The ASTRO-H project

Hiro MATSUMOTO (Nagoya University) on behalf of the ASTRO-H team
Outline

• X-ray astronomy

• ASTRO-H
  – Precise Soft X-ray Spectroscopy
    • Soft X-ray Telescope (SXT) + Soft X-ray Spectrometer (SXS)
  – Soft X-ray Imaging Spectroscopy
    • SXT + Soft X-ray Imager (SXI)
  – Hard X-ray Imaging Spectroscopy
    • Hard X-ray Telescope (HXT) + Hard X-ray Imager (HXI)
  – Soft Gamma-ray Observation
    • Soft Gamma-ray Detector (SGD)

• Summary
We would overlook real face without X-rays.

M_{gal} < M_{gas}

Cluster of galaxies

hot gas
ASTRO-H Satellite
Japan’s 6th X-ray Astronomical Satellite

Launch 2015

Extended Optical Bench: 6.3m
Total length: 14m
weight 2.7t
International collaboration

More than 160 scientists from Japan/USA/Europe
Wide energy range (0.3—600keV)
ASTRO-H vs other observatories

Energy resolution

Energy range

Angular Resolution

High-E sensitivity

low-E sensitivity

Chandra

XMM-Newton

suzaku

ASTRO-H
SXT + SXS (0.3—12 keV)

Soft X-ray Telescope

Soft X-ray Spectrometer (X-ray Calorimeter)

f=5.6m
Soft X-ray Spectrometer (SXS)

High-energy resolution even for spatially extended objects (cf. gratings)

$\Delta E < 7\text{eV}$ (goal $< 4\text{eV}$)
Detector array

- 6 x 6 pixels
- FOV 3' x 3'

Cooling system

- Cut-away view of the Dewar
- MLI
- MS-OVCS: 50 layers
- OVCS-MVCS: 30 layers
- MVCS-IVCS: 20 layers
- JT shield 4.5 K
- He tank 1.2 K
- dADR 50 mK
- CFRP strips from IVCS to He tank

He+JT+ST

Life time > 3 yrs (goal > 5 yrs)
SXS Energy resolution

Ground Experiment

Simulation

He-like Iron Kα lines

SXS

CCD

SXS can distinguish fine structure

→ Measure physical parameters of plasma directly.
ASTRO-H XRT (SXT, HXT)

Wolter-I optics

“Year ring” of foils

focus

X-ray source
Soft X-ray Telescope (SXT)

SXT-1 FM
203 nested shells
Angular resolution $\sim 1.3'$

Au-coated Al foils
Total reflection

450mm
101.6mm
SXT+SXS vs other gratings

Good for dim objects, high-energy X-rays
See Dynamic Universe!
Tycho SNR simulation

Gas expansion speed, ion temperature
SXT + SXI (0.3—12keV)

Soft X-ray Telescope

Soft X-ray Imager (X-ray CCD)

f=5.6m
Soft X-ray Imager (SXI)

Pch X-ray CCD

Thick depletion layer
~200um

Moderate $\Delta E$
($\sim 150eV @ 6keV$)

Largest FOV
$38' \times 38'$
HXT + HXI (5—80keV)

Hard X-ray Telescope

Hard X-ray Imager
(Si DSD + CdTe DSD)

f=12m
Hard X-ray Imager (HXI)

E<20 keV: Double-sided Si Strip Detector
E>20keV: Double-sided CdTe Strip Detector

FOV: 9’ × 9’
Hard X-ray Telescope

HXT-1 FM
213 nested shells

49cm

45cm

Pt/C multilayer

Bragg Reflection
E=5—80keV

Ang. Res. ~ 1.9′
SGD (10—600 keV)

Soft Gamma-ray Detector (Si+CdTe)
Soft Gamma-ray Detector (SGD)

- Si/CdTe Compton Camera
- Active shield of BGO
High Sensitivity for high-E X-rays
SNRs seen with HXI

Clarify the mechanism of particle acceleration.

Y. Uchiyama’s talk

Today’s afternoon
ASTRO-H under test

ASTRO-H will be launched in 2015
Summary

- ASTRO-H carries four systems
  - SXT + SXS, SXT+SXI, HXT+HXI, SGD
  - Wide energy range
  - High energy resolution
  - High sensitivity for high-E X-rays
  - Wide FOV
- Many science topics can be addressed
- ASTRO-H will be launched in 2015

Visit http://astro-h.isas.jaxa.jp/index.html.en
backup
<table>
<thead>
<tr>
<th>Properties</th>
<th>SXS</th>
<th>SXI</th>
<th>HXI</th>
<th>SGD (photo-abs)</th>
<th>SGD (Compton)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Effective area (cm²)</strong></td>
<td>50/225</td>
<td>214/360</td>
<td>300</td>
<td>150</td>
<td>20</td>
</tr>
<tr>
<td>(0.5/6 keV)</td>
<td>(0.5/6 keV)</td>
<td>(0.5/6 keV)</td>
<td>(@30 keV)</td>
<td>(@30 keV)</td>
<td>(@100 keV)</td>
</tr>
<tr>
<td><strong>Energy range (keV)</strong></td>
<td>0.3-12.0</td>
<td>0.4-12.0</td>
<td>5-80</td>
<td>10-600</td>
<td>40-600</td>
</tr>
<tr>
<td><strong>Angular resolution in HPD (arcmin)</strong></td>
<td>1.3</td>
<td>1.3</td>
<td>1.7</td>
<td>N/A</td>
<td>N/A</td>
</tr>
<tr>
<td><strong>Field of view (arcmin²)</strong></td>
<td>3.05x3.05</td>
<td>38x38</td>
<td>9x9</td>
<td>33x33 (&lt;150 keV)</td>
<td>33x33 (&lt;150 keV)</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>600x600 (&gt;150 keV)</td>
<td>600x600 (&gt;150 keV)</td>
</tr>
<tr>
<td><strong>Energy resolution in FWHM (eV)</strong></td>
<td>5</td>
<td>150</td>
<td>&lt; 2000</td>
<td>2000</td>
<td>4000</td>
</tr>
<tr>
<td>(0.6 keV)</td>
<td>(0.6 keV)</td>
<td></td>
<td>(@0.6 keV)</td>
<td>(@0.40 keV)</td>
<td>(@0.40 keV)</td>
</tr>
<tr>
<td><strong>Timing resolution (s)</strong></td>
<td>8x10⁻⁵</td>
<td>4</td>
<td>several x 10⁻⁵</td>
<td>several x 10⁻⁵</td>
<td>several x 10⁻⁵</td>
</tr>
<tr>
<td><strong>Instrumental background (s/keV/FoV)</strong></td>
<td>2x10³/0.7x10⁻³</td>
<td>0.1/0.1</td>
<td>6x10⁻³/2x10⁻⁴</td>
<td>1x10⁻⁴/1x10⁻⁵</td>
<td></td>
</tr>
<tr>
<td>(@0.5/6 keV)</td>
<td>(@0.5/6 keV)</td>
<td></td>
<td>(@0.5/6 keV)</td>
<td>(@0/100/600 keV)</td>
<td></td>
</tr>
</tbody>
</table>

¹4 layers, ²1 layer
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<tr>
<th>Properties</th>
<th>SXT</th>
<th>HXT</th>
</tr>
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<tbody>
<tr>
<td>Diameter (cm)</td>
<td>45</td>
<td>45</td>
</tr>
<tr>
<td>Focal length (m)</td>
<td>5.6</td>
<td>12</td>
</tr>
<tr>
<td>No. of nested shells</td>
<td>203</td>
<td>213</td>
</tr>
<tr>
<td>Reflector coating</td>
<td>Au</td>
<td>Pt/C multilayer</td>
</tr>
<tr>
<td>Thermal shield</td>
<td>Al (0.03 μm) + polyimide (0.2 μm)</td>
<td>Al (0.03 μm) + PET (5 μm)</td>
</tr>
</tbody>
</table>

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<th>HXT</th>
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<tbody>
<tr>
<td>$A_{\text{eff}}$ (cm$^2$)</td>
<td>279/312 (@0.5/6keV)</td>
<td>338 (@30keV)</td>
</tr>
<tr>
<td>HPD (arcmin)</td>
<td>1.3</td>
<td>1.7</td>
</tr>
<tr>
<td>FoV (arcmin$^2$)</td>
<td>22.2$^2$/19.8$^2$ (@0.5/6 keV)</td>
<td>6.4$^2$/5.3$^2$ (@30/50keV)</td>
</tr>
<tr>
<td>Stray-light reduction rate</td>
<td>&gt;99 (@30' off-axis)</td>
<td>&gt;99 (@15'-25' off-axis)</td>
</tr>
<tr>
<td>Thermal shield transmission (%)</td>
<td>70 (@0.5keV)</td>
<td>92 (@5 keV)</td>
</tr>
</tbody>
</table>
Phase 0: 3 Months: Satellite/Instruments Check out (including Calibration)
Phase 1: 6 Months: SWG 90% (PV Phase) Observatory 10%
Phase 2: 12 Months: SWG Carry Over 15%, GO 75%, Observatory 10%
Phase 3: Rest of the mission: KeyProject 15% (TBD), GO 75%, Observatory 10%

Observatory 10% = Calibration + TOO + Director's Time

<table>
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<tr>
<th>Observatory</th>
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<tr>
<td>Sci. WG</td>
<td>Key Project?</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Check</th>
<th>Sci. WG</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>3</td>
</tr>
<tr>
<td>9</td>
<td></td>
</tr>
<tr>
<td>21 month</td>
<td>GO</td>
</tr>
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Data policy among J/Europe/US in the GO time, would be similar to the Suzaku case. But we are planning to introduce key-project type and/or early-data-released type observations from early phase of the mission.