



Illuminating the Dark Ages

Very high redshift quasars in
VIKING+KiDS

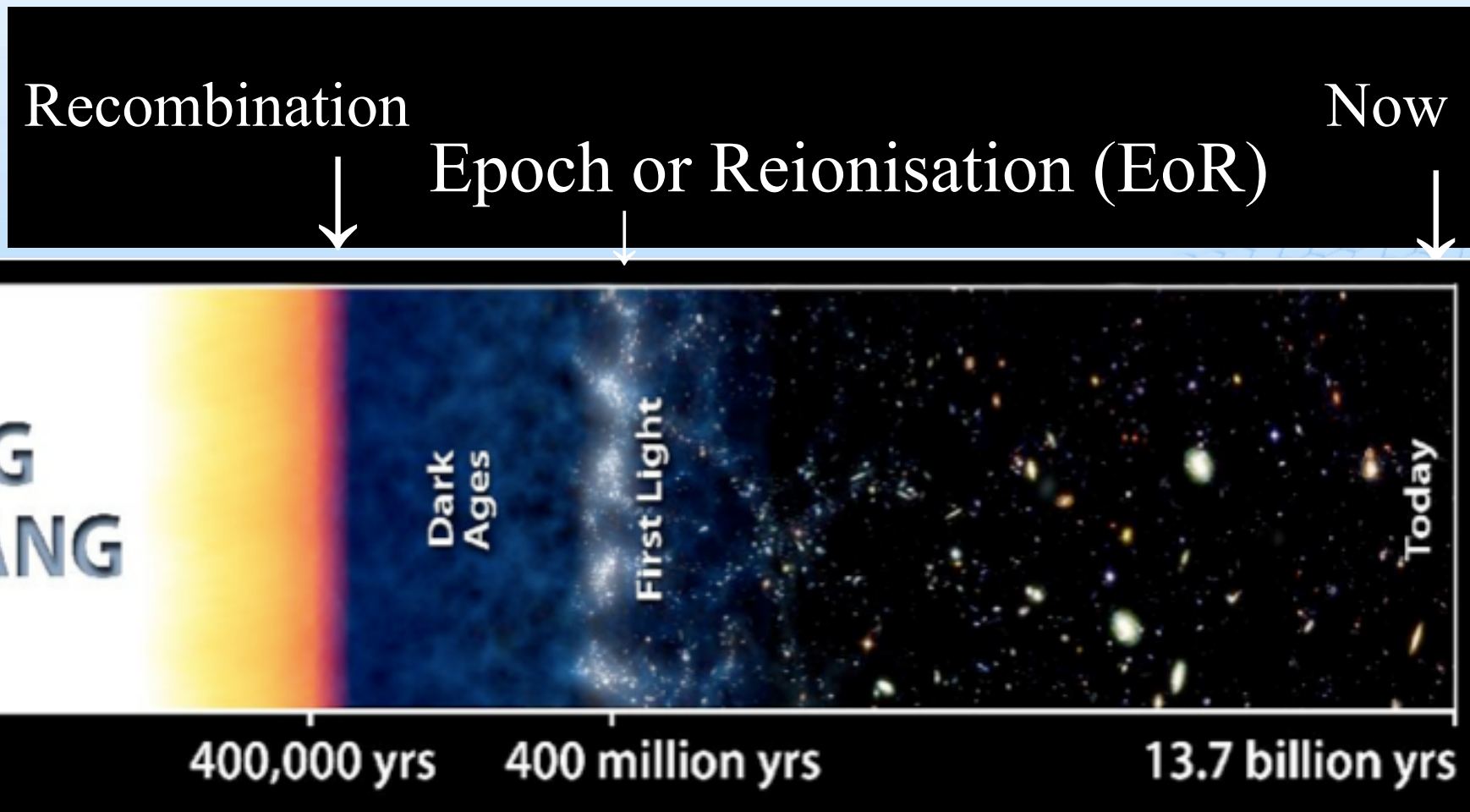
Bram Venemans (MPIA Heidelberg)



Collaborators

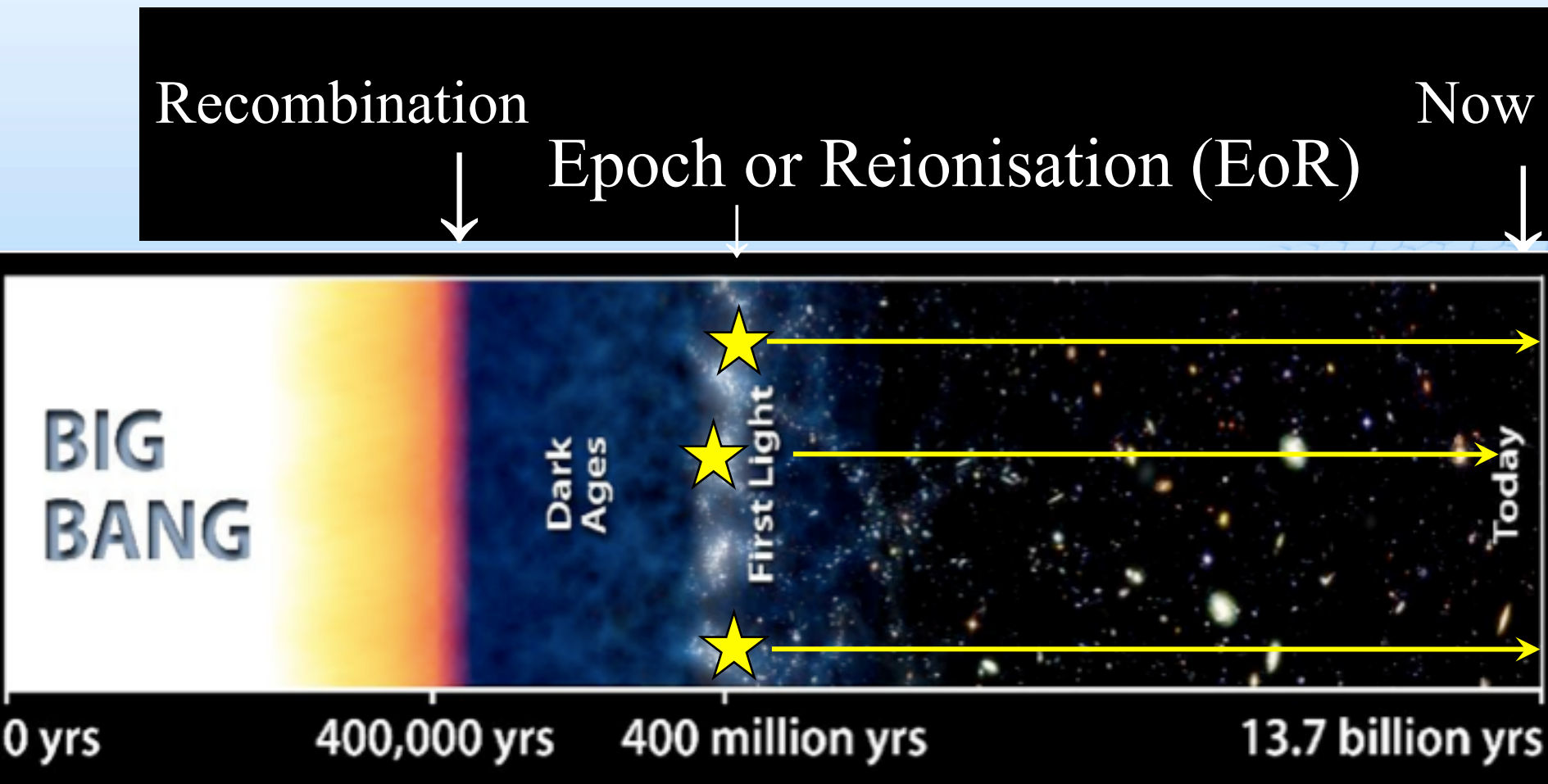
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- Richard McMahon (IoA Cambridge)
- Will Sutherland (QMUL)
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Very high redshift quasars



Time after Big Bang →

Very high redshift quasars



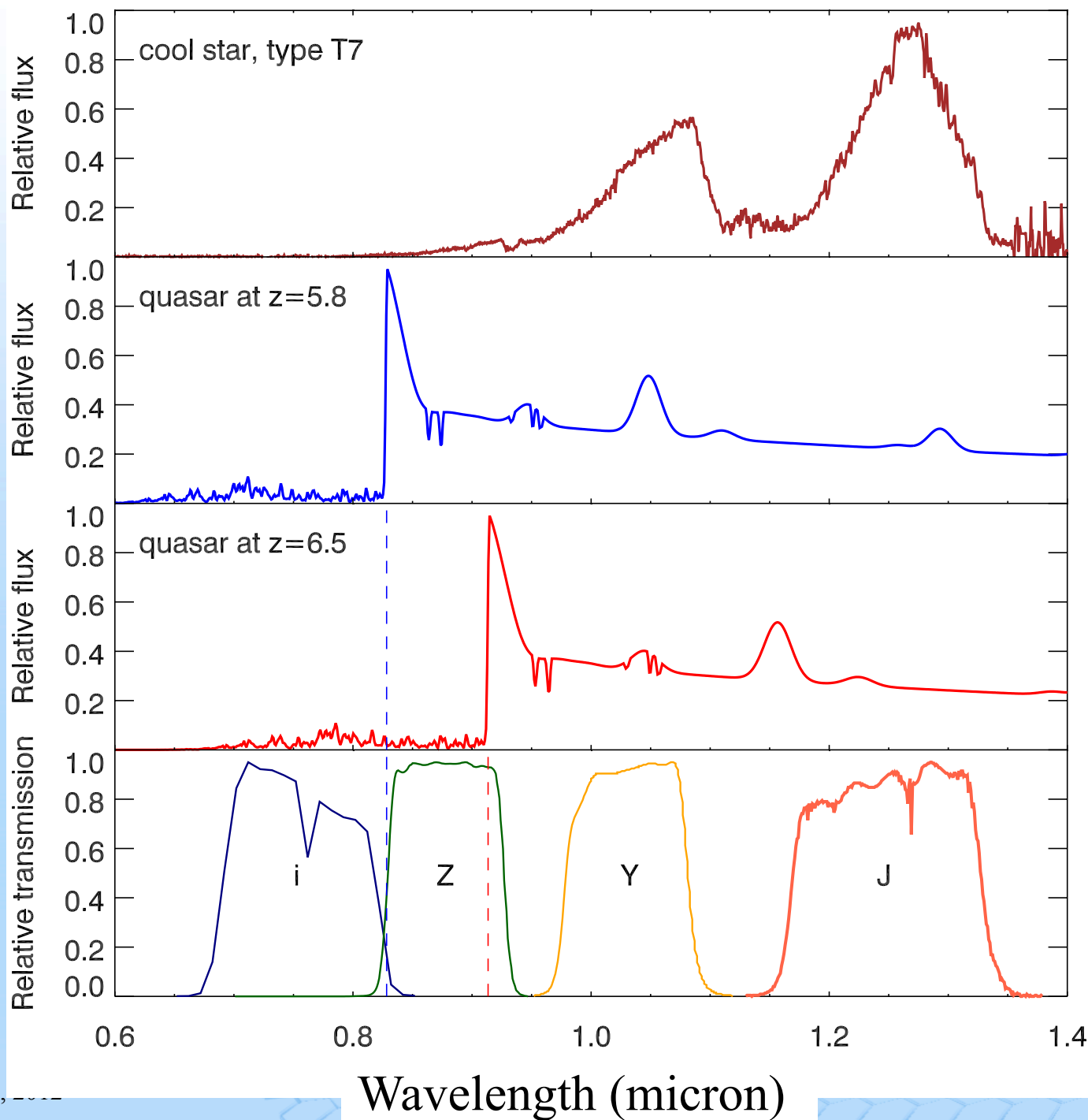
Time after Big Bang →

Quasars as probes of the EoR

- Quasars at redshifts $z \gtrsim 6$ can be used to:
 - determine the state of the intergalactic medium
 - measure space density of massive black holes
 - study the formation of massive hosts
 - locate galaxy overdensities in the early Universe
- Rare objects good way to test pipelines!

Quasars at $z \gtrsim 6$: optical searches

- Over 50 $z > 5.8$ quasars found in e.g. SDSS
- Most distant quasars at $z \sim 6.4$
- Hardly any progress in last decade
- Ly alpha line shifting out of z-band



Near infrared wide field surveys



- UK Infrared Deep Sky Survey (UKIDSS)
- Pan-Starrs: includes Y, a filter redward of z-band
- ESO VISTA surveys
- Just started: Dark Energy Survey, VST/ATLAS, ...

UK Infrared Deep Sky Survey

- Large Area Survey (LAS) will cover up to 4000 deg² in YJHK, depths matched to SDSS
- Good survey to look for quasars!
- Currently areal coverage is >3100 deg²
- Look for objects that are not visible in SDSS

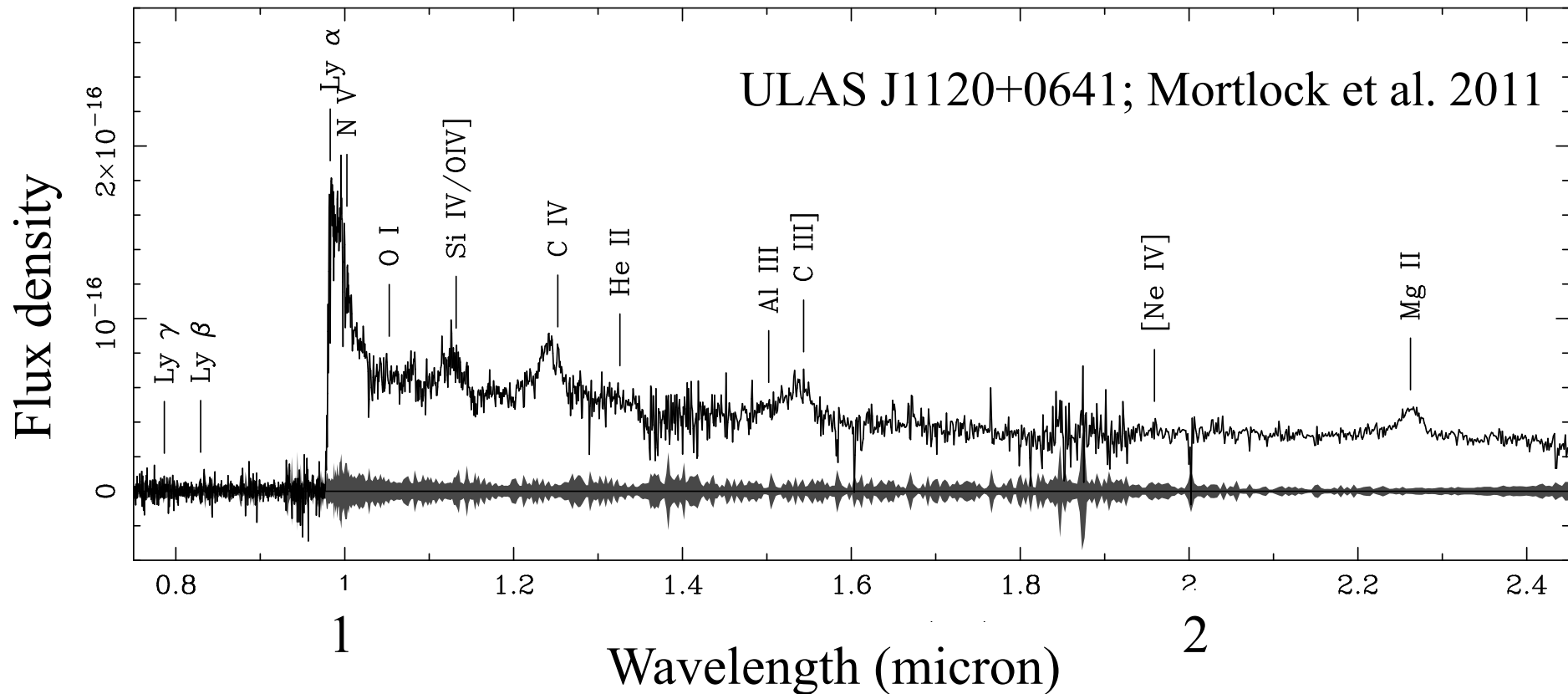
A luminous quasar at $z=7.1$ in UKIDSS



Bright quasar: $K_{\text{vega}}=17.7$, $M_{1450} = -26.6$

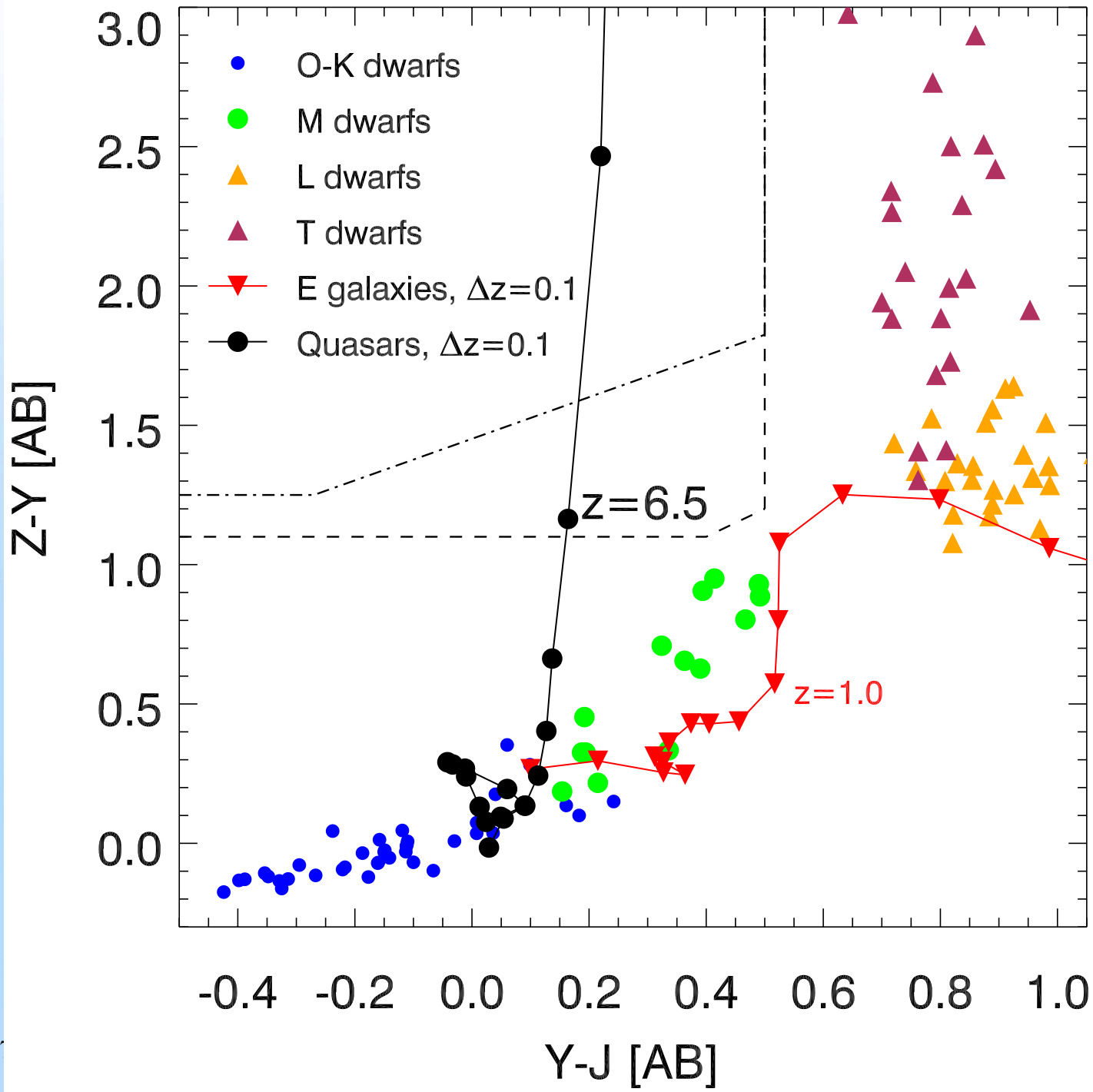
Black hole mass of $2 \times 10^9 M_{\odot}$

ULAS J1120+0641; Mortlock et al. 2011



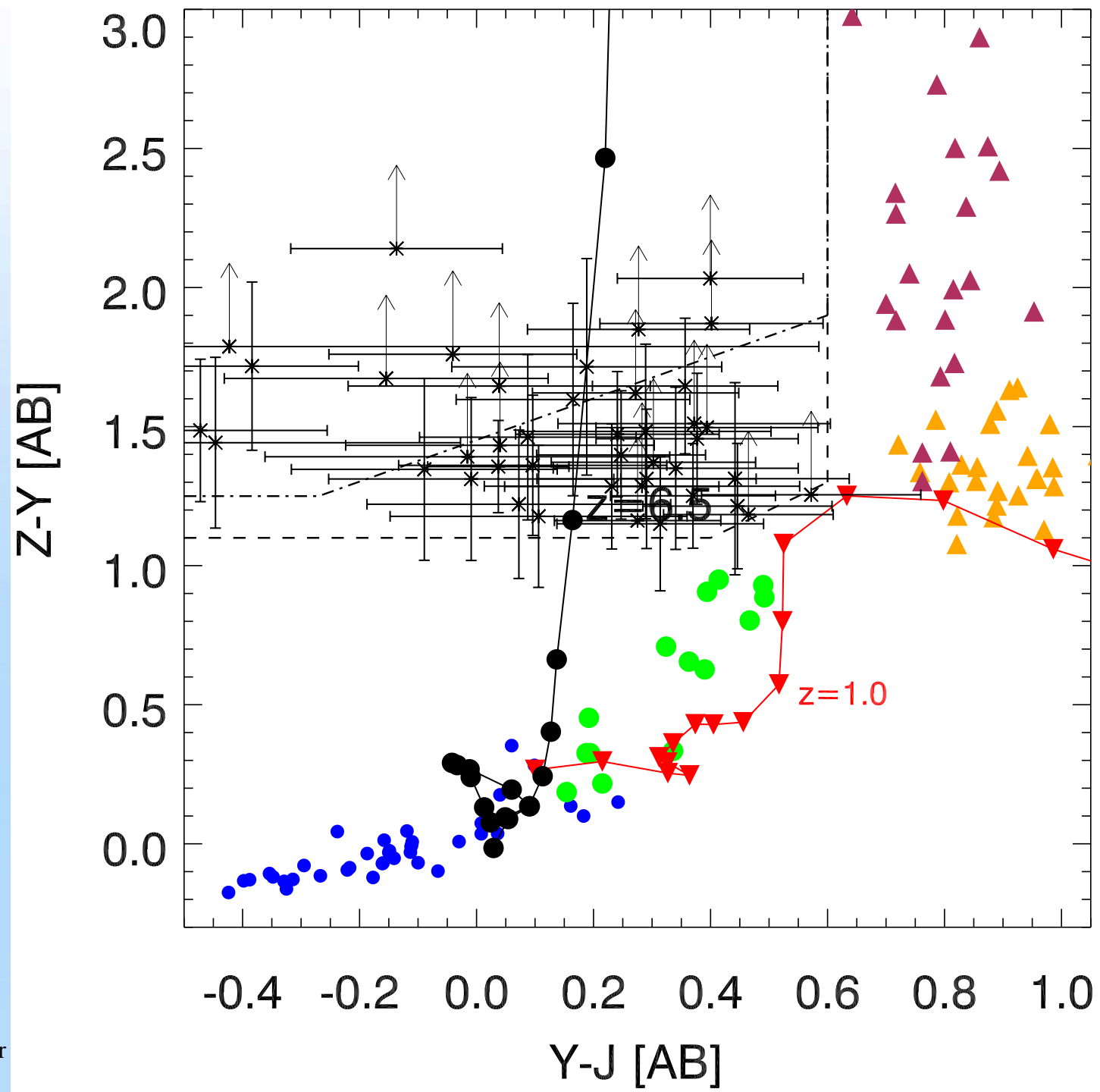
New IR survey: VISTA/VIKING

- Advantages of VIKING in quasar search:
 - deeper than UKIDSS LAS \rightarrow more quasars / deg^2
 - Z band also taken \rightarrow no matching of surveys
 - four infrared bands, additional colour information
- \rightarrow VISTA/VIKING: 1500 deg^2 , > 1 mag fainter than LAS
- Disadvantage of VIKING:
 - no deep optical imaging available

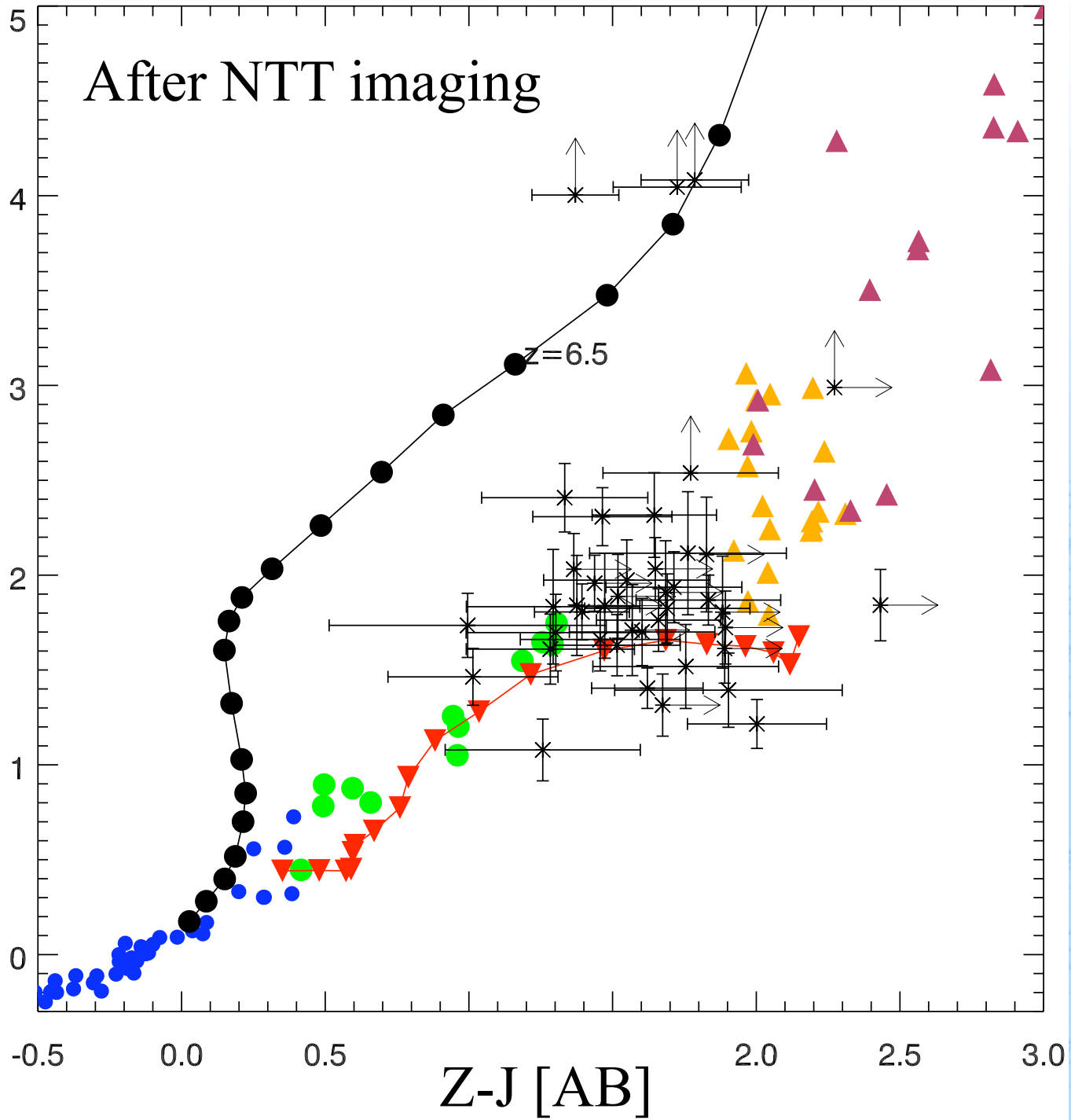


Quasar selection in VIKING

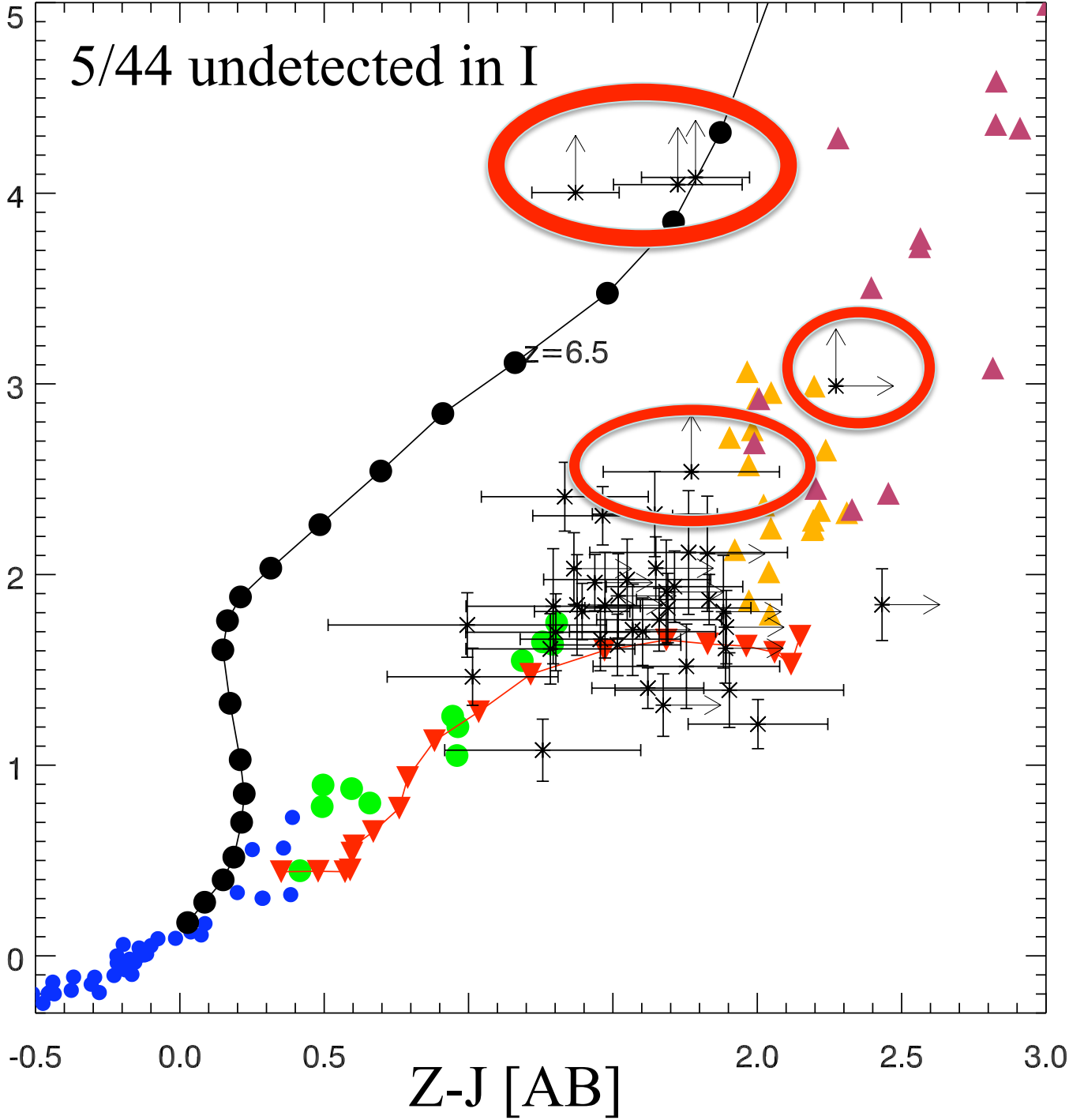
- Selected Z dropouts in first ~ 300 deg²
 - Test parameters for star/galaxy separation
 - Identify types of spurious objects
 - Test different colour criteria
 - Estimate completeness
- Followup optical imaging with the NTT

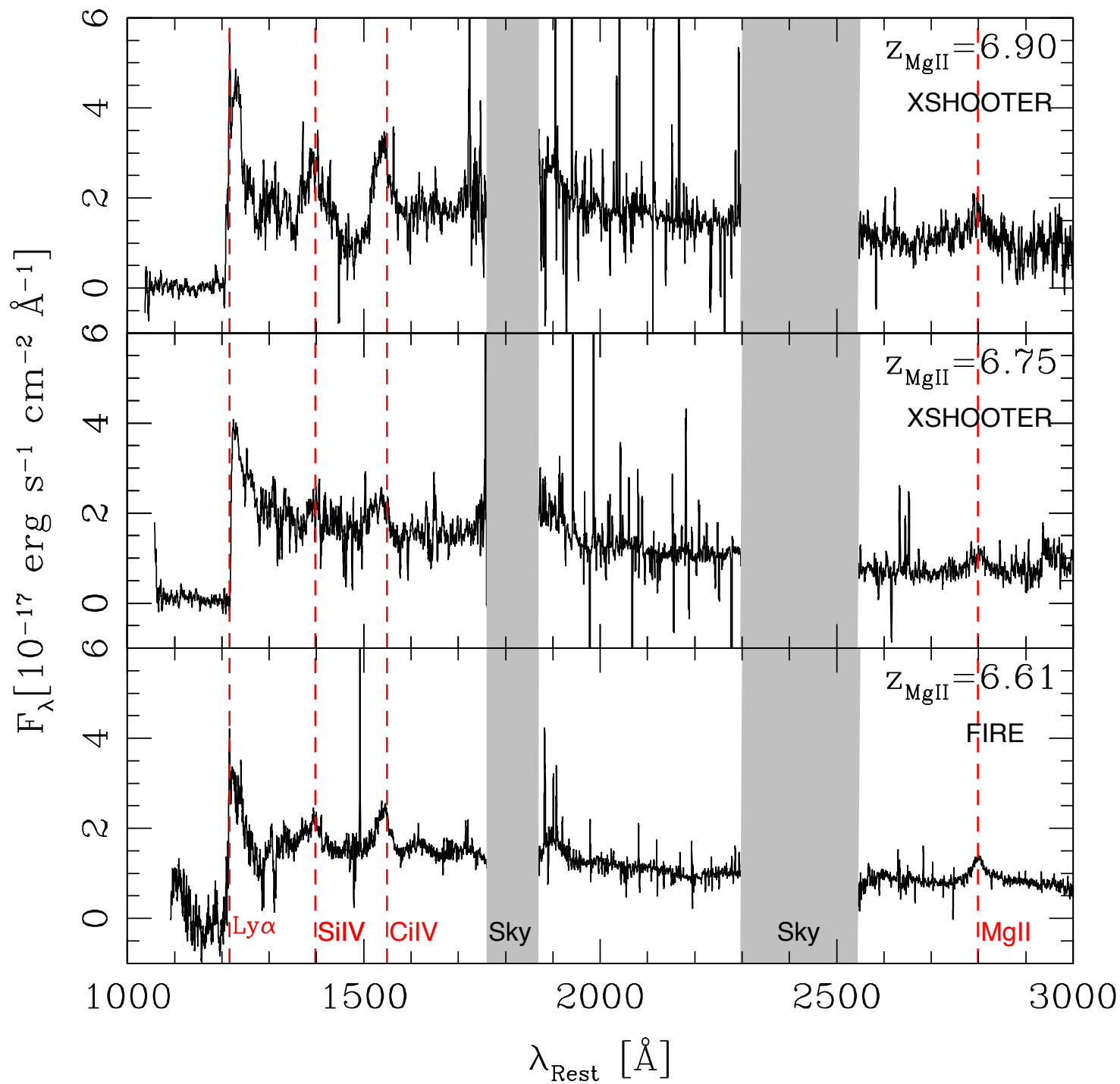


NTT I-Y [AB]



NTT I-Y [AB]

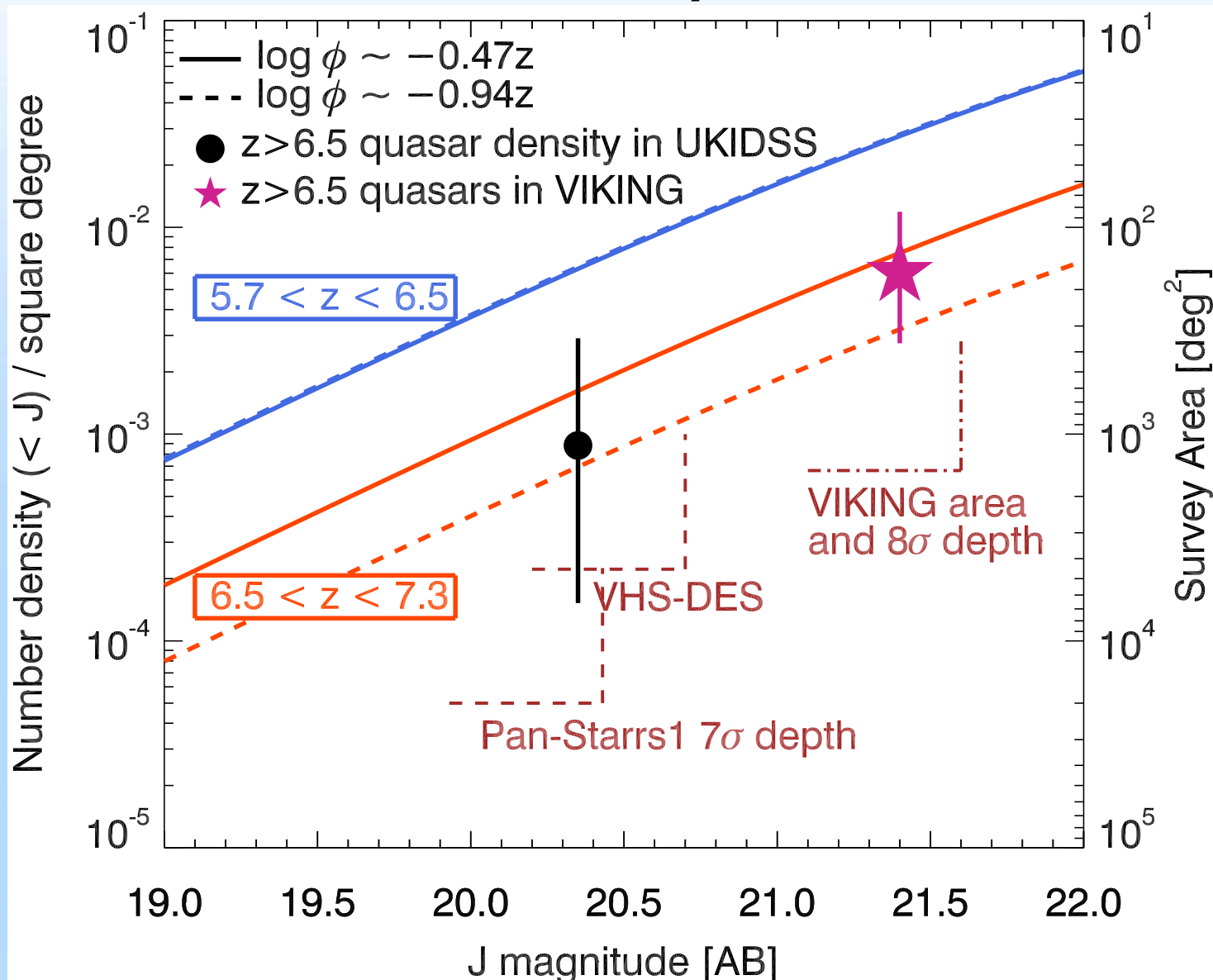




New high redshift quasars in VIKING

- 3/5 spectroscopic targets at $z > 6.5$
- Other 2 are stars \rightarrow star/galaxy separation ok
- Analysis of new quasars is ongoing
 - Black hole masses $\sim 1 \times 10^9 M_{\text{sun}}$
 - M_{UV} between -25.7 and -25.9
 - Ideal targets for ALMA & E-ELT
- Estimate point source completeness

Quasar luminosity function

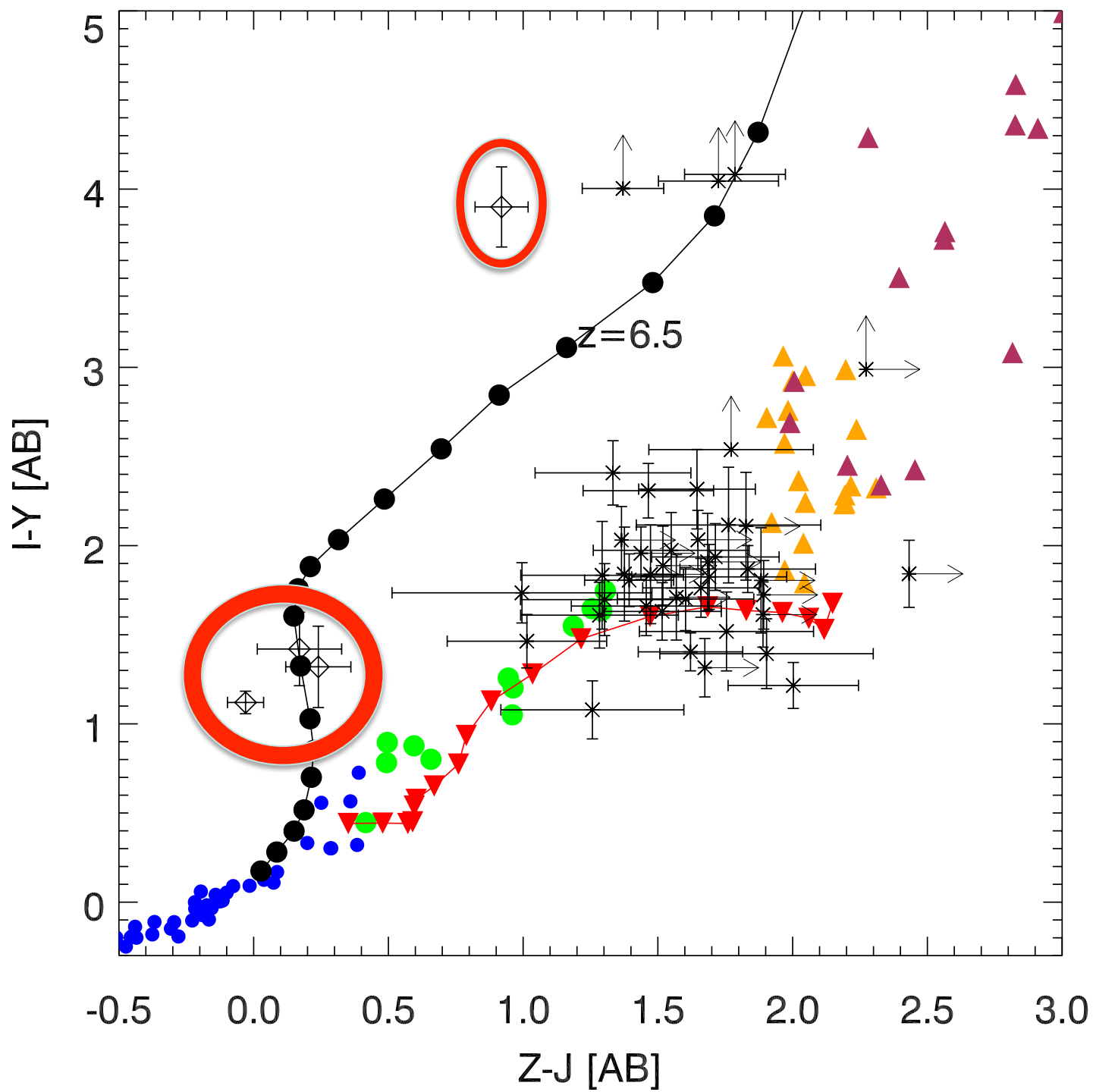


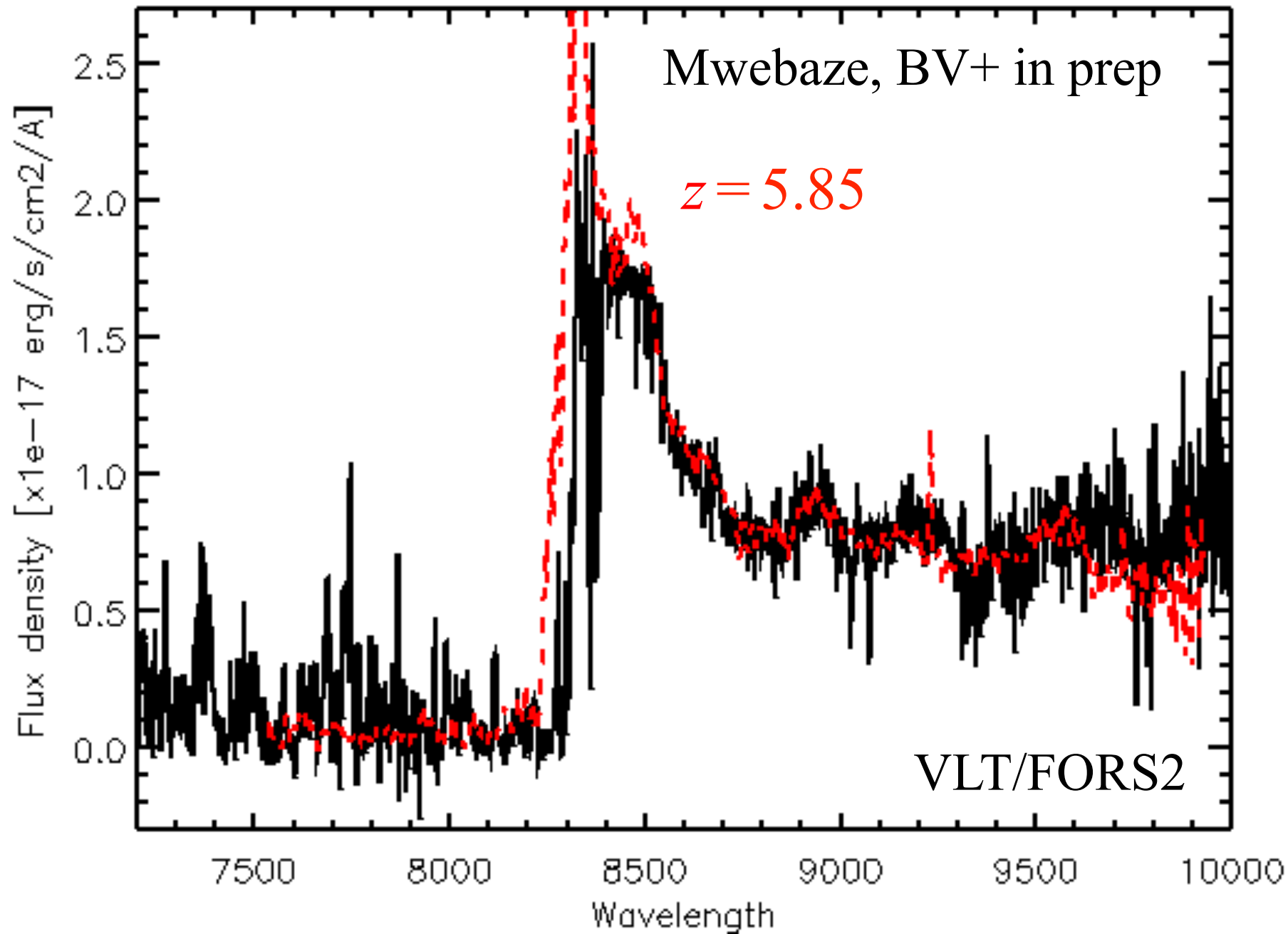
Quasar search in VIKING+KiDS

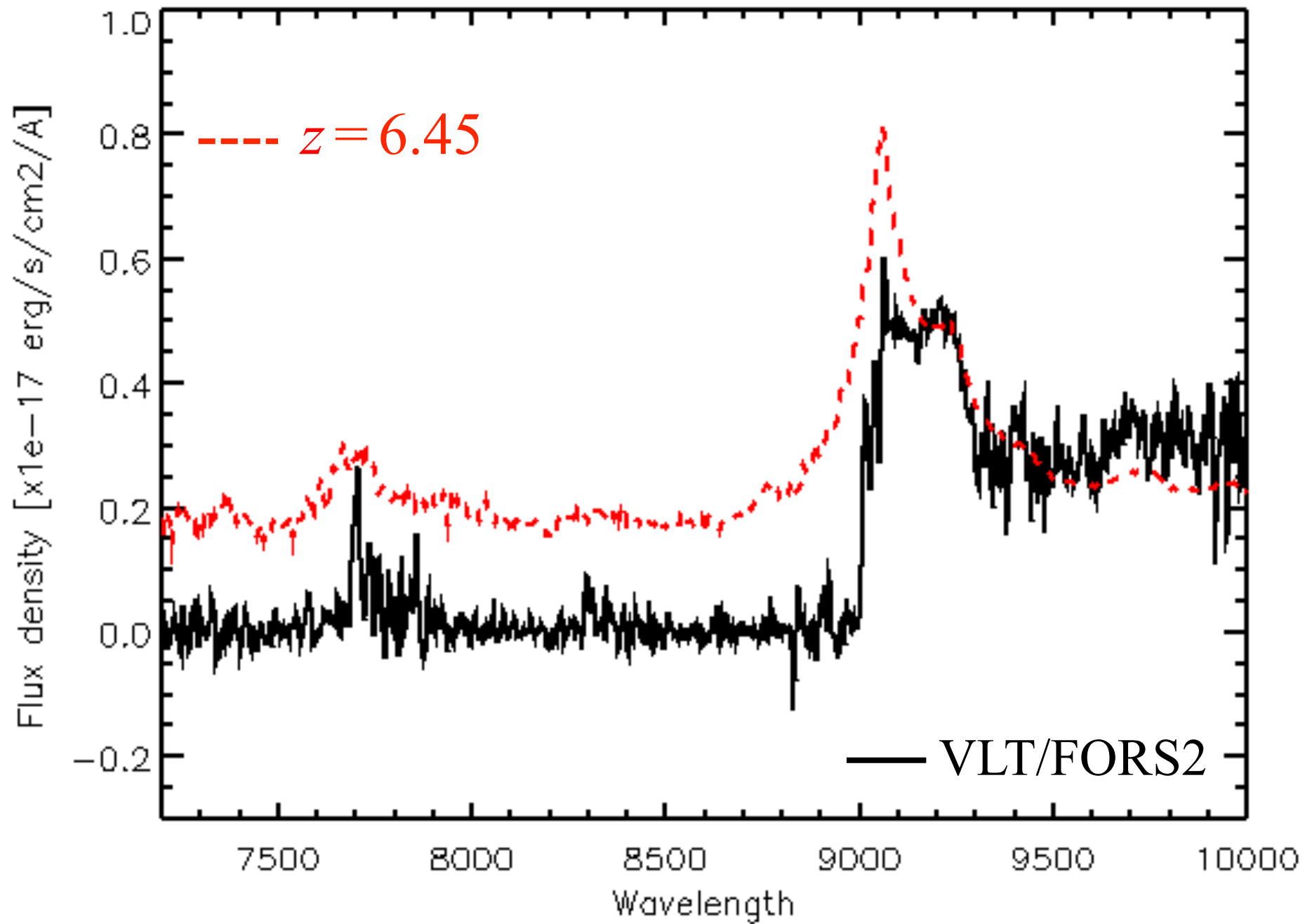
- Last year VST/KiDS survey started
- Optical imaging of VIKING area
- Project with Astro-WISE to test pipeline

VIKING + KiDS i-band catalogues:

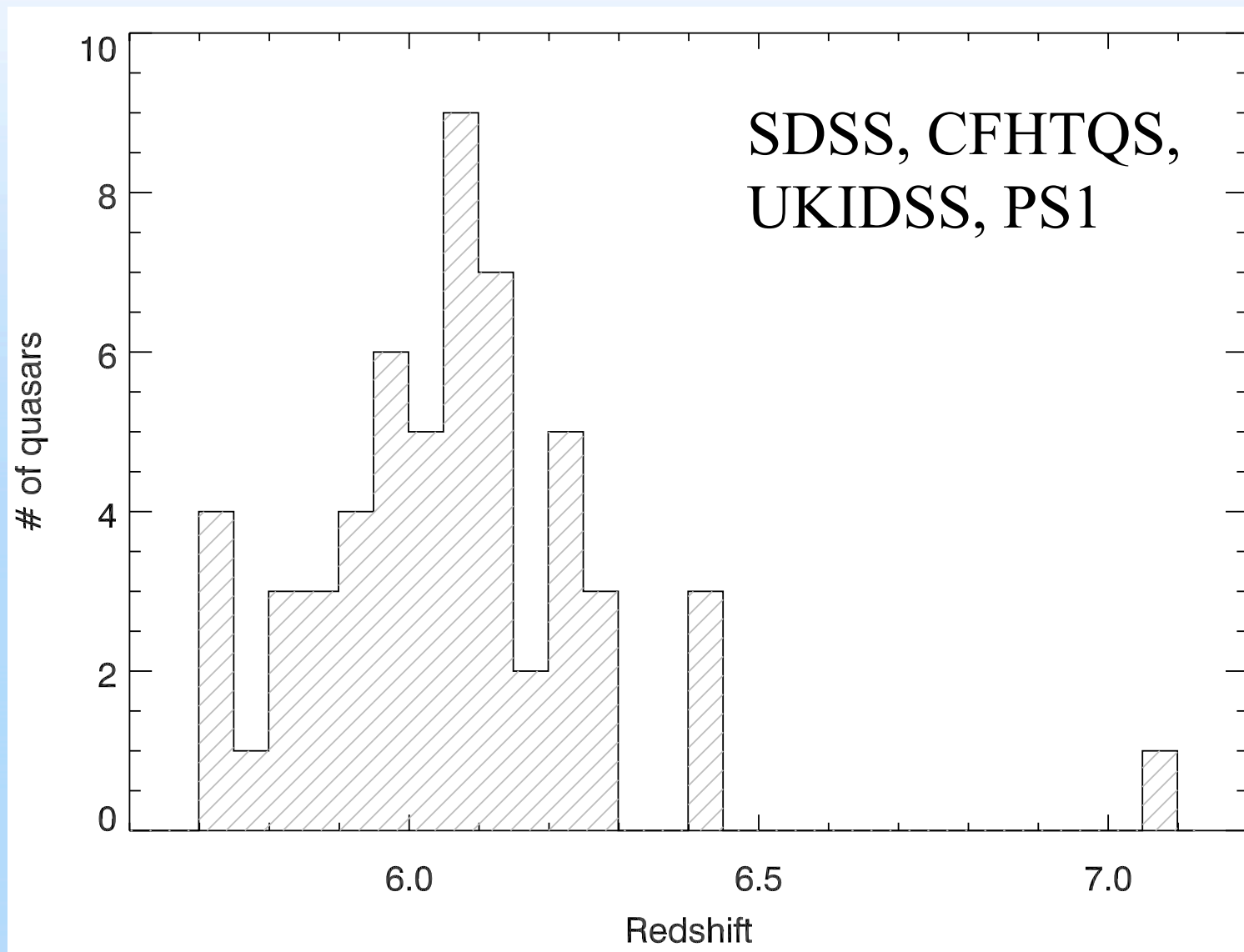
- Sensitive to quasars below $z \sim 6.5$
- Remove contaminants from $z > 6.5$ sample



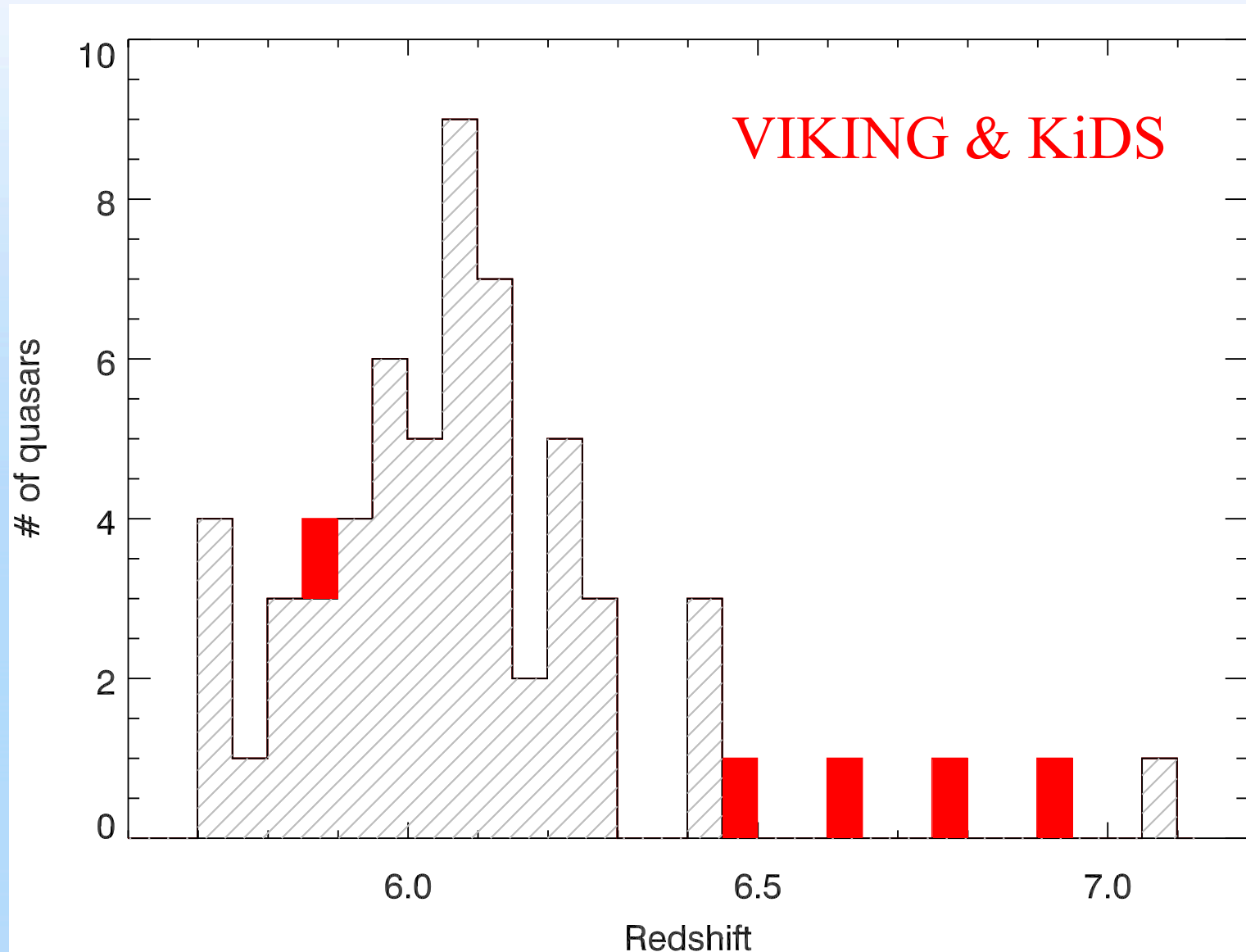




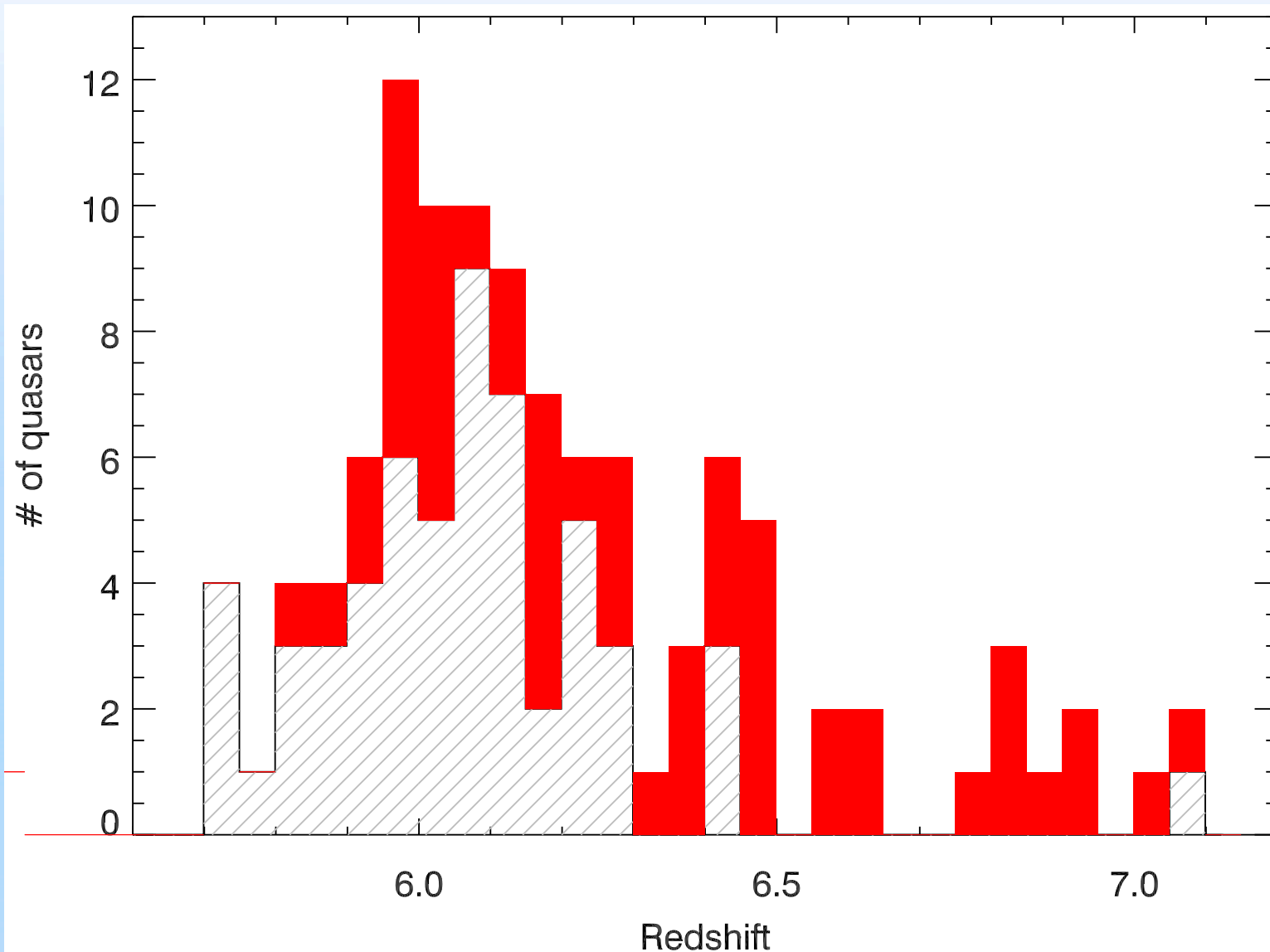
Known quasars before VIKING+KiDS



Known quasars at this moment



Known quasars after VIKING+KiDS



Summary

- Low fraction of spurious sources in VIKING
- Star/galaxy separation works well
- Working on optimal matching with KiDS
- VIKING+KiDS ideal for $z>6$ quasar search
- Quadrupled the number of $z>6.5$ quasars
- Full survey will double known $z\sim 6$ quasars and result in 10-15 $z>6.5$ quasars
- Next: Pan-STARRS and VHS+DES/ATLAS