

# STIS Bright Object Protection Observing Policies for the MAMA Detectors

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## 1. Overview

STScI will perform screening of all STIS MAMA science observations prior to their scheduling. Observations (target plus configuration combinations) which exceed defined limits will be disallowed. In this memo, we summarize STScI's policy for screening of GO and GTO STIS science observations for Bright Object Protection (BOP).

This memo is organized as follows:

- In “Ground Screening” on page 1, we define the rationale for and goals of screening prior to scheduling.
- In “The Flight Hardware and Software Triggers” on page 3, we summarize the flight hardware and software bright object triggers and their relationship to the ground screening limits.
- In “Ground Screening Limits” on page 5, we define the STScI ground screening limits for individual instrument configurations.
- In “Ground Screening Process and Policy” on page 7, we summarize the STScI policy for the implementation of the ground screening limits.

## 2. Ground Screening

### *(i) Responsibility of FSW*

The STIS flight software and hardware are responsible for protecting the detector from damage due to accidental over-illumination. As described in “The Flight Hardware and Software Triggers” below, the instrument protects itself from damage in almost all such instances, either by shuttering (in the case where the action can take up to 10 seconds) or by turning off the high voltage on the detector (in instances where immediate action is required to avoid damage). However, at very high illumination levels ( $\sim 10^7$  counts/sec) the global and local FSW triggers saturate and no longer operate to protect the detector. The Bright Scene Detector remains operative. However, due to its geometry, it may fail to detect certain overlight conditions.

When the shutter is closed, just the single exposure responsible for the overlight condition is lost. When the high voltage is shut down, all observations with that detector are lost for the remainder of the SMS (~1 week). The non-offending observations from that SMS must be rescheduled, and the cause of the over-light unambiguously identified before the detector can be brought back up. This may require observations planned for the following SMSs to be rescheduled as well.

Quick turn-offs of the high voltage on the MAMA detectors are believed to be potentially deleterious to detector health.

### ***(ii) Purpose of Ground Screening***

STScI provides ground screening of STIS targets in addition to the on-board protection. With the STIS sensitivity levels, it is not possible to provide guaranteed protection. Procedures have been developed to perform screening of all MAMA observations, prior to their scheduling. Observations which exceed the allowed limits will not be scheduled. The purpose of ground screening is threefold:

1. To keep high voltage off occurrences from BOP violations to a minimum.
2. To protect the detectors from damage at the very high levels where the hardware and FSW do not protect the MAMA detectors.
3. To maintain spacecraft efficiency by minimizing lost science observations due to BOP violations.

### ***(iii) Goals of Ground Screening***

STScI has set reliability goals for ground screening. The goals are:

- No more than 1% of all MAMA observations shutter due to a local rate check BOP violation.
- No more than 0.1% of all MAMA observations violate the Global Flight Software (FSW) or Bright Scene Detection (BSD) limits leading to the turn off of the MAMA high voltage.

If these goals are met, we expect (based on a maximum expected number of 1000 unique target plus configuration combinations observed by the MAMAs per year):

- To lose less than ~10 observations (where an observation is a set of exposures of a given target in a single configuration) a year due to local rate check violations.
- To turn off the MAMA HV less than once per year due to BOP violations.

### **3. The Flight Hardware and Software Triggers**

The STIS MAMA detectors can be permanently damaged by excessive global and local illumination levels. In order to protect the MAMA detectors from over-illumination a set of flight hardware and software count rate monitors have been implemented. A detailed summary of these monitors is presented in the Instrument Science Report “The STIS Bright Object Protection Scheme”. The bright object monitors are BSD, GSM, and LRC.

#### ***Bright Scene Detection Monitor (BSD)***

The BSD monitor is a hardware monitor which samples the output of two anode wires, corresponding to every 32nd row of pixels, where a row is perpendicular to the Y axis in the MAMA coordinate system. The output is monitored every 138 ms, and a count rate of  $> 16200$ , from one or both wires, will cause the monitor to trigger. In the case of full detector illumination the BSD trigger level corresponds to  $2 \times 10^6$  counts/sec, while illumination of a single row of monitored pixels can trigger at the level of 120000 counts/sec. When the BSD is triggered the MAMA high voltage is immediately shut down to prevent further over-illumination of the detector. The BSD is designed to prevent permanent damage to the detector and provide some protection at global illumination levels in excess of  $10^6$  counts/sec, where the Global Software Monitor starts to suffer from the 260 ns paralyzable deadtime of the decode chip. The BSD is always operational.

#### ***Global Software Monitor (GSM)***

The GSM is a software monitor which runs from the MCE and monitors the OR (Valid + Non-Valid events) event counter. It is primarily designed to prevent permanent damage to the detector and is always operational. The monitor is designed to trip when the OR event counter exceeds 770000 counts/sec, and immediately shuts down the high voltage to the MAMA detector.

#### ***Local Rate Check Monitor (LRC)***

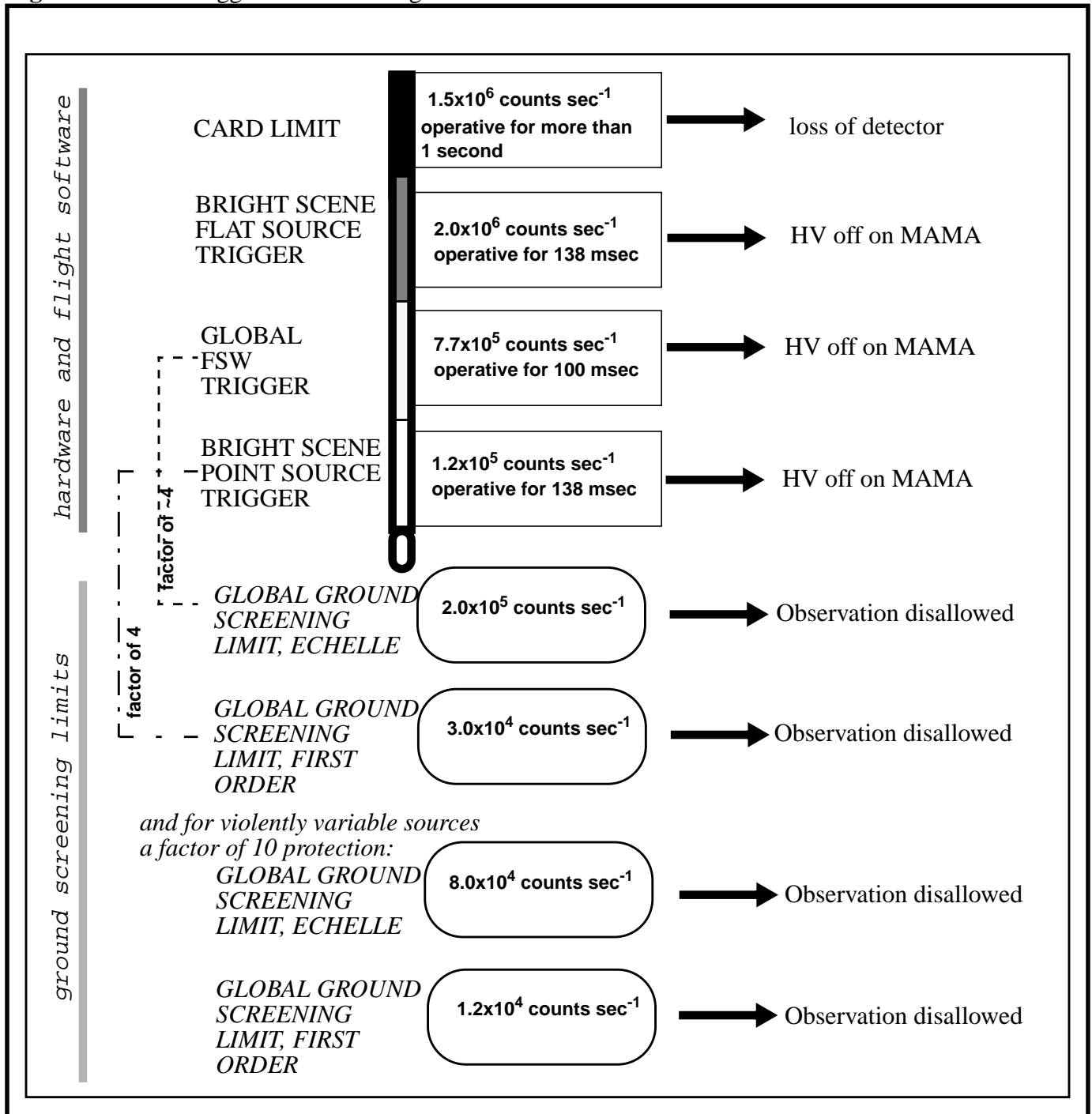
The local rate check monitor is designed to prevent local over-illumination of the MAMA detectors, which typically leads to accelerated aging of small areas of the detector, but can in extreme cases permanently damage the detector. The local rate monitor check is made prior to the start of an exposure. The detector is unshuttered and a 0.1 second image is taken and rebinned to 256x256 lo-res pixels. A two stage algorithm is then applied to the image to check for count rates which exceed 200 counts/sec/pixel for the NUV-MAMA and 150 counts/sec/pixel for the FUV-MAMA. If the algorithm detects a violation of these limits, the detector is shuttered and no science exposure is taken.

Figures 1 and 2 provide a summary of the actions of the three triggers, their relationship to the defined danger levels for the detector, and their relation to the screening limits.

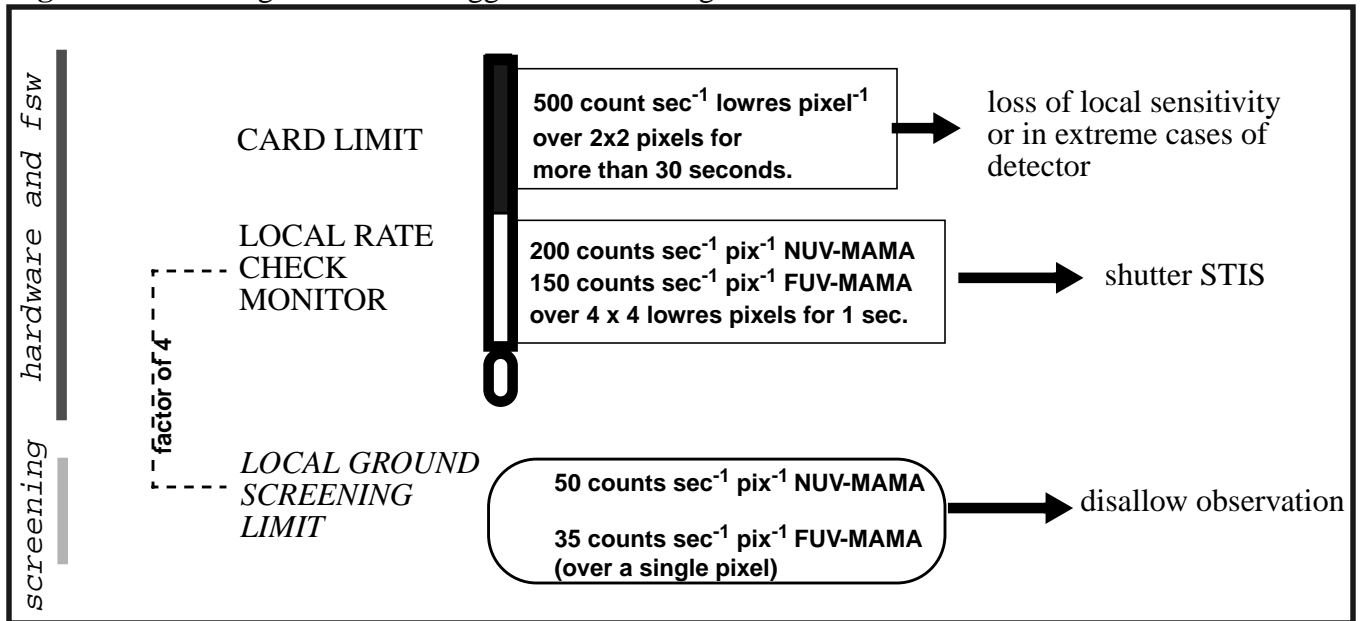
Table 1 indicates which hardware or flight software trigger dominates the setting of the ground screening limits; while all triggers are active for all science observations, in practice, one trigger will generally be encountered first (i.e., will be prime) for a given type of observations.

The screening limits are described in more detail in “Ground Screening Limits” on page 5.

**Figure 1:** Global Triggers and Screening Limits



**Figure 2:** Local Flight Software Trigger and Screening Limits



**Table 1.** What Defines the Screening Limits for Different Types of MAMA?

type of science	BSD Flat	GLOBAL FSW	BSD Point	LRC FSW	comment
echelle spectroscopy	no	prime	no	yes	screening magnitude limits set by Global FSW trigger (for continuum source Global exceeds LRC triggers) LRC trigger applies to individual emission lines
first order spectroscopy	no	yes	yes	yes	screening magnitude limits set by BSD Point Source and LRC Trigger (for continuum source, BSD Point and LRC exceed Global) LRC trigger applies to individual emission lines and Global FSW applies for extended objects
prism spectroscopy	no	yes	no	prime	LRC trigger sets magnitude limits
imaging	no	yes	no	prime	LRC sets magnitude limits Global FSW applies to entire image of field

## 4. Ground Screening Limits

In the absence of an ultraviolet spectrum of a source and firm evidence that the source is not variable, it is often difficult to accurately predict the ultraviolet flux of an astronomical source. Therefore, to assure the ground screening goals are met, the ground screening limits must be set below the instrument FSW and Hardware Trigger levels. The existing HST spectrographs (FOS and GHRS) have set the ground screening limits a factor of ten below their FSW and Hardware trigger levels and have roughly achieved the STIS ground screening goals (e.g., ~1 safing per year due to BOP violations for the FOS).

However, the bright object protection concerns are different for STIS than for FOS and GHRS in one key way: the STIS bright object limits are appreciably lower than for FOS and GHRS and therefore a much larger fraction of science observations are directly affected.

To minimize the science impact of the STIS BOP limits while still assuring robustness of the ground screening we adopt the following set of rules.

### ***Ground Screening Limits for Sources for Non Variable or Regularly Variable Sources***

For sources which are not members of a class of objects which are known to vary irregularly, we set the ground screening limits to be a factor of four more conservative than the onboard triggers. Observations which are predicted to exceed these limits will not be allowed. The global ground screening limits are:

- Global count rate  $< 200,000 \text{ count sec}^{-1}$  for all modes,
  - Global count rate  $< 30,000 \text{ count sec}^{-1}$  for first order spectroscopy of point sources,
- The local ground screening limits are:
- Local peak per pixel count rate  $< 50 \text{ count sec}^{-1} \text{ pixel}^{-1}$  for NUV-MAMA observations,
  - Local peak per pixel count rate  $< 35 \text{ count sec}^{-1} \text{ pixel}^{-1}$  for FUV-MAMA observations.

Further, observations which are predicted to come, at peak flux, to within approximately 1 magnitude of the global ground screening limits will only be allowed if a flux calibrated pre-existing observation of the source at or near the observing wavelength is provided to confirm the prediction (e.g., an existing UV spectrum of the source). Screening tables giving magnitudes corresponding to the ground screening limits, plus a safety margin of approximately 1 magnitude are published in STIS ISR 024. The safety margin is somewhat dependent on spectral type.

### ***Ground Screening Limits for Sources which are Irregularly Variable***

Irregularly variable sources are defined as objects whose variability amplitude cannot be accurately predicted. For sources which are members of a class of objects which are known to be irregularly or violently variable (e.g., cataclysmic variables), we set the ground screening limits for the actions which turn the high voltage off to be a factor of ten more conservative than the onboard triggers. This affects the Global limits only; the local limits are as for non-variable sources. Observations which can not be safely predicted to be below these limits at the time of the observations will not be allowed.

Specifically, the following limits apply:

- Global count rate  $< 80,000 \text{ count sec}^{-1}$  for all modes

- Global count rate  $< 12,000 \text{ count sec}^{-1}$  for first order spectroscopy of point sources
- Local peak per pixel count rate  $< 50 \text{ count sec}^{-1} \text{ pixel}^{-1}$  for NUV-MAMA observations
- Local peak per pixel count rate  $< 35 \text{ count sec}^{-1} \text{ pixel}^{-1}$  for FUV-MAMA observations

### ***Pointings Close to Objects Violating Safe Limits***

Pointings close to objects violating safety limits must be screened since (i) the possibility of HST pointing errors exists, and (ii) the light of a bright point source may pose a safety threat even if observed at a distance of several arcseconds.

The typical HST pointing accuracy is about  $0.5''$ , but cases have been observed when HST was pointing  $1\text{--}2''$  off its expected position. This results from some guide stars having less accurate coordinates or because they are not single. STScI will perform a screening of not only the targets in the field of view themselves (spectroscopy and imaging modes), but also of targets within  $5''$  of the boundaries of the used apertures (full field of view of the MAMA detector for imaging and slitless spectroscopy, field covered by slit for spectroscopy). If targets are found which would exceed the BOP limit for the particular instrument configuration, the observations will not be executed.

The distance limit of  $5''$  is imposed by concerns about pointing errors and about target acquisition failures. This distance is also used to screen for observations which are planned for execution in the vicinity of bright objects. An example would be a STIS observation of a faint star  $3''$  from a bright source whose brightness is above the safety limit. There is the concern that the faint wing of the bright star PSF would cause an overligh condition even if the faint star was perfectly centered. GHRS measurements of the PSF suggest that the count rate of a point source will drop by at least a factor of  $10^8$  between the center of the target and a radius of  $5''$ . Pointings outside  $5''$  of any non-variable astronomical target are therefore safe and need not be screened. Observations within  $5''$  will be screened assuming a conservative PSF and the limiting count rates in Figures 1 and 2.

## **5. Ground Screening Process and Policy**

### ***Observing Policy for Cycle 7 MAMA observations***

As described in the STIS Instrument Handbook, we have adopted the following Bright Object Protection related policies for Cycle 7 observations:

1. It is the observer's responsibility to provide sufficient information that STScI can verify that the observations do not exceed BOP limits; time lost to BOP violations will not be returned.
2. No MAMA pure parallel observations will be allowed (since the spacecraft pointing is not known a priori).

3. MAMA coordinated parallels require an explicit orient specification.

### ***GO/GTO Responsibility***

The observer (GO or GTO) has primary responsibility for assuring their observations will not exceed the bright object limits stated above.

To assist the observer in evaluating the feasibility of their observations, STScI publishes (in the *STIS Instrument Handbook* and updates to that document) the following information for each STIS spectroscopic and imaging mode:

- Fluxes (in  $\text{erg sec}^{-1} \text{cm}^{-2} \text{\AA}^{-1}$  and  $\text{erg sec}^{-1} \text{cm}^{-2} \text{\AA}^{-1} \text{arcsec}^{-2}$ ) corresponding to each bright object limit.
- Magnitude limits corresponding to each bright object limit, for a range of spectral types (where these spectral type specific limits have been derived by fitting curves to models and observations to guard against observational and intrinsic scatter).
- Aperture throughputs (relevant for slitted spectroscopy).

The flux and magnitude limits are calculated assuming full aperture transmission (zero slit losses) and zero reddening. These limits are advisory—the fundamental screening limits are as described in “Ground Screening Limits” on page 5, above and apply after correction for slit transmission and reddening, as appropriate.

In addition, for Phase I and II planning, STScI has made a World Wide Web exposure time calculator available which computes the global and local illumination rates and advises the user if the limits are exceeded.

In Phase II, the observer will be required to provide the information needed to allow screening. This includes:

#### *For UV spectroscopy with the MAMAs:*

- V magnitude.
- Expected source flux at observing  $\lambda$  and explanation of how derived.
- Spectral type.
- E (B-V).
- B-V color.
- A pre-existing observation of the object at the wavelength of observation if the object is within 1 magnitude of the safety limits.

#### *For UV imaging with the MAMAs:*

- UV image of field or magnitude and color information for each target in field of view.

## ***STScI's Process and Policy for Phase I and II***

### ***Phase I***

During Phase I, STScI performs a quick technical review of each proposal, including a quick spot check that the BOP limits are not grossly exceeded. If the BOP limits are grossly exceeded, that information is provided to the Panel; an evaluation of the additional orbit time request needed to perform the observation in an alternate “safe” configuration will be provided at the request of the Panel.

### ***Phase II***

During Phase II a full check is performed by STScI. Observations will not be executed unless they have been approved by an instrument scientist as not exceeding the BOP limits. Phase II observations which are identified as exceeding the BOP limits will not be executed. In these cases, if the observer wishes, she or he can submit a change request to alter their observing configuration or change their target to allow them to safely perform their observation. The request will be handled as a major change request (see User Support Coordination Committee Change Request Procedures). As with all major change requests;

- The change must be consistent with the overall scientific goals of the program as approved by the TAC,
- The change cannot result in any duplication conflicts.
- The change must not be contrary to any TAC mandates for the program.
- Any additional orbits requested must be highly justified in terms of the scientific return from the program.

Each change request will be evaluated individually according to the existing procedures.