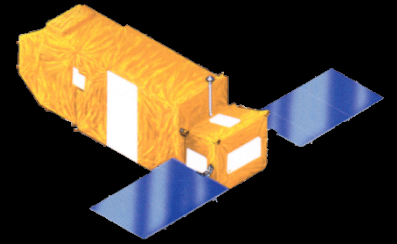


FUSE

JOHNS
HOPKINS
UNIVERSITY



FUSE Mission Status

Bill Blair

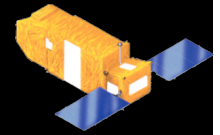
FUSE Deputy PI

Chief of Observatory Operations

FOAC Meeting--June 9, 2005

At JHU

Overall Performance (as of 12/31/2004)

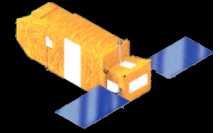


Summary of All Science, Cycles 1-5.7

Cycle	N(obj)	N(obs)	Sci. Time (ks)	Eff (Tot/Pri)%
1	623	884	8914.6	28.2/28.2
2	527	736	9781.6	31.0/28.5
3*	522	868	13387.3	31.9/17.9
4	416	689	11995.1	37.9/22.3
5	234	433	7309.2	31.3/22.4
TOTAL	2322	3610	51387.8 ks	

*Cycle 3 was 16 months including 2 months of down time.
(Info thanks to Alex Fullerton.)

FUSE--A Brief History



FUSE-Dec. 1999



FUSE-Feb. 2002

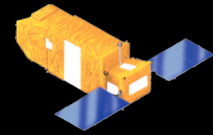


FUSE-Mar. 2004

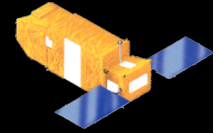


FUSE-June 2005

Loss of Roll RWA-Chronology



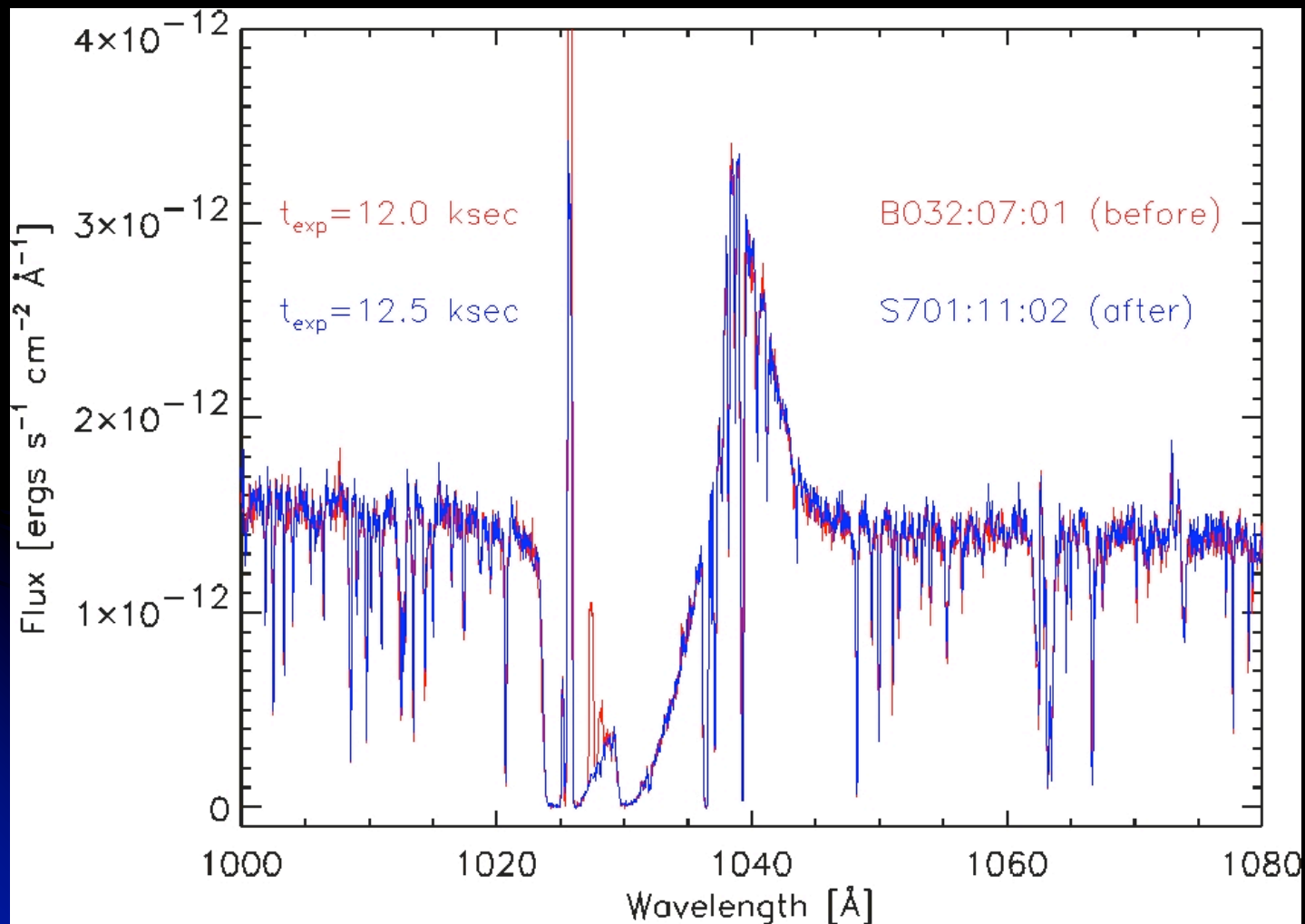
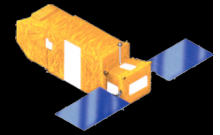
- **Dec. 27, 2004: Roll RWA stopped, leaving only 1 operational wheel (Skew).**
 - Safe Pointing Mode in (roughly) an antisun direction.
 - But SPM with 1-wheel not “safe”. Required nearly constant attention and manual interaction to maintain power-positive config.
- **Jan. 20, 2005: New Safe Mode, “LVLH,” uplinked.**
 - “Nadir” pointing safe mode (i.e. not inertial pointing).
 - Stable to gravity gradient disturbances, but very limited power.
- **Feb. 8, 2005: Revised LVLH mode with “yaw steering” uplinked.**
 - Improved solar array pointing when sun far off orbit plane.
- **Up to this point, little effort available to put toward a “fix.”**



Chronology, con't.

- **Mid-Feb. to mid-Mar.:** Develop and test 1-wheel control s/w.
- **Mar. 22, 2005:** Uplink revised (initial) 1-wheel ACS s/w.
 - Testing slews and stability with doors still closed.
 - Sat at a position 20° off-pole for >5 hours as a test.
- **Mar. 28, 2005:** Opened doors and returned to limited science operations.
 - Observed previous, new, and bkgd positions, mainly at $<5^\circ$ off pole.
 - Demonstrated sub-arcsec pointing control on the fine controller.
 - Demonstrated no significant loss of sensitivity from downtime.
 - (Demonstrated momentum unloading will be a pain to deal with!)
- **Apr. 17, 2005:** Lost last remaining roll axis gyro --> LVLH with doors closed.
 - Initial ACS s/w required 3-axis gyro control for fine pointing (science).

1-wheel Operations: Sensitivity check

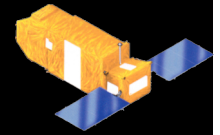


**IC2448
PN Central Star**

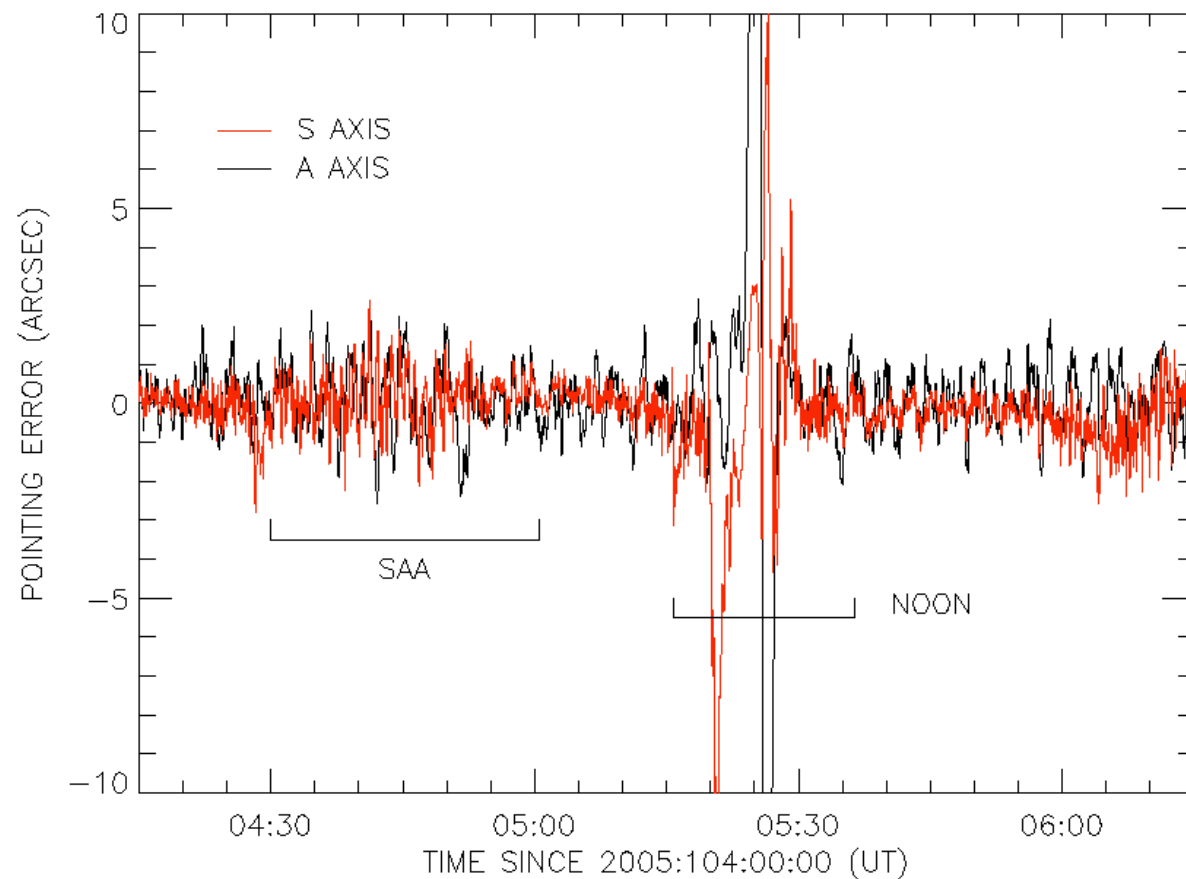
**Before:
March 2002**

**After:
March 2005**

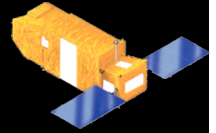
1-wheel Operations: Pointing Performance



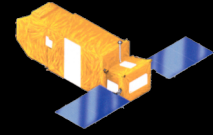
RMS ~1"
during
useful part
of orbit
(Well within
LWRS)



Since April 17



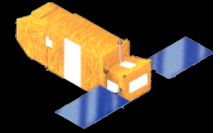
- On the Spacecraft side...
 - Developed, tested, and loaded 3 separate ACS s/w patches.
 - Allow <3-gyro control for fine pointing.
 - Tweaks to improve performance and/or work around “features.”
 - Now incorporating all changes to date (plus some additional improvements) into a clean new code load.
 - Getting too hard to patch the patches.
 - Will gain back precious memory (needed for future changes).
 - Will be loaded to both A and B-side computers and EEPROMs.
 - Safer, simpler configuration.
 - May take a month or more to complete and test.
 - In the mean time, get back on-line with what we have, & do some science and testing.



Since April 17, con't.

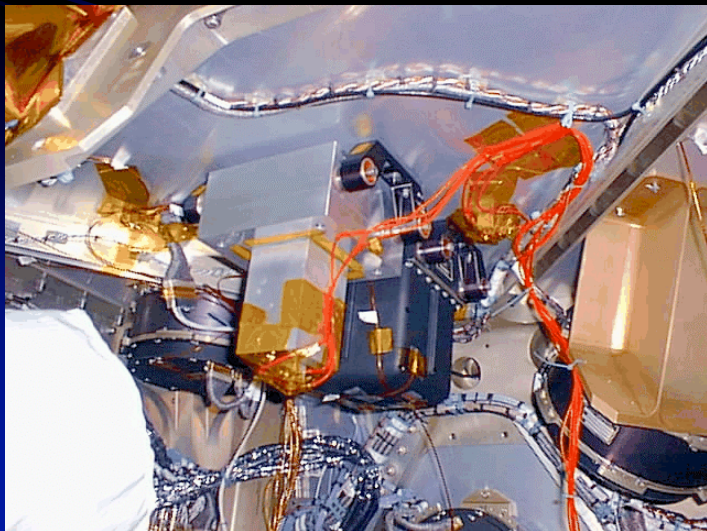
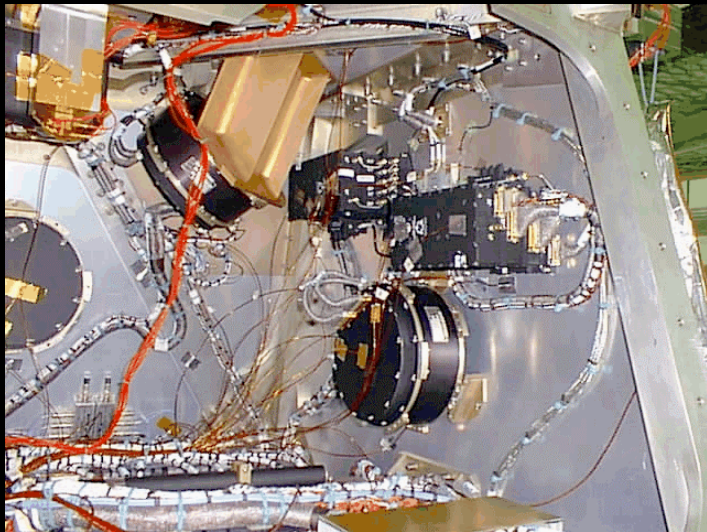
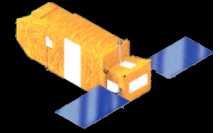
- On the Ground... Tool Development & Training
 - Preliminary assessments of probable sky coverage.
 - Tool to calculate stable regions as a function of time.
 - Torque Authority Contour (TACO) plots and L-buildup skymaps.
 - A 1st-order tools: don't tell the whole story.
 - Don't include unloading.
 - 90% contour doesn't illuminate "how bad" TA loss is during other 10%.
 - But should be a great aid to target selection/scheduling.
 - Development of the HDS as a tool for operations.
 - High fidelity s/w testing simulator provided by Orbital.
 - Being used as a predictive tool, to validate other tools, and to validate actual spacecraft performance.
 - Training of MP and SciOps staff has been non-trivial.
 - Improved tools to display/assess telemetry and compare HDS sims and real telemetry.

Chronology, con't.



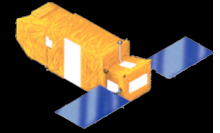
- **Late-May 2005: Off-pole slew tests, ACS (and HDS) s/w performance testing and validation.**
 - 0-5-10-5-0 and 0-5-10-15-10-5-0 slews sequences away from pole have provided modest confidence in TACO predictions and ability to operate in this mode.
- **June 2, 2005: Reopened doors and performed tracking tests to verify current (patched) ACS code performance.**
 - Fine pointing w/<3 gyros works fine now.
- **June 6, 2005: Ramped up detector high voltage and returned to conservative operations near S-pole.**
 - [Currently in LVLH due to SCC hardware problem.]
- **Will continue in this mode until new ACS code is ready to be loaded.**

1-wheel Operation Basics

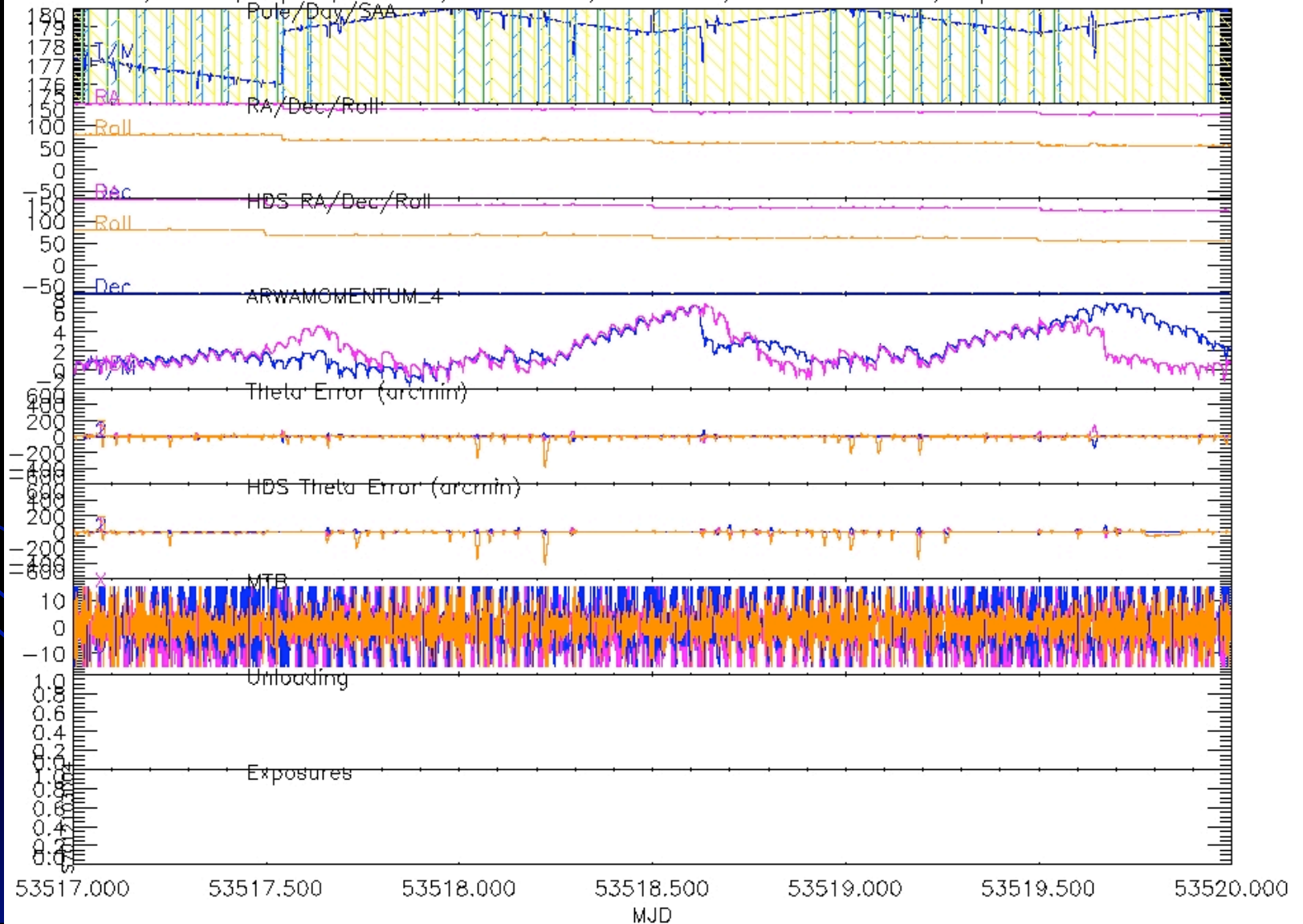


- Skew reaction wheel and 3 Magnetic Torquer Bars (MTBs).
- MTBs, orthogonal to each other but at differing angles to Skew wheel.
- Static pointing: Primary external disturbances are from gravity-gradient (GG) effects.
- Dynamic pointing (slewing): disturbances from GG and cross-coupling torques from Skew wheel.
 - Skew reaction wheel $\sim 10x$ stronger than MTBs and can easily overpower them.
- MTBs need to be shared between L-management and attitude control.
 - A delicate and tenuous balancing act.

HDS vs. Real Telemetry



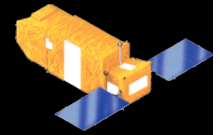
/home/aquila/calvani/HDS_sims/HDSvsSC/5_27_weekend/atpole_147.TXT^



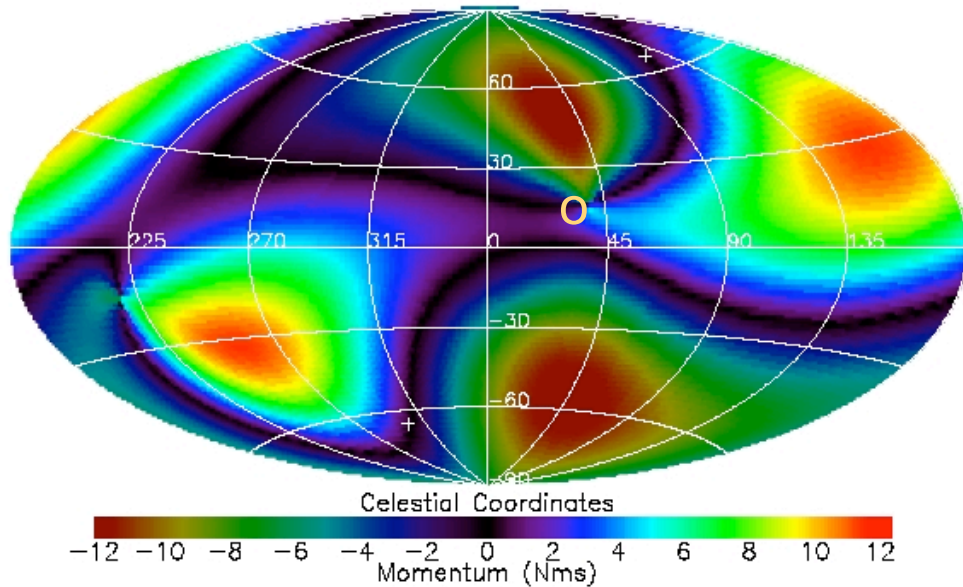
-->

Skew wheel
Momentum
Blue-actual
Pink-HDS

L-buildup Skyplots



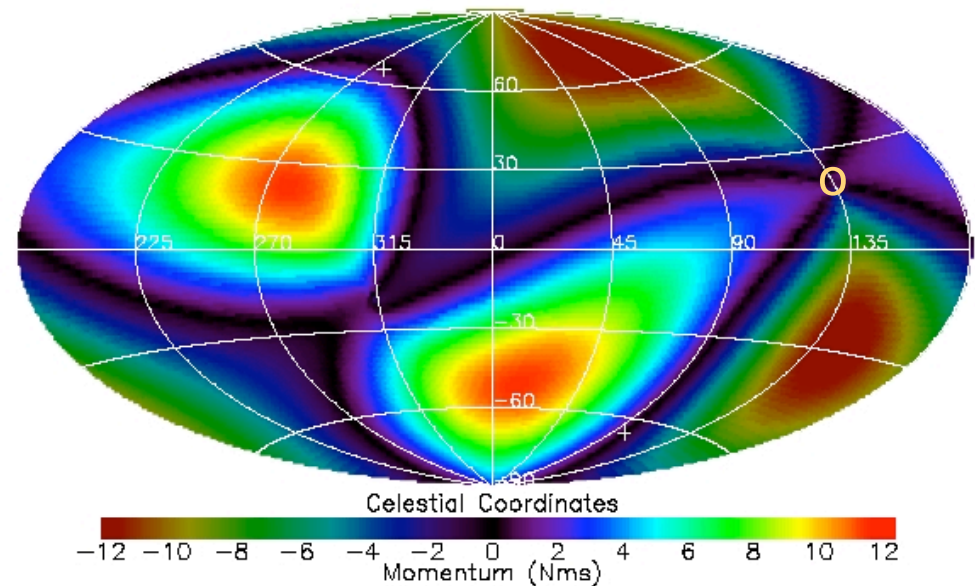
Skew Wheel Momentum Build Up Per Orbit
 Date: 2005:121:00:00:00 Roll offset: 0°



Bright and shaded regions:
 Positive and negative wheel
 momentum buildup.

Aug. 1, 2005

Skew Wheel Momentum Build Up Per Orbit
 Date: 2005:213:00:00:00 Roll offset: 0°

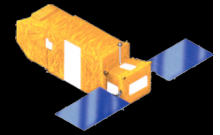


May 1, 2005

Low rate paths run through
 orbit poles, sun and anti-sun,
 and near orbit plane.

June 9, 2005

TACO Plot Examples



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

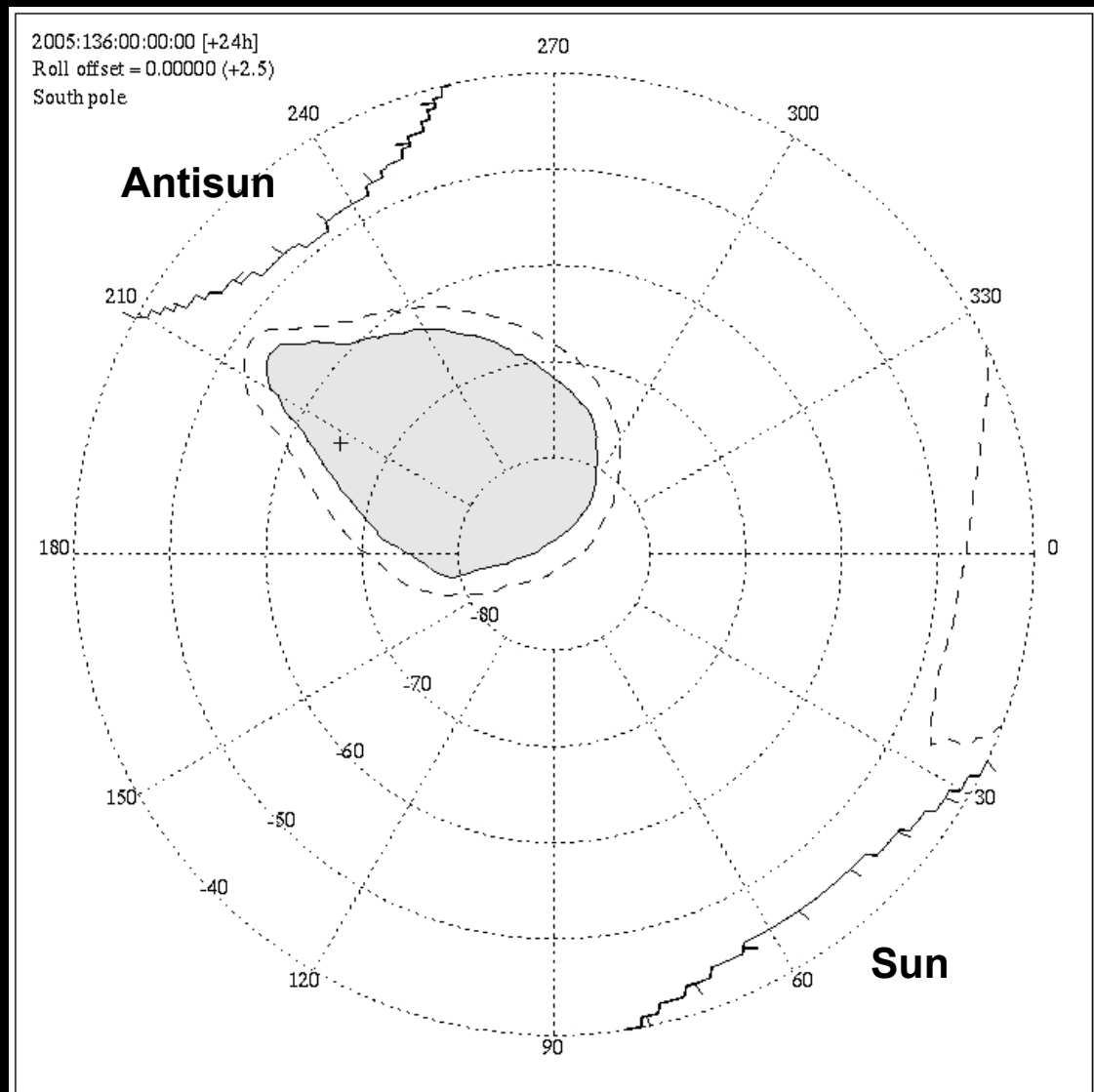
Stable region for 24 hours (time selectable)

Solid line: 90% of time is stable

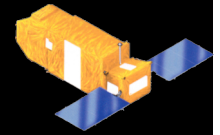
Dashed line: 85%

+ is orbit pole (south)

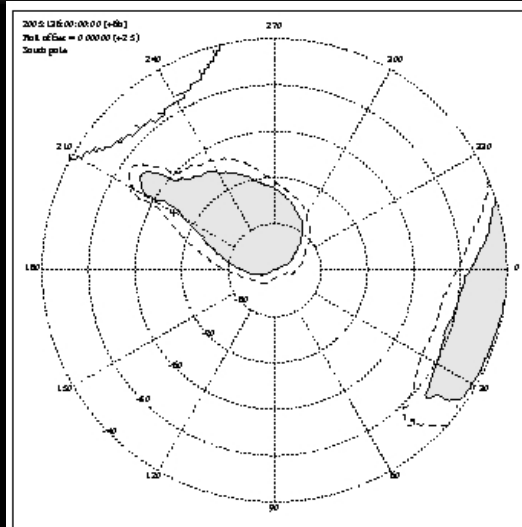
June 9, 2005



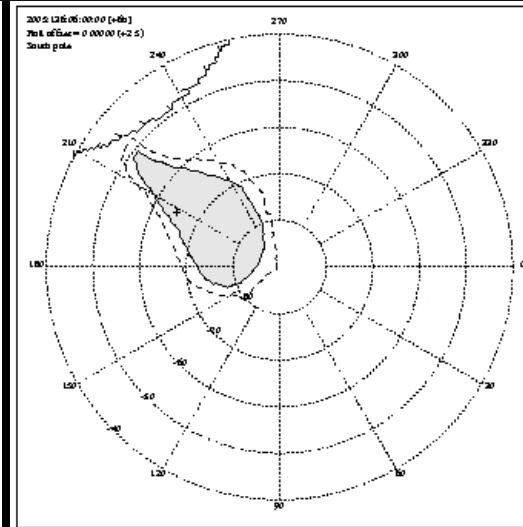
Day 136, 4 6-hour TACO's (relatively stable)



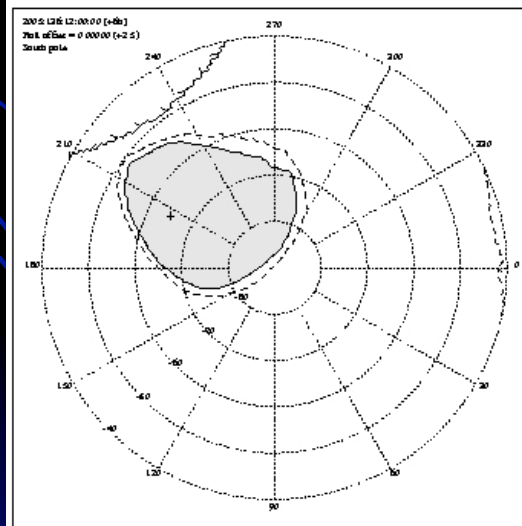
0 - 6 UT



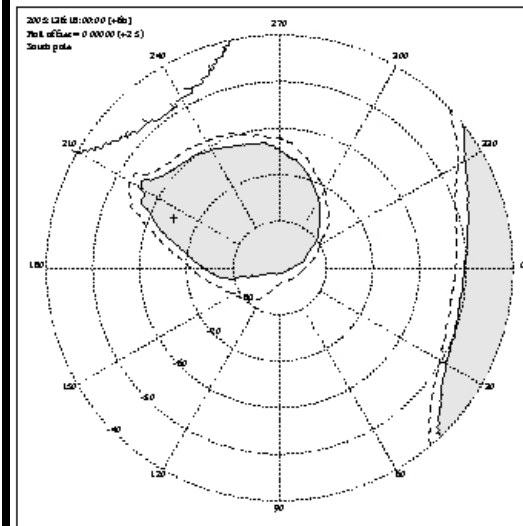
6 - 12 UT



12 - 18 UT

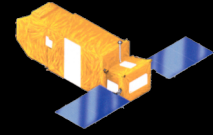


18-24 UT

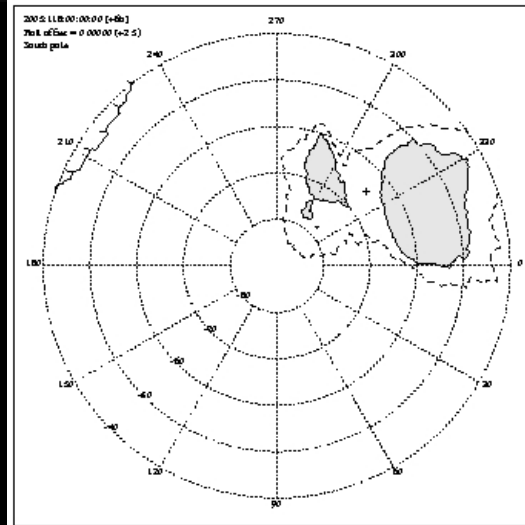


June 9, 2005

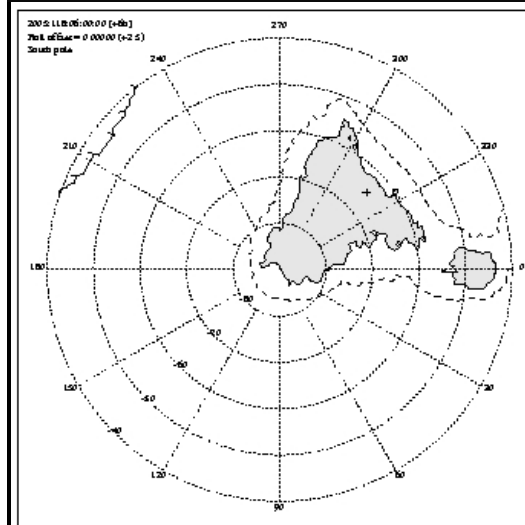
Day 118, 4 6-hour TACO's (relatively dynamic)



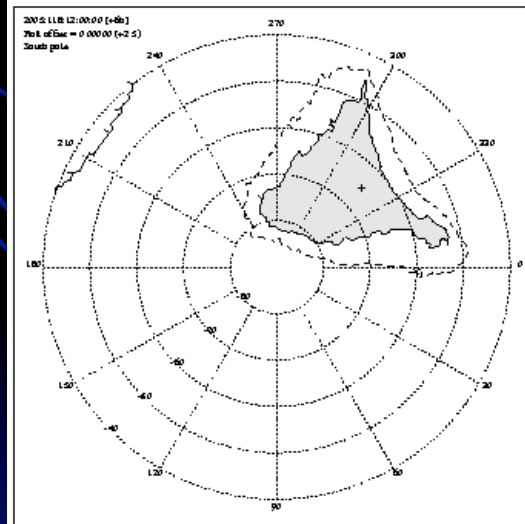
0 - 6 UT



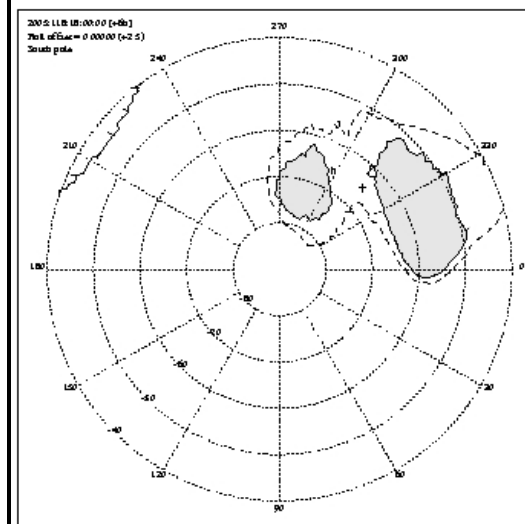
6 - 12 UT



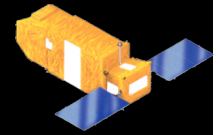
12 - 18 UT



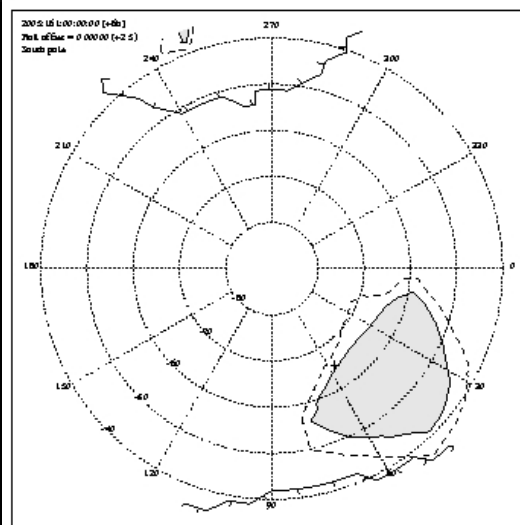
18-24 UT



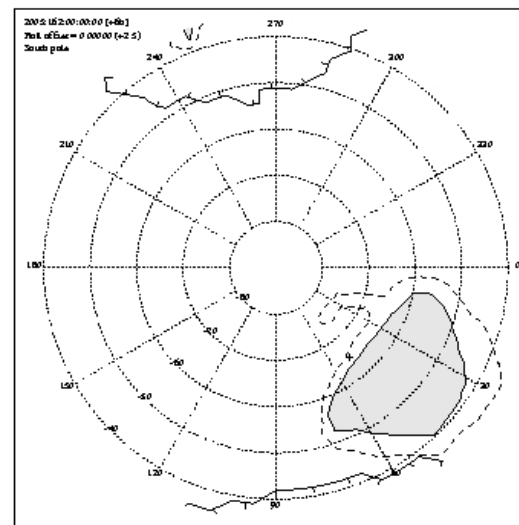
Day 161-164, 6-12 UT (repeating stable regions)



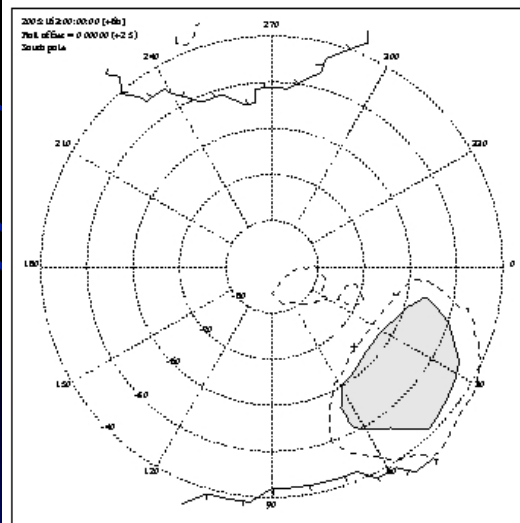
6 - 12 UT
 d161



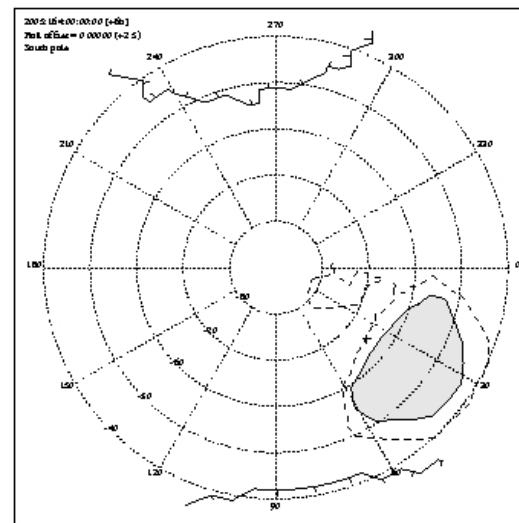
6 - 12 UT
 d162



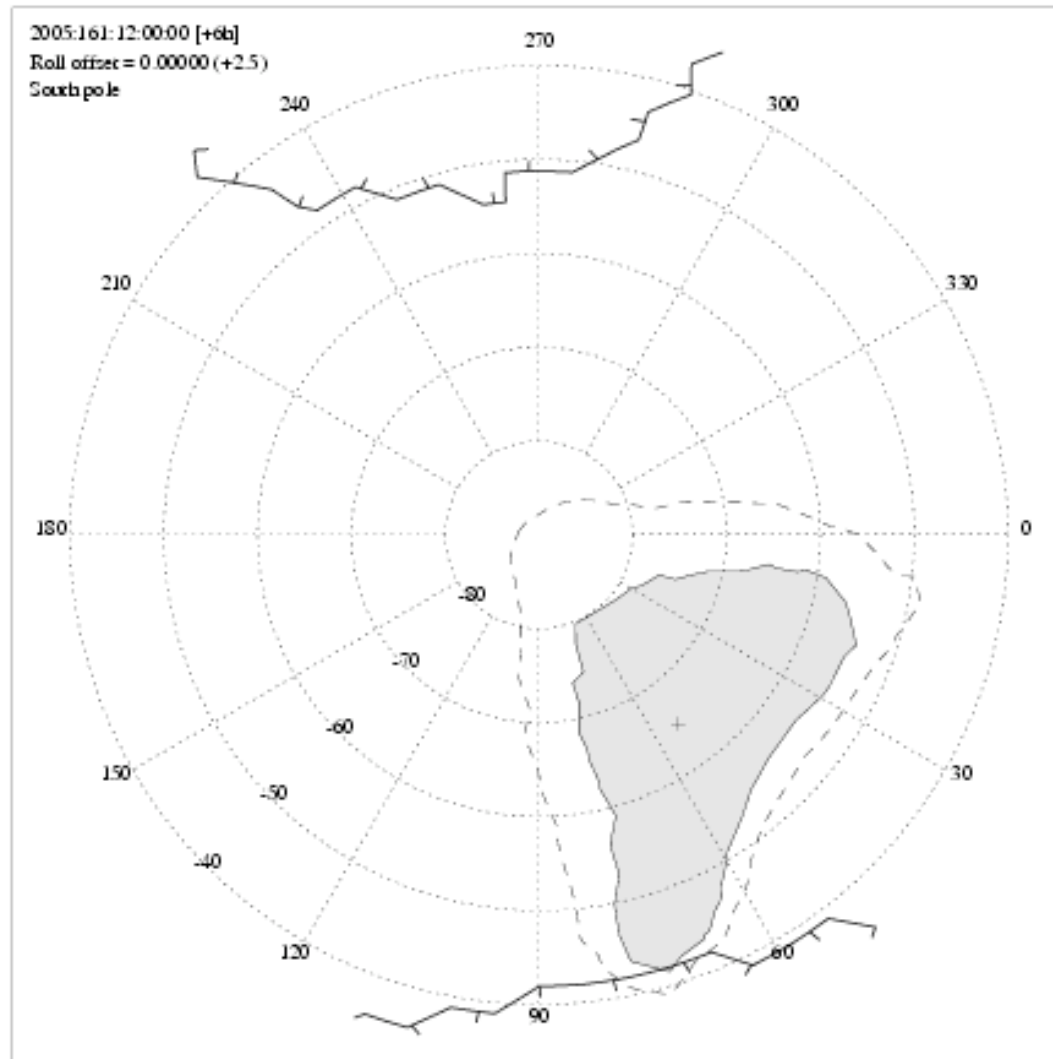
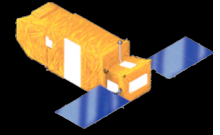
6 - 12 UT
 d163



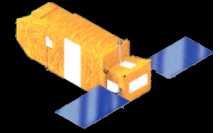
6-12 UT
 d164



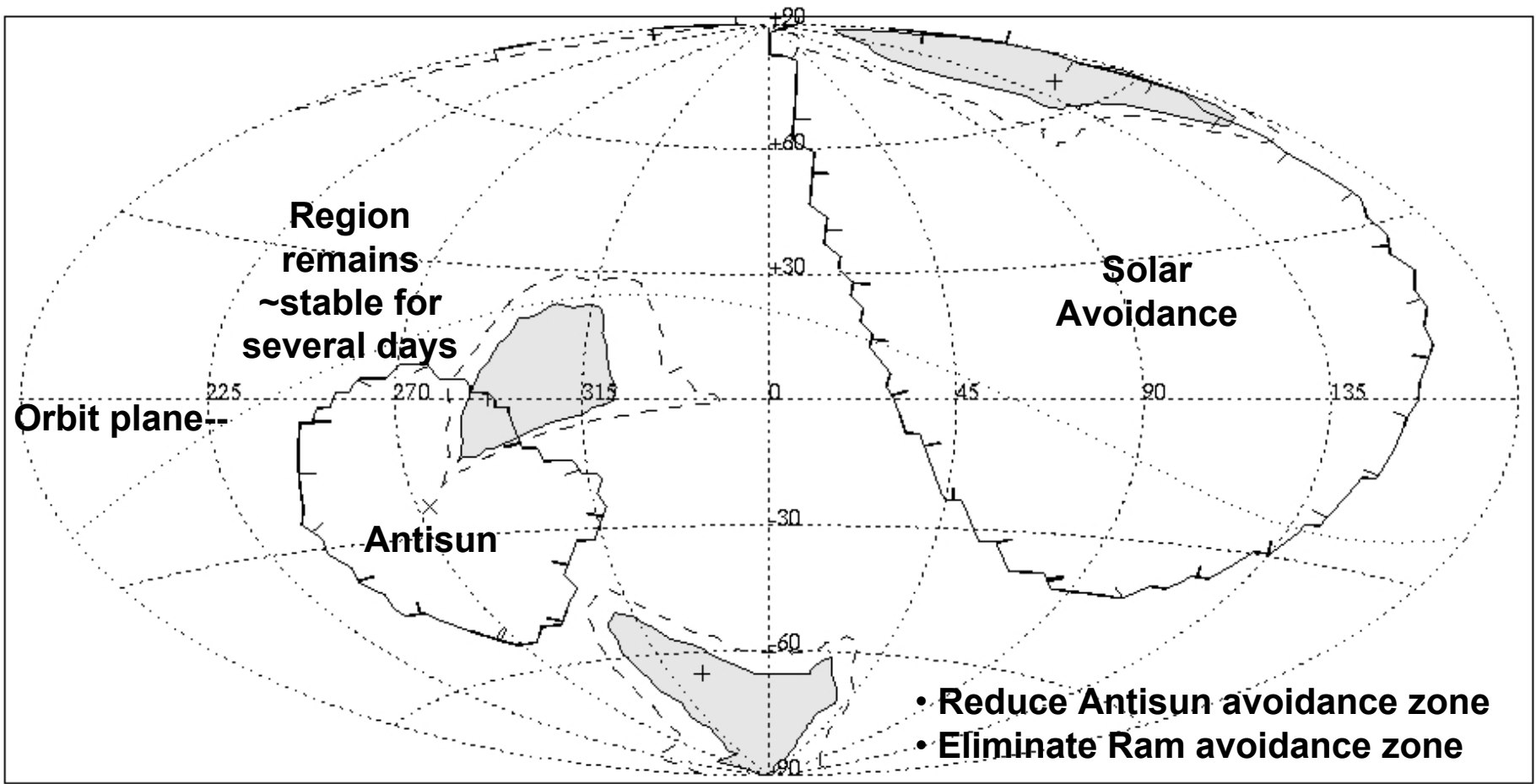
Day 161-180, 12-18 UT (repeating stable regions)



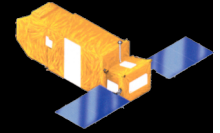
All-Sky Plot, day175 (Stable islands at low declination)



2005:175:06:00:00 [+6h]
Roll offset = 0.00000 (+2.5)



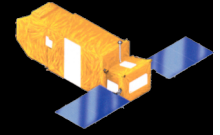
Where do we go from here?



- 1-wheel operations have been demonstrated in principle.
- We need to continue to develop tools and improve operations.

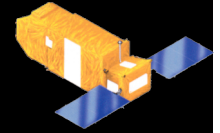
We will get better with time, but it will take practice!





Operational Realities

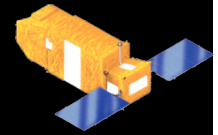
- Channel alignment has become a secondary concern for the near term.
- LWRS is back to being the primary aperture!
- Sky Coverage: temporal and limited in comparison to 2-wheel mode.
- Long exposure times possible in certain parts of the sky, but may require multiple visits over days or even over multiple precession cycles (~60 day cycles).
 - [Exposure times in certain parts of the available sky will be limited.]



To Do List

- **Develop/Improve Slew Capability.**
 - Slewing from pole-to-pole.
 - Slewing from either pole to plane and back.
 - Investigate different slew algorithms and rates.
- **Develop better understanding of Momentum Unloading.**
 - Unloading currently autonomous in the ACS s/w, when conditions are right.
 - Need to learn to manage and schedule unloading around obs.
- **Develop/validate better tools for planning and scheduling.**
 - Integrate existing preliminary tools into planning/target selection tools that are robust.

Integrating Tools Together



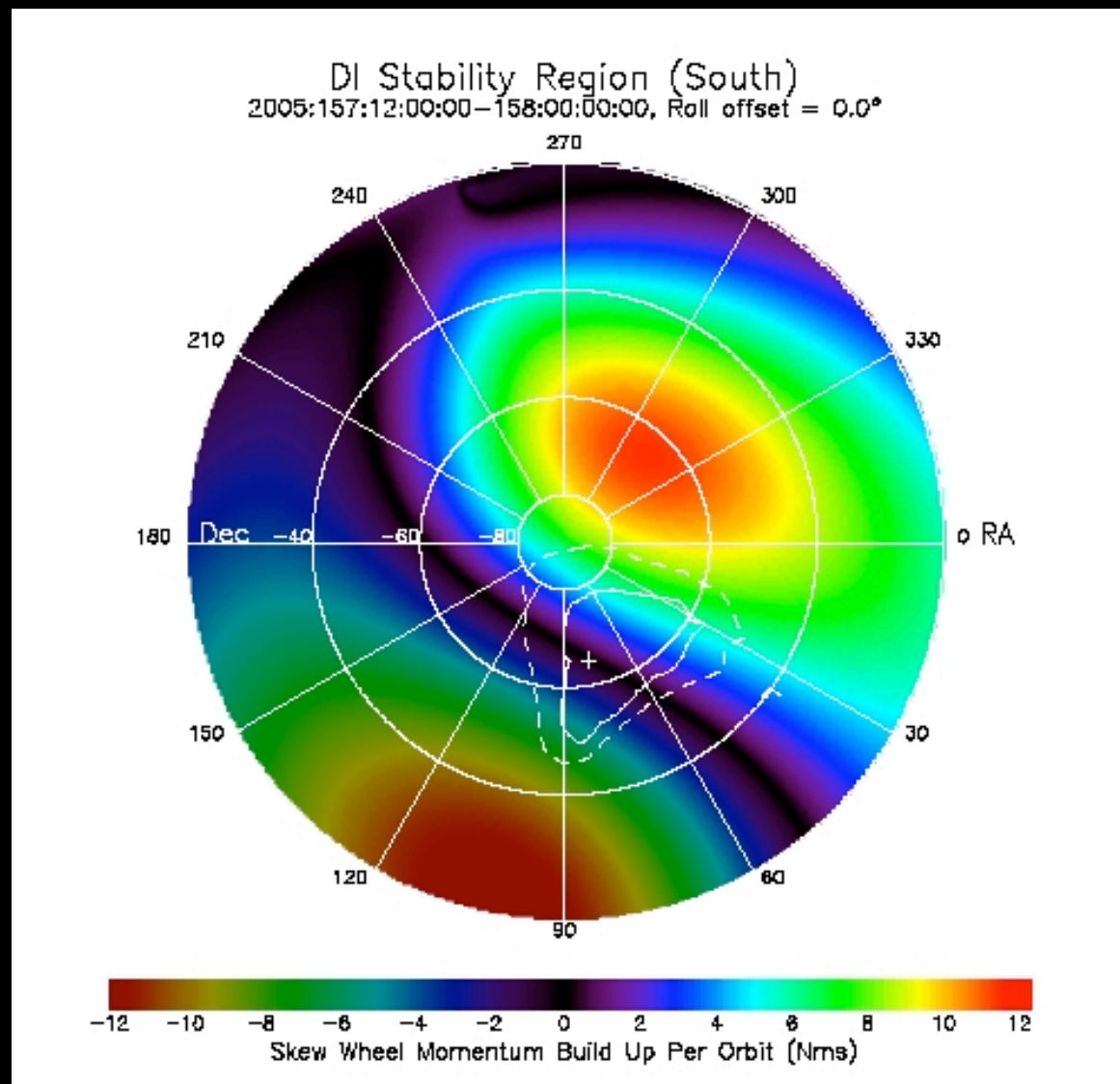
✓ Test and integrate TACO (stability) regions and low-L buildup regions.

✓ Learn to choose and schedule targets better.

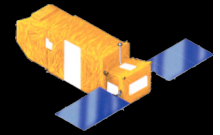
✓ Ex: Pair pointings where L-buildup cancels.

✓ Revise MPS generation process to include HDS validation.

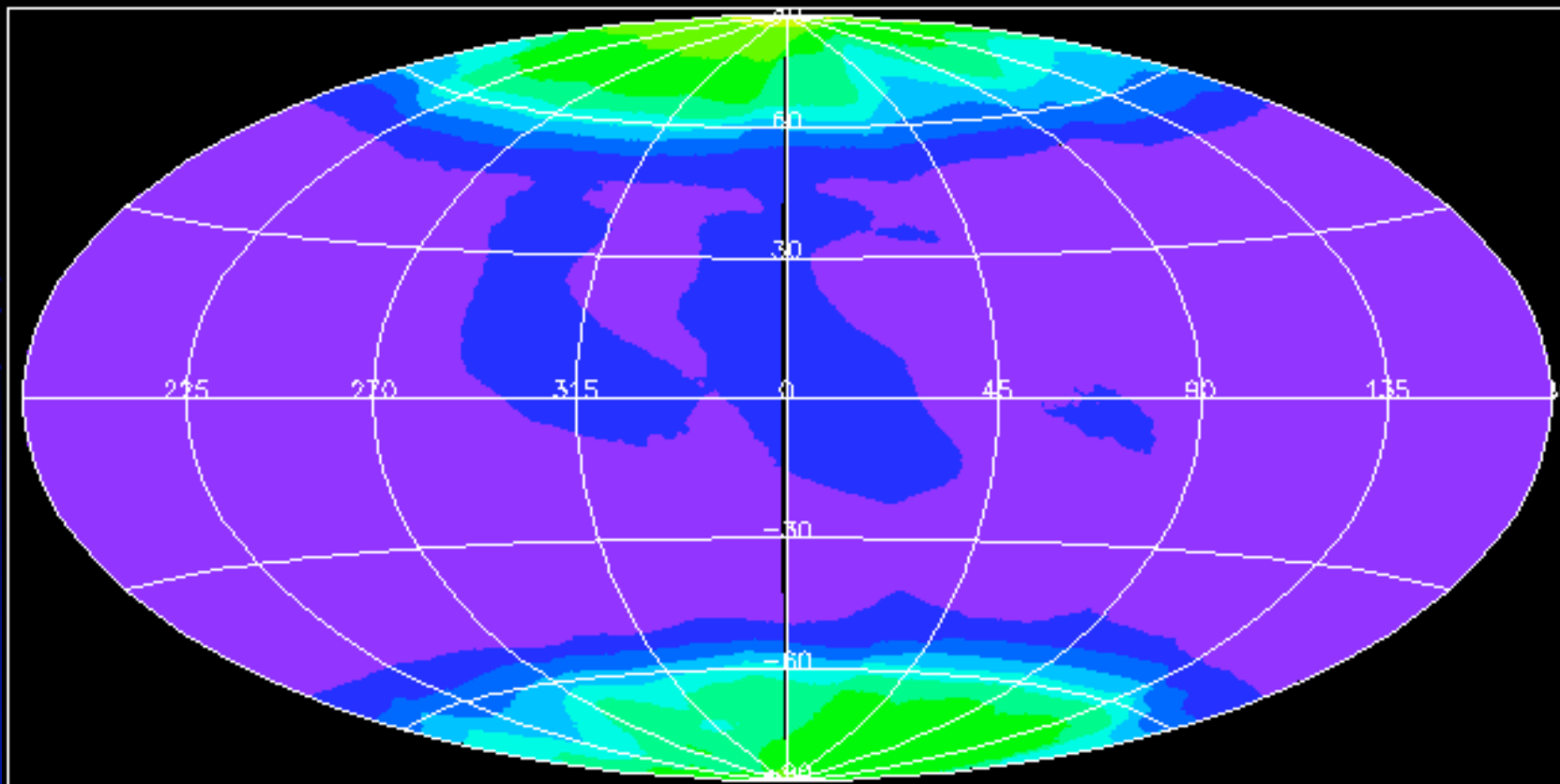
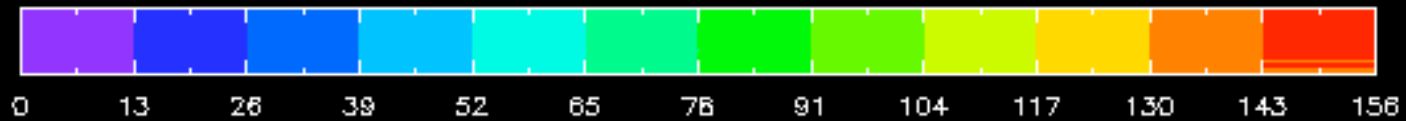
✓ Etc.....



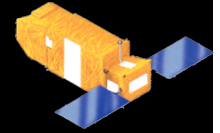
PRELIMINARY 1-wheel Sky Coverage Estimate-Nominal Roll



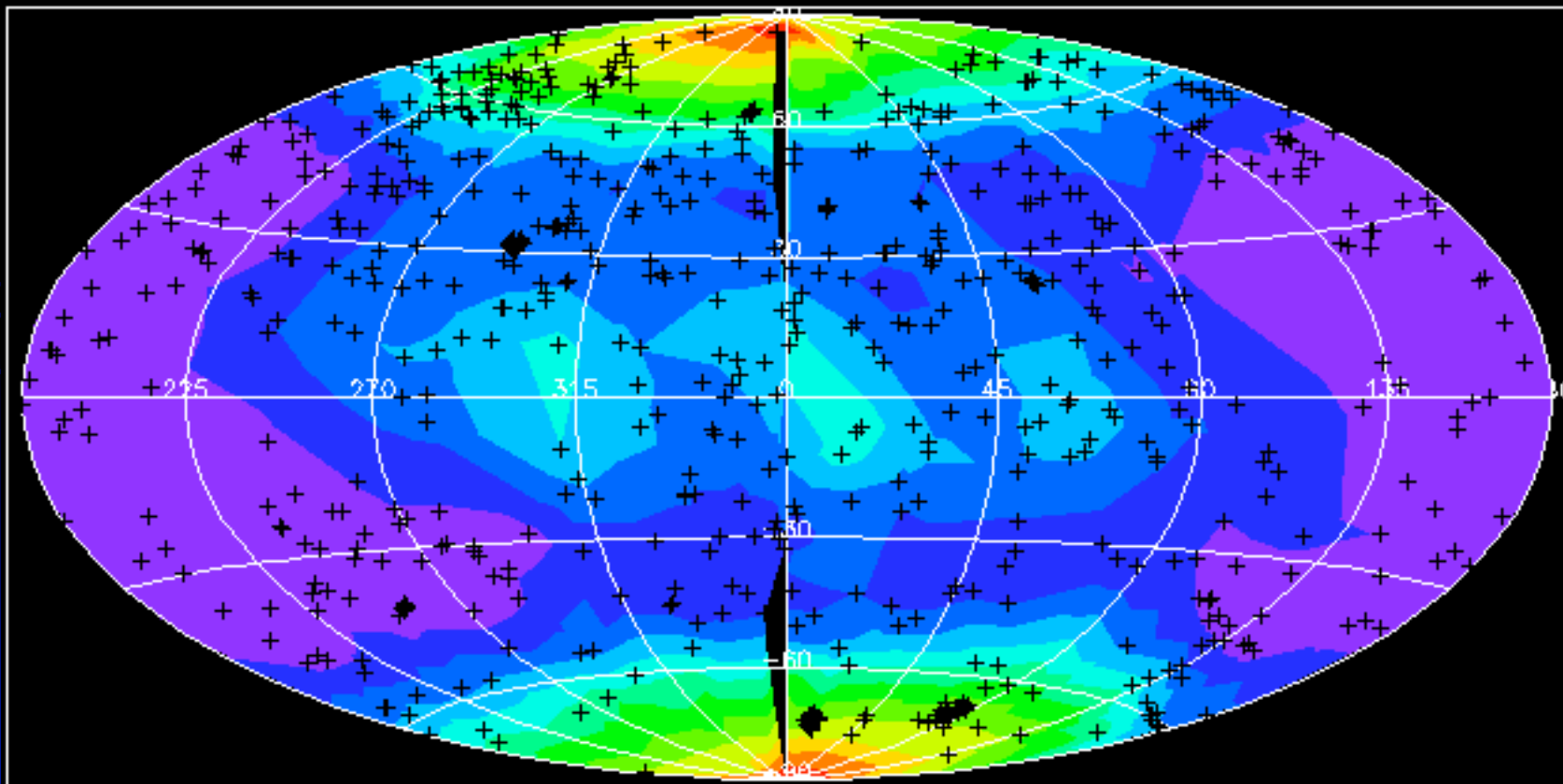
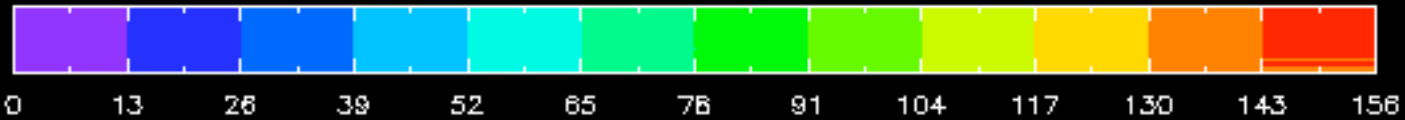
FUSE Sky Visibility [days] : w/o unloading, roll-offset=0



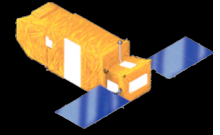
PRELIMINARY 1-wheel Sky Coverage Estimate-Roll Offsets



FUSE Sky Visibility [days] : w/o unloading, but including roll-offsets

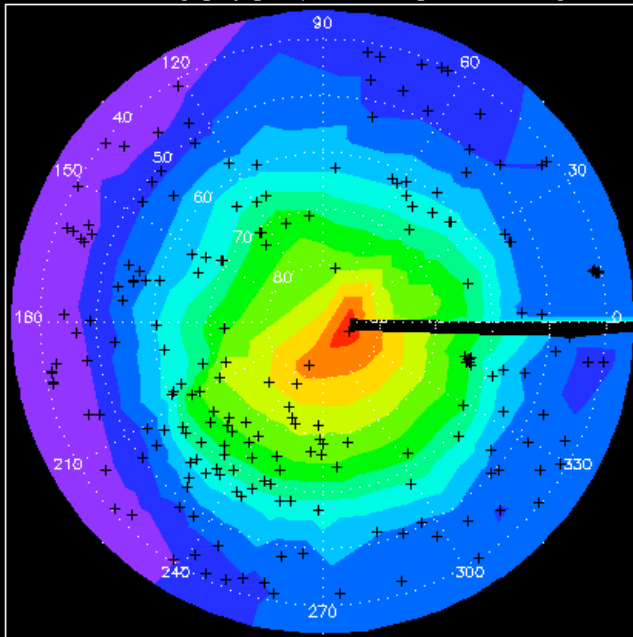
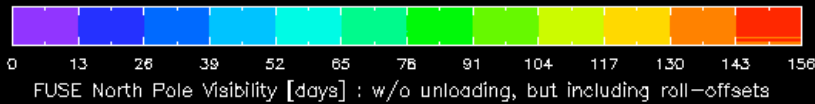


Pending targets near the poles

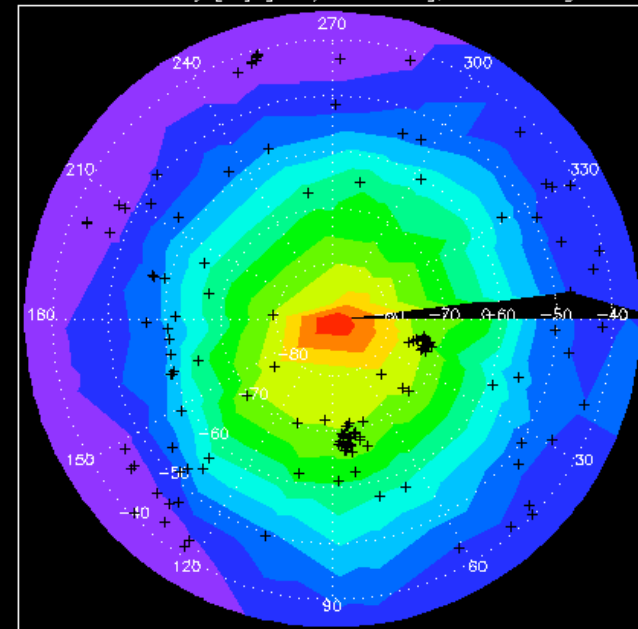
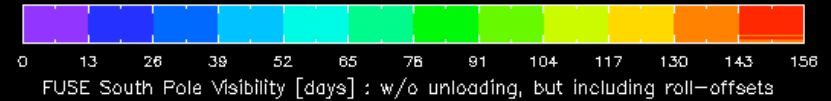


- Numerous areas with few pending targets in current pending pool, especially in the south.

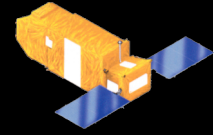
North



South

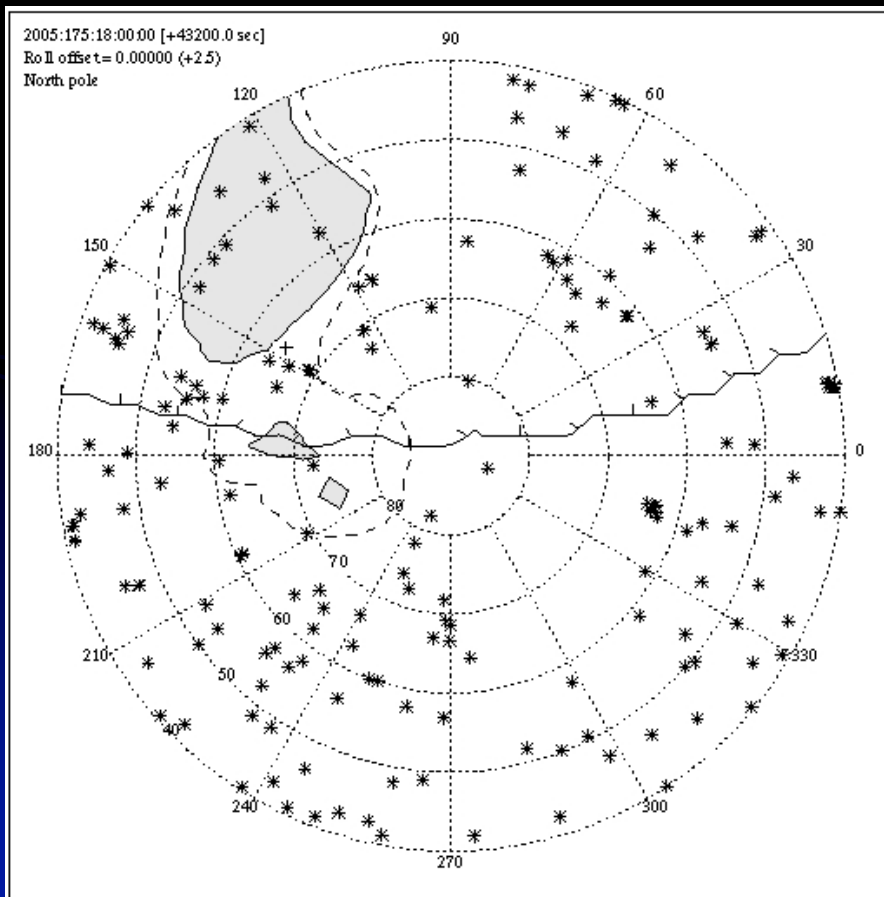


Pending targets near the poles

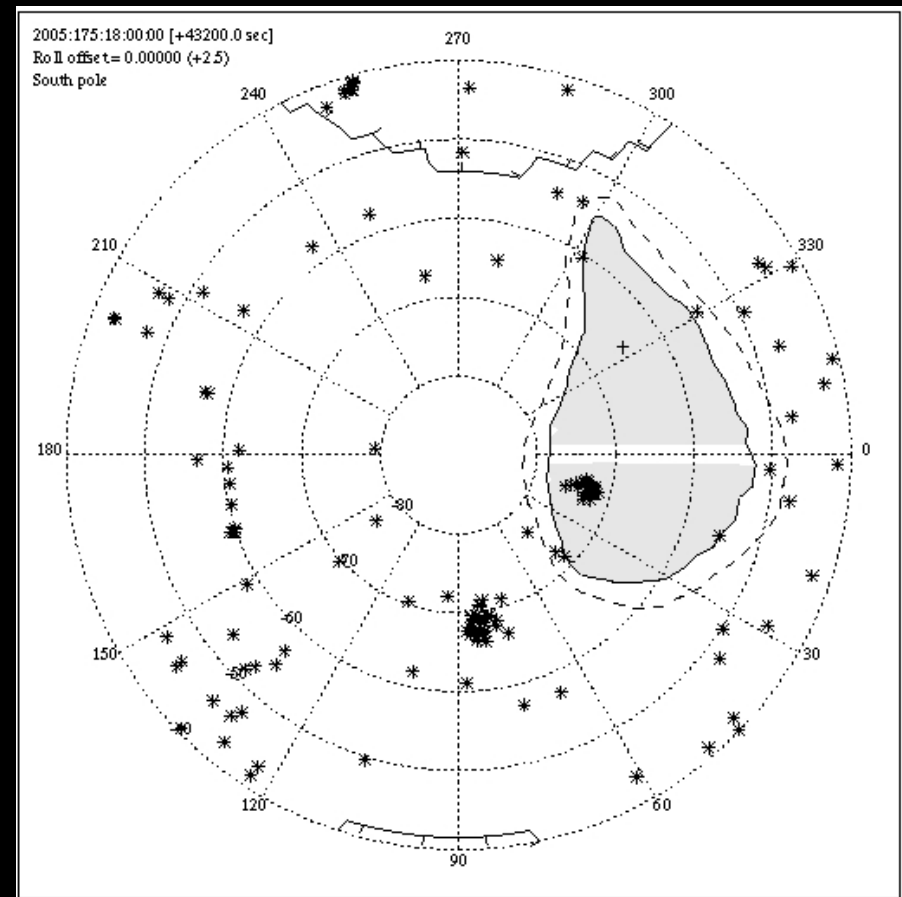


- Numerous areas with few pending targets in current pending pool, especially in the south.

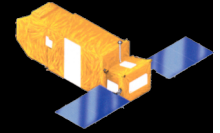
North



South

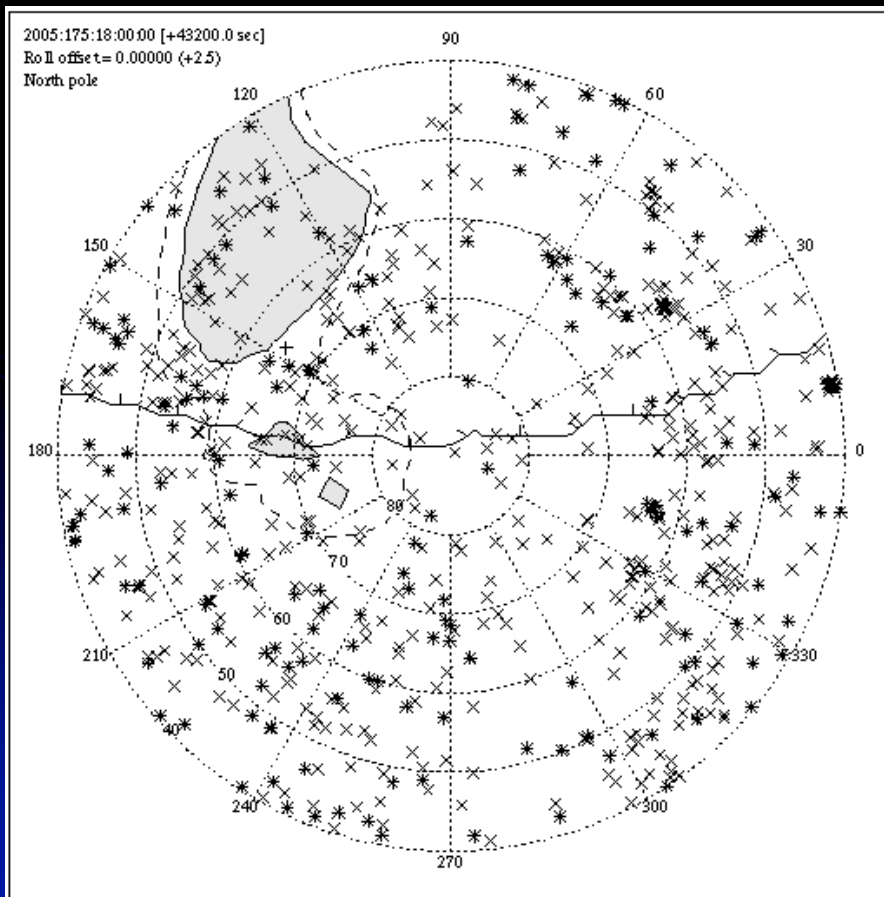


All targets near the poles

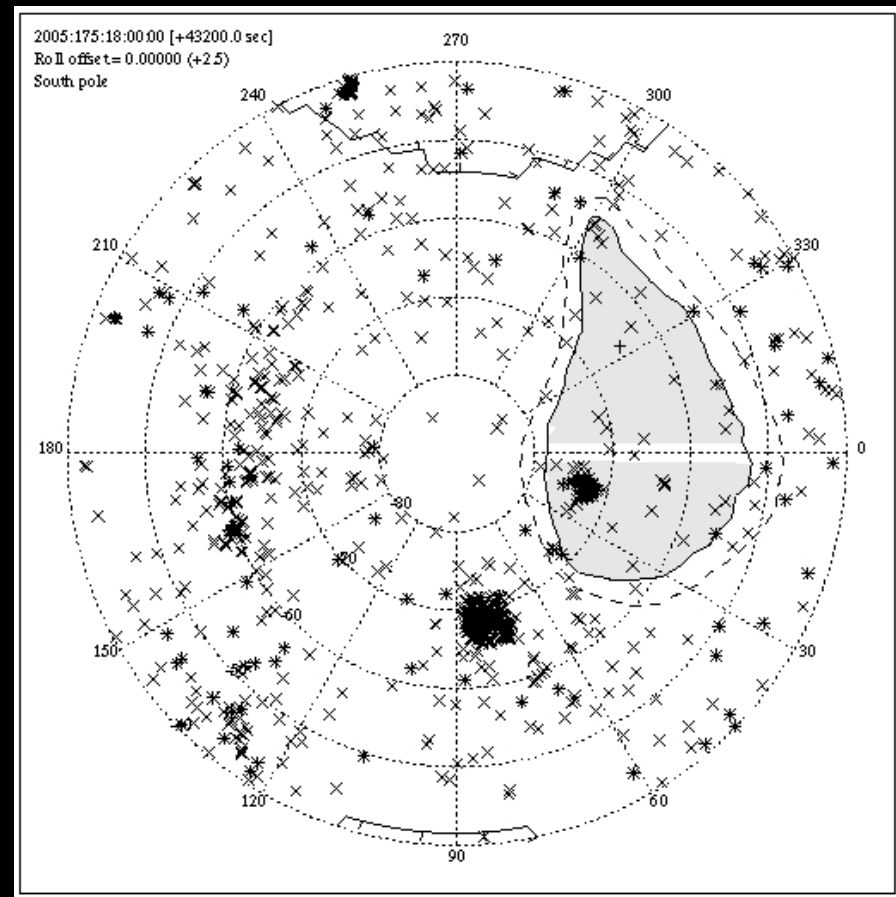


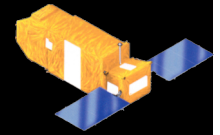
- In principle, much better target selection is possible for our current visibility expectations, even near the poles.

North



South

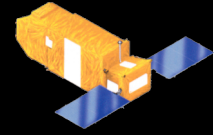




SciOps Staffing Changes

- Helen Hart left early March 2005 (APL/Messenger)
- Bryce Roberts left end of March 2005 (UCB/Themis)
- Jean Dupuis has accepted a position with CSA (Canada) starting July 1.
- Ravi Sankrit will be phasing off of FUSE support this summer.
- Bernard Godard left but Thomas Civeit arrived (France).
- Alex Fullerton and Pierre Chayer have scaled back FUSE fractions to transition to JWST.
- MOT: Steve Vaclavik (senior) >> new job at GSFC, but one add'l (junior) person being trained for console ops.
- [Approximately 3+ FTEs decrease in SciOps staffing.]

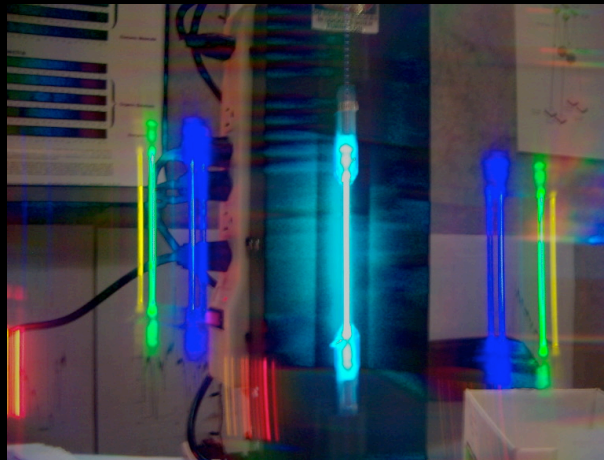
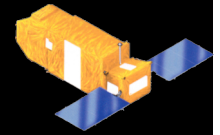
This has caused significant restructuring/retraining of the remaining staff to fill gaps and adjust to new roles.



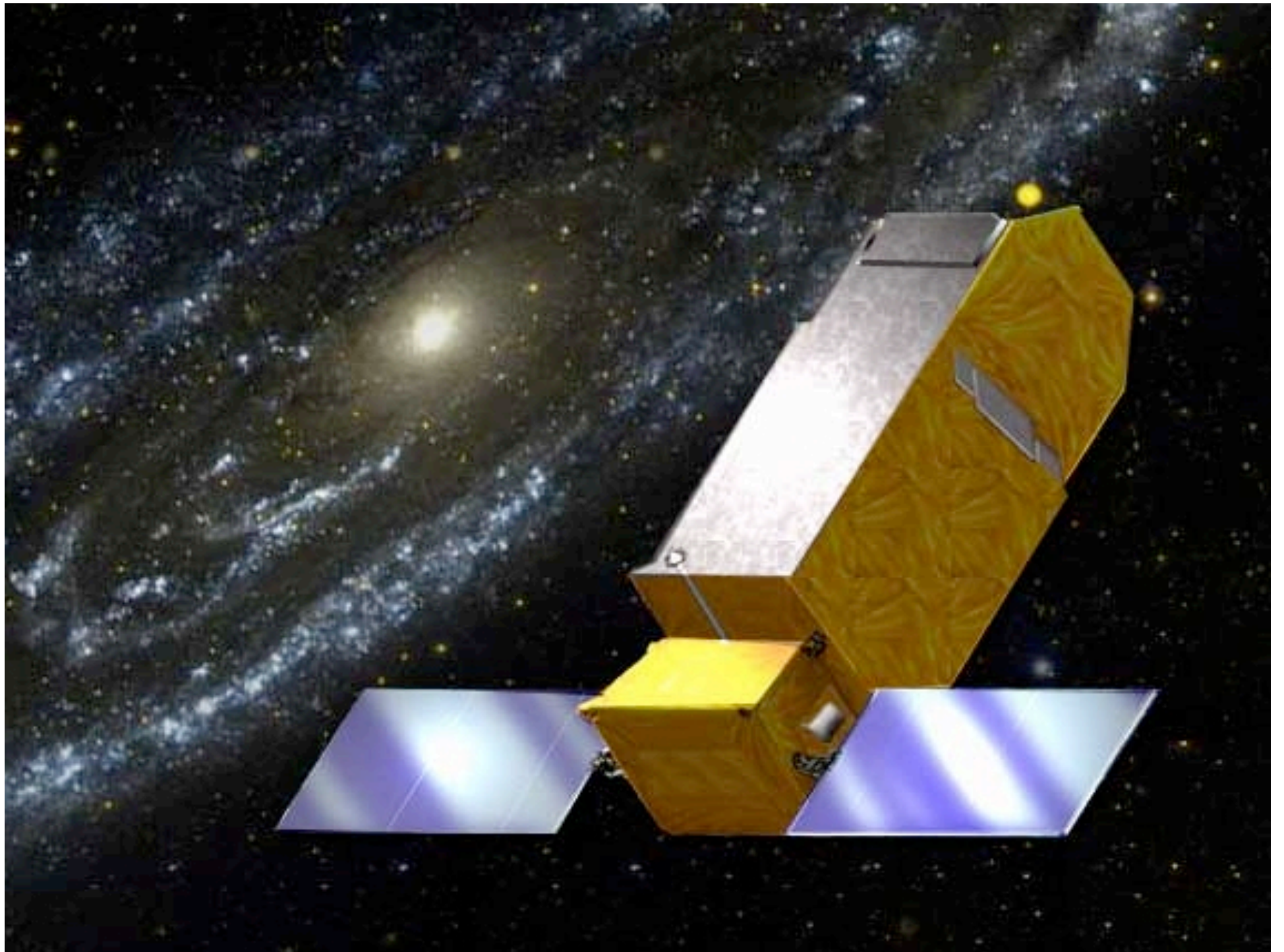
Other Operations Activities

- Solicited, ingested, and are now processing accepted Cycle 6 programs.
 - 49/55 accepted Phase 2 proposals have been received.
- CalFUSE 3.1 development and testing.
 - Includes generation of new one-look data set (NVO).
 - (Van Dixon will discuss later.)
- Continued reprocessing of early mission data to provide full telemetry needed for final processing/archiving.
 - Level Zero Reprocessing from original raw data tapes.
 - CalFUSE 3.0 processing and rearchiving.

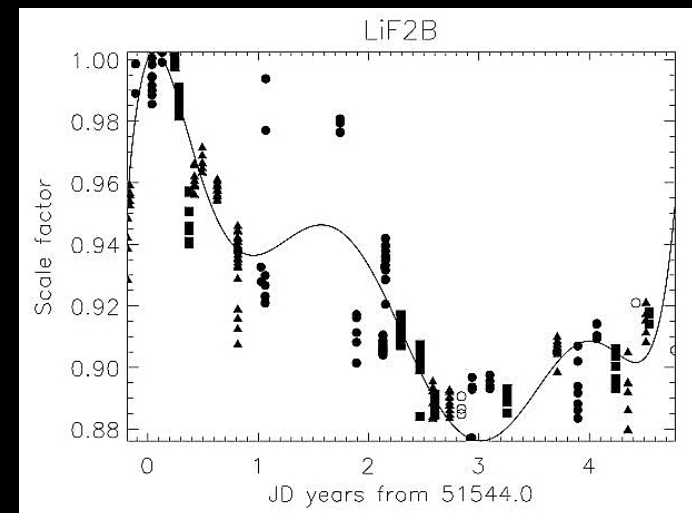
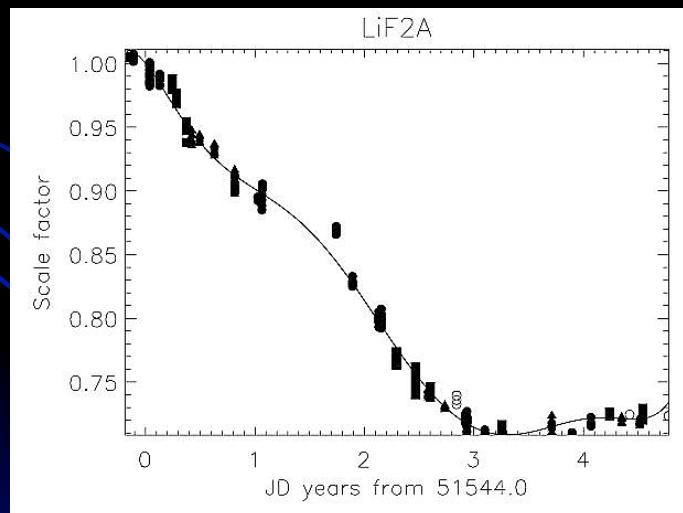
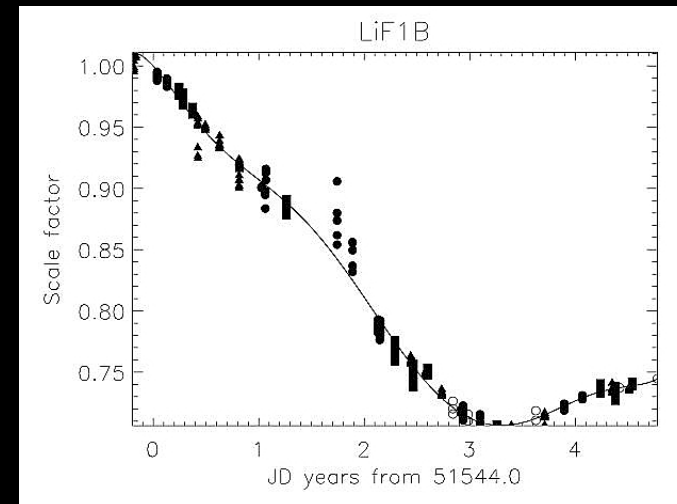
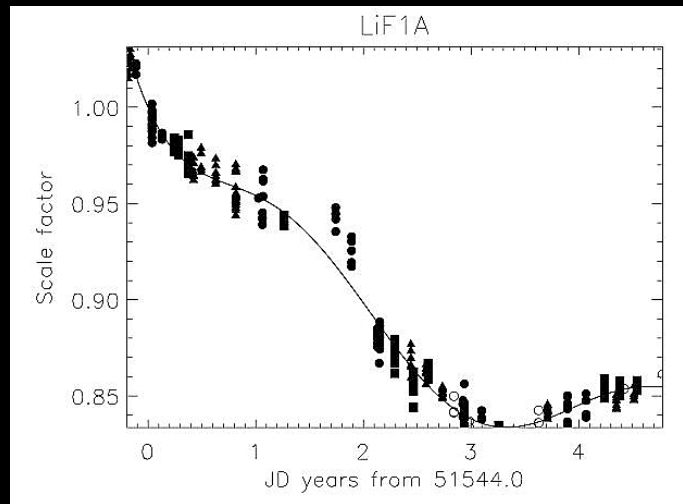
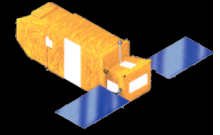
FUSE E/PO Activity



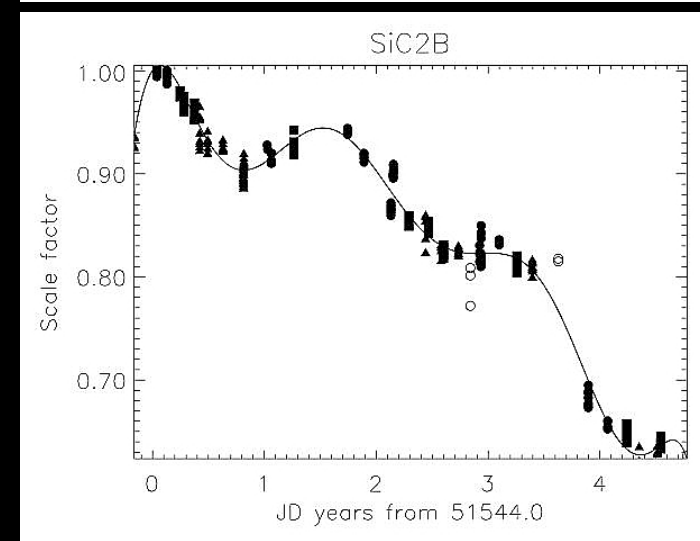
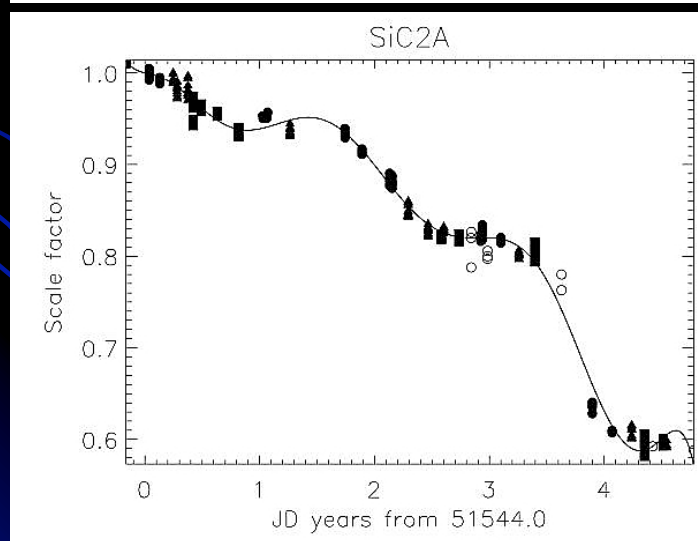
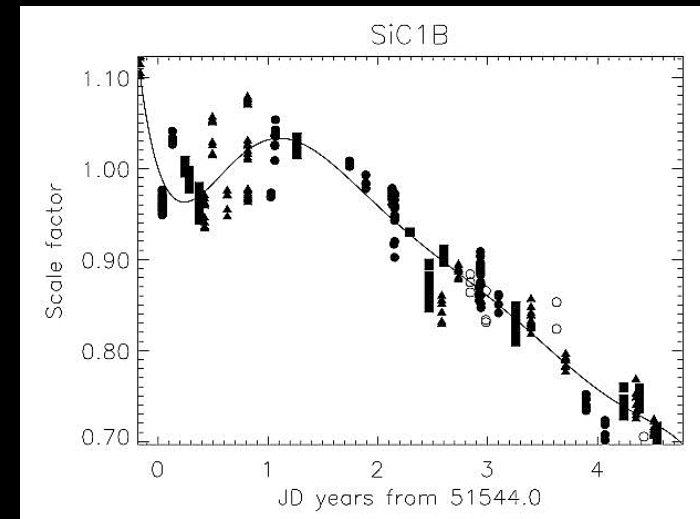
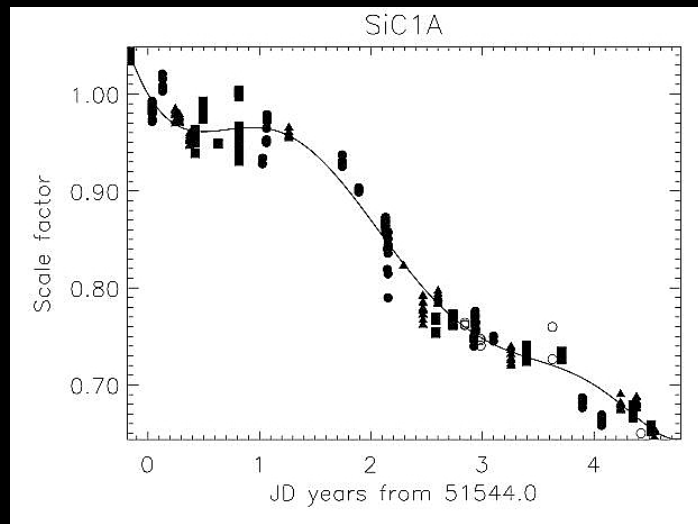
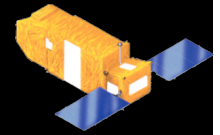
- 2005 JHU Physics Fair, held April 30; over 500 people attended.
 - FUSE volunteers staffed Atomic Spectra and Solar Cell demos.
 - FUSE paper model construction table.
- New Web E/PO activities and Science summaries have been added.
 - Some Spanish pages being added.
- Looking for ways to involve GIs. (Web Science summaries?)



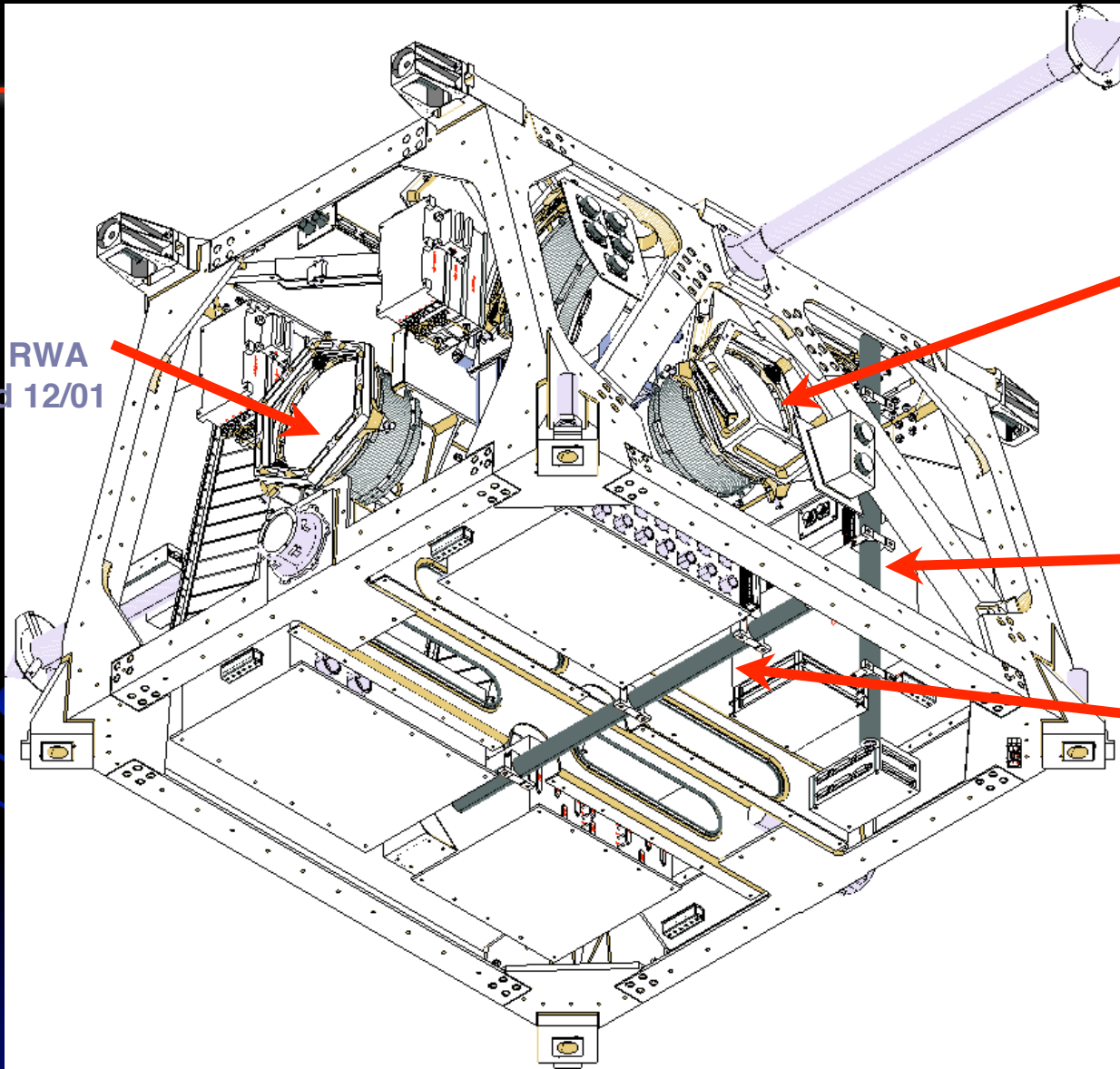
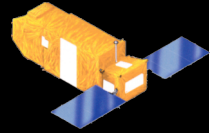
LiF Channel Sensitivity



SiC Channel Sensitivity



Internal Configuration (1)

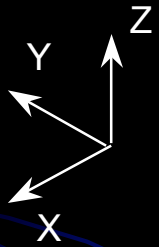


Pitch RWA
Failed 12/01

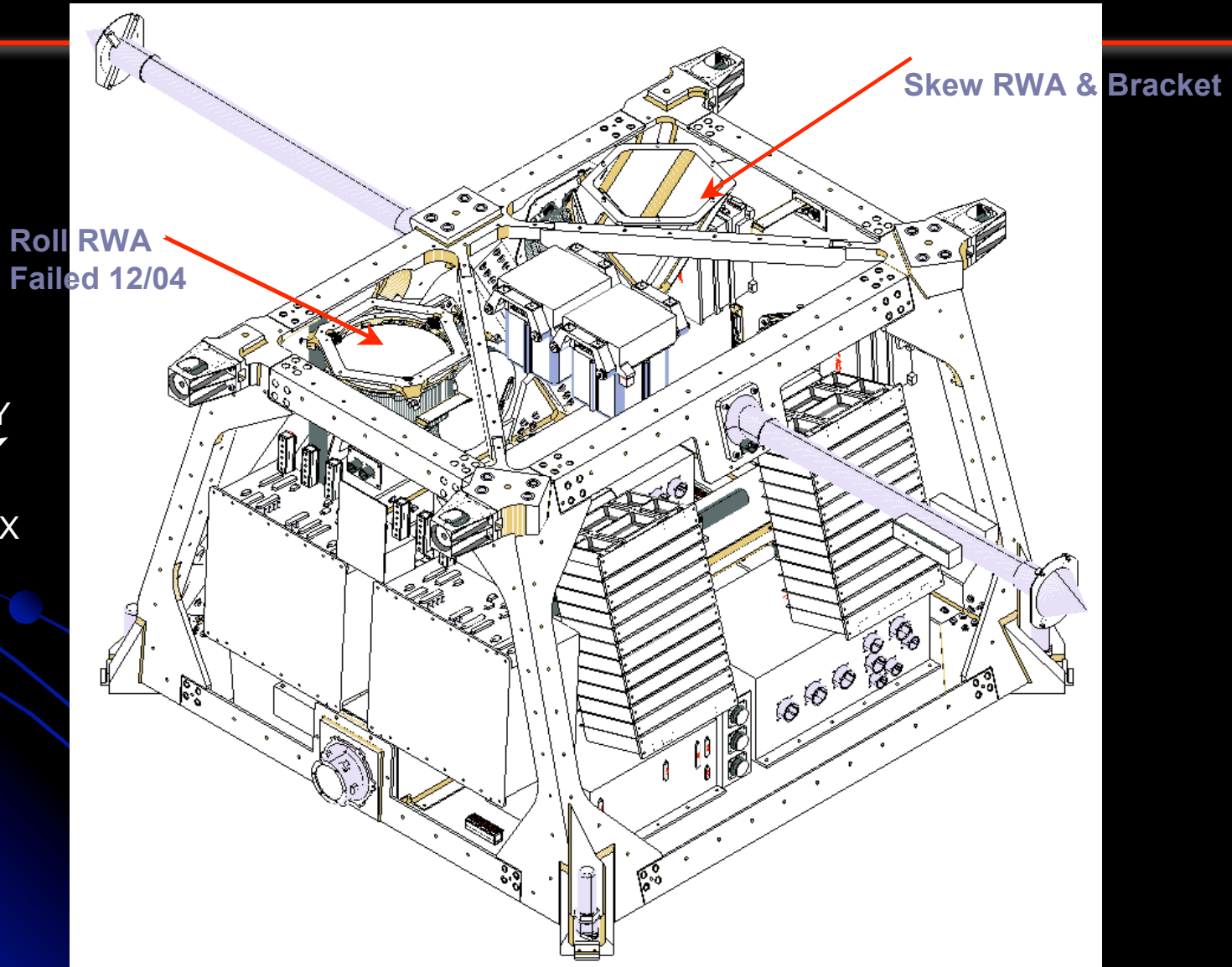
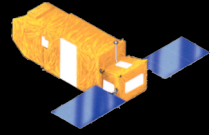
Yaw RWA
Failed 11/01

Z Torquer Bar

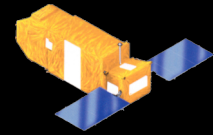
X Torquer Bar



Internal Configuration (2)



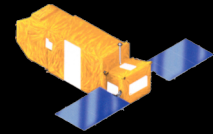
Expected Carry-over to Cycle 6



Schedulable programs carried over from Cycles 2-5 into the Cycle 6 time period (April 2005 - April 2006), based on LRP run of Oct. 6, 2004.

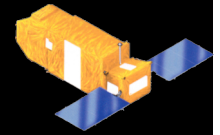
	Observations	Exp. Time (ks)
	-----	-----
B programs:	2	16
C programs:	5	41
D prime:	6	99
D survey:	11	145
E prime (Std):	36	740
E prime (Legacy):	8	223
E survey:	26	498
P programs:	1	11
Q programs:	1	20
M programs:	5	34
	----	-----
TOTALS:	101	1827 ks

On HOLD: Totals



	No. Obs	Exp. Time	Comments
	----	-----	-----
		(ks)	
B programs:	0	0	Was 3/49 at last FOAC.
C programs:	10	89	Was 13/142.
D programs:	24	66	Was 41/202.
E Std. programs:	17	85	New
E Sur. Programs:	7	162	New; PI holds.
E Leg. programs:	28	1137	2-year programs.
P programs:	37	241	Was 42/257. (Include. 5 moving target obs)
M programs:	4	50	
Z programs:	1	33	2007 - FUSE/COS Cross Calibration (!)
	----	-----	
TOTALS:	129	1865.6 ks	

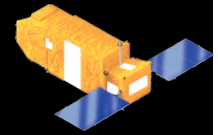
On HOLD: Overbright (Subset of previous pg.)



	Observations -----	Exp. Time -----
C programs:	9	87 ks
D programs:	23	63 ks
E programs:	15	35 ks
P programs:	32	124 ks
	-----	-----
TOTAL:	79	309 ks

Note: Not all of these will require defocus technique.
 Details are still being assessed.

Total Carry-over to Cy6

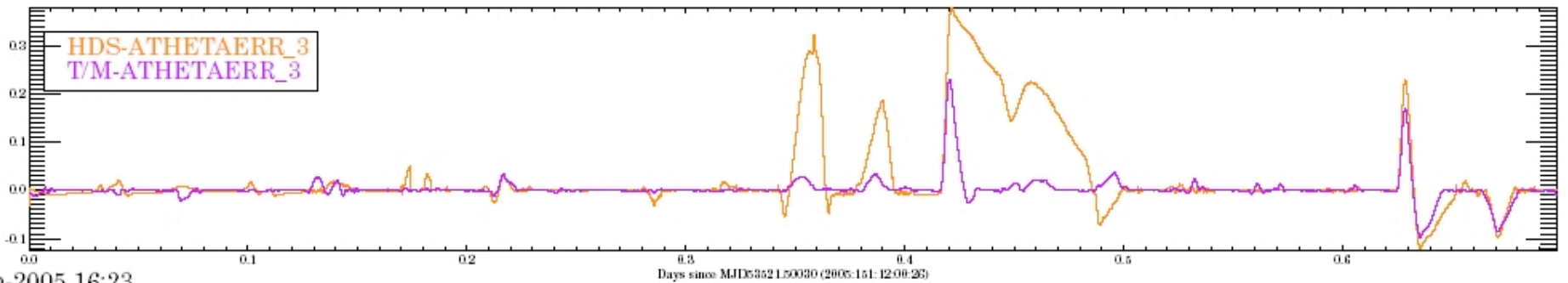
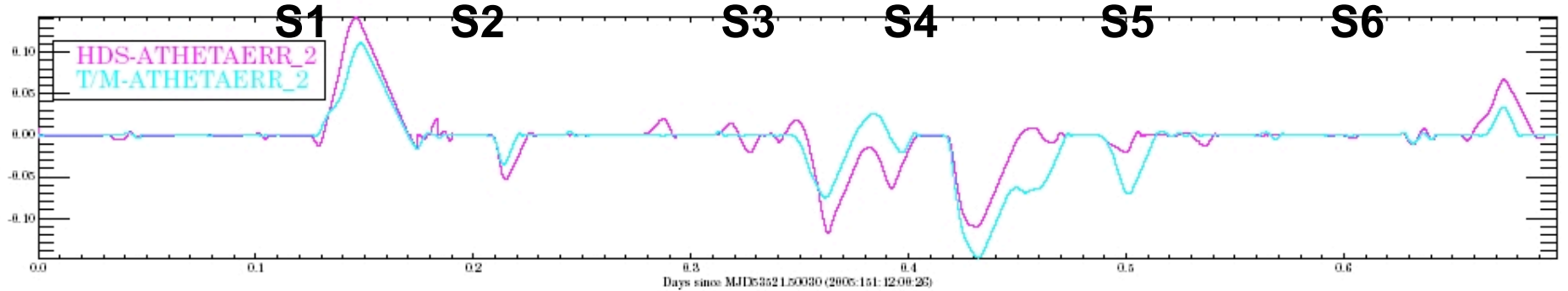
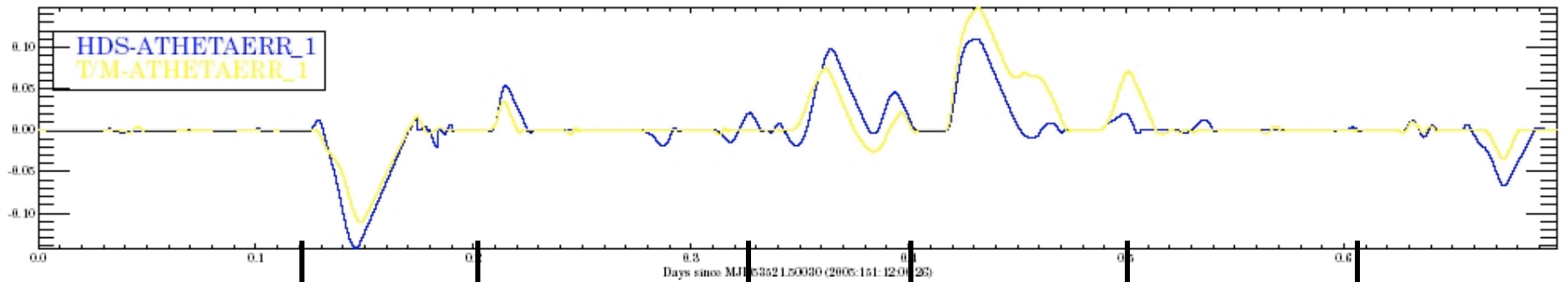
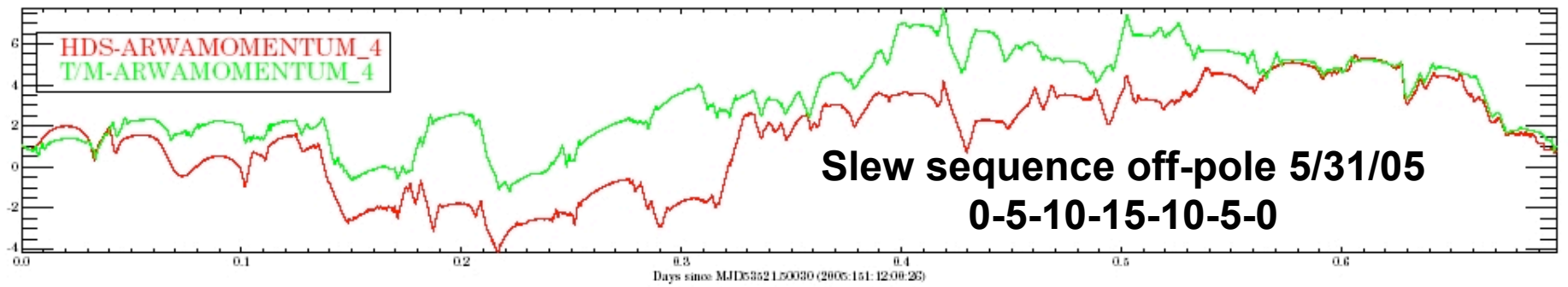


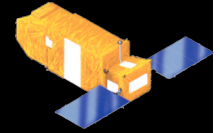
	Observations -----	Exp. Time -----
B programs:	2	16 ks
C programs:	15	131 ks
D programs (std):	30	165 ks
D programs (sur):	11	145 ks
E programs (std):	53	825 ks
E programs (leg):	36	1360 ks
E programs (sur):	33	661 ks
P programs:	38	252 ks
Q programs:	1	20 ks
Z programs:	1	33 ks
M programs:	9	84 ks
	----	-----
TOTAL:	229	3692 ks

**Total Survey CO:
806 ks**

**Total Prime CO:
2886 ks**
(of which 1866 ks
is on HOLD.)

(Information courtesy of Alice Berman, FUSE MP.)

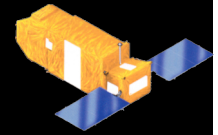




FES-A Performance

- FES-A has been the primary guidance camera since launch.
 - Located on the LiF1 optical channel.
- During April-May 2005 (after extended down time), FES-A performance has been spotty, with numerous spontaneous hang-ups and auto-reboots.
- Operations at somewhat reduced temperature seem to help, with only occasional power cycles needed.
 - Automated scripts are in place to power cycle when necessary.
- FES-B (on the LiF2 channel) is available for backup if needed.
 - Would require “compromise” focus setting to improve performance.
 - Other channels would then drift wrt LiF2 (instead of LiF1).
 - Some calibration of FES-B characteristics would be required.
- No immediate need to do anything.

Previous Sky Coverage



- We used two enhancements to improve sky availability:
 - Careful use of partially stable orbits.
 - Implemented “slow slew rate” for slews leaving marginal torque regions.
 - Used positive roll offsets (up to 25 degrees).
 - Better MTB alignment to local B fields.
- As of March 2004, we had recovered access to the whole sky at some time during the year.

FUSE Sky Availability (1 Apr 2004 - 31 Mar 2005)
Equatorial frame, $30 < \beta < 95$, $\text{ram} > 10$, $\text{moon} > 10$, optimized unloading, roll offsets, 4 orbits

