Feeding X-ray Searches with the Brightest Optical Quasars

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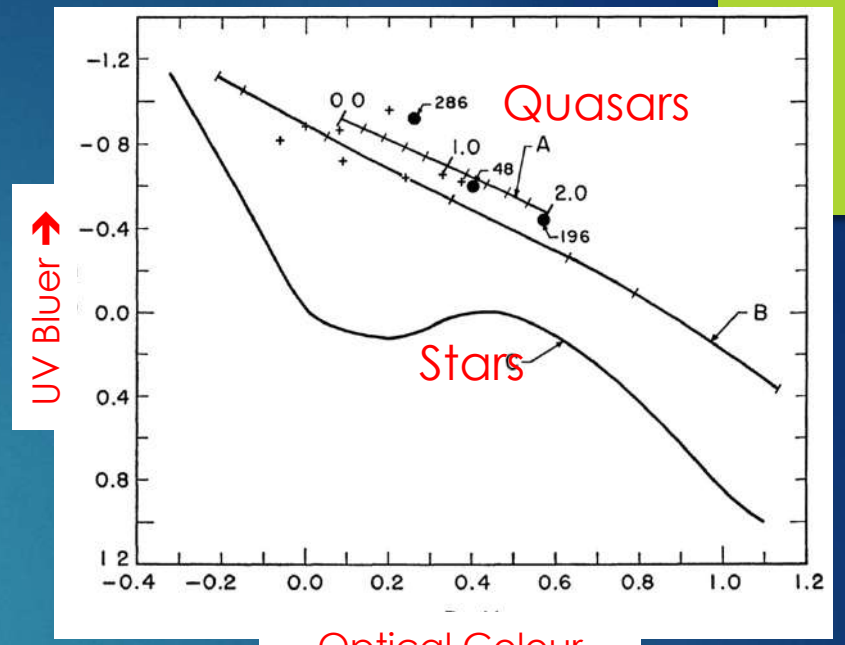
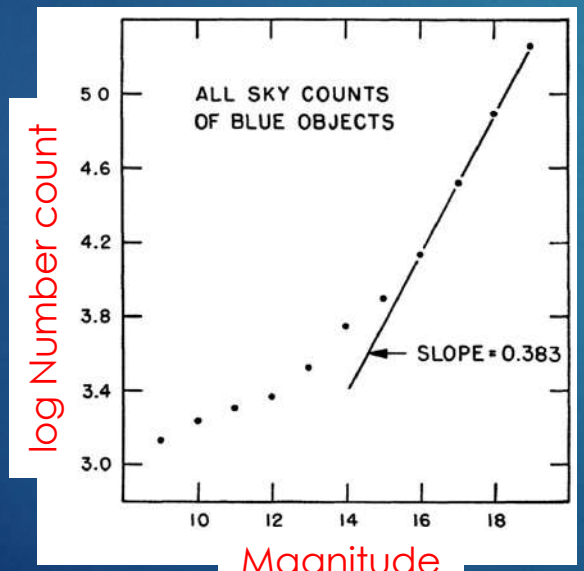
On behalf of the AllBRICQS team

Era 1: Quasars are Blue

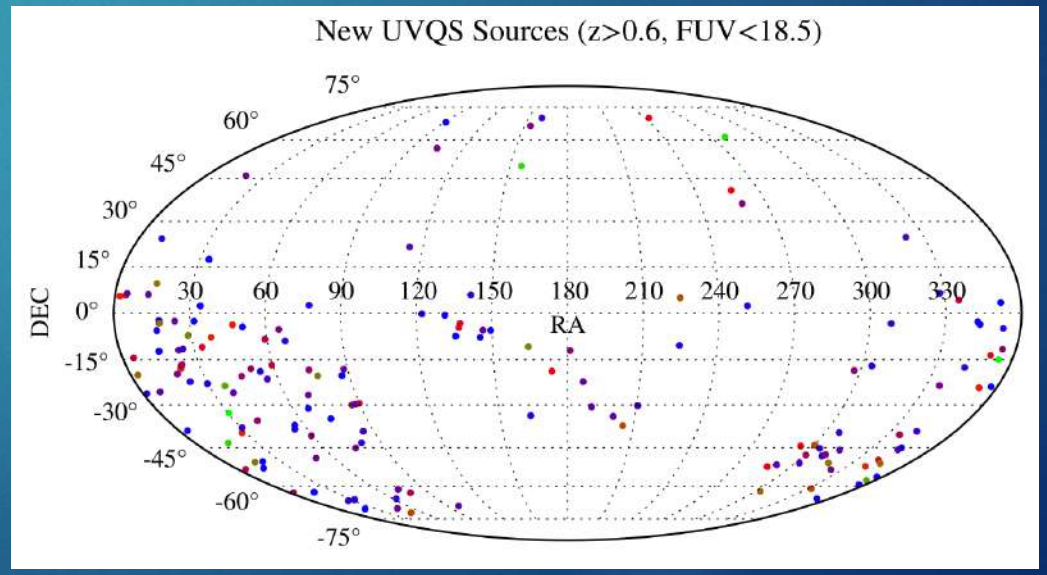
- Bluer than stars in ultraviolet
- Number densities dominate over halo stars beyond ~15mag
- Useful technique for over 50 years



Matthews & Sandage 1963



Sandage 1965

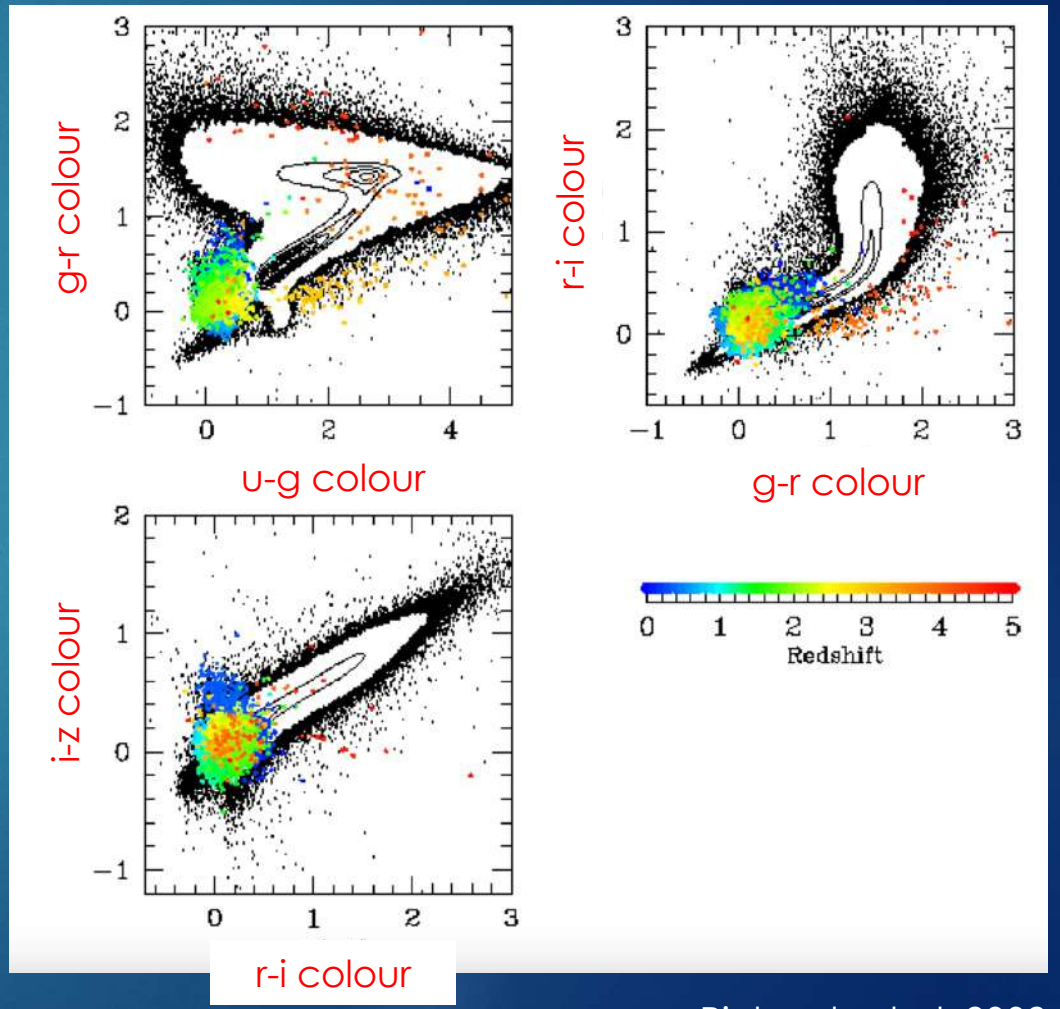


Monroe et al. 2016

Era 2:
Quasars Colours are Redshift-Dependent

- SDSS:
  - 4-colour selection
  - Supplemented with radio detections
  - Over 750,000 quasars in DR16Q (Lyke et al. 2020)

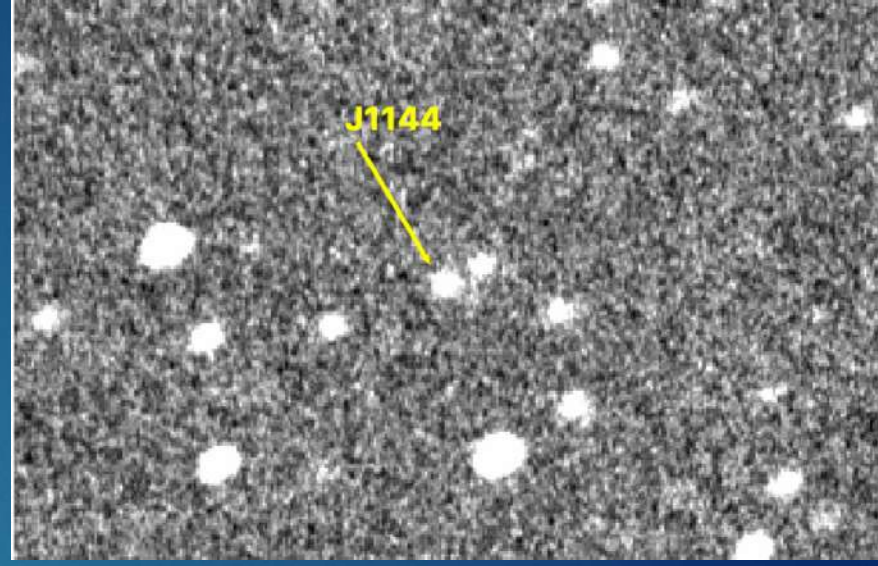
- SDSS has found > 75% of all spectroscopically confirmed quasars, but mostly faint and limited to SDSS sky area



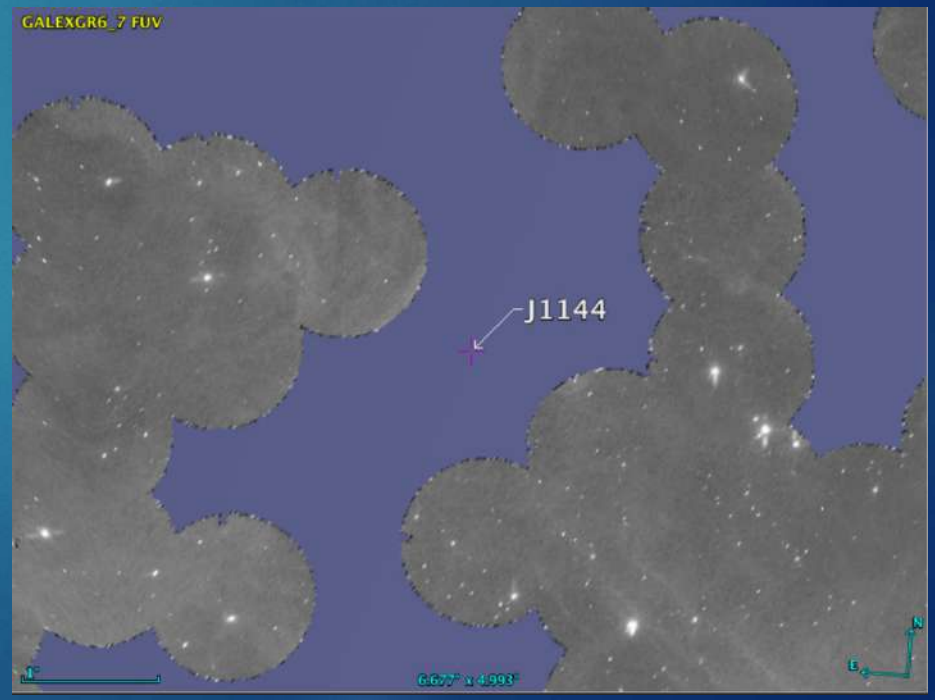
Richards et al. 2002

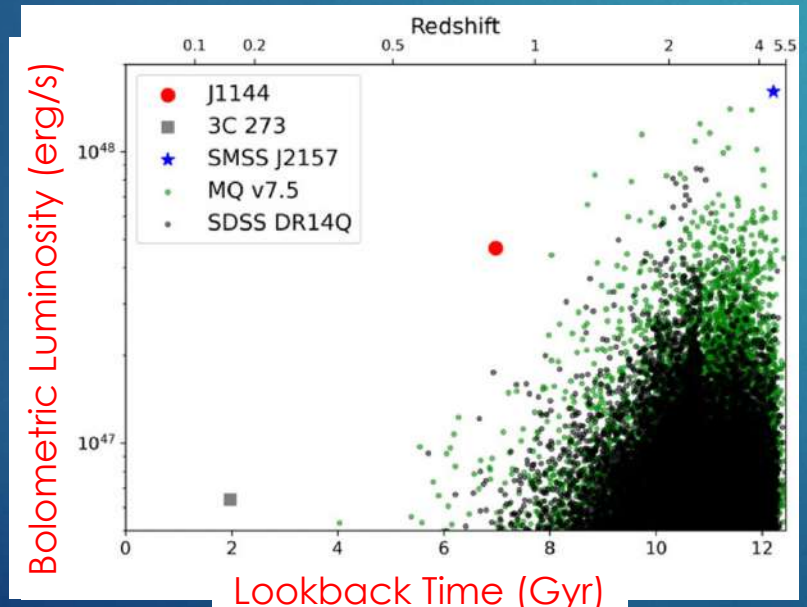
J1144-4308

- Redshift 0.8 quasar discovered in a search for Galactic symbiotic stars (A. Lucy, PhD thesis 2021)
- *Bp* = 14.6mag
- Optical images dating back to 1890
- Galactic latitude = 18.1deg
- Most luminous quasar to z~1.6
- eRASS1-5 variability (Kammoun et al. 2023)



GALEX FUV





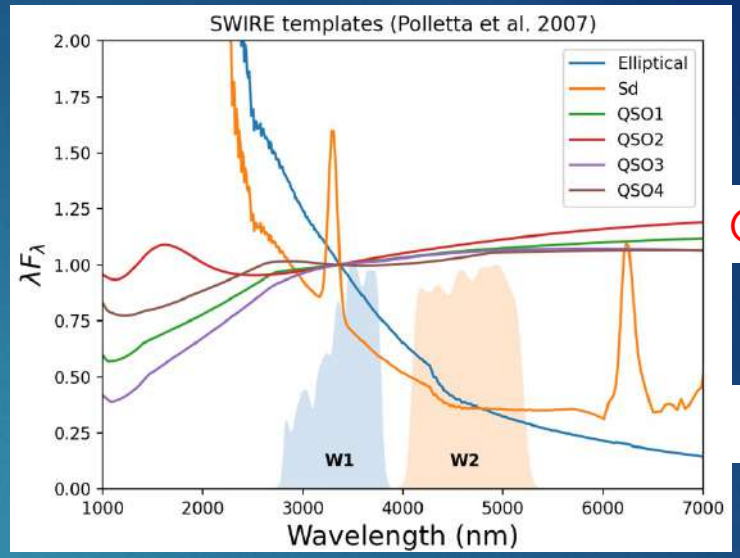
CAO et al. 2022

Era 3: Quasars are Red, Still

- Dust emission redder than stellar blackbody Rayleigh-Jeans tail
- ➔ *WISE* colour selection

- Stellar contamination remains high

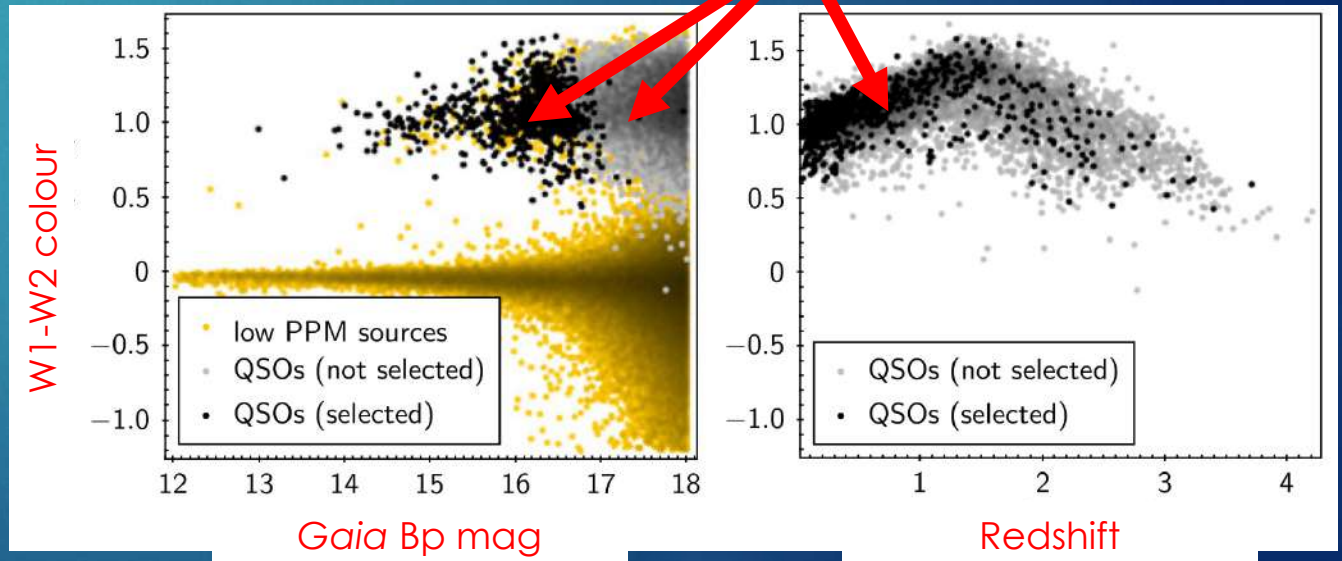
- Quasars don't move
- ➔ *Gaia* parallax and proper motion selection



Quasars

Stellar SEDs

Known quasars

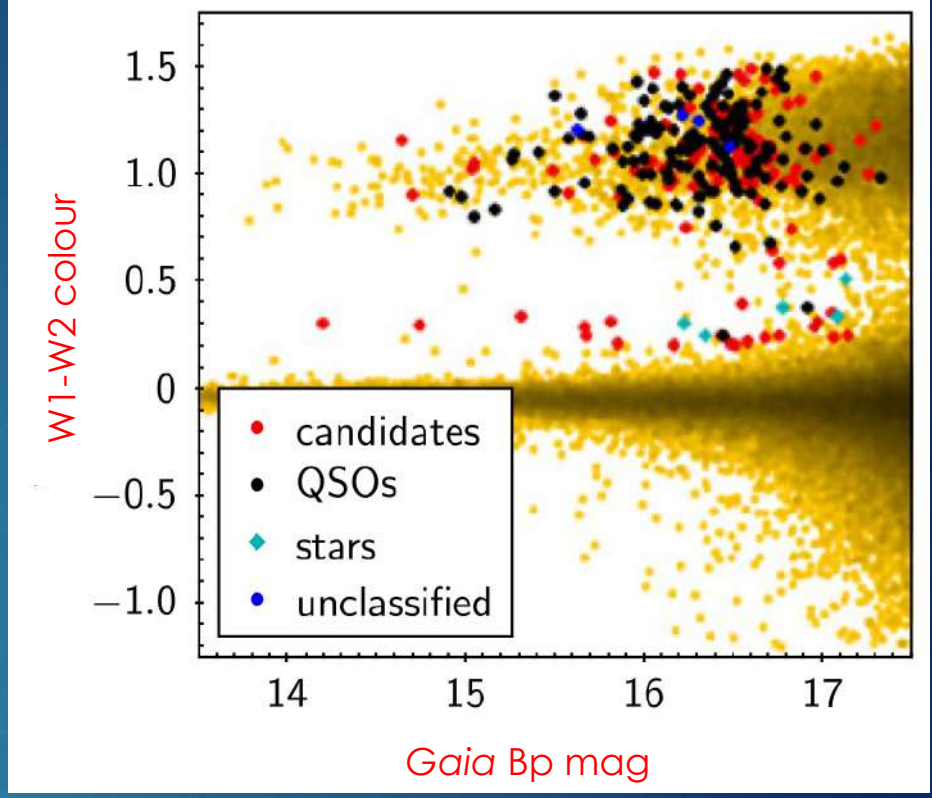


CAO et al. 2023

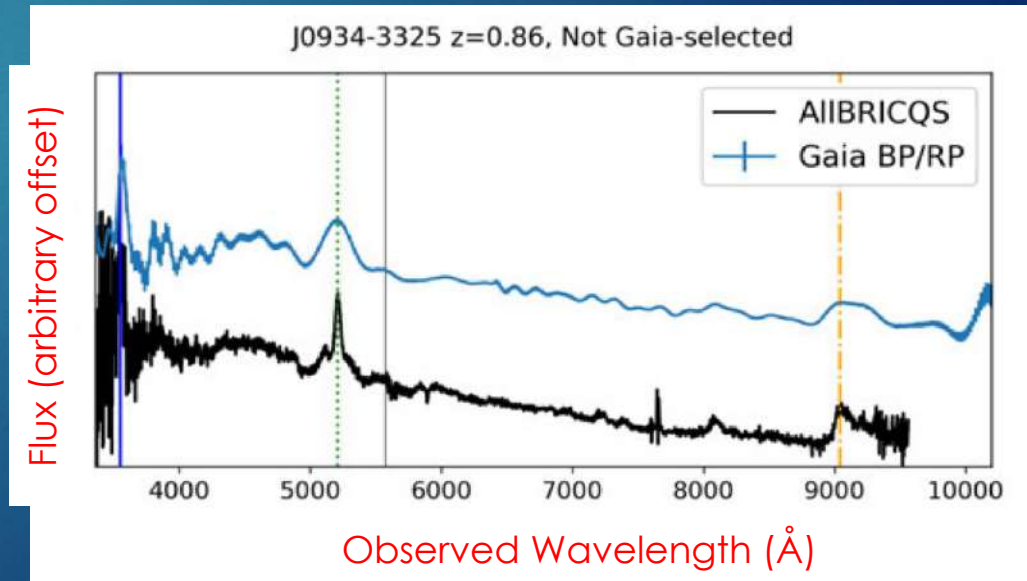
AllBRICQS

All-Sky Bright, Complete Quasar Survey

- Follow-up of candidates to *Bp*<16.5 or *Rp*<16mag
- |b| > 10deg
- Southern sample
  - ANU 2.3m / WiFeS IFU
  - 325-955nm, R>=3000
  - Paper I: CAO et al. 2023
    - 140 new quasars
    - 96% completeness
    - 96% purity
  - Paper 2 coming soon with more new quasars
- Northern sample
  - Collaborators in China & South Korea preparing publication now
  - ~50 new quasars, half within SDSS footprint



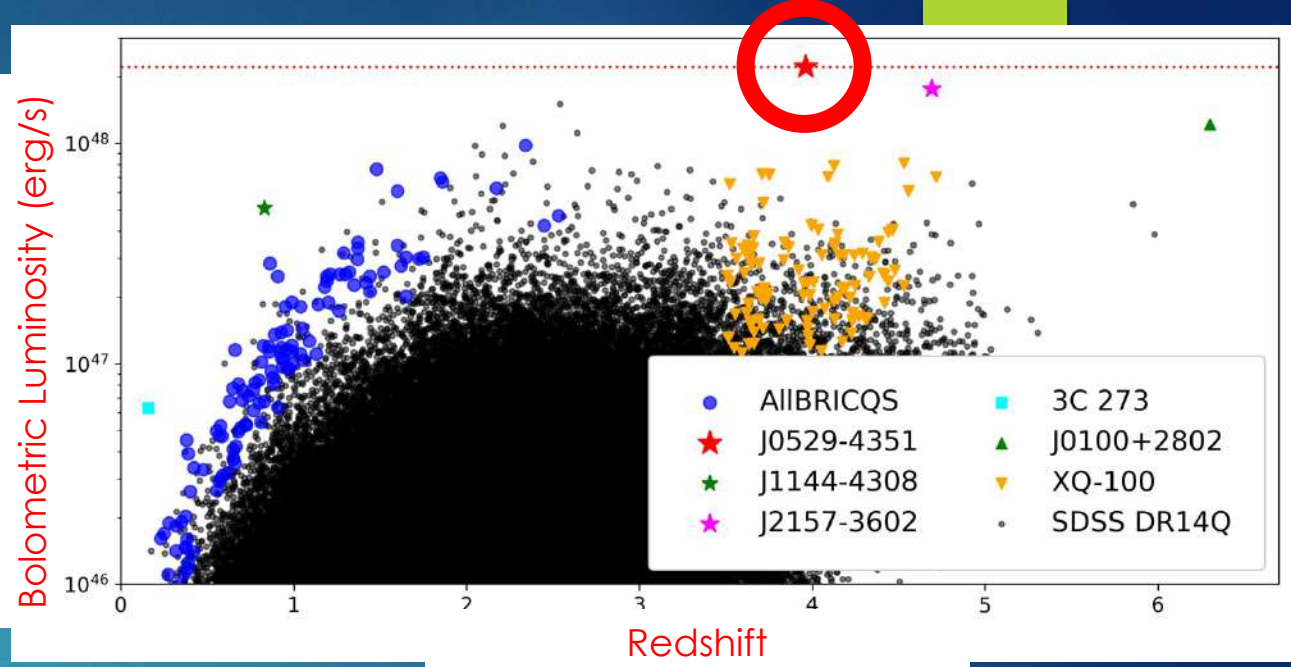
CAO et al. 2023



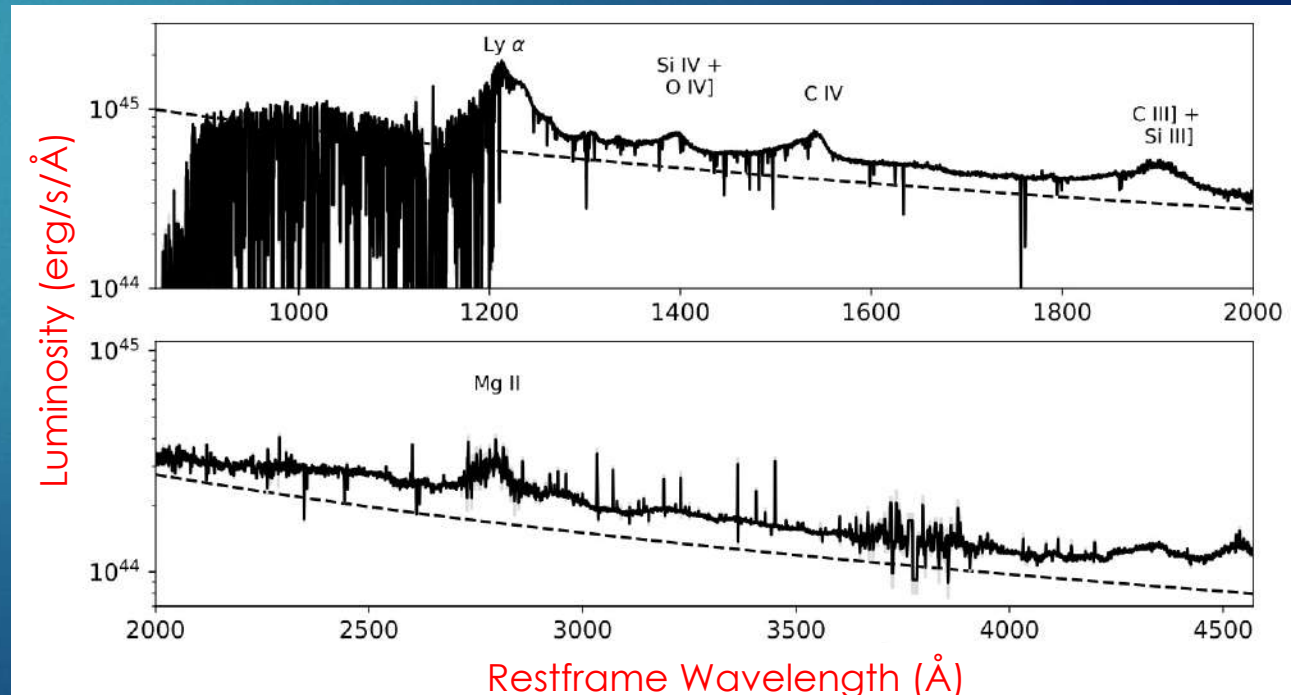
J0529-4351

- Part of first AllBRICQS paper
- Discovered independently by QUBRICS (Cristiani et al. 2023)

- VLT/X-Shooter spectrum
- BH mass = 17 billion M_{sun}
- Eddington ratio ~ 0.9
- No evidence of gravitational lensing
  - VLT/ERIS-NIX J/K AO-imaging in the current semester



Wolf, Lai, CAO, et al. 2024



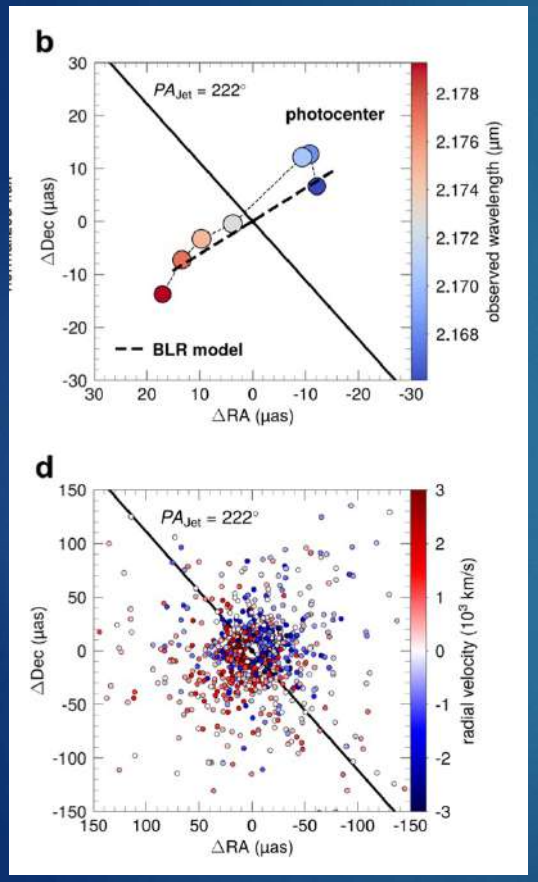
Extended Selection Criteria

- Relaxed W1-W2 limits has only revealed more stars
  - *WISE* photometry is reliable enough at these magnitudes
- Relaxed *Gaia* BP_RP_Excess_Factor limits
  - Among known quasars meeting the new criteria:
    - Half are low-z AGNs with detectable host galaxies
    - Half are z=1-3 quasars with neighbours (projected or real) or gravitational lenses
  - Another 92 sources being followed up
    - 15 observed so far
    - 5 $z<0.4$ quasars, 6 $z>0.4$ quasars, 1 galaxy, and 3 unidentified

Utilising Bright Quasars

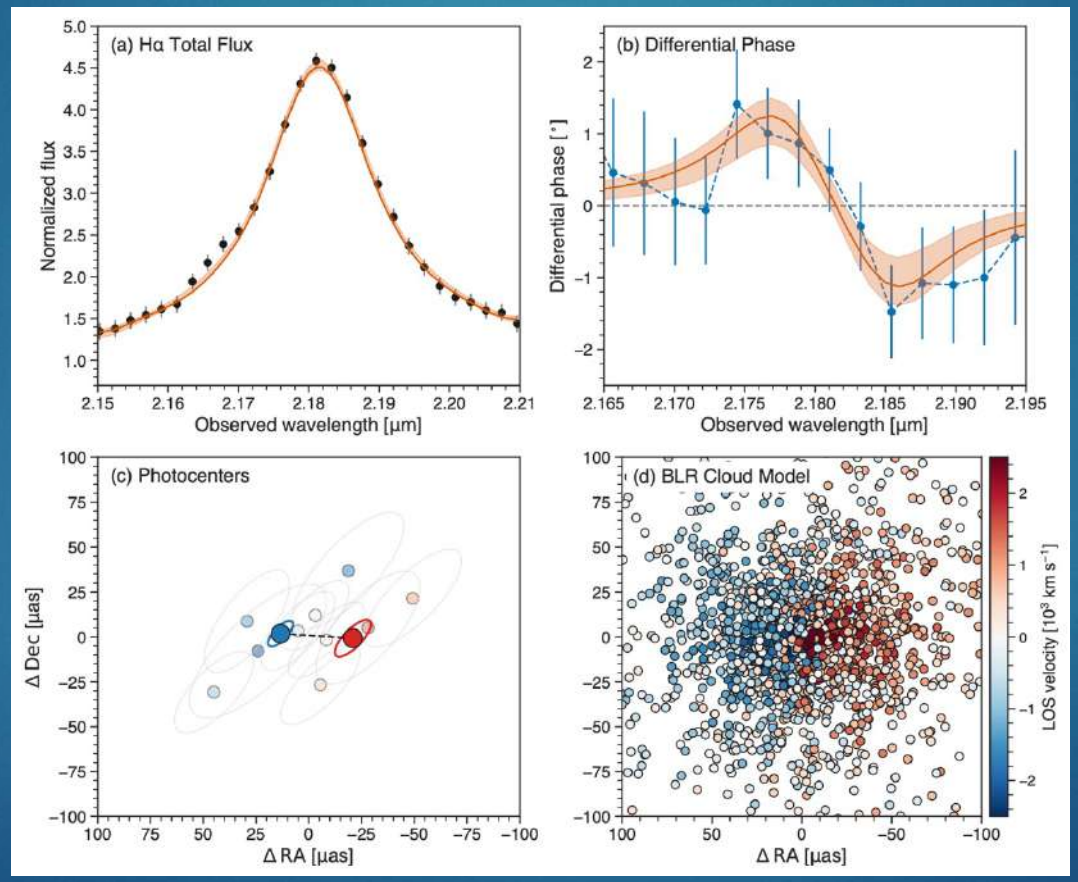
VLT/GRAVITY Interferometric BLR sizes

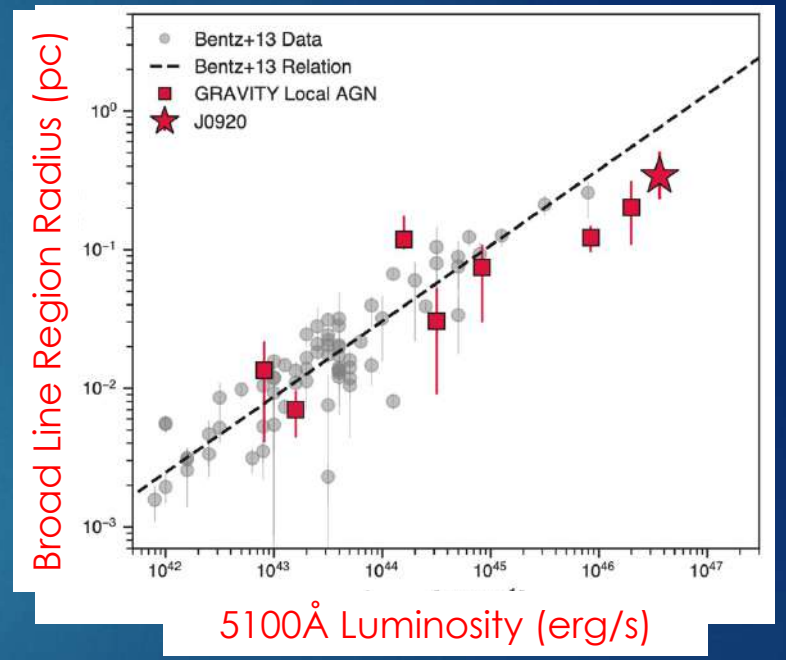
3C 273, z=0.158



GRAVITY Collab. et al. 2018

SDSS J0920, z=2.3

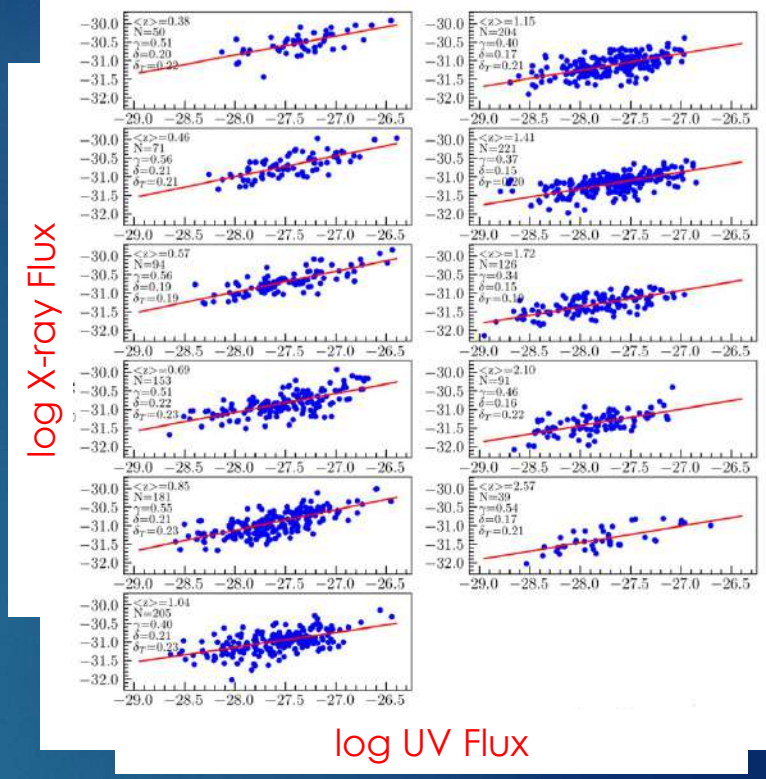




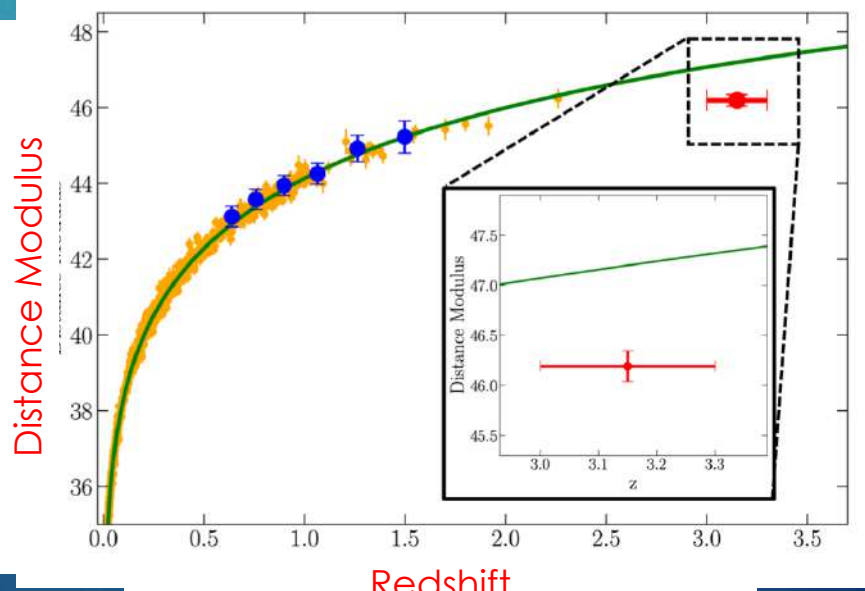
Abuter et al. 2024

X-ray Connections

- L_X – L_UV
  - Non-linear relation means flux ratio determines L_UV
  - Flux and luminosity → D_L
  - D_L and redshift → cosmology
- Want the most complete samples at high L to ensure best possible constraint on UV-Xray relation for application across redshift



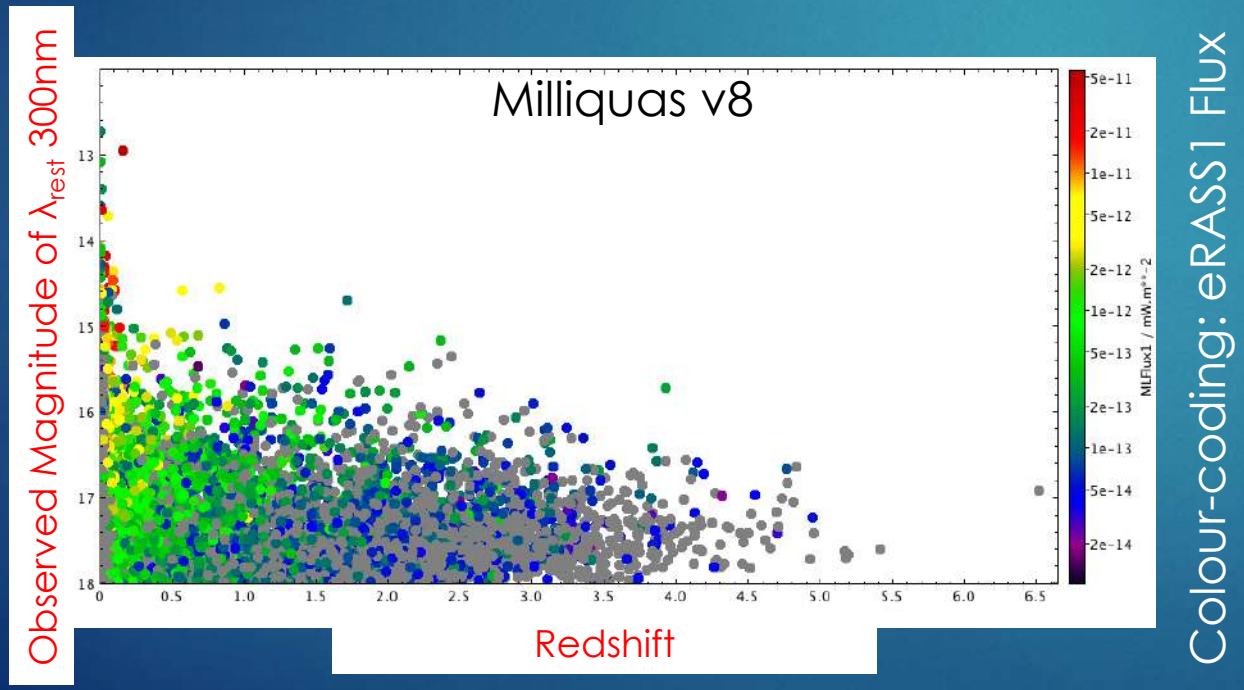
Signorini et al. 2023

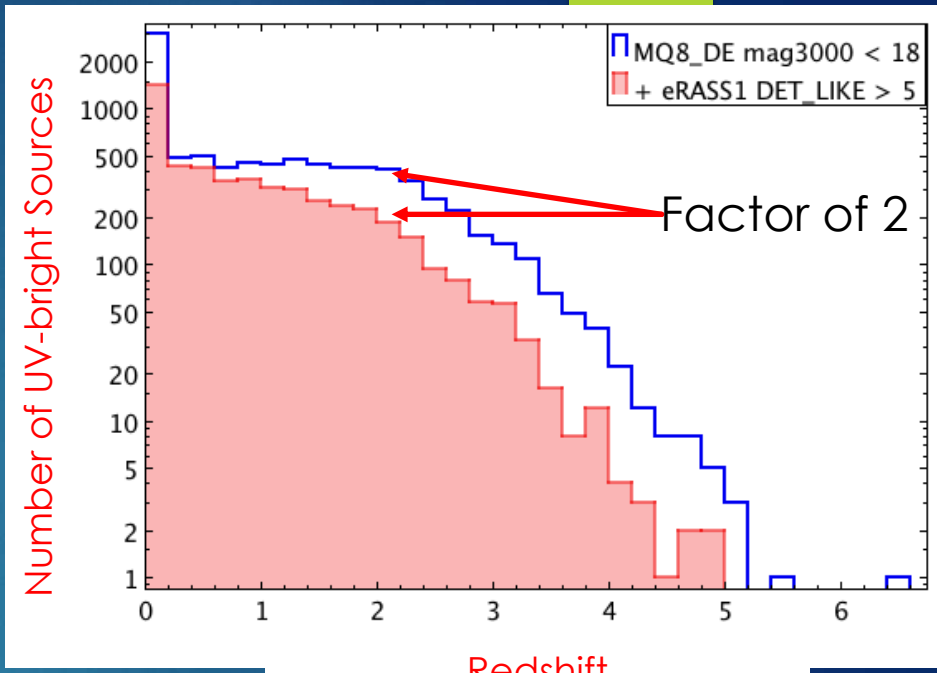


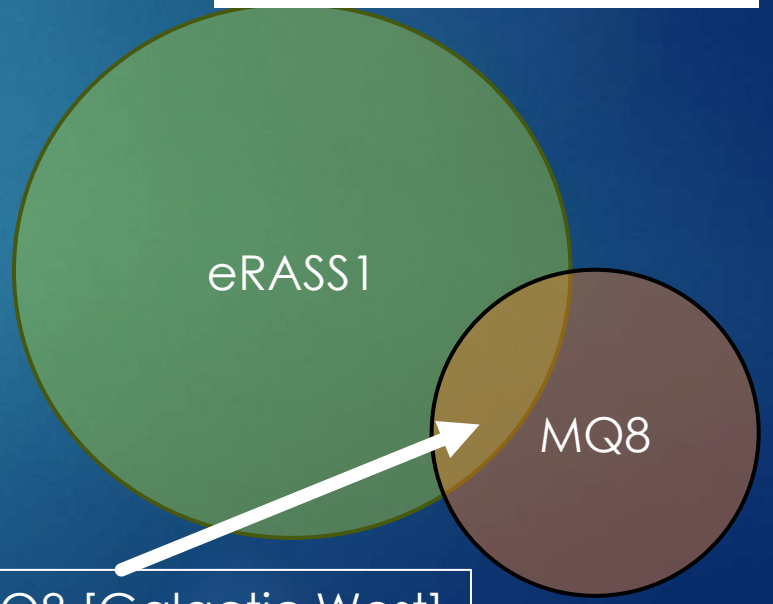
Sacchi et al. 2022

Understanding AGNs

- Bright optical quasars must have minimal extinction
- Best laboratory for a clean view of the diversity of optical – X-ray relationships



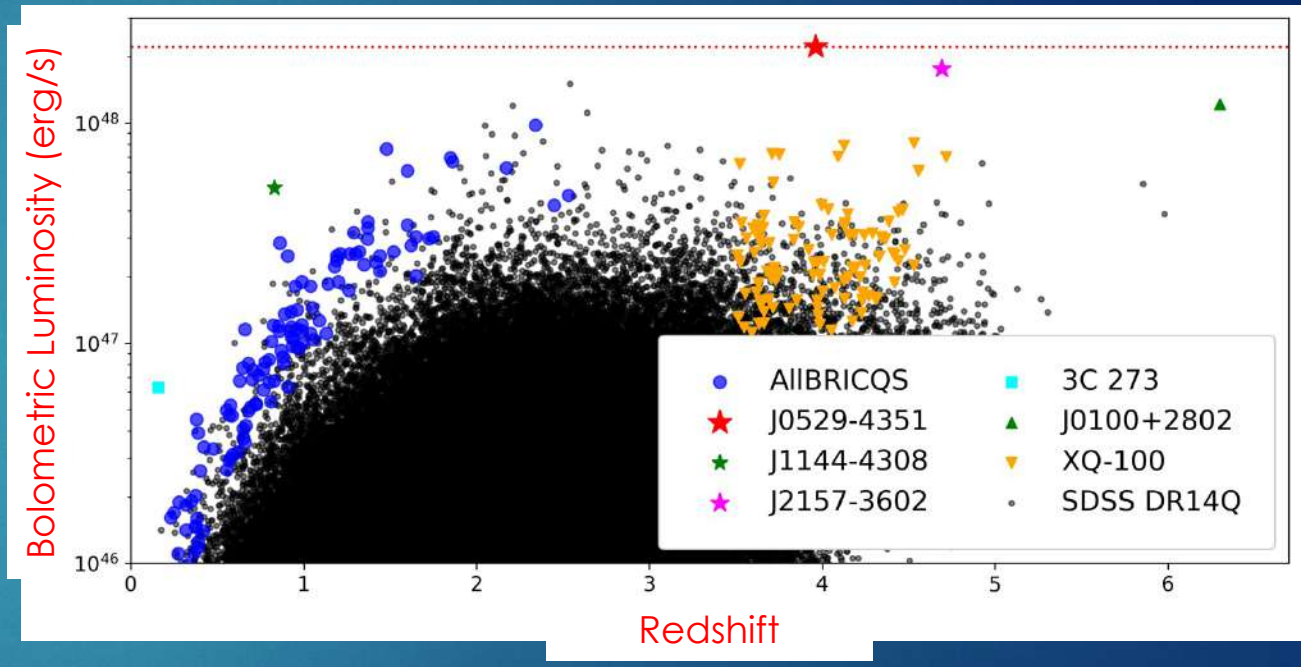




15% of MQ8 [Galactic West]
5% of eRASS1-main

More to do?

- Do we need to push fainter to avoid leaving a luminosity gap?
- SDSS-V and 4MOST bright limits not firmly defined and mostly aim for large numbers rather than complete coverage
- Photometric and astrometric noise will see increased contamination at fainter magnitudes
- But ANU 2.3m could probe deeper than current AllBRICQS limits



Wolf, Lai, CAO, et al. 2024

AllBRICQS + eRASS

- AllBRICQS has contributed ~15% of UV-luminous (m300<16.5) distant (z>0.3) eRASS1 quasar detections
- Fully complete optical samples will enable inclusion of lower-significance eRASS detections

A bright future ahead!