Observing with SOFIA

B-G Andersson

Associate Director for Science Operations

- Getting time

Time solicitations

- Annual Call for Proposals
  - US (USRA/NASA) queue – open to the world, funding for US-based astronomers
  - German (DSI/DLR) queue – open to Germany-based astronomers
  - Cy 4: February 2016 – January 2017; Deadline July 2015
- Director's Discretionary Time
  - 7% of available observing time
    - Unanticipated, urgent, observations
    - Limited "proof of concept" projects
  - Proposals at any time of year
- Instrument team Guaranteed Time Observations (GTO)
  - Reserved Observations Catalogs (in CfP)

SOFIA Cycle 4 Assumptions

- Cycle 4 time available
  - About 110 Science Flights
  - NASA: Approximately 500 Hours
  - DLR: Approximately 80 Hours
- Available US funding: ~$5.5 M (>x3 from Cy 3)
- Cycle 4 period: 1 February 2016 – 31 January 2017
  - Proposal deadline: July 10, 2015.
- Southern Hemisphere Deployment in June-July period with two instruments

SOFIA Instrument Status

- The SOFIA Instruments fall into three categories:
- Facility-class Science Instruments (FSI)
  - Maintained and operated by the SMO
  - No direct interaction with instrument [building] team
- Principal Investigator Science Instrument (PSI)
  - Maintained and operated by instrument builder team
  - Operations (observations) and data reduction by PI team
  - No pre-proposal interaction with PI team required (but recommended)
  - Some requirements of co-authorships (GREAT, FIFI-LS)
- Special Purpose Science Instruments (SSI)
  - Maintained and operated by instrument builder team
  - Operations (observations) and data reduction by PI team
  - Proposals must have instrument PI as co-I

Available Instruments and Modes

- Wide range of Instruments available
  - EXES (PSI) – High-resolution spectrometer, 5-28 μm
    - R = 4000 – 100,000
  - FIFI-LS (FSI) – Dual wavelength, FIR Integral Field Spectrometer, 50-205 μm
    - R = 500 - 2000
  - FLITECAM (FSI) – imager and grism spectrometer 1-5 μm
    - Filters: J, H, K, L, L_{narrow}, M, , M_{narrow}, Pa α, Pa α cont., Water Ice (3.08 μm), PAH (3.29 μm)
    - R ≈ 1200
  - FORCAST (FSI) - imager and grism spectrometer 5-37 μm
    - Large number of filters 5.4 – 37.1 μm
    - R= 70 – 300
  - FPI+ (FSI) – Fast read-out sensitive visual imager
    - Filters: SDSS and ND
  - GREAT (PSI) – Heterodyne (multi-beam!) receiver 1.35 – 4.74 THz
    - Dual receiver L1(1.25-1.52 THz)/L2(1.81-1.91 THz), L2/H(4.74 THz), LFA/L1
  - HAWC+ (FSI) - FIR camera and imaging polarimeter 50-215 μm
    - Filters: 53, 63, 89, 154, 214 μm.
    - Polarimetry
  - HIPO (SSI) – sensitive dual-band high-speed visual imager
    - Filters: Johnson, SDSS, Methane
  - In addition, the FLITECAM + HIPO (or, FLIPO; SSI) combination is offered

Major Changes from Cycle 3

- Added **capabilities**:
  - HAWC+, FPI+, upGREAT (LFA), long-wavelength FLITECAM
- Removed **capabilities** (for Cycle 4):
  - Cross dispersed FORCAST spectroscopy
  - M channel for GREAT
- New **policies**:
  - "Impact Proposal" category – large, multi-year, aimed at focused, specific scientific questions of high potential impact (not, primarily, "just" surveys). Execution/implementation parallel to GTO programs
  - Carry forward highly ranked "southern proposals" for non-selected instruments for two cycles

New Policies I – "Impact Programs"

- Large, multi-year (2-3 cycles) programs, aimed at specific scientific questions of high potential impact (not, primarily, "just" surveys).
  - Anticipate selecting 2-3 with ~100hr-class observing each
  - Any instrument combination (except no mix of FSI/PSI and SSI)
- To encourage US-German scientific collaboration, the queues will allow submission of joint "Impact program" proposals to the US and German queues. If the two proposals are both successful the programs will be merged with the US and DE PIs becoming co-PIs on the resulting program and the time charged 80:20.
- Organized in two phases:
  - Short "test phase" in about 10-20 hour of proof of concept observations, followed by review to implement main part
  - PI (with SMO Dir. approval) gets to update observations list before subsequent calls (like GTO programs)
  - Balance of program is executed in Cycle 5

Timeline

- Call issued: May 1
- Observers' Workshop: May 20-21, Mountain View
- Condensed workshop: June 4, Columbia MD
- Call update: June 8
- Proposal deadline: July 10
- US TAC: Aug 19-21
- German TAC: "early September"
- Selection announced: October 1

- Nominal Cycle 4 observing period:
  1 March 2016 – 28 February 2017.

- Proposal – to – Observation process

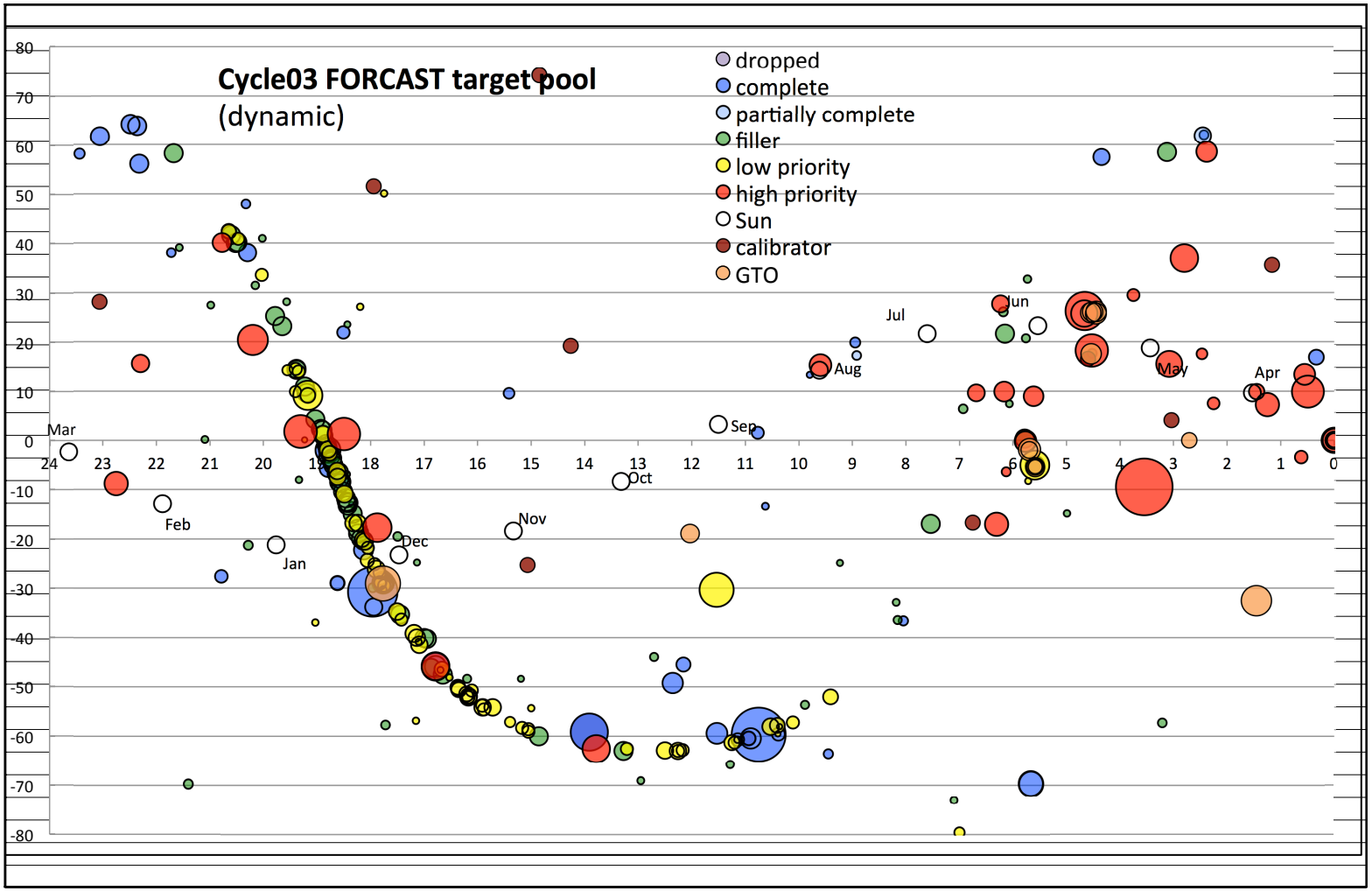
Observations Execution Processes

- Phase I proposals (SPT)
  - Science Justification; targets; exposure times
  - ➢ Proposal selection; Long range schedule; instrument cadence
    - Phase II entries (SSPOT)
      - Detailed observation information; AORs
      - Observation blocks (scheduling units)
        - Flight Planning
          - Ten-week process, incorporating science, calibration and engineering requirements
          - Scripting of observations
            - Flight Execution
              - Queue/Service observing
              - 2 GI seats per flights

SOFIA Science Scheduling – Cycle

- Targets from the
  - Annual proposal solicitation, and
  - Guaranteed Time Observing requests
- Merged with maintenance requirements, PSI/SSI instrument team availability etc.
- Targets are assigned to "Flight Series" based on sky visibility and observing time constraints
- Flight series are typically 2-3 weeks long
- Number of flights per week limited by available crews
  - Aircraft fuel is another main constraint on number of flights
- SOFIA observations are, normally, queue mode
  - *Assumes* no GI participation in flight, but GIs are invited to fly.

Targets are not evenly spread over the sky



Long term schedule – Instrument Cadence

Proposals

TAC ranking, GTO

Schedulability

RA, Dec., "competition", time-critical observations
NOTE: Targets away from the inner Galaxy are easier to schedule

Aircraft/ Instrument Maintenance

PI team availability

Sky conditions

Budget

Staffing

Instrument Cadence ("example")

Instrument changes take time and effort

Feb	March	April	May	June	July	Aug	Sept.	Oct	Nov	Dec	Jan
EXES	FORCAST / FIFI-LS	GREAT/ HAWC+	EXES/ FLIPO	FORCAST/ FIFI-LS	FORCAST/ FIFI-LS	FORCAST / GREAT	HAWC+ / FLIPO	FORCAST /GREAT	FIFI-LS/ EXES	Maint	HAWC+ / GREAT

Cycle 3 Daily Overview - 1 of 2

PMR / ICMC / HQ

Chart Revision 4/29/15

Cycle 3 Start

	OC#3 A EXES					OC#3 B FIFI-LS								
	2 Flights				SI Rem.	SI Install			LO(F)	8 Flights				
S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
28	1	2	3	4	5	6	7	8	9	10	11	12	13	14
	March -- 2015													

OC#3 B FIFI-LS															Maintenance / Upgrades #7																			
8 Flights (cont.)												SI Rem			MD Instl																			
S	M	T	W	T	F	S	S	M	★ T	★ W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
March -- 2015			✓							✓							April -- 2015																	

Maintenance / Upgrades #7	Safety Day							cancelled		Autoland moved		upGREAT Commissioning																			PossibleAutoland			
								Eng LO		Eng LO	MD Rem	SI Install			Ins/Prep	Prep		EMI/LO	LO			4 Flights											SI Rem	
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
19	20	21	22	23	24	25	26	27	28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
April -- 2015												May -- 2015																						

		OC#3 C FORCAST						PossibleAutoland				PossibleAutoland				OC#3 D FORCAST					NZ Time												OC#3 E FLIPO	
		SI Install / half LO		5 Flights												Prep			Ferry to CHC					6 Flights								SI Rem	SI Install	
S	H	T	W	★ T	F	S	S	M	★ T	W	★ T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
24	25	26	27	28	29	30	31	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27
May -- 2015					✓			June -- 2015		✓															✓					✓				

OC#3 E FLIPO			OC#3 F FORCAST								OC#3 G GREAT																			Maintenance / Upgrades #8				
Check	Pluto	SI Rem.	SI Install		4 Flights					SI Rem	SI Install / align / tune			6 Flights									Prep & SI Swap (TBD)			Ferry			SI Rem	MD Instl				
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S
28	29	30	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1
June -- 2015			July -- 2015			✓									✓					✓														

Maintenance / Upgrades #8																			OC#3 H EXES															
																Cont. LO			SI Install				6 Flights									SI Rem		
S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	T	W	T	F	S	S	M	★ T	W	★ T	F	S	S	★ M	T	★ W	T	F	S
2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	1	2	3	4	5
																August -- 2015		U						✓					U	September -- 2015				

Key

Observing cycle: 3 *Planned flights: 77* *RHs*: 548* * These values assume an 89% reliability factor

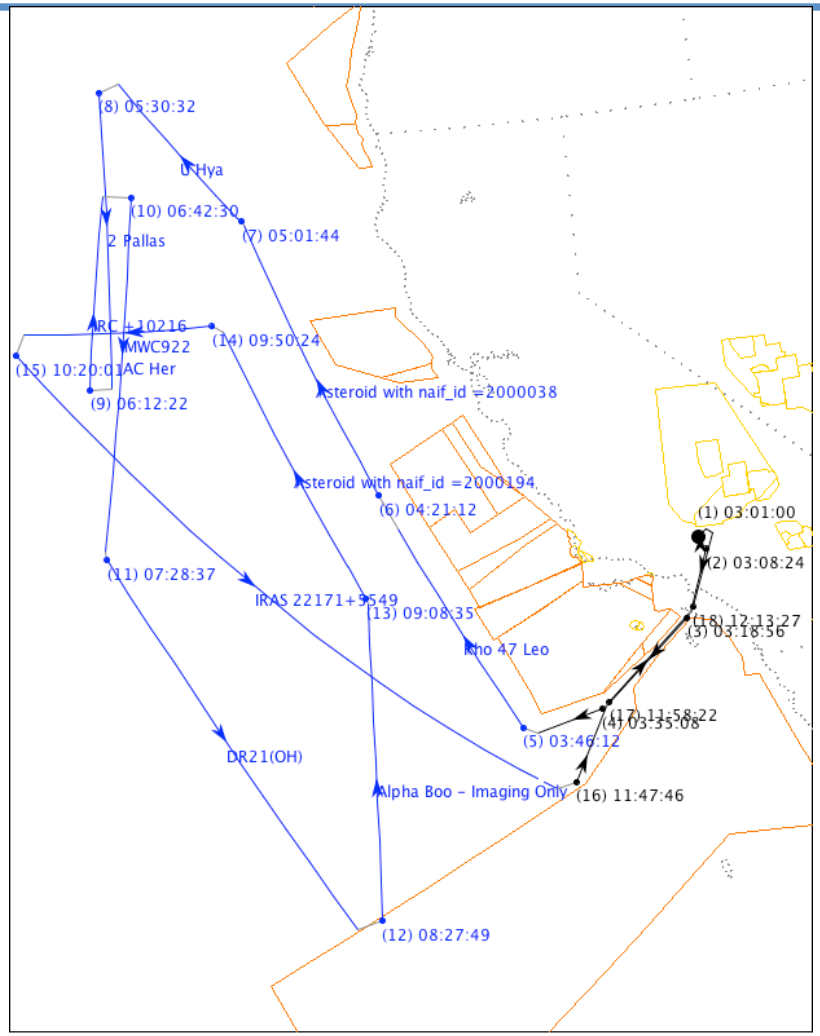
- **S / 7 — Weekend day** (black text with no fill)
- **H / 4 — US or German Holiday** (day of week box H or GH w/ red fill)
- **F / 6 — Deployment Observing Flights** (bold white text, light blue fill, bold border)
- **F / 6 — Return to Base (RTB) Flight** (single slash through day and date)
- **F / 6 — Contingency Ferry/Maint./Non-Sci Flt** (day box with green fill)
- **S / 28 — Short Flight** (colored fill on only half)
- **U — Notional Unfunded Flight** (yellow fill with U below day)
- **F / 6 — Work day** (black text w/ day box grey fill)
- **F / 6 — Line Operations** (bold border)
- **F / 6 — Instr. Commissioning Flight** (bold white text, purple fill, bold border)
- **F / 6 — Canceled Flight** (x through day and date)
- **F / 6 — Maint./Upgrade Possible Check Flight** (day and date box filled with light green)
- **★ F / 6 — Guest Participant** (white star on day of week)
- **✓ — Restored Flight** (check mark below day)
- **F / 6 — AFRC Regular Day Off** (day and date shown in red)
- **F / 6 — Observing Flight** (bold white text, blue fill, bold border)
- **F / 6 — Contingency Instr. Comm. Flight** (day box with purple fill)
- **F / 6 — Ferry/Maint./Non-Sci Flight** (bold white text, green fill, bold border)
- **S / 13 — Half Sci. & Half Ferry/Maint./Non-Sci** (two colored fill)
- **★ F / 6 — Press on Flight** (yellow star on day of week)

OC3C Flight #3 Flight plan

Flight planning is a 10 week process incorporating science requirements and trades, Mission Operations constraints and airspace regulations

Flight plans must:

- Observe the astronomical targets efficiently
- Account for constraints on water vapor and timing requests
- Acquire the required calibration
- Return to base in <10h
- Avoid any active SUAs



Flight Plan Name: File: 201505_FO_03_postSci.fp
Flight ID: 2015/06/03
Est. Takeoff Time: 2015-Jun-03 03:01 UTC
Est. Landing Time: 2015-Jun-03 12:42 UTC
Flight Duration: 09:41
Weather Forecast: 1800 Thu Mar 26 2015 - 0600 Sun Mar 29 2015 UTC
Forecast Timestamp: 1045 Thu Mar 26 2015 UTC
Saved: 2015-Apr-22 19:28 UTC User: ameyer

Modifications to Cycle Plan

- Aircraft and instrument issues may make a given “Flight Series” infeasible
- Triggered ToO’s may change the content of the series (and if high enough scientific priority change the instrument)
  - It is important for “quick turn- around” ToO proposals to, not only, discuss the required response time (for the nominal instrument), but the utility of each instrument for the science.
- Flight planning is not fully deterministic and hence we don’t know with certainty when an observation will be scheduled.
  - Observations nominally planned for a given Flight Series may be delayed and hence the subsequent series pool will change

Summary

- Cycle 4 Call is now out
  - ~500h available through USRA/NASA
  - $5.5M in funding
  - 8 science instruments
  - Proposal deadline July 10, 2015
  - Cycle 4 runs Feb. 2016 – Jan. 2017
- Long range planning take into account the selected target pool and "practical" considerations.
  - Instrument campaigns typically 2-3 weeks long, every few months
    - Can constrain target observability
    - ToO triggering is limited by flight planning and instrument change "cost"
    - Only one Southern campaign per cycle (expect two instruments)
- Flight Planning is a complicated and constrained process
  - Flights must be [topological] circles
    - Parts of the sky heavily over-subscribed (Inner Galaxy, Orion, etc.)
    - Other parts are under-subscribed (e.g. Galactic "Pole")
    - Targets in the under-subscribed regions easier to "get through"