INTEGRAL SOURCE RESULTS PAGES AND ACCESS TO INTEGRAL DATA THROUGH VIRTUAL OBSERVATORY: SCIENTIFIC MOTIVATION AND RECENT STATUS

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ABSTRACT

In its current status, the Virtual Observatory (VO) is an international effort to handle distributed databases of all data taken from the sky. It should enable quick and common access to all data products - ranging from images to light curves and spectra. Once created, scientists will have a common interface to access multi-mission, multi-wavelength data on few mouse-clicks. We will discuss motivations to create Virtual Observatory access to INTEGRAL data, challenges we have to overcome while creating it, and current status of development VO enabled interface to public INTEGRAL data.

Key words: INTEGRAL; Virtual Observatory.

1. VIRTUAL OBSERVATORY

The Virtual Observatory[2] (VO) is an effort to consolidate all available astronomical information, so they can be accessed through a set of common protocols. As all astronomical information cannot be stored in a single place, Virtual Observatory make it possible to retrieve information from different archives connected by the Internet.

2. MOTIVATIONS FOR INTEGRAL VO

At ISDC, INTEGRAL telemetry data are transformed into FITS files, and stored at the ISDC archive. Then they are accessible using various methods - from FTP or SCP retrieval to WWW access through modified HEASARC Browse interface. Before scientific results can be obtained, the data must be processed by the Off-line Science Analysis (OSA) package or by a similar analysis tool. Based on user input, OSA produces high-level products - images, light-curves and spectra - from raw data.

This kind of data processing using OSA or a custom algorithms is acceptable for regular users of INTEGRAL data. But scientists outside the INTEGRAL community have to learn all the details of OSA processing, stepping from installation to various parameters used during processing, before they can start to explore the data INTEGRAL provides.

For those occasional users of INTEGRAL data, we would like to provide an interface that they can use to quickly gain access to processed INTEGRAL data, without any need to do OSA processing. They can use that interface as a quick check to see if INTEGRAL can provide any data for the paper they are writing, or for the theory they would like to confirm. As the VO tries to unify all astronomical data in one set of common protocols, the VO is the first choice for such interface.

The availability of INTEGRAL data in VO will enable scientist who know how to use VO to use INTEGRAL data. As VO is widely propagated and as its user base expands, inclusion of INTEGRAL data will enlarge the community of INTEGRAL users. This is expected to lead to an increase of number of publication that exploit INTEGRAL data.

3. CHALLENGES ON WAY TOWARDS VO FOR INTEGRAL DATA

The VO is primarily developed by the community of optical and radio astronomers. This leads to a bias in interfaces, to design them in a way that they will allow access to 2D images data, with the possibility of providing 3D image data (e.g. radio data taken on different wavelengths).

Data from INTEGRAL can be provided as 3D image set, with extra dimension corresponding to different bands chosen for image processing. The image access is defined by Simple Image Access (SIA).

Access to spectra in VO is defined in Simple Spectra Access (SSA). For γ-ray astronomy, this is more straightforward than image access, so we do not expect problems there.

Access to Light curve (LC) data is still in a preliminary phase, so we cannot judge how much work will be needed

to transform LC data stored in FITS format to VO Tables holding LC data.

The data size of INTEGRAL archive is comparable to other archives, for which the VO interface was created, so we do not see any problem in the size of INTEGRAL data.

4. DIFFICULTIES IN VO

IVOA, the International Virtual Observatory Alliance, was created as a standard setting organisation. That removes from *IVOA* the responsibility for designing, creating, testing and shipping actual software. This is appropriate for standard setting organisation. But no standard will become widely accepted without a reference implementation.

The VO effort currently lacks this kind of standard application, similar to what Netscape web-browser was for WWW or GoogleEarth is for Google GIS. Some small steps towards that application have been achieved, but a full featured version has not yet arrived.

5. CURRENT STATUS

We designed and developed INTEGRAL Source Results (ISR) pages. These simple web-pages allow quick access to high-level INTEGRAL data - images, light-curves and spectra. They allow users to select sources, display whole light curves in predefined ISGRI and JEM-X bands, used for default off-line data processing, and zoom in on part of a light curve. They also display ISGRI mosaics and JEM-X images with sources overplotted, and ISGRI spectra of source.

ISR is coded with Perl CGI scripts. For the VO interface to the ISR data, we decided to use Tomcat servlet containers. Tomcat runs servlets - Java classes, which responds to users requests. Java offers significant advantages for development of web service, at least compared to Perl scripts. We found and use Java FITS I/O library, which we changed significantly, resulting in reduced memory usage and faster FITS processing. The current version of FITS I/O can be downloaded from net.ivoa.fits site - http://net-ivoa-fits.sf.net.

We have a beta version of VO access, which allows access to INTEGRAL Source Results catalogue, and to the INTEGRAL images. This interface is written in Java, and run as a servlet in a servlet container (we use Tomcat, but other containers can be used). It accesses the catalogue and image metadata stored in an Oracle database using a JDBC driver. For FITS access we use the net.ivoa.fits library.

This prototype offers SIAP (Simple Image Access Protocol) for image access, and an Aladin-compatible VO

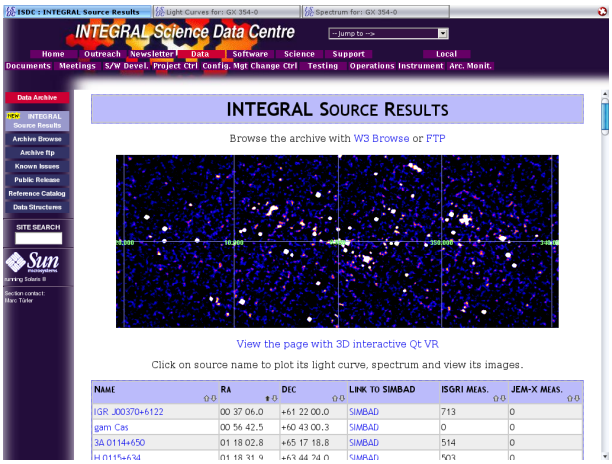

Figure 1. INTEGRAL Source Results entry page (http://isdc.unige.ch/index.cgi?Data+sources)

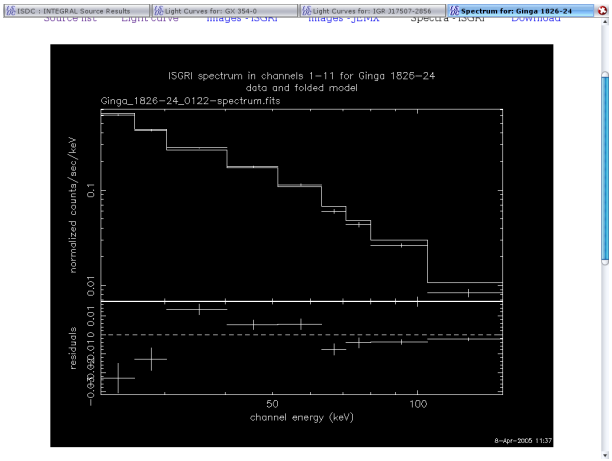

Figure 2. ISGRI Spectra of GINGA 1826-24

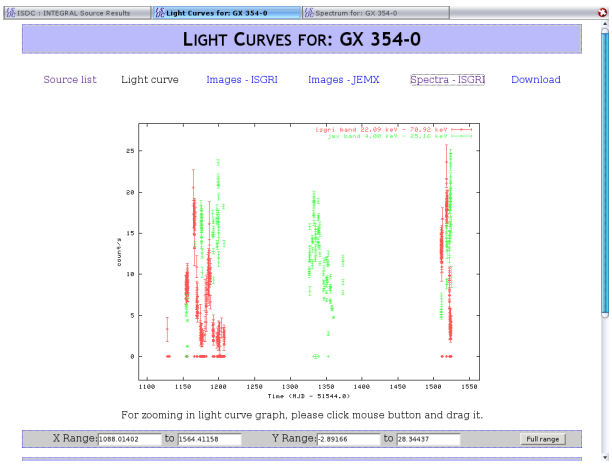

Figure 3. Light curve of source GX 354-0

name resolver, which lists sources in current INTEGRAL catalogue.

We did some rough performance tests of both services, and found them surprisingly fast. SIAP was much faster then image access in ISR, and performance on multiple extension IBIS files was very good, most probably due to Java's nature to load everything in memory and then to work with data. It also seems to us that system caching gave performance a boost.

We plan to make this interface available when we have finished making fixes to the FITS I/O library. Due to our current involvement in other experiments, this will unfortunately not happen before third quarter of 2007. We expect that we will provide source code for the interface together with a reference implementation in ISDC. Release of the interface should follow few months after release of the fixed FITS I/O. We expect that we will provide pre-built jar files, a zipped source tree and anonymous read-only access to the CVS repository with the source.

6. *VOEVENT* AND *IBAS*

VOEvent is an *IVOA* effort to distribute computer and human readable messages about transient events. It can be thought as extension of the *GCN*[1] and *IBAS*[4] services, which provide reports about γ-ray bursts. It should distribute reports about all discoveries which are worthy of follow up observations by other instruments. The use of *VOEvent* should enable better exploration of the sky time domain.

VOEvent is currently in design phase. On the *IVOA* web site (*http://www.ivoa.net*) is an XML Schema for *VOEvent* messages together with documents that describes rationale behind the chosen design. Although the *VOEvent* specification did not endorse any transport protocol, most participants use Jabber message API to distribute *VOEvent* messages.

We would like to make a bridge between *IBAS* and *VOEvent*, which would enable *VOEvent* to transfer *IBAS* messages. We plan to work on this bridge together with our implementation of VOEvent to our RTS2[3]-driven network of telescopes. Due to our commitment to further development of that network, we do not have resources to work on VOEvent issue before the end of 2007.

7. ACKNOWLEDGEMENTS

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