

X-Ray Data Archives

<http://heasarc.gsfc.nasa.gov/>

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Early X-ray Observatories

1948 - 49: Sun is discovered to be bright (dim?) X-ray source: $L_x = 10^{27}$ erg/s

1962: First extrasolar X-ray emission detected: Sco X-1 & diffuse background

The 1960s: The decade of rocket (mostly soft X-ray)
and balloon (hard X-ray/gamma-ray) astronomy

The 1970s: The decade of the exploratory X-ray satellites
(Uhuru, ANS, SAS 3, OSO 8, Copernicus) and gamma-ray satellites
(SAS 2 and COS B)

Progress in the late 1970s to 1980s: X-Ray Missions for the Masses

HEAO-1 operated from Aug 1977 to Jan 1979

It carried out a sky survey as well as pointed observations, and had four instruments which covered a very wide energy range (0.15 keV - 10 MeV)

Einstein (HEAO-2) operated from Nov 1978 to Apr 1981

It detected **7,000 X-ray sources**, most with the Imaging Proportional Counter, which obtained very-low resolution spectra.

$E/DE \sim 0.5$, $A_{\text{eff}} \sim 100$ sq. cm, Bandpass: 0.4 - 4.0 keV

EXOSAT operated from May 1983 to Apr 1986

It also detected **thousands of X-ray sources**, many of them stars, and got **low-resolution, hard-band spectra** (with ME telescope) :

$E/DE \sim 5$, $A_{\text{eff}} \sim 1600$ sq. cm, Bandpass: 1-50 keV

Progress in the 1990s: X-Ray Missions

- **ROSAT operated from June 1990 to Feb 1999**, and carried out an All-Sky Survey and then thousands of pointed observations, detecting **~200,000 X-ray sources**, and obtaining crude spectra of thousands with higher S/N:
E/DE ~ 3, A_eff ~ 240 sq. cm, Bandpass: 0.1 - 2.4 keV (PSPC)
- **ASCA operated from Feb 1993 to Mar 2001** and carried out thousands of pointed observations in a fairly broad bandpass; it had the capability to get **moderate-resolution spectra** (but limited spatial resolution):
E/DE ~ 30, A_eff ~ 100 sq. cm, Bandpass: 0.4 - 10 keV
- **BeppoSAX operated from Apr 1996 to Apr 2002 in a pointed observations mode**; it had the capability to obtain low-resolution spectra, but **very broad-band spectra**:
E/DE ~ 10, A_eff ~ 150 sq. cm, Bandpass: 0.1 - 300 keV
- **EUVE operated from June 1992 to Jan 2001**, and carried out an All-Sky Survey and then thousands of pointed observations, some for very long exposures, obtaining both photometry and **high-resolution spectra in the ultrasoft X-ray/EUV band**:
E/DE ~ 300, A_eff ~ 2 sq. cm, Bandpass: 0.02 - 0.2 keV
- **RXTE has been operating since Dec 1995**, and observes handful of stars in the **hard X-ray band**, and has **good monitoring and fast timing capability (but no spatial resolution**, since it uses collimators), **as well as an All-Sky Monitor**:
E/DE ~6, A_eff ~ 6000 sq. cm, Bandpass: 2 - 250 keV

The 2000s: The Great X-Ray Missions

- * **Chandra** launched 23 July 1999: **high spatial resolution** (0.5'') and high spectral resolution gratings

ACIS: E/DE ~ 40, A_eff ~ 700 sq. cm, Bandpass: 0.2 - 10 keV

HETG: E/DE ~ 1000, A_eff ~ 200 sq. cm, Bandpass: 0.4 - 10 keV

- * **XMM-Newton** launched 10 December 1999: **parallel instruments** (including optical monitor) and **high throughput**

EPIC: E/DE ~ 30, A_eff ~ 1400 sq. cm, Bandpass: 0.1 - 15 keV

RGS: E/DE ~ 300, A_eff ~ 140 sq. cm, Bandpass: 0.3 - 2.5 keV

- * **Astro E-2** to be launched in 2005: **very wide bandpass** including hard X-rays and gamma-ray region

XRS: E/DE ~ 700, A_eff ~ 250 sq. cm, Bandpass: 0.4 - 10 keV

HXD: E/DE ~ 10, A_eff ~ 330 sq. cm, Bandpass: 10 - 700 keV

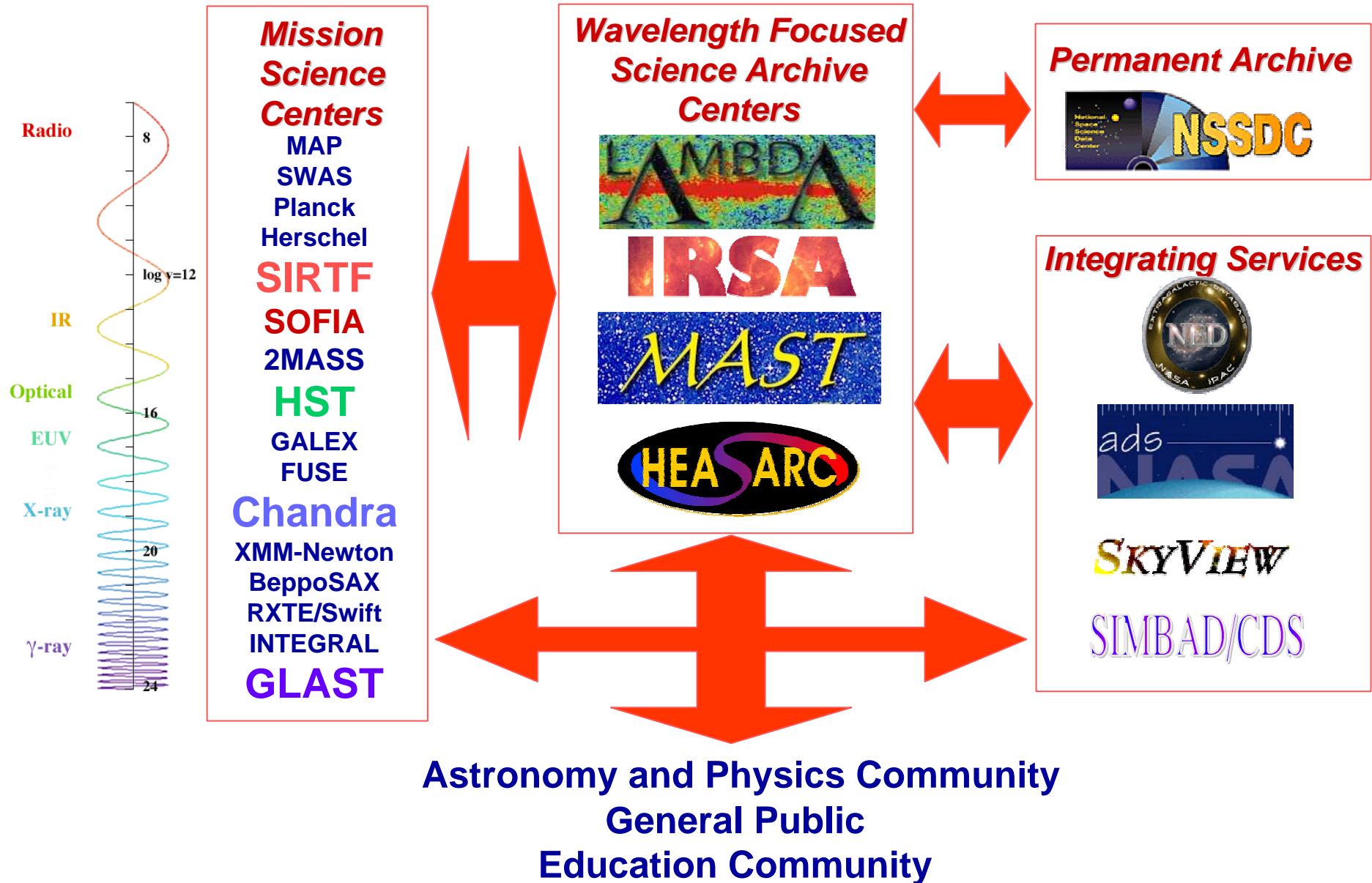
ABRIXAS	GLAST	Prognoz 6
ALEXIS	Granat	Prognoz 7
AGILE	Hakucho	Prognoz 9
ANS	HEAO 1	Proton 1 & 2
Apollo 15 & 16	HEAO 3	Radsat
Apollo-Soyuz	Helios 2	Ranger 3 & 5
ARGOS (USA)	HETE-2	ROSAT
Ariel V	IMP 6	RXTE
Ariel VI	IMP 7	Salyut-4
Aryabhata	ISEE-3	SAS 2
ASCA	INTEGRAL	SAS 3
Astro E	IRS-P3	SIGNE 3
Astro E2	Kvant	Skylab
Astron	Luna 10 & 12	Solar Max
BeppoSAX	Mars 4 & 5	Solrad 10
BBXRT	Mars Observer	Solrad 11A/B
CATSAT	Minisat 1 (LEGRI)	Spacelab 1
CGRO	NEAR	Spacelab 2
Chandra (AXAF)	OGO series	Spartan 1
Copernicus	ORS 3	SROSS
COS-B	ORS 4	Spectrum X-Gamma
Cosmos series	OSO 1	Swift
Constellation-X	OSO 3	TD-1A
Discoverer series	OSO 4	Tenma
DMSP series	OSO 5	Uhuru
DXS	OSO 6	Ulysses
Einstein (HEAO 2)	OSO 7	Vela 5A
ESRO-2B	OSO 8	Vela 5B
EURECA	P78-1	Vela 6A/B
EUVE	Phobos 1	Venera 11 & 12
EXOSAT	Phobos 2	Venera 13 & 14
Explorer 11	Pioneer Venus	Wind
Gamma	Prognoz 2	XMM-Newton
Ginga		

HEASARC Overview

NASA's archive for X-ray and Gamma ray data

- Established in Nov 1990
 - First wavelength specific “active” archive
- Partnership between GSFC and SAO (since 1999)
- Contains data from 23 missions
- All data in FITS format, along with associated software and calibrations
- Provides the necessary scientific and technical expertise for the use and interpretation of the data
- Develop/maintain multi-mission analysis/support tools such as XSPEC, PIMMS, and Proposal Submission
- Online access to all data, catalogs of observations and sources and browse data products
- Defines and coordinates data, software, and media standards

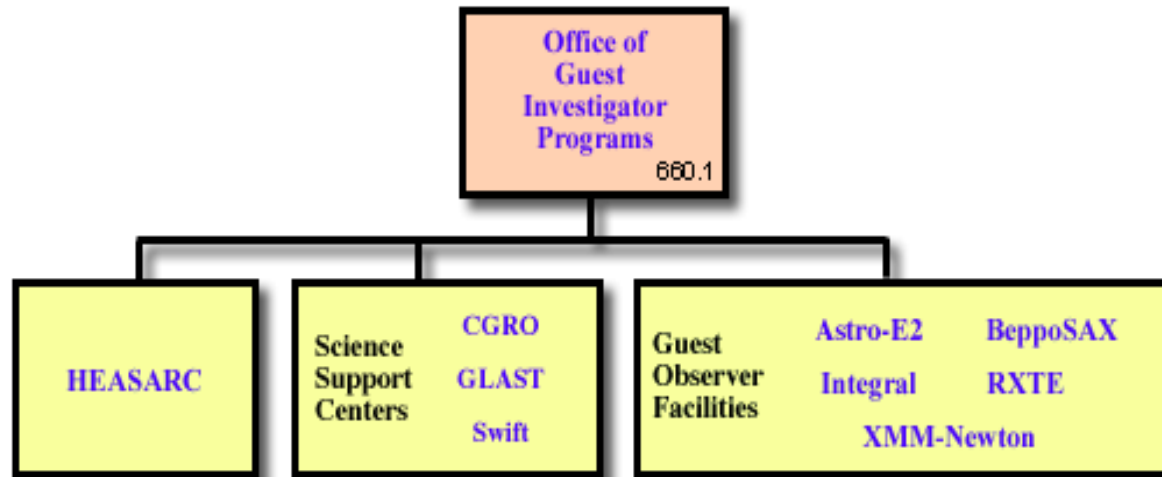
Astrophysics Data & Information Services



The Astrophysics Data Infrastructure

- HEASARC is part of a confederation of wavelength specific astrophysics archive centers & dedicated value added services
 - *EUVE, X-ray, Gamma ray: CXC, HEASARC*
 - *UV/Optical: STScI/MAST*
 - *IR: IPAC*
 - *CMB/Submm: Lambda*
 - *Data Services: NED, ADS*
- *Coordinated via the Astrophysics Data Executive Committee (ADEC)*
 - *Representatives from each data center or service*
 - *Meets 3 times a year*
 - *Currently increasing archive interoperability*

HEASARC Overall Organization



HEASARC provides the **multi-mission infrastructure** that is used by the GOFs and science support centers:

Archive, database, web services, FITS standards, multimission software, & expertize

Science staff are colocated with LHEA science branches

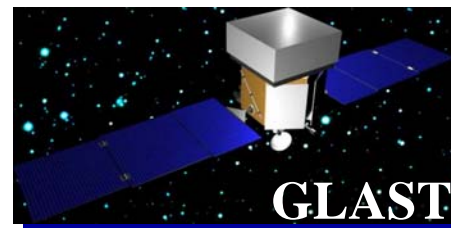
HEASARC Mission Support

HEASARC provides the multi-mission infrastructure that is used by dedicated mission data centers (RXTE, Chandra, XMM-Newton, INTEGRAL, Swift, Astro-E2, and GLAST)

Archive infrastructure, database support, web services, proposal software, FITS standards, multimission software, & science expertise

Prevents duplication of effort and promotes reuse of software which result in cost savings to missions

At the end of mission life the HEASARC maintains the archive, science expertise and software (e.g. CGRO, ASCA, ROSAT)



The HEASARC Customers

The HEASARC has at least 4 groups of external users:

- Investigators proposing and/or selected to use the current high-energy observatories which have NASA participation, e.g., RXTE, XMM-Newton, Swift, Astro E-2 (soon), including scientists
 - at US universities and other institutions
 - at NASA's GSFC and other government facilities
 - from around the world
- Researchers interested in its archives, both high-energy specialists and others
- Members of the general public who are interested in what NASA is doing in the area of high-energy astronomy
- Teachers, parents, and school children for educational and outreach materials

The HEASARC Web



HEASARC

High Energy Astrophysics
Science Archive Research Center

[HEASARC Archives, Software & Tools](#)

---Archives & Software---

[HEASARC Resources/Education](#)

---Resources/Education---

HEASARC [Observatories](#) [Archive](#) [Software](#) [Tools](#) [Help/FAQ](#) [Education & Outreach](#)

Search the HEASARC site:

The HEASARC is an archive of astronomy data from extreme ultraviolet, X-ray, and gamma-ray observatories. On this site, you'll find archival data, multi-mission software and analysis tools, information about current and past observatory missions, and information for educators and the public.

- [More about the HEASARC](#)
- [Frequently Asked Questions](#)

Latest News

- [New Browse: version 7 released](#) (30 Jan)
- [Imagine News: A Neutron Star Emerges As A Rare Magnetic Emerald](#) (28 Jan)
- [NVO service hosted by HEASARC: Search 12 Data Archives with one click!](#) (21 Jan)
- [Imagine News: Einstein Makes Extra Dimensions Toe The Line](#) (17 Dec)
- [Proposals: Chandra Cycle 6 Call for Proposals released](#) (16 Dec)
- [Analysis Software Update: HEASOFT 5.3 released](#) (25 Nov)

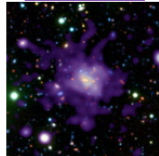
[More News](#)

Latest Gamma-Ray Bursts

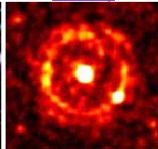
[GRB031220: GCN Circ archive: HETE, optical, IR](#)
[GRB031203: GCN Circ archive: INTEGRAL, optical, IR, x-ray, radio](#)

[Gamma-ray burst Coordinates Network Circulars Archive](#)

[HEASARC Picture of the Week](#)



[Astronomy Picture of the Day](#)



[Browse the Archive](#)

[Education & Public Outreach](#)

- [StarChild](#) (Grades K-8: general astronomy)
- [Imagine the Universe](#) (Grades 7-12: high-energy astronomy)
- X-ray and Gamma-ray [images of celestial objects](#) [...and more](#)

[Is my favorite object an X-ray, gamma-ray, or EUV source?](#)

enter source name

Frequency Regime:

HEASARC Services

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Dedicated Support Facilities

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[Chandra](#)
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[HETE-2](#)
[Integral](#)
[ROSAT](#)
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Other NASA Archive Services

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Assist astrophysicists in all stages of their archival research:

- Information and latest news about HEASARC Catalogs
- Mission information
- Search catalogs & retrieve data
- Download analysis software
- Access documentation
- Astronomical Web site links
- Public outreach & education

Data Format Standards

Sample FITS File

```
XTENSION= 'BINTABLE' / FITS BINARY TABLE
BITPIX = 8 / Binary data
NAXIS = 2 / Table is a matrix
:
:
EXTNAME = 'EVENTS' / Table name
TTYPE1 = 'TIME' / Label for 1st column
TFORM1 = '1D' / Data type: Double precision
TTYPE2 = 'RAWX' / Label for 2nd column
TFORM2 = '1I' / Data type: Short integer
```

TIME	RAWX	RAWY	DETX	DETY	X	Y	PHA
24305.2	18	25	19	25	235	344	4
24306.9	211	79	213	78	874	514	7
.....
.....
.....
.....

The HEASARC develops, coordinates and promotes standardized FITS formats for use within the High-Energy Astrophysics community.

These standards allow multi-mission analysis packages and encourage recycling of software at considerable cost savings.

The HEASARC publishes these standards on the Web and in its journal, *Legacy*. It also collaborates with new missions to ensure that their data products conform to these standards.

The Physical Archive

Past Missions

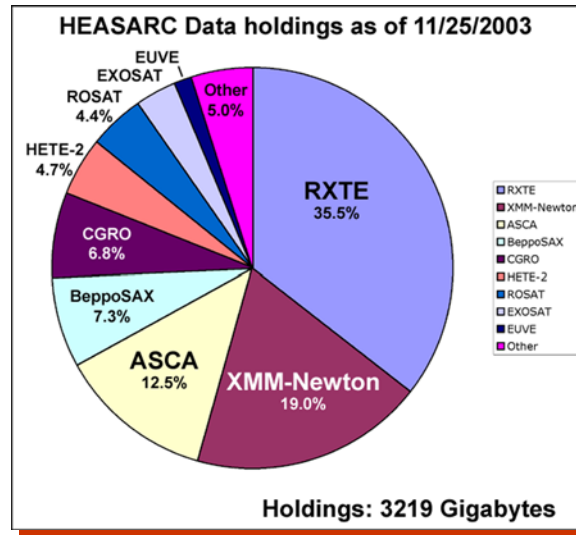
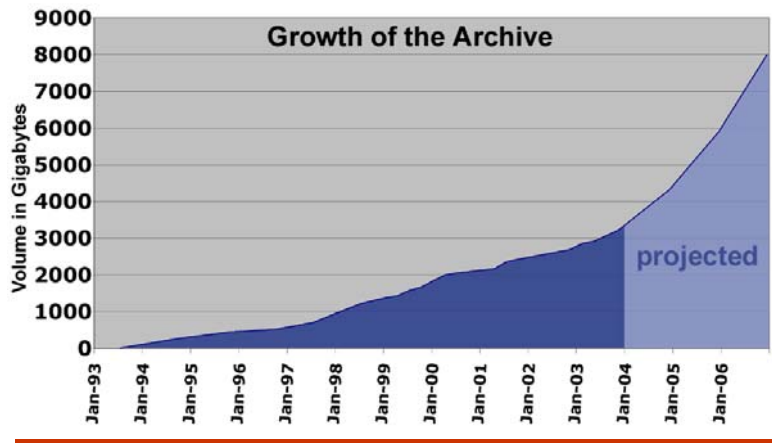
Ariel 5	EXOSAT
ASCA	Ginga
BBXRT	BeppoSAX
CGRO	HEAO 1
Copernicus	HEAO 3
COS B	OSO 8
DXS	ROSAT
Einstein	SAS 2
EUVE	SAS 3
	Vela 5B

Active Missions

RXTE (1995-)
 Chandra (1999-) [data at CXC]
 HETE-2 (2000-)
 Integral (2001-)
 XMM-Newton (1999-)

Upcoming Missions

Swift (2004 Launch)
 Astro-E2 (2005 Launch)
 GLAST (2007 Launch)



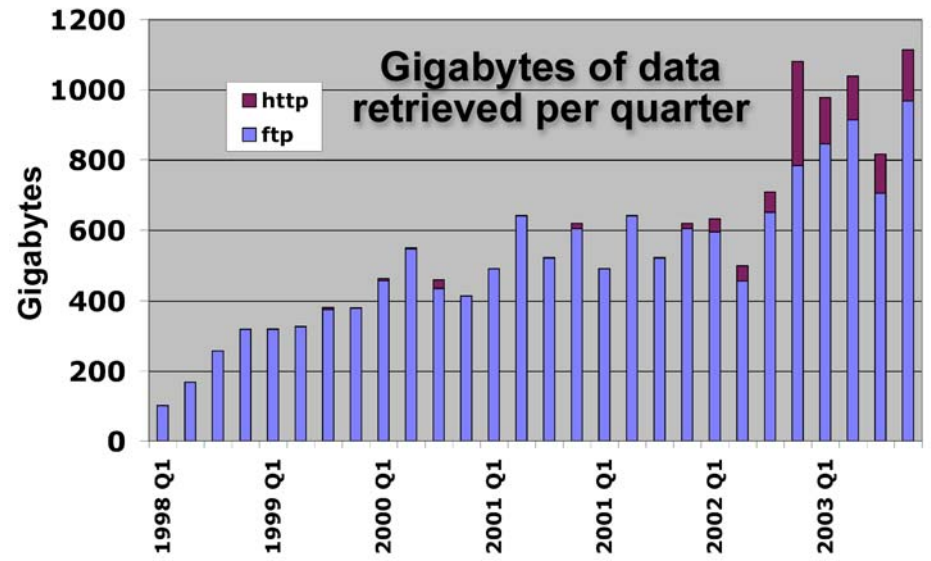
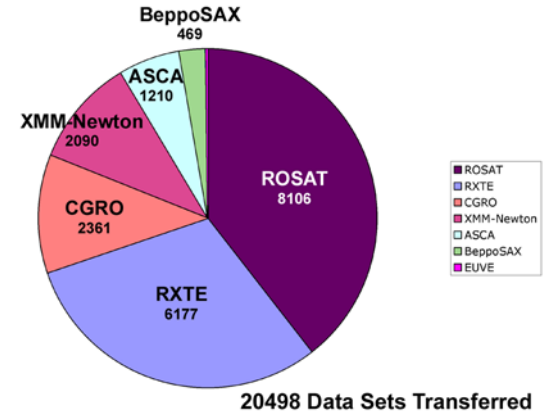
- Data from 24 missions currently in the archive
- 355 astronomical catalogs & mission tables
- The archive volume was 3250 Gigabytes as of the end of 2003

Usage & Data Statistics

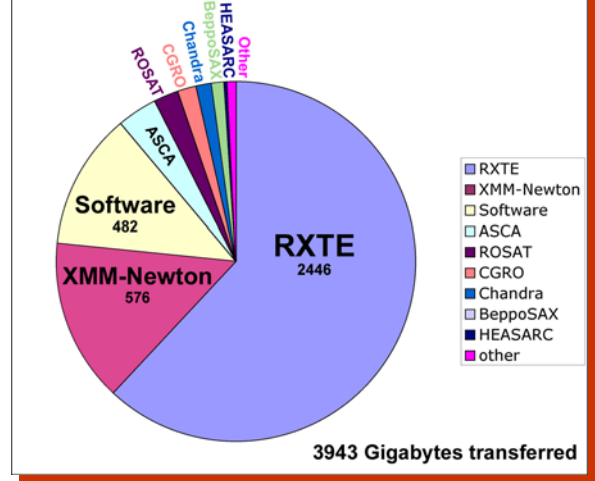
Gigabytes transferred per year

	1998	1999	2000	2001	2002	2003
Datasets by ftp & http	844	1406	1880	2270	2917	3943
Science Web Pages & Images	198	234	371	399	580	872
Main E&PO Web Pages & Images	203	358	678	1010	3108	7581

Number of Data Sets Transferred via ftp & http in 2003



GB of Data Transferred via ftp & http in 2003



Some Useful HEASARC Short Cuts

- Many HEASARC datasets analyzed in the literature are accessible via the Astrophysics Data System http://adsabs.harvard.edu/abstract_service.html and/or CDS's Simbad service <http://simbad.u-strasbg.fr/sim-fid.pl>
- A good high-level introduction to X-ray astronomy is available in the X-Ray Astronomy School 2003 presentations at <http://xrayschool.gsfc.nasa.gov/docs/xrayschool/> (Next X-Ray Astronomy School will be held in 2005)
- Pick up a copy of the 'Short Guide to the HEASARC' at the HEASARC booth: it has lots of tips and URLs describing the HEASARC's services

How Do I...?

...Quickly get the X-ray or Gamma-Ray or EUV flux of my favorite object?

Use the 'Is my Favorite Object...?' tool to do a quick search for your object in the appropriate HEASARC master catalog.

http://heasarc.gsfc.nasa.gov/cgi-bin/Tools/high_energy_source/high_energy_source.pl

...Find an Image, Graphic or Movie of my Favorite Object?

The HEASARC has several resources which cover this, including an Image Archive and a Video Archive, as well as the HEASARC Picture of the Week and a link to the Astronomy Picture of the Day (the latter two both are available via our home page).

<http://heasarc.gsfc.nasa.gov/docs/objects/objects.html>

<http://heasarc.gsfc.nasa.gov/docs/heasarc/videos/videos.html>

...Convert X-ray flux/energy/etc units to those used in my field?

Our WebPIMMS service can convert from the arcane units used in some X-ray papers (and a few of our catalogs) to more standard units.

<http://heasarc.gsfc.nasa.gov/Tools/w3pimms.html>

A general energy converter also helps translate energy units.

<http://heasarc.gsfc.nasa.gov/cgi-bin/Tools/energyconv/energyConv.pl>

...Find out which X-ray satellites have looked at my favorite source?

You can use Browse to search the observation catalogs of individual, several or all satellites which have X-ray instruments.

<http://heasarc.gsfc.nasa.gov/W3Browse/>

...Find and download data from the HEASARC?

The HEASARC's Browse service helps you find data by specific astronomical criteria and will help you create a tar file of interesting data. If you already know the structure of our archive and the dataset that you want, you can get also get the data directly through FTP.

<http://heasarc.gsfc.nasa.gov/W3Browse/>

<ftp://legacy.gsfc.nasa.gov/>

...Figure out which satellite can do the science I'm interested in?

The HEASARC maintains extensive documentation for each mission at

<http://heasarc.gsfc.nasa.gov/docs/corp/observatories.html>

and has a number of tables which compare capabilities, e.g.

<http://heasarc.gsfc.nasa.gov/docs/heasarc/missions/comparison.html>

Conclusions

- The HEASARC is NASA's gateway to the X-ray and gamma-ray data archives of the last few decades and to the currently operating high-energy missions
- Next milestones are the opening of the Integral Archive (Jul 2004) and the launches of Swift (Fall 2004) and Astro-E2 (Spring 2005)