

# IACHEC

International Astrophysical Consortium for High Energy Calibration

# Galaxy Clusters WG Summary

Eric Miller (MIT)

19 May 2021

# Clusters WG Recent History

- Jukka left IACHEC shortly before 2019 Workshop in Japan. Eric took over the Clusters WG and Herman took over the Contamination WG.
- The Clusters WG has been dormant for two years.
- WG was previously **very** active:
  - "Cross-calibrating X-ray detectors with clusters of galaxies: an IACHEC study"  
Nevalainen, David & Guainazzi 2010, A&A, 523, 22
  - "Cross-calibration of Suzaku XIS and XMM-Newton EPIC using clusters of galaxies"  
Kettula, Nevalainen & Miller 2013, A&A, 552, 47
  - "XMM-Newton and Chandra Cross Calibration Using HIFLUGCS Galaxy Clusters"  
Schellenberger et al. 2015, A&A, 575, 30
- It should be again!
  - eROSITA, XRISM, ATHENA will do lots of cluster science and use cluster calibration targets.
  - The Multi-Mission Study is in progress and promising useful results.

# WG Membership

- E. Miller (chair, XRISM, Hitomi, Suzaku/XIS)
- A. Beardmore (Swift/XRT)
- M. Bonamente
- Y. Chen (HXMT)
- Y.-P. Chen (HXMT)
- L. David (Chandra)
- J. de Plaa
- K. Forster (NuSTAR)
- C. Grant (Chandra/ACIS)
- S. Jia
- C. Li
- K. Madsen (NuSTAR)
- H. Matsumoto (XRISM/Xtend, Hitomi/SXI, Suzaku/XIS)
- N. Ota (XRISM, Hitomi, Suzaku/XIS)
- A. Read (XMM-Newton/EPIC-MOS)
- G. Schellenberger (XMM-Newton/EPIC, Chandra/ACIS)
- S. Snowden (XMM-Newton/EPIC-MOS)
- M. Stuhlinger (XMM-Newton/EPIC)
- I. Valtchanov (XMM-Newton/EPIC)
- N.-J. Westergaard (NuSTAR)
- H. Zhao (HXMT)

# WG Membership at meeting last Tuesday

- E. Miller (chair, XRISM, Hitomi, Suzaku/XIS)
- A. Beardmore (Swift/XRT)
- M. Bonamente
- Y. Chen (HXMT)
- Y.-P. Chen (HXMT)
- L. David (Chandra)
- J. de Plaa
- K. Forster (NuSTAR)
- C. Grant (Chandra/ACIS)
- S. Jia
- C. Li
- K. Madsen (NuSTAR)
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- N.-J. Westergaard (NuSTAR)
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# WG Meeting

## WG Meeting #1: 2021-05-11 (virtual)

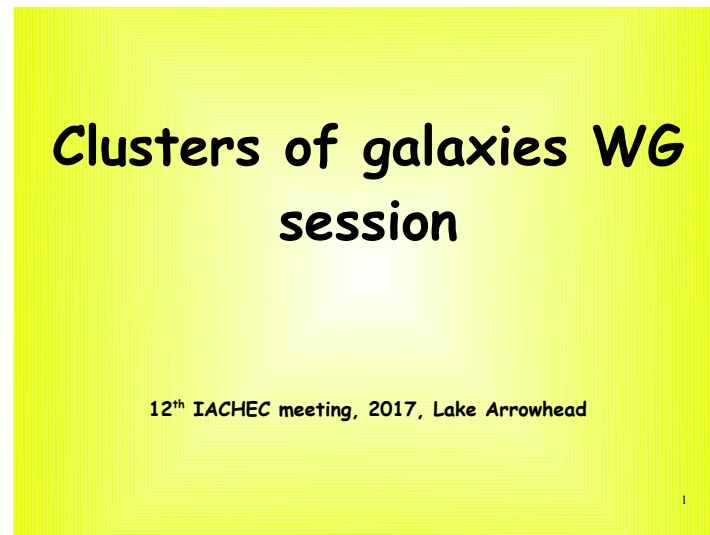
🔒 2 Added by [Eric D Miller](#), last edited by [Eric D Miller](#) on May 11, 2021 11:54 ([view change](#))

### Meeting information

- Date: May 11, 2021 at 07:00 PDT = 10:00 EDT = 14:00 UTC = 16:00 CEST = 22:00 CST = 23:00 JST
- Connection: Zoom connection circulated by email
- Attendees: Eric Miller, Catherine Grant, Andy Beardmore, Chen Yong, Gerrit Schellenberger, Hiro Matsumoto, Ivan Valtchanov, Karl Forster, Kristin Madsen, Larry David
- Next meeting: TBD

### Agenda

- Where the Clusters WG left off



- Where do we go from here?



AHEAD

INTEGRATED ACTIVITIES FOR THE HIGH-ENERGY ASTROPHYSICS DOMAIN



Funded by the Horizon 2020  
Framework Programme of the European Union

# Program

1) Erosita cross-calibration with clusters



(A/I Eric) Contact Konrad about  
eROSITA cluster calibration targets  
and observations (A1795, A2029, ...)

2) Multi-mission review from last year



3) Updates on the Multi-Mission Study



Described below.

# Multi-Mission Study (MMS)

## Review 2015

- ★ Comparison of cluster spectra measured with XMM-Newton/EPIC, Chandra/ACIS, Swift/XRT, Suzaku/XIS, ROSAT/PSPC i.e. 5 missions, 10 instruments
- ★ Residual ratios to evaluate the effective area cross-calibration:
  - We use EPIC-pn as a reference. (Try also ACIS, **TBD**)
  - For instrument *i* we calculate the mean of the ratio

$$R_{i/pn} = \frac{data_i}{model_{pn} \otimes resp_i} \times \frac{model_{pn} \otimes resp_{pn}}{data_{pn}}$$

- ★ The latter term corrects for deviations btw. pn model and pn data which cannot be produced by the model (no point in comparing reference instrument with another using a model which does not fit the reference instrument data)

# Multi-Mission Study (MMS)

## Review 2015

# Sample

★ Currently the sample consists of

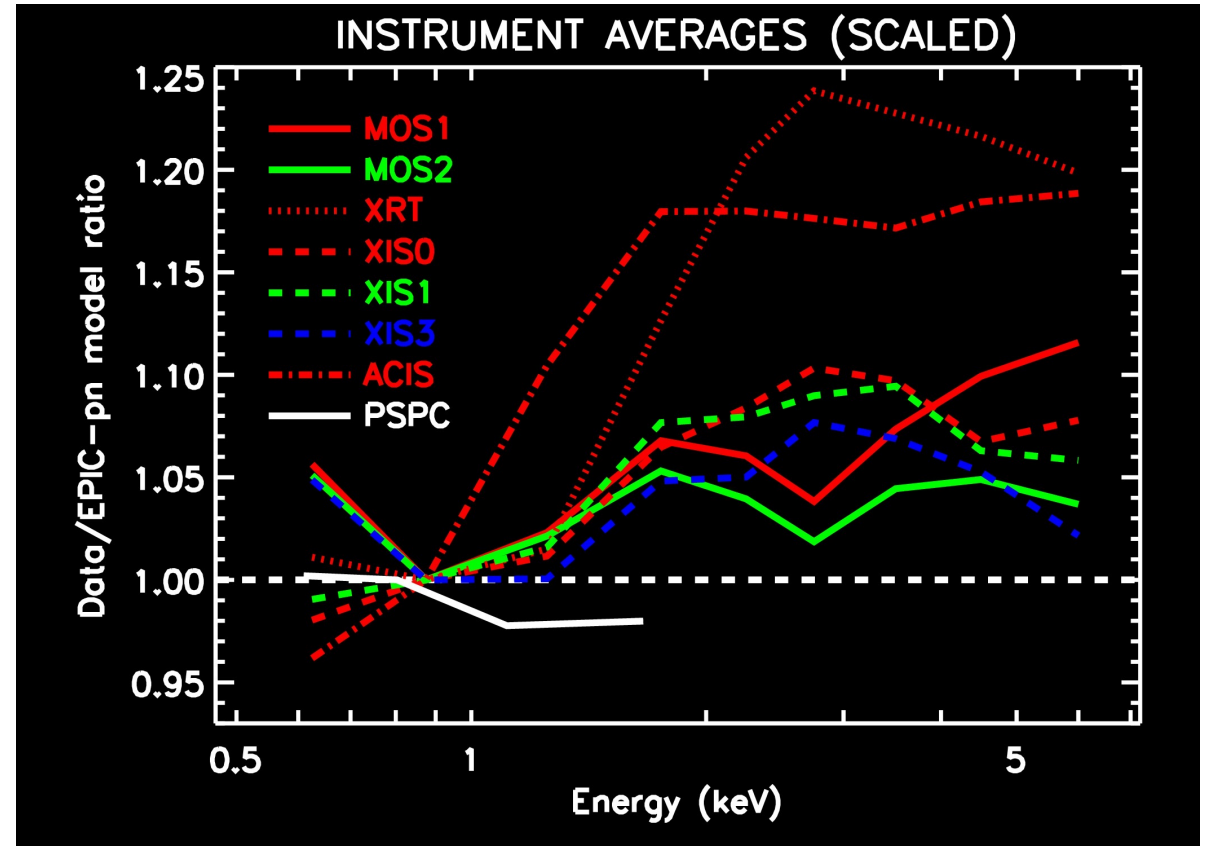
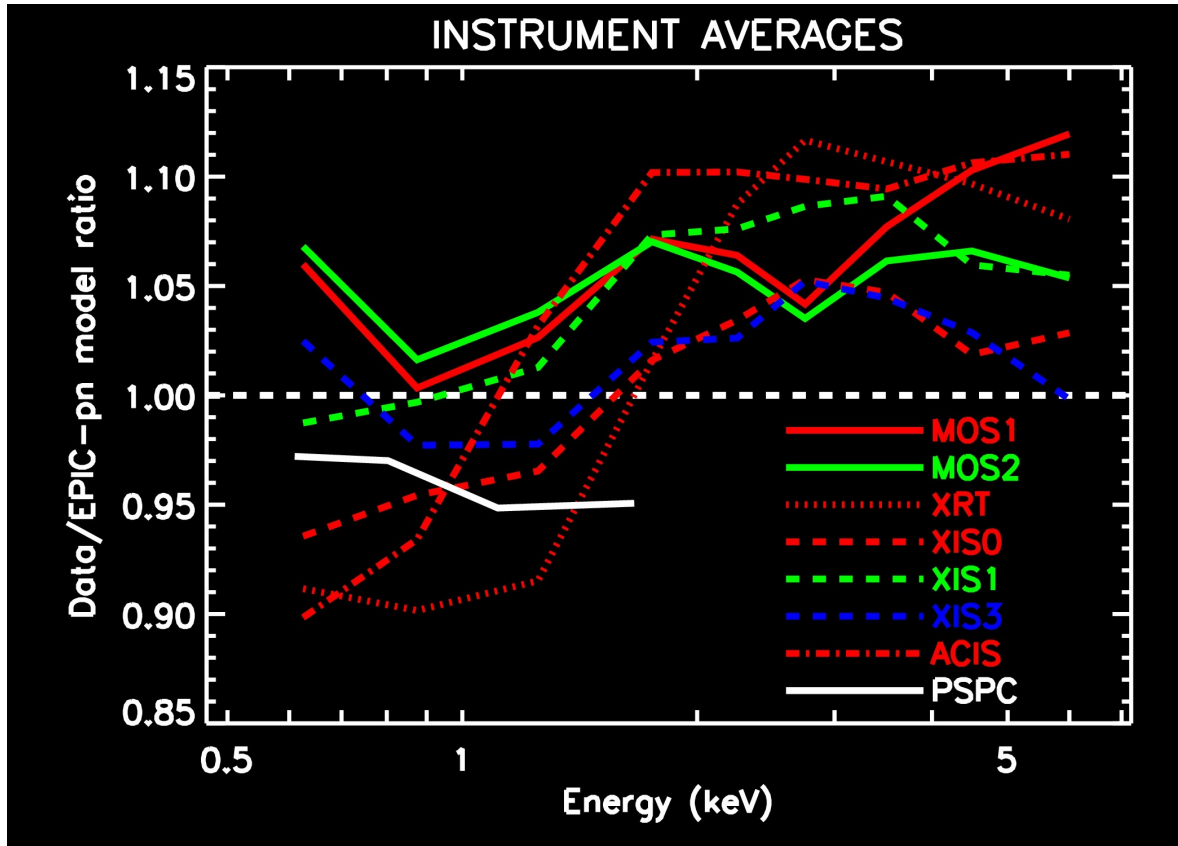
**A1795, A2029, Coma and PKS 0745-19**

Satellite/instrument	Date of processing	Software/CALDB
XMM-Newton/EPIC	April 2014	xmmsas_20131209_1901-13.5.0
Chandra/ACIS	May 2014	ciao-4.6
Swift/XRT	April 2014	
Suzaku/XIS	May 2014	xissimarfgn 2010-11-05 ae_xi0_contami_20130813.fits
ROSAT/PSPC-B	May 2013	

**At the moment the results apply to calibration status on May 2014**



# Multi-Mission Study (MMS) – Review



# Multi-Mission Study (MMS) – Review

- 2017 TASK 1: Define the extraction radius
  - Statistics requirement and PSF minimization prefer bigger values
  - BG and vignetting minimization prefer smaller values
  - Extraction radius = 6 arcmin
- 2017 TASK 2: Define suitable clusters
  - Hot enough (minimize 1 keV line emission, better source/BG ratio at 7 keV)
  - Not too distant to yield enough photons
  - Prefer low NH, but no requirement for NH at the moment
  - $kT > 6$  keV,  $z < 0.1$
- 2017 TASK 3: Define suitable observations
  - Long enough for statistics.
  - Cluster centered on-axis.
  - Use single observations. If too constraining, we will discuss merging observations.
  - 100,000 cts in central 6 arcmin (40,000 for PSPC)
  - Center  $< 3$  arcmin off-axis

# Multi-Mission Study (MMS) – Review

X: XMM/EPIC  
 C: Chandra/ACIS  
 R: ROSAT/PSPC  
 SW: Swift/XRT  
 SU: Suzaku/XIS  
 A1835?

cluster	X	C	R	SW	SU
A85	☺	☺	☺	☹	☹
A119	☺	☺	☺	☹	☹
A399	☺	☺	☺	☹	☹
A401	☺	☺	☺	☺	☹
A478	☺	☺	☺	☹	☹
A754	?	☺	☹	☹	☹
A644	☺	☺	☺	☹	☹
A1413	☺	☺	☺	☹	☹
A1650	☺	☺	☹	☹	☹
A1651	☺	☺	☺	☺	☹
Coma	☺	☺	☺	☺	☺
A1689	☺	☺	☺	☹	☹
A1795	☺	☺	☺	☺	☺
A1914	☺	☺	☺	☹	☹
A2029	☺	☺	☺	☺	☺
A2065	☺	☺	☹	☹	☹
A2142	☺	☺	☺	☹	☹
A2163	?	?	☹	☹	☹
A2204	☺	☺	☺	☹	☹

cluster	X	C	R	SW	SU
A2244	☺	☺	☺	☺	☺
A2255	☺	☺	☺	☹	☹
A2256	☺	☺	☺	☹	☺
A2319	☺	☺	☹	☹	☹
A3158	☺	☺	☹	☹	☹
A3266	?	☺	☹	☹	☹
A3391	☺	☺	☺	☹	☹
A3558	☺	☺	☹	☹	☹
A3571	☺	☺	☺	☹	☺
A3627	?	?	☺	☹	☺
A3667	?	☺	☺	☹	☺
A3827	☺	☺	☹	☹	☹
A3888	☺	☺	☺	☹	☹
Ophiu	☺	☺	☺	4ks	☺
Perse	☺	☺	☺	☺	☺
PKS0745	☺	☺	☺	☺	☺
RXCJ1504	?	?	?	☹	?
Triang	☺	☺	☺	☹	☺
ZwCl1215	☺	☺	☹	☹	☹

- Cluster sample is hot HIFLUGCS (+ others) that meet these criteria (plus Perseus), and:
  - Offset btw. the cluster center and pointing FOV center < 3 arcmin
  - Exposure > 10 ks in the available data

# Multi-Mission Study (MMS) – Review

- 2017 TASK 4: Compile a list of available clusters and obs. ID:s fulfilling our criteria: Larry (Chandra), Eric (Suzaku), Andy B. (Swift), Steven Snowden (ROSAT), Jukka (XMM) Deadline end of April
- 2017 TASK 5: Extract and process data with May 2017 calibration information. Deadline end of June
- 2017 TASK 6: Jukka will do the stack residuals ratio analysis.
  
- Only XMM-ROSAT comparison has been done, for ~12 clusters, presented at 2018 IACHEC.

# Multi-Mission Study (MMS) – Update

	cluster	X	C	R	SW	SU
	A85	☺	☺	☺	☹	☹
	A119	☺	☺	☺	☹	☹
	A399	☺	☺	☺	☹	☹
	A401	☺	☺	☺	☺	☹
	A478	☺	☺	☺	☹	☹
	A754	?	☺	☹	☹	☹
	A644	☺	☺	☺	☹	☹
	A1413	☺	☺	☺	☹	☹
	A1650	☺	☺	☹	☹	☹
	A1651	☺	☺	☺	☺	☹
	Coma	☺	☺	☺	☺	☺
	A1689	☺	☺	☺	☹	☹
	A1795	☺	☺	☺	☺	☺
	A1914	☺	☺	☺	☹	☹
	A2029	☺	☺	☺	☺	☺
	A2065	☺	☺	☹	☹	☹
	A2142	☺	☺	☺	☹	☹
	A2163	?	?	☹	☹	☹
	A2204	☺	☺	☺	☹	☹

X: XMM/EPIC

C: Chandra/ACIS

R: ROSAT/PSPC

SW: Swift/XRT

SU: Suzaku/XIS

A1835?

cluster	X	C	R	SW	SU
A2244	☺	☺	☺	☺	☺
A2255	☺	☺	☺	☹	☹
A2256	☺	☺	☺	☹	☺
A2319	☺	☺	☹	☹	☹
A3158	☺	☺	☹	☹	☹
A3266	?	☺	☹	☹	☹
A3391	☺	☺	☺	☹	☹
A3558	☺	☺	☹	☹	☹
A3571	☺	☺	☺	☹	☺
A3627	?	?	☺	☹	☺
A3667	?	☺	☺	☹	☺
A3827	☺	☺	☹	☹	☹
A3888	☺	☺	☺	☹	☹
Ophiu	☺	☺	☺	4ks	☺
Perse	☺	☺	☺	☺	☺
PKS0745	☺	☺	☺	☺	☺
RXCJ1504	?	?	?	☹	?
Triang	☺	☺	☺	☹	☺
ZwCl1215	☺	☺	☹	☹	☹

- Swift now has lots of data on PKS0745.
- Chandra has lots of data on A1795.
- Ivan has worked on A1795 work flow.
- Jukka, Ivan et al. worked on chip gap/bad pixel correction on pn using image from MOS
  - Reduces the effect on the ARF to 0.1% (TN: <https://arxiv.org/abs/2103.01753>)

# Multi-Mission Study (MMS) – Update

- Action items from 2018
  - 2018 TASK 1: Check ROSAT PSPC calibration using one of our clusters (Jukka & M. Freyberg) (Postpone)
  - 2018 TASK 2: Check one cluster with Konrad's methods. Needs isothermal region for simple and accurate modelling. (Postpone)
  - 2018 TASK 3: Swift XRT flux weighting of ARFs (A/ Andy B.) XRT mkarf doesn't flux-weight ARFs, so Andy has to figure out how to do this by hand.
  - 2018 TASK 4: Draft ready by next IACHEC (Postpone)
- Where do we go from here?
  - Complete multi-mission study
  - Supply data to the concordance effort (Statistics WG)

# Multi-Mission Study (MMS) – Update

Instrument	Contact Person	Notes
XMM EPIC MOS & pn	Ivan	
Chandra ACIS	Larry & Gerrit	
Suzaku XIS	Eric	
Swift XRT	Andy B.	
ROSAT PSPC	?	<b>(A/I Eric)</b> Ask Konrad and Michael F. about ROSAT cluster person.
NuSTAR	Karl and Dan Wik	NuSTAR LP, A2029, A478, A1795, A2199, all completed according to Karl <b>(A/I Eric)</b> contact Dan and Karl about NuSTAR data
eROSITA	?	<b>(A/I Eric)</b> Ask Konrad and Michael F. about eROSITA cluster person and data set.
ASTROSAT	?	<b>(A/I Eric)</b> Ask ASTROSAT team about cluster person and data set.
HXMT	Chen Yong	Only two clusters have been observed: Coma, Perseus
NICER	?	<b>(A/I Eric)</b> Ask about cluster observations/calibration, interest in cross-calibration, contact.

# Summary and Future Plans

- CluWG is still useful, will be more so for future missions.
- We have a path forward for the MMS.
  - Assign WG member for each mission. Include additional missions.
  - Identify and gather existing data.
  - Select ~4 clusters to include.
  - Update calibration.
  - Extract spectra and responses, provide to Eric for residual ratio determination.
- Provide data for Calstats WG concordance effort.
  
- Two CluWG meetings planned before September IACHEC Workshop. If in person, we hope to work real-time on this effort.