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The ROSAT RESULTS ARCHIVE: Tools and Methods

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Abstract. The *ROSAT* Results Archive (RRA) is a publicly accessible collection of source lists, images, spectra, lightcurves and counting rates derived from pointed-phase observations of the *ROSAT* X-ray satellite observatory. The RRA contains X-ray source data from both the *ROSAT* Position Sensitive Proportional Counter (PSPC) and the *ROSAT* High Resolution Imager (HRI) instruments, using only data processed with the current (REV2) version of the processing system to ensure data uniformity and accuracy. Each detected source is visually inspected and possible problems are flagged. In this paper we describe the methods used to screen the data products and the GUI-based tools used to screen and access the data.

1. Introduction

ROSAT (Röntgensatellit) is a joint German-US-UK satellite observatory for astronomical observations in the soft X-ray through extreme UV band. *ROSAT* was launched in 1990 and continues to obtain wide-field images of X-ray and UV sources.

ROSAT has two X-ray instruments: the Position-Sensitive Proportional Counter (PSPC) and the High-Resolution Imager (HRI). Both offer wide field imaging and sensitive detection of astronomical X-ray sources. The PSPC provides energy-sensitive observations with a 2° field of view; the HRI has a field of view of 1° and provides high spatial resolution imaging but no real energy sensitivity.

The PSPC and HRI on *ROSAT* are the most sensitive X-ray imagers yet flown. This sensitivity means that, in general, a large number of sources are detected in each X-ray image. The *ROSAT* Data Processing System uses an automated detection routine to determine properties of each X-ray source (position, counting rate, variability, etc.) for each observed field. However, due to the complexity of the X-ray sky seen by *ROSAT*, no automated analysis method can be 100% accurate.

In the 6 years since launch, *ROSAT* has scheduled more than 7000 observations. These data have a 1-year proprietary period, after which they enter the public domain and are made available through archive sites in the US,[1] Germany,[2] and the UK.[3]

The *ROSAT* RESULTS ARCHIVE (RRA) is being developed to make available all information ("results") derived from detected *ROSAT* sources identified by the Standard Analysis System Software (SASS) processing system. Before these results are made available to the public they are screened by the data centers, and obvious problems are flagged as a guide for the archive user.

This paper discusses the methods and tools used to screen *ROSAT* source results, and discusses ways in which the data will eventually be made accessible to the general astronomical community.

2. Screening and Archiving

Screening and archiving of the RRA data occurs in the following steps:

1. *ROSAT* pointed data are delivered via an automated pipeline from the *ROSAT* Data Centers to the *ROSAT* screening centers (in the US at the Goddard Space Flight Center and the Smithsonian Astrophysical Observatory; in Germany at the Max-Planck Institute for Extraterrestrial Physics and the Astronomical Institute of Potsdam; and at Leicester University in the UK).

2. After delivery, the data are "pre-screened" by automated scripts which look for obvious problems (sources near edges or other detector structures, sources in regions of high background, or sources below a S/N threshold). Each field and source gets assigned a set of quality flags by these scripts:

   - FIELD FLAGS which depend on characteristics of the entire field-of-view of the observation, and
   - SOURCE FLAGS which depend on the characteristics of individual sources in the field-of-view.

   For each observation, the source characteristics derived by the processing system detection routine and the set of flags are written to an output file.

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[1] http://heasarc.gsfc.nasa.gov/

[2] http://www.rosat.mpe-garching.mpg.de/

[3] http://ledas-www.star.le.ac.uk/

3. The pre-screened data are then visually inspected by personnel at the screening centers as a final check on source validity. Visual inspection consists of comparing an overlay of flagged X-ray sources to the X-ray images.

4. Screeners can accept the quality flag settings provided by the automated screening software, override these flags, or set additional flags. Screeners may also mark sources missed by the detection software.

5. Consistency checks are done periodically in order to determine the amount of variation from screener to screener.

6. After screening, the data plus quality flags are saved to a file. This file is released to the public, along with additional products (images, spectra, lightcurves, etc.).

3. Screening Tools

Visual inspection of each dataset can be time-consuming, since sequences can have dozens of significant sources. For example, many sequences contain large extended X-ray sources (like supernovae remnants or galactic cluster emission) which can confuse the source detection algorithm resulting in large numbers of spurious sources, all of which must be flagged.

In order to minimize the amount of time spent in visual inspection, software tools have been written which allow easy access to the derived source characteristics and the X-ray images. These GUI-based tools allow the screener to select data sets and sources, overplot sources on X-ray images of the field, and view and set quality flags. There are two software tools currently in use, one for PSPC data and one for HRI data:

- the PSPC screening tool operates in the Munich Interactive Data Analysis System (MIDAS) environment, using the Tcl/Tk toolkit, and
- the HRI screening tool operates in the Interactive Data Language (IDL) environment using the IDL widget toolkit.

4. User Access

The most basic product in the RRA is the source list (source properties + quality flags) produced for each dataset. However, users also want to access the combined list of all sources from all *ROSAT* observations, and to access appropriate data products for each significant detected source. Users may also want an easy way to identify an X-ray source with an optical, radio, or UV source.

Thus, access software must be fairly sophisticated. One method of access which provides most of the required functionality is the BROWSE interface, currently supported by the High Energy Astrophysics Science Archive Research Center (*HEASARC*). Using BROWSE, a list of sources can be identified and selected, and data products can be extracted from an on-line archive for further analysis. In addition, a version (W3BROWSE) which uses the WWW as a convenient graphical interface, is currently available. Source lists from the RRA will be made available to the community from BROWSE and W3BROWSE.

In addition, the *ROSAT* project is currently developing other tools which can provide more flexible and extended access to the RRA. One tool under development lets the user select sources interactively using user-specified quality flag criteria, and, optionally, by position. The user can display selected sources in an X-ray image, and may display an optical image (from the Digitized Sky Survey, created with SkyView) with an overlay of detected X-ray sources. In addition, users can retrieve a list of SIMBAD catalogued sources, along with the separation between the catalogued source and the currently selected X-ray source, as an aid to source identification.

5. For More Information

For more detailed information see the following Web sites:

ftp://heasarc.gsfc.nasa.gov/rosat/data/qsrc/www/RRA.html
http://www.aip.de:8080/~rra/rra.html
http://www.rosat.mpe-garching.mpg.de/~jer/rra/rra.html