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# Data Processing Status

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SUG #13

16 Nov. 2018

# SOFIA Pipeline Products:

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**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 from different flights (e.g. mosaics, spectral cubes, polarization maps)

# SOFIA FSI Pipeline Process (General Outline):

- Store raw (L0/L1) data in DCS
- Repair/modify data headers
- Ingest modified L1 files into DCS Archive database
- Process data through pipeline to generate L2 data ← Re-processing starts here
- Perform QA analysis on L2 data products
- Carry out calibration analysis
- Apply calibration results to L2 data to generate L3 data
- Generate L4 data products from L3 data files
- Perform QA analysis on L3/L4 data products
- Store L2/L3/L4 data products and ingest into the DCS Archive database
- Generate, vet, send notification e-mails to GOs

15 days

# Pipeline Developments

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- **FORCAST:**

- Improvements to mosaic generation step
- Added ability to handle slit scan data
- Imaging pipeline re-written in Python (converted from IDL)

- **FIFI-LS:**

- Improved the ramp fits and filtering
- Derived better calibration files (bad pixels, spectral and spatial flats)
- Derived new response curves
- Verified reliability of flux calibration (better than ~10% on average)
- Starting to convert IDL code to Python

- **HAWC+:**

- Full release of the pipeline, including error propagation instrumental polarization corrections, diagnostic plots, and polarization maps
- Verified accuracy of telluric correction/flux calibration (better than ~15%)

- **Redux:**

- Converted IDL code to Python to serve as an interface for HAWC+ pipeline
- Incorporating other pipelines into it

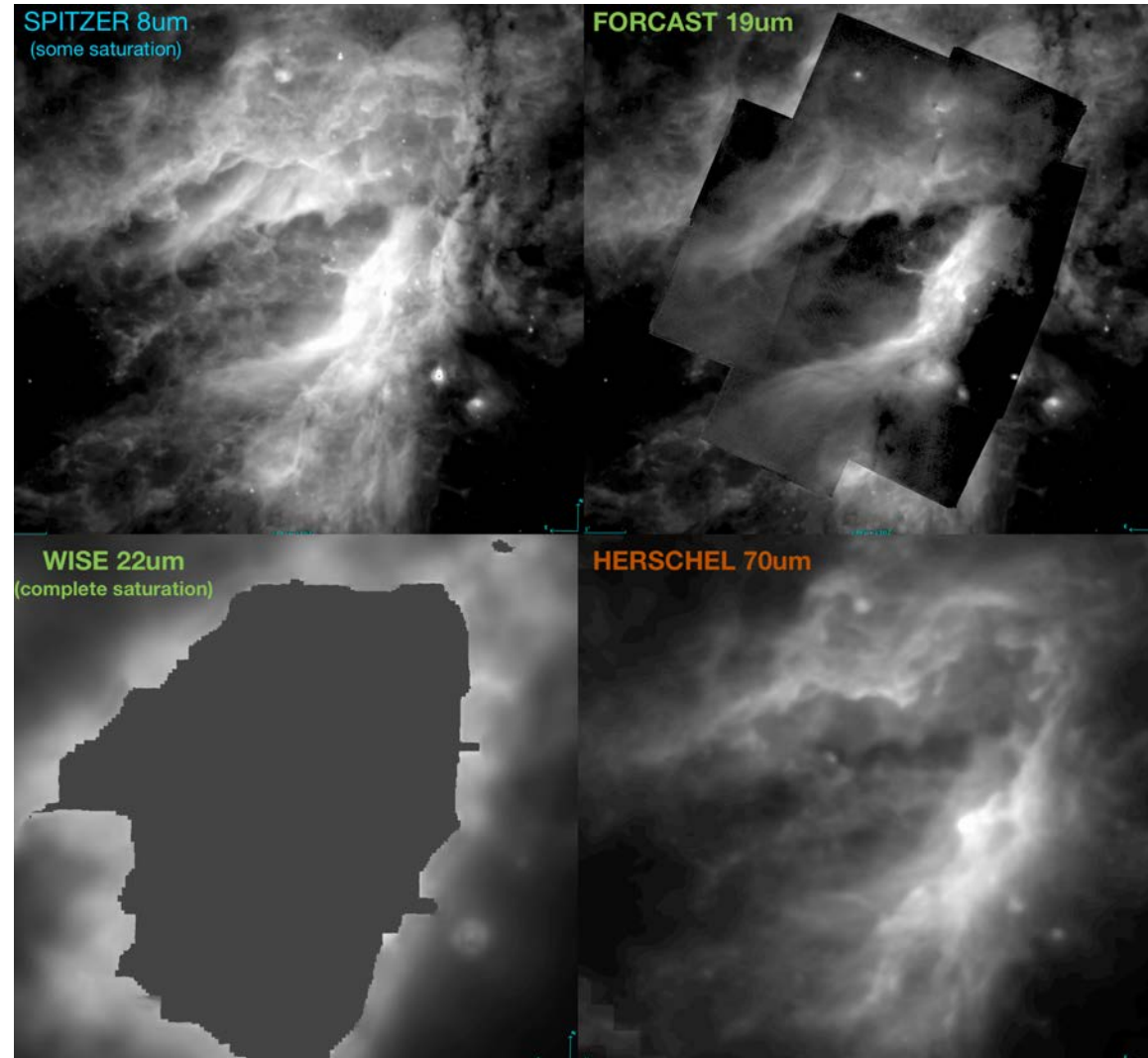
- **Pipetools** (Pipeline Infrastructure):

- Re-written in Python (converted from Korn shell)

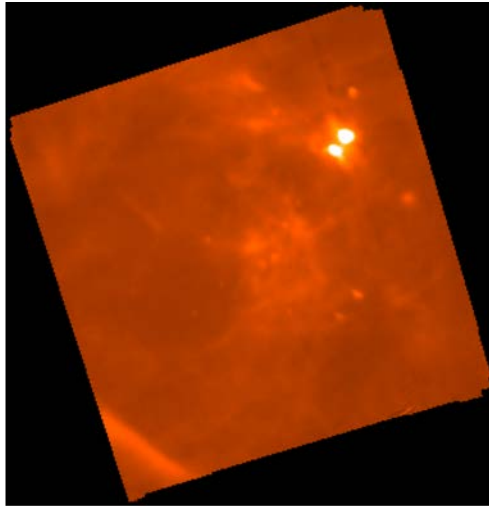
- **Tools:**

- Restructured and expanded the SOFIACruiseDirector (e-log)
- Released SOSPEX – Python code for visualizing FIFI-LS and GREAT data cubes

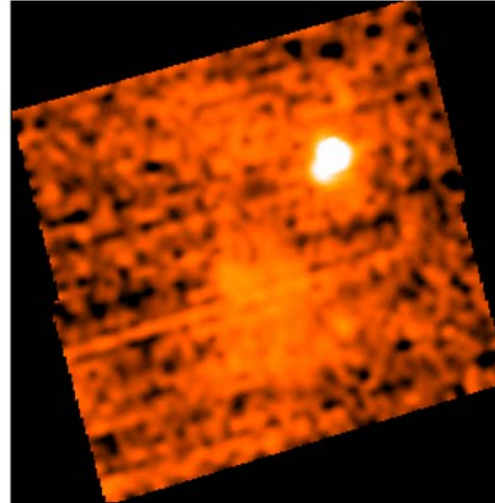
# FORCAST Mosaic Observations of M17



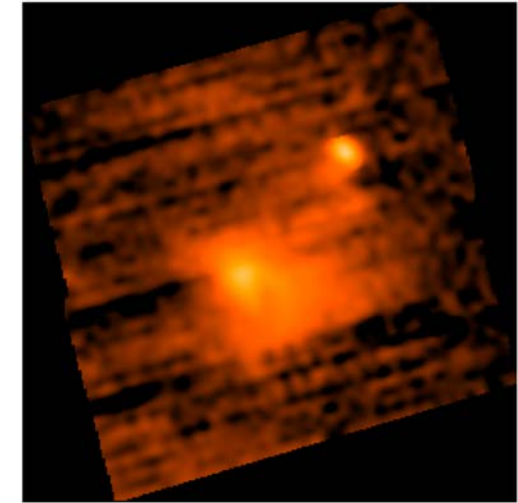
# FORCAST Slit Scan Processing - Preliminary



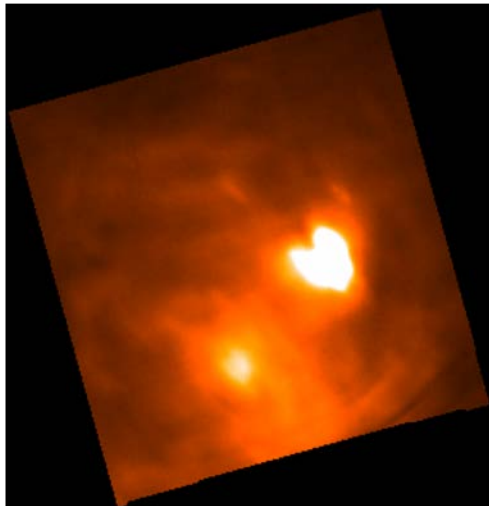
F077



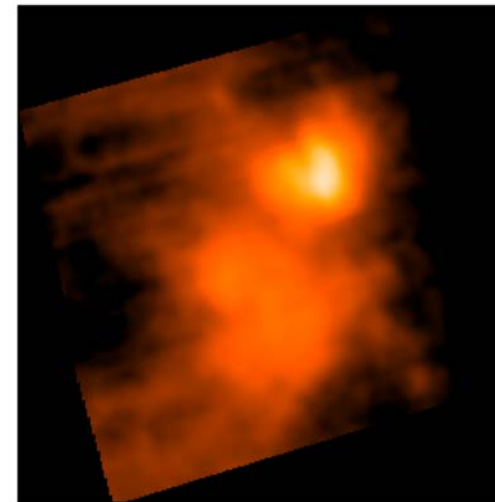
G063



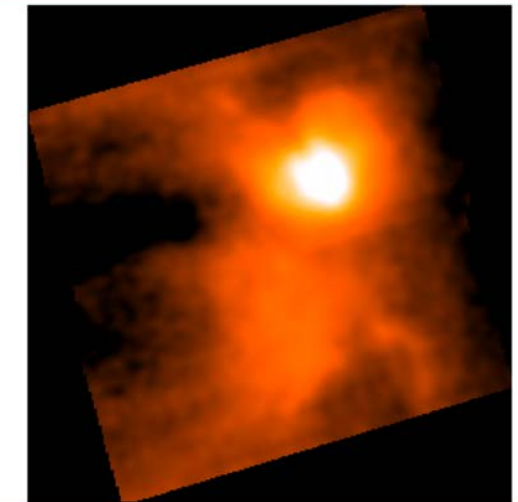
G227



F197



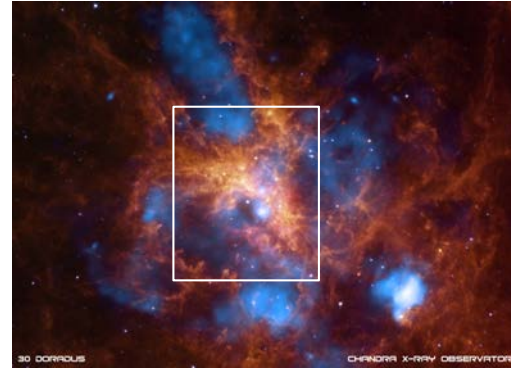
G227



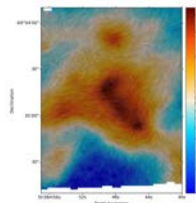
G329



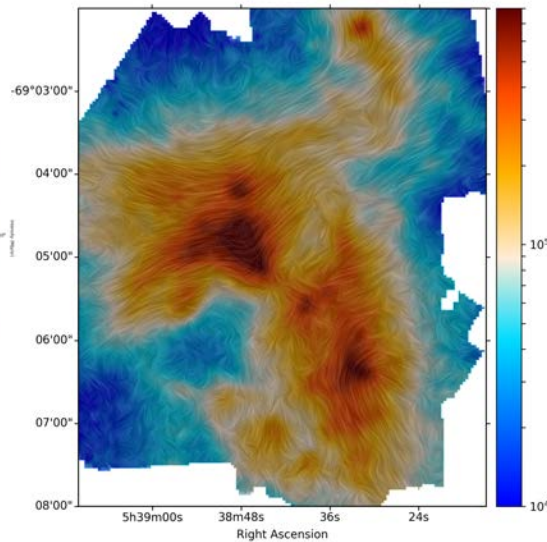
# HAWC+ Polarimetry Observations of 30 DOR



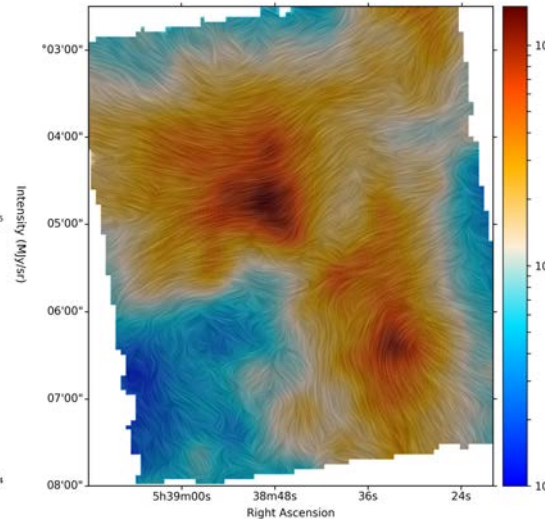
HAWC+ Band A  
(53 microns)



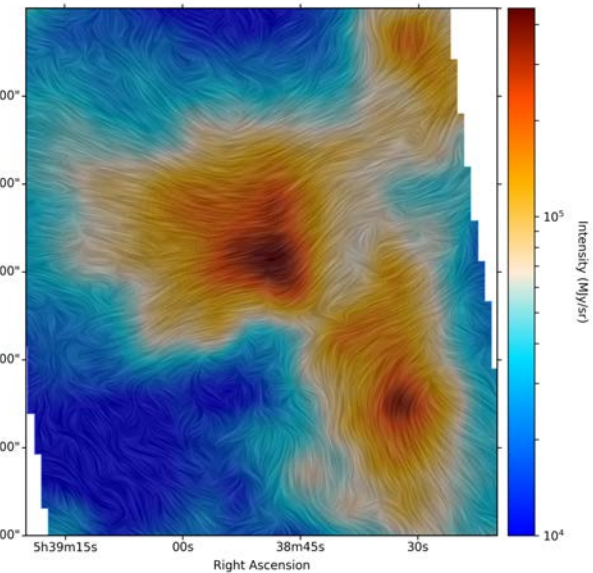
HAWC+ Band C  
(89 microns)



HAWC+ Band D  
(154 microns)



HAWC+ Band E  
(214 microns)



# SOFIA CruiseDirector

**Set Up**

**Flight Plan:** 201803\_FI\_DIANA\_SCI.mis  
**Director Log:** SILog\_20181115.txt  
**Data Log:** DataLog\_20181115.txt  
**Data Location:** /home/jrvander/repos/SOFIACruiseTools/inputs/sourceFits/fifi-ls  
**Instrument:** FIFI-LS

**Start**

**End**

Set Takeoff from Plan **Leg:** 5 Science  
 11/14/2018 20:55:00 **Target:** Antennae  
 Set Landing from Plan **Elevation Range:** 25.3 to 34.3  
 11/15/2018 16:41:35 **ROF | ROFrate:** 333.5 to 338.4 | 0.0 to 0.1  
 Previous Leg Next Leg **ObsPlan:** 70\_0608

**Cruise Director Log** Data Log Flight Map

Autoupdate every: 5 seconds **Network Good**  Toggle Network

NOTES	BADCAL	HEADER_CHECK	DATE-OBS	OBJECT	MCCSMODE	SPECTEL1	SPECT^
00006_111436_00001_30dor-1_act3_-104_140_A_sw.fits		Passed	2017-07-28T11:14:37	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00008_111548_00003_30dor-1_act3_-104_140_B_sw.fits		Passed	2017-07-28T11:15:49	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00007_111513_00002_30dor-1_act3_-104_140_B_sw.fits		Passed	2017-07-28T11:15:14	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00010_111700_00005_30dor-1_act3_-104_140_A_sw.fits		Passed	2017-07-28T11:17:02	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00009_111625_00004_30dor-1_act3_-104_140_A_sw.fits		Passed	2017-07-28T11:16:26	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00011_111739_00006_30dor-1_act3_-104_140_B_sw.fits		Passed	2017-07-28T11:17:40	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00012_111818_00007_30dor-1_act3_-77_129_A_sw.fits		Passed	2017-07-28T11:18:20	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00014_111931_00009_30dor-1_act3_-77_129_B_sw.fits		Passed	2017-07-28T11:19:32	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00013_111855_00008_30dor-1_act3_-77_129_B_sw.fits		Passed	2017-07-28T11:18:57	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00015_112008_00010_30dor-1_act3_-77_129_A_sw.fits		Passed	2017-07-28T11:20:09	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00016_112043_00011_30dor-1_act3_-77_129_A_sw.fits		Passed	2017-07-28T11:20:44	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00018_112200_00013_30dor-1_act3_-88_101_A_sw.fits		Passed	2017-07-28T11:22:02	30dor-1	fifi-ls_standard	FIF_BLUE	NONE
00017_112120_00012_30dor-1_act3_-77_129_B_sw.fits		Passed	2017-07-28T11:21:22	30dor-1	fifi-ls_standard	FIF_BLUE	NONE

**Dialog**

201803\_FI\_DIANA\_SCI.mis

**Time Remaining**  **Time Elapsed**

**Leg Duration:** 01:20:00

**Leg:** 5 / 12  
**Time:** 00:00:00  
**Leg Completion:** 24%  
 Show Labels  Use Current Time **Flight Completion:** 57%

**Dialog**

2018-11-15T16:11:08> Beginning of flight, getting set up  
 2018-11-15T16:11:12> On heading, TOs setting up  
 2018-11-15T16:11:14> On target, SI taking over  
 2018-11-15T16:11:14> Turning off target  
 2018-11-15T16:11:15> On heading, TOs setting up  
 2018-11-15T16:11:15> On target, SI taking over  
 2018-11-15T16:11:17> SI fault encountered



# FSI Pipeline Processing in the Last Year

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- **FLITECAM**

- Processed OC5-L data (4 flights)

- **FORCAST**

- Processing of OC6-J (12 flights) delayed due to IT/MMOC transition and problems due to degradation of entrance window (see next 2 slides)
- Will work to salvage data after HAWC+ OC6-K data processing is finished.
- Nominal delivery date is 30 Nov, but will almost certainly slip

- **FIFI-LS**

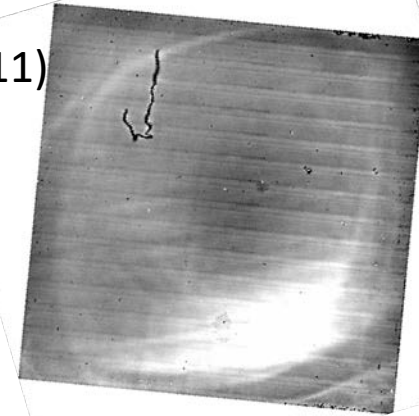
- Processing of OC6-M data (4 flights) has started
- Nominal delivery date is 03 Dec.

- **HAWC+**

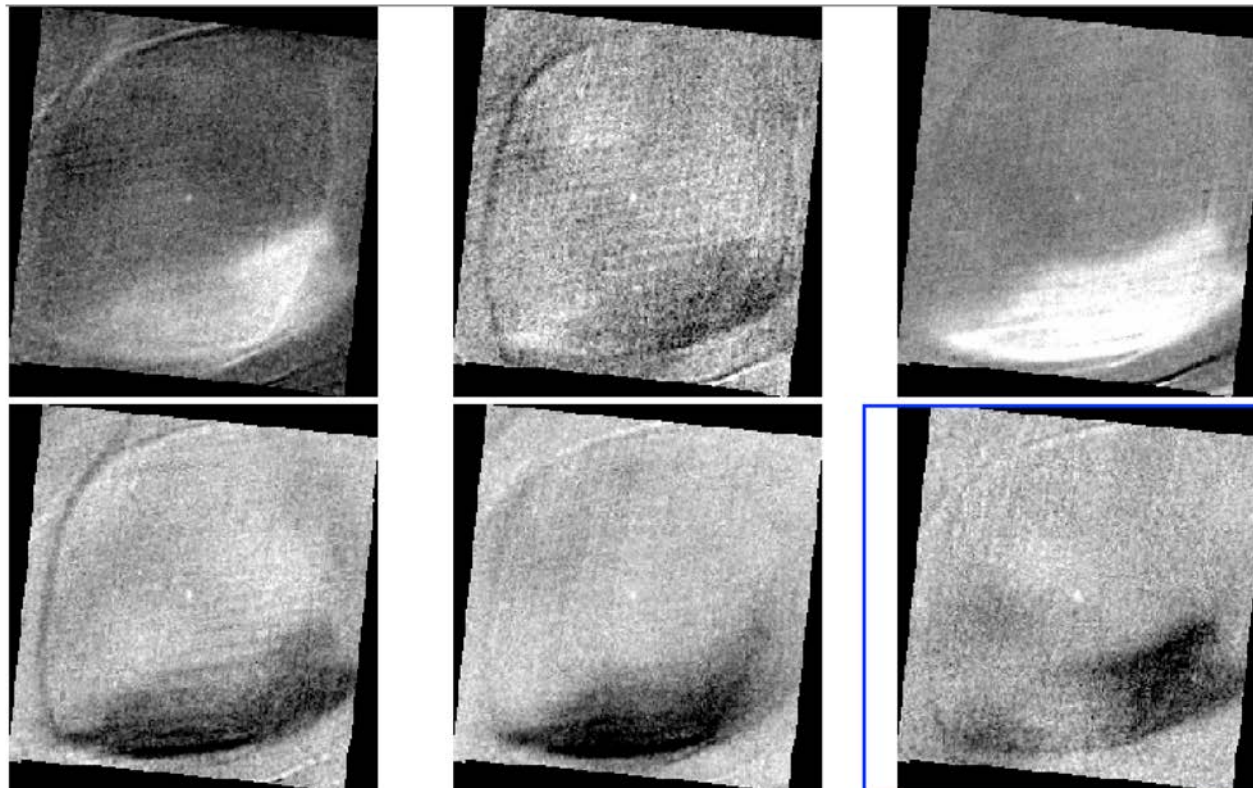
- Processed all available data: Sep. 2016 Commissioning, OC4-L, OC5-E, OC5-N, OC6-I, and OC6-K (45 flights)
- OC6-K data processing delayed by IT/MMOC transition, but should be available before 30 Nov.

# Examples of problems with FORCAST OC6-J data

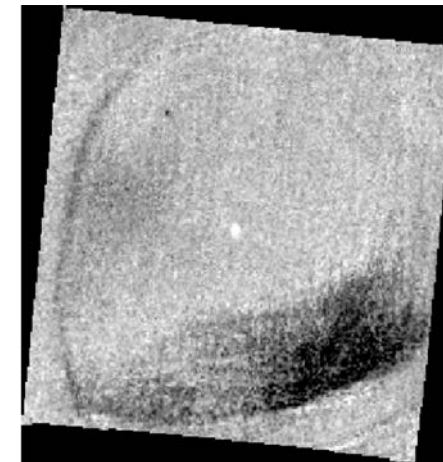
Raw sky image (F111)



Individual reduced (chop/nod subtracted) images (F111)



Final image

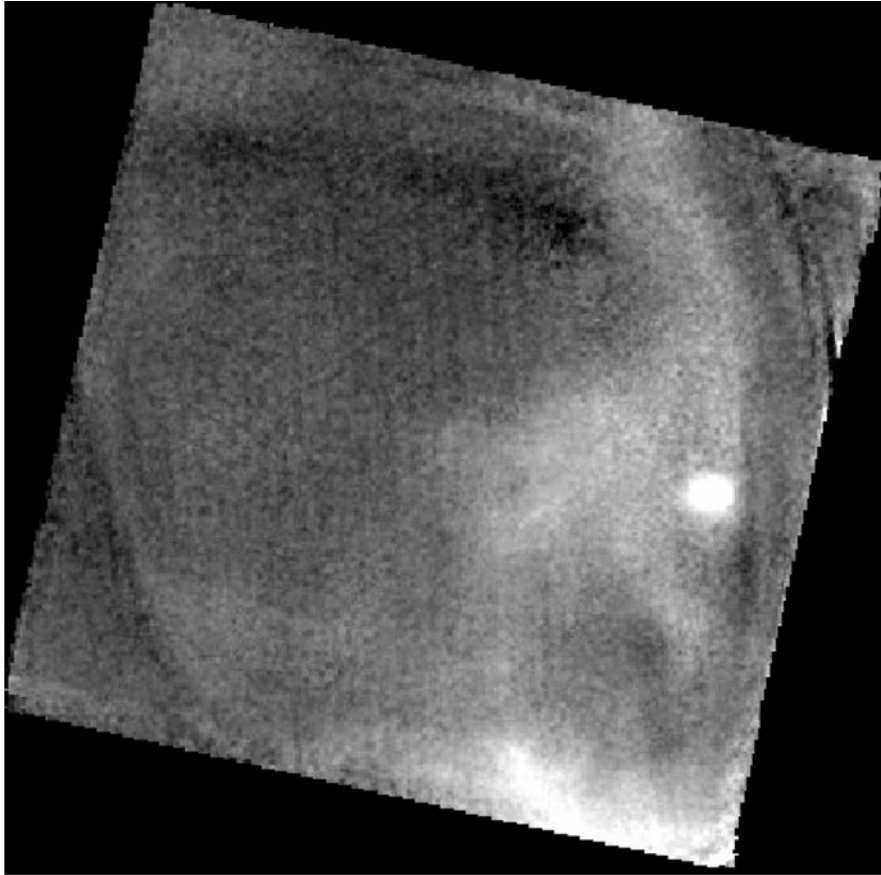


# Example of problems with FORCAST OC6-J data

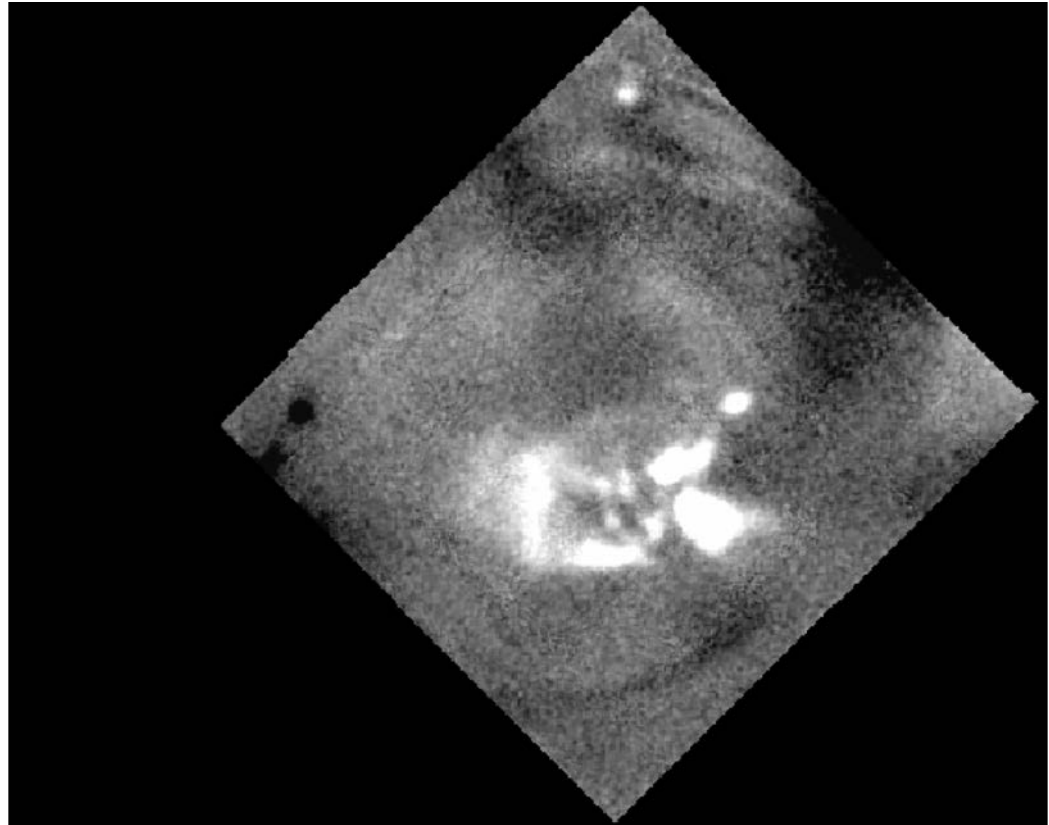
Impact on observations of faint extended sources

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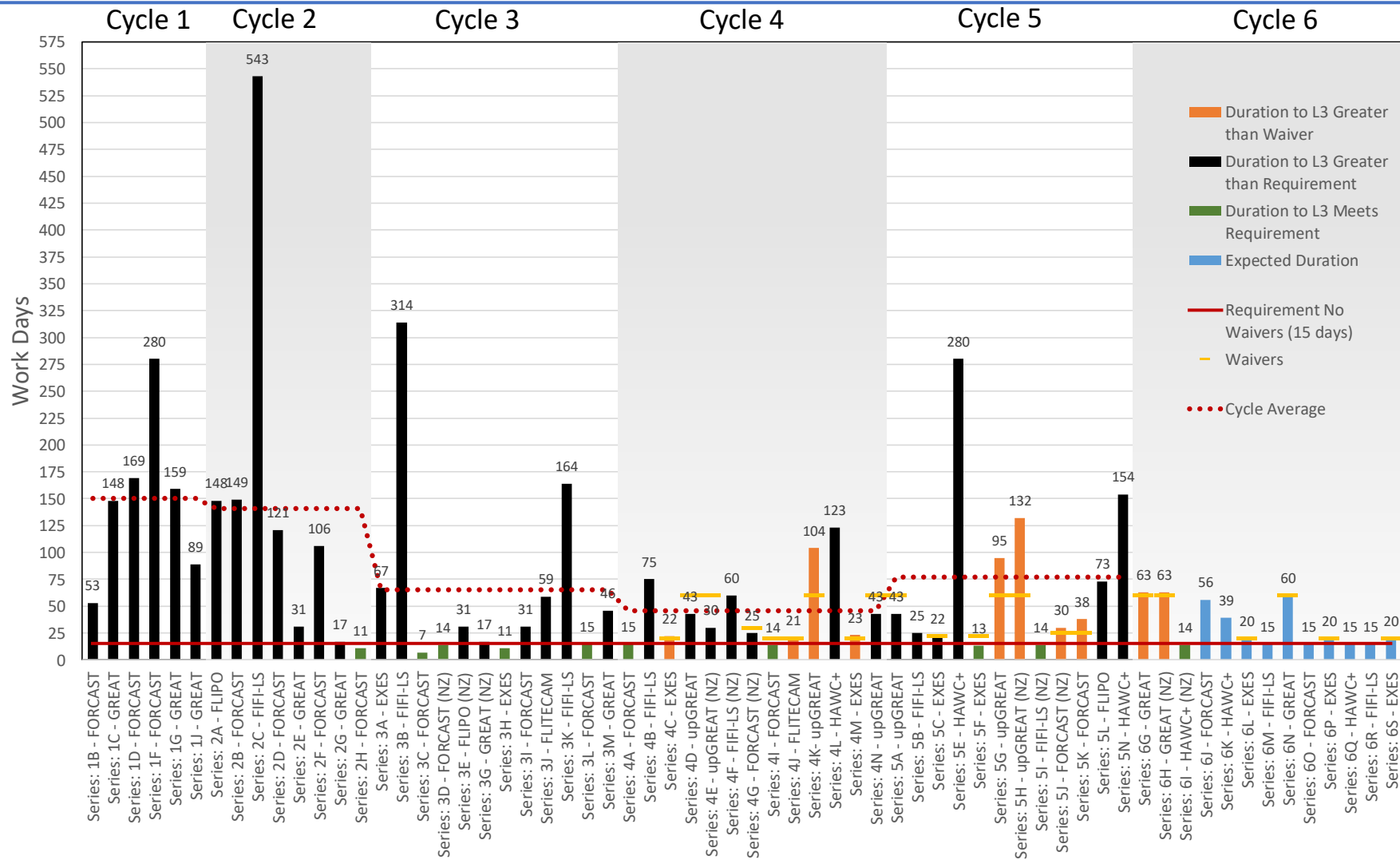
M17 (F197)



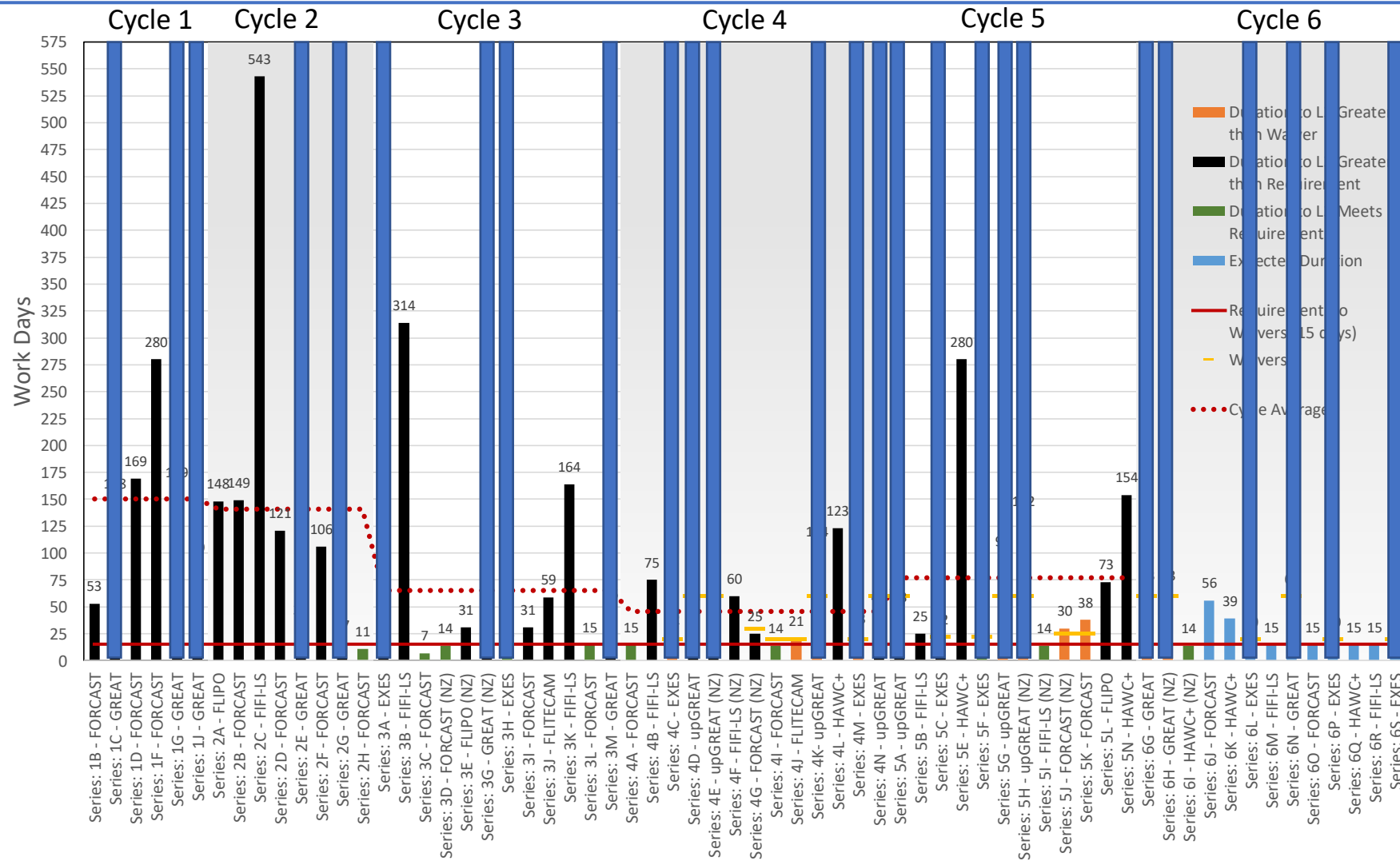
Cyg XN46 (F197)



# Duration to L3 processed and archived by series & cycle



# Duration to L3 processed and archived by series & cycle for FSIs



Avg for Cycles 4 & 5 = 35 days (excl. HAWC+)



# Cycle 5 Data Reduction Status

Observing Campaign	Science Instrument	Last Flight Date	Baseline L3 Date	Completed/ Expected L3
5-A	upGREAT	16 Feb 2017	15 May 2017 <sup>†6</sup>	20 Apr 2017
5-B	FIFI-LS	8 Mar 2017	30 Mar 2017	13 Apr 2017
5-C	EXES	22 Mar 2017	24 Apr 2017 <sup>†7</sup>	24 Apr 2017
5-D	FORCAST	<del>26 Apr 2017</del>	<del>2 Jun 2017<sup>†8</sup></del>	N/A <i>No flights flown in series</i>
5-E	HAWC+	17 May 2017	9 Jun 2017 <sup>**</sup>	30 Jun 2018 <sup>**</sup> <small>(PAR: 26 March 2018, ORR: 30 May 2018)</small>
5-F	EXES	26 May 2017	29 Jun 2017 <sup>†7</sup>	16 Jun 2017
5-G/H	upGREAT	14 Jul 2017	11 Oct 2017 <sup>†6</sup>	26 Jan 2018 <small>OC-5G completed Nov 2017</small>
5-I	FIFI-LS	27 Jul 2017	18 Aug 2017	18 Aug 2017
5-J	FORCAST	8 Aug 2017	30 Aug 2017	22 Sep 2017 <small>reference waiver PRG-WAV-010</small>
5-K	FORCAST	27 Sep 2017	20 Oct 2017	24 Nov 2017 <small>reference waiver PRG-WAV-011</small>
5-L	FLIPO	6 Oct 2017	31 Oct 2017	26 Jan 2018
5-N	HAWC+	16 Nov 2017	11 Dec 2017	30 Jun 2018 <small>(PAR: 26 March 2018, ORR: 30 May 2018)</small>
5-O	EXES	<del>19 Jan 2018</del>	<del>22 Feb 2018<sup>†7</sup></del>	N/A <i>No flights flown in series</i>
5-P	FORCAST	<del>15 Feb 2018</del>	<del>16 Mar 2018</del>	N/A <i>No flights flown in series</i>

Status updated  
June 30, 2018

L3 Level-3 Data  
Products

Green	Expected completion on Track
Yellow	Expected completion less than 2 weeks after baseline (or newly commissioned instrument best effort)
Red	Expected completion more than 2 weeks after baseline
Blue	Completion date

†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 because it is a newly commissioned instrument.

Slide Revision: 30 June 2018

# Cycle 6 Data Reduction Status

Observing Campaign	Science Instrument	Last Flight Date*	Baseline L3 Date*	Completed/ Expected L3
6-A	<i>Not used</i>	<i>N/A</i>	<i>N/A</i>	<i>N/A</i>
6-B	<i>Not used</i>	<i>N/A</i>	<i>N/A</i>	<i>N/A</i>
6-C	<i>GREAT</i>	<i>Not flown</i>	<i>N/A</i>	<i>N/A</i>
6-D	<i>FIFI-LS</i>	<i>Not flown</i>	<i>N/A</i>	<i>N/A</i>
6-E	<i>EXES</i>	<i>Not flown</i>	<i>N/A</i>	<i>N/A</i>
6-F	<i>HAWC+</i>	<i>Not flown</i>	<i>N/A</i>	<i>N/A</i>
6-G/H	GREAT	29 Jun 2018	26 Sep 2018 <sup>†16</sup>	1 Oct 2018
6-I	HAWC+	18 Jul 2018	8 Aug 2018	3 Aug 2018
6-J	FORCAST	9 Sep 2018	1 Oct 2018	30 Nov 2018
6-K	HAWC+	1 Oct 2018	25 Oct 2018	30 Nov 2018
6-L	EXES	31 Oct 2018	3 Dec 2018 <sup>†15</sup>	3 Dec 2018
6-M	FIFI-LS	8 Nov 2018	4 Dec 2018	4 Dec 2018
6-N	GREAT	20 Dec 2018	21 Mar 2019 <sup>†16</sup>	21 Mar 2019
6-O	FORCAST	16 Jan 2019	8 Feb 2019	8 Feb 2019
6-P	EXES	31 Jan 2019	4 Mar 2019	4 Mar 2019
6-Q	HAWC+	13 Feb 2019	8 Mar 2019	8 Mar 2019
6-R	FIFI-LS	28 Feb 2019	22 Mar 2019	22 Mar 2019
6-S	EXES	25 Apr 2019	24 May 2019 <sup>†15</sup>	24 May 2019

Status updated  
October 25, 2018

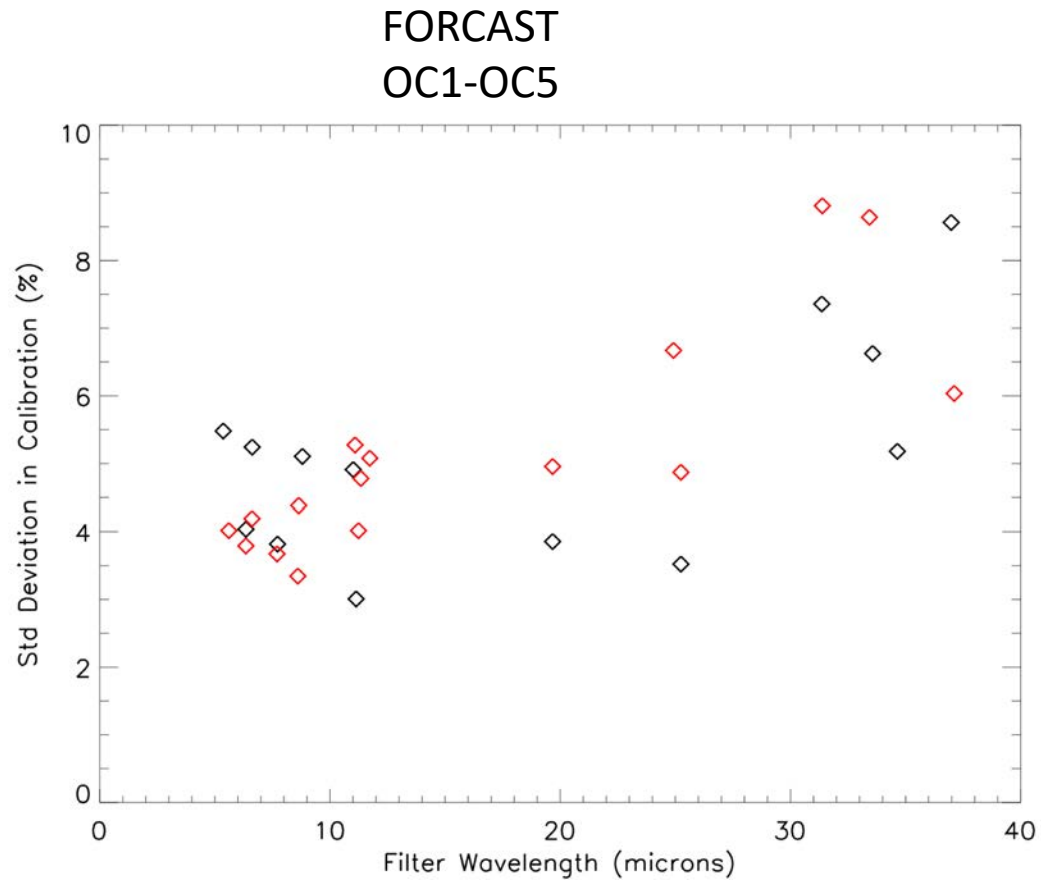
L3 Level-3 Data  
Products

<b>Green</b>	Expected completion on Track
<b>Yellow</b>	Expected completion less than 2 weeks after baseline (or newly commissioned instrument best effort)
<b>Red</b>	Expected completion more than 2 weeks after baseline
<b>Blue</b>	Completion date

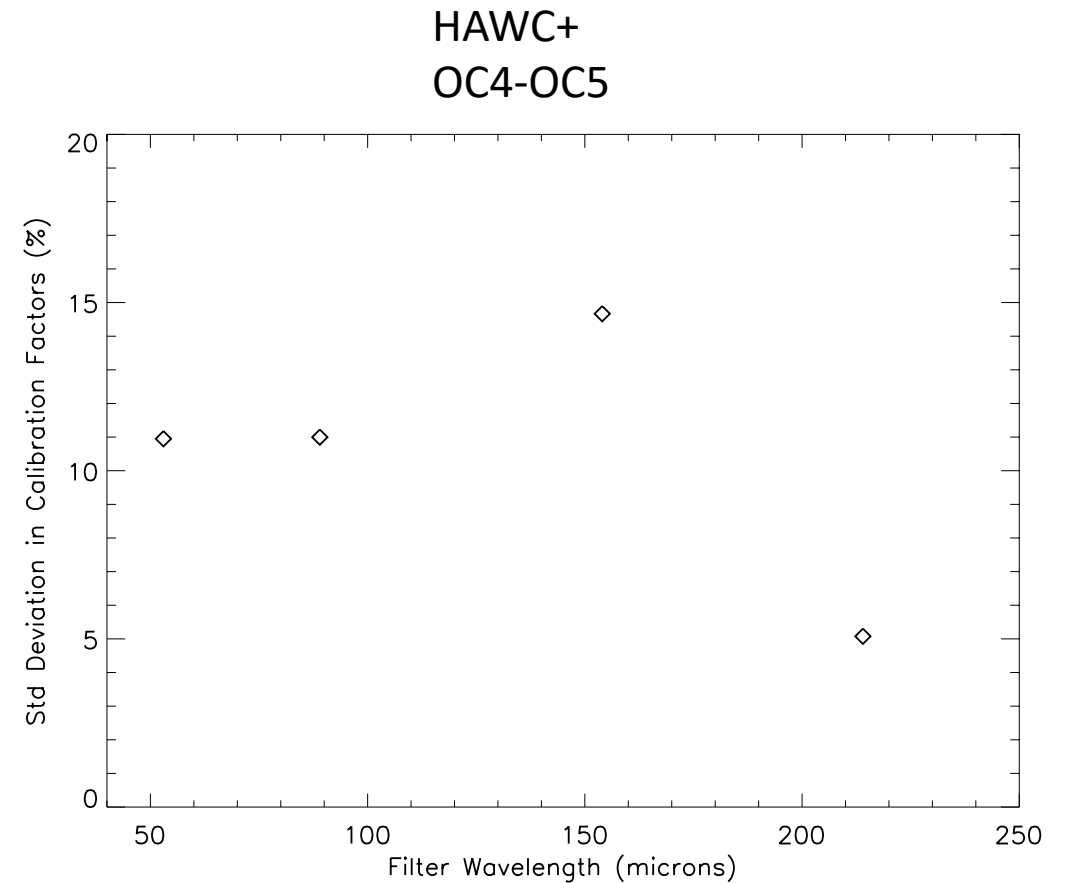
†15: Reference waiver PRG-WAV-015  
 †16: Reference waiver PRG-WAV-016  
 \* Dates reflect re-baselined flight dates including PMB cycle 6 schedule update 1 and 2

Slide Revision: 26 October 2018

# Flux Calibration Accuracy



- ◊ = Dual Channel
- ◊ = Single Channel



# DPS Staff

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- **Scientists:**

- **W. Vacca** – DPS Lead, pipeline development, QA, calibration scientist for FORCAST, FLITECAM, FIFI-LS, HAWC
- **J. Radomski** – QA scientist for FORCAST, HAWC
- **D. Fadda** – QA scientist for FIFI-LS
- **S. Shenoy** – QA scientist for FORCAST, FLITECAM, HAWC (sub-contractor)
- **R. Arneson** – Research Associate, IRSA transition
- **E. Montiel** – QA scientist for HIRMES (starts 02 Jan 2019)

- **Software Engineers:**

- **M. Clarke** – Development Lead; Redux (pipeline interface), develops/maintains pipelines, header checker; testing
- **D. Perera** – maintains pipeline infrastructure; testing; converting IDL code to Python
- **M. Langer** – CRUSH software support for HAWC+ (esp. modifications for new Scan-Pol mode) and HIRMES
- **J. Vander Vliet** – QA tools, SOFIA CruiseDirector (elog) (sub-contractor)
- **B. Clarke (NASA)** – IT&V lead; testing; documentation

- **IT:**

- **J. Fenwick** – DPS hardware and operations support

# Summary

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- DPS team continues to make improvements to FSI pipelines and software tools
  - Bug fixes
  - Algorithm improvements
  - Conversion of all pipelines from IDL to Python
  - Development and release of visualization tools and e-logger
- DPS team finally has sufficient staff to handle the data processing workload
  - Six scientists for QA examination
  - Software development team with four software engineers
  - One scientist to help with the IRSA transition
- DPS team has been able to carry out reductions and calibration of FSI data within about a month 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 ~10-15% (better than the requirement of 20%)