The FIFI-LS Pipeline at the SOFIA Data Center

Preserving the legacy of Far-Infrared Imaging Spectroscopy

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Introduction

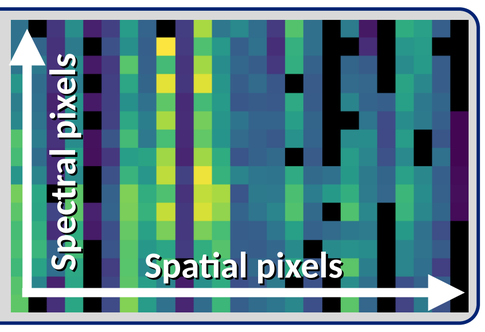
The goal of the **SOFIA Data Center** (SDC) is to preserve the entire scientific and technical databank of the former airborne observatory SOFIA, in the form of a "**Virtual Observatory**" (VO), adhering to the "FAIR" principles of data assets. Among the science pipelines being maintained at the SDC is that of the **far-infrared imaging spectrometer FIFI-LS**, delivering a wealth of spectral data. Much of this data remains unpublished, and contains astrophysical diagnostics from wavelength ranges that are now unreachable by any observatory, and will likely remain so for some time. This poster will overview the general functionality of the **FIFI-LS pipeline**, and present several major **data reduction enhancements** implemented at the SDC.

Pipeline Functionality

Raw FIFI-LS data represent **multi-wavelength readouts** of the detector arrays in units of [V/s], written as multi-extension FITS images. From this, the pipeline produces a **3D spatial-spectral cube** of calibrated data over a wavelength band at a single sky source.

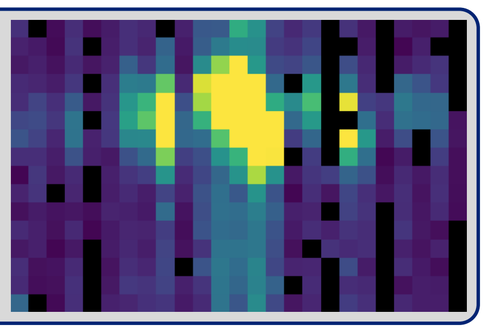
1. Reformatting

- Split data by chopper & diffraction grating position
- Fit voltage readout ramps [V/s] → [ADU/s]



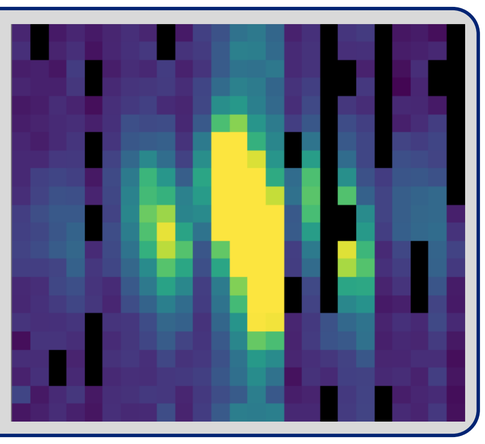
2. Demodulation

- Subtract chopper positions to remove sky background
- Combine nod positions to remove radiative offset



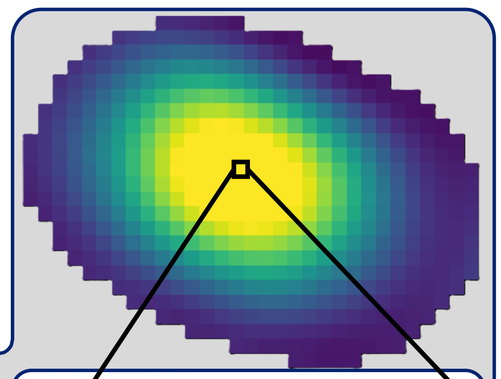
3. Pixel Calibration

- Generate 2D wavelength & sky coordinate grids
- Apply flat fields to correct for pixel response variation
- Combine grating positions to reconstruct spectral scan



4. Signal Calibration

- Correct for atmospheric transmission & emission
- Convert flux to physical units [ADU/s] → [W/m²/Hz]

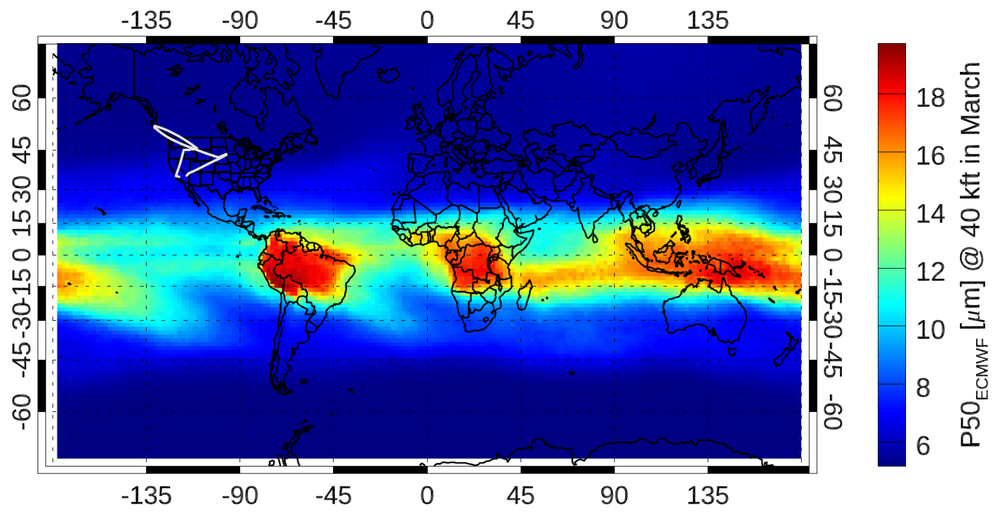


5. Resampling

- Resample onto regularly spaced 3D grid with 2 spatial & 1 spectral axes
- Superposition of source line & continuum emission

Calibration Enhancements

Atmospheric calibration is now performed using **modified ATRAN** transmission spectra and **ECMWF** global weather data (Fischer *et al*. 2021[1], Iserlohe *et al*. 2021[2], 2022[3]).



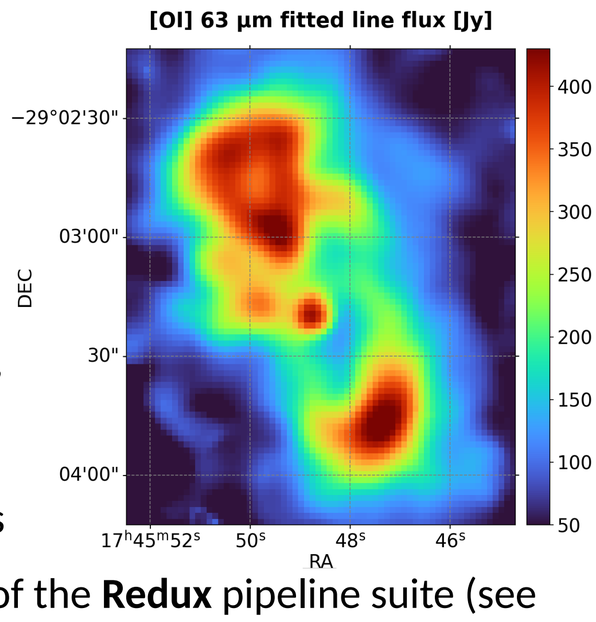
Flux calibration is performed by comparison of data with **Mars brightness model** of Lellouch & Amri 2006[4]. Recent improvements include fully resolving the model to every observed wavelength-timestamp tuple, and using a flux-conserving "**Drizzle**"-based resampling algorithm.

1: https://doi.org/10.1088/1538-3873/abf1ca
2: https://doi.org/10.1088/1538-3873/abef76
3: https://doi.org/10.1088/1538-3873/ac82c5
4: https://www.lesia.obspm.fr/perso/emmanuel-lellouch/mars/

Securing the FIFI-LS Science Legacy

The SDC continues work on the FIFI-LS pipeline, in preparation for a **complete re-reduction of all archived raw data**. Ongoing and planned improvements include:

- Parallel WV-Ozone determination
- Pointing quality filter
- Science project-oriented grouping for re-reduction
- Science-ready data products, spectral line fits, map mosaics
- Updated user documentation & tutorials



The FIFI-LS pipeline is part of the **Redux** pipeline suite (see poster B. Greiner). Contributions are welcome on our public GitHub repository.

```
pip install sofia-redux
```

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