International X-ray Observatory (IXO)

Optimisation of the X-ray Optics for IXO

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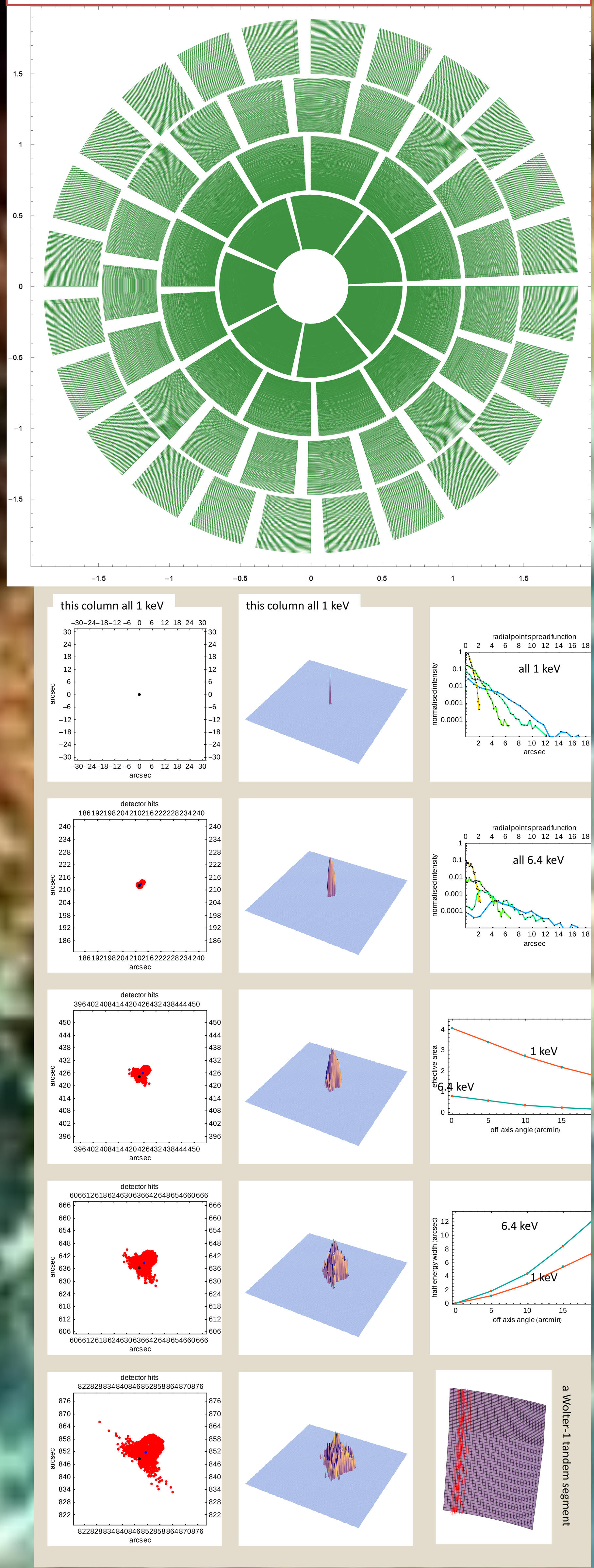
The primary X-ray mirror for the International X-ray Observatory is arguably the most crucial element of the entire mission concept, and the optimization of the optics has a profound influence on the science which can be achieved by the mission. The basic specification aims to provide a collecting area of 3 m^2 at 1 keV and an angular resolution of 5 arc seconds or better. There are different optical designs which could be employed and competing technologies which can be used to implement these designs and meet the goal. We show ***preliminary*** results concerning 3 possible combinations of design and technology and how these could impact on the angular resolution, the collecting area, the field of view, the operating energy range and therefore ultimately the scientific performance of the observatory.

Ray tracing results of different constellations of the IXO optics

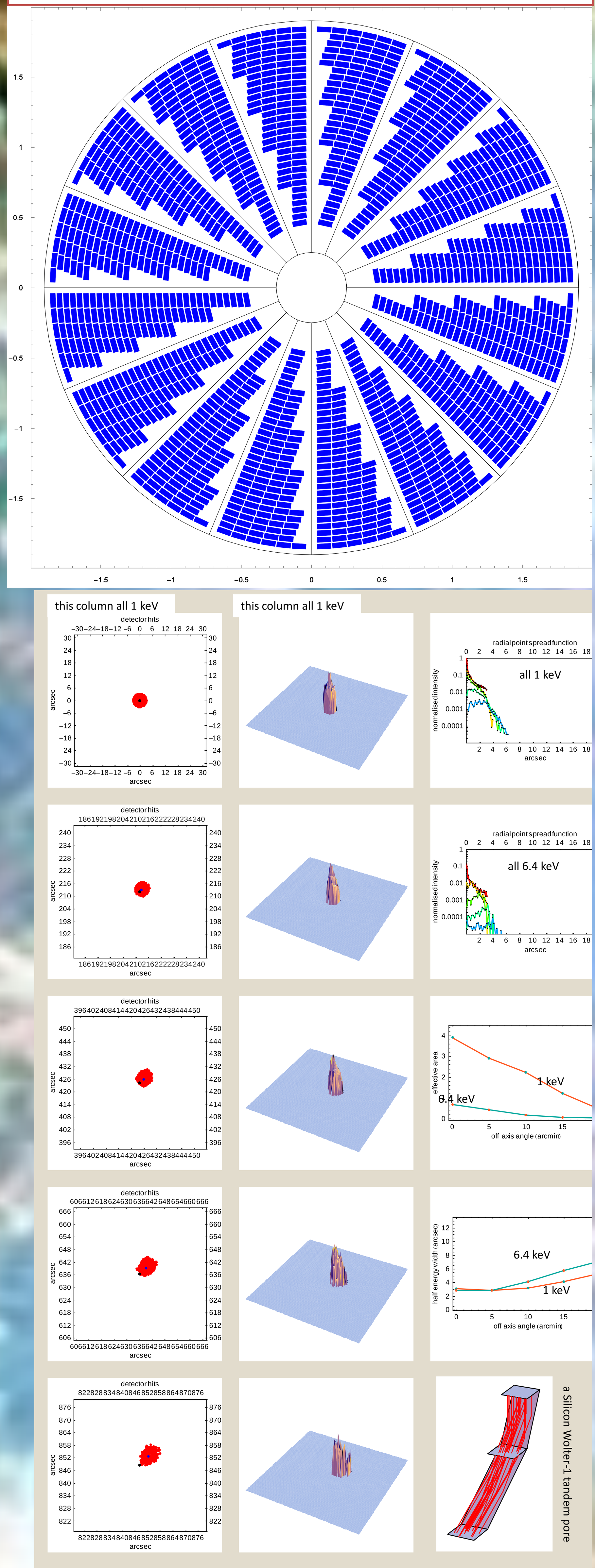
Segmented Glass Wolter-I

sections of parabolas and hyperbolas



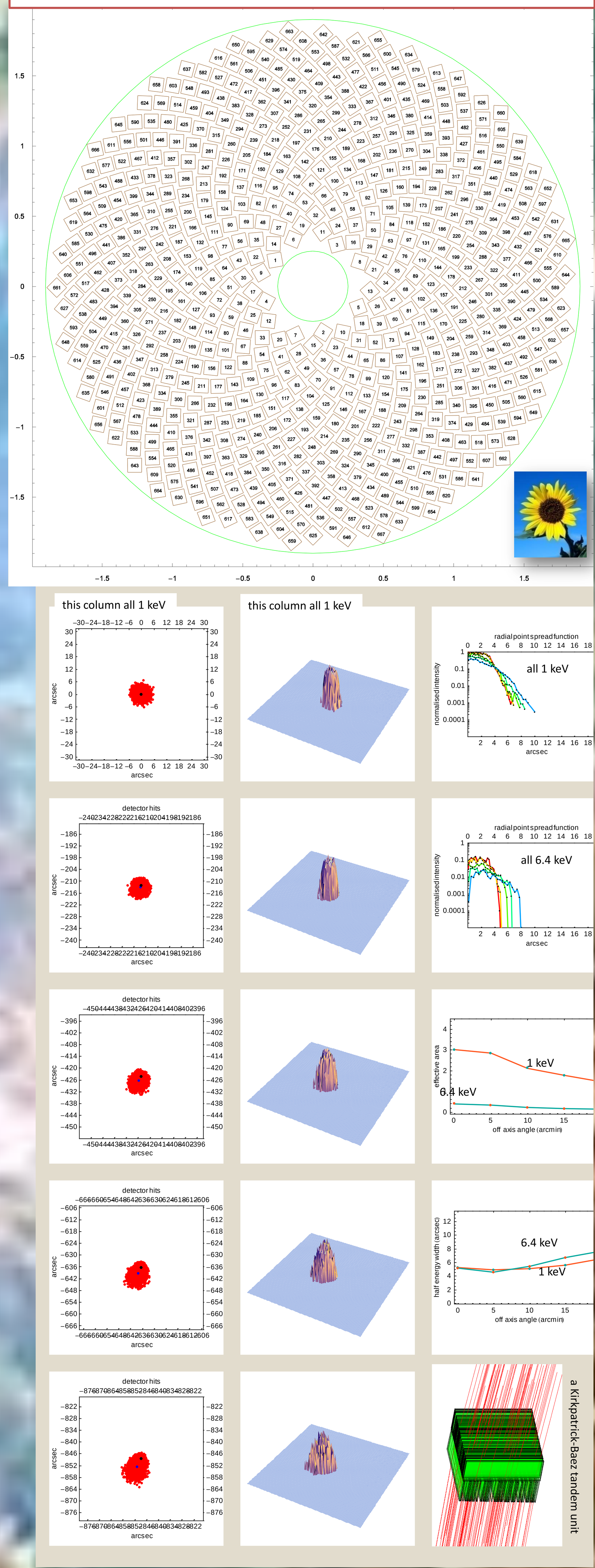
Silicon Pore Wolter-I

sections of cones



Silicon Pore Kirkpatrick-Baez

flat surfaces



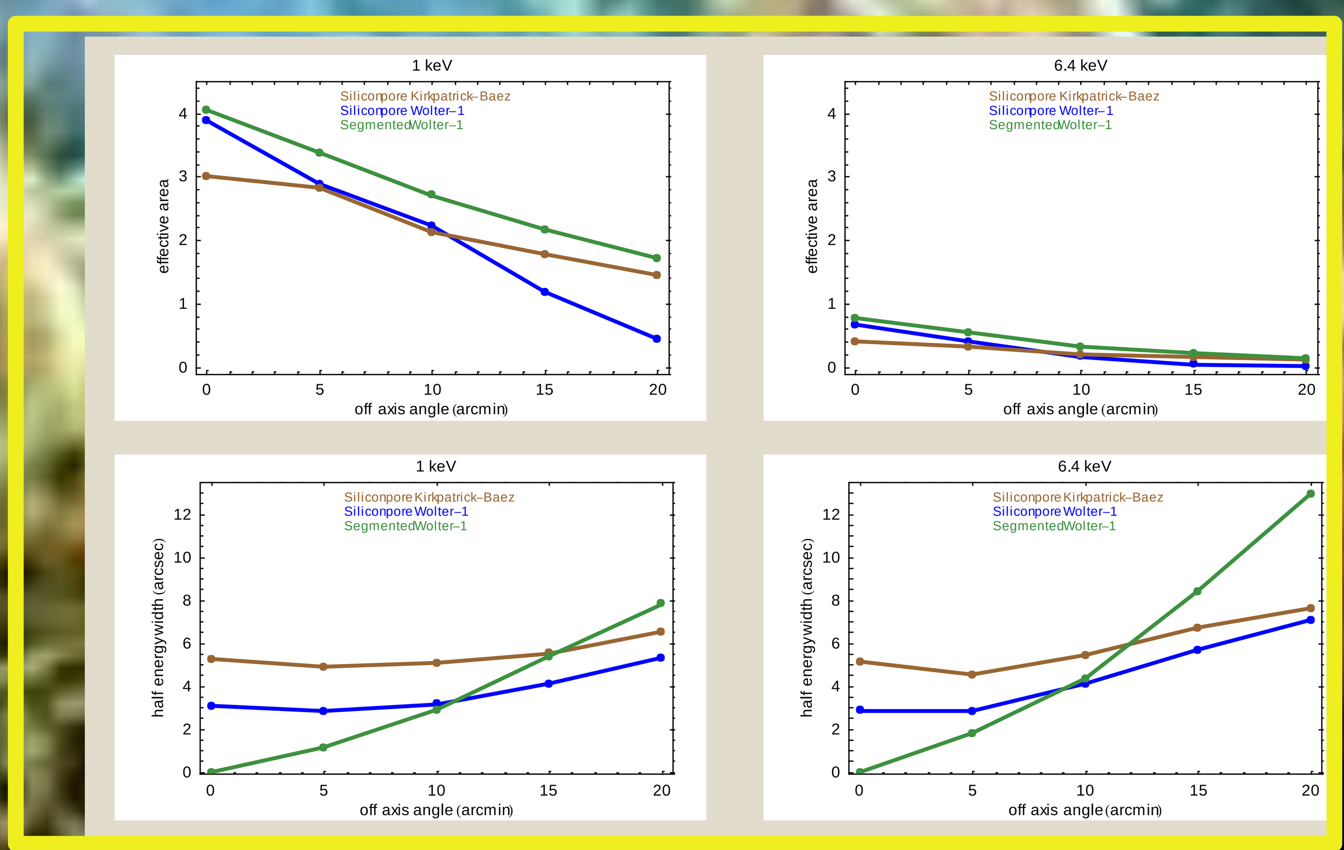
Discussion =>

- For the **effective area**, the values have been **scaled** such that all systems have the same collecting entrance pupil area - this is similar to **assuming an equal blocking factor** due to the support structure for all systems - and such that the Kirkpatrick-Baez system has an *effective* area of 3 m^2. The 1 keV results show best performance for the segmented Wolter-1 system, with the Kirkpatrick-Baez being relatively efficient off axis. For 6.4 keV the same behaviour can be seen.

- **Vignetting** is evident in the *relative* decrease of the effective area for off axis sources; the Kirkpatrick-Baez shows the best results, followed by the segmented Wolter-1 and then the Silicon pore Wolter-1.

- For the **angular resolution** the results show a better on axis performance of the segmented Wolter-1, which degrades significantly off axis (especially at 6.4 keV); the other two systems show a more or less constant angular resolution - the Silicon pore Wolter-1 better than the Kirkpatrick-Baez.

- For **other parameter settings**, these results can **change** substantially.



The preliminary results presented here do not take into account any errors of the optics, such as scattering and figure error, and represent a type of best case. No optimisation has been attempted yet, but certain trends in the on- and off-axis behaviour of the different optical constellations may already become visible. The optical parameters have mainly been chosen for best focusing. Reflection off surfaces other then the mirrors has not been taken into account. Diffraction too is not taken into account in the ray tracing, but some analytical results are shown below.

For each data point 10^4 rays have been traced. The reflection calculation was based on Iridium, the focal length 20 m, in the segmented Wolter-1 the length of the parabola was 0.2 m and the glass thickness 0.0003 m. The precision of the results was > 16 digits.

Analytical results for diffraction : the half energy width as a function of focal length and energy

focal length \ energy	0.050	0.074	0.11	0.16	0.24	0.36	0.53	0.78	1.2	1.7	2.6	3.8	5.6	8.3	12.
30.	4.34	3.07	2.2	1.69	1.43	1.58	1.79	1.89	2.04	2.09	2.15	2.09	2.15	2.09	2.09
25.	4.39	3.12	2.3	1.79	1.69	2.09	2.09	2.3	2.45	2.55	2.5	2.5	2.5	2.5	2.5
20.	4.39	3.22	2.45	2.04	2.3	2.61	2.86	3.01	3.17	3.17	3.07	3.17	3.17	3.17	3.17
15.	4.5	3.37	2.76	2.86	3.47	3.58	3.88	4.14	4.24	4.09	4.19	4.14	4.19	4.19	4.19
10.	4.8	3.99	4.14	5.16	5.31	5.77	6.18	6.28	6.08	6.23	6.18	6.23	6.23	6.23	6.23

For the pore optics, diffraction starts to be the dominant factor at lower (<1 keV) energies. In earlier work, analytical calculations were made in one dimension (radially) on the point spread function of one Silicon Wolter-1 pore including diffraction. The table shows the resulting half energy width (in arcsec) as a function of the energy (horizontal) and the focal length (vertical).

The right figure shows radial point spread functions, including diffraction, for a focal length of 35 m and at an energy of 0.05, 1 (lower left), 6 and 15 keV (lower right).