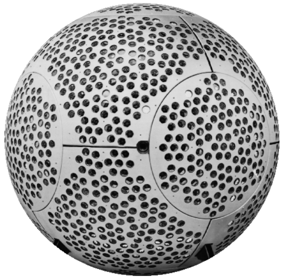
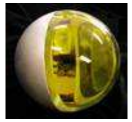
OPEN JOINT-STOCK COMPANY «RESEARCH-AND-PRODUCTION CORPORATION "PRECISION SYSTEMS AND INSTRUMENTS»







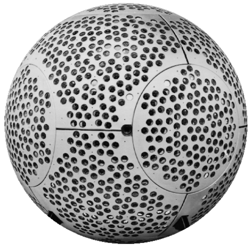

Laser retroreflector systems of new generation

M.A.Sadovnikov, A.L.Sokolov, N.M.Soyuzova

Saint-Petersburg, 2012

Retroreflector systems used in laser ranging of geodetic and navigation satellites

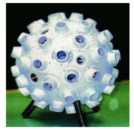
Ajisai / Japan



ETALON / Russia

LAGEOS / USA

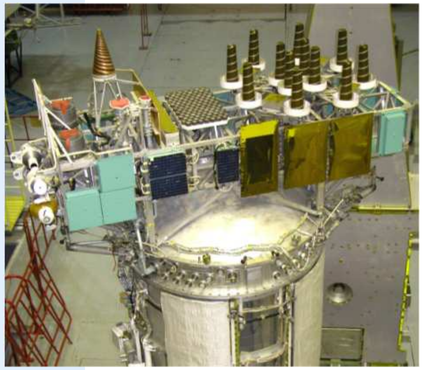
GFZ-1 / Russia



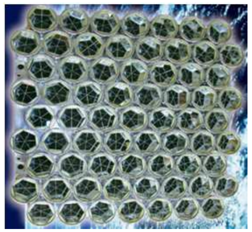
WESTPAC / Russia

LARETS / Russia

METEOR / Russia



GLONASS / Russia



Compas / China

GIOVE / Russia

GPS №35,36 / Russia

Main Laser Retroreflector System of “RPC “PSI”

Type of spacecraft	Altitude, km	Launching	Number of spacecrafts	Number of CCR on a spacecraft	Type of reflective coating
Etalon - 1, -2 (Russia)	19 100	1989	2	2142	*Al*
GPS - 35, - 36 (USA)	20 150	1993, 1994	2	32	*Al*
GLONASS (Russia)	19 100	2000 - 2006	8	132	*Al*
REFLECTOR (Russia - USA)	1 020	2002	1	32	*Al*
Meteor-3M-1 (Russia)	1 020	2002	1	sphere	*Al*
LARETS (Russia)	690	2003	1	60	*Al*
Mozhaets (Russia)	690	2003	1	6	*Al*
GLONASS-M (Russia)	19100	from 2003 to present	17	112	*Al*
GLONASS-M № 729 (Russia)	19100	2008	1	112	*TIR*
GIOVE-A (ESA) (Galileo)	23 916	2006	1	76	*Al*
GIOVE-B (ESA) (Galileo)	23 916	2008	1	67	*Al*
GOCE (ESA)	295	2009	1	7	*Al*
BLITS 2009 (Russia)	832	2009	1	autonomous sphere	*Al*
GLONASS-K	19100	2010	1	123	*TIR*
SPECTOR-R(Russia)	до 330 000	2010	1	100	*Ag*

The main directions of laser retroreflector systems (LRS) optimization:

1. New interference coatings (generally – gradient) with a view to:

- *optimize FFDP of reflected radiation to compensate speed aberrations;*
- *reduce solar heating influence;*
- *decrease a loss of light in CCR;*

2. Size of CCR and value of CCR dihedral angles.

3. LRS configuration for an accurate correspondence to the center of mass of the satellite.

4. Remote control of onboard LRS FFDP

- *Rotation of CCR array;*
- *Variation of the polarization state of laser radiation.*

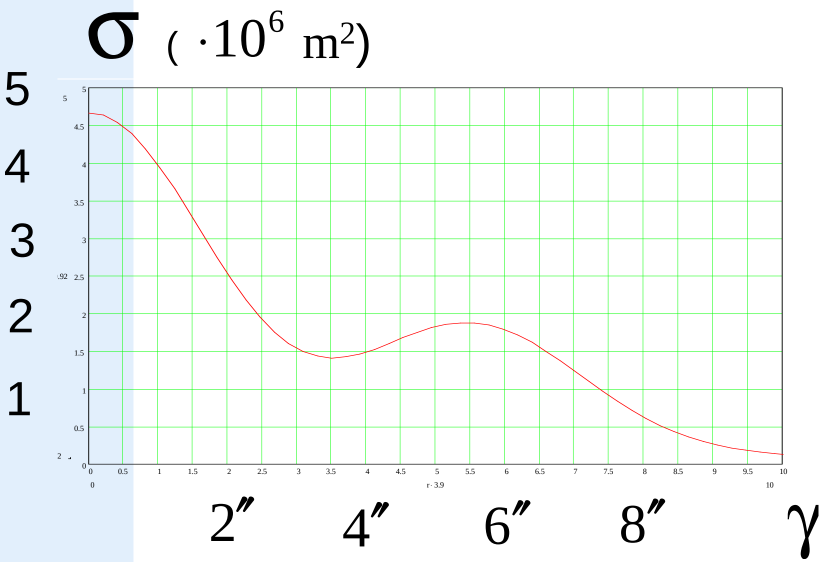
5. Glass spherical satellites of BLITS type – absolute correspondence of measurements to the center of mass of the spacecraft.

Goals:

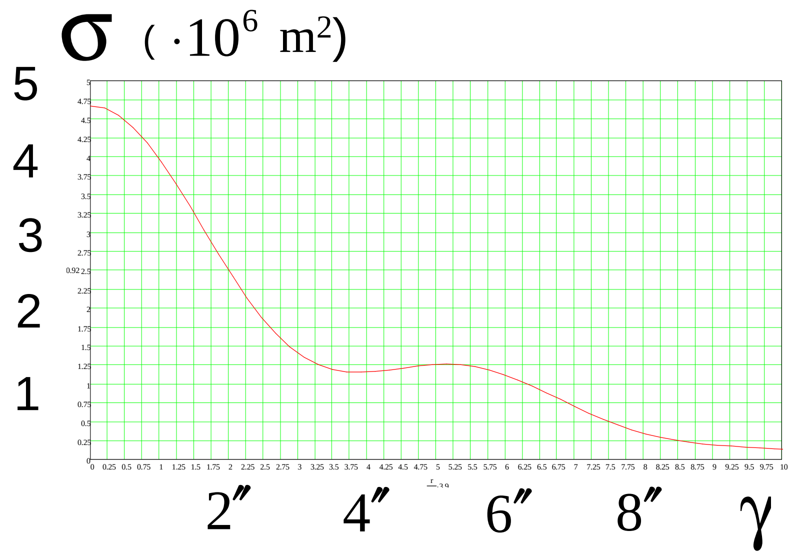
- decrease of the correction to the results of measurement;
- increase of cross-section.

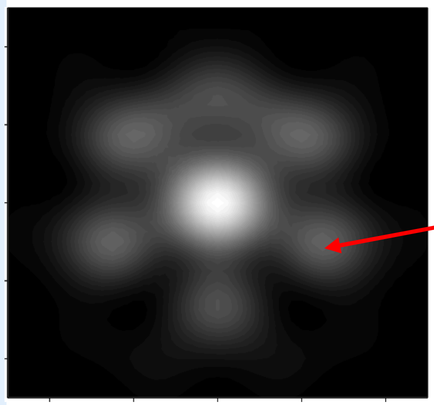
FFDP and Cross Section of CCR(TIR). Diameter – 28 mm

CS of one CCR



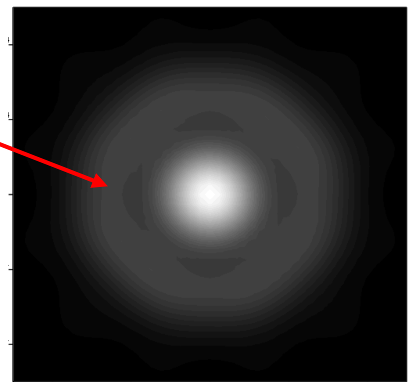
Average CS for the four turned CRR





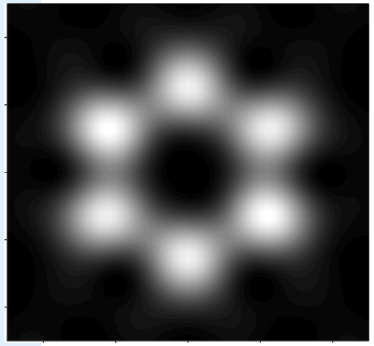
$CS = 1{,}9 \cdot 10^6\, m^2$

$CS = 1{,}2 \cdot 10^6\, m^2$

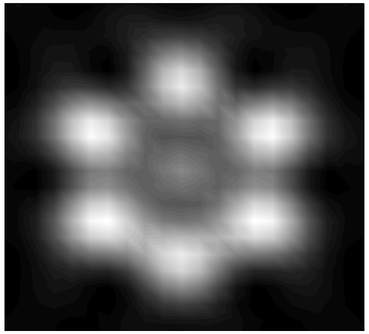


New interference coatings

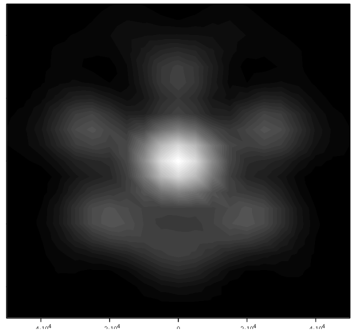
CCR’s far field diffraction patterns as a function of the phase shift on reflection



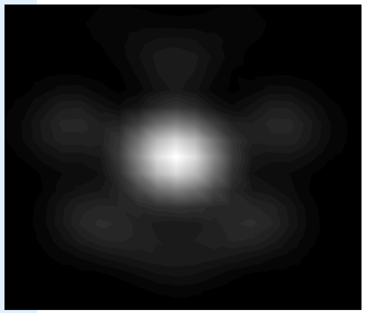
$\delta = 0$



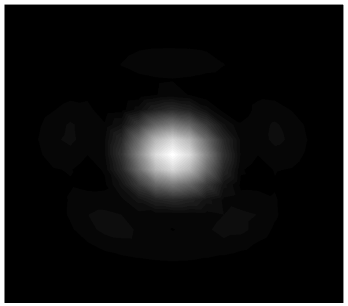
$\delta = 20$



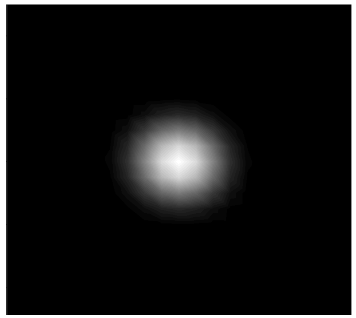
$\delta = 45$



$\delta = 60$



$\delta = 90$

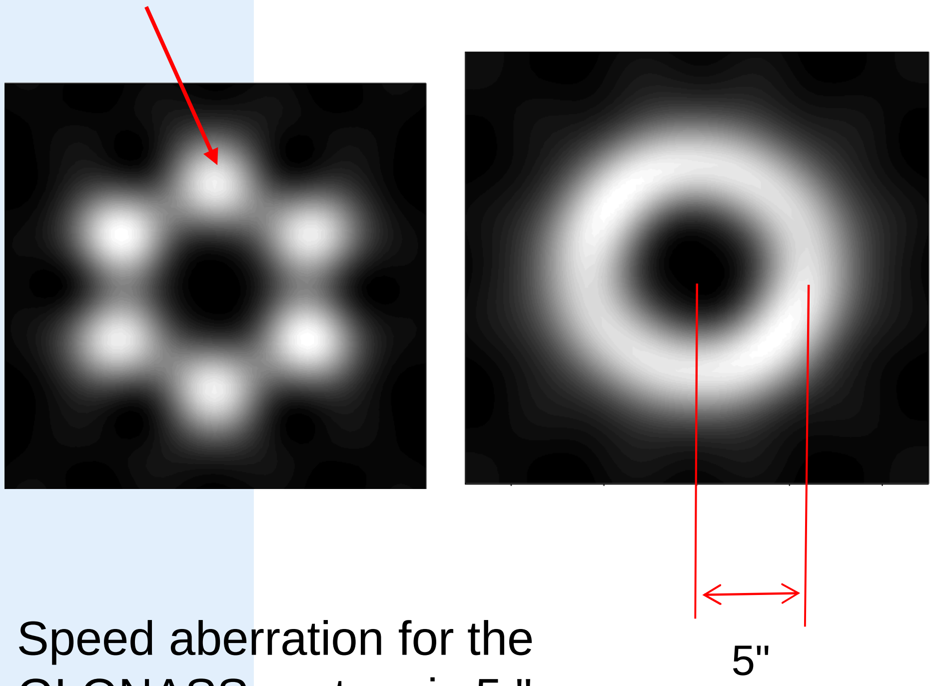


$\delta = 120$

Far Field Diffraction Pattern of CCR with dielectric interference coatings of faces (the phase shift = 0)

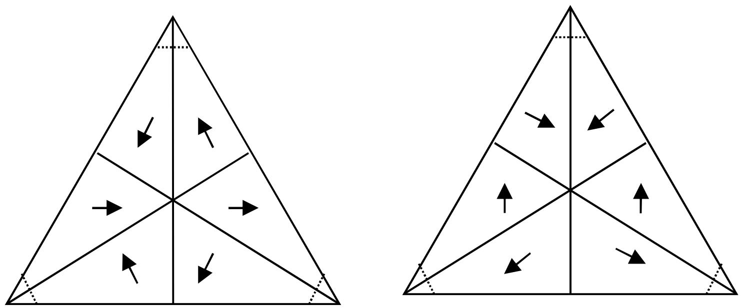
$CS = 2,4 \cdot 10^6$ м^2

Averaged
$CS = 1,9 \cdot 10^6$ м^2

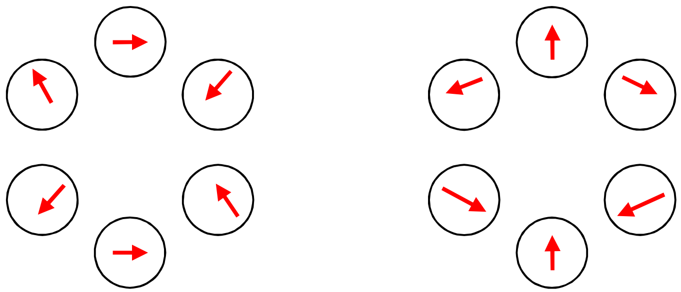


Speed aberration for the GLONASS system is 5 "

Polarization structure
in the near field:

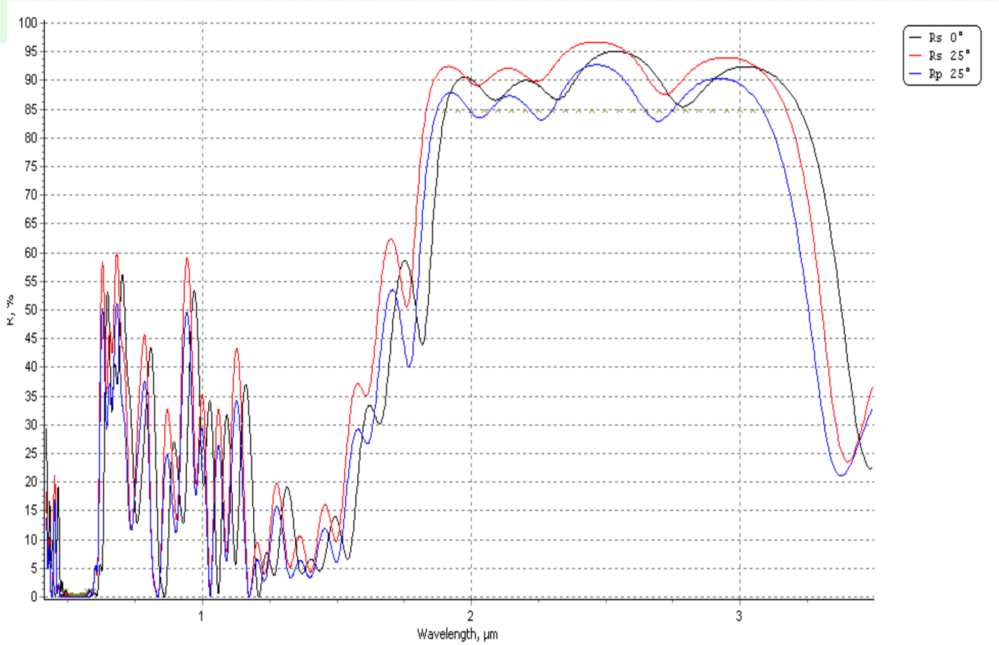


and far-field:



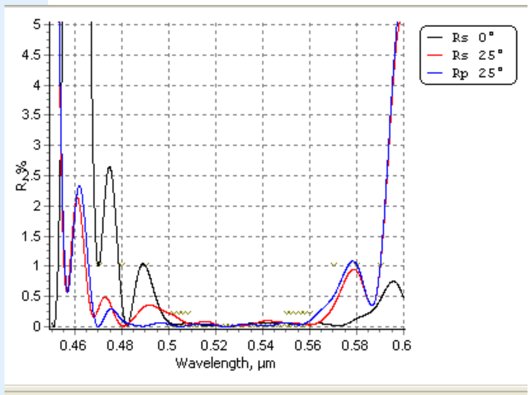
Reduce solar heating influence

ρ

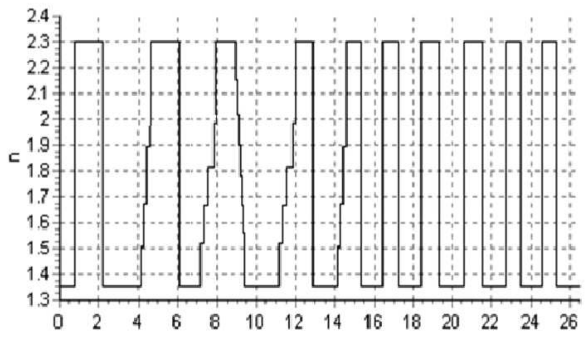


ρ

λ



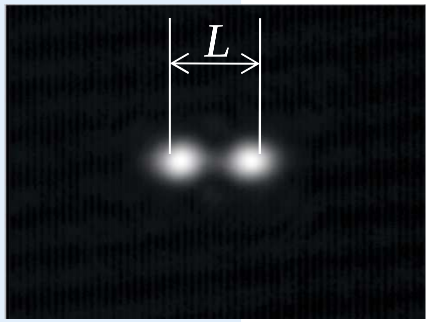
λ

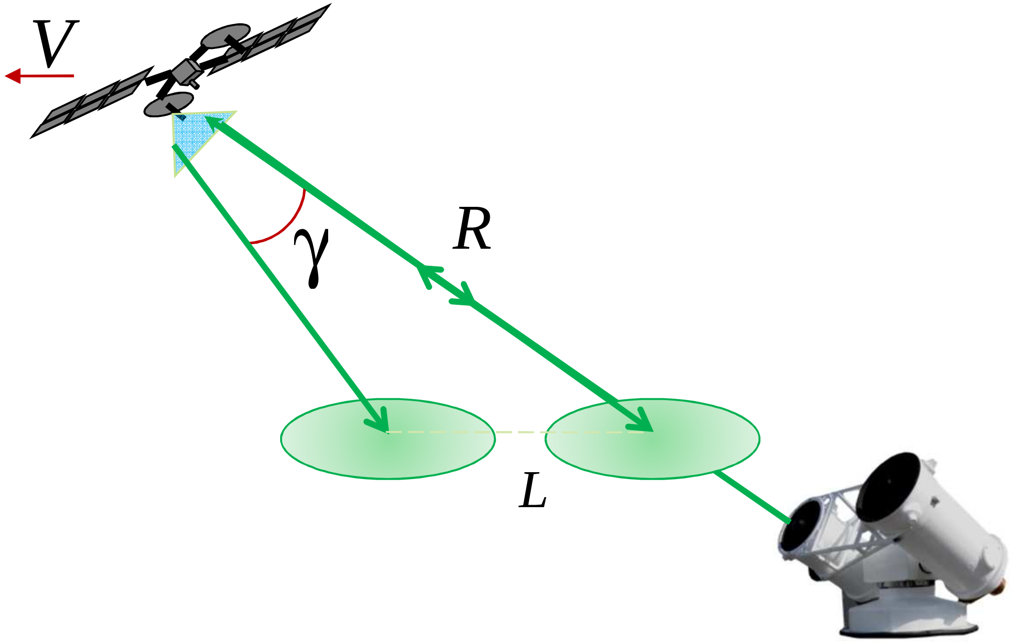


CCR with the controlled value of the dihedral angle. Optimization of FFDP

Optimization of FFDP:

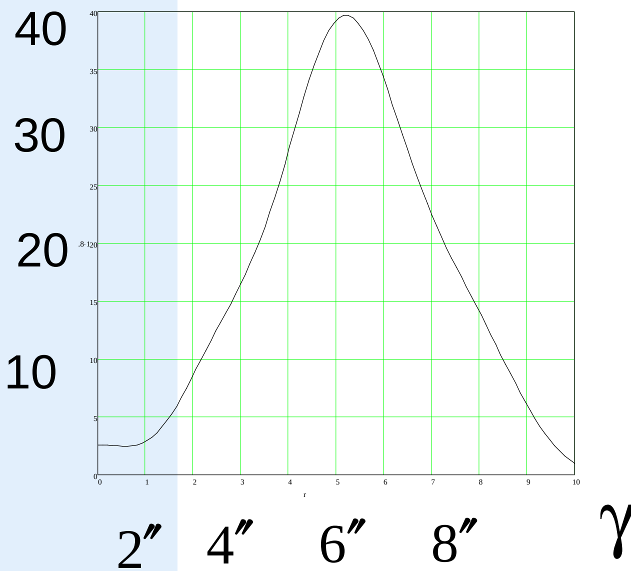
- for low-orbit triaxially oriented spacecrafts;
- for medium spacecrafts in a circular placement in LSR array;
- for geostationary satellites.

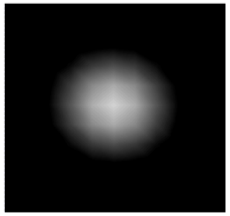




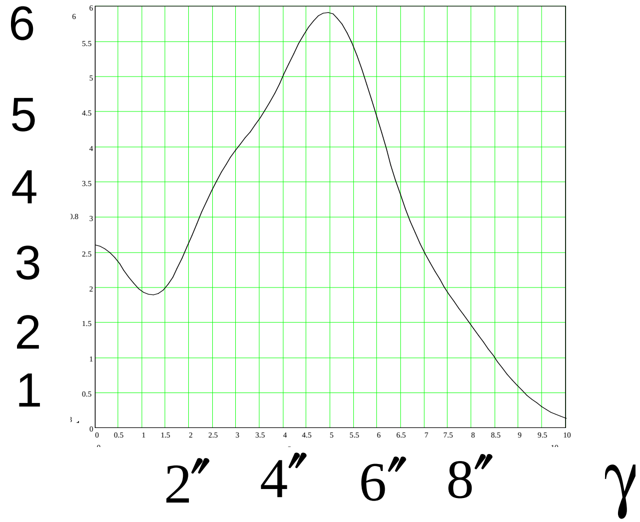
CCR with the controlled value of the dihedral angle. Diameter 50 mm. Dihedral angle 2,4”

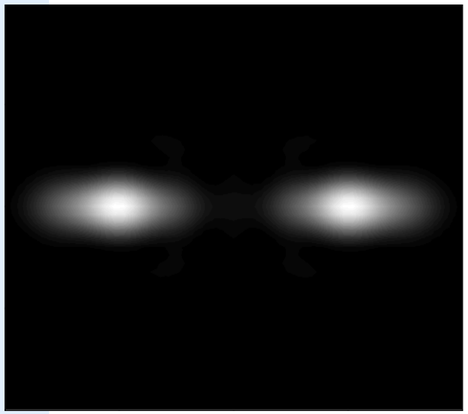
CS ($\cdot 10^6$ м2)



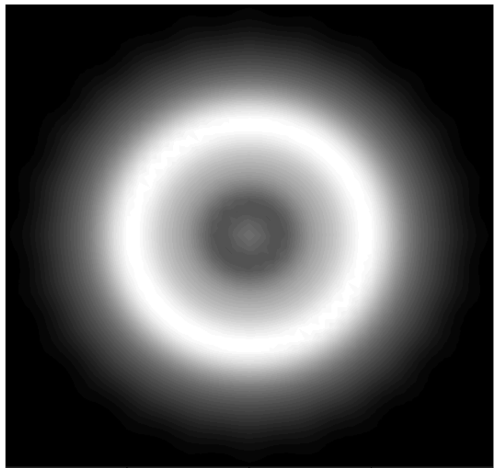


Averaged CS ($\cdot 10^6$ м^2)

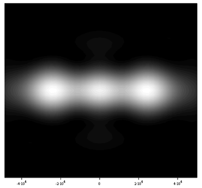
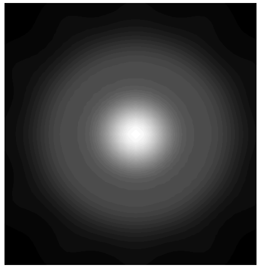
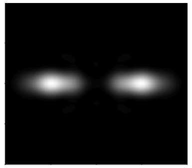
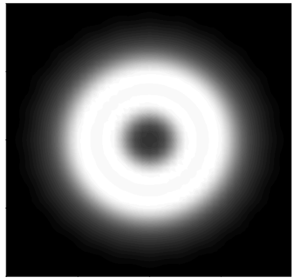
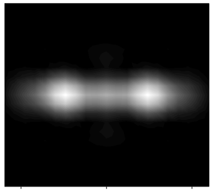
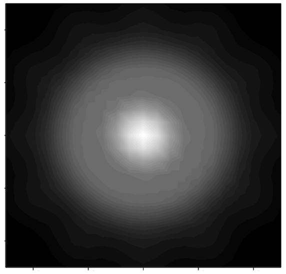
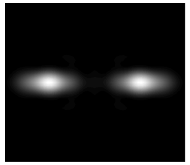
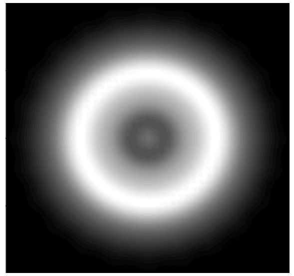
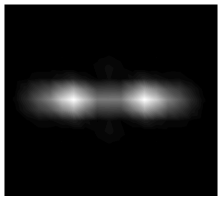
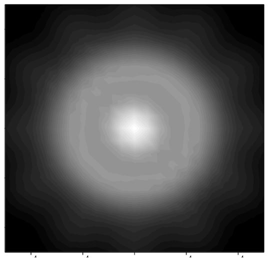
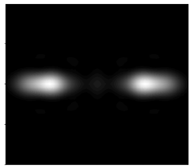
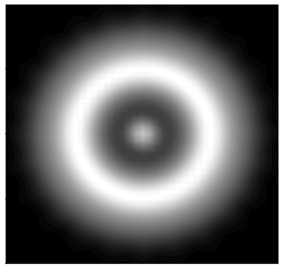




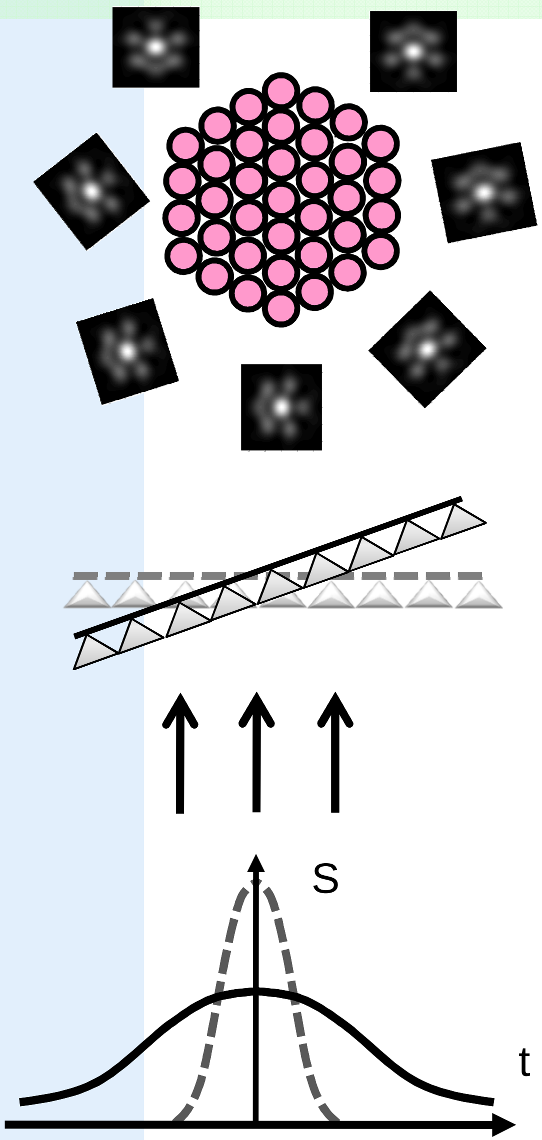
Range of 24 CCR

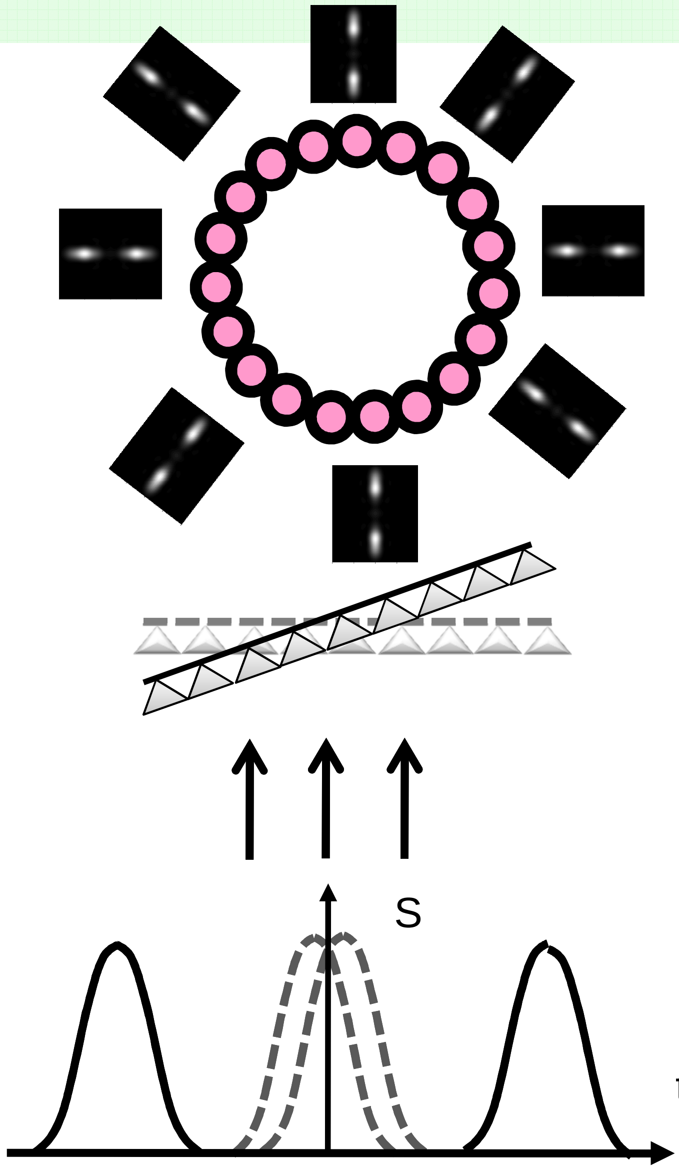


CCR with different values of the dihedral angle. 28 mm and 50 mm

dihedral angle	Equivalent diameter - 28 mm		Equivalent diameter - 50 mm	
	One CCR	Range of CCR	One CCR	Range of CCR
2,2″				
2,4″				
2,6″				

Optimization of LRR array configuration





OPEN JOINT-STOCK COMPANY «RESEARCH-AND-PRODUCTION CORPORATION “PRECISION SYSTEMS AND INSTRUMENTS»

Improved ball-lens retroreflector satellite for operation in higher orbits

V.P.Vasilev, I.S.Gashkin

A problem of achieving submillimeter accuracy of laser range measurements

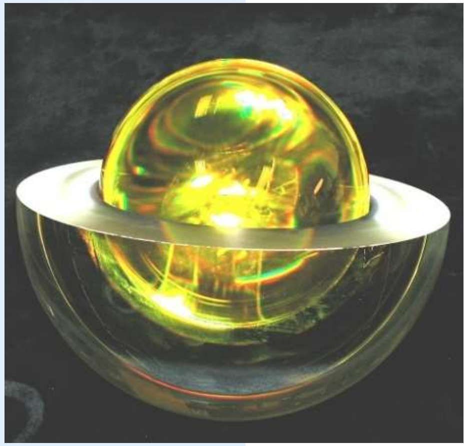
Retroreflector system	Orbit altitude (km)	Cross section ($\cdot 10^6$ m²)	Variants of the correction to the results of measurement (mm)
Ajisai	1400	23	20…50
Etalon	19100	55	10…40
GLONASS	19100	60…120	5…25
Lageos	5800	9…15	2…10
Larets	690	0.2…0.8	1,5
Westpac	835	0.04…0.2	0.5
BLITS	835	0.1	0.1
LARES	1450	2…4	?

Spherical glass nanosatellite «BLITS»

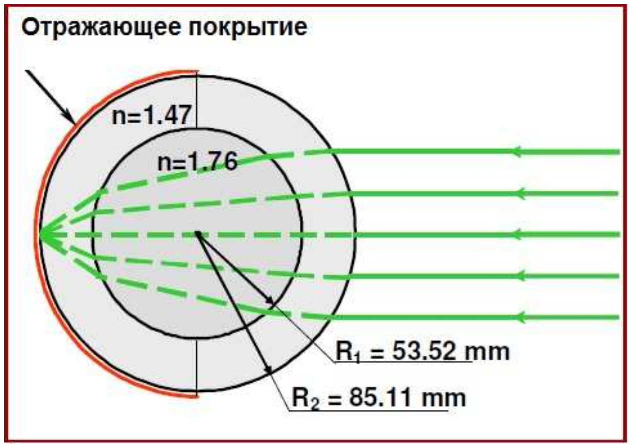
The spacecraft "Meteor-M" with a spherical glass nanosatellite «BLITS» on board was launched on September 21st, 2009.

The basic parameters of the nanosatellite «BLITS»:

- diameter…………………………………………..170 mm
- weight…………………………………..……..7.5 kg
- orbital altitude……………………………………. 835 км
- Cross Section……………………………….....100000 м^2.
- error goal …..………………………………< 100 мкм

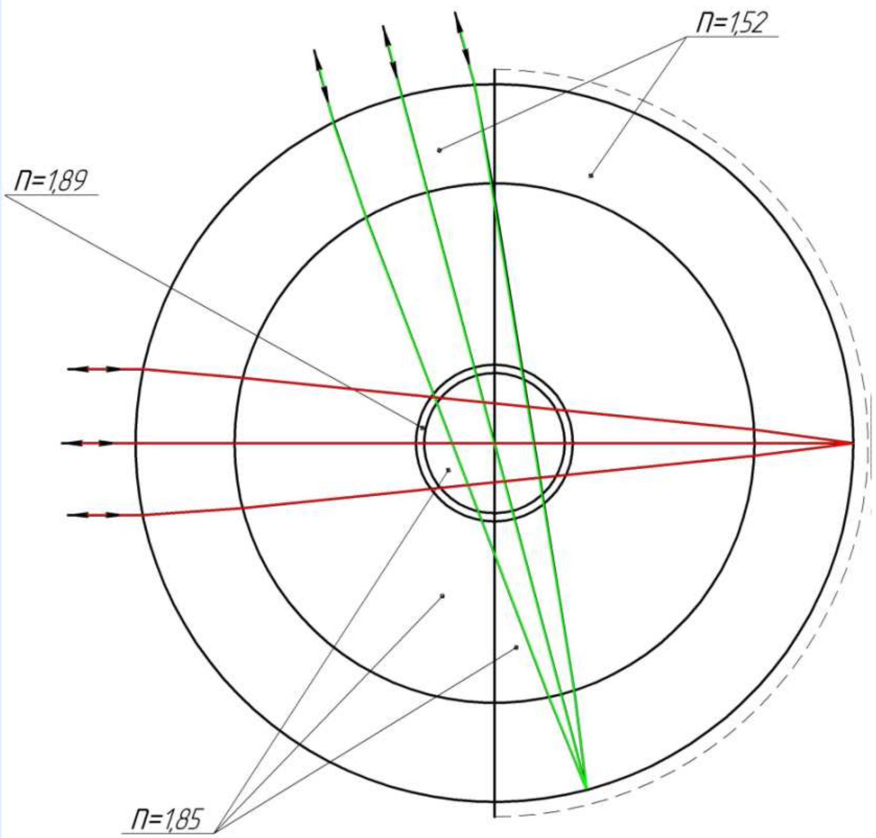


Spherical satellite «BLITS» non-assembled



Spherical satellite «BLITS» weighing 7.5 kg, Ø 170 mm

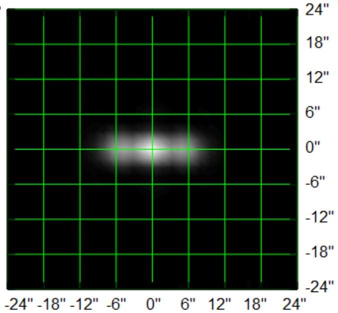
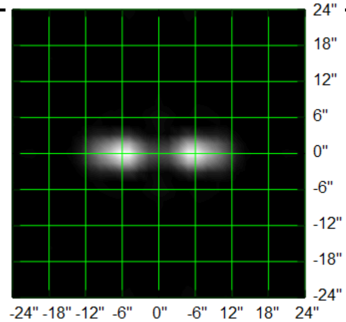
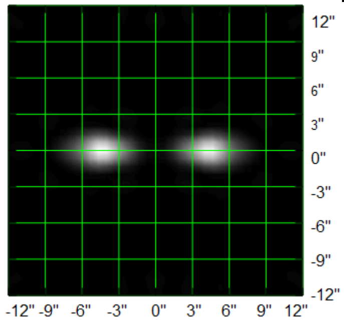
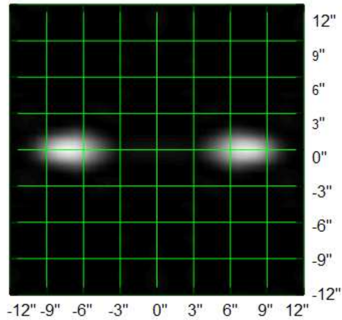
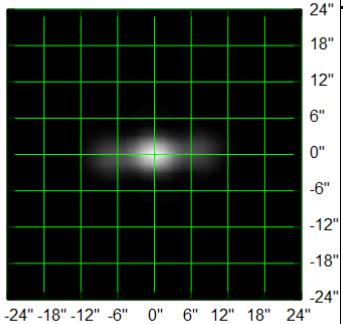
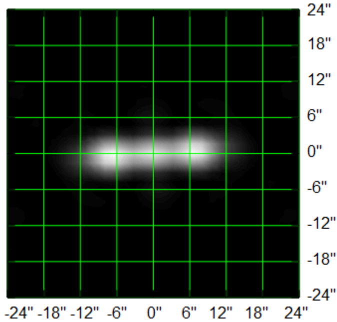
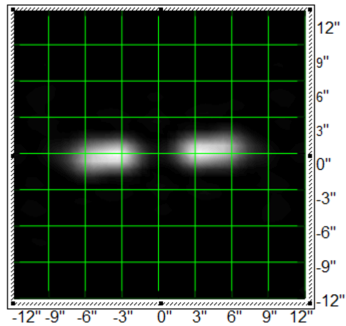
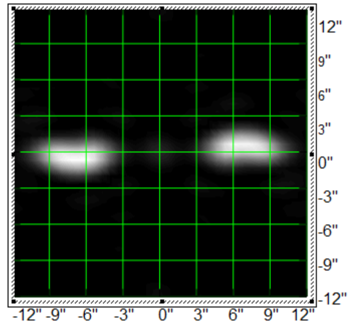
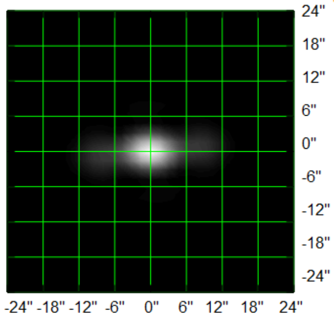
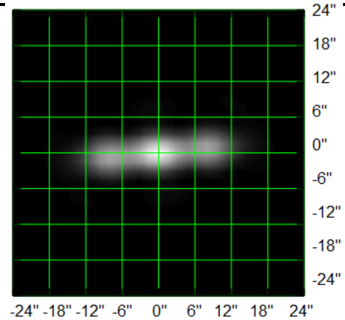
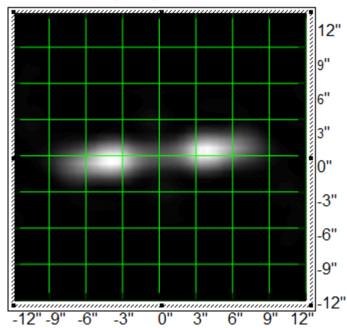
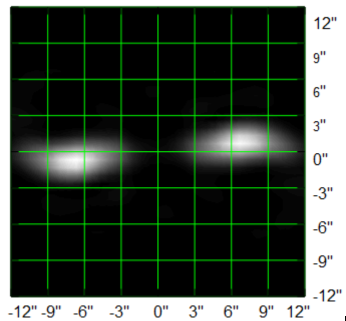
Spherical glass nanosatellite «BLITS-M»



Expected target parameters of the nanosatellite «BLITS-M»	
goal error	no more than 0.1 mm
CS	$0.3 \cdot 10^6$ - $1 \cdot 10^6$ m^2
time of service under the condition of a flight	at least 10 years
orbital altitude	1500 km – 3000 km
diameter	no more than 250 mm
mass	at least 20 kg

Thank you for your attention!

Влияние угла падения света на двухпятенные УО

	28 мм. Угол развала – 2”	28 мм. Угол развала – 3”	56 мм. Угол развала – 2”	56 мм. Угол развала – 3”
Угол падения - 0				
Угол падения – 12				
Угол падения – 18				

Статистика наблюдений наноспутника «BLITS» станциями Международной службы лазерной дальнометрии

Satellite	Site Name	Station	Start Date	End Date	No. Passes	No. Points
BLITS	Altay	1879	24-Sep-2009	20-Nov-2011	192	1,347
BLITS	Arequipa	7403	12-Apr-2010	07-Oct-2011	26	83
BLITS	Beijing	7249	03-Oct-2010	03-Jan-2012	28	113
BLITS	Borowiec	7811	11-Mar-2010	11-Mar-2010	1	3
BLITS	Changchun	7237	28-Sep-2009	07-Feb-2012	597	2,868
BLITS	Concepcion	7405	02-Oct-2009	31-Jan-2012	11	44
BLITS	Grasse	7845	28-Oct-2009	06-Dec-2011	136	1,133
BLITS	Graz	7839	26-Sep-2009	08-Feb-2012	665	4,748
BLITS	Greenbelt	7105	30-Sep-2009	07-Feb-2012	290	2,316
BLITS	Haleakala	7119	03-Dec-2009	05-Feb-2012	125	647
BLITS	Hartebeesthoek	7501	02-Nov-2009	11-Jan-2012	149	796
BLITS	Herstmonceux	7840	25-Sep-2009	07-Feb-2012	512	3,552
BLITS	Katzively	1893	26-Sep-2009	23-Sep-2011	35	158
BLITS	Kiev	1824	28-Sep-2009	16-Nov-2011	51	206
BLITS	Koganei	7308	15-Oct-2009	02-Feb-2012	100	688
BLITS	Komsomolsk-Na-Amure	1868	26-Sep-2009	12-Oct-2011	65	416

Satellite	Site Name	Station	Start Date	End Date	No. Passes	No. Points
BLITS	Lviv	1831	25-Sep-2009	25-Sep-2009	1	3
BLITS	Matera	7941	29-Sep-2009	19-Jan-2012	242	1,144
BLITS	McDonald	7080	11-Oct-2009	07-Jan-2012	35	123
BLITS	Monument Peak	7110	07-Oct-2009	03-Feb-2012	396	3,139
BLITS	Mount Stromlo	7825	30-Sep-2009	05-Feb-2012	334	1,231
BLITS	Potsdam	7841	25-Sep-2009	08-Feb-2012	264	2,251
BLITS	Riga	1884	02-Oct-2009	26-Oct-2011	102	555
BLITS	Riyadh	7832	26-Apr-2010	25-Aug-2010	10	58
BLITS	San Fernando	7824	01-Oct-2009	01-Feb-2012	22	50
BLITS	San Juan	7406	24-May-2010	09-Feb-2012	95	680
BLITS	Shanghai	7821	06-Oct-2009	31-Jan-2012	136	669
BLITS	Simeiz	1873	24-Sep-2009	25-Sep-2011	56	336
BLITS	Tahiti	7124	03-Dec-2009	27-Jan-2012	85	530
BLITS	Tanegashima	7358	28-Oct-2009	14-Nov-2011	30	155
BLITS	Wettzell	8834	30-Sep-2009	08-Feb-2012	163	638
BLITS	Yarragadee	7090	26-Sep-2009	08-Feb-2012	1,312	8,905
BLITS	Zimmerwald	7810	30-Sep-2009	06-Feb-2012	899	6,624

Функциональный ряд УО

	Размер УО (диаметр эквивалентной окружности)	Вид покрытия граней (потери в УО при наличии покрытия – 20%)	Отклонение двухгранного угла (развал)	Справочные данные		
				Усредненный ЭПР для одного УО (м^2)	Вид диаграммы направленности	Назначение
1	28 мм (базовый)	серебряное или интерференционное покрытие	$2{,}4'' \pm 0{,}2''$	$4{,}25 \cdot 10^6$	два пятна	КА ГЛОНАСС с вращением панели
2	28 мм (базовый)	серебряное или интерференционное покрытие	$3'' - 4''$	$\leq 4 \cdot 10^6$	два пятна	Низкоорбитальные КА
3	36 мм	серебряное или интерференционное покрытие	$2{,}4'' \pm 0{,}2''$	$2 \cdot 10^6$	кольцо с центральным пятном	КА ГЛОНАСС
				$10 \cdot 10^6$	два пятна	КА ГЛОНАСС с вращением панели
4	50 мм	серебряное или интерференционное покрытие	$2{,}4'' \pm 0{,}2''$	$60 \cdot 10^6$	два пятна	КА ГЛОНАСС с вращением панели. Геостационарный КА