

GRI Observers' Guide

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1. GALEX Surveys and Sensitivities

The GALEX mission consists of a series of nested imaging and spectroscopic surveys. These surveys are performed concurrently. Observations for each survey type are scheduled based on target availability. Table 1 summarizes the primary GALEX surveys.

Table 1. – Primary Science Survey Summary from [Martin, et al.](#)

Survey	Survey Parameters			Science Objectives		
	Area [deg ²]	Nominal Length [Month]	Expos [ksec]	Mag. Lim [m _{AB}]	#Gals (est.)	Volume [Gpc ³]
Nearby Galaxies (NGS)	–	0.5	0.5	27.5 [mag arcsec ⁻²]	300	–
All-sky (AIS)	40,000	4	0.1	20.4	10 ⁷	1
Medium Imaging (MIS)	1000	2	1.5	22.7	3 x 10 ⁶	~1
Deep Imaging (DIS)	80	4	30	24.6	10 ⁷	1.0
Ultra-Deep	1	0.2	200	26	3x10 ⁵	0.05
Imaging (UDIS)	–	–	–	–	–	–
Wide Spectroscopic (WSS)	80	4	30	20	10 ⁴⁻⁵	0.03
Medium	8	2	300	21.5 [R=100]	10 ⁴	0.03
Spectroscopic (MSS)	–	–	–	23.3 [R=20]	10 ⁵	0.03
Deep Spectroscopic (DSS)	2	4	2000	24.3 [R=20]	10 ⁴	0.05
					10 ⁵	0.05

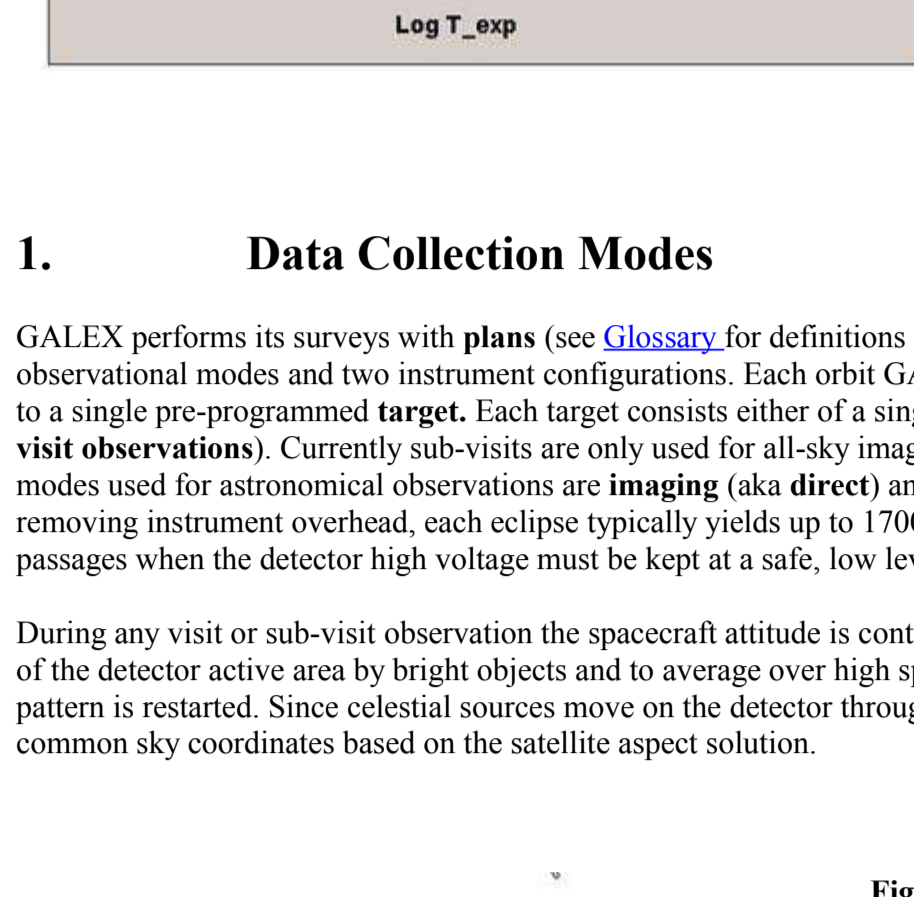


Figure 1. – Sensitivity vs. exposure time for low background targets (DIS, which have low diffuse galactic light and zodiacal background). At these background levels, imaging surveys are background limited for exposures longer than 2 ksec (NUV) and 10 ksec (FUV) respectively. Background levels for non-DIS fields may be 3-5 times higher, with a corresponding reduction in the exposure time to reach background limitation. Baseline survey sensitivities (typically specified as 5 sigma for imaging and 10 sigma for spectroscopy) are given in Table 1, above.

1. Data Collection Modes

GALEX performs its surveys with **plans** (see [Glossary](#) for definitions of terms in bold) that employ a simple operational scheme requiring only two observational modes and two instrument configurations. Each orbit GALEX collects data during night segments (**eclipses**) of its orbits during visits to a single pre-programmed target. Each target consists either of a single pointing (**single visit observation**) or multiple adjacent pointings (**sub-visit observations**). Currently sub-visits are only used for all-sky imaging survey (AIS) and in-flight calibration observations. The two instrument modes used for astronomical observations are **imaging** (aka **direct**) and **grism**. Only one optics wheel configuration is set once per visit. After removing instrument overhead, each eclipse typically yields up to 1700 seconds of usable science data. Some observations are shortened by SAA passages when the detector high voltage must be kept at a safe, low level.

During any visit or sub-visit observation the spacecraft attitude is controlled in a tight, spiraled **dither**. A spiral dither is used to prevent “burn-in” of the detector active area by bright objects and to average over high spatial frequency response variations. For each sub-visit the spiral dither pattern is restarted. Since celestial sources move on the detector throughout an exposure, the pipeline software corrects each time-tagged photon to common sky coordinates based on the satellite aspect solution.

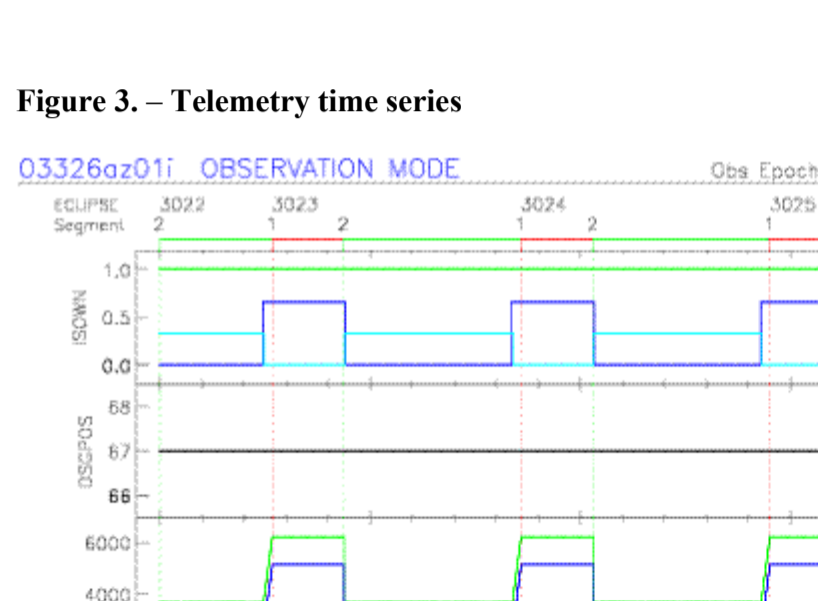


Figure 2. – GALEX Dither spiral pattern during a 2100 second observation. Diamond symbols are spaced every 120 seconds (1 revolution every two minutes). The GALEX dither is a controlled spiral motion of the satellite that moves the telescope bore-sight in a tight, slow spiral pattern that moves outward to ~1.5 arcminute diameter across the sky. This motion is used for all targeted observations. The dither spiral has the following angular rate profile:

$$\omega_x = K_1 \omega \sin(\omega t) + K_2 \omega \cos(\omega t)$$

$$\omega_y = -K_1 \omega \cos(\omega t) + K_2 \omega \sin(\omega t)$$

$$\omega_z = 0$$

$$K_1 = 2.2442 \text{ rad}$$

$$K_2 = 0.1000 \text{ rad}$$

$$n = 0.40$$

$$\omega = 0.05236 \text{ rad/s}$$

As many as 12 sub-visits are allowed per eclipse period (typical for AIS), with all-sky survey sub-visits obtaining 100-110 s exposure time per leg. For plans with sub-visit targets, a 20 second slew time is required to move between each leg of the observation. For some survey plans (e.g. deep imaging, spectroscopy), a single visit is insufficient to build up the requisite signal-to-noise, so a series of visits are needed in order to obtain the minimum required exposure time.

Figure 3. – Telemetry time series

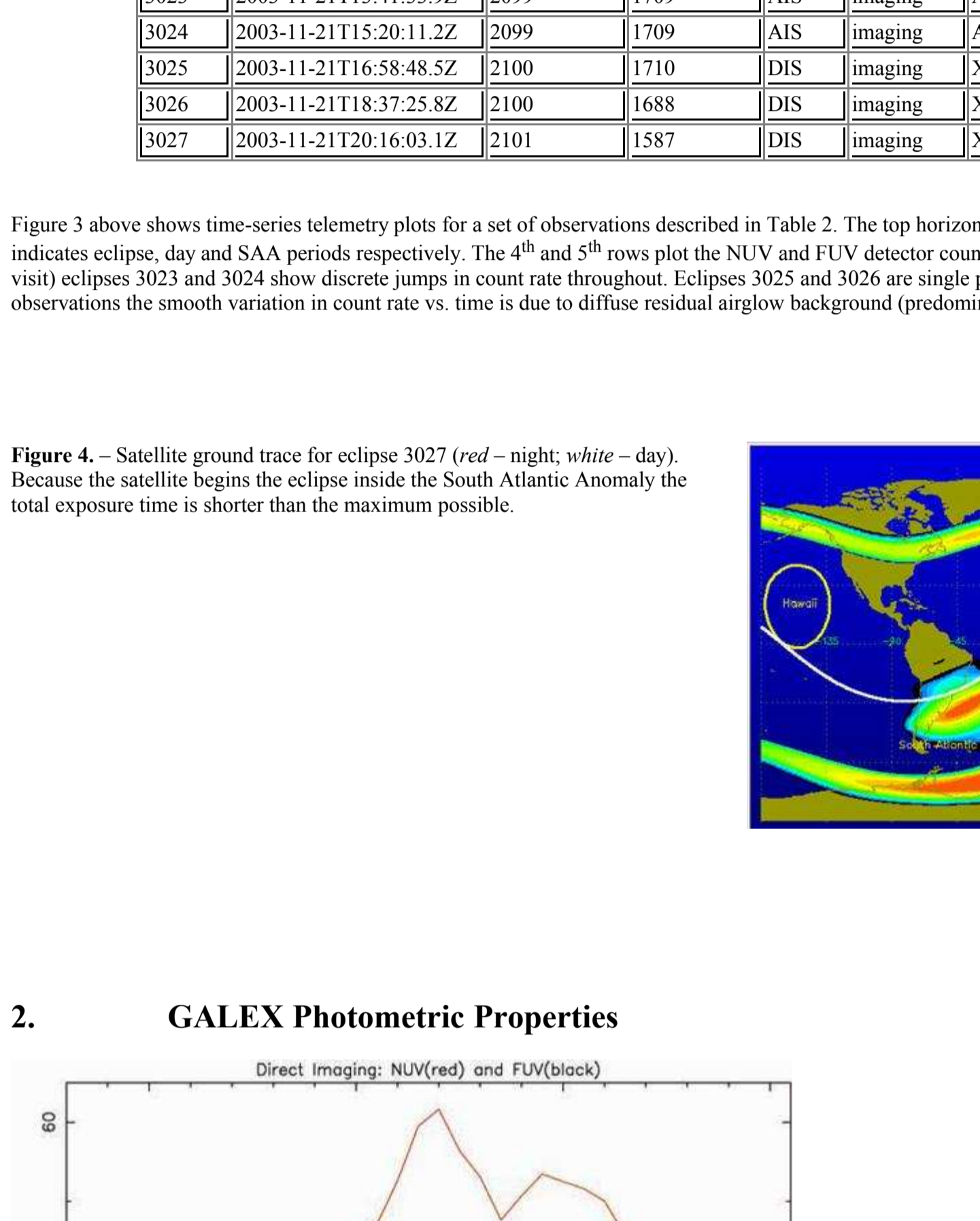
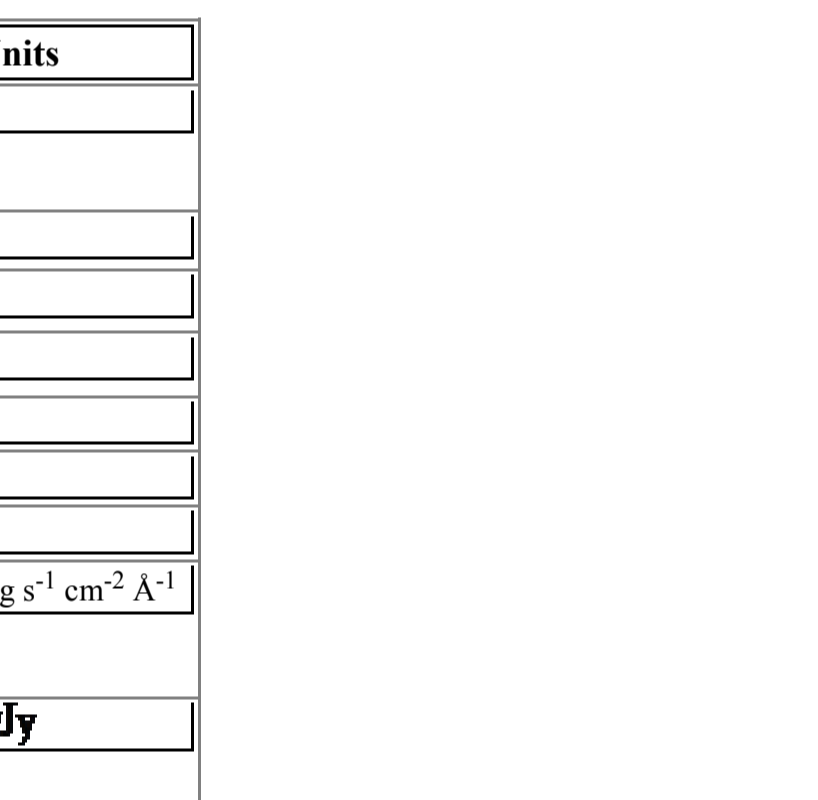


Table 2. – Sample observation summary

Eclipse Number	Time (UT)	Duration (s)	Total Exposure (s)	Survey	Instrument Mode	Target Name
3023	2003-11-21T13:41:33.9Z	2099	1709	AIS	imaging	AISCHV2_183_17172
3024	2003-11-21T15:20:11.2Z	2099	1709	AIS	imaging	AISCHV3_185_17921
3025	2003-11-21T16:58:48.5Z	2100	1710	DIS	imaging	XMMLSS_00
3026	2003-11-21T18:37:25.8Z	2100	1688	DIS	imaging	XMMLSS_00
3027	2003-11-21T20:16:03.1Z	2101	1587	DIS	imaging	XMMLSS_00

Figure 3 above shows time-series telemetry plots for a set of observations described in Table 2. The top horizontal lines in red, green and orange, indicates eclipse, day and SAA periods respectively. The 4th and 5th rows plot the NUV and FUV detector count rate vs. time. All-sky survey (sub-visit) eclipses 3023 and 3024 show discrete jumps in count rate throughout. Eclipses 3025 and 3026 are single pointing visits. For these observations the smooth variation in count rate vs. time is due to diffuse residual airglow background (predominantly a function of zenith angle).

Figure 4. – Satellite ground trace for eclipse 3027 (red – night; white – day). Because the satellite begins the eclipse inside the South Atlantic Anomaly the total exposure time is shorter than the maximum possible.



2. GALEX Photometric Properties

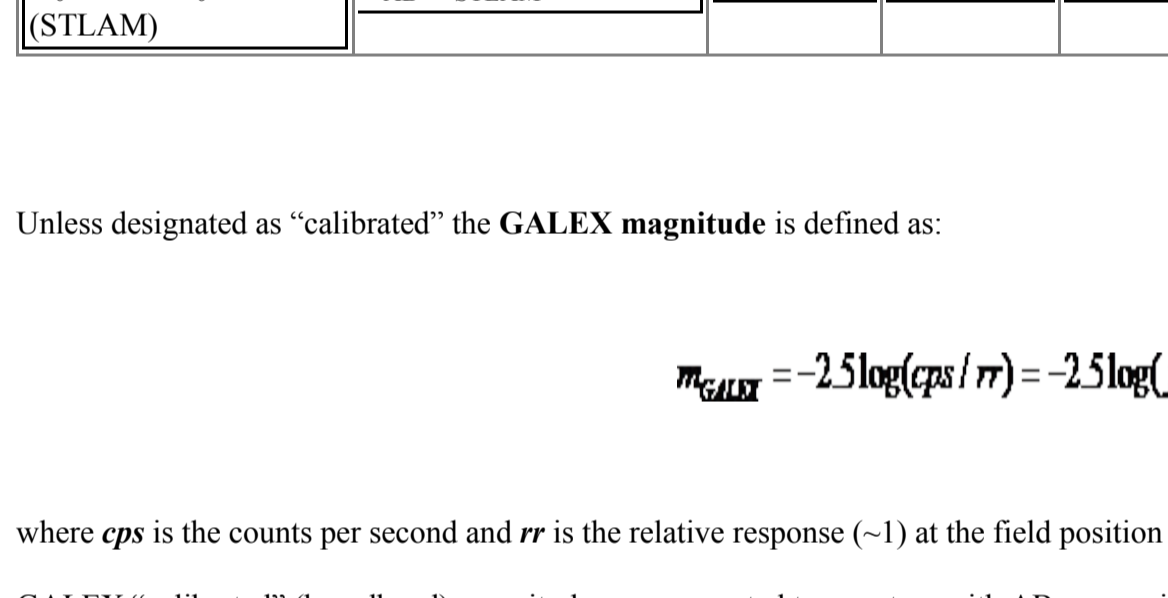


Figure 5. – Effective area vs. wavelength for imaging mode.

Basic properties of the FUV and NUV bands are given below in Table 3. Ground calibration measurements initially determined GALEX zero-points for FUV and NUV bandpasses. By appropriately scaling the new flat fields measured in flight, we have maintained the original zero points with respect to the in-flight measurements of spectrophotometric standards. Current estimates are that taken together, the zero-points and flat fields produce imaging photometry accurate to within +/-7% (1 sigma).

Table 3. – GALEX imaging bands, in part from [Morrissey, et al.](#) (Values marked as approximate need to be updated, but should be within a few Å of the updated value.)

Parameter	Description	Fuv	Nuv	Units
bandwidth	wavelengths with effective area >10% of the peak	1344 – 1786	1771 – 2831	Å
λ_c	effective wavelength	1528	2271	Å
λ_p	Pivot wavelength	~1524	~2297	Å
λ_m	Average wavelength	~1529	~2312	Å
$\Delta\lambda_{rms}$	rms bandwidth	~114	~262	Å
$\Delta\lambda_{FWHM}$	FWHM bandwidth	~269	~616	Å
$\Delta\lambda_{eff}$	effective bandwidth	~268	~732	Å
Uresp	unit response (1 cps; $m_{GALEX}^0 = 0$)	1.40×10^{-6}	2.05×10^{-6}	erg s ⁻¹ cm ⁻² Å ⁻¹
f_0	f_{GALEX}^0 (1 cps; $m_{GALEX}^0 = 0$)	108	36	μJy
m_0 (AB)	$m_{AB}^0 - m_{GALEX}^0$	18.82	20.08	Magnitudes
m_0 (STLAM)	$m_{STLAM}^0 - m_{GALEX}^0$	16.04	18.18	Magnitudes
m_0 (AB) – m_0 (STLAM)	$m_{AB}^0 - m_{STLAM}^0$	2.78	1.90	Magnitudes

Unless designated as “calibrated” the GALEX magnitude is defined as:

$$m_{GALEX} = -2.5 \log(cps/r) = -2.5 \log(f_{GALEX})$$

where cps is the counts per second and r is the relative response (~1) at the field position of the object.

GALEX “calibrated” (broadband) magnitudes are converted to a system with AB zero-point:

$$m_{AB} = -2.5 \log(cps/r) + m_0(AB)$$

3. GALEX Imaging Bands – Relation to other instrument bandpasses

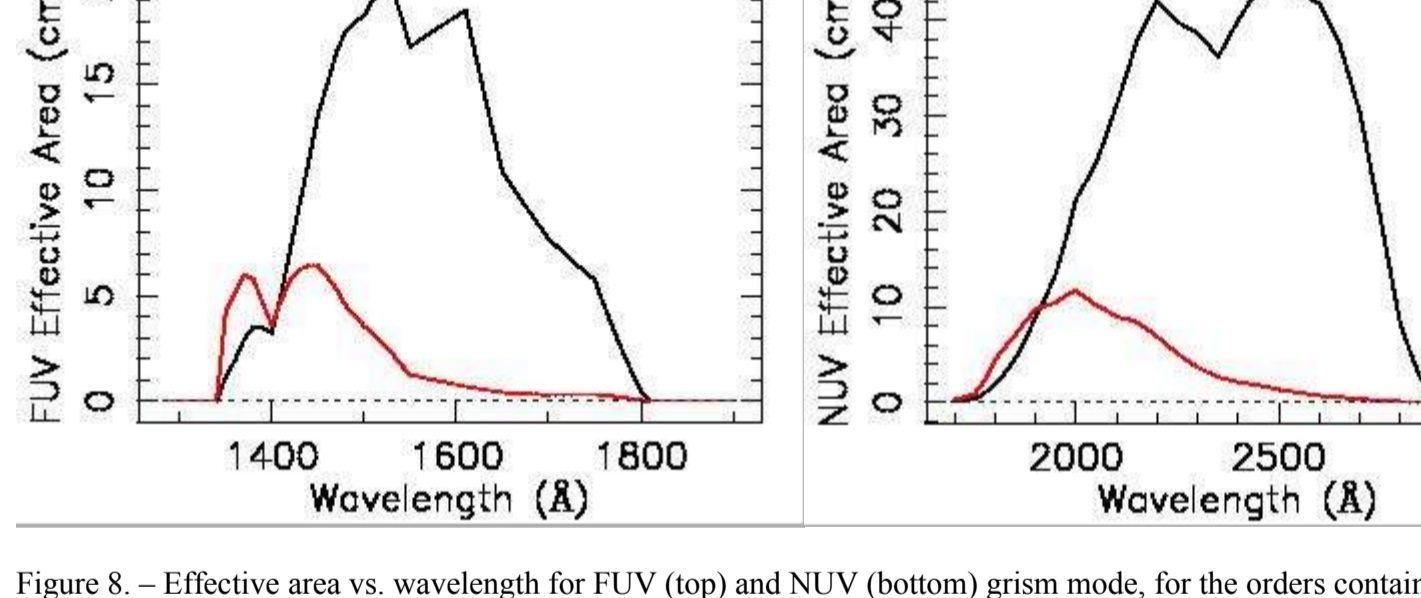


Figure 6. – GALEX FUV and NUV shown in relation to bandpasses from other missions. All are in normalized units (with the exception of UIT)

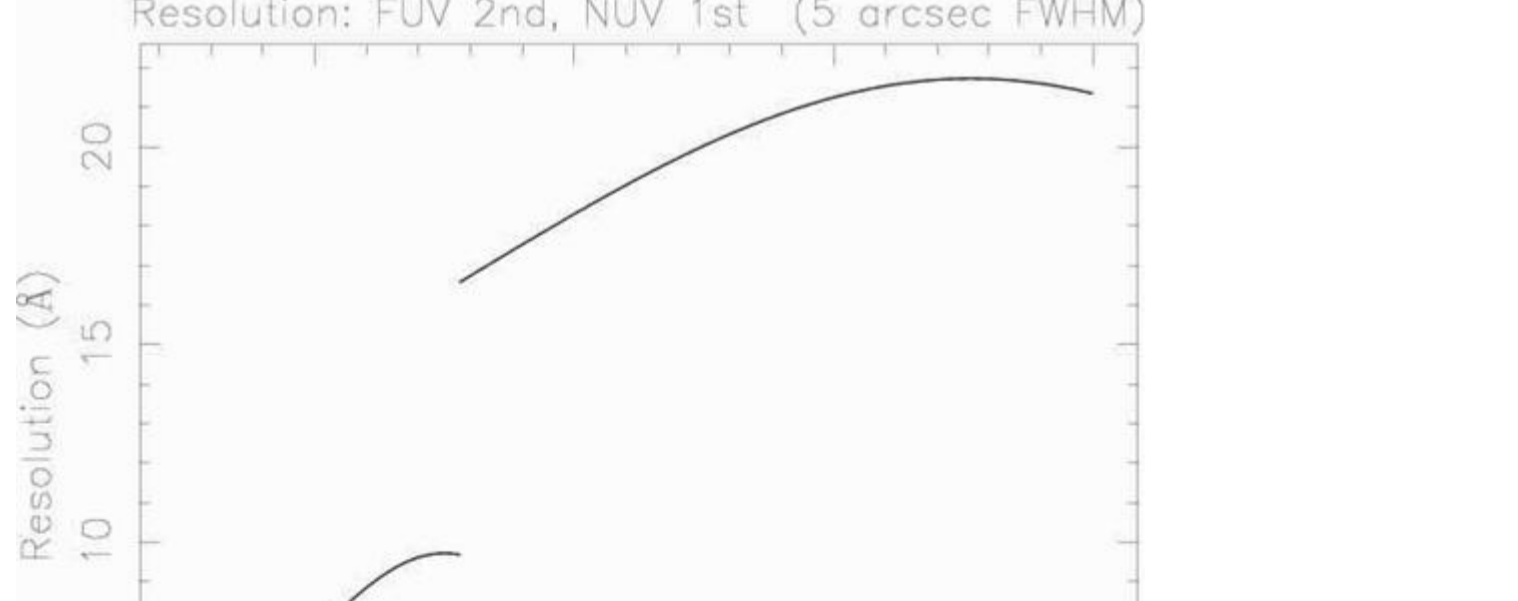


Figure 7. – GALEX FUV and NUV shown in relation to SDSS bands. (Dashed) Spectra of galaxies with varying burst history (young to old)

4. GALEX Spectroscopic Properties

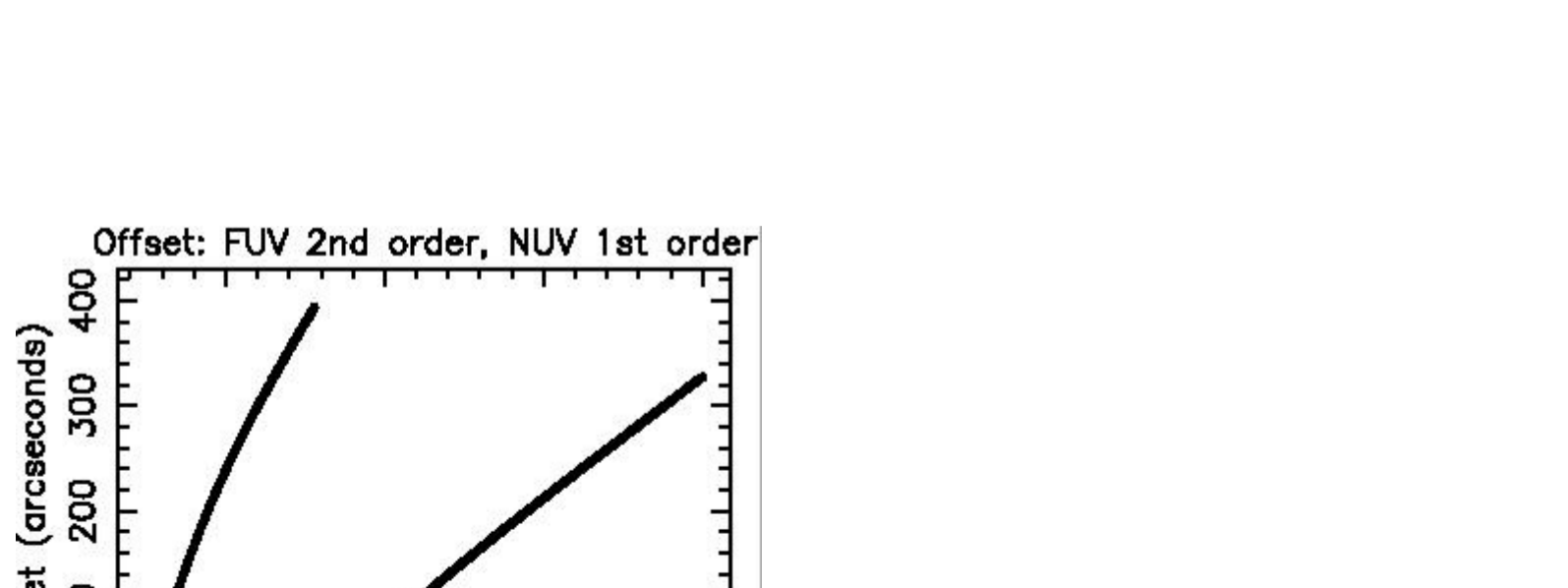


Figure 8. – Effective area vs. wavelength for FUV (top) and NUV (bottom) grism mode, for the orders controlling the majority of the power.

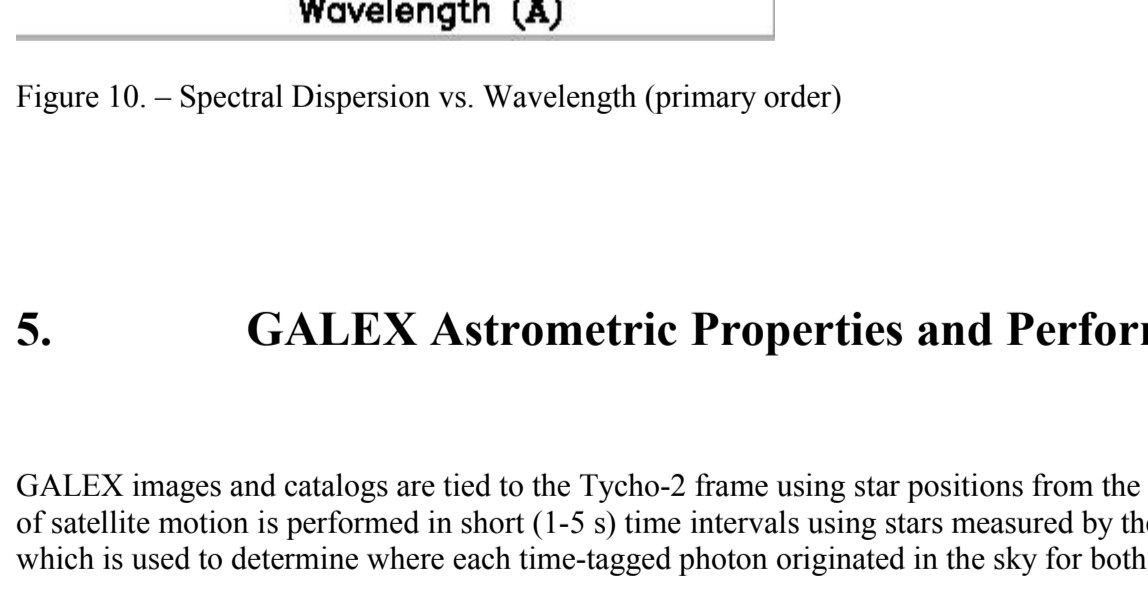


Figure 9. – Spectral Resolution vs. Wavelength for FUV (2nd order, left) and NUV (1st order, right) grism mode.

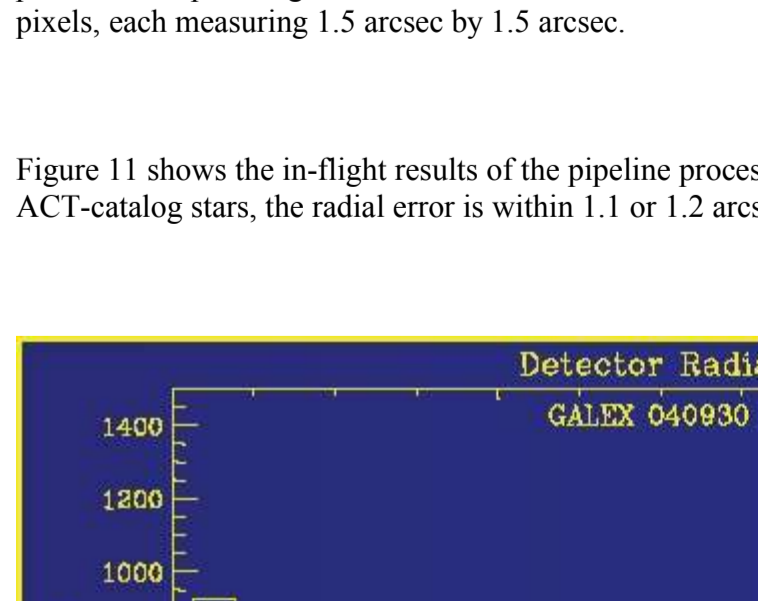


Figure 10. – Spectral Dispersion vs. Wavelength (primary order)

5. GALEX Astrometric Properties and Performance

GALEX images and catalogs are tied to the Tycho-2 frame using star positions from the ACT catalog. Relative and absolute astrometric correction of satellite motion is performed in short (1-5 s) time intervals using stars measured by the NUV detector. This results in refined aspect solution which is used to determine where each time-tagged photon originated in the sky for both the NUV and FUV detectors.

Because GALEX records time-tagged positions with digitization that quantizes the instrumental PSF (by a factor of 3-5), the pipeline map accumulator can re-bin photon positions onto an idealized projection. Sky images are generated using a gnomonic projection onto the tangent plane. All output images contain standard FITS WCS astrometric header information. Currently, intensity and count maps contain 3840 x 3840 pixels, each measuring 1.5 arcsec by 1.5 arcsec.

Figure 11 shows the in-flight results of the pipeline processing using the GRI astrometric calibration, from [Morrissey, et al.](#) For 80% of detected ACT-catalog stars, the radial error is within 1.1 or 1.2 arcsec, for FUV or NUV respectively.

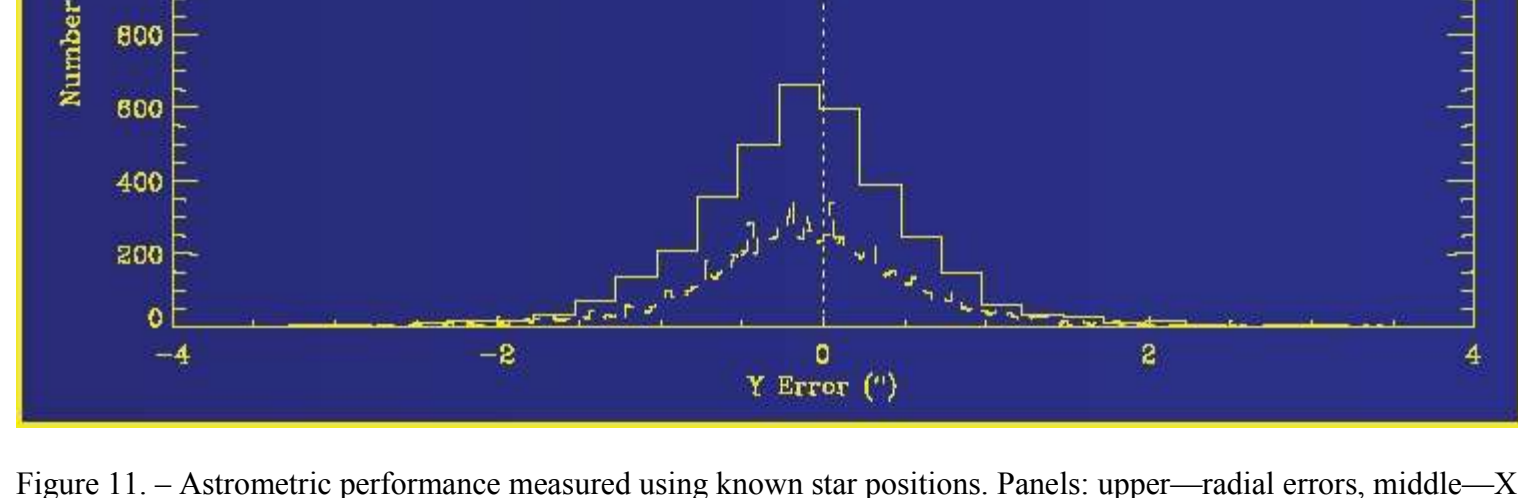


Figure 11. – Astrometric performance measured using known star positions. Panels: upper—radial errors, middle—X errors, bottom—Y errors.