THE FUTURE IS HERA!
ANALYZING ASTRONOMICAL DATA OVER THE INTERNET

L.A. VALENCIC[1,2], P. CHAI[2], W. PENCE[2], R. SHAFER[2] & S. SNOWDEN[2]
[1]JHU, [2]NASA-GSFC HEASARC & XMM GOF

Why Do We Need Hera?

The rapid pace of improvements in computer technology and limited funds to modernize data processing software have combined to pose a problem for astrophysicists: how can we process data for certain missions when the software the data require can no longer be run on modern computers? This compatibility issue is particularly relevant in light of recent budget cuts and our increasing reliance on archival data; for instance, it is virtually guaranteed that ***when current X-ray observatories are decommissioned, mission-specific software such as SAS and CIAO will not be maintained, and will only be usable on so-called "legacy" machines***. Moreover, regular maintenance of software on personal computers can be time-consuming and challenging, as development teams often release patches and database updates several times a year.

To address these issues, NASA-GSFC HEASARC and the XMM-Newton GOF has developed Hera, an interface which affords educators, students, and scientists internet access to analysis software and the ability to process data on either their own personal computers or in temporary holding space on NASA computers. Hera hardware includes of a cluster of Linux workstations, local disk space, and access to the HEASARC data archive. The software includes general packages such as ftools, xspec, and xselect, as well as mission-specific packages such as SAS and CIAO. While it is likely some groups will produce similar systems for analysis of their own mission's data, ***Hera is the only interface to provide multi-mission data analysis capabilities.*** To better meet users' needs, there are three types of Hera: Standard, Anonymous, and Runtask.

Standard and Anonymous Hera

Both Standard and Anonymous Hera provide interactive access to a GUI through which the user can analyze data with the software of his or her choice; the main difference between them is data storage. Standard Hera, which requires users to log in to an account (see Fig. 1), affords them the option of saving their data on a private area of the Hera server. Anonymous Hera, which users can access through the HEASARC data archive (see Fig. 2), deletes all data files at the end of the session. It does, however, give the user the option of saving the files to a new or existing Hera account, or downloading them to the user's computer. Users of both Standard and Anonymous Hera can easily copy files between their computers and the Hera servers by "dragging and dropping" the files in question.

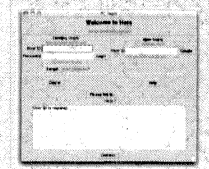

Fig. 1: The login window for Standard Hera.

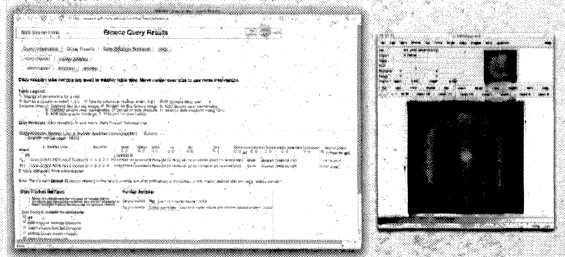

Fig. 2. Left: An entry in the HEASARC data archive for our example, an XMM observation of X Per; data may be immediately analyzed with Anonymous Hera by clicking on the "H" next to the desired dataset. Right: An MOS1 image of X Per.

Abstract

Hera is the new data processing facility provided by the HEASARC at the NASA Goddard Space Flight Center for analyzing astronomical data. Hera provides all the preinstalled software packages, local disk space, and computing resources needed to do general processing of FITS format data files residing on the user's local computer, and to do advanced research using the publicly available data from High Energy Astrophysics missions. Qualified students, educators, and researchers may freely use the Hera services over the internet for research and educational purposes.

An Example

Here we show how the user can filter an XMM-Newton event file and extract a spectrum using SAS with the Hera GUI. This is an Anonymous session, so the data is held temporarily on the Hera server. Fig. 3 shows the main work window, where the tasks and datafiles are selected. The *evselect* pop-up, used to filter the event file, is shown in Fig. 4 (top left). *Evselect* is then used again on the filtered event file to extract the spectrum, and the response matrix and ancillary file are made with *rmfgen* and *arfgen* (see Fig. 4, top right and lower left, respectively). The command dialogue window, giving feedback to the user, is shown in Fig. 4 (lower right). The final extracted spectrum is shown in Fig. 5.

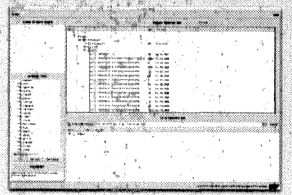

Fig. 3: The main work window. The large top window lists files on the Hera server. The window directly below it lists files on the user's computer. The top left window shows special analysis scripts; beneath it, the available tools and their descriptions are listed. In this case, we have selected tasks in the XMM-SAS toolbox.

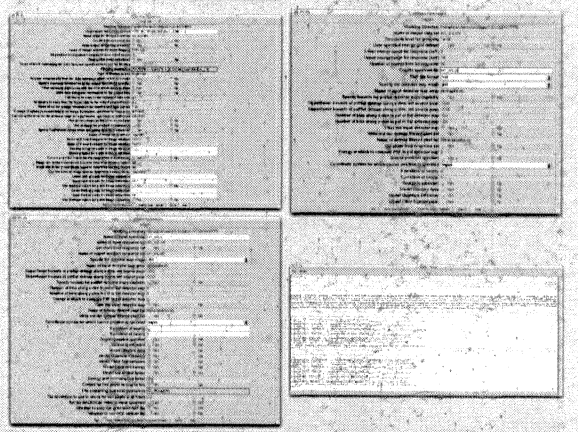

Fig. 4. Top left: The window for the SAS evselect task, set to apply standard filters to the MOS1 event file and write the output to "m1_evt2.fits". Top right: window for rmfgen. *Lower left: window for* arfgen *task. Lower right: command window, echoing the task input parameters and issuing warnings and error messages as needed.*

Runtask Hera

Any of the software installed on the Hera servers can also be run on the command line to analyze data on the user's local computer, provided that the user had installed fv. The user simply executes each task in the same way as if he or she were using a locally-installed package, calling the procedure and providing parameters as necessary, but precedes each command with "fv -r". The input data files are then copied to temporary disk space on the Hera server, where the task is run. The output files (and any feedback from the procedure) are then copied to the user's computer. If the user thinks a task will take a long time to run, he or she may have Hera send an email notification when the task is finished, at which point the user can reconnect to Hera and download the results.

For example, to filter the same event file and extract a spectrum with the Runtask interface, the user would type:

```
fv -r evselect table=P0151380101M1S001MIEVLI0000.FTZ
  withfilteredset=yes expression='(PATTERN<=12)&&(PI in
  [200:12000]) &&#XMMEA_EM' filteredset=m1_evt2.fits
  filtertype=expression keepfilteroutput=yes
  updateexposure=yes filterexposure=yes

fv -r evselect table='m1_evt2.fits:EVENTS'
  energycolumn='PI' withfilteredset=yes
  filteredset='m1_filtered.fits' keepfilteroutput=yes
  filtertype='expression' expression='((X,Y) in
  CIRCLE(27372.5,27298.5,3000))&&(FLAG==0)
  withspectrumset=yes spectrumset='m1_src.pi'
  spectralbinsize=15 withspecranges=yes specchannelmin=0
  specchannelmax=11999

fv -r rmfgen format=var rmfset=m1_src.rmf threshold=1e-6
  spectrumset=m1_src.pi

fv -r arfgen arfset=m1_src.arf spectrumset=m1_src.pi
  withrmfset=yes rmfset=m1_src.rmf extendedsource=no
  modelee=yes withbadpixcorr=yes modelootcorr=no
  badpixlocation=m1_flt_evt2.fits
```

The output files are identical to those produced with the GUI.

For more information, please visit our website:
http://heasarc.gsfc.nasa.gov/hera/heramain.html

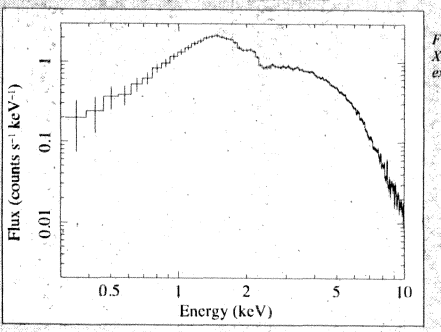

Fig. 5. X Per's spectrum in the XMM-Newton MOS1 camera, extracted with Hera.