Welcome to the IACHEC online symposium 2020

The Symposium will be interactive, but to reduce bandwidth and avoid disruption we request that all attendees stay muted with their video off unless presenting.

Please indicate questions through the raised hand and chat window features, and once recognized by the session chair feel free to turn on your microphone and video and ask your question.

For technical difficulties with Zoom, or if you would like to submit a question for the Q/A session, or request being added to a working group, please use meeting2020@iachec.org

November 23rd: 9:00 – 12:00 EST

Topic	Time	Speaker	Title
Welcome:	09:00 – 09:30	Kristin Madsen	The IACHEC charter
Calibration Issues & Solutions:	09:30 – 09:50	Jeremy Drake	Chandra
	09:50 – 10:10	Craig Markwardt	Nicer
	10:10 – 10:30	Jamie Kennea	Swift
Break	10:30 – 10:40		
	10:40 – 11:00	Michael Smith	XMM
	11:00 – 11:20	Gulab Dewangan	AstroSAT
	11:20 – 11:40	Brian Grefenstette	NuSTAR
	11:40 – 12:00	Guillaume Belanger	Integral

Welcome!

GOAL OF THE SYMPOSIUM

Introduce those unfamiliar with IACHEC to our work and the available resources

Have the calibration scientists of our beloved missions talk directly to you about the data analysis of their instruments

Hear from the community about how we can best help you

The IACHEC

Chair of the IACHEC
Kristin K. Madsen (GSFC/UMBC)

Working Group Chairs

Guillaume Belanger (ESA)
Vadim Burwitz (MPE)
Karl Forster (Caltech)
Adam Foster (CfA)
Catherine Grant (MIT)
Matteo Guainazzi (ESA)
Herman Marshall (MIT)
Vinay Kashyap (CfA)
Eric Miller (MIT)
Lorenzo Natalucci (INAF)
Paul Plucinsky (CfA)
Yukikatsu Terada (U. Saitama)

What is the IACHEC

Founded in 2006 by Marcus Kirsch (ESA) and Steve Sembay (University of Leicester)

What is the IACHEC

- A shared undertaking among high-energy calibrators to coordinate (and therefore strengthen) our work
- A forum where astronomers involved in calibration of past, operational, and future missions work together to:
  - Define calibration standards
  - Document (=publish) calibration and cross-calibration status
  - Improve the cross-calibration among their instruments

Program: Day 1

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Program: Day 2

November 24th : 9:00 – 12:00 EST

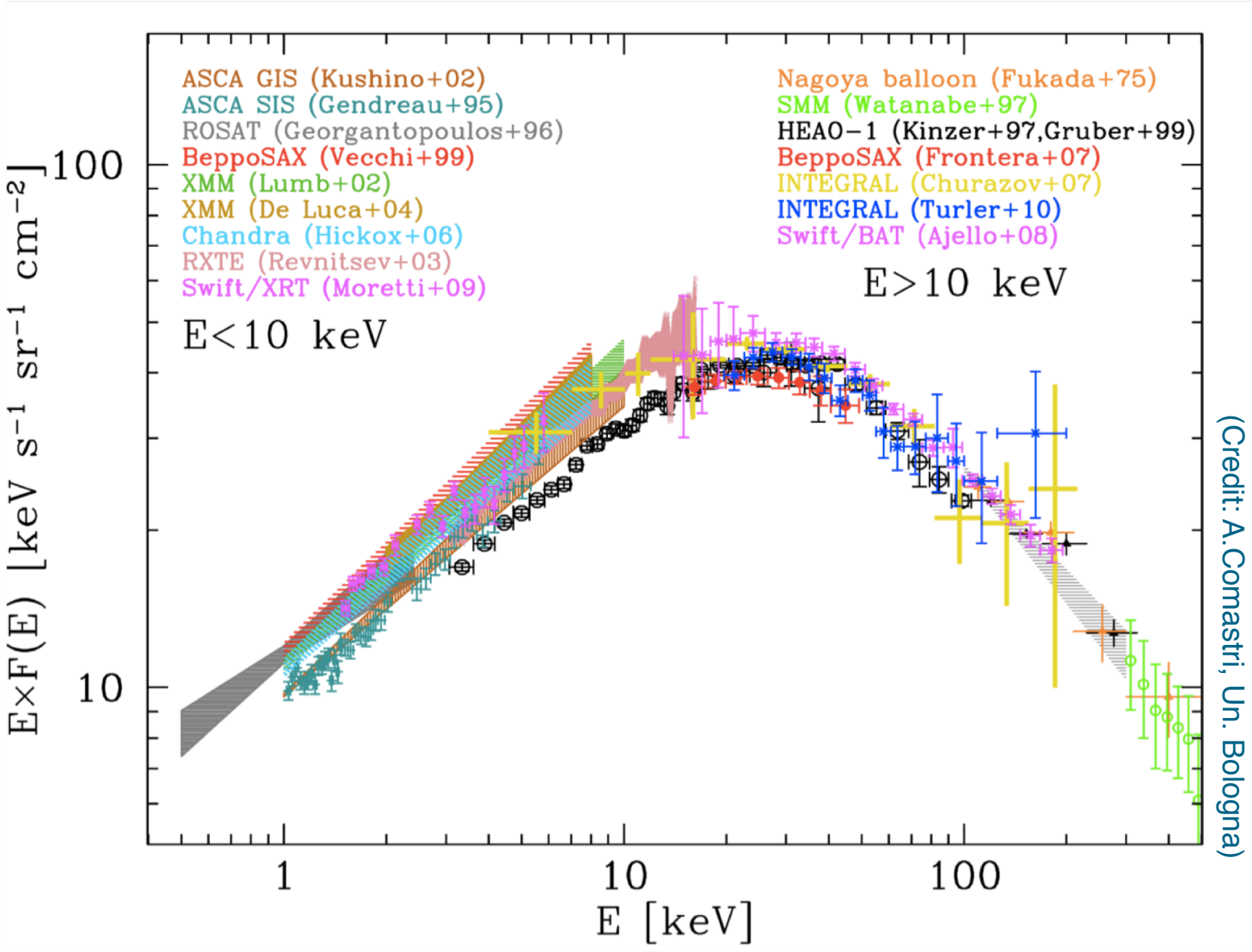
Topic	Time	Speaker	Title
Cross-calibration	09:00 – 09:25	Madsen / Beardmore	Cross-calibration of Swift/NuSTAR
	09:25 – 09:40	Craig Markwardt	Nicer cross-cal
	09:40 – 10:00	Smith/Marshall	Cross-calibration of XMM/Chandra
Understanding pileup	10:00 – 10:30	Richard Saxton	What is pileup and how should it be correctly dealt with in data?
Statistical Best Practices:	10:30 – 10:45	Guillaume Belanger	Choice of Likelihood
	10:45 – 11:00	Eric Miller	Background modeling
	11:00 – 11:15	Herman Marshall	Concordance results
Q/A session:	11:15 – 11:30		How can we help the Community; how can the Community help us?
	11:30 – 12:00		Submit/Ask your calibration problems to the IACHEC experts

Submit question to: meeting2020@iachec.org

Why calibration? A textbook example: the XRB

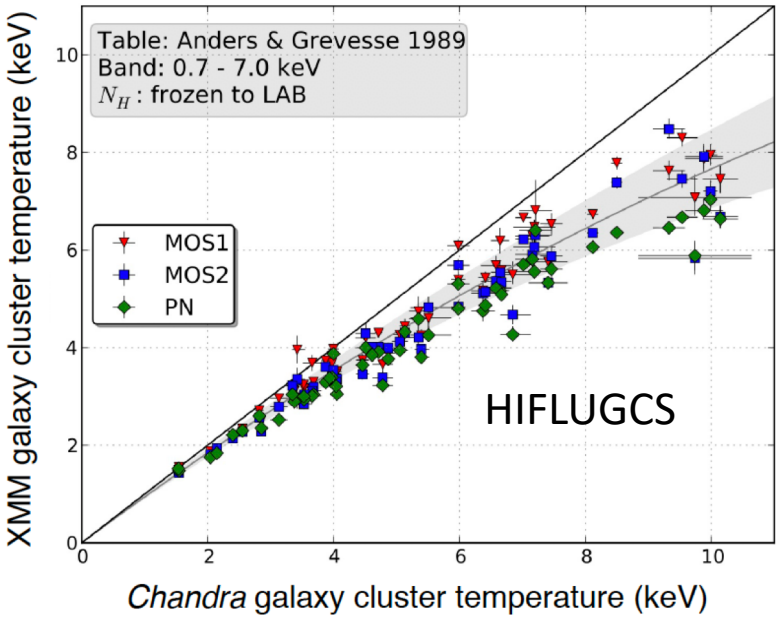
~20% flux difference between focusing and non-focusing instruments

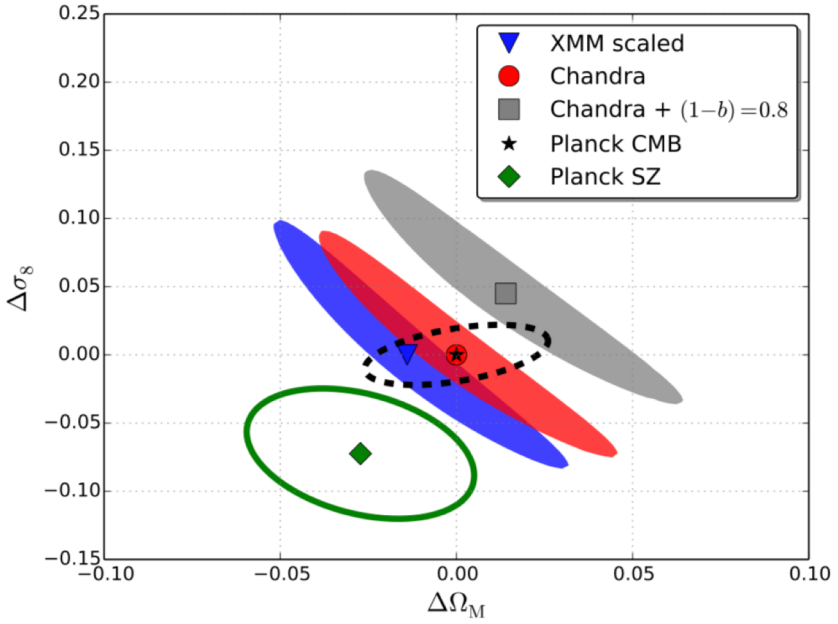
➤ Factor ~3 difference in the fraction of Compton-thick AGN



Impact on cosmology

- The distribution of galaxy cluster masses depends on cosmological parameters
- Cluster masses can be derived assuming hydrostatic equilibrium
- X-ray measurements (yielding electron density and temperature) are required
- Determination of cosmological parameters depends on our ability to measure kT!



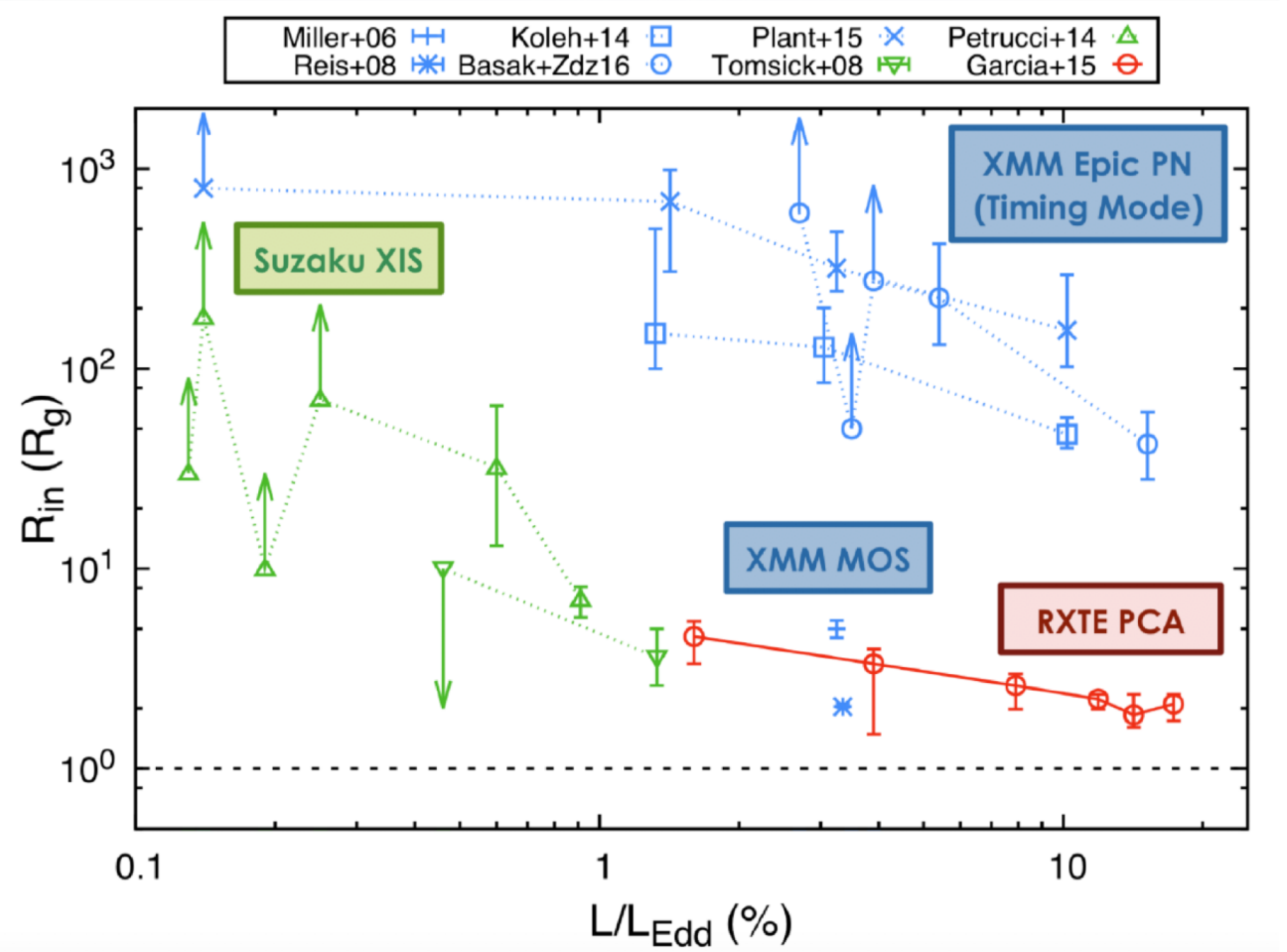


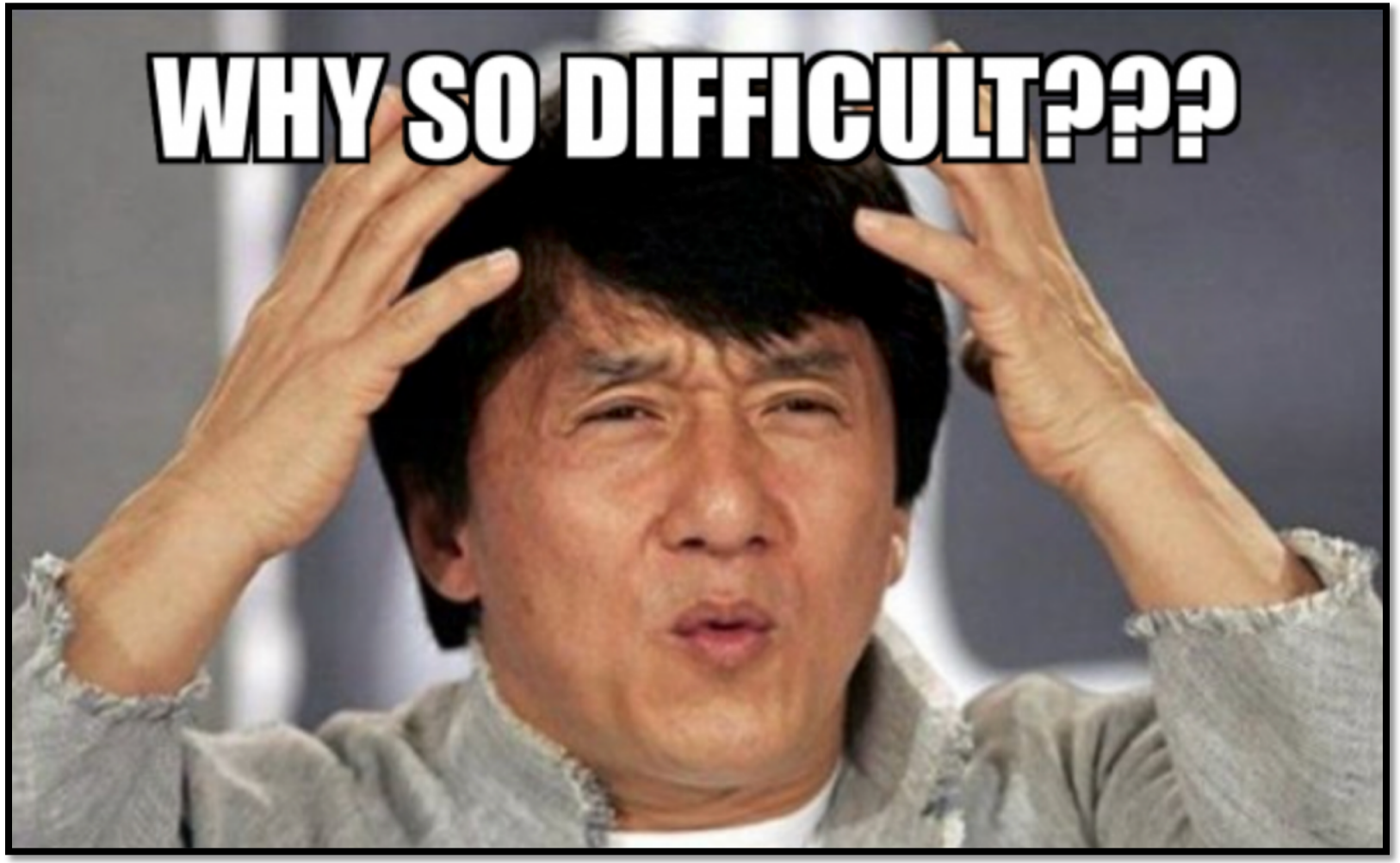
Not-negligible impact, although smaller than uncertainties of Planck measurements!

(Schellenberger et al., 2015, A&A, 575, 30)

Impact on accreting black hole physics

GX 339-4 Disk truncation disagreement

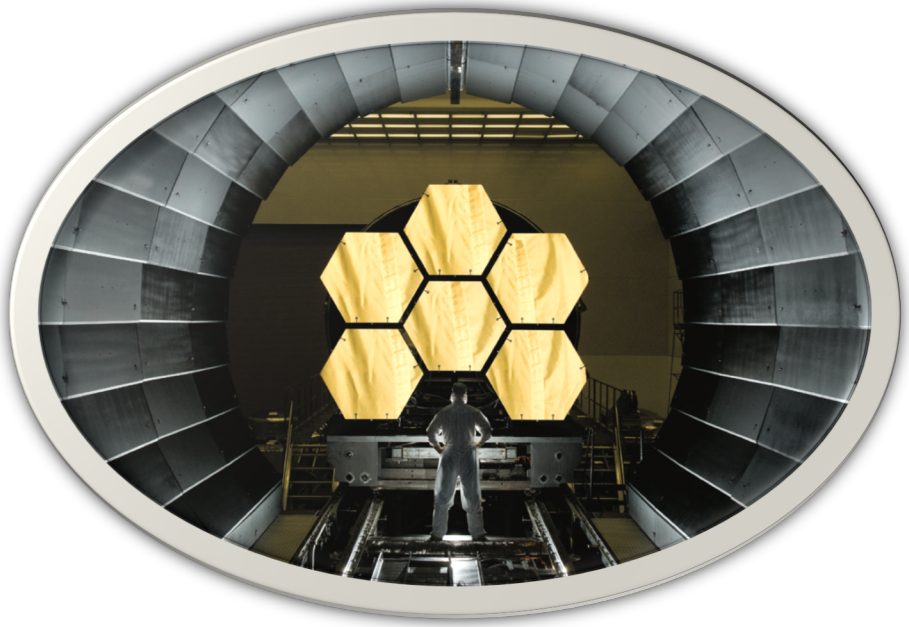



WHY SO DIFFICULT???

Why so difficult?

Theory

Full ground-calibration ➤ Complete instrument physical model

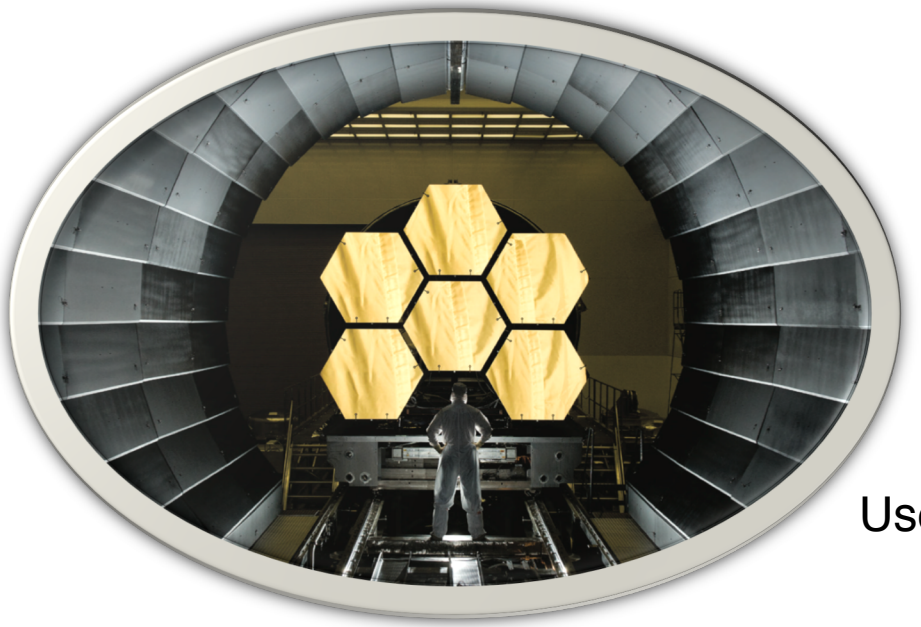


IDEAL

Why so difficult?

Practice

There is rarely enough time for a thorough ground-based calibration, research oddities, or opportunity to redo measurements

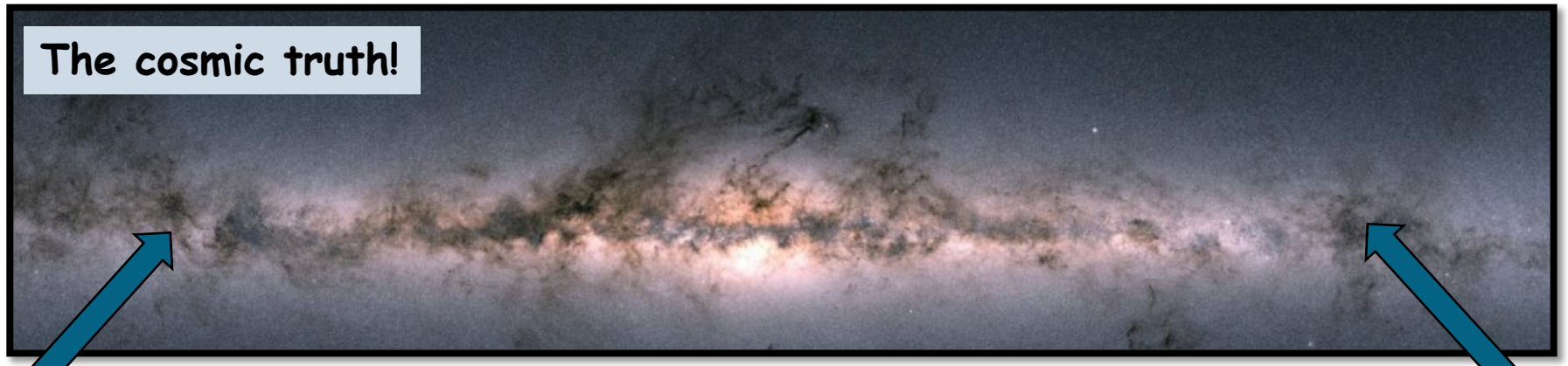


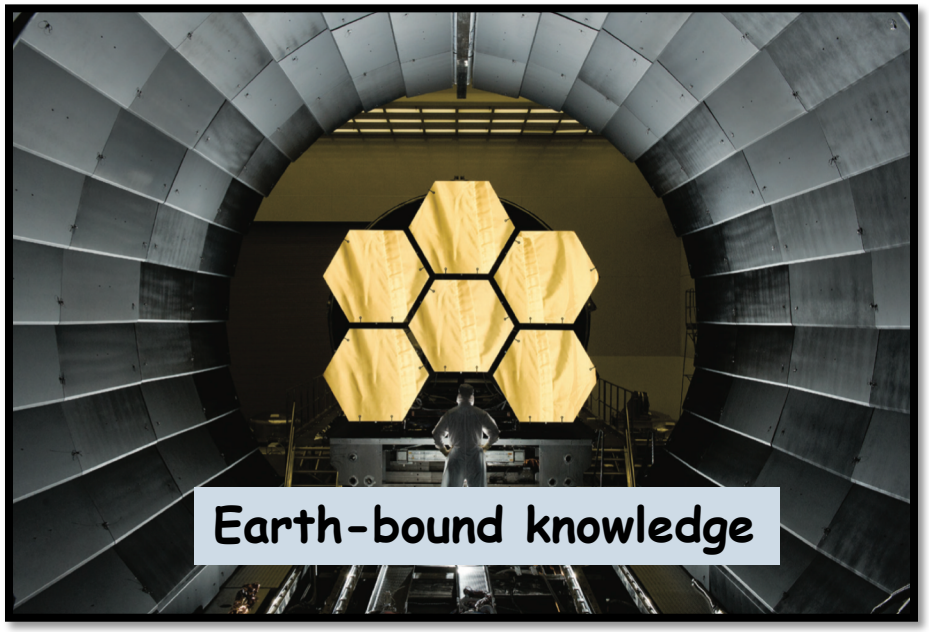
REALITY

Use ”standard candles” to update calibration

But these ”standard candles” are defined by the measurements of previous instruments with their own problems!

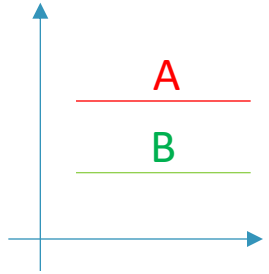
Calibration “chicken and egg”



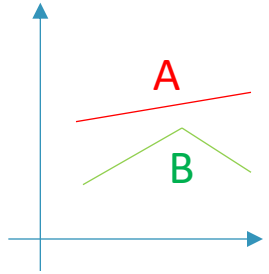


Cross-calibration parameters

- Cross-normalization
  - A constant that is equal to the flux ratio between two instruments in a specified band: $N_{1\text{-}5keV} = F_A/F_B$
  - A "fairly well-known" global offset
  - Fluctuations of this number between instruments can often be explained

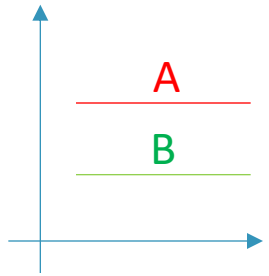


- Slope differences
  - Differences in the measured flux of sub-bins across an overlapping energy band between two instruments
  - Much harder to quantify
  - Difficult to measure due to source spectrum and instrument mode biases
  - Causes the most headache for instrument calibrators and users



Cross-calibration parameters

- Cross-normalization – Bookkeeping exercise
  - A constant that is equal to the flux ratio between two instruments in a specified band: $N_{1\text{-}5keV} = F_A/F_B$
  - A "fairly well-known" global offset
  - Fluctuations of this number between instruments can often be explained



- Slope differences – The main bulk of the IACHEC effort
  - Differences in the measured flux of sub-bins across an overlapping energy band between two instruments
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  - Difficult to measure due to source spectrum and instrument biases
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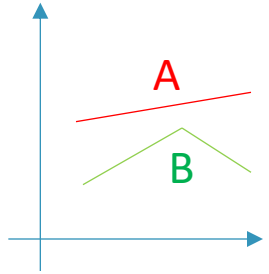
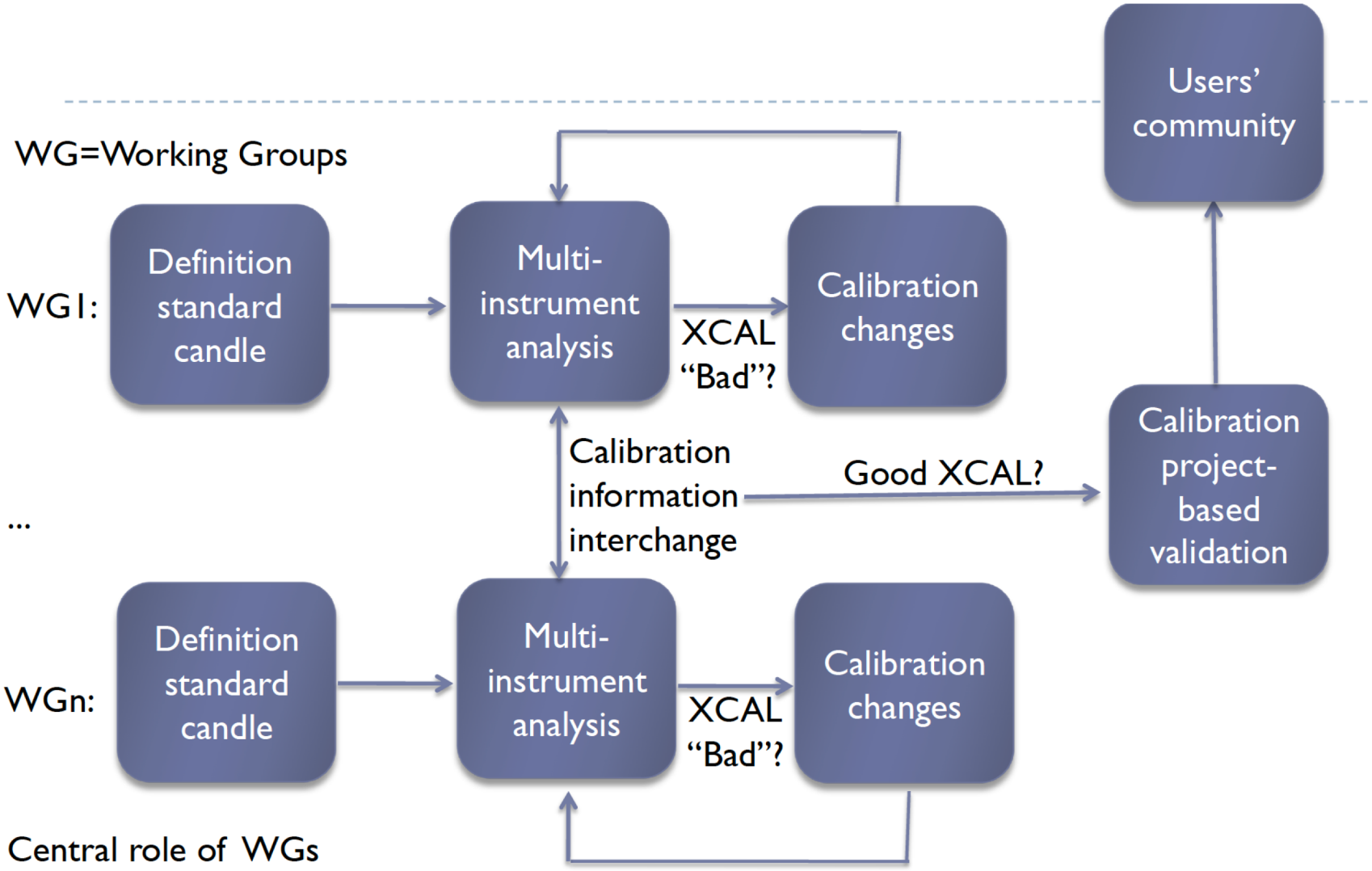


How does the IACHEC work



IACHEC Working Groups

- Methods:
  - Background (particles, “space weather”, cosmic sources)
  - Detectors (CCDs, calorimeters, proportional counters)
  - Coordinated observations
  - Emission line identification
  - Statistics
- Sources
  - Cluster of galaxies
  - Non-thermal SNR (e.g., Crab)
  - Thermal SNR
  - White Dwarfs and isolated Neutron Stars
- Infrastructure:
  - Communication, Legacy

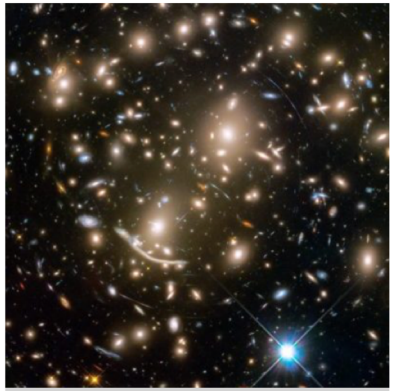
IACHEC Working Groups

Calibration Statistics

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

Read More »

Vinay Kashyap



Clusters of Galaxies

Aims to use clusters of galaxies as cross-calibration standards, using a systematic comparison of X-ray spectroscopy results obtained with all recent and current major X-ray missions.

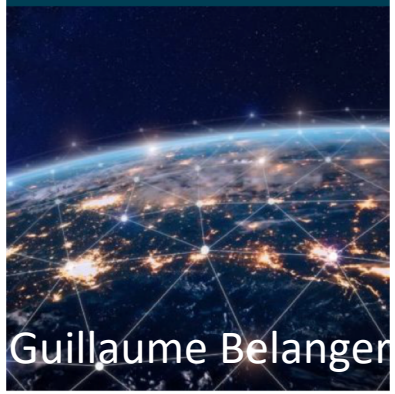
Read More »

Eric Miller

Communication

Aims to bring word of IACHECs activities and results to the greater astrophysical community

Read More »



Guillaume Belanger

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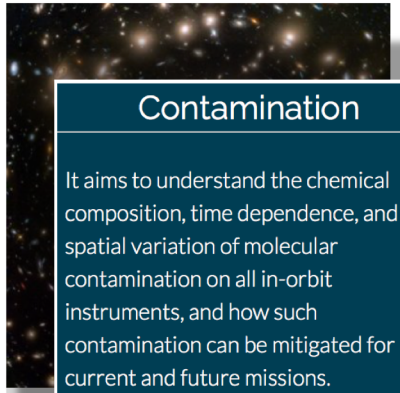
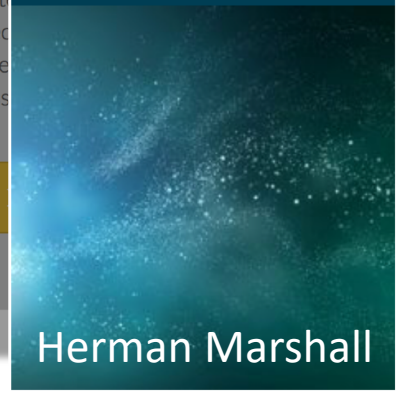


Contamination

It aims to understand the chemical composition, time dependence, and spatial variation of molecular contamination on all in-orbit instruments, and how such contamination can be mitigated for current and future missions.

Read More »



Herman Marshall

Communication

Coordinated Observations

The goal of this working group is to facilitate the coordination of calibration observations among operational observatories and the analysis and publication of the corresponding data.

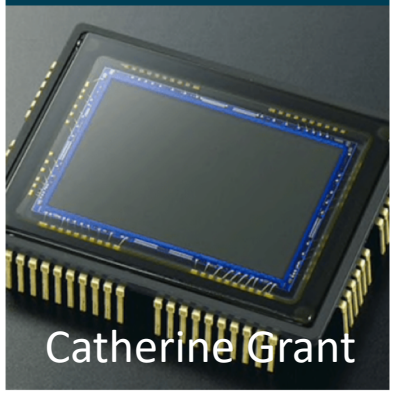
Read More »

Karl Forster

Detectors and Background

Provides a forum for cross-mission discussion and comparison of detector-specific modeling and calibration issues, and for measuring and modeling instrument background in the spatial, spectral, and temporal dimensions.

Read More »



Catherine Grant

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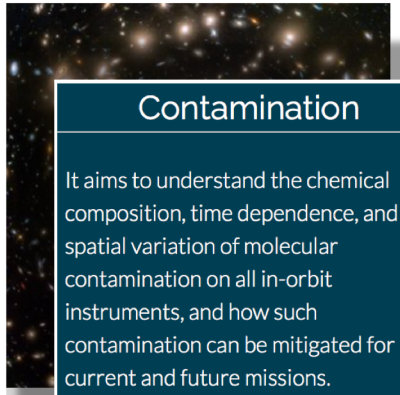

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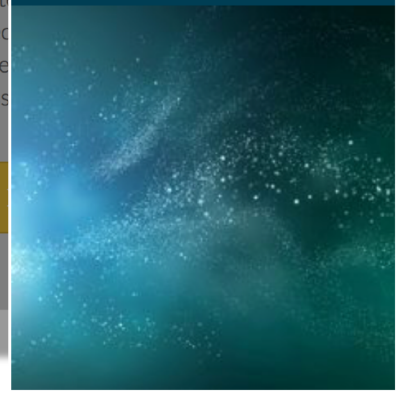

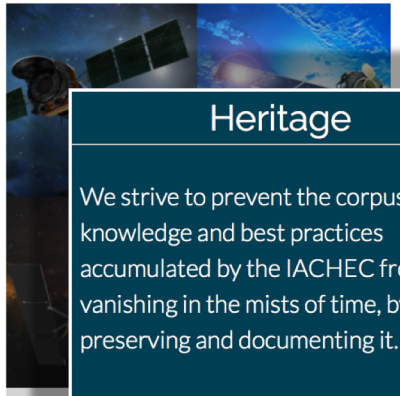

Detectors and Background

Heritage

We strive to prevent the corpus of knowledge and best practices accumulated by the IACHEC from vanishing in the mists of time, by preserving and documenting it.

Read More »

Matteo Guainazzi

High Resolution

It aims at a complete census of emission lines in high resolution observations made by the Chandra LEG/HEG and RGS, starting with the spectrum of Capella.

Read More »

Adam Foster

Non-thermal SNR

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

Read More »

Lorenzo Natalucci

IACHEC Working Groups

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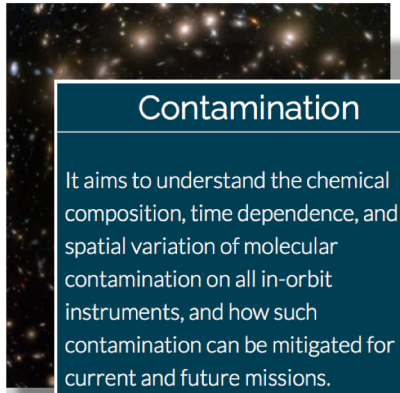

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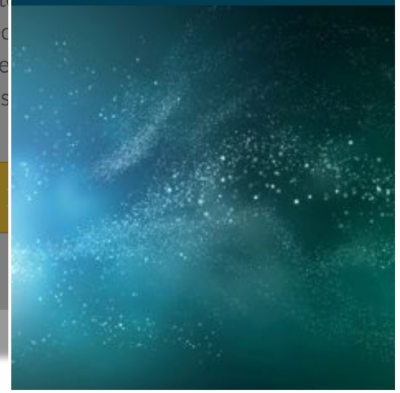

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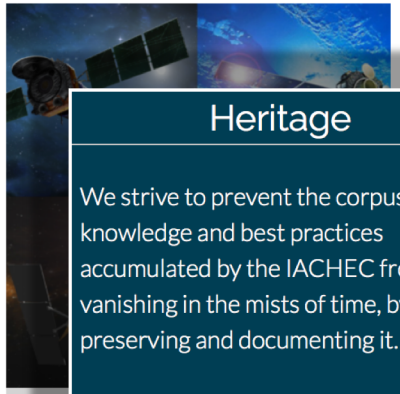

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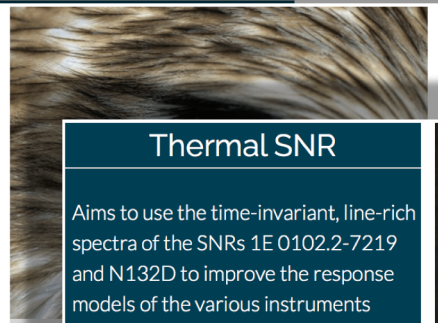
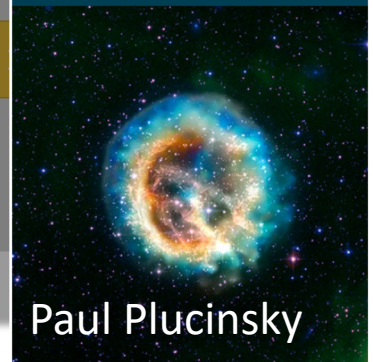


Non-thermal SNR

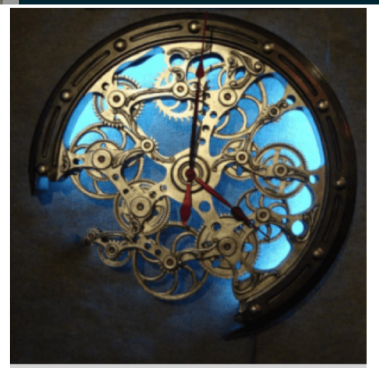
Thermal SNR

Aims to use the time-invariant, line-rich spectra of the SNRs 1E 0102.2-7219 and N132D to improve the response models of the various instruments (gain, CTI correction, QE, spectral redistribution function, etc) Â and to compare the absolute effective areas of the instruments at the energies of the bright line complexes.

Read More »



Paul Plucinsky



Timing

Provides a forum for in-orbit and on-ground timing calibrations, focusing on calibration discussions, issues, and lessons learned.

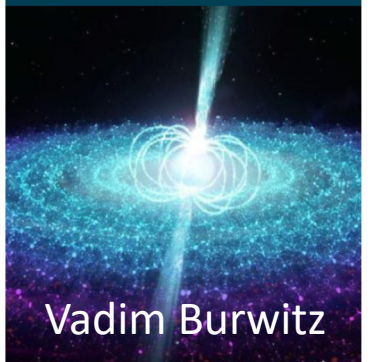
Read More »

Yukikatsu Terada

White Dwarf and Isolated Neutron Stars

It aims at comparing atmospheric models in conjunction with analysis of high-resolution data.

Read More »



Vadim Burwitz

Special WG meetings

Calibration statistics chair: Vinay Kashyap

Working Group Meeting
2020 Dec 1

6-8am PST / 9-11am EST / 2-4pm GMT / 3-5pm CET / 7:30-9:30pm IST / 10pm-Midnight CT / 11pm-1am(+1d) JST

iachec.org/calibration-statistics/#2020dec1

A follow-up to the IACHEC 2020 Online Symposium, this two-hour meeting is designed to give more opportunity for detailed discussions. Each presenter will have approximately 5 min to speak, with the rest of the time given over to discussions. On the agenda:

- **High-Energy Polarization**: *Herman Marshall* (MIT)
- **Handling model uncertainties by means of comparison densities**: *Sara Algeri* (Minnesota)
- **Suzaku XIS background treatment: A case study with N132D**: *Eric Miller* (MIT)
- **Likelihood selection**: *Guillaume Belanger* (ESA)
- **Using the Kaastra cstat goodness-of-fit in Sherpa**: *Vinay Kashyap* (CfA)
- **Concordance Q&A**: *Yang Chen* (Michigan) and *Herman Marshall* (MIT)

Thermal SNRs chair: Paul Plucinsky

Working Group Meeting Dec 11th, 10 am EST, 16:00 UTC
Contact Paul Plucinsky if you are interested

Coordinated Observations chair: Karl Forster

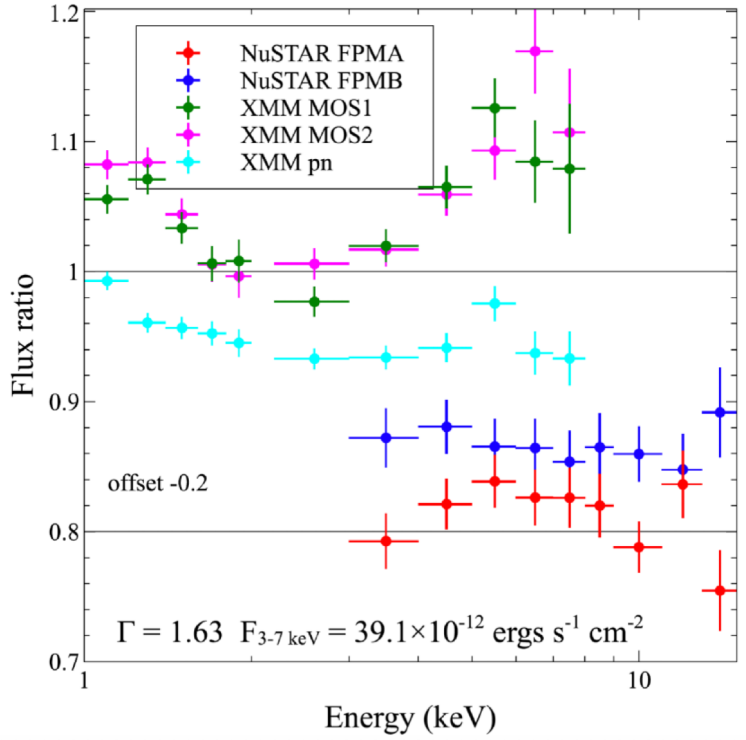
Working Group Meeting in December TBD
Contact Karl Forster if you are interested

What does the IACHEC do

- Define new calibration standards
  - Characterize sources (physically and/or phenomenologically)
  - Compare results from different missions
- Review in-flight calibration plans and results
  - Document the cross-calibration status (refereed journals)
  - Investigate optics and detector physics
  - Propose calibration adjustments (responsibility of Projects)
- Advise on calibration plans for new missions
  - Support the design and development of ground-based plans
  - Support the definition of in-flight plans
- Best practices: analysis, statistics, knowledge preservation

Compare results from different missions

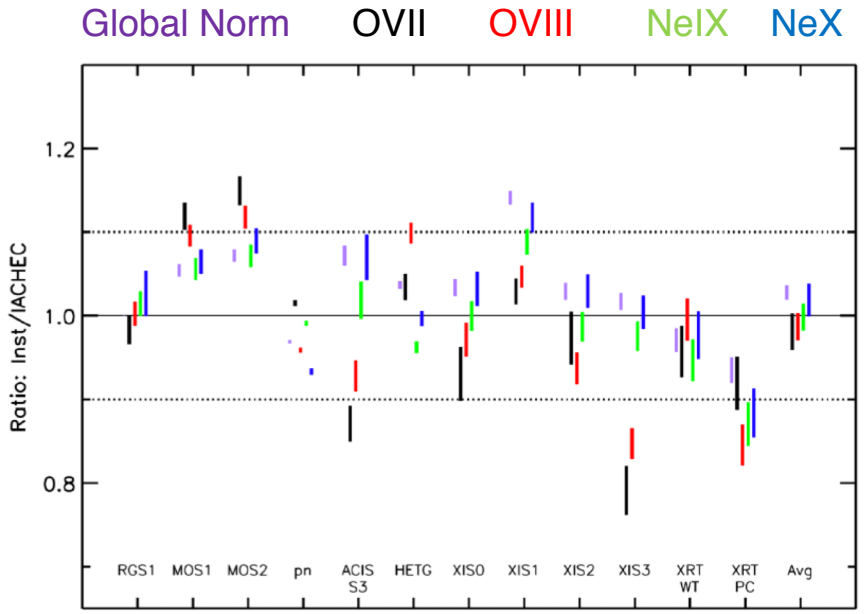
Comparing broad-band fluxes
(3C273, radio-loud AGN)



Madsen et al., 2017, AJ, 153, 2

Comparing emission line intensities

(1E0102.2-7219 SNR)



Plucinsky et al., 2017, A&A, 597, 35

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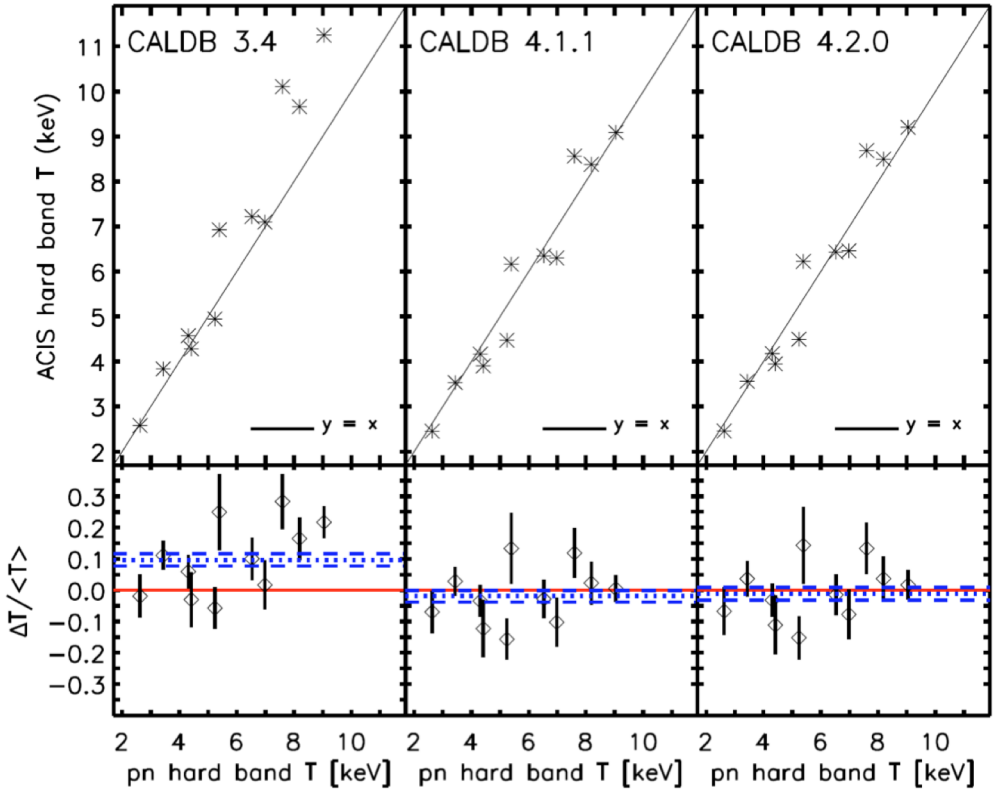
  - Support the definition of in-flight plans
- Best practices: analysis, statistics, knowledge preservation

Propose/inform calibration updates

- Galaxy clusters: stable sources, “simple” physics
- Larger temperature discrepancies in the past
- EPIC temperatures validated with Fe line ratios
- Chandra optics model improved to reduce discrepancy
- Project started at the 2nd IACHEC. Still an issue now.

Difference between galaxy cluster temperatures with ACIS and EPIC as a function of CALDB



Nevalainen et al., 2010, A&A, 523, 22

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- Advise on calibration plans for new missions
  - Support the design and development of ground-based plans
  - Support the definition of in-flight plans
- Best practices: analysis, statistics, knowledge preservation

Support to future missions

- Synopsis of calibration plans for modern X-ray observatories
- Heavily used for the preparation of the Hitomi and XRISM in-flight plan

Guainazzi et al., 2015, JATIS, 1(4), 047001

On the in-flight calibration plans of modern x-ray observatories

Matteo Guainazzi
Laurence David
Catherine E. Grant
Eric Miller
Lorenzo Natalucci
Jukka Nevalainen
Robert Petre
Marc Audard

Table 3 Main sources used for the calibration of the effective area below 10 keV.

Source	HRC	LETG	HETG	RGS	ACIS	EPIC-MOS	EPIC-pn	GSC	SSC	JEM-X	PCA	XIS	XRT
1E0102-72					X	X						X	X
3C273		X	X										X
Abell1795					X	X	X						
Abell2029					X	X	X					X	
Bright Earth limb												X	
Cygnus Loop												X	
Coma cluster					X	X	X					X	
Crab Nebula				X				X	X	X	X		X
G21.5-0.9	X				X								X
H1426+428			X										X
HZ43	X	X											
Mkn421	X	X	X	X	X[a]								X
Perseus cluster						X	X						
PKS2155-304	X	X	X	X	X[a]							X	
RXJ1856.5-3754		X		X								X	X

[a]Observations done with a combination gratings + detector.

Table 4 Sources used for the calibration of the effective area above 10 keV.

Source	AGILE	BAT	HXD	HEXTE	IBIS	NuSTAR
Crab Nebula	X[a]	X	X	X	X	X
PSR1509-58			X		X	

[a]Crab pulsar.

What does the IACHEC do

- Define new calibration standards
  - Characterize sources (physically and/or phenomenologically)
  - Compare results from different missions
- Review in-flight calibration plans and results
  - Document the cross-calibration status (refereed journals)
  - Investigate optics and detector physics
  - Propose calibration adjustments (responsibility of Projects)
- Advise on calibration plans for new missions
  - Support the design and development of ground-based plans
  - Support the definition of in-flight plans
- Best practices: analysis, statistics, knowledge preservation

Concordance Project

”How to change Effective Areas (EAs) given that observations by different instruments differ?”

- Method: multiplicative Shrinkage
  - Uses all data to fit the best true fluxes, then correct EAs
- Developed jointly with statistic academicians
- Working on various cross-calibration data
- Goal: informing further EA calibration improvements

Presentation on November 24th at 11:00 ET

Program: Day 1

November 23rd: 9:00 – 12:00 EST

Topic	Time	Speaker	Title
Welcome:	09:00 – 09:30	IACHEC WG Chairs	The IACHEC charter
Calibration Issues & Solutions:	09:30 – 09:50	Jeremy Drake	Chandra
	09:50 – 10:10	Craig Markwardt	Nicer
	10:10 – 10:30	Jamie Kennea	Swift
Break	10:30 – 10:40		
	10:40 – 11:00	Michael Smith	XMM
	11:00 – 11:20	Gulab Dewangan	AstroSAT
	11:20 – 11:40	Brian Grefenstette	NuSTAR
	11:40 – 12:00	Guillaume Belanger	Integral

Session Chair: Adam Foster

Special WG meetings

Calibration statistics chair: Vinay Kashyap

Working Group Meeting
2020 Dec 1

6-8am PST / 9-11am EST / 2-4pm GMT / 3-5pm CET / 7:30-9:30pm IST / 10pm-Midnight CT / 11pm-1am(+1d) JST

iachec.org/calibration-statistics/#2020dec1

A follow-up to the IACHEC 2020 Online Symposium, this two-hour meeting is designed to give more opportunity for detailed discussions. Each presenter will have approximately 5 min to speak, with the rest of the time given over to discussions. On the agenda:

- **High-Energy Polarization**: *Herman Marshall* (MIT)
- **Handling model uncertainties by means of comparison densities**: *Sara Algeri* (Minnesota)
- **Suzaku XIS background treatment: A case study with N132D**: *Eric Miller* (MIT)
- **Likelihood selection**: *Guillaume Belanger* (ESA)
- **Using the Kaastra cstat goodness-of-fit in Sherpa**: *Vinay Kashyap* (CfA)
- **Concordance Q&A**: *Yang Chen* (Michigan) and *Herman Marshall* (MIT)

Thermal SNRs chair: Paul Plucinsky

Working Group Meeting Dec 11th, 10 am EST, 16:00 UTC
Contact Paul Plucinsky if you are interested

Coordinated Observations chair: Karl Forster

Working Group Meeting in December TBD
Contact Karl Forster if you are interested

2021 Mountain Lake Lodge (Pembroke, VA, USA)

15th IACHEC meeting, 26-29 April, 2021

If the in-person meeting remains impossible we will convert into a virtual meeting on the same dates