Athena: revealing the hot and extreme Universe, from black holes to large-scale structures

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X-ray Microcalorimeter Spectrometer for Athena
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Athena XMS 50 ksec

Line Broadening: 200±18 km/s (90% confidence)
Chandra ↔ Athena ↔ ASTRO-H
(how to combine strength of Chandra and ASTRO-H)

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4.2 The X-ray Microcalorimeter Spectrometer (XMS) is being developed by a consortium led by SRON (the Netherlands). The consortium includes in Europe CSL (Belgium), IRAP and CEA/Saclay (France), INAF (Italy), MSSL and Leicester University (UK), ISDC (Switzerland), IFCA (Spain) and Erlangen University (Germany).

The work breakdown structure makes fully use of existing expertise of these institutes and is based on similar contributions in many earlier instruments. To reduce cost related to technology development for this innovative instrument we expect additional contributions from NASA (sensor and last stage cooling) and JAXA (cooling chain) based on existing collaborations between SRON, ISAS and GSFC. However, the TRL level of these contributions in Europe is also sufficient to build this instrument in Europe.

4.2.1 The XMS is a 2-D imaging camera, which allows identifying and characterising the different ionisation stages in hot plasmas thanks to its excellent spectral resolution (few eV at 6 keV).

This requires that the camera operates at cryogenic temperatures. Complexity and heat load limit the size of the camera to about 1000 pixels. Compared to the planned cryogenic spectrometer on ASTRO-H, the first mission which will include a calorimeter, the number of pixels will be increased by a factor 30, the spectral resolution by a factor 2, effective area by a factor 10 and the angular resolution by a factor 8.

The instrument requirements are listed in Table 4.2.

<table>
<thead>
<tr>
<th>PARAMETER</th>
<th>REQUIREMENT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Energy range</td>
<td>0.3 - 12 keV</td>
</tr>
<tr>
<td>Energy resolution</td>
<td>( \Delta E = 3 \text{ eV} ) ( E/\Delta E = 2300 )</td>
</tr>
<tr>
<td>Field of View</td>
<td>2 x 2 arcmin</td>
</tr>
<tr>
<td>Plate scale (32 x 32 array)</td>
<td>4.3 arcsec/pixel</td>
</tr>
<tr>
<td>Quantum efficiency</td>
<td>&gt; 60%</td>
</tr>
<tr>
<td></td>
<td>&gt; 80%</td>
</tr>
<tr>
<td>Energy scale stability</td>
<td>1 eV/h (peak - peak)</td>
</tr>
<tr>
<td>Non X-ray background</td>
<td>( 2 \times 10^{-2} \text{ counts/cm}^2/\text{keV/s} )</td>
</tr>
<tr>
<td>Continuous observing time</td>
<td>&gt; 20 hr, regeneration time &lt; 10%</td>
</tr>
</tbody>
</table>

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• Calorimeter senses temperature change due to absorption of a photon using a TES.

• Read-out by Time Domain Multiplexing (one pixel after the other)

• Anti-coincidence detector to reject charged particle
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- Demonstrated performance on 2 x 8 array < 3 eV
- Production of arrays in GSFC, SRON
- Production of TES: GSFC, SRON, Spain
- Production SQUIDs: NIST, VTT, PTB
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Focal plane assembly

- Sensor at 50 mK
- Multiplexed readout
- Suppression of magnetic fields
- X-ray entrance
- Cryoperm shield @ 4K
- Filter
- Thermal shield @ 600 mK
- TES sensor array @ 50 mK
- Niobium shield @ 50 mK
- 1st stage readout @ 50 mK
- Thermal insulating
- Electrical signal

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Cooling chain

Cooling to 4 K
- ASTRO-H type cooling chain (2-stage Stirling coolers ST + 4He Joule Thomson coolers)
- Technology in Europe at same level

Cooling to 50 mK
- 3 stage ADR (Adiabatic Demagnetization Refrigerator)
  or
- Combination of ADR/Sorption
European contributions to the cooling chain

But other solutions also feasible eventually in combination with Japanese cooling chain including European ADR (MSSL)

ESA development model of full cooling chain start in summer 2012

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Instrument implementation

- PI, focal plane assembly: Netherlands (SRON)
- Digital/event processing: France (IRAP, CEA)
- Anti-coincidence/instrument control: Italy (INAF)
- Power systems: UK (MSSL)
- Filter wheel: Switzerland (UniGe)
- Aperture cylinder: Belgium (CSL)
- Sensor/front end electronics: USA(GSFC/IST) / Spain/NL/UK/FRG
- Last stage cooler: USA(GSFC) / France (CEA)
- Cooling chain: Japan(JAXA) / ESA (UK)

Commitments from all parties including Japan. US contribution has to go through open competition. Additional interest expressed in Canada and Poland.
• Detailed design is available

• Chosen technology has shown the required performance and spatial resolved spectroscopy with high spectral resolution (R 2000) will allow for major advances in high-energy astrophysics

• Technology available within Europe

• Development plan defined: experienced partners in Europe identified and a realistic schedule meeting the deliveries to ESA. This includes contributions from the Netherlands, Italy, France, the UK, Spain, Switzerland, Belgium and the FRG. Interest in some other countries to contribute as well (Poland, Canada)

• Potential contributions from Japan and the US also identified

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