# The red sequence in proto-clusters associated with radio galaxies at $2 < z < 3$

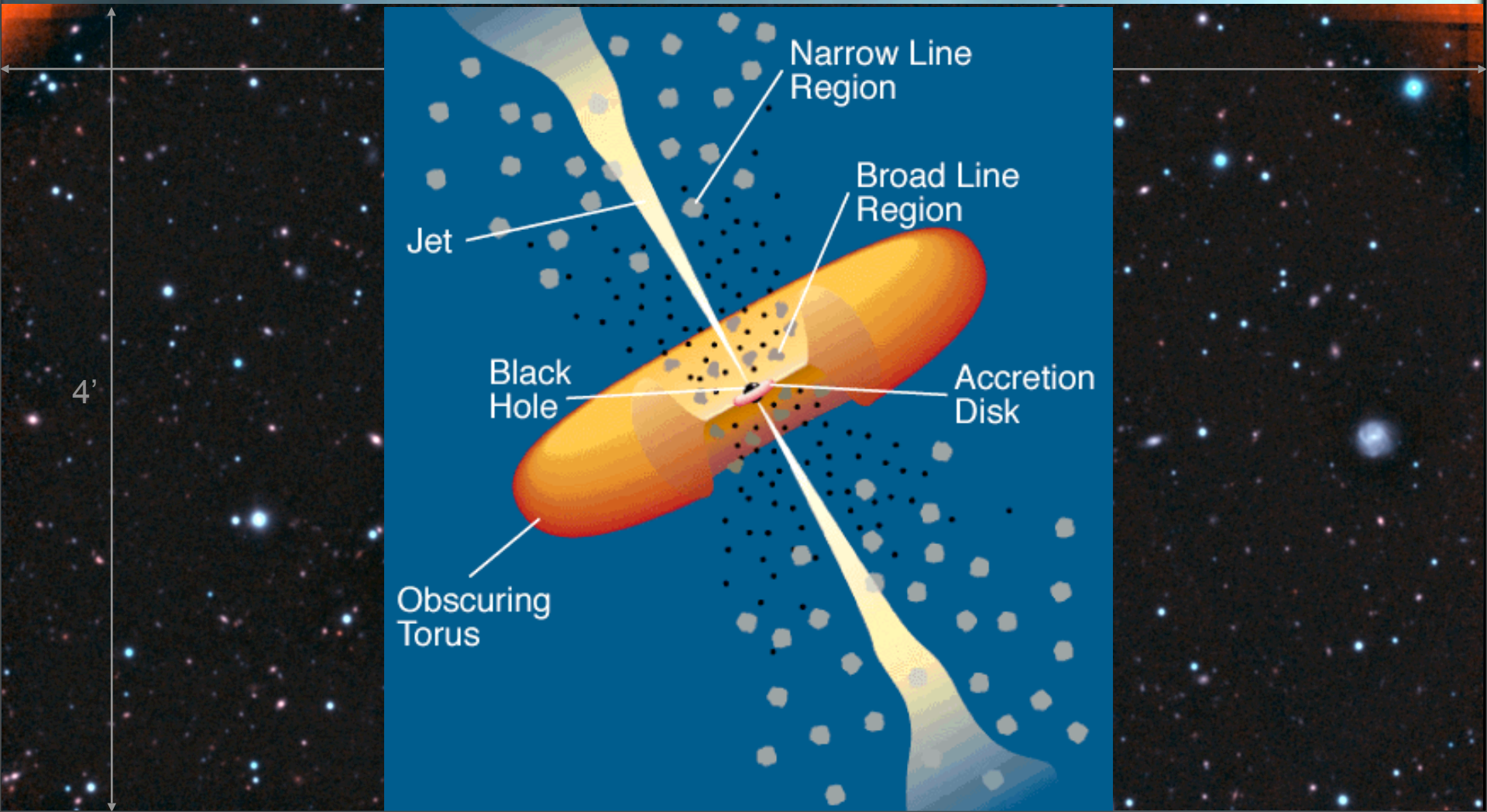
Jaron Kurk (MPIA, Heidelberg)

T. Kodama, I. Tanaka, M. Kajisawa, B. Venemans,
C. De Breuck, J. Vernet, C. Lidman, M. Doherty

Kodama et al. (2007), MNRAS in press, astro-ph/0703382

# A proto-cluster at z = 2.16

Subaru/MOIRCS J 83m, Ks 55m, seeing 0.5”-0.7”



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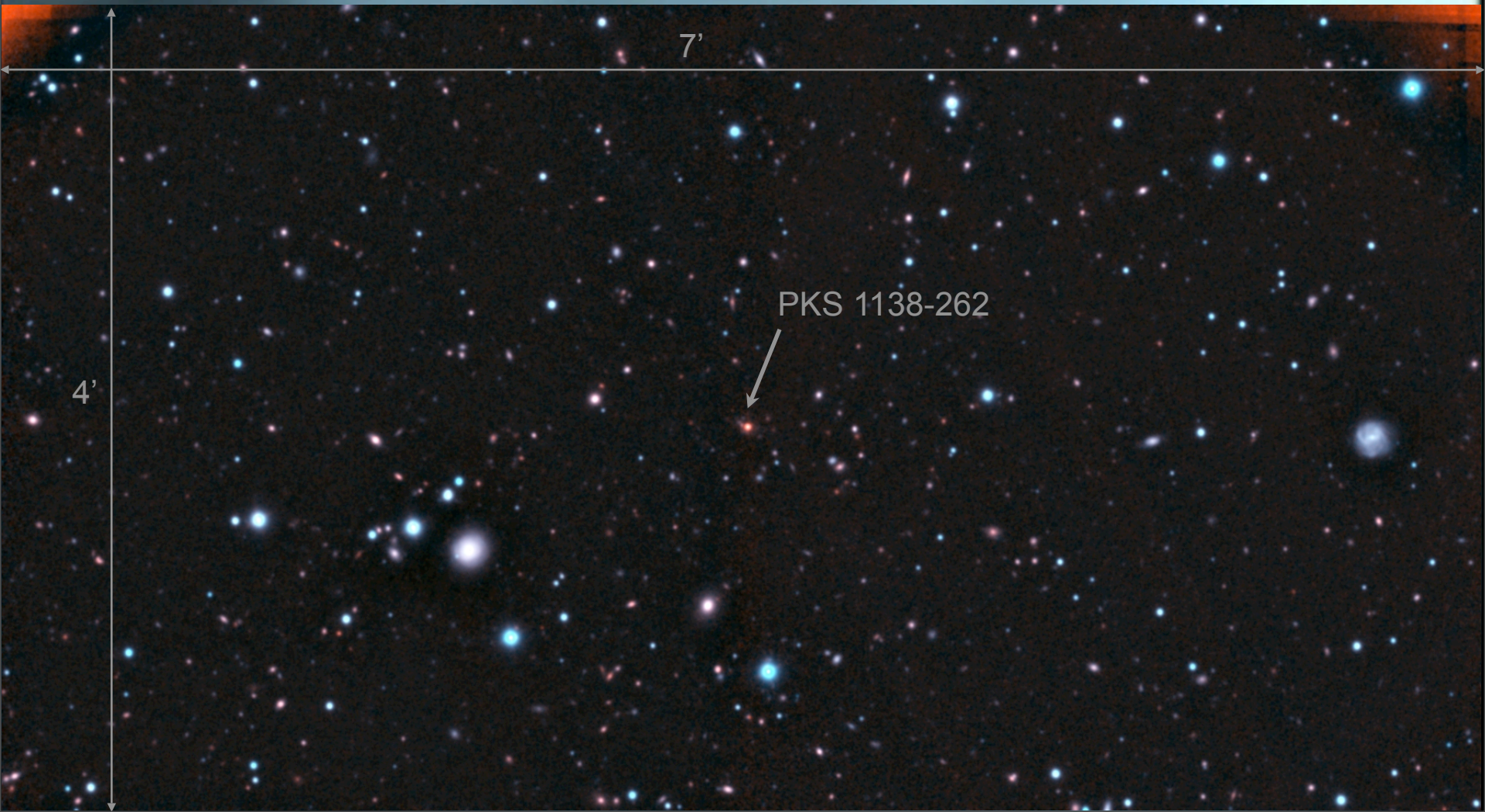


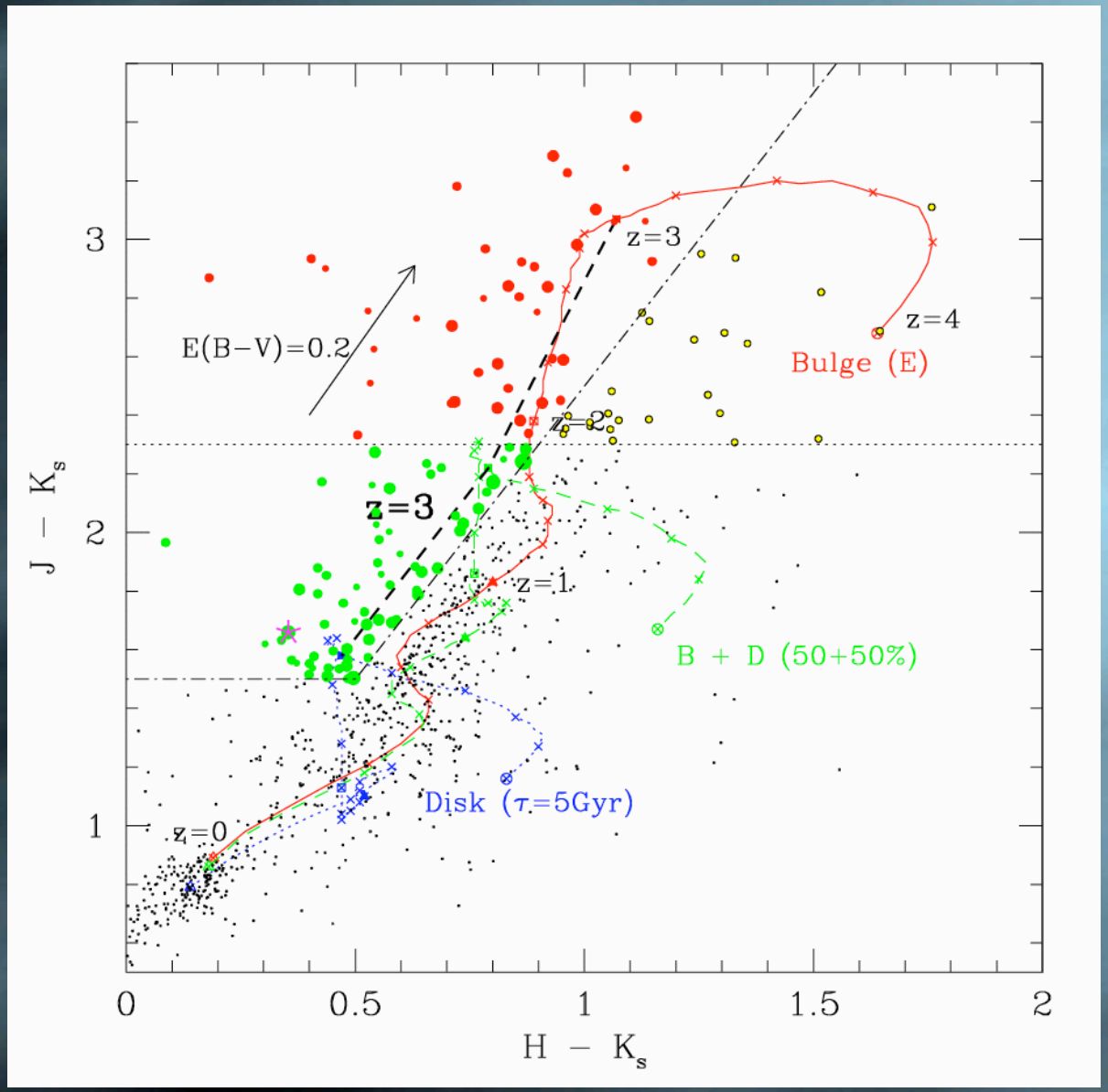
# Four HzRGs fields

## Subaru/Moircs (7'x4') and NTT/SOFI (5'x5')

| Targets | redshift | J (min) | H (min) | Ks (min) | PSF (arcsec) |
|---|---|---|---|---|---|
| PKS 1138-262 | 2.156 | 83 | | 55 | 0.5~0.7 |
| USS 1558-003 | 2.527 | 180 | | 175 | 0.7 |
| USS 0943-242 | 2.923 | 118 | 68 | 63 | 0.4~0.6 |
| MRC 0316-257 | 3.130 | 78 | 60 | 55 | 0.6~0.7 |

J=23.5, H=22.3, K=22.0 (5 sigma, Vega)

# DRG/JHK colour selection




Kajisawa et al. (2006)

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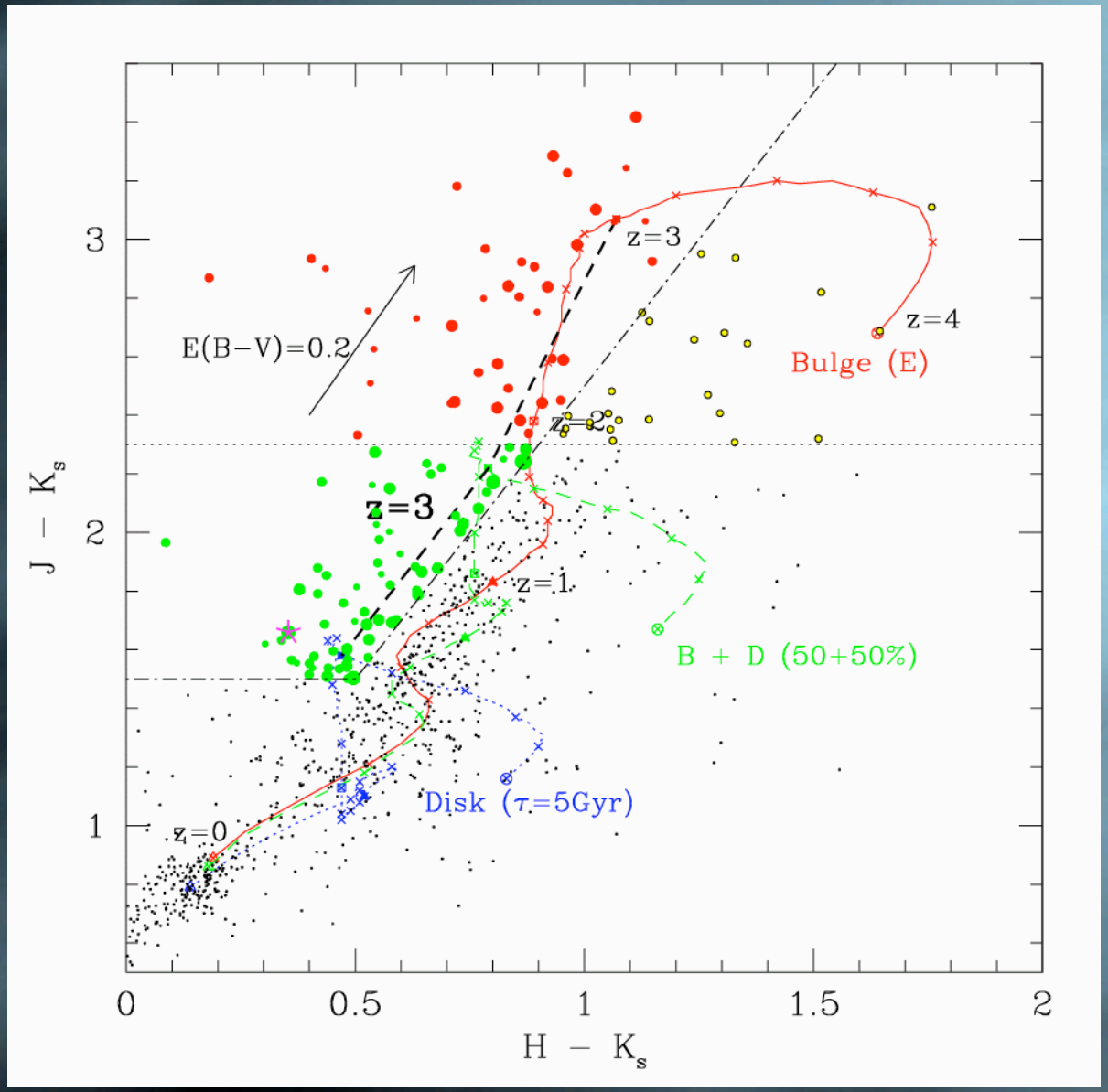


Early-type galaxies at
z > 2 have J-K > 2.3

Franx et al. 2003

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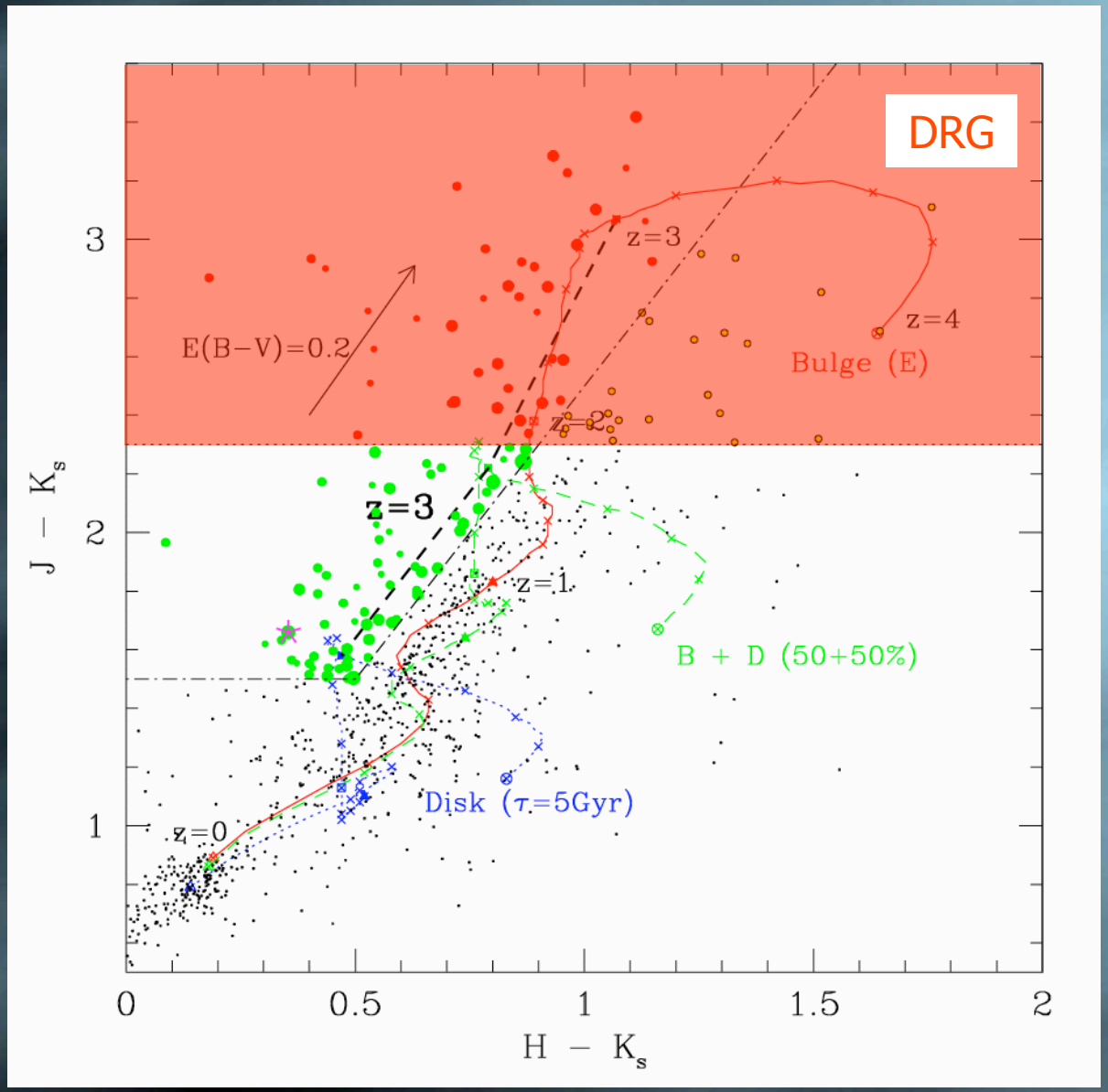


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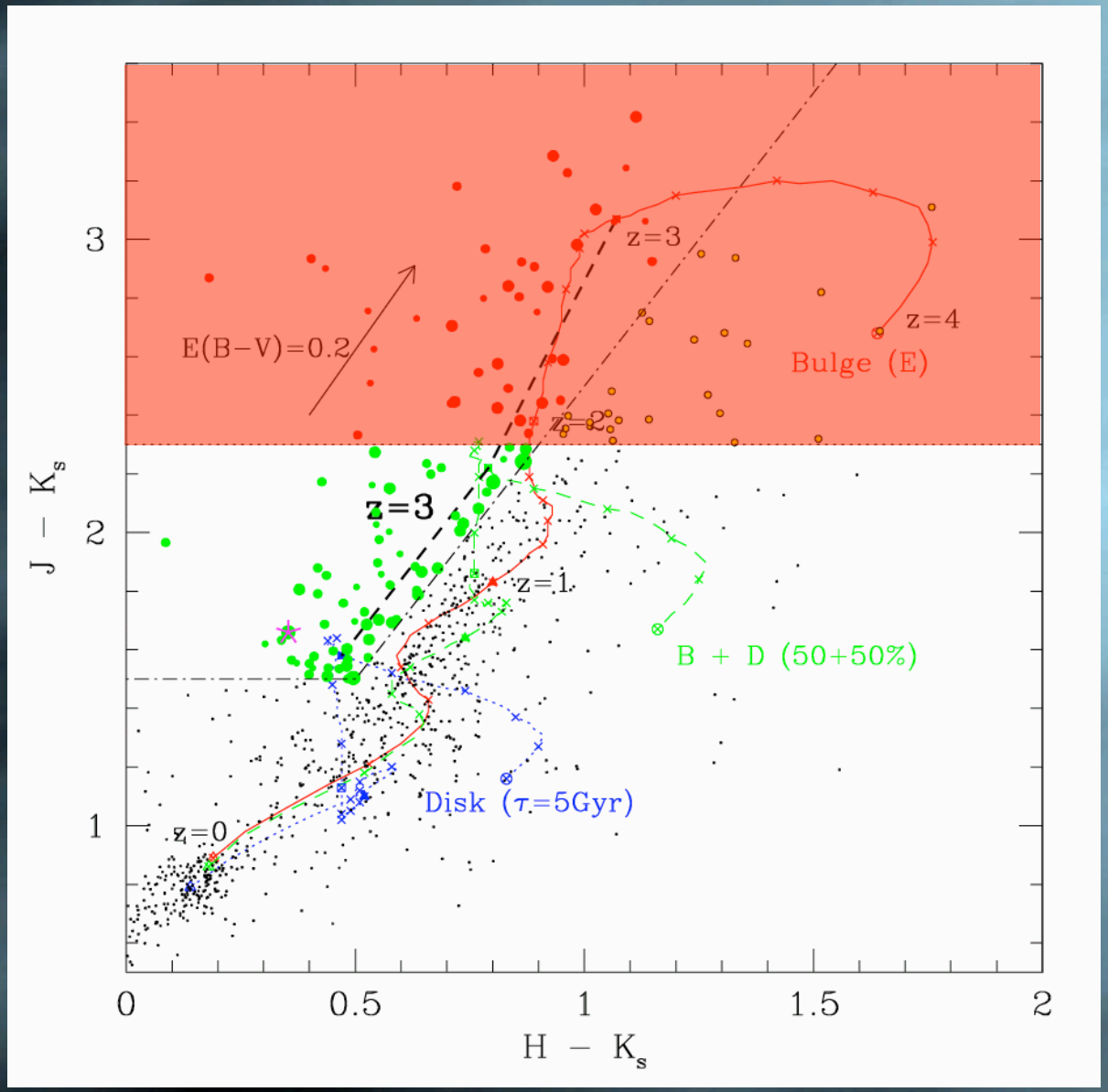


Early-type galaxies at
$z > 2$ have $J-K > 2.3$

Using additional criterium
$(J-K) > 2\,(H-K) + 0.5$
only galaxies at $z < 3.1$

Kajisawa et al. (2006)

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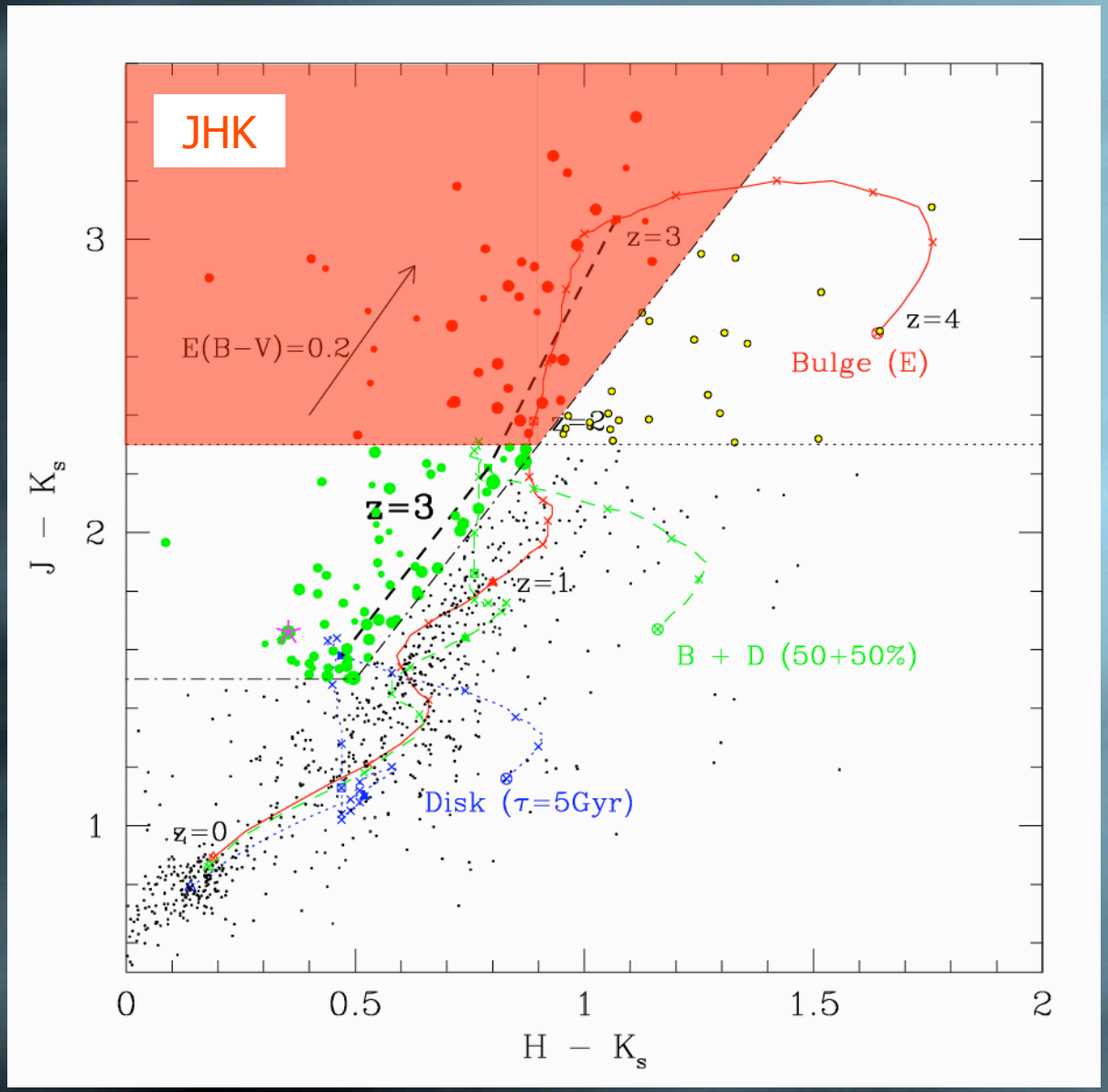


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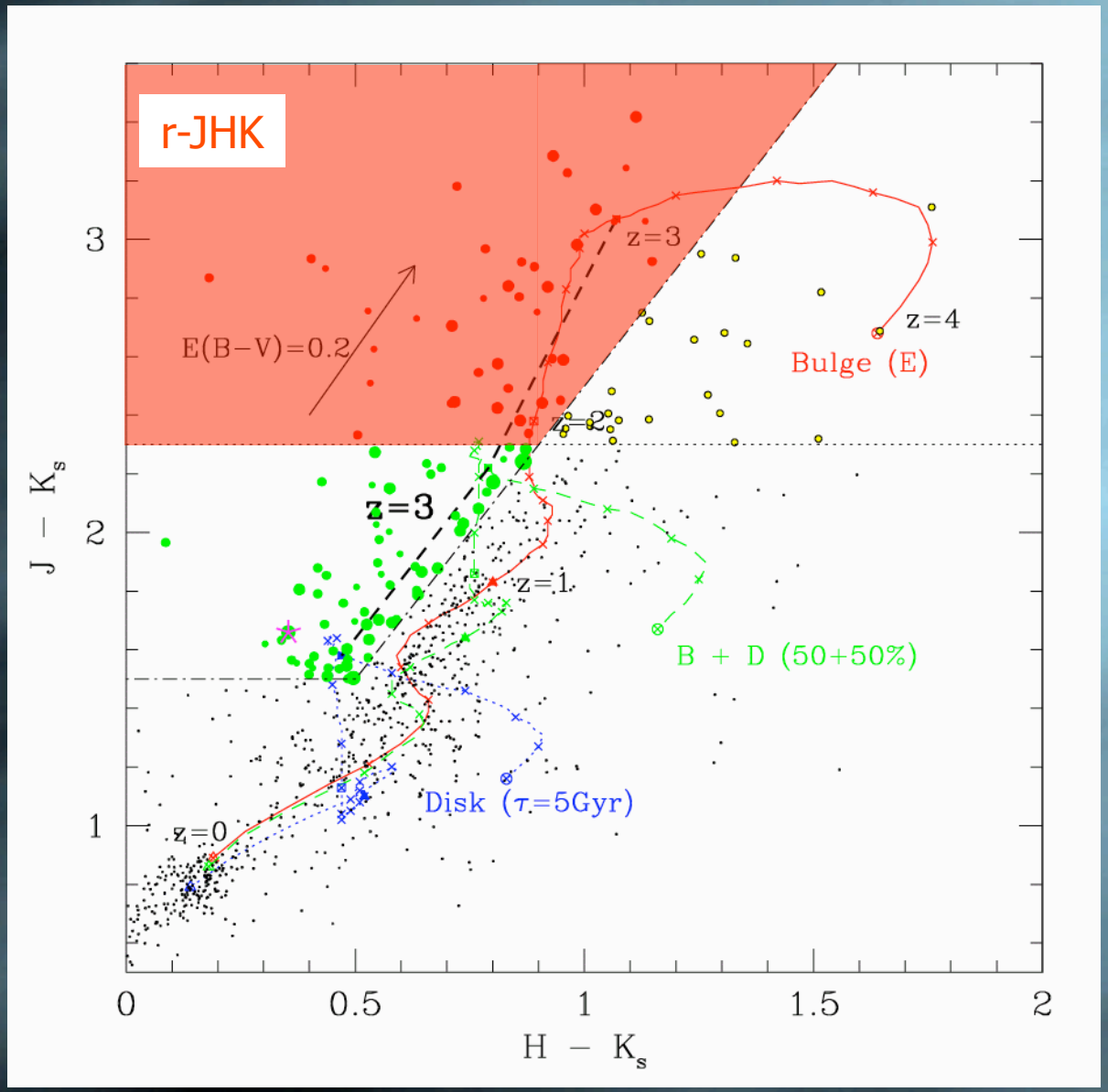


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Combined with $J-K > 1.5$, one gets also star-forming galaxies at $2.4 < z < 3.1$

Kajisawa et al. (2006)

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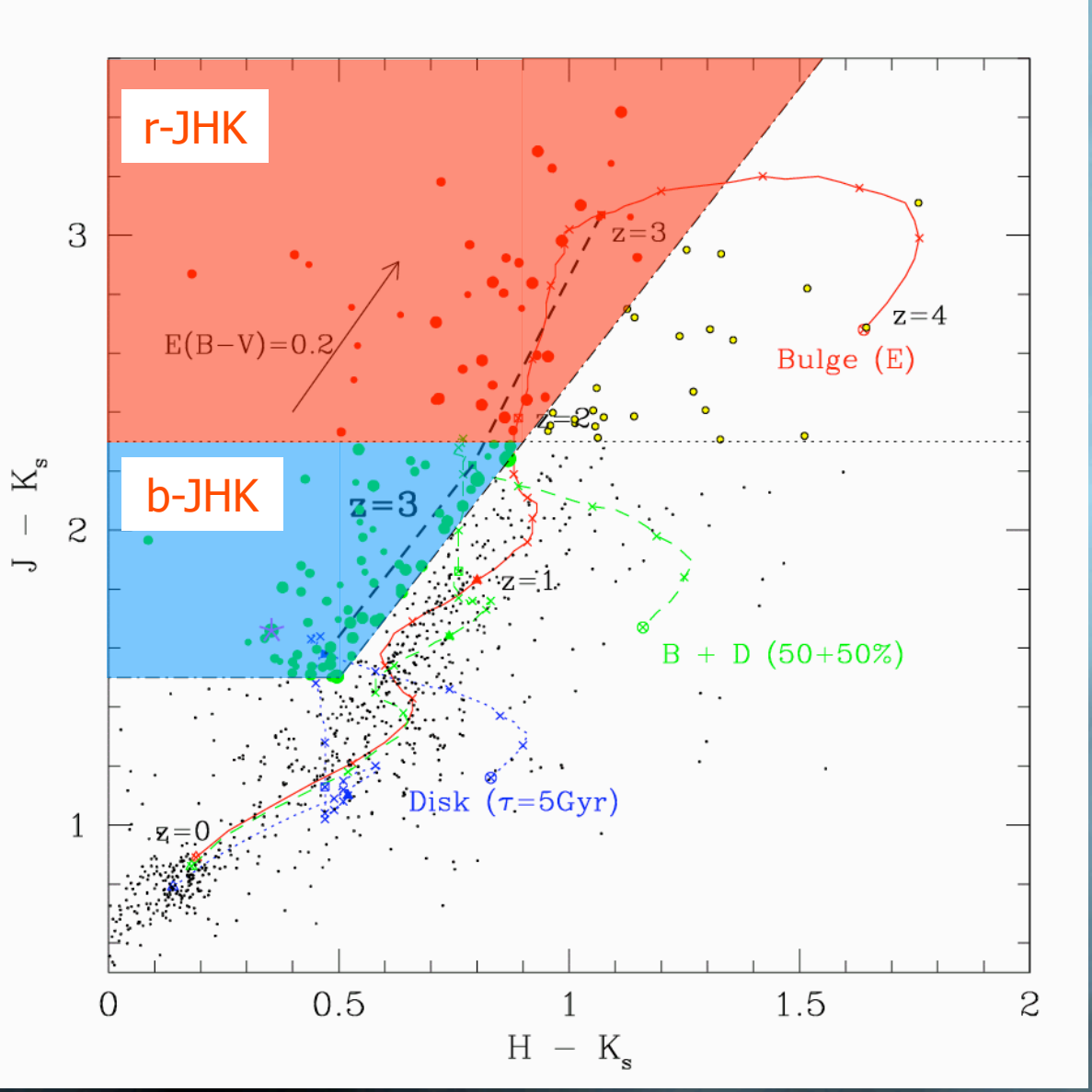


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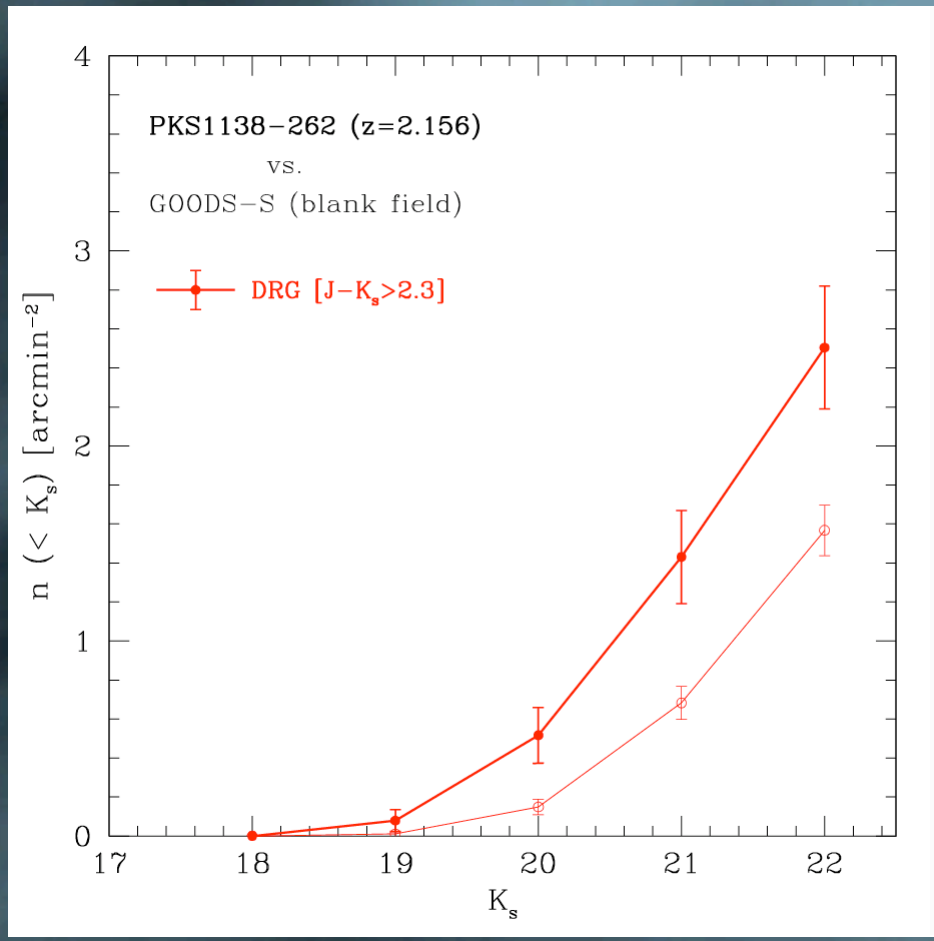
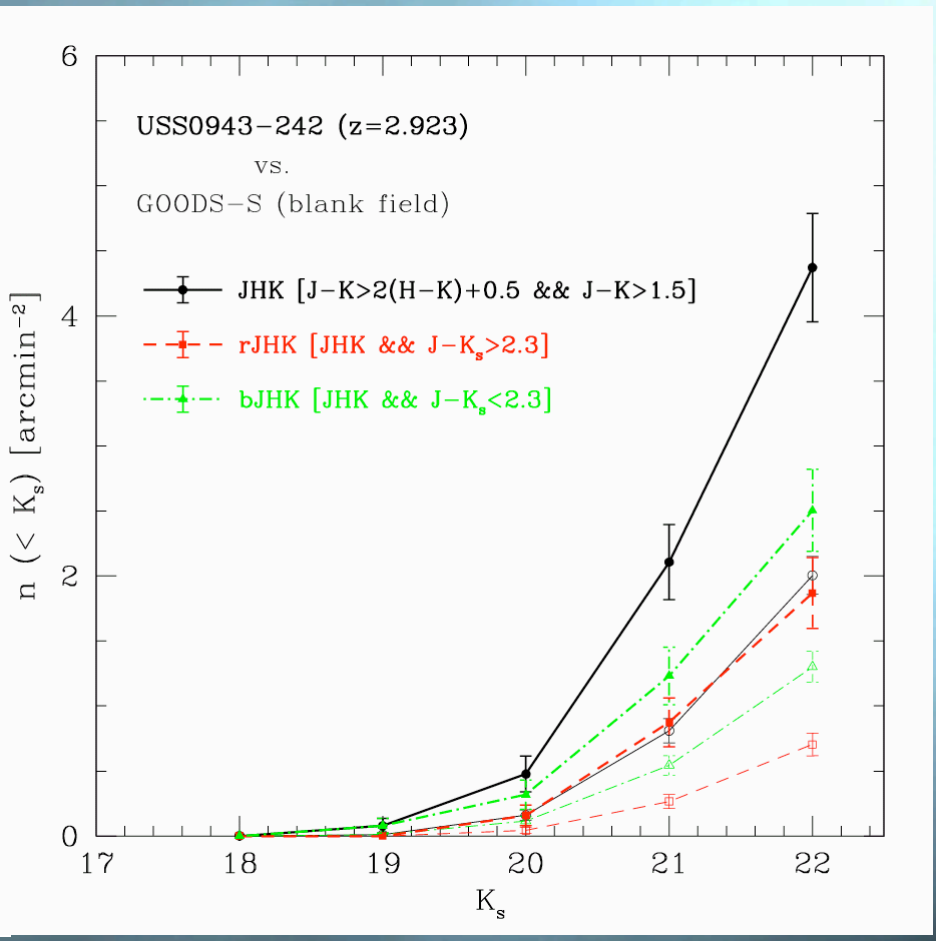
Kajisawa et al. (2006)

# DRG/JHK overdensities

PKS 1138-262 (z = 2.16)




USS 0943-242 (z = 2.92)

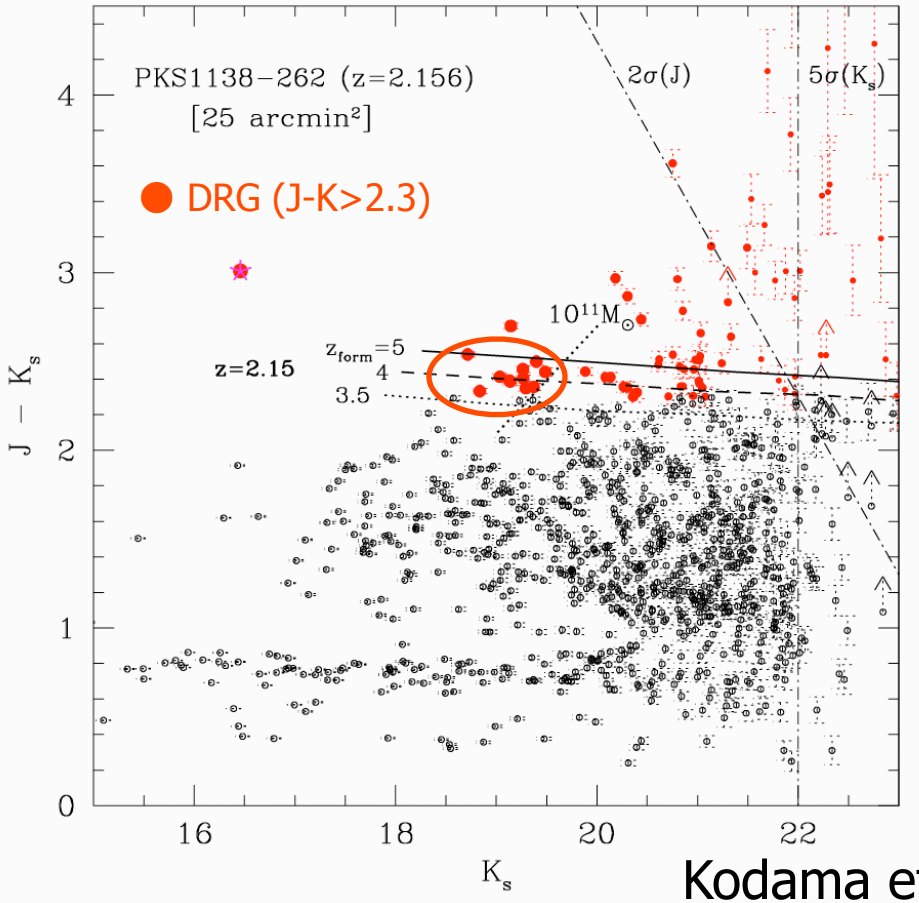


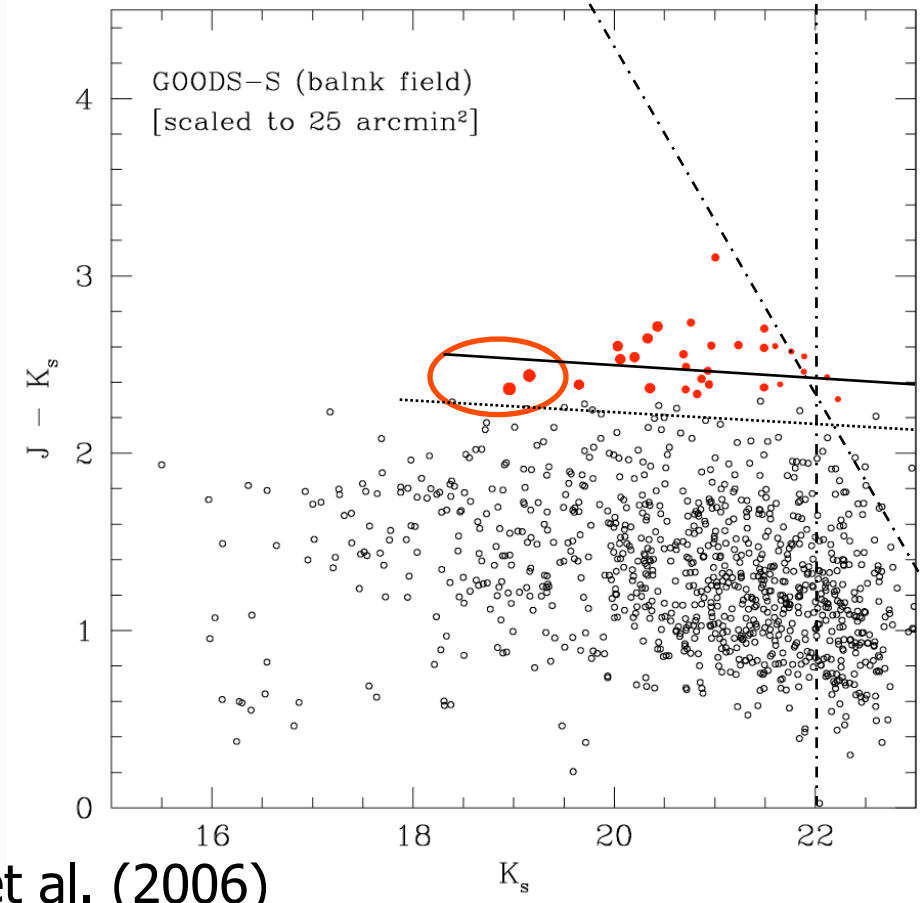

Statistical excess of 2~4 in comparison with GOODS-S

# Colour-magnitude diagram

PKS 1138-262 (z = 2.16)

GOODS-S



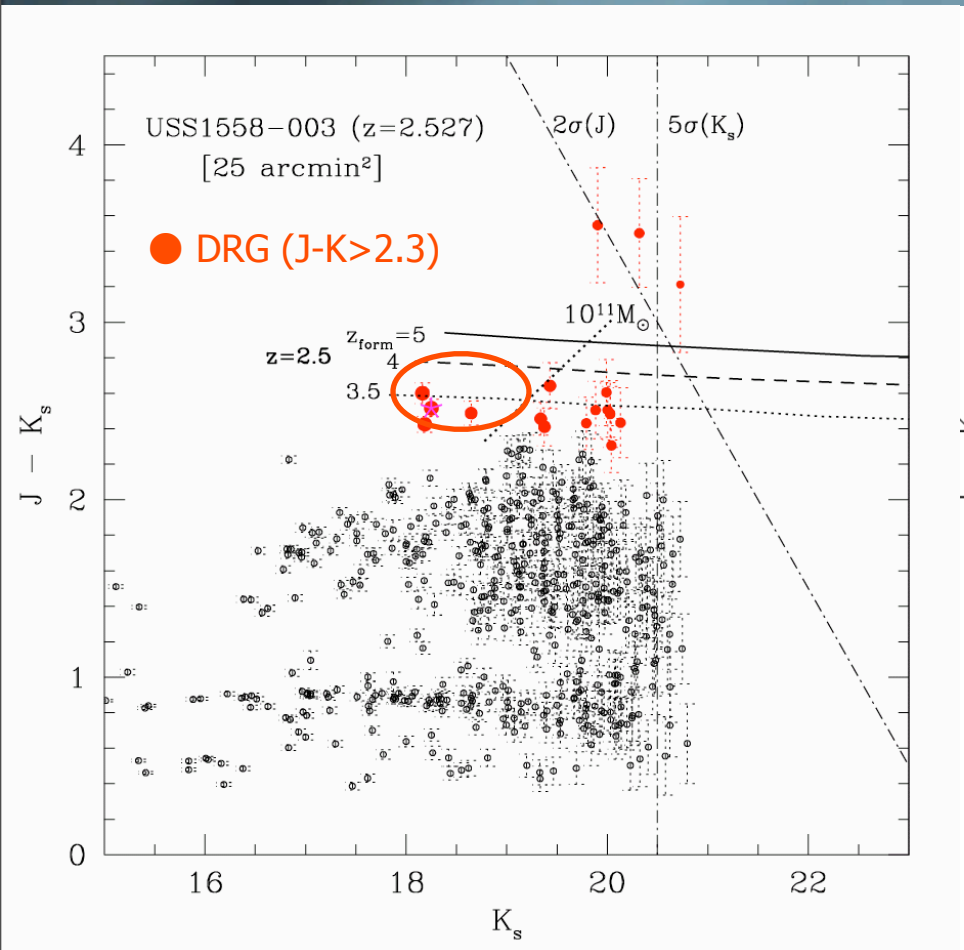

Kodama et al. (2006)

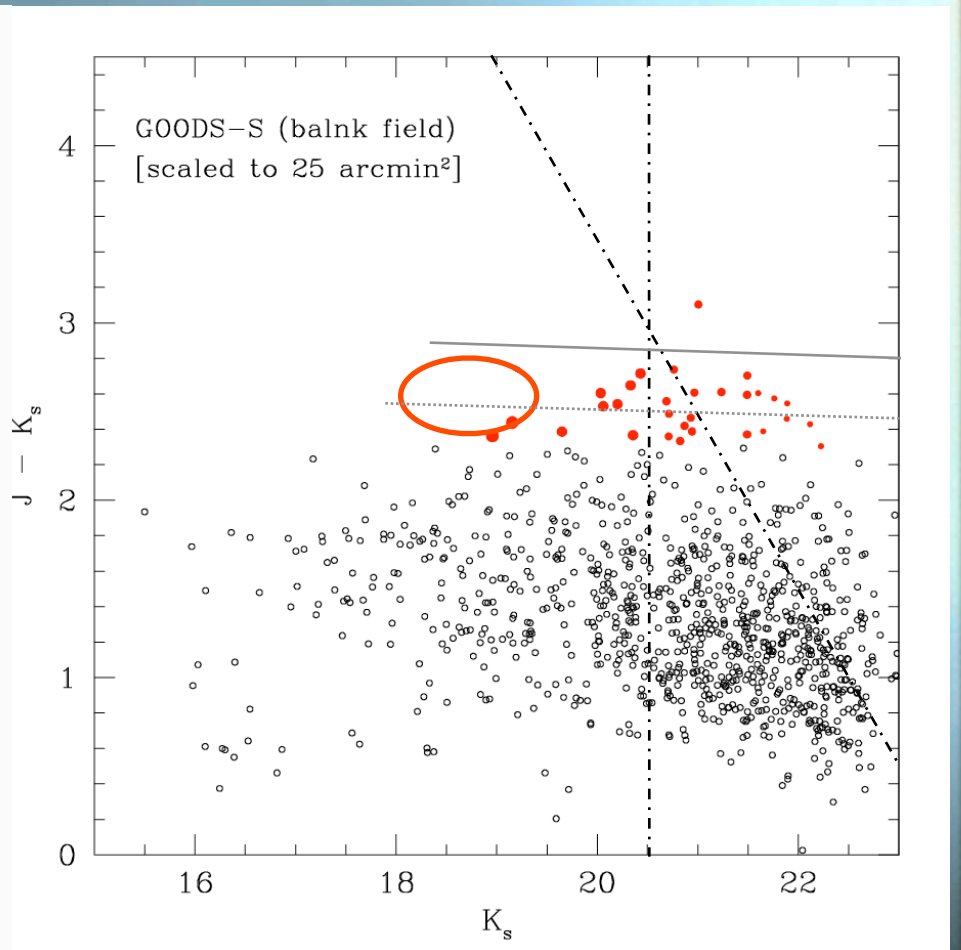
Red sequence with massive ($10^{11}$ $M_o$) galaxies present, $z_f$ ~ 4-5

# Colour-magnitude diagram

USS 1558-003 (z = 2.53)

GOODS-S



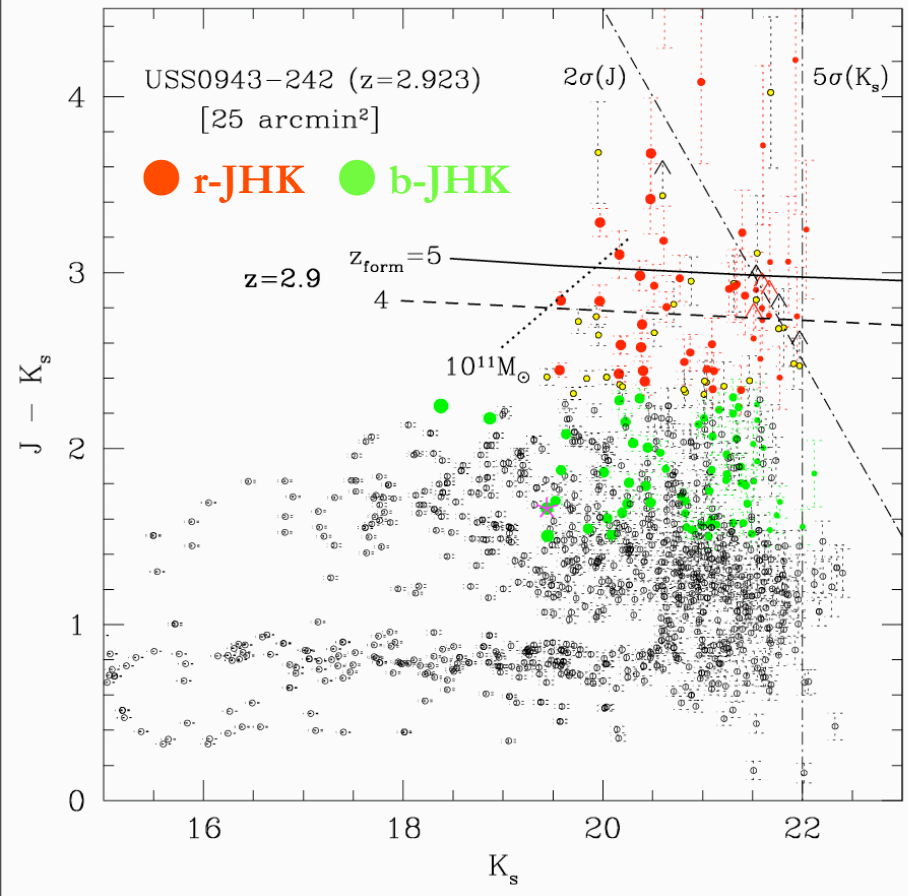



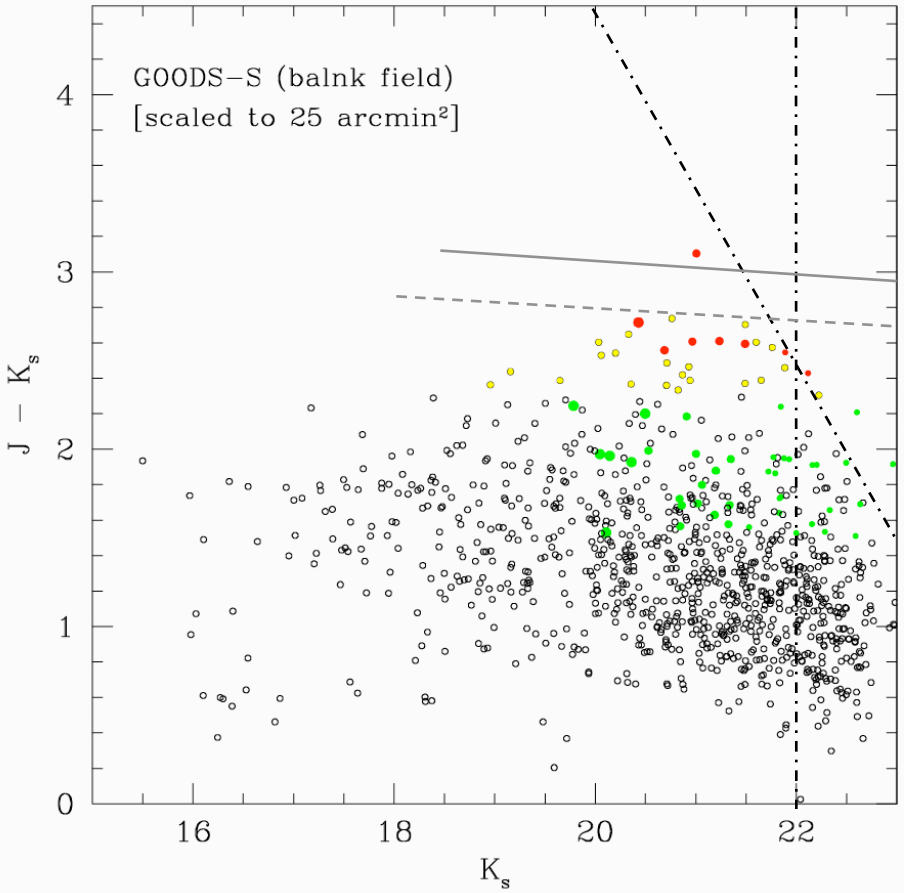

Red sequence with massive ($10^{11}$ $M_o$) galaxies present, $z_f \sim 3.5$

# Colour-magnitude diagram

USS 0942-242 (z = 2.92)

GOODS-S

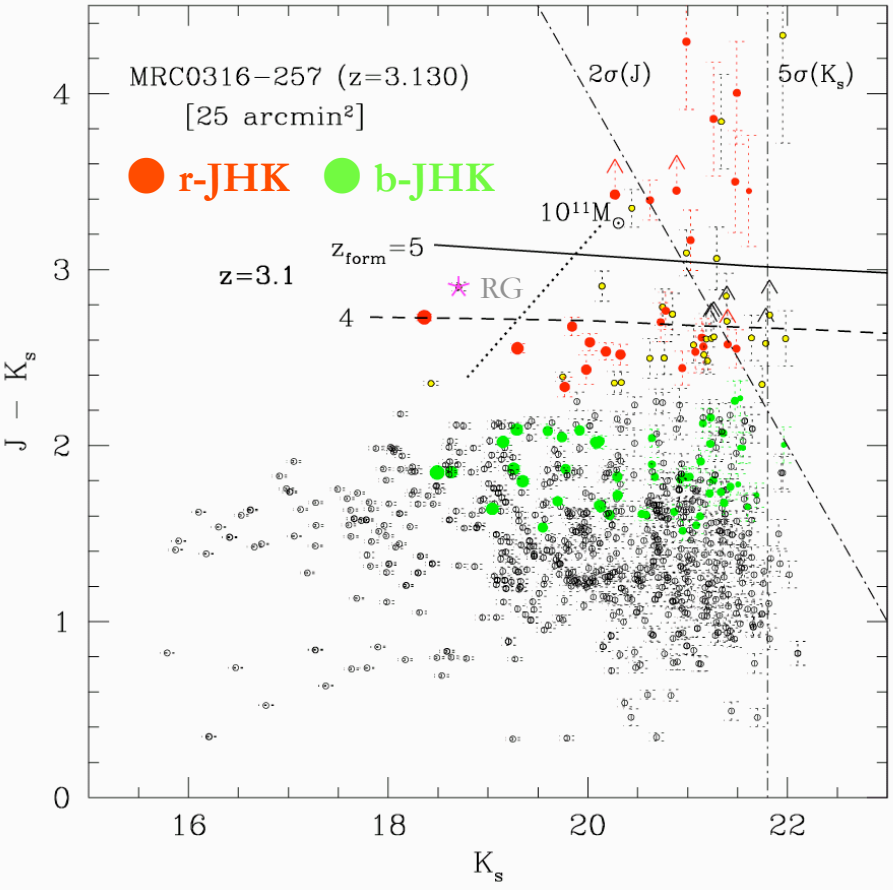


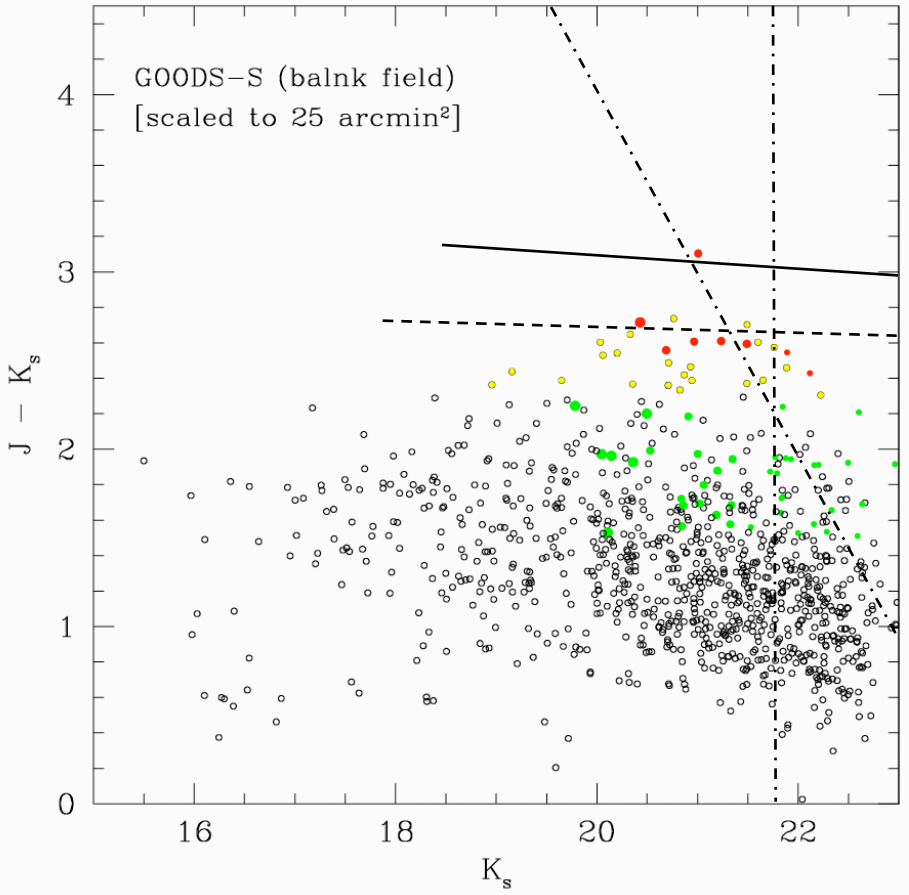

Excess of red galaxies, $z_f > 4$, but no massive ($10^{11}$ $M_o$) galaxies

# Colour-magnitude diagram

MRC 0316-257 (z = 3.13)

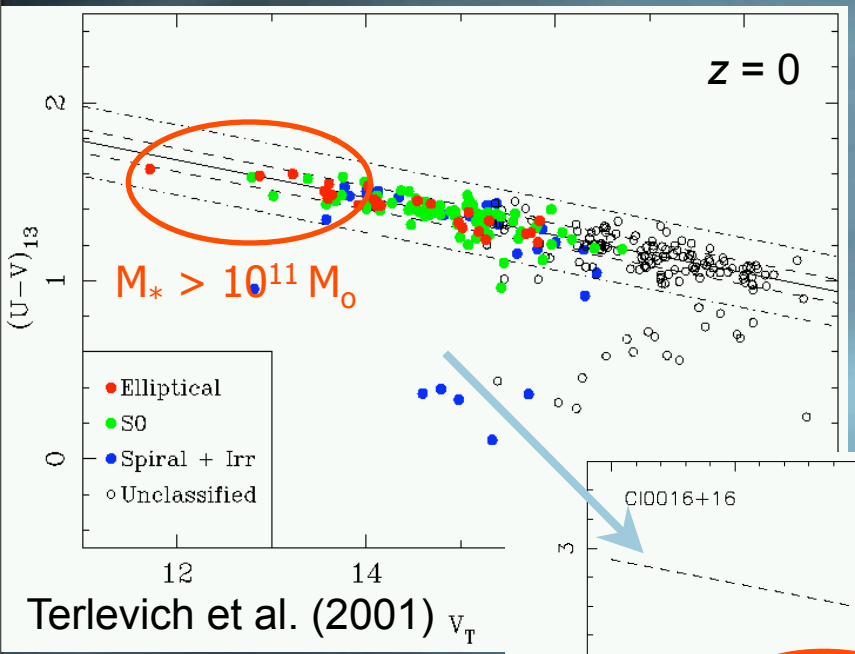



GOODS-S

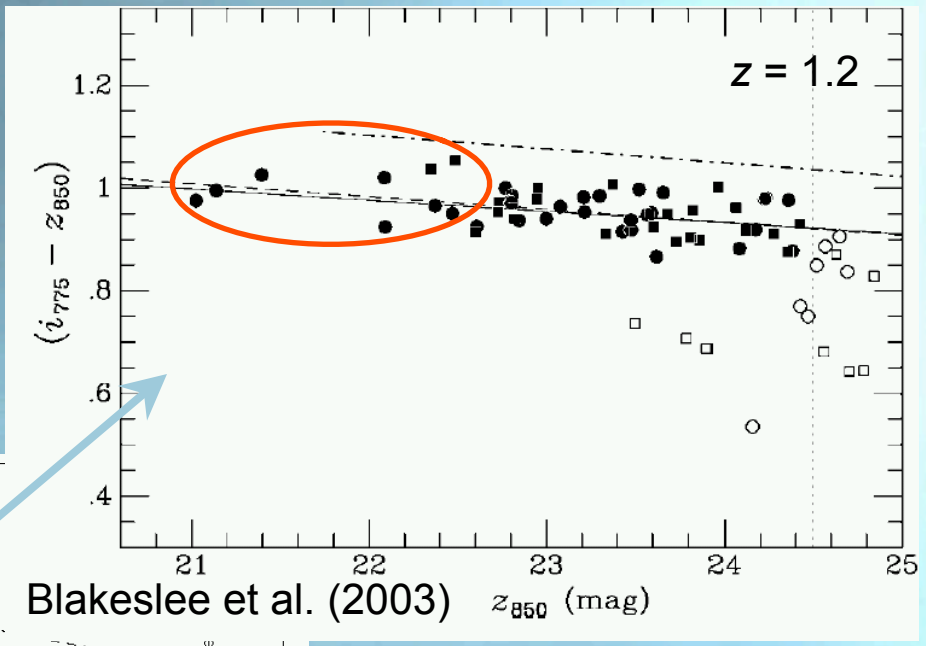



No clear RS, but some red massive ($10^{11}$ $M_o$) galaxies present, $z_f \sim 4$

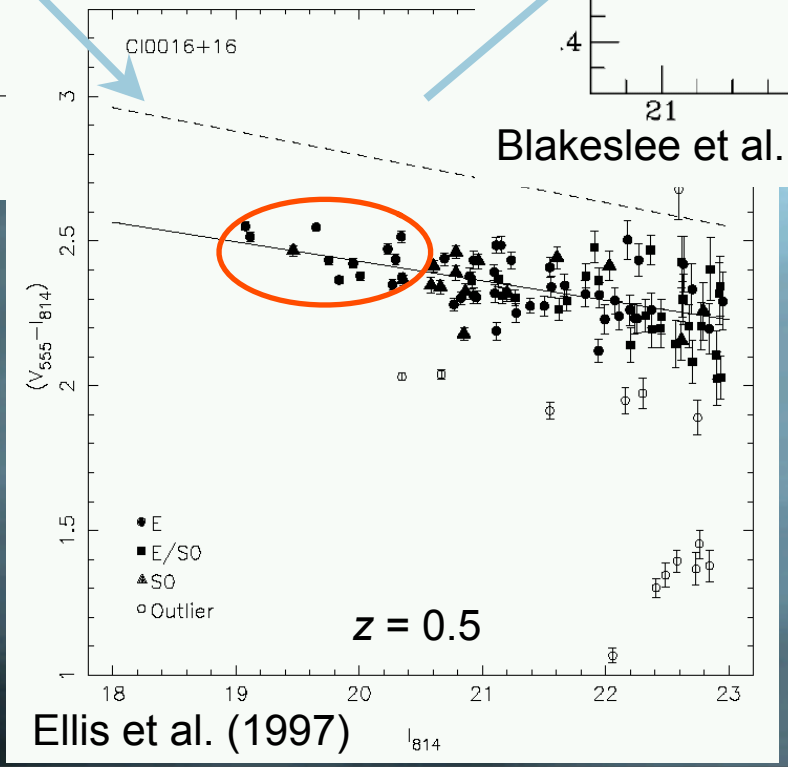
# When does the RS appear?




Terlevich et al. (2001)




Blakeslee et al. (2003)




Ellis et al. (1997)

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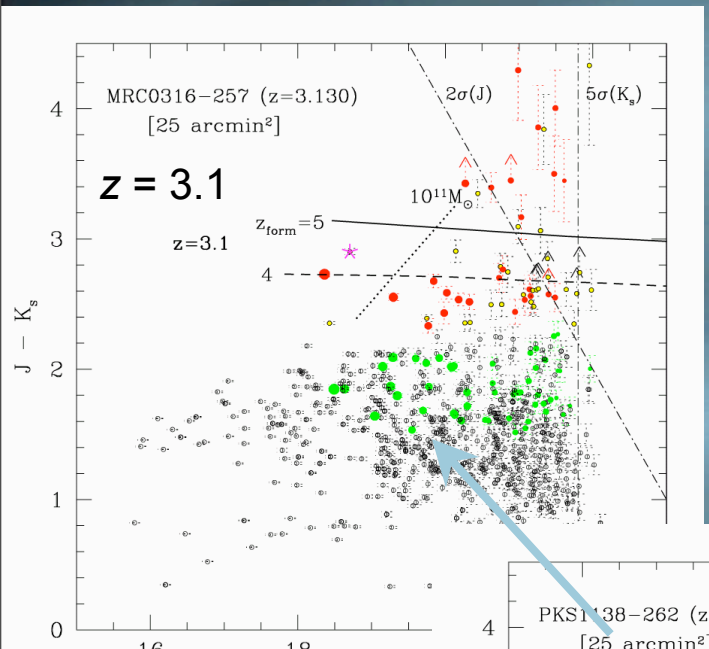
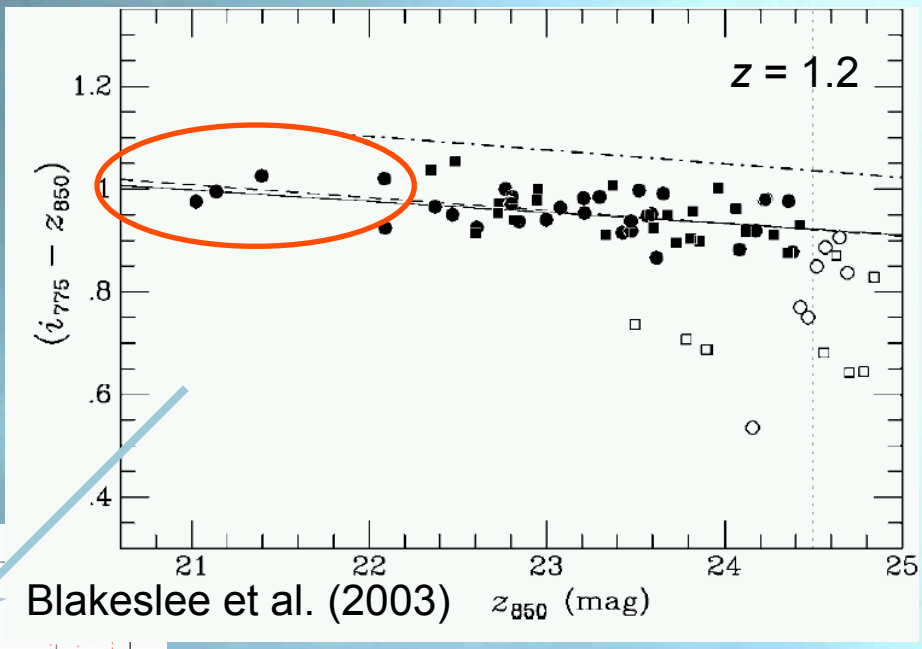



Kodama et al. (2007)

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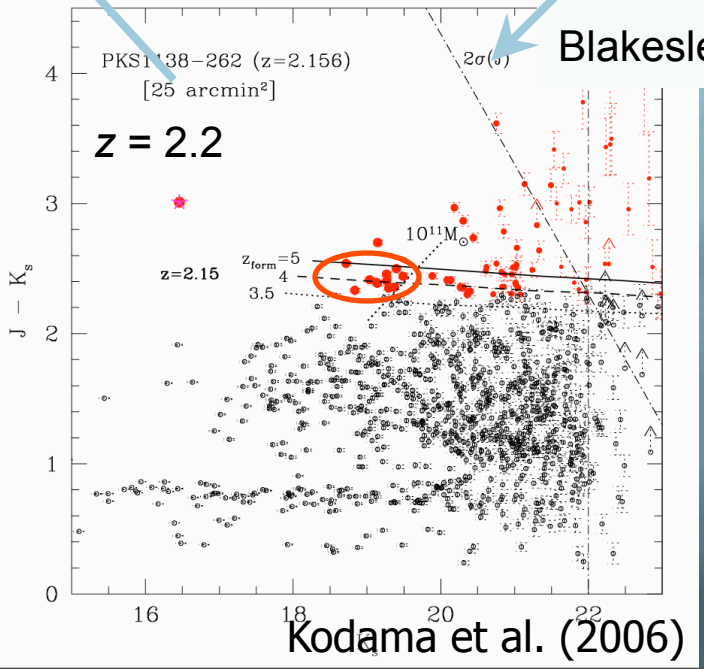
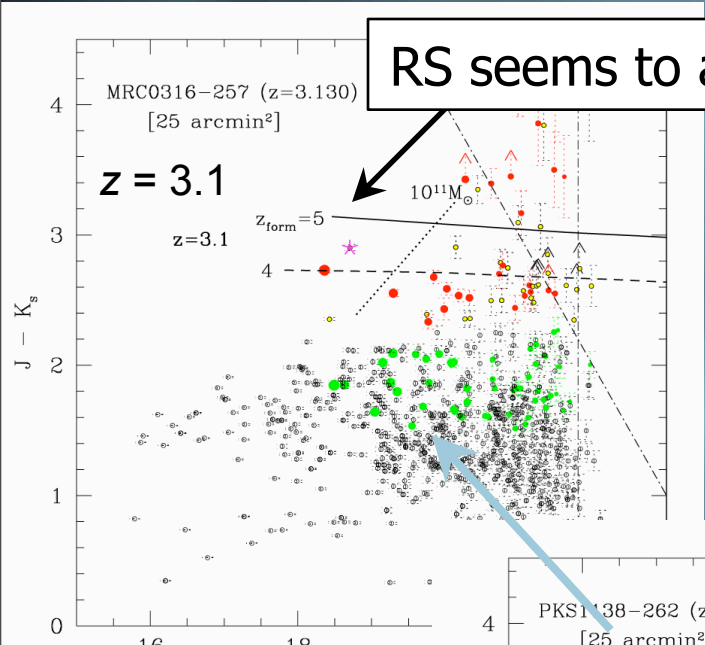



Kodama et al. (2006)

# When does the RS appear?

RS seems to appear first around z ~ 3

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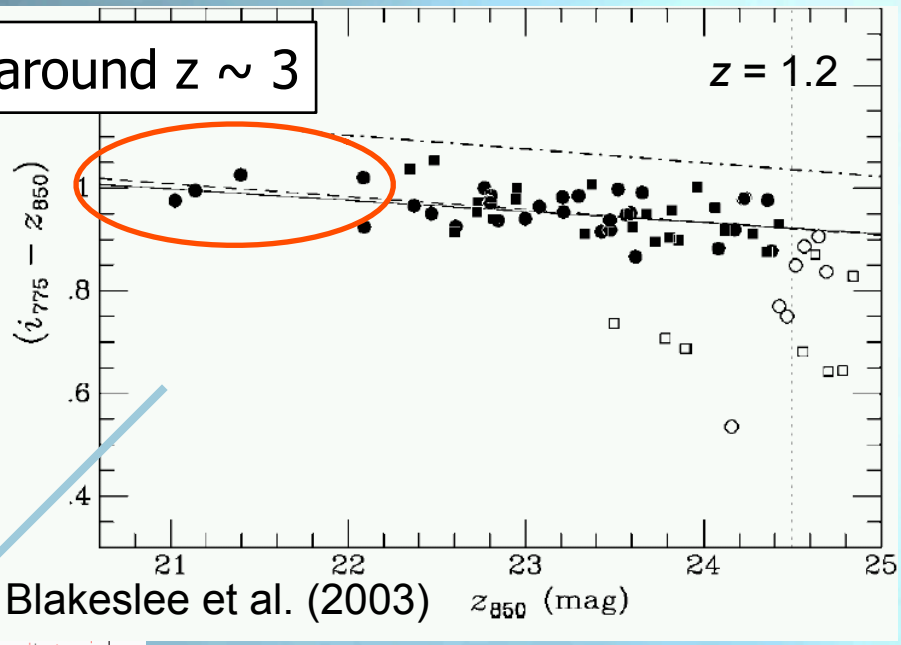


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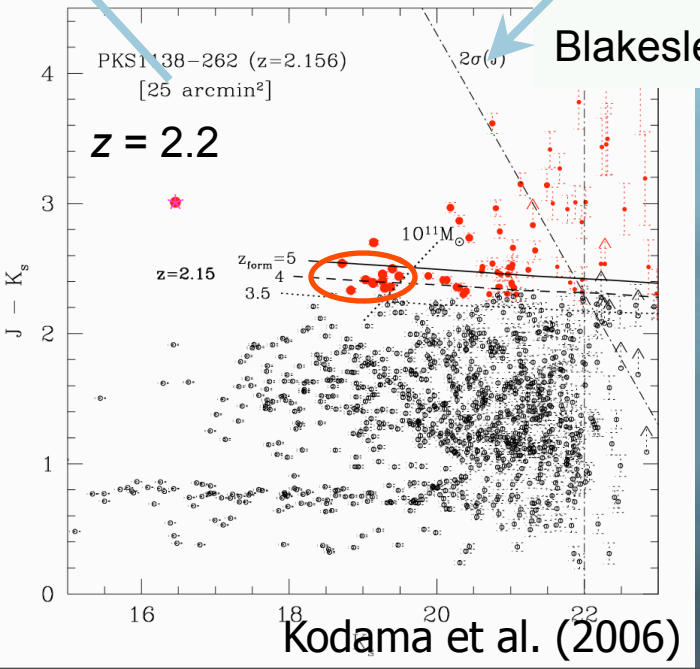


Kodama et al. (2006)

MOIRCS NIR multi-object spectroscopy allocated (again, after being weathered out two times),

FORS optical multi-object spectroscopy proposed