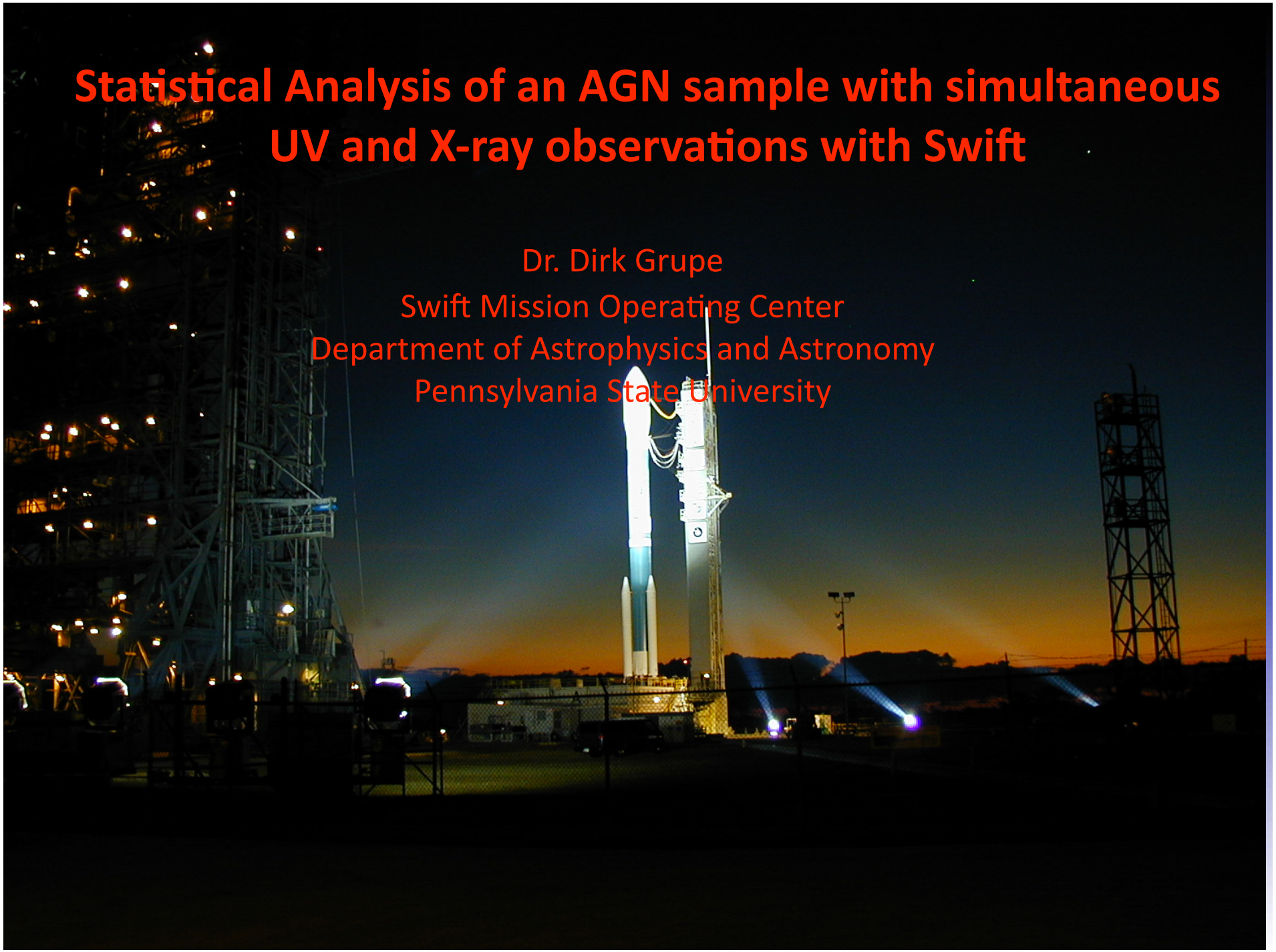
Statistical Analysis of an AGN sample with simultaneous UV and X-ray observations with Swift



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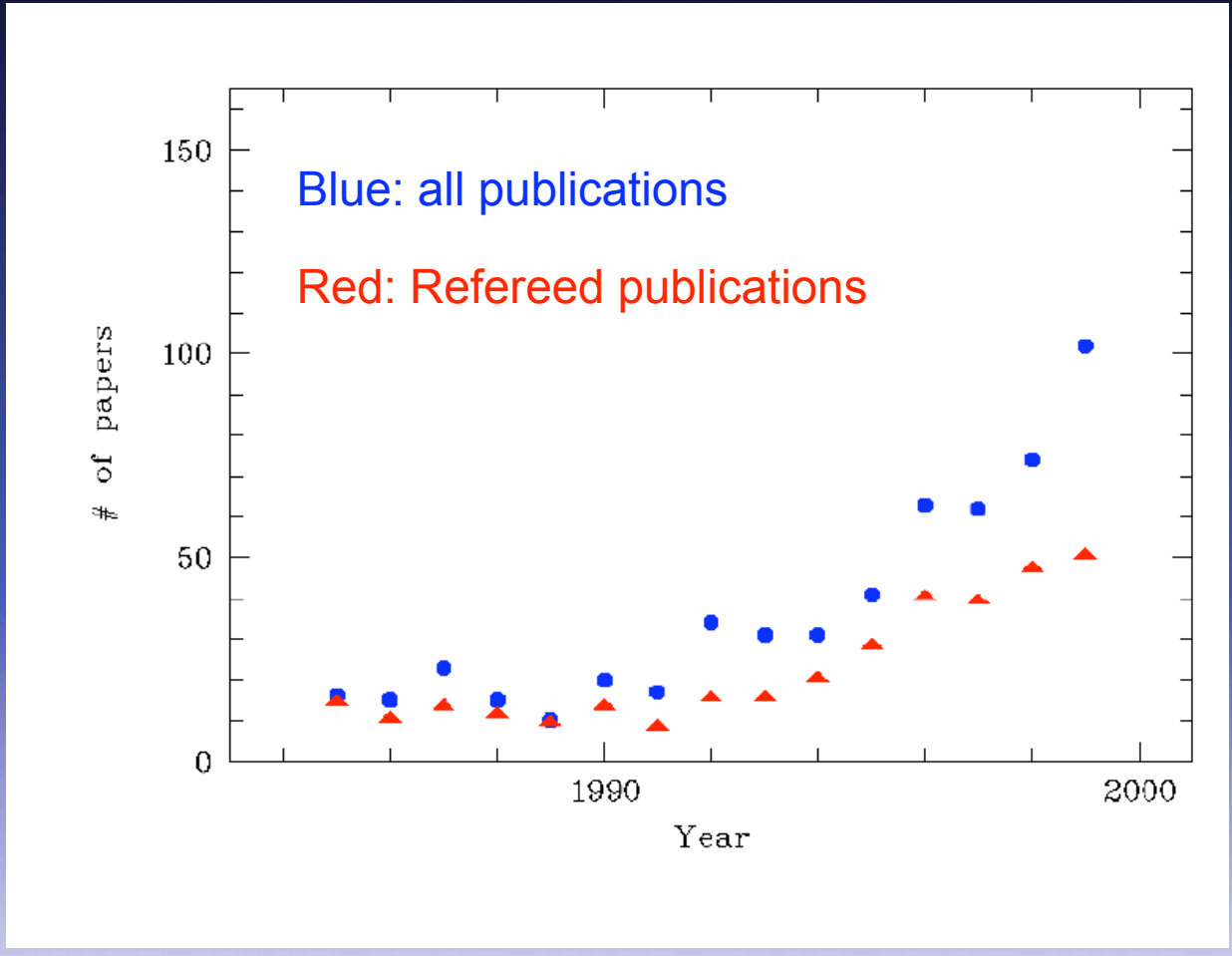
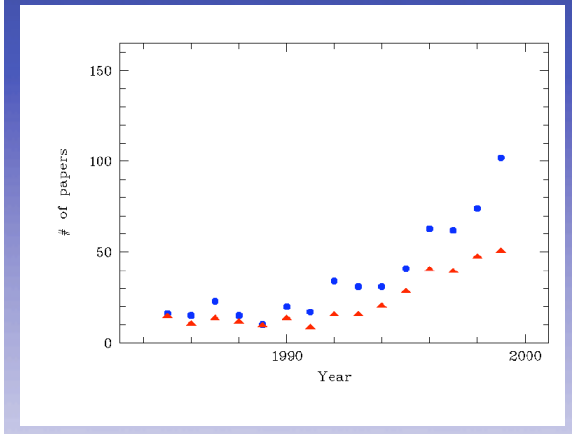
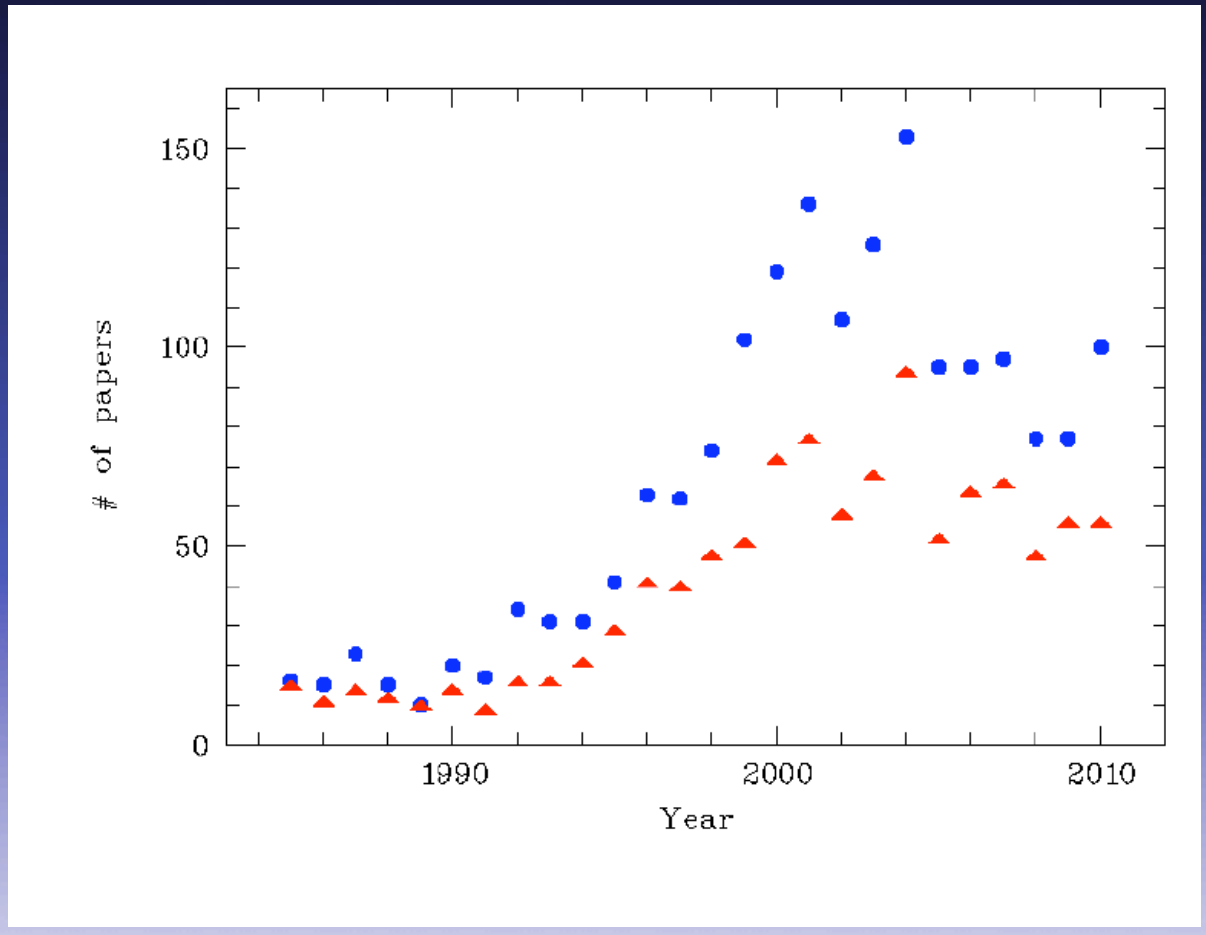
How many paper with Narrow Line Seyfert 1s have been published?



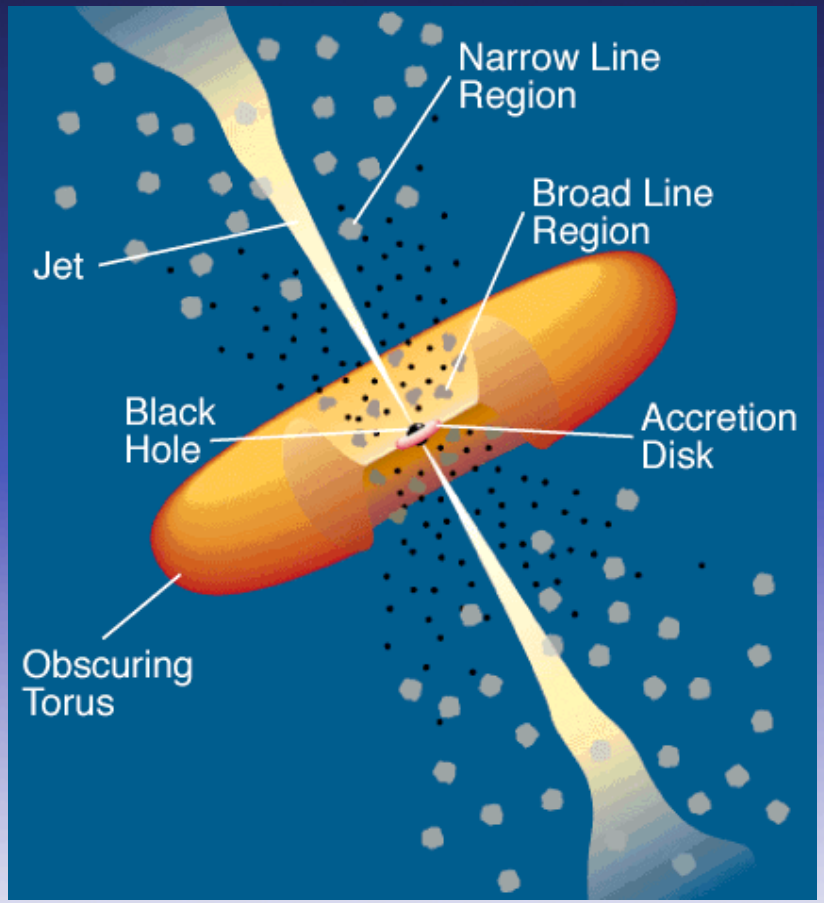
1999: Year we had the Bad Honnef NLS1 meeting

Narrow Line Seyfert 1s remain still strong in the literature!





Properties of AGN are driven by the Black Hole mass and accretion rate/Eddington ratio L/L_{Edd}



Urry & Padovani, 1995

Task: Search for estimator of L/L_{Edd}

Solution: Spectral slope

Application: e.g. high-redshift quasars

Search how AGN can be classified

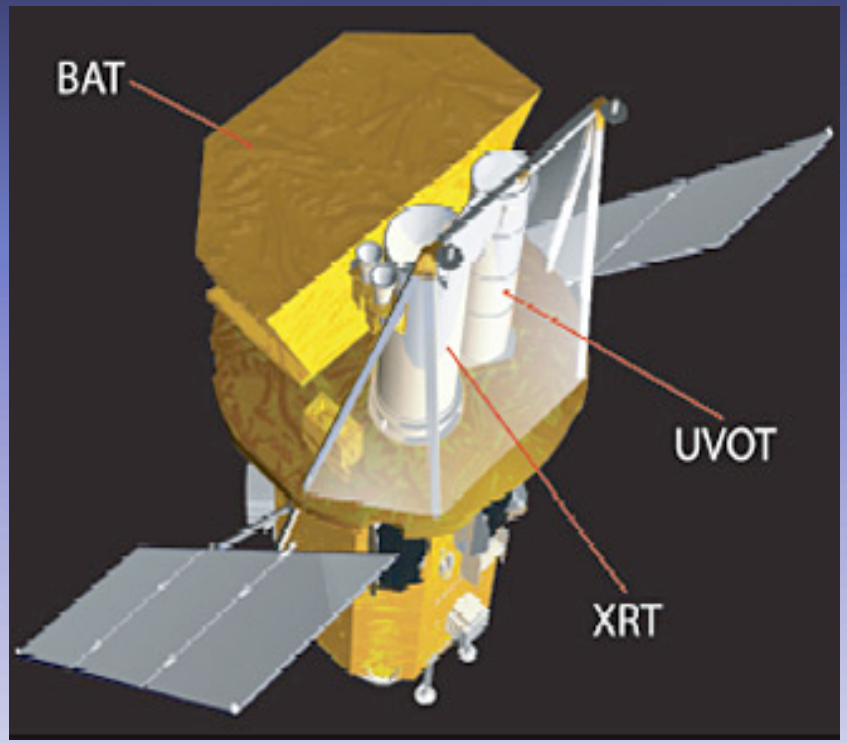
AGN Sample Selection

- Selected from the ROSAT Bright Soft X-ray AGN sample by Grupe et al. 2001, 2004 (110 AGN in total)
- All AGN are X-ray bright and bright in the Optical/UV
- ALL AGN are intrinsically unabsorbed and not highly reddened in the UV
- All have previous ROSAT observations → Long-term variability
- All have optical spectroscopy data → Multi-variant analysis between optical and X-ray properties

AGN Sample Selection

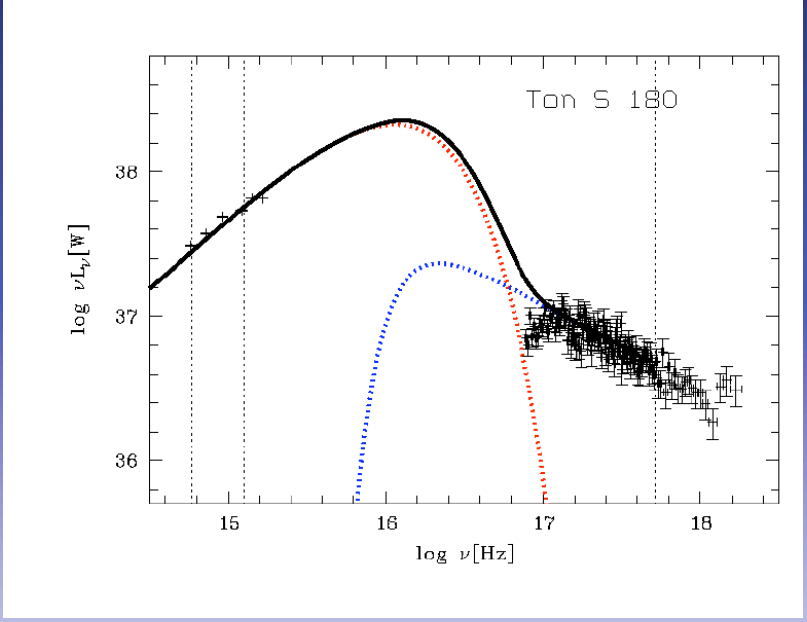
- Selected from the ROSAT Bright Soft X-ray AGN sample by Grupe et al. 2001, 2004 (110 AGN in total)
- Swift Fill-in project
- 92 AGN observed by Swift by January 2010 (Grupe et al. 2010, ApJS, 187, 64)
- Now (2011) about 105 AGN
- ~Half are NLS1s
- All have sufficiently exposed X-ray spectra
- Almost all have UVOT observations in all 6 Filters
- Most AGN have multiple observations → variability studies

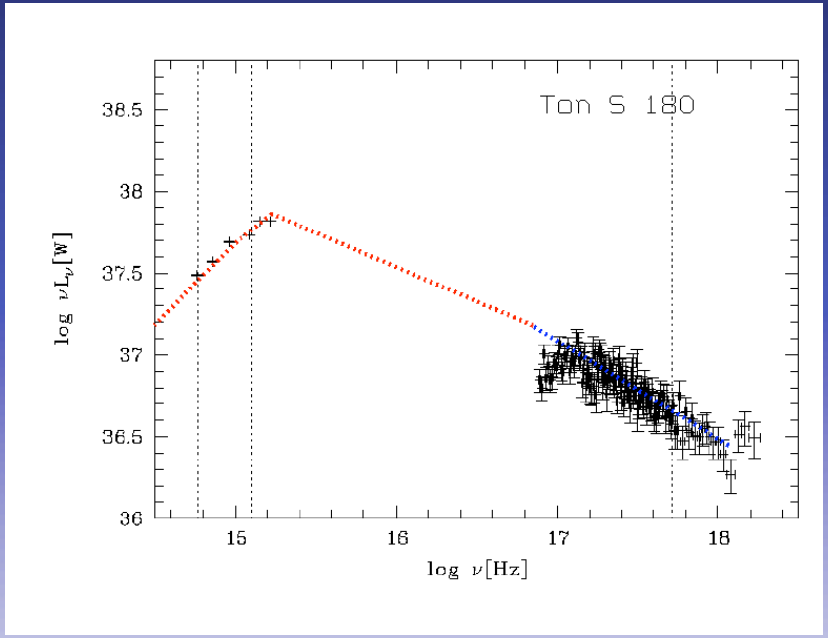
SWIFT is ideal for AGN observations because it allows short simultaneous UV and X-ray coverage



- BAT: 15-150 keV
- XRT: 0.3-10 keV
- UVOT: 1700-6500 A

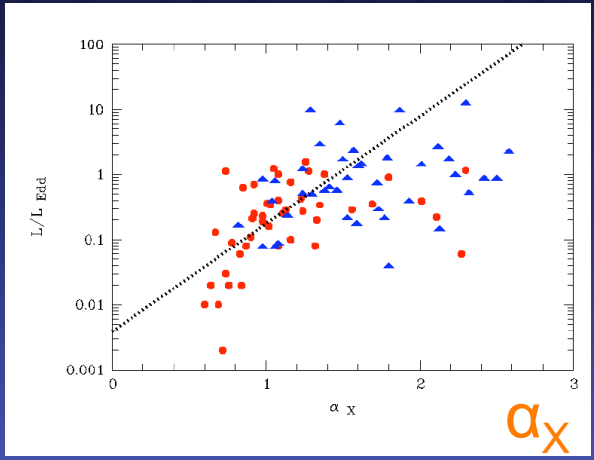
In order to estimate the bolometric luminosity we assume a power law model with exponential cut off, and a double broken power law model



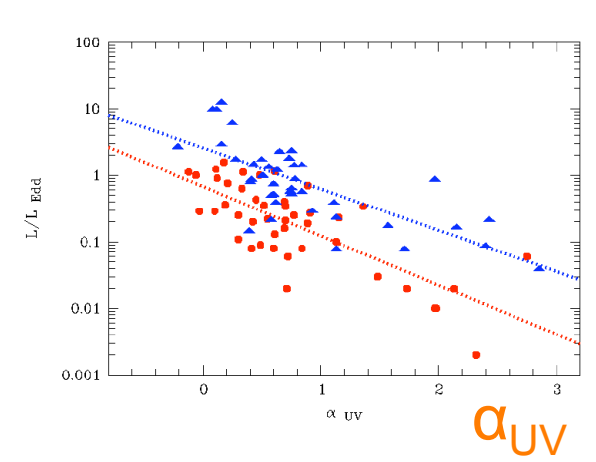


$L/L_{Edd} = L_{bol}/L_{Edd}$

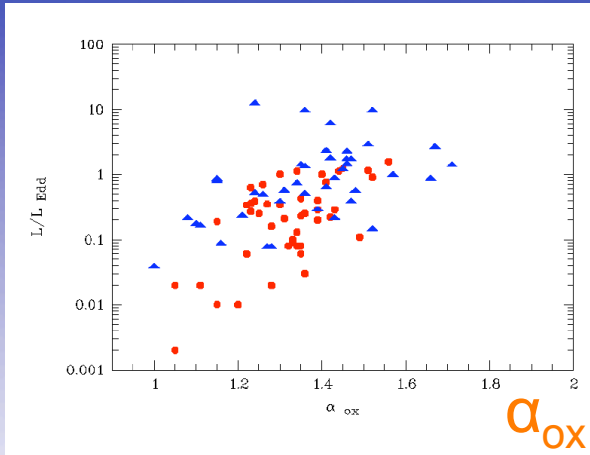
Eddington ratio L/L_{edd} correlates with spectral slopes and FWHM(Hβ)



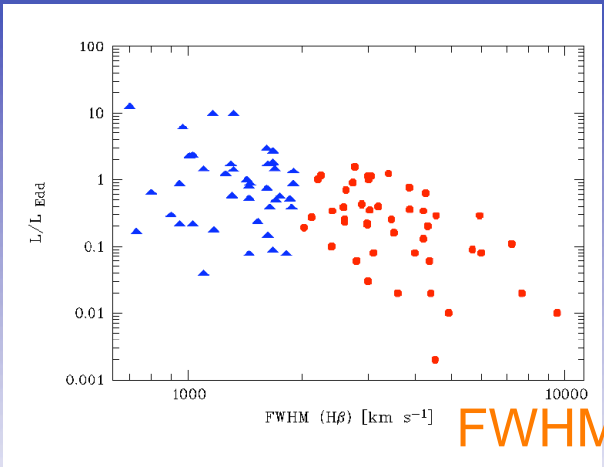
α_X



α_{UV}



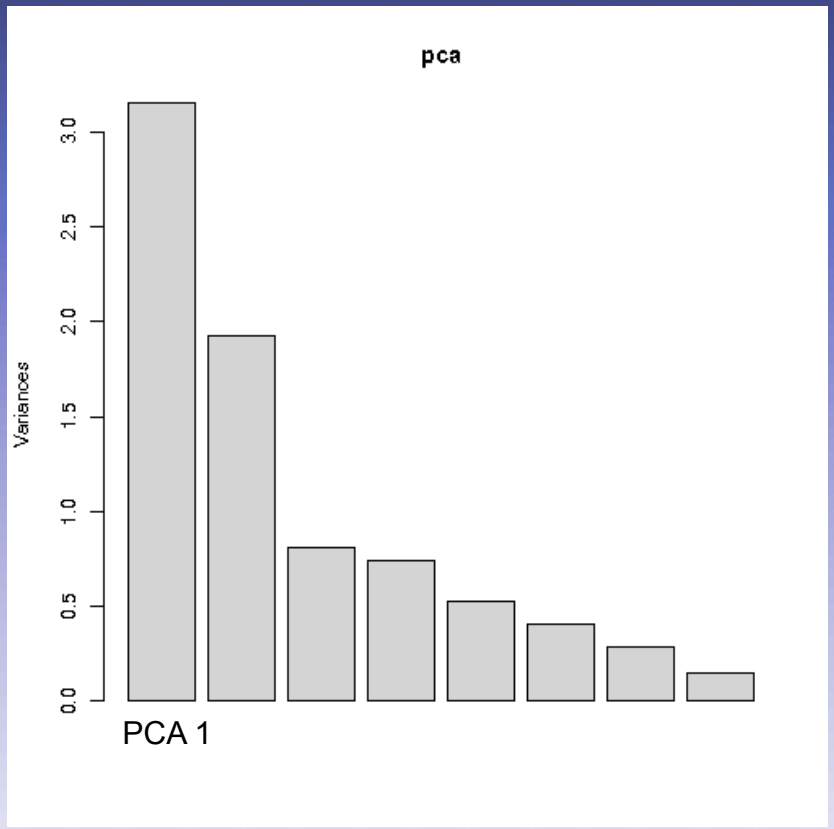
α_{ox}

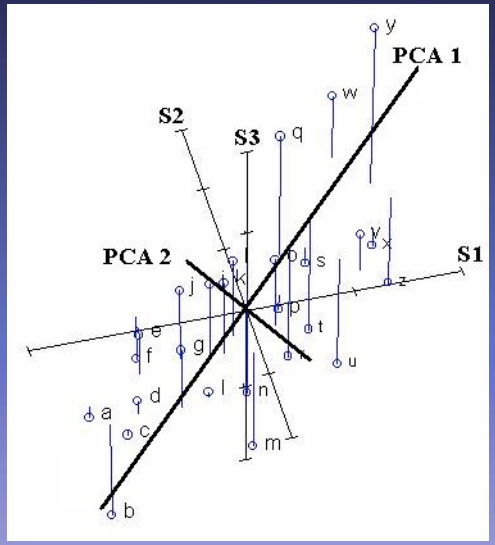


FWHM(Hβ)

NLS1s: blue triangles; BLS1s: red circles

PCA in our sample is dominated by the first two Eigenvectors (64%)



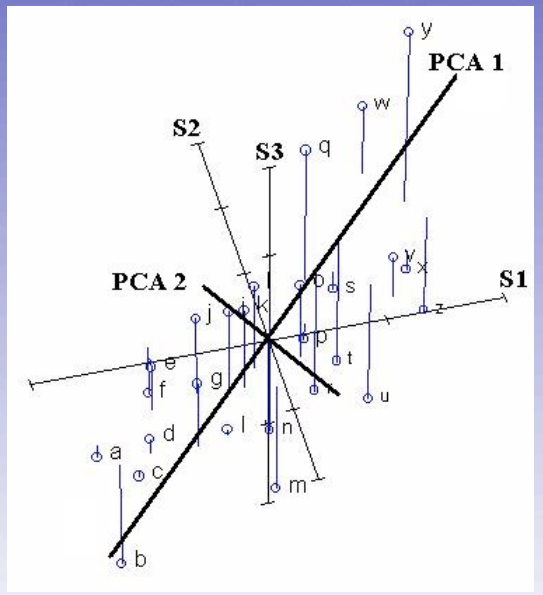


Input: α_X , α_{UV} , α_{OX} , FWHM(Hβ), FWHM([OIII]), FeII/Hβ, [OIII]/Hβ, L_X

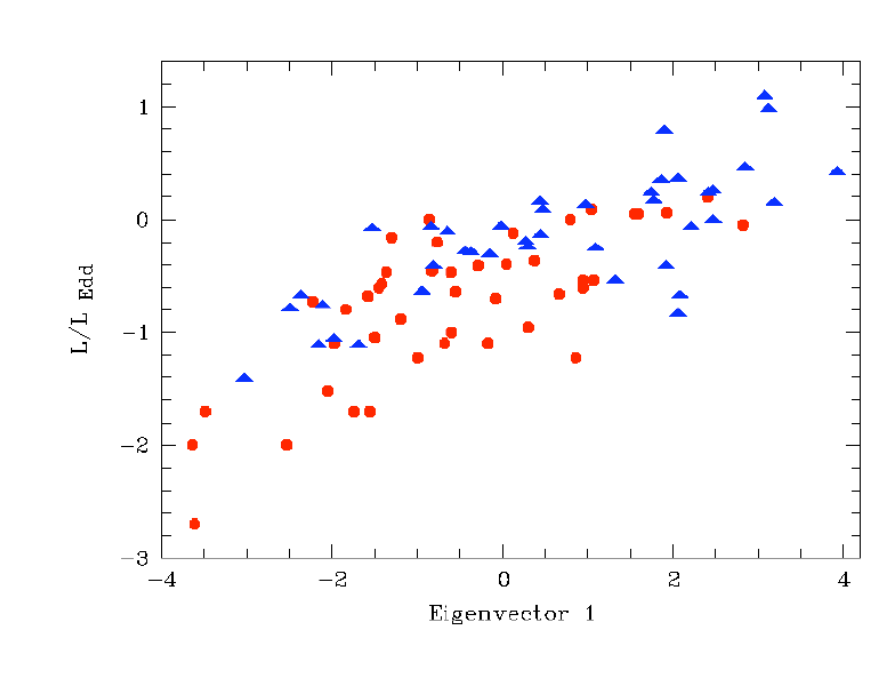
All Multi-Component Analysis done in R (www.r-project.org/)

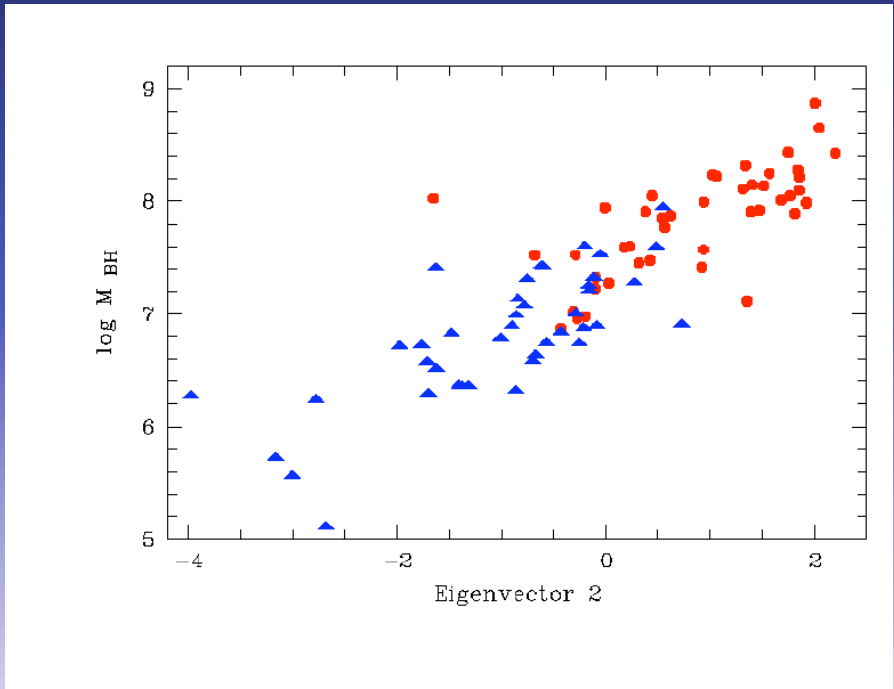
First eigenvector dominates spectral slopes and luminosity and the second one FWHM(Hβ)

	Eigenvector 1	Eigenvector 2
α_x	+0.366	-0.346
α_{uv}	-0.353	-0.402
α_{ox}	+0.469	+0.112
log FWHM(Hβ)	-0.208	+0.576
log FWHM([OIII])	+0.368	+0.046
log [OIII]/Hβ	-0.351	-0.136
log FeII/Hβ	+0.261	-0.509
log L_X	+0.390	+0.309



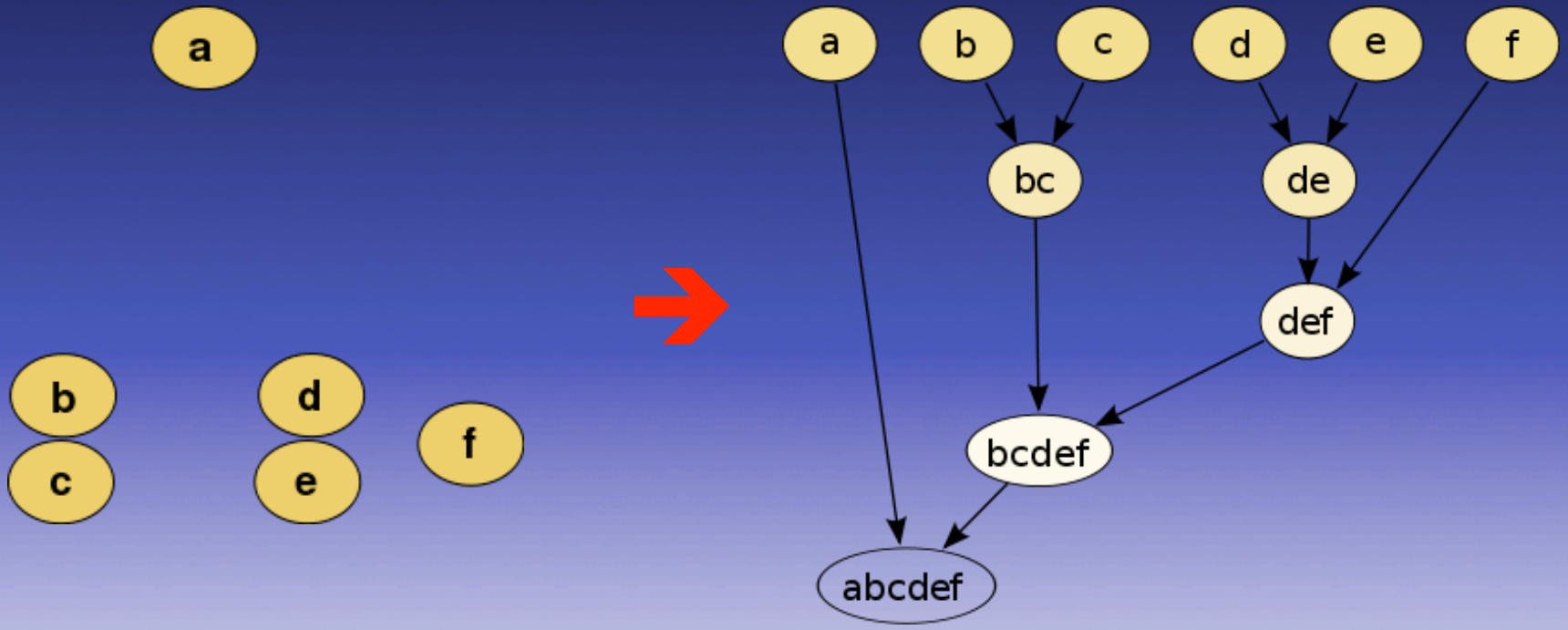
Eigenvector 1 represents L/L_{edd} while eigenvector 2 represents M_{BH}





NLS1s: Blue Triangles
BLS1s: Red Squares

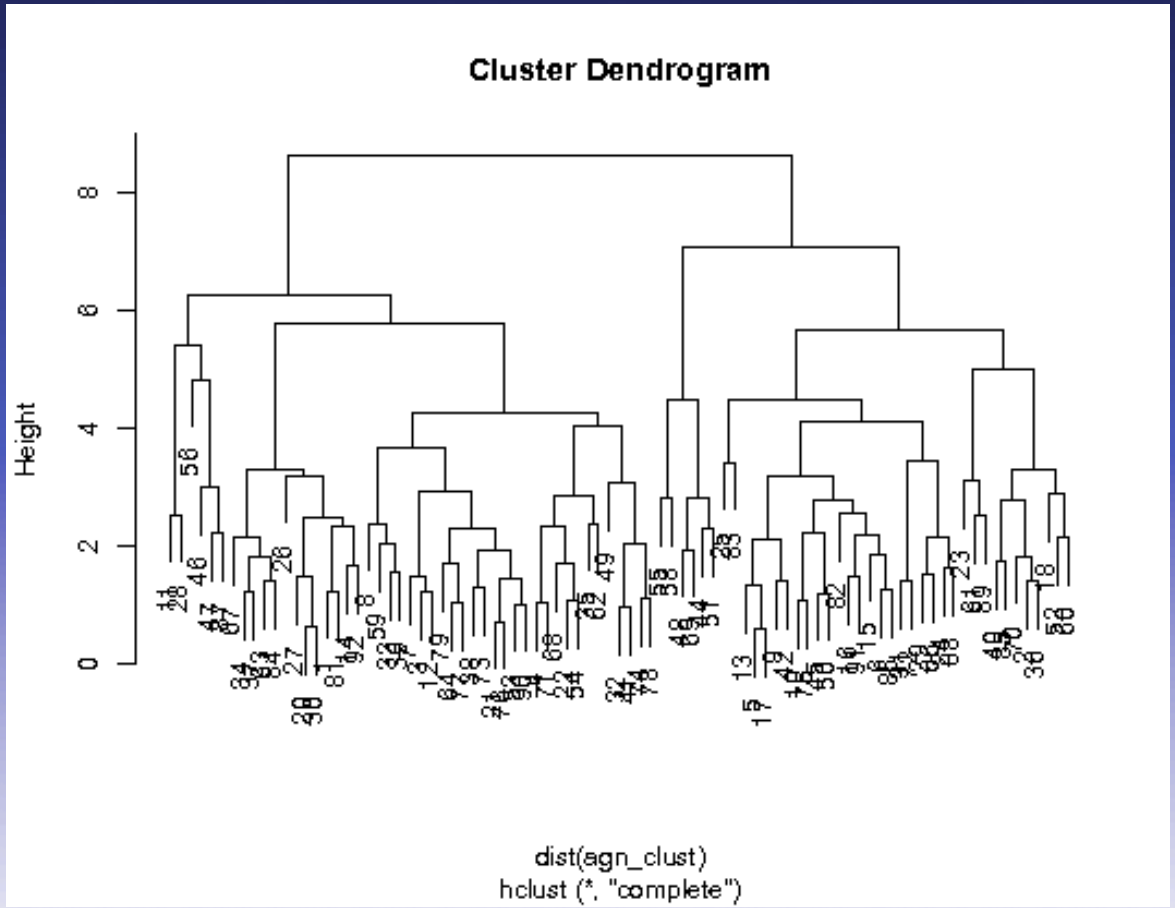
Cluster Analysis



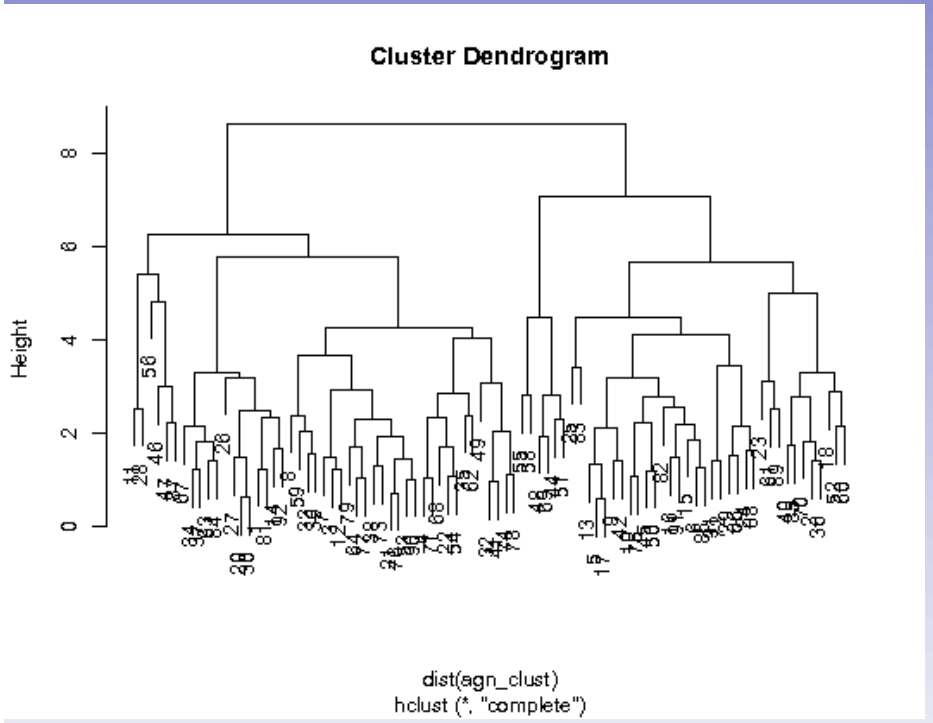
Source: Wikipedia

Dendrogram

Cluster Analysis shows that AGN sample can be separated into two groups

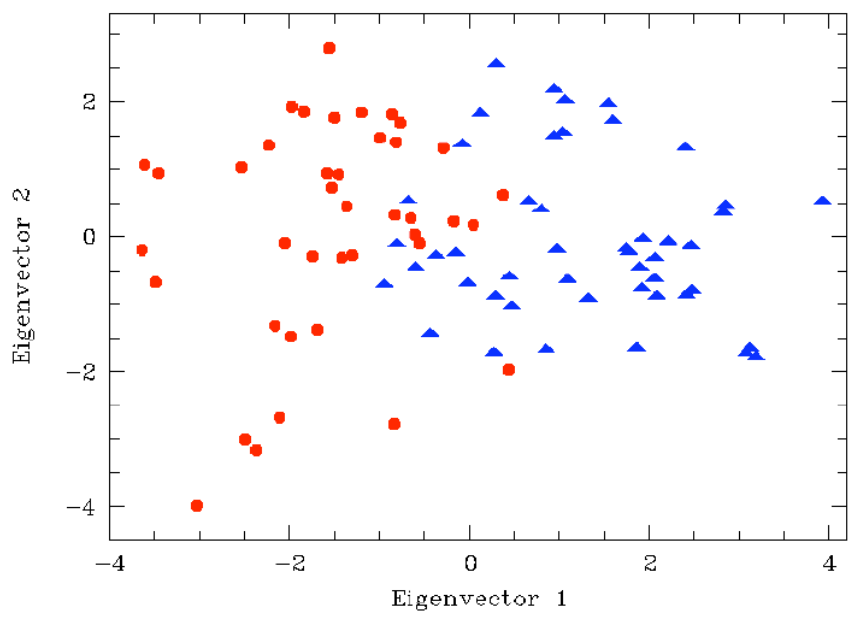


Properties of the 2 groups



	group 1	group 2
α_X	1.64	1.08
α_{UV}	0.54	1.14
α_{OX}	1.42	1.23
Log L/L_{edd}	-0.13	-0.84
FWHM(Hβ)	2210	3420
FWHM(OIII)	580	350
FeII/Hβ	1.00	0.58
[OIII]/Hβ	0.22	1.05
Log L_X	37.22	36.62 [W]
Type?	NLS1?	BLS1?

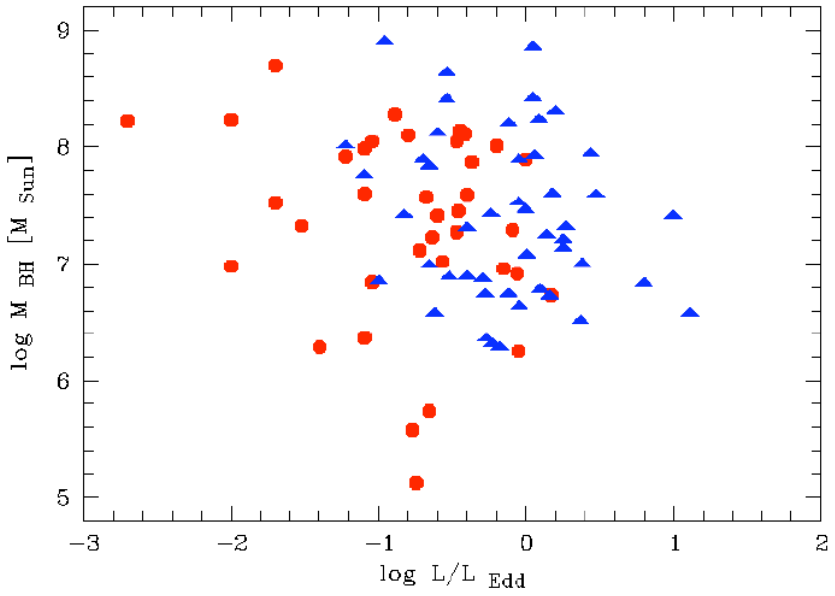
Apply the groups from the Cluster analysis to PCA



- Group 1: AGN with high Eigenvector 1
- Group 2: AGN with small Eigenvector 1
- If EV1 = L/L_{edd} then separation is driven by Eddington ratio.

Blue Triangles: Cluster Group 1
Red Squares: Cluster Group 2

L/L_{edd} vs M_{BH}

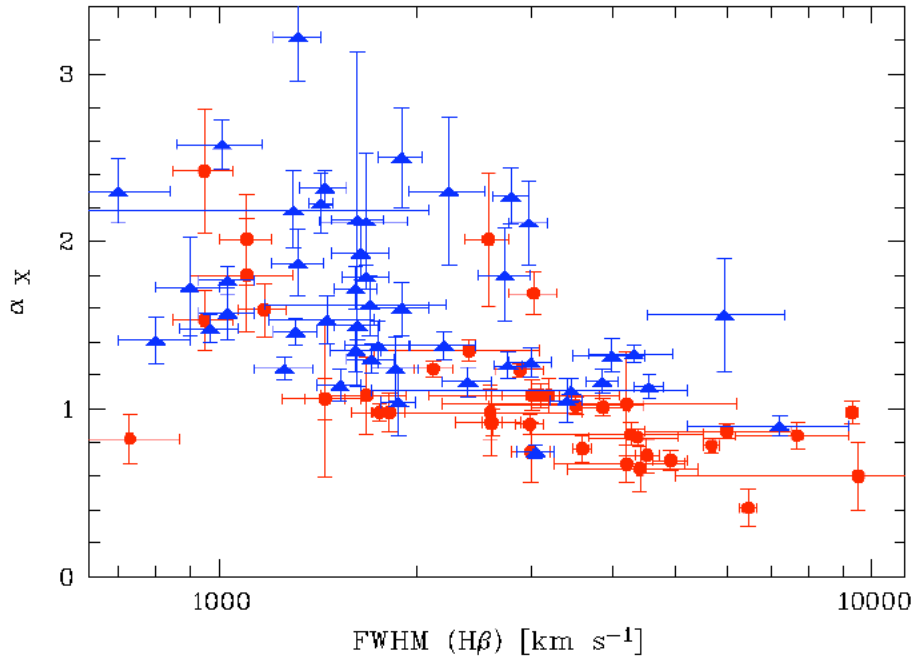


- Group 1 dominated by AGN with high L/L_{edd}
- Independent of NLS1 – BLS1 classification
- In agreement with PCA

Blue Triangles: Cluster Group 1
Red Squares: Cluster Group 2

Instead of using NLS1 – BLS1 classification, maybe better to separate AGN into high and low L/L_{edd} AGN

FWHM(Hβ) vs α_X



Blue Triangles: Cluster Group 1
Red Squares: Cluster Group 2

Conclusions/Summary

- PCA shows that EV1 is L/L_{edd} and EV2 is M_{BH}
- Cluster analysis separates AGN into high and low L/L_{edd} AGN
- Future: Extend the sample to low L/L_{edd} AGN
- Swift is the ideal observatory for AGN studies, monitoring as well and SEDs
- NLS1 is still a valid classification
- NLS1s are dominated by high L/L_{edd} AGN
- NLS1s remain important in research and literature.
- NLS1s are not an historical accident!