

Providing on-line access to the ‘Pi of the Sky’ data

M. Biskup^a, K. Malek^{b1}, L. Mankiewicz^b, L. W. Piotrowski^a, M. Sokolowski^c, G. Wrochna^c,
A. F. Zarnecki^a

^a Institute of Experimental Physics, University of Warsaw, Hoza 69, 00-681 Warsaw, Poland

^bCenter for Theoretical Physics, Polish Academy of Sciences, Lotnikow 32-46,
02-668 Warsaw, Poland,

^c A. Soltan Institute for Nuclear Studies, Hoza 69, 00-681 Warsaw, Poland,

ABSTRACT

The main aim of the “Pi of the Sky” experiment is to search for optical flashes associated with the gamma ray bursts. The detector also allows us to study other kinds of short timescale astrophysical phenomena. During everyday observations “Pi of the Sky” detector collects many measurements of interesting objects like blazars, quasars, variable stars etc. It is very important to make this data available to other experiments as fast as possible. Dedicated WWW interface connected with the “Pi of the Sky” database in Chile was created to provide on-line access to selected objects. The interface allows quick and easy accesses to the “Pi of the Sky” data right after all measurements processes are finished.

Keywords: variable stars, star database, light curve, Gamma Ray Burst (GRB), Global Telescope Network (GTN)

1. INTRODUCTION

“Pi of the Sky” is an experiment designed to search for optical transients in the sky and to investigate variable objects over a large range of variability timescales, from seconds to years. The prototype detector is located in Las Campanas Observatory (LCO) in Chile and consists of two CCD cameras that perform about five 10 seconds exposures per minute. Cameras are installed on robotic, parallactic mount. Regular prototype running started in July 2004 [1].



Fig. 1. Pi of the Sky prototype, Las Campanas Observatory, Chile

The main concept of “Pi of the Sky” experiment is to detect optical flashes of astrophysical origin by continuous monitoring of a large part of the sky – about π steradians. For this purpose a dedicated triggering system was

¹ malek@cft.edu.pl

designed. Full “Pi of the Sky” system will include two sets of 16 cameras each, separated by a distance of about 100 km, in order to reject satellite flashes by parallax. Full version of the apparatus is currently under construction.

Every night two cameras of the “Pi of the Sky” prototype in Chile continuously monitor the sky and search for short optical flashes by taking relatively short, 10s exposures. On average, there are 10 hours of data acquisition per night, which amounts to over three thousand frames per camera [2], about six thousand frames per night. Each frame contains about 25 thousand objects for which measurements have to be stored in the database in Chile. This gives the amount of measurements for only one night at the level of about 150 millions.

During the observation period “Pi of the Sky” detector collected many measurements of interesting objects like blazars, quasars, etc. The experiments interested in short timescale phenomena need to analyze the data regularly and without unnecessary delay. However it is not possible to download all measurements every night because of the size of the data. The solution was to create a list of interesting objects, mark all these objects in our database in Chile and download only associated measurements to our local database in Warsaw.

2. LISTS OF INTERESTING OBJECT

The first lists of interesting objects were created by “Pi of the Sky” team itself. These lists consist of a few dozen of variable and flare stars, which were mainly taken from SIMBAD astronomical database providing basic data and measurements for astronomical objects outside the solar system [3]. Some of the variable stars were descended from the General Catalogue for Variable Stars (GCVS) [4]. These first lists were made for testing proposes and internal use only. Nowadays “Pi of the Sky” still creates some internal object lists but also receives them from other experiments. A few lists of interesting objects have been made available during the last six months. Each of them has its own dedicated web interface with on-line access to selected stars.

There are currently four main lists of interesting objects:

- *The Global Telescope Network list* consists of 30 objects, most of them are quasars and blazars but also the cataclysmic variable AM Her type stars, SRA and SRB objects - two classes of semiregular stars. The Global Telescope Network (GTN) is an informal association of observatories, scientists and individuals interested in astronomy. GTN involves students, teachers and amateur astronomers in cutting-edge astronomical research [5].
- *The Whole Earth Blazar Telescope list* consists of 8 objects, 5 of them are quasars and 3 are BL Lac objects. BL Lac is a class of Active Galactic Nuclei. Because of their occasional wild variability, these objects are sometimes referred to as blazars. The Whole Earth Blazar Telescope (WEBT) is a network of optical and radio observers who in concert have the capability to obtain continuous, high-temporal-density monitoring of blazars [6].
- *Waldemar Ogloza list of interesting objects* consists of more than 3000 objects. Waldemar Ogloza is an astronomer from Pedagogical University of Cracow. Together with his students, he is using this list for searching minima of the eclipsing stars.
- internal “Pi of the Sky” lists with more than 400 objects.

The accesses to GTN, WEBT and Waldemar Ogloza lists via dedicated web pages is free and not restricted (password is not required). A link to these pages can be found on the “Pi of the Sky” official web site.

3. DATABASE SYNCHRONIZATION

Every day, after observations in Chile are finished, data extracted from all collected images are transformed into a database record. This process can be divided into four following steps: first corrections for background and apparatus effects are performed, next a list of stars with instrumental coordinates is created and their instrumental brightness calculated. In the third step all stars are being compared with the stars catalog and instrumental coordinates are transformed into celestial ones. Finally all obtained data is saved to the database. The process of interesting object selection is carried out every day during the cataloguing. Stars from the database in Chile are matched with objects from

the list using the coordinates. As a part of the output of this software pipeline, all interesting object's measurements are downloaded from LCO to Warsaw via Internet.

In addition, a dedicated shell script was created for making `fits` and `jpeg` format images, which are downloaded from Chile to Warsaw and are available for an interface user together with the measurements.

4 WEB INTERFACE

Web interface consists of three different categories: main list of interesting objects, a detailed web page and a form for adding new objects. The main web page lists all interesting objects that "Pi of the Sky" has ever observed. One can find the information about the kind of the list (GTN, WEBT or Waldemar Ogloza list) and link to "Pi of the Sky" official web page.

[Pi of the Sky home page](#)

.: Pi of the Sky - GTN interface .:

List of GTN interesting objects

Add new interesting object

Get data from LCO

DATABASE: scan aver

NAME	RA	DEC	MAGNITUDE	#POINTS	LAST OBSERV.	COMMENT
J0210-5055	02:10:46.20	-51:01:1.00	13.0	1	20061111	
AO 0235+164	02:38:38.90	16:36:59.00	12.1	59	20070116	Blazar
EF Eri	03:14:13.03	-22:35:41.00	11.6	1	20070215	Nova-like Star
J0458-4635	04:55:50.80	-46:15:58.00	12.5	1	20060909	
PKS 0537-441	05:38:50.30	-44:05:8.00	12.7	2	20070320	Quasar
OI 158	07:38:7.40	17:42:19.00	9.3	1	20070201	Quasar
SU Mon	07:42:17.00	-10:52:47.00	7.4	170	20070417	SRB object
VV Pup	08:15:6.73	-19:03:16.00	13.2	4	20070312	Cataclysmic Var. AM Her type
OJ 049	08:31:48.90	04:29:39.00	13.8	1	20070320	Blazar
OJ 287	08:54:48.80	20:06:30.00	10.9	1	20070401	Quasar
TZ Cnc	09:04:1.00	20:56:55.00	9.1	66	20070407	SRA object
R Sex	09:42:42.00	-8:05:60.00	8.7	144	20070422	LB: object
RY Leo	10:04:15.00	13:58:58.00	10.0	70	20070422	SRB object
YY Leo	10:08:20.00	20:00:13.00	9.5	47	20070417	SRB object
4C 29.45	11:59:31.80	29:14:44.00	13.1	1	20070121	Quasar
W Com	12:21:31.70	28:13:58.00	12.1	60	20070416	Blazar

Fig. 2. Web interface – list of GTN interesting objects

User may add new interesting objects using 'Add new interesting object' form (the password is required). Adding new interesting objects creates a new mark in database. After adding new objects, corresponding stars is found in the database by matching their coordinates. In the next step the corresponding measurements are downloaded from Chile to Warsaw.

The 'Get data from LCO' button launches procedure for receiving new data for all objects from LCO. The same procedure is automatically executed every day after night data cataloguing is finished.

On the main web page there is a switch selecting the database: “aver” database is a star catalogue created from images averaged over twenty exposures and “scan” database is a catalogue created from all sky scan images averaged over three.

[List of GTN interesting objects](#)

:: Adding new objects ::

Name:

RA [HH.Dec or HH MM SS]:

Dec [Dec. Deg or Deg MM SS]:

Magnitude:

Priority: 0 to 5 (5 - higher):

Comment:

Visibility period:

Fig. 3. Web interface - add new interesting object form

On the main web page one can find a table with main information about the interesting objects: name, equatorial coordinates, magnitude (an average of all measurements for this object in our database), number of measurements, night of last observation and some comments.

The name of the object is a link to the details web page. We choose as an example one of the GTN interesting objects, SU Mon star. It is a semiregular late-type giant with poorly defined periodicity. After choosing SU Mon object detailed web page opens with various additional information about it:

- general information like the name of the database catalog and name of the object,
- equatorial coordinates and magnitude,
- links to light curves for both cameras and to directories, which contain `fits` and `jpeg` format images.

At the bottom of this detailed web page a form with interactive fields is situated, which allows to add some comments to the database.

.: SU Mon .:

(scan)

LAST OBSERV : 20070417
LAST FIELD : 0720-20
#POINT : 170
MAGNITUDE : 7.36324
RA : 7.7047222222222
DEC : -10.8797222222222
ON K2A : 1414978
ON K2B : 4079302
LIGHT CURVES : k2a [1414978](#) k2b [4079302](#)
ALL FITS: [k2a camera](#) [k2b camera](#)

- ALL FoV
 Native field (0800-10)
or
 0720-10 (49)
 0720-20 (44) *edge field*
 0800-10 (37)
 0800-20 (40) *edge field*

native field - star registered closest to the chip center so far
edge field - star registered less then about 200 pixels from the edge of the CCD. Usually means less accurate photometry.

EDIT:

QUALITY : 0
COMMENT : SRB object
PRIORITY:

Fig. 4. Web interface - detailed web page

After clicking on the star number near the LIGHT CURVE caption, the application will show a page with the star's light curve (magnitude vs. time) and additional information about the star. This light curve's plot is interactive. User can zoom the light curve by selecting a range of star measurements and the time interval, or even simpler by drawing a rectangle using a computer mouse. After that, new database query with new parameters will be executed on the server and results presented to the user.

Points on the light curve are marked with different colors corresponding to different fields of the sky. To select data from specific field one can enter its name in the text field denoted 'FILED', separating different fields by a comma, and redraw, or select the "Default Field" option to choose only the native field – where the star is registered closest to the chip center.

To eliminate data which are suspected to be of bad quality one can set all 'Skip' checkboxes on. One can skip measurements which are suspected to be biased because of:

- open shutter – for some period of time pictures were taken with camera shutter permanently open. In this case bright stars may influence magnitude measurements for stars which lie below them on the frame.
- strong background – observed field is close to the moon or the moon is very bright.
- hot pixel – sometimes hot pixels, defects of CCD chip, can significantly affect measurements of the stars.
- neighboring bright star – as in an open shutter case, a close bright star may influence magnitude measurement

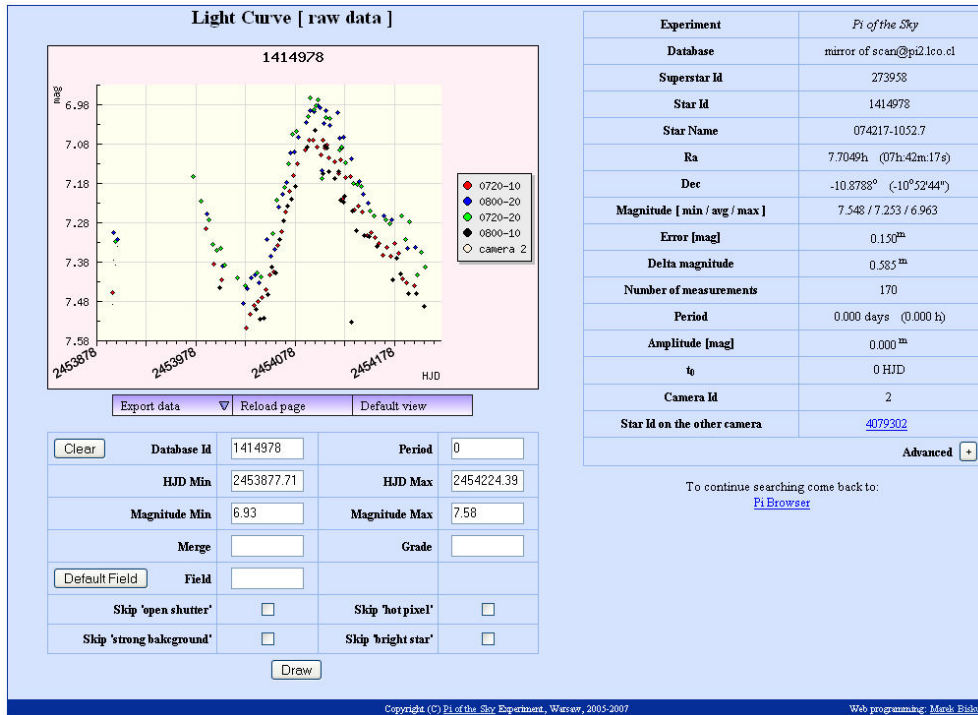


Fig. 5. Light curve's web interface, SU Mon light curve

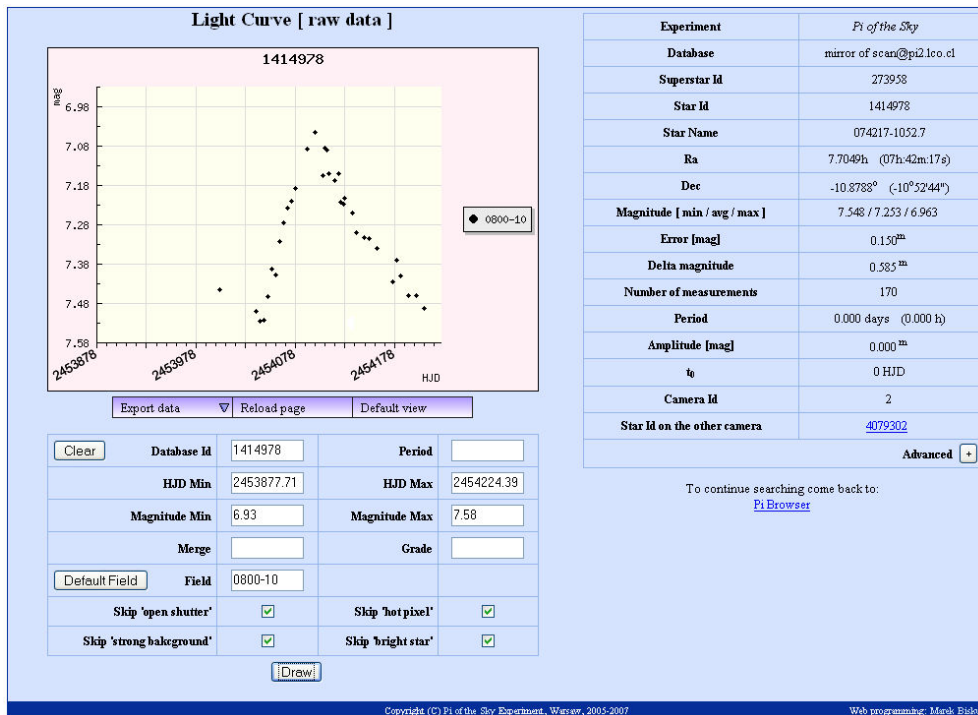


Fig. 6. The SU Mon light curve created only for a native field. All measurements which are suspected to be of bad quality were eliminated

With 'Export data' menu it is possible to download data for further processing as a html table, CSV file or ROOT package macro which plots the light curve in a nice, ready-to-publish way.

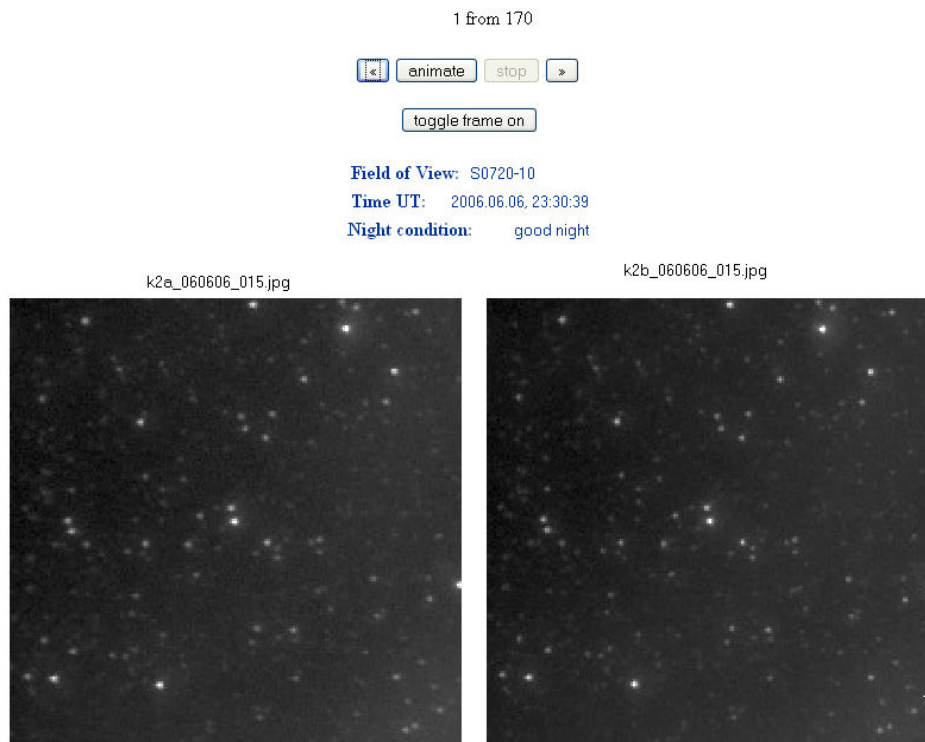


Fig. 7. Web page - an animated form using to view jpeg format images for a selected star

On details web page there are two links that enable to view images for a selected star. First of them is a link next to the 'ALL FITS' caption. After clicking on a star number the application will show directories which contain fits and jpeg images. The second option is to view animated sequence of jpeg images. by choosing fields of view and clicking 'VIEW DATA' button.

5. TECHNICAL DESCRIPTION OF WEB INTERFACE TECHNOLOGY

Our interface is a small web-based application built in PHP technology. PHP scripts connected to local database generate HTML code.

In "Pi of the Sky" experiments we use PostgreSQL as an open source relational database management system (RDBMS). This database's source code is available under open source license. Additionally it is very useful because PostgreSQL procedures are available in more than a dozen programming languages, including Perl and C/C++ [7].

For data presentation the interface uses three main kinds of html web page:

- table – with whole lists of interesting objects for selected user (for example Figure 2 – Web interface – list of GTN interesting objects),
- details forms – with detailed information about object with interactive fields (for example Figure 4 - Web interface - detailed web page),
- adding forms – for adding new object to the list (for example Figure 3 - Web interface - add new interesting object form).

All of these forms involve on-line interactions with the database fields and are generated in runtime by the PHP scripts.

An additional table `InterestingObjects` was created in the database to store all interesting objects. Each record has a numeric label identify a list of objects it was taken from what is essential for generating special web interface for different list.

A special guest interface created in our experiment has bilateral interaction with the database. User can add, delete and modify items directly in the database using this interface.

6. CONCLUSIONS

“Pi of the Sky” experiment created a dedicated web interface for making its data available to other experiments. As a result of collaboration between our experiment and The Global Telescope Network, list of GTN interesting objects being the first external list in our project, more user-friendly and well-organized web pages emerged. This way of providing on-line access to the ‘Pi of the Sky’ data was checked and now the “Pi of the Sky” project can automatically open new web interfaces for other experiments.

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