Optical Tests of Lobster Eye X-Ray Optics Prototype for Nano-Satellite Missions Based on New Technology

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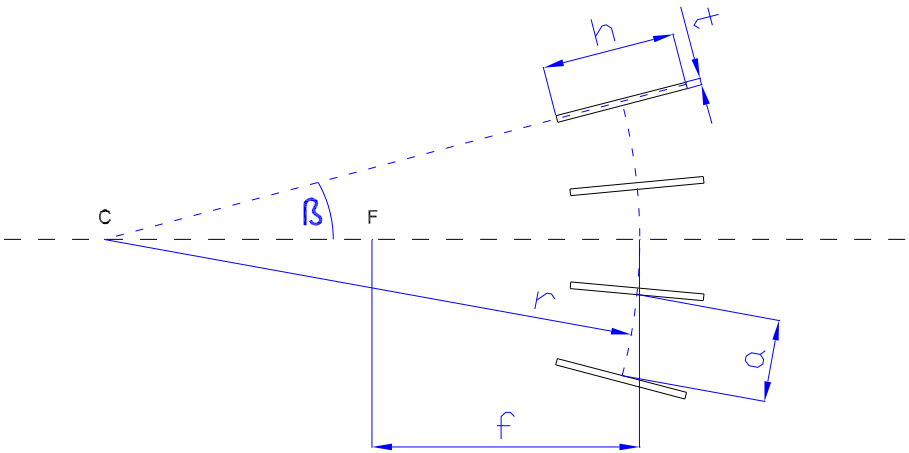
One-dimensional Schmidt lobster eye

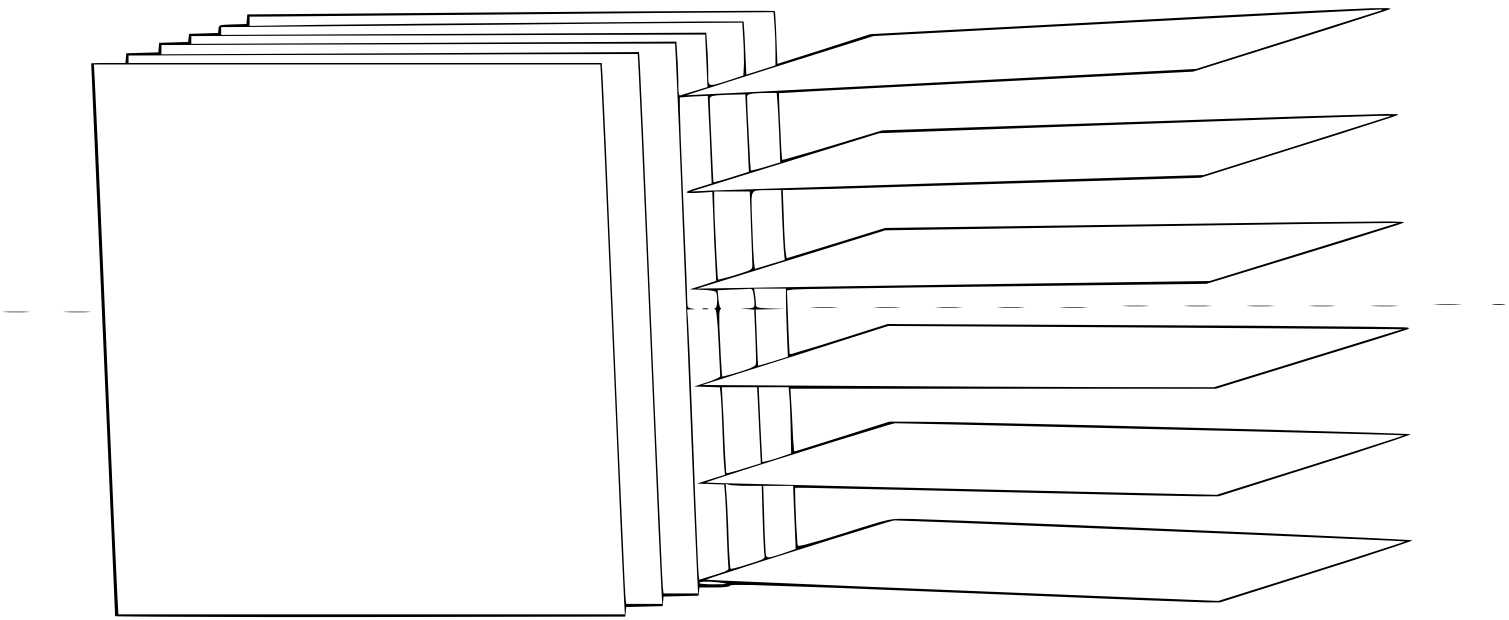


The system is composed of flat rectangular mirrors forming an uniform pattern around of a virtual cylinder of centre **C**. This set of mirrors is called stack. Point **F** is the focus.

- r radius of the system
- a mirror spacing
- t mirrors thickness
- h mirrors depth
- N number of mirrors
- β is angle position of a mirror

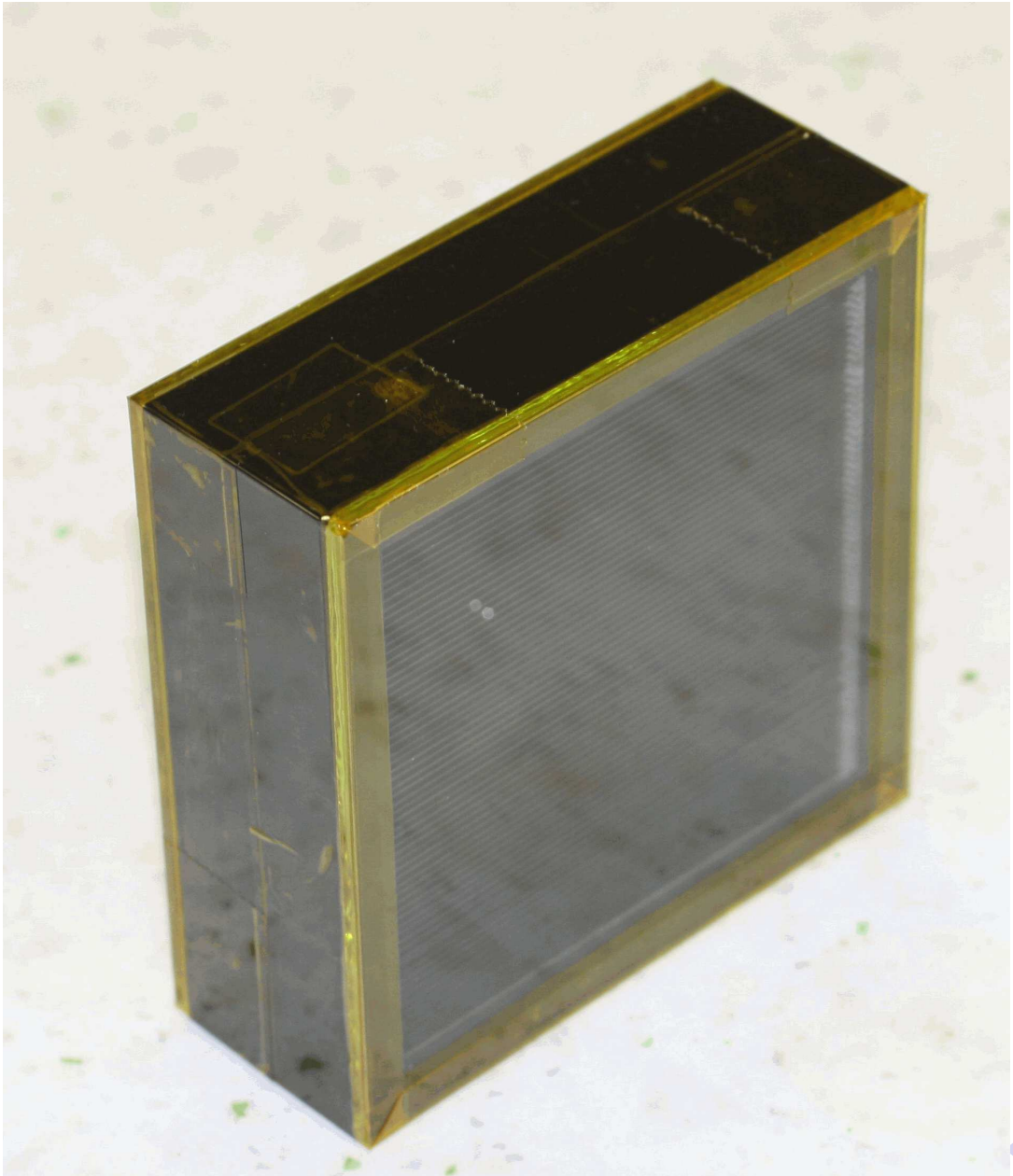
Lobster optics is intended mainly for X-rays. Its main advantage is wide field of view

Two-dimensional Schmidt lobster eye



Two orthogonally arranged stacks of mirrors form two-dimensional lobster eye.

Prototype one-dimensional optics module LNA



Parameters

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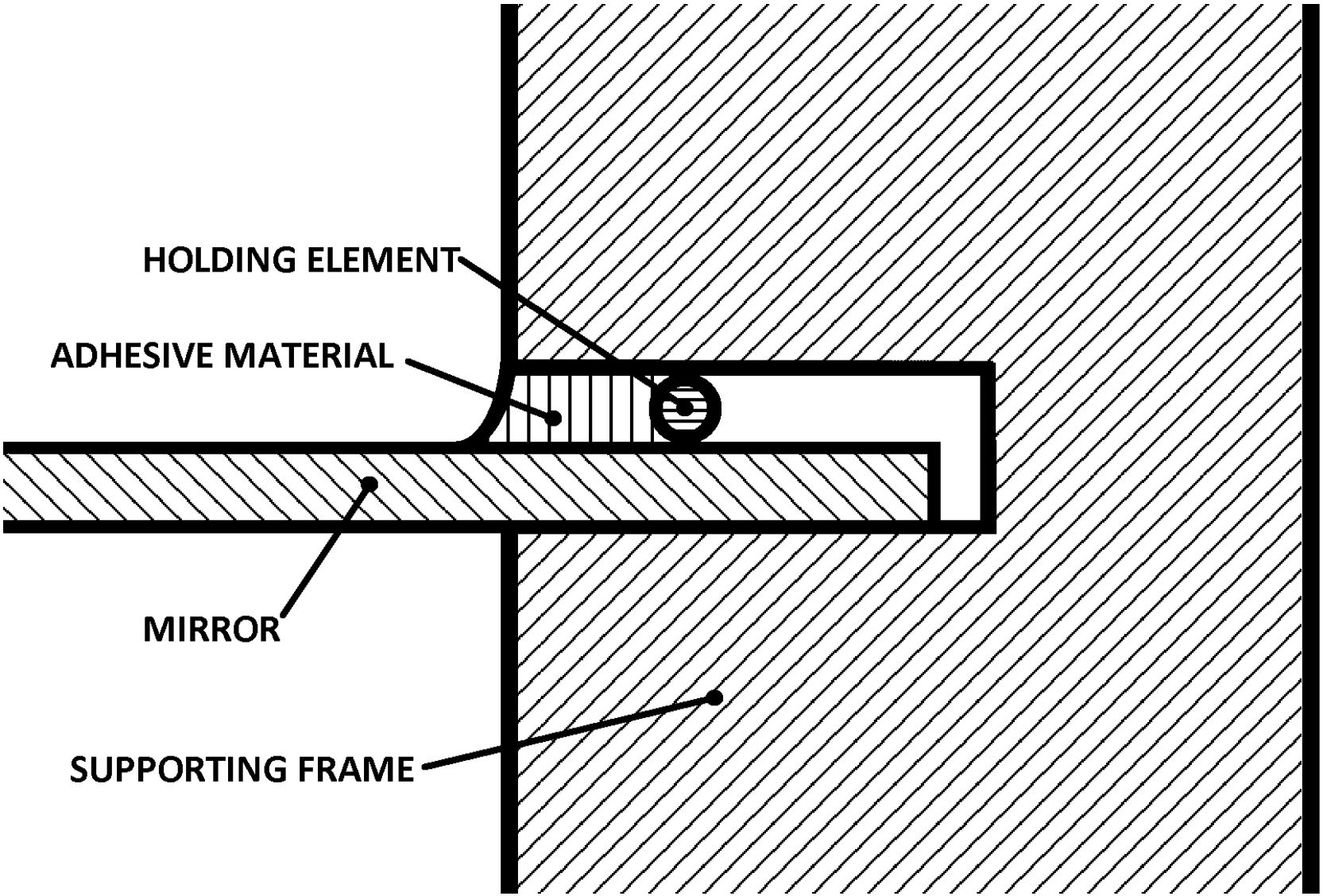
- Focal length 230mm measured from the rear plane of the housing to the focus.
- Input aperture 87x84mm.
- Composed of N=66 glass mirrors of depth h=24mm and thickness t=0.28mm coated with gold.
- Mirror pitch A = 1.34mm.
- Outer dimensions 95.8x95.8x26mm without external housing. It allows application on 3U or larger CubeSat.
- Intended for X-ray energy 1keV but test is possible in wider range.
- Calculated field of view 10.4°.
- Calculated effective collecting length 1.6cm at 1keV.
- Corresponding effective collecting area 2.4cm^2 for 2-D system.

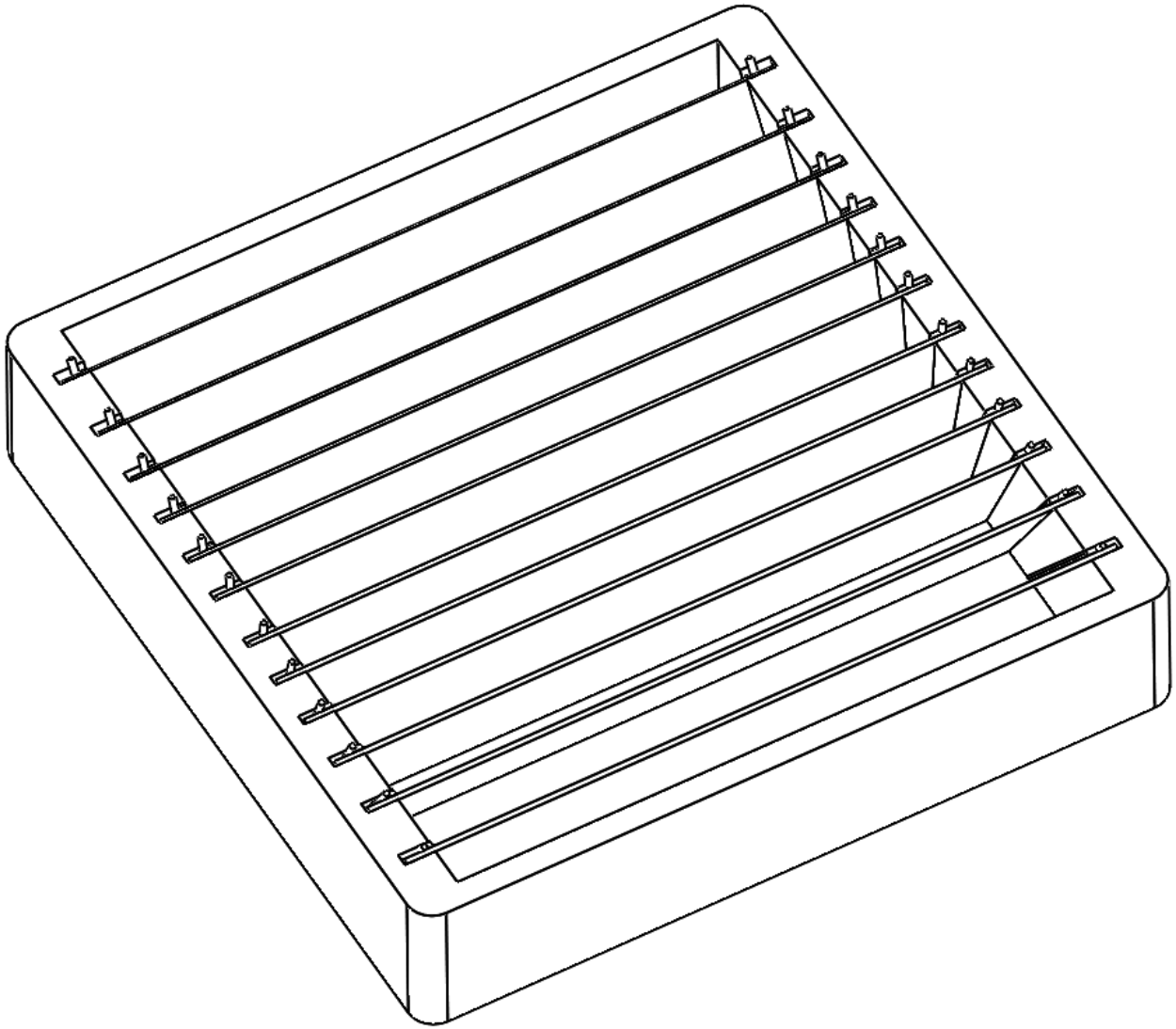
The module is based on new technology of precise assembling registered as

- Czech patent CZ 310 015 B6
- Czech utility model CZ UV 36 961
- German utility model 20 2023 107 238.0

Technology - detail of mirror holding

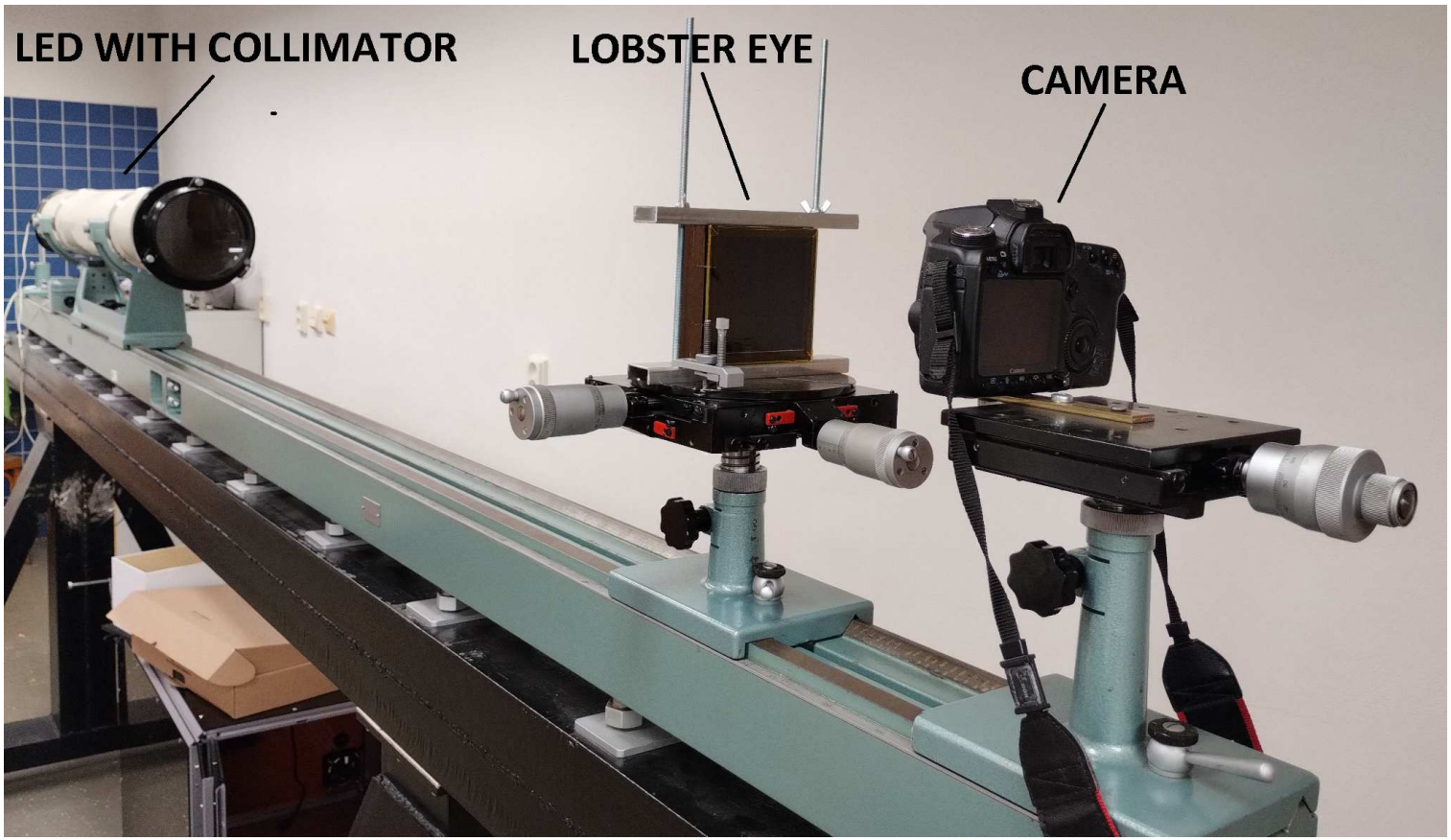


Technology - 3D view of entire stack



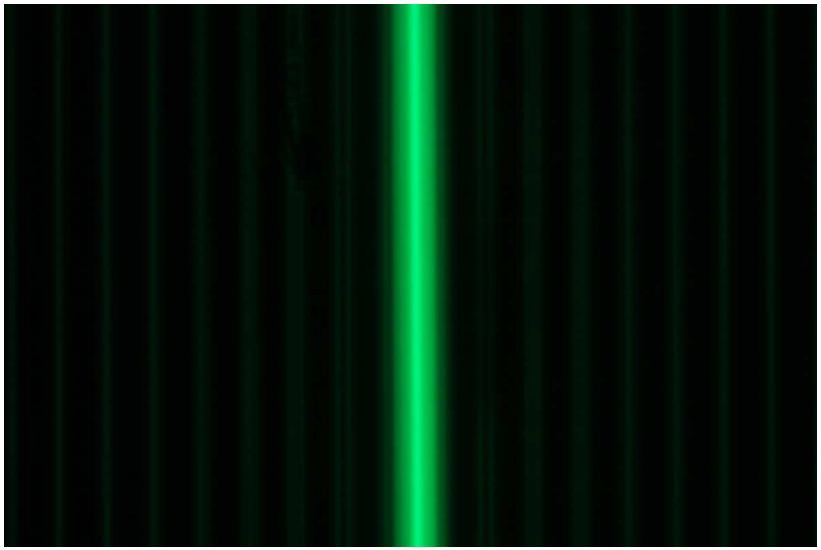
Experimental setup

OSKA optical bench in optical laboratories of Faculty of Mechanical Engineering of Czech Technical University in Prague.

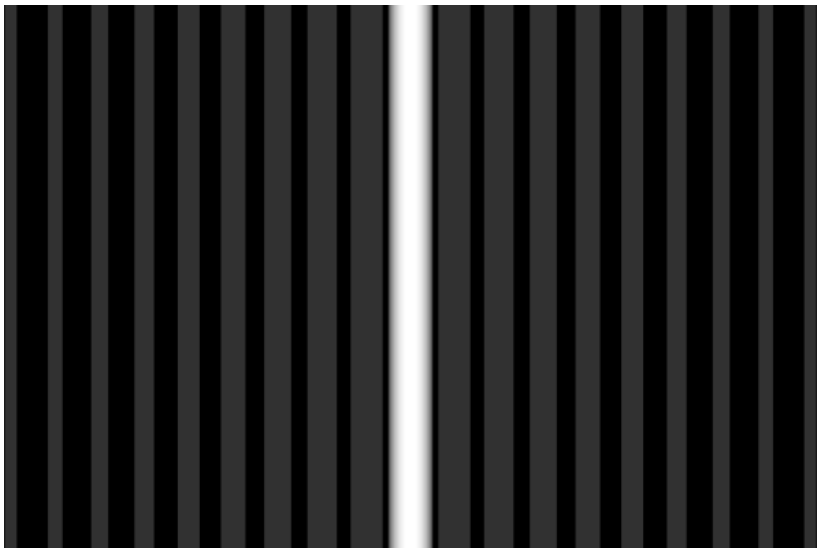


- Light source: green light emitting diode (LED).
- Focal length of the collimator 1600mm.
- Camera: Canon EOS 50D, sensor size 22.3 x 14.9mm, resolution 4752 x 3168 pixels.

Focal image



Experiment

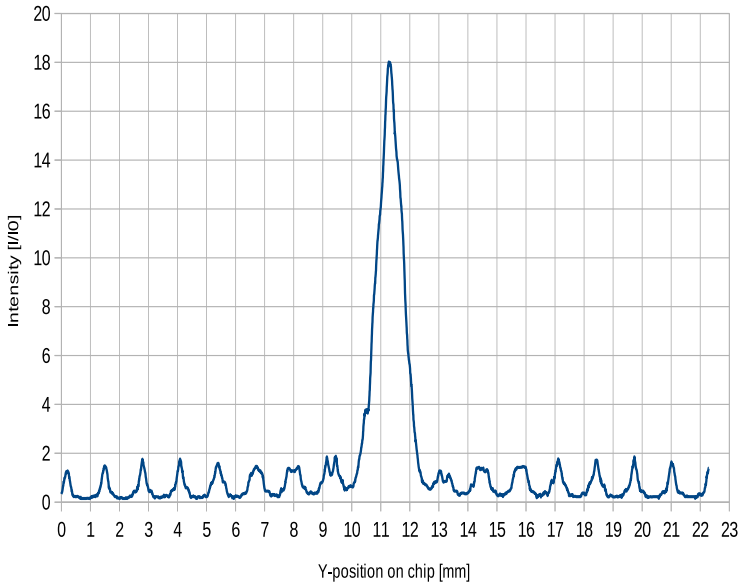


Simulation

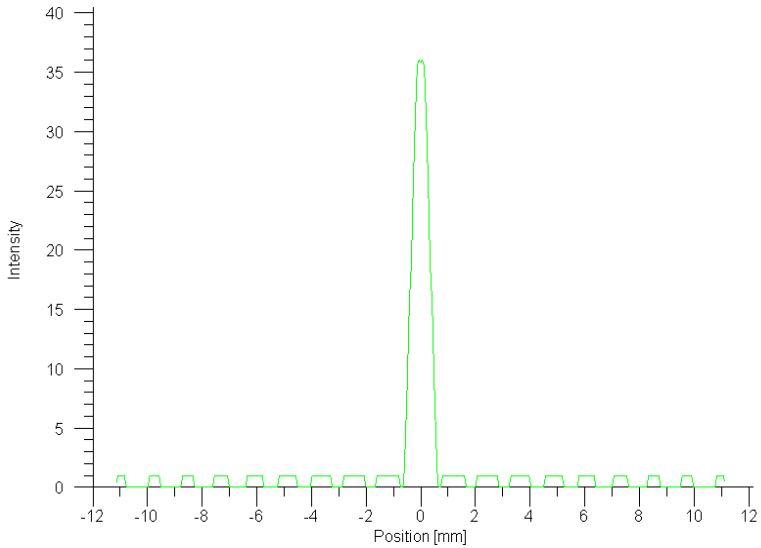
Ideal mirrors were considered for simulations. Experimental image with visible light is strongly affected by diffraction effects.

Simulations were done using LOPSIMUL software *www.lopsimul.eu* by simplified ray-tracing algorithm published in Exp. Astron. (2016) 41:377-392; DOI 10.1007/s10686-016-9493-2.

Graphs of profiles



Experiment, FWHM = 1.02mm



Simulation, FWHM = 0.71mm

Experimental image has little worse FWHM because of following reasons:

- Diffraction effects, they will not appear in X-rays.
- The light beam has same small divergency as LED chip has non-zero size. However, LED chip size is not known and therefore, it cannot be included into simulations.
- Simulation is done for mirrors of 100% reflectivity. For test in X-rays, the relevant reflectivity model will be included into the simulations.

For named reasons, vertical scales of graphs are not comparable.

Conclusions

- The prototype is operating.
- The technology is proved.
- Experimentally measured FWHM is little worse than result of ray-tracing. However, we expect much better result in X-rays.

We search for partners for:

- X-ray tests.
- Ballon or sounding rocket test.
- This lobster eye is available for applications /missions.
- Financial support.

Acknowledgments

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