

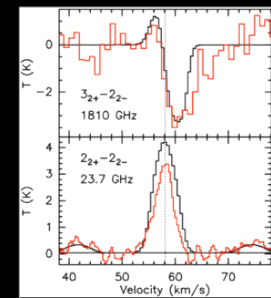
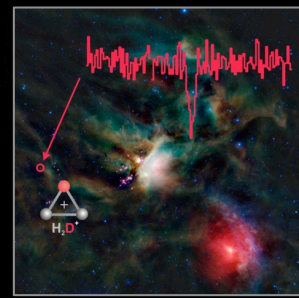
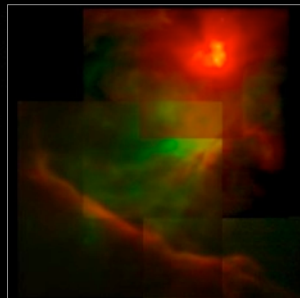
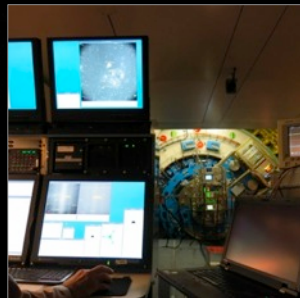
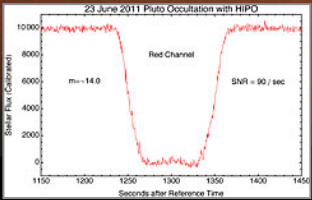
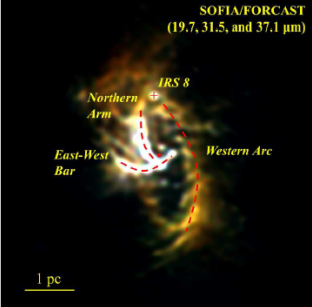
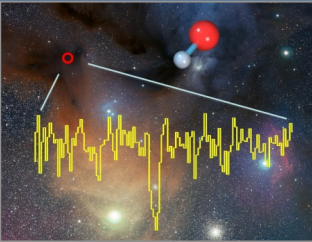


National Aeronautics and Space Administration

Stratospheric Observatory For Infrared Astronomy Mission Update

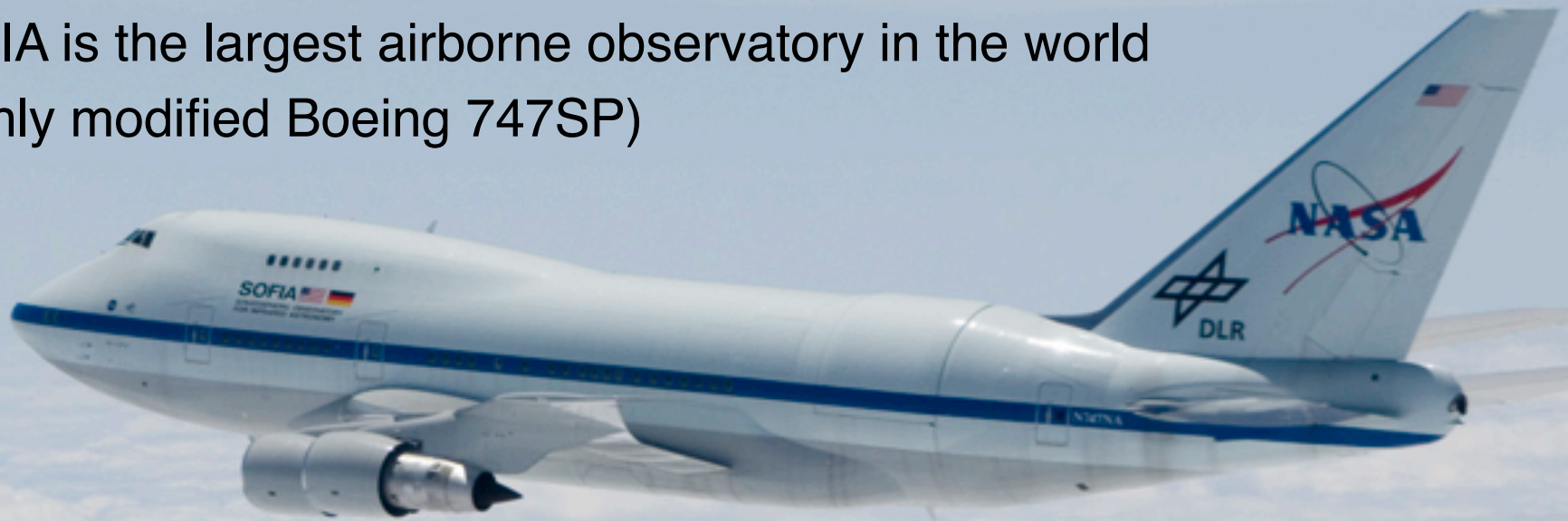
Pamela Marcum
Project Scientist

AAS SOFIA splinter session
January 6, 2014



The SOFIA Aircraft

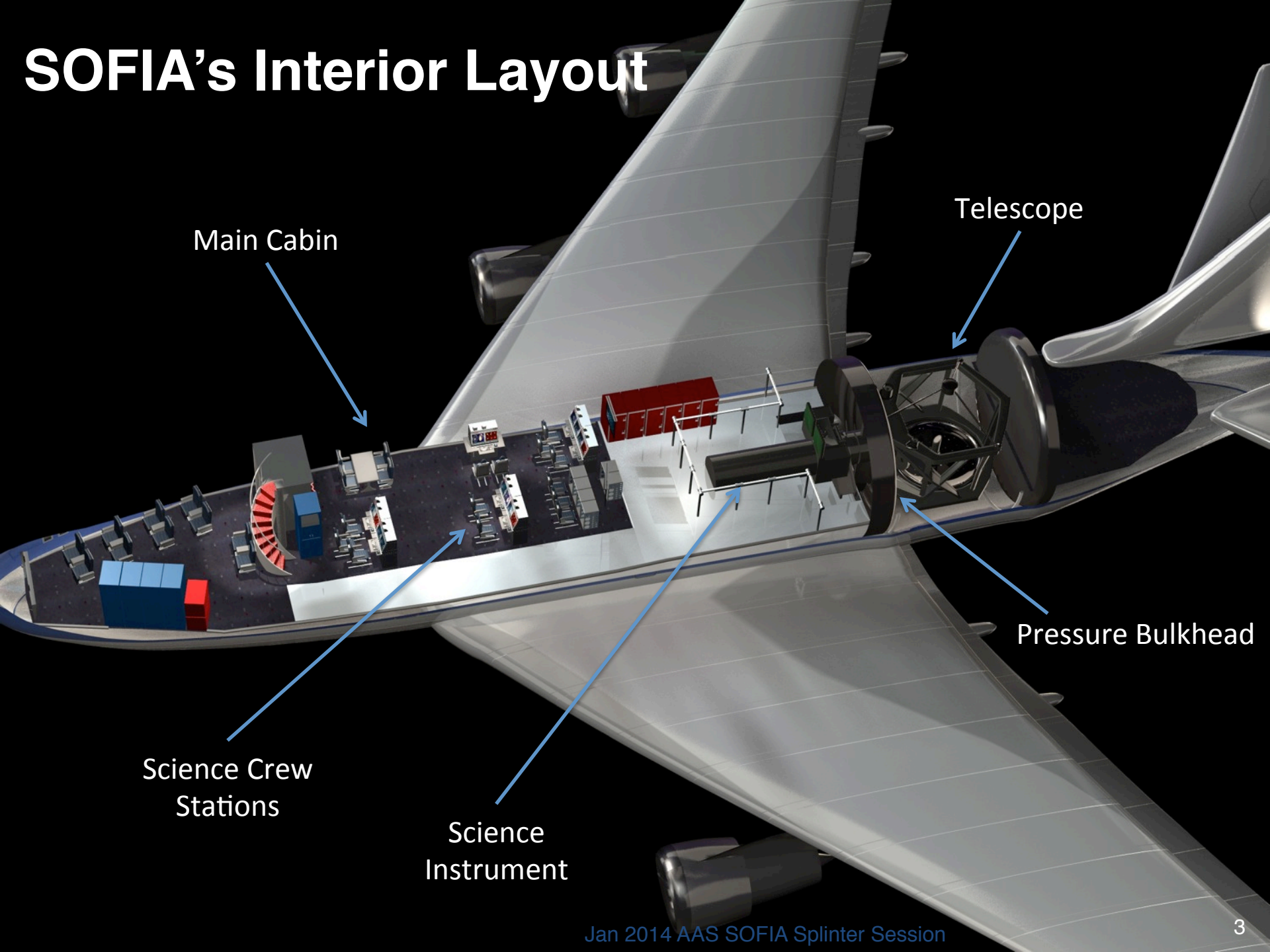
SOFIA is the largest airborne observatory in the world
(Highly modified Boeing 747SP)



- Length: 177 feet
- Wingspan: 196 feet
- Service Ceiling: 45,000 feet (13.7 km)
- Airspeed at 41,000 feet: 450 knots (Mach 0.8 or 520 mph)
- Range: 6,625 nautical miles
- Mission Duration: 8 to 10 hours (standard); 12.2 hours (maximum)
- Cavity Door (18 ft x 14.3 ft)
- Fuel Usage: 150,000 to 250,000 pounds (standard duration mission)



SOFIA's Interior Layout



Main Cabin

Telescope

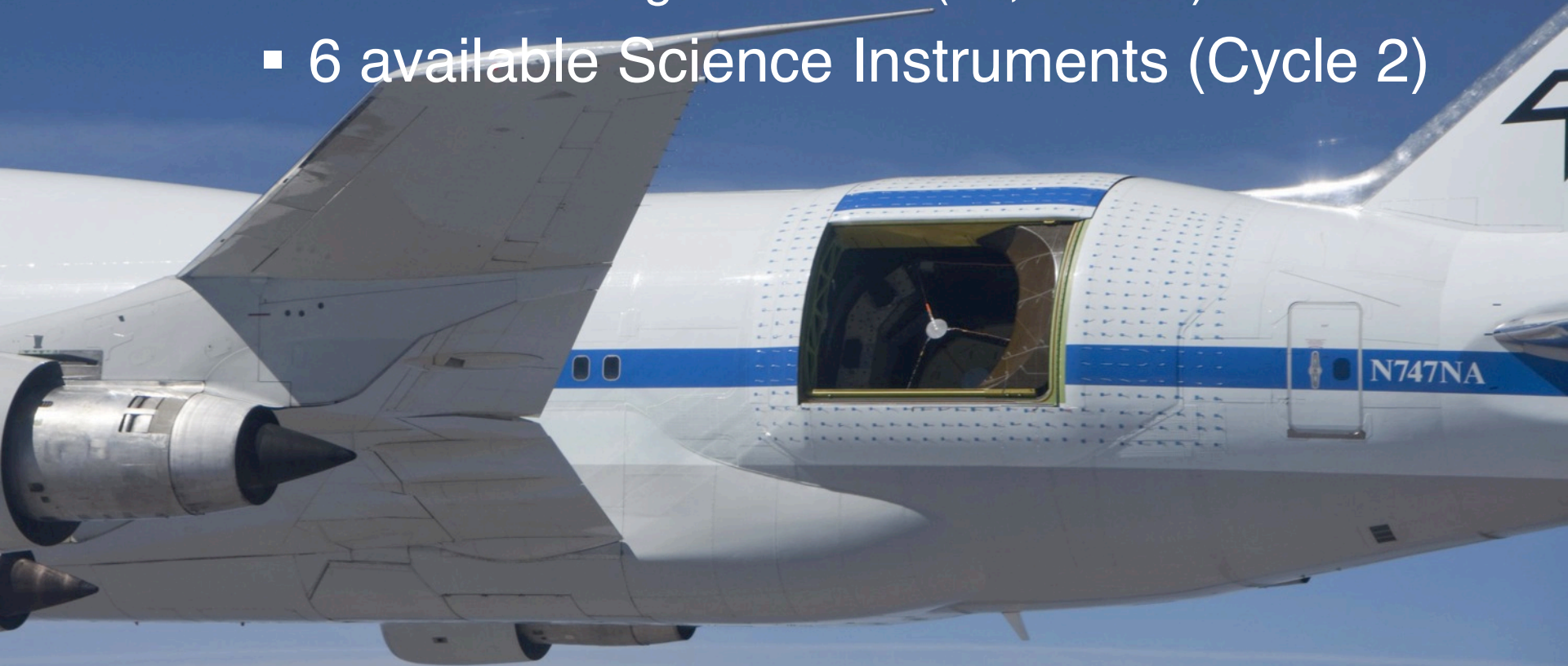
Pressure Bulkhead

Science Crew
Stations

Science
Instrument

Observatory Details

- Onboard Telescope
 - › Bent Cassegrain, 2.7 meter mirror (~10 feet)
 - › Wavelength range: 0.3 - 1600 microns
 - › Installed Weight: 17 tons (34,000 lbs)
- 6 available Science Instruments (Cycle 2)



SOFIA Science and Operations Centers



**SOFIA Science Center
NASA Ames Research Center**

**SOFIA Operations Center
Dryden Aircraft Operations Facility**

Accomplishments

- Deployment to New Zealand provided maximal science yield, due to near-perfect observing conditions and completion of 9 problem-free flights
- Target of Opportunity observations were made of interesting time-critical targets, including Comet ISON and Nova Del 2013
- 3 science instruments – FORCAST, GREAT, HIPO – are now fully commissioned and have produced unique scientific data
- 3 other instruments – FLITECAM, FIFI-LS and EXES – have passed their pre-ship reviews and will complete their commissioning this year
- Cycle 2 Guest Investigator selections have been made and observations will soon begin, using all six 1st-generation science instruments
- Significant Observatory performance improvements were made in support of Cycle 2 science and SI commissioning

SOFIA CY13 Missions



First science deployment to New Zealand
(July/August 2013)

Science, SI Commissioning & Engineering Flights Achieved*

- 25 Science Flights
 - › 153 Research Hours Achieved
 - › First New Zealand Deployment
- 10 Instrument Commissioning Flights
 - › 1 Instrument remains to be commissioned
- 5 Engineering / V&V Flights

* Planned flights not included in this tally were lost due to Government shutdown & Observatory system issues.



Deep Impact imaged ISON for the first time on January 17 and 18, 2013, from 493 million miles away



MESSENGER observed ISON as it passed by Mercury on November 19th on its way to the Sun



SOHO will be continually observing ISON as it passes by the Sun in late November



Hubble observed ISON in April-May and will see it again in October and December (if ISON survives)



STEREO observed ISON as it passed by on its way to Sun in October

Astronauts aboard the International Space Station will be able to observe Comet ISON as it passes by Earth in late November



In January and March, Swift observed ISON in X-ray and UV when it was 460 million miles away from the Sun

Curiosity was not able to observe ISON as it passed by Mars.



Opportunity was not able to observe ISON as it passed by Mars

In November, Chandra observed ISON with its X-ray instruments



How NASA Space Assets Observe Comet ISON

(items in yellow successfully observed the comet)

For more information, visit: <http://solarsystem.nasa.gov/ison>

Lunar Reconnaissance Orbiter was not able to observe ISON



Mars Reconnaissance Orbiter observed ISON as it passed by Mars on October 1st



BARRISON, a sub-orbital balloon, launched successfully, but its instrument failed and did not observe the comet



Spitzer observed ISON on June 13. The comet was 310 miles away from the Sun



FORTIS, a sounding rocket, launched on November 20, 2013 will obtain ultra-violet spectra from ISON



SDO will have the ability to observe ISON under extreme-ultraviolet light when the comet is closest to the Sun

Pointing/tracking improvements

Observatory pointing & tracking improvements were addressed over the past year, including:

- new guide camera (“Focal Plane Imager”, FPI) installation
- Absolute pointing
- Tracking schemes
- Matched chop-nod
- Drift



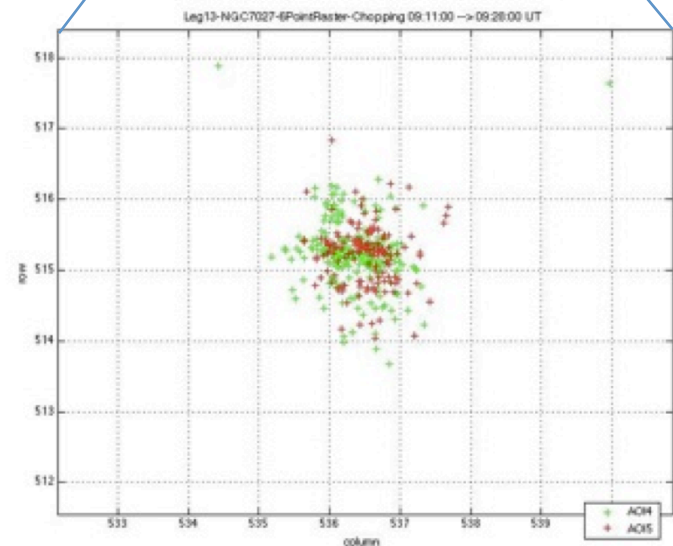
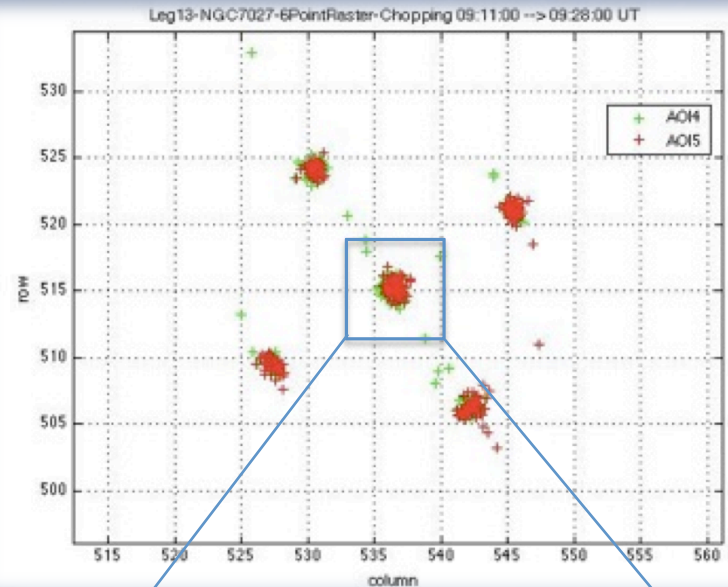
The upgraded guide camera:

- High QE (~90%), low read noise, fast read out
- Demonstrated tracking on $R \approx 15^{\text{th}}$ mag stars \rightarrow 100x more sensitive than the old FPI
- Can now successfully guide on >98% of the sky fields
- Neutral density and near IR (~1 micron) filters allow bright star, lunar and day time tracking (still to be demonstrated)

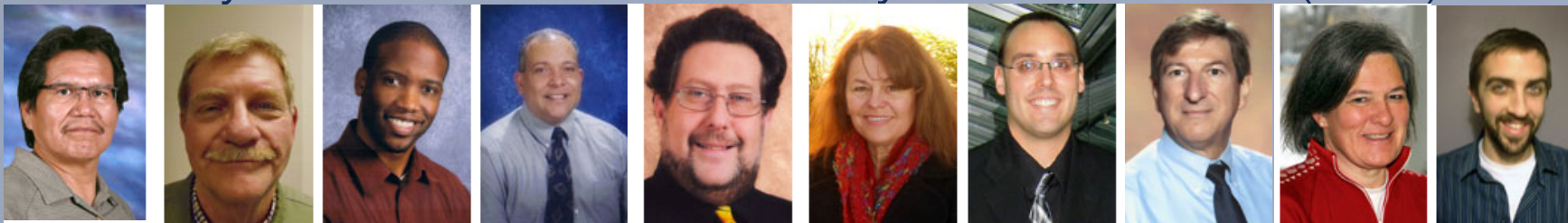
Pointing/tracking improvements

- offset tracking stability as good as $\sim 0.5''$ radial rms
- pointing drift rate: $\sim 0.3''/\text{hr}$
- on-axis chop-nod matching while dithering
 - matches up to $0.1''$ rms
 - pointing stability at each raster point is $\sim 0.3''$ rms
 - able to maintain this performance even through “LOS rewinds”

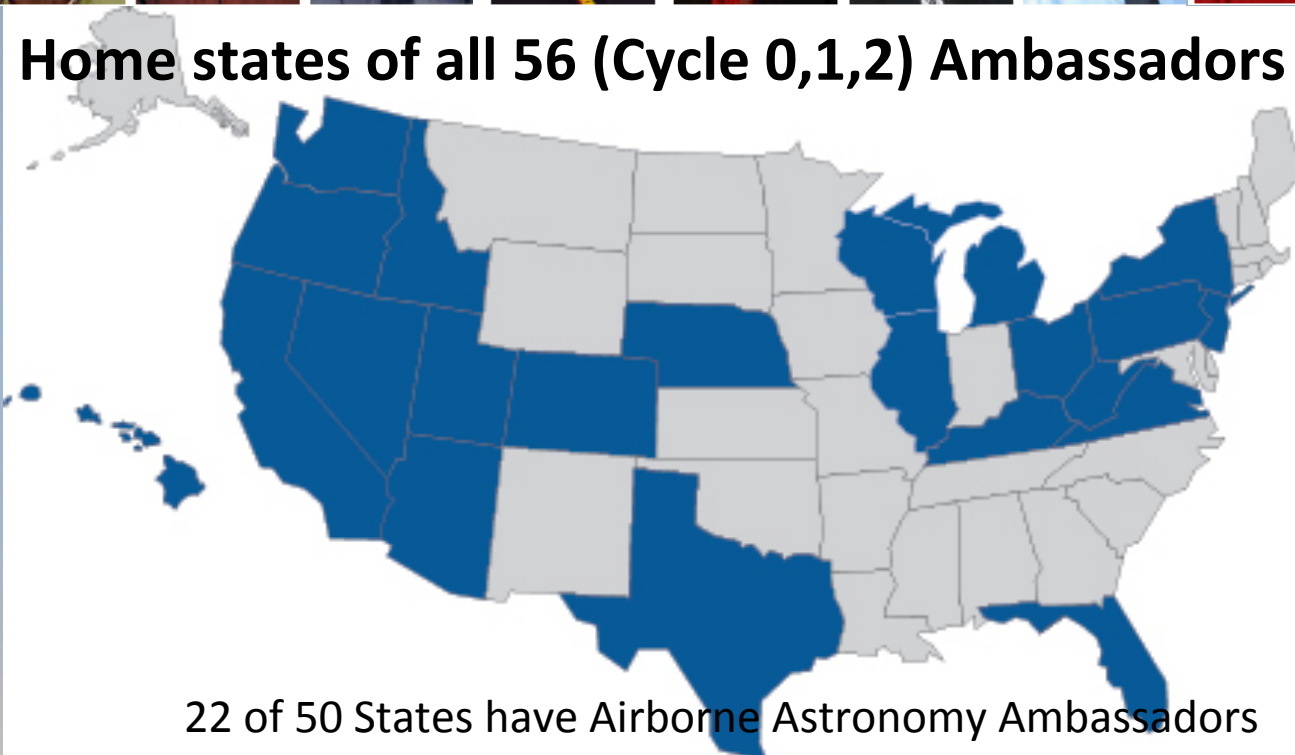
Tracking/pointing performance shows significant improvement relative to that of Early Science phase



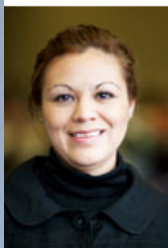
SOFIA Cycle 1 Airborne Astronomy Ambassadors (U.S.)



Home states of all 56 (Cycle 0,1,2) Ambassadors



22 of 50 States have Airborne Astronomy Ambassadors



SOFIA 2014 Priorities

SCIENCE OPERATIONS

- Complete Cycle 2 Science Instrument Commissioning
 - FLITECAM
 - FIFI-LS
 - EXES
- Perform Cycle 2 science observations (235 Research Hours)
- Finalize Cycle 3 planning and associated Observatory improvements

PROGRAM MILESTONES

- Complete KDP-E reviews and receive formal Agency-level approval to transition to Operations phase (January through March)
- Complete the Heavy Maintenance Visit (in Germany) on schedule (June through mid-October)
- Demonstrate full flight rate capacity with full operations staff and the supporting systems and processes in place (104 RH in 30 days)

New Science Instrument Commissioning



FIFI-LS

**Field Imaging
Far-Infrared Line
Spectrometer**

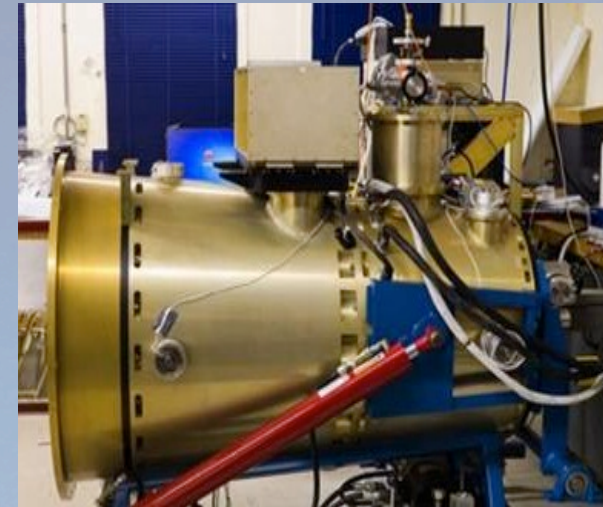
PI: Alfred Krabbe
Universitat Stuttgart



EXES

**Echelon Cross Echelle
Spectrograph**

PI: Matthew Richter
Univ of California, Davis



HAWC+

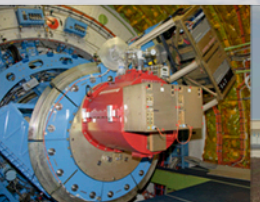
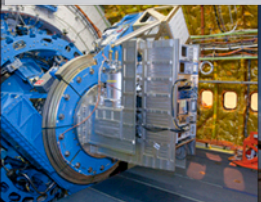
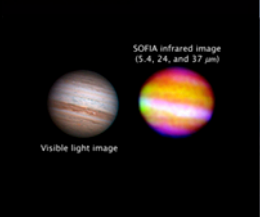
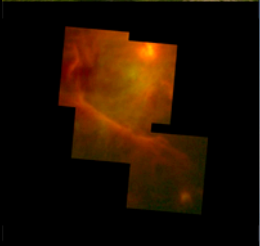
**High-resolution
Airborne Wideband
Camera**

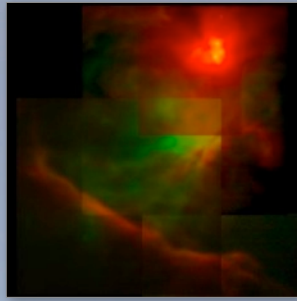
PI: Darren Dowell
Jet Propulsion Lab

to be commissioned in 2014

Get Ready for a Productive 2014!

- SOFIA is online and providing unique observational capabilities to the astronomical community!
- Future successes will build on the many SOFIA accomplishments made this past year
- The SOFIA team is committed to improving performance to meet evolving science community expectations
- This year will mark the completion of the transition to the operations phase

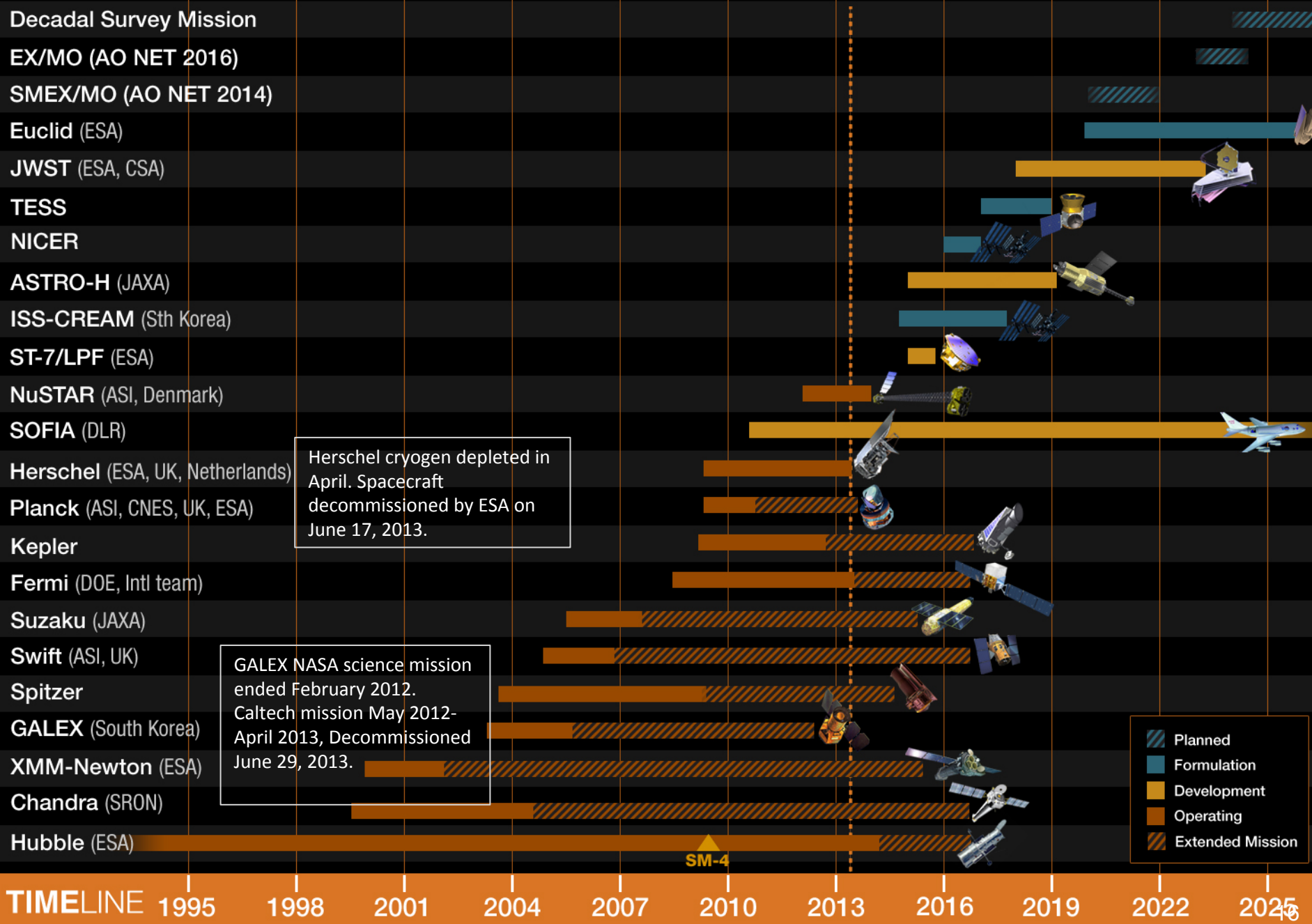




Back Up

Astrophysics Missions timeline

Last updated: June 29, 2013



TIMELINE

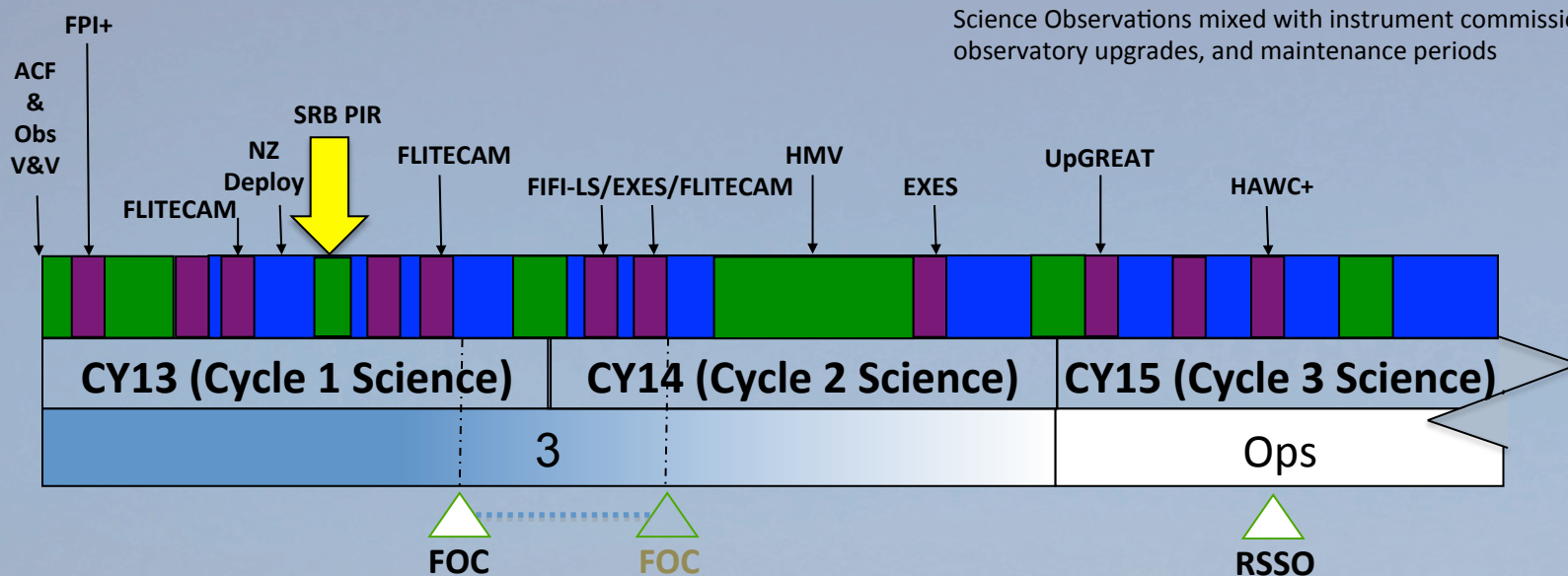
1995 1998 2001 2004 2007 2010 2013 2016 2019 2022 2025

SM-4

-  Planned
-  Formulation
-  Development
-  Operating
-  Extended Mission

Flight Segment Timeline/Phased Science Observations

- Science flight activity
- SI Commissioning flight activity
- A/C testing, maintenance and engineering work



Science Observations mixed with instrument commissioning, observatory upgrades, and maintenance periods

- ✓ Segment 0: Functional check flight and ferry flight
- ✓ Segment 1: Closed door flight test
- ✓ Segment 2: Open door flight test and early science
- Segment 3: Shared purpose observations, upgrades, and observatory characterization
- Operations: Mission operations

- ISF = Initiation of science flights
- SS = Short science
- FOC = Full operational capability
- RSSO = Ready for sustained science ops

Science Cycles

- Cycle 1: Performed with 4 1st Gen Instruments
- Cycle 2: Performed with all 6 1st Gen Instruments
- Cycle 3: Performed with all 1st Gen and 2nd Gen Instruments