

HRC - Y Shutter Anomaly

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Outline

1. Anomaly Description
2. Review of Telemetered Data
3. Laboratory Investigation
4. Conclusions & Recommendations

Anomaly Description

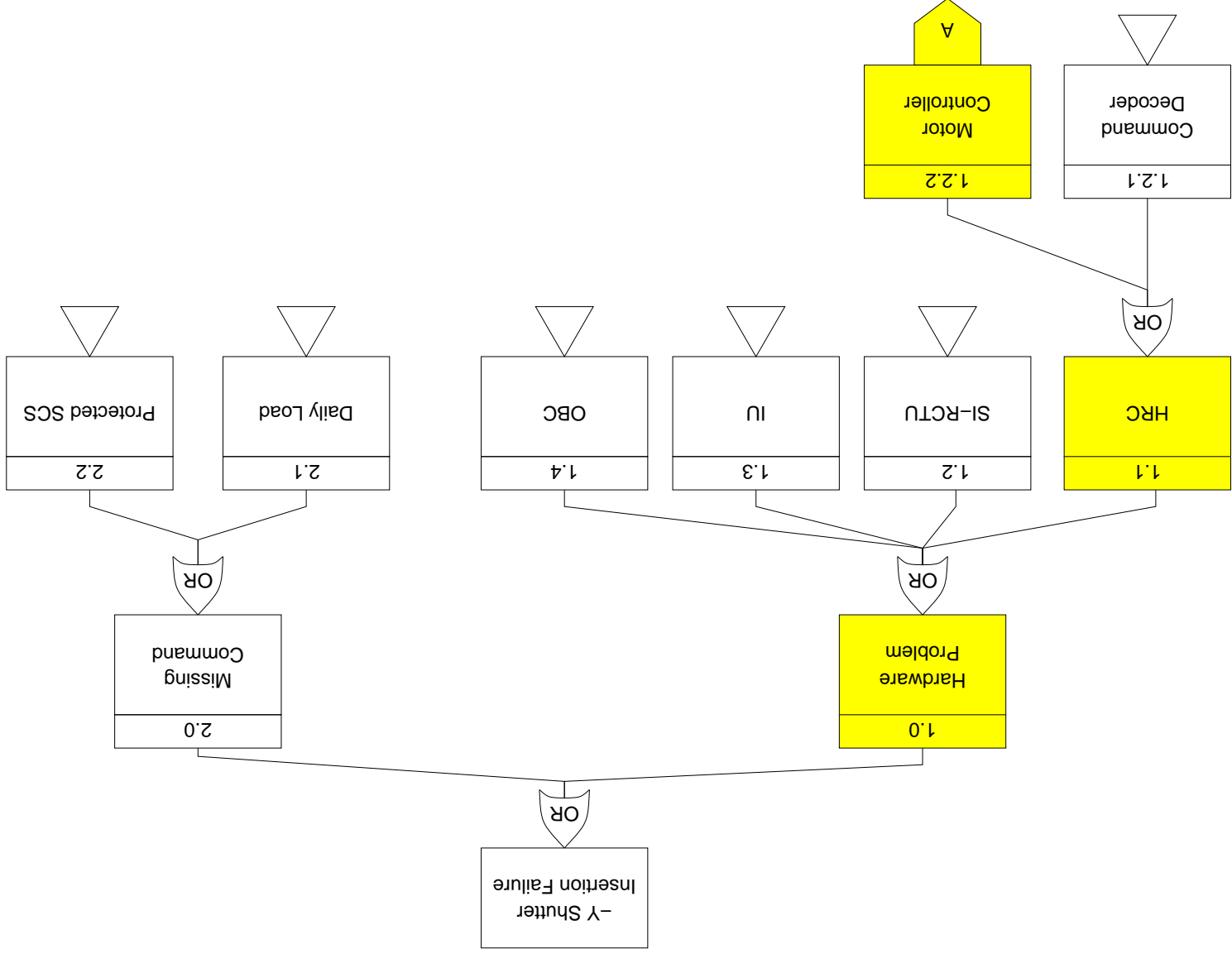
ObsID 3831 planned to use HRC shutters to block $\sim 3/4$ of the on-axis X-rays to reduce total rate below the telemetry saturation level. Commands for inserting shutters were included in the daily load.

- Total event rate during observation was above the telemetry saturation rate (mean of ~ 260 counts/s versus ~ 184 counts/s).

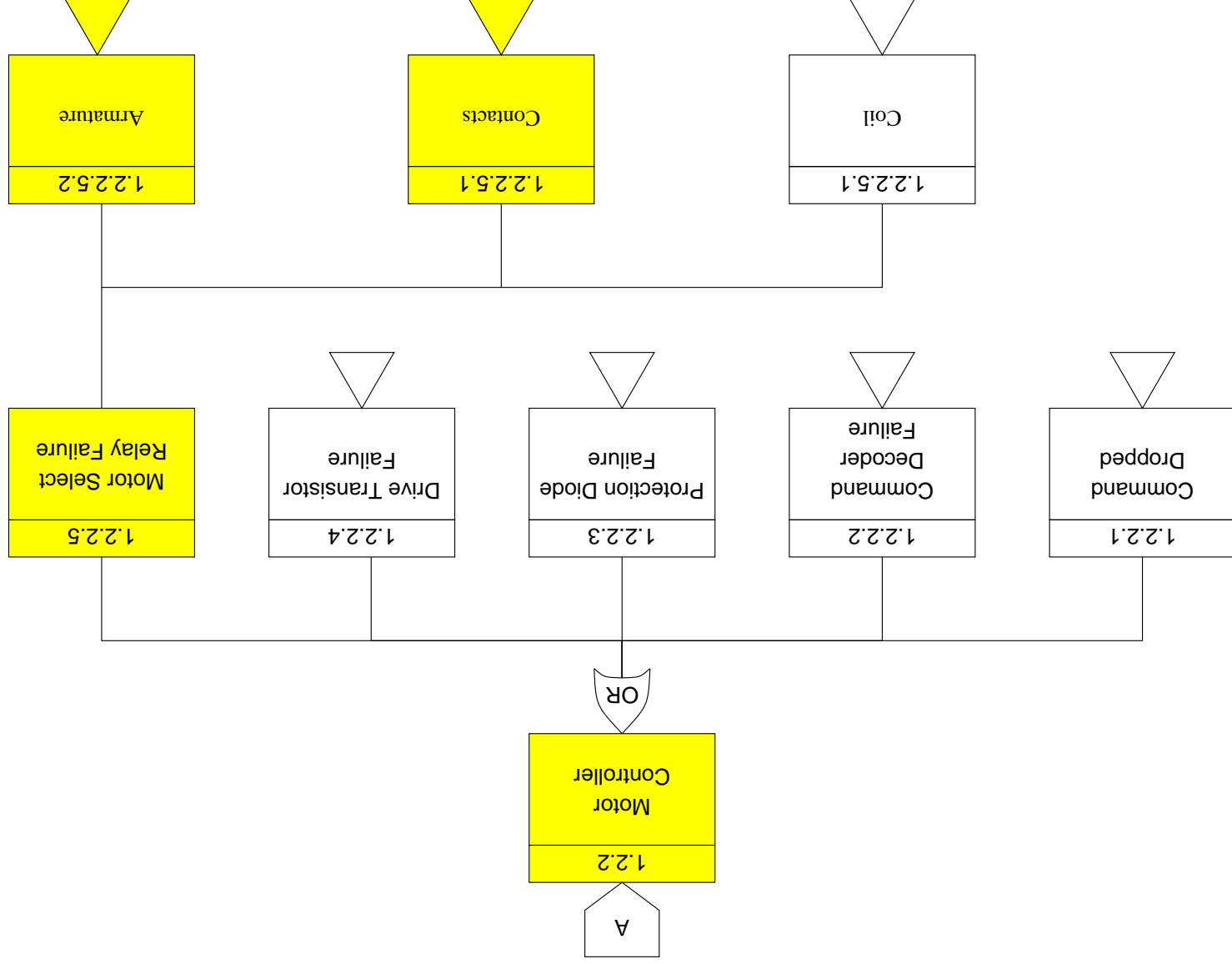
- Event distribution on the detector did not show the “shadowing” expected.

-Y shutter failed to insert for ObsID 3831

Fault Tree - Top Level



Fault Tree - HRC Motor Controller



Review of Telemetered Data

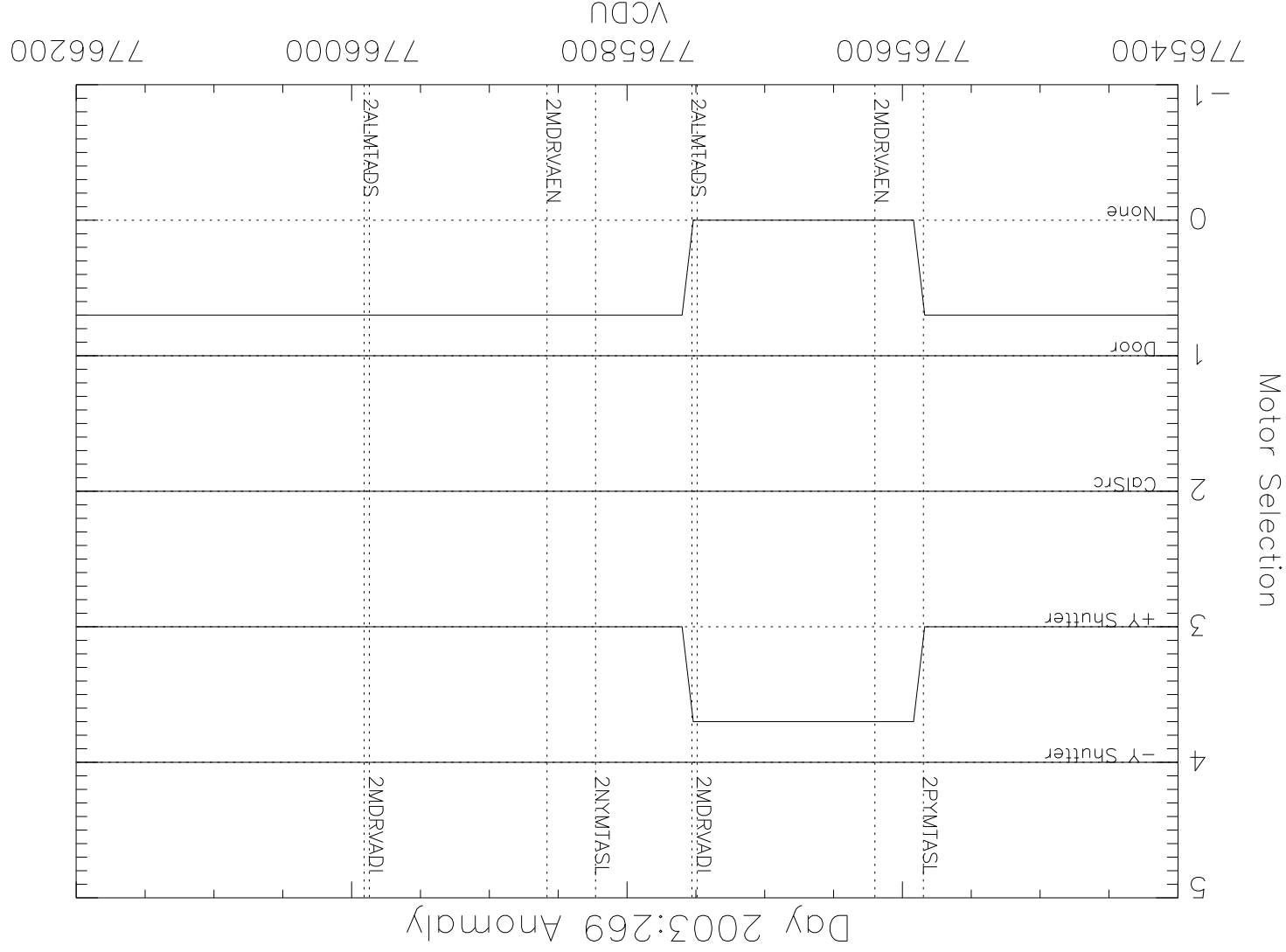
Mechanism selection is via serial digital command; selects motor and its associated limit switches and thermistor.

HRC received -Y shutter selection command and acted on it.

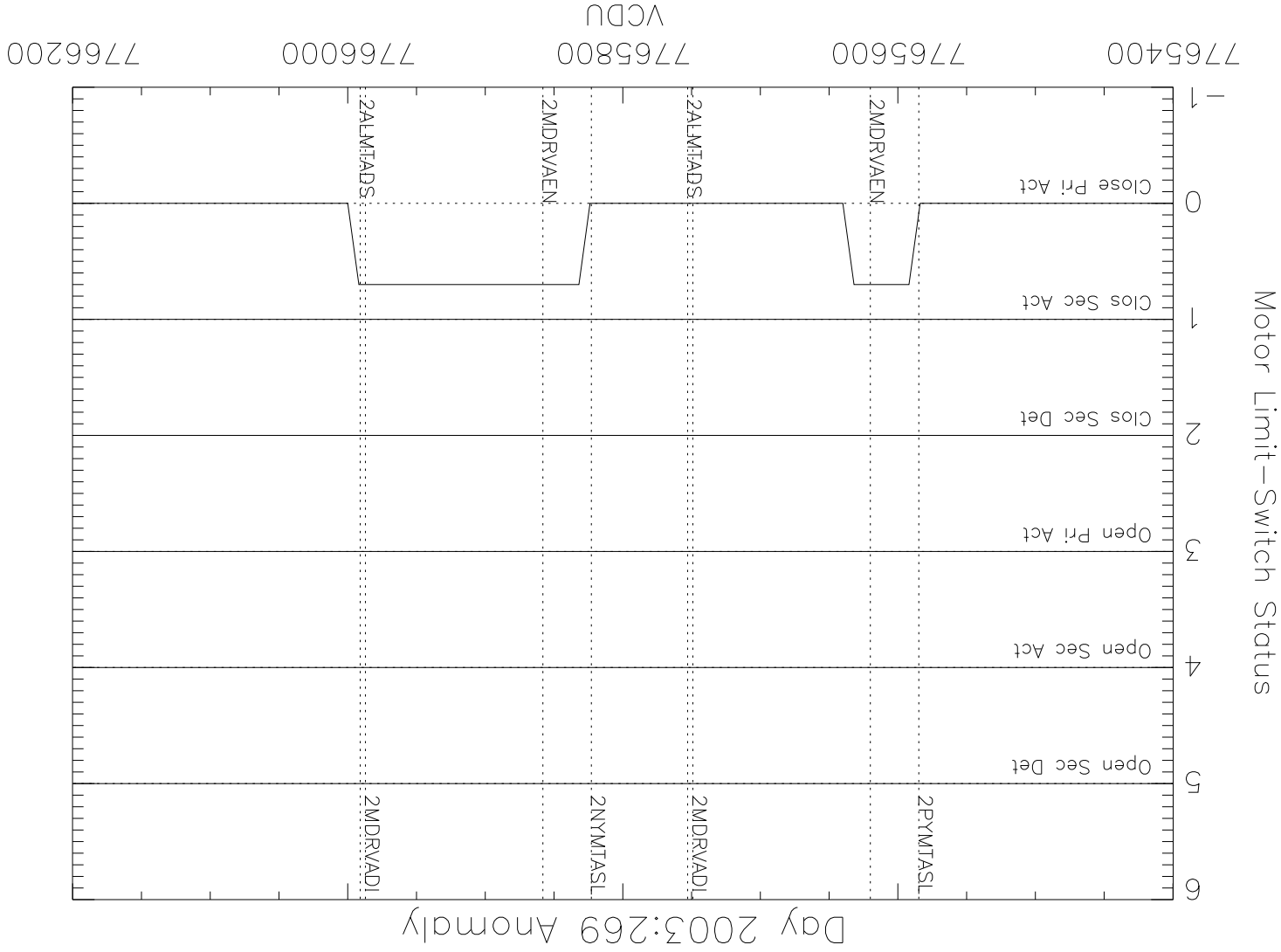
- -Y shutter limit switch set selected
- -Y shutter motor thermistor selected
- HRC bus current increased

However, -Y shutter motor selection was not indicated and shutter did not move.

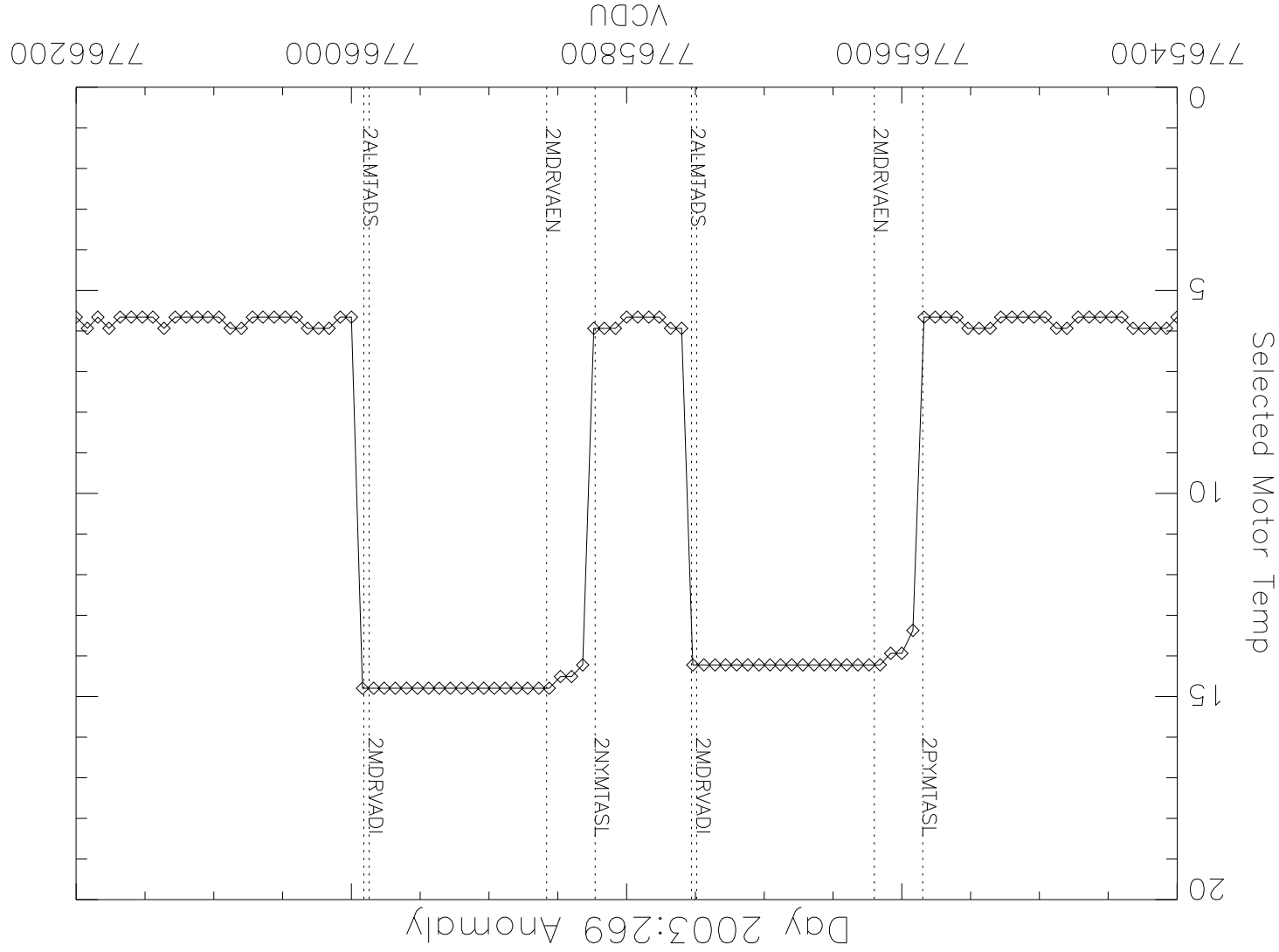
Review of Telemetered Data



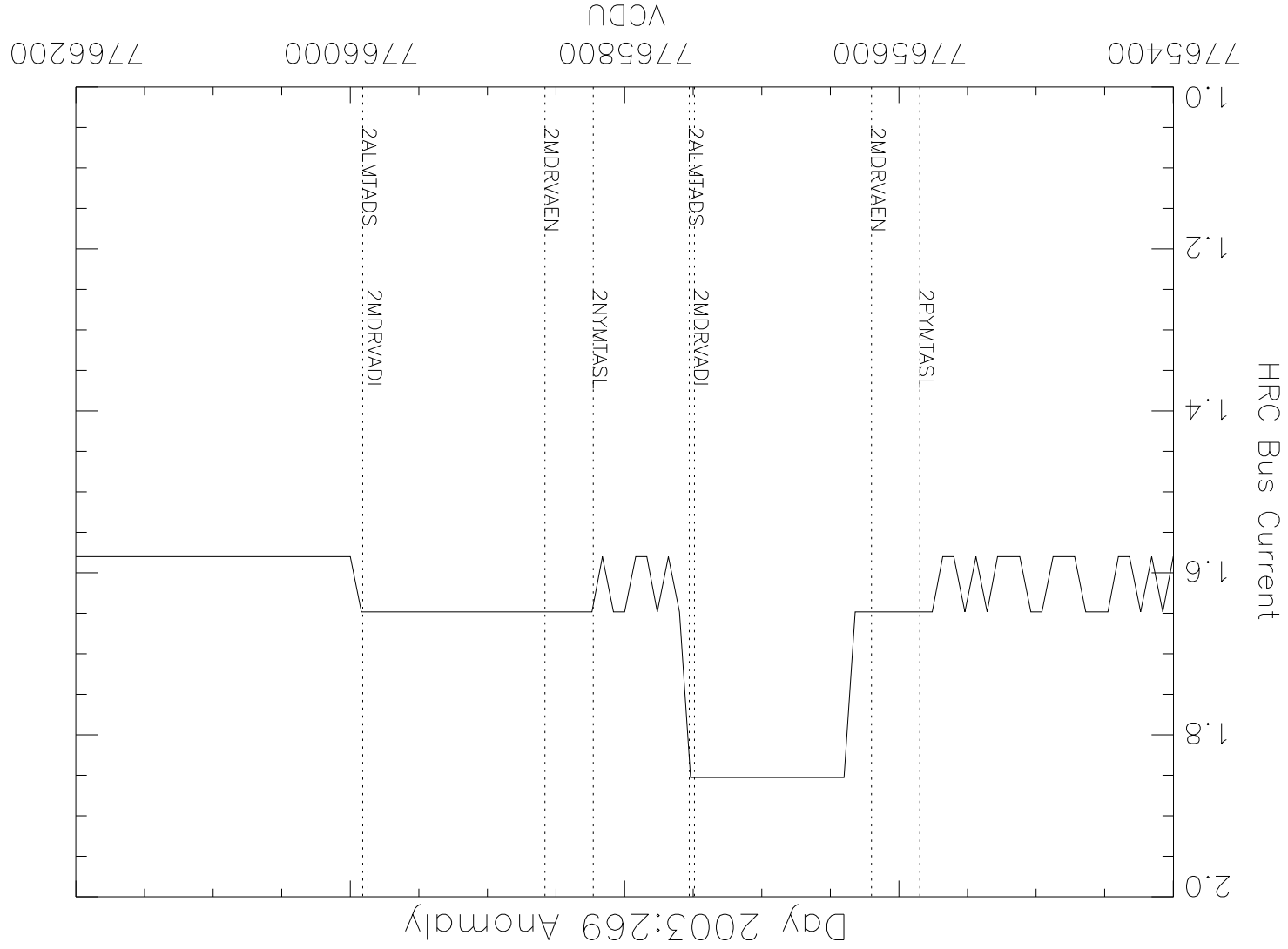
Review of Telemetered Data



Review of Telemetered Data



Review of Telemetered Data



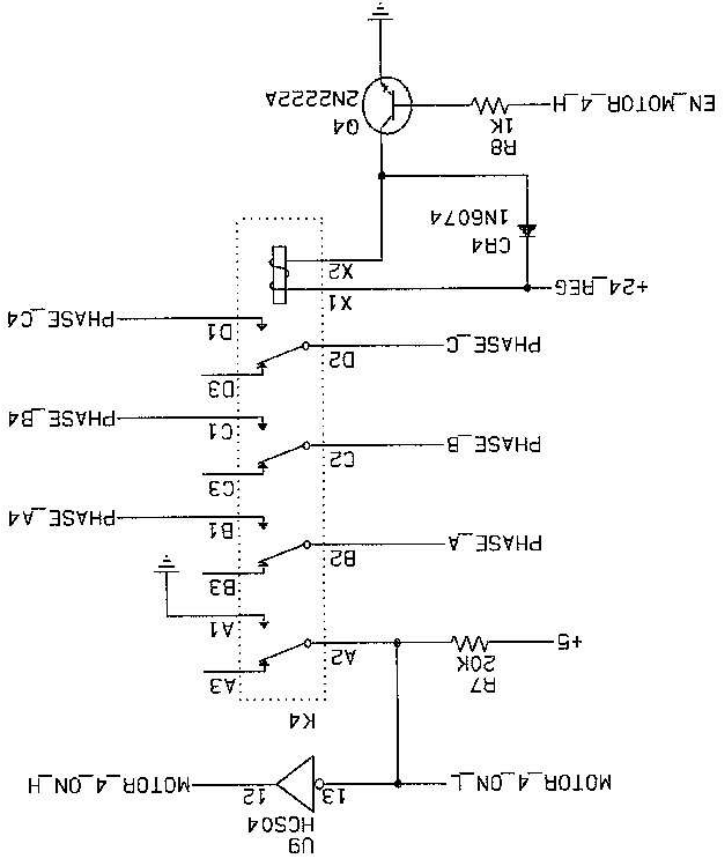
Laboratory Investigation

HRC laboratory “Proof of Concept” (POC) electronics used to trouble-shoot the anomaly. POC is built to flight design but not to flight specifications.

Verified that slight increase in the HRC bus current indicates that the coil for the -Y shutter motor select relay was energized but that the relay did not switch.

Fault traced to a problem with the relay armature or contacts

Laboratory Investigation



Laboratory Investigation

Relay failure is the most likely cause for the shutter insertion failure.

Genicom relay: S311P754/09-003 DC9536 used in flight electronics for mechanism motor selection. Qualified to GSFC specification S311P754 including PIND test per MIL-R-83536 for fine particles.

POC use same relays except for the additional screening to the GSFC spec.

1 Flight-spec. relay (in bonded stores as a “spare”) and POC relays available for diagnostic tests.

Tests identify the most-likely cause for the relay failure as particles, generated as a result of oxidation of the copper elements of the contact assembly during long-term storage in an oxidizing environment.

Conclusions and Recommendations

The failure of the -Y shutter insertion was due to failure of the motor select relay. The most-likely cause for the relay failure was particle contamination from oxide generation.

The possibility for a similar failure of the motor select relay for any of the other HRC mechanisms cannot be considered unlikely.

- Stop routine HRC door operation [Done]
- Remove mechanism commanding from HRC safing SCSS [Done]
- Increase frequency of bright UV source monitoring [Done]
- Stop use of the HRC shutters and calibration source

Conclusions and Recommendations - HRC Door

Stopping the use of the HRC door has one potential impact — there is an unknown potential for long-term degradation of the UV/Ion shield from low-energy protons during radiation zone passages

Published data and tests on HETG facets suggest that this has a low likelihood of having an impact

HRC monitoring observations of the bright UV source Vega show no evidence for change over nearly one year of radiation zone passages with the door “open”.

Increased frequency of monitoring for a possible degradation will catch a problem early

Measurements could be made to find how much radiation the UV/Ion shield can take using witness samples produced during shield fabrication

It might be possible to minimize exposure to low-energy protons during radiation zone passages by translating the SIM to the mid-point rather than to the HRC-S position without exposing the ACIS

Conclusions and Recommendations - Shutters

Shutters are seldom used in operations

- Used in calibration for focus and HRMA tilt measurement — shutter use no longer required
- Could be used to completely block zeroth order in a grating observation — never requested
- Used in ObsID 3831 to reduce total rate — unsuccessful due to relay failure

Stopping shutter use will impact some amount of science

Failure of a relay while the shutter is inserted will impact all HRC observations until shutter can retract.

Retraction in this case will require either switching to the B-side electronics or operating the failsafe.

Failsafe operation requires the development and test of procedures to operate a wax actuator that will release the mechanism from its motor without burning out the heater prior to complete actuation.

Both retraction options entail risks which need to be weighed against the benefit of using the shutter.

Conclusions and Recommendations - Cal Source

The HRC has a door mounted ^{55}Fe calibration source

- Door must be moved toward closed to illuminate detector
- longer of sufficient strength to be seen above background

No impact to stopping calibration source use