A First Look at the Evolution of Brightest Cluster Galaxies beyond z= 1

John Stott
Liverpool JMU

Collins et al. 2009, Nature, 458, 603
Stott et al. ApJ submitted

Chris Collins, Matt Hilton, Scott Kay, Adam Stanford,
Ed Lloyd-Davies, Martin Sahlen,
The XCS Collaboration (PI: K Romer)

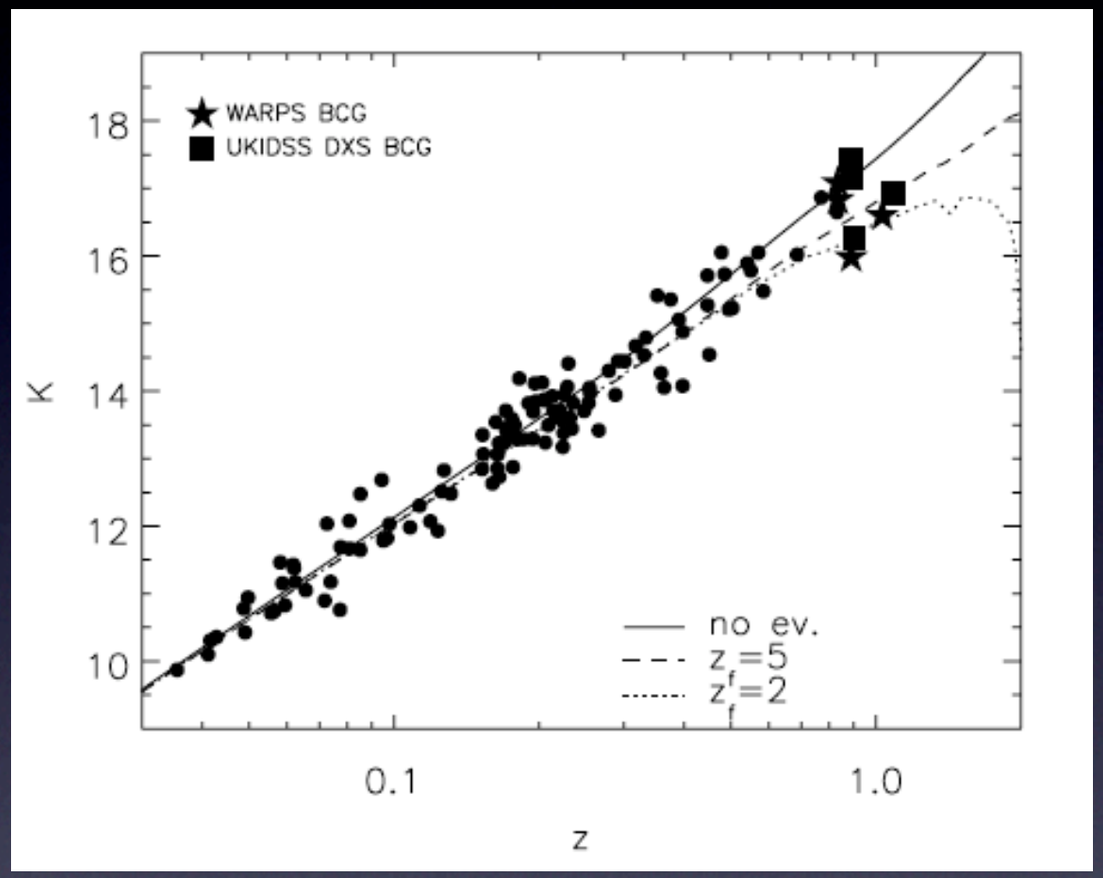
Outline

- Brightest Cluster Galaxies (BCGs)
  - Mass evolution
  - Size evolution
- XCSDXS searching for high z clusters
  - z=1.04 cluster? XCS0222b
  - z=1.18 cluster? XCS0222a
  - XCS0226 (IKCS041) spectroscopy

Brightest Cluster Galaxies

- Most luminous objects in terms of stellar light
- Homogenous population (σ <0.4 abs mag)
- Centres of large potential wells, ideal for studying hierarchical formation

Brightest Cluster Galaxies



- Previous work compared Hubble (K-z) diagrams to various stellar population models to constrain BCG evolution: Aragon-Salamanca et al. 1998, Collins & Mann 1998, Burke, Collins & Mann 2000, Whiley et al. 2008, Stott et al. 2008

High redshift BCGs

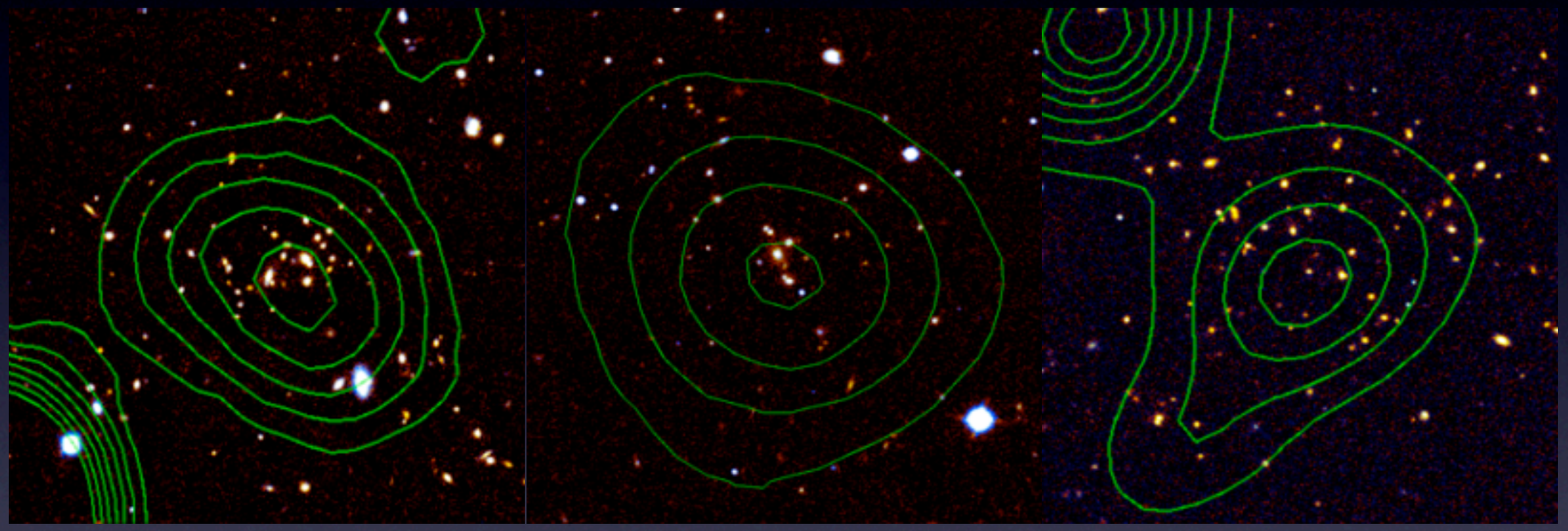
- 20 BCGs in X-ray selected clusters at 0.8<z<1.5
- Observed with Subaru MOIRCS (07B, 08B, 09A)
- Deep J and K band imaging
- Aims: colours and magnitudes to investigate age, mass and size of high z BCGs.

High redshift BCGs

- 20 B <z<1.5
- Obs 3, 09A)
- Dee
- Aims te age, mass

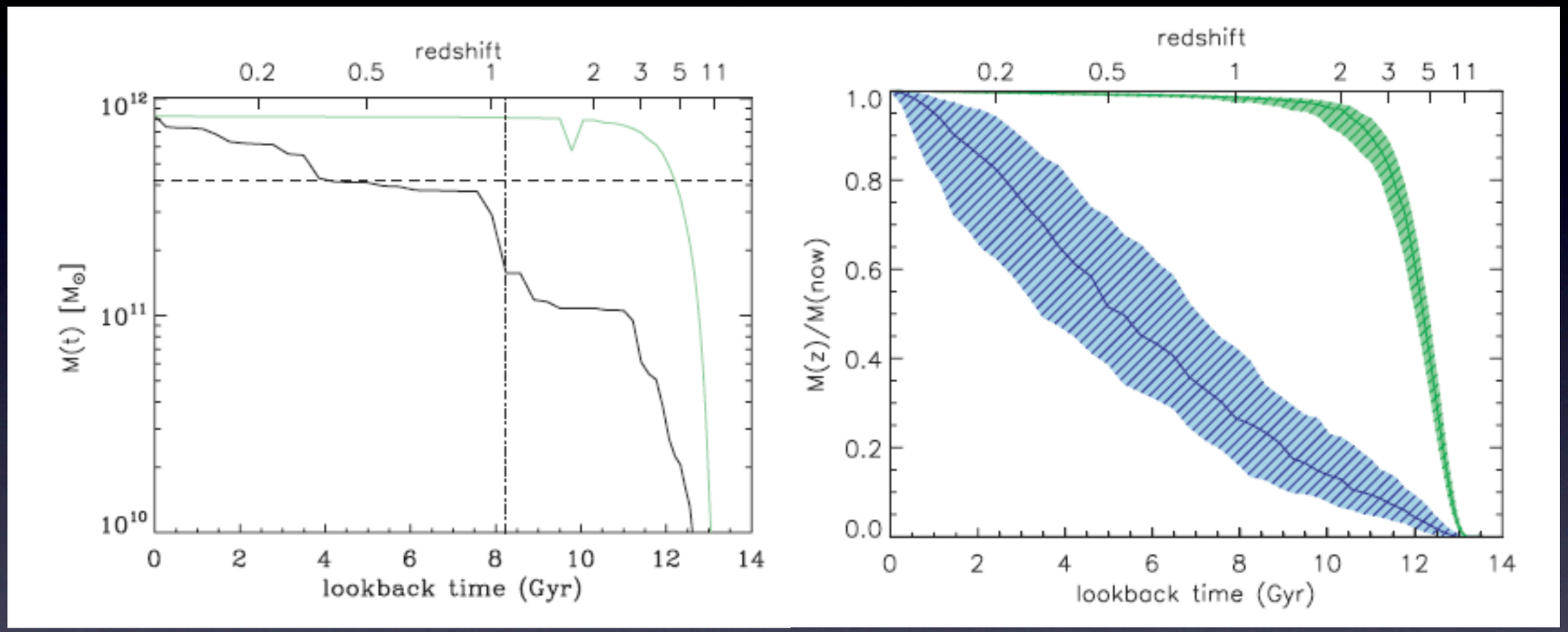
Cluster	R.A.	Dec. (J2000)	z
CL J0152.7-1357	01h52m41s	-13d57m45s	0.83
XLSS J022303.0 – 043622	00h23m53.9s	04d23m16s	1.22
XLSS J022400.5 – 032526	02h24m00s	-03d25m34s	0.81
RCS J0439 – 2904	04h39m38s	-29d04m55s	0.95
2XMM J083026 + 524133	08h30m25.9s	52d41m33s	0.99
RX J0848.9 + 4452[b]	08h48m56.3s	44d52m16s	1.26
RDCS J0910 + 5422	09h09m60s	54d22m0s	1.1
CL J1008.7 +5342	10h08m42s	53d42m0s	0.87
RX J1053.7 + 5735	10h53m39.8s	57d35m18s	1.14
MS1054.4 – 0321	10h57m0.2s	-03d37m27s	0.823
CL J1226 + 3332	12h26m58s	33d32m54s	0.89
RDCS J1252.9 – 2927	12h52m54.4s	-29d27m17s	1.237
RDCS J1317 + 2911	13h17m21.7s	29d11m18s	0.805
WARPS J1415.1 + 3612	14h15m11.1s	36d12m03s	1.03
CL J1429.0 + 4241	14h29m06.4s	42d41m10s	0.92
CL J1559.1 + 6353	15h59m06s	63d52m60s	0.85
CL 1604+4304	16h04m25.2s	43d04m53s	0.895
RCS J162009 + 2929.4	16h20m09.4s	29d29m26s	0.87
XMMXCS J2215.9 – 1738	22h15m58.5s	-17d38m3s	1.45
XMMU J2235.3 – 2557	22h35m20.6s	-25d57m42s	1.393

MOIRCS Observations



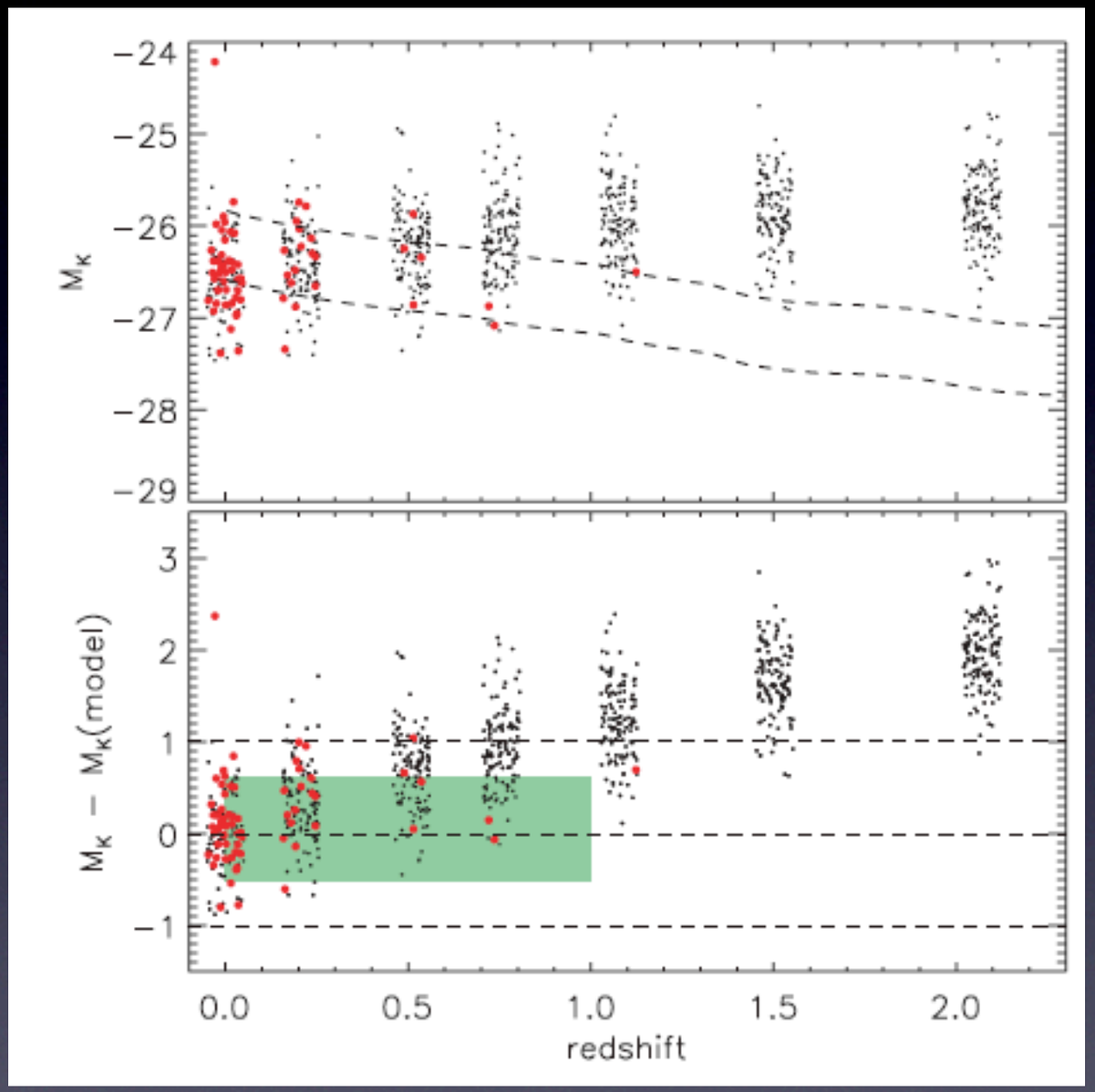
J0223 J2235 J2215

Modelled BCG stellar mass evolution



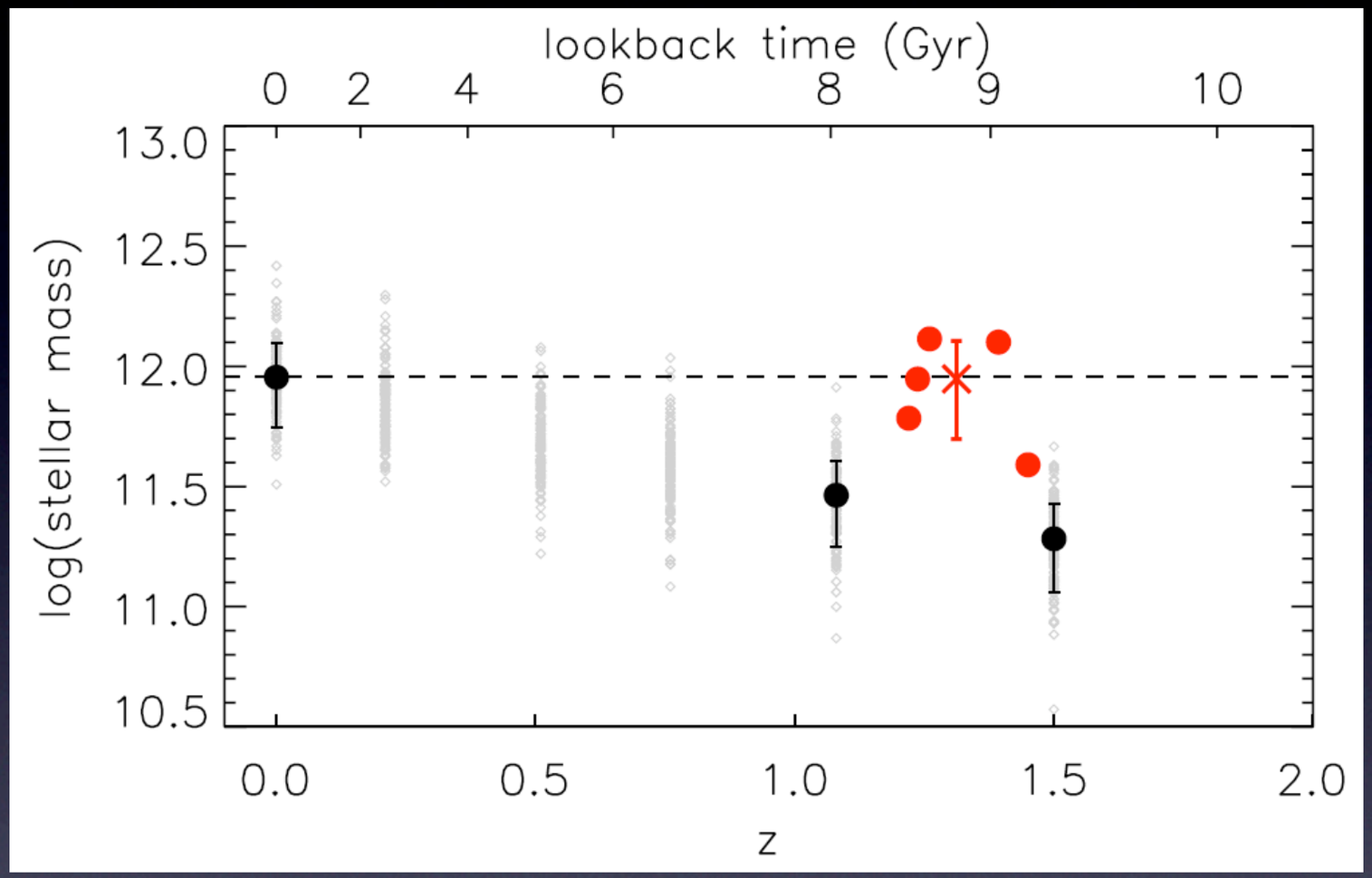
- De Lucia & Blaizot 2007 predictions for star-formation and hierachical assembly
- Mass in main progenitor at z=1 is 30% that of local BCGs

BCG models



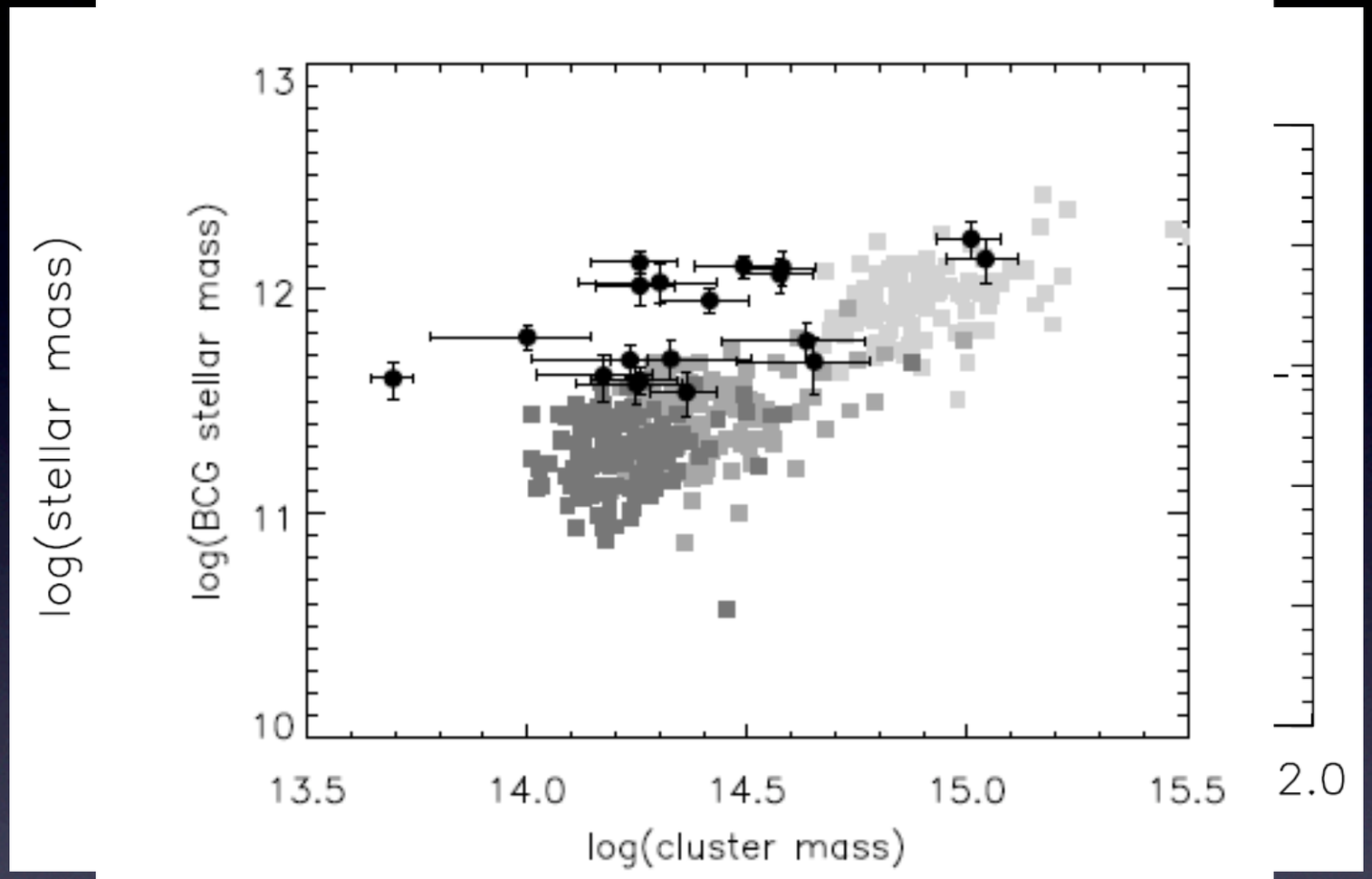
- De Lucia & Blaizot predictions for magnitudes of BCGs

Main result: Mass evolution



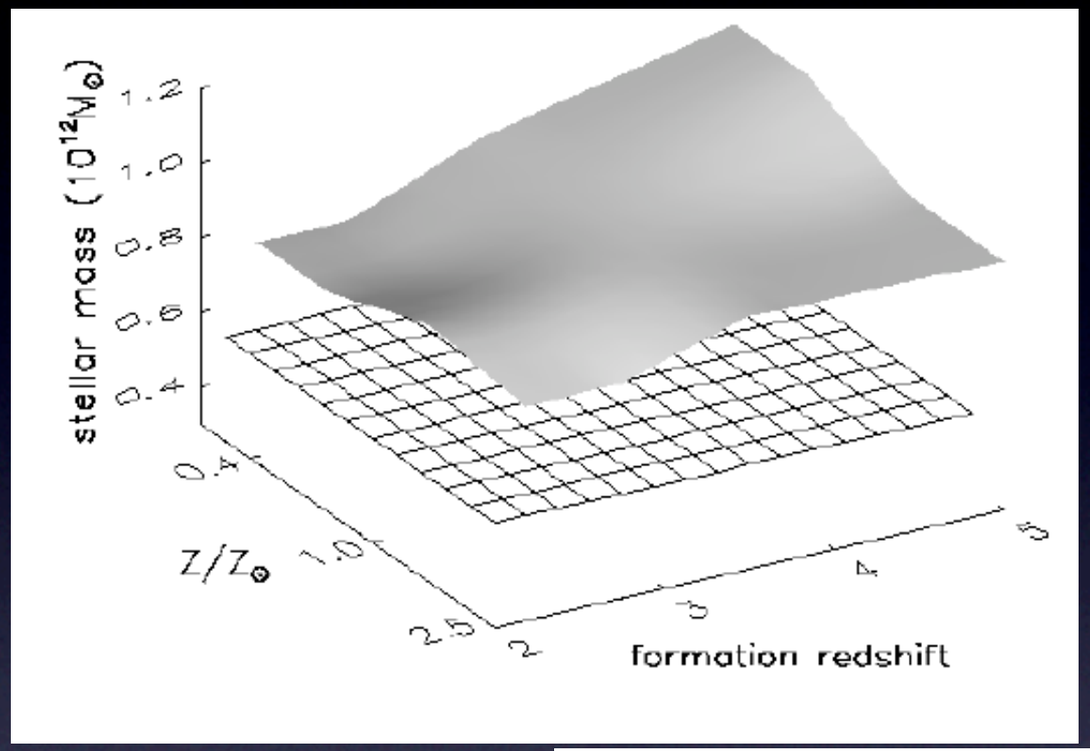
- By calibrating the stellar mass of the observed BCGs with the semi-analytic models and SSPs we find no evolution in BCG mass from z=1.5 to present
- For comparison with semi-analytics of D&B 2007 30% of final mass expected at z=1 observations predict >95% of mass built up at this epoch.
- New result has significance >5 sigma with caveats...

Main result: Mass evolution

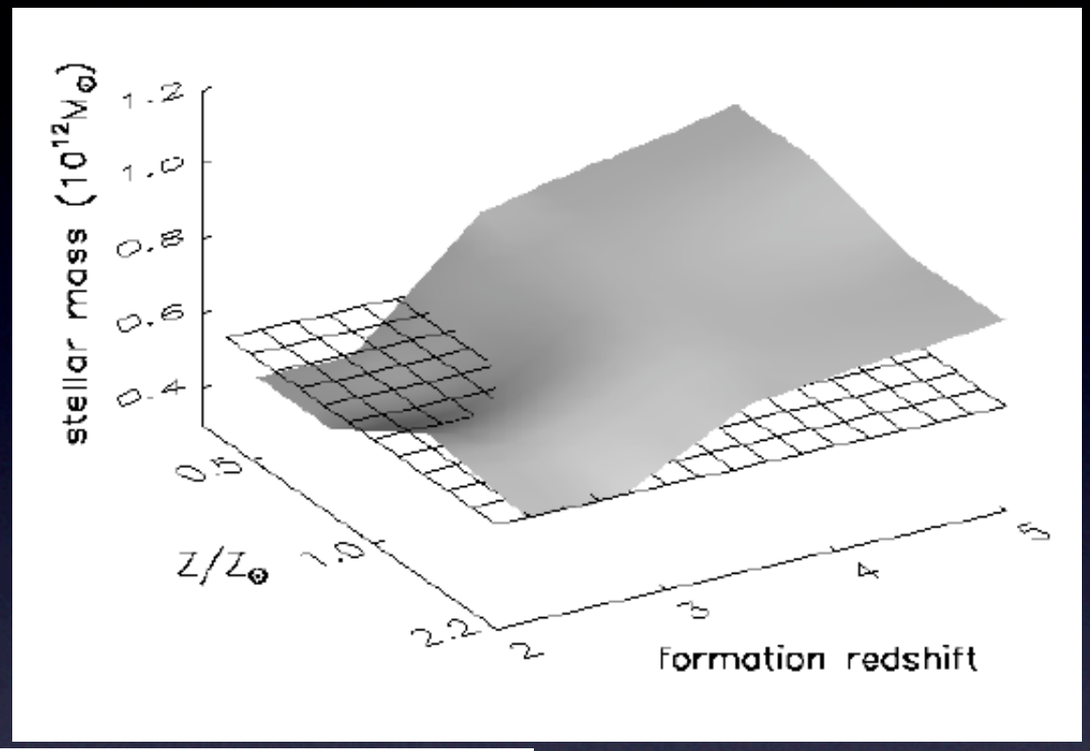


- By calibrating the stellar mass of the observed BCGs with the semi-analytic models and SSPs we find no evolution in BCG mass from z=1.5 to present
- For comparison with semi-analytics of D&B 2007 30% of final mass expected at z=1 observations predict >95% of mass built up at this epoch.
- New result has significance >5 sigma with caveats...

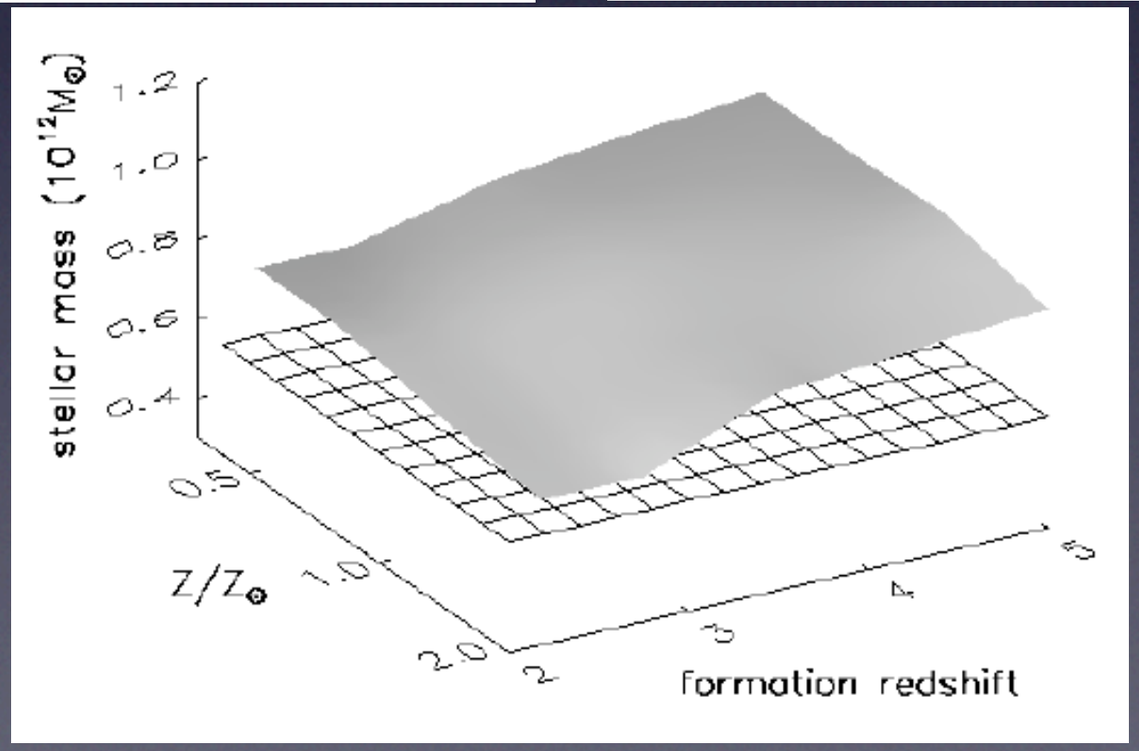
Stability of this result: mass surfaces



B&C

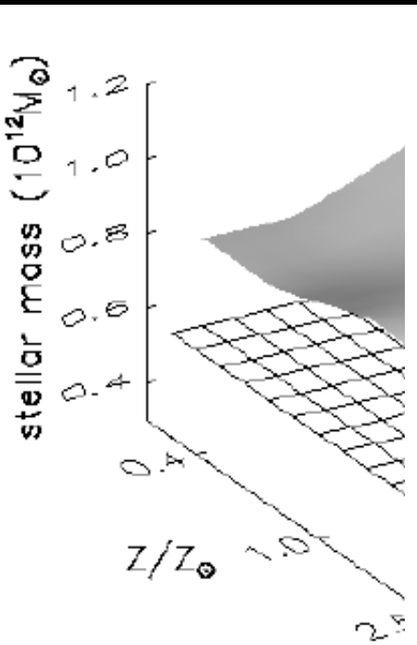


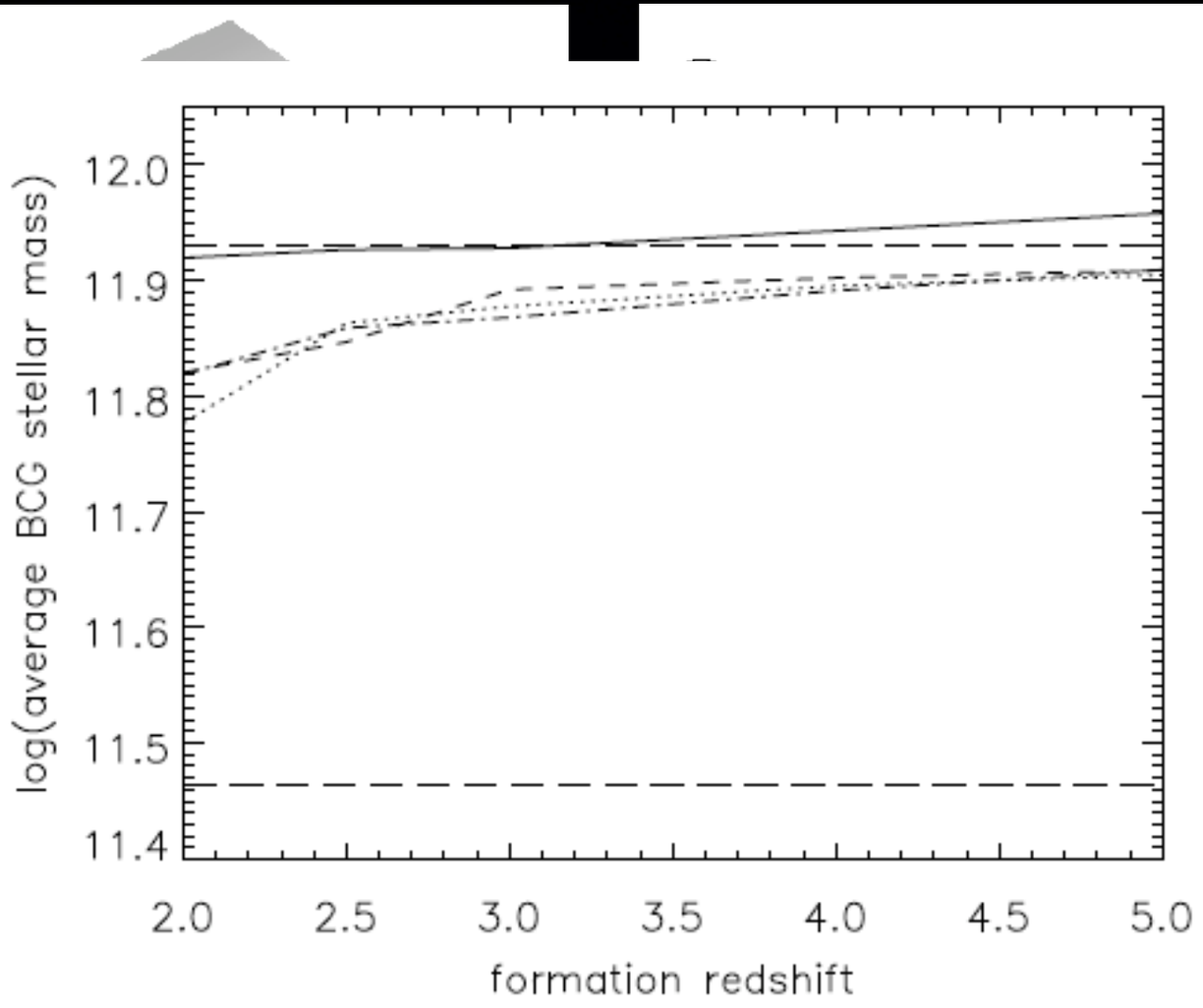
Maraston

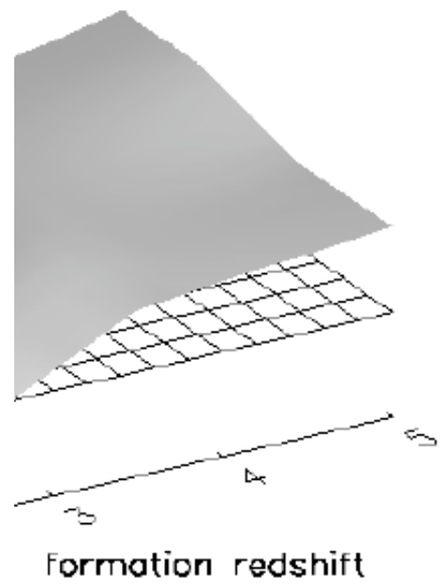


BaSTI

Stability of this result: mass surfaces

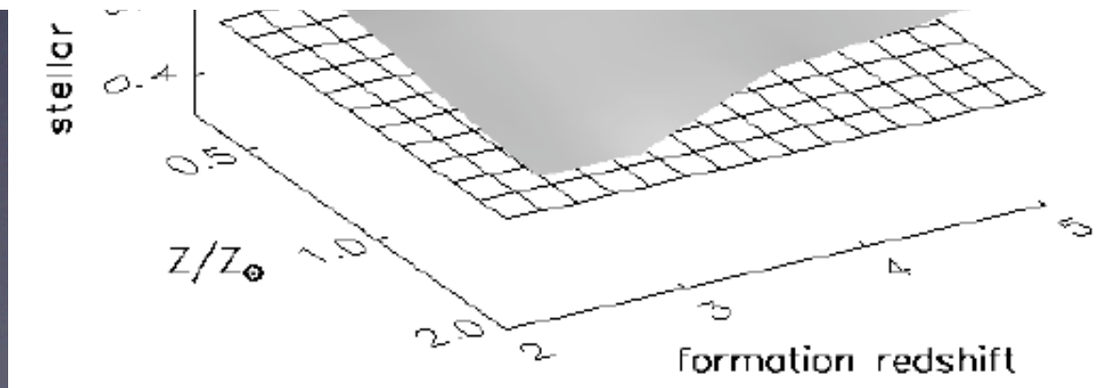






B&C

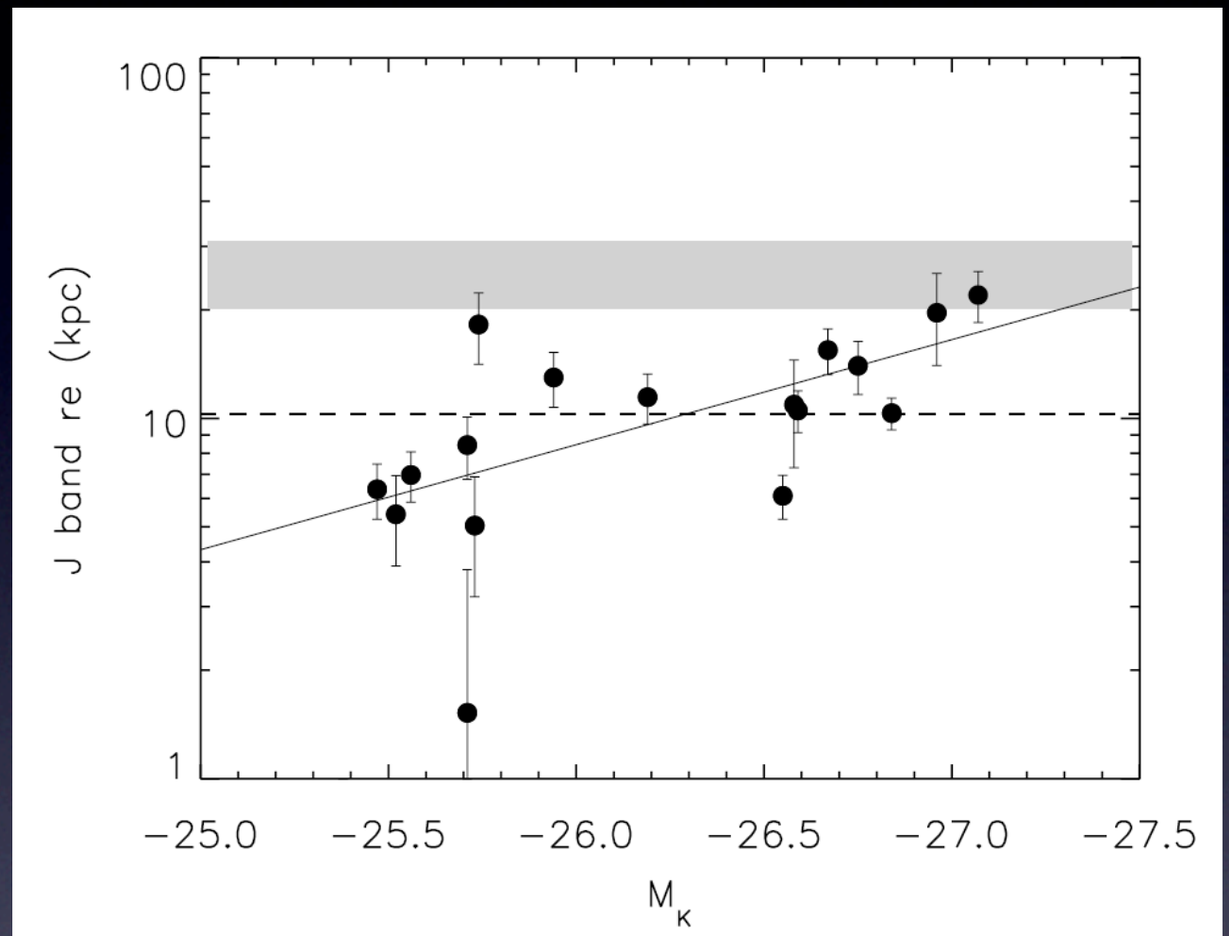
Maraston



BaSTI

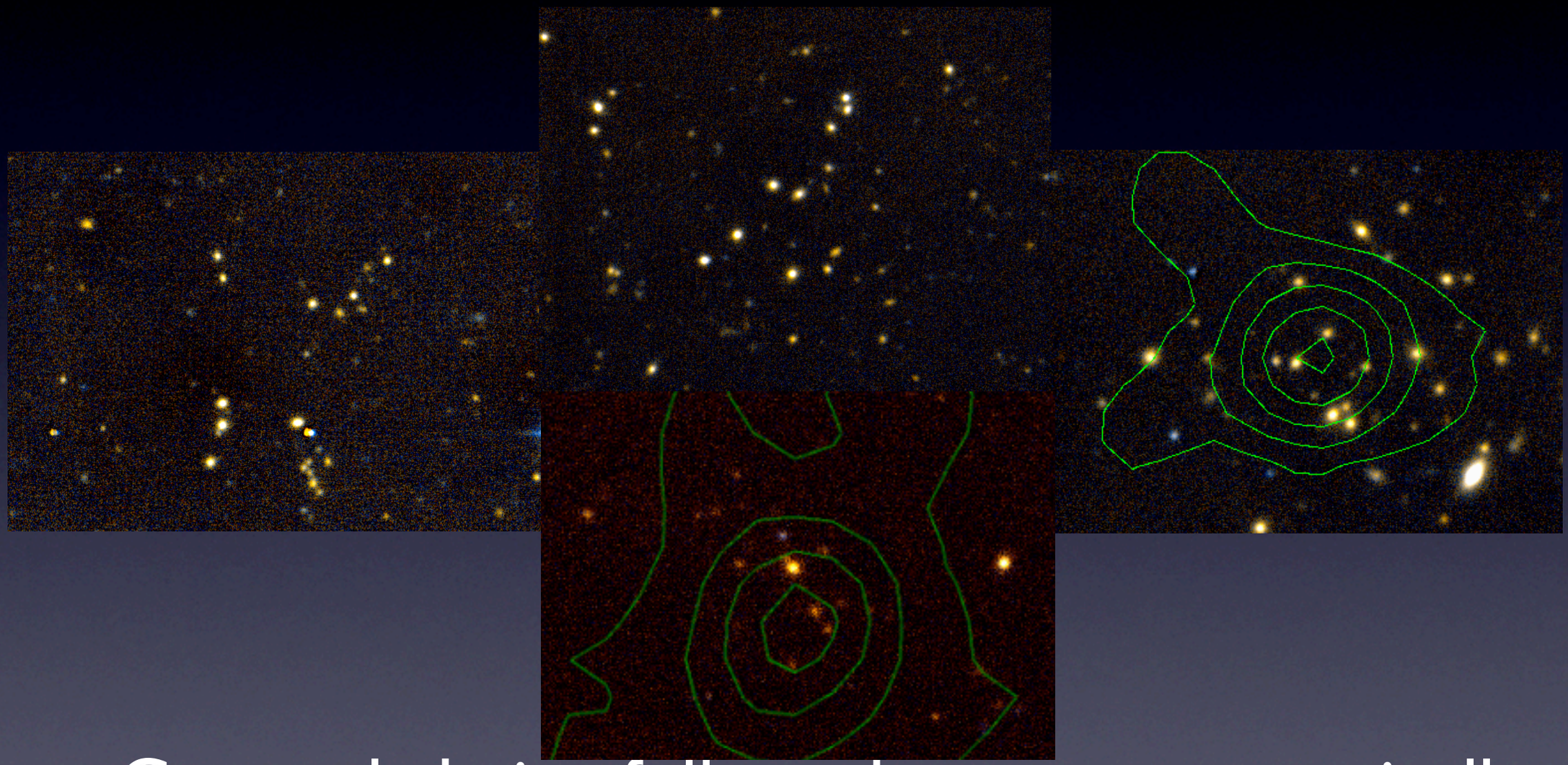
BCG Size evolution

- Van Dokkum et al. 2009 high redshift massive compact galaxies (z=2, M=~1x$10^{12}M_{sol}$, Re=~1kpc)
- Do BCGs at z~1 follow similar evolution?
- 2 fold increase in scale size from z~1 to local (e.g. Graham et al. 1996).
- If mass ~constant then minor mergers responsible for this size increase?



Stott et al. in prep

XCSDXS High z Candidates

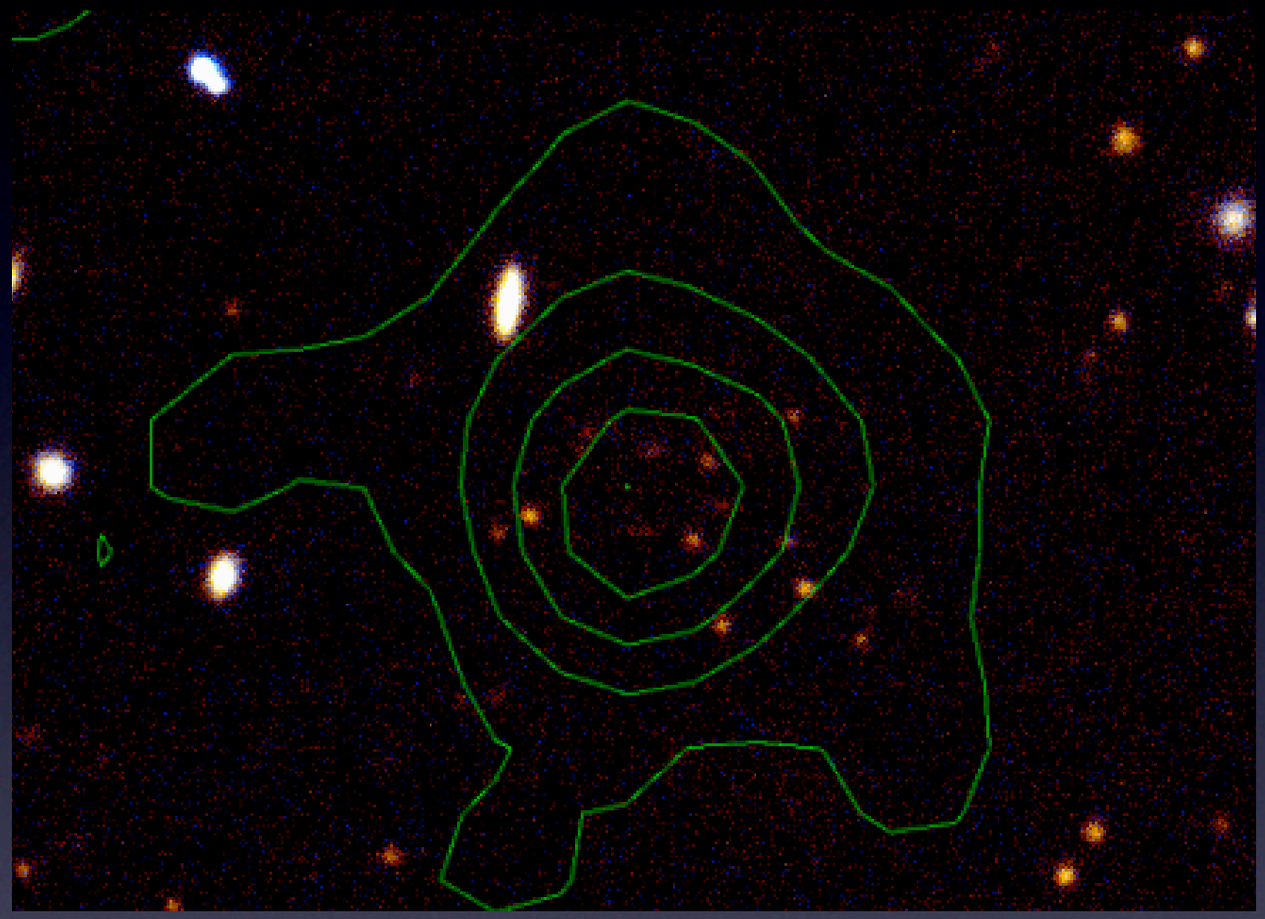


- Currently being followed up spectroscopically with GMOS

z=1.04 group/cluster?

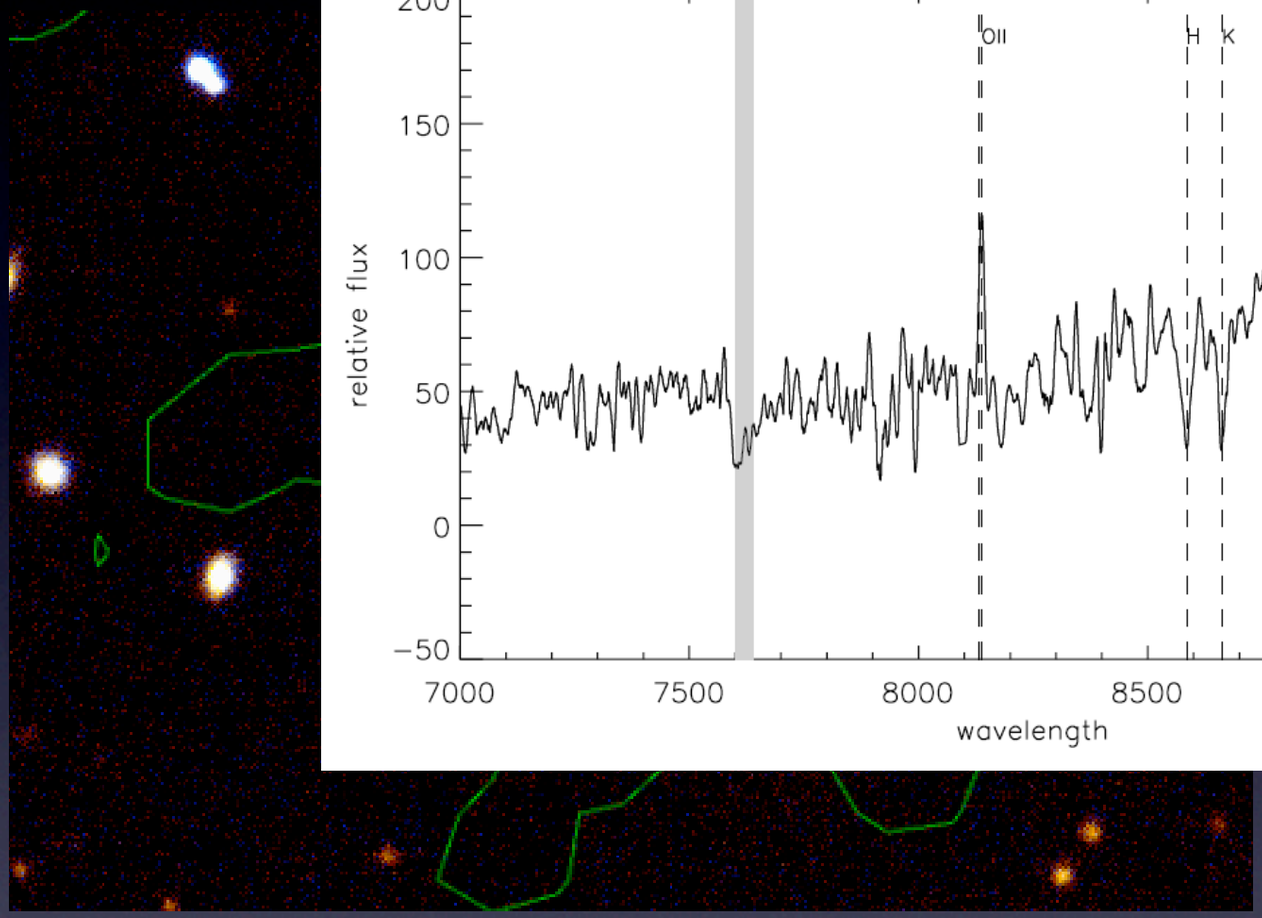
- XCSDXS candidate XCS0222b observed with Keck DIEMOS (PI Stanford)
- 5 z=1.04 galaxies found

z=1.18 group/cluster?



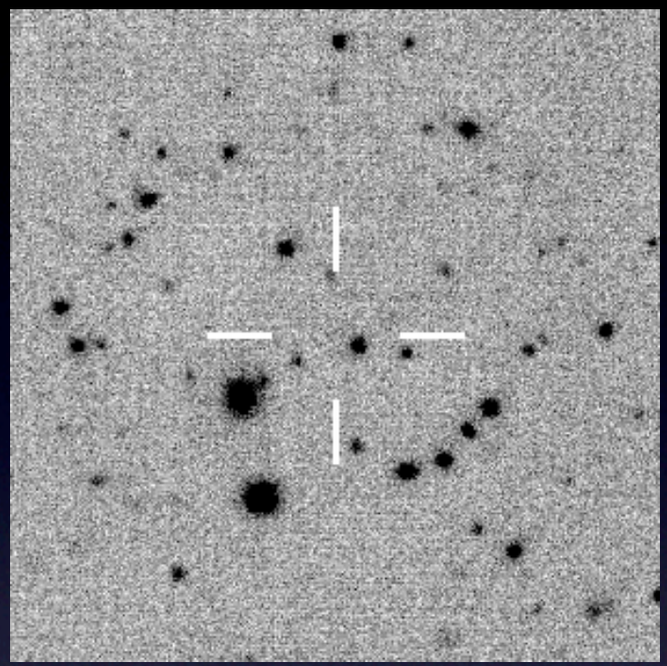
- XCSDXS candidate XCS0222a observed with Keck DIEMOS (PI Stanford)
- several z=1.18 galaxies found, cluster?

z=1.18 group/cluster?



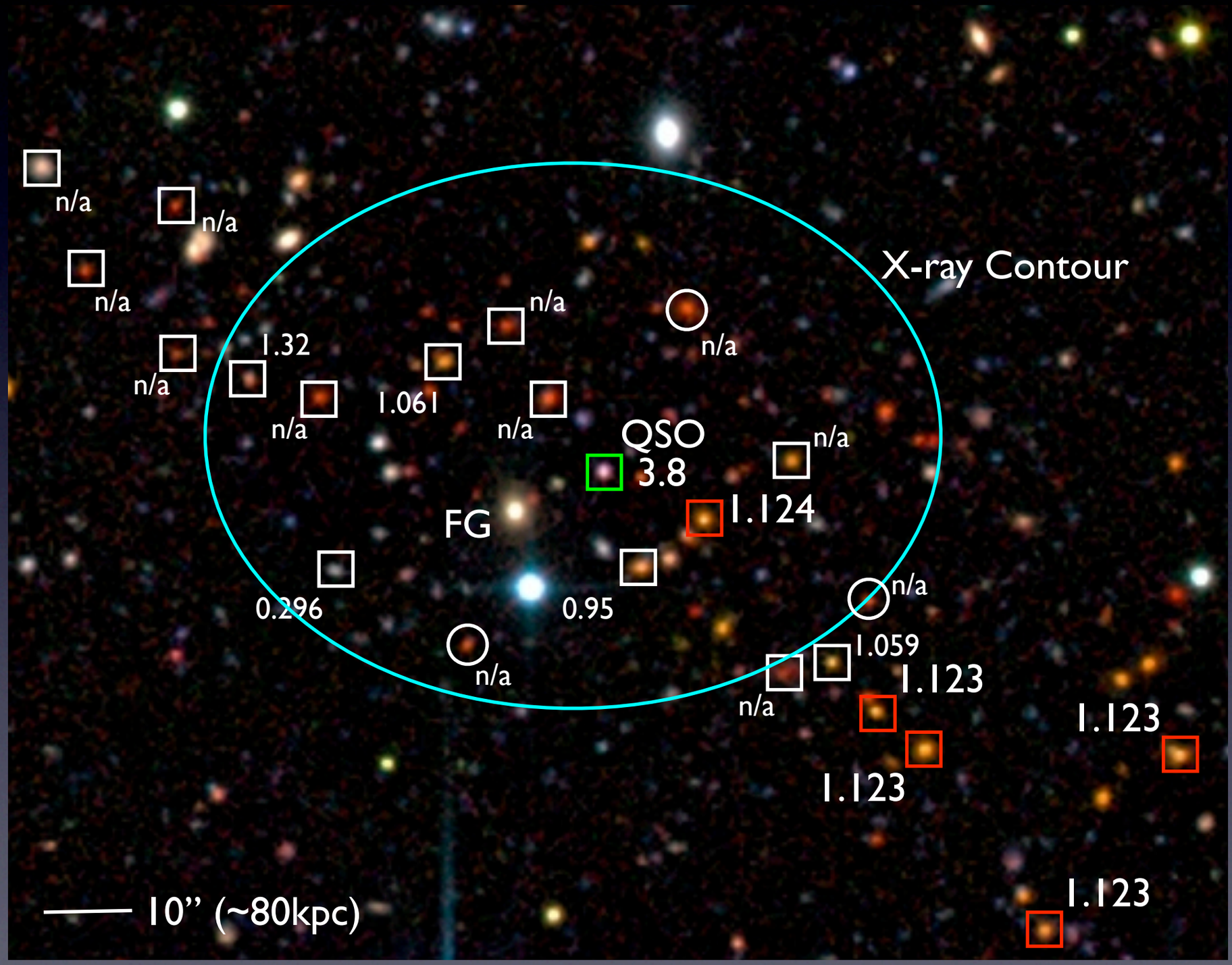
- XCSDXS candidate XCS0222a observed with Keck DIEMOS (PI Stanford)
- several z=1.18 galaxies found, cluster?

XCS0226 z=1.9 cluster?



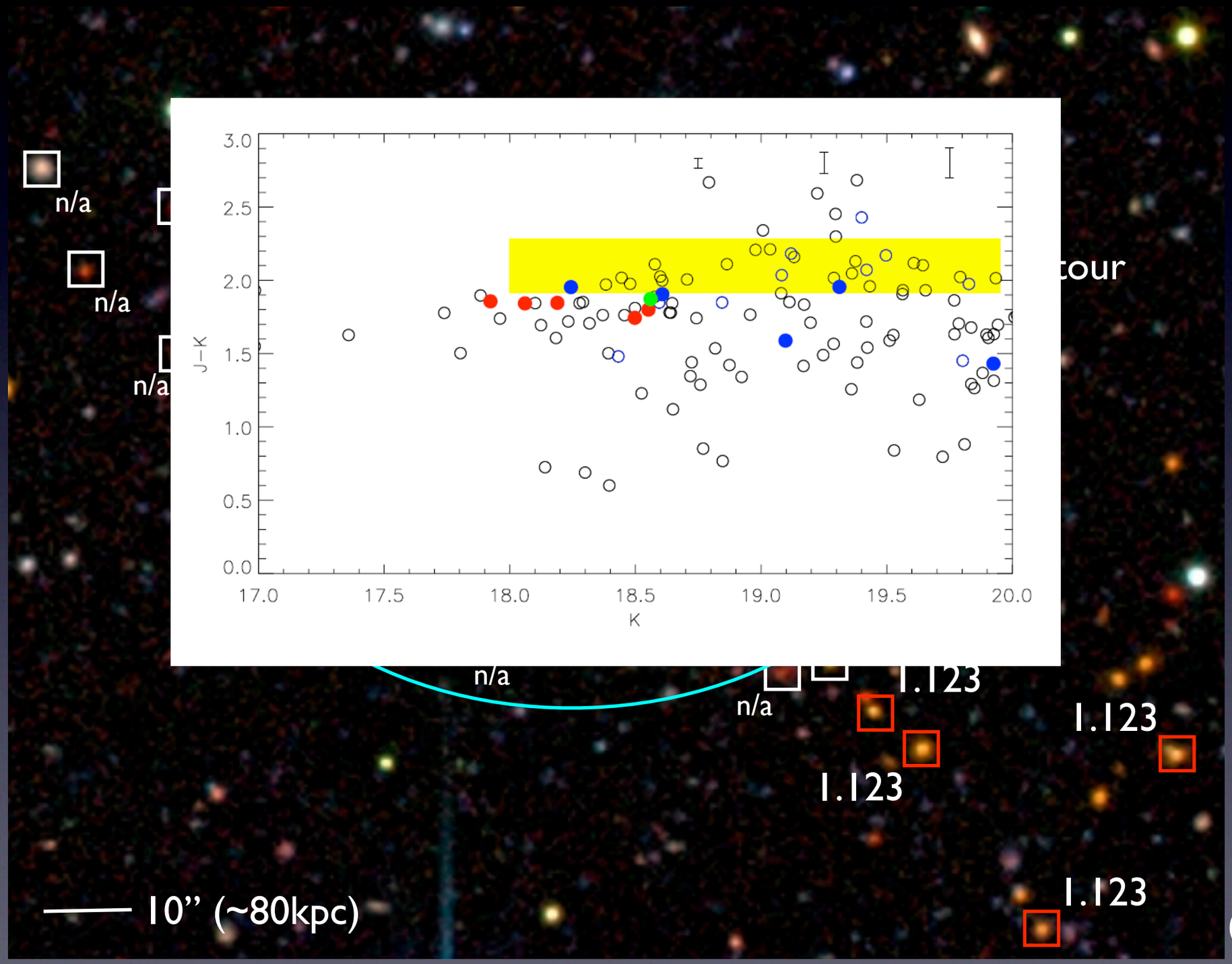
- XCSDXS candidate discovered independently by Andreon et al. 2008 (JKCS041, arXiv:0812.1699)
- Keck DEIMOS follow up (P.I. Stanford) analysis by Stanford, Hilton, Stott
- Very complicated region
  - Galaxy Group of 5+ members at z=1.123 south-west of X-ray centroid.
  - X-ray emission centred on z=3.8 QSO (point X-ray emission removed in Andreon et al. 2008)
  - Bright foreground galaxy near centre of field.

XCS0226 (JKCS 041) complicated

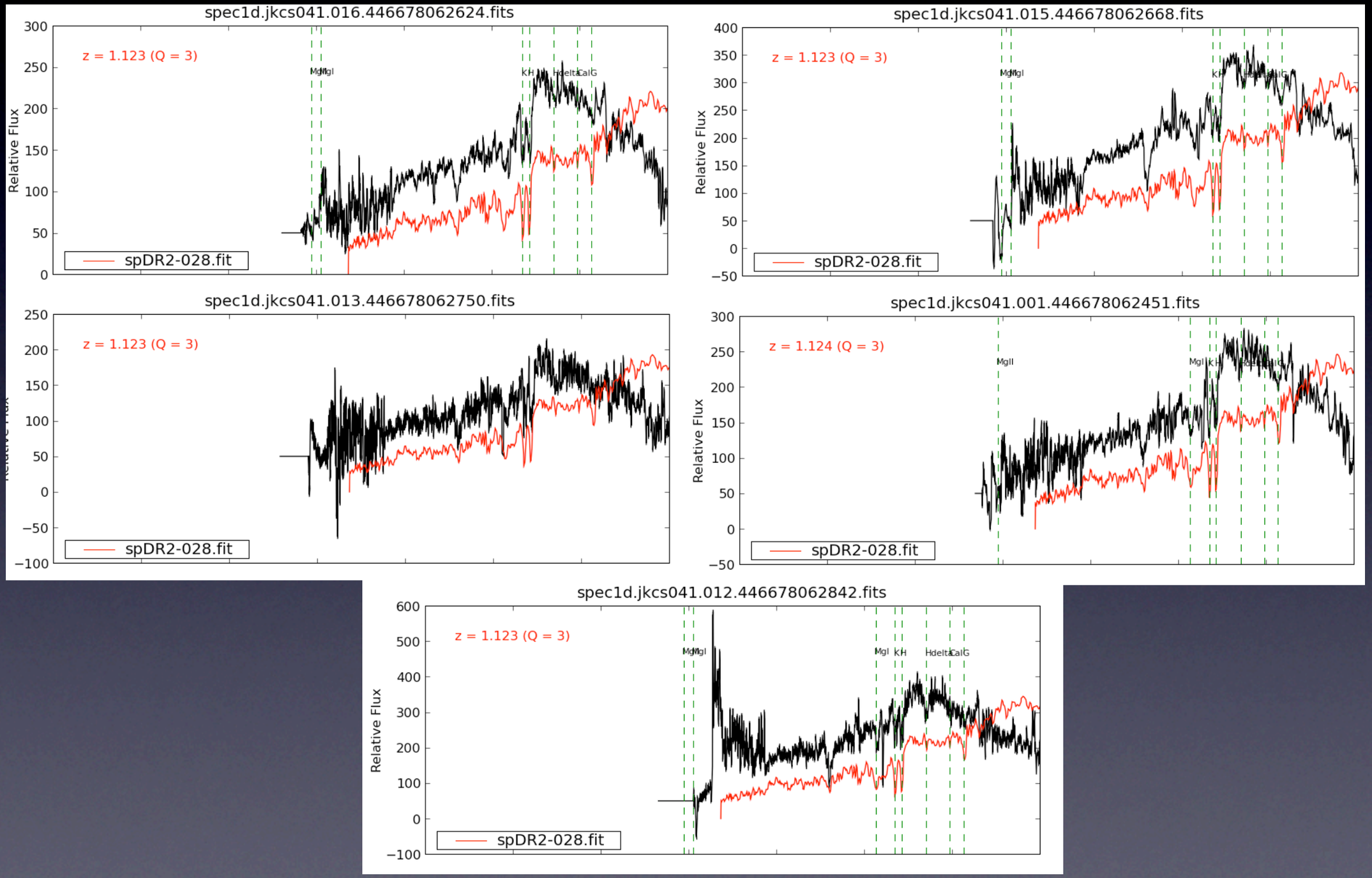


CFHT

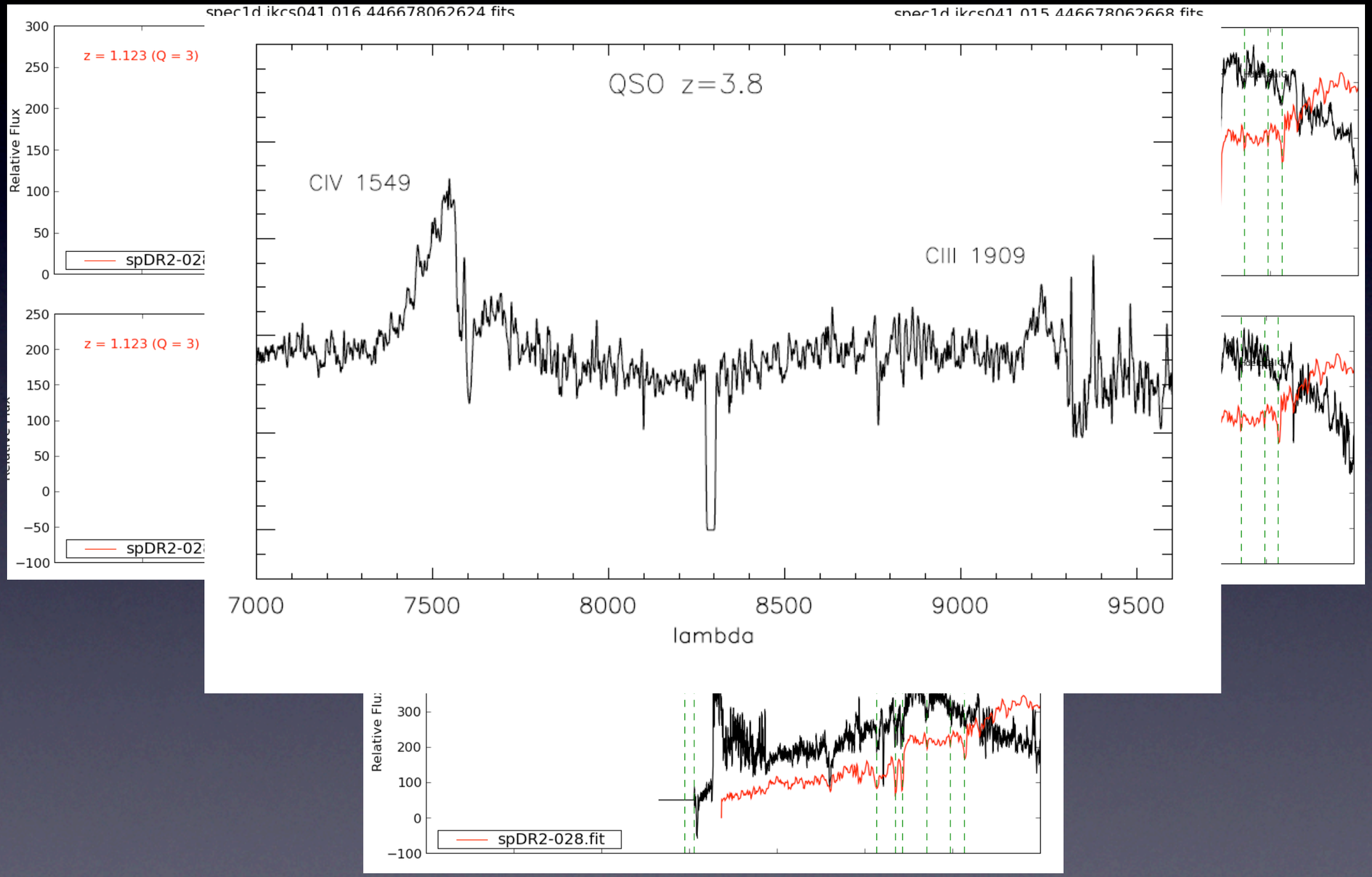
XCS0226 (JKCS 041) complicated



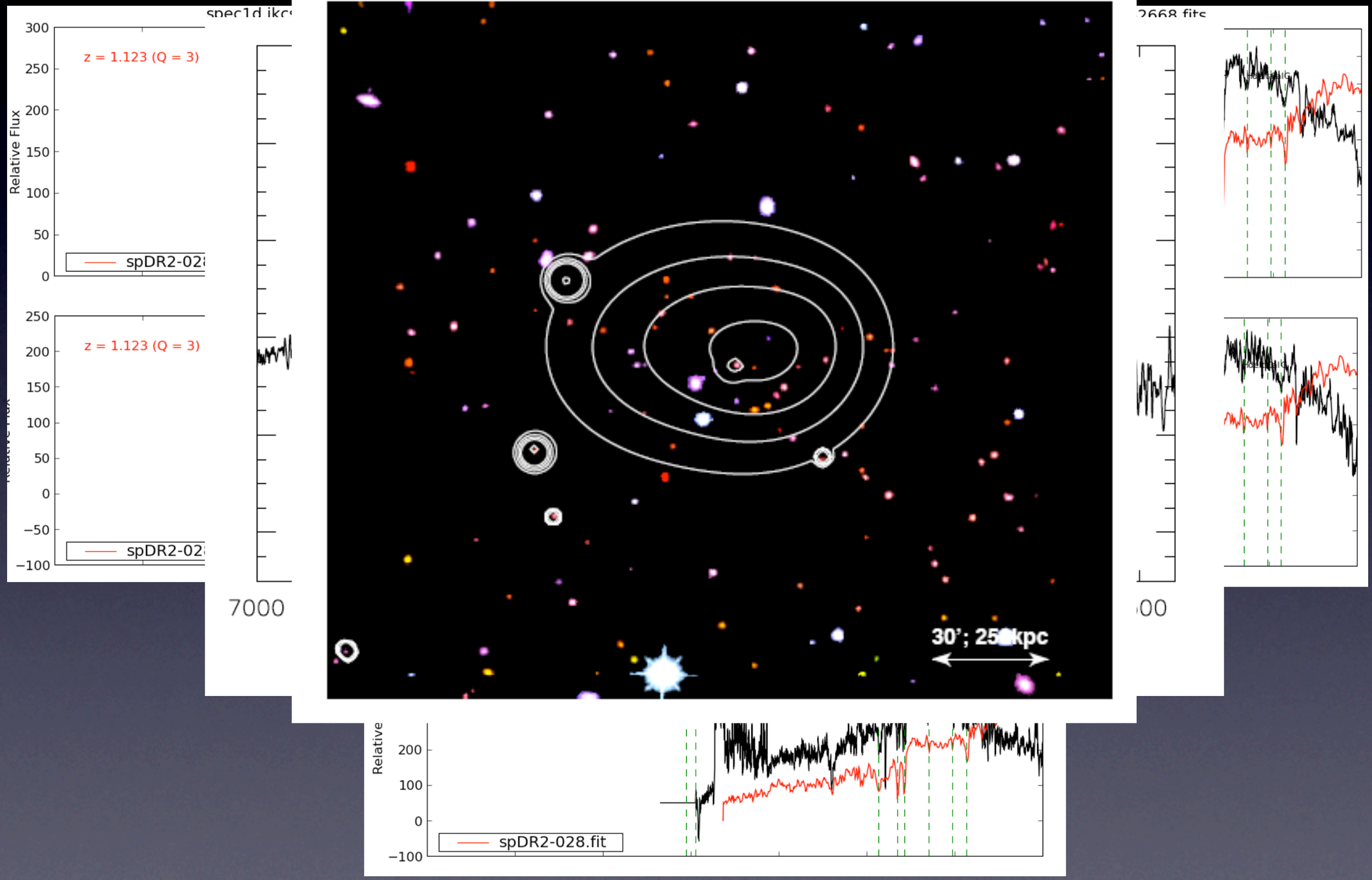
z=1.123 group and z=3.8 QSO



z=1.123 group and z=3.8 QSO



z=1.123 group and z=3.8 QSO



Summary

- BCGs are found to have assembled the majority of their mass before z=1.5 which is discrepant with latest semi-analytic models.
- BCGs have increased by a factor of 2 in scale size since z~1, influence of minor mergers?
- XCS in combination with UKIDSS DXS finding high redshift galaxy clusters, z=1.04 cluster confirmed
- XCS0226 (JKCS041) in very complicated region
- See: Collins et al. 2009, Nature, 458, 603
  Stott et al. ApJ submitted