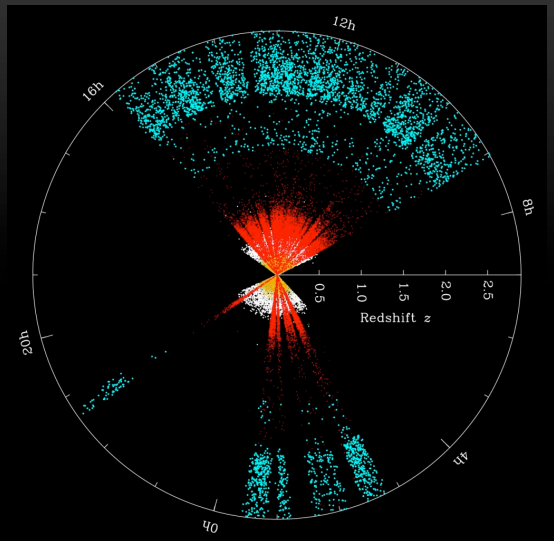
STUDYING QUASAR-GALAXY CO-EVOLUTION AT HIGH REDSHIFTS WITH MSE

Manda Banerji (Cambridge → University of Southampton)

MSE AGN SCIENCE THEMES



Single Epoch

- BH seeds
- *AGN triggering and mergers*
- *Host galaxies*
- *Obscured AGN*
- *The earliest SMBHs*
- *AGN feedback*
- Clustering
- Demographics
- Lensed quasars
- *Reionisation*
- Intervening absorbers

Time Domain

- Reverberation mapping
- Nuclear outflows
- AGN variability
- Close SMBH binaries

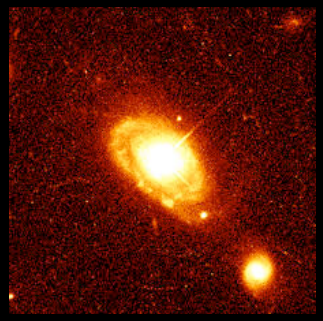
FUELLING AND FEEDBACK THE "STANDARD" PARADIGM

MERGER: Multiple components; interaction

Dusty starbursts formed via major mergers

STARBURST: Intense star formation; dust obscuration

Star formation / black hole accretion fuelled by common gas supply. Quasar initially dust obscured – "blowout" phase.



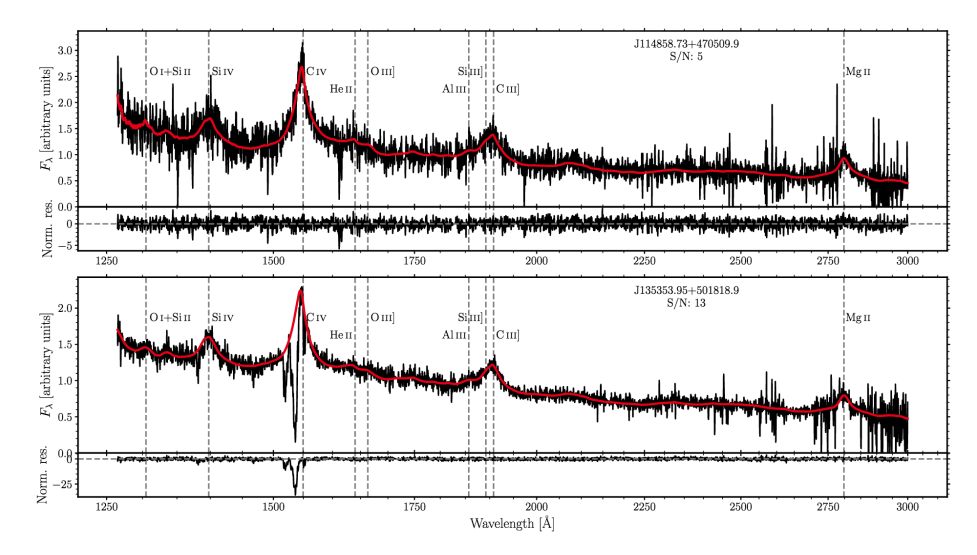
QUASAR: Accretion onto supermassive black hole

Feedback from black hole shuts off star formation

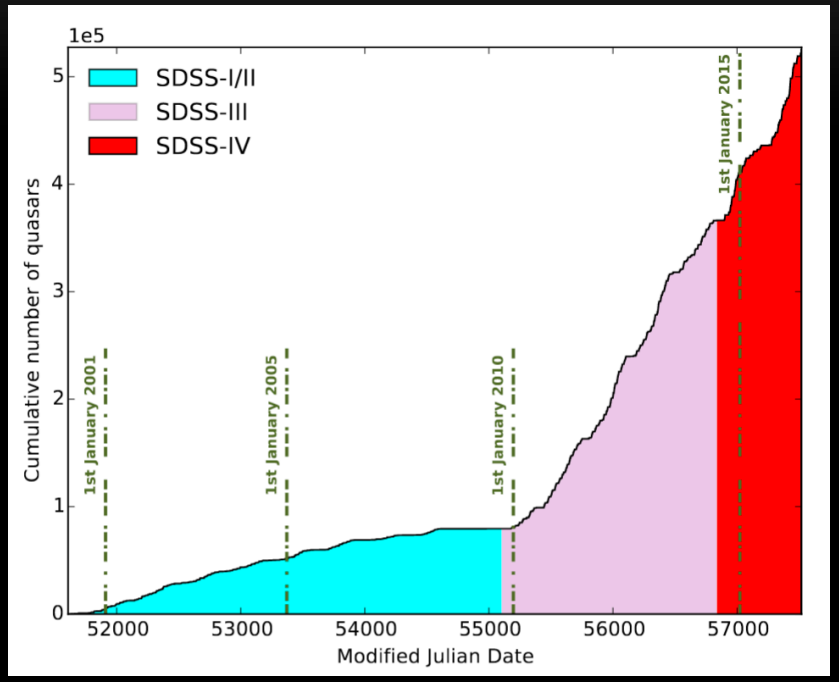
ELLIPTICAL: Old stars; Most massive galaxies today

e.g. Sanders+86,88, Hopkins+05

THE LEGACY OF SDSS

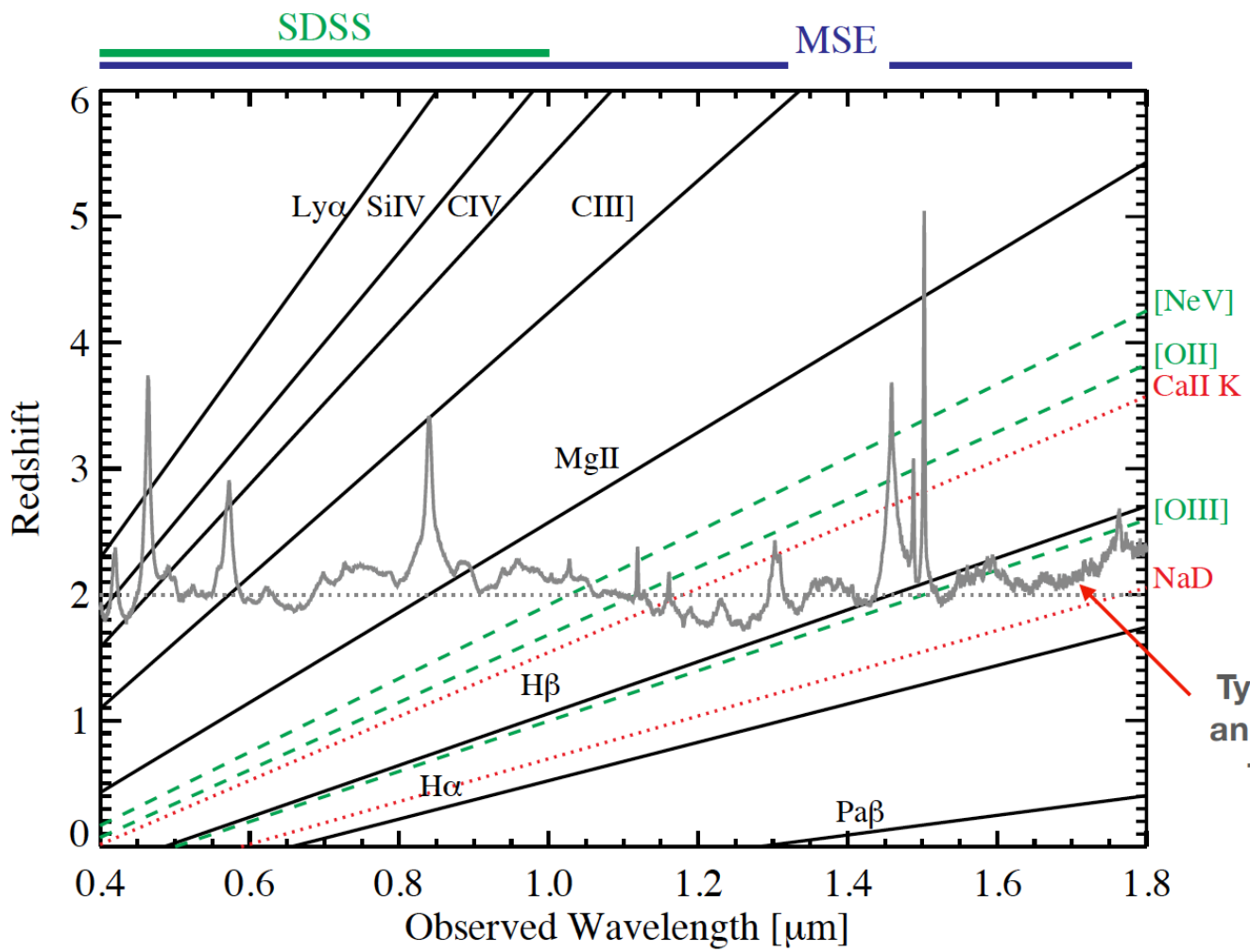


Rankine et al. 2020



SDSS DR16QSO contains 750k quasar spectra (Lyke et al. 2020) opening up a wealth of new observational studies of quasars as a function of fundamental properties such as redshift, luminosity and black-hole mass.

SPECTRUM = NOT JUST A REDSHIFT!

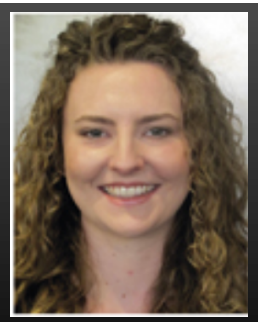


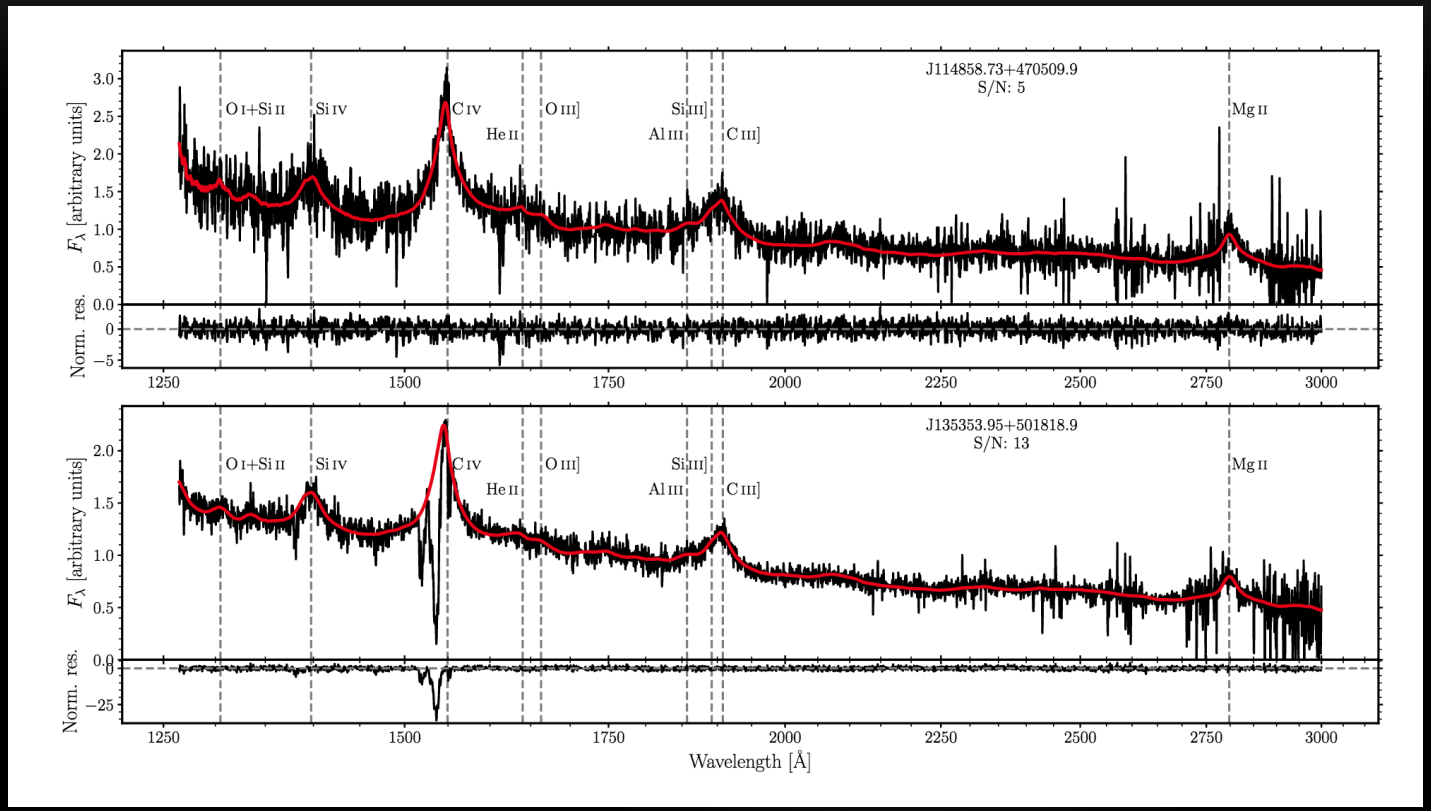
MSE Advantages:

- Sensitivity
- **NIR Coverage**
- Multiplexing
- Dedicated Survey Capability

Credit: Yue Shen

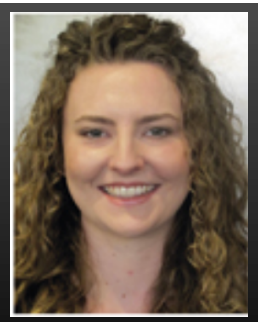
STATISTICAL STUDIES OF QUASAR SPECTRA





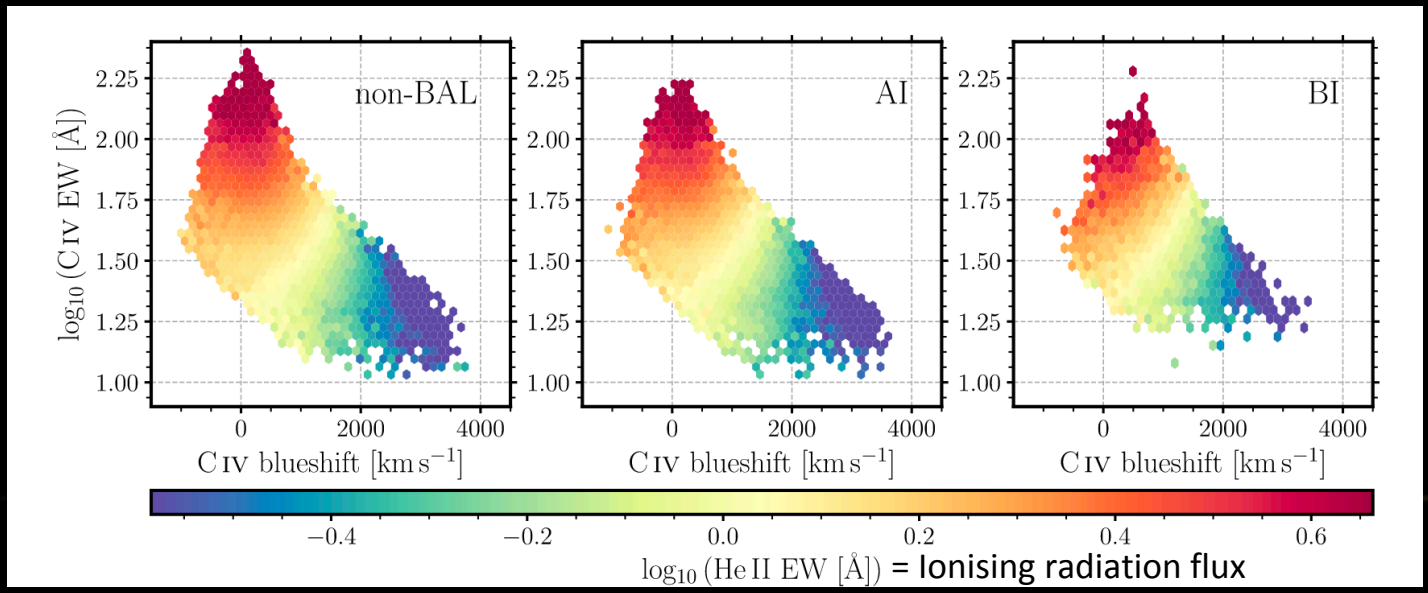
Rankine et al. 2020 & In Prep

Broad and narrow absorption features in spectra probing gas around the central BH. Do these absorption features arise due to viewing angle or do they represent a particular phase in the quasar fuelling cycle? Are the outflow velocities seen capable of impacting the host galaxies?



OUTFLOWS & ACCRETION PHYSICS

- The strength of emission line blueshifts (outflows) depends very systematically on the hardness of the ionising SED – disc winds can only form when ionising SED is soft
- Quasars with broad absorption features show very similar trends in emission line properties with the ionising radiation flux – same parent population
- Structure and properties of the absorbing gas can potentially be constrained with MSE by looking at their variability signatures



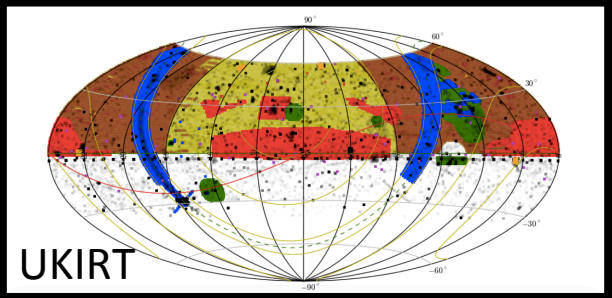
Rankine, Hewett, MB+20

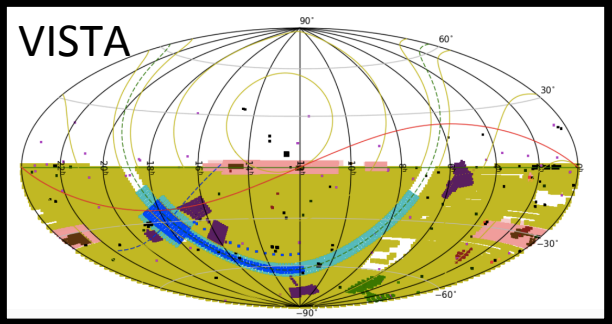
THE INFRARED PHOTOMETRIC SURVEY REVOLUTION

- Leap in infra-red detector technologies have brought about a revolution in infra-red imaging surveys in the last decade
- UKIRT Infra-red Deep Sky Surveys (Lawrence+07), ESO VISTA Public Surveys e.g. VHS (McMahon, MB+13), VIKING (Edge+13), WISE All-Sky Survey (Wright+10)
- Cover wide areas, probe to high-redshifts and are also sensitive to obscured populations
- Exploited to discover large numbers of “red quasars” consistent with significant levels of dust extinction (e.g. MB+12,15, Glikman+12, Assef+15, Lacy+15, Hamann+17, LaMassa+17, Temple+19)

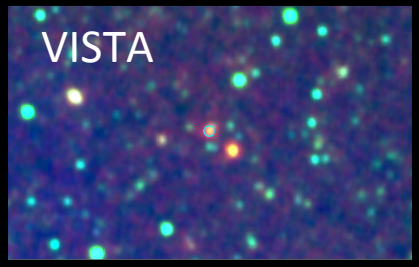
HEAVILY REDDENED QUASARS (HRQ)

SURVEY DATA

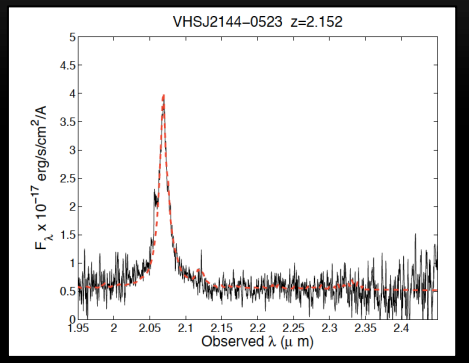


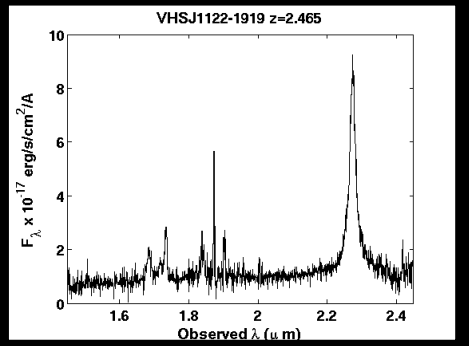


PHOTOMETRIC SELECTION



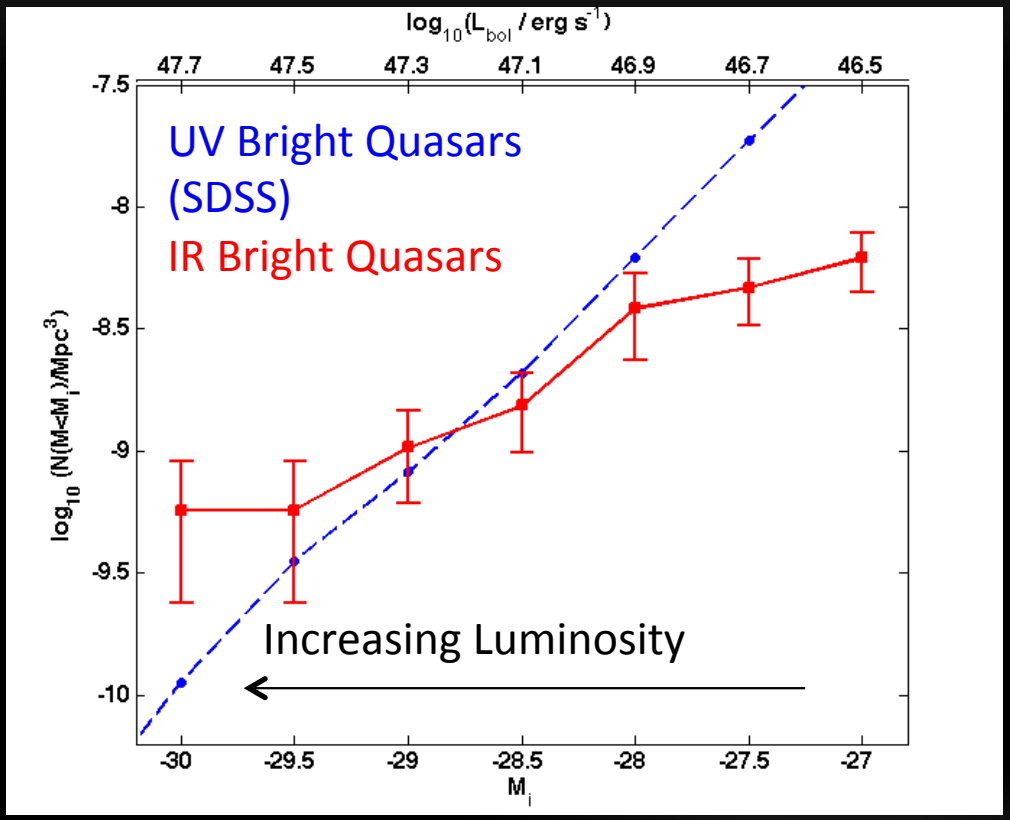
SPECTRA



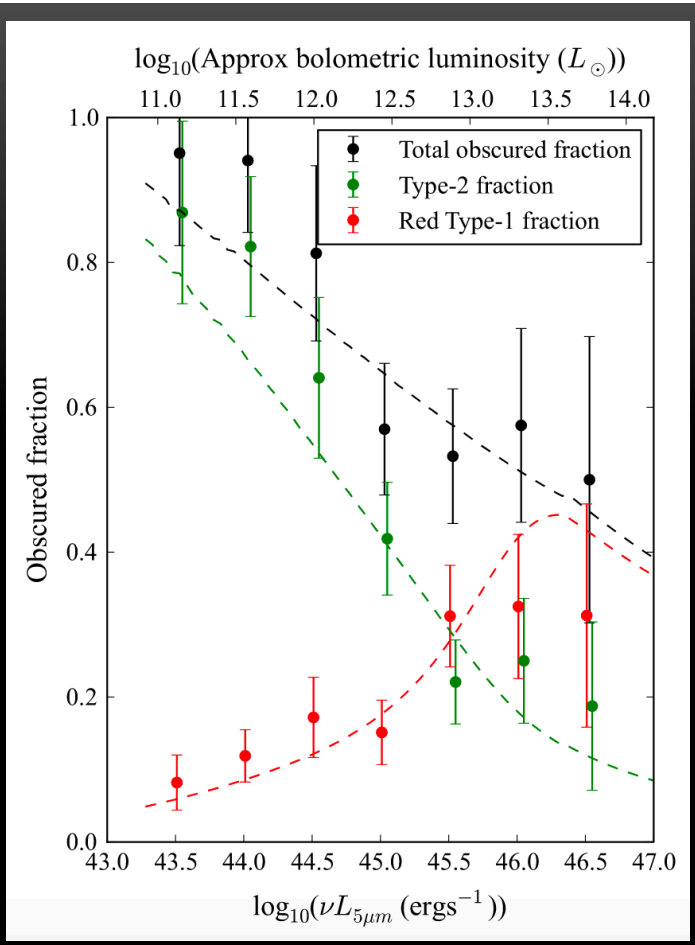


More than 60 HRQs now spectroscopically confirmed mostly at z~2-3 using VLT-SINFONI and Gemini-GNIRS (MB+12,13,15, Temple, MB+19). Not in X-ray or UV surveys (high-L, high-z, obscured) – new population

THE OBSCURED FRACTION



MB+15

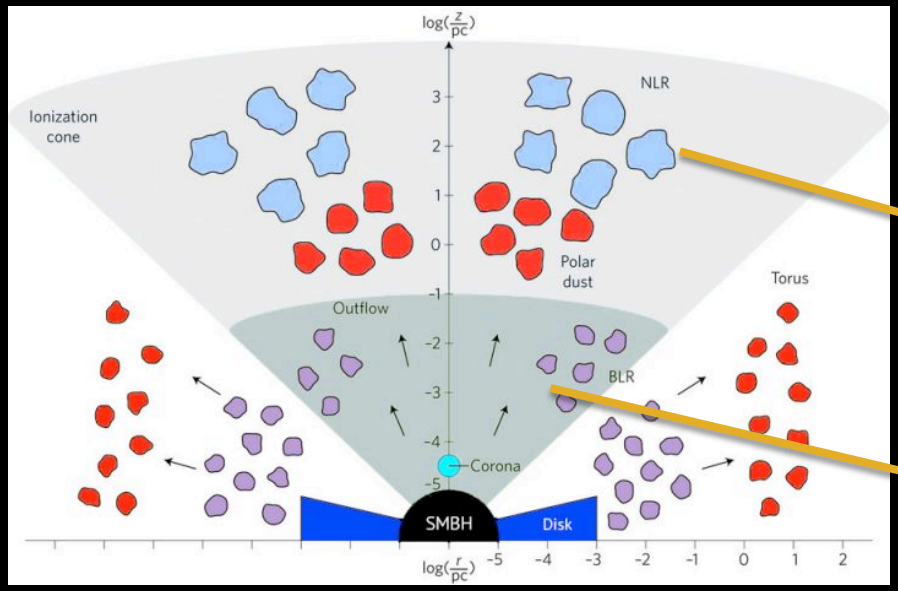


Lacy+15

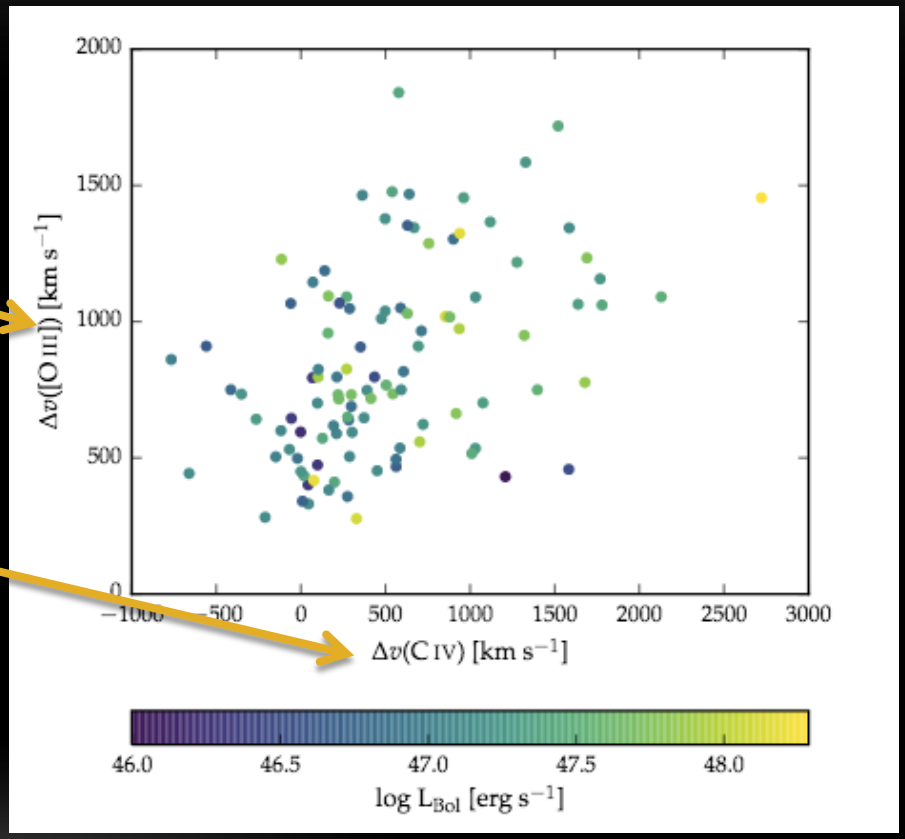
- Evolutionary differences between obscured and unobscured AGN?
- Obscured AGN can only be spectroscopically confirmed using deep optical and IR spectroscopy -> MSE

AGN OUTFLOWS

Hickox & Alexander 18

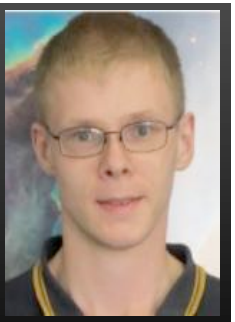


Coatman, Hewett, MB+19

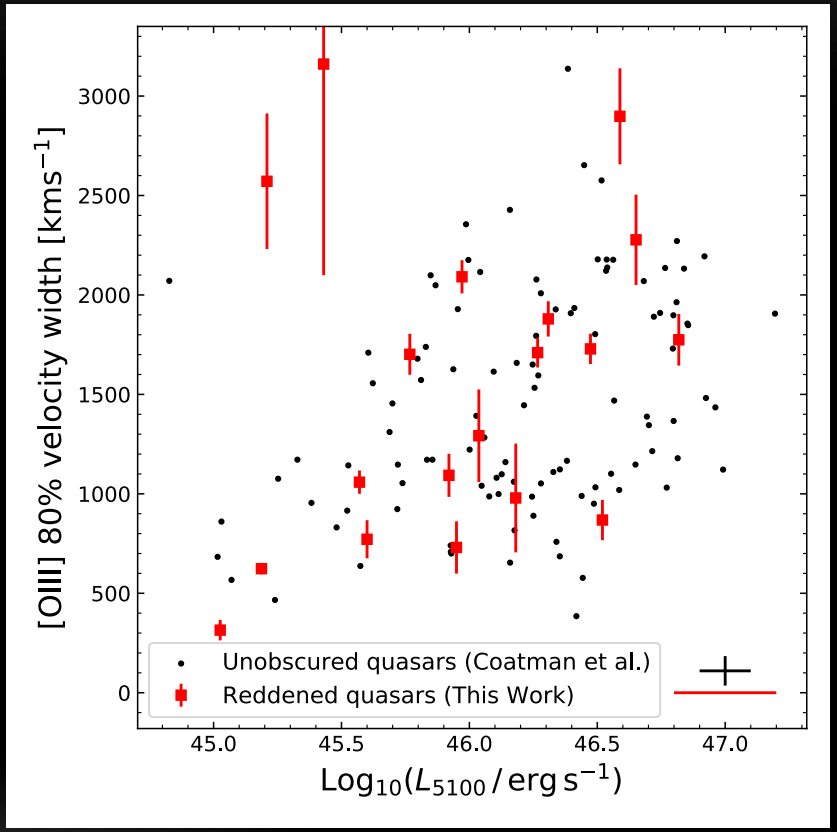


Broad-line region (pc scale) and narrow-line region (kpc scale?) outflows are correlated in luminous quasars at z > 2

OUTFLOWS & OBSCURATION

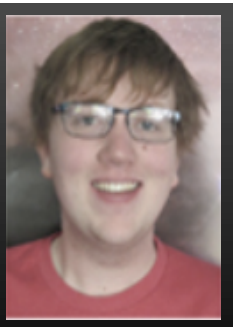


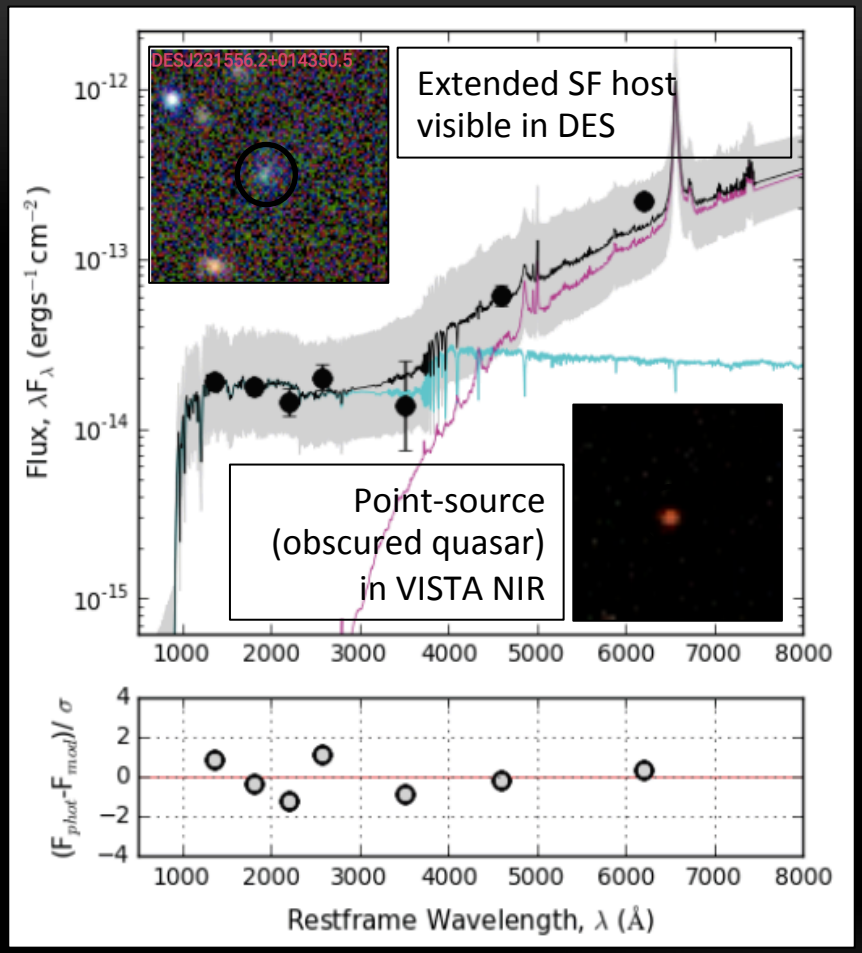
- Current state-of-the-art is a few hundred quasars where emission lines such as [OIII] have been studied as a function of quasar properties at high-z
- When matching to samples of quasars with dust obscuration the number reduces to only a few tens – no difference in outflow properties as a function of obscuration
- [OIII] will be visible out to z~2-2.5 with MSE- peak epoch of galaxy formation and black hole accretion
- MSE will allow us to investigate differences in outflow properties as a function of luminosity, redshift and obscuration (controlling for host galaxy properties and environment)



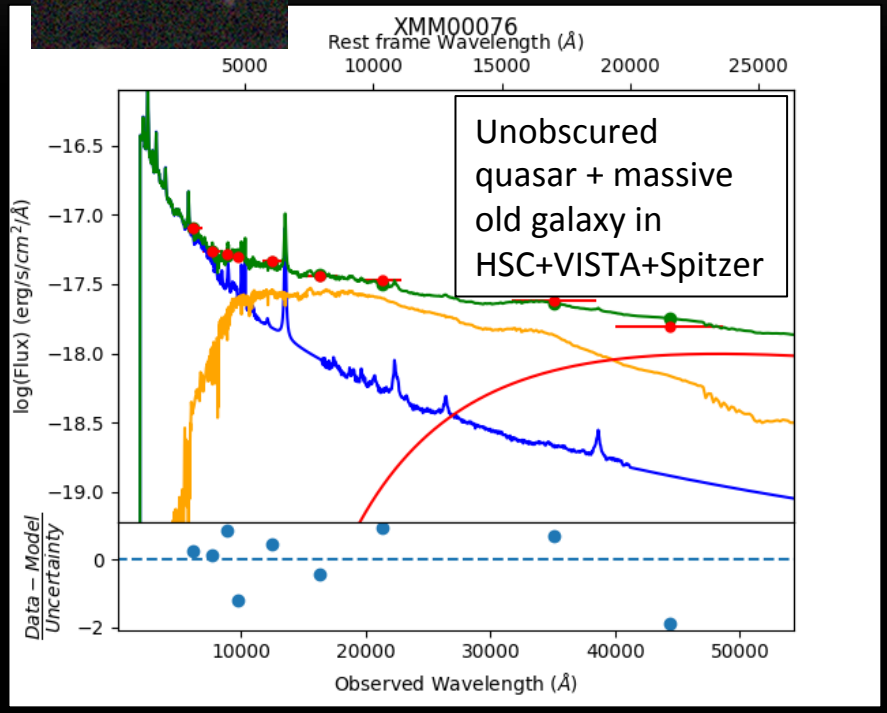
Temple, MB+19, Coatman,+19

AGN HOST GALAXIES





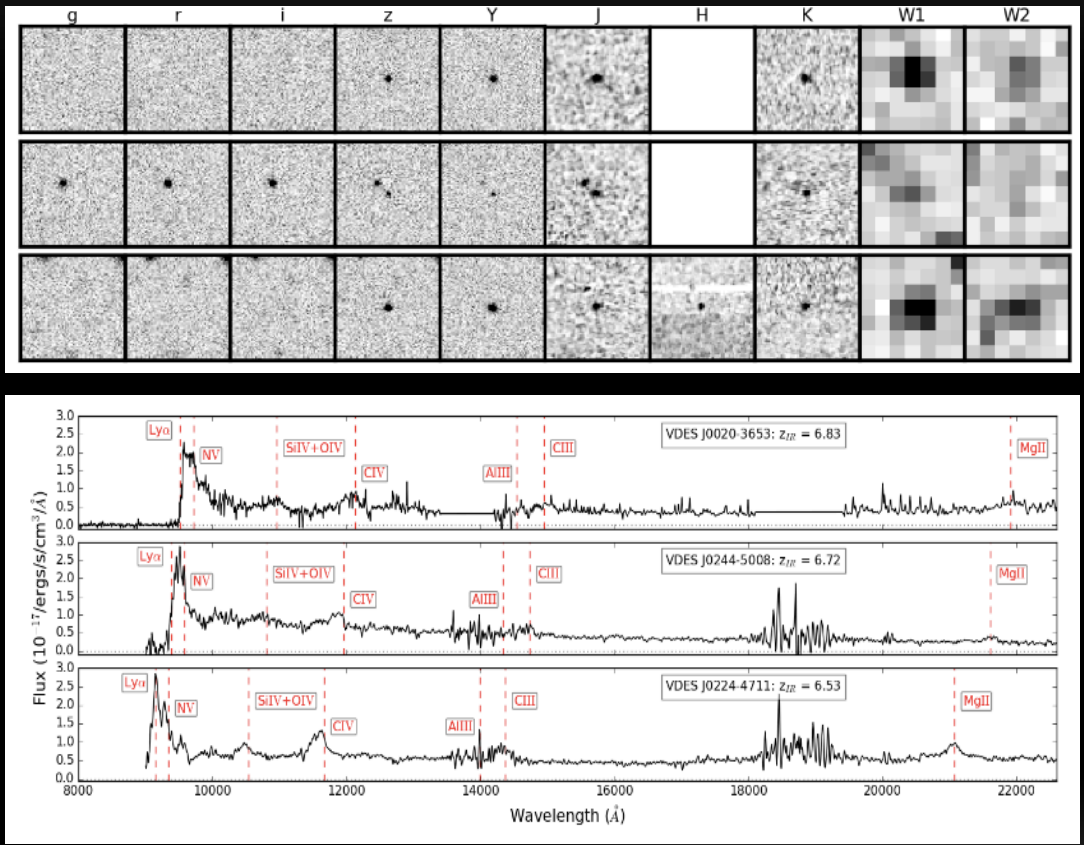
Wethers, MB+18



Marshall, Auger, MB + in prep

MSE will make it possible to decompose AGN and host galaxy emission from high SNR spectra (e.g. stacks from RM sample). H-band -> stellar mass measurements

THE EARLIEST SMBHS IN THE EPOCH OF REIONISATION



Reed, MB+19

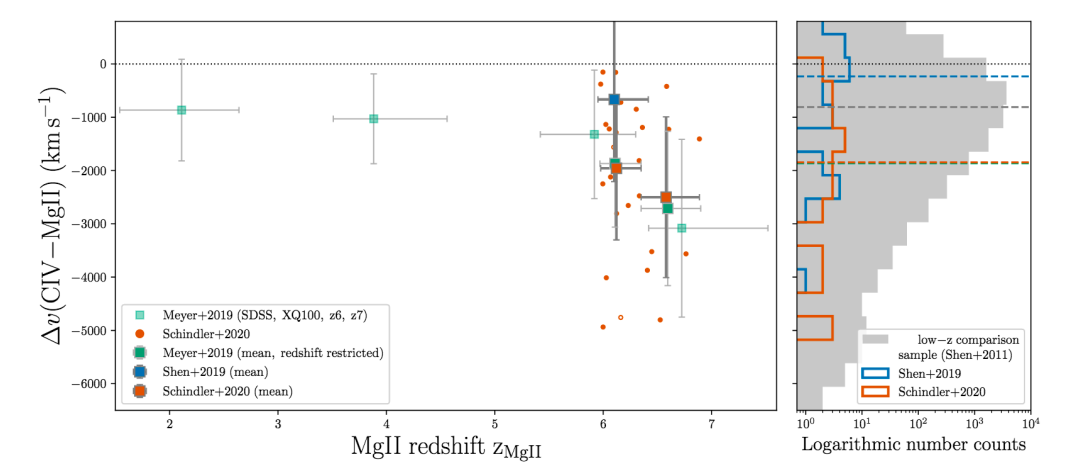
Hundreds of quasars now known at redshift > 6 (e.g. Jiang+16, Reed+17, Banados+16, Wang+19, Yang+19).

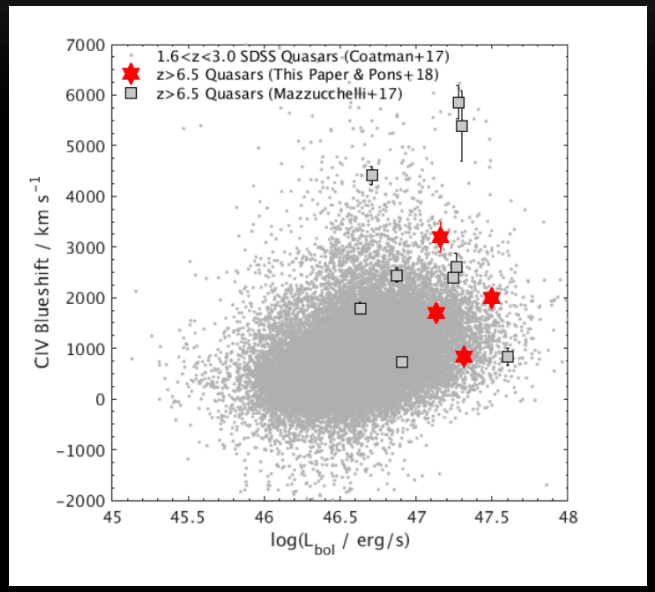
However still relatively few at z >7 (Mortlock+11, Banados+18, Yang+20) and also at low luminosities (Matsuoka+18). MSE will help build a large sample of z > 7.5 quasars as well as lower-L AGN at z~6.

NIR spectroscopy with MSE gives access to MgII emission line out to z~5 for BH mass estimates. High ionization lines e.g. CIV often biased by outflows (Coatman+16, 17)

AGN OUTFLOWS AT THE EPOCH OF REIONISATION

Schindler et al. 20



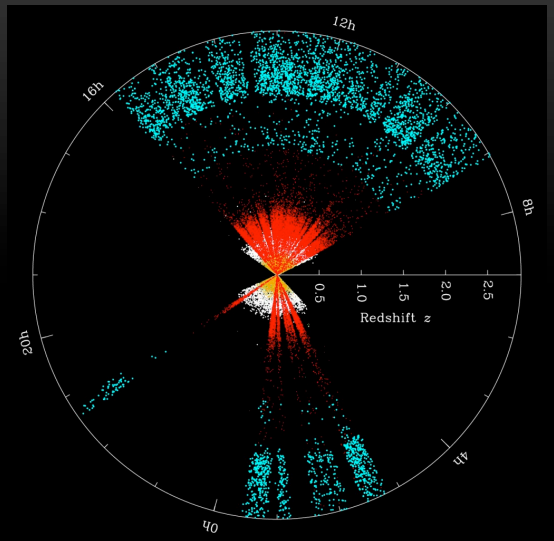


Reed, MB+19

Is there evidence that high-z quasars have stronger signatures of broad-line region outflows compared to their low-z counterparts? Is feedback more efficient in the high-z Universe? Evidence is currently mixed and limited by sample size

Much larger samples needed to confirm/refute any trends -> MSE

MSE AGN SCIENCE THEMES



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