Pre-flight Optical Tests and Calibration for the Cosmic Infrared Background ExpeRiment 2 (CIBER-2)

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INTRODUCTION

- Extragalactic Background Light (EBL) contains contributions from the first generation of stars and galaxies formed during the Epoch of Reionization (EoR). The EBL measurement is crucial to constrain cosmological models of structure formation.[1]
- Spatial fluctuations of the near-infrared EBL as measured by the Cosmic Infrared Background ExpeRiment (CIBER),[2] Spitzer[3,4] and AKARI[5,6] exceed that predicted from galaxy clustering.[7,8]

Possible sources for excess fluctuations

- New EBL component, such as EoR and Intra Halo Light (IHL)

Cosmic Infrared Background ExpeRiment 2 (CIBER-2)

- Observe the fluctuation of the visible and near-infrared wavelength bands with a sensitivity ~10 times more than that of CIBER, and clarify origin of the excess.[9-11]
  - 6-band photometric imaging observation with Dichroic Beamsplitter and Bend Mirror
  - Spectral observation with Linear Variable Filter(LVF: R~20)

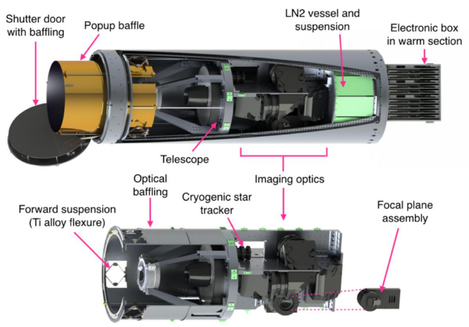


Fig. 1 Schematics of CIBER-2 payload.

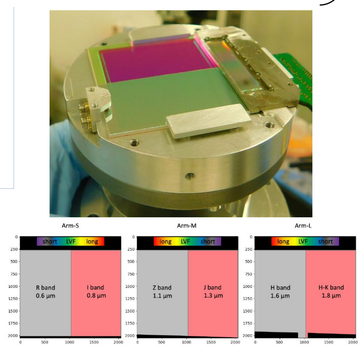


Fig. 2 Focal plane assembly.

PRE-FLIGHT PERFORMANCE EVALUATION

① Focus Adjustments

The detector position was adjusted with an accuracy of ± 50 μm to minimize the point-source image sizes as a whole over the detector area from the focus scan profiles at various locations on the focal plane taken with a collimator.

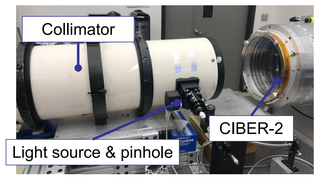


Fig. 3 Setup of focus scan with collimator.

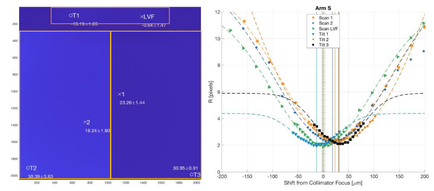


Fig. 4 Variety of the focus position on the detector surface is less than ~50 μm.

② Integration Testing

CIBER-2 was integrated at Wallops Flight Facility in summer 2019 and underwent additional vibration testing in early 2020 with NASA-provided payload equipment for a sequence of flights.

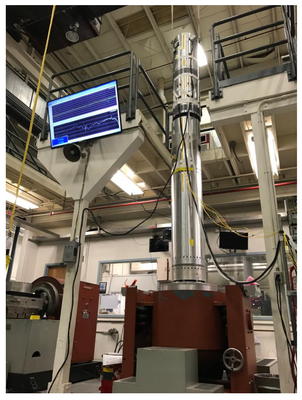


Fig. 5 Payload vibration test at the required vibration level.

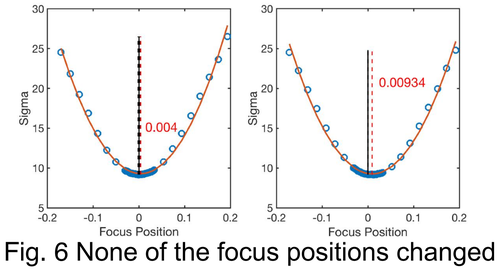


Fig. 6 None of the focus positions changed significantly from the vibration test.

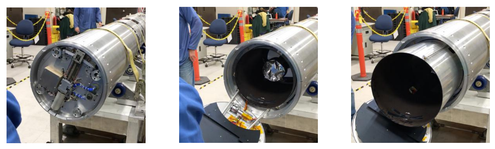


Fig. 7 Flight sequence testing of shutter door and popup baffle operations.

③ Spectral Response Measurements

Wavelength calibration and spectral resolution measurement for the LVF were carried out with a scannable monochromatic light source.

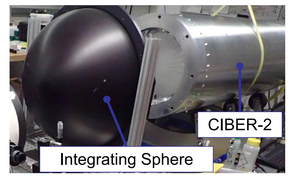


Fig. 8 Setup of monochromator scan with integrating sphere.

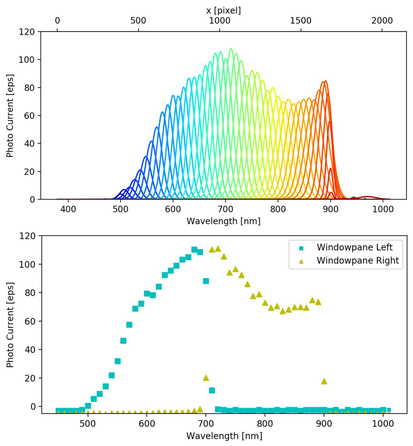


Fig. 9 The pixel-to-wavelength calibration for Arm-S.

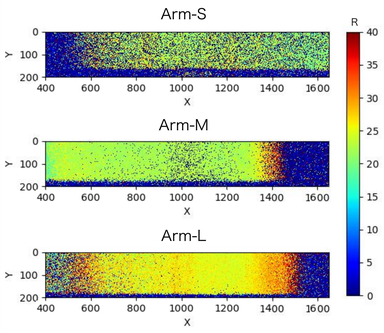


Fig. 10 Wavelength resolution in the LVF region satisfied the required values R~20.

④ Absolute Photometric Calibrations

For the visible band calibration, we used a high temperature source composed of a Tungsten-Halogen lamp with an effective temperature of 2800K, fiber-coupled to a series of integrating spheres through a fiber in-line attenuator module. Absolute radiance at the sphere output was measured with an absolutely calibrated spectrometer. Since the sphere aperture was smaller than the telescope aperture, aperture stitching method was used.

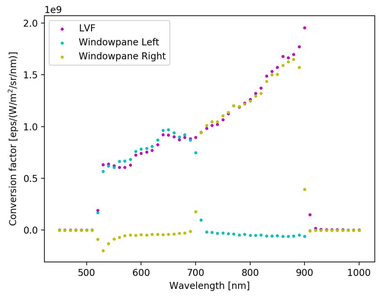


Fig. 12 Preliminary measurement of conversion factor for Arm-S.

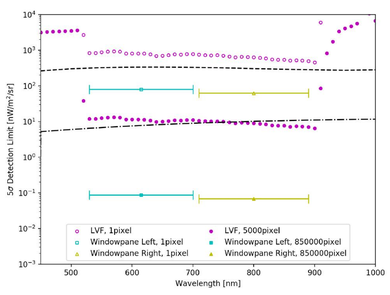
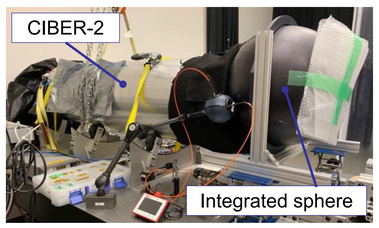


Fig. 13 5σ detection limit of Arm-S for 50 s estimated from the readout noise.



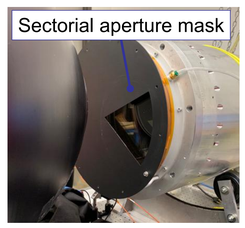


Fig. 11 Setup with calibration light source using integrating sphere and a sectorial aperture mask.

In preparation: for visible to NIR calibration

For relative flux calibration in the near-infrared bands, we will use a standard blackbody source at 1200K with a pinhole aperture and neutral density (ND) filter stack, and the absolute radiance will be scaled by using the wavelen-gth overlap with the visible band calibration.

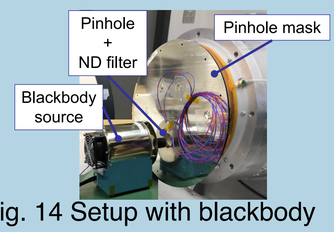


Fig. 14 Setup with blackbody source using pinhole mask.

⑤ Baffle Performance Estimates

We estimated the stray light from the Earth with the baffle function derived based on the signal response simulation that would be caught by the incident point source to CIBER-2. According to the simulation, the estimated stray intensity from the Earth is negligible.

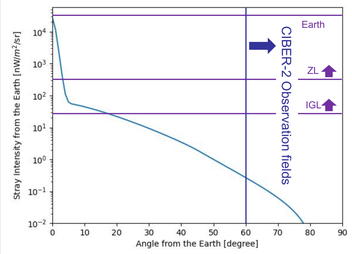


Fig. 15 The estimated stray intensity from the Earth to the CIBER-2.

FUTURE WORK

- Implementation of 1st flight and equipment repair in early 2021.
- EoR and IHL model investigation from 1st flight imaging and spectroscopic data.
- Preparation for the 2nd flight, such as repair, improvement, and testing.

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