# SOFIA Observing and Flight Planning

# Useful Information for Proposing and Planning SOFIA Observations

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# Airborne Observing

What is special about airborne observing?

- The observatory is moving while observing.
  Local sidereal time loses its meaning. Sources rise and set faster or slower.
  The elevation where a certain target culminates can vary.
- The targets dictate the aircraft heading.
  The observing plan translates into a flight plan and the observing plan has to be prepared so that the flight plan can be flown and starts and ends at the (same) airport.
- *You can help us flight planners to your own benefit.*

# SOFIA's Telescope

*Before you can propose observations, you need to know what the telescope can do:*

- The telescope door is on the **port side** of SOFIA. Thus, the azimuth dictates aircraft heading (~AZ+90°).
- Telescope door elevation range: 24.15° – 57°
- The telescope can exceed the door elevation range by ~5° without getting vignetted (depends on instrument).
- Due to variability of aircraft pitch and roll angle and their effect on available elevation, observations should not exceed the door elevation range more than ~3°.

For planning purposes:

➔ **20° < useful elevation range < 60°**

# Flight Planning

*Flight Planning starts with you, the observer!*

*You need to provide targets that are observable.*

- Target observability can be evaluated via the Visibility Tool https://dcs.sofia.usra.edu/ ➔ Visibility Tool (publically available)
  - It calculates **elevation** and **aircraft heading** (~AZ+90°) for a given target, location, and date and plots it over 24 hours.
  - Default location is Palmdale Airport (N34° 38', W118° 05'). You can select from a few airports or enter coordinates freely.
  - The proposal call allows sources with DEC>-36° for flights from Palmdale, i.e. SOFIA will routinely fly from there to latitudes south of N30°.

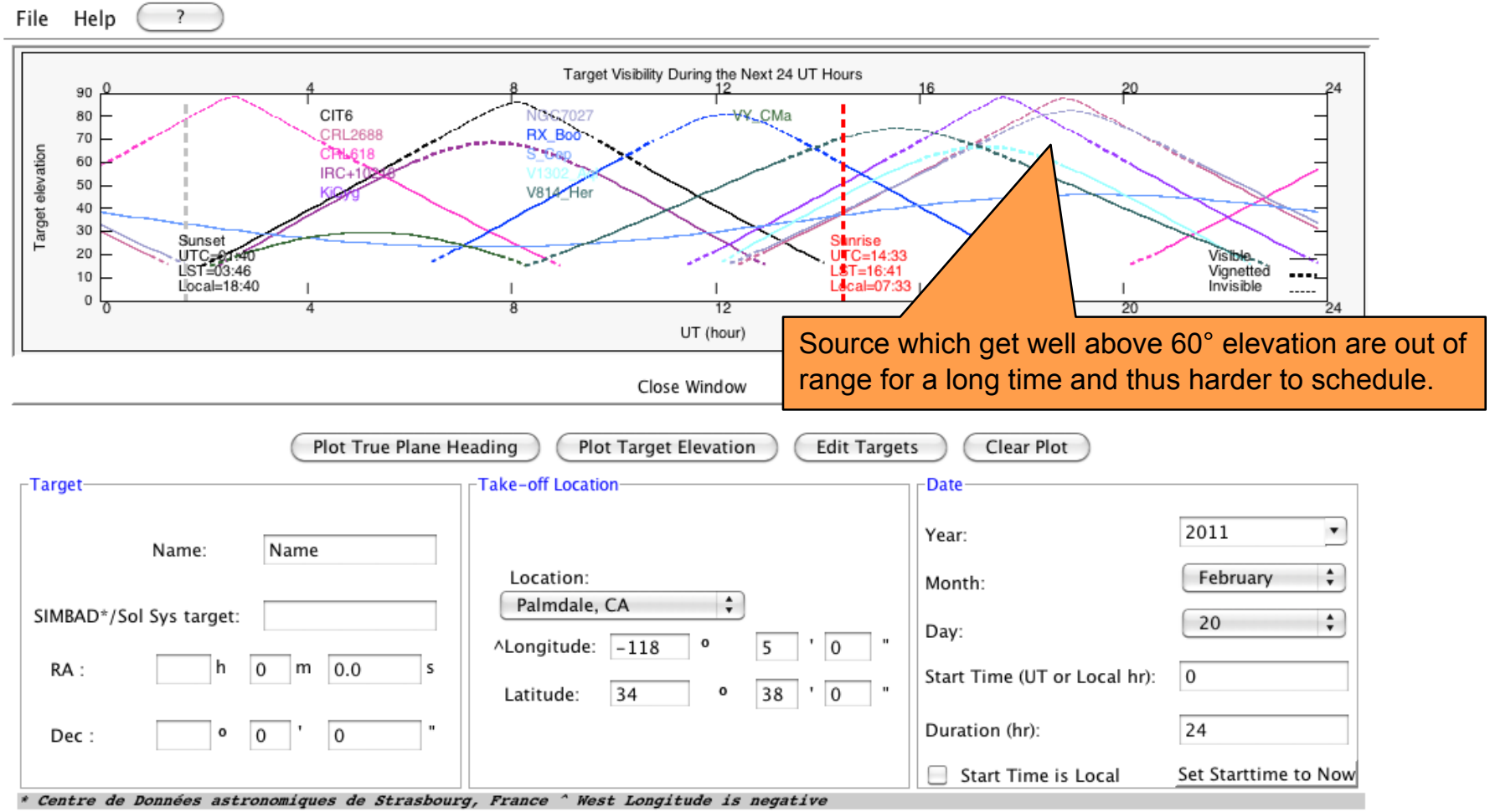
# Flight Planning

Since SOFIA has to fly back to Palmdale usually**, targets need to be well distributed over the sky**. Flight Planners will be in need of targets **opposite in azimuth of popular regions** like the Galactic Center in summer or Orion in winter. Give us good choices.

*A good source distribution on the sky does not help your proposal to get approved. But once approved, sources culminating in the north tend to have higher completion rates.*

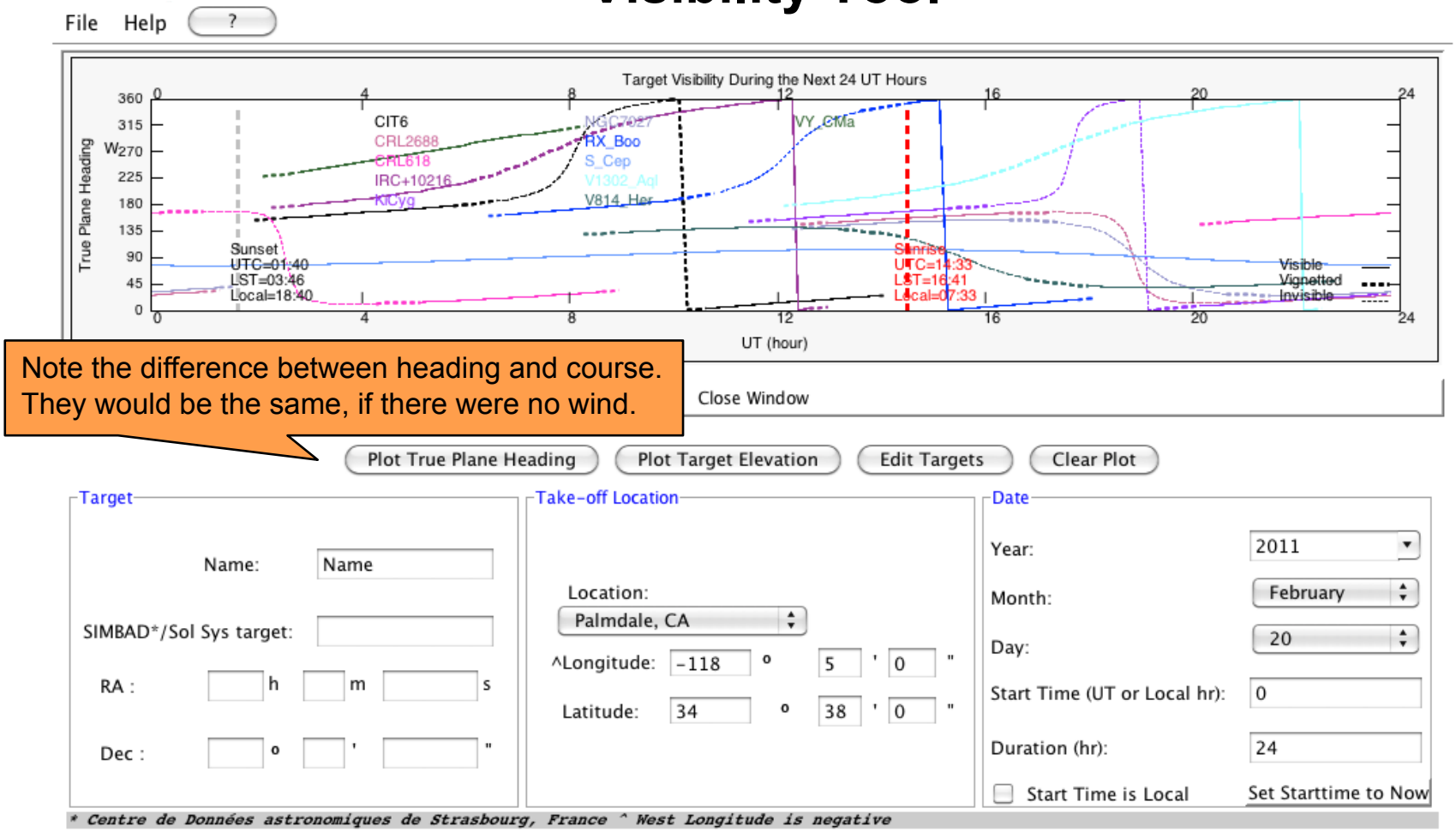
- For top rated proposals that can mean completion rates of >100%, while 80% is considered completed in oversubscribed regions.
- Second tier proposals only got observed if they were outside of oversubscribed regions.
- Surveys should not expect a uniform sky coverage but to be biased towards the north.

# Visibilitv Tool




Dashed lines means vignetted or invisible.

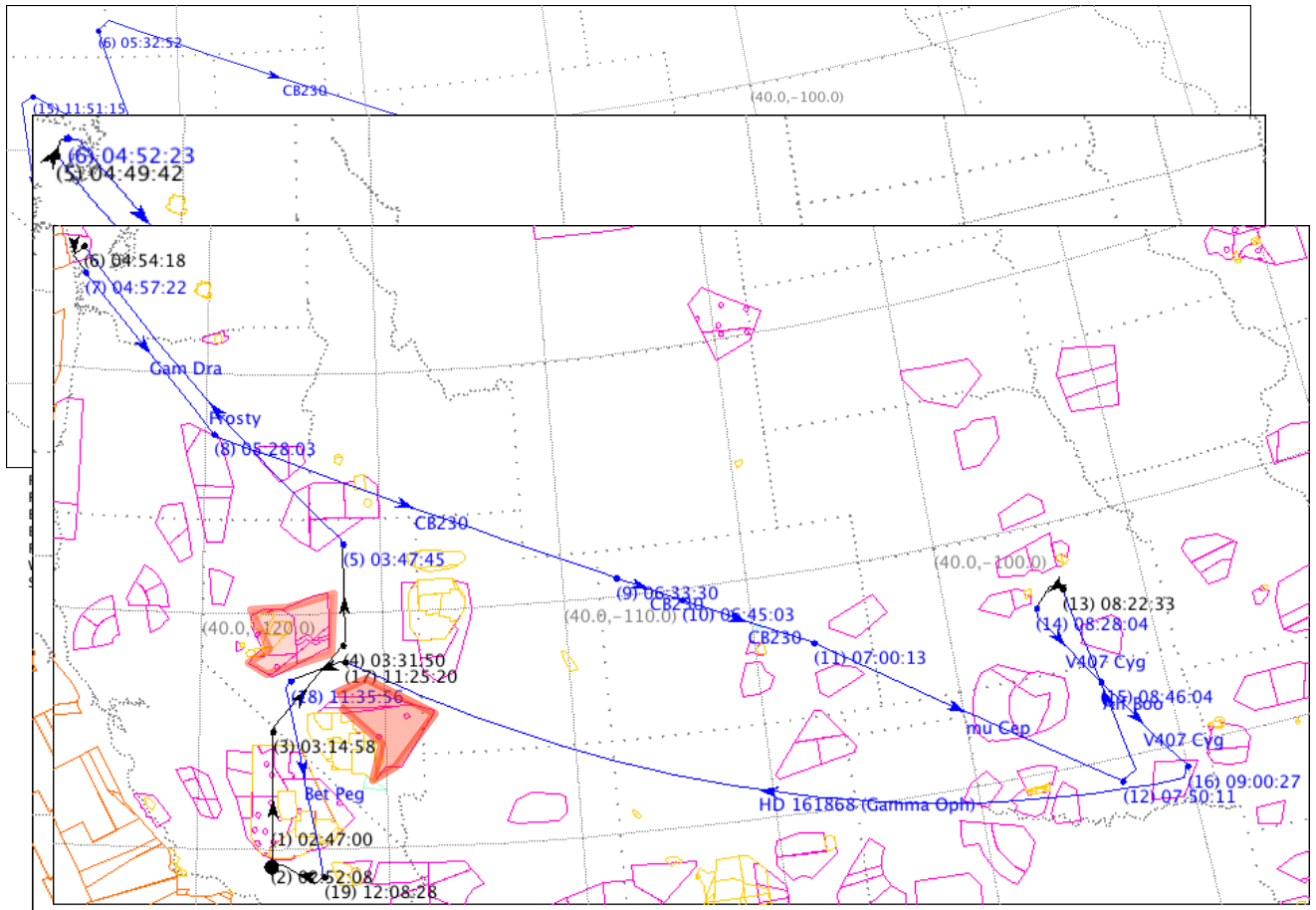
# Visibility Tool




Note the difference between heading and course. They would be the same, if there were no wind.

Dashed lines means vignetted or invisible..

# Flight Planning – A jig saw puzzle with changing tiles




Flight Plan Name: File: BS1_postMOPs.fp
Flight ID: 2011/05/06
Est. Takeoff Time: 2011-May-06 02:47 UTC
Est. Landing Time: 2011-May-06 12:18 UTC
Flight Duration: 09:31
Weather Forecast : 1200 Mon Apr 25 2011 - 0000 Thu Apr 28 2011 UTC
Saved: 2011-Apr-27 19:28 UTC User: kbower

Flight Plan: Basic Science 1 flight #1
Planned for 2011-05-06 (UT)

1.The top panel shows a draft version of the plan, which was too long.
2.The plan shortened.
3. When the pilots reviewed the plans, they indicated additional problematic airspaces.

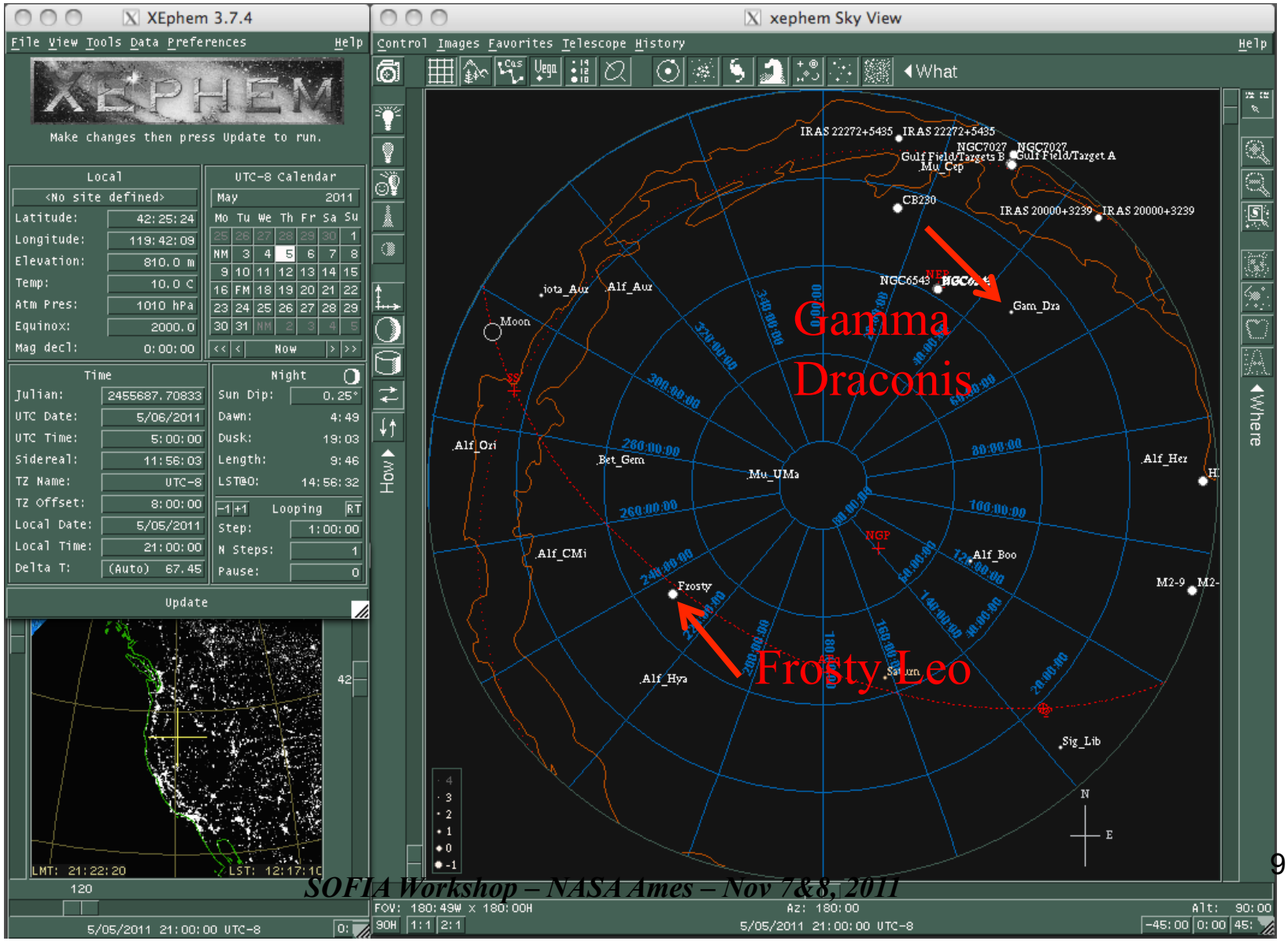
A set-up leg needs to be added.

The orange and yellow areas (SUAs) are off-limits except Edwards.

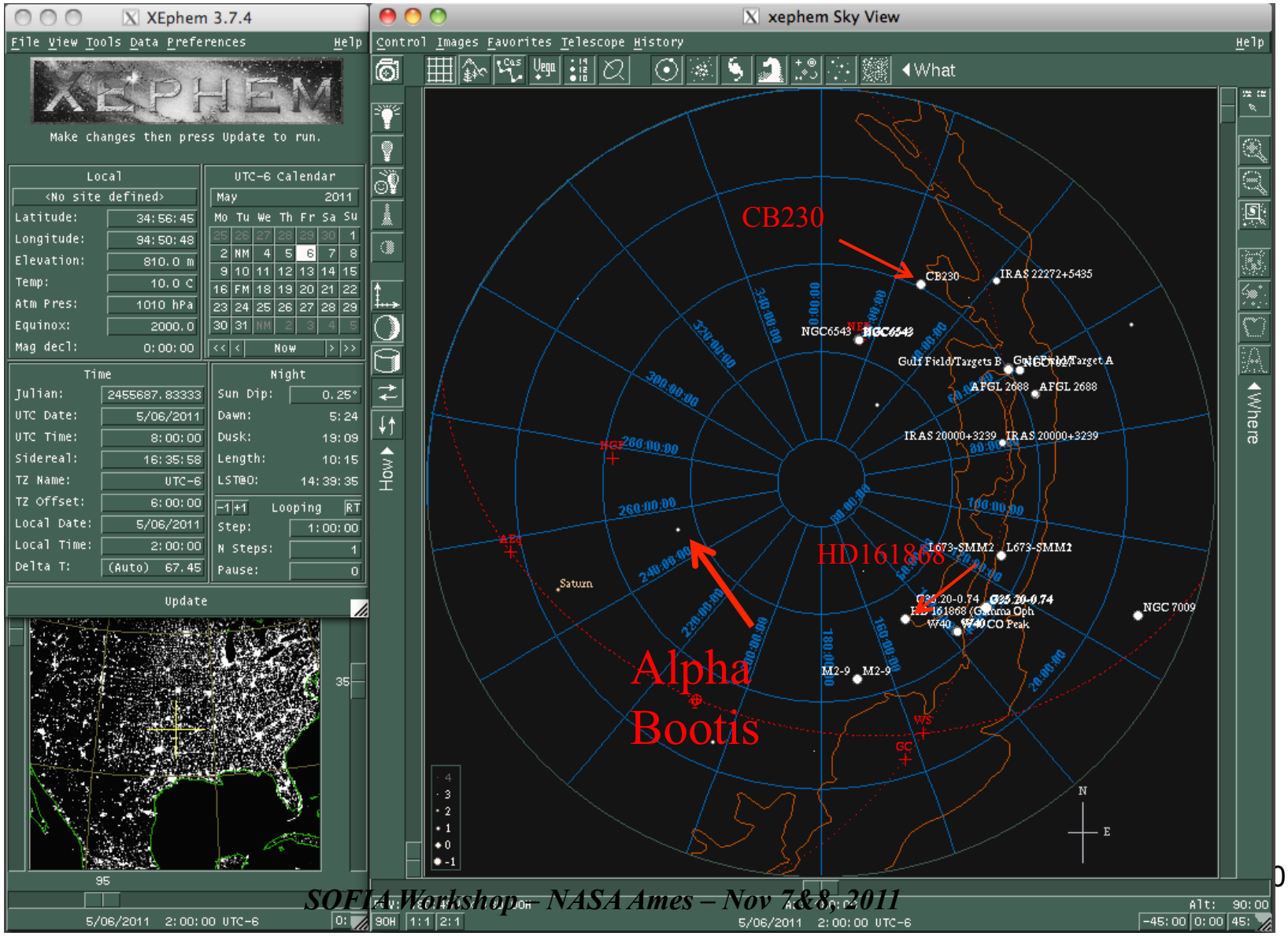
Mexican air space is off-limits for now. Canadian will become available.

On the next slides, see how tracks and source positions relate.

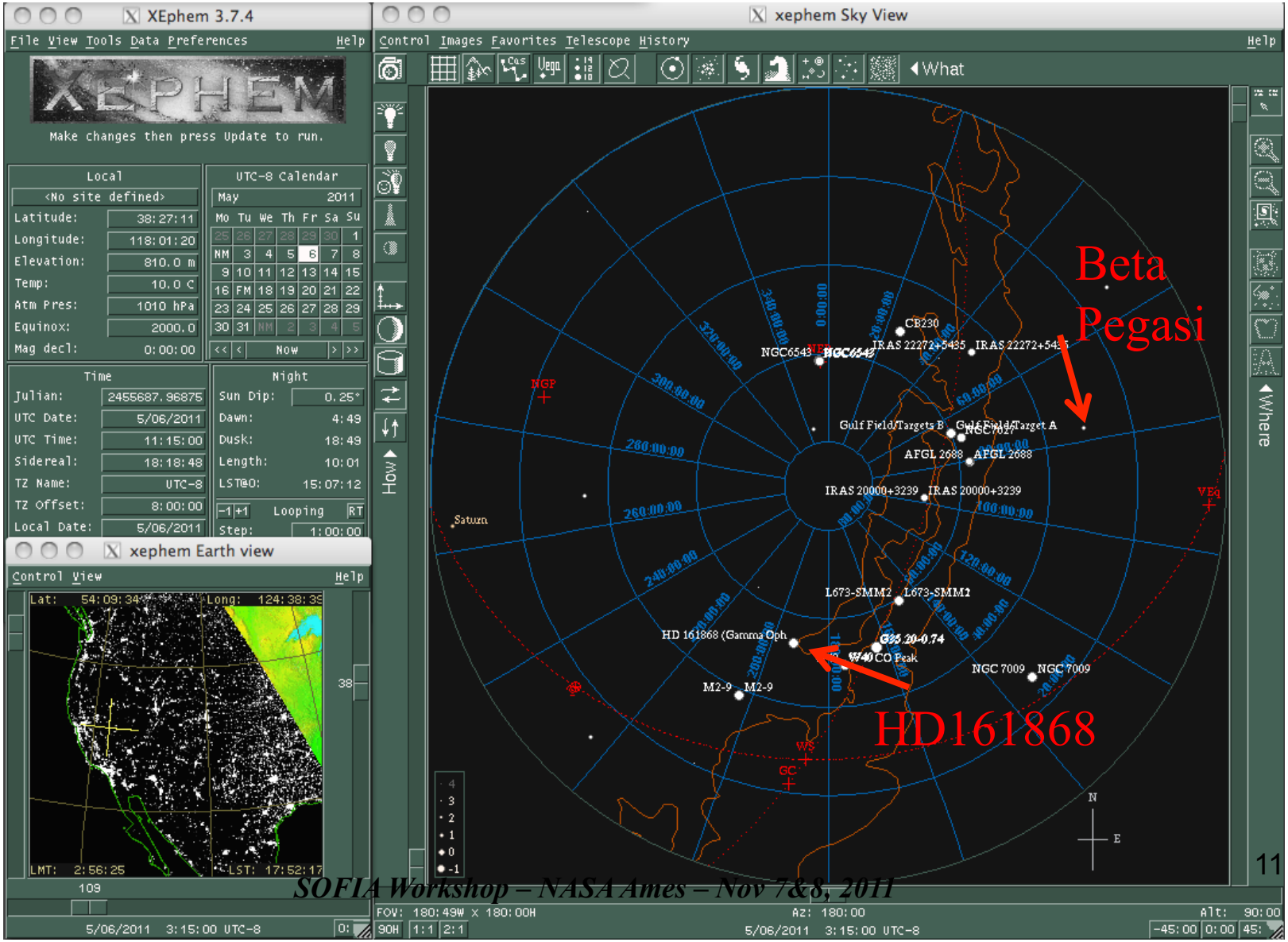
# 5:00 UT – Frosty Leo/Gamma Draconis



# 8:00 UT – Alpha Bootis



# 11:15 UT – HD 161868 & Beta Pegasi



# Input to Flight Planning

Per Flight Rules

- Total maximum flight time is **10 hours** per flight take-off till landing Shorter in the summer. Initially we plan for **9.5hrs** to have room for adjustments.
- Approximate altitude profile:
  - 4 hours before landing at 43,000ft
  - 6 hours before landing at or above 41,000ft
  - 9 hours before landing at or above 38,000ft
- Telescope cavity door remains closed below 15,000ft.
- Telescope door remains closed when the sun is above the horizon as seen from the aircraft.
- First observation ~60 minutes after take-off
- Last observing leg should end within 150nm of Palmdale
- Observations should end when sun comes above -10°
- Aircraft descent and approach takes 30min, and SOFIA must land before 30min before sunrise.

# Flight Planning Timeline

*A flight series is an uninterrupted sequence of flights with one instrument. "T" is the start date of a flight series.*

- T - 2months: Series requirements defined:
  [T – 2months to T - 6wk: Flight planners work on flight series.]
- T - 6wk: "**Initial Series Plan**" released to Science and Mission Operations and to pilots and navigators.
  - The Series Plan contains detailed flight plans for all flights in a series.
  - The Series Plan gets reviewed for observing efficiency, target ranking, calibrator requirements, calibration times get adjusted
    [T-6wk to T-4wk: Science Operations and Flight planners iterate series plan until signed of by Director]
  - Observers get notified of possible chances to fly with SOFIA
- T - 4wk: "**Post-Science Series Plan**" released
  - This package gets reviewed by Mission Operations for flight constraints, schedule, etc.
    [T-4wk to T-2wk: Mission Ops and Flight Planners finalize Series Plan]
- T - 2wk: "**Post-MOPS Series Plan**" released. Final Series Plan

# Flight Planning Timeline

*"t" is the take-off time of an individual flight in the series.*

- t - 7d: "**Initial Flight Plan**" is submitted to the pilots.
  [t - 7d to t-3d: Pilots and Science Flight Planners iterate individual flight plan]
- t - 1d: "**t-36hWX Flight Plan**" Flight Planners submit the flight plan updated to the weather forecast from 12:00 UT (04:00 PST) the day before the flight.
- t-8to12h: "**t-12hWX Flight Plan**" submitted to pilots.
  Forecast from 12:00 UT (04:00 PST) the day of the flight.

# Summary

- Flight Planning starts with you!
  - Check source visibility with the visibility tool on the DCS web page or your favorite tool
  - Elevation range ~20°-60° plus moving observatory
  - ***If possible,*** choose your sources "opposite" of popular regions, ie. northern sources. Avoid sources that transit near the zenith.
- The flight plans go through many checks by Science and Mission Operations and pilots. No big changes after T-2m.
  ➔ Flight planning has a two month lead time.
- Once the flight plan is filed with Air Traffic Control on the day of flight, SOFIA has to stay on it.
  ➔ In general no adjustment of the observing sequence or even durations in flight.
- Questions: sofia_help@sofia.usra.edu

Thank you!