

Shedding New Light on Black Holes with the Sloan Digital Sky Survey

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Summary

- Description and goals
- Previous work
- The surveys
- Finding Active Galaxies
- Preliminary results
- Future work

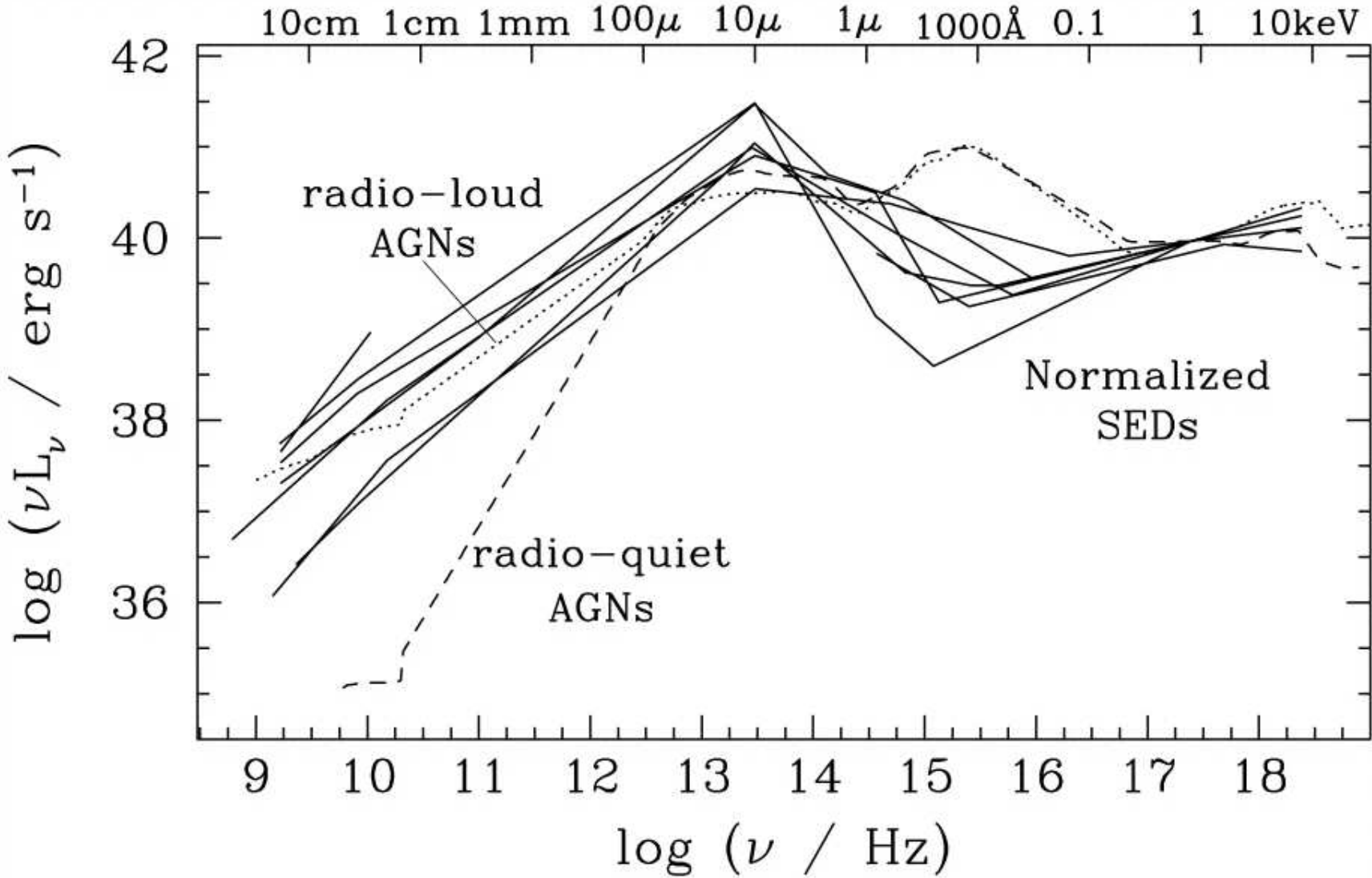
Goals for this work

- Cross match multiwavelength surveys
- Examine the nuclear bolometric luminosities of various galaxy types
- Compute black hole masses for the galaxies
 - Estimate the accretion rate

Previous work

- Ho 1999: *The Spectral Energy Distributions of Low-Luminosity Active Galactic Nuclei*
 - 7 very nearby AGN
 - high resolution imaging of the central source
 - Eddington ratios from 10^{-6} – 10^{-2} : “weak” sources
- Elvis 1994: *Atlas of quasar energy distributions*
 - 47 Quasars - high luminosity objects

Previous work: SEDs



Wide area surveys

SDSS Sloan Digital Sky Survey: optical

GALEX GALaxy Evolution eXplorer: UV

VLA/FIRST Faint Images of the Radio Sky at Twenty-centimeters

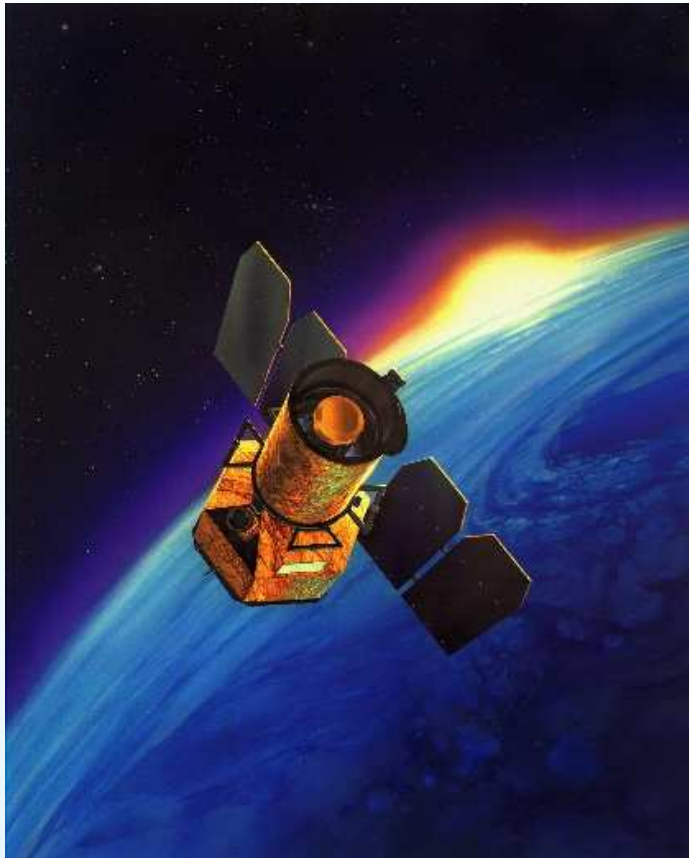
ROSAT Röntgen Satelite: X-ray

SDSS: Sloan Digital Sky Survey



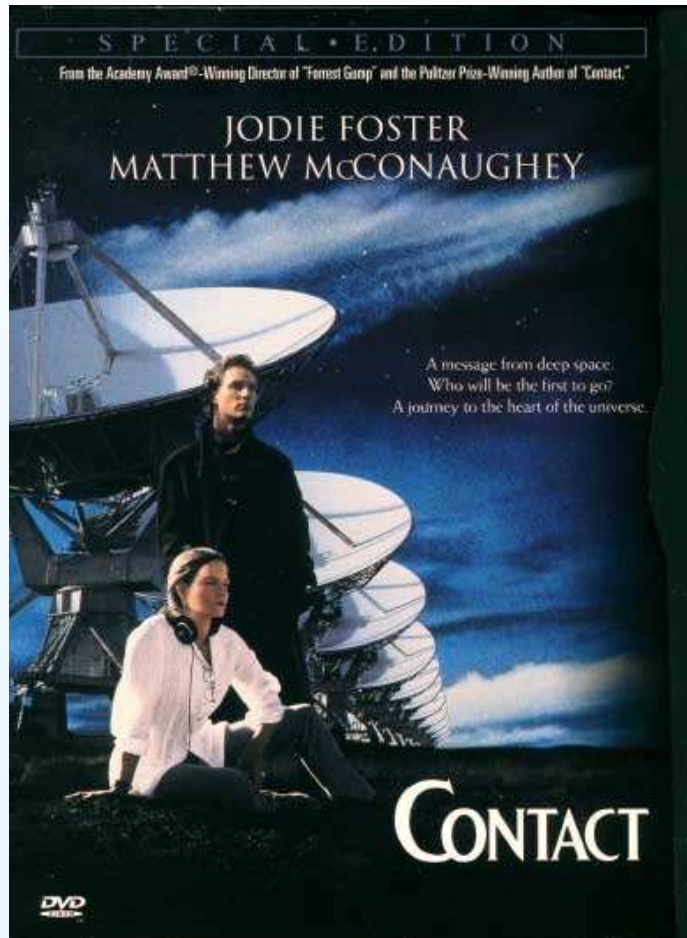
- Wavebands
 - u: 355.1nm
 - g: 468.6nm
 - i: 616.5nm
 - r: 748.1nm
 - z: 893.1nm
- Field of view: $\sim 2.5^\circ$
- Resolution: 0.4"
- Drexel is a partner

GALEX



- GALaxy Evolution eXplorer
- Wavebands
 - Far UV: 134 - 179nm
 - Near UV: 171 - 283nm
- Field of view: 1.2°
- Resolution: 4"
- GR1 available now, GR2 coming out now

VLA/FIRST



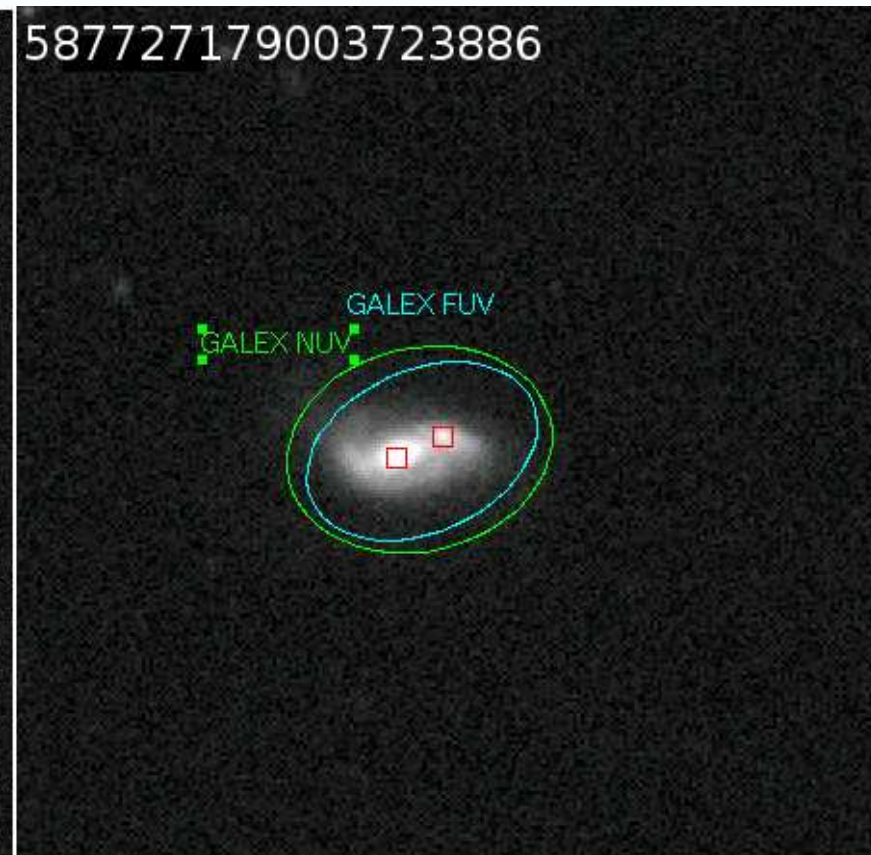
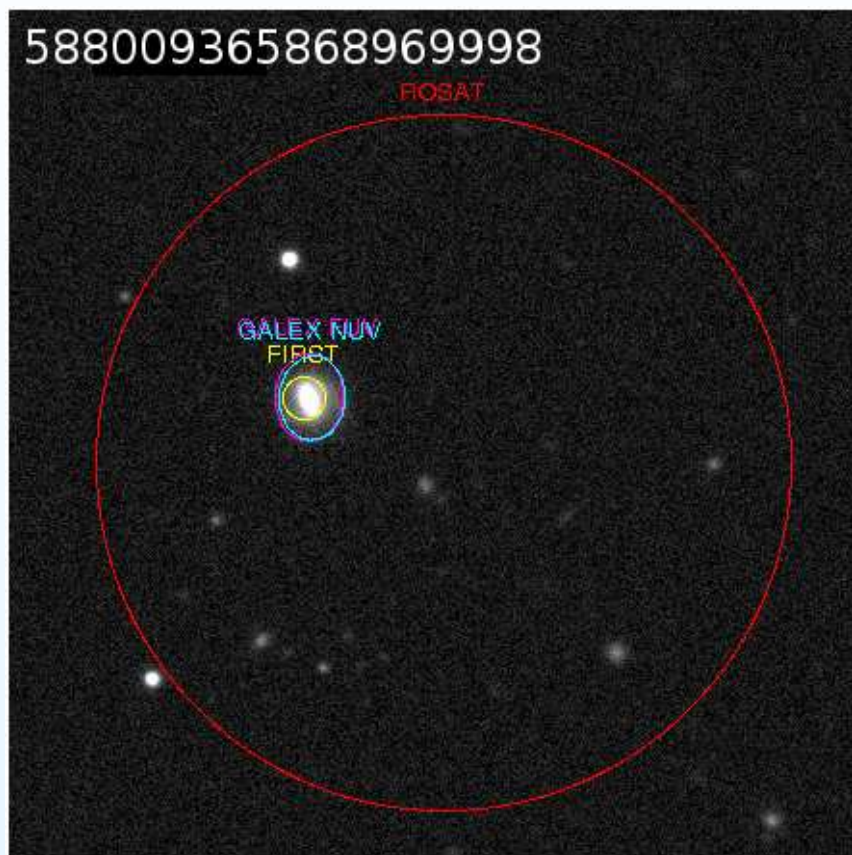
- Faint Images of the Radio Sky at Twenty-centimeters
- The Very Large Array, New Mexico
- ~21 cm waveband
- Northern sky ++
- Resolution: 5"
- Survey complete: all data available

ROSAT

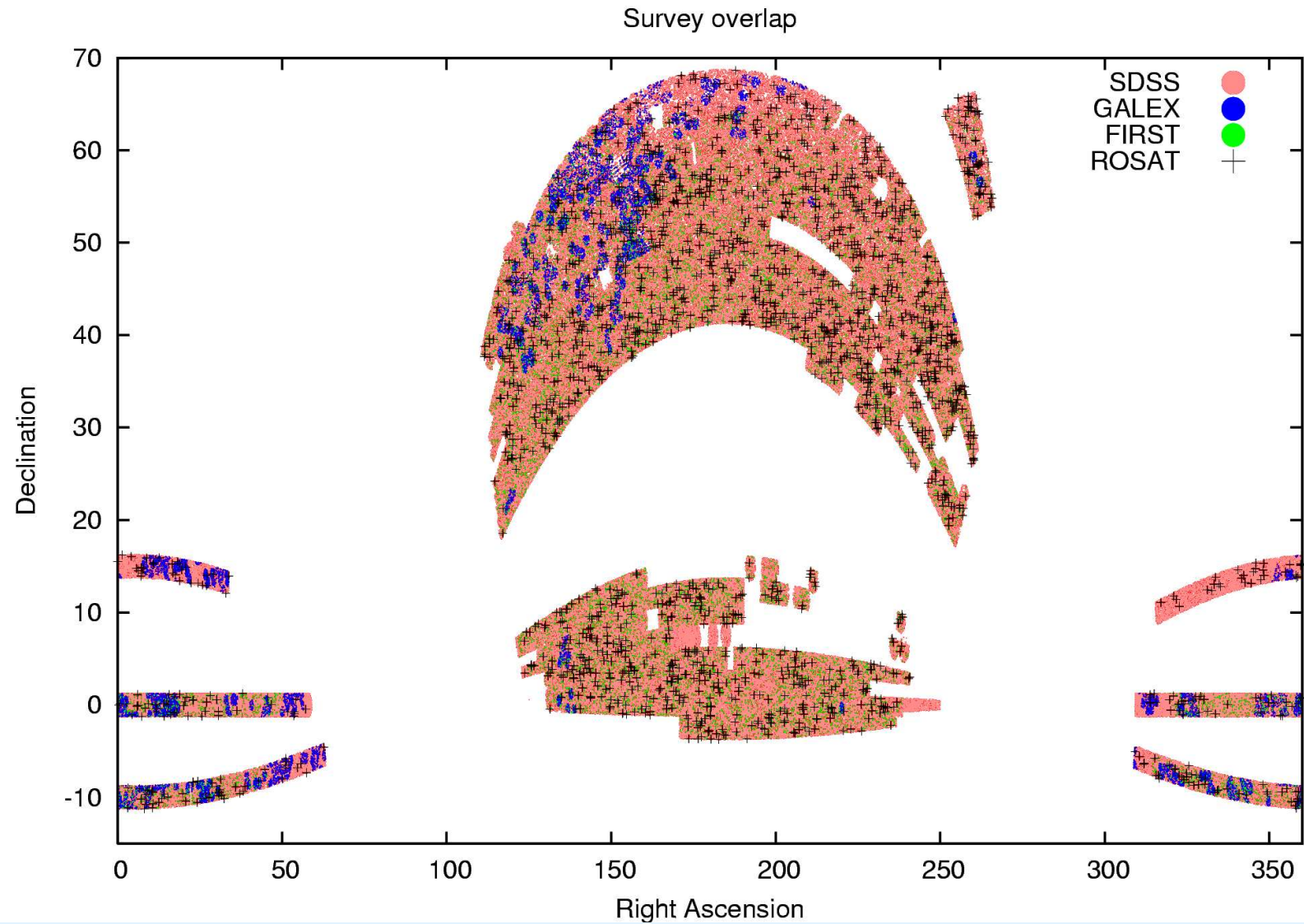


- Röntgen Satellite
- Soft to semi-hard X-rays: 0.1 - 2.4 keV
- Resolution: ~30"
- Survey complete: all data available

Example matches



Observational overlap



Survey summary

Survey summary

	GALEX	FIRST	ROSAT
SDSS DR4 overlap (sq. deg.)	TBD	6600	6600
wavelength range	134-179nm, 171-283nm	21cm	0.1-2.4keV
upper-limit (nominal, 5σ)	(*)	1 mJy	0.01cps (*)
PSF resolution	4"	5"	~20"
astrometric precision	1.1"	<1"	~30"
SDSS DR4 matches (total)	34616	18238	2837
SDSS DR4 matches (unique)	20508	18226	2059

Additional Surveys?

Spitzer Spitzer Space Telescope: 1-10"

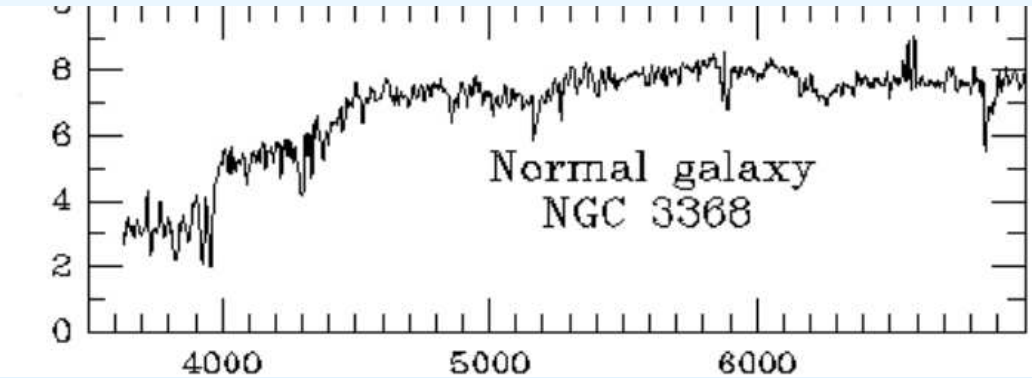
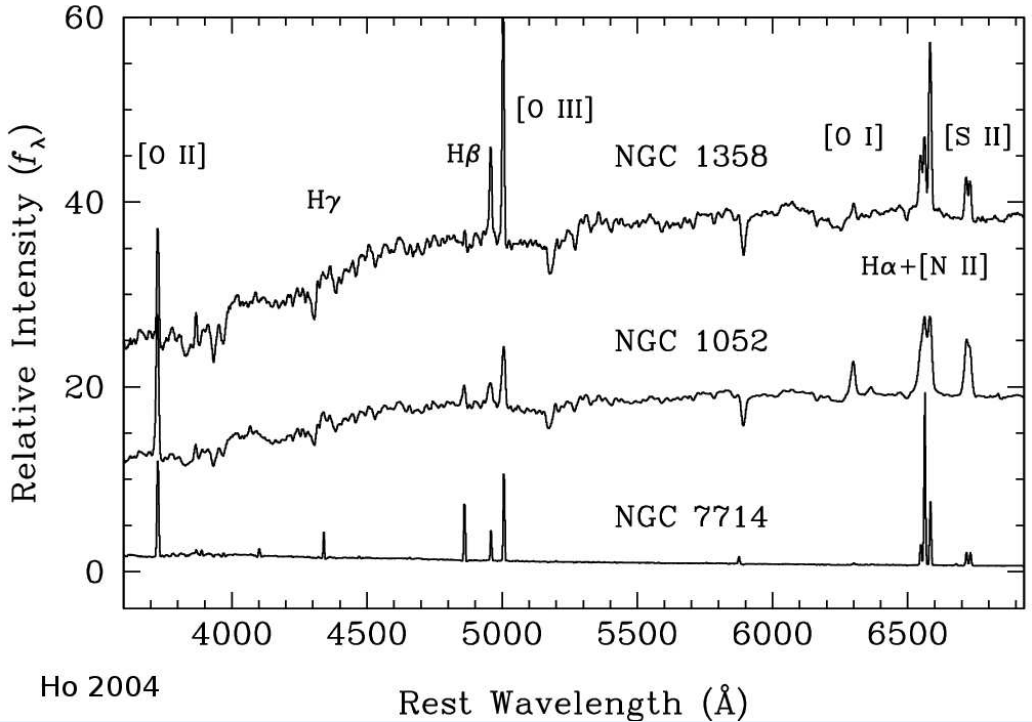
2MASS 2-Micron All Sky Survey: ~2"

IRAS Infrared Astronomical Satellite: 20-60"

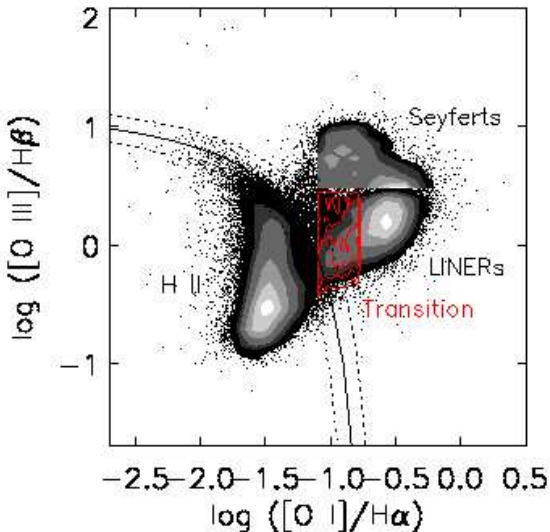
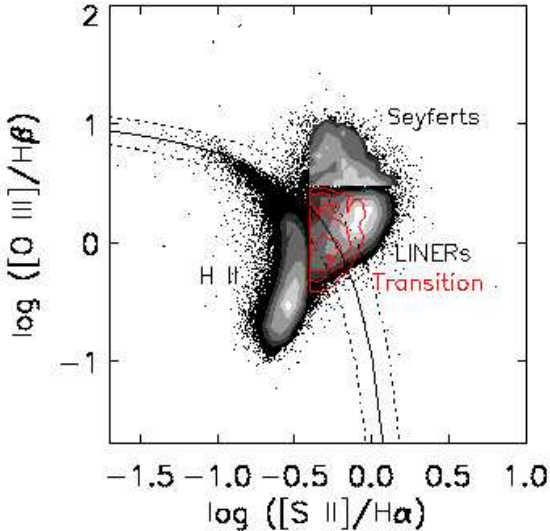
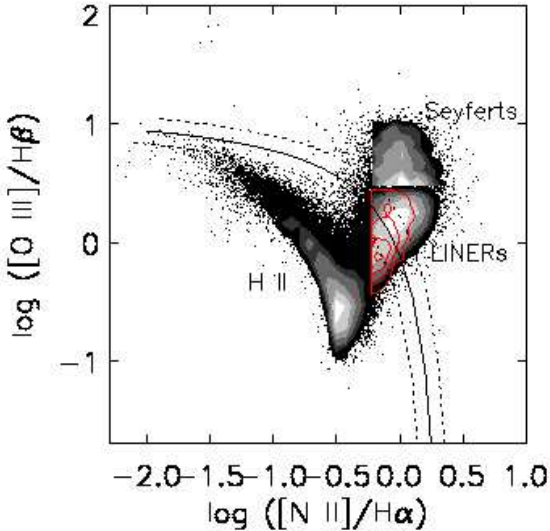
XMM-Newton Slew survey: 6" slew survey

Swift all-sky gamma ray catalog in preparation

Distinguishing AGN

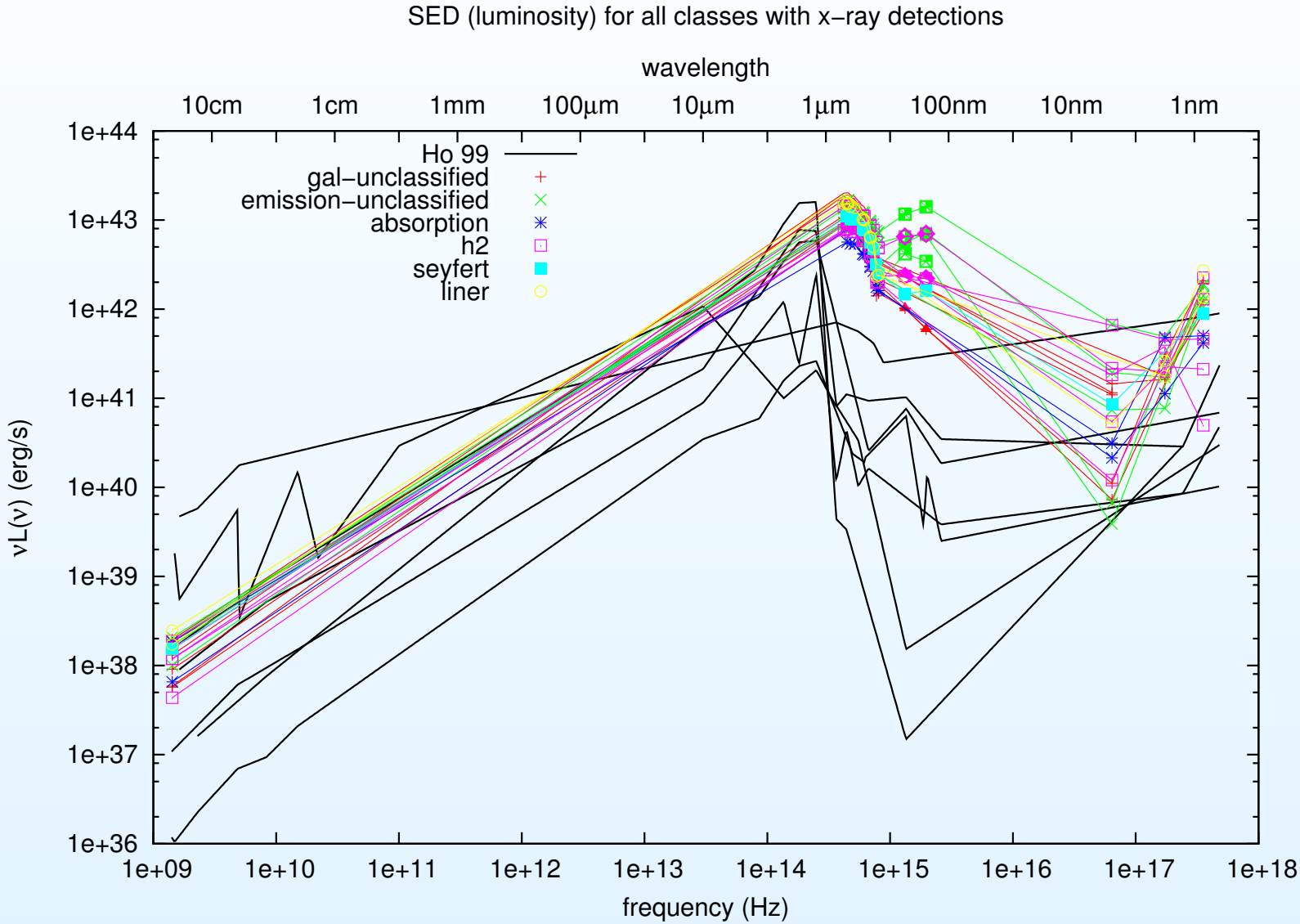


Distinguishing AGN



Constantin &
Vogelej 2006

Spectral Energy Distributions (Luminosity)



Black hole activity

- MPA/JHU catalog provides a stellar velocity dispersion from SDSS

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Black hole activity

- MPA/JHU catalog provides a stellar velocity dispersion from SDSS
- $\sigma \Rightarrow M_{BH}$ from Tremaine et. al. 2002
- $L_{edg} \propto M_{BH}$
- The Eddington ratio: L_{bol}/L_{edg}
 - Proxy for accretion efficiency

Preliminary

galaxy type	D (Mpc)	L_{bol} (erg/s)	M_{BH} (M_{\odot})	L_{edd}	L_{bol}/L_{edd}
unclassified	231	7.83×10^{42}	7.37×10^7	9.27×10^{45}	8.45×10^{-4}
unclassified	186	1.36×10^{43}	2.03×10^8	2.56×10^{46}	5.32×10^{-4}
unclassified	277	1.60×10^{43}	1.32×10^8	1.66×10^{46}	9.61×10^{-4}
emission	314	1.20×10^{43}	3.79×10^7	4.77×10^{45}	2.51×10^{-3}
emission	328	8.37×10^{42}	8.86×10^7	1.11×10^{46}	7.52×10^{-4}
emission	252	2.17×10^{43}	1.12×10^{10}	1.40×10^{48}	1.55×10^{-5}
passive	329	5.01×10^{42}	2.52×10^6	3.16×10^{44}	1.59×10^{-2}
passive	196	5.81×10^{42}	1.64×10^7	2.07×10^{45}	2.81×10^{-3}
passive	347	1.67×10^{43}	1.75×10^8	2.21×10^{46}	7.56×10^{-4}
H II	160	6.16×10^{42}	3.15×10^7	3.96×10^{45}	1.56×10^{-3}
H II	264	1.54×10^{43}	3.75×10^7	4.72×10^{45}	3.26×10^{-3}
Seyfert	301	9.06×10^{42}	2.35×10^7	2.95×10^{45}	3.07×10^{-3}
LINER	192	1.25×10^{43}	3.0×10^8	3.77×10^{46}	3.33×10^{-4}
LINER	318	1.43×10^{43}	2.08×10^8	2.62×10^{46}	5.44×10^{-4}

Future work

- Correct for stellar contamination
 - Stellar continuum template fitting?
 - Use galaxy morphology to describe light profile
 - Subtract profile of passive galaxies from emission-line galaxies
 - Follow-up observations with Hubble (comparison with Ho's new study?)
 - Ratio of nuclear to bulge luminosities
- Fill in missing data
 - Spitzer, 2MASS and/or IRAS for Infrared
 - XMM-slew for better Xray resolution

References/Thanks

- Dr. Anca Constantin
- Dr. Michael Vogeley
- Alina Badus
- B. Peterson, 1997, *Active Galactic Nuclei*
- L. Ho 1999, *SEDs of low-luminosity AGN*
- (See the paper for a full reference list!)