Data Processing Status

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SUG #13

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SOFIA Pipeline Products:

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):

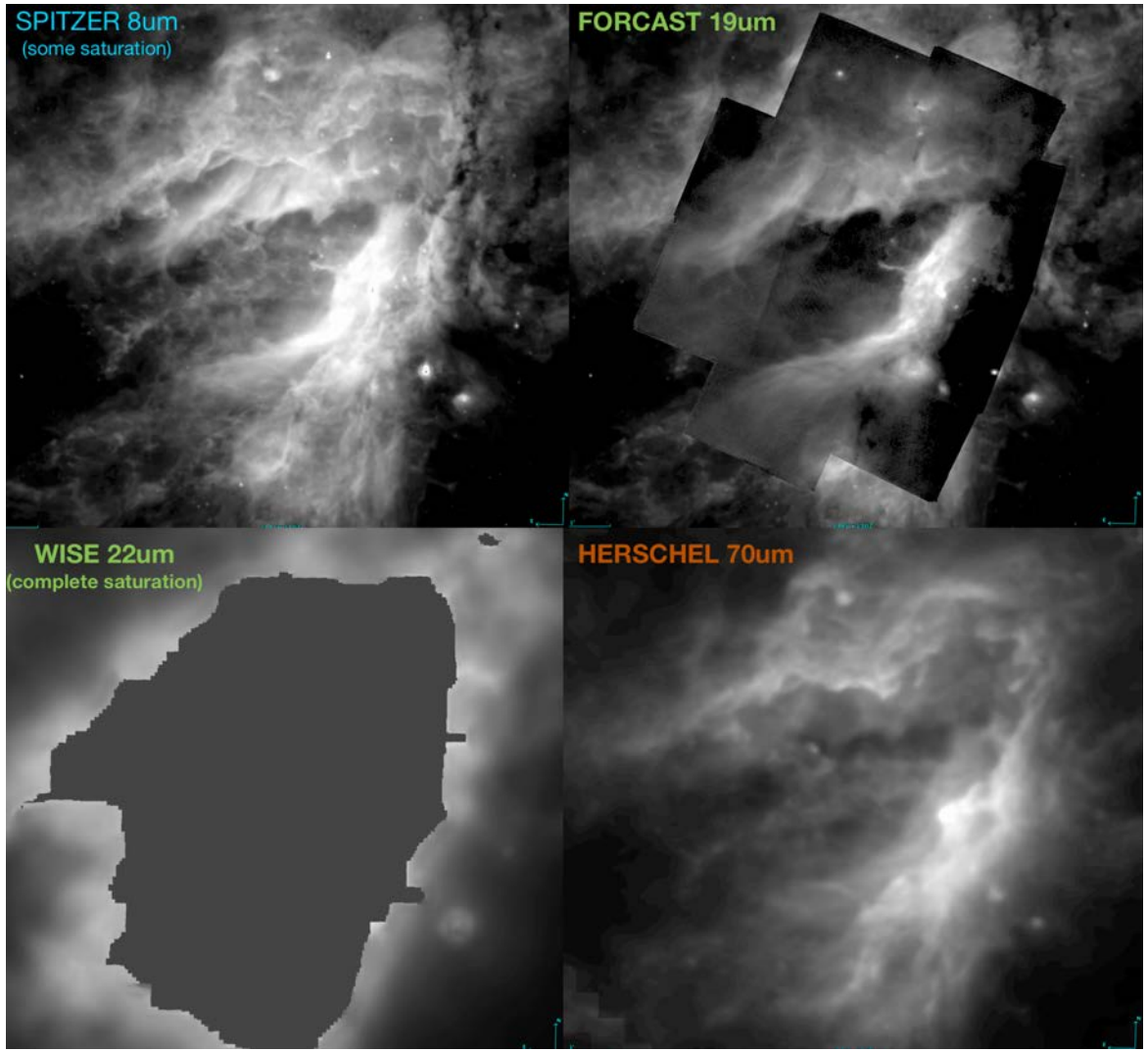
- Store raw (L0/L1) data in DCS
- Repair/modify data headers
- Ingest modified L1 files into DCS Archive database
- Process data through pipeline to generate L2 data ← Re-processing starts here
- Perform QA analysis on L2 data products
- Carry out calibration analysis
- Apply calibration results to L2 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

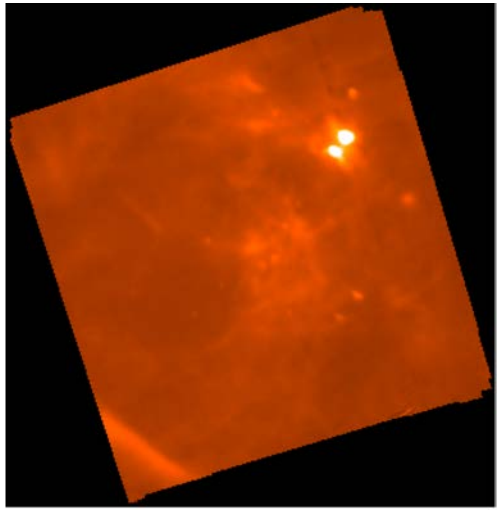
Pipeline Developments

- **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

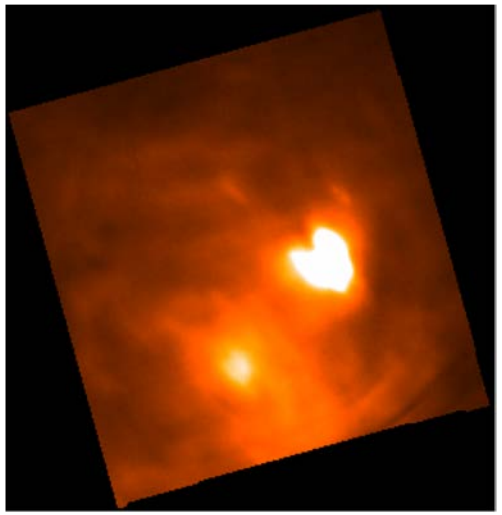
FORCAST Mosaic Observations of M17



FORCAST Slit Scan Processing - Preliminary

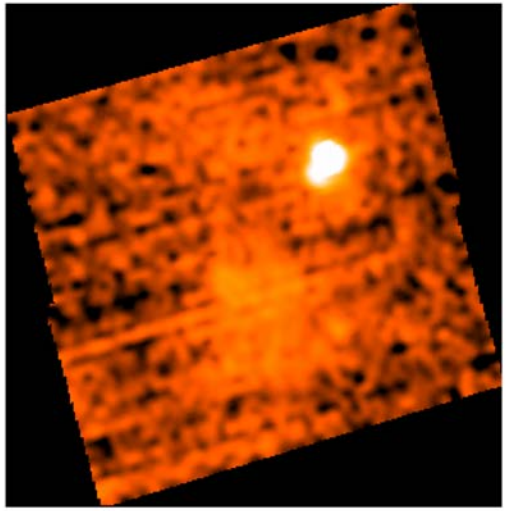


F077



F197

G063



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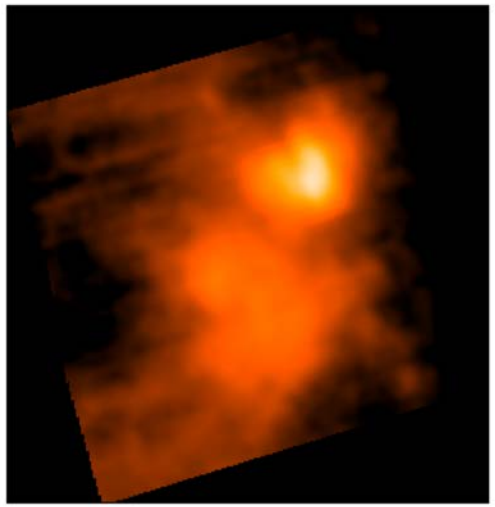

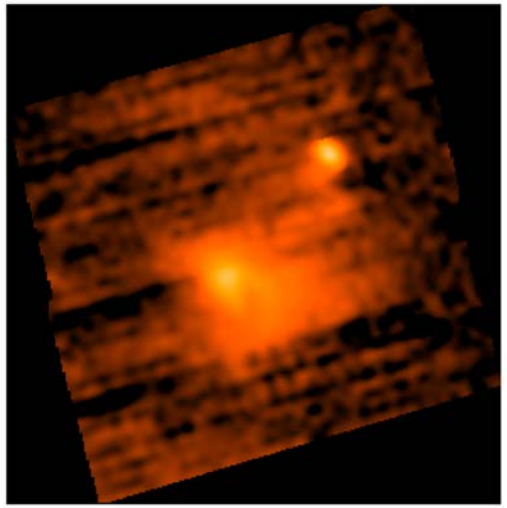

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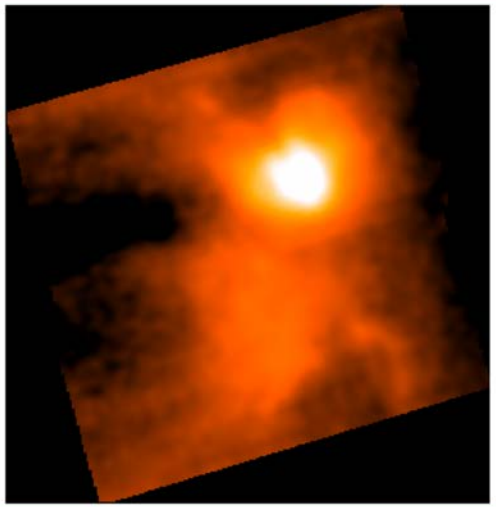
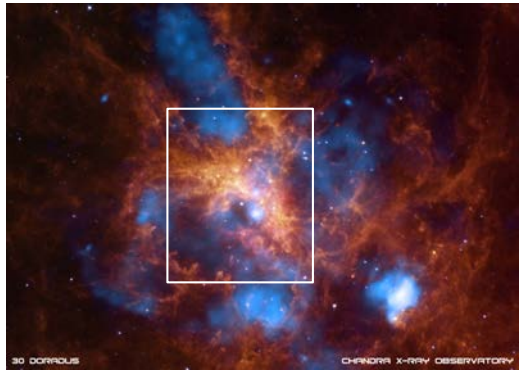
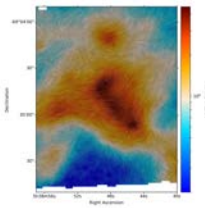


G329

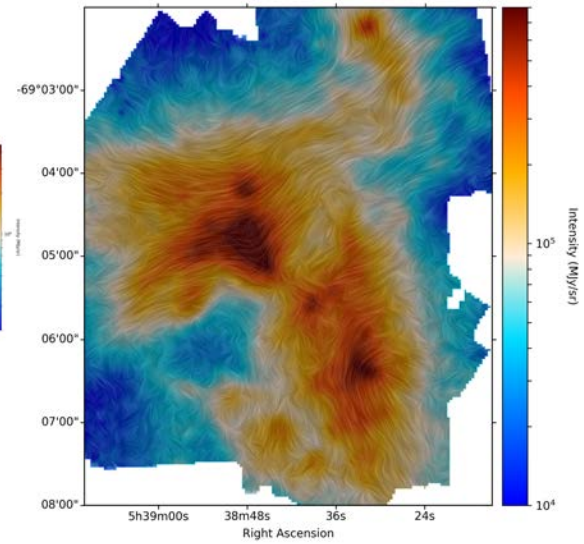
HAWC+ Polarimetry Observations of 30 DOR



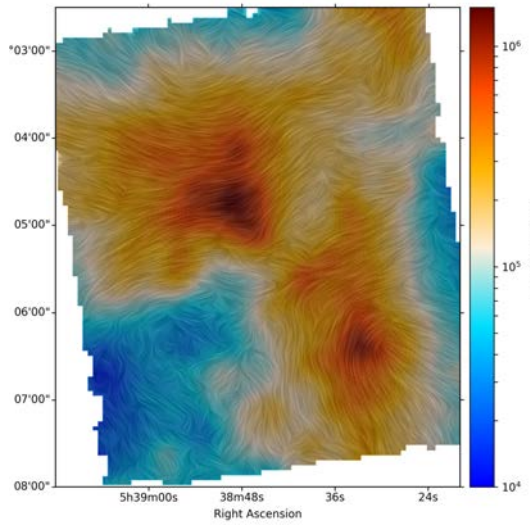
HAWC+ Band A
(53 microns)



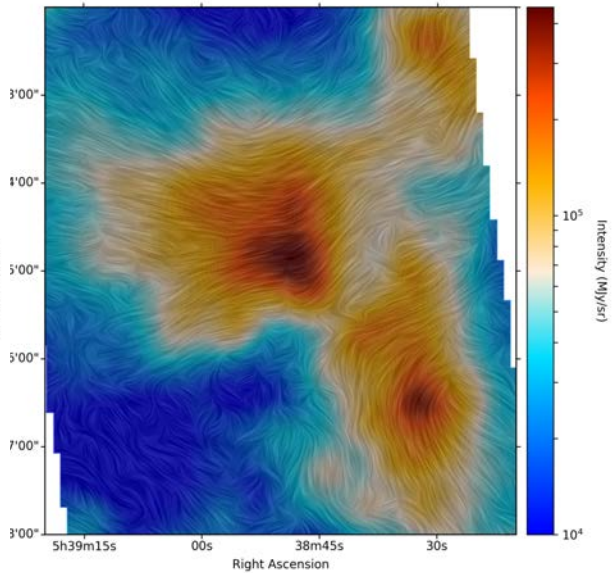
HAWC+ Band C
(89 microns)



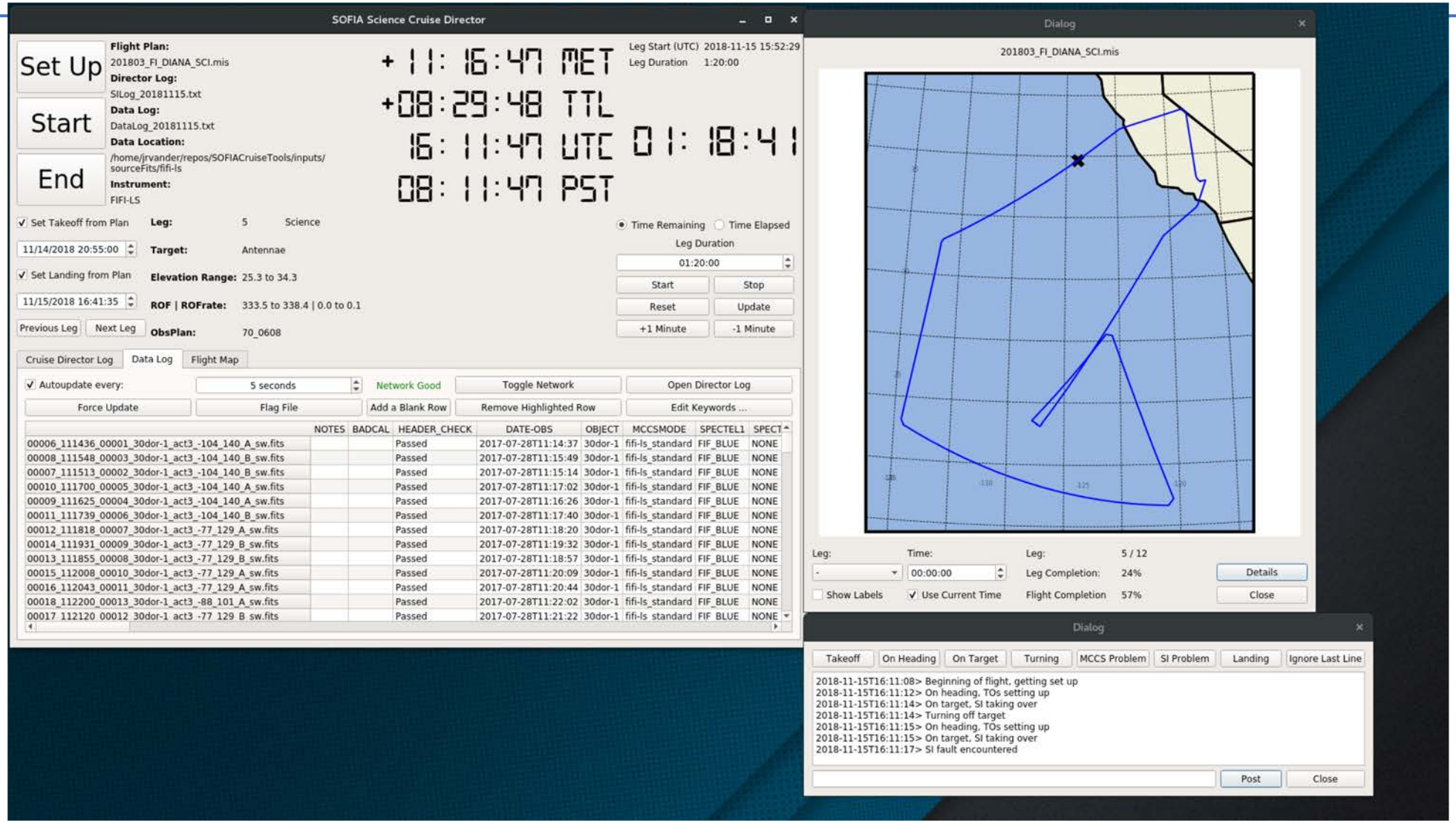
HAWC+ Band D
(154 microns)



HAWC+ Band E
(214 microns)



SOFIA CruiseDirector

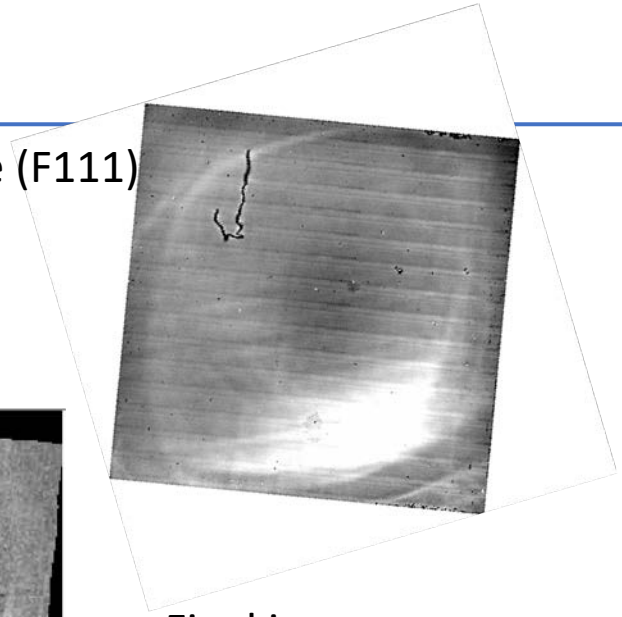


FSI Pipeline Processing in the Last Year

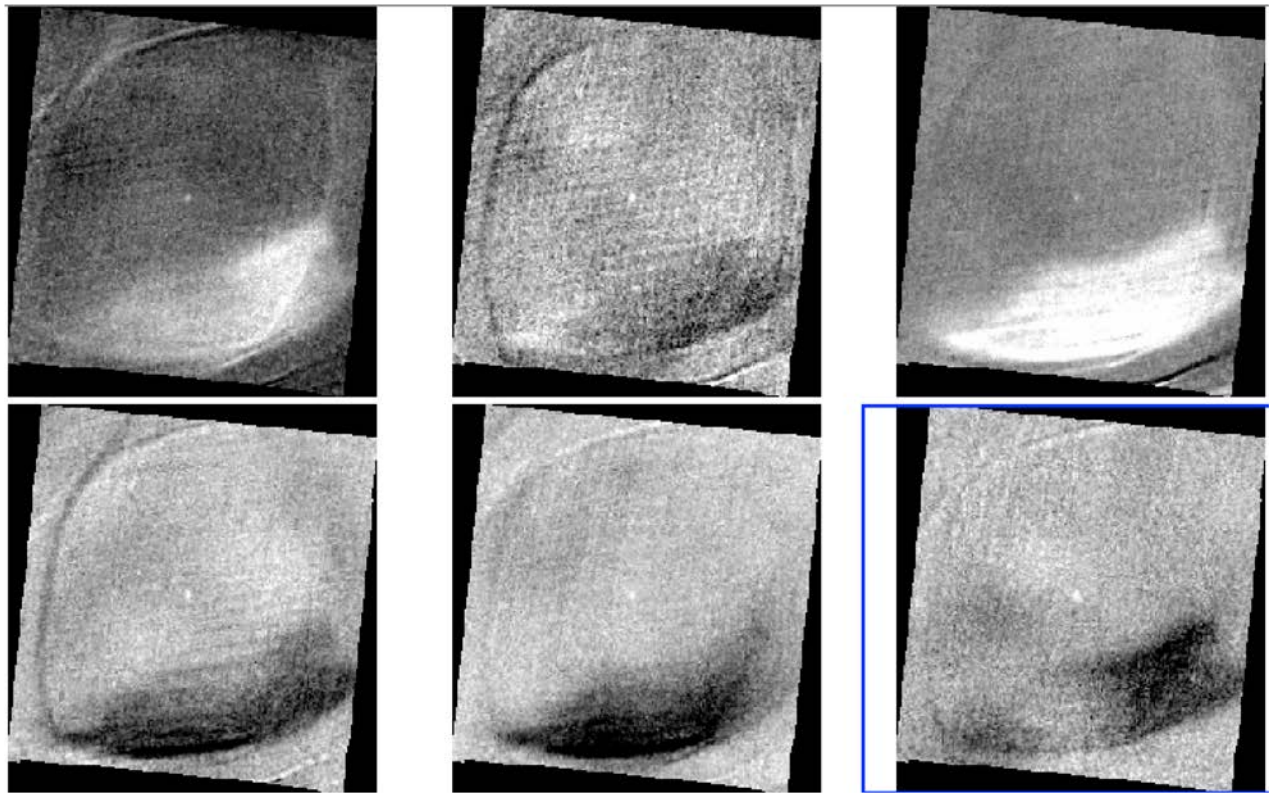
- **FLITECAM**
  - Processed OC5-L data (4 flights)
- **FORCAST**
  - Processing of OC6-J (12 flights) delayed due to IT/MMOC transition and problems due to degradation of entrance window (see next 2 slides)
  - Will work to salvage data after HAWC+ OC6-K data processing is finished.
  - Nominal delivery 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

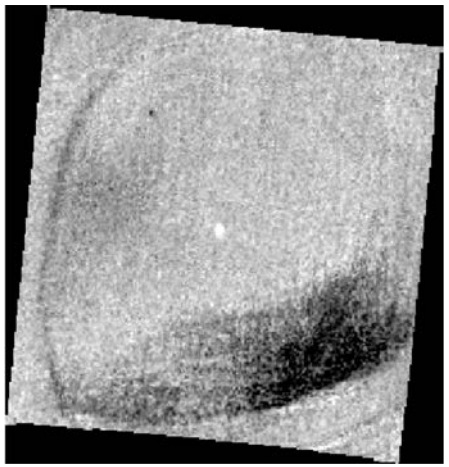
Raw sky image (F111)



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



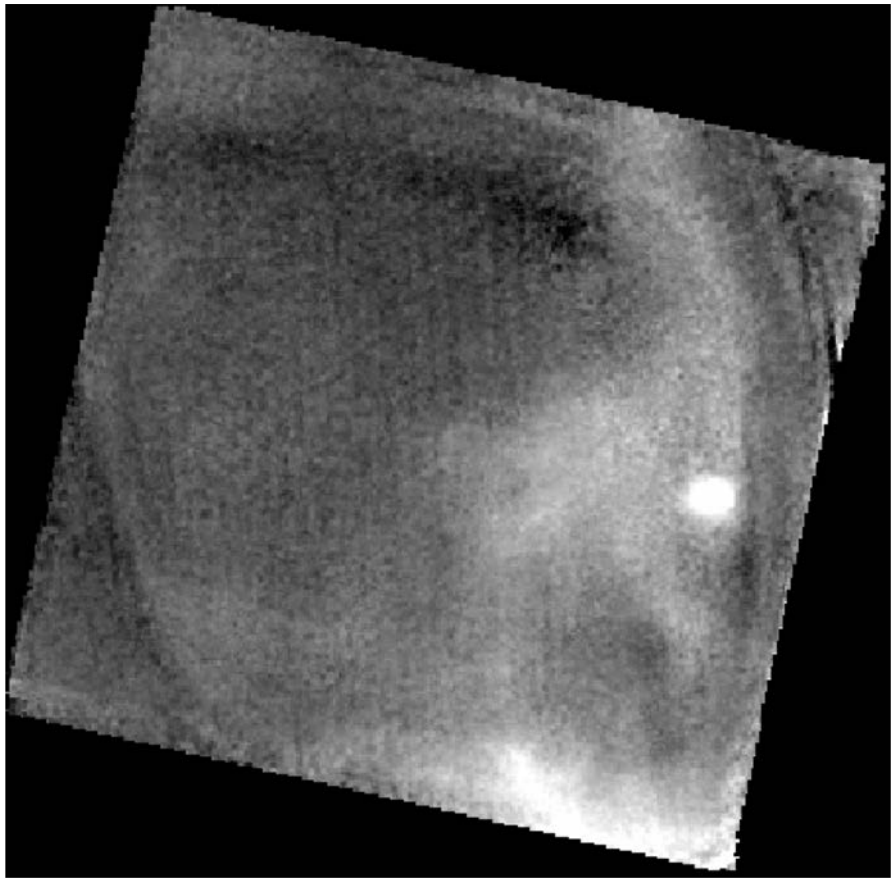
Final image



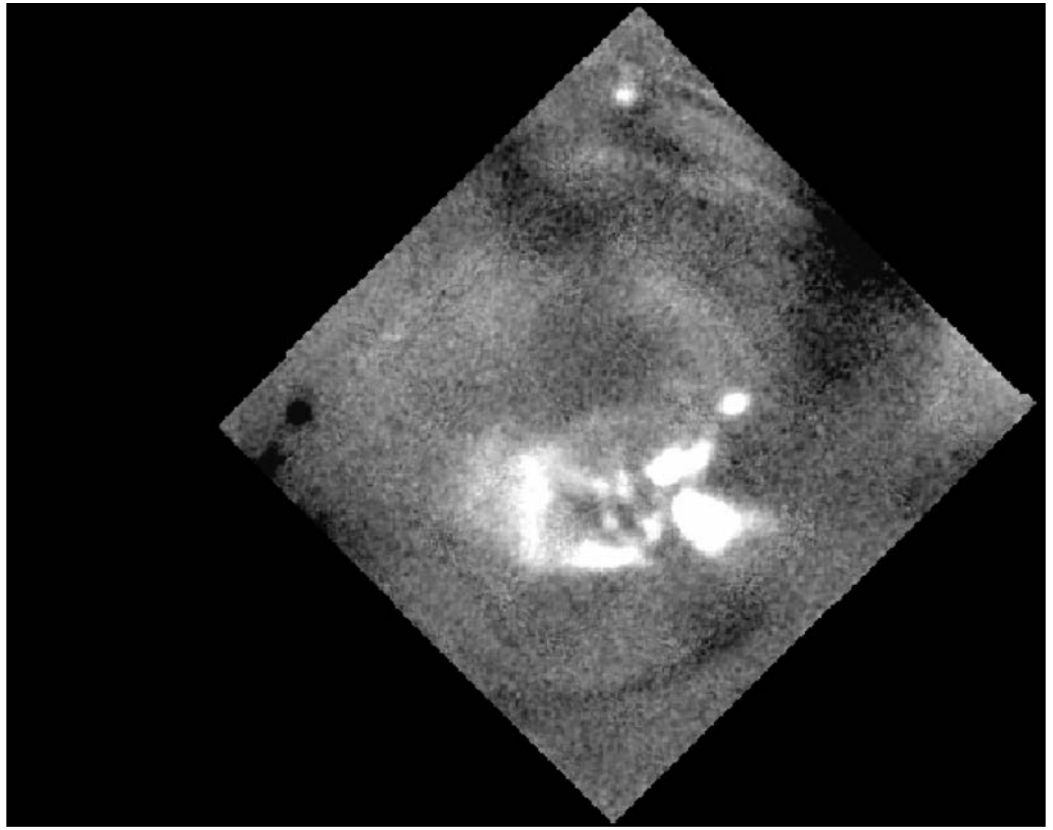
Example of problems with FORCAST OC6-J data

Impact on observations of faint extended sources

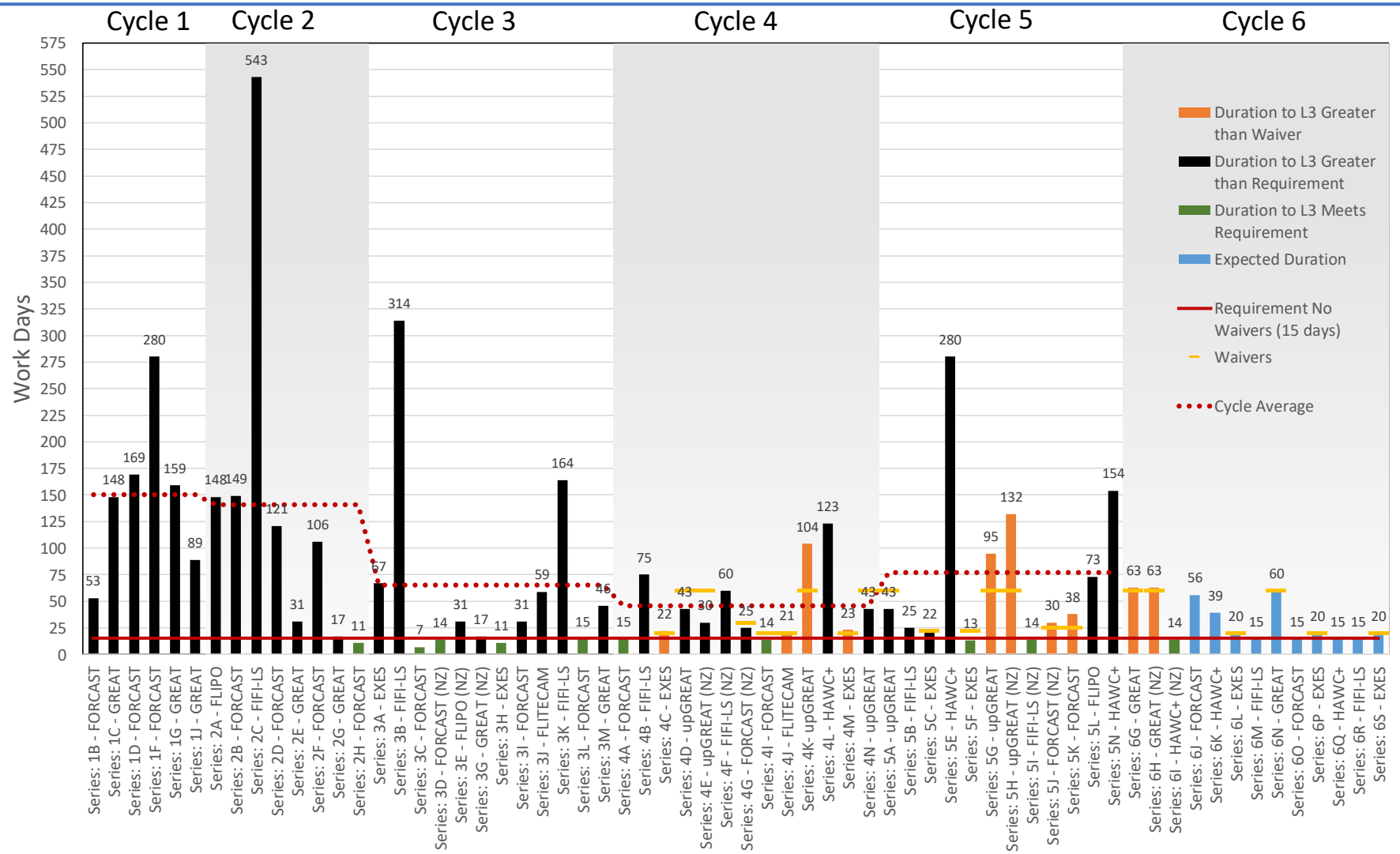
M17 (F197)



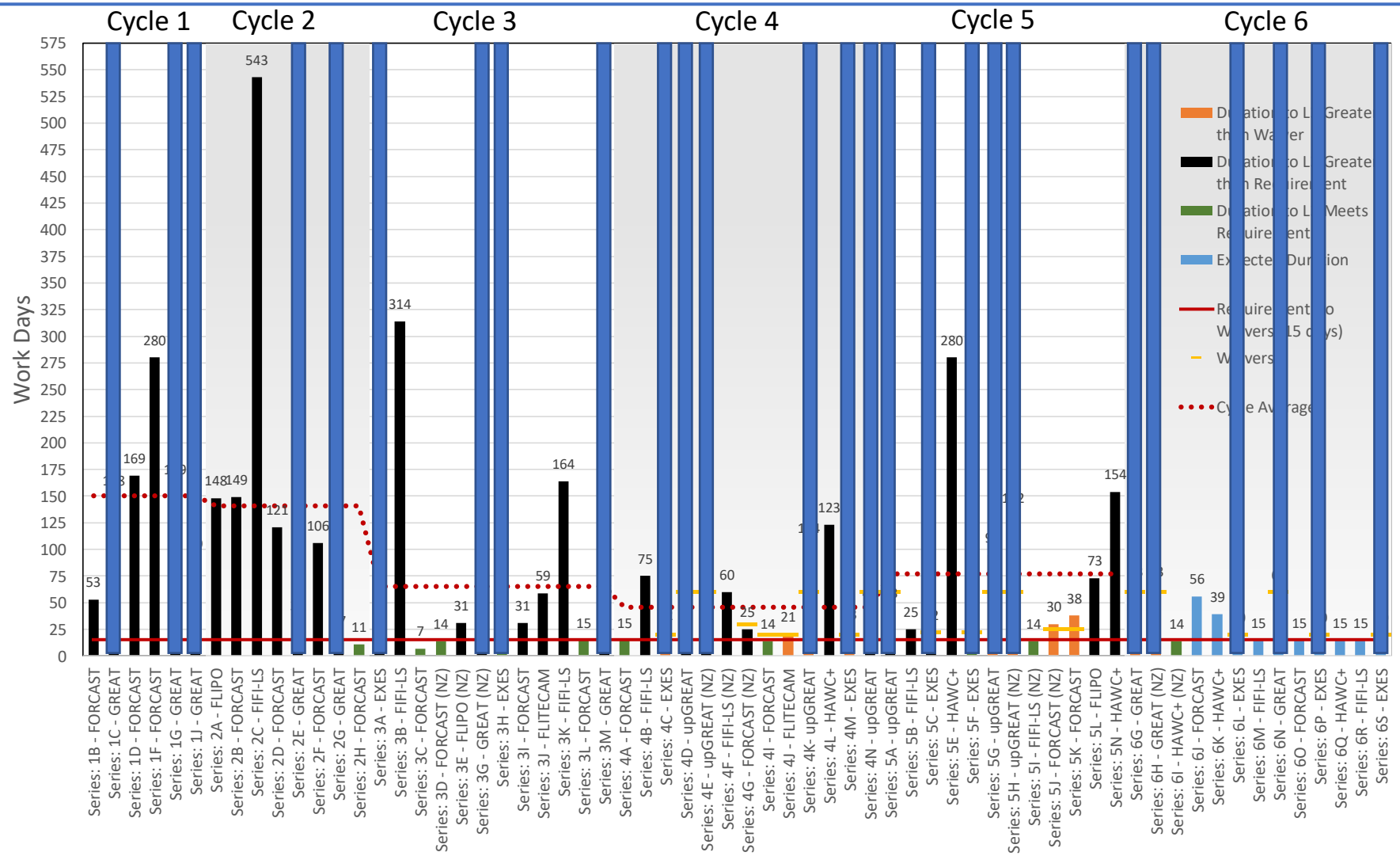
Cyg XN46 (F197)



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†6	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†7	24 Apr 2017
5-D	FORCAST	~~26 Apr 2017~~	~~2 Jun 2017~~†8	N/A *No flights flown in series*
5-E	HAWC+	17 May 2017	9 Jun 2017**	30 Jun 2018** (PAR: 26 March 2018, ORR: 30 May 2018)
5-F	EXES	26 May 2017	29 Jun 2017†7	16 Jun 2017
5-G/H	upGREAT	14 Jul 2017	11 Oct 2017†6	26 Jan 2018 *OC-5G competed Nov 2017*
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 reference waiver PRG-WAV-010
5-K	FORCAST	27 Sep 2017	20 Oct 2017	24 Nov 2017 reference waiver PRG-WAV-011
5-L	FLIPO	6 Oct 2017	31 Oct 2017	26 Jan 2018
5-N	HAWC+	16 Nov 2017	11 Dec 2017	30 Jun 2018 (PAR: 26 March 2018, ORR: 30 May 2018)
5-O	EXES	~~19 Jan 2018~~	~~22 Feb 2018~~†7	N/A *No flights flown in series*
5-P	FORCAST	~~15 Feb 2018~~	~~16 Mar 2018~~	N/A *No flights flown in series*

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.

Cycle 6 Data Reduction Status

Observing Campaign	Science Instrument	Last Flight Date*	Baseline L3 Date*	Completed/ Expected L3
6-A	*Not used*	*N/A*	*N/A*	*N/A*
6-B	*Not used*	*N/A*	*N/A*	*N/A*
6-C	~~*GREAT*~~	*Not flown*	*N/A*	*N/A*
6-D	~~*FIFI-LS*~~	*Not flown*	*N/A*	*N/A*
6-E	~~*EXES*~~	*Not flown*	*N/A*	*N/A*
6-F	~~*HAWC+*~~	*Not flown*	*N/A*	*N/A*
6-G/H	GREAT	29 Jun 2018	26 Sep 2018†16	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†15	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†16	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†15	24 May 2019

Status updated October 25, 2018

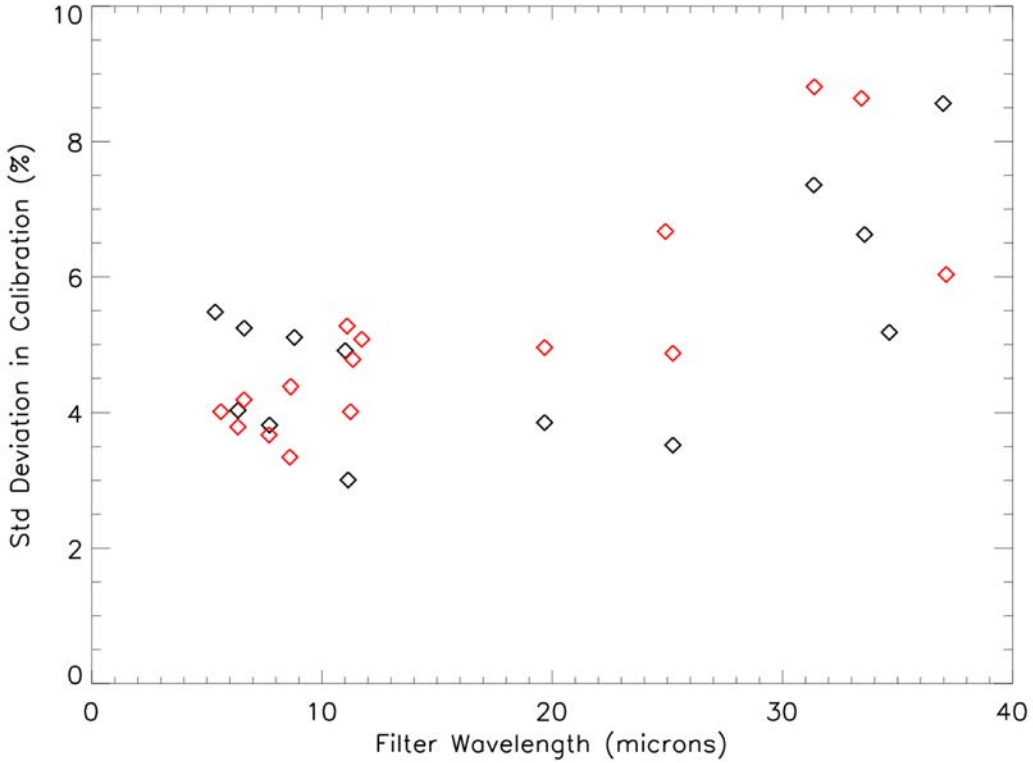
L3 Level-3 Data Products

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

†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

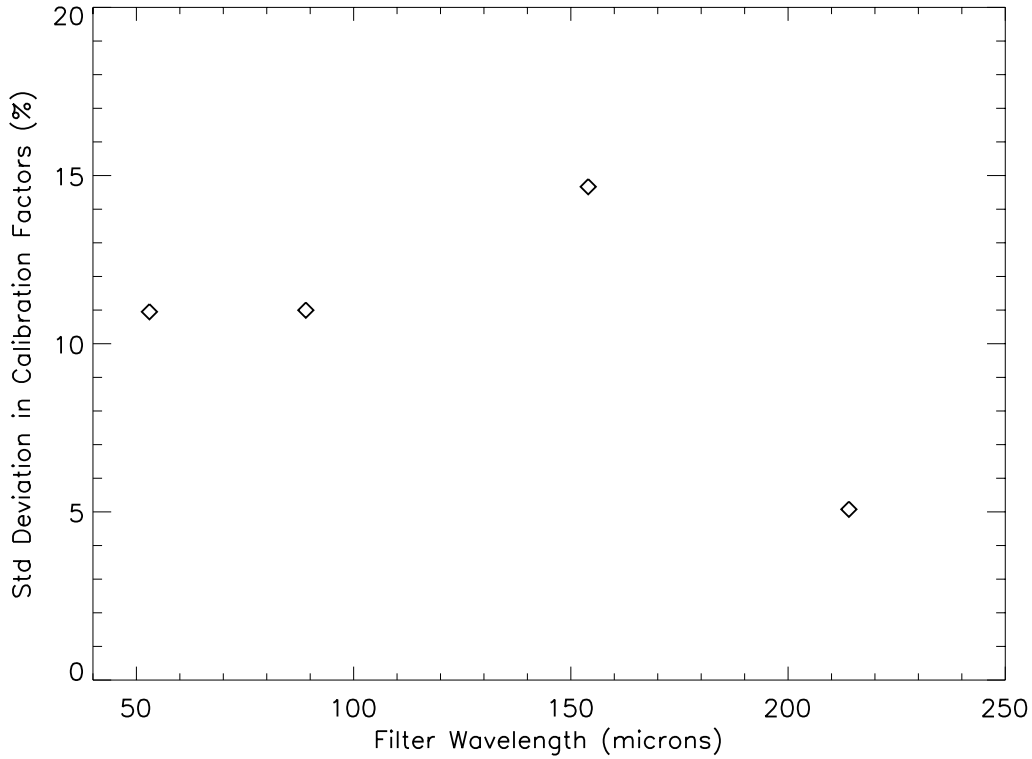
Flux Calibration Accuracy

FORCAST
OC1-OC5



◇ = Dual Channel
◇ = Single Channel

HAWC+
OC4-OC5



DPS Staff

- 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

- 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%)