The XMM slew survey: status and future

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Overview

390 slew datasets in archive
PN, MOS-1/2 exposures in Medium filter with the observing mode set to that of previous pointed observation
Average slew length is 70 degrees
Data available for slews > 30 mins
Closed slew, open slew, closed slew. Open slew speed = 90 degrees / hour, i.e. on-source time ~14 secs
Area covered to date ~8000 deg² (~20% of sky)
CAL or science?

We could use the time usefully for closed-cal observations (MOS needs more exposure time as CAL source gets weaker)

Only 14 secs on-source exposure time

Bright stars may cause false detections due to optical loading

Earlier surveys may have already done the science, e.g. ROSAT

High background may hide sources
Flux limits

Rosat limit = $5 \times 10^{-13}$ (92% of sky)
EMSS = $5 \times 10^{-14} - 3 \times 10^{-12}$ (2% of sky) (0.3-4)
HEAO-1 survey = $6 \times 10^{-12} - 3.6 \times 10^{-11}$ (all-sky)
Exosat slew survey = $5 \times 10^{-11}$ (n% of sky)
RXTE ASM = $7 \times 10^{-10}$ (2-10)
Initial impressions

- MOS
  - Source extended into a 4 arcmin streak due to 2.6 second frame time

- PN
  - Full frame mode streak = 6 arcsecs
  - Extended full frame streak of 18 arcsecs

- Extra pn sensitivity + additional MOS background means little to be gained from analysing MOS slews

- Epic-pn attitude reconstruction very good
Pilot study 1:

To check if slew data scientifically useful

Process 9 slews from revs 300 to 400, source searching single 0.2-15 keV image with flag=0, pattern<=4, flat exposure map

SAS worked fine after small OAL change.

Tangential projection not valid over whole slew. Long slews need to be subdivided to maintain astrometry.

Divide slew into 1 deg² images and recalculate sky positions

Source search using standard pipeline eboxdetect/emldetect combination tuned for ~zero background.
Source searched images from 9 pn slews and found 139 sources down to det_ml=10, ~0.5 source/deg$^2$

All 139 sources eyeballed and look ok, i.e. no obvious false detections due to background effects.

Minimum number of counts = 6 giving detection limits of $F_{0.2-2} = 1.5 \times 10^{-12}$, $F_{2-10} = 2.2 \times 10^{-12}$ ergs s$^{-1}$ cm$^{-2}$
Optical loading assessment

DSS images with 20" error circle

DSS on slew positions + 1 hour RA

18 sources coincident with bright stars – an issue but not dominant
Detector problems

Affects one CCD so must be detector related

Very soft spectrum with a peak at 100 eV and secondary peak at 240 eV

Events occur within 1 frame with very fast decay

Detector map shows events Confined to 1 CCD.
Other spurions

Sources 1 & 3

Due to crab off-axis!

Source 9 seems to be a source detection algorithm problem
Has Rosat already done it?

63 correlations, with RASS within 1 arc min of XMM position

RASS bright source cat = 42
RASS faint source cat = 21
Identifications

Total sources = 139
ROSAT survey IDs = 63
10 bright stars, non-RASS sources
9 detector flashes
2 crab off-axis
1 other spurious
8 sources with NED counterparts but consistent with null hypothesis
1 source observed twice in separate slews
2 sources seen in ROSAT pointed obs. and not in RASS (14 not seen in either).

~50 unidentified
Extended source analysis

FF mode point sources give a good fit to PSF, e.g. source 4

Source 2: 2x2 arcmin

The 20 brightest sources - 5x5 arcmin images

- Enough counts to detect extension in brighter sources
Known clusters: Abell 3581

Source 5

Easily detected as extended in 14 second exposure

(EFF mode)

Slew direction
Conclusions from pilot 1

- MOS slew data effectively useless
- ~10% of sources caused by optical loading
- High background affects 10-20% of slews
- Expect to find ~ 4,000 sources from current data
- Sensitive to extension in brighter sources
- 40-50% of sources not present in RASS
- Soft band detection limit ~2 times RASS limit
- Deepest 3-10 keV “all sky” survey to date at 2.2x10^-12

New operations strategy:

- MOS slews will be used for calibration
- All PN slews larger than 15 mins down-linked and processed
- Medium filter if FF, EFF, LW and Closed for other modes
Pilot study 2:

To investigate optimum processing and source search strategy

Three long slews ~ 110 degrees, 1 each of FF, EFF and LW modes

A) 1XMM scheme - separate 0.2-0.5, 0.5-1.0, 1.0-2.0 and 2.0-12.0 keV images – 23 detections (mean of 14.4 counts)

B) Search single 0.2-12 keV, pattern<=4 image – 110 detections, many spurious

C) Search 0.2-0.5 (pattern 0) + 0.5-12.0 (patt <=4), single image - 64 detections (mean of 8.6 counts)

Best results from scheme C: we lose band-specific count rates and hardness ratios but can calculate these \textit{a posteriori} with eregionanalyse on individual images.
With exposure maps

One slew searched using variable exposure maps and detector mask. Two new sources found and one lost, all at low-significance end.

Uneven exposure at end of slew due to closed-loop.

Next to last degree of slew

Final degree of slew
Exposures per source

For slew 1: 22 sources found within open loop slew and one very faint detection in closed loop phase.

Simple discriminator may be applied using exposure time.
Conclusions from pilot 2

- Source density again ~0.5 / deg^2
- Use 0.2-0.5 (patt=0) + 0.5-12.0 keV (patt<=4) image
- Use exposure maps and detector masks
- Find individual band count rates after source search
- Only use FF, EFF and LW mode data
- For uniform survey ignore sources with exp>11 secs
Processing scheme

Processing of slew data (MJF)
Creation of images, exposure maps (Pili,RDS)
Source search 0.2-12 keV image (AMR)
Make catalogue of detections (Pili)
Make DSS images for each detection (AMR)
Check for and flag spurions (Pili, MJF)
Check for and flag optical loading due to bright stars (Pili, AMR)
Find hardness ratios from individual band images (RDS, Pili)
Make clean catalogue of sources (Pili)
Cross-correlate with Rosat (MJF)
Cross-correlate with other catalogues (?)

Analyse extensions (UCM trainee, AMR)
Co-add slews and re-search (?)
Optical follow-up, piggy-back on XID program (??)
### Schedule

<table>
<thead>
<tr>
<th>Task Name</th>
<th>Duration</th>
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<tbody>
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