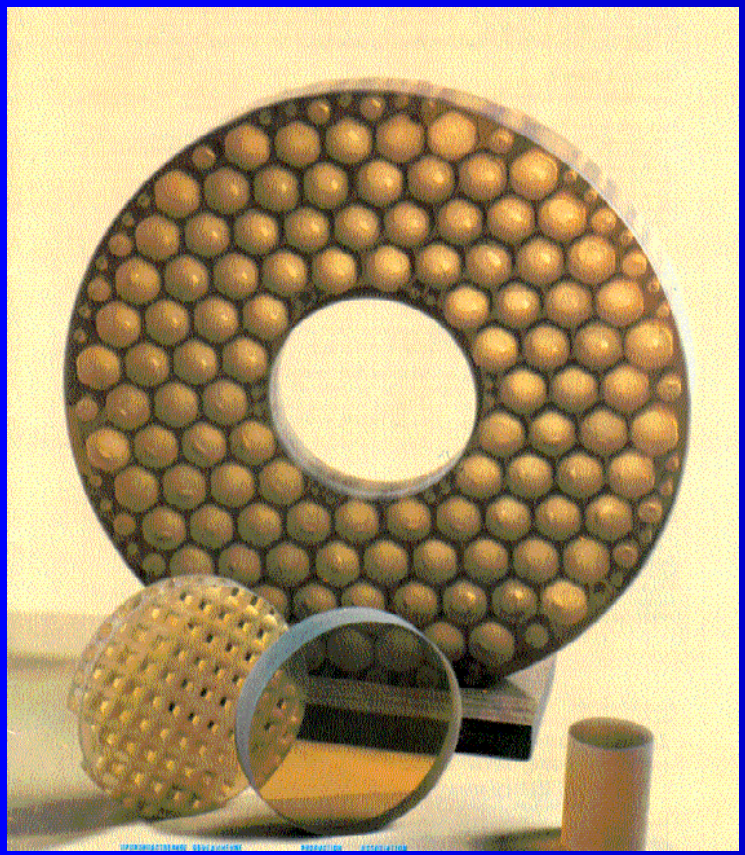


Computer technologies of aspherical high-precision optical machining

TSAM

Technologic

Systems of

Automated

Machining

PURPOSE

Production of high-precision optics, including aspherical and off-axis devices

CONTENT

- Automated systems (computer-aided machines);
- Metrology;
- Technological software

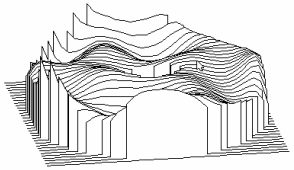
TECHNICAL CHARACTERISTICS

➢ Diameter of workpieces	from 10 up to 2000 mm;
➢ Machining accuracy	from λ/30up to λ/80 (λ = 0,6328 mcm);
➢ Type of worked surfaces	flat, spherical, aspherical (of 2 and higher order), off-axis

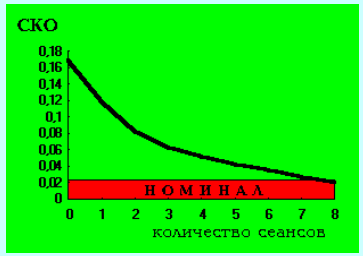
TSAM

Workpiece

Control before processing



WORK CYCLE



Detail processing

on APD-1000 machine tool

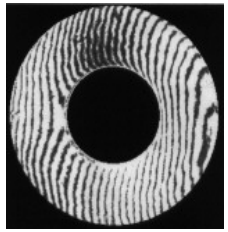
On APD-250 Machine tool

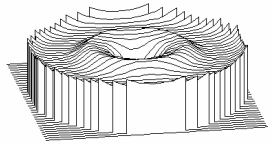
Surface form control

Interferometer IKI-1

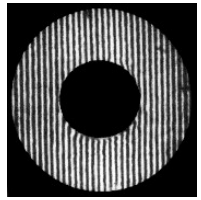
Interferometer PIK - PS

Surface Topographic map





Detail certification

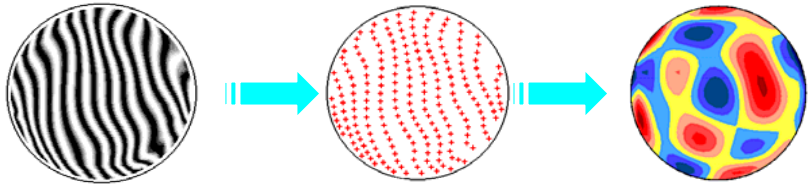


RMS, P-V

TSAM

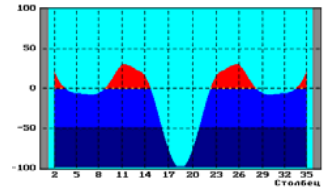
Program Int_to_Top

Interference pattern → *Extremum search* → *Topographic map*



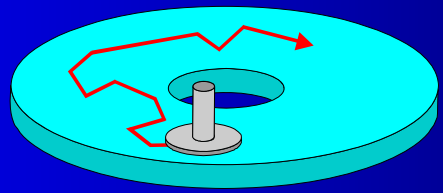
Program OSA

Axisymmetric detail machining using a polishing tool



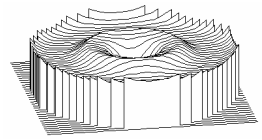
Program of automated machining - ADK

Program of process modeling MODEFOR



Program ION

Axisymmetric detail machining using an ion source

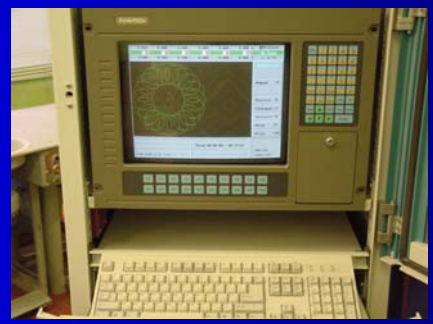


Automated computer-aided polishing machine APD

Basic control systems
For polishing machine APD

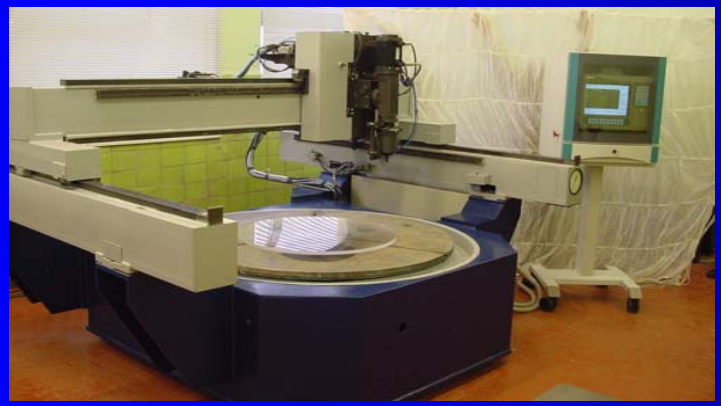
Control frame

Industrial computer



Driving unit

Finishing machine APD-250

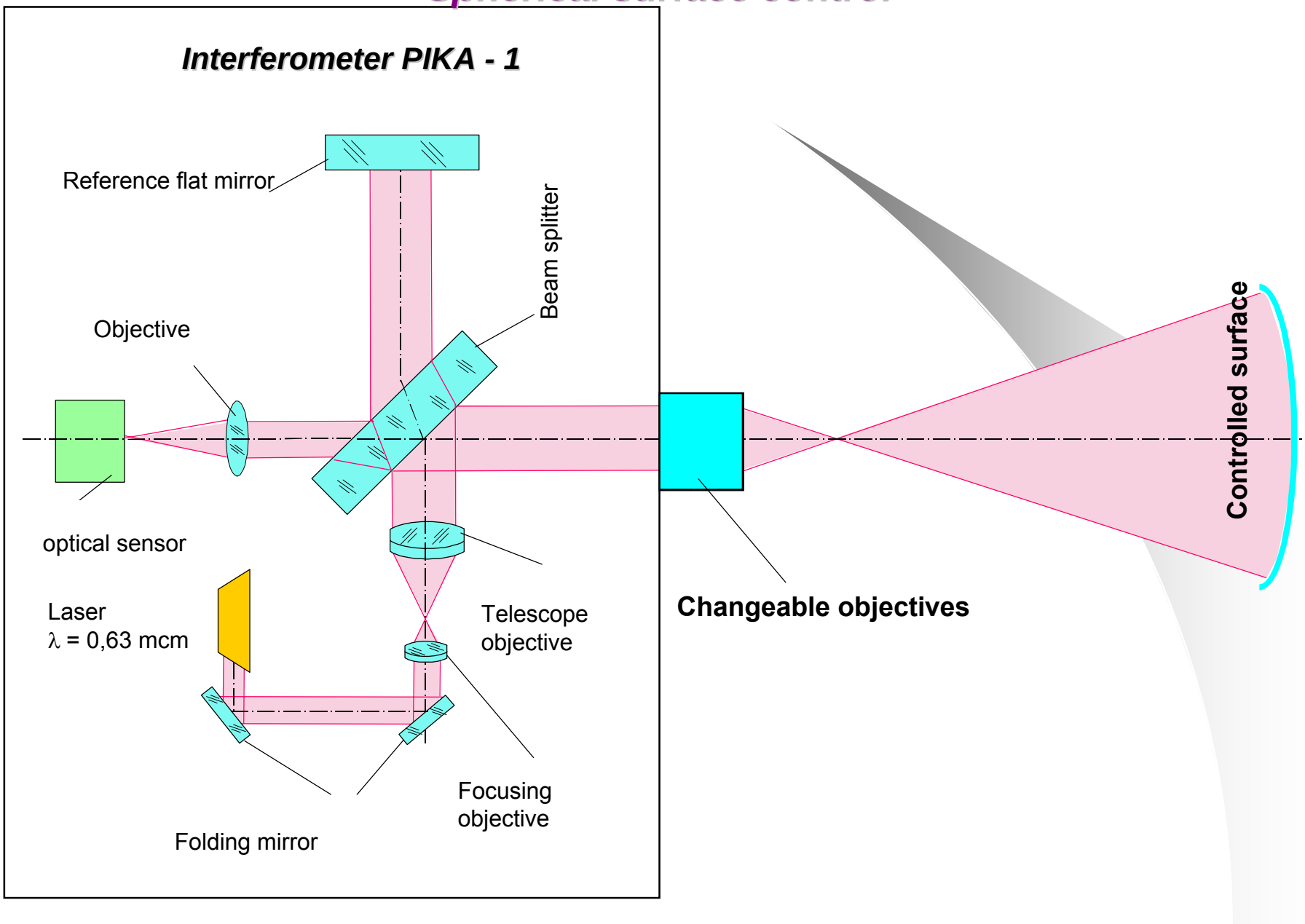


Automatic finishing machine APD-1000

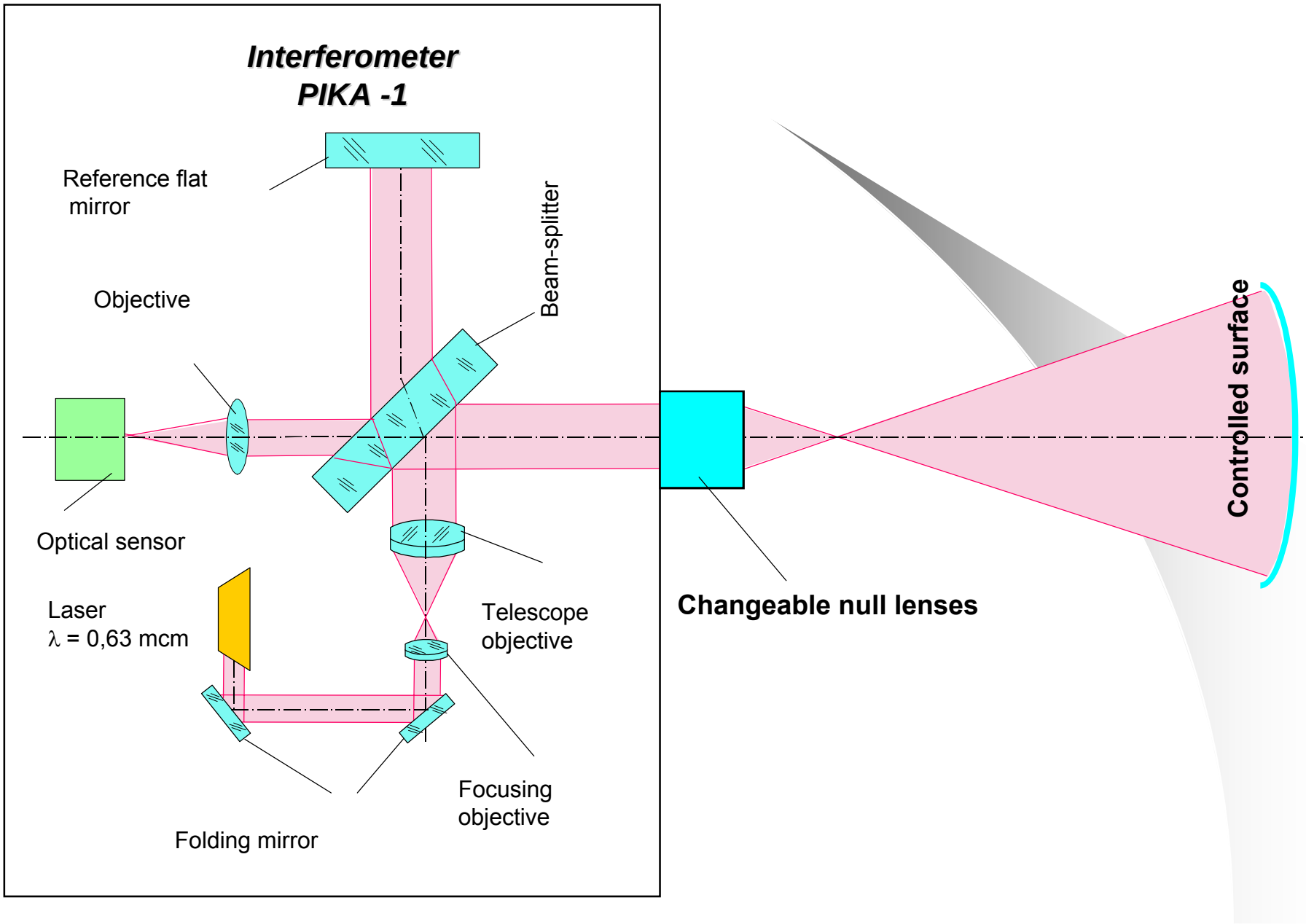
Automated aspherical mirror machining

Interference control systems

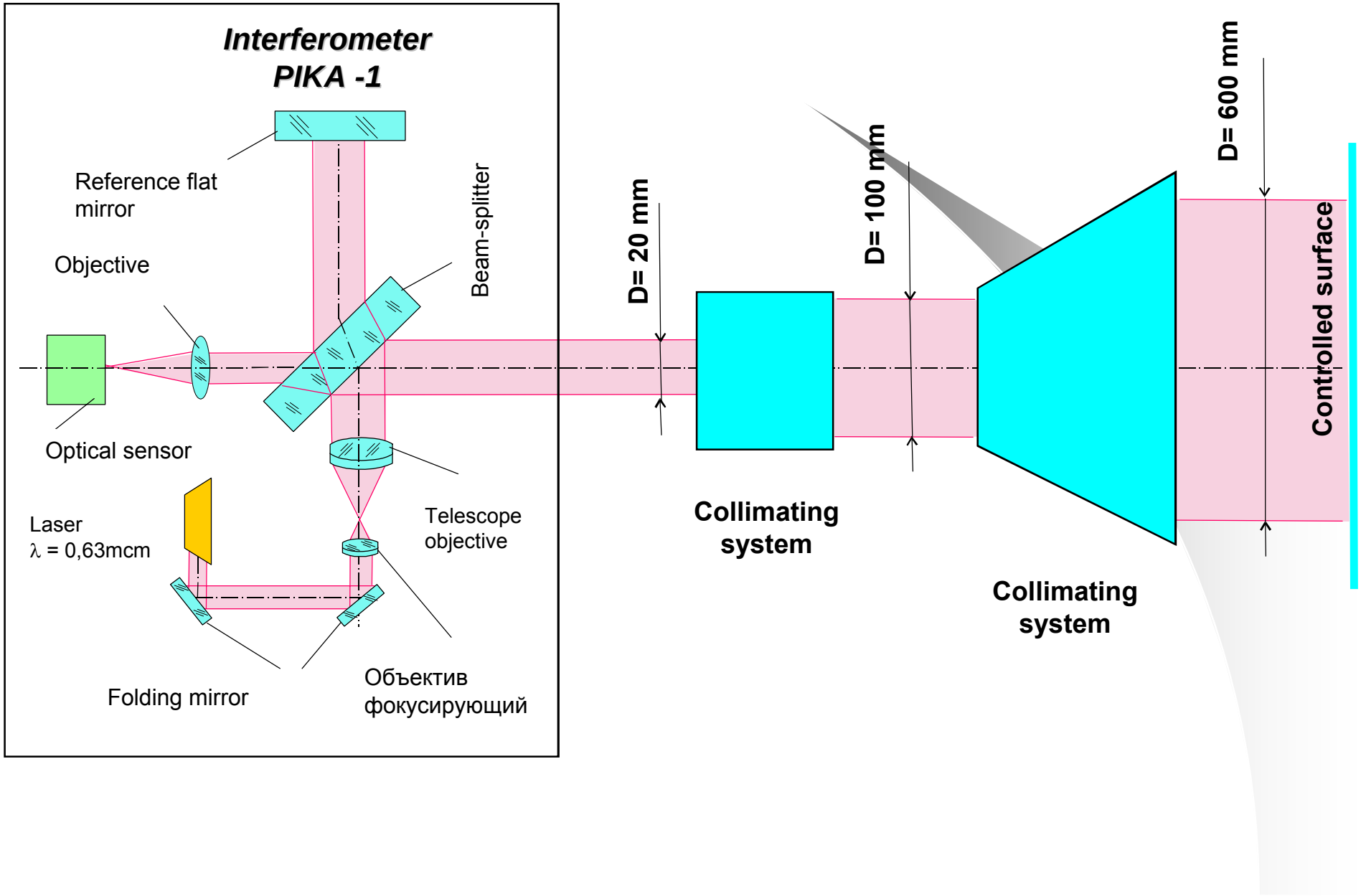
Spherical surface control



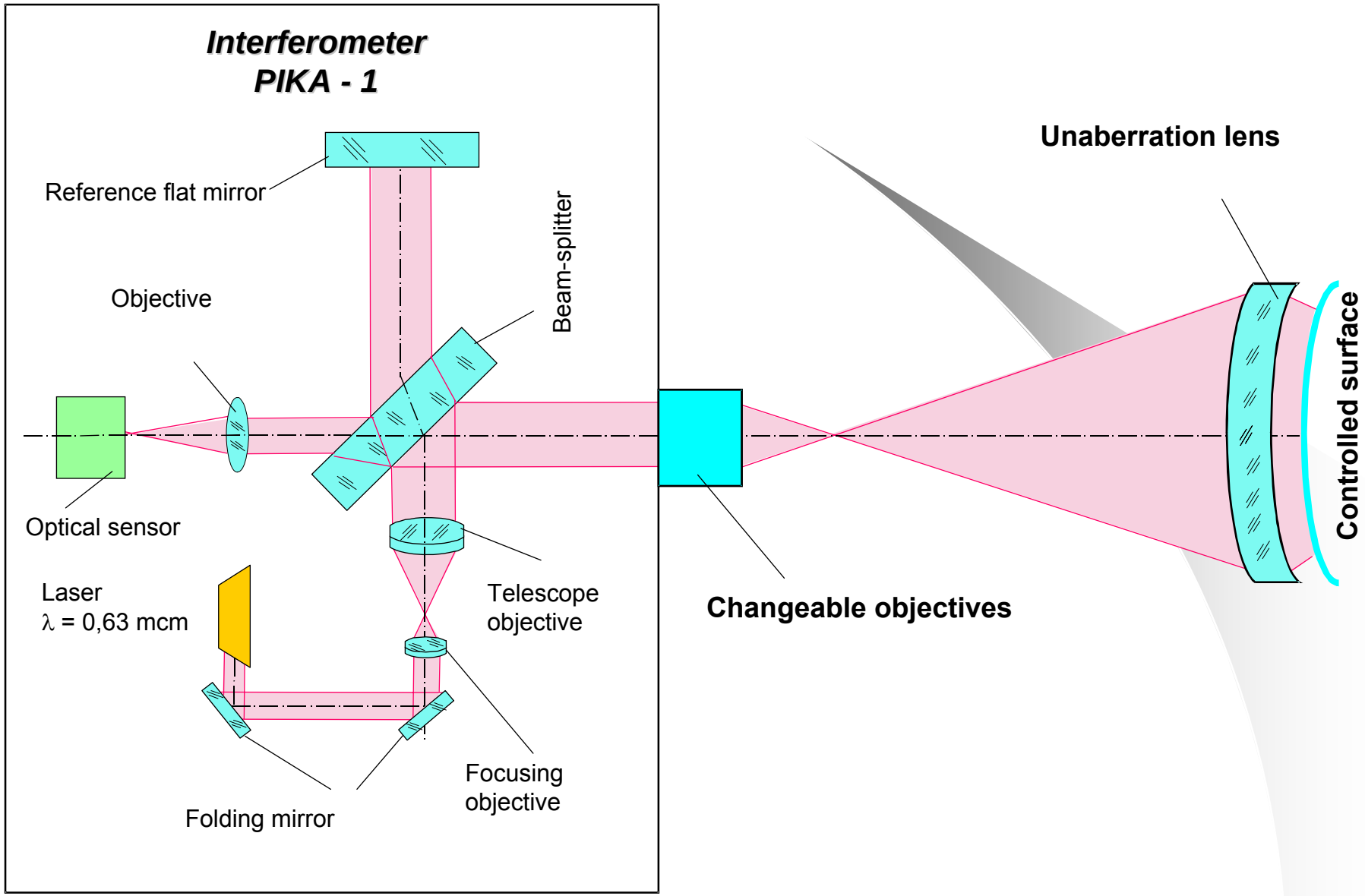
Aspherical concave surface control



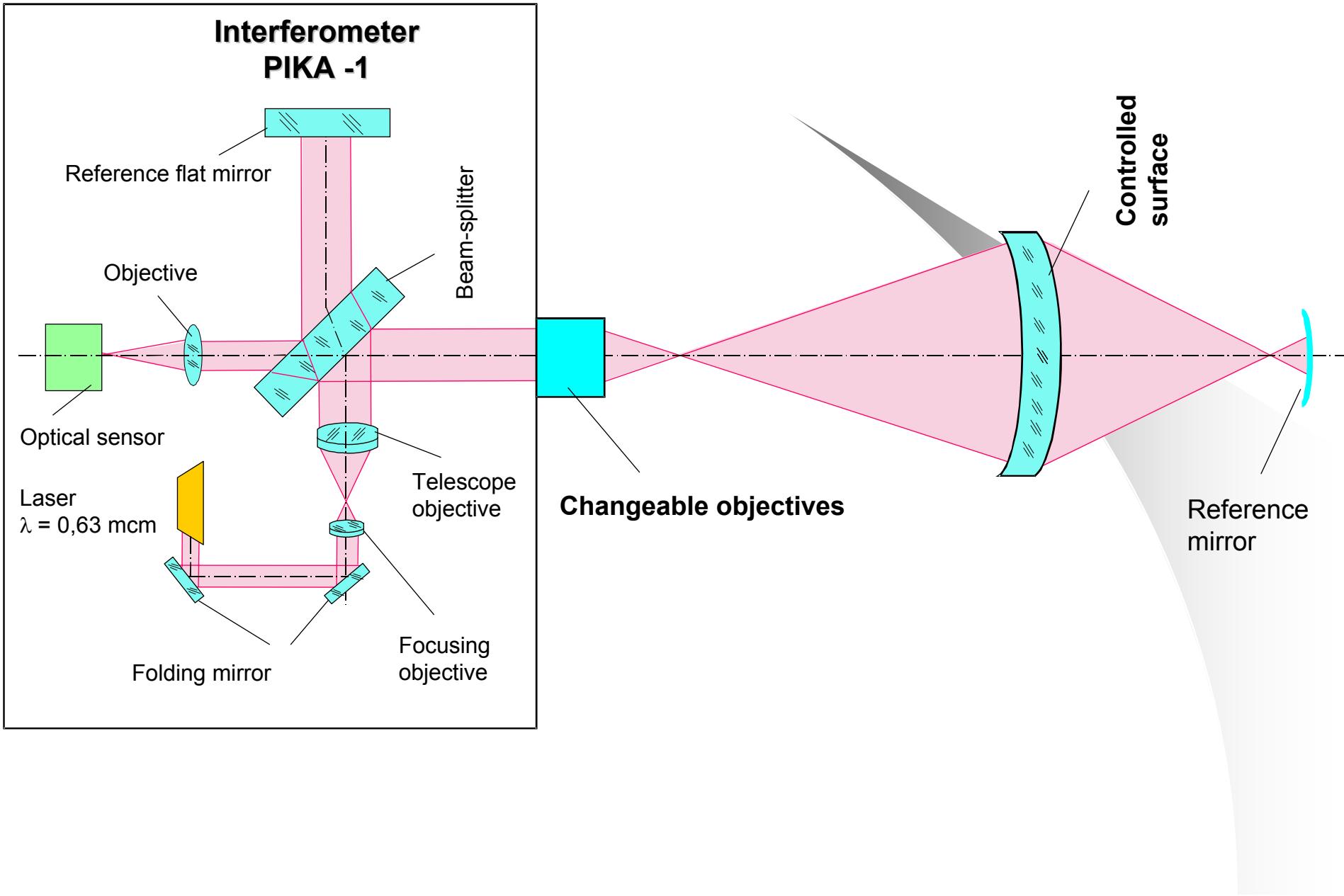
Flat surface control



Spherical convex surface control



Aspherical convex surface control



Interference control systems in visible and IR ranges

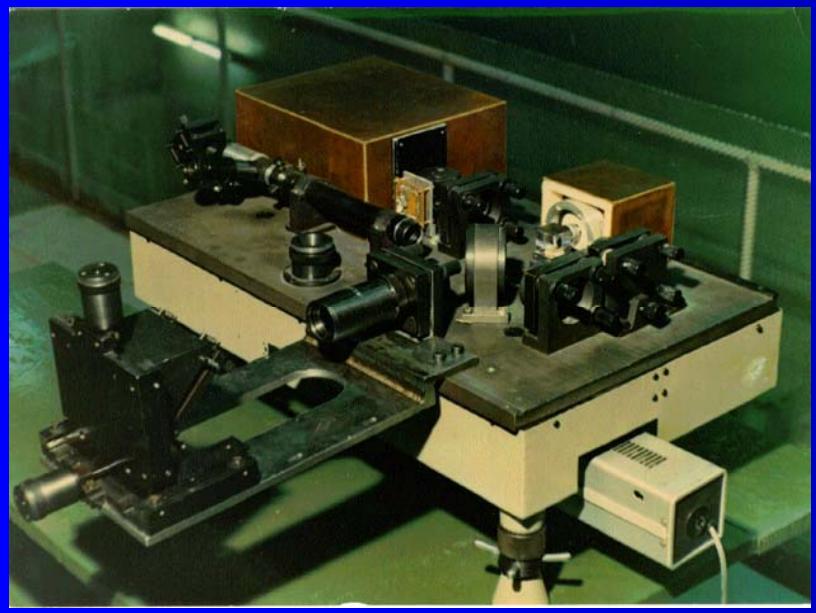
Universal interference complex MIK

Control of spherical and aspherical surfaces;
Wave front quality control;

In the lateral shift mode
Interferometer is resistant to external effect

- *Working mode* — *with reference wave front; lateral shift interference*
- *RMS measurement error* — *λ/ 60 with reference wavefront; λ/40 with lateral shift*
- *Maximal aperture of controlled surface* — *up to 1 : 3*
- *Interferogram analysis software* — *program Int_to_Top*

Photoelectric phase interferometer



Control of of flat, spherical (convex and concave) and aspherical surfaces; control of the wavefront quality

- *Controlled surfaces diameter* *up to 3000 mm*
- *Aperture ratio* *1 : 6 – 1:1*
- *RMS measurement error* *λ/ 250*
- *Interferogram analysis software* *program Int_to_Top*

Interferometer for aspherical control

Control of aspherical surfaces using an aberration compensator

- *Diameter of controlled surfaces* — *from 20 mm up to 3000 mm*
- *Aperture ratio* — *1 : 6 – 1:2*
- *RMS measurement error* — *λ/ 150*
- *Interferogram analysis software program Int_to_Top*

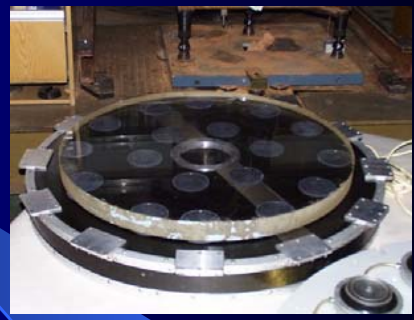
IR interferometer

Control of grinded surfaces

- *Controlled surfaces aperture 1:6 – 1:2*
- *RMS measurement error λ/ 60*
- *Main wave length 10,6 mcm*
- *Tuning wave length 0,6 mcm*
- *Measurement method amplitude*

Technological mountings for optical workpieces holding, basing and off-loading

Membrane - pneumatic mounting for workpieces up to 600 mm (vertical testing)



Membrane - pneumatic mounting for workpieces up to 1000 mm (vertical testing)

Mechanical tape mounting (horizontal testing)

Up to ∅600 mm

Up to ∅1000 mm

Technological equipment and accessory for the technology of optical coating vacuum sputtering with ion assistance

BASIC DATA:

SUBSTRATE
- glass (n=1,48-1,8)
- crystals (n=1,8-3,0)
- semiconductors (n=3,0-4,0)
- plastics

FILM-FORMING MATERIALS:
fluorides, oxides, selenides, rare-earth metals sulphides (n=var)

REQUIRED SPECTRAL CHARACTERISTICS

R, T, $\lambda\Delta 0{,}5/\lambda$ etc

COATING CORRECTION

TECHNOLOGICAL CONTROL:
multiwave spectrophotometer

REQUIRED SPECTRAL CHARACTERISTICS OBTAINING

Program PLENKA

Coating design and synthesis, adapted for the use of ILO-200 source, the photometric control process calculation

VACUUM UNIT VU-2M:
the coating deposition process
(substrate ion cleaning, coating deposition

with ion assistance ILO-200)

FINISHED PRODUCTS

TECHNOLOGICAL EQUIPEMENT:
ILO-200;
the system of gas SNA-2 puffing;

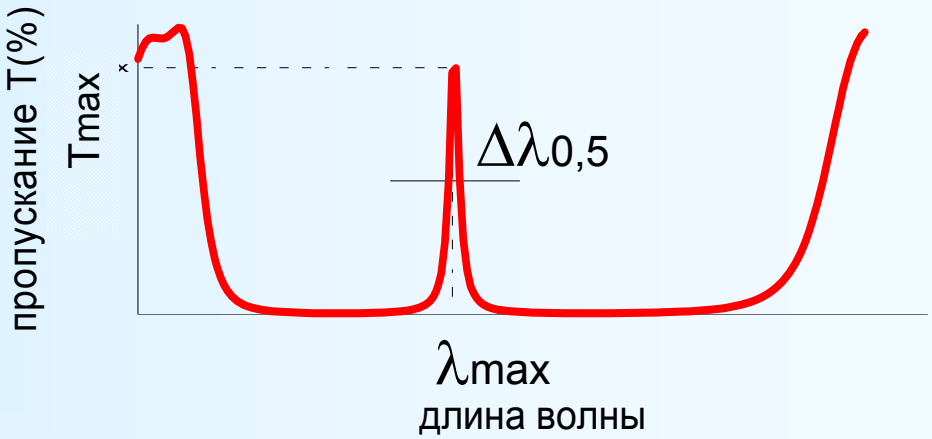
evaporators

ION-BEAM SOURCE ILO - 200

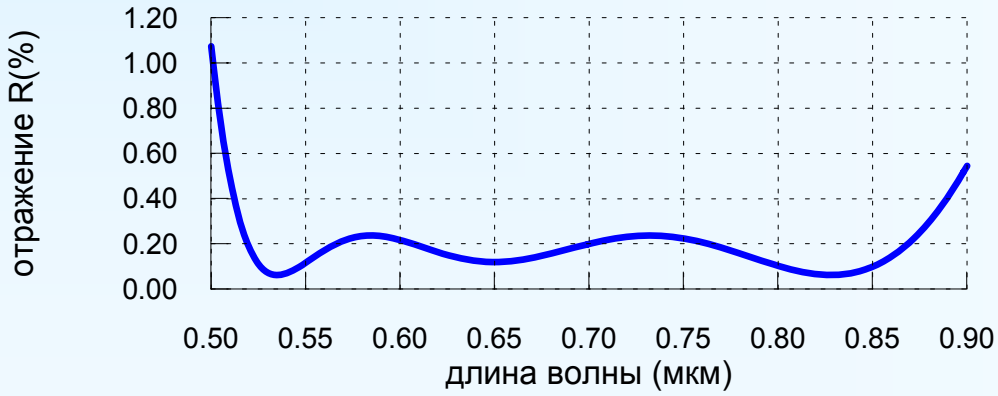
Masks set for ion machining

Optical coatings

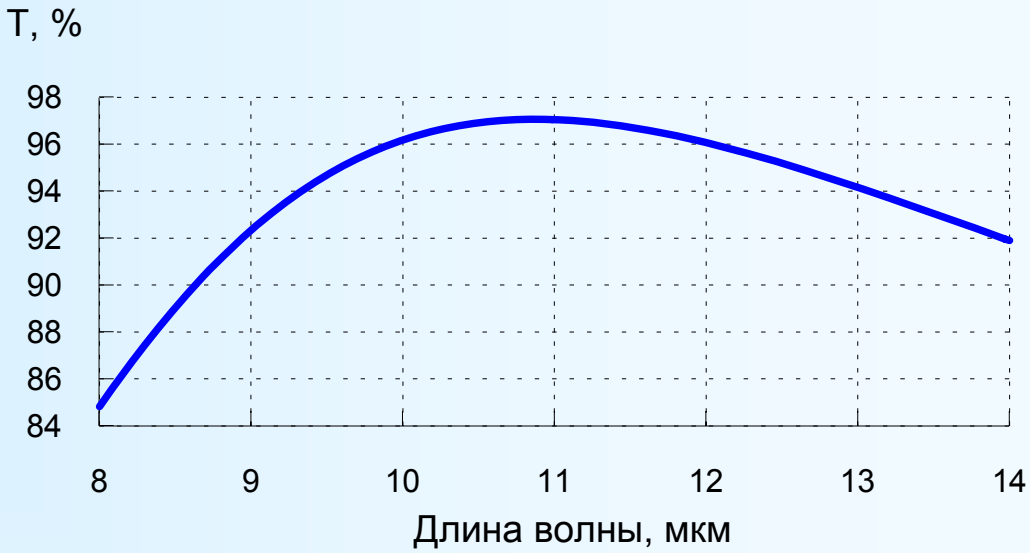
Multilayer narrow-band filters for UV, visible and IR spectral ranges



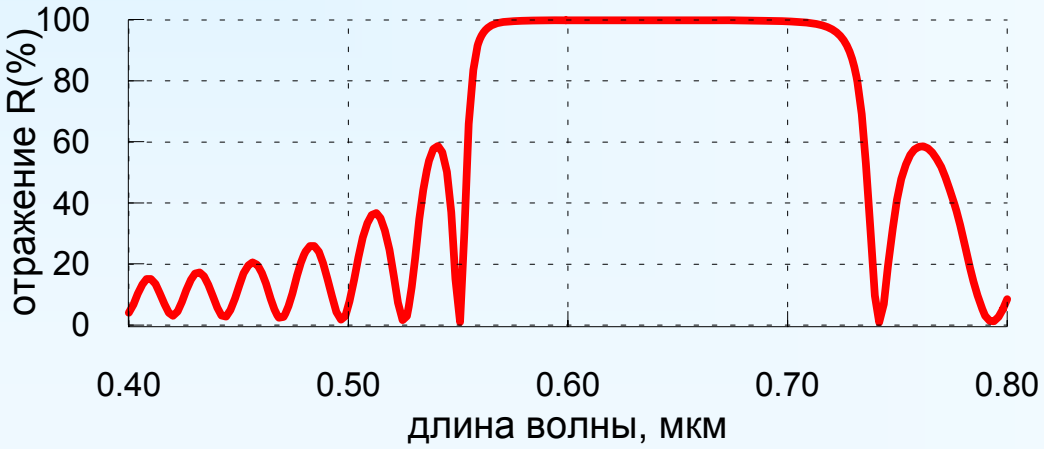
Achromatic AR Coatings for spectral range 0,3÷1,2 μm



AR coatings of semiconducting materials and optical ceramic for IR spectral range

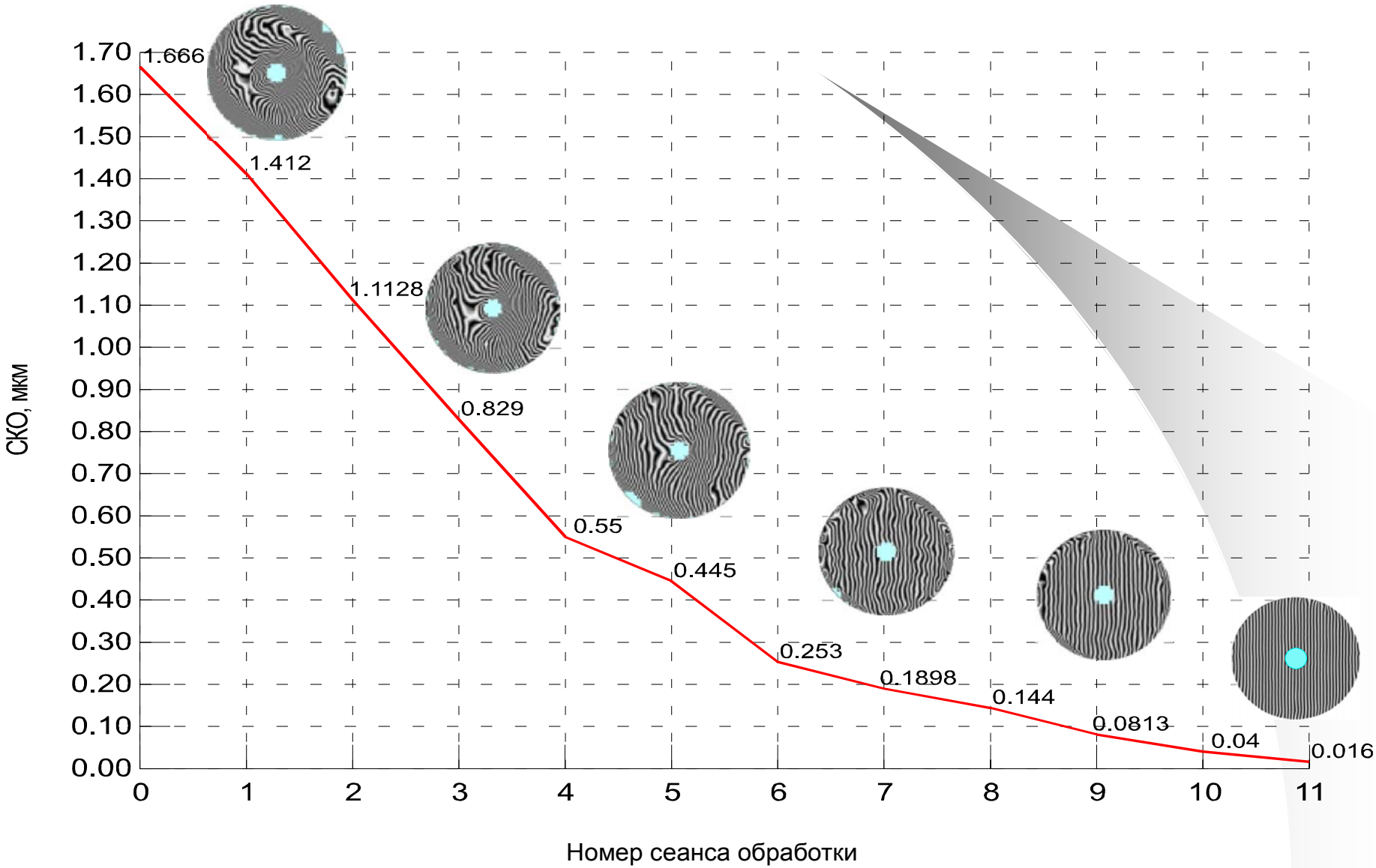


Multilayer dielectric coatings for mirrors



Optical work bay for automated machining

Stages of parabolic mirror machining ∅1000 mm



Results of the mirror processing of different diameter

Form accuracy:
RMS nominal
RMS real

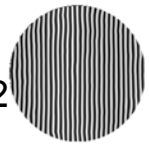
for wave length λ = 0,6328 mm

∅ 200 мм

λ/30
λ/35,7

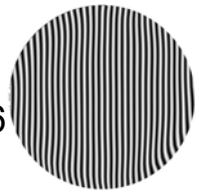
∅ 300 мм

λ/30
λ/42,2



∅ 400 мм

λ/30
λ/52,6



∅ 500 мм

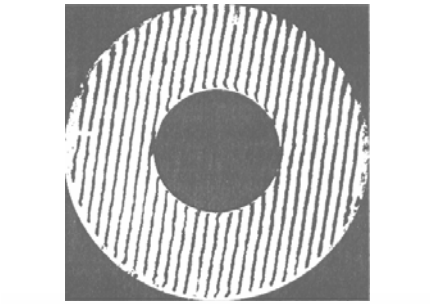
λ/30
λ/46,9

λ/30
λ/40

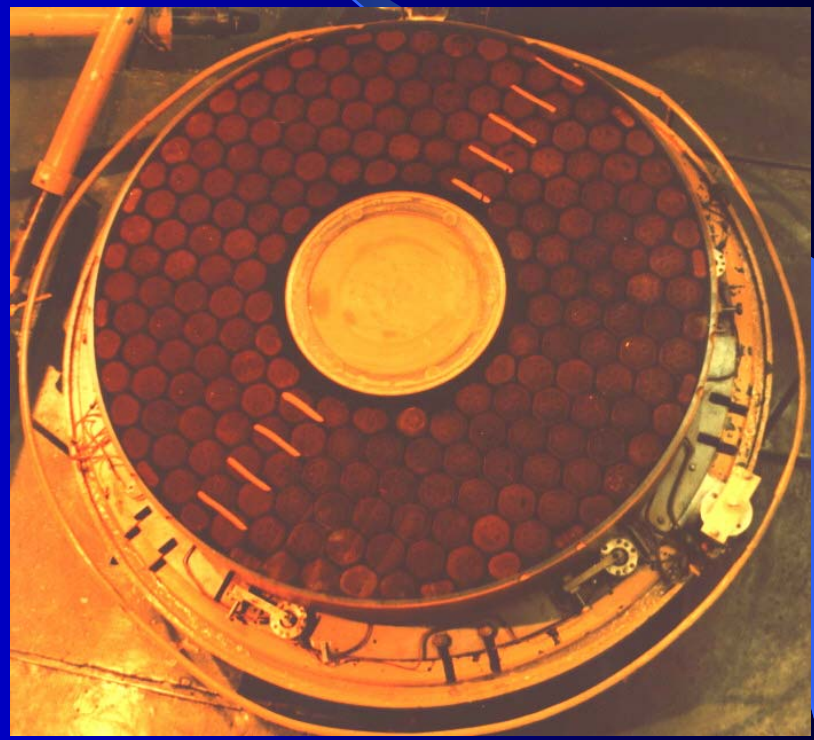
∅ 1500 мм

Optical details produced with computer technologies

Hyperbolic mirror
(Zerodur, diameter = 1540 mm,
axial thickness = 300 mm)

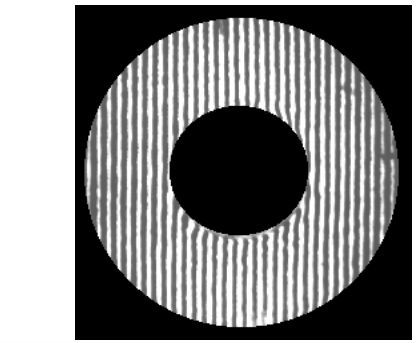


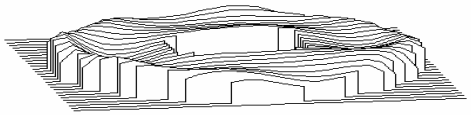
RMS=0,015 мкм= λ/42
P-V=0,075 мкм= λ/8,4



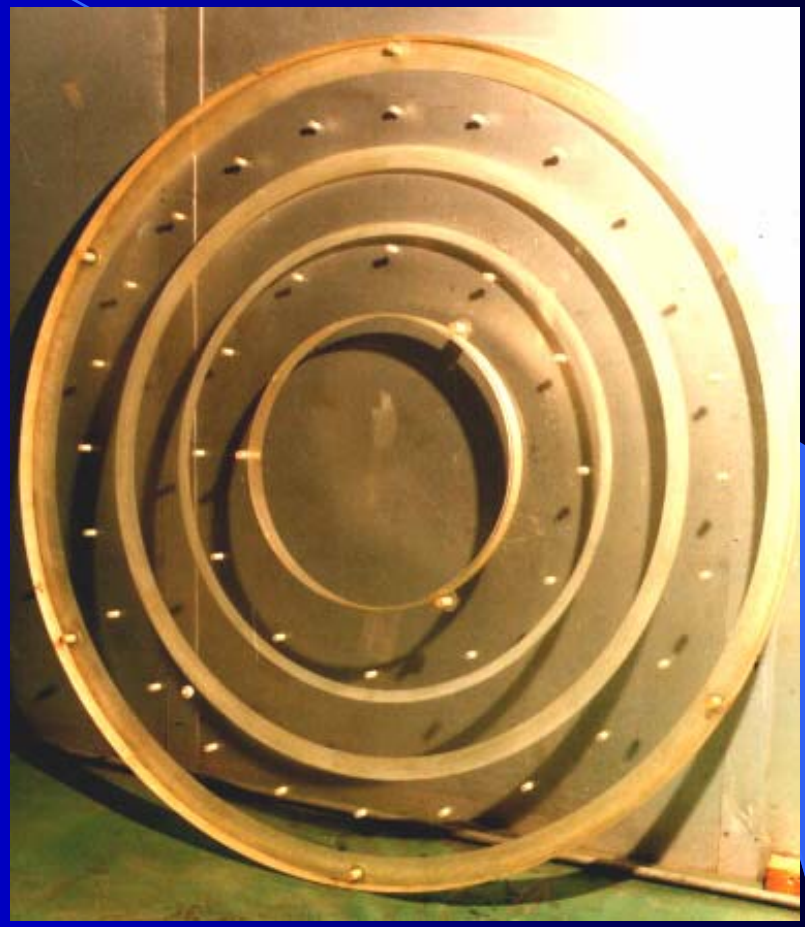
Thin adaptive mirror

(quartz, diameter = 1550 mm, axial thickness = 45 mm)



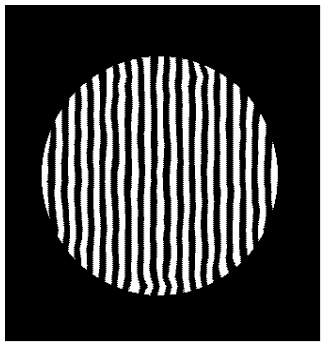


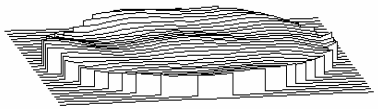
RMS=0,025 мкм= λ/25
P-V=0,15 мкм= λ/4,21



Off-axis parabolic mirror

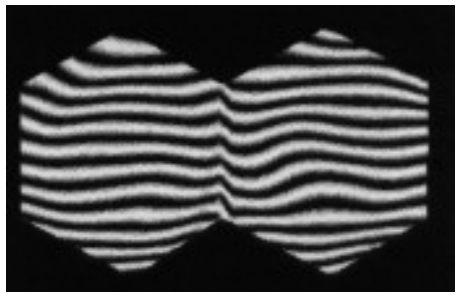
∅400 mm

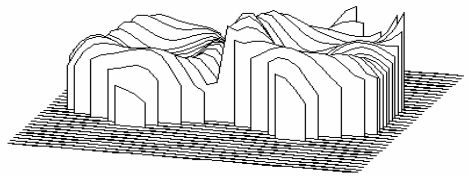




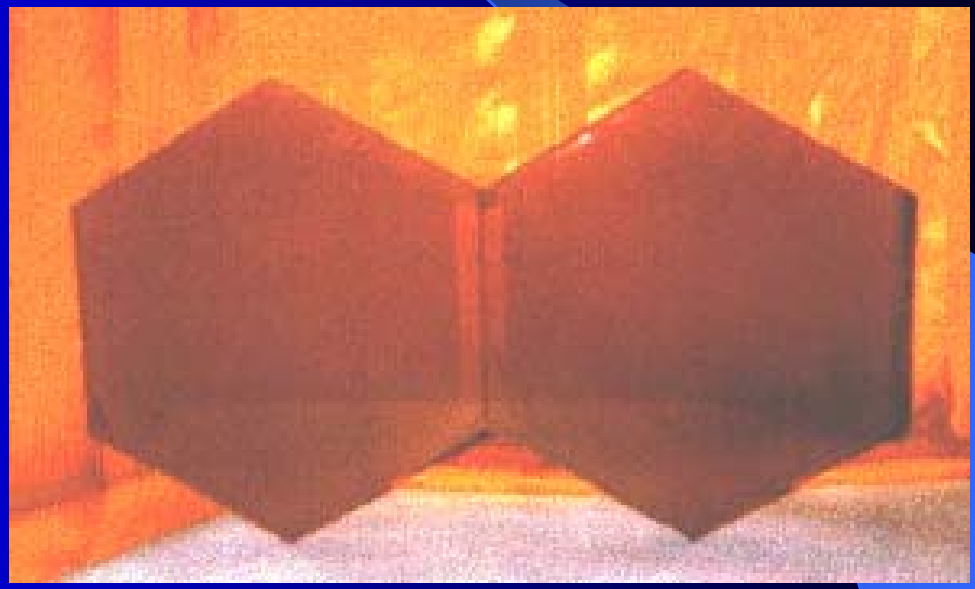
RMS=0,009 мкм=λ/70
P-V=0,091 мкм=λ/6,96

Central and off-axis elements of parabolic mirror (off-axis parameter = 375 mm, diameter of circumcircle = 420 mm)

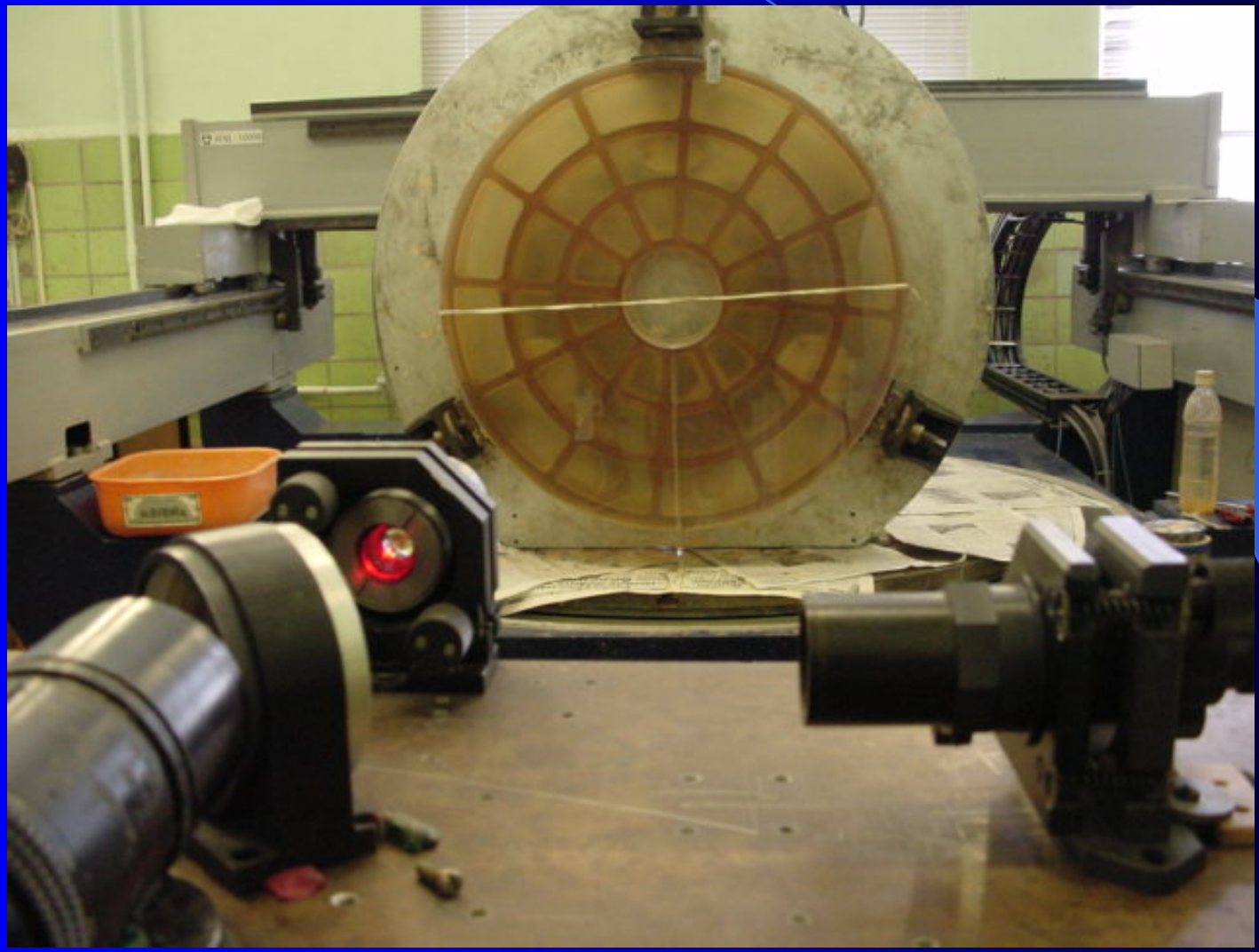




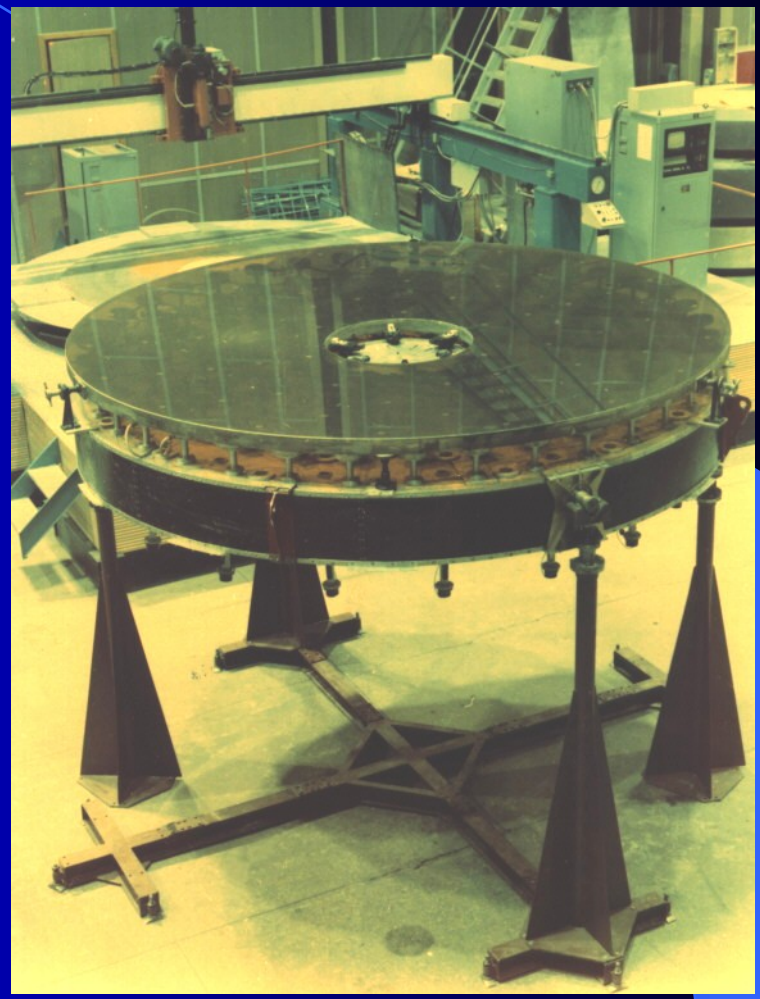
RMS=0,06 мкм=λ/11
P-V=0,31 мкм= λ/2



Interference control of aspherical mirror ∅ 700 mm



Adaptive mirror ∅ 3000 mm



Toroidal mirror

Optical elements with aspherical surfaces

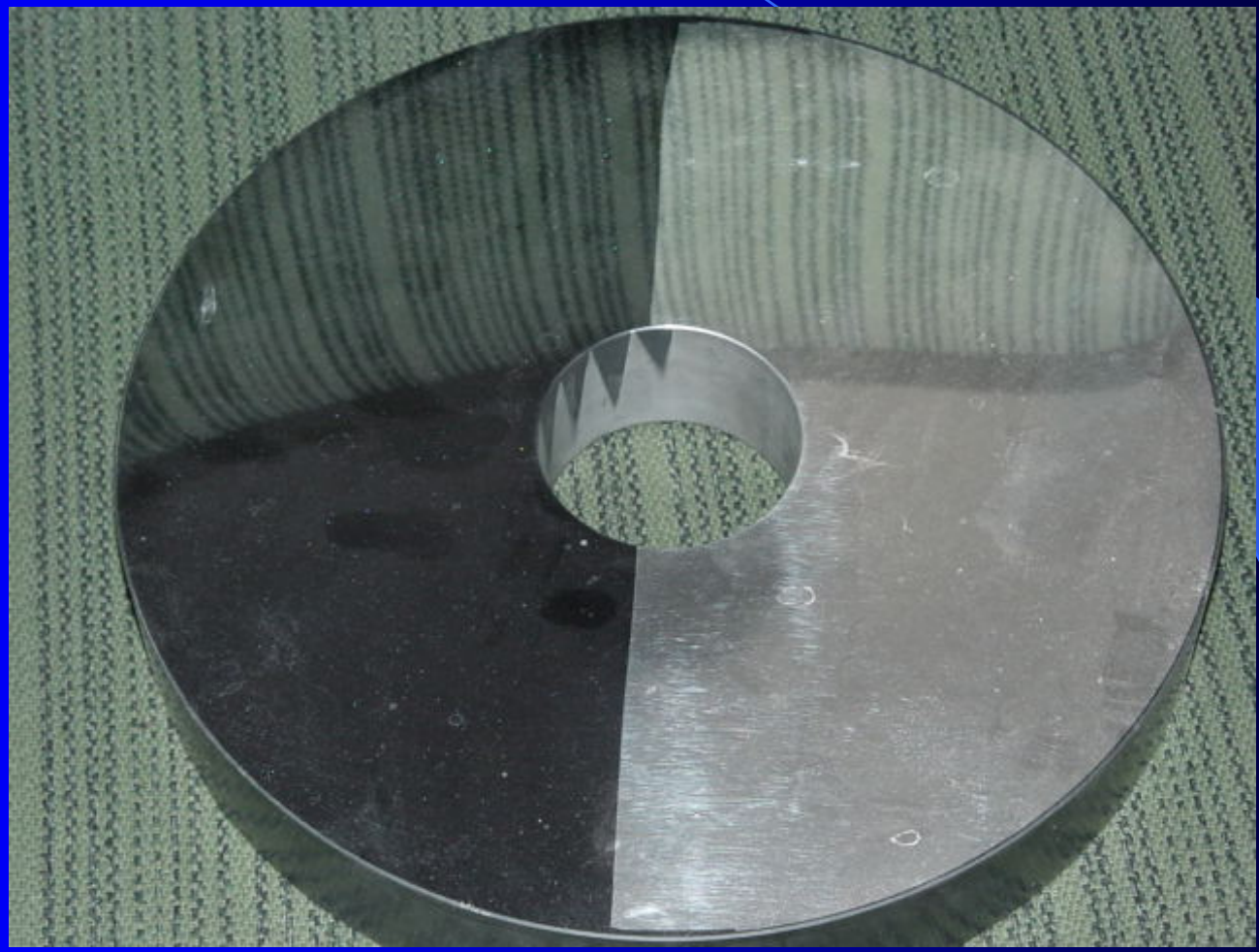
Mirror collimator ∅ 700 mm

Lightweight parabolic mirrors

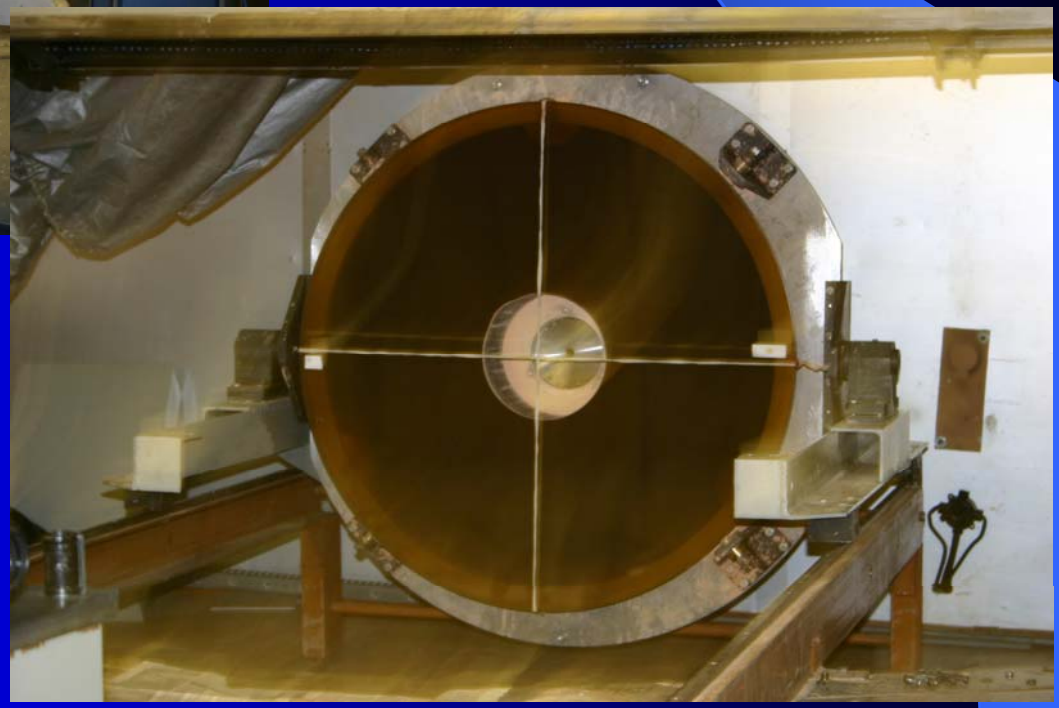
D = 250 mm

D = 400 mm

Silicon carbide aspherical mirror ∅ 250 mm



Aspherical reflector ∅ 1000 mm



Radiometer aspherical components

Radiometer (optical-mechanical system)

Optical element with two aspherical surfaces glued