

# XMM-NEWTON

Prepared by XMM Users group (R.Griffiths (CMU), M. Eracleous (PSU), M. Donahue (MSU), Y-H Chu (U of Ill) , P. Pluchinsky (CfA), A. Brown (Colorado)+XMM GOF (GSFC)



Why should NASA support a US XMM GO program ?

## ❖ *Exceptional scientific return*

❖ Excellent data on a wide variety of astrophysical phenomena in support of NASA's goals of discovering the Structure and Evolution of the Universe: **from comets to quasars.**

❖ **XMM papers are cited ~3x more often than average paper\***

❖ Response by the US community to the 7 Guest Observer AOs was extensive and successful

❖ Success rate for US PIs is excellent with **~1/3 of the accepted proposals awarded to US scientists in all AOs**

❖ Of the remaining accepted proposals, **~1/3 have US Co-Investigators (Co-Is), 2/3 of all GO projects have US participation.**

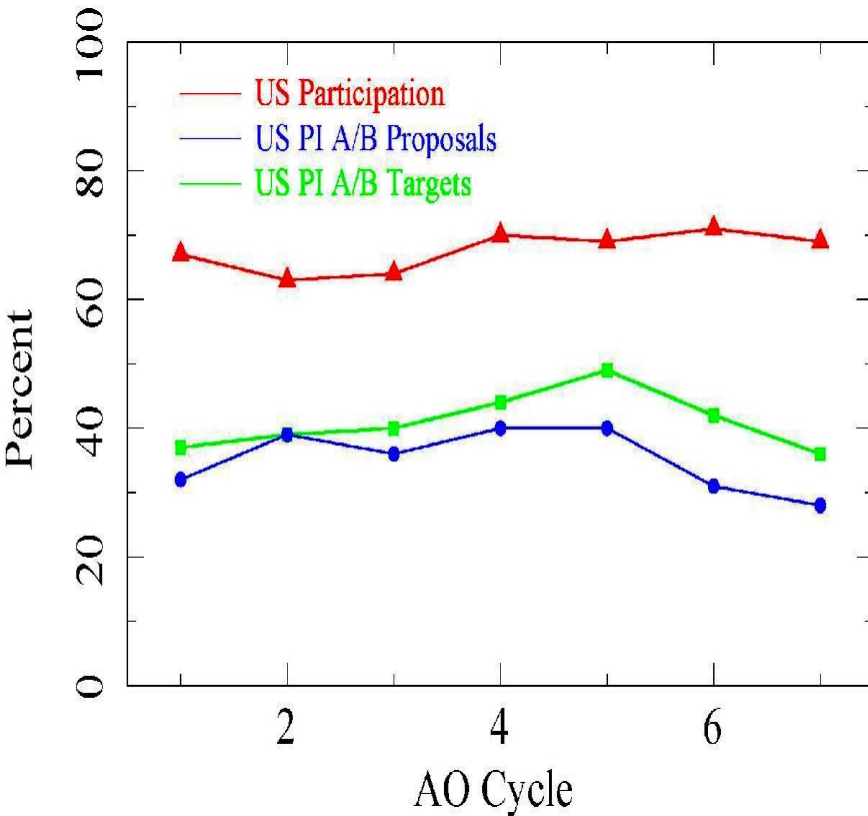
• **~30% of XMM papers are in the top 10% of all cited papers in the last 5 years.~**

# XMM

- ❖ Strong proposal pressure: **the last AO oversubscribed by ~7.8** (586 proposals from 424 different Principal Investigators in 23 countries, 699 targets were approved)
- ❖ Complementarity of XMM-Newton, Suzaku and Chandra observations
- ❖ **Low cost to NASA** for access by US astronomers to Great-Observatory class observations.
- ❖ ESA has allocated resources to support European XMM-Newton users, assume the US GOF provides support to the large US community

# US Participation in the XMM-Newton GO Process

US PIs+Co-Is and fraction of PI proposals is at a very high level



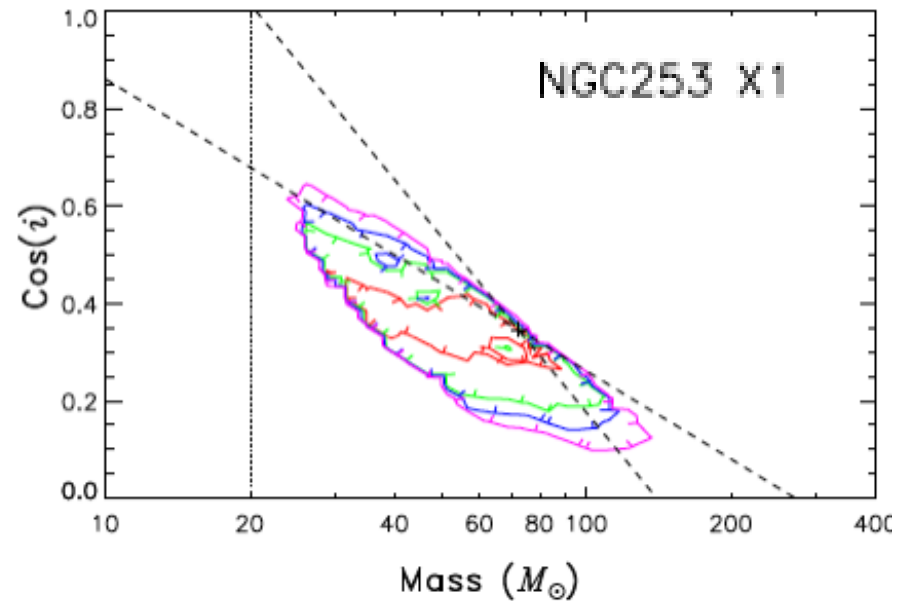
Cycle	Total Props.	US PI/CoI	US PI
<b>AO-7</b>	<b>183</b>	<b>128</b> <b>70%</b>	<b>80</b> <b>44%</b>
<b>AO-6</b>	<b>239</b>	<b>164</b> <b>69%</b>	<b>104</b> <b>44%</b>
<b>AO-5</b>	<b>255</b>	<b>177</b> <b>69%</b>	<b>123</b> <b>48%</b>
<b>AO-4</b>	<b>229</b>	<b>161</b> <b>70%</b>	<b>101</b> <b>44%</b>
<b>AO-3</b>	<b>378</b>	<b>245</b> <b>65%</b>	<b>152</b> <b>40%</b>
<b>AO-2</b>	<b>365</b>	<b>209</b> <b>57%</b>	<b>97</b> <b>27%</b>
<b>AO-1</b>	<b>350</b>	<b>234</b> <b>67%</b>	<b>131</b> <b>37%</b>

# XMM Updates

High publication rate continues

- March 2008 astro-ph had 31 papers using XMM data -94 as of April 4, 2008 (compared to 74 during the same time frame in 2006)
- 83 referred papers and 112 conference abstracts appeared in first 3 months of 2008

- Release of SAS V7.1.2
- Proceedings of "XMM-Newton: The Next Decade" 2007 available at: [http://xmm.esac.esa.int/external/xmm\\_science/workshops/2007\\_science/](http://xmm.esac.esa.int/external/xmm_science/workshops/2007_science/)
- AO-7 observations started



Determination of Mass of a ULX via x-ray spectral fitting (Hui and Krolik 2008)

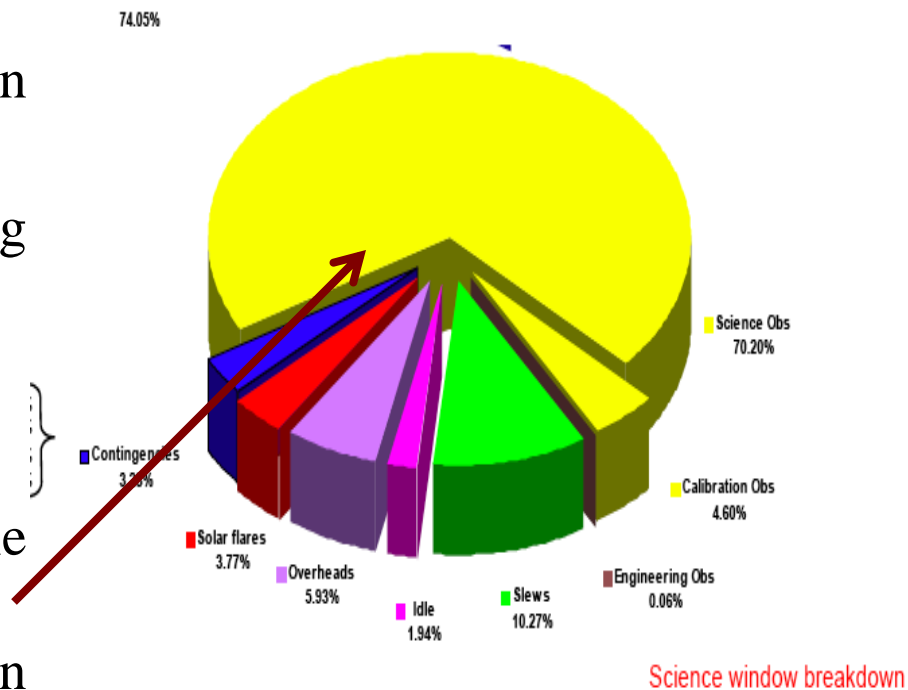
QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

A filament in the IGM  $\rho < \rho > \sim 100, T \sim 10^7$  K  
between A222 and A223 (Werner et al 2008)

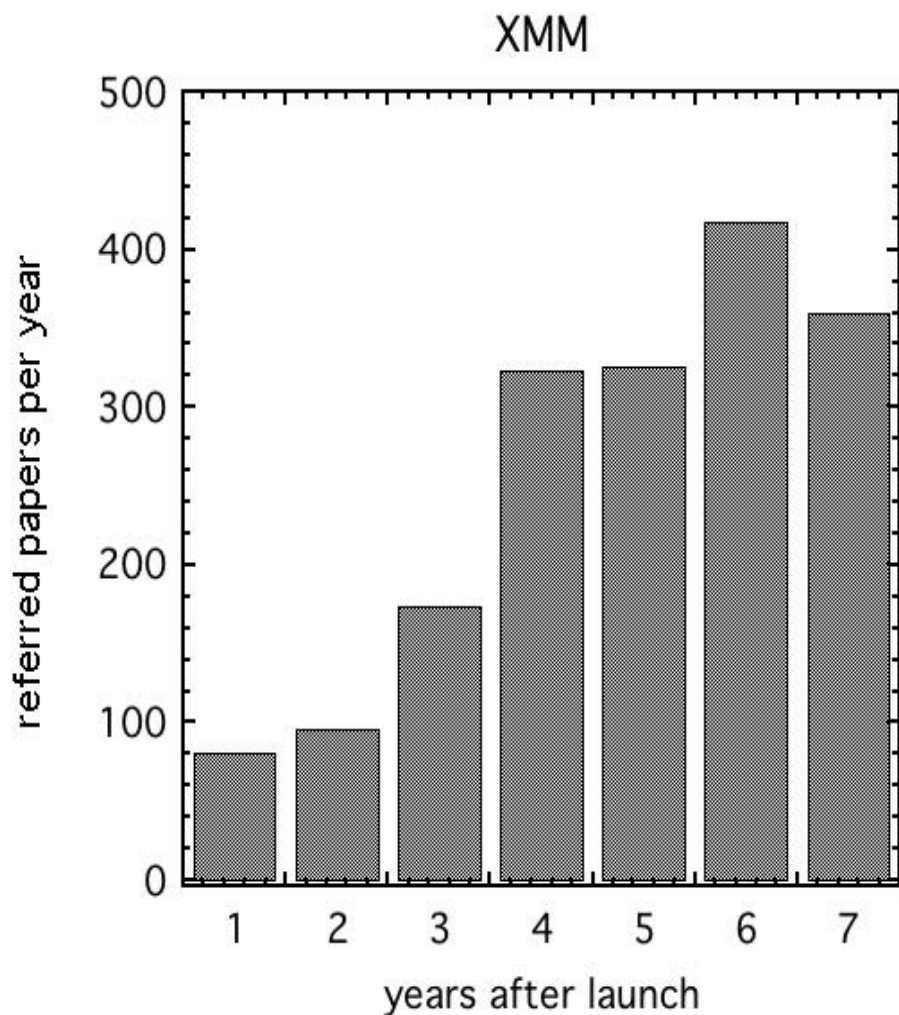
# XMM Updates 2006-2007



- ❖ Mission extension approved by ESA to 2012 Dec 31, and very likely beyond
- ❖ Consumables (Fuel/Power etc) enough until 2017
- ❖ OM Catalog released- available in MAST and HEASARC
- ❖ Slew survey and 2nd XMM catalog released
- ❖ Slow-survey mode nearly ready
- ❖ Full reprocessing of all data completed
- ❖ Observing efficiency ~70% of available time; (lost time: 4% solar flares, 10% slews, 6% calibration etc)
- ❖ Low-energy QE of EPIC/RGS reduced slightly due to Carbon contamination. QE change well calibrated



# Comparison of HST and XMM referred publication rate



HST

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are needed to see this picture.

**In the first 7 years, XMM has a similar but larger number of referred papers than HST**

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

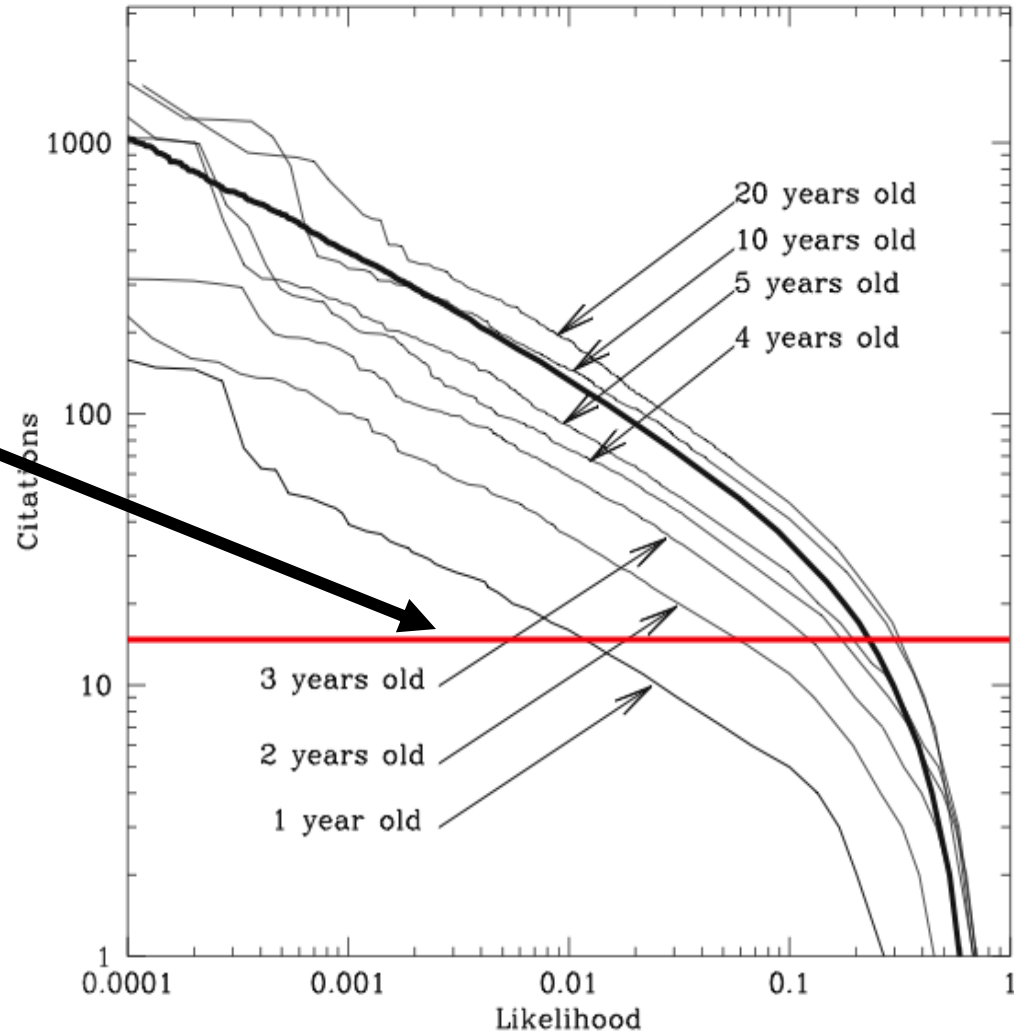
# XMM Citation rate

A study of citation rates ( Pearce (astro-ph/0401507) ) showed the number of citations a paper a given number of years old would have to have to put it into the top 10% or top 1%,

A paper 1 year old with  $> 16$  citations is in the top 1% (in terms of citations).

XMM papers	Top 10%	Top 1%
1 year ago :	52.01%	9.65%
2 years ago:	38.48%	3.43%
3 years ago:	29.56%	2.55%
4 years ago:	34.07%	1.48%
5 years ago:	28.48%	1.32%

XMM papers are cited at least 3x more often than "average" astrophysical papers (since the number of XMM papers in the top 10% is ~30% over all 5 years).



# Responses to the 2006 Senior Review

In the 2006 SR the Panel had two suggestions

**We have responded with the following actions**

1) ***Plan for reduced budget-*** GOF staff reduced by 20% (11 → 8.9 FTEs\*), Hardware teams reduced significantly \$285K/yr to \$63K/yr  
**Further reduction in personnel possible: natural attrition as parts of the program end or reach maintenance levels (e.g Profit, Xsim, HERA support) over next few years**

1b) The SR noted that “it seems that some of the software development being funded by the GOF goes beyond that directly required for support of the mission.” based on input from user groups, and the comments of the NAS/NRC report we disagree.

2) ***Reduce GO funding***

**We believe (users group and project) this to be undesirable and contrary to the recent sense of changes at NASA. Hdqtrs has reduced our overall funding and we have asked for restoration of the funds in the over guide to keep the GO funding level.**

\* In proposal we said 0.5 FTE, the difference is due to NASA accounting changes, in the past we had ‘overheads’ in units of FTEs, these are now gone.



## Responses to the 2006 Senior Review (cont.)



We have Reduced the Scope and Cost of Program

Reduced Funding for Instrument Teams

OM Team Zeroed Out in FY07

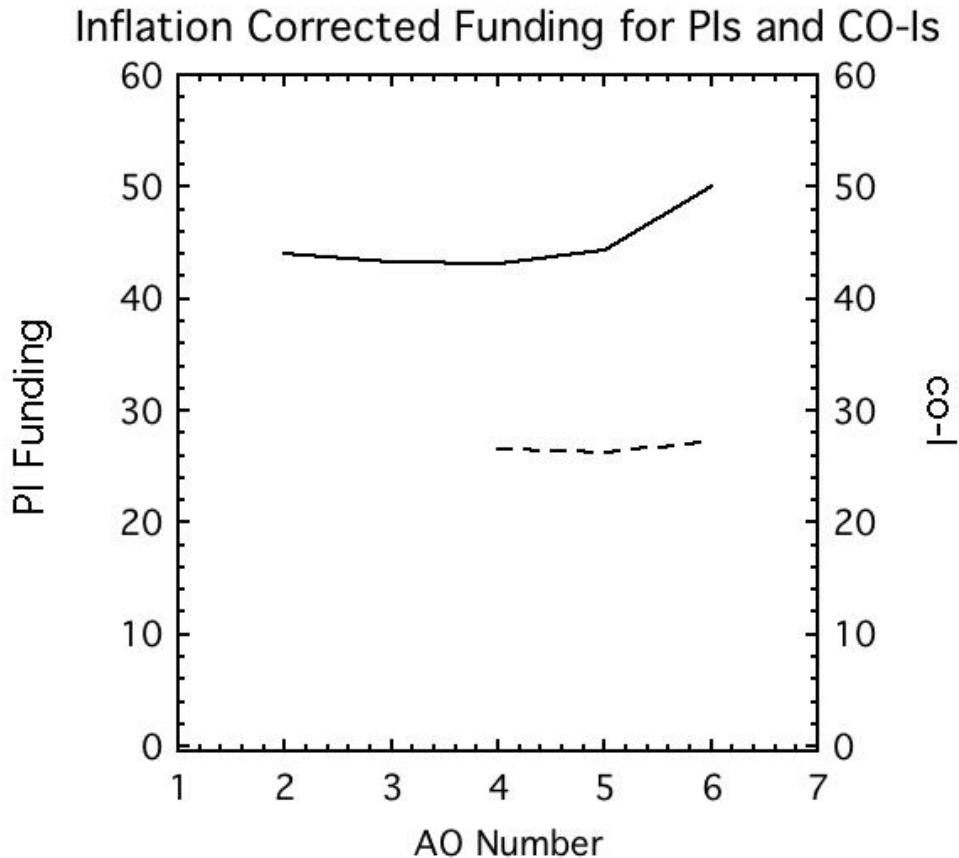
RGS Team Funding Significantly Reduced over 4 Years

No Request for a Theory Program - (was funded in SR 2004, but overall budget reduced by Hdqtrs)

Reduced GOF Science Support (down to 2.7 FTE)

*Have tried to keep GO funds constant in real year \$*

# GO Funding



Rise in GO funding for AO-6 is due to increase in mean exposure times

We are using (again) an algorithm based on number of targets, observation complexity, exposure time, number of proposals per PI and grade to allot funding.

The users group reviews all the funding requests and adjusts them.

Typically very few, if any, complaints about funding levels per AO cycle.

By deleting funds from the hardware teams and making additional changes in GOF staffing we have kept the GO funding levels (corrected for 5% inflation) constant.

However we have now reached the limit of this and requested \$500k/yr (restoring the cut in funds) in overguide to continue the present policy.

# GOF Manpower breakdown FY 2008

Significant reduction in GOF manpower since previous senior review

## Civil service

Mission Scientist	0.9	FTE
GOF Scientists	1.7	
Archive Scientist	0.4	
Financial analyst and support	0.6	
GSFC CS overhead (computer support + management overhead etc)	0.3	
Total	3.9	(4.04 in FY06)

## Contract staff

Scientists	1.0	
Archive support	0.4	
HERA	1.0	
SAS	1.0	
Other software	1.0	
Data base,RPS, HEASARC	1.0	
Grants	0.3	
Total	5.0	(6.37 in FY06)

GSFC other	0	(0.62 in FY06)
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<b>Total</b>	<b>8.9</b>	<b>(11.03 FY06)</b>
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# Mission Status

General status: **All instruments working nominally**

## **New Modes**

PN Mosaic mode: testing complete. Intended for AO8

RGS Multipointing mode observations: testing also complete. To be included in AO8

Slow slew survey

## **Operations**

Major reduction in manpower from 24 hr real time monitoring to 1 data aid 4 hrs/day (~20% savings in op's cost)

At the end of 2008 April, 87 kg of fuel remain with usage of around 6 kg per year.

The solar array is generating around 1950 W and between 800-1200 W are used.

All other consumables fine

the SPC approved an extension of operations from 31 March 2010 to 31 December 2012 (2.75 yrs)

# Result of AOs

31% of C time was allocated-  
this is caused by the acceptance  
of LPs and VPS in 1 place in the  
sky.

413 targets scheduled

All but 7 of the 388 rejected  
proposals received comments of  
some type- decided to drop the  
relative grade of the proposal.

All categories of proposals were  
oversubscribed by ~8

There will be a joint  
Integral/XMM program with  
Integral able to allocate <300ks  
of XMM time.

# Changes at ESA

On 16 June (TBC) the Directorate of Science will join with the Exploration part of D/HME and become the Directorate of Science and Robotic Exploration (D/SRE).

David Southwood has been appointed D/SRE until 30 April 2011.

The ExoMars mission will become part of the Directorate's responsibilities.

A. Parmar acting Head of the Astronomy Science Operations Division (SCI-OA) at ESAC until 30 June 2008 (as well as Mission Manager and XEUS study scientist).

Marcus Kirsch has left ESAC to join the Newton operations team at the MOC. His role as EPIC calibration scientist has been taken over by Matteo Guainazzi.

**2007-06-07/42: To introduce a new proposal type for very large programs, asking for 1-3 Ms of time and to increase the time dedicated to large and very large programs to about 30% of the total available time for priority A and B observations. The distribution of time between Large and Very Large Programs shall be left flexible to allow OTAC decisions be based on the expected scientific outcome. ✓**

# Slew Survey/VLP Issues

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

Notice that certain parts of the  
Sky do not have enough time in  
one year to support a VLP

QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

# Responses to the 2006 Senior Review (cont.)



## 2) Constrain development of non-mission-specific software

- a) **Profit:** while Profit is a general software tool for examining high-resolution spectra, its applicability to RGS data is very clear and useful. Development is inexpensive.
- b) **SimX:** while SimX will be able to be easily modified for use with other mission, the main reason for replacing QuickSim with SIM X is to simplify the yearly updates for new AOs.
- c) **HERA:** the development of HERA is vital to the long-term viability of XMM-Newton data analysis
- d) **Development of science oriented data bases important for entry into VO and science use of XMM data (since there is no archive program)**





## **US GOF Activities – Ongoing/Additional Efforts**

driven by inputs from user community

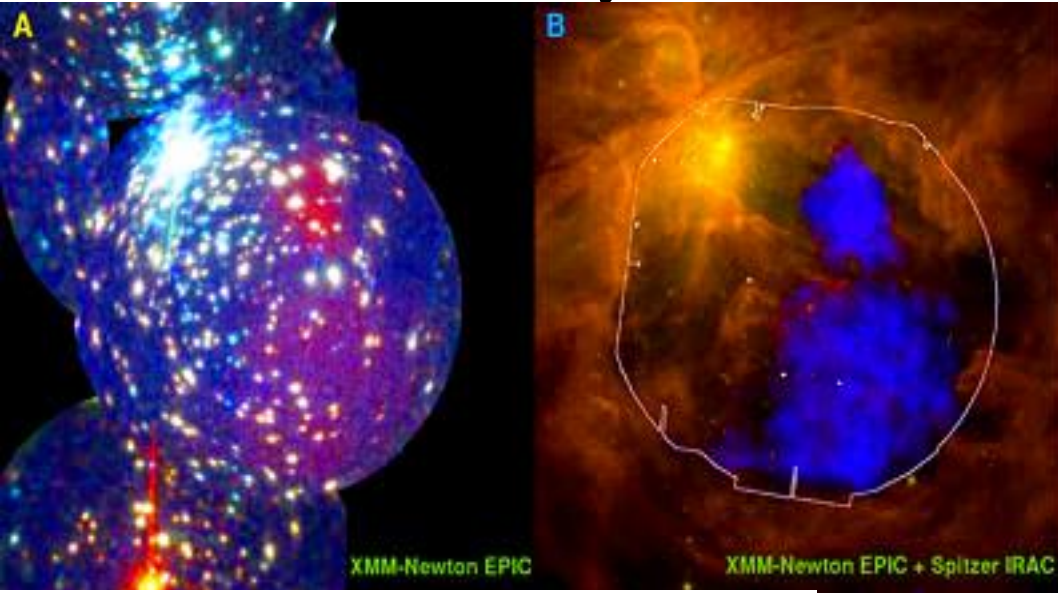
US software efforts coordinated with ESA XMM team

Some overlap in Web based efforts

## **Proposed Software Development Tasks for Next 4 Years**

- **XMM-Newton Extended Source Analysis Software (XMM-ESAS ) ESA collaboration**
  - Add PN to background modeling**
  - Inclusion of XMM-ESAS in SAS**
- **Analysis Aids for new approach to XMM analysis**
  - Inclusion of XMM in Hera : users do not have to know or download SAS to process XMM data**
- **Trend Data Base development (in collaboration with ESA)**
  - Develop tools to exploit the Trend data base, e.g.,**
  - diagnostic tools to predict SP and SWCX contamination**
- **Profit – continuing development and enhancement to allow easier interpretation of grating data**
- **SimX – Replacement for QuickSim**
  - Easier to update for new AOs, easily adaptable for other missions**
- **Development of Science oriented databases.**

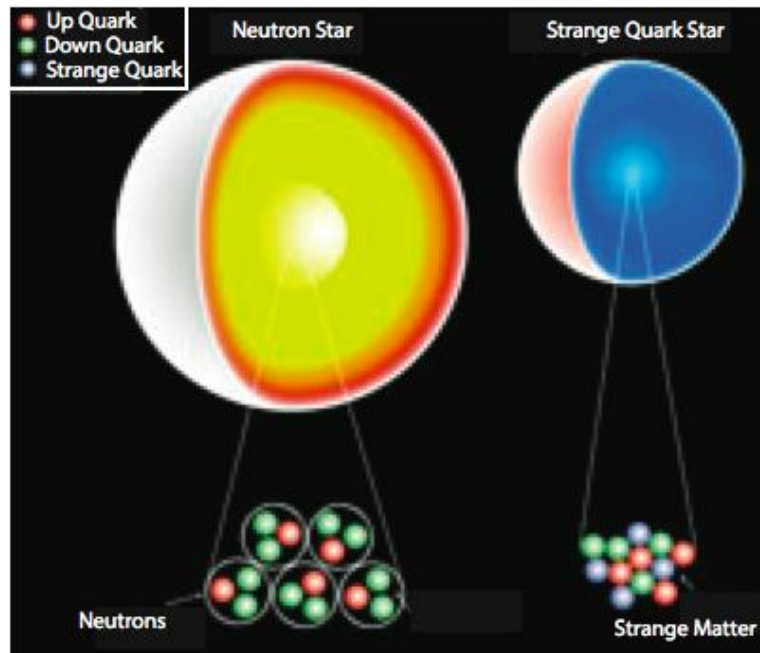
# XMM Press releases and public information in last year include



**An X-Ray Santa Claus in Orion-**  
XMM and Spitzer imaging of Orion show that the *diffuse* x-ray emission (blue) occupies a hole in the IR dust emission (rust)

The XMM-Newton Gallery is now listed on the "Google Earth" web page as one of the "featured files in the Google Earth Gallery" and in [myspace](http://myspace.com) (127 friends)

[www.myspace.com/xmmnewton](http://www.myspace.com/xmmnewton)



## Neutron Star/Quark Star Interior

XMM data shows that the masses were underestimated and the radii over-estimated for some neutron stars. Webb and Barrett conclude that neutron stars can have masses up to 2.4 solar masses and radii greater than 8 km. The most likely composition of a neutron star is : **neutrons**. Only one exotic solution remains feasible, an interior made of quarks

# XMM Slew Survey

[http://xmm.esac.esa.int/external/xmm\\_science/slew\\_survey/](http://xmm.esac.esa.int/external/xmm_science/slew_survey/)

Data covering ~20% of the sky released. Eventually 80% will be covered.

~10x more sensitive than HEAO-1 in 2-8 keV band

Similar in sensitivity to Rosat All Sky Survey in .2-2 keV band

Some preliminary results include:

- Highly variable sources:

The most extreme of these are variable stars and, surprisingly, galaxies,

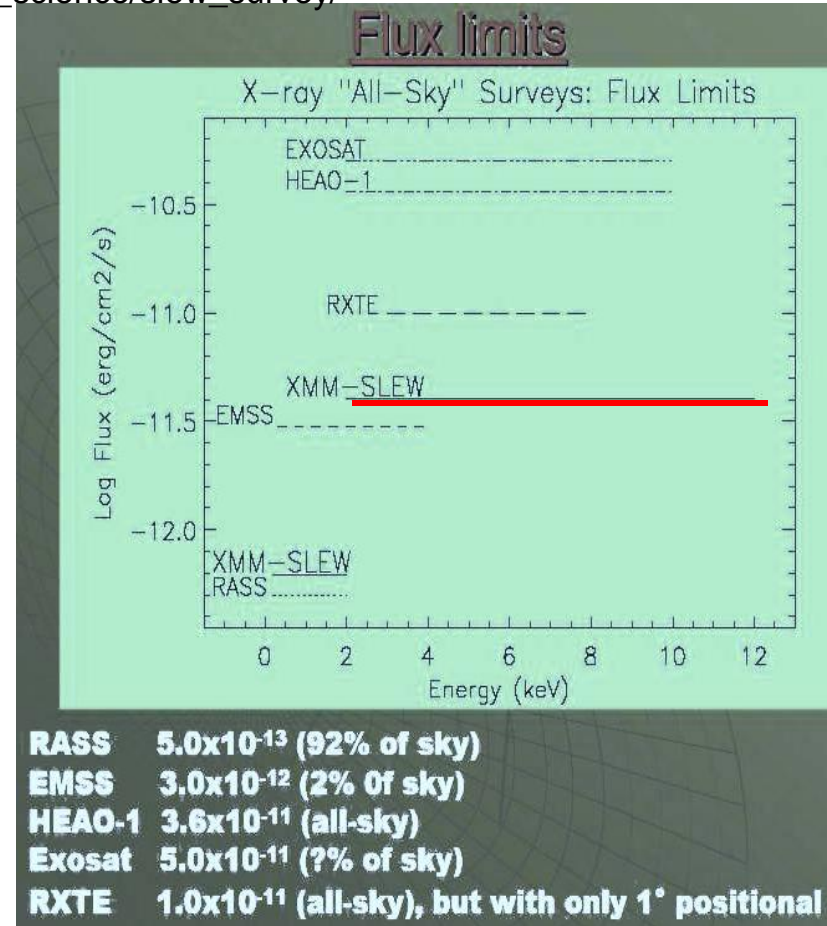
- ~ 15% of the sources have extended emission, 81 of these are previously known clusters, many new clusters are detected. These include high luminosity, very distant clusters

The first XMM-Newton slew survey catalogue: XMMSL1

Authors: R.D. Saxton, A.M. Read, P. Esquej, M.J. Freyberg, B.

Altieri, D. Bermejo

(Submitted on 24 Jan 2008)



Energy Band

0.2-12.0 keV

Detection Limit

$1.2 \times 10^{-12}$  ergs/s/cm<sup>2</sup>

0.2-2.0 keV  $6.0 \times 10^{-13}$  ergs/s/cm<sup>2</sup>

2-12.0 keV  $4.0 \times 10^{-12}$  ergs/s/cm<sup>2</sup>

# Completeness Of Slew Survey

	Apr 2005	Aug 2008	Dec 2011	Apr 2014
Fraction of Sky Covered	20 % (25%)*	40 % (50%)	60 % (75%)	80 % (100%)
Number of sources (full)	5200 (6500)	10400 (13000)	15600 (19500)	20800 (26000)

~10 papers so far

# 2nd XMM catalog

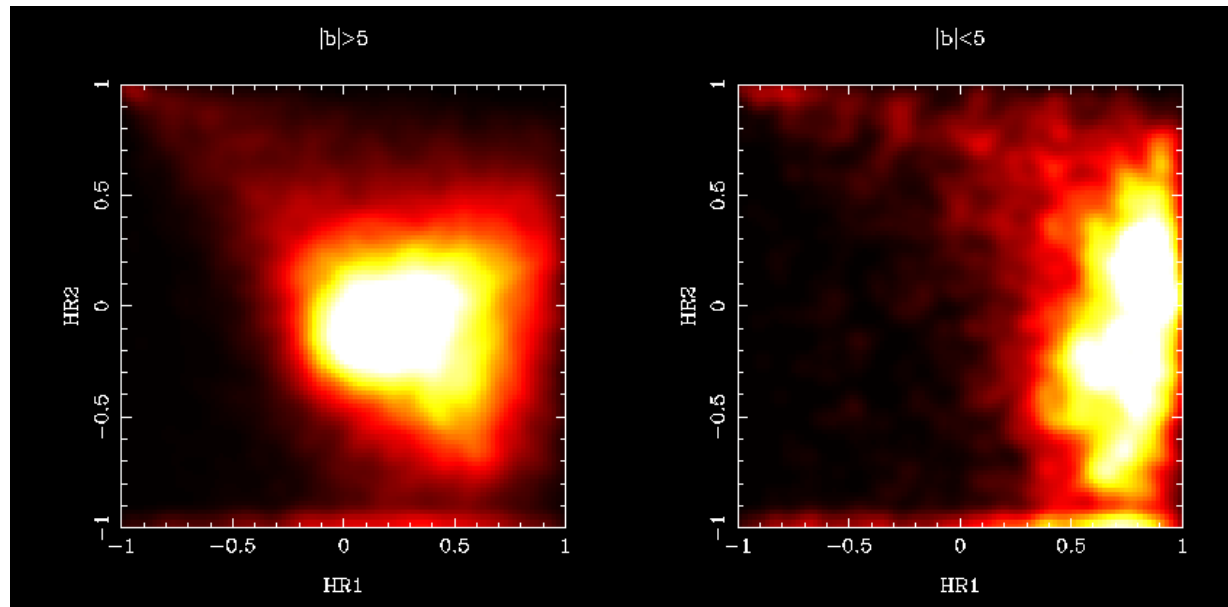
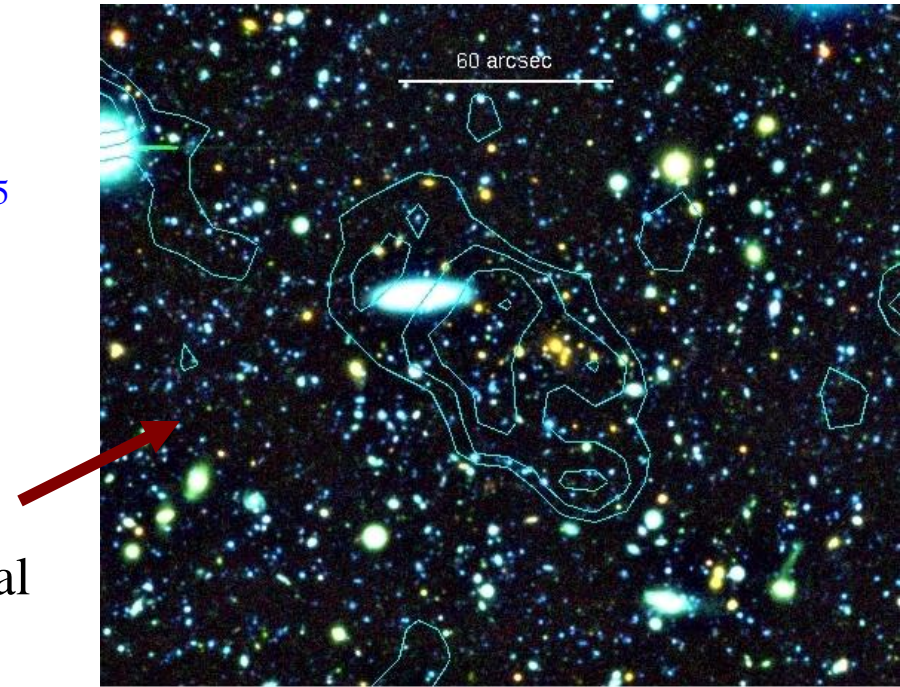
The XMM science survey consortium (SSC) produced the 2nd XMM catalog based on reprocessing of all public *pointed* data.  $\sim 2 \times 10^5$  sources

*Largest x-ray source catalog ever !*

Light curves, spectra, x-ray colors

Some sample results:

Candidate  $z \sim 1.2$  cluster - x-ray contours optical image



X-ray color-color plot for low and high galactic latitude sources.

# Status of SSC- M. Watson

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

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TIFF (Uncompressed) decompressor  
are needed to see this picture.

Nice Web interfact at LEDAS

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# XMM-Newton Extended Source Analysis Software

Steve Snowden & Kip Kuntz

- Publicly Released 5 April 2006 - *GOF development coordinated with ESA working group*
- XMM-Newton Extended Source Analysis Software
  - Suite of Fortran 77 programs and Perl scripts
- EPIC Instruments (MOS for now)
- Particle Background Modeling
  - Position Dependent Background Spectra
  - Particle background images
- Creates exposure corrected, background subtracted, and adaptively smoothed images
- Manual/Cookbook and spectral/imaging examples including suggested treatment for other background components
- **Future extensions**
  - Mosaicking of multiple observations**
  - Extension to PN data**

# Improvements in Calibration

Extensive efforts have gone into improving the calibration of all the XMM detectors

- 10 epochs for the calibration

The energy resolution as a function of time is well calibrated

Now <10% deviations between all instruments  $E > 0.3$  keV

Flux stability better than 4%

## Remaining Calibration Problem

At high energies MOS and PN differ by ~10%

Problem understood- fixes underway

Flux difference of 8% between PN and MOS

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are needed to see this picture.

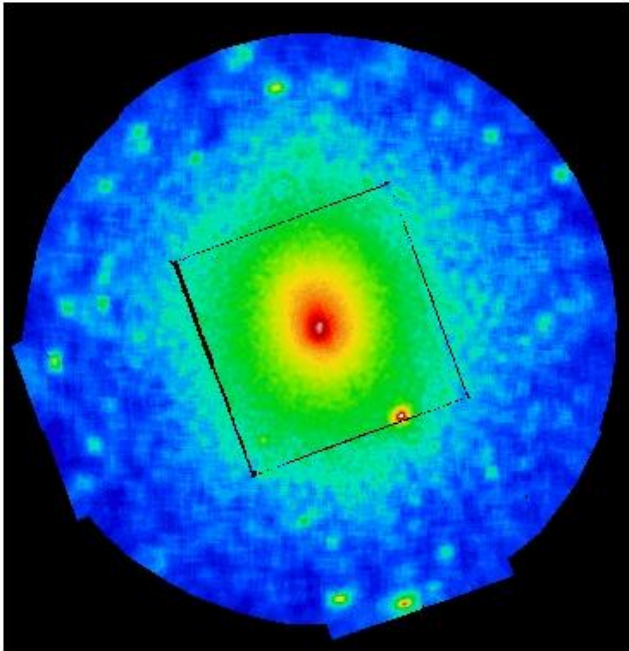
PKS2155 all 5 x-ray detectors-  
Comparison of SAS 7 vs SAS 7.1





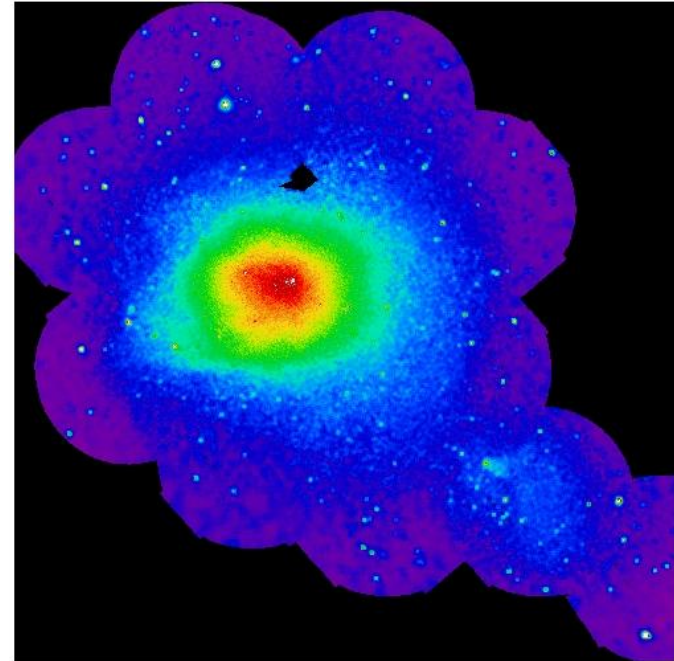
# XMM-Newton Extended Source Analysis Software

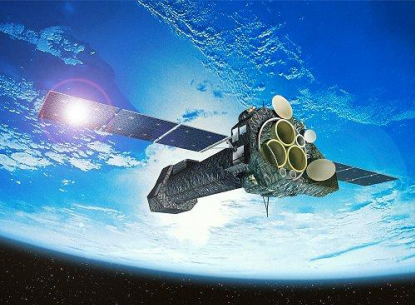
Background subtracted, exposure corrected, and adaptively smoothed image of **Abell 1795** in the 0.35-1.25 keV band.



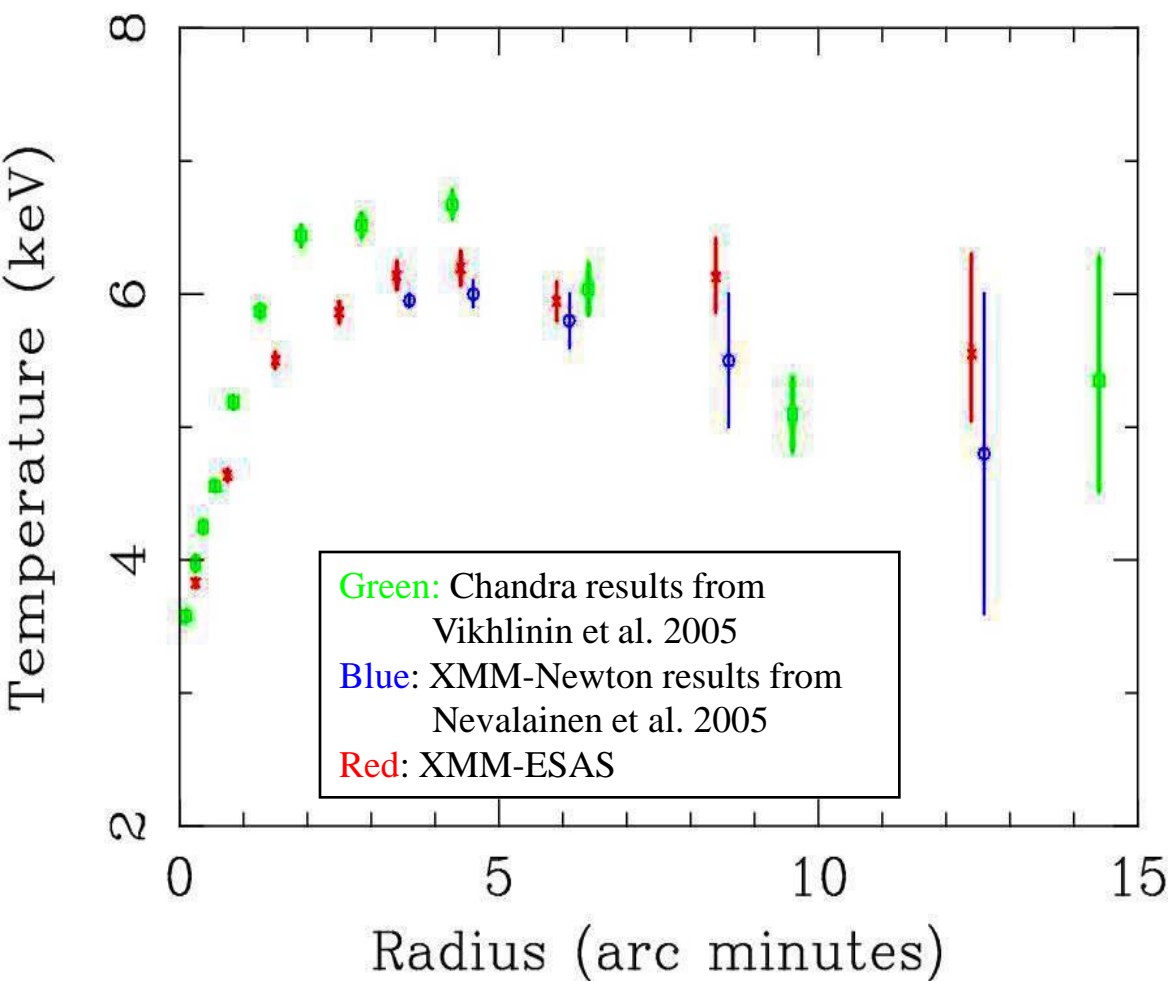
Prototype mosaicking of **Coma Cluster** observations.

The data have been similarly processed.





# Significant Impact on Scientific Results



**Comparison of XMM and Chandra results.**

**Bright, well observed cluster, Abell 1795, clearly shows the problem.**

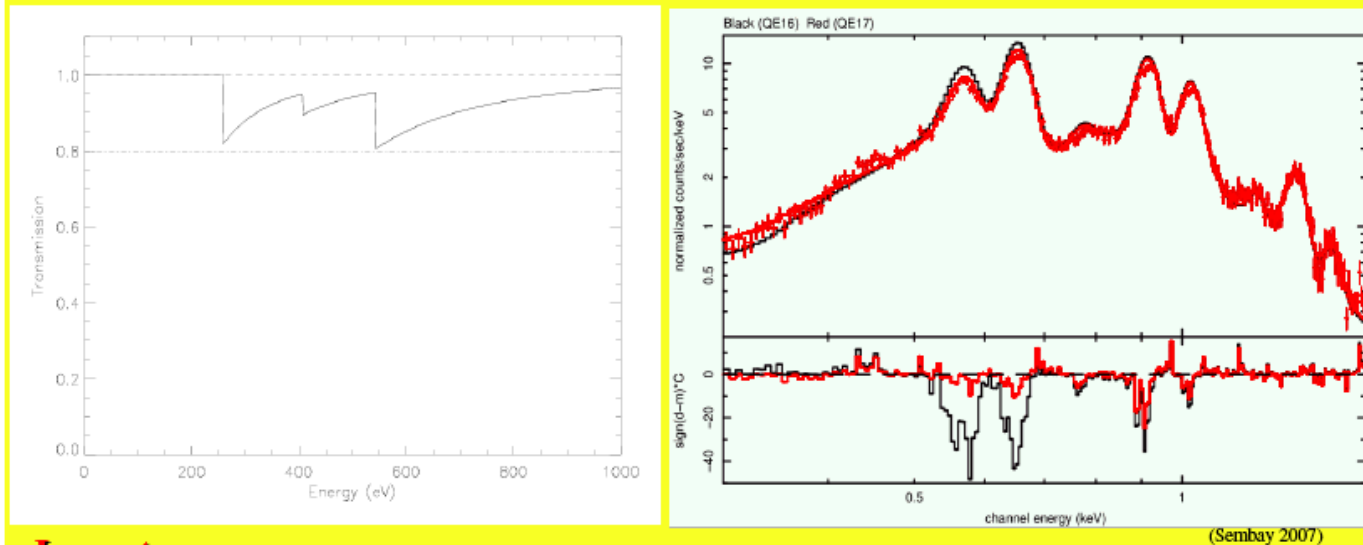
**The effect is to enhance the fall-off of the cluster temperature with increasing radius.**

**This systematic effect has consequences for cluster theory.**

# New Calibration Improvements

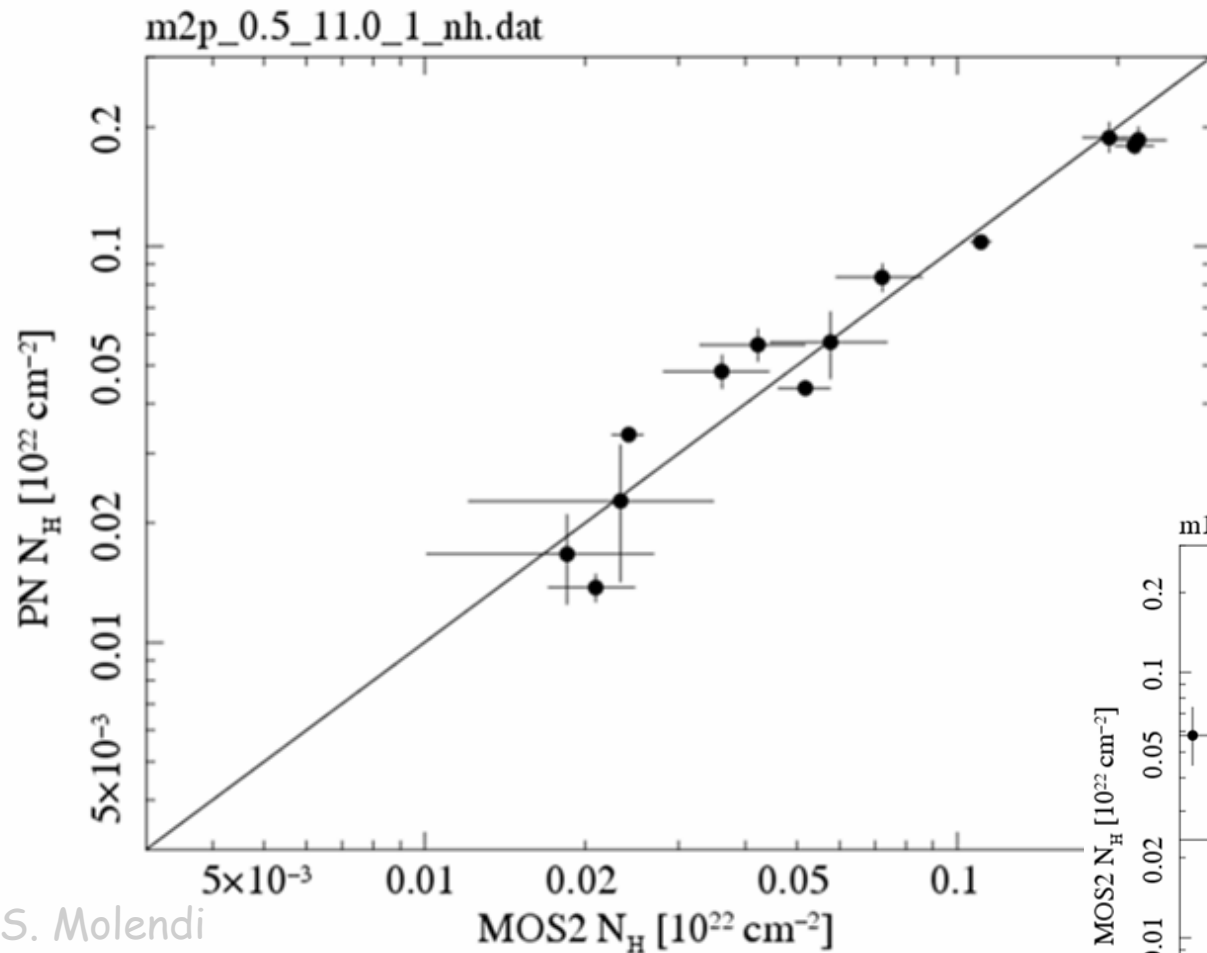
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TIFF (Uncompressed) decompressor  
are needed to see this picture.

## Adjustment of the MOS Quantum Efficiency at the C, N, O edges



# EPIC $N_{\text{H}}$ comparison for 21 blazars

MOS2 vs PN  $N_{\text{H}}$   
new eff. areas



S.Molendi,

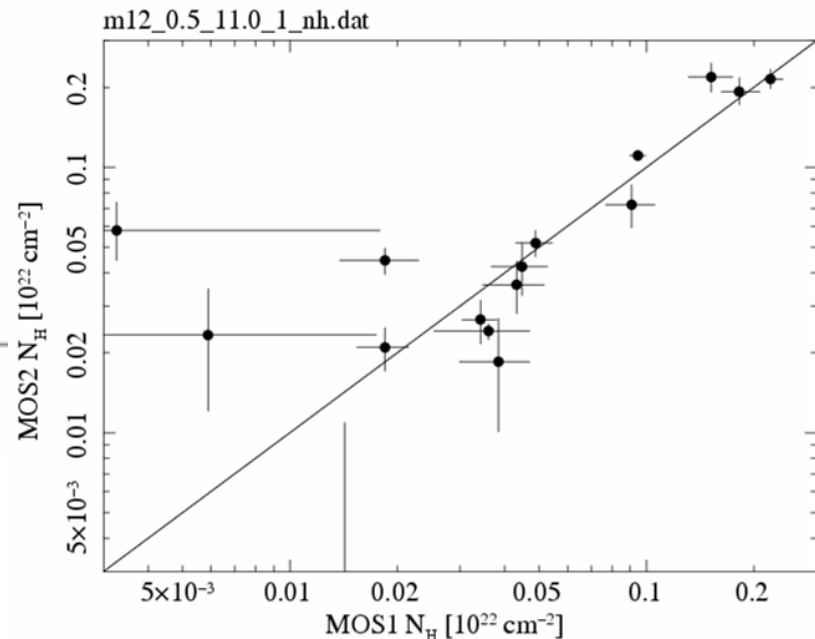
EPIC CAL meeting

Nov. 2007:

Very good agreement between  
MOS and pn

Agreement between MOS1 and  
MOS2 did not change

MOS1 vs MOS2  $N_{\text{H}}$   
new eff. areas



S. Molendi

# Rate dependent Gain and CTI changes in PN

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are needed to see this picture.

# For Off Axis Sources there is a 'directional' flux change due to RGS Shadowing

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TIFF (Uncompressed) decompressor  
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TIFF (Uncompressed) decompressor  
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# Summary for internal cross-calibration

## SASv7.1

MOS flux above  $\sim 0.8$  keV higher than pn by 5-8%.

Dependent on energy band, MOS flux ratios decrease over mission.

RGS fluxes are stable.

RGS and EPIC-pn flux ratios agree above O-edge to 2% on average.

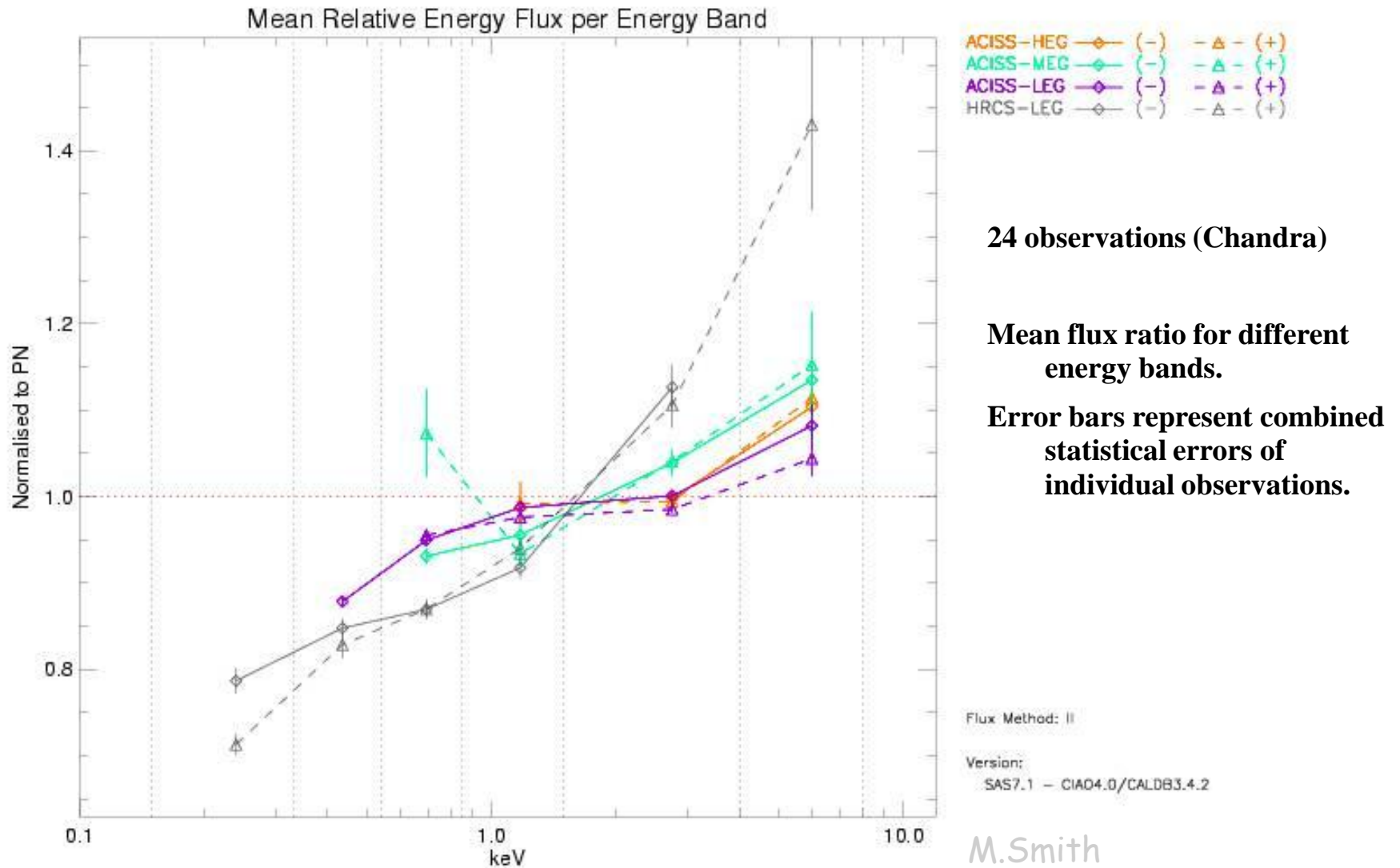
Current implementation of time-dependent RGS effective area model shows discrepancies below O-edge of 5-10%.

**EPIC and RGS are consistent on average within 10%.**

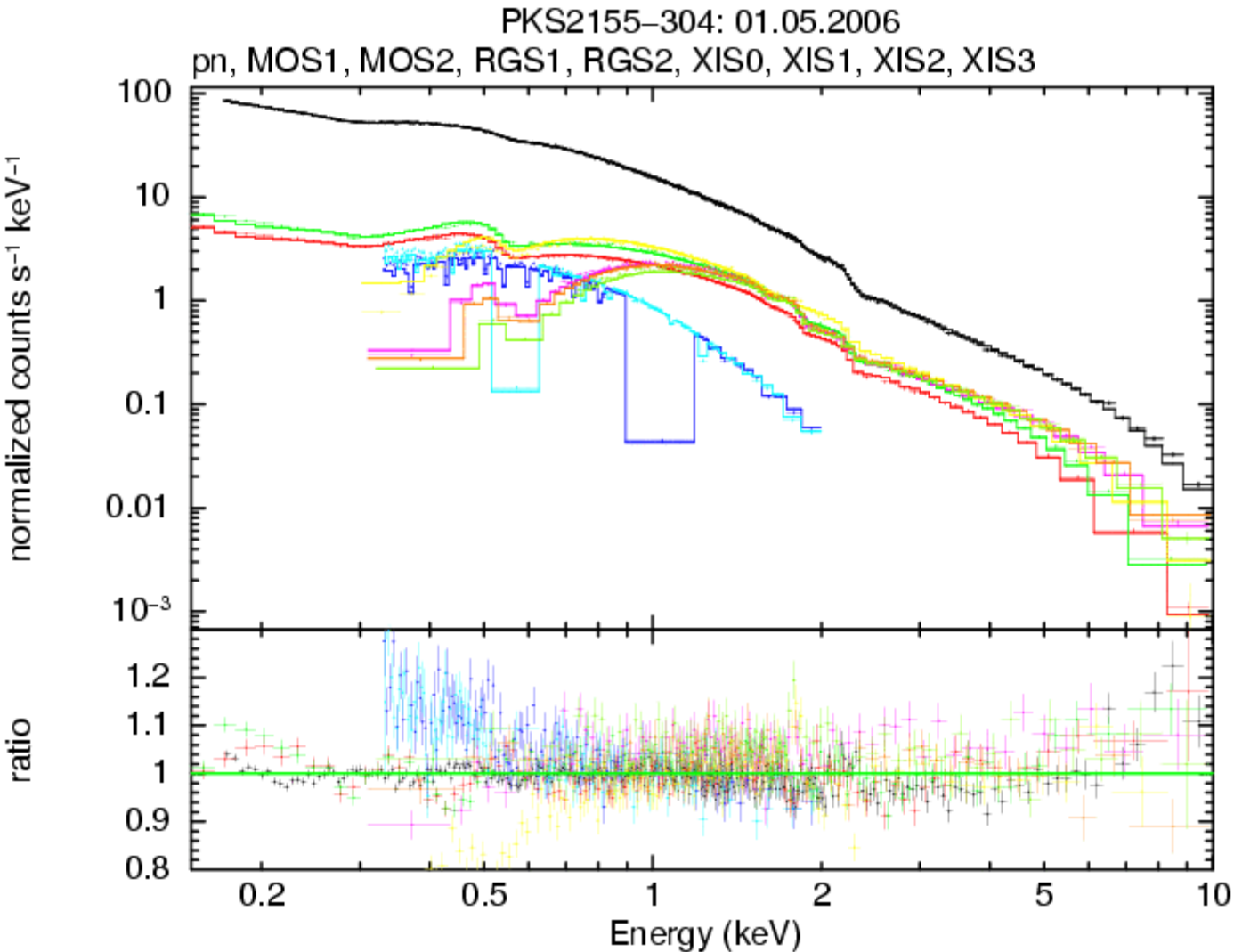


# XMM-Newton/Chandra comparison

New SOC XMM-Newton/Chandra cross-calibration archive



# XMM-Newton versus Suzaku



**PKS2155-304**

**XMM rev. 1171**

**FTOOLS 6.4**

**Joint fit to all instruments.**

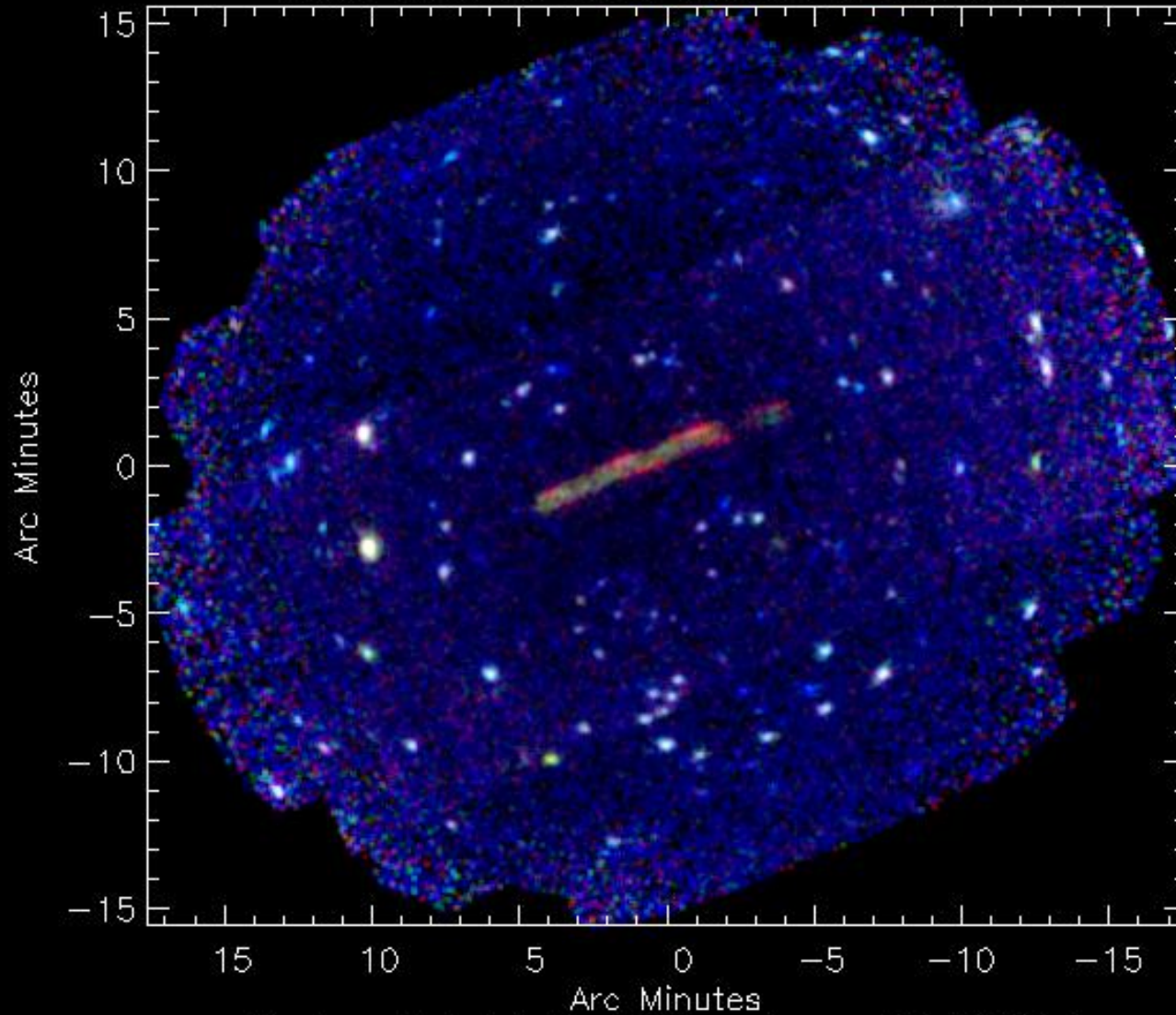
**Absorbed single power law  
model**

**Red.  $\chi^2 = 1.36 / 10439$  dof**

**Good general slope  
agreement.**

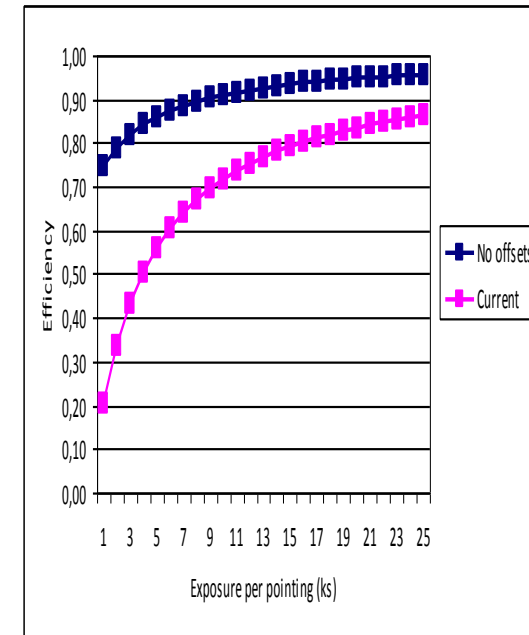
**XIS fluxes slightly higher than  
EPICs.**

XMM-Newton EPIC image of JUPITER



## EPIC Mosaic Mode

Improve efficiency  
For short mapping  
observations



# The XMM-Newton Science Oriented Database

**Facilitating multiwavelength and cross-discipline studies with “one stop shopping”**

Grouping data by object type to allow easy access to researchers

SNRs, AGN, XRBs, Galaxies, Galaxy clusters...

Presenting XMM data, images, catalog holdings, MAST data, literature search results for each object

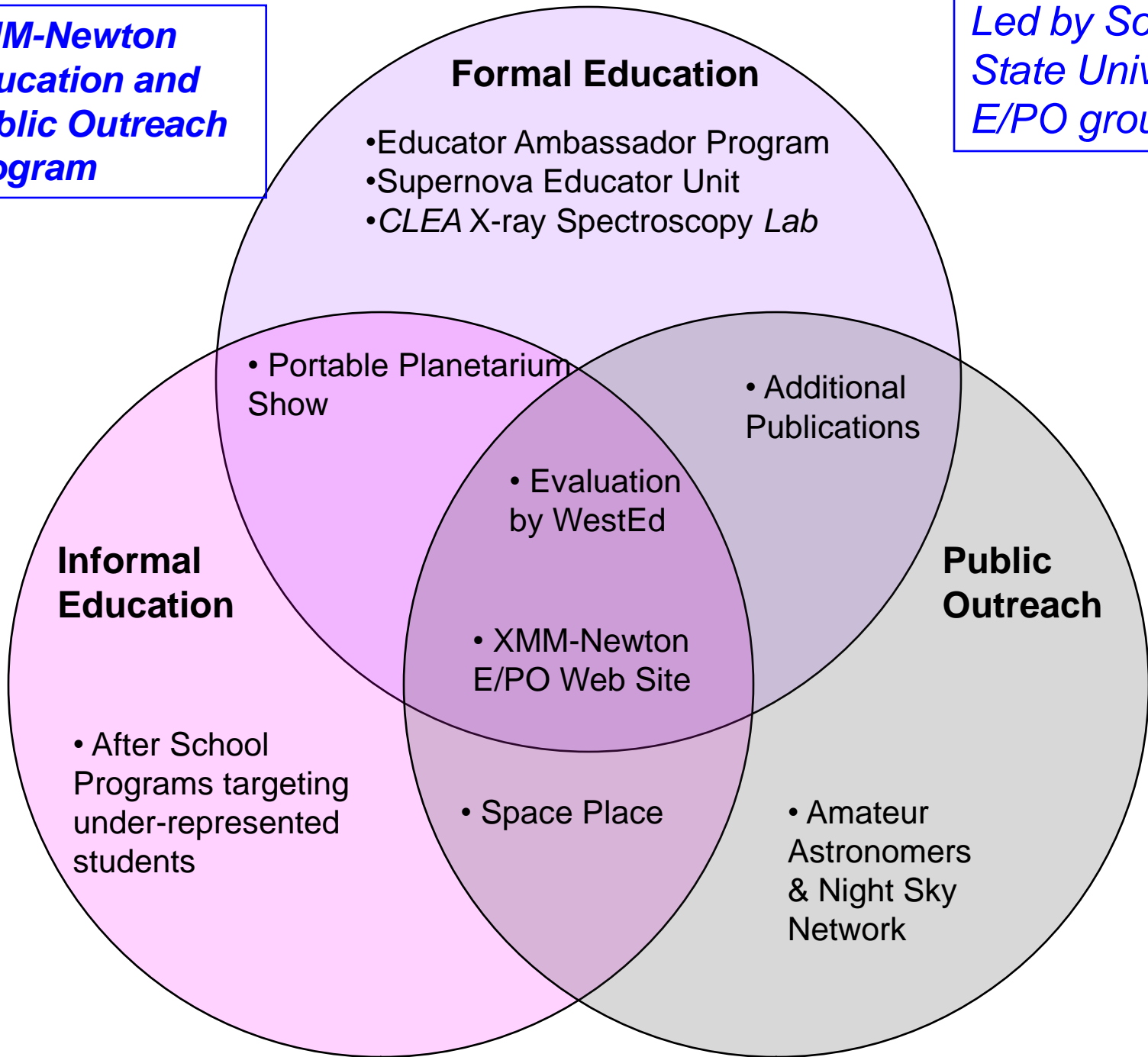
Each data base is being guided by an expert in the field (drawn from HEASARC staff) and contains those data that are appropriate to the science area.

**This activity has just started but we anticipate that it will be a pathfinder to similar activities of the data centers**


**This will be a major entry point for XMM into the Virtual Observatory allowing ‘non-xray’ astronomers to easily utilize XMM data**

***XMM-Newton  
Education and  
Public Outreach  
Program***

***Led by Sonoma  
State University  
E/PO group***



# XMM-Newton in the Journals



QuickTime™ and a  
TIFF (Uncompressed) decompressor  
are needed to see this picture.

Since last senior review the **XMM publication rate has risen to ~95 papers per quarter from ~75 in 04-05 :**

38 ~1/4th of papers have a US first author, 1/2 have a US co-author