Status of the Concordance Project

Herman L. Marshall

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Okunoshima ("Rabbit Island")
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

Observed Count Rate

Source Flux

$C_{13}/T_{13}$

$F_1$, $F_2$, $F_3$

$A_1$, $A_2$, $A_3$

$a_1$, $a_2$, $a_3 = A_3$

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Estimated EA

Ideal EA

Concordance - 5/22/19
Concordance Approach

- Shrinkage method (Meng, 2015 IACHEC)
  - Start with $C_{ij} = \text{Counts for instrument } i \ (1..N), \text{ source } j \ (1..M)$
  - Assume “true” areas $A_i$, “true” fluxes $F_j$, $s_{ij} = \text{st. dev. in } \ln(C_{ij})$
  - Estimate $F_j$ by $f_{ij} = C_{ij} / a_i$ ($a_i = \text{prior estimate of } A_i$)
  - Method determines “best” $F_j$ and “better” EAs $a_i = a_i^w \ (C_{ij}/F_j)^{1-w}$
    - $w = 1/(1+Mt_i^2/s_{ij}^2)$, $t_i = \text{“a priori” st. dev. in } \ln(a_i)$
    - $w = 0$ means data dominate, drive change in EA
    - $w = 1$ means data are mediocre, EA isn’t changed
    - brings $f_{ij} = C_{ij} / a_i$ closer to but not precisely to $F_j$

- IACHEC team sets $t_i$, runs shrinkage analysis
  - IACHEC team recommends changes from $a_i$ to $a_i$
  - 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% DONE
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
- Work with MCCAL, pyBLoCXS (Drake et al.)
# The Matrix (v4)

<table>
<thead>
<tr>
<th>Energy Range</th>
<th>Chandra ACIS</th>
<th>Chandra HETGS</th>
<th>Chandra LETGS</th>
<th>XMM pn</th>
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## The Matrix

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Concordance - 5/22/19
Concordance 1: 1E0102

\[ \ln \left( \frac{A}{A^*} \right) \]

Chen+ '18
Concordance 1: 1E0102

Marshall+ ‘19

\[
\ln\left(\frac{A}{\bar{A}}\right)
\]

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Concordance 2: 2XMM

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

\[
\ln \left( \frac{A}{\overline{A}} \right) = t = 5\%
\]

\[
\ln \left( \frac{A}{\overline{A}} \right) = t = 2.5\%
\]

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

\[ \ln(\frac{A}{A}) \]

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

\[\ln(A/A)\]

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
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
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