Revised Catalog of *GALEX* Ultraviolet Sources. I. The All-Sky Survey: GUVcat _AIS_

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Abstract

The *Galaxy Evolution Explorer* (*GALEX*) imaged the sky in two ultraviolet (UV) bands, far-UV (FUV, λ_{eff} ~ 1528 Å) and near-UV (NUV, λ_{eff} ~ 2310 Å), delivering the first comprehensive sky surveys at these wavelengths. The *GALEX* database contains FUV and NUV images, ~500 million source measurements and over 100,000 low-resolution UV spectra. The UV surveys are a unique resource for statistical studies of hot stellar objects, z ≤ 2 QSOs, star-forming galaxies, nebulae and the interstellar medium, and provide a roadmap for planning future UV instrumentation and follow-up observing programs. We present science-enhanced, “clean” catalogs of *GALEX* UV sources, with useful tags to facilitate scientific investigations. The catalogs are an improved and expanded version of our previous catalogs of UV sources (BCScat). With respect to BCScat, we have patched 640 fields for which the pipeline had improperly coadded non-overlapping observations, and we provide a version with a larger sky coverage (about 10%) by relaxing the restriction to the central area of the *GALEX* field to 1° diameter (GUVcat _AIS_ fov055), as well as the cleaner, more restrictive version using only the 1° central portion of each field as in BCScat (GUVcat _AIS_ fov050). We added new tags to facilitate selection and cleaning of statistical samples for science applications: we flag sources within the footprint of extended objects (nearby galaxies, stellar clusters) so that these regions can be excluded for estimating source density. As in our previous catalogs, in *GUVcat* duplicate measurements of the same source are removed, so that each astrophysical object has only one entry. Such a unique-source catalog is needed to study the density and distributions of sources, and to match UV sources with catalogs at other wavelengths. The catalog includes all observations from the All-Sky Imaging Survey (AIS), the survey with the largest area coverage, with both FUV and NUV detectors exposed: over 28,700 fields, made up of a total of 57,000 observations (“visits”). The total area covered, when overlaps are removed and gaps are accounted for, is 24,790 square degrees for GUVcat _AIS_ fov055 (GUVcat _AIS_ fov055 and 22,125 square degrees for (GUVcat _AIS_ fov050). The total numbers of “unique” AIS sources (eliminating duplicate measurements) are 82,992,086 (GUVcat _AIS_ fov055) and 69,772,677 (GUVcat _AIS_ fov050). The typical depth of the GUVcat _AIS_ catalog is FUV = 19.9, NUV = 20.8 AB mag.

Key words: catalogs – Galaxy: stellar content – stars: AGB and post-AGB – stars: early-type – surveys – ultraviolet: general

Supporting material: machine-readable tables

1. Introduction

Current observational astrophysics benefits from data mining of modern sky surveys, enabled by large-format detectors, improved instrument stability, and computational database facilities capable of easily handling large data volumes. At optical wavelengths, the relevance and variety of science facilities capable of easily handling large data volumes. At optical wavelengths, the relevance and variety of science facilities capable of easily handling large data volumes. At optical wavelengths, the relevance and variety of science facilities capable of easily handling large data volumes. At optical wavelengths, the relevance and variety of science facilities capable of easily handling large data volumes. At optical wavelengths, the relevance and variety of science facilities capable of easily handling large data volumes. At optical wavelengths, the relevance and variety of science facilities capable of easily handling large data volumes. 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planning follow-up observations and missions, and for extracting science from the still largely unexplored database (for earlier, pioneering UV missions, see, e.g., Bianchi 2016).

This work presents the latest version of the *GALEX* catalog of UV sources, GUVcat, which will facilitate statistical investigations involving UV measurements, and cross-matching with other samples. It follows, expands, and improves the earlier versions by Bianchi et al. (2011a, 2011b, 2014a: BCScat). We present here the catalog from the survey with the largest sky coverage; similar source catalogs from the deeper surveys, more limited in area coverage, will follow, as well as catalogs of UV variables, and a UV spectroscopic database.

The paper is arranged as follows. First we recall the characteristics of the *GALEX* instrument (Section 2), of the major surveys performed (Section 3), and of the *GALEX* data and photometry (Section 4) of relevance for catalog users. In Section 5 we describe the criteria used for construction of the new catalog and improvements with respect to previous versions; in Section 6 we give a statistical overview of the catalogs’ source content, and provide relevant information for using the catalog; in Section 7 we explain the calculation of the area coverage; and in Section 8 we discuss the distribution of sources across the sky as well as summarize useful caveats and
suggestions for using this catalog and GALEX data. A detailed description of the procedure used to identify and remove duplicate measurements of sources is given in Appendix A. A complete list of the tags of catalog sources is given in Appendix B. Appendix C illustrates in more detail some caveats and the most relevant artifacts.

2. GALEX Instrument and Data Characteristics

GALEX (Martin et al. 2005), a NASA Small Explorer class mission with contributions from the Centre National d’Etudes Spatiales of France and the Korean Ministry of Science and Technology, performed the first sky-wide UV surveys. It was launched on 2003 April 28 and decommissioned by NASA on 2013 June 28. GALEX’s instrument consisted of a Ritchey–Chrétien-type telescope with a 50 cm primary mirror and focal length of 299.8 cm. Through a dichroic beam splitter, light was fed to two detectors simultaneously, yielding observations in two broad bands: far-UV (FUV, $\lambda_{\text{eff}} \sim 1528$ Å, 1344–1786 Å) and near-UV (NUV, $\lambda_{\text{eff}} \sim 2310$ Å, 1771–2831 Å). GALEX had two observing modes, direct imaging and grism field spectroscopy. The FUV detector stopped working in 2009 May; subsequent GALEX observations have only NUV data (Figure 1).

The GALEX field of view (fov) is $1.2^2$ diameter (1.28/1.24, FUV/NUV), and the spatial resolution is $\approx 4.2/5.3$ (Morrissey et al. 2007). For each observation, an FUV and an NUV image, sampled with virtual pixels of $1''5$, are reconstructed from the photon list recorded by the two photon-counting micro-channel plate detectors. From the reconstructed image, the GALEX pipeline then derives a sky background image by interpolating a surface from flux measurements in areas with no detected sources, and performs source photometry in various ways: aperture, psf, Kron-like elliptical (see Appendix B). Sources detected in the FUV and NUV images of the same observation are matched by the pipeline to produce a merged-source list (both bands combined) for each observation. We will return to this matching later.

To reduce local response variations, in order to maximize photometric accuracy, each observation was carried out in “AIS mode” for most AIS data and with a 1' spiral dithering pattern for MIS and DIS. The surveys were accumulated by covering contiguous “tiles” in the sky, with series of such observations, sometimes repeated, called “visits.”

The Galactic plane was largely inaccessible during the prime mission phase because of the many bright stars that violated high count-rate safety limits. Such constraints were relaxed at the end of the mission. A survey of the Magellanic Clouds (MC), also previously unfeasible due to brightness limits, was completed at the end of the mission, when the initial count-rate safety threshold (Bianchi 2014; Simons et al. 2014; D. Thilker et al. 2017, in preparation) was lowered. Because of the FUV detector’s failure in 2009, these extensions include only NUV measurements (Figure 1).

3. The Sky Surveys

GALEX has performed sky surveys with different depth and coverage (Morrissey et al. 2007; Bianchi 2009). The two detectors, FUV and NUV, observed simultaneously as long as the FUV detector was operational; however, there are occasional observations in which one of the two detectors was off (mostly FUV) due to brief shutdown episodes, even in the early part of the mission; in addition, in some observations the FUV and NUV exposure times differ (see Bianchi et al. 2014a, in particular their Table 1 and Figure 2).

The surveys with the largest area coverage are the All-Sky Imaging Survey (AIS) and the Medium-depth Imaging Survey (MIS); the sky coverage is shown in Figure 1. Exposure times slightly vary within each survey, around the respective nominal exposures of 100 s for AIS, which corresponds to a detection limit (5$\sigma$) of FUV $\sim 20$/NUV $\sim 21$ ABmag, and 1500 s for MIS, corresponding to a depth of $\sim 22.7$ ABmag in both FUV and NUV. The Deep Imaging Survey (DIS) accumulated exposures of the order of several tens of thousand of seconds in selected fields (for example, for a 30,000 s exposure, the depth

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3 A trailing mode, rather than the spiral dithering pattern, was instead used for the latest, privately funded observations, to cover some bright areas near the MW plane. These latest data currently are not in the public archive. Also, a so-called Petal-mode was used in special cases. The spiral dithering pattern was used for most of the science data, and for all of the data used in this catalog.
reached is ~24.8/24.4 ABmag in FUV/NUV). In addition, the “Nearby Galaxies Survey” (Bianchi et al. 2003; Gil de Paz et al. 2007), dedicated to mapping large nearby galaxies, initially covered 436 fields at MIS depth, but hundreds of additional nearby galaxies were mapped by GALEX, as part of MIS or other surveys (see also Section 6.1). Other observations were obtained during guest investigator (GI) programs, and for other targeted regions such as, for example, the Kepler field (e.g., Smith et al. 2014).

The current GALEX database (data release GR6plus7) contains 582,968,330 source measurements resulting from a total of 100,865 imaging visits; most of these source measurements are from observations with both FUV and NUV detectors on (64551 visits, 47239 of which from the AIS survey). Figure 1 shows the sky coverage of all GALEX observations performed with both FUV and NUV detectors on (right panel), and in NUV regardless of the FUV detector status (left panel). The figure does not include the last NUV trailed observations (the privately funded “CAUSE” observing phase, conducted in scan mode).

### 4. GALEX Data and Photometry

GALEX data include images through either direct imaging or grism, and associated photometry from the pipeline or extracted spectra respectively. High-level science products (HLSp) have also been released (Bianchi et al. 2011a), as well as unique-source catalogs (i.e., with no duplicate observations of the same source; Bianchi et al. 2011a, 2014a: BCScat); these are available at MAST and Vizier, and are precursors of the present catalog.

The photometry calibration for any data release uses the zero-points of Morrissey et al. (2007); any subsequent pipeline updates were reflected in revised extracted source count-rates (CTRs), so that the zero-points remained unchanged. On the AB magnitude scale, the GALEX magnitudes are defined as:

\[
UV\text{\_mag} = -2.5 \times \log(CTR) + ZP\ (AB\ \text{mag}),
\]

where CTR is the dead-time-corrected, flat-fielded count-rate (counts s\(^{-1}\)) and the zero-point values are \(ZP_{\text{FUV}} = 18.82\) and \(ZP_{\text{NUV}} = 20.08\).

The transformations to Vega magnitudes are (Bianchi 2011):

\[
\begin{align*}
FUV\_\text{mag}_{\text{Vega}} &= FUV\_\text{mag}_{\text{AB}} - 2.223, \quad (2) \\
NUV\_\text{mag}_{\text{Vega}} &= NUV\_\text{mag}_{\text{AB}} - 1.699. \quad (3)
\end{align*}
\]

In Sections 4.1–6.1 we discuss additional details and relevant caveats for using GALEX data. Practical advice on use of GALEX data and this catalog is summarized in Section 8.2.

### 4.1. Bright Sources

High CTRs from UV-bright sources cause nonlinearity in the response, or saturation, due to the detector’s dead-time correction being overtaken by the photon arrival rate. Morrissey et al. (2007) reported nonlinearity at a 10% rolloff in 109 counts s\(^{-1}\) for FUV and 311 counts s\(^{-1}\) for NUV. These CTRs correspond to FUV\_mag = 13.73 ABmag (~1.53 \times 10^{-13} \text{erg s}^{-1} \text{cm}^{-2} \text{ÂÅ}^{-1}) and NUV\_mag = 13.85 ABmag (~6.41 \times 10^{-14} \text{erg s}^{-1} \text{cm}^{-2} \text{ÂÅ}^{-1}).

A correction for nonlinearity is applicable over a limited range, beyond which the measured CTR saturates and the true source flux is no longer recoverable (see their Figure 8). The bright-object limit during the primary mission was 30,000 counts s\(^{-1}\) per source, corresponding to ~9th ABmag for NUV (~7 \times 10^{-12} \text{erg s}^{-1} \text{cm}^{-2} \text{ÂÅ}^{-1}) and 5000 counts s\(^{-1}\) per source in FUV (ABmag ~9.6, 6 \times 10^{-12} \text{erg s}^{-1} \text{cm}^{-2} \text{ÂÅ}^{-1}). Such limits were relaxed at the end of the mission.

In addition to the nonlinearity for sources with high CTRs, the total CTR over the entire field affects the stim-pulse correction, which in turn affects the correction for non linearity. We refer to D. Thilker et al. (2017, in preparation) for details on the issue, and a recipe for correction.

The calibration of GALEX fluxes is tied to the UV standards used for HST (Bohlin 2001). However, all but one of the white dwarf (WD) standard stars have GALEX CTRs in the nonlinear range. Camarota & Holberg (2014) derived an empirical correction to the GALEX magnitudes in the nonlinear range, using a well-studied sample of WDs with previous UV spectra and model atmospheres. Their correction is valid in the bright-flux regime as specified in their work, but would diverge if extrapolated to fainter fluxes. Further refinements of the calibration have not yet been explored, to our knowledge. In future works we will examine the stability of the response at very high CTRs (L. Bianchi et al. 2017a, in preparation; A. de la Vega & L. Bianchi, 2017 in preparation).

### 4.2. Crowded Fields

Source detection and photometry measurements performed by the GALEX pipeline become unreliable where sources are too crowded relative to the instrument’s resolution. Conspicuous examples include stellar clusters in the Milky Way (Figure 2), fields in or near the MC (Bianchi 2014; Simons et al. 2014), and nearby extended galaxies (Section 6.1). The pipeline, designed for the general purpose of detecting both pointlike and extended sources (such as galaxies, typically with an elliptical shape), sometimes interprets two or more nearby point sources as one extended source; this seems to occur in crowded regions, as Figure 2 shows. Note that, in some crowded fields, at times the pipeline fails to resolve even pointlike sources with separation comparable to or larger than...
the instrumental resolution; see Figure 2 for an example, or Figure 3 of Simons et al. (2014) for a Magellanic Cloud field. In extended galaxies, the local background of diffuse stellar populations may compound the crowding around clustered sources or bright star-forming complexes.

In extended galaxies, because UV fluxes are sensitive to the youngest, hottest stars, which are typically arranged in compact groups within star-forming regions, UV-emission peaks are identified by the pipeline as individual sources and some star-forming structures may be shredded in individual peaks, or tightly clustered sources may be merged into an extended source. In other cases, the extended emission of the central galaxy disk is often interpreted as a single extended source. In many cases, the result from the pipeline is a single measurement of a large central area and an overdensity of sources in the outer disk. An example is shown in Figure 5. Custom measurements are needed in area and an overdensity of sources in the outer disk. An example result from the pipeline is a single measurement of a large central often interpreted as a single extended source. In many cases, the extended emission of the central galaxy disk is tightly clustered sources may be merged into an extended source. Forming structures may be shredded in individual peaks, or identifying groups within star-forming regions, UV-emission peaks are young, hottest stars, which are typically arranged in compact sources or bright star-forming complexes.

For consistency and completeness, all AIS measurements from the master database with both FUV and NUV exposures >0 s were used to produce our GALEX source catalogs GUVcat_AIS. Large galaxies, stellar clusters, and MC fields4 were not excluded, to avoid introducing arbitrary gaps in the catalog coverage, because the choice of which regions must be excluded depends on the specific science application and the characteristics of the sources to be analyzed (e.g., magnitude range, Bianchi et al. 2011b). As with every large database, it is ultimately the user’s choice (and responsibility) to check crowded or problematic regions or extended objects, and exclude such regions if needed, or carefully check the photometry if these areas cannot be excluded (see Section 6.1), and use specific custom-vetted photometry catalogs for these particular areas when necessary. For the MC, initial custom photometry was performed by Simons et al. (2014); the final and complete version of the MC catalog is published by D. Thilker et al. (2017, in preparation) and should be used in these regions, instead of GUVcat or the database products.

5. The UV Source Catalog

For several sources there are multiple measurements in the GALEX master database, due to repeated observations of the same field, or overlap between contiguous fields. For studies involving UV-source counts, or to match UV samples with catalogs at other wavelengths, one needs to eliminate repeats, as well as artifacts. Therefore, we have constructed catalogs of unique UV sources, eliminating duplicate measurements of the same object. Separate catalogs were constructed for AIS and MIS, because of the ~2–3 mag difference in depth. The catalog presented here is an expanded and improved version of “BCScat” published by Bianchi et al. (2014a), who also presented the first sky maps showing the density of UV sources with various cuts. An earlier version, based on the fifth data release (GR5), was published by Bianchi et al. (2011a), who extensively discussed the criteria for constructing GALEX source catalogs and matched catalogs between GALEX and other surveys. Bianchi et al. (2011b) presented distributions of the densities of sources as a function of Galactic latitude, magnitude, and colors. We refer to these papers for useful presentations of the UV source distributions across the sky, and in magnitudes and colors; such considerations will not be repeated here because the overall statistics will appear very

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4 We recall that only the periphery of the MC has both FUV and NUV exposures; the coverage of the inner portions has mostly NUV data (Bianchi 2014; Simons et al. 2014), and therefore was not included in our catalog; the whole MC catalog, from custom-vetted photometry, will be published elsewhere (D. Thilker et al. 2017, in preparation).
similar, but we strongly advise using the catalog presented here for better quality and completeness. The improvements with respect to the earlier versions are described in the next section. Bianchi et al. (2011a) also released matched GALEXxSDSS catalogs, and Bianchi et al. (2011b) presented matched GALEXxGSC2 catalogs. Work on source classification from the matched catalogs was presented by Bianchi (2009) and Bianchi et al. (2005, 2007, 2009, 2011a). The earlier versions of the unique-source catalogs (Bianchi et al. 2011a, 2014a) are superseded by GUVcat presented here. Matched catalogs of GUVcat with SDSS, PanSTARRS, 2MASS, WISE, and Gaia will be released by L. Bianchi et al. (2017b, in preparation).

In the GALEX database, an FUV magnitude with a value of $-999$ means either that the FUV detector was on and the source was detected in NUV but too faint in FUV to be measured, or that the FUV detector was off. In order to examine and classify sources by color, and the relative fraction of sources with different colors, Bianchi et al. (2011a, 2014a) restricted the catalogs to those observations in which both detectors were exposed. We do the same here. In addition, our previous catalogs were conservatively restricted to measurements within the central 1° diameter of the fov, to exclude the outer rim, where distortions prevent position and photometry of sources to be derived accurately, and counts from rim spikes cause numerous artifacts to intrude the source list. In the present version we again offer a catalog restricted to sources within 0.5° from the field center, GUVcat_AIS_050, and also a version relaxing this limit to 0.55, GUVcat_AIS_055, to reduce gaps in area coverage, as described in Sections 5.2 and 7. Sections 5 and 8.2 clarify which catalog is preferable depending on the science purpose. The present catalog includes all AIS fields with both FUV and NUV exposed.5

5.1. Patching and Updating BCScat

The initial need for patching BCScat came from the discovery that in some fields the GALEX pipeline had coadded observations from different visits which are largely not overlapping. GALEX observed each field (termed “tile” in the database) in one or more “visit” (composed of one or more “subvisit”); the partial-exposure images (visits) that passed the either automated or manual quality test (“QA”) were coadded, and “coadd” products (images, photometry) from the pipeline were entered in the database; the exposure time listed for the coadd is the sum of the partial exposures that were combined. A data set is listed as “coadd” in the database even if it consists only of one visit. The coadd products are the default data level accessed by browsing the GALEX database with GALEXview (galex.stsci.edu/galexview). For constructing the catalog, and for most other purposes, using the coadds as a starting point is the best option since they provide the total exposure available for each field, with all visits already coadded. Our previous catalogs were therefore constructed combining sources from the coadds, and so
is the catalog being released with this paper, with the exceptions described below.

The UV source catalog BCScat_AIS (Bianchi et al. 2014a) was constructed from the 28,707 AIS coadds with both FUV and NUV total exposures $>0$. These coadds are made up of 57,000 visits (47,239 of which have both detectors exposed). We discovered, however, that in some GALEX AIS fields the pipeline had coadded visits centered at significantly differing positions, up to 26'/8 apart (which means, in this extreme case, almost no overlap). The pipeline then places the nominal center of the resulting coadd in between the centers of the merged visits, compounding the problem and making some critical tags useless (misleading), coadds made of non-overlapping visits cause three potential problems, affecting any analysis, and all previous catalogs. To illustrate these problems we show an example, tile AIS_480, in Figure 3. In this case the database has merged two visits: one with both detectors exposed (shown as green dots in Figure 3) and one with only the NUV detector exposed (yellow dots). The database sources associated with this tile, i.e., the coadd, are shown in purple. The total exposure time given in the database is the sum of the exposures of the two visits, hence all the AIS_480 sources (the purple dots) appear to have FUV exposure equal to that of the first visit, and NUV exposure equal to the sum of the two visits. But this is only true in the area of overlap of the two visits, which is very small in this case. In the yellow-dot-only area (portion of visit 2 not overlapping with visit 1), sources have FUV-mag $= -999$ (i.e., non-detection), but they appear to have an FUV exposure $>0$ (as the same exposure is given for the entire coadd), therefore they would be erroneously interpreted as having FUV flux below the detection threshold, while in fact they have no FUV data. In the green-dot-only area, sources appear to have an NUV exposure equal to the sum of the two visits, while they only have the exposure time of visit 1. Such improper coadds then introduce two biases when one selects—as we do in our previous, and current, catalogs—only fields with both detectors exposed, and we include for each field only sources within a certain radius from the field center to avoid rim artifacts and poor source photometry in the outer edge of the fov.

First, the green-only sources, which would meet our catalog selection criteria (both detectors exposed), are not included in the catalog, because the center of the tile is the center of the coadd (in Figure 3, top panel, the black dots are the sources within 0.5' from the coadd’s field center). Second, some yellow-only sources (within the 0.5 circle from the coadd center) intrude on the sample despite actually having no FUV exposure. The consequences will be, for example, that the ratio of FUV detections over NUV detections will be incorrect, and thus any interpretation of UV color will be incorrect as well. In sum, these “bad coadds” cause: (i) loss of sources that should have been included, (ii) intrusion of sources not meeting the criteria, and (iii) misleading exposure times for the included sources. In addition, and worst of all, (iv) our criterion of limiting the catalog to sources within 0.5' from the field center, intended to exclude the numerous rim artifacts and distorted sources along the edge of the fields, is nullified by the fov_radius value being assigned by the pipeline with respect to the centering of the coadd: Figure 3 shows that the merged sources within 0.5' from the coadd center include part of the rim of both visits. In fact, by imposing a limit of fov_radius $\leq 0.5'$, we would expect no sources with rim artifact flag in the catalog; instead, there are 116,530 sources with fuv_artifact = 32 and 74,579 with nuv_artifact = 32 in BCScat_AIS. These were introduced by the coadds in which non-overlapping visits had been merged by the pipeline (hereafter bad coadds). This problem had never been reported previously to our knowledge. When we discovered it, we undertook an effort to identify all the bad coadds in the database, and patch the catalogs. The result is the GUVcat_AIS presented here.

The first step for constructing a revised catalog was therefore to identify the bad coadds, and to use the data from the corresponding individual visits instead of the coadd in such cases. To identify the bad coadds, we compared the center of each of the 28,707 AIS tiles with the centers of their associated visits (i.e., the visits used by the pipeline to build each coadd). For all cases where the center of one or more of the associated visits differs by more than 5' from the center of the coadded tile, we discarded the coadd and ingested in the catalog the corresponding visits (those that satisfy the criteria of both detectors being exposed). In this way we ensure that an FUV non-detection in the catalog is an actual non-detection and not a non-exposure, that the exposure times are correct, and that the centers correspond, within a given tolerance, to the actual centers of the observation (visit) so there is no loss of good sources, and no inclusion of rim artifacts (see also the next section). We chose a tolerance of 5' between visit centers as a good compromise, to use as many of the coadds (which offer the most exposure available in each field) as possible without introducing the negative effects described above.

Out of a total 28,707 AIS fields with both FUV and NUV exposure $>0$, made up of 57,000 visits, there are 640 bad coadds$^6$, made up of 1195 visits. Of these visits, 886 have both FUV and NUV exposed: these have been used to construct the new catalog, in place of their corresponding 640 bad coadds. The bad coadds identified in this way are spread all across the sky, therefore it was not possible to simply patch a subset of the previous (BCScat) catalog by removing the bad coadds and replacing them with data from the individual visits, because to construct the unique-source catalog, duplicate measurements of the same source had been identified and removed. Some of the bad coadds overlap with other (good) fields, and the procedure constructing the catalogs eliminates duplicate measurements from overlapping fields.

We therefore constructed a new catalog, GUVcat_AIS, using all the “good” coadds (28067, with both FUV and NUV exposed, visit positions within each coadd differing by no more than 5'), and for the bad coadds, the individual visits of that tile instead. Table 4 (electronic only) lists the centers of the tiles used to construct the new catalog, and specifies whether coadd (“C”) or visit (“V”) photometry was used. The 640 bad coadds are listed in Table 5 (electronic only); we release this list too, because it may be of general interest, in providing to users of the GALEX database a quick quality check of the data they use. Because of its potential more general use, in Table 5 we include all AIS coadds and visits regardless of exposure, although in our catalog we only retain observations with both detectors exposed. These are easy to identify, having both exposure times $>0$, and are indicated as “G” in the last column of the table (they were included in BCScat); “N” indicates those that are not included.

In the next section we describe the criteria used to construct the new catalog, which largely follows our previous recipe

\footnote{We define as bad coadd a field in the database that was made by combining visits of which at least one has its center $>5'$ away from the coadd’s center.}
(Bianchi et al. 2011a, 2014a), with several improvements. Five of the coadds, which appear to have both FUV and NUV exposure, were not replaced by their individual visits because each one consists only of two visits, non-overlapping, one exposed only in NUV and one exposed only in FUV. These coadds were included in BCScat, but are excluded in the present catalog, and not replaced by visits. They have the following photoextractid: 6385728408348786688, 63857284-22307430400, 638572848788762880, 6385728475084439520, 63867487594330112. These entries are marked with “N” in the last column of Table 5. For one of these fields the difference between the center of the two visits is only 5’/4: this implies that most of their sources (except for an outer annulus) may have good measurements in both filters. We had nonetheless to apply a consistent criterion to discard bad coadds, therefore these data are not included in GUVcat_AIS.

To summarize: in the GALEX database there are 28,707 AIS fields (coadds) that appear to have both FUV and NUV exposure >0; we examined the distance between the center of each coadd and the center of the visits which were combined to produce it, and found 28,067 good coadds (distance between all visits of the same coadd < 5’) resulting from 54,996 visits, and 1195 visits whose centers differ >5’ from the center of their coadd, affecting 640 coadds. These 640 bad coadds are made up of 2400 visits in total; we discarded these coadds, and used only visits with both FUV and NUV exposure >0 to replace them: 1468 visits.

5.2. Criteria for Constructing the UV Source Catalog

The catalog was constructed from the database source photometry with the criteria given below, following the recipe of Bianchi et al. (2011a, 2011b, 2014a), where other details can be found, and of which the present catalogs represent the updated and expanded version. We used the photometry from 28,067 AIS good coadds, plus 1468 visits that replaced 635 of the 640 bad coadds as described in the previous section; the ensemble of these data sets includes the whole AIS coverage with both FUV and NUV detectors exposed.

The catalog includes sources:

1. From observations with both FUV and NUV detectors on. This restriction is useful for science applications in which the fraction of sources with a given FUV–NUV color is of interest, or to estimate the fraction of sources with significant detection in FUV over the total NUV detections (e.g., Bianchi et al. (2014a), and Sections 6 and 8). More observations, taken with one of the two detectors turned off (mostly FUV), exist in the MAST database. Including in our catalog observations where one detector was not exposed would bias any statistical analysis, since the FUV magnitude of a NUV-detected source appears in the database as a non-detection (FUV$_{mag}$ = −999) either because the FUV detector was turned off, or the FUV detector was on but the FUV flux of that source was actually below the detection threshold. In some cases the exposure is not the same in both detectors (exposure times are also given in Table 4). We used all AIS data in which both detectors’ exposures were >0.

2. Within the central 0.55% (GUVcat_AIS_055) or 0.50% (GUVcat_AIS_050) radius of the field of view (fov$_{radius}$ ≤ 0.55 or 0.50, respectively), to avoid sources with poor photometry and astrometry near the edge of the field, and rim artifacts. This restriction yields source samples with overall homogeneous quality, and minimize artifacts, without great loss of area coverage. Users interested in a particular source that falls on the outermost edge of a GALEX field should obtain the measurements from the GALEX database and carefully examine the quality. The less conservative fov$_{radius}$ ≤ 0.55 limits reduce gaps between fields and increases total area coverage (see Section 7), while still excluding the outermost rim in nearly all data (Section 6.2).

3. With NUV magnitude errors ≤0.5 mag; that is, all sources with NUV detections are retained, regardless of detection in the FUV filter. Typically, about 10% of the NUV-detected sources are also detected in FUV (Bianchi et al. 2011b). Effects of error cuts on the resulting samples can be seen from Figure 4 of Bianchi et al. (2011a), and Figures 2–4 of Bianchi et al. (2011b). Sources in the database having a FUV detection with no NUV counterpart will not make it into the catalog: these cases are very rare, and are either mismatches or artifacts (see later), or cases where the pipeline resolves individual sources in FUV but merges them into one extended source in NUV, such as, for example, in the center of globular clusters (Figure 5(c)).

4. Unique, i.e., duplicate measurements of the same source are identified and removed: each object is counted only once in the GUVcat catalog. The procedure for defining duplicates is fully described in Appendix A, as it involves often neglected complexities. The unique-source catalog is useful for most science applications, such as examining the density of sources, and for cross-matching with other catalogs. Online, we also provide a master catalog (GUVcat_plus) in which duplicate measurements are identified and flagged but not removed. Details can be found in Appendix A. The identified repeated measurements could be used in principle for serendipitous variability searches; we provide tags giving magnitude difference between “primary” and “secondary” sources, but...
mainly for the purpose of checking consistency between repeated measurements. Because our catalog made use of coadds as much as possible, variability searches will be more productive on catalogs extracted at the visit level, or better yet with subvisit integrations, which we will present in follow-up works (L. Bianchi et al. 2017c, in preparation; C. Million et al. 2017, in preparation).

There are five AIS fields (photoextractid $=$ 637992303312-5027840, 6381259965176217600, 6379711852804308992, 6372041728408420352 and 6379571150749433856) where both FUV and NUV detectors were exposed, but NUV and FUV sources do not match: all sources with NUV measurements show no FUV detection (FUV$_{\text{mag}} = -999$), and vice versa all FUV sources have NUV$_{\text{mag}} = -999$. These fields are nonetheless included in the catalog because they satisfy all the defined criteria; however, users must keep in mind that such a mismatch would cause a false statistics of FUV–NUV colors in these fields. In Appendix C we show one of these fields, and also use it as example to illustrate the main artifact flags of the GALEX sources.

Figure 5. (a) Example of pipeline photometry for an extended disk galaxy, NGC 300 ($D_{25} \approx 0.2$). The central parts of the disk are measured by the pipeline as unresolved extended sources; in the periphery and less dense regions, where individual peaks are resolved, the source density is much higher than that in the surrounding field. Therefore, density counts of foreground stars or background AGNs, for example, will be highly biased if sources in this region were not excluded. We marked all sources retained in GUVcat (duplicate measurements are removed) and associated with NGC 300 by our inlargeobj flag (within 1.25X $D_{25}$). The source shape is drawn, with an ellipse based on the pipeline-derived $2.35 \times \text{nuv}_a \_\text{world}, 2.35 \times \text{nuv}_b \_\text{world}$ (this choice is to match the pipeline ds9reg file), nuv$_{\text{theta}}$ (position angle). They may appear different using kron radius $\times$ nuv$_a \_\text{world}$, which would show the area where the mag$\_\text{auto}$ are integrated. Aside from details and differences among various magnitude extraction options, which can be examined in the catalog, the figure illustrates convincingly that pipeline photometry in very extended galaxies must not be used for source counts. The GUVcat tag inlargeobj allows sources in these areas to be excluded. Note that some large sources have two measurements: these come from two overlapping AIS observations, which placed the centers of the big ellipses more that 2''5 apart from each other, therefore they were not eliminated as duplicates in GUVcat. The image is 1455'' on a side. (b) GALEX pipeline sources in the master database around NGC 300: AIS as blue circles, NGS (about two mag deeper than AIS; see Bianchi 2009) as orange circles. Note that here duplicates have not been removed, and all measurements are shown, making the sources appear more numerous than in GUVcat (previous figure). There is an even deeper GI observation that is not shown, for clarity. The left panels show all entries in the master database, and the right panels only show those with NUV$_{\text{err}} \leq 0.5$ (as in GUVcat, which eliminates some spurious sources and many artifacts). (c) Example of pipeline photometry for a crowded stellar cluster, NGC 6218. Sources retained in GUVcat are drawn, as in the Figure 5(a), according to their database photometry extraction parameters. The color image was constructed for all available imaging for the field, including deeper exposures. Clearly visible blue sources in the cluster are only detected by the pipeline in FUV (and therefore not retained in GUVcat, which uses as a starting point the NUV source detections); see the next figure. The large circle shows the pipeline aperture of the central source (drawn as explained in the previous figure), taken from NUV, showing how the pipeline neither provides accurate integrated measurements nor robust crowded-field measurements of resolved stars in the cluster. The image is 1332'' on a side. (d) AIS detections in the master database for NGC 6218 (only source centers shown, not source shapes). Top: FUV detections (left) and NUV detection (right); bottom: sources detected in both FUV and NUV. Note that from the shape of the pipeline sources shown in the previous figure, matching FUV and NUV colors in the central region would not be correct, even for sources where a match exists.
6. Content and Structure of the Catalog

The catalog includes 82,992,086 unique sources (GUVcat_AIS_055), from a total of 86,632,284 AIS measurements (GUVcat_AIS_plus, before duplicates are removed). The version restricted to sources within the central $1^\circ$ of the GALEX field, GUVcat_AIS_050, contains 69,772,677 sources. Note that the majority of these measurements are from coadds (Section 5.1), therefore duplicate measurements only occur in field overlaps or repetitions. These fields are the result of over 56,000 visits; many repeats at visit level were already merged in the good coadds we used.

Tables 6 and 7 give the number of sources included in GUVcat_AIS, at different galactocentric latitudes, the fraction which have multiple measurements, those affected by artifacts, and samples with magnitude and color selections. Whole-sky maps of the density of UV sources and their characteristics across the sky were shown by Bianchi et al. (2014a), who highlighted interesting distributions of hot stars in the Milky Way, among other trends.

The catalog gives several tags for each source, including position (R.A., decl., Galactic $l, b$), photometry measurements in FUV and NUV, and their errors (“nuv_mag” and “fuv_mag” are the “best” measurements as chosen by the pipeline, and preferable in most cases; other measurements are also included, such as PSF photometry, aperture photometry with different apertures, and Kron-like elliptical aperture magnitudes), other parameters useful to retrieve the original image from which the photometry was extracted (tag photoextractid), as well as artifact flags and extraction flags that can be used to eliminate spurious sources (see Section 6.2 below). In addition to these astrometry and photometry tags, propagated from the GALEX pipeline processing, we include new tags informative of the existence of duplicate AIS measurements or nearby sources described in Appendix A, and tags indicating whether the source falls within the footprint of a large object such as a galaxy or Milky Way stellar cluster. These added tags facilitate extraction of clean samples for science applications of the catalog. The complete list of tags and their description is given in Appendix B.

The catalogs can be downloaded from the author’s web site: http://dolomiti.pha.jhu.edu/uvsky/#GUVcat, and will also be available from the MAST casjobs web site (http://mastweb.stsci.edu/gcasjobs) and from the SIMBAD Vizier database, which allows VO-type queries, including cross-correlation with other catalogs in the same database.

6.1. Sources in Extended Clusters or Galaxies

While we cannot and should not exclude from the catalog the sources (as measured by the pipeline) in extended galaxies or crowded fields, for the convenience of the catalog’s users we...
flagged all sources that fall within the footprint Galactic stellar clusters or galaxies larger than 1′. We added a tag \texttt{inlargeobj} that contains the identifier of the large object prefixed by “GA:” for galaxies (e.g., GA:NGC300), “GC:” or “OC:” for globular clusters and open clusters, respectively (e.g., GC:NGC 5272), and “SC:” for less well-defined cluster types. We also added the tag \texttt{largeobjsize}, which gives the D$_{25}$ diameter for galaxies, or twice the radius for stellar clusters. Note that 1′ is a very conservative limit, for the purpose of eliminating crowded regions, but a user can choose to worry only about larger objects using a combination of these two tags, which we highly recommend. We provide finding charts for all of the extended objects (>1′) in the footprint of GUVcat_AIS. These can be found in the GUVcat tools on the author’s web site \url{http://dolomiti.pha.jhu.edu/uvsky/#GUVcat}.

The stellar clusters included for flagging were taken from the compilation available at \url{https://heasarc.gsfc.nasa.gov/W3Browse/all/mwsc.htm}, which basically includes all globular clusters from Harris (1996), which are all confirmed objects, and includes as “open clusters” confirmed, candidate or doubtful clusters, or spurious objects such as OB associations and large nebulae. Of course, the definition of open clusters is less specific than is possible for globular clusters, and their stellar density also varies more widely. As pointed out in Section 4.2, only in the most crowded regions of clusters would the source extraction fail. In the dense central regions of globular clusters, the pipeline sometimes integrates a large area as one extended source. This may happen both for galaxies and for crowded stellar clusters; examples are shown in Figure 5.

The \texttt{heasarc} catalog gives three values of radius: $r_0$ (radius of the cluster core in the visible, corresponding to the distance from the center where the radial density profile becomes flatter), $r_1$ (where the radial density profile abruptly stops decreasing), and $r_2$ (where the surface density of stars equals the average density of the surrounding field); it also gives the number of (optical) sources within these radii. In order to select the most appropriate value of cluster radius for our purpose, i.e., to exclude only sources that would very likely introduce statistical biases, we examined two classical examples, NGC 188 and NGC 2420. By combining the number of sources with the cluster sizes, we concluded that $r_1$ is a good compromise, although somewhat conservative. OB associations are interesting objects per se, but are sparse and are much less likely to suffer from crowding problems, and to introduce significant overdensities in global source counts. Therefore, we restrict the “open cluster” list to only confirmed clusters, and we further restricted these by combining the criteria of \texttt{cluster\_status}, not “C” (candidate), and \texttt{cluster\_type}, neither “DUB” nor “NON.” In total, 48 GC and 324 OC are included, entirely or partly, in the GUVcat footprint, and all are shown in our \texttt{uvsky} web pages. Table 2 (electronic...
only) lists the centers, size and other parameters for Galactic clusters.

Table 3 (electronic only) gives a list of centers, major and minor axes, position angles (PAs), and other basic parameters for extended galaxies with major axes $D_{25} \geq 1\arcmin$. The galaxies (22,037) were selected from the hyperleda database, with no other restriction than the size, $D_{25} \geq 1\arcmin$. In total, 15,659 of these galaxies with $D_{25} \geq 1\arcmin$ are included (at least partly) in the GUVCat_AIS footprint. We flagged sources out to $1.25 \times D_{25}$, a choice based on inspection of several maps, available on our web site,\textsuperscript{8} of which Figure 5 shows an example. Note that most galaxies with sizes $\approx 1\arcmin$ are probably detected as a single (extended) source, or a few sources, in the GALEX data. Therefore, while the $1\arcmin$ size limit provides a very comprehensive flagging, for statistical analyses of large samples of sources, a much larger radius can be used to exclude only galaxies for which the pipeline photometry is misleading.

For many science applications, such as statistical studies of source densities and luminosity functions, the area covered by the catalog must be calculated. Portions optionally excluded (because they are in the footprint of a cluster or galaxy) must be taken into account in the area calculation. Our interactive area calculation tools will offer some options (Section 7) for area estimates in the cases where large object footprints are

\begin{table}
\centering
\caption{List of Clusters Included in the GUVCat Footprint}
\begin{tabular}{cccccc}
\hline
Name & R.A. & Decl. & Central Radius & Broad Type & Cluster Status & Cluster Type \\
\hline
IC4499 & 225.076996 & $-82.213997$ & 0.085000 & G & O & GLO \\
\hline
\end{tabular}
\end{table}

\textsuperscript{8} http://dolomiti.pha.jhu.edu/uvsky/#GUVCat

\textbf{Figure 5.} (Continued.)
Note. In total, 28067 coadds and 1468 visits are used to build GUVcat_AIS.

Table 3
List of Galaxies Larger than 1° Included in the GUVcat Footprint

| Name          | Type | R.A. degrees | Decl. degrees | v3k km s⁻¹ | vlg km s⁻¹ | PA degrees | Inclination degrees | log(D25) (0.1 arcmin) | log(D25 Error) (0.1 arcmin) | log(R25) D25/d25 | log(R25 Error) |
|---------------|------|--------------|---------------|------------|------------|-------------|---------------------|----------------------|---------------------------|------------------|---------------|
| UGC 12889     | G    | 0.0070005    | 47.27450      | 4751       | 5319       | 163.5       | 53.4                | 1.27                 | 0.03                       | 0.20             | 0.03          |

(This table is available in its entirety in machine-readable form.)

Table 4
List of AIS GALEX Fields (coadds and visits) Used to Construct the GUVcat_AIS Catalog

| Field          | R.A. Center degrees (avaspra) | Decl. Center degrees (avasapdec) | l Center degrees | b Center degrees | FUV exp.time (s) | NUV exp.time (s) | C or V |
|----------------|-------------------------------|---------------------------------|-----------------|-----------------|-----------------|-----------------|-------|
| 6370915756560875520 | 291.449459                   | 75.146935                       | 106.972770     | 23.963759       | 219.050         | 219.050         | coadd |
| 63709157557634617344 | 273.010299                   | 80.131423                       | 111.833168     | 28.552309       | 213.000         | 213.000         | coadd |
| 6370915758708359168 | 282.810539                   | 78.033136                       | 109.575259     | 26.360347       | 251.000         | 251.000         | coadd |
| 6370915759782109992 | 278.835416                   | 78.547001                       | 110.147665     | 27.387182       | 216.000         | 216.000         | coadd |
| 6370915760855842816 | 273.760205                   | 79.023568                       | 110.744419     | 28.396397       | 198.000         | 198.000         | coadd |
| ...             | ...                           | ...                             | ...            | ...             | ...             | ...             | ...   |
| 63709157608343156736 | 257.1537508                  | 71.986534                       | 103.457631     | 33.558659       | 109.000         | 109.000         | visit |

(These tables are available in their entirety in machine-readable form.)

6.2. Flagged Artifacts

Table 2 of the GALEX GR6 documentation (galex.stsci.edu/GR6/?page=ddfqa#6) lists the value of the artifact flags (FUV_artifact and NUV_artifact in the catalog), and suggests that the only artifact flags causing real concern are the Dichroic reflection (artifact = 4, base 10 value, or artifact = 64 when a coadd has enough visits at different PAs that masking the Dichroic reflection does not decrease the flux by more than 1/3rd) and Window reflection (applicable to the NUV detector only: NUV_artifact = 2). Most of the artifacts in the original database are caused by the detector rim (artifact = 32), or reflections around the edge: these do not affect our catalog since we exclude the outer edge of the fov (Figure 8). In more detail: the version that retains sources within 0.5° from the field centers, GUVcat_AIS_055, excludes a 0°06-wide outer ring; this is sufficient to eliminate rim artifacts, except in a few cases, because in GUVcat we retained coadds of visits with a tolerance of up to 5° between the pointings of the individual visits. In the worse case of two coadded visits having centers 5° apart, the fov_radius of the coadd sources may also differ by up to 5° from the actual distance of the source from the center of its visit, therefore a few rim artifacts may be included. Such tolerance of 5° centering difference between visits of coadds was chosen to maximize the area coverage of the catalog, and to avoid throwing away much data or much exposure depth. As a consequence, in GUVcat_AIS_055 there remain 23,218 sources with either the FUV or NUV rim artifact flag set, out of the ~83 million catalog sources. These sources have fov_radius (distance from the coadd center) between 0°5125 and 0°55, and all come from coadds as expected. By comparison, there are 31,184,260 sources with either the fuv_artifact or nuv_artifact rim flag set (6,765,612 with fuv_artifact flag set) in the whole visitphotoobjall GALEX database, and 25,259,384 sources with the fuv_artifact or nuv_artifact rim flag set (25,221,382 NUV: 18,592,421 FUV) in the whole photoobjall GALEX database of 292,296,119 entries. Note that the GALEX field has a diameter of ≈1°2, therefore the actual fov_radius of any source should always be <0°6, and rim sources should have fov_radius ~ 0.6, but in the MAST GALEX database the sources with “rim” artifact flag set have values of fov_radius between 0° and 1°, an effect of the improper coadd described in Section 5.1, where the rim artifact has been propagated from the visit-level processing, while fuv_radius has been recalculated using the center of the coadd; therefore an actual rim source may end up having an apparent fov_radius near zero (near the center of the coadd), or a value almost twice the GALEX fov radius. This is illustrated in Figure 3 and was explained in Section 5.1. This problem is cured in GUVcat.

In the GUVcat_AIS_050 catalog there are no rim or edge artifacts, since we only retained sources within 0°5 from the field center, which leaves out, even with a 5° tolerance for coadds, an outer ring of ≥0°71 width. This restriction comes at the price of a ~10.7% decrease in area coverage, as explained in Section 7, introducing occasional gaps between adjacent fields.

Masked variable pixels (artifact = 128) and masked detector hotspots (artifact = 256) may degrade the quality of a photometric measurement but would not introduce spurious sources, and they are rare, therefore they are not relevant for the purpose of source counts. What does introduce a high number of spurious source detections (once the rim is excluded) are reflections and “ghosts” near very bright sources. We show examples in Appendix C. A conservative recommendation is to eliminate sources with artifact = 4 or 2. Note that if more than one artifact is deemed to be present, the flag value is the sum of all the artifacts affecting the source. Table 6 also gives the fraction of
sources with different artifact flags in GUVcat_AIS catalog, and reports the artifact definitions in the table’s footnote.

7. Area Coverage of the Catalogs

For studies involving density of sources (number per unit area), the exact area coverage of the catalog must be known. As we removed duplicate measurements of the same source, we must calculate the area covered by the surveys accounting for overlaps. We must also account for possible gaps between fields; these may occur because of the tiling strategy (for example, to avoid bright stars that would damage the detectors), or because the actual pointing of an observation is slightly off from the planned position, and because we limited our catalogs to sources within the central 1°1 (or 1°0) diameter of the GALEX field.

We calculated the total actual area covered by GUVcat_AIS with the method of Bianchi et al. (2011a): we divided the sky into small tesserae, and added the areas of all tesserae that fell within 0°55 (or 0°50) from the center of every field used in the catalog, ensuring that each tessera was counted only once. The total area covered is 24,790 square degrees for GUVcat_AIS_055, and 22,125 square degrees for GUVcat_AIS_050. This area of “unique-coverage” is ≈95% (with fov_radius ≤ 0.55) and 88% (with fov_radius ≤ 0.5) of the sum of areas of the fields used (if there was no overlap between observations), implying an overall overlap of ≈11.7% and 4.6%, respectively, among the AIS fields used. Area coverages of 5° latitude slices for the catalog are given in Table 6.

Because both gaps and overlaps between fields occur, the actual area coverage must be computed for each region of the sky where one desires to extract a sample, if the density of sources has to be estimated. An online interactive tool will be presented elsewhere, for area calculations of custom-chosen regions, for the GUVcat and BSCcat catalogs, and for matched GUVcat–optical catalogs (L. Bianchi & A. de la Vega 2017, in preparation).

8. Conclusions and Summary

8.1. The UV Sources across the Sky

Bianchi et al. (2014a) published several maps showing the distributions of UV sources in the sky, for both the AIS and the deeper MIS survey. In Figure 6 we show the density of sources (number per square degree) detected in the NUV and FUV bands; as discussed extensively by Bianchi et al. (2011a, 2011b, 2014a) the number of FUV detections is typically 10 times less than the NUV detections overall; this happens because hot stars, and blue galaxies, are much more rare than cooler (redder) objects. More specifically, the fraction depends on Galactic latitude and on the magnitude depth considered, because the number of extragalactic sources with respect to Galactic stars increases rapidly toward fainter magnitudes. The relative fractions are a combinations of the intrinsic distribution of different types of sources, whereby the density of Galactic stars increases toward the disk of the Milky Way, while the distribution of extragalactic sources does not depend on the Milky Way structure, but all sources are affected by the Milky Way dust, which is mostly confined to a thin disk. The reddening therefore depends on the line of sight toward the sources going through more or less of the dust disk. This effect was dramatically illustrated by Figure 2 (bottom) of Bianchi et al. (2011a): the “V-shape” region devoided of UV-source counts in their figure is essentially a direct image of the dust disk. It is also visible, though less evident, in Figure 6.

In Figure 6 we plot the density of NUV and of FUV sources in GUVcat_AIS (top plot) as a whole and divided by NUV magnitude ranges; the plots show that the sources fainter than NUV_mag = 21mag dominate the sample, despite AIS being the shallowest survey, and especially in the NUV, where extragalactic objects are more prominent. The bottom panels show the fraction of FUV detections over NUV detections, again as a function of Galactic latitude, and among these, the hot and very hot sources (FUV_mag-NUV_mag ≤ 0.5 and ≤ 0.0 respectively). Such UV color cuts correspond to different stellar Teff for different types of stars (Bianchi 2009), but roughly hotter than ~15,000 K. Some QSOs may intrude on these FUV–NUV color cuts, as shown by Bianchi et al. (2009): these affect the faint sources most. The different behavior of relative source densities in Figure 6 reflects the fact that brighter samples (and hotter samples) are dominated by Galactic stars, which are more numerous in the Milky Way disk (see, e.g., Bianchi et al. (2011a)).

8.2. Summary of Suggestions and Caveats for Using the Catalog

To conclude, we distill here, in terms of practical advice for users, the relevant information on the catalogs presented in this paper.

1. GUVcat_AIS contains unique measurements of all sources from AIS observations with both FUV and NUV detectors exposed. Duplicate measurements are removed in the main catalog, however, a version called GUVcat_AISplus is accessible where duplicate measurements are flagged but not removed.

2. GUVcat is available from http://dolomiti.pha.jhu.edu/uvsky/#GUVcat as well as MAST casjobs (http://mastweb.stsci.edu/gcasjobs), and SIMBAD Vizier.

3. Sources near the field’s edge have been excluded, because they are mostly artifacts or have poor photometry. GUVcat_AIS_0.55 contains sources within 0°55 of the field’s center, GUVcat_AIS_0.50 only sources within 0°50. The first has a larger area coverage, fewer gaps, at the expense of a few rim artifacts intruding the catalog; these must be sieved from samples using the artifact = 32 flag (Section 6.2). Tables 6 and 7 give statistical information on the number of sources, and the fraction of sources affected by artifacts, or in given UV-color ranges, in total and divided by Galactic latitude.

4. Area coverage of our catalog GUVcat, BSCat, and of overlap of these catalogs with optical databases, can be calculated for any desired region of the sky with the tool of L. Bianchi & A. de la Vega (2017, in preparation). See also Column 9 of Table 6.

5. Extended Objects: beware of sources in the footprint of large galaxies or crowded stellar clusters (Section 6.1). These can be identified and eliminated with the two tags inlargeobj and largeobisize, provided in GUVcat. The web site http://dolomiti.pha.jhu.edu/#GUVcat also gives finding charts and information on all large objects included entirely or partly in GUVcat.

The size limit of the extended objects that one should eliminate from the catalog depends on the specific objectives and sample size; if one needs to compute area
### Table 5

List of AIS Eliminated bad coadds, and Their Associated Visits

| coadd ID (photoextractID) | coadd R.A. (degrees) | coadd Decl. (degrees) | coadd lon (degrees) | coadd lat (degrees) | coadd exp.time (s) | visit ID (photoextractID) | visit R.A. (degrees) | visit Decl. (degrees) | visit exp.time (s) | Distance coadd-visit in GUVcat? |
|--------------------------|----------------------|-----------------------|---------------------|---------------------|-------------------|--------------------------|----------------------|---------------------|-------------------|-----------------------------|
| 6370915845681446912      | 257.195457           | 71.984578             | 103.457631          | 33.558659           | 109.000           | 267.000                  | 6370915708276047872 | 257.490785          | 71.946748          | 5.937 N                     |
| 6370915845681446912      | 257.195457           | 71.984578             | 103.457631          | 33.558659           | 109.000           | 267.000                  | 6370915708309602304 | 257.051516          | 72.006587          | 2.978 N                     |
| 6370915845681446912      | 257.195457           | 71.984578             | 103.457631          | 33.558659           | 109.000           | 267.000                  | 6370915708343156736 | 257.153751          | 71.986534          | 0.783 G                     |
| 6370950948449157120      | 250.541348           | 70.399218             | 102.543859          | 36.089296           | 171.000           | 350.050                  | 6370950811043758080 | 250.893395          | 70.436709          | 7.428 N                     |
| 6370950948449157120      | 250.541348           | 70.399218             | 102.543859          | 36.089296           | 171.000           | 350.050                  | 6370950811077312512 | 250.64435           | 70.466918           | 4.489 N                     |
| 6370950948449157120      | 250.541348           | 70.399218             | 102.543859          | 36.089296           | 171.000           | 350.050                  | 637095081110866944 | 250.340422          | 70.356973           | 4.776 G                     |
| 6370950948449157120      | 250.541348           | 70.399218             | 102.543859          | 36.089296           | 171.000           | 350.050                  | 637095081144421376 | 250.346796          | 70.319619           | 6.181 G                     |
| ...                      | ...                  | ...                   | ...                 | ...                 | ...              | ...                      | ...                  | ...                 | ...              | ...                          |

**Note.** Note that the 640 bad coadds were included in BCScat, prior to our discovery of the database improper coadding of non-overlapping visits; they are not used in GUVcat, and their corresponding visits with both FUV and NUV exposure times >0 are used instead (1468 out of 2004 total).

(This table is available in its entirety in machine-readable form.)
| Latitude Range | #Sources Total | #Sources with Grank % | % Sources with Grank Area | Area (deg^2) | #Sources with Artifact= |
|----------------|---------------|-----------------------|-------------------------|-------------|------------------------|
| 85.0N          | 249745        | 240811                | 8934                    | 0           | 96.42                  |
| 80.5N          | 575444        | 20563                 | 0                       | 96.43       |
| 75.0N          | 1044253       | 36999                 | 0                       | 96.46       |
| 70.75N         | 1465351       | 54229                 | 7                       | 96.30       |
| 65.70N         | 1703241       | 62371                 | 51                      | 96.34       |
| 60.65N         | 2098214       | 78030                 | 155                     | 96.27       |
| 55.60N         | 2593208       | 94480                 | 134                     | 96.35       |
| 50.55N         | 2684044       | 258214                | 101731                  | 96.20       |
| 45.50N         | 3235685       | 125810                | 93                      | 96.11       |
| 40.45N         | 3621419       | 148252                | 288                     | 95.89       |
| 35.40N         | 3724140       | 150061                | 167                     | 95.97       |
| 30.35N         | 3887581       | 156816                | 113                     | 95.96       |
| 25.30N         | 3923424       | 163994                | 95                      | 95.82       |
| 20.25N         | 3830858       | 163192                | 185                     | 95.74       |
| 15.20N         | 2813302       | 104400                | 117                     | 96.28       |
| 10.15N         | 3417929       | 142954                | 140                     | 95.81       |
| 05.10N         | 1129788       | 35866                 | 12                      | 96.82       |
| 00.05N         | 137477        | 134551                | 296                     | 97.87       |
| 05.00S         | 98225         | 96655                 | 1570                    | 98.40       |
| 10.05S         | 576514        | 15380                 | 0                       | 97.64       |
| 15.10S         | 1885871       | 59315                 | 5                       | 96.85       |
| 20.15S         | 2980857       | 106665                | 59                      | 96.42       |
| 25.20S         | 3296612       | 137154                | 253                     | 95.83       |
| 30.25S         | 3562226       | 159010                | 420                     | 95.65       |

Table 6
Catalog Source Statistics
| Latitude Range | #Sources Total | #Sources with Grank | % Sources with Grank | Area (deg²) | Band | #Sources with Artifact = |
|----------------|----------------|----------------------|---------------------|-------------|------|---------------------|
|                |               | =0                   | =−1                 | =+1        |      |                     |
| 35_30S         | 3872172       | 3702613              | 169181              | 378         | 95.62 | 4.37 0.010 1126.6   |
|                |               |                      |                     |            |      |                     |
| 40_35S         | 3628761       | 3456338              | 171585              | 838         | 95.25 | 4.73 0.023 1115.4   |
|                |               |                      |                     |            |      |                     |
| 45_40S         | 3438189       | 3287766              | 149958              | 465         | 95.62 | 4.36 0.014 1058.0   |
|                |               |                      |                     |            |      |                     |
| 50_45S         | 3210828       | 3054911              | 154880              | 1037        | 95.14 | 4.61 0.033 957.5    |
|                |               |                      |                     |            |      |                     |
| 55_50S         | 2936108       | 2786459              | 147733              | 1916        | 94.90 | 5.03 0.065 885.6    |
|                |               |                      |                     |            |      |                     |
| 60_55S         | 2825703       | 2694479              | 130287              | 937         | 93.56 | 4.61 0.033 829.0    |
|                |               |                      |                     |            |      |                     |
| 65_60S         | 2358898       | 2260825              | 97496               | 577         | 95.84 | 4.13 0.024 672.8    |
|                |               |                      |                     |            |      |                     |
| 70_65S         | 2181934       | 2082443              | 99008               | 483         | 95.44 | 4.54 0.022 620.9    |
|                |               |                      |                     |            |      |                     |
| 75_70S         | 1695985       | 1624317              | 71484               | 184         | 95.77 | 4.21 0.011 471.7    |
|                |               |                      |                     |            |      |                     |
| 80_75S         | 1169851       | 1111405              | 57573               | 873         | 95.00 | 4.02 0.075 333.0    |
|                |               |                      |                     |            |      |                     |
| 85_80S         | 811212        | 767146               | 43119               | 947         | 94.57 | 5.32 0.117 211.5    |
|                |               |                      |                     |            |      |                     |
| 90_85S         | 227334        | 217689               | 9574                | 71          | 95.76 | 4.21 0.031 66.4     |
|                |               |                      |                     |            |      |                     |
| Total          | 82992086      | 79549861             | 3431053             | 11172       | 95.85 | 4.13 0.01 24790.3   |

Note. GALEX artifact flags: Artifact 1 (1): (edge) detector bevel edge reflection (NUV only). Artifact 2 (2): (window) detector window reflection (NUV only). Artifact 3 (4): (dichroic) dichroic reflection. Artifact 4 (8): (varpix) variable pixel based on time slices. Artifact 5 (16): (brtedge) bright star near field edge (NUV only). Artifact 6 (32): detector rim (annulus) proximity (>0.6 deg from field center). Artifact 7 (64): (dimask) dichroic reflection artifact mask flag. Artifact 8 (128): (yarmask) masked pixel determined by varpix. Artifact 9 (256): (hotmask) detector hot spots. Artifact 10 (512): (yghost) possible ghost image from YA slope.
coverage of the extracted sample, the excluded footprints can be accounted for with our area calculation tool (L. Bianchi & A. de la Vega 2017, in preparation); however, the interactive public version currently uses a sky tessellation with a grid step of 0°.1 (so that a computation over the whole sky can be accomplished in a few tens of seconds); excluding any area smaller than, or comparable to the grid tesserae will introduce uncertainties in the area estimate.

6. Magellanic Clouds: only the periphery of the MC is included in GUVcat, because the central regions are only observed in NUV. Even the peripheral fields are crowded enough to pose a challenge to the pipeline photometric procedures: for point sources within a 15° radial distance from the center of the LMC, and a 10° radial distance from the SMC, it is preferable to use the custom-made catalog of D. Thilker et al. (2017, in preparation) and to avoid using this catalog or the master database. In Table 7 we count sources within 15°/10° radial distance from LMC/SMC, but for consistency with other galaxies, the flag inlargeobj is set only for GUVcat sources within 1.25× the hyperleda $D_{25}$ size, which is much smaller; these sources have the flags GA:ESO056-115 and GA:NGC0292 for the LMC and SMC, respectively. For the statistical overview in Figure 6 we conservatively excluded the 15°/10° degree areas, since we noted an overdensity of sources even in the outermost periphery of the Clouds.

7. Reddening correction: Table 1 gives extinction coefficients in the GALEX FUV and NUV bands for representative known types of interstellar dust; these coefficients can be used to correct the UV magnitudes for reddening. In the GUVcat catalog, an $-E_{BV}$ value is given for each source, based on the extinction maps of Schlegel et al. (1998); this value is approximate, as it represents an interpolation from low-resolution maps at the source position, and as such it is also an upper limit (a Galactic source very close will only suffer the absorption by the local component of the dust along the line of sight); it is a convenient indication of reddening. As
noted by Bianchi et al. (2011a, 2011b) and Bianchi (2011), the GALEX FUV–NUV color is almost reddening-free, for Milky Way typical dust (see also Table 1), and therefore it could be used to select hot stellar sources, almost independently of reddening, by Bianchi et al. (2011a).

8.3. Is a Source Not Detected, or Not Observed?

When one matches a source list to the GALEX catalog, if a source is not found (either in the entire database, or in GUVCat_AIS, or in any other catalog), one needs to know whether the source was observed but too faint to be detected in a given filter, or if it was not in the footprint of any actual observation. This holds for GALEX, SDSS, and any database that does not have a complete coverage of the sky, due to the nature of the survey or because there are some gaps or unusable portions of data.

The easiest and safest way to find out whether a given celestial position is within the footprint of any GALEX observation is to match the source coordinates to the list of visit centers (visitphotoextract in MAST casjobs) and check if the source position is within the fov radius from the center of any observation (navaspra, navaspsde for NUV; favaaspra, favaaspsde for FUV; avaspra, avaspspec for the combined FUV+NUV source list). This test should be done at the visit level, because of the issue of bad coadds described in Section 5.1. For the “good coadds” (only) one could use the photoextract values.

For other surveys, such as, for example, SDSS, where gaps among fields or failed observations are not always mapped consistently into the footprint tool (e.g., Bianchi et al. 2011a), one has to search for sources in a wider area around the source of interest, and if other sources are found around the position, a negative detection for the source of interest will imply that the source was observed but its flux is below the detection threshold. In this case, one could derive an upper limit from the exposure time of the observations in the area. This procedure works in any case, but it is more cumbersome, and it may not be entirely safe: if the catalog sources are sparse, one would need to probe fairly large portions of sky around the source of interest, to avoid false negatives; but in this way a “positive” detection will mean that some wide area around the desired position has some sources. If that happens to be near a field edge and the desired position is
just outside the edge, the “poor resolution” sampling of the surroundings may give a false positive.

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Appendix A
Criteria for Identifying and Removing Duplicate Measurements

The GALEX database in the MAST archive contains all existing measurements. For sources with repeated AIS observations (e.g., where different fields overlap, or the same field was repeated), we removed duplicate measurements as follows, to produce a unique-source catalog. GALEX sources within 2\(^{\circ}\)5 of each other but from different observations were considered duplicates. In such cases, the measurement from the observation with the longest exposure time (sum of FUV and NUV exposures) was retained, and—in cases of equal exposure time—the one closest to the center of the field in its parent image.

The choice of a 2\(^{\circ}\)5 match radius was based on several considerations. According to the archive documentation, the accuracy of GALEX source positions is of "0.32/0\(^{\circ}\)34 (NUV/FUV) in the GR7 data" and slightly worse, especially in FUV, in previous data. The GALEX pipeline uses a complicated probability algorithm to match FUV sources to the NUV sources of the same observation. In short, NUV and FUV matches are allowed up to 7\(^{\circ}\). We have examined statistically the tags informative of the FUVxNUV match process. Figure 4 shows the distribution of the separation between FUV and NUV position for a 2 million source subsample of the database, as a whole and divided by cuts in match probability (as defined by the pipeline algorithm). Our choice of a 2\(^{\circ}\)5 match radius to define duplicates corresponds statistically to a FUVxNUV match probability >0.3, and is consistent with the early versions of our catalogs (Bianchi et al. 2011a, 2014a), where it was found from other tests to be a good compromise between not excluding real sources and not retaining duplicate measurements. GALEX astrometry is more accurate than 2\(^{\circ}\), but the deblending of sources closer than this separation is not always robust due to the instrument resolution (∼4.2/5\(^{\circ}/3\), FUV/NUV). This was discussed in Section 4.2. In general, we expect most science applications of this catalog to be restricted to point sources, for which the chosen limit is appropriate.

While the criterion is simple in principle, here we add some important clarifications that were not described in the previous versions of the catalog, and that are relevant for any work requiring merging of overlapping observations. To identify duplicates, and eventually remove them, we search the master catalog around the position of each source, within the chosen match radius. If there is no other entry within the match radius of 2\(^{\circ}\), we assign to the source “grank = 0.” Thus, all sources with grank = 0 are also unique (i.e., they have only one measurement)

in the original AIS database.\(^{10}\) If within the match radius around a source “i” we find other sources, measured in a different observation, we assign grank = 1 to the best measurement of this group, the “primary” (which will be retained in the final catalog when duplicates are removed); the best measurement is the one with the longest exposure, or—for equal exposure—closer to the field center in its parent observation; we assign grank = 2, 3, \ldots to other sources within 2\(^{\circ}\)5 of the primary, ranked in order of distance from the primary. To keep track of duplicate measurements, since only the primary is retained in the end, we added a tag ngrank, indicating the number of matches to the primary (including the primary itself), and primgid, the identifier of the primary (the source with grank = 1) to which the sources with grank > 1 are associated. This basic definition is simple. However, there may happen to be sources—let’s say, a source “j”—farther than 2\(^{\circ}\)5 from the primary “i,” therefore not included in its group, but closer than 2\(^{\circ}\)5 to a source with grank > 1 in the group of the primary “i.” If the source previously assigned grank > 1 (with respect to source “i”), has better exposure time than its neighbor “j,” its grank cannot be reclassified to = 1 because it does not satisfy the primary criterion with respect to the (better) primary “i.” Therefore, the new source “j” must be retained in the catalog because it’s farther than 2\(^{\circ}\)5 from “i,” but we set its grank = −1 (instead of = 1), to indicate that another source within 2\(^{\circ}\)5 would have been a primary with respect to “j,” according to our “best measurement” criteria, if it were not a secondary with respect to another, better primary. The grank > 1 neighbor in our example is given ngrank = −89, so it can be identified in the master catalog as a potential primary (with respect to source “j”), which could not be retained in the unique-source catalog because it was a secondary with respect to source “i.” If, instead, source “j” has longer exposure than its neighbor with previous grank > 1 but shorter exposure than source “i,” for the source with grank > 1, which is a secondary associated to “i” (its primgid tag indicates the objid of its primary “i”), we still want to retain the information that there is another source ("j") within the match radius from it. This information is given in the tag groupgid, where all objid’s of sources within the match radius are concatenated. Also, the tag ngrank for source “j” indicates the number of all sources within the match radius (including the grank > 1 secondary associated to source “i”) but fewer secondaries than its ngrank will have primgid equal to objid of source “j.” This is easier to understand from some examples, which are shown in Figure 7. Such a variety of cases may seem like irrelevant subtleties for users of the final catalog, but is worth mentioning; in fact, any code performing associations of repeated measurements must include provisions for such cases, and more odd (and rare) situations, otherwise more sources will be eliminated than is necessary, or wrong associations will result. A code simply performing rank assignment looking for neighbors of each source sequentially, and not accounting for intersecting groups, would eliminate duplicates inconsistently among the sample.

With these—or any other—criteria to define duplicates, there may be sources that are within the match radius of more than one primary, the primaries being more distant than 2\(^{\circ}\)5 from each other. The assigned primary to each secondary, according to our standard recipe, is the one with the longest exposure time (best

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\(^{9}\) The current GALEX database is called “GR6plus7” because not all data have been reprocessed yet; the latest version of the pipeline was used only for the GR7 addition.

\(^{10}\) We recall that GUVCat AIS only includes the AIS exposures, for homogeneity of exposure depth across the catalog. Some regions were observed repeatedly with deeper exposures, (see Bianchi 2014), therefore some AIS sources may have additional observations in other surveys, with longer exposure times. A unique-source catalog at M5-depth was published by Bianchi et al. (2014a). Deeper exposures will be addressed in a future work.
Figure 7. Examples of multiple observations for the same source. (a) The source at the center of the lower left circle (blue diamond, id = 67138) has the best measurement out of three within 2''5 from its position (dashed circle); therefore it is assigned grank = 1, ngrank = 3 (blue numbers at the left). Its closest neighbor has grank = 2, ngrank = −99 (because it is not a primary). The second closest, with id = 44309, has grank = 3, but ngrank = −89 because it also falls within 2''5 of another source (id = 26091), which is farther than 2''5 from the first primary and has an exposure time shorter than source 44309. Object id = 26091 is therefore assigned grank = −1, because it cannot be discarded as a duplicate of the first primary, but has a nearby source that has a better measurement but cannot be “primary” because it is secondary with respect to a better primary. The black numbers to the right of the sources are exposure time in seconds. The grank tag is used to eliminate secondaries in the unique-source catalog. The red numbers show the values of the same tags if we instead used a distance criterion and associate secondaries with the closest primary rather than with the “best” primary. In that case, each of these two primaries would get one secondary. Note that grank for primaries would not change. (b) Another example illustrating the definition of multiple observations for the same source, showing a different combination; the tag coding is the same as in Figure 7(a).
Table 8
Catalog Columns

| Tag                  | Description                                                                 |
|----------------------|-----------------------------------------------------------------------------|
| photoextractid       | Pointer to photoExtract Table (identifier of original observation on which the measurement was taken) |
| mpstype              | which survey (e.g., “MIS,” or “AIS,” ...)                                    |
| avaspra              | R.A. of center of field where object was measured                           |
| avaspecde            | Decl. of center of field where object was measured                          |
| objid                | GALEX identifier for the source                                             |
| ra                   | source’s Right Ascension (degrees).                                         |
| dec                  | source’s Declination (degrees)                                              |
| glon                 | source’s Galactic longitude (degrees)                                        |
| glat                 | source’s Galactic latitude (degrees)                                         |
| tilenum              | “tile” number                                                                |
| img                  | image number (exposure # for _visits)                                        |
| subvisit             | number of subvisit if exposure was divided                                  |
| fuv_radius           | distance of source from center of the field in which it was measured        |
| type                 | Obs.type (0 = single, 1 = multi)                                            |
| band                 | Band number (1 = nuv, 2 = fuv, 3 = both)                                    |
| c_bv                 | E(B-V) Galactic Reddening (from Schlegel et al. 1998 maps)                  |
| istherspectrum       | Does this object have a (GALEX) spectrum? Yes (1). No (0)                   |
| chkobj_type          | Astrometry check type                                                        |
| fuv_mag              | FUV calibrated magnitude                                                     |
| fuv_magerr           | FUV calibrated magnitude error                                               |
| nuv_mag              | NUV calibrated magnitude                                                     |
| nuv_magerr           | NUV calibrated magnitude error                                               |
| fuv_mag_auto         | FUV Kron-like elliptical aperture magnitude                                  |
| fuv_magerr_auto      | FUV rms error for AUTO magnitude                                             |
| nuv_mag_auto         | NUV Kron-like elliptical aperture magnitude                                  |
| nuv_magerr_auto      | NUV rms error for AUTO magnitude                                             |
| fuv_mag_aperture_4   | FUV Magnitude aperture (8 pxl)                                               |
| fuv_magerr_aperture_4| NUV Magnitude aperture (8 pxl)                                               |
| fuv_mag_aperture_8   | FUV Magnitude aperture error (8 pxl)                                        |
| fuv_magerr_aperture_8| NUV Magnitude aperture error (8 pxl)                                        |
| fuv_mag_aperture_17  | FUV Magnitude aperture (17 pxl)                                             |
| fuv_magerr_aperture_17| NUV Magnitude aperture (17 pxl)                                             |
| fuv_artifact         | FUV artifact flag (logical OR near source)                                   |
| nuv_artifact         | NUV artifact flag (logical OR near source)                                   |
| fuv flux             | FUV calibrated flux (micro Jansky)                                           |
| fuv fluxerr          | FUV calibrated flux (micro Jansky) error                                     |
| fuv_x_image          | Object position along x                                                     |
| fuv_y_image          | Object position along y                                                     |
| nuv_x_image          | Object position along x                                                     |
| nuv_y_image          | Object position along y                                                     |
| fuv_fwhm_image       | FUV FWHM assuming a Gaussian core                                           |
| nuv_fwhm_image       | NUV FWHM assuming a Gaussian core                                           |
| fuv_fwhm_world       | FUV FWHM assuming a Gaussian core (WORLD units)                             |
| nuv_fwhm_world       | NUV FWHM assuming a Gaussian core (WORLD units)                             |
| nuv_class_star       | S/G classifier output                                                       |
| fuv_class_star       | S/G classifier output                                                       |
| nuv ellipticity      | Position angle (east of north) (J2000)                                      |
| fuv ellipticity      | Position angle (east of north) (J2000)                                      |
| nuv_theta_J2000      | Position angle error (east of north) (J2000)                                |
| nuv_errtheta_J2000   | Position angle error (east of north) (J2000)                                |
| fuv_theta_J2000      | Position angle error (east of north) (J2000)                                |
| fuv_errtheta_J2000   | Position angle error (east of north) (J2000)                                |
| fuv_ncat_fwhm_image  | FUV FWHM_IMAGE value from -fd-ncat.fits (px)                                |

Table 8 (Continued)

| Tag                  | Description                                                                 |
|----------------------|-----------------------------------------------------------------------------|
| fuv_ncat_flux_radius_3| FUV FLUX_RADIUS #3 (-fd-ncat(fpx))(0.80)                                     |
| nuv_kron_radius      | Kron apertures in units of A or B                                           |
| nuv_a_world          | Profile rms along major axis (world units)                                  |
| fuv_kron_radius      | Kron apertures in units of A or B                                           |
| fuv_b_world          | Profile rms along minor axis (world units)                                  |
| nuv_weight           | NUV effective exposure (flat-field response value) in seconds at the source position (center pixel) given alpha, delta |
| fuv_weight           | FUV effective exposure                                                       |
| prob                 | probability of the FUV x NUV match                                          |
| sep                  | separation between FUV and NUV                                            |
| nuv_poserr           | [arcseconds] position error of the source in the FUV image                  |
| fuv_poserr           | [arcseconds] position error of the source in the FUV image                  |
| IB_POSERR            | [arcseconds] inter-band position error in arcseconds                        |
| NUV_PPERR            | [arcseconds] NUV Poisson position error (the part of the position error due to counting statistics) |
| FUV_PPERR            | (arcseconds) FUV Poisson position error (the part of the position error due to counting statistics) |
| CORV                 | whether the source comes from a coadd or visit                             |
| GRANK                | strand = 0 if the are no other sources (from different observations) within 2.5 |
|                     | strand = 1 if this is the best (see text) source of >1 sources within 2.5 |
|                     | strand = -1 if this is a primary but has a better source within 2.5         |
|                     | strand = n (n > 1) is this the nth source within 2.5 of the primary        |
| NGRANK               | if this is a primary, number of sources within 2.5                         |
|                     | (otherwise, 99 or 89, see text)                                             |
| PRIMGID              | objid of the primary (only of use for the “plus” catalog)                   |
| GROUPGID             | objid’s of all sources (AIS) within 2.5, concatenated by “+”               |
|                     | as for grank, but based on distance criterion                              |
| NGRANKDIST           | as for ngrank, but based on distance criterion                              |
| PRMGIDDIST           | as for primgid, but based on distance criterion                             |
|                     | (objid of the closest primary rather than the best primary)(only of use for the “plus” catalog) |
| GROUPGIDDIST         | as GROUPGID, but based on distance criterion                                |
| GROUPGIDTOT          | objid’s of all sources within 2.5                                           |
| DIFFUV               | mag difference between primary and secondary (only of use for the “plus” catalog) |
| DIFFNUV              | mag difference between primary and secondary (only of use for the “plus” catalog) |
| DIFFUVDIST           | mag difference between closest and secondary (only of use for the “plus” catalog) |
| SEPSA                | separation (arcsec) between primary and secondary                         |
| SEPSADIST            | separation (arcsec) between primary (distance criterion) and secondary     |
| INLARGEOBJ           | is the source in the footprint of an extended object? if not, INLARGEOBJ = N |
|                     | if yes, INLARGEOBJ = XX-name-of-the-extended-object ; where XX = GA (galaxy), |
|                     | GC (globular cluster), OC (open cluster), SC (other stellar clusters)       |
| LARGEOBSIZE          | size of the extended object; LARGEOBSIZE = 0. if NOT INLARGEOBJ = N,       |
|                     | otherwise LARGEOBSIZE = D25 for galaxies and 2xR1 for stellar clusters     |

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measurement), as explained above. For completeness, we also include in the master catalog the tags `grankdist`, and `primgiddist`, the latter indicating the closest primary to the source, and the former indicating its ranking with respect to the closest primary. This may be different from the “best measurement” primary (`primgid`). With the distance criterion tags, a secondary may be reassigned from the original primary (best measurement, `primgid`) to the closest primary (`primgiddist`) and therefore the number of secondaries for each primary may differ from `ngrank`; we record this number in the tag `nkgrank`. These details only concern users who wish to delve in the master catalog GUVcat_AISplus, where we include all AIS measurements from the archive, and create these tags so that one can chose the primary sources only (`grank = 0, 1 or −1`), i.e., removing all duplicates at once, and obtain a catalog where each source is counted only once, or vice versa examine repeated measurements of AIS sources. GUVcat_AISplus is also available from MAST’s casjobs.

However, for most purposes only the primary sources are needed, and it is not convenient for a user to download all measurements and have to apply cuts later using our `grank` tags described above. GUVcat_AIS contains only “unique sources,” with duplicate measurements removed. This is extracted from the master catalog GUVcat_AISplus by retaining only sources with `grank = 0, 1 or −1`.

Appendix B
Description of the Catalogs’ Columns

Below we list the tags included in the online catalogs presented in this paper, and available at http://dolomiti.pha.jhu.edu/uvsky/GUVcat, as well as at MAST casjobs and SIMBAD/Vizier. The columns of greatest interest in most cases are in bold. The first sets of tags are propagated from the pipeline database, and give information on the source photometry; tags `CORV` and beyond, indicated in italics, are generated by us and described in this paper;
some indicate whether the source has duplicate (AIS) measurements, that have been removed (Appendix A), or flagged if one uses the “plus” catalog. The last two tags indicate whether the source is in the footprint of a large (>1') object (Section 6.1).

Appendix C
Odd Fields and Artifacts

In Section 6.2 we mentioned the different artifacts flagged by the GALEX source extraction pipeline, and Table 6 gives the statistics of sources with artifact flags. Figure 8 shows
examples of ghost reflections from bright sources, in FUV and NUV, and of other types of artifacts. We use as an example one of the fields where there is also an apparent mismatch in coordinates between FUV and NUV detections (Section 5.2). The definitions of artifacts can be found in the documentation and are reported in the footnote of Table 6.

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