Data Processing Status

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SOFIA Users Group Meeting #11

June 2017

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
  - Incorporated telluric corrections for individual images; grouping files by altitude can be eliminated
  - Improved the grism response generation procedure
  - Incorporated more accurate method of applying telluric corrections for grism spectra (estimating the PWV during individual observations) into pipeline
  - Incorporated mosaicing routine into pipeline
  - Released v1.3.0 of the FORCAST pipeline
- FIFI-LS
  - Improved the wavelength and spatial calibrations
  - Incorporated better spatial flats obtained from SI team
  - Developed automated procedure to generate flat fields from "skydips"
  - Derived non-linearity corrections, which appear to be small (~1-2 %)
  - Derived new response curves and incorporated them into pipeline
  - Verified reliability of flux calibration (good to better than ~10% on average)
  - Released v1.4.0 of the FIFI-LS pipeline
- HAWC+
  - Modified pipeline to run in automated mode in DPS environment
  - Incorporated dynamic flat field procedure into pipeline
  - Incorporated instrumental polarization values into pipeline
  - Incorporated telluric correction and flux calibration steps into pipeline
  - Verified accuracy of telluric correction/flux calibration (better than ~10%)
  - Initial release of HAWC pipeline, verifying all requirements, in Jan.
  - Released v1.1.1 of the HAWC pipeline

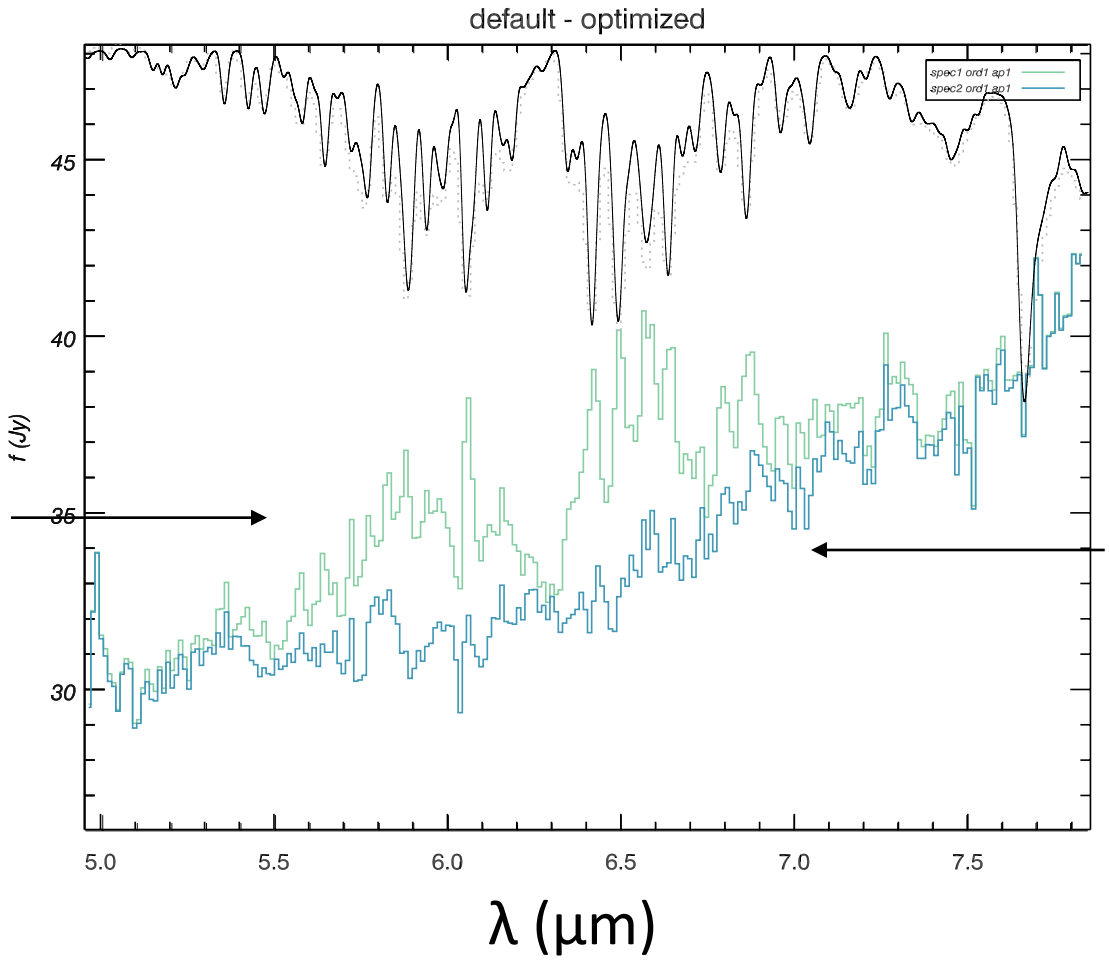
PWV Optimization for FORCAST Grism Spectra

- SOFIA has not had a calibrated/working Water Vapor Monitor
- FORCAST grism pipeline incorporates ATRAN spectra corresponding to the nominal model for the airmass and altitude of the observations
  - Telluric correction can leave residuals
  - Especially noticeable in grism data acquired in NZ (telluric overcorrection)
- DPS team has developed a procedure to minimize telluric residuals, and simultaneously estimate the PWV, independent of the WVM
  - Assumes the source spectrum F_i can be modeled as a smooth polynomial P_i across a grism band
  - Uses a large set of ATRAN model spectra T_i computed for a range of airmasses, altitudes, and PWV values
  - Computes χ_j^2 for each PWV_j value over the i pixels in the spectrum whenever the S/N of the spectrum > 10 (excluding the G111 grism data)

$$\chi_j^2 = \sum_i^n \left(F_i^{obs} - P_i \cdot T_i\left(PWV_j\right)\right)^2 / \sigma_i^2$$

  - Uncertainty on the resulting PWV value is ~1-2 microns, as determined from curve of χ^2 as a function of PWV

PWV optimization

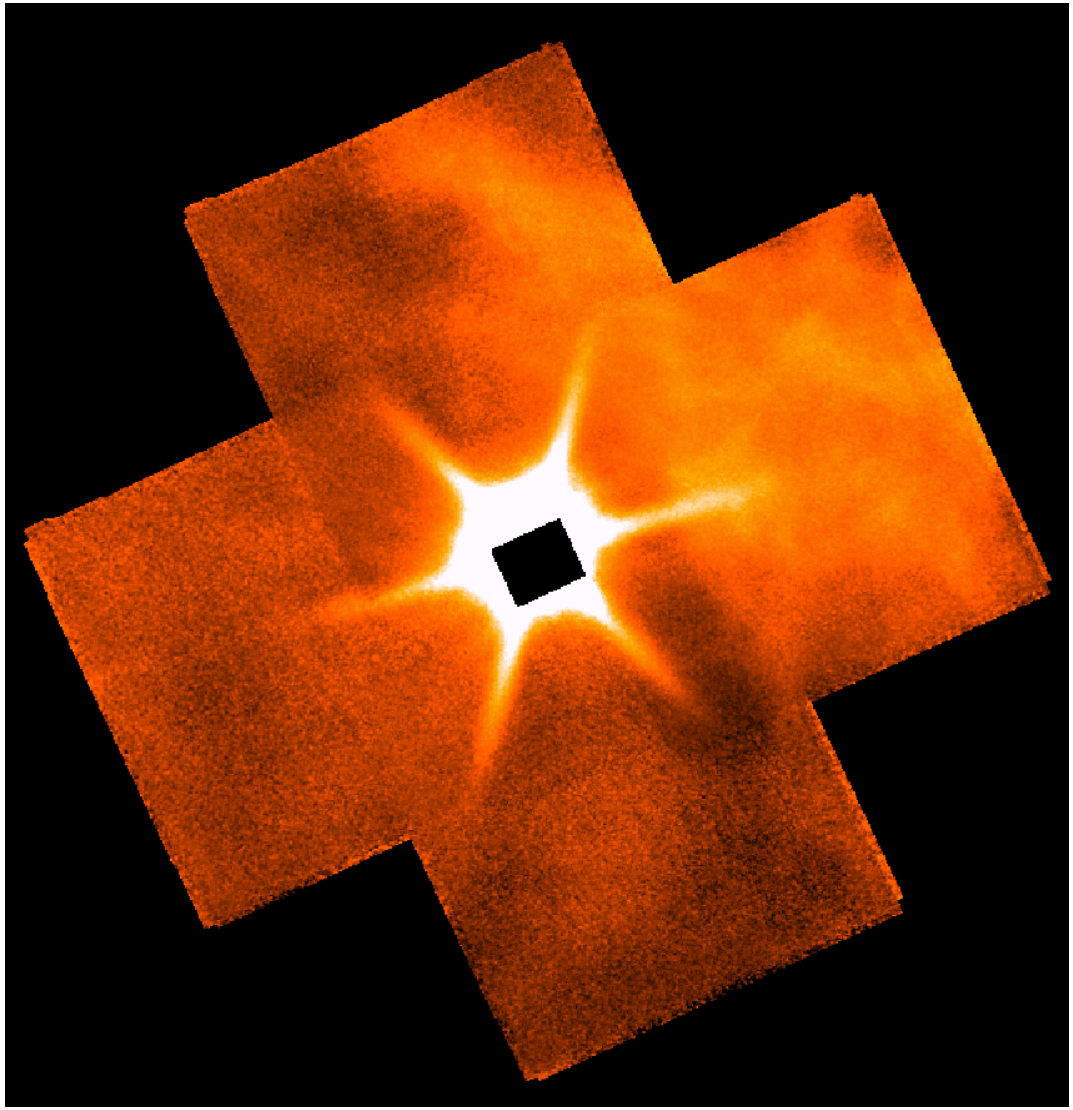


Previous reduction

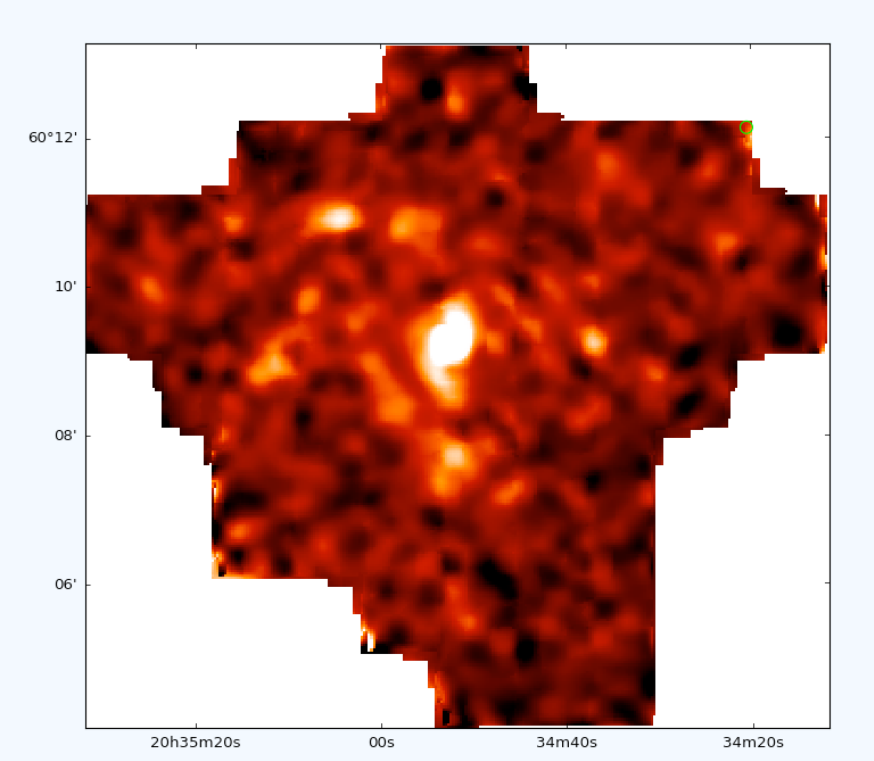
Atmospheric Transmission

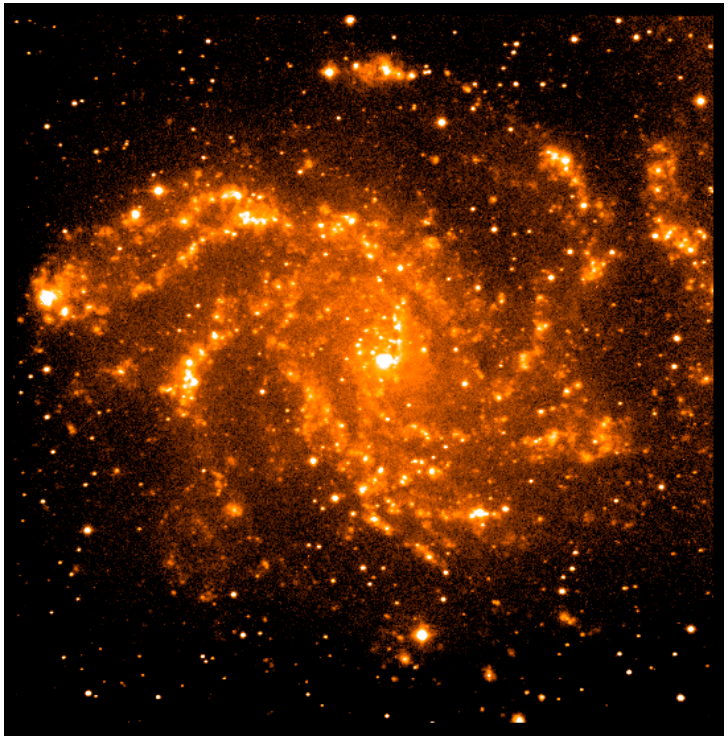
New reduction

Eta Carinae observed with FORCAST at 31 microns

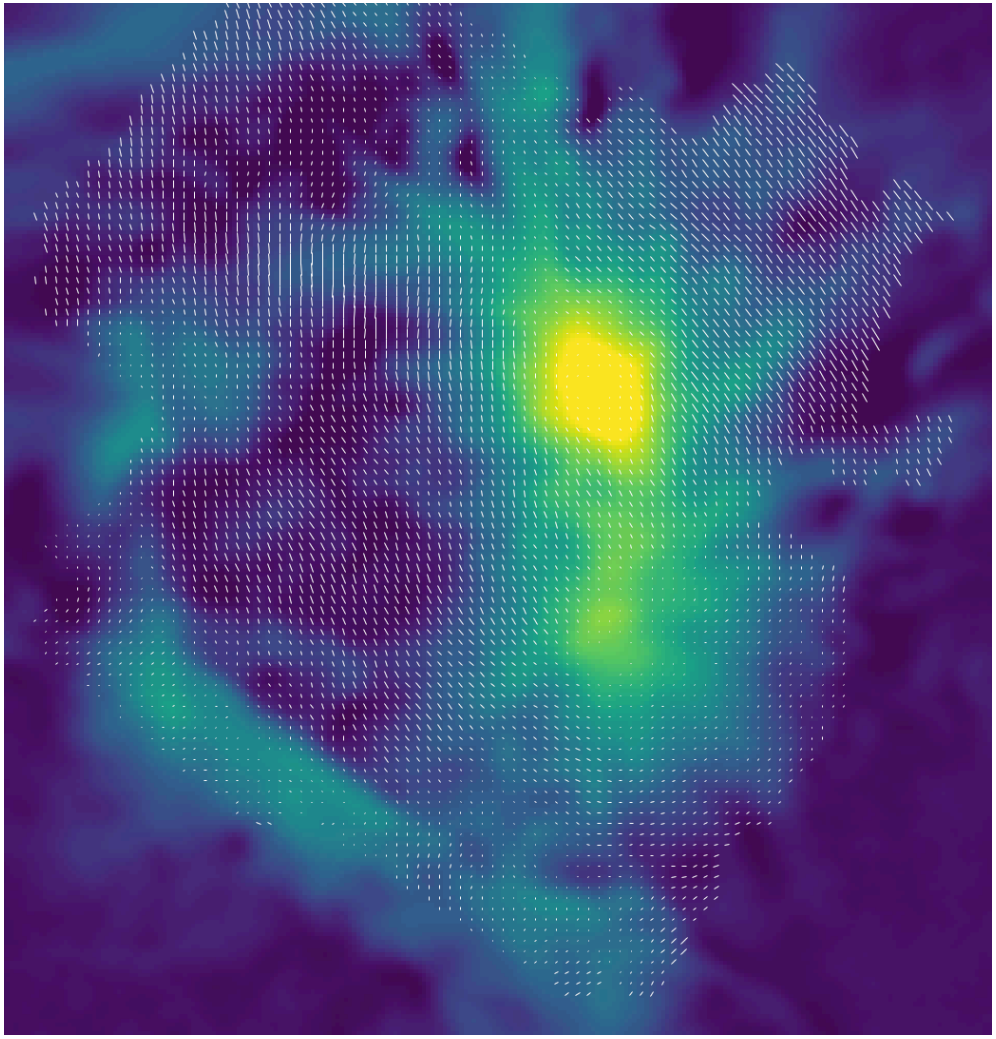


NGC 6946 observed with FIFI-LS at 158 microns (compared with a ground-based 6570 A image)

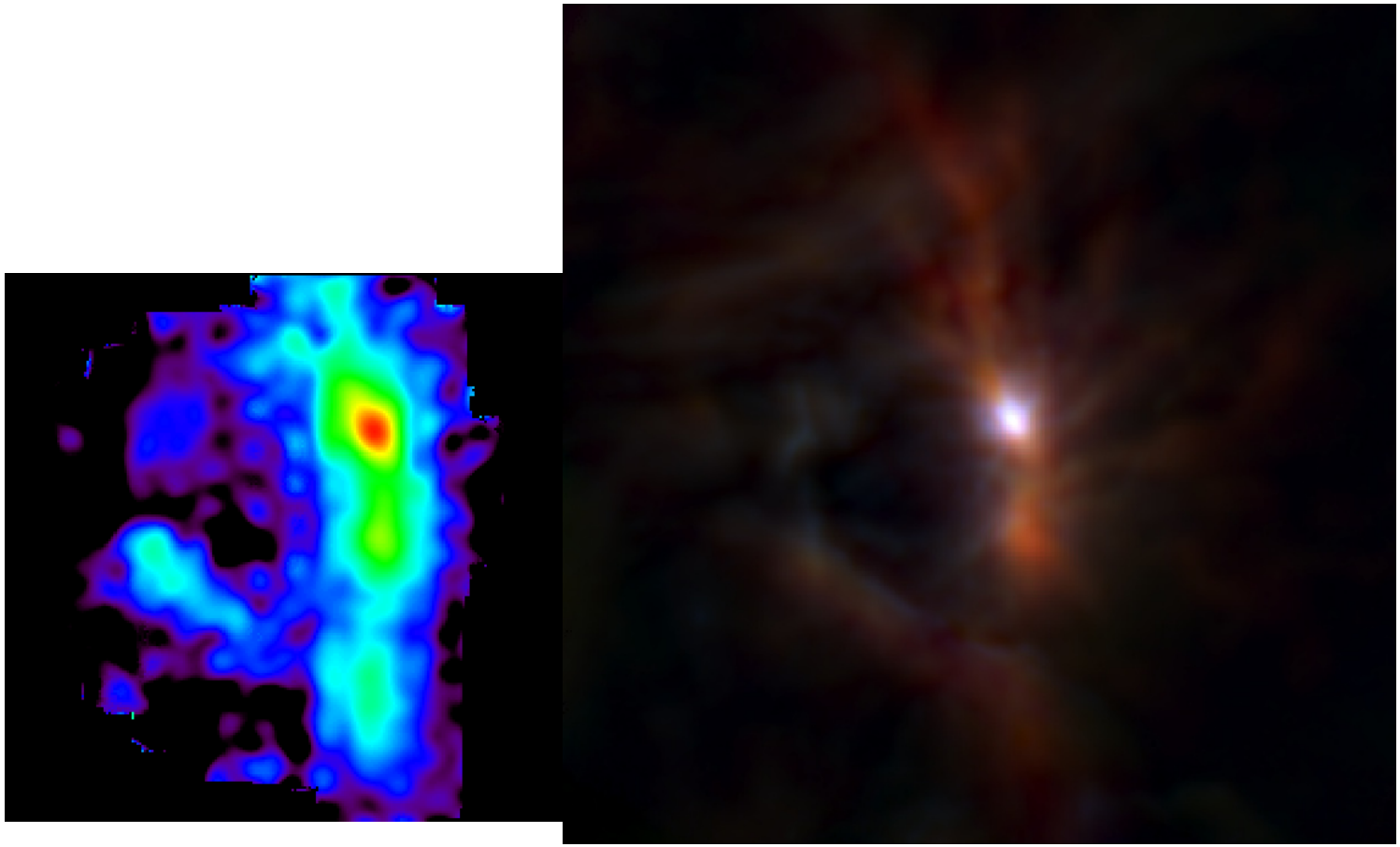




Orion observed with HAWC+ Band C (89 microns) with polarization vectors overlaid



Orion observed with FIFI-LS (158 μm) and HAWC+ (Bands A [53 μm], C [89 μm], and E [214 μm])



FIFI-LS HAWC

FSI Pipeline Processing

- FLITECAM
  - Processed OC4-J data
  - Products have been ingested into Archive and notifications sent to GOs
- FORCAST
  - Re-processed **all** FORCAST grism data obtained since the start of OC2 with new PWV optimization procedure and updated response curves
  - OC2-D, OC2-F, OC2-H, OC3-D, OC3-I, OC3-L, OC4-A, OC4-G, OC4-I
  - Sachin Shenoy has done all of the QA
  - Products have been ingested into Archive and notifications sent to GOs
  - Will re-process imaging data that could benefit from new mosaicing procedure
- FIFI-LS
  - Re-processed **all** FIFI-LS data from OC2 to the present with new flats and improved pipeline
  - Commissioning, OC2-C, OC3-B, OC3-K, OC4-B, OC4-F, OC5-B
  - Dario Fadda has done all of the QA
  - Products, including multi-mission L4 data cubes, have been ingested into Archive and notifications sent to GOs
- HAWC+
  - Processed all data from Oct. Commissioning and Dec. OC4-L series with v1.1.1 of the pipeline
  - Awaiting approval from SI team to ingest into Archive
  - Pipeline won't be officially accepted until Fall 2017
  - Will begin processing OC5-E data shortly

Cycle 4 Data Reduction Status

Observing Campaign	Science Instrument	Last Flight Date	Baseline L3 Date	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	24-Jun-16
4-C	EXES	24-Mar-16	21-Apr-16†2	26-Apr-16
4-D	GREAT	27-May-16	22-Aug-16†1	29-Jul-16
4-E	GREAT (NZ)	20-Jun-16	13-Sep-16†1	29-Jul-16
4-F	FIFI-LS (NZ)	6-Jul-16	8-Sep-16	30-Sep-16
4-G	FORCAST (NZ)	21-Jul-16	11-Aug-16	25-Aug-16 ref. waiver OCCB-WAV-0089
4-I	FORCAST	27-Sep-16	18-Oct-16	18-Oct-16
4-J	FLITECAM	20-Oct-16	9-Nov-16	21-Nov-16 ref. waiver PRG-WAV-003
4-K	GREAT	18-Nov-16	15-Feb-17†1	20-Apr-17
4-L	HAWC+	16-Dec-16	26-Apr-17**	9-Jun-17**
4-M	EXES	26-Jan-17	23-Feb-17†2	1-Mar-17
4-N	GREAT	4-Feb-17	15-May-17†1/*	20-Apr-17

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

†1: Reference waiver PRG-WAV-001
†2: Reference waiver PRG-WAV-002
* Assumes a 4N/5A sequence
** HAWC+ data processed as "best effort" for Cycle 4 because it is a newly commissioned instrument. Dates posted are an estimate.

L3 Level-3 Data Products
NZ New Zealand

Slide Revision: 25 May 2017

Cycle 5 Data Reduction Status

Observing Campaign	Science Instrument	Last Flight Date	Baseline L3 Date	Completed/ Expected L3
5-A	upGREAT	17Feb 2017	15 May 2017†6	20 Apr 2017
5-B	FIFI-LS	9 Mar 2017	30 Mar 2017	13 Apr 2017
5-C	EXES	23 Mar 2017	24 Apr 2017†7	24 Apr 2017
5-D	FORCAST	26 Apr 2017	2 Jun 2017†8	N/A *No flights flown in series*
5-E	HAWC+	18 May 2017	9 Jun 2017**	9 Jun 2017
5-F	EXES	26 May 2017	29 Jun 2017†7	
5-G/H	upGREAT	14 Jul 2017	11 Oct 2017†6	
5-I	FIFI-LS	27 Jul 2017	18 Aug 2017	
5-J	FORCAST	8 Aug 2017	30 Aug 2017	
5-K	HAWC+	27 Sep 2017	20 Oct 2017**	
5-L	FLIPO	6 Oct 2017	31 Oct 2017	
5-M	FORCAST	25 Oct 2017	17 Nov 2017	
5-N	HAWC+	16 Nov 2017	11 Dec 2017	
5-O	EXES	31 Jan 2018	6 Mar 2018†7	

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

L3 Level-3 Data Products

†6: Reference waiver PRG-WAV-006
†7: Reference waiver PRG-WAV-007
†8: Reference waiver PRG-WAV-008
** HAWC+ data processed as "best effort" for 5E and 5K because it is a newly commissioned instrument.

DPS Staff

- Scientists:
  - **W. Vacca** – DPS Lead, pipeline development, QA, calibration scientist for FORCAST, FLITECAM, FIFI-LS, HAWC
  - **R. Shuping** (SSI) – 80%; processing and operations support
  - **J. Radomski** – QA scientist for FORCAST, HAWC
  - **S. Shenoy** – QA scientist for FORCAST, FLITECAM, HAWC
  - **D. Fadda** – QA scientist for FIFI-LS
- Software Engineers:
  - **M. Clarke** – Development Lead; Redux (pipeline interface), develops/maintains four pipelines, header checker, QA tools; testing, documentation
  - **K. Shabun** – DPS database project
  - **B. Clarke** (NASA) – IT&V lead; testing, documentation
- IT:
  - **D. Sandel** – DPS hardware and operations support
  - **E. Proudfit** – DPS machine set-up and maintenance

Summary

- DPS team continues to make improvements to FSI pipelines
  - Bug fixes
  - Algorithm improvements
- DPS team has re-processed significant fraction of data to take advantage of pipeline improvements
  - **All** FIFI-LS data have been re-processed to L3/L4 with revised pipeline
  - **All** FORCAST grism spectra back to OC2 have been re-processed with revised pipeline
- DPS team is ready to process HAWC+ data
- DPS team has been able to meet most scheduled deadlines for reductions of FSI data despite substantial re-processing efforts as well as supporting flights (e.g., in-flight reductions)
- Flux calibration for FSI pipelines is generally accurate to better than ~10%
- Improvements in spectroscopic reduction products would result from a calibrated WVM (especially for FIFI-LS data)