Tests Of Schmidt Lobster Eye Based On New Technology

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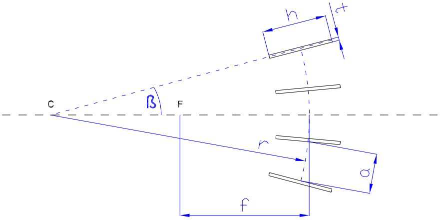
December 5, 2023

AHEAD 2020

Funded by the Horizon 2020 Framework Program of the European Union Grant Agreement No. 871158

One-dimensional Schmidt lobster eye

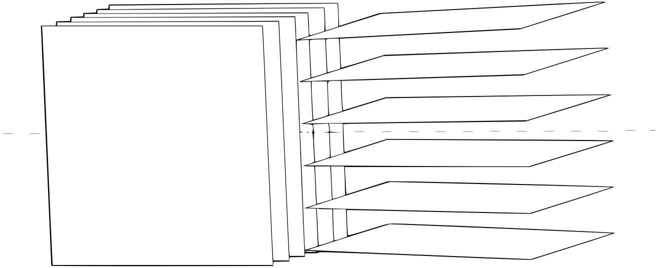


The system is composed of flat rectangular mirrors forming an uniform pattern around of a virtual cylinder of centre **C**. This set of mirrors is called stack. Point **F** is the focus.

- 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; it is equal to grazing angle β if beams are parallel

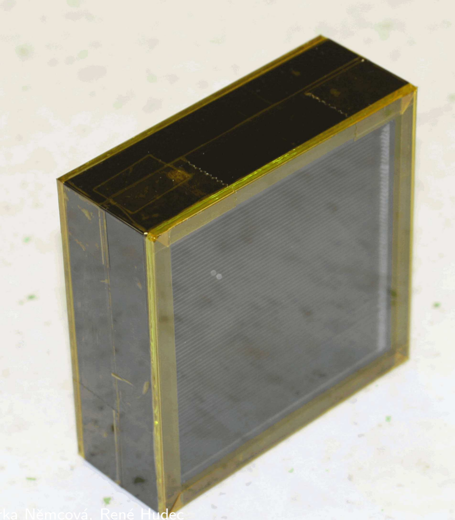
Lobster optics is intended mainly for X-rays. Its main advantage is wide field of view

Two-dimensional Schmidt lobster eye



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

Prototype one-dimensional optics module LNA-240



Parameters

Parameters

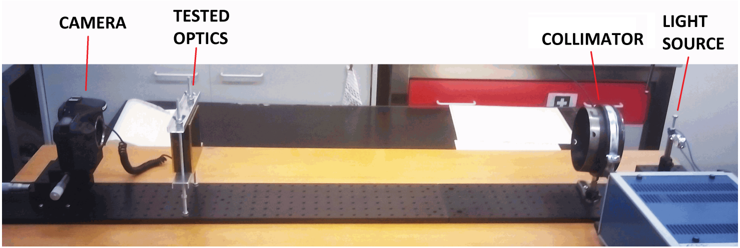
- Focal length $F = 240$mm.
- Input aperture 87x84mm.
- Composed of N=66 glass mirrors of depth h=24mm and thickness t=0.28mm coated with gold.
- Mirror pitch $A = 1.34$mm.
- Outer dimensions 95.8x95.8x26mm without external housing. It allows application on 3U or larger CubeSat.
- Intended for X-ray energy 1keV but test is possible in wider range.

Parameters (2)

- Calculated field of view 10.4°.
- Calculated effective collecting length 1.6cm at 1keV.
- Corresponding effective collecting area $2.4 cm^2$ for 2-D system.

The module is based on new technology of precise assembling registered as utility model CZ UV 36 961, patent application CZ PV 2022-511.

Experimental setup



- Light source: white high-power LED with an aperture (aluminium foil with a small hole ca. 0.1mm).
- Collimator: plano-convex lens.
- Camera: Canon EOS 50D, sensor size 22.3 x 14.9mm, resolution 4752 x 3168.

Images

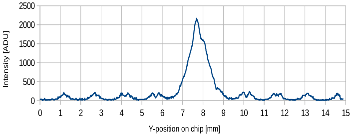

(a) (b) (c)

It is seen that optics was tilted a little but the setup did not allow perfect aligning. By manual fit, it has been found that the optics was tilted by ca. 0.1°.

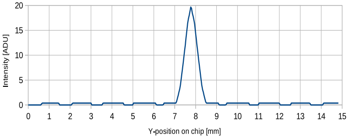
- (a) Experiment (red channel only).
- (b) Ray-tracing, optics tilted by 0.1°.
- (c) Ray-tracing, aligned optics.

Images are in negative colors and enhanced contrast. 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.

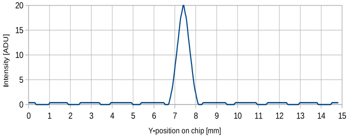
Graphs of profiles



(a)



(b)

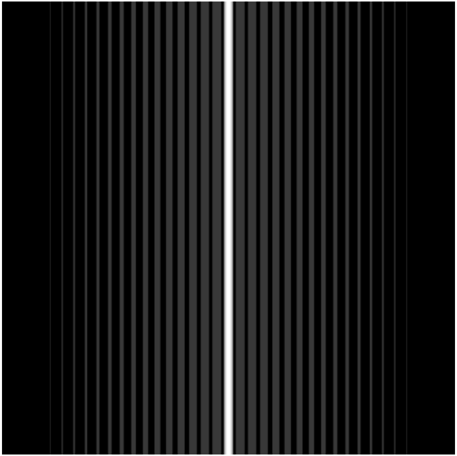


(c)

- (a) Experiment (red channel only). FWHM = 0.96mm. Corresponding angular resolution 15arcmin.
- (b) Ray-tracing, optics tilted by 0.1°. FWHM = 0.71mm. Corresponding angular resolution 11arcmin.
- (c) Ray-tracing, aligned optics. FWHM = 0.71mm. Corresponding angular resolution 11arcmin.

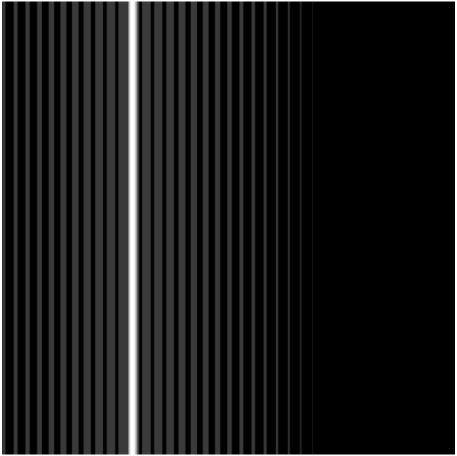
Vertical scales of experimental and simulated images are not comparable.

Full focal image with aligned optics (simulation)



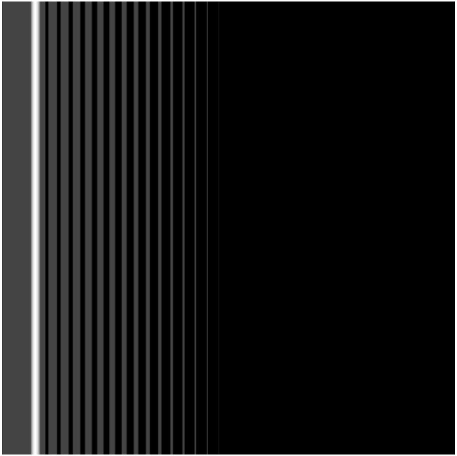
Detector 512×512 pixels of 100μm size.

Full focal image with yaw = 2.6° (simulation)



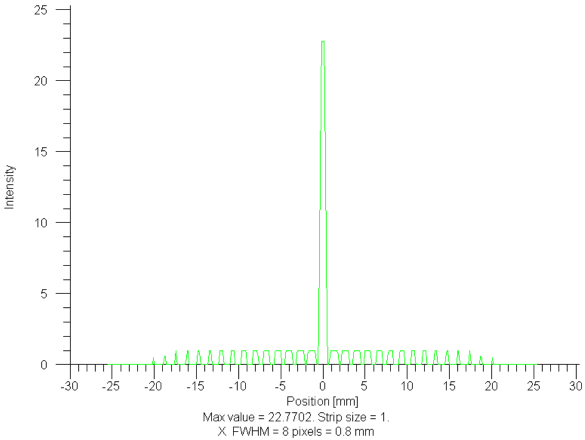
Detector 512×512 pixels of 100μm size.

Full focal image with yaw $= 5.2^\circ$ (simulation)



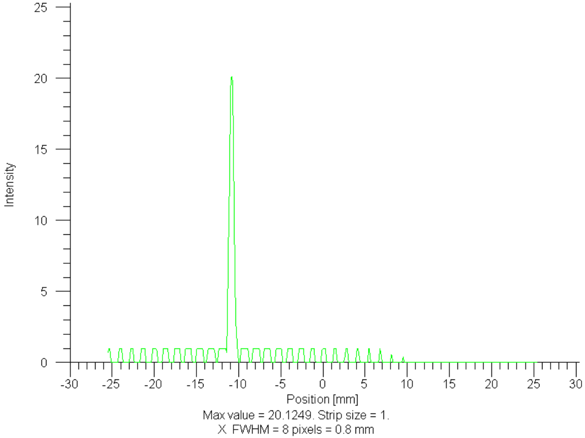
Detector 512×512 pixels of 100μm size.

Profile of intensity at 1keV, yaw = 0.0° (simulation)



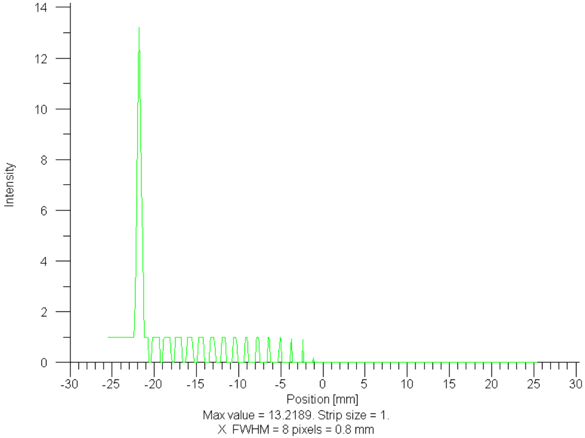
Incoming rays are scaled to have intensity 1.

Profile of intensity at 1keV, yaw = 2.6° (simulation)



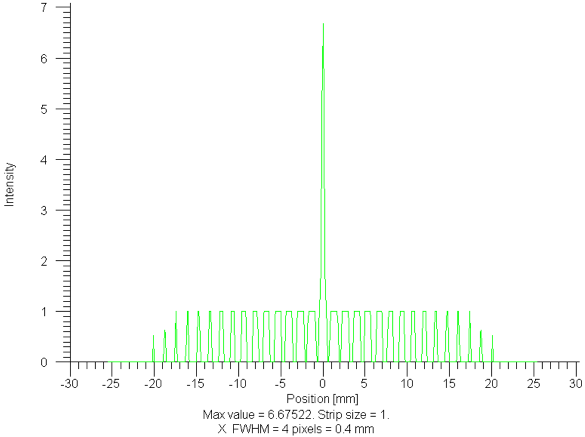
Incoming rays are scaled to have intensity 1.

Profile of intensity at 1keV, yaw = 5.2° (simulation)



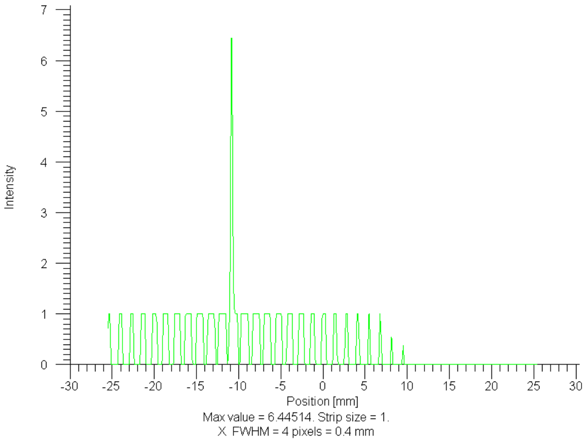
Incoming rays are scaled to have intensity 1.

Profile of intensity at 4.5keV, yaw $= 0.0^\circ$ (simulation)



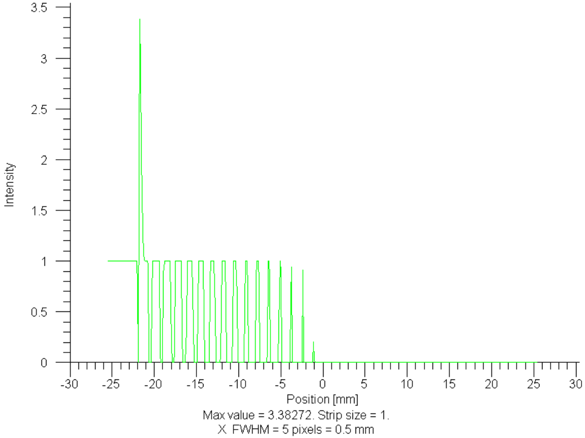
Incoming rays are scaled to have intensity 1.

Profile of intensity at 4.5keV, yaw = 2.6° (simulation)



Incoming rays are scaled to have intensity 1.

Profile of intensity at 4.5keV, yaw = 5.2° (simulation)



Incoming rays are scaled to have intensity 1.

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.

Do you like it ?

We search for partners for:

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

THANK YOU FOR THE ATTENTION

Acknowledgments

Thank for the invitation to the conference and for the support by HORIZON 2020 and AHEAD 2020.