

Advanced Camera for Surveys Exposure Time Calculator: III. Baseline Tests for the Spectroscopic Modes.

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August 25, 2000

ABSTRACT

Our baseline suite of test cases for the Spectroscopic Exposure Time Calculator are documented for all five spectroscopic modes with a variety of point source flux distributions.

1. Introduction

A set of three ACS Exposure Time Calculators (ETCs) are available: one for imaging, one for spectroscopy, and one for ramps. There are two versions of each of the three ETCs: one for public use, and one for testing. The public version Web URL can be found at <http://garnet.stsci.edu/ACS/ETC/simulator.html>, where “*simulator.html*” is one of the three calculators and “*simulator*” is either “*acs_ramp_etc*” or “*acs_img_etc*” or “*acs_spec_etc*”. Also, a coronagraphic ETC is planned for the Cycle 11 proposal preparation.

2. Baseline of Exposures for the Spectroscopic ETC

In order to check the calculations for all detectors and for all imaging elements, we have created a baseline of exposures for a selection of point source flux distributions. We have already published two ISRs, one for the Imaging and the other for the Ramps (Boffi et al. 2000, Van Orsow et al. 2000, respectively). In this third document, we present our suite of cases for the Spectroscopic ETC. ACS has only slitless spectroscopy capability and can obtain undegraded spectra only for point sources, while the spectra of small diffuse objects will have degraded spectral resolution. In Table 1, all exposures are listed for the point source case. The first five columns give the other input parameters. They are detector, spectroscopic element (prism or grism), normalization (in flux or magnitude, as appropriate), spectral distribution, and exposure time, respectively. In the fourth column, i.e. the spectrum column, “flat” indicates a constant flux distribution in $\text{erg sec}^{-1} \text{cm}^{-2} \text{\AA}^{-1}$,

“p. law” is the power law spectrum of the form $F(\lambda) = \lambda^n$ (where the default $n=-1$ is used), and BB is a black body spectrum of Temperature = 10000 K. G5V is a Kurucz model atmosphere and GD71 is a standard star. A 100 second exposure (CRSsplit=2) was run in most cases to achieve at least ~ 100 counts for the source; a one second exposure (CRSsplit=1) was run in the brightest cases to avoid saturation of the CCD; and a 100 second exposure was run for all SBC cases to achieve a signal-to-noise ratio, SNR ~ 10 . In Table 1, only GD71 reaches the bright object limit (see Boffi & Bohlin 1999). Default gain and sky values were used (respectively, 2 and average). For Wide Field Channel and High Resolution Channel, the detector dark rate is $2.78 \times 10^{-3} \text{ e}^- \text{ sec}^{-1} \text{ pix}^{-1}$, and the read noise is $4.5 \text{ e}^- \text{ rms}$. For the Solar Blind Channel, the dark count is $\sim 2.5 \times 10^{-4} \text{ counts sec}^{-1} \text{ pix}^{-1}$ and there is no read noise. See also Version 1.0 of the ACS Handbook by Jedrzejewski et al. (2000). The calculations adopted the default extraction apertures of 5×1 , 9×1 and 15×1 pixels, respectively, for WFC, HRC, and SBC, i.e. 1 pixel in the dispersion direction, while in the cross-dispersion direction a number of pixel as per the default imaging modes is adopted (see Boffi et al. 2000). The four last columns, starting with column 6, give the main output results of the ETC: SNR, brightest pixel, source, and total sky. The SNR is calculated for a resolution element of 2 pixels in the dispersion direction and is at a wavelength specified by the user. Source and sky are expressed in counts for one px in the dispersion direction, and the source counts are given for the same wavelength as the SNR. For this set of calculations, the default reference wavelength is 6500 \AA for the grism, 1400 \AA for the SBC prisms, and 4000 \AA for the HRC prism. The brightest pixel is in counts $\text{sec}^{-1} \text{ pix}^{-1}$ for the SBC and in counts pix^{-1} for the CCDs. The brightest pixel is for one image of a CRSplit, while the other three results are for combined images of a CRSplit.

Table 1: Point Source Exposures:

Detector	Sp. el.	Normal.	Spectrum	Exp. Time	SNR	Br.pixel	Sou.	Sky
wfc1	g800l	1.e-16	flat	100	47.8	453	1346	79.7
hrc	g800l	1.e-16	flat	100	24.6	118	521.1	23.9
hrc	pr200l	1.e-16	flat	100	83.3	1750	3813	12.1
sbc	pr110l	1.e-16	flat	1000	6.5	0.053	70.8	333
sbc	pr130l	1.e-16	flat	1000	8.2	0.032	55.2	64.6
wfc1	g800l	NO	GD71	1	54.5	727	1579	0.8
hrc	g800l	NO	GD71	1	30.3	217	598.4	0.2
hrc	pr200l	NO	GD71	1	215.8	6.2e+3	2.4e4	0.1
sbc	pr110l	NO	GD71	1	54.6	528.2	1490	0.33

Table 1: Point Source Exposures:

Detector	Sp. el.	Normal.	Spectrum	Exp. Time	SNR	Br.pixel	Sou.	Sky
sbc	pr130l	NO	GD71	1	48.3	430.3	1167	0.07
wfc1	g800l	V=20	p. law	100	22.5	131	404.6	79.7
hrc	g800l	V=20	p.law	100	9.5	36.2	156.1	23.9
hrc	pr200l	V=20	p.law	100	55.5	691	1852	12.1
sbc	pr110l	V=20	p.law	1000	8.5	0.2	98.4	333
sbc	pr130l	V=20	p.law	1000	10.2	0.06	76.8	64.6
wfc1	g800l	V=20	BB	100	19.2	98	324.3	79.7
hrc	g800l	V=20	BB	100	7.8	27.2	124.6	23.9
hrc	pr200l	V=20	BB	100	63.9	773	2363	12.1
sbc	pr110l	V=20	BB	1000	1.1	0.1	10.3	333
sbc	pr130l	V=20	BB	1000	1.7	0.03	8.0	64.6
wfc1	g800l	V=20	G5V	100	22.6	129	408.4	79.7
hrc	g800l	V=20	G5V	100	9.6	35.9	158.1	23.9
hrc	pr200l	V=20	G5V	100	38.5	662	1012	12.1
sbc	pr110l	V=20	G5V	1000	0.0	0.1	4.6e-6	333
sbc	pr130l	V=20	G5V	1000	0.0	0.02	3.9e-6	64.6
wfc1	g800l	1.e-15	e.line	100	18.9	90.7	316.1	79.7
hrc	g800l	1.e-15	e.line	100	12.2	42.1	208.4	23.9
hrc	pr200l	1.e-15	e.line	100	11.4	37	190.9	12.1
sbc	pr110l	1.e-15	e.line	100	2.8	0.2	10.5	33.3
sbc	pr130l	1.e-15	e.line	100	4.1	0.06	11.3	6.5

3. Further Checks of the ETC

Additional features that have been verified are:

- A SNR can be specified and the required exposure time is calculated.
- Bright object warnings are given, if the SBC is above the maximum permitted counting rate or if the total counts in any pixel exceeds the saturation limit of the CCDs.
- A user may input their own spectrum as an ascii file, a fits file, or a SDAS table with extension name .tab. See the HELP files of each ETC for the details of this procedure.
- For the limiting case of a source of zero flux, the sky rates per pixel are recovered.

In the following, we present our hand calculations to check the ETC output for one point source. More examples are in Chapter 6 of the ACS Handbook along with the documentation for our equations.

Example:

The ETC calculates what SNR and number of counts are achieved for a 1 sec exposure for the standard star GD71, using the Solar Blind Channel and the prism pr110l.

The results for the source count rate and SNR given in the Table are for a wavelength of 1401.7 Å. The flux of GD71 at 1400 Å is 2.122×10^{-12} erg sec⁻¹ cm⁻² Å⁻¹, the sensitivity at 1400 is calculated as $S_{1400} = 2.27 \times 10^{12} * T_{1400} * 1400$ (where 2.27×10^{12} is a constant, T_{1400} is the system throughput at 1400 Å, and 1400 is the wavelength of interest, see Chapter 6 of the Instrument Handbook), and is equal to 1.211×10^{14} . For a 15 pixel height containing a fraction of the PSF $\epsilon = 0.87$ and the dispersion of 6.67 Å/px, the total counts from the star are $2.122 \times 10^{-12} * 1.211 \times 10^{14} * 0.87 * 6.67 = 1491$, while the ETC value in Table 1 is 1490. The detector dark is calculated as $15 * 0.00025 = 0.004$, the read noise is equal to zero for the MAMA, and the sky background is 0.33. A lower limit for the average sky is one half the dominant Ly α geocoronal line of 20kR, i.e. 6.1×10^{-13} erg sec⁻¹ cm⁻² arcsec⁻² from Figure 6.1: $0.5 * 6.1 \times 10^{-13} * (1.211 \times 10^{14} / 2.57) * (0.034 * 0.030) * 15 * 1 = 0.23$, which is close to the ETC value of 0.33. The value 2.57 Å/px is the dispersion of the prism at 1216 Å. Since the brightest pixel contains 0.3 of the total source rate, the rate for the central pixel is calculated as $0.3 * 1490 / 0.87 = 514$ (the brightest pixel of 528 calculated by the ETC is at a wavelength of 1437.6 Å). For fainter sources, the pr110l sky rate of 0.022 ct sec⁻¹ px⁻¹ must be added to the source rate for the brightest pixel. Finally, we apply the usual signal-to-noise ratio equation for 15x2 px and obtain $SNR = 2 * 1490 / (2 * 1490 + 2 * 0.33 + 2 * 0.004)^{0.5} = 54.6$, which is what the ETC calculates.

4. Acknowledgements:

We would like to thank Bernie Simon for essential help with *synphot* and for supporting *synphot* development.

5. References:

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