THE PROJECT OF CRIMEAN ASTRONOMICAL VIRTUAL OBSERVATORY (CrAVO)

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An overview of the most important components of the CrAVO is presented, including the main principles of formation of databases with information about astronomical objects and their physical characteristics, derived from observations obtained at the Crimean Astrophysical Observatory (CrAO) and published in the “Izvestiya of the CrAO” and elsewhere. Emphasis is placed on the DBs missing from the most complete global library of catalogs and data tables, VizieR. We specially consider the problem of forming a digital archive of observational data obtained at the CrAO as an interactive DB related to database objects and publications. We present examples of all our DBs as elements integrated into the CrAVO. We illustrate the work with the CrAO DBs using tools of the IVO: Aladin, VOPlot, VOSpec, in conjunction with the VizieR and Simbad DBs.

1. INTRODUCTION

The history of scientific research at the Crimean Astrophysical Observatory (CrAO) goes back for more than a century. The amateur astronomy industrialist N. S. Maltsov donated his observatory to the Russian Academy of Sciences in 1908. In 1945, the department of Pulkovo Observatory in Simeiz was transformed into an independent organization. In the second half of the 20th century, the CrAO became well known in the world. Early in the 20th century, the observatory used a small 0.12-m double astrograph for observations, but already in 1925, one of the world-largest telescopes of that time, the 1-meter telescope of the British firm Grubb & Parsons, was installed in Simeiz. During the World War II, the telescope was destroyed. At the new site (in Nauchnyj), a 1.22-m Zeiss reflector replaced the destroyed 1-m telescope and began its continuous operation. In 1960, the new 2.6-m reflecting telescope (ZTSh) was inaugurated; in was named after the Academy Member G.A. Shajn ("Sh" in the abbreviation). In 1966, the 22-m RT-22 radio telescope was installed in Katsively near Simeiz. In 1974, after reconstruction, the Tower Solar Telescope (TST-1) came into operation. The unique gamma-ray telescope, consisting of 48 mirrors with the total area of 54 square meters, began to operate at the CrAO in 1989. All the above instruments were, at the time of installation, the largest in Europe.

After the beginning of the space age, the observatory made a significant contribution to the development of extra-atmospheric research. Since 1959, fourteen instruments designed and built with the participation of the CrAO were installed on satellites and space stations. The most significant among these instruments were the orbital solar telescope (OST-1) installed on board the Salut-4 space station in 1975 and the ultraviolet telescope, SPIKA, with the main mirror 0.8 m in diameter, on board the ASTRON space station that operated from 1983 to 1989.

In total, the CrAO DBs currently list 32 telescopes that were used for observations, together with 55 devices used to record radiation in the range from gamma-rays, with energies of $E > 10^{12}$ eV, to radio waves with a wavelength of 0.2 m.

The park of observational equipment that large made it possible to solve a wide range of problems, covering almost all areas of the development of astronomy in the 20th century. It is important that many outstanding scientists, founders of scientific schools and prominent astrophysicists whose ideas laid foundations of promising research, worked at the CrAO.

In the structure of the CrAO databases, the DB "Employees" plays a key linking role between the DBs "Publications" and "Observations". These DBs, along with the databases "Projects", "Instruments", "Objects", and "Catalogs", constitute the main part of the "Crimean Astronomical Virtual Observatory" (CrAVO) project (Shlyapnikov et al. 2015).

More information on the history of the CrAO can be found in the 5th issue of Volume 104 of "Izvestiya of the Crimean Astrophysical Observatory" which presents materials of the conference dedicated to its 100th anniversary. The CrAVO project was described by the authors (Shlyapnikov 2007).

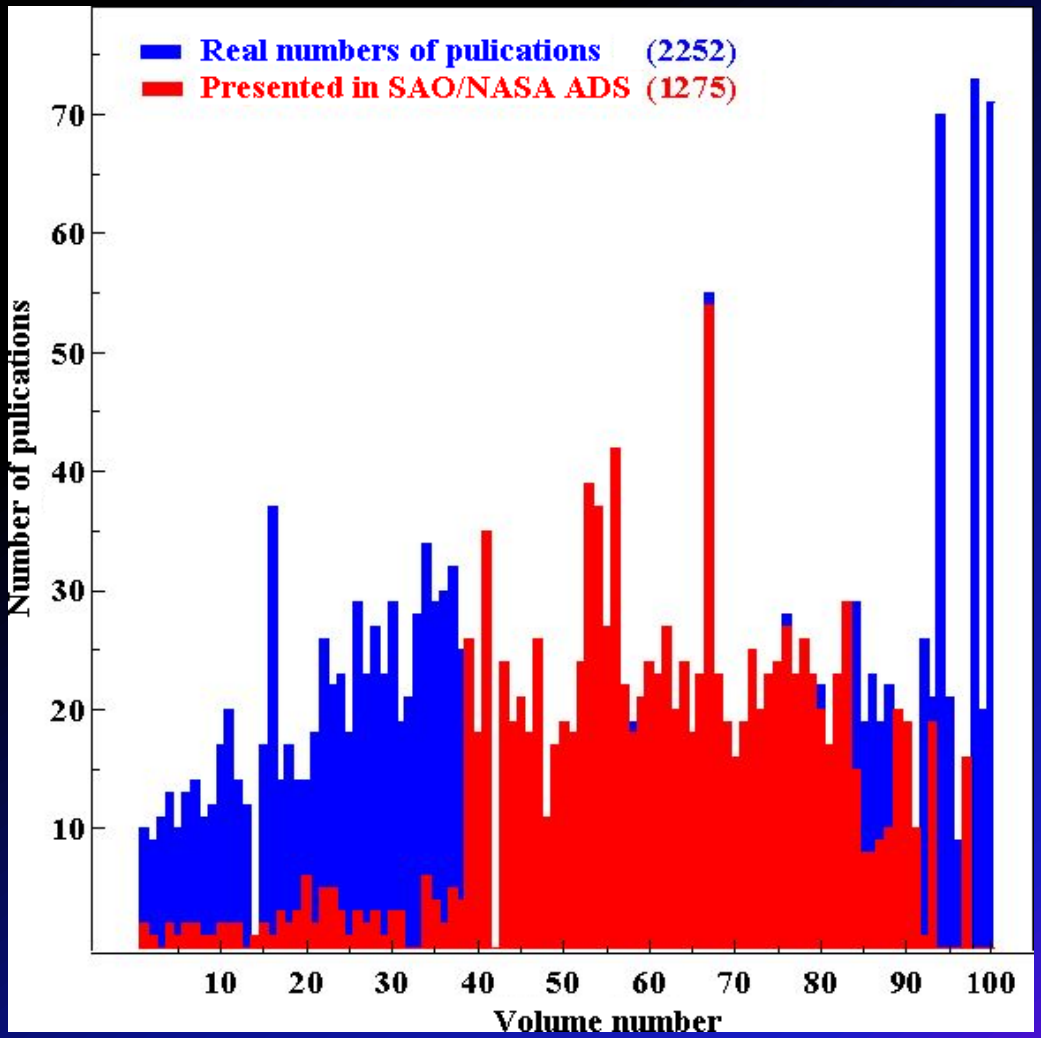
2. DB "PUBLICATIONS" (DBP)

This database is formed from publications by the CrAO staff, based on observations obtained at the CrAO and/or in other observatories. Studies performed at other institutions with the CrAO staff members being co-authors were also included. The first volume of "Izvestiya of the CrAO" was published in 1947. The DBP includes 100 volumes: subsequent volumes are available in the interactive mode, and thus it is easier to search for information in them compared to the printed version. Before the release of the first volume of "Izvestiya", the papers of the CrAO staff were published in various journals, while the number of papers published in the "Izvestiya of the CrAO" became dominant by the end of the 20th century.

The motivation for creating the DBP was to analyze how "Izvestia of the CrAO" was represented in the most complete world database of astronomical publications - the digital library portal of the Smithsonian Astrophysical Observatory for researchers in astronomy and physics, which is supported by grants from NASA (the SAO/NASA Astrophysics Data System, ADS; Kurtz et al. 2000).

Until mid-2013 (the time of the latest analysis), the ADS search system had provided a gateway to information on 1283 articles published in the "Izvestiya of the CrAO". Note that during the six years (Shlyapnikov 2007), the number of links to the "Izvestiya" has increased by 406 publications; however, it is only 57% of the entire list of publications. The main suppliers of information to ADS are:

the NASA program of scientific and technical information (609 publications); the Astronomical Center of the University of Heidelberg, Germany (491 publications); and the Astronomical Data Center in Strasbourg, France (136 publications). The interest of different organizations to the journal is due to the information contained in the articles, including results of observations. However, the main problem is that there is still no access to original publications and, in some cases, to their abstracts. To improve this situation, we started digitization of articles in the "Izvestia of the CrAO".



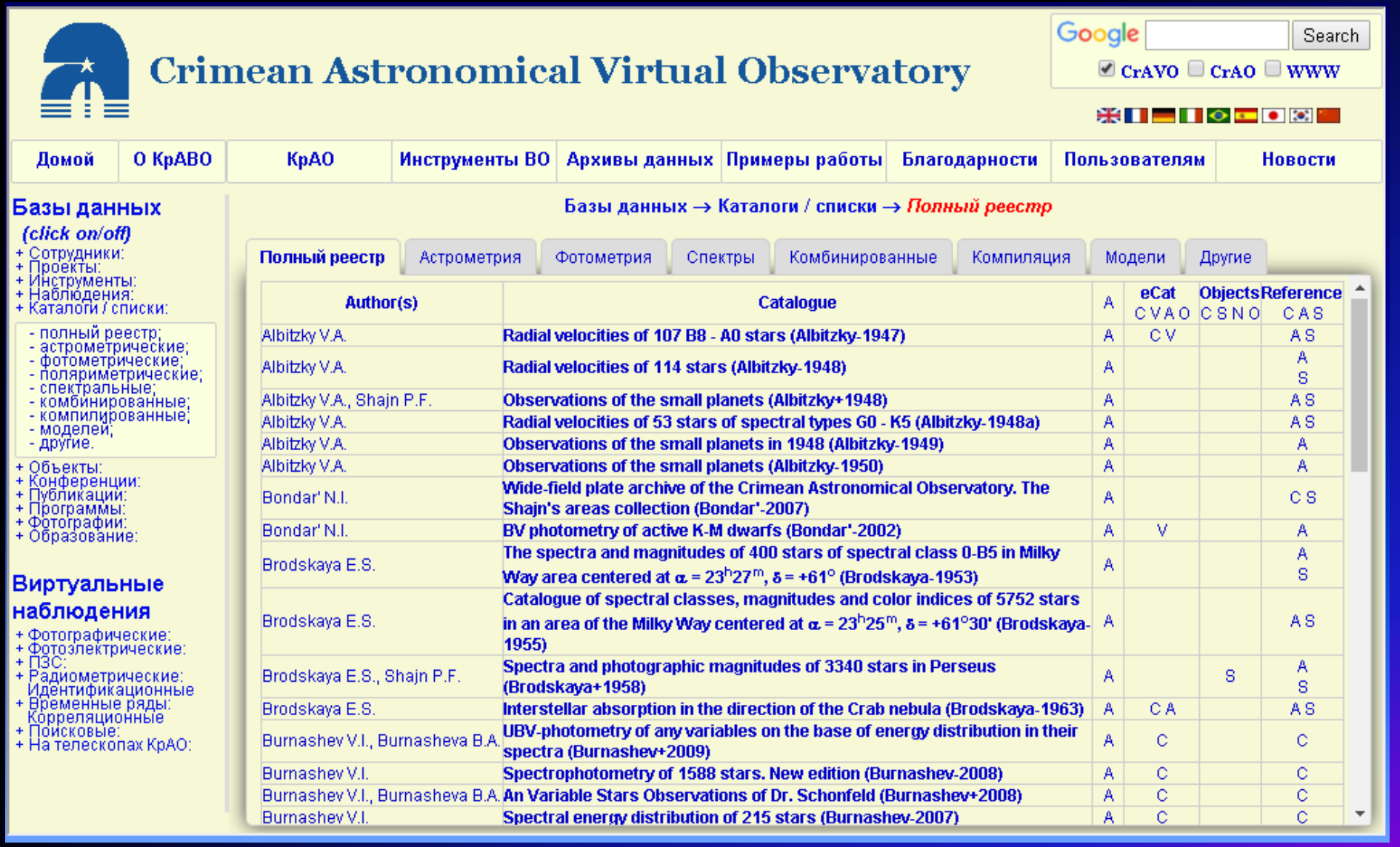
In Bondar' et al. (2013), we discussed in detail the problem of creating a digital version of "Izvestiya". The basic and most time-consuming work in creating the DBP is compiling an index of contents (IC) for published articles. IC is not a part of the structure of "Izvestia of the CrAO", which makes it virtually impossible to conjugate the use of "Publications" and "Objects" DBs. We have started compiling the IC. A brief example of its format is shown in Table 1. We see links to "Izvestiya", with the object/objects mentioned in the corresponding article listed. In its advanced format, the IC is supplemented with information on the instrument used for observations, specifics of the data (photometric, spectroscopic, polarimetric, etc.), and time of observation.

Table 1. Example of indexing the "Izvestiya of the CrAO" journal.

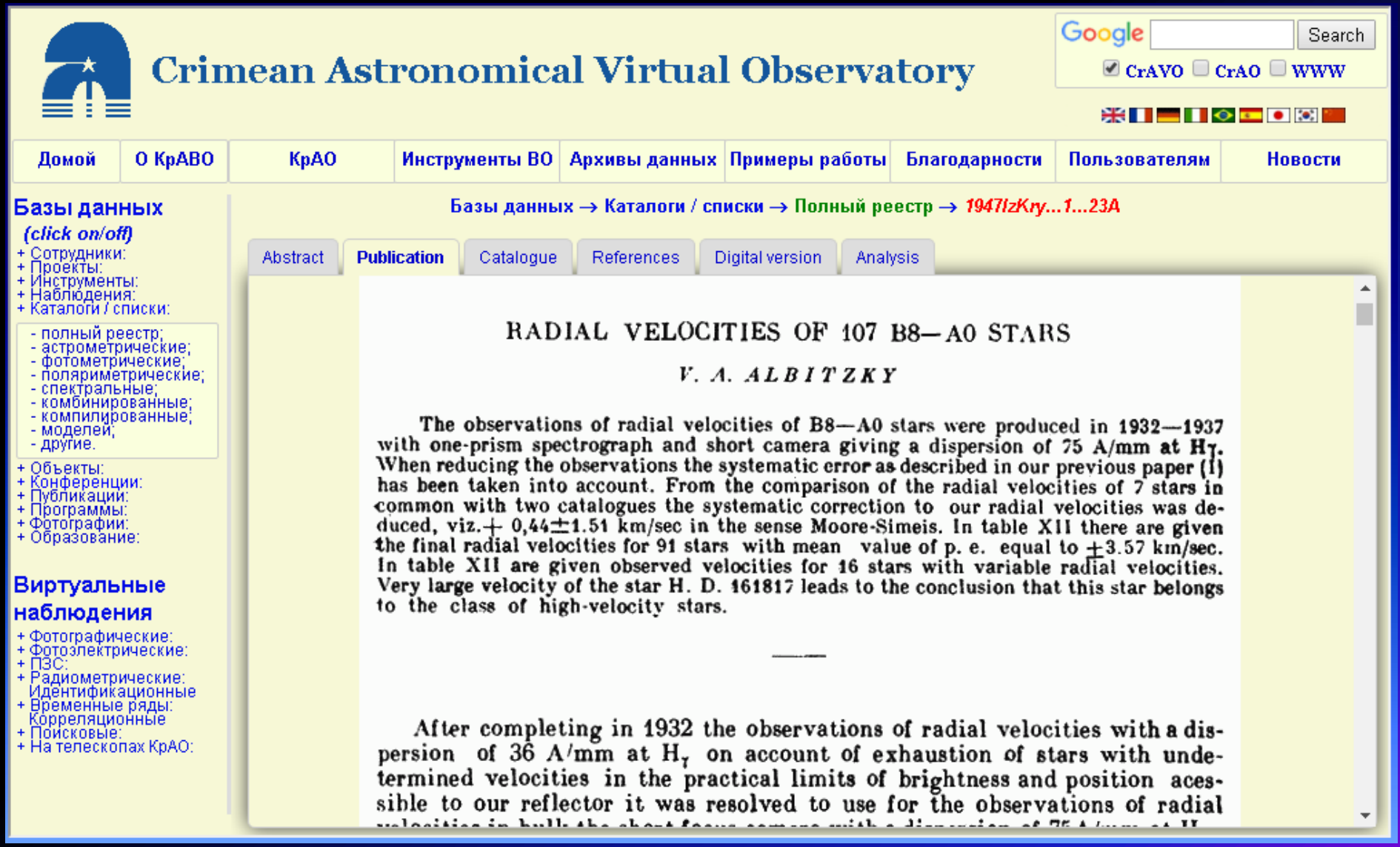
IzKry	Name	IzKry	Name	IzKry	Name
1966..66.139	MetS	1976..55. 85	HD 224085	1978..58. 51	Cyg X-3
1975..53. 29	GRS	1976..55. 94	BY Dra	1978..58. 56	V 599 Aql
1975..53. 59	Cyg X-3	1976..55.100	EM Cep	1978..58.104	NGC 4151
1975..53. 59	Cas GAM-1	1976..55.112	OAs*	1979..59.104	Jupiter
1975..53.150	Fl*	1976..55.112	YCl*	1979..59.133	Cl Cyg
1975..53.154	RD*	1976..55.127	Sp.*	1979..59.143	AN And
1975..53.165	Fl*	1976..55.157	Cyg X-3	1979..59.182	Mrk 279

When preparing the digital version of "Izvestia of the CrAO", we present abstracts of articles and papers proper, in the GIF and PDF formats, along with the data they contain, for inclusion in the VizieR database (Ochsenbein et al. 2000) and in the SAO/NASA ADS.

The "Publications" DB, supplemented with the IC, contains a hyperlink to the ADS database and to SIMBAD (Wenger et al. 2000) and provides an interface to the "Observations" DB of the CrAVO.



Example of DBP from CrAVO



Scan of original publication

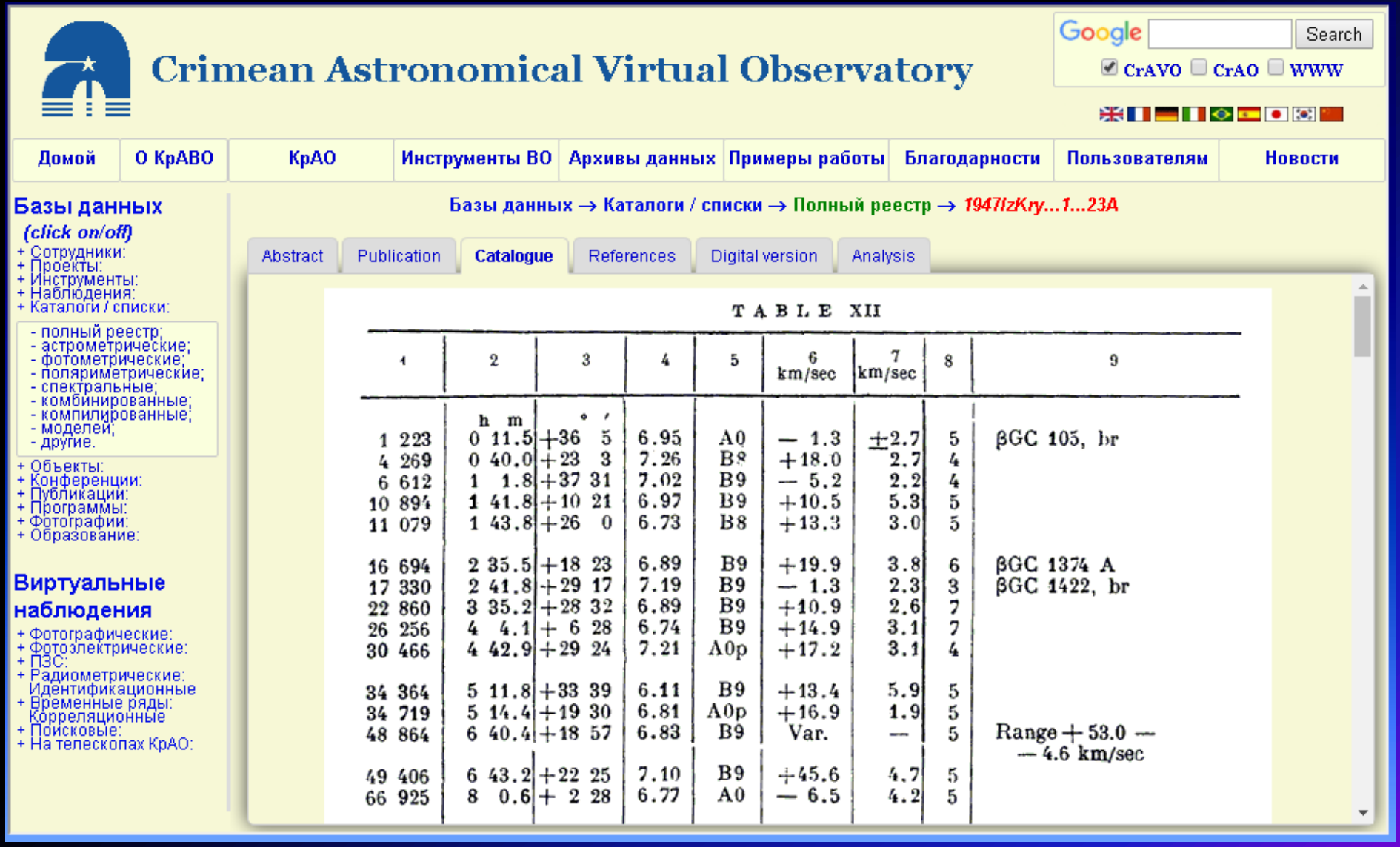


TABLE XII

1	2	3	4	5	6 km/sec	7 km/sec	8	9
	h m	° ′						
1 223	0 11.5	+36 5	6.95	A0	— 1.3	±2.7	5	βGC 105, br
4 269	0 40.0	+23 3	7.26	B8	+18.0	2.7	4	
6 612	1 1.8	+37 31	7.02	B9	— 5.2	2.2	4	
10 894	1 41.8	+10 21	6.97	B9	+10.5	5.3	5	
11 079	1 43.8	+26 0	6.73	B8	+13.3	3.0	5	
16 694	2 35.5	+18 23	6.89	B9	+19.9	3.8	6	βGC 1374 A
17 330	2 41.8	+29 17	7.19	B9	— 1.3	2.3	3	βGC 1422, br
22 860	3 35.2	+28 32	6.89	B9	+10.9	2.6	7	
26 256	4 4.1	+ 6 28	6.74	B9	+14.9	3.1	7	
30 466	4 42.9	+29 24	7.21	A0p	+17.2	3.1	4	
34 364	5 11.8	+33 39	6.11	B9	+13.4	5.9	5	
34 719	5 14.4	+19 30	6.81	A0p	+16.9	1.9	5	
48 864	6 40.4	+18 57	6.83	B9	Var.	—	5	Range + 53.0 — — 4.6 km/sec
49 406	6 43.2	+22 25	7.10	B9	+45.6	4.7	5	
66 925	8 0.6	+ 2 28	6.77	A0	— 6.5	4.2	5	

Original catalogue

Crimean Astronomical Virtual Observatory

Google Search

CrAVO CrAO WWW

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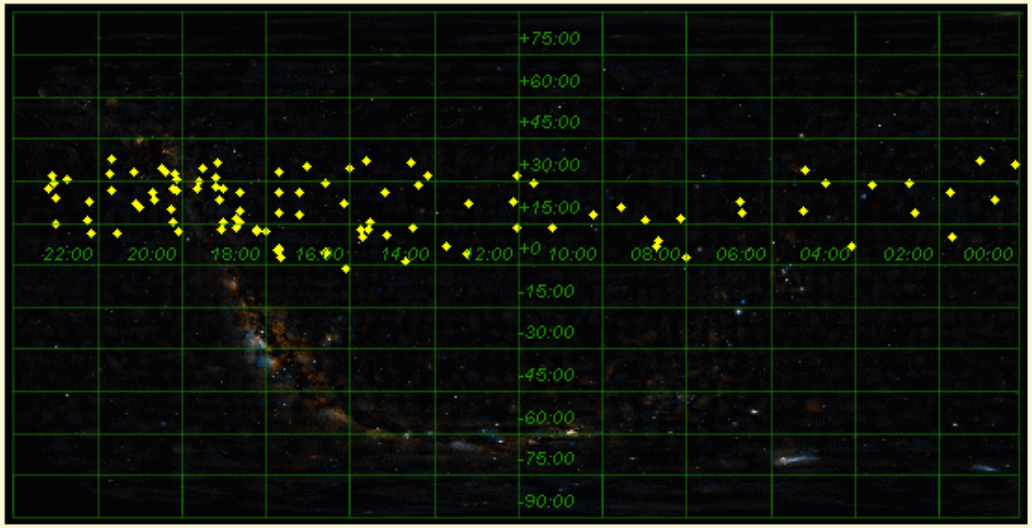
  Идентификационные
+ Временные ряды:
  Корреляционные
+ Поисковые:
+ На телескопах КрАО:

Базы данных → Каталоги / списки → Полный реестр → *1947IzKry...1...23A*

Abstract | Publication | Catalogue | References | **Digital version** | Analysis

Description
Summary
ReadMe



The distribution objects of the catalogue on the sky in cartesian projection (360° x 180°).

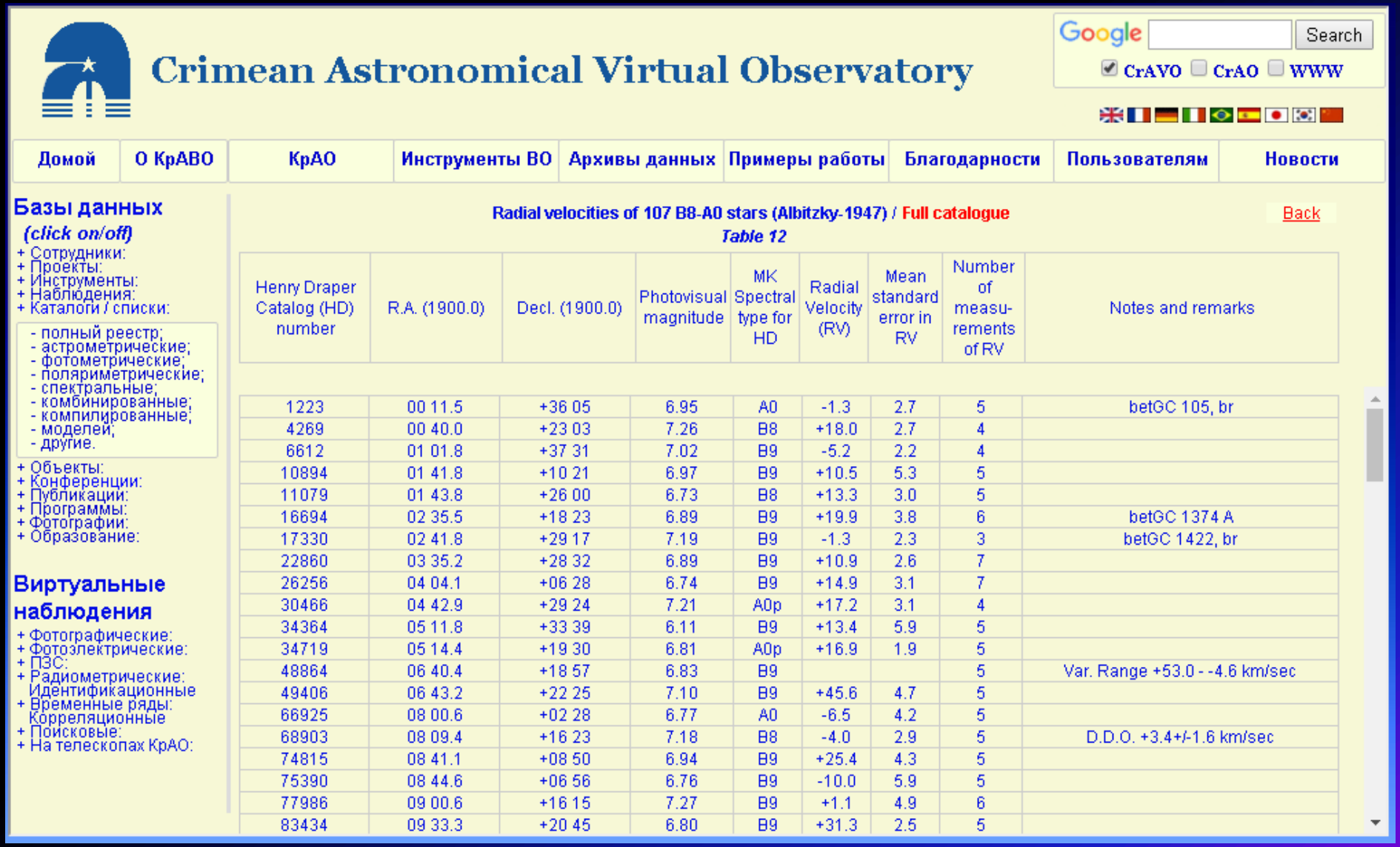
Your Query Open in new window !

Examples: *HD 102056; 11 39.6 +29 13*, or other identifier and format of coordinates used in SIMBAD.
The used full zoom ("-") in Aladin for see all objects in the A-1947 catalog and option "Location" after download sky atlas for search objects (identifier or coordinates).

Full catalogue:
- **HTML** (CurWin, NewWin);
- **XML;**
- **DATA.**

Full catalogue with:
- **ALADIN;**
- path for local version of **ALADIN;**
- **SIMBAD;**
- **VizieR.**

Digital version of catalogue



Crimean Astronomical Virtual Observatory

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CrAVO CrAO WWW

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  - фотометрические;
  - поляриметрические;
  - спектральные;
  - комбинированные;
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+ Радиометрические:
  Идентификационные
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  Корреляционные
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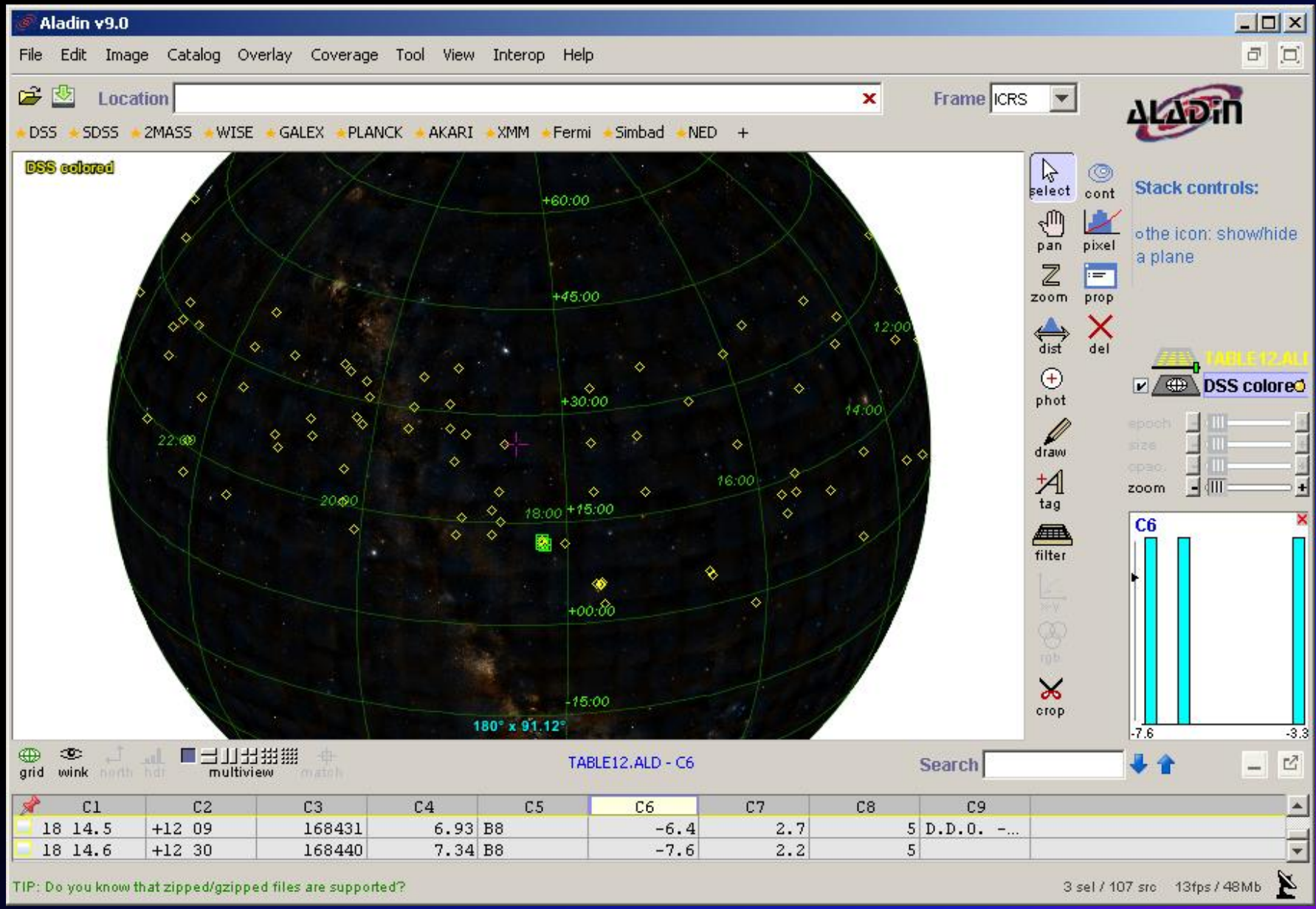
Radial velocities of 107 B8-A0 stars (Albitzky-1947) / Full catalogue

Back

Table 12

Henry Draper Catalog (HD) number	R.A. (1900.0)	Decl. (1900.0)	Photovisual magnitude	MK Spectral type for HD	Radial Velocity (RV)	Mean standard error in RV	Number of measu-rements of RV	Notes and remarks
1223	00 11.5	+36 05	6.95	A0	-1.3	2.7	5	betGC 105, br
4269	00 40.0	+23 03	7.26	B8	+18.0	2.7	4	
6612	01 01.8	+37 31	7.02	B9	-5.2	2.2	4	
10894	01 41.8	+10 21	6.97	B9	+10.5	5.3	5	
11079	01 43.8	+26 00	6.73	B8	+13.3	3.0	5	
16694	02 35.5	+18 23	6.89	B9	+19.9	3.8	6	betGC 1374 A
17330	02 41.8	+29 17	7.19	B9	-1.3	2.3	3	betGC 1422, br
22860	03 35.2	+28 32	6.89	B9	+10.9	2.6	7	
26256	04 04.1	+06 28	6.74	B9	+14.9	3.1	7	
30466	04 42.9	+29 24	7.21	A0p	+17.2	3.1	4	
34364	05 11.8	+33 39	6.11	B9	+13.4	5.9	5	
34719	05 14.4	+19 30	6.81	A0p	+16.9	1.9	5	
48864	06 40.4	+18 57	6.83	B9			5	Var. Range +53.0 - -4.6 km/sec
49406	06 43.2	+22 25	7.10	B9	+45.6	4.7	5	
66925	08 00.6	+02 28	6.77	A0	-6.5	4.2	5	
68903	08 09.4	+16 23	7.18	B8	-4.0	2.9	5	D.D.O. +3.4+/-1.6 km/sec
74815	08 41.1	+08 50	6.94	B9	+25.4	4.3	5	
75390	08 44.6	+06 56	6.76	B9	-10.0	5.9	5	
77986	09 00.6	+16 15	7.27	B9	+1.1	4.9	6	
83434	09 33.3	+20 45	6.80	B9	+31.3	2.5	5	

Digital version of catalogue (HTML version)



Digital version of catalogue with Aladin sky atlas

3. DB "OBSERVATIONS" (DBO)

In the mid 1990s, creating digital databases of observations with different tele-scopes of the observatory was commenced at the CrAO. Details of the process of forming the database of photographic archives, creation of its digital version, and of the possibility of using it to solve astrophysical problems were described by us earlier (Bondar' 1999, 2002; Bondar' et al. 2005; Bondar' & Shlyapnikov 2006, 2009). We summarize some results of this work below. It is convenient to subdivide the DBO into three archives according to specifics of the accumulated material: di-rect images of the sky; photographs obtained with objective prisms; spectroscopic photographic observations with the 1-m, 1.22-m, and 2.6-m telescopes.

The largest collections of direct images were obtained according to "G. A. Shajn's Plan", aimed at studies of the Galaxy's structure, in 1947-1965 (~ 1500; Pronik 1998) and, as a result, from the "Crimean Survey of Minor Planets" in 1963-1999 (~ 10 000; Chernykh 1992). The distribution of the sky photographs obtained within these projects is shown in Fig. 1. The DBO was compiled in a variety of formats, including those recommended for work with applications of the Interna-tional Virtual Observatory (IVO). Fig. 1 represents the DBO using the Aladin application of the IVO (Bonnarel et al. 2000).

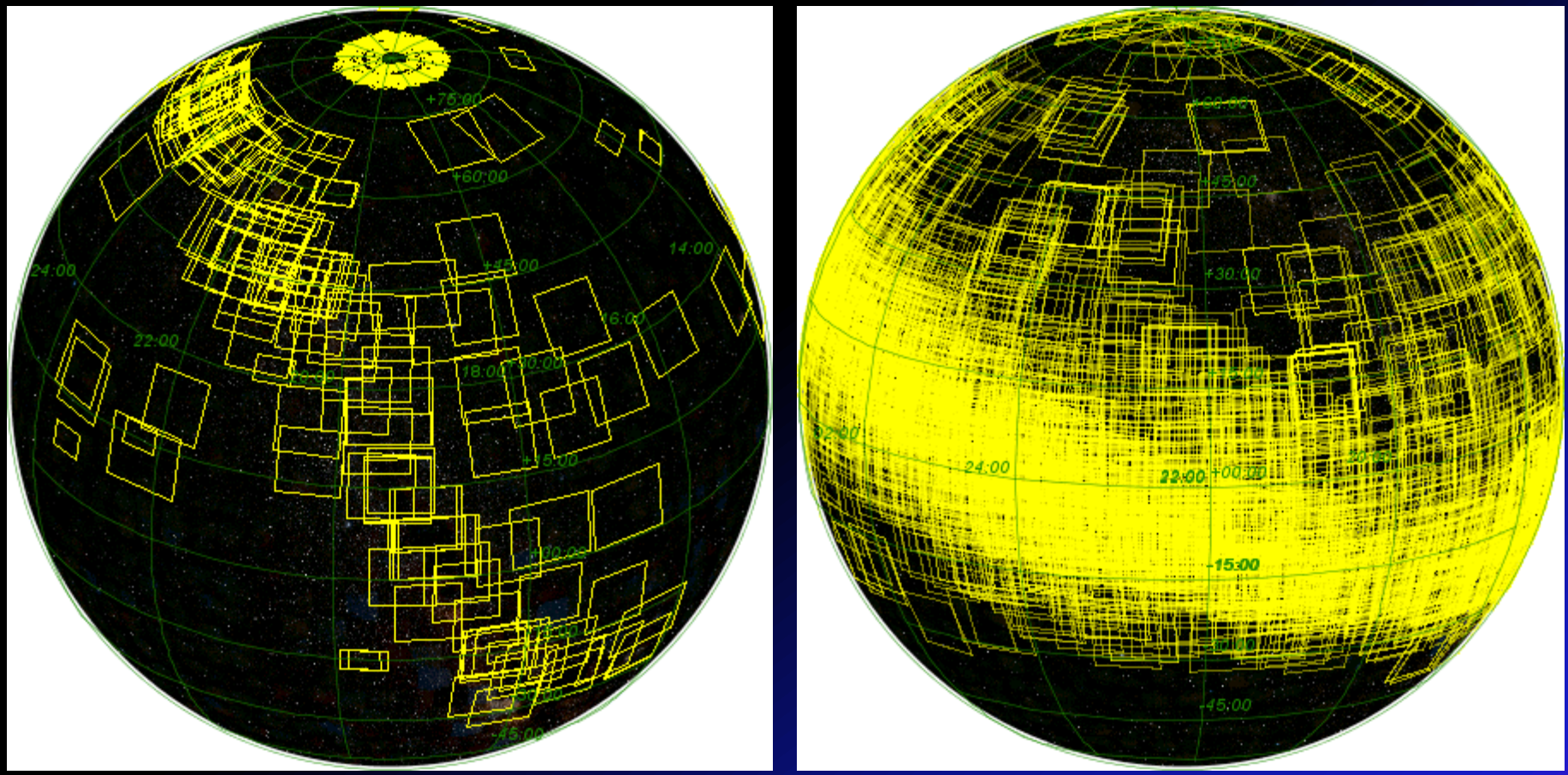


Fig.1. The distribution of the photographs on the celestial sphere, obtained within the projects "G. A. Shajn's Plan" (left panel) and "Crimean Survey of Minor Planets" (right panel).

Access to the local archive with the DBO and preview images from the collection of "G. A. Shajn's Plan" photographs is organized at the Ukrainian Virtual Observatory portal (Vavilova et al. 2012a, 2014) at:

http://ukr-vo.org/digarchives/index.php?b5&1

or at the CrAO server at:

http://www.crao.crimea.ua/~aas/PROJECTs.

The information described above is placed in the WFPA archive:

http://www. skyarchive.org/

and observations, in the WFPDB; they are available with the key CRI at the address:

http://draco.skyarchive.org/search/,

or through the catalog VI/90 in the VizieR database (Tsvetkov et al. 1997). Prospects for scientific research with the DBO and the archive of direct images are described in detail in Bondar' & Shlyapnikov (2009) and Vavilova et al. (2012b).

An example of using the Aladin IVO application for working with the DBO is shown in Fig. 2. The central part of the interface shows a preview image of one of the photographs; the bottom part shows the database of observations with hyperlinks to the digital version of the database of small copies intended for previewing and assessing the quality of photographic plates.

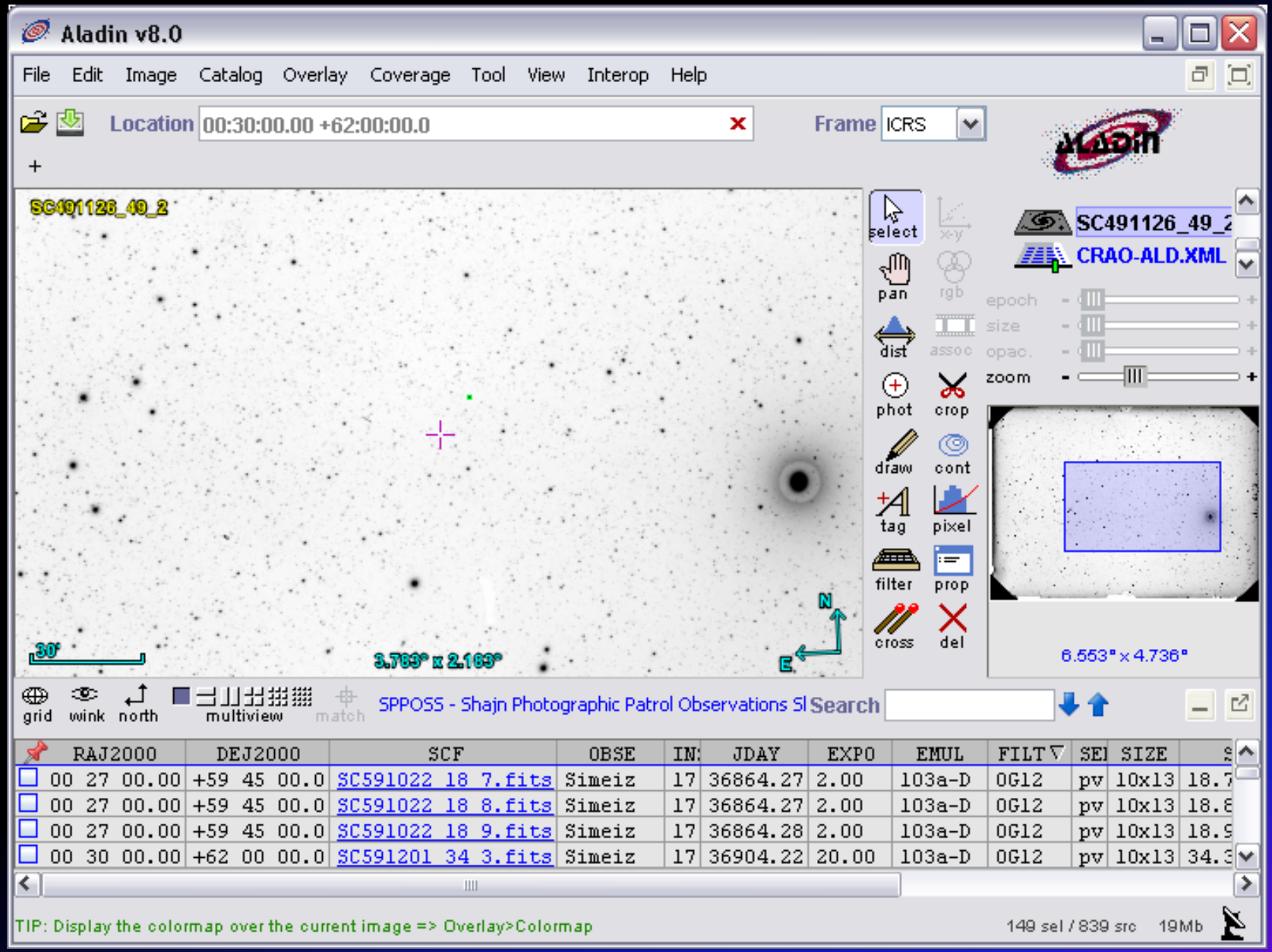


Fig. 2. Example of using the Aladin IVO application for work with the DBO, for photographs obtained within the project "G. A. Shajn's Plan".

Along with direct images of photographic sky plates, the CrAO archive contains a considerable number of spectroscopic plates. Between 1929 and 1992, about 15,000 spectra were taken with different instruments of the CrAO. Among them, there are 1340 photographs taken in 1929-1941 with the 1-m Simeiz telescope; more than 500 plates taken with objective prisms from 1929 to 1965 using the 0.17-m and 0.4-m astrographs, including photographs from "G. A. Shajn's Plan" (Pronik 1998); 5570 plates of different spectral resolution in different wavelength ranges, obtained between 1953 and 1990 with the 1.22-m Zeiss reflector (Shlyap-nikov 2013); 2900 spectra taken with different spectrographs and different spectral resolution in 1963-1987 with the 2.6-m Shajn telescope (ZTSh); 3450 spectra taken with an image-tube spectrograph (ZTSh, Nasmyth focus) in 1982-1992 (Polosukhina et al. 1997). Examples of digital versions of spectroscopic archives were described by Gorbunov & Shlyapnikov (2013) and Pakuliak et al. (2014).

When creating a digital version of archives of spectroscopic observations, spe-cial attention should be paid to preparing data in a format compatible with the IVO means and using them in the interactive IVO applications: Aladin, VOSpec, Specview. The photographic archives of spectroscopic observations are subdivided into collections obtained with the three astrographs with objective prisms and with the three large telescopes (Fig. 3)

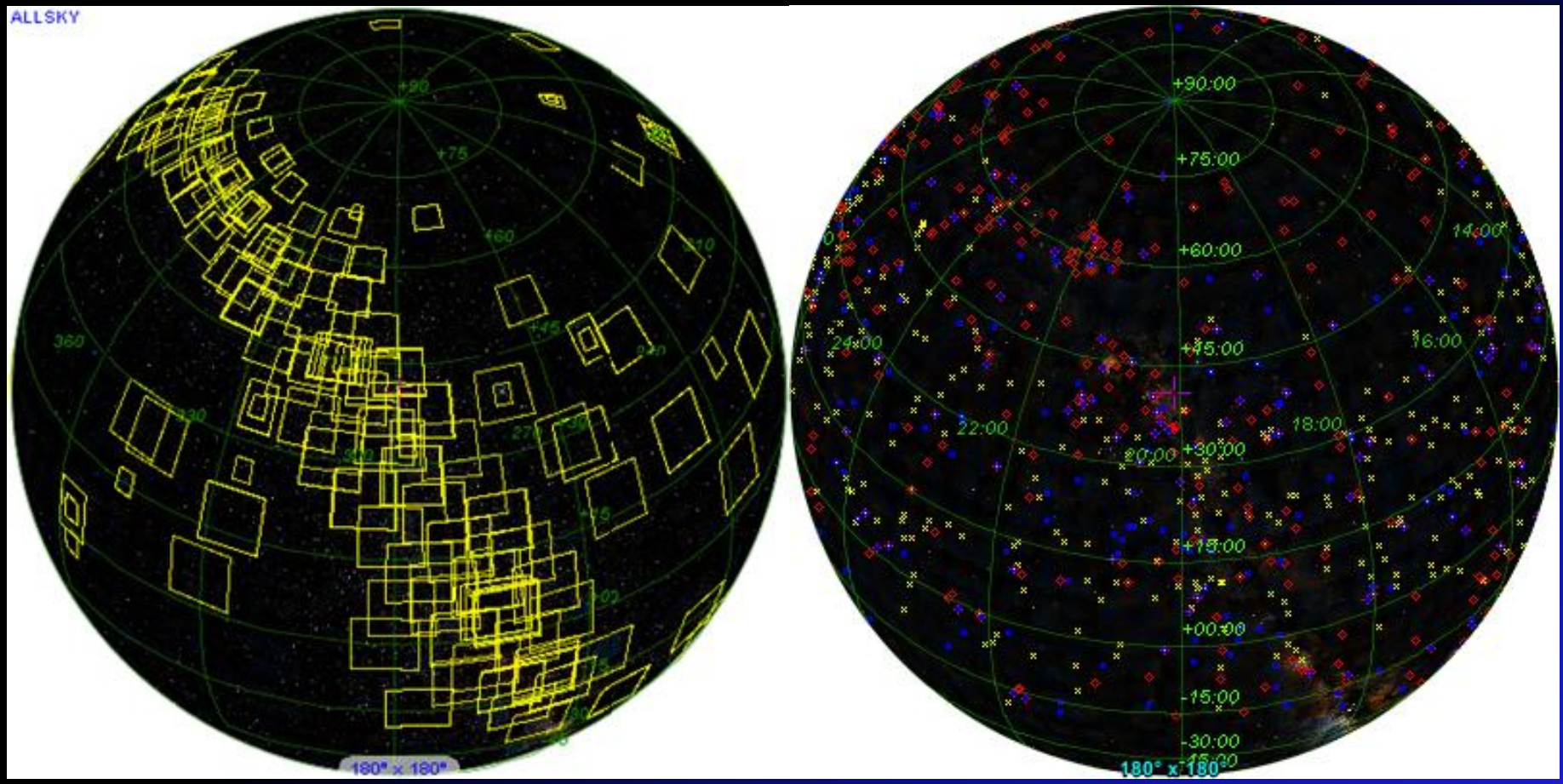


Fig. 3. The distribution on the celestial sphere of spectroscopic plates taken using the astrographs with objective prisms (left panel) and with the 1-m (yellow), 1.22-m (red), 2.6-m (blue) telescopes (right panel).

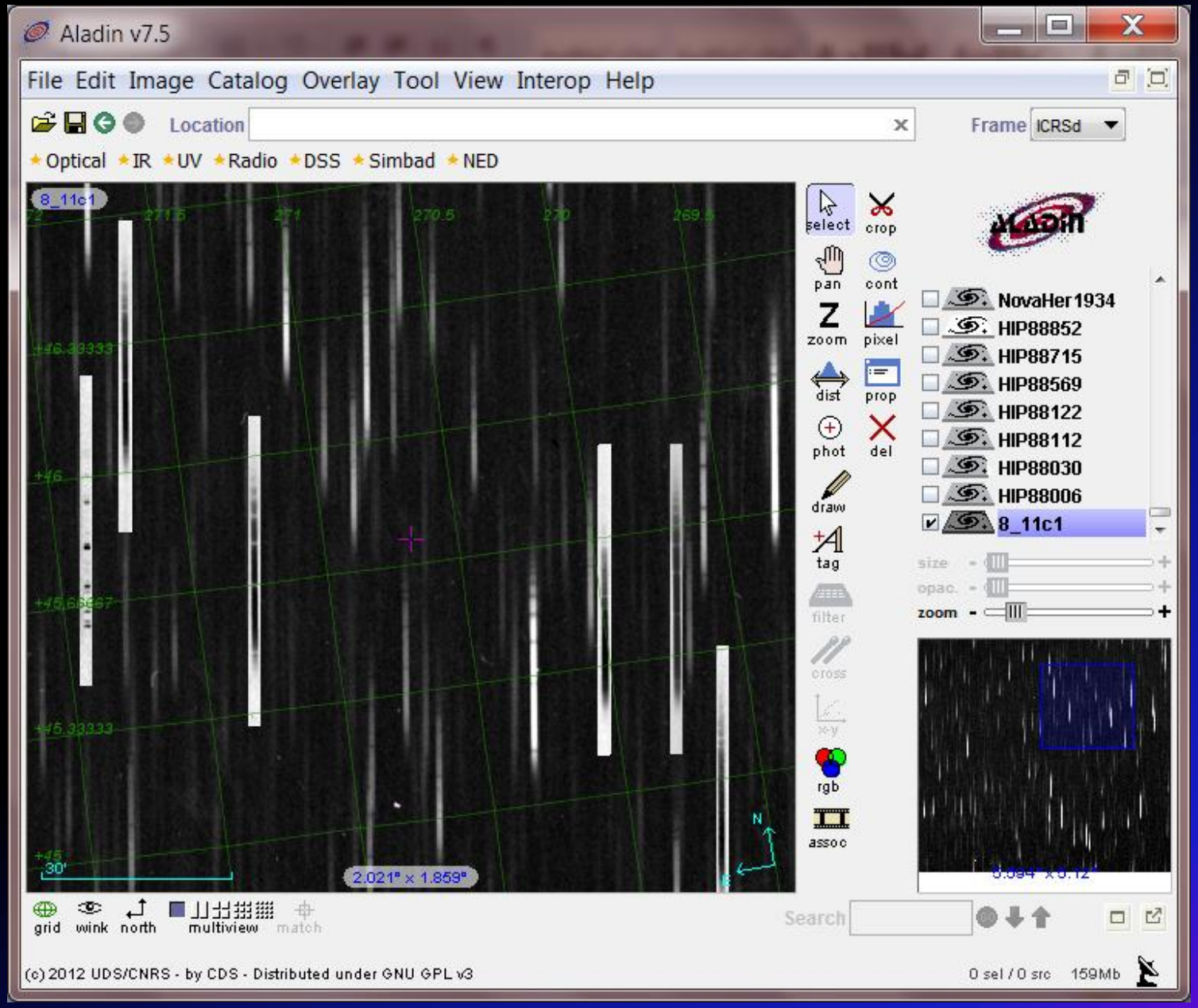
Brief description of spectra collections

Objective prism spectroscopy

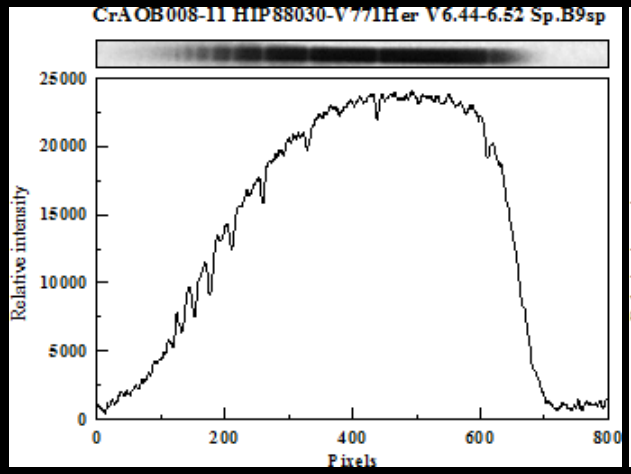
Collection of spectral observations conducted with an objective prism consists of three parts determined by three types of astrographs (table 2), on which the spectra were obtained.

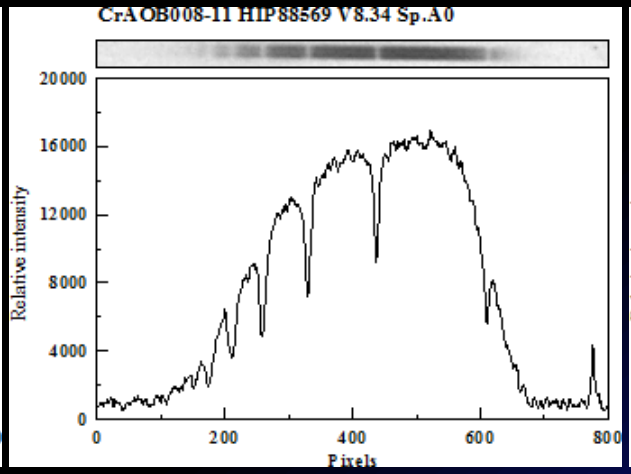
Table 2. Basic parameters of astrographs and dispersion for digitized spectra

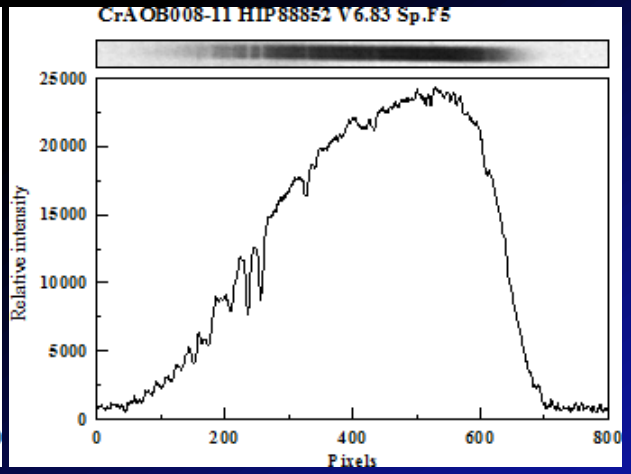
Name of astrographs	Diameter of objective (mm)	Focal length (mm)	Dispersion at H_γ (Å/pix)
Unar	117	600	1.5
Dogmar	167	750	1.4
400-mm	400	1600	1.5

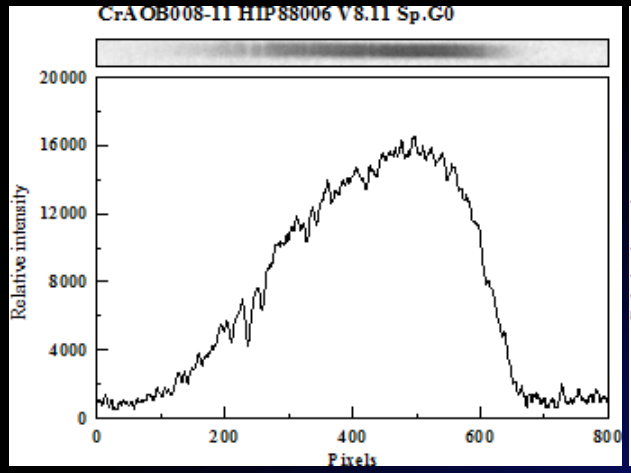


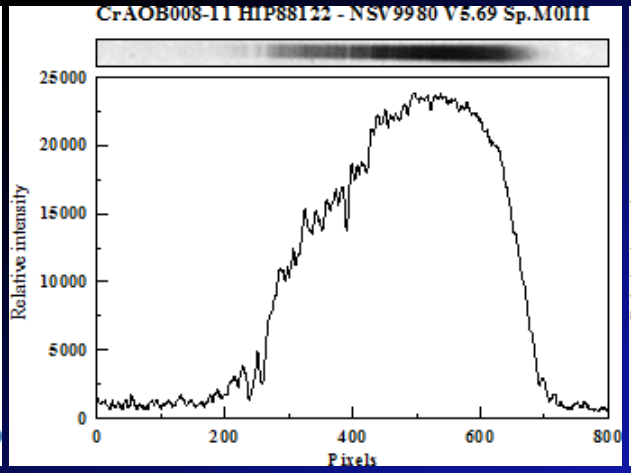
Fragment of full image photographic plate (positive) with the spectra of the extracting objects (negative)

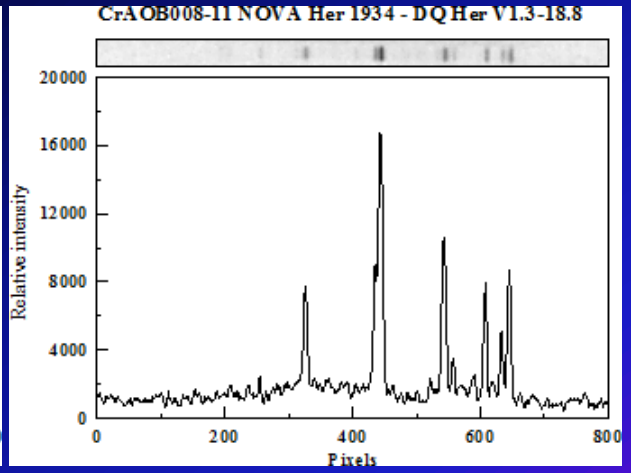






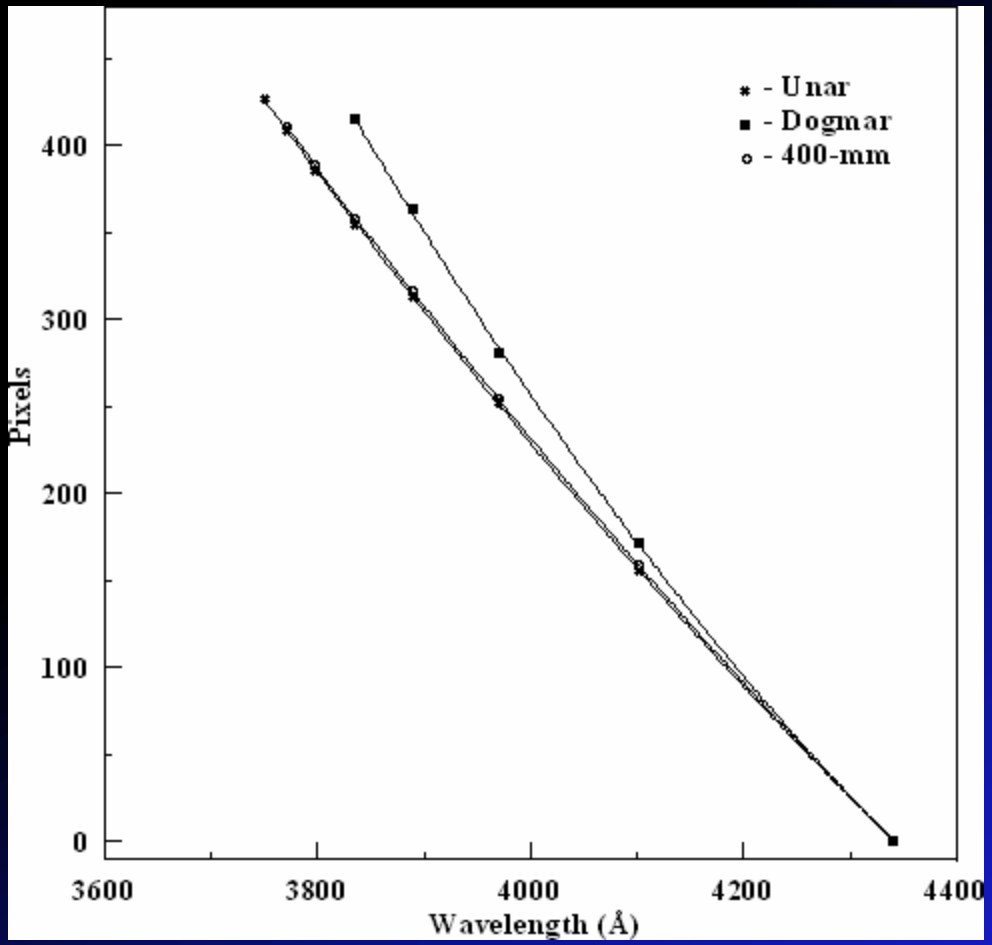




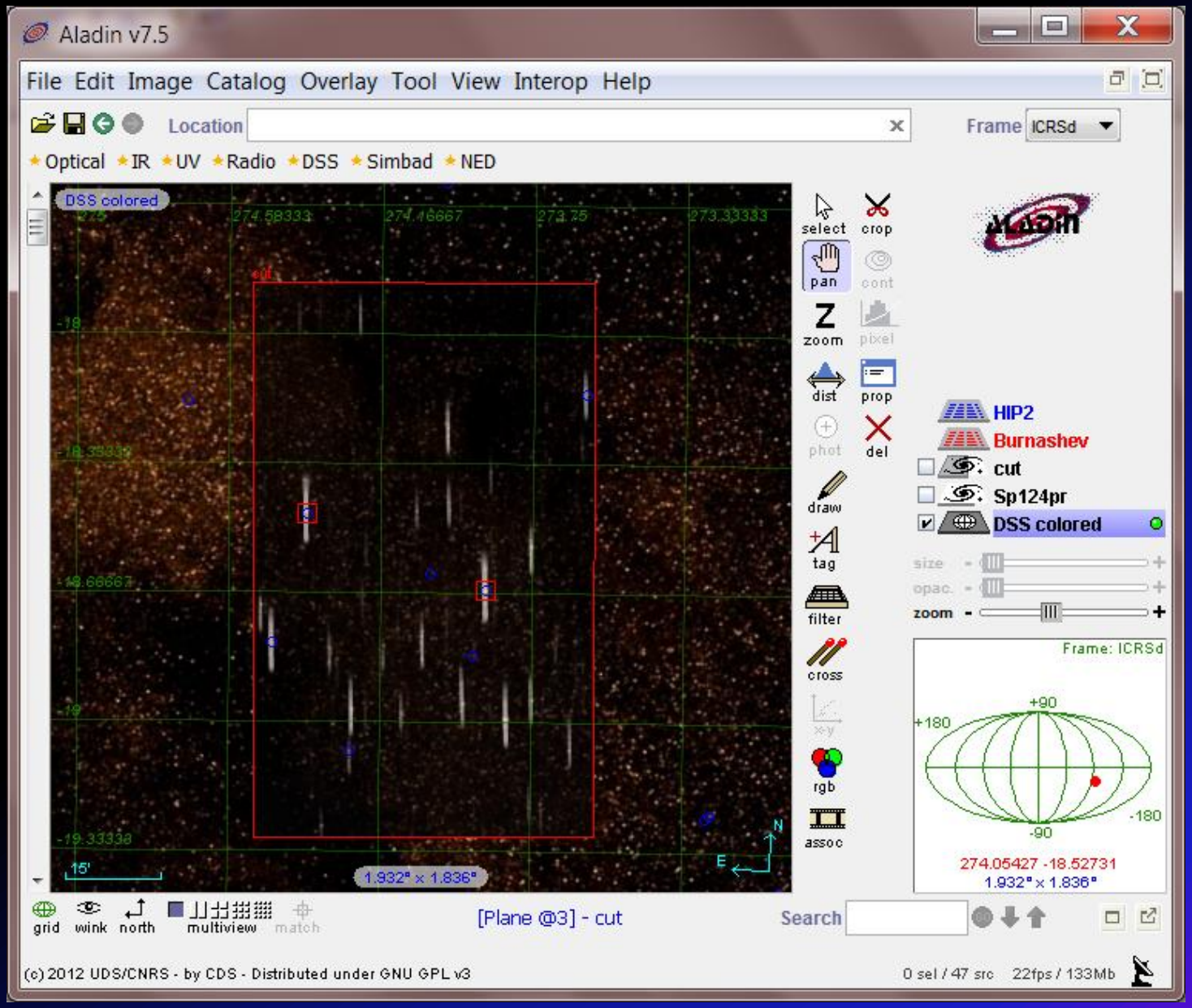


Examples of spectra extracted from the plate obtained with an objective prism on the Unar astrograph

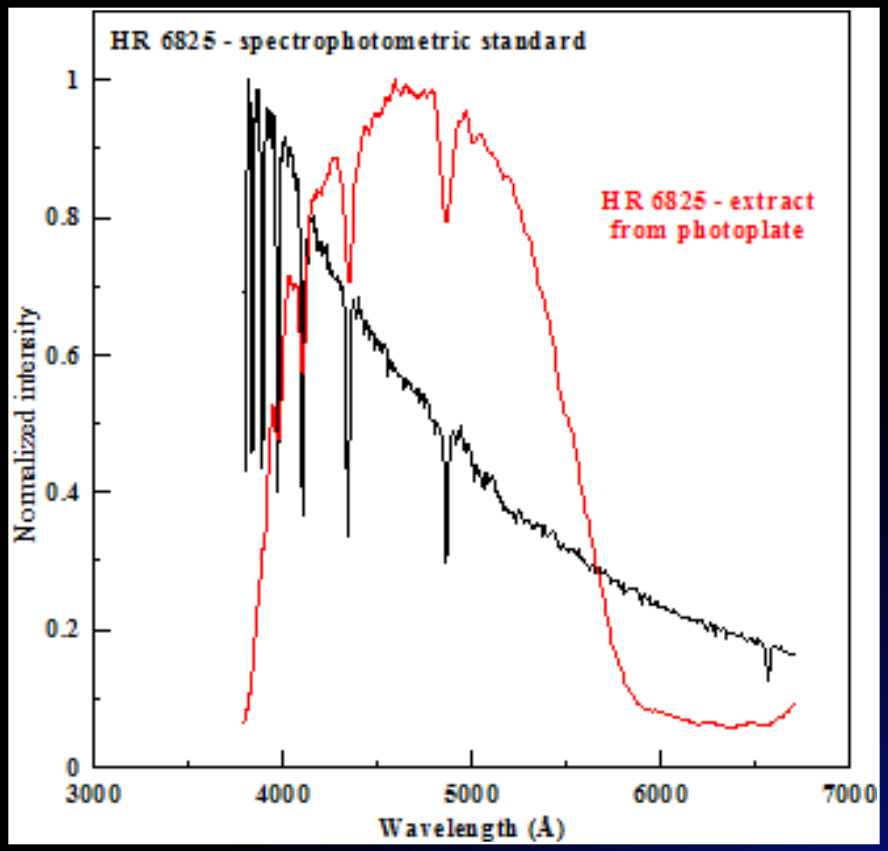
We conducted measurements for different A-stars to convert pixels scale in wavelength scale. Next figure illustrates the dispersion curves for Unar, Dogmar, and 400-mm astrographs.

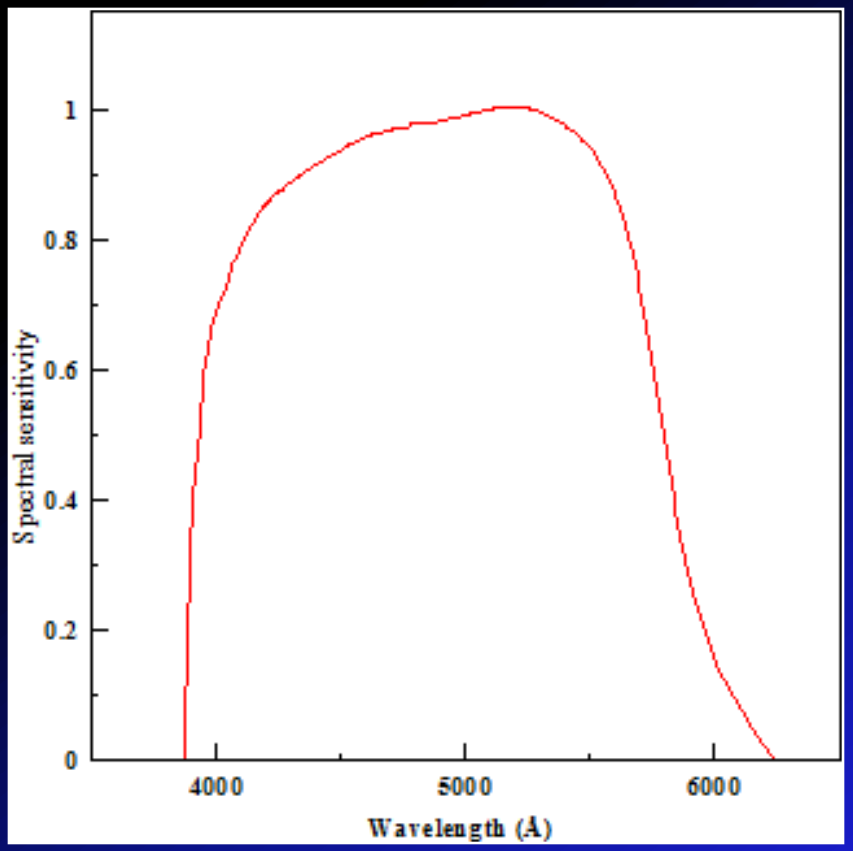


Dispersion curves for digitized plates obtained with different astrographs



Fragment of a full-format image with spectrophotometric standards

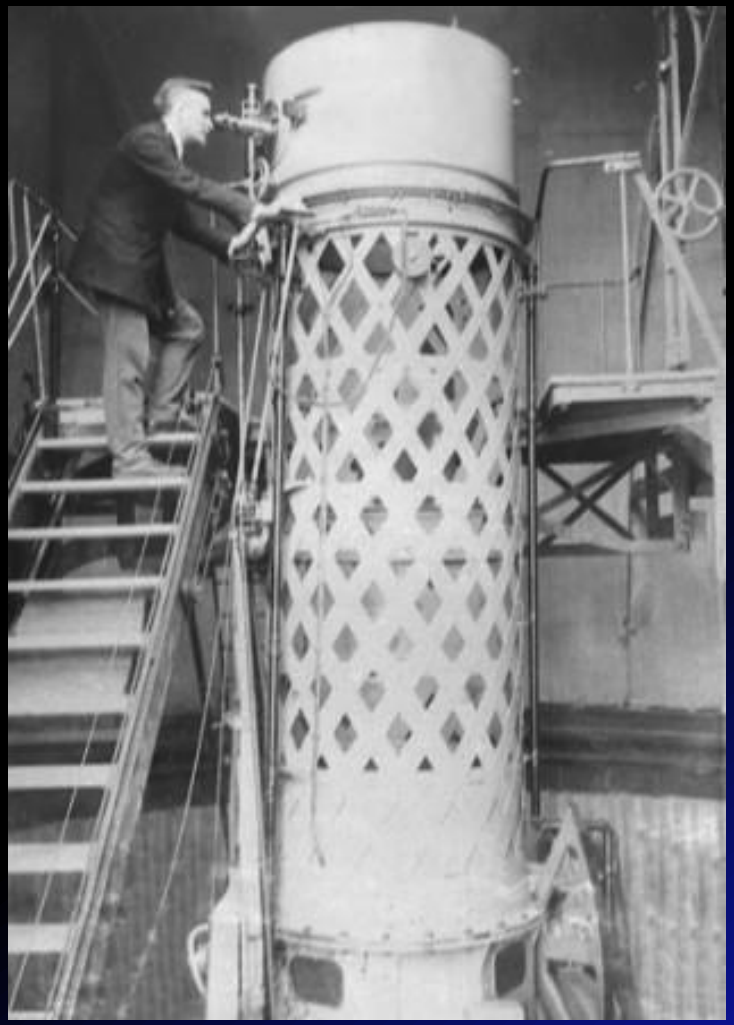


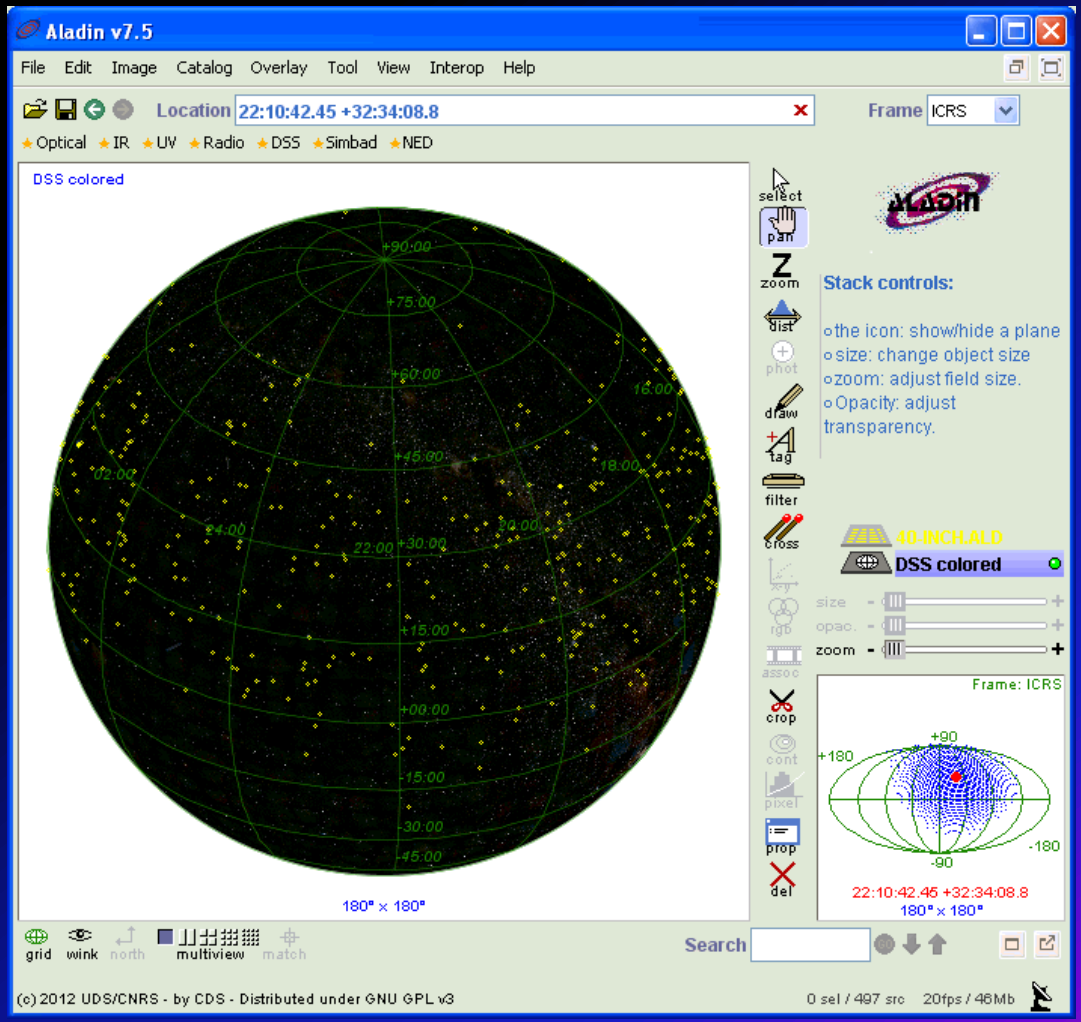


We used SEDs to determine the spectral sensitivity of the negative in the SwOP collection. It is given in Figure up: left panel – a comparison of the normalized data of spectrophotometric standard with the data extracted from the digitized negative; right panel – a certain spectral sensitivity of the negative (from the data presented on the left panel) for the further reduction of the extracted spectra.

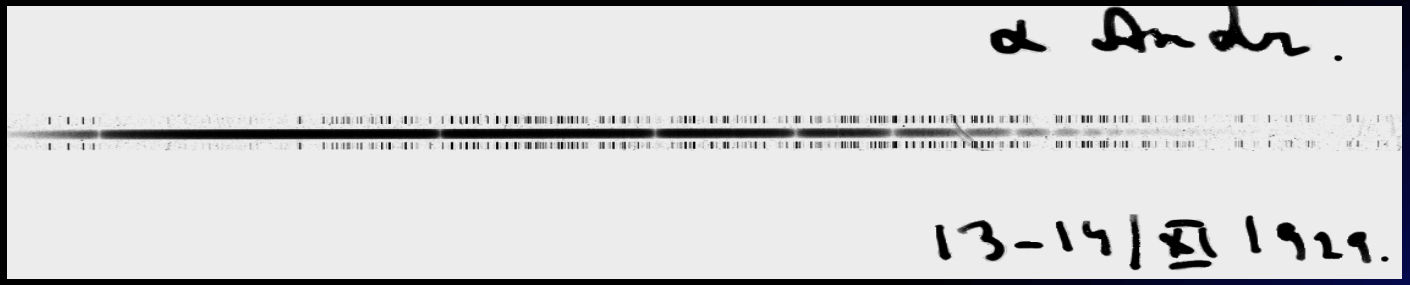
The following are examples of digital versions of spectral observations carried out on large telescopes.

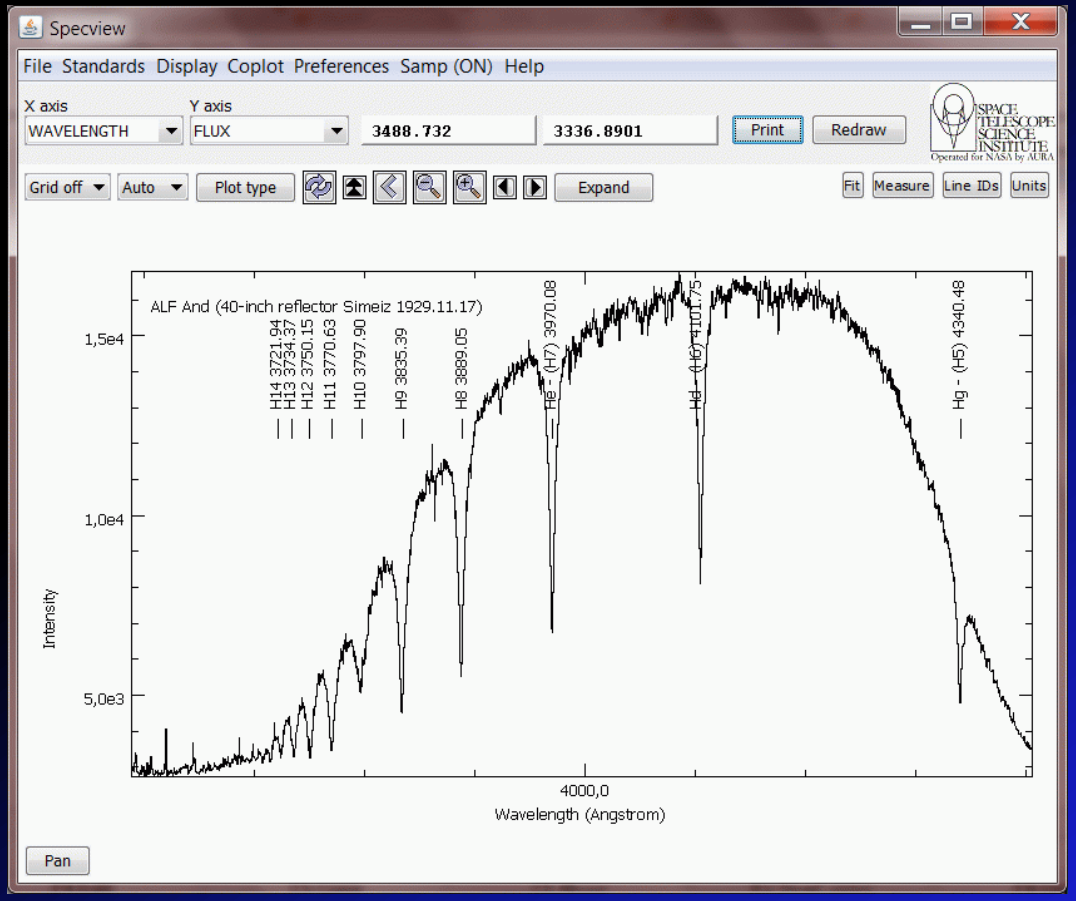
40-inch reflector "Goward Grabb" collection





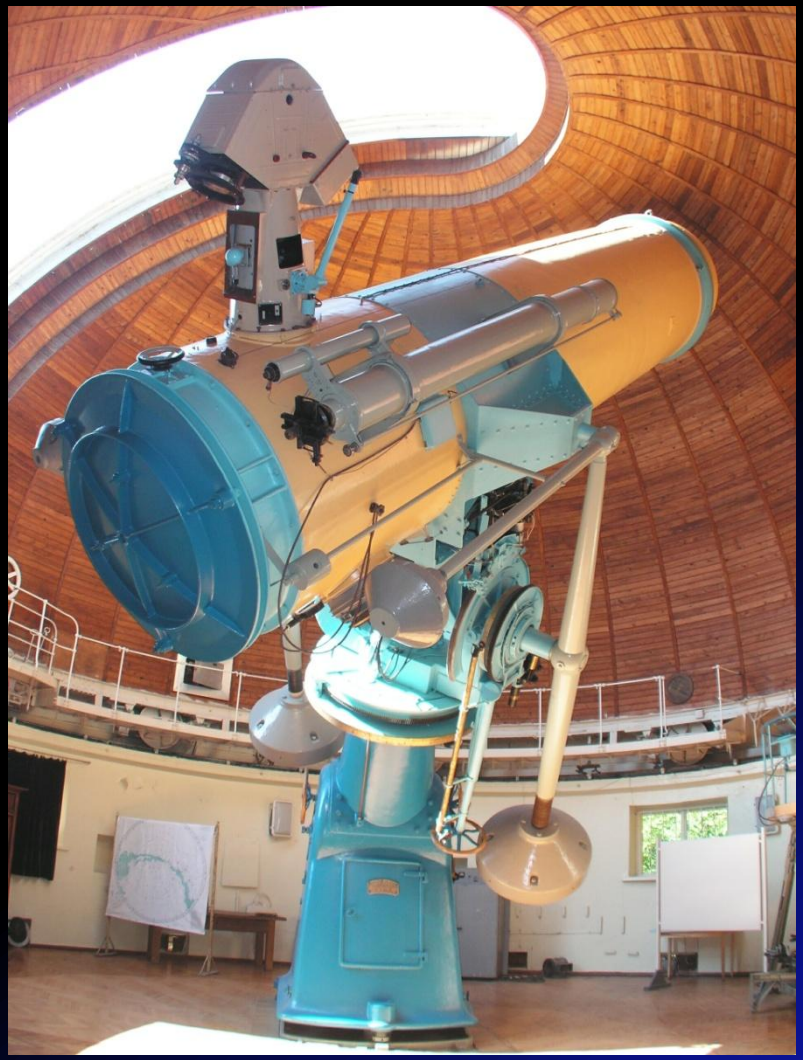
40-inch telescope and distribution on the celestial sphere of spectroscopic observations

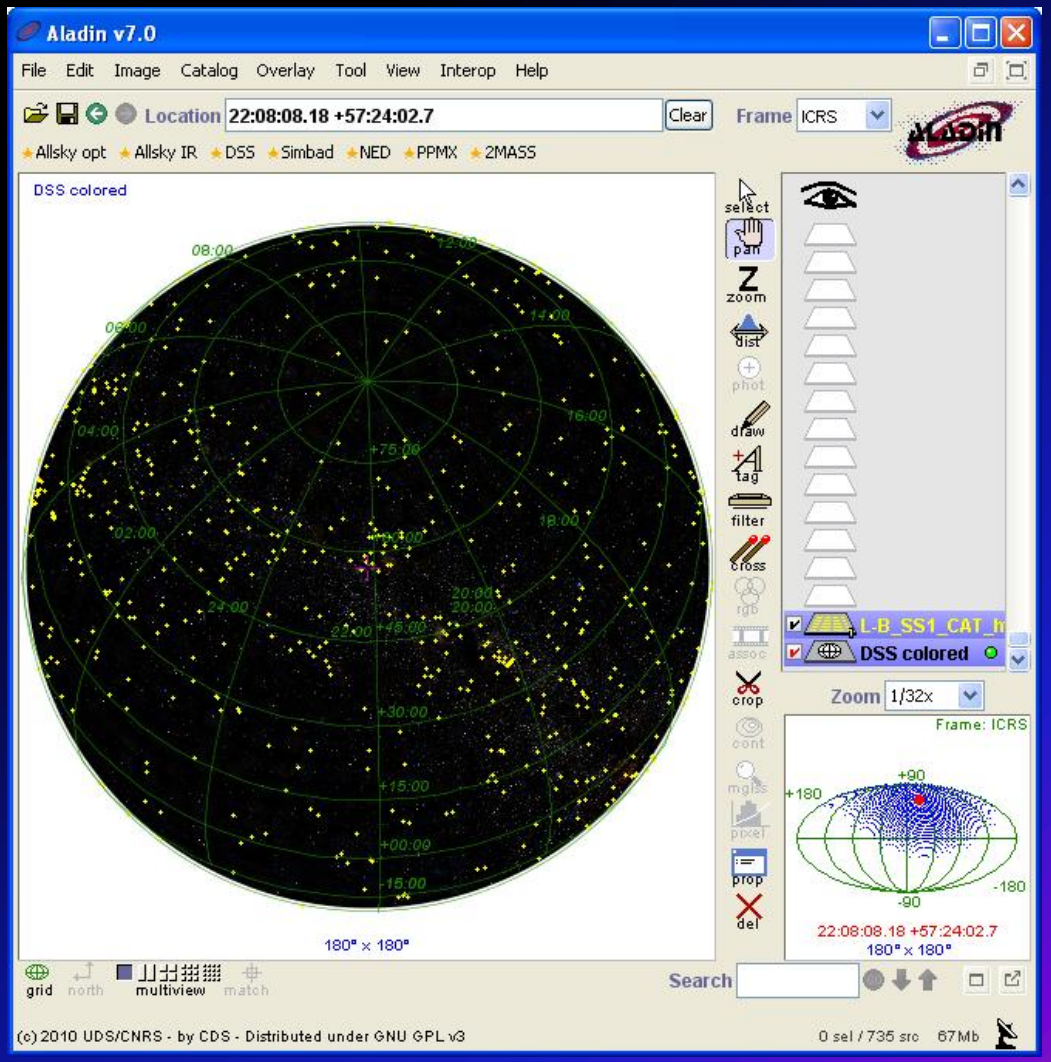




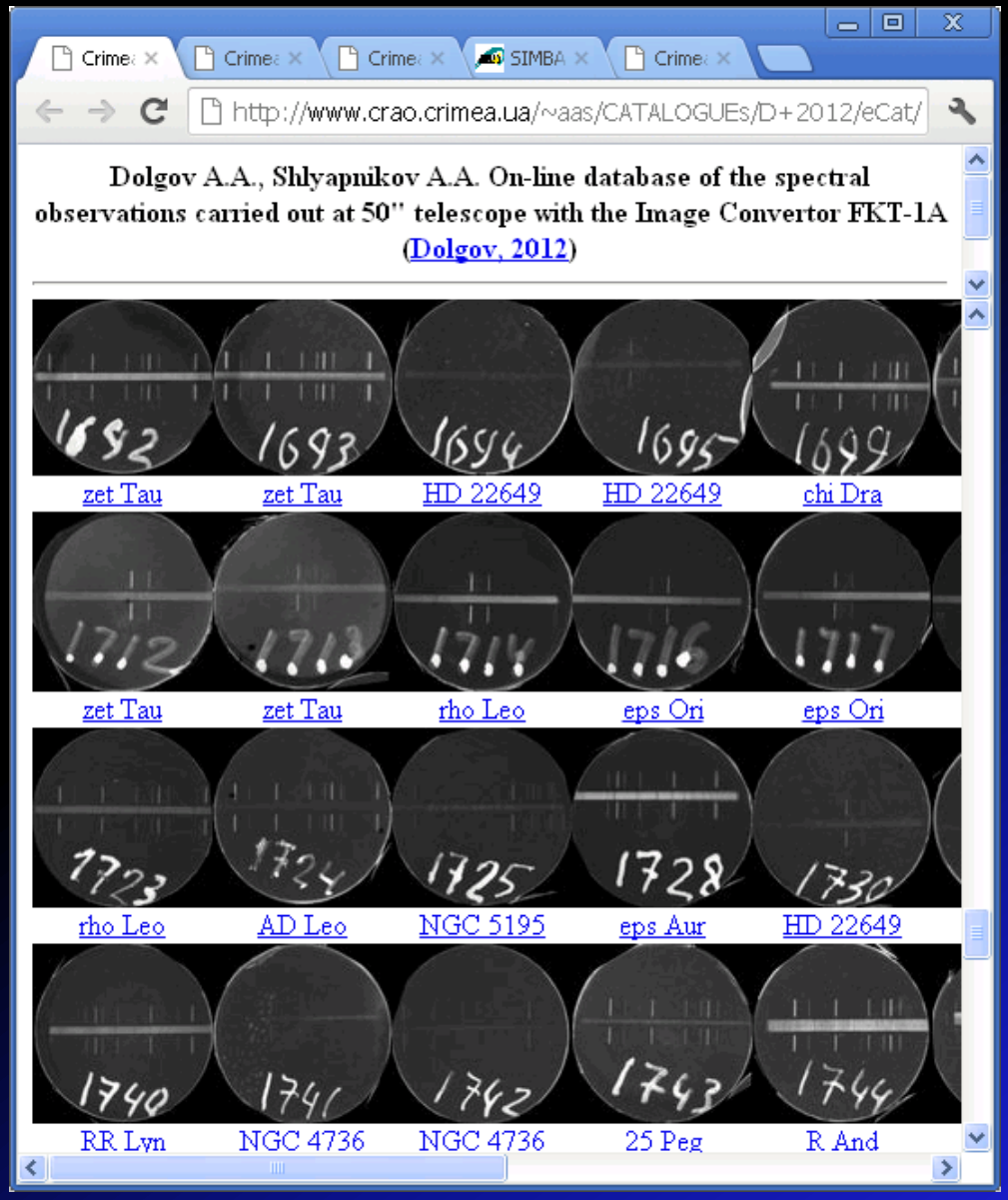
The alfa And spectrogram obtained with 40-inch reflector on November, 13-14, 1929 and spectrum in Specview

The 1200-mm reflector of collection spectra

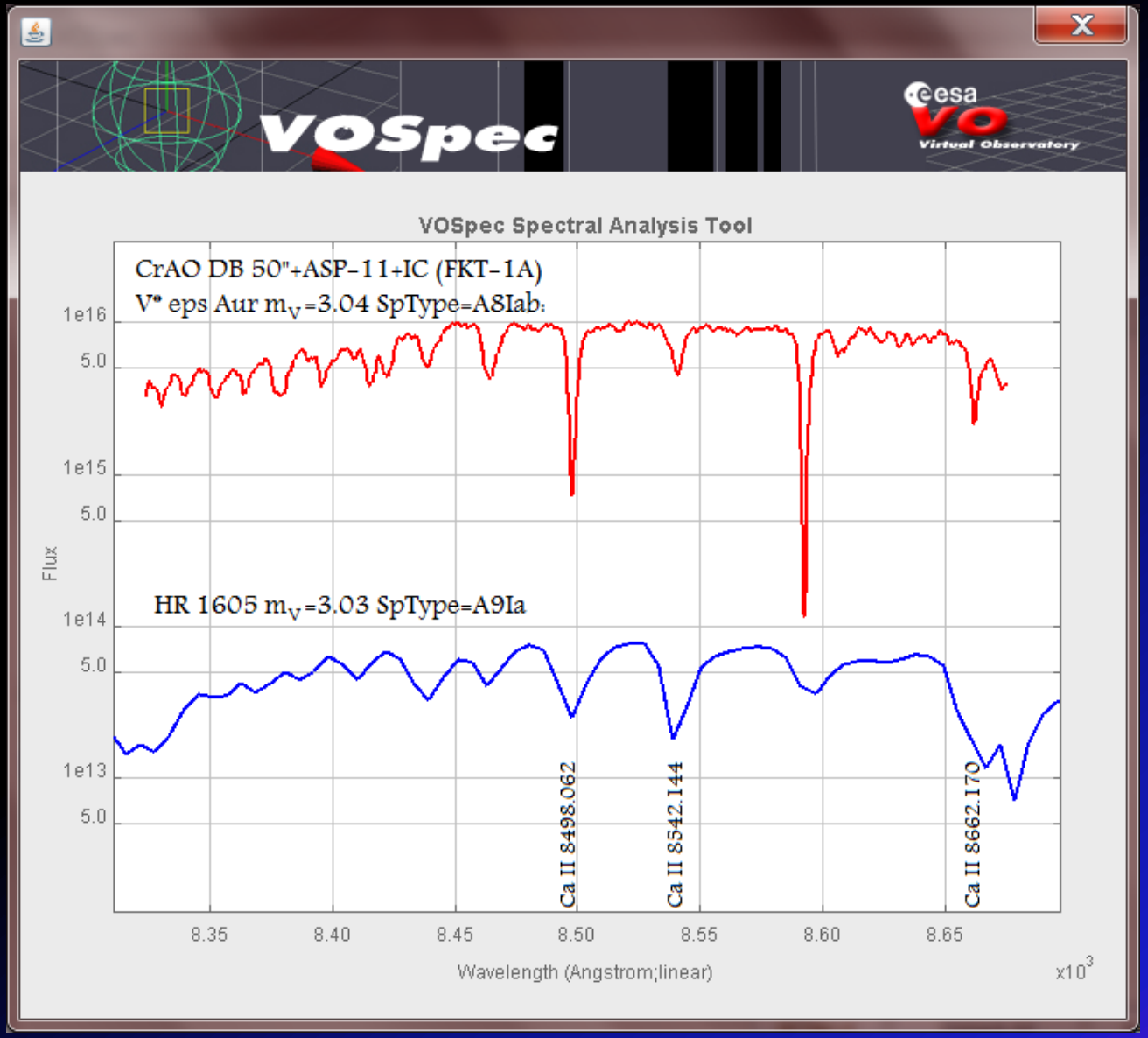




48-inch telescope and distribution on the celestial sphere of spectroscopic observations

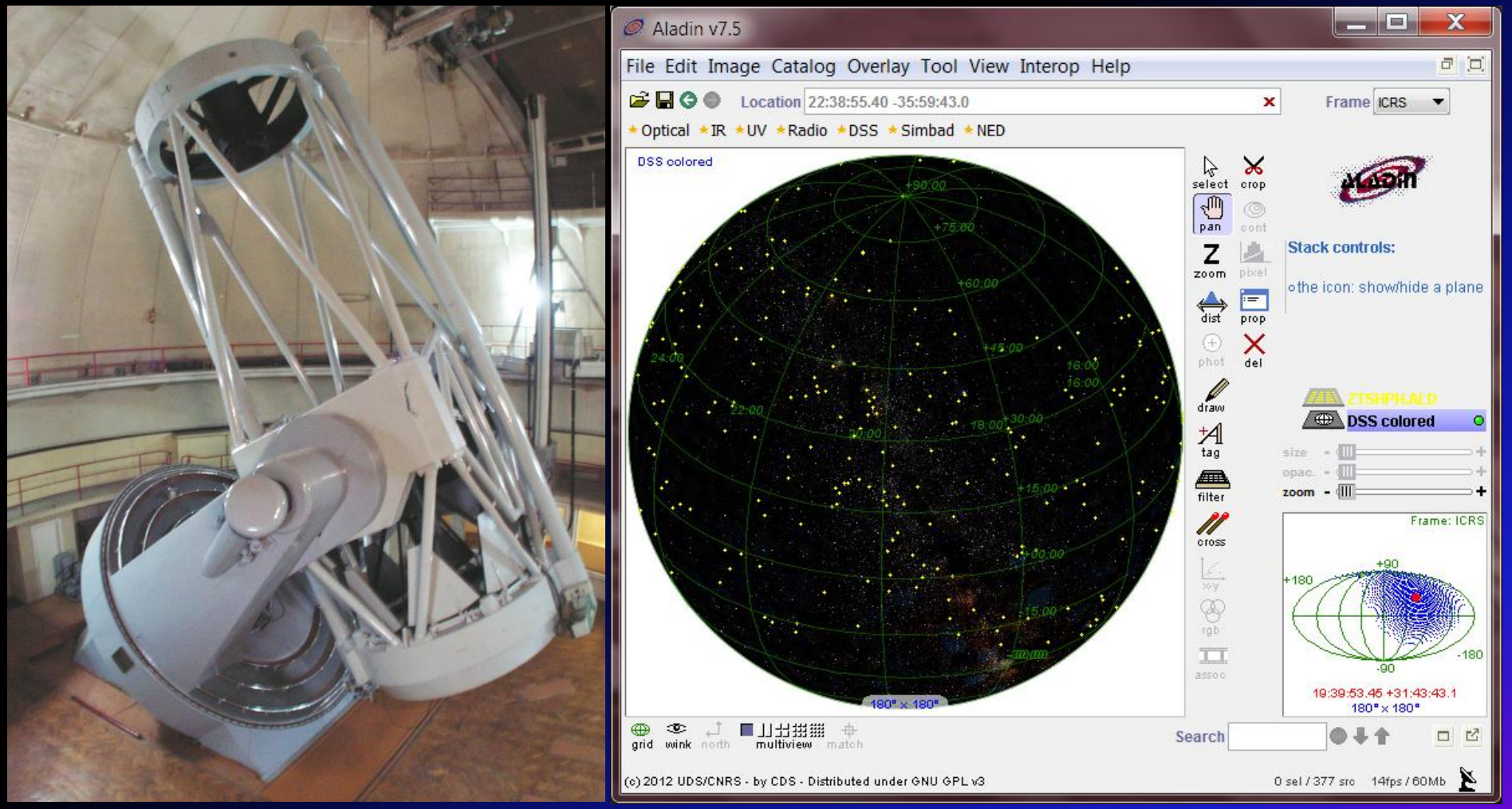


Database of observations conducted on the 1200-mm telescope with the image convertor FKT-1A (HTML - version)

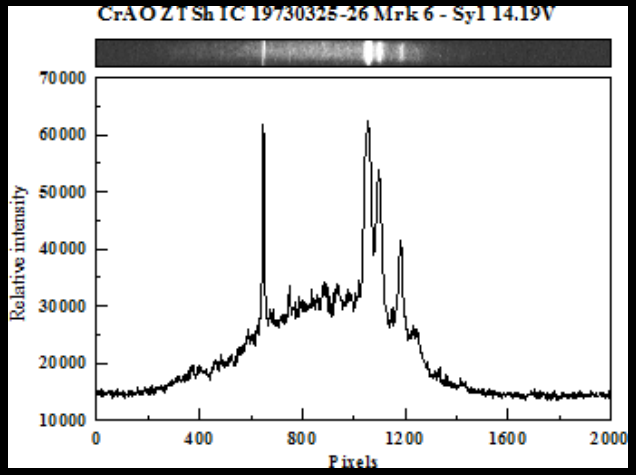


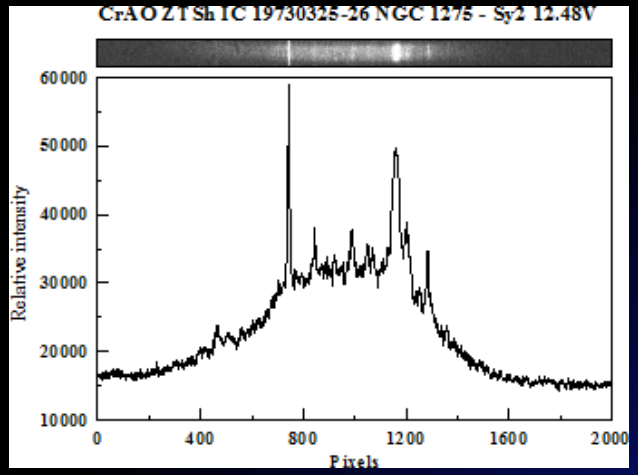
Example of the VOSpec presentation of infrared spectroscopic observations eps Aur, obtained with 48-inch telescope as compared with the data for the object taken from the IVOA database

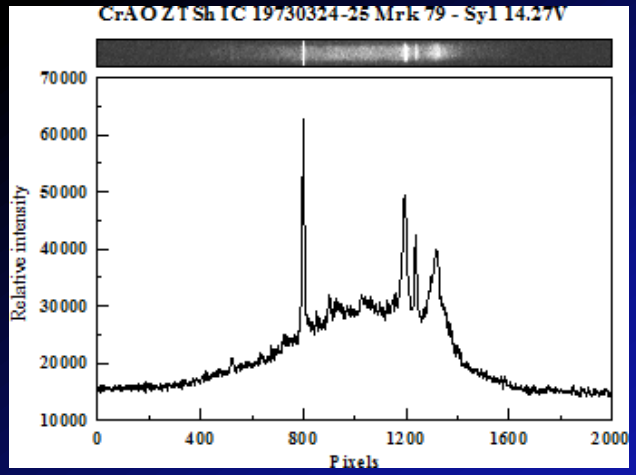
Collection of the ZTSh

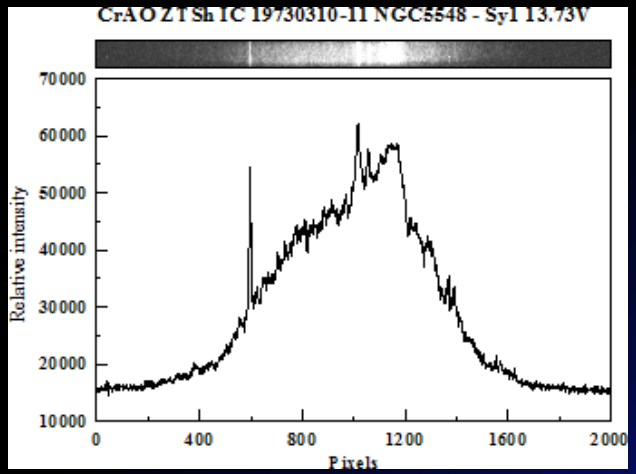


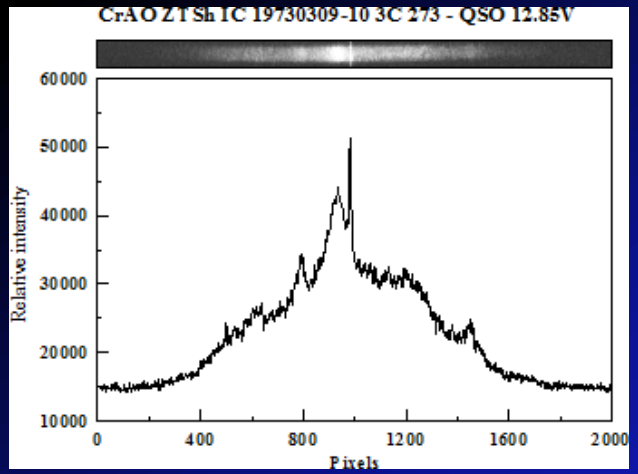
2.6-m telescope ZTSh and distribution on the celestial sphere of spectroscopic observations

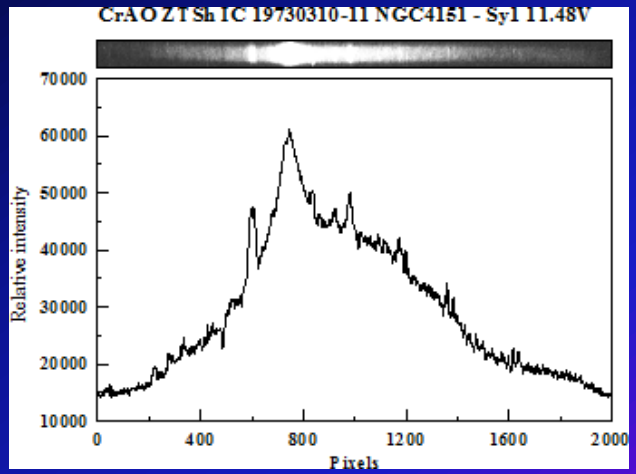












The examples of digitized spectra of extragalactic objects

4. CONCLUSIONS

As a result of this work, we outlined the main goals of further development of the "Publications" and "Observations" databases, their integration into the CrAVO, in conjunction with the DBs "Employees", "Projects", "Instruments", "Objects", and "Catalogs".

In its current state, the "Publications" database contains information on nearly 1500 articles prepared by the CrAO staff members, where data for more than 20 000 objects, included in the "Observations" database, were published. The DBO is partially integrated into the VizieR database and is also available, as a CrAVO archive of observations, via interactive IVO applications.

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If you have questions, please ask me later!!!

Thank you for your attention!