National Aeronautics and Space Administration
Dryden Flight Research Center

Evolution of a SOFIA Mission

SOFIA Stratospheric Observatory for Infrared Astronomy

Randy Grashuis SOFIA Mission Director

National Aeronautics and Space Administration
Dryden Flight Research Center

Flight Planning Timeline

SOFIA Stratospheric Observatory for Infrared Astronomy

- Current FIFI-LS flight series - March 12-27 2015 UT
  - T = flight #1 of 8
- T-10 weeks – Series Kick Off
  - Accepted proposals “Phase 2” completed
- T-7 weeks – Science Review
  - Air Traffic Constraints reviewed
- T-4 weeks – MOPS Review
  - Leg by Leg review of observing strategy
- T-2 weeks – Detailed Observing Preparation
  - Challenging observations tested in the simulator

No Flight Pl
Saved: 2015

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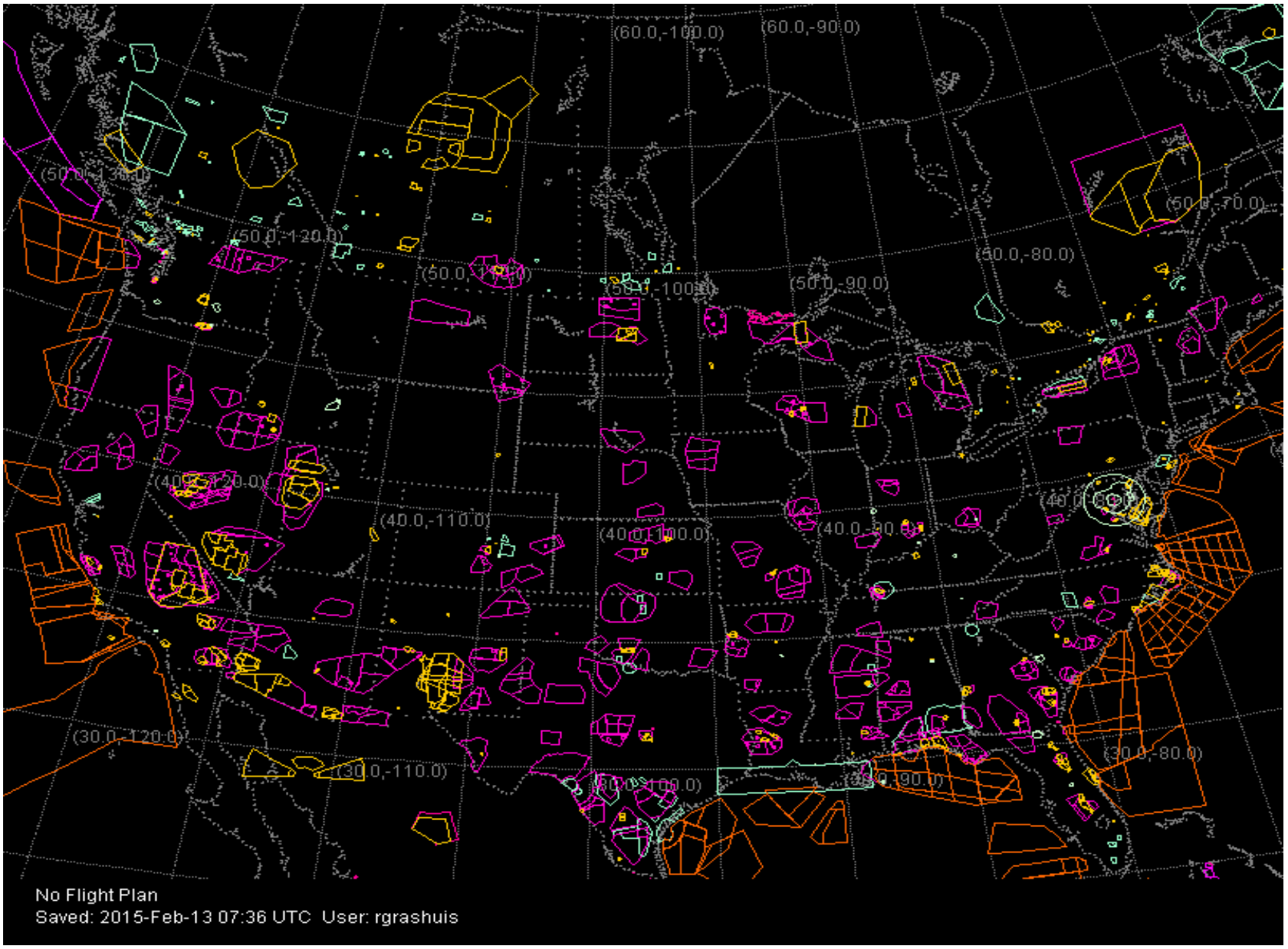
Restricted Airspace - US

SOFIA Stratospheric Observatory for Infrared Astronomy



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Restricted Airspace – SW

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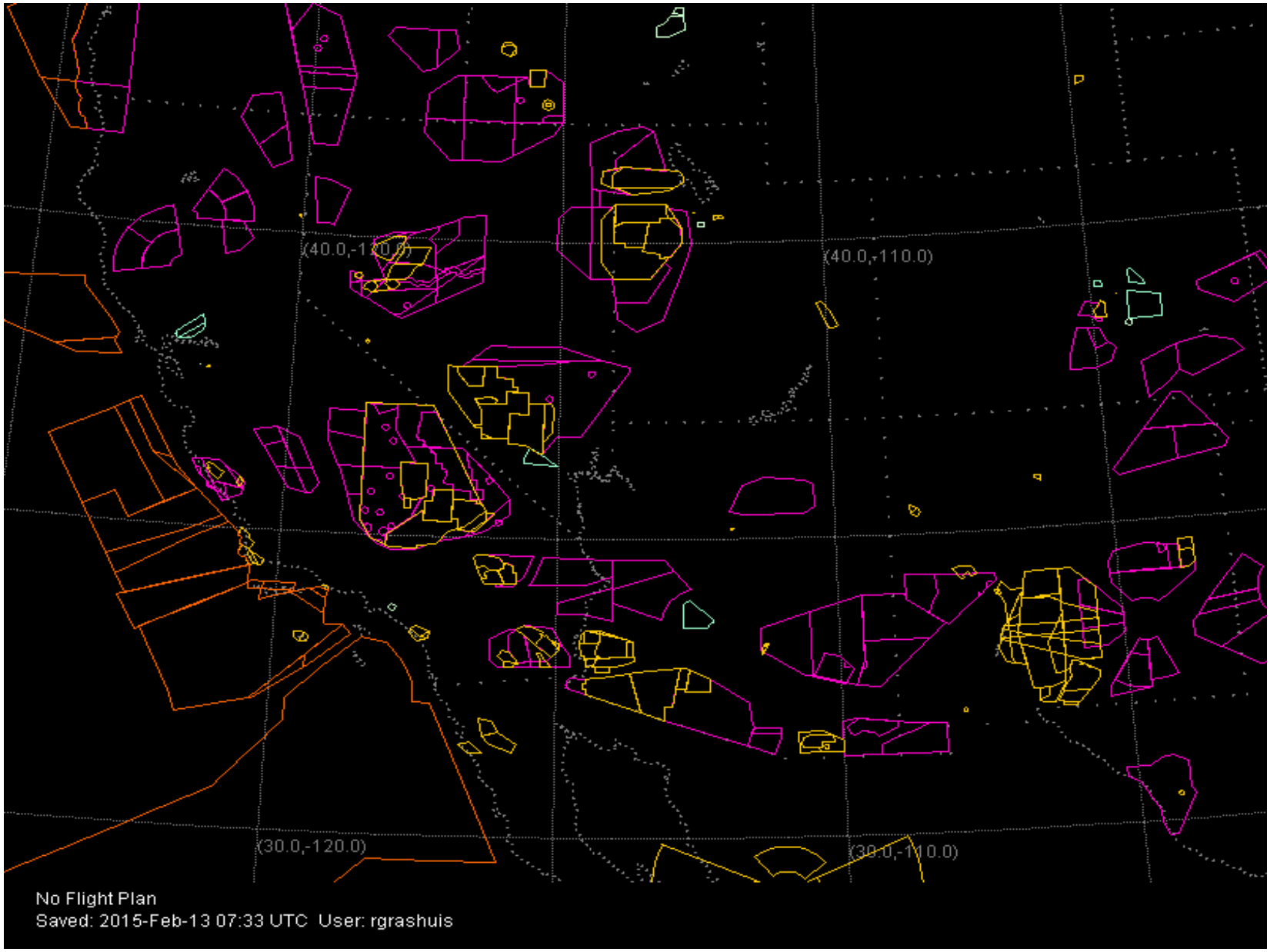

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Mission Timeline

SOFIA Stratospheric Observatory for Infrared Astronomy

- Mission flown on March 13, 2015 UT
  t = take off @ 02:10 UT
- t-36 hours – First Weather Update
  - predicted winds can move the flight track significantly
- t-24 hours – Finalize Target “Position” files
  - TO acquisition and tracking files to be loaded onto aircraft
- t-12 hours – Final Weather Update
  - mission planners request clearance for potential restricted airspace incursions, flight plan filed with ATC
- t-6 hours – Day of Flight checks
  - Ground crew loads fuel, starts on board pre-flight checks, loads “Position” files, final cryogen top off for SI
- t-2 hours – Mission Brief
  - Flight crew arrives to go over upcoming mission and receive status of aircraft, telescope, and on-board systems

Flight Plan Name: File: 201503_FI_series_postMOps.fp
Flight ID: 2015
Est. Take
Est. Landing Time: 2015-Mar-13 11:57 UTC
Flight Duration:
Weather Forecast
Forecast Timestamp: 0345 Tue Mar 03 2015 UTC
Saved: 2015-Mar-03 18:47 UTC User: bwarrington

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TAKE OFF @ 02:10 UT

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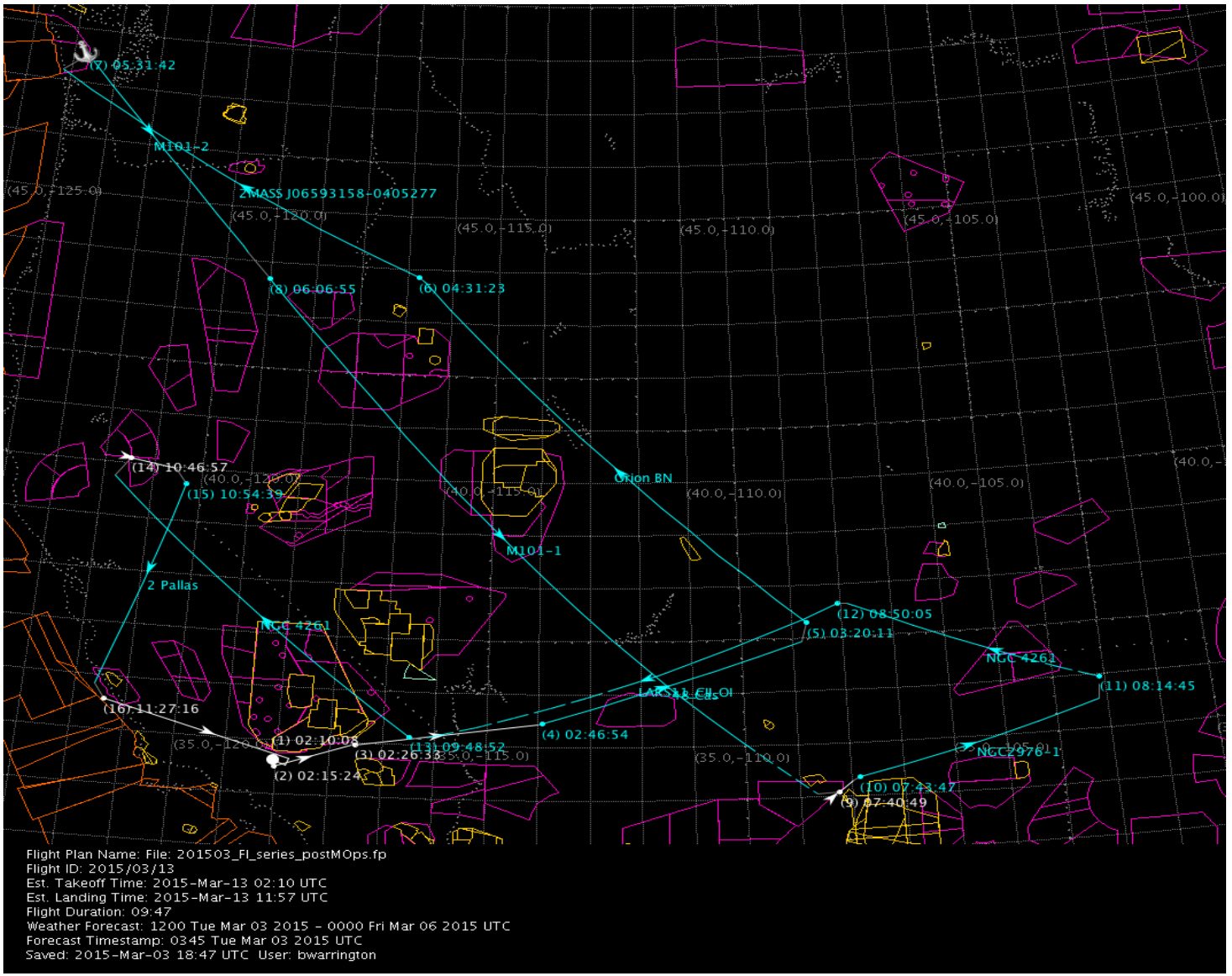
Mission ID: 2015-03-13_FI_F200



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Take Off +~20 minutes

SOFIA Stratospheric Observatory for Infrared Astronomy

Open cavity door above 28K feet

Take off +~30 minutes

- Above 35K feet - Telescope setup ~30minutes
  - Uncage the telescope (decouple from the aircraft)
  - Start balance drive slew (cryogen boil-off)
  - Initialize IRF to ERF coordinate transformation
  - Calibrate chopper & gyros
  - Set up trackers
- Review of Telescope Subsystems
  - Secondary Mirror Mechanism
  - Tracking imagers
  - Telescope Pointing Control

Secondary Mirror

- Secondary Mirror SiC 0.35m ⟶
- Tilt Chopping Mechanism active component controls ⟶ Chopping and FBC
- Focus Centering Mechanism sets optical collimation and ⟶ focus

Symmetric chopping up to 4.5’ throw, all angles
Asymmetric chopping up to 9’, some angles limited

Courtesy of A. Reinacher

Tracking Imagers

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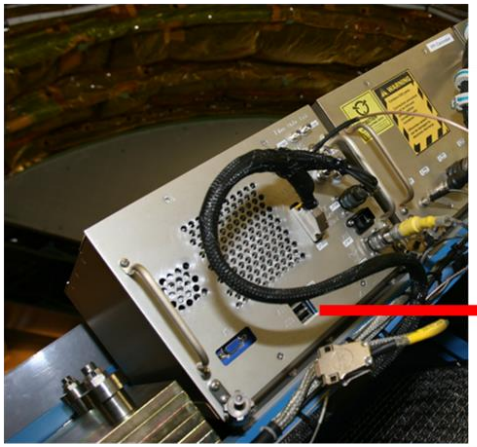

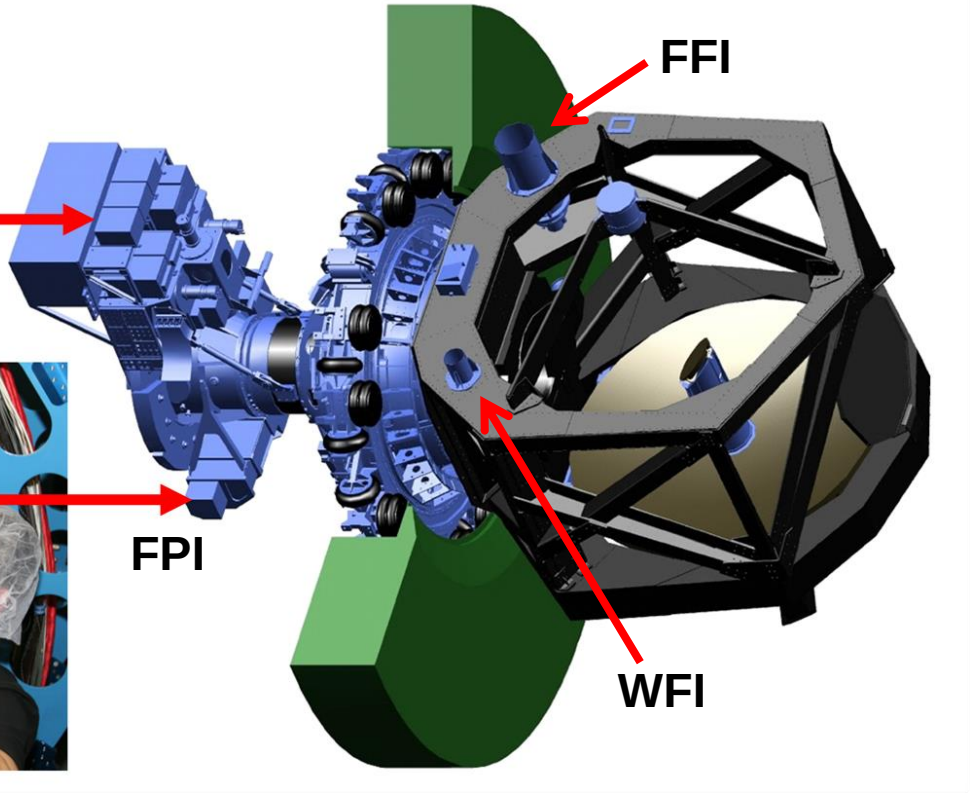

- **FPI - Primary tracker, used 95% of the time**
  - FOV ~9', mag limit while chopping V~15, accuracy <~1"
- **FFI - Alternate tracker, FOV 1° , mag limit V~9, accuracy <~5"**
- **WFI - Target field recognition, FOV 5°**

Courtesy of E. Pfueller

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Telescope Structure

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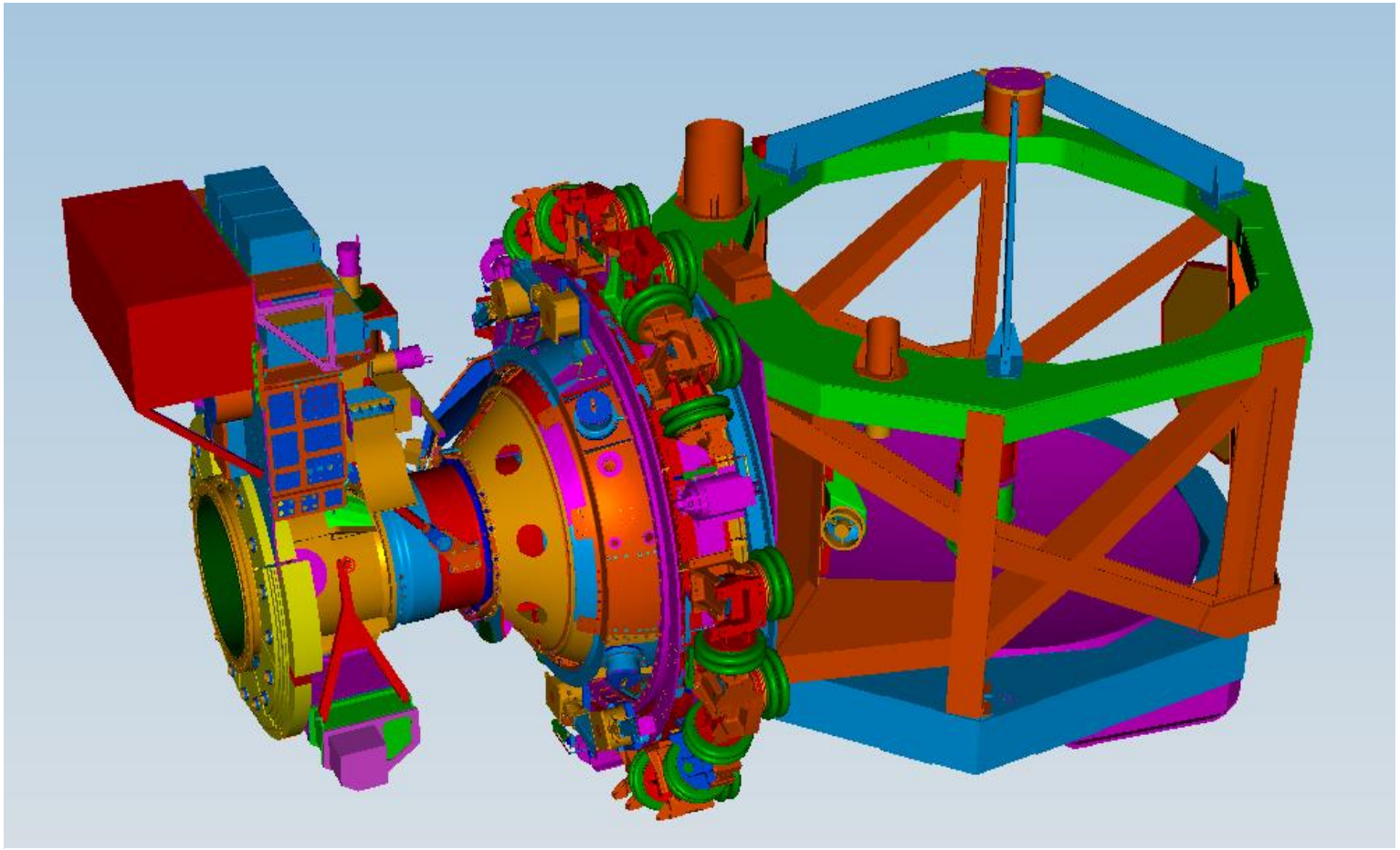
Fine Drive Motion Range:
±~2.8° in all rotational DoF

Coarse Drive Motion Range:
17-65° in Elevation



Vibration Isolation System

Courtesy of U. Lampater

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Telescope Pointing Control

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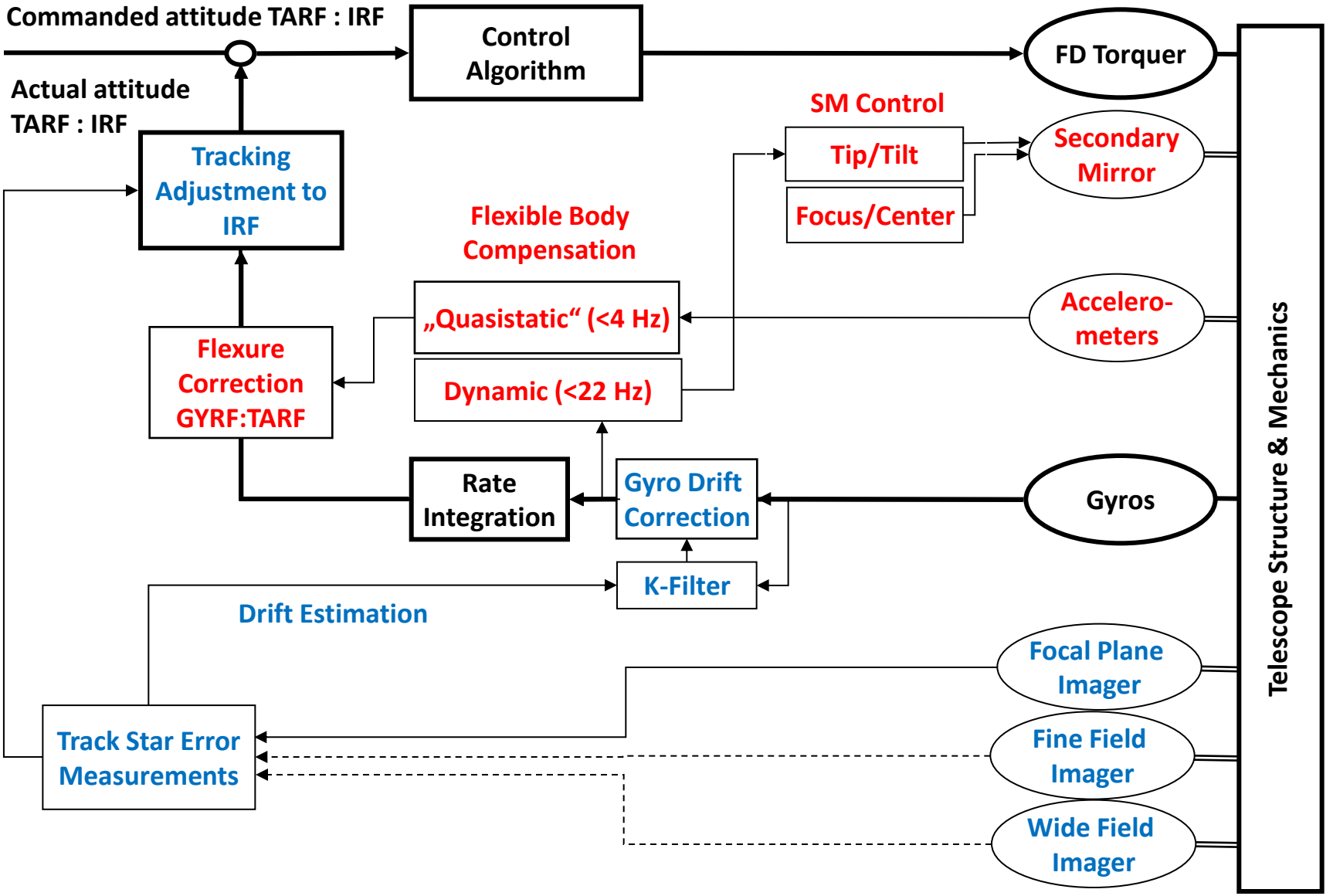

Courtesy of U. Lampater

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The Telescope in action

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Aircraft travelling at 0.85 Mach ~1000 km/hour

Courtesy of M. Agnew

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Image Quality – Flight #190

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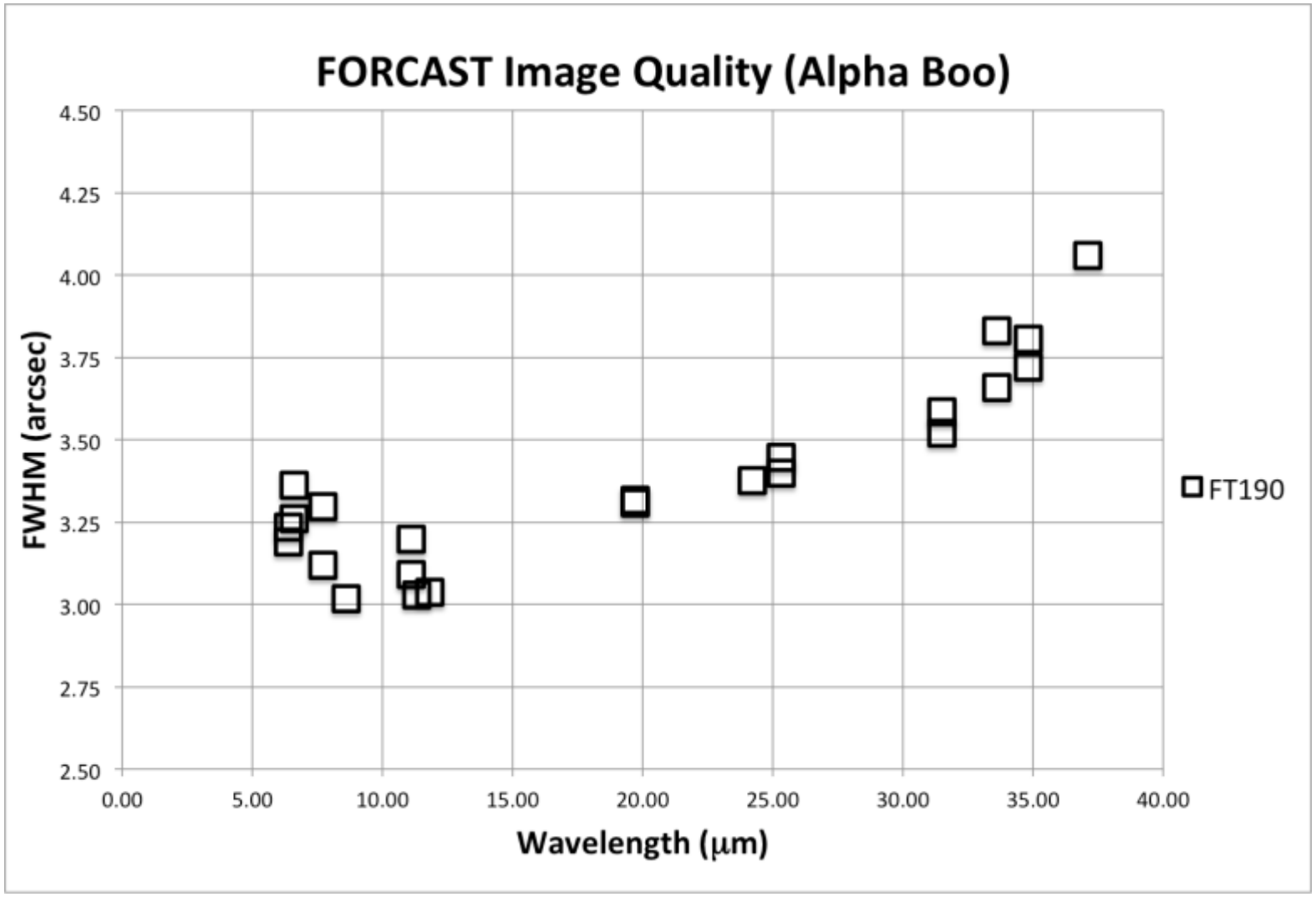

FORCAST measured ~3-3.75” IQ FWHM, 10-35microns

Courtesy of J. Radomski

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In Flight

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- ~t+1hour science data acquisition for the next ~8.5 hours
- ~10 minutes between observing legs
  - "Hand-offs" between Flight Deck -> Mission Director -> Telescope Operator -> Science Instrument Team
- Climb restrictions dominated by fuel load and outside air temperature
  - ~t+2hours climb to ~39K feet
  - ~t+4hours climb to ~41K feet
  - ~t+6hours climb to ~43K feet
- Available flight altitude depends on direction of flight
  - West -> Even, East -> Odd
  - Takes time to get ATC clearance to climb

Flight Plan N... Fl...
Flight ID: 2015/03/13
Est. Takeoff Time: 2015-Mar-13 02:10 UTC
Est. Landing Time: 2015-Mar-13 11:57 UTC
Flight Duration: 09:47
Weather Forecast: 1200 Tue Mar 03 2015 - 0000 Fri Mar 06 2015 UTC
Forecast Timestamp: 0345 Tue Mar 03 2015 UTC
Saved: 2015-Mar-03 18:47 UTC User: bwarrington

End of Flight

- ~t+9.5 hours end science observations
  - 43K feet with ~30 minutes to landing
  - Close cavity door
  - Telescope & SI safe for landing
  - Start Cavity Environmental Control System
- ~t+10 hours Landing
- Post flight
  - ~7AM data removed from aircraft via disk pack
  - Ground crew starts working issues that affect the next flight
  - Raw science data ingested into the Data Cycle System archive at Ames by ~5PM

Summary

SOFIA Stratospheric Observatory for Infrared Astronomy

- For Observing Cycle 3 we are executing continuous back to back flight series

- SOFIA is a hybrid of ground and space based observing with unique constraints and capabilities

- THANK YOU!