Status of ASTRO-H

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ASTRO-H Hard X-ray Telescope Team
Outline

• Overview of ASTRO-H Mission
• Current Status of ASTRO-H
• Status and topics of each instrument
• Future master schedule
ASTRO-H Mission

Launch site: Tanegashima Space Center
Launch Vehicle: JAXA H-2A Rocket
Orbit Altitude: 550 km
Orbit Type: Approximate circular orbit
Orbit Inclination: 31 degrees
Orbit Period: 96 minutes
Launch: 2014

Key Features
1. High resolution spectroscopy with the micro-calorimeter
2. Imaging capability with hard X-ray telescope + hard X-ray imager
3. High sensitive wide-band spectroscopy from 0.3 to 600 keV

Scientific Objectives
1. Revealing the large-scale structure and its evolution of the Universe
2. Understanding the extreme condition in the Universe
3. Exploring the diverse phenomena of non-thermal Universe
4. Elucidating dark matter and dark energy
ASTRO-H Mission

H-2A
(for ASTRO-H)

M-V
(for Suzaku)
Instruments onboard ASTRO-H
Current Status of ASTRO-H

- Many sub-system Critical Design Reviews (CDRs) were held before production of flight model (FM)
- System CDR is divided into two steps (CDR1 and CDR2)
- Reason for the necessity of CDR1
  - ASTRO-H is very large and complex satellite compared with past missions (e.g., one sub-system corresponds to one mission). This means that a change of design in a sub-system possibly impacts on whole system. In order to avoid such a situation, I/F between system and sub-system should be fixed as early as possible. CDR1, therefore, should be done before the Mechanical/Thermal test (MTM/TTM) of the S. C.
  - CDR2 will be done after MTM/TTM
- System CDR1 was done on Feb. 8 & 10 in 2012
Results of CDR 1

We Passed!

Based on carefully prepared design reports by the team members, the reviewers recognize the size and complexity of the satellite (And of course, the importance of the mission). The reviewers all agree that we need to go ahead for further testing, since we can verify our design, only through thermal distortion, TTM MTM and micro-vibration tests.

Flight model production phase
&
Preparation of test model for TTM/MTM
Current Status and/or Topics of Each Instrument
Instruments Overview

Energy Coverage

FoV Coverage
# SXT Basic Design

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Diameter</td>
<td>45 cm</td>
</tr>
<tr>
<td>Focal length</td>
<td>5.6 m</td>
</tr>
<tr>
<td># of nested shells</td>
<td>203</td>
</tr>
<tr>
<td>Reflector surface</td>
<td>Au mono-layer</td>
</tr>
<tr>
<td>Pre-collimator blade height</td>
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</tr>
<tr>
<td>Blade thickness</td>
<td>0.12 mm</td>
</tr>
<tr>
<td>Thermal shield thickness</td>
<td>Al 0.03 um + Polyimide 0.2 um</td>
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</tbody>
</table>
SXT EM Test Results

E.A./quadrant = 122 cm$^2$@6keV

HPD \sim 1.1$ arcmin
due to the lower heat capacity of the HgTe and our ability to operate the SXS at 50 mK instead of the 60 mK on XRS.

An example of an SXS prototype detector operating in our laboratory at 50 mK is shown in Figure 3.

Figure 2. (a, left) SXS microcalorimeter detector array without the HgTe absorbers attached. Note the triangular gold heat sinks in the upper right and lower left. These are a substantial improvement to the XRS design that significantly reduce thermal crosstalk. (b, right) a partially assembled SXS detector array showing pixels with (center) and without (left and right) HgTe absorbers.

The performance of the XRS detectors in space was slightly worse than on the ground (6.7 eV vs. 6.0 eV). The degradation is due to thermal crosstalk between cosmic rays interacting with the silicon frame of the detector die and the calorimeter pixels. For SXS we have added gold heatsinking layers to both the front and back of the detector die, and this has effectively eliminated the thermal crosstalk in ground testing. We expect the performance of the SXS detector system to be the same in space as in our ground testing.

Figure 3. Spectrum of Mn Kα from a 55Fe source measured with a prototype SXS detector system. This particular device yields an energy resolution of 3.7 ± 0.4 eV FWHM at 6 keV. We have tested several dozen prototype devices and the performance ranges from 3.5 to 4.5 eV.

### SXS ANTICOINCIDENCE DETECTOR

The SXS anticoincidence detector (anti-co) is identical to that deployed in the XRS instrument on Astro-E2. The anti-co die for SXS is from the same fabrication lot as the XRS detector. This is described in detail in Kelley et al. For completeness we describe the SXS anti-co briefly here.

The SXS detector system uses a Low Voltage Silicon Ionization Detector (LVSID) anti-coincidence detector placed directly behind the detector array to veto events in the main array due to minimum ionizing particles. A conceptual

<table>
<thead>
<tr>
<th>Parameter</th>
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<tbody>
<tr>
<td>Operating Temperature</td>
<td>50 mK</td>
</tr>
<tr>
<td>Pixel size</td>
<td>814 x 814 μm</td>
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<tr>
<td>Pixel pitch</td>
<td>832 μm</td>
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<tr>
<td>Pixel format</td>
<td>6 x 6</td>
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<tr>
<td>Field of view</td>
<td>3.05’ x 3.05’</td>
</tr>
<tr>
<td>X-ray absorber</td>
<td>HgTe, 8 μm thickness</td>
</tr>
<tr>
<td>Optical Blocking filters</td>
<td>5 filters, polyimide (460 μm) + Al (400 nm) total, Si mesh on two filters</td>
</tr>
</tbody>
</table>
## SXS Current Status

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Requirement</th>
<th>Goal</th>
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<tbody>
<tr>
<td>Energy range</td>
<td>0.3 - 12 keV</td>
<td></td>
</tr>
<tr>
<td>Energy resolution</td>
<td>7 eV</td>
<td>4 eV</td>
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<tr>
<td>Array format</td>
<td>6 x 6</td>
<td></td>
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<tr>
<td>Field of view</td>
<td>2.9’ x 2.9’</td>
<td></td>
</tr>
<tr>
<td>Effective area</td>
<td>160 cm²@1 keV</td>
<td>210 cm²@6 keV</td>
</tr>
<tr>
<td>Lifetime</td>
<td>3 years</td>
<td>5 years</td>
</tr>
<tr>
<td>Time assign accuracy</td>
<td>80 us</td>
<td></td>
</tr>
<tr>
<td>Max count rate</td>
<td>150 c/s/array</td>
<td></td>
</tr>
<tr>
<td>Energy scale cal. accuracy</td>
<td>2 eV</td>
<td>1 eV</td>
</tr>
</tbody>
</table>
SXI Design

CCD format (1 chip)
  Imaging area: 31 x 31 mm²
  Pixel format: 1280 x 1280
  Pixel size: 24 x 24 um
  Si thickness: 200 um

Large FoV (38 x 38 arcmin²)
Low/stable background
→ suitable for studying diffuse sources
SXI Current Status

- Low energy tail of SXI is slightly higher than that of XIS
- Background level is also higher (by a factor of 4) below 8 keV
- Above 8 keV, considerably amount of background is suppressed
# HXT Basic Design

Conically approximated Wolter 1 type optics

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<tr>
<td>Focal length</td>
<td>12 m</td>
</tr>
<tr>
<td># of nested shells</td>
<td>213</td>
</tr>
<tr>
<td>reflector surface</td>
<td>Pt/C depth-graded multilayer</td>
</tr>
<tr>
<td>Pre-collimator blade height</td>
<td>50 mm</td>
</tr>
<tr>
<td>Blade thickness</td>
<td>0.15 mm</td>
</tr>
<tr>
<td>Thermal shield thickness</td>
<td>Al 0.03 um + PET 5 um</td>
</tr>
</tbody>
</table>
HXT Current Status

BBM (30% reflectors) test results
HPD = 1.78’, E.A. = 65.1 cm$^2$@30 keV

→ expected E.A. = 316 cm$^2$ (roughness = 4.5Å)@30 keV

- End of Feb. 2012, all reflectors needed for HXT1 were completed!
- Now under assembly, and the ground calibration will start in this April.
HXI Design

- Fine position resolution (250 um = 4”@12 m)
  - Double-sided strip semiconductor detector
  - 128ch to cover 32 mm (FOV ~ 9’)
- High detection efficiency up to 80 keV
  - Multi-layer of double sided silicon detector
  - Employment of CdTe-DSD
- Good energy resolution
  - Low-noise signal processing electronics
  - Analog ASIC (low-power)
- Low detector background
  - Active shielding (Suzaku-HXD)
  - Hybrid structure of Si + CdTe
  - APD readout of BGO
    - (high-voltage, compact, modularization)
- $^{241}$Am used for energy/gain calibration
HXI BBM Test Results

- CdTe-DSD BBM
  - 0.75 mm thickness, 250 um pix
  - Hard X-ray image is obtained successfully
  - Energy resolution $\Delta E = 1.6$ keV (FWHM)
SGD Design

- Compton cameras
  - Compton kinematics
  - energy coverage 10-600 keV
- BGO active shield
- Fine collimator
  - Narrow field of view $\sim 0.55$ deg.
- SGD-WAM (Wide-band All-sky Monitor)
- Activation lines are used for energy/gain cal.
SGD Test Results

- Production of prototype (final design) SGD modules started
  - Robust performance even with long flexible cable
    (much longer than flight hardware)
  - consistent with expected performance
Master Schedule

Due to the north-Japan earth quake (2011/Mar/11), we have decided to revise the master schedule of ASTRO-H. Test facilities in the Tsukuba test center got severe damages by the earth quake (Broken ceilings and walls in these buildings). The recovery process is still on going. The facilities will be open again from April 2012.
Summary

• We passed CDR1 (1st Critical Design Review)
• Starting pFM/FM production & mechanical/thermal test
• Ground measurements of BBM/EM
• Next important review is CDR2
• Launch planned for middle of 2014