The Genesis and Early Days of XMM

and the Importance of the Science Working Team (1989 – 2001)

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Chair, US Users’ Group, 2000 - 2008
Status of X-ray Astronomy 1970’s – early 1980s

- Late 1970’s ~1000 sources (prior to Einstein Obs.) – proportional counter energy resolution (sources ‘soft’ / ‘hard’, overall kT)

- Bragg crystal Spectroscopy using rocket experiments only prior to 1978 (Columbia, Leicester, MSSL):
  upper limits on bright Galactic binaries, e.g. Sco X-1, Cyg X-1, A0620-00
  positive result on mCrab

Einstein FPCS results on 41 sources, including positive results on SNR and clusters (see archive in Lum, Canizares et al. 1992, ApJS 78, 423)

### Missions prior to 1985

<table>
<thead>
<tr>
<th>Mission</th>
<th>Date</th>
<th>log(S)</th>
<th>E-Range</th>
<th>&lt;Energy&gt;</th>
<th>Res.</th>
<th>A(eff)</th>
<th>Mirrors</th>
</tr>
</thead>
<tbody>
<tr>
<td>UHURU</td>
<td>1969</td>
<td>0</td>
<td>2-10</td>
<td>7</td>
<td>3</td>
<td>200</td>
<td></td>
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<tr>
<td>HEAO-1</td>
<td>1977</td>
<td>-1</td>
<td>0.1 - 0.3</td>
<td>3</td>
<td>2</td>
<td>200</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>2 – 60</td>
<td>7</td>
<td>7</td>
<td>1000</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>20-1000</td>
<td>50</td>
<td>5</td>
<td></td>
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<tr>
<td>HEAO-2</td>
<td>1978</td>
<td>-3</td>
<td>0.1 – 0.3</td>
<td>1</td>
<td>100-1000</td>
<td>0.21</td>
<td>Ni on fused quartz [+ OGS, FPCS]</td>
</tr>
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<td></td>
<td></td>
<td></td>
<td>0.5 – 4</td>
<td>2</td>
<td>2</td>
<td>100</td>
<td>IPC</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td>1 – 50</td>
<td>7</td>
<td>5</td>
<td>700</td>
<td>CFRP</td>
</tr>
<tr>
<td>EXOSAT</td>
<td>1982</td>
<td>-2</td>
<td>0.04 – 2</td>
<td>1</td>
<td>2</td>
<td>15</td>
<td>CFRP</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>1 – 50</td>
<td>7</td>
<td>5</td>
<td>700</td>
<td></td>
</tr>
<tr>
<td>ROSAT</td>
<td>1987</td>
<td>-3</td>
<td>0.1 – 3</td>
<td>1</td>
<td>3</td>
<td>300</td>
<td>Au on zerodur</td>
</tr>
</tbody>
</table>

(continued on next page)
European X-ray Spectroscopy and Polarimetry on Spacelab
EXSPOS study – mid 1970’s

Candidate for Single Spacelab pallet –
Multiple flights, modular instruments
Selected for Phase A Study
Several aspects later used for XMM

Consortium members involved in XMM
(Spacelab flew 22 times)

Free-standing spherically curved crystal panels for individual emission lines
  e.g. Fe XXV/XXVI Si XIII/XIV, S XV/XVI
Nested paraboloid mirrors, <2keV
Transmission Gratings, Reflection Gratings
Free-standing non-dispersive detectors
(GSPC, PC)
Optical / UV monitors
Modular approach – multiple flights

No CCDs (not yet developed for X-rays)

See also Schnopper et al. Spherical Crystal Cosmic X-ray Spectrometer, 1981
Advent of CCD’s for X-ray Imaging / Spectroscopy

- 1969 Boyle & Smith (Bell Labs.) – bucket-brigade optical device (linear array)
- Early 1970’s: Fairchild, RCA, Westinghouse, TI, GEC(UK), Thompson (France), Philips (Germany)
- WF/PC proposal for HST using TI 3-phase – Westphal et al.
- Late 1970’s: Application to single-photon X-ray imaging / spectroscopy.
  
  CfA-HEAD, using Fairchild, RCA, Westinghouse (deep depletion), GEC
  see Griffiths et al., 1981, SPIE 290, 62
- TI 3-phase also tested for X-ray imaging (JPL - Janesick et al.) → AXAF
- Clear potential for AXAF and ESA mission when scaled up – ESA support from 1988
The Lyngby Workshop – June 1985

• Following UHURU, Copernicus, OSO-7, OSO-8, Ariel V, EXOSAT, Ginga, ANS, SAS-3, HEAO-1, Einstein Obs. (< 2keV, IPC)

• Widely recognized need for X-ray spectroscopy

• High throughput X-ray spectroscopy mission* proposed to ESA in 1982

• In response, Lyngby workshop (DTU) organized by ESA/ESTEC (Taylor, Peacock)

• Candidate for Second Cornerstone Mission

• ----> The High-Throughput X-ray Spectroscopy Mission

• Nested X-ray telescopes (set of 20 + set of 7) CFRP

• Reflection gratings

• CCD cameras

Candidates for ESA’s Horizon 2000 (AP)

• Physics of the Sun/Earth system (SOHO/Cluster)
• The hot and energetic Universe (XMM-Newton, INTEGRAL)
• The molecular and dusty universe (Herschel)
• Primordial material in the solar system (Rosetta)
• Galactic dynamics (Hipparcos/Gaia)
• European landers (Huygens/Philae)
• The oldest light (Planck)
• Planetary Science in Europe (MarsExpress, VenusExpress)
The XMM ‘AO’

• Following Definition Study, XMM Selected as ESA Horizon 2000 second Cornerstone mission
• Major Differences from a NASA AO
• Instruments were largely pre-selected, collaborations organized in advance
  • EPIC – UK (M.Turner), Germany, Italy, France
  • RGS – Netherlands (A.Brinkman), USA
  • OM – UK (K.Mason), Italy, Belgium
• Instruments funded separately by national science agencies, not ESA
• Some competing instrument proposals were not selected
  • E.g. Alternative Gratings
  • Doubly Curved Bragg Crystal Spectrometer (NSI, DTU, Lyngby – Byrnak, Schnopper et al.)
  • Polarimeter
• Five Mission Scientists also selected (2 from USA) and Telescope Scientist
  • Bergeron, Bleeker, Pallavicini, Griffiths, Mushotzky, Aschenbach
XMM Science Working Team 1989 - 2001

- Instrument PI’s, Telescope Scientist, Mission Scientists
- Quarterly Meetings – reviews of all aspects of mission
Change from CFRP → Electroformed Nickel

- Mirrors were originally Carbon Fiber Reinforced Epoxy, CFRP**
  Following EXOSAT (Piet de Korte, Utrecht) App. Optics., 1988, 27, 1440
- Mirrors on Critical Path, given early start
- XMM Contract with Carl Zeiss, Germany
- Found to exhibit warping on outgassing in vacuum testing
  - Did not meet spec. – and unknown degradation long-term
- Projected performance in orbit was unacceptable
- Inertia to change!
- Decision effectively made by A. Peacock and Brian Taylor
  Under pressure from SWT 1993
  → R. Lainé + Dsci + DG

New contract with MediaLario, founded 1993, for electroformed Ni (JETX, Beppo-SAX)
start of testing 1995

Other Issues Addressed by the Science Working Team

- 1990 – contamination issues, radiation damage, OM mechanical complexity, OM → UV coverage, rather than IR
- Jan 92 – ESTEC project Management changes needed
- 1993 – MOS CCDs for gratings, PN in open position
- 1994 – report on optical IDs of survey sources → Survey Scientist, SSC
- 1996 Stray Light investigation (RFM, from ASCA) – baffle introduced
- 1998 Discussion of contamination and phasing of instrument turn-on (this was related to experience with the HST instruments).
- Calibration requirements (science sub-groups)
- Electron deflector located in the exit aperture.
- Also examined the solar-wind proton problem (don’t look upwind!)
  reflection of MeV protons
- May 98 – Ground s/w not ready, but EPIC took blame for launch slip
Post-launch ESA Users’ group meetings, Villafranca near San Lorenzo de el Escorial
Charoles Restaurant

US users’ group meetings
Greenbelt
US Users’ Group 2000 -

• Oversight of Guest Observer Facility
• Usefulness of software packages
• Results of GO AO process
• Thank you for the invitation!!