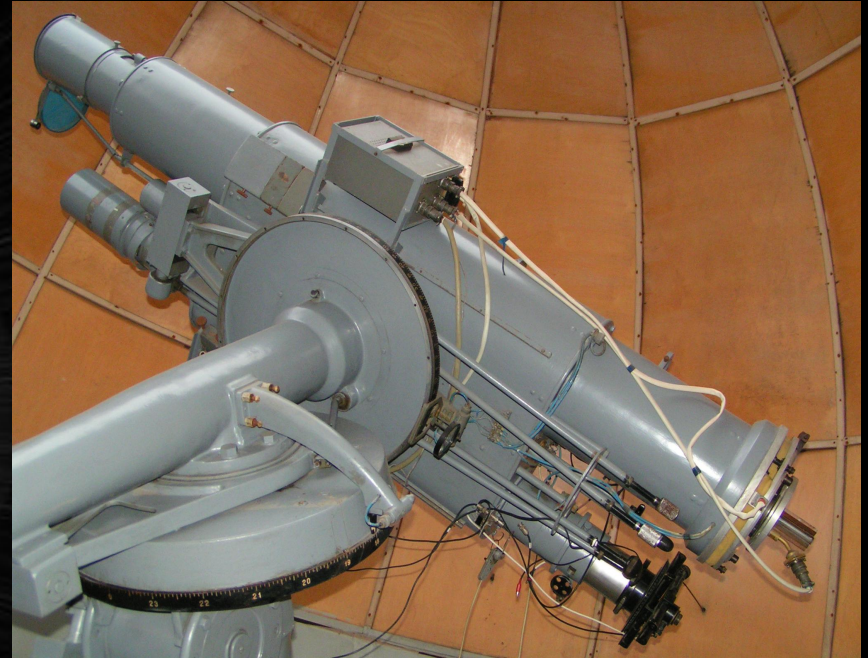


Plate archive of Nikolaev Astronomical Observatory: digitization, databases, image processing and results of current research



Yuri Protsyuk, Alexander Mazhaev, Olga Kovylianska
Nikolaev Astronomical Observatory

Multi Channel Telescope (MCT) former Zonal Astrograph

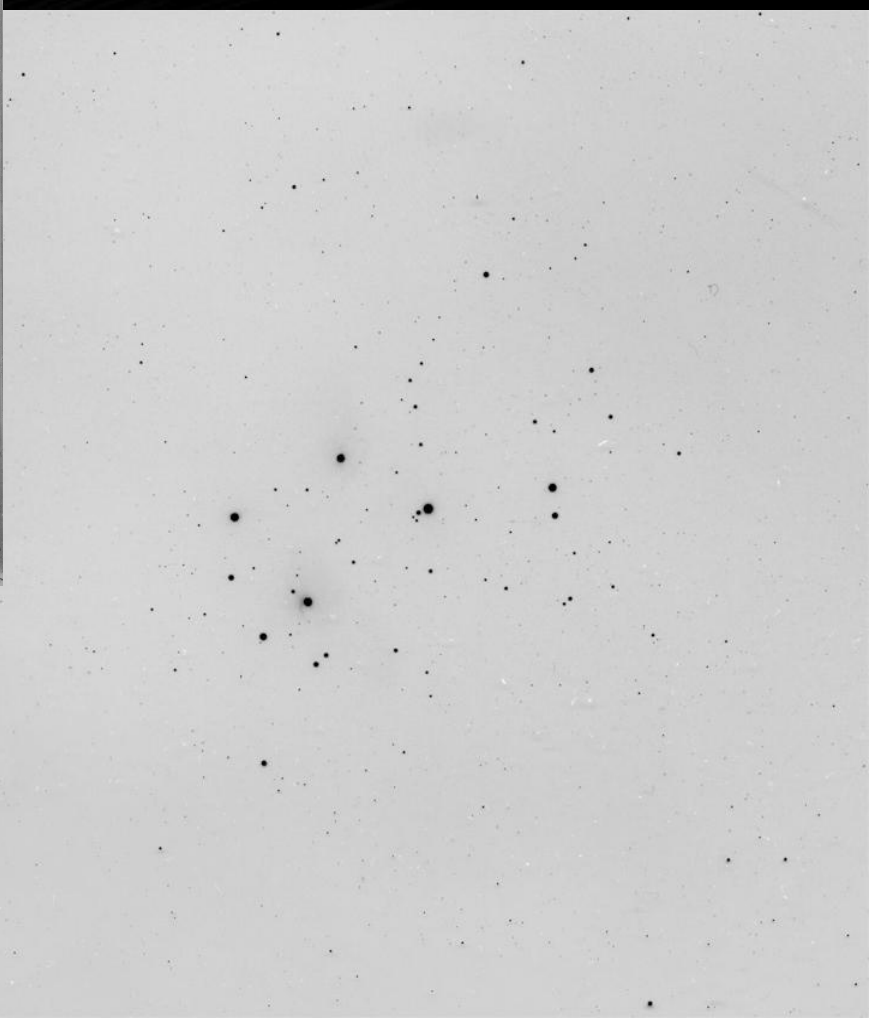


Zonal Astrograph (D=160 mm, Iris = 120 mm, F=2040 mm, FOV= 5° x 5°) operated from 1929 to 1999

- ✓ Preview image of photoplate from database of observation. Plate made in NAO in 1976 ($\delta = -24^\circ$, $t = 20\text{min}$).



- ✓ Digitization of plates at first with 600DPI and then with 1200DPI resolution has been carried out since 2007 to obtain preview images with all marks made on plates.



- ✓ Digitization of plates with 1200 DPI resolution after clearing of all marks on plates has been carried out since 2009 for astrometric image reduction.

Scanners

EPSON PERFECTION V200 Photo
(2008) 3.2D max
A4, 4800DPI optical
Transparency 9"-2", 3.2D



EPSON PERFECTION V750 Pro (2011) 4.0D max
A4, 4800x9600DPI optical
Transparency 10"-8", 4.0D



Database management system of photographic observations

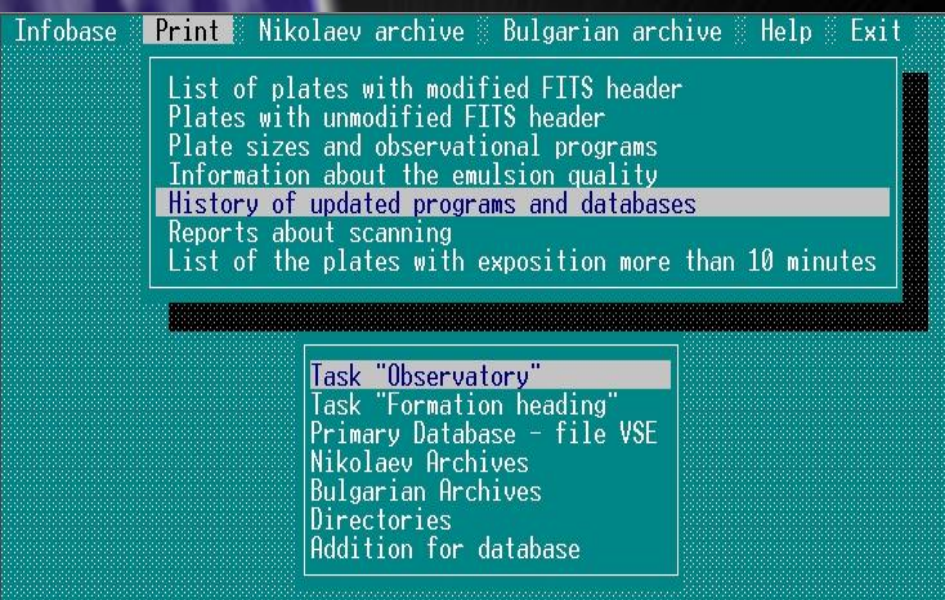


All text data from the observational log books was transferred into the database management system (DBMS) written in FoxPro. Total number of plates is 8325, and 8271 of them were already scanned. DBMS allows us to carry out data handling and processing by using various menu options. The main menu consists of five parts. The first part contains various text data viewers and hour angle calculator.

N plate	Alpha	Delta	Date	Clocking angle	1 exp.	2 exp.	Nu
603	7 22.4	19 3	19640827	012557	-321.9	2	0.02
604	7 22.5	19 3	19640827	014354	-306.0	2	0.02
616	7 51.4	18 32	19640903	013320	-314.4	2	0.02
619	7 55.6	18 26	19640904	013723	-310.6	2	0.02
631	8 38.7	16 58	19640914	011102	-340.7	2	0.02
643	9 40.9	13 34	19640928	022338	-277.9	2	0.02
650	10 3.1	12 0	19641003	000318	-421.1	2	0.02
651	10 3.2	12 0	19641003	002115	-403.7	2	0.02
655	10 16.6	10 59	19641006	024402	-261.8	2	0.02
1332	4 28.5	23 26	19670421	175346	+333.0	3	0.17
1333	4 28.6	23 26	19670421	181043	+354.9	3	1.00
1334	4 28.6	23 26	19670421	183439	+371.2	3	0.17
1336	4 48.8	24 16	19670425	183521	+377.7	3	0.50
1345	5 29.2	25 23	19670503	180725	+333.3	3	0.50
1349	5 34.4	25 29	19670504	183440	+327.1	3	0.60
1350	6 4.6	25 47	19670510	182333	+341.8	3	0.50
1351	6 5.2	25 47	19670510	184942	+365.2	3	1.00
1355	6 9.7	25 48	19670511	181333	+341.8	3	1.00
1356	6 9.7	25 48	19670511	184546	+311.2	3	0.50

КОЛИЧЕСТВО ПЛАСТИНОК ПО ПРОГРАММАМ НА 13.08.2013					
Название программы	Кол-во пласт.	Отсканировано			Имя файла
		Всего	BMP	FIT	
КОМЕТЫ	218	208	0	208	1 con_2000
ЭКВАТОРИАЛЬНЫЙ КАТАЛОГ	489	471	0	471	2 ekzod
ЮПИТЕР	458	457	0	457	3 jup_2000
МАРС	426	426	19	407	4 mars_bas
СПИСОК МИХАЙЛОВА	106	106	0	106	5 ni hail
МАЛЫЕ ПЛАНЕТЫ	2492	2484	573	1911	6 mp_s
НЕПТУН	225	224	0	224	7 nep_basa
ПОЛЯРНАЯ ЗОНА 1-Я ЭПОХА	196	195	0	195	8 polarz1
ПОЛЯРНАЯ ЗОНА 2-Я ЭПОХА	276	275	0	275	9 polarz2
РАДИОИСТОЧНИКИ	211	209	0	209	10 roas
САТУРН	496	495	73	422	11 sat_2000
СПУТНИКИ САТУРНА	213	213	59	154	12 sp_sat
СПУТНИКИ ЮПИТЕРА	360	359	92	267	13 spj_2000
УРАН	230	230	0	230	14 uran_bas
ВЕНЕРА	360	360	285	75	15 ven_basa
ЗОДИАКАЛЬНЫЙ КАТАЛОГ - А	600	599	0	599	16 zod_a
ЗОДИАКАЛЬНЫЙ КАТАЛОГ - Б	527	525	0	525	17 zod_b
ПЛУТОН	10	10	0	10	20 pluton
ЛУНА	269	267	0	267	21 moon
ЗВЕЗДНЫЕ ПОЛЯ	151	145	0	145	22 stars
ПОЛЮС	93	93	0	93	23 test
ВСЕГО	8406	8351	1101	7250	

Database management system of photographic observations



The second menu allows us to view and print various text data, such as list of plates with (un)modified FITS header, plate sizes vs observational programs, quality of emulsion, history of database update, statistical reports about scanned plates, list of plates with long exposures.

The third menu allows us to compile output text files for all observational programs in the format of Nikolaev archive.

Infobase Print Nikolaev archive Bulgarian arch

Comets

Equatorial catalog

Yupiter

Mars

Mikhailov's list

Minor planets

Neptune

Polar zone 1-st epoch

Polar zone 2-nd epoch

Radio sources

Saturn

Satellites of Saturn

Satellites of Jupiter

Uranus

Venus

Zodiacal catalog - "A"

Zodiacal catalog - "B"

Pluto

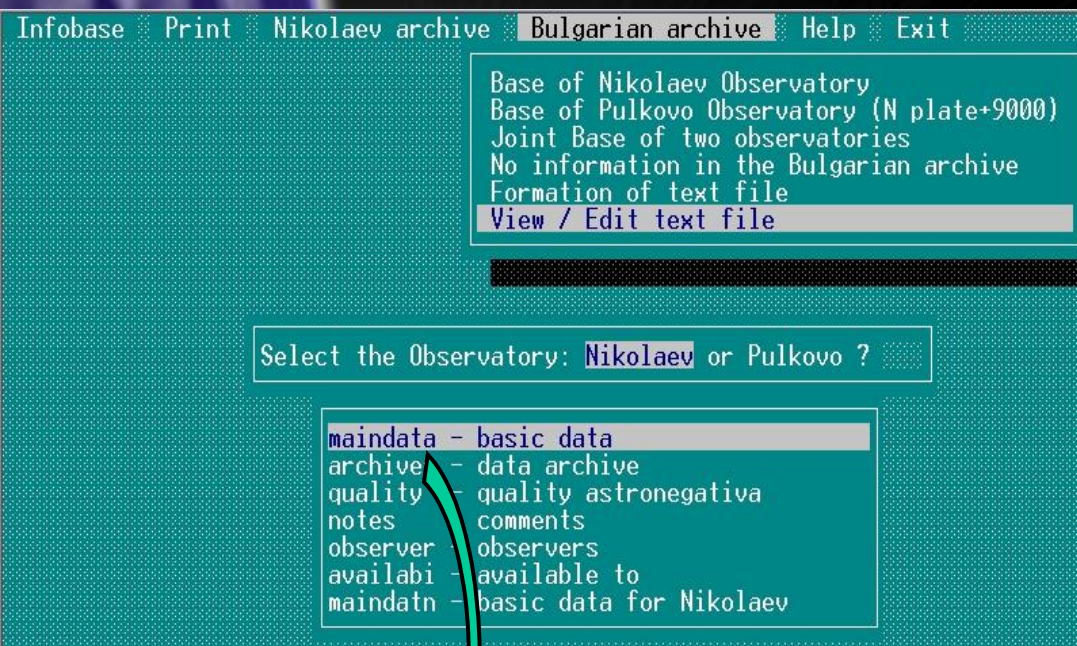
Moon (N plate + 9200)

Star fields

Nikolaev Joint Archive

N obj	N pl	Alpha	Delta	Date	Exp.1	Exp.2	N. of exp	Clock.angle	Emul	0
17	7	20.3	24 24	19610410	5	5.00	3	+161.1	A	
18	7	20.4	24 24	19610410	5	5.00	3	+189.0	A	
23	7	30.2	23 59	19610415	5	5.00	3	+145.1	A	
24	7	30.3	23 59	19610415	5	5.00	3	+169.0	A	
257	7	58.4	21 37	19621006	4	0.08	3	-140.7	A	
260	8	0.7	21 32	19621007	4	0.02	3	-150.4	K	
265	8	3.1	21 27	19621008	4	4.00	3	-141.8	K	
268	8	5.3	21 21	19621009	3	3.00	3	-144.5	K	
272	8	27.5	20 24	19621019	4	0.02	3	-108.5	K	
282	8	41.9	19 42	19621026	2	2.00	4	- 96.4	K	
283	8	42.0	19 42	19621026	2	2.00	4	- 76.8	K	
284	8	45.9	19 30	19621028	2	2.00	3	- 92.1	K	
285	8	45.9	19 30	19621028	2	2.00	4	- 79.3	K	
290	9	1.0	18 42	19621105	1	1.00	4	- 75.1	K	
291	9	1.0	18 42	19621105	1	1.00	3	- 64.2	K	
293	9	2.8	18 36	19621106	2	2.00	3	- 61.4	K	
294	9	2.8	18 36	19621106	2	2.00	4	- 42.9	K	
302	9	41.7	16 29	19621203	1	1.00	4	+ 20.3	K	
303	9	41.7	16 29	19621203	1	1.00	3	+ 36.0	K	

Database management system of photographic observations



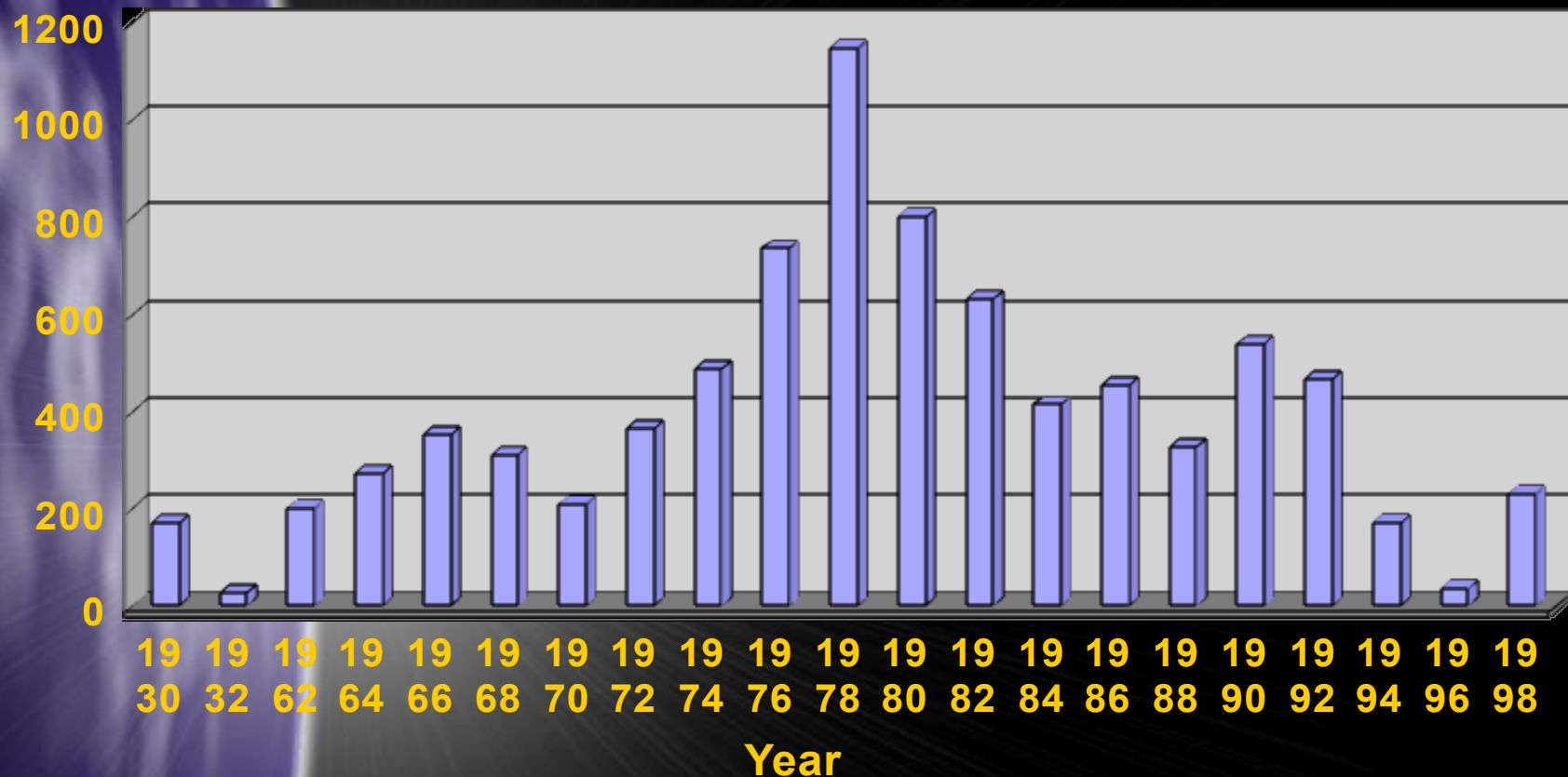
The fourth menu allows us to view and edit all text files in accordance with the format created by the Institute of Astronomy (Sofia, Bulgaria).

The fifth menu allows us to view any reference information about photographic plates, such as history of observations, programs and objects, observers, bibliography, quality of emulsion, log books of observations etc.



Databases of photographic observations.

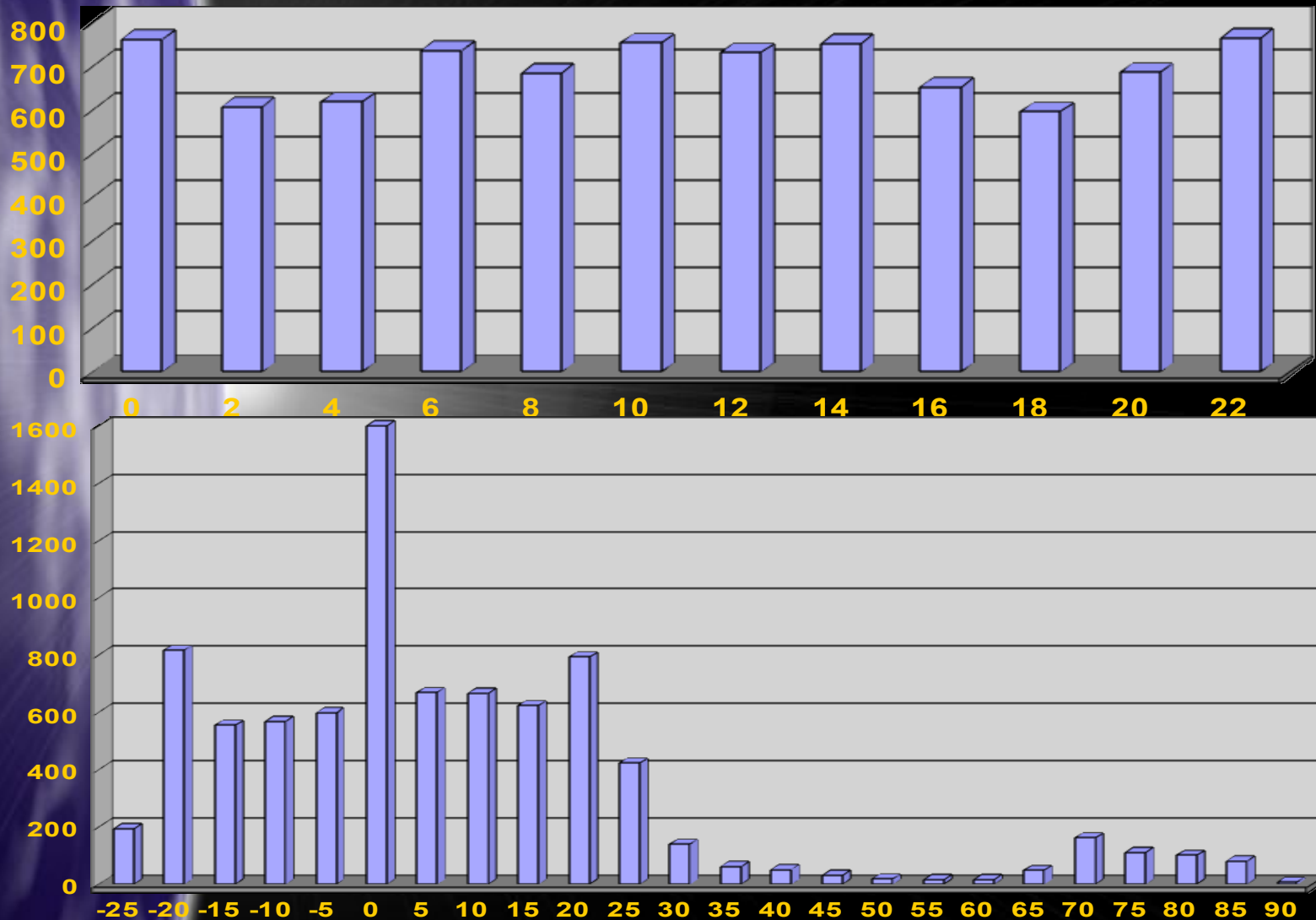
Distribution of photo plates by year of observation.



Now databases contain information about CCD observations obtained in 1996-2013 and photographic observations obtained in 1929-1931 and 1961-1999. The glass archive of NAO contains 8325 of photographic plates.

Databases of photographic observations.

Distribution of photo plates by RA & DEC.



Data volume of photo plate images obtained at NAO and stored in data bank

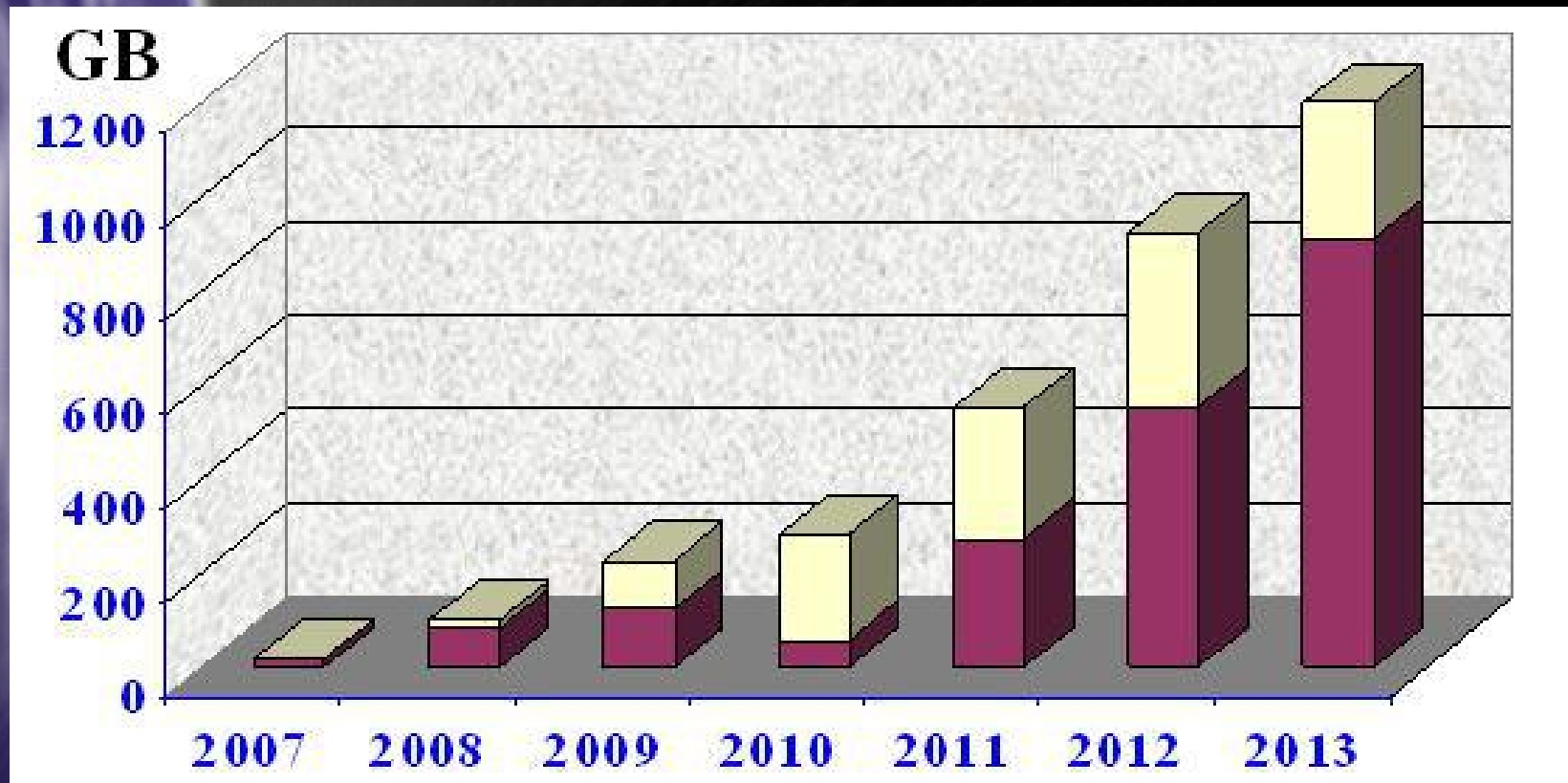
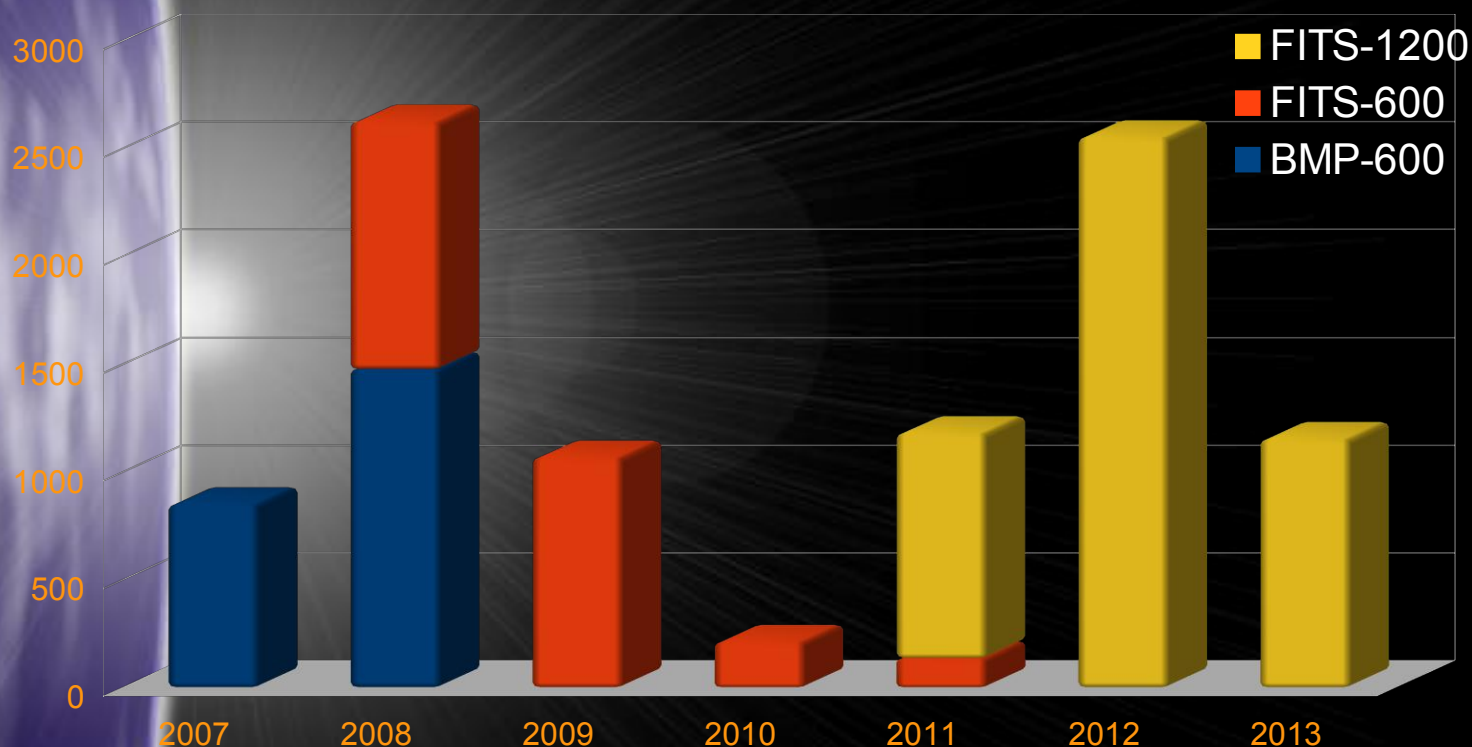


Plate archive of the Nikolaev observatory

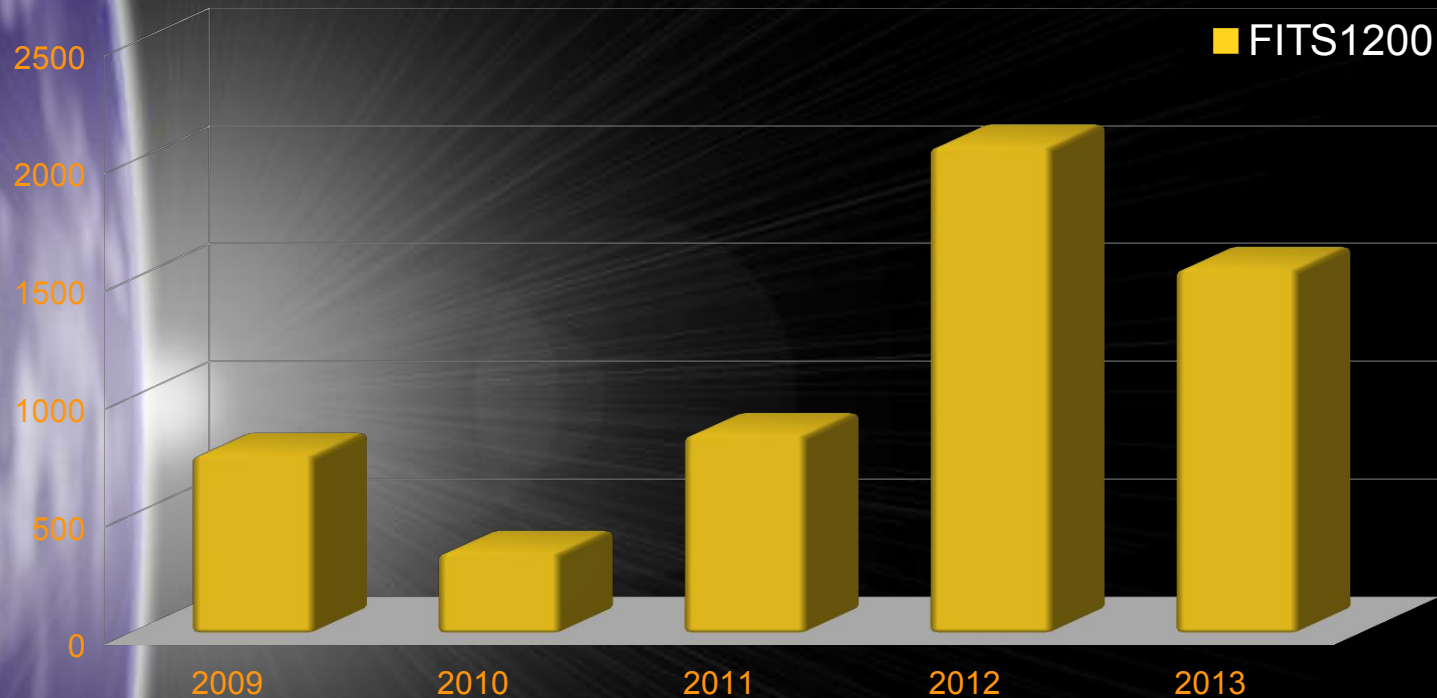


Number of preview images obtained in NAO



February 2014: Preview images - 99% of plate archive, 93% in FITS format. 99% of images are available in UkrVO.

Number of plate images obtained in NAO for astrometric reduction

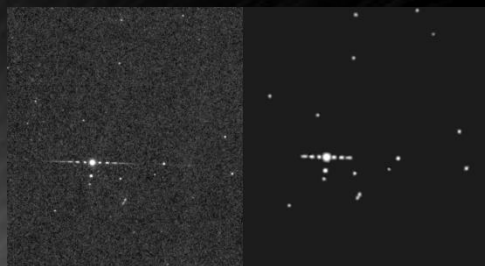
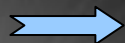


First astrometric results of data processing were obtained in 2009. Images of 50 plates containing about 17000 stars were processed. The obtained accuracy was about 0."07 for both coordinates and resolution of 1200 DPI.

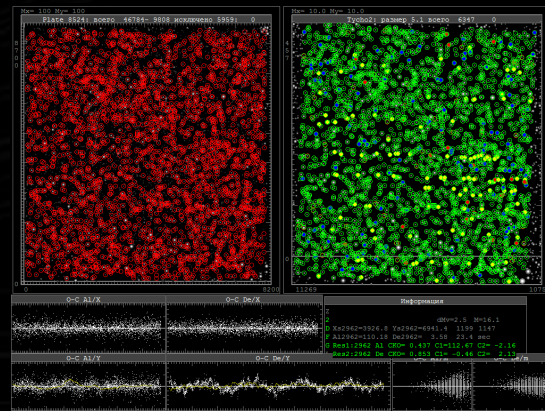
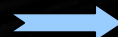
Catalogues of stars in fields near Galactic plane were obtained with common reduction of CCD observation and plate archive images



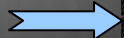
Use scanner Epson V750 Pro for receiving of 2100 images of photo plate in 210 fields



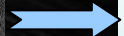
Reduction of 2100 images.
Obtained coordinates of about
20,000,000 objects.



Use telescope Mobitel KT-50 for receiving 6500 CCD frames in 172 fields



Reduction of 6500 CCD images,
Obtained coordinates of about
9,000,000 objects.



Obtained 3 catalogues in 2013:

Photographic catalogue for epoch 1981.6:

903000 stars (8-16)^m, accuracy : **0."⁰² - 0."⁰⁷**

CCD catalogue for epoch 2012.2:

760000 stars (9-17)^m, accuracy : **0."⁰² - 0."⁰⁴**

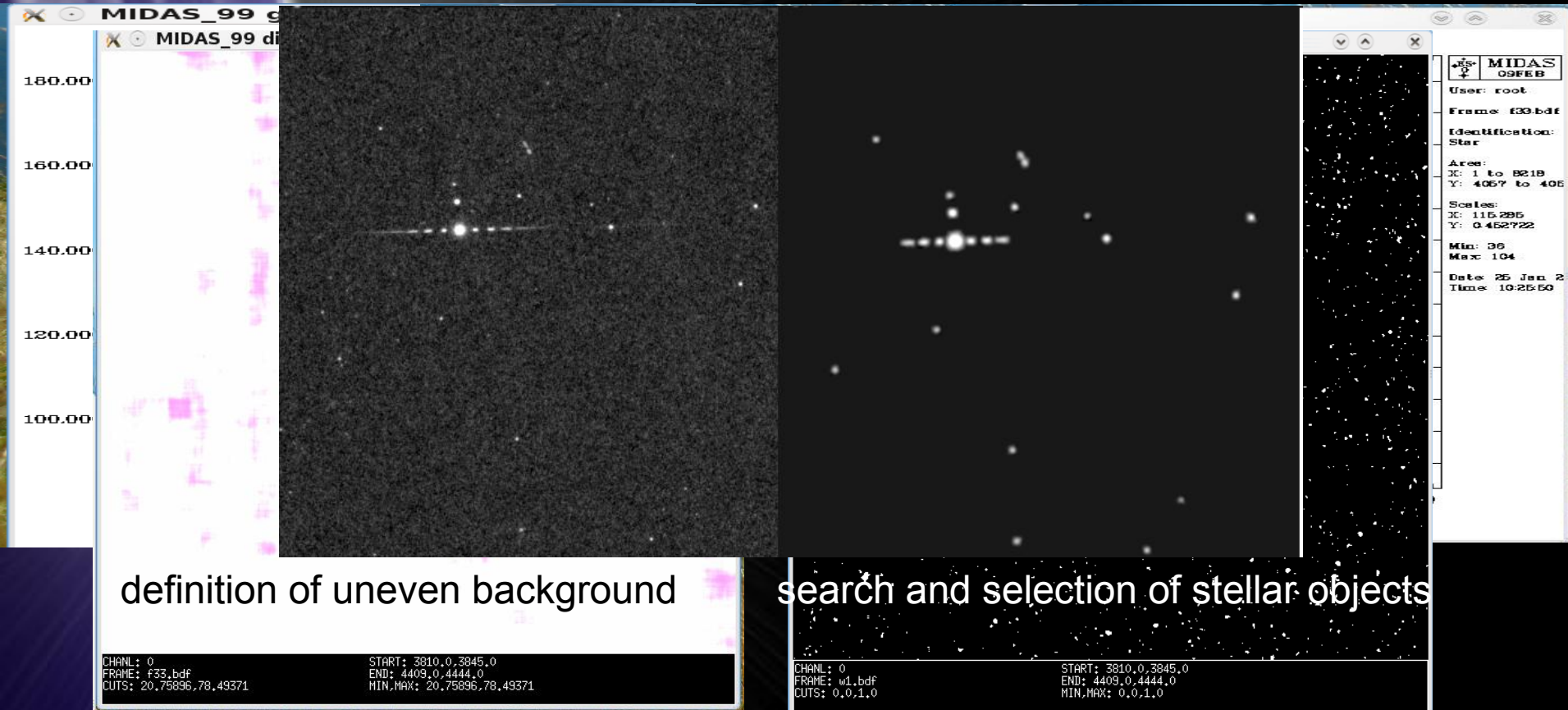
Catalogue of coordinates and proper motions:

700000 stars (8-16)^m, accuracy:**0."⁰²-0."⁰⁴ , 0.005"/year**

In 2013, using 2100 images of 210 plates distributed close to the Galactic plane and 6500 CCD images we obtained a catalogue of coordinates and proper motions for about 700000 stars. The catalogue accuracy is about 0."⁰⁴, proper motion - 0."⁰⁰⁵/year. Also we obtained a catalogue of coordinates for more than 900000 stars from plates with accuracy about 0."⁰⁶.

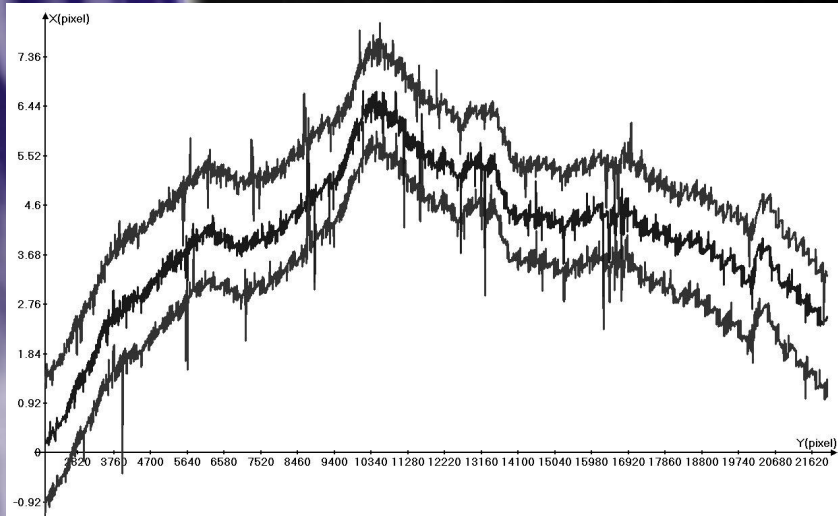
MIDAS data reduction for photo plate images

Data reduction process: filtering, bright stars image restore, find stars and save X,Y coordinate and brightness. 20-30 minutes per image on Core2Duo 2.5Ghz

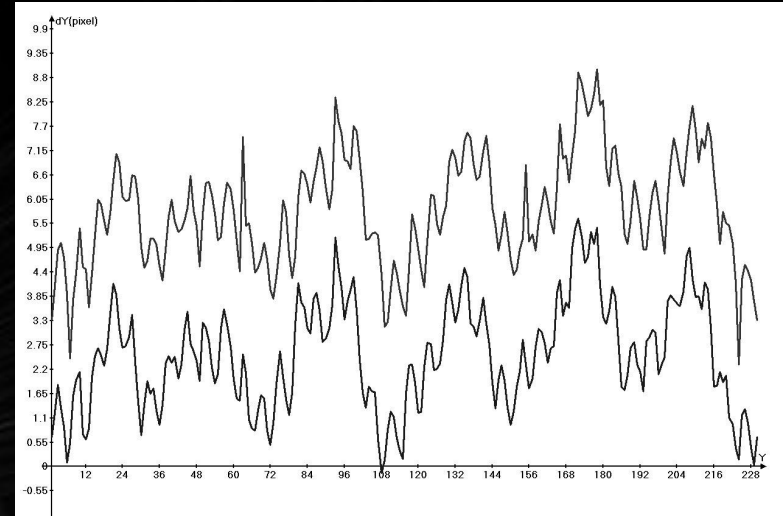


Part of image before (left) and after (right) filtering.
Processing was carried out in a batch mode of 30-50

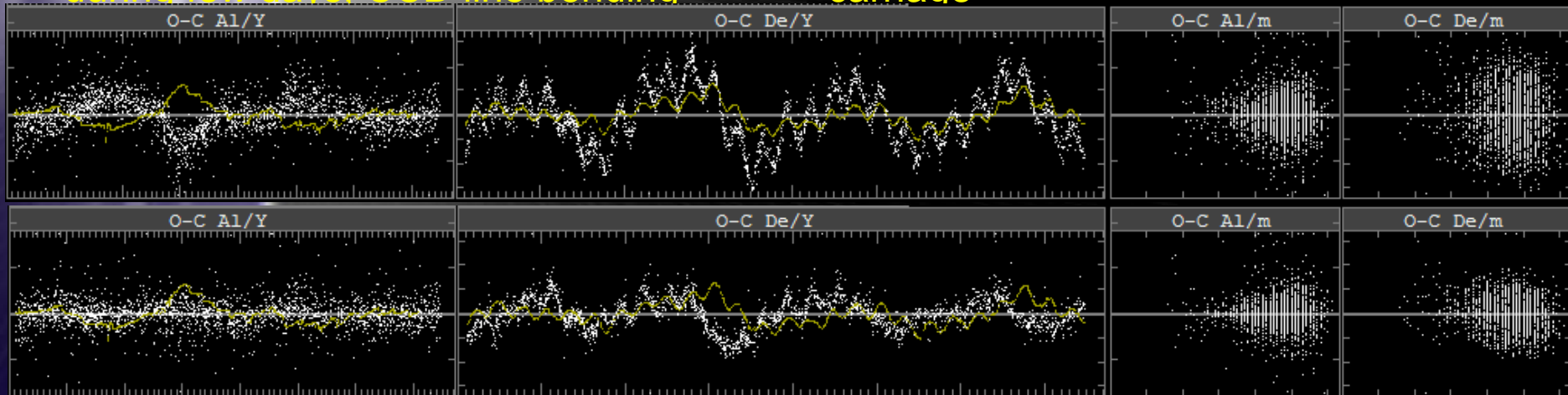
Using high precise ruler to check V750 scanner in 2400 DPI



It has linear biases up to 10 pixels per 10000 pixels of movement, stable during few days, CCD line bending

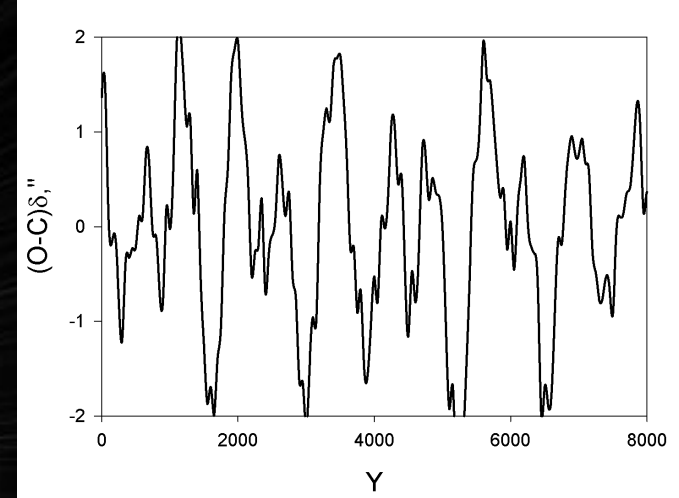
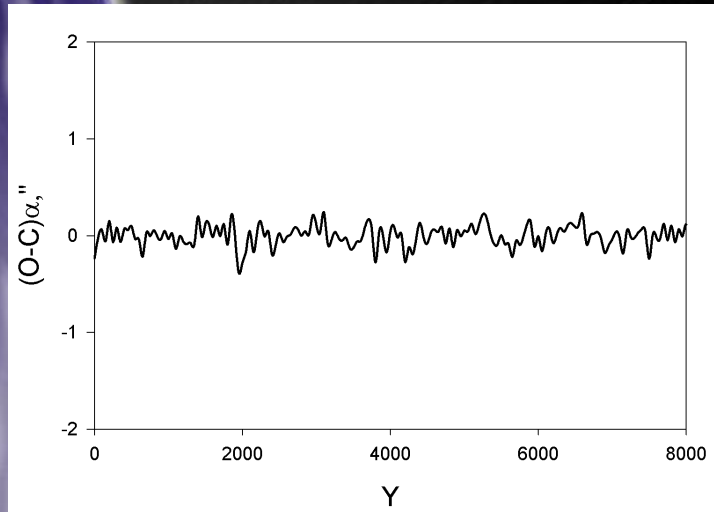


It has periodic counterpart from 2 to 5 pixels, unevenness of the carriage

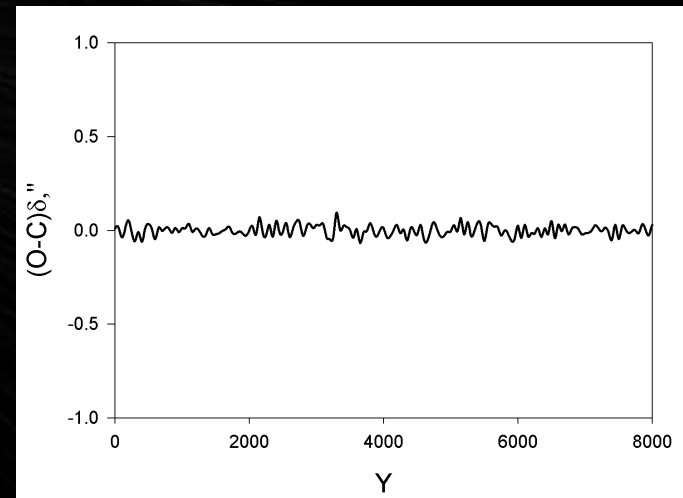
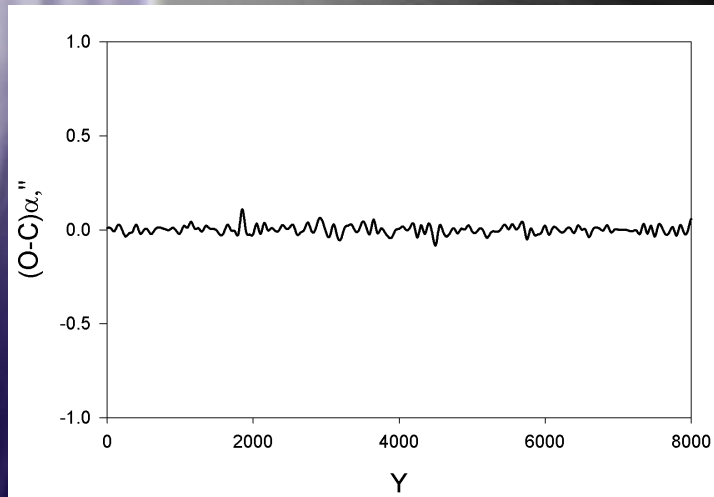


The results are used as amendments in calculating the coordinates of the objects on images. Consideration of amendments improves the result by RA of about 25-30% and by DEC of about 40-60%.

Improvement of results by statistical methods using reference stars

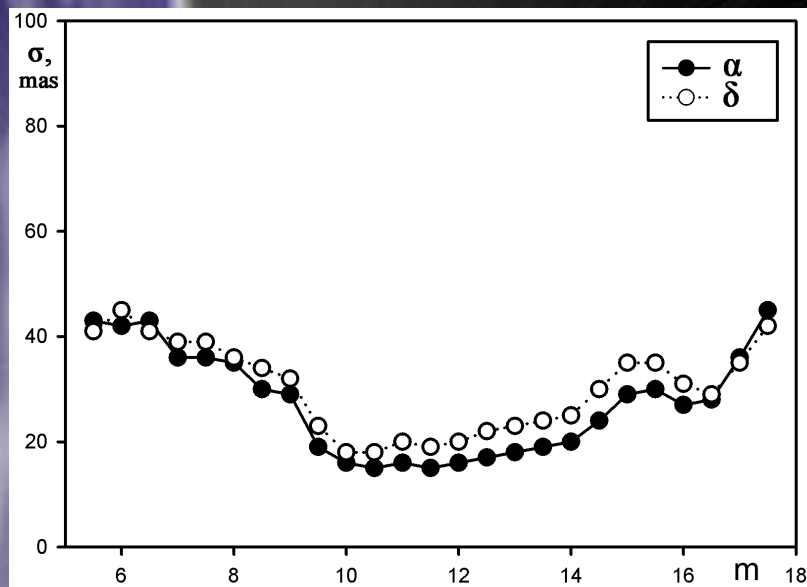


RA (left) and DEC (right) after first iteration

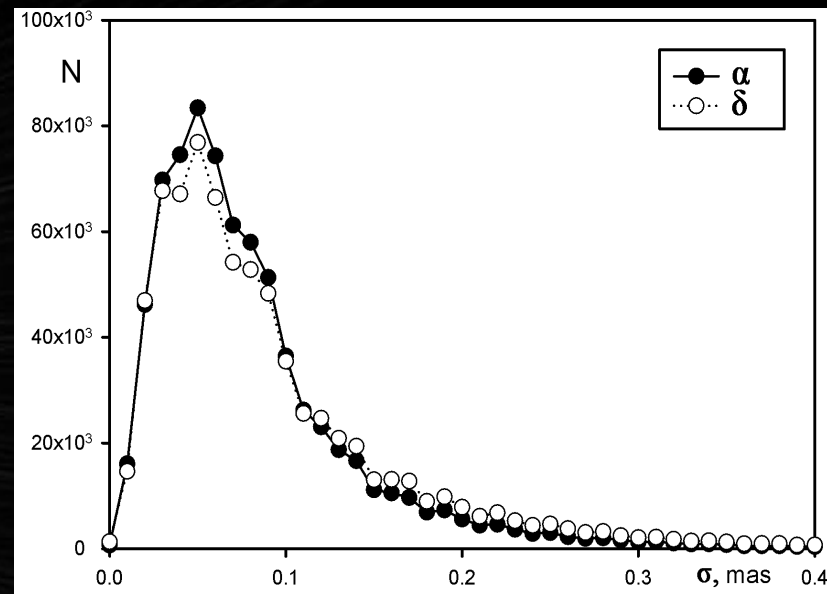


RA (left) and DEC (right) after third iteration

Catalogue accuracy



Distribution of catalogue accuracy in mas by magnitude (RA – black, DEC – white)



Distribution of number of stars in catalogue by accuracy (RA – black, DEC – white)

Development of the digital database

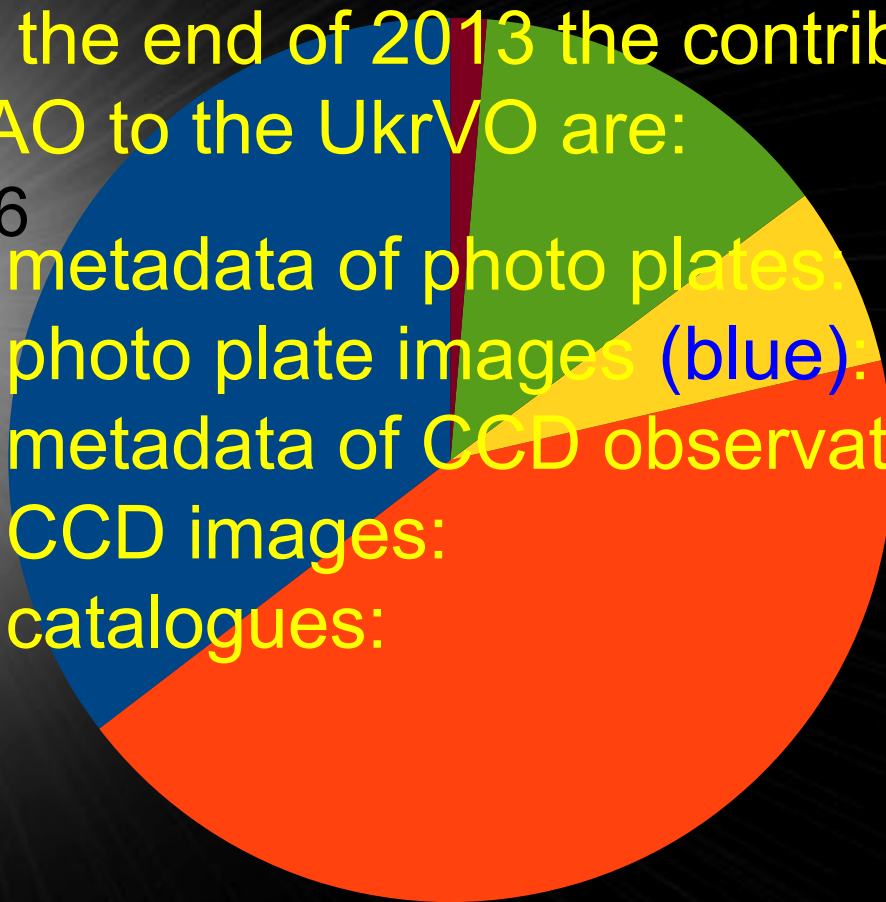
- ✓ Development of astronomical databases with web interface has been started since 2004, connect databases to Aladin program has been started since 2005.
- ✓ The daily average volume of the new astronomical information obtained from the CCD instruments makes from 1 GB up to 12GB, depending on the purposes and conditions of observations. For compare: size of all observation from 1996 till 1998 was near 5GB.
- ✓ The total data volume of obtained plate and CCD images was about 3 TB at the middle of 2013.

Ukrainian Virtual Observatory (UkrVO) is a member of IVOA since 2011

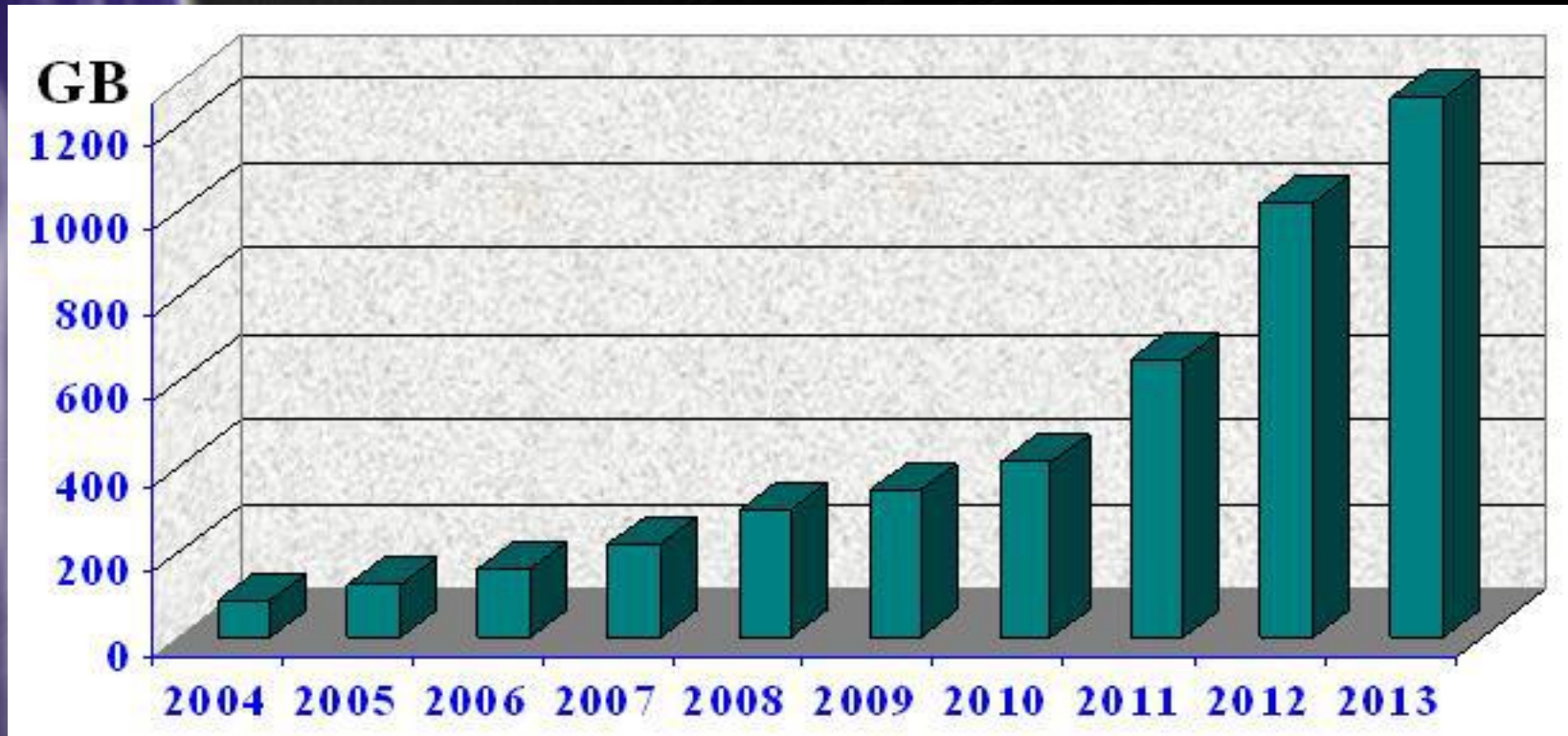
At the end of 2013 the contribution of the
NAO to the UkrVO are:

8066

- ✓ metadata of photo plates: 20%
- ✓ photo plate images (blue): 35%
- ✓ metadata of CCD observations: 100%
- ✓ CCD images: 100%
- ✓ catalogues: 80%



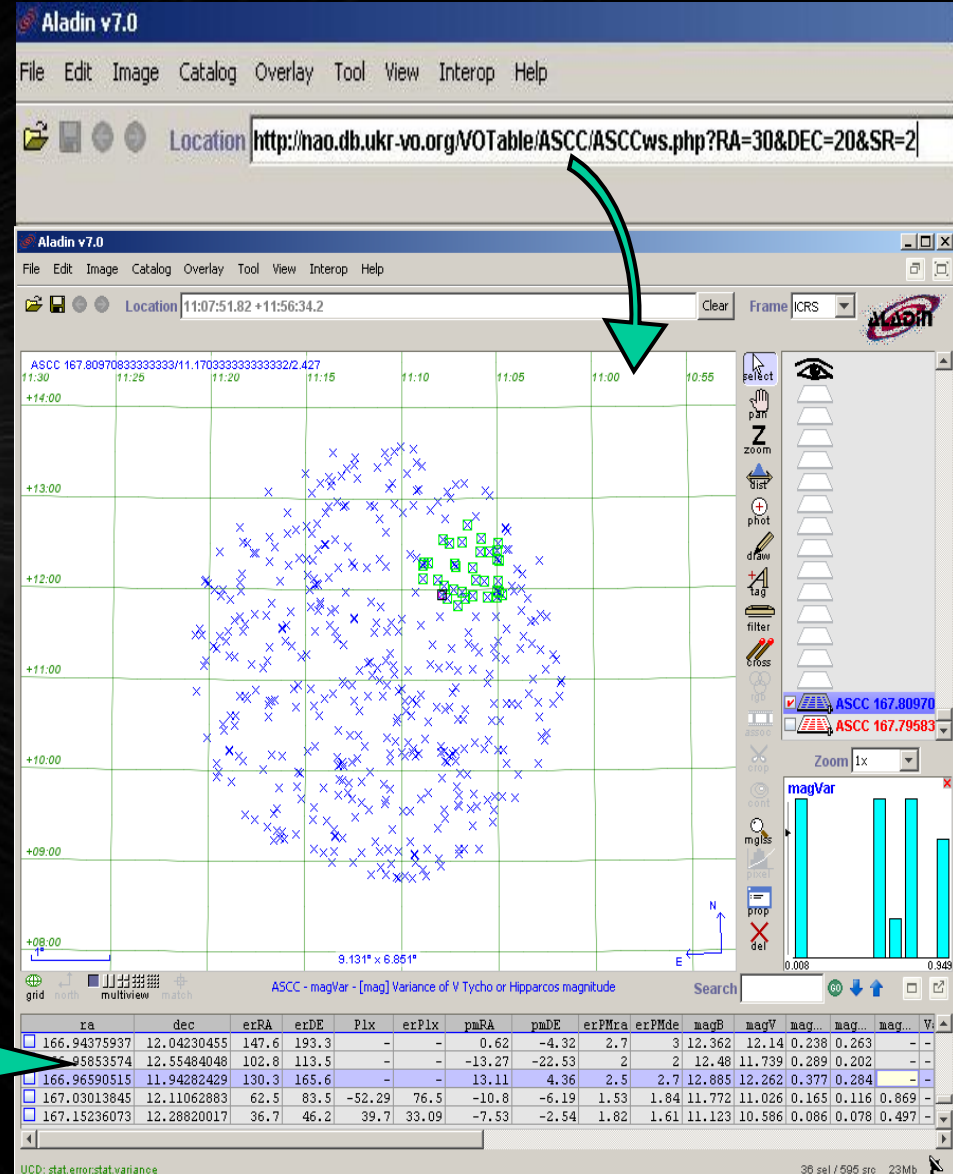
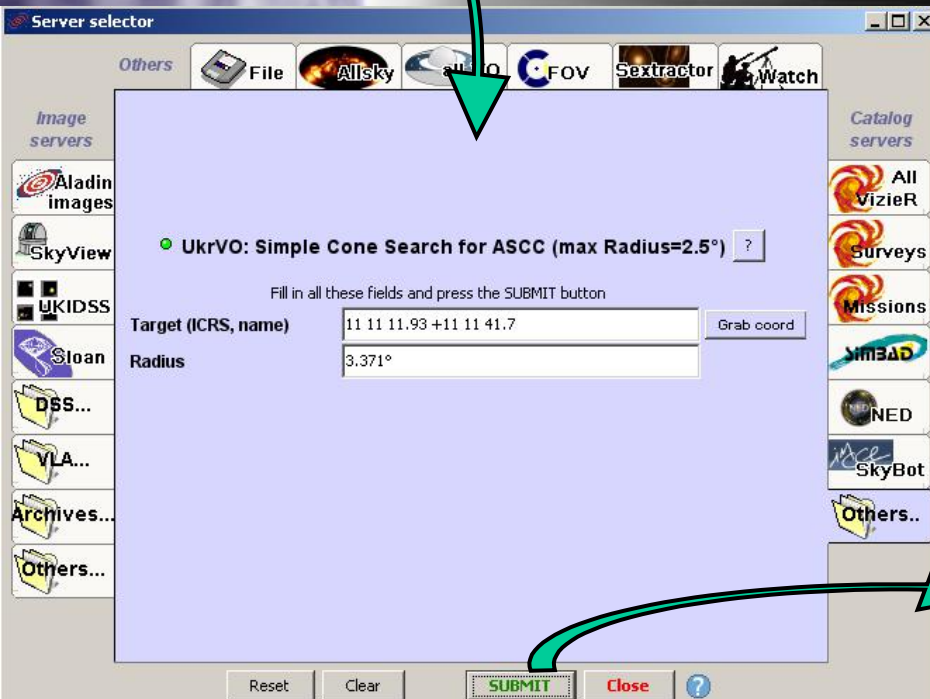
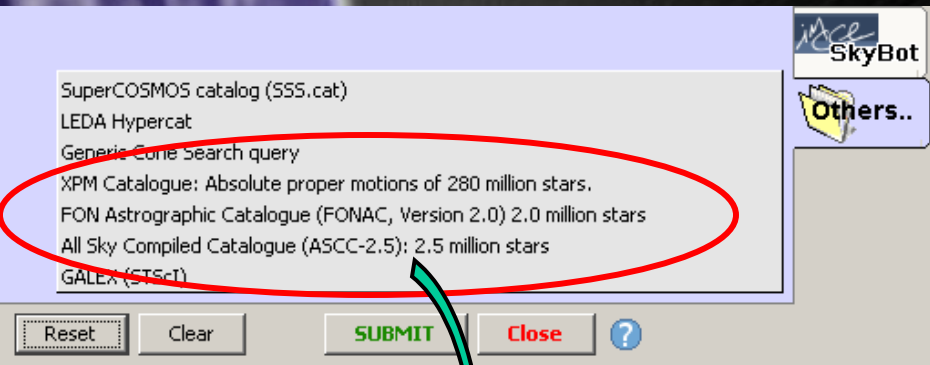
Volume of the CCD raw data obtained in NAO and stored in the data bank



All receiving data are stored on servers in two copies, namely, working and backup. Also we made copies of observational data as archives on DVD. All obtained observations have been stored in FITS format since 1998 and for plate images since 2008.

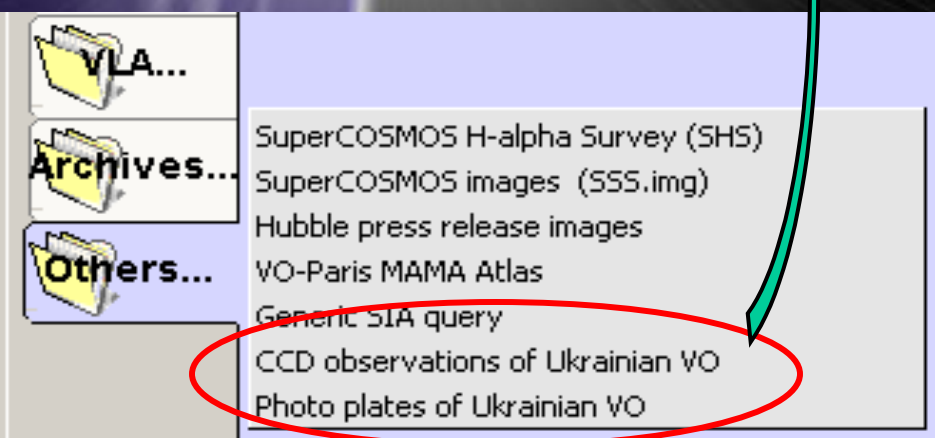
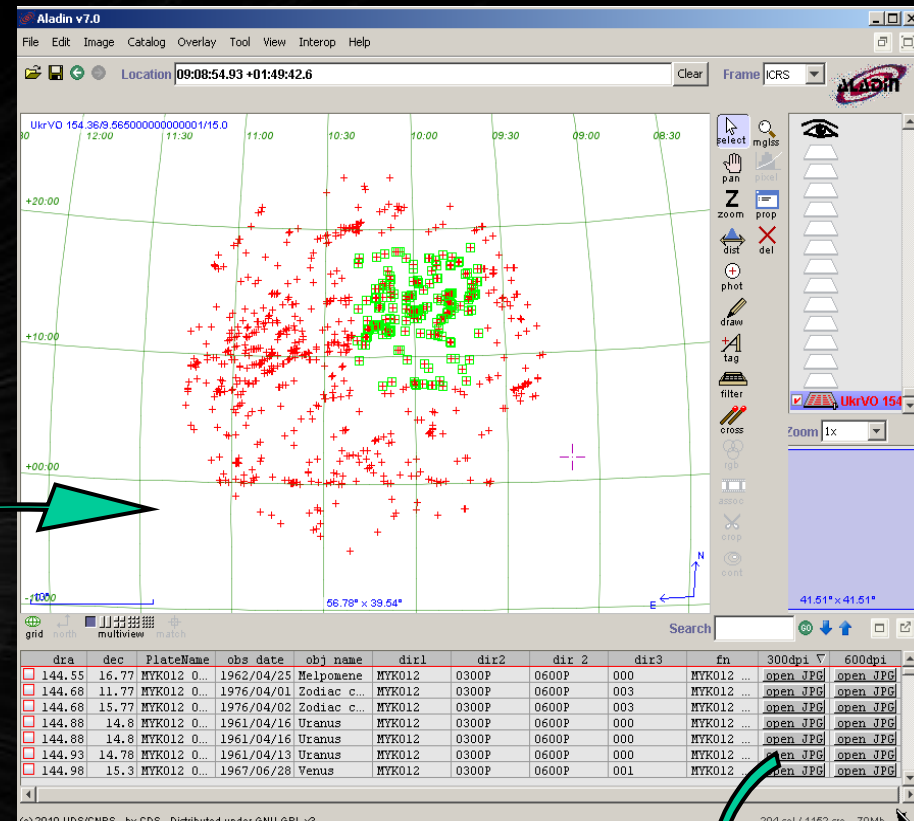
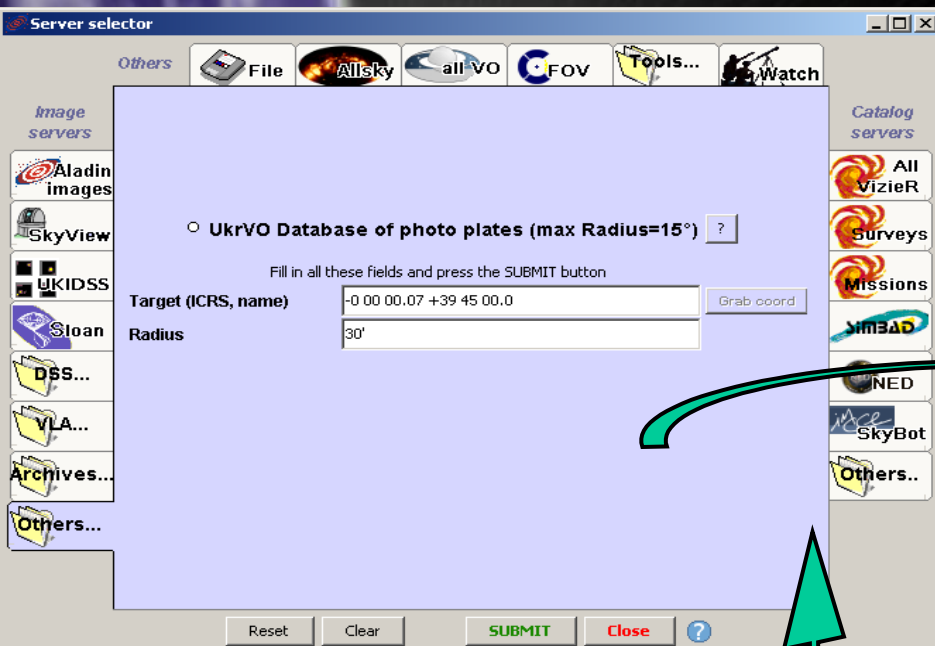
Web services via Aladin graphical interface

ASCC, FONAC, XPM



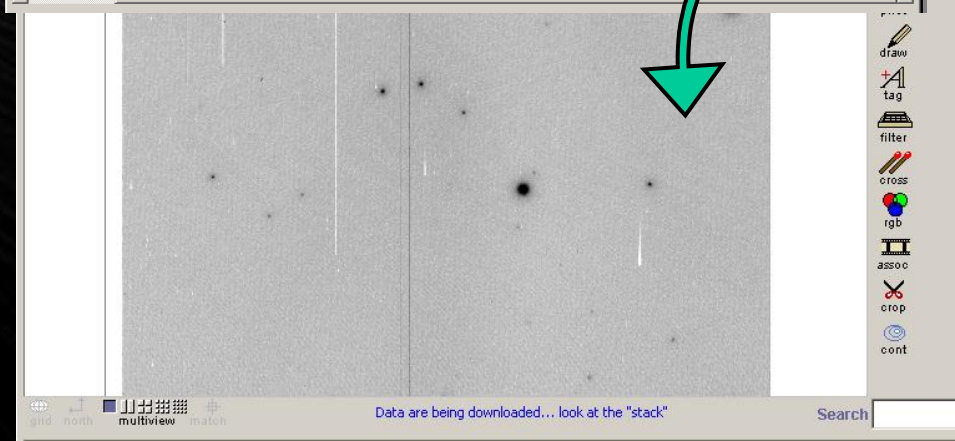
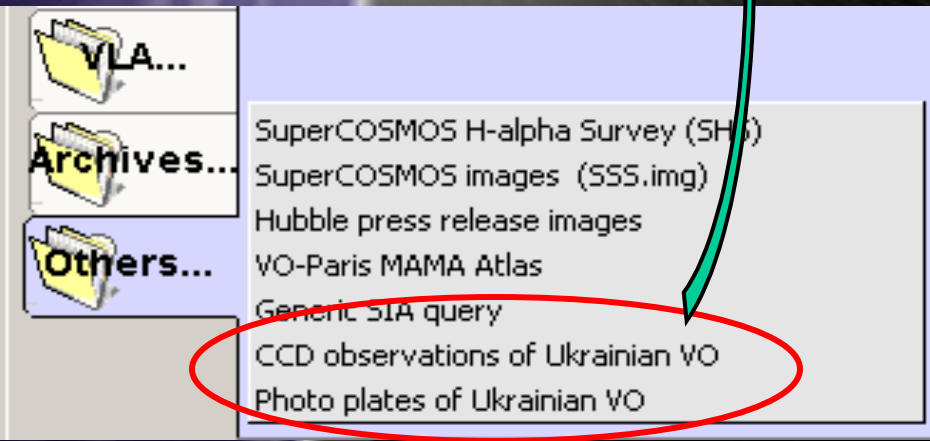
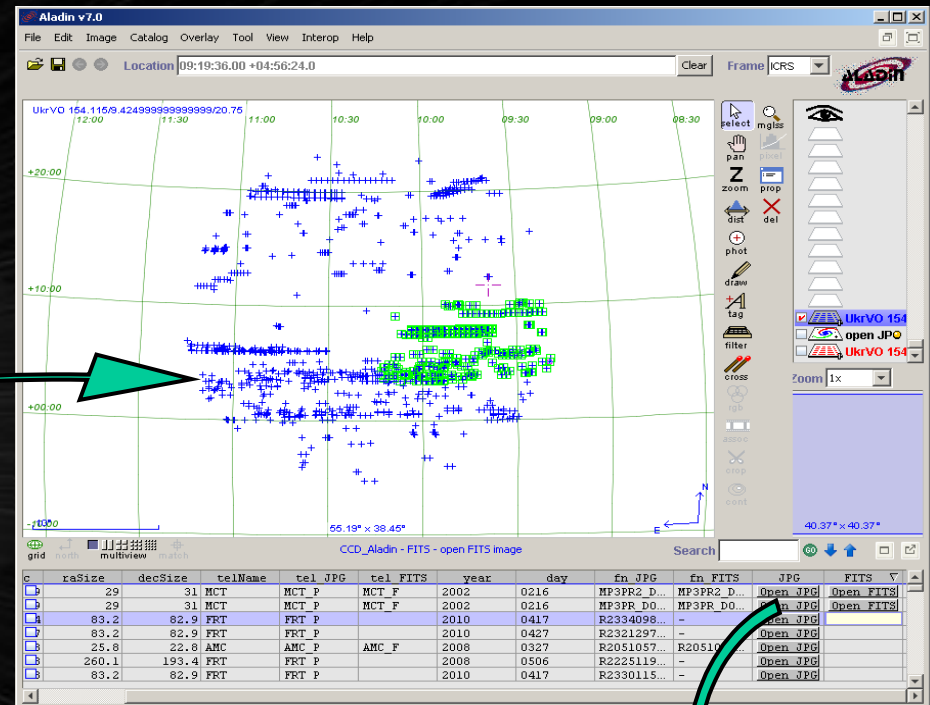
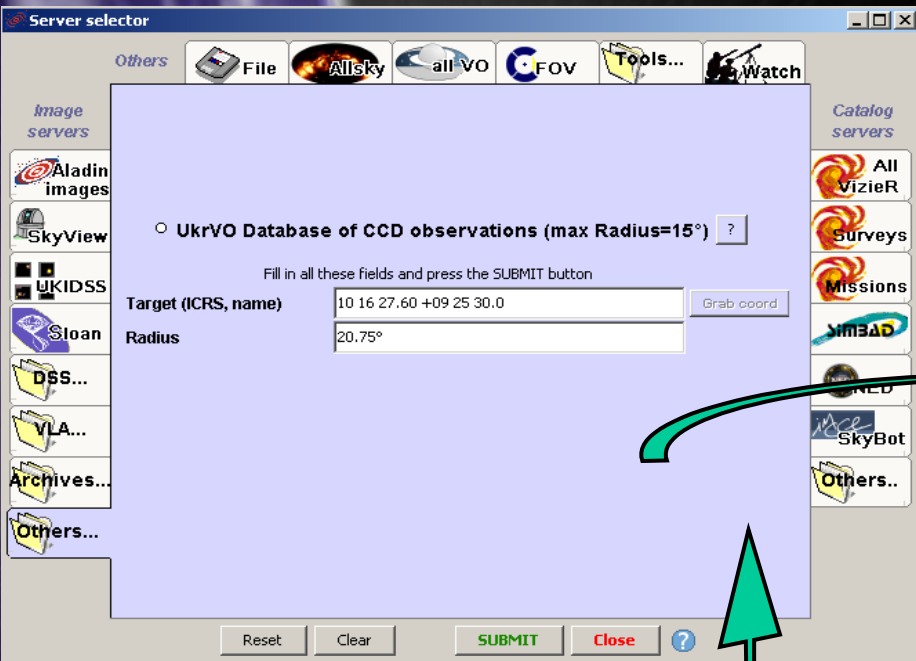
Database of photographic observations via Aladin

More than 34000 plates from 15 telescopes (GAO+MAO).
More than 8000 preview images (MAO): 300 or 600 dpi.



Database of CCD observations via Aladin

More than 70000 CCD frames from 3 telescopes (MAO) up to 2012. Preview images for all frames. FITS for AMC (2002-2005) and MCT (2001-2005).



Database of photographic and CCD observations via browser

More than 34000 plates from 15 telescopes (GAO+MAO)
More than 8000 preview images (MAO): 300 or 600 dpi.
More than 70000 CCD frames from 3 telescopes (MAO).
Preview images for all frames.
FITS for AMC (2002-2005) and MCT (2001-2005).



Ukrainian Virtual Observatory

RA and Dec (h m d m OR d d):

Sizes of search region (RA, Dec), deg:

Period of observations (YYYY MM DD): from to

Observations with: ☒ photo plates ☐ CCD

Observational campaigns with photo plates

Optional parameters of photo plates

☒ Date, Y/M/D ☐ UT, hh:mm:ss ☒ Object name ☐ Number of exposures
☐ Exposure, min ☐ Type of emulsion ☐ Filter ☐ Sizes of plate, cm/cm

Do you want to select only the plates with preview images? ☒ Yes ☐ No

Select plates with exposure more than: min

Optional telescopes for photo plates

Observational campaigns with CCD

Optional parameters of CCD frames

Optional telescopes for CCD observations

Login, password

Number of plates in the database: 34198

Plate	RA, h:m:s	Dec, d:m	Y/M/D	Object	300 dpi	600 dpi
MYK012 007895	00:40:00	+02:00	1990/08/29	Equatorial catalog	preview	preview
MYK012 007896	00:40:00	+02:00	1990/08/29	Equatorial catalog	preview	preview
MYK012 007935	00:40:00	-02:00	1990/09/24	Equatorial catalog	preview	preview
MYK012 007936	00:40:00	-02:00	1990/09/24	Equatorial catalog	preview	preview
MYK012 004677	00:42:30	-05:44	1978/10/22	Zodiac catalog - B	preview	preview
MYK012 005020	00:42:36	-01:44	1979/08/25	Zodiac catalog - B	preview	preview
MYK012 005438	00:42:36	+02:16	1980/08/17	Zodiac catalog - B	preview	preview
MYK012 007851	00:48:00	-00:00	1990/08/25	Equatorial catalog	preview	preview
MYK012 007852	00:48:00	-00:00	1990/08/25	Equatorial catalog	preview	preview
MYK012 004186	00:50:30	-03:44	1977/10/12	Zodiac catalog - A	preview	preview
MYK012 004153	00:50:36	+00:16	1977/10/06	Zodiac catalog - A	preview	preview
MYK012 004655	00:50:36	+04:16	1978/10/07	Zodiac catalog - A	preview	preview
MYK012 007865	00:56:00	+02:00	1990/08/26	Equatorial catalog	preview	preview
MYK012 007866	00:56:00	+02:00	1990/08/26	Equatorial catalog	preview	preview
MYK012 007877	00:56:00	-02:00	1990/08/27	Equatorial catalog	preview	preview
MYK012 007878	00:56:00	-02:00	1990/08/27	Equatorial catalog	preview	preview
MYK012 004135	00:58:36	-01:44	1977/09/16	Zodiac catalog - B	preview	preview
MYK012 004767	00:58:36	+02:16	1978/12/19	Zodiac catalog - B	preview	preview
MYK012 007959	01:04:00	-00:00	1990/10/14	Equatorial catalog	preview	preview
MYK012 007960	01:04:00	-00:00	1990/10/14	Equatorial catalog	preview	preview
MYK012 004120	01:06:30	-03:44	1977/09/14	Zodiac catalog - A	preview	preview
MYK012 004165	01:06:36	+00:16	1977/10/10	Zodiac catalog - A	preview	preview

Number of found plates in the table: 34

Conclusions

- ❑ We obtained preview images of all plate archive of NAO. The database is available in the UkrVO web site
- ❑ Photographic and CCD databases are populated with new data and work via graphical interfaces of browser as well as Aladin.
- ❑ We obtained new catalogues using new CCD and old photographic observations.



Thank you for
attention!