BlazEr1: The eROSITA Blazar Catalog

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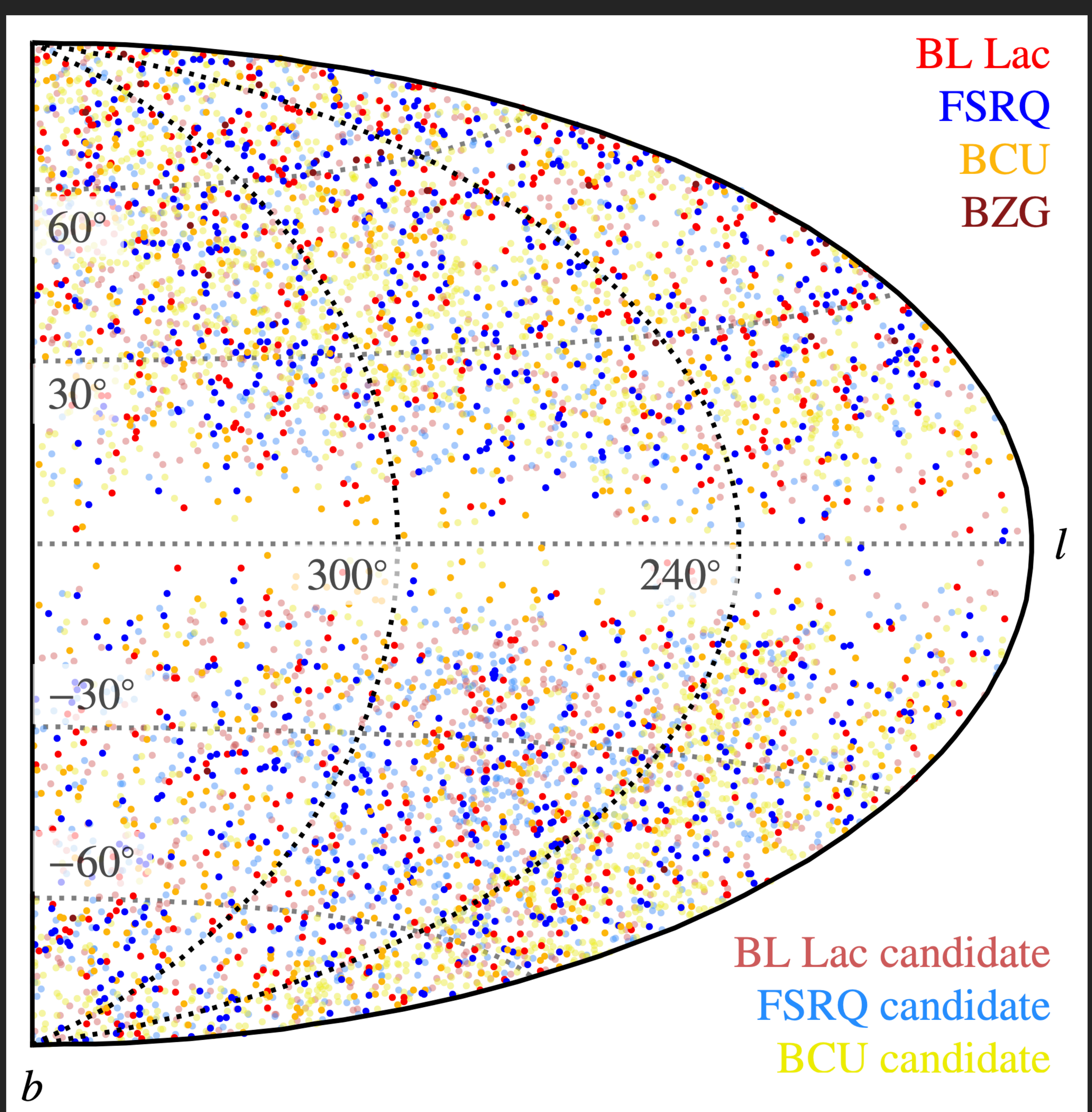
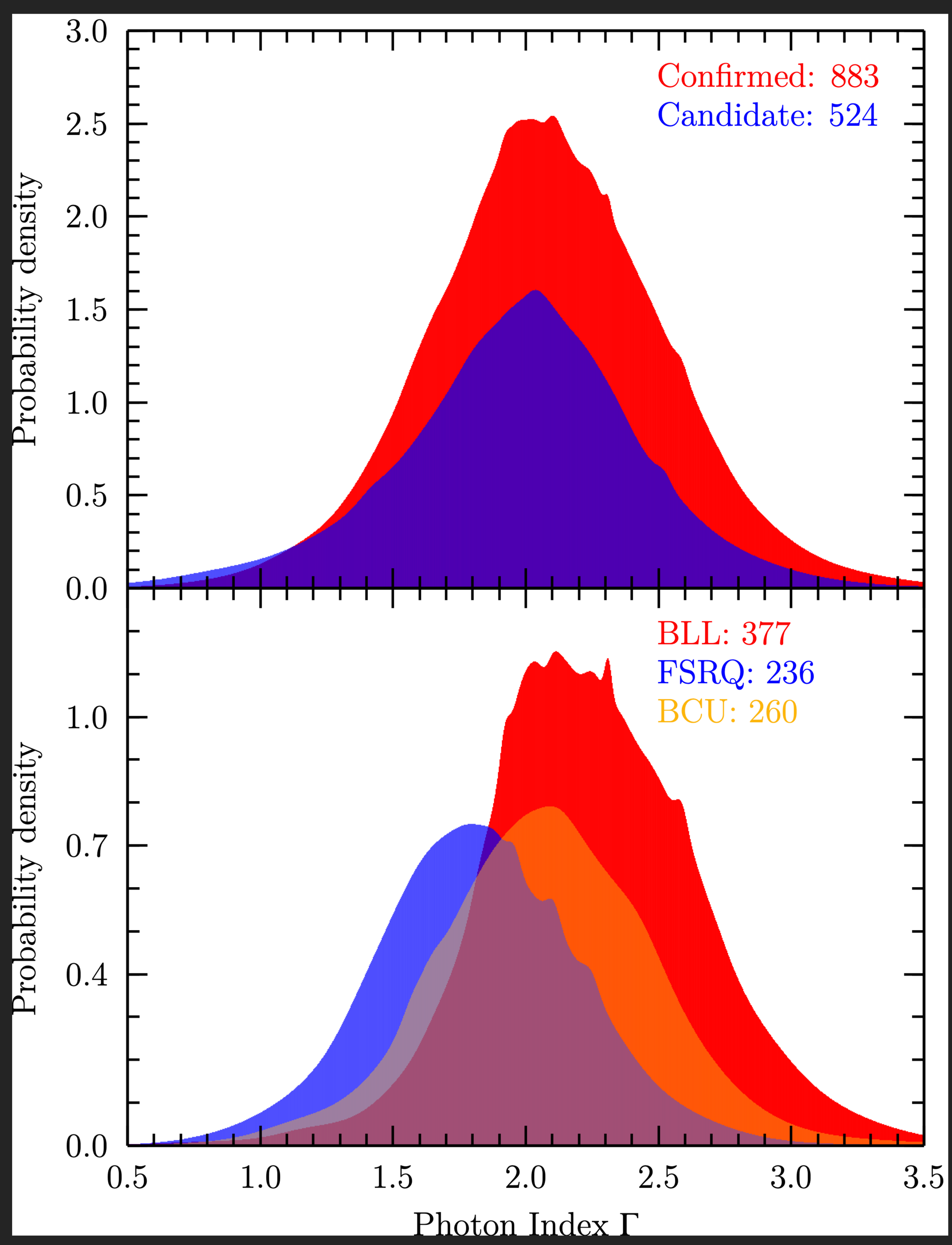
The eROSITA blazar population



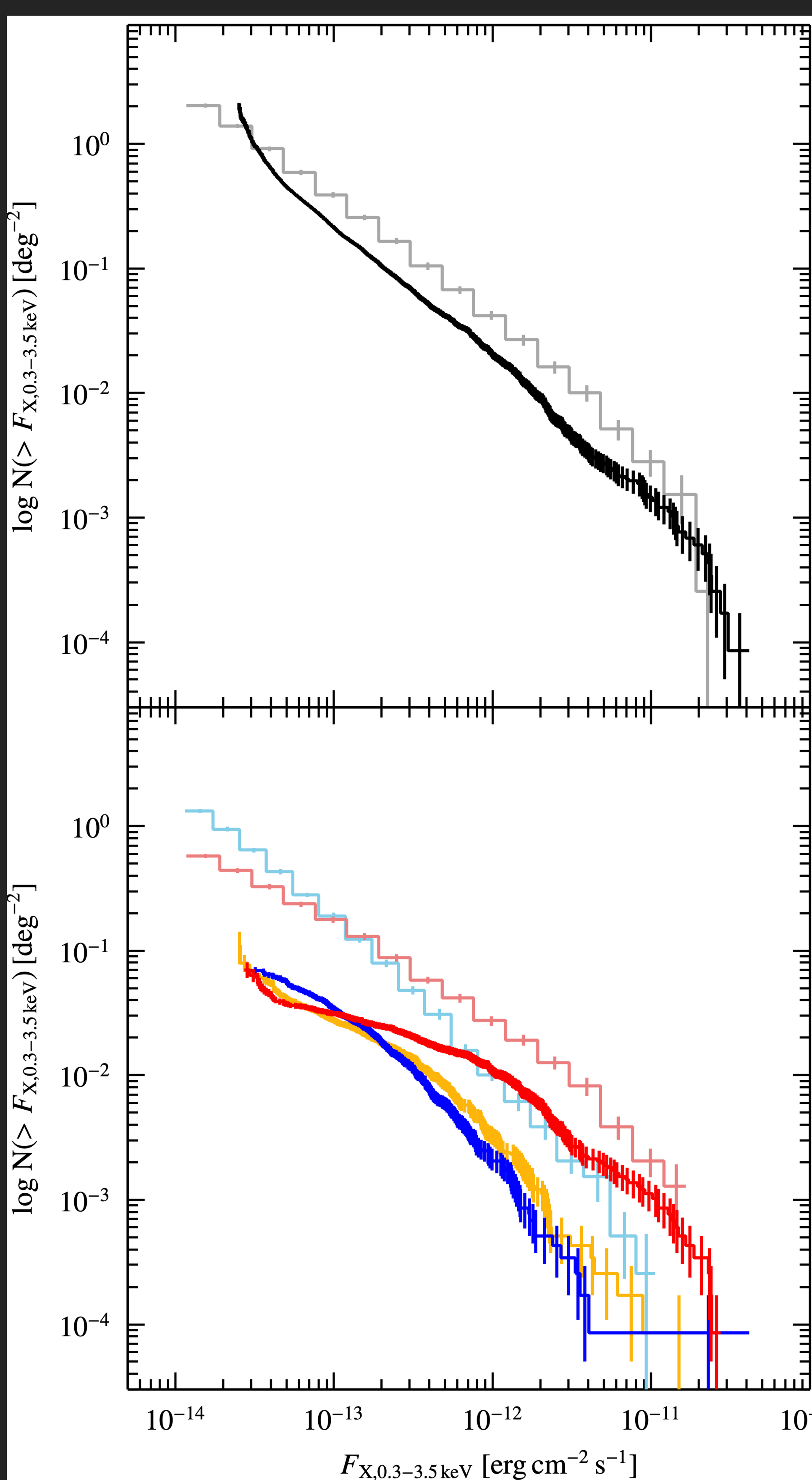
The extended ROentgen Survey with an Imaging Telescope Array (eROSITA) instrument onboard the Russian-German Spectrum-Roentgen-Gamma (SRG) performed its first all-sky survey (eRASS1) from late 2019 up until mid 2020 in the 0.2-10 keV band [1]. During eRASS1, more than 1 million sources were detected and active galactic nuclei (AGN) account for 80% of the sources in the eRASS1 catalog [2]. By combining sources from the 4FGL [3], ROMA BZCAT [4], 3HSP [5], HighZ [6], Milliquas [7], KDEBLLACS [8], WIBRaLS2 [8], ABC [9], and BROS [10] catalogs, and matching these with the eRASS1 catalog we find 2212 confirmed blazars and 4209 blazar candidates to be significantly detected by eROSITA. The resulting BlazEr1 (**Blaz**ars in **eR**ASS**1**) catalog contains X-ray and multiwavelength information for 6421 eROSITA observed blazars and blazar candidates of various blazar types, of which more than 4000 have no prior X-ray detection available, making the BlazEr1 catalog the largest blazar X-ray sample to date.

X-ray spectral properties



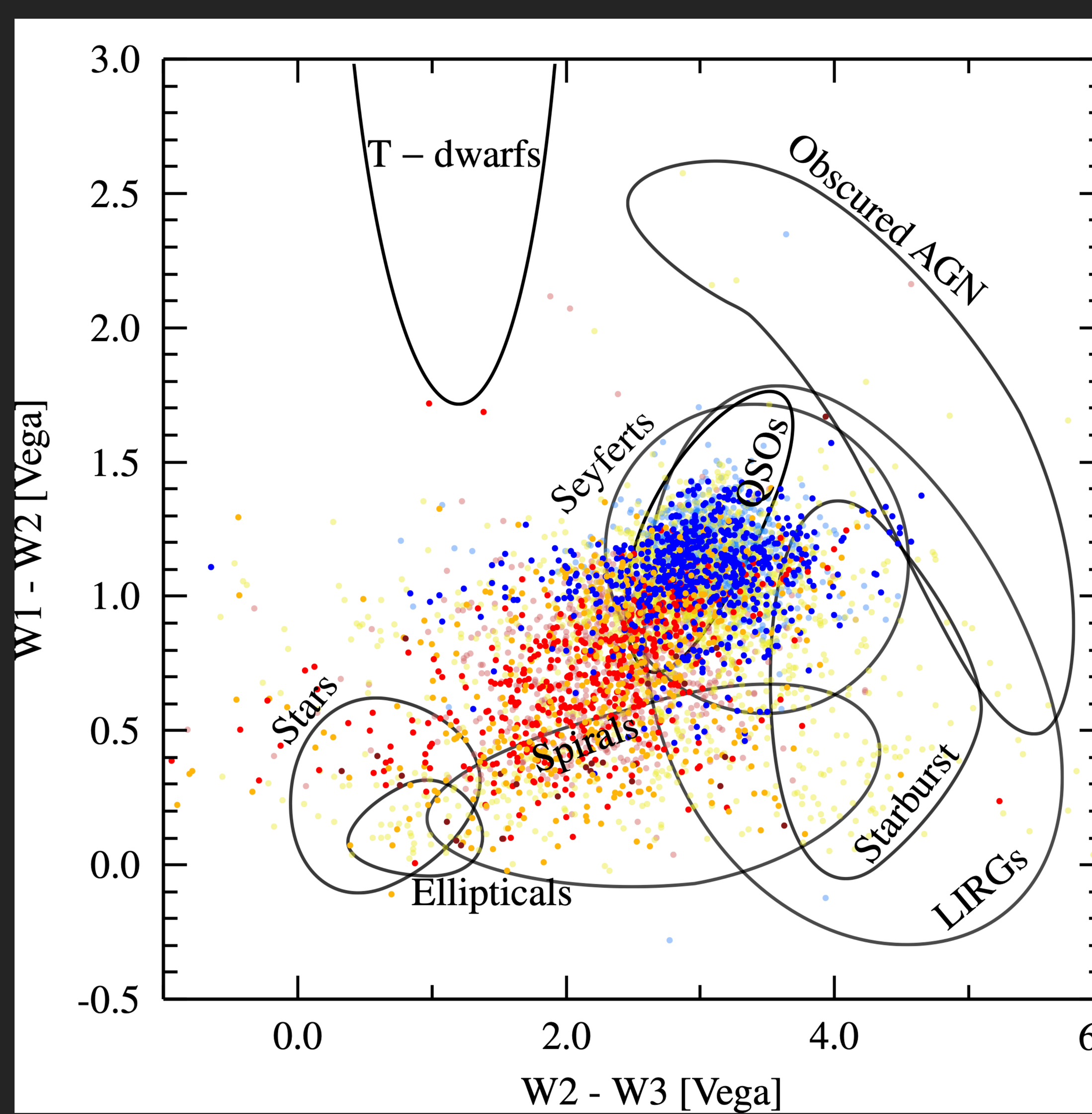
Of the eROSITA observed blazars and blazar candidates 1407 sources were detected with sufficient counts to perform spectral analysis. For this sample we fitted the X-ray spectra with an absorbed powerlaw (*tbabs*powerlaw*) in *ISIS*, and obtained photon indices. The N_H is fixed to the Galactic absorption at the source position [11]. With photon indices for 883 individual blazars we are able to study the distribution of spectral shapes of blazars in great detail due to our large unbiased sample. The derived photon indices are within the expected range and the distribution clearly peaks at values around $\Gamma \sim 2.0$, as can be seen in the upper panel. The candidate source exhibit a similar distribution. When looking at the different blazar classes it is evident that the distributions are different. BL Lac objects have on average softer photon indices than FSRQs. This indicates that the X-rays in BLLs have a higher probability for a synchrotron origin. The harder spectra of FSRQs indicate the contribution of inverse-Compton photons for a large number of these sources. Blazars of unknown types have a photon index distribution in between. A similar trend is observed for the candidate sources, which are associated with different blazar classes, however, way less prominent.

X-ray blazar population



The catalog covers a broad range of soft X-ray fluxes from $5.1 \cdot 10^{-15}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$ to $6.2 \cdot 10^{-11}\,\mathrm{erg\,cm^{-2}\,s^{-1}}$ in the $0.2-2.3\,\mathrm{keV}$ band. An important factor to take into account for the analysis of the sample is the sensitivity of the eRASS1 survey. Using SIXTE [12] we simulated eRASS1 and derived location based sensitivity limits. This information is used to obtain the logN-logS distribution, correcting it according to the eROSITA survey sensitivity and the distribution of sources across the sky. In order to ensure an even distribution over the sky for all input sources we exclude sources close to the Galactic plane and only use sources within the footprint of the BROS survey. The distribution of all eROSITA observed blazars and blazar candidates (black) is similar to the theoretical prediction by [13; gray]. For the different blazars classes a larger deviation from the expected distribution is observed, however, the population inversion predicted (light red and light blue) is observed at the correct flux value.

The multiwavelength picture



Blazars exhibit emission over the entire electromagnetic spectrum, therefore, it is important to study these objects in the multiwavelength context. Since the BlazEr1 catalog contains a large number of sources it is also possible to study the sample in other wavelengths. We matched the X-ray sources with multiwavelength catalogs ranging from the radio band up to the gamma regime and collected fluxes, redshifts and other spectral information. The fluxes across different wave bands are used to calculate broad band spectral indices, which correlate the X-ray band with other spectral ranges, so correlations among different wave bands can be studied. The collected data also includes IR information obtained by WISE. A WISE-based IR color-color diagram separates different types of AGN, as they occupy different spaces in the color-color plane. The majority of blazars are located where they are expected to be, above the spirals and partly overlapping with the QSOs and the Seyferts. Sources far from the usual blazar position, indicate that some other source types contaminate the sample. Additionally, the blazar classes are well separated.

E-mail: steven.haemmerich@fau.de ; **References**: [1] Predehl et al., 2021; [2] Merloni et al., 2024; [3] Ballet et al., 2023; [4] Massaro et al., 2015; [5] Chang et al., 2019; [6] Sbarrato et al., in prep.; [7] Flesch, 2023; [8] D'Abrusco et al., 2019; [9] Paggi et al., 2020; [10] Itoh et al., 2020; [11] HI4PI Collaboration, 2016; [12] Dauser et al., 2019; [13] Giommi & Padovani, 2015 ; **Acknowledgements**: This work is supported by the German Science Foundation (DFG grant number WI 1860/14-1). This work is based on data from eROSITA, the soft X-ray instrument aboard SRG, a joint Russian-German science mission supported by the Russian Space Agency (Roskosmos), in the interests of the Russian Academy of Sciences represented by its Space Research Institute (IKI), and the Deutsches Zentrum für Luft- und Raumfahrt (DLR). The SRG spacecraft was built by Lavochkin Association (NPOL) and its subcontractors, and is operated by NPOL with support from the Max Planck Institute for Extraterrestrial Physics (MPE). The development and construction of the eROSITA X-ray instrument was led by MPE, with contributions from the Dr. Karl Remeis Observatory Bamberg & ECAP (FAU Erlangen-Nuernberg), the University of Hamburg Observatory, the Leibniz Institute for Astrophysics Potsdam (AIP), and the Institute for Astronomy and Astrophysics of the University of Tübingen, with the support of DLR and the Max Planck Society. The Argelander Institute for Astronomy of the University of Bonn and the Ludwig Maximilians Universität Munich also participated in the science preparation for eROSITA.