IACHEC Virtual Working Groups Meeting 2021 May 17-19

CalStats

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2020 Foresight

1. Concordance
2. ARF and RMF uncertainties
3. Atomic emissivity uncertainties
4. Background models
5. The IACHEC Analysis Tips & Tricks Guide

Summary slide from Syonan Kokusaimura

2021 Hindsight

1. Concordance
2. ARF and RMF uncertainties
3. Atomic emissivity uncertainties
4. Background models
5. The IACHEC Analysis Tips & Tricks Guide
6. New Directions: Timing Tools, Polarization
7. Other activities

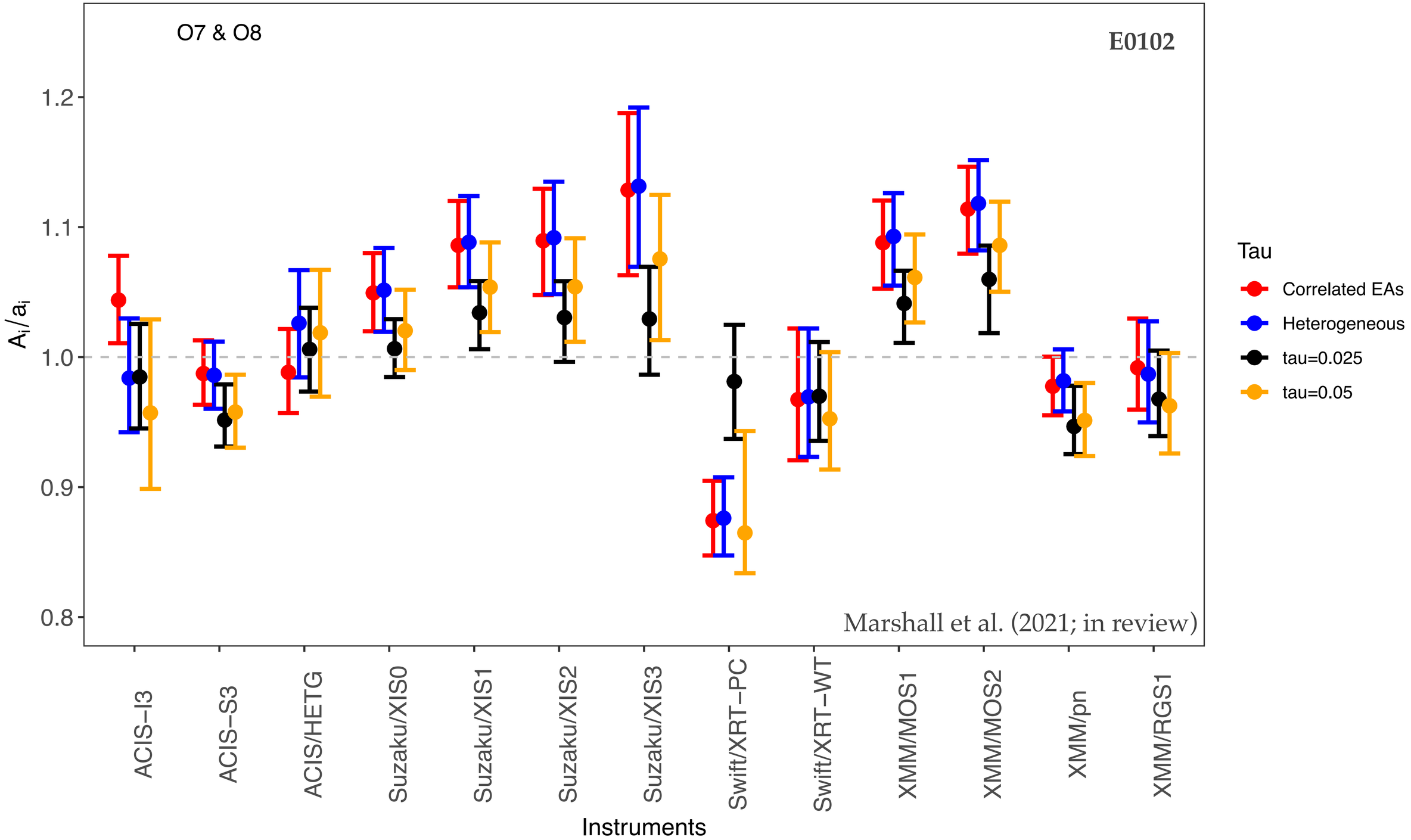
1. Concordance

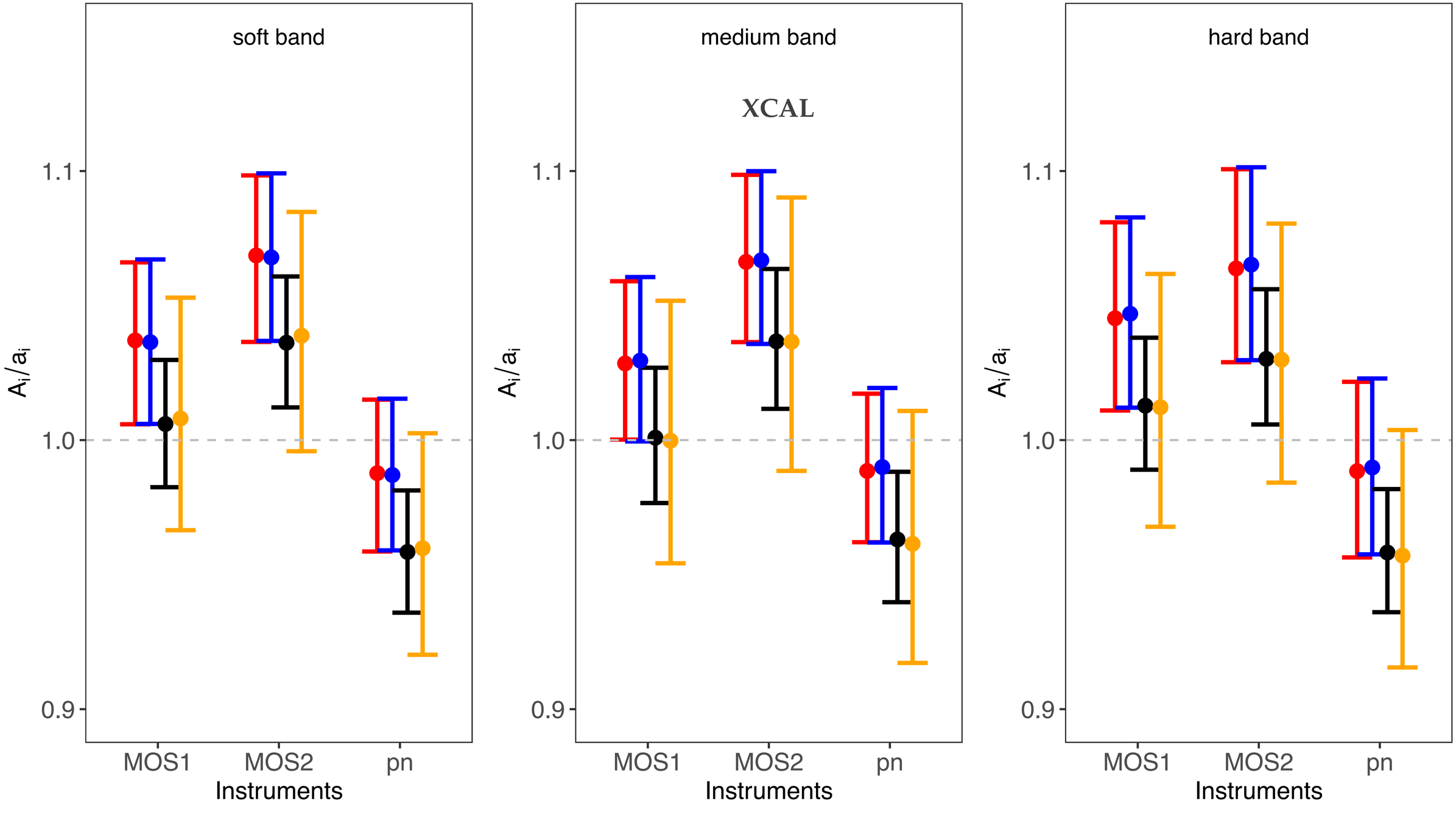
- "Astro" paper is in review

CONCORDANCE: IN-FLIGHT CALIBRATION OF X-RAY TELESCOPES WITHOUT ABSOLUTE REFERENCES

HERMAN L. MARSHALL,[1] VINAY L. KASHYAP,[2] MATTEO GUAINAZZI,[3] JEREMY J. DRAKE,[2]
PAUL P. PLUCINSKY,[2] PETER RATZLAFF,[2] YANG CHEN,[4] XIAO-LI MENG,[5] XUFEI WANG,[5] AND
D. A. VAN DYK[6]

- Improvements over Chen et al. 2018 (*Calibration Concordance for Astronomical Instruments via Multiplicative Shrinkage*, JASA 114:527, 1018)
  - instrument specific τ
  - cross-passband correlations in EA (including uncertainties)
  - new results for multi-instrument E0102; *Chandra*/Capella; 2*XMM* and XCAL MOS+pn


O7 & O8
E0102
1.2
1.1
1.0
0.9
0.8
A_i/a_i
Marshall et al. (2021; in review)
ACIS–I3
ACIS–S3
ACIS/HETG
Suzaku/XIS0
Suzaku/XIS1
Suzaku/XIS2
Suzaku/XIS3
Swift/XRT–PC
Swift/XRT–WT
XMM/MOS1
XMM/MOS2
XMM/pn
XMM/RGS1
Instruments
Tau
Correlated EAs
Heterogeneous
tau=0.025
tau=0.05



Marshall et al. (2021; in review)

2. ARF and RMF

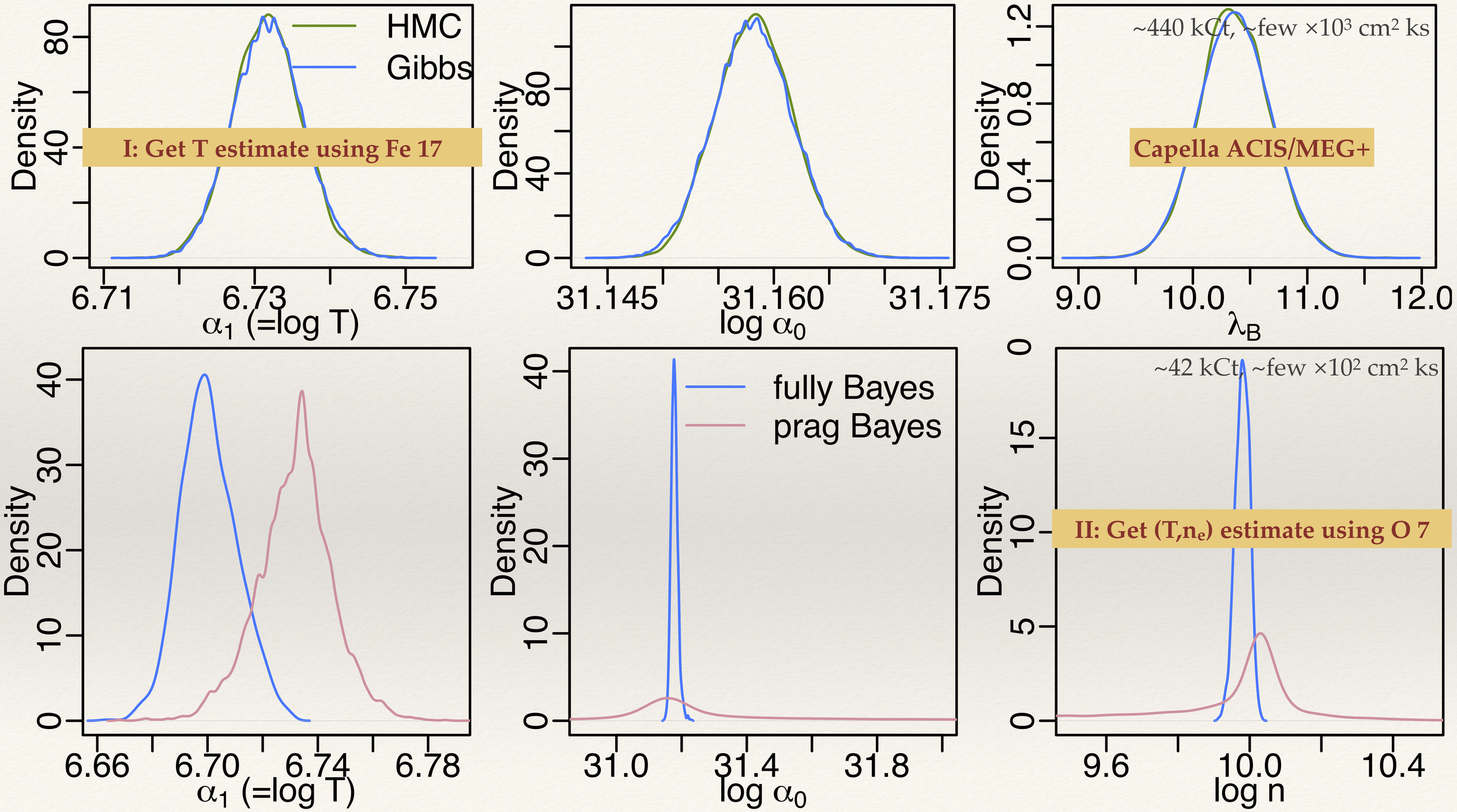
- Paper detailing how EA uncertainties are computed for *Chandra* is in preparation (Drake et al.)
  - Used to compute cross-band correlations for Concordance paper
- Work has started to adapt the same procedure to characterize *AstroSat*/SXT ARFs,(Dewangan, Drake, et al.)
- Keith Arnaud reports that XSPEC can now handle large wavelength grids via split RMFs — a sparse matrix focused on just the high-res features, and a coarse matrix to describe smooth tail at lower E

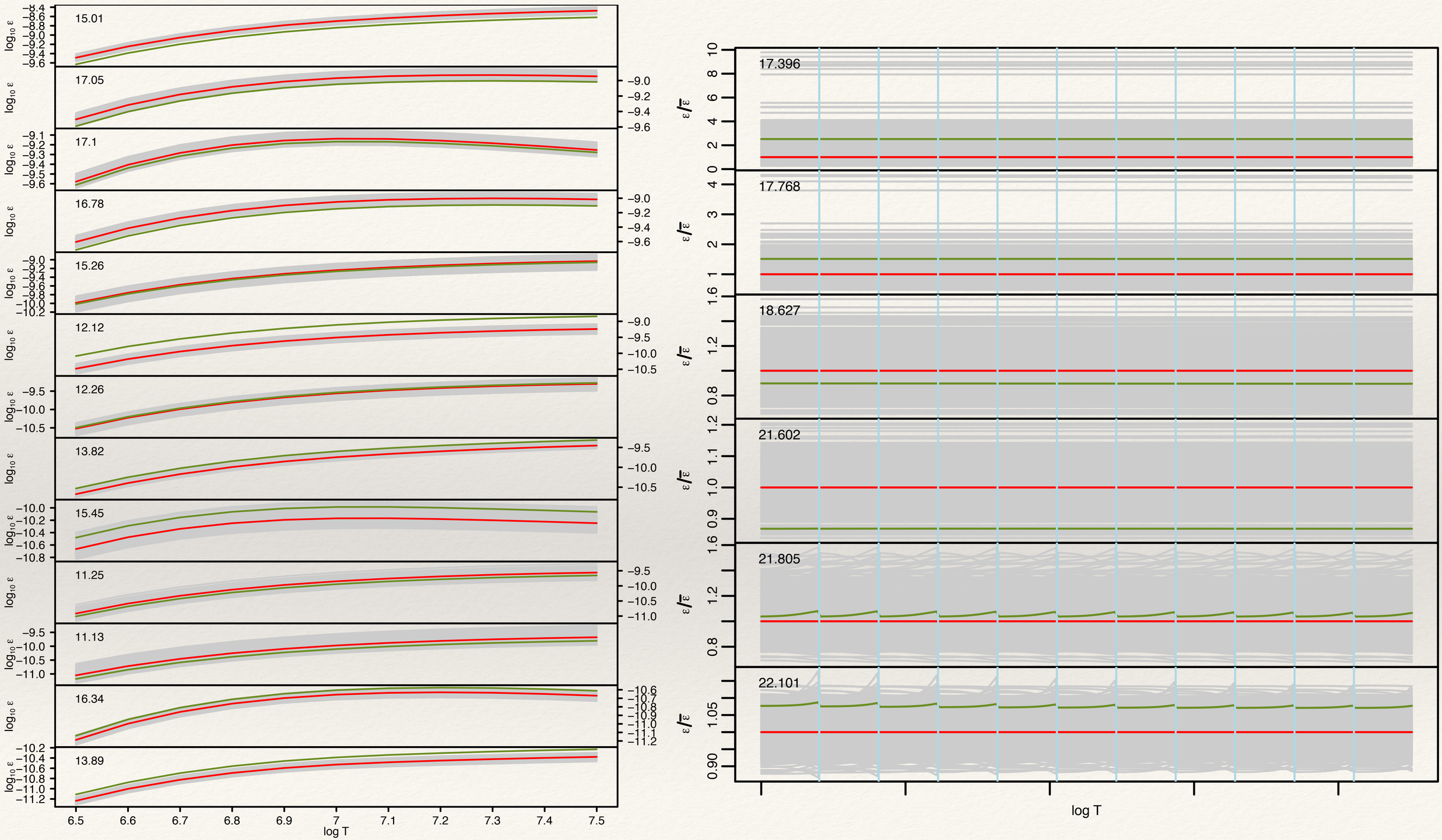
3. Atomic Data Uncertainties

- See High-Resolution Working Group discussion tomorrow, Tue May 18, 11am EDT (includes talks on Capella line list [Liyi Gu], the θ^1 Ori project [Norbert Schulz])
- AAS 238 Special Session 107: *Unaccounted Uncertainties: The Role of Systematics in Astrophysics* [Monday June 7 Noon-1:30pm EDT]
  - Stuart Loch (Auburn) *On Atomic Data Uncertainties*
  - Yang Chen (Michigan) *Systematic Uncertainties in Multi-Telescope Observations*
- Xixi Yu 2021 PhD Thesis (Imperial University; *Multistage Analysis in Astrostatistics*)

Effect of Systematic Uncertainties on Density and Temperature Estimates in Coronae of Capella (DRAFT)

Xixi Yu,[1] Vinay L. Kashyap,[2] Giulio Del Zanna,[3] David A. van Dyk,[1] David C. Stenning,[4] Connor P. Ballance,[5] and Harry P. Warren[6]

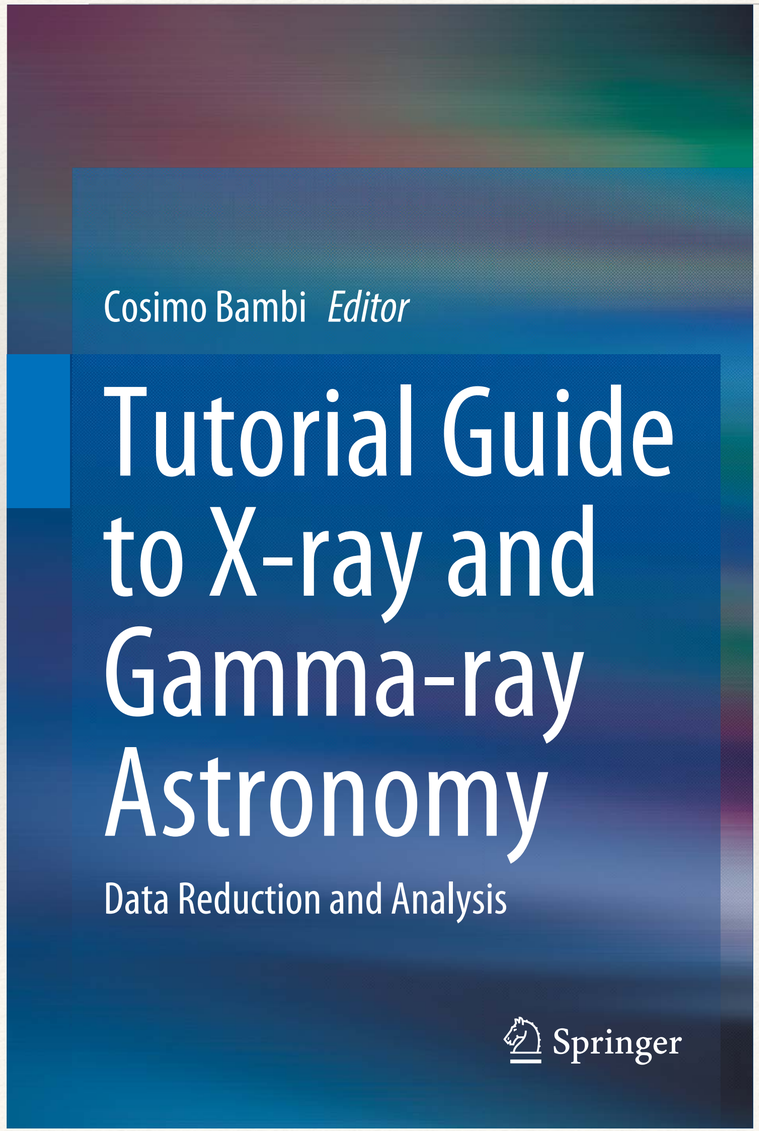

HMC
Gibbs
I: Get T estimate using Fe 17
Density
α_1 (=log T)
log α_0
~440 kCt, ~few ×10³ cm² ks
Capella ACIS/MEG+
λ_B
fully Bayes
prag Bayes
~42 kCt, ~few ×10² cm² ks
II: Get (T,n_e) estimate using O 7
log n


15.01
17.05
17.1
16.78
15.26
12.12
12.26
13.82
15.45
11.25
11.13
16.34
13.89
log10 ε
log T
17.396
17.768
18.627
21.602
21.805
22.101
ε/ε̄

4. Background Models

- See Detectors & Background Working Group discussion on Tuesday May 18 10am EDT
- Of relevance from a statistics viewpoint, see Algeri 2020, PhysRev D 101, 015003; *Detecting new signals under background mismodeling*

5. Analysis Tips & Tricks



Chapter 6
Basics of Astrostatistics

Check for updates

Vinay L. Kashyap

The purpose of this chapter is to provide a framework for astronomers to understand statistical issues that are relevant to astronomical analysis and place them in context. In particular, we will describe the basic statistical tool-set needed for contemporary analysis of high-energy astronomical data. Thus, we will first discuss the Poisson distribution, in the context of several others that are relevant, in Sect. 6.2. Next, in Sect. 6.3, we will provide a guideline to how error bars and uncertainties are evaluated, and how uncertainty intervals are set. We will also briefly discuss Bayesian analysis in Sect. 6.3.2 in the context of uncertainty intervals. Then, in Sect. 6.4, we will discuss the underpinnings of the fitting process, introducing the concept of likelihoods and parametric curve fitting. In Sect. 6.5 we will then discuss the basics of decision making, via hypothesis tests, p-value thresholds, goodness-of-fit tests, and model comparisons, and point out some important limitations in the process. Finally, in Sect. 6.6, we will point the reader to resources for more in depth study.

6. Timing Tools // Polarization

- Guillaume Belanger — discussion on choosing appropriate likelihood → video

- Matteo Bachetti — tools to assess timing calibration
  - PINT — https://github.com/nanograv/pint
  - Stingray — https://github.com/stingraysoftware/stingray
  - hendrics — https://github.com/stingraysoftware/hendrics

- Herman Marshall on *Statistical Topics in X-ray Polarimetry*

7. Other activities

- WG remote telecons on 2020 May 5, 2020 Dec 1; plenary session on Statistical Best Practices (Belanger, Miller, Marshall) during Winter Virtual IACHEC 2020 Nov 24
- Talks
  - 2020 Aug 6: Kristin Madsen at JSM Session 431, *X-ray Data and its Many Challenges*
  - 2020 Sep 8: Herman Marshall and Yang Chen at CHASC, *Concordance: In-flight Calibration of X-ray telescopes Without Absolute References*
  - 2020 Dec 8: Diab Jerius at CHASC, *Doing the Hokey-Pokey (or) Deriving Statistical errors for Measurements of the Chandra X-ray Observatory PSF*
- Forthcoming:
  - AAS 238 Special Session on Systematic Uncertainties should be of special interest to IACHEC
  - At least one more WG telecon before September
  - Tutorial(s) on Machine Learning
  - Talks on c-stat, PSF modeling and uncertainty, incorporating RMF and PSF uncertainties in analysis, atomic data uncertainty, spectral line detection
- Let me know if you want to be on the IACHEC mailing list (also, join the **#calstats** Slack channel)