Cross-Calibration of Chandra with XMM-Newton

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Contributors

- **Chandra X-ray Center**
  - Coordinated observations: Marshall, Drake
  - ACIS QE: Edgar, Grant, Plucinsky
  - ACIS Contamination: Plucinsky, Marshall, Grant, Vikhlinen, others
  - HRC-ACIS: Drake, Wargelin, Marshall
  - LETG-HETG: Marshall, Wargelin

- **XMM-Newton**
  - Coordinated observations: Kirsch, Pollack
  - EPIC PN: Haberl
  - RGS-PN-MOS comparison: Kirsch, Pollack
  - RGS: den Herder
Coordination Efforts

• Ongoing cross-calibration observations
  • Observing 3C 273 and PKS 2155-304 once per year
  • XMM is “on-call” to coordinate with Chandra bakeout

• Face-face meetings
  • HLM met with Jan Willem den Herder and RGS scientists in July 2002
  • Marcus Kirsch and Andrew Pollack attended the Chandra Calibration workshop in October 2003
  • HLM meeting with Kirsch and Pollack in June 2004 cancelled due to airline delays

• Other communication
  • XMM cal presentations passed along to Cal group
  • Kirsch is spearheading coordination for XMM

Cross-Calibration
Chandra Internal Cross-Calibration

• First tried with 3C 273 in January 2000 using LETG/HRC, LETG/ACIS, HETG/ACIS
  • Effect of contaminant first found — -70% at 288 eV
  • BI/FI QE discrepancy first noted — -15% at 600 eV
  • Also obs’d by ASCA, RXTE — Agree to <10% (1-8 keV)
• Contaminant is still under scrutiny
  • Edges known but continuum absorption is uncertain
  • Time dependence found in 2002 is well characterized
  • Spatial dependence found in 2003
  • More observations planned for July 2004
• BI/FI issues may be solved
  • BI QE has been revised — in testing
  • FI QE affected by cosmic rays residuals
Chandra Internal Cross-Cal: Methods

- BI QE compared to FI QE
  - LETGS and HETGS comparison of +1 against -1
  - Use spectral fitting of SN and galaxy clusters
  - Reanalyze XRCF data

- HEG compared to MEG
  - Use any bright target (without pileup)
  - Compare after correcting for BI/FI

- ACIS-S compared to HRC-S
  - Use back-back LETGS observations of PKS 2155-304
  - Update high order efficiencies using LETG/ACIS

- LETGS compared to HETGS
  - Use back-back observations of 3C 273, PKS 2155-304
  - Renormalize due to variability via XMM, XTE, or ASCA
All observations are simultaneous, so many targets are used
- N-stars and blazars are good for checking RGS and PN
- More extended sources can be used than in Chandra cal
- Several modes and filters are alternated

Pileup is important in bright point sources
- Imaging mode: do not use core of PSF
- Timing mode: no pileup but not often used

Technique: fit jointly, allow normalizations to vary by instrument

XMM-Newton Internal Cross-Calibration
• PN results (timing mode, by Haberl)
  - Still some residuals at 0.5 keV of ± 5%
  - Thin and thick filters do not yet agree

• PN — MOS — RGS
  • MOS require -17 to +15% adjustment relative to PN
  • RGS require -27 to -9% adjustment

• Features remain in fits
  • PN: Si-K and Au-M edges appear in residuals
  • MOS: low E response seems to be time-dependent
  • PN: RMF requires adjustments below 1 keV
## Cross-normalization

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features in relative calibration

- MOS low energy problem evolving with time

- The old fellows for RGS and EPIC
  - Si-edge
  - Au-edge

- pn-redistribution problem

Cross-Calibration
Other XMM Results

Figure 1-16: 3C 273: blue: PN black: MOS1, red: MOS2. Expressed as a ratio, DATA/MODEL, with error bars removed for clarity.

Figure 1-17: Simultaneous spectral fits to PKS0558-508. Back: pn, red: MOS1, green: MOS2 and blue RGS1, light blue RGS2. The zoomed ratio (lower panel) has been binned more for clarity.
Upcoming Milestones

• July-August 2004
  • Complete/revise contaminant spectral model
  • Complete testing of BI QE and FI CR loss models
  • XMM: internal cross-cal meeting

• September 2004
  • Test/revise MEG-HEG efficiencies
  • Verify HETG-LETG cross-cal
  • Iterate XMM-Chandra cross-cal (PN, RGS — TGs)

• October 2004
  • Distribute reports
  • Chandra Calibration workshop

• Bakeout in September?