WG reports Spring 2022

IACHEC Chairs

Order

- Heritage Matteo Guainazzi
- Calibration statistics Vinay Kayshap
- Clusters of Galaxies Eric Miller
- Contamination Herman Marshall
- Non-thermal SNR Lorenzo Natalucci
- Timing Yukikatsu Terada
- Thermal SNR Paul Plucinsky
- Coordinated Observations Karl Forster
- White Dwarfs and Isolated Neutron Stars Vadim Burwitz

Heritage WG report

- Goals
 - Providing a platform for the discussion of experiences coming from operational missions
 - Working group sessions and discussions
 - Facilitating the usage of good practices for the management of pre- and post-flight calibration data and procedures
 - Published articles
 - Documenting the best practices in analyzing high-energy astronomical data as a reference for the whole scientific community
 - Published articles, curated data, wiki-pages
 - Ensuring the usage of homogeneous data analysis procedures across the IACHEC calibration and cross-calibration activities
 - Published articles and curated data sets
 - Consolidating and disseminate the experience of operational missions on the optimal calibration sources for each specific calibration goal
 - Published articles, curated data, wiki-pages

The Heritage WG Grand Ambition

 Calibration data base containing all the data-set of all the IACHEC published papers

Progress report

- Pilot project database funded by AHEAD and created by James Rodi
 - Funding run out
- Approached the HEASARC to host it
 - HEASARC were positive
 - More discussions were/are planned
- Working group chair switch
 - Matteo Guianazzi -> Keith Arnaud

Cal Stats WG

- * **Calibration Uncertainty:** *Incorporate ARF and RMF systematic* uncertainties into spectral analysis
 - derive calibration sample for AstroSAT
 - improve pyBLoCXS compatibility in Sherpa
- * **Concordance:** Adjust instrument ARFs based on observations of common sources without absolute references
 - (see Herman's talk from Monday)
 - XMM+Chandra XCAL sample
 - Incorporate time dependence, source spectral modeling
 - astro applications too: infer source brightness when different instruments give conflicting estimates

* **C-stat:** *mostly unbiased measure to evaluate model parameters and ..* appropriateness of model?

 place under solid statistical foundation, explore properties even in non-asymptotic situations

Polarization statistics

- develop formalism for fitting of polarization data
- detector response depends on (U,Q,α) *

IACHEC Virtual Spring Meeting: May 25, 2022

Forum for discussion of statistical, methodological, and algorithmic issues that affect calibration of instruments, how calibration data are used in data analysis and analysis results are interpreted.

Cooperation with other WGs

- Hi-Res: how to use information on atomic data uncertainties, incompleteness, etc. in analysis; improve analysis techniques and RMF products for high-res spectroscopy
- Background: effects of high background on spectral feature detection; dealing with background in hi-res; compile and document scripts/packages for background models
- Timing: develop threads and descriptions of methods
 - * See review: *Time Domain Methods for X-ray and γ-ray* Astronomy, Feigelson et al. 2022, https://arxiv.org/abs/ 2203.08996

Communications

- Statistics and Machine Learning techniques: standalone talks, tutorials, and sessions at AAS and HEAD meetings
- Webpage: <u>https://iachec.org/calibration-statistics/</u>
- Slack channel #cal-stats
- Mailing list: <u>iachec-calstats@cfa.harvard.edu</u>
- * Next WG meeting: sometime in June (check your email for doodle poll)



IACHEC Galaxy Clusters WG — Spring 2022 Update

International Astrophysical Consortium for High Energy Calibration

We study galaxy clusters as broad-band X-ray standard candles.

E. Miller (chair, XRISM, Hitomi, Suzaku/XIS)	K. Madsen (NuSTAR)
A. Beardmore (Swift/XRT)	C. Markwardt (NICER)
M. Bonamente	H. Matsumoto (XRISM/Xtend, Hitomi/SXI, Suzaku/XIS)
Y. Chen (Insight-HXMT)	N. Ota (XRISM, Hitomi, Suzaku/XIS)
YP. Chen (Insight-HXMT)	A. Read (XMM-Newton/EPIC-MOS)
L. David (Chandra)	G. Schellenberger (XMM-Newton/EPIC, Chandra/ACIS)
J. de Plaa	S. Snowden (XMM-Newton/EPIC-MOS)
G. Dewangan (ASTROSAT)	M. Stuhlinger (XMM-Newton/EPIC)
K. Forster (NuSTAR)	I. Valtchanov (XMM-Newton/EPIC)
F. Gastaldello (XMM-Newton/EPIC)	N-J. Westergaard (NuSTAR)
C. Grant (Chandra/ACIS)	D. Wik (NuSTAR)
S. Jia	H. Zhao (Insight-HXMT)
C. Li	Mailing list: <u>iachec-clusters@mit.edu</u>

Contact milleric@mit.edu to join

Clusters WG — current action items

• Action items for the Multi-Mission Study

- (A/I Ivan, Larry, Gerrit, Eric, Andy B., Karl, Chen Yong) Update compiled list of available clusters and ObsIDs for your mission that fulfill our criteria. See the table of clusters, the criteria, and the mission assignments on the wiki page.
 → Ivan and Larry have supplied this information.
- (A/I All) Should we add A2199 to the sample? Probably cooler than 6 keV, but also probably observed by many missions. → Yes.
- (A/I Andy) XRT mkarf doesn't flux-weight ARFs, so Andy has to figure out how to do this by hand. → No update.
- (A/I Eric) Ask eROSITA team (Konrad and Michael F.) about cluster observations/calibration, interest in cross-calibration. → Not done.
- (A/I Eric) Ask Konrad and Michael F. about someone who can cover ROSAT analysis. → Not done.
- (A/I Eric) Ask Dan Wik and Karl about NuSTAR cluster calibration data. → Done. Dan has joined the WG.
- (A/I Eric) Ask ASTROSAT team about cluster observations/calibration, interest in cross-calibration, contact person.
 → Gulab Dewangan volunteered for this at the May 2021 WG presentations.
- (A/I Eric) Ask NICER team about cluster observations/calibration, interest in cross-calibration, contact person.
 → Craig Markwardt volunteered for this at the May 2021 WG presentations (TBC).

• Other activity since Nov 2021

• Fabio Gastaldello added to WG.

• Future plans

- We have a path forward for the MMS. Plan WG telecon for summer.
- (Eventually) provide data for Calstats WG concordance effort.

Contamination Working Group: Status & Plans

Herman L. Marshall May 25, 2022

Goals and Status

- Goals
 - Update and compare contamination models
 - Generate a white paper on mitigation and analysis
- Updates since WG meeting of Nov. 2021
 - Chandra ACIS (H. Marshall)
 - contamination is still growing
 - model is OK but may be updated later in 2022
 - XMM (M. Smith)
 - Some update to RGS is needed, model is not settled
 - MOS contamination continues for MOS2, level for MOS1
 - No change in pn
- No progress on white paper after WG meeting

Herman L. Marshall

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White Paper Plan

- Develop on overleaf, link to edit was distributed
- Review progress monthly
- Target completion by next IACHEC Plenary (May 2022)
- Initiate as white paper, decide on journal later

DRAFT VERSION NOVEMBER 8, 2021 Typeset using LATEX default style in AASTeX63

Contamination on Detectors in X-ray Telescopes

HERMAN L. MARSHALL¹ AND MORE IACHEC AUTHORS²

¹Kavli Institute for Astrophysics and Space Research, Massachusetts Institute of Technology, 77 Massachusetts Ave., Cambridge, MA 02139, USA ²Various Institutions

Submitted to A Very Good Journal

ABSTRACT

We describe efforts to avoid or eliminate the buildup of molecular contamination on the sensors of X-ray astronomy telescopes. In cases where contamination has been found, we provide an overview of the nature of the contaminant and the methods of characterizing and monitoring the buildup.

Keywords: Astronomical methods, X-ray astronomy, Calibration

Herman L. Marshall

Introduction and Objectives

V File outline

- Status by Mission
 - Chandra [P. Plucinsky, with H...
 History of Contaminatio...
 - Current Status of the Co...
 - XMM-Newton [M. Smith]
 - Suzaku [E. Miller]
 - AstroSat [S. Chandra]
 - Swift [A. Beardmore]
 - NICER [C. Markwardt]
 - NuSTAR [K. K. Madsen]
 - eROSITA [F. Haberl]
 - MAXI, HXMT?
- Plans for Mitigation or Monitorin...
 Athena [A. von Kienlin]
 Arcus [E. Miller]
 - XRISM [Coordinated by E. Mi..
 - IXPE [W. Baumgartner]
 - SMILE/SXI [S. Sembay] Einstein Probe, eXTP?
- ✓ Summary

Sources of Contamination Best Practices to Avoid Cont...

3 /3 IACHEC Contamination Update — 5/25/22

International Astrophysical Consortium for High Energy Calibration

IACHEC

Non-Thermal WG goals

It mainly aims at the cross-calibration analysis of G21.5-0.9 (mainly below 10 keV) and of the Crab spectra (mainly above 10 keV).

- Define a reference model for cross-calibration in the energy band from soft X-rays to hard X-rays
- Analyse observational data in the context of cross-calibration. Extract ratios for instrument renormalisation in different energy bands

The WG started its activities in 2007 (Lake Arrowhead). Initial chairperson: Manabu Ishida

An important milestone is reached in 2010 (chairperson: M.Tsujimoto) with publication of cross-cal paper on G21.5-0.9

Current WG e-mail list

Andy Beardmore, Giancarlo Cusumano, Larry David, Jelle Kaastra, Manabu Ishida, Keith Jahoda, Elisabeth Jourdain, Keiichi Maeda, Andrew Read, Richard Rotschild, Taka Sakamoto, Kristin Madsen, Brian Grefenstette, Gary Case, Dipankar Bhattacharya, Craig Markwardt, Yukikatsu Terada, Xiabo Li, Liming Song, James Rodi, Lucien Kuiper, Paul Plucinsky, Masahiro Tsujimoto, M.Y.Ge, Jeremy Drake, Herman Marshall, Vinay Kashyap, Matteo Guainazzi

If interested to join, please contact: lorenzo.natalucci@inaf.it

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International Astrophysical Consortium for High Energy Calibration Crab Flux history 25-80 keV



Summary

- Main targets of WG are still the Crab and G21.5: good primary standards also for upcoming missions.
- No big update in the last 6 months.
- NuSTAR new CALDB issued; INTEGRAL/ISGRI OSA11.2 release with new calibration. ISGRI dataset updated.
- New studies planned for G21.5-0.9: new model needed. Kickoff meeting of a subgroup with the goal to analyse data of Chandra, XMM, NuSTAR, Hitomi, INTEGRAL, Swift.
- ISGRI new analysis with OSA11.2 multi-year data is planned on PSR1509 (see J.Rodi's talk)

IACHEC Timing Working Group

(Report by Y.Terada)

Goals

- Share information on Timing calibration methods/protocol, lessons learned (to enhance timing capability)
- 2. In-orbit timing calibration (coordinated) observations/ planning, studies
- 3. Studies on Timing products

ML: iachec-time@heal.phy.saitama-u.ac.jp SLAC: iachec.slack.com #timing

Current Members:

Yukikatsu Terada (Suzaku, Hitomi, XRISM), Craig Markwardt (NICER), Teruaki Enoto (NICER), Matteo Bachetti (NuSTAR), Katja Pottschmidt (NuSTAR), Kristin Madsen (NuSTAR) Felix Fuerst (XMM-Newton), Simon Rosen (XMM-Newton), Vinay Kashyap (Chandra), Arnold Rots (Chandra), Amy Lien (Swift), Giancarlo Cusumano (Swift), Guillaume Belanger(INTEGRAL), Volodymyr SAVCHENKO(INTEGRAL), Lucien Kuiper(INTEGRAL) Xiaobo LI (HXMT), Gulab Dewangan (Astrosat), Dipankar Bhattacharya(Astrosat) Michael Freyberg (eROSITA), Makoto Sawada(XRISM), Takaaki Tanaka (XRISM) Minami Sakama (XRISM), Takumi Shioiri (XRISM)

Update from Nov 2021

Summary of Activities in 2021-2022

Timing WG telecom

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- 13 May 2022
 - Meeting notes (PDF) are available on the timing WG wiki page <u>https://wikis.mit.edu/confluence/display/iachec/Timing</u>
 - Presentation on STINGRAY by M. Bachetti
 - Two short reports on estimation of in-orbit calibration for XRISM by M.Sakama and T.Shioiri

Major activities

- Goal #1) Summary of timing calibration/performance of multiple missions Activity continues, in maintenance.
- Goal #2) Systematic study of Crab timing using archive data among instruments Activity continues.
- Goal #3) Effects of dead time / grade selection etc on timing products New, just started.

Updated

Goal #1 Summary of timing calibration/performance

Outputs: https://wikis.mit.edu/confluence/display/iachec/Timing **Columns on the table**:

- Science Requirement Absolute Time (Requirement & Goal)
- Timing System Design (GPS yes/no, Clock Stability)
- Timing Calibration Status (Timing offset, deviation, notes)
 - Definition of the timing offset and deviation (description added)
 - Reference time for timing offset (column added)
- In-orbit Timing Calibration Targets
- Reported Issues
- Reference

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Discussion: The definitions of the timing "offset" and "deviation" are not uniform among instruments.

- Offset: offset time from a reference timing (Crab radio, Crab X-ray, or TAI)
- Deviation: scatter of the offset

Note: the difference between radio and Xray on the arrival time of Crab main pulse has energy dependency.



Update from Nov 2021

Goal #2 Comparison of Crab ephemeris

Purpose

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- I. Systematic-timing cross-calibration of instruments using archive data.
- 2. Systematic check of Crab Timing delay between the X-ray and Radio.

Status:

- I. No major update from Nov 2021. We plan to add IXPE data.
- 2. Matteo found an discrepancy of trend on Jodrell Bank radio ephemeris.

Goal #3 Effects of DAQ behavior on timing products

Purpose:

check the effect of the following items timing products Time resolution, timing accuracy, dead time, bgd events, GTI, etc

Status:

- Presentation on STINGRAY by M. Bachetti
- Short presentations on XRISM by M.Sakama and T.Shioiri using a Monte Carlo photon simulator (study has just started)







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What We Do

- develop standard spectral models for bright SNRs
- fit SNR data from different instruments with these standard models and compare the results to determine the consistency of the calibrations
- see E0102 results in Plucinsky et al. 2017, A&A, 597, A35
- see "https://wikis.mit.edu/confluence/display/iachec/Thermal+SNR"

Standard Models Exist For:



Thermal SNRs 20220525

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What have we been doing recently ? N132D Model Update

- improve model in the 3.2-8.0 keV band *empirical* model with "No Line APEC" models for the continua and Gaussians for the lines (called N132D_E0310_v2.14_20210511.mdl)
- in this band, focus on the 1.14 keV continuum norm, 5.47 keV continuum norm, and Fe XXV Heα norm
 Chandra ACIS S3
- fits indicate that we must allow each instrument to have a different normalization for the 1.14 and 5.47 keV components, in order to get acceptable fits
- but freezing the temperatures at 1.14 and 5.47 keV does provide acceptable fits

N132D:ACIS 2006, N132D_E0310_v2.14_20210511.mdl, CStat=2258, DOF=1972,PChi=1.02 GlNorm=1.00, 1.14 keV=3.97e-2(fix), 5.47 keV=9.61e-4(fix), FeXXV =3.21e-6(fix)





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N132D Model Update: Suzaku and NuSTAR

- Suzaku has the lowest background in this band
- NuSTAR has highest effective area above 8.0 keV
- \bullet all instruments show residuals around the Fe XXV He α complex
- gain issue or a deficiency in the model ?





N132D Model Update: XMM-Newton

- XMM has the most counts in the Fe XXV region
- fit used the latest effective curves released in XMM-CCF-REL-388, 7 April 2022 & has "applyxcaladjustment = yes"



Paul Plucinsky



Empirical Model Fit Results

Red: highest values Blue: lowest values in the group

Instrument	1.14 keV nlapec norm	5.47 keV nlapec norm	Fe XXV Norm		
ACIS	4.27+/-0.10 e-2	7.90+/-1.16 e-4	3.56+/-0.30 e-6		
pn	3.38+/-0.03 e-2	9.28+/-0.24 e-4	2.55+/-0.06 e-6		
MOS1/MOS2	3.49+/-0.02 e-2	6.88+/-0.20 e-4	2.47+/-0.05 e-6		
XIS0	3.71+/-0.07 e-2	1.01+/-0.07 e-3	3.20+/-0.14 e-6		
XIS3	3.83+/-0.06 e-2	1.03+/-0.07 e-3	3.23+/-0.14 e-6		
XIS1	3.80+/-0.07 e-2	1.06+/-0.07 e-3	3.00+/-0.16 e-6		
NuSTAR	3.00+/-0.07 e-2	1.23+/-0.05 e-3	2.63+/-0.12 e-6		



Empirical Model Fit Results



Paul Plucinsky

Thermal SNRs 20220525

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• *physical* model (Suzuki et al. 2020) with a thermal component with a temperature of kT=1.36 keV in addition to a high temperature component provides sufficient flux on the low side of the Fe XVV Heα peak to reduce the residuals in the XMM data



1 nermal SNRs 20220525

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Future Work

- decide on how to model the emission on the low energy side of the Fe XXV He α peak in the empirical model
- allow the centroid energy of the Fe XXV Heα complex to vary and explore different ratios for the f,i,r lines in the Fe XXV Heα complex
- finalize the high energy part of the model
- compute fluxes in the 3.2-8.0 keV band to perform a more meaningful comparison of the effective areas in this band
- revise the N_H model to be more realistic
- release new version for Martin
- Martin refits the lines in the RGS data in the 0.3-1.5 keV range with the new normalization for the 1.14 keV component
- finalize the model in the 0.3-1.5 keV range
- focus on the 1.5-4.5 keV range, this promises to be difficult in that the instruments clearly do not agree with each other



The Spectral Fitters

Those who did the work:

NuSTAR Suzaku XIS XMM pn & MOS Models XMM-RGS Chandra ACIS Brian Grefenstette (Caltech) Eric Miller (MIT) Adam Foster (SAO) Adam Foster (SAO) Martin Stuhlinger (ESAC) Paul Plucinsky (SAO)

Thank You !!!!

CXC



Coordinated

Observations

Working Group

Report for IACHEC Spring Virtual Workshop

Karl Forster (Caltech)

May 25th, 2022



Scope of the Co-Obs Working Group

"Facilitate the coordination of calibration observations among operational observatories and the analysis and publication of the corresponding data. An annual cross-calibration observation of the quasar 3C 273 involving as many operational observatories as possible is undertaken in June/July each year."

Activity in 2022

Coordination with IXPE observations

- No specific cross-calibration observations
 - + coordinated science observations available

Annual coordination of 3C 273 observations

- 2022 June 27-29th with Chandra, INTEGRAL, NICER, NuSTAR, Swift, & XMM-Newton
 - + No AstroSat observations possible
 - + IXPE June 1-3rd & 8-11th

Fall WG meeting topics

- Planned for ~ October on zoom
- 2022 3C 273 observing campaign
 - + Expand analysis to include Chandra + Swift
- XMM-Newton/NuSTAR Crab campaign
 - + Felix Fuerst extended analysis to include Chandra, NICER and Swift (below 3 keV)
- Supporting in-flight calibration of XRISM
 - + Enhanced PV science program with NuSTAR



3C 273 cross

calibration

Corin Marasco & Kristin Madsen

Analysis Continues

- check Chandra and Swift analysis
- include NICER observations
- update with 2021 NuSTAR CALDB
- extend analysis to evaluate within concordance framework
 - flux ratios examined in narrow bands (model independent)
- investigate complexity seen in XMM-Newton spectrum
- publish this year

2021/2 XMM-MOS/pn SAS ?



IXPE observations in 2022 ...

GO (science) programs

Target	Start	End	DU1 [ks]	NuSTAR	NICER	XMM	Chandra	Swift	INTEGRAL	Other
Cas A	2022-01-11 11:23:47	2022-01-29 12:39:44	887.8		Y		Y		Y	
Cen X-3	2022-01-29 12:39:44	2022-01-31 06:58:13	67.6						(y)	
4U 0142+61	2022-01-31 07:23:26	2022-02-27 19:14:18	124.3		Y					
Cen A	2022-02-15 00:13:20	2022-02-17 13:52:46	100.4	Y				(y)	Y	
Her X-1	2022-02-17 13:52:46	2022-02-24 19:36:00	80.5		Y				Y	
Crab	2022-02-21 16:12:23	2022-03-08 02:38:53	45.4	Y*	Y	Y	(y)		Y	
Sgr A complex	2022-02-27 19:14:18	2022-03-24 01:51:08	63.8	Y	Y	Y	Y	Y	Y	VLT-Gravity
Mrk 501	2022-03-08 02:38:53	2022-03-10 08:19:08	104.0	Y		Y		Y		
4U 1626-67	2022-03-24 01:51:08	2022-03-27 05:39:23	189.2		Y					
Mrk 501	2022-03-27 05:39:23	2022-03-29 07:14:28	86.7	Y	Y	Y		Y	(y)	MAGIC
GS 1826-238	2022-03-29 07:14:28	2022-03-31 09:20:06	90.1		Y				Y	
S5 0716+714	2022-03-31 09:20:06	2022-04-05 19:50:31	357.1	Y				Y		
Vela Pulsar	2022-04-05 19:50:31	2022-04-30 10:33:42	426.9		Y				Y	
Vela X-1	2022-04-15 18:07:09	2022-04-21 12:21:02	276.6		Y					
Cyg X-2	2022-04-30 10:33:42	2022-05-03 11:21:38	135.1	Y	Y			Y	Y	
1ES 1959+650	2022-05-03 11:21:38	2022-05-04 10:00:28	53.5			Y		Y		
Mrk 421	2022-05-04 10:00:28	2022-05-06 11:10:18	96.6	Y		Y		Y		MAGIC
BL Lac	2022-05-06 11:10:18	2022-05-14 12:52:30		Y		Y		(y)	(y)	
MCG-5-23-16	2022-05-14 12:52:30	2022-05-15 15:20:54		Y		Y				
Cyg X-1	2022-05-15 15:20:54	2022-05-20 01:14:39		Y*	Y			Y	Y	(XL-Calibur)
				*includes S	tray light		(y) within	7 days		

CO-OBS REPORT FOR IACHEC SPRING WORKSHOP - 2022

KARL FORSTER

HEH

Neutron star Interior Composition ExploreR

ΜΙΤ ΚΑνι

INSTITUTE

NICER Observations of RX J1856 Craig Markwardt (NASA/GSFC)

MOOG

NICER Modeling of RX J1856







- NICER consists of 52 non-imaging X-ray modules with nearly 2x effective area as EPIC-pn @ 1keV and ~3' radius FOV
- New analysis of existing J1856 data with in-development cal products
 - Includes 1BB for J1856 and Galactic Bulge, CXB, Local Hot Bubble, Galactic Halo, and other NXB components
 - NICER statistical error bars are ~1%
- J1856 parameters are coupled with background parameters but are reasonable overall; no evidence of ~1 keV excess