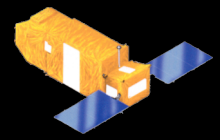
Far Ultraviolet Spectroscopic Explorer



The New FUSE Observatory: Status and Update of One Wheel Operations

Bill Blair

FUSE Deputy-PI and

Chief of Observatory Operations

FOAC Meeting, October 25, 2005

FUSE--A Brief History

FUSE-Dec. 1999

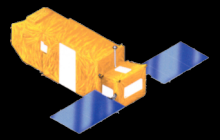
FUSE-Feb. 2002

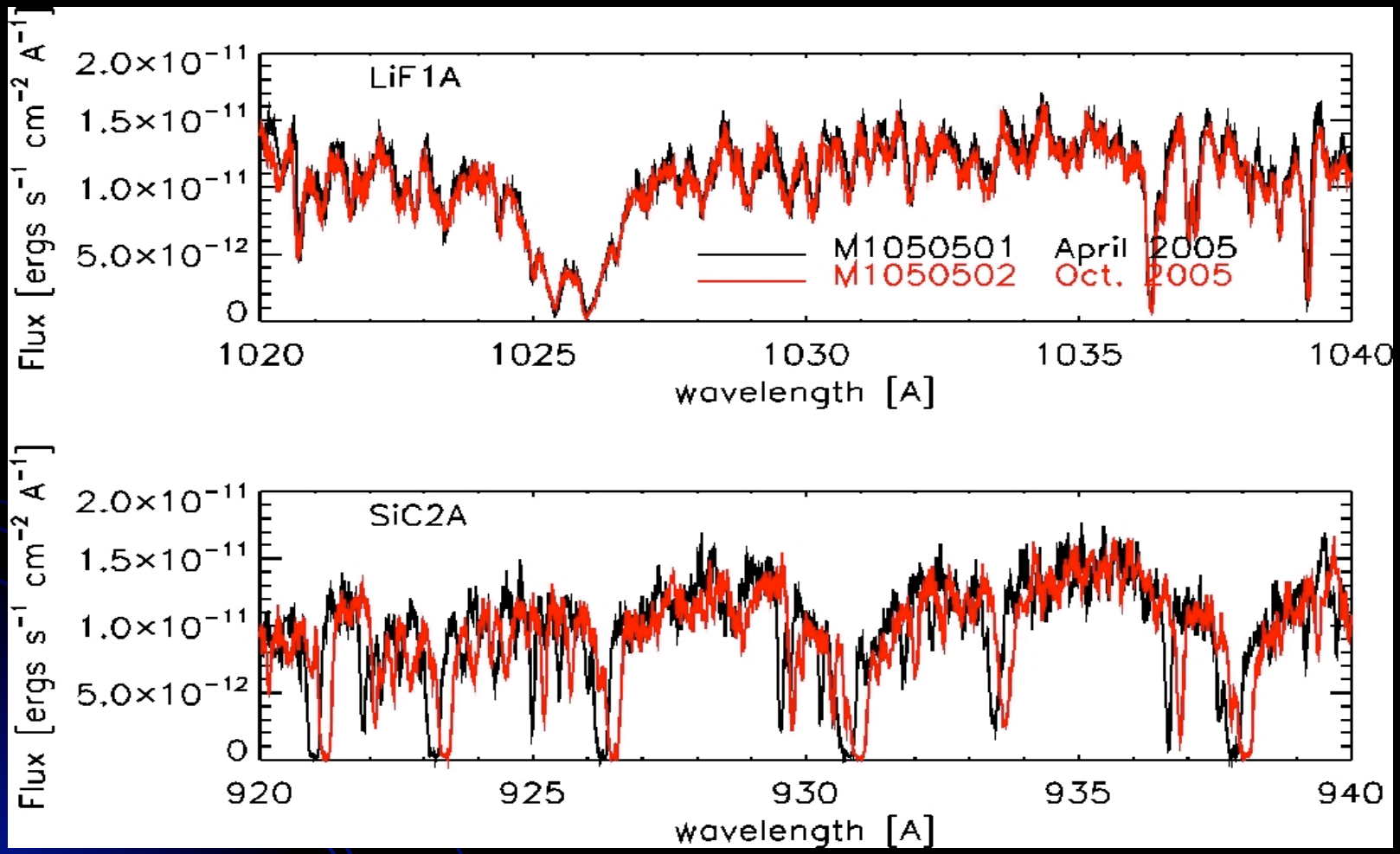
FUSE-Mar. 2004

FUSE-~~June~~ 2005

October 2005

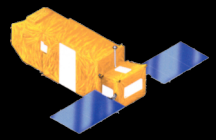
Science Instrument Status





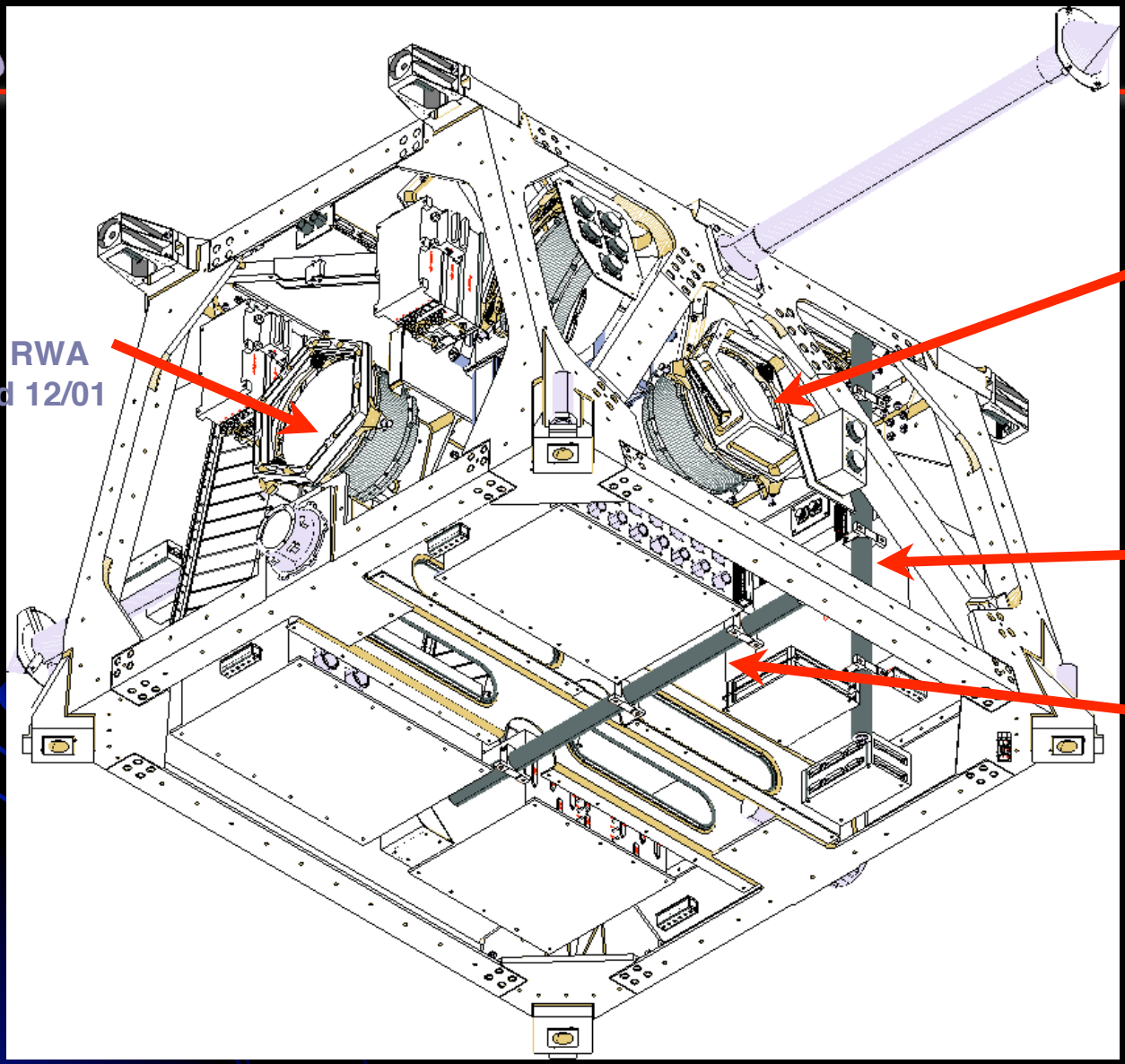
- M10505, CPD-71d172 (sdOB), comparison of data taken in Apr. 2005 and Oct. 2005. (Selected channels.)

One-Wheel Ops
A Primer

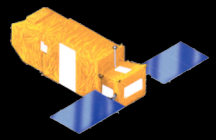


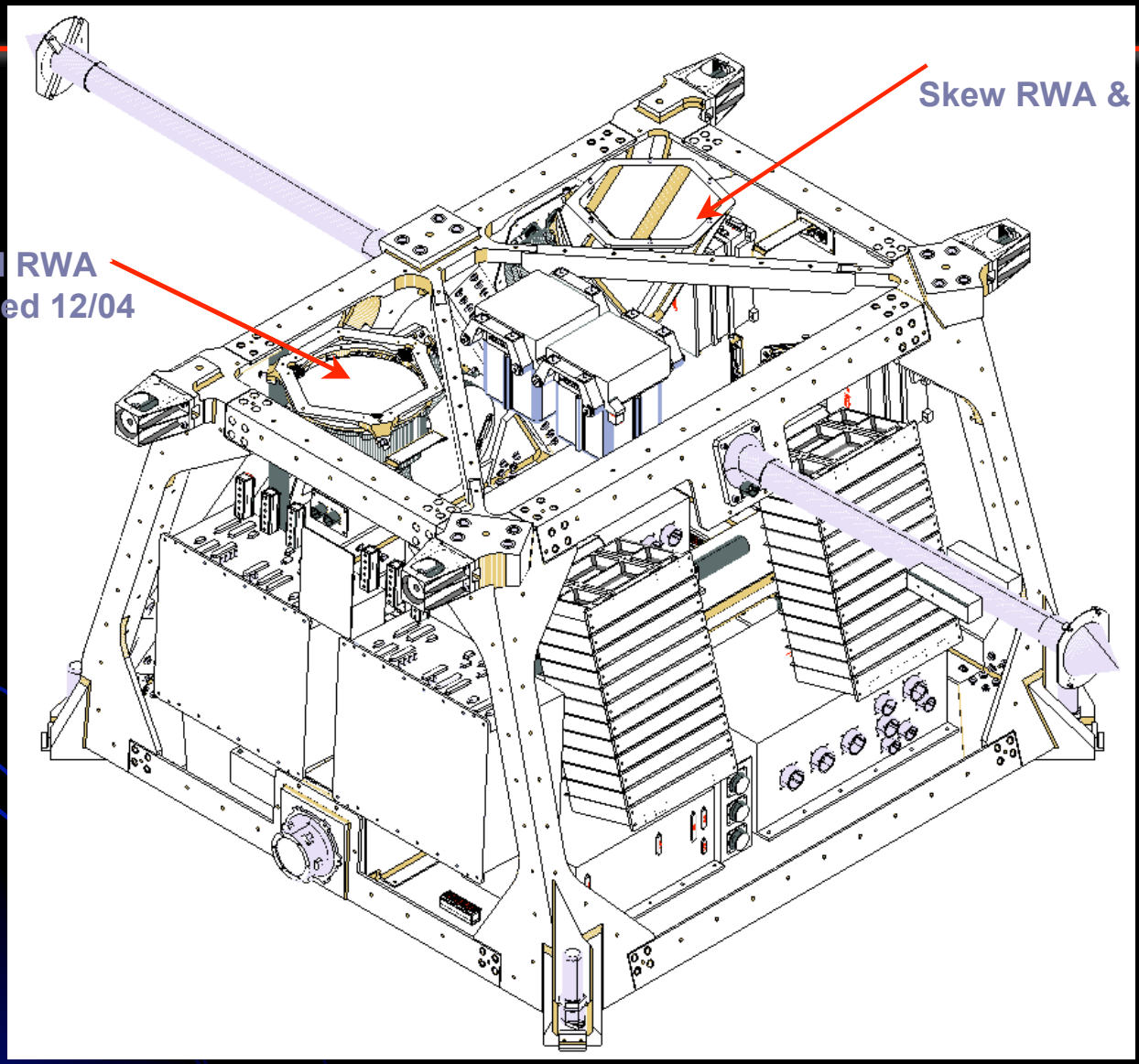
- Attitude Control System (ACS) is the S/C software that controls pointing.
- Only Wheel remaining is the Skew Reaction Wheel.
  - +/- 6500 rpm top speed (+/-21 Nms).
  - Higher wheel speeds mean more gyroscopic torques when slewing.
  - We “plan” to keep this below +/-15 Nms.
- Three Magnetic Torquer Bars (MTBs) mounted on the body axes of the satellite, need to share duty between control and momentum unloading for the wheel(s).
- Two-axis Magnetometers (TAMs) provide attitude knowledge to +/-2 degrees.
- FES (controlled by the IDS) provides Fine Pointing Data (FPDs) to the ACS.

Internal Configuration (1)

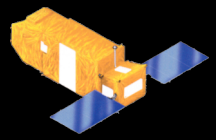


Internal Configuration (2)





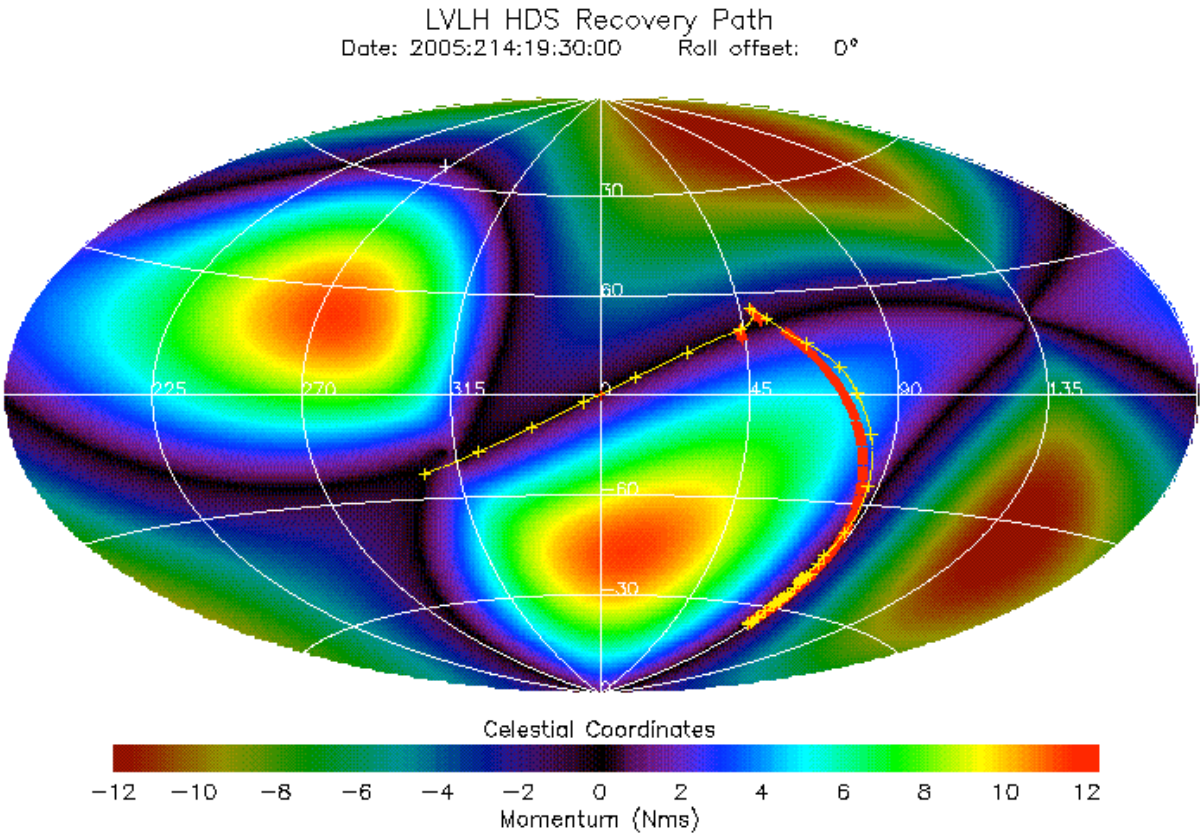
LVLH Safe Mode



- LVLH (Local Vertical Local Horizontal) is a nadir-pointing, non-inertial safe mode.
  - Have implemented improved (and automated) Solar Array tracking.
- Because it in not an inertial pointing mode, transitions back from LVLH to an inertial pole-pointing (pick up point) can be difficult to find.
  - Nominally “safe” slews are found with the HDS.
  - Typically just a few opportunities “per day” are found, and sometimes secondary criteria make some of these undesirable.
  - TDRS or other contact times must be arranged to monitor slew progress and attempt intervention if needed.
- Once at an orbit pole, we must “match momentum” with a planned timeline before picking up.
  - Typically end slew with moderately high momentum on the wheel.
  - By design, we try to keep momentum relatively low on timelines.

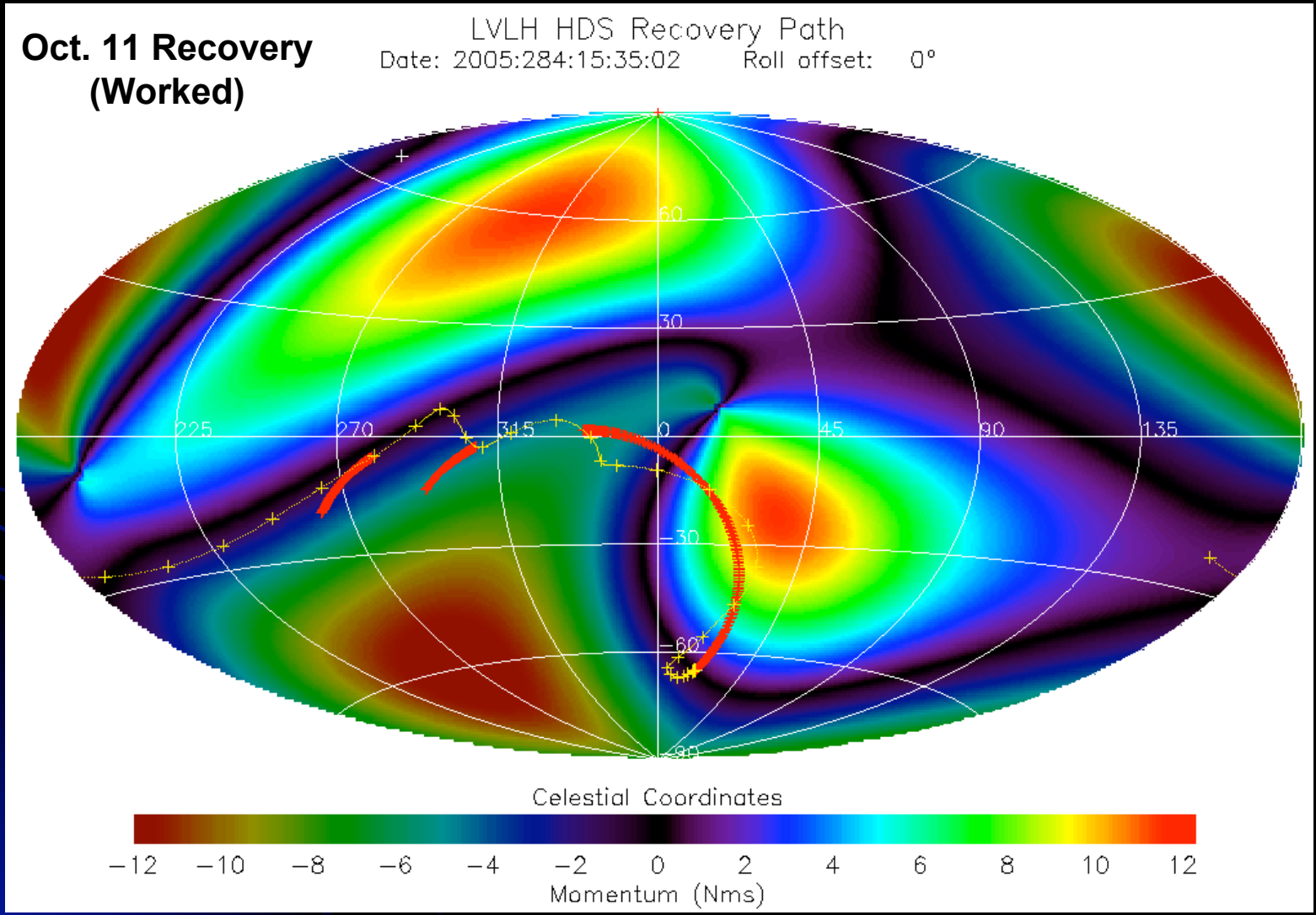
LVLH Recovery Prediction
(on Gravity-Gradient Rate Skymap)

Red track: commanded path.
Yellow track: Predicted path.

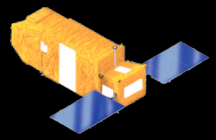


LVLH Recovery Prediction
(on Gravity-Gradient Rate Skymap)

Oct. 11 Recovery (Worked)

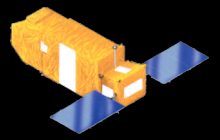


One-Wheel Ops
A Primer, cont.



- Unloading is most effective when B-field is perpendicular to the skew axis.
  - Allowed angles for unloading are controllable. (“Manual unloading”)
  - When wheel speed exceeds a setable threshold, unloading kicks in automatically and tries to reduce wheel speed.
  - With two-wheels, momentum could be traded between them both and the MTBs, providing flexibility and better sky coverage. We no longer have this luxury.
- There are many parameters within the control system that can be tweaked to improve performance, but some of them interact in ways that make prediction of performance difficult.
- Predictive tools, such as the Hybrid Dynamic Simulator, are only accurate to a point. There are non-deterministic aspects that drive simulation and reality apart.

Timeline of Events and Milestones since Last FOAC

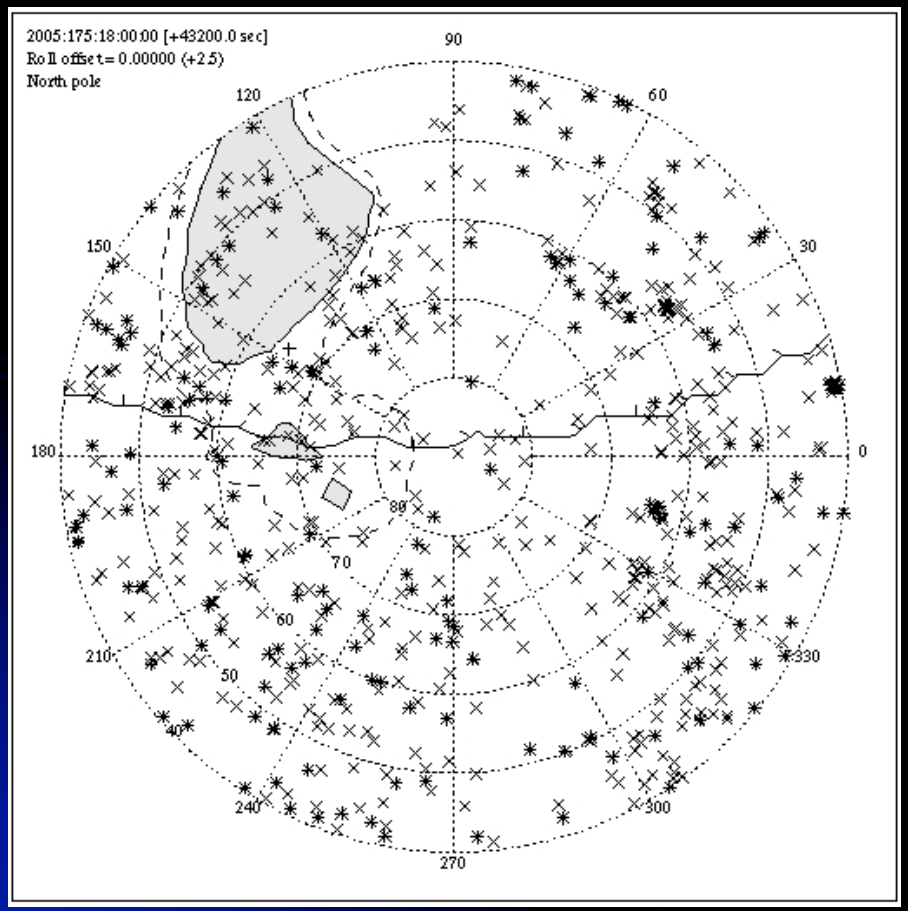


- Officially Switched to FES-B for Operations (mid-July)
  - LiF2 is now held in position, while LiF1 and SiC channels drift.
    - Little impact for LWRS observations.
  - LiF2 FPA refocussed for better FES performance.
    - May affect throughput in MDRS but spectral resolution not impacted.
  - Performance of FES-B has been nominal.
- Implemented Programs to Address Lack of Targets in Accessible Regions of Sky
  - S605/S705 Pole Background rings (pre-defined positions, N&S).
    - Late-July 2005
  - "U" programs: ~600 previous FUSE targets made available for standardized, plain vanilla LWRS, 8 ks, observation requests.
    - Mid-August 2005
    - Will reduce the amount of time we spend on backgrounds.

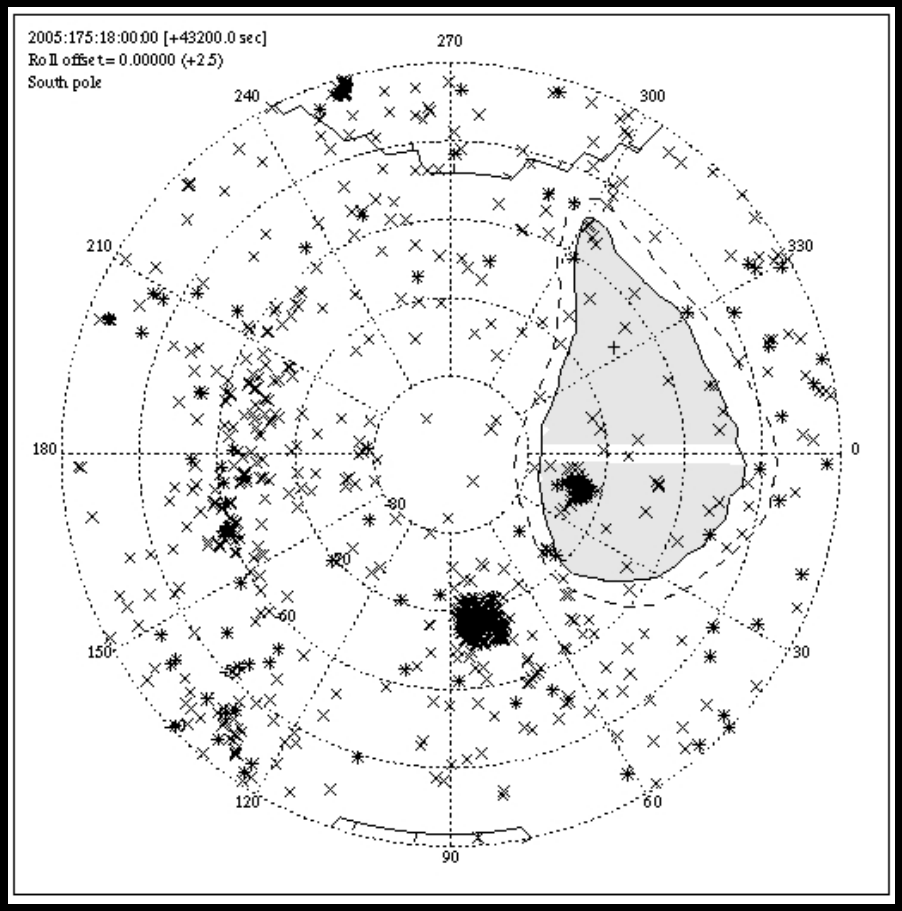
All targets near the poles

- "U" programs are a substantial subset of the targets shown, minus very bright targets and minus the Magellanic Clouds.
- Approx. 600 "Plain vanilla" 8 ks LWRS observations.

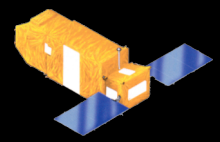
North



South

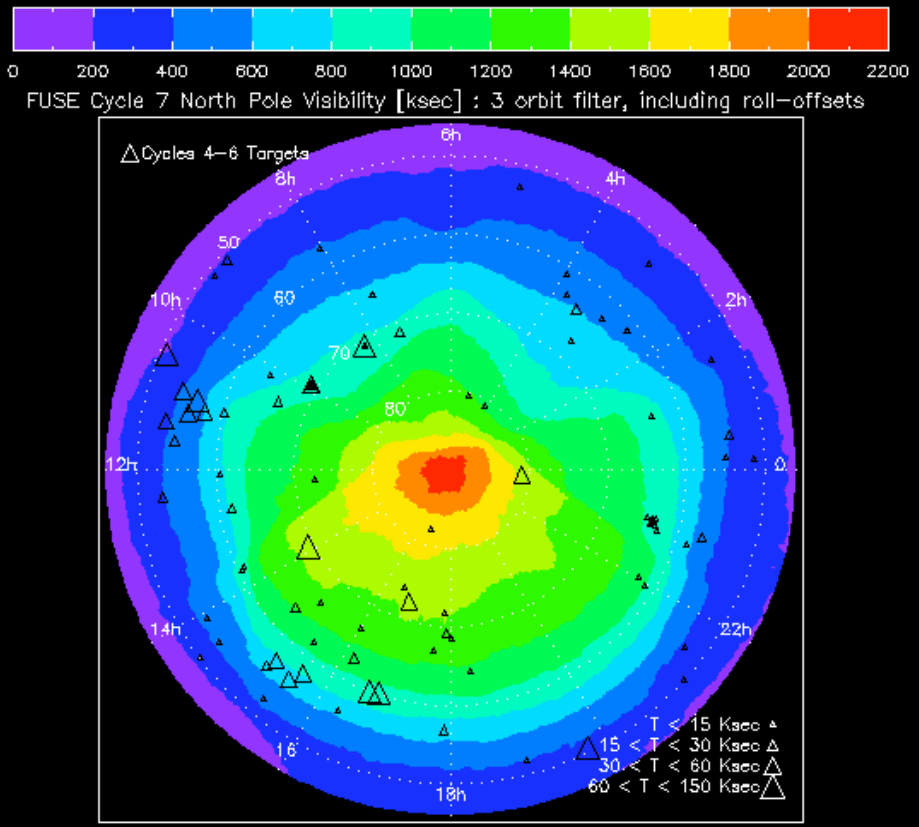


Pending targets near the poles

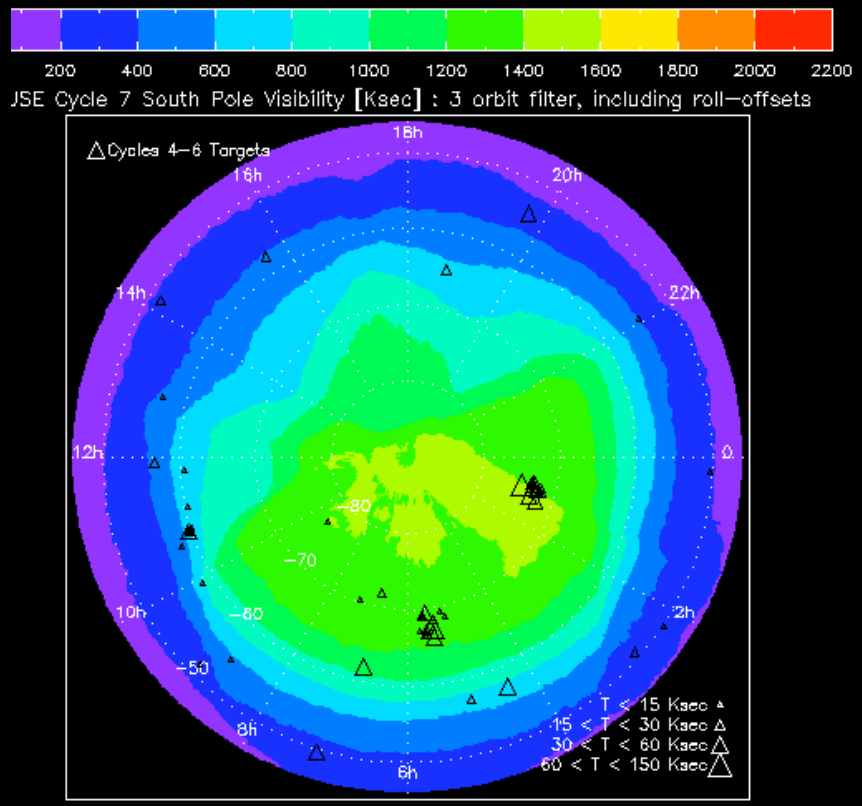


- Numerous areas with few pending targets in current pool, especially in the south.

North

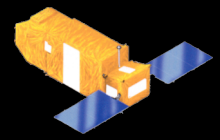


South

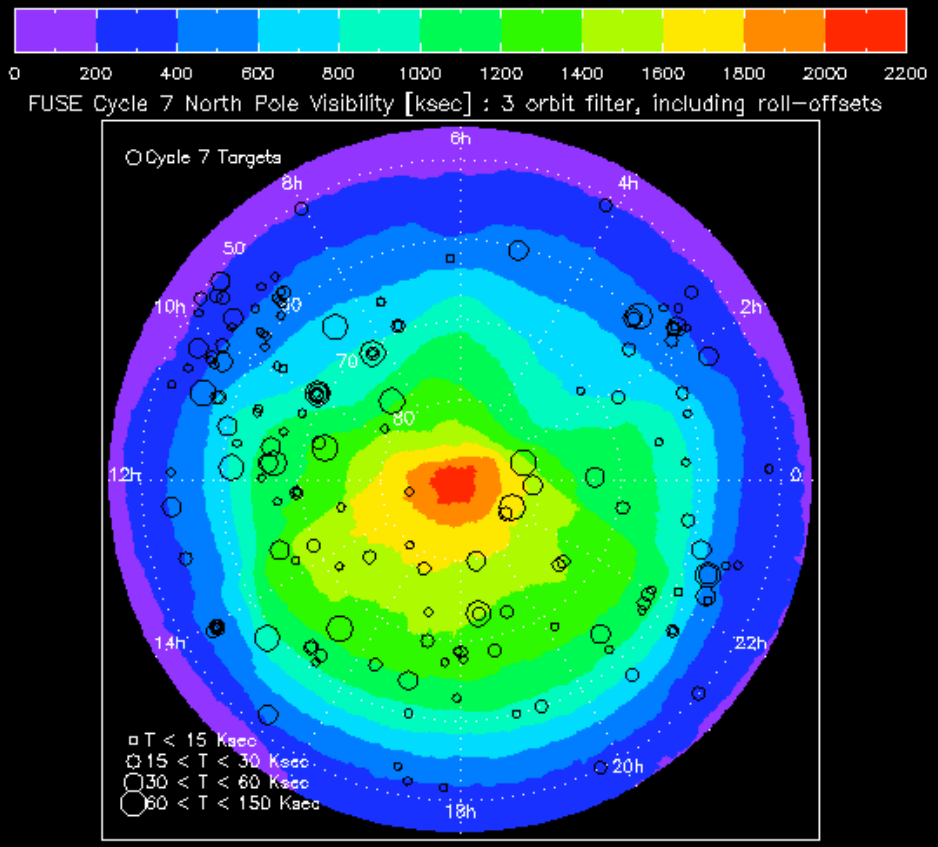


(Note: Size of symbols scaled to requested integration time.)

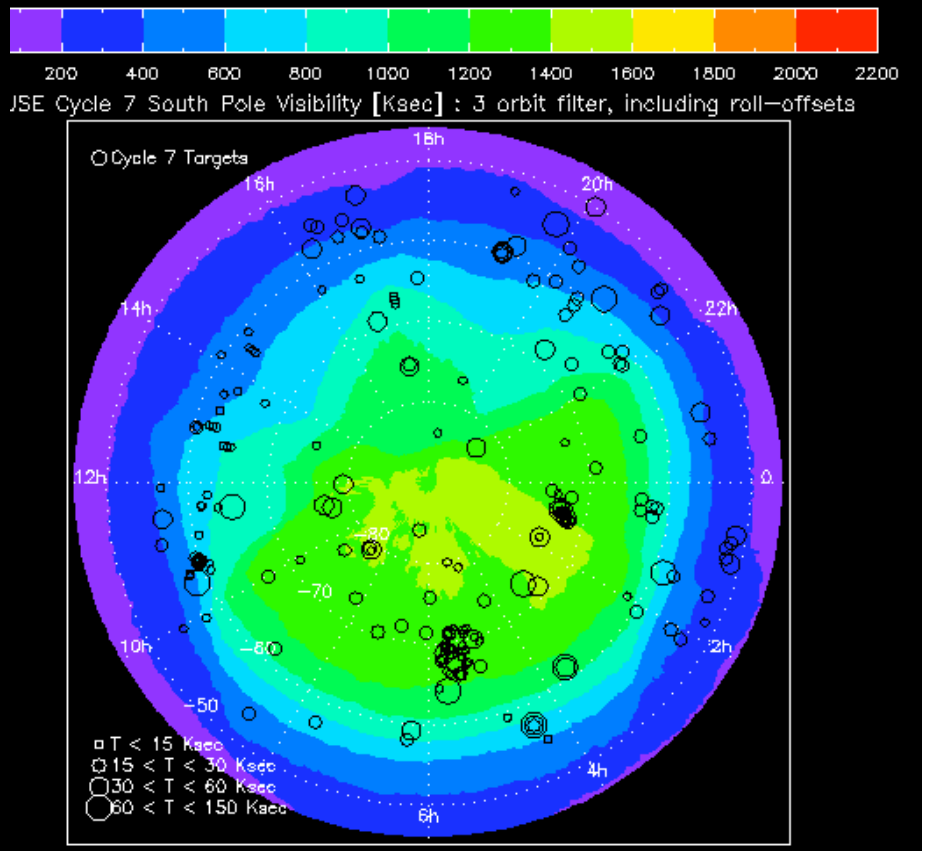
Cy 7 Proposed Targets



North

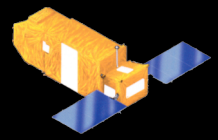


South

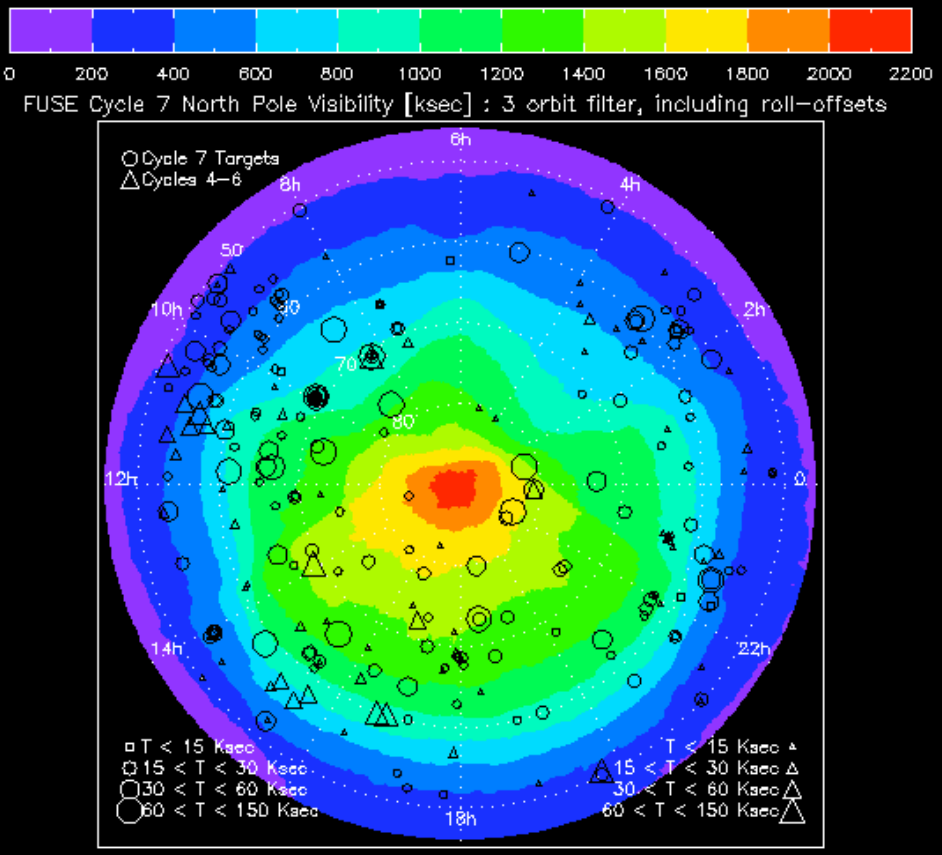


(Note: Size of symbols scaled to requested integration time.)

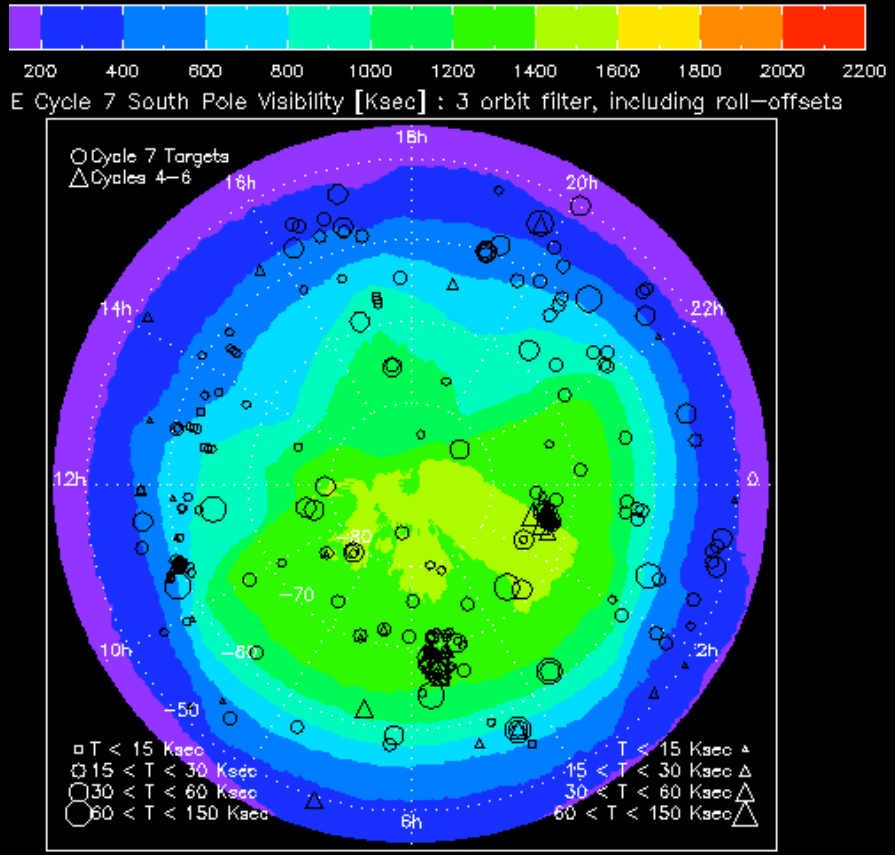
Pending + Cy7 Proposed



North



South



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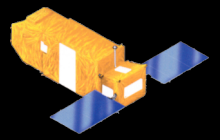
Timeline of Events and Milestones since Last FOAC, cont.

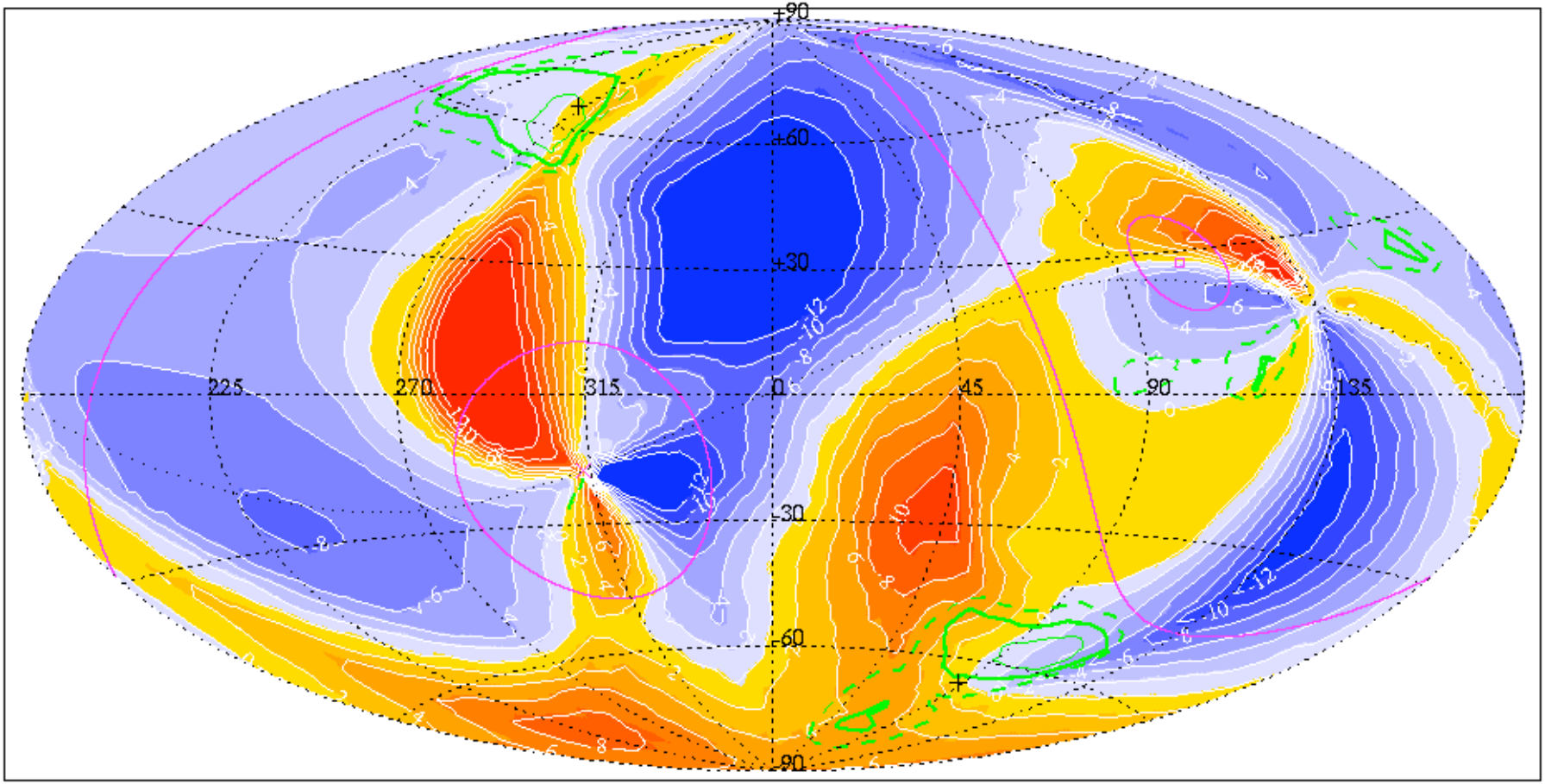


- Improvements to momentum management in operations.
  - Early July: Developed tool to calculate and plot momentum buildup per unit time as a function of sky position.
  - Integrated L-buildup and TACO tools for better target/momentum management.
  - Early August: More aggressive use of roll offsets in momentum management.
  - End of August: Essentially “turned off” manual unloading and manage momentum strictly by target/pointing selection pattern.
  - MP tools and procedures continue to improve as we learn.
- Late-July: Revised IDS Code/scripts reloaded.
- Still in progress: Improved ACS-IDS handshaking, especially vis a vis handling of bad FPDs.

Momentum Rate of Change

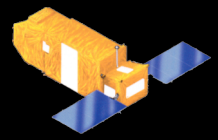
2005:214:19:00:00
Roll offset = 2.5 (-2.5)
[+3 orbits] estimate

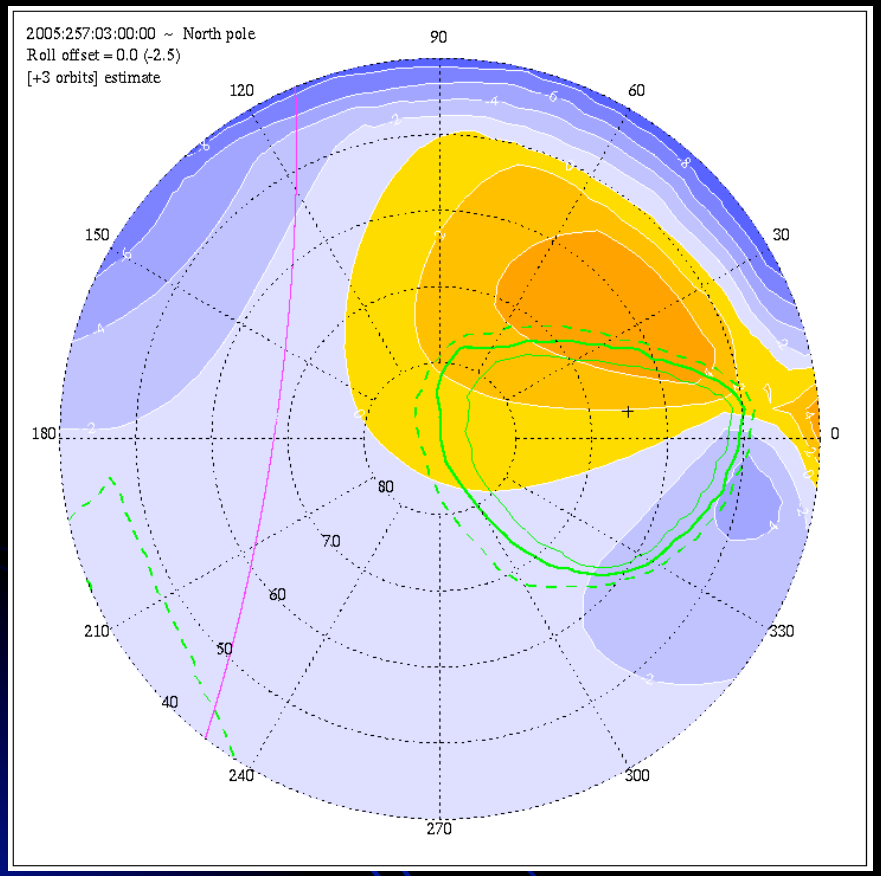
Contours are +2 (red) and -2 (blue) Nms of momentum change per orbit at a given position on the sky.



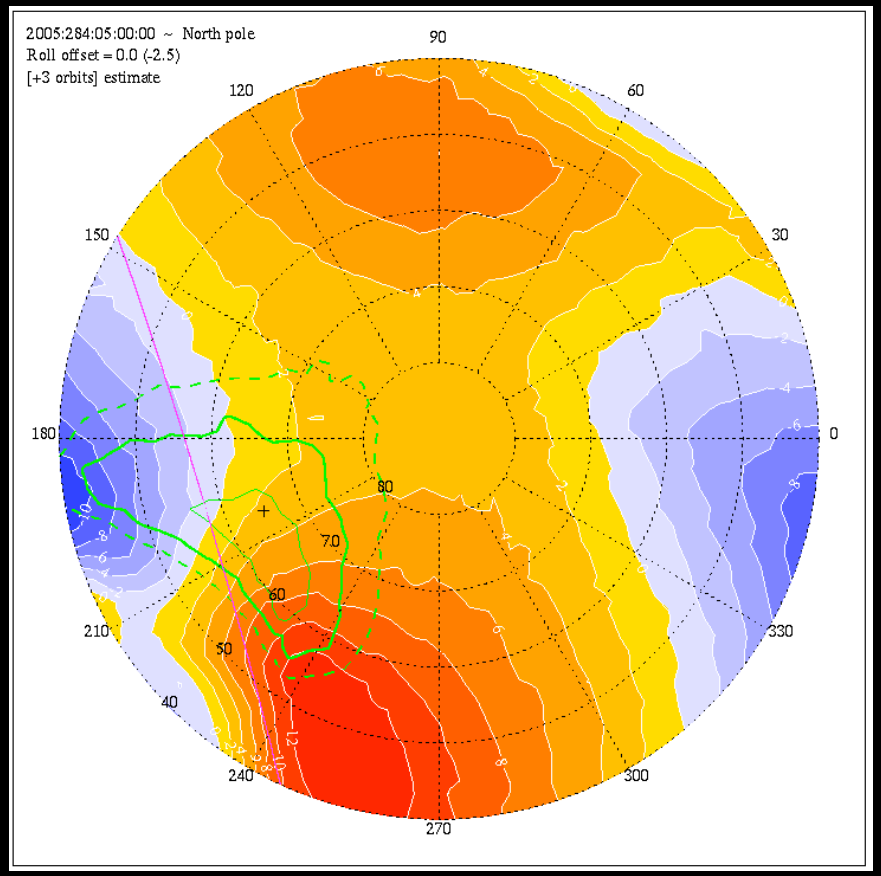
These maps are dynamic on a several-orbit timescale.

Momentum Management



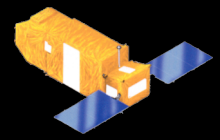


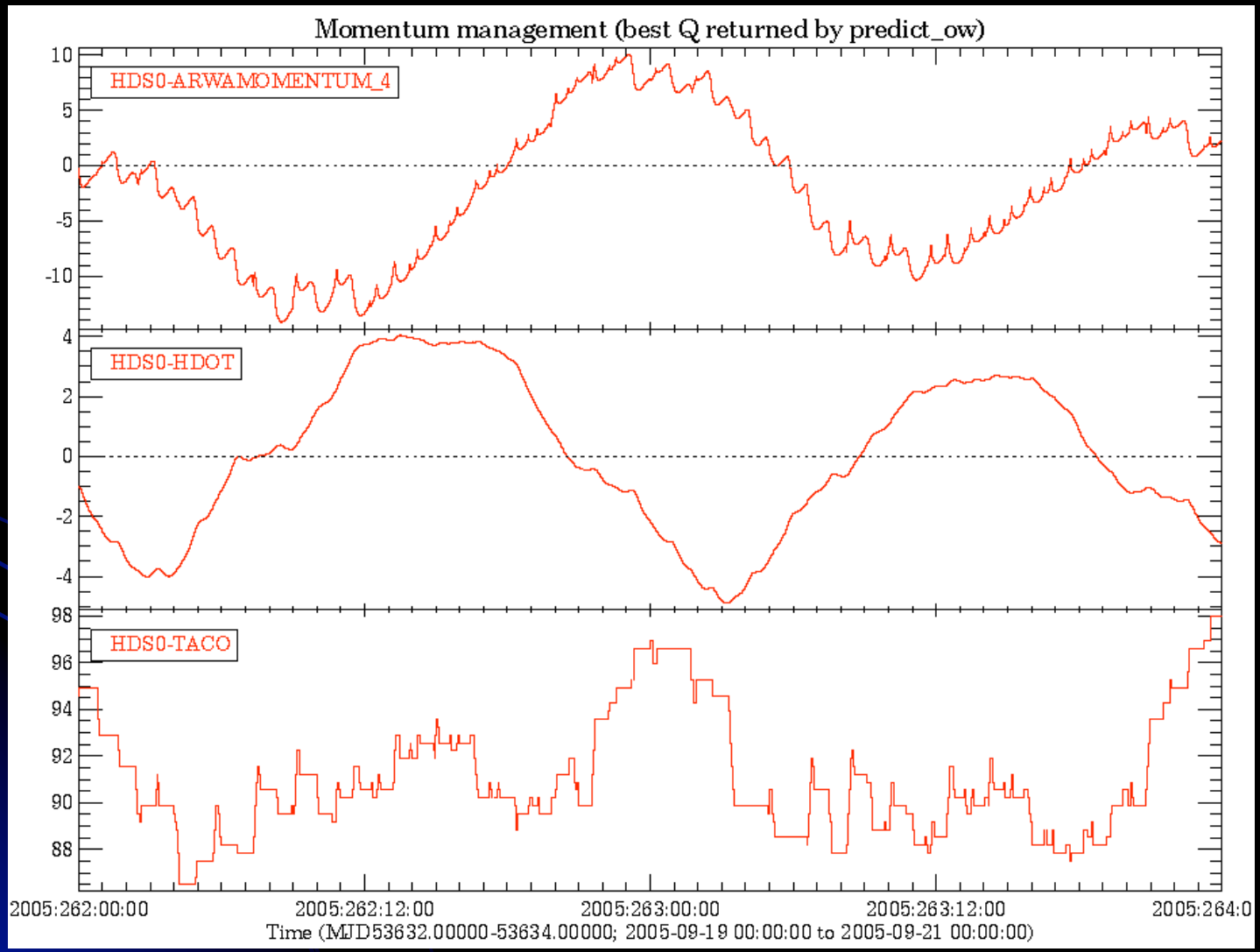
Happy days…
(Shallow contours and good mix of colors.)



Not-so-happy days…
(Tighter contours and dynamic TACO region.)

Momentum Management Using Target Positions



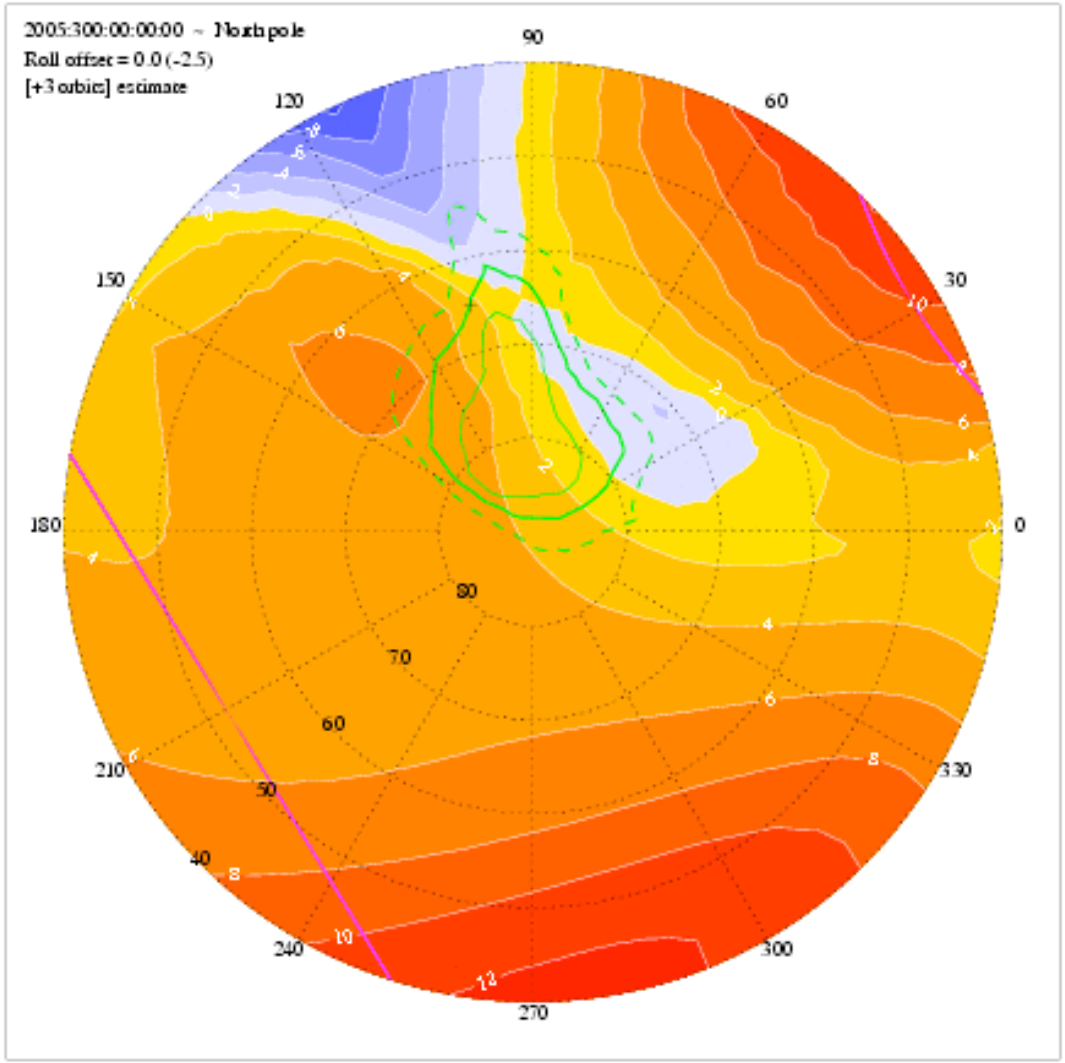


Dynamic Conditions

For nominal roll angle.

Can also change pattern by using roll offsets.

(2nd order effect.)



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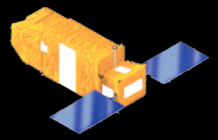
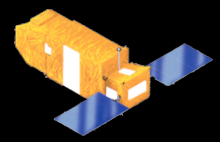


- Supported Cycle 7 NRA preparation and proposal ingest.
  - NRA prep work, documentation updates, sky visibility plots.
  - Prep for Technical review and support of proposal ingest.
  - Tech review in progress; prepare TAC support materials.
- ACS Code (E32) preparation, development, and testing.
  - Was begun prior to last FOAC.
  - Ground testing and debugging took longer than anticipated.
  - Prep to load both processors A and B (different configs).
  - Load and safe mode testing, week of Sept. 14-20.
  - On-orbit testing/debugging took approx. one month.
- Ground Station issues.
  - UPRM LEO-T has been down for ops since mid-August.
    - Making do with Wallops (4/day) and TDRSS.
    - UPRM repair situation has recently received heightened priority @ NASA/GSFC and HTSI.
  - Capability with USN-Hawaii has been re-established.

August 2005 Performance*
(Hope for the Future?)



August, 2005 – Estimated Summary of Performance
9/7/2005

NOTE: Some jitter data currently not processed; therefore, *italicized* values are estimates.

Scheduling vs. Guiding

Prog Type	# obs sched	Time Sched (ks)	Time Guiding (ks)
D9xx	1	6.3	0.0
E5xx	6	129.7	22.6
E9xx	6	113.8	79.3
F0xx	1	17.7	0.0
F3xx	4	60.2	19.5
M	5	43.9	9.4
S	23	420.2	90.5
TOTALS	**46**	**791.8**	***221.2***

August Summary

Statistic	Time (ks)	%
Total Time Available (31 days)	2678.4	
Total Scheduled	791.8	29.6%
Total Guiding	*221.2*	8.3%

LVLH #

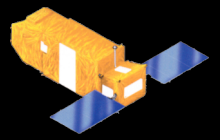
	Number	%
Days affected by LVLH	12	38.7%
Obs affected by LVLH	23	50.0%

***Still very much on the learning curve.**

#LVLH = "Local Vertical Local Horizontal" (Nadir-pointing Safe Mode).

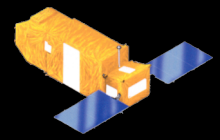
Analysis courtesy of Alice Berman, FUSE MP.

To Do List



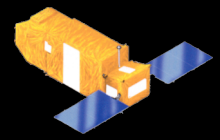
- Consider different/better slew algorithms.
  - Currently use eigenaxis slews.
  - Can play with slew rates and acceleration limits, but
  - Different slew algorithms may provide more flexibility.
    - Would require further ACS s/w development.
- Continue to carefully analyze telemetry/performance, improve tools, and refine control parameter settings.
- Improve ACS-IDS handshaking.
- Pursue better integration of unloading and control to improve sky coverage.
- Streamline/simplify/increase robustness of LVLH recoveries.
  - We are likely to continue to go to LVLH occasionally, so let's improve recovery from it.

The New FUSE Observatory



- One-wheel operations near the orbit poles have been demonstrated and are feasible.
- Pointing as a function of time will be driven largely by momentum management concerns. Hence,
  - Efficient operations will require substantial target density on the sky and flexibility to pick and choose targets that “work” --> larger Suppl/survey target pool.
  - And/or accept a larger fraction of random sky background observations.
- A relatively smaller fraction of “standard” proposals can be done, since they effectively act like “constrained” targets in the old FUSE model.
- Relatively few long observations can be accomplished, and these will typically require multiple visits (perhaps even over multiple precession cycles) to accomplish.
  - Shorter observations “near” these long observations may be difficult to schedule, as the longer observation will use up the available resource.

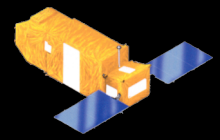
The New FUSE Observatory



The FUSE Operations Team is ready to declare the Observatory is back in Science Operations.

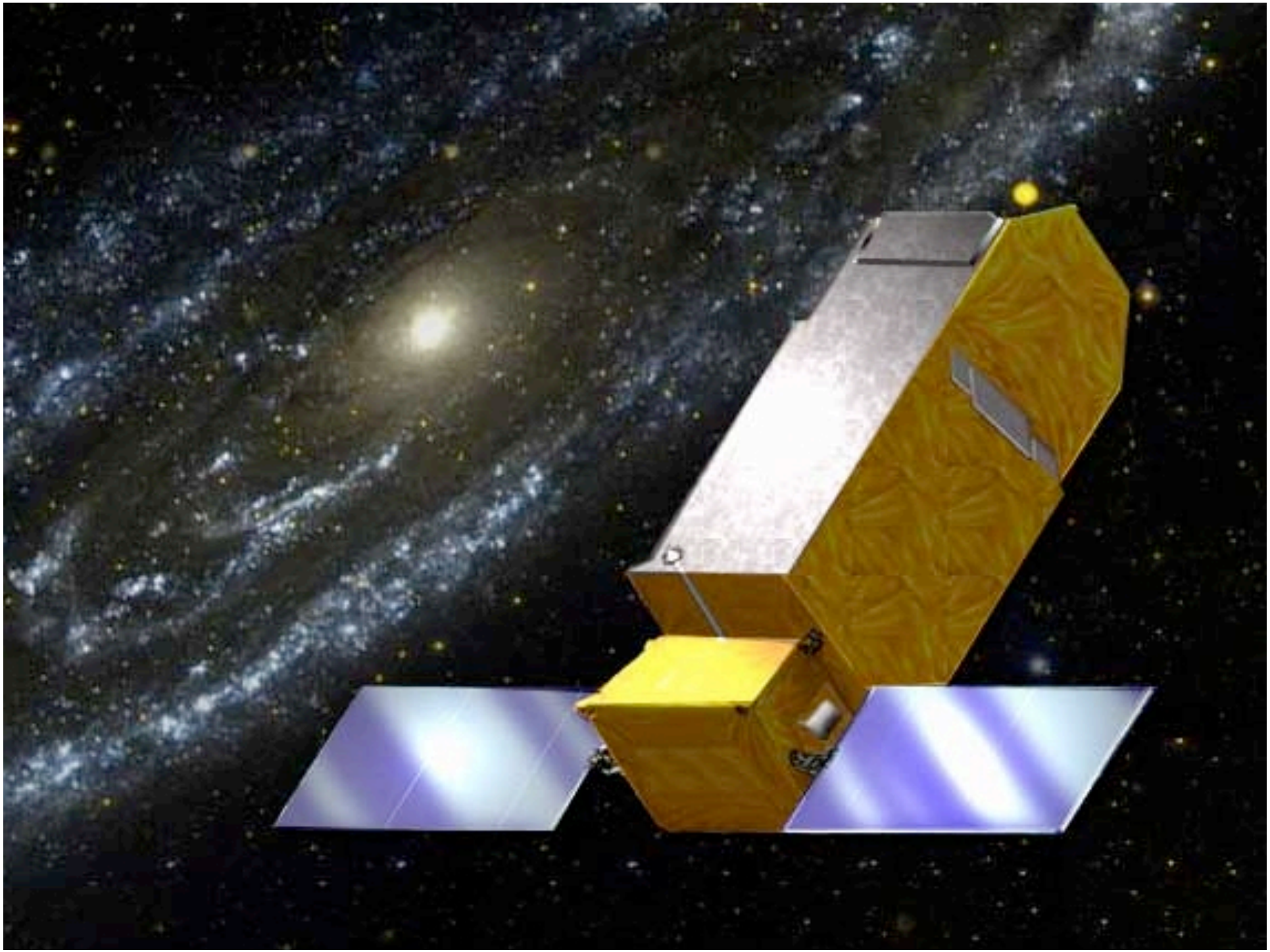
We are open for business.

Staffing/Personnel



- Science Operations Team [17people, ~14 FTE]
  - Two Staff added in mid-August
    - Mark Kochte (primarily mission planning)
    - Bob Boyer (telemetry analysis, programming)
  - Three Staff have left*
    - Jean Dupuis (end of June) [Calib. and User Support]
    - Ravi Sankrit (end of August) [User Support]
    - Alex Fullerton (CSA) -> JWST [General Ops Support]
- Mission Operations Team (Control Center) [8]
  - Two staff added (one temp. employee hired on as full time employee and one new hire last month).
  - Currently supporting 16/7 operations of SCC.
- Administration/Management [3]

***Science research staff member Gerry Williger also departed Aug. 2005.**



TACO Plot Examples

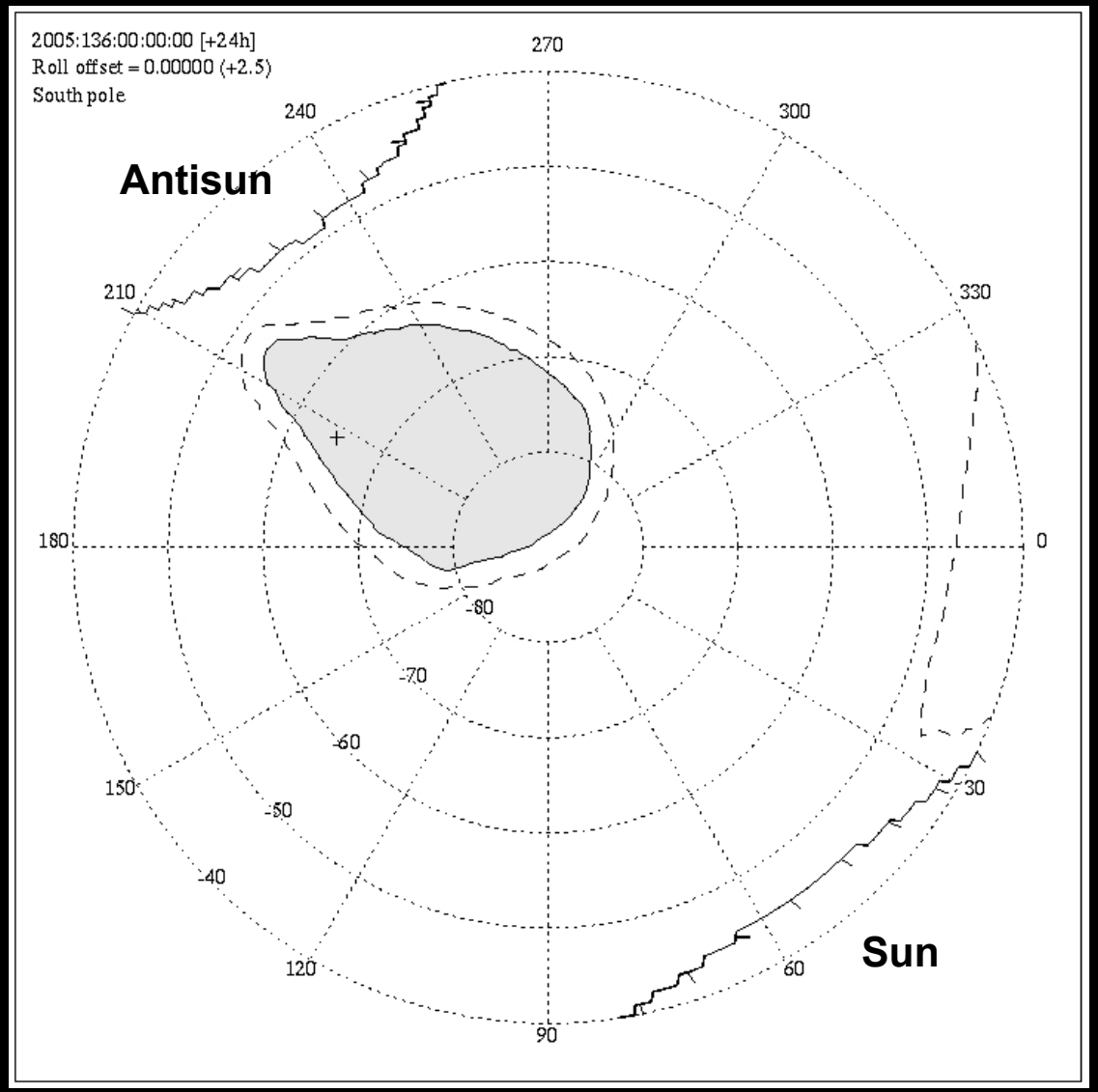
Shows regions where MTB torque is greater than expected gravity gradient disturbance.

Stable region for 24 hours (time selectable)

Solid line: 90% of time is stable

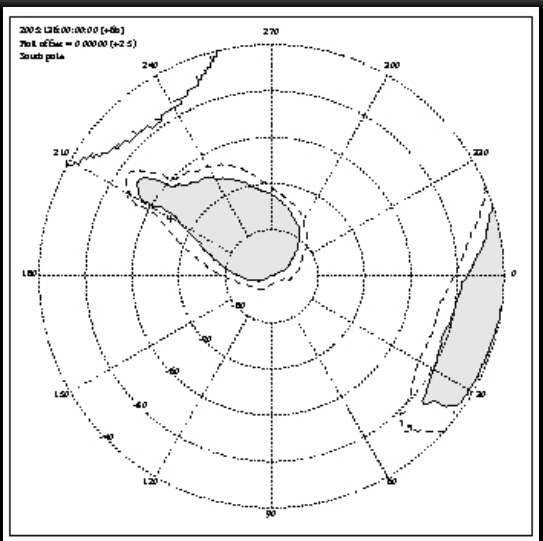
Dashed line: 85%

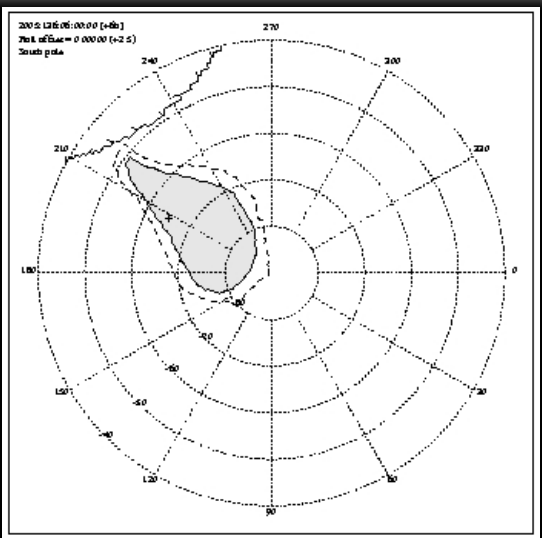
+ is orbit pole (south)



Day 136, 4 6-hour TACOs (relatively stable)

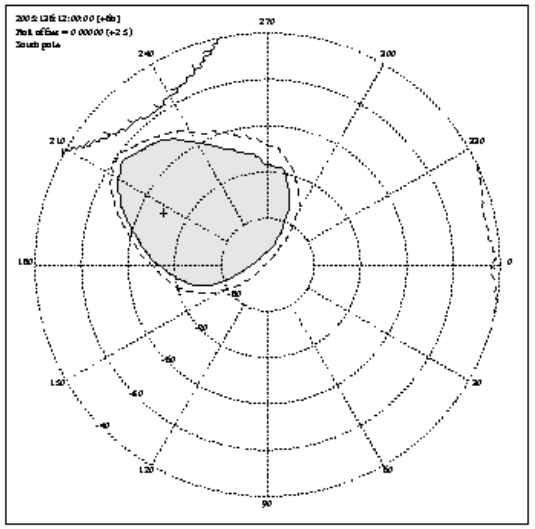
0 - 6 UT

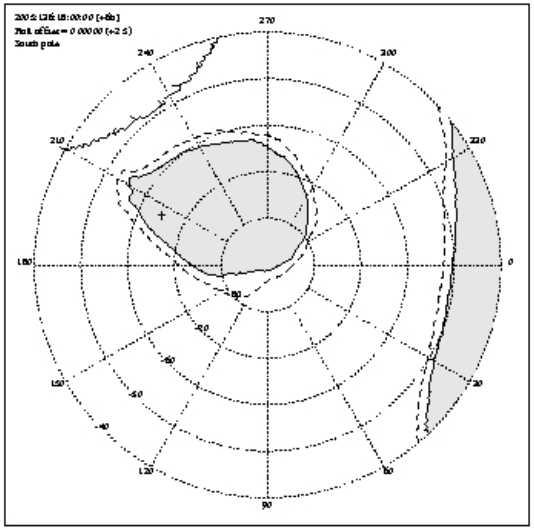




6 - 12 UT

12 - 18 UT

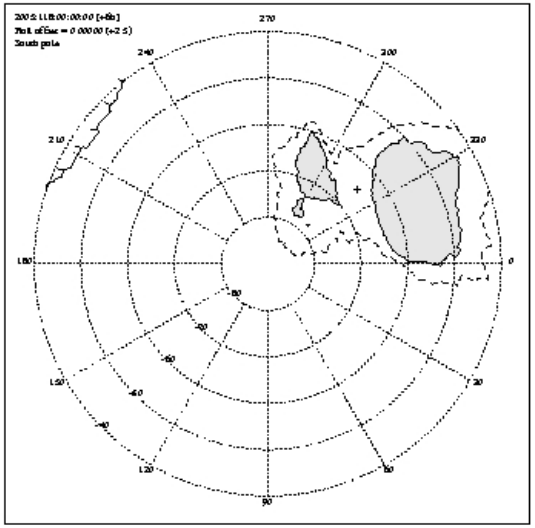




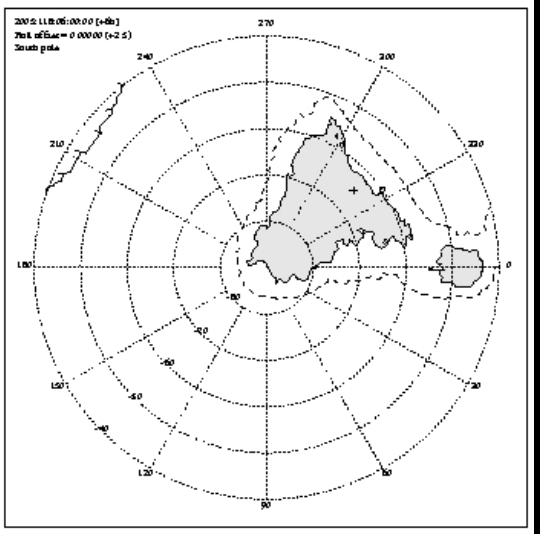
18-24 UT

Day 118, 4 6-hour TACOs (relatively dynamic)

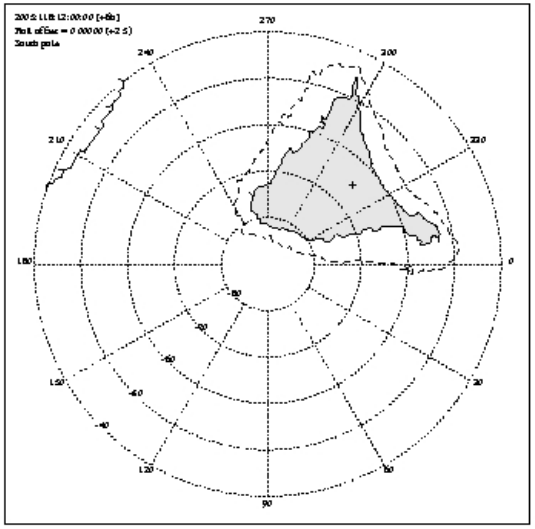
0 - 6 UT



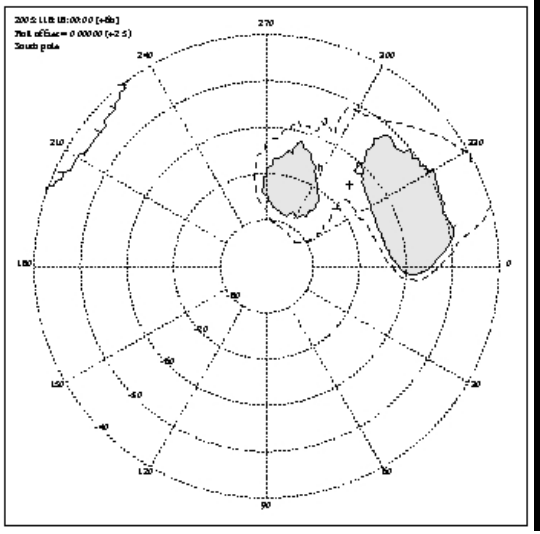
6 - 12 UT



12 - 18 UT

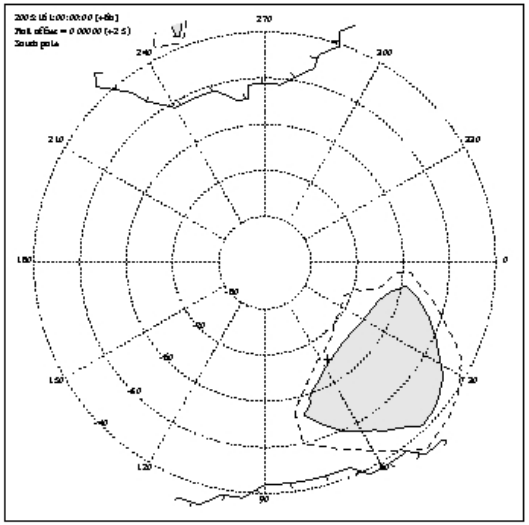


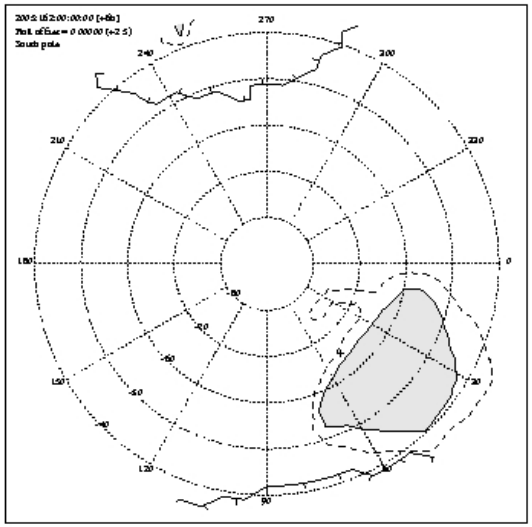
18-24 UT



Day 161-164, 6-12 UT (repeating stable regions)

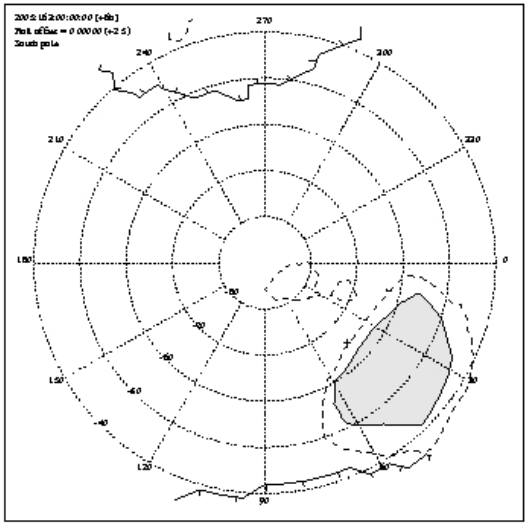
6 - 12 UT
d161

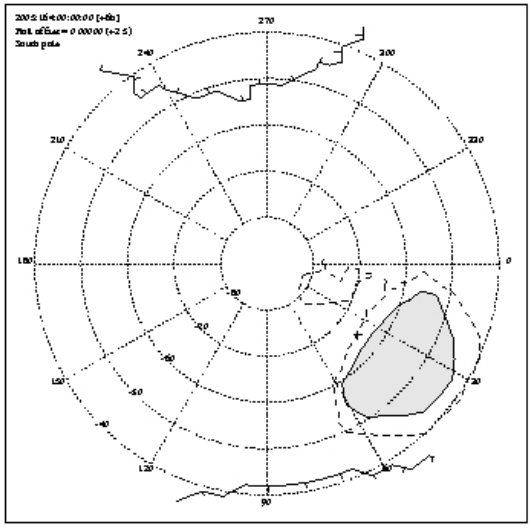




6 - 12 UT
d162

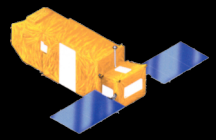
6 - 12 UT
d163





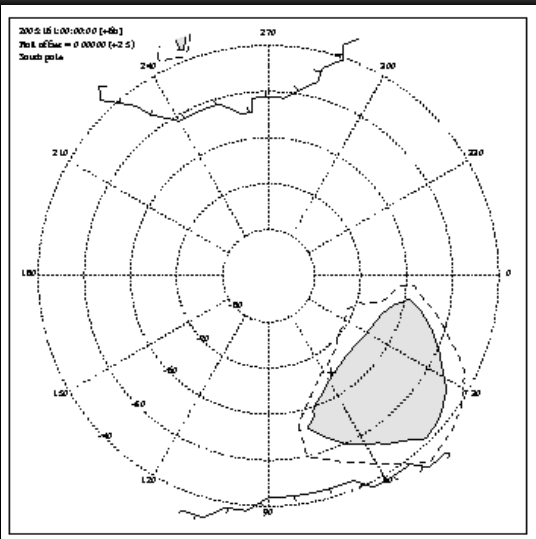
6-12 UT
d164

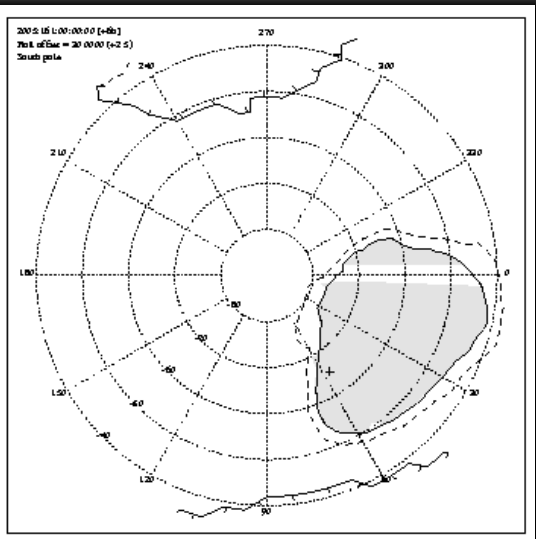
Affect of Roll Angle

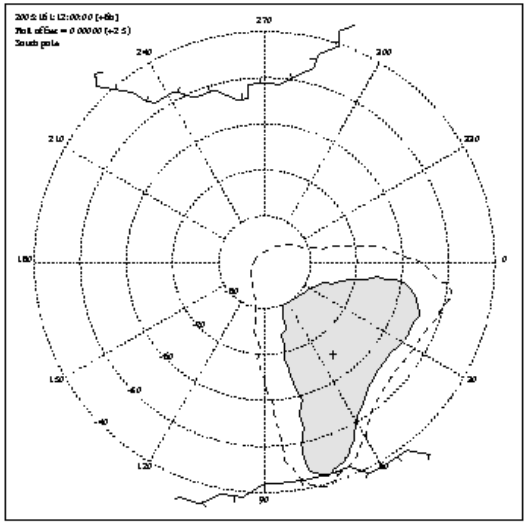


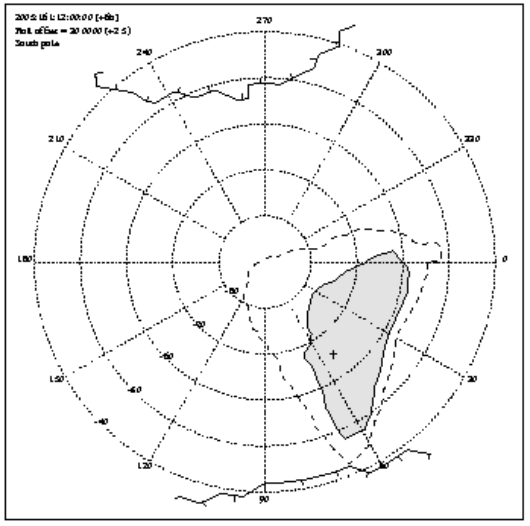
Left: Nominal roll

Right: Roll +30
For the same times.









PRELIMINARY 1-wheel
Sky Coverage Estimate-Roll Offsets