Zodiacal Light Model for the SPHEREx Mission

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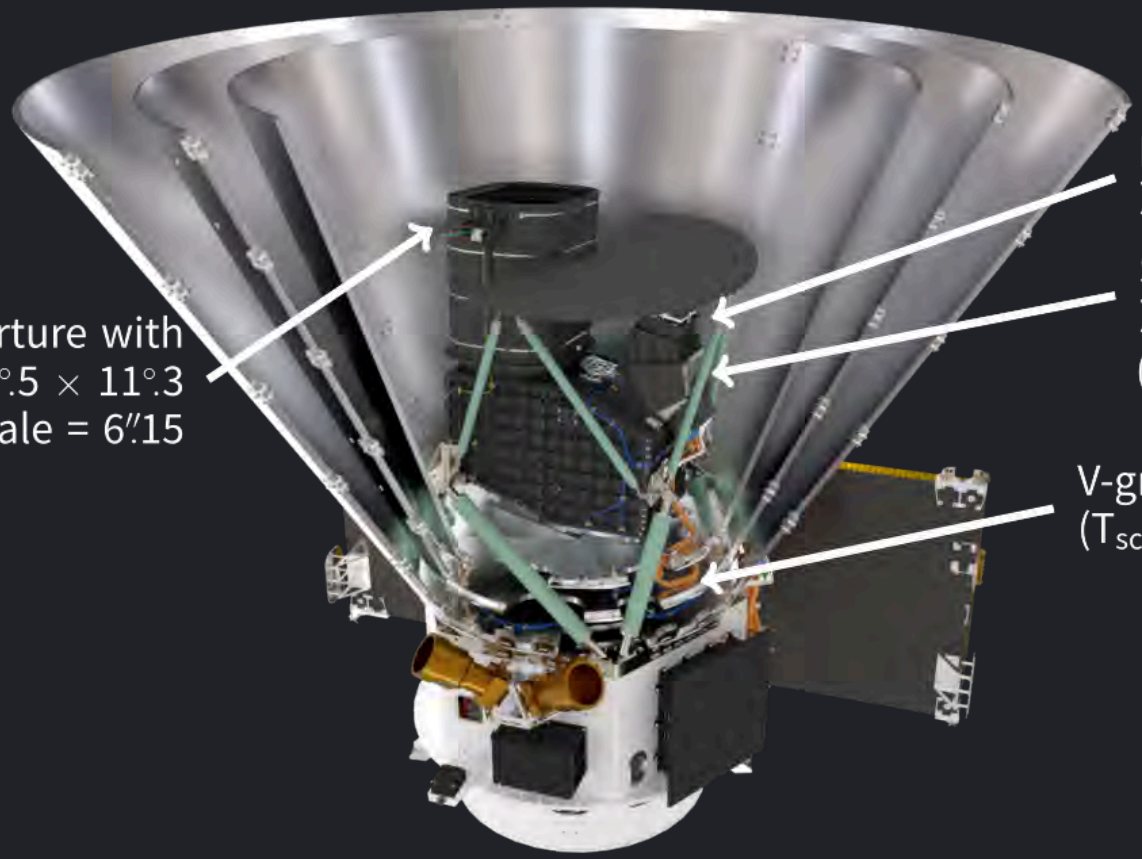
The 11th East-Asian Meeting on Astronomy

TOKI MESSE, Niigata, Japan

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SPHEREx

- NASA Astrophysics Medium-class Explorer mission
- All-sky near-IR spectral survey with LVFs (linear variable filters)
- Led by Caltech (PI: James J. Bock); KASI provided the calibration chamber



SPHEREx

Surveys

- 4 independent all-sky surveys for ~2 years
- Deep surveys of two 100-deg^2 fields (near the north and south ecliptic poles)

Key Sciences



Cosmic Inflation



Galaxy Formation



Interstellar Ices

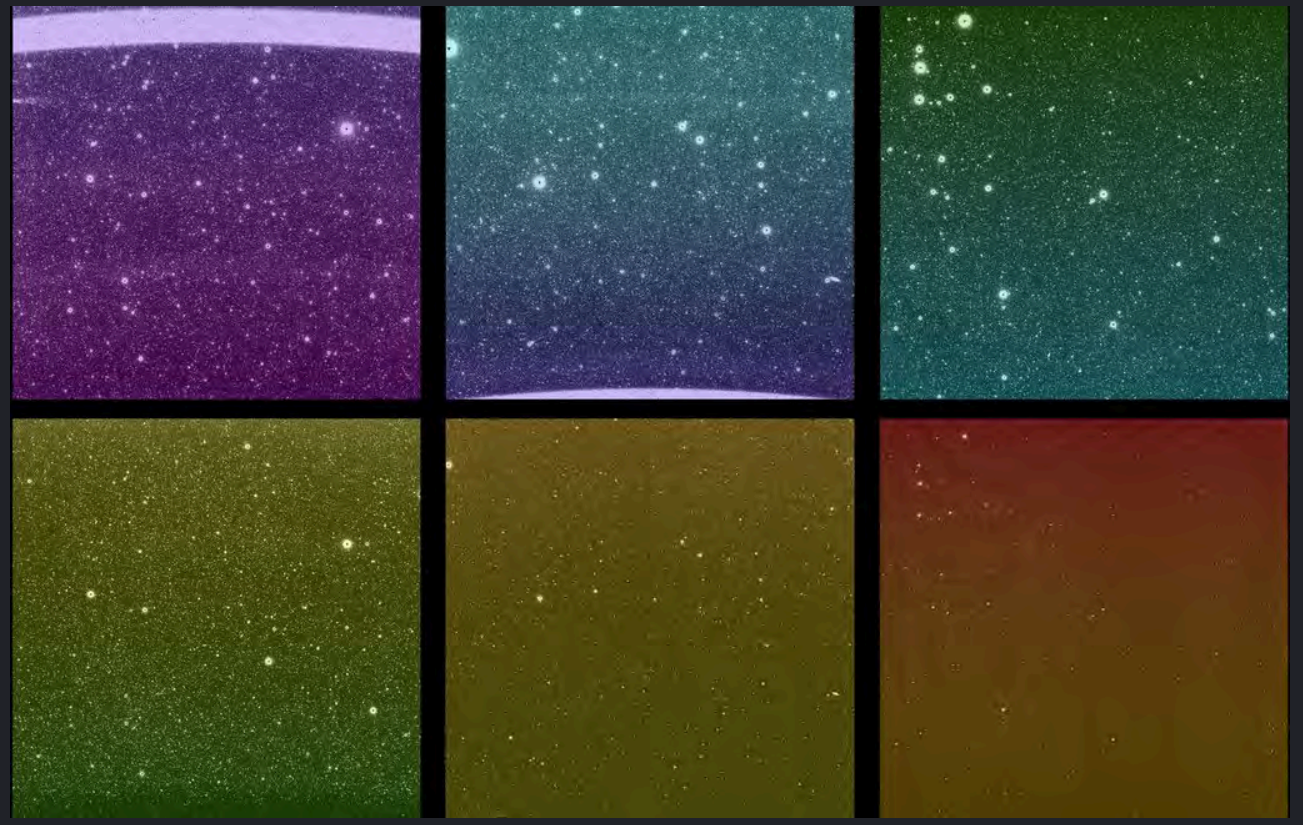
Mission Status

- SPHEREx spacecraft **launched** on March 11



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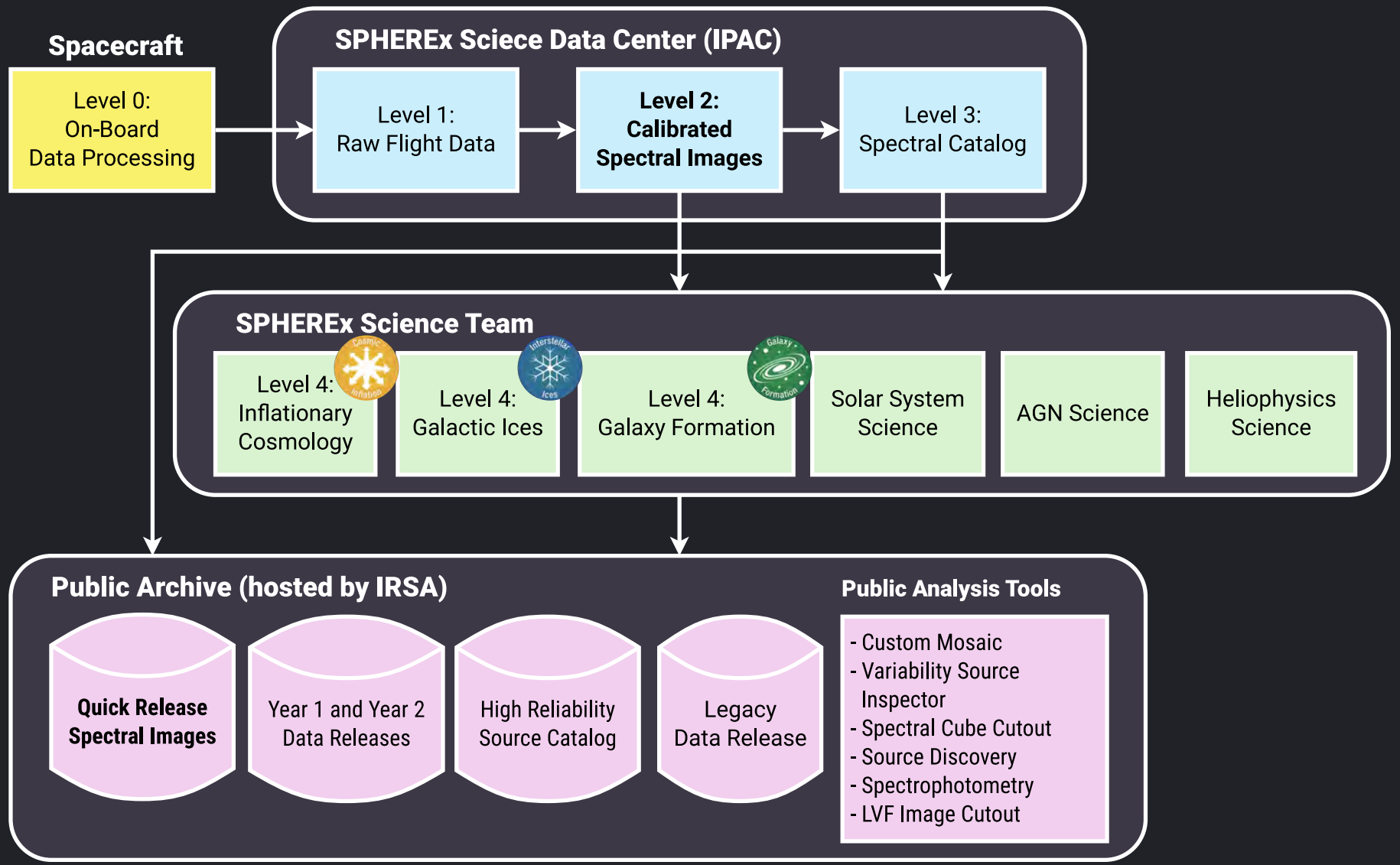


Mission Status

- SPHEREx spacecraft **launched** on March 11
- **First light** image released on April 1
- **Science survey** started on May 1
- Spectral images **released publicly** on July 2



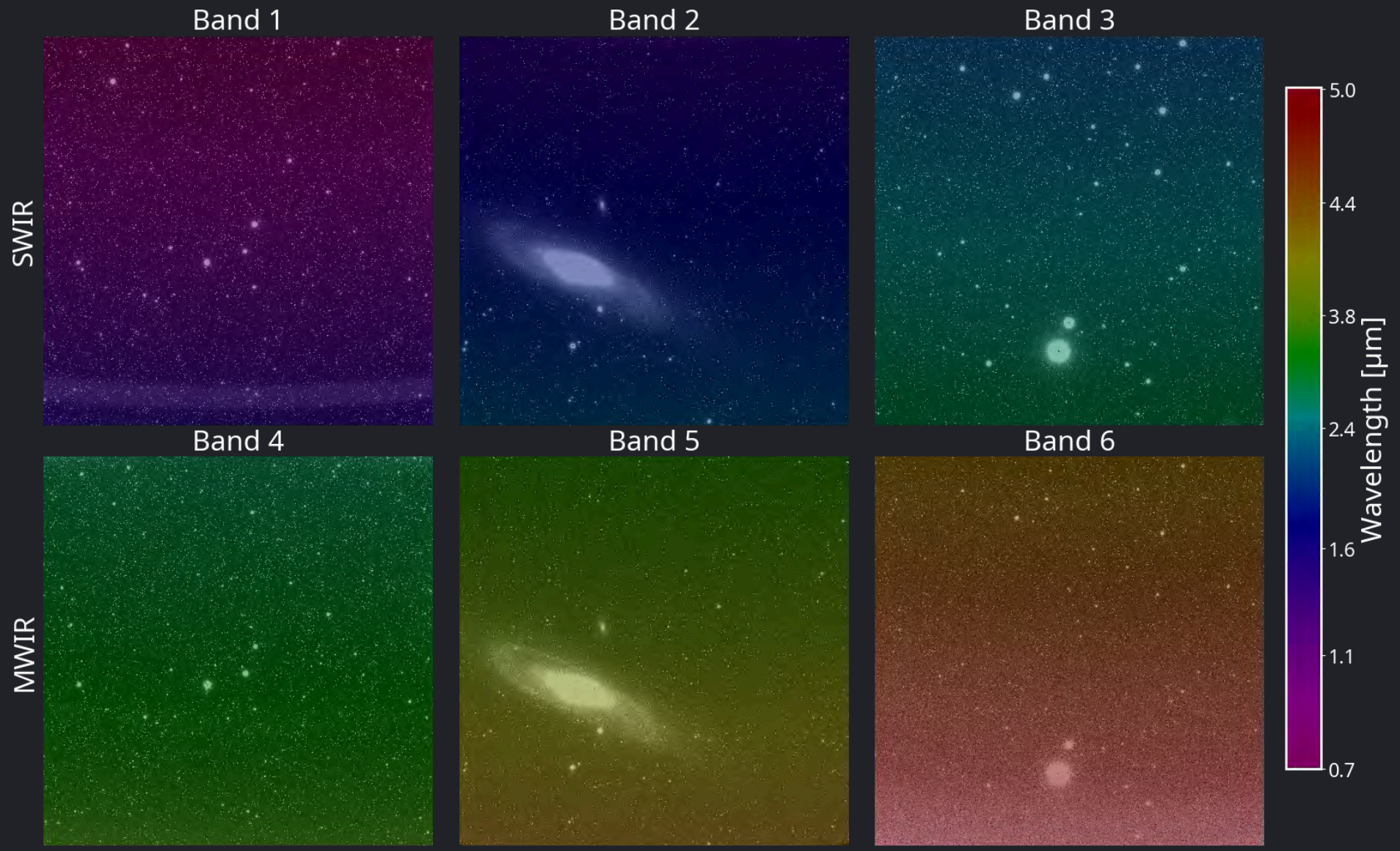
Science Data Flow & Products



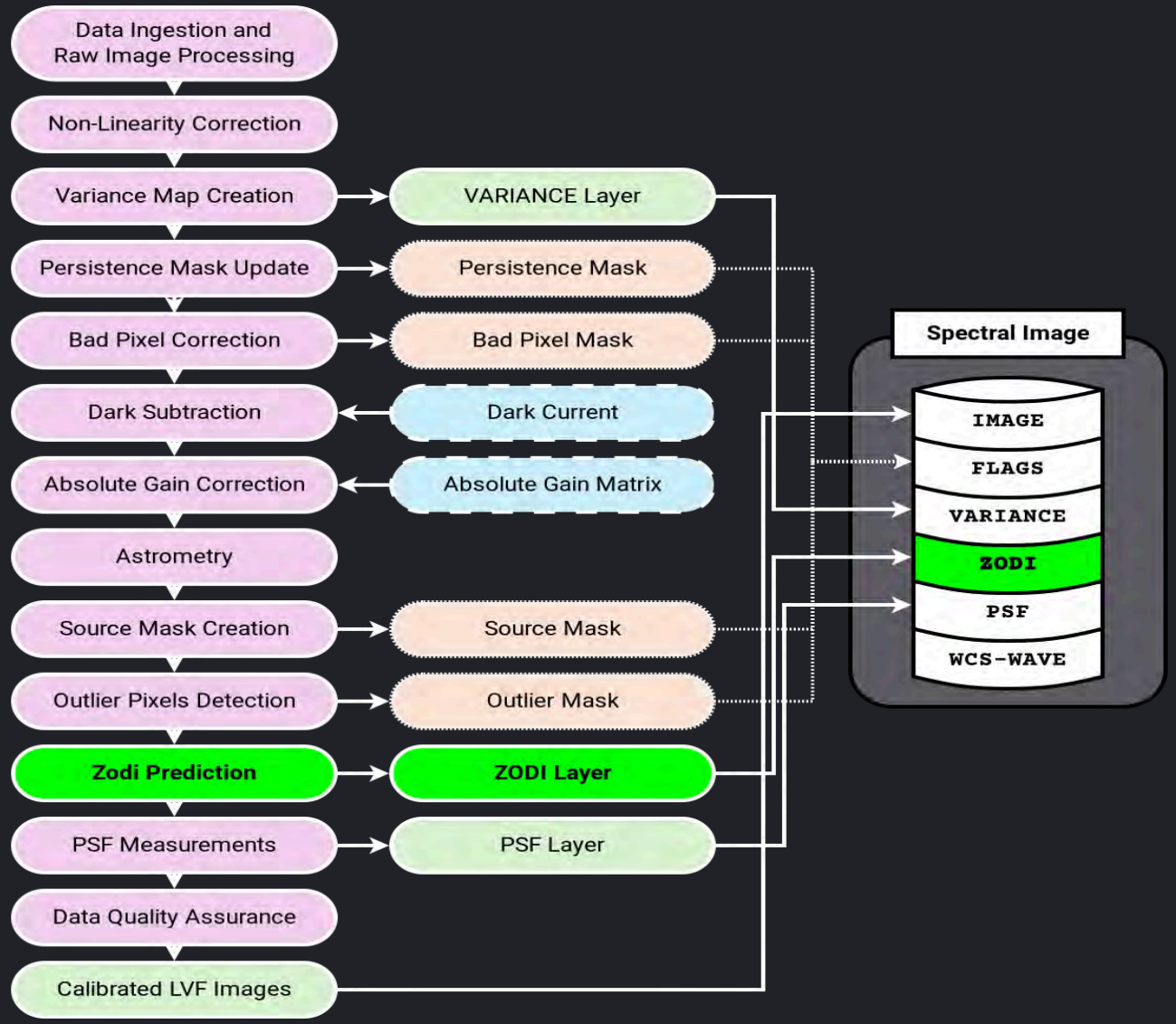
Public Archive at IRSA



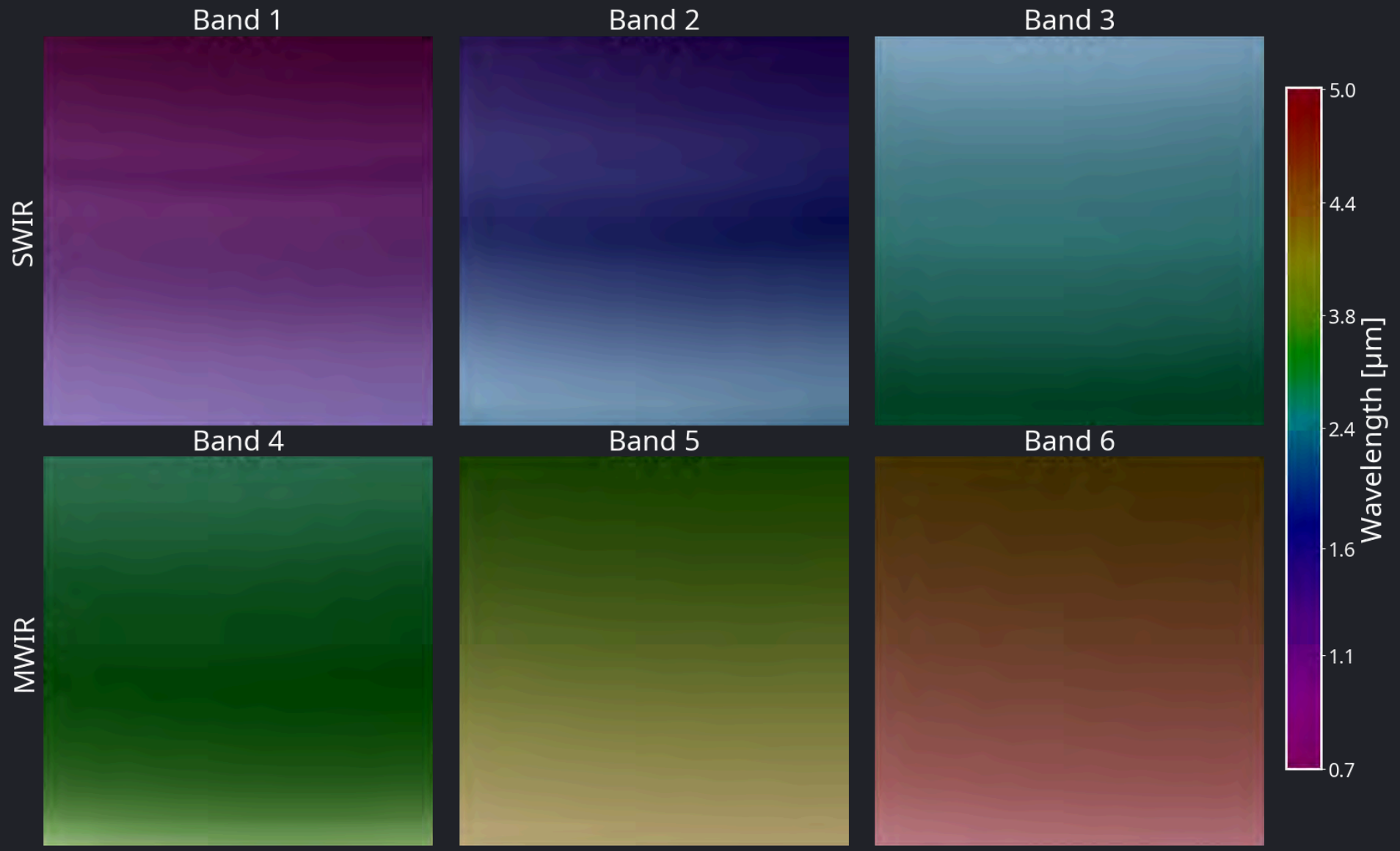
Spectral Images



Spectral Images » ZODI Extension

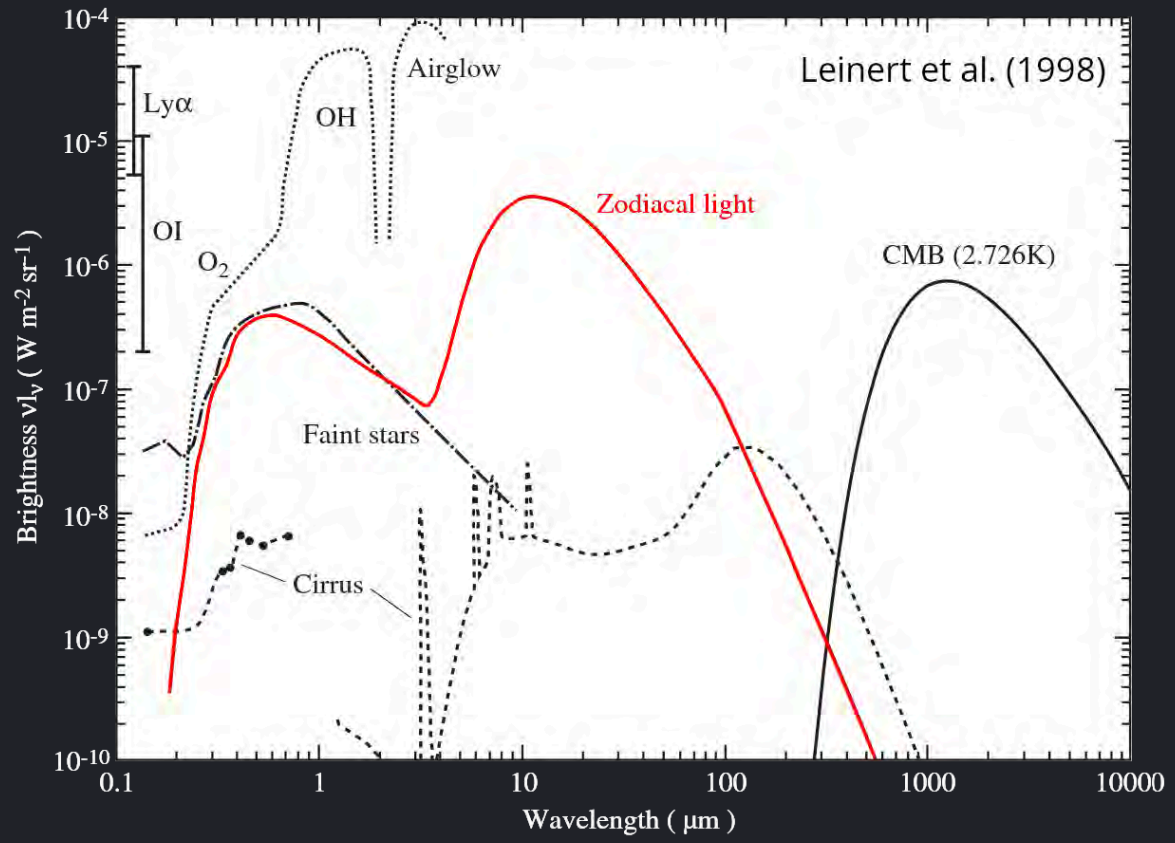


Spectral Images » ZODI Extension



Zodiacal Light (ZL)

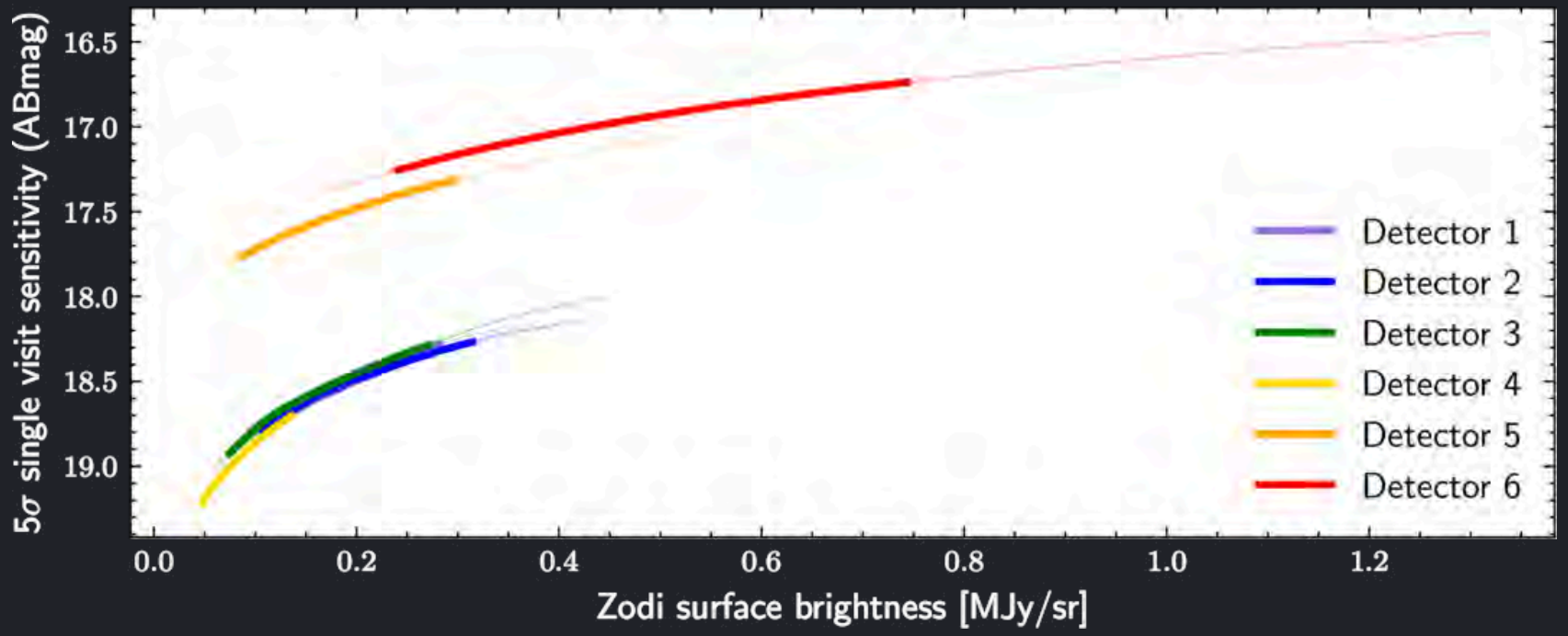
- **Sunlight scattered by** + **Thermal emission from** the interplanetary dust (IPD) particles
- Dominant source of the background (or foreground) surface brightness at infrared wavelengths





Zodiacal Light Model

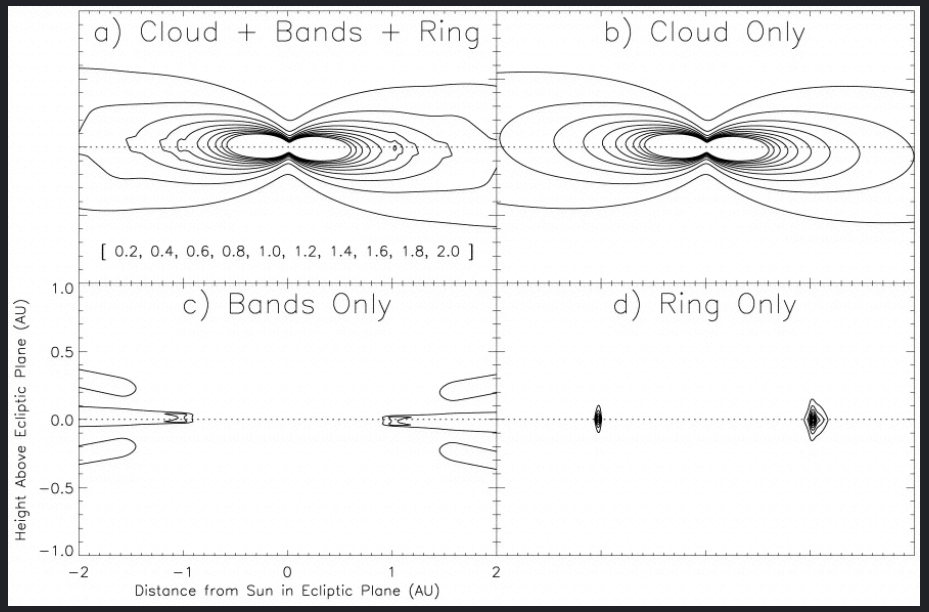
- For simulations of SPHEREx-observed background emission (Crill et al. 2025) → Prediction of the SPHEREx sensitivity



- To provide the community with a handy prediction of background emission
  - `ZODI` extension of the Spectral Image MEF (multiple extension FITS) files

Zodiacal Light Model

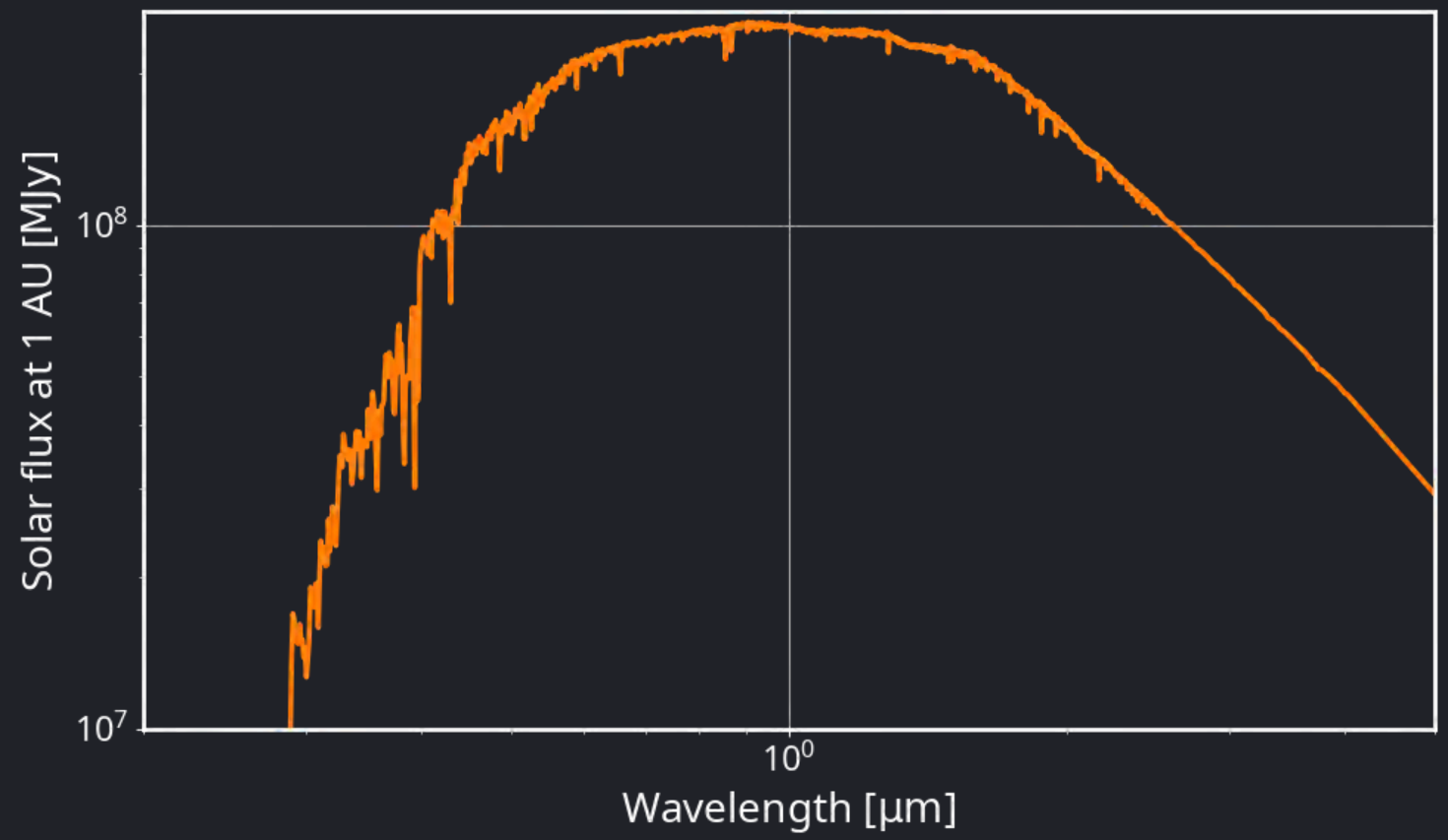
- Based on the IDP cloud model of Kelsall et al. (1998)
  - **3 components** of the IDP distribution：
    Smooth cloud, 3 dust bands, and resonant ring + trailing blob



  - IDL code downloaded from LAMBDA, converted to Python.
  - Original code calculates the ZL brightness at COBE/DIRBE wavelengths (1.25, 2.2, 3.5, ... μm).

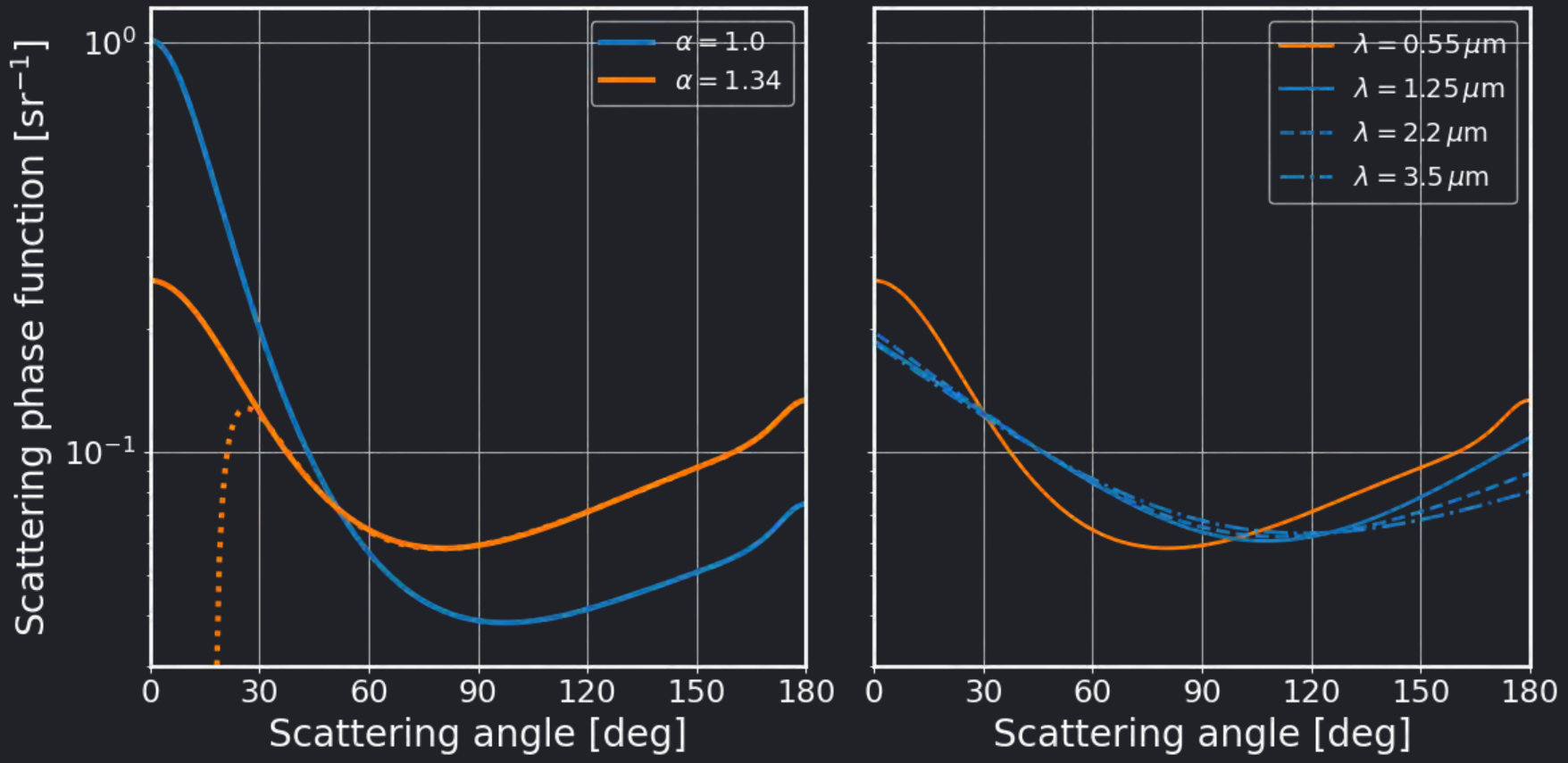
Zodiacal Light Model

- Extend to shorter wavelengths and enhance the spectral resolution by including
  - High resolution **solar spectrum**, 2000 ASTM Standard Extraterrestrial Spectrum Reference E-490-00



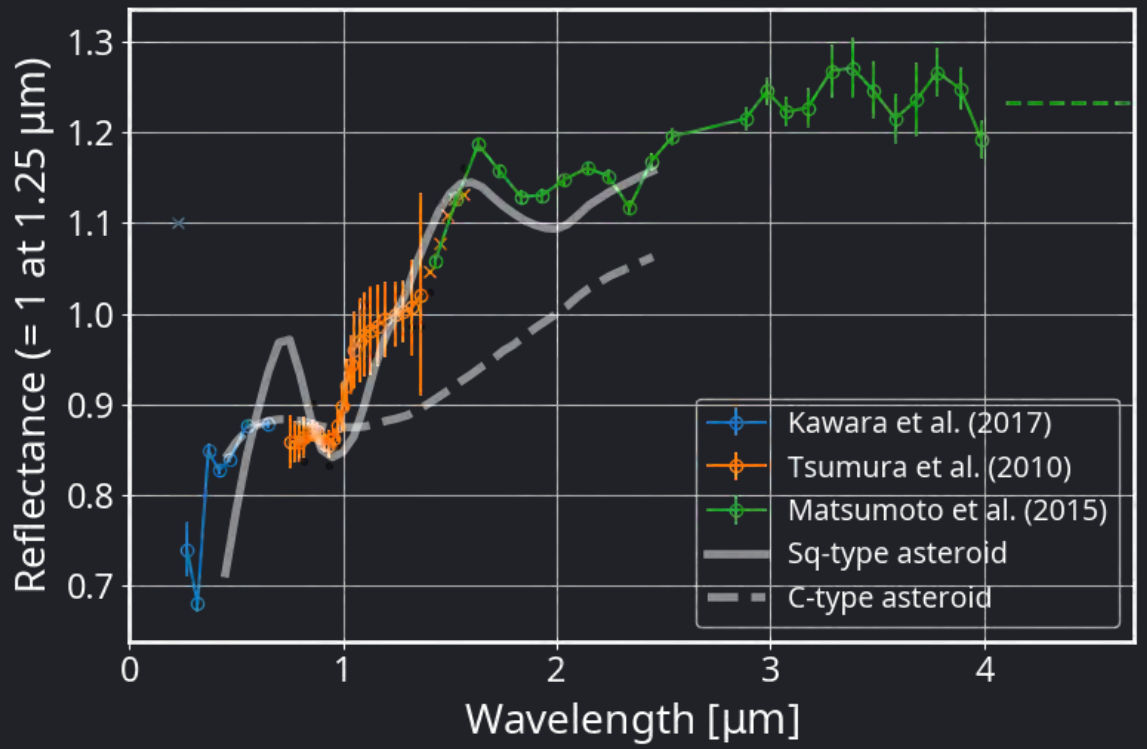
Zodiacal Light Model

- Extend to shorter wavelengths and enhance the spectral resolution by including
  - **Scattering phase function** at visible wavelengths (Hong 1985)
    - Sum of 3 Henyey-Greenstein functions fitted to the $\alpha = 1.34$ case



Zodiacal Light Model

- Extend to shorter wavelengths and enhance the spectral resolution by including
  - **Reflectance** of the zodiacal light from
    - Kawara et al. (2017): 0.3–0.7 μm from HST
    - Tsumura et al. (2010): 0.75–1.6 μm from CIBER (smoothed)
    - Matsumoto et al. (2015): 1.4–4.0 μm from IRTS



Zodiacal Light Model

- Extend to shorter wavelengths and enhance the spectral resolution by including
  - **Albedo parameters** updated to match the reflectance
  - **Interpolation** and **extrapolation** taking into account the solar spectrum and the reflectance

Summary

Development of the zodiacal light model to

- Forecast the **performance** of the SPHEREx observations
  - ZL: bright background source and dominant source of photon noise in the IR
- Provide users with the modelled ZL surface brightness
  - `ZODI` extension in the SPHEREx spectral image data

Improvement of the model with the SPHEREx surveys

- Continuous **wavelength coverage** from 0.75–5 μm
- **All-sky** survey (though the solar elongation coverage is limited)
- Observations for **more than 2-years**

Papers:

- Simulation paper (Crill et al. 2025) published
- Mission paper (Bock et al.) submitted (available on arXiv)