IACHEC: an example of international multi-mission collaboration

Matteo Guainazzi
(*Athena*/THESEUS/XRISM Study Scientist & former IACHEC Chair)

Neural correlates of interspecies perspective taking in the post-mortem Atlantic Salmon: An argument for multiple comparisons correction

Craig M. Bennett[1], Abigail A. Baird[2], Michael B. Miller[1], and George L. Wolford[3]

[1] Psychology Department, University of California Santa Barbara, Santa Barbara, CA; [2] Department of Psychology, Vassar College, Poughkeepsie, NY; [3] Department of Psychological & Brain Sciences, Dartmouth College, Hanover, NH

INTRODUCTION

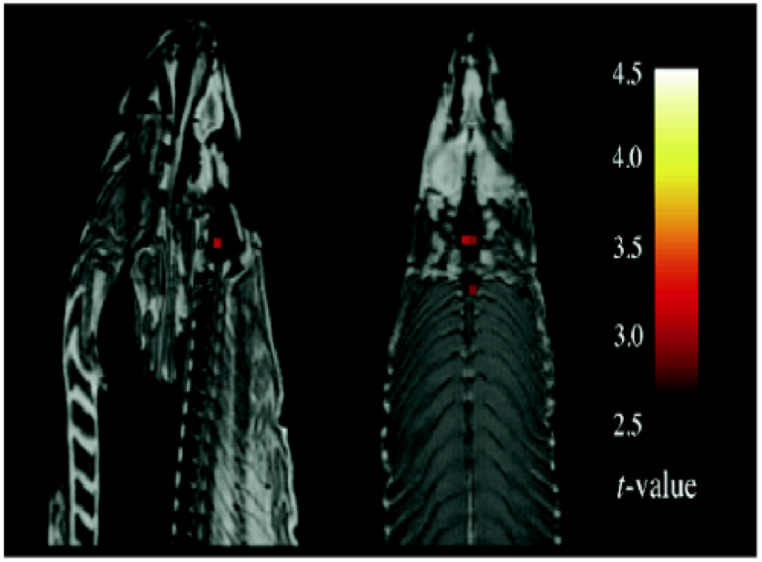
With the extreme dimensionality of functional neuroimaging data comes extreme risk for false positives. Across the 130,000 voxels in a typical fMRI volume the probability of a false positive is almost certain. Correction for multiple comparisons should be completed with these datasets, but is often ignored by investigators. To illustrate the magnitude of the problem we carried out a real experiment that demonstrates the danger of not correcting for chance properly.

METHODS

Subject. One mature Atlantic Salmon (Salmo salar) participated in the fMRI study. The salmon was approximately 18 inches long, weighed 3.8 lbs, and was not alive at the time of scanning.

Task. The task administered to the salmon involved completing an open-ended mentalizing task. The salmon was shown a series of photographs depicting human individuals in social situations with a specified emotional valence. The salmon was asked to determine what emotion the individual in the photo must have been experiencing.

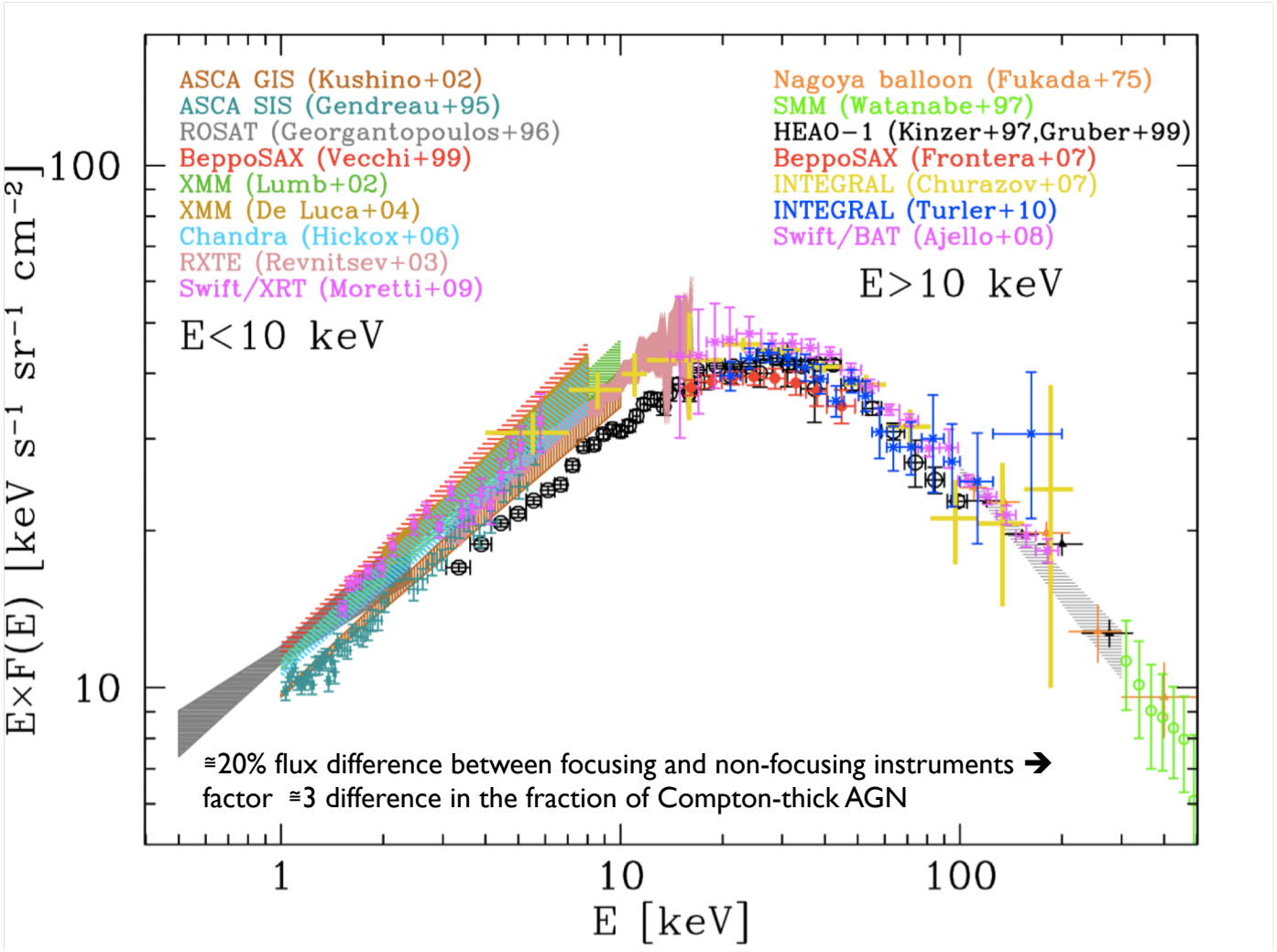
GLM RESULTS



A *t*-contrast was used to test for regions with significant BOLD signal change during the photo condition compared to rest. The parameters for this comparison were $t(131) > 3.15$, p(uncorrected) < 0.001, 3 voxel extent threshold.

Several active voxels were discovered in a cluster located within the salmon's

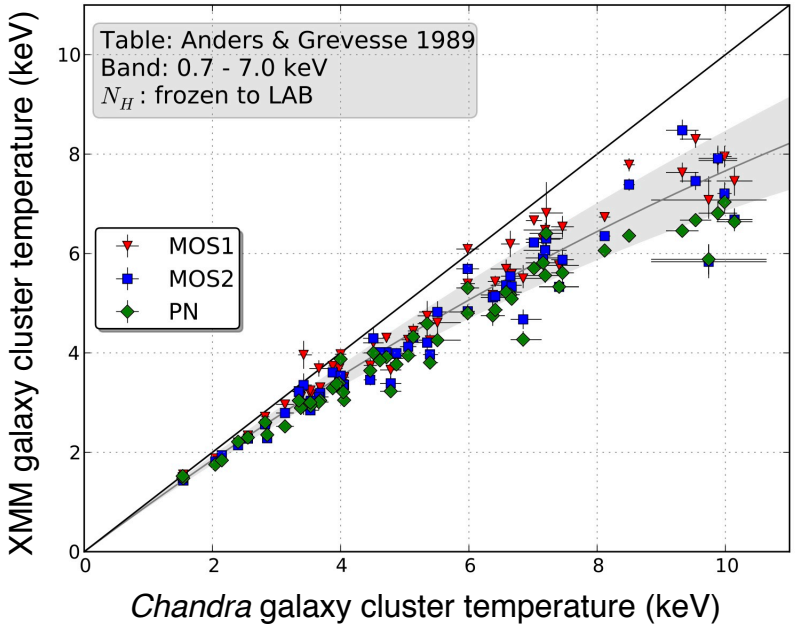
A textbook example: the XRB

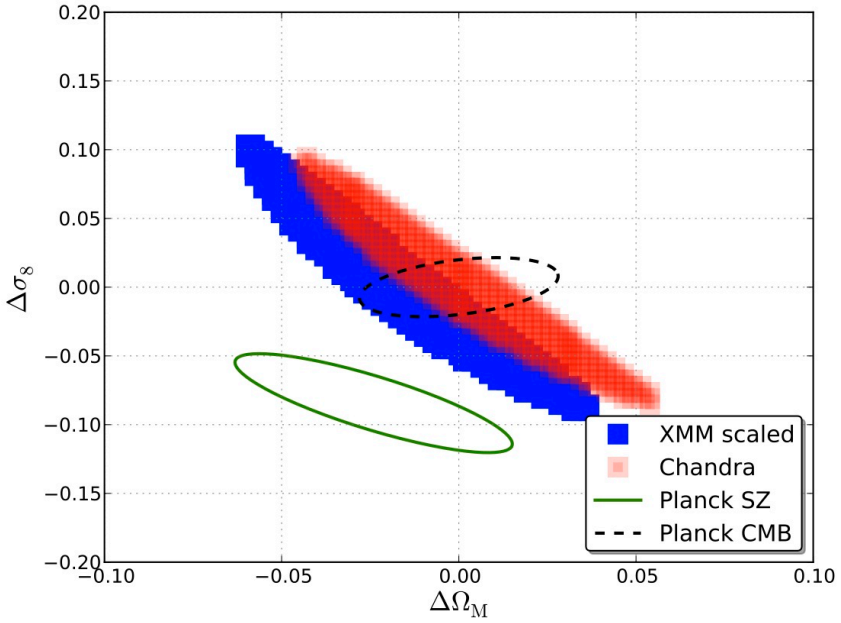


(Credit: A.Comastri, Un. Bologna)

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!

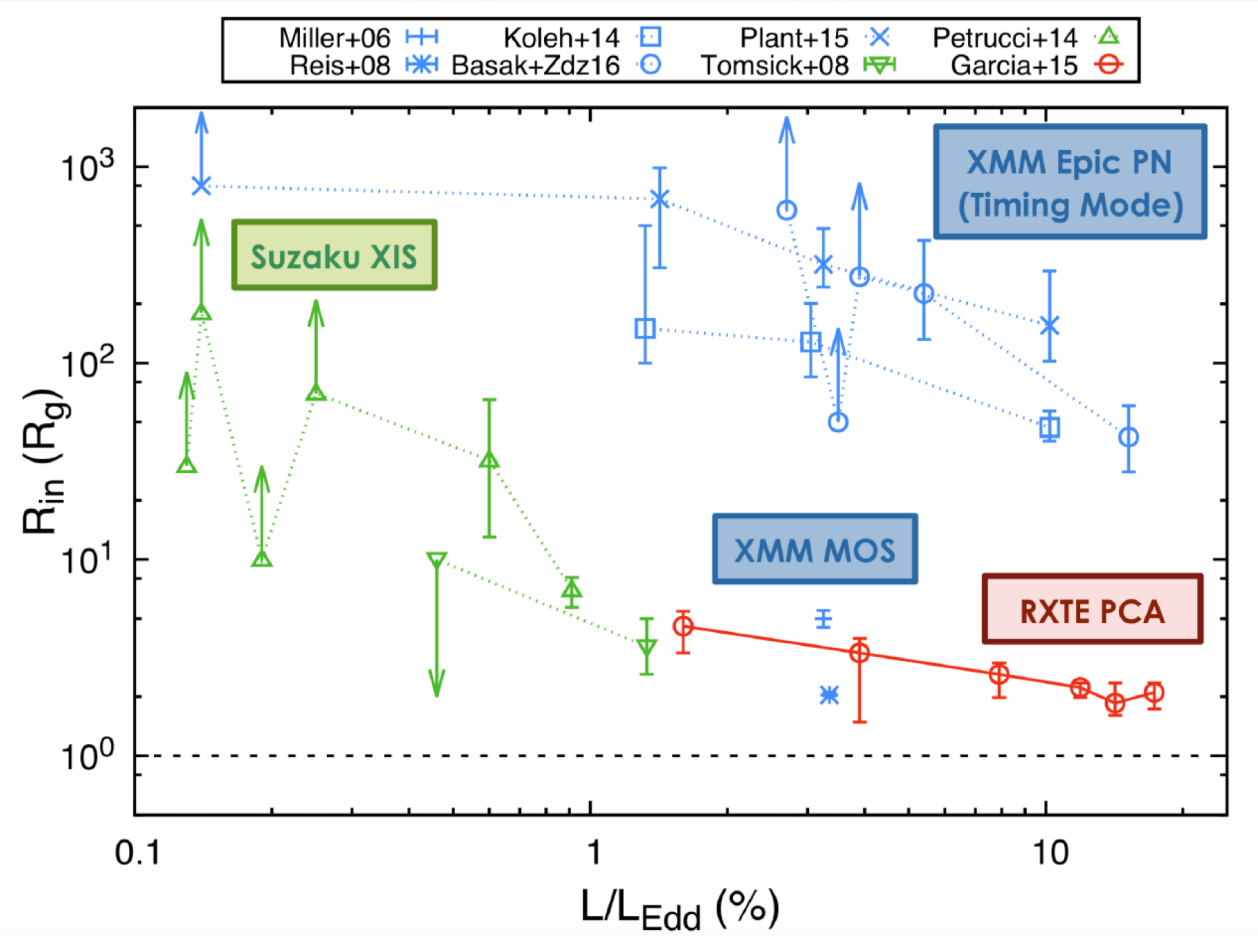




Not-negligible impact, although smaller than uncertainties of Planck measurements!

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

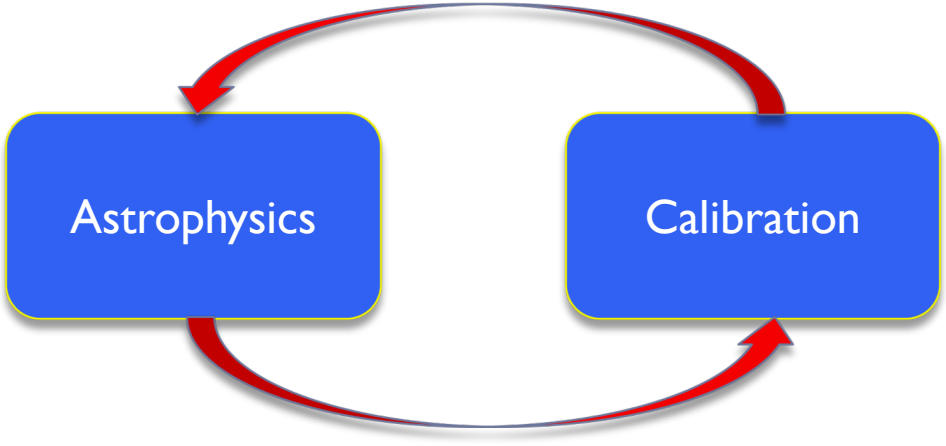
Impact on accreting black hole physics



5% systematic error on the calibration of the effective area → ≥0.1 error on the BH spin

Why so difficult?

- Theory: full ground-calibration ➔ complete instrument physical model
- Practice: there is hardly enough time for full ground-based calibrations, and to properly maintain know-how and data
- Reality: instrument on-flight performances change
- X-ray astronomy cannot rely on standard candles *strictu sensu*



Calibration of X-ray instruments is always "with respect to ..."

IACHEC in a nutshell

- The IACHEC is the *International Astronomical Consortium for High-Energy Calibration*
- Founded in 2006 on impulse by Marcus Kirsch (ESA) and Steve Sembay (University of Leicester).
- It is a shared undertaking among high-energy calibrators to coordinate (and therefore strengthen) our work
- It acts as 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
- Not directly funded by any Agencies or institutions. Individual projects/missions contribute through the work and mission budget of their calibration teams
- **Strongly endorsed** by the *XMM-Newton* and *Chandra* User's Group

http://web.mit.edu/iachec/

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

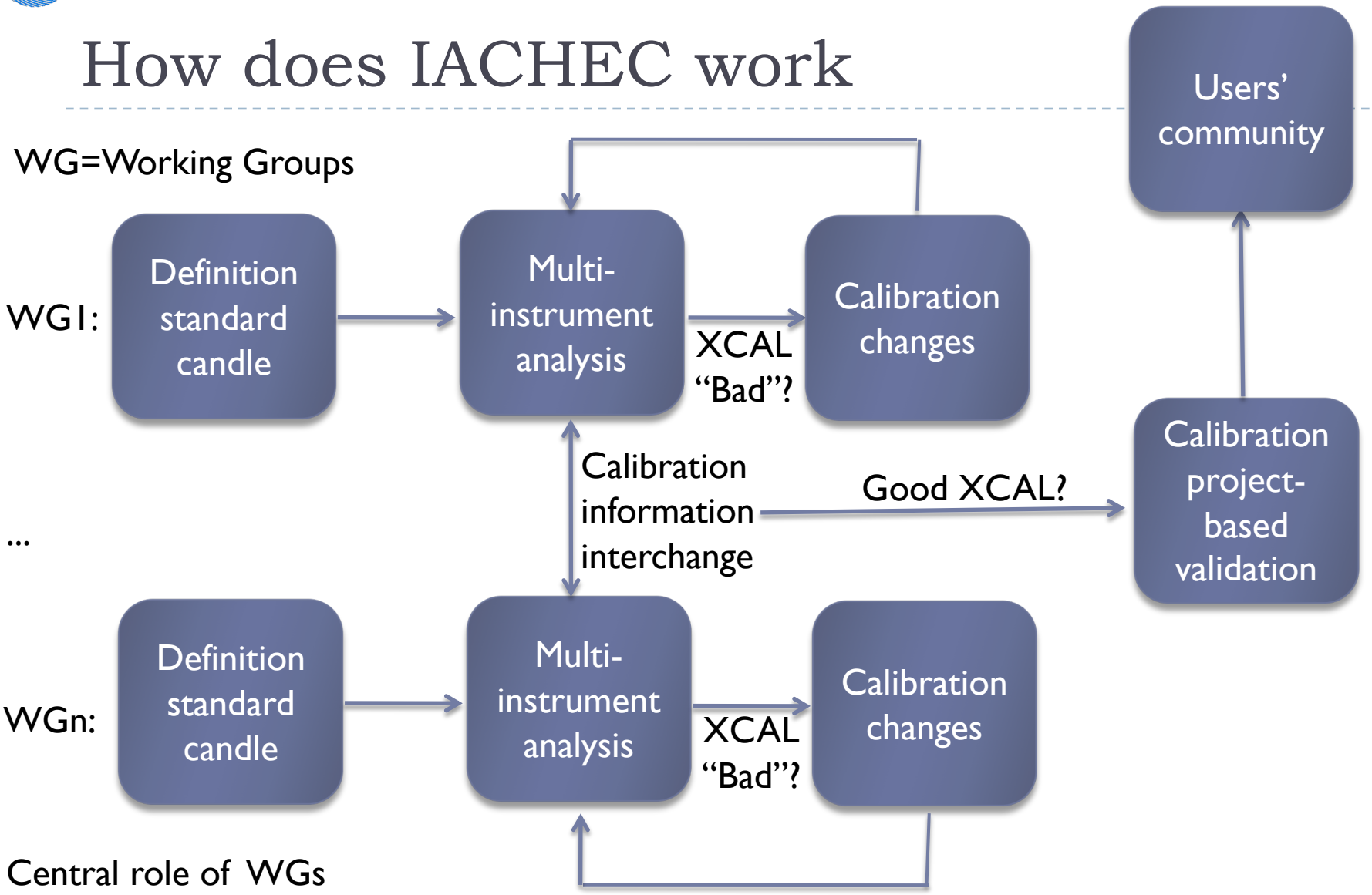
`http://web.mit.edu/iachec/wgs/index.html`

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

`http://web.mit.edu/iachec/`

How does IACHEC work



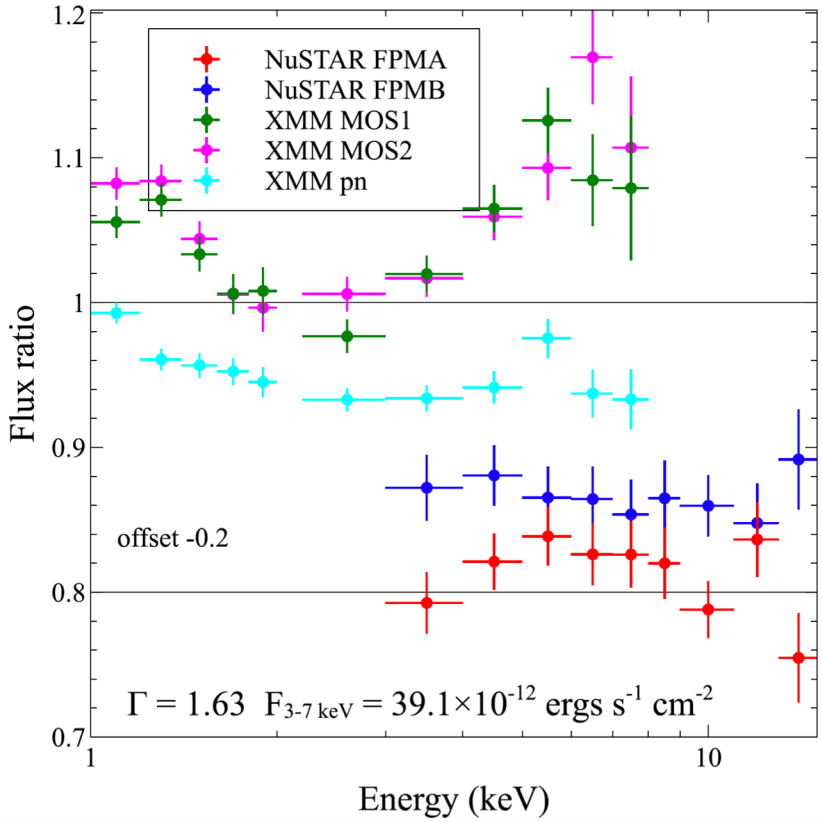
Central role of WGs

Process not always smooth and linear!

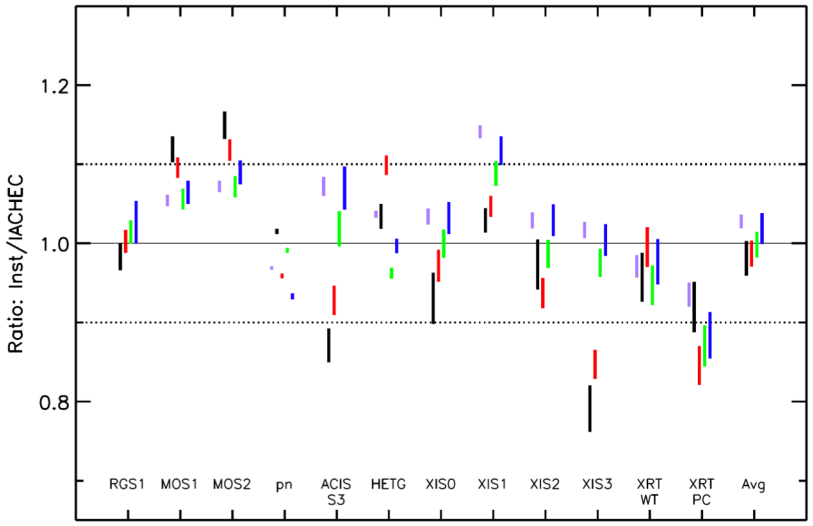
http://web.mit.edu/iachec/wgs/index.html

Document cross-calibration status

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



Comparing emission line intensities
(1E0102-72, SNR)

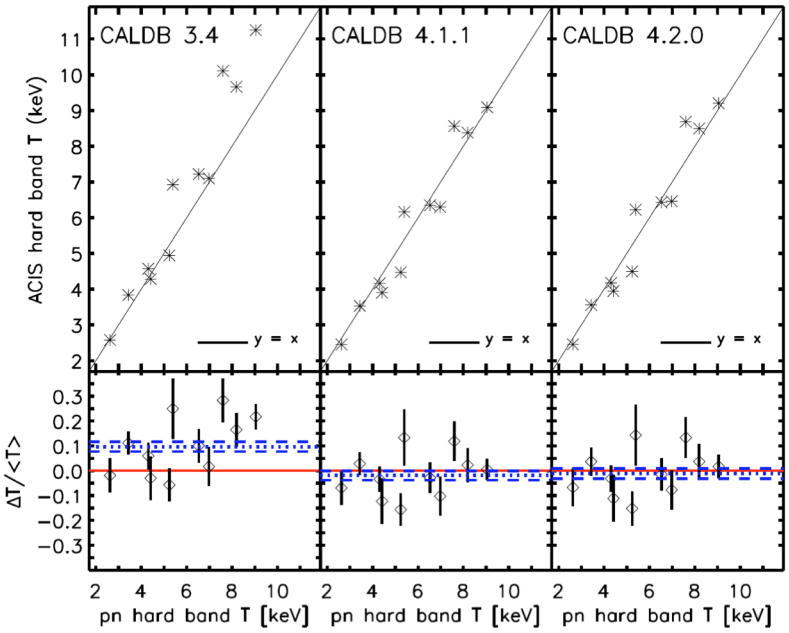


(Madsen et al., 2017, AJ, 153, 2; Plucinsky et al., 2017, A&A, 597, 35)

Propose/inform calibration updates

- Galaxy clusters: stable sources, "simple" physics
  - Cons: complex morphology
- 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

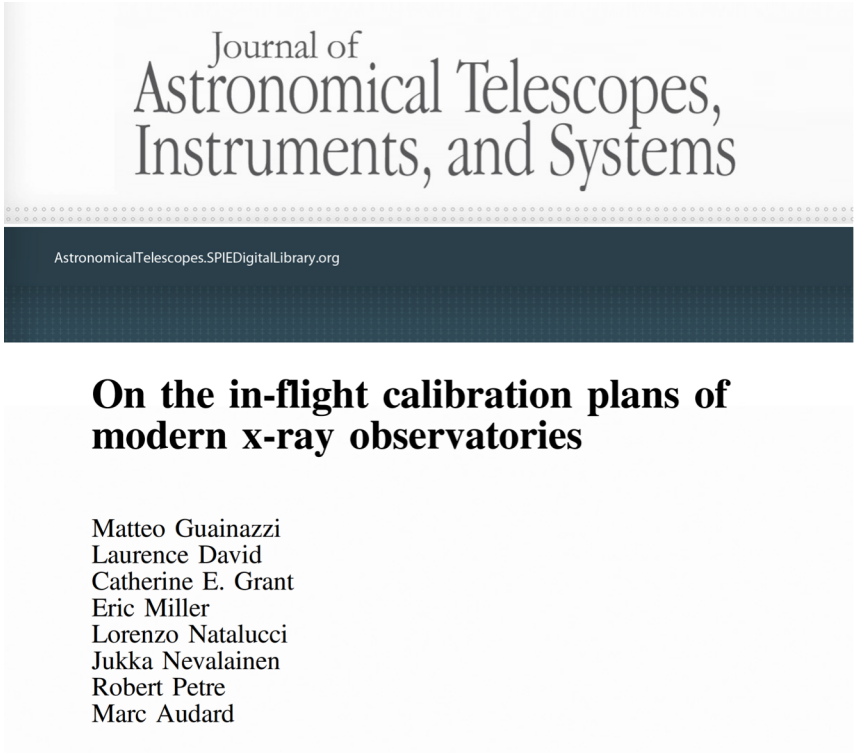


(Nevalainen et al., 2010, A&A, 523, 22)

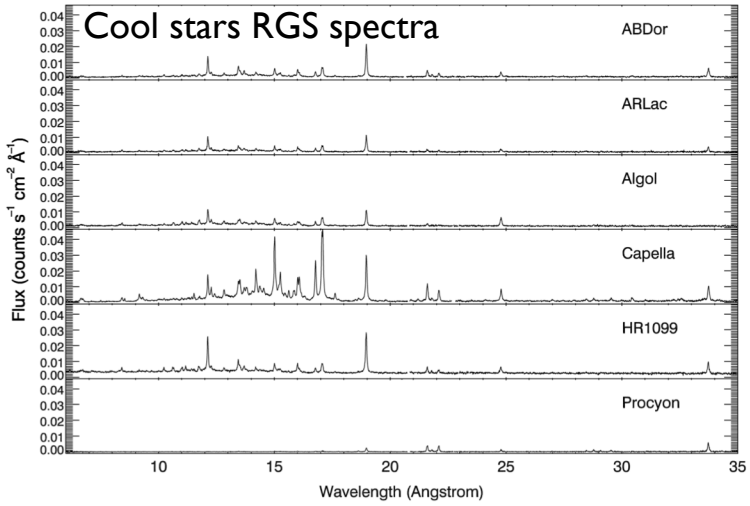
Concordance project

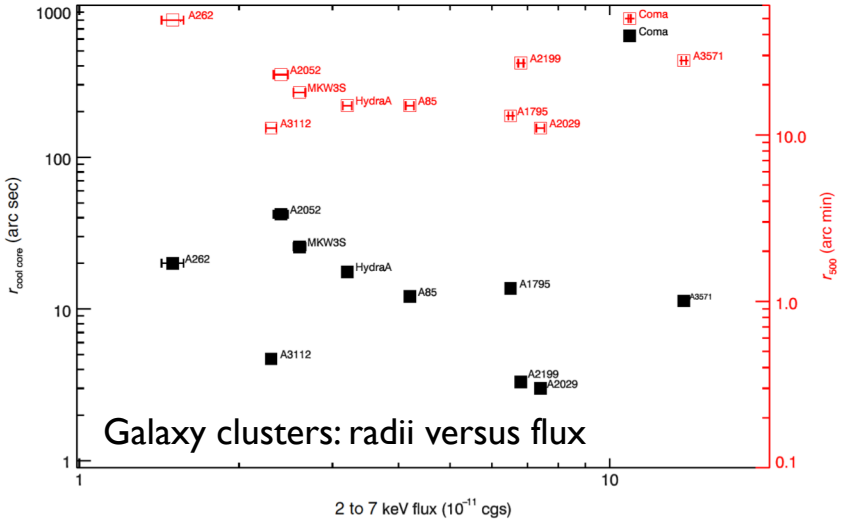
- Aims at answering: "How to change Effective Areas (EAs) given that observations by different instruments differ?"
- Method: multiplicative Shrinkage
  - Uses all data to fit the best true fluxes, then correct EAs
  - Needs prior on the fractional uncertainty on EAs (τ)
  - If ground calibration is poor (large τ), observations drive EA
  - If observations are poor (large σ), prior prevails
- Developed jointly with statistic academicians
- IACHEC scientists set τ values
- Working on various cross-calibration data
- Goal: informing further EA calibration improvements

Support to future missions



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





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

10 **Golden Rules** of (X-ray) calibration

1. **Think of a mission as a single instrument** [credit: S.Sembay]
2. Ground calibration is never sufficient ...
3. ...one might end-up need recalibrate everything
4. Integrate calibration data in "CALDB" as early as possible
5. Integrate calibration procedures in science analysis s/w
6. Establish *before launch* a cross-calibration working team
7. Facilitate communication among Instrument Teams since $T_{0,ops}$
8. Allow Instrument Teams access to all data
9. Do not neglect the potential help of the community
10. Do not hesitate to rely on colleagues from the IACHEC

11. There is no golden rule, of course