LE X-ray Optics for Astrophysics: Recent Status

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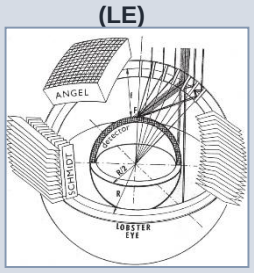
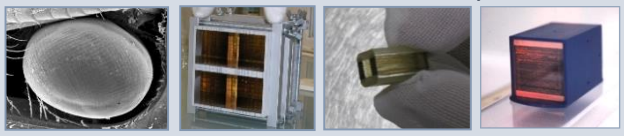
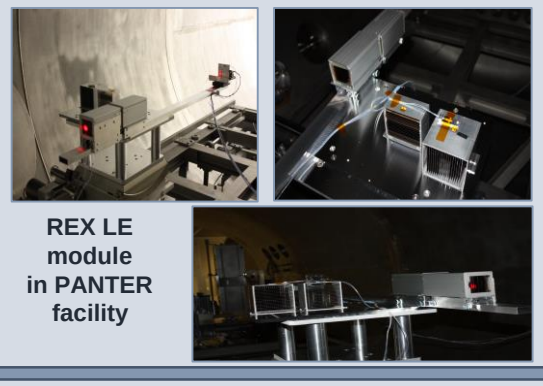
Lobster Eye optics (LE)



- Analogy with lobster eyes
- Wide FOV - FOV of 100 sq. deg. and more easily possible (classical X-ray optics only 1 deg or less)
- Designed for astronomy, but laboratory applications also possible
- Glass and / or silicon substrates for soft X-rays
- Planar & ellipsoidal mirrors
- Foils 3 × 3 mm to 300 × 300 mm
- Foil thickness from 30 μm to 1 mm



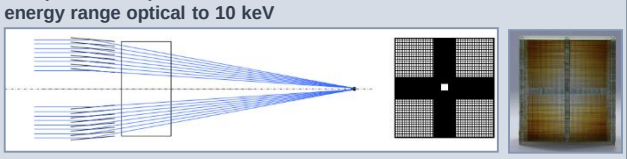
REX LE module in PANTER facility



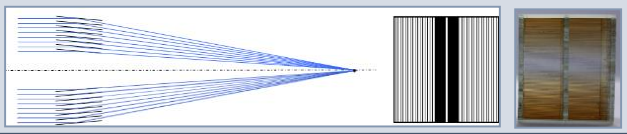
LE system – Schmidt geometry

1D vs. 2D system

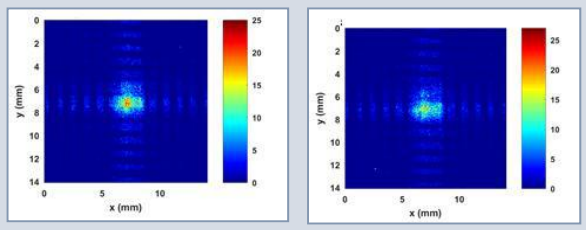
2D optics – composed of two 1D sub-modules, 2 reflections, energy range optical to 10 keV



1D optics - 1 reflection, energy range optical to **30 keV**



LE REX PANTER X-ray test results

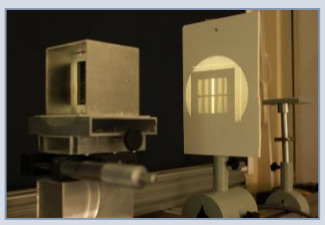


2D LE X-ray optics (REX) – image of the 2D focus at 8.04 keV for different focal distance
Best focus in vertical direction 1.21 mm FWHM (1.5 arcmin) and in horizontal direction 0.94 mm (1.3 arcmin) .

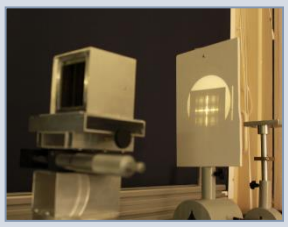
1D LE system for VZLUSAT- 1

Parameters of optic	
Aperture [mm]	23x29
F [mm]	250
R [mm]	500
t [mm]	0.145
N [/]	100
l [mm]	60
w [mm]	25
h [mm]	38
Spacing [mm]	0.28
Surface	Au
Detector	Timepix
Pixel size [μm]	27.5
Detector size [px]	512x512

LE system - 1D system VIS test



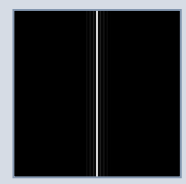
LE system - 2D system VIS test

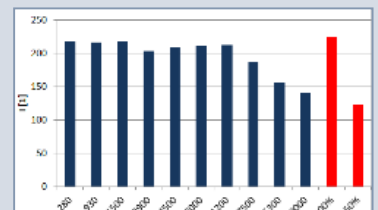


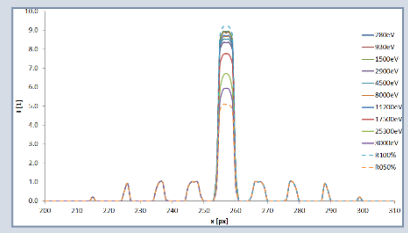
LE optics for rocket experiment – tests in Iowa

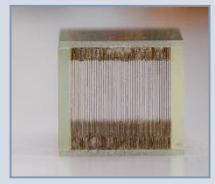
- X-ray testing with Timepix detector in vacuum chamber at the University of Iowa
- Energy: **keV (Cu Kα)**
  1.25 keV (Mg Kα)
- Source-to-detector distance: 10 m

Lobster Eye for VZLUSAT-1



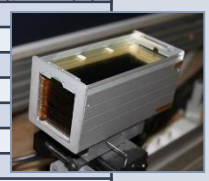




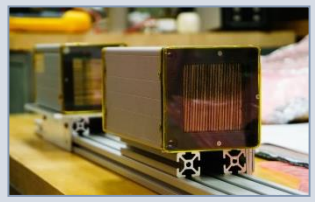


LE optics for rocket experiment REX

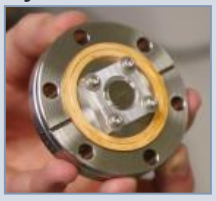
Aperture [mm]	54 x 54
F [mm]	1190 (L), 960 (M)
R [mm]	2380 (L), 1920 (M)
t [mm]	0.1
N [/]	55
l [mm]	150
w [mm]	75
h [mm]	55
Distance between foils [mm]	0.75
Surface	Au
Detector	Timepix
Pixel size [μm]	27.5
Detector size [px]	512x512



MFO for rocket experiment
Tests in Penn State University vacuum tunnel



LE system
- MFO, glass foils



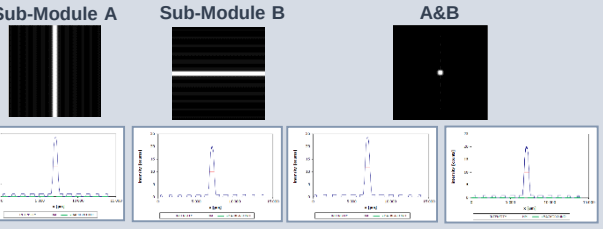
Source
- Fe-55
- Kα = 5.9 keV

Detector
- pixel detector with 256 x 256
- 55 μm pixel size
- 14 x14 mm²

LE optics for rocket experiment - Simulation

for source-detector distance 10 m at 8 keV

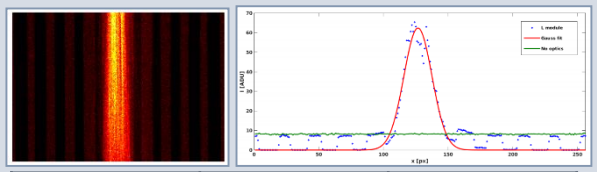
Sub-Module A | Sub-Module B | A&B



	Sub-module A / horizontal	Sub-ModuleB / vertical
FWHM [mm]	0.645	0.630
G_{max} [1]	17.2	20.6
φ [arcmin]	1'50"	1'48"

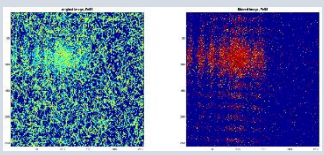
Real experiment in vacuum chamber

1D LE optical system



	Model G_1 (L)	Model G_2 (M)
FWHM [mm]	1.41	1.09
G_{max} [1]	16.1	13.1
w [arcmin]	3,52	3,00

LE for rocket experiment Pennstate test results



985 min exposure time

Experimental tests of LE optics in hard X-rays

- CuKα X-ray tube
- Timepix detector

- LE optics was placed in the middle between source and detector

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