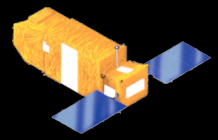
Far Ultraviolet Spectroscopic Explorer



FUSE End of Mission Status and Update

Bill Blair

FUSE Deputy-PI and

Chief of Observatory Operations

FOAC Meeting, Nov. 19, 2007

Overview since Apr. 2007

FUSE Performance, April 2007

- The final (skew) reaction wheel stopped temporarily in May, then stopped for good on July 12, 2007.
- After ~1 month of trying to restart the wheel, an end to science operations was declared.
- The project is in a closeout mode that should be complete by the end of GFY 2008.

Overview since Apr. 2007

FUSE Performance,

July 2007

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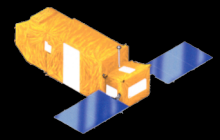
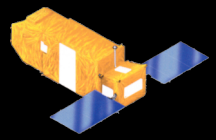
Timeline of Events



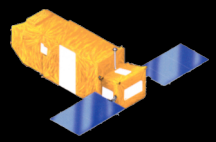
- May 8, 2007: Skew wheel friction increase slows wheel to a stop over ~17 minutes.
  - Immediate attempts to restart wheel fail.
- May 13, 2007: Wheel is restarted temporarily.
  - Lack of safe mode allowing a wheel bias truncates restart.
- May 23, 2007: Presentation to NASA-HQ.
- May 24, 2007: With new safe mode in place, wheel is once again started spinning.
  - Bias of approx. -3000 rpm maintained; friction ragged at first, but then systematically but slowly decreasing with time.
  - Developed capability for LVLH-to-pole slews with bias on wheel.
- June 12, 2007: FUSE is slewed to N-pole. Join a pre-planned T/L.
  - As a precaution, T/Ls planned with no zero-crossings, using only "half" of the wheel.

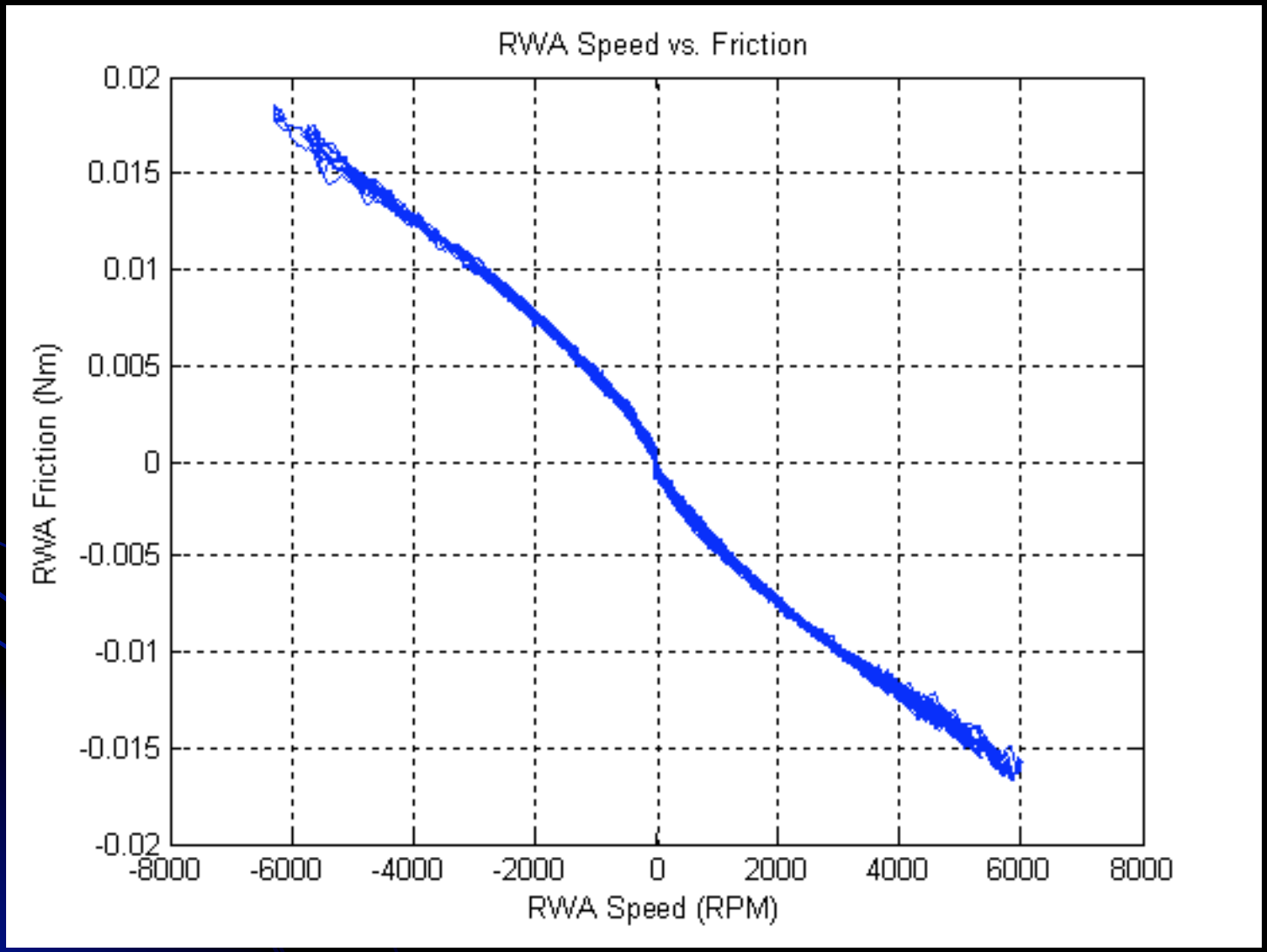
Timeline of Events, con't.



- June 29, 2007: Second presentation to NASA-HQ.
  - OK to proceed, and to solicit proposals for "Cycle 9" granted.
- July 12, 2007: Skew wheel stops rapidly and unexpectedly.
  - Review of TLM shows no evidence of problem prior to failure.
- Next month spent trying to recover motion in ANY wheel.
  - Series of hot and cold soaks in attempt to break wheel(s) free.
  - Semi-automated procedure developed to alternate direction of applied torque.
- Aug. 14, 2007: Message sent to NASA-HQ recommending termination of science operations.
- Aug. 17, 2007: Meeting at NASA-HQ; SciOps ends officially.
  - Close-out plan and budget presented and accepted at that time.
- Next ~two months spent obtaining long dark exposures and running various modest engineering tests.
- Oct. 18, 2007: Satellite decommissioned. End of on-orbit operations.

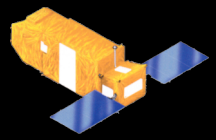
Skew Wheel Performance
(Data from March 2007)

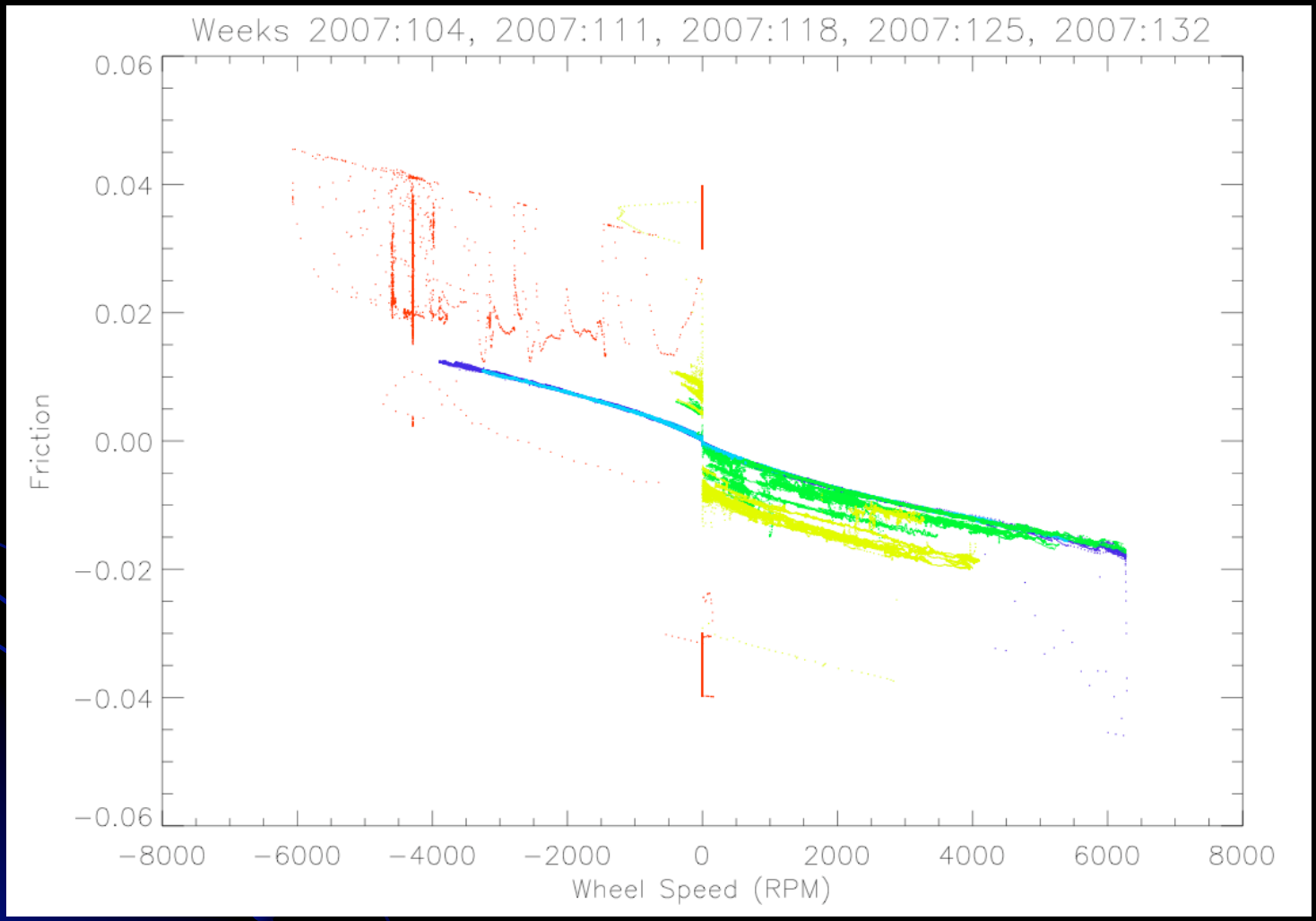




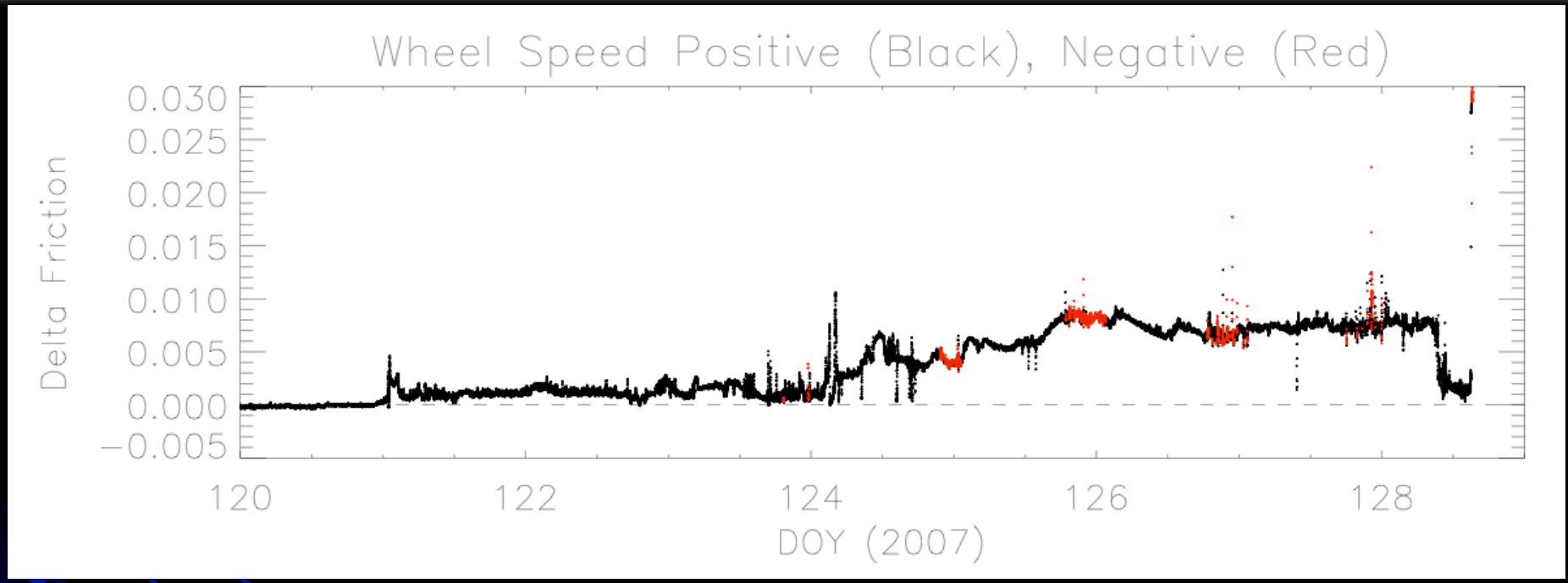
Courtesy: Ithaco, Orbital Sciences Corp.

Degradation of Wheel
(April-May 2007)

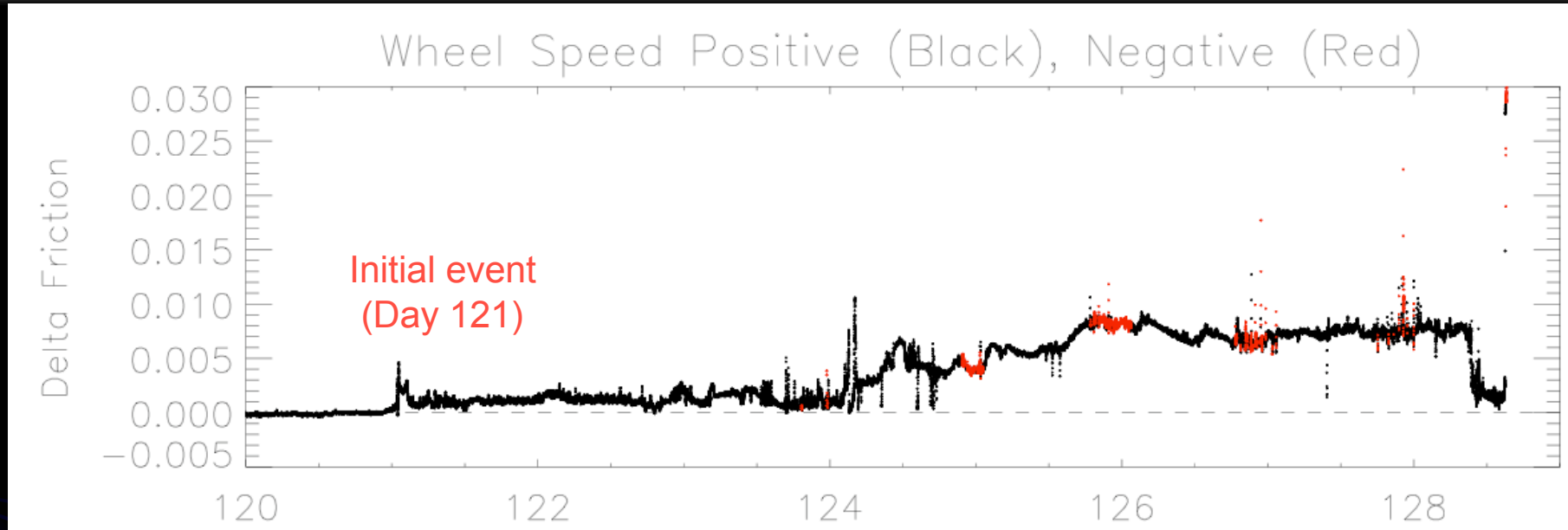


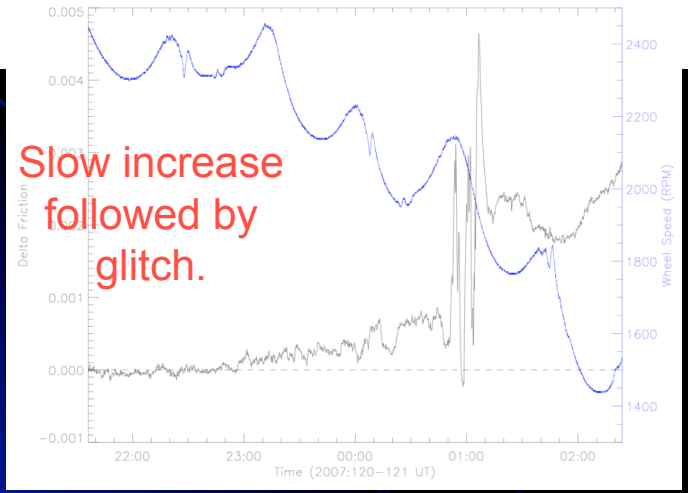


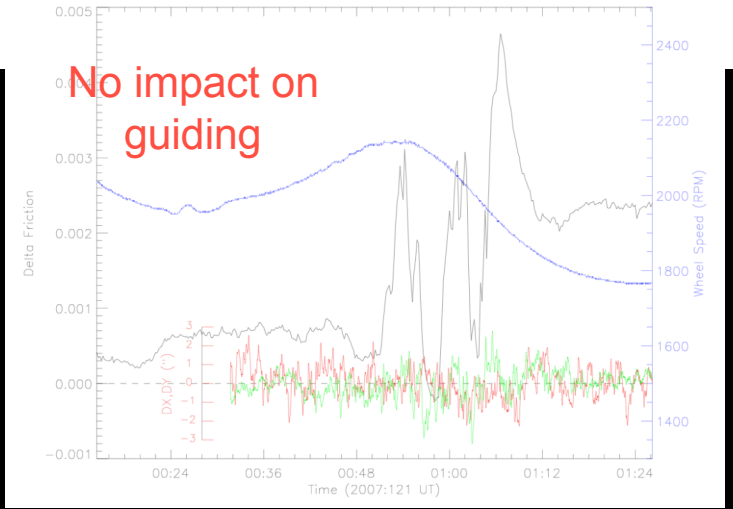
Run up to May 8 Event



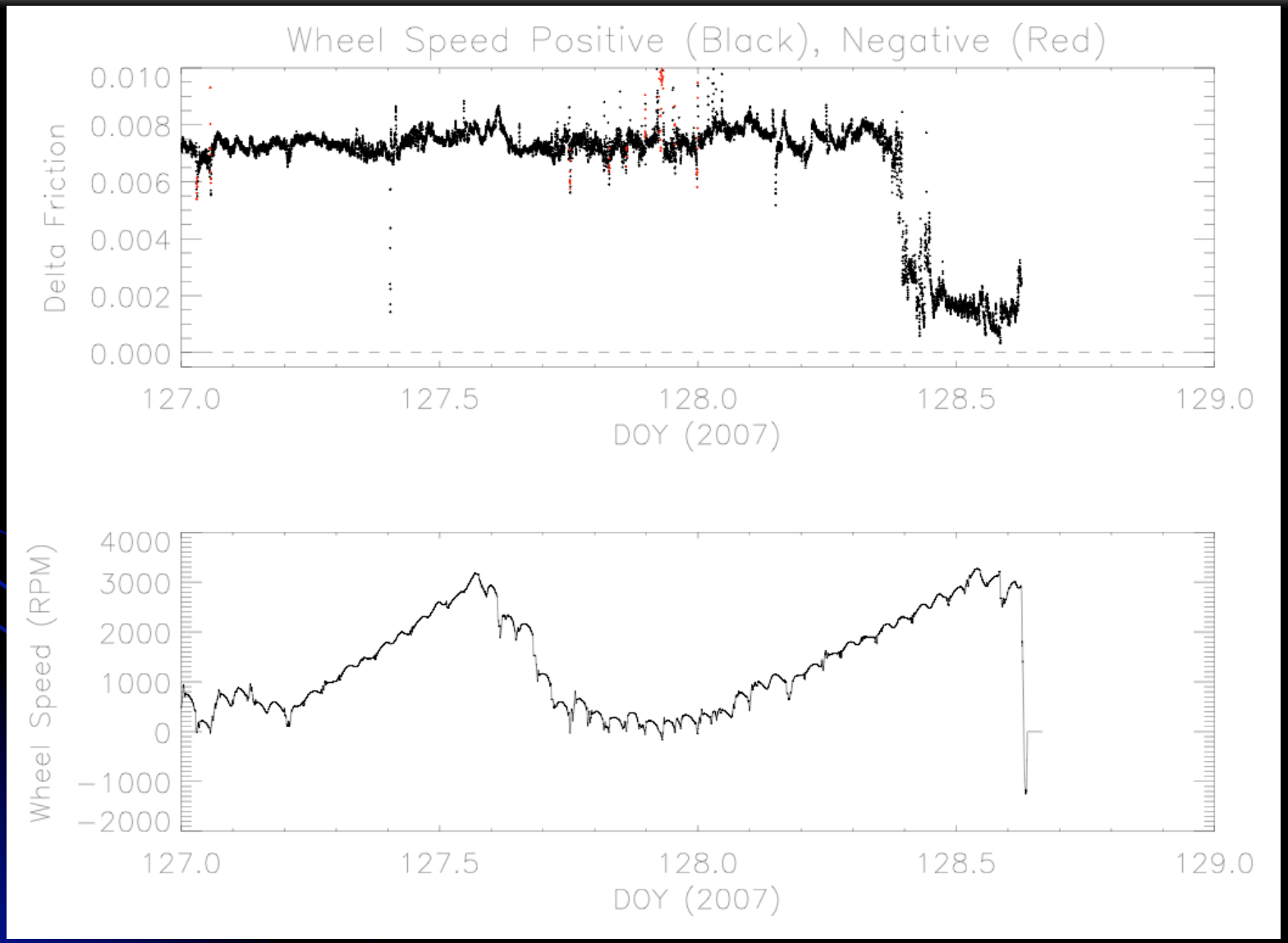
Run up to May 8 Event



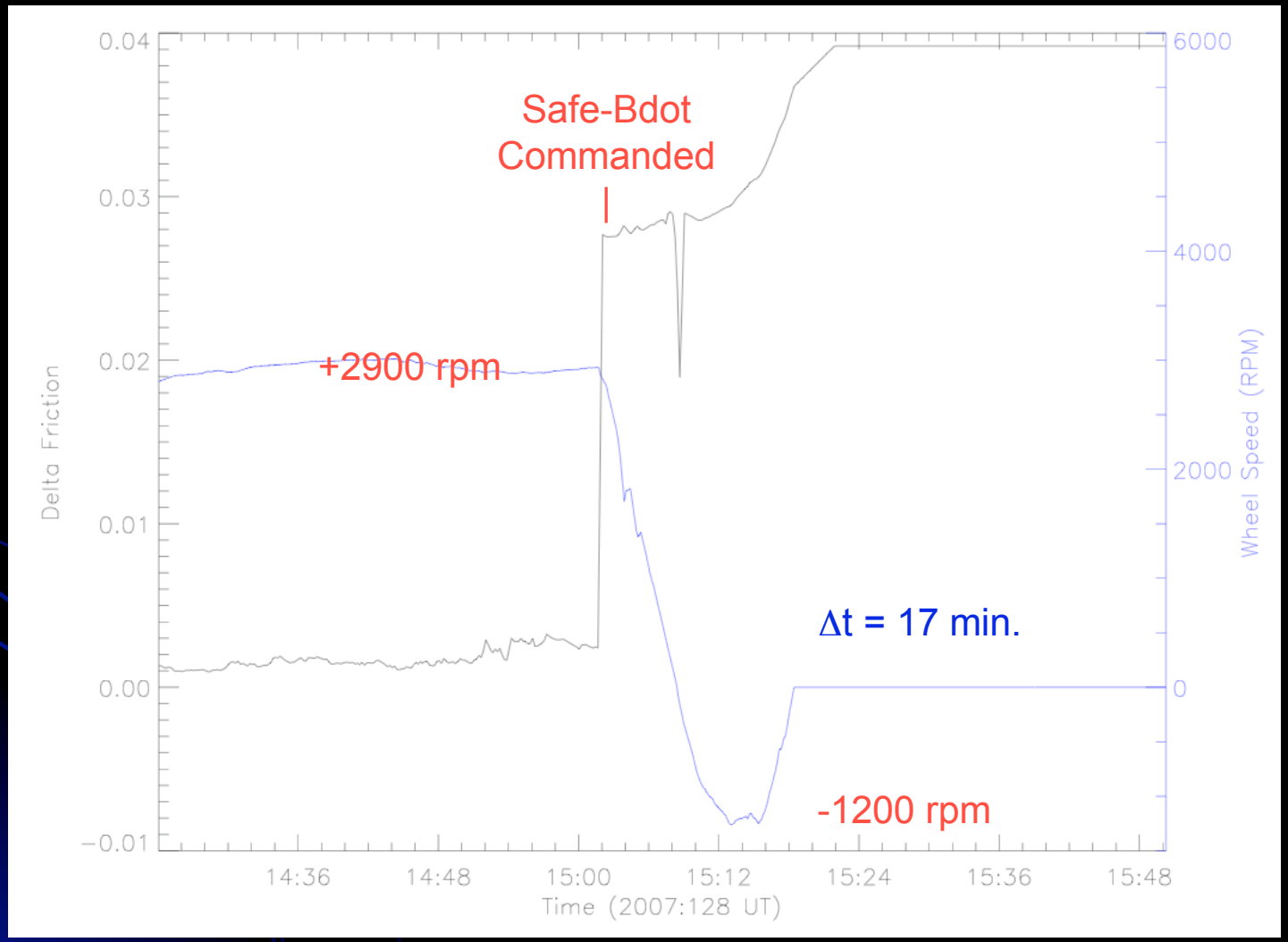




Run up to May 8 Event

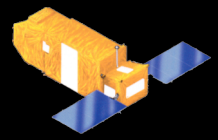


May 8 Event Detail



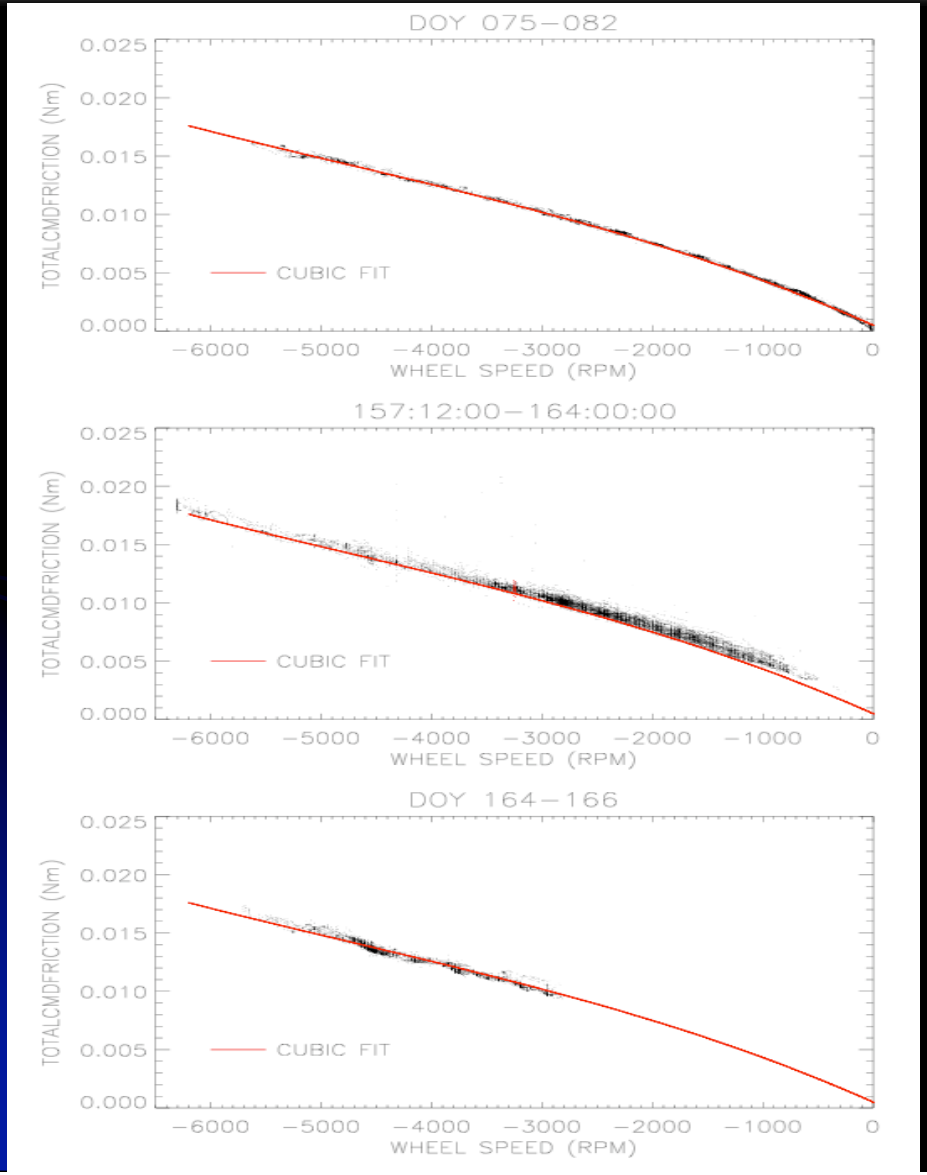
Safe-Bdot attempted to command wheel to -2000 rpm.

May-June Activities



- May 13: From cold start, warmed wheel while applying full torque; got wheel moving for ~8 hours, but pointing/power concerns caused need to return to LVLH. Wheel stopped.
- May 13 - 24: Developed “biased” safe mode and LVLH patches (so we could keep the wheel spinning AND maintain a safe configuration), test, and upload.
- May 24: Got wheel running again, and this time were able to maintain safe mode and power.
  - Biased wheel at ~4000 rpm.
- Just let the wheel crank while monitoring performance.
  - Slowly improved to just about pre-anomaly performance.
- Developed ability to simulate LVLH-to-pole slews that avoided zero-crossings.
- Developed T/L procedures to avoid zero-crossings.
- June 12: Executed slew to N-pole and returned to operations.

May-June Wheel Improvement

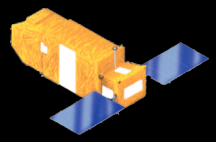


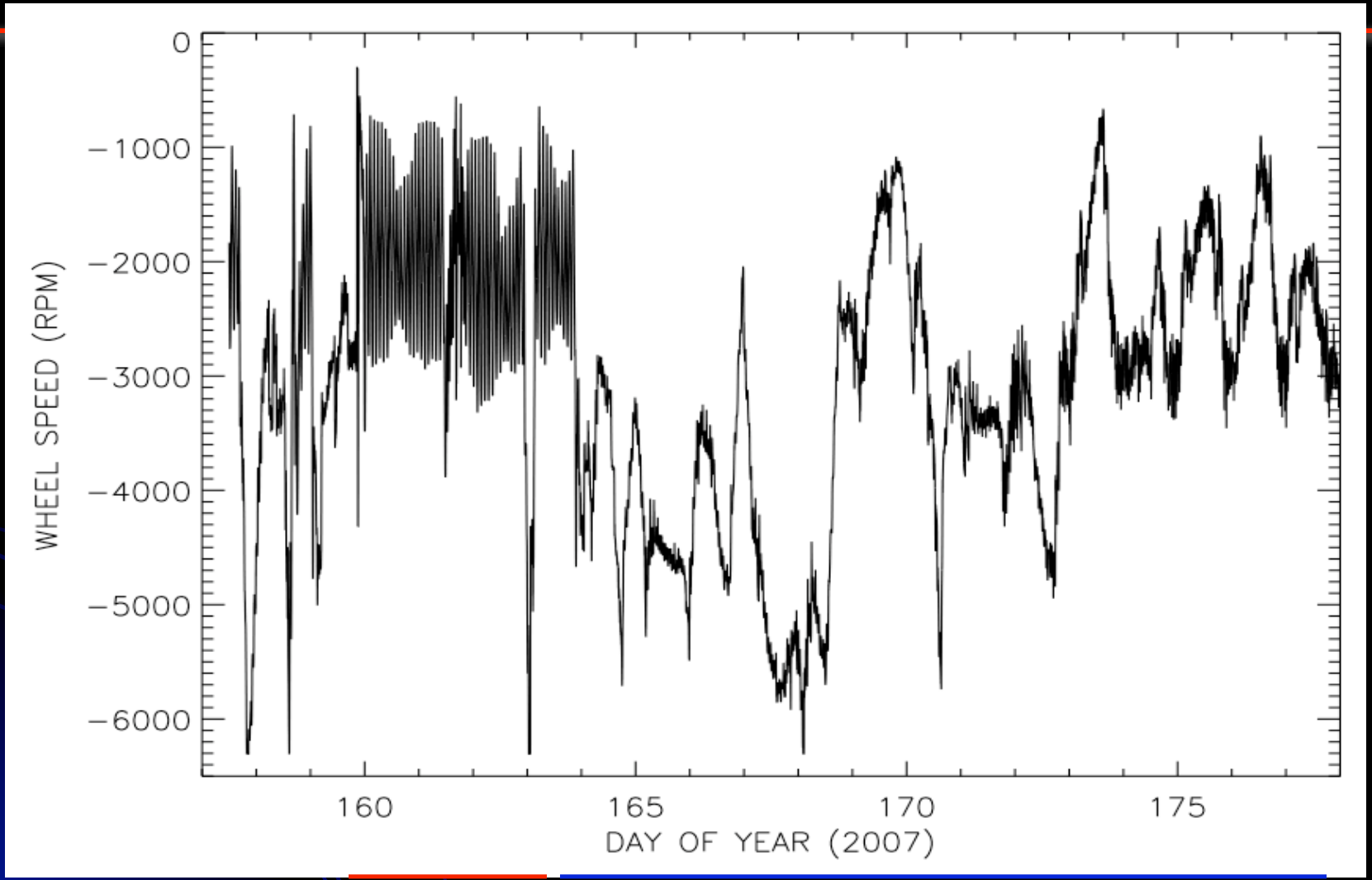
< March 2007; period used to define "normal" friction.

< June 6-13, 2007; period just prior to return to ops.

< June 13-15, 2007; period just after return to ops.

Managing Wheel Speed

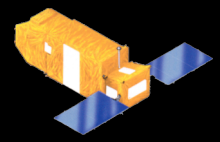




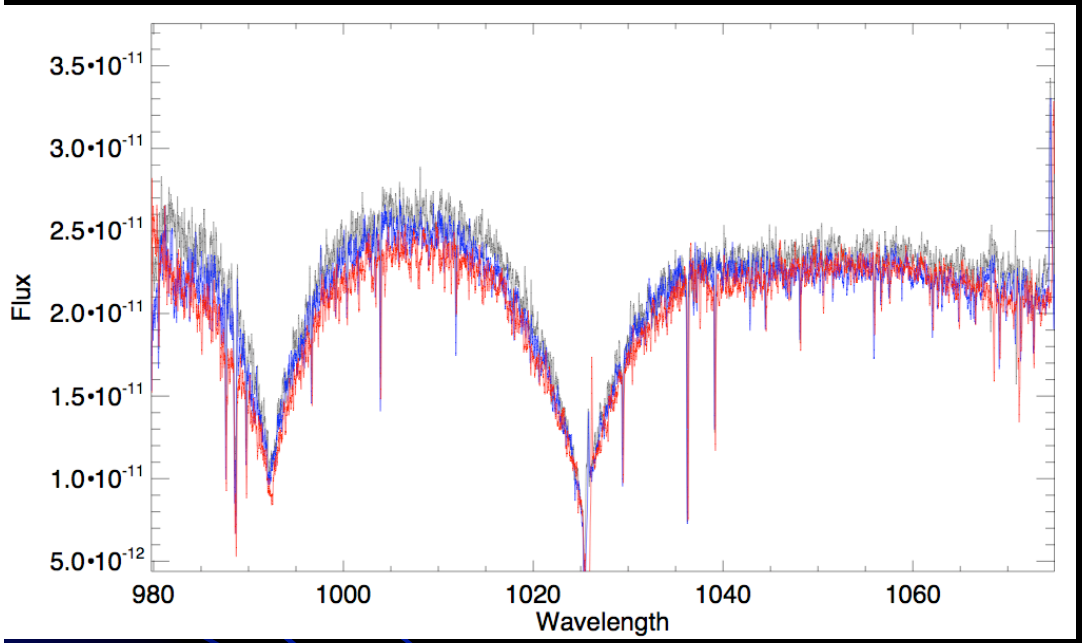
Biased Safe Mode Performance

Operations Performance Since June 12, 2007

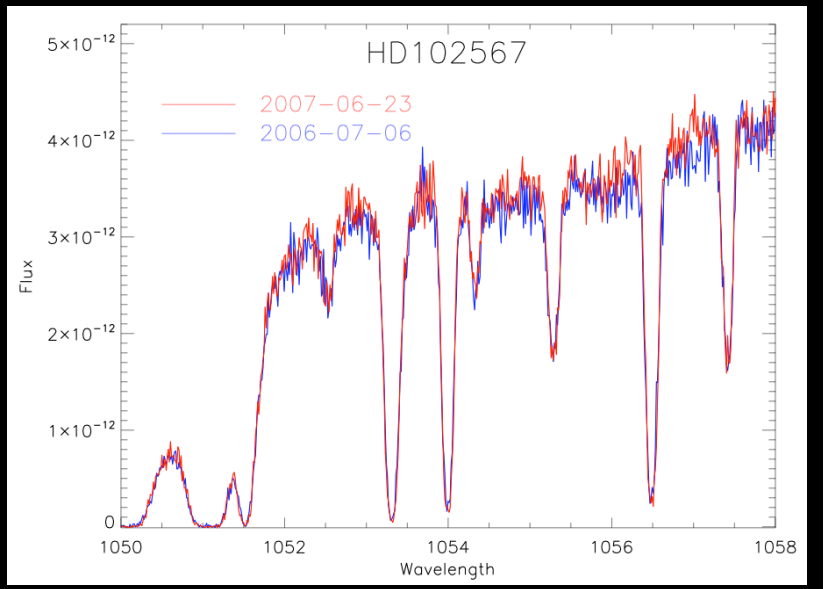
Before/After Performance Comparison



Calibration unchanged

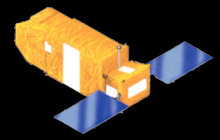


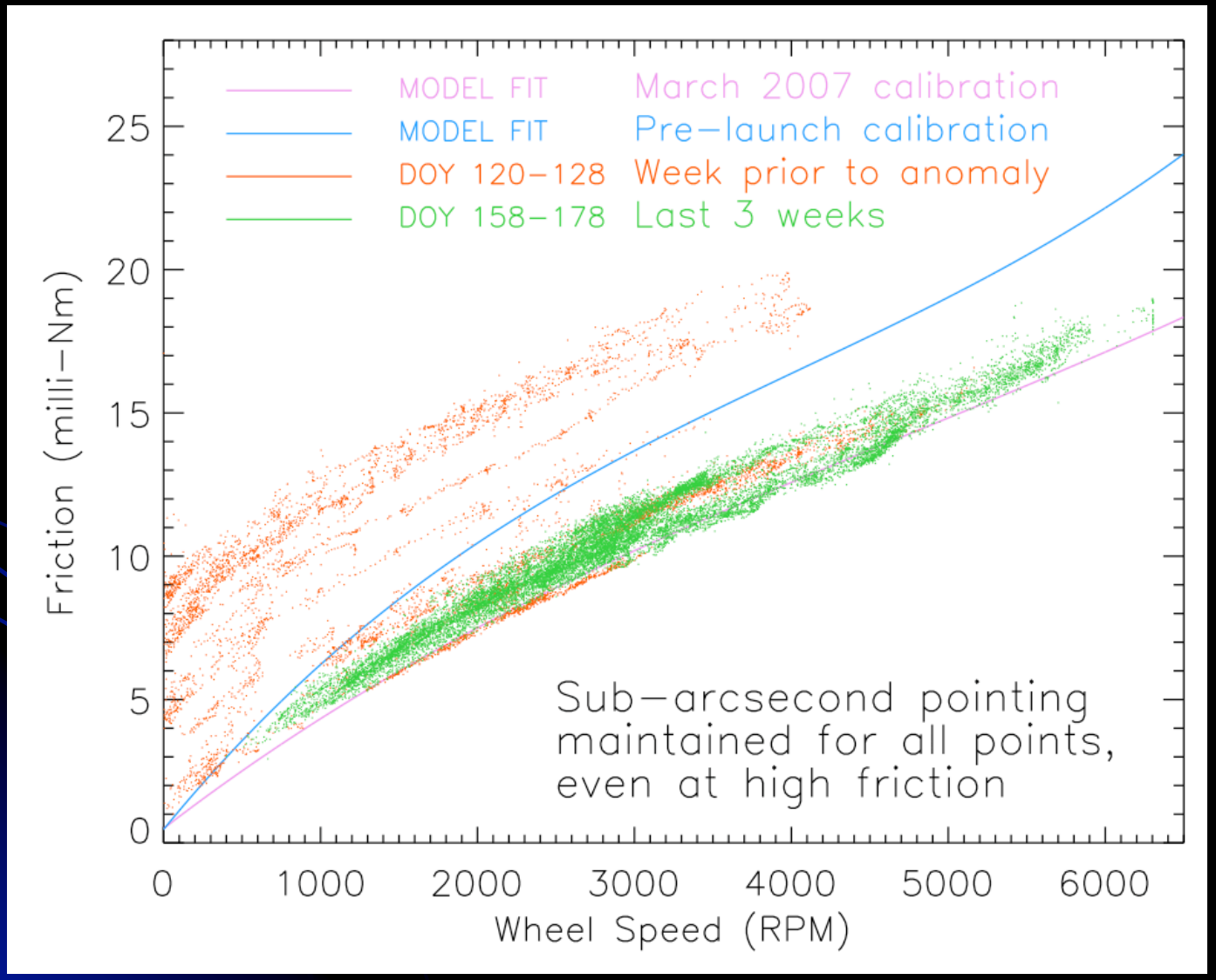
M1031407 observed on July 20 2004
M1051201 observed on July 30 2003
M1051211 observed on June 13 2007



Resolution unchanged

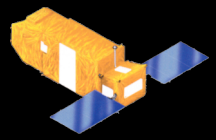
Wheel Performance Summary

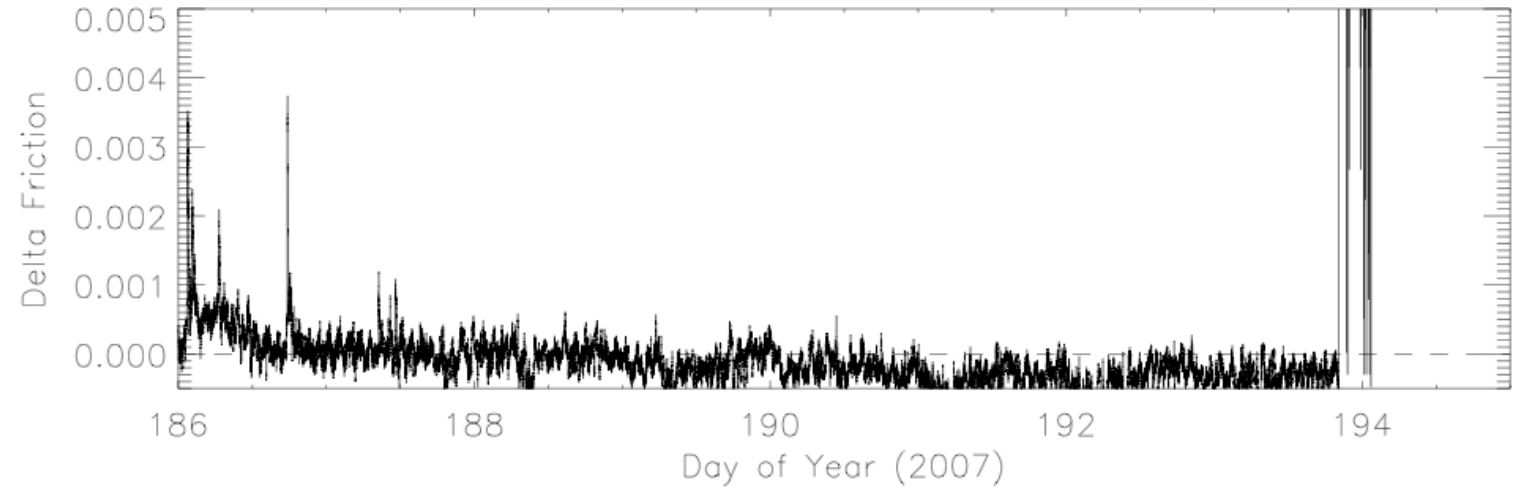


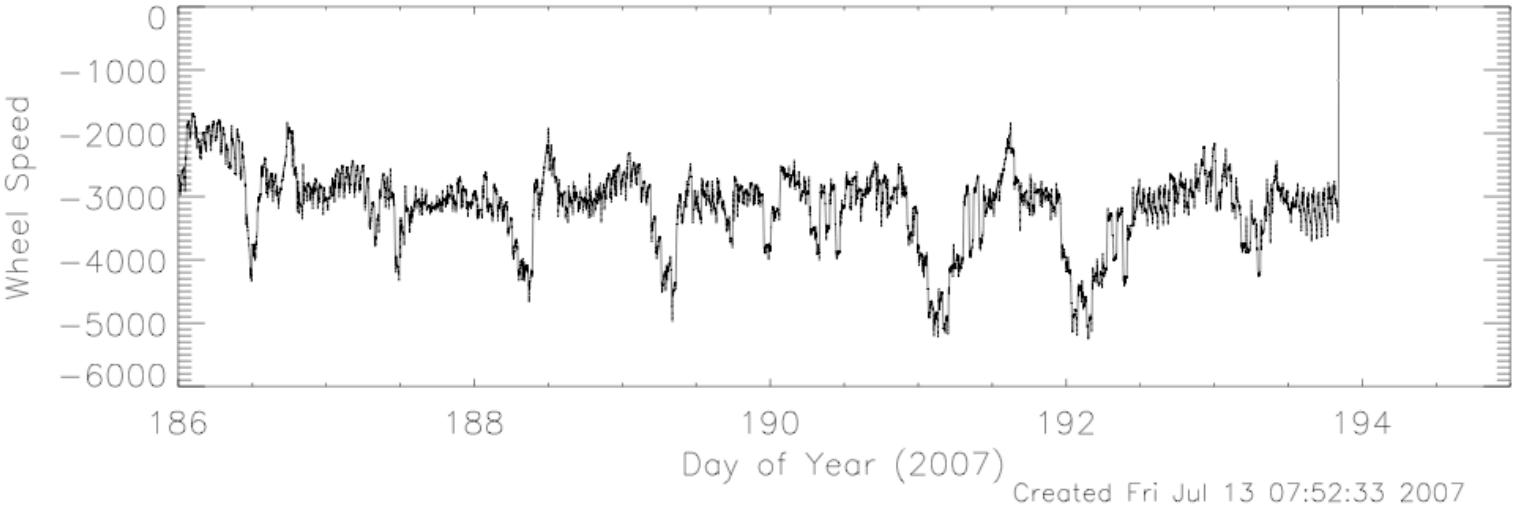


(J. Kruk)

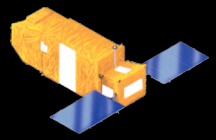
Run up to July 12 Event

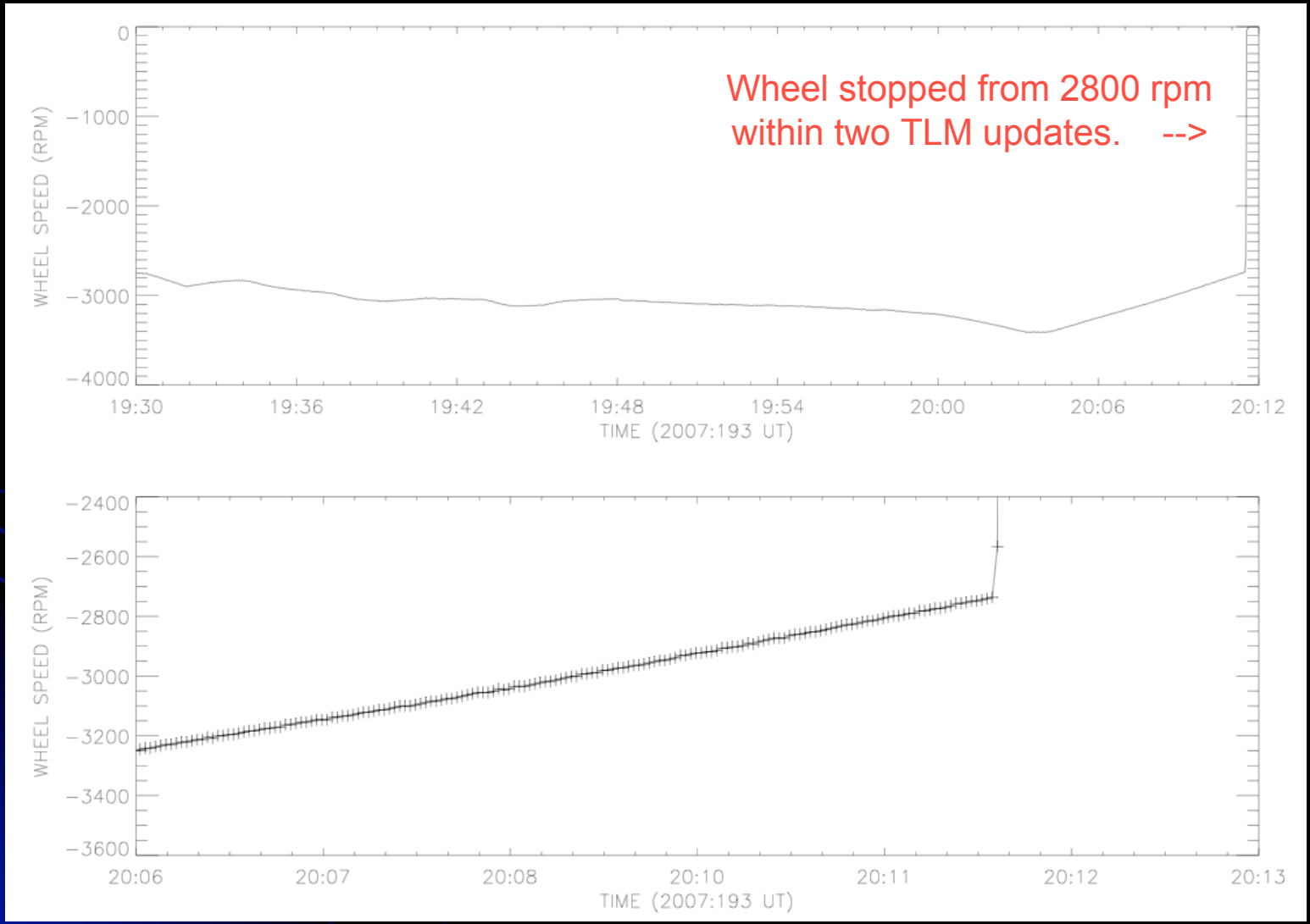




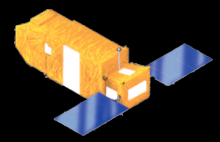


July 12 Event Detail



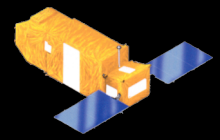


Major Close-out Activities @ JHU
(GFY 2008)



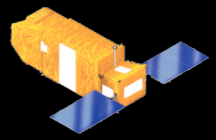
- End-of-Mission observations, calibrations, and tests.
- Passivation and Decommissioning of satellite.
- Retrieve, assess, and deliver wheel data to NASA.
- Disposition of UPRM LEO-T antenna and supporting equipment.
- Continue/Complete reprocessing/redelivery of all FUSE data to MAST.
  - Includes obtaining jitter data for “missing year” of data.
- Revise and Deliver Archival Documentation to MAST.
- Transition FUSE Web presence to MAST.
- Catalog and Deliver all mission documentation to NASA Code 400 Library.
- Security safing and Dispensation of control center and other hardware.
- Generation of Technical and Final Reports for delivery to NASA.
- Closing the books.

EoM On-Orbit Activities



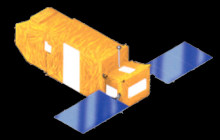
- Final Down-looking airglow (science) program.
  - Discretionary program.
- Detector Dark Exposures (doors closed).
- STIM lamp calibrations.
- Several Engineering tests requested by NASA (e.g. power system, RF test in support of AIM, etc.)
- Detector “stress tests” in support of COS.

Detector Darks



- Decided to take end-of-mission dark data while the baffle doors were closed.
  - No darks were obtained earlier in the mission due to concerns about ramping up detector high voltage with possible pressure build up inside the baffles, and amount of time required to obtain data.
- The doors were designed not to close tight, so some unknown amount of scattered light was expected.
- The plan was to collect and evaluate the data, but not change CalFUSE to use a dark calibration file.
  - CalFUSE models exposure background based on day and night time scattered light calibration images, but only a scalar value for the dark rate.
- 786 exposures were obtained from 1 Aug. - 17 Oct. 2007 for a total of 1.8 Msec day time, 1.0 Msec night time.

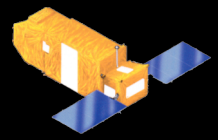
Detector Darks, con't.

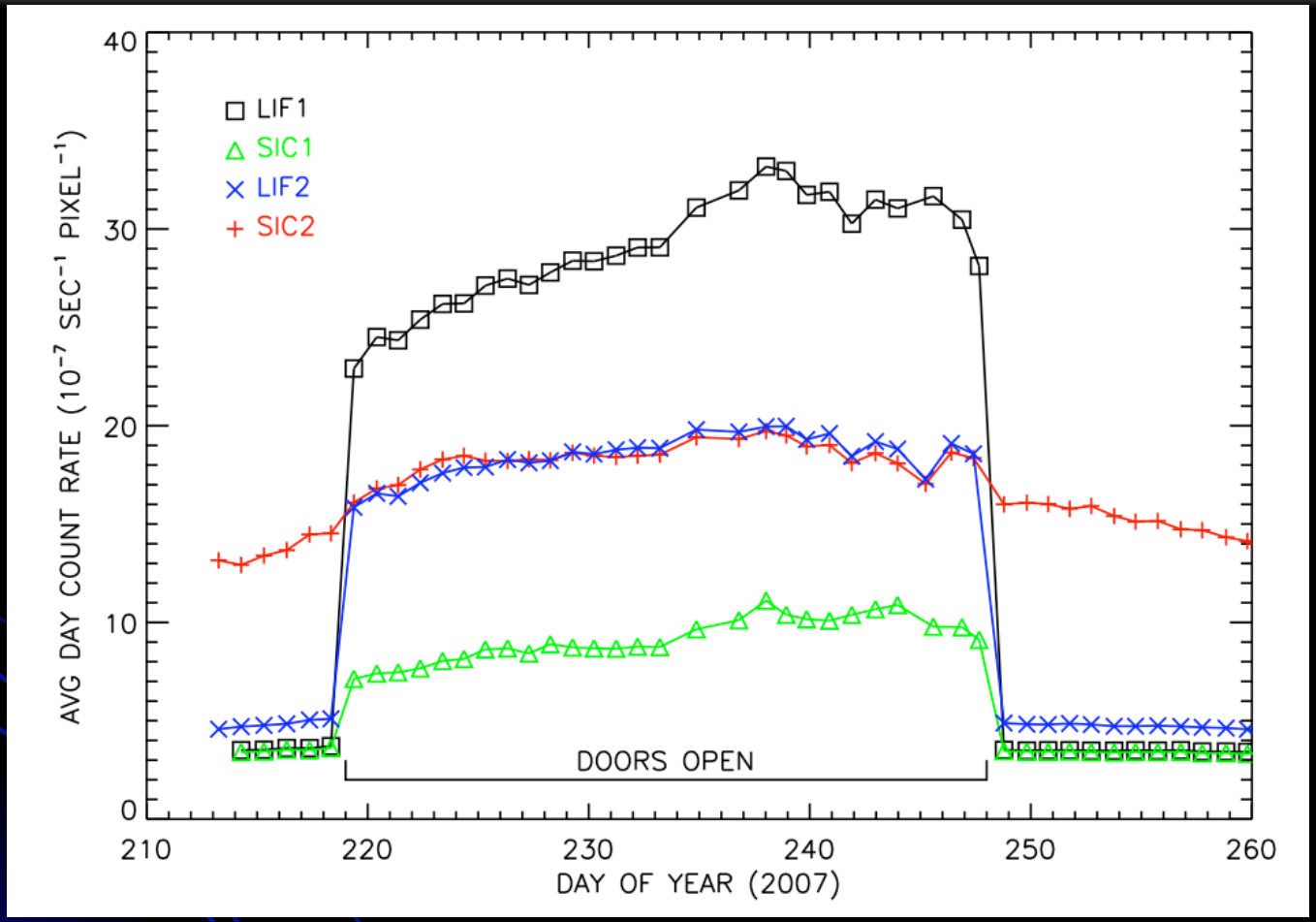


- Detector 1 dark rate was as expected, 3.2e-7 cts/sec/pix. Day time rate is <10% higher than night time, so the LiF1 and SiC1 doors are well closed.
- Found that the SiC2 door does not close anymore, so Detector 2 day time data are contaminated by airglow. Night time rate is 4e-7 cts/sec/pix.
- Dark rates vary by 20% with orbital position.
  - Explains why CalFUSE has to iterate the intrinsic count rate when forming the background model for each exposure.
- Found that event bursts disappear when the doors are closed.
- Total counts obtained were too low to derive true flat field images, but structure can be seen in the summed data.
  - The data could be used to create dark calibration files, but it's not clear that an improved background subtraction would result.
- One improvement identified would be the background modeling for SiC1B LWRS exposures since the spectra fall near the bright edge at the bottom of the detector segment. The edge is currently scaled along with the scattered light rather than as an intrinsic component.

What (if anything) to do with these data is undetermined at this time.

SiC2 Baffle Door Anomaly

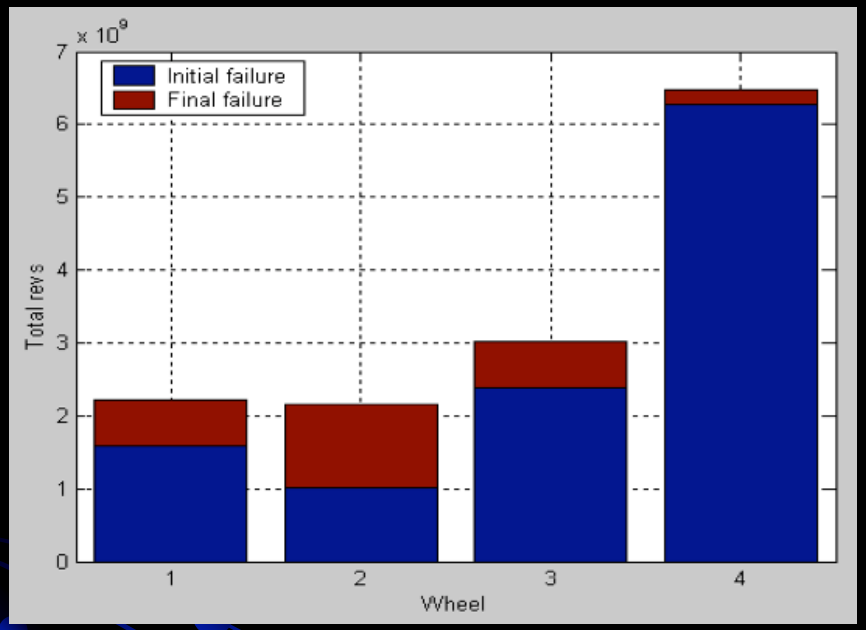


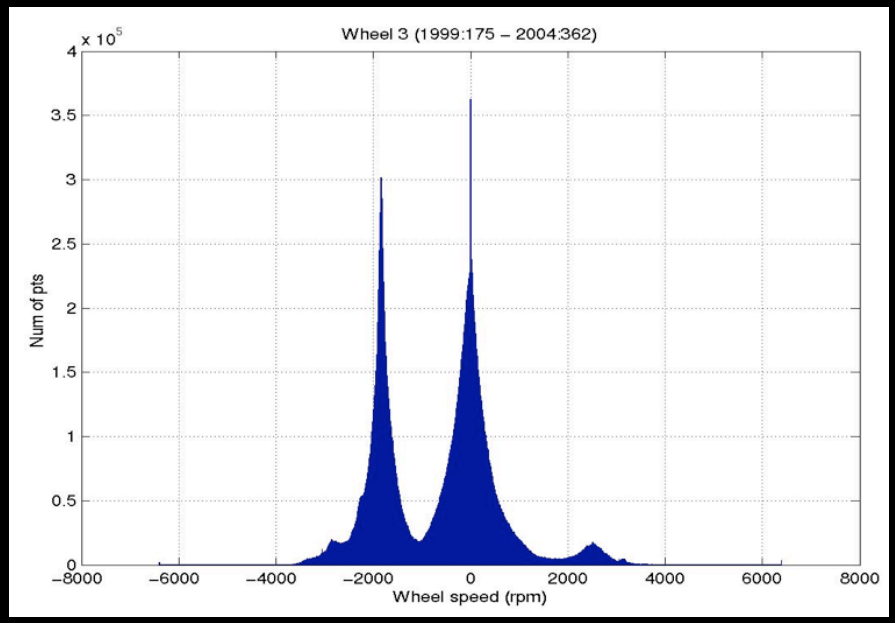


(T. Ake)

- Discovered during EoM airglow observation program.
- No change in SiC2 ct rate whether door commanded open or closed!
- Door has probably been open since 6 June 2004! (Thermistor/HOP failure?)

Wheel Analyses

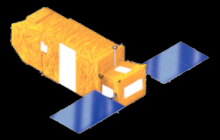


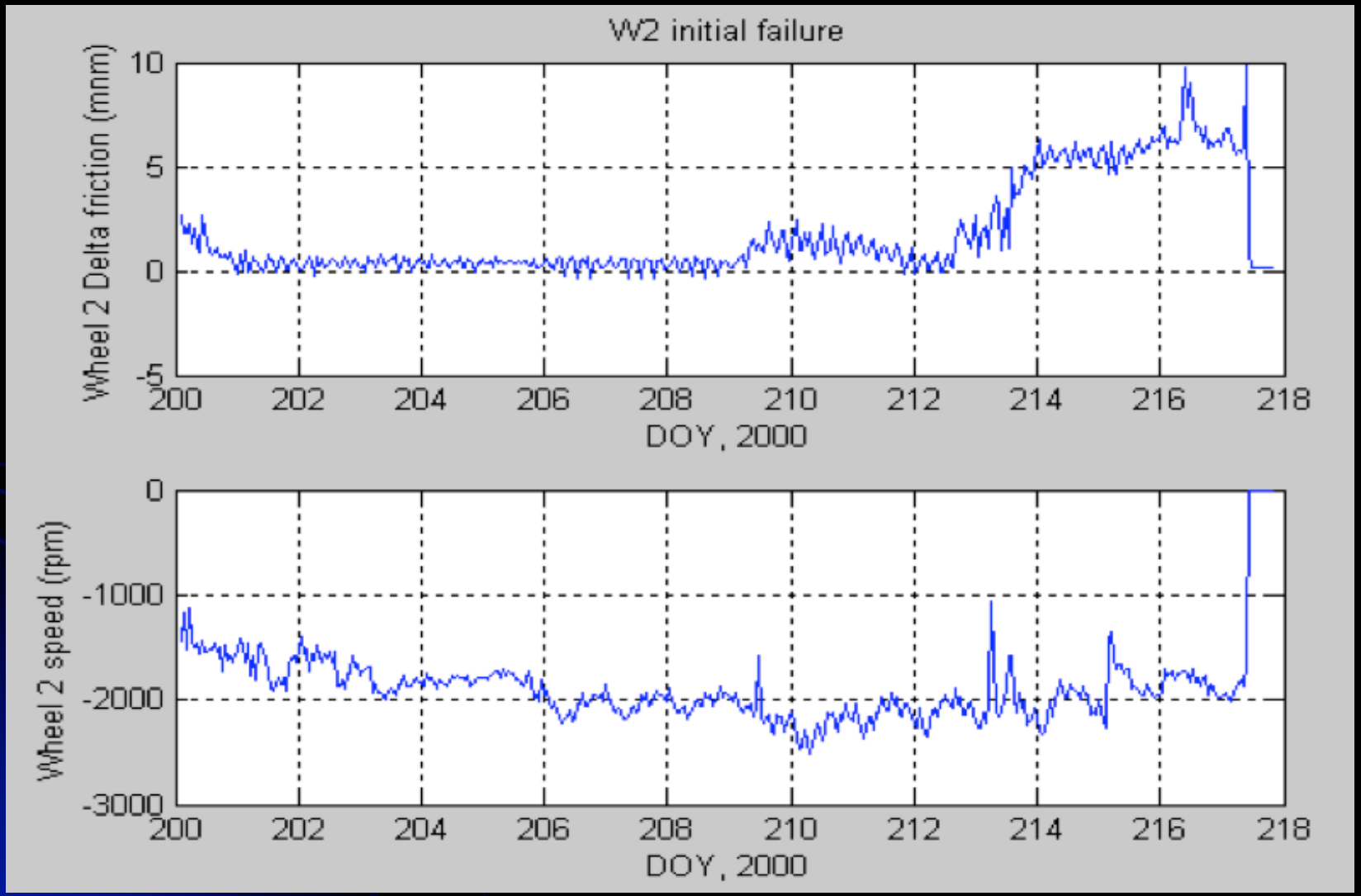


- Have performed summary analyses of all wheels and delivered to NASA. (Examples shown).

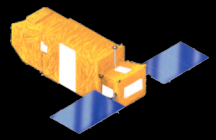
(J. Rowe)

Previous Wheels: Similar?

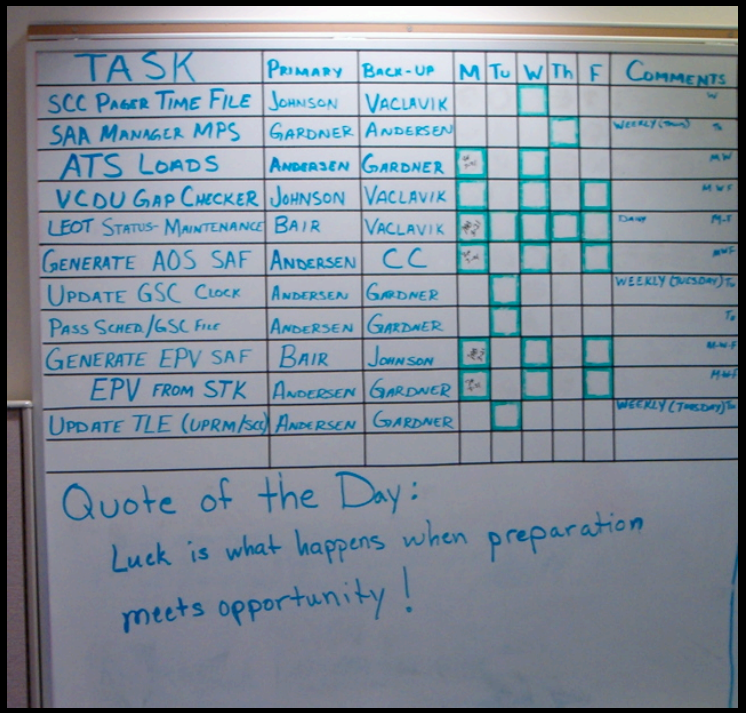




Satellite Decommissioning (Oct. 18, 2007)



- Disable FDC rules (safety protections).
- Discharge batteries and reset max threshold to prevent charging.
- Leave all computers in “standby” mode (no command processing).
- Leave load on bus.
- Turn off RF transmitter.
- [Go drink beer.]



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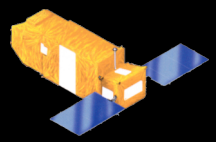

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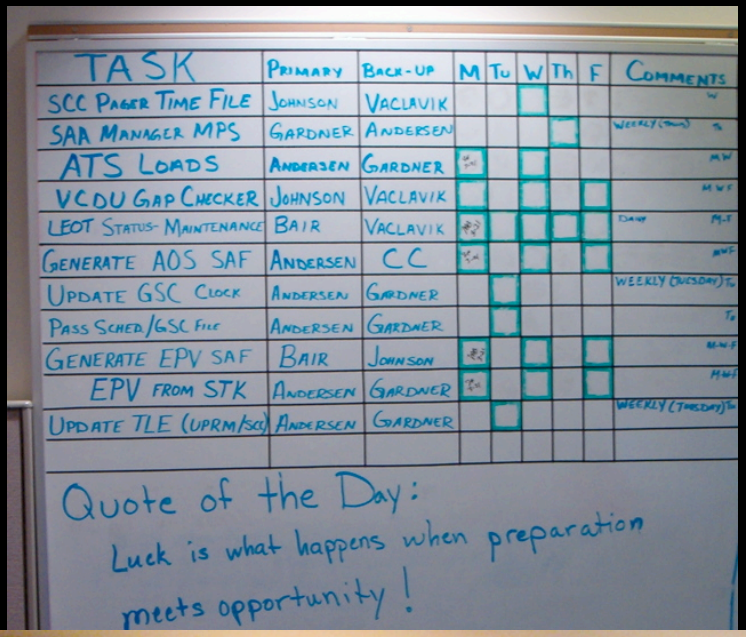
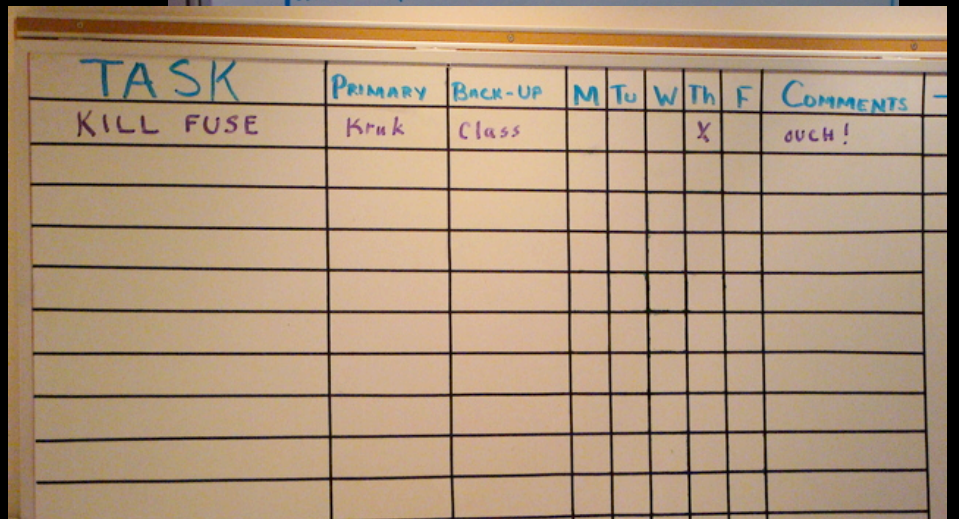
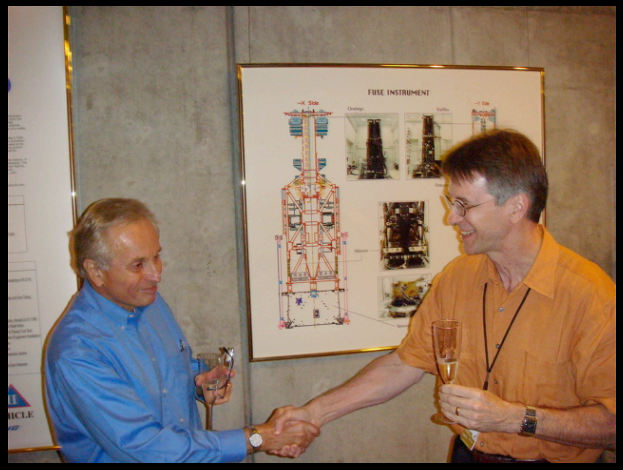




Oct. 18, 2007

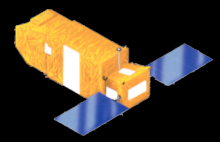

FAILURE
WAS NOT AN OPTION


FUSE INSTRUMENT


Goodbye
FUSE!!
Far Ultraviolet Spectroscopic Explorer

Thanks FUSE!

Far Ultraviolet Spectroscopic Explorer



FUSE End of Mission Data Processing, Archiving, Web Presence, & Documentation

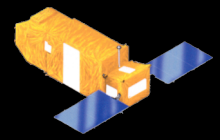
Bill Blair

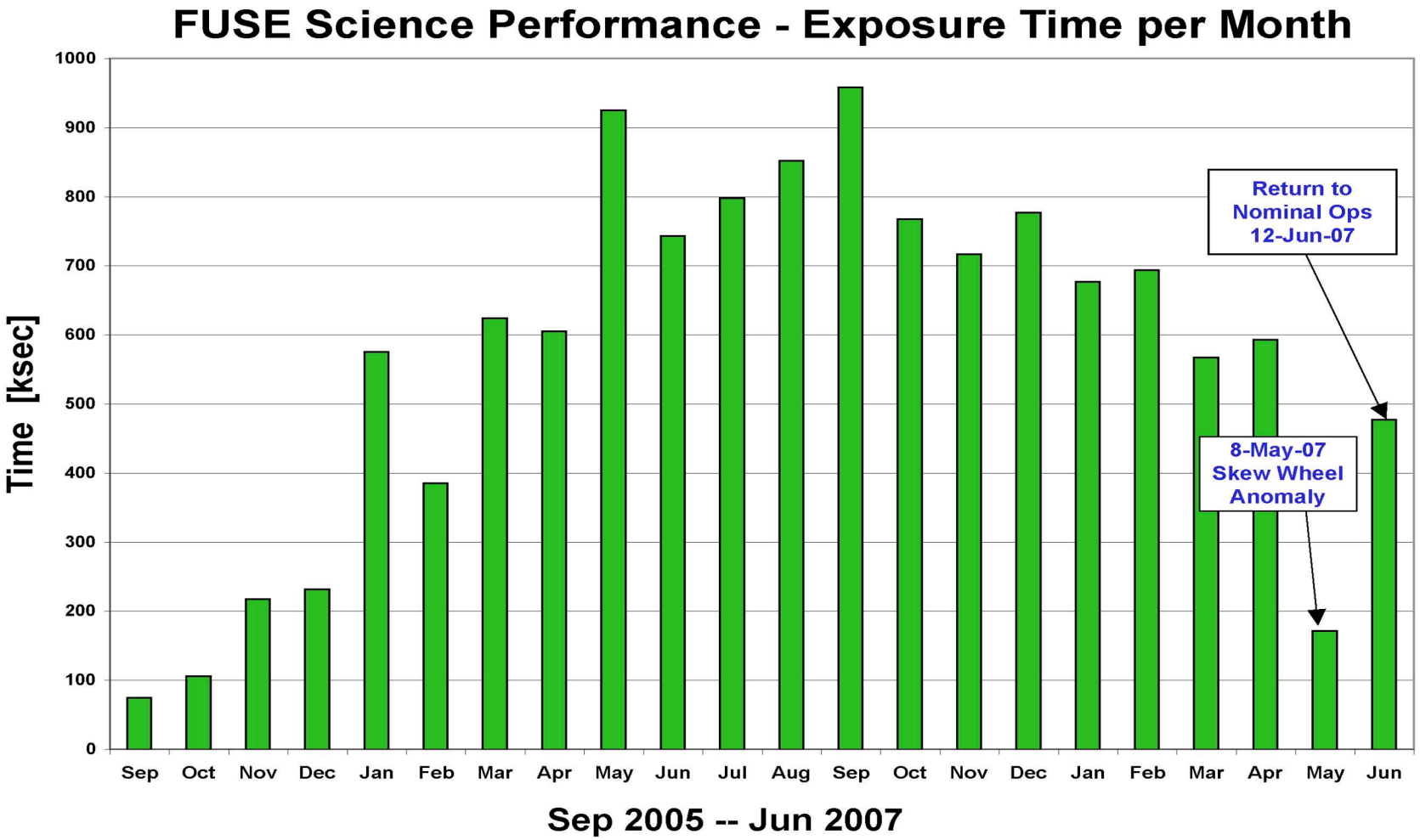
FUSE Deputy-PI and

Chief of Observatory Operations

FOAC Meeting, Nov. 19, 2007

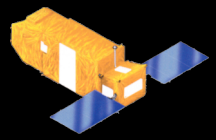
One-Wheel Science Performance





(M. Kaiser, H. Calvani)

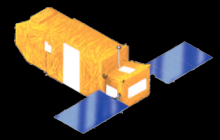
Mission Totals by Program Type



FUSE EOM Program Summary						
Program	PH2 Requested	S/C Executed (MPDB)	Calibrated (MAST)	% Completed (wrt MPDB)	% Completed (wrt MAST)	Pending [ksec] @ EOM
GI Cycle 1 (A)	3610755.6	4130358	3835382	114	106	0
GI Cycle 2 (B)	4303941.0	4871949	4356492	113	101	0
GI Cycle 3 (C)	6432709.0	6770004	5859454	105	91	0
GI Cycle 4 (D)	9309455.0	10131200	8509330	109	91	86.9
GI Cycle 5 (E)	7372888.0	5603645	4807270.6	76	65	614.8
GI Cycle 6 (F)	5409791.0	3395820	2294582.4	63	42	1112.0
GI Cycle 7 (G)	6990054.0	4955691	3347049.8	71	48	2117.9
GI Cycle 8 (H)	9370375.0	1164713	646418.6	12	7	6639.6
PI Team - French (Q)	554144.0	690070	627750	125	113	0
PI Team (P)	12422651.0	12235470	12066906.2	98	97	20
ERO (X)	379660.0	400888.3	372327	106	98	0
Discretionary (Z)	3574533.0	5236443	4413653.2	146	123	49
Background Observations (S)	N/A	17608007	9722899.4	N/A	N/A	N/A
Re-Observations (U)	N/A	6419203	4084450.6	N/A	N/A	N/A
Grand Total	69730956.6	83613461.3	64943965.0	85	78	10640.2

83.6 Msec executed science; 65 Msec in MAST (post-CalFUSE)

Final Reprocessing

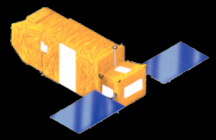


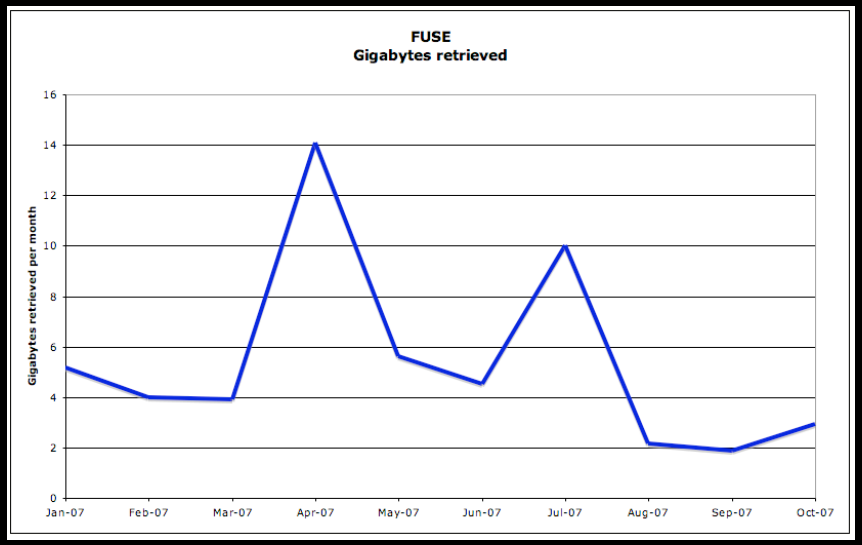
- 5316/5743 FUSE observations archived in MAST.
  - 287 “Do not archive” and 140 Misc (I, M, and S) are still missing.
- 2970 observations reprocessed with CalFUSE 3.2 (~55%).
- “Level-Zero” Reprocessing for ~1 year of data also in progress.
- Expect all reprocessing to be complete by May 1, 2008.

CalFUSE 3.2 Reprocessing Status (11/07)

PID	Total	V3.2	<V3.2
A	426	213	213
B	416	133	283
C	375	262	113
D	515	496	19
E	343	268	75
F	174	96	78
G	254	156	98
H	60	60	0
I	25	2	23
M	403	272	131
P	988	437	551
Q	58	27	31
S	597	250	347
U	291	53	238
X	22	7	15
Z	369	238	131
TOT	5316	2970	2346

MAST Stats




FUSE
Gigabytes retrieved
Gigabytes retrieved per month
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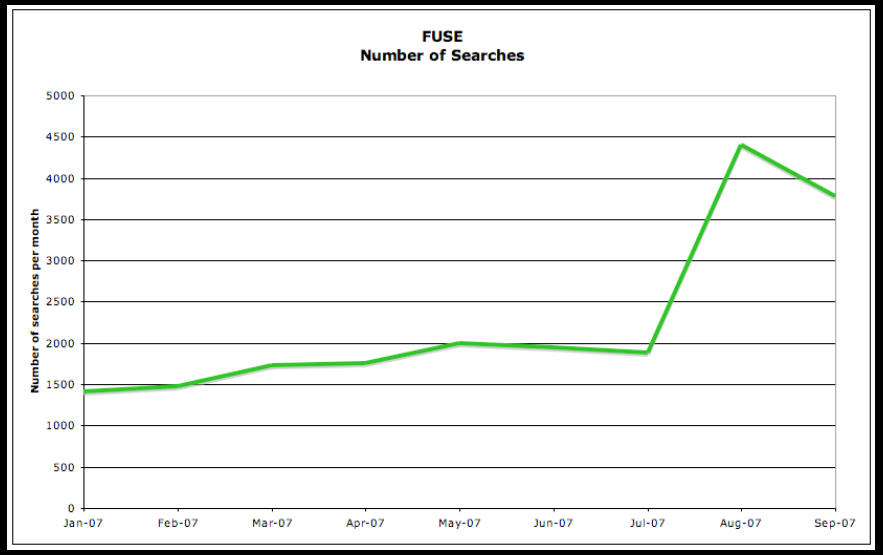
2
4
6
8
10
12
14
16
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07


FUSE
Number of Searches
Number of searches per month
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500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Jan-07
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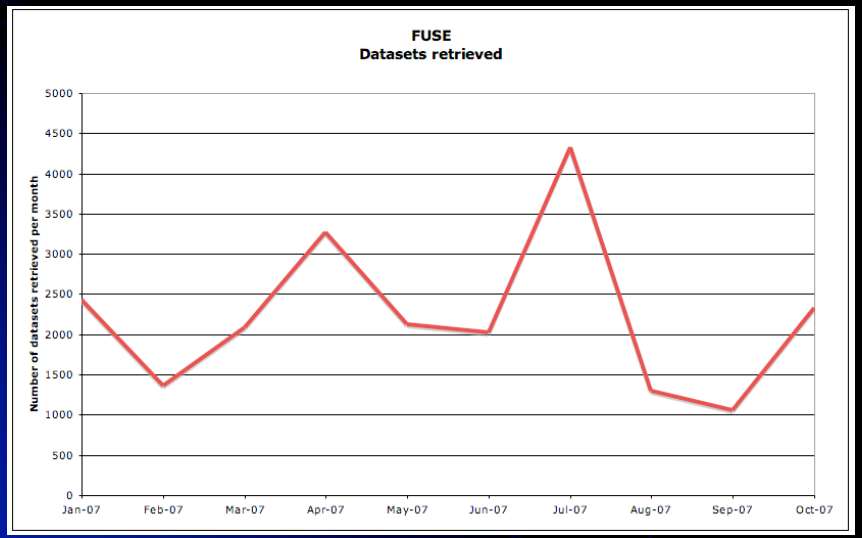
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07


FUSE
Datasets retrieved
Number of datasets retrieved per month
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500
1000
1500
2000
2500
3000
3500
4000
4500
5000
Jan-07
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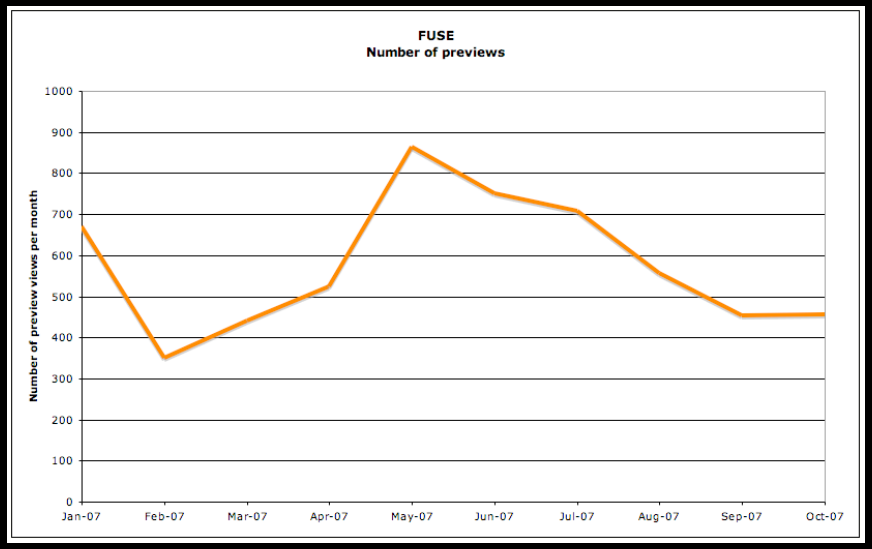
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07


FUSE
Number of previews
Number of preview views per month
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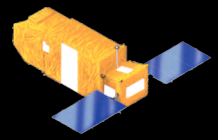
100
200
300
400
500
600
700
800
900
1000
Jan-07
Feb-07
Mar-07
Apr-07
May-07
Jun-07
Jul-07
Aug-07
Sep-07
Oct-07

FUSE Web to MAST



Far Ultraviolet Spectroscopic Explorer

Operated by JHU for NASA

FUSE is a NASA-supported astrophysics mission that was launched on June 24, 1999, to explore the Universe using the technique of high-resolution spectroscopy in the far-ultraviolet spectral region. The Johns Hopkins University has the lead role in developing and now operating the mission, in collaboration with The University of Colorado at Boulder, The University of California at Berkeley, international partners the Canadian Space Agency (CSA) and the French Space Agency (CNES), and corporate partners. ***FUSE*** is part of NASA's *Origins* Program under the auspices of NASA's Office of Space Science.

All About FUSE
FUSE Home
Mission Overview
Science Summaries
Public Outreach
FAQ's
Personnel
Photo File
FUSE Animations
FUSE On-line
Press Materials
Publications
FUSE Newsletter
French Site

Mission Operations
Status Report
FUSE Operations
Status Report Archive

User Support
GI Home Page
Observer's Guide
Planning Tools
Data Archive
Data Analysis
U-Program List
MPS Plots
Visitor Info

FUSE Publications
FUSE Paper Summary
Scientific Overviews
Technical Papers
Early Release Papers
Ph.D. Theses

FUSE Headlines

- New FUSE is Dead...Long Live FUSE! See Mission Status Report #111, Oct. 18, 2007.
- New See 8-year Space Vigil Goes Dark, an article by Frank Roylance, Baltimore Sun, Oct. 19, 2007.
- By popular demand, FUSE's Lament, End-of-Mission song.
- The Universe in Ultraviolet: Bill Blair on the FUSE Mission, A Planetary Radio interview with Mat Kaplan of the Planetary Society (10/29/07).
- See the FUSE On-line page for links to other End-of-Mission stories.
- Check out the new Canadian Space Agency FUSE Science Summary page and FUSE Mission Summary page! (added 4/27/07)

Science News Flashes

- FUSE Investigates a Clash of Titans, released May 2, 2007.

FUSE

MAST | STScI | Tools | Mission_Search | Tutorial | Site Search

FUSE Home | About Fuse | Getting Started | Registration | Archive Status | FUSE Search form | Suggestion Box

FUSE Target Search

FUSE Proposal Abstracts

FAQ

Search & Retrieval

FUSE Daily Data Reports

About FUSE Data

High-Level Science Products

Data Reduction & Analysis

Atlases

Proposal Support

Documentation

Publications

Related Sites

Gallery

Data Use Policy

Acknowledgments

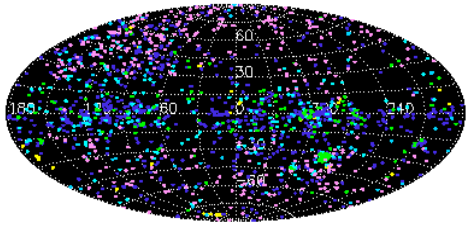
The Far Ultraviolet Spectroscopic Explorer (FUSE), launched on June 24, 1999, covers the 905-1187 Å spectral region and will obtain high resolution spectra of hot and cool stars, AGNs, supernova remnants, planetary nebulae, solar system objects as well as perform detailed studies of the interstellar medium. FUSE will be able to observe sources 10 000 times fainter than Copernicus, an early FUV mission, and has superior resolving power than the Hopkins Ultraviolet Telescope (HUT) and the Berkeley Spectrograph (BEFS) and the Tübingen Echelle Spectrograph (TUES) of the Orbiting Retrievable Far and Extreme Ultraviolet Spectrometers (ORFEUS). FUSE was planned for a 3 year lifetime with funding for an additional 2 years expected.

An overview can be found by Moos et al., ApJ, 538, L1. A first discussion of post-launch post-launch performance is given by Sahnow et al., ApJ, 538, L7.

More information about the FUSE Guest Investigator program, including PI and GI target lists, may be found at the FUSE Guest Investigator Program site at http://fusegi.pha.jhu.edu.

Although FUSE data is maintained and archived within MAST, most of the documentation available from the MAST FUSE page is obtained from the Johns Hopkins FUSE website.

Real time satellite tracking for FUSE



Map of FUSE Observations

NEWS

October 11, 2007:
Quick Search and Cross Correlation Search forms Improved

August 30, 2007:
Sorting and Paging of MAST Search Results now Offered

August 01, 2007:
MAST Newsletter

July 30, 2007:
MAST Survey Results Posted

February 22, 2007:
MAST Annual Report

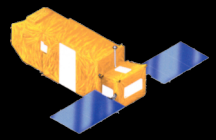
RSS 2.0

Missions

Hubble
HSTonline
DSS
GALEX
FUSE
XMM-OM
BEFS (ORFEUS)
Copernicus
EUVE
GSC
HPOL
HUT
IMAPS (ORFEUS)
IUE
TUES (ORFEUS)

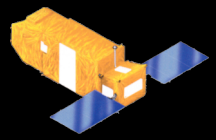
FUSE info currently spread across several separate but related sites:
Home page, GI site, EPO site, even technical (SciOps) site.

FUSE Archival Web Presence



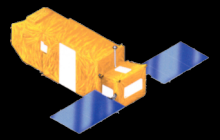
- Will not/Should not just be a transfer of the current site(s) to MAST.
  - Operations-related materials/tools mostly go.
  - Proposal-related materials on GI page will go away.
- Target Audience(s) need to be clearly defined.
  - Scientific archival users community.
  - General public/general information about mission.
  - Technical (operations) community.
  - Education/Outreach community.
  - Historical/mission archival aspects.
- Needs of these audiences will drive the content and format of the interface.
- A JHU FUSE page linked into `fuse.pha.jhu.edu` will likely stay active indefinitely, but will link to MAST site for all significant information.

Archival Documentation Strategy



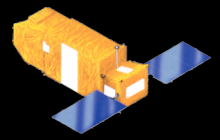
- Initial plans to clean-up/patch-up existing documentation have been scrapped.
  - Too much material directed toward “knowledgeable” FUSE users has crept into the documents over the years.
  - Too much old, no-longer-relevant information is still included.
  - Too much redundancy is present; not always clear where to direct a user for desired information.
- Instead, we plan a clearer, streamlined interface, more friendly toward a non-specialist audience.
  - Two basic documents will become primary, one directed toward instrument and instrumental characteristics, and one directed toward data and data processing.
    - Maintain as clean a break as possible between these two.
  - Topical, menu-driven interface to get users to the information they are looking for quickly.

Additional User Support



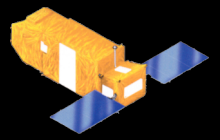
- Archiving of Mission Planning Schedule plots.
  - 24 hour per page plots showing observations in context of orbital events. (PDF files, typically 7 days per file.)
  - Will work with MAST to get pointers from overview plot page to correct MPS file.
  - User will have to find the correct page(s) with their observation.
- Archiving of SDOG/SDAF forms.
  - These are semi-automatically generated observation assessments, sometimes with hand-entered comments about data quality at the bottom of the file (html format).
  - They contain useful (but sometimes flawed) information (since they are generated automatically).
  - Trick is to supply sufficient info so that a user will know what to use and what not to.

Other Audiences



- Need to sort through Web materials and decide on archival relevance to at least one of the target audiences.
  - Not black & white in many cases. Lots of materials in the gray zone.
- General public, future PR
  - Mission overview, science descriptions, high quality photos and graphics.
- Technical Audience
  - Links to technical hardware & operations papers, white papers, additional instrument photos.
- Education and Outreach
  - Need to maintain active links to NASA-cataloged materials.
- Historical info
  - Mission status archive, science and development team info?

FOAC Help?



- We will be developing the new site/interface with the MAST team over the coming several months, and will be assembling drafts of the revised documents.
- We will be looking for reviewers/testers of the new site and materials as they are developed.
  - Who on the FOAC would like to work with us?
  - Should we be seeking input from the broader FUSE community, and if so, what is the mechanism?