

# **Overview of the database of photographic observations of natural satellites obtained at MAO NASU during 1961-1990**

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# TALK DESIGN

- Telescopes used for the observations
- Overview of the collected observations
- Mars' satellites: data set statistics, accuracy of astrometric positions
- The main satellites of Saturn: data set statistics, astrometric positions accuracy
- Brief conclusions

# TELESCOPES

**Golosiiv Plate Archive:** ~26 000 plates, obtained with 14 instruments at 9 observational sites; plate scales: from 20 to 412 "/mm; exposing time: from 10 sec to 1.5 h; number of exposures/plate: from 1 to 10;



## **Tepfer Double Long-Focus Astrograph**

D=400mm, F=5500mm

Period of operation: 1949-1984 ;  
Plate scale 38.47 "/mm;  
ORWO-ZU21, ZU2 (B<sub>ph</sub> band);  
Ilford Ordinary and NP27 (V band);  
Field of view: 2.5×2.5°



## **Zeiss Double Wide-Angle Astrograph**

D=400mm, F=2200mm

Period of operation: 1976-1989;  
Plate scale 103.13 "/mm;  
ORWO-ZU21 (B<sub>ph</sub> band)  
Field of view: 8×8°

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60-cm **ZEISS Reflector**, high-altitude observational station, M. Maidanak (Uzbekistan)

D=600 mm, F=7500mm; Period of the observations: 1986-1990;

Plate scale=27.5 "/mm

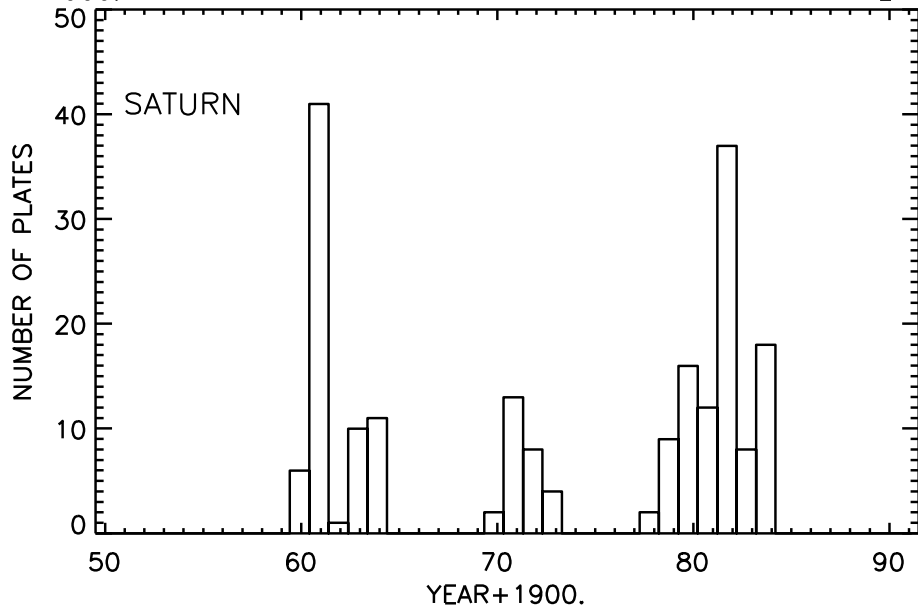
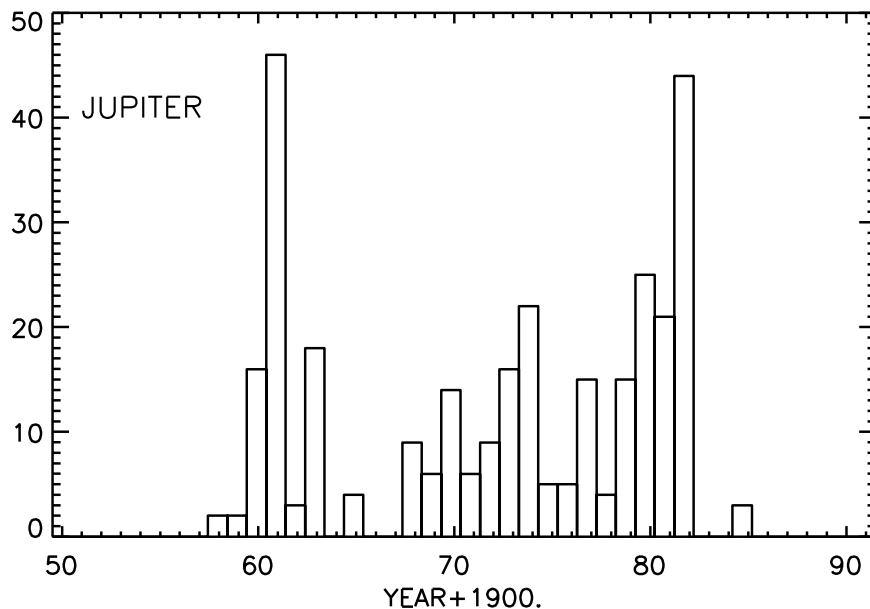
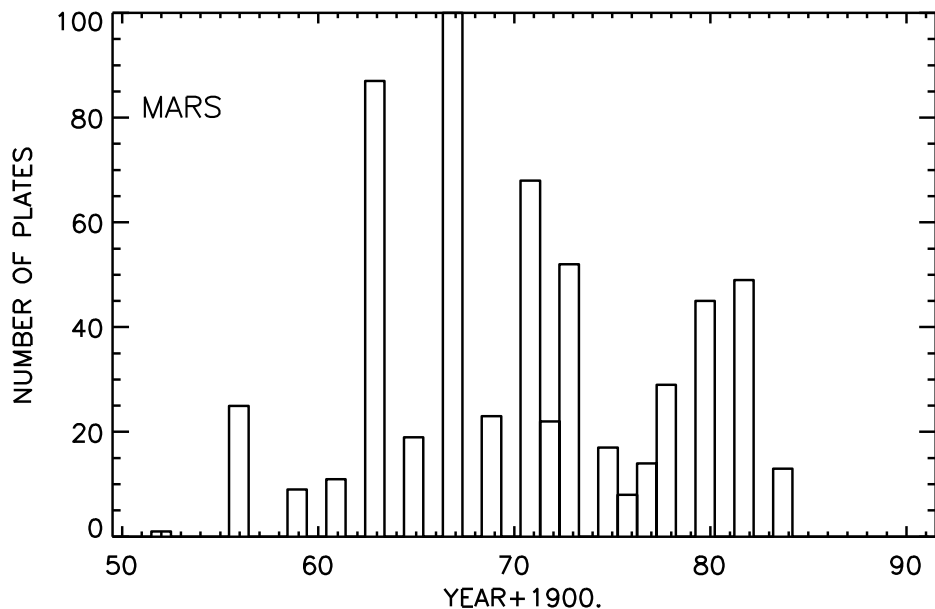
Field of view=0.5×0.5°;

Plates: ORWO ZU 21, ZU2, NP27

# OBSEVATION STATISTICS

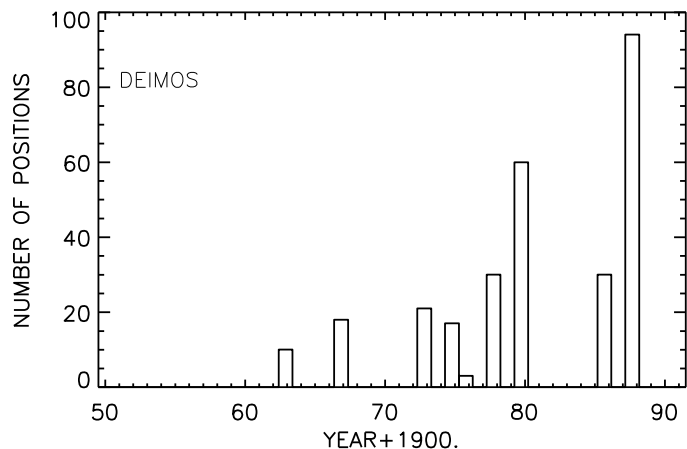
TELESCOPE	OBJECT	TIME SPAN	NUMBER OF PLATES	OTHER OBJECTS ON THE PLATES
DOUBLE LONG FOCUS ASTROGRAPH (Golosiiv)	Mars	1956-1984	590	Deimos
	Jupiter	1958-1984	310	Galilean satellites
	Saturn	1960-1984	200	S2-S8
DOUBLE WIDE ANGLE ASTROGRAPH (Golosiiv)	Jupiter	1976-1988	120	Galilean satellites
	Saturn	1976-1988	70	S6, S8
	Uranus, Neptune, Pluto	1977-1989	60	U3-U4
60-cm ZEISS (Maidanak )	Phobos	1986, 1988	130	
	Deimos	1986, 1988	200	
	S2-S8	1990	230	
	U1-U4	1990	58	
	JVI-JVIII	1987-1989	24	

# OBSERVATION STATISTICS, Long Focus Astrograph



# STATISTICS OF DATA SET AND RESIDUALS OF DEIMOS

(Izhakevich et al., 2001, KFNT 17, 65-70)



Residuals (O-C) LT 1.2''

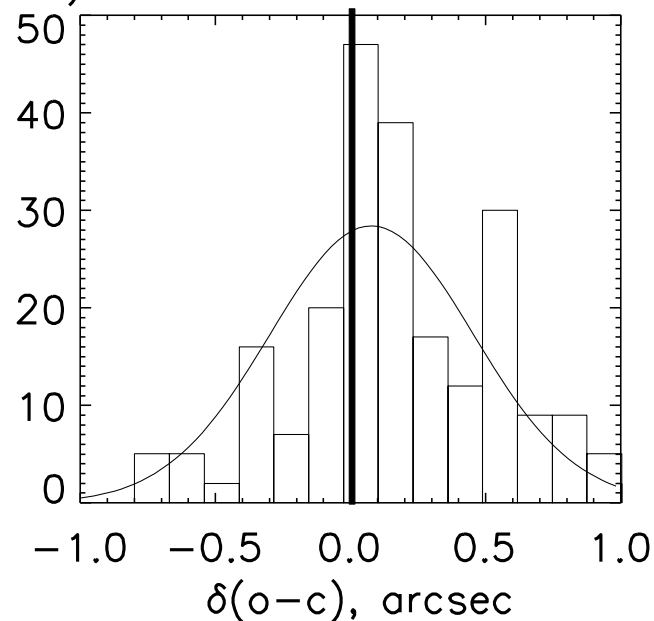
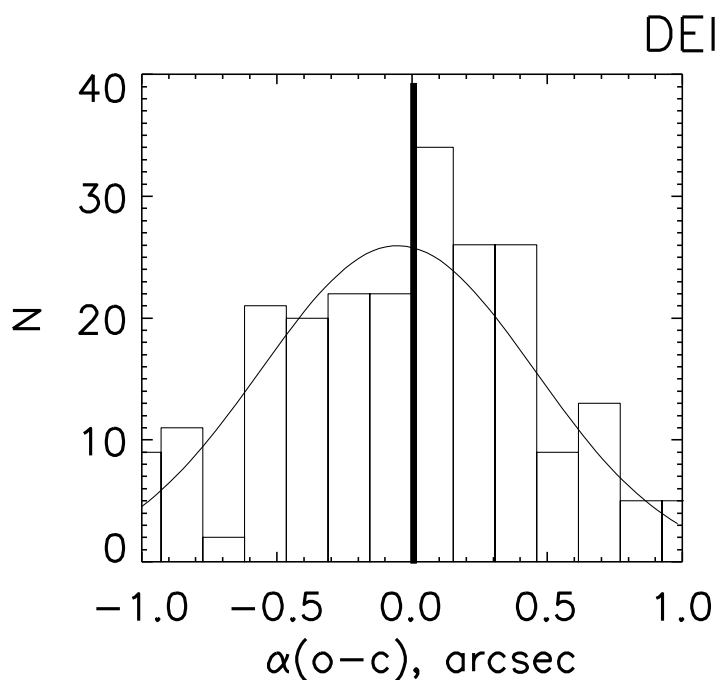
TEL	(O-C) $\alpha$		(O-C) $\delta$		N
DLFA	-0.22	0.04''	0.34	0.04''	127
60-cm Zeiss	0.04	0.04''	0.13	0.03''	115

mean  $\sigma_{\alpha}=0.50$

mean  $\sigma_{\delta}=0.40''$

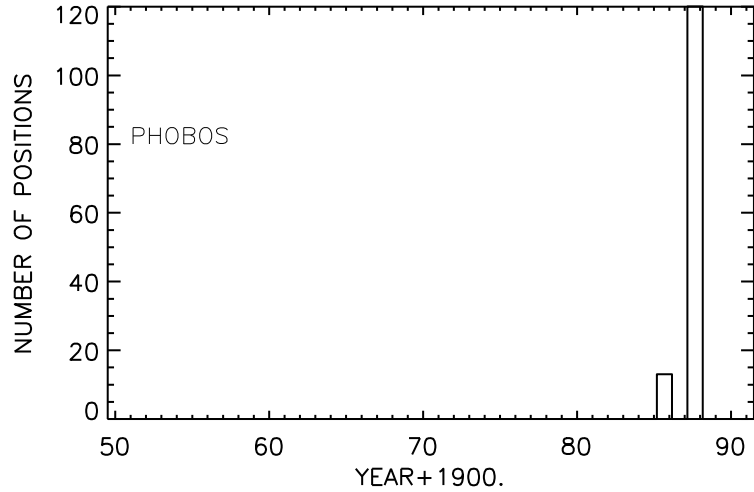
REFERENCE STARS:

Ref. catalogue: ACT (1997, Urban et al.)



# STATISTICS OF DATA SET AND RESIDUALS OF PHOBOS

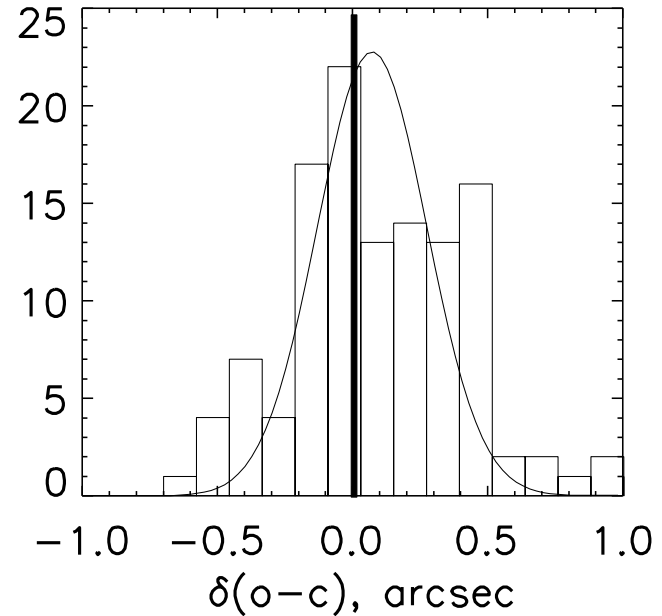
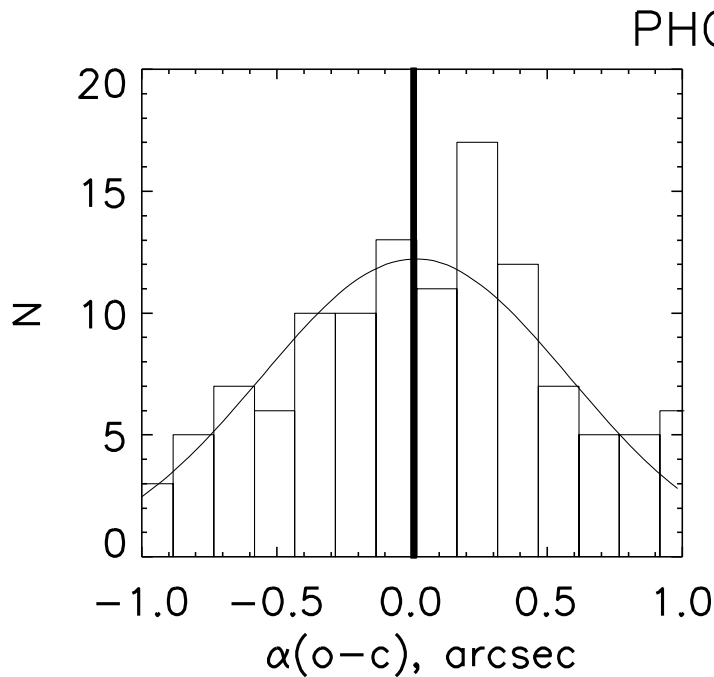
(Izhakevich et al., 2001, KFNT 17, 65-70)



Residuals	(O-C) LT 1.2"				
TEL	(O-C) $\alpha$	(O-C) $\delta$		N	
60-cm Zeiss	0.06	0.05"	0.09	0.03"	112
	mean $\sigma_{\alpha}=0.50''$		mean $\sigma_{\delta}=0.31''$		

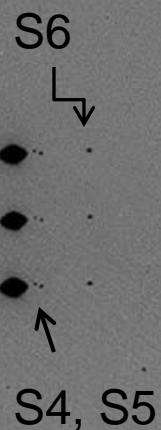
REFERENCE STARS:

Ref. catalogue: ACT (1997, Urban et al.)



# Main Satellites of Saturn

Preview of plate 6291, 1981/05/18



	V (mag)	a (Rsat)	Satellite- planet, mm
Mimas 1s	12.9	3.1	0.7
Enceladus 2s	11.8	4.0	0.9
Tethys 3s	10.3	4.9	1.1
Dione 4s	10.4	6.7	1.4
Rhea 5s	9.7	8.8	2.0
Titan 6s	8.4	20.4	4.7
Iapetus 8s	10.2- 11.9	59.3	13.2



# Reduction of the observations of the Saturnian satellites

REFERENCE STARS: ACT (1997, Urban et al.)

AUTOMATIC MEASUREMENT MACHINE “PARSEC”

MEASURED POSITIONS ARE STORED at NSDC

EPHEMERIS POSITIONS WERE OBTAINED

1) via IMCCE ephemeris generator

Saturn: DE405

Satellites: TASS1.7 A.Vienne,L.Duriez(1995)A&A, 297, 588;

G.Dourneau, Ph.D. Thesis (1987);

Harper & Taylor (1993) A&A, 268, 326

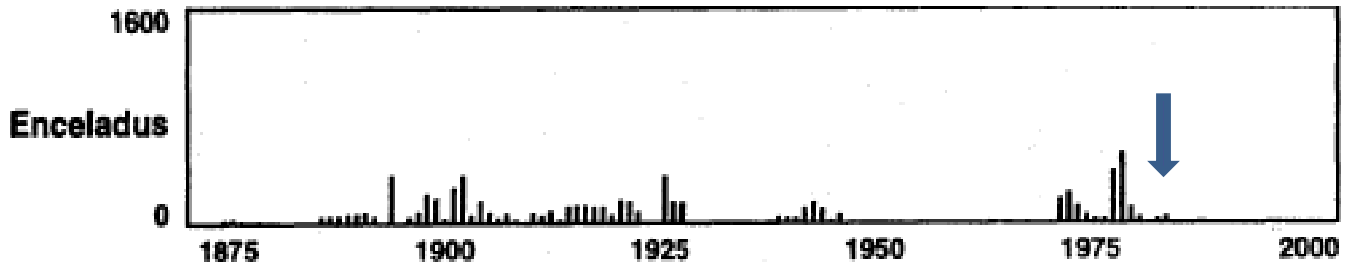
2) via HORIZONS SYSTEM

Saturn: DE405

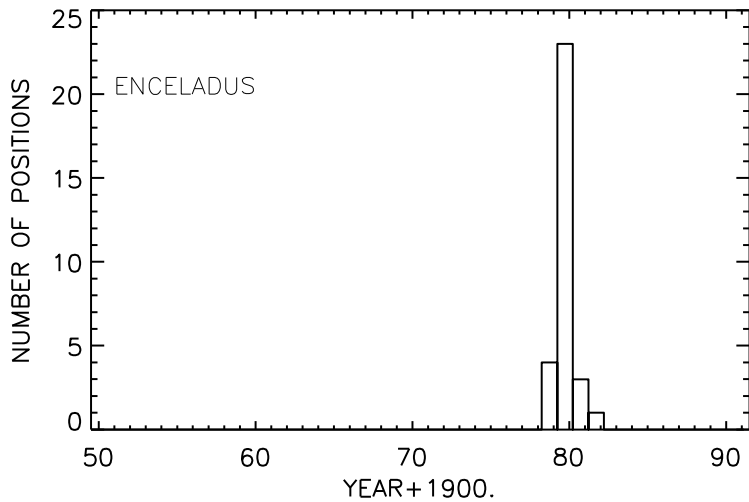
Satellites: SAT317

Jacobson, R.A. (2009) SAT317 - JPL satellite ephemeris

# STATISTICS OF DATA SET AND RESIDUALS OF ENCELADUS



Harper and Taylor , “Analysis of ground-based observations of the satellites of Saturn 1874-1989”, 1994, A&A, 284,619-628

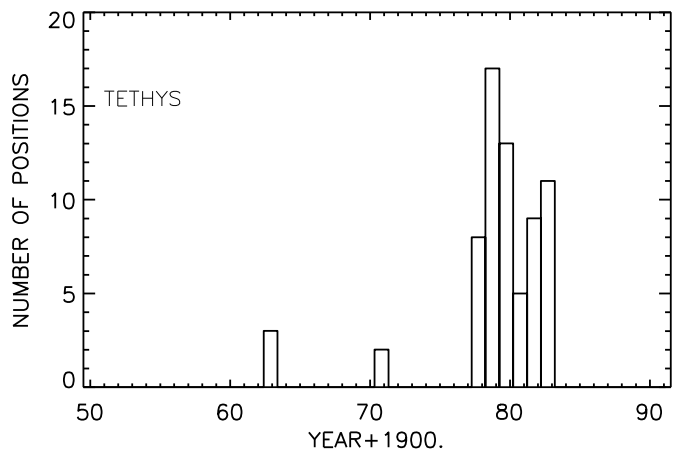
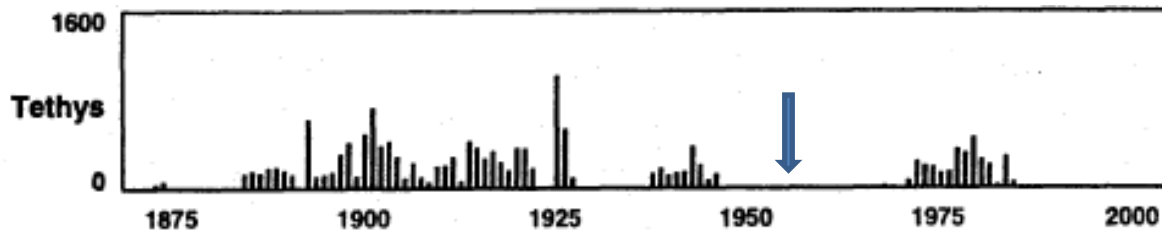


Residuals (O-C) LT 0.9"

TEL	(O-C) $\alpha$	(O-C) $\delta$	N	Ndate		
DLFA	0.21	0.04"	0.06	0.04"	27	6

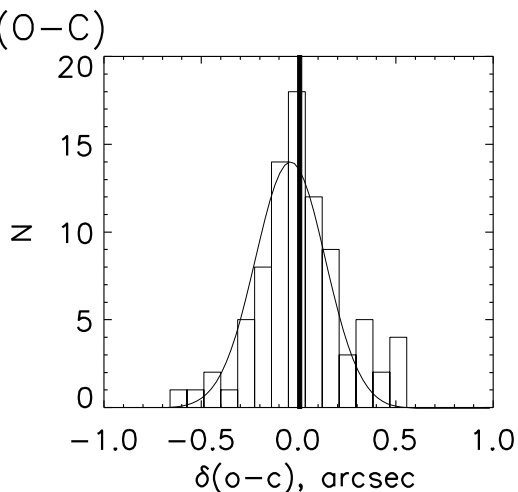
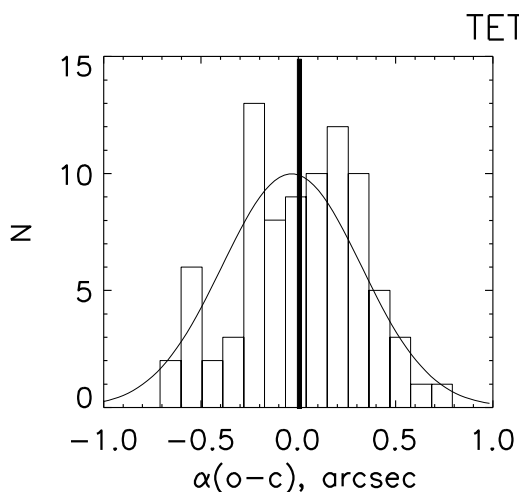
$\sigma_{\alpha(o-c)}=0.33''$   $\sigma_{\delta(o-c)}=0.30''$

# STATISTICS OF DATA SET AND RESIDUALS OF TETHYS

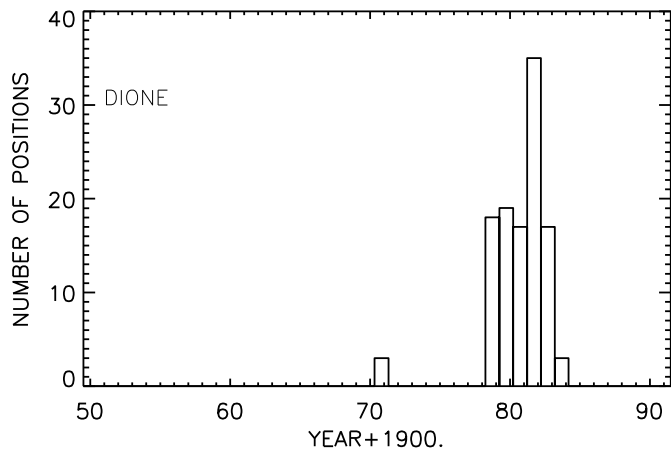
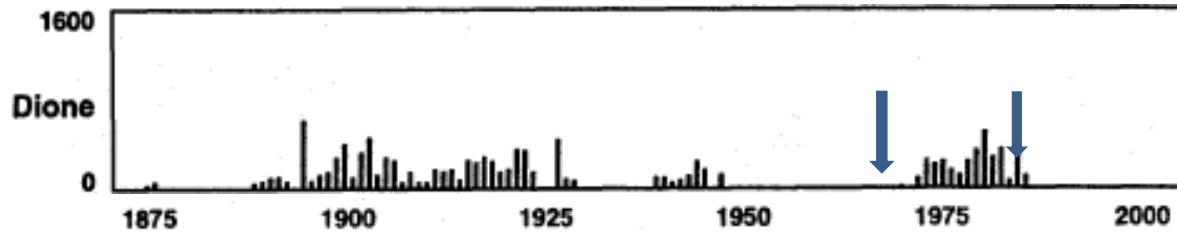


Residuals : (O-C) LT 0.9"

TEL	(O-C) $\alpha$	(O-C) $\delta$	N	DATES
DLFA	0.01 0.03"	0.00 0.03"	86	14
	$\sigma_{\alpha(o-c)}=0.31"$	$\sigma_{\delta(o-c)}=0.24"$		

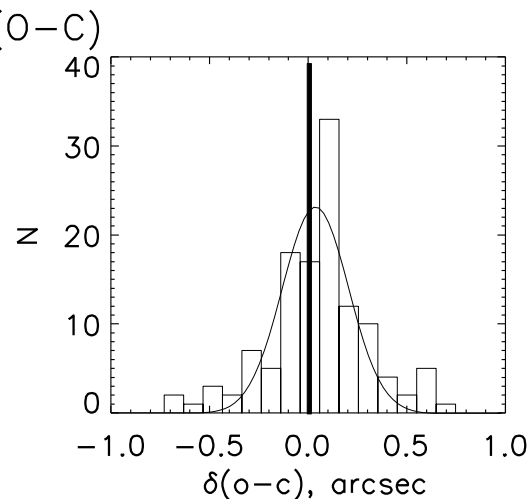
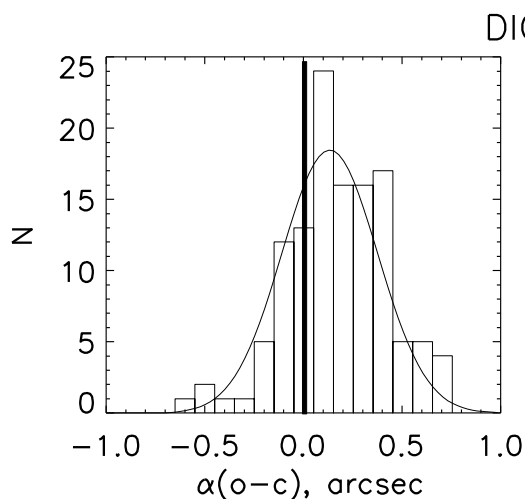


# STATISTICS OF DATA SET AND RESIDUALS OF DIONE

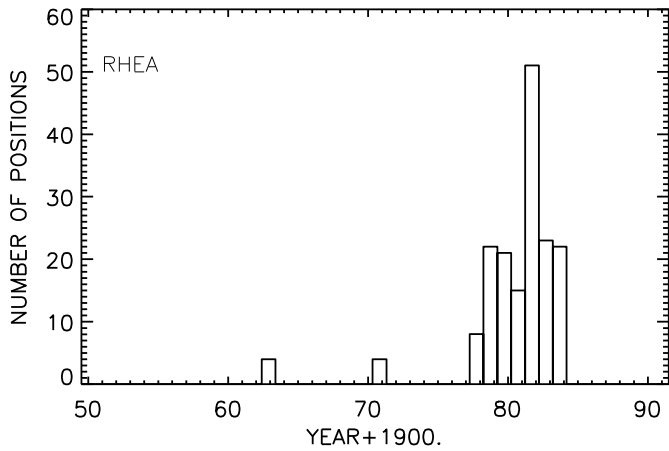
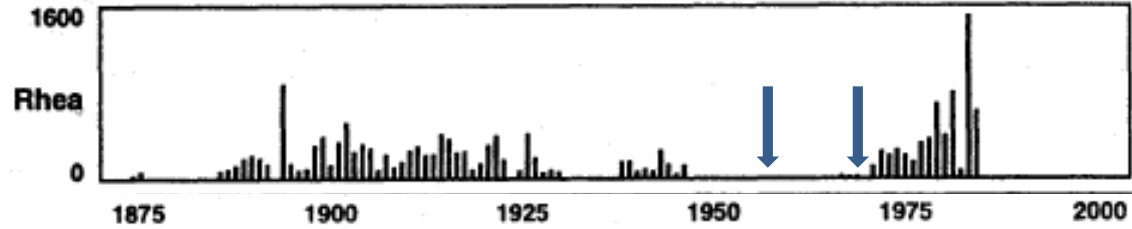


Residuals (O-C) LT 0.9"

TEL	(O-C) $\alpha$	(O-C) $\delta$	N	DATES
DLFA	0.18	0.02"	123	18
	$\sigma_{\alpha(o-c)}=0.26''$	$\sigma_{\delta(o-c)}=0.25''$		

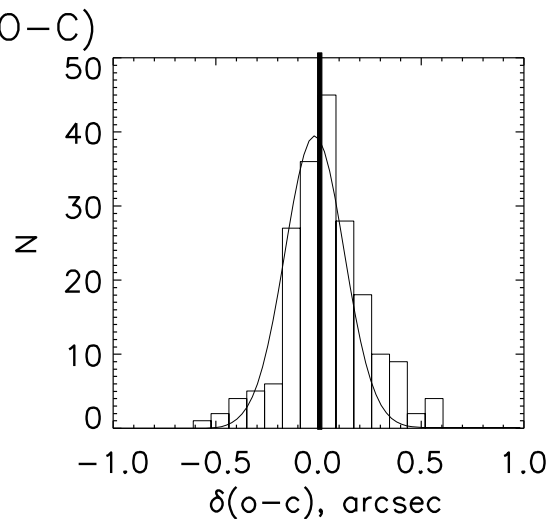
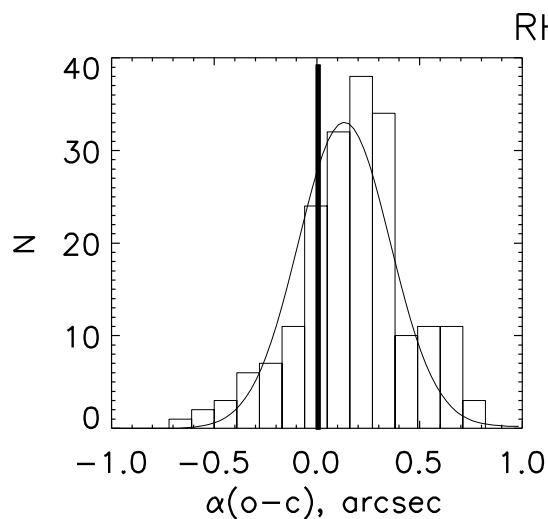


# STATISTICS OF DATA SET AND RESIDUALS OF RHEA

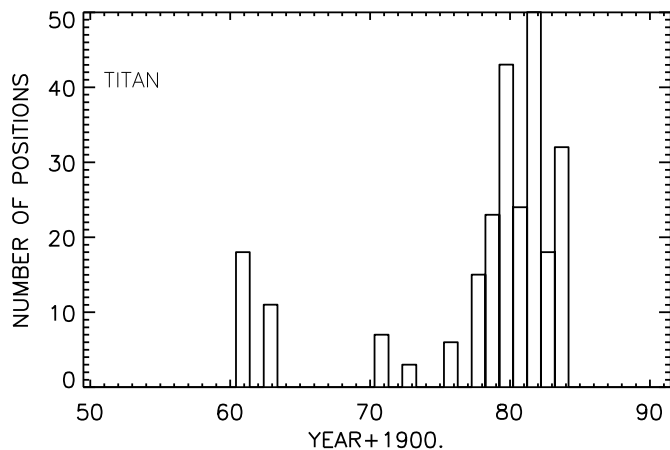
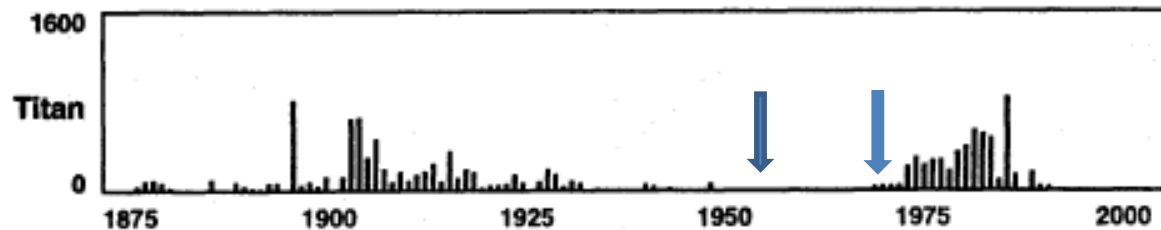


Residuals (O-C) LT 0.9''

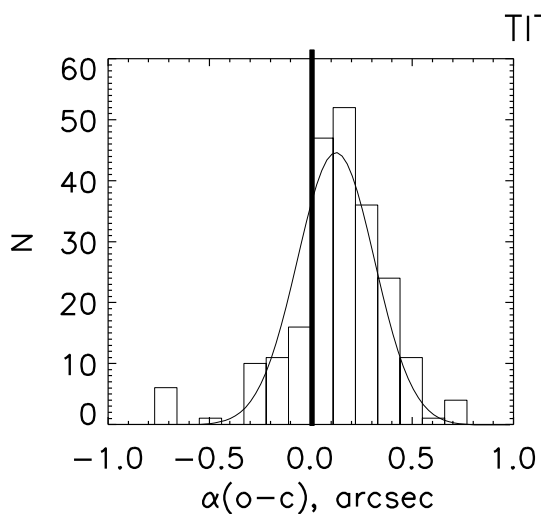
TEL	(O-C) $\alpha$	(O-C) $\delta$	N	Ndate
DLFA	0.18 0.02''	0.04 0.02''	196	24
	$\sigma_{\alpha(o-c)}=0.28''$	$\sigma_{\delta(o-c)}=0.21''$		



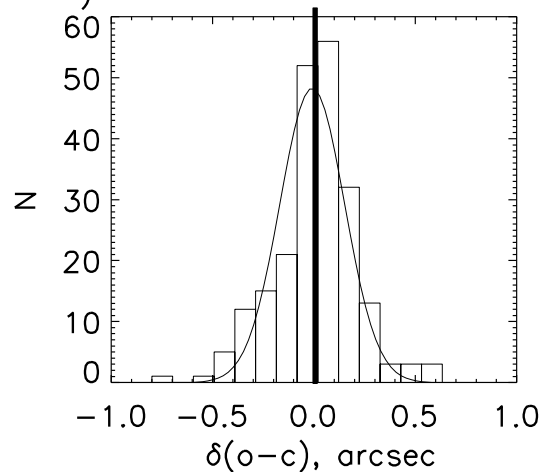
# STATISTICS OF DATA SET AND RESIDUALS OF TITAN



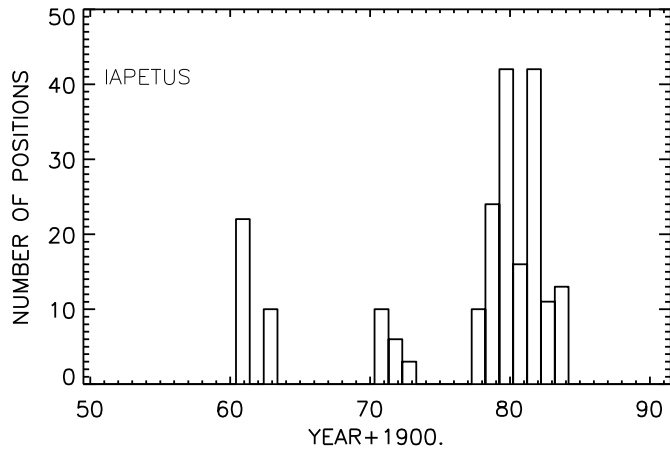
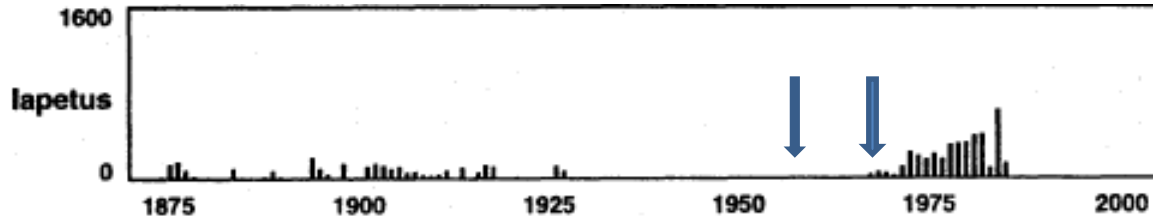
TEL	$\alpha(O-C)$	$\delta(O-C)$	N	Ndate
DLFA	0.13 0.02"	0.02 0.01"	221	27
	$\sigma\alpha(O-C)=0.27''$	$\sigma\delta(O-C)=0.21''$		
DWAA	0.15 0.04	-0.15 0.04	43	6
	$\sigma\alpha(O-C)=0.24''$	$\sigma\delta(O-C)=0.27''$		



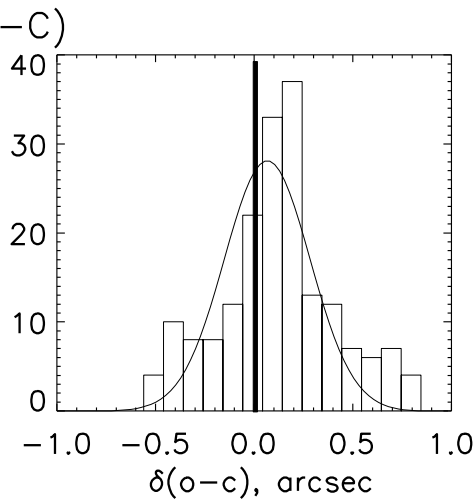
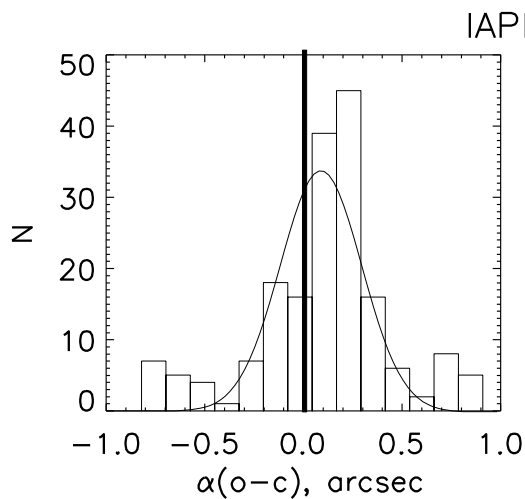
TITAN (O-C)



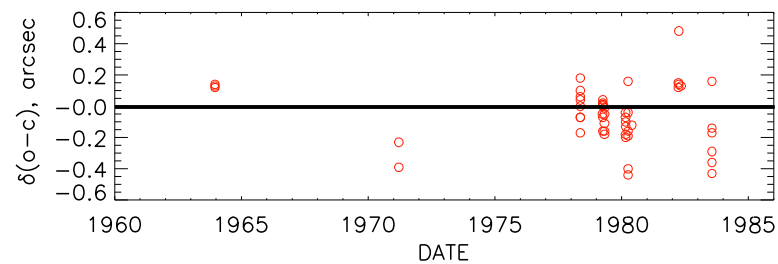
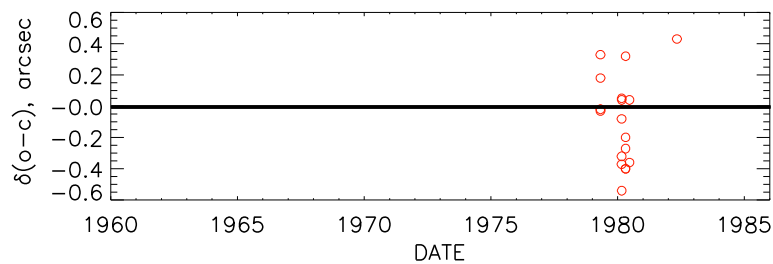
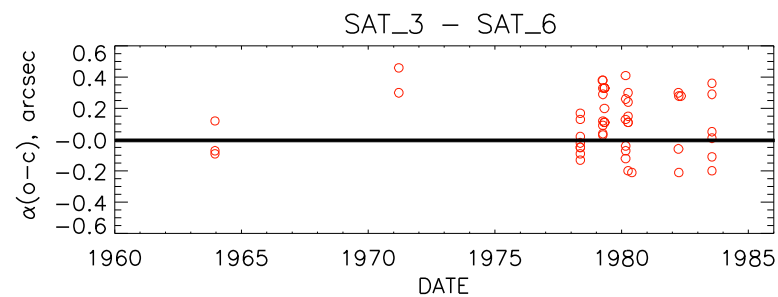
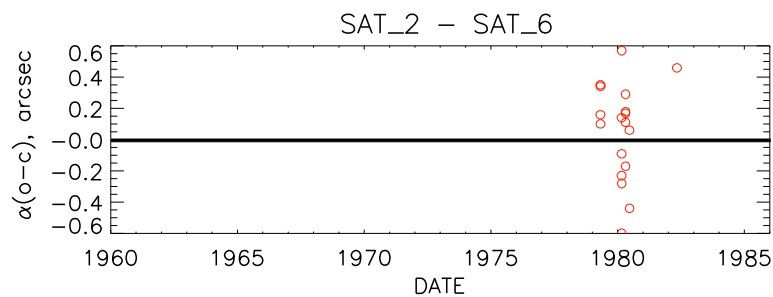
# STATISTICS OF DATA SET AND RESIDUALS OF IAPETUS



TEL	$\alpha(O-C)$	$\delta(O-C)$	N	DATES		
DLFA	0.10	0.03"	0.12	0.02"	179	25
	$\sigma\alpha(O-C)=0.34"$	$\sigma\delta(O-C)=0.28"$				
DWAA	0.14	0.07	-0.07	0.04	43	4
	$\sigma\alpha(O-C)=0.44"$	$\sigma\delta(O-C)=0.26"$				



# INTER-SATELLITE DIFFERENCES $\Delta\alpha\cos(\delta)$ and $\Delta\delta$

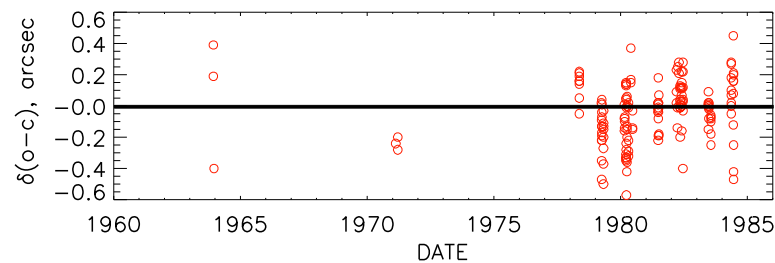
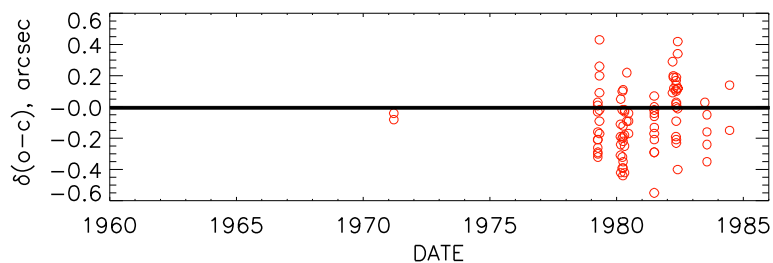
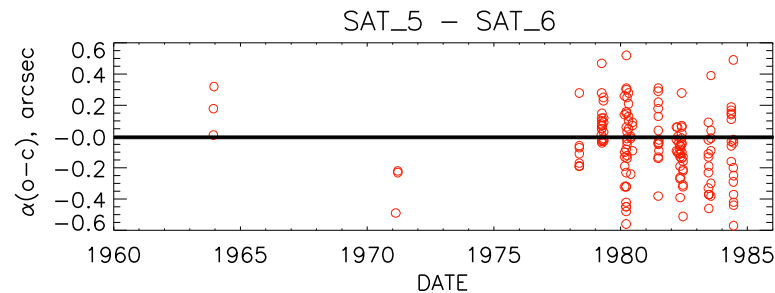
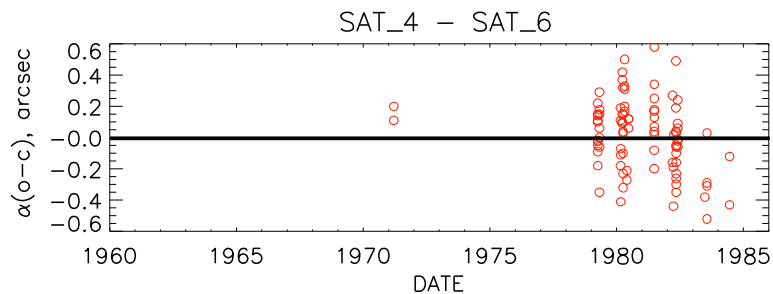


S2 - S6			
N=18			
$\Delta\alpha\cos(\delta)$		$\Delta\delta$	
-0.06	0.07	-0.08	0.07
$\sigma\alpha=0.31$		$\sigma\delta=0.28$	

S3 - S6			
N=50			
$\Delta\alpha\cos(\delta)$		$\Delta\delta$	
0.11	0.03	-0.06	0.03
$\sigma\alpha=0.19$		$\sigma\delta=0.18$	



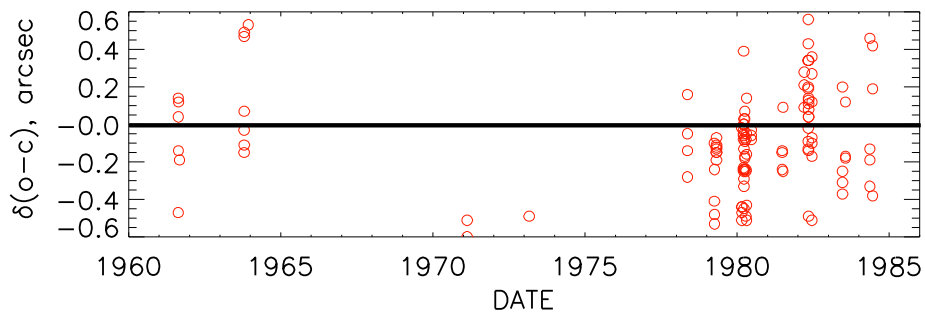
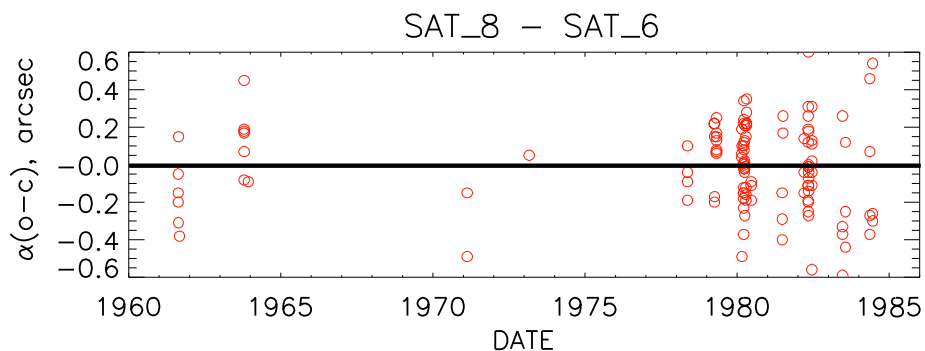
# INTER-SATELLITE DIFFERENCES $\Delta\alpha\cos(\delta)$ and $\Delta\delta$



S4 - S6			
N=88			
$\Delta\alpha\cos(\delta)$		$\Delta\delta$	
0.02	0.02	-0.08	0.02
$\sigma\alpha=0.22$		$\sigma\delta=0.20$	

S5 - S6			
N=161			
$\Delta\alpha\cos(\delta)$		$\Delta\delta$	
-0.05	0.02	-0.04	0.02
$\sigma\alpha=0.21$		$\sigma\delta=0.19$	

# INTER-SATELLITE DIFFERENCES $\Delta\alpha\cos(\delta)$ and $\Delta\delta$



S8 - S6			
N=119			
$\Delta\alpha\cos(\delta)$		$\Delta\delta$	
-0.02	0.02	0.08	0.02
$\sigma\alpha=0.23$		$\sigma\delta=0.26$	

# BRIEF SUMMARY

The Golosiiv Plate Archive contain about 500 photographic plates of Deimos and Phobos , 200 plates of Saturn with its main satellites and about 300 plates with Jupiter and Galilean satellites.

Previous reduction of Mars' and Saturn's satellites in ACT catalogue system revealed the moderate accuracy of the measured coordinates at the level of 0.2-0.3" that is typical for the photographic observations.

Residual statistics for the main Saturnian satellites point out a bias in the measured absolute right ascension coordinates comparative to ephemeris positions, nevertheless the inter-satellite mean (O-C) residuals seem to be free of it.

Some of the plates with Saturn's satellites Tethys, Dione, Rhea, Titan, and Iapetus may be worth to be digitized and re-processed taking into account small number of the observations of these satellites in the period of 1950-1975.

THANK YOU FOR YOUR  
ATTENTION !!!!!