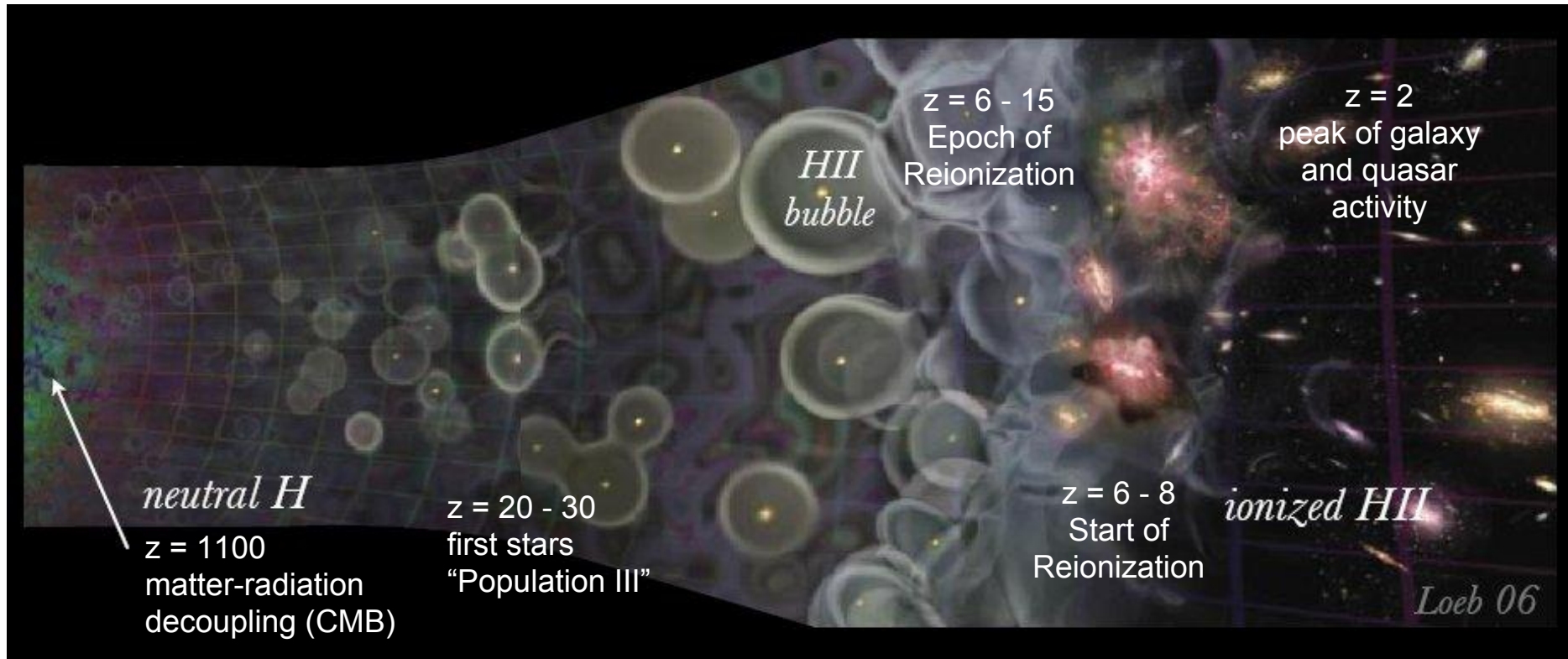# A Sample of 8 New Quasars from the Dark Energy Survey

Quasars in the Epoch of Reionisation

Sophie Reed
Supervisors: Richard McMahon, Manda Banerji
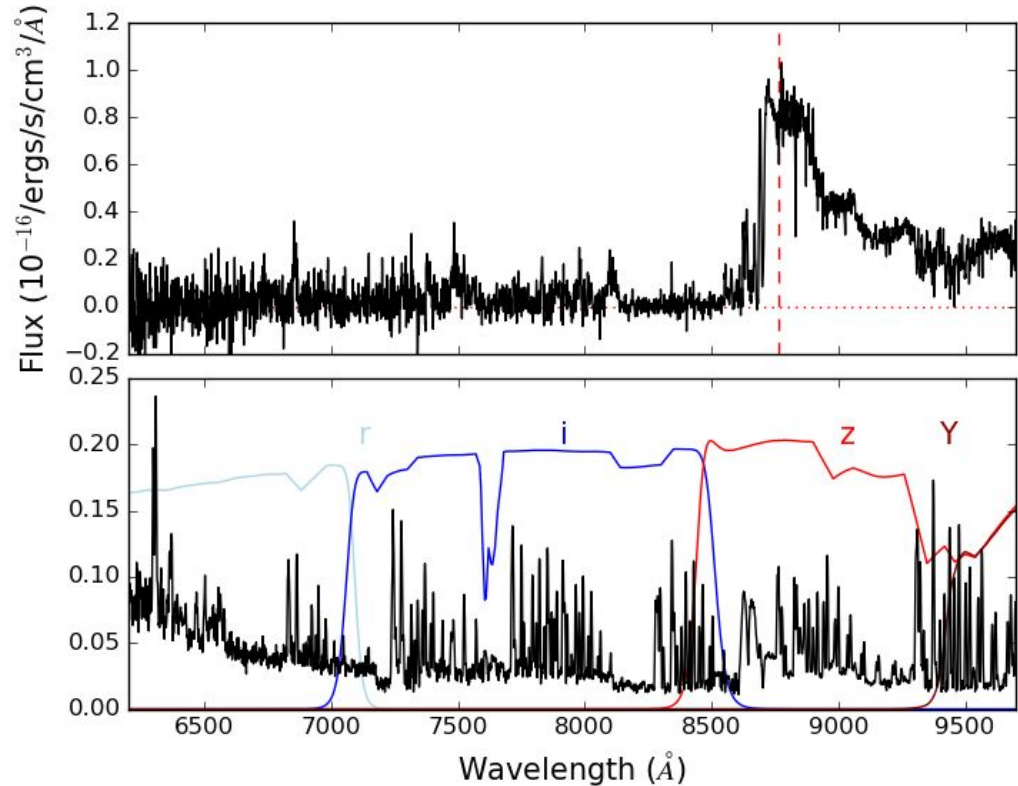
Why?

z = 6 - 15
Epoch of
Reionization

z = 2
peak of galaxy
and quasar
activity

HII bubble

z = 20 - 30
first stars
"Population III"

z = 6 - 8
Start of
Reionization

neutral H

ionized HII

z = 1100
matter-radiation
decoupling (CMB)

Loeb 06

Quasar Spectrum at z ~ 6

A quasar at z ~ 6.2

Between 6.0 and 6.5 the Lyman-α (λ_{rest}=121.6nm) emission line falls in the z band.

Quasar Spectrum at z ~ 6

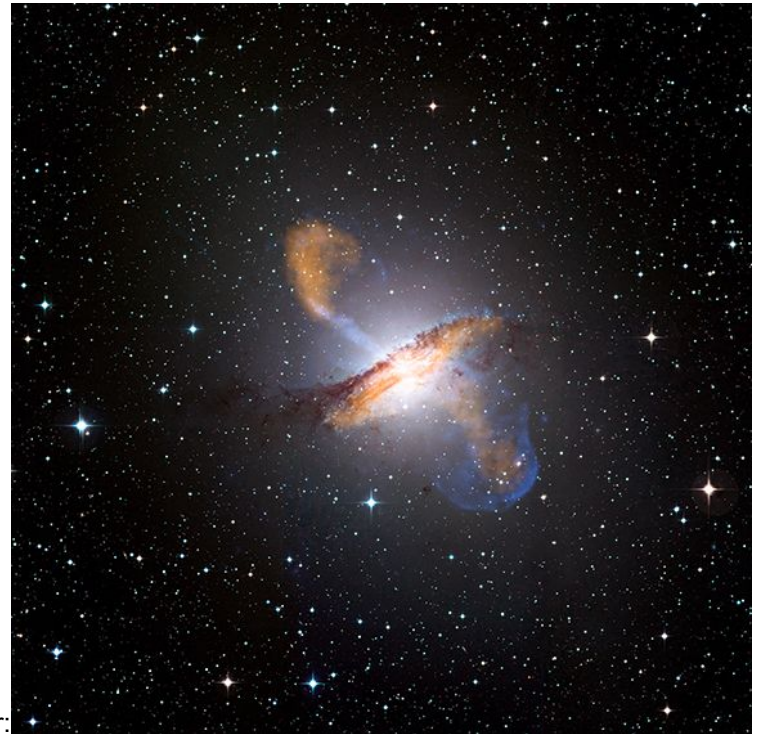| g	r	i	z	Y	J	K
480 nm	640 nm	780 nm	920 nm	990 nm	1252 nm	2147 nm

DES

VISTA
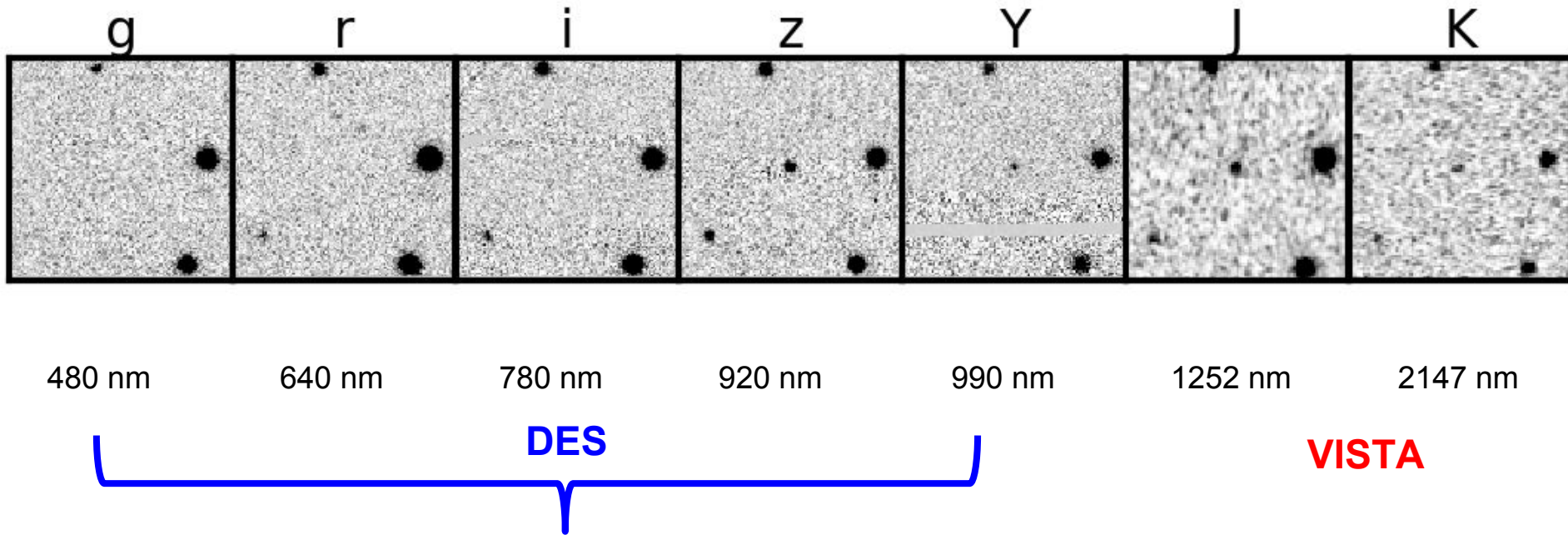
Currently Known Objects

Lots of quasars known at z < 4.0 (~88,000 in SDSS DR9)

Between z = 5.7 and z = 6.5 there are ~70 known objects
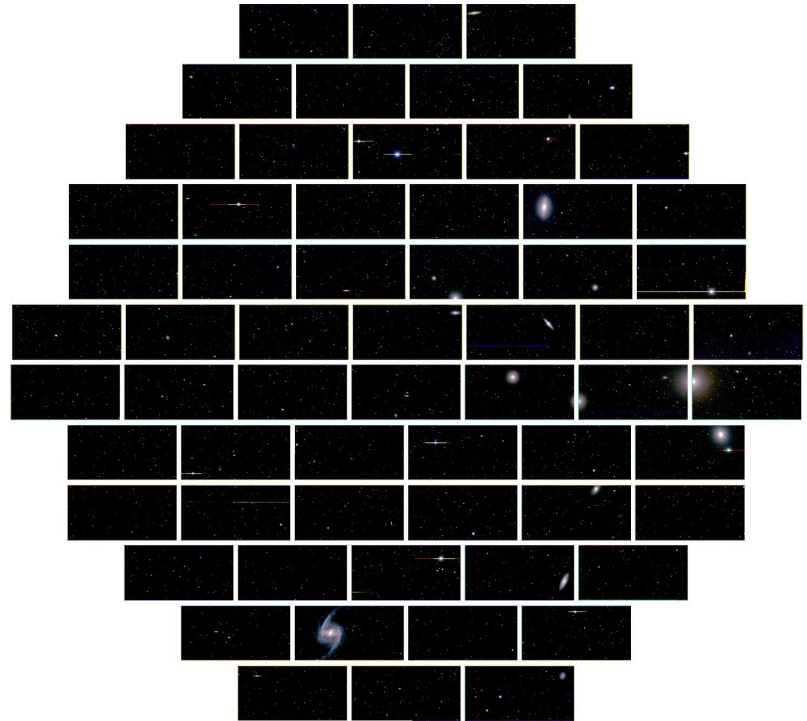
z > 6.5 there are 8, one is above z = 7

Credit: X-ray: NASA/CXC/CfA/R.Kraft et al.; Submillimeter: MPIfR/ESO/APEX/A.Weiss et al.; Optical: ESO/WFI

The Dark Energy Survey (DES)

First Light September 2012

Very large area when completed: ~5000 deg^2, currently have ~2000 deg^2

Deep imaging: 10 σ limits for i and z are AB = 23.4 and AB = 23.2

Sophisticated camera, DECam
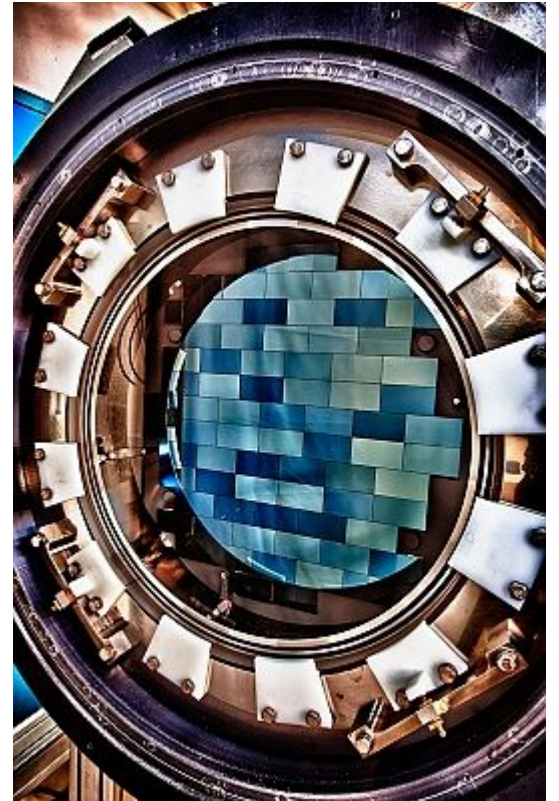
Credit: DES Collaboration

DECam

Mosaic of 62 2k by 4k CCDs (0.27" pixels)

Multi waveband imaging: Visible (400 nm) to Near IR (1050 nm), g, r, i, z and Y bands covered
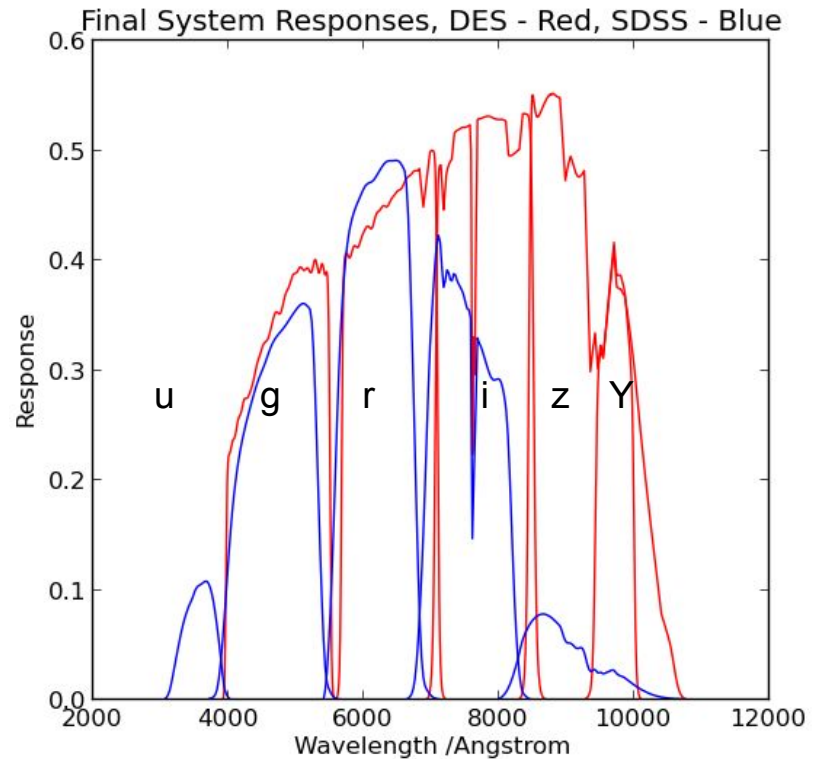
Much more sensitive to red light than SDSS

Credit: DES Collaboration

DES - SDSS Comparison

SDSS was most sensitive to bluer light in the r band
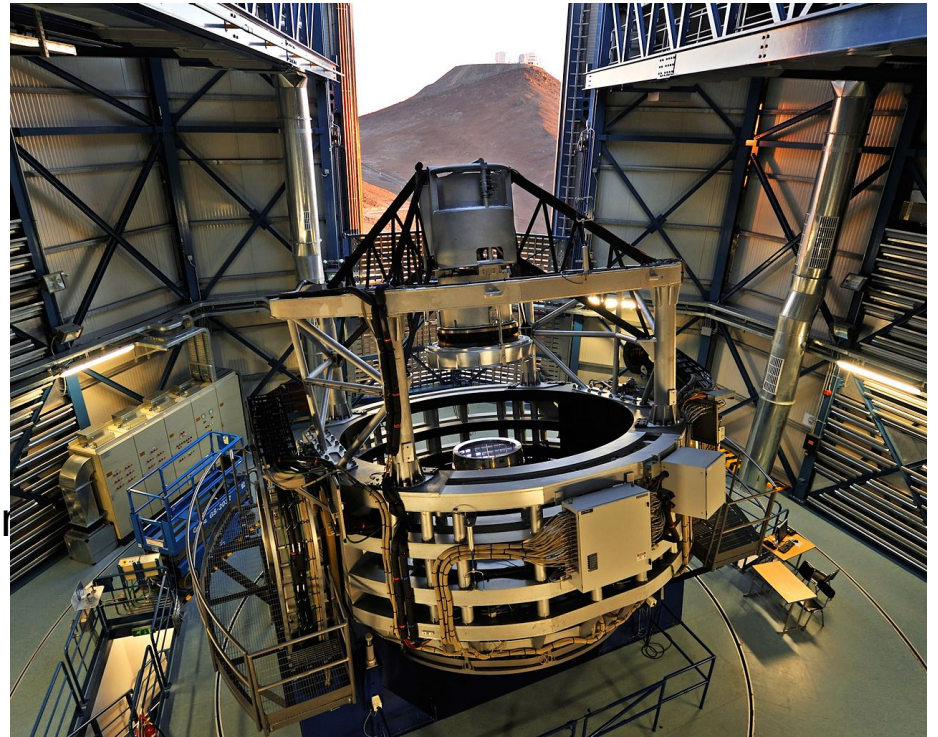
DES is most sensitive to redder light in the z band

Final System Responses, DES - Red, SDSS - Blue

The VISTA Hemisphere Survey (VHS)

Will cover 10,000 deg^2 in the infrared when completed

VHS-DES (J and K) overlaps DES and is deeper

VHS-ATLAS (Y, J and K) is a shallower survey

z ~ 6 Selection Criteria

Loose colour cuts were used to cut down the list

Bad image areas were removed

| Step	Description	Number Removed	Number Remaining
	Number of objects in database		139,142,161
1	Steps 1-8b from paper 1[1]	139,135,538	4,195
2	Y - J < 1.0	3,235	960
3	Remove Chip Edges in z Band	498	462
4	Remove Bad Image Areas	105	393
5	Remove Objects Bright in r	246	147
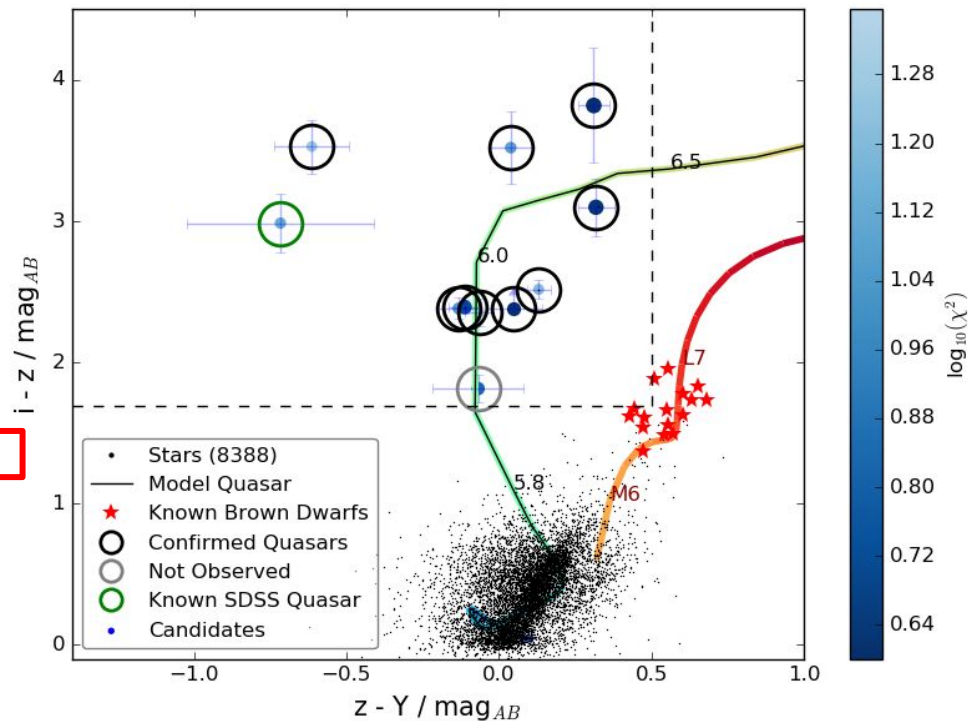
z ~ 6 Selection Criteria

Model fitting was done to four different quasar models and brown dwarf models.

χ^2 was done to each model and the candidates were ranked.

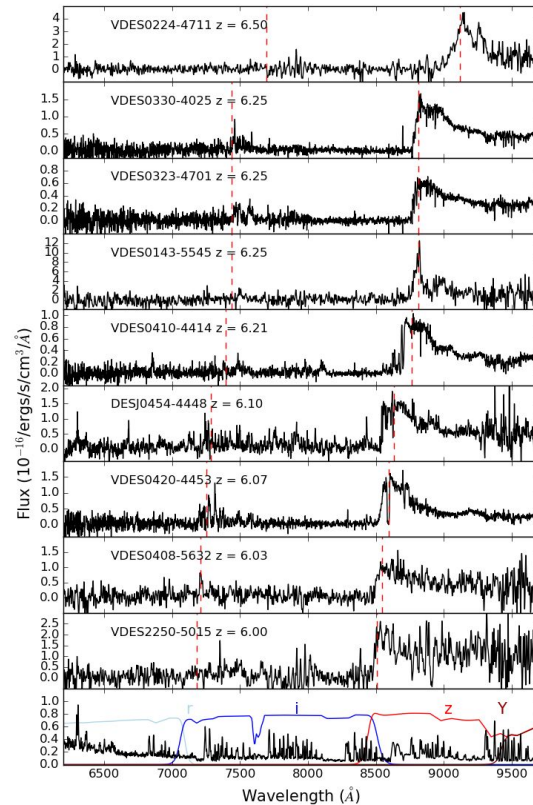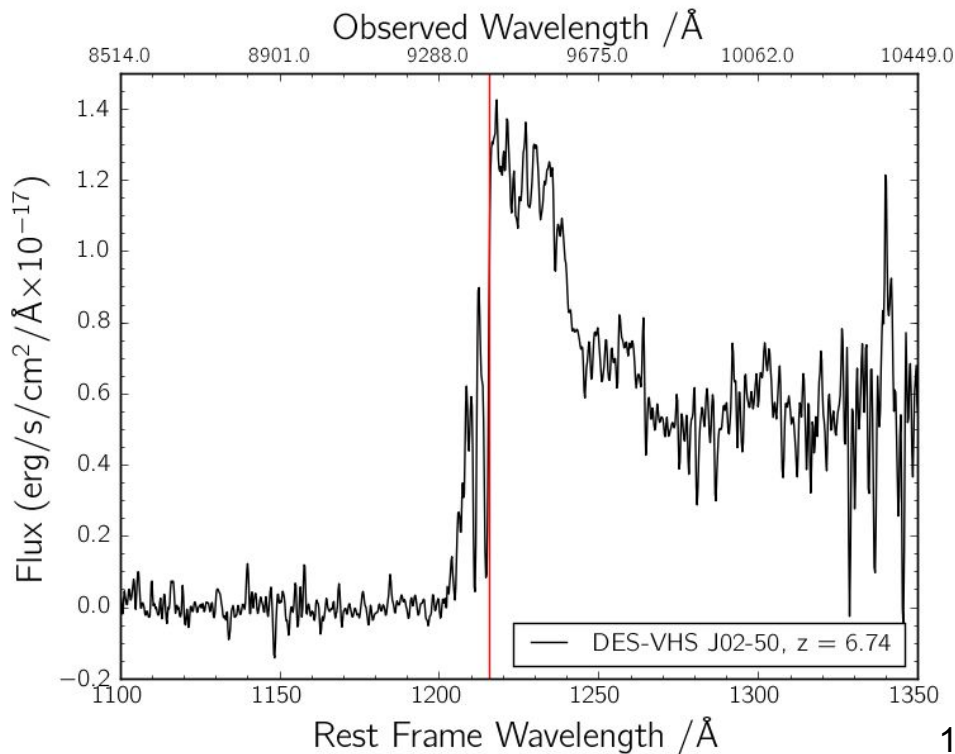Brown dwarf models from Skrzypek+ 2015
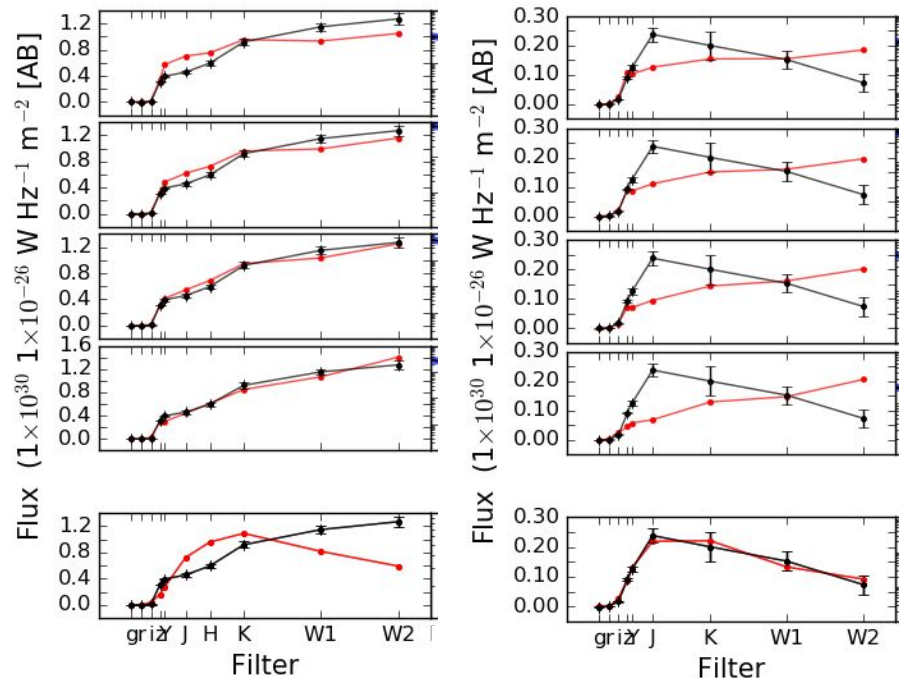
Spectroscopic Follow up - z ~ 6

Spectra were taken using the NTT at La Silla and by Paul Martini using Gemini-S.
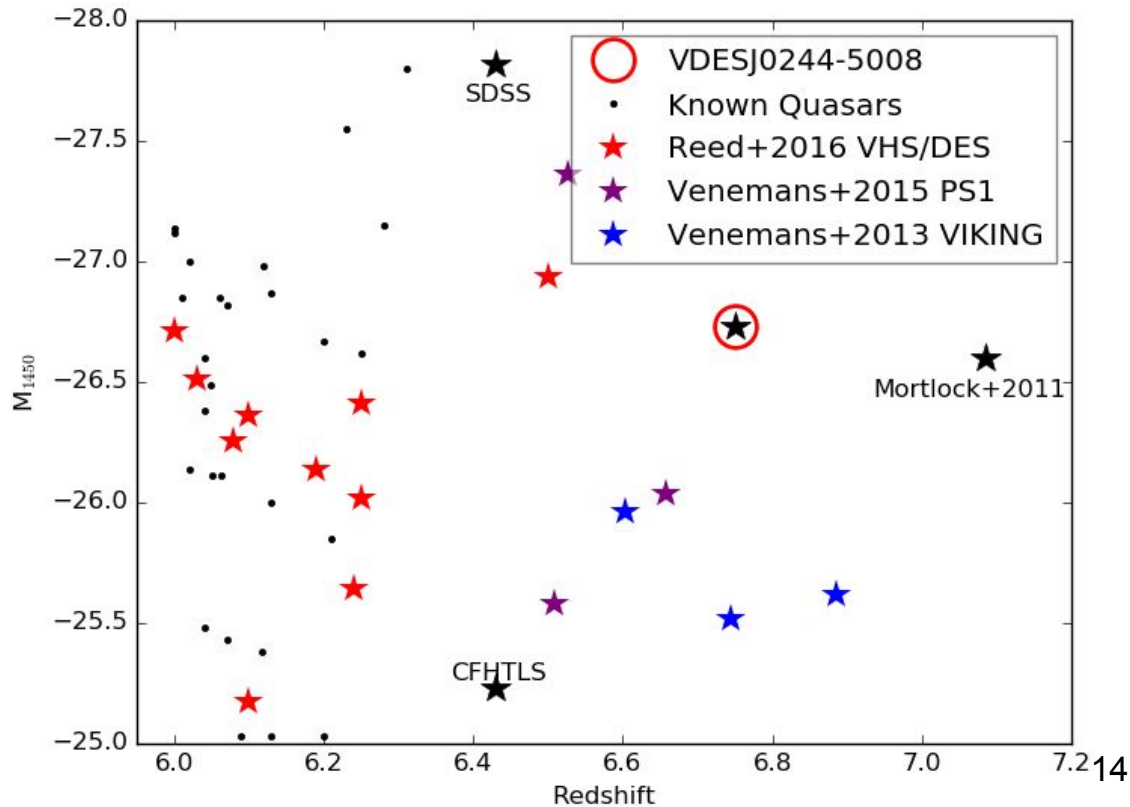
Spectroscopic Follow up - z > 6.5

Taken by Michael Rauch
using Magellan

Photometric Details

New quasars from DES/VHS compared to previously known objects.

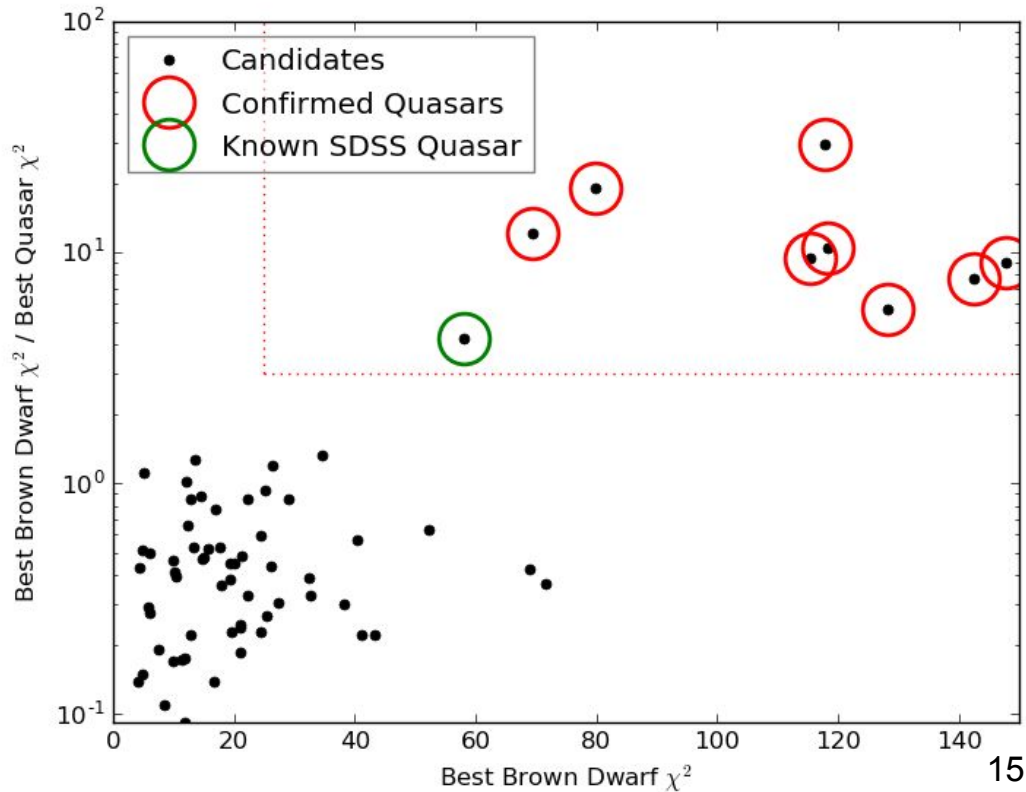Our large area allows us to find bright objects useful for follow-up studies.

Selection Without Colour Cuts

Quasars and non quasars are separated well by χ^2.

Working on a catalogue using no colour cuts and separating by χ^2.

Currently limited by resolution of WISE catalogues; working on a new forced photometry catalogue using unWISE images and SExtractor.

Summary

Eight new quasars at 6.0 < z < 6.5 and recovery of two already know ones from a combination of DES, VHS and WISE photometry.

No photometric follow-up required and very high success percentage

Working on a method to select quasars without using any colour cuts - can find more unusual objects.
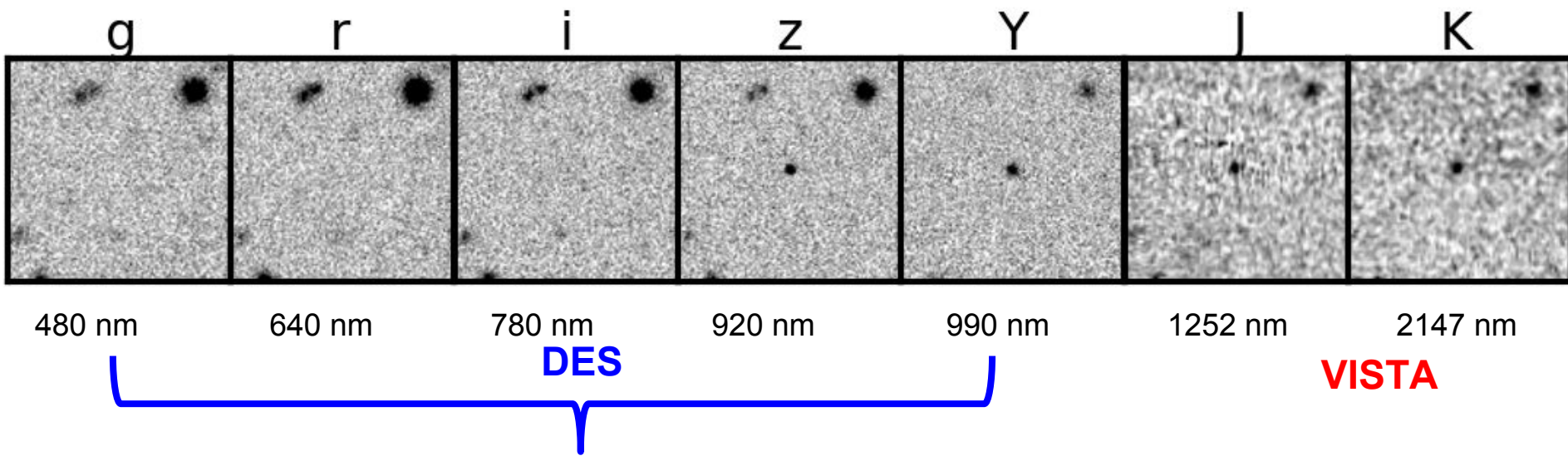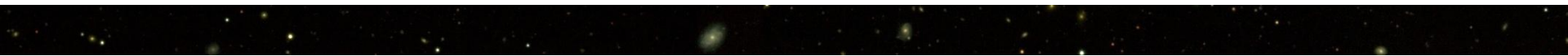
Quasar Spectrum at z ~ 7

Above z = 6.5 the Lyman-α has an observed wavelength of 9120 Å and starts to move into the Y waveband

Also need near infrared colours to separate quasars from more numerous galactic cool brown dwarfs
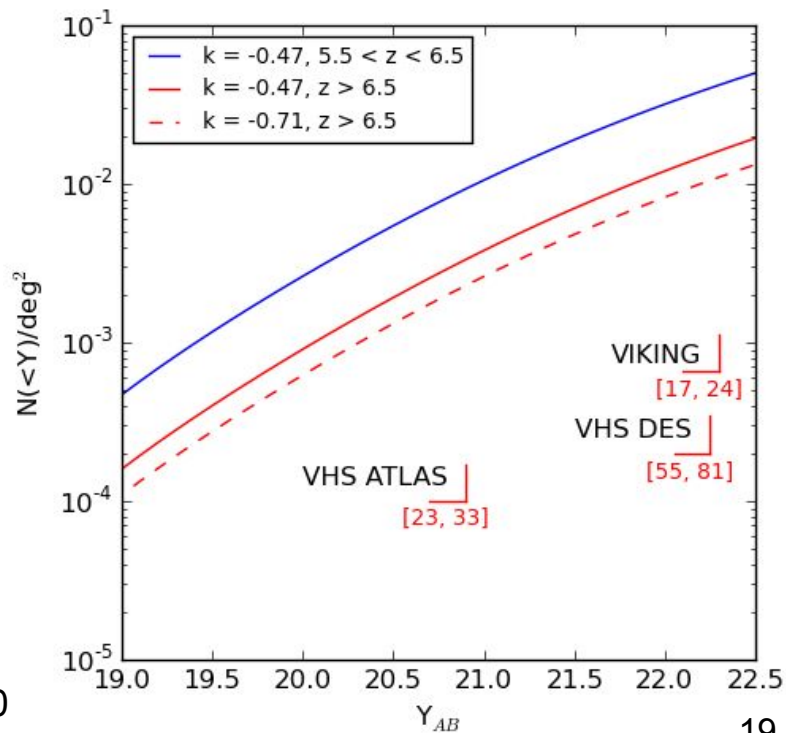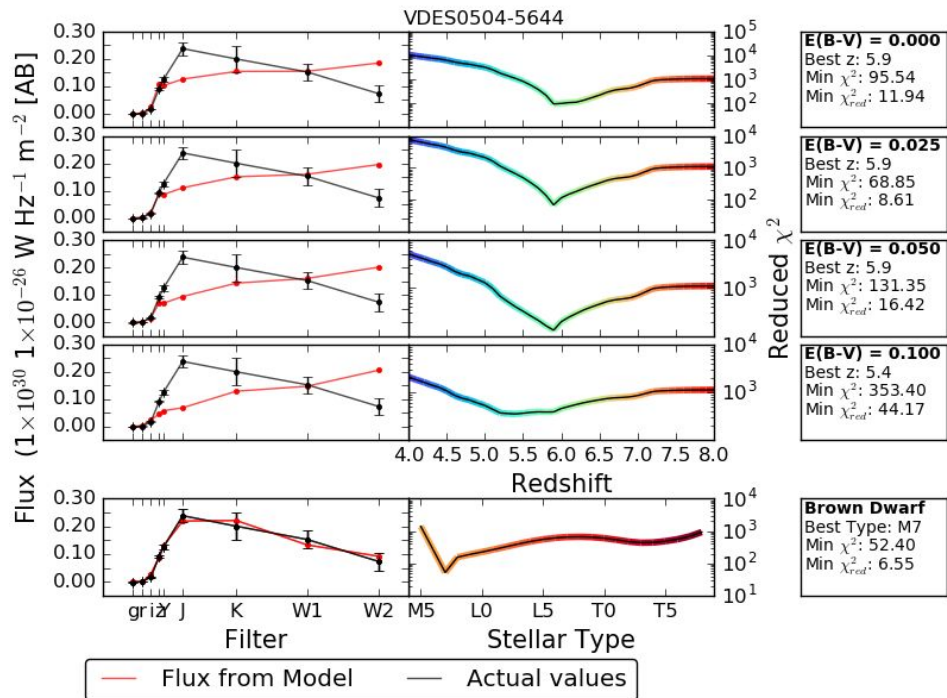
Colours at z > 6.5

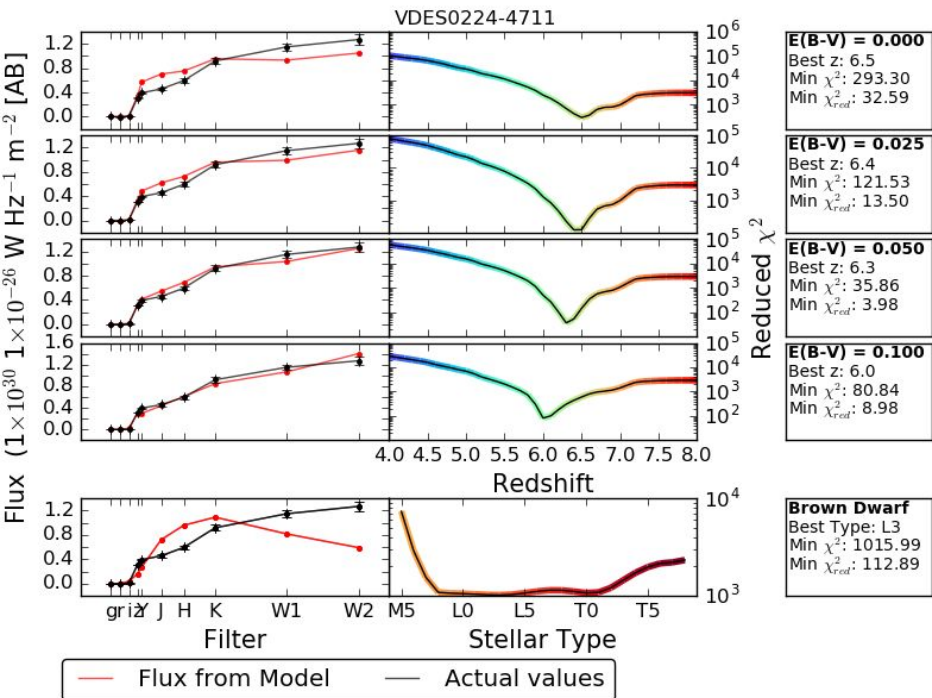| g	r	i	z	Y	J	K
480 nm	640 nm	780 nm	920 nm	990 nm	1252 nm	2147 nm

DES

VISTA
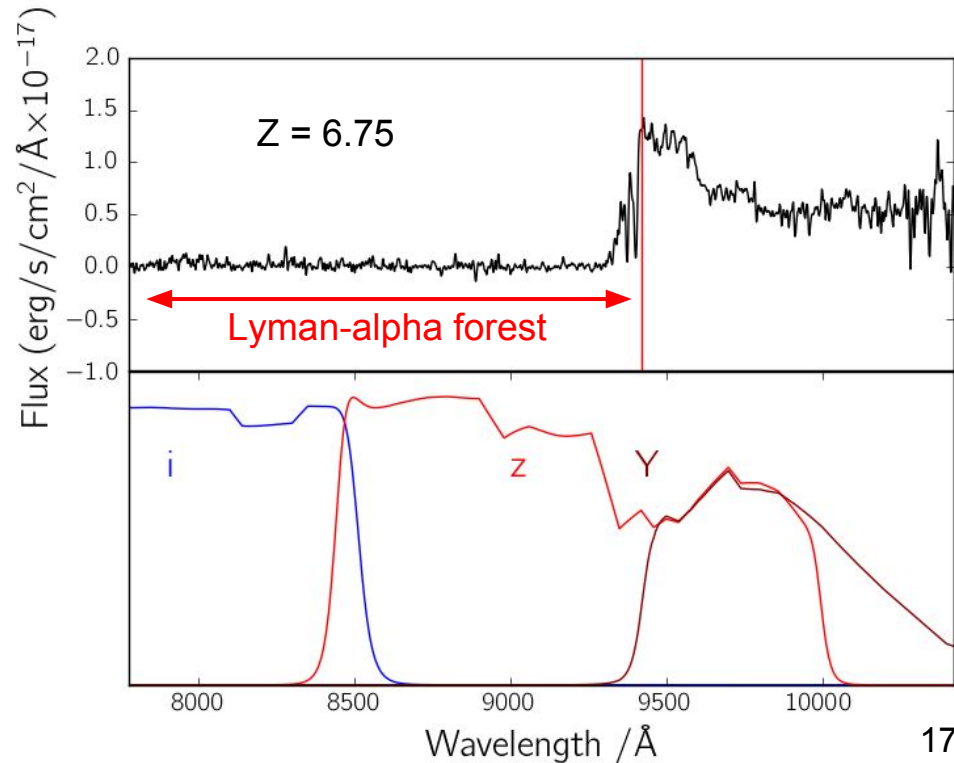
Expected Numbers

5,000 deg^2 of DES footprint
z > 6.5 50-80 with Y < 22 [AB]
z > 7.0 3-10 with J < 21 [AB]

10,000 deg^2 of VHS + DES/VST-ATLAS
z > 6.5 20-30 with Y < 21 [AB]
z > 7.0 2-5 with J < 20 [AB]
Note brighter limits

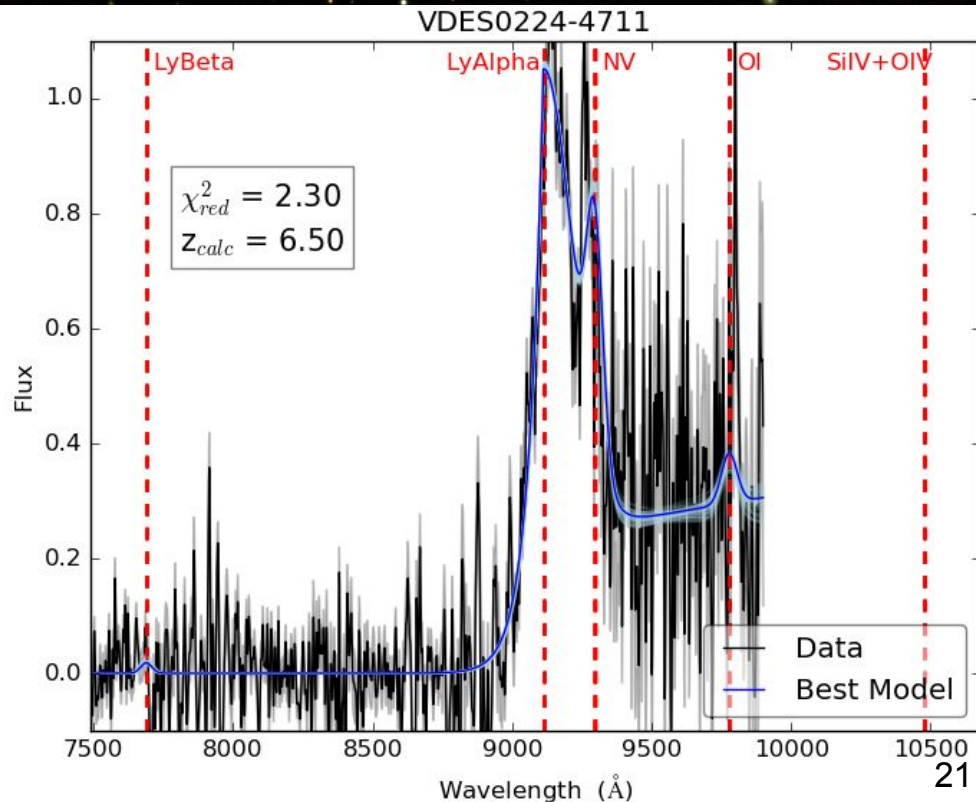Based off Manda Banerji's calculations from Willott et al 2010

z ~ 6 Selection Criteria

Redshift Determination

Fitting of a quasar model to the optical discovery spectra

Fit for five lines, model Ly-α as a combination of exponential decay and a gaussian.

VDES0224-4711

$\chi^2_{red} = 2.30$
$z_{calc} = 6.50$

Photometric Details

New quasars from DES/VHS compared to previously known objects.

Our large area allows us to find bright objects useful for follow-up studies.