РОССИЙСКИЙ ФЕДЕРАЛЬНЫЙ ЯДЕРНЫЙ ЦЕНТР ВНИИЭФ

Laser Facility Development and Principle results during recent 5 years

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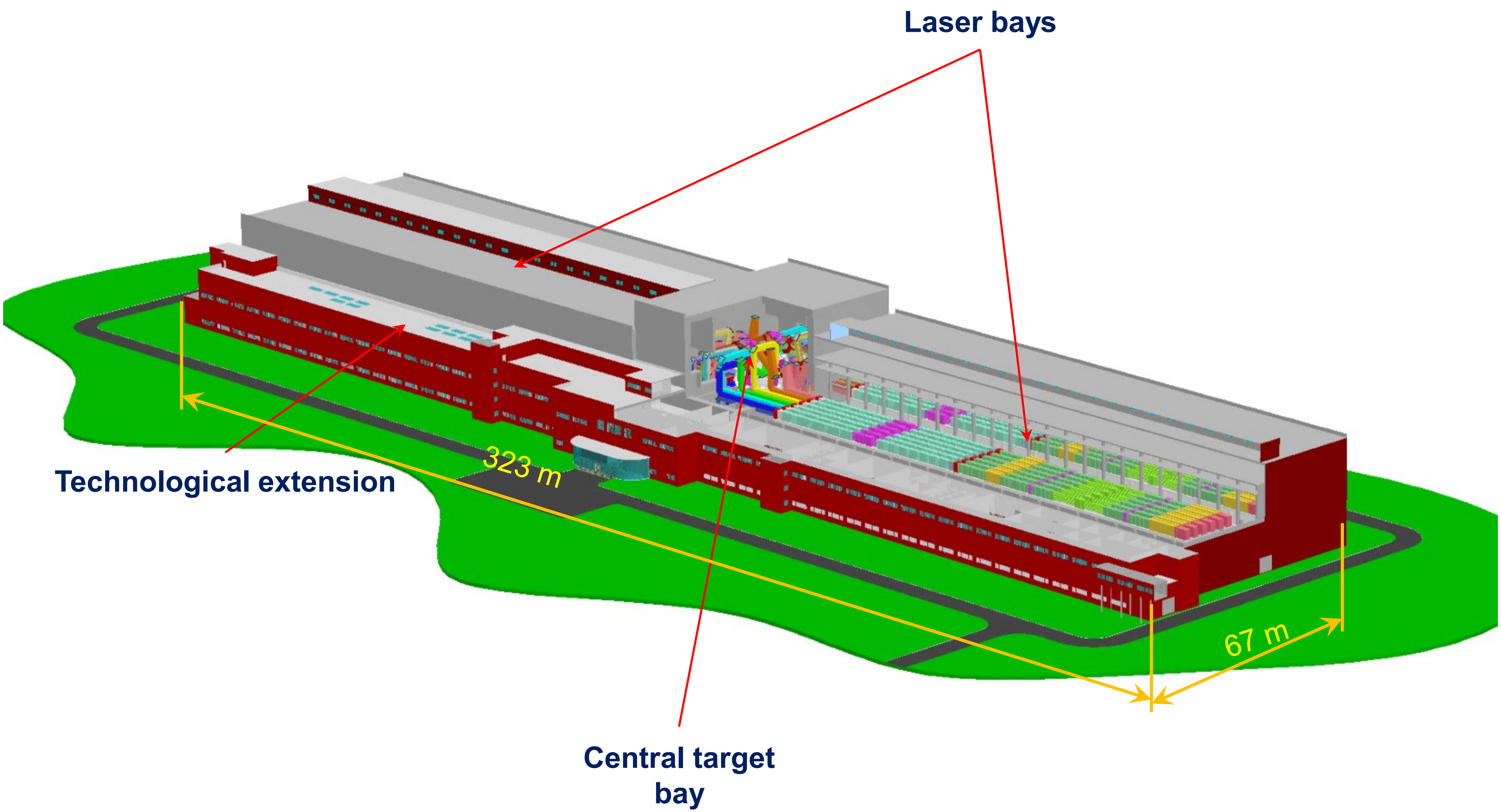
Main stages finished up to now

- Complex of buildings to house systems of laser facility was developed. Construction activity was begun.
- Set of input test benches to control regular large aperture optical components and high voltage electronics were developed.
- Technologies of serial production of key elements and component parts of laser were created.
- Prototype units of component parts were manufactured and tested.
- Industry is ready to make component parts.

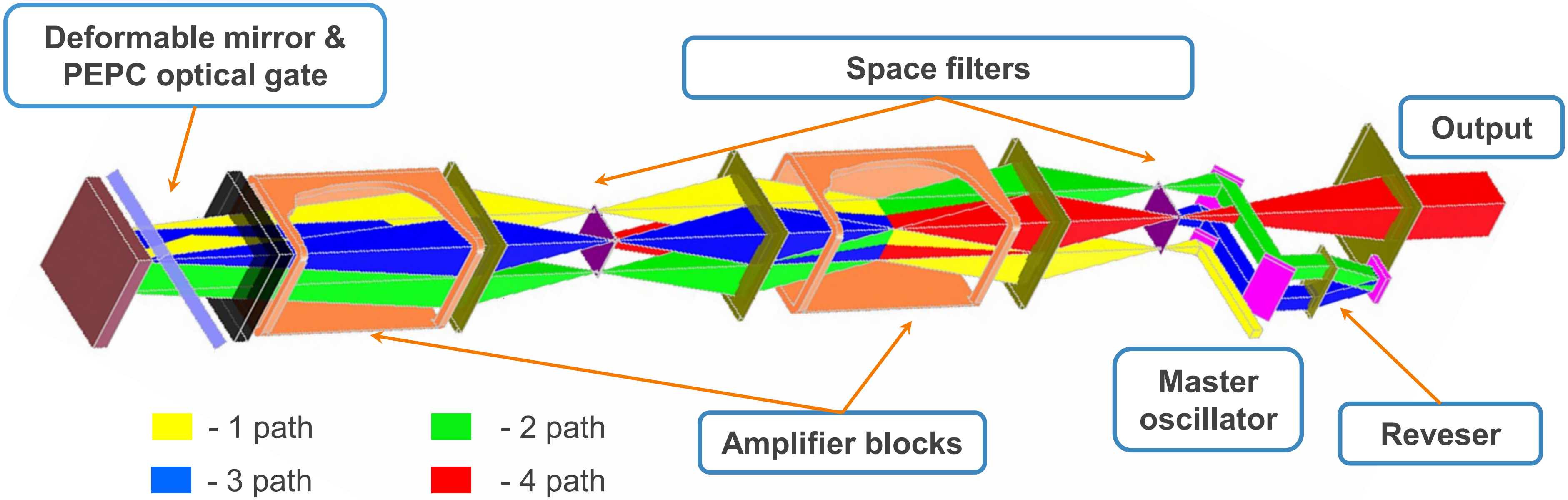
Common view of laser facility



Building construction

top – 30.09.2015 bottom – 16.09.2016

4 pass op ain laser amplifier

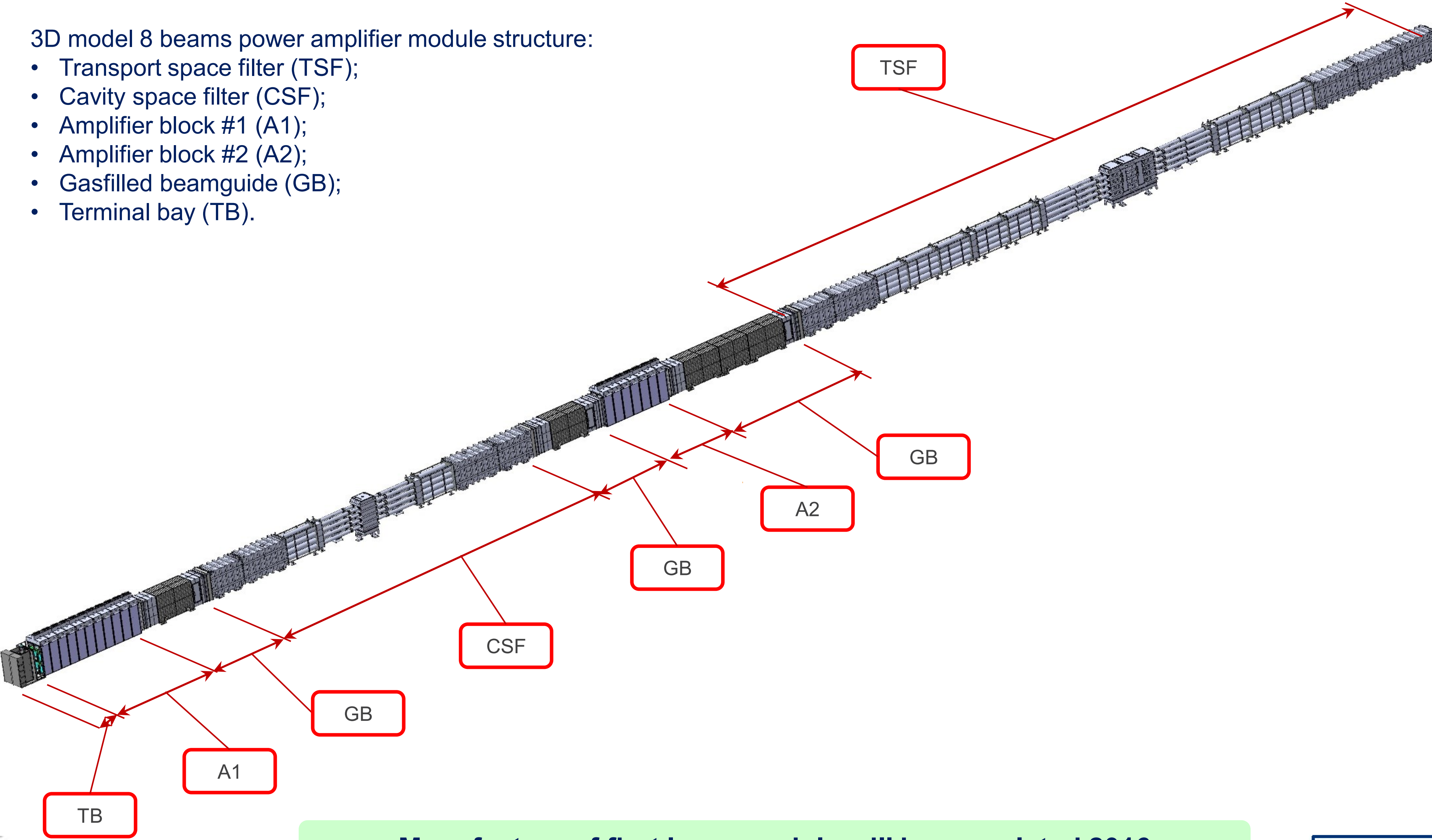


Numbers of laser beams will be 192

8 beams power amplifier module

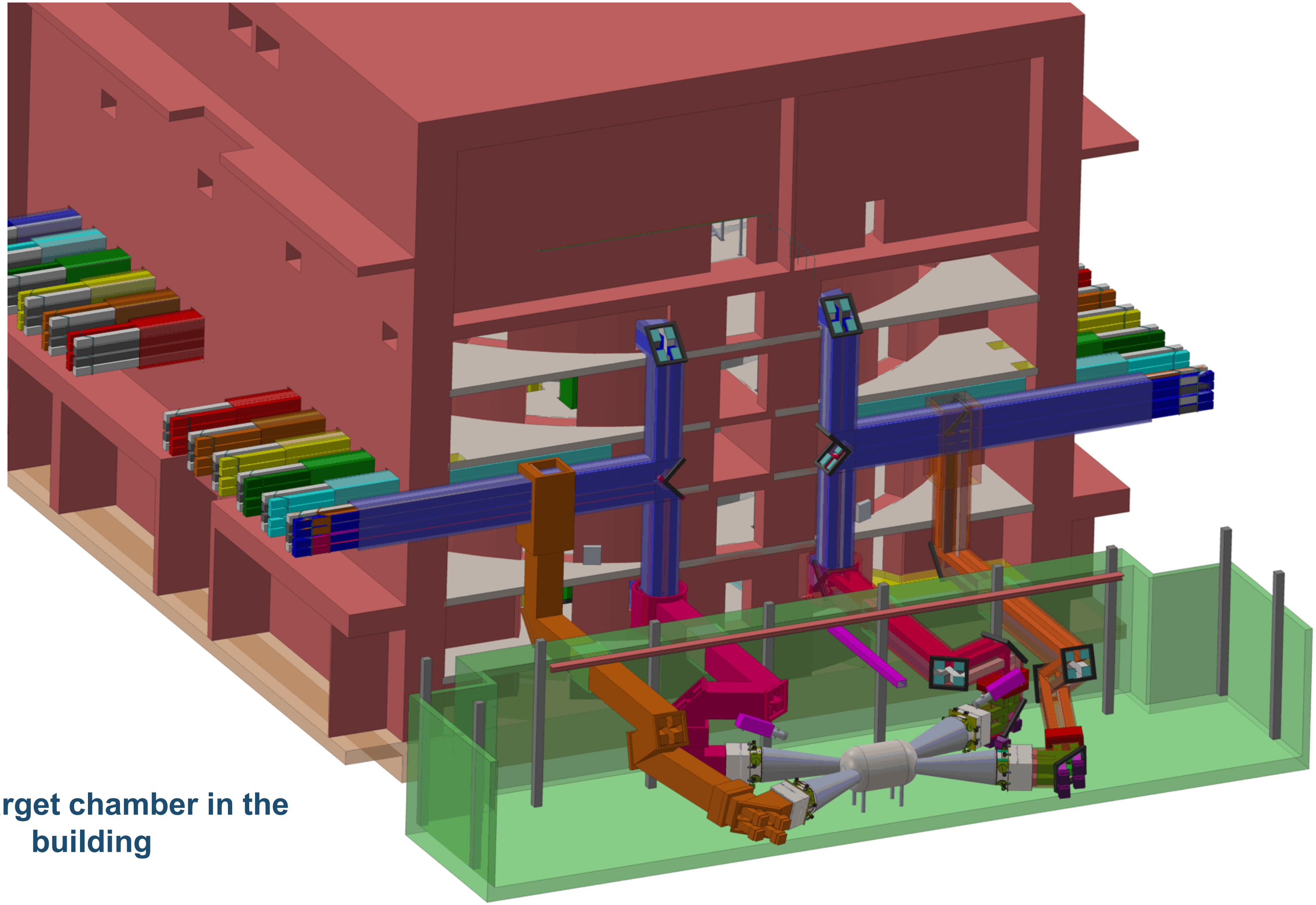
3D model 8 beams power amplifier module structure:

- Transport space filter (TSF);
- Cavity space filter (CSF);
- Amplifier block #1 (A1);
- Amplifier block #2 (A2);
- Gasfilled beamguide (GB);
- Terminal bay (TB).



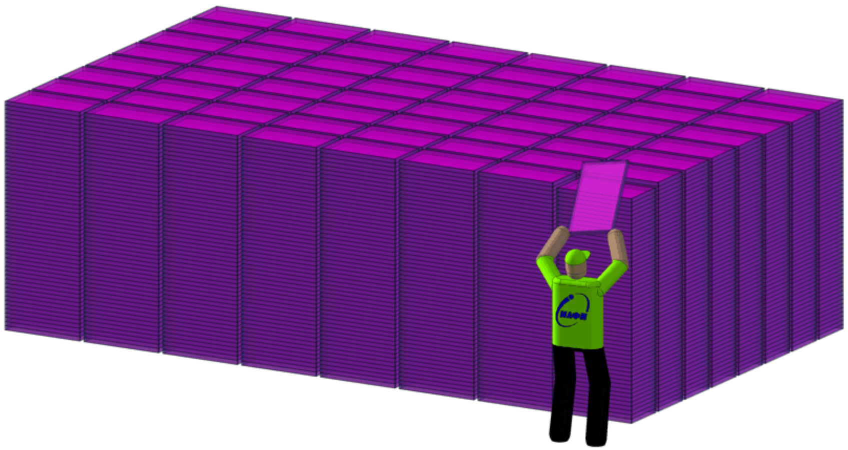
Manufacture of first laser module will be completed 2016

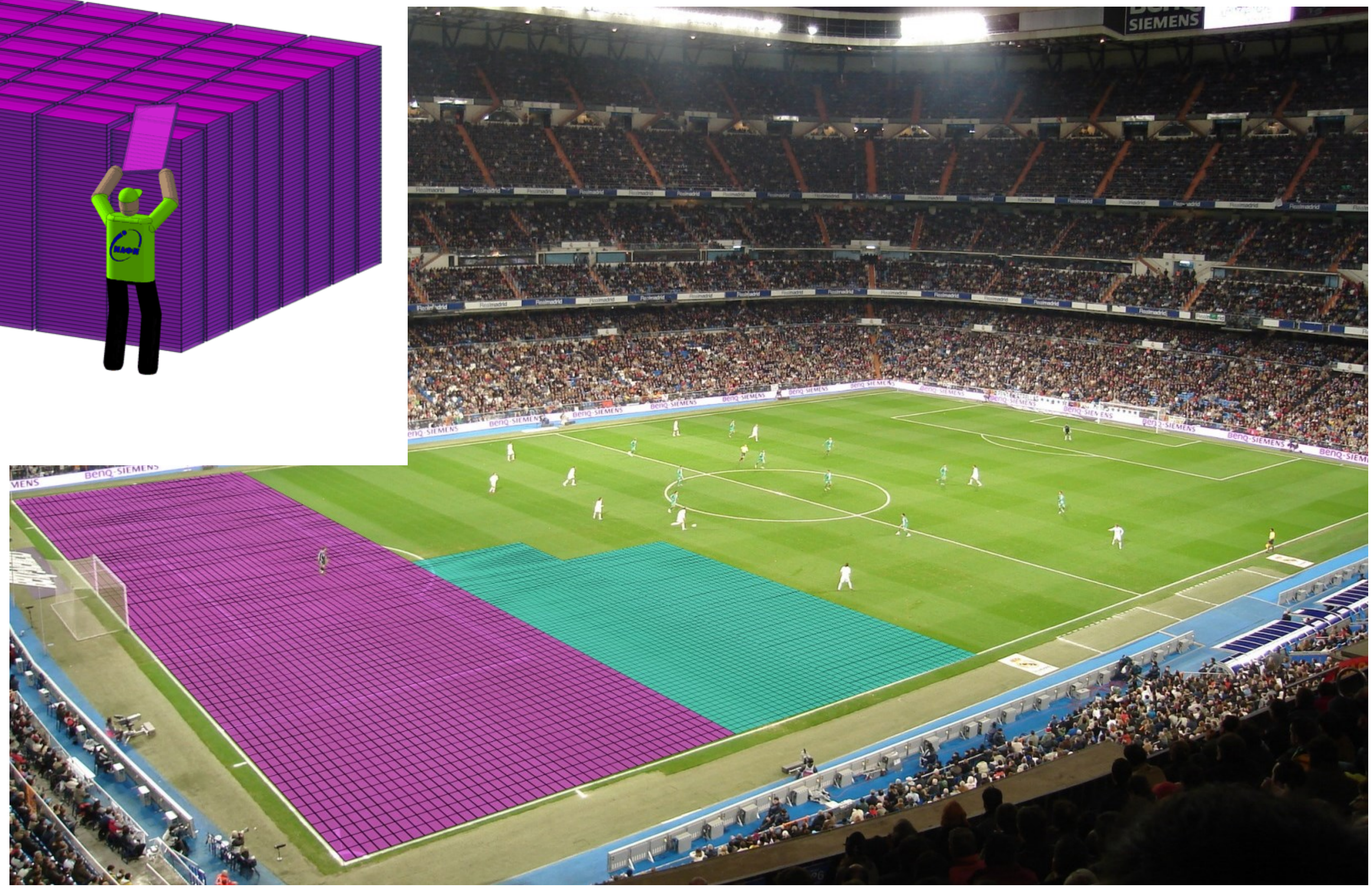
Laser facility will have 2 target chambers. Second chamber will be used for different application studies as Multipurpose Research Center (MRC)



MRC target chamber in the building

Laser facility will have huge numbers largescale





All elements are needed to test before they will be mounted. For this purpose set of test benches of input control were developed.

Optical elements fabrication errors, influence on the beam quality

Wave front and surface profile parameters					
Measured band	I		II	III	IV
Spatial scale, mm	> 33		2.5 - 33	0.12 – 2.5	0.01 – 0.12
Apertures size, mm	415 x 415				
Beam size, mm	415 x 415		415 x 415	18 x 18	1 x 1
Parameter	PV (λ)	Rms gradient (nm/cm)	Rq (nm)	Rq (nm)	Rq (nm)
Optical type: Glass	0.3	7	1.8	1.1	0.4

Optical elements with size from ∅ 360 to 900 mm

Radiation dispersion

Intensity modulation

Divergence on the output of amplifying channel

General subject: Θ=5×10⁻⁵radian

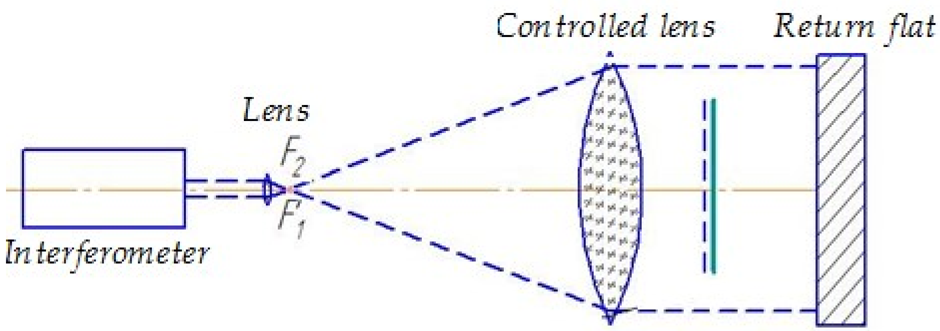
Aberrations of an ideal optical system

Aberrations rose from optics fabrication errors and their misplacement in scheme

Thermal aberrations

Test benches for interferometric control

Focal distance measurements



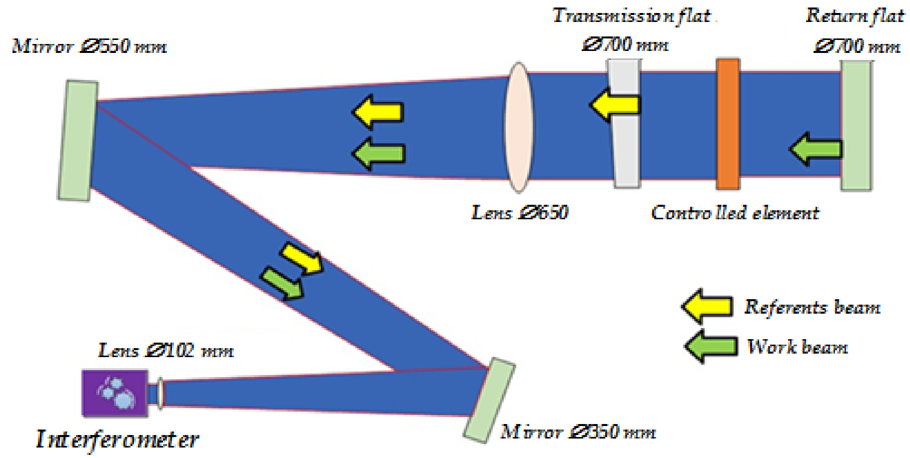
1. **Determination of actual values of focus in the range from 5 to 30 m lens with diameter from 100 to 600 mm with inaccuracy ≤1 mm.**

2. **Measuring of radiation wave front transmitted through the lens with diameter up to 600 mm with inaccuracy <0.002λ (RMS).**

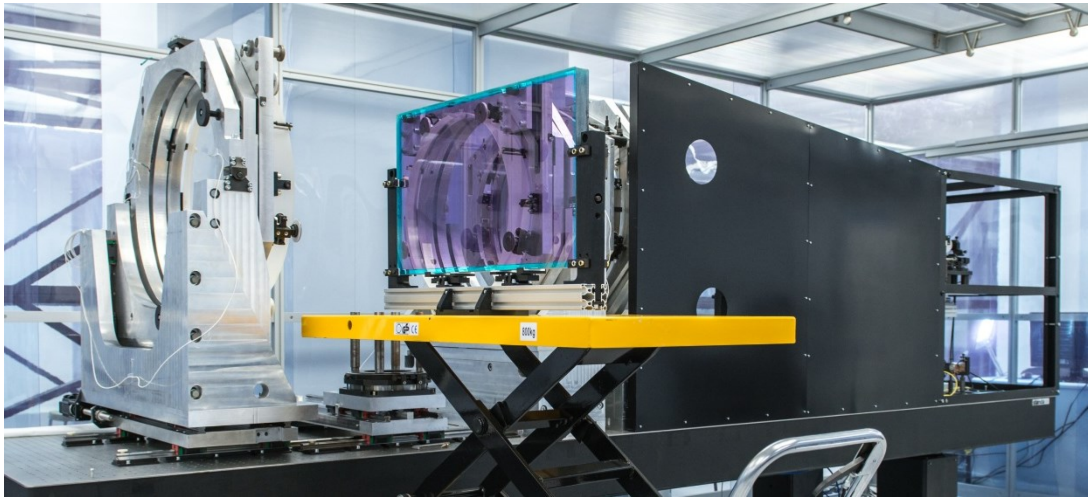
Phase shifting dynamic interferometer with a source on 0.6328 mm, based on the unequal-path scheme interferometer of Twyman-Green.

Test benches for interferometric control

Input control of an active Nd glass disk



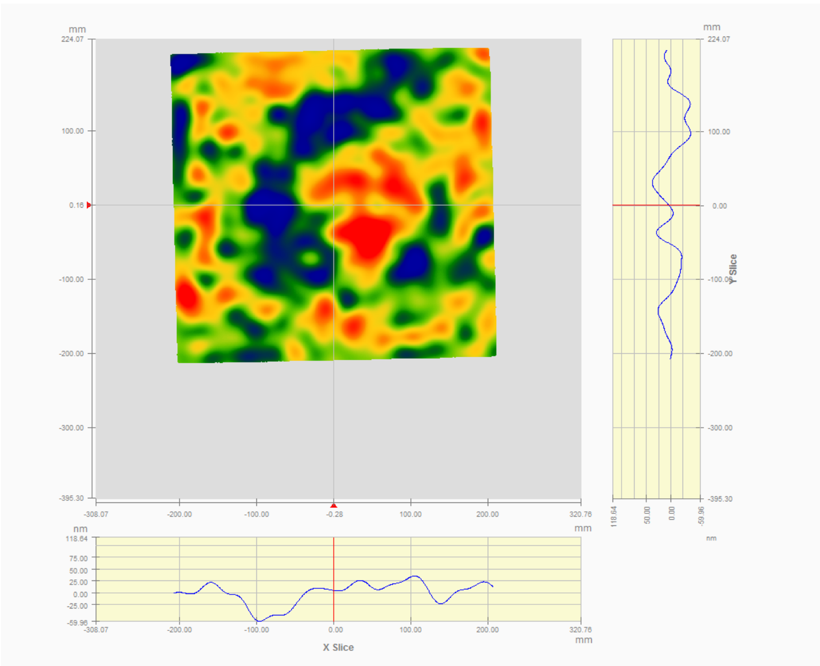
1. **Measurement of the transmitted and reflected radiation wave fronts for flat optics with diameter up to 710 mm with inaccuracy < 0.002λ (RMS)**
2. **Surface pattern with inaccuracy ≤1Å at the single-count measurement in 1 mm² square**

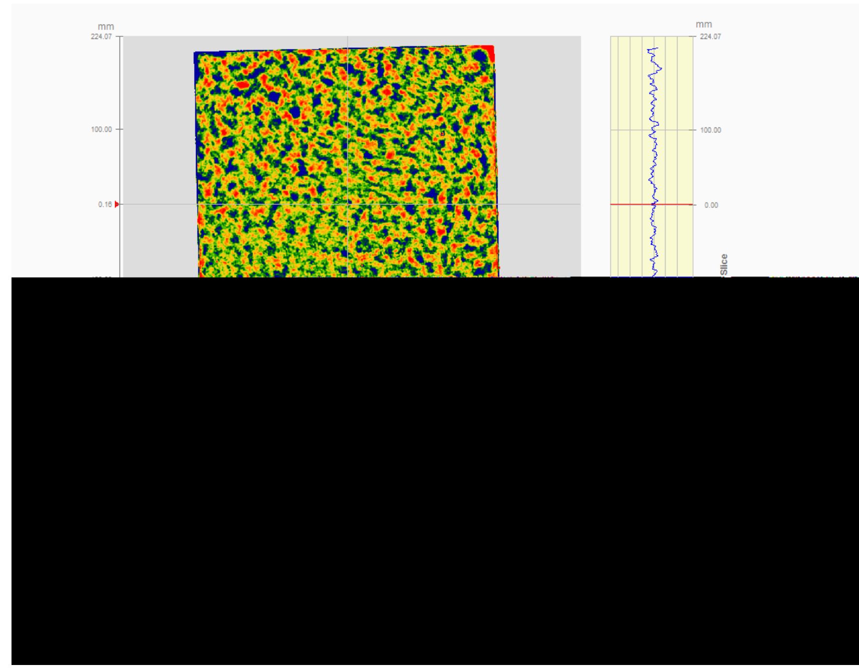


Phase shifting dynamic interferometer with a source on 0.6328 mm, based on the Fizeau scheme (right) and noncontacting profilometer (left), based on the Twyman-Green scheme.

Interferometric testing of large-size lenses TSF and CSP

Lens of spatial filter with focus ≈29 m with size 435x435x50.
Material – fused quartz



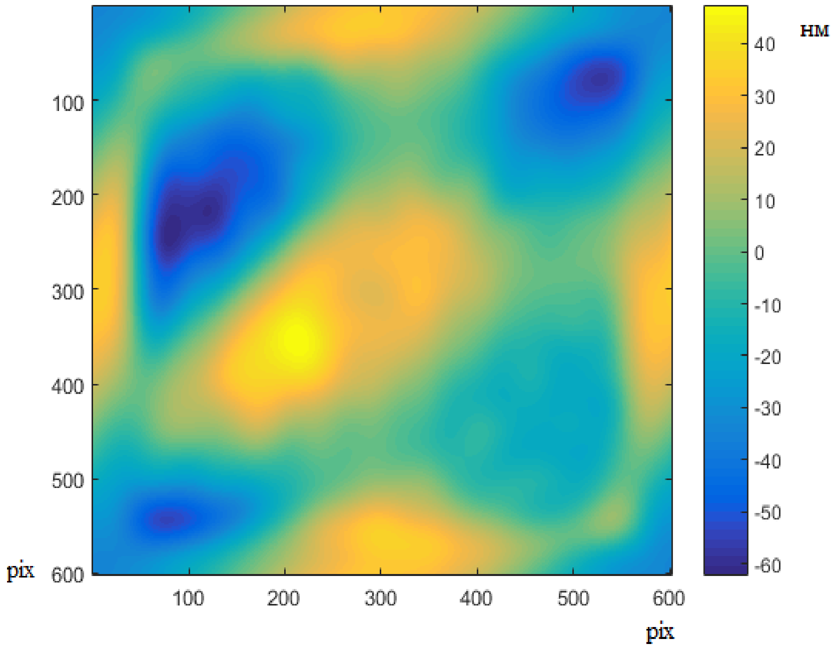


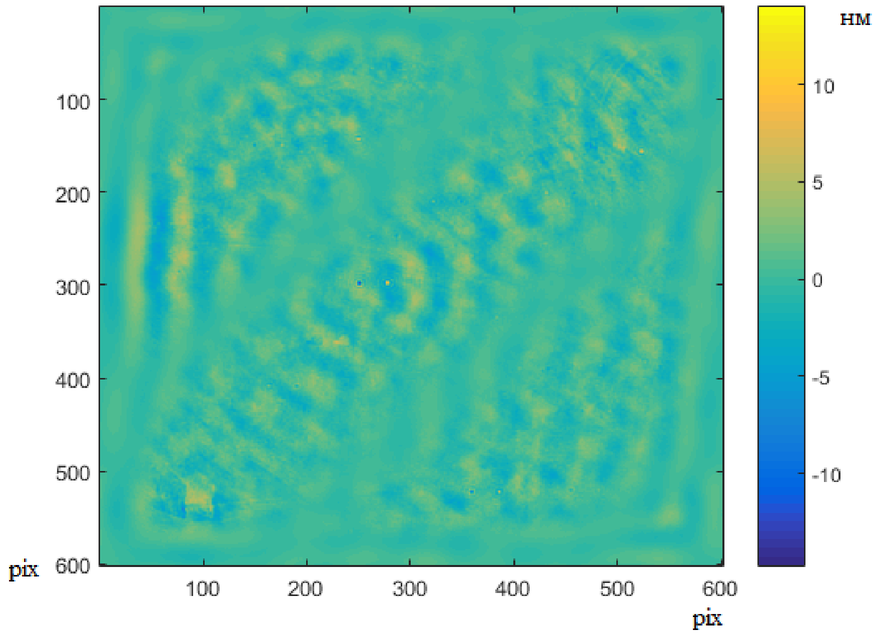
Wave front distortions with spatial scales >33 mm
PV=0.15λ (0.3λ) RMS$_{gradient}$=7 (7) nm/cm

Wave front distortions with spatial scales from 2.5 to 33 mm
Rq= 3 (1.8) nm

Interferometric testing of Nd slabs

Nd slab with sizes 808.5x458x41 mm.



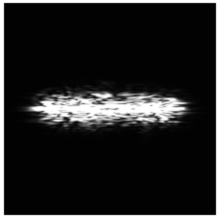


Wave front distortions with spatial scales >33 mm
PV=0.2λ (0.3λ) $RMS_{gradient}$= 13 (7) nm/cm

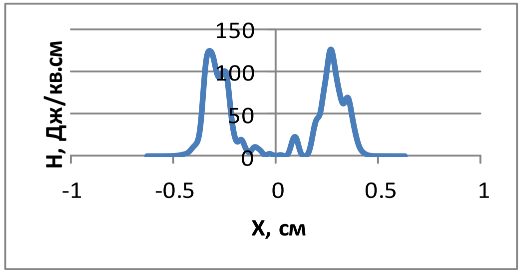
Wave front distortions with spatial scales from 2.5 to 33 mm
Rq=1.8 (1.8) nm

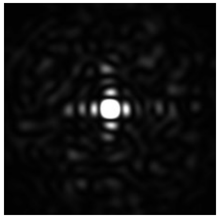
Investigation of deformable mirror possibility to compensate aberration of optical perturbations

Fabrication errors of optical elements + thermal aberration of Nd slab

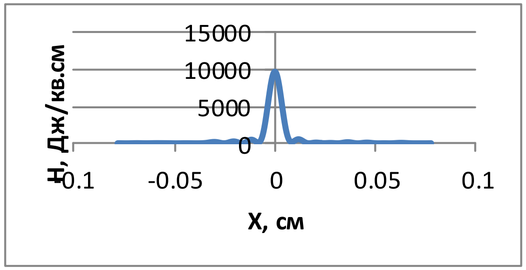


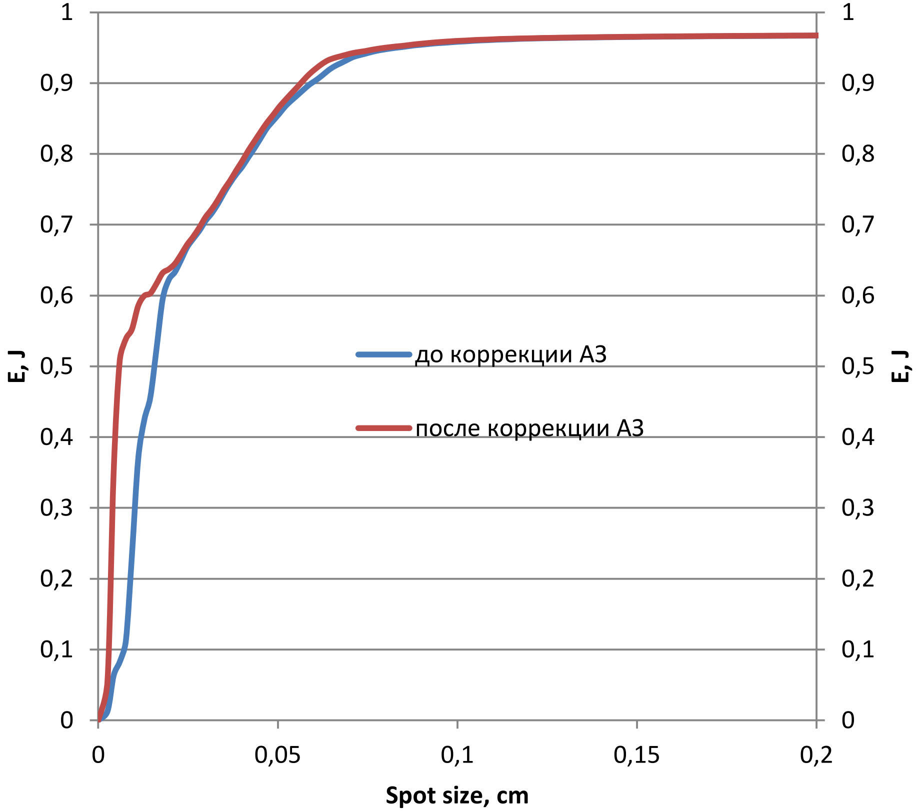
220,4 μrad
0,6 cm





34,6 μrad
0,1 cm

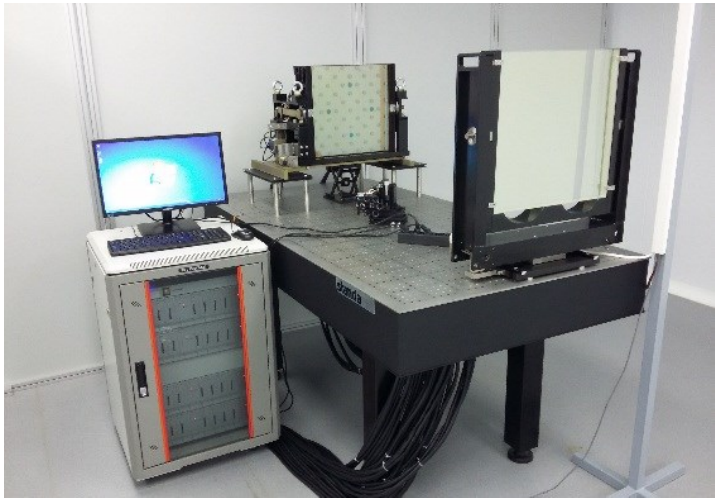




Energy density distribution in cross section of diaphragm 4-th path TSF before (top) and after (bottom) wave front correction

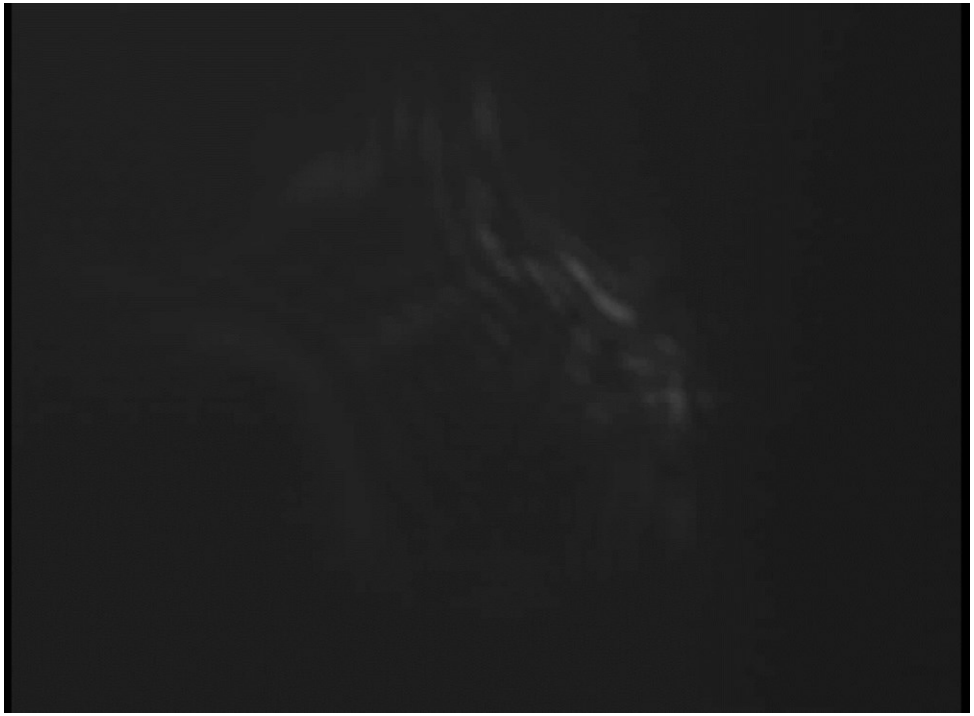
Concentration energy function at the output of laser facility power amplifier before (blue) and after (red) wave front correction

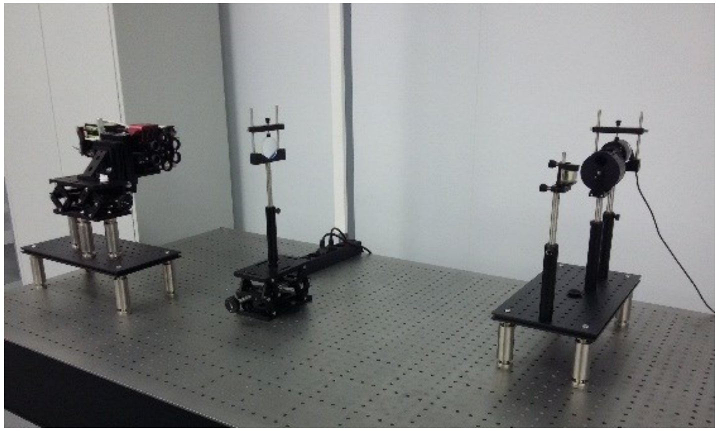
Adaptive system of wave front correction



DM with control system

Far field distribution





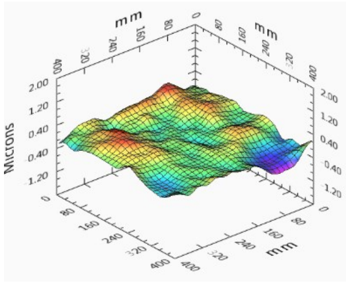
Wave front registration system

After correction beam divergence less then $1.7 \cdot 10^{-5}$ rad

Now we have adaptive system to complete two 8 beams modules.

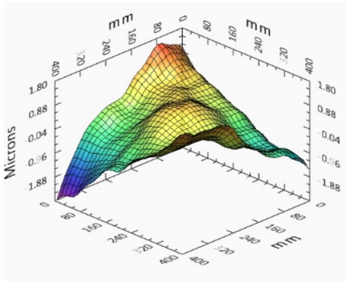
Test results of adaptive system

Initial mirror nonflatness

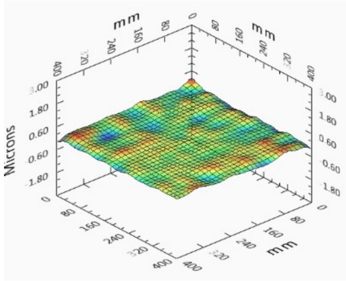


PV≤2.0 mcm, RMS≤0.3 mcm

Reduction to flat

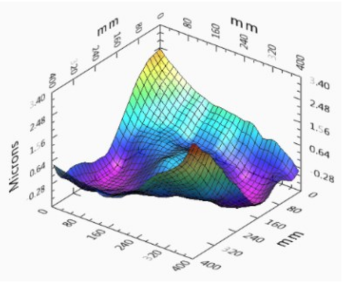


before correction
PV~20 mcm, RMS~2 mcm

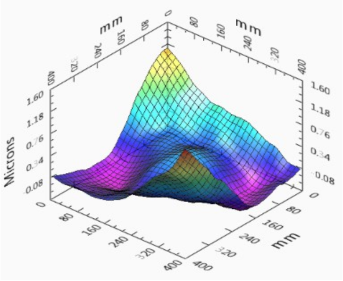


after correction
PV≤1.0 mcm, RMS≤0.2 mcm

Reduction to specified wave front



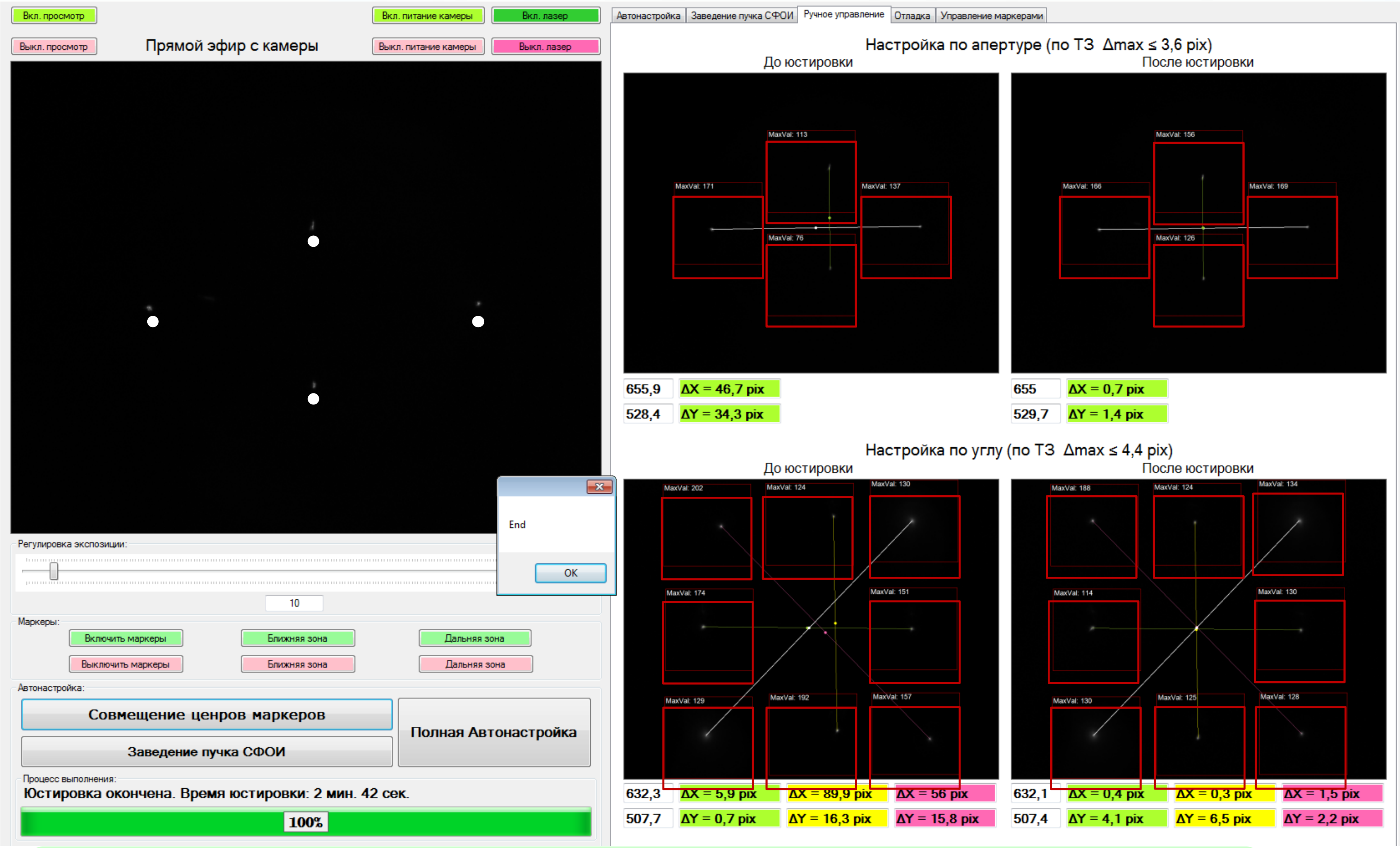
given wave front
PV~10 mcm, RMS~1 mcm



resulting wave front
ΔPV≤1.1 mcm, ΔRMS≤0.2 mcm

Time instability:
after reduction to flat less than ΔPV≤0.2 mcm/hour,
after reduction to given wave front ΔPV≤0.2 mcm/hour.
Mechanical hysteresis less than Γ≤14%

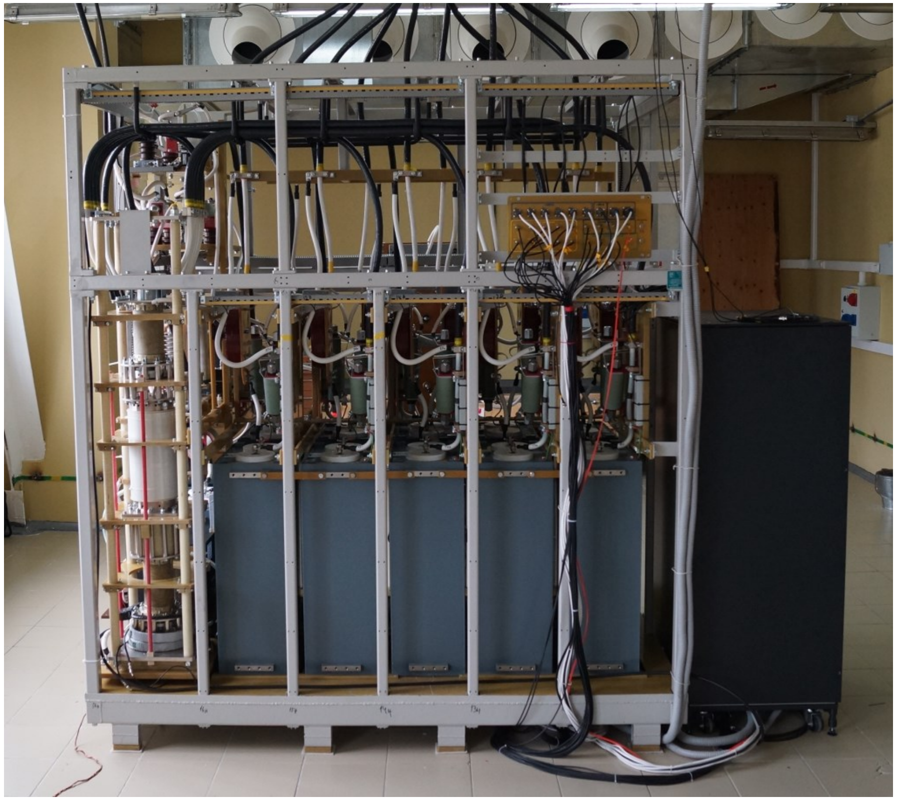
Automatic alignment system of optical channel of power amplifier



Automatic alignment system gives accuracy in far field zone better than of 10^{-5} rad

Electric capacitor bank module

Prototype

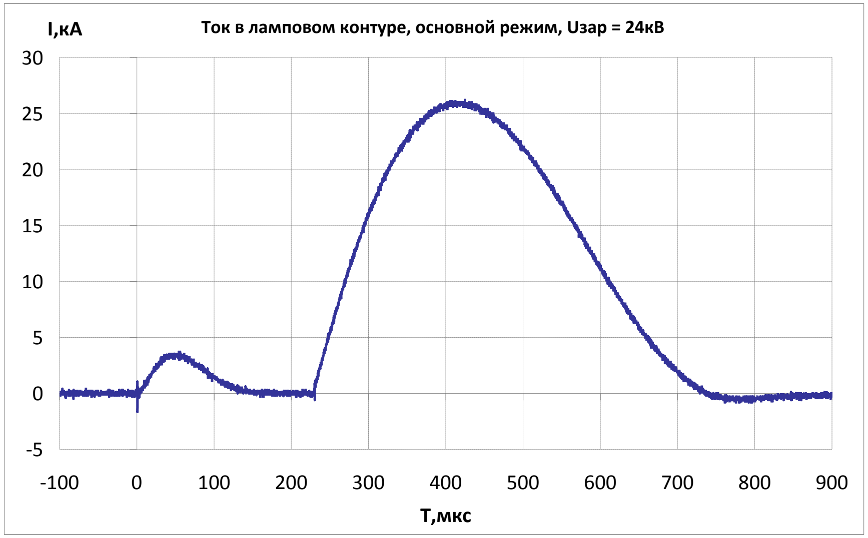


Electric capacitor bank module consists of high voltage unit and rack with controlling system.

- Working voltage – 24 kV
- Energy per module – 835 kJ
- Solid state semiconductor switch
- Modules full numbers – 432

Preliminary test showed robust of prototype.

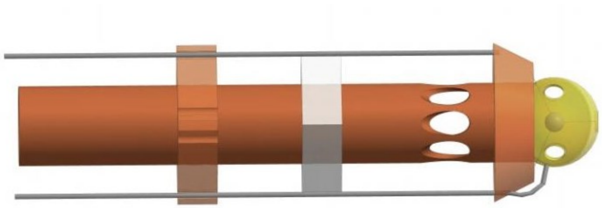
Now first amplifier block with 7 amplification sections is under testing.



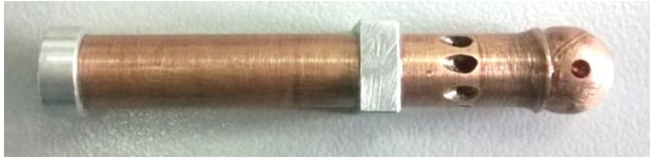
We began serial production of these modules in 2016

Model of indirect drive target

Spherical box

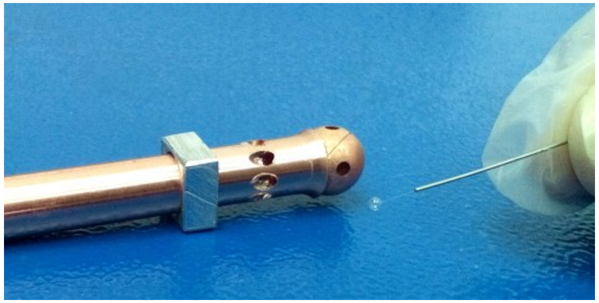


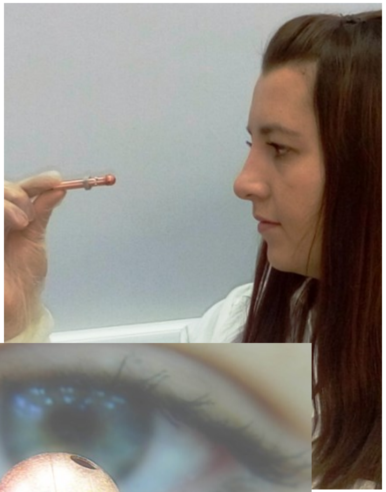
3D-model

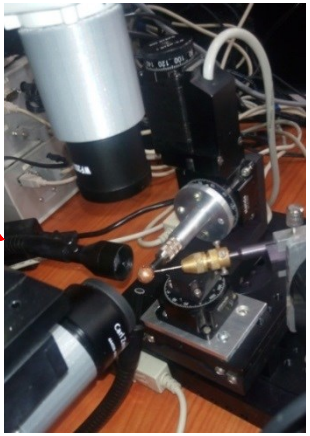


Prototype no cryogenic target

Model of cryogenic target printed using additive technology







Boxes assembly stand

Thank you for attention