The Future of X-Ray Optics

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Looking to the Future.

- Progress in X-ray optics, with emphasis on the angular resolution, is central to the paradigm-shifting discoveries and the contributions of X-ray astronomy to multiwavelength astrophysics over the past 51 years.
  - Rocket, Uhuru, Einstein, Rosat, Chandra

Learn from the Chandra experience.

- Clear scientific goals drove the design of the mission.
- Approaching our next X-ray mission in this way is more important than ever.
  - Why? The lesson of history is that this next mission will certainly not launch until after 2020 or, more likely, after 2030.

Take advantage of the hiatus.

- Use the time for developing technologies and manufacturing approaches that will satisfy our scientific needs for the next 51 years.
  - Seek fresh ideas from a broad community for the challenge that I will describe.

What should the next (notional) major X-ray mission be?

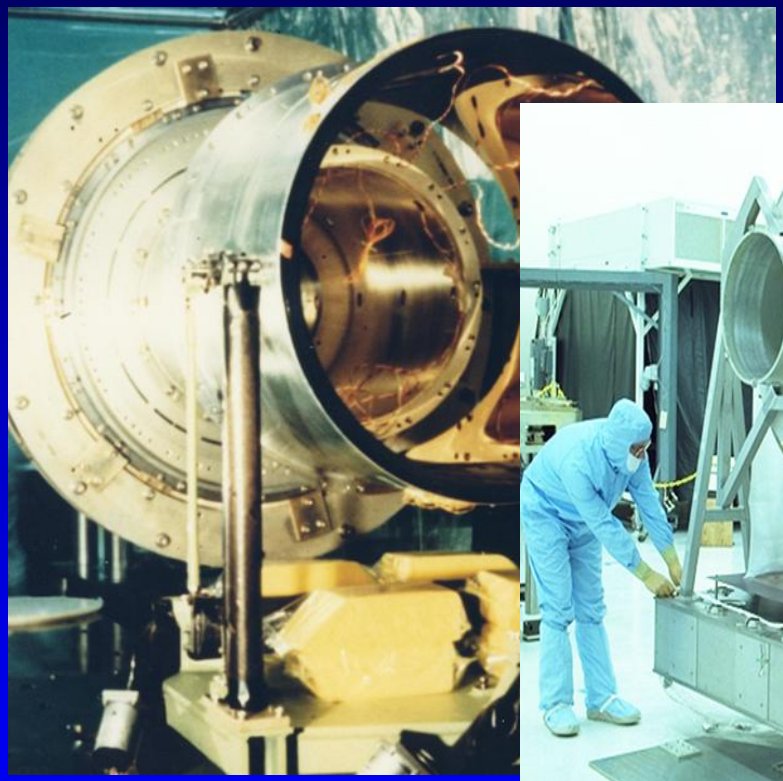
- Conservative (i.e., reasonable) requirements:
  - Sub-arcsecond on-axis angular resolution
  - Capability for wide-field deep surveys
  - Effective area sufficient to detect the first galaxies in an integration time ≈ Msec
  - Wide energy band to enable spectroscopy.

- To (inexpensively) realize such specifications will require a technology program of the type I shall describe.

Learn from Chandra - develop the optics before we have a mission!

- Follow multiple, competitive, physics-based (not programmatic-based) approaches.
  - Currently several ideas but no proven answers.
    - Adjustable X-ray optics
    - Differential deposition
    - New materials
  - Even then, prove both technical readiness *and* manufacturing readiness.
- Defining and costing the mission before the technology is in hand hurts us.
  - Outrageous and self-fulfilling cost estimates.

Learn from Chandra - develop the optics first!



Demonstrate technology

Demonstrate manufacturing

Build flight optics

Do not drive the optics design to:

- satisfy an arbitrary mass limit.
  - Scientific performance takes precedence.
- address thermal and vibration issues.
  - Assume that external hardware will provide adequate thermal stability and vibration isolation.
- accommodate horizontal 1-g operations.
  - Assume & impose *vertical* alignment, assembly, metrology, and X-ray testing of the mirror assembly.

What will these optics look like?

- Grazing incidence technology.
- Full-shell or segmented --- unclear.
- Total weight --- unclear.
- Number of telescopes to achieve the required area --- unclear.

Conclusions.

- The most important next step is the development of X-ray optics comparable to (or better than) Chandra in angular resolution that far exceed Chandra's effective area.
- Use the long delay to establish an adequately funded, competitive technology program along the lines I have recommended.
- Don't be diverted from this objective, except for Explorer-class missions.