



Earth Observing Systems Microwave Limb Sounder



MLS Instrument Operations Status Update

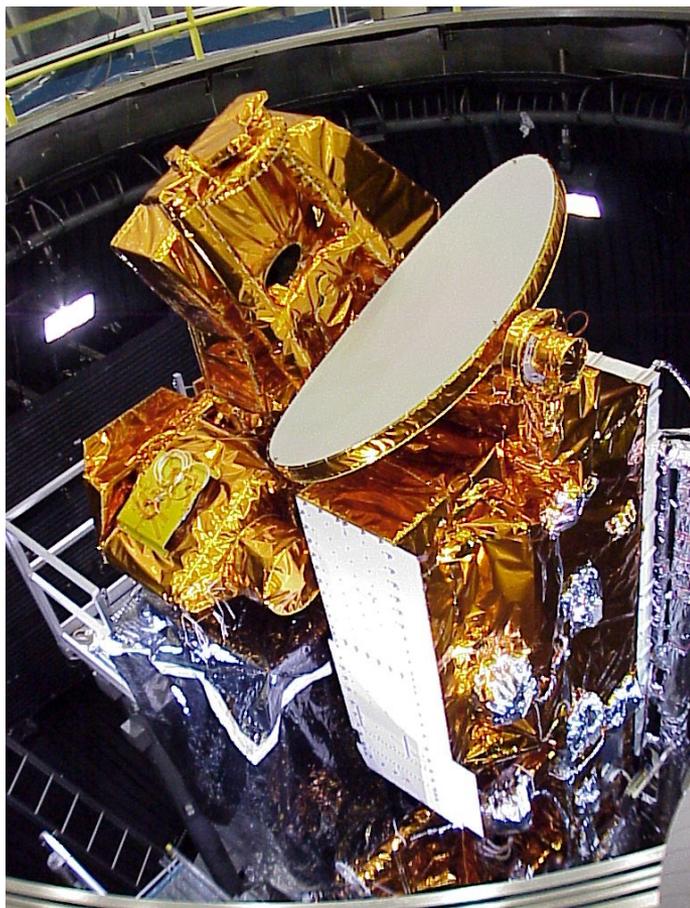
Gerson Melgar

Jet Propulsion Laboratory
California Institute of Technology
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Rotterdam, NL
August 31, 2016



Overview



- Overall Status
- MLS Significant Events
- Close Watch Trends
- Trend Updates
- Operational Plans
- MLS Team Updates



Overall Instrument Status Mechanisms



MLS GHz mechanisms continue to operate within their nominal range with over 14.5M atmospheric scan cycles on the GHz mechanisms

- **AAA continues to exhibit excellent performance. Minor temperature changes have been noted in recent years but, significant analysis has determined that these are expected**
- **GMEB substitution for GMEA continues to perform well since April, 2011**

MLS THz mechanism has had limited periods of operation, about 1 month per year from 2011 through 2014

- **THz is currently in stand-by mode**

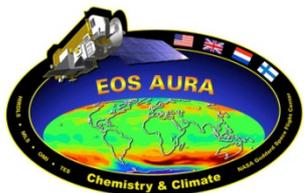


Overall Instrument Status GHz Module



All MLS GHz science products continue to be produced 24/7

- **MLS HCl and N₂O products have been shifted from their original signal sources to alternate sources due to speculated HBT (transistor) issues which were identified and accepted as a prelaunch risk**
- **Using alternate signal sources does result in some degradation in the sensitivity and accuracy of these two products**
- **The HCl product was shifted from Band 13 to Band 14 in February 2006**
- **The N₂O product was shifted from Band 12 to Band 3 in August 2013**
- **Overall, the MLS instrument continues to perform very well**

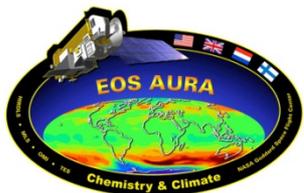


Overall Instrument Status THz Module



After exceeding its lifetime requirement by 3x by the end of 2009, the THz OH measurements resumed in 2011 through 2014 for 1 month per year

- **THz Module Laser Local Oscillator (LLO) was last powered on in August of 2014 and it remained in lock approximately 50% of the time on average during this period**
- **Current ground-based observations of both OH trends and the solar cycle suggest the conditions to take an OH measurement will be better suited for the MLS THz measurement in a year's time or later.**
- **These observations will likely provide a scenario where the OH trend shows a decrease so as to be clearly off the solar peak**
- **The consensus amongst the MLS Science Team is to wait at least one more year before applying power to the THz Module in what could potentially be the last feasible measurement of atmospheric OH by the MLS THz**



MLS Instrument Significant Events

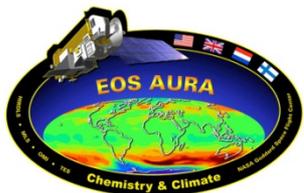
Oct. 2014 – Sep. 2015



- **THz Module 2014 Measurement** **- Aug. – Oct., 2014**
 - Completed successfully in accordance to planned yearly OH Measurement
 - Averaging around 50% of the time in lock which is the maximum possible percentage of profiles; actual number of useful profiles was less

- **Moon Track 10 measurement** **- Mar. 07, 2015**
 - Provided long term primary reflector stability information
 - Small increases in ohmic loss have been observed in recent years but overall stability and reflectivity is excellent

- **Band 14 Attenuation Test** **- Mar. 10, 2015**
 - Set Band 14 attenuator value to a value of 14.
 - This action confirmed that an unplanned change to the B14 signal levels was due to a minor SEU configuration register change



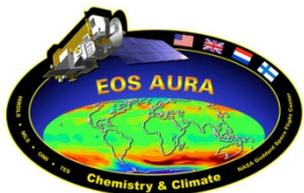
MLS Instrument Significant Events

Oct. 2015 – Sep. 2016



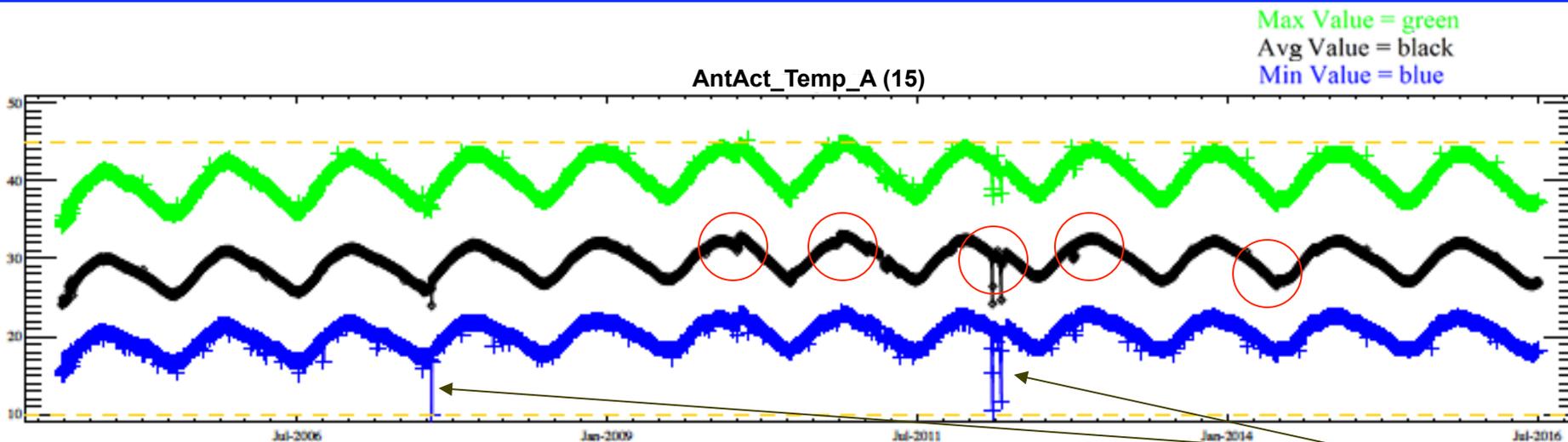
- **R2 Gunn Bias Voltage Yellow Limit Alert Triggered** - Jan. 02, 2016
 - Occurred intermittently
 - Suspected cause was simply graceful aging of the subsystem observed over last few years
 - R2 Gunn Bias Voltage yellow alert limit was updated to provide headroom since this value continues to decline
 - Further evaluation of these data proved to having no impact on science quality

- **MLS Moon Track 11 measurement** - Mar. 25, 2016
 - Provides long term primary reflector stability information
 - Inferred effects on Antenna transmission are negligible
 - Overall stability of reflector remains excellent



MLS Close Watch Trends

AAA temperature; full mission trend



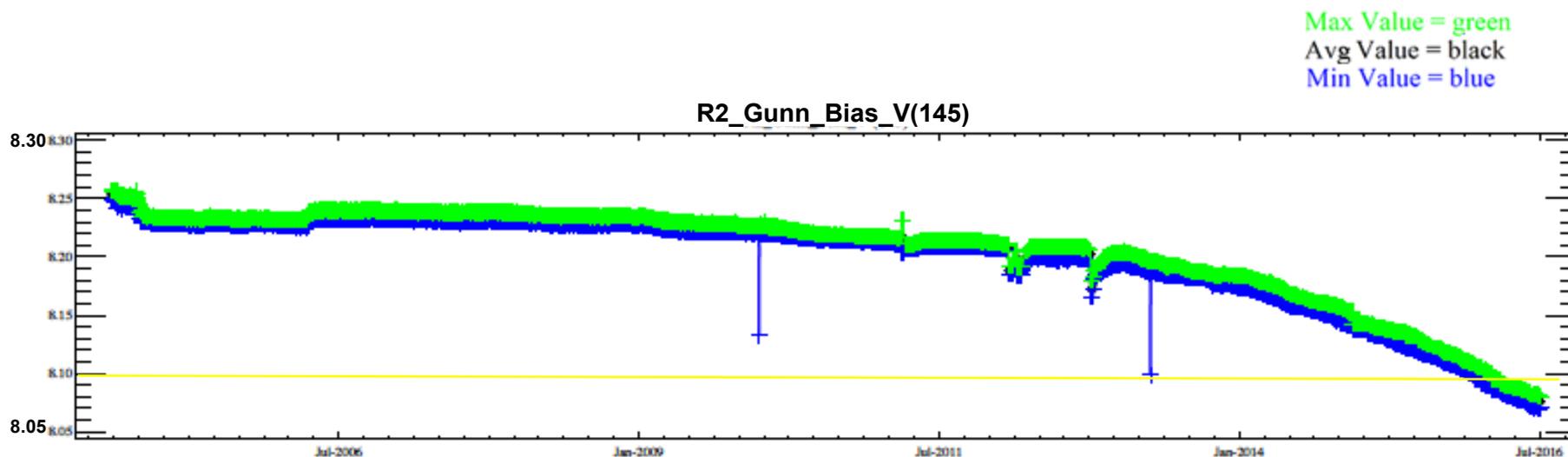
Spikes due to survival mode events and AAA parked

- **MLS Antenna Actuator Assembly temperature trend**
 - Occurrences of a small temperature increase ($< 1\text{ }^{\circ}\text{C}$) noted in the AAA temperature since 2010
 - Graph shows one set of data points per mission day
 - After each event, the temperature has drifted back towards its norm
- Suspected cause is slightly larger than usual wear product in the mechanism travel that is being reduced over time
- The behavior of this temperature does not pose a concern as it has not had an impact on science data



MLS Close Watch Trends

R2 Gunn Bias Voltage, Full Mission Trend

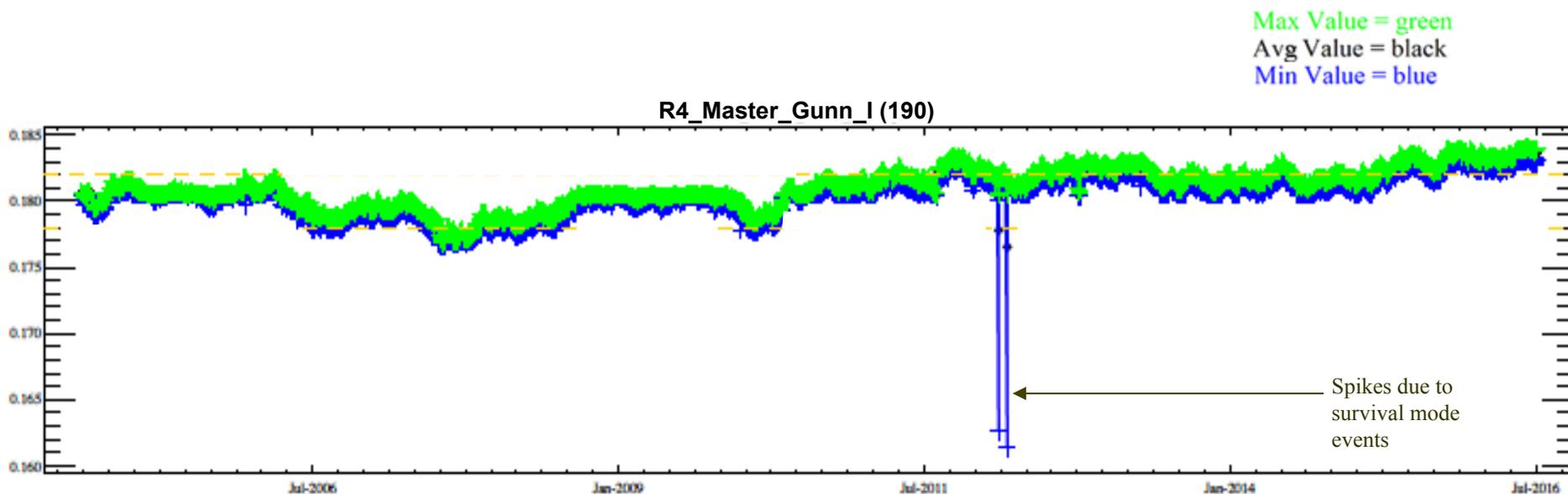


- R2 Gunn Bias Voltage has been gradually decreasing
- Yellow alert limits have been updated since March 2016
- We have incorporated this point into our closely watched with daily text messages



MLS Close Watch Trends

R4 Master Gunn Current, Full Mission Trend



- The R4 Master Gunn current has remained at near mission high levels over the past several months
- We continue to monitor this point closely with daily text messages

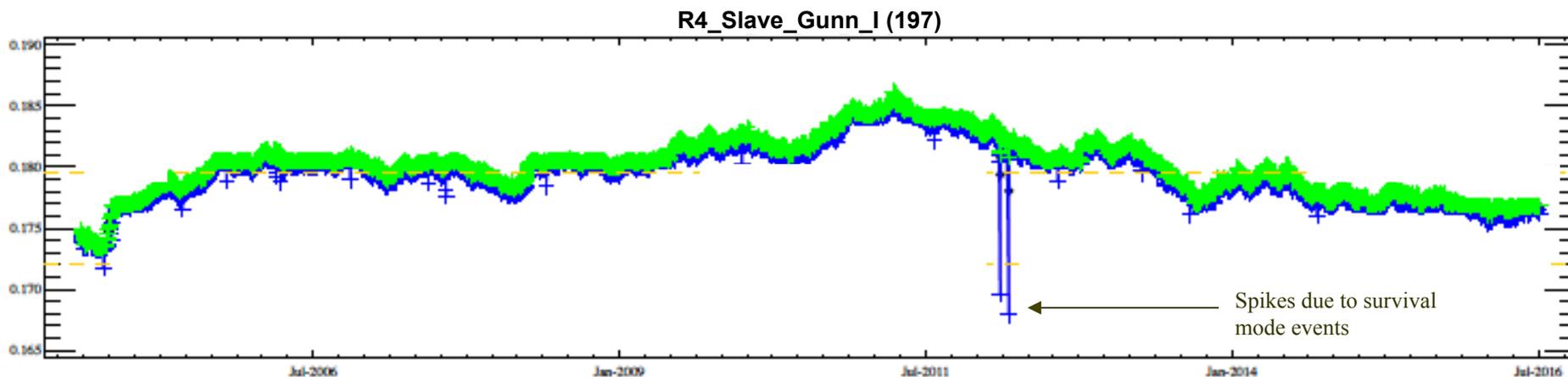


MLS Close Watch Trends

R4 Slave Gunn current, full mission trend



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



- The R4 Slave Gunn current has remained well within the nominal mission range over the past couple of years
- This point continues to be monitored on a daily basis

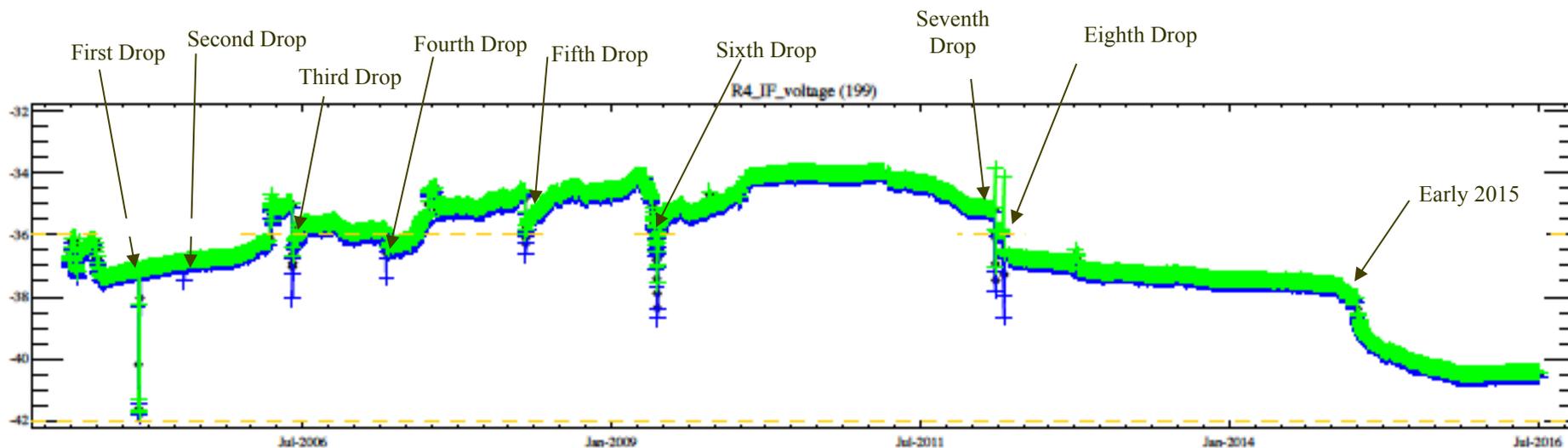


MLS Close Watch Trends

R4 Receiver LO IF Power Monitor, full mission trend



- The MLS 640 GHz receiver (R4) LO IF power telemetry has temporarily dropped, with no apparent cause, on six occasions but has recovered each time
- There were also two small drops in 2012 associated with survival mode events
- A gradual decline in its median dB value started to occur early February through September of 2015
- This closely monitored telemetry point has settled since
- These drops have had no observable effect in the science data





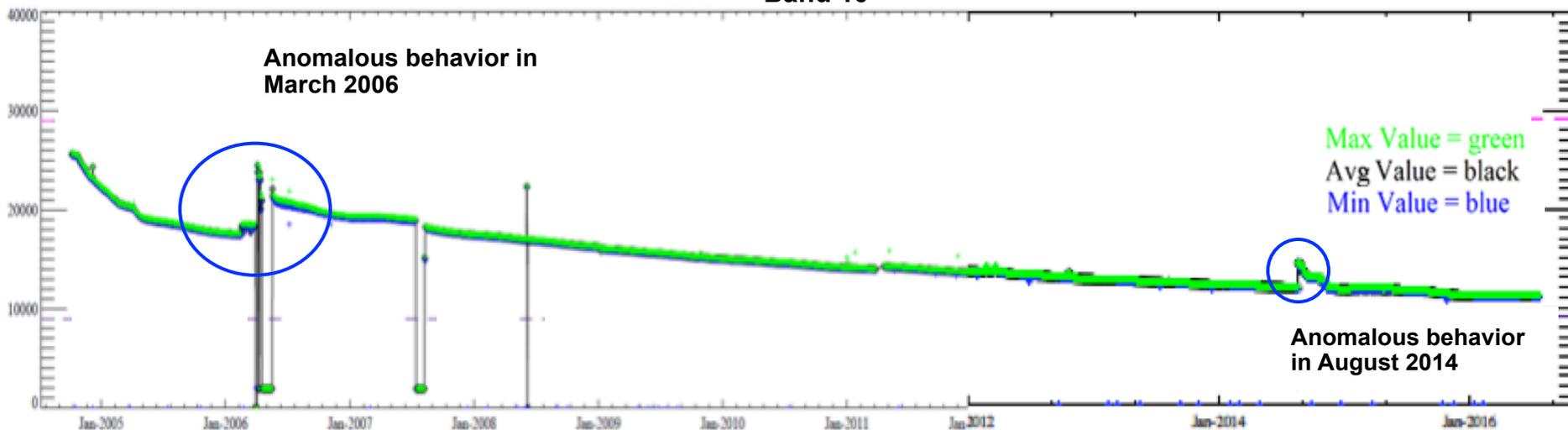
Trend Updates

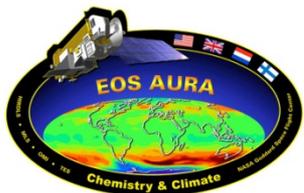
Bands 10 and 29 (CIO and HOCl), full mission trend, one data set per day



- Bands 10 and 29, fed from a common signal in SIF4, exhibited anomalous behavior/thermal sensitivities in 2006 leading to operational practices which minimize thermal cycling of the Band 10/29 specific hardware
- Bands 10 and 29 remained stable from May 2006 through the SIF4 configuration register anomaly which occurred in August 2014
- At this point, the erratic changes in Bands 10 and 29 have subsided and the counts are trending back towards their pre anomaly values
- Bands 10 and 29 have also experienced three larger ($> 30^{\circ} \text{C}$) temperature cycles during survival mode transitions with no adverse effects

Band 10



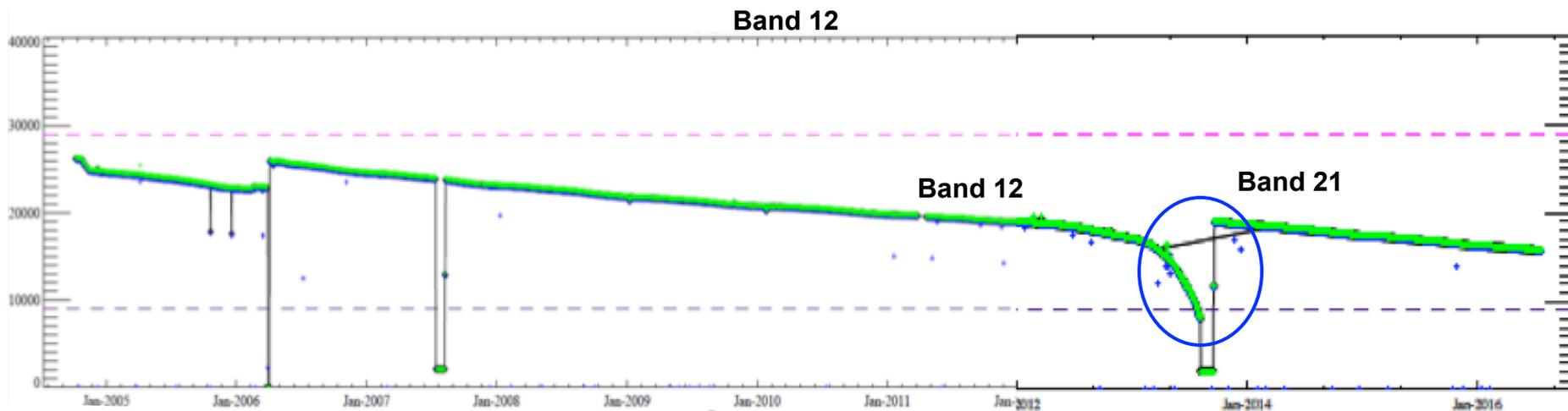


Trend Updates

Band 12 (N₂O), full mission trend



- Band 12 specific electronics were powered down on Aug. 06 2013 after the L0 science count rate of decline had accelerated over the course of a year
- MLS N₂O product is now being generated using the Band 3 N₂O spectral line
- Filterbank 12 spectrometer is now being used to monitor Band 21, which covers the 118 GHz pressure-temperature line

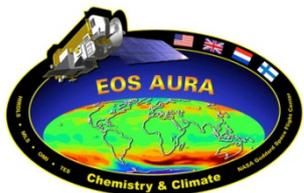




Operational Plans



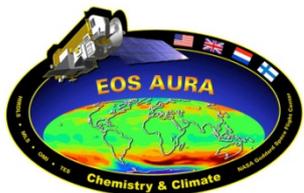
- **Continue with MLS routine and calibration activities**
 - AAA Reconditionings
 - Spectral Baseline updates
 - EEPROM Checksum Verify
 - Moon Track Measurement #12
 - March 14, 2017 14:00:00
- **R2 Gunn Bias Voltage adjustment**
 - Evaluate and select a new coarse setting to fine tune the voltage setting close to post launch levels
 - A reasonable amount of contact time will be required to determine the optimal coarse setting
 - This may potentially align with our next Moon Track measurement in the Spring of 2017
- **THz Module (OH)**
 - Skip measurement in 2016 to allow currently observed trends in the Solar cycle help optimize conditions for arguably last MLS THz OH measurement
 - Next potential measurement in August 2017



EOS MLS Contact Information



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Backup Slides

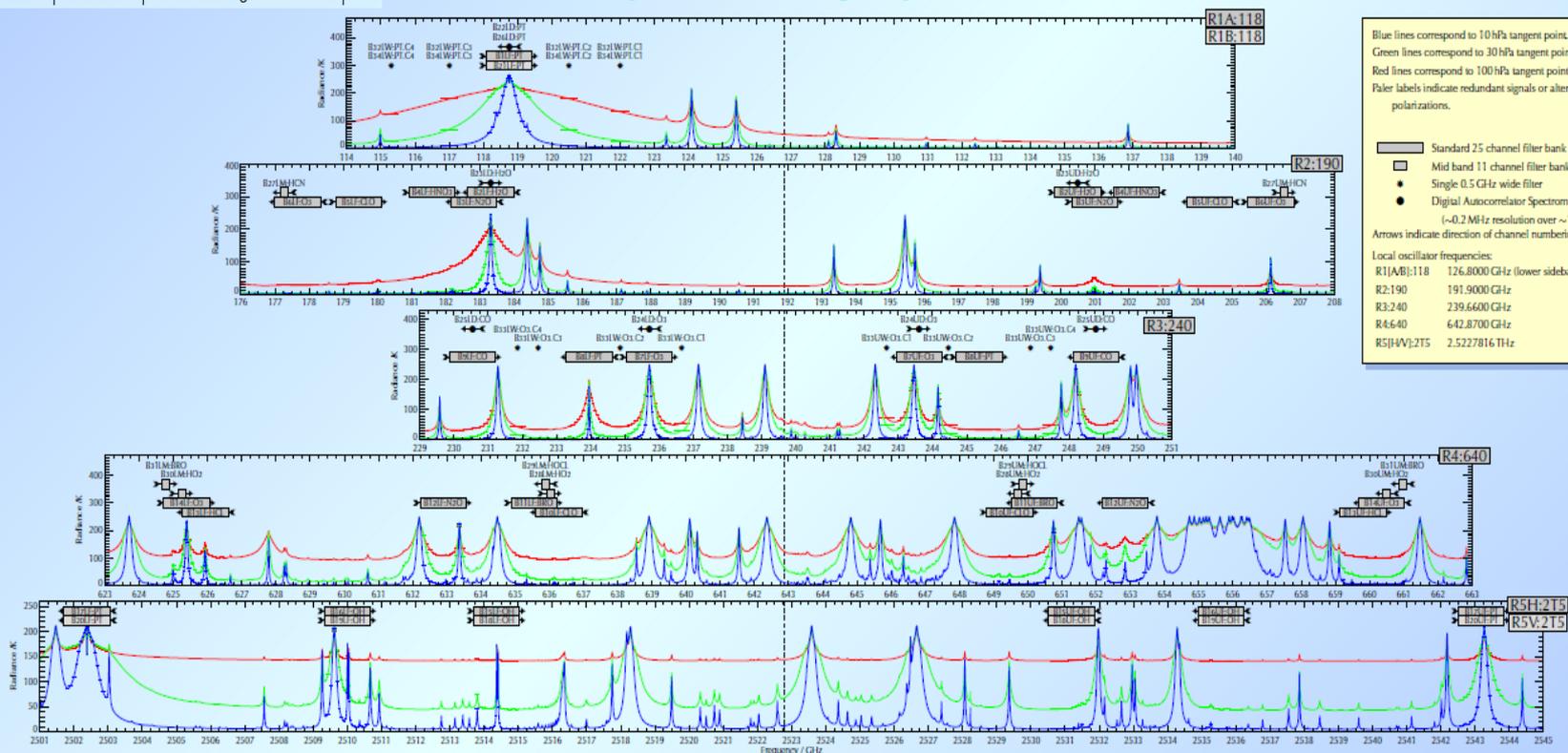


Thermal Emissions Spectral Lines and MLS Filterbank Coverage



June 9, 2003. Nathaniel Livesey
Spectroscopic data provided by Mark Filipiak

EOS MLS Spectral Coverage (split sideband)



Blue lines correspond to 10 hPa tangency point.
Green lines correspond to 30 hPa tangency point.
Red lines correspond to 100 hPa tangency point.
Paler labels indicate redundant signals or alternate polarizations.

Standard 25 channel filter bank
 Mid band 11 channel filter bank
 Single 0.5 GHz wide filter
 Digital Autocorrelator Spectrometer (~0.2 MHz resolution over ~10 MHz)
 Arrows indicate direction of channel numbering.

Local oscillator frequencies:
 R1[A/B]:118 126,800 GHz (lower sideband only)
 R2:190 191,900 GHz
 R3:240 239,660 GHz
 R4:640 642,870 GHz
 R5[H/V]:2T5 2,527,816 GHz

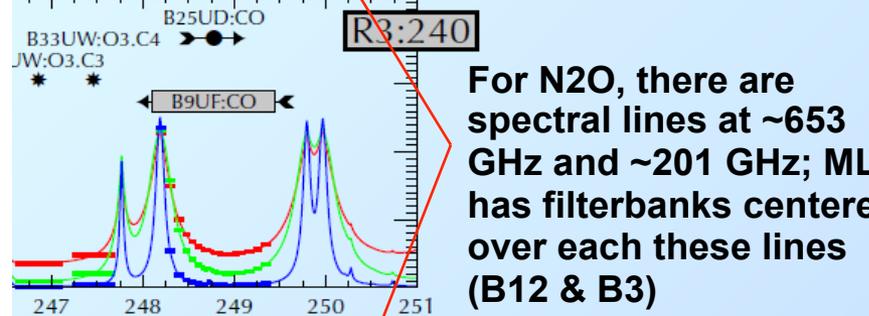
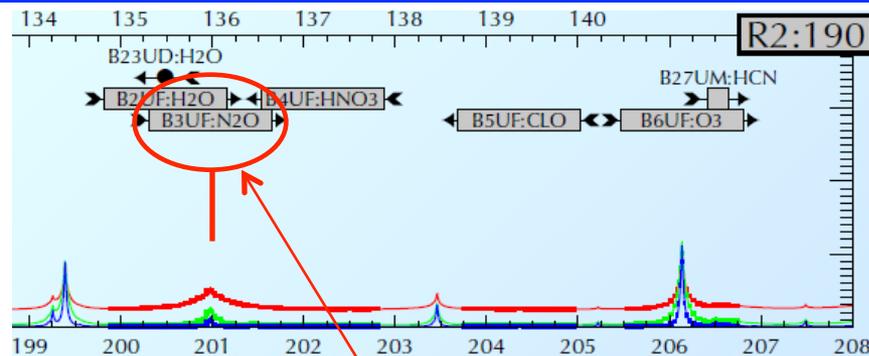
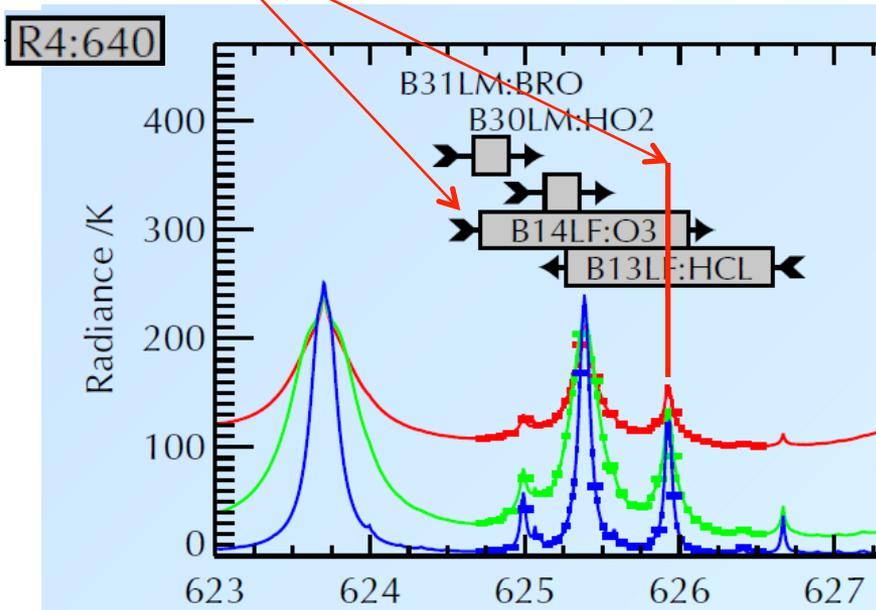
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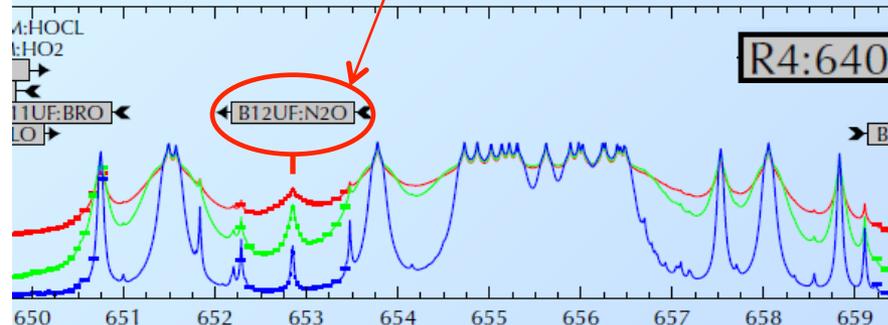
Multiple Paths to Monitor Some Signals



Band 14 filterbank is centered over the O₃ spectral line but it extends enough to also measure the Band 13 HCl line



For N₂O, there are spectral lines at ~653 GHz and ~201 GHz; MLS has filterbanks centered over each these lines (B12 & B3)





Longevity Concerns

Spectrometer Module



- **The Band 27 Saturation Test confirmed we had room to adjust the Band 6 attenuator without saturating Band 27**
- **Attenuator adjustment boosted Band 6 counts away from noise margin levels for at least several years**

The potential tradeoff decision listed below is no longer necessary at this time

- **Band 6 and Band 27 share a common signal source**
- **Band 6 signal levels have been decreasing slowly (due to voltage regulator issue) while Band 27 has held steady**
- **We have sufficient attenuation adjustment available to boost Band 6 levels as needed, but, boosting Band 6 will also boost Band 27 and may cause it to enter saturation levels**
- **Based on current trends, we have ~ 6 months to 1 year before a few channels in Band 6 reach minimal levels and a Band 6/ Band 27 tradeoff decision may be necessary**



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 a certain batch of voltage regulators

- 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**
- Current gain settings are good for the foreseeable future**