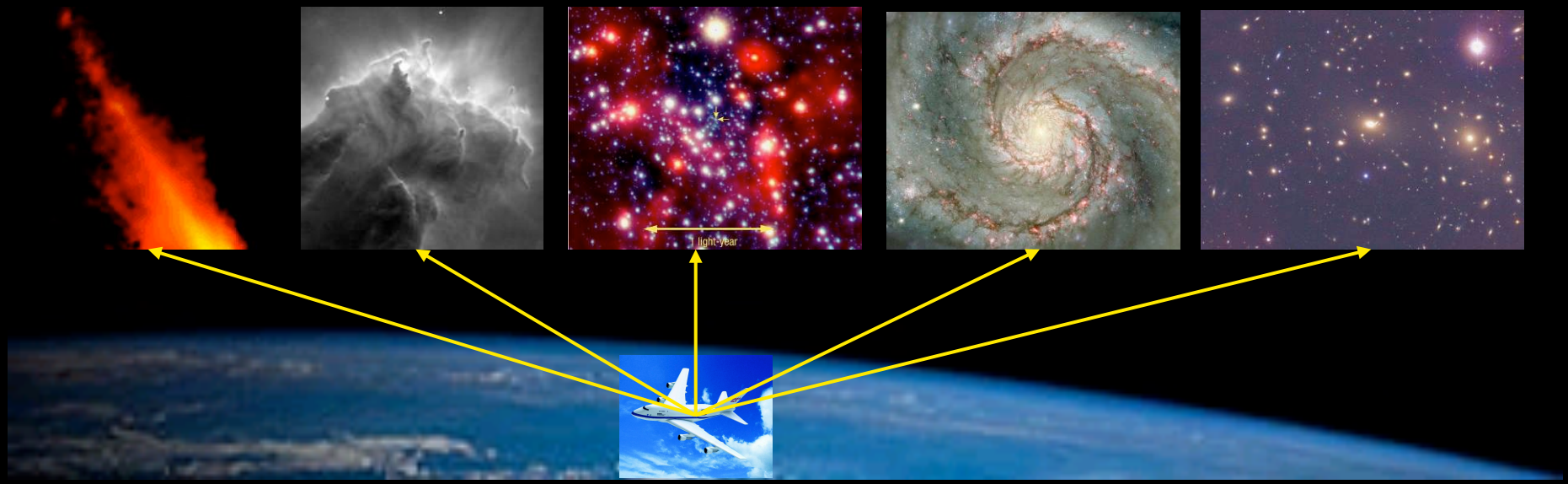
SOFIA

Stratospheric Observatory for Infrared Astronomy

Program Update

SOFIA Splinter Meeting,
AAS, Pasadena
7 June 2009



Presented by:
Thomas Roellig – Deputy Project Scientist

Outline

- **Personnel Updates**
  - Pam Marcum (SOFIA Project Scientist, May 26, 2009)
  - Erick Young (SOFIA Science Mission Operations Director, July 2009)
- **Recent Development Progress**
  - Aircraft progress
  - Telescope progress – line ops
  - Instrument progress
  - Science mission operations progress
- **Early Science Status**
- **Schedule for Completion**
  - Schedule slip and its reasons
  - Schedule for new instrument development
  - Budget (out of the President's budget)

Recent Progress Since Last AAS Meeting

- **Aircraft Progress**
  - Operated cavity doors with door actuator
  - Completed initial cavity insulation installation

- **Telescope Assembly Progress**
  - Installed repaired telescope gyros
  - Two TA line ops
  - Telescope performance good on ground
    - 2” seeing
    - Gryo drift rate 0.05”/sec after compensation

- **First generation instrument progress**
  - Both FORCAST and GREAT have held their pre-ship reviews

- **Science Mission Operations Progress**
  - Held successful scenarios testing exercises

Early Science Definitions

- **Early Science period added to schedule before development is complete**
  - Science community gets to use SOFIA earlier
  - Early tests of astronomical observing
  - German instruments need to show progress to their funding agencies

- **Two first generation instruments selected on basis of submitted proposals**
  - FORCAST – mid IR imager
  - GREAT – German sub-mm heterodyne receiver

- **Each instrument team gets a few-flight Short Science period**

- **Open up both instruments for GO proposals for a longer Basic Science period with more flights**

Early Science Definitions (2)

- **Have added a modified "Short Science" flight series for second German instrument: FIFI-LS**
- **Limited instrument modes, limited aircraft operations, incomplete aircraft missions systems**
- **Finish observatory development and commission all the first-generation instruments after Early Science period**

Early Science Update

Basic Science Allocations

- Observing time is split between the German (DLR) and US partnerships: US: 80%, DLR: 20%

- US observing time (80% share):
  - Is open to proposals from anywhere (except Germany, see below)
  - Either instrument (FORCAST, GREAT) may be used.

- DLR observing time (20% share):
  - All of the DLR time will be exclusively with the GREAT instrument.
  - The GREAT team gets this guaranteed time.

- See Andersson presentation for more details

FIFI-LS "Short Science"

- Four FIFI-LS characterization/observation flights planned immediately after Basic Science.

TWO EARLY SCIENCE INSTRUMENTS

FORCAST

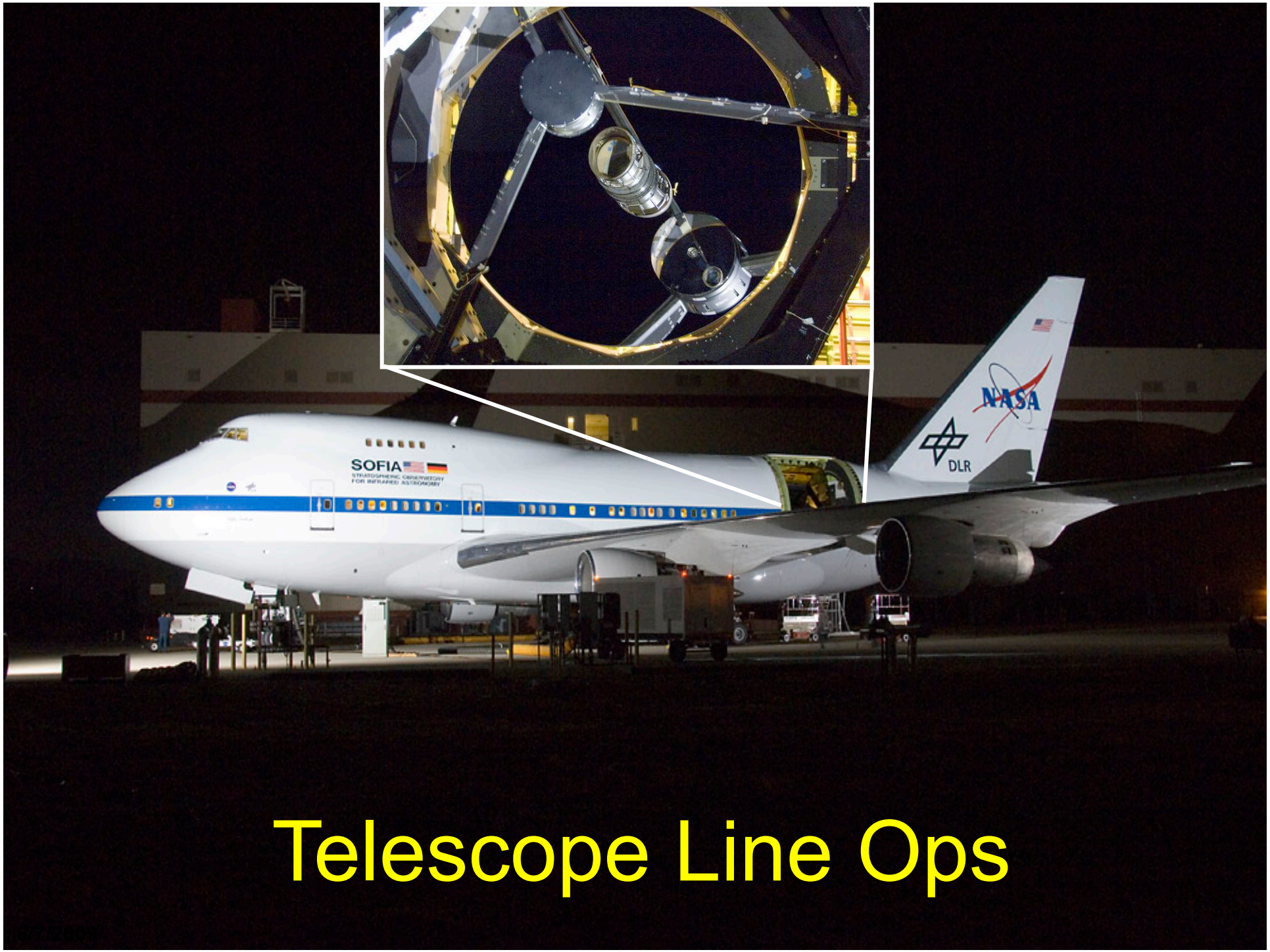
Faint Object infraRed CAmera for the SOFIA Telescope

- **Facility-class instrument**
- **Mid IR, two-channel camera for simultaneous imaging**
- **Selectable ($\Delta\lambda \sim 2\mu m$) filters in 4-8 μm, 16-40 μm regimes**
- **0.75 arcsec/pixel**
- **3.2x3.2 arcmin field-of-view**

GREAT

German REceiver for Astronomy at Terahertz frequencies

- **Principal Investigator instrument**
- **Heterodyne spectrometer**
- **60-200 microns**
- **Dual-channel, 3 frequency windows**



Telescope Line Ops

SOFIA Schedule

- **Program will experience a schedule slip to both first door open and first science flight**
  - Late delivery of cavity door drive system software and hardware
  - Under-estimated sub-system integration/test and flight period
  - Limited budget reserve available to correct/mitigate

- **Program worked detailed re-plan. Schedule with reserve shows:**
  - First door open flight fall 2009
  - First light image, beginning of 2010
  - First Early Science late summer 2010

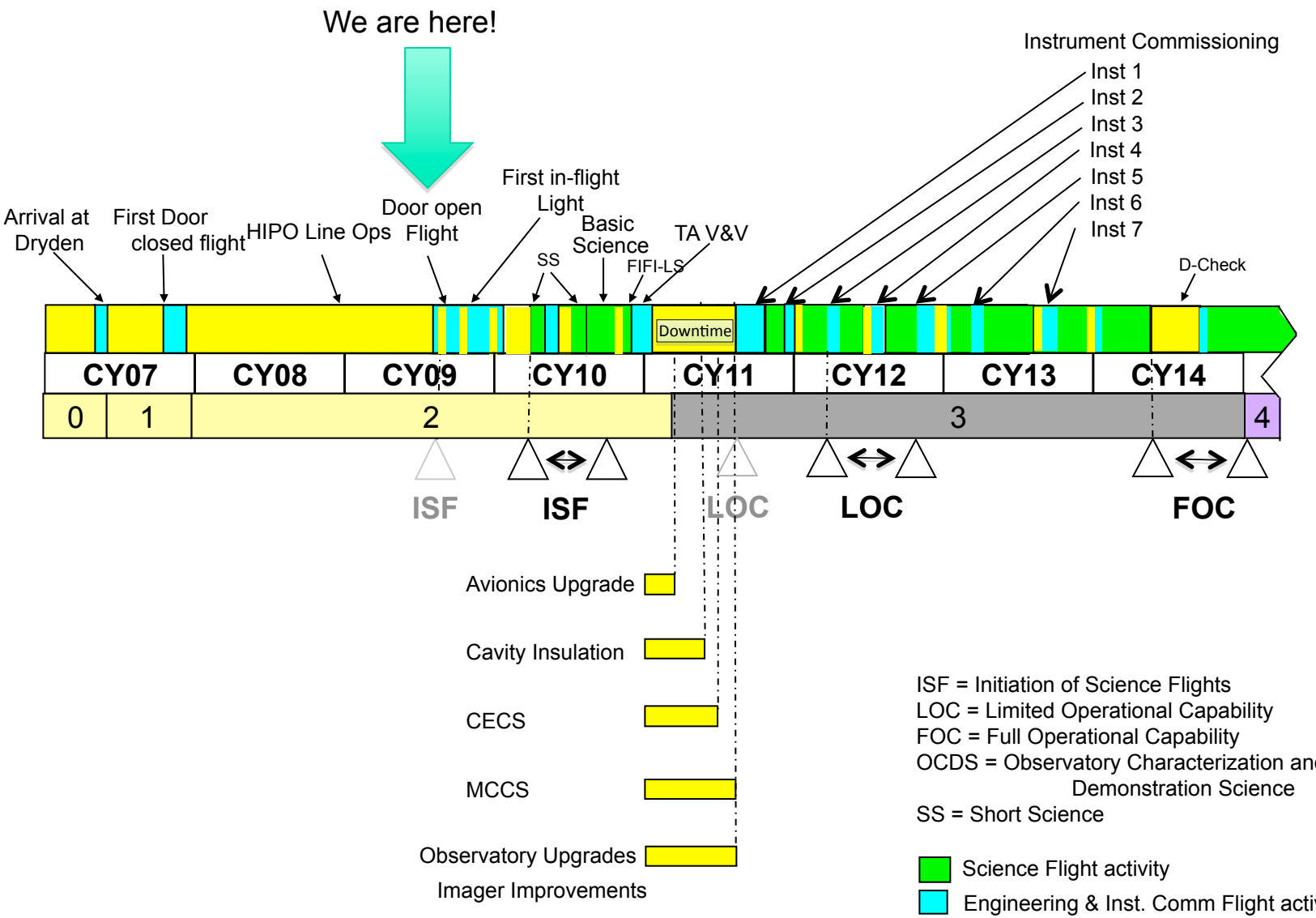
- **With schedule reserve management plans, expect to beat these dates significantly, e.g. presently first Early Science flight is tracking to spring/summer 2010**

- **New schedule and associated budget has been approved by SMD at HQ, but still needs final Agency-level approval**

Why Did Schedule Slip?

- **Cavity door drive system delivery slips from vendor**
- **Underestimated time required to accomplish tasks in preparation for envelope expansion flight test and for early science:**
  - Now in highest work flow period in restructured program
  - HIPO line ops indicated parallel activities more difficult than expected (telescope, instrument, aircraft system activities)
  - Short science required more mission systems software capability than anticipated
  - Longer open door flight test period (envelope expansion and sub-system/SI integration) than anticipated
  - Developed backlog of maintenance work on aircraft

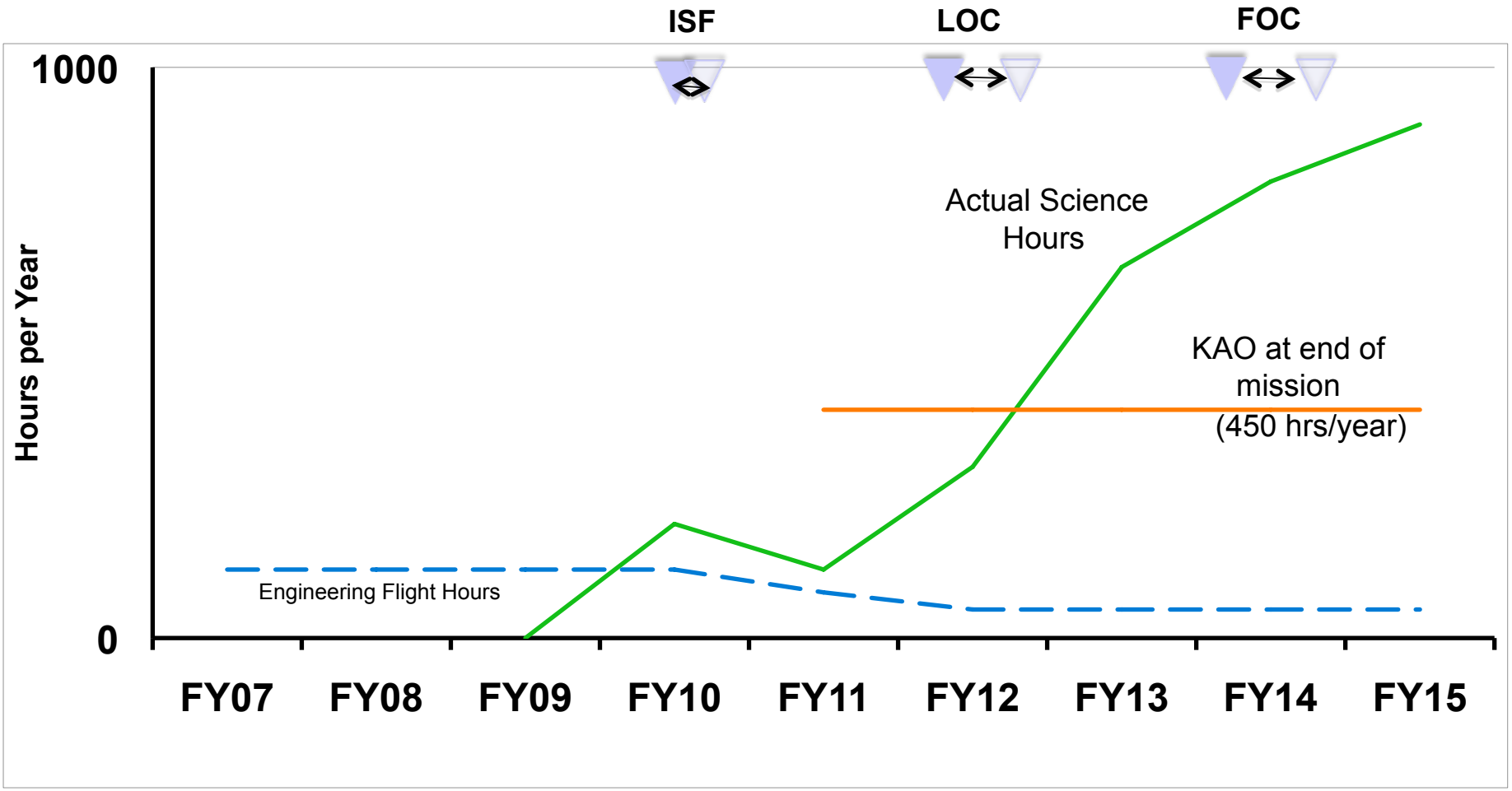
Schedule Overview



ISF = Initiation of Science Flights
LOC = Limited Operational Capability
FOC = Full Operational Capability
OCDS = Observatory Characterization and Demonstration Science
SS = Short Science

Science Flight activity
Engineering & Inst. Comm Flight activity
A/C Testing/Work

Science Flight Hours Ramp Up



Science in the Re-plan

- **Funding now available for implementing:**
  - Pipeline reduced and flux-calibrated data in the science archive for all US instruments, including the PI instruments
  - Similar data available from FIFI-LS under special arrangement with the PI team
  - No plans for reduced GREAT data in the archive

- **Second-generation science instruments (more details later):**
  - Calls for new science instruments from HQ
  - New date for the Call – phased with new schedule

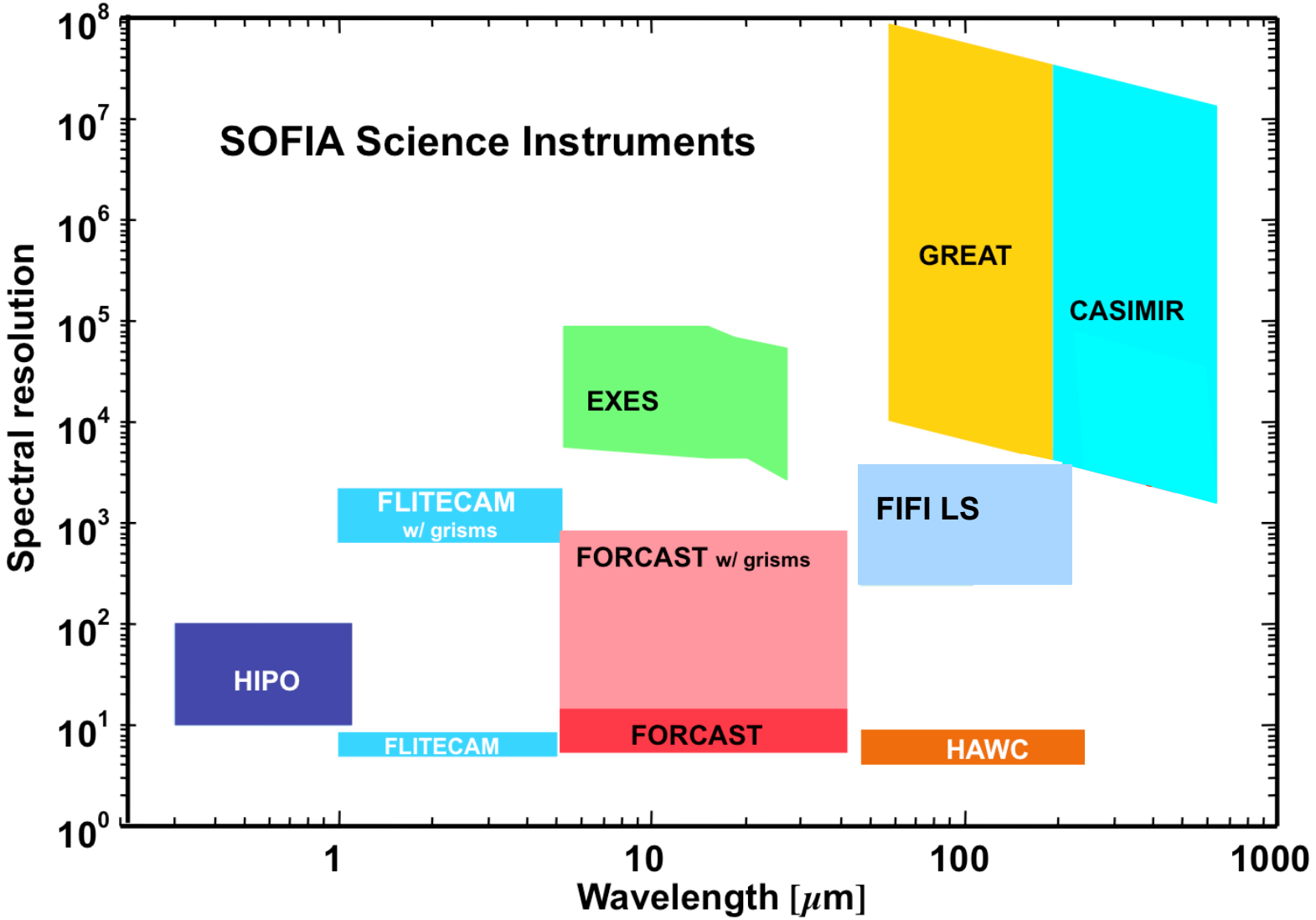
- **SOFIA technology development effort is now covered within the Cosmic Origins SR&T (Supporting Research and Technology) program. Earlier SOFIA technology development funding will stay within SOFIA to help rebuild a reserve**

Science in the Re-plan (2)

- **SAFIRE instrument de-selected, is now tech development only, encouraged to re-propose for flight**

- **GO financial support tied to flight hours made available to community, at $3k/hr rate. Turns out to be ~same as Spitzer support rate/hr.**

Instrument R/λ graph



Science Instruments – Key Activities

- **HIPO** – ready for installation
- **FLITECAM** – ready for installation (Instrument is in storage at UCLA)
- **FORCAST** – needs to complete some airworthiness documentation, then ready for installation
- **GREAT** – needs to complete some airworthiness documentation, then ready for installation
- **FIFI-LS** – will be ready for installation in early 2010
- **CASIMIR** – ready in mid-2011
  - 550 GHz and 1.2 THz channels will be first to fly

Science Instruments – Key Activities (2)

- **HAWC** – ready in mid-2011
- **EXES** – ready in early 2013
  - PI change from John Lacy (UT) to Matt Richter (UCD)
- **SAFIRE**
  - Informed of de-selection by HQ on 8 May 2009 because of budget pressures
  - Are proceeding on a close-out plan due the week of 22 May 2009
  - PI receives SMD Cosmic Origins SR&T funds to complete technology development. Also, encouraged to re-submit during second-generation instrument call in 2011.

2nd Generation Instrument Plan

- **A draft call for proposals should be issued in late 2010**
- **Proposal call date for new instruments is planned for 2011**
- **Call size should be ~$35M (for 3 years)**
- **Instrument selection will be modeled on the Explorer process where proposals are ranked by scientific merit and programmatic feasibility**
- **A single-round unfunded proposal process is planned**

2nd Generation Instrument Plan (2)

- **The call will be open to any instruments the community wants to propose (Any new instruments under development in Germany will be taken into consideration in the proposal review)**
- **The proposer can choose to propose as a PI or Facility Instrument**
- **First generation instruments can propose upgrades as part of the call (similar to Missions of Opportunity in Explorer or Discovery calls)**
- **Instrument starts should be staggered to have instrument deliveries separated by about 1 year**
  - Instrument commissioning requires about 1 month of aircraft time
  - More than one commissioning a year would overly disrupt science data collection

SOFIA in the President's Budget

- **SOFIA costs are in the budget for the full life-cycle lifetime of 20 years of operations**
- **The $17M/year has been restored so we do not need to find an additional foreign partner**
- **Further details can be found by downloading the astrophysics budget (http://www.nasa.gov/news/budget/index.html)**

Backups

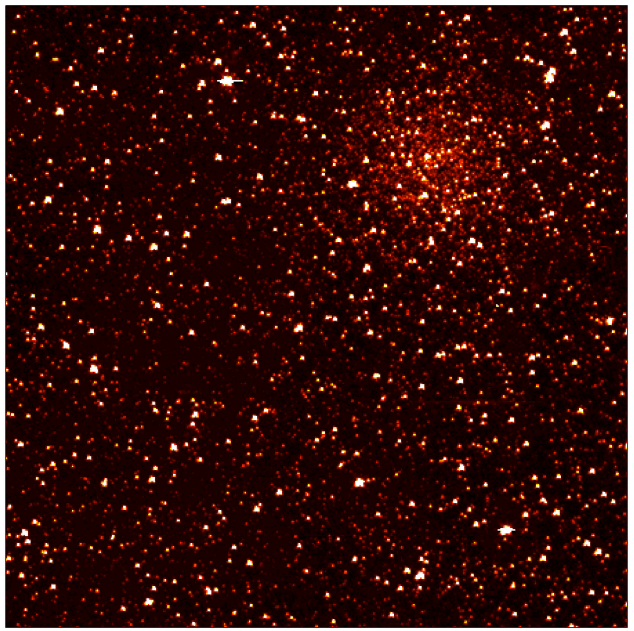
Key Milestone Dates

Milestone	PCA Date	Non-risk Adjusted	Risk Adjusted
1st Flight (Aircraft Functional Checks)	-	9/10/2009	10/1/2009
Segment 3 Planning Downtime	-	9/29//2009	10/21/2010
1st Open Door Flight	-	10/16/2009	12/7/2009
FORCAST Line Ops	-	11/18/2009	1/21/2010
First Light Opportunity	-	1/8/2010	2/23/2010
ISF – Short Science 1 Flights	8/2009	5/13/2010	8/16/2010
Envelope Expansion #2	-	6/25/2010	9/28/2010
Segment 3 Progress Review	-	8/16/2010	1/6/2011
GREAT Line Ops	-	8/25/2010	1/18/2011
Short Science 2 Flights	-	9/15/2010	2/7/2011
Basic Science Flights	-	10/13/2010	4/8/2011
FIFI-LS Line Ops	-	1/8/2011	6/22/2011
FIFI-LS Science Flights	-	2/1/2011	7/7/2011
TA V&V / Aircraft Performance Flights	-	2/24/2011	8/5/2011
Open Door Flight Test Complete	9/2010	3/23/2011	9/16/2011
Limited Operation Capability (LOC)	-	9/20/2012	7/18/2013
Full Operational Capability (FOC)	12/2014	8/4/2014	6/1/2015

First Light Image

- Very limited elevation angle range
- FORCAST image
- Little or no impact to the schedule
- Planned before the holidays 2009

- **Example**
- Spitzer first light image
- Taken just after the aperture cover ejected – not in an IR-interesting area



FORCAST – Mid Infrared Imager

- PI – Terry Herter, Cornell
- FORCAST will be the first instrument to fly on SOFIA
- Instrument is in its flight configuration in the lab at Cornell
- Operations Technical Interchange Meeting (TIM) to be held at Dryden Aircraft Operations Facility (DAOF) in Palmdale, CA June 9 & 10
- Instrument to ship to DAOF in early August
- FORCAST to support telescope checkout flights
- First light image opportunity in late 2009
- Short science on track for spring/summer, 2010

GREAT - Heterodyne

- PI – Rolf Güsten, Max Planck Institute
- GREAT completed preship review in Dec, 08
- Instrument is ready to ship (>February 2010)
- Short science to fly with two low frequency channels (1.25 - 1.50 THz, 1.82 - 1.92 THz)
- PI has requested that Short Science flights be deferred until after aircraft flight envelope expands to >41,000 ft altitude
- Basic Science flights to add mid-frequency (2.4 - 2.7 THz) channel

ONE ADDITIONAL "SHORT SCIENCE" INSTRUMENT

FIFI LS

Far Infrared Field-Imaging Line Spectrometer

- **Principal Investigator instrument**
- **Integral field design**
- **Simultaneously map spectral lines in two FIR bands**
  Red 110-210 μm, Blue 42-110 μm
- **Angular scale:**
  Red: 12 arcsec/pixel, Blue: 6 arcsec/pixel
- **Field of view:**
  Red: 1 degree, Blue: 0.5 degree
- **Velocity resolution:**
  Red: 100-250 km/s, Blue: 50-150 km/s