

2MASS AGN Down Under: brute force spectroscopy with 6dF

Frank Masci, Roc Cutri, Paul Francis, Brant Nelson, John Huchra, Heath Jones, Mathew Colless, & Will Saunders

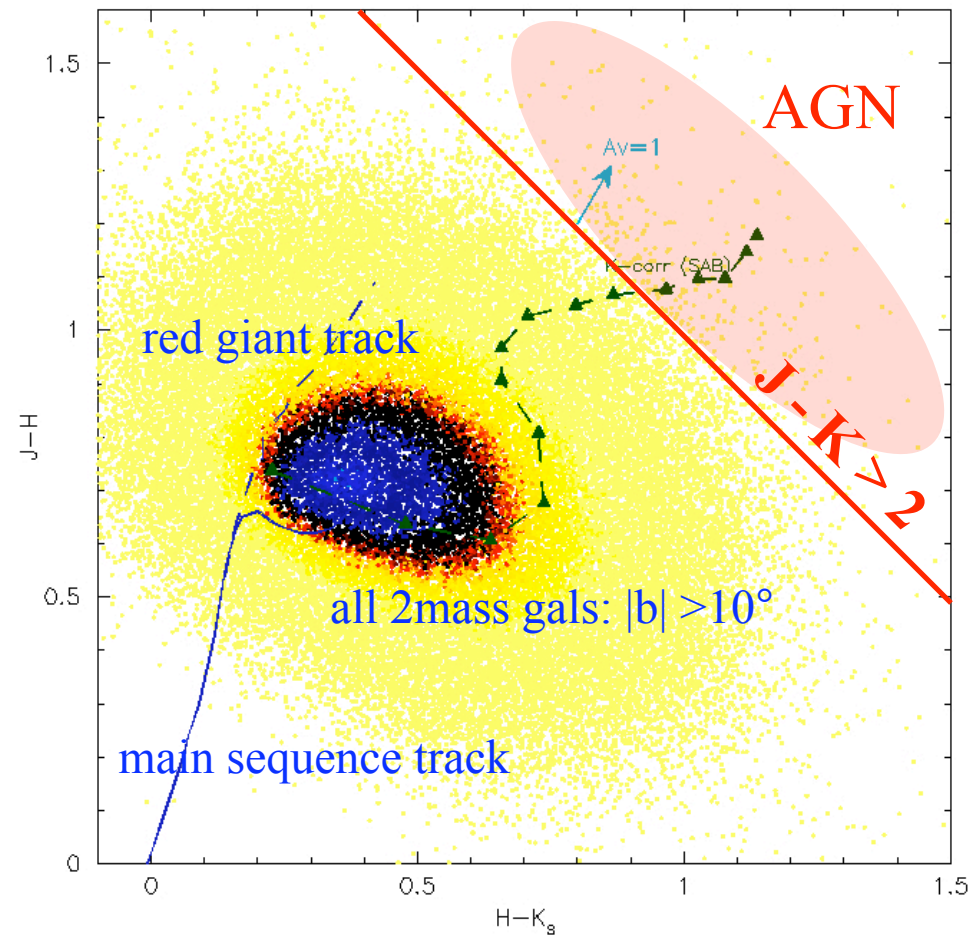


Goals

- We continue the pioneering of work of Cutri et al. initiated ~13 years ago to search for red (or “extreme”) AGN in the 2MASS catalog
- Most of earlier follow-up was in the north. We extended the search to the southern equatorial sky using the highly efficient Six-degree Field (6dF) multi-object spectrograph in Australia
 - piggy-backed off the 6dF Galaxy Redshift Survey - a unique opportunity to cover a large region, fast!
- Objectives (long-term):
 - provide a more complete census of local(ish) galaxies with active nuclei to $z \sim 0.5$
 - irony: we know more about the high redshift AGN/QSO population than the local one!
 - of interest: fraction of galaxies with active (or dormant) BHs?
 - ⇒ constraints on duty cycle for black-hole fueling
 - provide a low- z reference survey against which the high- z ones can be compared
 - ⇒ use to calibrate search criteria at other wavelengths for future surveys

Sample Selection / Observing Strategy

- simple color cut $J - K_s > 2 \Rightarrow$ selects reddest AGN, reduces contamination from galaxies + stars
- detected in all J, H, K_s bands (10 sigma)
with $K_s \leq 15.5$ mag
- $|\text{galactic latitude}| > 30^\circ$
- opt. mag cuts for spectroscopy:
 $B_J \leq 18, r_F \leq 17$
 \Rightarrow spectra: $S/N > 10/\text{pixel}$
 \Rightarrow biases us against dustiest objects
- 1182 AGN candidates were allocated
fibers for follow-up with 6dF
- scheduled as auxiliary targets
during 6dF Galaxy z-survey



6dF is on the UK-Schmidt at Siding Spring

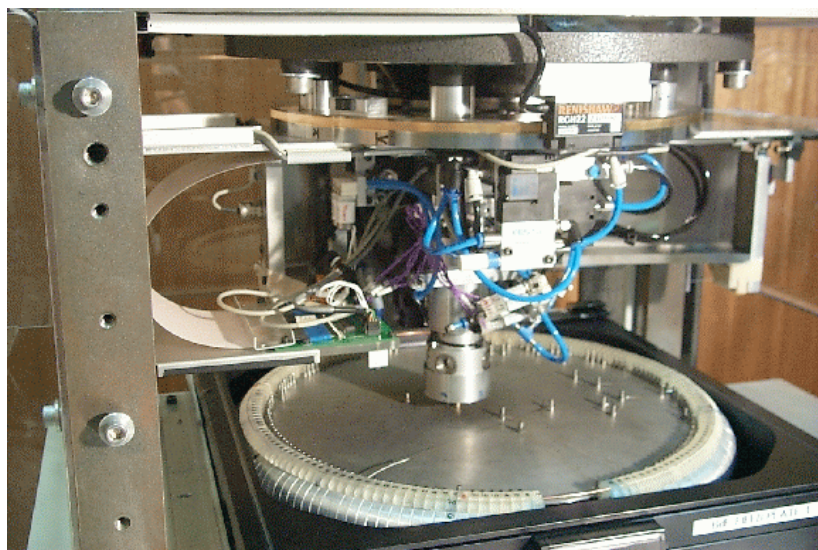


UKST

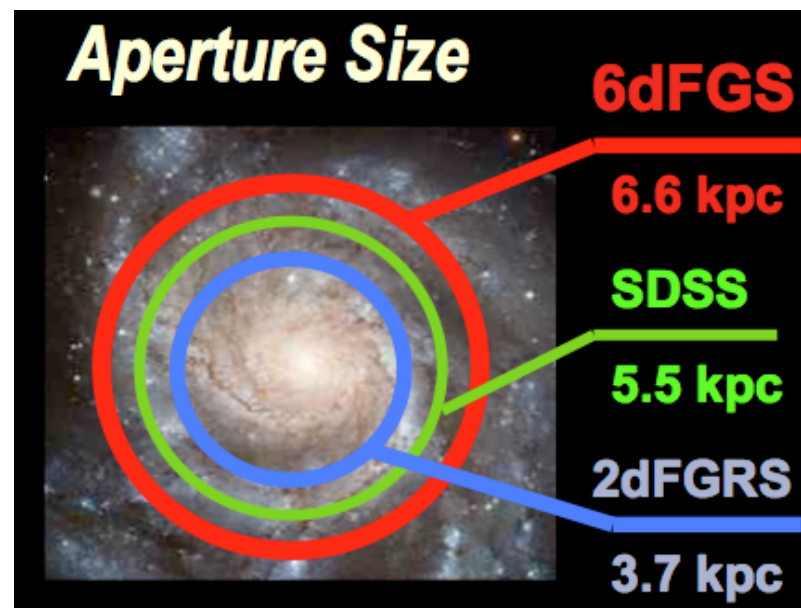


1.2m aperture, $6.4^\circ \times 6.4^\circ$ FOV, commissioned in 1973

6dF multi-object spectrograph



- can record up to ~ 120 simultaneous spectra over a 5.7° field



- fibers project diameter of 6.6 arcsec on sky
=> samples physical scales of > 6 kpc
for objects at > 0.05 ($\sim > 210 h_{72}^{-1}$ Mpc)

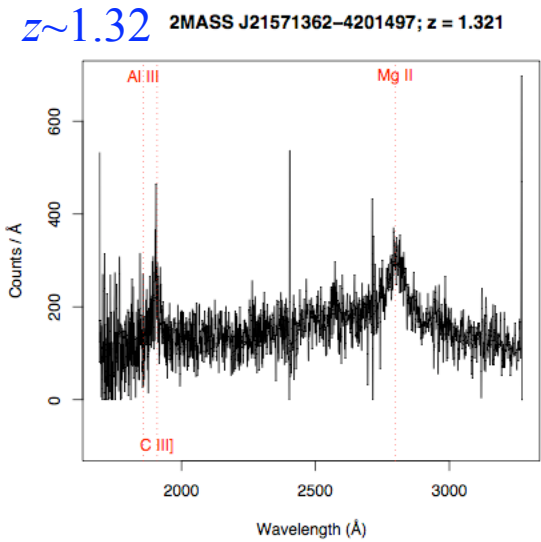
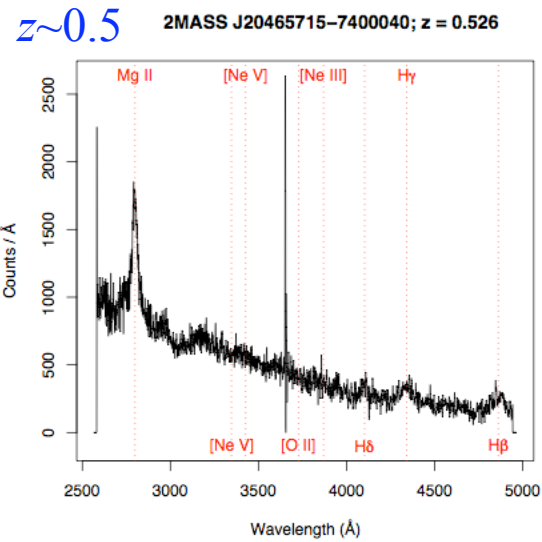
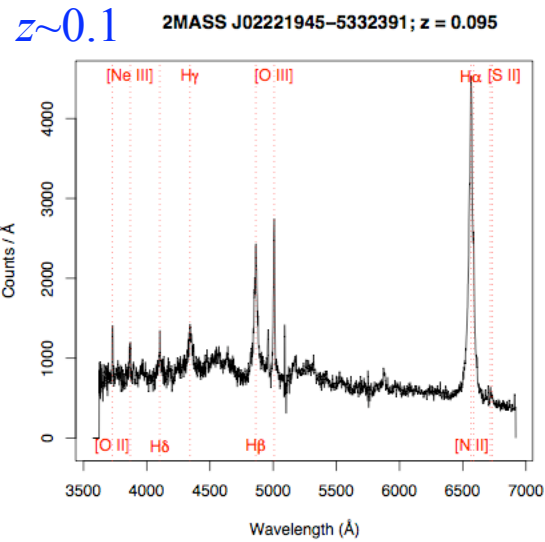
Spectral classifications

- Type 1 (broad-lined AGN) using rest frame FWHM(H α , or H β , or other) > 1000 km s⁻¹
- Type 2 (narrowed-lined AGN), liners, and starburst/late-types used classic line ratio diagnostics

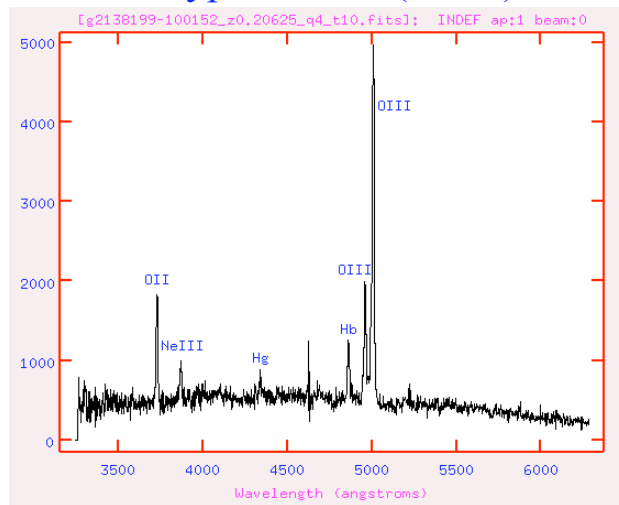
| | This study | Cutri et al '02 |
|-------------|-------------------|------------------------|
| #classified | 432 | 664 |
| Type 1 AGN | 116 (26.8%) | 385 (57.9%) |
| Type 2 AGN | 57 (13.2%) | 100 (15%) |

- Only 8 of our AGN (~6%) were previously classified as “AGN/QSO” in NED
- We have increased the number of 2MASS red AGN by ~35%
- Cutri et al. had ~2 \times higher detection rate for type 1 AGN
(deeper opt-spectroscopic follow-up? Or, narrower spectroscopic slits to probe nuclei?)

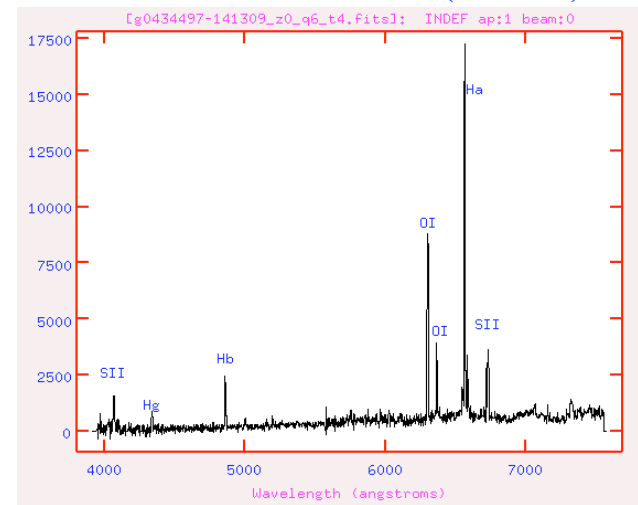
Spectra of some New AGN



Type 2 AGN ($z \sim 0.2$)

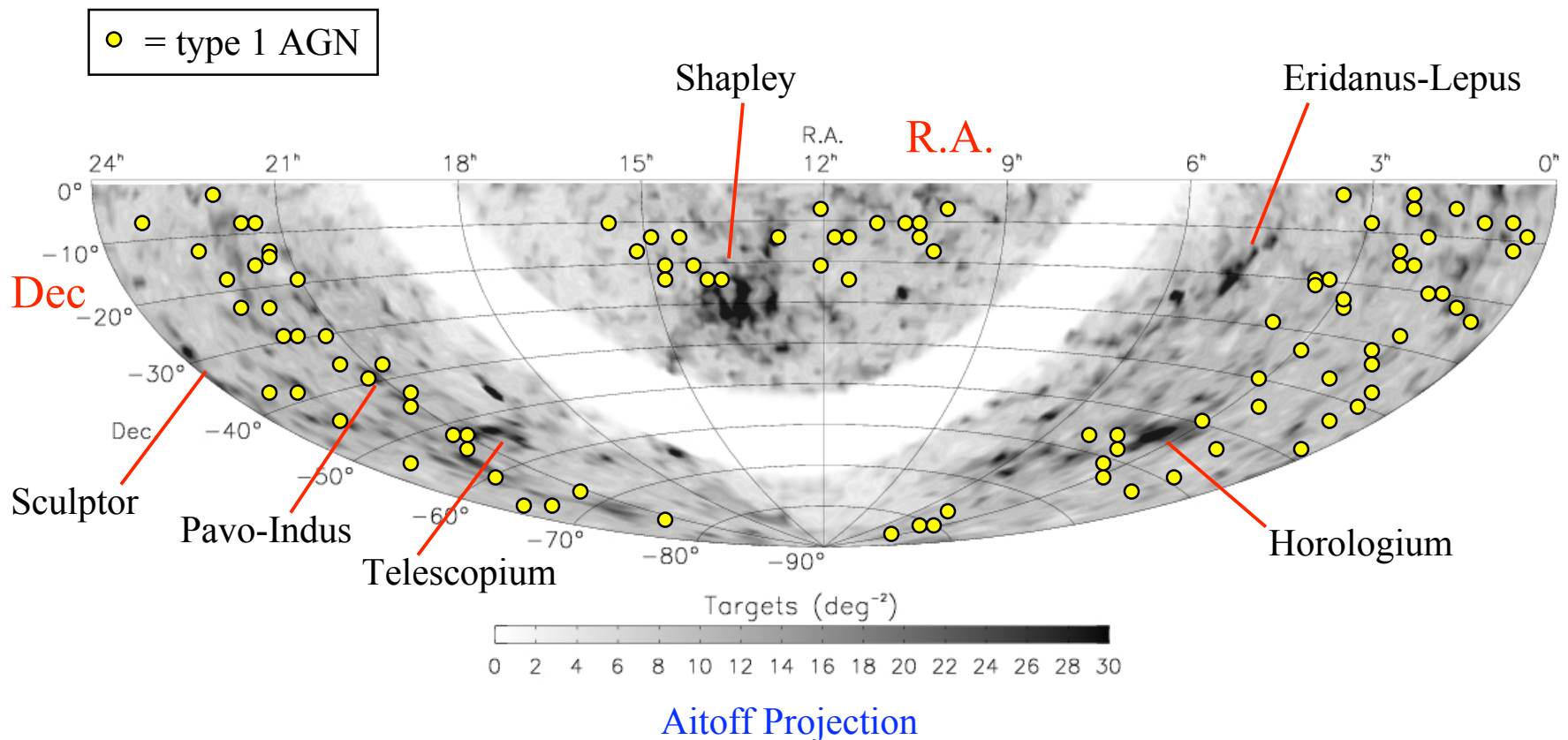


LINER / Starburst ($z \sim 0.03$)



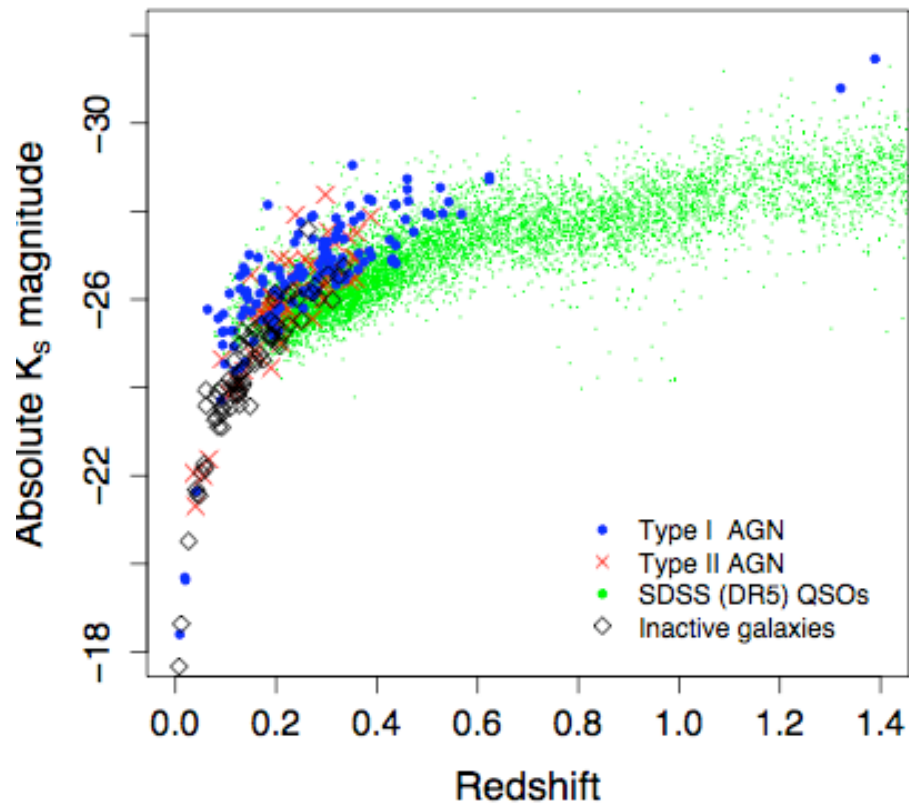
Distribution in 6dF Galaxy Redshift Survey

- 6dFGRS: measured distances to $\sim 125,000$ 2MASS galaxies to $K_s \sim 12.6$, $B_J \sim 16.7$, final rel: 03/2009
- mapped out local large scale structure to $z \sim 0.1$. Our AGN uniformly distributed to $z \sim 0.5$.



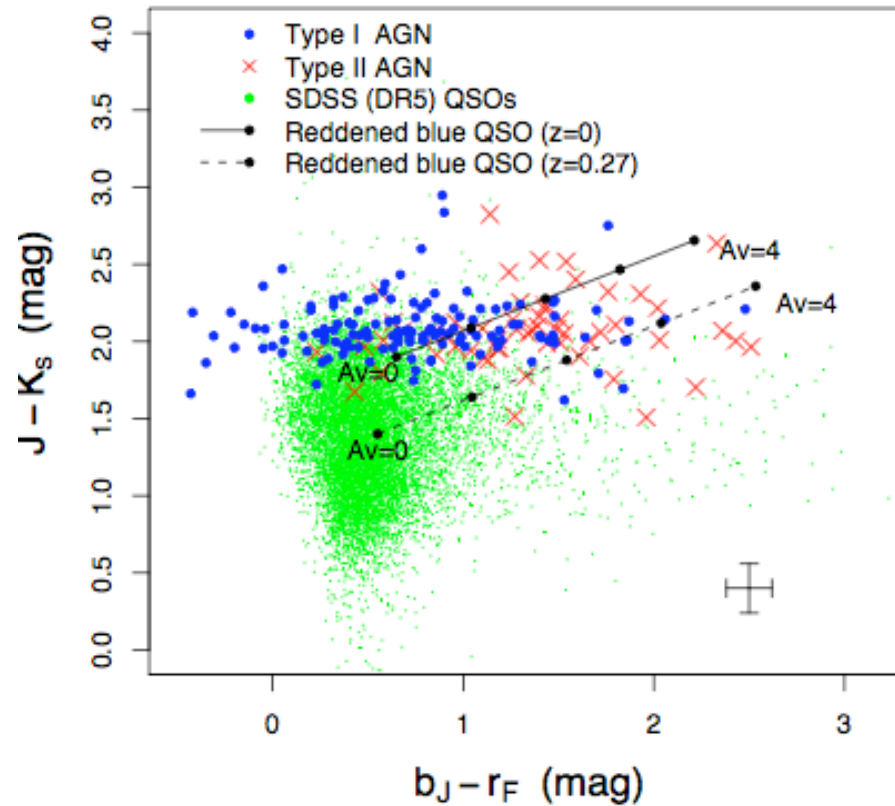
Redshift & Luminosity Distribution

- Redshifts span $\sim 0.01 - 1.38$, with type 1 AGN detected to higher $z \Rightarrow$ easier to classify, eg. MgII?
- 2MASS red AGN have near-IR luminosities closer to QSOs than Seyferts
- At $z > 0.2$, we're sensitive to the most near-IR luminous QSOs of the optically selected pop.



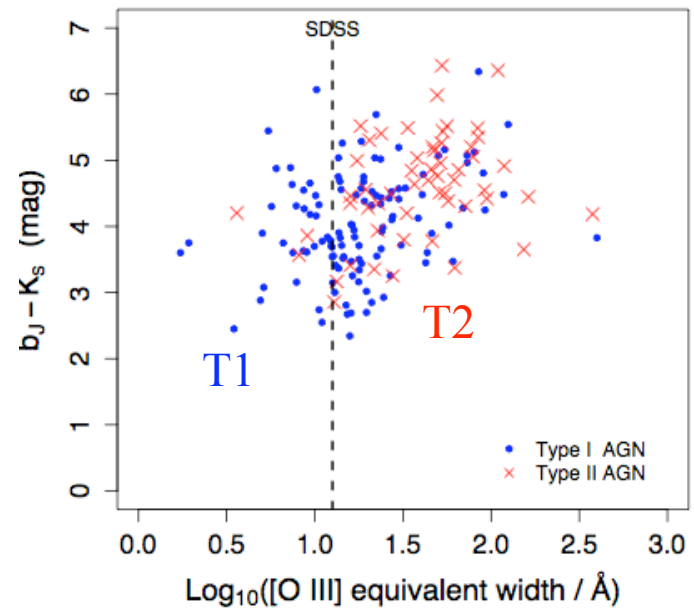
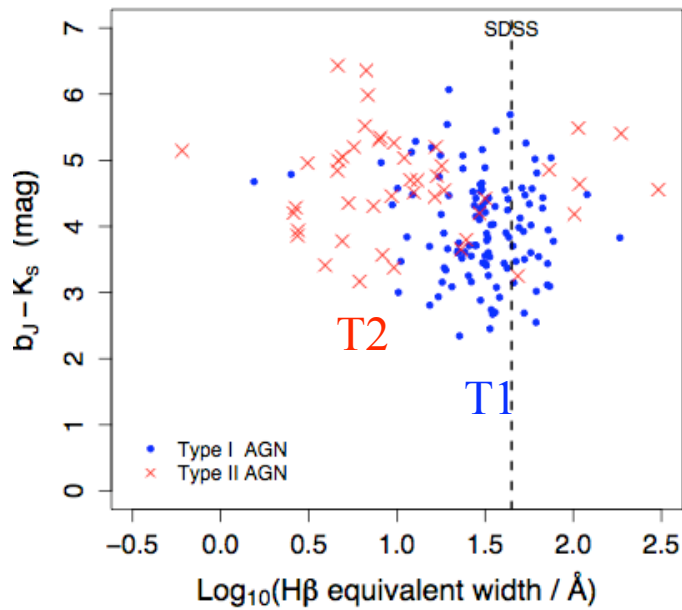
Near-IR vs Optical color

- Overall, optical properties of 2MASS red AGN similar to optically-selected (SDSS) QSOs
- Type 2 AGN ~ 1 mag redder in B-R color than Type 1s \Rightarrow consistent with Unified Models



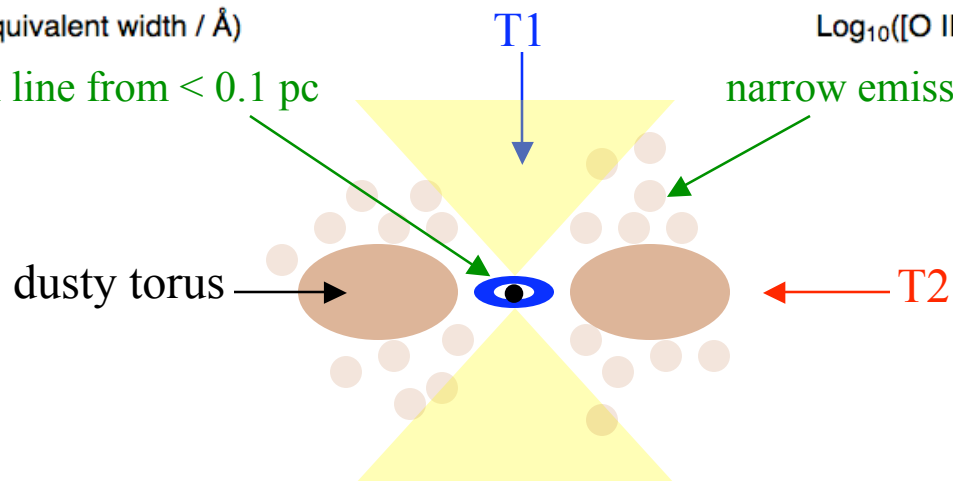
Optical-near-IR color vs Equivalent Width

EW = integrated line flux / local continuum flux density



broad emission line from $< 0.1 \text{ pc}$

narrow emission line from $< \sim 3 \text{ kpc}$



Summary

- We have extended the search for 2MASS red AGN to the southern equatorial sky
- We have increased the statistical base of 2MASS red AGN by $\sim 35\%$ relative to northern surveys
- Discovered 165 new AGN. 95% have redshifts: $0.02 < z < 0.5$.
- Over same z -range, we match the Sloan QSO surface density to $i = 18.5$ of $\sim 0.48 \text{ deg}^{-2}$
- Selection method has detected the most luminous objects in the near-IR - the tip of the iceberg
- For more details, see:
Masci et al. 2010, Publications of the Astronomical Society of Australia [accepted 5/11/2010]
- Done with ancient history: now onto WISE!
 - 2MASS will continue to provide a benchmark for future AGN searches
 - AGN are only part of the cosmic story
 - ultimate goal: explore link between obscured accretion, SFR, stellar mass, and environment vs z