SPHERICAL GLASS SLR TARGET

MICROSATELLITE

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CURRENT SLR TARGET DISADVANTAGES

- It is difficult to obtain target errors less than 1 mm if return signals come from several cube corners having different positions relative to the Center of Mass (CoM) of the satellite

- Even if the "one direction - one reflector" principle is used (e.g. in the WESTPAC or LARETS satellite design), the active retroreflector position varies relatively to the CoM, and the cube corner internal delay time also varies when the active retroreflector moves away from the line connecting the SLR system with the satellite CoM

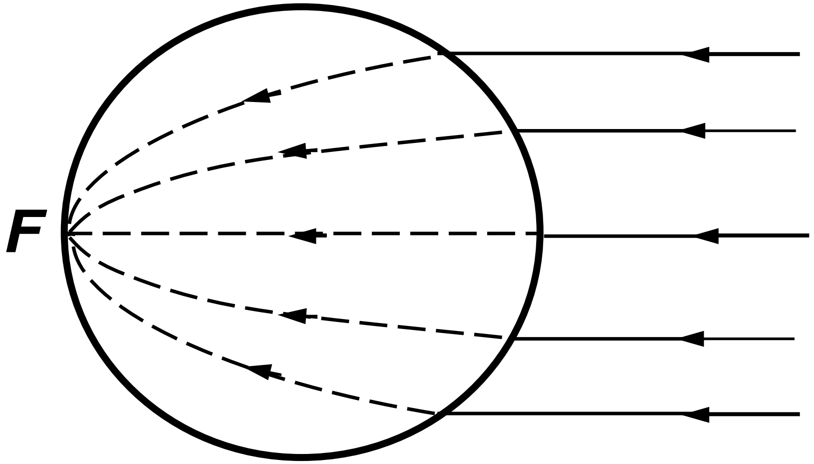
- The return signal strength varies significantly with the satellite rotation

- The satellite shape is not an ideal sphere, especially for design using the "one direction - one reflector" principle (WESTPAC, LARETS)

- Interaction with the Earth magnetic field (due to eddy currents induced in the massive metal body): slow-down of spinning, some disturbance of orbital motion

SOLUTION: SPHERICAL GLASS LENS

Luneberg lens principle



$$n = \sqrt{2 - \left(\frac{r}{a}\right)^2}$$

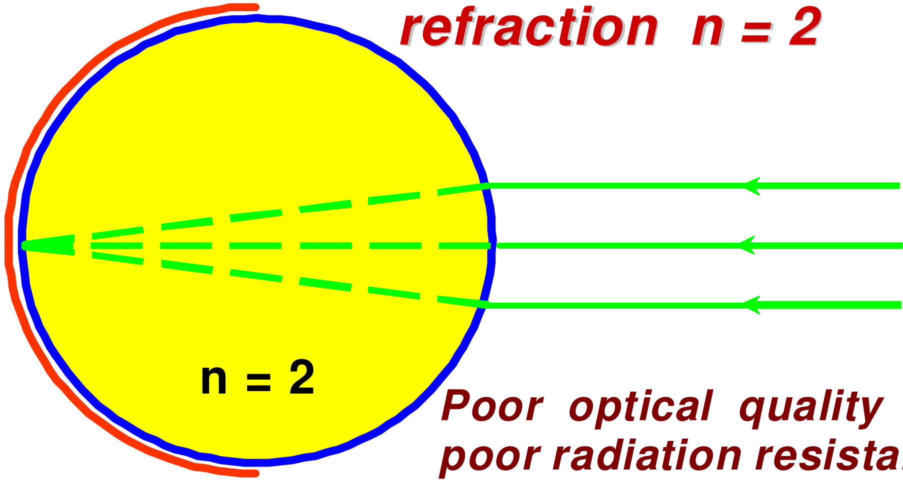
n – index of refraction

a – radius of sphere

r – current radius value

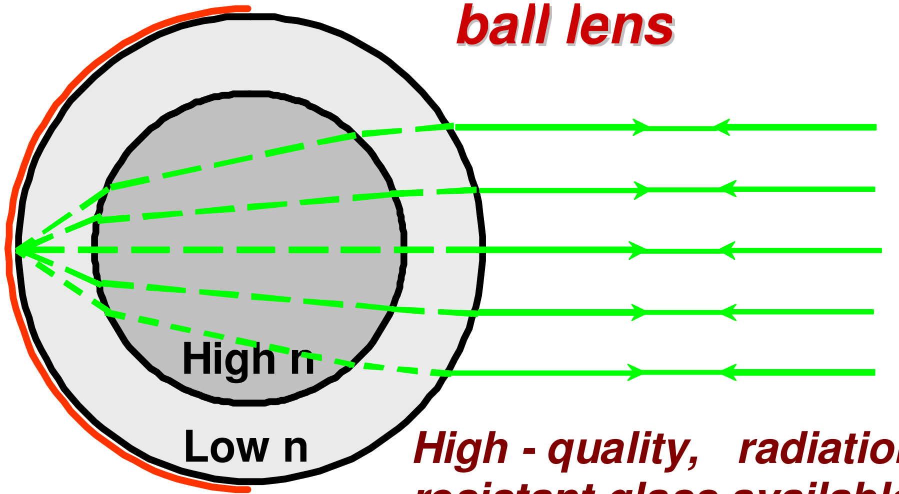
Implementation impossible for optical wavelengths: no suitable optical materials

Ball lens made of glass with index of refraction n = 2



Poor optical quality and poor radiation resistance of available extra-dense glass; low return efficiency

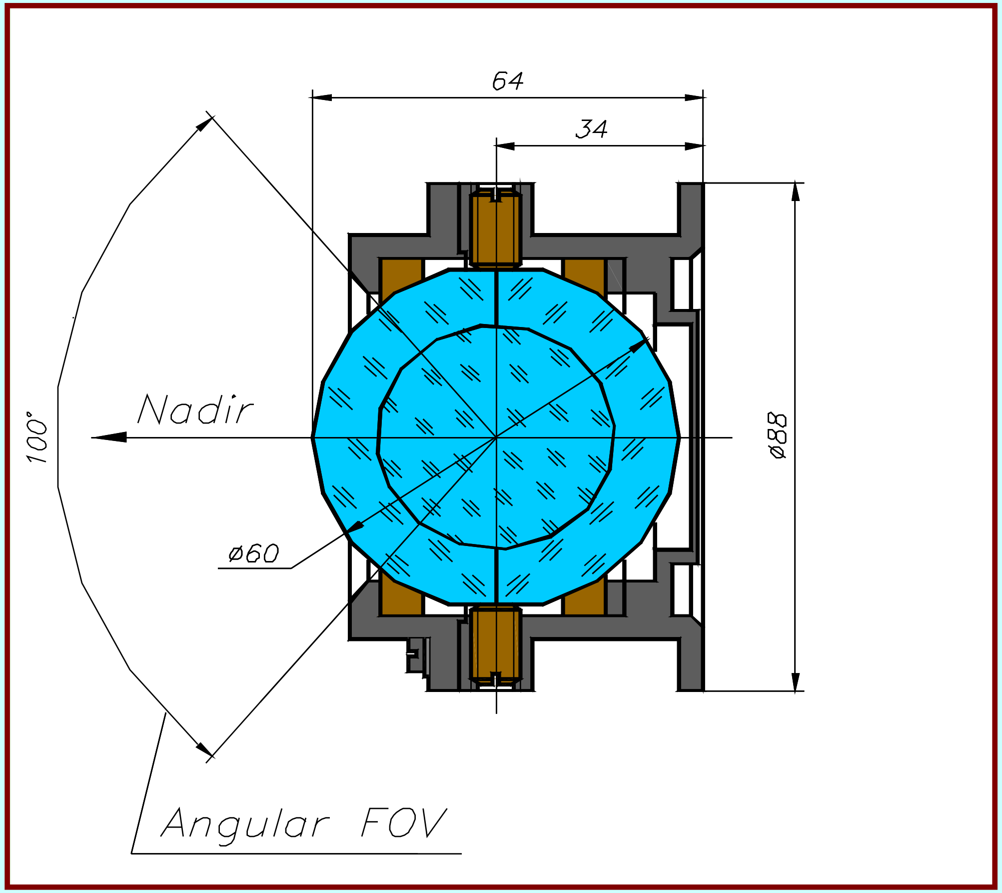
Spherical retroreflector: a two-layer ball lens

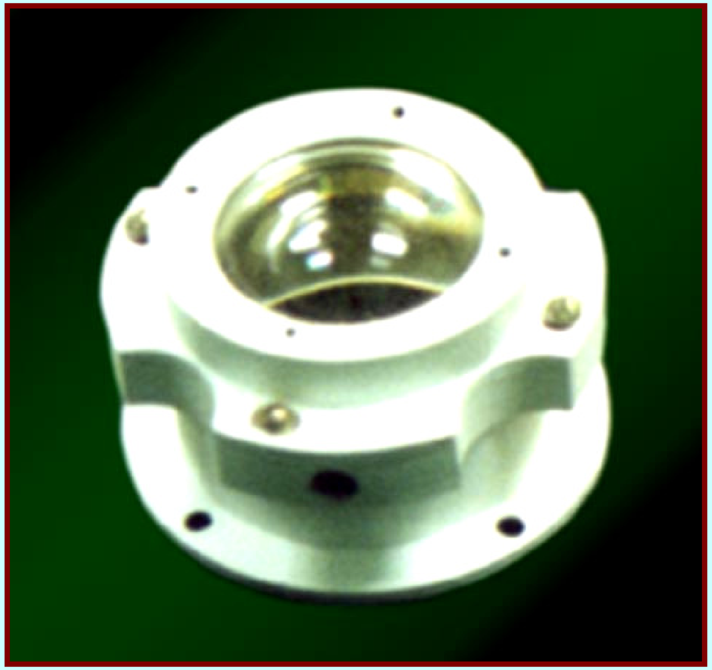


High - quality, radiation-resistant glass available; reasonable return efficiency

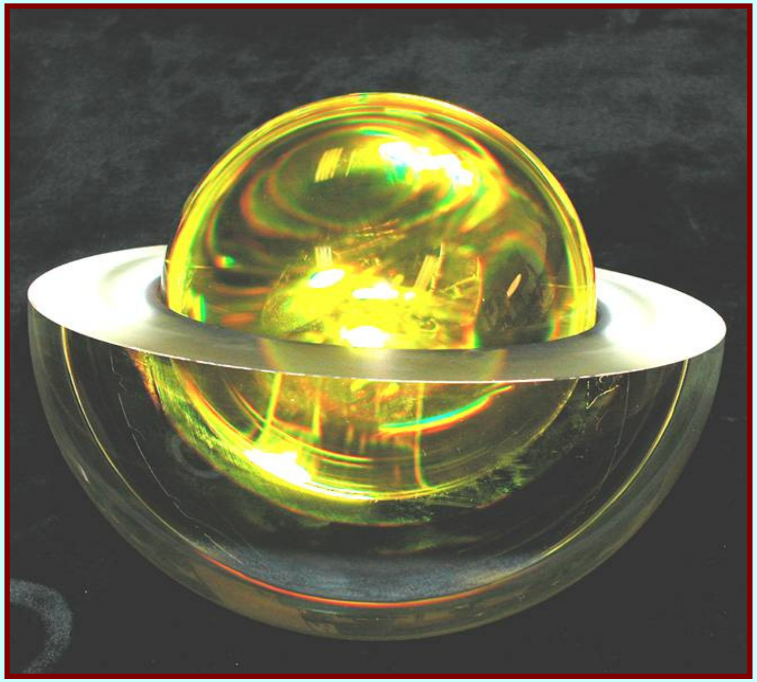
FIRST OPERATIONAL PROTOTYPE

An experimental 60-mm-diameter spherical retroreflector, after being tested in laboratory conditions, has been 10 December 2001 launched into space on board of the METEOR-3M(1) satellite having a 1018.5-km-high circular orbit. During four years of operation, the spherical retroreflector provided precision orbit determination for the SAGE-III experiment.

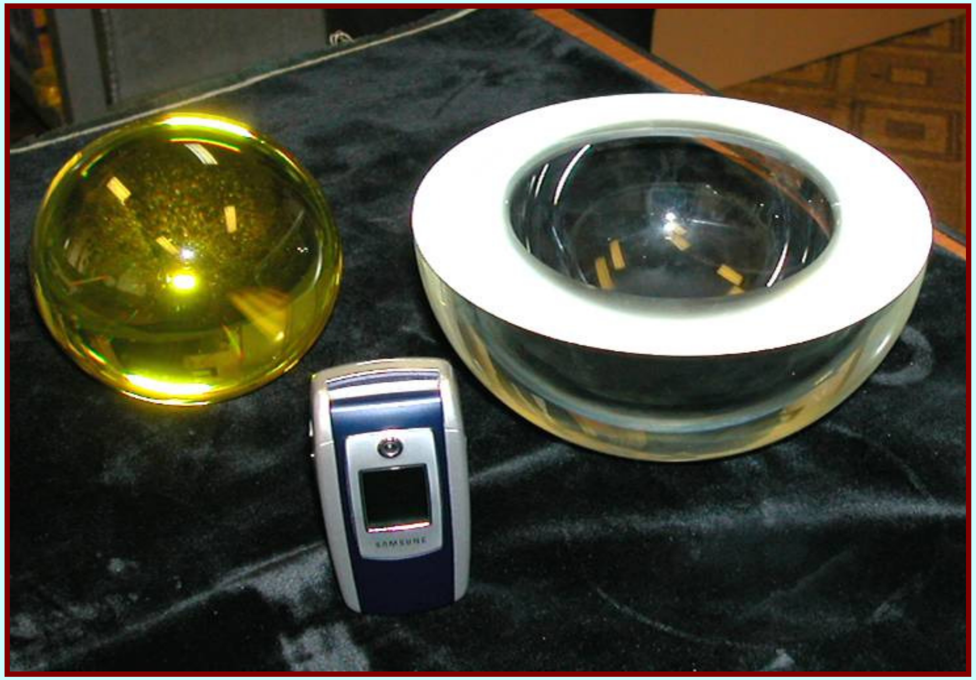




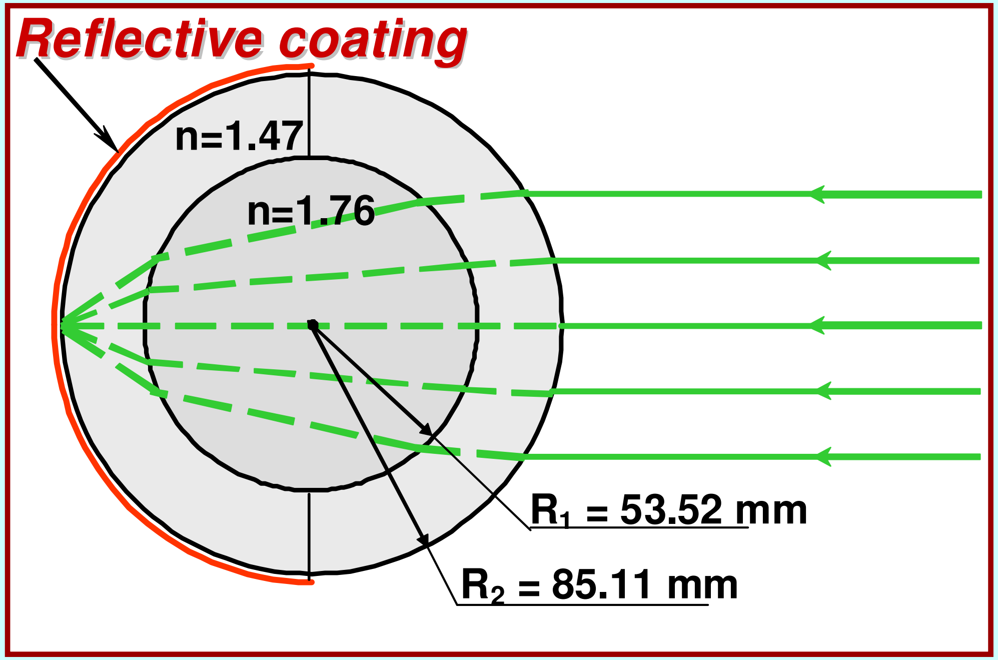
17-cm-diameter spherical retroreflector



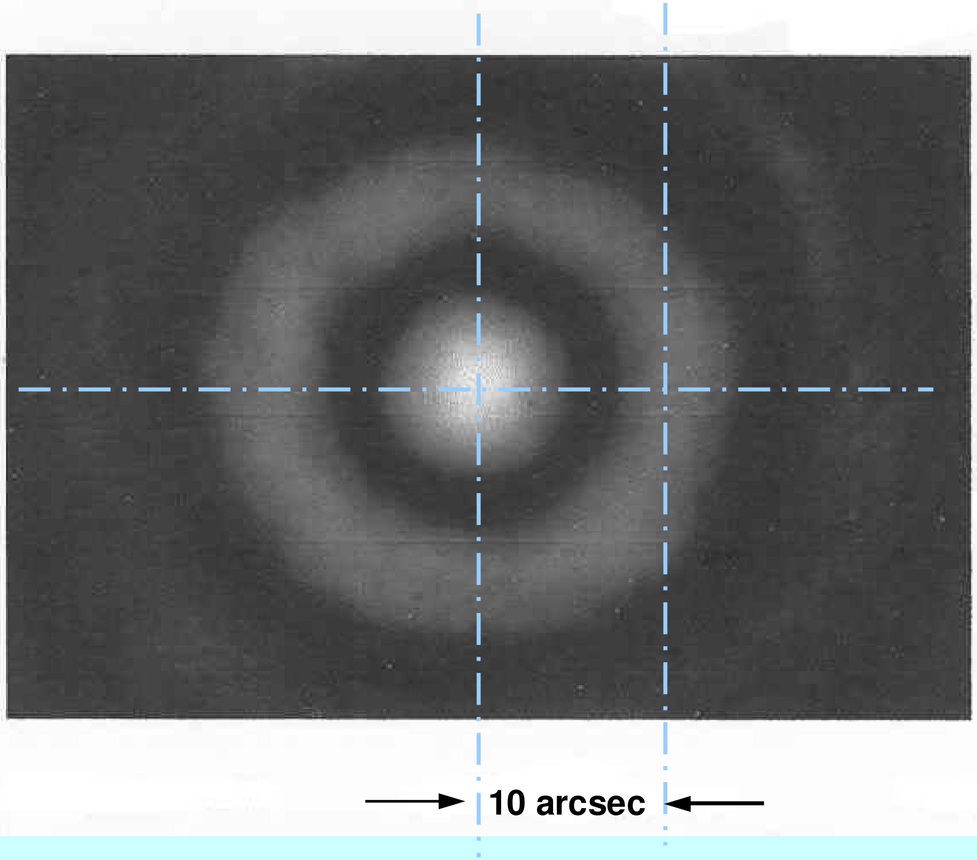
dissembled

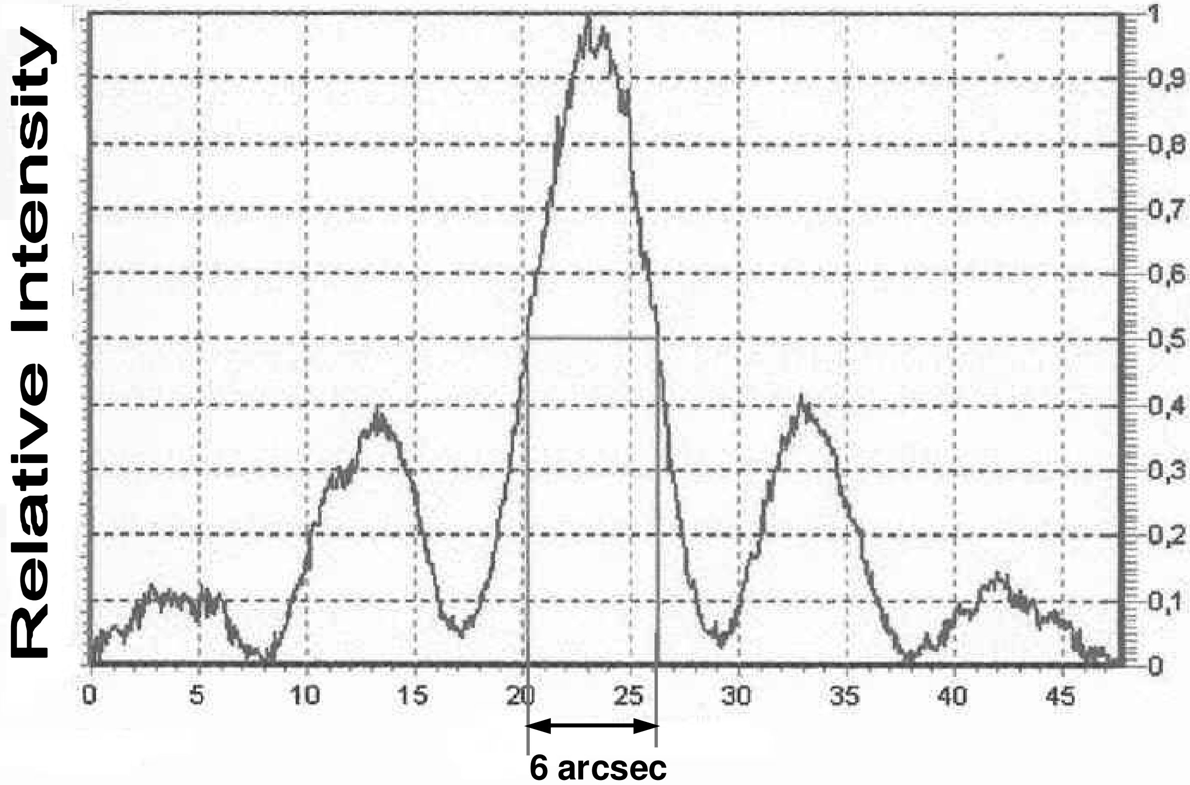


Ready for testing



Far-field diffraction pattern



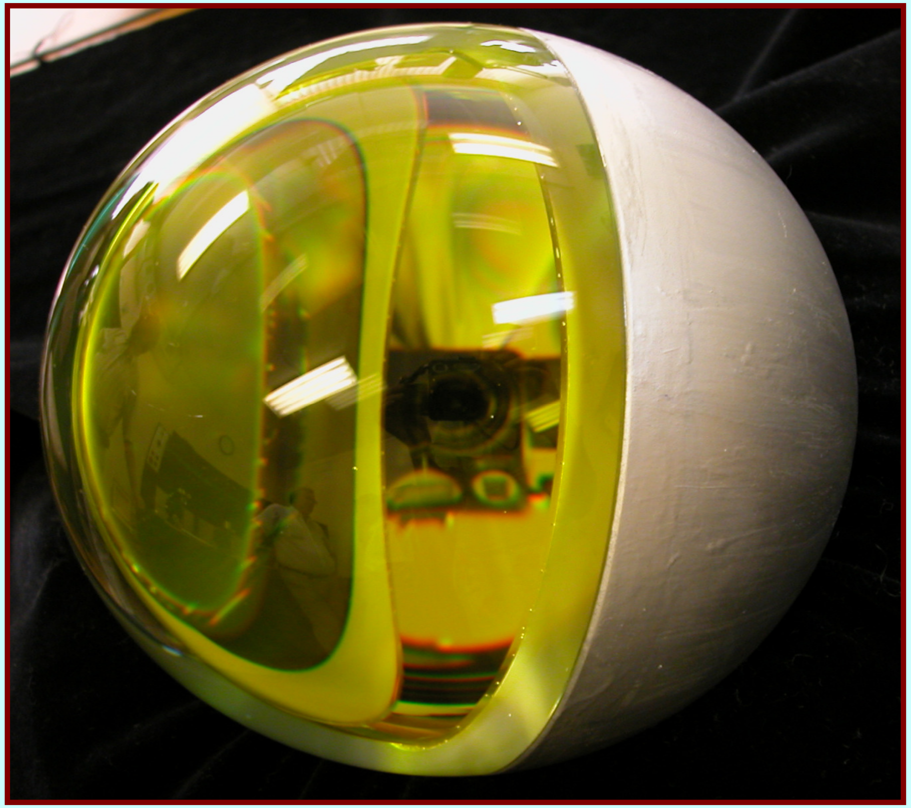


Most of the return signal energy is in the first-order annular mode

ZERO-SIGNATURE SPHERICAL RETROREFLECTOR MICRO-SATELLITE

Microsatellite parameters

- Diameter: 17 cm
- Mass: 7.46 kg
- Cross-section: ~100,000 sq. m at λ=532 nm



Current status

- Return pattern measurement under varying ambient conditions
- Separation system development

Mission

- Carrier satellite: METEOR-M
- Carrier satellite orbit parameters: Height: 835 km (circular)
  Inclination: 99.7°
- Planned launch date: Late 2007

PERSPECTIVES:

1. INCREASED NUMBER OF GLASS LAYERS – INCREASED RETURN EFFICIENCY

2. SPHERICAL RETROREFLECTOR FOR OPERATION AT TWO WAVELENGTHS

λ_1 = 532 nm, λ_2 = 1064 nm