Libera: Earth Radiation Budget Continuity



Dave Harber and the ***Libera*** **Team**

Libera, NASA Earth Venture Continuity-1 Mission

'Li-be-ra, named for the daughter of Ceres in ancient Roman mythology

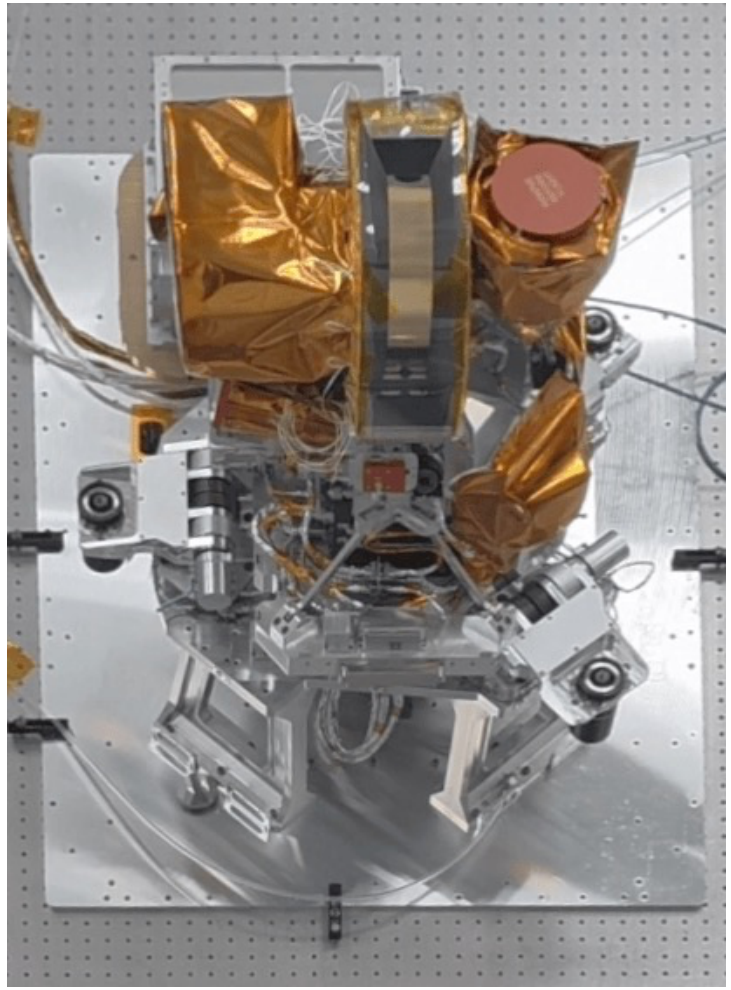


Provides continuity of the Clouds and the Earth's Radiant Energy System (CERES) Earth radiation budget

- ***Measures integrated shortwave (0.3–5 µm), longwave (5–50 µm), total (0.3–100+ µm) and (new) split-shortwave (0.7–5 µm) radiance over 24 km nadir footprint; uncertainty ~ 0.2%***
- ***Includes a wide FOV camera for scene ID and simple ADM generation to pave way for future free-flyer ERB observing system***
- ***Electrical substitution radiometers (ESRs) using vertically-aligned carbon nanotube (VACNT) detectors***
- ***Primary operational modes: Cross-track and azimuthal scanning; on-board calibrators; solar and lunar viewing.***
- ***Partners: LASP, BAE, NIST Boulder, Space Dynamics Lab***
- ***Science Team: CU, JPL, CSU, UA, UM, LBL***

Libera Delivered to Spacecraft Feb. 2026

Cross-track scanning

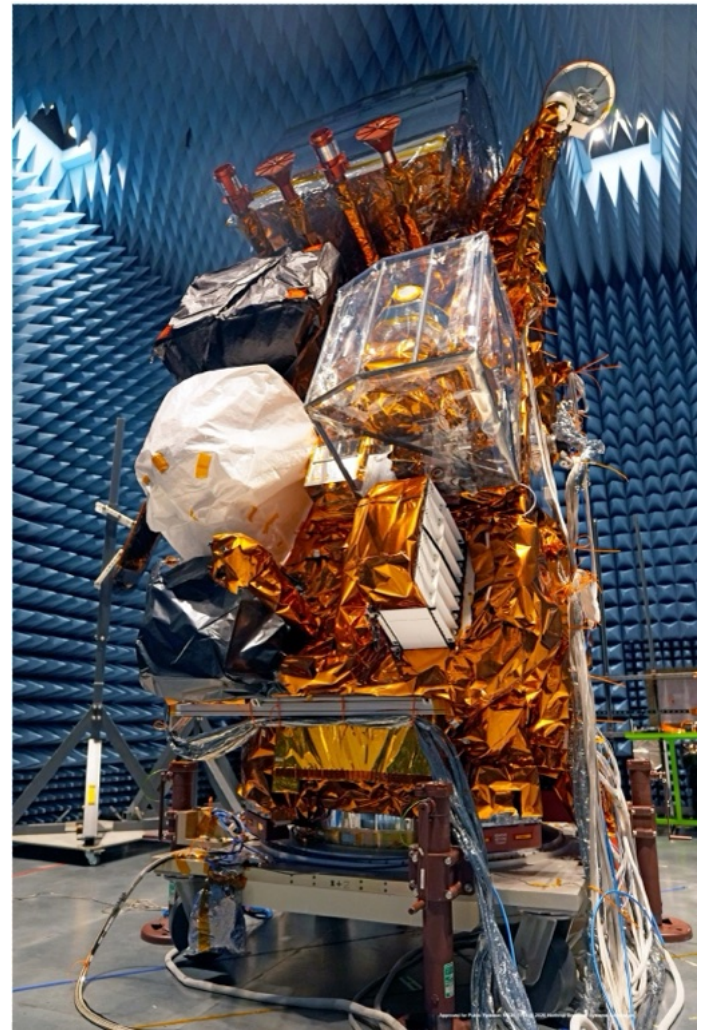




Delivery to JPSS-4 Spacecraft Integration on January 30, 2026

Libera Integrated on JPSS-4





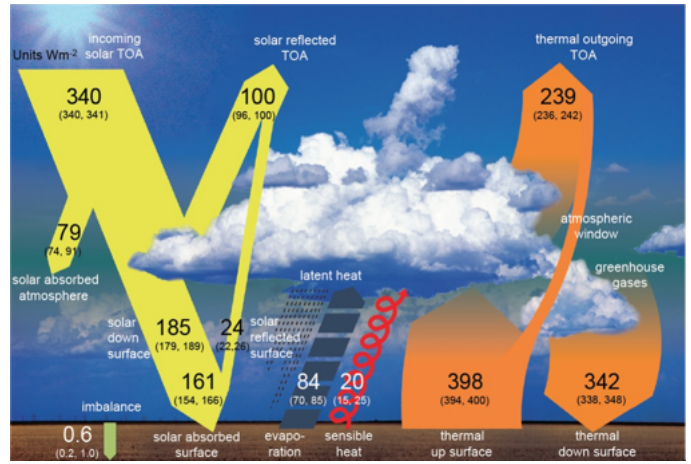
Approved for Public Release: NG26-0581 @ 2026 Northrop Grumman Systems Corporation

Libera Major Reviews and Key Milestones

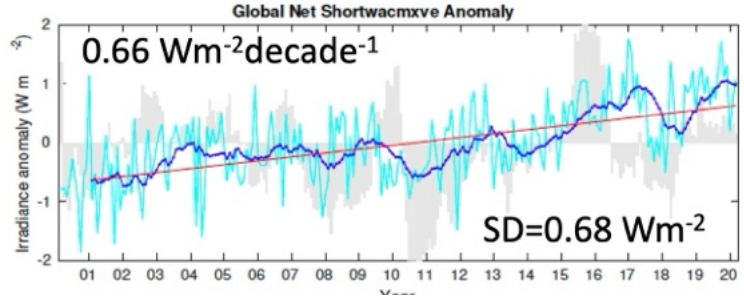
Milestone	Acronym	Date	Convening Authority
Authorization to Proceed	**ATP**	**6 Jul 20**	**-**
System Requirements Review	**SRR**	**22 Feb 21**	**SRB**
Key Decision Point - B	**KDP-B**	**30 Apr 21**	**SMD PMC**
Preliminary Design Review	**PDR**	**8-10 Feb 22**	**SRB**
Key Decision Point - C	**KDP-C**	**Apr 22**	**SMD PMC**
Critical Design Review	**CDR**	**27-29 Jun 23**	**SRB**
Scan-Mode dPMC		**22 Mar 24**	**ESD**
Libera Accommodations Review	**LAR**	**15-16 May 24**	**JPSS**
Re-plan DPMC		**13 May 25**	**SMD**
Instrument Build Complete		**Jun 25**	
Pre-Environmental Review	**PER**	**Sep 25**	**SRB**
Pre-Ship Review	**PSR**	**27 Jan 26**	**SRB**
Delivery to Spacecraft		**23 Feb 26**	**-**
Launch Readiness		Sep 2027	-
Key Decision Point E	KDP-E	2027	SMD PMC
Post Launch Assessment Review	PLAR	L+90d	SRB
Operational Transition Review	OTR	PLAR + 9mo	TBD

Libera Science Goals & Objectives

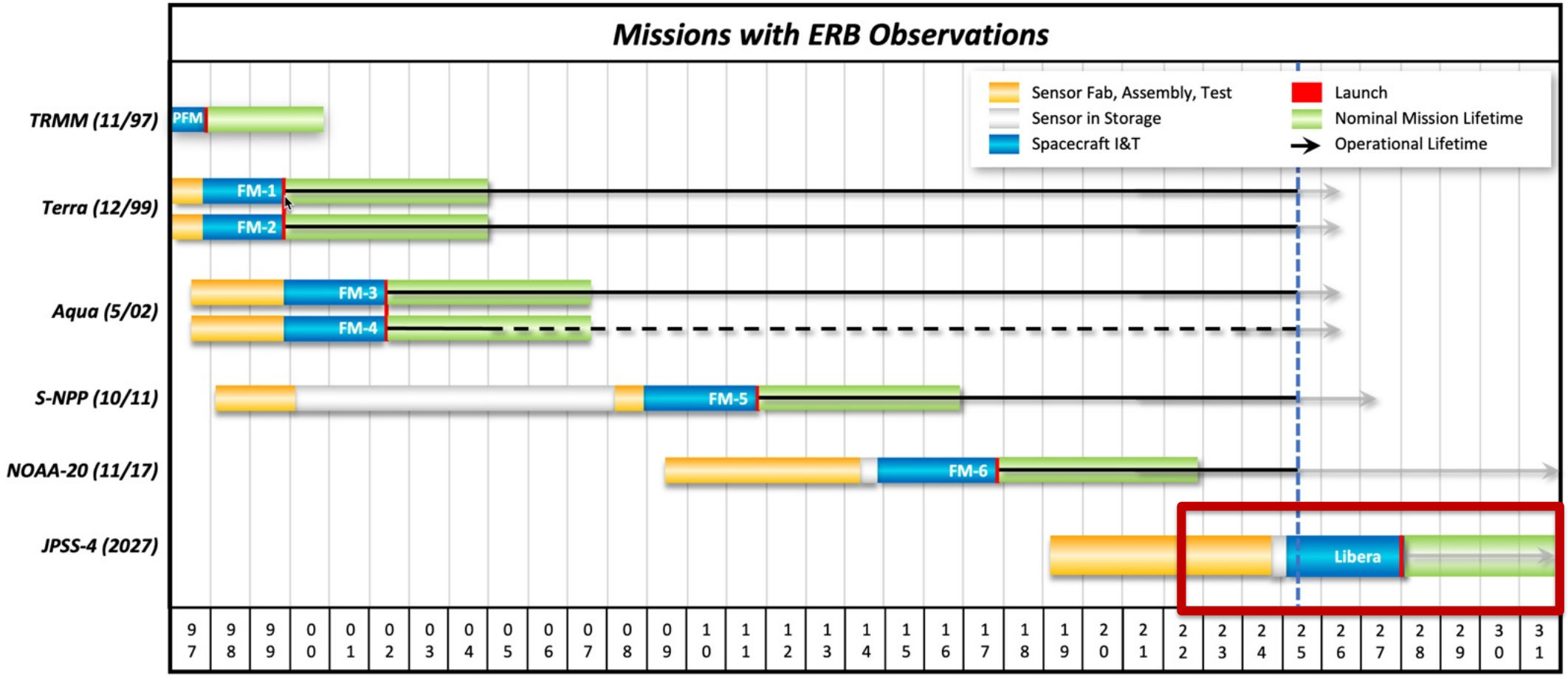
1) **Provide seamless continuity of the ERB measurement with characteristics identical to CERES**
   - ➢ Prevents gap in ERB data record critical for assessing trends in Earth's energy budget.
   - ➢ Tied to **Science objective 1**: Use extended record to identify and quantify processes responsible for the instantaneous to decadal variability of ERB
2) **Develop a self-contained, innovative, affordable observing system**
   - ➢ Novel, miniaturized detectors greatly improve accuracy & stability and pave way toward smaller & cost-effective follow-on mission.
   - ➢ **Science objective 2** *Libera* tests a miniature wide field-of-view camera to provide scene & angular context crucial for irradiance retrieval
3) **Provide new and enhanced capabilities that support extending ERB science goals**
   - ➢ Employ Split-Shortwave channel to derive SW VIS and NIR fluxes and quantify SW energy disposition
   - ➢ Tied to **Science objective 3**: Revolutionize understanding of spatio-temporal variations in SW, VIS & NIR irradiance



Shortwave Deposition Trend



Near-term ERB Continuity

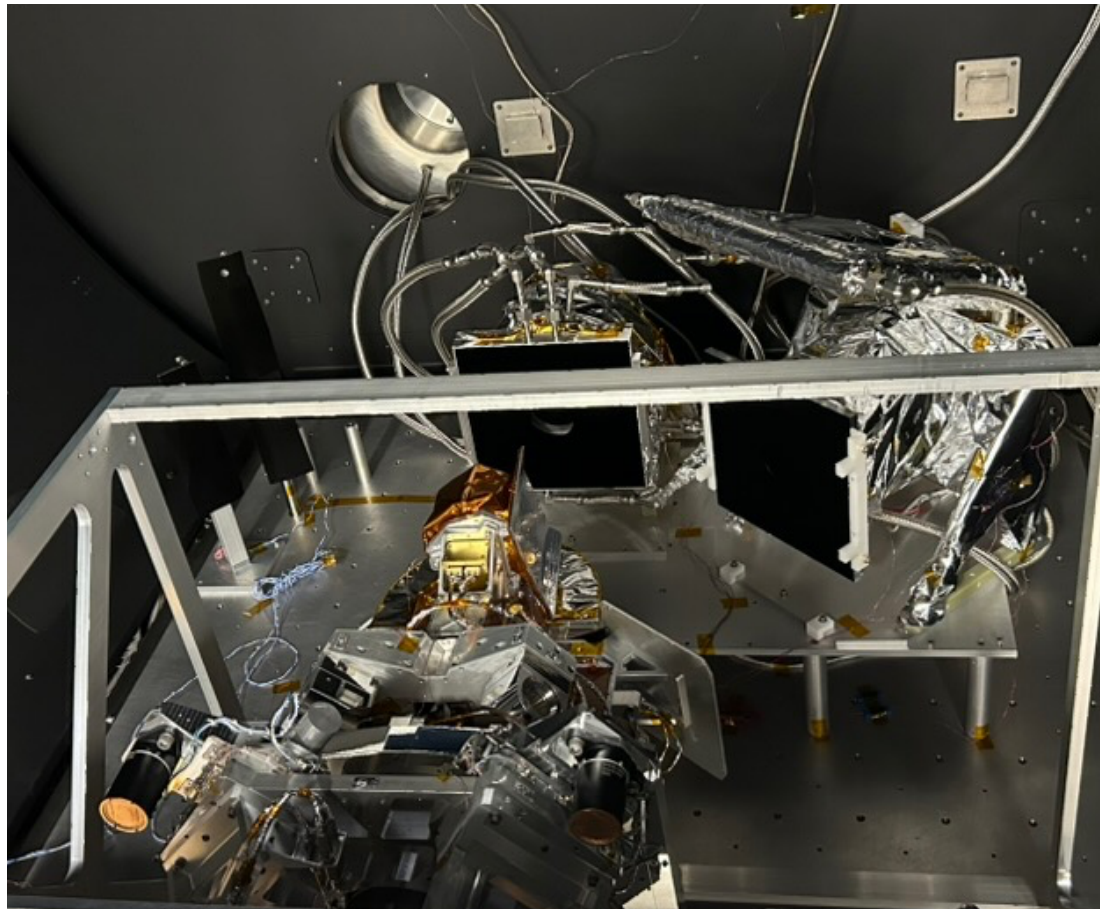


- *Currently, 6 CERES instruments fly on 4 satellites: Terra (L1999), Aqua (L2002), SNPP (L2011), NOAA-20(L2017)*
- *Libera scheduled for launch in 2027 on JPSS-4*

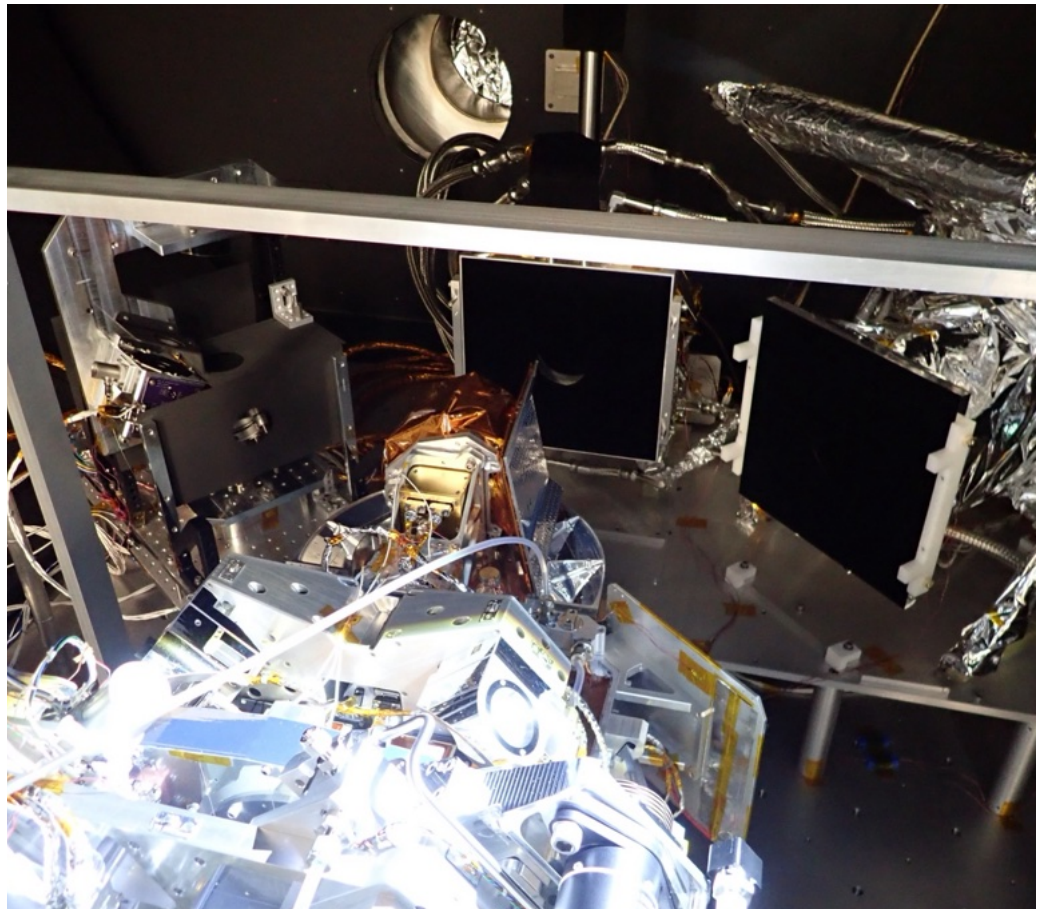
Libera Radiometric Testing

Libera Radiometric Testing in 2025

Pre-Environment Integrated Test

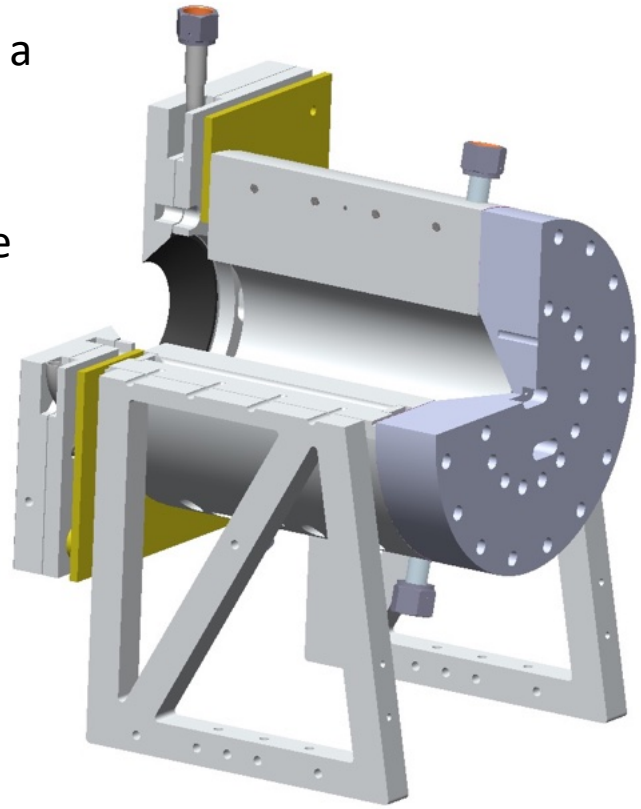


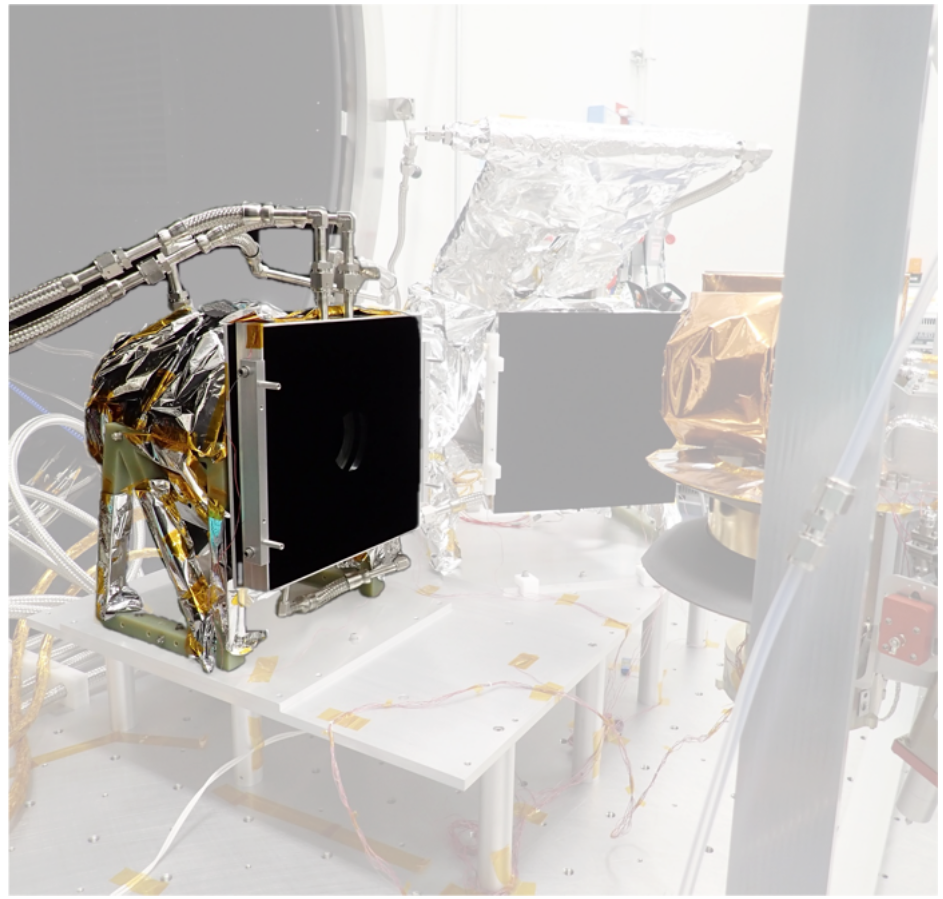
Post-Environment Integrated Test



LASP Blackbodies: Earth View Simulator

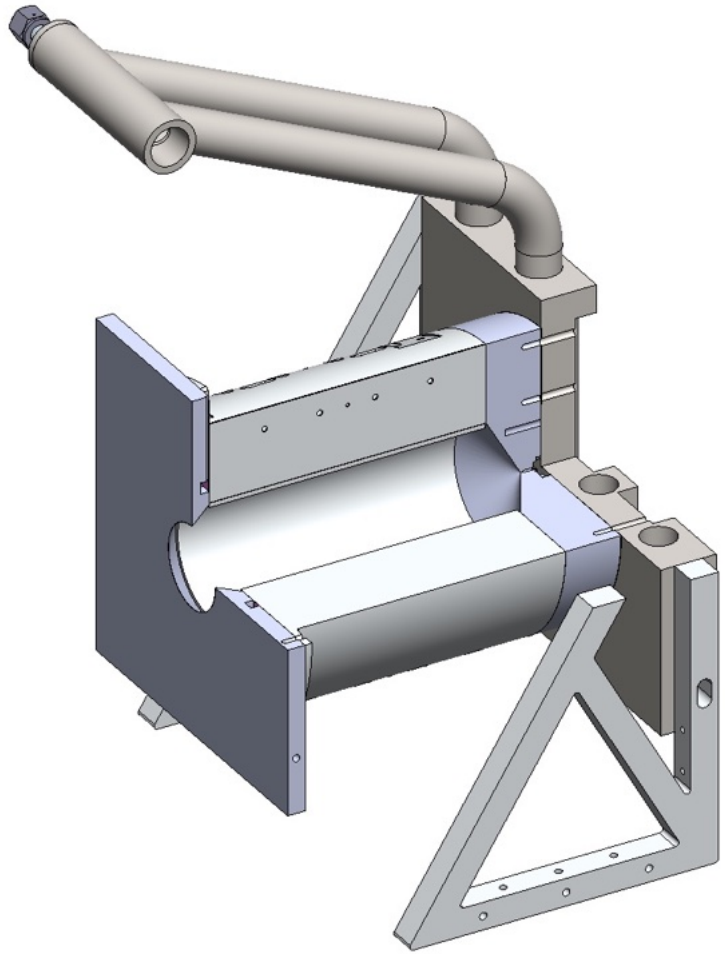
- Variable temperature cavity blackbody
- Temperature controlled with a closed-loop fluid chiller
  - Range: -23˚C to +74˚C
- Thermally isolated front plate individually controlled with a closed-loop fluid chiller
  - Range: -23˚C to +74˚C

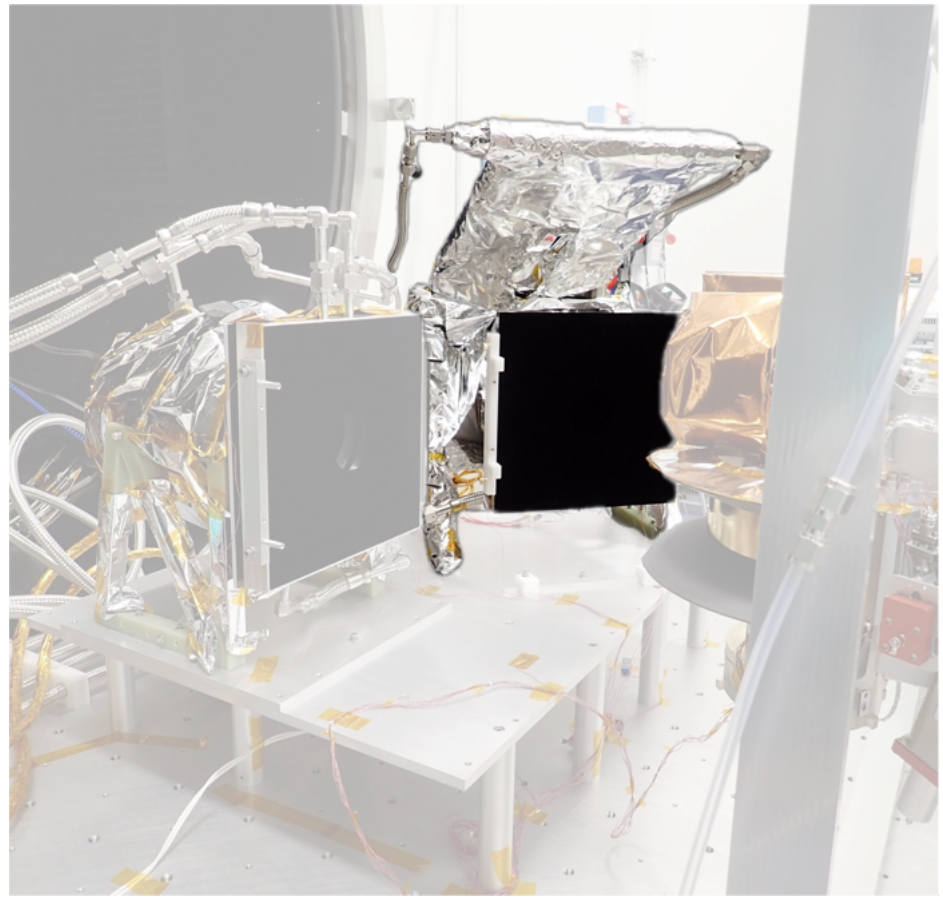




LASP Blackbodies: Space View Simulator

- LN2 cooled cavity blackbody
- LN2 cooled front plate
- Operating temp: -188˚C

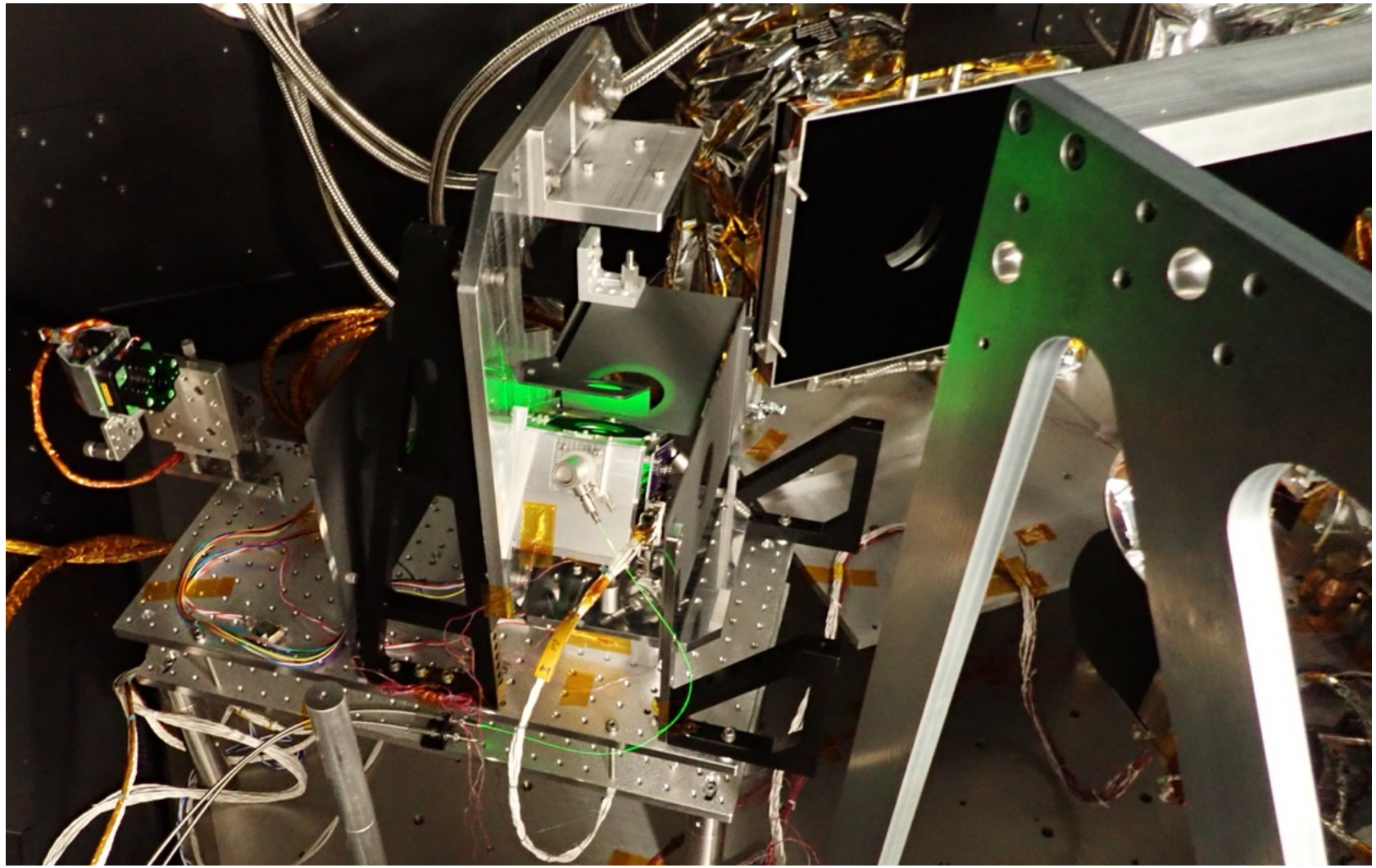




Post-Environment Testing SW SRF Check

Allows us to check the spectral response in the SW

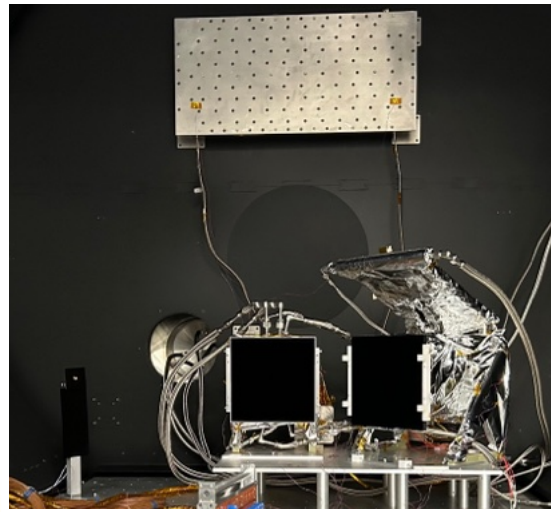
- Spectralon integrating sphere fiber-fed using our tunable laser system
- Off-axis parabola collimator flat fold mirror on motorized rotation stage
- Directs beam to calibrated Libera EM radiometer or science radiometers
- Covers 300nm to 2400nm

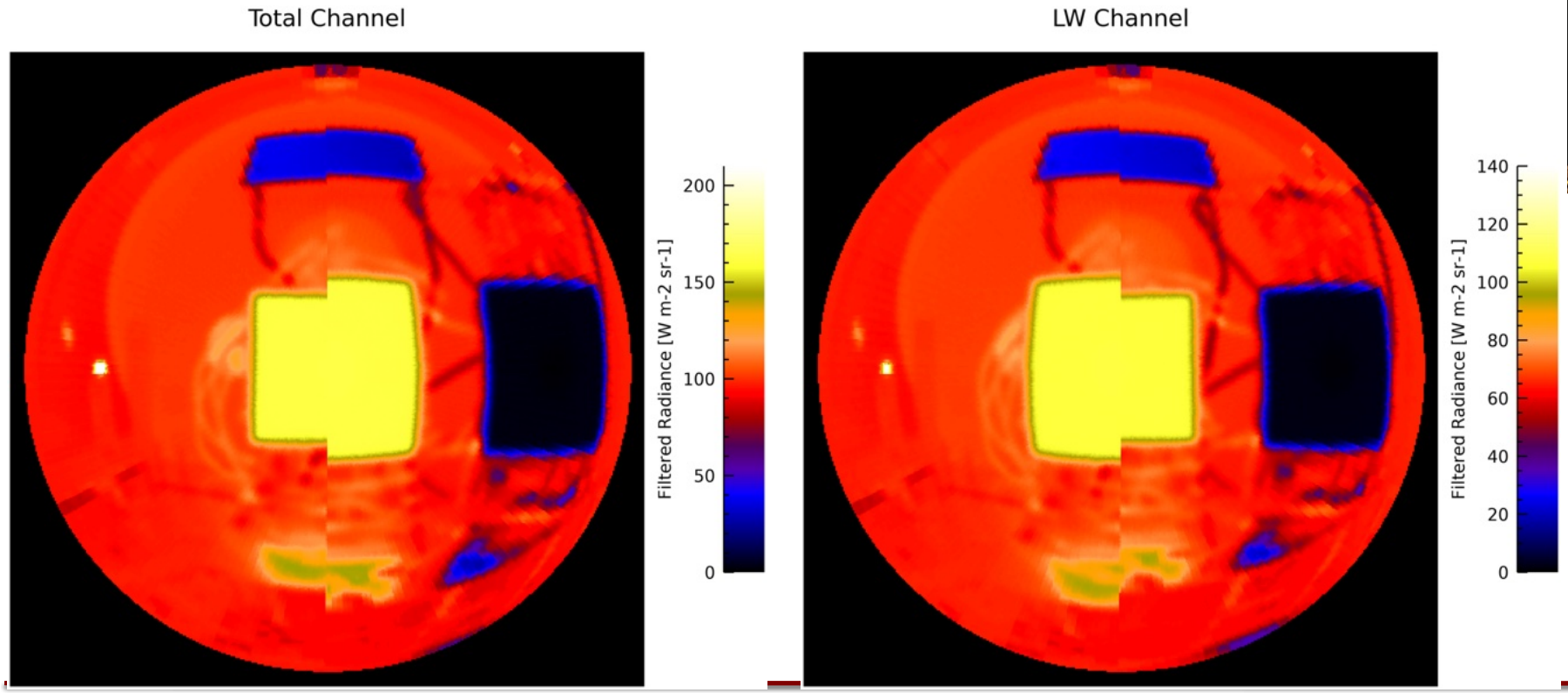


Integrated System Testing

Images from RAP Test

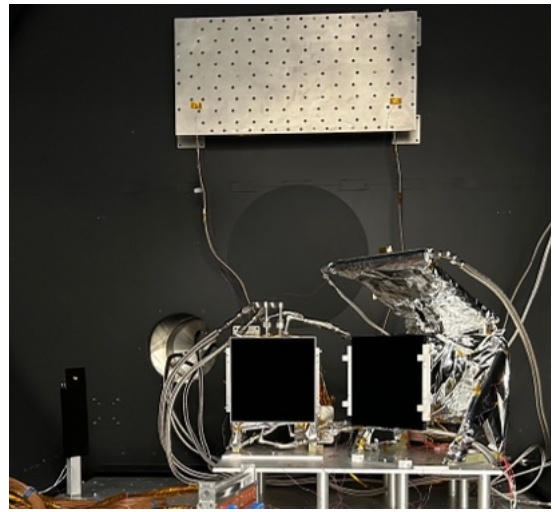
- RAP mode testing was done during testing
- Create an image of the radiance observed in the chamber
- Parallax effects cause the observed left-right asymmetry



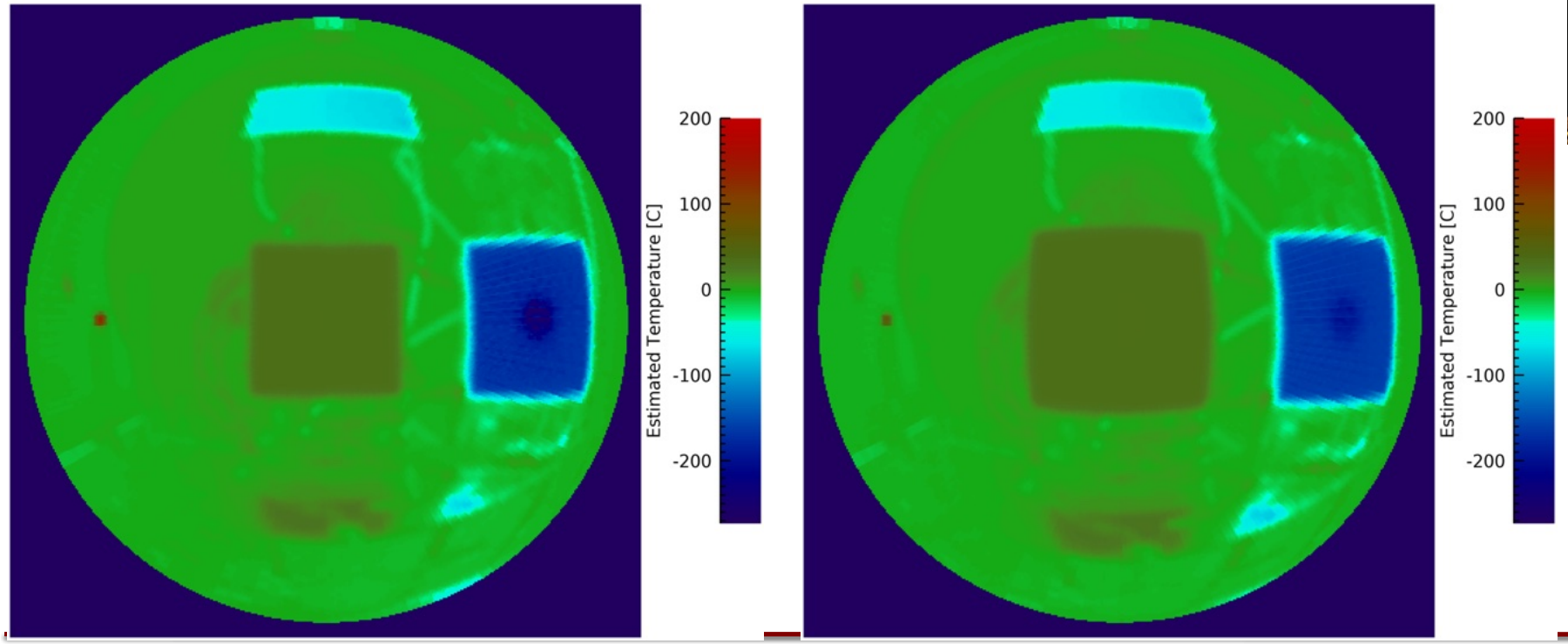


Images from RAP Test

- RAP mode testing was done during testing
- Create an image of the radiance observed in the chamber
- Perform simple conversion to radiation temperature
- Stitch together Total, LW images to correct for parallax



Total Left, LW Right

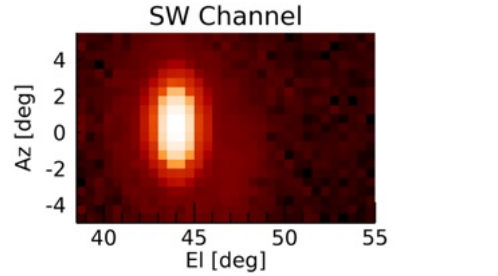


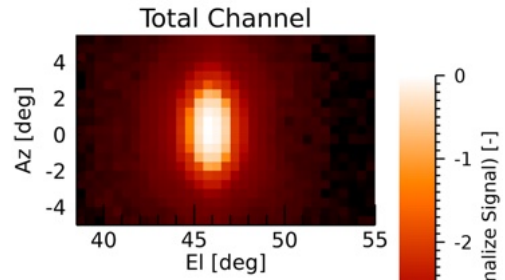
LW Left, Total Right

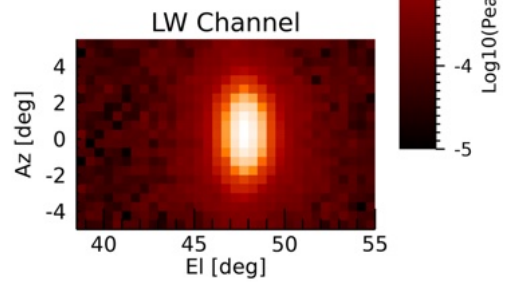
Out of Field/Glint

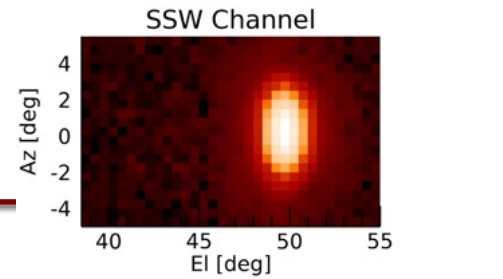
- Check the response outside of the FOV for unwanted glints with the integrated instrument
- The Hot BB source is pulsed at 0.5 Hz

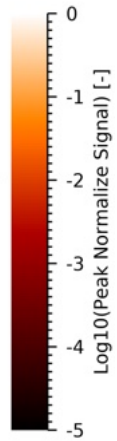
Log Scale



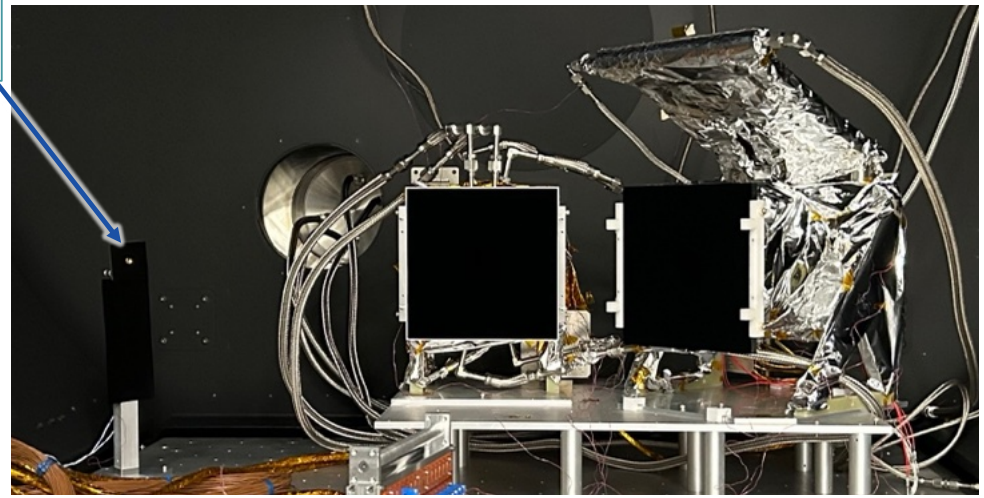








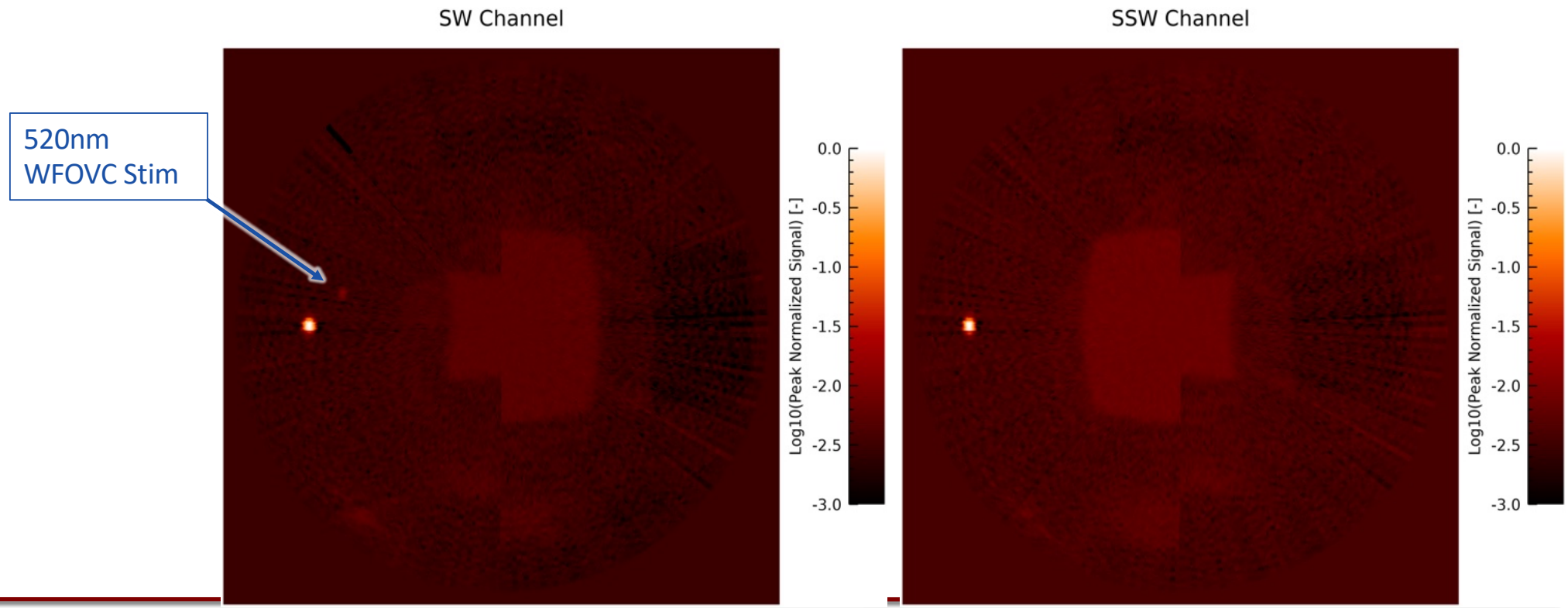
Hot BB Point Source



Wide Angle Out of Field/Glint

- Look at SW and SSW channels during RAP mode testing

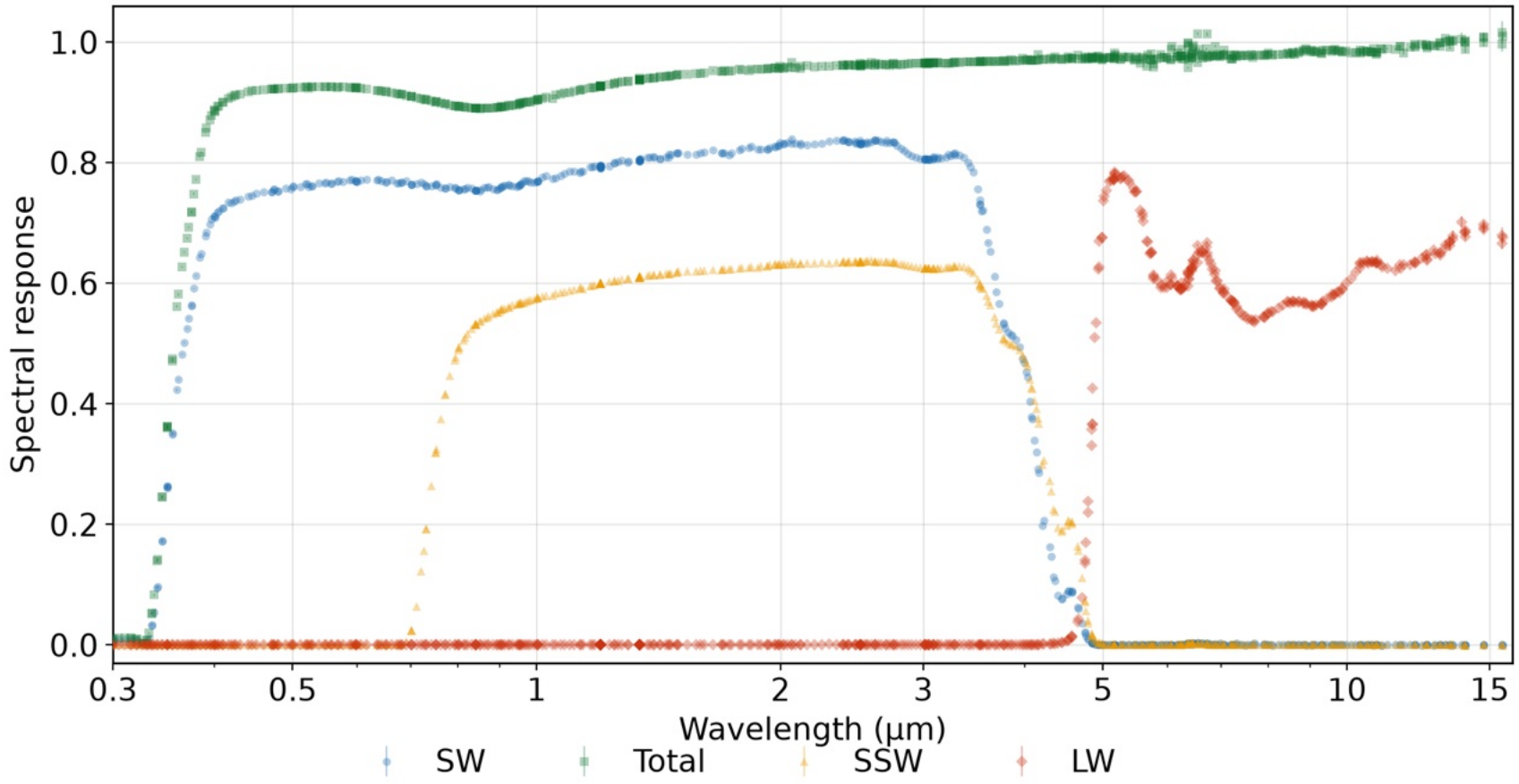
Log Scale



Absolute Response Measurements: SW

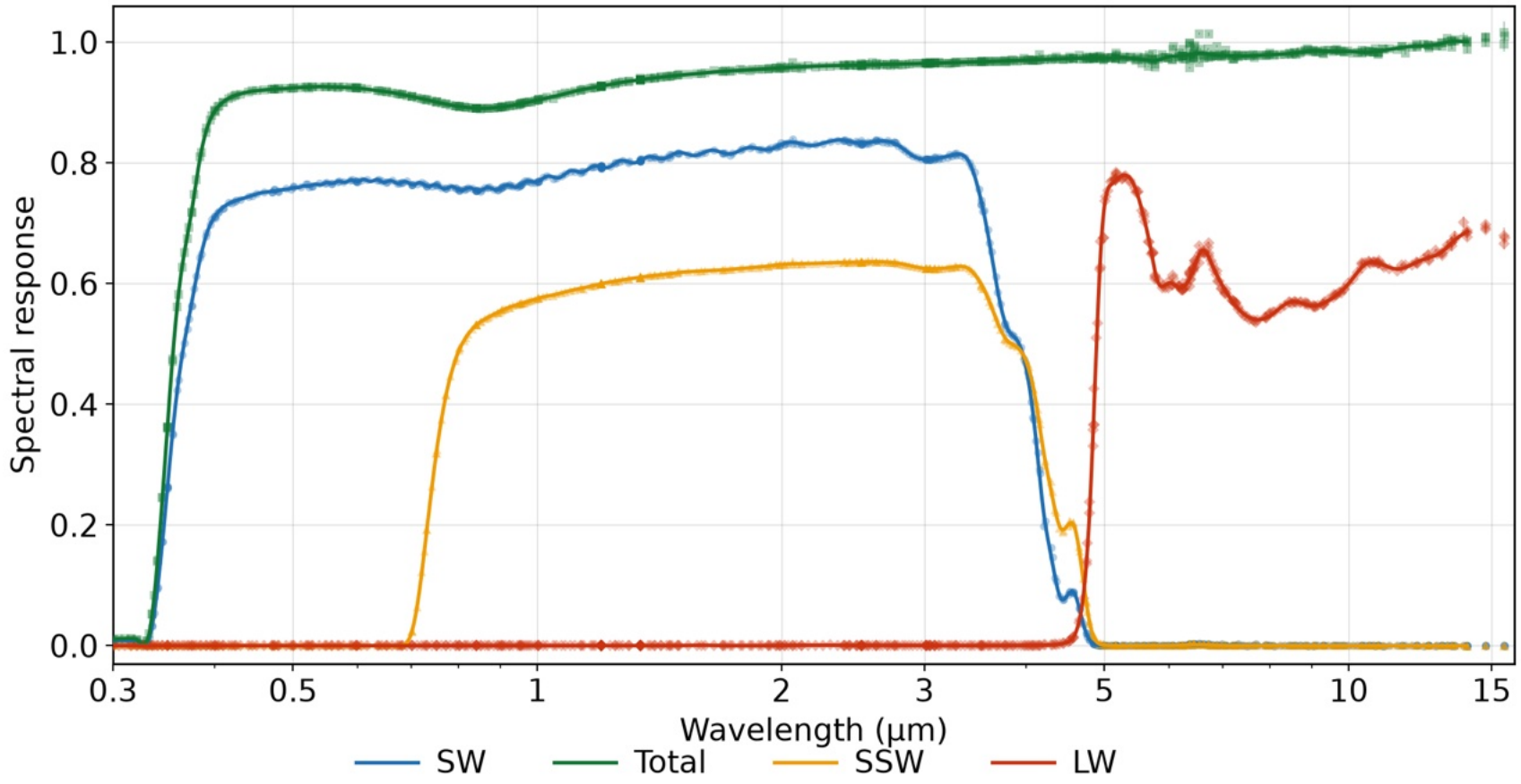
All Pre-Environment Laser Measurements

654 measurements, 249nm to 15.5µm, Taken August 2024 - May 2025



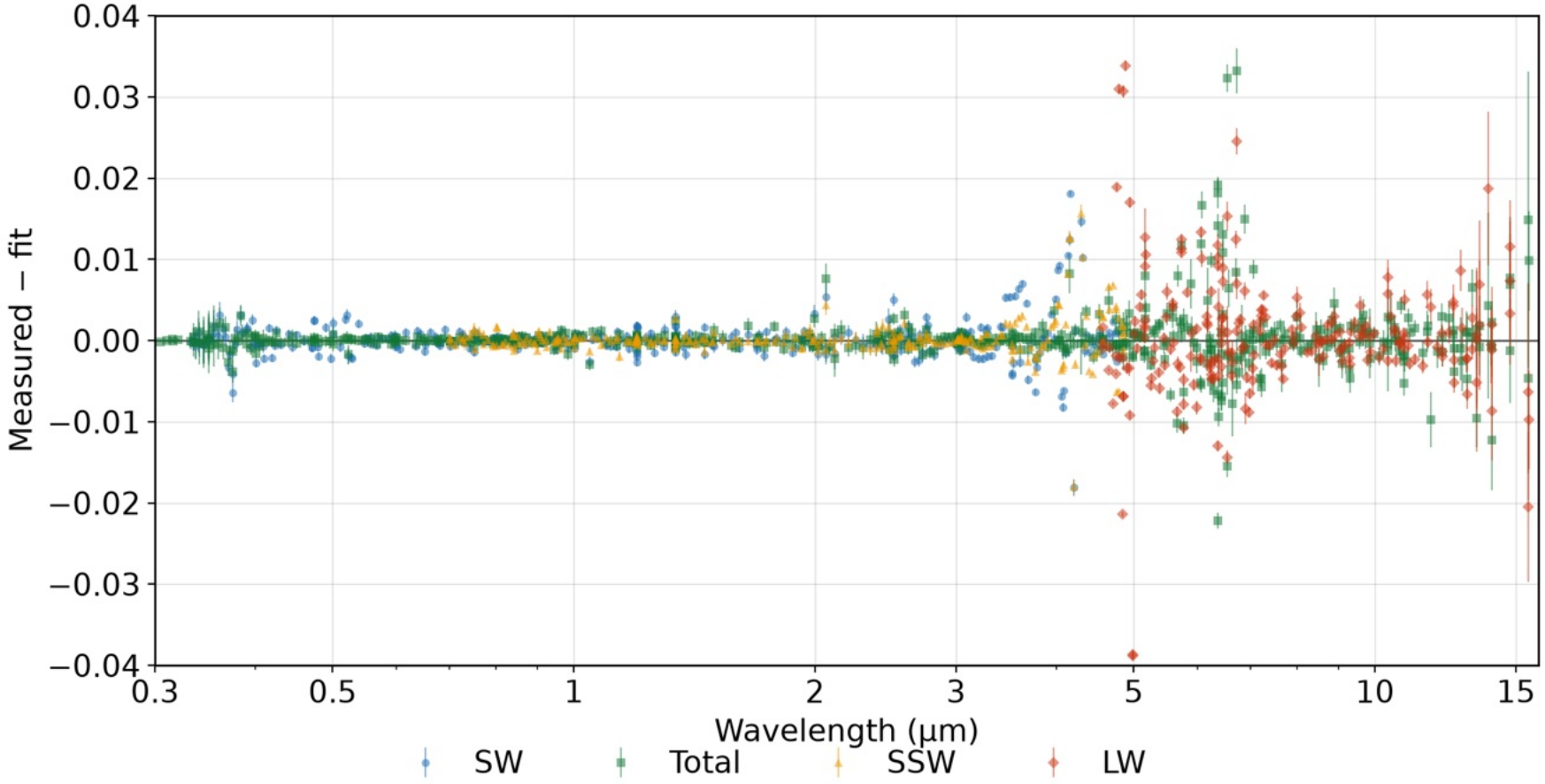
All Pre-Environment Laser Measurements

SRF Fits to the Measurements



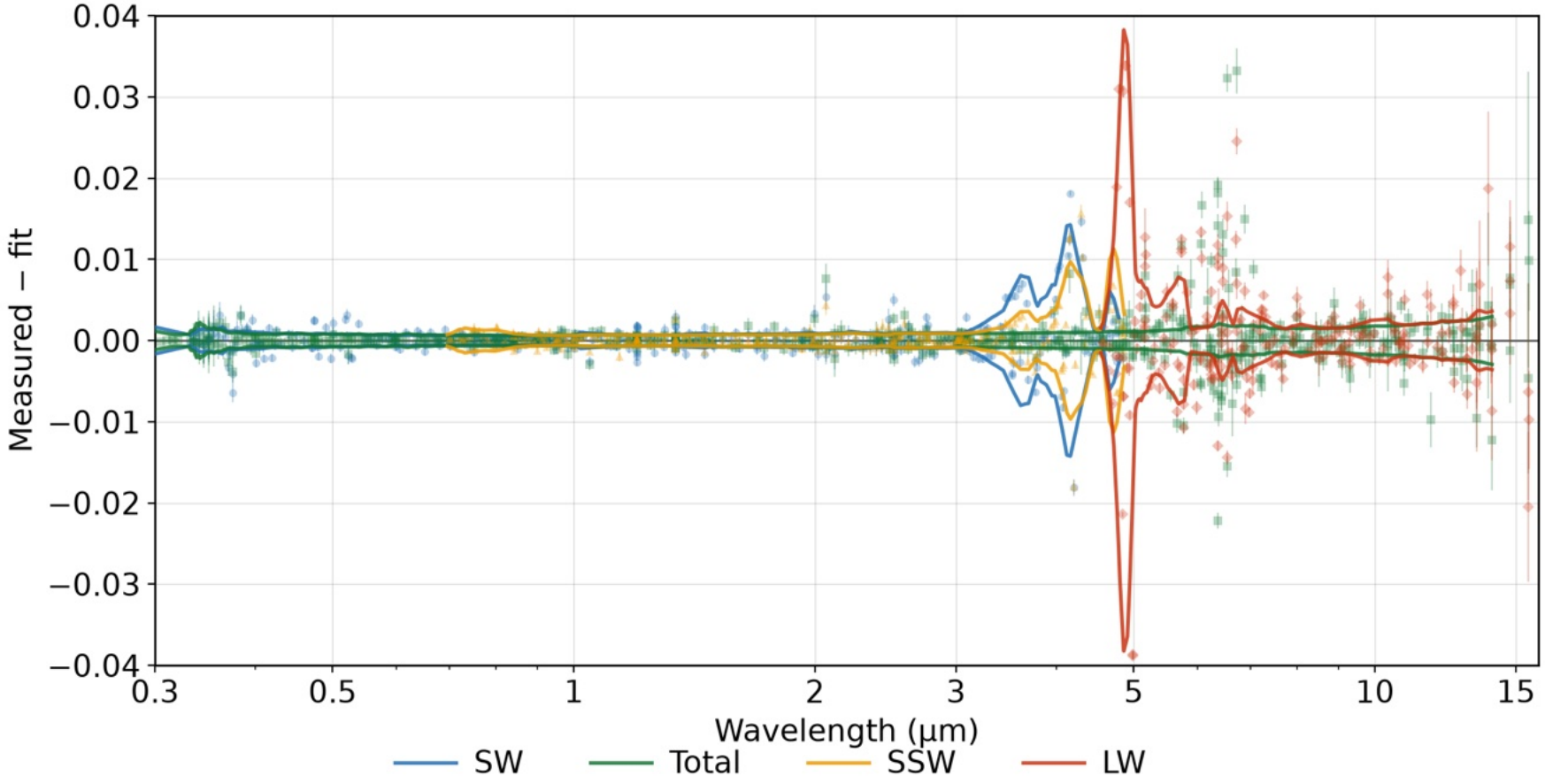
All Pre-Environment Laser Measurements: Residuals

Residual Errors to the SRF Fits



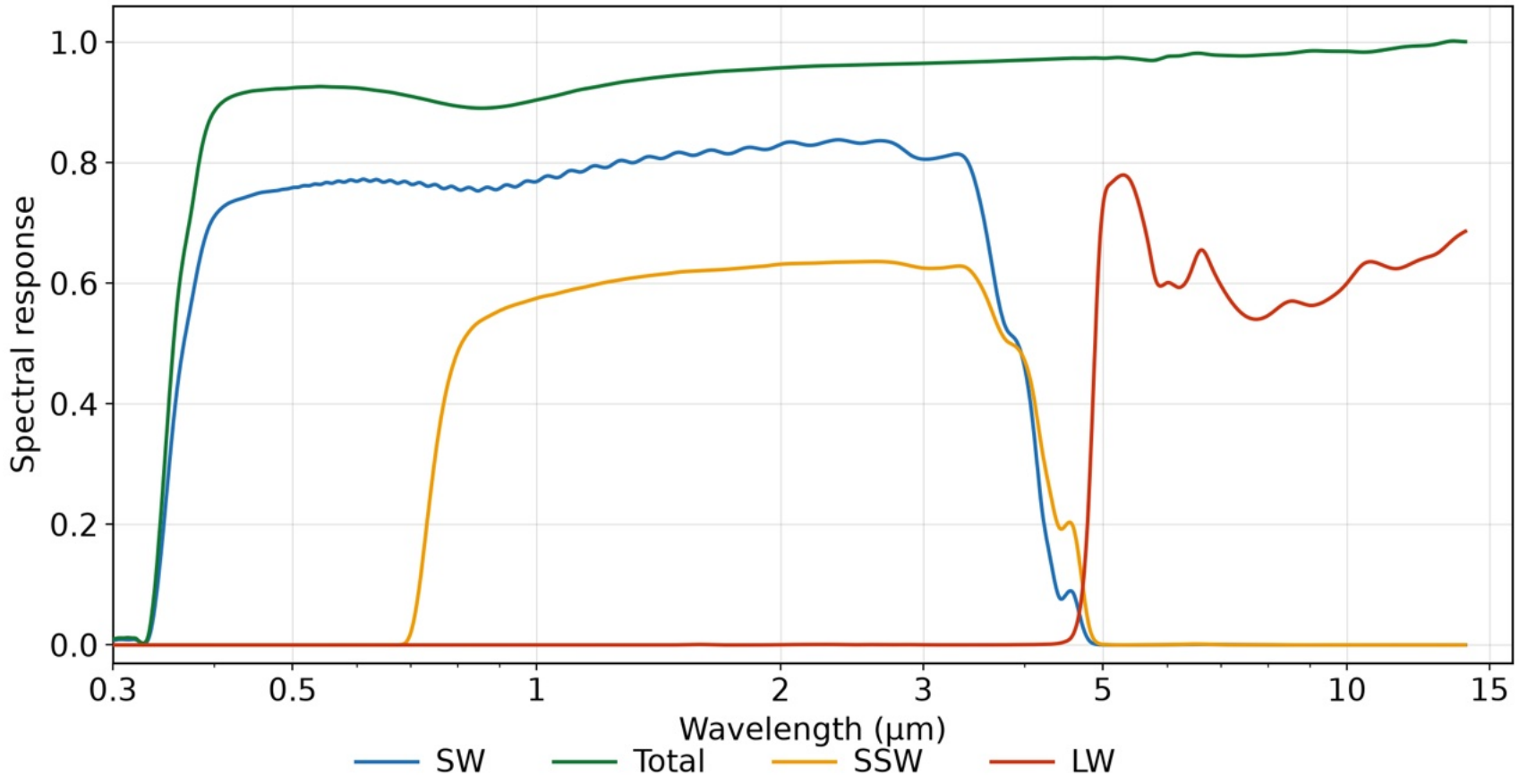
All Pre-Environment Laser Measurements: Residuals

Residual Errors to the SRF Fits, with k=1 uncertainties

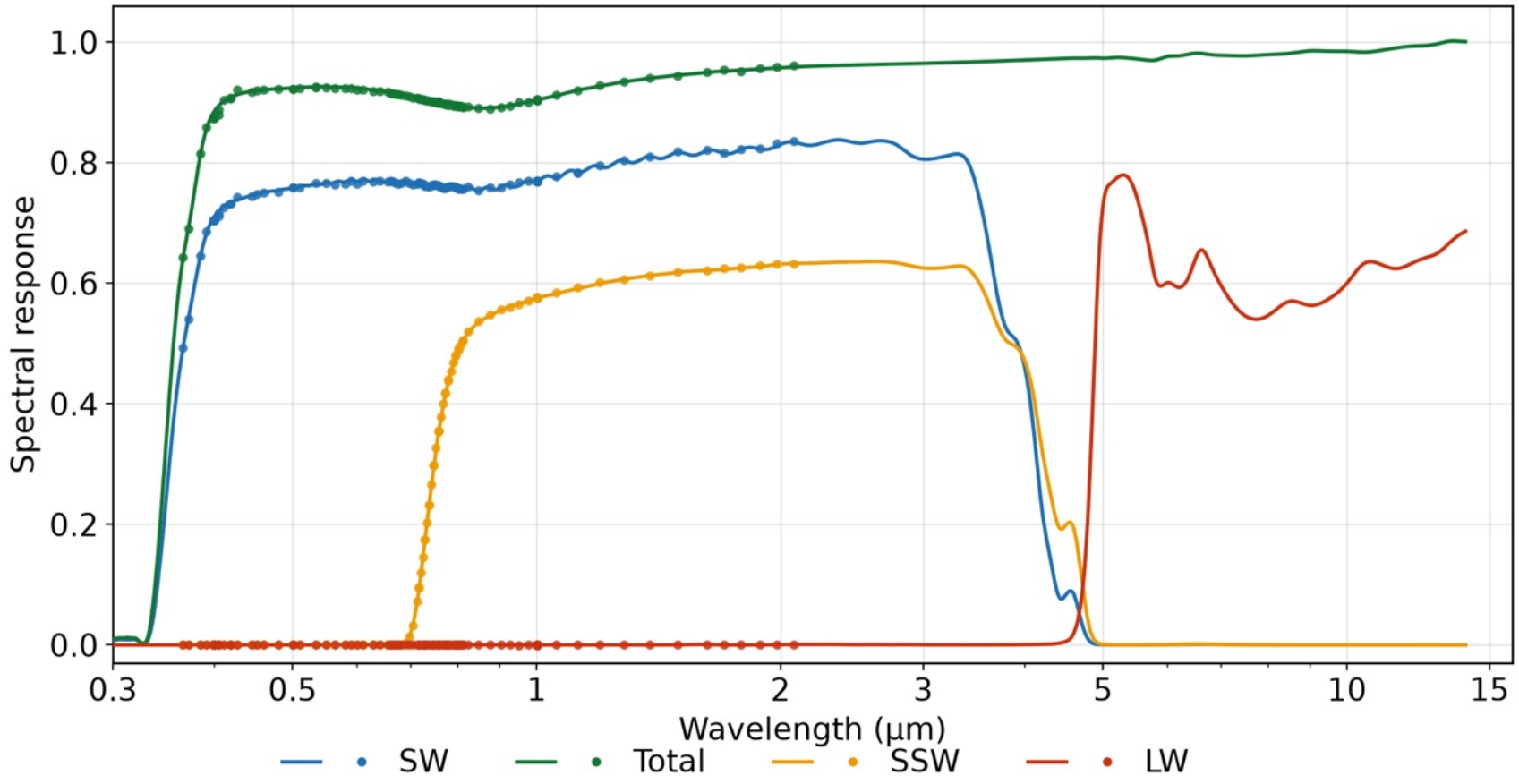


Post-Environment Check

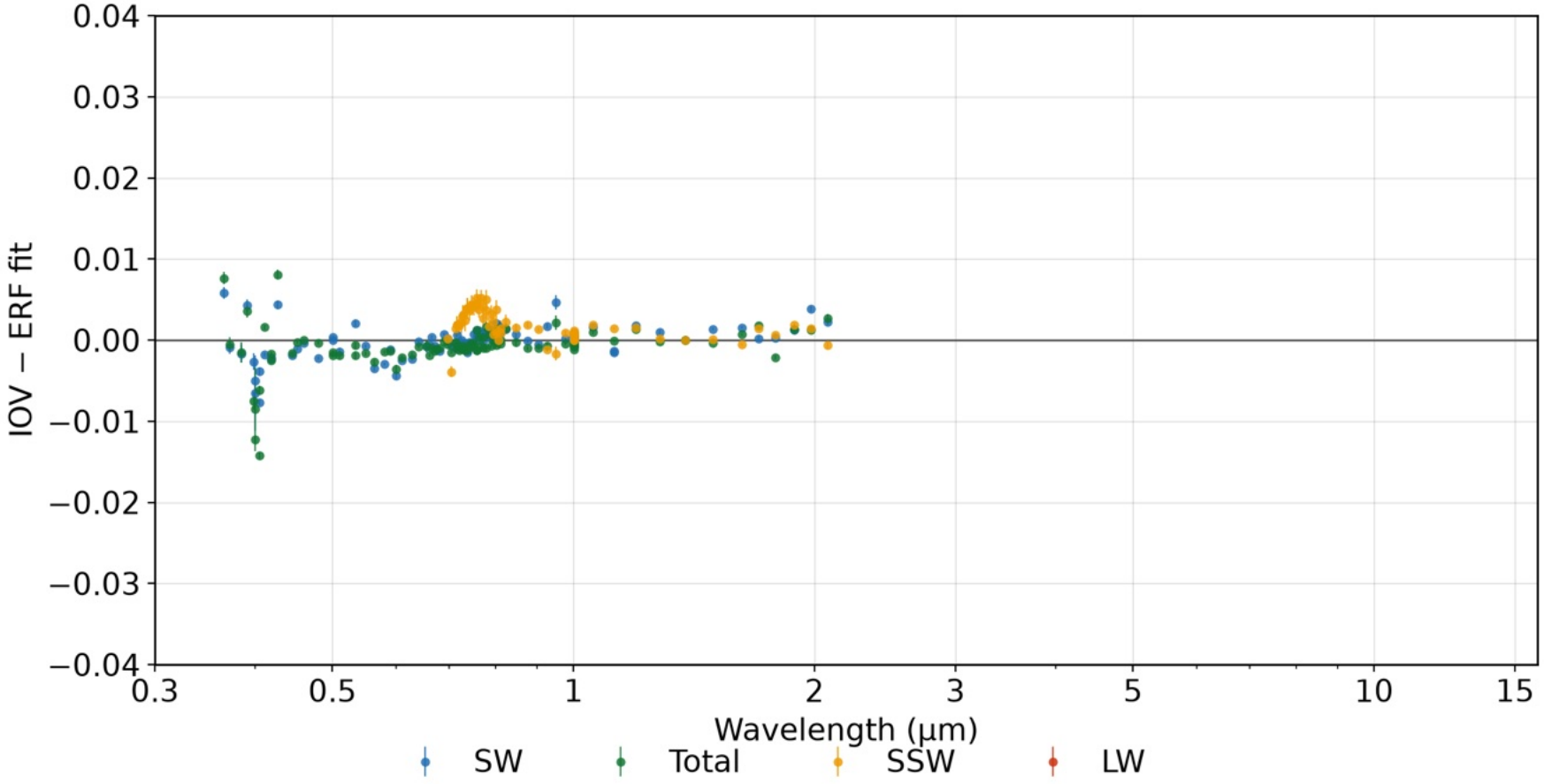
Pre-Environment SRF Fits



Pre-Environment SRF Fits with Post-Environment Measurements



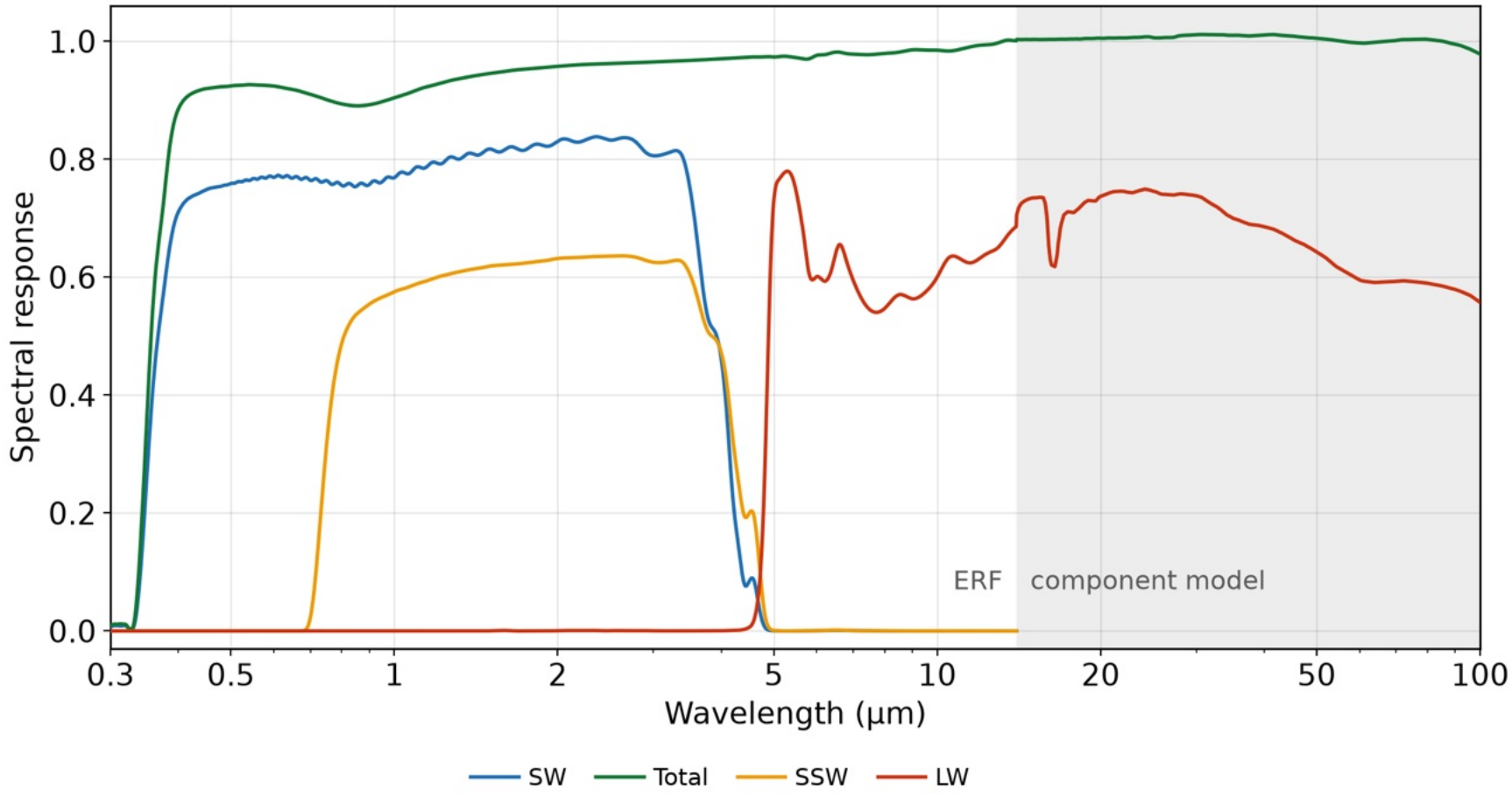
Residual Difference between Pre- SRF Fits and Post-Measurements



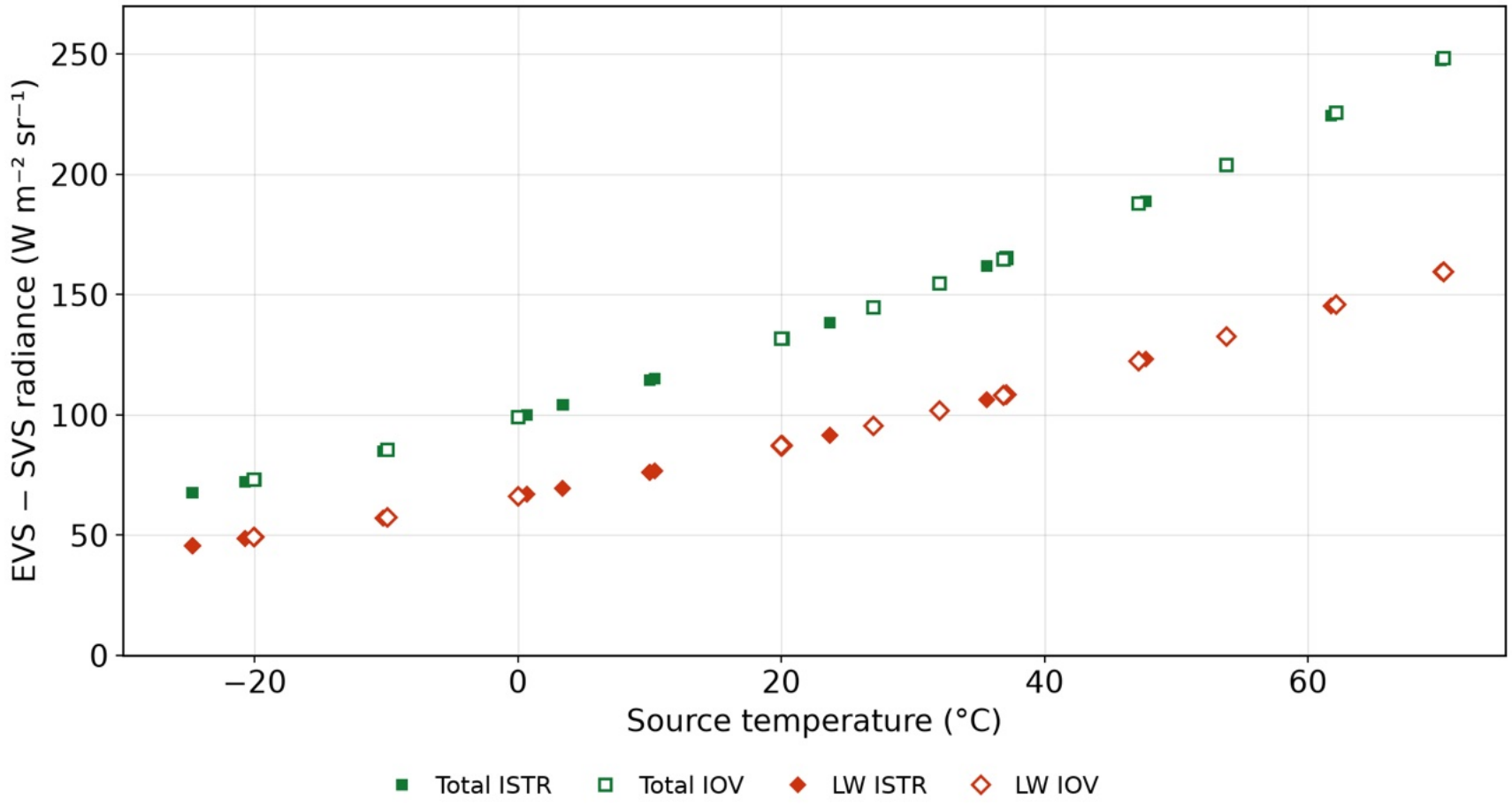
Absolute Source Measurements: LW

Full Spectral Response Models

Cover >14µm using component-level measurements and adjust to match IR measurements

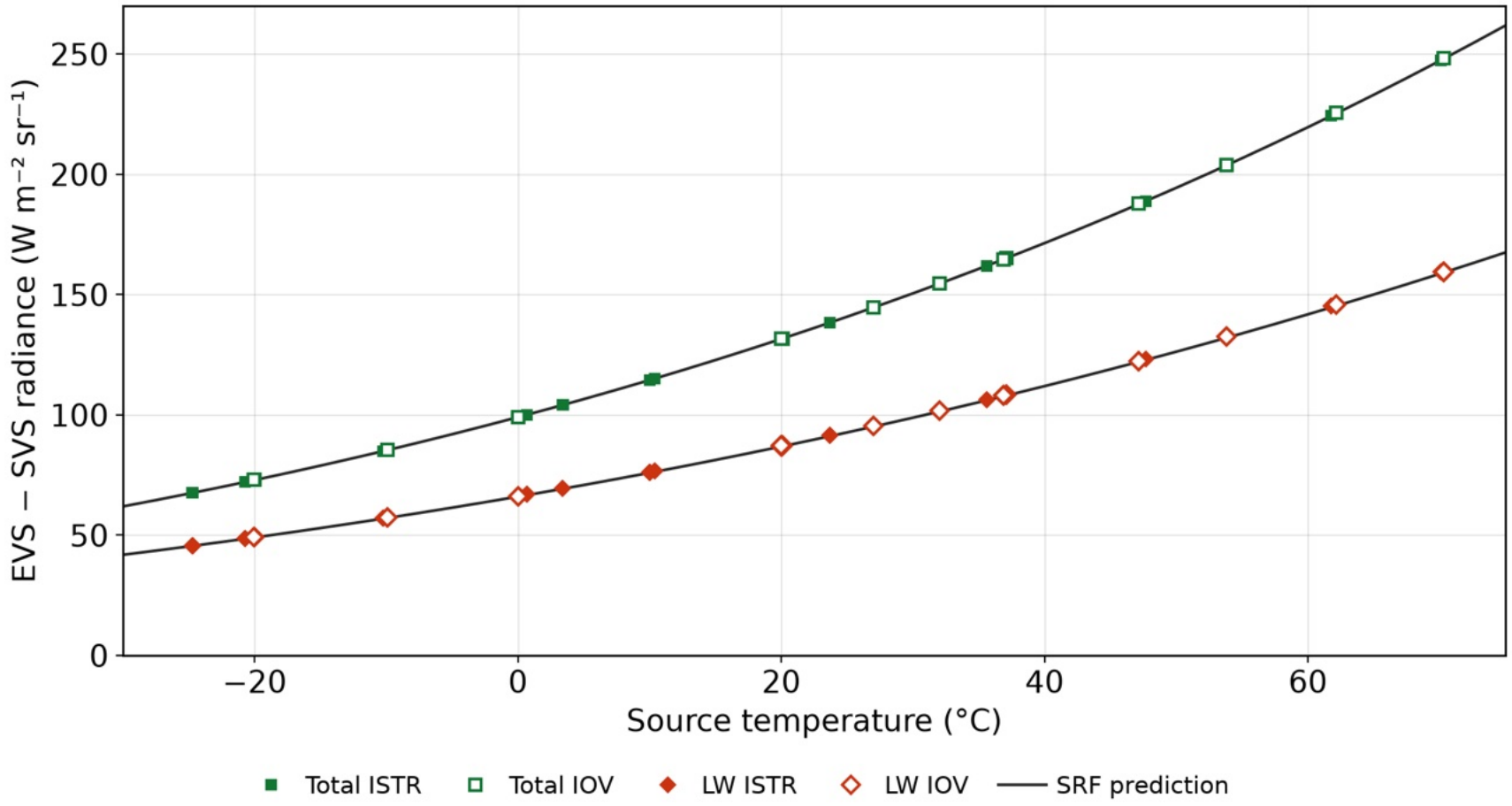


Blackbody Measurements

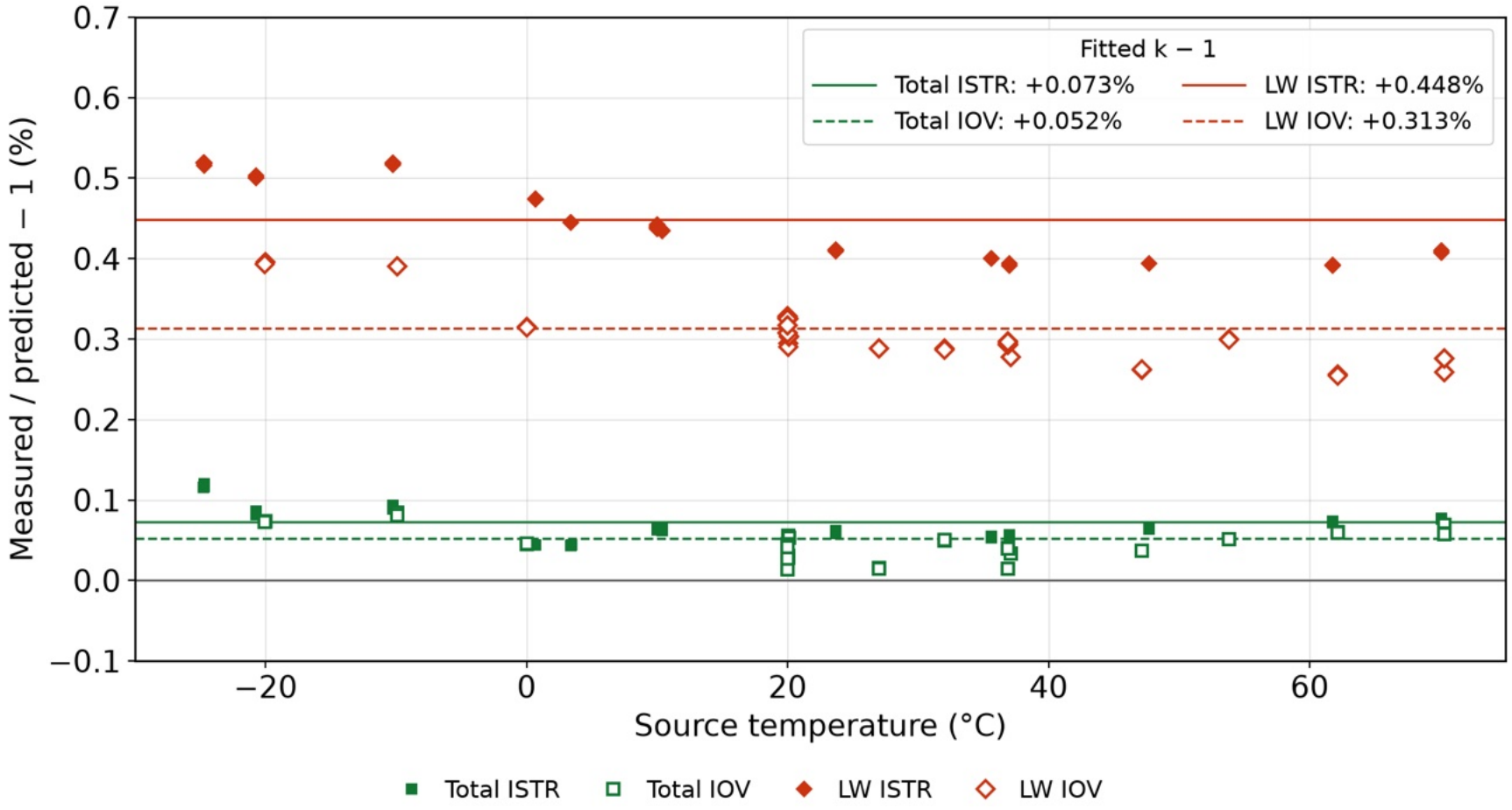


Blackbody Measurements

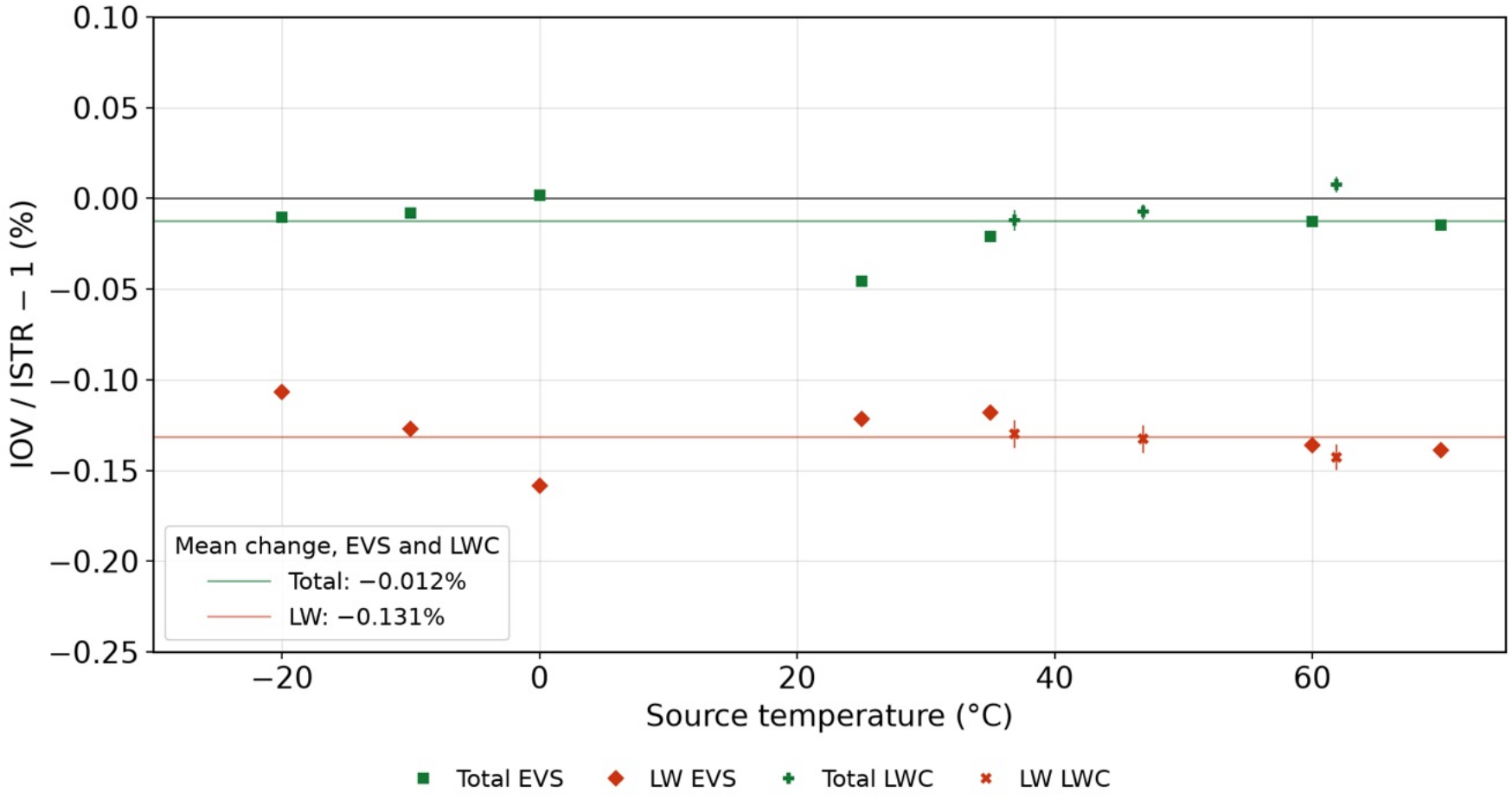
Predicted response using the 0.3-100µm SRFs



Residual Difference between Measurement and Prediction



Total and LW Channel Response Tracked by LWC



Summary

- Refining the SRFs and the associated uncertainty from our ground calibration dataset
- Libera radiometers have demonstrated good stability through environmental testing
- LW channel has shown good performance
- On-board blackbody has shown that it can track the LW response to ~0.01%