SWIFT UVOT Bright Source Safety Philosophy

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SWIFT safety philosophy

Overview
The SWIFT mission is designed to investigate GRB's, the most energetic phenomena in the Universe. The duration of GRB's initial shockwave is typically very short ~50s from initial burst to maximum brightness.

It is critical to the scientific objectives of the mission that the UVOT instrument begins its scientific investigation as soon as possible. The GRB brightness will decay rapidly, once it is too faint (m_B<17) red-shift measurements will not be possible.

The immediate exposure requirement of the UVOT instrument requires that the instrument is self-configured, ready to start collecting data as soon as the GRB enters the UVOT field of view. A consequence of such operational requirements is that the UVOT may 'see' bright objects either during slew or when the spacecraft settles on the GRB field. The following safety philosophy has been adopted to guard against such potentially damaging sources of illumination.

Image intensifier damage avoidance
As the SWIFT spacecraft slews to a new target it will, in some circumstances pass bright objects (m_B>10^{th}). Such bright objects can and cause irreparable damage to the UVOT instrument (gain depression of MCP) if they remain in the field of view for extended periods of time. The instrument must be capable of protecting itself from such objects.

The following section summarises the auto-safing features of the UVOT instrument and is based on the current understanding of the mission operations as described in the SWIFT phase-A report.

Safing systems overview

Count rate (frequency) meter (non-autonomous operation)
A count rate system will be used to monitor the number of valid events reported during a 1 second period. The ICU will read the count rate. A dynamic range of 1 – 256 000 events per second will be supported (saturation of the BPE will occur at 200 000 c/s). This safety system will rely on the ICU to switch off the HVU and place the filter wheel in the safe (blocked) position under high-count rate situations.

Image intensifier brightness monitor (autonomous operation)
The UVOT instrument is design to investigate features that lie within the intensity range 10^{th} – 24^{th} magnitude. Bright objects (>10^{th} magnitude) will damage the image intensifier if viewed for extended periods of time.

Sources of greater than m_B > 10^{th} will cause saturation of the image intensifier, pixel charge will be >250 ADU (Analogue to Digital Units). Adjacent pixels will also be affected. The number of pixels affected will depend on source brightness.

A system that counts the number of adjacent pixels above a pre-defined threshold will be capable of recognizing such saturation, and hence bright sources. The detection circuit will be connected to the HVU (high Voltage Unit) cathode disable system. Switch off time will be 10ms.

Switching off the photo-cathode will reduce the sensitivity of the detector (~ factor 10 000) to bright sources. However, this solution is not considered a suitable means of protection from Sun, Earth or Moon glint (see glint section).

Bright source catalogue
An on-board catalogue of bright sources (m_B>8th) will be stored in the ICU. The ICU will use this catalogue to set up the detector during slew to a new target, ensuring the appropriate filter is chosen (science and safety requirements).

Planet avoidance algorithm
ICU on-board software will be capable of calculating whether 'moving' bright sources (planets, asteroids etc.) are located in the GRB field of view and selecting an appropriate filter.

Glint
Reduction in photo-cathode gain (cathode off) does not apply to the UV wavelengths. UV will produce photo-electrons, through interaction with photo cathode material. Photoelectrons will be amplified by MCP_1 and MCP_{23} plates. This effect can be alleviated by reducing the voltage on plate MCP_{23} to 70% nominal levels, with a resulting further drop in detector gain of 1000.

Commanding of MCP23 is only possible via the ICU. The ICU will monitor the count rate monitor during slew. An increase beyond a pre-defined set threshold will cause Vmcp23 to be ramped down to 70%..

Slew safety
It is critical that the UVOT is prepared for slew. Hence, a simple, fast handshake scheme has been developed with the spacecraft:

- The UVOT will be alerted to a slew by the FoM computer.
- Upon reception of the alert, the UVOT will acknowledge the receipt of the command by sending a 'message received' back to the FoM computer.
- Only after full confirmation of the slew command being received will the S/C begin its slew to the GRB target.

Further information regarding the slew will be required from the FoM if the slew is too include any very bright objects: Sun, Moon or Earth and (TBD).

Sources of damage

Listed below are the prime sources and the proposed safing state of the instrument

Operation	Detector bias	Filter position	Time
Sun in FOV[1]	$V_{cathode}$ = Off V_{mcp23} = Off. V_{mcp1} = Off	BLOCKED	$V_{cathode}$ = 10ms V_{mcp23} = 60s V_{mcp1} = 20s Filter = 5s
Earth glint in FOV[1]	$V_{cathode}$ = Off V_{mcp23} = Off. V_{mcp1} = Off	BLOCKED	$V_{cathode}$ = 10ms V_{mcp23} = 60s V_{mcp1} = 20s Filter = 5s
Moon glint in FOV[1]	$V_{cathode}$ = Off V_{mcp23} = Off. V_{mcp1} = Off	BLOCKED	$V_{cathode}$ = 10ms V_{mcp23} = 60s V_{mcp1} = 20s Filter = 5s
Comets in FOV	$V_{cathode}$ = Off V_{mcp23} = Norm. V_{mcp1} = Norm.	OPEN	$V_{cathode}$ = 10ms V_{mcp23} = N/A V_{mcp1} = N/A Filter = N/A
Planets in FOV	$V_{cathode}$ = Off V_{mcp23} = Norm. V_{mcp1} = Norm.	OPEN	$V_{cathode}$ = 10ms V_{mcp23} = N/A V_{mcp1} = N/A Filter = N/A
Bright stars in FOV[1]	$V_{cathode}$ = Off V_{mcp23} = Norm. V_{mcp1} = Norm.	OPEN	$V_{cathode}$ = 10ms V_{mcp23} = N/A V_{mcp1} = N/A Filter = N/A
Satellite in FOV[1]	$V_{cathode}$ = Off V_{mcp23} = Norm. V_{mcp1} = Norm.	OPEN	$V_{cathode}$ = 10ms V_{mcp23} = N/A V_{mcp1} = N/A Filter = N/A
Safe Hold/Off	$V_{cathode}$ = Off V_{mcp23} = Off. V_{mcp1} = Off	BLOCKED	$V_{cathode}$ = 10ms V_{mcp23} = 60s V_{mcp1} = 20s Filter = 5s
Radiation belt passage (SAA) [2]	$V_{cathode}$ = Off V_{mcp23} = 70% V_{mcp1} = Norm.	BLOCKED	$V_{cathode}$ = 10ms V_{mcp23} = 22s V_{mcp1} = N/A Filter = 5s
Safe Mission state	$V_{cathode}$ = Norm. V_{mcp23} = Norm. V_{mcp1} = Norm.	OPEN	V $V_{cathode}$ = 10ms V_{mcp23} = N/A V_{mcp1} = N/A Filter = N/A

[1] It is assumed that these conditions will not be exercised since the s/c will remain within the agreed (UVOT IRD) viewing constraints.

2. It is assumed that the HV is already at nominal working voltage levels. If the HV is currently ramping up, it must be allowed to finish before ramping down. The HV should therefore not be allowed to ramp up within 3 minutes of the SAA.

3. 111 seconds to ramp up the HV to nominal levels.