

The XMM slew survey: status and future

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Overview

390 slew datasets in archive

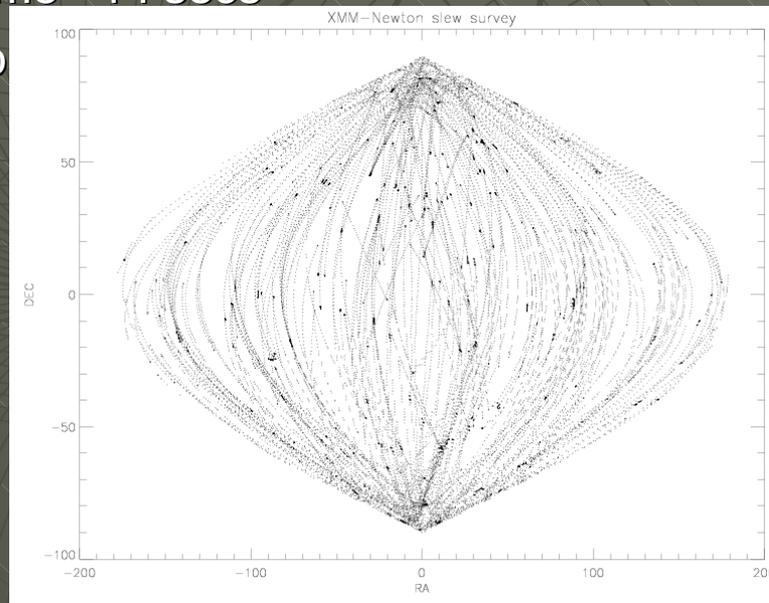
PN, MOS-1/2 exposures in Medium filter with the observing mode set to that of previous pointed observation

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



CAL or science ?

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

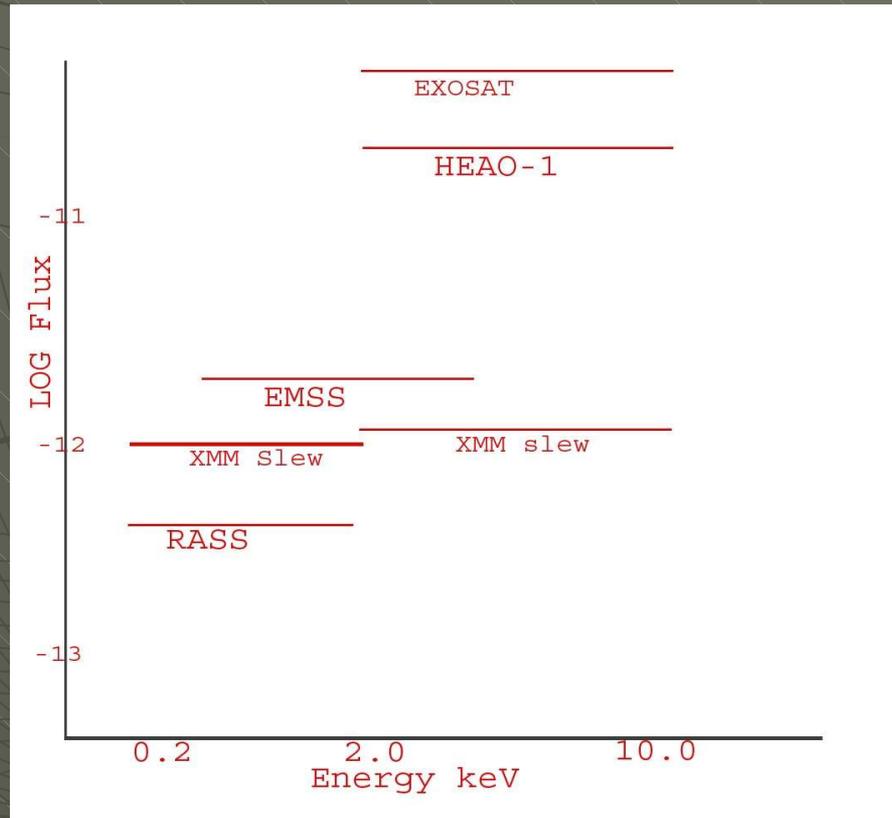
Only 14 secs on-source exposure time

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 = 5×10^{-13} (92% of sky)

EMSS = 5×10^{-14} – 3×10^{-12} (2% of sky) (0.3-4)

HEAO-1 survey = 6×10^{-12} – 3.6×10^{-11} (all-sky)

Exosat slew survey = 5×10^{-11} (n% of sky)

RXTE ASM = 7×10^{-10} (2-10)

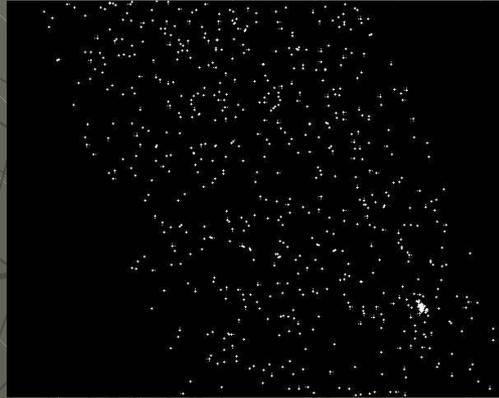
Initial impressions

MOS



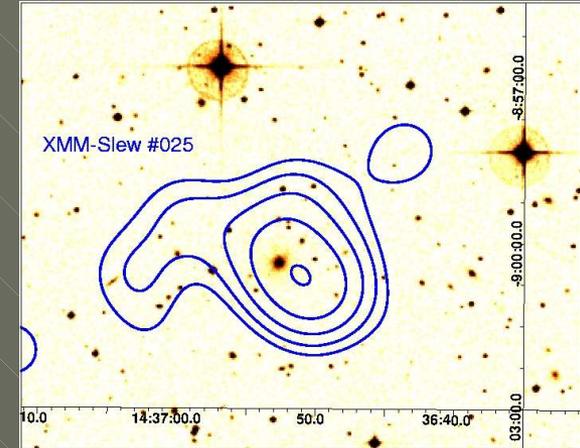
Source extended into a 4 arcmin streak due to 2.6 second frame time

PN



Full frame mode streak = 6 arcsecs
– not noticeable

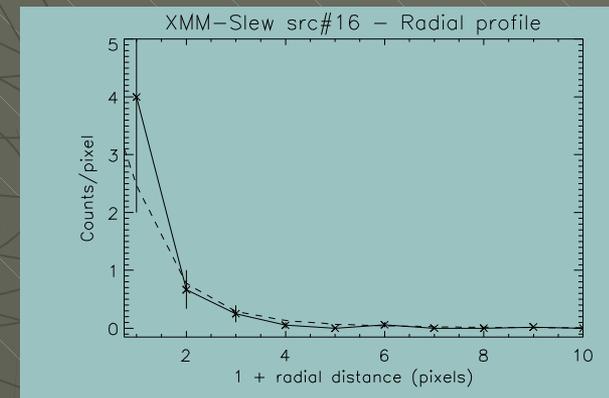
PN



Extended full frame streak
of 18 arcsecs

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

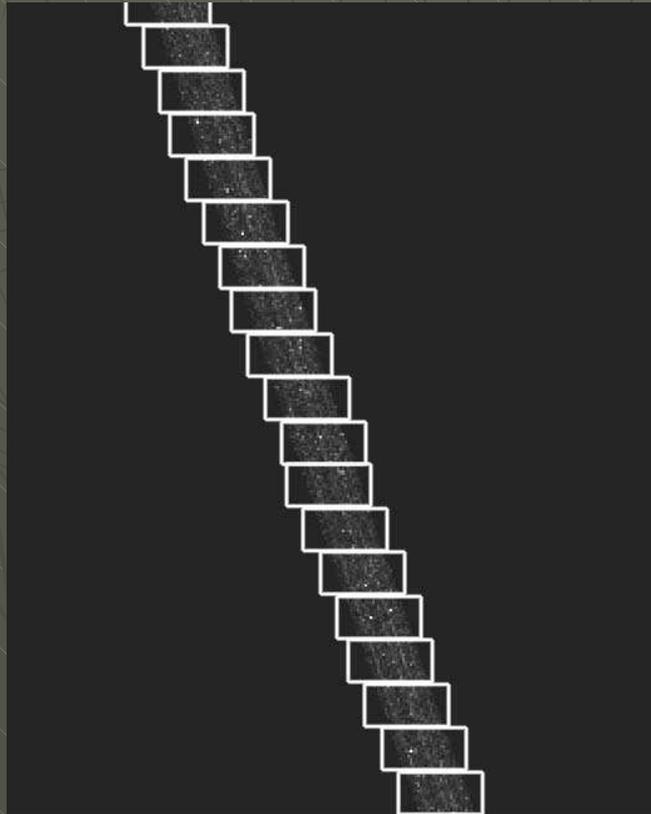
Epic-pn attitude reconstruction very good



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.

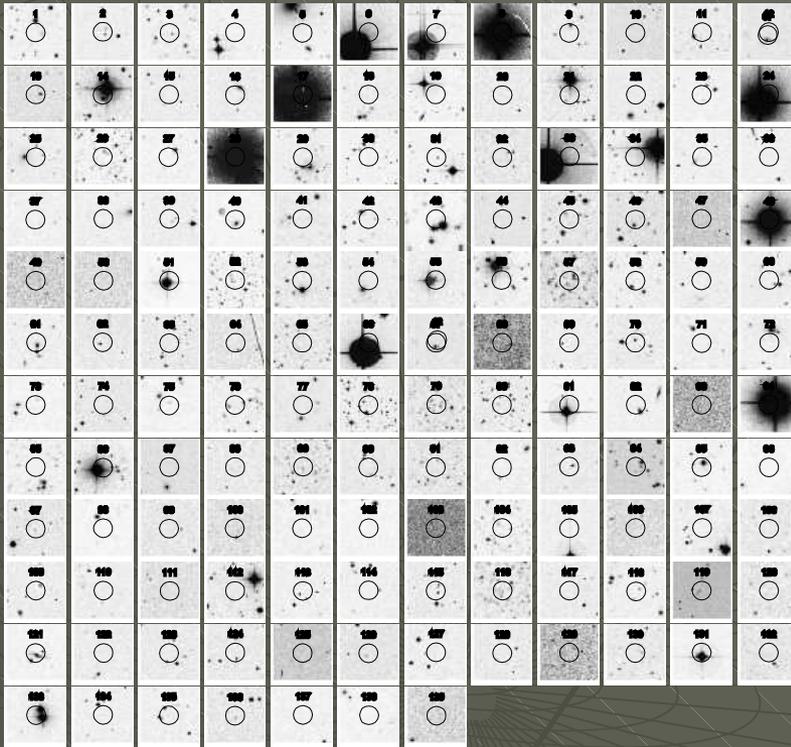
Pilot 1 SUMMARY

Source searched images from 9 pn slews and found 139 sources down to $\text{det_ml}=10$, ~ 0.5 source/deg²

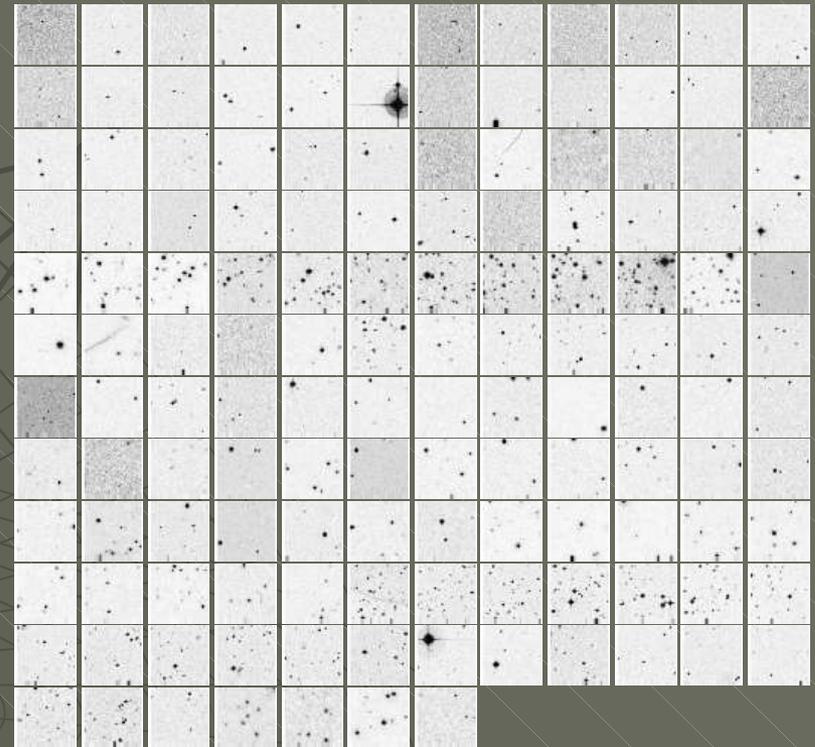
All 139 sources eyeballed and look ok, i.e. no obvious false detections due to background effects.

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



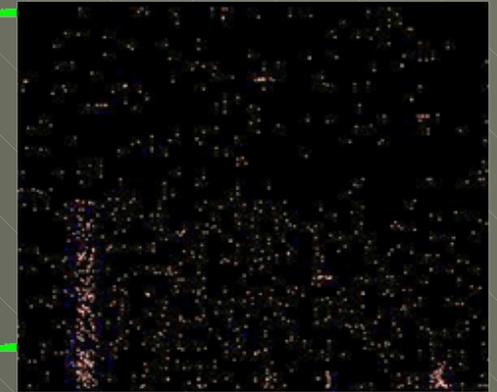
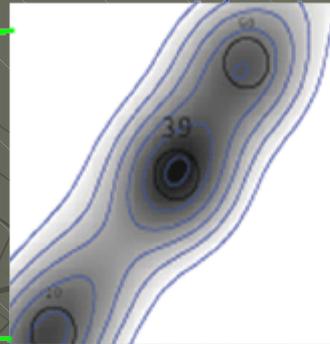
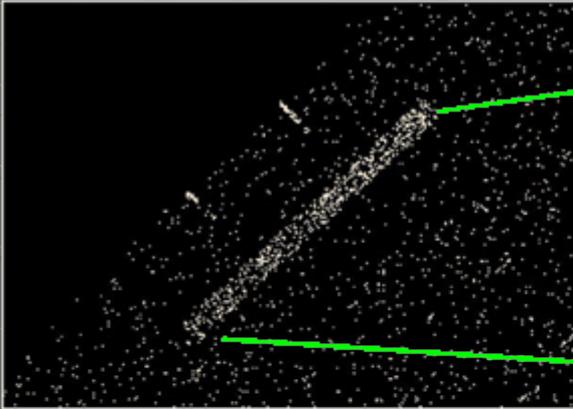
DSS images with 20" error circle



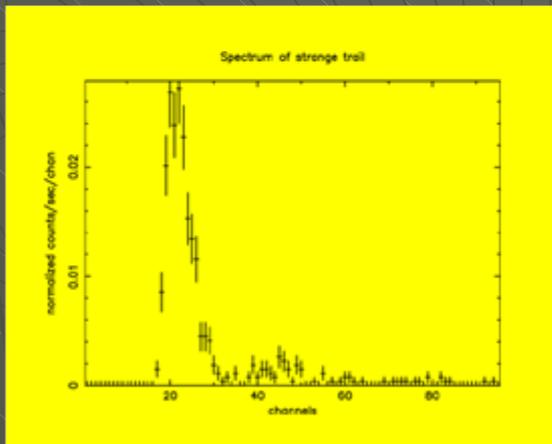
DSS on slew positions + 1hour RA

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

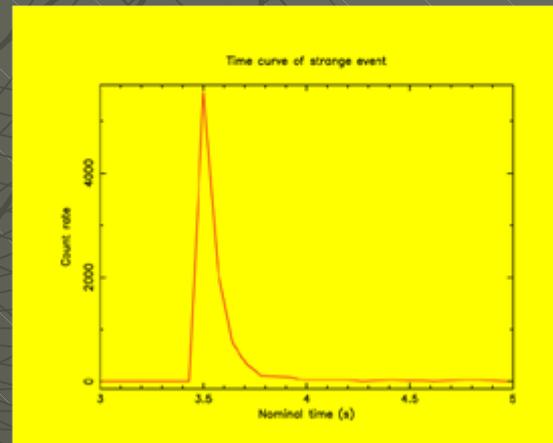
Detector problems



Detector map shows events
Confined to 1 CCD.



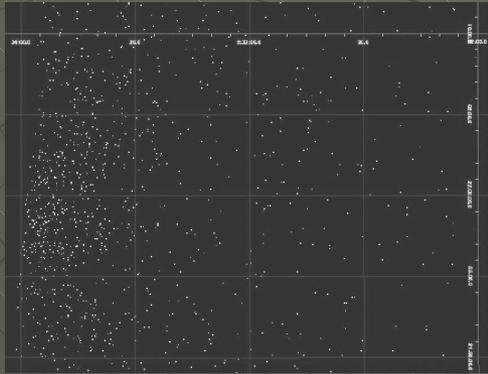
Very soft spectrum with a peak at 100 eV
and secondary peak at 240 eV



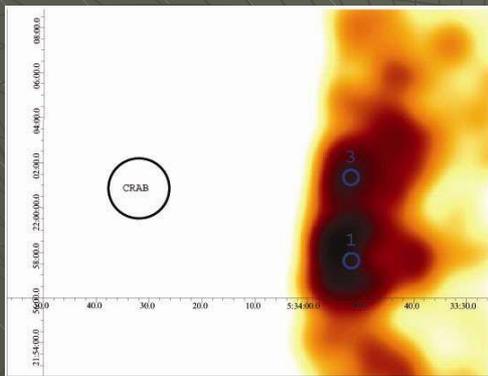
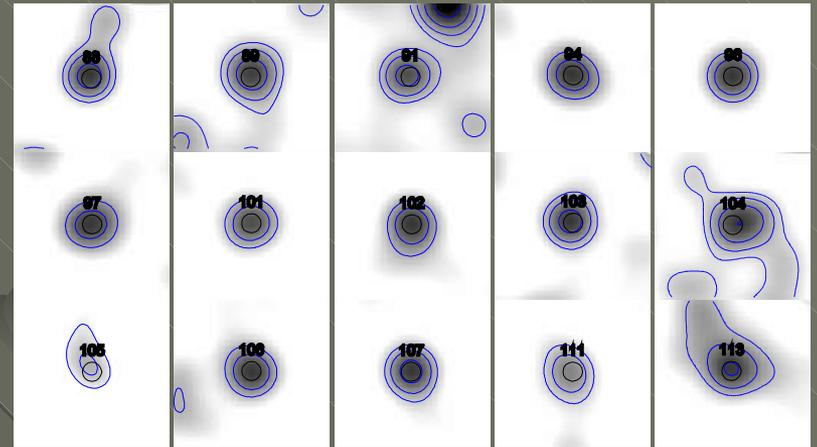
Events occur within 1 frame with very fast decay

Affects one CCD so must be detector related

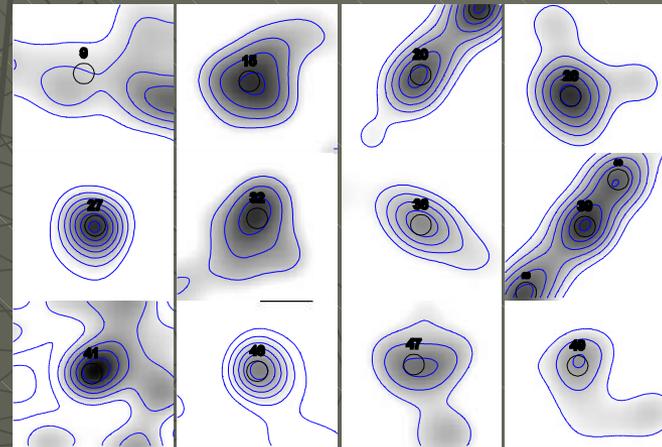
Other spurions



Sources 1 & 3



Due to crab off-axis !

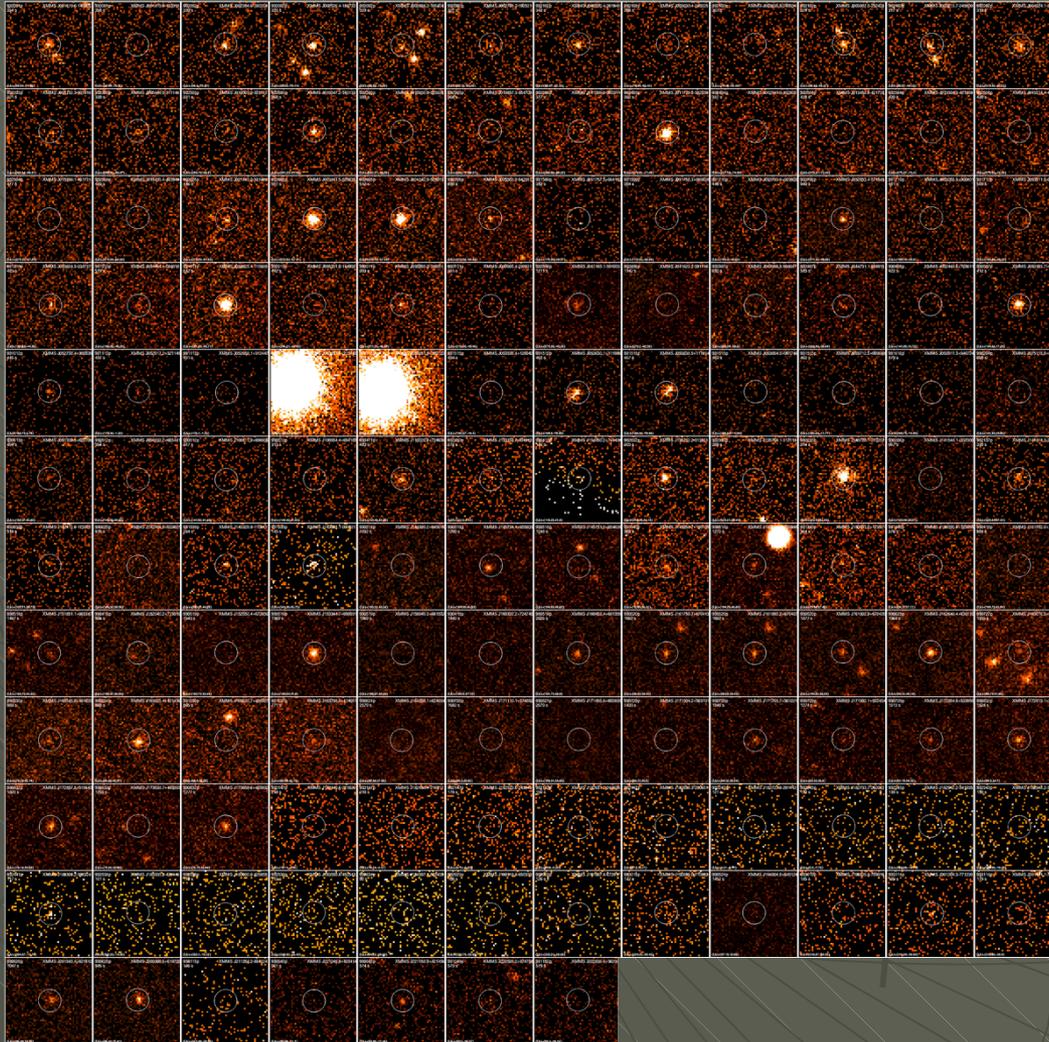
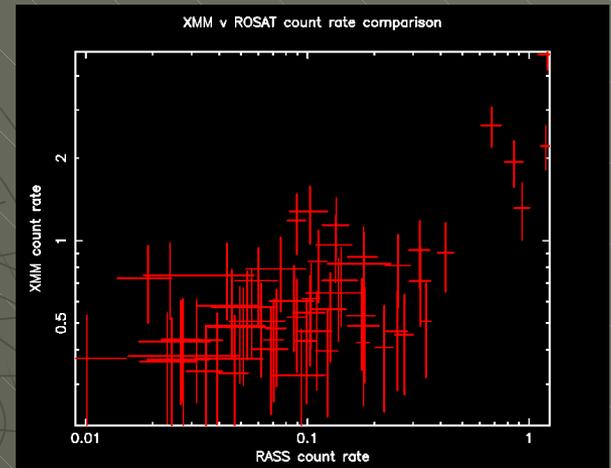


Source 9 seems to be a source detection algorithm problem

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

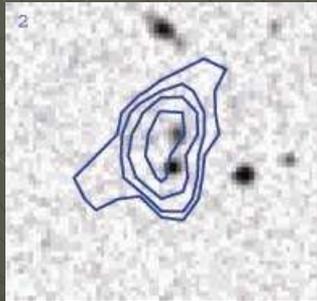
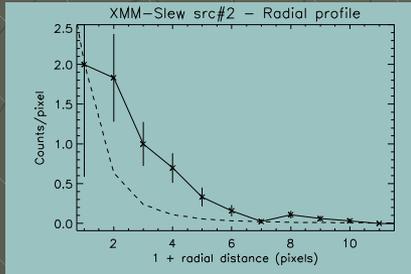
8 sources with NED counterparts but consistent with null hypothesis

1 source observed twice in separate slews

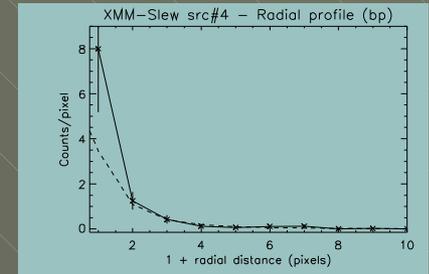
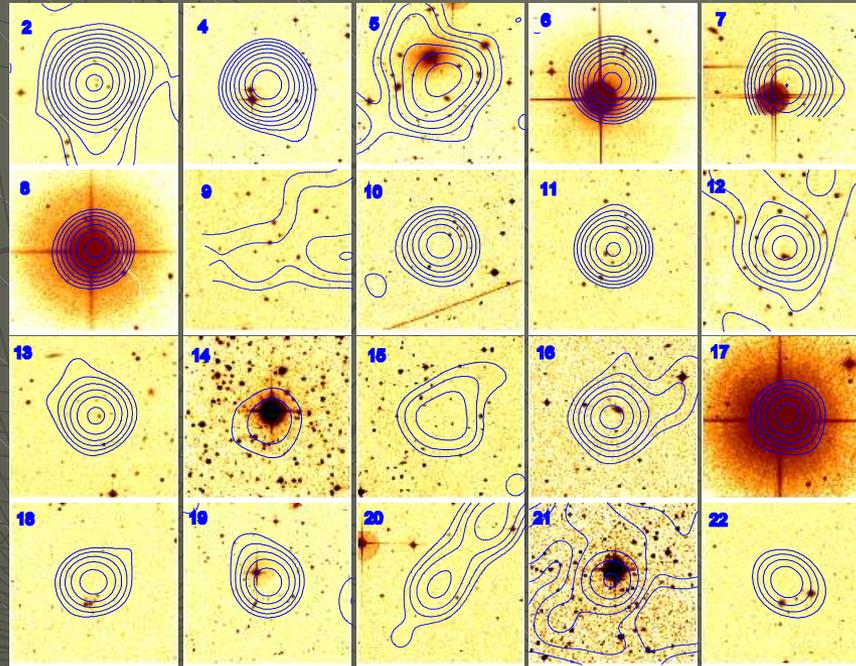
2 sources seen in ROSAT pointed obs. and not in RASS (14 not seen in either).

~50 unidentified

Extended source analysis



Source 2: 2x2 arcmin

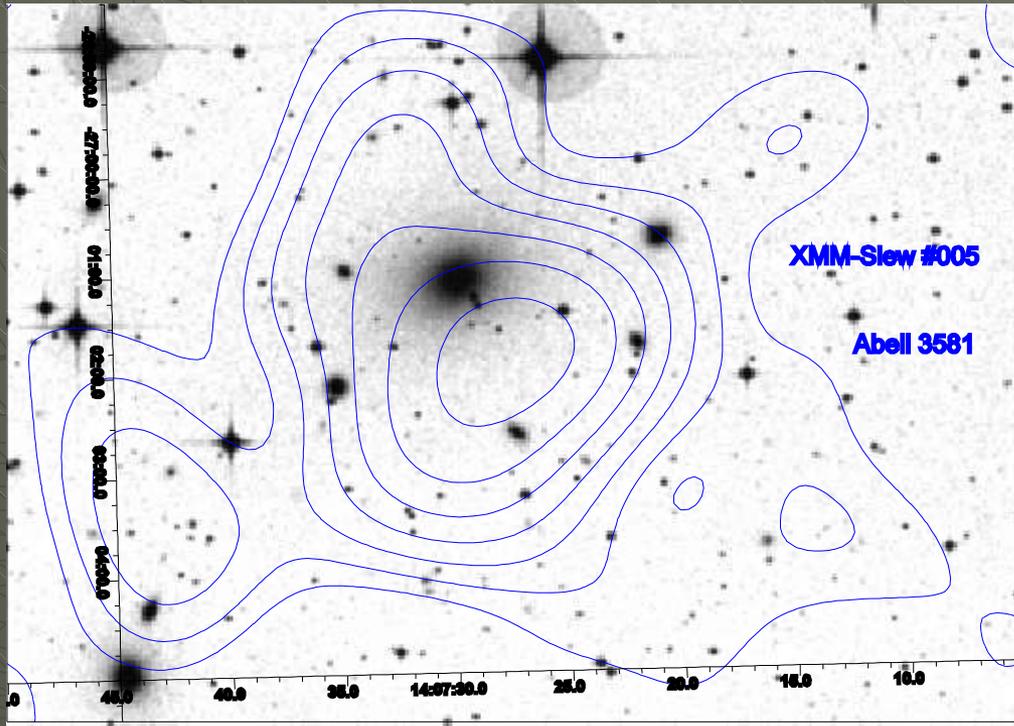


FF mode point sources give a good fit to PSF, e.g. source 4

The 20 brightest sources - 5x5 arcmin images

- Enough counts to detect extension in brighter sources

Known clusters: Abell 3581



(EFF mode)

↖ Slew direction

Source 5

Easily detected as extended in 14 second exposure

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

? Deepen 2-10 keV “all sky” survey to date at 2.2×10^{-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

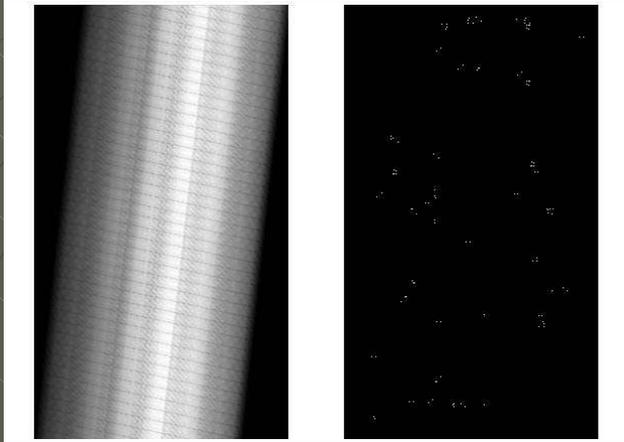
A) 1XMM scheme - separate 0.2-0.5, 0.5-1.0, 1.0-2.0 and 2.0-12.0 keV images – 23 detections (mean of 14.4 counts)

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

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

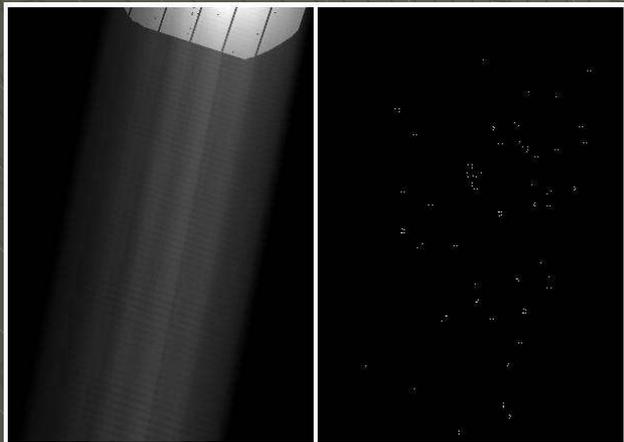
Best results from scheme C: we lose band-specific count rates and hardness ratios but can calculate these *a posteriori* with eregionanalyse on individual images.

With exposure maps

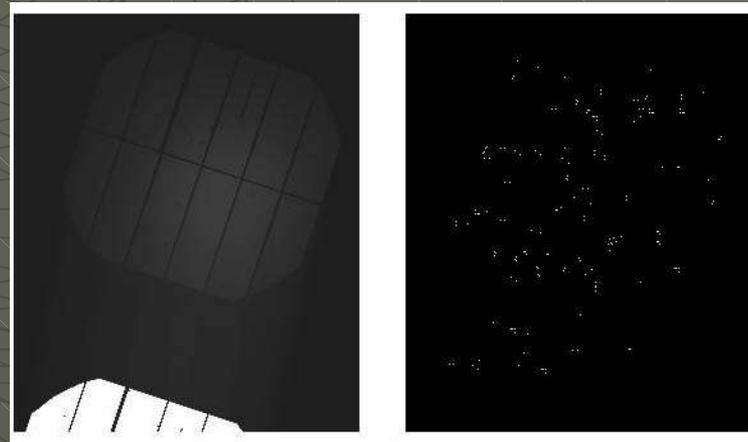


One slew searched using variable exposure maps and detector mask. Two new sources found and one lost, all at low-significance end.

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

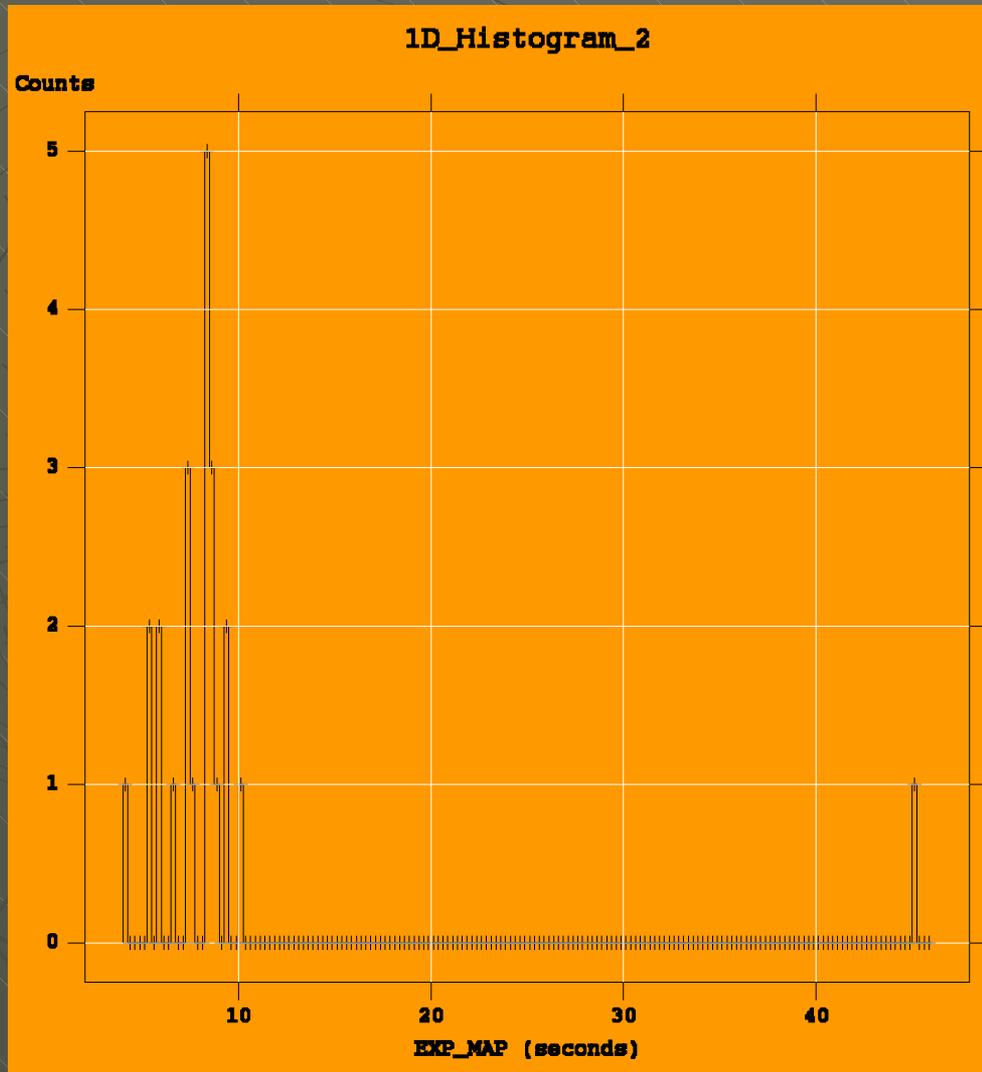


Next to last degree of slew



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 $\sim 0.5 / \text{deg}^2$
- ? 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 $\text{exp} > 11$ 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)

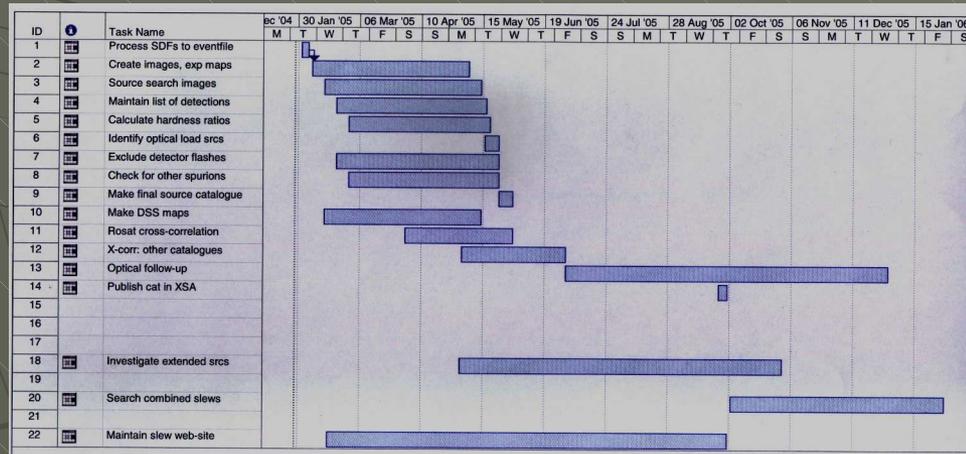
Cross-correlate with other catalogues (?)

Analyse extensions (UCM trainee, AMR)

Co-add slews and re-search (?)

Optical follow-up, piggy-back on XID program (??)

Schedule



Initial processing of slew data (finished)

Creation of images, source searching, rejection of spurious sources (Feb to May)

Cross correlation with ROSAT, other catalogues, DSS, SDSS etc. (May to July)

Creation of final catalogue for ingestion into XSA (Aug to Sep)

Ingestion into XSA (end of September)

Investigate extended sources (begin May)

Search co-added slews (?)