Chandra - XMM-Newton
Synergies

Now and in the Future

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Chandra: 16.5 years and counting!

Detailed engineering review showed no show-stoppers to 10(+) more years of observing

***Little red or yellow!***

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XMM-Newton: the Next Decade
Chandra Challenges

• Thermal degradation:
  – Limits dwell time over most solar pitch angles
  – Long exposures generally split
  – Complex scheduling limits constrained time to maintain an efficient schedule

• Contaminant build-up on ACIS OBF
  – Reduced $A_{\text{eff}} < 2$ keV by $\sim 80\%$ since launch
  – Longer exposures for science requiring soft data
Joint *Chandra* & *XMM-Newton* Observing Time

- Proposals whose science question(s) require data from both observatories
- Up to 400ks time allocated by each observatory on the other
- 217 programs since Chandra Cycle 4 including all science categories
- **PLUS**: many projects which combine and/or compare results across both observatories
## Capabilities of XMM-Newton and Chandra

<table>
<thead>
<tr>
<th>Feature</th>
<th>XMM-Newton</th>
<th>Chandra</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field-of-View</td>
<td>~30’*30’</td>
<td>16’*16’</td>
</tr>
<tr>
<td>Effective Area</td>
<td>4500 cm²</td>
<td>800 cm²</td>
</tr>
<tr>
<td>Spatial Resolution</td>
<td>6”</td>
<td>0.5”</td>
</tr>
<tr>
<td>Grating Spectroscopy</td>
<td>0.35-2.5 keV Simultaneous</td>
<td>0.08-10 keV</td>
</tr>
<tr>
<td>Spectral Resolution</td>
<td>200-800</td>
<td>200-1000</td>
</tr>
<tr>
<td>Timing Resolution</td>
<td>30µs (+imaging and spectra)</td>
<td>16µs (HRC) (+imaging or spectra)</td>
</tr>
<tr>
<td>Background</td>
<td>10 ct s⁻¹ keV⁻¹ srad⁻¹</td>
<td>0.25 ct s⁻¹ srad⁻¹</td>
</tr>
</tbody>
</table>
Synergies

- Large Area Surveys: XMM-Newton
- Imaging Large Objects: XMM-Newton
- Imaging Crowded Regions: Chandra
- Source Identification: Chandra
- Detecting Complex Structure: Chandra
- High S/N Imaging Spectroscopy: XMM-Newton
- Grating Spectroscopy: ?? Science
- Rapid Timing: ?? Science

Overlap – common in most other wavebands:
- Independent confirmation/not of results
- Complementary monitoring of variables and transients
- Coordinate on DDTs to avoid duplication
**XMM-Newton Spectra of Red Quasars**

2MASS1049+5837 (z=0.115)

- **Chandra (5ks):**
  - HR~0.6 → Γ~0.4,
  - \(N_H\sim4\times10^{22}\ \text{cm}^{-2}\)

- **XMM-Newton (26 ks)**
  - Power Law (PL), \(\Gamma=1.8\),
  - \(N_H\sim4\times10^{23}\ \text{cm}^{-2}\)
  - ~2% Scattered PL
  - Line emission from extended photoionized plasma
  - Reflection component (R~2) and Fe K\(\alpha\)

Wilkes, Pounds & Schmidt 2008

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M87: BCG of Virgo Cluster

- **ROSAT**: whole galaxy+, some structure
- **XMM-Newton**: whole galaxy, sloshing structures
- **Chandra**: central regions, detailed structure, resolves edges, filaments, voids etc.
- e.g. **XMM-Newton** selects bright outer regions for detailed **Chandra** study of filaments

Image: courtesy Bill Forman
SNR Physics

Kosenko et al. 2010

- RGS & EPIC, ACIS spectra: multiple NEI emission line model
- Forward shock velocity $\sim 2770$ kms$^{-1}$
- Location: radial stratification O, IME, Fe
- Derive fractional masses in various regions

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XMM-Newton: the Next Decade
Large Area Surveys: e.g. COSMOS

- **XMM-Newton** (July 2006):
  - $2^\circ$, 1.4 Ms (total)
  - 50 ks depth

- **Chandra** (Jan 2014):
  - $2.2^\circ$, 4.6 Ms (total)
  - 180 ks depth
  - 4000 sources
  - Resolves 10% of XMM sources into multiples
  - Reaches 5* depth

*Courtesy: Francesca Civano*
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Courtesy: Francesca Civano
Galaxy Groups: FRI NGC 4261

O’Sullivan et al. (2011)

• Radio jets inflate large cavities
• Rims of compressed hot gas surround cavities
• Cool core, r~10 kpc, T~0.6 keV
• Spectra do not confirm shocks
Future: X-ray Legacy

• Assess *XMM-Newton* and *Chandra* archives for Legacy (using source catalogs, by science area):
  – Missing “Rosetta Stone” sources (in any waveband)
  – Incomplete samples of sources, e.g. 3CR, PG (AGN)
  – Multi-wavelength Survey fields
  – Confused *XMM-Newton* fields needing *Chandra* data
  – Athena (& X-ray Surveyor) preparatory science

• Expand joint program(s) to include Large Projects

• HST, Spitzer, ALMA, NuSTAR etc. “Legacy” science, e.g. Frontier Fields
Future: Multi-λ Opportunities

- **ALMA**: AGN outflows, star forming regions
- **LOFAR and/or VLASS**: observe one/more survey fields to study related X-ray emission
- **E-ROSITA (2017)**: follow-up, e.g. clusters
- **JWST (2018)**: CT AGN, galaxy structure, high-redshift galaxies etc.
- **LSST**: strategies to follow-up transients/variables
Chandra Workshop 2016

“Chandra Science for the Next Decade”
16-19 Aug, Cambridge MA

cxc.cfa.harvard.edu/cdo/next_decade2016/

Please join us to continue the conversation we are starting this week!

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