

A Bright Source Defocusing Optic for the IXO NFI

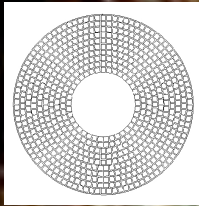
Richard Willingale

The Problem

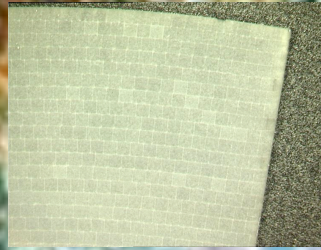
The PSF of the IXO optics is specified as 5 arc seconds Half Power Diameter. With a focal length of 20 m this translates to 0.485 mm in the focal plane and therefore the large collecting area provided by the mirrors, 3 m² at 1 keV, is focused into a very small area on the detector. For bright sources the Narrow Field Imager (a TES array) will be severely count rate limited because each pixel cannot be read out fast enough. **It will not be possible to use the NFI on IXO for many astrophysically important bright X-ray sources.**

The Solution

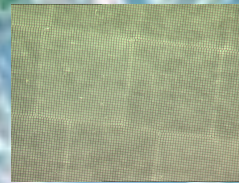
Defocus the telescope when observing bright sources so that the counts are spread over the detector. The central area of the NFI with small pixels and the best spectral resolution is expected to be 2.5 by 2.5 arc minutes equivalent to 14.5 by 14.5 mm. We want to defocus the telescope so that the PSF covers a significant fraction of this area as evenly as possible. **This can be achieved using a square pore Micro Channel Plate (MCP) mounted in the filter wheel in front of the NFI.**



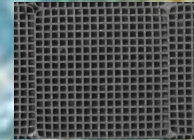
Radial packing of square pores



A radially packed square pore MCP from the Bepi Colombo MIXS instrument

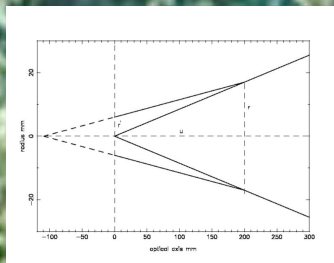


The multi-fibre structure in the MCP

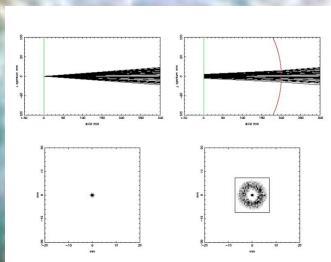


Square pores in a single multi-fibre

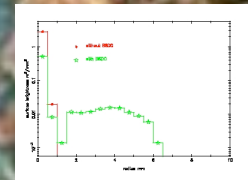
- The MCP must be slumped to a radius of curvature of R=240 mm to defocus the beam of X-rays from the IXO main mirror. Such slumping has already been demonstrated on the Bepi Colombo MIXS plates.
- If the filter wheel is at a distance of 200 mm from the focal plane the MCP must have a diameter of 36 mm to accommodate the full beam.
- For high efficiency the ratio of the length of the channels to the width must be ~100. Plates with this l/d have been manufactured.
- The channel walls must be coated with Iridium to provide high reflectivity. This has already been successfully achieved and tested. The open fraction of the plates is 0.58 and the low energy efficiency will be close to this value.
- The alignment of the channels in current plates is 1-2 arc minutes which is more than adequate for this application.



Geometry of defocusing



Verification of the basic design by ray-tracing



The radial surface brightness with and without the BSDO

Predicted performance of the Bright Source Defocusing Optic

- At low energies ~1 keV the BSDO utilizes ~38% of the mirror area giving an effective area of ~1.2 m²
- The surface brightness ratio is 180 so sources ~200 times brighter can be observed using the BSDO
- At high energies ~6.4 keV the BSDO utilizes ~26 % of the mirror area giving an effective area of ~0.24 m²
- The surface brightness ratio at ~6.4 keV is 73

Accommodation

- The MCP optic is a disk of glass diameter ~36 mm, thickness ~1mm, full of microscopic holes with a mass of just a few grams
- It can be accommodated in the filter wheel like any other thin filter
- The alignment/positioning for this application is not critical. Small tilts/shifts make little difference to the defocused distribution

The Astrophysics

We will be able to use the NFI on IXO for the observation of matter under extreme conditions using very bright sources to produce time resolved spectra with excellent signal to noise and an energy resolution of ~3 eV.

- Cataclysmic variables – variable accretion onto a white dwarf in all its manifestations
- Bright X-ray pulsars - finding the neutron star equation of state
- Low/High Mass X-ray Binaries – high resolution spectra of accretion onto a neutron star or black hole
- Magnetars - Soft Gamma Ray Repeaters – systems dominated by very strong magnetic fields