HEASARC – The High Energy Astrophysics Science Archive Research Center

Alan P. Smale, Astrophysics Science Division, NASA/GSFC

The High Energy Astrophysics Science Archive Research Center (HEASARC) is NASA's archive for high energy astrophysics and cosmic microwave background (CMB) data, supporting the broad science goals of NASA's Physics of the Cosmos theme. It provides vital scientific infrastructure to the community by standardizing science data formats and analysis programs, providing open access to NASA resources, and implementing powerful archive interfaces. Over the next five years the HEASARC will ingest observations from up to 12 operating missions, while serving data from these and over 30 archival missions to the community. The HEASARC archive presently contains over 37 TB of data, and will contain over 72 TB by the beginning of 2016. The HEASARC continues to secure major cost savings for NASA missions, providing a reusable mission-independent framework for reducing, analyzing and archiving data. This approach was recognized in the NRC Portals to the Universe report (2007) as one of HEASARC's great strengths. This poster describes the past and current activities of the HEASARC and our anticipated activities in coming years. These include preparations to support upcoming high energy missions (NuSTAR, Astro-H, GEMS) and ground-based and sub-orbital CMB experiments, as well as continued support of missions currently operating (Chandra, Fermi, RXTE, Suzaku, Swift, XMM-Newton, and INTEGRAL). In 2012 the HEASARC (which now includes LAMBDA) will support the final nine-year WMAP data release. The HEASARC is also upgrading its archive querying and retrieval software – with the new Xamin system in early release – and building on opportunities afforded by the growth of the Virtual Observatory and recent developments in virtual environments and cloud computing.
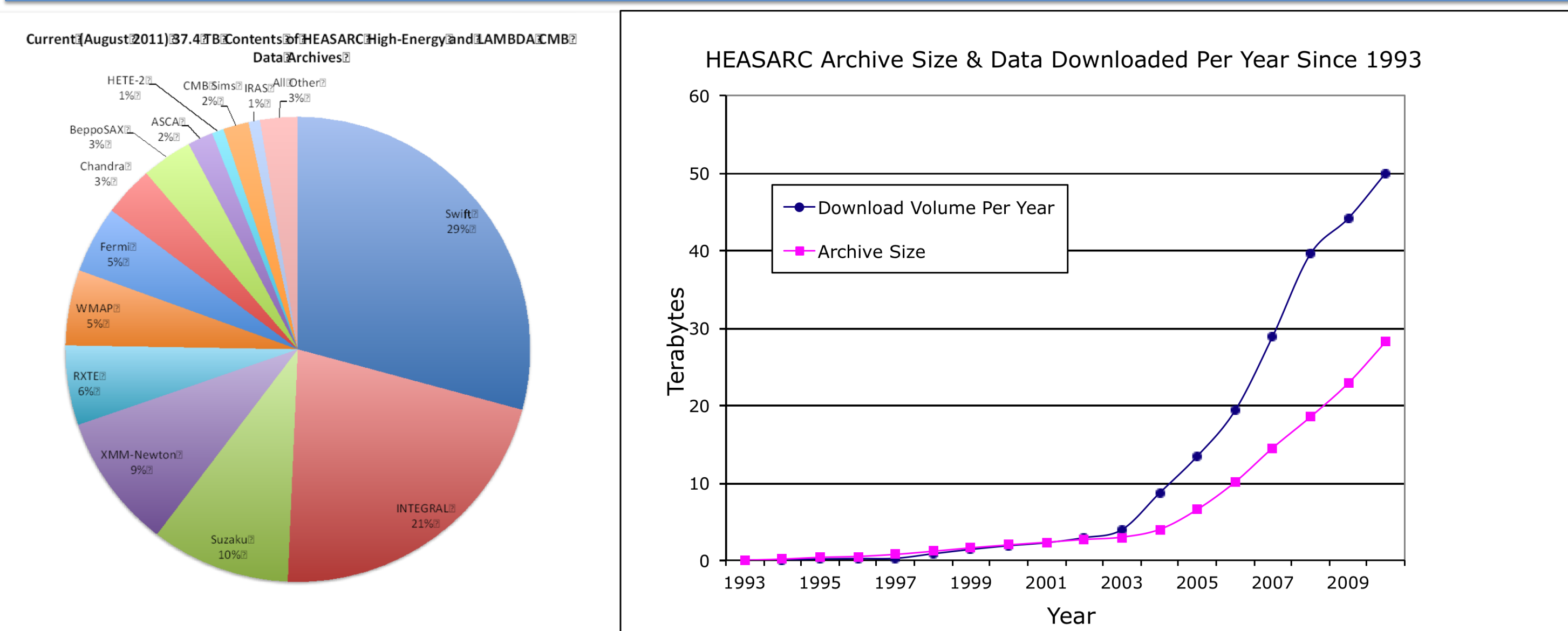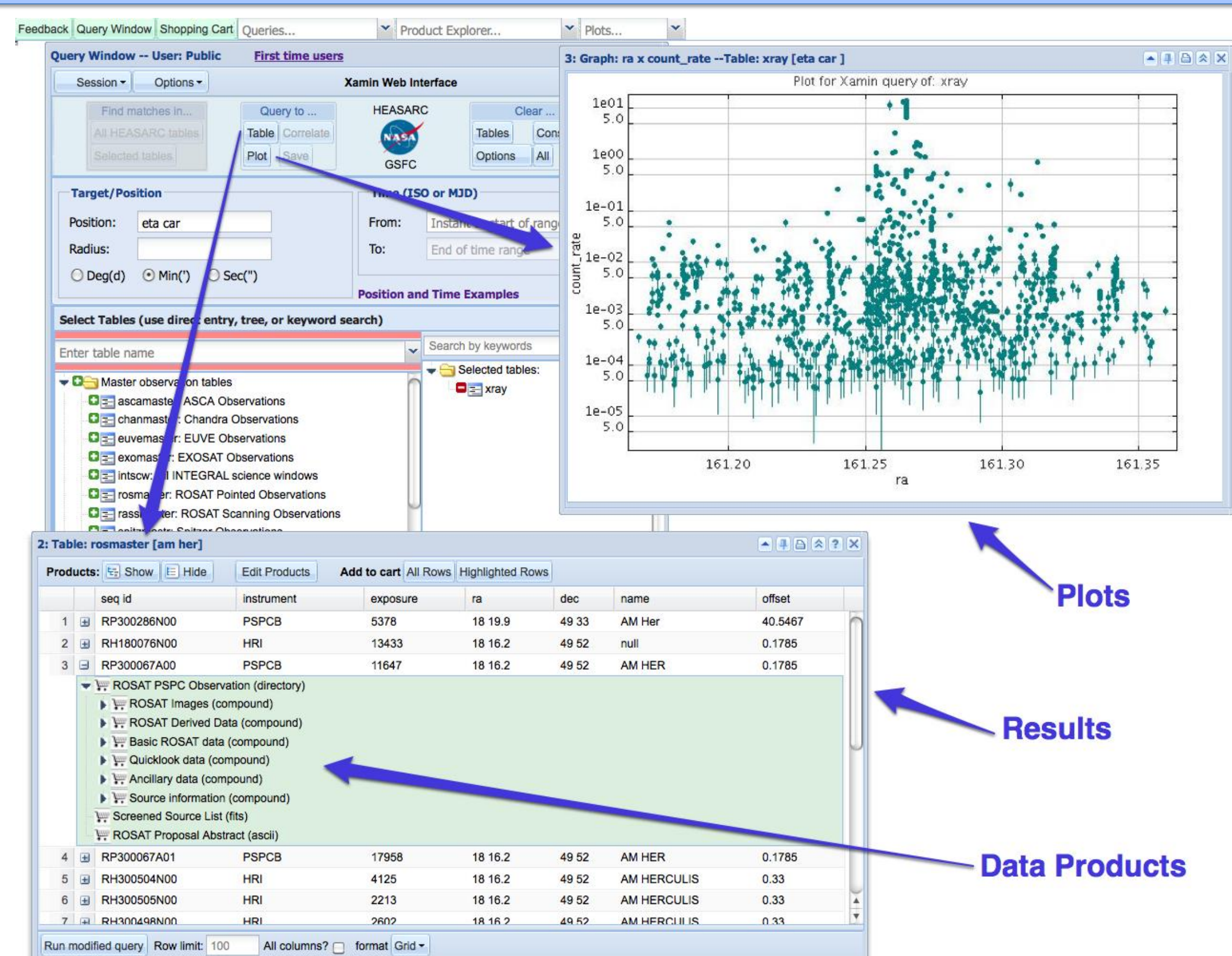
The HEASARC:

• Curates, maintains and disseminates the world's premier collections of high energy astrophysics and cosmic microwave background data from previous and currently-operating missions;
• Develops and maintains the multi-mission analysis and software tools that enable astronomical research in high-energy and CMB astrophysics;
• Provides technical expertise and software tools to help upcoming NASA-led and partnered astronomy missions to economically meet their data processing and archiving requirements;
• Provides catalogs of observations and ancillary information for the data holdings;
• Promotes standards for data formats and software within the astronomical community; and
• Supports education and public outreach in high energy and CMB astrophysics.

In these roles, the HEASARC acts in concert with other NASA and international astronomy centers, recognizing that much current astronomical research transcends the traditional wavelength regimes and mission boundaries on which most of them are organized.

The HEASARC archive has grown almost exponentially for years in both data volume and data served per year. Swift and RXTE are the most popular data sets by download volume, but older missions such as ROSAT and CGRO are still popular. By 2016 the HEASARC will contain 72 TB of data, including new datasets from the **NuSTAR**, **Astro-H** and **GEMS** missions, as well as the ground-based **SPT** and **ACT** facilities.

Selected HEASARC Achievements Over The Past Five Years

• Opened the *Fermi Gamma-ray Space Telescope* Archive
• Supported the seven-year *WMAP* data release
• Designed and developed **Xamin**, a new HEASARC data access and retrieval system
• Transitioned HEASARC Web and database servers to a virtualized environment
• Released **Hera**, a new Web-based analysis server, and added support for key *XMM-Newton* analysis routines
• Continued to support 7 active missions, and developed active archive support for *NuSTAR, Astro-H,* and *GEMS*
• Implemented archival support for CMB experiments ACT and SPT
• Cross-indexed most HEASARC archival mission data to ADS papers using bibliographic codes
• Released the HEASARC Browse notification service
• Released substantial HEASOFT upgrades to support operating missions (five updates in 2009, three in 2010)
• Released 15 major upgrades to FITSIO with >100 enhancements to support external users; implemented new x10 compression technique
• Created/updated many Browse tables (57 in 2009, 70 in 2010, 61 in 2011 so far), bringing the total number to ~700
• Released two major XSPEC upgrades, adding new models and improving multiwavelength support
• Added *Fermi, WMAP,* Sloan DR7/DR8, *GALEX* GR4, and Mellinger all-sky surveys to *SkyView*
• Released *Chandra* CALDB toolkit (2011); performed frequent CALDB updates: 44 in 2009, 35 in 2010, 34 in 2011 so far

Active and Upcoming Missions in High-Energy Astrophysics

Name	HEASARC archive role*	Energy range	Status/Launch	Characteristics
RXTE	Main	2–300 keV	Operational	Very large collecting area and high time resolution. All-sky monitoring of bright sources.
Chandra	Mirror	0.5–10 keV	Operational	High spectral resolution imaging, large effective area, and high resolution grating spectroscopy.
XMM-Newton	Mirror	0.1–15 keV	Operational	Very large collecting area with imaging capability and high resolution grating spectroscopy.
INTEGRAL	Mirror	3 keV–10 MeV Optical	Operational	High spectral and spatial resolution. Simultaneous gamma-ray, X-ray, and Optical observations.
Swift	Main	0.3–150 keV Optical and UV	Operational	Autonomous spacecraft response to GRB. Accurate position estimates within minutes. Data immediately in the public archive.
Suzaku	Main	0.4–700 keV 30 MeV–50GeV	Operational	Broad band spectroscopy, hard X-ray/soft gamma-ray capability.
AGILE	Mirror	20–60 keV	Operational	Large field of view. Sensitivity two times more at 400 MeV than EGRET; GRB monitor. Fast transients, and GRB with arcmin localization.
Fermi	Main	20 MeV–200 GeV	Operational	Large field of view. Sensitivity 50x more at 100 MeV than EGRET. GRB monitor.
MAXI	Mirror	0.5–30 keV	Operational	All-sky X-ray monitoring. Fast alert transient sources and GRB.
NuSTAR	Main	5–80 keV	2012	First hard X-ray imaging with good spatial resolution.
ASTROSAT	TBD	0.3–150 keV + UV	2012	Broad band X-ray spectroscopy. X-ray, UV Survey. Transient monitoring.
Spectrum-RG	TBD	0.1–120 keV	2013	X-ray Sky-Survey. Transient monitoring. Hard X-ray spectroscopy.
GEMS	Main	2–10 keV	2014	First sensitive X-ray polarimeter.
Astro-H	Main	0.3–600 keV	2014	High-resolution and wideband X-ray spectroscopy.

* Indicates if the HEASARC is the main archive, or the data are mirrored from another site.

Xamin: The Next HEASARC Data Interface

Xamin is the HEASARC's next-generation interface to its archive and catalog holdings, along with other datasets within the Virtual Observatory. It will gradually supersede the **Browse** interfaces which have served this role for 15 years, but whose limitations (e.g. for searching, cross-correlating and plotting large tables) are becoming apparent.

Xamin Supports:

• Faster queries and immediate data downloads;
• Scalable resource discovery for dozens of missions, thousands of tables;
• Access to data from the HEASARC and through all **VO DAL protocols** (TAP, SIA, SSA, ConeSearch);
• Access to all capabilities through both Web and CLI interfaces;
• Cross-correlations among tables from all sources (HEASARC, VO, user-supplied);
• **Complete customization of queries** including selection of output fields, constraints based upon any field (or fields) in any of the tables being queried, user defined fields, group constructs, generic SQL input, etc;
• Plotting through the STILTS plotting package, allowing a wide variety of formats and detailed plot control and customization;
• (Optional) user accounts, enabling (a) upload and saving of persistent tables that can be used interchangeably with native tables; (b) searching for (or automatic notification of) changes to existing tables or new observations of a given target or class; (c) save and reuse of query configurations;
• New data product **shopping cart** with concatenation of multiple queries, WGET or Curl download scripts, quicklook data browsing including full scale image comparison, and access to VO image and spectra products;
• And a wide variety of other new and augmented capabilities.

What's Next For The HEASARC?

• Continue to support seamless community access to a rich archive of data and metadata from past and current high energy astrophysics and CMB missions
• Ingest new observations from Chandra, Fermi, INTEGRAL, Suzaku, Swift, XMM
• Continue development of NuSTAR pipeline processing and archive to support a Feb 2012 launch
• Develop mission interfaces, file formats and archives to support the 2014 launches of GEMS and Astro-H, and the 2015 launch of XNAV/SEXTANT
• Support the final 9 year WMAP release of data and results in 2012
• Archive additional data products from suborbital CMB experiments (ACT, SPT, and CMB polarimeters) leading up to a future space mission
• Several releases of HEASoft, CFITSIO, XSPEC, and other packages per year
• Many CALDB updates – often averaging one per week
• Full release of Xamin to the community
• Major enhancements of Web Hera   [see poster P112 by Bill Pence]
• Further investigation of the opportunities presented by cloud computing
• Continuing strong involvement with the Virtual Astronomical Observatory
• Planning further ahead for future mission support: many high energy astrophysics and CMB missions with proposals in development have identified the HEASARC as their first choice for their data processing and archiving needs.