The 58-month BAT AGN catalogue: results from the Northern Galactic Cap

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Lisa Winter (AER, USA), Wayne Baumgartner (NASA/GSFC, USA),
Poster: Luigi Gallo (St. Mary’s, Canada), Dom Walton (Caltech), Abdu Zoghbi (UMD), Anne Lohfink (Cambridge)

related:
Vasudevan et al. (2013c), MNRAS, 431, 3127
Swift/BAT’s utility: ‘unbiased’ detection of AGN

- Gilli, Comastri & Hasinger (2007)
The BAT catalogue (9-month)

- Tueller et al. (2008)
The BAT catalogue (22-month)
The BAT catalogue (58-month)
The BAT catalogue (70-month)

- Baumgartner et al. (2013)
Earlier work on BAT AGN catalogue

- Vasudevan et al. (2009, 2010) - X-ray, optical/UV, IR, energy budget
- Burlon et al. (2011, 2013) – X-ray properties, radio properties/jets
- Matsuka et al. (2012), Melendez et al. (2014 – submitted) – hard X-ray & IR correlations, torus properties
- Ajello et al. (2008, 2012) – X-ray properties, stats
- Koss et al. (2010, 2011) – host galaxy properties of BAT AGN, merging/clustering
Scope

- **NB:** 58-month catalogue has **720 AGN candidates** (BAT SNR > 4.8), many without XMM or equivalent coverage; Galactic plane has many local contaminants (X-ray binaries, Galactic absorption etc), so **better to target a complete subsample of manageable size.**

- Therefore restrict to Galactic latitude **$b > 50^\circ$** (Brandt et al. 2008 XMM proposal). **Low Galactic $N_H$ allows analysis of soft features too**

- Performed a comprehensive analysis of a **complete subsample from the 58-month BAT catalogue** and updated the analysis of previous versions of the catalogue (Winter et al. 2009, Burlon et al. 2011)

- Determined up-to-date **absorbing column density distribution, luminosity distribution and details of spectral features**

- **Aim:** construct **multi-wavelength SEDs** for this complete sample; sky area has **complementary coverage at other wavelengths for SEDs** (e.g. SDSS, 2MASS, WISE, AKARI, GALEX+...)
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Ranjan Vasudevan

The X-ray Universe, Dublin
Sample properties: key statistics

- **106 non-blazar AGN candidates** (at SNR > 4.8)
- **High proportion have** targeted **XMM** data (49 objects)
- Targetted **Swift/XRT** observations for 46 objects
- **ASCA/Tartarus** archival objects used for 6 objects
- 5 objects without data at the time of writing
- **Local:** $z < 0.2$
### Analysis: spectral fitting

#### Model Combinations Used

<table>
<thead>
<tr>
<th>Model Identifier</th>
<th>XSPEC Model String</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Simple power-law models</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S1</td>
<td>TBABS(POWERLAW)</td>
<td>Power-law with Galactic absorption only</td>
</tr>
<tr>
<td>S2</td>
<td>TBABS(ZTBABS(POWERLAW))</td>
<td>Absorbed power-law with Galactic and intrinsic (neutral) absorption</td>
</tr>
<tr>
<td>S3</td>
<td>TRABS(ZTBABS(POWERLAW+ZGAUSS))</td>
<td>As for S2, with a Fe Kα line at (default) 6.4 keV</td>
</tr>
<tr>
<td>S4</td>
<td>TBABS(ZTBABS(POWERLAW+ZBBODY))</td>
<td>As for S2, with a soft excess modeled as a blackbody</td>
</tr>
<tr>
<td>S5</td>
<td>TBABS(ZTBABS(ZEDGE(POWERLAW))))</td>
<td>As for S2, with an edge at 0.73 keV (default) to model a warm absorber</td>
</tr>
<tr>
<td>S6</td>
<td>TRABS(ZTBABS(ZEDGE(POWERLAW+ZBBODY))))</td>
<td>As for S2, with both a soft excess and Fe Kα line</td>
</tr>
<tr>
<td>S7</td>
<td>TBABS(ZTBABS(POWERLAW+ZGAUSS)))</td>
<td>Absorbed power-law with warm-absorber edge and Fe Kα line</td>
</tr>
<tr>
<td>S8</td>
<td>TBABS(ZTBABS(POWERLAW+ZGAUSS+ZBBODY))))</td>
<td>Absorbed power-law with warm-absorber edge, Fe Kα line and soft excess</td>
</tr>
<tr>
<td>S9</td>
<td>TBABS(ZTBABS(ZEDGE(ZEDGE(POWERLAW))))</td>
<td>Absorbed power-law with two warm-absorber edges at 0.73 and 0.87 keV (default energies)</td>
</tr>
<tr>
<td>S10</td>
<td>TBABS(ZTBABS(ZEDGE(ZEDGE(POWERLAW+ZGAUSS)))))</td>
<td>Absorbed power-law with two warm-absorber edges and a Fe Kα line</td>
</tr>
<tr>
<td>S11</td>
<td>TBABS(ZTBABS(ZEDGE(ZEDGE(POWERLAW+ZGAUSS+ZBBODY))))</td>
<td>Absorbed power-law with two warm-absorber edges, Fe Kα line and soft excess</td>
</tr>
<tr>
<td><strong>Complex models (partial covering)</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>C1</td>
<td>TBABS(ZPCFABS(POWERLAW))</td>
<td>Partially covered absorbed power-law with Galactic absorption</td>
</tr>
<tr>
<td>C2</td>
<td>TRABS(ZPCFABS(POWERLAW+ZGAUSS))</td>
<td>As for C1, including a Fe Kα line at (default) 6.4 keV</td>
</tr>
</tbody>
</table>
Analysis: spectral fitting
Results: column density distribution

\[ \log(L_{2-10 \text{ keV}}) \]

\[ \text{Intrinsic absorption } \log(N_{\text{H}}/\text{cm}^{-2}) \]

\[ \text{Percentage of objects with } \log(N_{\text{H}}) > \text{threshold } \log(N_{\text{H}}) \]

- 58-month catalog (this work)
- 9-month catalog (W09)

Ranjan Vasudevan

The X-ray Universe, Dublin

19 June 2014
Results: column density distribution and flux limit

- **5 times fainter** detection limit than 9-month catalogue, uncovers wider absorption distribution
Results: column density distribution – some statistics

- **57-61 per cent** with logNH>22
- **41-45 per cent** with logNH>23
- **9 per cent Compton Thick** (logNH>24.15)

These fractions use a **basic absorption** model (no Compton scattering – see Monday’s Extragalactic Surveys talks – e.g. Georganopoulos talk)

More robust ‘plcabs’ includes Compton scattering but degeneracies involved; yields **lower columns** by factor ~0.65 and would **reduce the Compton Thick fraction** (c.f. 4.6% from Burlon et al. 2011 for 36-month catalogue); MyTorus (Murphy & Yaqoob 2009) may yield different results.
Results: luminosity distribution

Fig. 16.— Histograms of intrinsic 2–10 keV luminosity $\log(L_{2-10\text{keV}})$. The grey shaded portions represent high-absorption objects ($\log(N_H) > 22$), whereas the blue shaded portions represent low-absorption objects ($\log(N_H) < 22$).
Results: spectral features

Ionised absorber edges (OVII and OVIII): 18% (or 32% of unabsorbed logNH<22 AGN)
Results: Iron K-α line properties


\[ \log(N_H) < 22 \]
\[ 22 < \log(N_H) < 23 \]
\[ \log(N_H) > 23 \]
Results: soft X-ray (0.4-2keV) excess (see poster)

All unabsorbed (logNH<22)

Soft excess fraction = $L_{BB}/L_{PL}$
Results: Compton reflection

- $\log NH < 22$
- $22 < \log NH < 23$
- $\log NH > 23$

$<R> = 2.7 \pm 0.75$

Fold energy outside BAT bandpass on average

BAT renormalisation allows 3 reflection parameters to be better constrained by removing a degree of freedom
Spin-off studies: the origin of the soft excess using broad-band X-ray data


See poster I8 (I10 in programme) Also see poster F06 – Boissay et al. (paper in prep.)

Ranjan Vasudevan
The X-ray Universe, Dublin
19 June 2014
Spin-off studies: Can we reproduce the X-ray background spectrum using local AGN?

See X-ray background synthesis models of e.g. Akylas et al. (2012) – also R. Walter talk on Monday (Extragalactic Surveys & Populations, CXB session), Ricci et al. (2011)
Future work: multi-wavelength AGN SEDs for a complete sample

Vasudevan et al. (2013), MNRAS, 431, 3127

Uses:
- Bolometric luminosities/bolometric corrections (Vasudevan et al. 2007, 2009a,b, 2010)
- If good UV, accretion efficiencies – Davis & Laor (2011), Raimundo et al. (2012), Trakhtenbrot (2014), talk by Matthew Middleton (Monday)
- Relative power emitted in the corona vs. the disc
- If coupled with $M_{\text{BH}}$ estimates, can study effect of radiation pressure ($\lambda_{\text{Edd}}$) on absorption ($N_H$)

HST-COS very desirable to constrain the accretion disc

NuSTAR campaign to observe ~200 BAT AGN; reflection and coronal properties constrained (Marinucci talk)
Summary

- The Northern Galactic Cap is a complete, hard X-ray selected, representative local AGN sample.

- We have already produced key results on the absorption and luminosity distribution, spectral features, connection to the X-ray background.

- This sampled has ‘inspired’ simulation work on the soft excess production mechanism (poster I8/10).

- The extensive multi-wavelength archival data is ripe for broad-band SEDs, which will give a complete picture of bolometric accretion luminosity output and shed light on other issues e.g. radiation pressure vs. absorption.

- Plenty of scope for proposals, e.g. NuSTAR, XMM, HST-COS...
Summary

- The Northern Galactic Cap is a complete, hard X-ray selected, representative local AGN sample
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- This sampled has ‘inspired’ simulation work on the soft excess production mechanism (poster I8/1)
- The extensive multi-wavelength archival data is ripe for broad-band SEDs, which will give a complete bolometric accretion luminosity output and shed light on other issues e.g. radiation pressure vs. absorption
- Plenty of scope for proposals, e.g. NuSTAR, XMM, HST-COS…

Vasudevan et al. (2013c), MNRAS, 431, 3127
Extra slides
Using broad-band (0.4-200 keV) data – renormalising BAT data

XRT + BAT fit **before** renormalisation

XRT + BAT fit **after** renormalisation (done for ~40% of sample)
Counts distribution

Figure 1. Histogram of total counts (0.4–10 keV) per observation for the 100 objects in our study. *XMM-Newton* (49 objects) clearly shows far superior counts statistics compared to *Swift/XRT* (46 objects) and *ASCA* (6 objects). (A color version of this figure is available in the online journal.)
From data to results

### Table 1
Table of Observations Used for Each Object

<table>
<thead>
<tr>
<th>AGN</th>
<th>Redshift</th>
<th>R.A.</th>
<th>Decl.</th>
<th>l</th>
<th>b</th>
<th>Instrument</th>
<th>ObsID</th>
<th>Obs. Date</th>
<th>Source Counts</th>
<th>Obs. Time (ks)</th>
<th>Usable % of obs</th>
<th>Optical Type</th>
<th>BAT Flux (SNR)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C 34</td>
<td>0.1849</td>
<td>150.457</td>
<td>28.715</td>
<td>200.208</td>
<td>52.708</td>
<td>XMM</td>
<td>00053410301</td>
<td>2006-06-24</td>
<td>2914</td>
<td>39.9</td>
<td>84</td>
<td>Sy1/Sy2</td>
<td>8.73 (5.10)</td>
</tr>
<tr>
<td>NGC 3227</td>
<td>0.0059</td>
<td>155.878</td>
<td>19.865</td>
<td>216.992</td>
<td>55.446</td>
<td>XMM</td>
<td>01010430301</td>
<td>2004-11-28</td>
<td>53612</td>
<td>40.1</td>
<td>99</td>
<td>Sy1.5</td>
<td>112.78 (56.21)</td>
</tr>
<tr>
<td>SDSS J104326.47+110524.2</td>
<td>0.0476</td>
<td>160.800</td>
<td>11.089</td>
<td>234.761</td>
<td>55.932</td>
<td>XRT</td>
<td>00040950401</td>
<td>2010-10-20</td>
<td>2085</td>
<td>9.8</td>
<td>–</td>
<td>Sy1</td>
<td>14.65 (4.84)</td>
</tr>
<tr>
<td>MCG +06-24-008</td>
<td>0.0259</td>
<td>161.203</td>
<td>38.181</td>
<td>182.222</td>
<td>61.326</td>
<td>XRT</td>
<td>00040955004</td>
<td>2010-10-31</td>
<td>133</td>
<td>4.4</td>
<td>–</td>
<td>galaxy</td>
<td>13.69 (5.04)</td>
</tr>
<tr>
<td>UGC 05881</td>
<td>0.0206</td>
<td>161.679</td>
<td>25.932</td>
<td>208.222</td>
<td>62.148</td>
<td>XRT</td>
<td>0007314002</td>
<td>2008-07-03</td>
<td>217</td>
<td>8.8</td>
<td>–</td>
<td>Sy2</td>
<td>20.94 (10.42)</td>
</tr>
</tbody>
</table>

### Table 2
Basic Fit Results

<table>
<thead>
<tr>
<th>AGN</th>
<th>Model (\chi^2/dof, P(\text{Null Hyp}))</th>
<th>(N_{\text{HI}}) (Covering Fraction) (N_{\text{HI}}) (Covering Fraction) (I)</th>
<th>(E_{\text{5.5-2keV}}) (E_{\text{2-10keV}}) (E_{\text{14-10keV}})</th>
<th>(R_L = L_{\text{5GFI}}/L_{\text{14-10keV}})</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C 34</td>
<td>C2 (658.26, 361.000) (1.76) 23.81 (0.03) (0.98)</td>
<td>0.94 (12.34) (44.70) (44.64) (44.9) (44.65)</td>
<td>(-5.33)</td>
<td></td>
</tr>
<tr>
<td>NGC 3227</td>
<td>C2 (198.13, 1775.000) (1.99) 23.05 (0.03) (0.92)</td>
<td>1.5 (0.01) (3.83) (84.25) (41.18) (41.58) (42.6) (42.7)</td>
<td>(-3.91)</td>
<td></td>
</tr>
<tr>
<td>SDSS J104326.47+110524.2</td>
<td>S2+BAT (80.53, 89.728) (2.47) 20.82 (0.12) (18.33) (29.18) (51.99) (43.44) (43.9) (43.8)</td>
<td>(-5.40)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCG +06-24-008</td>
<td>C1+BAT (4.72, 9.694) (1.26) 23.81 (0.36) (0.92) (0.94) (46.06) (42.81) (43.20) (43.3)</td>
<td>(-4.89)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>MCG +06-24-008</td>
<td>S2+BAT (6.04, 8.945) (1.26) 22.98 (0.31) (1.50) (34.11) (42.46) (42.83) (43.3) (43.3)</td>
<td>(-4.67)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>UGC 05881</td>
<td>C1+BAT (7.81, 38.856) (2.51) 24.39 (0.15) (0.97) (0.97) (22.63) (33.48) (43.44) (43.47) (43.3) (43.67)</td>
<td>(-5.25)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

### Table 3
Fit Results—Detailed Features (Iron Kα Lines, Soft Excesses and Warm-absorber Signatures) for Objects with >6000 counts in the Fit Spectra

<table>
<thead>
<tr>
<th>AGN</th>
<th>Model</th>
<th>(E_{\text{FeK}}) (1)</th>
<th>(E_{\text{SWW2K}}) (2)</th>
<th>(E_{\text{HII}}) (3)</th>
<th>(D_{\text{HII}}) (4)</th>
<th>(L_{\text{HII}}) (5)</th>
<th>(\tau_{\text{OIII}}) (6)</th>
<th>(\tau_{\text{OIII}}) (7)</th>
<th>(\tau_{\text{OIII}}) (8)</th>
<th>(L_{\text{OIII}}) (9)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C 234</td>
<td>C2</td>
<td>6.40+1.1 1.17+1.01 1.17+1.01 1.17+1.01</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
</tr>
<tr>
<td>NGC 3227</td>
<td>C2</td>
<td>6.40+1.1 1.17+1.01 1.17+1.01 1.17+1.01</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
</tr>
<tr>
<td>Mrk 728</td>
<td>S3</td>
<td>6.36+1.1 1.17+1.01 1.17+1.01 1.17+1.01</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
</tr>
<tr>
<td>IC 2637</td>
<td>S6</td>
<td>6.40+1.1 1.17+1.01 1.17+1.01 1.17+1.01</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
</tr>
<tr>
<td>PG 1114+445</td>
<td>S10</td>
<td>6.40+1.1 1.17+1.01 1.17+1.01 1.17+1.01</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
</tr>
<tr>
<td>IRX J1127+1909</td>
<td>S7</td>
<td>6.40+1.1 1.17+1.01 1.17+1.01 1.17+1.01</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
<td>(&lt;0.01)</td>
</tr>
</tbody>
</table>
Radio loudness

Figure 9. Radio loudness ($\nu L_\nu (\nu = 5\,\text{GHz})/L_{2-10\,\text{keV}}$) against intrinsic 2–10 keV luminosity. Downward-pointing arrows show upper limits where FIRST radio detections were not available (assuming a flux limit of 0.75 mJy to calculate the luminosities).
Absorbed fraction vs. luminosity

Figure 13. Absorbed fractions against intrinsic 2–10 keV luminosity (10 objects per bin). Filled circles connected by thin solid lines show the fraction of sources with \( \log(N_{\text{H}}) > 22 \), whereas empty squares connected by thick lines show the fraction of sources with \( \log(N_{\text{H}}) > 23 \). The solid gray and blue hatched shading reveal the uncertainty in these fractions due to the 13 sources with ambiguous spectral types (and hence two estimates for their \( \log(N_{\text{H}}) \)). The absorbed fraction in the highest luminosity bin (indicated by the red square) is more uncertain since it contains only four objects.
Photon index vs. Luminosity

Figure 15. Photon index $\Gamma$ against intrinsic (absorption-corrected) 2–10 keV luminosity $L_{2-10\text{keV}}$. The gray shaded areas delineate the hard limits imposed on $\Gamma$ in the fit.
Figure 23. Soft-excess strength against photon index $\Gamma$. The soft-excess strength is parameterized as described in Figure 22. Downward-pointing arrows show upper-limiting soft-excess strengths wherever a source did not have a statistically significant soft excess (using the ZBBODY model).
### Table 5

Reflection Fit Results for Objects with *XMM-Newton* Data, Fit in Conjunction with BAT Data

<table>
<thead>
<tr>
<th>AGN</th>
<th>Partial Covering?</th>
<th>BAT Renormed?</th>
<th>$R$</th>
<th>$E_{fold}$</th>
<th>$\Gamma_{PEXRAY}$</th>
<th>$\Delta\Gamma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3C 234</td>
<td>Y</td>
<td>Y</td>
<td>$&lt;0.58$</td>
<td>138$^{+1044}_{-85}$</td>
<td>2.03$^{+0.14}_{-0.13}$</td>
<td>$-0.17$</td>
</tr>
<tr>
<td>NGC 3227</td>
<td>Y</td>
<td>...</td>
<td>12.86$^{+3.10}_{-3.14}$</td>
<td>$&gt;636$</td>
<td>2.08$^{+0.05}_{-0.09}$</td>
<td>0.58</td>
</tr>
<tr>
<td>Mrk 417</td>
<td>Y</td>
<td>Y</td>
<td>$&lt;0.45$</td>
<td>38$^{+13}_{-17}$</td>
<td>0.75$^{+0.08}_{-0.31}$</td>
<td>$-1.31$</td>
</tr>
<tr>
<td>Mrk 728</td>
<td>...</td>
<td>...</td>
<td>0.07$^{+1.30}_{-0.07}$</td>
<td>616$^{+590}_{-90}$</td>
<td>1.70$^{+0.38}_{-0.09}$</td>
<td>$-0.07$</td>
</tr>
<tr>
<td>IC 2637</td>
<td>...</td>
<td>Y</td>
<td>1.09$^{+2.38}_{-0.91}$</td>
<td>$&gt;156$</td>
<td>1.79$^{+0.24}_{-0.09}$</td>
<td>0.10</td>
</tr>
</tbody>
</table>
Reflection vs. luminosity for stacked spectra

**Fig. 4.** Reflection vs intrinsic 2–10 keV luminosity for \( \log N_H < 22 \) sources, stacked in different luminosity bins.
Summed soft spectrum from entire catalogue

sources with ambiguous spectral types assumed to be 'simple'
‘Evolution’ of the BAT AGN with flux limit

<table>
<thead>
<tr>
<th>Catalog</th>
<th>Flux Limit</th>
<th>Completeness Limit</th>
<th>Ambiguous Sources</th>
<th>( \log(N_H &gt; 22) )</th>
<th>( \log(N_H &gt; 23) )</th>
<th>( \log(N_H &gt; 24.15) ) (C-thick)</th>
<th>Simple Abs. ((\log N_H), \sigma)</th>
<th>Complex Abs. ((\log N_H), \sigma)</th>
</tr>
</thead>
<tbody>
<tr>
<td>9 month</td>
<td>-10.70</td>
<td>-11.0</td>
<td>0%</td>
<td>55%</td>
<td>33%</td>
<td>0% (&lt;6%)</td>
<td>45% (20.58,0.74)</td>
<td>55% (23.03,0.71)</td>
</tr>
<tr>
<td>22 month</td>
<td>-10.96</td>
<td>-11.25</td>
<td>10%</td>
<td>59%–64%</td>
<td>49%–54%</td>
<td>5% (&lt;18%)</td>
<td>36%–46% (20.47–20.56, 0.86–0.90)</td>
<td>54–64% (23.28–23.4, 0.57–0.68)</td>
</tr>
<tr>
<td>58 month</td>
<td>-11.40</td>
<td>-11.6</td>
<td>13%†</td>
<td>57%–61%</td>
<td>41%–45%</td>
<td>9% (&lt;15%)</td>
<td>38%–50% (20.67–20.80, 1.12–1.18)</td>
<td>43–56% (23.27–23.55,0.71–0.95)</td>
</tr>
</tbody>
</table>

Notes. (1) Catalog. (2) Logarithm of BAT flux limit (14–195 keV) in erg cm\(^{-2}\) s\(^{-1}\). (3) Completeness limit, given as log(S) for 2–10 keV flux S in units of erg cm\(^{-2}\) s\(^{-1}\). (4) Percentage of sources with ambiguous spectral types. (5) Percentage of sources with \( \log(N_H) > 22 \). (6) Percentage of sources with \( \log(N_H) > 23 \). (7) Percentage of Compton-thick sources, with \( \log(N_H) > 24.15 \) (upper limits are based on consideration of the other Compton-thickness metrics discussed in Section 5.1). (8) Percentage of simple absorption sources, with average column density and standard deviation. (9) Percentage of complex-absorption sources, with average column density and standard deviation. Ranges in these values are due to sources with ambiguous spectral types. † An additional 5% of our 58 month sources do not have enough counts to construct a spectrum, so these are not classified into any of the categories shown here.
Future work: multi-wavelength AGN SEDs for a complete sample

- Mrk 50

- Swift-UVOT, XMM-OM

- SDSS

- Spitzer

- <= Herschel

- XMM

- BAT

(e.g. current campaign to observe 100 BAT AGN with NuSTAR+XRT – Lu et al. 2013 AAS conf. proceedings, Keck et al. 2014 AAS)
Figure 30. Plot of log($N > S$) against log($S$), for 2–10 keV flux $S$ in erg s$^{-1}$ cm$^{-2}$, where log($N > S$) is the logarithm of the number of sources with flux greater than $S$. The thin line shows a slope of $-1.5$ expected for a uniform distribution. Our sample shows a slope consistent with this down to fluxes of log($S$) = $-11.6$. 

log $N$ – log $S$