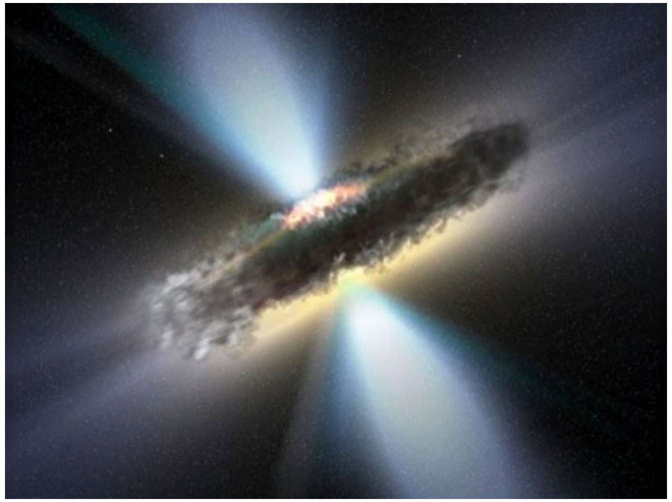


AGN Surveys in a Strobe-X context

Michael Koss

Eureka Scientific

What I won't talk about

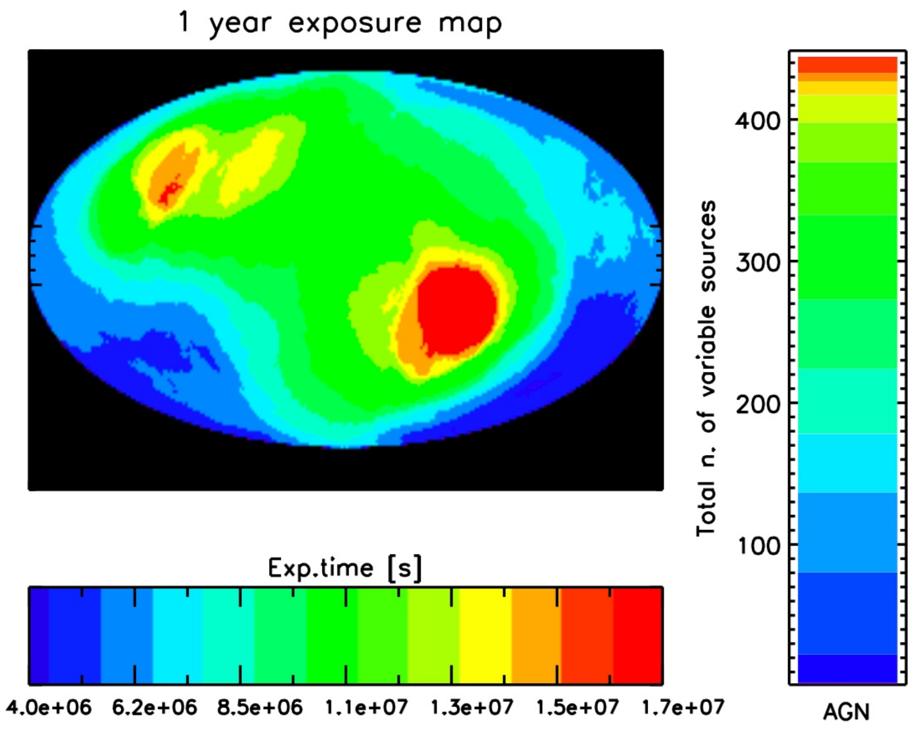
- Modeling Large number sources
  - Reverberation Mapping & Black Hole Masses
  - Γ /Reflection/Coronal Cutoff/Soft Excess/UFOs/Covering factor
- Radio loud AGN/Blazars
- These are all LAD heavy topics, **what can we do with the WFM**
- Lots thought/work from LOFT on AGN Surveys with LAD/WFM (e.g. De Rosa et al. 2013)

What are the Big Questions for AGN surveys?

1. How much black hole growth occurs in heavily obscured AGN? Host morphology/black hole growth?

2. What is the distribution and column density of material and how does it vary over timescales of days/months? How do AGN vary radio/X-ray and optical/X-ray for large samples.

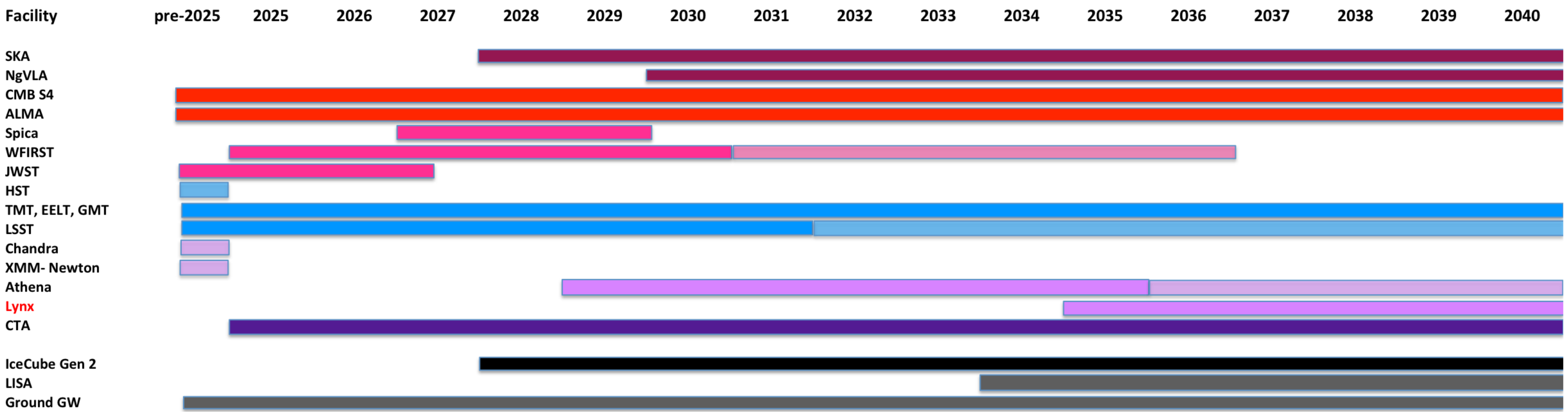
WFM 1 year sensitivity



De Rosa et al. LOFT AGN whitepaper

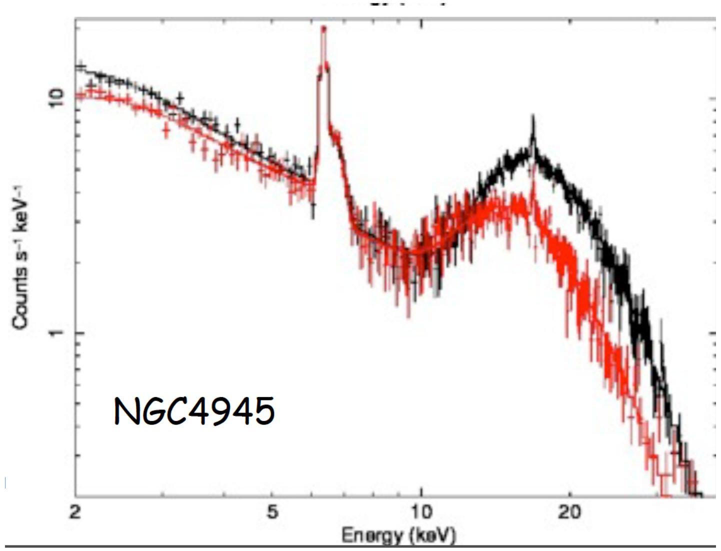
In 1st year, WFM will return light curves with at least 10 points, for several hundreds of *variable* AGN
Both individual (for the brightest) and ensemble studies of AGN variability on long (months) timescales.
Study the variability-luminosity, variability Eddingtion-ratio etc.
Test anti-correlation between the BH mass and the X-ray variability at a variety of energies

Survey Overlap



- E-ROSITA will have already mapped the sky, but only every 6 months
- XARM (Hitomi relaunch early 2020s no >10 keV imager)
- Good Overlap with LSST/SKA/CTA

Geometry of obscurers in BLR (NH Variability)



NGC 4945

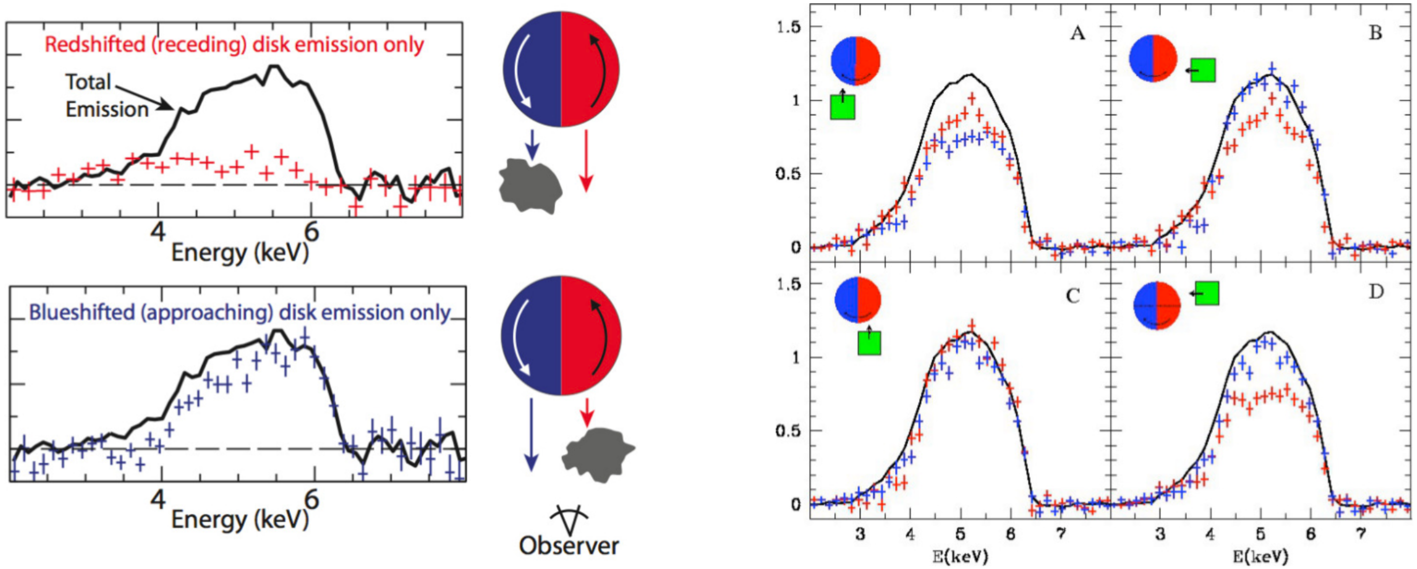


Figure 3: *Left:* simulation of a 50 ks total eclipse by a Compton-thick cloud in NGC 1365. The approaching and receding part of the disc are subsequently eclipsed, allowing the observation of the redshifted and blueshifted line profiles separately. *Right:* The same, for partial eclipses by a Compton-thin cloud, i.e., 50% covering factor and $N_H \sim 3 \times 10^{23}$ cm^{-2}.

E-ROSITA will only map the sky every 6 months
WFM will enable tracking many nearby AGN for NH variability (2-10 keV unique)
LAD can measure NH variability of large number of nearby AGN, particularly above 10 keV

Combination of LAD/WFM enables longterm study of AGN variability

Above 10 keV, very difficult to study with BAT and NuSTAR.
Study variability Black Hole (BH) mass, luminosity, and accretion rate
Full PSD at soft and hard energies
Radio/X-ray variability with SKA, particularly important radio-quiet AGN
LSST Accretion disk X-ray vs. grizY

What can LAD do for AGN surveys LAD Sensitivity

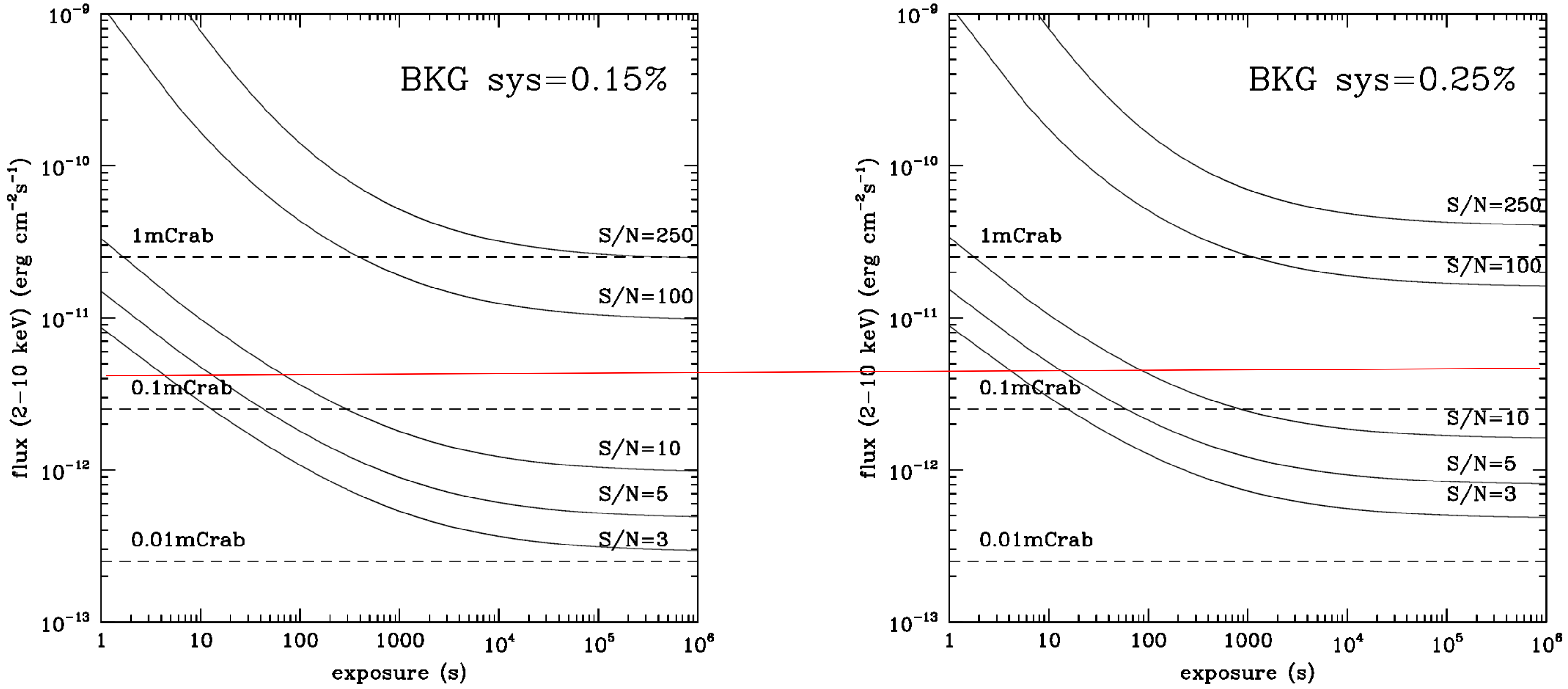
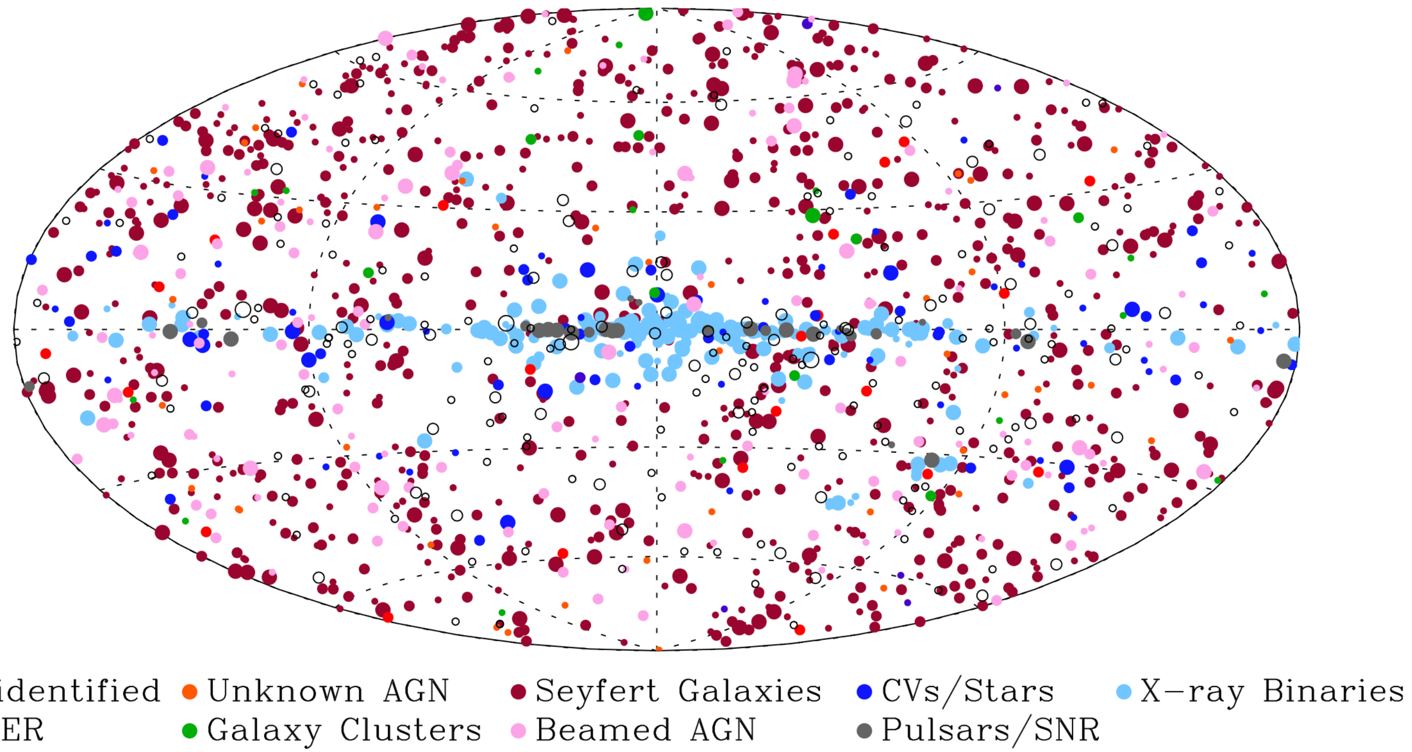


Figure 1: LAD sensitivity curves for S/N = 3, 5, 10, 100 and 250. On the left we assume the estimated value for the background systematics, 0.15%, while on the right the requirement value of 0.25%.

BAT 105m sensitivity 90% sky, 4.4e-12 at 2-10 keV

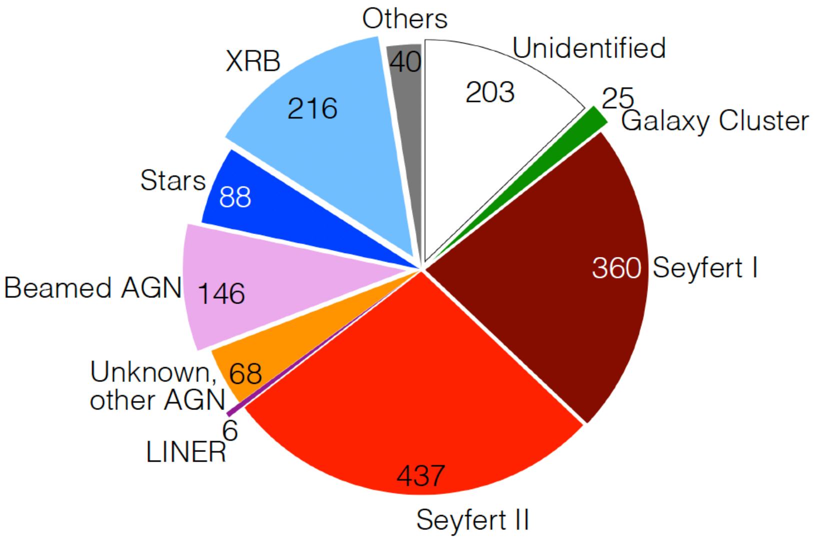
De ROSA et al. LOFT whitepaper

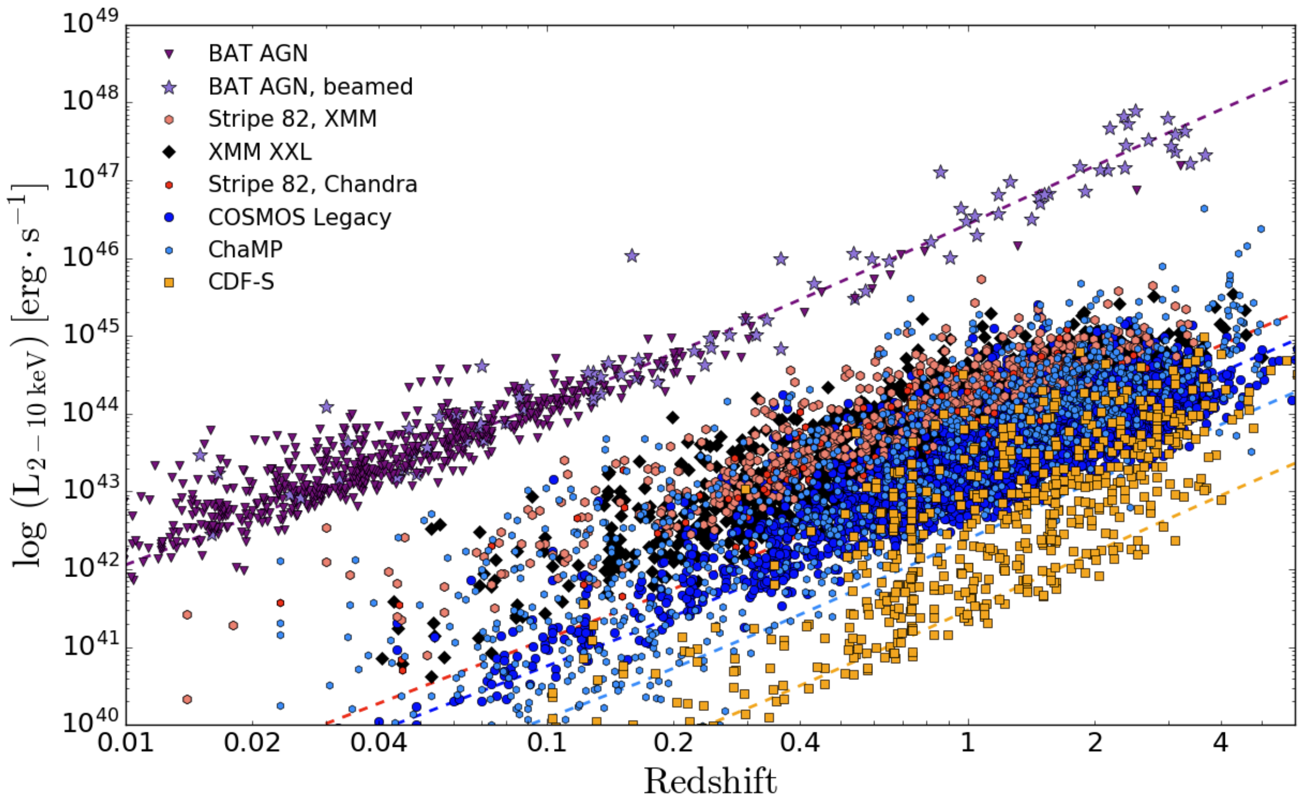
105 Month Swift Catalog



Large fraction of nearby AGN, 90% sky is roughly 4.4 erg/cm/s (Oh et al. submitted)

LAD/WFM All Sky Surveys





Koss et al. 2017a

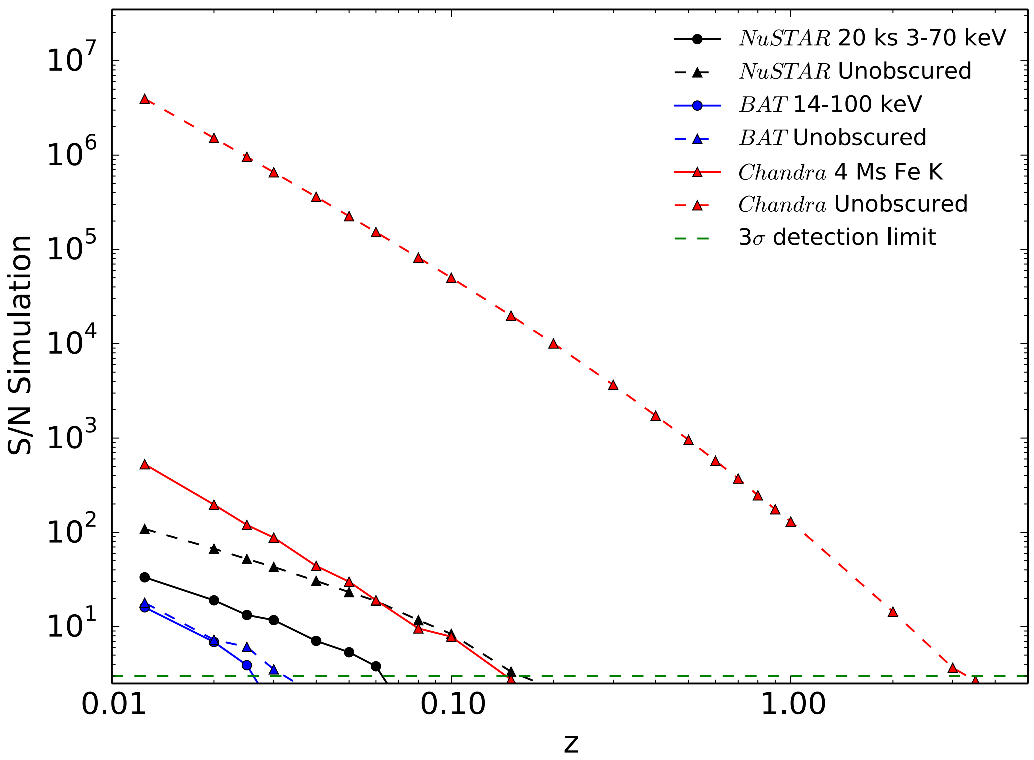
LAD can survey all Swift BAT AGN

WFM can detect AGN at 500 Mpc with 4–10 keV luminosities of 10^{43} erg/sec (30 Msec of on-source time ~few years)

~5 deeper intrinsic luminosity than Swift BAT 105m

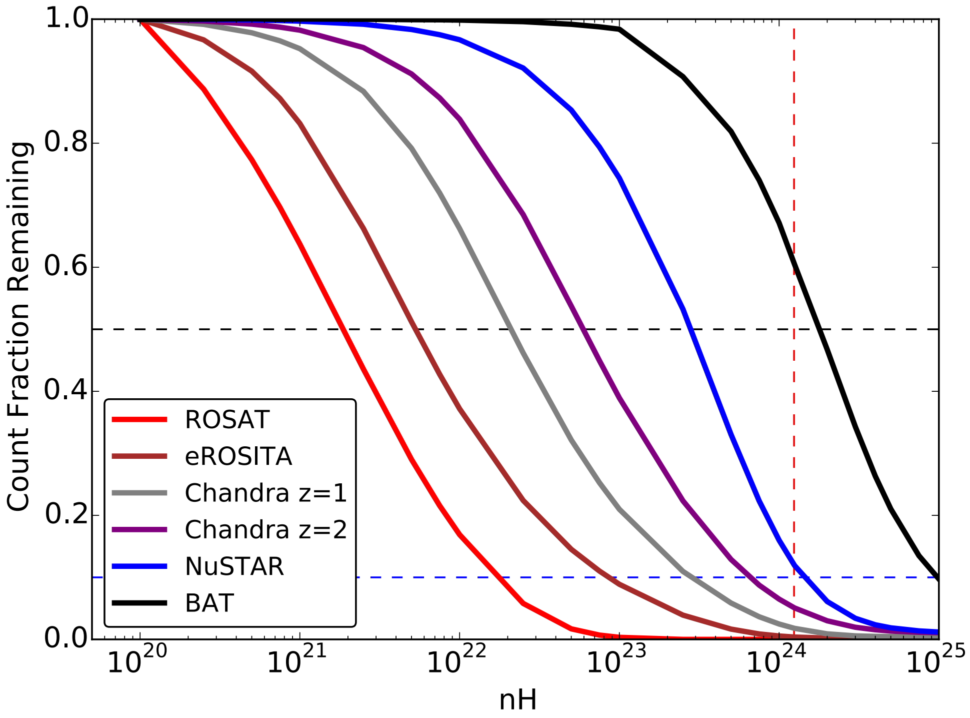
Much more sensitive than E-ROSITA to obscured AGN (Need to simulate depth after survey 4-10 keV/confusion)

Finding Heavily Obscured AGN is incredibly difficult



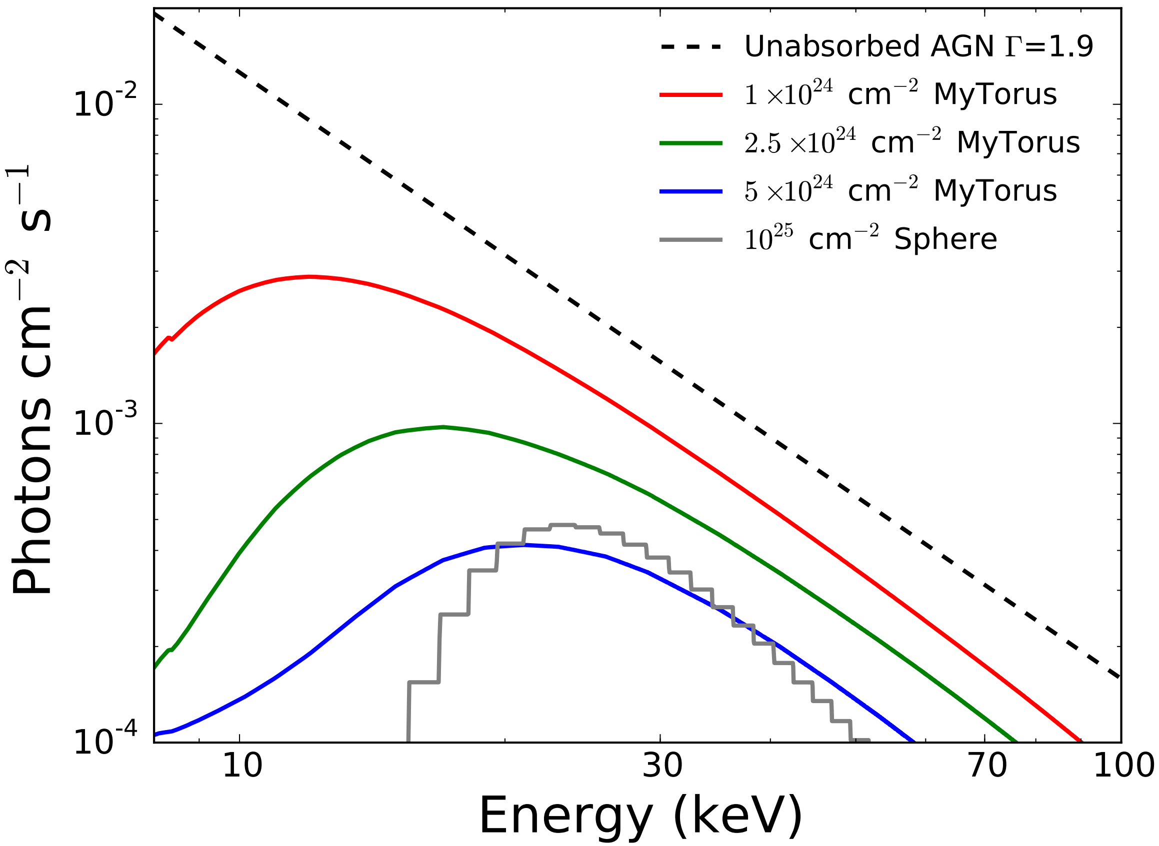
Simulation for Compton thick AGN with 10^{45} erg/s L_bol (NGC 3393, z=0.012)
Find this source out to z=3-5 unobscured in CDF-S, but only z=0.3-0.5 if Compton thick, However can only determine intrinsic luminosity out to z<0.2 (Fe Ka).
Deepest Surveys are massively biased against Compton thick AGN.

Why High Energy Selection?



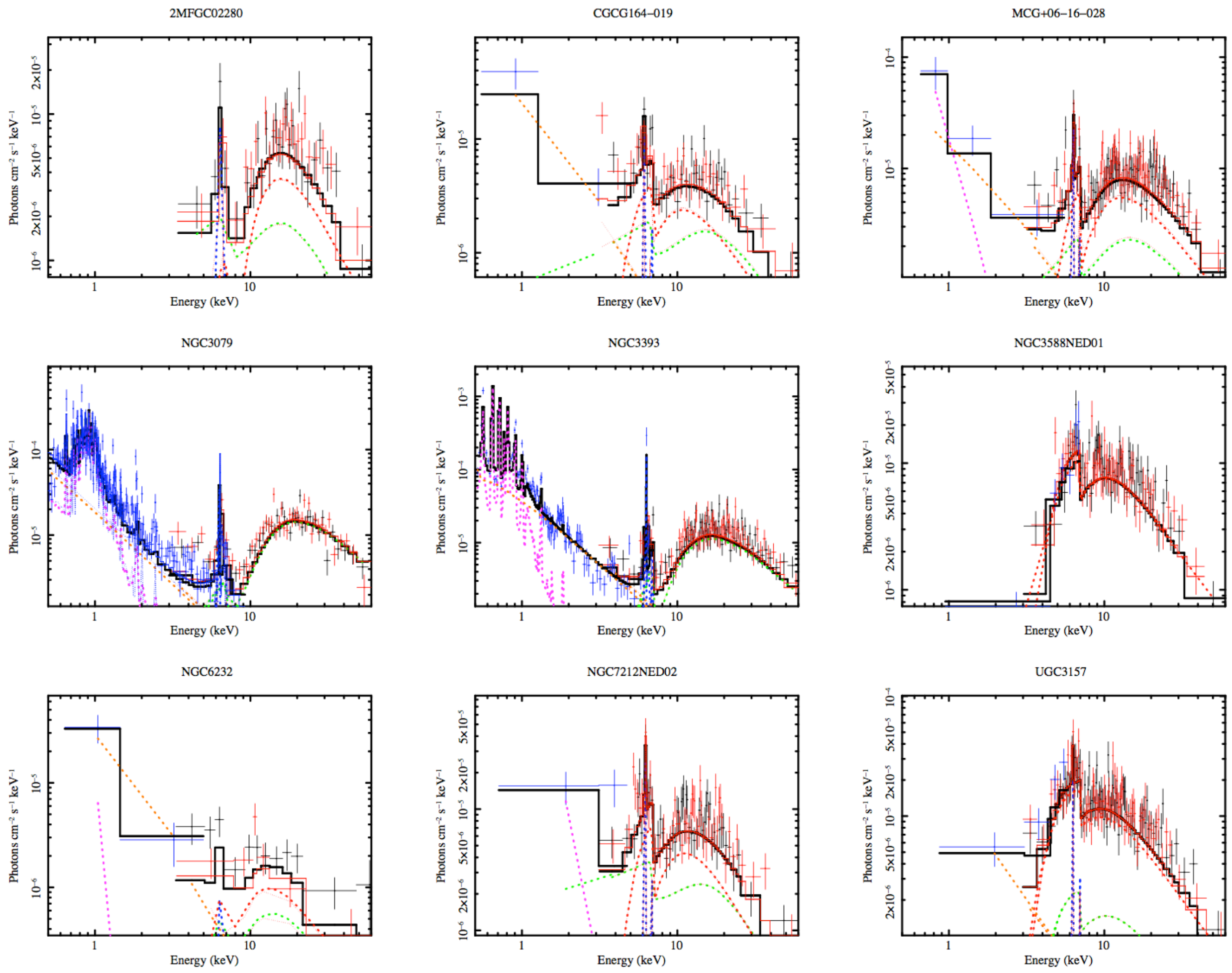
A complete sample of unobscured and obscured is critical to understanding BH growth.

Finding the Most Obscured AGN Using Spectral Curvature



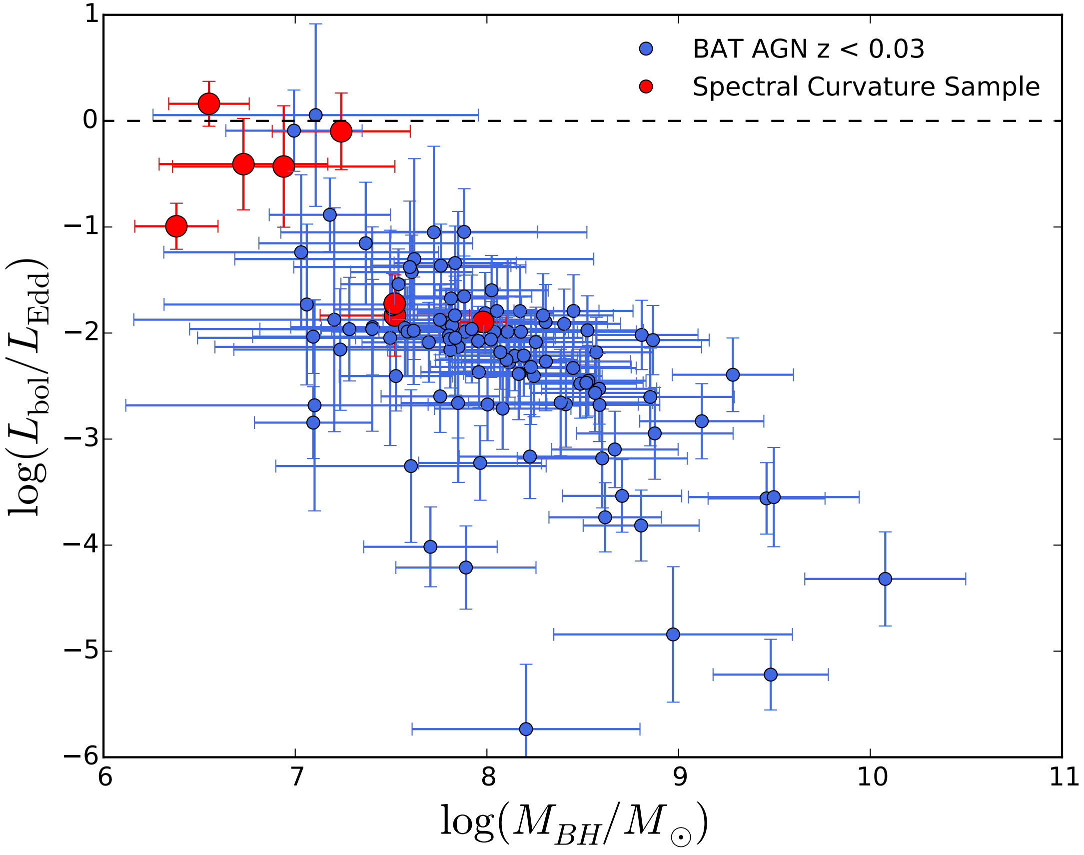
Increasing spectral curvature of BAT spectra around Compton-hump
Can be used to select unknown Compton-thick AGN (Koss et al. 2016)

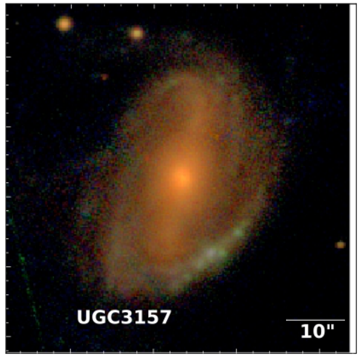
NuSTAR Confirmation of Compton-thick candidates

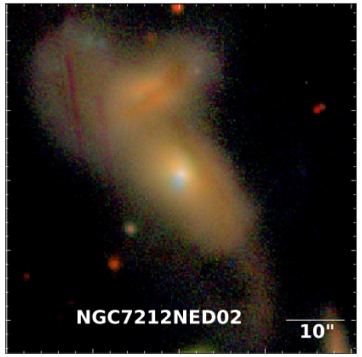


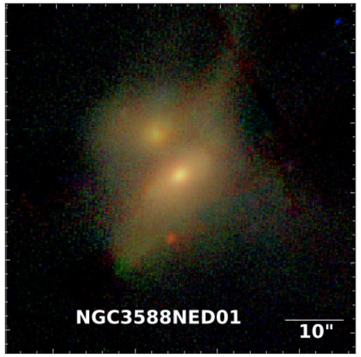
Majority are Compton thick (7/9), most newly discovered
Spectral Curvature (Koss et al 2016a)

Compton-thick candidates: Fraction and Accretion Rates









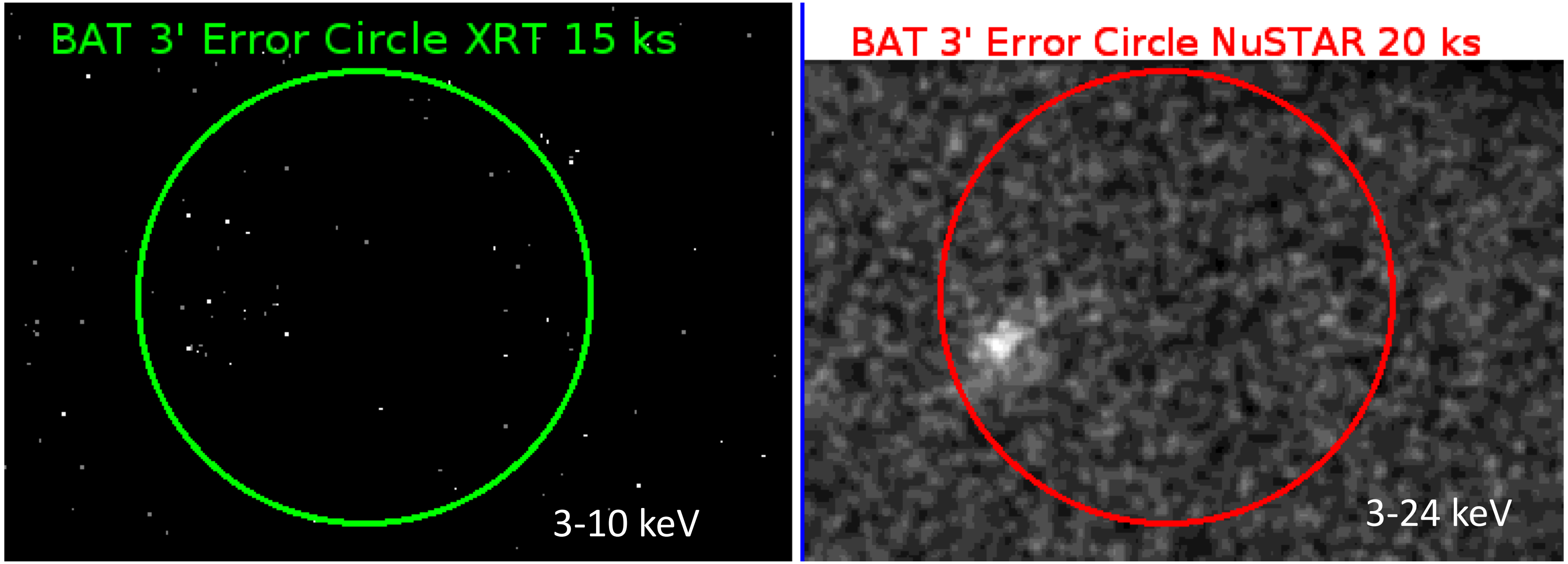
Spectral curvature suggest CT AGN fraction is 22%

Accretion rates are 4x higher than typical BAT AGN

Sum BH growth in Compton-thick as large as the rest of the population of obscured and unobscured AGN.

Many host galaxies studies enabled

Finding Unidentified BAT AGN

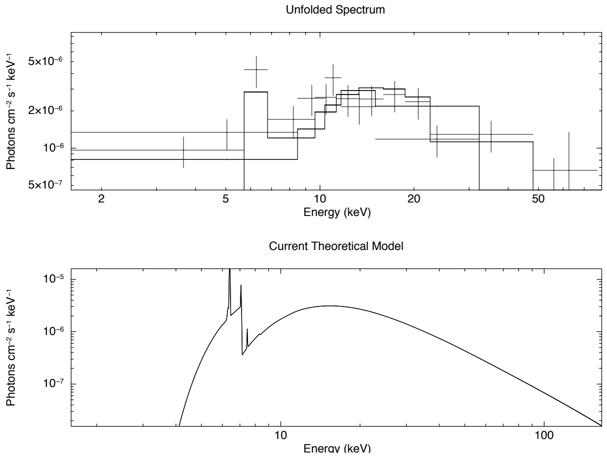


NGC 6232, Sey 2

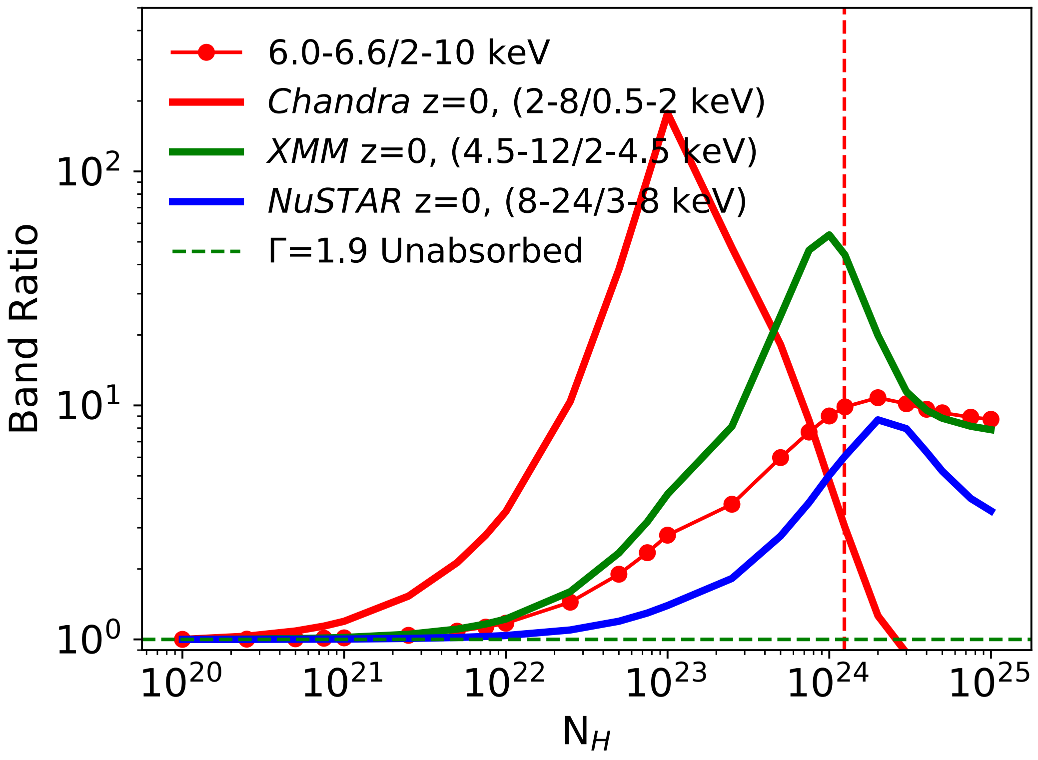
No detection >2sigma at 3-10 keV with Swift XRT

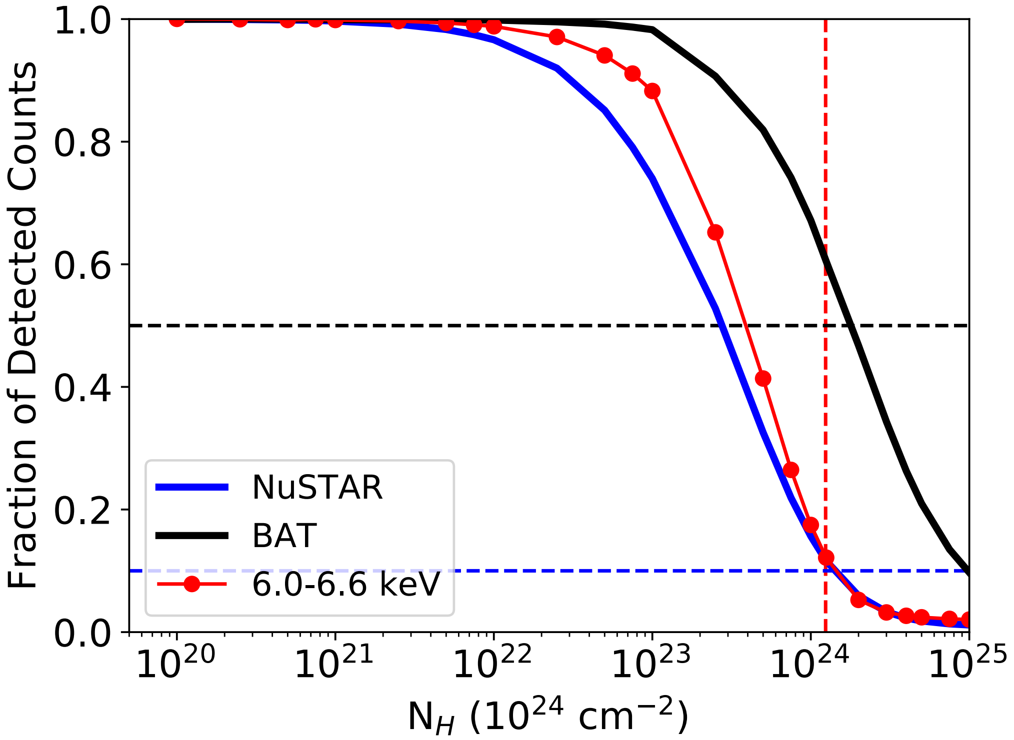
At about 15 ks, factor of few more sensitive E-ROSITA

SN 9.7 Detection NuSTAR vs. 5.1 BAT



Blind Fe Ka Study with WFM for nearby galaxies





Very difficult to do blind survey for heavily obscured AGN in faint sources because Fe Ka gives factor of 10 improvement in signal, also much lower background

Summary

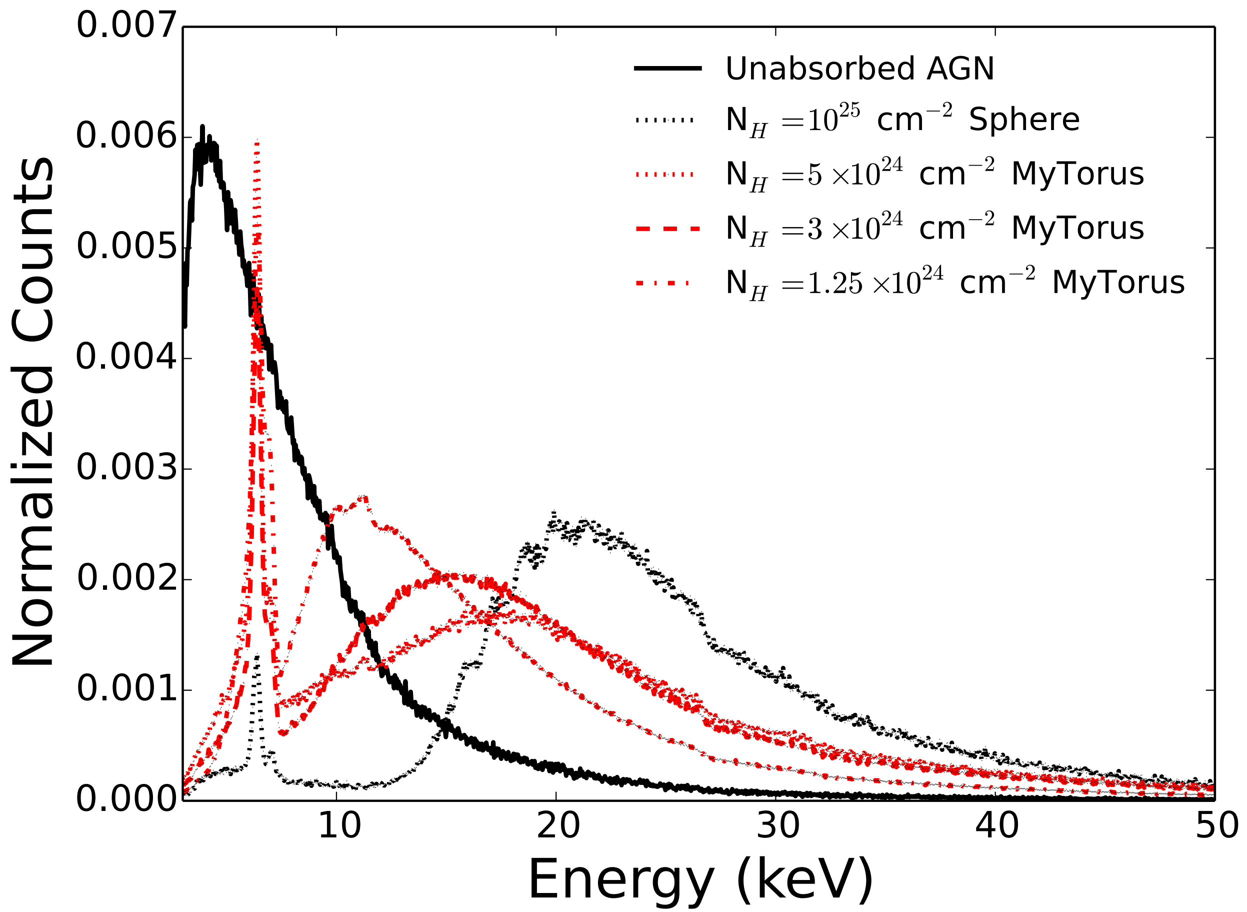
- STROBE-X great science on a sizeable sample of radio-quiet AGN
  - E.g. Swift-BAT AGN catalogue
- Distribution of (large) NH
- Variability of X-ray/radio and optical/radio
- Fraction of Compton-thick sources (in the local Universe) from Fe Ka

- WFM
  - Fe Ka is critical (5-8 keV), 2-5 keV important, 5-15 keV somewhat, >15 keV less
  - PSF not so important because eROSITA will have mapped sky
  - Sensitivity more important than FOV

- LAD
  - Given lack >12 keV for XARM (Early 2020s) and Athena high energy sensitivity to study obscured AGN

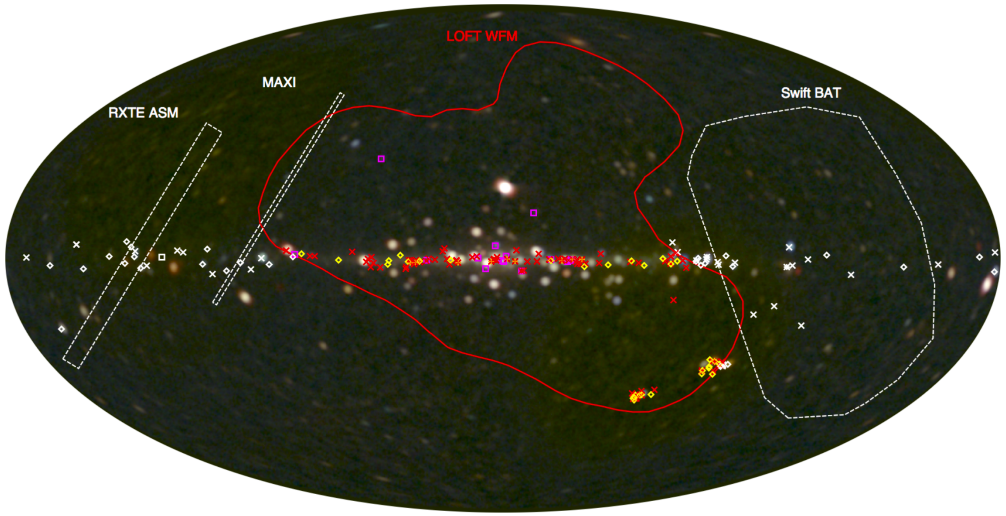
Backup

Identifying the Most Obscured AGN



Future of high sensitivity >10 keV observations is here
Can study heavily Compton-thick AGN.
Are they detected? Are they associated with mergers?

WFM FOV



	Energy Band	FOV sr	Energy resolution keV	Peak eff. area cm^2	Source location accuracy	Operation
CGRO/BATSE	20 keV–2 MeV	4π	10 (100)	~ 1700	> 1.7°	ended
BeppoSAX/WFC	2–28 keV	0.25	1.2 (6)	140	1′	ended
HETE-2/WXM	2–25 keV	0.8	1.7 (6)	350	1–3′	ended
Swift/BAT	15–150 keV	1.4	7 (60)	~2000	1–4′	active
Fermi/GBM	8 keV – 40 MeV	4π	10 (100)	126	> 3°	active
Konus–WIND	20 keV – 15 MeV	4π	10 at 100 keV	120	–	active
SVOM	4 keV – 5 MeV	2	2 (60)	400	2–10′	2021-2025
Lomonosov/UFFO–p	5–100 keV	1.5	2 (60)	191	5–10′	2015–2020?
CALET/GBM	7 keV – 20 MeV	3	5 (60)	68	–	2015–2018?
LOFT/WFM	2–50 keV	4.1	0.3 (6)	90	0.5–1′	2025–2028

Orlandini et al. 2015