X-ray Telescopes

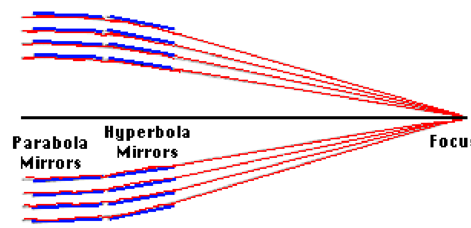
Copied from: http://imagine.gsfc.nasa.gov/docs/science/how_l1/xray_telescopes.html and
Copied from: http://nobelprize.org/nobel_prizes/physics/laureates/2002/illpres/telescope.html (Nobel Web AB)

How Do You Focus X-rays and Why Would You Want to Focus Them?

The first X-ray telescope used in astronomy was to observe the Sun, the only X-ray source in the sky producing an abundance of measurable signal. The first X-ray picture of the Sun, by a rocket-borne telescope, was taken in 1963. The first orbiting X-ray telescope flew on Skylab in the early 1970's and recorded over 35,000 full-disk images of the Sun.

The utilization of X-ray mirrors for extra-solar X-ray astronomy had to await two developments in electronic detectors:(1) the ability to determine the location of the arrival of an X-ray photon in two dimensions, and (2) simultaneously possessing a reasonable detection efficiency. Such detectors as the imaging proportional counter, the microchannel plate detector, CCD spectrometers, and imaging gas scintillation proportional counters have been developed to fit this need.

The design of an X-ray imaging system is difficult because of the constraints imposed by the interaction of X-rays with matter. X-rays impinging at normal incidence (that is, perpendicular) on any material are largely absorbed rather than reflected. Normal incidence mirrors, like those used for optical telescopes, are thus ruled out. For an X-ray telescope, you must select a material which reflects the X-ray photon (so that the X-rays are not absorbed) and design your telescope so that the X-ray photons hit the mirror at small, "grazing", incidence (so that they will be reflected). The most commonly used reflecting materials for X-ray mirrors are gold (used in the Suzaku, XMM, and Swift satellites) and iridium (used by the Chandra X-ray Observatory).



For gold, the critical reflection angle at 1 keV is 3.72 degrees.
It was shown mathematically that a reflection off a parabolic mirror followed by a reflection off a hyperbolic mirror could lead to the focusing of X-rays. Several designs have been used in X-ray telescopes based on this principle: the Kirkpatrick-Baez design and a couple of designs by Wolter.

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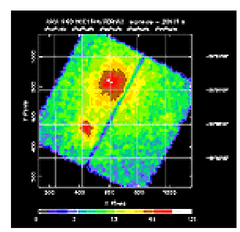

So why focus X-rays at all? Focusing helps create a clearer and shaper image of the X-ray source. It also allows scientists to get a better measure of faint X-ray sources which they could not otherwise detect. Sharp images help scientists to understand the distribution of hot gas between galaxies, the physics of supernova remnant expansion, and many other important issues. The ability to make an X-ray telescope moved astronomy forward in a big leap; the creation of X-ray telescopes with better spatial resolution and larger effective collection areas will continue to reveal exciting new information about the workings of our Universe.

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HOW DOES AN X-RAY TELESCOPE WORK?

In an ordinary optical telescope, lenses or mirrors are used to focus the light and form an image. However, a normal mirror will not reflect X-ray radiation, since it would pass straight through the mirror! Reflection will occur only if the X-rays graze the surface of a finely polished metal surface. This principle is used in an X-ray telescope, which is built from several nested cylinders with a parabolic or hyperbolic profile.

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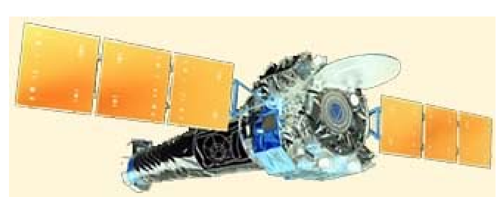

The Chandra X-ray telescope