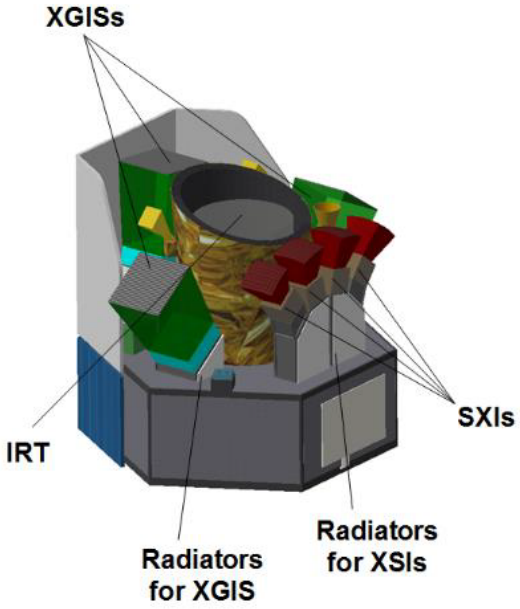
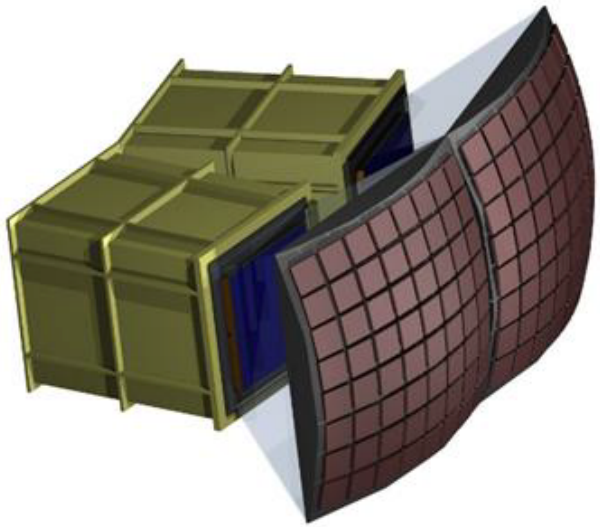
UNIVERSITY OF LEICESTER

The Soft X-ray Imager on THESEUS



Paul O'Brien
Dick Willingale
Ian Hutchinson



What do we need from the SXI?

- Discovery instrument in the soft X-ray band to meet THESEUS science goals
- Field of view ~ 1sr
- Sensitivity of ~1 x 10^{-10} erg cm^{-2} s^{-1} (0.3-5 keV) in 1ksec
- PSF to provide ~1 arcmin localisation

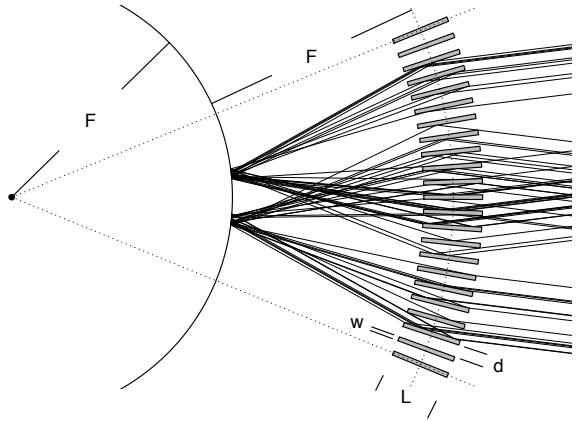
The “usual” soft X-ray imaging systems do not provide the field of view

Scintillator or coded-mask devices do not go below a few keV

A scintillator device does not provide the sensitivity or localisation accuracy

A coded-mask device does not provide the sensitivity

Lobster Geometry – Wide Field



Originally described by Angel 1979

Pores packed on spherical surface radius R_c=2F

Pores point to a common centre of curvature

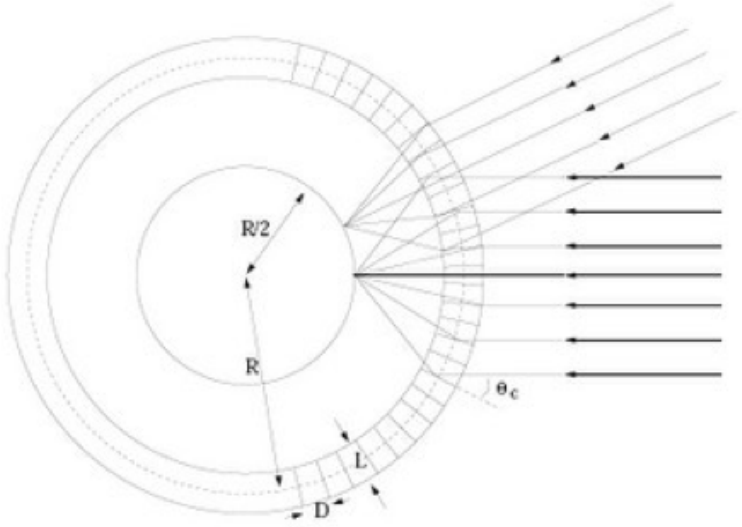
Focal surface spherical radius F

1 reflection – line focus

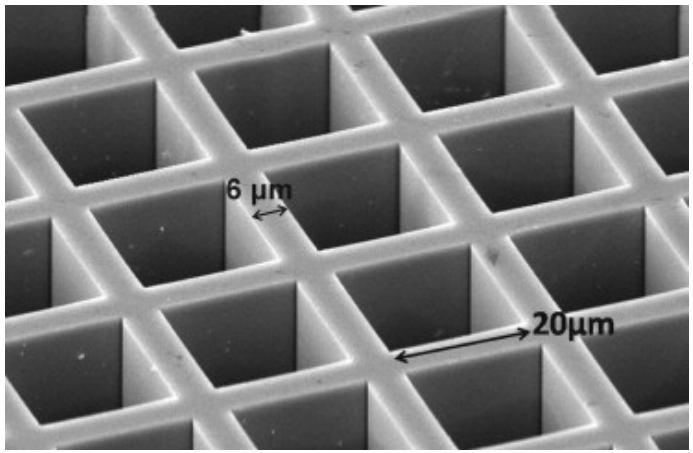
2 reflections – true focus

No limit to FOV
If optic wide enough no vignetting

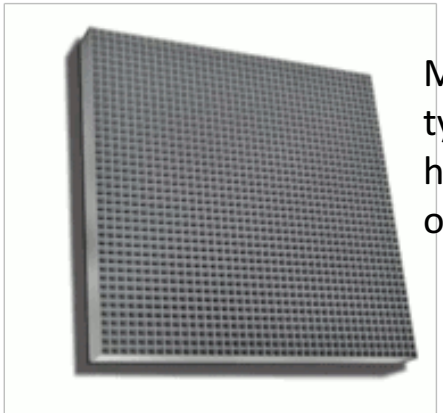
Lobster-eye Micropore Optics (MPO)



Square-packed 20 µm pores, 6 µm walls

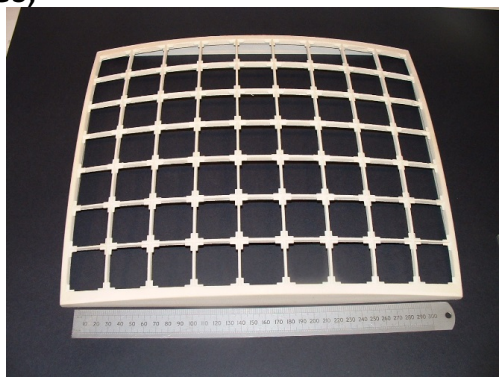


Open area >= 60%

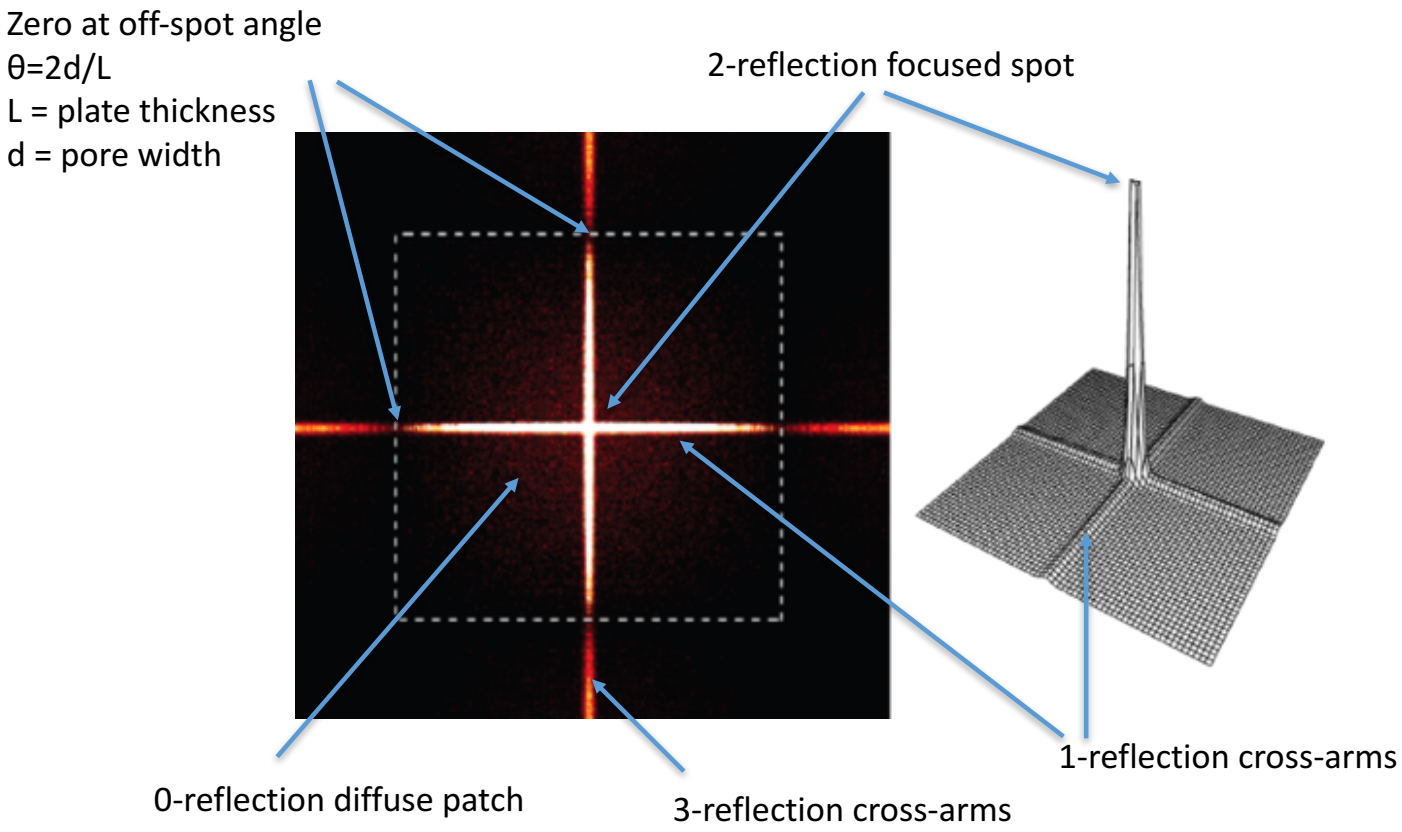


Manufactured (Photonis) as glass plates, typically 4x4 cm, 1mm thick, heat-slumped to required radius of curvature

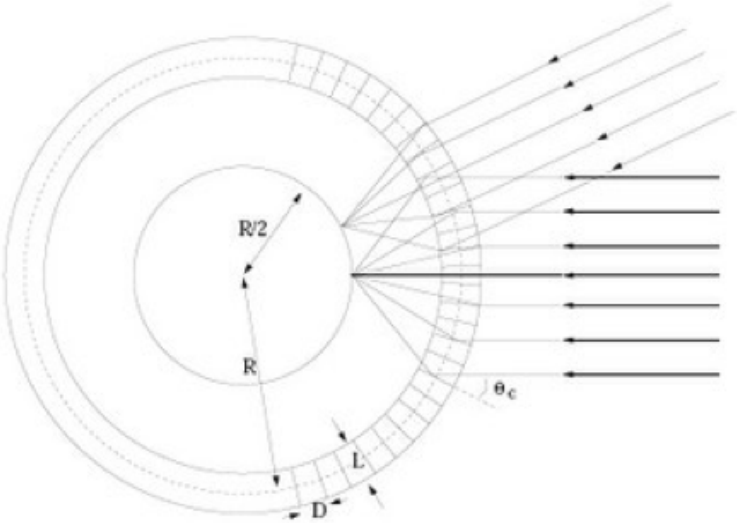
Plates glued onto frame to build FOV. 1mm overlap.
Low mass: Flight optic ~ 1kg

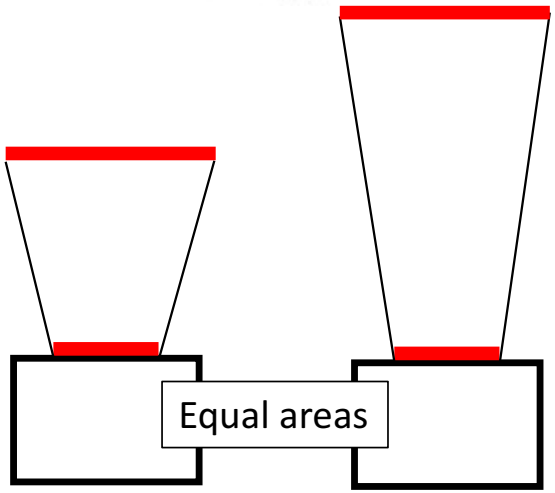


MPO Point Spread Function



Detectors vs optics: Basic Geometry





A consequence of the geometry is that the detector geometrical area is ¼ the optic geometrical area.

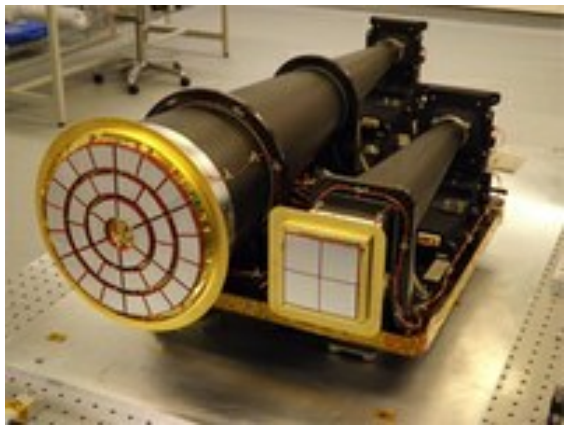
Wide FOV → Big Detector Plane

Cooling an issue with CCDs (less if we can use CMOS)

FOV goes closely as linear with focal length

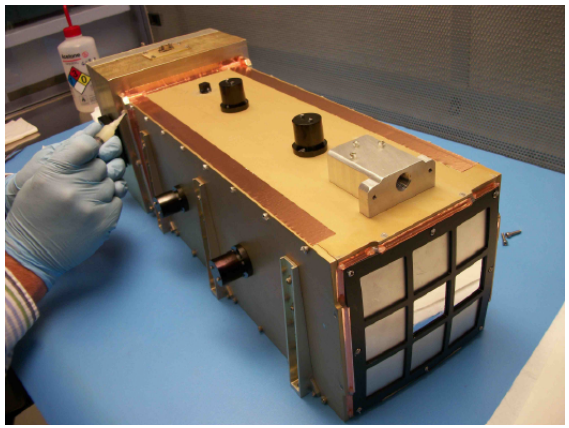
Effective area goes as focal length^2

MPOs – Space Instrumentation Heritage



MIXS (MIXS-T and MIXS-C) instruments on ESA/JAXA BepiColombo mission to Mercury. Launch 2018(?) MIXS PI institute UoL

MIXS-T: Radially-packed MPOs in Wolter Geometry
MIXS-C: Square-packed MPOs employed as collimators. MPOs slumped to 55 cm ROC, detector at distance equal to slump radius

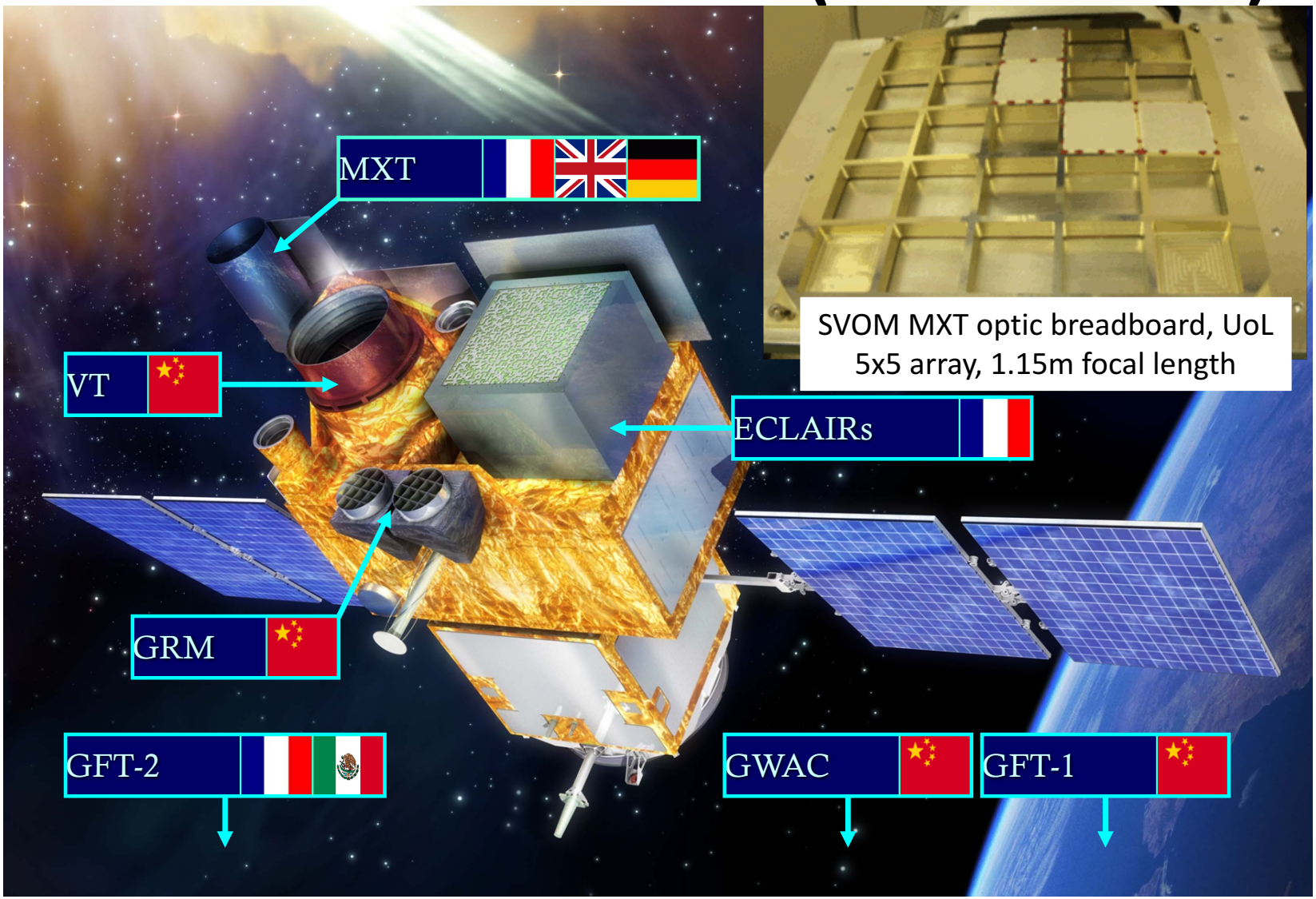


DXL/STORM Module. PI Michael Collier, NASA/GSFC

Flew on DXL sounding rocket flight, December 2012

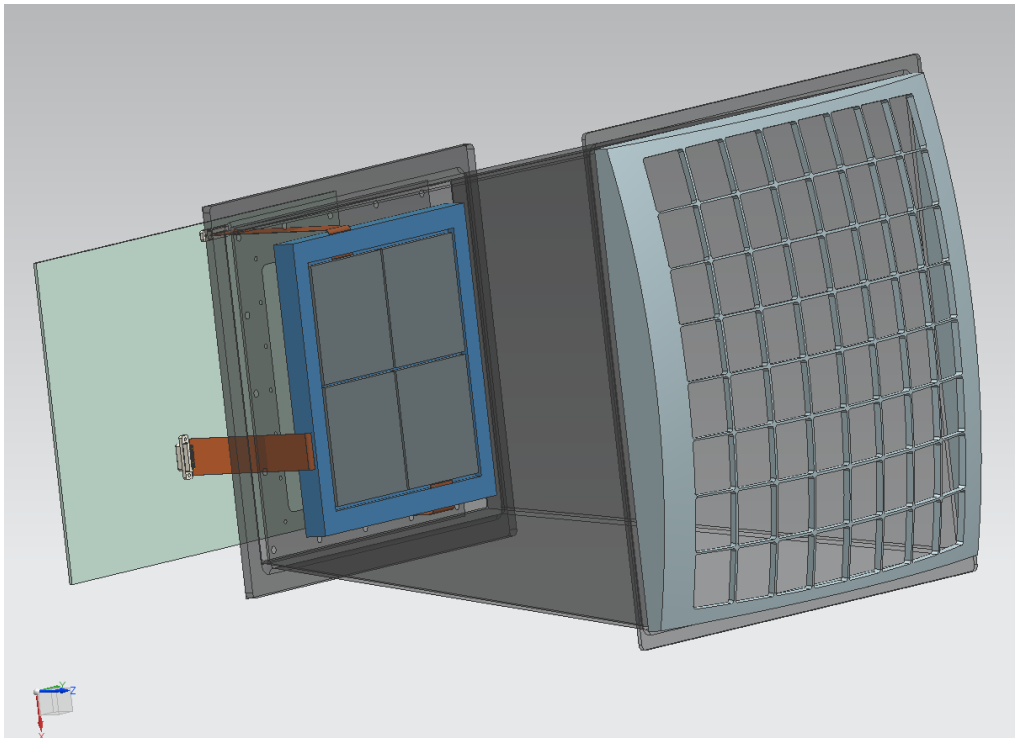
First Lobster-eye MPO telescope to be launched into space. Detected X-rays from soft X-ray background. Successfully recovered despite abnormal vibration during launch.

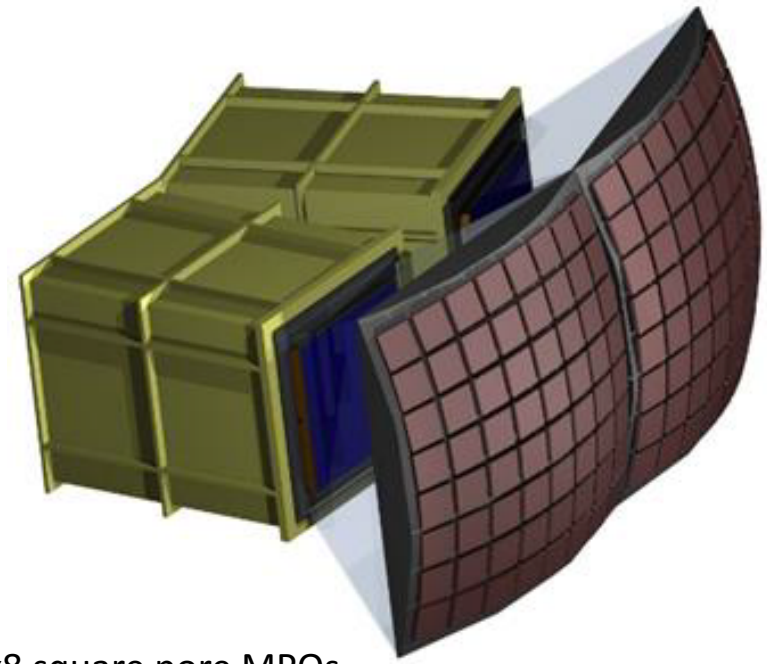
Future Mission: SVOM (Launch 2021)



SVOM MXT optic breadboard, UoL
5x5 array, 1.15m focal length

SXI modules (baseline is 2x2 modules)

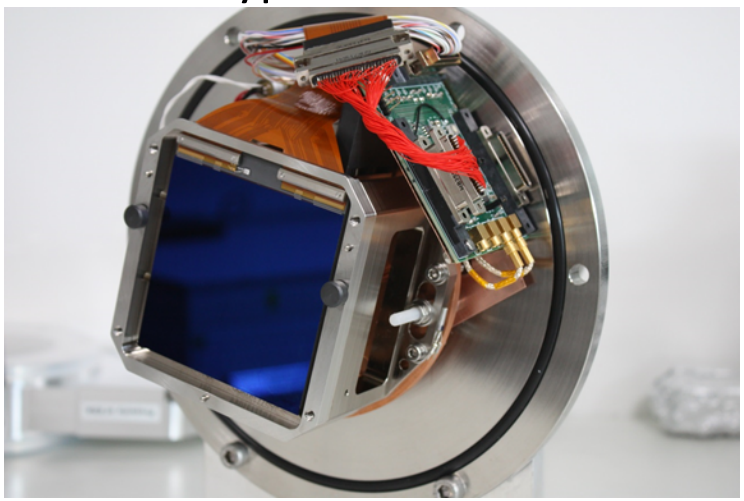




8x8 square pore MPOs
300mm focal length
2x2 e2v CCD270s in the focal plane
Baseline provides ~800 sq. deg. per module

Detector plane – CCD

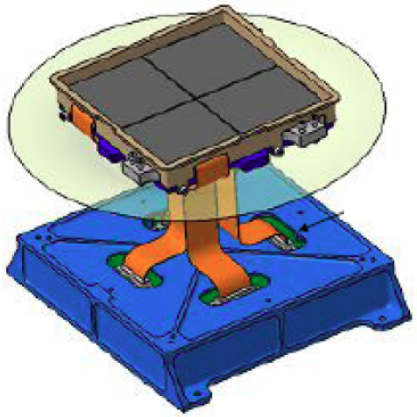
CCD270 type CCDs



e2v CCD270 – PLATO (ESA M3) derivative
Native 4510 x 4510 18 µm pixels
Native Image area **8.12 x 8.12** cm
Back-illuminated
2-node readout available
Operated with asymmetric frame store
6 x binning giving 108 µm pixels
Baseline ~1s frame time

PLATO:
ESA M3 exoplanet mission
36 cameras, each with
2x2 array of CCDs 4k x 4k, 18micron pixels

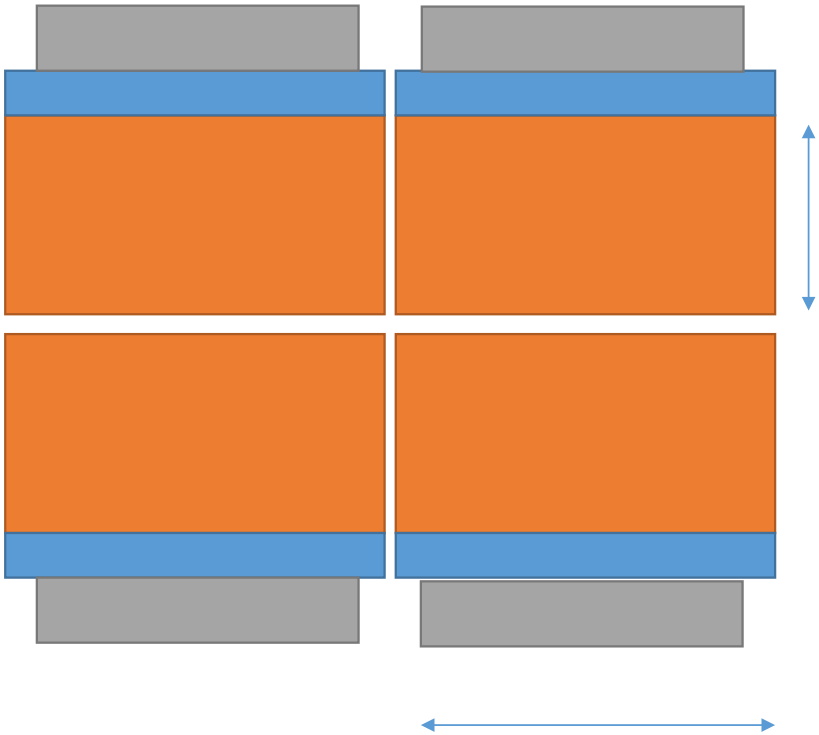
SXI leverages work done for PLATO on
CCDs and readout electronics



SXI CCDs optimised for X-ray detection
e.g. no AR coating, 40 µm depletion depth

Baselined for SMILE mission (China-ESA) – not thickened

Baseline configuration
(4 modules = 16 CCDs)



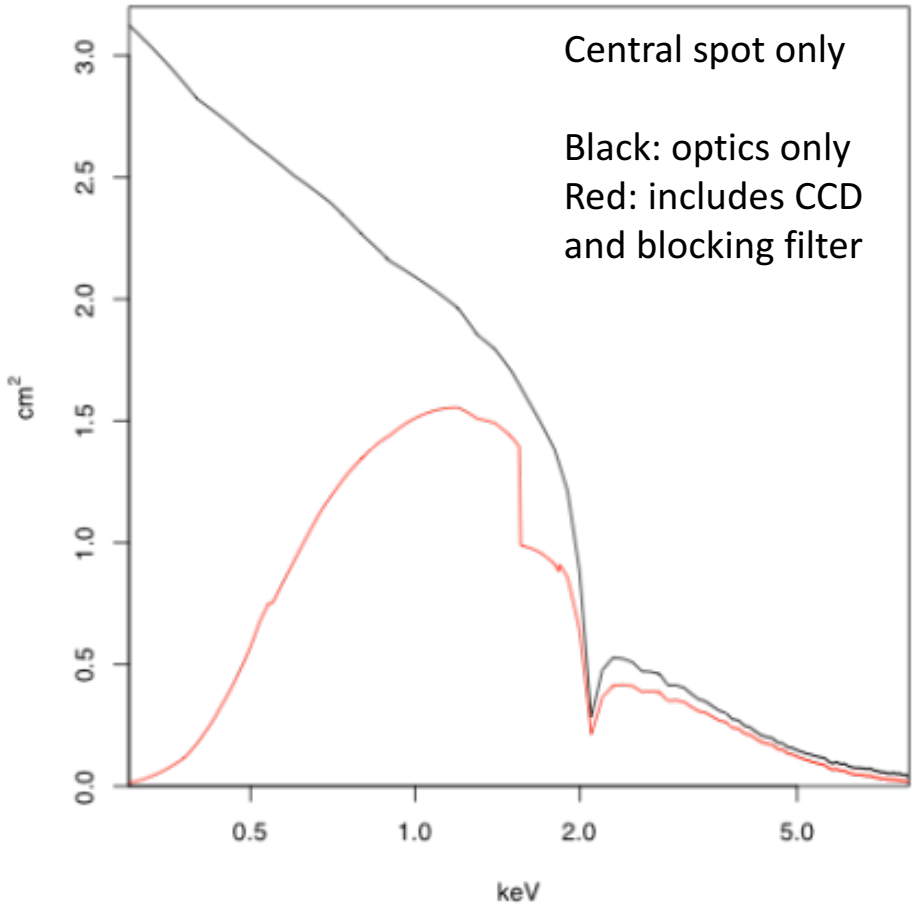
This assumes a frame store (1/6)

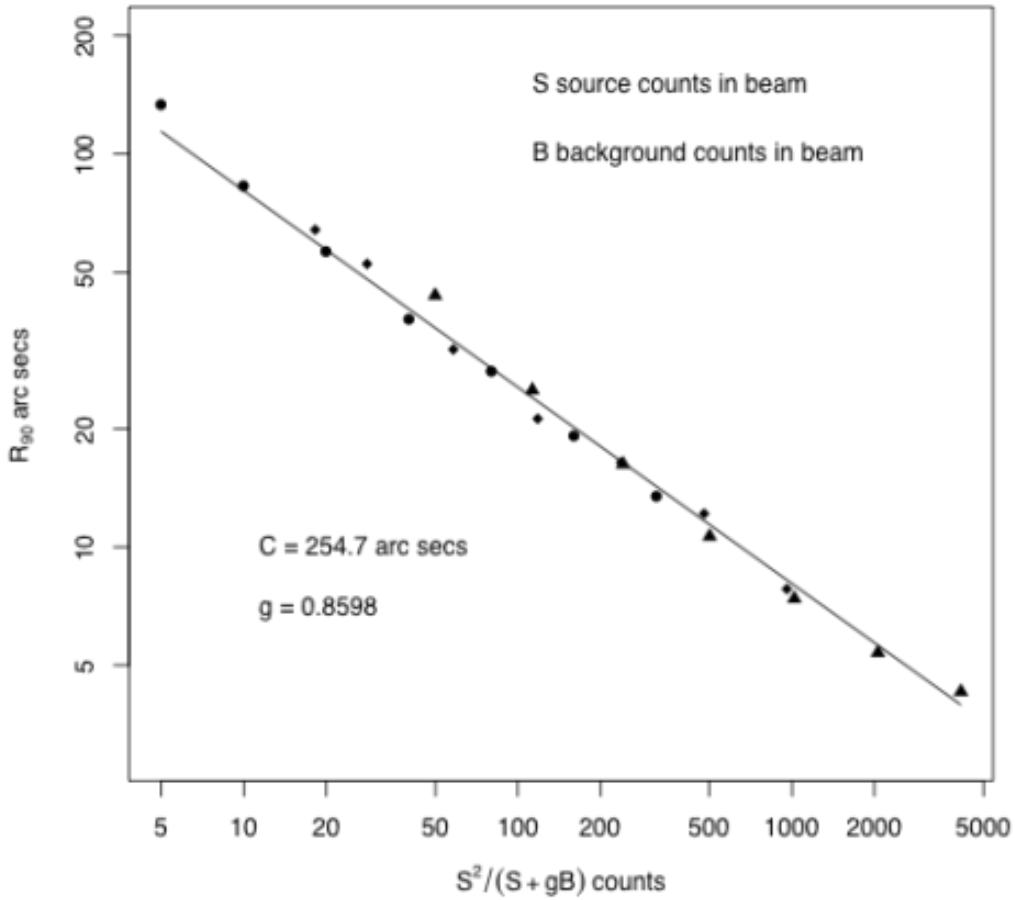
2 x 2 gives 220 cm^2

With this format you get a sky area of ~800 square degrees for a 2x2 CDD array for each module

In practice have some module overlap so slightly less total sky area

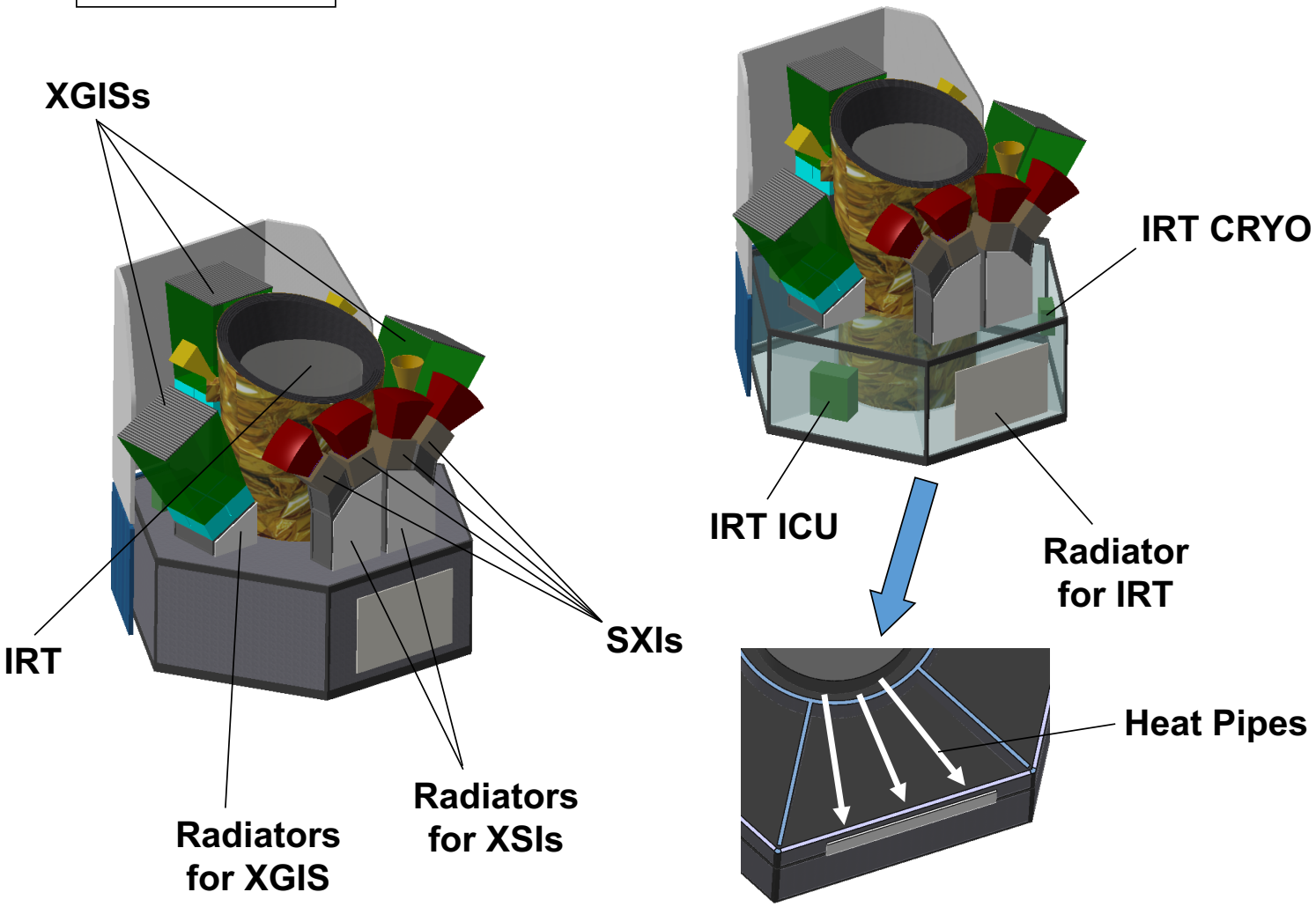
SXI effective area and localisation





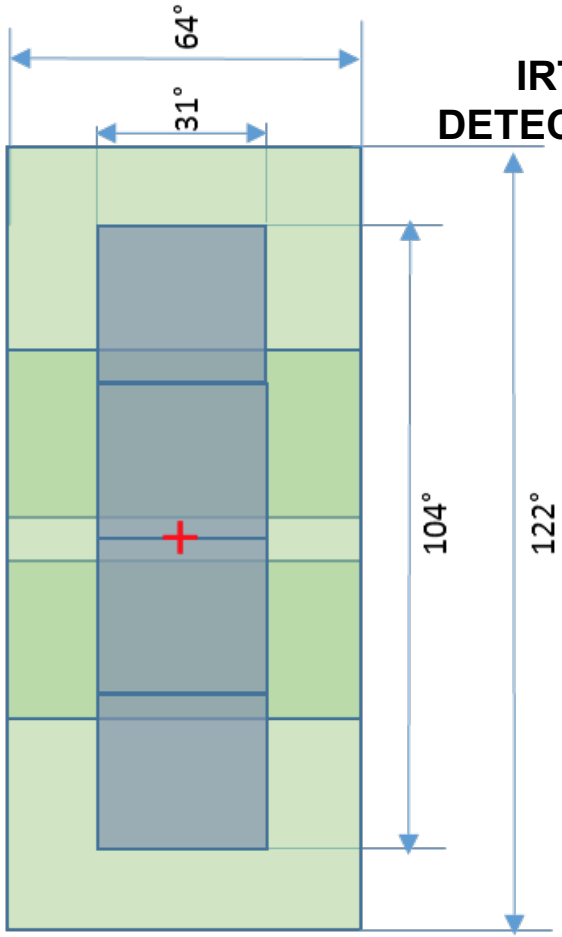
THESEUS

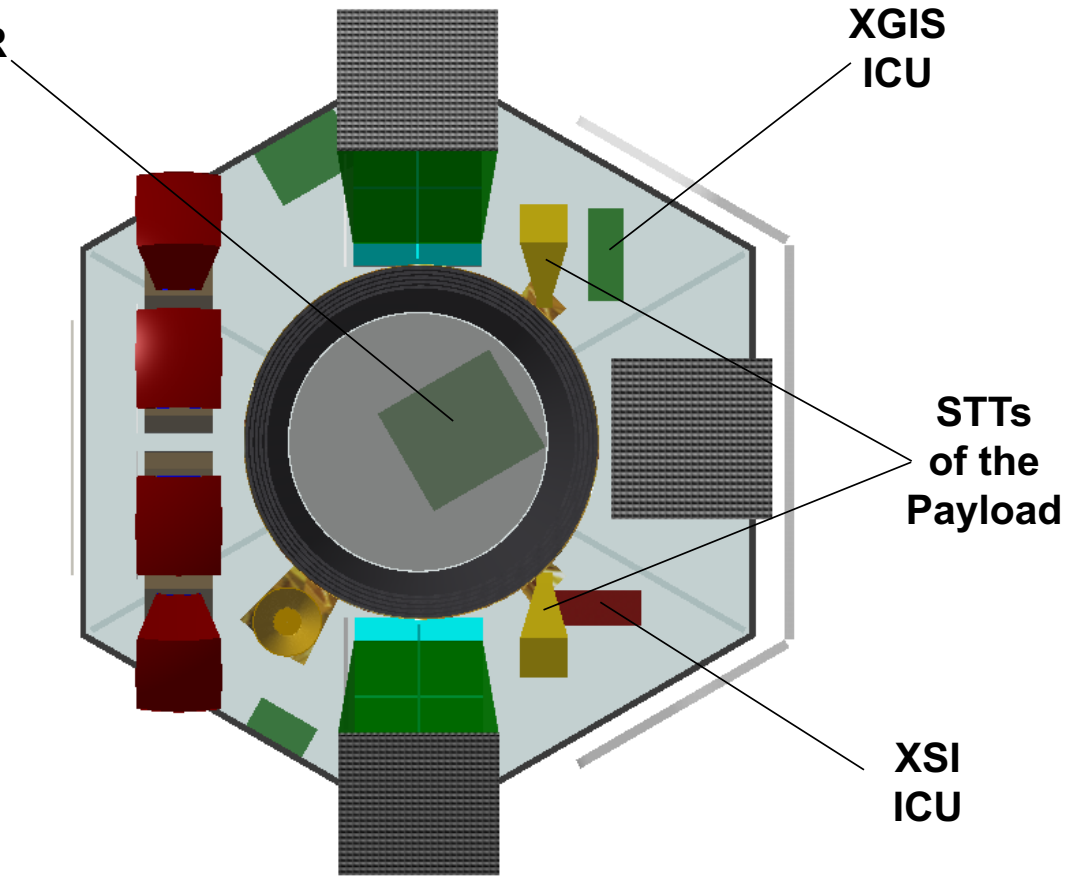
Accommodation – Payload Module



THESEUS

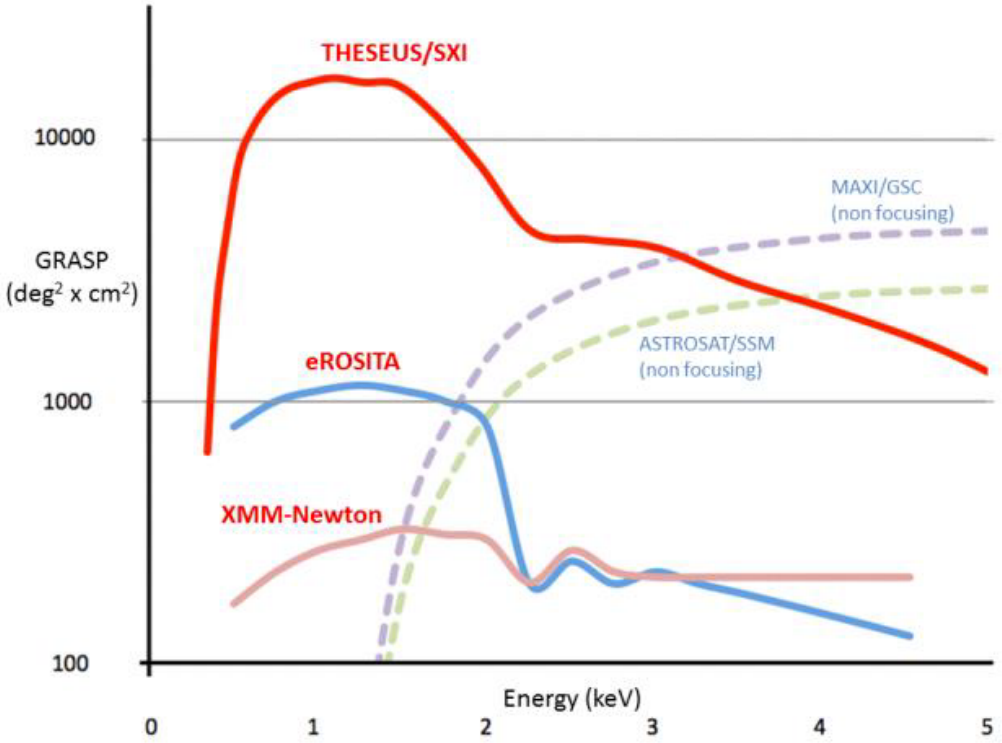
Accommodation – Payload Module

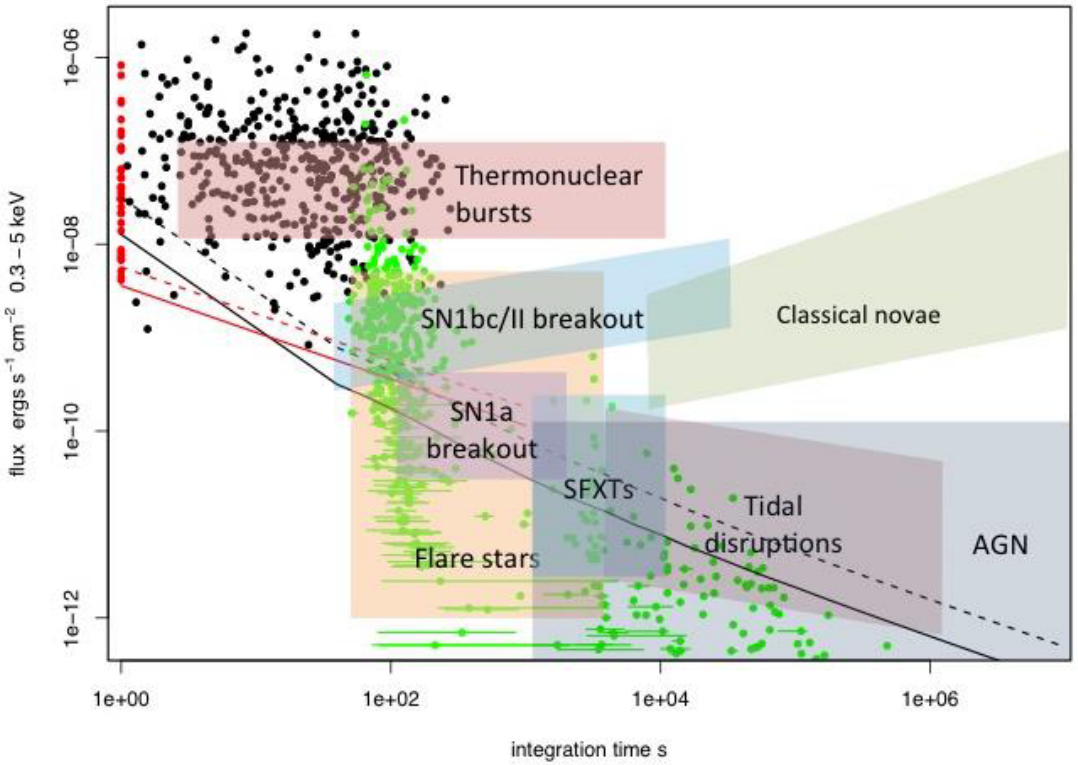




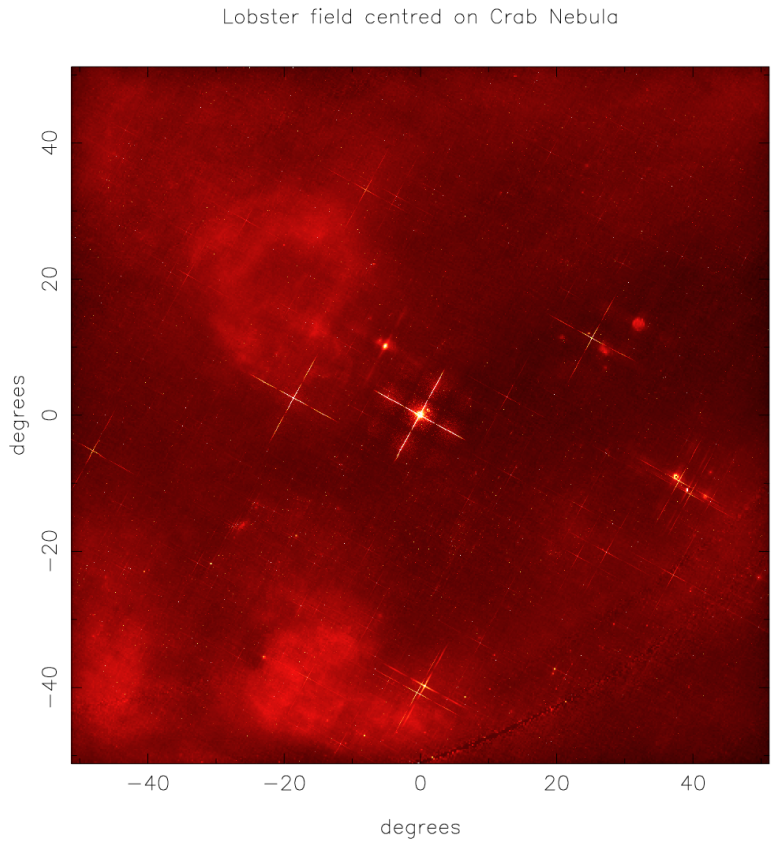
SXI total FOV, 104x31=3224 sq. deg

SXI GRASP (total) and sensitivity vs. time





Lobster image of the soft X-ray sky



Crab field – using the RASS