Libera Mission Update

Peter Pilewskie

Laboratory for Atmospheric and Space Physics, University of Colorado Boulder

and the ***Libera*** **Team**

Libera, NASA Earth Venture Continuity-1 Mission

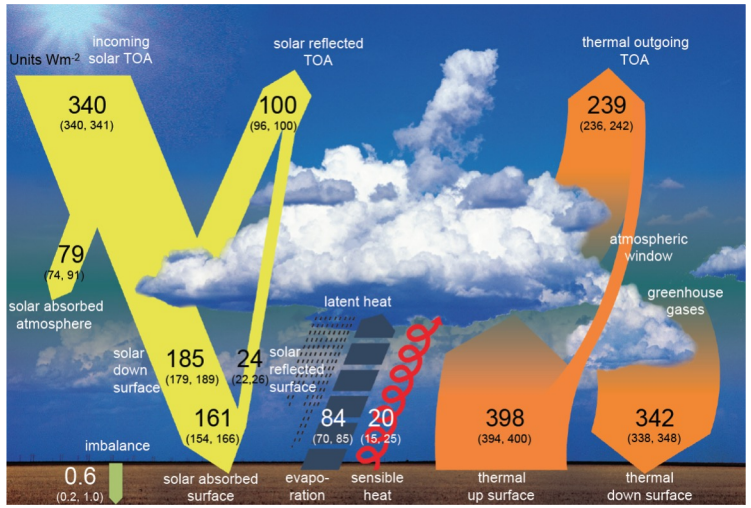
'Li-be-ra, named for the daughter of Ceres in ancient Roman mythology

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

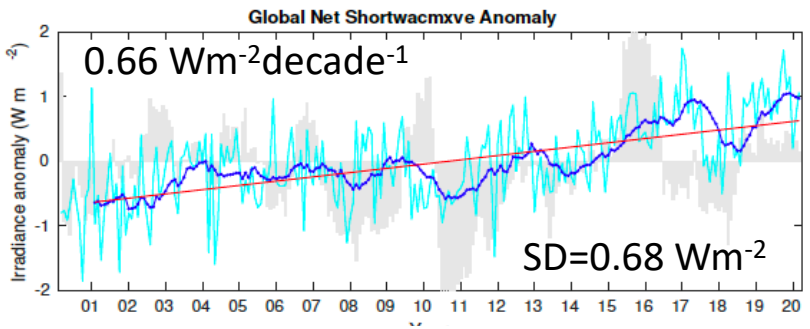
- ***Measures integrated shortwave (0.3–5 µm), longwave (5–50 µm), total (0.3–100+ µm) and (new) split-shortwave (0.7–5 µm) radiance over 24 km nadir footprint; uncertainty ~ 0.3%***
- ***Includes a wide FOV camera for scene ID and simple ADM generation to pave way for future free-flyer ERB observing 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, Ball Aerospace, NIST Boulder, Space Dynamics Lab***
- ***Science Team: CU, JPL, CSU, UA, UM, LBL***

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 studies of global climate change
   - ➢ 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 irradiance and quantify SW energy disposition
   - ➢ Tied to **Science objective 3**: Revolutionize understanding of spatio-temporal variations in SW, VIS & NIR irradiance



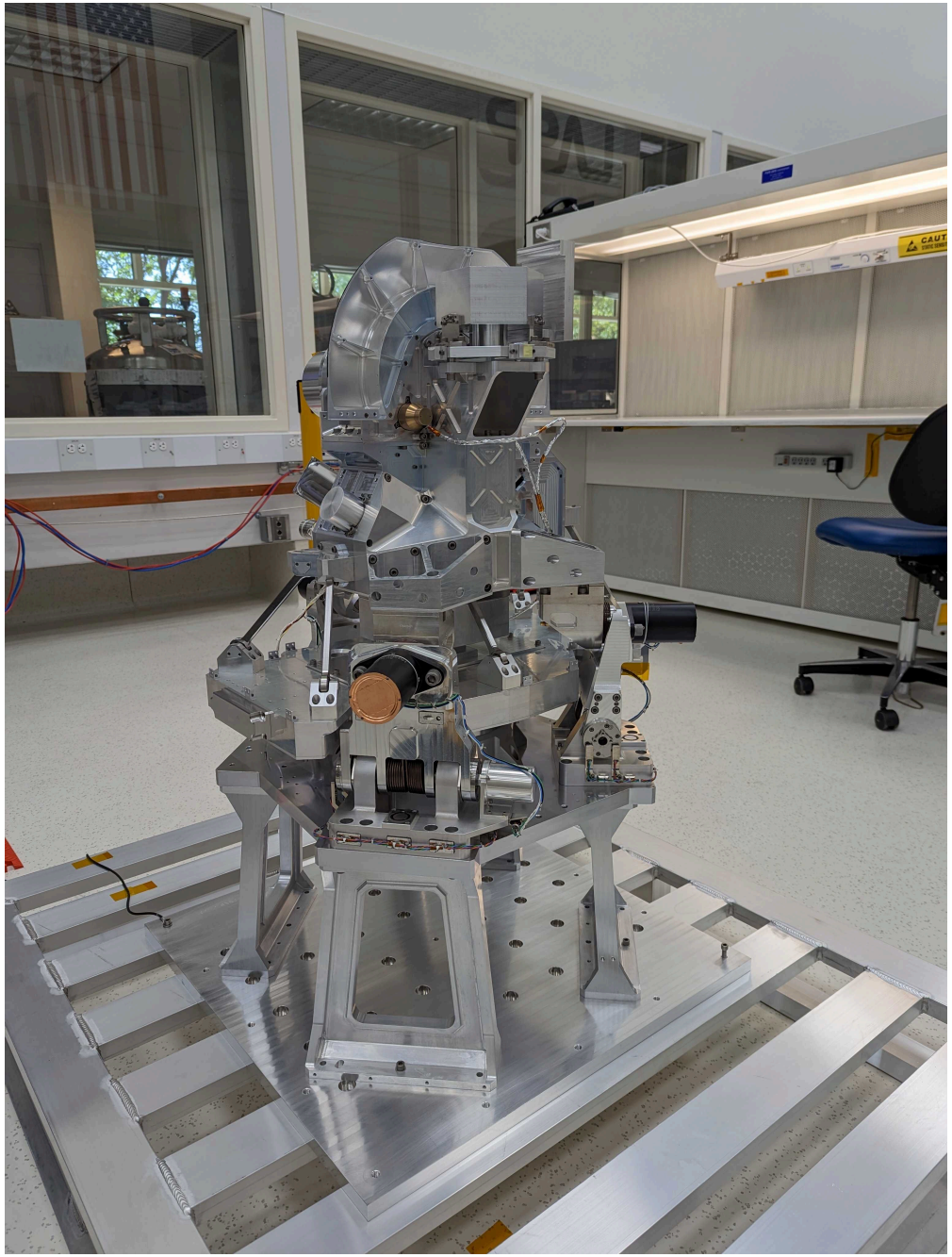
Shortwave Deposition Trend



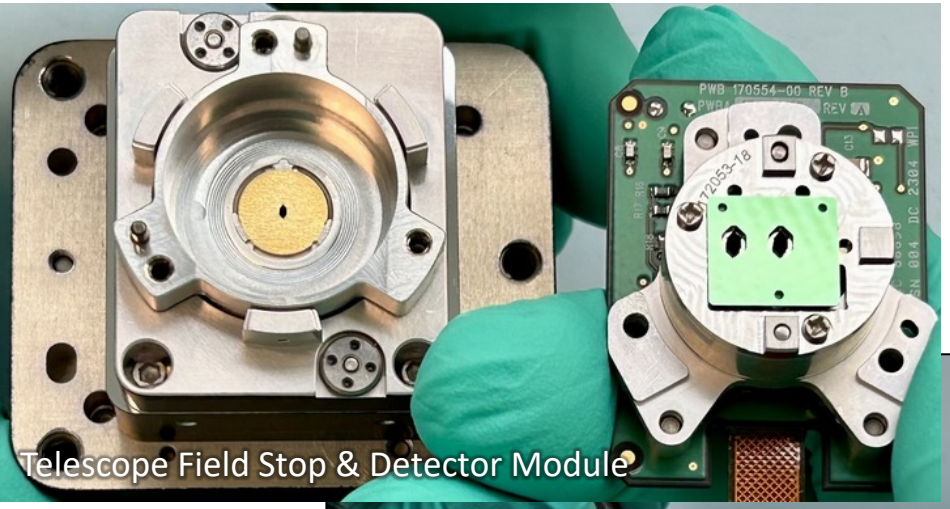
Libera Major Reviews and Key Milestones

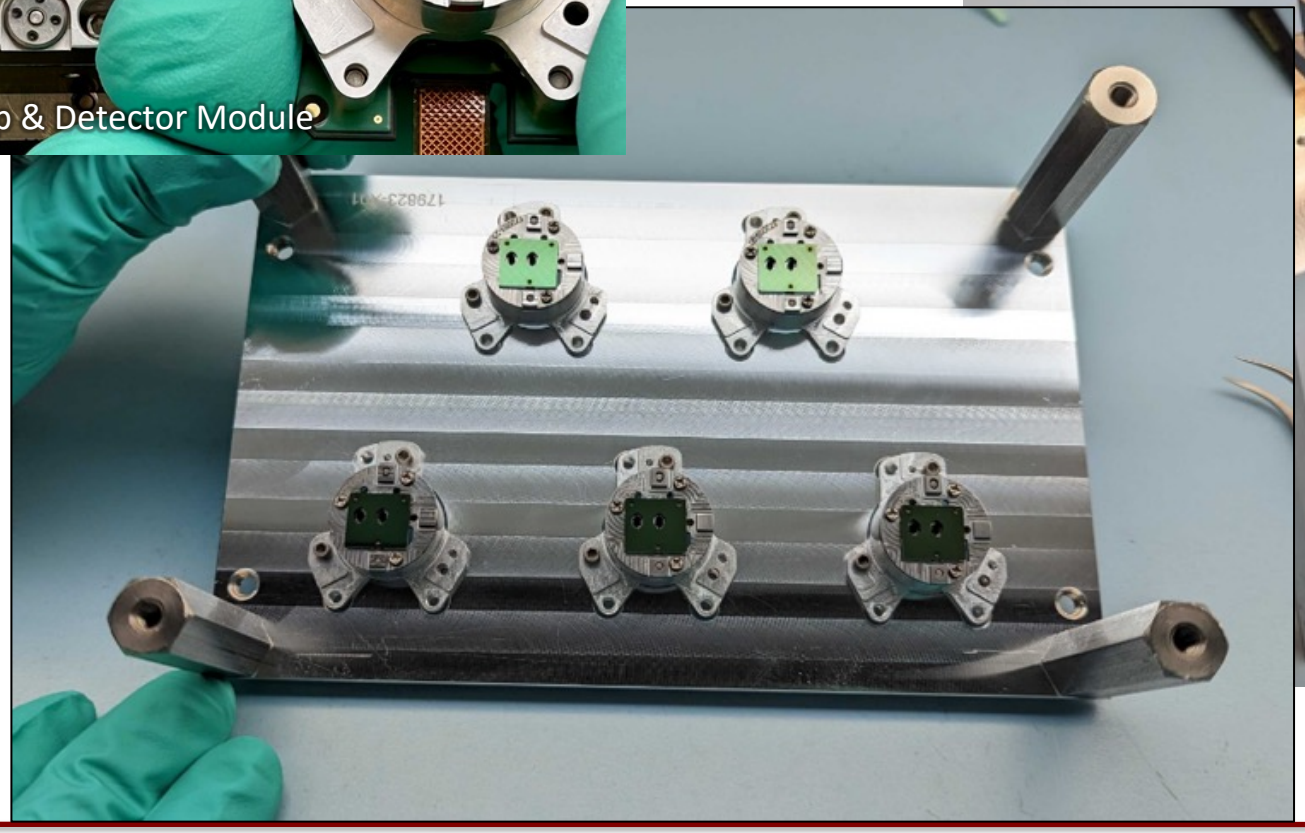
Milestone	Acronym	Date	Convening Authority
Authorization to Proceed	**ATP**	**6 Jul 20**	**-**
System Requirements Review	**SRR**	**22 Feb 21**	**SRB**
Key Decision Point - B	**KDP-B**	**30 Apr 21**	**SMD PMC**
Preliminary Design Review	**PDR**	**8-10 Feb 22**	**SRB**
Key Decision Point - C	**KDP-C**	**Apr 22**	**SMD PMC**
Critical Design Review	**CDR**	**27-29 Jun 23**	**SRB**
Libera Accommodations Review	**LAR**	**15-16 May 24**	**JPSS**
Pre-Environmental Review	PER	28 May 25	SRB
Pre-Ship Review	PSR	18 Sep 25	SRB
Delivery to Spacecraft		23 Sep 25	-
Key Decision Point D	KDP-D	Nov 25	SMD PMC
Launch Readiness Date	LRD	Sep 27	-
Key Decision Point E	KDP-E	Dec 27	SMD PMC
Post Launch Assessment Review	PLAR	L+90d	SRB
Operational Transition Review	OTR	PLAR + 9mo	TBD

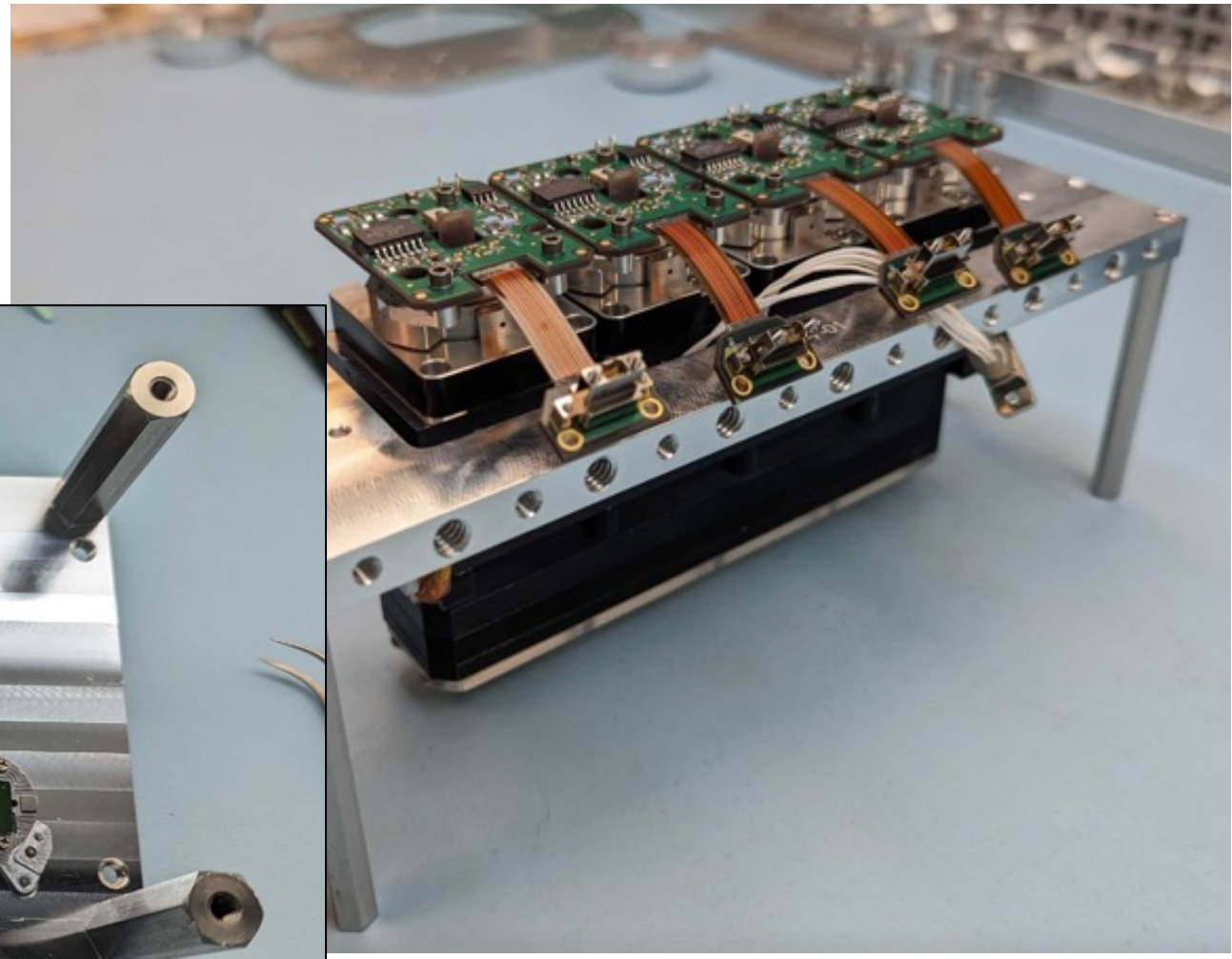
Libera structure in preparation for vibe testing



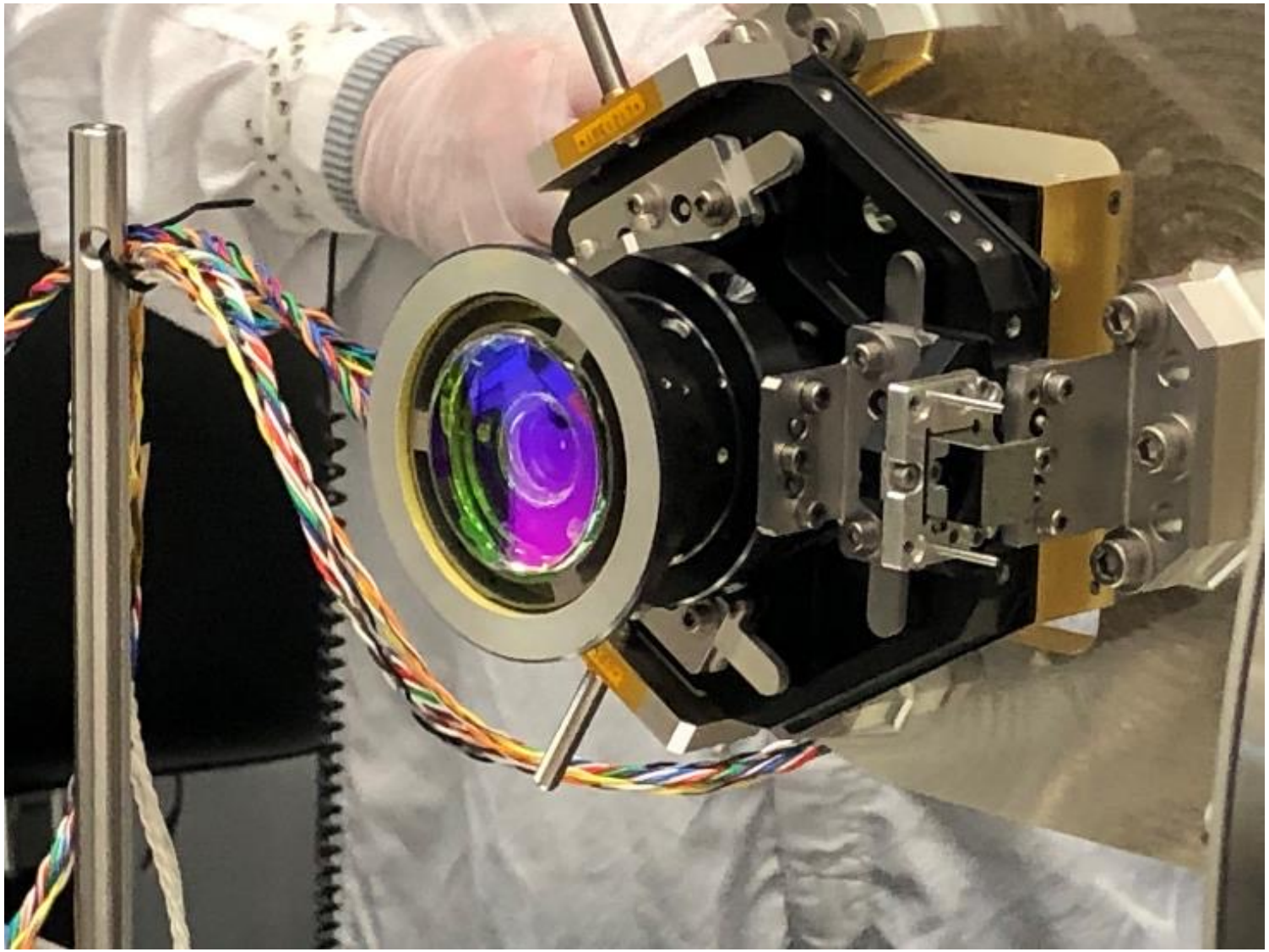
Libera Radiometers







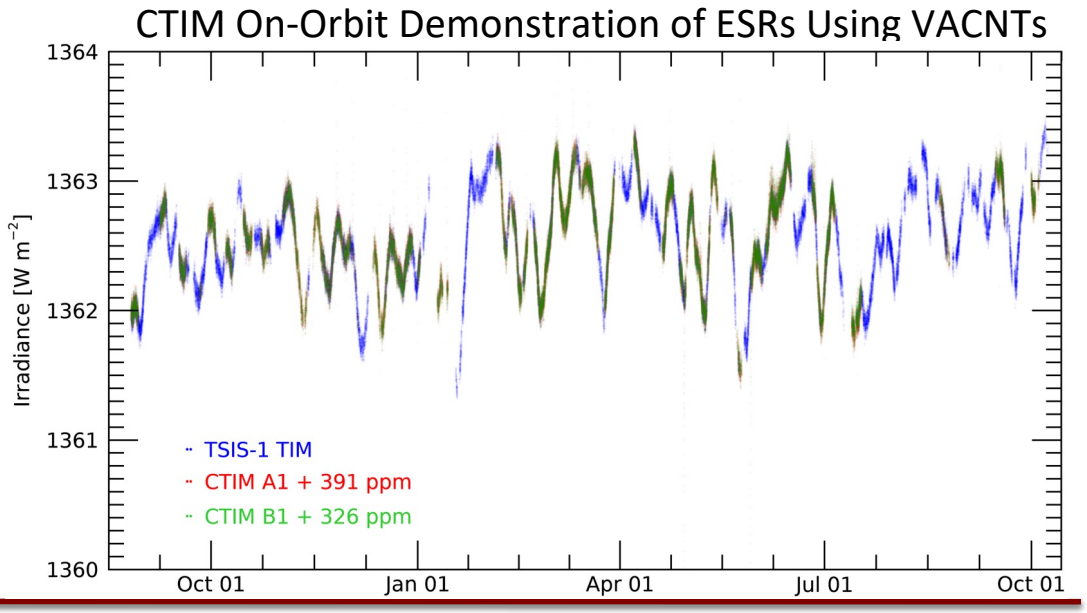
Wide Field of View Camera



Pre-launch Calibration & Characterization

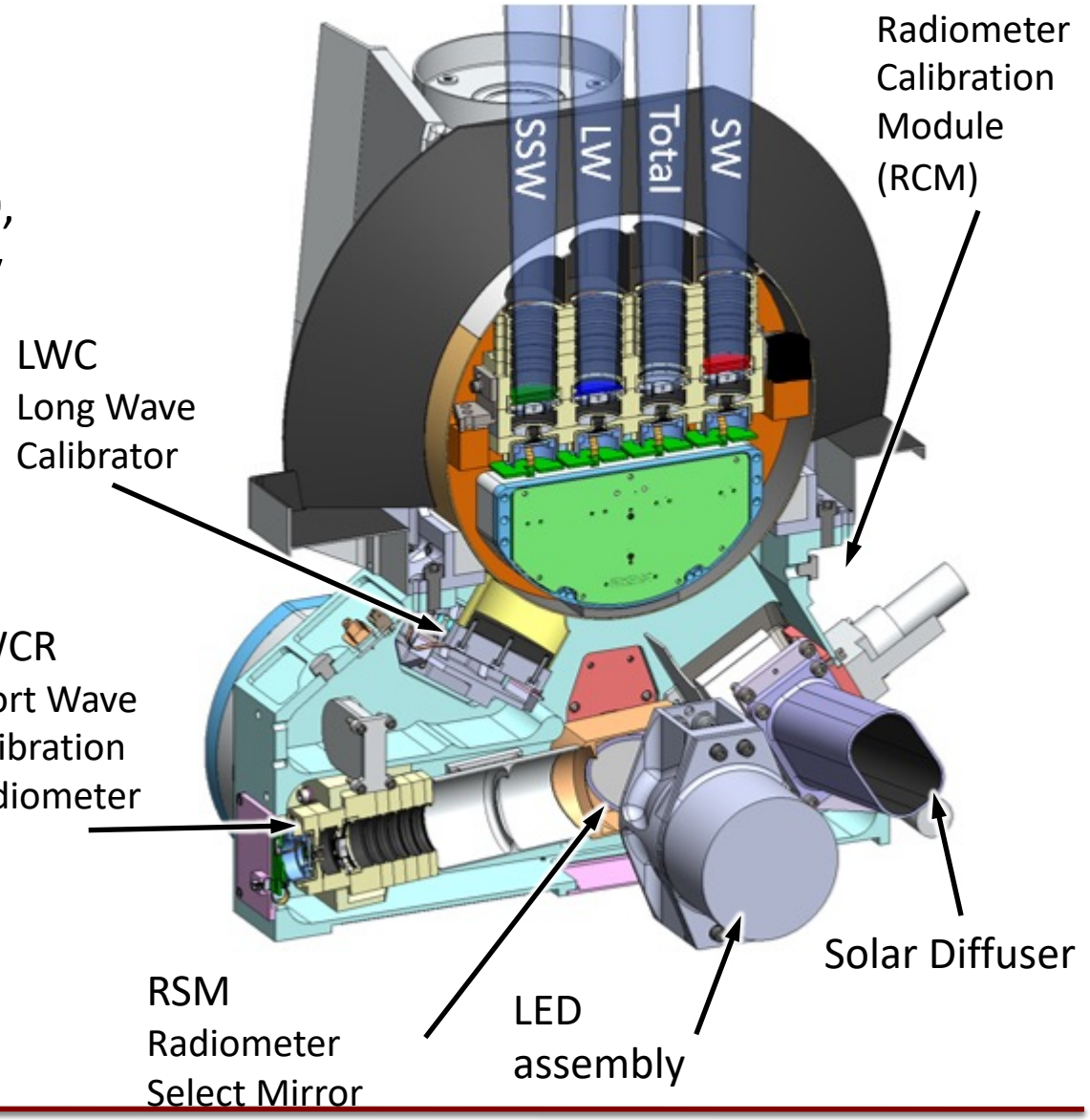
- Component-Level Characterizations
  - Properties of all optical surfaces (mirrors, filters, detectors) measured at NIST and PTB, Germany
  - Used in instrument model to generate expected spectral response functions
- Radiometer Calibrations
  - End-to-end channel calibration at LASP's *Earth Radiance Facility* against NIST-traceable absolute radiance standard detector
  - Uses laser tie-points from 300 nm to 16 µm and broadband blackbody sources.
- System Level Validation
  - Integrated system transported to SDL for independent validation using SW & LW targets at a facility developed for RBI
- System Level Calibrations
  - Testing and calibration of integrated system at LASP

Libera utilizes advanced carbon nanotube detector technology developed by LASP and NIST over a number of ESTO projects: BABAR ACT, CTIM-FD, CAESR, and CSIM-FD.

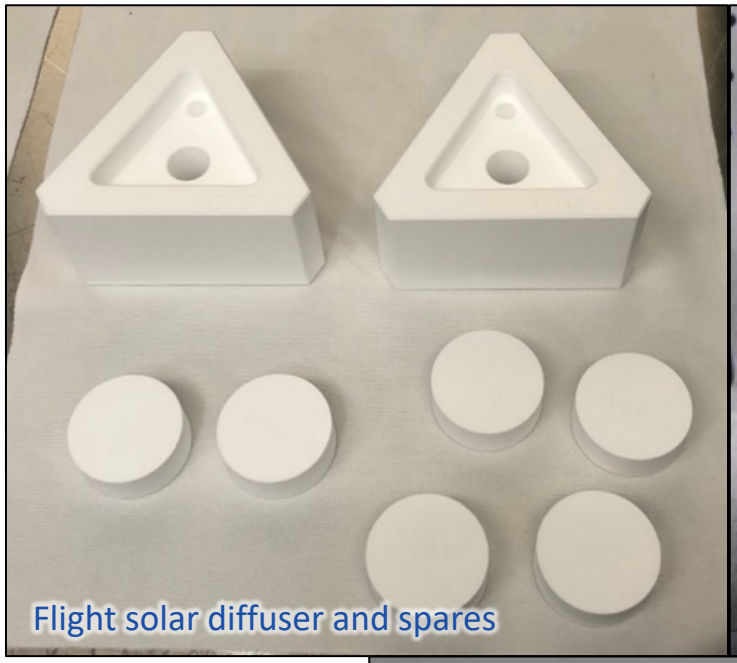


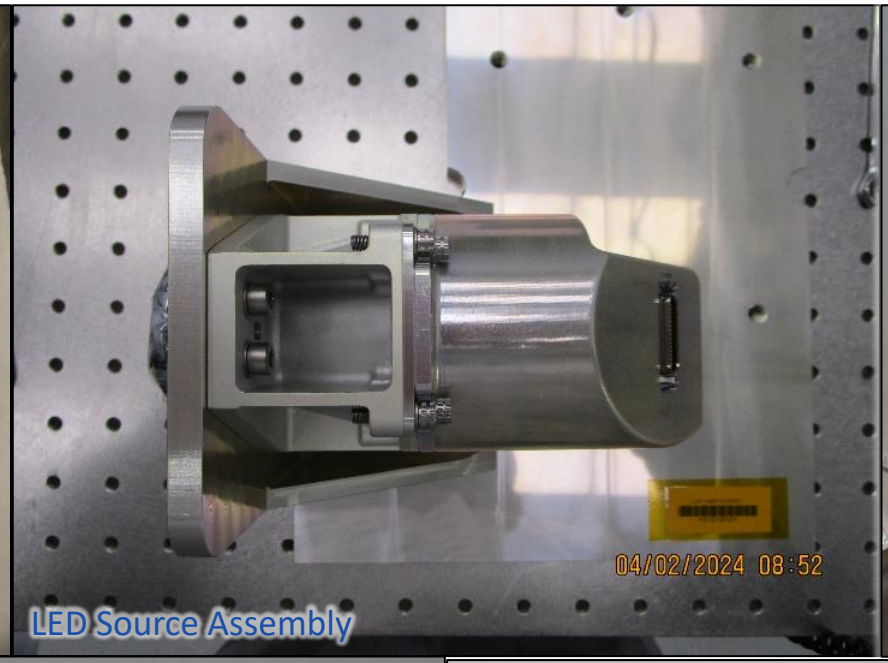
On-Orbit Calibration and Validation

- Onboard calibration targets (daily)
  - Shortwave calibrator using LED sources (365, 405, 520, 635, 840, 1550 nm) and transmissive diffuser; stability tracked via a SW calibration radiometer
  - Longwave calibrator: flat-plate blackbody (310-335K) with VANTABLACK®S-IR coating, SI-traceable PRTs to NIST standards
- Solar calibrations (bi-monthly)
  - Spectralon reflective diffuser, three separate faces viewed bi-monthly/monthly/semi-annually for degradation tracking
- Lunar calibrations (~ 12-16 per year)



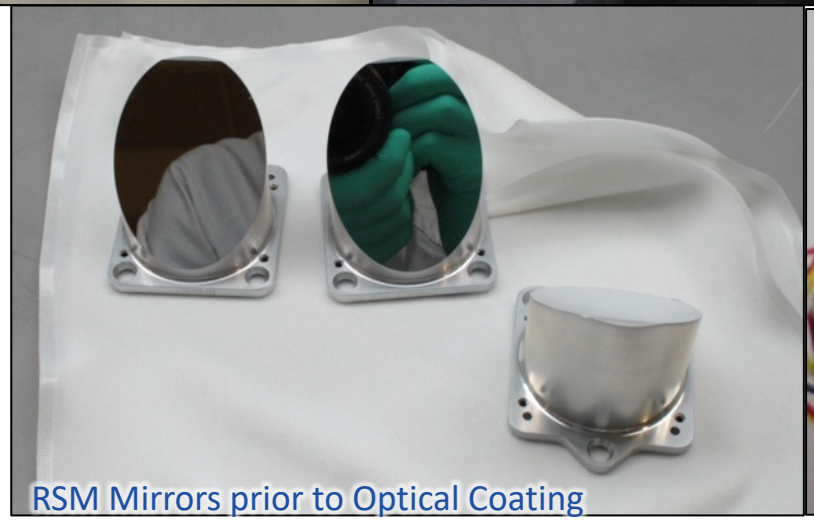
Calibration Assemblies


Flight solar diffuser and spares



LED Source Assembly

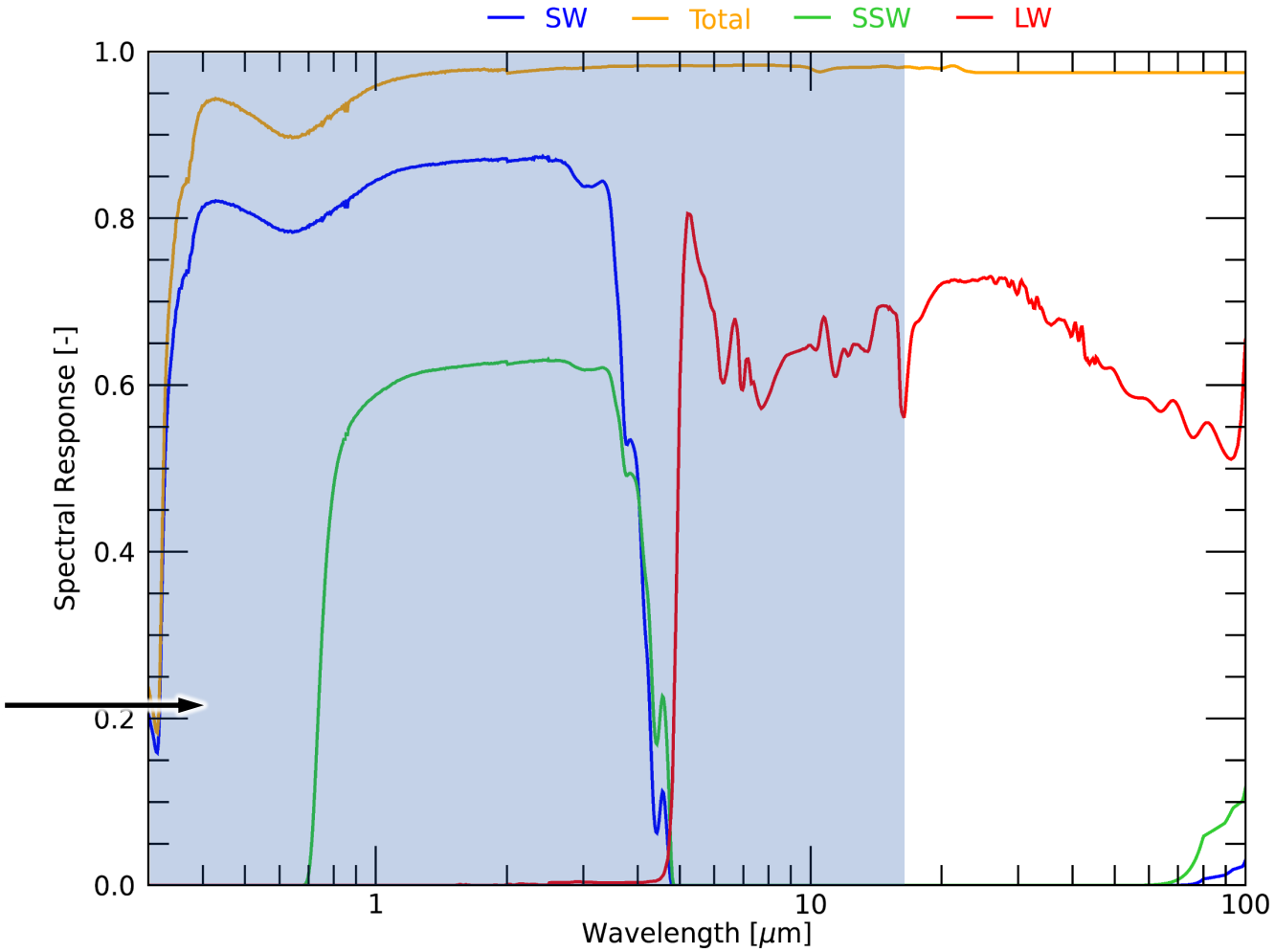

Long Wave Calibrator


RSM Mirrors prior to Optical Coating


Shutter Actuator motor and gearhead

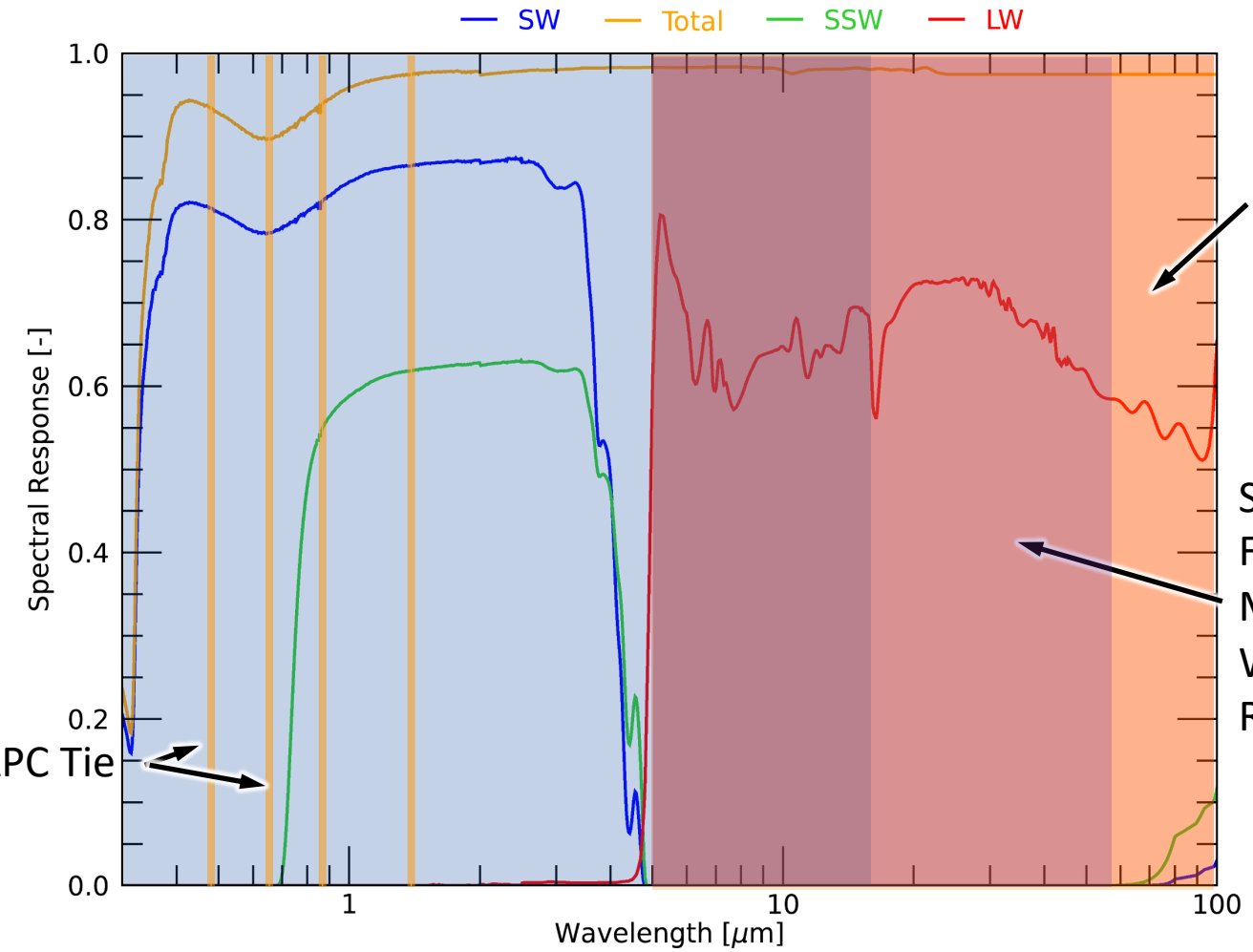
Absolute Spectral Response Overview

Detector Based Laser Calibrations 0.3-16µm



Range covers entire reflected solar spectrum and >50% of the Earth blackbody emission.

Absolute Spectral Response Overview

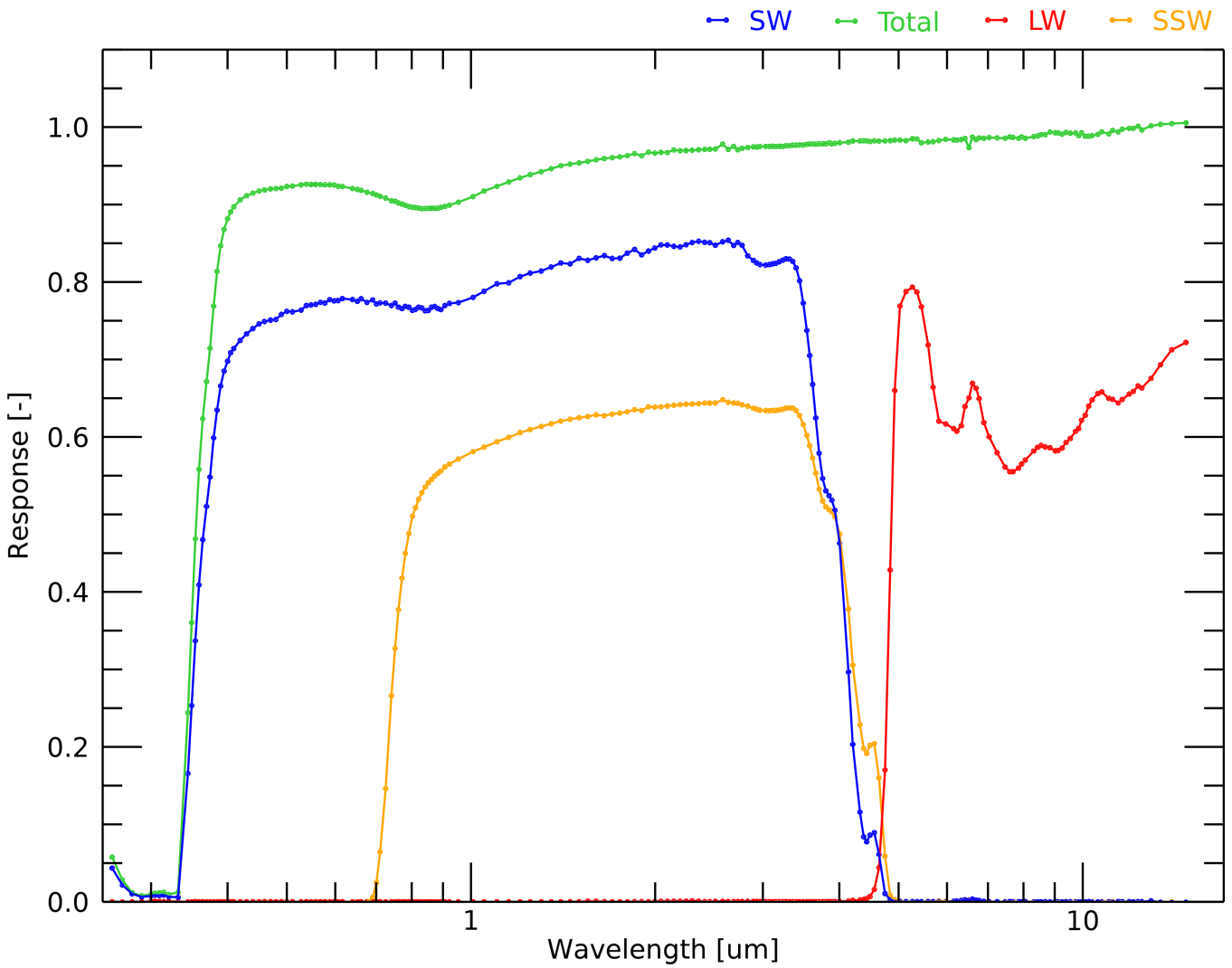


LASP and SDL Blackbody Coverage 5-100μm

SDL FTS RSR Measurement Wavelength Range

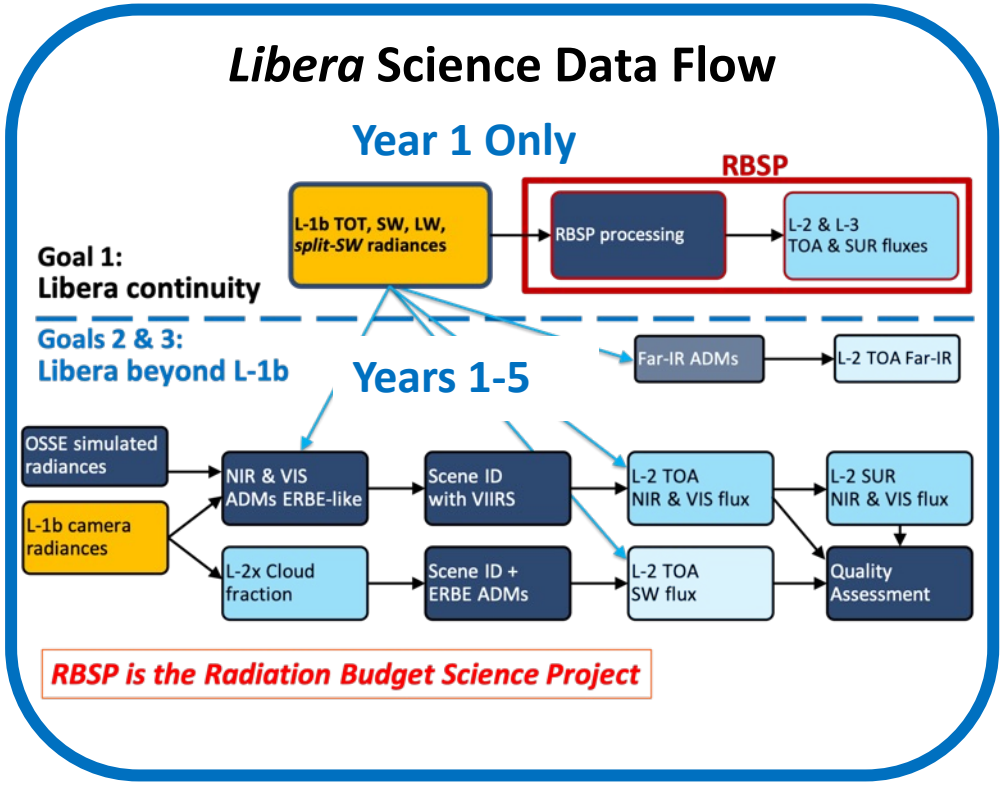
SDL VIS/NIR APC Tie Points

Libera Measured Spectral Response Functions



Transfer of Mission Operations to the RBSP

- *Libera* is responsible for the first year of Phase E mission operations.
  - ➢ During this time Libera produces L-1b radiance products for the RBSP to ingest and produce higher level ERB data products.
- After one year, operations are transferred to the RBSP.
  - ➢ RBSP also takes over production of L-1b data.
- *Libera* continuity plan describes the process for maintaining continuity
  - Regular Libera-RBSP meetings
  - Working groups: data management, cal/val, operations
- *Libera* science team activities continue in years 2-5.
  - Beyond year one, Libera is responsible for:
    - primary science data processing of split channel radiance
    - production of camera radiances and derived products
    - addressing *Libera* science objectives related to all goals



Libera RAPS: Current Status

- Discussions between Libera and RBSP teams have helped refine Libera RAPS approach
  - Shift focus from ADM generation to ADM evaluation
  - Requires less RAPS, introduces along-track scans
  - Libera and RBSP teams plan to collaborate on an alternate split-SW ADM approach that does not require RAPS or the WFOV camera
- Greater reliance on Libera WFOV camera for split-SW ADMs
- Reduced RAPS will still serve multiple purposes
  - Establish spectral conversion required for camera ADM generation
  - Direct integration validation

What's Next?

- This summer – completed fabrication and assembly of flight components
  - Cheese wheel assembly – ERF calibration
  - Structural vibration assembly - September
- 21 Oct 2024: SDL Independent Radiometric Validation
- 25 Mar 2025: Complete Libera Assembly
- 28 May 2025: Pre-Environmental Review
  - 29 May 2025: Vibration
  - 6 June 2025: Electromagnetic Interference/Electromagnetic Compatibility
  - 17 July 2025: Thermal Balance /Thermal Vacuum
  - 18 August 2025: Integrated Optical Calibration
- 17 Sep 2025: Pre-Ship Review
- 23 Sep 2025: Deliver to JPSS-4 Spacecraft vendor, Northrop Grumman, Gilbert, AZ