The International X-ray Observatory

Paul Plucinsky on behalf of Randall Smith
on behalf of the ESA-JAXA-NASA IXO team
Basic Facts about IXO

• Merger of ESA/JAXA XEUS and NASA’s Constellation-X missions

• Part of US Astro2010 Decadal Review and ESA Cosmic Visions

• Guest Observatory, with time allocation done as with Hubble, Chandra, Spitzer

• Launch planned 2020
Basic Facts About IXO

• Flight Mirror Assembly (FMA)
  – Highly nested grazing incidence optics
  – 5” PSF (HEW)

• Instruments
  – X-ray Micro-calorimeter Spectrometer (XMS)
  – X-ray Grating Spectrometer (XGS)
  – Wide Field Imager (WFI) and Hard X-ray Imager (HXI)
  – X-ray Polarimeter (X-POL)
  – High Time Resolution Spectrometer (HTRS)

• XMS, WFI/HXI, XPOL and HTRS observe one at a time
  – XGS always operational
Basic Facts about IXO

Effective area a factor of $>10x$ of current missions
Spectroscopy capabilities $>100x$ of current missions
NASA/ESA Mission Design

- The observatory is deployed to achieve 20 m focal length
- Observatory Mass ~6100 kg (including 30% contingency)
- Launch on an Atlas V 551 or Ariane V
- Direct launch into an 800,000 km semi-major axis L2 orbit
- 5 year required lifetime, with expendables for 10 year goal
X-ray Mirror Baseline

- Key requirements:
  - Effective areas:
    - ~3 m$^2$ @ 1 keV
    - ~1 m$^2$ @ 6 keV
  - Angular Resolution <= 5 arc sec

- Single segmented optic with design optimized to minimize mass and maximize the collecting area ~3.2m diameter

- Two parallel technology approaches being pursued
  - Silicon micro-pore optics – ESA
  - Slumped glass – NASA
Optics Technologies: Resolution and Mass

CHANDRA
<0.5” (HEW)
18500 kg/m²
$A_{\text{eff}}$ @ 1 keV

XMM-NEWTON
14” (HEW)
2300 kg/m²
$A_{\text{eff}}$ @ 1 keV

Slumped Glass
5” (HEW)
~270 kg/m²
$A_{\text{eff}}$ @ 1 keV

Si-HPO
5” (HEW)
~200 kg/m²
$A_{\text{eff}}$ @ 1 keV

IXO Options
**FMA Module Layout**

- Module size constrained by glass size (<35 cm)
- 5022 segments in 24 outer modules
  4248 segments in 24 middle modules
  2538 segments in 12 inner modules
Focal Plane Layout (Aft View)
IXO Calibration Challenges

• Flight Mirror Assembly (FMA)
  – Ground calibration of modules must be time-efficient, calibration time cannot simply scale with collecting area
  – Which facility could accommodate the integrated FMA?

• Instruments
  – XMS, gain stability & background from ASTRO-H, but a much larger number of pixels and different orbit for IXO
  – XGS, highest resolution X-ray spectrometer ever flown, pushes the limits of our knowledge of atomic physics and astrophysics
  – WFI, uniformity across the FOV
  – HXI, build on Suzaku and ASTRO-H experience, but will the technology be significantly different such that previous experience is less applicable
  – X-POL, how does one calibrate a polarimeter on-orbit?
  – HTRS, build on RXTE experience

• Programmatic
  – As we discussed at the Iceland IACHEC, ground & flight calibration must be a priority of the agencies ESA/JAXA/NASA
The two order of magnitude increase in capability of IXO is well matched to that of other large facilities planned for the 2010-2020 decade.
## Key Performance Requirements

<table>
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<tr>
<th>Parameter</th>
<th>Value</th>
<th>Science Driver</th>
<th>Inst.</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mirror Effective Area</strong></td>
<td>3 m² @ 1.25 keV</td>
<td>Black Hole Evolution</td>
<td>XMS</td>
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<tr>
<td></td>
<td>0.65 m² @ 6 keV</td>
<td>Strong Gravity</td>
<td>XMS</td>
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<td></td>
<td>150 cm² @ 30 keV</td>
<td>Strong Gravity</td>
<td>WFI/HXI</td>
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<tr>
<td><strong>Spectral Resolution (FWHM), FOV, bandpass</strong></td>
<td>ΔE = 2.5 eV</td>
<td>Galaxy Cluster Evolution</td>
<td>XGS</td>
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<td>ΔE = 10 eV</td>
<td>Cosmic Feedback</td>
<td>XMS</td>
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<tr>
<td></td>
<td>ΔE = 150 eV</td>
<td>Black Hole Evolution</td>
<td>WFI/HXI</td>
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<td></td>
<td>E/ΔE = 3000</td>
<td>Cosmic Web</td>
<td>XGS</td>
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<tr>
<td></td>
<td>2 arcmin</td>
<td>0.3– 7 keV</td>
<td>XMS</td>
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<tr>
<td></td>
<td>5 arcmin</td>
<td>0.3– 10 keV</td>
<td>XMS</td>
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<tr>
<td></td>
<td>18 arcmin point src</td>
<td>0.1–15 keV</td>
<td>WFI/HXI</td>
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<tr>
<td></td>
<td></td>
<td>0.3– 1 keV</td>
<td>XGS</td>
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<tr>
<td><strong>Angular Resolution</strong></td>
<td>5 arcsec HPD</td>
<td>Cosmic Feedback</td>
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<td>5 arcsec HPD</td>
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<td><strong>Count Rate</strong></td>
<td>$10^6$ cps with &lt;10% deadtime</td>
<td>Neutron Star Eq. of State</td>
<td>HTRS</td>
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<tr>
<td><strong>Polarimetry</strong></td>
<td>1% MDP, 100 ksec, $5 \times 10^{-12}$ cgs (2-6 keV)</td>
<td>Strong Gravity</td>
<td>XPOL</td>
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