Modest Goals

- completely re-do the last 50 years of AGN research with the least biased sample possible.
- In order to determine
  - the physical relation of the different spectral bands to each other,
  - the bolometric luminosity
  - Eddington ratios
  - **relation of the host galaxy and the AGN**
  - **the triggering mechanism for AGN in the low redshift universe**.
- and
  - Provide the needed data to understand feedback in the low z universe where 'everything' is observable and provide scaling relations to higher z.

The 2-10 keV world

- XMM/Chandra results on AGN have shown that
  - The number of AGN
  - The evolution of AGN
  - The nature of the hosts of AGN
  - The total energy radiated by AGN
  - The correlation function of AGN

Were all incorrectly estimated by optical and radio* surveys (Barger et al 2005)

- **the integrated luminosity of hard x-ray AGN exceeds that of optically selected objects by ~4 and has a different redshift distribution - constraint on efficiency of accretion and spin of black holes**

Because most the sources are optically "dim" **only** high quality x-ray spectral and timing data can

•determine the nature of these "new" objects

•set the basis for theories of the origin and evolution of massive black holes in the universe

•**However the data sets are dominated by z~1 objects which are hard to study**

•***Need low z large sample*** **- low areal density of bright sources (at $1x10^{-11}$ ~ 1/40 sq degree)** - **require all sky survey**

Method

- Utilize the very hard x-ray (14-195 keV) Swift BAT sample (>700AGN) as the basis set

  obtain
  - optical 5 band Sloan images
  - optical, near-IR (Spitzer) and x-ray spectra
  - far IR (Herschel) and UV photometry
  - radio images and spectra
- search for relationships and compare with what has come before

THE 70 MONTH *Swift*-BAT ALL-SKY HARD X-RAY SURVEY

W. H. BAUMGARTNER[1,2,4], J. TUELLER[1], C. B. MARKWARDT[1], G. K. SKINNER[1,3,4], S. BARTHELMY[1], R. F. MUSHOTZKY[3], P. EVANS[5], N. GEHRELS[1]

ABSTRACT

We present the catalog of sources detected in 70 months of observations of the BAT hard X-ray detector on the *Swift* gamma-ray burst observatory. The *Swift*-BAT 70 month survey has detected 1171 hard X-ray sources (more than twice as many sources as the previous 22 month survey) in the 14–195 keV band down to a significance level of 4.8σ, associated with 1210 counterparts. The 70 month *Swift*-BAT survey is the most sensitive and uniform hard X-ray all-sky survey and reaches a flux level of 1.03×10^{-11} ergs sec^{-1} cm^{-2} over 50% of the sky and 1.34×10^{-11} ergs sec^{-1} cm^{-2} over 90% of the sky. The majority of new sources in the 70 month survey continue to be AGN, with over 700 in the 70 month survey catalog.

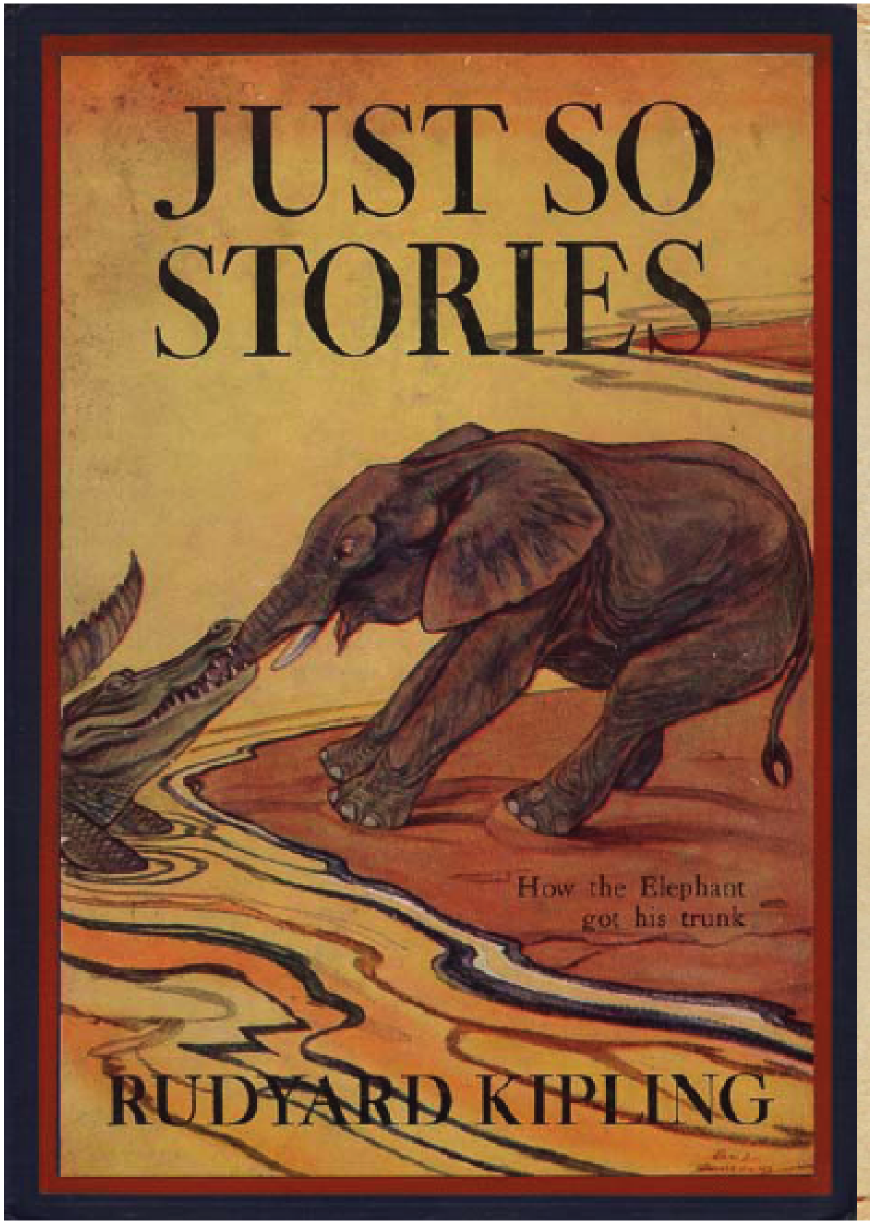
As part of this new edition of the *Swift*-BAT catalog, we also make available 8-channel spectra and monthly-sampled lightcurves for each object detected in the survey.

Subject headings: Catalogs — Survey: X-rays

ApJ Suppl published- arXiv:1212.3336
See also Burlon et al 2011

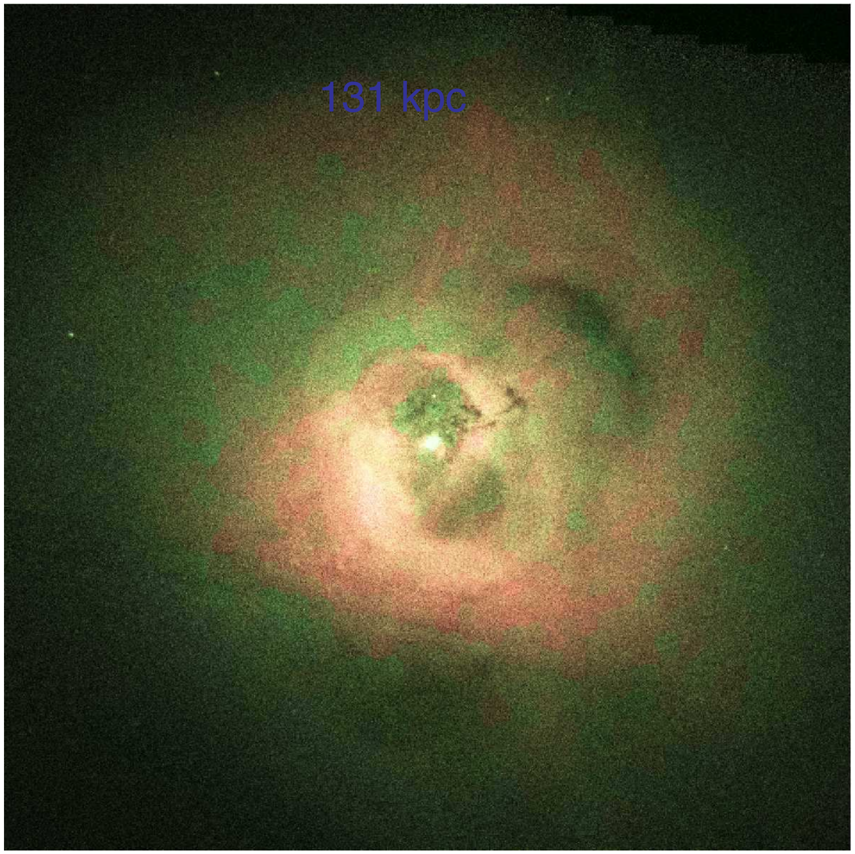
How the Observable Universe Came to Be- Or Why AGN are interesting to a non-AGN audience

- Dark matter evolution in the universe now understood
  - **it is not at all understood how 'baryonic structures' (galaxies, groups, clusters) form.**
- For models to fit the data <u>additional physics</u> (beyond gravity and hydrodynamics) is required (heating, cooling, mass and metal injection, gas motions etc)- however direct observations of this process are rare
- Up until now this has been parameterized in 'semi-analytic' models - **just so stories**
- ***The critical problem in all of astrophysics is to put physics into these stories***

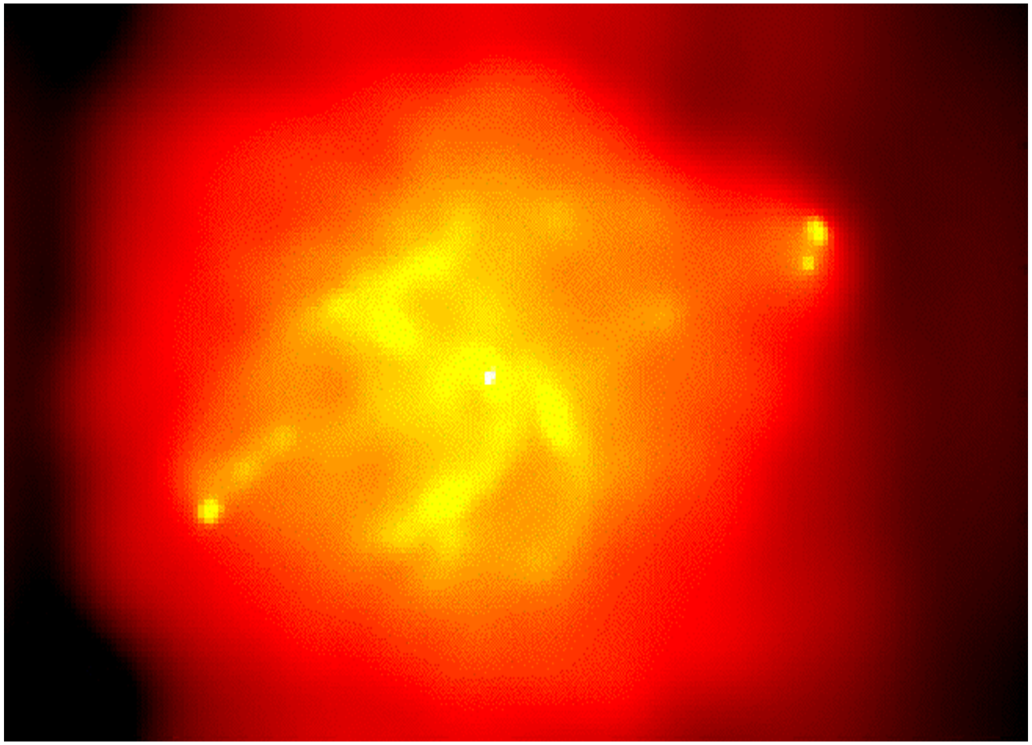


Direct Evidence From Chandra Images of Influence of Black holes on their Environment

X-ray temperature Map of Perseus cluster- AGN at the center

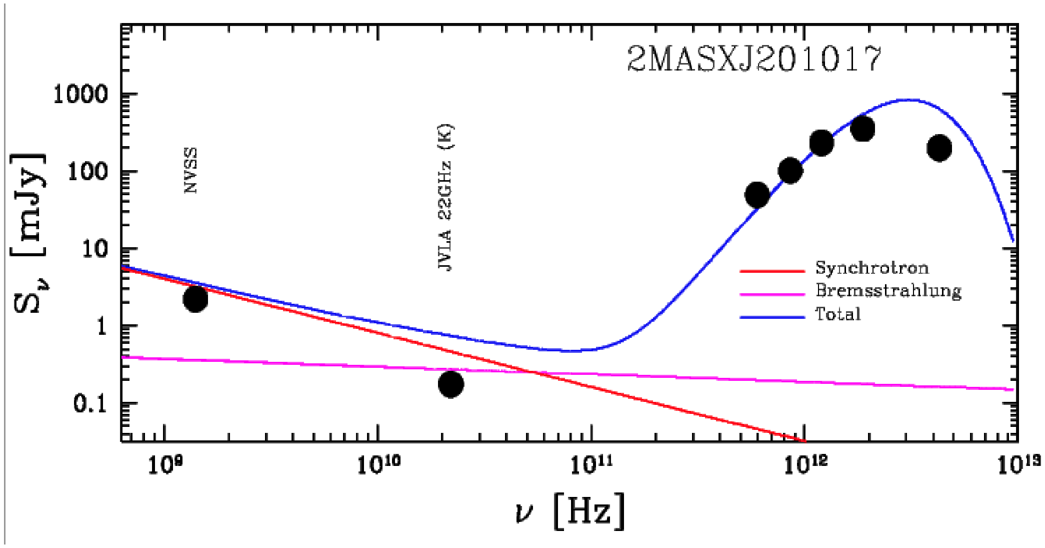


Fabian et al. 2003



- Chandra x-ray image of Cygnus-A Cluster of Galaxies with AGN in center (Wilson et al 2002)- structure related to the radio source

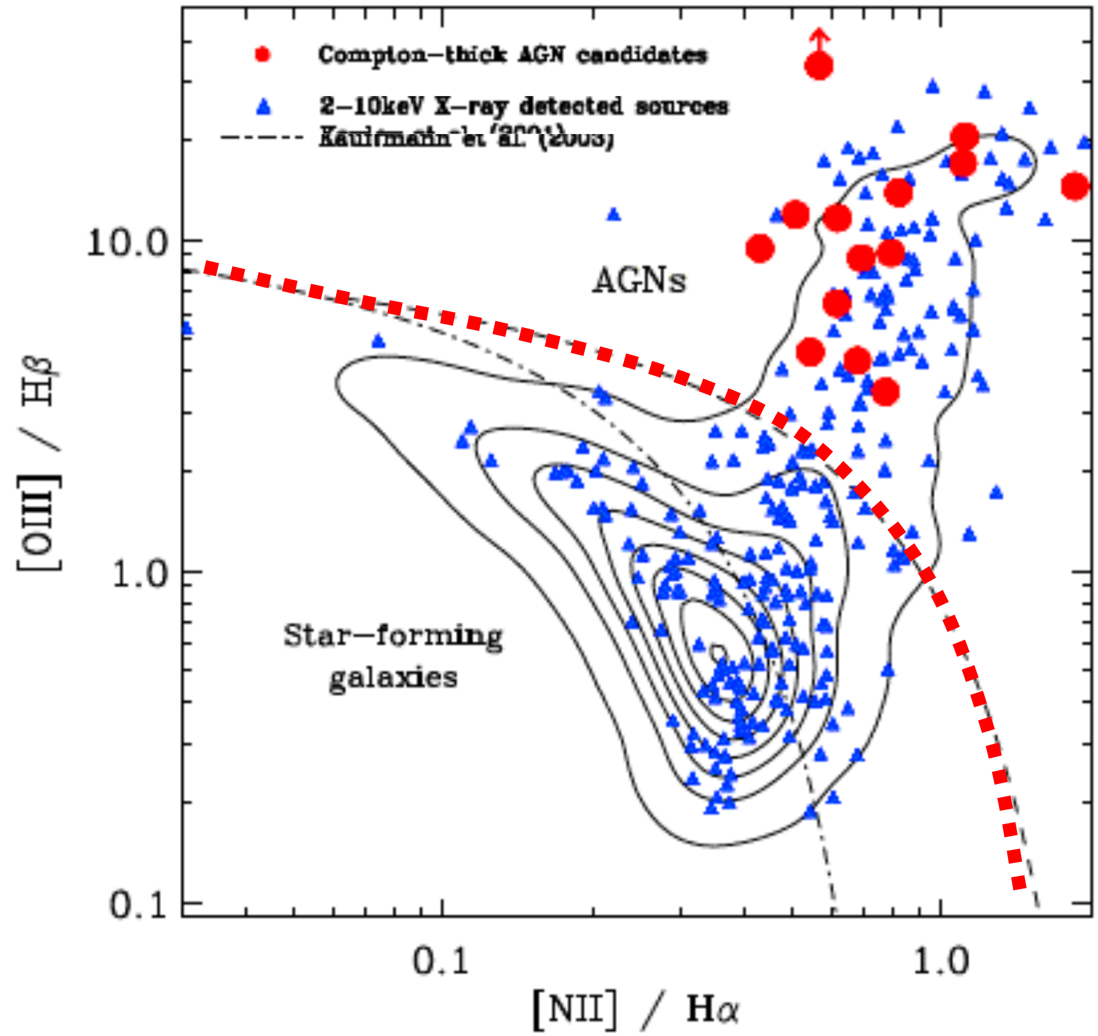
How to Find AGN



- Classical optical signatures
  - colors
  - emission line (ratios and widths)
  - Variability
- IR color
  - Ability to select AGN via these criteria depends strongly on relative properties of galaxy and AGN- strongly biased against low luminosity AGN- at z~0 integrated bolometric luminosity of AGN dominated by log L_{Bol}~44 erg/sec objects
- **Less biased techniques**
- Radio luminosity and morphology- but only ~10% of AGN detected this way (at low L_{radio} hard to distinguish star formation from AGN)
- X-ray luminosity, spectra, variability and position
  - at log L(x)<42 ULXs may 'confuse' AGN identification

Why Are X-rays Important?

- 'Best' way to find AGN: classical optical line ratio indicators miss (even at low z) many AGN (>1/2)- same with IR
- The broad properties of x-ray selected AGN are representative of the total population (Hickox et al 2009)- IR selected AGN tend to have high Eddington ratios and small masses, radio selected high black hole masses, low Eddington ratios



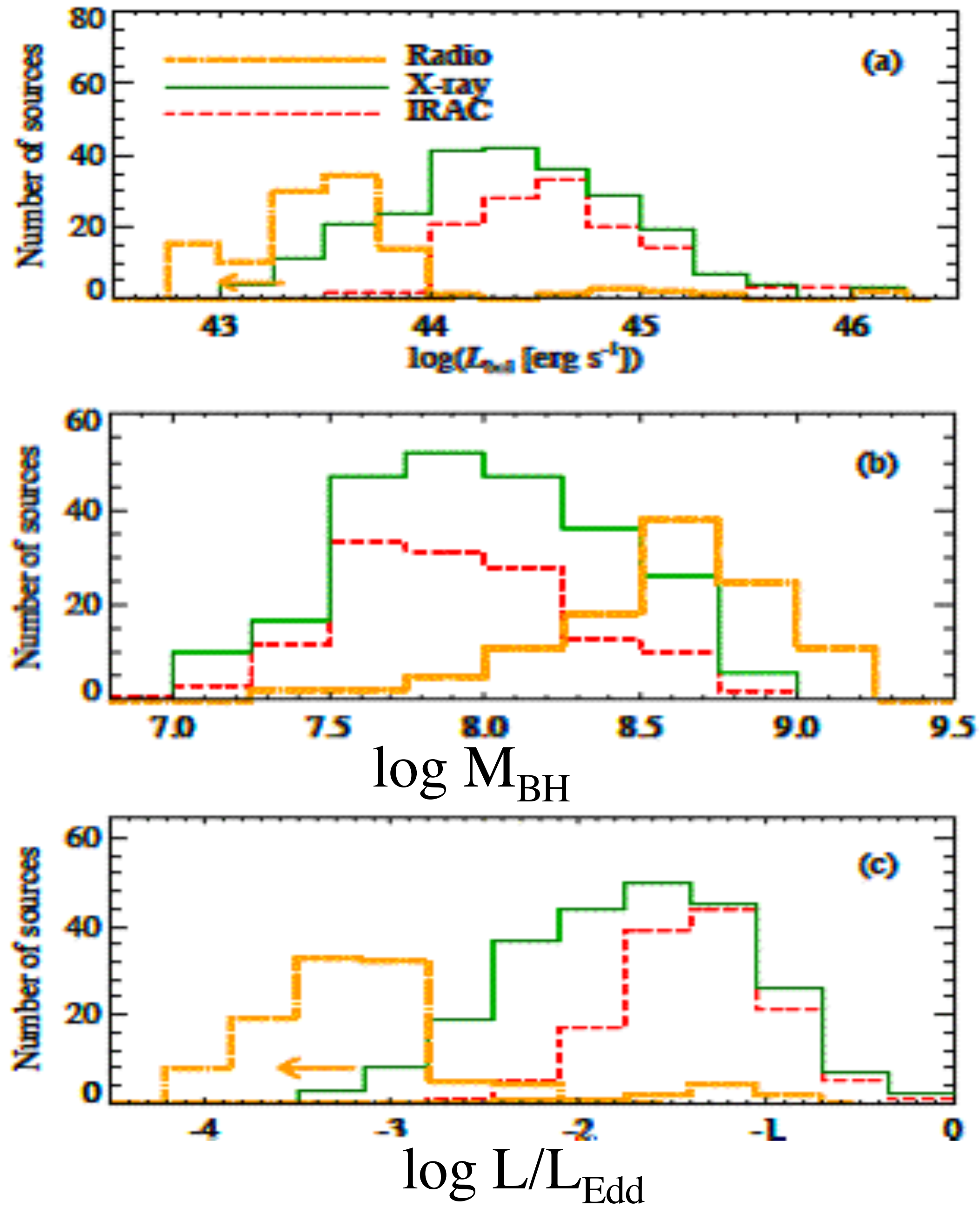
x-ray detected AGN

Goulding et al 2010

Trouille and Barger 2010

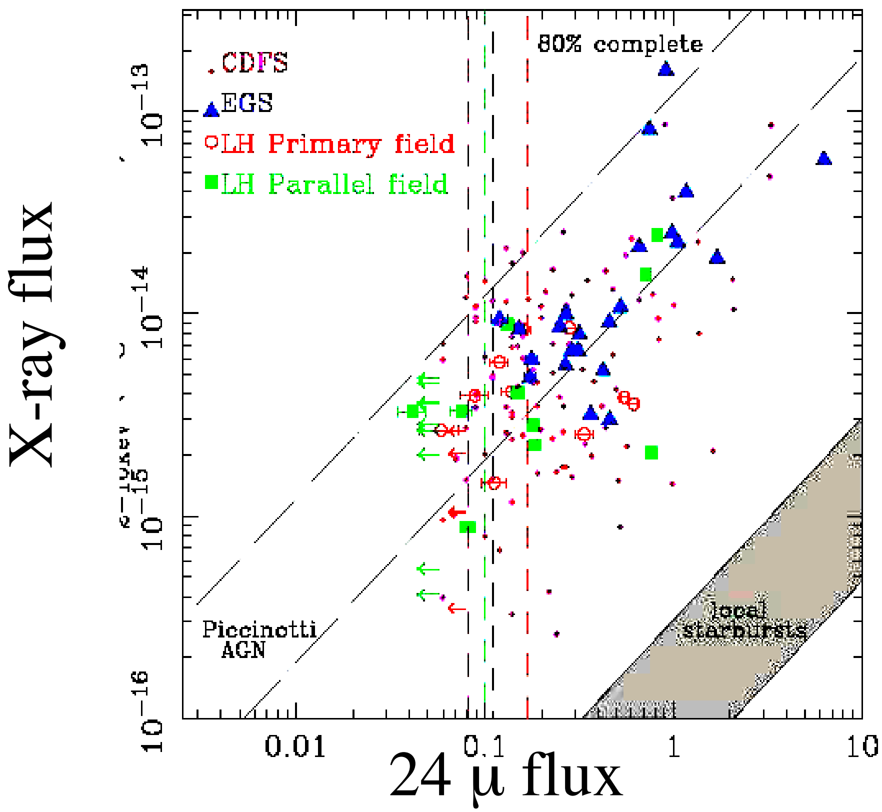
What About Object Selected by Different Criteria?

- AGES Survey (Hickox et al 2009) at <z> ~0.5
- **Radio AGNs are found in luminous red-sequence galaxies with massive blackholes (M_{BH} > 10^8 M) and very small Eddington ratios.**
- **IR AGN have low BH masses, high Eddington ratios and hosts are relatively bluer and less luminous than those of the X-ray or radio AGNs**
- **X-ray AGNs have wide range of luminosity and Eddington ratio and are found in galaxies of all colors, with a peak in the "green valley".**

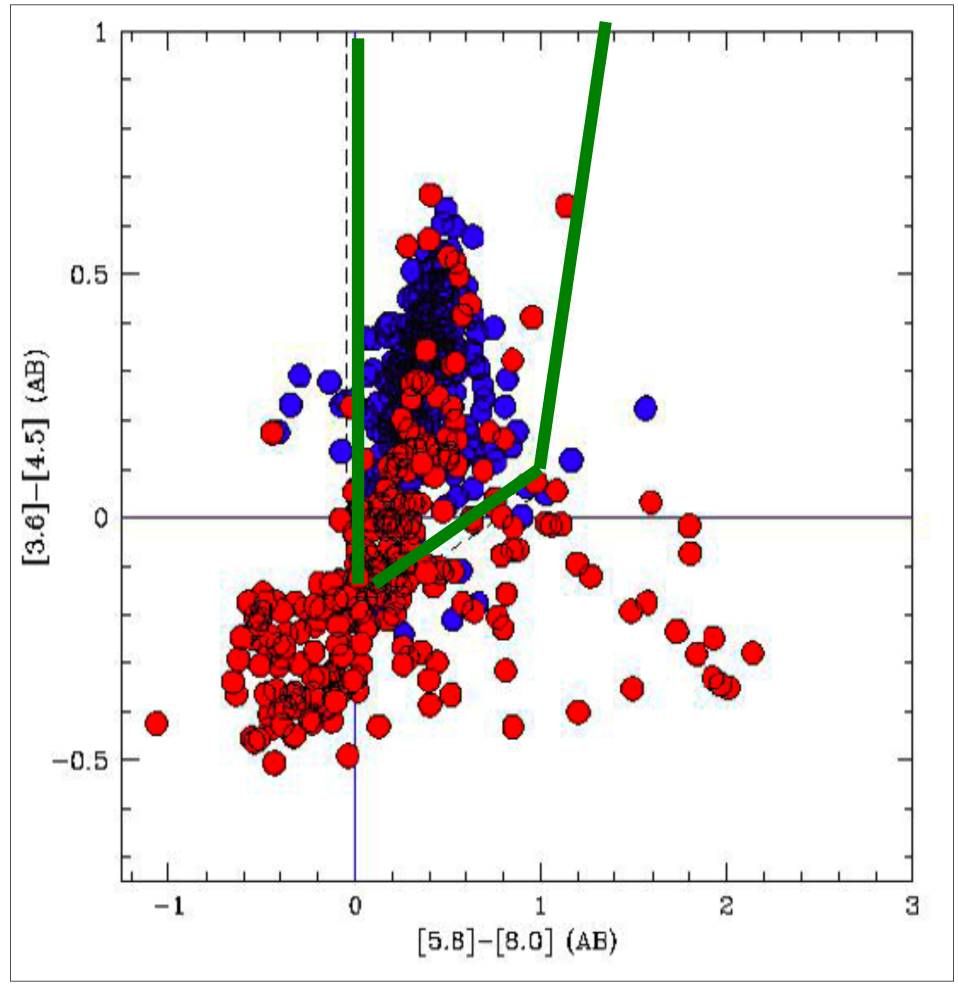


Comparison of IR and Medium Energy X-ray Selection

- A large fraction of x-ray selected AGN do not have the IR ‘colors’ of AGN- presumably due to galaxy dilution
- Wide range in IR/x-ray flux for AGN



X-selected AGN in color
Green is IR AGN selection region

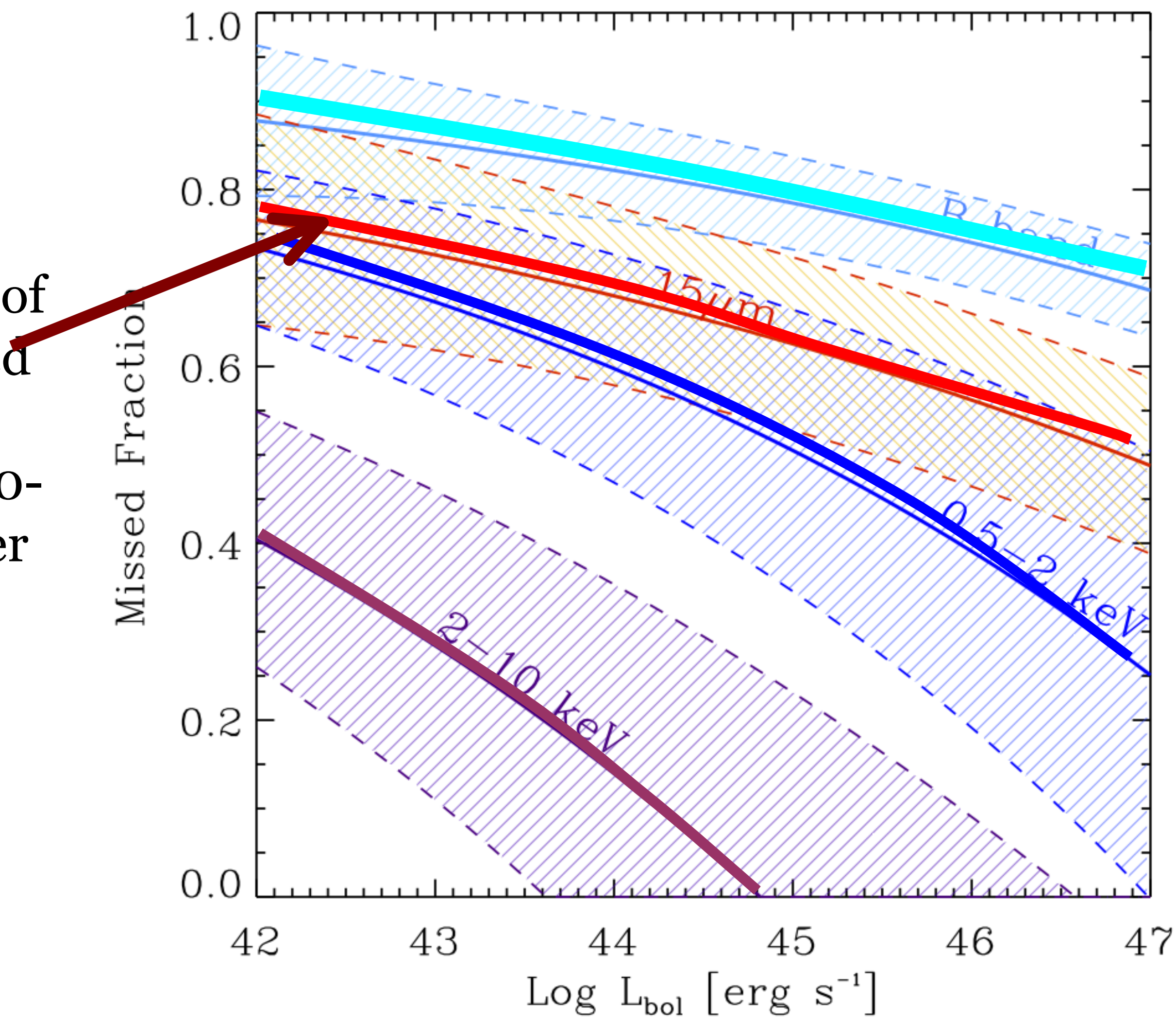


How are AGN Selected

Hard X-rays provide the most complete census of AGN activity (Merloni 2011)

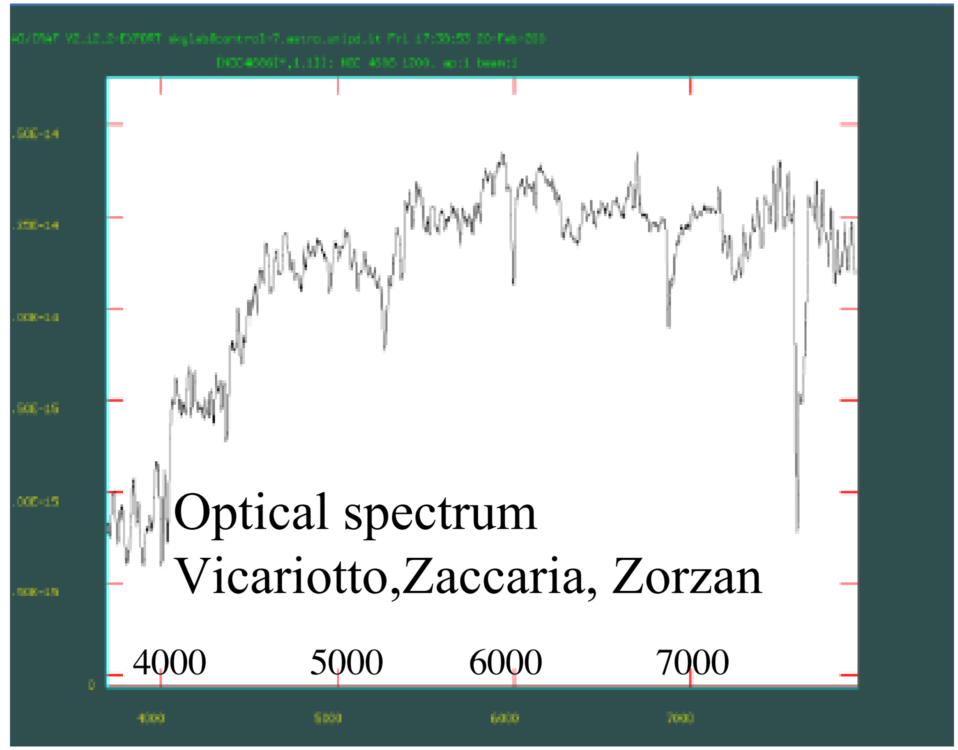
the fraction of AGN that are missed in a survey in a given band as a function of the energy range observed

The fraction missed in the 10-30 keV band is even lower (HXI on Astro-H)

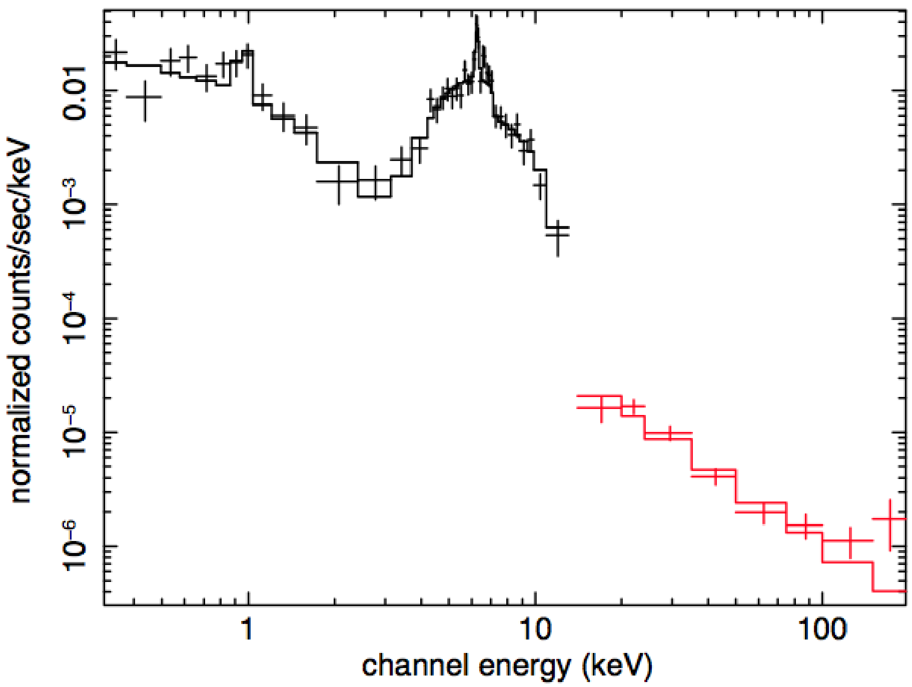


NGC4686

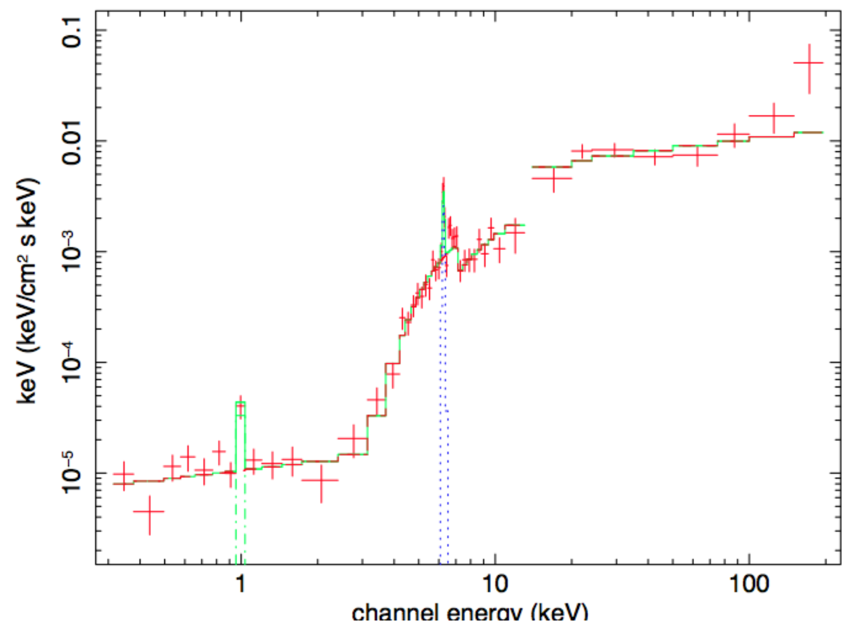
- Swift BAT source- very high column density ~5x10^{23}
- log L(x)~42.5, EW ~400 eV, slope=1.8
- Energy spectrum peaks in 20-100 keV range



NGC4686 XMM+BAT

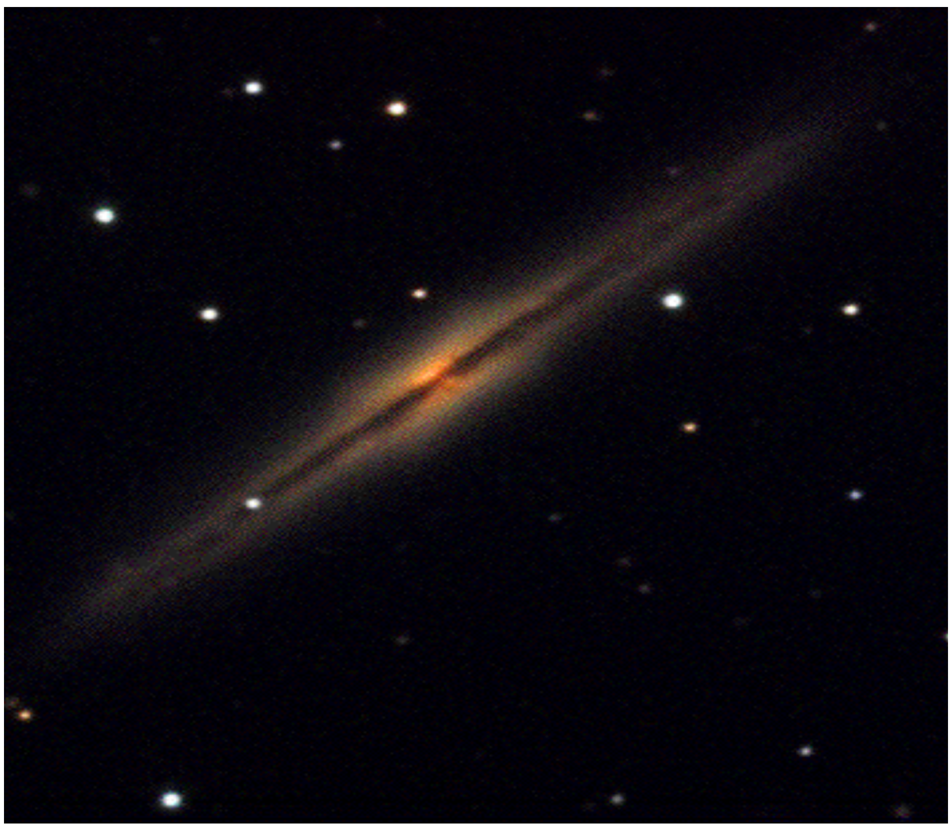


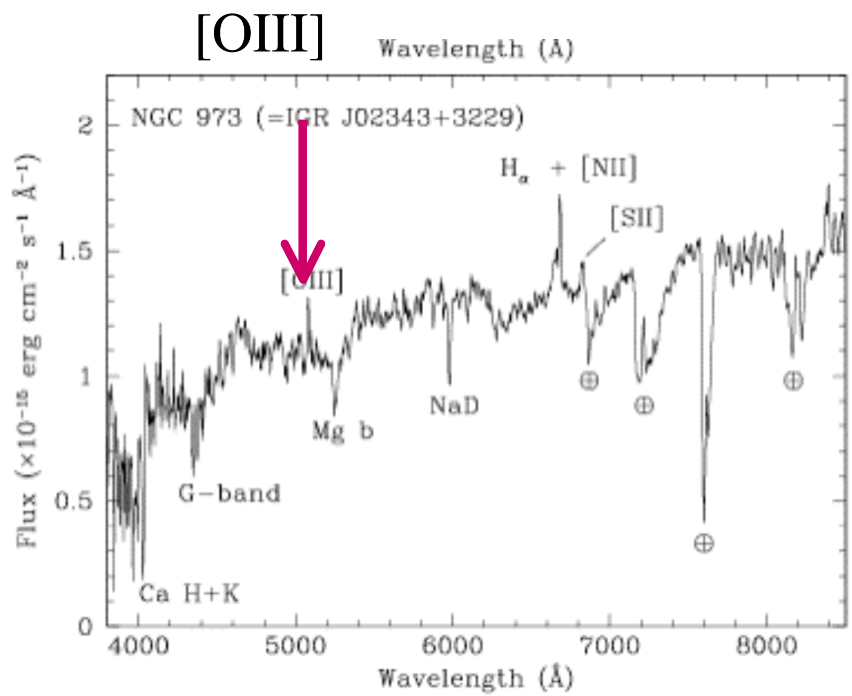
NGC46486 XMM+BAT



NGC 973

- Swift data show Γ=1.8+/-0.2, N(H)=2.7+/-.3x10^{22}, simple spectrum
- E.g. not a Seyfert II but an AGN absorbed by ISM in galaxy.
- Would be missed in [OIII] survey of AGN



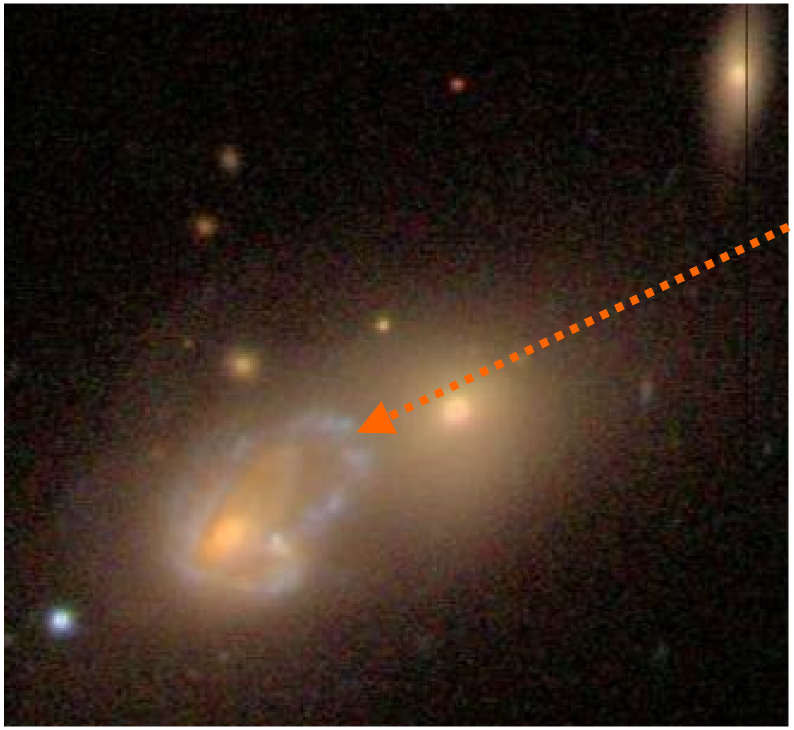


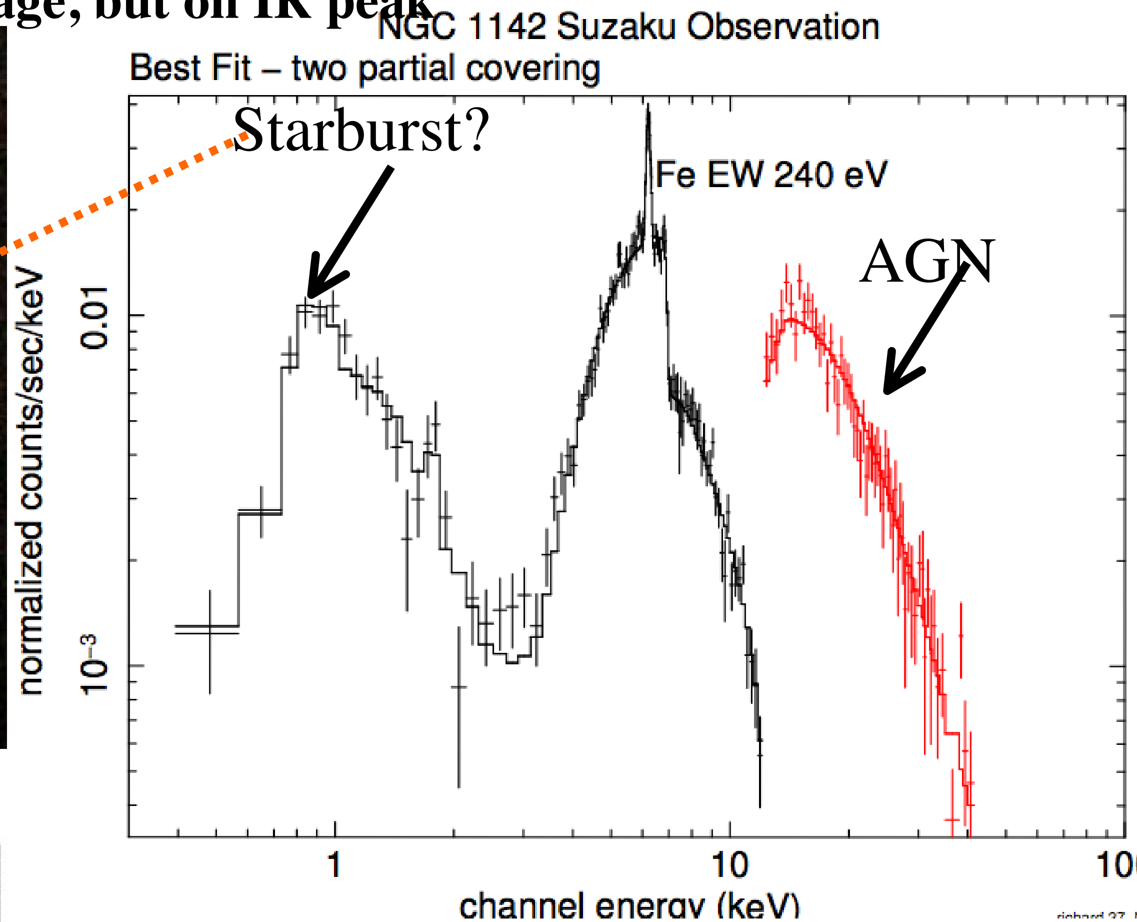
Masetti et al 2008

Source is variable by >2 and thus the radiation is not mostly scattered

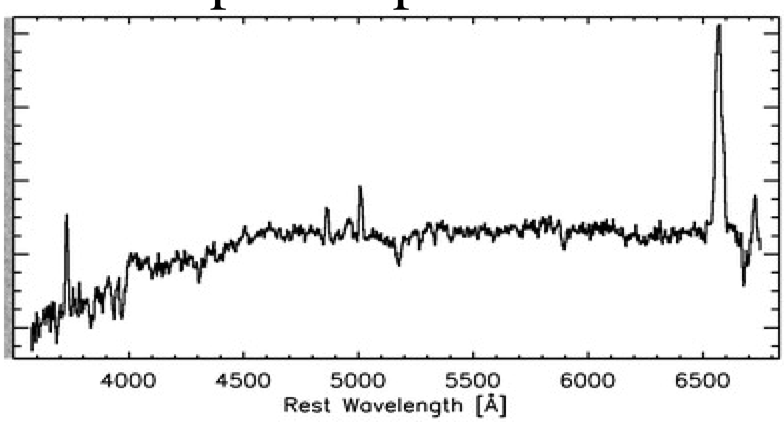
NGC 1142 Example of Available data

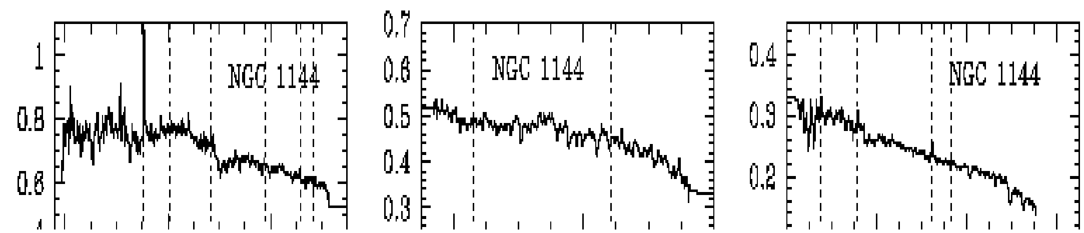
No optical or IR signatures of an AGN- **x-ray source not on peak in UV image, but on IR peak**





Optical spectrum

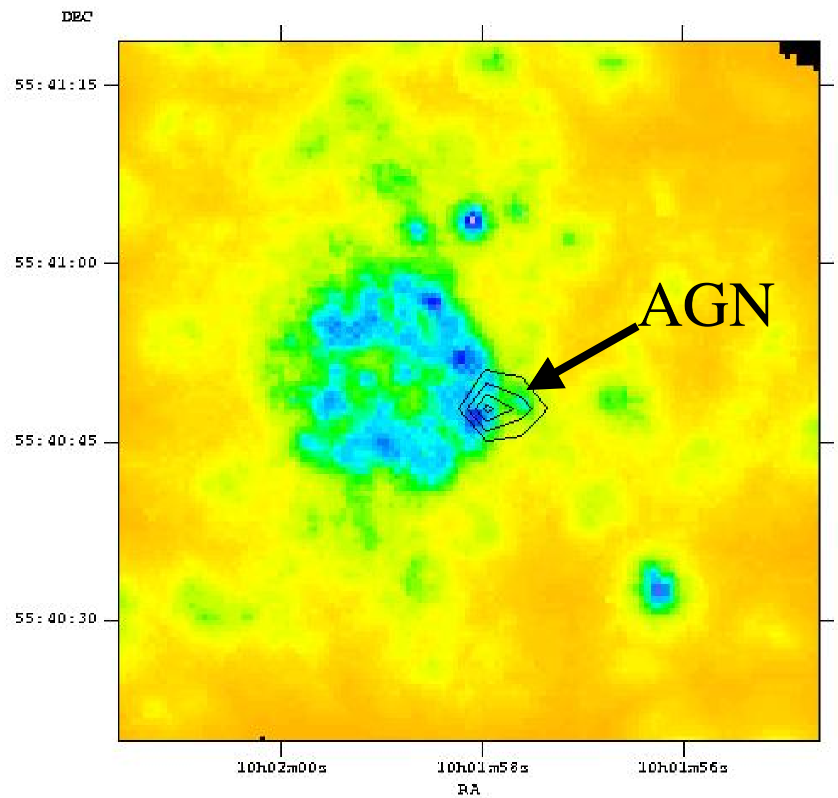




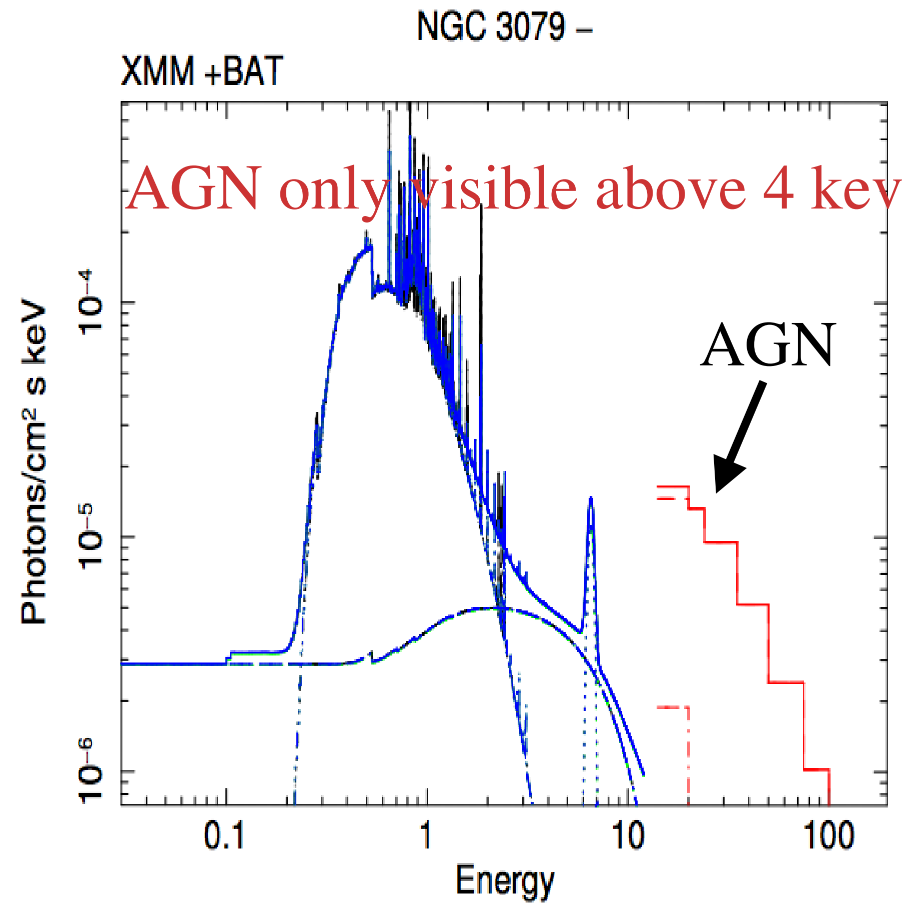
Only IR line is [SIII]

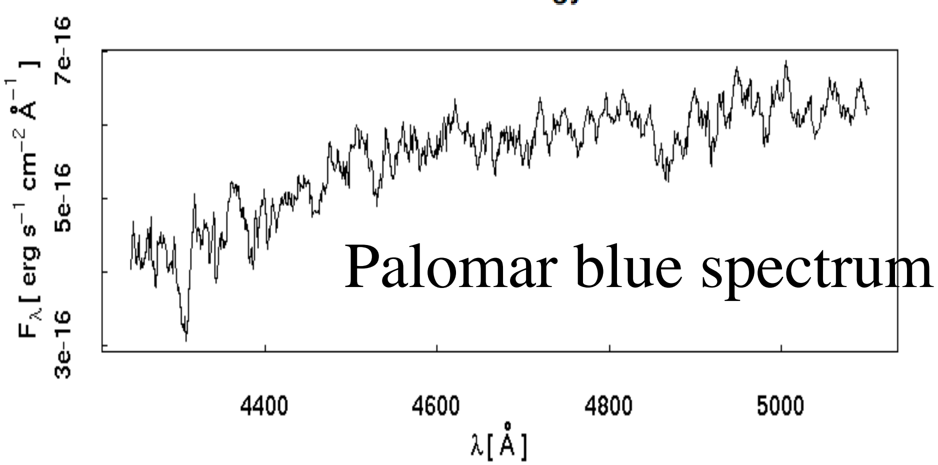
NGC 3079- AGN Invisible in Soft X-rays

- Chandra image dominated by extended soft emission



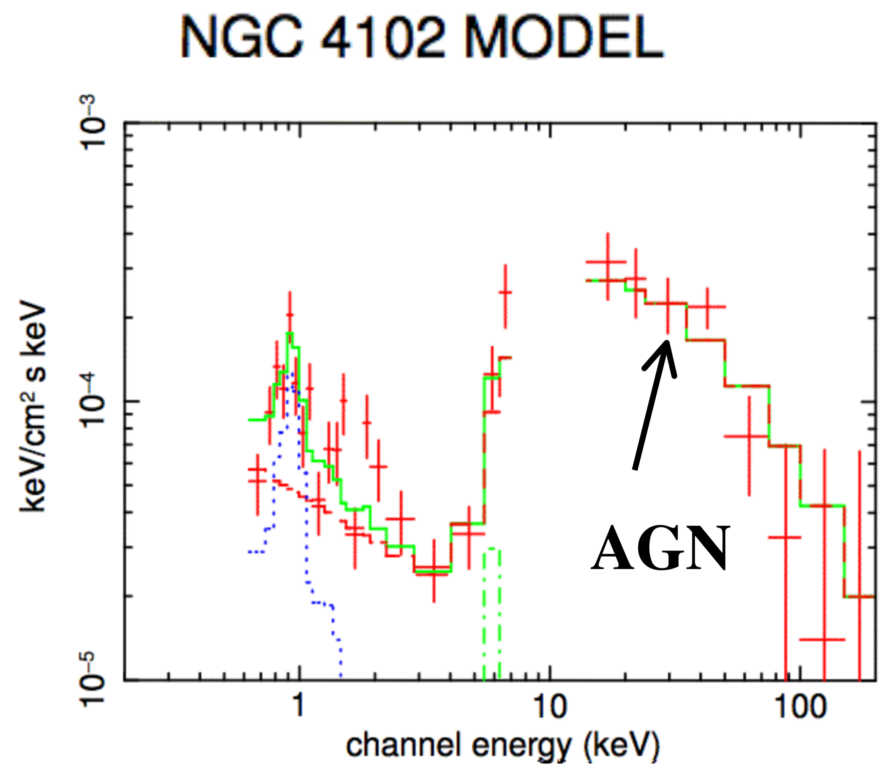
Chandra Soft Image of NGC3079- Contours are hard band (2-10 kev)

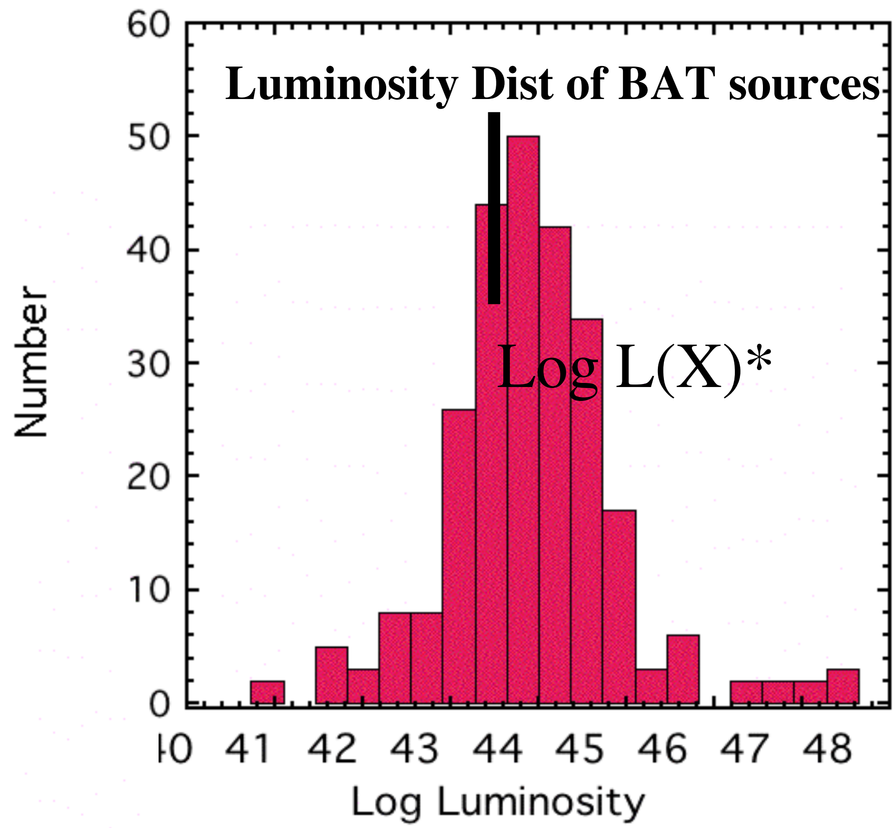


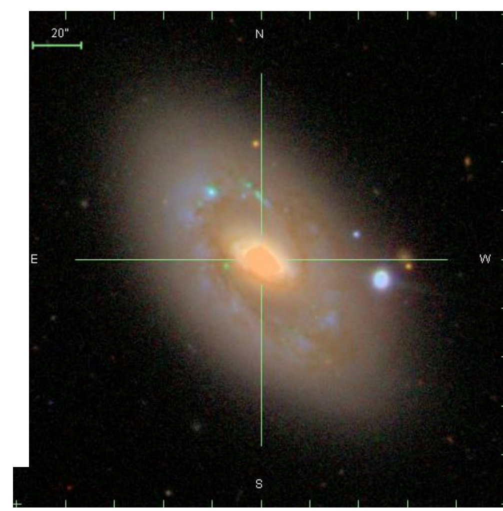


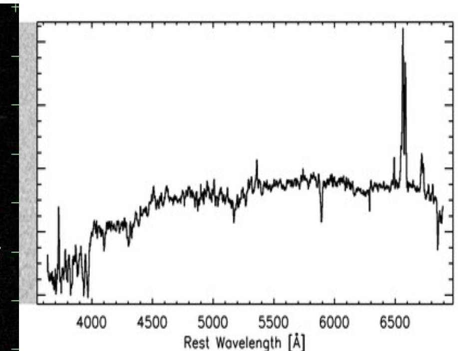
Lowest Luminosity sources

- The 4 lowest luminosity sources log L(x) < 41.6-
  - NGC4395, NGC4258, NGC4102 and NGC3718
- all but NGC3718 highly absorbed
- No Fe K line, no reflection -RIAFs?







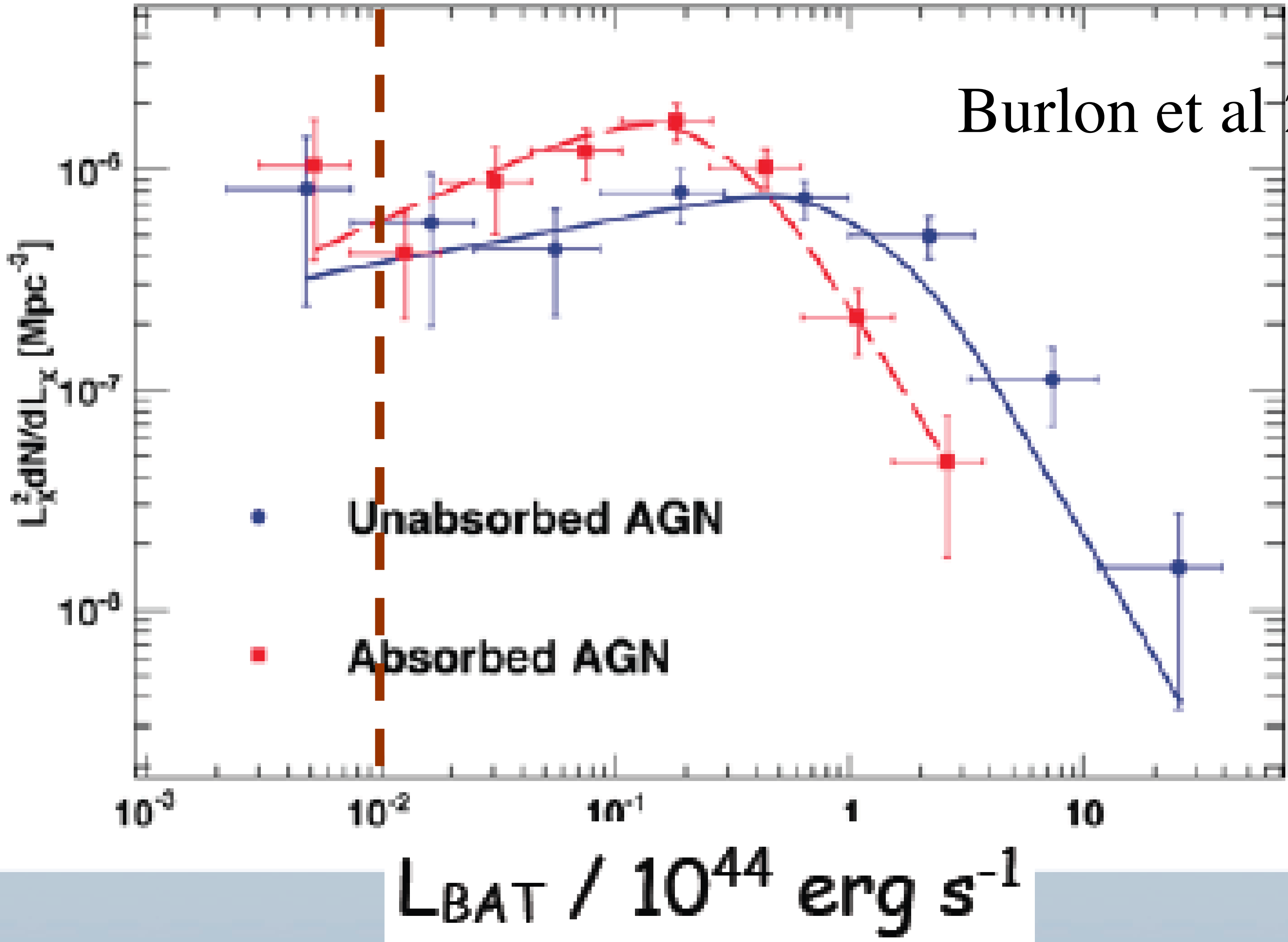


NGC4102

No stellar nucleus in NICMOS data

Limit of AGN Completeness

Burlon et al 2011



Why is the BAT survey for AGN Important?

- *All previous AGN surveys were biased*-
  - Most AGN are 'obscured' in the UV/optical (Fabian 1999)
  - IR properties show wide scatter wrt x-ray properties
  - Host galaxy can hide low L AGN
- ***BAT survey is unbiased wrt*** **Compton thin obscuration, host galaxy properties, redshift, optical, UV, IR properties**

- large sample ~700 AGN
- Wide time coverage -
- Good angular accuracy
- Spectra
- ~15 papers so far: lots more to go !

BAT data allows comparison of

• host galaxy properties

• relation of optical spectral properties to intrinsic luminosity

•Direct comparison with z~1 Chandra and XMM surveys

• Distribution of N(H) values

• Luminosity function (Tueller et al 2008)

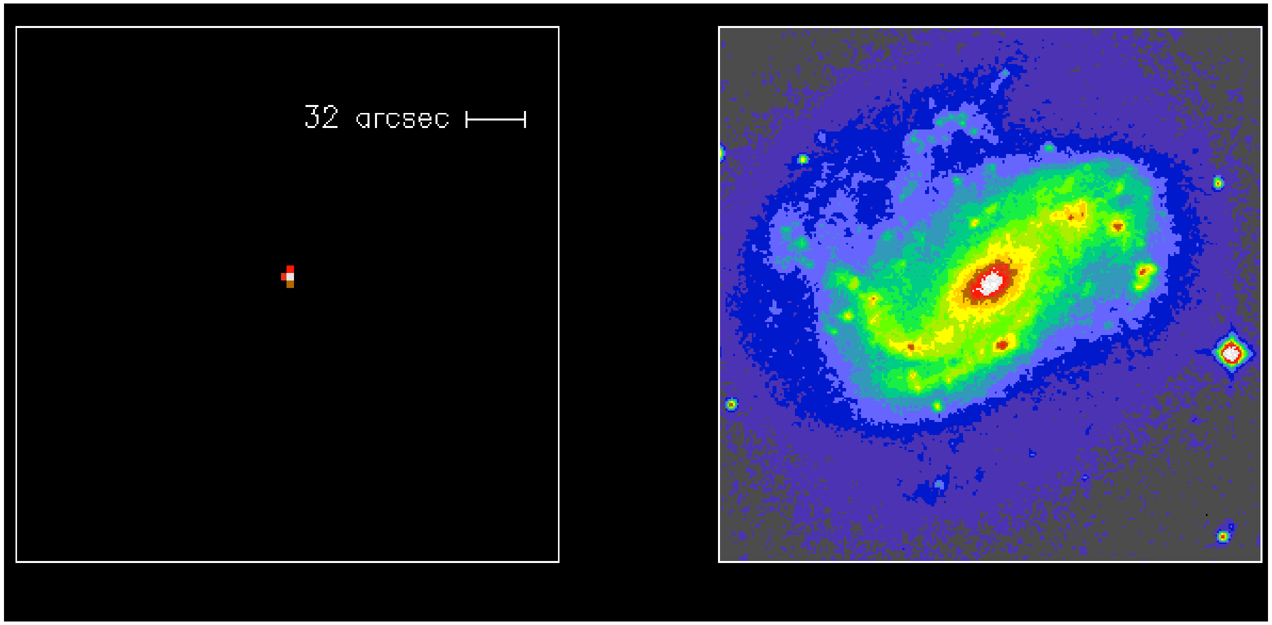
• Log N-Log S(Tueller et al 2008)

•"True" nature of objects (Suzaku,XRT and XMM +Spitzer, optical spectra and imaging)

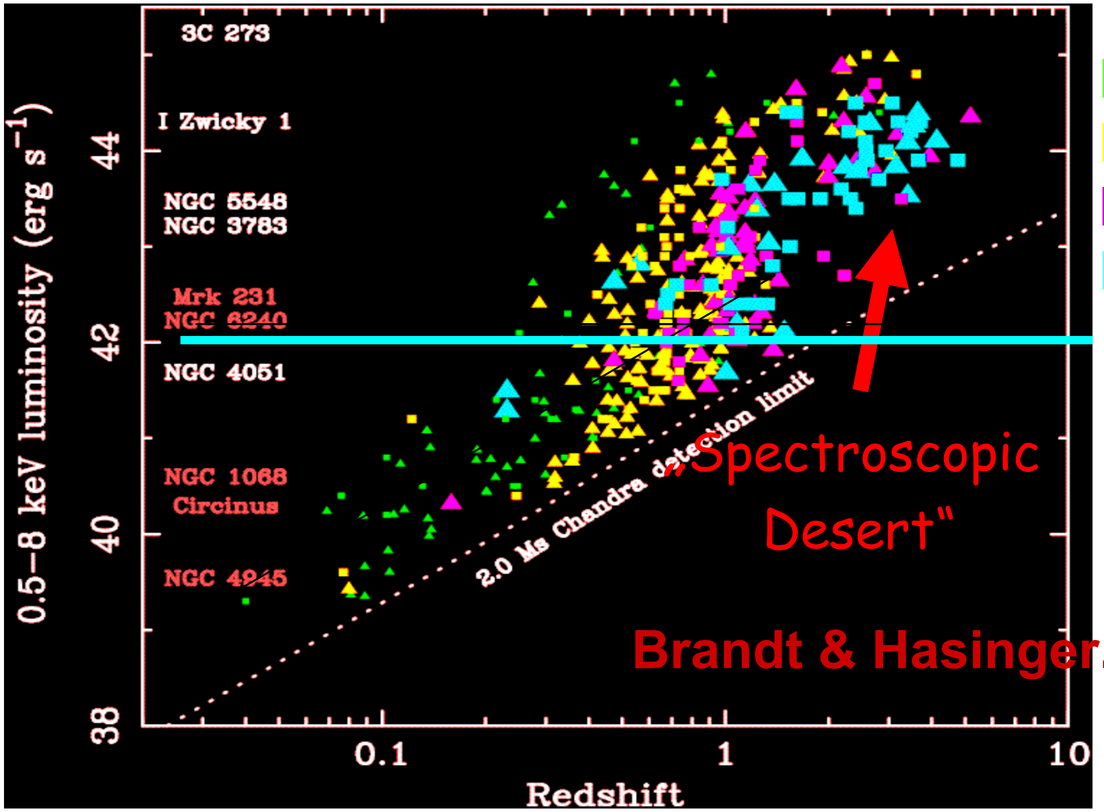
Find rare and unusual objects -type II qso's , binary AGN, very high z blazars, dwarf galaxies hosting AGN

X-ray Selection of Active galaxies

- X-ray and optical image of a nearby AGN NGC4051-
- very high contrast in the x-ray image



- the upper limit of x-ray luminosity of ULXs ~5x10^{41} ergs/sec and of entire starburst galaxies ~3x10^{42} ergs/sec
  - *All nuclear sources with L(x) > 10^{40} are AGN*
- **Right now we know more about x-ray selected AGN at z~0.8 than at z~0**



Brandt & Hasinger. 2005

The Local Census of Active Galaxies-aka Radiating Massive Black Holes

The change in
AGN with
understand
massive bl
and evoluti

- ~20% of al
life of the u
strong influ
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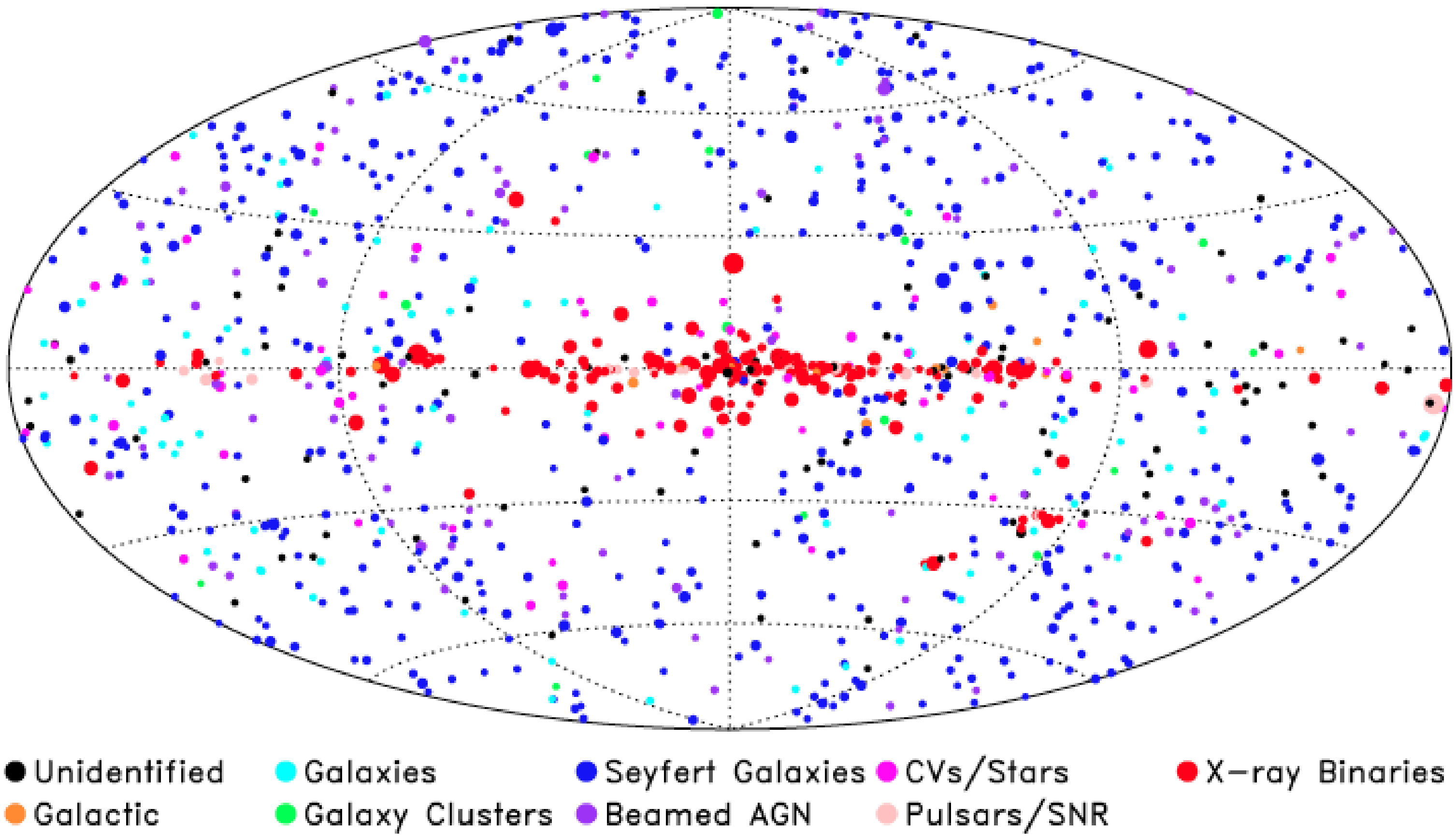
- **A large fra
their radia
which are
optical/UV**

- **Chandra a
revolution
the numbe**



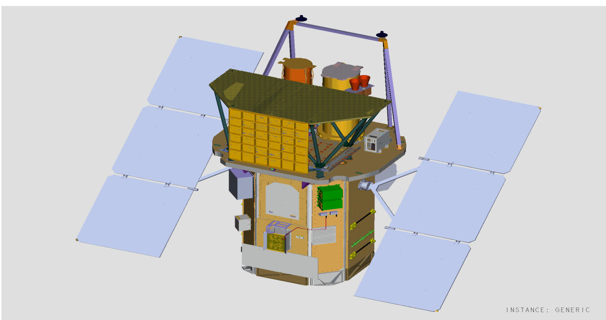
of active galaxies from 0<z<4

- **BAT is changing our understanding of the z<0.1 AGN universe**

X-ray Color Image (1deg)
of the Chandra Large Area X-ray Survey-
CLASXS-400ks, 525 sources

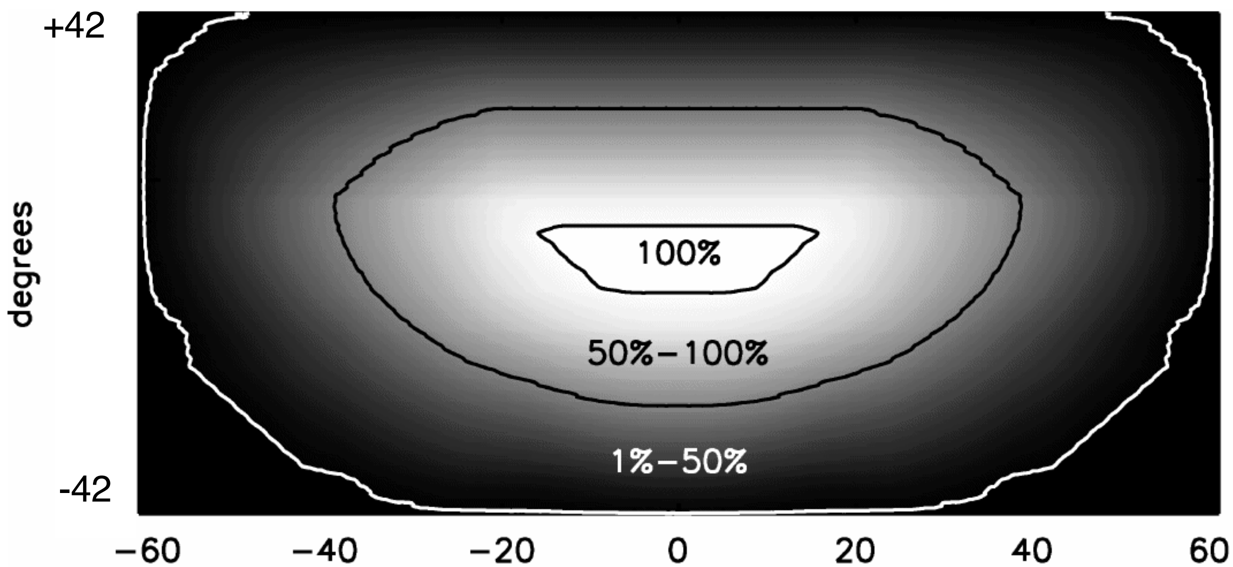
Swift BAT Survey of Active Galaxies

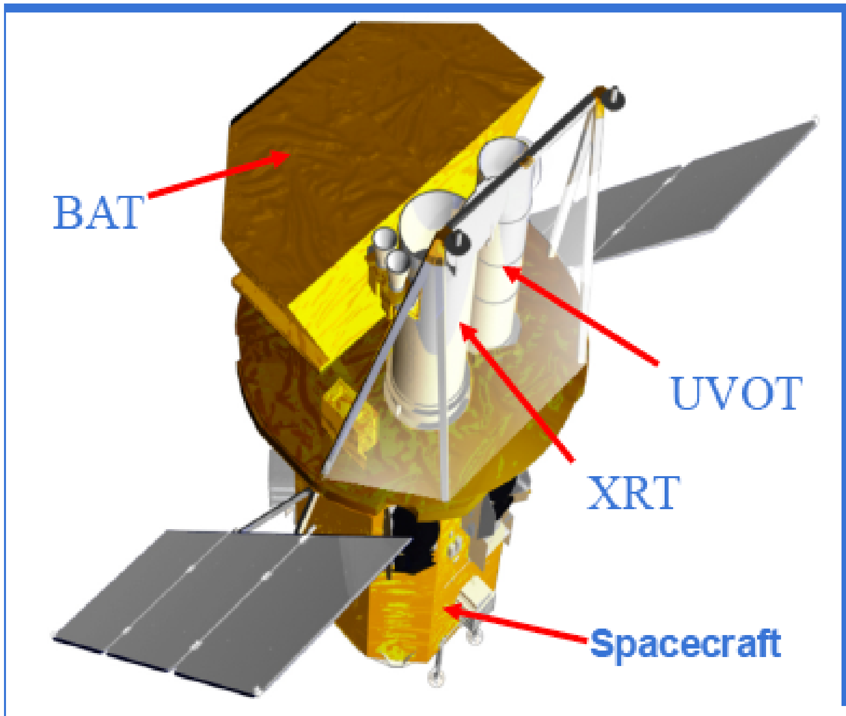
- Swift BAT is a ‘all sky’ instrument sensitive in the 15-150 keV band
- - covers ~20% of the sky at a time and ~ 50% of the sky each day ; Random nature of GRBs leads to relatively uniform sky coverage for BAT
- Extensive follow-up of sources by the two other telescopes on SWIFT (UVOT- (a ultraviolet-optical telescope) and XRT (a x-ray telescope)) with relatively short exposures



Field of view of the Swift BAT- contours are efficiency

BAT Instantaneous Field of View

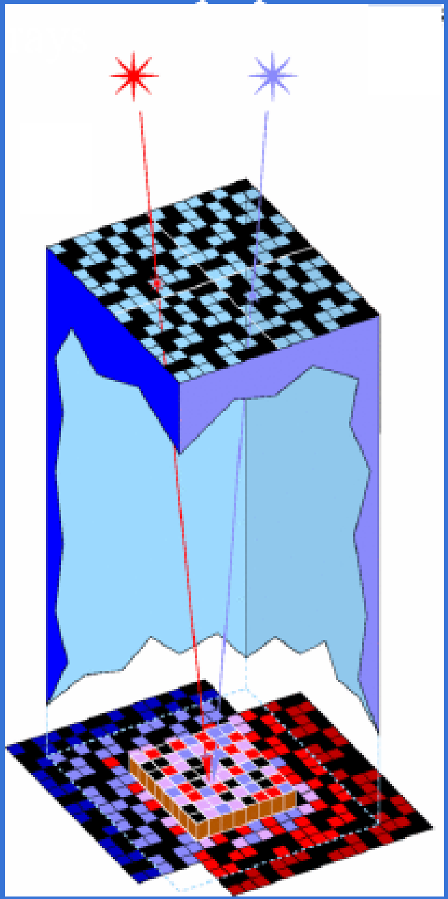




Swift–BAT

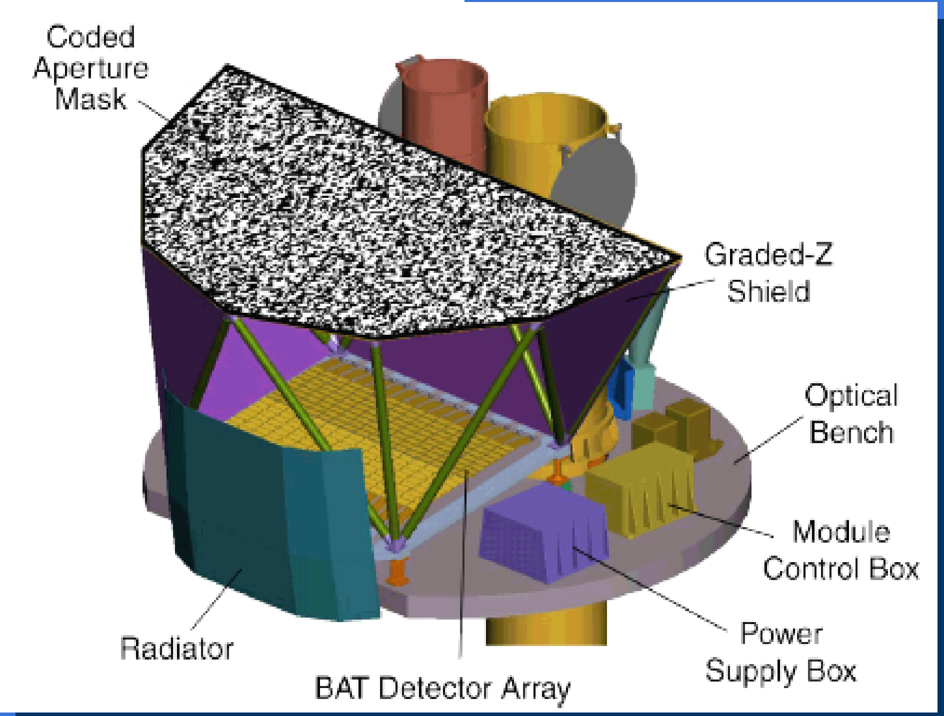
Coded Aperture Imaging:
1-3 arcmin resolution

~50,000 1-mm thick lead tiles are opaque to X



32,768 detectors give finely pixellated array

Good compromise -- large field of view with reasonable angular resolution!

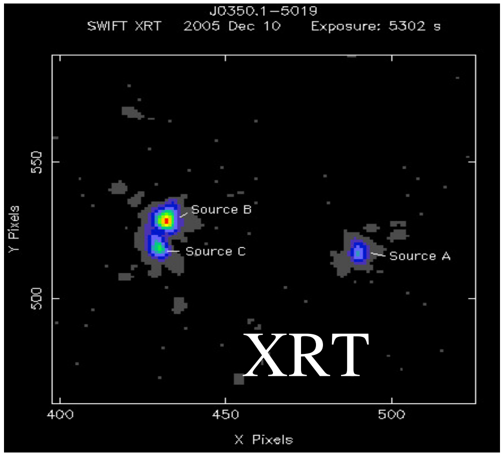


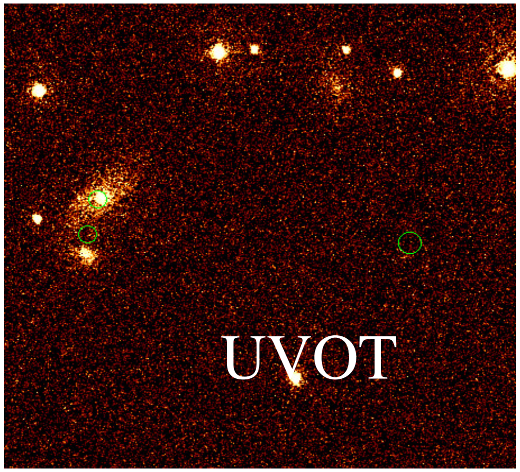
Swift Telescopes

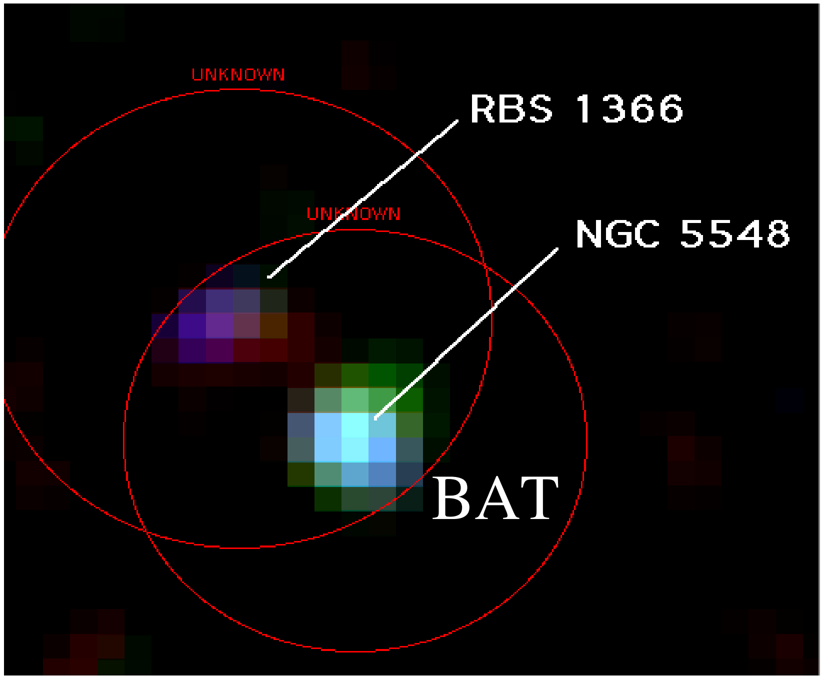
- XRT: $110 cm^2$ in 0.3-12 keV band (1/3 of ROSAT) 18" HPD, 24' FOV
- UVOT 1600-6000A multiple filters +grism 30cm , 1.6" HPD, 17x17' FOV

- BAT 2ster FOV, 22' HPD, 1-6' centroiding

  BAT on 'all' the time

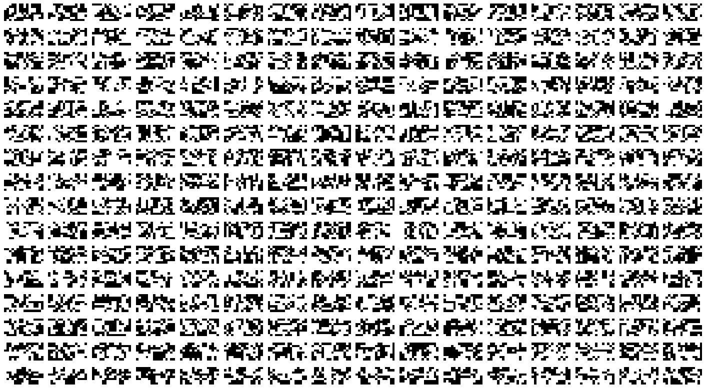




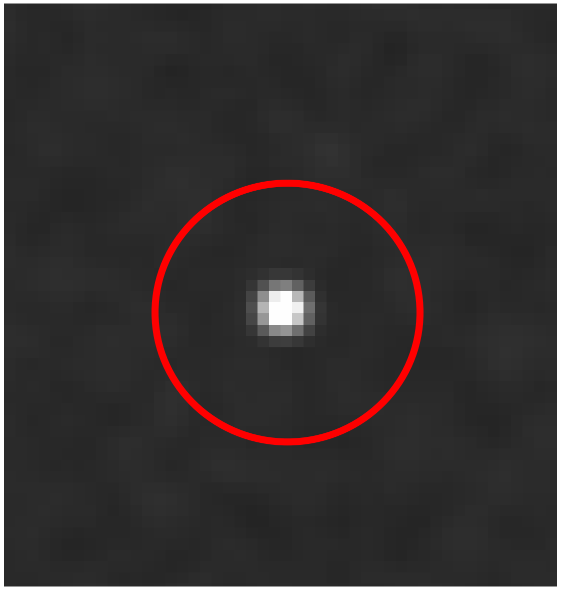


BAT imaging

- No focusing optics
- Each detector can be illuminated by **many points on the sky**; and
  Each point on the sky illuminates **many detectors- Fourier transform imaging**
- Two distinct spaces:
  - Detector space
  - Sky space
- Transform between two spaces with special cross-correlation software
- Background dominated- S/N ~sqrt (time)
  - Brightest hard x-ray source in sky Crab Nebulae = ~10% of background

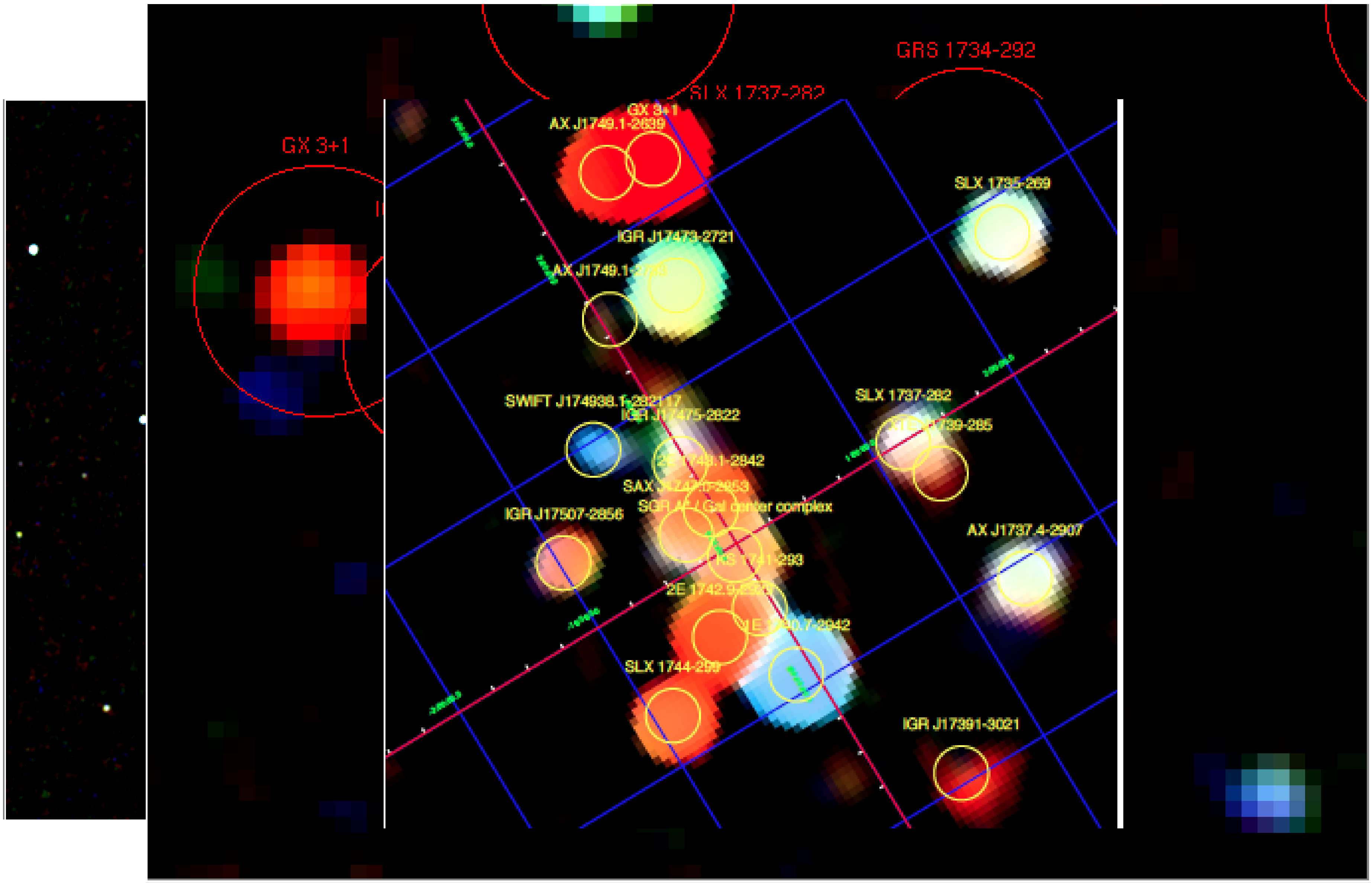


Detector Space



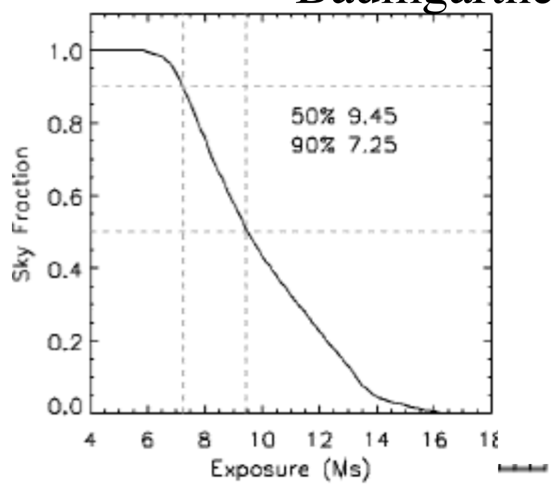
Sky Space

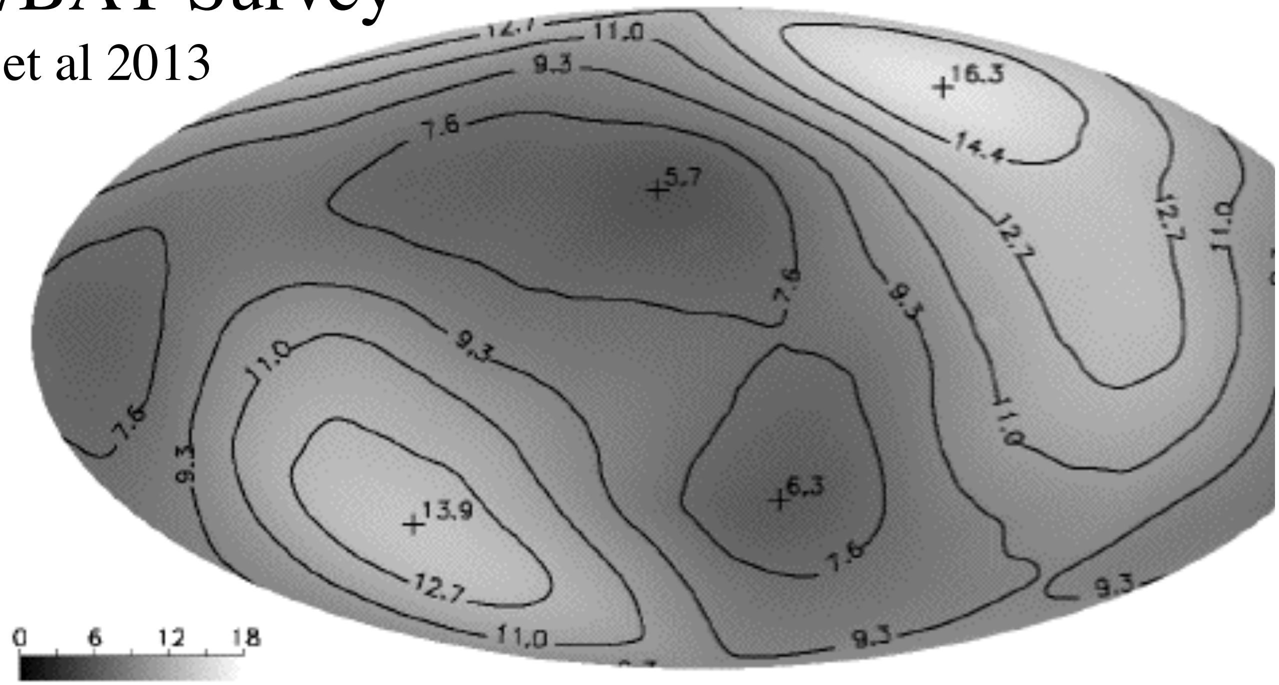
Galactic Center Image (40x40 deg^2)

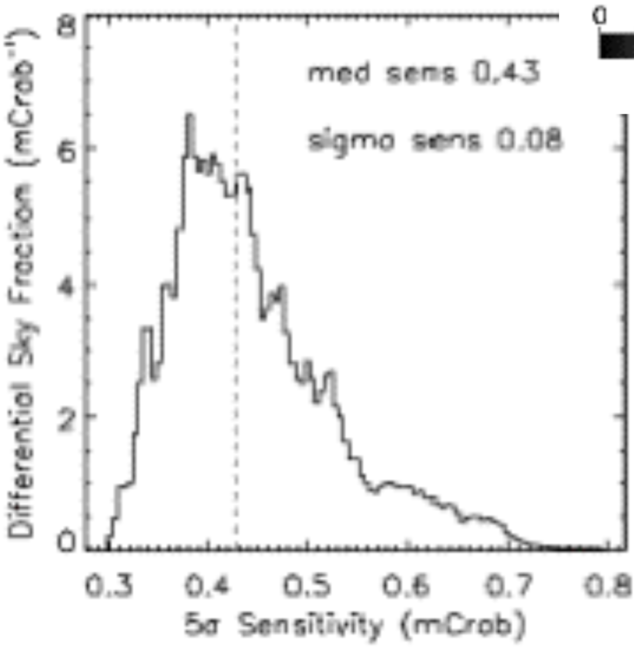


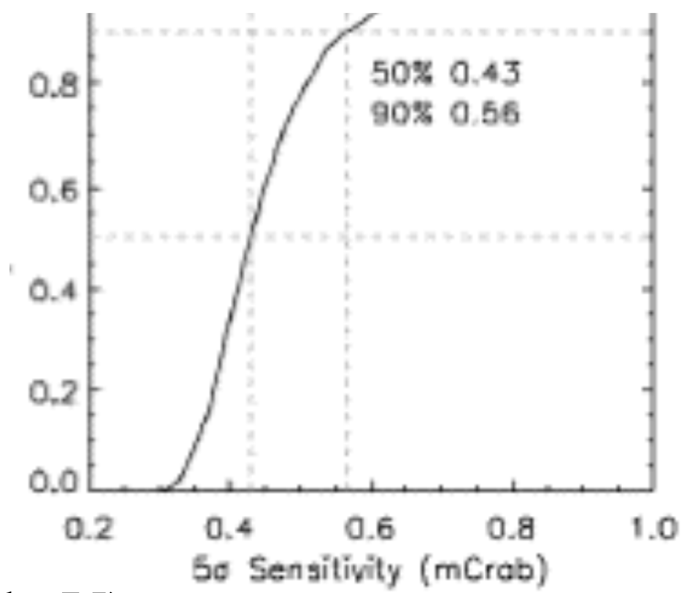
70-month Swift/BAT Survey

Baumgartner et al 2013









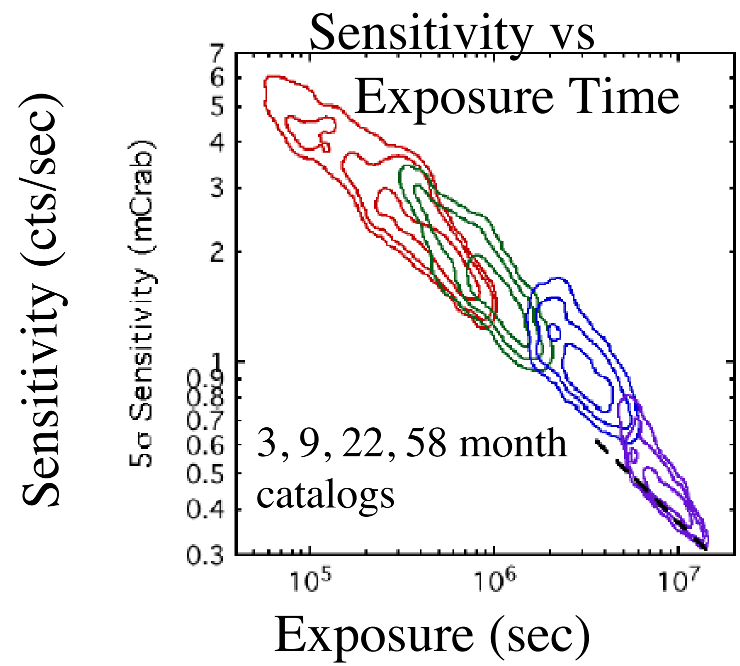
1mc=2.4x10^{-11} (14-195 keV)

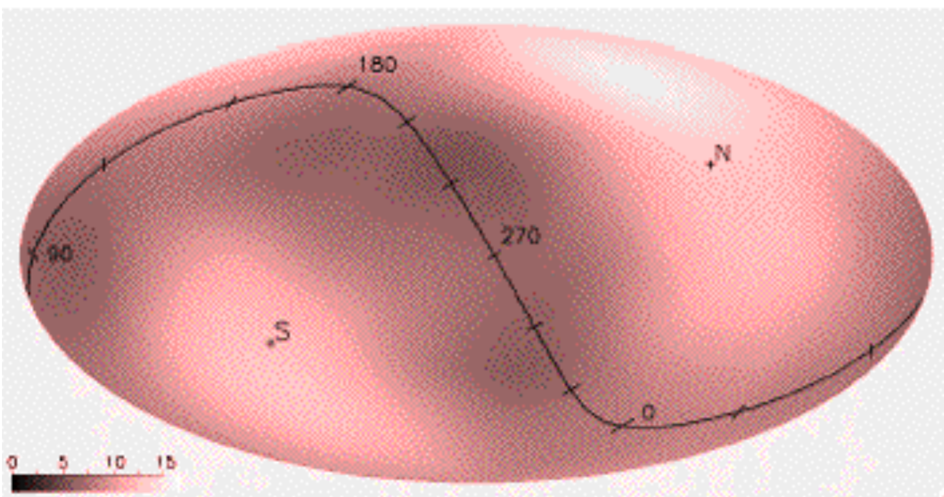
70-month Swift/BAT Survey

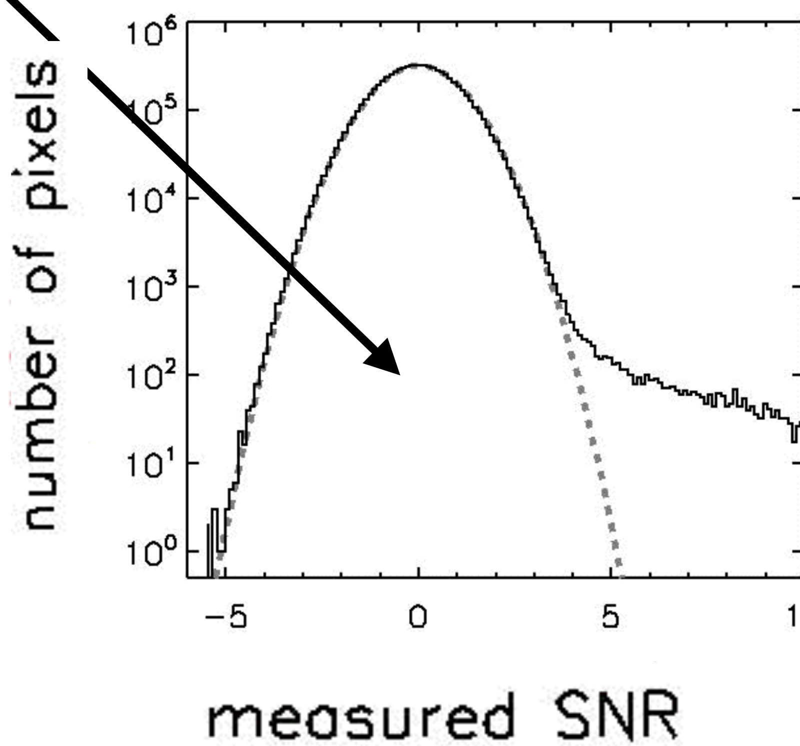
Baumgartner et al 2013

- Covers 90% sky, >7Ms-deficit on Ecliptic Plane due to Sun avoidance
- Sensitivity improves as square root of time
- Noise is Gaussian

# of bins



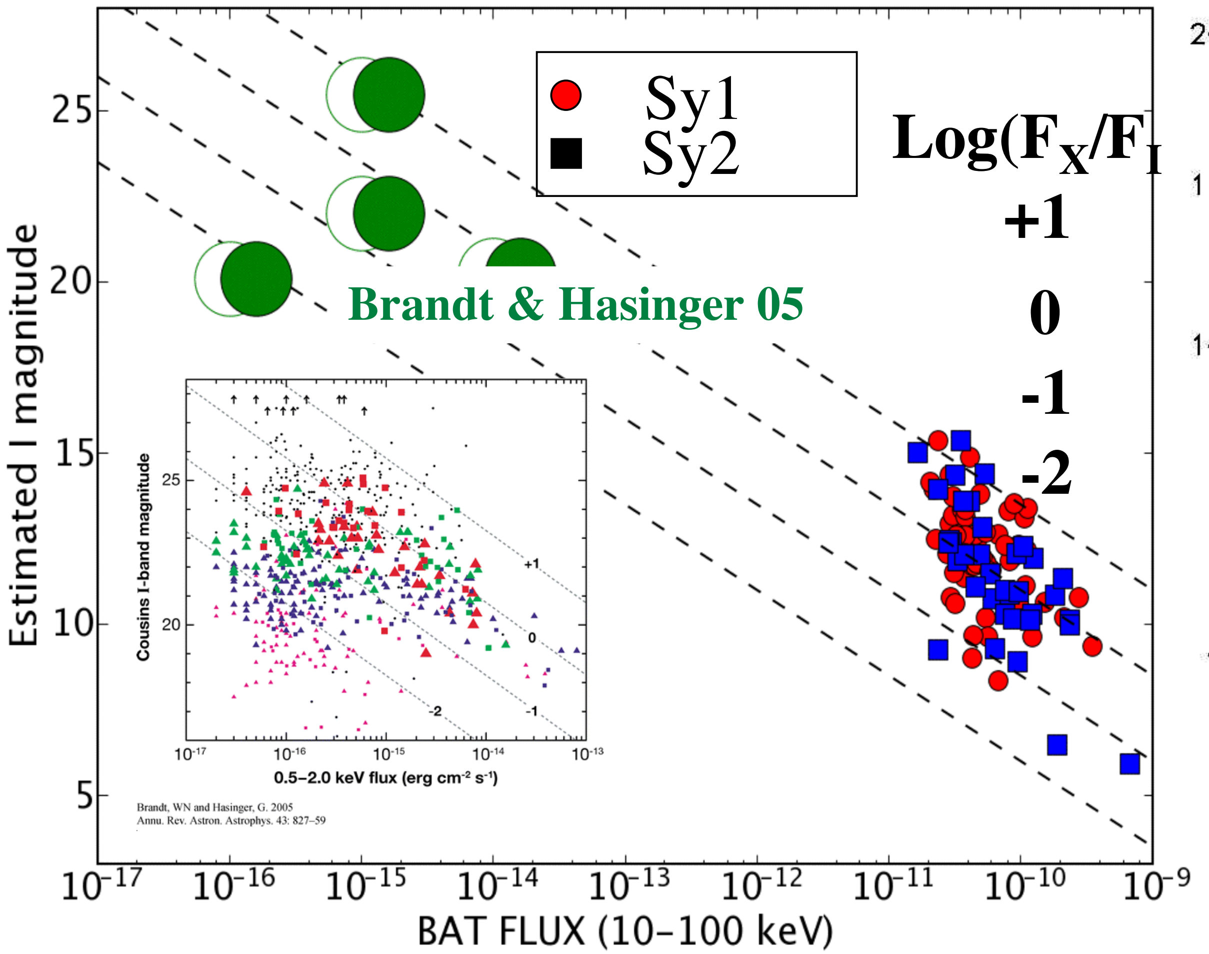


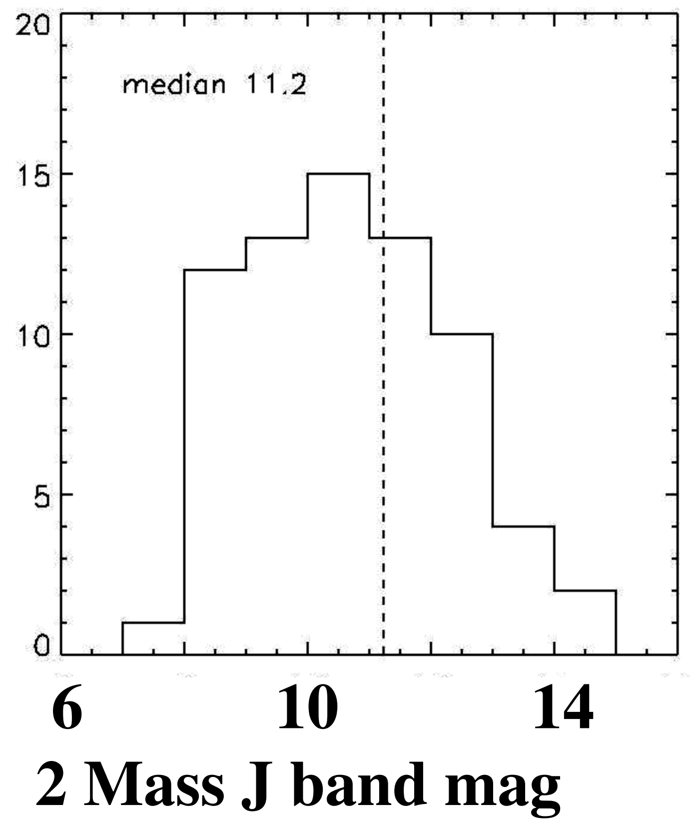


SWIFT BAT Survey Compared to Other X-ray Surveys

To first order x-ray to optical ratio of the BAT sources consistent with deep x-ray surveys

BAT sources tend to be *optically bright <J>=11.2 and near <z>=0.026*
- SDSS +6dF spectra

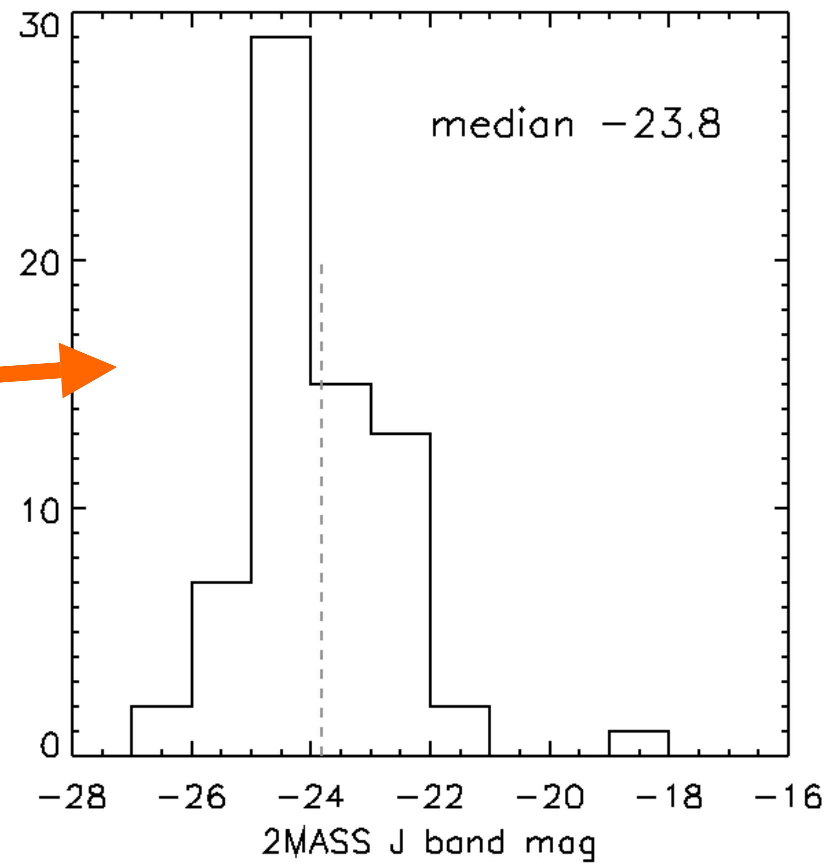




Statistics of 58 Month Survey

COUNTERPART TYPES IN THE *Swift*-BAT 58-MONTH

Class	Source Type	# in catalog
0	Unidentified[a]	95
1	Galactic [b]	16
2	Galaxies[c]	187
3	Galaxy Clusters	17
4	Seyfert Galaxies	516
5	Beamed AGN[d]	109
6	CVs / Stars	58
7	Pulsars / SNR	27
8	X-ray Binaries	174
		—
	Total	1099

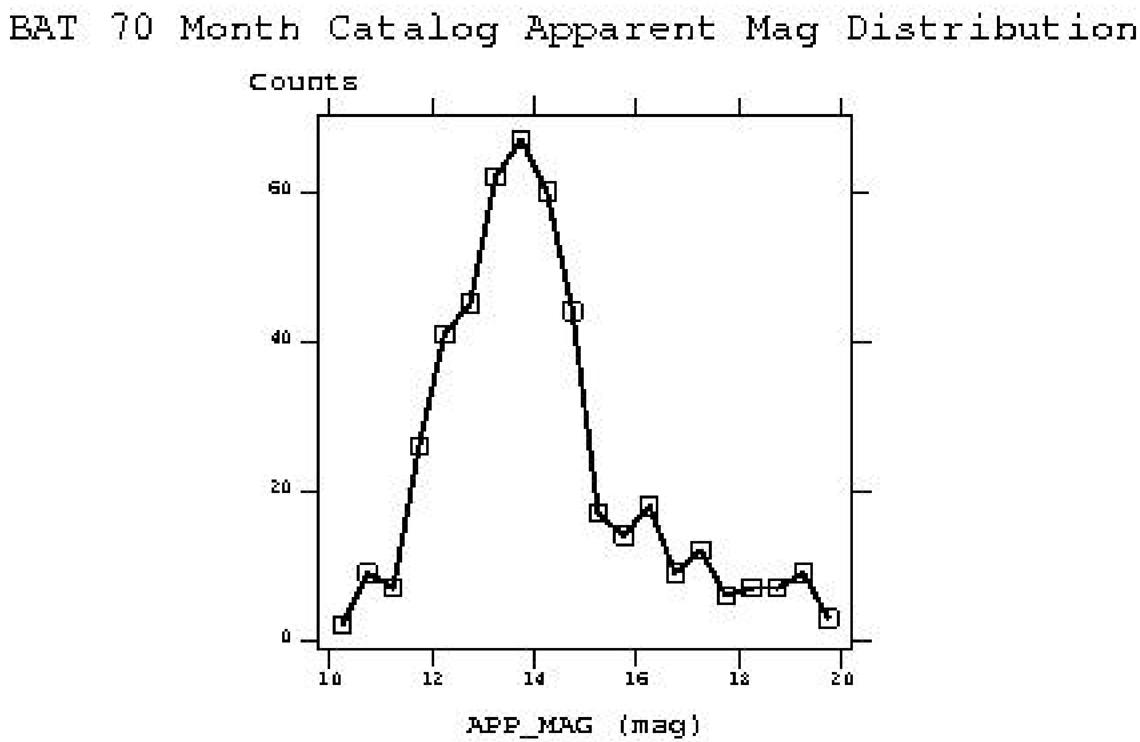


Most of the unidentified objects are at low galactic latitude

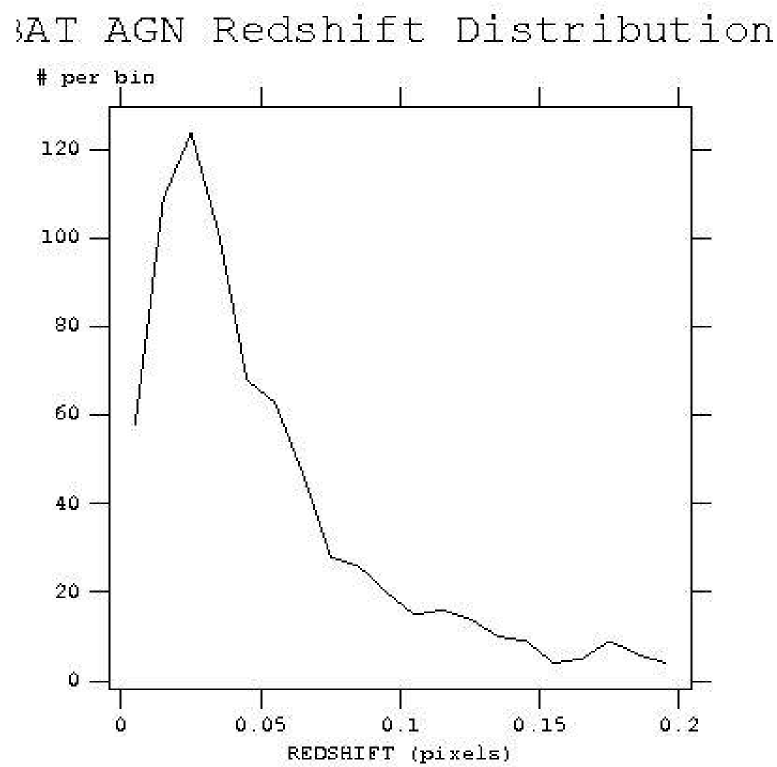
Objects labeled 'extragalactic' have a galaxy ID but are not classified as AGN in the catalogs (e.g NGC 0973)

IDS are mostly based on Swift XRT follow-up observations

Markwardt et al 2005, Tueller et al 2008, Winter et al 2008ab, Mushotzky et al 2008, Melendez et al 2008a



BAT 70 Month Catalog Apparent Mag Distribution
Counts
0
20
40
60
10
12
14
16
18
20
APP_MAG (mag)

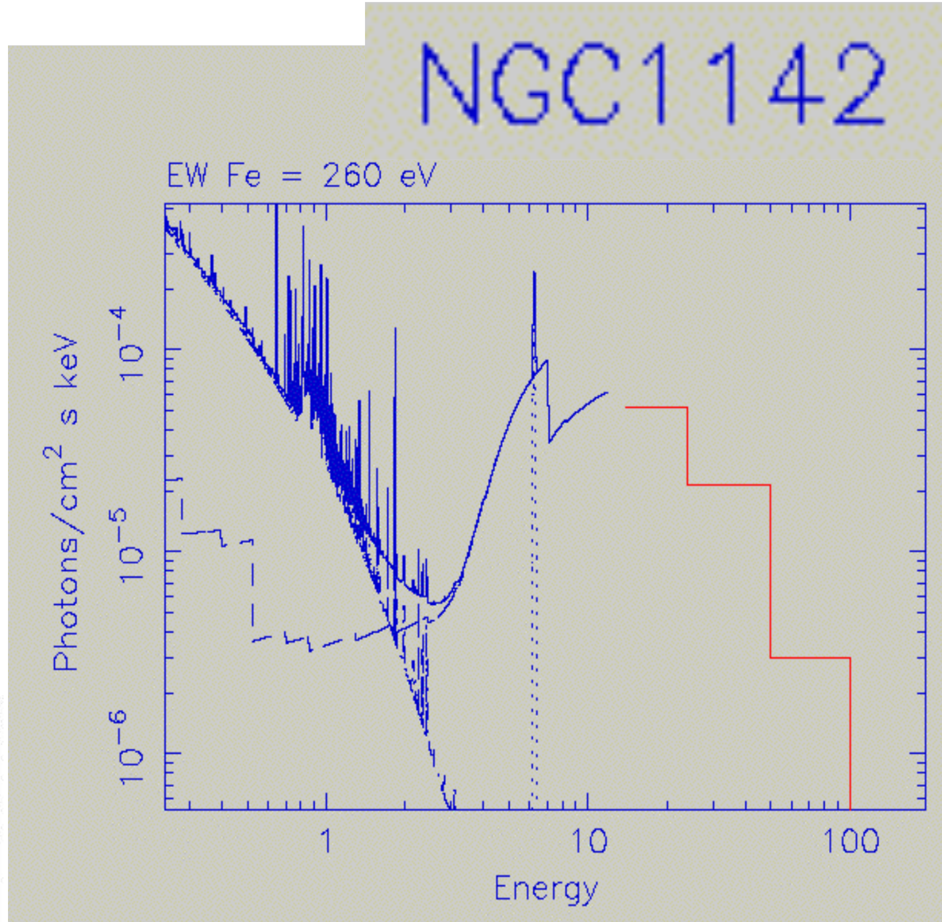


AT AGN Redshift Distribution
per bin
0
20
40
60
80
100
120
0
0.05
0.1
0.15
0.2
REDSHIFT (pixels)

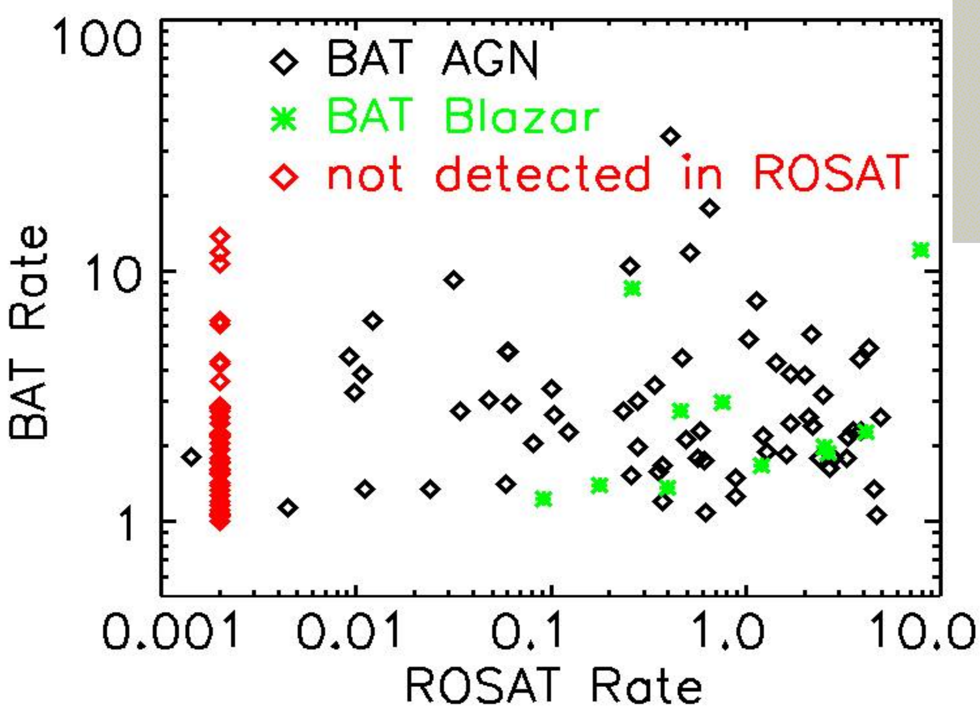
Nature of Hard X-ray selected sources

- Followed up Swift BAT selected sources with XMM, Suzaku and XRT
- Wide range of x-ray spectra

No correlation with Rosat flux (0.2-2 keV)



XMM + BAT spectra

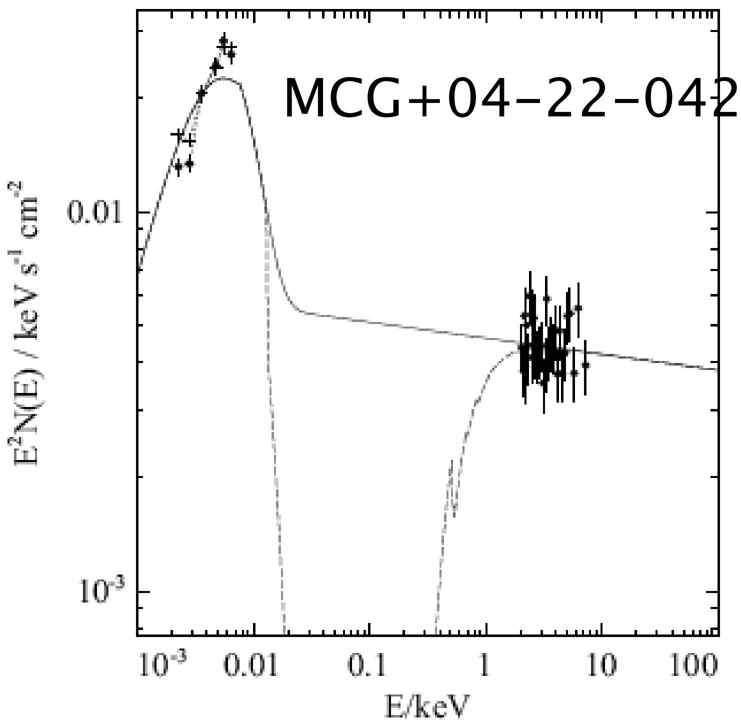


Obvious why soft and hard x-ray band are uncorrelated

"Optical" Data

- Obtain 5 color SDSS photometry with Kitt Peak 2m (Mike Koss- U of Md)
- Swift OM data to get nuclear spectral energy distribution (Ranjan Vasudevan) simultaneously with x-rays
- CO J=0-1 data with JCMT

Optical and IR spectroscopy
- Kitt Peak 2m and SAAO spectra
- 6dF and SDSS data
- ~110 objects with Spitzer
- 340 with Herschel



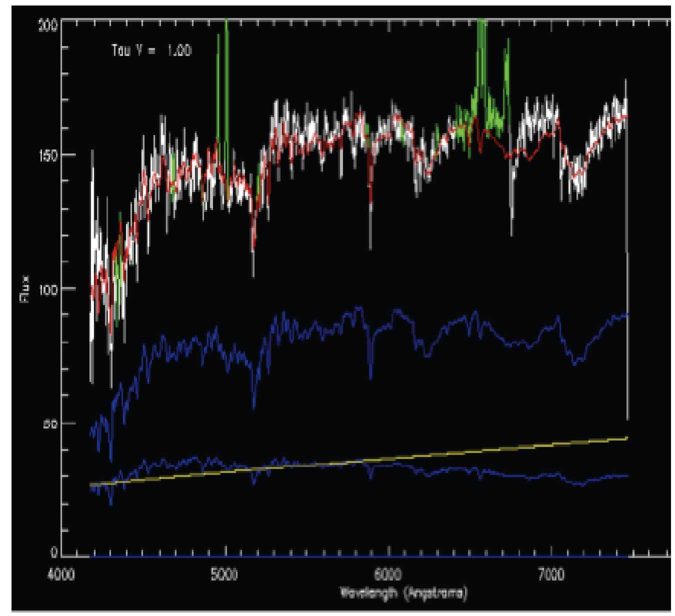
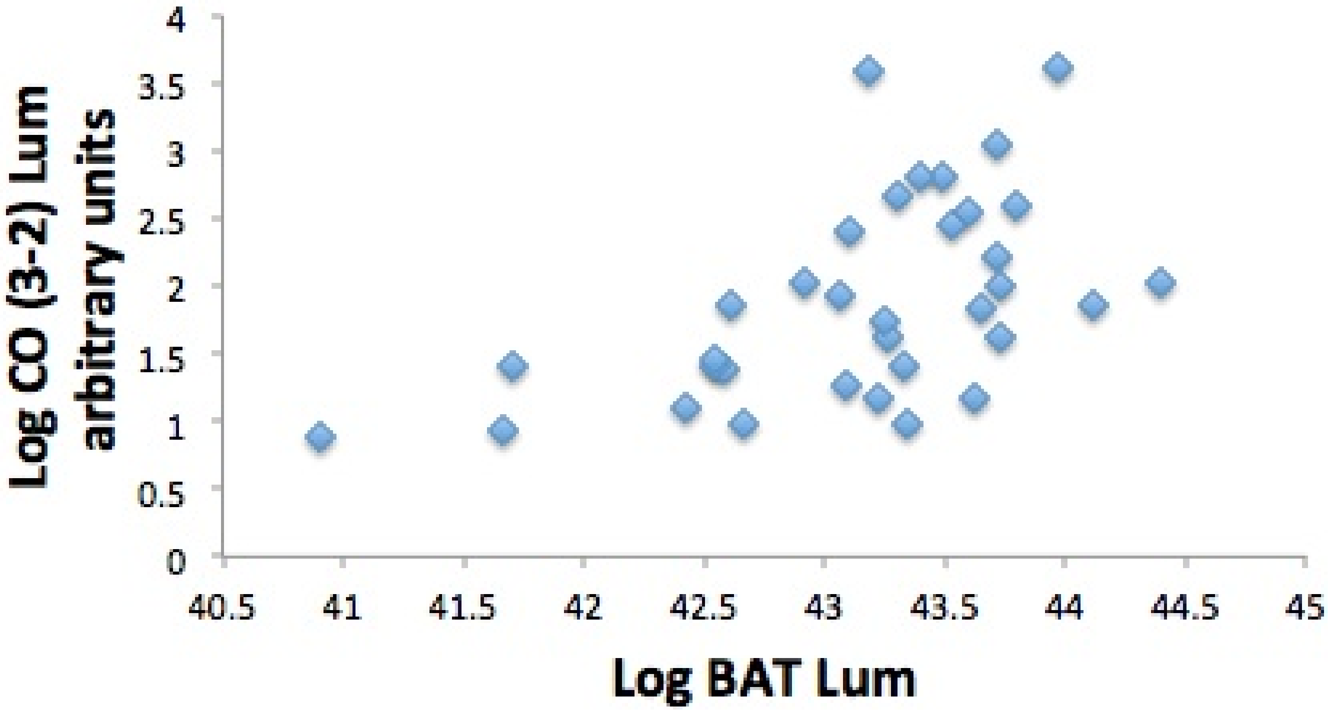


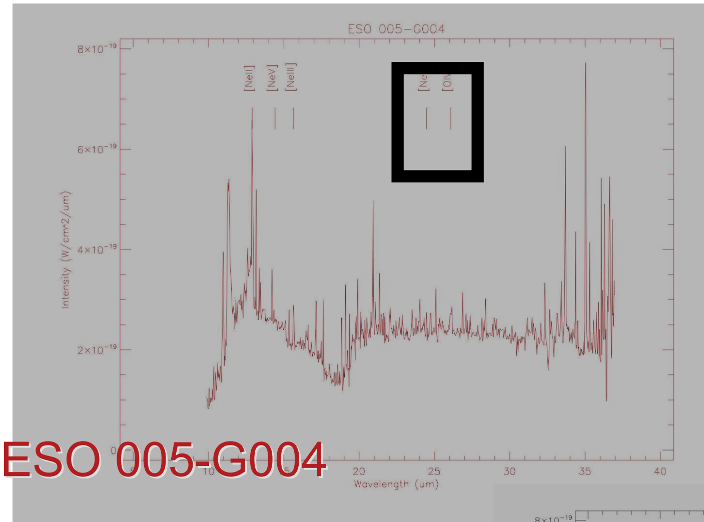
Fig. 12.— On left, gri image of UGC 12741 from Kitt peak 2.1m telescope. The galaxy is spiral in shape and has a NED galaxy classification of Sa. On right, fitting of stellar models and AGN power law to the spectra of UGC 12741. Galaxy spectra is shown in white.

CO Data

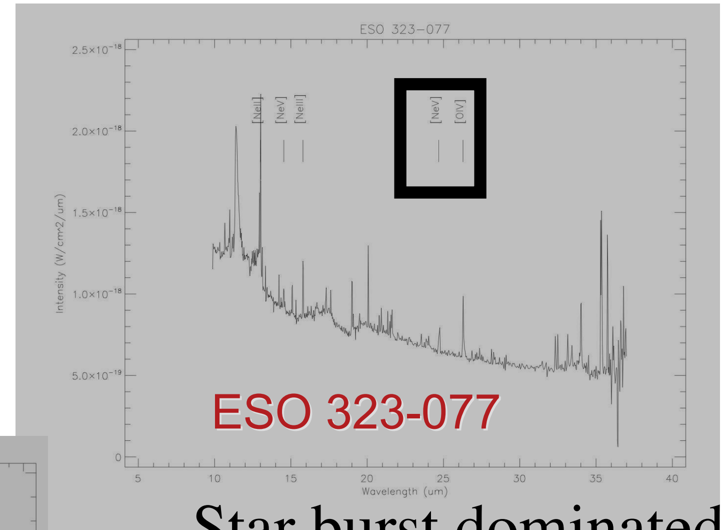


Log CO (3-2) Lum
arbitrary units
4
3.5
3
2.5
2
1.5
1
0.5
0
40.5
41
41.5
42
42.5
43
43.5
44
44.5
45
Log BAT Lum

IRS High resolution spectra- diagnostic [NeV] and [OIV] lines



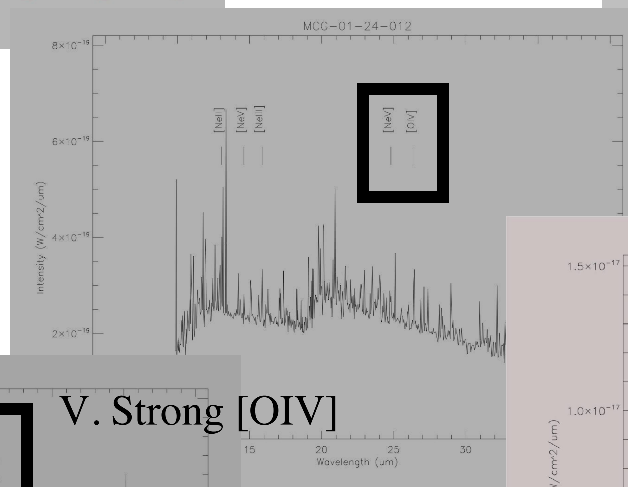
ESO 005-G004

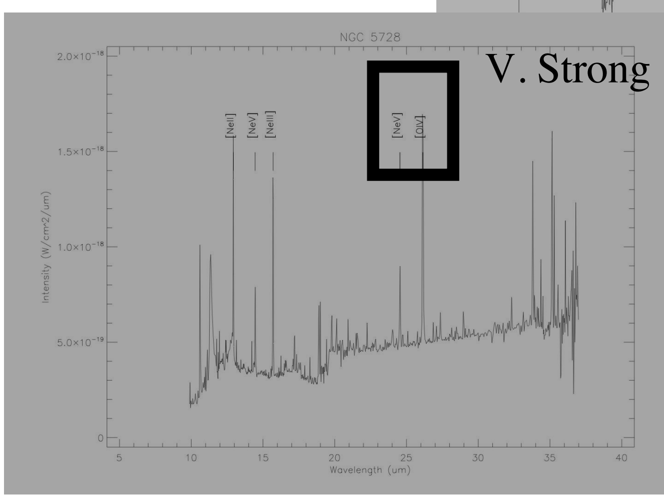


ESO 323-077

Star burst dominated

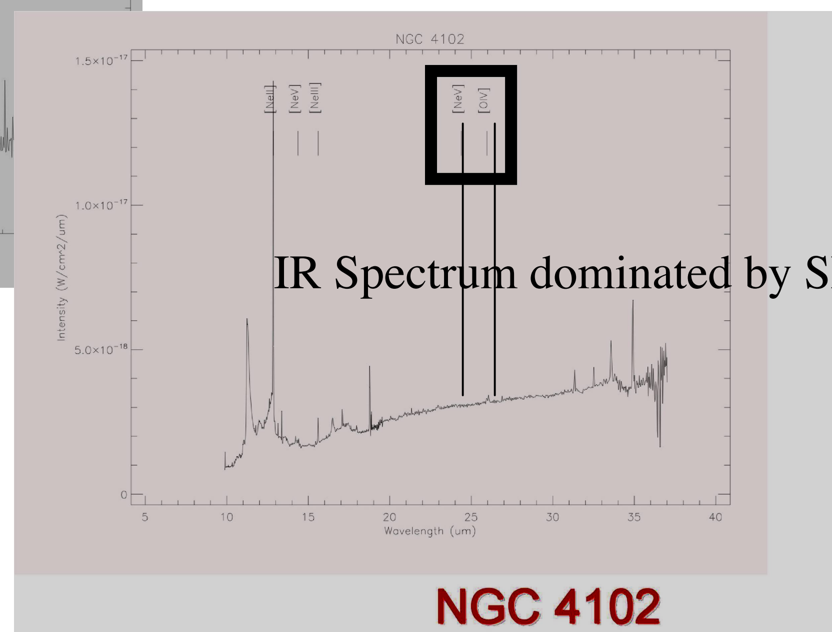
MCG-01-24-012





V. Strong [OIV]

NGC 5728



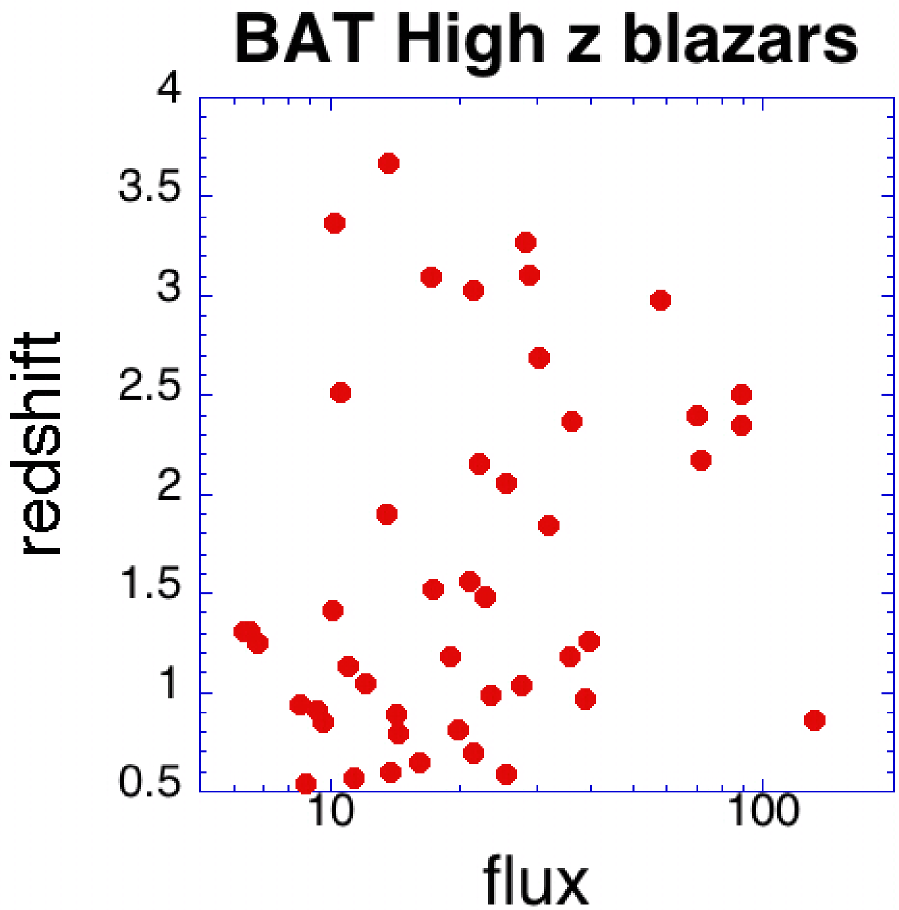
IR Spectrum dominated by SF

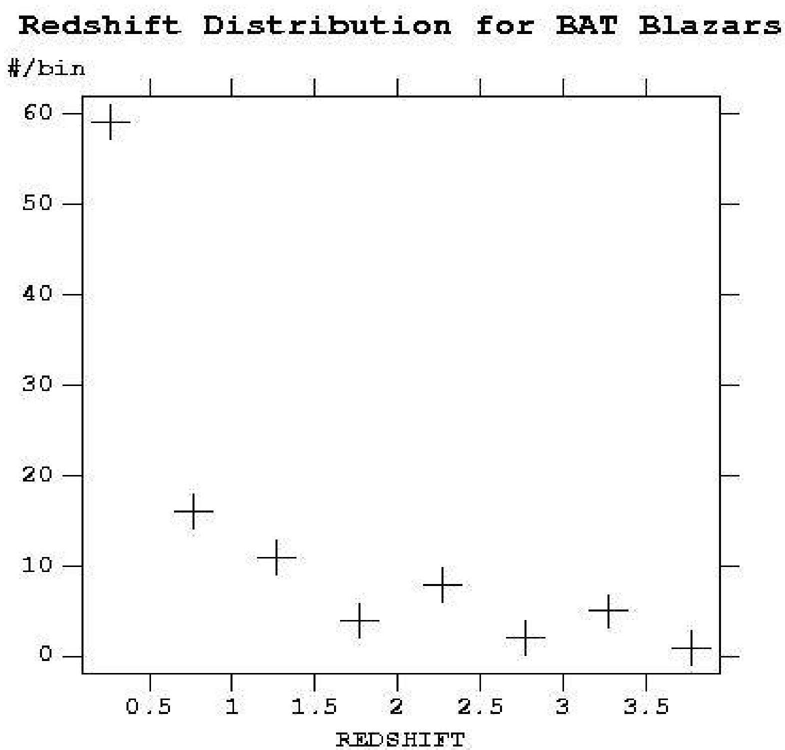
NGC 4102

Notice very wide range of continum shapes, EWs and absolute fluxes

Some 'New' Science I will not Mention Further

- High Redshift Blazars
- AGN in dwarf galaxies
- AGN with no optical or IR spectral indications of 'AGNess'
- RIAFs



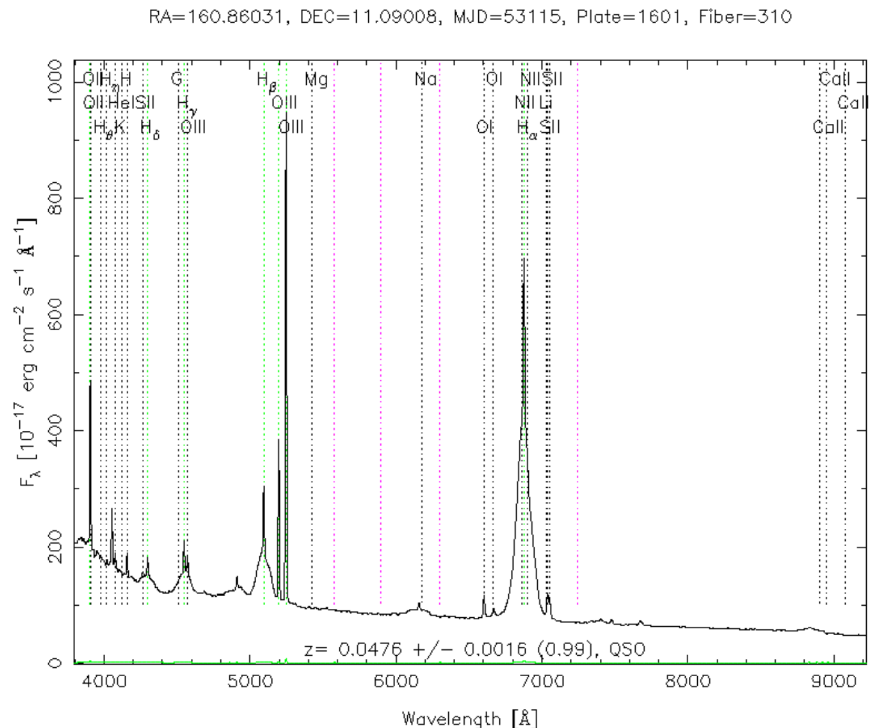


No relation between flux and redshift for hard x-ray selected blazars.

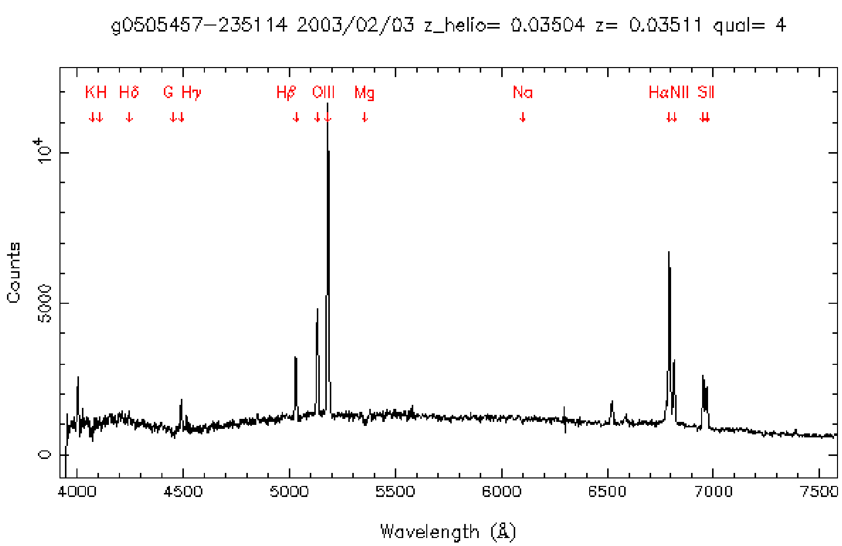
'New' Dwarfs

- SDSS J104326.47+110524.2

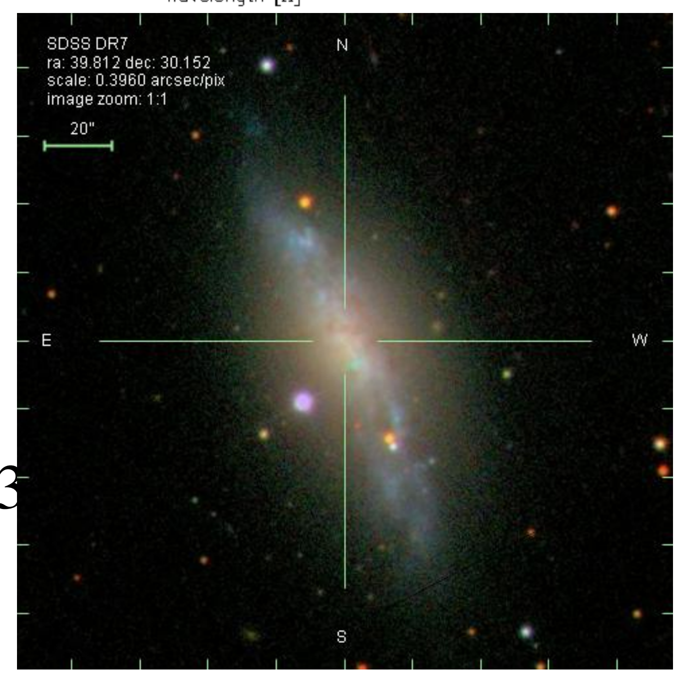
M^{*}~8.6, M_B~-19.2 (removing nucleus, 70% of the light- total abs mag is -19.8) type I



- LEDA 178130 type II M_B~-19, M^{*}~9.13

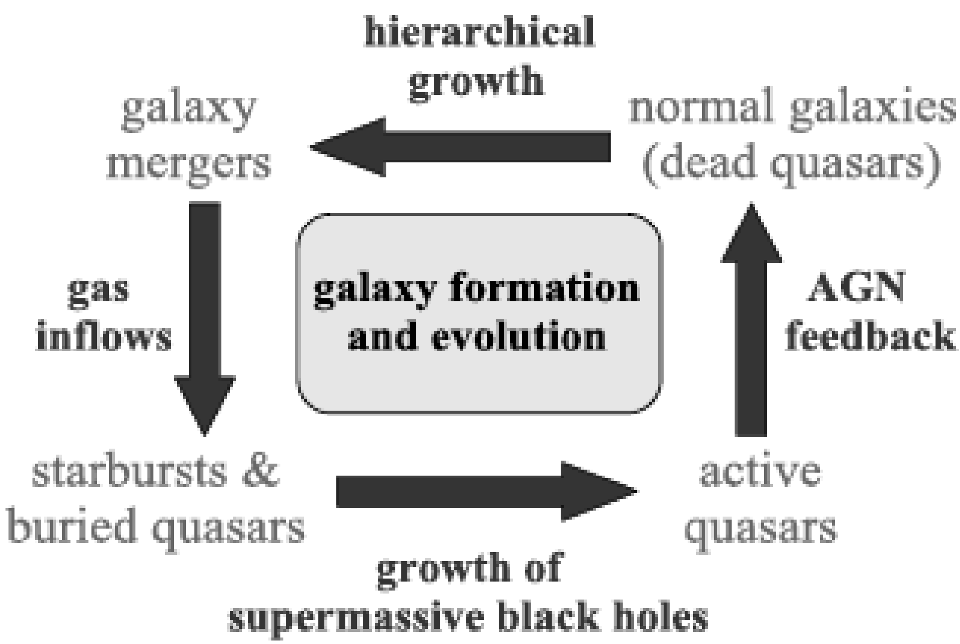


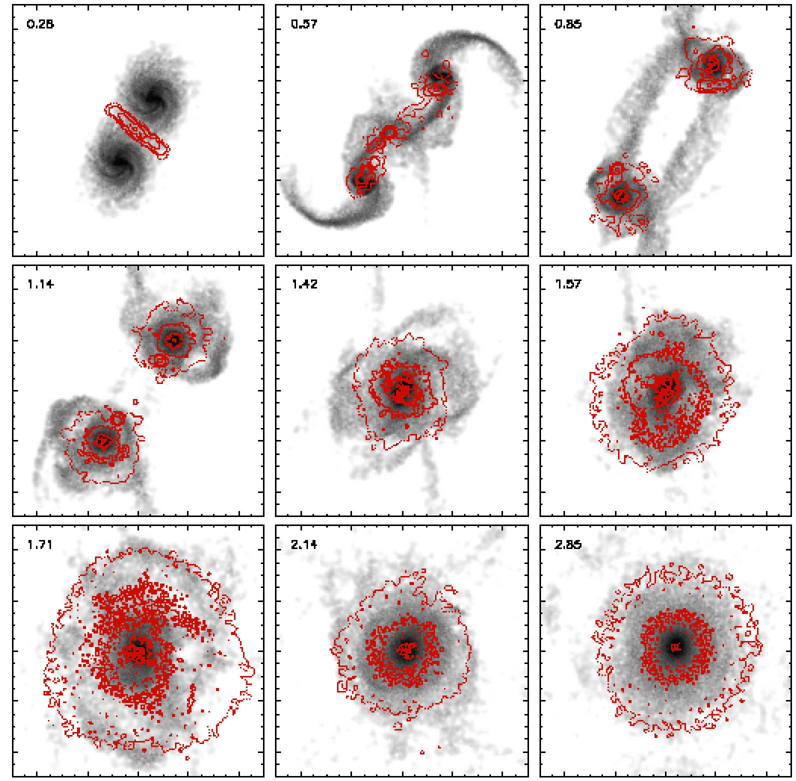
NGC 1012 M_B~-18.4 no optical spectra, highly abs x-ray spectrum log L(x)>41.3



What Can Trigger AGN?
Do AGN Live in 'Special Galaxies'/ Special Times ?

AGN triggered by mergers?- something else ?





X-ray emission in red

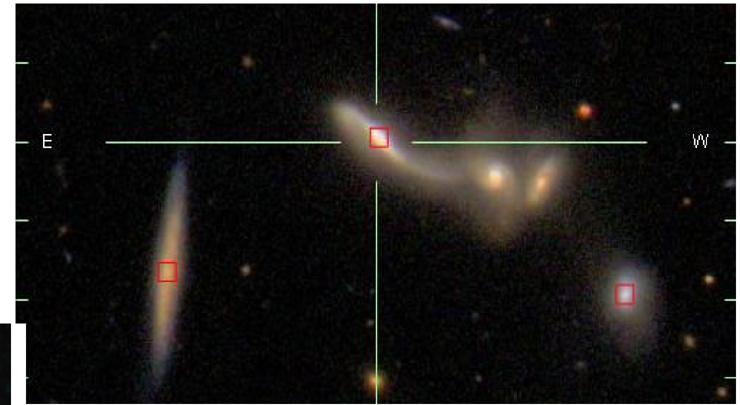
Di Matteo et al 2005,Hopkins 2005

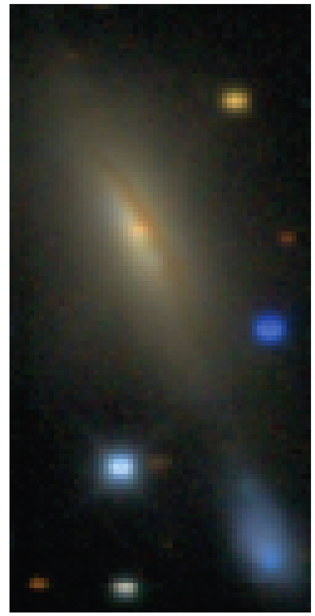
The Nature of AGN Hosts- Koss et al 2010, 2011

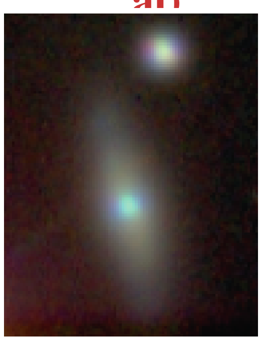
- Theory - AGN strongly influences galaxy formation - BAT sample perfect for testing this idea
- The BAT sample - hosts are mostly spiral and irregular galaxies: **> 30% involved in mergers or interactions**

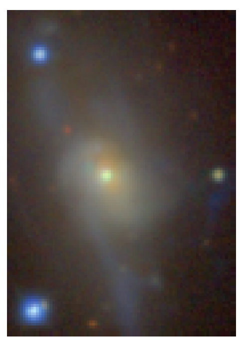
(~2% for 'normal' galaxies) - 3% Ellipticals

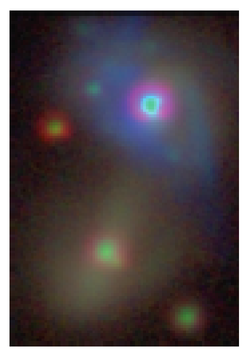
- The 'colors' of the hosts are mid-way between that of 'red' and dead galaxies and active star forming galaxies
  - **Chandra/XMM selected AGN at z~1 hosts are luminous red galaxies (e.g Barger et al, Brusa et al)**





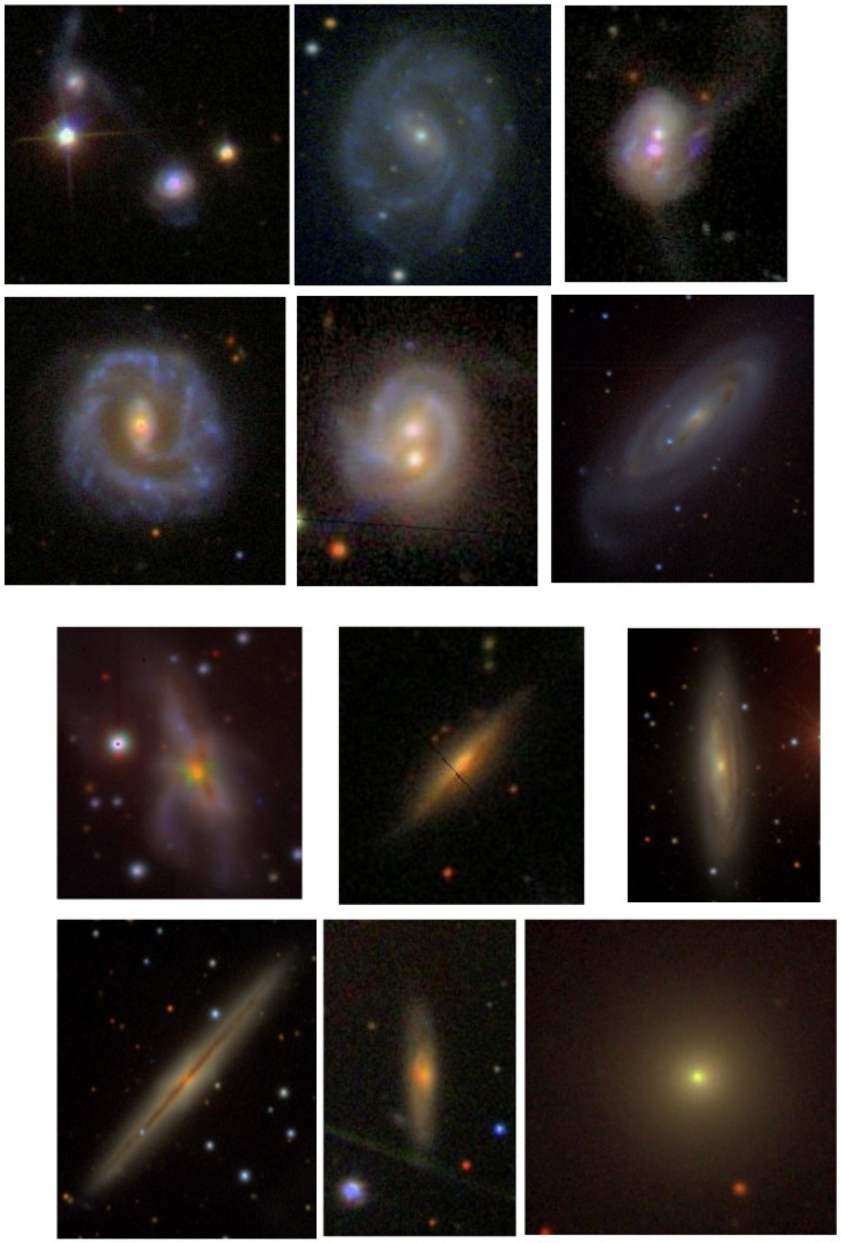


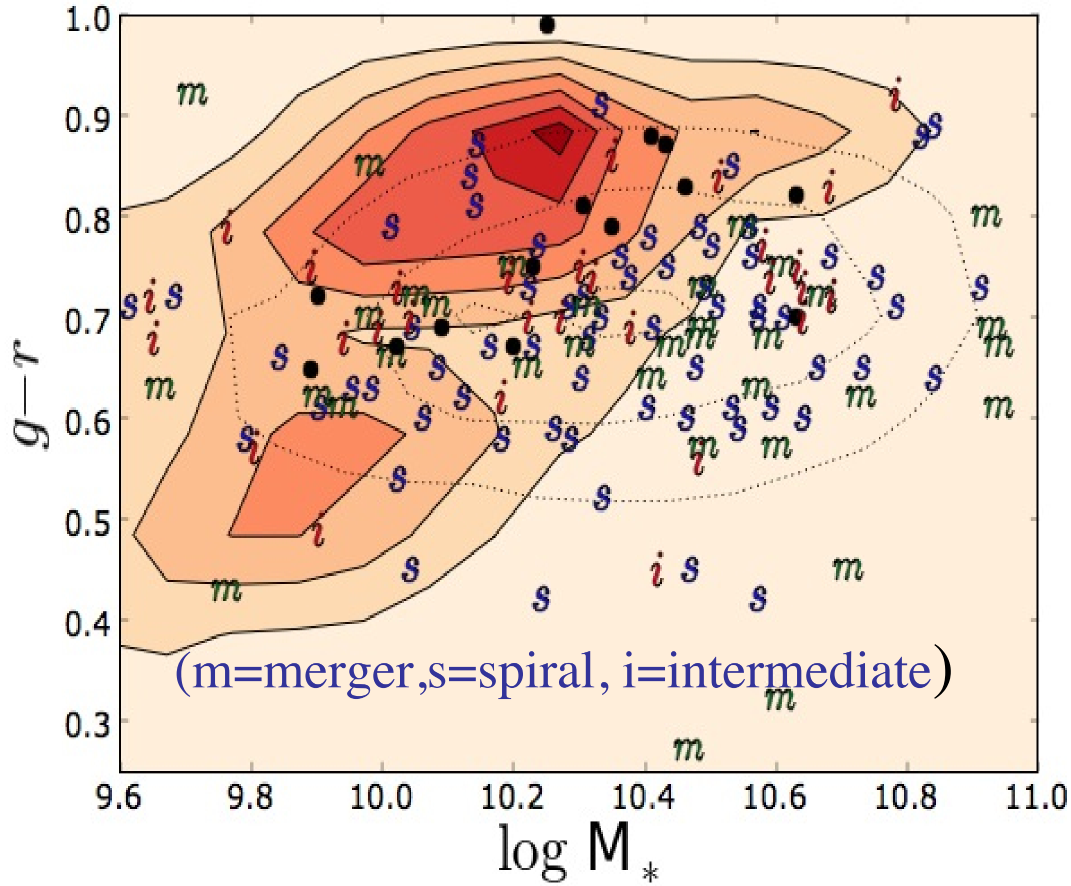




<u>Some</u> of the optical images of **interacting galaxies** from the BAT sample

Morphology/Color/Mass

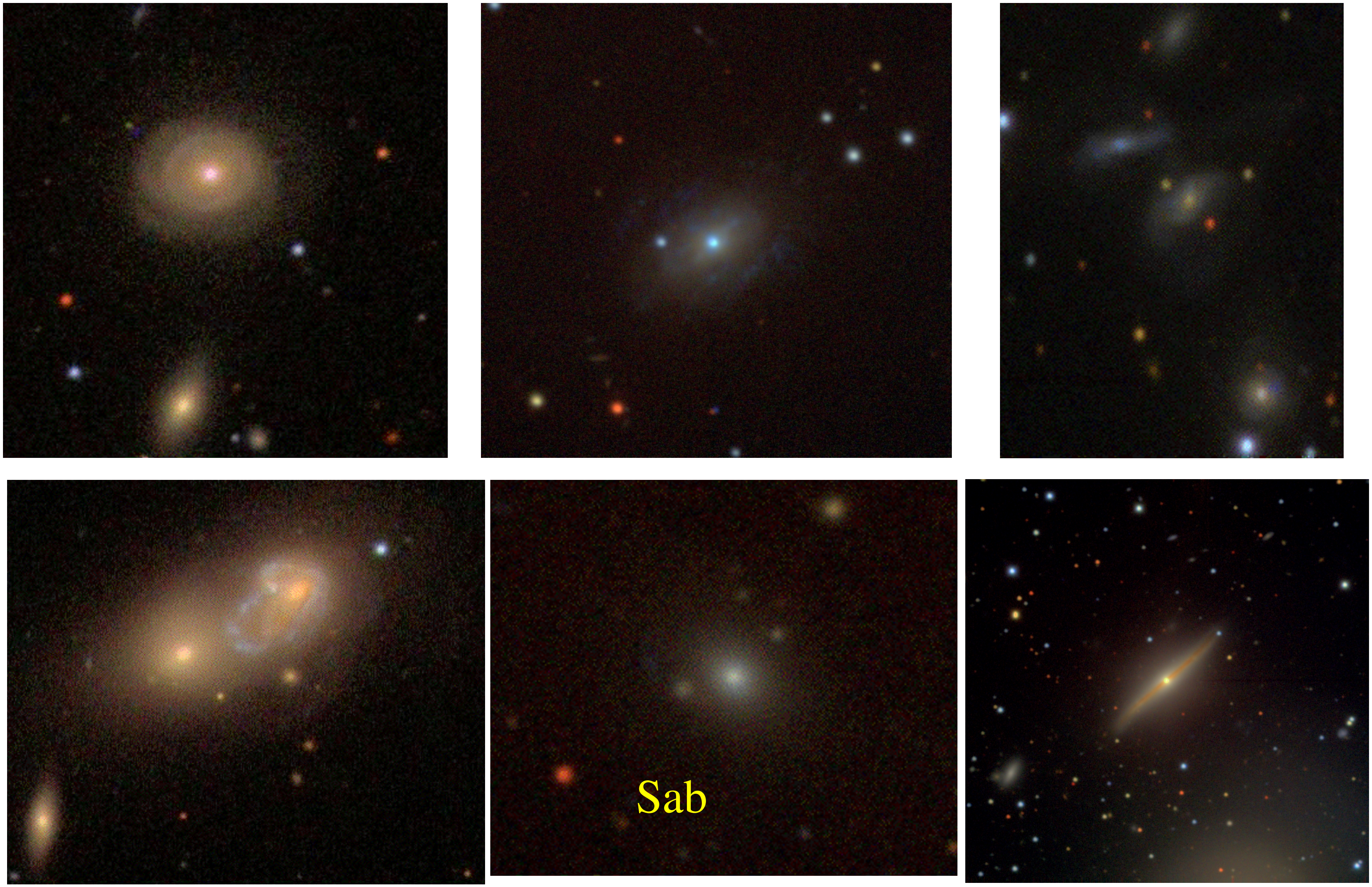




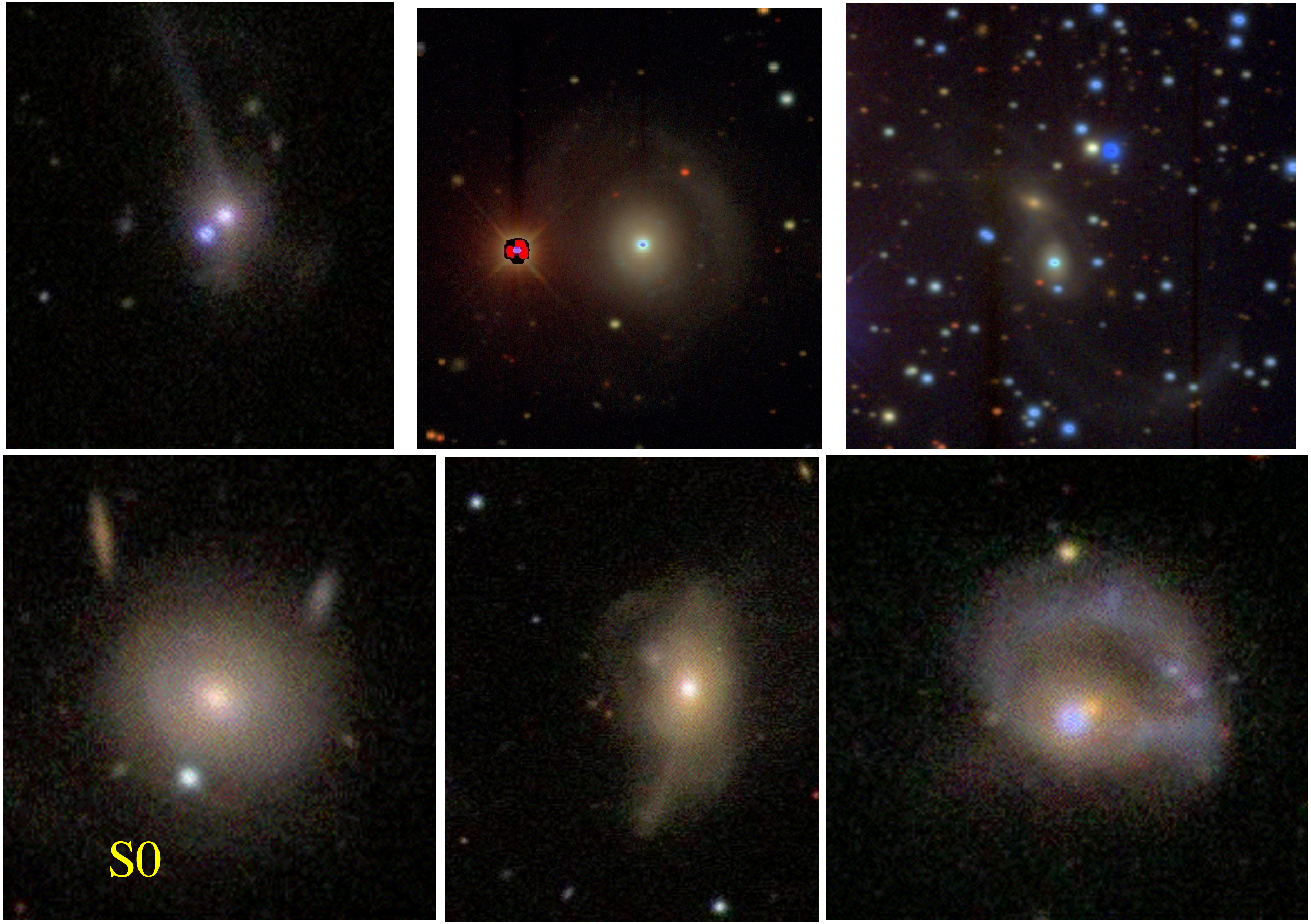
Reddest systems tend to be edge on
Bluest systems face on
~1/3 of BAT AGN are in massive spirals- a very rare class of galaxy
BAT AGN tend to lie in massive galaxies (log M >10.5), 5 to 10 times higher rate of spiral morphologies than SDSS AGN or inactive galaxies.

All the Most Luminous BAT Sources are Mergers or Massive Spirals

Mrk 926, 3C120, 2MASX J06411806+3249313, NGC1142 , 2MASS05054575, IC4329A



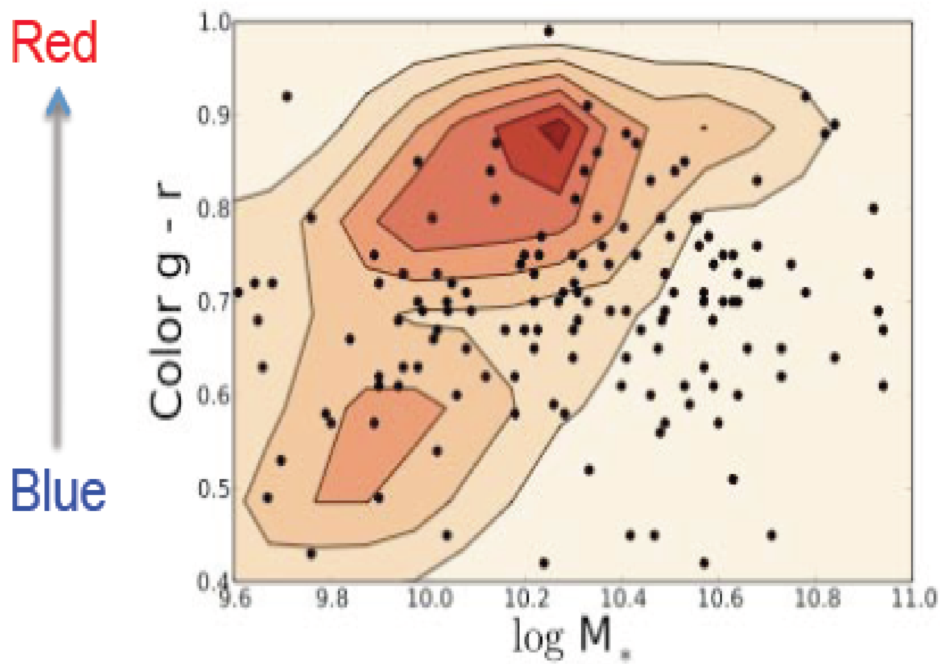
Mrk110, Ark120, IRAS055892828
LEDA170194, Mrk1018, and NGC985

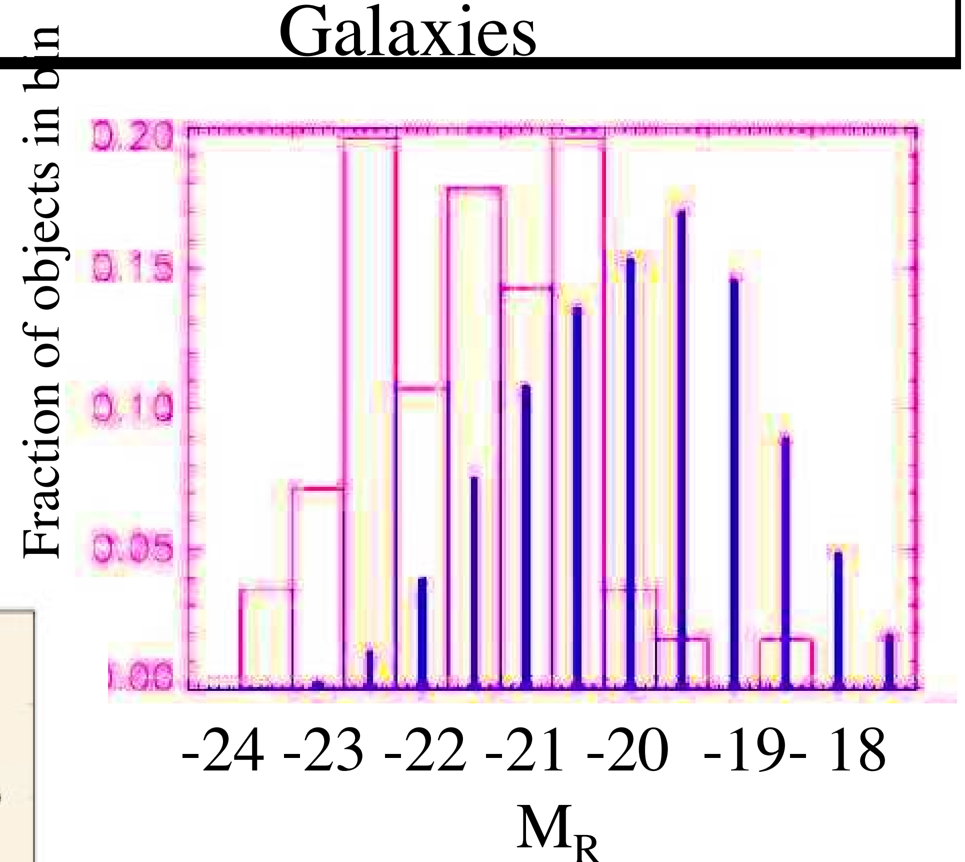


Host Galaxies of AGN are More Luminous than Field Galaxies

- <L> of BAT AGN hosts 1.3 mag brighter -galaxies 2x more massive than for SDSS inactive galaxies

- AGN Hosts preferentially live in 'green valley'- luminous galaxies with star formation- **Does AGN cause star formation or turn it off?- (cf. Schawinski et al 2009)**





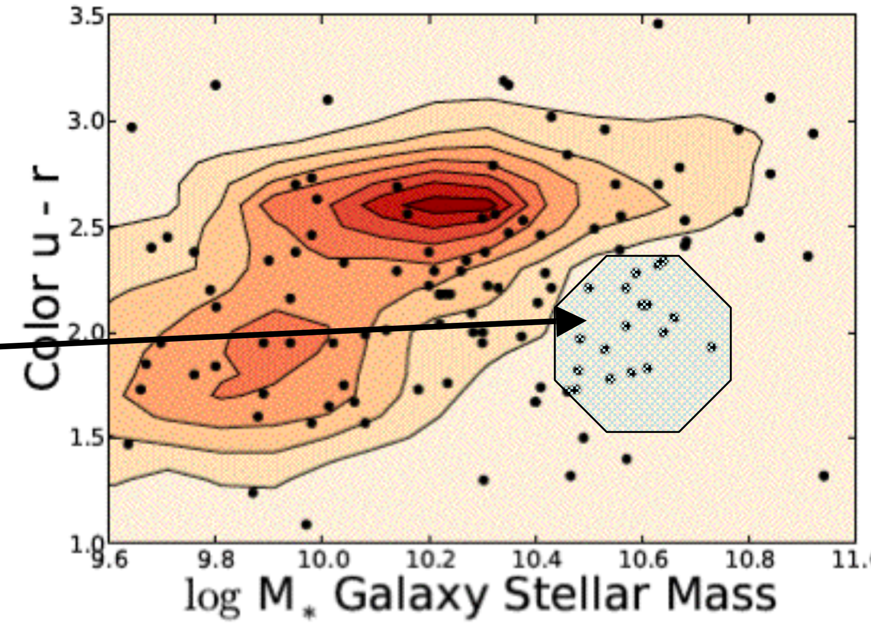
Colors/contour - field galaxies +AGN Hosts

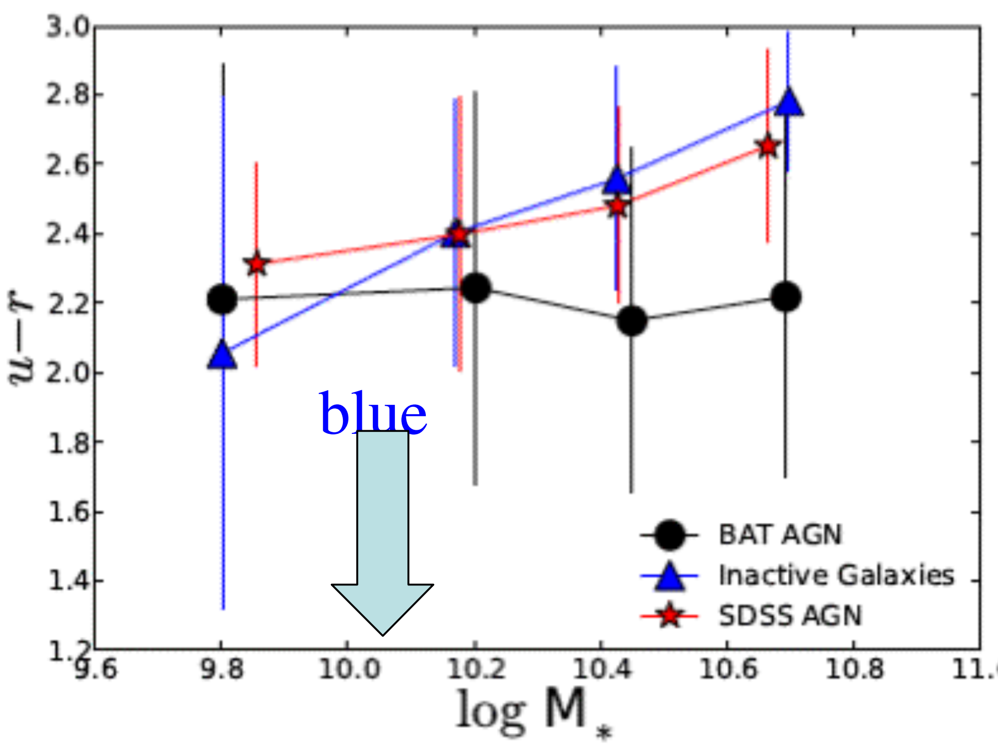
Koss et al 2010

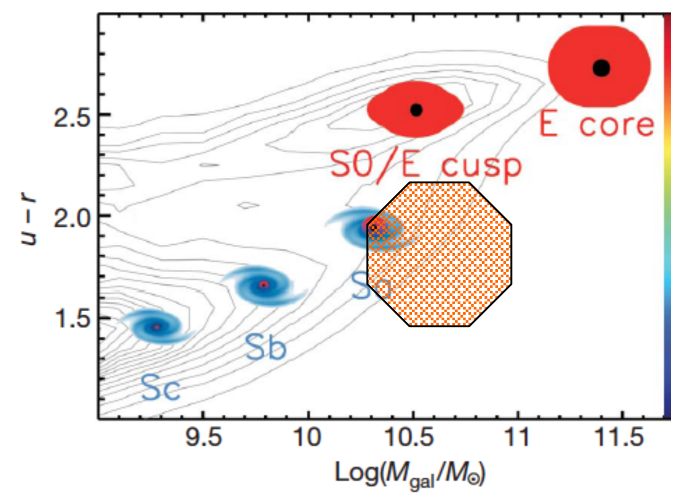
- BAT AGN

BAT Hosts are Bluer and Have More Star Formation

- At log M_{star}> 10.3 the hosts of the BAT AGN are 'bluer' and have higher ratios of 90μ/M_{star}
- massive spirals - large and seem undisturbed







Colors of Hosts

- **Optically selected AGN** from the Sloan Digital Sky Survey **lie in the red contours**

- ‘Normal’ SDSS galaxies in blue contours

- ***BAT selected AGN green contours***
  - **The BAT sample differs from the SDSS sample systematically - Host galaxy properties- ‘bluer’**
  - **Relatively few normal galaxies lie in this green valley**

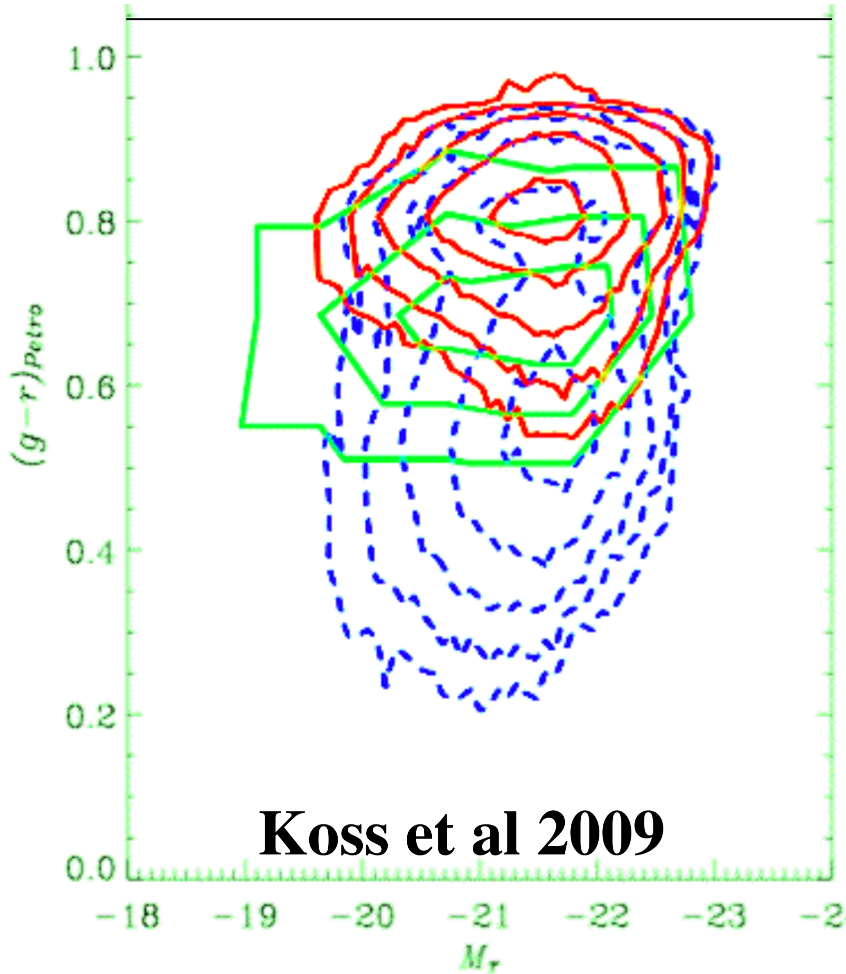
Does AGN cause star formation or turn it off?- (see Schawinski et al 2009)

Samples selected to have same M_R

Color

Red

Blue

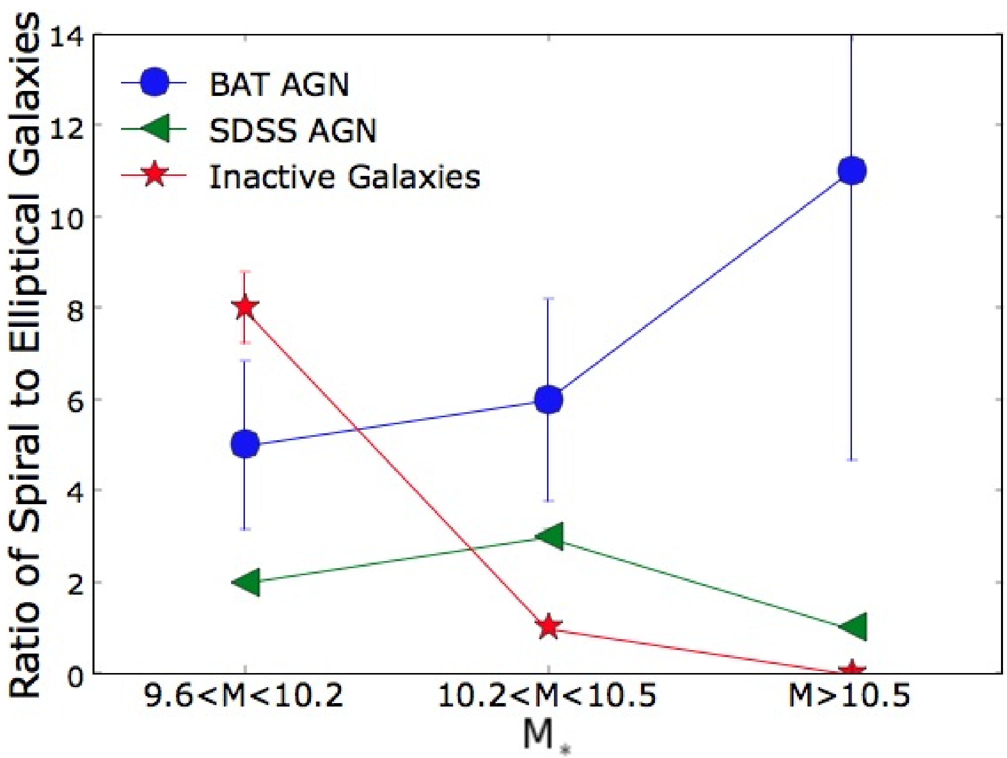


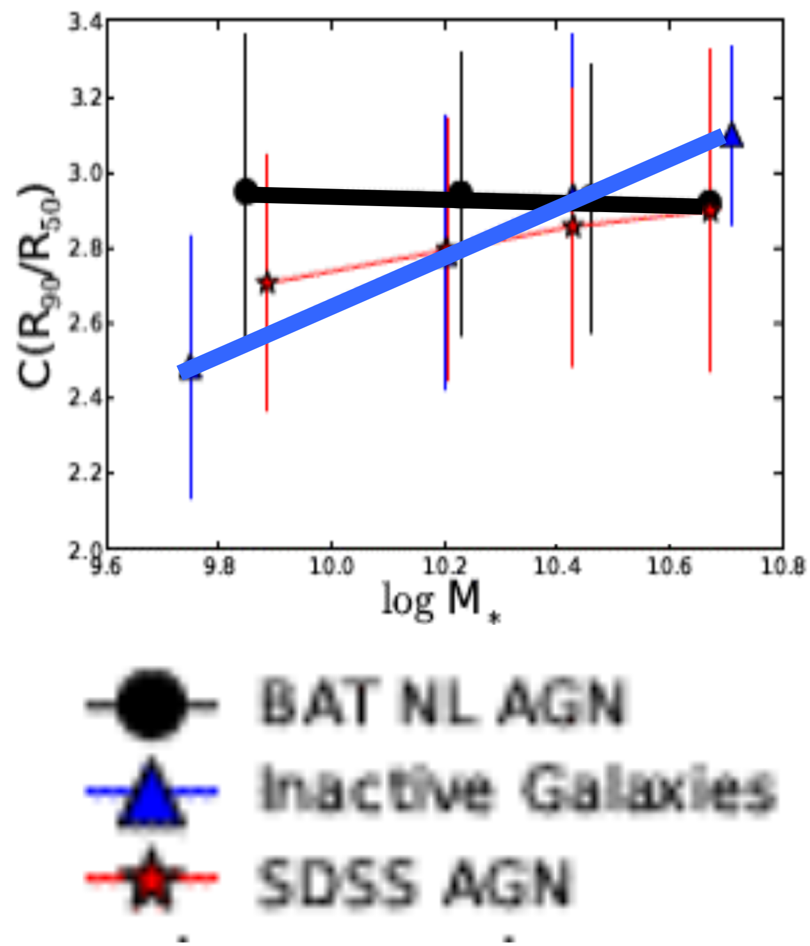
Dim Luminous

Optical Absolute Magnitude

BAT Hosts are more 'Concentrated" at All masses
Massive systems are spirals

- At low masses field galaxies and SDSS selected AGN are less concentrated (spiral like)
- At high masses more concentrated (elliptical like)- but morph of spirals
- BAT host galaxies are concentrated at all masses !

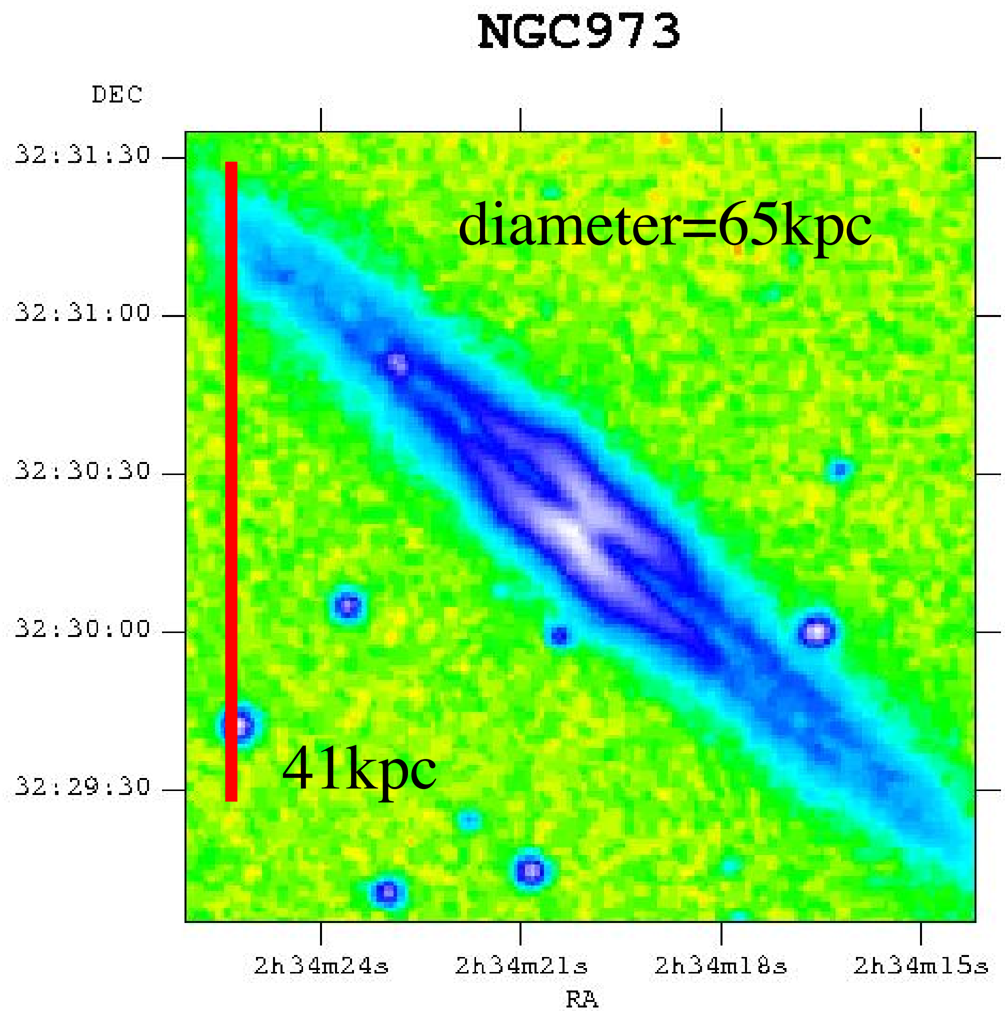


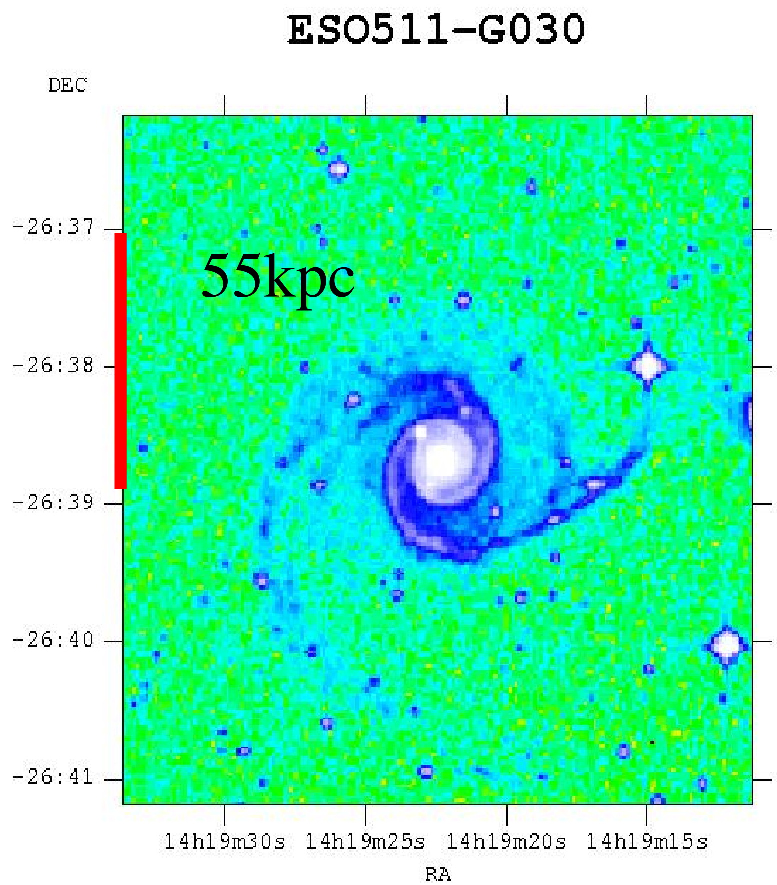


#1 and #3 most massive spiral BAT hosts

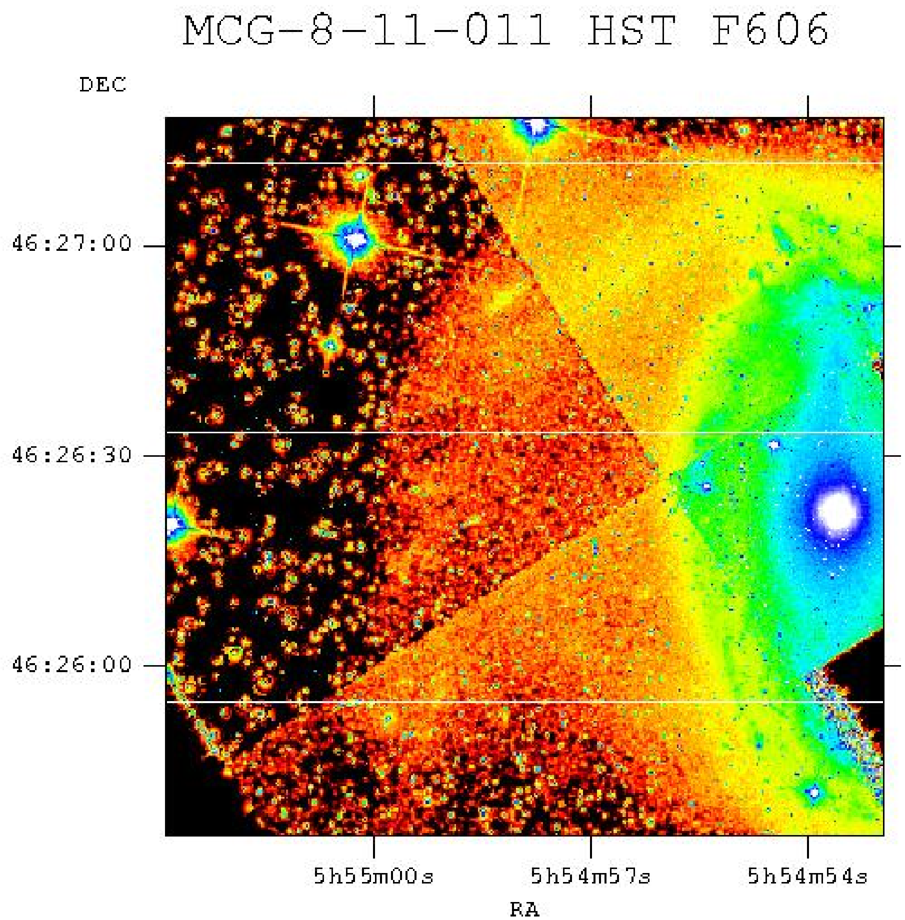
- Very large, very massive spirals
- NGC973 V_{max}=270km/sec, M=-22.12

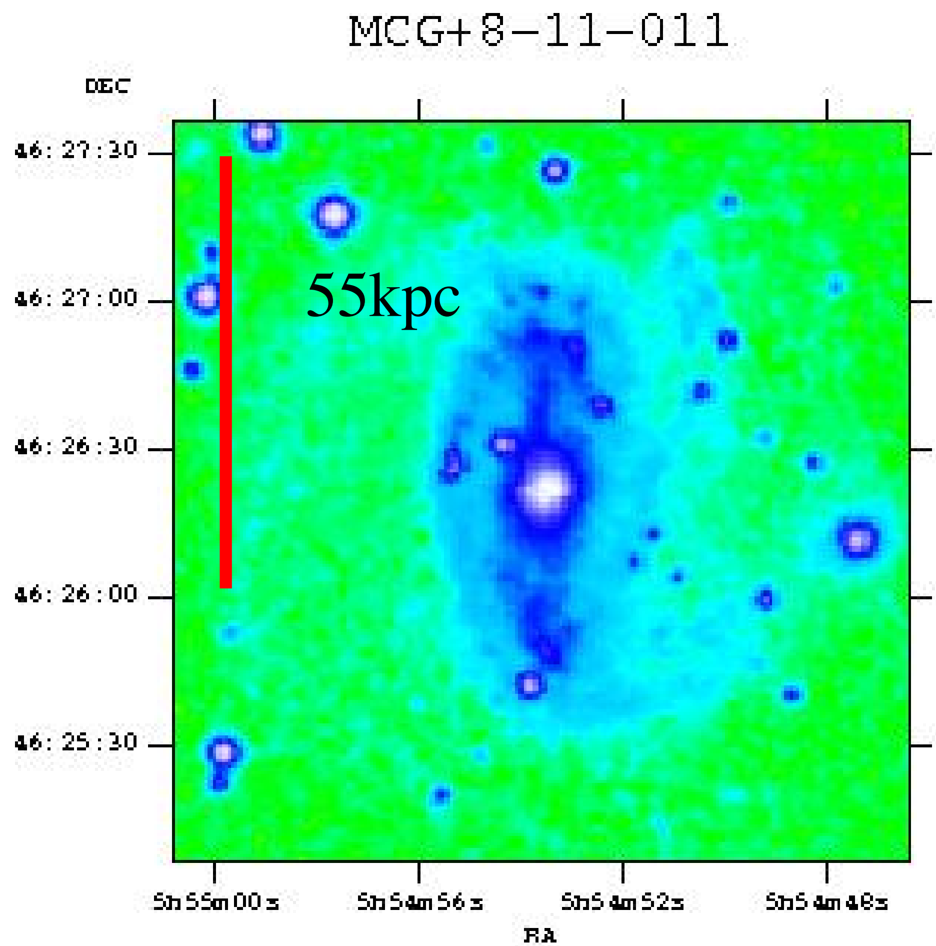
•ESO511 , M=-21.74





Second most massive spiral BAT host

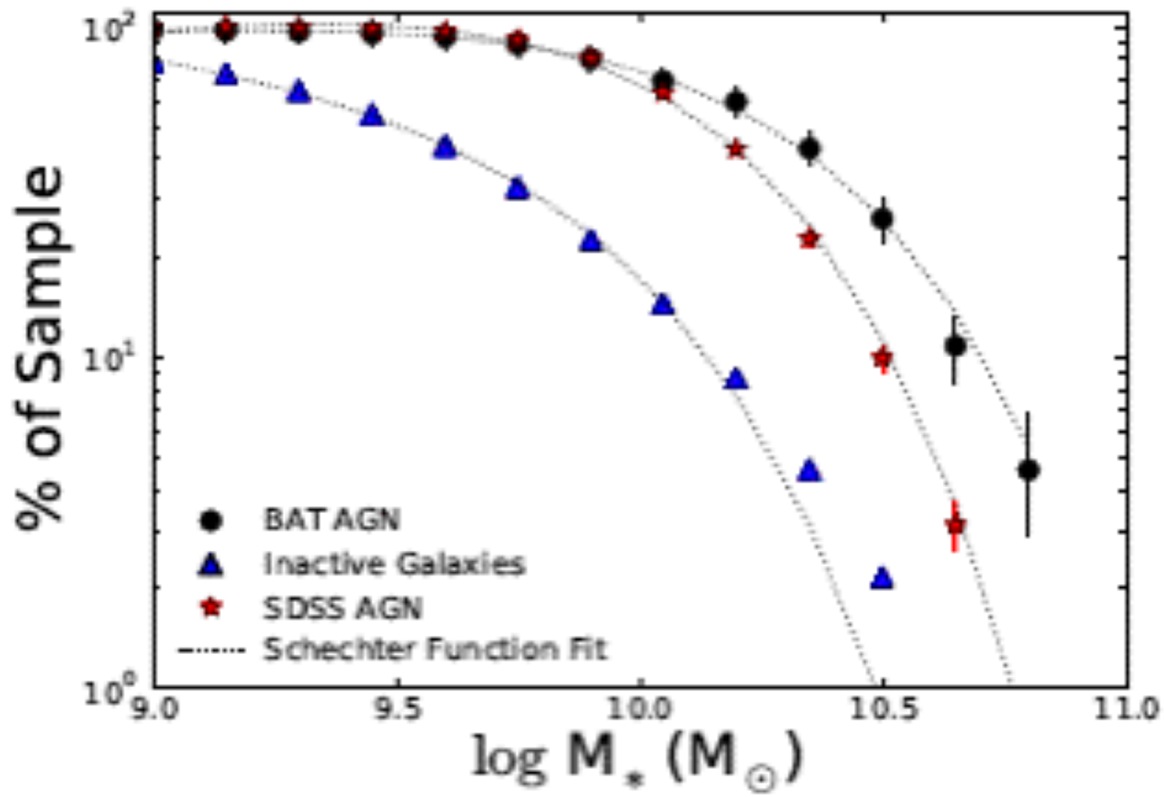




v_{rot}=296 (!) M=-22.4

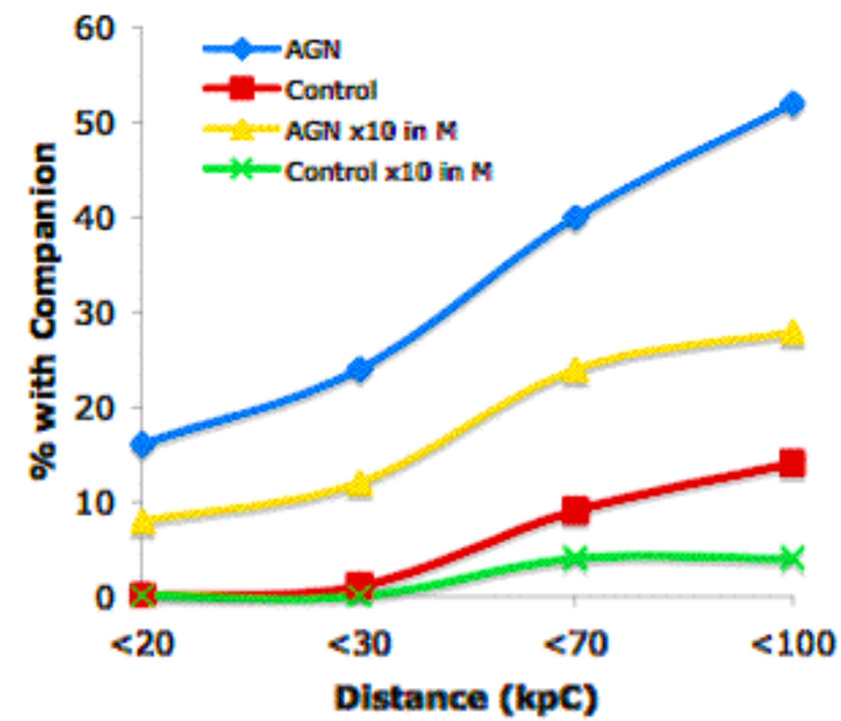
BAT Host Mass Function

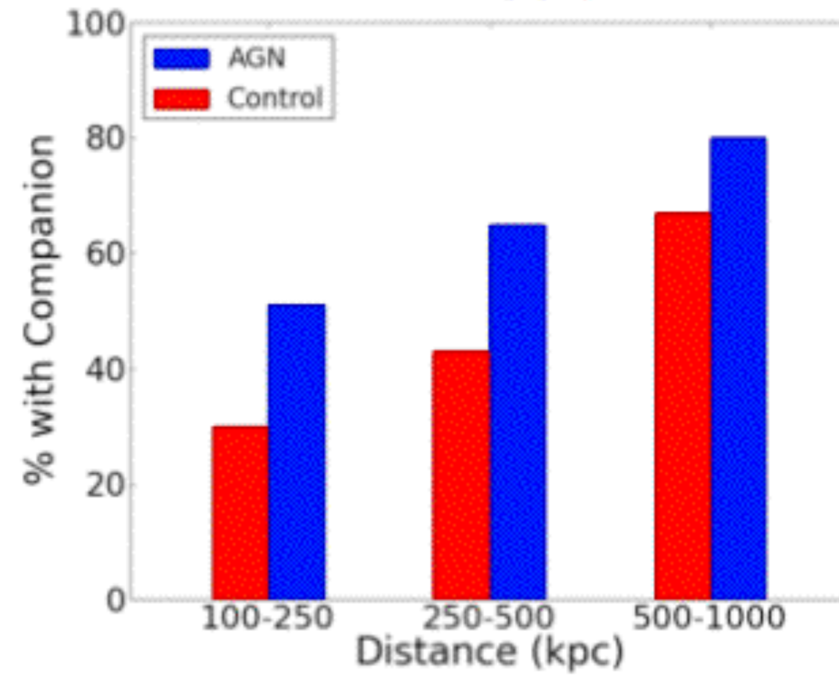
- M*~0.4 dex larger than field galaxies and 0.2 dex larger than SDSS selected AGN



BAT AGN MANY More Mergers than SDSS AGN or Field Galaxies

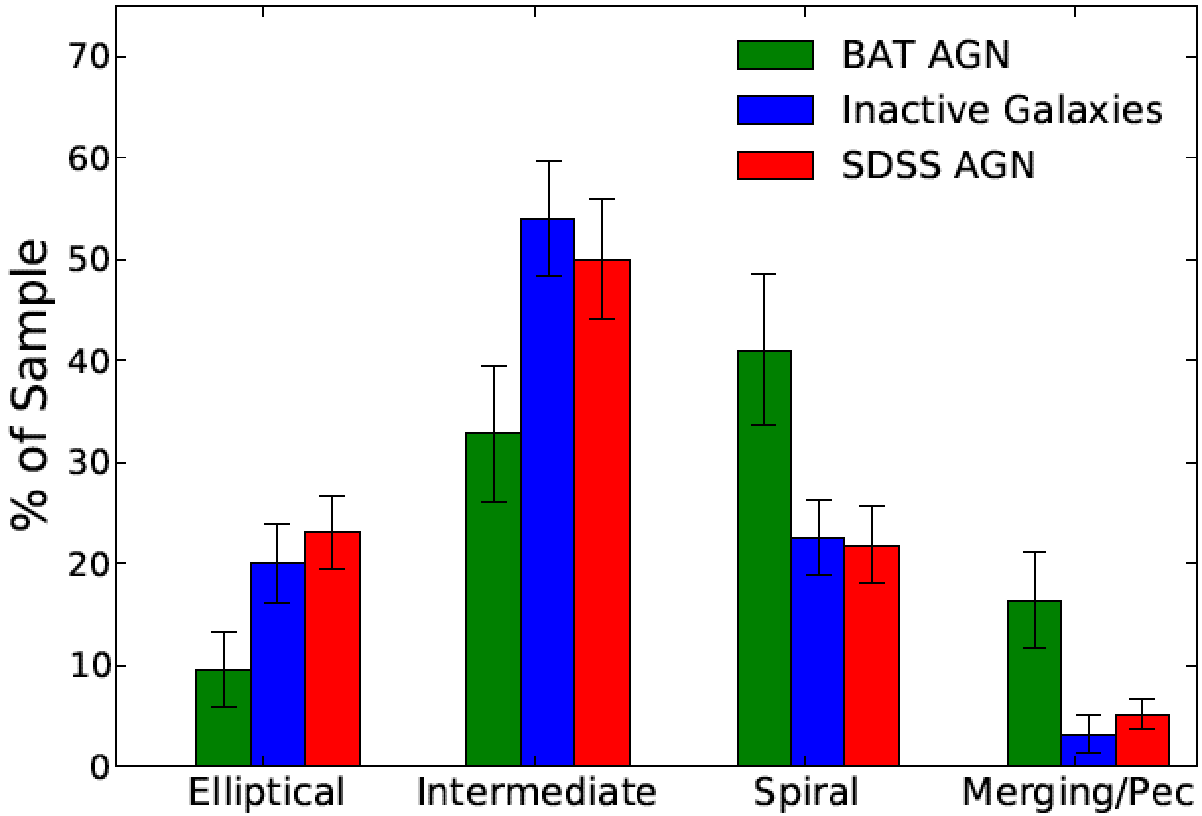
- At both short <30 kpc and intermediate separations 70-500kpc the BAT AGN have more companions and show more evidence of merger morphologies than field galaxies OR SDSS [OIII] selected AGN
- Merger objects tend to have
  - High $L_{hard}/L_{[OIII]}$
  - High $L_{60\mu}/M_{star}$
  - Dust from SF obscure [OIII] making objects hard to find with optical surveys ?
- Long sort for evidence of mergers triggering AGN activity??





Using the Galaxy ZOO Morphologies

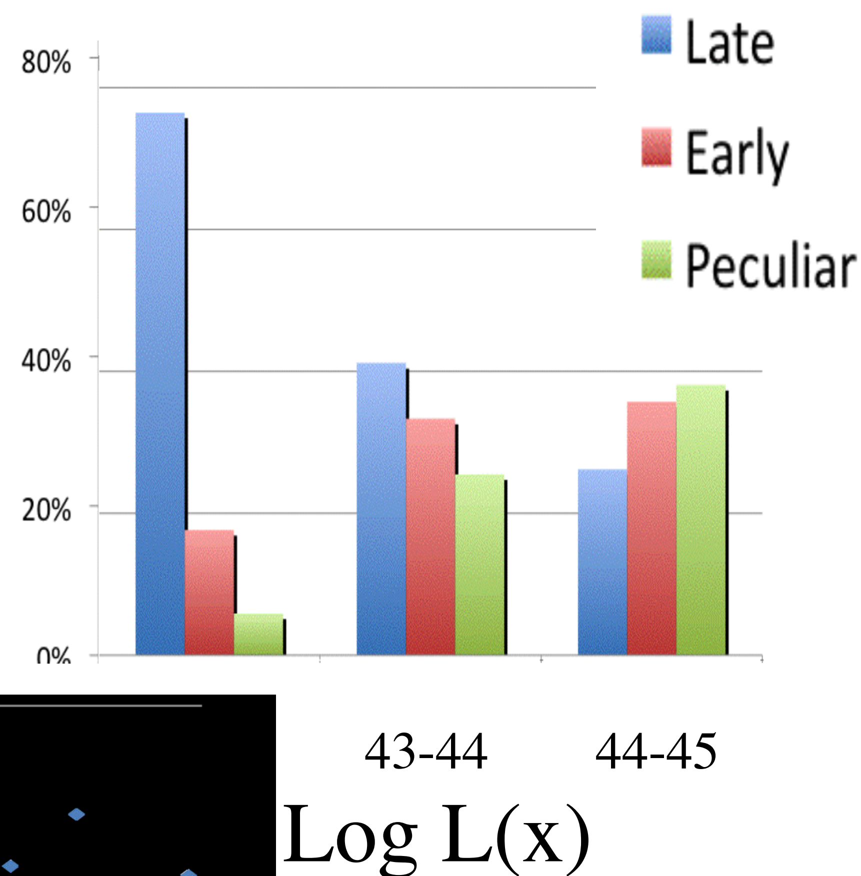
- Very few BAT AGN are in elliptical hosts (~1/3 the field rate)
- ~40% are in spirals- 2x as many as field galaxies or SDSS AGN
- Optical spectral analysis also shows hosts are late type systems dominated by intermediate/old populations. (Winter et al 2009) with weak or no contribution from young stellar populations in optical spectra
- No correlation of stellar age indicators with L_x

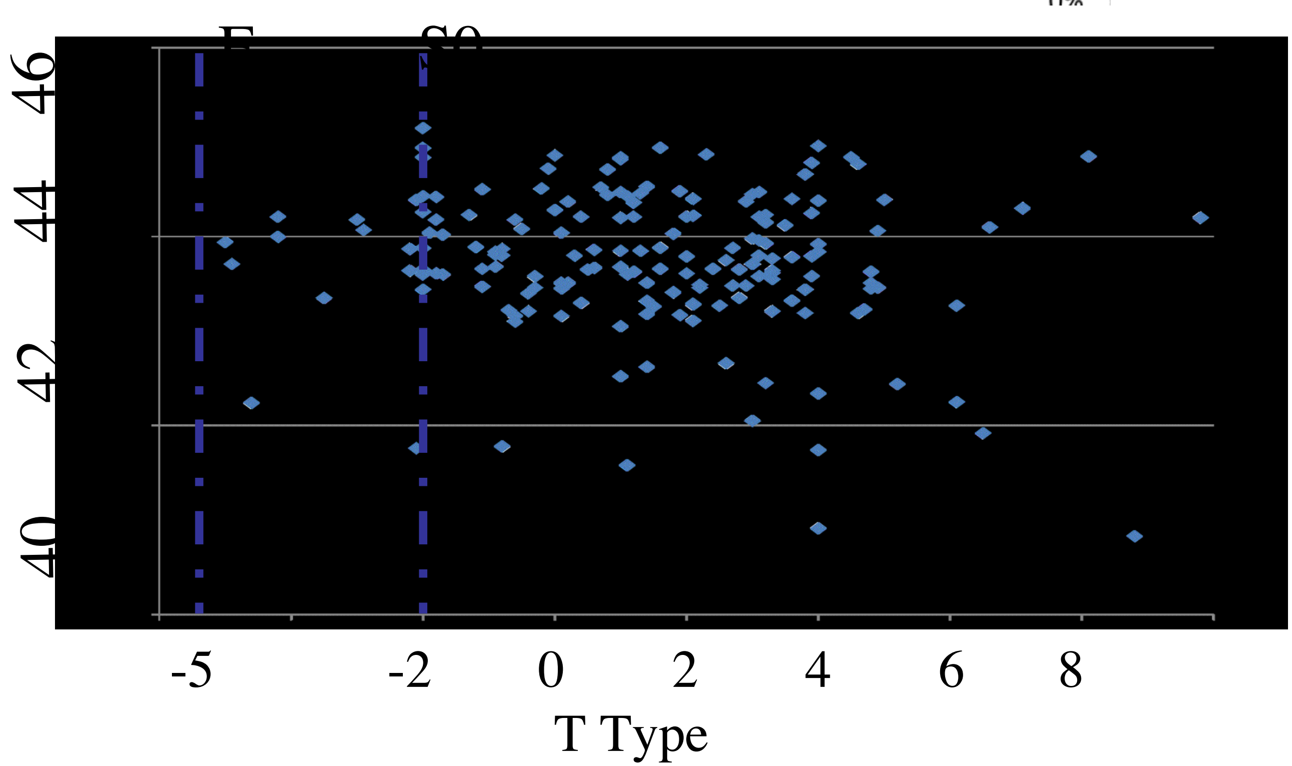


Conclusion Hard x-ray selected low z AGN are in massive galaxies
that tend to be spirals- a rare beast indeed !

Galaxy Type of BAT Sources related to Luminosity

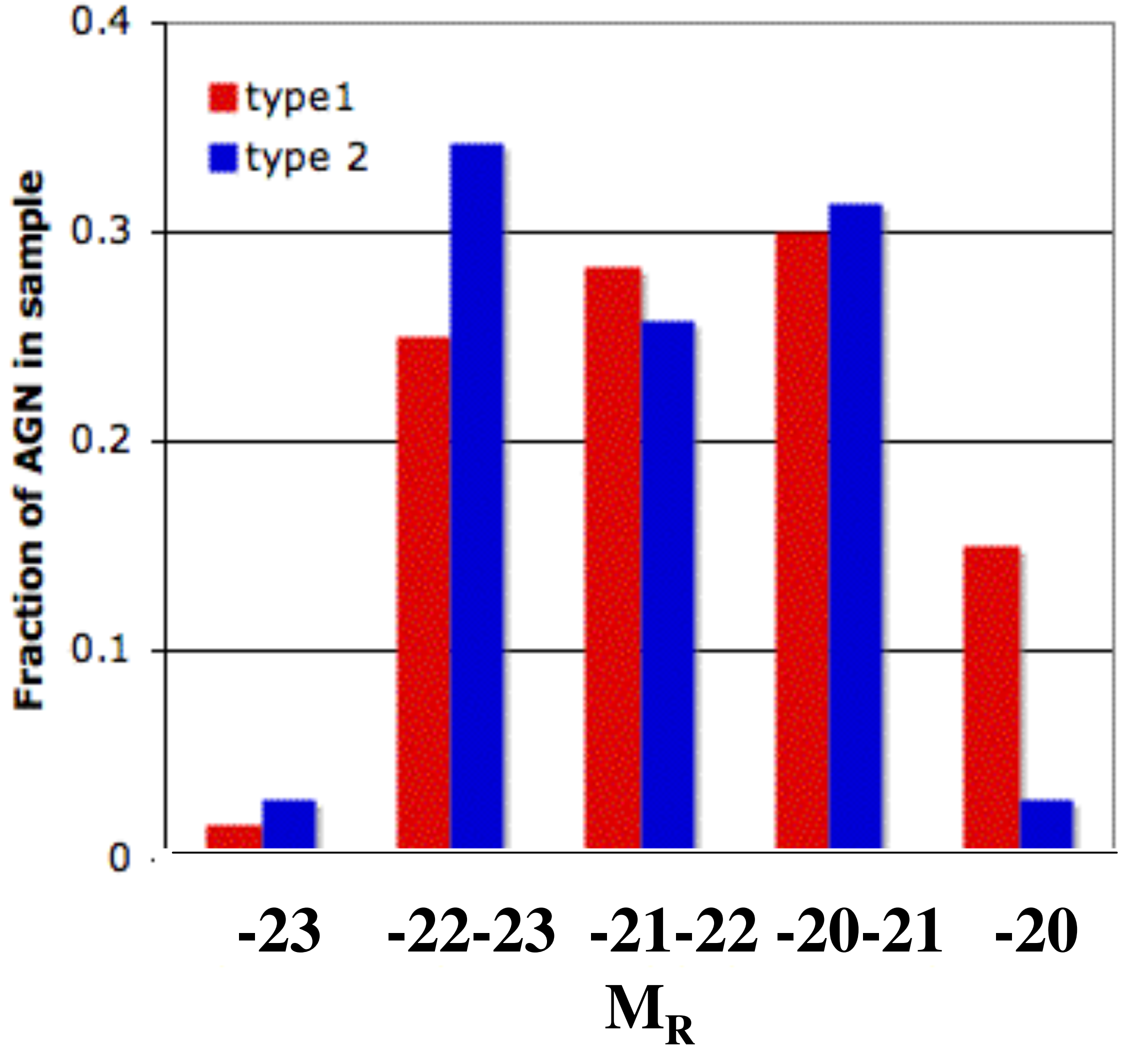
- At low L large fraction of 'early' types
- As L increases fraction of peculiars (e.g. mergers) increases





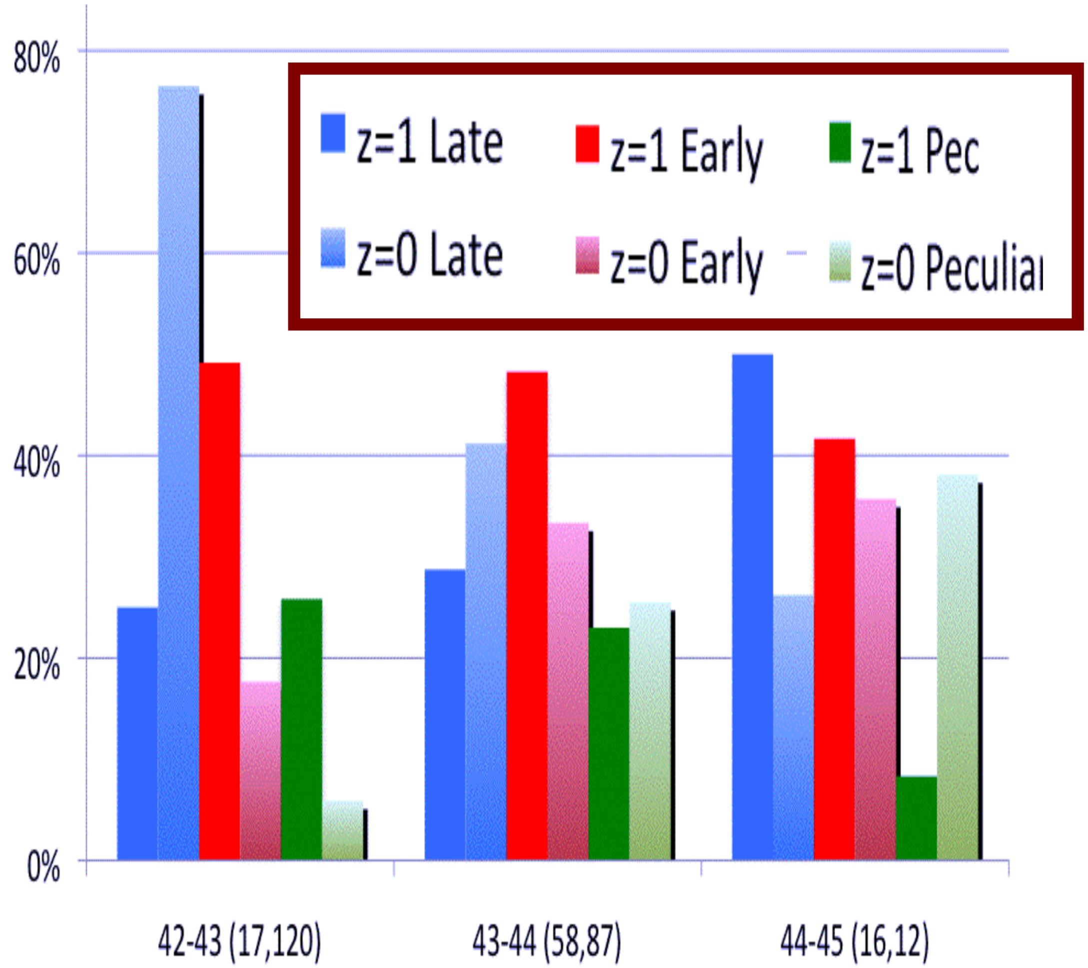
Host Galaxy Magnitudes

- Seyfert Is and IIs have similar host galaxy magnitudes
- Host galaxy magnitude distribution biased to luminous galaxies- almost all L^*_R or brighter
- very few dwarfs (L^*_R=-21.5)



Nature of Hosts Changes with Redshift?

- At redshift <0.7> the majority of hosts (~48%) are early type galaxies and disks are ~28%, peculiars ~20%. *Georgakakis et al*.
- In low z universe peculiars are ~28% while early types ~32%, disks 41%- large fraction of z=0 luminous objects are peculiar (mergers)
- A noticeable change in the nature of the host galaxies with redshift and x-ray luminosity

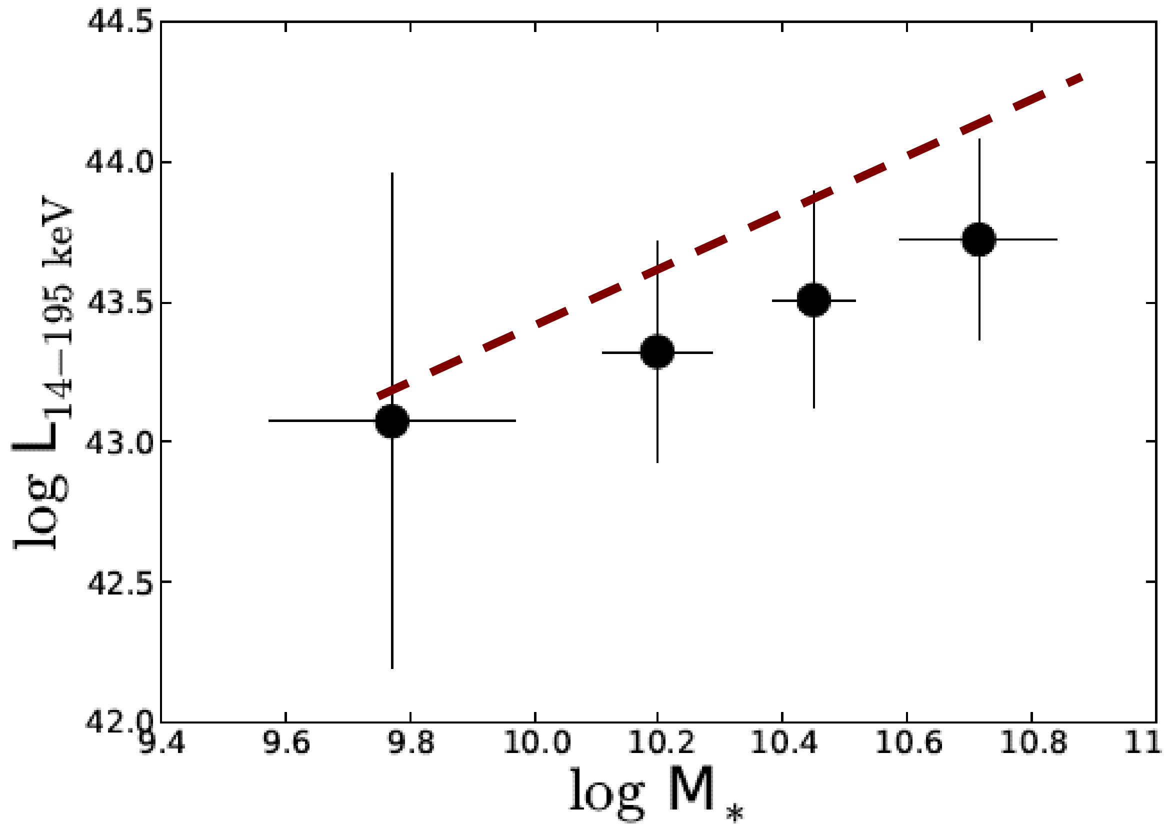


X-ray luminosity bins

Stellar mass and Hard X-ray Luminosity

- Linear relation between mass of stars and hard x-rays luminosity

- If we use bulge-black hole relation this indicates that the median Eddington ratio is ~ constant as a function of BH mass.



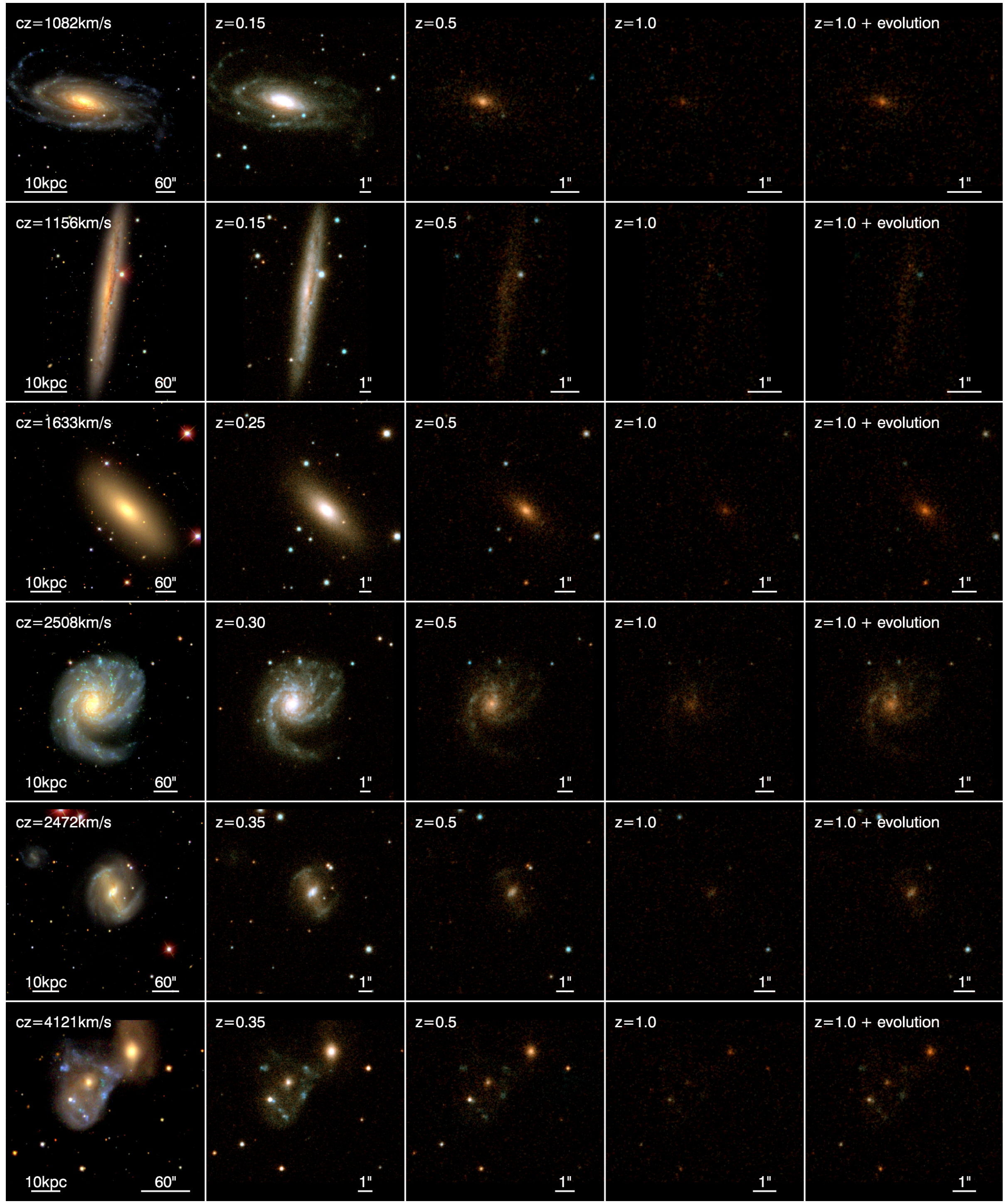
Why Mergers are not seen in COSMOS

At high redshift the combination of

- surface brightness dimming,
- redshifting
- small size of HST mirror makes

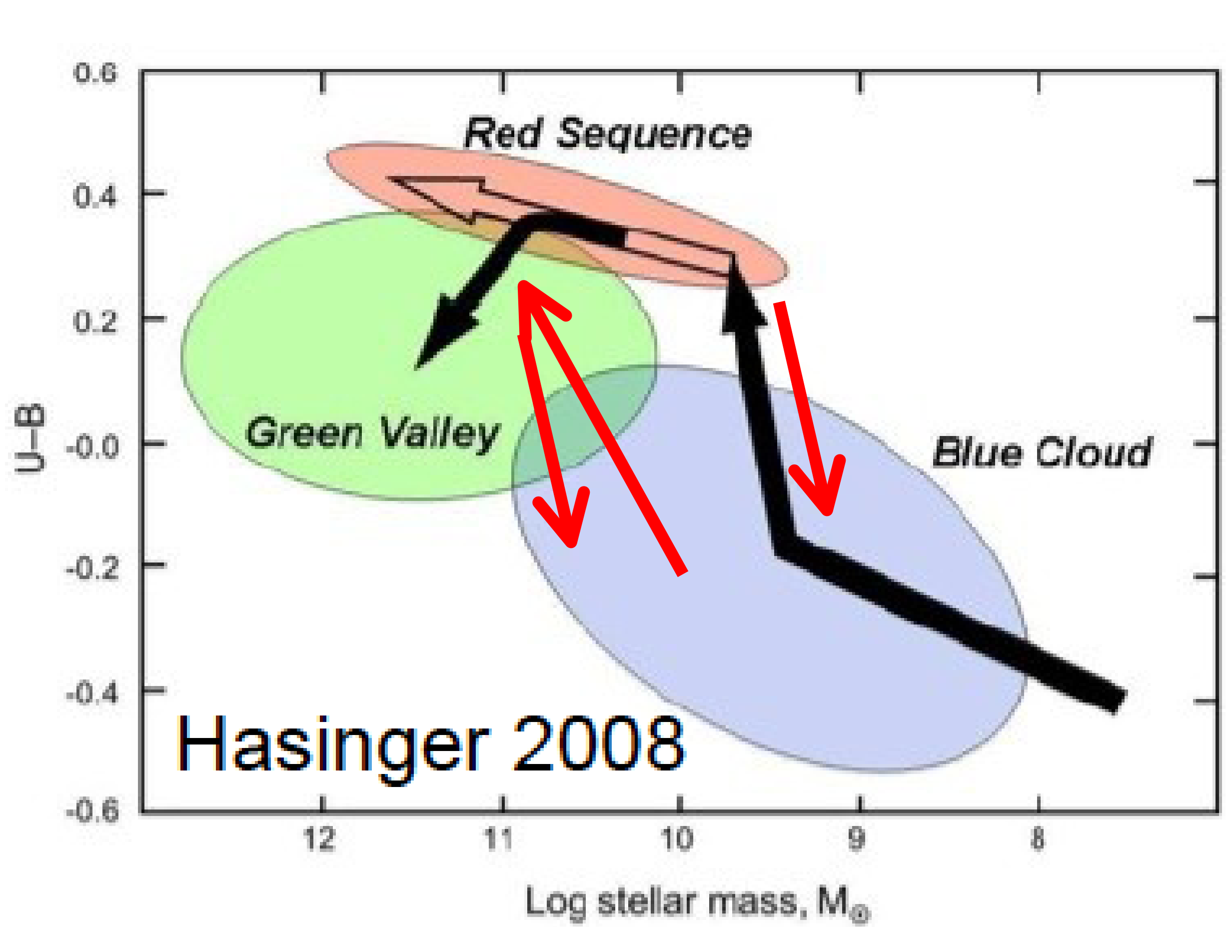
it very difficult to detect tidal tails, distortions and other signs of mergers

Koss et al in prep



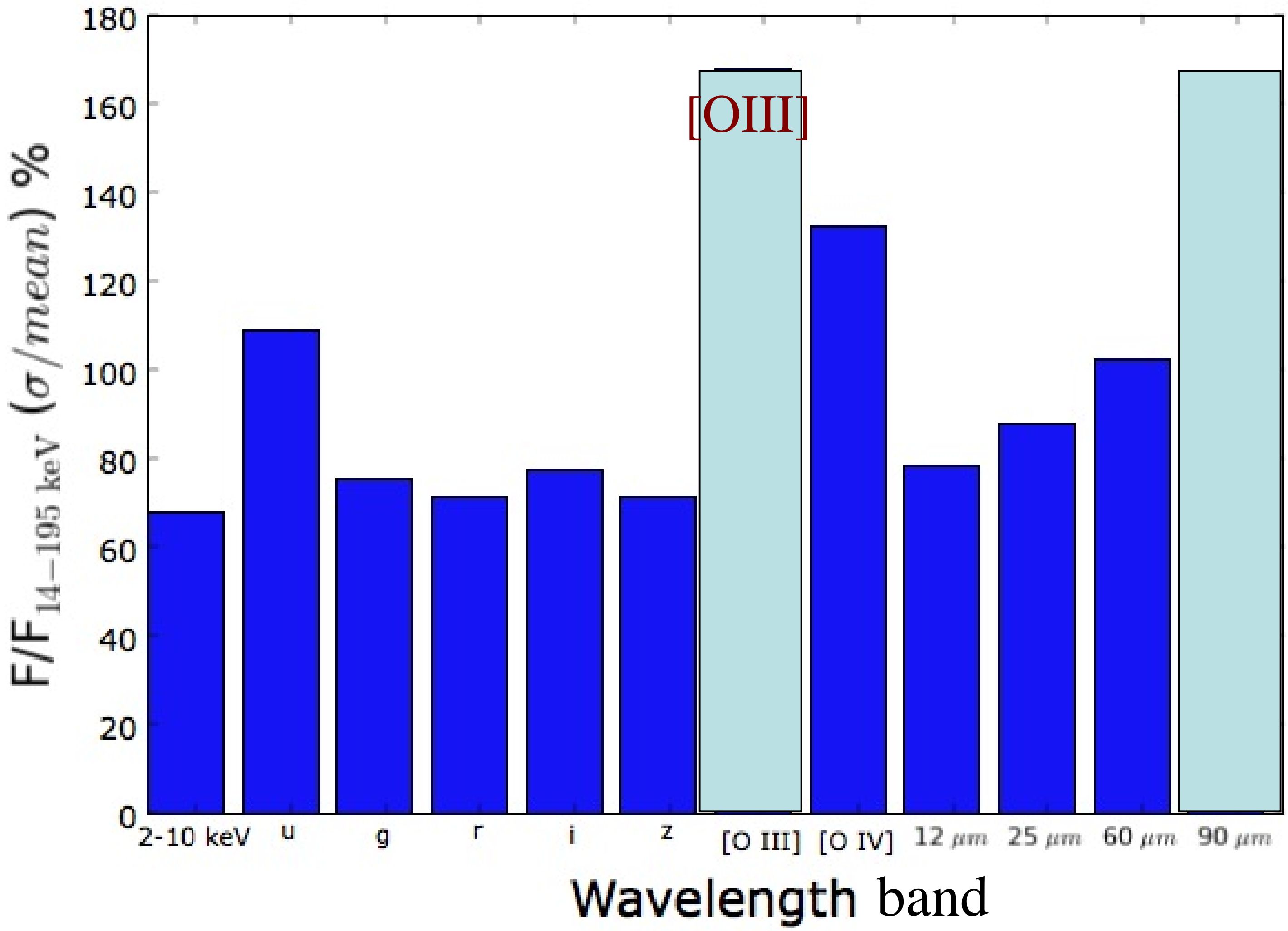
What Is the Effect of the AGN on the Host or VV

- BAT Hosts- massive star forming spiral, strong bulge galaxies- very few field galaxies have this problem
- Are these special objects or a special time?



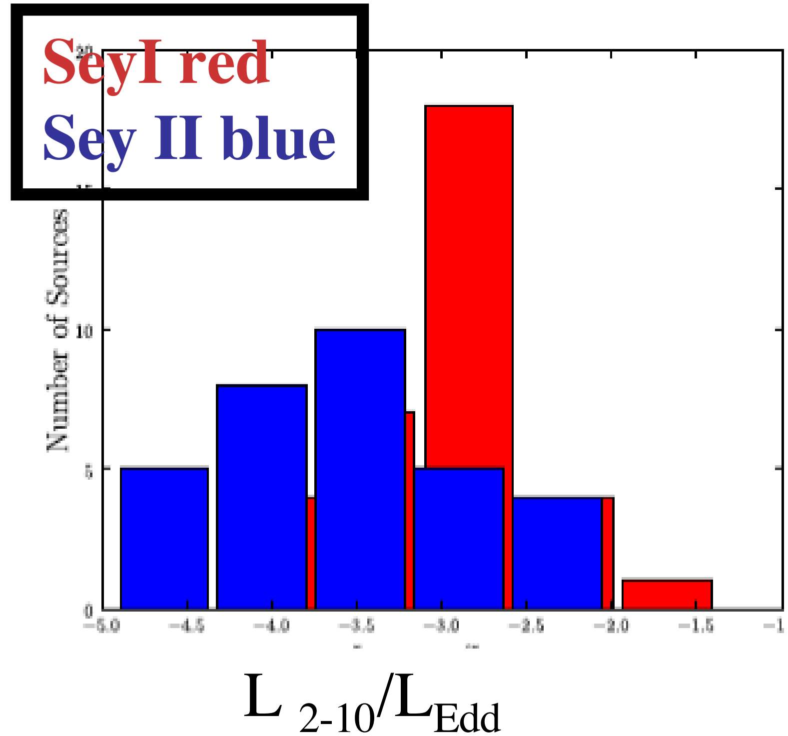
What is the Worst Predictor of the Hard X-ray Luminosity?

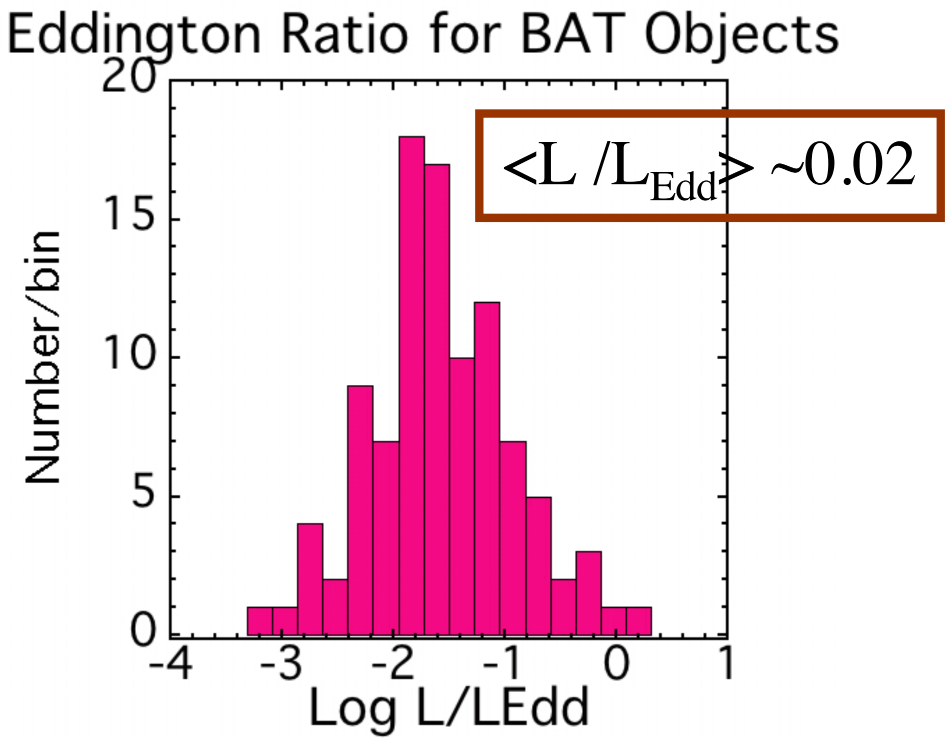
[OIII] and 90μ luminosity
- largest variance wrt to 14-195 keV luminosity

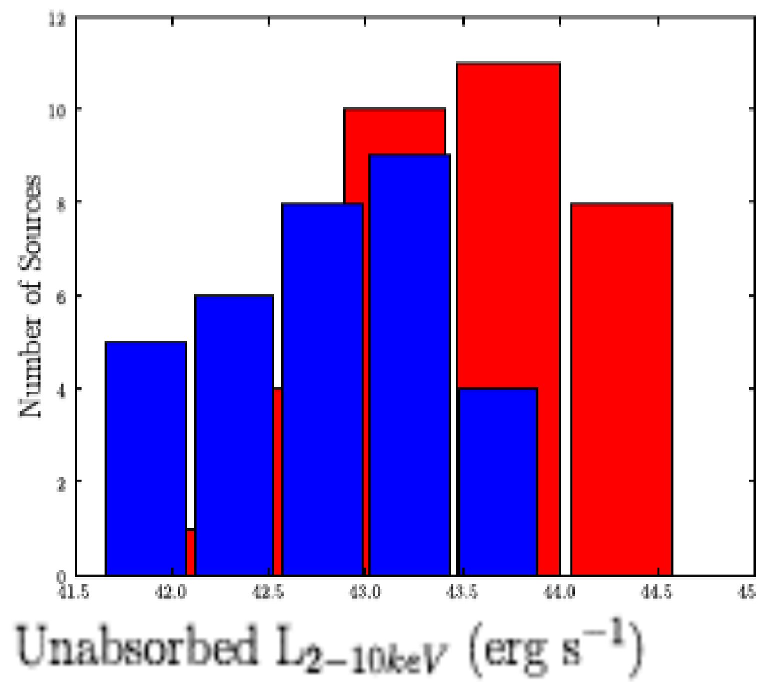


Luminosity and Eddington ratio

- $<L/L_{Edd}>$~0.02 (using 15 as a bolometric correction,- range of 10^3
- Seyfert Is (red) have a higher L(x) and higher x-ray to Eddington limit ratio (using a constant bolometric correction) -
- Either
  - Our black hole estimators are not correct for Seyfert IIs
  - Bolometric corrections are not the same
  - *Eddington ratios are truly different*







Bottom Line

- The host galaxies of AGN at $z<0.05$ are NOT drawn from the average galaxy population- beware subtracting normal galaxy templates from AGN+host galaxy spectra to measure either component (!)
- Therefore there must be a relation between the AGN and the galaxy: which way does the relation go?
  - not sure right now
  - need 'theoretical' help
- Lesson learned
  - biases in optical AGN selection processes are SEVERE and resulted in wrong ideas OR there is something very odd about hard x-ray selection
  - beware analysing HST observations of $z>0.3$ AGN hosts without correcting for surface brightness diminution or spectral redshifting