Hard X-ray Response and its developments in Japan

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Science with HXT/HXI

Evolution of Massive Black Holes
without biases due to absorption

Resolving point sources of CXB in 10-60 keV

Higher S/N ratio in Hard X-rays
better determination of continuum spectra
better time resolution of variability

Mapping diffuse hard X-ray sources
on Galactic plane
cluster of galaxies
# Hard X-ray Imaging telescopes

<table>
<thead>
<tr>
<th><strong>Hard X-ray response</strong></th>
</tr>
</thead>
</table>
| 1. Small incident angles --> Long EOB  
  <!-- low efficiency (obscuration by t~0.2mm)  
| 2. Multilayer coatings  
  design and implementation  
  Stress?  

<table>
<thead>
<tr>
<th><strong>Image quality</strong></th>
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</table>
| 90” --> 10”  
  Necessary for resolving point sources  
  Utilize same optics? |
Multilayer design for Hard X-ray Telescopes

\[ \theta \leq 0.3 \text{ degrees} \]

\[ d \geq 25 \text{ Å} \]

\[
\begin{array}{cccc}
\theta (\text{deg}) & N & d_{\text{max}} (\text{Å}) & d_{\text{min}} (\text{Å}) \\
0.110 & 28 & 126.4 & 46.2 \\
0.123 & 37 & 117.8 & 40.0 \\
0.135 & 56 & 117.8 & 35.3 \\
0.152 & 79 & 117.8 & 31.6 \\
0.169 & 93 & 117.8 & 28.6 \\
0.187 & 121 & 106.5 & 26.1 \\
0.208 & 138 & 98.5 & 24.0 \\
0.230 & 138 & 98.5 & 24.0 \\
0.253 & 123 & 88.5 & 24.0 \\
0.280 & 123 & 88.5 & 24.0 \\
0.310 & 108 & 77.4 & 24.0 \\
0.342 & 108 & 24.0 & 24.0 \\
\end{array}
\]
Hard X-ray Telescopes for IXO

<table>
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<th>Characteristic</th>
<th>Value</th>
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<tbody>
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<td>Aperture annulus radii</td>
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<td>Focal length</td>
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Multilayer Coating with Pt/C

![Graph showing effective area vs. energy](image)

- **75cm Φ x 1 Tele**
- **320cm Φ x 1 Tele**

Effective area (cm²) vs. energy (keV)
**Hard X-ray Telescopes for IXO**

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*Multilayer Coating with Pt/C*

![Diagram showing effective area vs. energy for different telescope sizes](image)

- **40cm Φ x 1 Tele**
- **320cm Φ x 1 Tele**

Effective area ~300 cm²
Hard X-ray telescopes

Multilayer on Si wafers

Si wafers for XEUS from ESTEC
10 x 100 x 1 mm³

Standard Pt/C Multilayers
d = 5 nm, N = 30 layer pairs

Float glass plate as a reference

First Bragg peak reflectivity
Si ~ Float glass
Reflectivity of ML on Si surface

DC Pt/C d=40 μm, N=30
fitting model = NG
substrate = Si
factor = 1.060
I(0.4 Å) = 0.42
first peak = 72.16%
second peak = 2.00%
vacuum ~9.9×10^{-4} Pa
Cu-K

Reflectivity of ML on Float glass surface

//Users/oh-ishii/Mirror/fit/result/r-N080120a-1.dat

DC Pt/C d40 l0.4 N30
fitting model = NG
substrate = fg
factor = 1.015
l0.4 -> 0.39
first peak = 70.31%
second peak = 1.82%
vacuum ~ 9.9*10^(-4) Pa
Synchrotron Beam at SPring-8
E<200 keV

8 GeV
2 \pi R = 1436 m

Power User
(Machine time is reserved for calibration)

Himeji, JAPAN
Synchrotron Beam at SPring-8
E<200 keV

BL20B2: $6 \times 10^6$ photon s$^{-1}$ mA$^{-1}$ mm$^{-2}$@30keV

Si DCM $E/dE=10^4$
111 (5.0 to 37.5 keV), 311 (8.4 to 72.5 keV), and 511 (13.5 to 113.3 keV)
Hard X-ray Measurements

Astro-H HXT on stages

Hard X-ray Imager (Image Intensifier)
Study Activities in Japan

1. Conceptual Design of the Mission
   ==> DSC study in XEUS

2. Extensible Optical Bench
   ==> ASCA/Suzaku Heritage

3. X-ray telescope and Imager
   Hard X-ray Response + Calibration
   ==> Astro-H HXT/HXI

4. Cryogenics
   ==> XRS of Suzaku/Astro-H
3. EOB Comparison of Mirror/Detector at 20/25m

(1) Detector extension
- FOB, total weight is comparable
- Twist frequency is much higher

(2) 20/25m comparison
- Detector (600kg)
- Deck (200kg)
- Mast (300-400kg)
- Canister (~430kg)
- Cylinder A (164-193kg)
- Cylinder B (540-650kg)
- Canister Deck (160kg)
- Detector Deck (150kg)
- Telescope (2300kg)
- Adapter (250kg)
Hard X-ray imaging detector

A draft design

- Detailed design to be done.
- Astro-H HXI EM design (2008-2009) will be incorporated.

Analog ASICs

Double-sided Si strip detector X 2

Top-view of imager part

Double-sided CdTe strip detector

Cross-section-view of HXI-Sensor part

Guard counters

APDs

BGO

HXI
new design

70mm
iv) Cryogenic system for IXO: a draft plan

**Side view**

- Radiators: 1m², 1.1m²
- X-ray beam: Φ 750 mm
- S/C structure: (290 K)
- X-ray entrance window

**Bottom view**

- Weight: 132kg
- Power: 378W / 398W

©SHI
**Study Activities in Japan**

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<th>Study Area</th>
<th>Collaboration</th>
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<td>Nippi</td>
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<td>Calibration</td>
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<tr>
<td>(Hard X-ray Response)</td>
<td>Beam Line at</td>
</tr>
<tr>
<td>4. Cryogenics</td>
<td>SPring-8</td>
</tr>
<tr>
<td>5. Detector developments</td>
<td>SHI</td>
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<tr>
<td></td>
<td>Hamamatsu</td>
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- DSC study in XEUS
- ASCA/Suzaku Heritage
- Astro-H HXT/HXI
- XRS of Suzaku/Astro-H
- CCD, ASIC, Calibration