

First results of MAO NASU SS bodies photographic archive digitization

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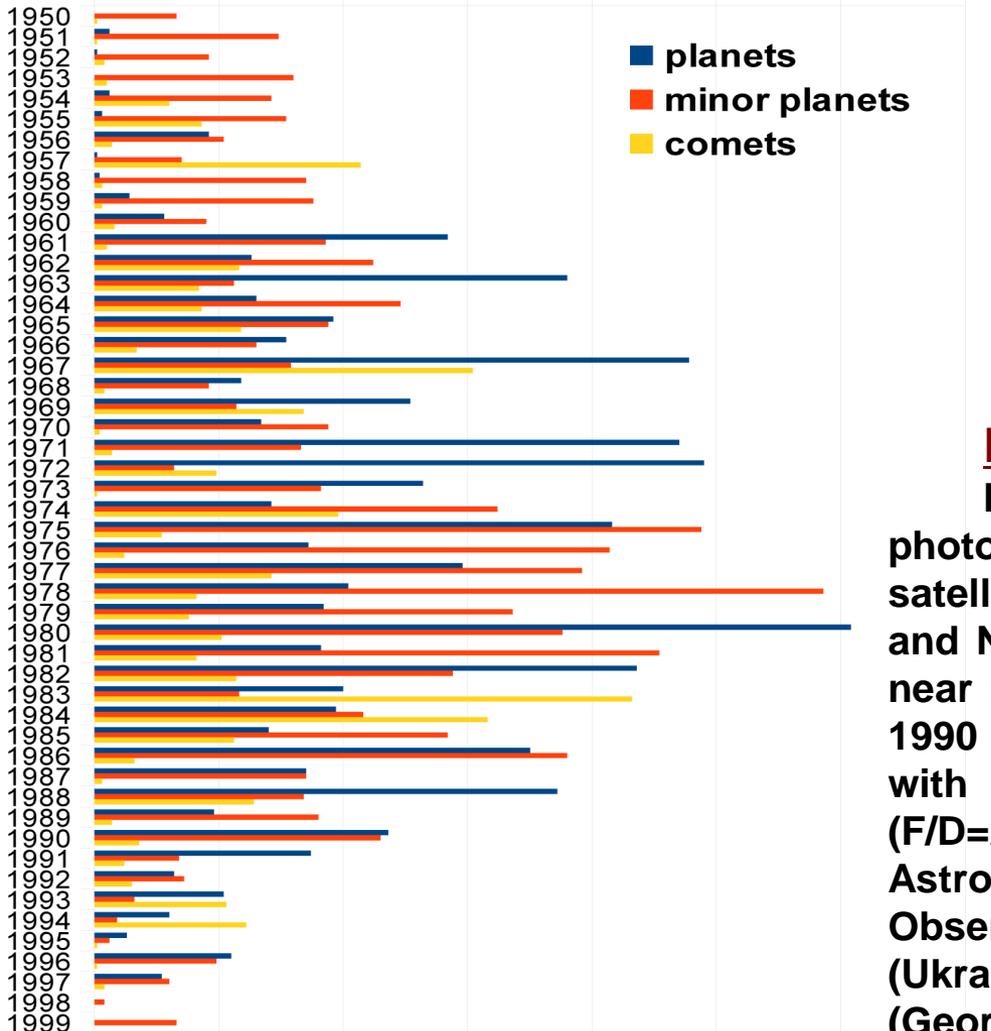
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Number of SS Bodies observations in the collection of MAO NASU

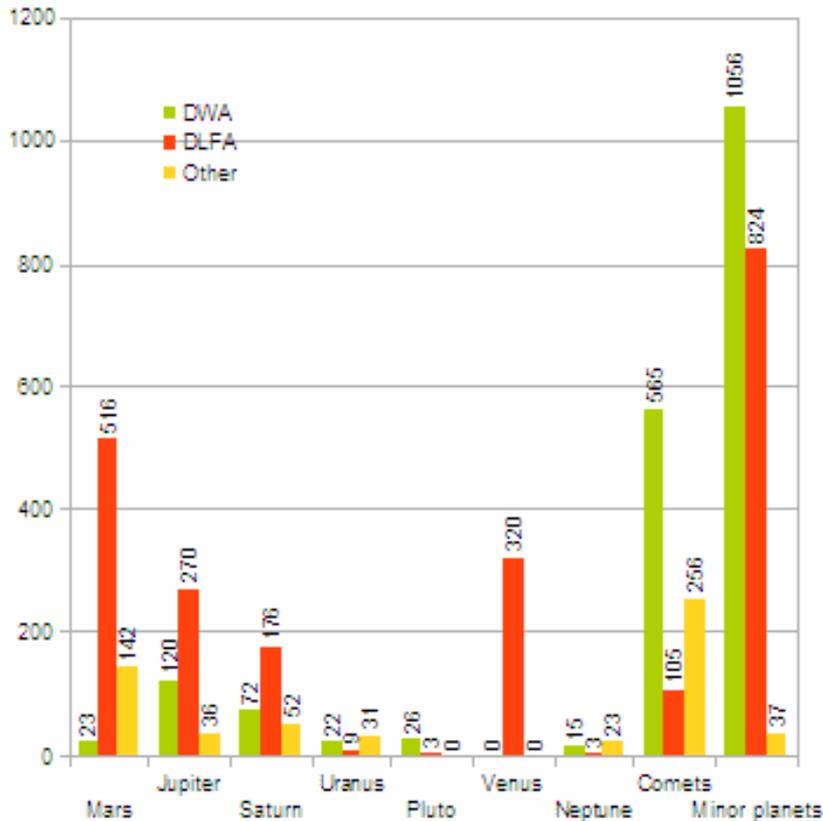
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Review of archives

MAO NASU glass archive contains about 1800 photographic plates with the planets and their satellites (including near 80 images of Uranus, Pluto and Neptune), 1700 plates with minor planets and near 900 plates with comets, obtained during 1949-1990 using 11 telescopes of different focus, mostly with the Double Wide-angle Astrograph (F/D=2000/400) and the Double Long-focus Astrograph (F/D=5500/400) of MAO NASU. Observational sites are Kiev (Ukraine), Lviv (Ukraine), Biurakan (Armenia), Abastumani (Georgia), Mt. Maidanak (Uzbekistan), Quito (Equador).

Number of SS bodies archival observations



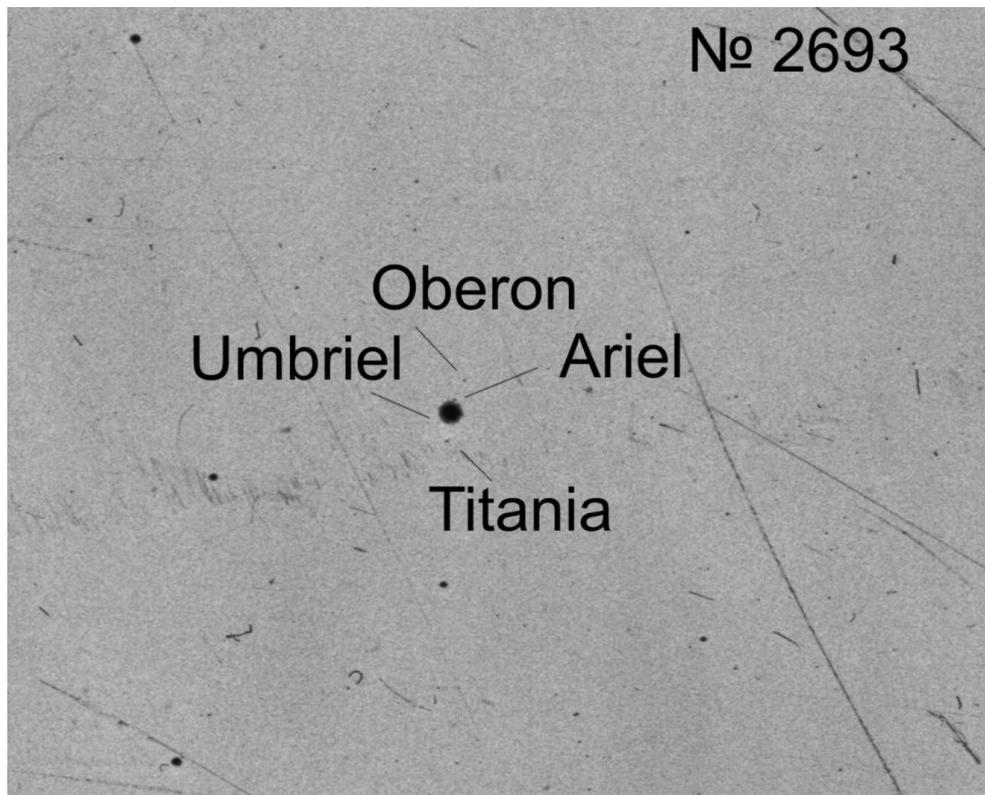
Scanning

Since 2008, the process of MAO NASU archive plates digitization and inclusion of plate preview images into GPA database has been under way, using two models of flatbed scanners: **Microtek ScanMaker 9800XL TMA** and **Epson Expression 10000XL**. Both digitizers were tested for intrinsic errors and possible accuracy. Table 1 presents the comparative positional and photometric accuracy data for selected negatives with star standard fields for two instruments.

Three plates obtained according the rules established for the Solar System Bodies observational program have been selected for further tests. The plates contain the images of Uranus satellites Titania and Oberon.

Table 1. Positional and photometric accuracy obtained for plates with star standards for two instruments and Microtek scanner

Telescope	color	exposure	scale, <i>s /mm</i>	field	σ_{ra} <i>mas</i>	σ_{dec} <i>mas</i>	σ_m
DWA	B	18 min	103	8°x8°	170	180	0.20
DLFA	B _{ph}	20 min	38	2°x2°	60	80	0.13



Plates were scanned with Microtek model at 16-bits grey dynamic range, with a resolution of 1200-1600 dpi, and saved in TIFF format. Linear dimensions of images are up to 8 thousand pixels (for plates 24x24 cm).

The astrometric and photometric calibration procedures have been done in the LINUX-MIDAS-ROMAFOT environment and Tycho-2

Table.2. Results of Microtek digitized images processing

№	N_T	σ_{α}	σ_{δ}	N_p	σ_B	N_T	σ_B
1	2	3	4	5	6	7	8
356	149	39	87	10	0.13 ^m	120	0.27 ^m
407	136	53	69	8	0.07	107	0.27
269 3	136	73	76	9	0.24	101	0.29

Description of Table 2 columns:

1 - original number of plate;

2 - number of reference stars;

3,4 - positional accuracy of reference stars , mas

5 - number of photoelectric standard stars

6 - photometric accuracy (Johnson B)

7 - number of Tycho stars for curve restoration

8 - photometric accuracy (Tycho photometric system)

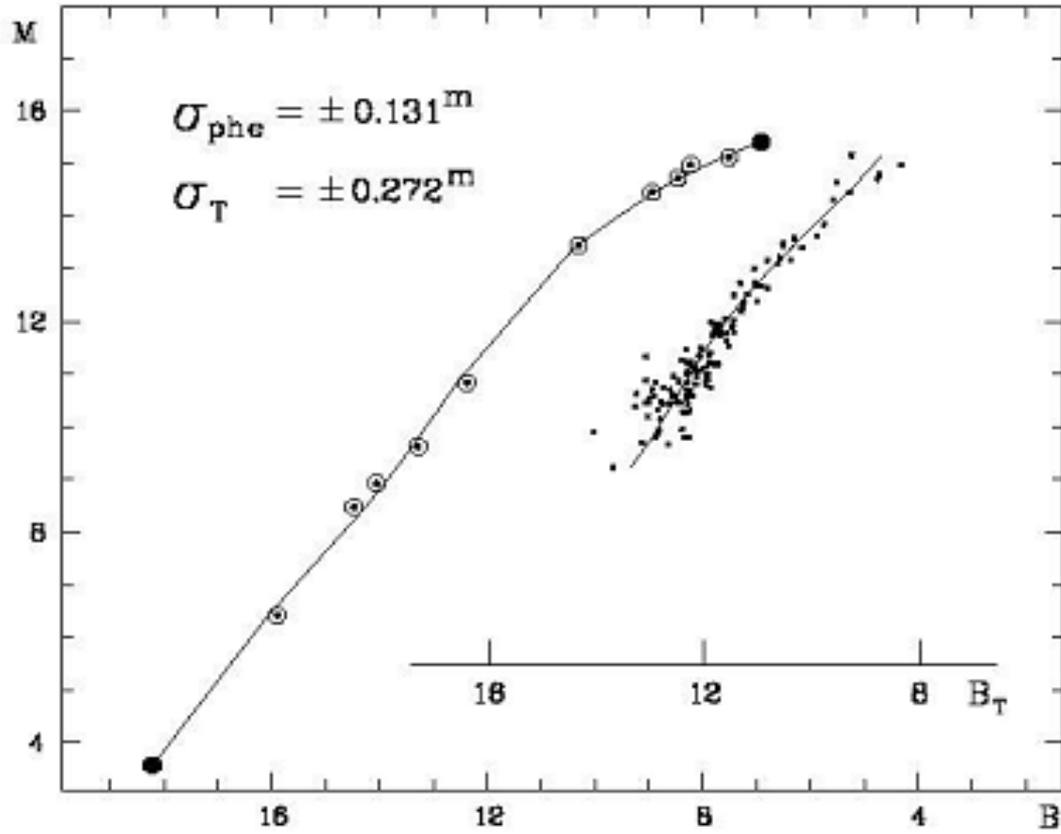


Fig.4. Photometric curves, restored from Tycho photometric data (dots), and photoelectric standard stars (circles).

Results for Epson Expression

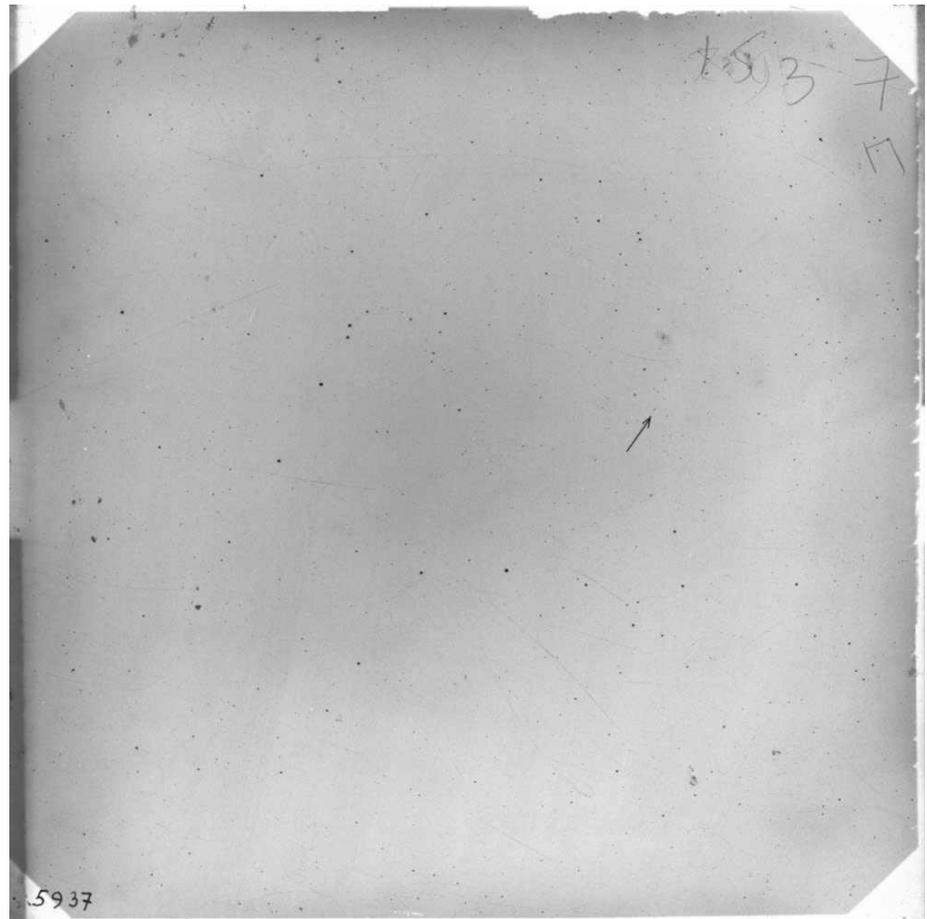
In order to display the aptitude of Epson Expression model for positional detections of SS bodies on digital plates the DLFA plate was selected.

The plate obtained in 1979, contain Pluto image and was digitized and processed by the same rules as previous ones (Fig.5).

The curves of discrepancies in coordinates vs pixel coordinates and Tycho star magnitudes are given on Fig.6 (raw, non-corrected) and Fig.7 (after corrections for scanner mechanics errors and telescope optics aberrations). Photometric dependence was built from Tycho photometric data only because there is no any photoelectric photometry standards in desired area and it is almost totally identical the Fig.4. The final accuracy estimations for different magnitude intervals are shown in Table 3. Table 4 presents the coordinates of all three objects, mentioned in the presentation , their (O-C) and Table 5 gives the accuracy, obtained earlier from processing of coordinates measurements with iris diaphragm for comparison.

First results of Pluto plates processing give the rms errors of 10 and 20 mas for RA, DEC respectively, 40 to 60 mas in the TYCHO system and (O-C) in comparison to JPL PLU021.DE405 are of 190(RA) and 270(DEC) mas. It follows from Table 5, that Epson Expression model of scanner gives a little better results in positional accuracy than Microtek one. And from the same table it is obvious that results, derived from digitized plates exceed ones had been obtained earlier with measuring appliances. The last fact opens the reassuring outlook for re-processing the MAO NASU archive data on the ground of digitized images of plates with the SS bodies.

Photographic plate
GUA040A005937 (1979)
with the image of PLUTO

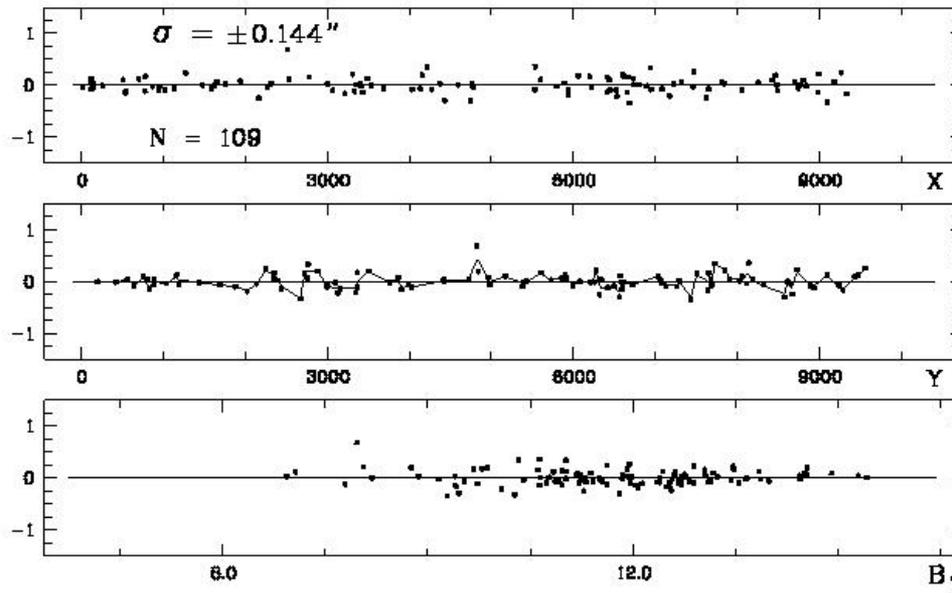


Results for Epson Expression

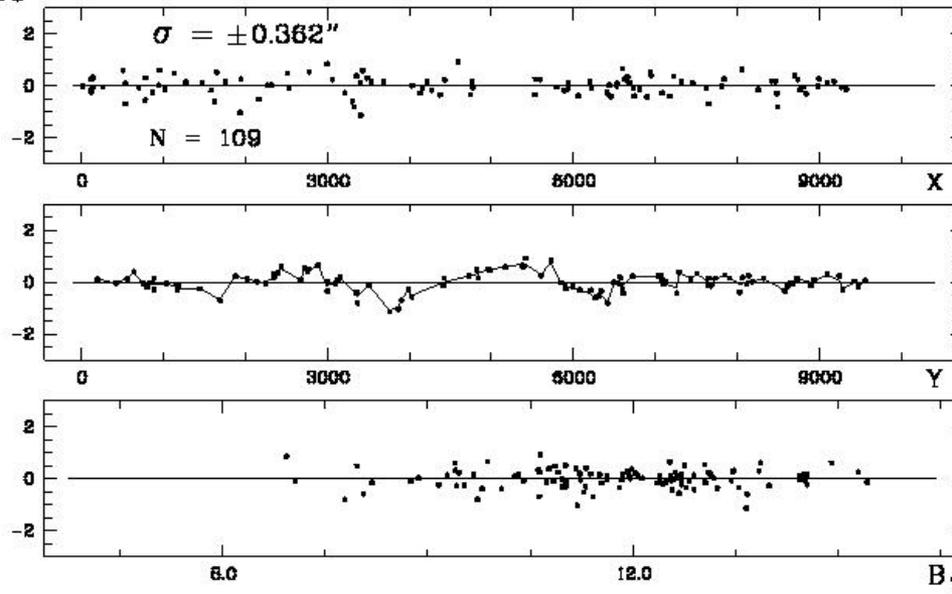
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$\Delta\alpha$



$\Delta\delta$



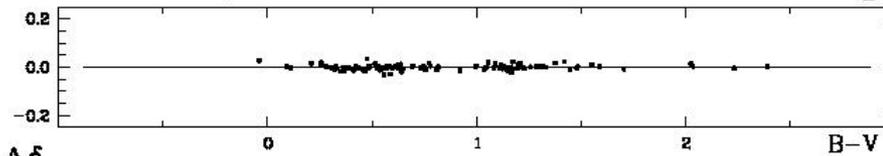
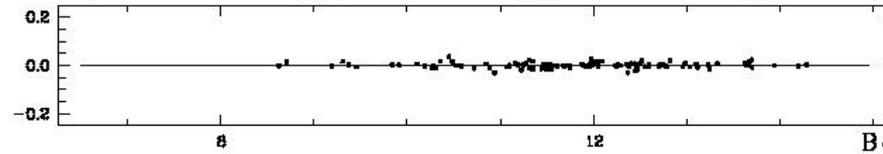
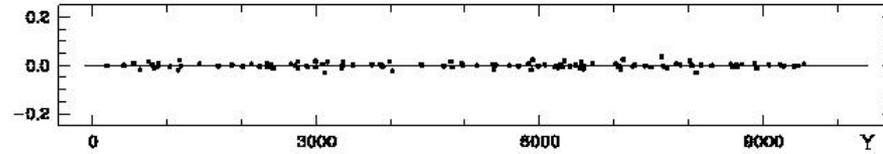
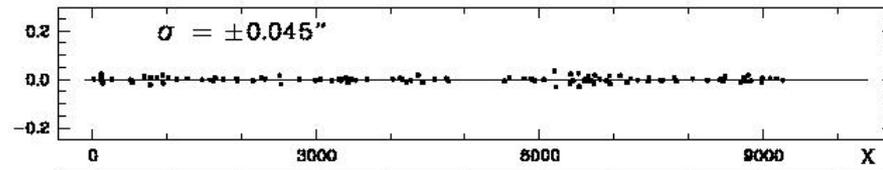
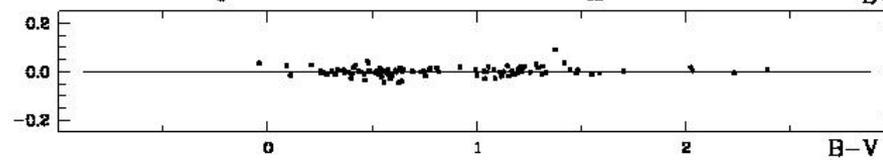
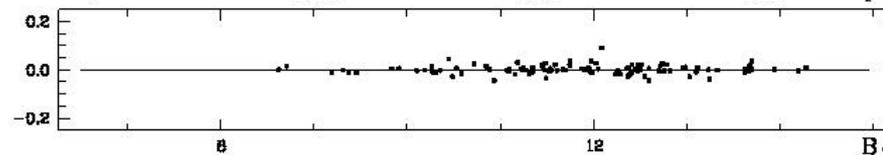
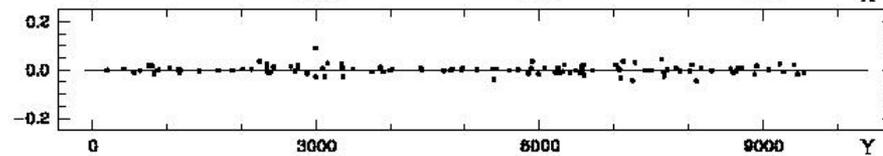
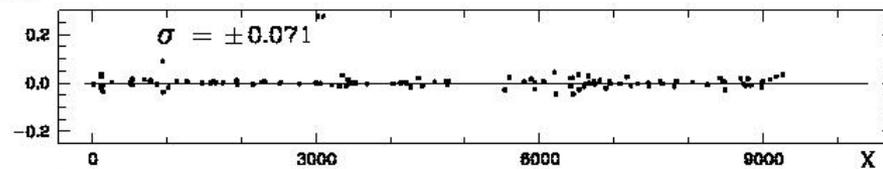
$\Delta\alpha$  $\Delta\delta$ 

Table 5. Data on available accuracy of digitized images in comparison to the accuracy, obtained from measurements with iris diaphragm appliances.

	Microtek, *Epson Expression				Iris Diaphragm appliances			
PL	σ_{ra} mas	σ_{dec} mas	N of stars		σ_{ra} mas	σ_{dec} mas	N of stars	
356	39	87	149	TYCH O	110	120	34	ACT
2693	73	76	136	TYCH O	90	120	15	ACT
407	53	69	136	TYCH O	120	110	27	ACT
5937*	45	71	109	TYCH O	160	200	19	ACT

Table 3. Rms errors by intervals of star magnitudes

#	B_{Tycho}	σ_{ra} mas	σ_{dec} mas	N of stars
1	8.66	38	43	2
2	9.51	56	69	6
3	10.48	49	60	15
4	11.52	39	72	36
5	12.5	53	89	35
6	13.46	38	46	13
7	14.24	15	11	2
aver.	11.81	45	71	

Prospects

Having regard to the above said precision considerations we can state the task of re-processing the archival data for the plates with SS bodies on the grounds of digitized images. The most interesting plates are plates with satellites of external planets, obtained on earlier epochs in comparison with numerous contemporary CCD observations.