New laser retroreflector arrays

1. Luna’s array (production stage)
2. Ring retroreflector array (RRA) for GLONASS (design stage)

Goals:

- correction reduction of measurement results ;
- cross-section increase;
- solar heating minimization.

Luna's array for “Luna-Glob”

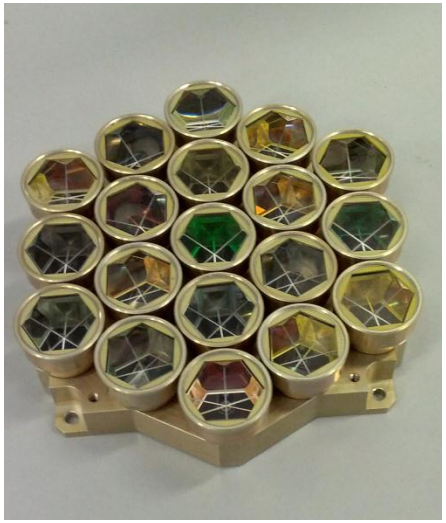
Basic characteristics:

1. Standard CCRs: 28 mm; DAO: 0.
2. Interference dielectric coatings for reducing of solar heating influence and losses.
3. Compact array of 19 CCRs.

$$CS = (2{,}3 - 2{,}5) \cdot 10^8 \, m^2$$

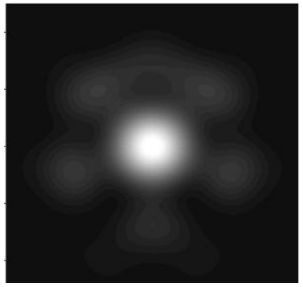
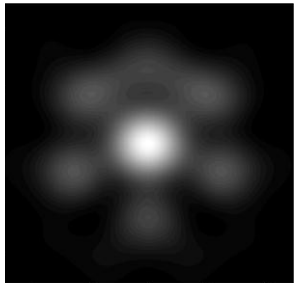
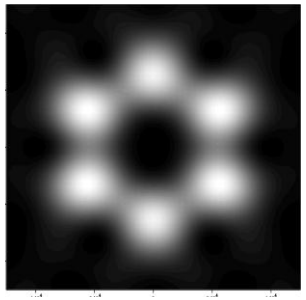
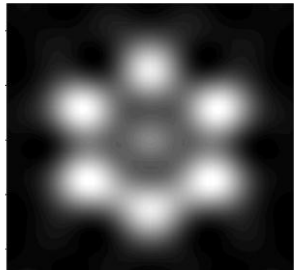
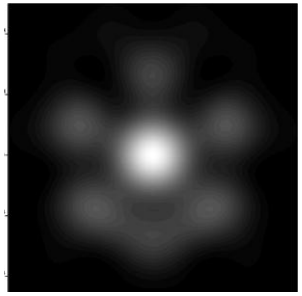
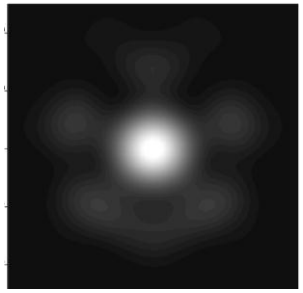
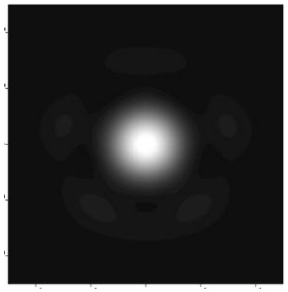
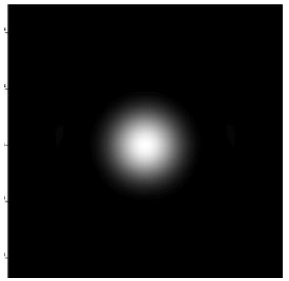
$$Mass < 1 \, kg$$

The experimental array

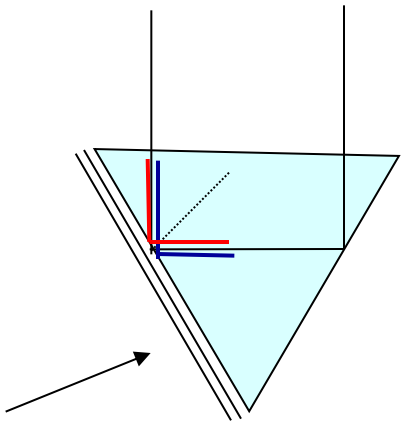


New interference CCR coatings

CCR far field diffraction patterns as a function of reflection phase shift

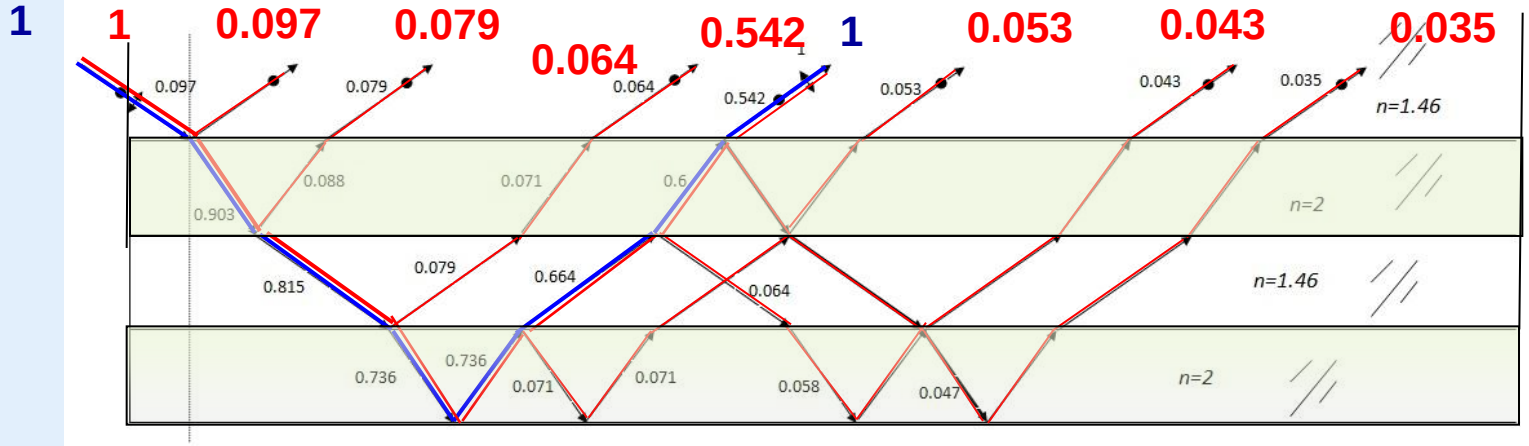
 $\delta = -60^{o}$	 $\delta = -45^{o}$	 $\delta = 0$	 $\delta = 20^{o}$
 $\delta = 45^{o}$	 $\delta = 60^{o}$	 $\delta = 90^{o}$	 $\delta = 120^{o}$

Ray configuration in three dielectric layers



p-component

s-component

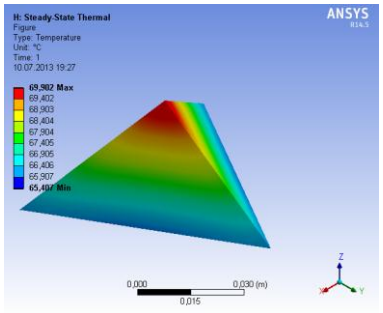


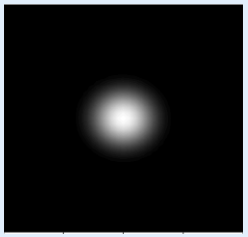
$$\delta_s - \delta_p = f(h_i, N, n_i, \theta_i)$$

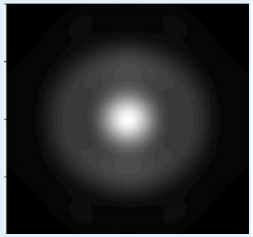
Temperature effects in CCRs

Al-coatings CCRs

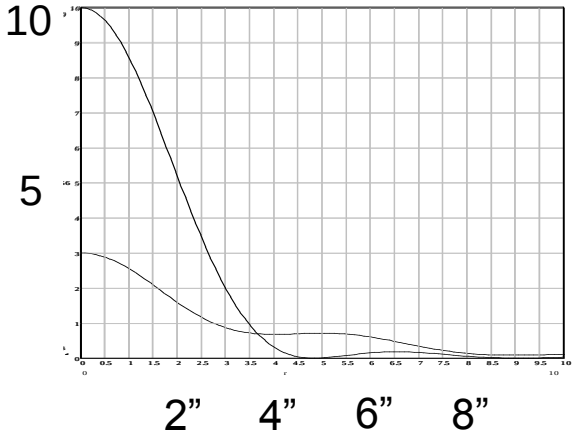
$\Delta T = 4^{o} C$







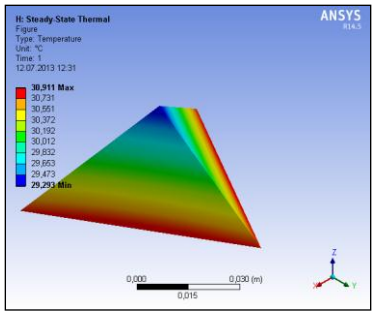
CS ($\cdot 10^{6}$ м^{2})



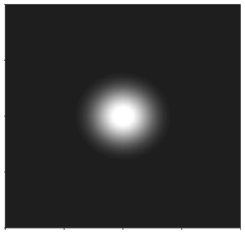
diffraction angle

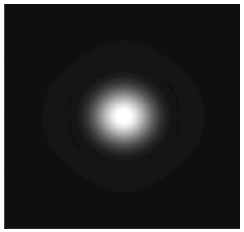
Dielectric-coatings CCRs

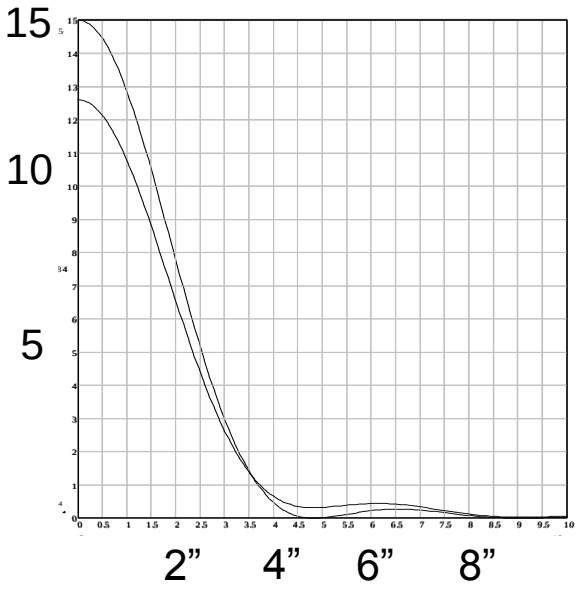
$\Delta T = 1{,}6^{o} C$



CS ($\cdot 10^{6}$ м^{2})





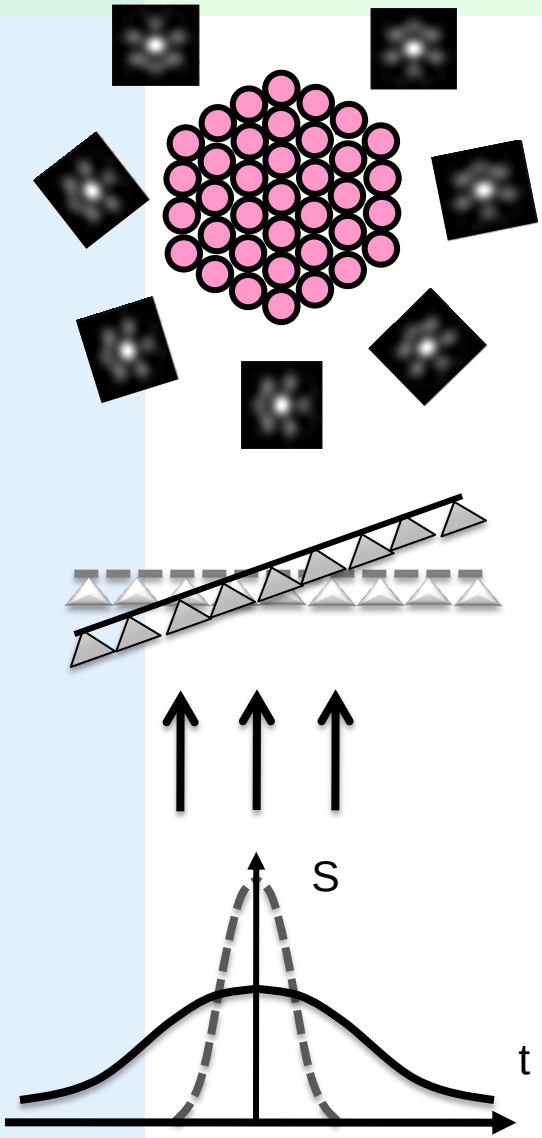


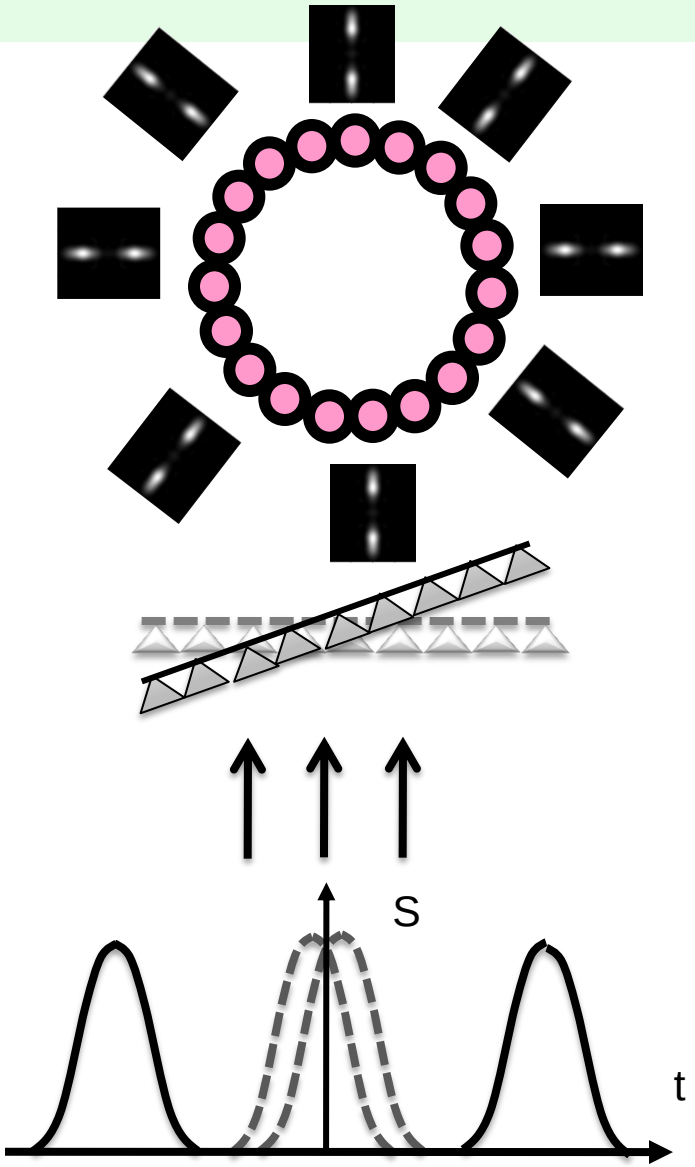
The ring retroreflector array for GLONASS

Basic ideas:

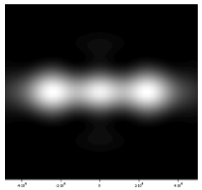
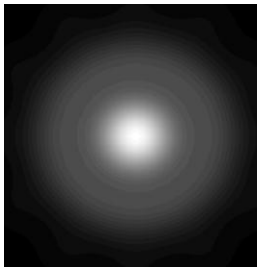
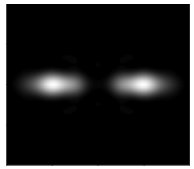
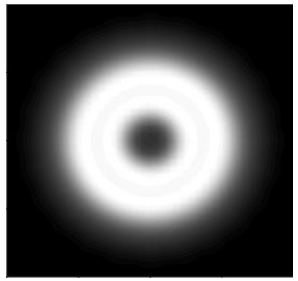
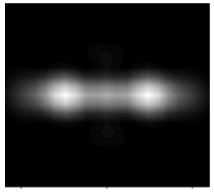
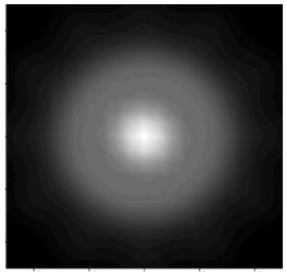
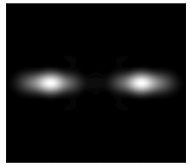
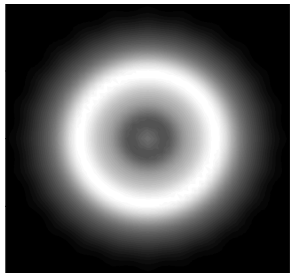
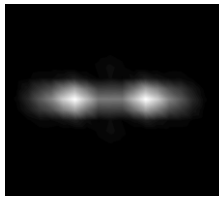
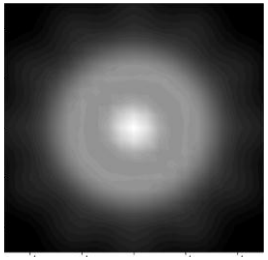
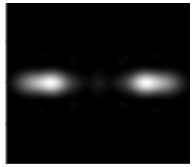
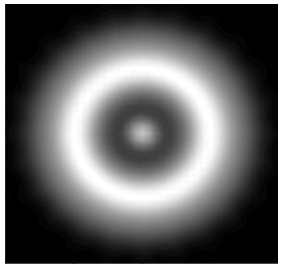
1. Increased aperture CCRs: 42 – 48 mm
2. DAO: 2” – 3” (single DA)
3. Interference dielectric coatings for reducing of solar heating influence
4. Orientations of two-spot FFDP along the radius of RRA

Optimization of LR-array configuration

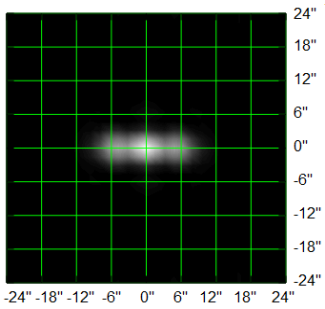
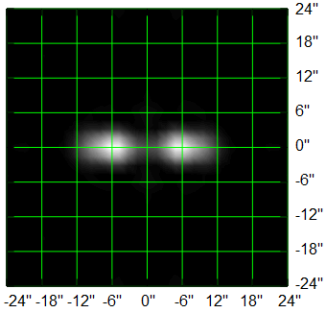
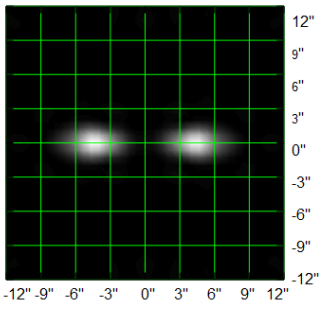
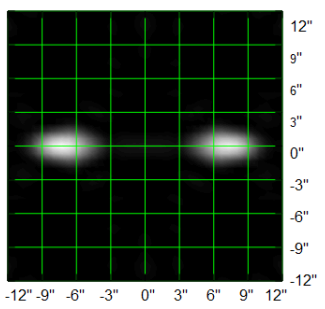
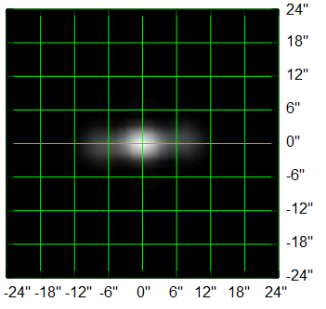
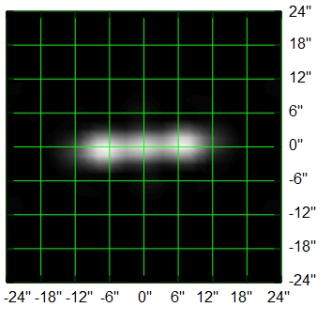
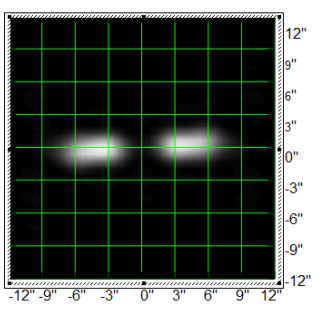
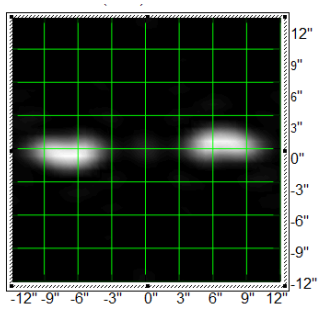
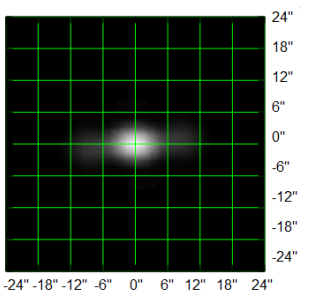
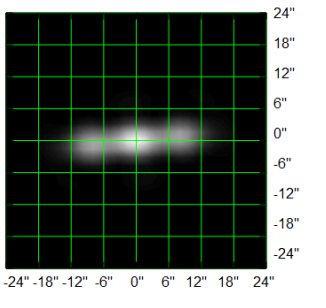
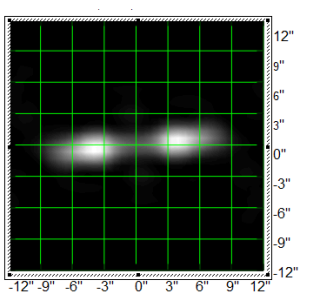
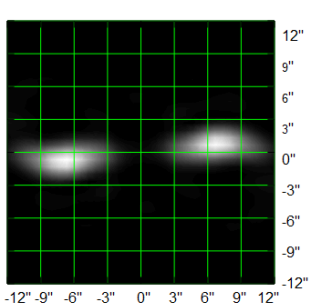




CCRs with different DAO.
Diameters: 28 mm and 50 mm

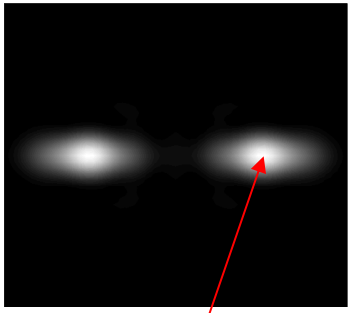
DAO	Equivalent diameter - 28 mm		Equivalent diameter - 50 mm	
	One CCR	36 CCRs	One CCR	36 CCRs
2,2″				
2,4″				
2,6″				

Influence of incidence angle on two-spots CCRs

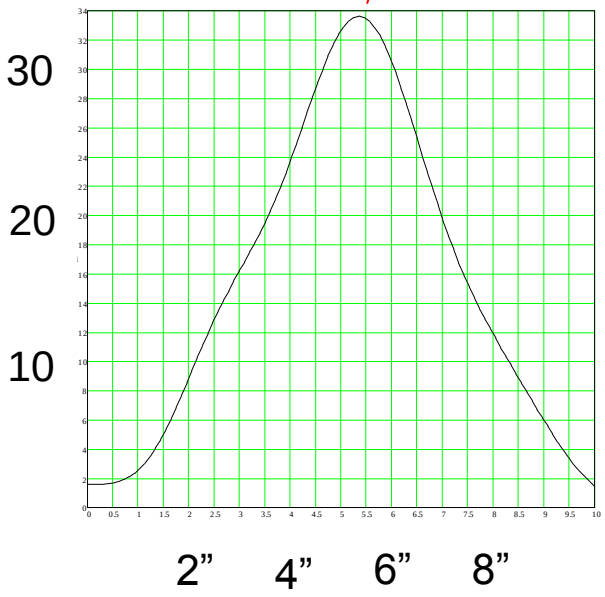
Incidence angle	28 mm		56 mm	
	DAO – 2”	DAO – 3”	DAO – 2”	DAO– 3”
0				
12				
18				

CCRs with DAO + coatings.
Diameter 48 mm. Dihedral angle 2,4”

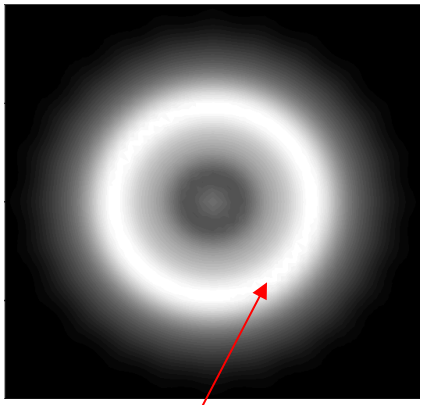
1 CCRs



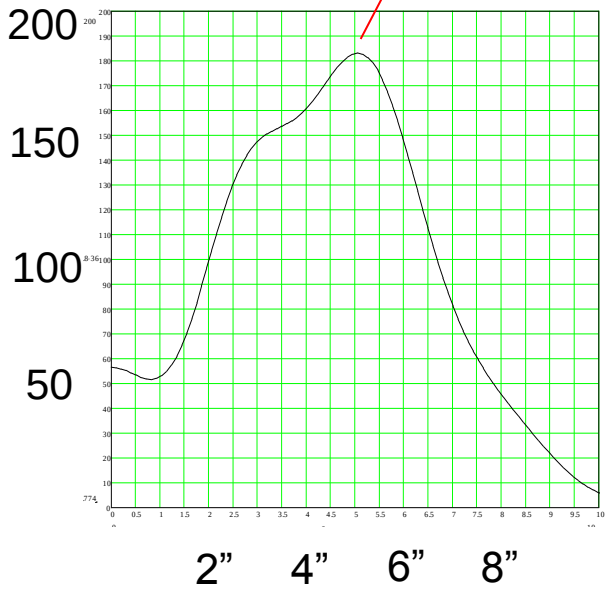
CS ($\cdot 10^6$ м^2)



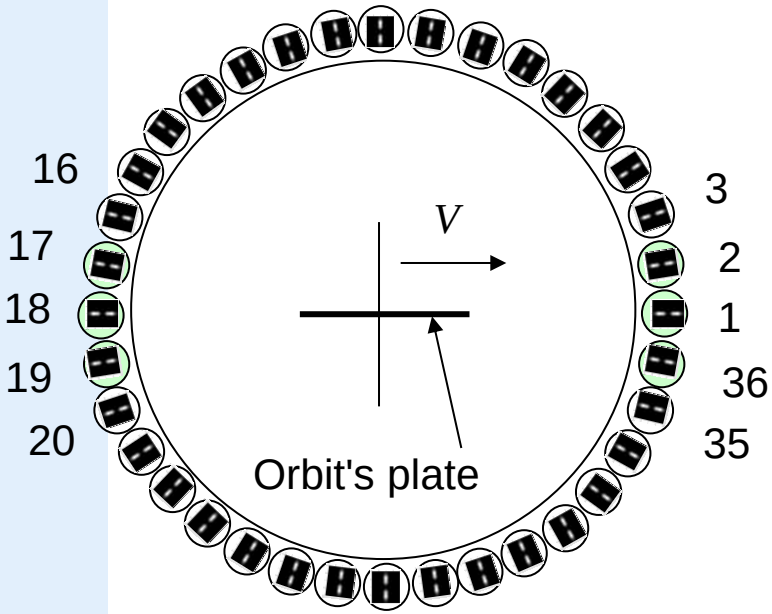
36 CCRs

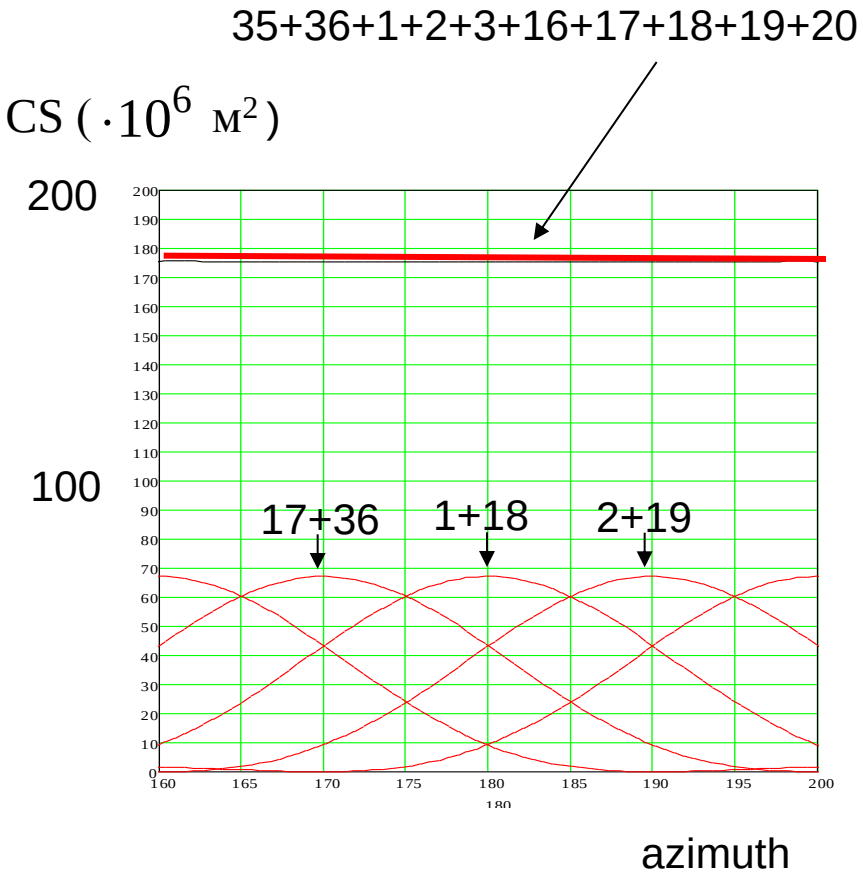


CS ($\cdot 10^6$ м^2)



The RRA of 36 two-spot CCRs

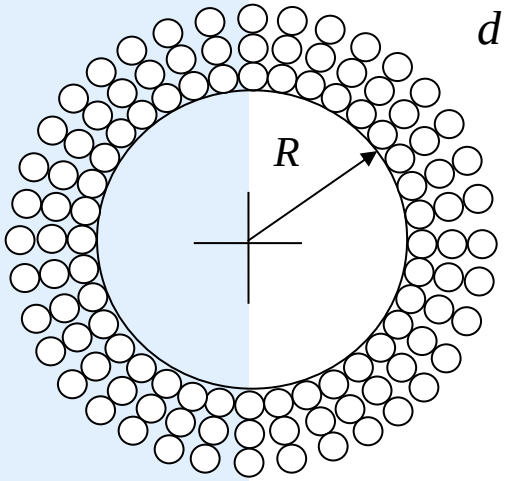




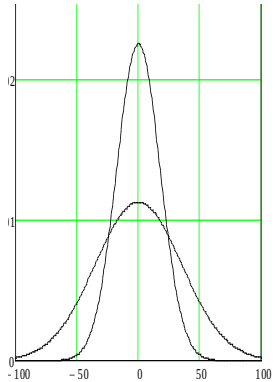
5 CCR’s from opposite sides act for definite orbit's orientation

Ring TIR-CCR array for GLONASS (K)

R = 230 mm
d = 28 mm

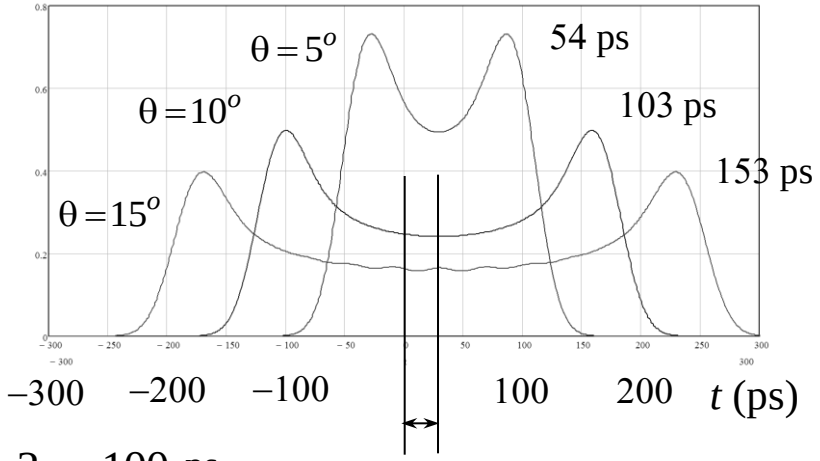


Incident pulse

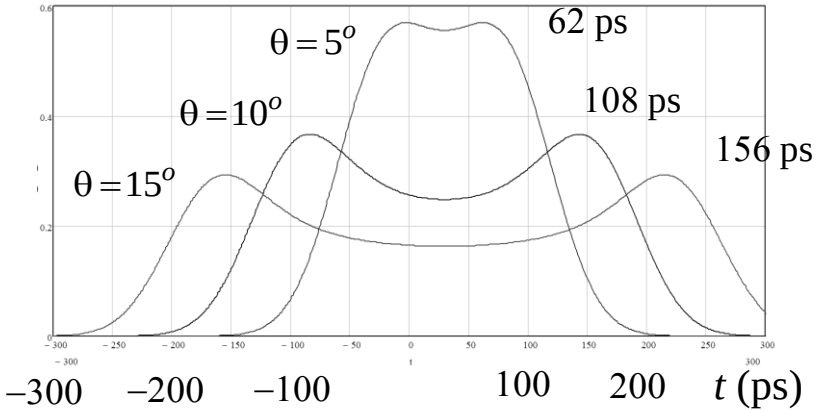


Envelops of reflected pulse

$2\tau = 50$ ps



$2\tau = 100$ ps

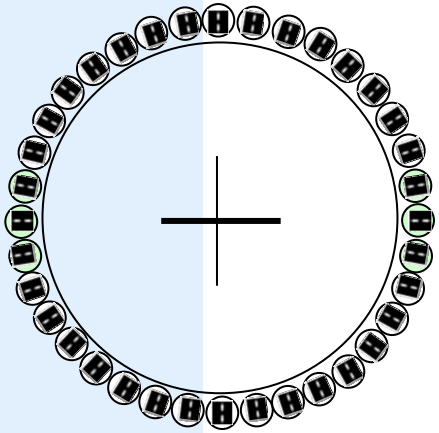


Standard deviation

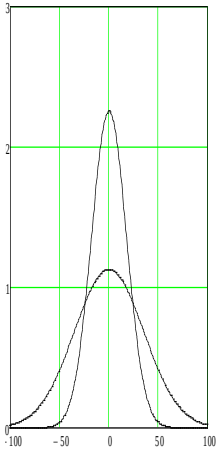
	$\theta = 5^o$	$\theta = 10^o$	$\theta = 15^o$
50 ps	16 mm	31 mm	46 mm
100 ps	19 mm	33 mm	47 mm

Ring two-spot CCR array for GLONASS

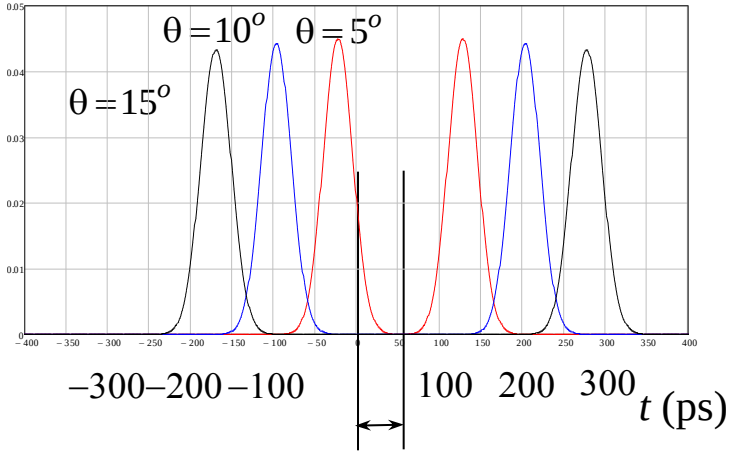
R = 265 mm
d = 48 mm



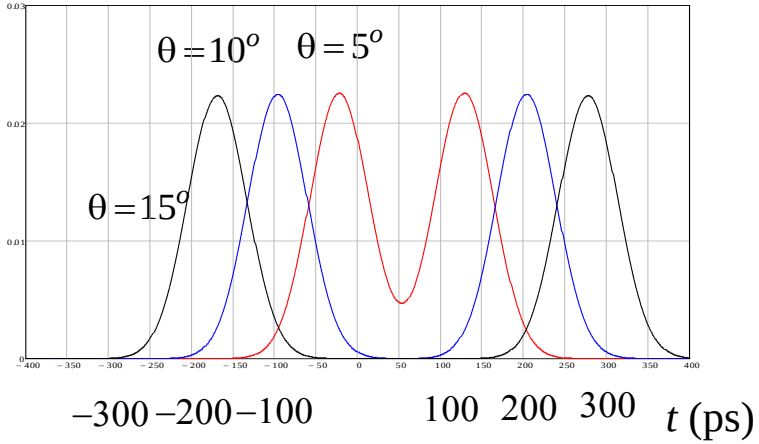
Incident pulse



$2\tau = 50$ ps



$2\tau = 100$ ps



Standard deviation

	$\theta = 5^o$	$\theta = 10^o$	$\theta = 15^o$
50 ps	8 mm	8 mm	8 mm
100 ps	16 mm	16 mm	16 mm

Conclusions

Thus, new technical and technological solutions:

- **dielectric interference coatings of CCRs;**
- **ring retroreflector array, composed by two-spot increased CCRs**

provide significant increase of cross-section with same mass, decrease of solar heating influence and get a higher laser ranging accuracy for navigation satellites.

Thank you for your attention!