Status of the Concordance Project

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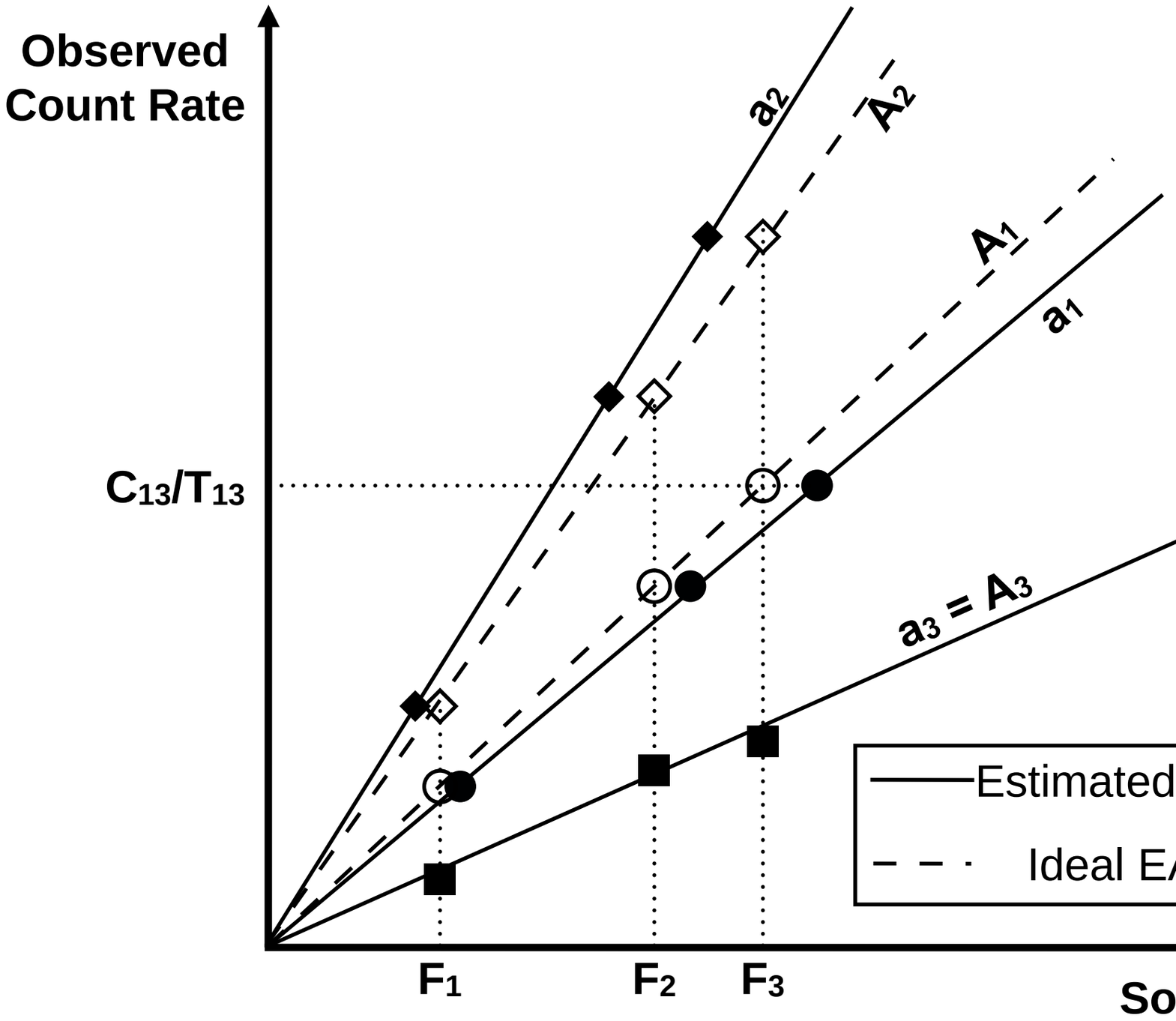
The Goal

- Answer to “How to change effective areas given many observations by different instruments differ?”
- Method: Multiplicative Shrinkage (Chen+ 2019)
  - uses all data to find best true fluxes, then correct EAs
  - needs t values, fractional uncertainties on prior EA
  - if ground-cal is poor (large t), observations drive new EA
  - if observations are poor (large s), prior dominates
- Developed jointly with statistics academicians
- IACHEC scientists set t values
- Working on new cross-cal data sets (Marshall+ 2019)

The Problem, Graphically



Concordance Approach

- 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, s_{ij} = st. dev. in $\ln(C_{ij})$
  - Estimate F_j by $f_{ij} = C_{ij} / a_i$ (a_i = prior estimate of A_i)
  - Method determines "best" $\underline{F}_j$ and "better" EAs $\underline{a}_i = a_i^w (C_{ij}/\underline{F}_j)^{1-w}$
    - $w = 1/(1+Mt_i^2/s_{ij}^2)$, t_i = "a priori" st.dev. in $\ln(a_i)$
    - w = 0 means data dominate, drive change in EA
    - w = 1 means data are mediocre, EA isn't changed
    - brings $\underline{f}_{ij} = C_{ij} / \underline{a}_i$ closer to *but not precisely* to $\underline{F}_j$
- IACHEC team sets t_i, runs shrinkage analysis
  - IACHEC team recommends changes from a_i to $\underline{a}_i$
  - Process runs for each of many bandpasses "independently"

Concordance Plan (2018)

- 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 (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% D

Concordance Activity (2019)

- Publish method (Chen+ ’18, JASA) — DONE
  - Outlier handling with t-distribution — DONE
  - Poisson distribution for fainter samples
- Complete the instrument-energy matrix — DONE
- Publish astro version (Marshall+’18, SPIE & JATIS) — In progress
  - Use tau values from ‘the Matrix’
  - Add Capella emission lines observed with Chandra — In progress
- Add more IACHEC cross-cal results
- Add features
  - Use covariances from EA models — In progress
  - Use smoothness from global source models
  - Consider handling of RMF uncertainties
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The Matrix (v4)

	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	15	8
.54-.8	15	15	15	10	5
.8-1.2	10	10	10	7.5	5
1.2-1.8	10	10	10	7.5	5
1.8-2.2	15	15	10	10	-
2.2-3.5	5	5	10	5	-
3.5-5.5	5	5	10	5	-
5.5-10	5	5	10	5	-

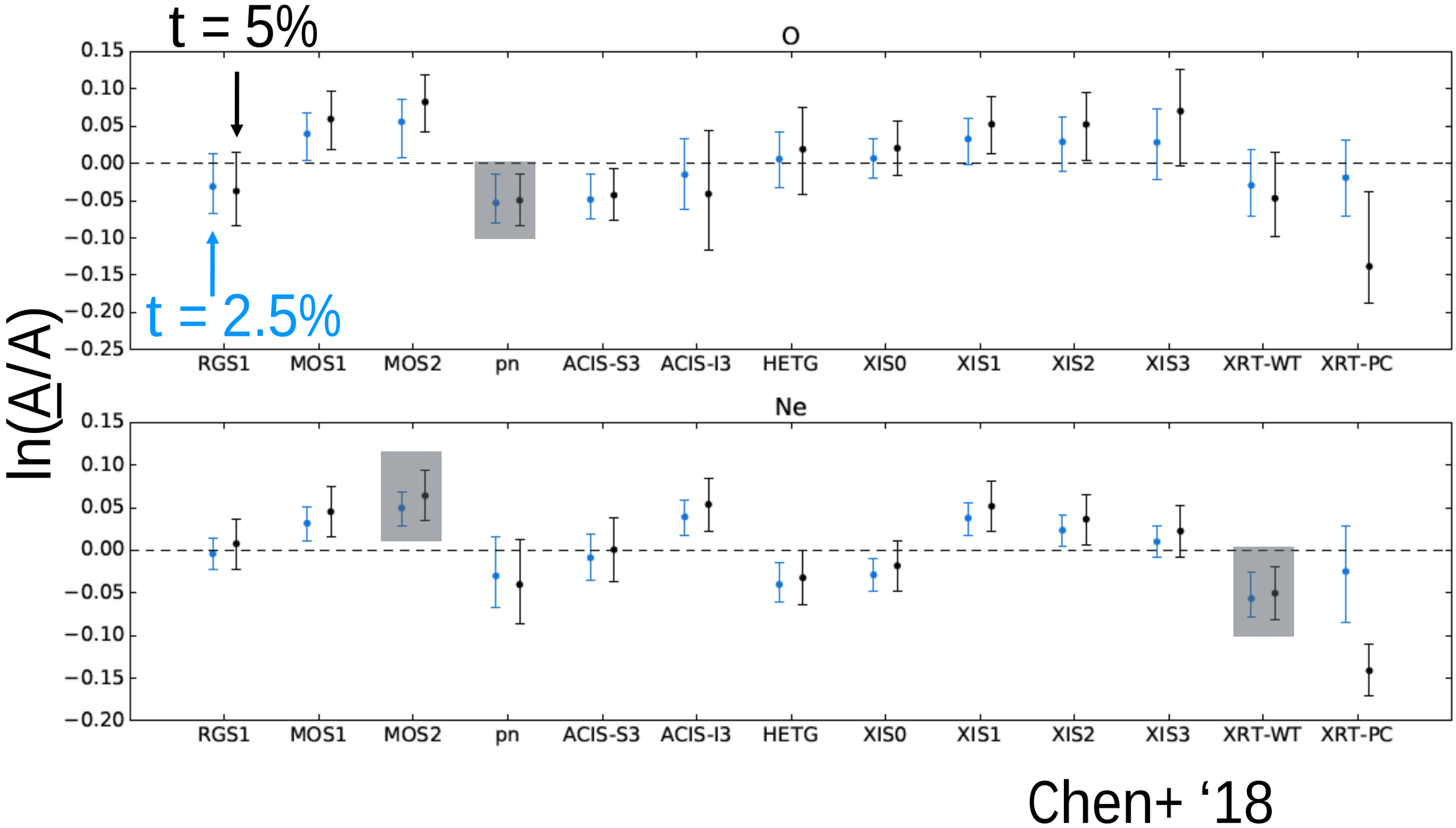
The Matrix

	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	8	5	15
50-100	50	5	15	5	20
100-300	-	-	20	5	-

The Matrix

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

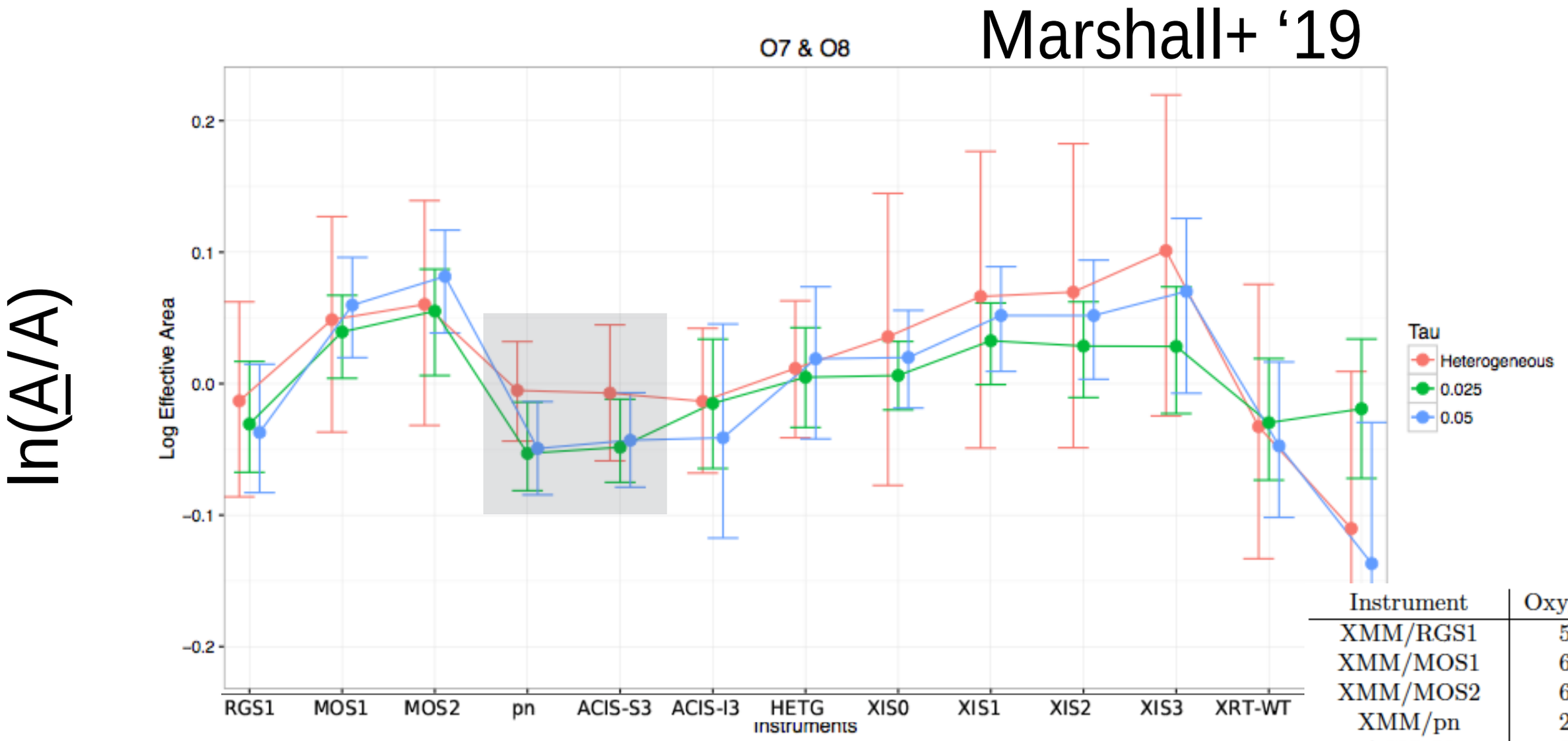
Concordance 1: 1E0102



Chen+ ‘18

Concordance 1: 1E0102

Marshall+ ‘19



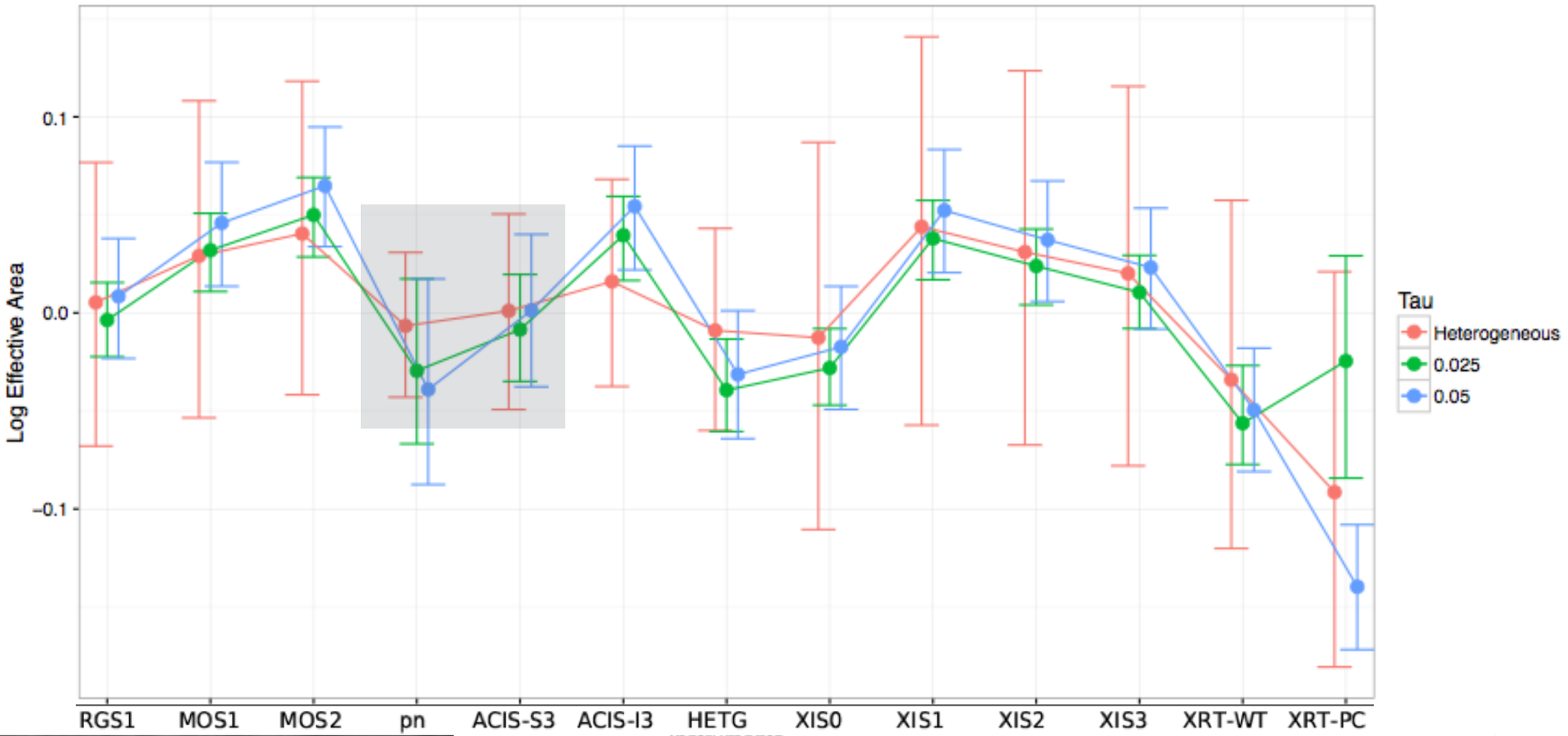
t

Instrument	Oxygen	Neon
XMM/RGS1	5	5
XMM/MOS1	6	6
XMM/MOS2	6	6
XMM/pn	2	2
ACIS-S3	3	3
ACIS-I3	3	3
ACIS/HETG	3	3
Suzaku/XIS0	15	10
Suzaku/XIS1	15	10
Suzaku/XIS2	15	10
Suzaku/XIS3	15	10
Swift/XRT-WT	10	7.5
Swift/XRT-PC	10	7.5

Concordance 1: 1E0102

Marshall+ ‘19

ln(A/Ā)



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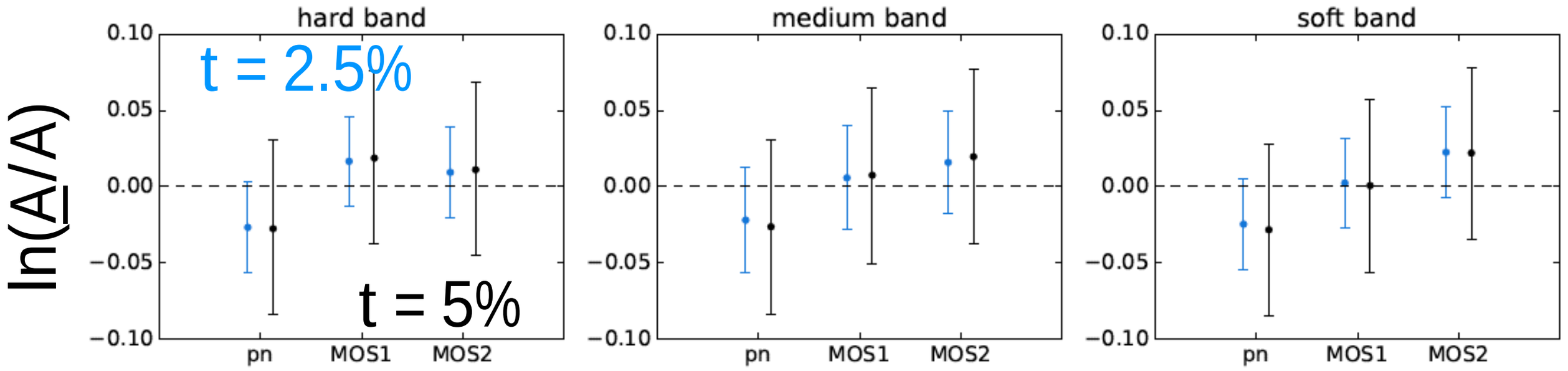
ACIS-S3	3	3
ACIS-I3	3	3
ACIS/HETG	3	3
Suzaku/XIS0	15	10
Suzaku/XIS1	15	10
Suzaku/XIS2	15	10
Suzaku/XIS3	15	10
Swift/XRT-WT	10	7.5
Swift/XRT-PC	10	7.5

Concordance 2: 2XMM

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

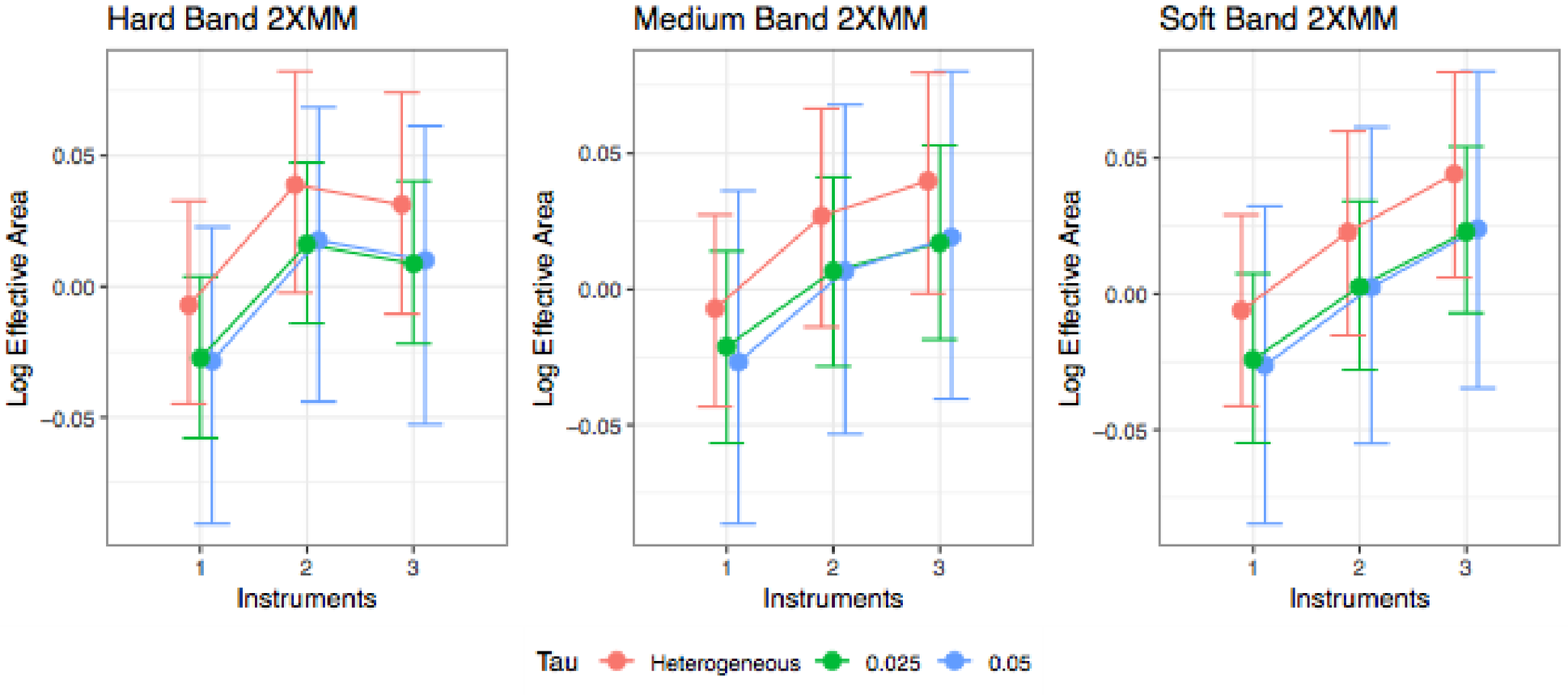


Chen+ ‘18

Concordance 2: 2XMM

- Data from Matteo Guainazzi, $t_{pn} = 0.02$, $t_{mos} = 0.06$
- Based on 42 sources from the 2XMM catalog
- Unaffected by pileup; pn drives EA mod

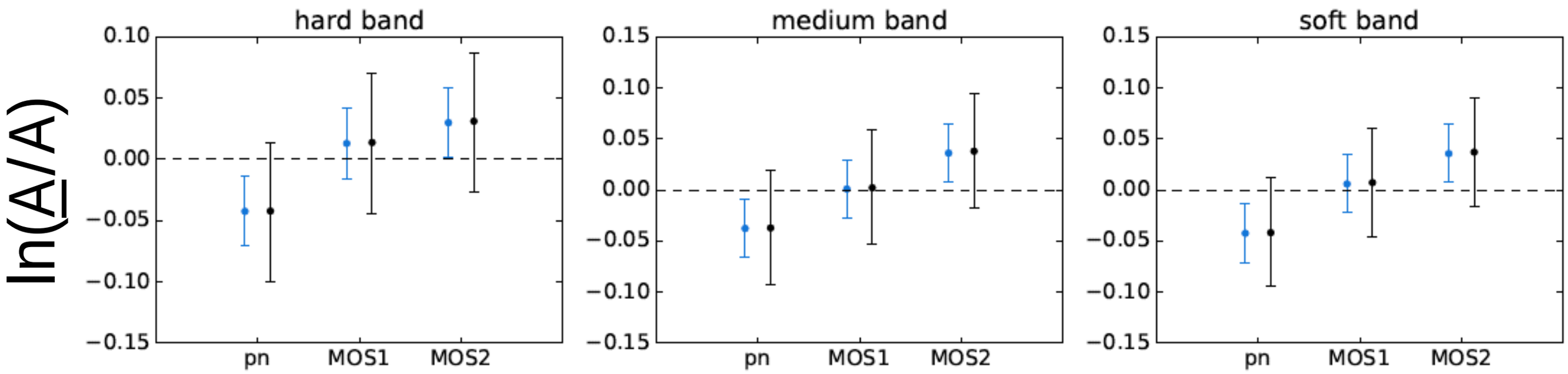
ln(A/A)



Marshall+ ‘19

Concordance 3: XMM Blazars

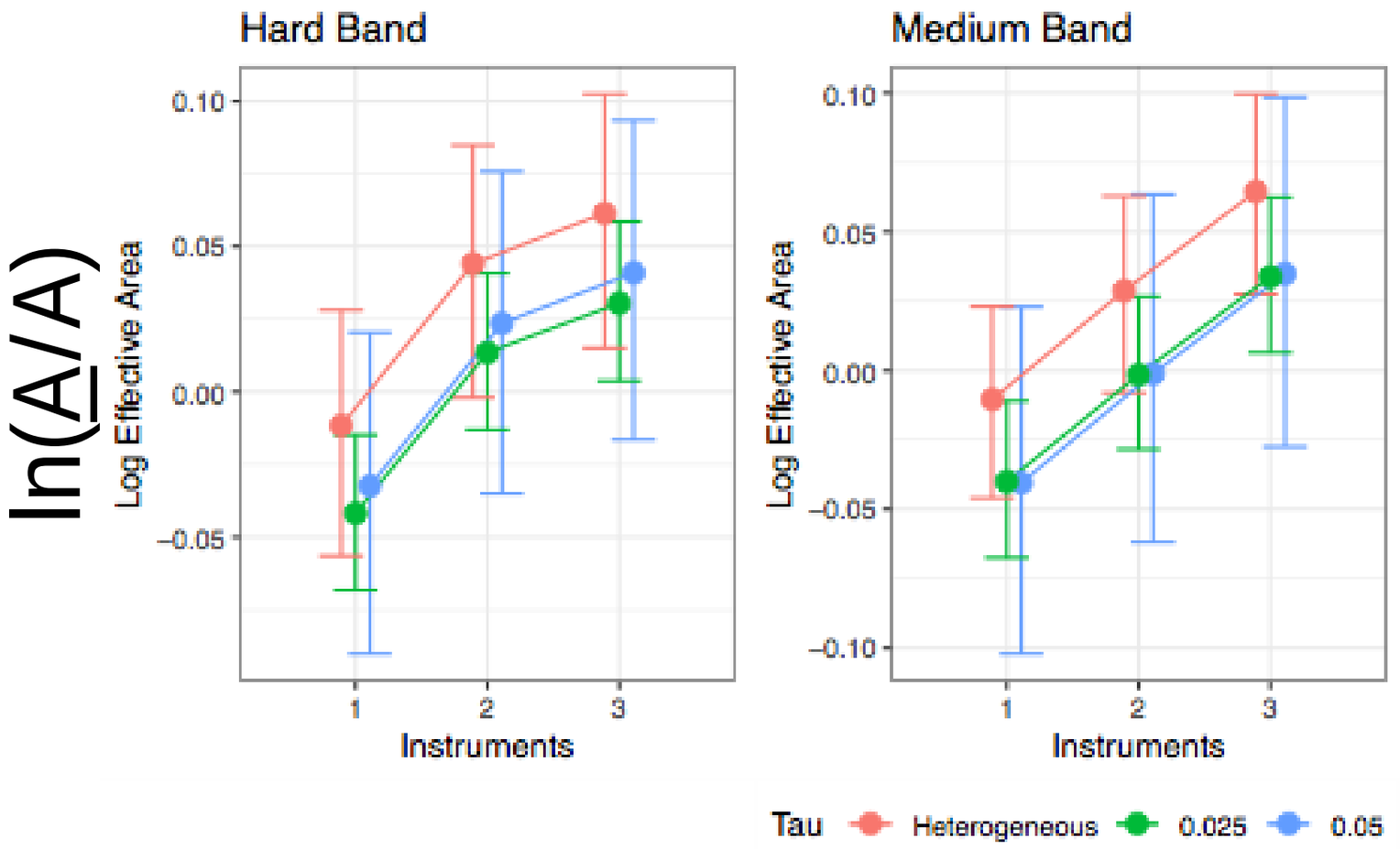
- 117 bright XMM sources from Matteo Guainazzi
- PSF clipped to reduce effect of pileup
- Result: 5% adjustment to pn indicated, 1-2% for MOS



Chen+ ‘18

Concordance 3: XMM Blazars

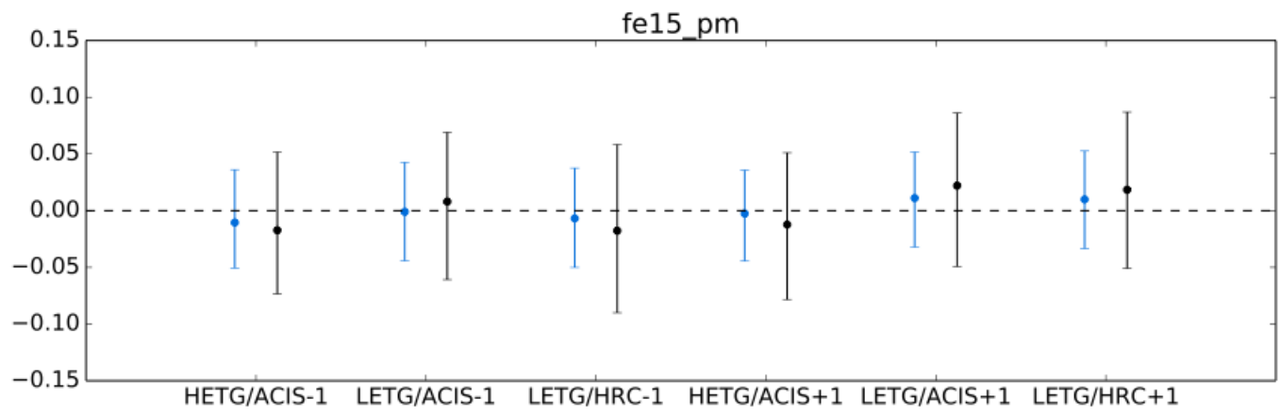
- 117 bright XMM sources from Matteo Guainazzi
- PSF clipped to reduce effect of pileup
- Result: same as with XMM2 sample

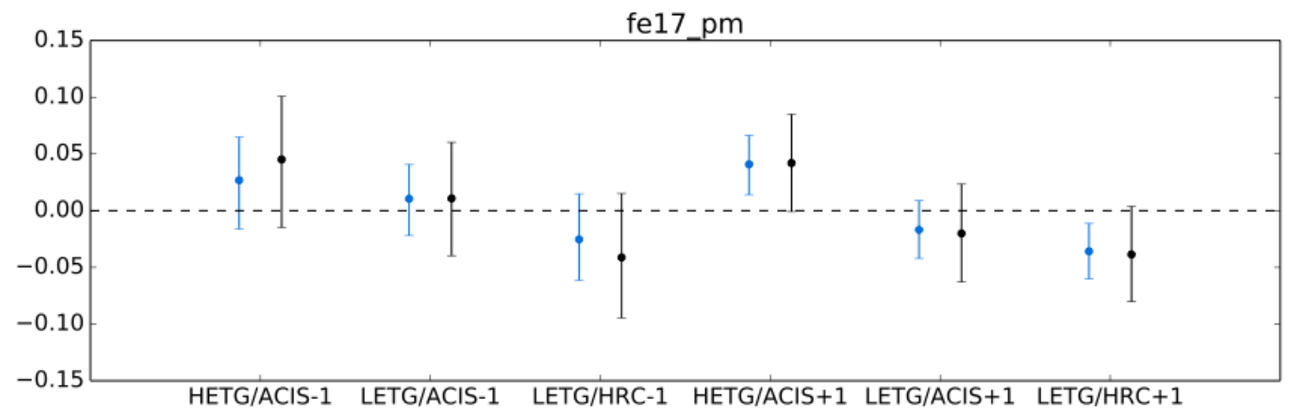


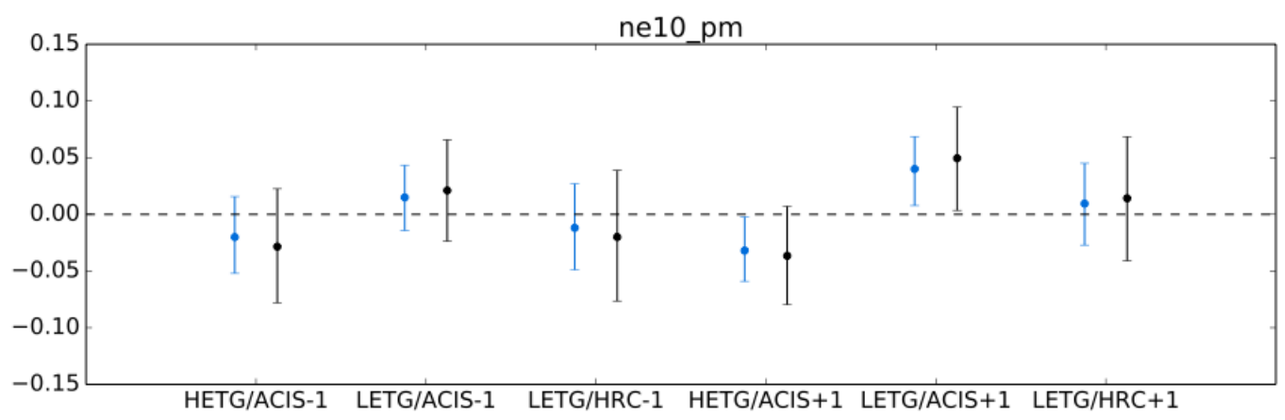
Marshall+ ‘19

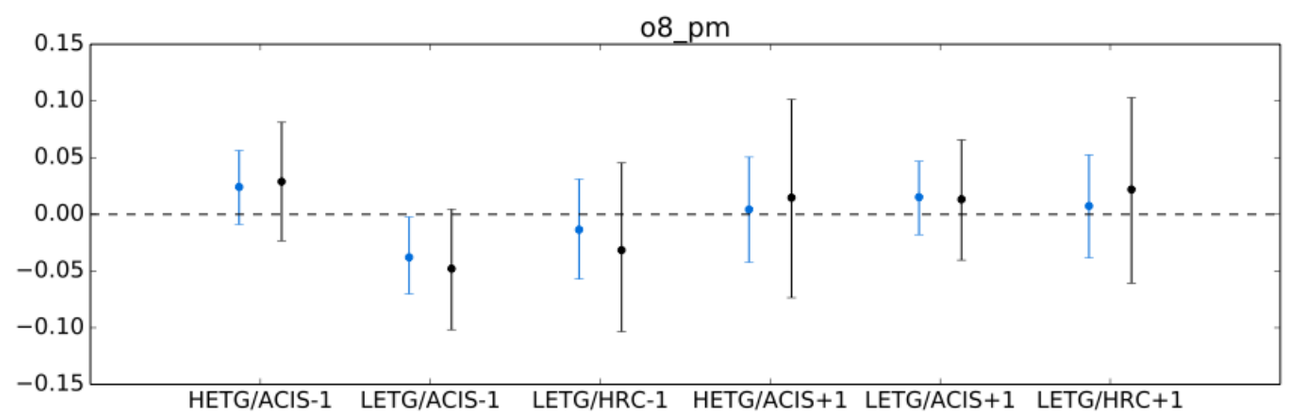
Concordance 4: Capella

- 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
- Heterogeneous analysis in progress









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