The Wide Field X-ray Telescope

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FOREWORD

Riccardo Giacconi, September 2010

Important discoveries in all branches of Astronomy and in particular in X-Ray Astronomy have often come about by a combination of physical intuition, technological improvements, and a boundless faith in the richness of Nature. It is clear that theories about the Universe only go so far as can be achieved given our current knowledge and our mathematical skills.

Nature has no such limitations and has already solved the questions we are asking; very simply Nature is. This perhaps is why so many discoveries in Astronomy are real discoveries rather than verifications. The existence of binary X-ray sources, of efficient energy production by in fall of matter on collapsed objects, the existence of an extragalactic X-ray background, and the existence of intergalactic plasmas were revealed in most cases by unexpected discoveries from broad surveys in the X-ray domain.

While faith in the bounty of Nature is justified, it is also important to realize that understanding Nature requires skill in providing discovery space and care in listening to its replies.

I am convinced that the Wide Field X-Ray Telescope (WFXT) will provide the required technological advance to open a significant new discovery space. The expectations discussed at this meeting are a testimony of the broad range of scientific questions that will become accessible through the proposed surveys. My own interest in wide field X-ray optics stems from my encounters with X-ray emission from clusters of galaxies with the UHURU, EINSTEIN and ROSAT observatories and the number of questions that those surveys left unresolved. It was clear that to obtain unbiased samples we needed to be able to recognize clusters at large Zs through their X-ray properties alone, and that we needed to obtain significant deep and large statistical samples to enable the study of the formation and evolution of these structures.

In the late 80s Richard Burg, Christopher Burrows and I came to the realization that what was needed was new X-ray optics, which combined reasonably high resolution ($\sim$5 arc seconds) and a wide field of view ($\sim$1 degree), in other words an X-ray Schmidt telescope. We submitted a paper on this subject to the Astrophysical Journal in April 1990 (it was published in June 1992 on Ap.J., 392, 760-765). We succeeded in showing that such optical design was entirely feasible and no more difficult to achieve practically than the EINSTEIN or the ROSAT optics (see figures below).

In 1995 we submitted a NASA Explorer proposal with the specific goal of a cluster survey out to $z > 1$. The proposal was rejected on the basis of the prejudice which dominated the theoretical and observational community in the early-mid 90s that clusters did not exist at $z > 0.5$. The pioneering efforts of Piero Rosati and later the results from *Chandra* and *XMM-Newton* demonstrated that this was nonsense. Still other proposals to ESA, ASI and NASA up to 2002 were not successful.

Development of the new X-ray optics fabrication techniques in the US has proceeded very slowly and the scarce available funds were mainly used for in house work at NASA centers with little success. In Italy ASI funded the efforts of the Brera Observatory that succeeded, with industrial support, in demonstrating the feasibility of wide field optics (1 degree) with angular resolution of 5-7 arc seconds.

We were encouraged to submit the description of a medium sized survey mission (which would become the ultimate survey for many decades) to the Decadal Survey of the National Academy of Sciences. This included a description of the mission, its cost and a projected launch date of six years after go ahead. Four supporting articles outlined the expected scientific returns ranging from stars and galaxies, clusters of galaxies, quasars and cosmology.

It is unfortunate that this mission that has broad community support was received at a time of great financial difficulties for NASA due to the ballooning costs (mainly due to NASA mismanagement) both in the the manned exploration and scientific programs. The concerns with the state of development and the future of IXO , which appears headed in the same direction, dominated the consideration of X-ray astronomy. If understandable, it was disappointing to find no mention of WFXT in the NASA report.

Still I remain convinced that WFXT is a necessary mission in X-ray Astronomy to fill the gap of 100,000 in sensitivity between the deep and all sky surveys. WFXT will generate a legacy set of 500,000 clusters to $z \sim 2$, 10,000,000 AGNs to $z \sim 6$, and 100,000 normal and starburst galaxies. For a fraction of this sample ($\sim 10\%$) will provide direct physical characterization, with no need of follow up observations.

WFXT will have a strong impact on a wide range of disciplines and provide unique synergy to present and planned observatories such as IXO, JWST, ELTs and ALMA. I have complete confidence that X-Ray Astronomy will continue in the future to contribute greatly to our understanding of the Universe, and that WFXT will play an important role in its progress.

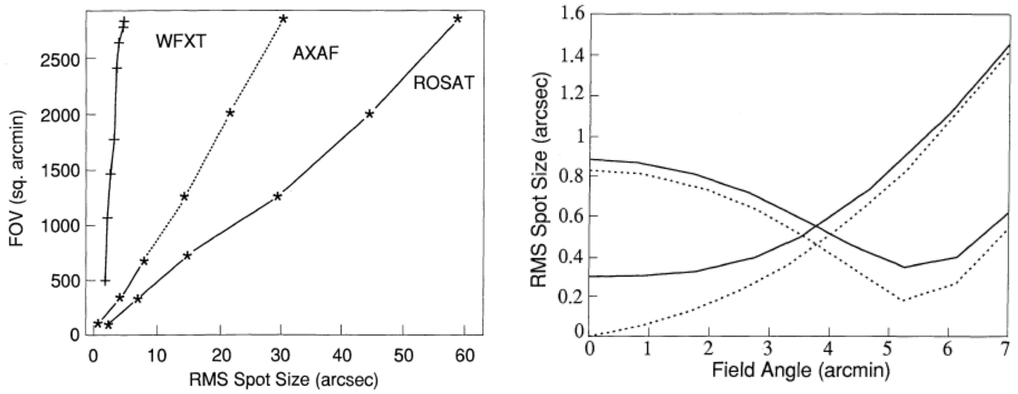

Fig. 1. [*From Burrows, Burg & Giacconi, 1992, ApJ, 392, 760*] *Left*: The cumulative field of view for ROSAT, AXAF (a.k.a. *Chandra*), and the *Wide Field X-ray Telescope*. The total available field area is plotted as a function of the average image quality. *Right*: the rms spot size for the outer shell of AXAF, in the existing and optimized designs (raising curves). The solid curves have an assumed image blur of $0.5''$caused by surface roughness added in quadrature to the dotted curves which represent the raytrace results. The optimized design (WFXT) has best image quality near $5'$. It remains sub-arcsecond over the full field. The existing paraboloid-hyberboid design is best on-axis, but when averaged over the field is about a factor of 2 worse than optimized design.