The Making of the *Chandra* X-ray Observatory: The Project Scientist’s Perspective

September 22, 2009

Martin C. Weisskopf
The Beginning

1963
My Introduction to X-Ray Astronomy

"SEX" & the "PIG"

SEX = Super EXplorer

PIG = Principal Investigator Group

1969
The Proposal

For the Study of the 1.2 Meter X-Ray Telescope
National Observatory
The Competitors

- MSFC and SAO
- JPL and Cal Tech
- GSFC
First SWG

- R. Giacconi – Chairman
- M. Weisskopf – Vice Chairman
- A. Opp (NASA HQ) – Ex Officio
  - E. Boldt (GSFC)  S. Bowyer (UCB)
  - G. Clark (MIT)  A. Davidsen (JHU)
  - G. Garmire (CIT)  B. Krasheur (Wisc)
  - R. Novick (Columbia)  S. Shulman (NRL)
  - H. Tananbaum (SAO)  A. Walker (Stanford)
  - K. Pounds (Leicester)  J. Truemper (MPE)
Einstein Observatory

HEAO-B EXPERIMENT CONFIGURATION

- Focal Plane Imaging Detector
- High Resolution Mirrors
- Objective Grating Spectrometer
- Broad Band Filter Spectrometer
- Aft Thermal Precollimator
- Forward Thermal Precollimator
- Experiment Sunshade
- Aspect Sensor (3) Sunshade
- Monitor Proportional Counter
- Optical Bench
- Central Electronics Assembly (6)
- Imaging Proportional Counter
- Solid State Spectrometer
Major New Programs:

#1: An Advanced X-Ray Astrophysics Facility (AXAF)
Instruments

- ACIS
- HRC
- LETG
- HETG
- FPCS – Focal Plane Crystal Spectrometer
  - Removed in 1988
- XRS – X-Ray (Calorimeter) Spectrometer
  - AXAF-S - 1991
  - Removed in 1993
The Second SWG

Andrew Wilson  Riccardo Giacconi
Andy Fabian  Bert Brinkman
Jeff Linsky  Steve Murray
Harvey Tananbaum  Gordon Garmire
Alan Bunner  Leon van Speybroeck
Steve Holt  Claude Canizares
Martin Weisskopf  Richard Mushotzky

1985
Brochures

AXAF
The Advanced X-Ray Astrophysics Facility
Space Station Appears

Servicing with the Space Station

Orbital servicing guarantees a long-lived AXAF mission and maximum scientific results.
Technology Mirror Assembly

1985-1989
The Next Hurdle

P1/H1 – uncoated and uncut

Needed Test Facility at least one year earlier than scheduled

1990
XRCF

X-Ray Sources

Focal Plane Detectors
• 1G Effects!

VETA - Hiccup

19 x 19 Scan with 0.010 Pinhole at nominal focus
File: 050991/1000AL10579.scn

Energy: 1.49 keV
Estimated Mirror Performance on Orbit
Facility Effects Removed Using Lucy Deconvolution of 19 x 19 Scan

Energy: 1.49 keV

FWHM = 0.19 arcsec
Restructuring

AXAF
- up to 4 instruments
- 33,000 lbs.
- low-Earth orbit
- 6 mirror pairs

AXAF-I
- 2 instruments
- 11,000 lbs.
- high-Earth orbit
- 4 mirror pairs

AXAF-S
- 1 instrument
- 4,000 lbs.
- Sun-synchronous orbit

1992
Restructuring

- Servicing Disappears
  - Assured by new orbit
- But benefits
  - Efficiency
  - Thermal
  - Iridium
- At a price
  - Loss of two mirrors
  - Ultimately “loss” of AXAF-S
Clusters and S-Z

MICROWAVE BACKGROUND PHOTON

HOT CLUSTER GAS

ENERGETIC ELECTRON

BLUE SHIFTED MICROWAVE PHOTON

OBSERVER
John Carlstrom & Marshall Joy to the Rescue

Consolidated Array for Millimeter Astronomy

1992
X-Ray Calibration
X-Ray Calibration
Integration with the S/C

1998
On to the Cape
Mate with the upper stage
Three Launch Attempts

Tue July 20
Sensor spike hydrogen in the engine compartment

Thurs July 22
Lightning

Fri July 23
Launch
Beyond the Sky
Words and Music by Judy Collins

“And we will fly beyond the sky
Beyond the stars beyond the heavens
Beyond the dawn we'll carry on
Until our dreams have all come true
To those who fly - we sing to you”
In the Control Center
August 8 --- ACIS Housing

- Had failed during ground test
- Needed to see a 70° reading
- 18° would indicate the seal was broken

Pulse 1 - no motion
Pulse 2 - 13°
Pulse 3 - 19.5°
Pulse 4 - 36°
Pulse 5 – 71.5°
The Real First Light

Leon X-1
A type 1 AGN at $z = 0.3207$
The First Pointing & Focus Adjustment
It Really Works!