Mitigating X-ray Obscuration Biases with Isotropic AGN Selection

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Key Questions

1. How prevalent are the most obscured AGN?

2. How can we construct a representative census of the most obscured AGN?
Predicted **Prevalence** of Obscuration

Tasnim Ananna+18

> 50% of z < 1 AGN are Compton-thick

(Also Comastri+95, Mushtozky+00, Gandhi+03, Gilli+07, Treister+09, Aird+15)
Our Cosmic Backyard

Circinus

NGC 4945

Cen A

We are here

100% heavily obscured

1 Mpc  Extragalactic Objects
Our Cosmic Backyard

We are here

100% heavily obscured

67^{+97}_{-54} % Compton-thick

1 Mpc  Extragalactic Objects
Swift/BAT Compton-thick AGN

Bias-corrected 27%

Ricci+15

20 Mpc

Compton-thick

D / Mpc

Fraction

0 20 40 60 80 100

0.0 0.2 0.4
Missed Compton-thick AGN

NGC 4968
Lamassa+17
+in prep.

ESO 116-18
Zhao+18

NGC 1320
Baloković+14

IC 3639
Boorman+16.

NGC 449, IC 4995
Guianazzi+05

Mrk 573
2M 2139
Boorman+, in prep.

ESO 18-9
UGC 9944
2M 2355

NGC 7674
Gandhi+17
1. How prevalent are the most obscured AGN?

2. How can we construct a representative census of the most obscured AGN?
Mid-infrared Isotropy

(Also Buchanan+06, Horst+08, Levenson+09, Gandhi+09, Lawrence & Elvis 10, Hönig+11)
Isotropic Selection – IRAS Flux Cut

Inherent prevalence of Type 1 & 2 AGN
Infrared Classification - Warm Colours

-de Grijp+1987 Selection

Non-active Galaxy

Active Galaxy

Normalized $\nu F_\nu$

$\lambda / \mu m$

Mullaney+11 templates
Optical Classification

• **Line ratio diagnostics - Keel+94**
  
  • May miss AGN with **large scale host dust** (e.g., Goulding+09, Buchner+17)

  • Would lead to **lower limit on obscured fraction**
Type 1: 36
Type 2: 48
Swift/BAT-Undetected
(70-Month): 38

\[ N_{\text{uLANDS}} = \text{NuSTAR LOCAL AGN N}_h \text{ DISTRIBUTION SURVEY} \]
Representative? **Optical traces infrared**

![Graph and diagram showing optical and infrared traces with respective CDFs and histograms.](image)

- **CDF**: Cumulative Distribution Function
- **N**: Number of observations
- **NLR e.g. [OIII]**: Narrow Line Region
- **SMBH**: Supermassive Black Hole
- **Corona**: Corona region
- **Gas+Dust Torus**: Gas and Dust Torus

*Boorman+, in prep.*
Representative?  **X-ray does not trace infrared**

- **Type 1**
- **Type 2**

![Diagram showing X-ray emission from different regions](image)

Boorman+, in prep.

Log $F_{14-195\,\text{keV}} / F_{60\mu\text{m}}$
Compton-thick candidates

Boorman+, in prep.

Swift/BAT Signal to Noise

Should have been detected...

Predicted from IR
Compton-thick candidates

But *weren’t!*

Observed

Predicted from IR

Should have been detected...

Swift/BAT Signal to Noise

Boorman+, in prep.
Directly Observed $N_H$ Distribution (so far)

- NuLANDS Boorman+, in prep.
- Observed \textit{Swift}/BAT
- Ricci+15, 17

\[ \log N_H / \text{cm}^{-2} \]
How can we construct a **representative census** of the most obscured AGN?

- NuLANDS is $N_H$ - unbiased selection
- We find many **Compton-thick AGN** missed by BAT - **complementary**
- Obscured fraction may still be **lower limit** due to **classifications**
¡Muchas gracias!

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