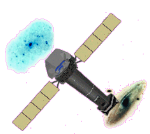
EPIC-BG Meeting June/July`05 - Introduction

At the end of the last UG meeting, and in line with the conclusions from Previous UG meetings, it was highlighted that there is a need for EPIC to progress in the description and treatment of the EPIC-BG

5) We need to understand the components of the (EPIC) X-ray background
6) We need to reduce as much as we can the (particle/instrumental) components of the X-ray background. This is relevant not just for EPIC, but for future missions also.
7) We need to model as correctly as possible the remaining components of the X-ray background

Understand – Reduce – Model



XMM
EPIC
MOS

Andy Read (amr30@star.le.ac.uk)
EPIC BG Working Group Meeting
ESAC, Spain 30/06/05-01/07/05

University *of* Leicester

1.

Overview of EPIC BG components

- General / EPIC
- EPIC-MOS
- EPIC-pn (MJF)

Table 1. Summary of the components within the XMM-Newton EPIC Background; temporal, spatial and spectral properties

	PARTICLES			PHOTONS	
	SOFT PROTONS	INTERNAL (Cosmic-ray induced)	ELECTRONIC NOISE	HARD X-RAYS	SOFT X-RAYS
Source	Few 100 keV solar protons	Interaction of High Energy particles with detector	1) Bright pixels 2) Elec. overshoot near pn readout	X-ray background (AGN etc)	Local Bubble Galactic Disk Galactic Halo
Variable? (per Obs) (Obs to Obs)	Flares ($>$1000%) Unpredictable. More far from apogee. Low-E flares turn on before high-E	$\pm$10% $\pm$10% No increase after solar flares	$\pm$10% 1) $>$1000% (pixels come and go, also meteor damage)	Constant Constant	Constant Variation with RA/Dec ($\pm$35%)
Spatial Vignetted? Structure?	Yes (scattered) Perhaps, unpredictable	No Yes. Detector + construction MOS: outer CCDs more Al, CCD edges more Si PN: Central hole in high-E lines ($\sim$8 keV)	No Yes 1) Individual pixels & columns 2) Near pn readout (CAMEX)	Yes No	Yes No, apart from real astronomical objects
Spectral	Variable Unpredictable No correlation between intensity + shape Low-E flares turn on before high-E	Flat + fluorescence + detector noise MOS: 1.5 keV Al-K 1.7 keV Si-K det.noise$<$0.5 keV. High-E – low-intensity lines (Cr, Mn, Fe-K, Au) PN: 1.5 keV Al-K no Si (self-absorbed) Cu-Ni-Zn-K ($\sim$8 keV) det.noise$<$0.3 keV	1) low-E ($<$300 eV), tail may reach higher-E 2) low-E ($<$300 eV)	$\sim$1.4 power law. Below 5keV, dominates over internal component	Thermal with $\lesssim$1keV emission lines

Read &
Ponman `03

Table 1. Summary of the components within the XMM-Newton EPIC Background; temporal, spatial and spectral properties

	PHOTONS	
	HARD X-RAYS	SOFT X-RAYS
Source	X-ray background (AGN etc)	Local Bubble Galactic Disk Galactic Halo
Variable? (per Obs) (Obs to Obs)	Constant Constant	Constant Variation with RA/Dec (±35%)
Spatial Vignetted? Structure?	Yes No	Yes No, apart from real astronomical objects
Spectral	~1.4 power law. Below 5keV, dominates over internal component	Thermal with $\lesssim$1keV emission lines

- Scientifically interesting ;-)

- Can’ t ‘ reduce’

◆ Understand and model

◆ Also single reflections from outside FOV – estimate that diffuse flux from 0.4-1.4 deg is ~ 7% of true in-FOV signal (reduce this? for future?)

Table 1. Summary of the components within the XMM-Newton EPIC Background; temporal, spatial and spectral properties

	PHOTONS
	SOFT X-RAYS
Source	Local Bubble Galactic Disk Galactic Halo
Variable? (per Obs) (Obs to Obs)	Constant Variation with RA/Dec (±35%)
Spatial Vignetted? Structure?	Yes No, apart from real astronomical objects
Spectral	Thermal with $\lesssim$1keV emission lines

- E<2keV
- exgal>0.8keV spat. uniform

? ph=1.4

- galactic - emission/absorption varie
- at 0.8-1.0keV, galactic 15% total BG
- residual soft BG flares

Table 1. Summary of the components within the XMM-Newton EPIC Background; temporal, spatial and spectral properties

	ELECTRONIC NOISE
Source	1) Bright pixels 2) Elec. overshoot near pn readout
Variable? (per Obs) (Obs to Obs)	±10% 1) >1000% (pixels come and go, also meteor damage)
Spatial Vignetted? Structure?	No Yes 1) Individual pixels & columns 2) Near pn readout (CAMEX)
Spectral	1) low-E (<300 eV), tail may reach higher-E 2) low-E (<300 eV)

- Most bad pixels removed on-board – vast majority of remainder removed by software

- Also dark current (thought negligible)

Table 1. Summary of the components within the XMM-Newton EPIC Background; temporal, spatial and spectral properties

	PARTICLES	
	SOFT PROTONS	INTERNAL (Cosmic-ray induced)
Source	Few 100 keV solar protons	Interaction of High Energy particles with detector
Variable? (per Obs) (Obs to Obs)	Flares (>1000%) Unpredictable. More far from apogee. Low-E flares turn on before high-E	±10% ±10% No increase after solar flares
Spatial Vignetted? Structure?	Yes (scattered) Perhaps, unpredictable	No Yes. Detector + construction MOS: outer CCDs more Al, CCD edges more Si PN: Central hole in high-E lines (~8 keV)
Spectral	Variable Unpredictable No correlation between intensity + shape Low-E flares turn on before high-E	Flat + fluorescence + detector noise MOS: 1.5 keV Al-K 1.7 keV Si-K det.noise<0.5 keV. High-E – low-intensity lines (Cr, Mn, Fe-K, Au) PN: 1.5 keV Al-K no Si (self-absorbed) Cu-Ni-Zn-K (~8 keV) det.noise<0.3 keV

- Particles

1) Soft Protons

2) Internal (cosmic ray induced) BG

The two main features/problems

Andy Read (amr30@star.le.ac.uk)
EPIC BG Working Group Meeting
ESAC, Spain 30/06/05-01/07/05

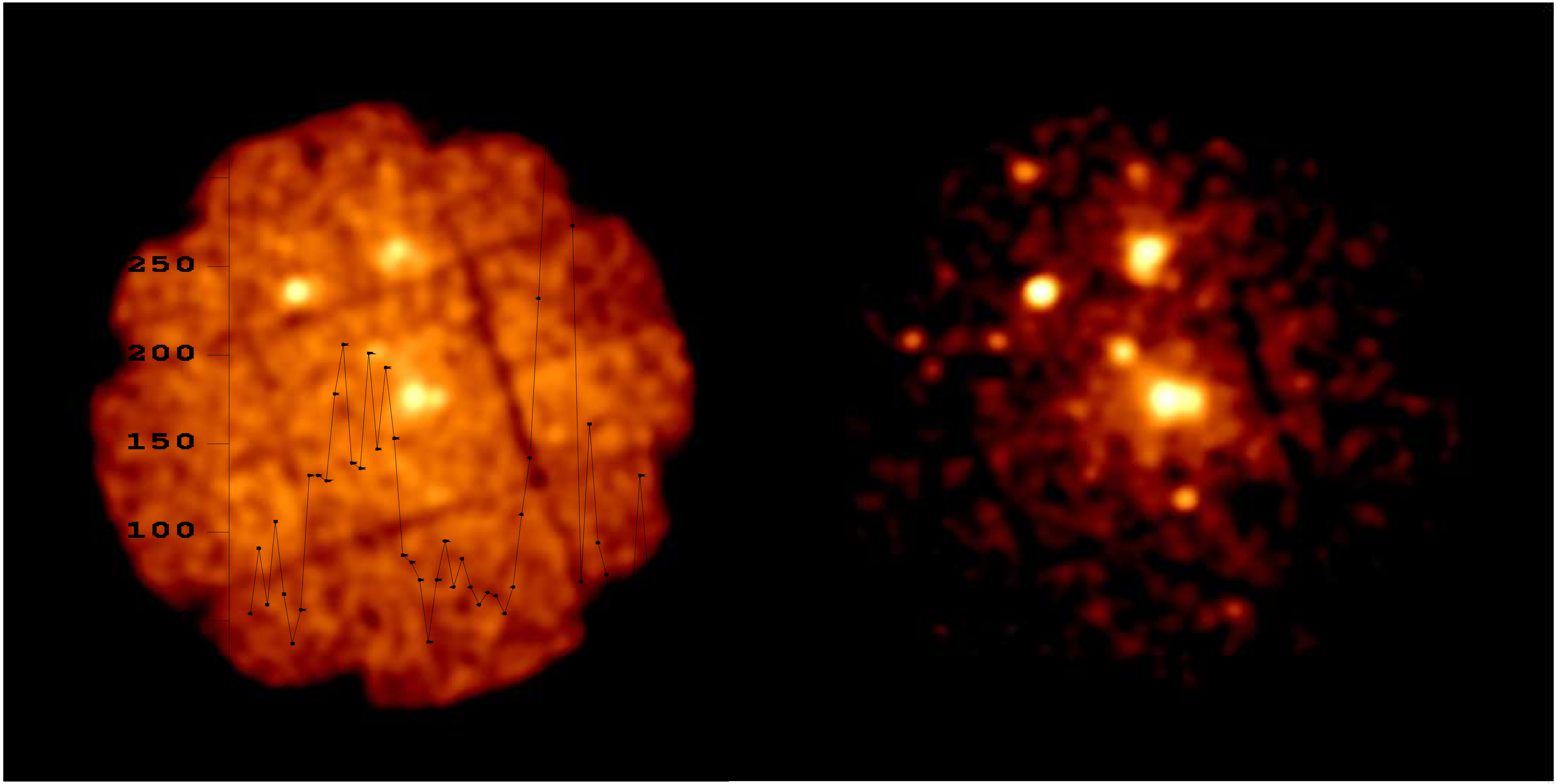
University of Leicester

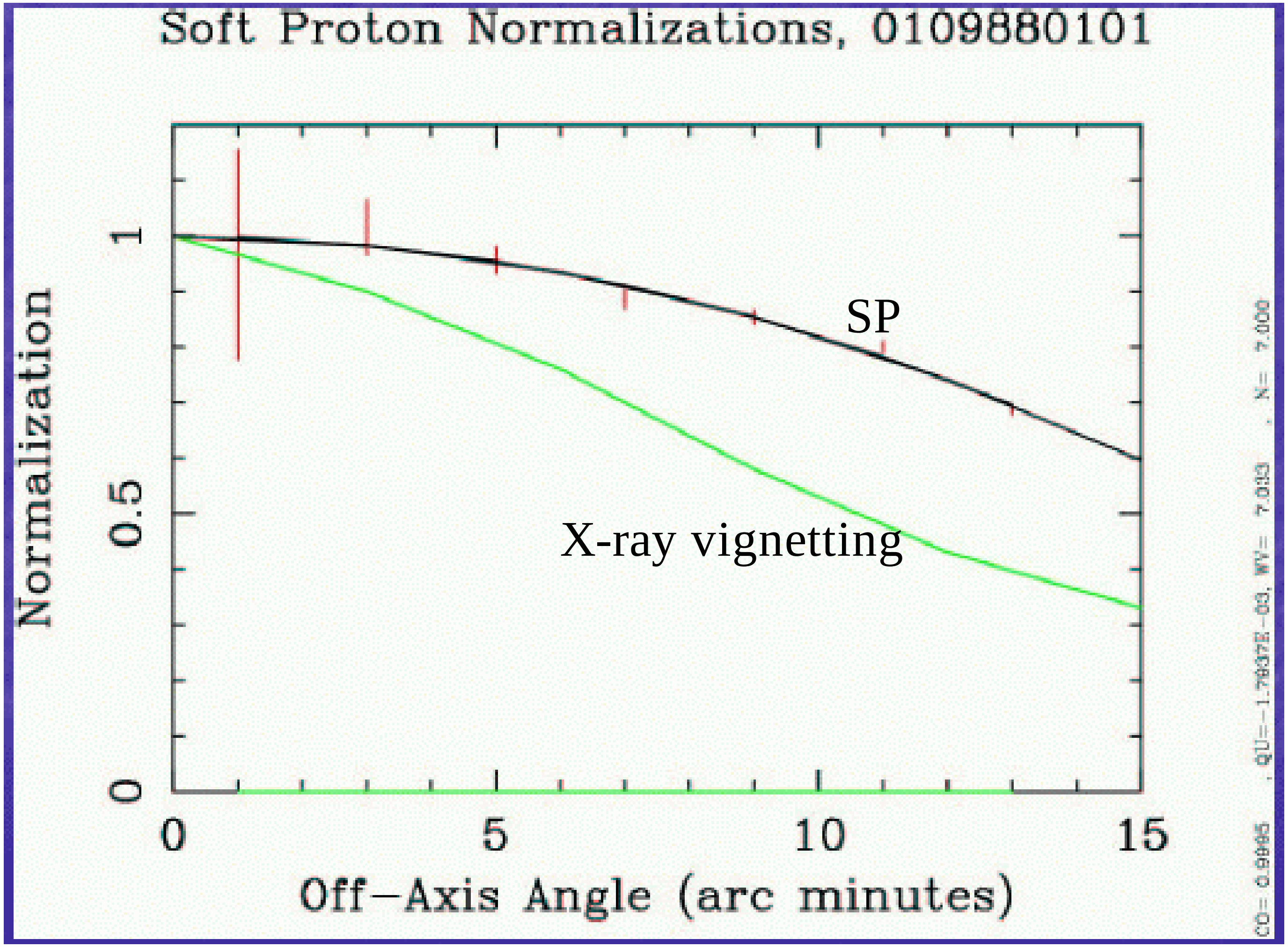
Table 1. Summary of the components within the XMM-Newton EPIC Background; temporal, spatial and spectral properties

	PARTICLES
	SOFT PROTONS
Source	Few 100 keV solar protons
Variable? (per Obs) (Obs to Obs)	Flares (>1000%) Unpredictable. More far from apogee. Low-E flares turn on before high-E
Spatial Vignetted? Structure?	Yes (scattered) Perhaps, unpredictable
Spectral	Variable Unpredictable No correlation between intensity + shape Low-E flares turn on before high-E

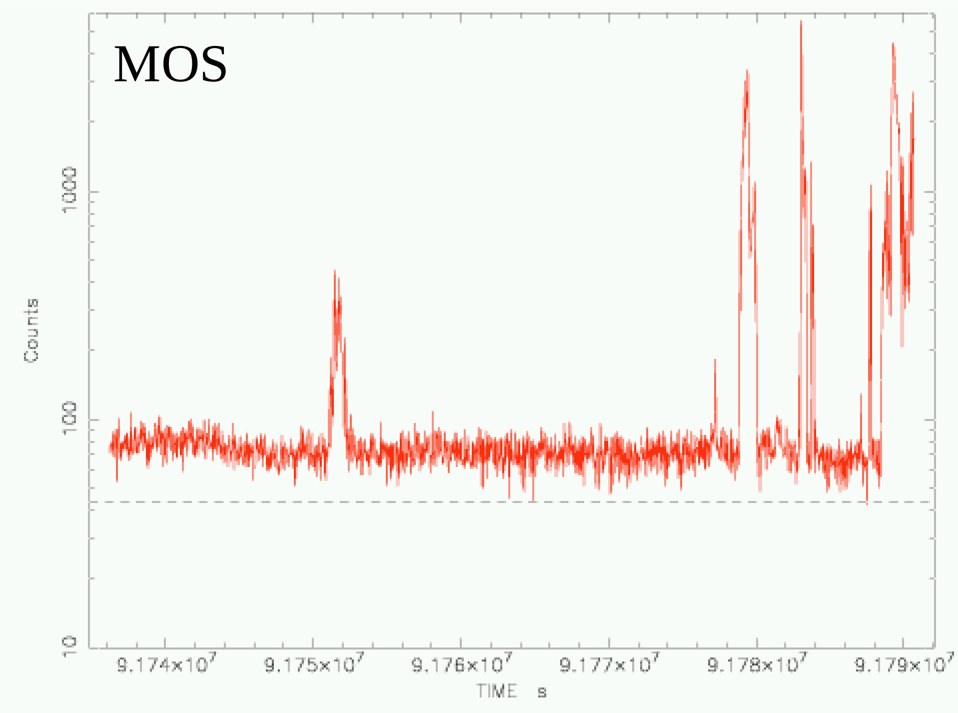
- Perhaps accelerated by magnetosphehric reconn. events – dominate times of high-BG
- Also:
- 30%-40% of time affected by SP flares
- Flaring SP flux getting worse?
- Quiescent SP flux not evolving (`02-`04)
- SPs observed only inside FOV
- SPs are ‘ vignetted’ (fn of r?, fn of E?)
- SPs have continuum spectrum (no lines) – fitted by PL/b model in xspec
- SPs v. variable in intensity and spectral shape
- SPs pattern distr. similar to genuine X-rays
- Indications of spatial variations
- PN sees more SP than MOS?

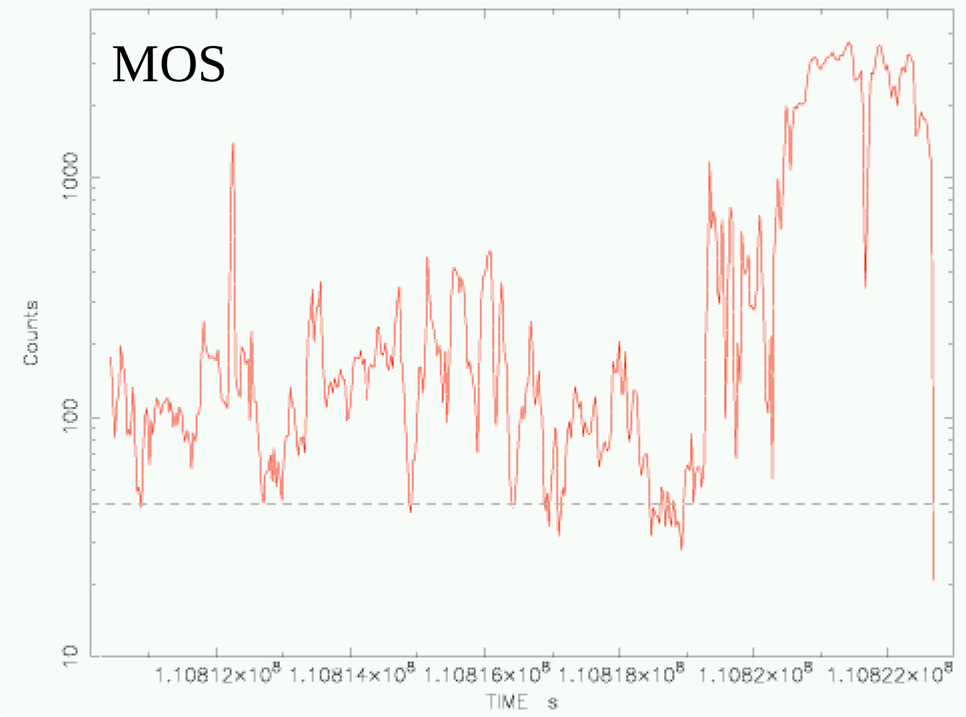
Soft Proton flaring in an observation of a Galaxy Group





Radial profile of the residual SP contamination (red points and a quadratic black model curve) compared to the vignetting function [Snowden]

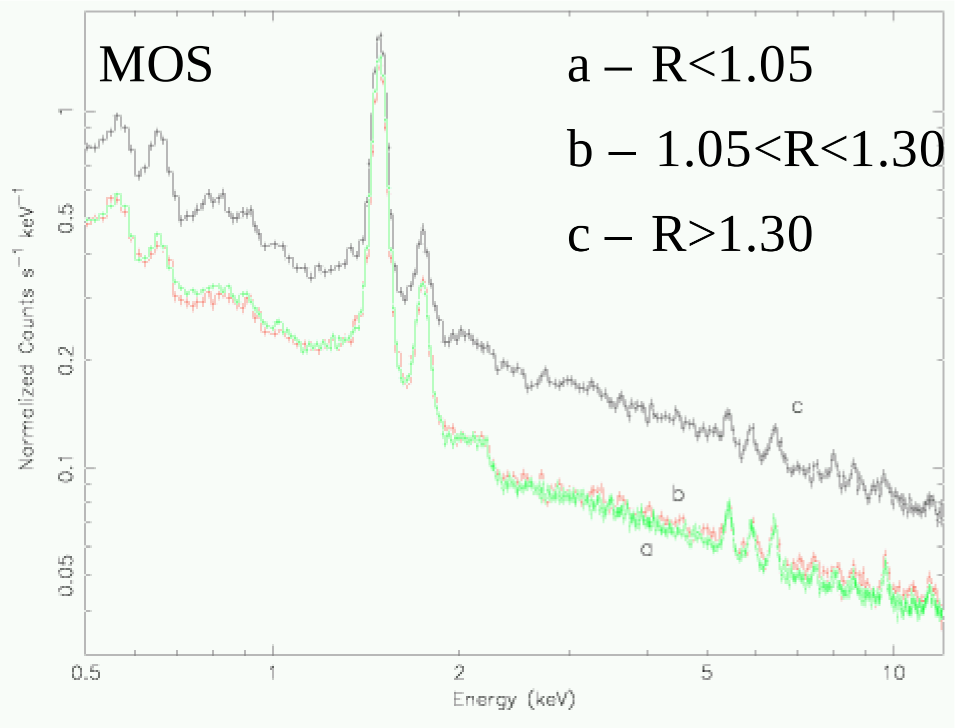


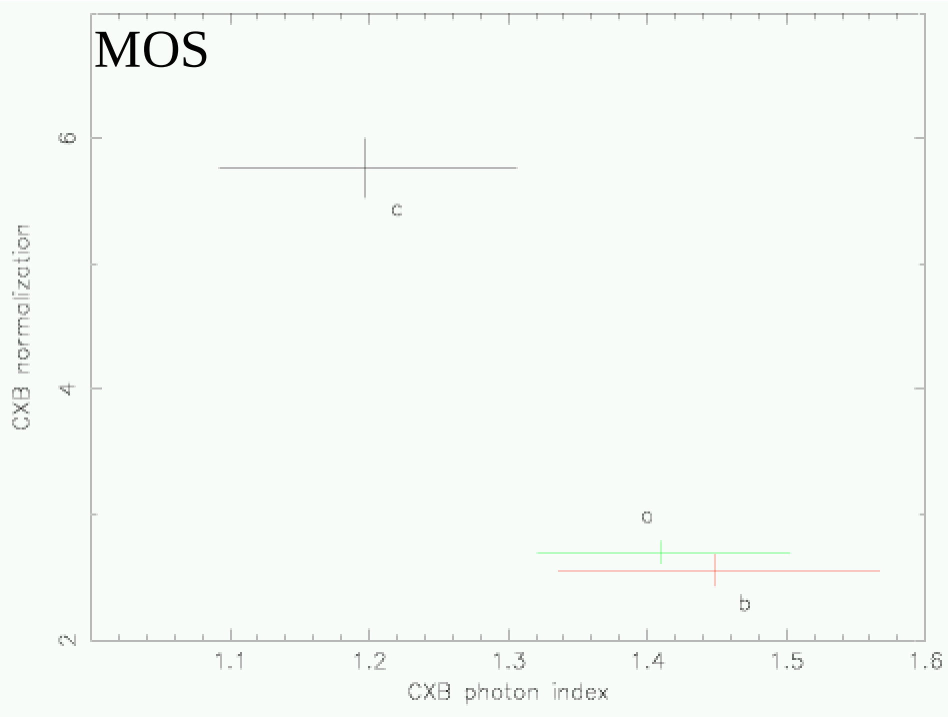


- Smooth lightcurve, obvious large flares
- Average ‘ quiescent’ rate higher than expected for typical blank-sky field
- Slow time variability
- Long SP flares?

- Highly variable lightcurve
- ~No quiescent time intervals

Residual low-level SP BG can be revealed by analysis of surface brightness ratio in and out of the FOV at 8-12keV = ? in/? out (de Luca, Molendi)





- Sky spectra having different R values R = surface brightness ratio in and out of the FOV at 8-12keV = ? in/? out

- Best fit cosmic X-ray BG parameters
- normalization and photon index for (c) are incompatible with (a) and (b)
- (a) & (b) are in good agreement

Andy Read (amr30@star.le.ac.uk)
EPIC BG Working Group Meeting
ESAC, Spain 30/06/05-01/07/05

- A significant SP BG component can survive after GTI screening
- Study of ratio of surface brightness ? in/? out at 8-12keV can reveal the presence of this residual BG
- Spectral shape flat power law, exp cut-off, typical of particle BG
- Spectral slope highly variable and unpredictable
- Intensity can be highly variable (up to 300% and beyond)
- When intensity of the residual SP BG is low (up to 30% higher than average) then acceptable results can be obtained using a simple renormalization of the quiescent BG spectrum
- There is a suggestion (<3?) of the presence of an irreducible flux of low-E particles always reaching the detectors (? in/? out for ‘ best’ sky observations is higher by ~10% than for closed observations)

Table 1. Summary of the components within the XMM-Newton EPIC Background; temporal, spatial and spectral properties

	PARTICLES	
		INTERNAL (Cosmic-ray induced)
Source		Interaction of High Energy particles with detector
Variable? (per Obs) (Obs to Obs)		±10% ±10% No increase after solar flares
Spatial Vignetted? Structure?		No Yes. Detector + construction MOS: outer CCDs more Al, CCD edges more Si
Spectral		Flat + fluorescence + detector noise MOS: 1.5 keV Al-K 1.7 keV Si-K det.noise<0.5 keV. High-E – low-intensity lines (Cr, Mn, Fe-K, Au)

-High-E, non-vignetted CR-induced events, un-rejected by the on-board electronics

-Associated instr. fluorescence – due to interaction of high-E particles with detector
-Also- MOS

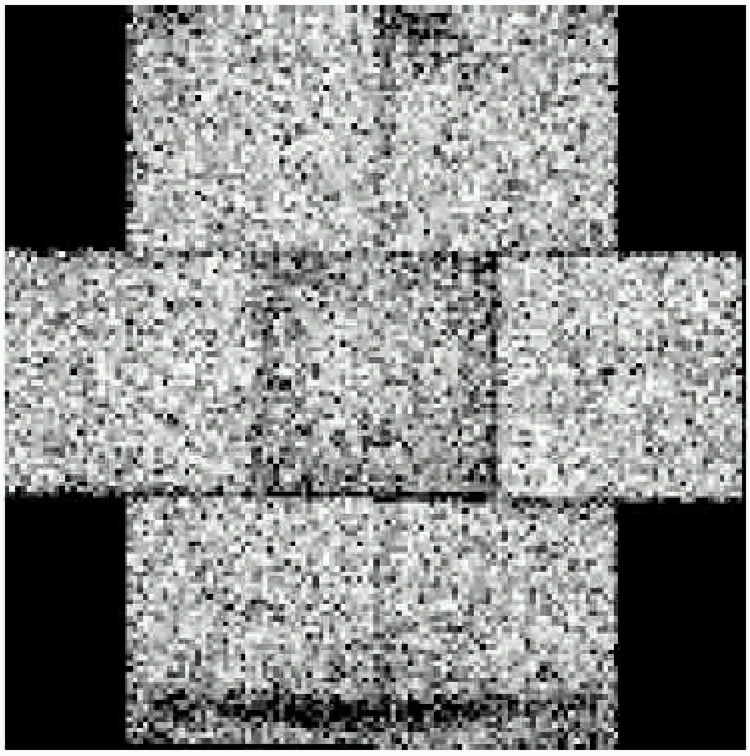
- Flat spectrum – photon index ~0.2

-Temporal: >2kev Continuum unchanged, small changes in fluor. Lines, <1.5kev, continuum varies – may be associated with Al redistribution.

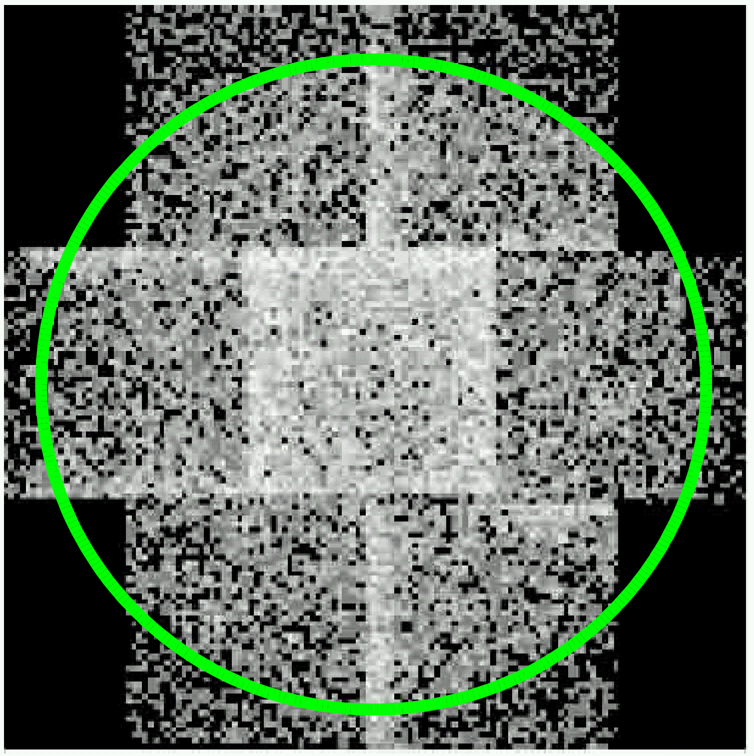
-Spatial: Continuum difference between corner (out-of-FOV) and in-FOV observed below Al line (redistribution?).

Au line also highly localised

MOS – Al-K emission



MOS – Si-K emission



Gaps barely visible

Shadows (top and bottom) – cut outs in camera body for CAL. Source

Rim of central CCD dim (CCD lower)

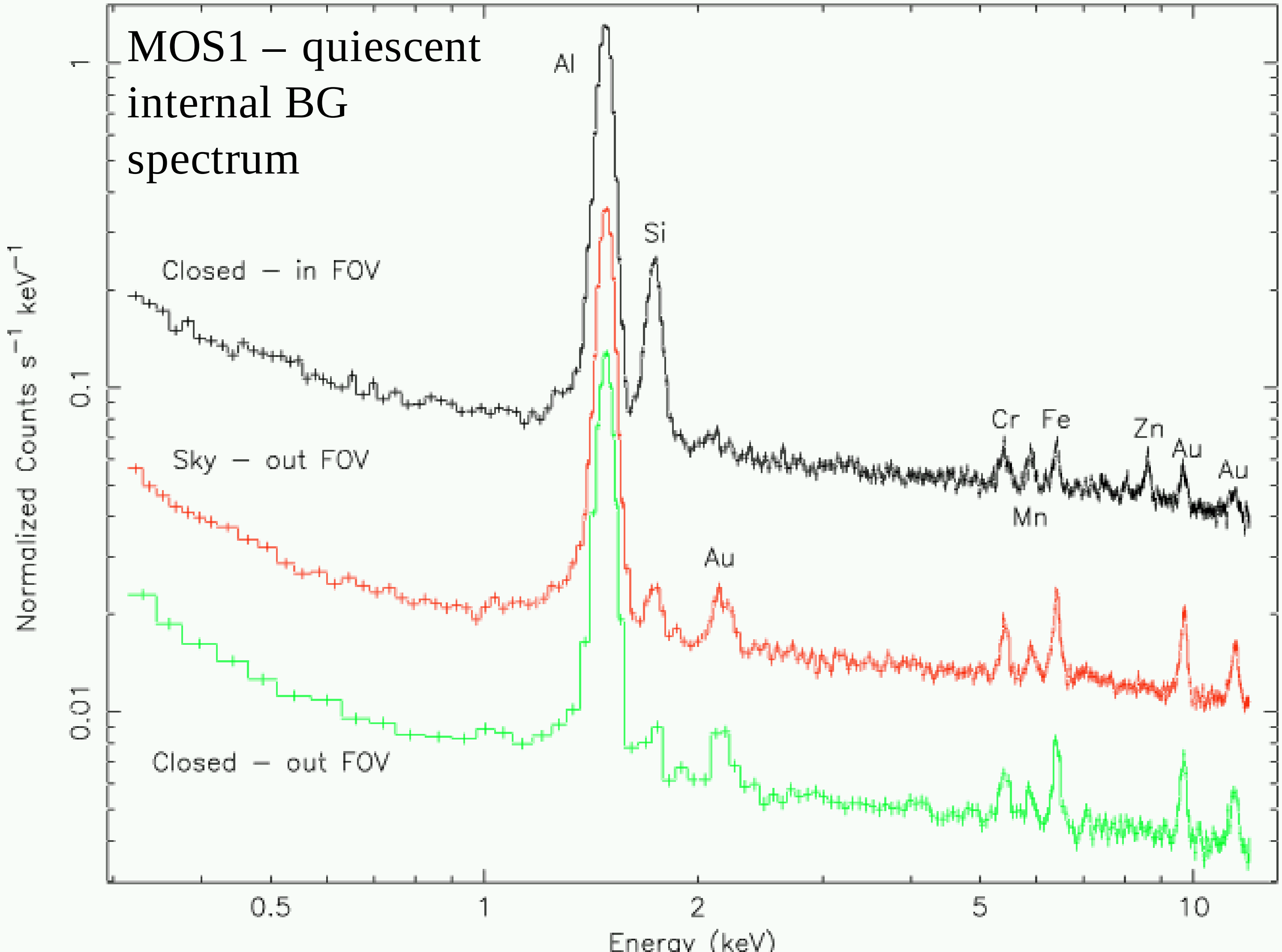
Gaps brighter

Central CCD brighter

Si-K photons collected from rear of chips (located ‘ higher’)

Difference in/out FOV visible

MOS1 – quiescent internal BG spectrum



Al-K and Si-K very different

Si much weaker out-FOV

Also Au much stronger out-FOV

Also changes in high-E lines

[De Luca, Molendi]

Also…

AdeL/SM found (in studying each MOS CCD separately):

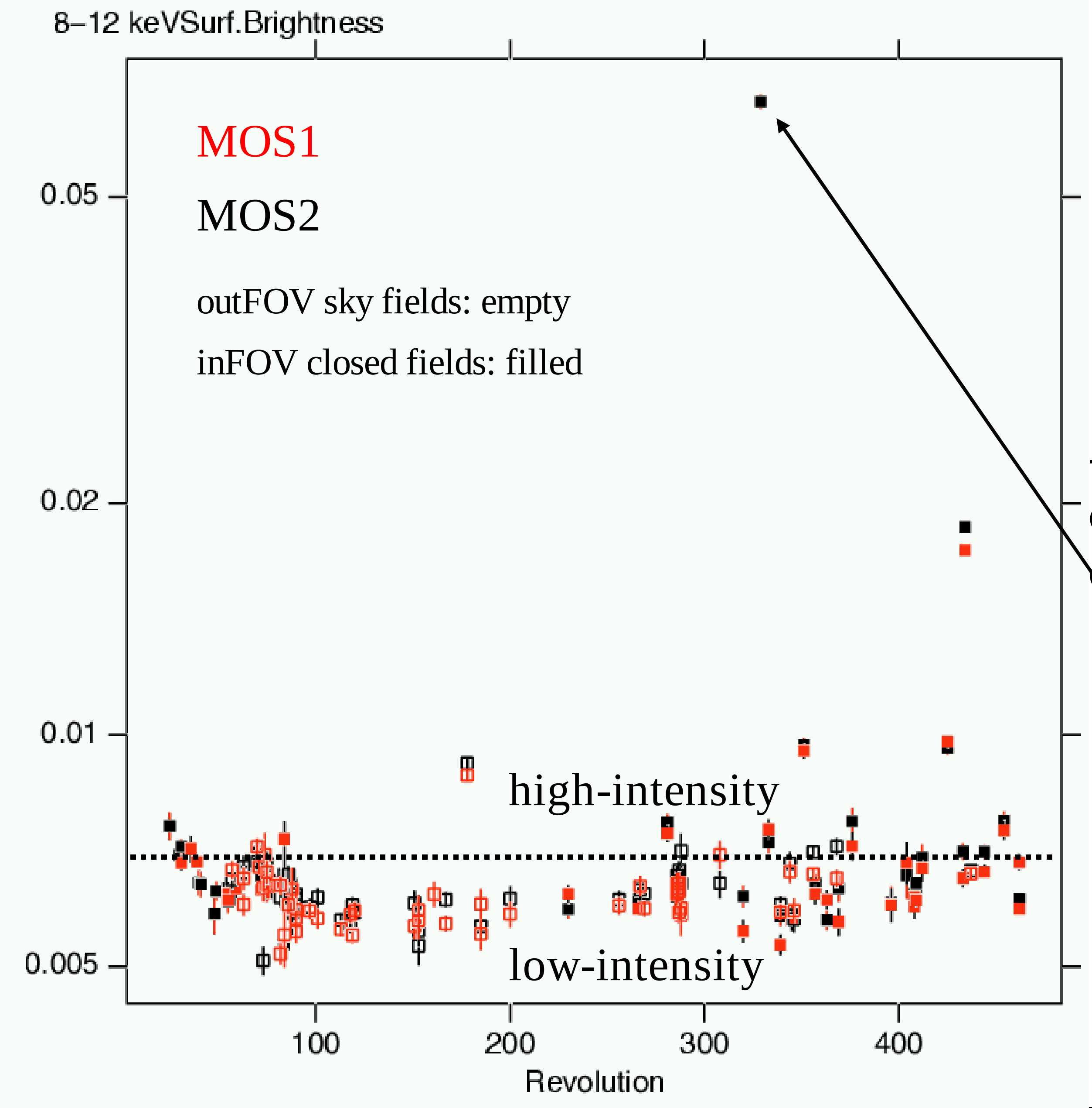
- Strong spatial variations in line intensities

- (Energies and widths found to be stable)

◆ Marginally significant spatial variations in photon index

◆ Better to extract P BG from same region of detector as S spectrum (i.e. used CLOSED data as opposed to ‘ corners’) ?

◆ Counter argument is that corner data is taken simultaneously with the source data? So – does spectrum change with time ?



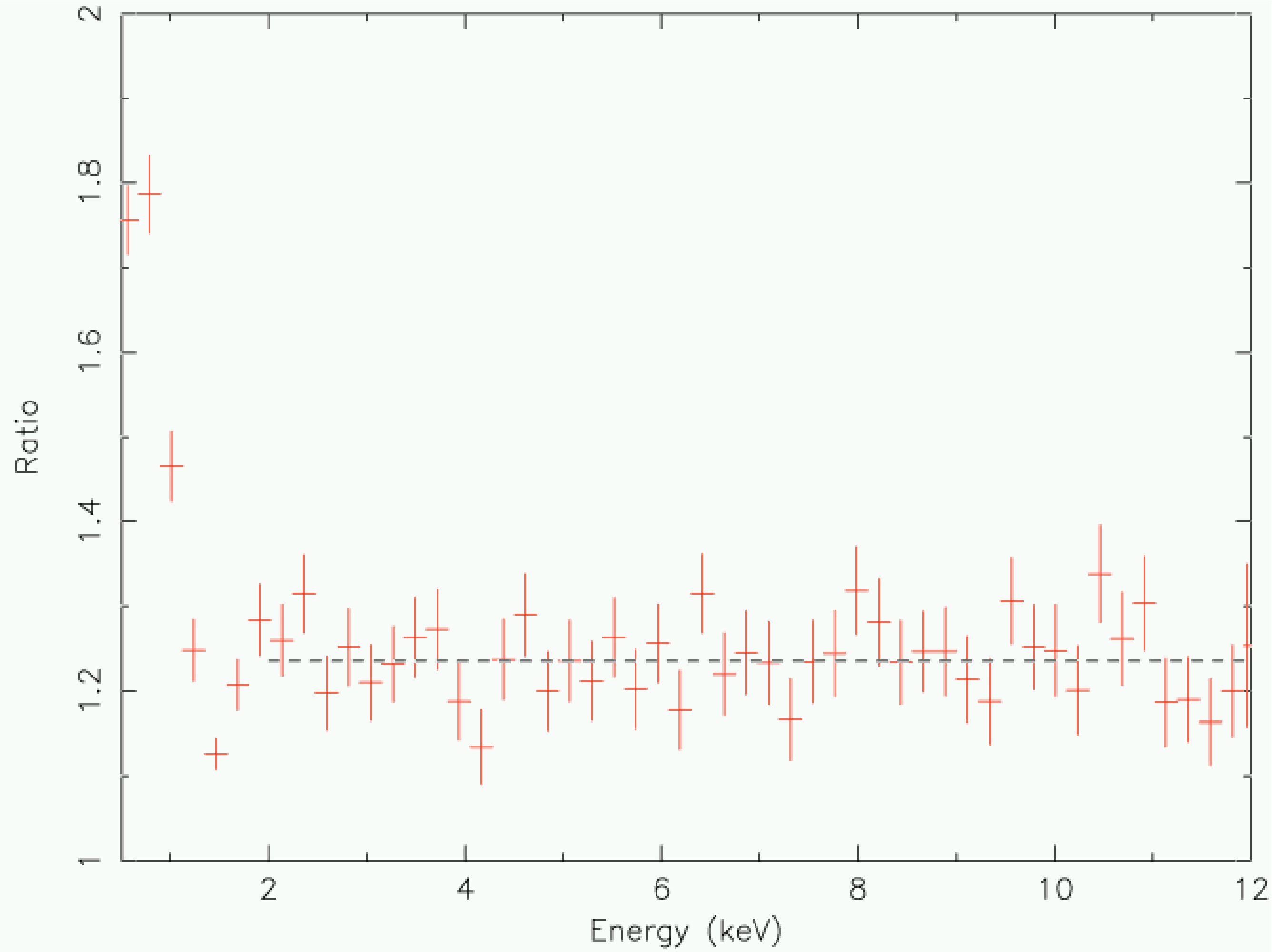
Internal particle BG

- Most follow smooth trend (to ~15%)
- Trends ~ equal for sky-outFOV and closed-inFOV

- Deviating points correspond to high radiation conditions
- e.g. rev 329 closed taken during intense solar flare

- During HR periods, P BG can be x10 higher

- Closed obs. often in start/end of orbit, closer to perigee, where particle flux greater, hence larger scatter



Ratio of inFOV spectra from ‘ high intensity’ and ‘ low intensity’ samples of closed observations for MOS1 (MOS2 v.similar)

>2keV

Overall spectral shape stable – does not depend on cosmic ray flux

<2keV

Large changes are seen

Possible to use non-simultaneous measures of the P BG (i.e. closed observations), but only for > 2keV

Table 1. Summary of the components within the XMM-Newton EPIC Background; temporal, spatial and spectral properties

	PARTICLES	
		INTERNAL (Cosmic-ray induced)
Source		Interaction of High Energy particles with detector
Variable? (per Obs) (Obs to Obs)		 ±10% ±10% No increase after solar flares
Spatial Vignetted? Structure?		 No Yes. Detector + construction PN: Central hole in high-E lines (∼8 keV)
Spectral		Flat + fluorescence + detector noise PN: 1.5 keV Al-K no Si (self-absorbed) Cu-Ni-Zn-K (∼8 keV) det.noise<0.3 keV

-Also- PN (MJF)

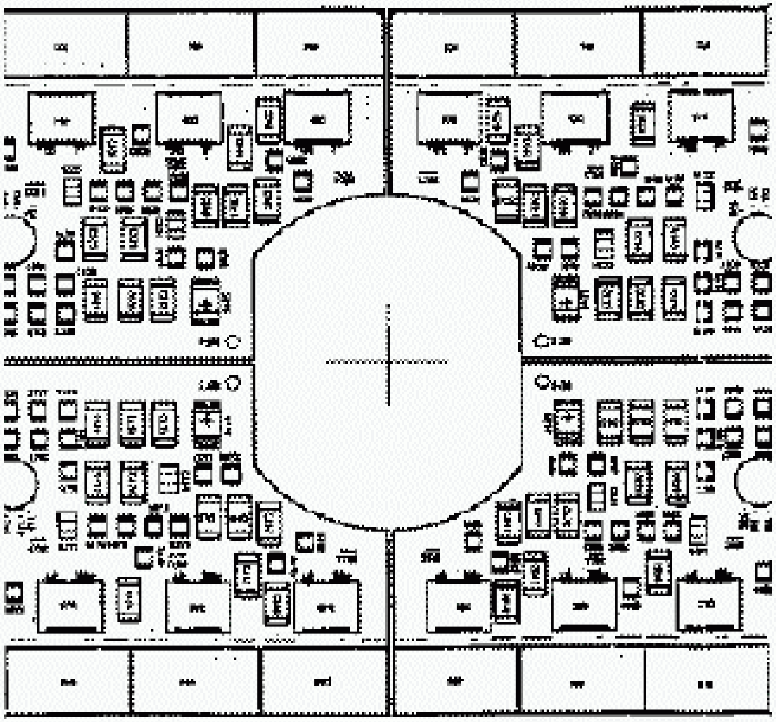
Large contribution from elec. board

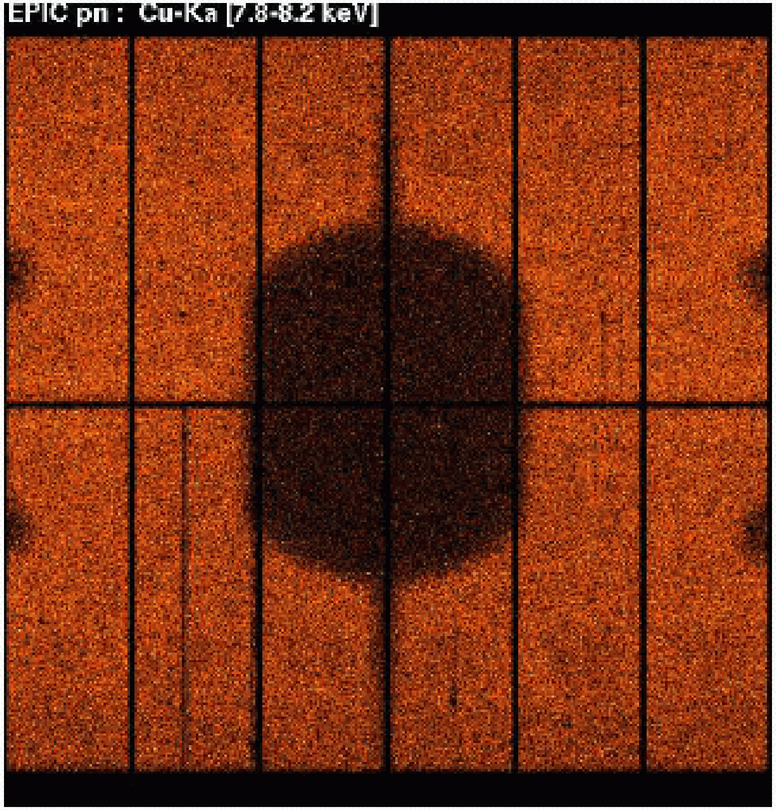
-Temporal: Different behaviour between continuum and lines (some correlation)

-Spatial: Line intensities show large spatial variations (elec. board)

Pattern distribution different from genuine X-rays

PN **Cu-K (7.8 – 8.2 keV)**





2.

What needs to be done regarding the background?

What has been done, and is ongoing?

What could be done?

A] UNDERSTAND

EPIC pn + MOS (particle) BG rates much higher than expected (by factor ~2)

- Are the Gamma ray rates wrong?

- pn rate is ~x2 greater than MOS
- Agrees with D.Lumb and ideas regarding thickness of detectors
- Cosmic rays should depend on cosmic flux, hence RM dependence?

A] UNDERSTAND

EPIC pn + MOS (particle) BG rates much higher than expected (by factor ~2)

- Can we get rid of quiescent soft protons? (some that appear ‘ irreducible’)

- Soft protons are vignetted/funnelled
- What is this function? as a function of energy (c.f. with photon vignetting)
- We can select soft protons quite easily

A] UNDERSTAND

EPIC pn + MOS (particle) BG rates much higher than expected (by factor ~2)

- Charged particles?
- Leave track going through the CCD – EDU removes track, but leaves behind a halo of dots

B] REDUCE

- Initial design

- EPIC-MOS was designed with little or no fluorescent or active metals
- Future Missions should make use of our knowledge and studies

B] REDUCE

- BG-reduction tasks

- General particle background reduction tasks
- Should go into SAS?

- epreject (MJF?)
  - upgrades?
- emreject equivalent?
  - MOS EDU removes charged particle track, but not halo
  - Develop task to remove halo

B] REDUCE

- Post-reduction tasks

- Soft protons?
- What is best way of screening these from the data?
  - Create high-energy (10-15keV) singles lightcurve, visually inspect this, set thresholds to create a GTI file and apply this to the data? (AMR+)
  - Similar methods, more or less stringent (e.g. SM)
  - Better than sigma-clipping or growth curve? – Allows homogeneous treatment
  - ? in/? out analysis (AdeL/SM - MOS)?
  - Other methods? e.g. J.Nevalainen – discards time periods when either hard-band or the soft-band rate exceeds the nominal value by >20%

- Should there be SAS/EPIC task to do this?
- Should SAS/EPIC state what they think the optimum strategy is?
- Optimum strategy might be different for particular sources or for science attempted

B] REDUCE

- Post-reduction tasks

- General knowledge and advice when extracting images/spectra etc.
- Recommended settings etc.
- e.g. Use only singles below 0.5keV

- Where should we collect together all these little bits of ‘ insider’ information? Somewhere on the SOC BG-webpages?

C] MODEL

- Have created large BG blank-sky event files plus associated analysis tasks.
- Used extensively. Improvements made and ongoing via users' suggestions.
- Other BG blank-sky event files exist (e.g. DL, JN, AdeL/SM).
- Subtle differences in obtained results due to differences in BG cleaning (AF).
- Collect together? Point to via SOC BG-webpage?

- Closed blank-sky (particle) event files also exist (e.g. PM). Where?
- Collect together? Point to via SOC BG-webpage?

- (re-)Make larger BG blank-sky event files.
- (re-)Make larger CLOSED blank-sky event files.

C] MODEL

- Dedicated task(s) to do BG modelling:

- Make as SAS tasks or as stand-alone tasks?

- AMR task(s)
  - Have couple of scripts/procedures that could be developed into full tasks (details follow)
  - Sent (2004) draft BG task to MSt to begin development along lines of these scripts

-Others (SS/Goddard, MJF/MPE, AF/MPE, AdeL/SM, JN..)

- Combine tasks (could be difficult) or leave separate?
- Set of separate tasks with one-line descriptions of for what objects, science, energy-ranges, data etc., they are valid/useful

C] MODEL

- PPS will do ‘ point source’ BG extraction soon

Andy Read (amr30@star.le.ac.uk)

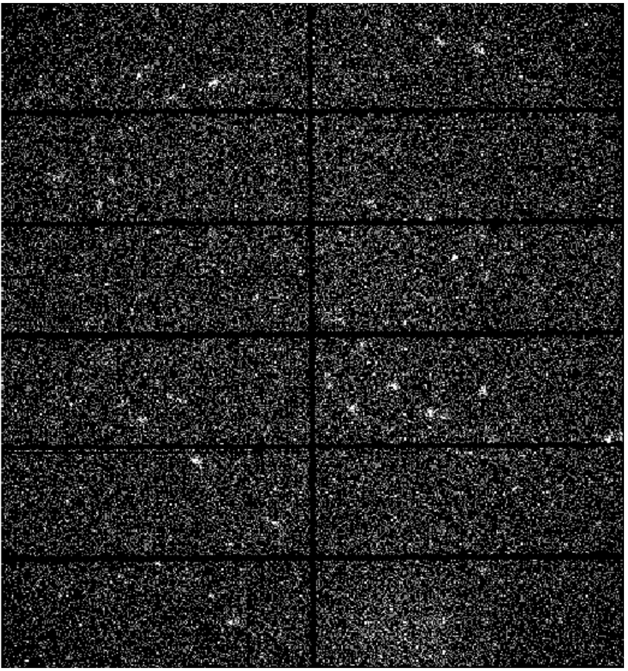
3.

Detailed descriptions of codes, tasks and procedures.

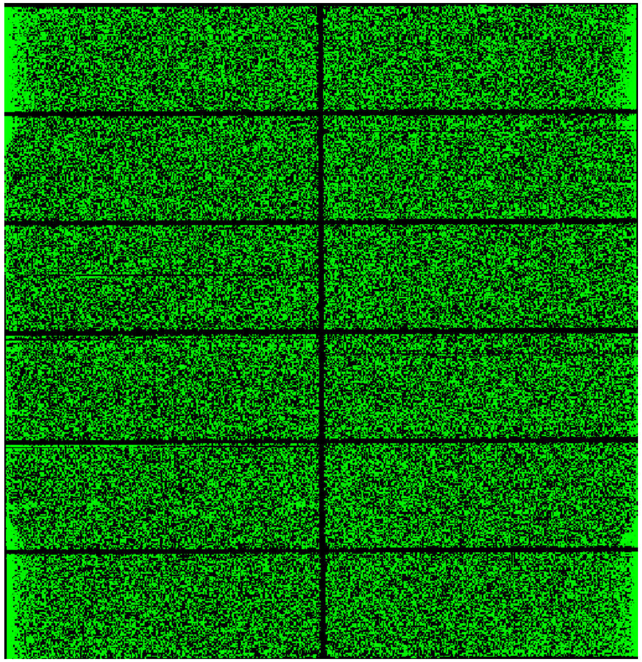
Andy Read (amr30@star.le.ac.uk)

Imaging: Background subtraction

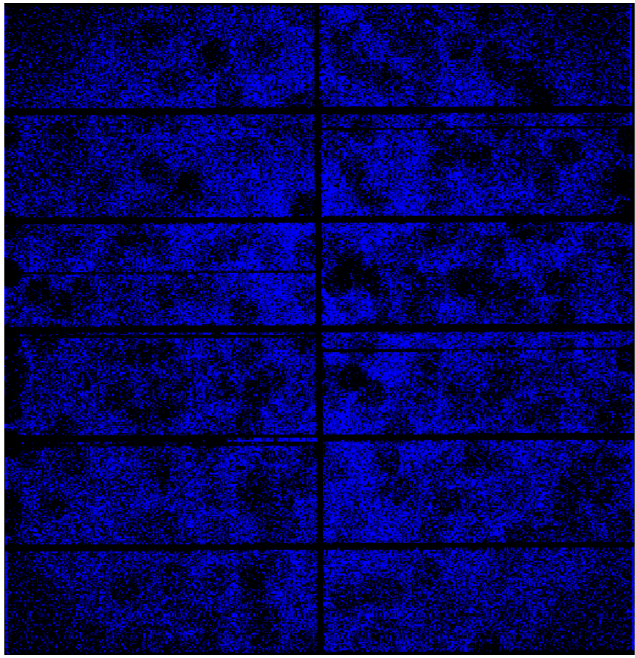
Source data



Closed data



Background data



Source (vignetted) +

Background: -
Photons (vignetted)
Particles (non-vignetted)

Background: -
Particles (non-vignetted)

Background: -
Photons (vignetted)
Particles (non-vignetted)

Only BG particles appear in out-of-FOV areas [i.e. corners]

Andy Read (amr30@star.le.ac.uk)

University of Leicester

Imaging: A double-background subtraction task

Source | Closed data (Particles) | Background data (photons+particles)

- Evaluate all out-of-FOV events – calculate scalings

Create image | Create scaled P image | Create scaled BG image

-Subtract to give
Source image (no particles)

-Subtract to give
scaled BG image (no particles)

* Start ' soft excess' loop over several small energy bands

Create large-R annular image (source-free) | Create large-R annular P image Scale to source | Create large-R annular BG image Scale to source

-Subtract to give
Source annulus (no particles)

-Subtract to give
BG annulus (no particles)

-Subtract to calculate ' soft excess' at large-R for particular energy

- Create exposure map in small energy band – use to create full field ' soft excess' image

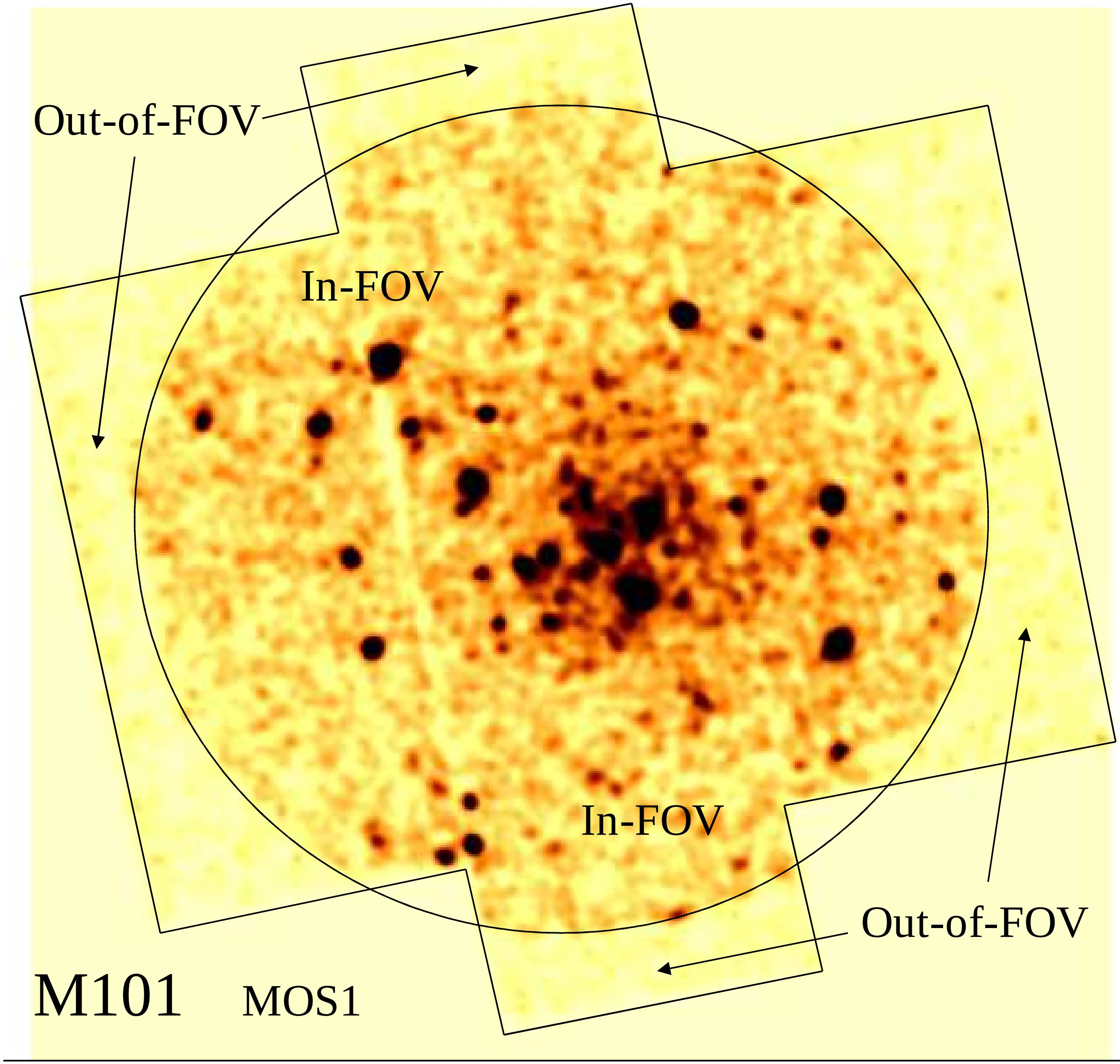
* End Loop over energies to accumulate total energy, full field ' soft excess' image

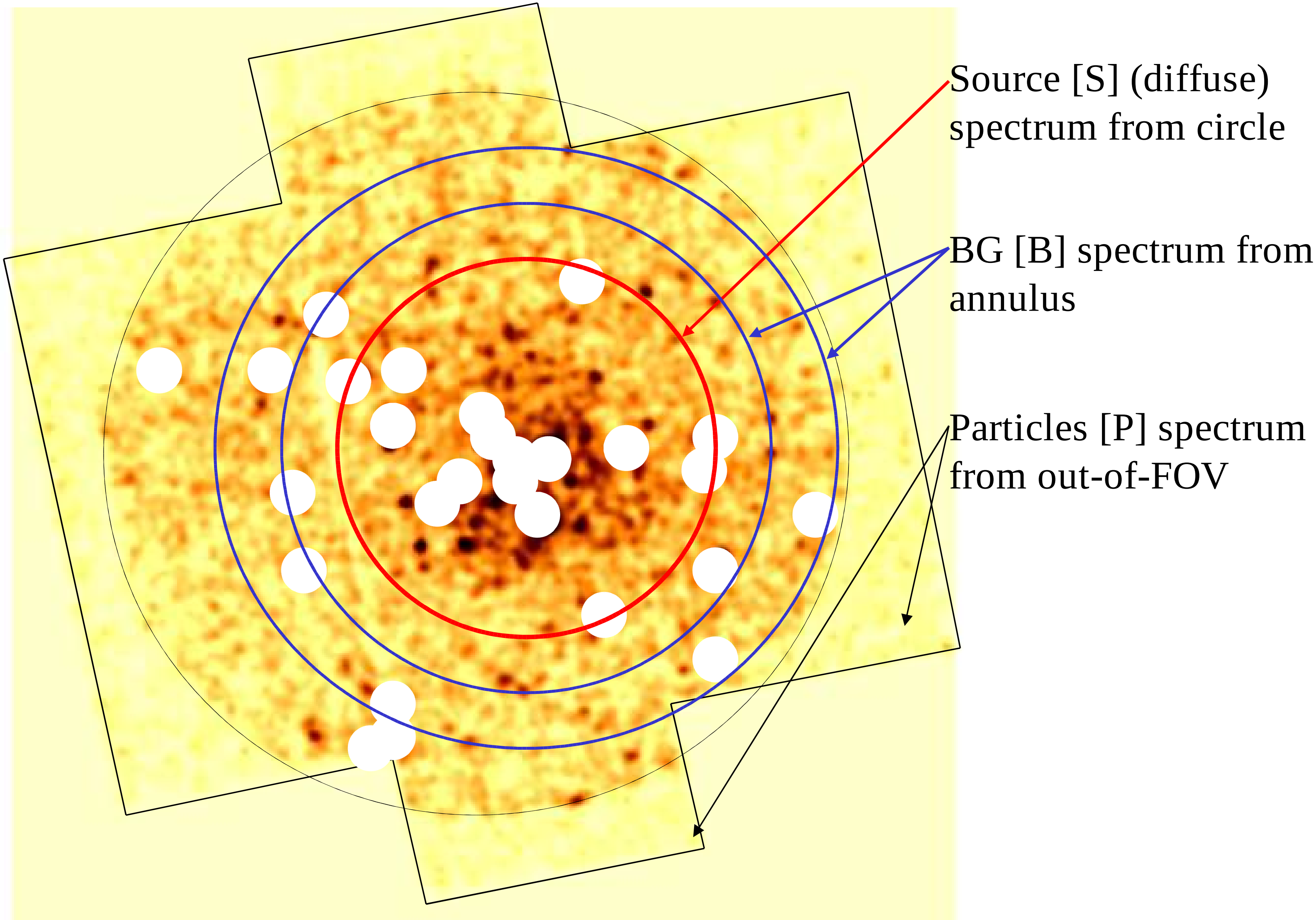
-Add \`soft excess' to Scaled BG image (no particles) to create double background

-Add double background to scaled particles image to create total background

Andy Read (amr30@star.le.ac.uk)

A spectral BG correction task





Andy Read (amr30@star.le.ac.uk)

Source [S] = S[S] + B[S] + P[S]

Local BG [B] = B[B] + P[B]

Particles [P] = P[P]

S (no particles) = S – (f1 x P[P]) f1=P[S]/P[P] (at high-E)

B (no particles) = B – (f2 x P[P]) f2=P[B]/P[P] (at high-E)

S (no BG, no P) = S (no P) – [f3 x B (no P)] f3=EA[S]/EA[B] (eff.area ratio)

= S – (f1 x P[P]) – (f3 x [B – (f2 x P[P])])

= S – (f1 x P[P]) – (f3 x B) + (f3 x f2 x P[P])

= S – [(f3 x B) + ((f1 – (f2 x f3)) x P)]

i.e. = S – [(t1 x B) + (t2 x P)] t1 = f3

t2 = f1 – (f2 x f3)

Total BG under source

Task to create appropriate ‘ BG2’ spectrum from input source [S] spectrum, given a local (or blank sky) [B] (sky+particles) spectrum and a local – i.e. ‘ corners’ (or blank-sky) particles [P] spectrum

BG2 spectrum given by summation of B spectrum and P spectrum:

BG2 = (t1 x B) + (t2 x P)

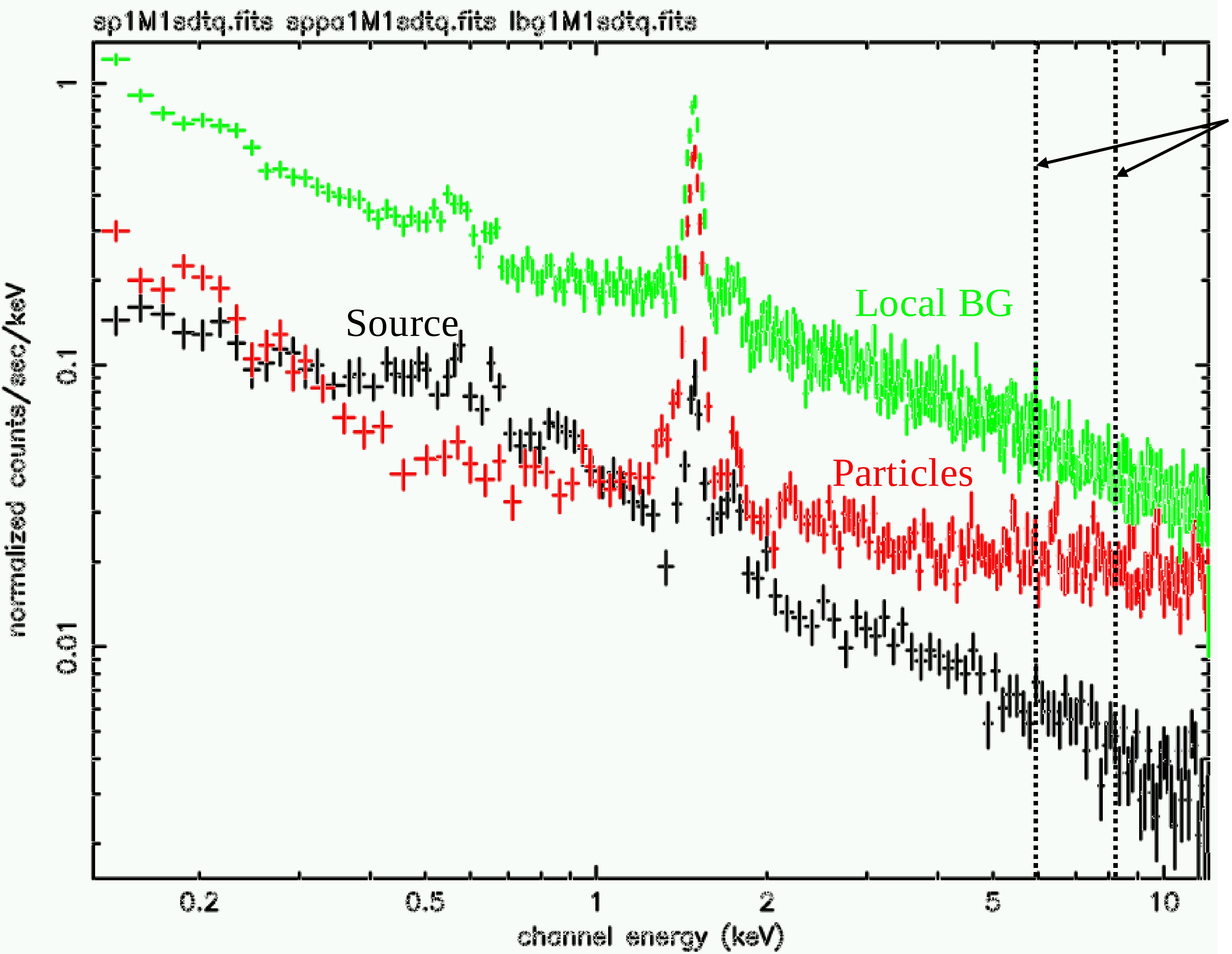
Where t1 = f3 = S/BG area ratio = eff.area ratio x BACKSCAL ratio, and

t2 = f1 – (f2 x f3)

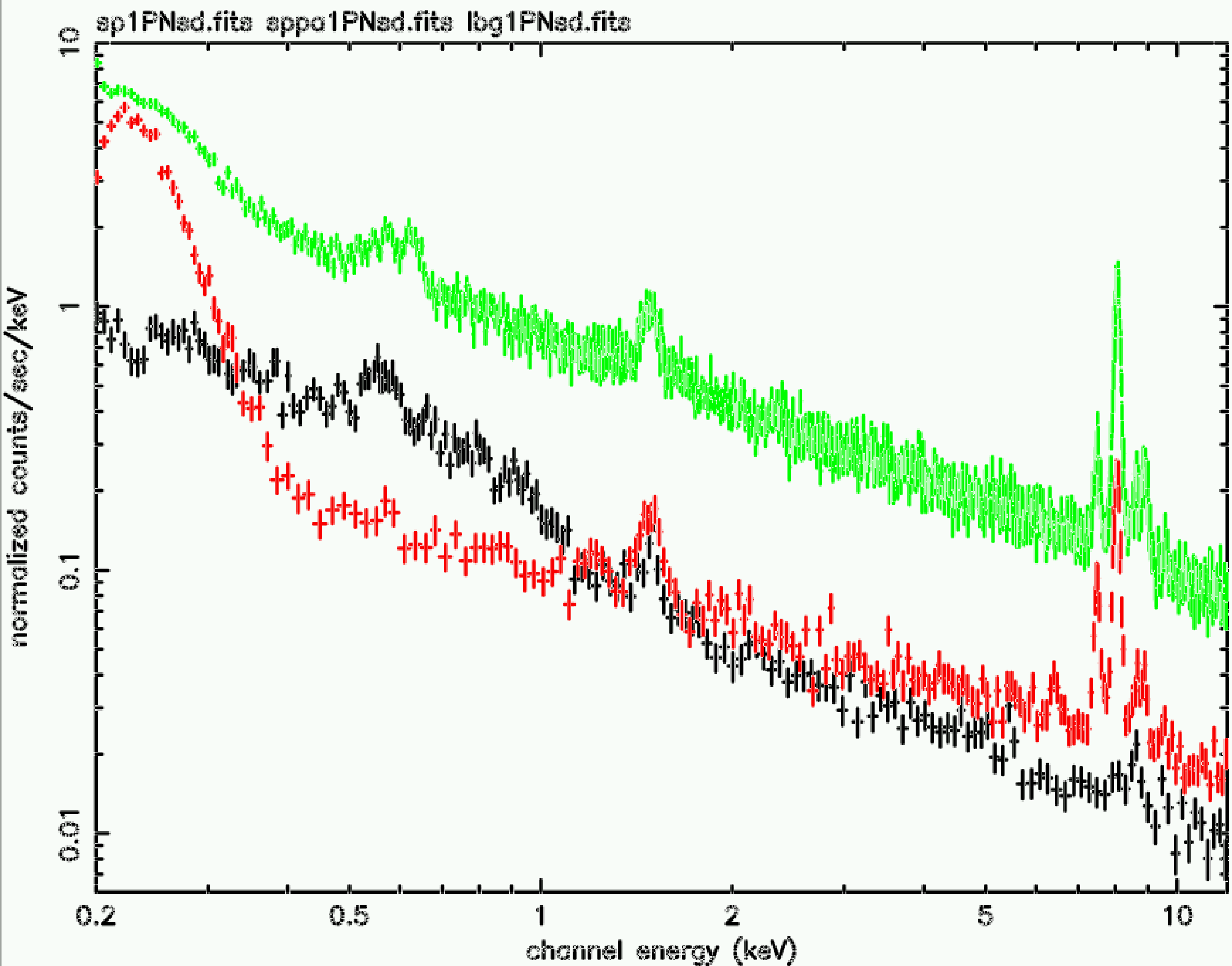
Where f1 and f2 are, respectively, the S/P countrate ratio and the B/P countrate ratio over a certain (usually hard) energy band. f3 can be calculated from S and B arfs (plus desired energy)

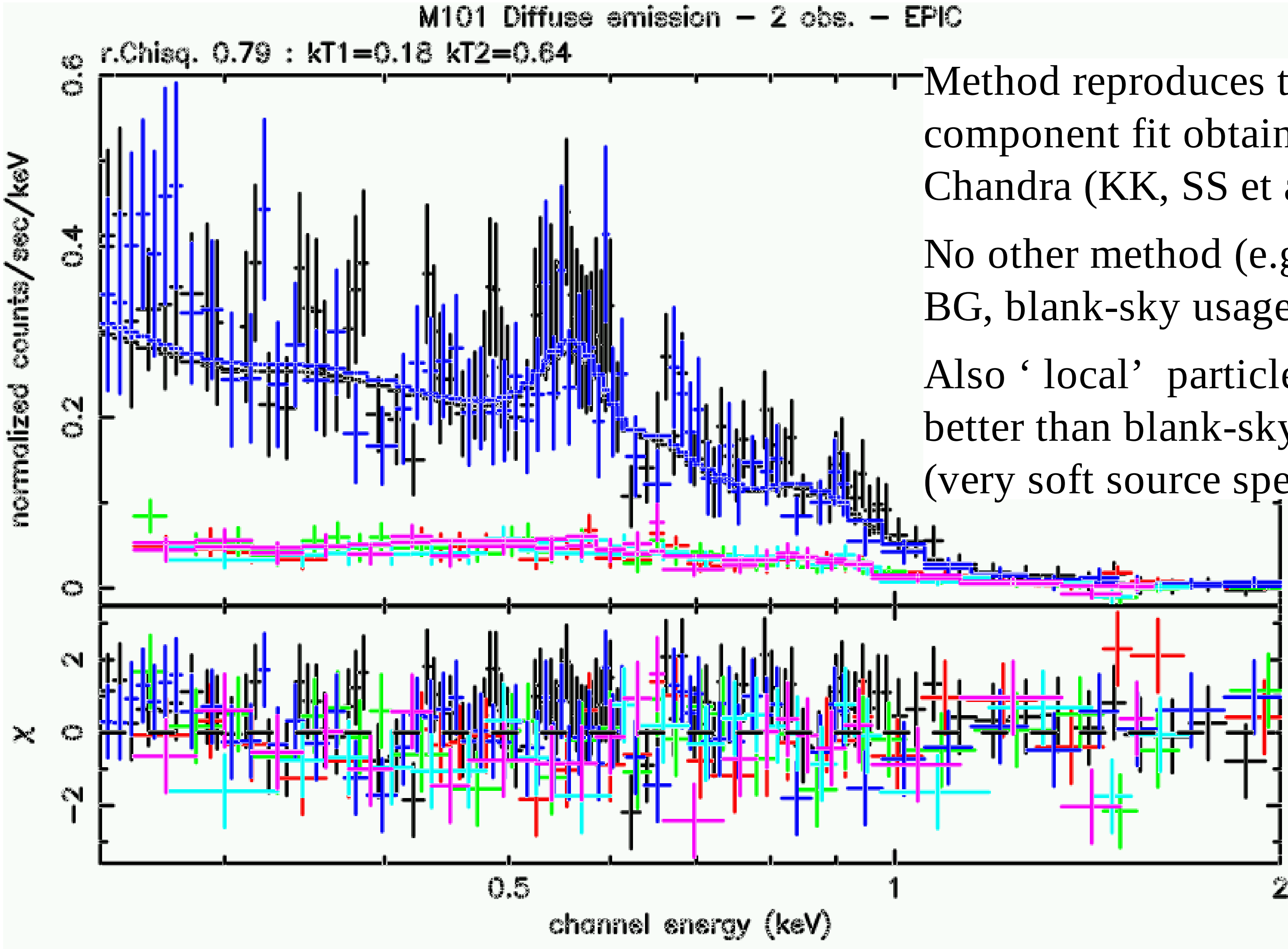
Works very well when there are in-FOV, off-S regions, and for softer sources, where one can find hard spectral regions where the S contributes ~0.

Such soft sources have great problems when using blank-sky BG methods (as blank-sky BG not representative of local BG at soft energies)



Calculate S/P and BG/P scalings over e.g. this range.


sp1PNsd.fits sppo1PNsd.fits lbg1PNsd.fits
normalized counts/sec/keV
10
1
0.1
0.01
0.2
0.5
1
2
5
10
channel energy (keV)



Method reproduces the 2-component fit obtained by Chandra (KK, SS et al.)

No other method (e.g. just local BG, blank-sky usage) does this

Also ‘ local’ particles (corners) better than blank-sky particles (very soft source spectrum!)

4.

Other already existing BG tools, tasks and knowledge ‘ out there’ .

Andy Read (amr30@star.le.ac.uk)

- Other Tasks, procedures etc. ?
- JN – ‘ XMM-Newton Background Modeling for Extended Sources’ astro-ph/0504362 – blank-sky and closed-cover BG files created – BG subtraction methods (including SP-rejection using hard- and soft-band lightcurves).
- AdeL/SM – ‘ The 2-8keV cosmic X-ray background spectrum as observed with XMM-Newton’ A&A 419, 837 (2004) – 8-12keV $?_{in}$/$?_{out}$ method

- Data available? Procedures available? In what form?

Also…

- It was decided (BG workshop Milano 6-8/10/03 – minutes SM) that 2 different possibilities would be followed…

5) Background modeling technique (SM?)
6) Background subtraction technique (aka double subtraction [GP]) – GP and SS to put into ftools

- Results from 2 techniques were to be compared at next cal-ops meeting (Mar/Apr 04?)

- Any progress?

5.

EPIC BG webpage(s).

- Create, as a short term solution, an up-to-date BG webpage describing the current status of EPIC BG knowledge (pointing to all available material) on the SOC pages

- Current SOC link to e.g. AMR-Birmingham very difficult to find (also link needs to be changed [points to out-of-date material])

- Main BG link needs to be more visible (front page?)

- Dedicated jump page at SOC – short 1 line descriptions of each page

- Links to other web sites:

AMR-Birmingham already linked
AMR-Leicester already linked
SS-Goddard
MJF-MPE
JN already linked (to single- and double-filtered data)
AdeL/SM? AF ? DL ? Others?

Questions/Suggestions/Miscellaneous

- All links should go to page where user is helped directly?

- Is P.Marty’ s closed data available anywhere? I have copies…
- Is AdeL/SM’ s closed 430ks and open 1.15Ms data available?

What has been done?

- AMR-Birmingham updated and tidied – more data and more user-friendly (details presented at Mallorca conf.)

- AMR-Leicester started (links between AMR pages put in place)

Andy Read (amr30@star.le.ac.uk)

Updates and Additions to EPIC Background Products

http://www.sr.bham.ac.uk/xmm3/BGproducts.html

A&A 409, 395 (2003)

XMM-Newton EPIC Background Analysis

XMM-Newton background Events files for the 3 EPIC instruments in their different instrument mode/filter combinations have been constructed using a superposition of many pointed observations. Background maps in several different instrument/mode/filter combinations and in several energy bands have also been constructed. On these pages, details can be found on how to obtain these background products together with related software and the paper on their construction and usage.

Contents:

- Latest updates to these web pages
- XMM-Newton background subtraction (brief introduction)
- Available XMM-Newton background files
- Software available relating to background files
- Production of Background Maps and Event Files
- Using these Background Files (some brief guidance)
- Jump straight to main ftp site

Andy Read (amr30@star.le.ac.uk)

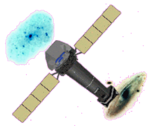
- Thick filter blank-sky background event files now available

Instrument	Mode	Filter	N_{OBS}	Exp.time (s)
MOS1	FF	Thin	49	1055905
MOS1	FF	Medium	21	488422
MOS1	FF	Thick	14	403938
MOS2	FF	Thin	46	1004709
MOS2	FF	Medium	26	592975
MOS2	FF	Thick	14	404717
PN	FF	Thin	18	351549
PN	FF	Medium	12	188159
PN	FF	Thick	12	242110
PN	FFext	Thin	32	416739
PN	FFext	Medium	8	82957
PN	FFext	Thick	5	87525

Other Updates

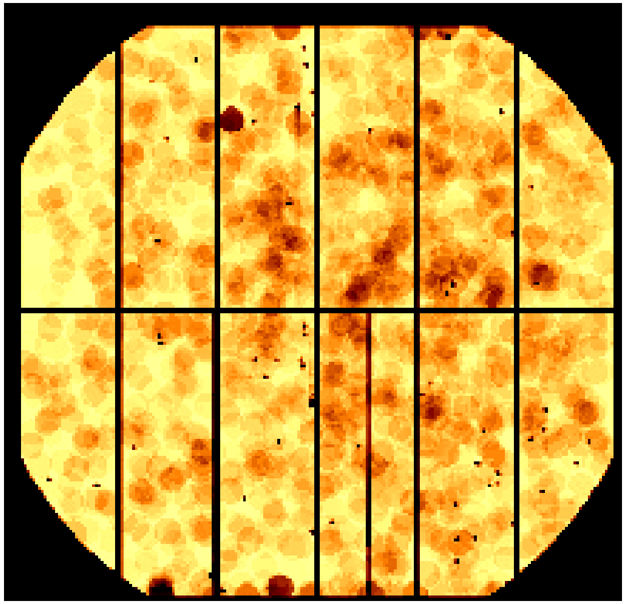
- Many due to requests & suggestions from users
- See web site for details
- Linked from main ESA website (Vilspa)

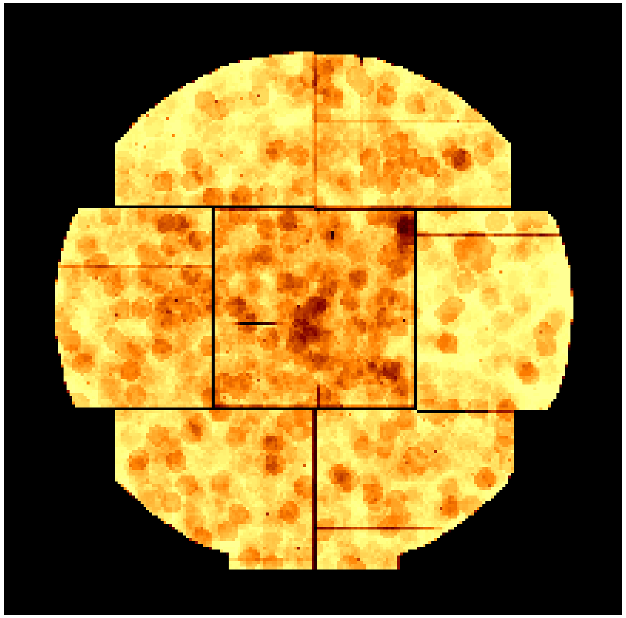
- Event files without (E1) and with (E2) the exposure extensions
    - Exposure extensions contain correct exposure times
- Exposure maps with and without the effects of source removal
- Source lists (position, obs.ID, TSTART/STOP) of each removed source for each (of 12) blank sky event files
- BGrebinimage2SKY_4arcs – A wrapper to rebin and reproject the 4" resolution exposure maps – transformation recently improved



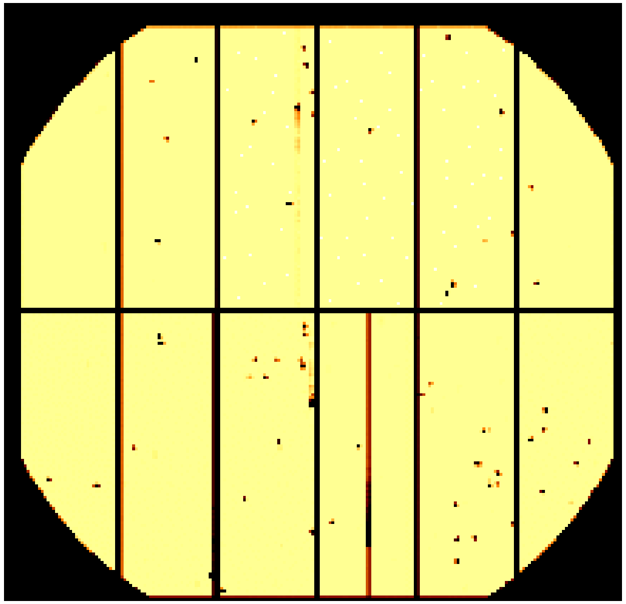
Andy Read (amr30@star.le.ac.uk)

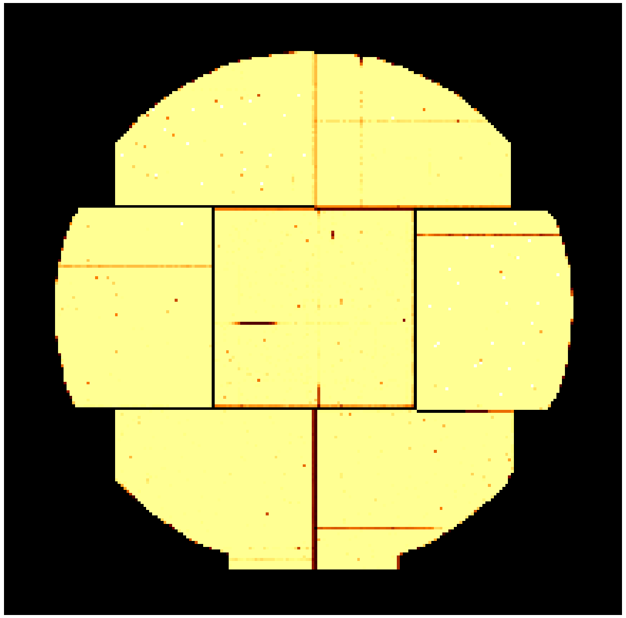
Exposure Maps





- With source removal

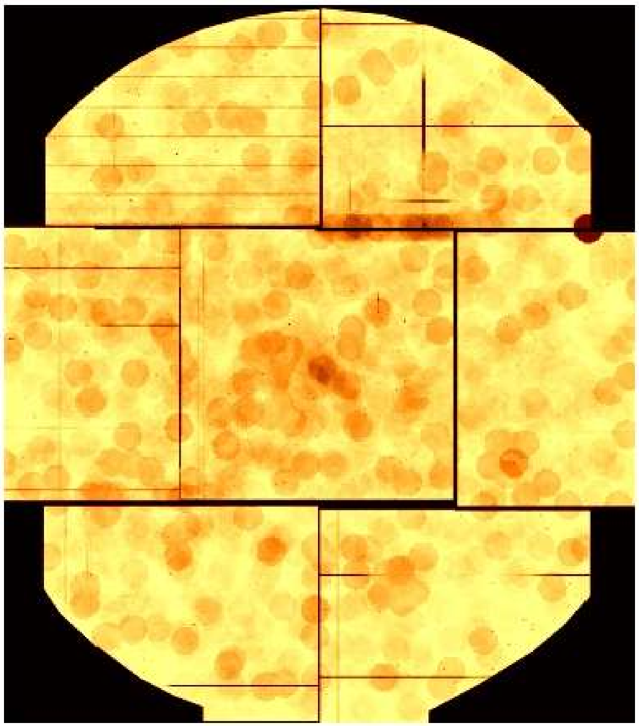




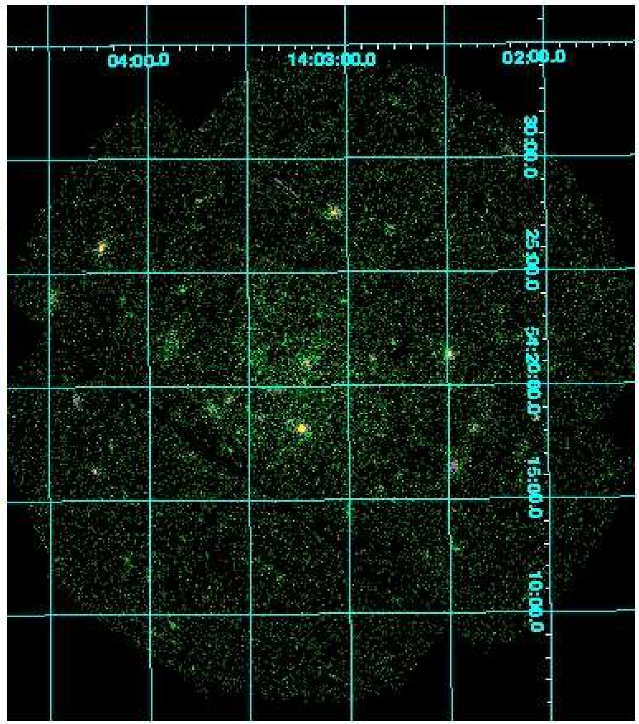
- Without source removal

- Use of BGrebinimage2SKY_4arcs to transform/rebin from DET to SKY

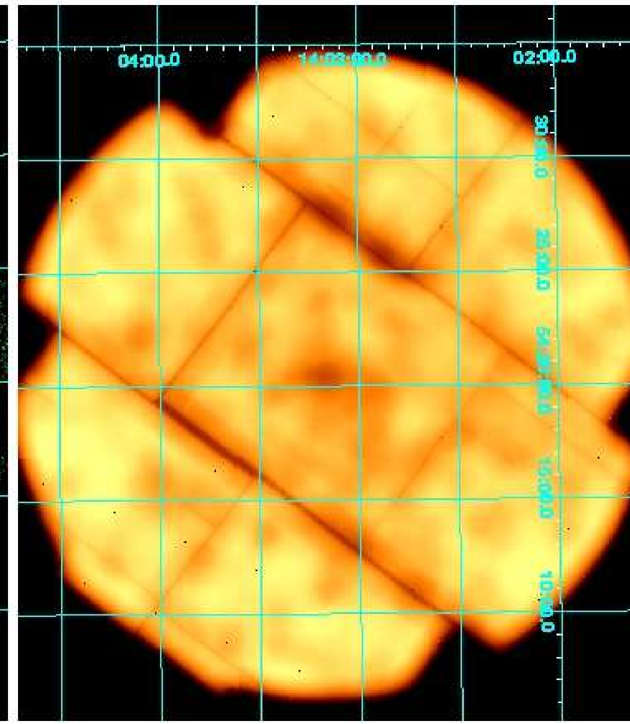
BG Exposure map (4") in detector coordinates



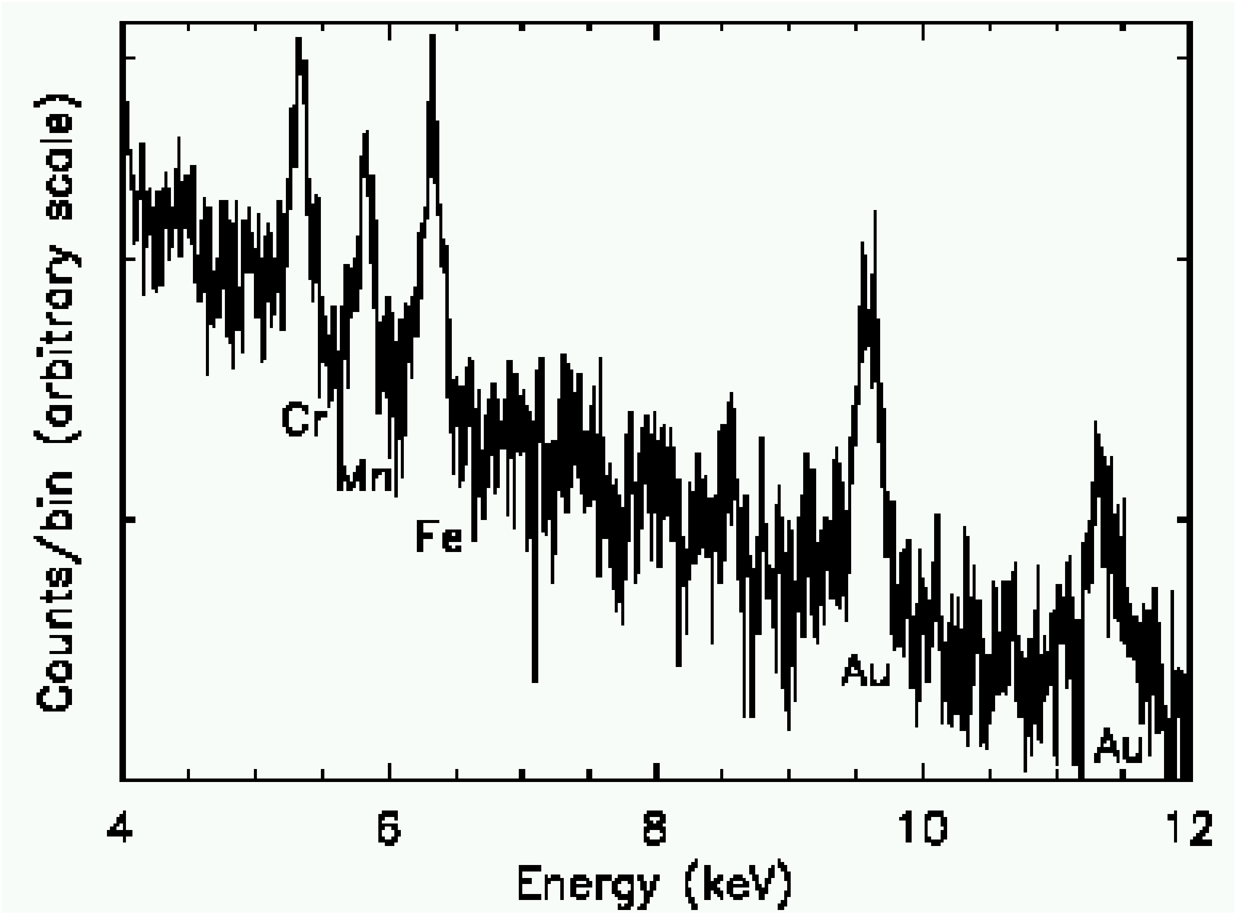
User’ s image (??") in sky coordinates



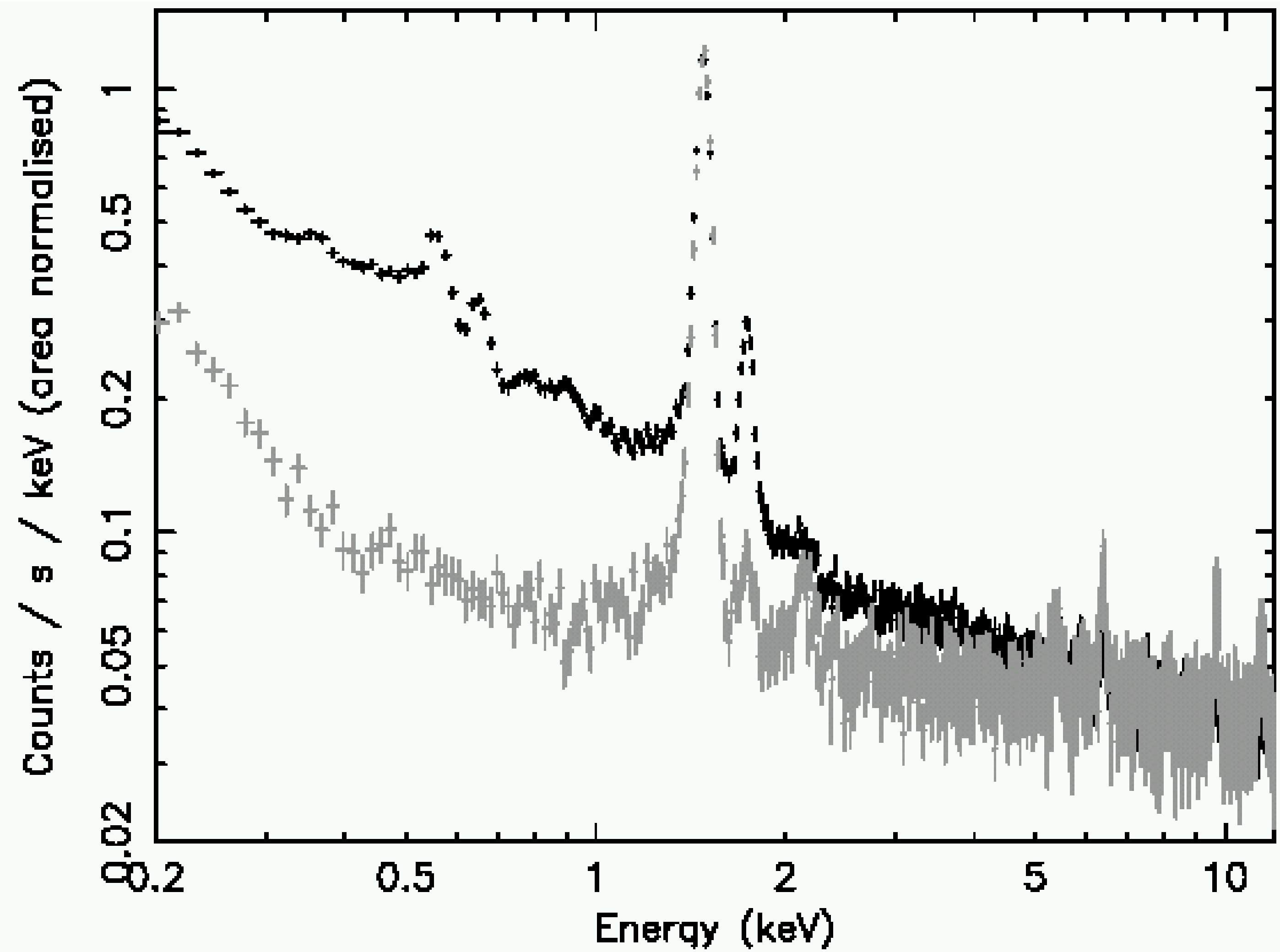
BG Exposure map (??") in user’ s sky coordinates



Andy Read (amr30@star.le.ac.uk)



Background spectrum from the MOS camera showing fluorescent emission from the camera body materials



Intensities at Al-K and Si-K require different scalings – spatial variations!

Si-K much smaller in out FOV

Comparison of the internal BG (grey – out FOV) and total BG spectrum (black – central 13') in MOS1

Table 5. Mean count rates for the *photon* background maps (over the central $16' \times 16'$), for the different instrument, mode and filter combinations, and for each of the six (five plus total) standard energy bands.

Instr.	Mode/ filter	N_{obs}	Mean Count Rate (ct ks^{-1} arcmin^{-2}) (± standard deviation) Band 0: 200–12000 eV	Band 1: 200–500 eV	Band 2: 500–2000 eV	Band 3: 2000–4500 eV	Band 4: 4500–7500 eV	Band 5: 7500–12000 eV
MOS1	ft	49	2.10 (1.36)	0.37 (0.18)	0.78 (0.46)	0.49 (0.37)	0.35 (0.22)	0.31 (0.18)
MOS1	fm	21	2.00 (1.06)	0.32 (0.12)	0.80 (0.38)	0.48 (0.27)	0.33 (0.16)	0.29 (0.14)
MOS2	ft	46	2.23 (1.40)	0.39 (0.19)	0.84 (0.50)	0.53 (0.39)	0.37 (0.22)	0.32 (0.18)
MOS2	fm	26	1.81 (1.07)	0.31 (0.12)	0.76 (0.39)	0.42 (0.27)	0.29 (0.16)	0.27 (0.13)
PN	ft	18	6.50 (3.89)	1.90 (1.02)	2.46 (1.28)	0.93 (0.71)	0.69 (0.43)	0.61 (0.24)
PN	fm	12	4.31 (2.24)	1.13 (0.50)	2.04 (0.94)	0.72 (0.33)	0.64 (0.36)	0.68 (0.48)
PN	et	32	5.19 (4.38)	1.87 (2.06)	1.71 (1.01)	0.86 (0.68)	0.72 (0.52)	0.79 (0.55)
PN	em	8	5.41 (2.66)	1.94 (0.77)	1.90 (0.47)	0.90 (0.60)	0.76 (0.50)	0.74 (0.40)

Table 6. Mean count rates for the *particle* background maps for the different instrument, mode and filter combinations, and for each of the six (five plus total) standard energy bands.

Instr.	Mode/ filter	N_{obs}	Mean Count Rate (ct ks^{-1} arcmin^{-2}) (± standard deviation) Band 0: 200–12000 eV	Band 1: 200–500 eV	Band 2: 500–2000 eV	Band 3: 2000–4500 eV	Band 4: 4500–7500 eV	Band 5: 7500–12000 eV
MOS1	ft	49	1.40 (0.11)	0.12 (0.03)	0.44 (0.04)	0.24 (0.02)	0.26 (0.02)	0.34 (0.03)
MOS1	fm	21	1.43 (0.11)	0.13 (0.03)	0.45 (0.04)	0.24 (0.02)	0.26 (0.02)	0.34 (0.02)
MOS2	ft	46	1.34 (0.09)	0.14 (0.02)	0.42 (0.03)	0.23 (0.02)	0.24 (0.02)	0.32 (0.02)
MOS2	fm	26	1.31 (0.09)	0.13 (0.02)	0.42 (0.04)	0.23 (0.02)	0.24 (0.02)	0.31 (0.02)
PN	ft	18	8.37 (2.29)	2.13 (0.43)	1.95 (1.36)	1.50 (0.86)	1.13 (0.31)	2.05 (0.21)
PN	fm	12	8.16 (1.60)	2.23 (0.31)	1.55 (0.77)	1.32 (0.47)	1.11 (0.20)	2.08 (0.25)
PN	et	32	7.96 (1.52)	2.10 (0.29)	1.61 (0.86)	1.32 (0.58)	1.15 (0.32)	2.01 (0.20)
PN	em	8	8.22 (2.72)	2.27 (0.87)	1.58 (0.81)	1.31 (0.64)	1.12 (0.31)	2.05 (0.26)

Andy Read (amr30@star.le.ac.uk)

University of Leicester