NICER Archive guide

Version 1.1

DATE Sep 2018

GSFC
Greenbelt, Maryland

Prepared by: Lorella Angelini

Table of Contents

.

CHANGE RECORD PAGE (1 of 2)

DOCUMENT TITLE : NICER archive guide			
ISSUE	DATE	PAGES AFFECTED	DESCRIPTION
Version 1.0	Mar 2018	All	First version
Version 1.1	Sep 2018	All	Correct detector/mission name

1   Archive

1.1   Introduction

The Neutron star Interior Composition Explorer (NICER) is an International Space Station (ISS) payload working in the energy range of 0.2-12 keV. The NICER X-ray Timing Instrument (XTI) has 56 X-ray concentrators (XRC) each associated with a Silicon Drift Detector (SDD). The SSD are housed in a Focal Plane Modules (FPM) and eight FPMs are connected to a Measurement/Power Unit (MPU). In total there are 7 MPU. NICER was launched aboard a SpaceX Falcon 9 rocket on June 3 2017 at 17:07 EDT from Kennedy Space Center. Normal operation started on 17 July 2017 after the commissioning phase period dedicated to system start up and initial calibration.
The archive opened in March 2018.

The NICER archive contains all the information, data and software needed for the analysis of the NICER data. This document describes the contents and organization of the NICER archive.

1.2   The Data

The NICER data are processed at the Science Mission Operation Center and delivered to the HEASARC. The data processing reformats the data from the telemetry (Level 0) into FITS and calibrates the data to produce the observation and the trend data and the database table.

The science data delivered to the HEASARC contain all the telemetered information relevant to an observation without loss of information. The science data are organized by observation where an observation is defined as the data for a single target collected by the NICER detector, the X-ray Timing Instrument (XTI), over a period of about day. Each observation is labeled with a number hereafter observation number or sequence number. An observation contains data from all MPUs, both science and housekeeping, as well as auxiliary data necessary to the NICER science analysis, The data delivered to the archive are :

a) Level 1 data are data file in FITS created using the CCSDS packets. The Level 1 data files contain all the information from the telemetry without loss of information. These data files are the uncalibrated information and are divided by MPU.
b) The Level 2 data files contain the calibrated-unscreened data where all the MPU have been merged into one file.
c) The Level 2a data files are the cleaned data, e.g. the Level 2 where the appropriate screening criteria are applied to the data
d) Level 3 are products as for light curves and spectra derived from the Level 2a

All the data are in FITS using FITS BINTABLE. The science data are in FITS with an "event" layout where each row contains the characteristic of an event in several columns. The HK data are unpacked into the FITS files using with a FITS BINTABLE the format where each column contains specific parameter value either as single element or as a fixed array of elements. The science and HK data are ordered by time and both contain a column named TIME. The event and housekeeping FITS files

contain data obtained during pointing and slew (slew to target goes with the target). The attitude and orbit are the auxiliary data necessary for the processing and the science analysis. They are generated for each observation and therefore they contain times to include the slew and on target periods. Attitude and orbit are created by in the pipeline and delivered with each observation. The file format of the attitude and orbit is FITS using a FITS BINTABLE similarly to the HK data.

The trend data consist in files that are either a subset of the instrument housekeeping data or calculated values in the pipeline useful to monitor some specific parameters. The trend files are organized in directories, each dedicated to a specific trend type. All the trend data files are in FITS format.

The pipeline also generates a database table recording high level information for each of the sequences At the archive site this table is ingested in the database system to allow users to select the data via a database browser.

1.3   Software and Calibration Data

The software and calibration used in the pipeline processing or in the post processing are also archived and distributed with the HEASARC HEASoft (**http://heasarc.gsfc.nasa.gov/docs/software/lheasoft/**) and CALDB (**http://heasarc.gsfc.nasa.gov/docs/heasarc/caldb/caldb_intro.html**).
The NICER software package includes mission-specific tasks, as well as multi-mission tasks. The NICER-specific tasks support various stages of the instrument calibration, data filtering, as well as response generation. Each task is built as an FTOOL (this is the standard within HEASoft) and uses a standard parameter file as interface, the CFITSIO library to access and write FITS files and a common makefile to build the code. Each of the NICER task is dedicated to a specific function.
The NICER software uses the HEASARC CALDB to access the NICER calibration information. The NICER calibration data are in FITS files and include all the pre-launch information as well as the post-launch updates. The calibration files are designed to accommodate dependencies either on time or specific mode or other parameters to allow software to retrieve the correct file via the CALDB metadata that lists these dependences.

2 Observation General

2.1 Sequence number definition

Each observation is identified by an observation number or sequence number. A sequence number is a 10 digits number defined as follows

APPPTTVVSS

where

- A indicates the announcement opportunity with the following special values.
    - A=0 reserved for calibration data taken on ground and data from check out phase .
    - A=1 reserved to observations during the first 18 months of the mission during the PI phase.
    - A=1+n reserved for data taken during the GO program where n start from 1.

- PPP is a 3 digits number reserved to identify the proposal number, proposal ID , within the specific announcement opportunity. The value of 00 is not allowed.

- TT is a 2 digits number reserved for the target within the proposal ID within the specific announcement opportunity. The value of 00 is not allowed. The target number is unique within a proposal ID.

- VV is a 2 digit number indicating the visit number. Within one proposal it is possible to request several pointing/visit for a target. The value of 00 is not allowed. The visit number is unique for target within the proposal ID.

- SS is a 2 digit number indicating the segment number within the visit number. The value of 00 is not allowed.

2.2 Keywords in the FITS file to ID an Observation

All files that enter the archive have a number of keywords that identify the observation, the processing version, software and calibration files used in the pipeline. The keywords are:

- OBS ID contains the sequence number and is stored as a string
- PROCVER containing the processing version specified
- DATE containing the file creation date using the standard FITS convention for dates.
- DATE-OBS and DATE-END containing the UTC values of the start and stop of the observation. The date is provided using the standard FITS convention for dates. The start and stop times for each sequence are defined as the time when the maneuver starts and the pointing observation stops (which is the next maneuver start) respectively.
- SOFTVER containing the version of the HEASoft and NICER specific software used during the processing. This is as string defined as follows:
  Hea_DDMMMYYYY_Vxxx_NICER_YYYYMMDD_Vyyy

  where DD is the day, MMM is the first 3 characters of the month name, YYYY the year and xxx and yyy the version number as advertised in the software distribution .

.

- CALDBVER containing the version of the calibration index that gives the calibration file list used during the processing of a given observation. This is a string defined as xtiYYYYMMDD where the YYYYMMDD referenced to the latest CALDB version for that instrument.
- TLM2FITS containing a string to identify the version of the tool that translates the telemetry into FITS. This string is defined as NICER2FITSvxxxx_FSWvYYYYMMDD where YYYYMMDD are the year month day.

3 Archive structure

3.1 Data organization

The NICER data are organized in two main directories:

- **obs/:** contains the NICER science data. These data are organized by sequence number.

- **trend/:** contains instrument monitoring data. These data are organized by data type.

The **obs/** and **trend/** directory is divided into subdirectories of one month interval named after the year and the month (YYYY_MM) of the observation. The sequences and the trend type are placed under these subdirectories as shown below.

```
          obs/                                    trend/
 2018_02/   2018_03/ 2018_04/ …        2018_02/   2018_03/  2018_04/ ….
              |                                       |
    sequence1/ sequence2/  …               type1/ type2/ ….
```

3.2 The obs/ directory structure

Science data are located under the \obs directory. Each sequence is organized into a two level directory structure. The first level of directories divides the data by instrument and includes directories with common information for that sequence. The second layer of directories divides the data according to their level of processing. The directory structure is:

```
                observation_num/
      auxil/           log/              xti/
                                          |
                 event_uf/ event_cl/  products/ hk/
```

The content of each directory is the following:

- **/auxil**: contains files related to the attitude, orbit as well as a catalog listing all the files present in the sequence.
- **/log**: contains html files reporting logs on the data processing.

.

- **/xti** : contains the science data divided in directory related to the processing level

  - o **/event uf:** contains the unfiltered event files, Level 1, for each of the MPU
  - o **/event cl:** contains the unfiltered and screened merged MPU science data
  - o **/hk:** contains housekeeping files related to the instrument.
  - o **/products:** contains all the high-level products derived from the science files. These are light curves and spectra on sourcein FITS together with GIF files showing a plot of the products. These files are not available for the first data release.

4 Data Files

4.1 Filename convention

The filename convention depends if the file contains science, auxiliary or log data. The NICER FITS science files are named according to the following convention:

a) The filename for the science files (event) uses the following convention:
  niXXXXXXXXXX_MmpuN_ll.ext.gz
 where
- ni : is the short for NICER
- XXXXXXXXXX : is the observation identifier and it is identical to the directory name. This is identical to the sequence number or observation number.
- M is used to index data file divided to limit the size. M=0 is used when the data files are not separated otherwise M ranges from 1-9. The file size is limited to 2 Gb uncompressed.
- N is a single digit number with the following values
    - from 0-6 used to identify data files from a single MPU.
    - The value of 7 is used to identify files containing data from all MPU
- ll : is the file level. Is set to 'uf' for unfiltered , 'ufa' unfiltered but all MPU merged or 'cl' for cleaned event file.
- ext : is the file extension.

b) The filename for the auxiliary files not instrument dependent uses the following convention:
  niXXXXXXXXXX.ext.gz
all these files are in the /aux directory.
c) The filename for the log files uses the following convention:
  niXXXXXXXXXX_nnnnnnnnn.ext.gz
 where nnnnnnnnn is the file identifier.

4.2   Data content within an observation

This section lists the science data files included within a sequence. The file listing is given below, broken down by directory, together with the specific filenames. Within this description the [obs-id] is the 9 digit number

— **auxil/ directory**

auxil directory content	
Filename	**Description**
ni[0-9].att	File containing the attitude information. If the observation includes the slew both slew and pointing attitude are present
ni[0-9].orb	File containing the orbit information
ni[0-9].mkf	Make filter file containing a subset of HK parameters from the individual instrument, the subsystems as well as from the spacecraft. This information is used to screen the data
ni[0-9].cat	File containing the list of files output of the processing that are included within the sequences in the archive

— **log/ directory**

log directory content	
Filename	**Description**
ni[0-9]_errlog.html	File containing the errors that occur during the processing.
ni[0-9]_joblog.html	File containing the entire log of the processing

— **xti/ directory**

xti directory content	
event_uf directory	
Filename	**Description**
ni[0-9]_MmpuN_uf.evt	File containing the science information of the NICER sensors.
M is set to 0 if files are less than 2 Gb. If files are larger than 2 Gb they are divided and M get the value from 1-9. N is the MPU number. Its value ranges from 0 to 6	
event_cl directory	
Filename	**Description**
ni[0-9]_Mmpu7_ufa.evt	Merged of all the event unfiltered MPU files
ni[0-9]_0mpu7_cl.evt	Clean event obtained from the *ufa.fits file
hk directory	
Filename	**Description**
ni[0-9]_MmpuN.hk	HK files . M and N have the same values as for the science uf files.

.