Optical and X-ray Properties of the Swift BAT-detected AGN

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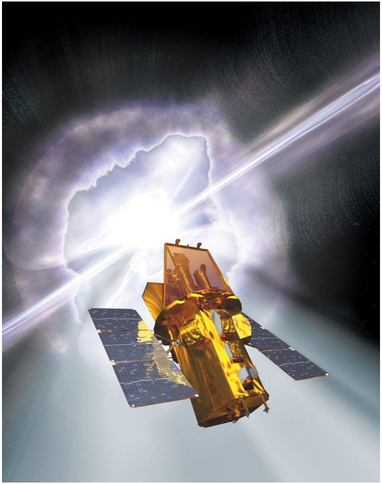
X-ray Astronomy 2009

Swift Burst Alert Telescope

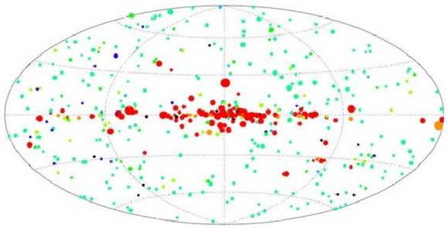


- The Swift BAT is an 'all sky' instrument – covering $\approx$ 20% of the sky at any one time and $\approx$ 50% of the sky each day when not triggering on GRBs
- Sensitive from 14–195 keV
- Extensive follow-up of sources by the two other telescopes on SWIFT (UVOT and XRT) with relatively short exposures

'Unbiased' Survey

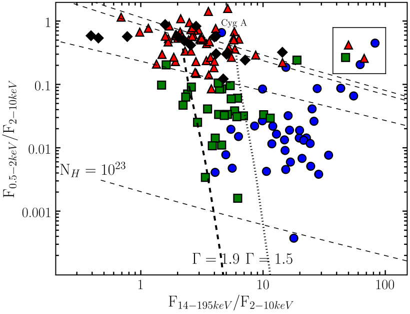
- All previous AGN surveys were biased (wrt obscuration)
- Much larger sample than HEAO-1 (and Integral) –1st sensitive all sky hard x-ray survey in 28 years!
- BAT data provides first large unbiased sample of host galaxy properties
- Direct comparison with z $\approx$ 1 Chandra and XMM surveys
  - Distribution of n_H values
  - Luminosity function
  - $\log N$ - $\log S$
  - necessary for modeling x-ray background

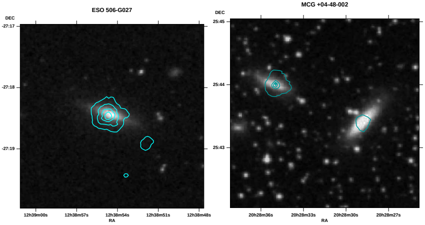
9-month BAT Survey



- 153 AGN detected at $\geq 4.8\sigma$
- $F_{14-195keV} >$ few $\times 10^{-11}$ erg s^{-1} cm^{-2}
- $< z > \approx 0.03$
- See Tueller et al. (2008)
- The Survey is continuing, with the completed 22 month (262 sources, ApJS, accepted) and on-going 36 month catalogs.
- Sensitivity is still scaling as $\sqrt{t}$

X-ray Sources

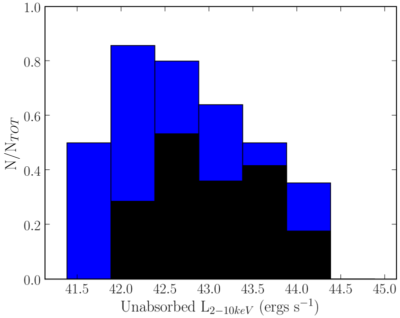


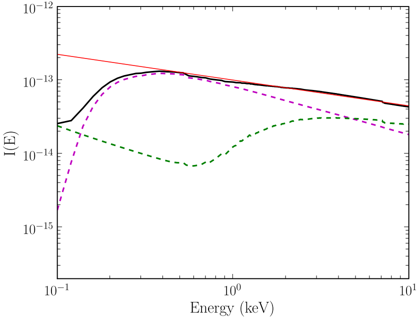


- Collected X-ray properties from Swift XRT, ASCA, *XMM-Newton*, and *Chandra*
- Sources selected:
  - Detected with BAT as a 5σ or higher detection
  - Optical counterpart clearly seen in DSS/2MASS images
- See Winter et al. (2009)

(Left) XMM-Newton contours on DSS images.

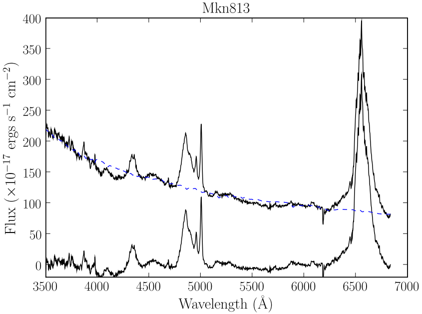
Among Our Results ...

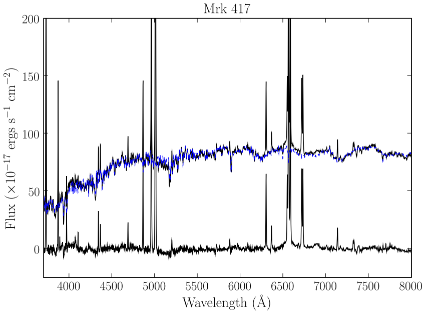




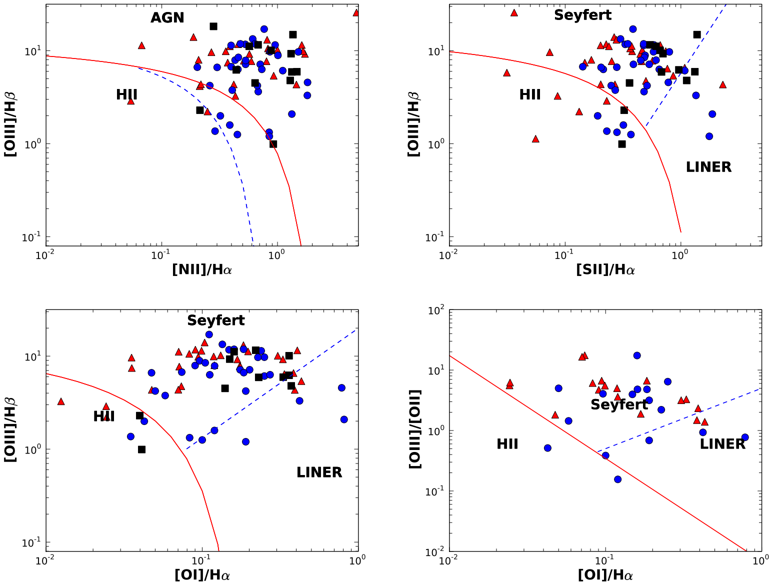
- Higher fraction of absorbed sources at low luminosity/accretion rate
- The average X-ray spectrum (0.6–10 keV) replicates the CXB slope of 1.4
- Very few Compton thick sources

Optical Study

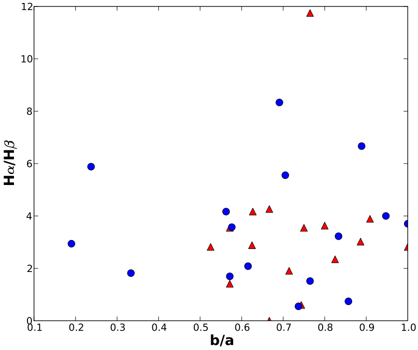


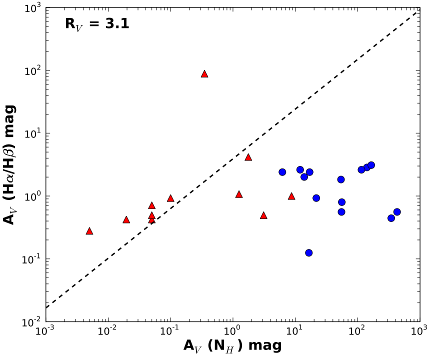


- Covered 80% of the 'Northern' BAT sources (see Koss poster 7.35 for images)
- Spectra from archived SDSS observations (27), our own KPNO 2.1-m observations (40), and the literature (5)
- Half of the spectra show broad H-Balmer lines


AGN
HII
[OIII]/Hβ
[NII]/Hα
Seyfert
HII
LINER
[OIII]/Hβ
[SII]/Hα
Seyfert
HII
LINER
[OIII]/Hβ
[OI]/Hα
Seyfert
HII
LINER
[OIII]/[OII]
[OI]/Hα

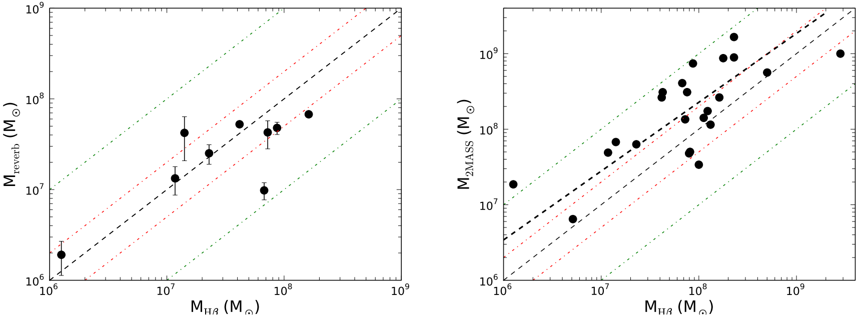
Reddening Estimates





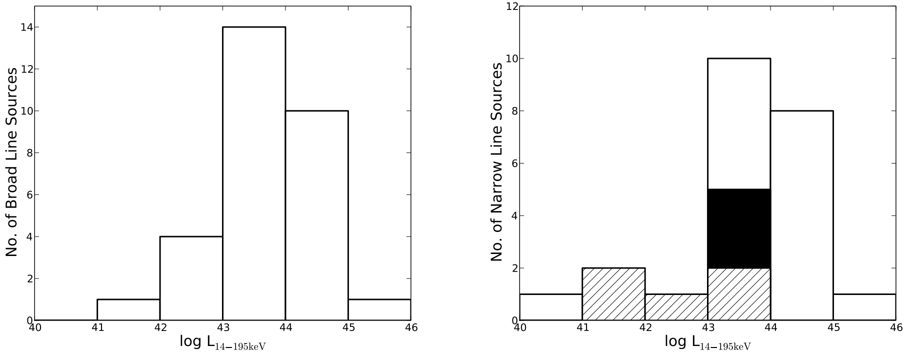
- No correlation between optical reddening and host inclination.
- No correlation between optical and X-ray extinction for narrow line sources.
- Unlike the results of Alonso-Herrero et al. (1997), most Sy 1s have more extinction in the optical than X-ray band.

Comparisons of Mass Determination Methods



- Reverberation mapping/H-β derived masses are well-correlated.
- 2MASS-derived/H-β derived masses are also well-correlated.
- Average mass of the Swift BAT-detected AGN: $< M/M_\odot >= 10^{7.87 \pm 0.66}$, consistent with previous studies (Woo & Urry, 2002)

Luminosity Distributions



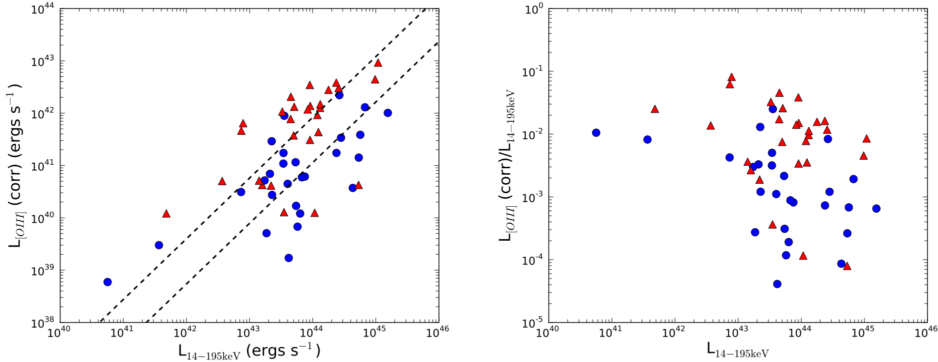
Broad Line: $\log L_{14-195keV} = 43.74$, $\log L_{[OIII]} = 41.79$

Narrow Line: Seyferts: $\log L_{14-195keV} = 43.87$, $\log L_{[OIII]} = 41.55$

LINERs: $\log L_{14-195keV} = 43.50$, $\log L_{[OIII]} = 40.73$

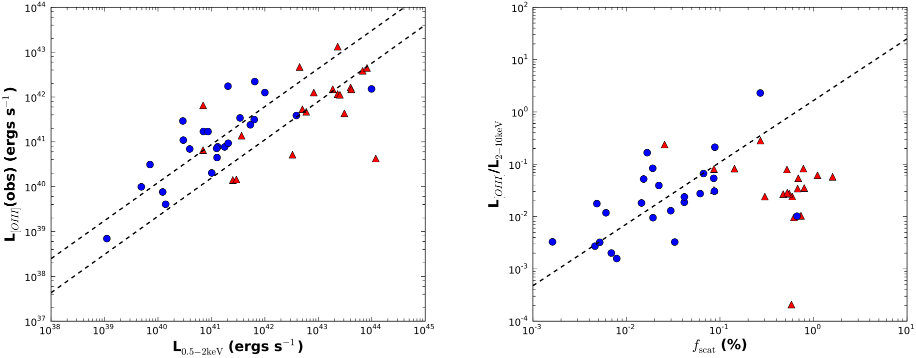
Others: $\log L_{14-195keV} = 42.69$, $\log L_{[OIII]} = 40.33$

X-ray/Optical Luminosity Comparison



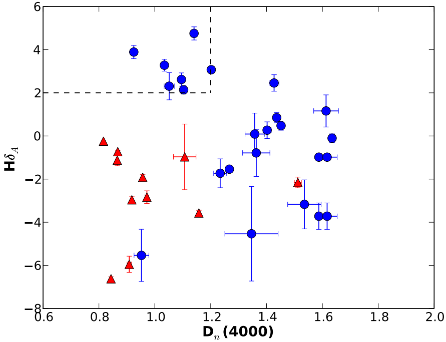
- Slight correlations ($R^2 < 0.4$) are seen between [O III] and BAT luminosities: $L_{[OIII]}(\mathrm{corr}) \propto L_{BAT}^{1.16\pm0.24}$. There is a lot of scatter.
- Agrees with Meléndez et al. (2008), in contrast to Heckman et al. (2005).

Soft X-ray and Optical Luminosity



- Best correlation ($R^2 = 0.6$) between the [O III] and soft X-ray flux for narrow line sources
- Same seen in the XMM sample presented by Terashima (2009)

Host Galaxy Properties



Narrow Line Sources
Broad Line Sources

- $D_n(4000)$: Old stars through the Ca II break
- $H\delta_A$: Young stars through $H\delta$ absorption
- Narrow Line sources are consistent with intermediate/old populations
- Broad Line sources have lower $H\delta$ EWs
- Low EWs (< 0) associated with very young populations of < 0.1 Gyr (Leitherer et al., 1999)
- But, see M. Koss's poster (7.35)

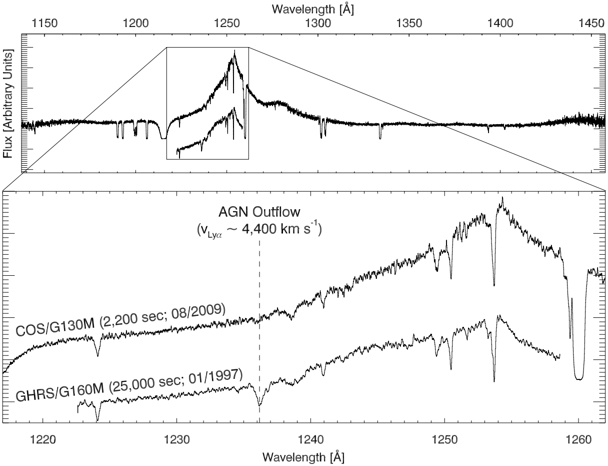
Summary

- We have completed analyses of the X-ray (0.3–10 keV) and optical spectra of the Swift BAT-detected AGN in the 9-month catalog.
- Optical extinction is not from the host galaxy and is correlated with X-ray extinction for Sy 1s but not Sy 2s.
- Optically identified Seyferts have the same distributions of both [O III] λ5007Å and 14-195 keV luminosities for narrow and broad line sources. This is in agreement with the Unified Model.
- Correlations between [O III] λ5007Å and 14-195 keV luminosities are weak with much scatter. $L_{[OIII]}$ is not the best indicator of L_{bol}.
- Broad Line sources appear to have much younger stellar host populations than narrow line sources (based on Lick indices). This conflicts with the Unified Model?

Future and On-going Work

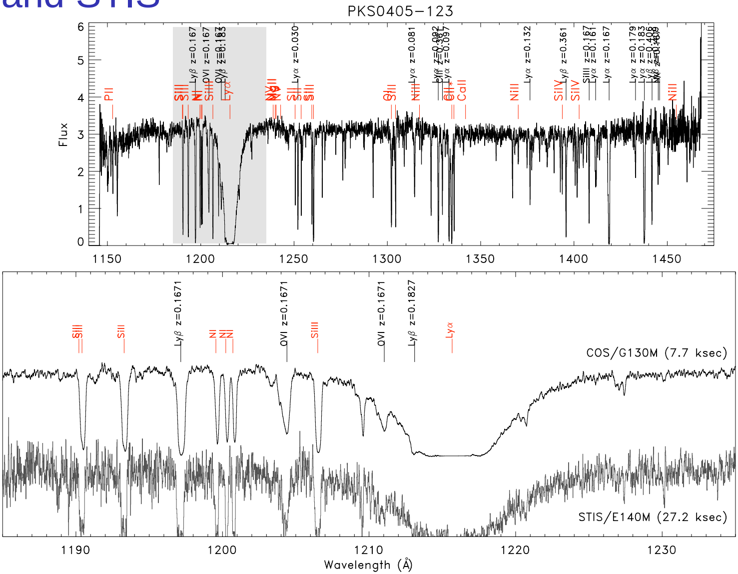
- Complete optical spectral properties from the 22-month catalog with coverage in the North (Koss) and South (Ueda)
- NIR imaging and spectroscopy (Koss)
- Fellowship program: A study of the Sy 1 warm absorber/outflow properties using X-ray, UV, and optical data

COS and GHRS spectra of an AGN outflow



COS observations achieved comparable S/N to the GHRS observations in about 1/10th the time with 10 times more spectral coverage! (credit: Brian Keeney, CASA)

COS and STIS



credit: Charles Danforth, CASA

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