Data Processing Status

William Vacca
Assoc. Director, Science Data Systems
USRA-SOFIA

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SOFIA Pipeline Products

Defined in the Data Processing Plan for SOFIA SIs :

Level 1: raw SI data in standardized format (FITS)

Level 2: corrected for instrumental artifacts (e.g. dark current, bad pixels, etc…)

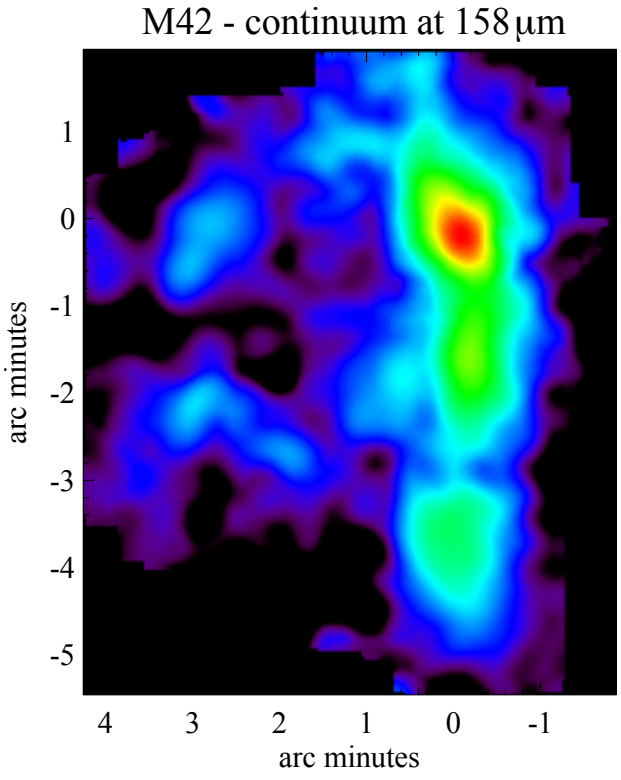
Level 3: flux calibrated (using FITS keywords; Jy)

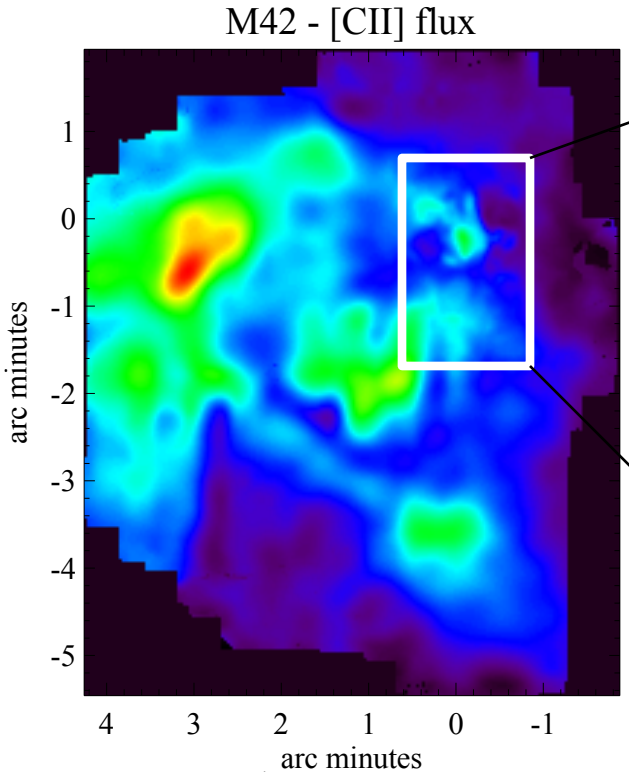
Level 4: high-order products possibly combining multiple observations (e.g. mosaics, spectral cubes)

Pipeline Development

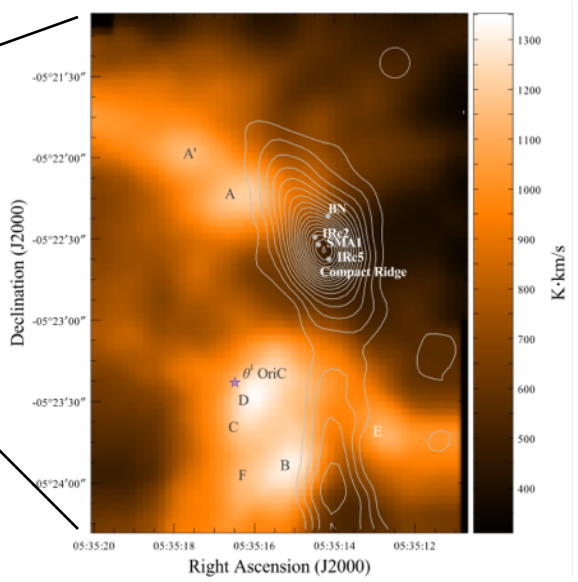
- FORCAST
  - Improved G227 and G329 grism response functions, derived from asteroids; will be incorporated in next release
  - Minor improvements, including better centroiding and suppression of edge artifacts
- FIFI-LS
  - Version 1.2.0 of pipeline released; used extensively on OC4-B flights for quick-look reduction and analysis
  - Implemented support that allows pipeline to be run across multiple missions
  - Implemented parallel processing in several steps
  - Incorporated telluric correction step
  - Implementing flux calibration step
- HAWC
  - Received alpha-version of pipeline and initial drafts of manuals from SI team; tested with on-sky data from commissioning flights
  - Modified pipeline interface (Redux) to accept and process HAWC data

FIFI-LS Observations of Orion



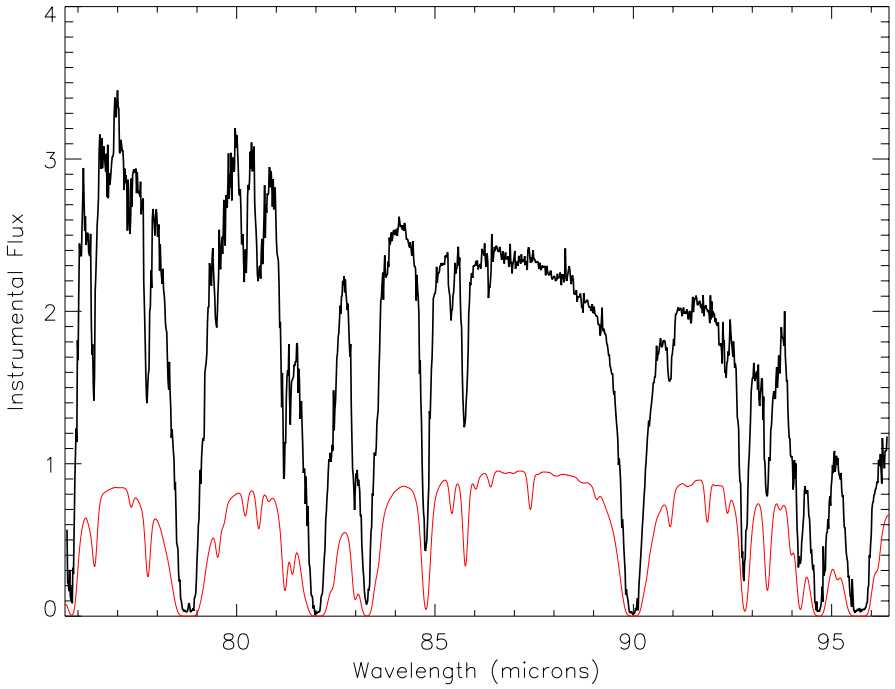


Herschel/HIFI

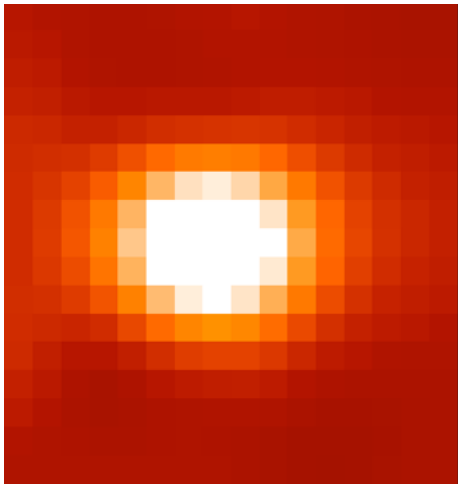


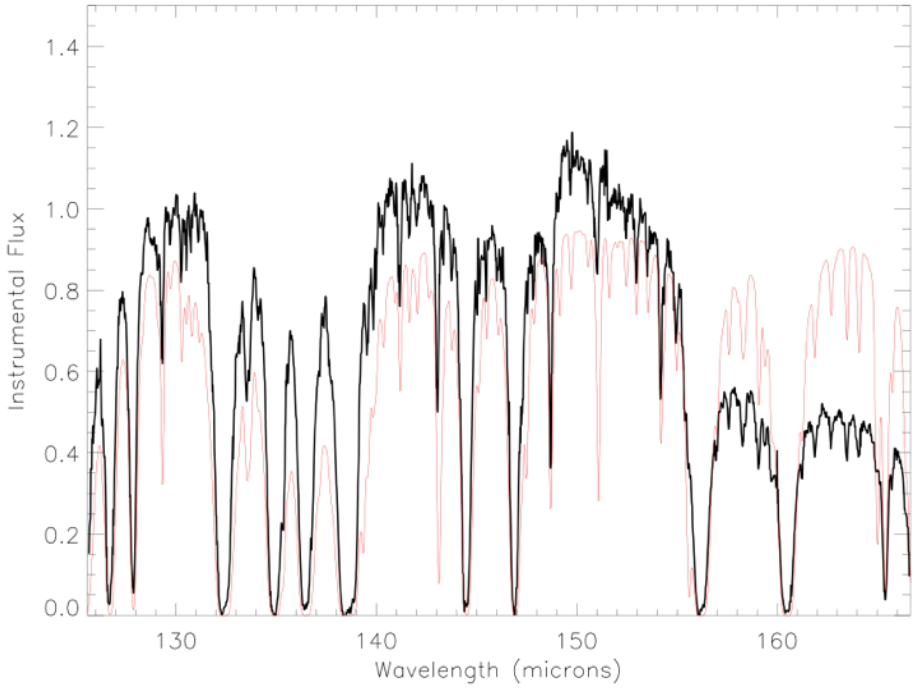
Morris et al. (2016)

FIFI-LS Pipeline example: Mars spectrum

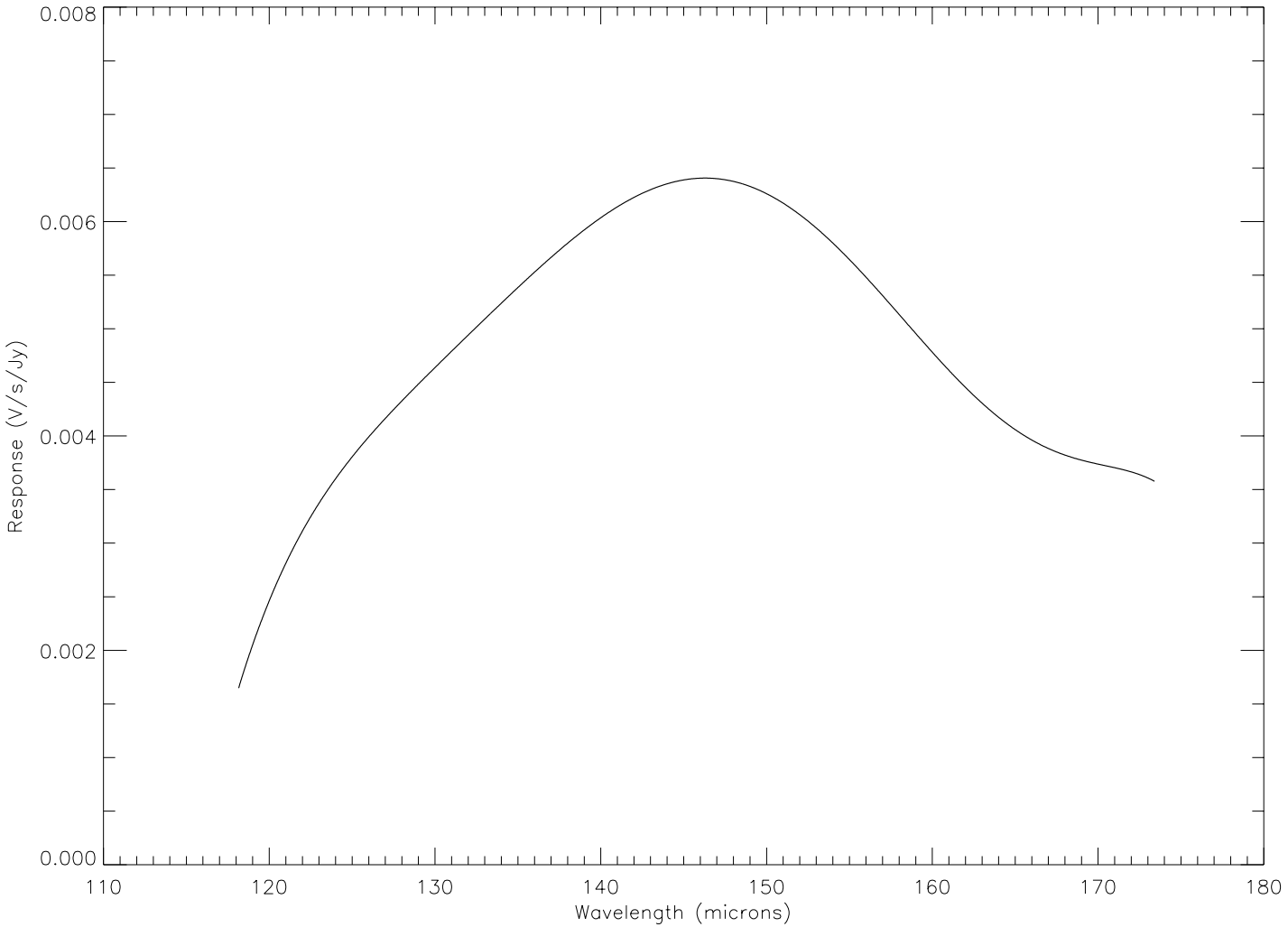


Program 03_0151 (Blake)



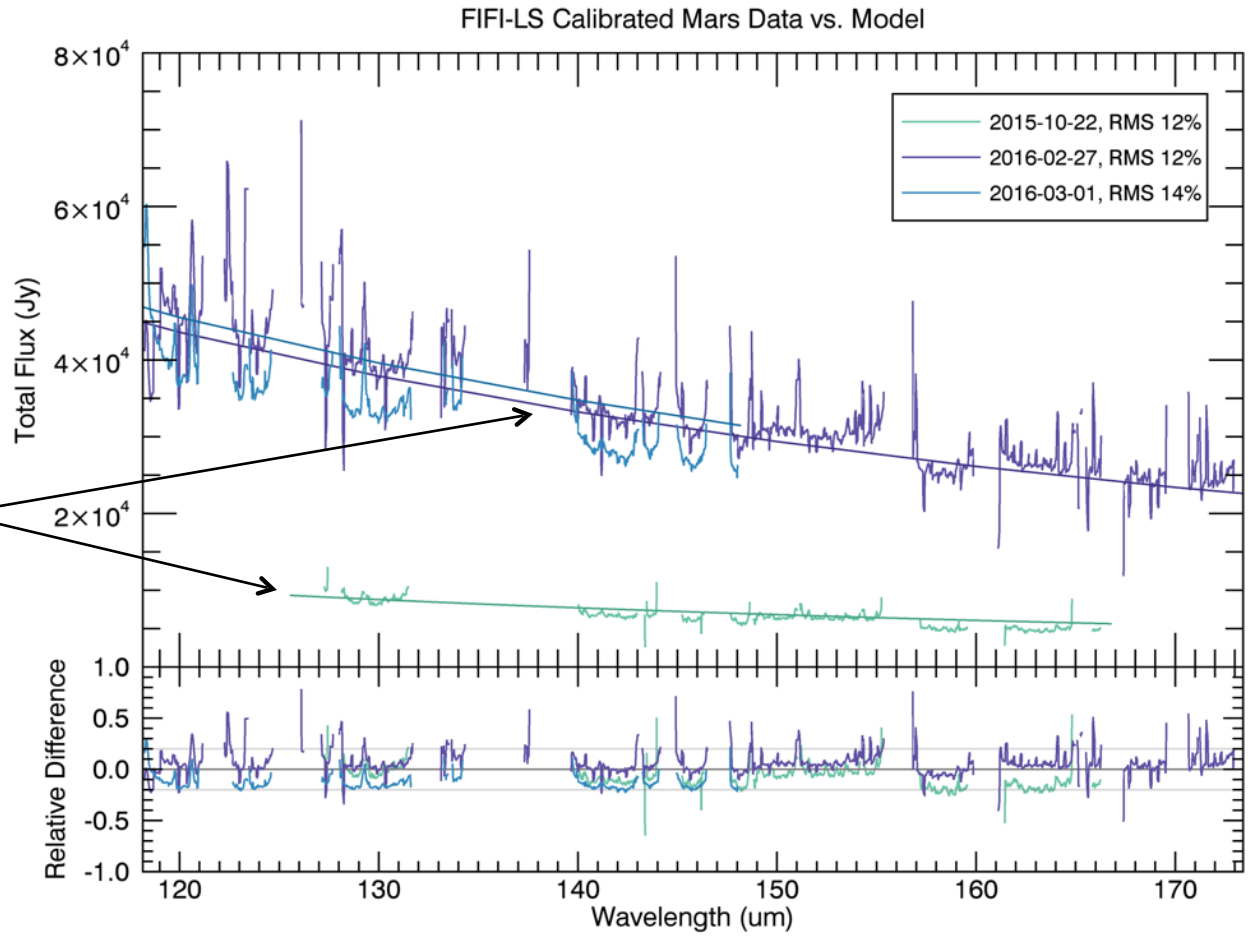


FIFI-LS Flux Calibration



FIFI-LS Flux Calibration

Models

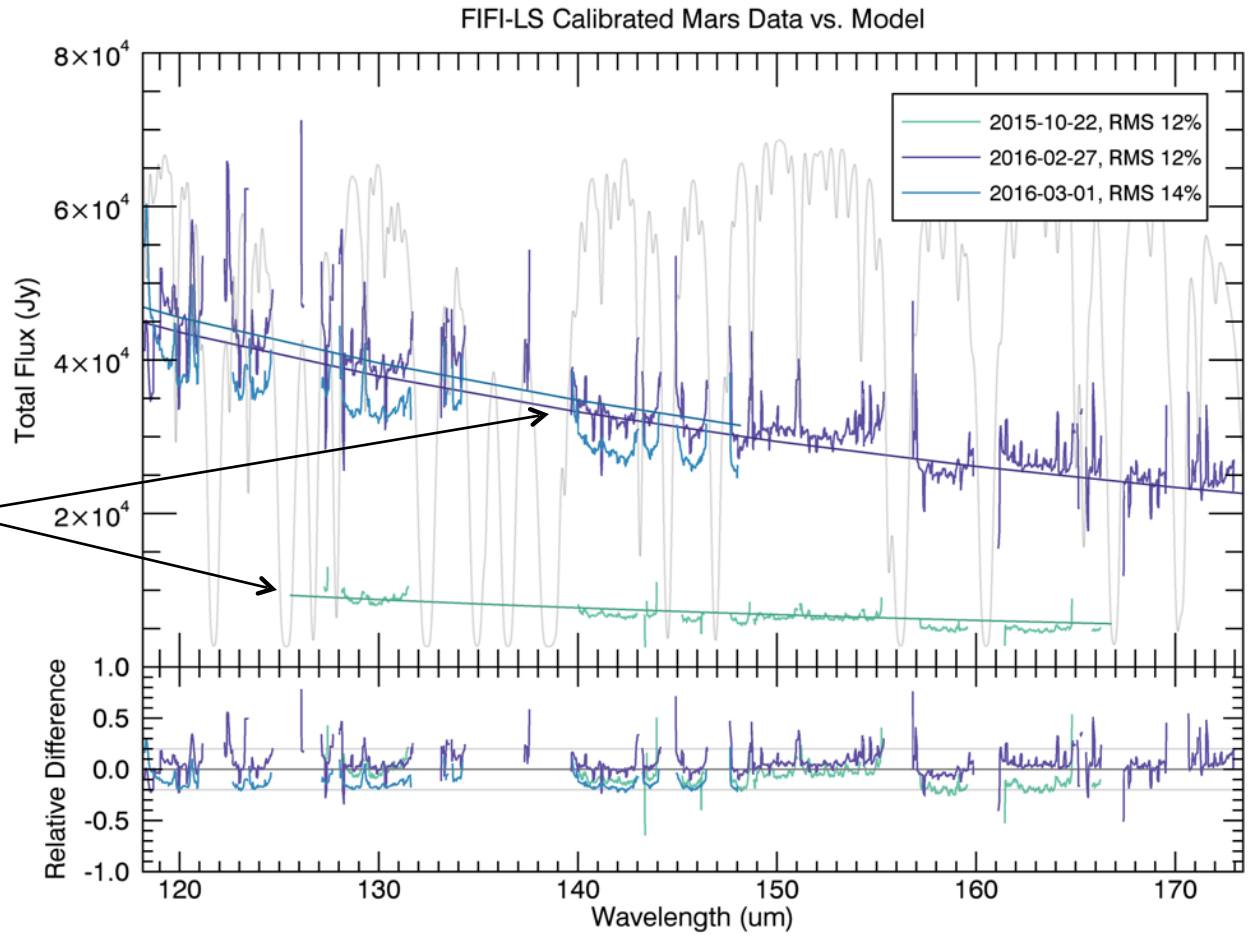


FIFI-LS Flux Calibration

Atmosphere

Models

Within 20%



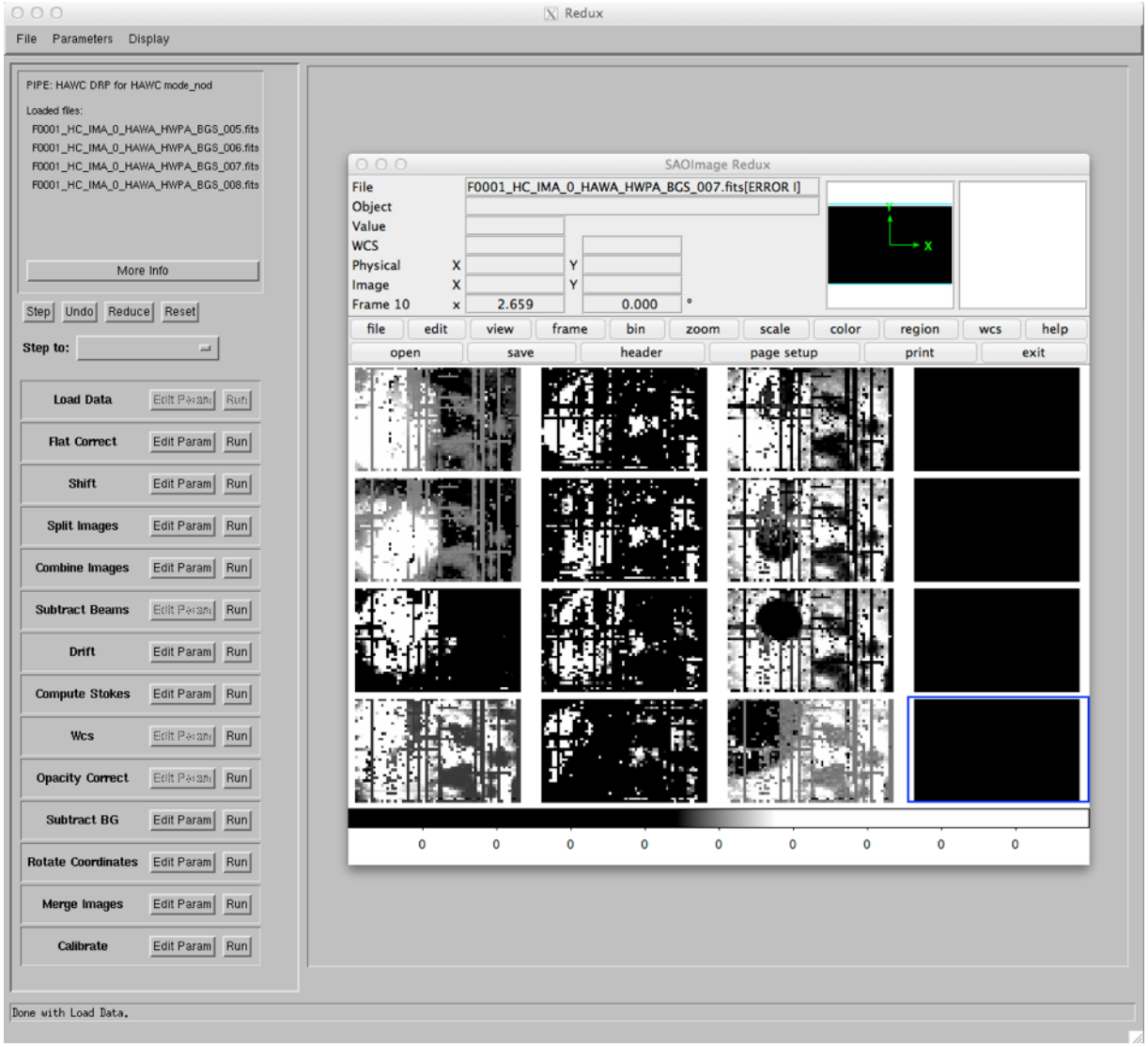
Status of FIFI-LS Pipeline and Data

- **PIPELINE**
  - All reduction steps have been implemented, including telluric correction and flux calibration
  - Preliminary response curves have been derived for one dichroic; currently working to derive all 6 response curves (red/blue1/blue2, two dichroics) from existing Mars data
  - Level 2 products (data cubes) look very good
  - Telluric correction has not been heavily tested, and is currently turned off
  - Entire development process took <1.5 years by two people (Holt/Clarke and Vacca);
    - Started from earlier pipeline version developed by R. Klein/K. Nishikida
    - Most of the code is new and was developed by us
- **DATA**
  - Reduced (Level 2) data from individual flights in OC2-F, OC3-B, OC3-K, and OC4-A series, with *no* telluric correction
  - Generated Level 2 maps for targets observed on multiple missions/series
  - Both sets of data have been ingested into the Archive
  - Data will be processed to Level 3 once response curves are finalized
  - Limiting factor in accuracy is telluric correction without WVM

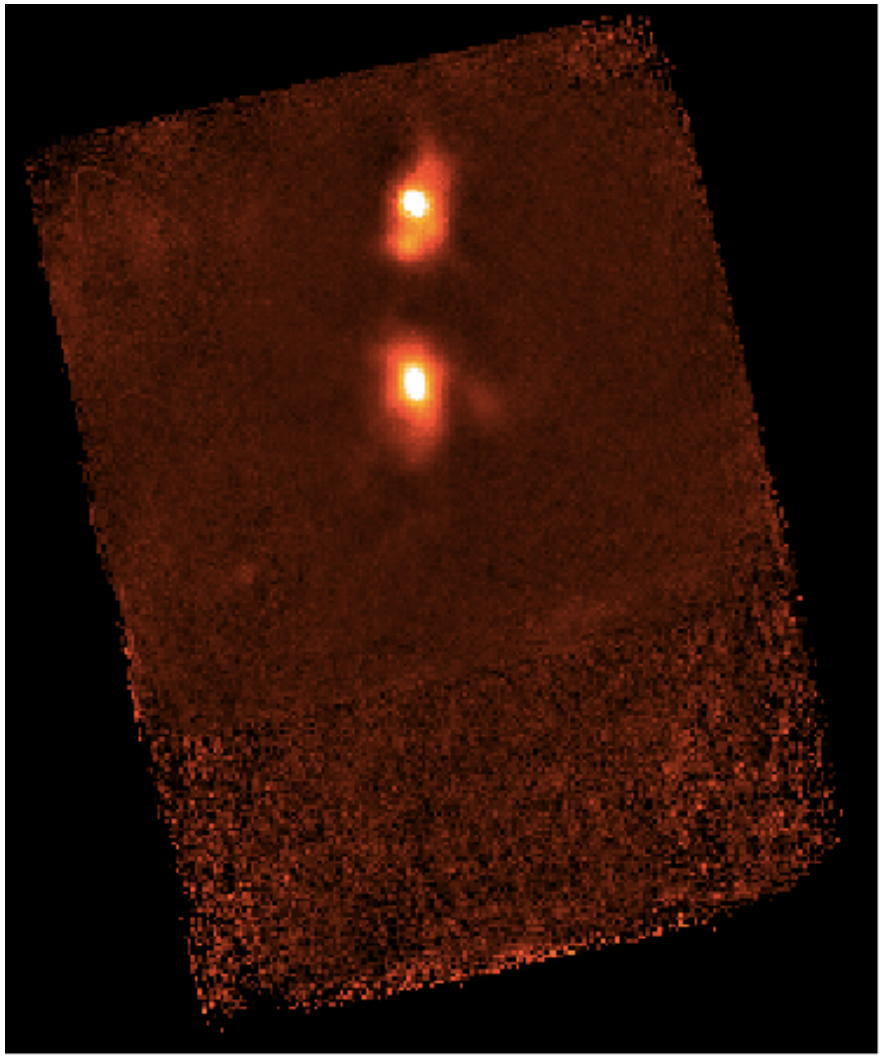
HAWC pipeline status

- DPS has received a working version of the HAWC+ pipeline
  - Pipeline developed by HAWC+ team (G. Novak et al.)
  - DPS Team flew on last HAWC+ commissioning flight
  - Pipeline has been partially integrated into DPS infrastructure and with Redux interface
  - CRUSH software (A. Kovacs) works well for reduction of scanning imaging mode data (polarization mode not supported)
  - Chop-nod mode (primary mode for polarization observations) pipeline is not as mature, needs more development
    - Can polarization observations be done in scanning mode?
- Next steps:
  - Design review (is pipeline meeting requirements?)
  - Verification & Validation
  - Finish documentation
  - Full integration into DPS infrastructure
  - Calibration

HAWC pipeline - Redux



HAWC pipeline – DR 21 (scanning mode)



Pipeline Operations

- FORCAST, FLITECAM, EXES, FPI+:
  - OC3 processing/archiving complete
  - OC4 processing/archiving complete
  - Re-processing of OC1-B (FORCAST; flights 108-110) data:
    - Including clean up of problematic data.
    - Completion expected by May 31 or shortly thereafter
  - Archived OC4-A L2 FPI+ (28 April 2016)
- FIFI-LS:
  - Processed individual FIFI-LS flights from OC2-F, OC3-B/K, and OC4-B FIFI-LS data to L2
    - Headers updated, data processed, QA analysis performed
    - All L2 data archived by 28 April 2016
  - Multi-mission maps (L2) from OC2-F, OC3-B/K, and OC4-B also produced
    - QA completed; Archived 17 May 2016

Cycle 3 Data Processing Status

Observing Campaign	Science Instrument	Last Flight	Baseline/MOU L3	Completed/ Expected L3
3-A	EXES	4-Mar-2015	30-Apr-2015	9-Jul-15 ✓
3-B	FIFI-LS	26-Mar-2015	26-Jun-2015	**23-Jun-16**
3-C	**FORCAST**	14-Jun-2015	07-Jul-2015	25-Jun-15 ✓
3-D	**FORCAST-NZ**	7-Jul-2015	28-Jul-2015	28-Jul-15 ✓
3-E[1]	**ToO – FLIPO - NZ**	29-Jun-2015	21-Jul-2015	10-Jul-15 ✓
3-G[2]	GREAT - NZ	20-Jul-2015	14-Oct-2015	22-Oct-15 ✓
3-H	EXES	3-Sep-2015	03-Nov-2015	21-Oct-15 ✓
3-I	**FORCAST**	21-Sep-2015	13-Oct-2015	19-Oct-15 ✓
3-J	**FLITECAM**	5-Oct-2015	27-Oct-2015	4-Jan-16 ✓
3-K	FIFI-LS	27-Oct-2015	28-Jan-16	**23-Jun-16**
3-L	**FORCAST**	19-Nov-2015	11-Dec-2015	14-Dec-15 ✓
3-M[2]	GREAT	17-Dec-2015	17-Mar-2016	26-Feb-16 ✓

Green	Expected completion on Track
Yellow	Expected completion less than 2 weeks after baseline
Red	Expected completion more than 2 weeks after baseline

1) Observing Campaign 3-E only requires Level-2 processing

2) GREAT Series – MOU date is later than the baseline date

Cycle 4 Data Processing Status

Observing Campaign	Science Instrument	Last Flight	Baseline L3	Completed/ Expected L3
4-A	**FORCAST**	18-Feb-16	9-Mar-16	**10-Mar-16 ✓**
4-B	FIFI-LS	10-Mar-16	11-May-16	**23-Jun-16**
4-C	EXES	25-Mar-16	21-Apr-16	**26-Apr-16 ✓**
4-D	GREAT	27-May-16	22-Aug-16	
4-E	GREAT (NZ)	20-Jun-16	13-Sep-16	
4-F	FIFI-LS (NZ)	5-Jul-16	6-Sep-16	
4-G	FORCAST (NZ)	21-Jul-16	11-Aug-16	
4-H	HAWC+	1-Sep-16	12-Jan-17**	
4-I	FORCAST	13-Oct-16	2-Nov-16	
4-J	FLITECAM	21-Oct-16	10-Nov-17	
4-K	GREAT	22-Nov-16	17-Feb-17	
4-L	HAWC+	16-Dec-16	26-Apr-17**	
4-M	EXES	1-Feb-17	2-Mar-17	

Green	Expected completion on Track
Yellow	Expected completion less than 2 weeks after baseline
Red	Expected completion more than 2 weeks after baseline

** Note: HAWC+ data processed as "best effort" for Cycle 4 because it is a newly commissioned instrument. Dates posted are an estimate.

Processing Notes and Summary

- DPS team has been able to meet most scheduled deadlines for reductions of FSI data (aside from FIFI-LS)
- Nearly all FSI observations have produced “NOMINAL” or “USABLE” L2/3 data products.
- Small fraction of observations require manual follow-up.
- Very small number “FAIL”; usually grism observations in which object not on-slit.
- FORCAST flux calibration good to 5 - 10%
- FITS Header issues continue to hamper processing of data from some instruments (FIFI-LS, FLITECAM)

DPS Staff

- Scientists:
  - **W. Vacca** – DPS Lead, pipeline development, QA, calibration scientist for FORCAST, FLITECAM, FIFI-LS, (HAWC?)
  - **R. Shuping** (SSI) – 80%, Ops lead
  - **J. Radomski** – QA scientist for FORCAST
  - **S. Shenoy** – QA scientist for FORCAST, FLITECAM
  - **D. Fadda** – QA scientist for FIFI-LS (*new hire*)
- Software Engineers:
  - **M. Clarke** – Development Lead; Redux (pipeline interface), develops/maintains four pipelines, header checker, QA tools; testing, documentation
  - **K. Shabun** – HAWC+ pipeline development and documentation (*new hire*)
  - **R. Krzaczek** (RIT) – 50%, pipeline infrastructure; ramping down to 20%
  - **E. Omelian** (NASA) – IT&V lead; testing, documentation, guiding us through NASA hoops
- IT:
  - **D. Sandel** – DPS hardware and ops support
  - **E. Proudfit** – DPS machine set-up and maintenance

Summary

- DPS team maintains and continues to make improvements to FORCAST, FLITECAM, and EXES pipelines
- DPS team has successfully developed a pipeline for FIFI-LS, and has taken delivery of an initial version of the pipeline for HAWC+
- DPS team is making its deadlines for processing FSI data
- Processing of all FIFI-LS data to L2 has finished
- We are working on FIFI-LS response curves and will process data to L3 (calibration) as soon as they are finalized

FSI Data Processing Flow