The Integrated Bright Object Tool (BOT) – STIS/CCD

R. Downes, T. Rogers, K. Peterson

December 21, 2006

Abstract

A integrated Bright Object Tool (BOT) has replaced the old VTT-based RObust Bright Object Tool. The main engine for the tool, as well as the basic processing steps, has remained unchanged, but the source of the input data, as well as the display of the results, have been changed to provide a more complete tool. The tool will check each exposure in a program for field (and prime) objects that are either health-and-safety concerns, or may impact the scientific value of the data. The tool will utilize the GSC2 catalog to determine the brightness and (rough) spectral type of all objects in the macro-aperture, determine the count rate and total counts for each object via a lookup table, and compare these values to limits set by the STIS Group. The output products will be a table listing the results for all objects, with the status of each object (health-and-safety concern, science concern, safe, or unknown status), and an Aladin image with the object's status indicated.

The new tool utilizes information in the proposal file, and also uses the APT and Aladin interfaces for its tabular and graphical display, respectively. For Instrument Scientists, the use of the proposal file, instead of the ASSIST database, allows for the support of position changes (e.g. POS TARGs) for exposures. For GOs, the use of the proposal file allows for more than one exposure to be processed at one time, making it much easier to run the tool on the entire proposal.

Introduction

The VTT-based Robust Bright Object Tool (ROBOT) has be utilized by both GOs and Instrument Scientists since Cycle 10. One of the main deficiencies of the tool for Instrument Scientists has been the inability to handle exposures with positional changes (e.g. POS TARGs), which is due to the need to access the ASSIST database. For GOs, the need to run each exposure individually makes proposal checking extremely tedious. The new tool will utilize information in the proposal, which eliminates both problems. The tool will use information in the Phase II proposal to identify all the stars in the macro-aperture that are in the GSC2 catalog. The color information of those stars will be converted to spectral types, and count rates (and total counts) for each star will be determined via a lookup table (based on Exposure Time Calculator results). The final products will be a tabular view of analysis of each star in the field (available through the APT interface) and a graphical view (available through the Aladin interface), in which all stars with health-and-safety concerns are labelled in red, all stars with science concerns (e.g. bright targets that could bleed) are labelled in orange, all stars for which an

analysis could not be performed (e.g. incomplete color information) are labelled in blue,and all stars that are safe are labelled in green. There will also be a printable and downloadable listing of the results for all targets.

It is important to note that BOT will only be useful for field stars that are in the GSC2, and for the target if it is a normal star. Since most science targets are not normal main-sequence stars, use of the ETCs to fully verify the prime targets will still be required. Extended targets will not appear in the GSC2, and will therefore need to be checked by hand. Variable targets, although in the GSC2, will only have the magnitude at the time of the GSC2 plate, and may therefore not have the "correct" magnitude for the time of observation. While most variables have small amplitudes, some objects (e.g. cataclysmic variables and symbiotic stars) have large amplitudes, which could pose problems (either as field objects, or as the prime target).

In this document, we describe how the tool works for the STIS/CCD; a separate document will describe the STIS/MAMAs. This tool will enhance (compared with the VTT-based ROBOT) the bright object checking performed by the Instrument Group, and can allow PIs to more easily do their own checks to assure their observations are valid from both a health-and-safety as well as scientific integrity perspective.

Assumptions

The following assumptions were made in implementing BOT processing:

- The size of the macro-aperture (search radius) is padded over the nominal size to account for possible mispointings (but still close enough for the Guide Star acquisition to be considered successful) of HST. The size of the pad – 20.9" - was determined by the Instrument Group.

- All field objects are Main Sequence stars. This is a reasonable assumption, although it will not be always correct (e.g. most prime targets are not normal stars). This is the only assumption possible due to only 1 color being available.

- All objects have no reddening. This is clearly incorrect in the plane, but is not unreasonable at high galactic latitude (where most HST observation are obtained). This is the only assumption possible due to only 1 color being available. Since reddening would decrease the ultraviolet flux, this is also the conservative assumption when doing health-and-safety checks.

Processing Steps

1. The user loads their Phase II APT file, and selects their desired exposure(s) to process.

2. The user clicks on the BOT button to bring up the tool, and clicks on the Update Display button to begin processing.

3. The GSC2 is searched for all objects (even those flagged as not usable as guide stars) within the macro-aperture. The macro-aperture is a circle centered on the fiducial point of the aperture (i.e. where the prime target will be placed) that encompasses the entire aperture with a pad to account for pointing errors.

Detector	**Shape**	**Radius**	**Radius in ROBOT**	**Radius in BOT**
STIS/CCD	quad	29.1”	35.4”	50.0”

   Note that this definition of the macro-aperture is not always consistent with the values in the SIAF files. All area targets are ignored. The information returned is the object name, coordinates, and magnitudes (**F** and **J**). If either the F or J magnitude is undefined, convert the default value of “-99.9” to “unknown”. Note that Tycho entries in the GSC2 will have **V** and **B-V**, and these must be corrected to get them on the standard system via:

   V(corrected) = **V**(Tycho) - 0.09*__B-V__(Tycho)

   B-V(corrected) = 0.85*__B-V__(Tycho)

4. The **F** and **J** magnitudes are converted to **V** and **B-V** via the following conversions:

   - for the northern hemisphere (determined by the coordinates of the stars)

     $\mathbf{V} = \mathbf{F} + 0.03 + 0.44*(\mathbf{J}-\mathbf{F}) - 0.03*(\mathbf{J}-\mathbf{F})^2 + 0.02*(\mathbf{J}-\mathbf{F})^3$

     $\mathbf{B-V} = -0.04 + 0.69*(\mathbf{J}-\mathbf{F})$

   - for the southern hemisphere

     $\mathbf{V} = \mathbf{F} + 0.03 + 0.43*(\mathbf{J}-\mathbf{F}) - 0.02*(\mathbf{J}-\mathbf{F})^2 + 0.02*(\mathbf{J}-\mathbf{F})^3$

     $\mathbf{B-V} = -0.03 + 0.73*(\mathbf{J}-\mathbf{F})$

5. Some objects in the GSC2 do not have both and F and J magnitudes, while other objects are not considered stars. The treatment of these objects is described below.

Detector	no F and no J	F and no J
STIS/CCD	list F, J, V, B-V, and reason as "unknown", spectral type as "no color info"	list J, V, B-V, and reason as "unknown", F as GSC2 value, spectral type as "no color info"

Detector	no F and J	F and J, not a star
STIS/CCD	list F, V, B-V, and reason as "unknown", J as GSC2 value, spectral type as "no color info"	list V, B-V, and reason as "unknown", F and J as GSC2 value, spectral type as "not a star"

6. After the **V** and **B-V** is derived, a sanity check should be performed. If the **V** magnitude is fainter than 24 or brighter than -2.0, or if the **B-V** color is redder than 3.0 or bluer than -0.5, the photometry is faulty and should not be used. The **V**, **B-V**, and spectral type should be listed as “unknown”.

7. The **B**-**V** color is converted to a spectral type (assumed main sequence) via the table below . The tool will adjust the color by the difference between the nominal error and the actual error (i.e. make the color bluer by [error - 0.28^{m}. To determine the error, use the square root of the sum of the squares of the **F** and **J** errors. To interpolate, always take the bluest color (e.g. if the star has B-V=0.85, select K0).

Table 1.Color to Spectral Type conversion

B-V	Spectral Type	B-V	Spectral Type
-0.32	O5	-0.30	B0
-0.24	B1	-0.14	B5
0.00	A0	+0.03	A1
+0.14	A5	+0.31	F0
+0.43	F5	+0.59	G0
+0.63	G2	+0.66	G5
+0.82	K0	+1.15	K4
+1.41	M0	+1.49	M2
+1.61	M4		

8. The exposure information is derived from the proposal file, and the relevant parameters are given below.

Exposure Parameters

Detector	Parameters
STIS/CCD	spectral element, central wavelength, exposure time, aperture, cr-split, gain

9. Based on the magnitudes, apertures, and exposure information, determine the count rate and total counts for each star via a lookup table (see **Appendix 1 - STIS Sample Lookup table**). The table contains the count rate for most (see **Appendix 2 – Number of Instrument Configurations**) instrument configurations for a $\mathbf{V} = \mathbf{V_o}$ object. To scale for the true **V** magnitude of a star, multiply the table value by $10^{(0.4*[Vo-\mathbf{V}obj])}$. To determine the total counts, multiply the corrected count rate by the exposure time.

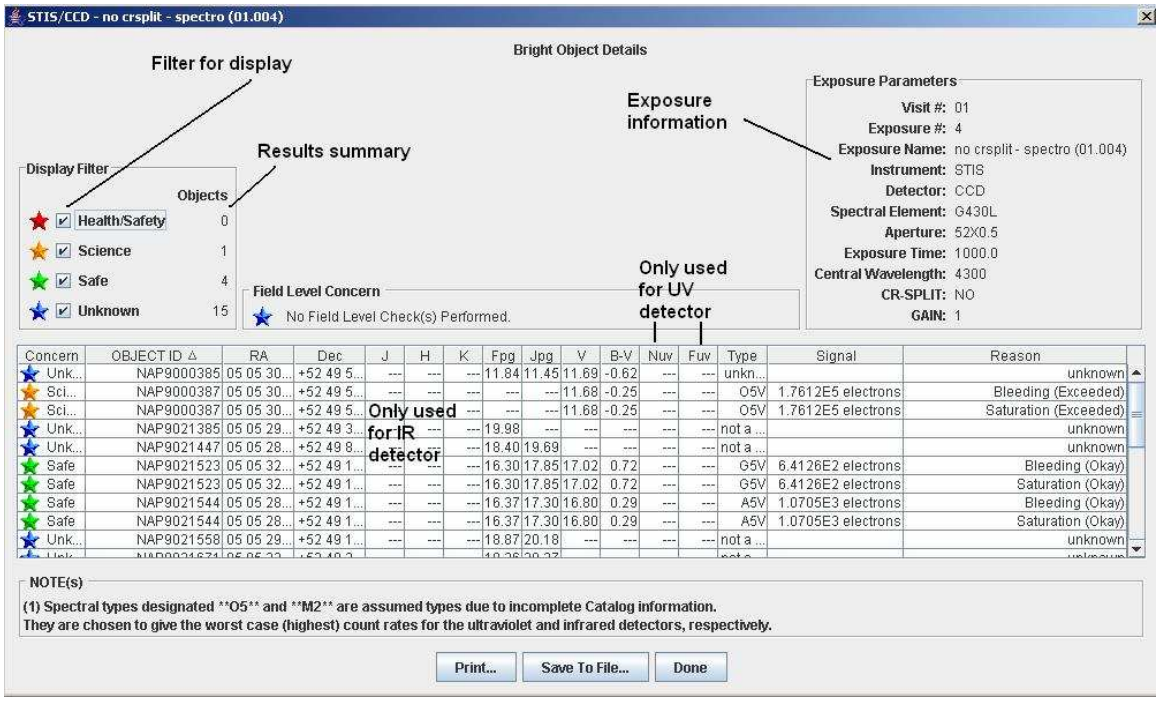
10. Based on the count rates and total counts, perform the health-and-safety and science checks as described in the table below.

Checks Performed by BOT

Detector	Health-and-Safety (counts/second)	Saturation (electrons)	Residual Image (electrons)
STIS/CCD	N/A	30,000 (gain=1) 120,000 (gain=4)	500,000[a]

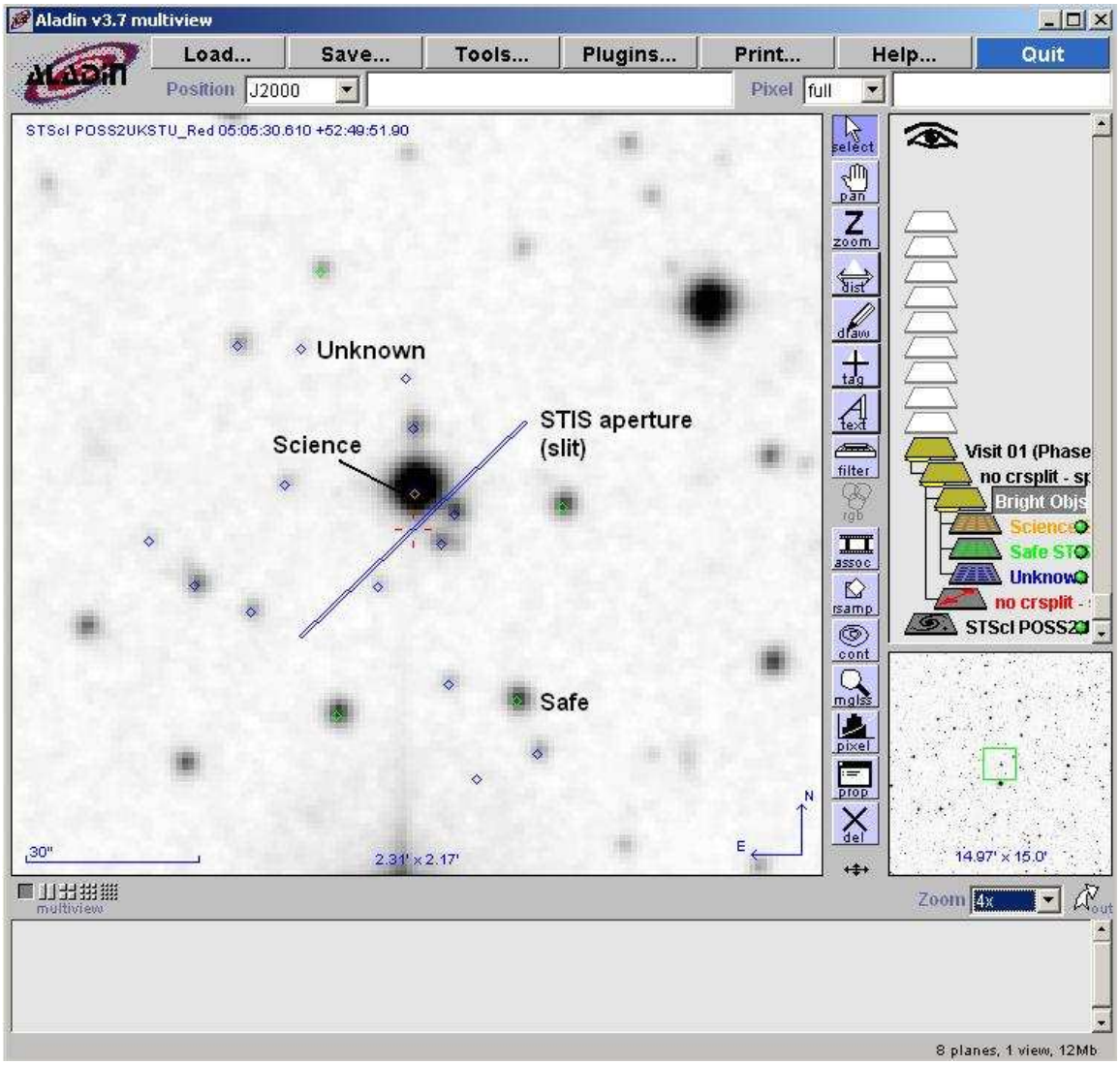
[a] only valid for observations using the 50CCD aperture and for UV-bright stars (**B-V<**0.0)

11. For all objects, produce a table giving the guide star name, coordinates, F and J magnitudes, converted V and B-V magnitudes, spectral type, signal (count rate and total counts), and an indication of the status of the object; a summary table is also produced. For assumed spectral types (i.e. O5), make clear that the type is assumed and not derived from the B-V color. Note that this table is printable and downloaded to be a file.



Concern	OBJECT ID	RA	Dec	J	H	K	Fpg	Jpg	V	B-V	Nuv	Fuv	Type	Signal	Reason
Unk...	NAP9000385	05 05 30...	+52 49 5...	---	---	---	11.84	11.45	11.69	-0.62	---	---	unkn...		unknown
Sci...	NAP9000387	05 05 30...	+52 49 5...	---	---	---	---	---	11.68	-0.25	---	---	O5V	1.7612E5 electrons	Bleeding (Exceeded)
Sci...	NAP9000387	05 05 30...	+52 49 5...	---	---	---	---	---	11.68	-0.25	---	---	O5V	1.7612E5 electrons	Saturation (Exceeded)
Unk...	NAP9021385	05 05 29...	+52 49 3...	---	---	---	19.98	---	---	---	---	---	not a ...		unknown
Unk...	NAP9021447	05 05 28...	+52 49 8...	---	---	---	18.40	19.69	---	---	---	---	not a ...		unknown
Safe	NAP9021523	05 05 32...	+52 49 1...	---	---	---	16.30	17.85	17.02	0.72	---	---	G5V	6.4126E2 electrons	Bleeding (Okay)
Safe	NAP9021523	05 05 32...	+52 49 1...	---	---	---	16.30	17.85	17.02	0.72	---	---	G5V	6.4126E2 electrons	Saturation (Okay)
Safe	NAP9021544	05 05 28...	+52 49 1...	---	---	---	16.37	17.30	16.80	0.29	---	---	A5V	1.0705E3 electrons	Bleeding (Okay)
Safe	NAP9021544	05 05 28...	+52 49 1...	---	---	---	16.37	17.30	16.80	0.29	---	---	A5V	1.0705E3 electrons	Saturation (Okay)
Unk...	NAP9021558	05 05 29...	+52 49 1...	---	---	---	18.87	20.18	---	---	---	---	not a ...		unknown

12. For all objects, produce an overlay for Aladin which marks objects that are health-and-safety concerns in red, science concerns in orange, unknown concerns in blue, and safe objects in green.



Appendix 1 - STIS Sample Lookup table

The following items are used in creating the lookup table (both imaging and spectroscopy);

- Exposure time = 1
- V=10 (point source) for spectra, V=8 (point source) for imaging, E(B-V) = 0.0
- Zodiacal light/Bright Earth = average
- CCD binning = 1x1, CR-SPLIT = 1

Spectral Type	Detector	Spectral Element	Central Wavelength	Aperture	Gain	Countrate Local/Global
B5	CCD	G750L	7751	52X2	1	TBD/---
B5	CCD	G750M	5734	52X2	1	TBD/---
B5	CCD	G750M	7283	52X2	1	TBD/---
B5	CCD	G750M	9851	52X2	1	TBD/---
B5	CCD	G430L	4300	52X2	1	TBD/---
B5	CCD	G430M	3165	52X2	1	TBD/---
B5	CCD	G430M	4194	52X2	1	TBD/---
B5	CCD	G430M	5471	52X2	1	TBD/---
B5	CCD	G230LB	2375	52X2	1	TBD/---
B5	CCD	G230MB	1713	52X2	1	TBD/---
B5	CCD	G230MB	2416	52X2	1	TBD/---
B5	CCD	G230MB	3115	52X2	1	TBD/---
B5	CCD	G750L	7751	52X2	4	TBD/---
B5	CCD	G750M	5734	52X2	4	TBD/---
B5	CCD	G750M	7283	52X2	4	TBD/---
B5	CCD	G750M	9851	52X2	4	TBD/---
B5	CCD	G430L	4300	52X2	4	TBD/---
B5	CCD	G430M	3165	52X2	4	TBD/---
B5	CCD	G430M	4194	52X2	4	TBD/---
B5	CCD	G430M	5471	52X2	4	TBD/---
B5	CCD	G230LB	2375	52X2	4	TBD/---
B5	CCD	G230MB	1713	52X2	4	TBD/---
B5	CCD	G230MB	2416	52X2	4	TBD/---
B5	CCD	G230MB	3115	52X2	4	TBD/---
B5	CCD	50CCD			1	TBD/---
B5	CCD	F28X50LP			1	TBD/---
B5	CCD	F28X50OII			1	TBD/---

B5	CCD	F28X50OIII			1	TBD/---
B5	CCD	50CCD			4	TBD/---
B5	CCD	F28X50LP			4	TBD/---
B5	CCD	F28X50OII			4	TBD/---
B5	CCD	F28X50OIII			4	TBD/---

Appendix 2 – Number of Instrument Configurations

To keep the lookup table manageable, we will make several simplifying assumptions. For STIS, the medium (M) and high (H) mode gratings have many central wavelengths. In the table, we will only list the bluest and reddest values, and the tool should select the setting closest to the requested one. Based on the above assumptions, the following table estimates the number of entries in the lookup table for the STIS/CCD.

Instrument Configurations

Instrument	Parameters	Configurations	Spectral Types	Total
STIS	CCD spectra gain 1 or 4, 9 cenwaves, 5 aperture	90	13	1170
	CCD imaging gain 1 or 4, 4 filters	8	13	104