

# Data Processing Status

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# SOFIA Data Products

Defined in the Data Processing Plan for SOFIA SIs :

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

**Level 2:** corrected for instrument artifacts (e.g., flats, darks, bad pixels)

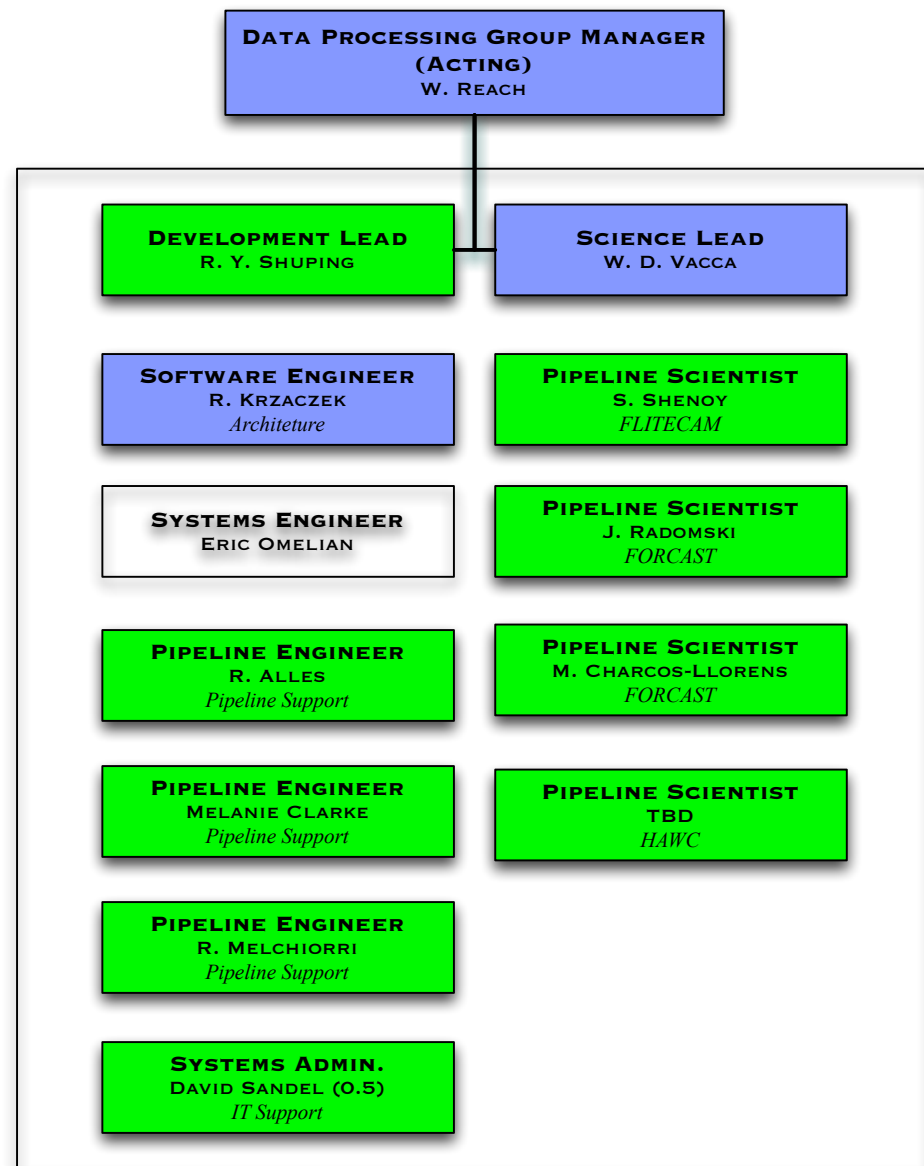
**Level 3:** flux calibrated (e.g. BSCALE/BUNIT keywords, MJy/sr)

**Level 4:** high-order products possibly combining multiple observations

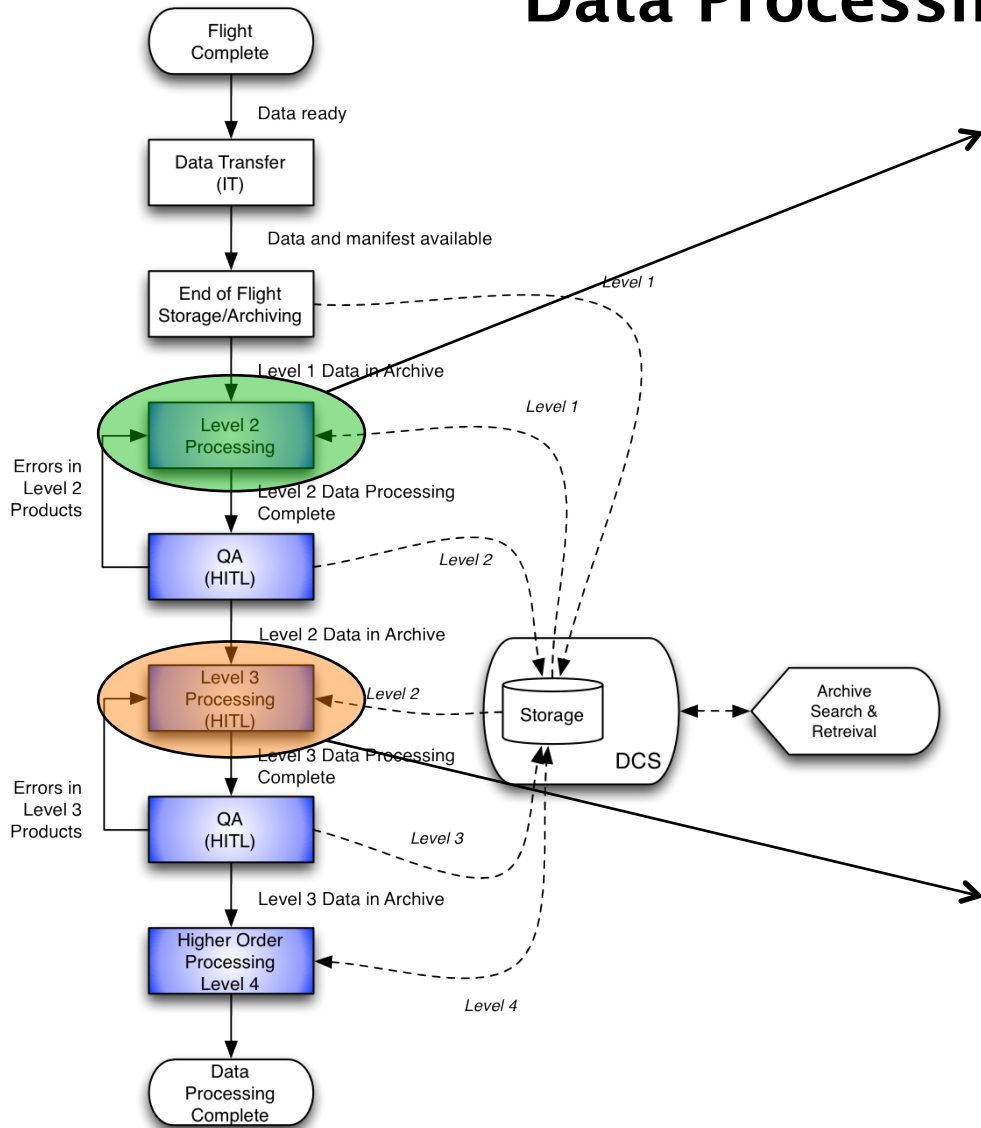
(e.g. mosaics, spectral cubes)

# SOFIA Data Processing Team

- Provide science-grade data products to GIs and science community:
  - process/analyze data
  - quality assurance
- Curate processed data in the archive and re-process as needed.
- Develop pipelines and other needed software tools.
- Support SI teams on pipeline development/delivery.



# Data Processing Flow

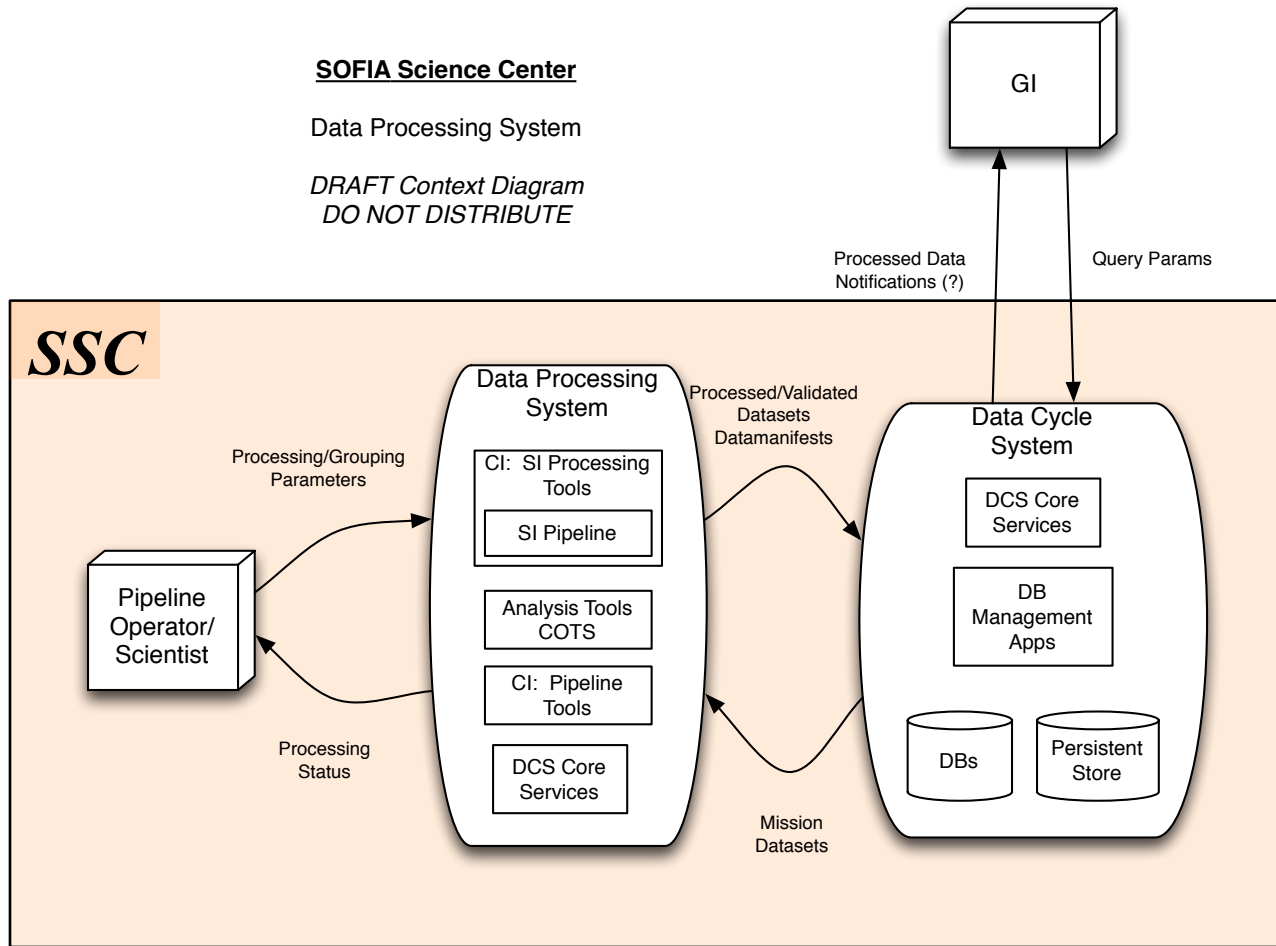


## Two modes of Level 2 Processing:

- **Manual:** operator runs established version of pipeline interactively in stand-alone environment (workstation) on a single observation.
- **“Automatic”:** pipeline is run automatically on data for a whole mission. Some provision for user-interaction will be made.

Level 3 Processing will be highly user interactive, utilizing both COTS and custom tools/pipelines.

# System Context



Requires access to persistent store

See Shuping et al. (ADASS 2012) for more on the DCS.

## SI Pipeline Readiness

SI Pipeline	Status
<b>FORCAST Imaging</b>	Automatic pipeline in operation.
<b>FORCAST Grism</b>	Automatic pipeline in operation.
<b>FLITECAM Imaging</b>	Ready; waiting for additional commissioning data.
<b>FLITECAM Grism</b>	Ready; waiting for additional wave calcs.
<b>GREAT</b>	Manual scripts in operation; Level 3 only.
<b>EXES</b>	Preliminary pipeline received; in development
<b>FIFI-LS</b>	Preliminary pipeline received; agreement with SI team to revisit.
<b>HAWC+</b>	Preliminary pipeline for HAWC received; will need additional development for HAWC+.
<b>HIPO</b>	N/A

# OC1 Level 2 Pipeline Processing

## FORCAST (Imaging/Grism):

- Chop/Nod subtraction
- Non-linear response correction
- Bad-pixel removal
- Droop & "jailbar" (cross-talk) correction
- Optical distortion correction (I)
- Field rotation/alignment (I)
- Flatfield correction (G)
- Wavelength calibration (G)

## FLITECAM (Imaging/Grism):

- Nod subtraction
- Flatfield correction
- Bad-pixel removal
- Optimal spectral extraction (G)
- Wavelength Calibration (G) (TBD)

# Flux Calibration for FORCAST and FLITECAM Imaging

- On each flight, observations of standard stars will be obtained at each altitude (as in Basic Science).
  - *See backup slides for standard star selection*
- For imaging, fluxes and wavelengths have been derived for each standard star for each filter using a comprehensive model of the instrument throughput and atmospheric transmission
- Corrections for differences in airmass, altitude, and pwv, between targets and standards have been derived from ATRAN models for each passband and incorporated into the calibration software
- Calibration parameters applied to Level 2 data to produce Level 3 products; calibration params also stored in archive for reference.
- All standards obtained in-flight are used for calibration.



# OC1 Processing Status

Series	Flight	Date	L1		L2				L3			
			ODC	DCS	Proc	QA	DCS	GI	Proc	QA	DCS	GI
OC1B	108im	6/22/17										
OC1B	108gr	6/22/17										
OC1B	109im	6/27/17										
OC1B	109gr	6/27/17										
OC1B	110	7/3/17										
OC1C	115	7/18/17		7/19								
OC1C	116	7/19/17		7/20								
OC1C	117	7/20/17		7/21								
OC1C	118	7/23/17		7/23								
OC1C	119	7/24/17		7/25								
OC1C	120	7/25/17		7/26								
OC1C	121	7/29/17		7/30								
OC1C	122	7/30/17		7/31								
OC1C	123	7/31/17		8/1								
OC1D	128	9/11/17		9/12	10/19		11/15					
OC1D	129	9/13/17		9/13	10/22		11/16					
OC1D	130	9/14/17		9/18	10/22							
OC1D	131	9/18/17		9/20	10/23							
OC1D	132	9/20/17		9/20	10/23							
OC1F	135	10/26/17		10/29	11/1							

## General Issues:

- Verification/update of raw FITS headers is time consuming.
- QA also time consuming.
- Govt shutdown caused >2-week delay in reqd SW updates.
- Unscheduled update to DPS production environment.

Complete
In Work
In Work; some issues.
Cannot Complete

## OC1B Results

### Processed GI 34 AORs (5 grism, 29 imaging; 9 GI programs)

- All flights auto-pipelined successfully\*: <20min per flight.
- Auto-pipelines generally produced good results; but there were some failures (particularly for grisms).
- Many datasets re-processed to improve quality:
  - Nearly all grism observations
  - 30 - 50% of imaging observations

**QA:** 7 AORs had generally poor results, despite re-processing.

### Flux Calibration: (Imaging):

- Standards: alpha Boo, beta And, beta Peg, beta UMi
- 7 AORs had missing or bad standards for one filter
- Reproducibility is good (but limited dataset...)
  - Dispersion of cal factors *within* flight: <10%
  - Dispersion of cal factors *across* flights: <5%.

\* *Once raw FITS headers were corrected.*

# OC1B Processed Data Issues

## General Issues:

- FITS header errors that require fixing before processing and rely on handwritten logs for correction.
- FORCAST Grism: no telluric correction or flux calibration.
  - *Will correct/calibrate once process is established.*
- Accuracy of WCS is poor:
  - Incorrect coordinates used occasionally when updating TA pointing.
  - Issue with WCS keywords in raw data (chopper offset)
  - Error in FORCAST pipeline (v1.0.2): *now corrected.*

## Isolated Issues:

- Chopper smear (short chop settle time); *now corrected.*
- Vignetting
- Some raw images with high backgrounds (wrong frame time); flux cal not attempted.
- Loss of pointing.

# Development for OC2

## Pipelines:

- FORCAST: Updates to improve integration with automated system; need G3xG4 wave calcs.
- FLITECAM: Finalize using commissioning results (Early 2014).
- FIFI-LS: Develop/test alpha for commissioning (Early 2014)
- EXES: Develop/test alpha for commissioning (Late 2014)

## Infrastructure upgrades:

- Adding dedicated test environment

## New capabilities:

- Metadata/reporting subsystem
- Re-processing tools

**SPR maintenance/upgrades:** on-going.

Backup Slides

# Completed Reviews

## DPS Requirements Review (Oct 15, 2012)

- 73 RFI/RFAs Captured
- Revised DPS Specs, ICD, and Pipeline Acceptance Plan approved by PCB on Feb 12, 2013.

## DPS Preliminary Architectural Design Review (Dec 13, 2012)

- Introduction to architecture presented; overall approach validated by review team.
- 9 RFIs/RFAs Captured

## SI Pipeline Requirements Review (Mar 11, 2013)

- SI Pipeline requirements (SW01) and DRAFT Users and Developers Manuals validated.
- 16 RFIs/RFAs Captured
- SI Pipeline Requirements (SW01s) approved by PCB (Apr 23, 2013).

## DPS Critical Architectural Design Review (Apr 15, 2013)

- Architectural design and V&V plans validated, pending resolution of RFIs/RFAs
- 22 RFIs/RFAs captured

## OC1B Test Readiness Review (Jul 1, 2013)

- All software baselined; test procedures/data validated.
- 2 RFIs/RFAs captured

## Standard Star Selection

- For FORCAST, standard stars chosen from list of Herschel standards for which good models covering the FORCAST bandpass are available:
  - $\alpha$  Boo,  $\alpha$  Cet,  $\alpha$  CMa,  $\alpha$  Tau,  $\beta$  And,  $\beta$  Peg,  $\beta$  UMi,  $\gamma$  Dra,  $\sigma$  Lib
  - Asteroids could also be used if accurate models are available (especially important for calibrating filter “blue leaks”)
- For FLITECAM, imaging standard stars chosen from Cohen et al. (2003) list of “Supertemplate” stars ( $\sim 22$  K–M giants with  $K \sim 5-8$ ); grism standards are A0V’s, as used for ground-based NIR spectroscopy

# Hardware/Network

