NuSTAR Data Analysis

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NuSTAR

Data access

Data analysis

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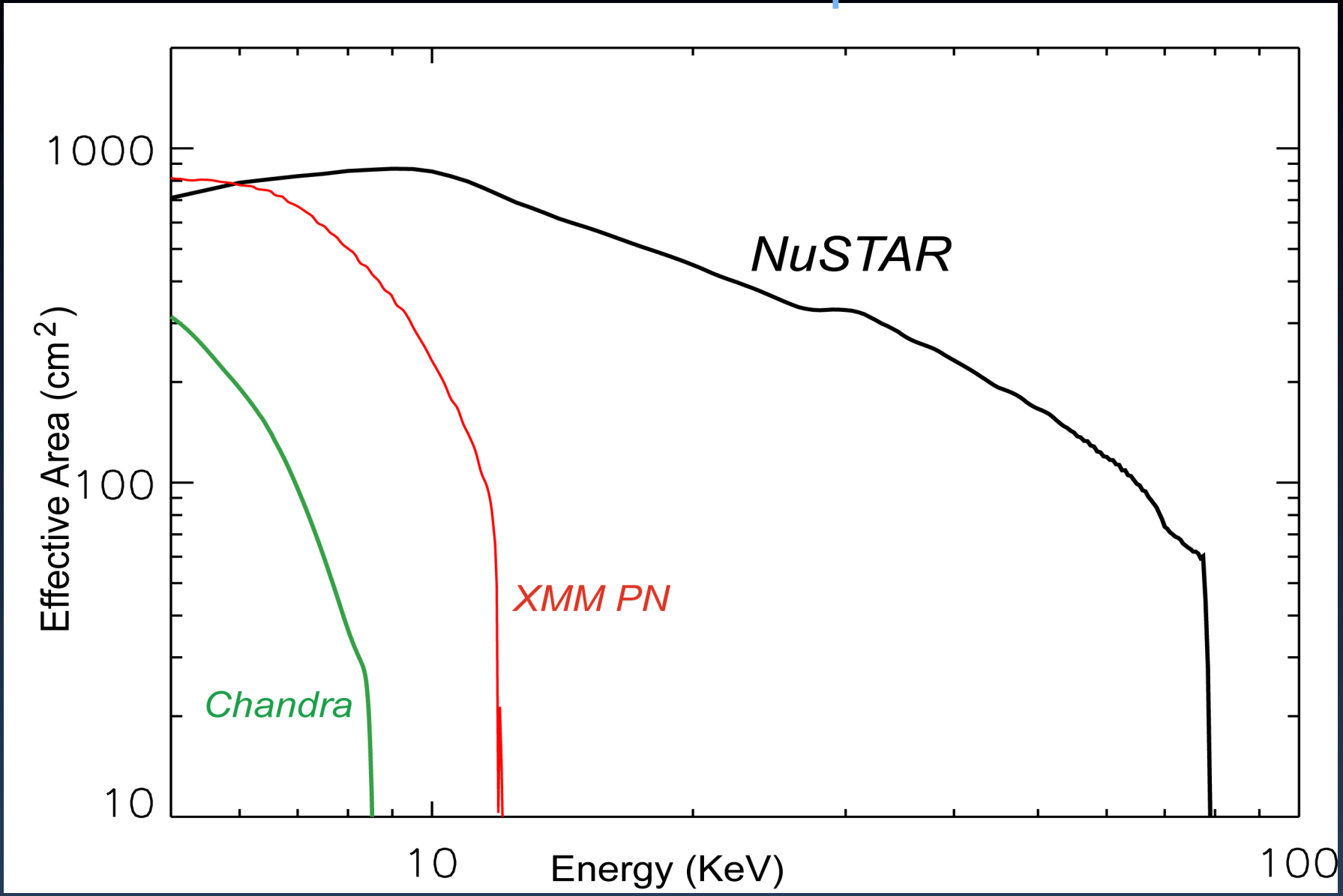
What is NuSTAR?

- Nuclear Spectroscopic Telescope Array
- NASA small explorer mission
- First focusing hard X-ray space telescope
- Currently in guest observer phase

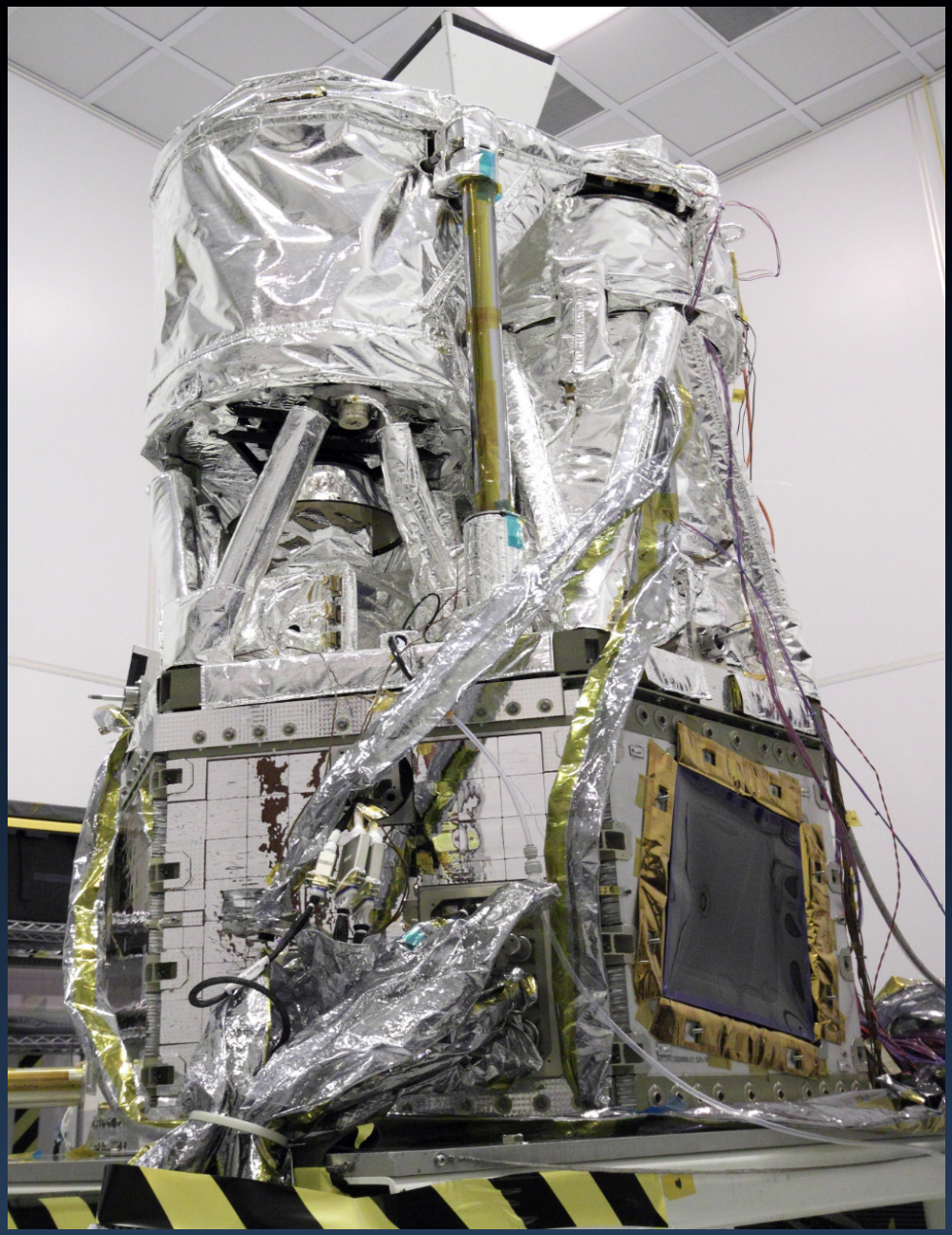
Proposals due 11 Dec !

Instrument Specs



Instrument Specs

- Energy range: 6 – 80 keV
- Angular resolution:
  - » Half-Power Diameter: 44”
  - » Sharp core of Point Spread Function: FWHM < 10”
- Point source positioning accuracy: 1.5”
- Field of view: 10’ at 10 keV, 6’ at 68 keV
- Sensitivity (1 Ms, 3-sigma):
  - » 6 – 10 keV : 2×10^{-15} erg cm^{-2} s^{-1}
  - » 10 – 30 keV : 1×10^{-14} erg cm^{-2} s^{-1}



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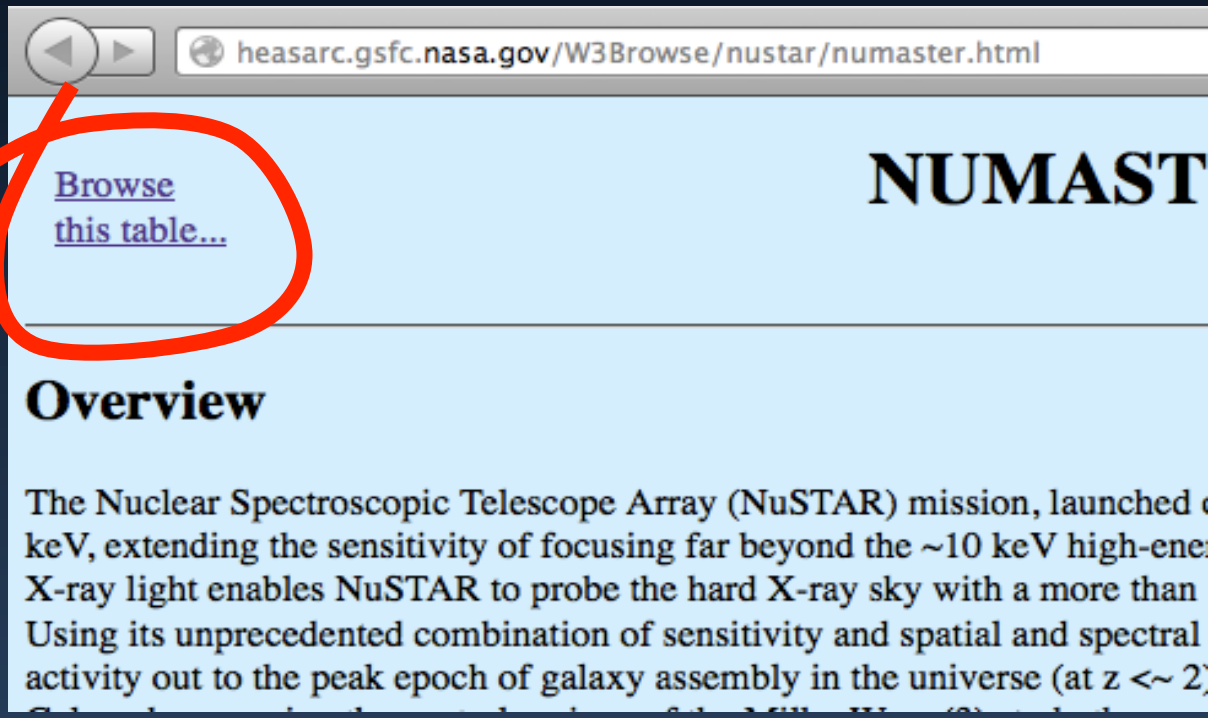
Objects in the first release

- The nustar master catalog: numaster

http://heasarc.gsfc.nasa.gov/W3Browse/nustar/numaster.html

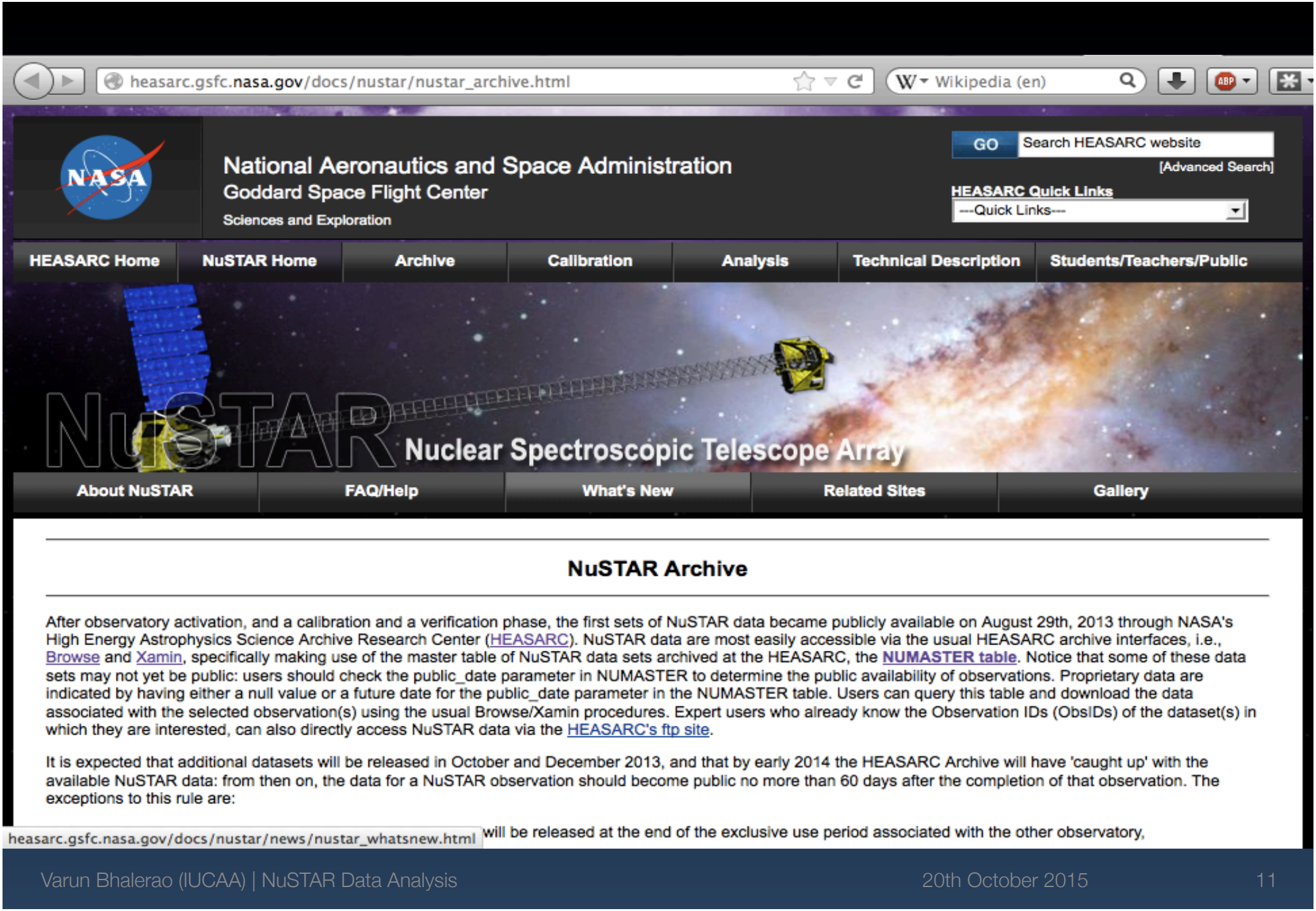
- Samples:
  - » Mkn 421, 3C 273
  - » LMC X-4, SMC X-1
  - » GRS 1915+105



Accessing data

- Standard HEASARC interfaces:
  - » Browse
  - » Xamin
  - » FTP
- CALDB through HEASARC CALDB service
  - » Download (~800 MB, recommended)
  - » Web interface
- The NuSTAR archive on heasarc:

http://heasarc.gsfc.nasa.gov/docs/nustar/nustar_archive.html


heasarc.gsfc.nasa.gov/docs/nustar/nustar_archive.html
Wikipedia (en)
National Aeronautics and Space Administration
Goddard Space Flight Center
Sciences and Exploration
GO
Search HEASARC website
[Advanced Search]
HEASARC Quick Links
---Quick Links---
HEASARC Home
NuSTAR Home
Archive
Calibration
Analysis
Technical Description
Students/Teachers/Public
NuSTAR
Nuclear Spectroscopic Telescope Array
About NuSTAR
FAQ/Help
What's New
Related Sites
Gallery
NuSTAR Archive
After observatory activation, and a calibration and a verification phase, the first sets of NuSTAR data became publicly available on August 29th, 2013 through NASA's High Energy Astrophysics Science Archive Research Center (HEASARC). NuSTAR data are most easily accessible via the usual HEASARC archive interfaces, i.e., Browse and Xamin, specifically making use of the master table of NuSTAR data sets archived at the HEASARC, the NUMASTER table. Notice that some of these data sets may not yet be public: users should check the public_date parameter in NUMASTER to determine the public availability of observations. Proprietary data are indicated by having either a null value or a future date for the public_date parameter in the NUMASTER table. Users can query this table and download the data associated with the selected observation(s) using the usual Browse/Xamin procedures. Expert users who already know the Observation IDs (ObsIDs) of the dataset(s) in which they are interested, can also directly access NuSTAR data via the HEASARC's ftp site.
It is expected that additional datasets will be released in October and December 2013, and that by early 2014 the HEASARC Archive will have 'caught up' with the available NuSTAR data: from then on, the data for a NuSTAR observation should become public no more than 60 days after the completion of that observation. The exceptions to this rule are:
heasarc.gsfc.nasa.gov/docs/nustar/news/nustar_whatsnew.html
will be released at the end of the exclusive use period associated with the other observatory,

Alternate access

- ASI Science data center: http://nustar.asdc.asi.it/

Search “all” by object class

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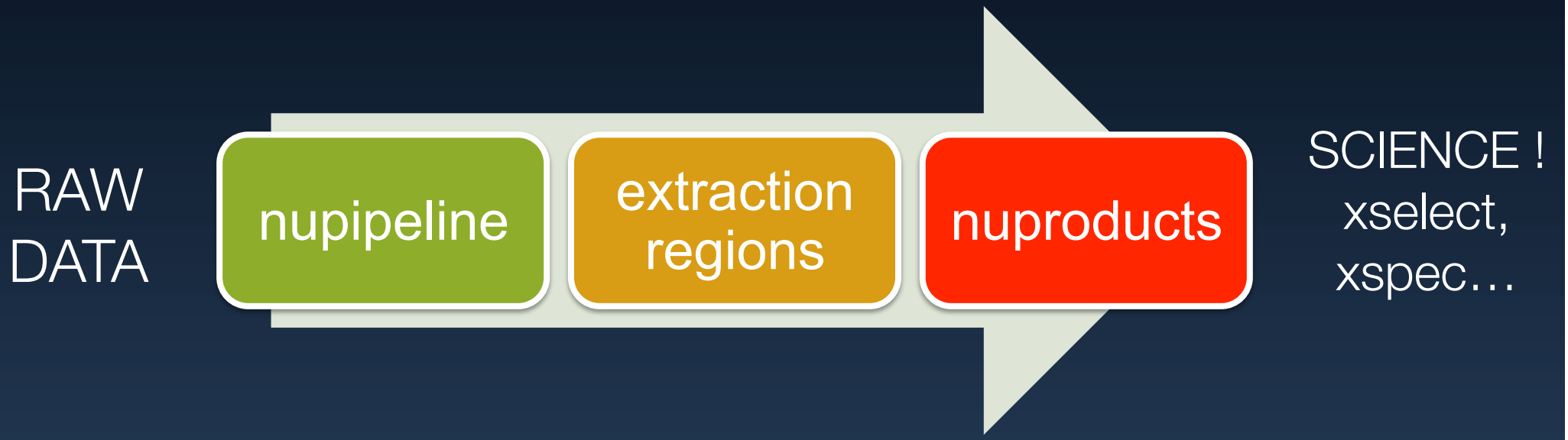
NuSTARDAS

NuSTAR Data Analysis Software

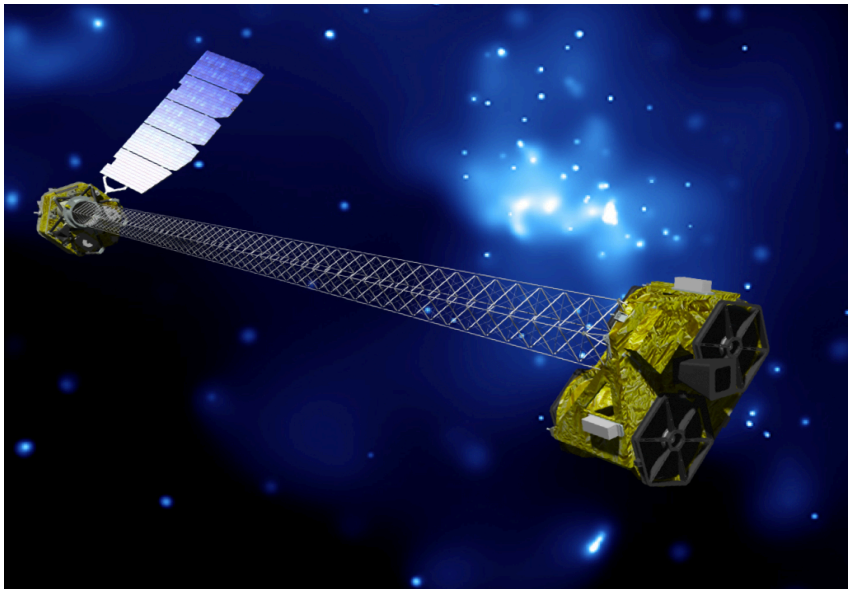


Getting started

- Heasoft 6.17 (~ 350 MB source code)
  - » http://heasarc.gsfc.nasa.gov/docs/software/lheasoft/
- NuSTAR CALDB files (~ 800 MB compressed)
  - » http://heasarc.gsfc.nasa.gov/docs/heasarc/caldb/nustar/
- Read the caveats:
  - » http://heasarc.gsfc.nasa.gov/docs/nustar/analysis/

NuSTAR DATA ANALYSIS

Quickstart Guide



Version 1.0 (August 2013)

Karl Forster, Brian Grefenstette, & Kristin Madsen
NuSTAR Science Operations Center,
California Institute of Technology

http://www.srl.caltech.edu/NuSTAR_Public/NuSTAROperationSite/Home.php

asdc
ASI Science Data Center

CALIFORNIA INSTITUTE OF TECHNOLOGY 1891

The NuSTAR Data Analysis Software Guide

M. Perri, S. Puccetti, N. Spagnuolo
(ASI Science Data Center)

&

A. Davis, K. Forster, B. Grefenstette, F. Harrison, K. Madsen
(California Institute of Technology)

Version 1.3
August 2013

Guides

- Quickstart guide – v1.1
  - » http://heasarc.gsfc.nasa.gov/docs/nustar/analysis/nustar_quickstart_guide.pdf
- Software manual – v1.8
  - » http://heasarc.gsfc.nasa.gov/docs/nustar/analysis/nustar_swguide.pdf
- FAQ:
  - » http://heasarc.gsfc.nasa.gov/docs/nustar/nustar_faq.html

Steps 1-2

- Download and extract data
  - » Organized by OBSID
- Run nupipeline
  - » Run time estimates: 11 ksec data set: 2.5 min
- Products:
  - » Cleaned event files (filtered for GTIs etc)

Downloaded data

OBSID

```
80002013024/auxil:
nu80002013024_att.fits  NUSTAR_TLE_ARCHIVE.txt.2013226
nu80002013024_orb.fits
```

Unfiltered event lists

```
80002013024/event_uf:
nu80002013024A_uf.evt  nu80002013024B_uf.evt
```

Housekeeping data

```
80002013024/hk:
nu80002013024A_dspx.fits  nu80002013024_chu123.fits
nu80002013024A_fpm.hk     nu80002013024_chu4.fits
nu80002013024B_dspx.fits  nu80002013024_eng.hk
nu80002013024B_fpm.hk     nu80002013024_met.fits
nu80002013024_ceb.hk      nu80002013024_obeb.hk
```

nupipeline

```
nupipeline \
indir=./80002013024/ \
steminputs=nu80002013024 \
outdir=./80002013024/event_cl/
```

Pipeline products

Cleaned event lists

Science mode data

2 sets of files: two telescopes

```
80002013024/event_cl/:
nu80002013024A01_cl.evt      nu80002013024B01_gti.fits
nu80002013024A01_gti.fits    nu80002013024B02_cl.evt
nu80002013024A02_cl.evt      nu80002013024B02_gti.fits
nu80002013024A02_gti.fits    nu80002013024B03_cl.evt
nu80002013024A03_cl.evt      nu80002013024B03_gti.fits
nu80002013024A03_gti.fits    nu80002013024B04_cl.evt
nu80002013024A04_cl.evt      nu80002013024B04_gti.fits
nu80002013024A04_gti.fits    nu80002013024B05_gti.fits
nu80002013024A05_gti.fits    nu80002013024B06_cl.evt
nu80002013024A06_cl.evt      nu80002013024B06_gti.fits
nu80002013024A06_gti.fits    nu80002013024B.attorb
nu80002013024A.attorb        nu80002013024B_bp.fits
nu80002013024A_bp.fits       nu80002013024B_det1.fits
nu80002013024A_det1.fits     nu80002013024B_fpm.hk
nu80002013024A_fpm.hk        nu80002013024B_hp.fits
nu80002013024A_hp.fits       nu80002013024B.mkf
nu80002013024A.mkf           nu80002013024B_oa.fits
nu80002013024A_oa.fits       nu80002013024B_uf.evt
nu80002013024_att.fits       nu80002013024_mast.fits
nu80002013024A_uf.evt        nu80002013024_psdcorr.fits
nu80002013024B01_cl.evt      nu80002013024_psd.fits_att.fits
```

Steps 3-4

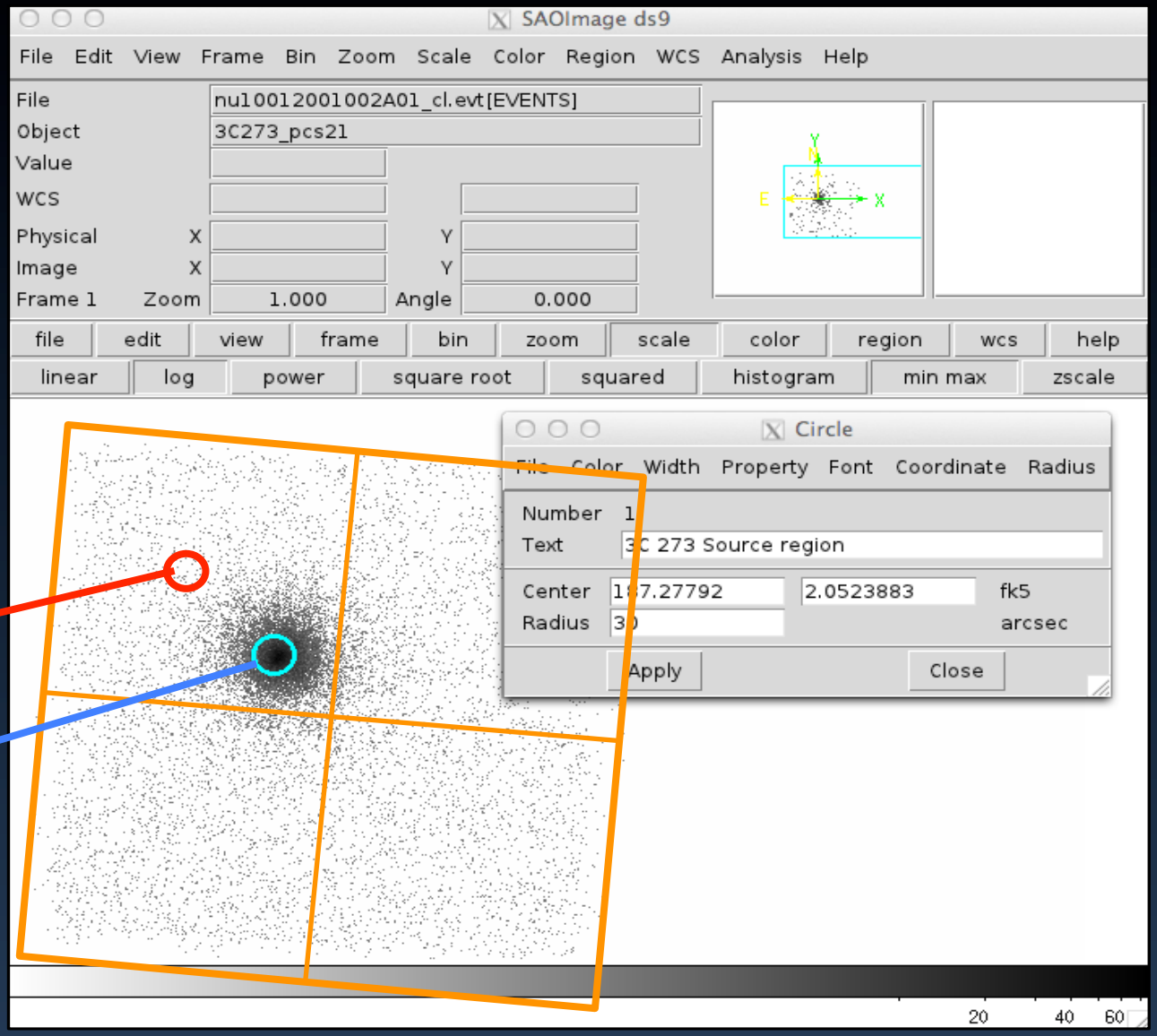
- Select source and background regions
  - » DS9 or FV
  - » Background on same chip
- Run nuproducts
  - » Run time estimates: 11 ksec data set: 2 × 1.5 min
  - » Once for each telescope
- Products:
  - » PHA files, lightcurves, ARF, RMF…

Select source and background regions

DS9 or FV

Background

Source



nuproducts

```
nuproducts \
srcregionfile=source.reg \
bkgregionfile=bkg.reg \
indir=./80002013024/event_cl/ \
infile=./80002013024/event_cl/
  nu80002013024A01_cl.evt \
instrument=FPMA \
steminputs=nu80002013024 \
bkgextract=yes \
outdir=./80002013024/event_cl/products
```

Final products

```
ls products/
nu80002013024A01_bk.lc    nu80002013024A01_sk.img
nu80002013024A01_bk.pha   nu80002013024A01_sr.arf
nu80002013024A01_im.ps    nu80002013024A01_sr.lc
nu80002013024A01_lc.ps    nu80002013024A01_sr.pha
nu80002013024A01_ph.ps    nu80002013024A01_sr.rmf
nu80002013024A01_offaxishisto.fits
```

Postscript files

Optional outputs

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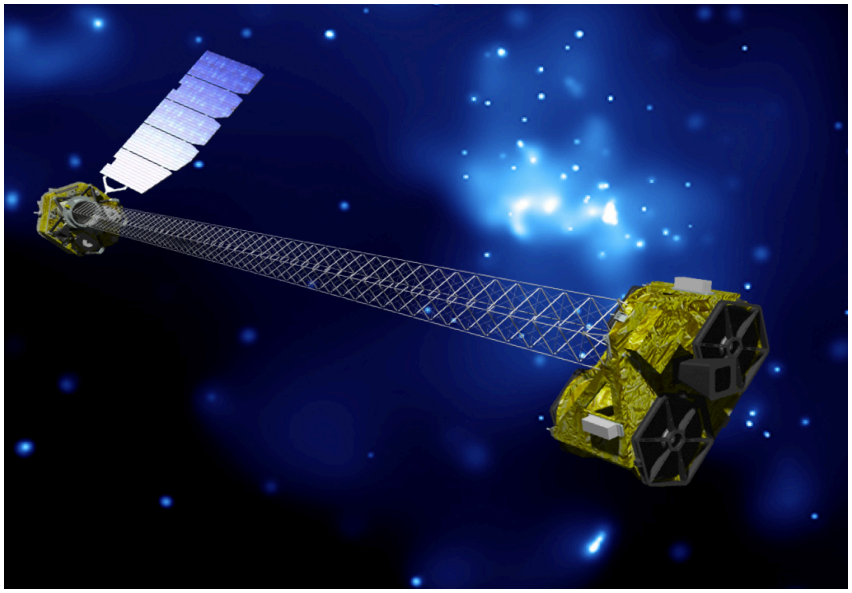

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Links

DATA:

http://heasarc.gsfc.nasa.gov/W3Browse/nustar/numaster.html

http://nustar.asdc.asi.it/

Software:

http://heasarc.gsfc.nasa.gov/docs/software/lheasoft/

http://heasarc.gsfc.nasa.gov/docs/heasarc/caldb/nustar/

Methods:

http://heasarc.gsfc.nasa.gov/docs/nustar/analysis/

http://heasarc.gsfc.nasa.gov/docs/nustar/nustar_faq.html