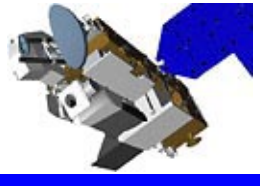


EARTH OBSERVING SYSTEM
MICROWAVE LIMB SOUNDER

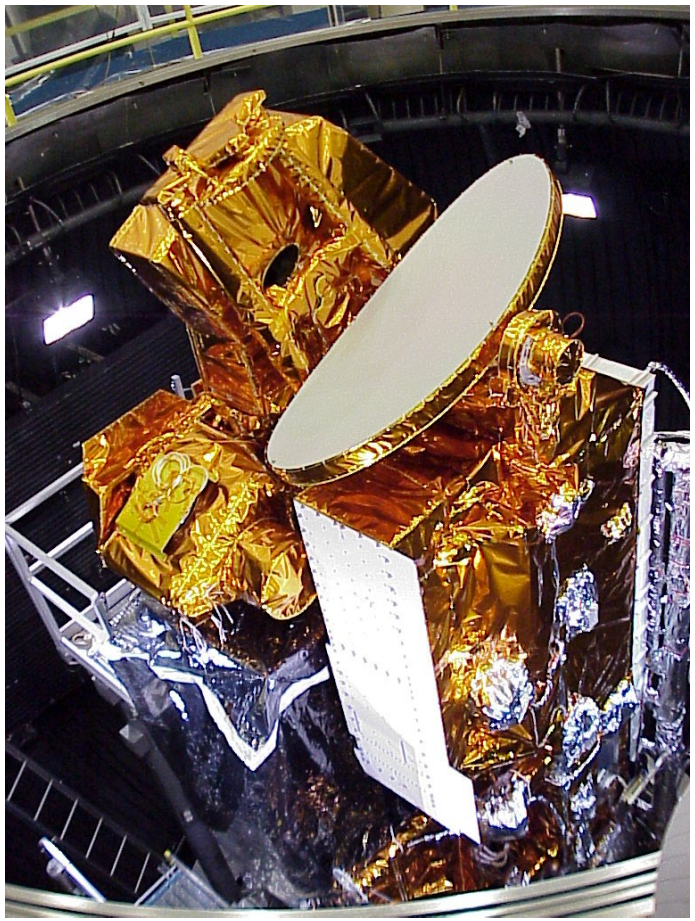
MLS Instrument Operations Status Update

Dominick Miller

Jet Propulsion Laboratory
California Institute of Technology

Leiden, The Netherlands
September 14, 2009

Overview



- MLS Significant Events
- MLS Data Generation Performance
- Anomalies In The Past Year
- Trend Updates
- Longevity Concerns
- Changes Since Last Year
- Performance Summary
- Operational Plans
- Instrument Activity Requests
- Future Work

MLS Significant Events
Oct 2008 - Sep 2009

- **Updated MLS Safe and Survival Ground Procs to CM - Oct. 08, 2008**
- **Updated Red Limit Response Ground Procs to CM - Dec. 10, 2008**
- **MLS Band 13 Measurement Day - Jan. 05, 2009**
- **MLS Red Limit Response Updates Final Version - Jan. 14, 2008**
- **MLS Red Limit Response Updates Delivered to Online - Jan. 26, 2008**
- **Updated MLS Internal Safing SCS Uplinked to Instrument - Jan. 27, 2009**
- **MLS Moon Track 4 - Mar. 13, 2009**
- **Updated MLS Safe & Survival SCS Uplinked to S/C - Mar. 26, 2009**
- **R1A Wide Band work around eliminated erratic science data - May 11, 2009**
- **THz Extended Out of Locks (EOLs) reduced - Aug. 19 2009**

- **Cumulative Items**
  - **NO MLS Mechanism anomalies since 2007!!!**

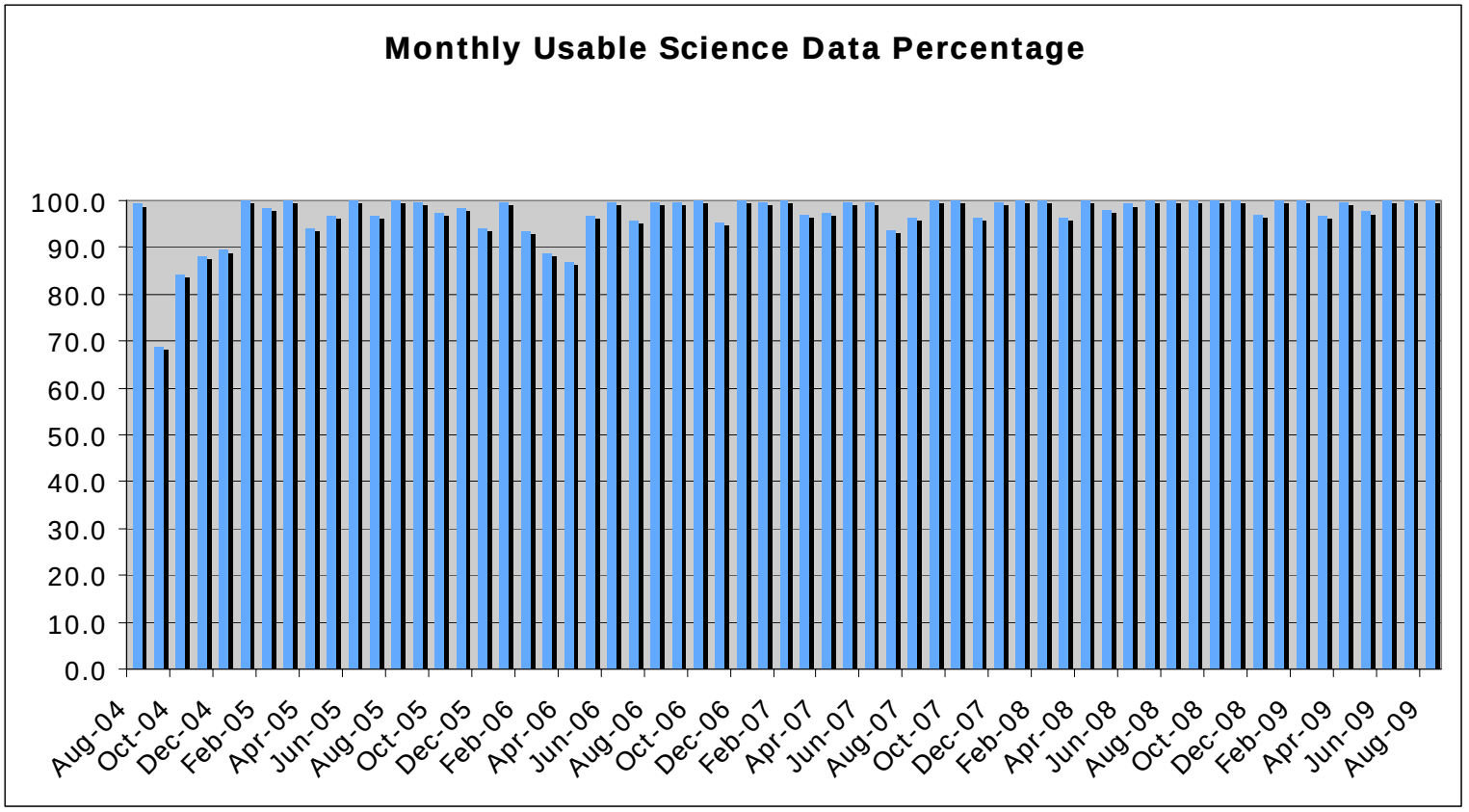
Instrument Data Generation Performance

- **On-orbit performance and sensitivity are consistent with the past five years**
  - **Small reductions in signal gains have been noted in the 25 channel spectrometers**
  - **Gain adjustments implemented to maintain optimal science data**
    - **Current gain settings are good; will revisit in 3 months**
  - **Adequate gain adjustment remaining for years of extended mission based on current trends**
  - **R1A Wideband channels 3 & 4 have been stable since May 2009**
  - **Band 13 measurement activity provided very useful HCl data**
  - **THz science data quality has recently improved due to a reduction in THz extended out of phase lock events**

Instrument Data Generation Performance

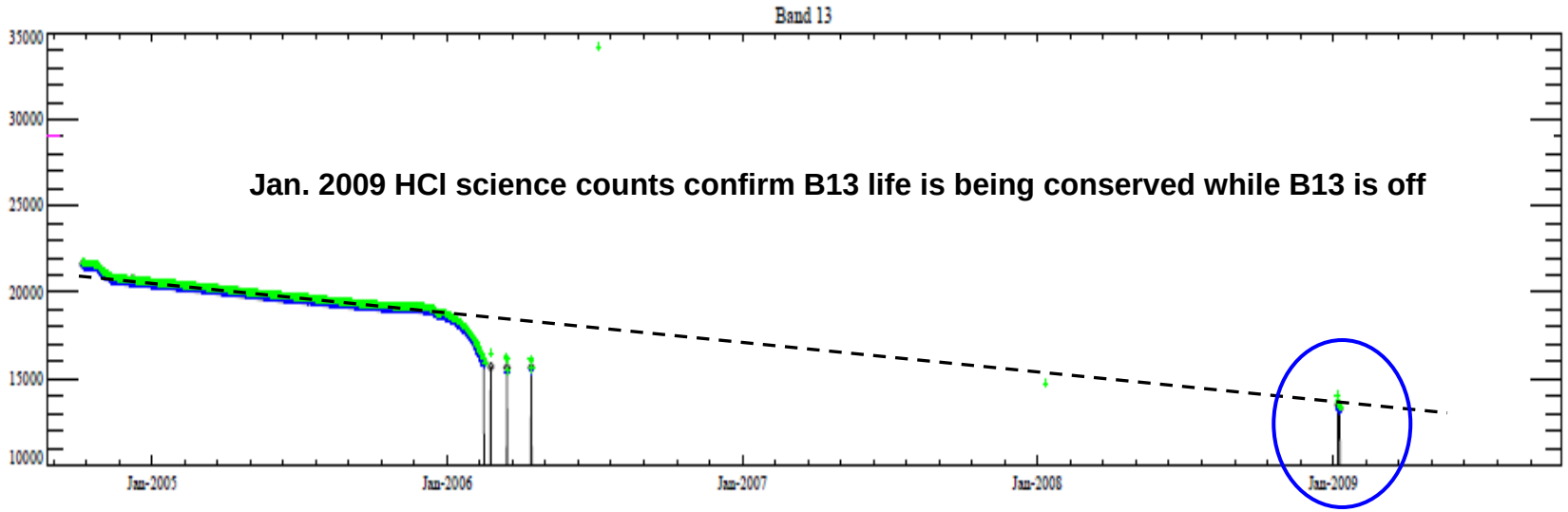
Beginning of mission through August 2009

(Not reduced for SIF4 SEU partial data impact)



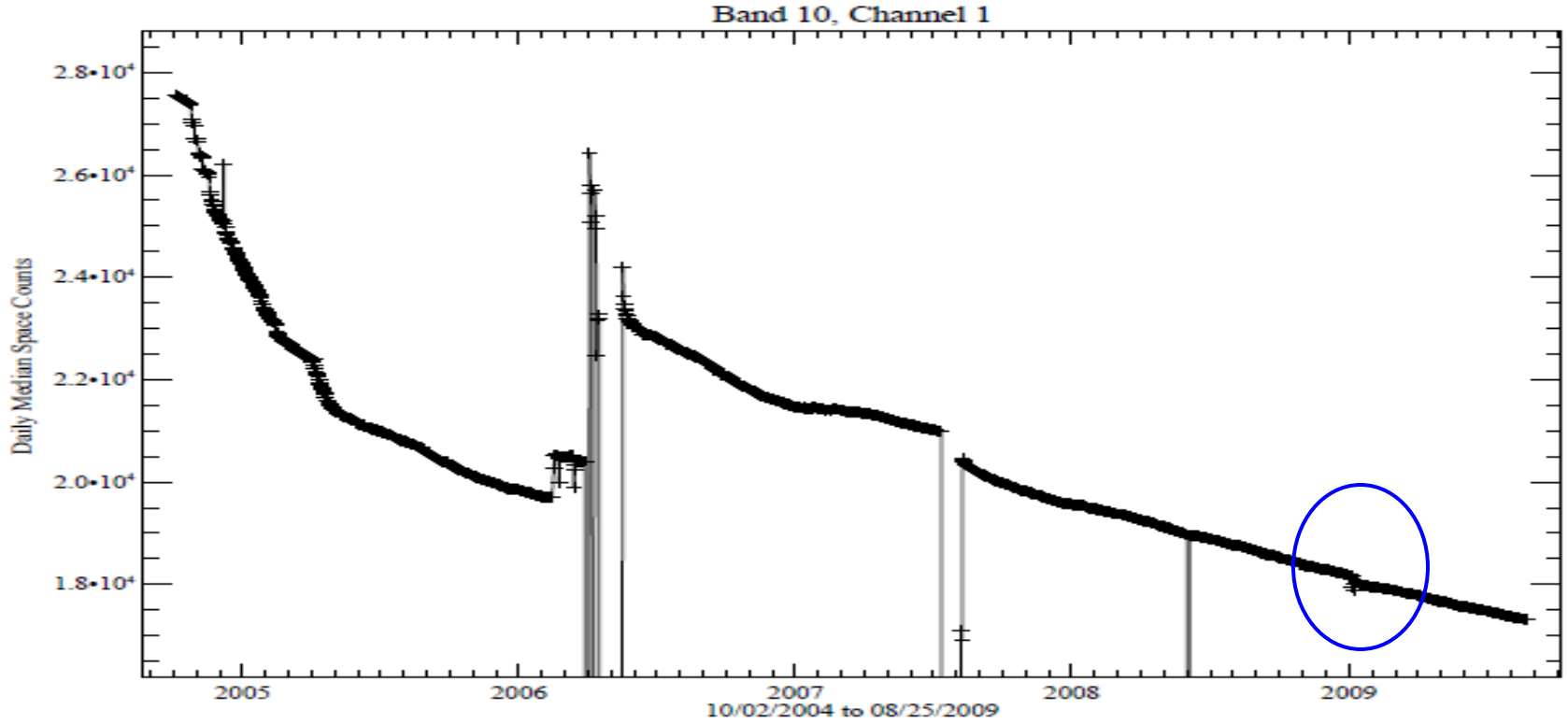
Band 13 (HCl) Update

- **Band 13 was powered off in 2006 to conserve life and to avoid adverse thermal effects on Band 10**
- **To answer long term HCl trend questions, a Band 13 measurement was made in Jan. 2009**
- **Measurement activity provided very useful science data and reaffirmed findings that Band 13 life was being conserved while Band 13 is off**



Band 10 (ClO) Update

- **The Band 13 HCl measurement in Jan. 2009 caused no lasting adverse effects to Band 10 which has shown thermal sensitivities in the past**
- **Band 10 has been stable over the past several years**



Anomalies in the past year

New/Repeat Anomalies

- **R1A Wide Band erratic science counts**
  - First occurrence of this anomaly occurred in October 2008 followed by nominal behavior without IOT intervention
  - Erratic behavior returned in May 2009
  - Diagnostic commands issued with an end result of isolating the erratic hardware
  - R1A Wide Band have exhibited no additional erratic behavior

- **R4 IF LO Power Measurement Drop; May 2009**
  - Signal level drop similar in nature to 5 other drops for this signal throughout the mission
  - Signal recovery similar in nature to 5 other recoveries with no IOT intervention
  - No corresponding effect in science data

Continuing Non-nominal Telemetry

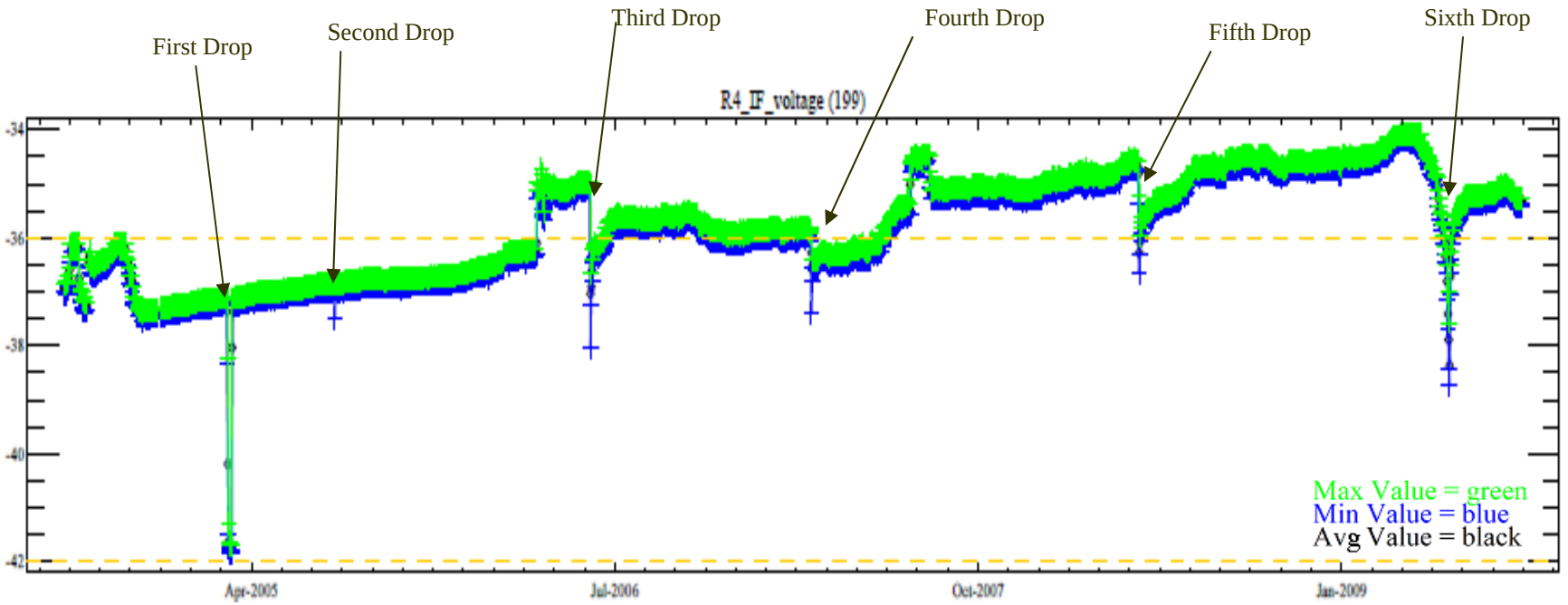
- **Band 17 Out of lock anomaly; May 2008**
  - Band 17 provides supplemental pointing information for THz science data
  - Band 17 out of lock condition has an insignificant impact to THz science data

Instrument Trends

- **Daily engineering telemetry and Level 0 science data are reviewed and trended by the IOT**
  - **Over 500 engineering telemetry points**
  - **Over 540 filterbank channels**
  - **Over 500 digital auto-correlator channels (trended daily as 16 high level parameters)**
- **Most trends are nominal**
- **A few non-nominal and "Close Watch" trends are included on the following slides**

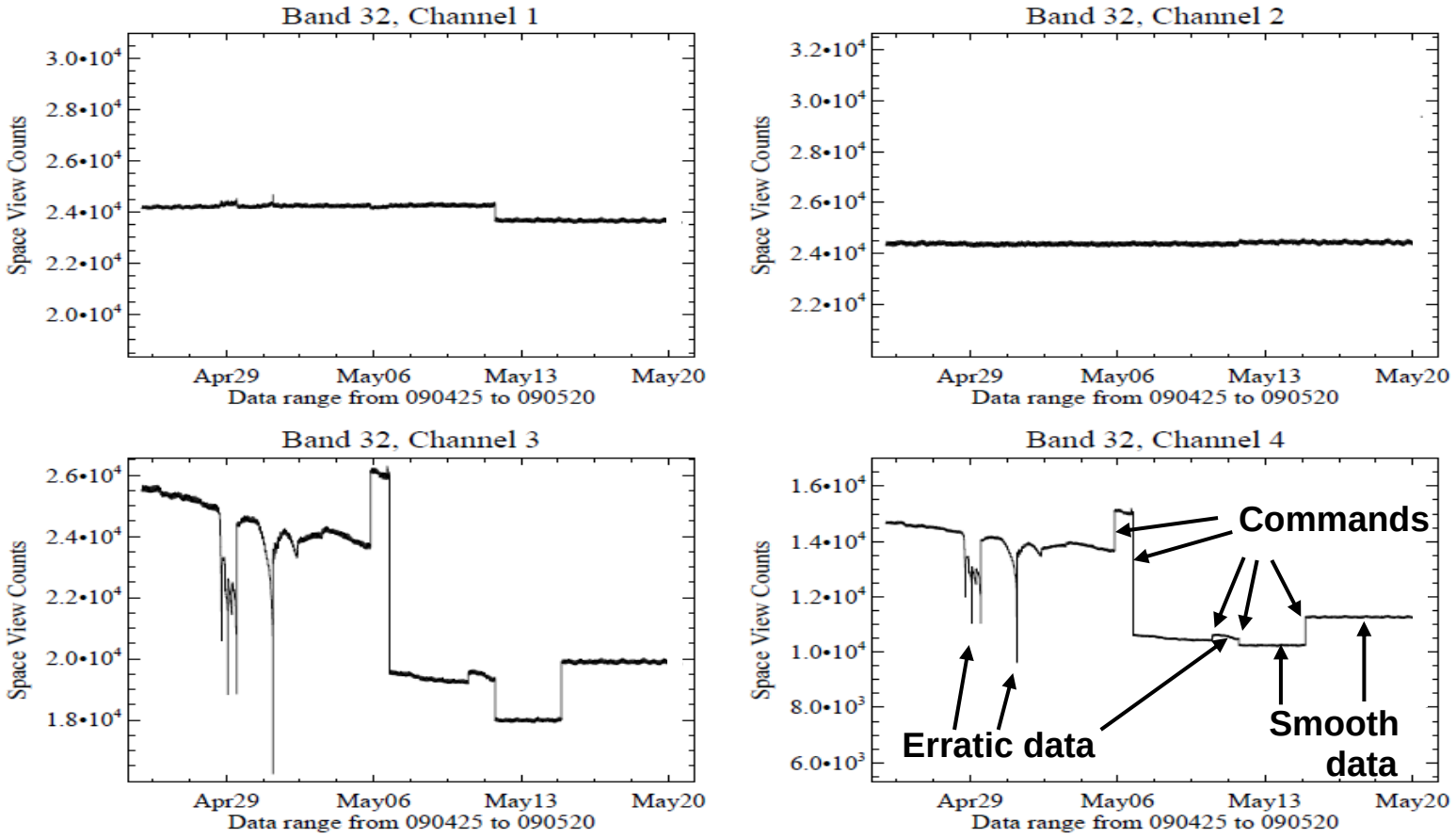
R4 Receiver LO IF Power Monitor Trend Update

- **The 640 GHz receiver (R4) LO IF power has temporarily dropped on six occasions but has recovered each time**
- **These drops have no observable effect in the science data**



R1A Wide Band Anomaly

April – May 2009

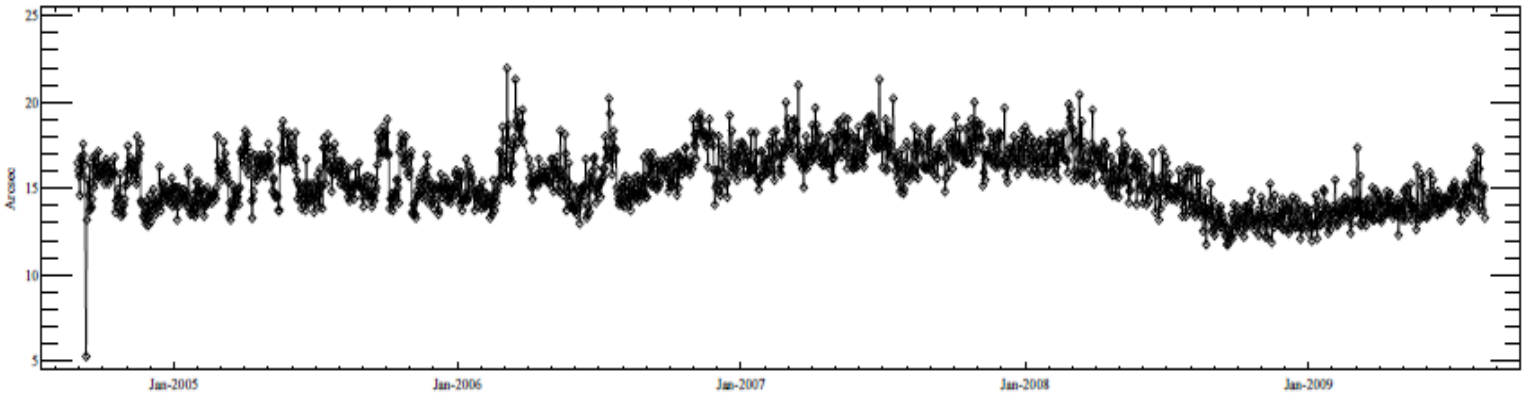


Successful work around on anomalous hardware

MLS Mechanism Trends

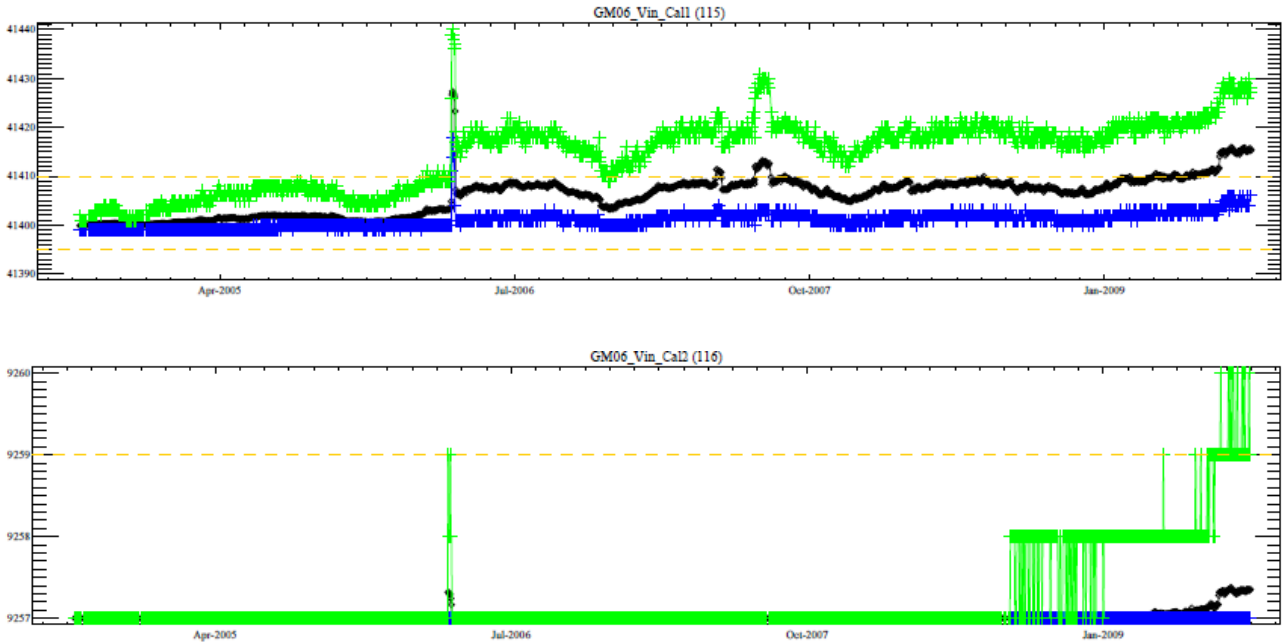
- **ASE, GME and TSE mechanism jitter trends have been stable**
  - **None of the three mechanisms show obvious sign of wear based on routine monitoring of jitter performance**
- **A change in the AAA jitter trend for the highest velocity portion of the limb scan did cause concern in late 2008**
- **A follow up communication with a mechanisms specialist revealed that these jitter changes are likely due to fibers breaking off from felt wipers (as seen during prelaunch testing) and are not a concern**

APE Mechanism Jitter Trend; Minor Frames 110-120



MLS Close Watch List

Calibration Points



Max Value = green
Min Value = blue
Avg Value = black

In recent months, numerous calibration point telemetry values throughout the instrument have changed. Changes are very minimal but uncharacteristic and so they have our attention.

Calibration point changes in the R1B (GM06) sub-assembly

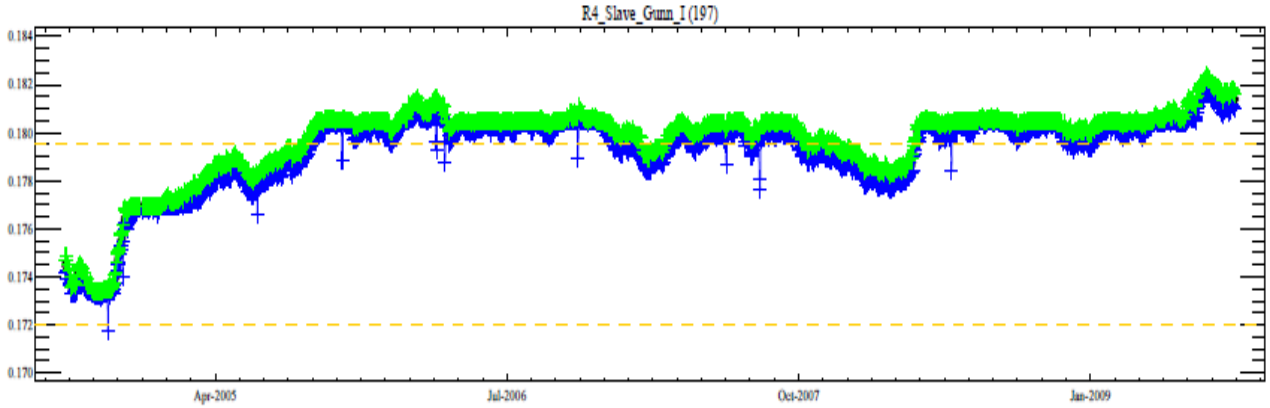
Vin Cal 1: ~ 20 count change out of 41000

Vin Cal 2: ~ 3 count change out of 9200

MLS Close Watch List

R4 Slave Gunn Current

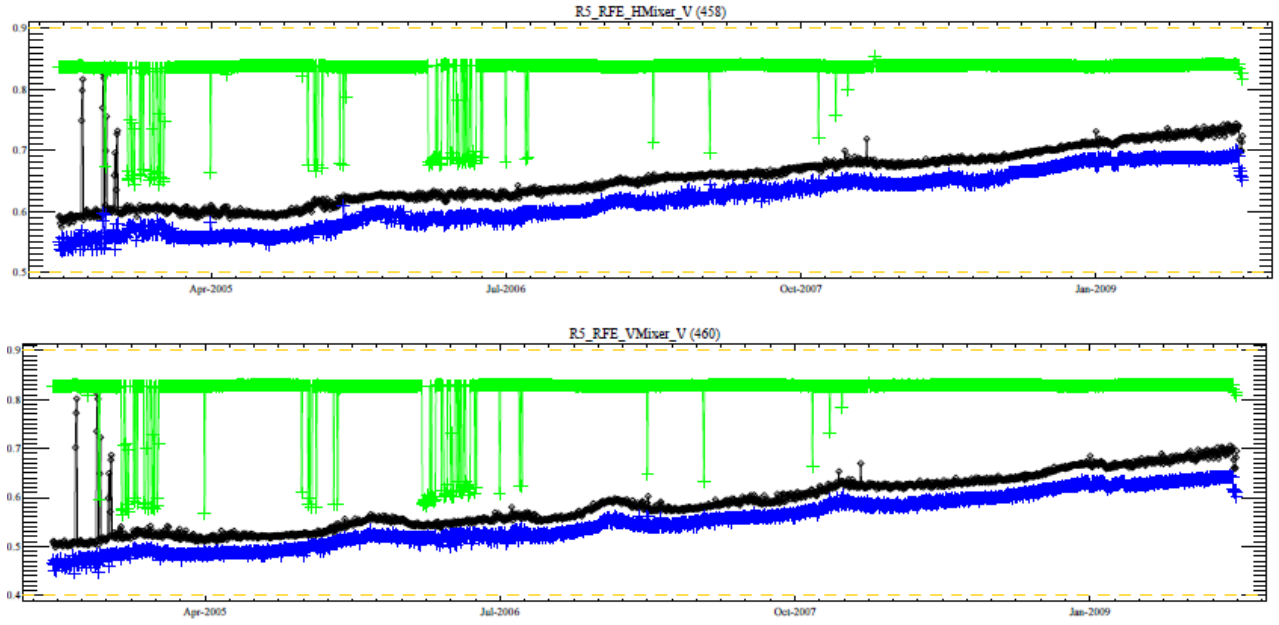
Max Value = green
Min Value = blue
Avg Value = black



A few weeks ago, the R4 Slave Gunn Current was at a mission high level with an upward trend. The vertical scale is in mV showing an ~ 2 mA change out of 180 mA and is not causing significant concern but the mission high level has us watching this point closely. The yellow "guide lines" on these plots are arbitrary in value and are based on the launch and activation period as a general guideline.

MLS Close Watch List

THz Mixer Voltages



Max Value = green
Min Value = blue
Avg Value = black

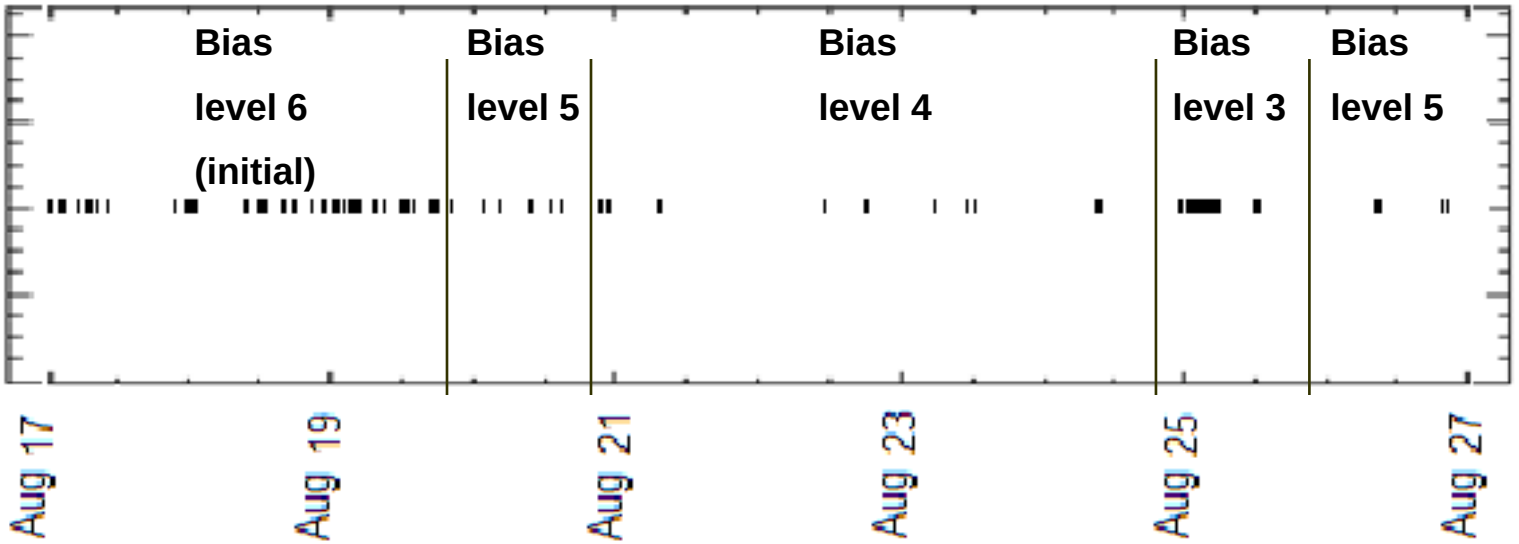
These two voltages from the THz R5 Receiver have been trending up as expected since launch as a result of hardware life expectancies. The R5 signal chain is used to measure horizontal and vertical polarizations of the OH molecule.

At ~0.75 V, it is expected that the signal to noise may diminish enough to make the OH data unusable. The Horizontal Mixer voltage is approaching this 0.75 V value but the recent R5 bias adjustments have lowered these voltages slightly

THz Extended Out of Lock Events
Affected Product: OH

Black sections indicate out of lock

(No science data during out of lock)

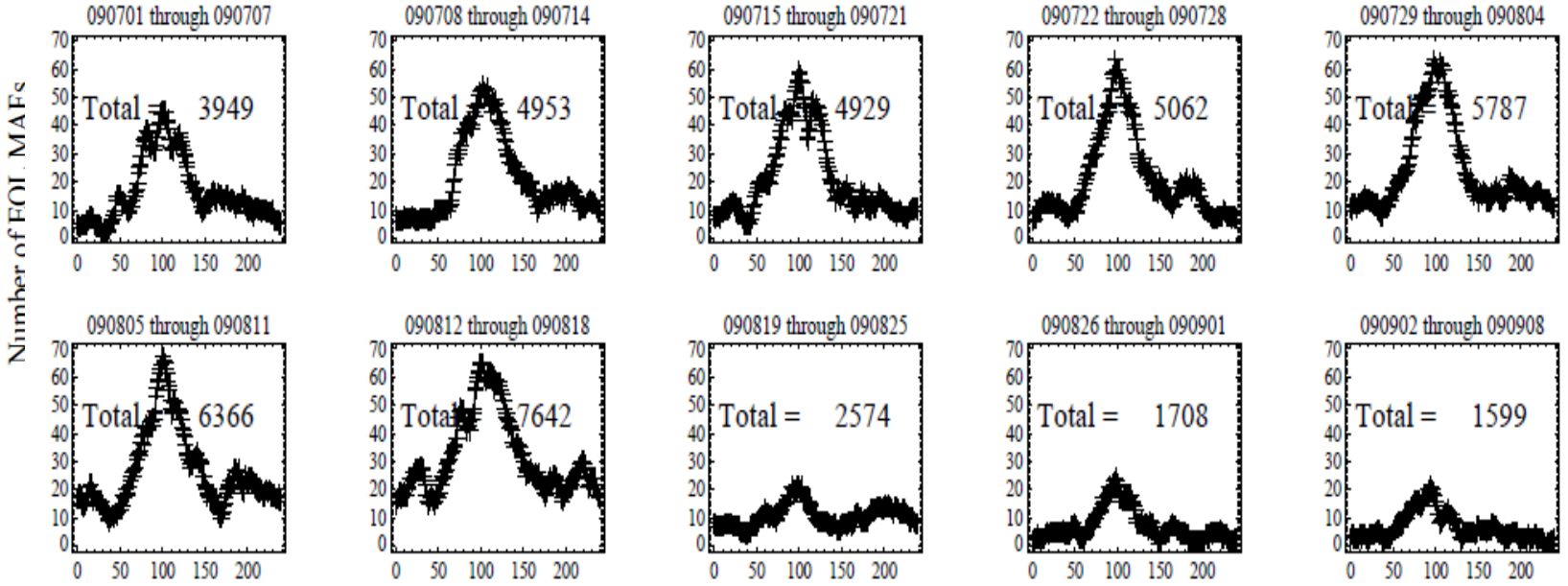


2009

THz Extended Out of Lock Events

Bias adjustments have reduced
but not eliminated EOL events

Number of THz H-Mixer Extended Out of Lock (EOL) MAFs vs. Orbital Phase
1 week panels ending 09 September



X Axis = Orbital Phase (MAF #)
MAF 0 = Descending Node Crossing; MAF 52 ~ Sunrise; MAF 212 = Sunset (on April 22)

Longevity Concerns

Spectrometer Module

- **The magnitude of many science signals from the spectrometer module have been decreasing slowly since launch due to a known issue with certain electronic components**
  - **Existing test data on these components is insufficient to project remaining life.**
  - **While we are aware of this performance degradation, none of the more than 5 dozen of these parts have failed since launch**

Longevity Concerns

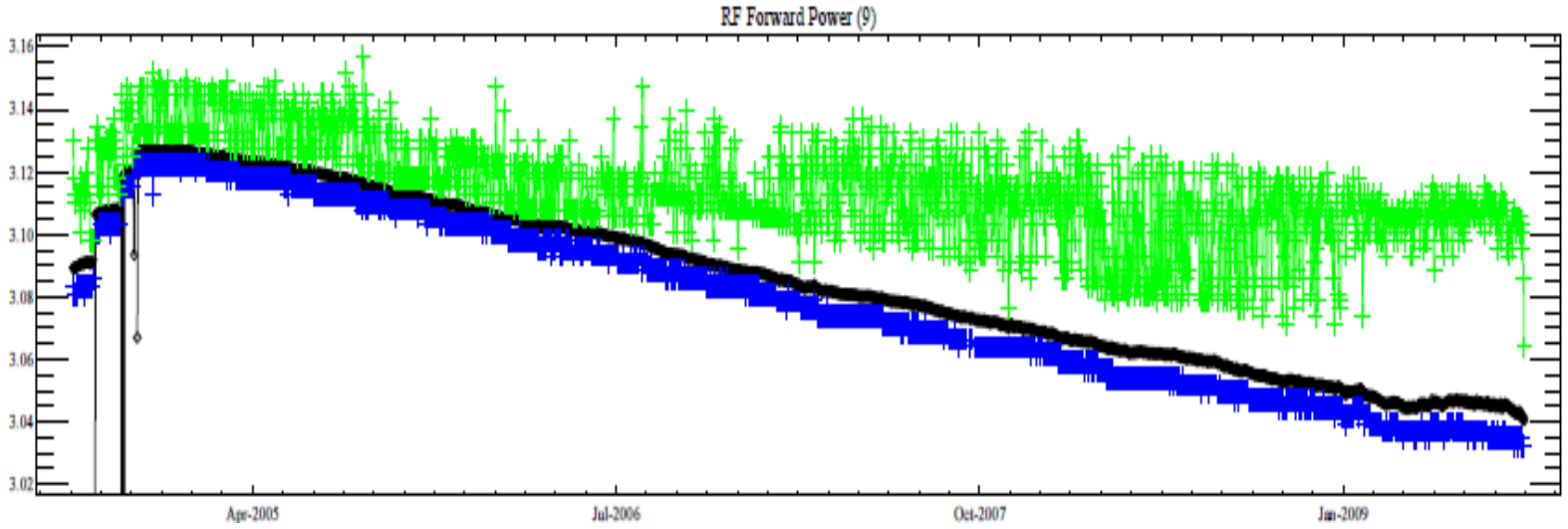
THz Module Laser Local Oscillator

- **The THz Laser Local Oscillator (LLO) output power level has been decreasing since launch**
- **This is an expected and life limiting trend**
- **THz Module success criteria was 1 year, we are now at 5+ years**
- **Once the LLO output drops below a certain threshold, the R5 signal chain will no longer function correctly**
- **Recent reduction of EOLs has been successful but they will return as LLO output power continues to drop**
- **Extrapolating current trends in THz mixer bias, the LLO power is projected to produce science data for an additional ~ 1 year**

THz Laser Output Power

- **Activation to present**
- **One data set per day (Max, Min, Ave)**

Max Value = green
Min Value = blue
Avg Value = black



Instrument Performance Summary

Status Summary

- MLS instrument performance continues to be very good
  - All science products are still being retrieved with only a slight degradation in the quality of the HCl measurement
- Recent THz bias commands have bought us additional life but it is hard to predict just how much
- MLS calibration tests confirm the current health of the instrument
- MLS data processing systems are operating smoothly
- All Level 1 and Level 2 files routinely archived & available from GSFC DAAC
- There are a few longevity concerns, but presently all is well

Operational Plans

- **Continue with MLS routine and calibration activities**
  - **AAA Reconditioning**
  - **Spectral Baseline updates**
  - **Moon Tracking Scans**
- **Bands 10 & 29 (ClO & HOCl)**
  - **Minimize thermal cycling of Bands 10 & 29 where reasonable**
- **Band 13 (HCl)**
  - **Potential for Band 13 measurement cycle in 2010**
- **Band 17 (THz supplemental pointing information)**
  - **No action planned**
- **THz Band EOL events**
  - **Monitor and attempt to reduce EOL events should they become significant again**

Instrument Activity Requests

Moon Tracking Scan S/C Yaw

- **MLS Moon Tracking Scan; March 2010**
  - **Similar to Mar. 2006 MLS Moon Track activity**
  - **Would require small S/C yaw and hold**
  - **Current predictions target Mar. 2, 2010 - 13:12**
    - **Predict time has only moved 5 min. between March and July predictions**
    - **Above time is preferred, additional possible times included in backup slides**

- **Science Benefits:**
  - **Additional data point for standing wave/radiometric cal. verification**
  - **Additional data point for radiometer co alignment**
  - **If we duplicate the Mar. 2006 point on the Moon, evaluate long-term stability of antenna transmission**

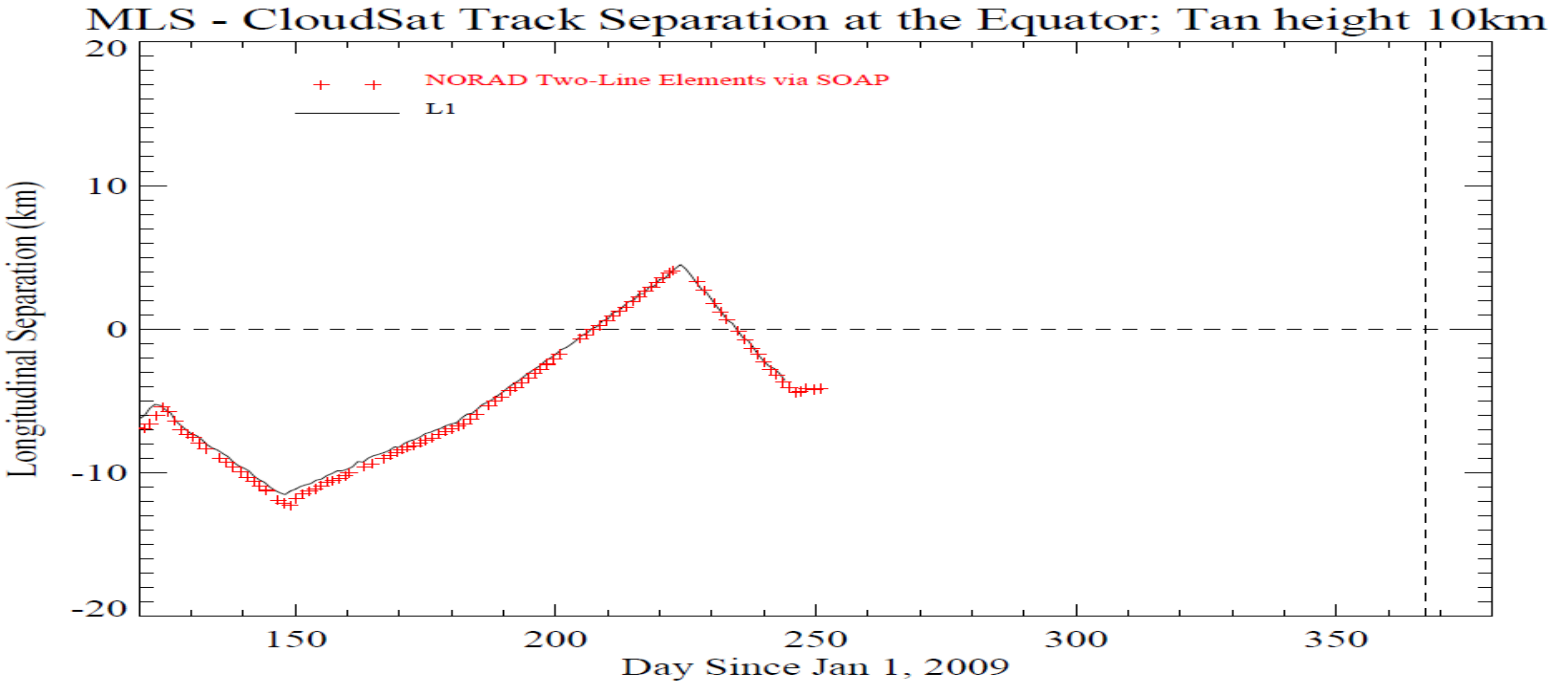
Instrument Activity Requests

Moon Scan w/ Synchronized S/C Yaw

- **MLS Moon Scan with synchronized Aura yaw**
  - **This is a re-attempt of the Oct. 2005 activity which had an unexplained 10 second mismatch in the predicted vs. actual time when the spacecraft was supposed to start the yaw maneuver**
  - **Similar to the previous attempt, the spacecraft would use the well established DMU yaw sequence**
  - **Critical detail is to have spacecraft start the yaw maneuver within 1 second of an MLS specified time**
- **Science Benefits:**
  - **Spreads MLS footprints over both horizontal and vertical directions on the Moon, which can make error bars in these scans up to 10x smaller than for the ~10 Moon scans done without Yaw to date.**

Instrument Activity Requests

CloudSat - MLS Ground Track Separation



- **CloudSat DMUs have decreased the slope of this plot in the past**
- **Aura DMUs have increased the slope of this plot in the past**
- **CloudSat – MLS ground track priorities request:**
  - **Maintain co-location over coincidence**
  - **Co-location within +/- 5km is good**
  - **Co-location > +/- 10 km does not provide useful data**

Future Work

- **Separate MLS hot and cold TMONs for more specific selection**
- **Update/remove specific MLS Survival limits from onboard limit set**
  - **Ie: MLS Primary, Secondary and Tertiary Reflectors**
- **Search for possible method of partial instrument shut down vs. MLS to Survival for any TMON trip**

Contact Information

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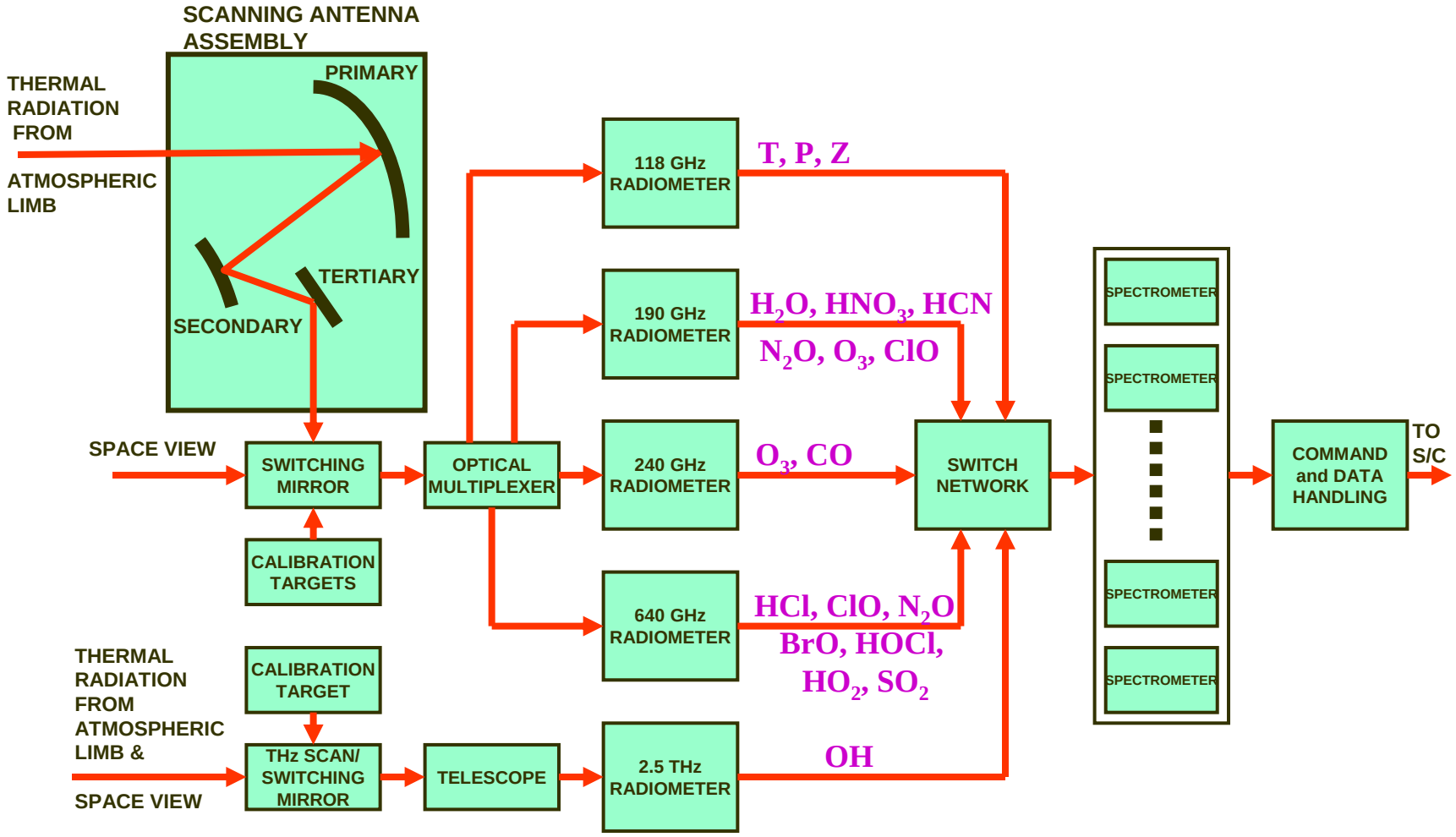
Backup Slides

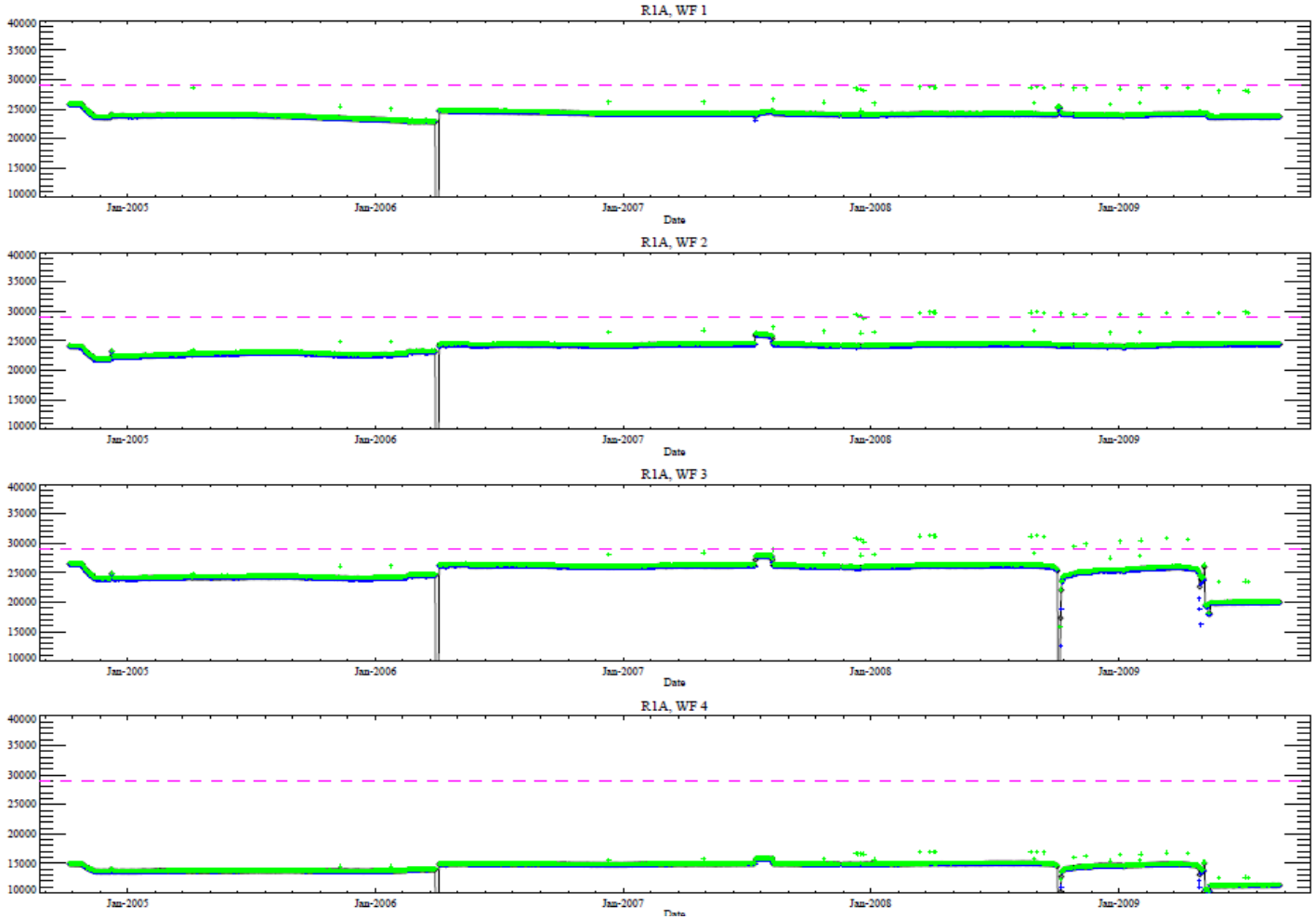
Instrument Overview
Signal Flow Block Diagram



R1A Wide Band Trend

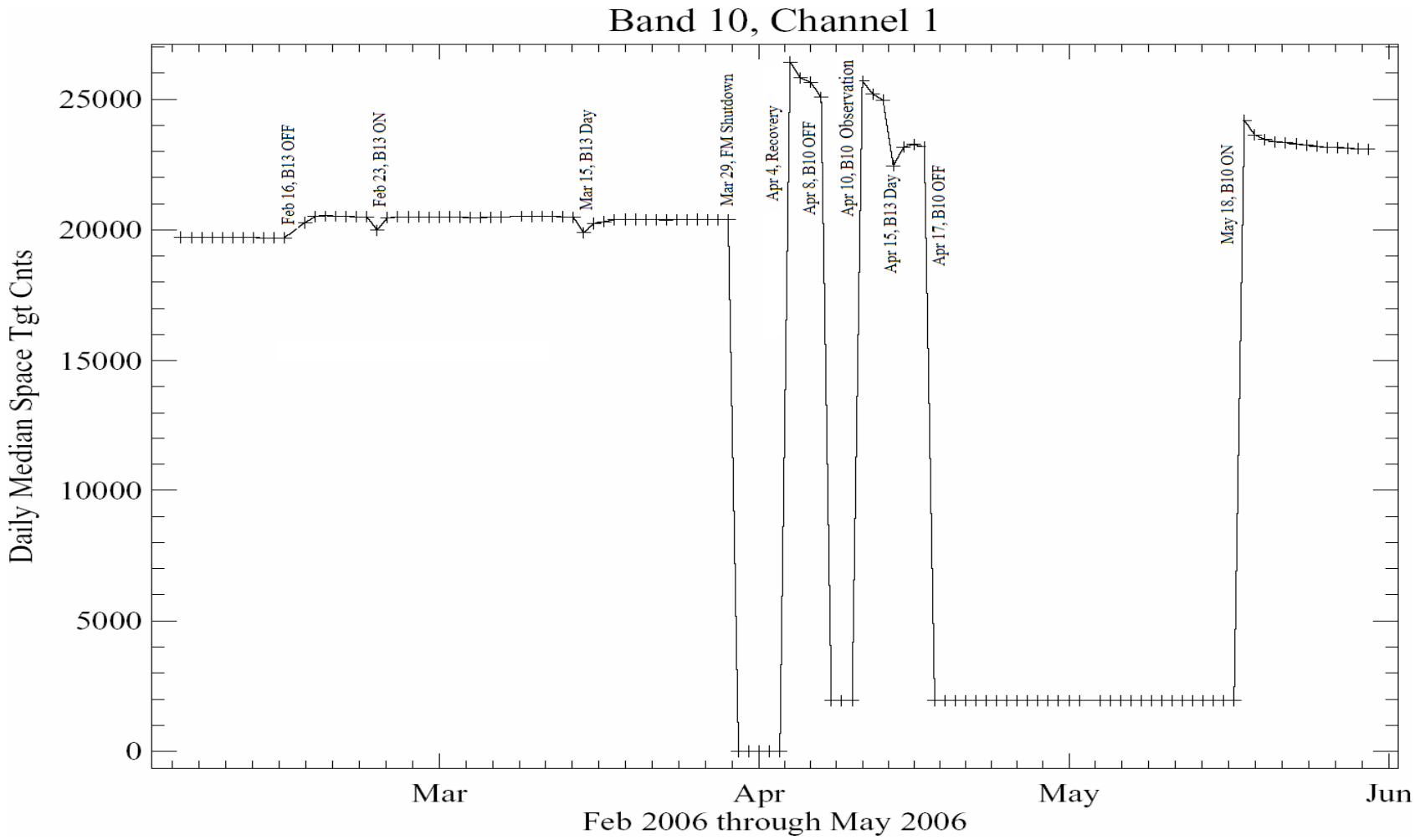
(aka Band 32)

Channels 1 – 4; Activation to present



MLS Band 10 (ClO) Trend

Focus: Feb. to May, 2006



2010 MLS Yawed Moon Track

- Predicted event time
  - MLS quick-look prediction tool uses current NORAD TLEs, adjusting RAAN to match ascending node time

date analyzed	TLE epoch	UTC event time	Yaw required
2009.03.10	09070	2010.03.02 *13:17	NA
2009.07.13	09193	*13:12	+1.58°
		or 03.01 14:06	+12.66°
		:	:
* preferred		or 03.02 14:51	+0.77°

  - When CH_LUNAREPH*.FDD covering 2010d061 is available, we can seek Moon unit vectors with
    - {x,z} within MLS scan range, and
    - {y} within Aura Yaw capability, e.g. [0,sin(13◦/cos(25◦)]