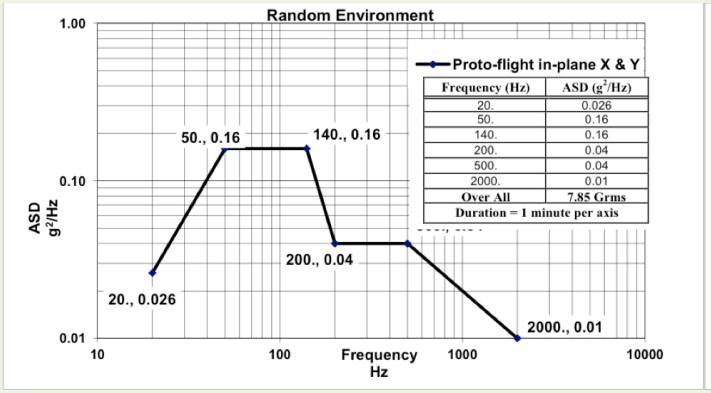


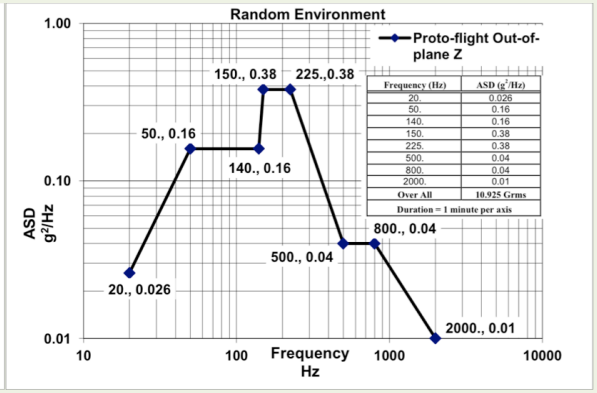
No change in optical transmission or peak wavelength after vibration testing

Test levels for sine burst and swept sine vibration tests

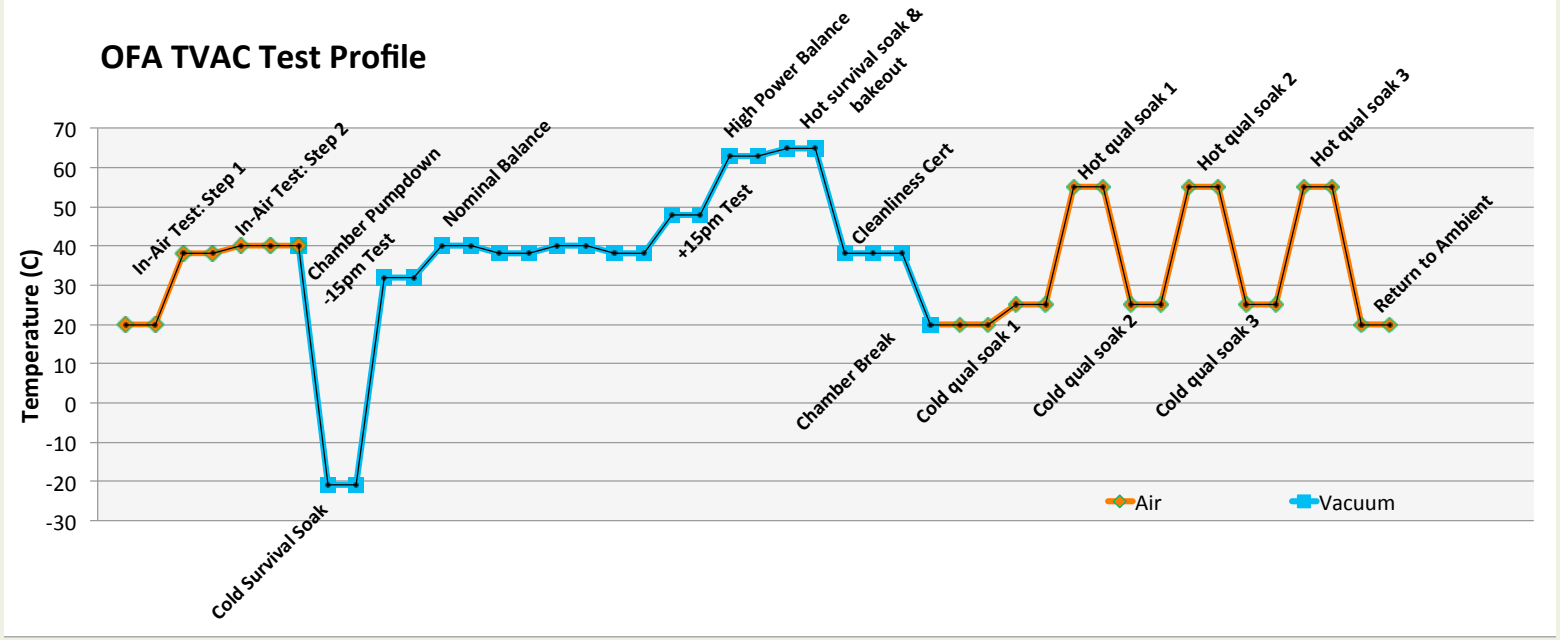
Type of testing	Axis	Protoflight Level
Sine Burst	X, Y, Z	15G, 5 cycles conducted at 25Hz
Swept Sine Vibration	X, Y, Z	0.63 inches D.A. (5-19.7Hz, 4 oct/min sweep rate) 12.5G (19.7-50Hz, 4oct/min sweep rate)

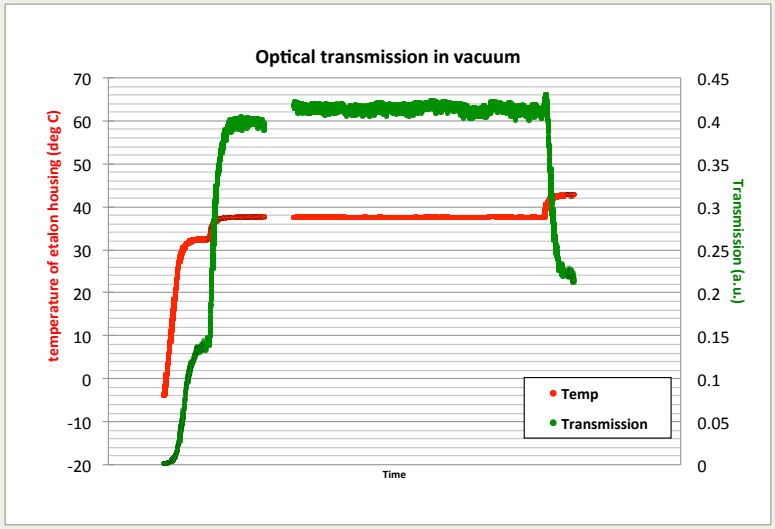
Random vibration levels for x and y axis (left) and z axis (right)

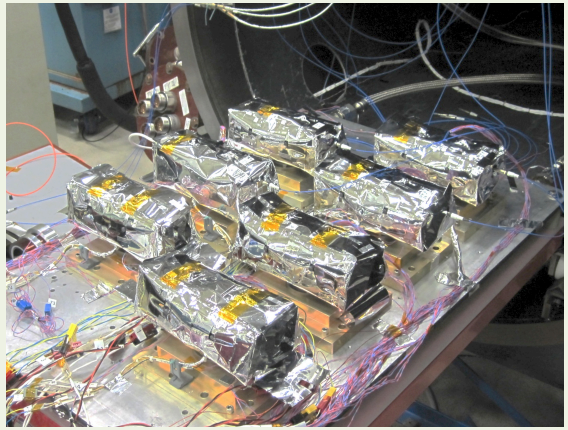




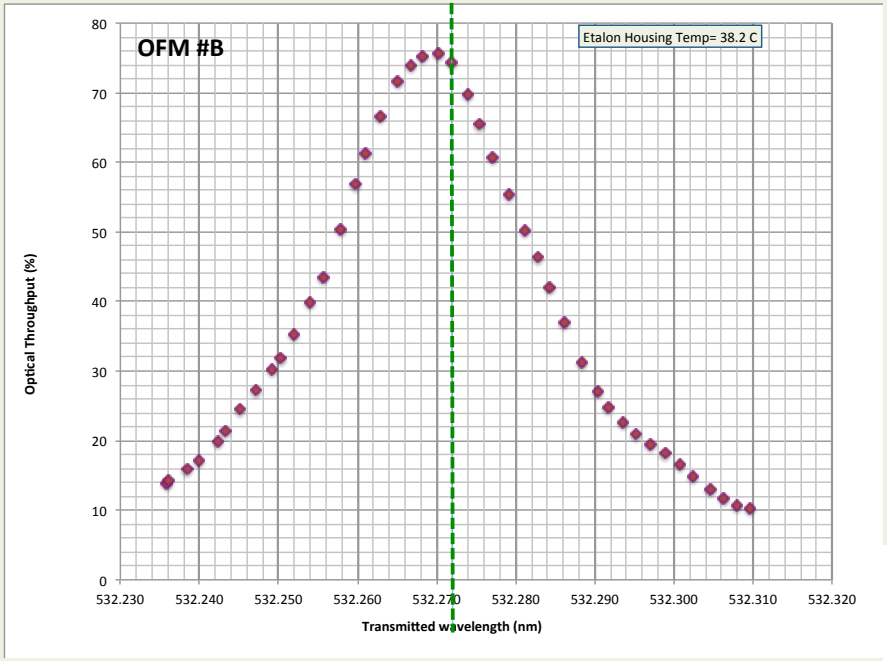
Thermal – Vacuum Testing



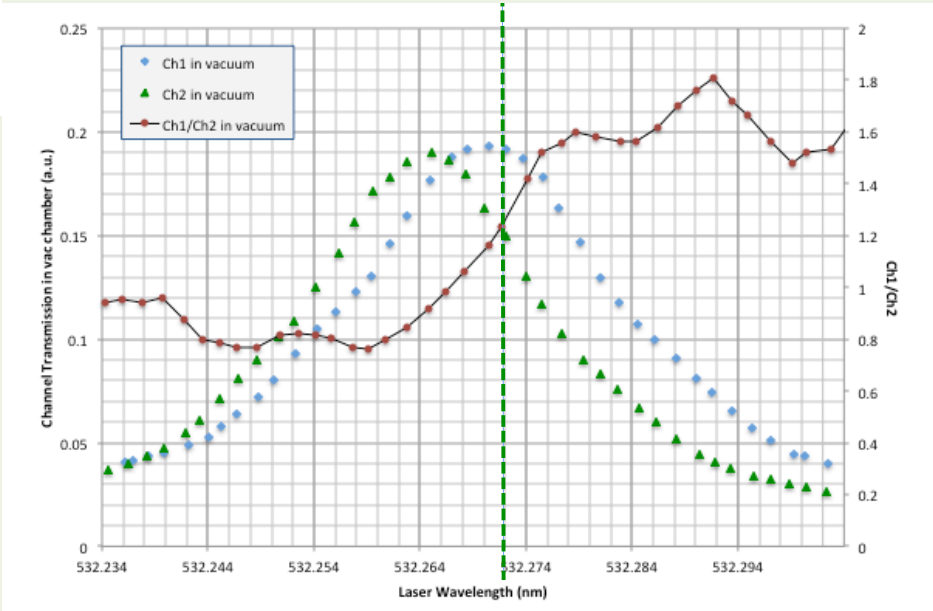




Performance in Vacuum

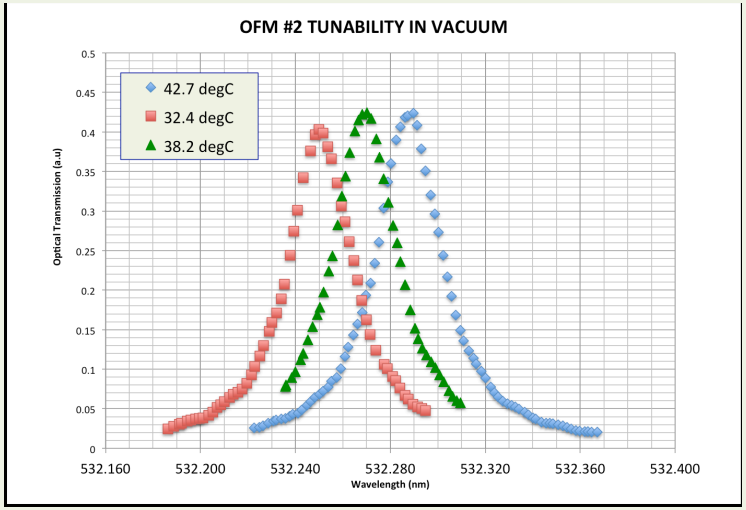


Optical throughput in vacuum (OFM)



Optical throughput in vacuum (WTOM)

Center Wavelength



Wavelength Tunability
(temp coeff=3.6pm/°C)

Center wavelength data before and after vibration and thermal-vacuum tests

		Center Wavelength at Nominal Temperature (nm, vacuum)		
OFM #	Nominal Temp (°C)	baseline test	after vibration	after TVAC
1	40.71	532.272	532.272	532.270
2	38.74	532.272	532.272	532.272
3	37.25	532.272	532.273	532.273
4	41.44	532.272	532.270	532.270
5	41.52	532.272	532.275	532.274
6	42.05	532.272	532.276	532.271
WTOM CH1	39.40	532.272	532.271	532.273
WTOM CH2	39.40	532.266	532.268	532.266

ICESat-2
ICE, CLOUD, AND LAND ELEVATION SATELLITE-2

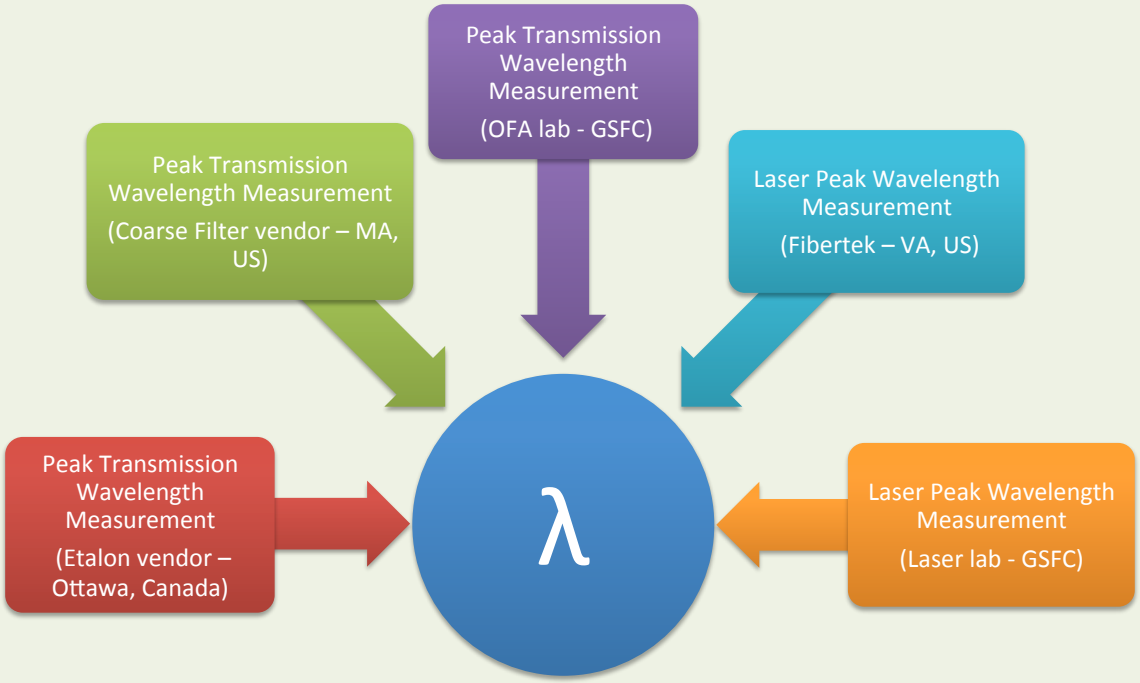
NASA
Goddard Space Flight Center

THANK YOU!

elisavet.troupaki-1@nasa.gov

BACKUP SLIDES

Matching the ATLAS laser center wavelength…



- Etalon and filter peak transmission wavelength (same as ATLAS center wavelength, specified by ATLAS laser vendor in July 2012) :

  532.272nm at 40°C in vacuum

- For any calculation of the index of refraction of air and/or vacuum, the following calculator shall be used: http://emtoolbox.nist.gov/Wavelength/Ciddor.asp assuming standard atmospheric pressure
- PO awarded for one reference/test etalon to be measured by both OFA and Laser groups
- Coarse filter sample was sent to etalon vendor in February 2013, who confirmed peak transmission wavelength (in vacuum) of 532.272nm at 40°C.