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Retroreflector complexes to determinate the coordinates of SC moving parts

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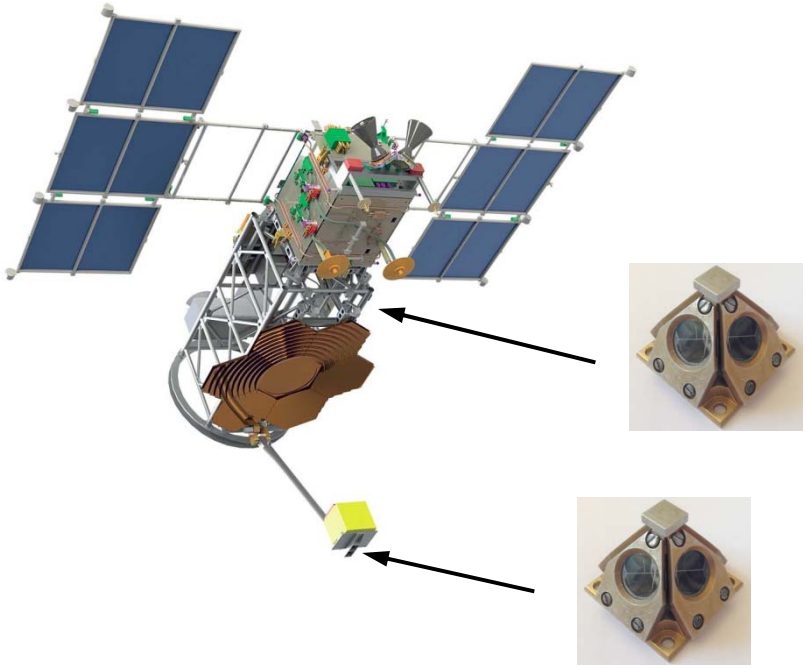
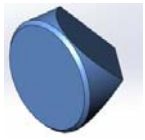


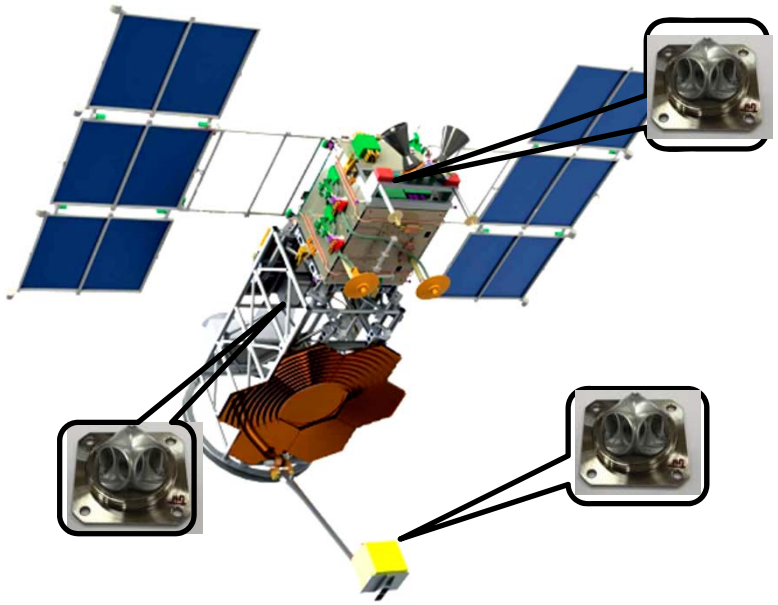
Used terminology

Retroreflector
(Cube corner reflector)



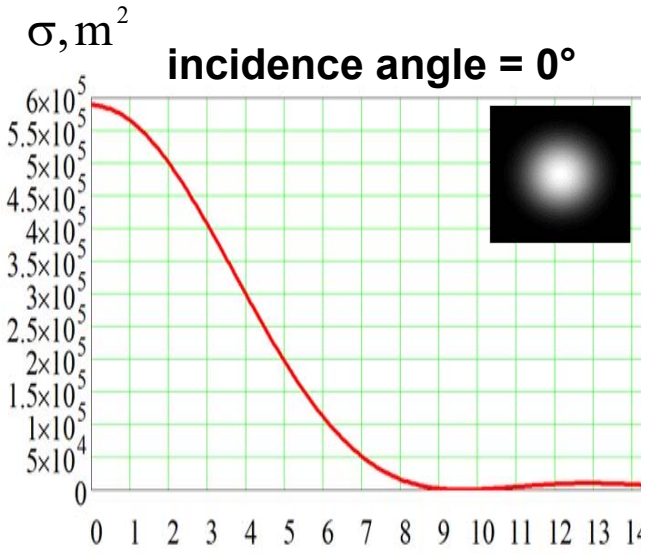
Retroreflector system (array)

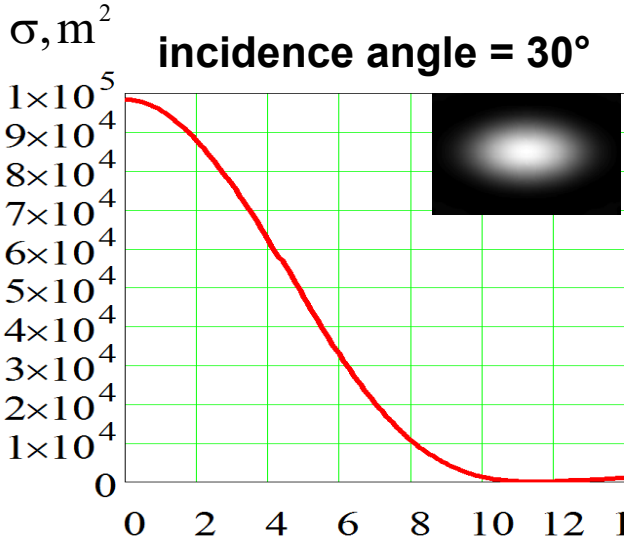
Spacecraft retroreflector complex



Retroreflector system “Pyramid”

Aperture diameter = 14 mm





velocity aberration angle, arc s.

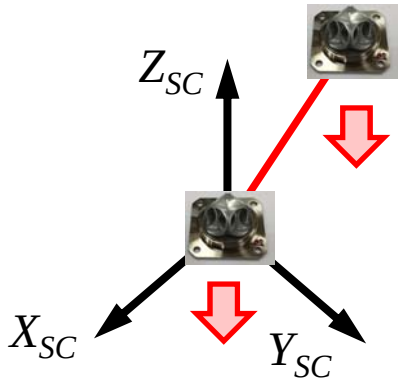
Gluing on the base

Mechanical assembly

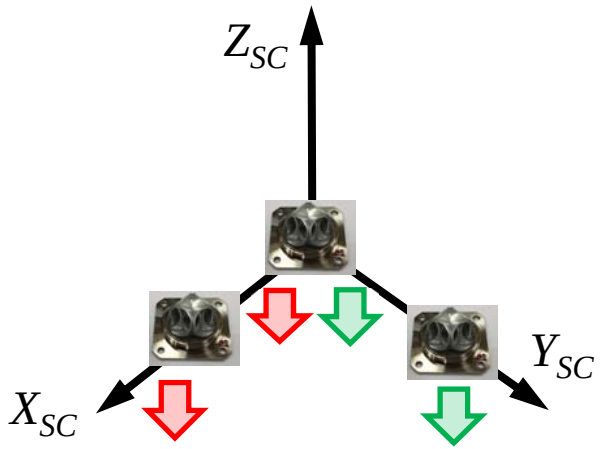
Mass (g)	Size (mm)	SC orbit height (km)	Target error (calculated value)	Displacement of the CRs vertex	Dihedral angle offset of the CCRs
41	41x41x20,5	1 000 – 2 000	< 0,5 mm	< 0,1 mm	< 0,4 arc s

Retroreflector complex for determination of the spatial orientation of the SC movable object

1. Checking laser ranging equipment by analyzing and investigating the return signal structure.
2. Monitoring of sliding parts of SC.
3. Determination of the object which are moves on the known trajectory in the three-axially oriented spacecraft.



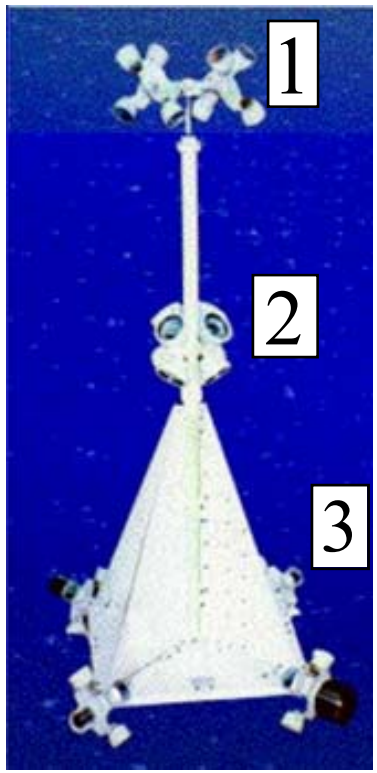
4. Identification of a SC.
5. Determination of the movable object in the three-axially oriented spacecraft.
6. Clarification or monitoring of the spatial spacecraft orientation (the trajectory of the flight is known)



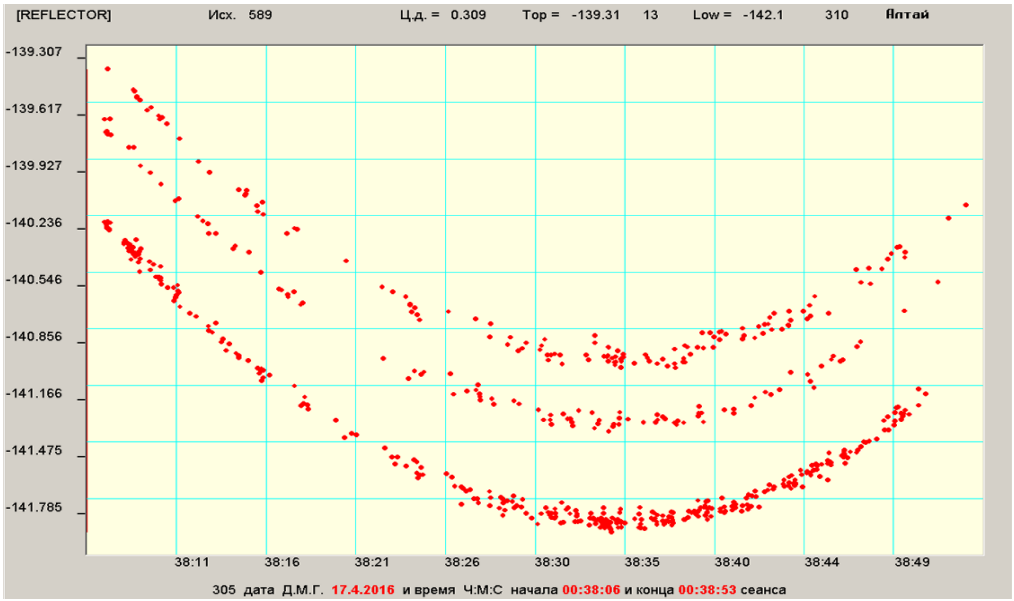
Do we need to use more than three RRS on one spacecraft ??

SC «Reflector» (task 1)

The “Reflector” was launched in 2001 as a piggyback payload on board of the Meteor-3M satellite. Orbit altitude is 1000 km

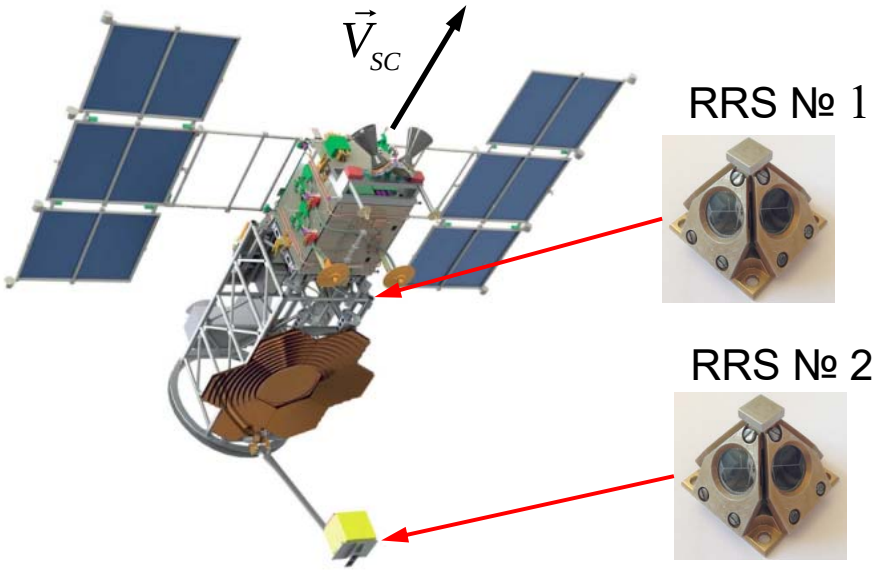


The session of laser ranging of the ALTAY station (17.04.2016)



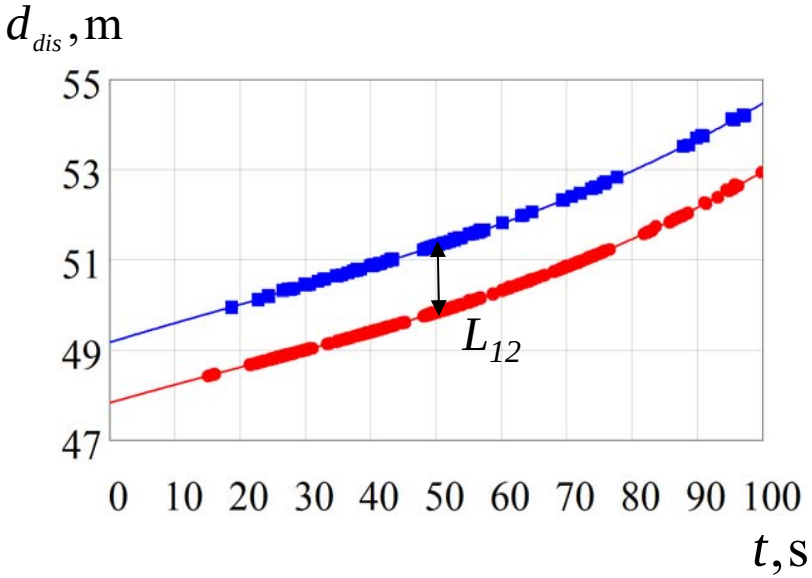
Distance between retroreflectors: 1 – 2: 0,35 m
2 – 3: 0,53 m

Retroreflector complex of the “Lomonosov” SC (task 2)



Orbit type	Sun-synchronous
Orbit height	500 km
Inclination	97,6 °
Mass	625 kg
Lifetime	3 years
Launch date	28.04.2016

The session of laser ranging of the GRAZ station (10.11.2016)



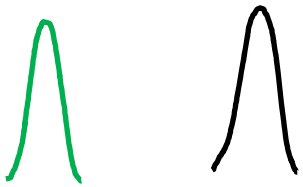
$\Delta L_{12} < 1$ mm

d_{dis} = predicted range – measured laser range

Retroreflector complex consisting of several RRS

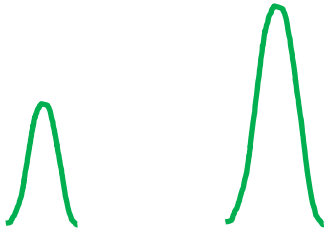
How to distinguish the signals coming from different RRS??

1



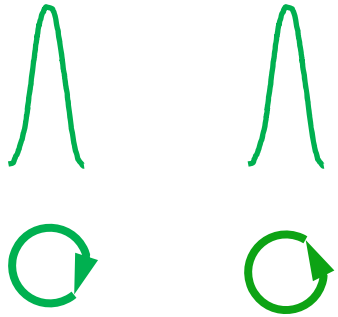
Two-wavelength mode

2



CCRs with different cross-section

3

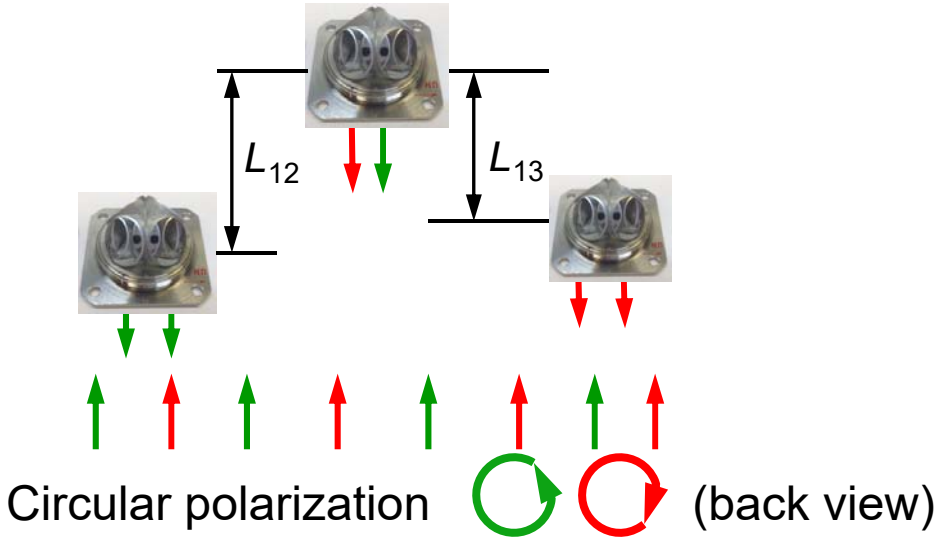


Mode with two circular polarization switching

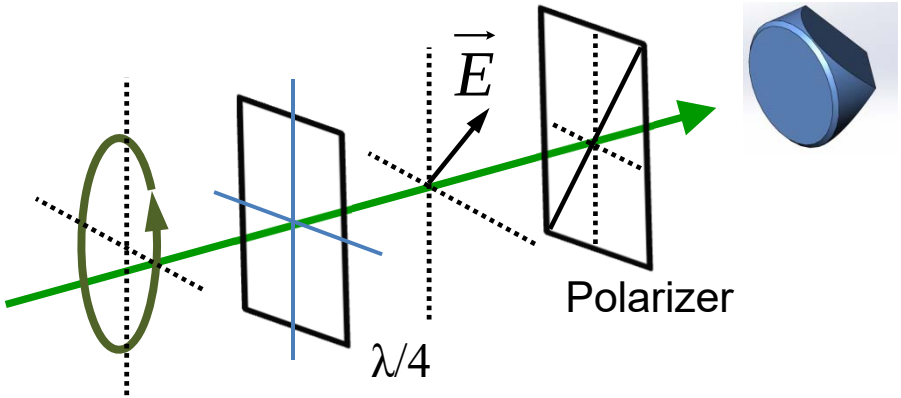
Are there any other options??

Separation of the signals from the retroreflector systems

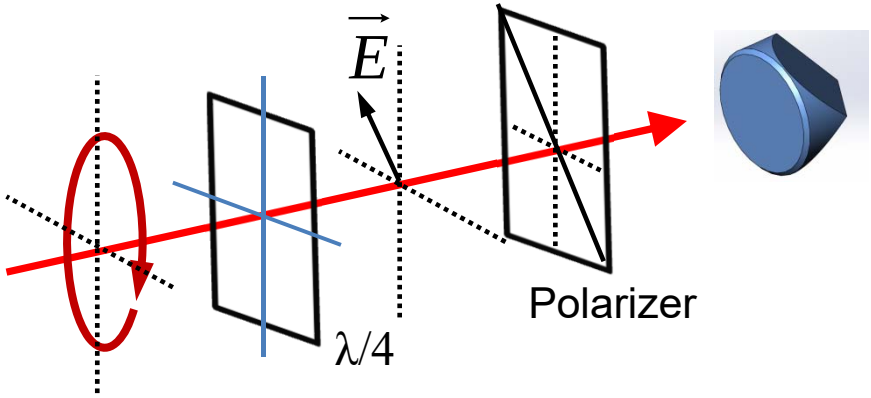
Polarization state of the radiation change from the **right** circular to the **left** during the laser ranging session



The optical system for the reflection of the radiation with **right** circular polarization

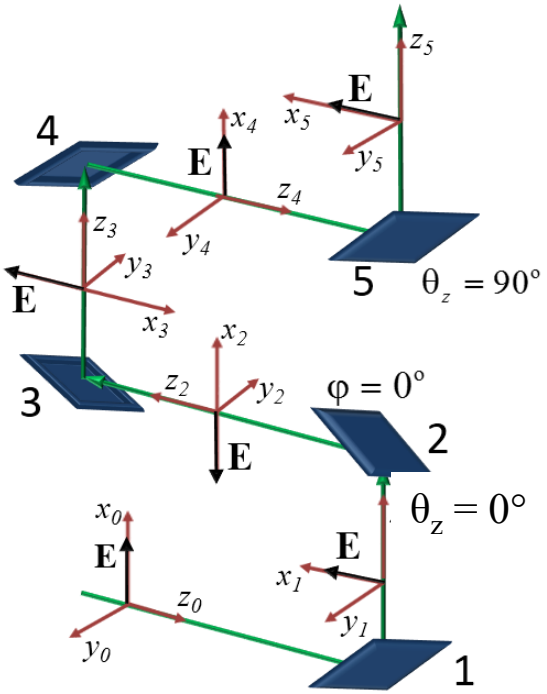


The optical system for the reflection of the radiation with **left** circular polarization

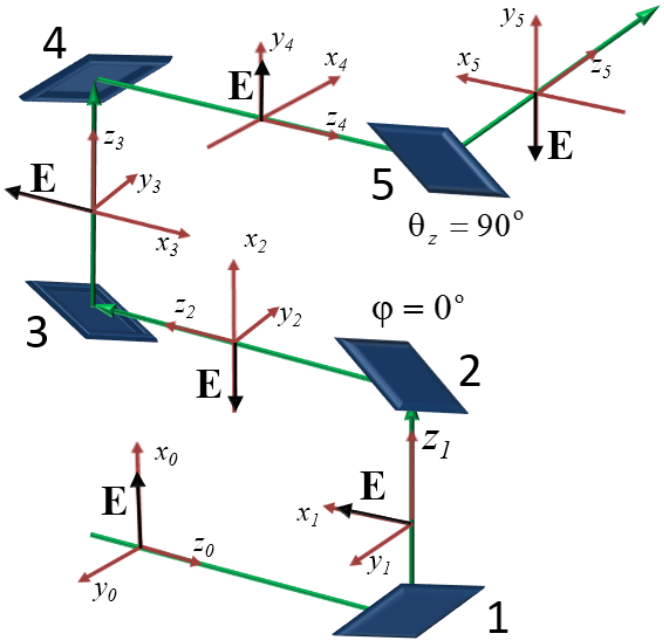


Polarization analysis of the beam-steering device of laser-optical stations

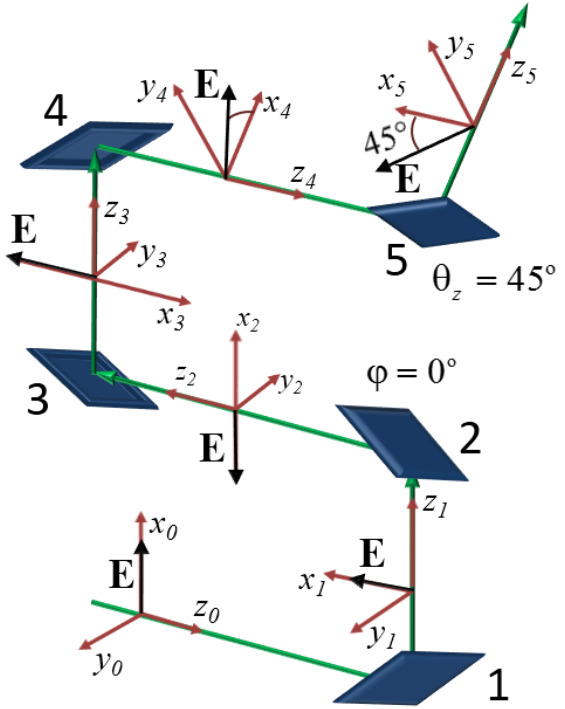
$\varphi = 0°, \theta_z = 0°$



$\varphi = 0°, \theta_z = 45°$

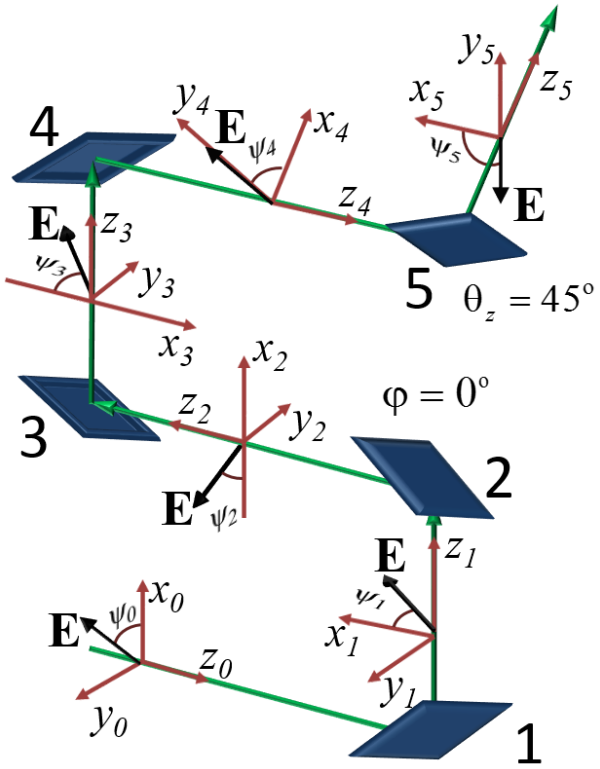


$\varphi = 0°, \theta_z = 90°$

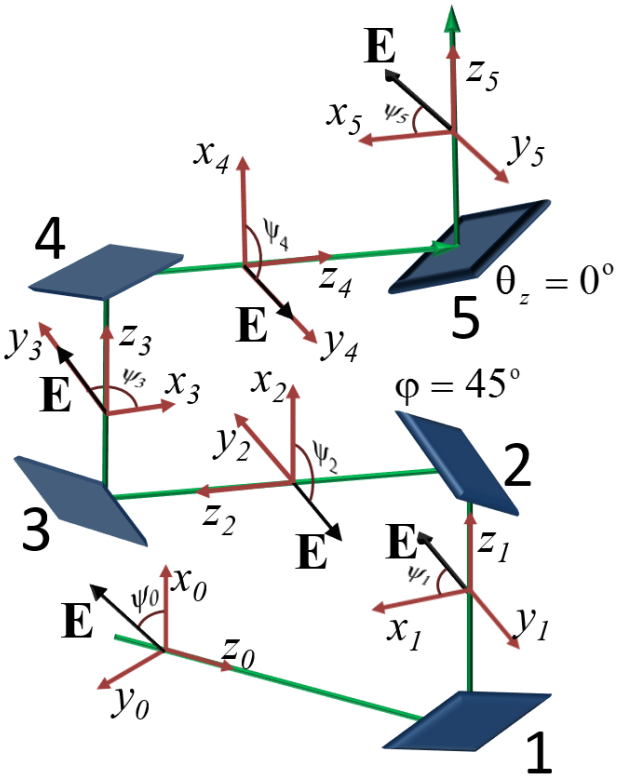


Polarization analysis of the beam-steering device of laser-optical stations (continue)

$\varphi = 0°, \theta_z = 45°$

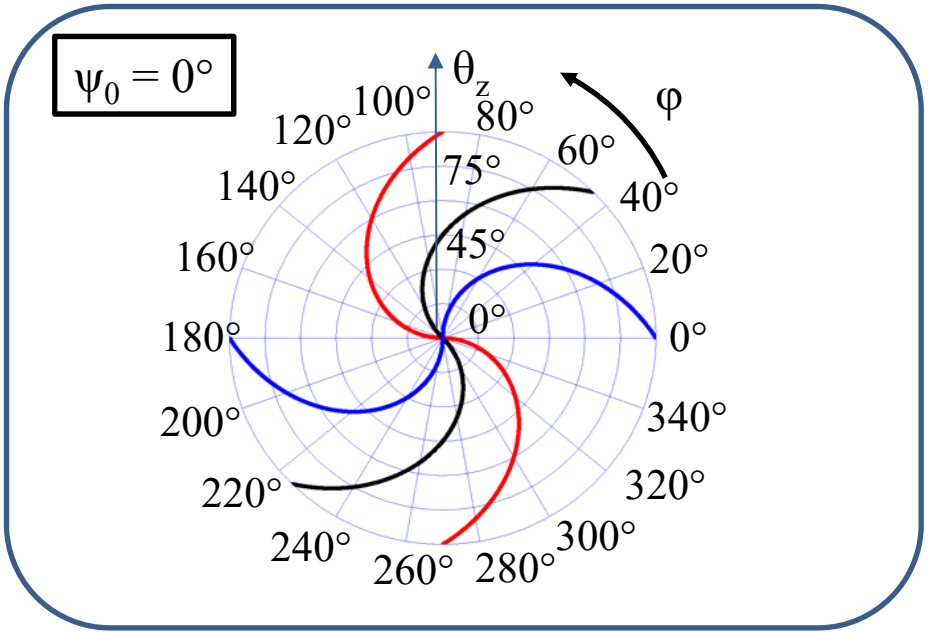


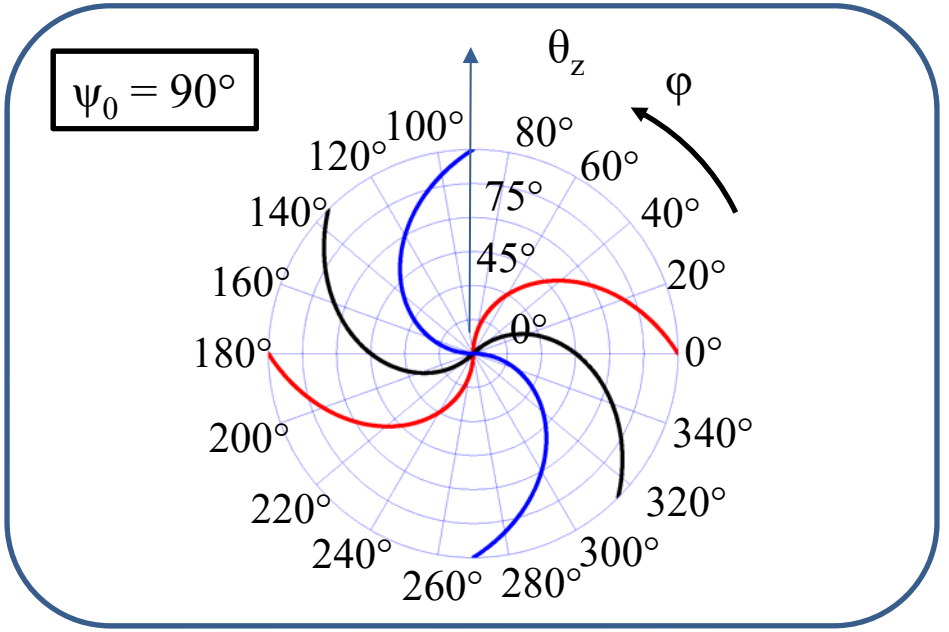
$\varphi = 45°, \theta_z = 90°$



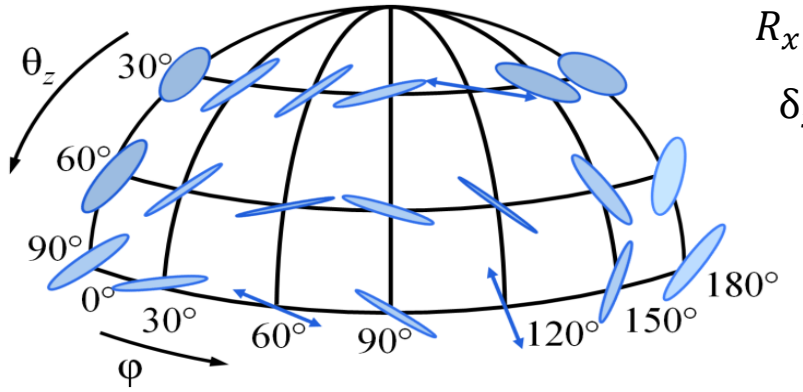
Results of polarization analysis of the beam-steering device

Beam direction on the sky hemisphere for ψ = 0° (red), ψ = 45° (black), ψ = 90° (blue)





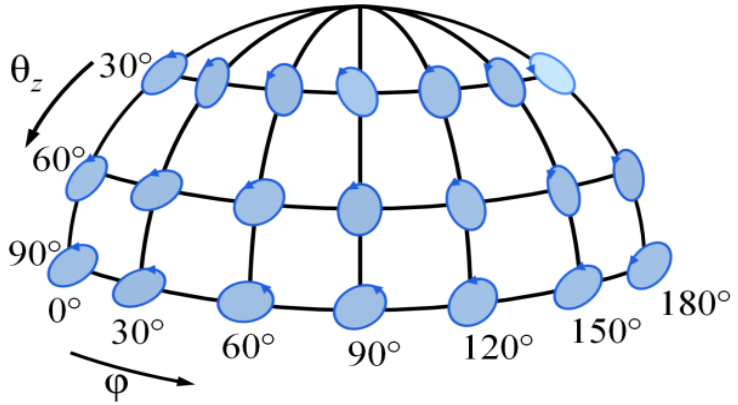
Linear polarization



$R_x/R_y = 0{,}995$

$\delta_x - \delta_y = 2°$

Circular polarization



Summary

1. The retroreflector complexes of the SC make it possible to determine the coordinates of the movable SC parts and to clarify its orientation, in particular, during an emergency operation.

2. The results of laser ranging of the SC Lomonosov allow us to recommend the installation of the RRS “Pyramid” on the LEO spacecraft as part of retroreflector complex for different tasks. Such non-expensive retroreflector complexes allow to identification of spacecraft, which may be defined as space debris.

3. Three RRSs with different polarization characteristics should be installed on the SC for the clarification and monitoring of spatial orientation. In order to divide the range differences between RRSs, the polarization state of the laser radiation should alternate change from *right* to *left* circular during the laser ranging session.

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Thank you for your attention!

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