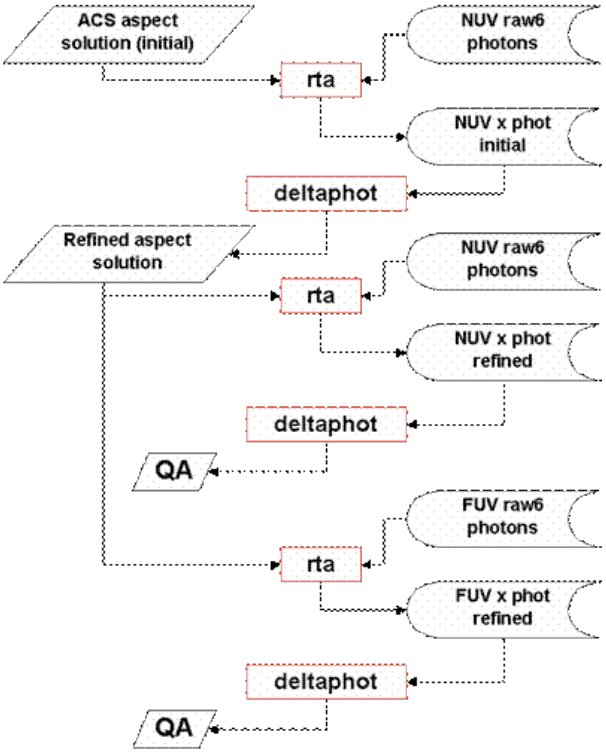
GALEX ERO – Pipeline Data Guide

1. Pipeline Overview

The GALEX data pipeline converts GALEX satellite telemetry data and any necessary corollary data into calibrated images and catalogs. The GALEX Science Operations Center (SOC) receives data from the satellite and **ingestpipe** unpacks it into time-tagged photon lists, instrument/SC housekeeping and satellite aspect information. From these data sets, **orbpipe** generates images, spectra and source catalogs.

Astrometric modules **rta** (for rectify, transform and aspect) and **deltaphot** correct the photon positions for detector and optical distortions and determines an aspect solution using star positions from the time-tagged photon data. The astrometric refinement process is diagrammed below.



A photometric module **simplemap** accumulates the photons into count and intensity maps and **sextra** extracts sources from images. A spectroscopic module **galexspac** uses image source catalog inputs to extract spectra of these sources from the multiple slitless grism observations.

2. Pipeline Products

Data from each single-orbit visit stored in a single directory in the GALEX file system. The directory path has the following format:

```
<ROOT>/<proc ver>/<tile>/<obs mode>/<product>/<image>/<try>/.
```

An example path and filename is:

```
Path: <root>/01-vsn/10330-AISCHV2_381_40554/d/00-visits/0002-img/03-try/

Filename: AISCHV2_381_40554_0002_sv12-xd-mcat.fits
```

This path contains the pipeline processing version number, a tile identification string, instrument observing mode (direct, grism, opaque; represented by *d, g, o*, in each case preceded by the wavelength, data product type (single visit, multiple visit), and the pipeline processing try. Additionally, a unique source ID

tag is be generated by the pipeline which uniquely encodes both the path information and the source number from merged source and spectra catalogs.

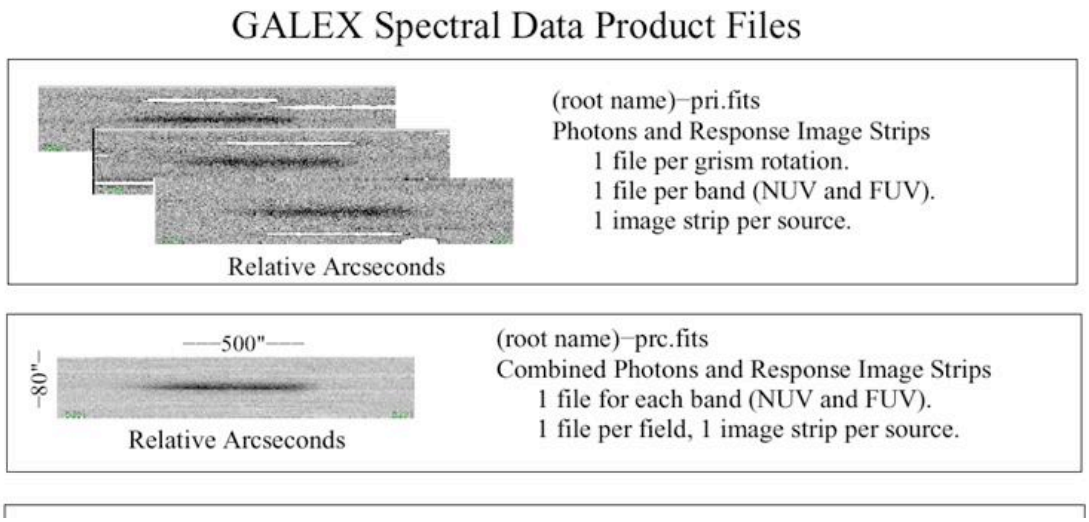
All of the pipeline products are described in the table below.

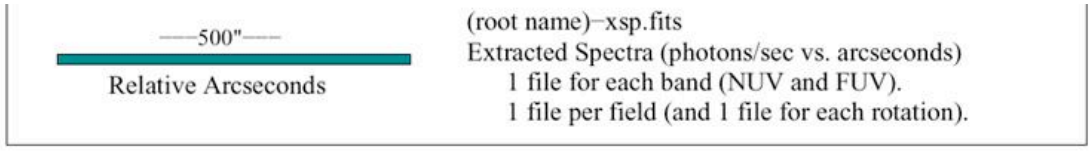
Table 3.1– Pipeline Products Summary

Filename Suffix	File type	Description
Low-level pipeline products		**Photon and housekeeping files**
-asp.rec	Binary record	Satellite attitude solution
-asprta.rec	Binary record	Refined attitude solution
-rtastar.fits	FITS binary table	Star catalog for attitude refinement
-scst.fits	FITS binary table	Spacecraft state file
-nd-dphcent.txt	ASCII record	Deltaphot attitude output
-nd-dph.fits	FITS binary table	Deltaphot photon delta output
-[n or f]d-raw6.fits	FITS binary table	Raw photon data
-[n or f]d-x.fits	FITS binary table	Extended photon record
Images		**Maps and associated files**
-[n or f]d-cnt.fits	FITS image	Count map (J2000)
-[n or f]d-dose.fits	FITS image	Dose map (detector frame)
-[n or f]d-exp.fits	FITS image	Exposure map (J2000)
-[n or f]d-intbgsub.fits	FITS image	Background subtracted intensity map (J2000)
-[n or f]d-int.fits	**FITS image**	**Intensity map (J2000)**
-[n or f]d-movie.fits	FITS image cube	Time-slice count maps (J2000)
-[n|f]d-rr.fits	FITS image	low res relative response (J2000)
-[n or f]d-rrhr.fits	FITS image	high-res relative response (J2000)
-[n or f]d-skybg.fits	FITS image	sky background image (J2000)
-[n or f]d-wt.fits	FITS image	weight/mask image (J2000)
Catalogs		**FUV, NUV and merged catalogs**
-[n or f]d-cat.fits	FITS binary table	Sextractor catalogs for images
-fd-ncat.fits	FITS binary table	FUV extractions using NUV positions
-nd-fcat.fits	FITS binary table	NUV extractions using FUV positions
-xd-mcat.fits	**FITS binary table**	**Merged source catalog**
Flags		**Artifact flag information**
-[n or f]d-flags.fits	FITS image	Artifact Flag image (J2000)
-[n or f]d-flagstar.fits	FITS binary table	Star catalog for flagging
-[n or f]d-flag_bright.ds9reg	ds9 Region file	Bright star flag regions
-[n or f]d-flag_dichroic.ds9reg	ds9 Region file	Dichroic reflection flag regions
-[n or f]d-flag_edge.ds9reg	ds9 Region file	Edge flag regions
-[n or f]d-flag_near.ds9reg	ds9 Region file	Near bright star flag regions
-[n or f]d-flag_window.ds9reg	ds9 Region file	Window reflection regions
Grism-specific files		
-[n or f]g-gsax.fits	FITS binary table	Spectral extraction parameter information for each source
-[n or f]g-pri.fits	FITS binary table	Image strips for each source from a single visit
-[n or f]g-prc.fits	FITS binary table	Image strips (combined) for each source from multiple visits
-[n or f]g-prm.fits	FITS binary table	Image strips (median) for each source from multiple visits
-[n or f]g-gsp.fits	FITS binary table	Spectral data for each extracted source vs. wavelength
-xg-gsp.fits	**FITS binary table**	**Spectral data for each extracted source vs.wavelength (both bands)**
-[n or f]g-xsp.fits	FITS binary table	Spectral data for each extracted source vs. offset

3. Spectral Data Product Files

The spectral data product files are stored in binary FITS format, but they are GALEX-specific. The formats of these files is described below:





(root name)–xsp.fits
Extracted Spectra (photons/sec vs. arcseconds)
1 file for each band (NUV and FUV).
1 file per field (and 1 file for each rotation).

(root name)–gsp.fits
Galex Spectra (photons/sec/cm^2 vs. Ang.)
1 file for both bands
1 file per field (and 1 file for each rotation).

-pri.fits (not included in ERO release)

This file contains the image strips for individual exposures for each spectral-extracted source. The photon data, response, and masking images are recorded for each source. Masking for the image strip is stored in the response image (neighbor masking) and the photon data image (other masking) as negative numbers. Spectral response variations with position (column) are stored in the response image in the final row. These images contain the total accumulated photon data for each source for a given single visit or exposure. Each source has its own FITS header unit. The order of the image strips is identical to the order of sources in the extracted source catalog given in the (root)-gsax.fits file.

First Header Unit: Grism angle used for these extractions, total exposure time, total number of spectrally extracted sources (ECOUNT), field center, and other extraction parameters.

Second through "N" Header Unit: Accumulated image strips for photon data and response for any of N-1 sources in the field of view. The header portion defines the image dimensions (PRI_NC,PRI_NR). The scale is given in arcseconds per pixel in both spatial and dispersion directions. The header key words also include the blue limit offset in arcseconds (ARCSEC1) relative to the object center (undeviated) position, which is used to derive the wavelength scale. The image strips typically cover multiple grism orders, e.g. 1st, 2nd, and 0th. The image data is stored as 2-byte integers, which can be scaled to true data values using the header key words DATZERO, DATSCALE, RSPZERO, and RSPSCALE.

-prc.fits

This file contains the combined or summed image strips for multiple exposures for each spectral-extracted source. The format is the same as for the pri files, except that masking has been applied before summing. That is, all masked pixels in the individual (pri) image strips were set to zero before summing.

First Header Unit: Contains the filenames of all *-pri.fits which have been combined, as well as their respective grism angles.

Second through "N" Header Unit: Accumulated image strips for photon data and response for any of N-1 sources in the field of view.

-prm.fits

This file contains the medianed image strips for multiple exposures for each spectral-extracted source. The format is the same as for the pri files, except that masked pixels have been ignored by the median value calculation.

First Header Unit: Contains the filenames of all *-pri.fits which have been medianed, as well as their respective grism angles.

Second through "N" Header Unit: Accumulated image strips for photon data and response for any of N-1 sources in the field of view.

-gsax.fits

General information (binary FITS table). This file contains parameter information, as well as a source list table including extraction parameters for each source. This source list catalog is created on the first exposure and read in and used for each subsequent exposure. This file also contains a table of data for each accumulated exposure.

First Header Unit: Header key words contain various extraction parameters for ``galaxspac" (spectral accumulation program). These include the flux cutoff (i.e., the brightest ``N" sources) used on the direct image source catalog, the field RA,Dec origin, the masking parameters, band number, the total number of exposures (or orbits) and exposure time accumulated.

Second Header Unit: Extracted source list. This contains a source catalog of all the sources which have been extracted. This includes the RA,Dec positions, global IDs, direct image FUV and NUV flux rates, direct image FWHMs, and extraction parameters (object and background widths and length of the spectrum) for each source.

Third Header Unit: Accumulated exposures (orbits) list. This contains a catalog of all the photon data sets added into the image strips. This includes all the *-pri.fits filenames, grism angles, field offsets used (x, y, twist (rotation) relative to the direct image source positions), exposure times, and reduction dates.

-xsp.fits

An xsp file, labeled *-fg-xsp and *-ng-xsp, is extracted for each wavelength band. Each file represents two sequential spectral orders as recorded along the spectral axis on the detector, so units are photons per second per arcsecond. Each source has its own FITS header unit, in the same order as the data occur in the -pri.fits file.

First Header Unit: Contains the header key word for the total number of sources extracted (ECOUNT).

Second through ``N'' Header Unit: Spectra for each source and its computed 1 sigma error. Spectra are given in photons/second/pixel vs. offset arcsecond (position relative to object center or undeviated object position).

-gsp.fits

There are three gsp files for each spectrum: *-fg-gsp, *-ng-gsp, and *-xg-gsp. The first two are grism-order combined (m =1 and 2 for NUV, and 2 and 3 for FUV), flux calibrated, and rebinned onto a linear wavelength scale. The third is the conjoined spectrum of the first two. The units for these are photons s^{-1} cm^{-2} $Angstrom^{-1}$. The fg-gsp and ng-gsp files are for many purposes rendered obsolete by the xg-gsp file. Since the dispersion is linear, the zero point and dispersion of the wavelength scale are given as table entries. Two of the vector entries (flux and error) are for a simple (summation) extraction, and two vectors are for the optimal extraction.

Each file consists of a short primary header (giving the number of spectra in the file) and a single extension. In this extension each row gives spectral information (default fluxes, associated errors, optimally extracted fluxes, associated errors) for an astronomical object. These rows are listed in order of their appearance in the extracted source catalog in the (root)-gsax.fits file. *However, "masked" sources appearing in the gsax file are not extracted as spectra and thus not included in the gsp file listing.*

4. Source Extraction

For source extraction, the GALEX pipeline utilizes the program SExtractor (Bertin & Arnouts 1996) for detection and photometry of sources in the GALEX imaging data. A general description of SExtractor is given in Bertin & Arnouts (1996) as well as in the Sextractor manual (Available from http://terapix.iap.fr/soft/sextractor/). Another useful reference is the ``SExtractor for Dummies'' manual written by Benne Holwerda {Available from his web site http://www-int.stsci.edu/holwerda/se.html}. The pipeline includes a module **poissonbg** which computes a background map for each image as well as a corresponding detection threshold image. Typical backgrounds in high Galactic latitude GALEX fields are ~10^3 and 10^4 photons s^{-1} $arcsec^{-2}$ in the FUV and NUV bands, respectively. With such low count rates, the distribution of count rates in each image is typically quite non-Gaussian, even for relatively long exposures. In order to deal with these low backgrounds, uses a modified clipping algorithm which makes use of the full Poisson distribution.

When running SExtractor, we use two images as input: one for detection and the second for photometry. For the detection image we use the ratio of the background-subtracted data image to the detection threshold map. All pixels in this ratio map which rise above the detection threshold will have values greater than one and we have therefore set the parameters in SExtractor so that it will consider all of these pixels as possibledetections. The image used for photometry is simply the background subtracted data image. Since we subtract the background from the data before running SExtractor, the background value within SExtractor is explicitly set to zero. As a result, the error estimates computed by Sextractor do not include the uncertainty due to the background counts. In the FUV-NUV merged catalog, we have updated the magnitude and flux errors to account for the background counts. (These are the fields called NUV_MAGERR, NUV_FLUXERR, FUV_MAGERR and FUV_FLUXERR in the merged catalog). These fluxes and errors refer to the Kron magnitudes measured by SExtractor and are computed as follows:

$$df = \frac{\sqrt{(f + s\Omega)t}}{t}$$

where f is the flux from the source in counts/sec, s is the sky level in counts/sec/pixel, is the area over which the flux is measured ($\Omega = \pi k^2 r_1^2$ for the Kron flux) and t is the effective exposure time in seconds. Then the corresponding magnitude error is $dm = 1.086 \sim df / f$.

SExtractor makes a few different measurements of the total flux of a source. For resolved sources, the MAG_AUTO measurement is probably the most appropriate choice while MAG_APER would be better suited for measurements of unresolved sources. Despite its name, MAG_BEST is not necessarily the best choice for most applications since the measurement for all objects are not made in a consistent way.

5. Primary Object Catalog - Merged FUV+NUV Catalog (mcat file)

The merged object catalog is the final catalog product from the GALEX data pipeline. It contains the full complement of source extractions from both the FUV and NUV images. The columns of the mcat file fall into the following major categories:

- Observation description
  - Contains global object ID, pipeline version, image tile number, observation type, optics wheel position, image product type, pipeline re-run (try) number, band, mcat ID, subvisit number and leg number (where applicable)
- Band merger output quantities and flags
  - Includes merged position in Equatorial and Galactic coordinates, extinction E(B-V) from Schlegel maps, and calibrated fluxes, magnitudes and errors. "Calibrated"currently means that values have been converted to AB magnitudes. Four additional columns contain FUV fluxes extracted at NUV detection positions, NUV fluxes extracted at FUV detection positions and their errors. These are useful for any study that is best performed using identical aperture photometry in each band (e.g. for colors, photometric redshifts)
- Neighbor properties
  - Includes neighbor count and total flux out to three radii (currently set to 5", 10" and 30"), closest neighbor distance, PA and nuv and fuv mag.
- Derived quantities and map levels at merged output position
  - Includes extractions from pipeline-generated maps at the position of the detected source. Sky background [counts s^{-1} $pixel^{-1}$], artifact [flag value], weight [exposure-relative response product], contrast [dimensionless] and masked pixel counts [number] values are given for each source.
- Sextractor output columns from FUV image extractions

- Sextractor output columns from NUV image extractions
  - Please consult the sextractor manual and Sextractor for Dummies for definitions of these outputs

Catalog Fields

Table 3.2 Merged Object Catalog (-mcat.fits)

Name	Format	Unit	Definition
Object ID and orbpipe info			
ggoid	2J	Number	Galex Global Object ID
vsn	1J	Number	Version number
tile	1J	Number	Tile number
type	1J	Number	Obs.type (0=single,1=multi)
ow	1J	Number	Optics wheel (1=drct,2=grsm,3=opaq)
prod	1J	Number	Product number (_visits,_main,etc.)
img	1J	Number	image number (exposure# for _visits)
try	1J	Number	Try number (processing attempt number)
band	1J	Number	Band number (1=nuv,2=fuv,3=both)
id	1J	Number	Merged ID.
Subvisit	1I	Number	Sub-visit number for AIS
leg	1I	Number	Planned leg number for AIS
Merged object quantities			
alpha_j2000	1D	Degrees	Merged Right Ascension(degrees).
delta_j2000	1D	Degrees	Merged Declination (degrees).
prob	1E	Probability	Chi-squared probability of match.
sep	1E	Arcseconds	Separation between band positions.
Extinction	1E	Number	E(B-V) Galactic Reddening.
glon	1E	Degrees	Galactic longitude in degrees.
glat	1E	Degrees	Galactic latitude in degrees.
nuv_flux	1E	flux	NUV calibrated flux
nuv_fluxerr	1E	flux	NUV calibrated flux error
nuv_mag	1E	mag	NUV calibrated magnitude
nuv_magerr	1E	mag	NUV calibrated magnitude error
fuv_flux	1E	flux	FUV calibrated flux
fuv_fluxerr	1E	flux	FUV calibrated flux error
fuv_mag	1E	mag	FUV calibrated magnitude
fuv_magerr	1E	mag	FUV calibrated magnitude error
nuv_fcat_flux	1E	flux	NUV calibrated flux using FUV catalog position
nuv_fcat_fluxerr	1E	flux	Error for nuv_fcat_flux
fuv_ncat_flux	1E	flux	FUV calibrated flux using NUV catalog position
fuv_ncat_fluxerr	1E	flux	Error for fuv_ncat_flux
Nearest neighbor			
nuv_nc_r1	1I	number	NUV neighbor count out to radius R1
nuv_nc_r2	1I	number	NUV neighbor count out to radius R2
nuv_nc_r3	1I	number	NUV neighbor count out to radius R3
fuv_nc_r1	1I	number	FUV neighbor count out to radius R1
fuv_nc_r2	1I	number	FUV neighbor count out to radius R2
fuv_nc_r3	1I	number	FUV neighbor count out to radius R3
nuv_nf_r1	1E	flux	NUV neighbor flux out to radius R1
nuv_nf_r2	1E	flux	NUV neighbor flux out to radius R2
nuv_nf_r3	1E	flux	NUV neighbor flux out to radius R3
fuv_nf_r1	1E	flux	FUV neighbor flux out to radius R1
fuv_nf_r2	1E	flux	FUV neighbor flux out to radius R2
fuv_nf_r3	1E	flux	FUV neighbor flux out to radius R3
cn_radius	1E	arcseconds	Closest neighbor radius in arcseconds
cn_pa	1E	degrees	Closest neighbor position angle in degrees
cn_mag_nuv	1E	mag	Closest neighbor NUV magnitude
cn_mag_fuv	1E	mag	Closest neighbor FUV magnitude
Image/detection map values			
nuv_skybg	1E	flux	NUV sky background flux (photons
fuv_skybg	1E	flux	FUV sky background flux (photons
nuv_weight	1E	seconds	NUV effective exposure (response)
fuv_weight	1E	seconds	FUV effective exposure (response)
nuv_contrast	1E	ratio	NUV ratio of min to max response near source
fuv_contrast	1E	ratio	FUV ratio of min to max response near source
nuv_maskpix	1J	number	NUV number of masked pixels near source
fuv_maskpix	1J	number	FUV number of masked pixels near source
nuv_artifact	1J	number	NUV artifact flag
fuv_artifact	1J	number	FUV artifact flag
Band merger QA			
nuv_ambg	1J	number	NUV ambiguity flag.
fuv_ambg	1J	number	FUV ambiguity flag.

nuv_nc	1J	number	NUV number of candidates.
fuv_nc	1J	number	FUV number of candidates.
nuv_cid1	1J	number	First candidate for NUV source(FUV IDs)
fuv_cid1	1J	number	First candidate for FUV source(NUV IDs)
nuv_cid2	1J	number	Second candidate for NUV source(FUV IDs)
fuv_cid2	1J	number	Second candidate for FUV source(NUV IDs)
nuv_cid3	1J	number	Third candidate for NUV source(FUV IDs)
fuv_cid3	1J	number	Third candidate for FUV source(NUV IDs)
Sourcepa	1E	degrees	position angle betw. band sources.
Objtype	1J	number	0=galaxy,1=star,-1=unknown,etc.
Quality	1J	number	Quality flag (undefined)
NUV source extraction catalog			
NUV_NUMBER	1J	value	Running object number
NUV_FLUX_ISO	1E	flux	Isophotal flux
NUV_FLUXERR_ISO	1E	flux	RMS error for isophotal flux
NUV_MAG_ISO	1E	mag	Isophotal magnitude
NUV_MAGERR_ISO	1E	mag	RMS error for isophotal magnitude
NUV_FLUX_ISOCOR	1E	flux	Corrected isophotal flux
NUV_FLUXERR_ISOCOR	1E	flux	RMS error for corrected isophotal flux
NUV_MAG_ISOCOR	1E	mag	Corrected isophotal magnitude
NUV_MAGERR_ISOCOR	1E	mag	RMS error for corrected isophotal magnitude
NUV_FLUX_APER	1E	flux	Flux vector within fixed circular aperture(s)
NUV_FLUXERR_APER	1E	flux	RMS error vector for aperture flux(es)
NUV_MAG_APER	1E	mag	Fixed aperture magnitude vector
NUV_MAGERR_APER	1E	mag	RMS error vector for fixed aperture mag.
NUV_FLUX_AUTO	1E	flux	Flux within a Kron-like elliptical aperture
NUV_FLUXERR_AUTO	1E	flux	RMS error for AUTO flux
NUV_MAG_AUTO	1E	mag	Kron-like elliptical aperture magnitude
NUV_MAGERR_AUTO	1E	mag	RMS error for AUTO magnitude
NUV_FLUX_BEST	1E	flux	Best of FLUX_AUTO and FLUX_ISOCOR
NUV_FLUXERR_BEST	1E	flux	RMS error for BEST flux
NUV_MAG_BEST	1E	mag	Best of MAG_AUTO and MAG_ISOCOR
NUV_MAGERR_BEST	1E	mag	RMS error for MAG_BEST
NUV_ZPMAG	1E	mag	NUV zero point magnitude correction.
NUV_KRON_RADIUS	1E	pixel	Kron apertures in units of A or B
NUV_BACKGROUND	1E	count	Background at centroid position
NUV_THRESHOLD	1E	number	Detection threshold above background
NUV_MU_THRESHOLD	1E	number	Detection threshold above background
NUV_FLUX_MAX	1E	number	Peak flux above background
NUV_MU_MAX	1E	number	Peak surface brightness above background
NUV_ISOAREA_IMAGE	1E	number	Isophotal area above Analysis threshold
NUV_ISOAREA_WORLD	1E	number	Isophotal area above Analysis threshold
NUV_XMIN_IMAGE	1J	pixel	Minimum x-coordinate among detected pixels
NUV_YMIN_IMAGE	1J	pixel	Minimum y-coordinate among detected pixels
NUV_XMAX_IMAGE	1J	pixel	Maximum x-coordinate among detected pixels
NUV_YMAX_IMAGE	1J	pixel	Maximum y-coordinate among detected pixels
NUV_X_IMAGE	1E	pixel	Object position along x
NUV_Y_IMAGE	1E	pixel	Object position along y
NUV_XPEAK_IMAGE	1J	count	x-coordinate of the brightest pixel
NUV_YPEAK_IMAGE	1J	count	y-coordinate of the brightest pixel
NUV_ALPHA_J2000	1D	degrees	Right ascension of barycenter (J2000)
NUV_DELTA_J2000	1D	degrees	Declination of barycenter (J2000)
NUV_X2_IMAGE	1E	pixel	Variance along x
NUV_Y2_IMAGE	1E	pixel	Variance along y
NUV_XY_IMAGE	1E	pixel	Covariance between x and y
NUV_X2_WORLD	1E	number	Variance along X-WORLD (alpha)
NUV_Y2_WORLD	1E	number	Variance along Y-WORLD (delta)
NUV_XY_WORLD	1E	number	Covariance between X-WORLD and Y-WORLD
NUV_CXX_IMAGE	1E	number	Cxx object ellipse parameter
NUV_CYY_IMAGE	1E	number	Cyy object ellipse parameter
NUV_CXY_IMAGE	1E	number	Cxy object ellipse parameter
NUV_CXX_WORLD	1E	number	Cxx object ellipse parameter (WORLD units)
NUV_CYY_WORLD	1E	number	Cyy object ellipse parameter (WORLD units)
NUV_CXY_WORLD	1E	number	Cxy object ellipse parameter (WORLD units)
NUV_A_IMAGE	1E	number	Profile RMS along major axis
NUV_B_IMAGE	1E	number	Profile RMS along minor axis
NUV_A_WORLD	1E	number	Profile RMS along major axis (world units)
NUV_B_WORLD	1E	number	Profile RMS along minor axis (world units)
NUV_THETA_IMAGE	1E	degrees	Position angle (CCW

NUV_THETA_WORLD	1E	degrees	Position angle (CCW
NUV_THETA_J2000	1E	degrees	Position angle (east of north) (J2000)
NUV_ELONGATION	1E	number	A_IMAGE
NUV_ELLIPTICITY	1E	number	1 - B_IMAGE
NUV_ERRX2_IMAGE	1D	number	Variance of position along x
NUV_ERRY2_IMAGE	1D	number	Variance of position along y
NUV_ERRXY_IMAGE	1E	number	Covariance of position between x and y
NUV_ERRX2_WORLD	1D	number	Variance of position along X-WORLD (alpha)
NUV_ERRY2_WORLD	1D	number	Variance of position along Y-WORLD (delta)
NUV_ERRXY_WORLD	1E	number	Covariance of position X-WORLD
NUV_ERRCXX_IMAGE	1E	number	Cxx error ellipse parameter
NUV_ERRCYY_IMAGE	1E	number	Cyy error ellipse parameter
NUV_ERRCXY_IMAGE	1E	number	Cxy error ellipse parameter
NUV_ERRCXX_WORLD	1E	number	Cxx error ellipse parameter (WORLD units)
NUV_ERRCYY_WORLD	1E	number	Cyy error ellipse parameter (WORLD units)
NUV_ERRCXY_WORLD	1E	number	Cxy error ellipse parameter (WORLD units)
NUV_ERRA_IMAGE	1E	number	RMS position error along major axis
NUV_ERRB_IMAGE	1E	number	RMS position error along minor axis
NUV_ERRA_WORLD	1E	number	World RMS position error along major axis
NUV_ERRB_WORLD	1E	number	World RMS position error along minor axis
NUV_ERRTHETA_IMAGE	1E	number	Error ellipse position angle (CCW
NUV_ERRTHETA_WORLD	1E	number	Error ellipse pos. angle (CCW
NUV_ERRTHETA_J2000	1E	number	J2000 error ellipse pos. angle (east of north)
NUV_FWHM_IMAGE	1E	pixel	FWHM assuming a gaussian core
NUV_FWHM_WORLD	1E	deg	FWHM assuming a gaussian core
NUV_FLAGS	1I	value	Extraction flags
NUV_CLASS_STAR	1E	value	S
FUV source extraction catalog			
FUV_NUMBER	1J	value	Running object number
FUV_FLUX_ISO	1E	flux	Isophotal flux
FUV_FLUXERR_ISO	1E	flux	RMS error for isophotal flux
FUV_MAG_ISO	1E	mag	Isophotal magnitude
FUV_MAGERR_ISO	1E	mag	RMS error for isophotal magnitude
FUV_FLUX_ISOCOR	1E	flux	Corrected isophotal flux
FUV_FLUXERR_ISOCOR	1E	flux	RMS error for corrected isophotal flux
FUV_MAG_ISOCOR	1E	mag	Corrected isophotal magnitude
FUV_MAGERR_ISOCOR	1E	mag	RMS error for corrected isophotal magnitude
FUV_FLUX_APER	1E	flux	Flux vector within fixed circular aperture(s)
FUV_FLUXERR_APER	1E	flux	RMS error vector for aperture flux(es)
FUV_MAG_APER	1E	mag	Fixed aperture magnitude vector
FUV_MAGERR_APER	1E	mag	RMS error vector for fixed aperture mag.
FUV_FLUX_AUTO	1E	flux	Flux within a Kron-like elliptical aperture
FUV_FLUXERR_AUTO	1E	flux	RMS error for AUTO flux
FUV_MAG_AUTO	1E	mag	Kron-like elliptical aperture magnitude
FUV_MAGERR_AUTO	1E	mag	RMS error for AUTO magnitude
FUV_FLUX_BEST	1E	flux	Best of FLUX_AUTO and FLUX_ISOCOR
FUV_FLUXERR_BEST	1E	flux	RMS error for BEST flux
FUV_MAG_BEST	1E	mag	Best of MAG_AUTO and MAG_ISOCOR
FUV_MAGERR_BEST	1E	mag	RMS error for MAG_BEST
FUV_ZPMAG	1E	mag	FUV zero point magnitude correction.
FUV_KRON_RADIUS	1E	pixel	Kron apertures in units of A or B
FUV_BACKGROUND	1E	count	Background at centroid position
FUV_THRESHOLD	1E	number	Detection threshold above background
FUV_MU_THRESHOLD	1E	number	Detection threshold above background
FUV_FLUX_MAX	1E	number	Peak flux above background
FUV_MU_MAX	1E	number	Peak surface brightness above background
FUV_ISOAREA_IMAGE	1E	number	Isophotal area above Analysis threshold
FUV_ISOAREA_WORLD	1E	number	Isophotal area above Analysis threshold
FUV_XMIN_IMAGE	1J	pixel	Minimum x-coordinate among detected pixels
FUV_YMIN_IMAGE	1J	pixel	Minimum y-coordinate among detected pixels
FUV_XMAX_IMAGE	1J	pixel	Maximum x-coordinate among detected pixels
FUV_YMAX_IMAGE	1J	pixel	Maximum y-coordinate among detected pixels
FUV_X_IMAGE	1E	pixel	Object position along x
FUV_Y_IMAGE	1E	pixel	Object position along y
FUV_XPEAK_IMAGE	1J	count	x-coordinate of the brightest pixel
FUV_YPEAK_IMAGE	1J	count	y-coordinate of the brightest pixel
FUV_ALPHA_J2000	1D	degrees	Right ascension of barycenter (J2000)
FUV_DELTA_J2000	1D	degrees	Declination of barycenter (J2000)
FUV_X2_IMAGE	1E	pixel	Variance along x
FUV_Y2_IMAGE	1E	pixel	Variance along y
FUV_XY_IMAGE	1E	pixel	Covariance between x and y

FUV_X2_WORLD	1E	number	Variance along X-WORLD (alpha)
FUV_Y2_WORLD	1E	number	Variance along Y-WORLD (delta)
FUV_XY_WORLD	1E	number	Covariance between X-WORLD and Y-WORLD
FUV_CXX_IMAGE	1E	number	Cxx object ellipse parameter
FUV_CYY_IMAGE	1E	number	Cyy object ellipse parameter
FUV_CXY_IMAGE	1E	number	Cxy object ellipse parameter
FUV_CXX_WORLD	1E	number	Cxx object ellipse parameter (WORLD units)
FUV_CYY_WORLD	1E	number	Cyy object ellipse parameter (WORLD units)
FUV_CXY_WORLD	1E	number	Cxy object ellipse parameter (WORLD units)
FUV_A_IMAGE	1E	number	Profile RMS along major axis
FUV_B_IMAGE	1E	number	Profile RMS along minor axis
FUV_A_WORLD	1E	number	Profile RMS along major axis (world units)
FUV_B_WORLD	1E	number	Profile RMS along minor axis (world units)
FUV_THETA_IMAGE	1E	degrees	Position angle (CCW
FUV_THETA_WORLD	1E	degrees	Position angle (CCW
FUV_THETA_J2000	1E	degrees	Position angle (east of north) (J2000)
FUV_ELONGATION	1E	number	A_IMAGE
FUV_ELLIPTICITY	1E	number	1 - B_IMAGE
FUV_ERRX2_IMAGE	1D	number	Variance of position along x
FUV_ERRY2_IMAGE	1D	number	Variance of position along y
FUV_ERRXY_IMAGE	1E	number	Covariance of position between x and y
FUV_ERRX2_WORLD	1D	number	Variance of position along X-WORLD (alpha)
FUV_ERRY2_WORLD	1D	number	Variance of position along Y-WORLD (delta)
FUV_ERRXY_WORLD	1E	number	Covariance of position X-WORLD
FUV_ERRCXX_IMAGE	1E	number	Cxx error ellipse parameter
FUV_ERRCYY_IMAGE	1E	number	Cyy error ellipse parameter
FUV_ERRCXY_IMAGE	1E	number	Cxy error ellipse parameter
FUV_ERRCXX_WORLD	1E	number	Cxx error ellipse parameter (WORLD units)
FUV_ERRCYY_WORLD	1E	number	Cyy error ellipse parameter (WORLD units)
FUV_ERRCXY_WORLD	1E	number	Cxy error ellipse parameter (WORLD units)
FUV_ERRA_IMAGE	1E	number	RMS position error along major axis
FUV_ERRB_IMAGE	1E	number	RMS position error along minor axis
FUV_ERRA_WORLD	1E	number	World RMS position error along major axis
FUV_ERRB_WORLD	1E	number	World RMS position error along minor axis
FUV_ERRTHETA_IMAGE	1E	number	Error ellipse position angle (CCW
FUV_ERRTHETA_WORLD	1E	number	Error ellipse pos. angle (CCW
FUV_ERRTHETA_J2000	1E	number	J2000 error ellipse pos. angle (east of north)
FUV_FWHM_IMAGE	1E	pixel	FWHM assuming a gaussian core
FUV_FWHM_WORLD	1E	deg	FWHM assuming a gaussian core
FUV_FLAGS	1I	Value	Extraction flags
FUV_CLASS_STAR	1E	Value	S

Primary Header Card for mcat.fits file

FITS Preamble

```
SIMPLE  =                    T / file does conform to FITS standard
BITPIX  =                   16 / number of bits per data pixel
NAXIS   =                    0 / number of data axes
EXTEND  =                    T / FITS dataset may contain extensions
COMMENT   FITS (Flexible Image Transport System) format is defined in 'Astronomy
COMMENT   and Astrophysics', volume 376, page 359; bibcode: 2001A&A...376..359H
ORIGIN  = 'galexmerge.c'
```

Band Merger Input Files

```
NUVFILE = '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-nd-cat.fits'
FUVFILE = '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-fd-cat.fits'
NUVWTFIL= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-nd-rrhr.fits'
FUVWTFIL= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-fd-rrhr.fits'
NUVCNTFI= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-nd-cnt.fits'
FUVCNTFI= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-fd-cnt.fits'
NUVSKYFI= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-nd-skybg.fits'
FUVSKYFI= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-fd-skybg.fits'
NUVFLGFI= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-nd-flags.fits'
FUVFLGFI= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-fd-flags.fits'
```

Band Merger Parameters and Output Quantities

```
NUVS2N  =                   2. / Minimum S/N for NUV merges.
FUVS2N  =                   2. / Minimum S/N for FUV merges.
NUVS2NCU=                   0. / S/N Cutoff for any NUV sources.
FUVS2NCU=                   0. / S/N Cutoff for any FUV sources.
NUVNUM  =                 948 / Number of NUV sources.
FUVNUM  =                 207 / Number of FUV sources.
SEPLIM  =                   7. / Maximum separation in arcsec.
PROBLIM =                   0. / Minimum probability for matches.
RPOSERR =     1.84049156740606 / Radial position error.
RA_CENT =           350.717645 / RA center for this field.
DEC_CENT=            -0.389996 / DEC center for this field.
RAO     =           350.717645 / RA center for this field.
DECO    =            -0.389996 / DEC center for this field.
TOTNUM  =                1046 / Total number of sources.
TOTFILL =                 109 / Number of filled sources.
TOTUFN  =                 839 / Number of unfilled NUV sources.
TOTUFF  =                  98 / Number of unfilled FUV sources.
LRGNUVID=                 949 / Largest NUV ID number plus one.
N_ZPMAG =     20.0823753525469 / NUV Zero Point Magnitude
F_ZPMAG =     18.8170737879193 / FUV Zero Point Magnitude
N_ZPSCAL=                   1. / NUV Zero Point Scale Factor
F_ZPSCAL=                   1. / FUV Zero Point Scale Factor
CALMAG  = 'AUTO    '           / Calibration magnitude type
R1      =                   5. / Neighbor radius limit 1 (arcsec)
R2      =                  10. / Neighbor radius limit 2 (arcsec)
R3      =                  30. / Neighbor radius limit 3 (arcsec)
N_AMBG0 =                 839 / Number of NUV 0 ambig.
N_AMBG1 =                 109 / Number of NUV 1 ambig.
N_AMBG2 =                   0 / Number of NUV 2 ambig.
N_AMBG3 =                   0 / Number of NUV 3 ambig.
N_AMBG4 =                   0 / Number of NUV 4 ambig.
N_AMBG5 =                   0 / Number of NUV 5 ambig.
N_AMBG6 =                   0 / Number of NUV 6 ambig.
N_AMBGM6=                   0 / Number of NUV -6 ambig.
N_AMBGM1=                   0 / Number of NUV -1 ambig.
F_AMBG0 =                  95 / Number of FUV 0 ambig.
F_AMBG1 =                 109 / Number of FUV 1 ambig.
F_AMBG2 =                   0 / Number of FUV 2 ambig.
F_AMBG3 =                   3 / Number of FUV 3 ambig.
F_AMBG4 =                   0 / Number of FUV 4 ambig.
F_AMBG5 =                   0 / Number of FUV 5 ambig.
F_AMBG6 =                   0 / Number of FUV 6 ambig.
F_AMBGM6=                   0 / Number of FUV -6 ambig.
F_AMBGM1=                   0 / Number of FUV -1 ambig.
COMMENT AMBG  0: unfilled, no candidates, no ambiguity.
COMMENT AMBG  1: filled, first choice candidates agree, no ambiguity.
COMMENT AMBG  2: filled, first choice matches second choice candidate.
COMMENT AMBG  3: unfilled, first choice taken, no second choice candidate.
COMMENT AMBG  4: filled, second choice matches a first choice candidate.
COMMENT AMBG  5: filled, second choice matches a second choice candidate.
COMMENT AMBG  6: unfilled, first and second taken, no third choice.
COMMENT AMBG -6: unfilled, first and second taken, third choice exists.
COMMENT AMBG -1: unfilled, cleared, unchecked.
COMMENT AMBG -2: not applicable, does not exist, blank.
FILENAME= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/AISCHV2_149_29047_0001_sv12-xd-mcat.fits'
DIRECTRY= '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try/'
VSN     =                     1 / Reduction version (high level)
TILE    =                 10221 / Tile number (a.k.a. field or target)
TYPE    =                     1 / Observation type (0=single,1=multi)
OW      =                     1 / Optics wheel (1=drct,2=grsm,3=opaq)
PROD    =                     0 / Reduction product number (type)
IMG     =                  1537 / Image number (exposure or run)
TRY     =                     3 / Reduction try number (low level)
HISTORY NUV: HISTORY 03/11/03 00:22 Catalog created
```

Header card from NUV catalog file – Sextractor Output

```
NEPOCH  =                2000.
NOBJECT = 'AISCHV2_149_29047_0001_sv12'
NORIGIN = 'SExtractor'
NCRVAL1 =           350.717645
NCRVAL2 =            -0.389996
NCRPIX1 =               1920.5
NCRPIX2 =               1920.5
NCDELT1 = -0.000416666666666667
NCDELT2 = 0.000416666666666667
NCROTA1 =                   0.
NCROTA2 =                   0.
```

Sextractor Parameters and Outputs (NUV)

```
NSXIMASX=                3840 / IMAGE WIDTH (PIXELS) originally SEXIMASX
```

```
NSXIMASY=                 3840 / IMAGE HEIGHT (PIXELS)
NSXSTRSY=                 1024 / STRIP HEIGHT (LINES)
NSXIMABP=                  -32 / FITS IMAGE BITPIX
NSXPIXS =                  1.5 / PIXEL SCALE (ARCSEC)
NSXSFWHM=                  4.5 / SEEING FWHM (ARCSEC)
NSXNNWF = 'default.nnw'        / CLASSIFICATION NNW FILENAME
NSXGAIN =                 71. / GAIN (IN E- PER ADU)
NSXBKGND=                  0. / MEDIAN BACKGROUND (ADU)
NSXBKDEV=       0.006104021799 / MEDIAN RMS (ADU)
NSXBKTHD=        0.02816901356 / EXTRACTION THRESHOLD (ADU)
NSXCONFF= 'default.sex'        / CONFIGURATION FILENAME
NSXDETT = 'CCD     '           / DETECTION TYPE
NSXTHLDT= 'SIGMA   '           / THRESHOLD TYPE
NSXTHLD =                  1. / THRESHOLD
NSXMINAR=                 10 / EXTRACTION MINIMUM AREA (PIXELS)
NSXCONV =                  T / CONVOLUTION FLAG
NSXCONVN=                  T / CONVOLUTION NORM. FLAG
NSXCONVF= 'gauss_3.0_7x7.conv' / CONVOLUTION FILENAME
NSXDBLDN=                 32 / NUMBER OF SUB-THRESHOLDS
NSXDBLDC=              0.005 / CONTRAST PARAMETER
NSXCLN  =                  T / CLEANING FLAG
NSXCLNPA=                  1. / CLEANING PARAMETER
NSXCLNST=                 32 / CLEANING OBJECT-STACK
NSXAPERD=                  0 / APERTURE DIAMETER (PIXELS)
NSXAPEK1=                2.5 / KRON PARAMETER
NSXAPEK2=                2.5 / KRON ANALYSIS RADIUS
NSXAPEK3=                3.5 / KRON MINIMUM RADIUS
NSXSATLV=           999999999. / SATURATION LEVEL (ADU)
NSXMGZPT=                  0. / MAGNITUDE ZERO-POINT
NSXMGGAM=                  4. / MAGNITUDE GAMMA
NSXBKGSX=                128 / BACKGROUND MESH WIDTH (PIXELS)
NSXBKGSY=                128 / BACKGROUND MESH HEIGHT (PIXELS)
NSXBKGFX=                  5 / BACKGROUND FILTER WIDTH
NSXBKGFY=                  5 / BACKGROUND FILTER HEIGHT
NSXPBKGT= 'GLOBAL  '           / PHOTOM BACKGROUND TYPE
NSXPBKGS=                 24 / LOCAL AREA THICKNESS (PIXELS)
NSXPIXSK=                50000 / PIXEL STACKSIZE (PIXELS)
NSXFBUFS=                 1024 / FRAME-BUFFER SIZE (LINES)
NSXISAPR=                  0. / ISO-APER RATIO
NSXNDET =                 1080 / NB OF DETECTIONS
NSXNFIN =                  948 / NB OF FINAL EXTRACTED OBJECTS
NSXNPARA=                  83 / NB OF PARAMETERS PER OBJECT
```

NUV Image and Exposure Data

```
NCTYPE1 = 'RA---TAN'
NCTYPE2 = 'DEC--TAN'
NEQUINOX=                2000.
NRA_CENT=           350.717645
NDEC_CEN=            -0.389996 / originally DEC_CENT
NEXPTIME=                 71.
NEXPSTAR=     1066079748.00512 / originally EXPSTART
NEXPEND =     1066079825.98502
NOBS-DAT= '2003-10-13'         / originally OBS-DATE
NOBS-TIM= 'unknown '           / originally OBS-TIME
NOBSSECS=     1066079748.00512
NOBSDATI= '031013T211548Z'     / originally OBSDATIM
NIMAGSZX=                 3840
NIMAGSZY=                 3840
NINTIMAG= '/home/ops1/tim/work/ir0.2/ais/AISCHV2_149_29047_0001/AISCHV2_149_29&'
CONTINUE  '047_0001_sv12-nd-int.fits' / orginally INTIMAGE
HISTORY FUV: HISTORY 03/11/03 00:29 Catalog created
```

Header card from NUV catalog file – Sextractor Output

```
FEPOCH  =                2000.
FOBJECT = 'AISCHV2_149_29047_0001_sv12'
FORIGIN = 'SExtractor'
FCRVAL1 =           350.717645
FCRVAL2 =            -0.389996
FCRPIX1 =               1920.5
FCRPIX2 =               1920.5
FCDELT1 = -0.000416666666666667
FCDELT2 = 0.000416666666666667
FCROTA1 =                  0.
FCROTA2 =                  0.
```

Sextractor Parameters and Outputs (FUV)

```
FSXIMASX=                 3840 / IMAGE WIDTH (PIXELS) originally SEXIMASX
FSXIMASY=                 3840 / IMAGE HEIGHT (PIXELS)
FSXSTRSY=                 1024 / STRIP HEIGHT (LINES)
FSXIMABP=                  -32 / FITS IMAGE BITPIX
FSXPIXS =                  1.5 / PIXEL SCALE (ARCSEC)
FSXSFWHM=                  4.5 / SEEING FWHM (ARCSEC)
FSXNNWF = 'default.nnw'        / CLASSIFICATION NNW FILENAME
FSXGAIN =                 71. / GAIN (IN E- PER ADU)
```

```
FSXBKGND=                   0. / MEDIAN BACKGROUND (ADU)
FSXBKDEV=      4.721388791E-08 / MEDIAN RMS (ADU)
FSXBKTHD=        0.02816901356 / EXTRACTION THRESHOLD (ADU)
FSXCONFF= 'default.sex'        / CONFIGURATION FILENAME
FSXDETT = 'CCD     '           / DETECTION TYPE
FSXTHLDT= 'SIGMA   '           / THRESHOLD TYPE
FSXTHLD =                   1. / THRESHOLD
FSXMINAR=                   10 / EXTRACTION MINIMUM AREA (PIXELS)
FSXCONV =                    T / CONVOLUTION FLAG
FSXCONVN=                    T / CONVOLUTION NORM. FLAG
FSXCONVF= 'gauss_3.0_7x7.conv' / CONVOLUTION FILENAME
FSXDBLDN=                   32 / NUMBER OF SUB-THRESHOLDS
FSXDBLDC=                0.005 / CONTRAST PARAMETER
FSXCLN  =                    T / CLEANING FLAG
FSXCLNPA=                   1. / CLEANING PARAMETER
FSXCLNST=                   32 / CLEANING OBJECT-STACK
FSXAPERD=                    0 / APERTURE DIAMETER (PIXELS)
FSXAPEK1=                  2.5 / KRON PARAMETER
FSXAPEK2=                  2.5 / KRON ANALYSIS RADIUS
FSXAPEK3=                  3.5 / KRON MINIMUM RADIUS
FSXSATLV=           999999999. / SATURATION LEVEL (ADU)
FSXMGZPT=                   0. / MAGNITUDE ZERO-POINT
FSXMGGAM=                   4. / MAGNITUDE GAMMA
FSXBKGSX=                  128 / BACKGROUND MESH WIDTH (PIXELS)
FSXBKGSY=                  128 / BACKGROUND MESH HEIGHT (PIXELS)
FSXBKGFX=                    5 / BACKGROUND FILTER WIDTH
FSXBKGFY=                    5 / BACKGROUND FILTER HEIGHT
FSXPBKGT= 'GLOBAL  '           / PHOTOM BACKGROUND TYPE
FSXPBKGS=                   24 / LOCAL AREA THICKNESS (PIXELS)
FSXPIXSK=                50000 / PIXEL STACKSIZE (PIXELS)
FSXFBUFS=                 1024 / FRAME-BUFFER SIZE (LINES)
FSXISAPR=                   0. / ISO-APER RATIO
FSXNDET =                  221 / NB OF DETECTIONS
FSXNFIN =                  207 / NB OF FINAL EXTRACTED OBJECTS
FSXNPARA=                   83 / NB OF PARAMETERS PER OBJECT
```

FUV Image and Exposure Data

```
FCTYPE1 = 'RA---TAN'
FCTYPE2 = 'DEC--TAN'
FEQUINOX=                2000.
FRA_CENT=           350.717645
FDEC_CEN=            -0.389996 / originally DEC_CENT
FEXPTIME=                  71.
FEXPSTAR=     1066079748.00532 / originally EXPSTART
FEXPEND =      1066079825.9851
FOBS-DAT= '2003-10-13'         / originally OBS-DATE
FOBS-TIM= 'unknown '           / originally OBS-TIME
FOBSSECS=     1066079748.00532
FOBSDATI= '031013T211548Z'     / originally OBSDATIM
FIMAGSZX=                 3840
FIMAGSZY=                 3840
FINTIMAG= '/home/ops1/tim/work/ir0.2/ais/AISCHV2_149_29047_0001/AISCHV2_149_29&'
CONTINUE  '047_0001_sv12-fd-int.fits' / orginally INTIMAGE
DATE    = '2003-11-06T21:15:56' / file creation date (YYYY-MM-DDThh:mm:ss UT)
GRELEASE= 'int-3.2-RC1'
ABSCAL  = '/home/galex/cal/targ/cal01.00'
ABSPIPE = '/home/ops1/tim/work/ir0.2/ais/pipe/01-vsn/10221-AISCHV2_149_29047/d&'
CONTINUE  '/00-visits/0001-img/03-try'
END
```

6. Pipeline Products Gallery

The images below show ds9 snapshots of some of the main pipeline image products. FUV images are on the left, NUV on the right. Specific details can be seen in the magnifier image (upper right), which is providing a zoom around the cursor position (indicated by the white arrow in the image).

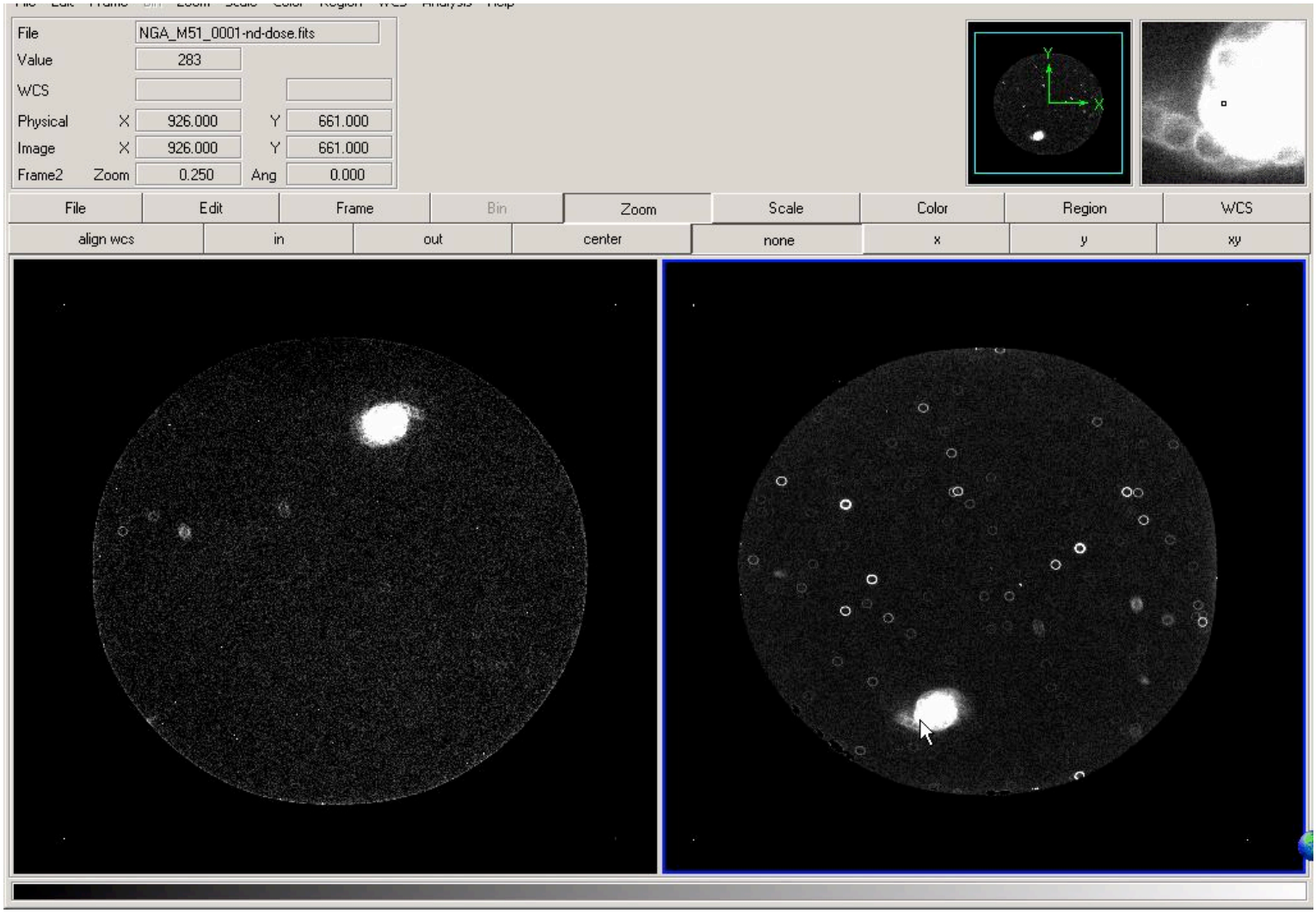
These images have been obtained from the pipeline a single visit to the target M51 (NGA_M51_0001)

Dose Map

The dose map contains photon positions in the instrument frame. The full field of view is 65 mm diameter, or 1.24 degrees in the telescope focal plane. Note that the NUV image frame is rotated 180 degrees from the FUV frame.

Because of the dither motion by the satellite, stars and galaxies move in this frame during an observation (appearing in this image as donuts or smeared objects). Point sources in these images are “detector hot spots” which are masked in further processing.

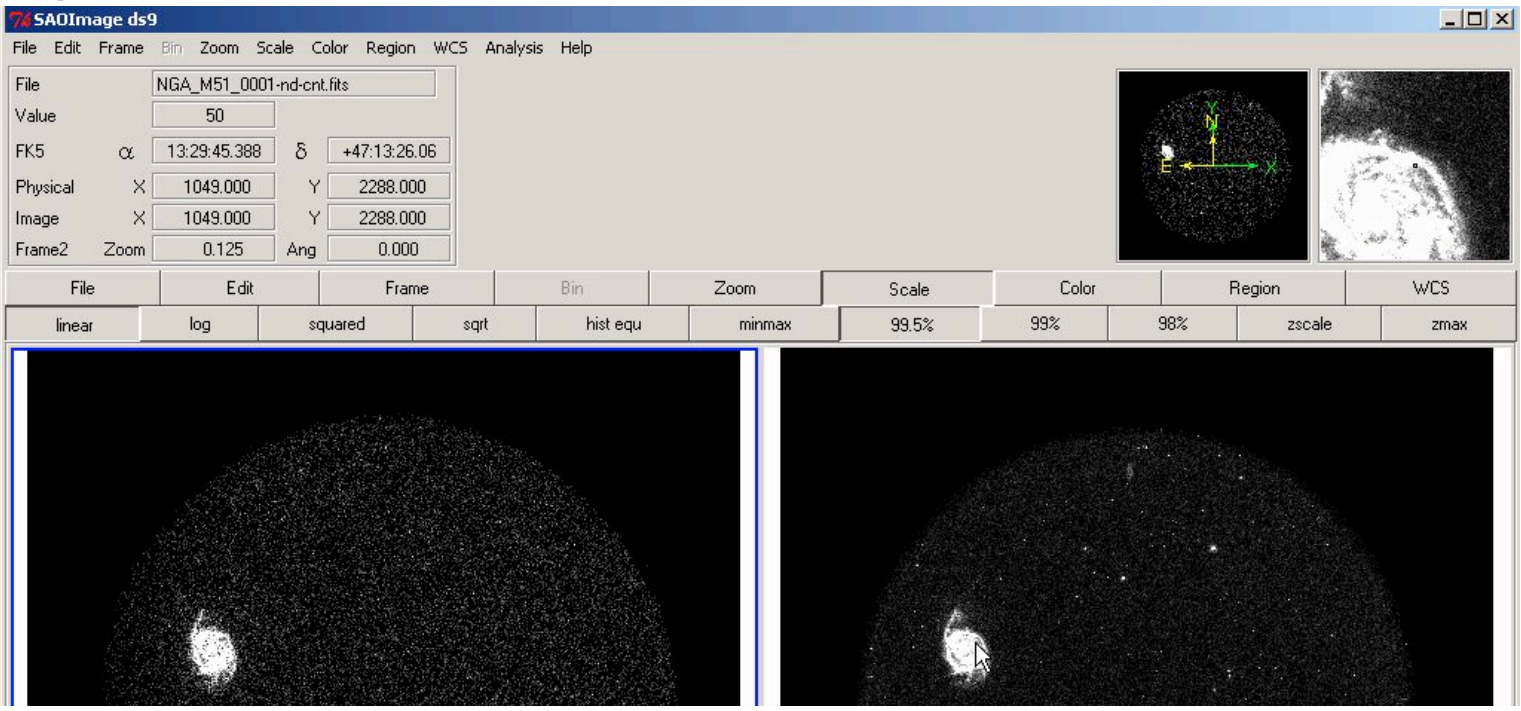
The four points at the corners are the images are generated by electronic stimulus pulses in the detector system. These are used for calibration of electronic drift and dead time corrections only and do not show up in the final images.

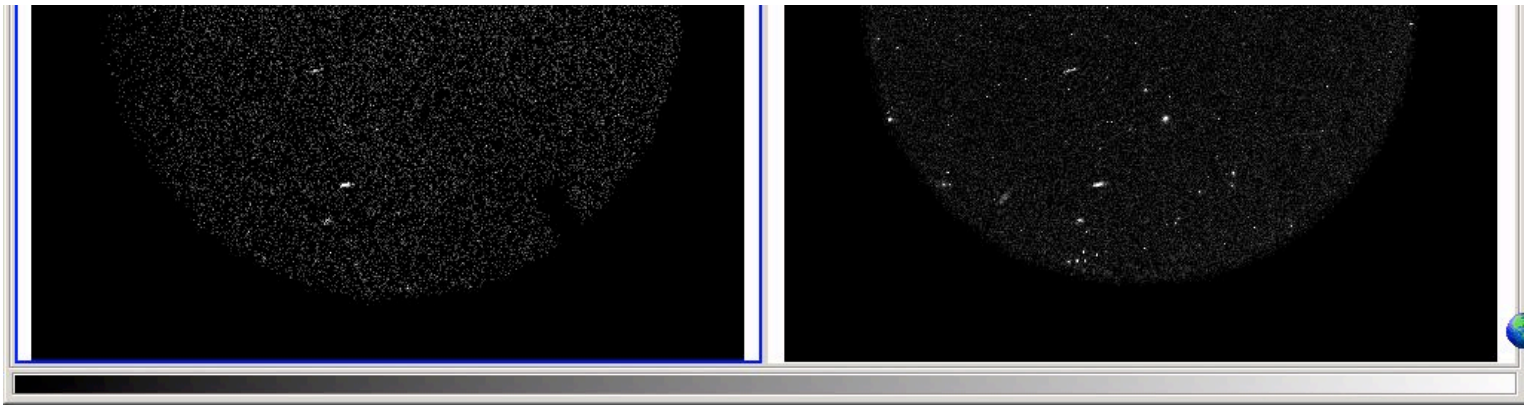


Count Map

The combination of time-tagged photon positions and satellite aspect satellite are used to generate a count map in sky coordinates. This observation was acquired at a roll angle of 90 degrees (measured with respect to the Y axis of the detector/instrument frame), which explains why the image is rotated with respect to the dose maps above.

The image quantities are in units of counts per pixel. Each pixel is 1.5"x1.5". Note that at the position of the arrow, 50 counts were detected in this exposure.

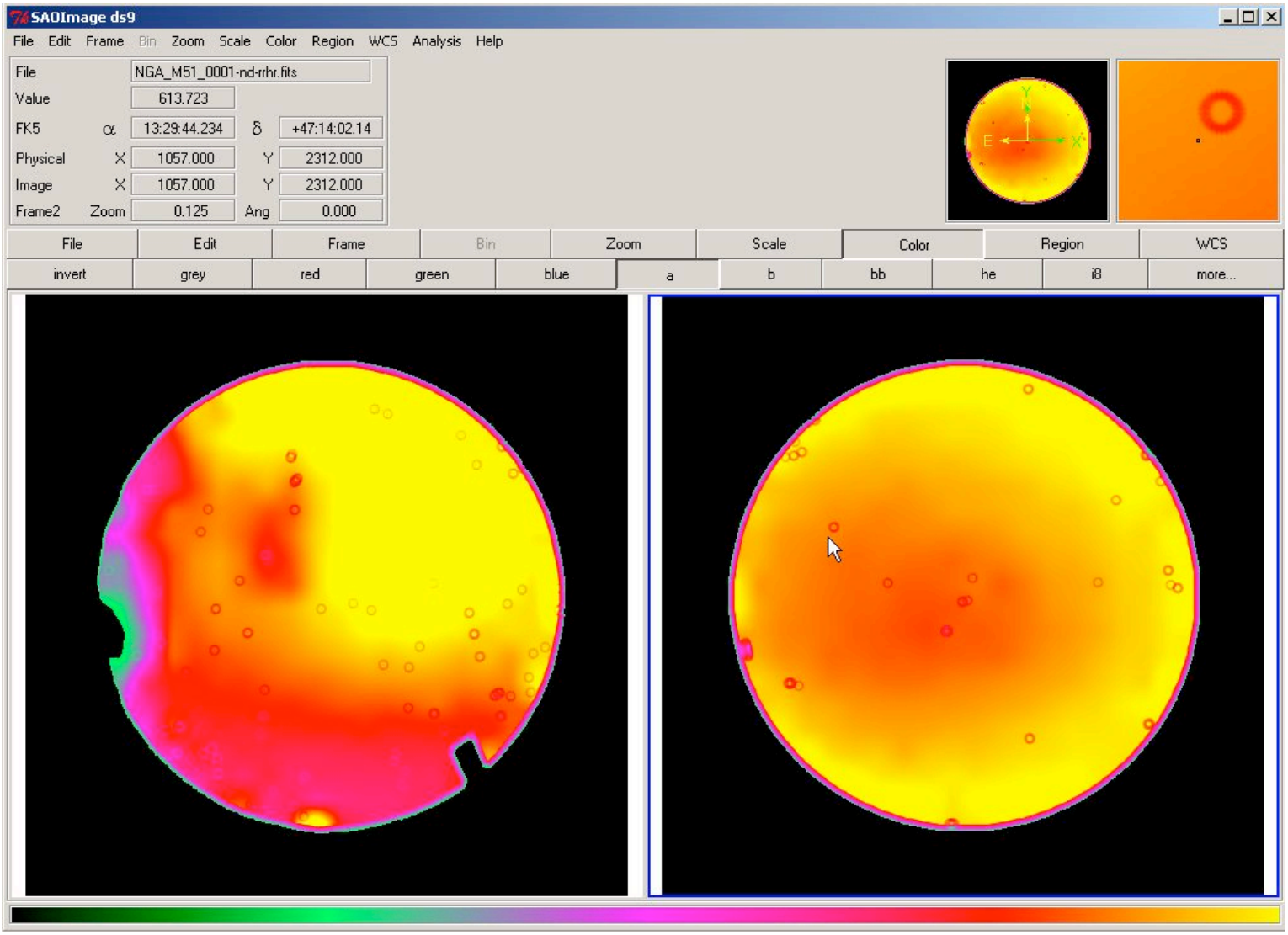




Relative Response Map

The high resolution relative response map shows the effective normalized instrument response (based on flat field) * exposure (seconds) projected onto the sky. The small donuts result from regions of the detector active area (hot spots) which have been masked in pipeline processing.

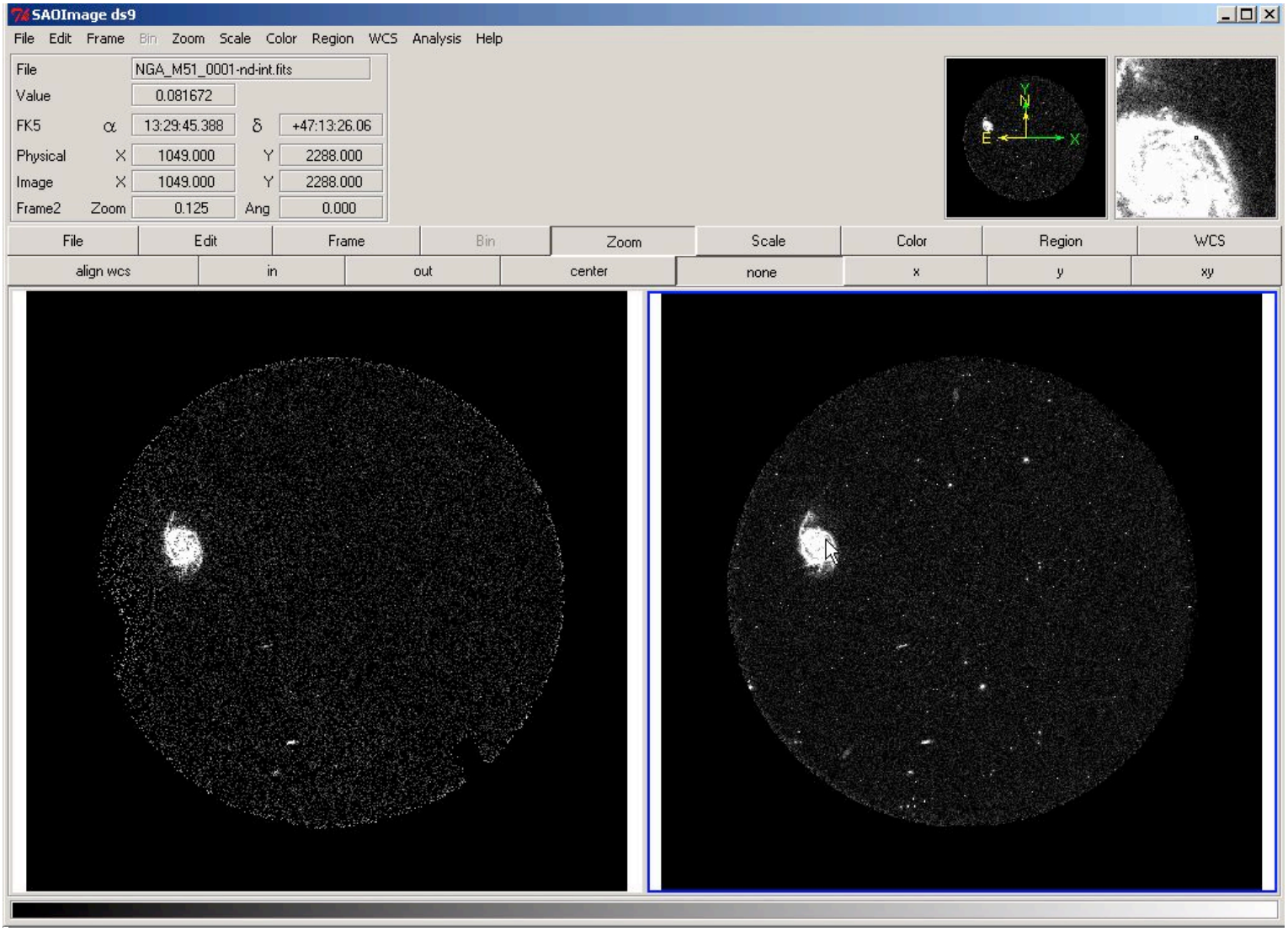
Over most of the active area, the response varies by less than +/- 20%. The FUV detector shows much larger response variation across the field, particularly on one side where the response drops off significantly.



Intensity map

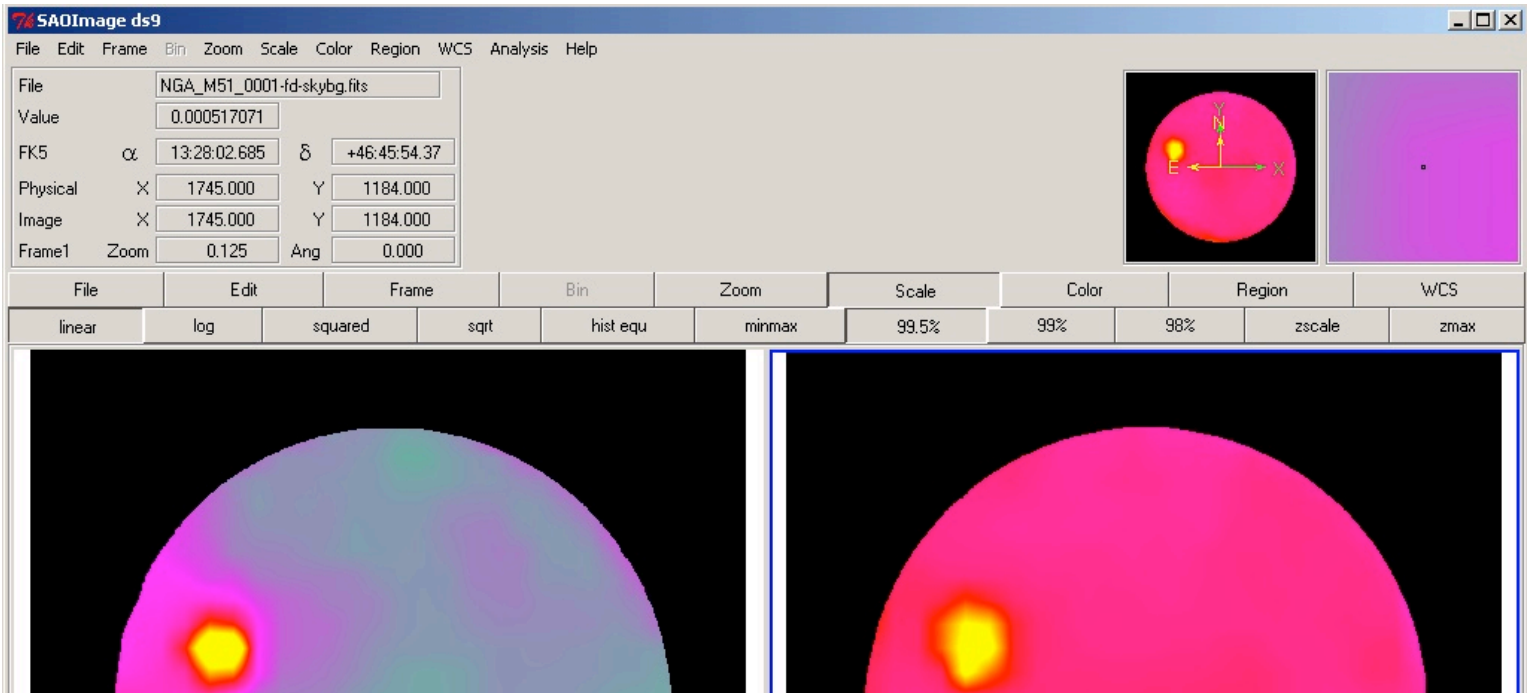
The intensity map is generated by dividing the count map by the relative response map. The units are in counts / pixel s (normalized effective area*bandwidth), which means that while the image is 'flattened' to reflect the true instrument response, the units correspond roughly to counts per second per pixel. At the position of the arrow (highlighted in the magnifier), we detected ~ 0.082 counts/(s normalized EA pixel) in the NUV image. This can easily be converted to a surface brightness using the conversion factors provided in the table above.

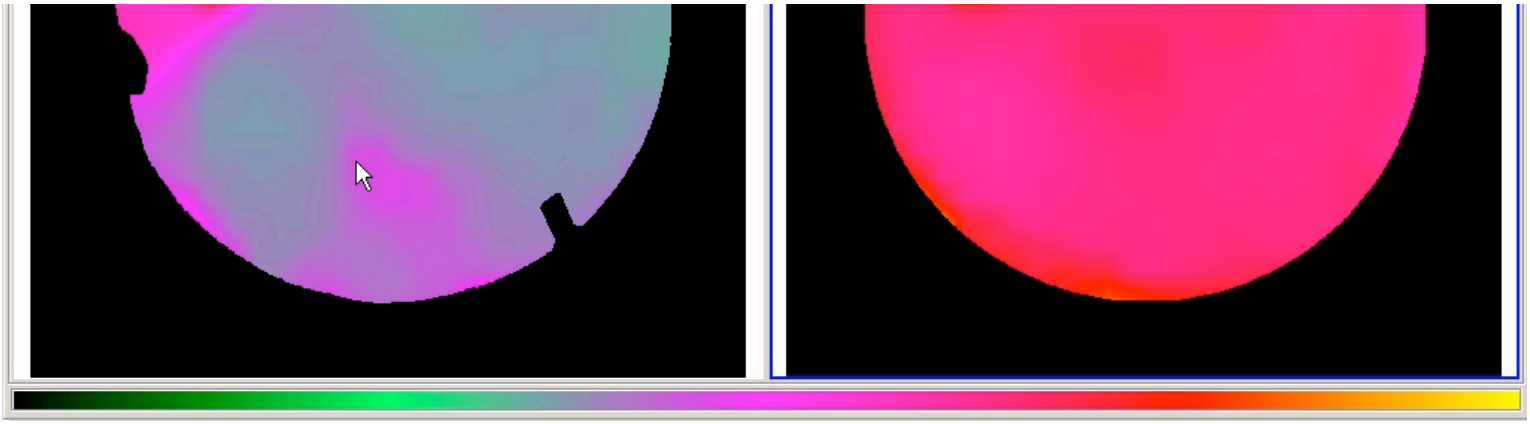
Note that in the low response region of the FUV detector, the average level is relatively flat, but the image becomes noisy as expected due to the low throughput in this region.



Sky Background Map

The GALEX pipeline generates a smoothed sky background map which is subtracted from the intensity image prior to the final source extraction processing step.





Grism Intensity Maps

Intensity maps are also built up in grism mode. The quad image below shows imaging and grism intensity maps of the ELAISS1_00 field. The grism data are from a single visit (and grism rotation).

7. GALEX Image Artifacts

The GALEX optics and detector produce several image artifacts which the pipeline flags to indicate regions where analysis problems may arise. Most image artifacts are observed in the NUV channel due to a bevel on the edge of the NUV window and the abundance of bright stars detected vs. the FUV. The principal artifacts are:

- Bright star halos (both)
- Bright star NUV beveled edge reflections (NUV only)
- Dichroic ghosts (NUV only)
- Detector window ghosts (both)
- Near-field stray light from bright stars

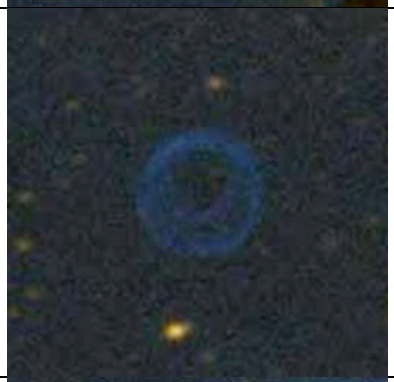
Other artifacts are produced by transient effects. These include

- Unmasked detector hot spots
- Satellite transits

- Asteroid motion
- Local flaring of detector count rate caused by South Atlantic Anomaly, solar activity

The pipeline flags possible artifacts for the NUV detector and masks known detector hot spots.

Table 3.3 -- Artifact Gallery

Artifact	Pipeline Flag	Picture [NUV=red/yellow, FUV=blue]
Bright star halo [NUV] Due to diffraction, and electron halo due to proximity focused photocathode.	NONE	
Bright star halo [FUV]	NONE	
Ghosts—Window & Dichroic The largest (red, lower) ghost is due to the 10 mm thick NUV detector window. Detector window ghosts are radially offset due to curvature on the window. The small ghost to the upper right is due to the dichroic beam splitter. It is offset along the detector Y-axis (instrument X-axis) and oblique due to the oblique angle of the beam splitter.		
FUV hot spot Normally masked out in pipeline, new hotspots not in database will appear as spiral echoing dither pattern (since hot spots are fixed in detector coordinates).		
NUV Window Bevel Reflection – Edge Ghost		

The NUV window has a beveled exterior surface required to mate to the microchannel plate surface. Total internal reflection causes light from stars within 5 arcminutes of the edge to reflect into the field of view. Depending on the exact location of the star, a ghost image can be produced far inside the field of view, as shown in the next image		
NUV Window Bevel Reflection – Interior Ghost