

New Operations Strategy after RF switch failure

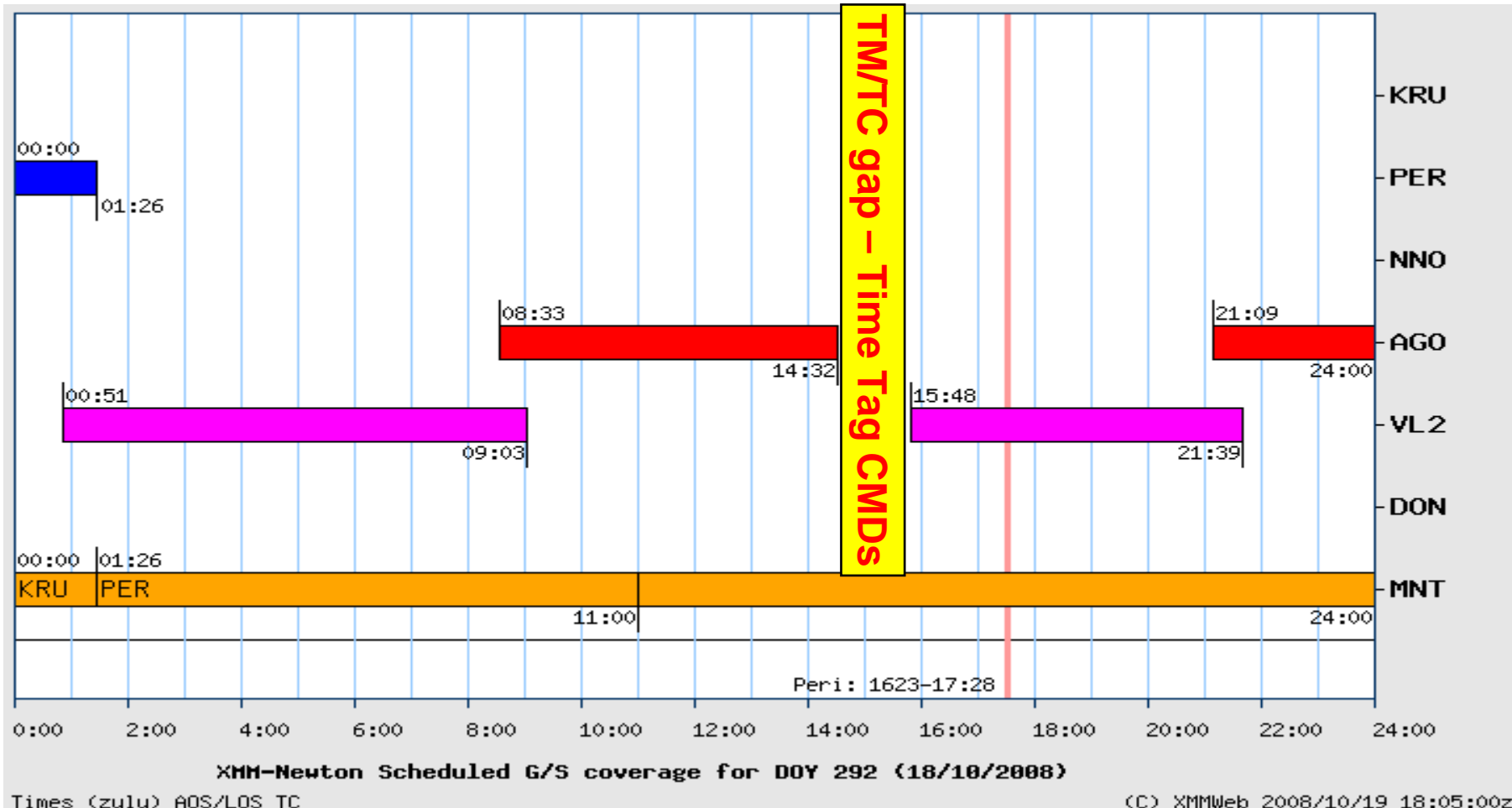
Pedro M. Rodriguez Pascual

XMM-Newton UG#10

ESAC, May 6-7, 2009

Loss of contact: October 18th

- 14:19 LOS Santiago OK
- 15:37 AOS Villafranca NO SIGNAL



Assessment: October 19th

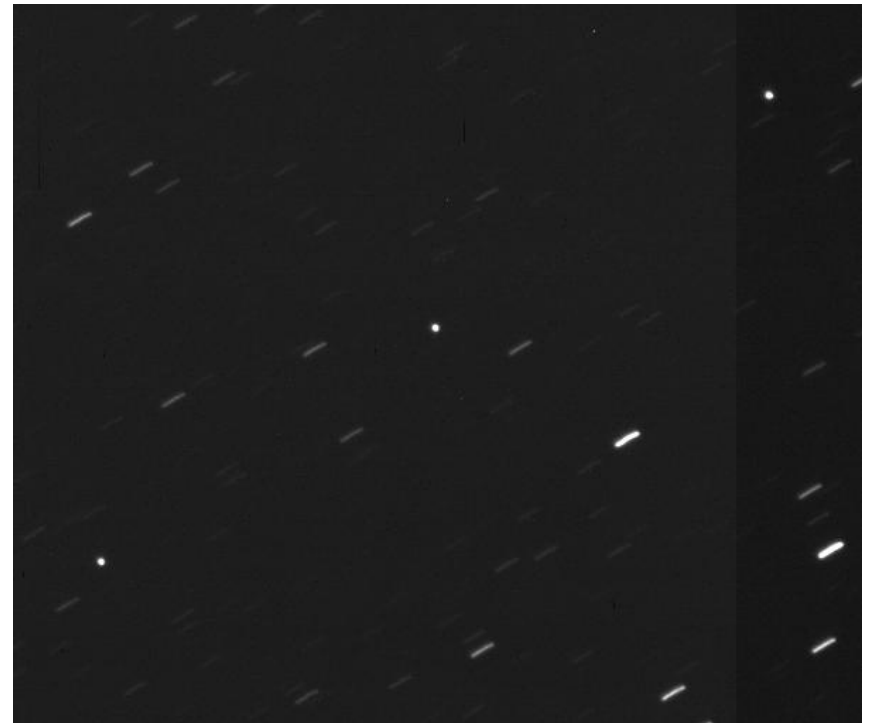
- Configuration
 - Instruments in a safe configuration (perigee)
 - Attitude safe until Oct. 24
 - Reaction Wheels speeds safe for a few days
- Failure assessment
 - ✗ Ground Station failure
 - ✗ Time-tag command failure
 - ✗ Error in orbit prediction
 - ✗ Transmitter switch-off by SEU (Single Event Upset)
 - ✗ Transmitter failure
 - Antenna Switch failure

Optical detection: October 20th

Starkenburg Observatory
Heppenheim, Germany

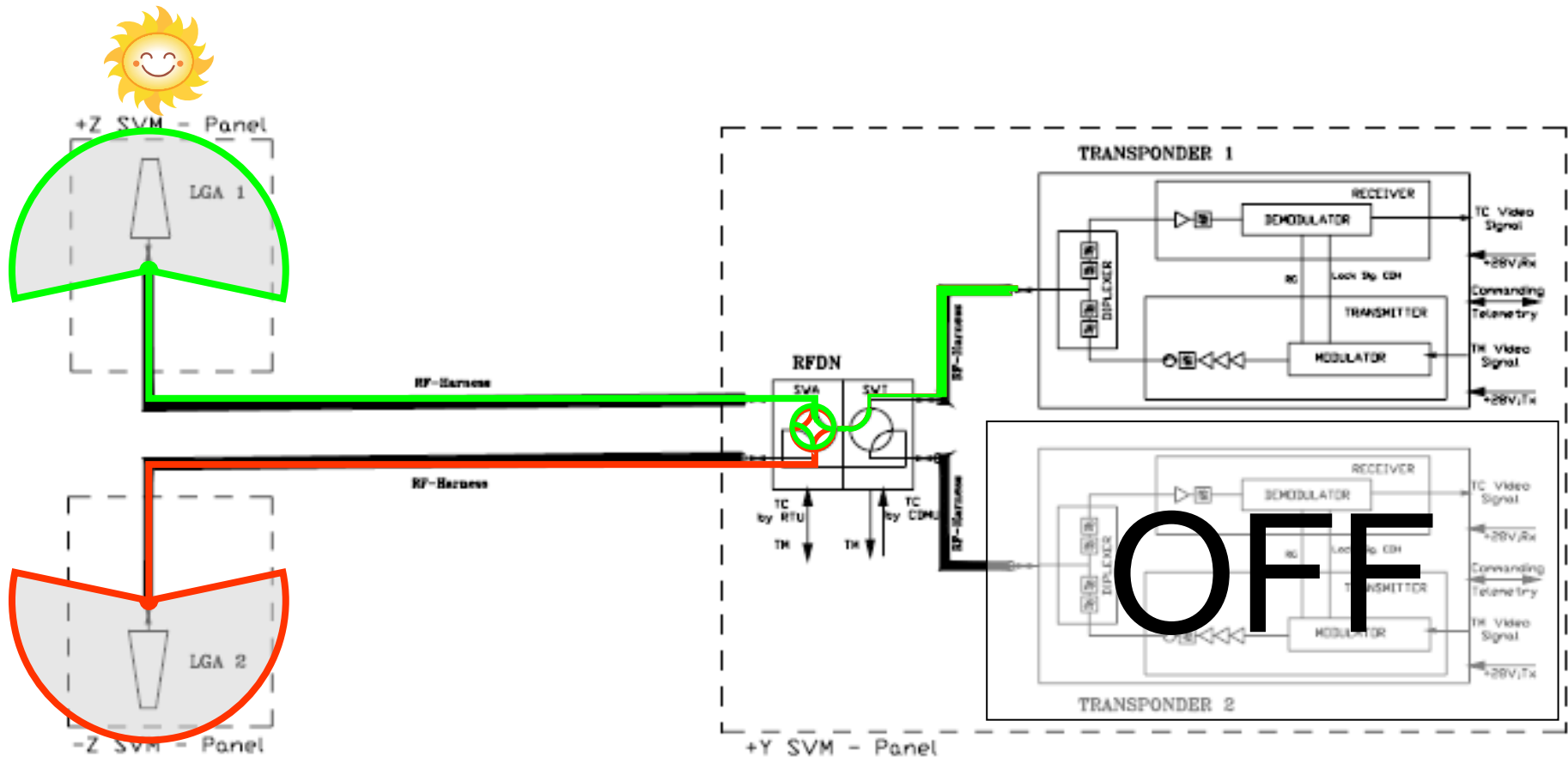


ESA Space Debris Telescope
Tenerife, Spain
(three frames, along expected path)



Radio contact: October 21st

- Very weak signal picked-up by ESA's 35m antenna in New Norcia
- Signal attenuation (-55dB) pointing to **switch in intermediate position**
- Commanding not possible from New Norcia (uplink power)
- Commanding not possible from Canberra (frequency not supported)



Spacecraft Recovery: October 22nd

- Goldstone (70m) antenna configured to support XMM near perigee.
- Uplink command to put the RF switch back to its position before the failure
- Immediate TM at ESOC and ESAC
- Check spacecraft status: all sub-systems OK
- Update platform and payload configuration to put satellite in a safe state
- Testing and basic maintenance
- Science operations partially (only 1 antenna) resumed in Nov 03
- Science operations fully resumed in Dec 09

Possible causes

1. Simultaneous switch commands
 - Not possible with s/c and ground segment design
2. Extremely high vibration and shock levels
 - Not possible
3. Mechanical problem
 - Switch was moved back to +Z
 - Switch cannot be moved to -Z (?)
4. Electrical Problem
 - Full or partial coil failure (?)
 - SEU caused imperfect pulse (?)
 - Other component failures (none identified)
5. **Imperfect switch command**
 - Never achieved during pre-launch testing
 - But reproduced in ESOC Lab testing

Recommendations

R1: Establish Operational Concept without the use of any RF switch

- use of only 1 transmitter
- use both transmitters permanently on or TX1 always on and TX2 on/off
- alternate operations of transmitters TX1 on/TX2 off and TX1off/TX2 on

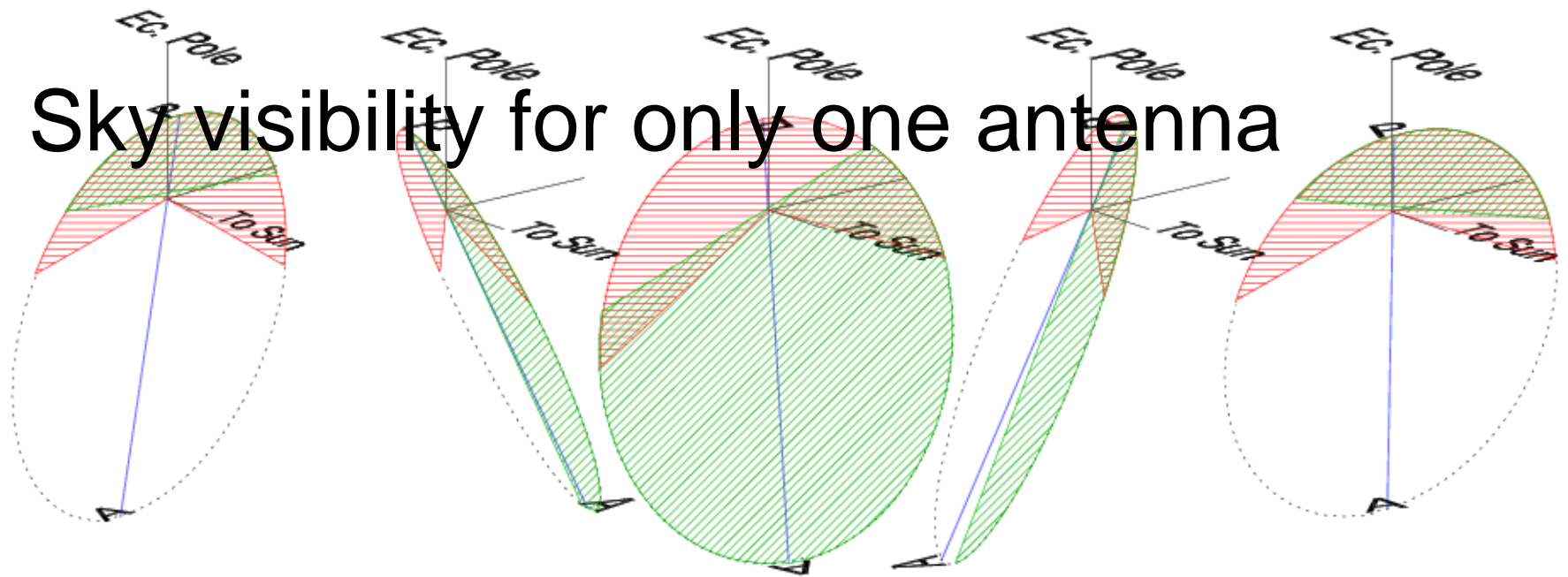
R2: Use back-up RF switch

- switch can only be commanded with direct commands
- switch cannot be commanded by use of time-tag commands
- therefore if switch gets stuck, safety time-tag commands to move switch back to previous position cannot be used

R3: Test of RF-A switch

- most likely cause of anomaly is an imperfect pulse
- multiple time-tag commands to move switch would cover both cases

Sky visibility for only one antenna



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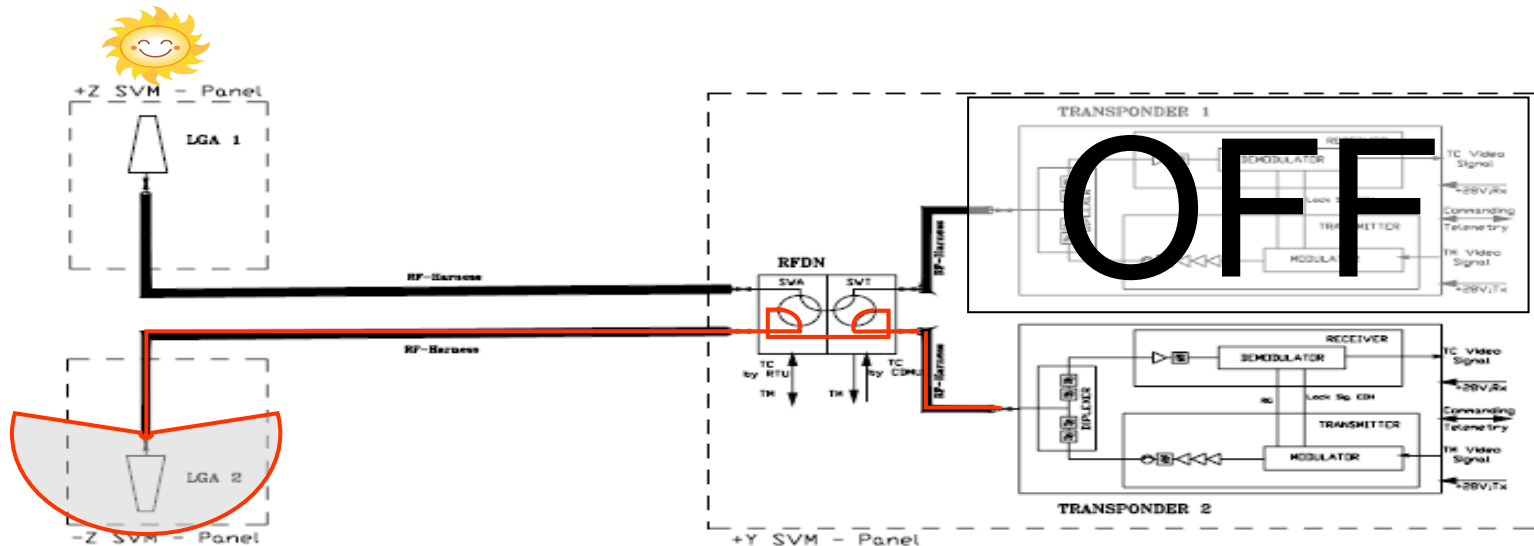
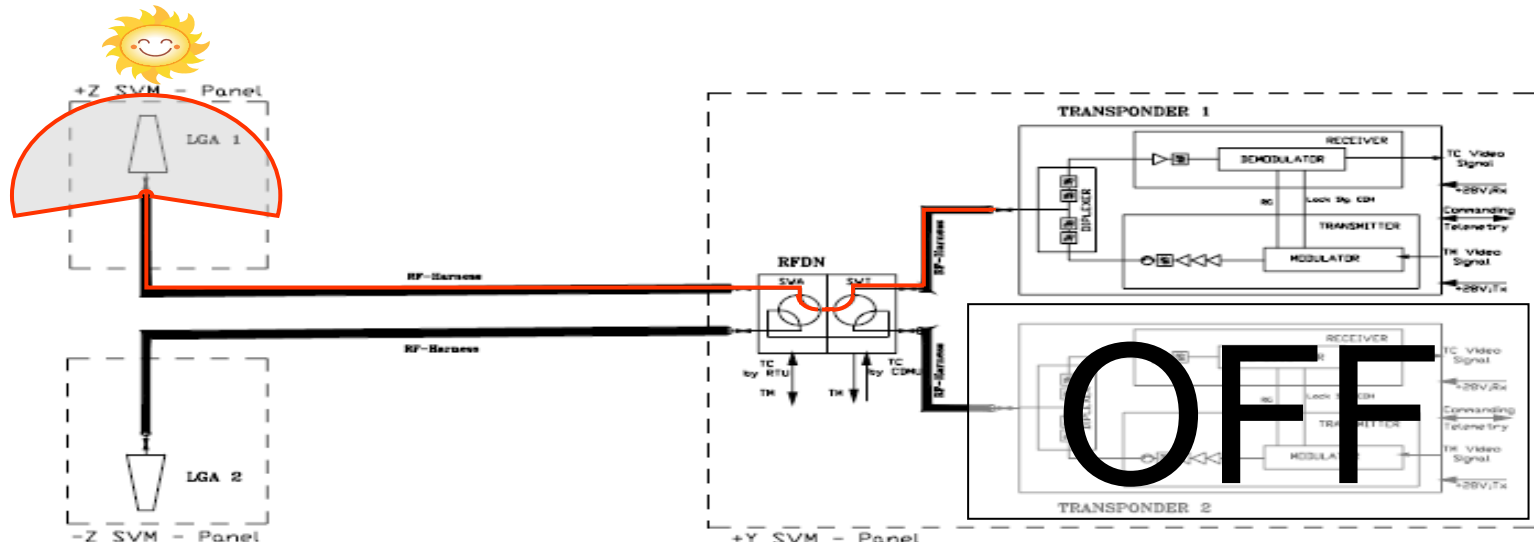
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New Swap Strategy

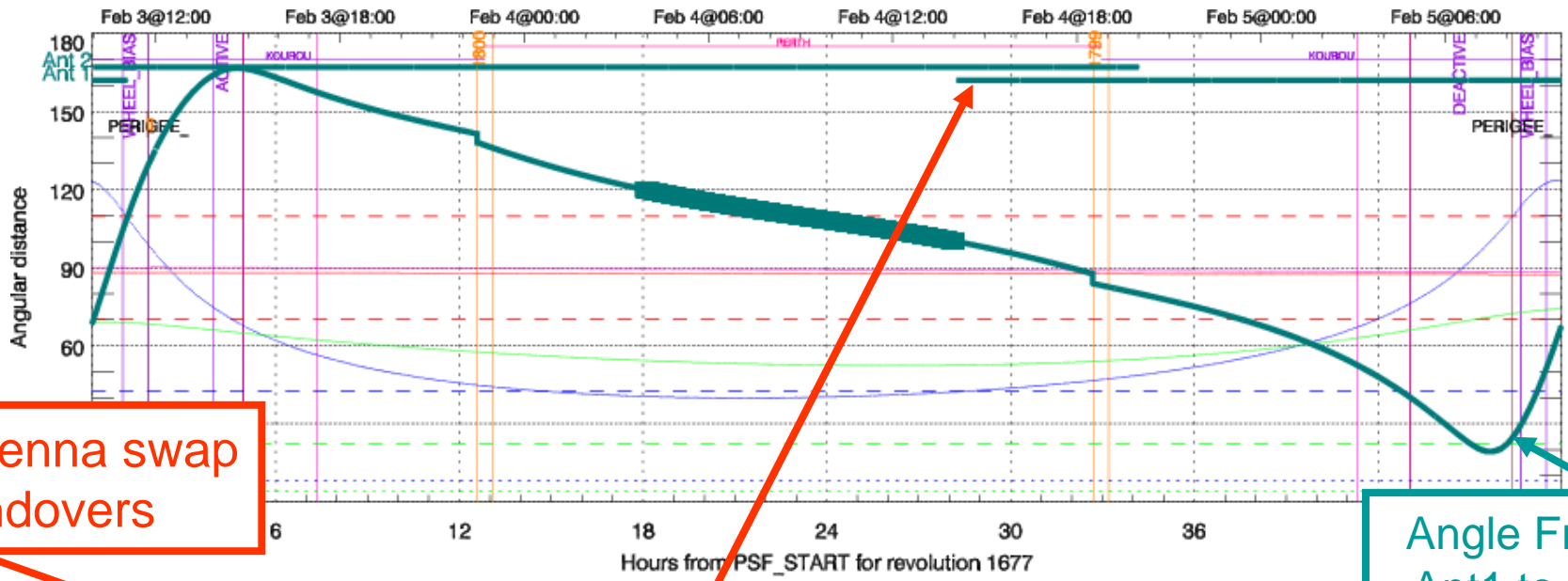


Operational Constraints

- Angle between antenna direction and ground station cannot be larger than 100deg (\Rightarrow 20 deg overlap)
 - Two swaps within each revolution (as before)
- Only one receiver shall be locked at any time
 - Chance of command rejection when locked on “weaker” RX
 - Command rejection interrupts execution of command time line and requires manual intervention
 - 30 minutes “handover”
- No TC to be uplinked during TX/RX swap
 - No Slew, No Start/Stop exposures
- Antenna availability depends on epoch of year, pointing attitude and ground station
 - Science Planning

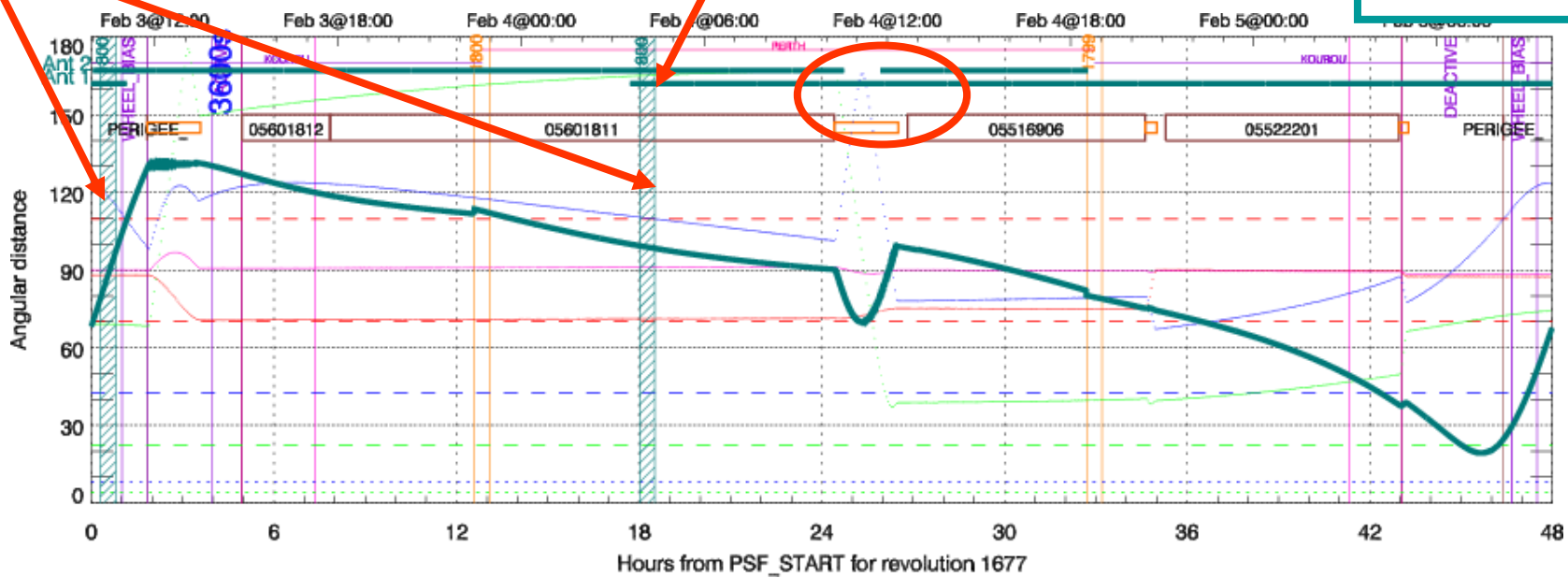
Mission Planning Strategy

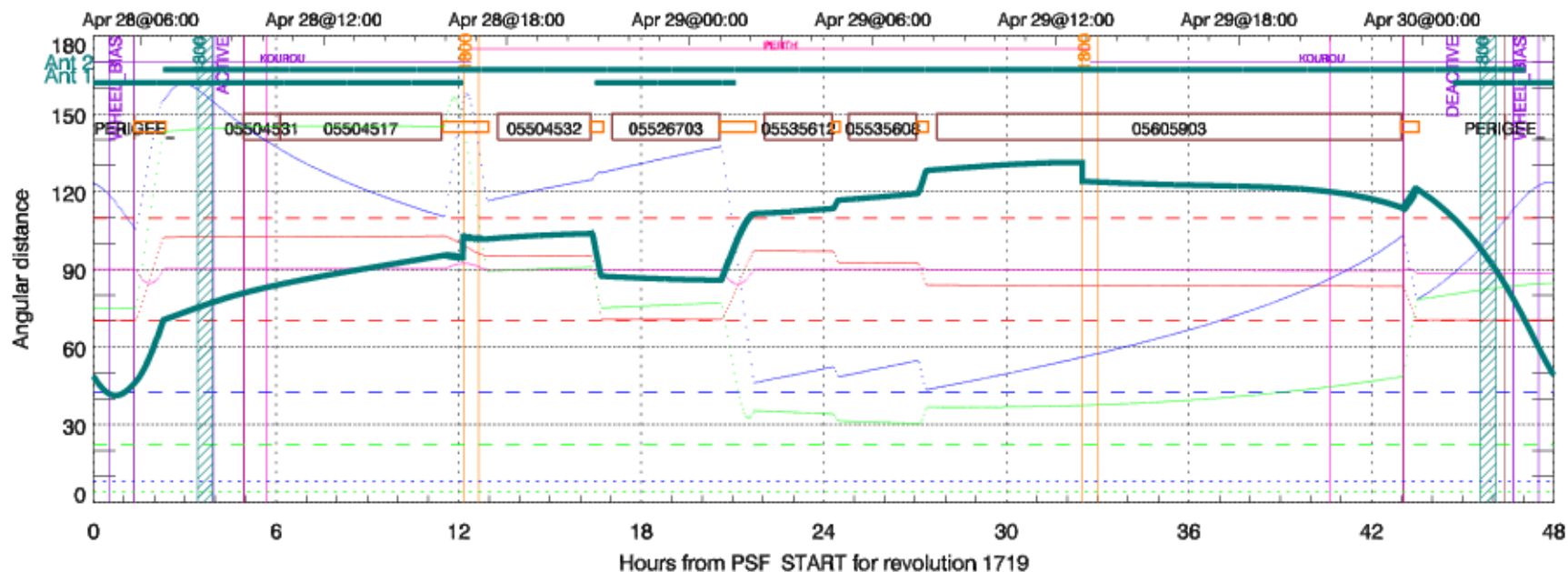
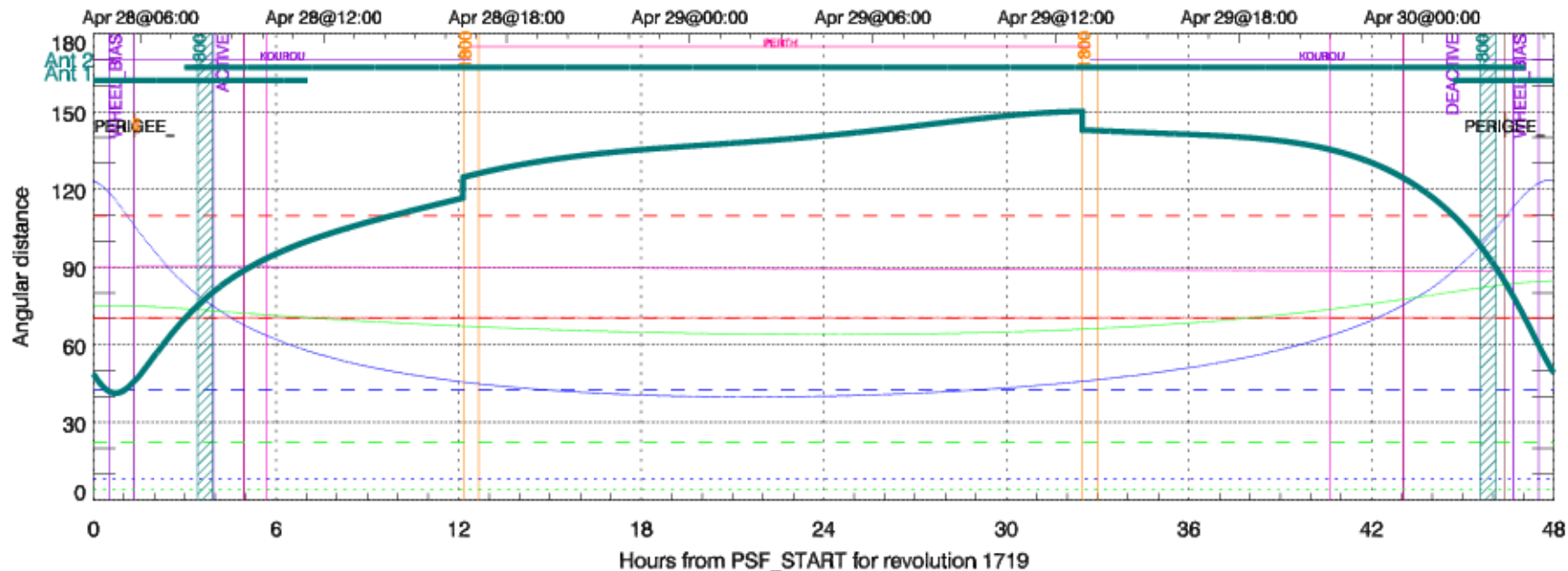
- **P**lanning **S**keleton **F**ile (MOC)
 - On orbit/revolution basis defines windows for Reaction Wheel Bias (RWB), instrument activation/deactivation, ground station handovers, and science observations
- **P**referred **O**bservation **S**chedule (SOC)
 - Observations and slews slots
- **I**nstrument **C**ommand **P**arameters (SOC)
 - Sequence of instrument commands and their parameters, ordered by execution time
- **E**nhanced **P**referred **O**bservation **S**chedule (MOC)
 - Parameters for RWB and orbit maintenance, slews execution and target acquisition



Antenna swap handovers

Angle From Ant1 to GS





Mission Planning Strategy

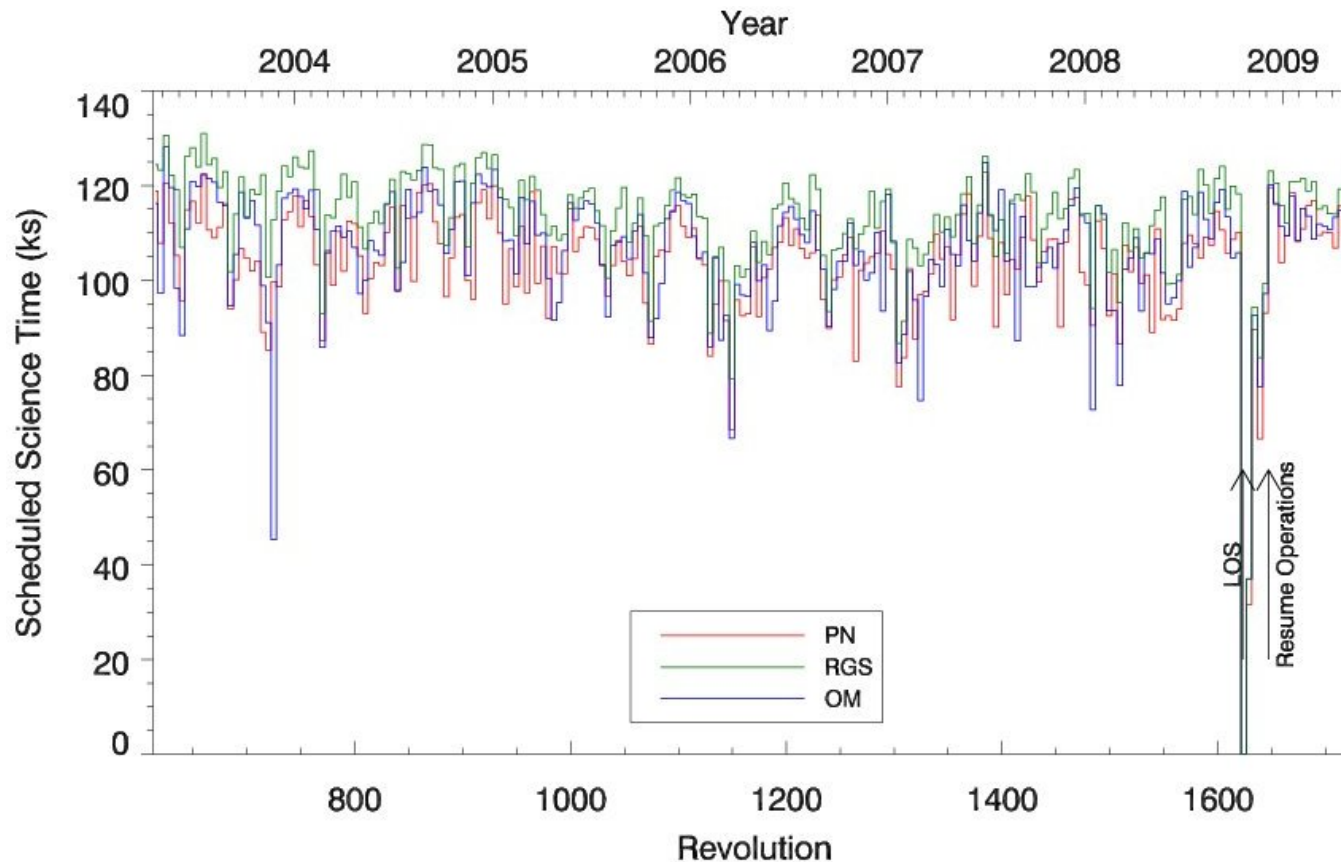
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 - On orbit/revolution basis defines windows for Reaction Wheel Bias (RWB), instrument activation/deactivation, ground station handovers, and science observations
- **P**referred **O**bservation **S**chedule (SOC)
 - Observations and slews slots, on-board antenna handovers (slots)
- **I**nstrument **C**ommand **P**arameters (SOC)
 - Sequence of instrument commands and their parameters, ordered by execution time
- **E**nhanced **P**referred **O**bservation **S**chedule (MOC)
 - Parameters for RWB and orbit maintenance, slews execution and target acquisition, command stack for antenna swap (to be executed manually by SPACON)

Mission Planning Changes

- FCT/MOC: new operational procedure to swap transponders/antennas
- USG/SOC tools to
 - check antenna angles
 - insert on-board antenna handover into PSF generated at MOC
 - transfer new PSF to SOC operational area
 - include antenna checks in ToO assessment
- FDS/MOC tools to
 - check antenna angles
 - insert antenna swap commands on EPOS

Science recovery

- Science operations resumed in rev. 1631 (Nov. 3), but only with one antenna
- Full orbit science operations resumed in rev. 1649 (Dec. 9), with the new operations strategy.
- 6 ToO + 5 Triggered observations have been scheduled after rev. 1649



Summary and future

- Science Planning efficiency has been fully recovered after the switch failure
- If the current strategy (TX/RX on-off) fails
 - Back-up switch is still available (not yet tried)
 - One TX always on and the other on/off
 - Prime switch may be attempted