Status of the Concordance Project

Herman L. Marshall

Yang Chen, Xiao-Li Meng, Xufei Wang, David van Dyk, Vinay Kashyap, Paul Plucinsky, Matteo Guainazzi

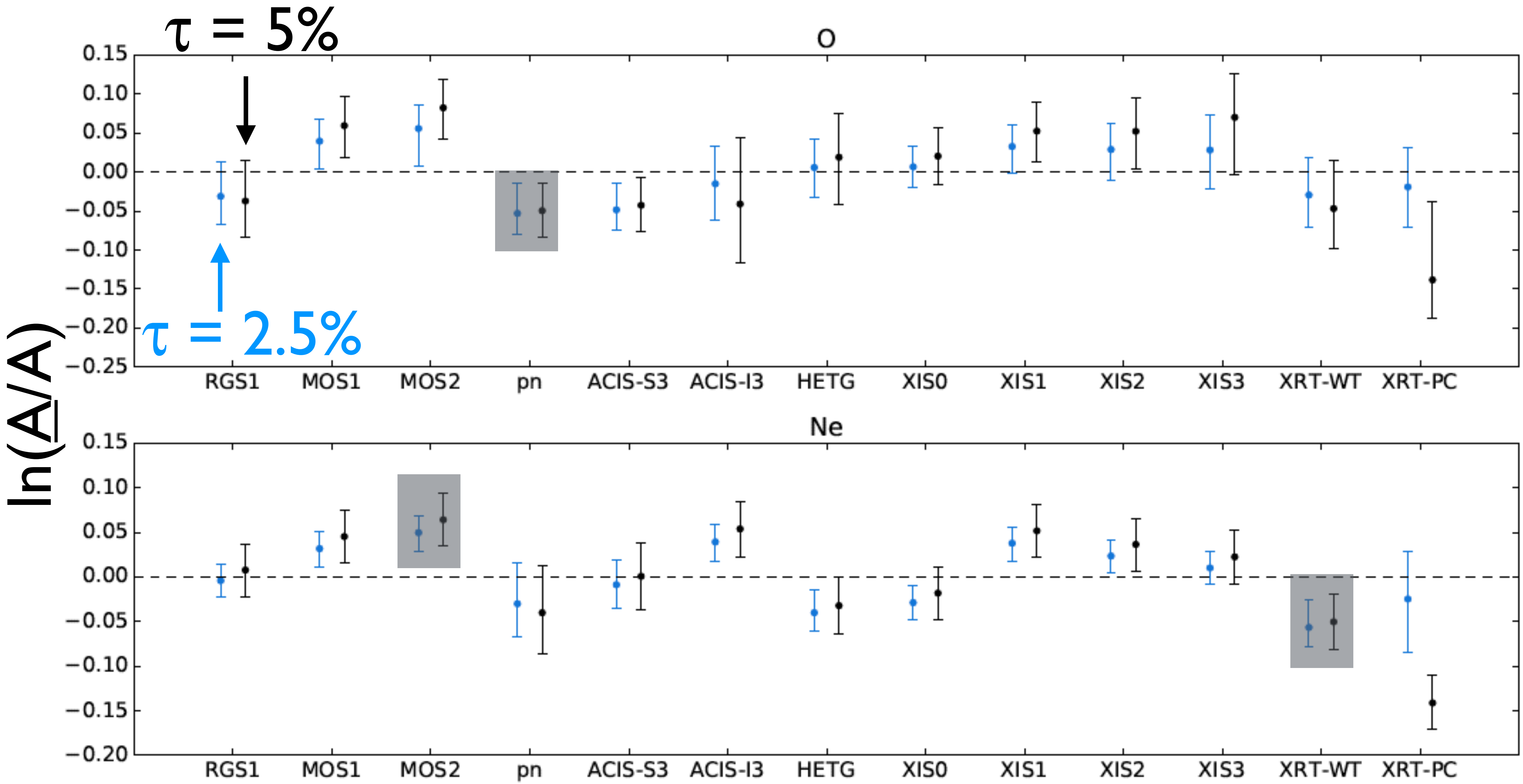
The Goal

- The problem: in-flight data show discrepancies
  - Cluster temperatures and fluxes
  - Blazar fluxes from simultaneous observations
  - SNR line fluxes
  - No absolute calibrators across all bands
- Missions characterize systematic uncertainties internally and independently
- Assuming we *should*, how does IACHEC *change* a mission's calibration?
- Specifically: derive EAs changes for optimal agreement

Concordance Overview

- Shrinkage method (Meng, 2015 IACHEC)
  - Start with C_{ij} = Counts for instrument i (1..N), source j (1..M)
  - Assume "true" areas A_i, "true" fluxes F_j, σ_{ij} = st. dev. in $\ln(C_{ij})$
  - Estimate F_j by $f_j = C_{ij} / a_i$ (a_i = prior estimate of A_i)
  - Method determines "best" $\underline{F}_j$ and "better" EAs $\underline{a}_i = a_i^w (C_{ij}/\underline{F}_j)^{1-w}$
    - $w = 1/(1+M\tau^2/\sigma_{ij}^2)$, τ = "a priori" st.dev. in $\ln(a)$
    - w = 0 means data dominate, drive change in EA
    - w = 1 means data are mediocre, EA isn't changed
    - brings $\underline{f}_j = C_{ij} / \underline{a}_i$ closer to *but not precisely* to $\underline{F}_j$
- IACHEC team sets τ, runs shrinkage analysis
  - IACHEC team recommends changes from a_i to $\underline{a}_i$
  - Process runs for each of many bandpasses "independently"

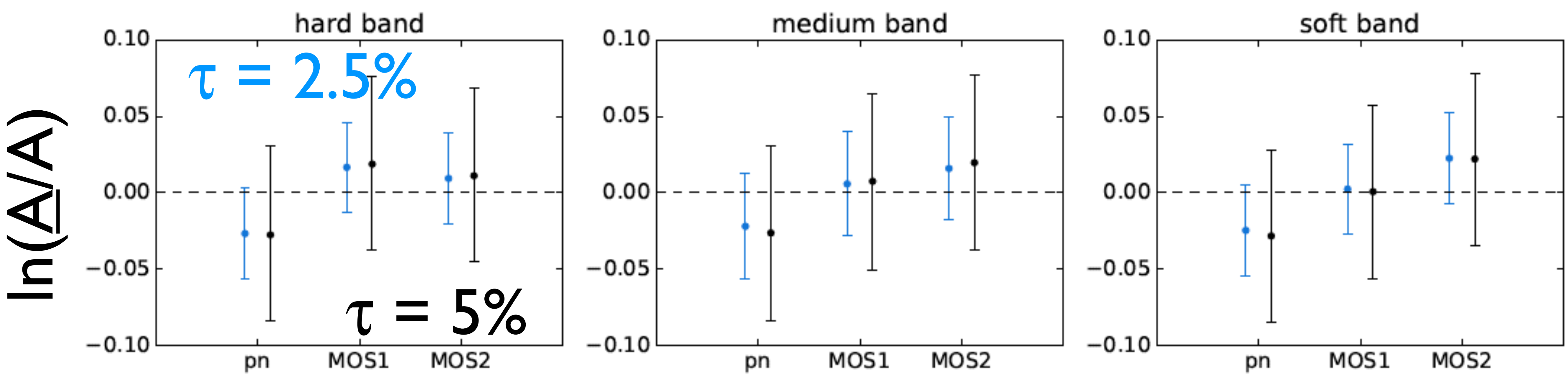
Concordance 1: 1E0102



Chen+ '18

Concordance 2: 2XMM

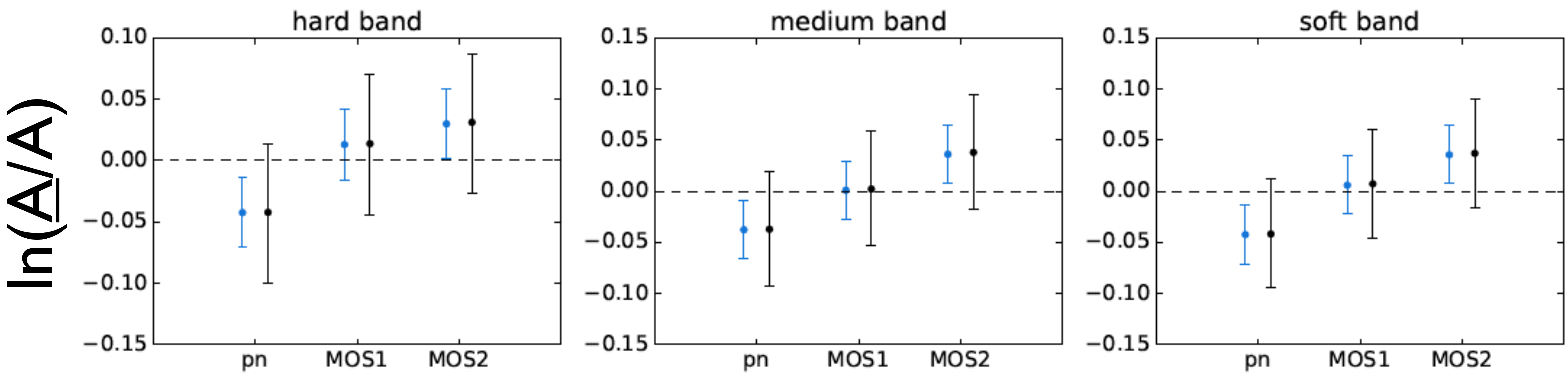
- Data from Matteo Guainazzi
- Based on 42 sources from the 2XMM catalog
- Unaffected by pileup; no EA change required



Chen+ '18

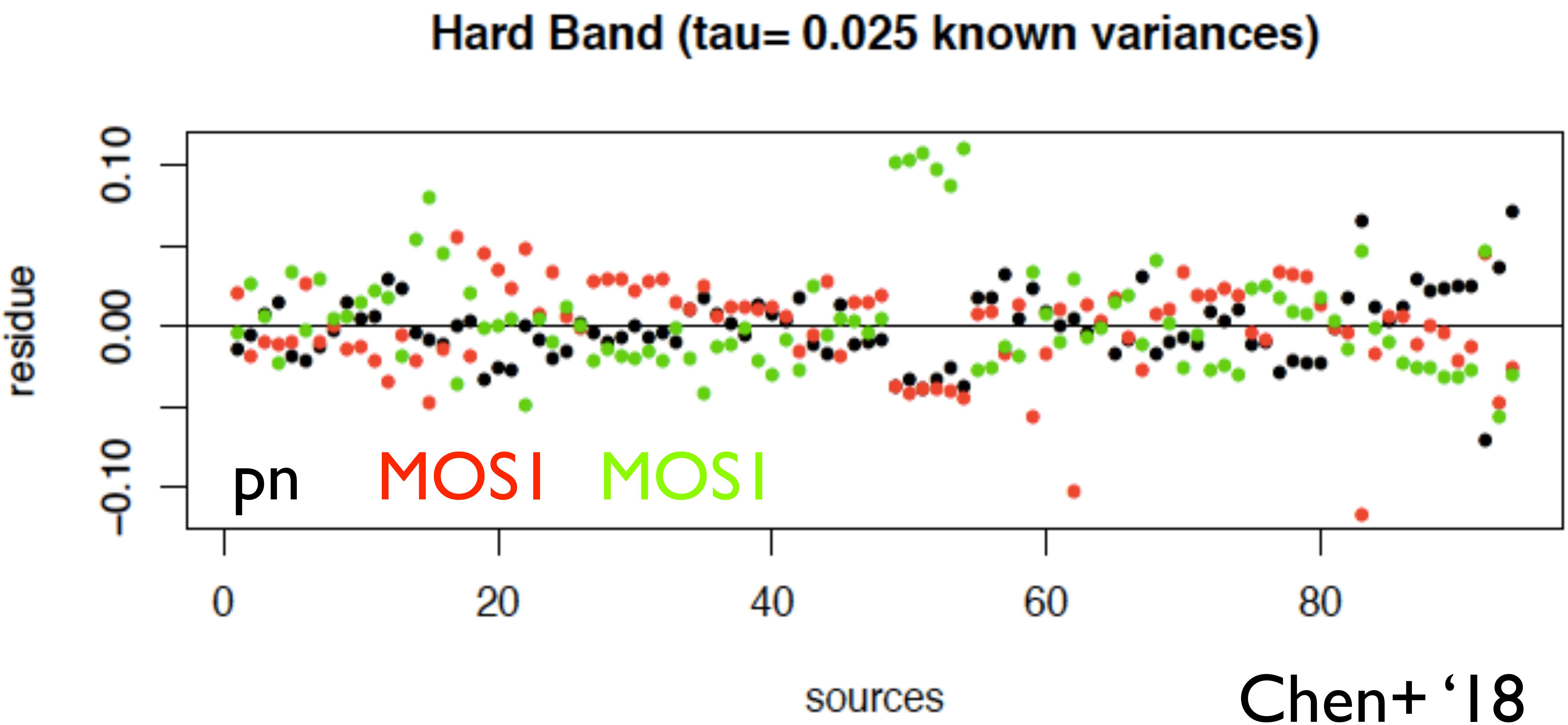
Concordance 3: XMM Blazars

- 117 bright XMM sources from Matteo Guainazzi
- PSF clipped to reduce effect of pileup
- Result: 5% adjustment to pn indicated, 1-2% for MOS



Chen+ '18

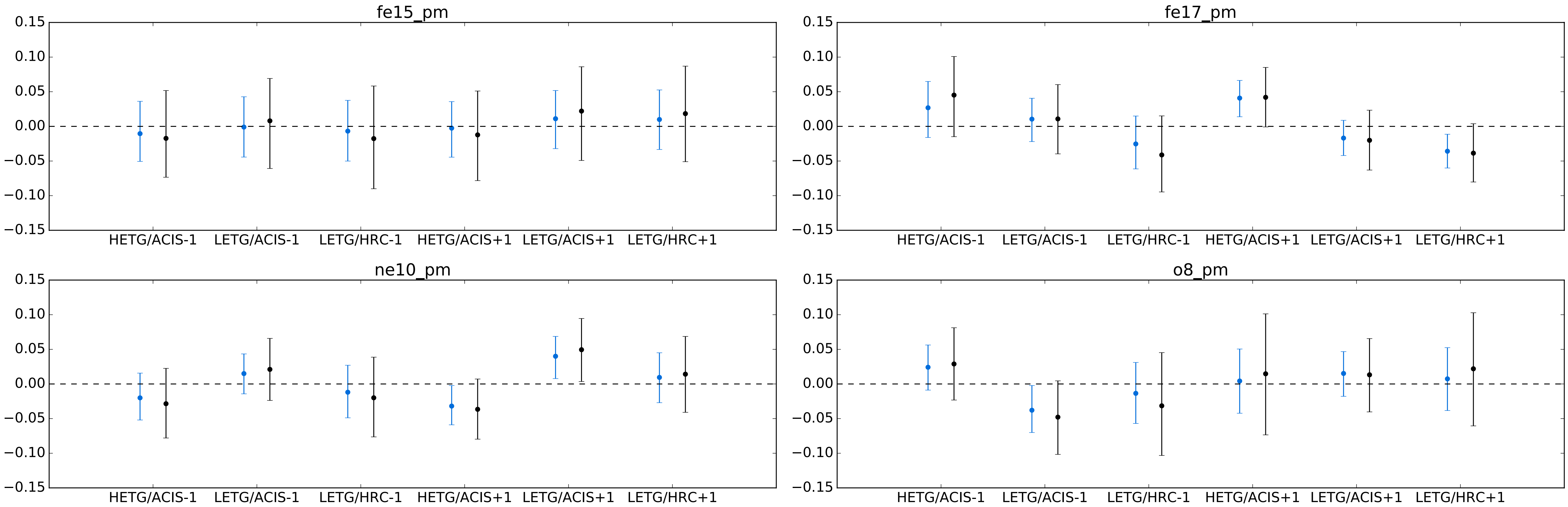
Data Validation



Chen+ '18

Concordance 4: Capella

- Lines from Chandra grating spectra
  - Ne x, Fe xxvii (15 Å), Fe xxvii (17 Å), O viii
- 5 sets of adjacent observations compared
- Not all instruments used each time



Marshall+ '18

Concordance Plan (2017)

- Publish method (Chen+ ’18, JASA) — DONE (responding to ref.)
  - Outlier handling with t-distribution — DONE
  - Poisson distribution for fainter samples
- Publish trial results (Marshall+’18, SPIE & JATIS)
  - Oriented to astronomers
  - Add Capella emission lines observed with Chandra
- Add more IACHEC cross-cal results
- Add features
  - Use smoothness from global source models
  - Use covariances from EA models
  - Consider handling of RMF uncertainties
- Work with MCCAL, pyBLoCXS (Drake et al.)
- Complete the instrument-energy matrix — 90% DONE

Paper I Submitted

Calibration Concordance for Astronomical Instruments via Multiplicative Shrinkage

Yang Chen[*], Xiao-Li Meng[†], Xufei Wang[‡], David A. van Dyk[§], Herman L. Marshall[¶], Vinay L. Kashyap[‖]

April 10, 2018

We present analytical solutions in the form of power shrinkage in special cases and develop reliable Markov chain Monte Carlo (MCMC) algorithms for general cases, both of which are available in the `Python` module *CalConcordance*. We apply our method to several data sets including a combination of observations of *active galactic nuclei* (AGN) and spectral line emission from the *supernova remnant* E0102, obtained with a variety of X-ray telescopes such as *Chandra*, XMM-*Newton*, *Suzaku*, and *Swift*. The data are compiled by the *International Astronomical Consortium for High Energy Calibration* (IACHEC). We demonstrate that our method provides helpful and practical guidance for astrophysicists when adjusting for disagreements among instruments.

[*]Yang Chen is Assistant Professor, Department of Statistics and Michigan Institute for Data Science (MIDAS), University of Michigan, Ann Arbor, MI 48109; email: ychenang@umich.edu.

[†]Xiao-Li Meng is Whipple V. N. Jones Professor of Statistics, Harvard University, Cambridge, MA 02138.

[‡]Xufei Wang was a Ph.D. candidate, Department of Statistics, Harvard University, Cambridge, MA 02138.

[§]David A. van Dyk is a Professor of Statistics and Head of the Department of Mathematics at Imperial College London, London, UK SW7 2AZ.

[¶]Herman Marshall is Astrophysicist, MIT Kavli Institute, Cambridge, MA 02139.

[‖]Vinay Kashyap is Astrophysicist, Harvard-Smithsonian Center for Astrophysics, Cambridge, MA 02138.

The Matrix (v3)

	Chandra ACIS	Chandra HETGS	Chandra LETGS	XMM pn	XMM MOS1,2	ROSAT PSPC
.15-.33	3	-	5	2	20	10
.33-.54	3	-	7	2	10	10
.54-.8	3	10	7	2	6	10
.8-1.2	3	5	7	2	6	10
1.2-1.8	2.6	4	7	2	6	10
1.8-2.2	3.3	4	7	2	6	10
2.2-3.5	3.3	4	7	2	6	-
3.5-5.5	4.9	5	10	2	6	-
5.5-10	5	7	10	3	10	-

The Matrix

	Suzaku XIS1	Suzaku XIS0,1,3	Astrosat SXT	Swift PC/WT	XMM RGS
.15-.33	-	-	-		-
.33-.54	20	-	?	15	8
.54-.8	15	15	?	10	5
.8-1.2	10	10	?	7.5	5
1.2-1.8	10	10	?	7.5	5
1.8-2.2	15	15	?	10	-
2.2-3.5	5	5	?	5	-
3.5-5.5	5	5	?	5	-
5.5-10	5	5	?	5	-

The Matrix

	RXTE PCA	RXTE HEXTE	INTEGRAL IBIS	INTEGRAL SPI	NuSTAR
2.2-3.5	5	-	-	-	-
3.5-5.5	10	-	-	-	4
5.5-10	3	-	-	-	3
15-25	3	5	-	-	3
25-50	10	5	3	2	?
50-100	50	5	?	?	?
100-300	-	-	?	?	-

The Matrix

	Astrosat LAXPC	Astrosat CZTI	Suzaku HXD	Swift BAT	Fermi GBM
2.2-3.5	-	-	-	-	-
3.5-5.5	?	-	-	-	-
5.5-10	?	-	-	-	-
15-25	?	?	20	15	?
25-50	?	?	20	4	?
50-100	?	?	20	4	?
100-300	-	-	20	12	?