The DEEP Galaxy Redshift Survey: Color, Luminosity and Structural Properties of Galaxies

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and the DEEP Collaboration

DEEP 2 Participants:

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DEEP 1: Groth Strip Redshift Survey

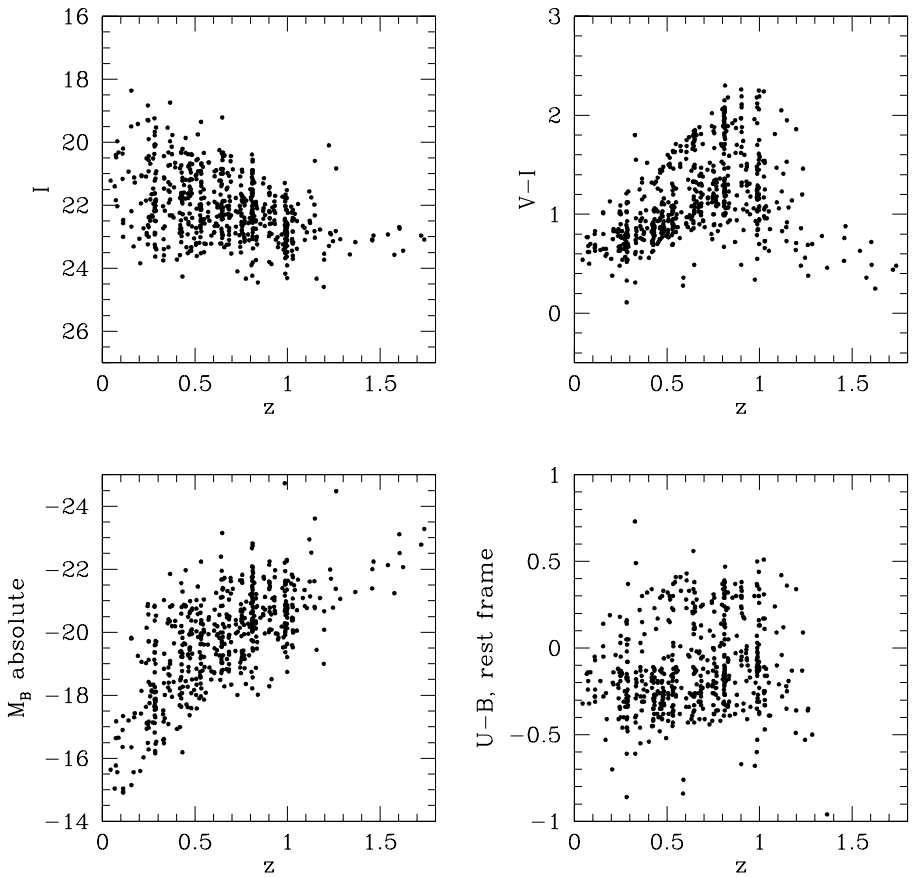
- Galaxy properties at redshifts to $z = 1$
- deep HST imaging in V and I over 3.5×53 arcmin ($\sim 1 \times 15$ Mpc at $z = 1$); much supplemental data
- Keck+LRIS spectroscopy 1995–1999
- 620 galaxies, to $(V + I)/2 = 24$, of 843 objects targeted, including 52 stars
- Median $< z >= 0.651$
- Morphological & structural parameters: surface photometry, bulge/disk ratios, scale lengths

DEEP 2: Redshift Surveys with DEIMOS

- Targets both large scale structure and galaxy properties at $z \sim 1$
- Much larger area, 3.5 square degrees, uniform coverage/selection to $R_{AB} = 24$
- Ground-based imaging from CFHT (Kaiser); potential overlap with future HST ACS imaging
- Keck+DEIMOS spectroscopy began fall 2002, for three year period
- Goal: >40,000 galaxy redshifts in 1 Hour Survey; deeper extensions for red and high-z galaxies
- Photometric preselection for $0.7 < z < 1.4$ in all fields but Extended Groth Strip; in EGS, no photo-z cut

Magnitudes and colors of galaxies in DEEP 1

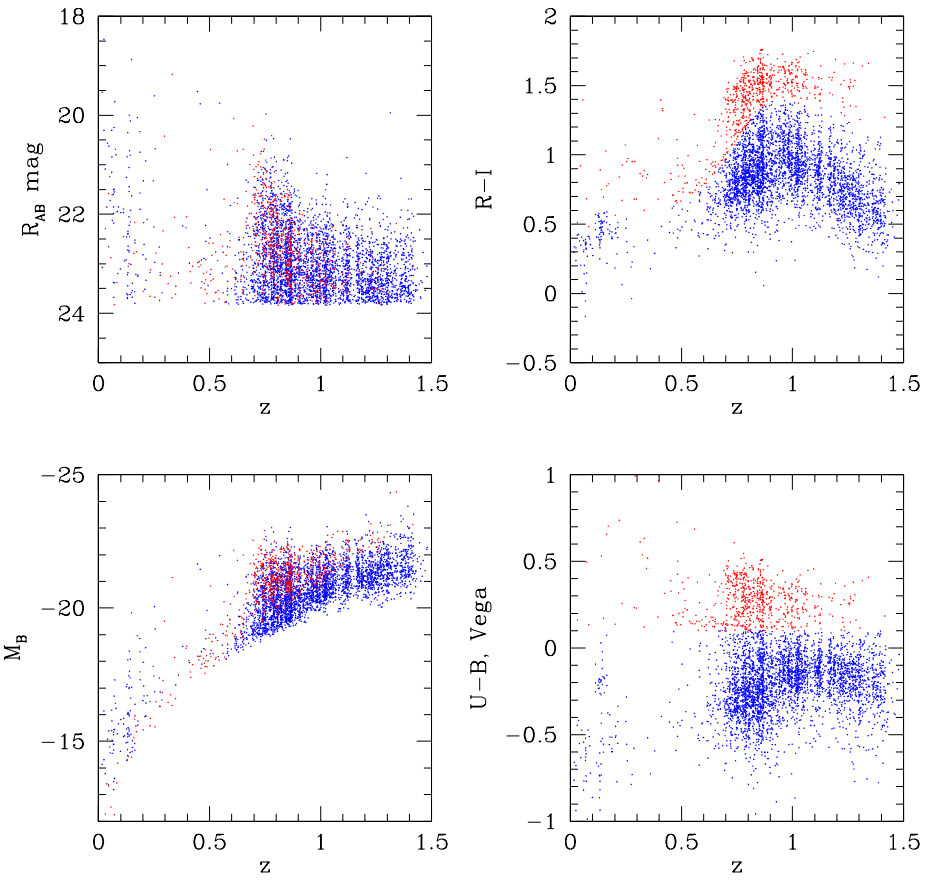
- Note the bimodality in color, observed and restframe
- lack of variation of the $U - B$ envelope with z
- possible evolution of L^* with z.



Magnitudes and colors of galaxies in DEEP 2

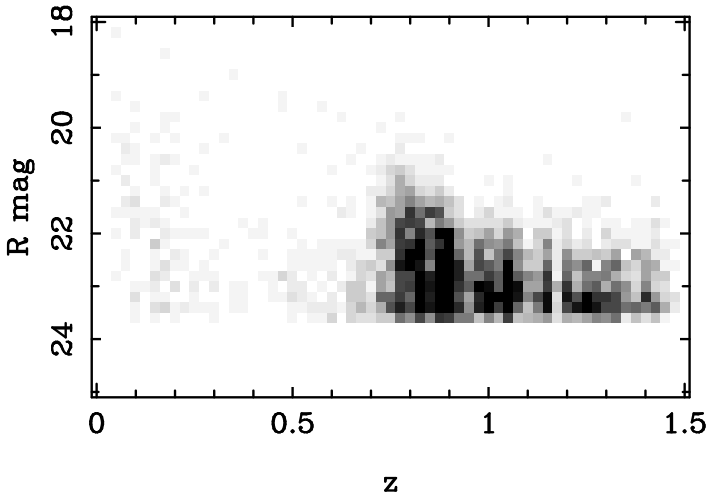
Color indicates the red/blue galaxy division at $U - B = 0.1$

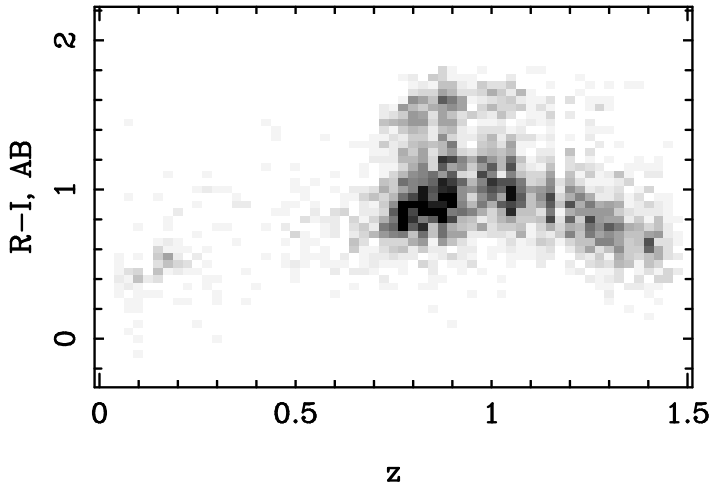
- The division in color persists
- Red galaxies begin to disappear at $z = 1.2$ because they fall below the selection limit



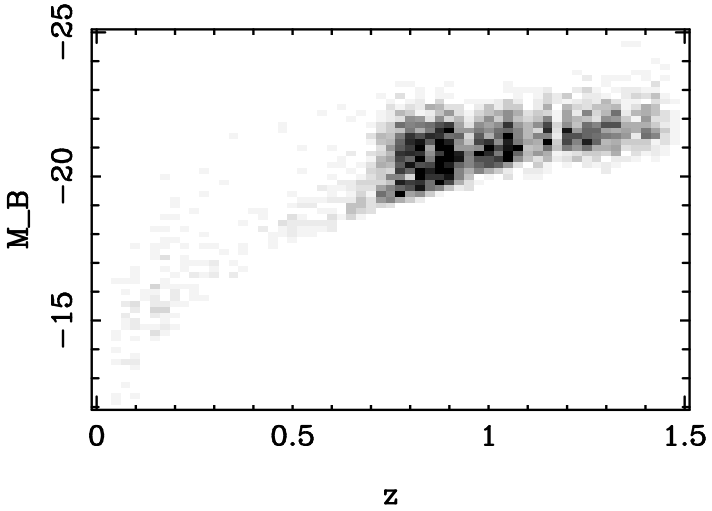
Magnitudes and colors of galaxies in DEEP 2

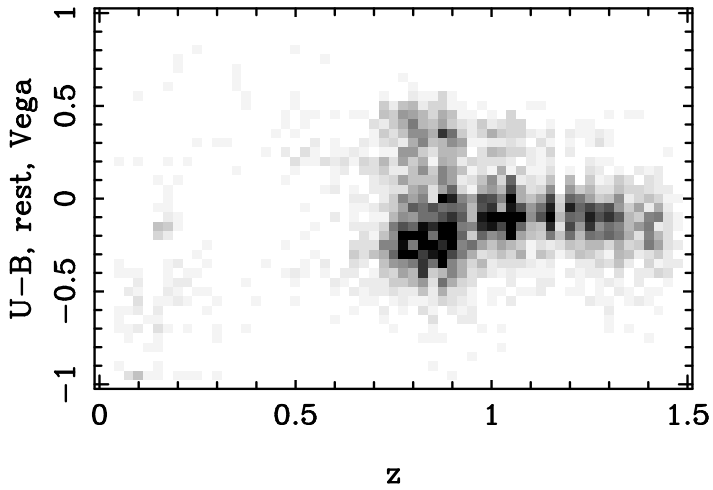
Observed





Restframe





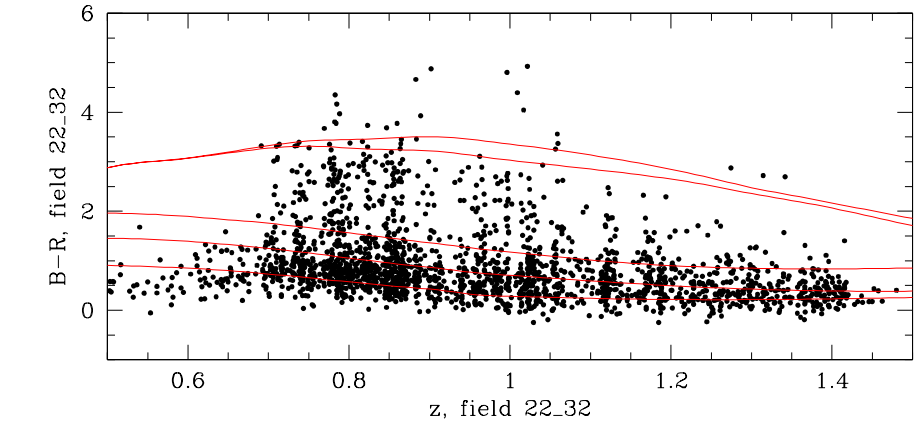
Magnitude

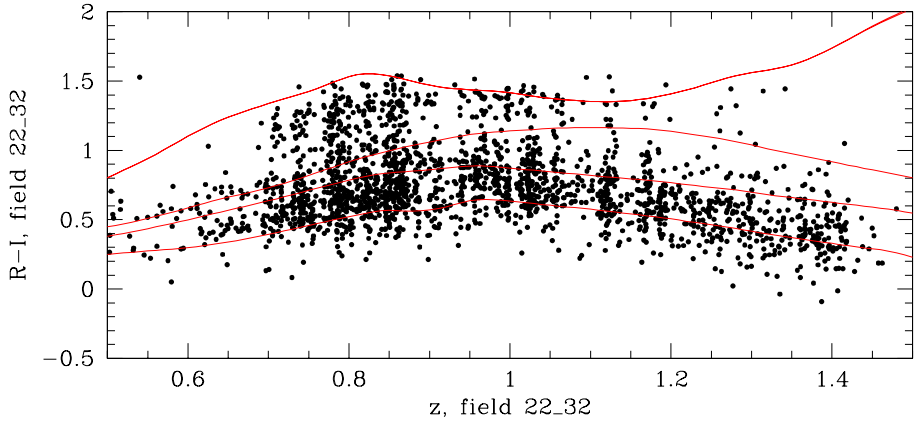
Color

Colors of DEEP 2 galaxies

2200 galaxies from DEEP 2, half of the current sample. Color tracks of non-evolving E bulge, Sbc, Scd, and Im are superimposed.

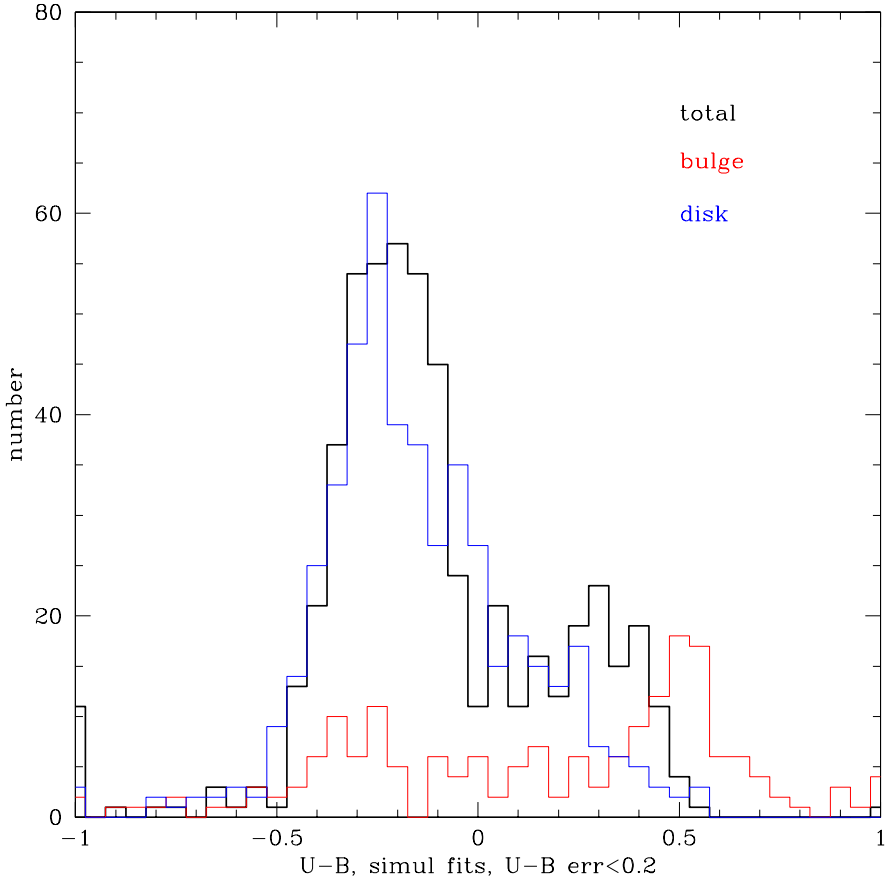
- The division between the main body of blue galaxies and the red galaxies is again clear
- It persists at least to $z = 1.1$
- Beyond $z = 1.2$ the red galaxies disappear below our limit of $R_{AB} = 24$.





Bimodality in U-B restframe galaxy color from DEEP 1

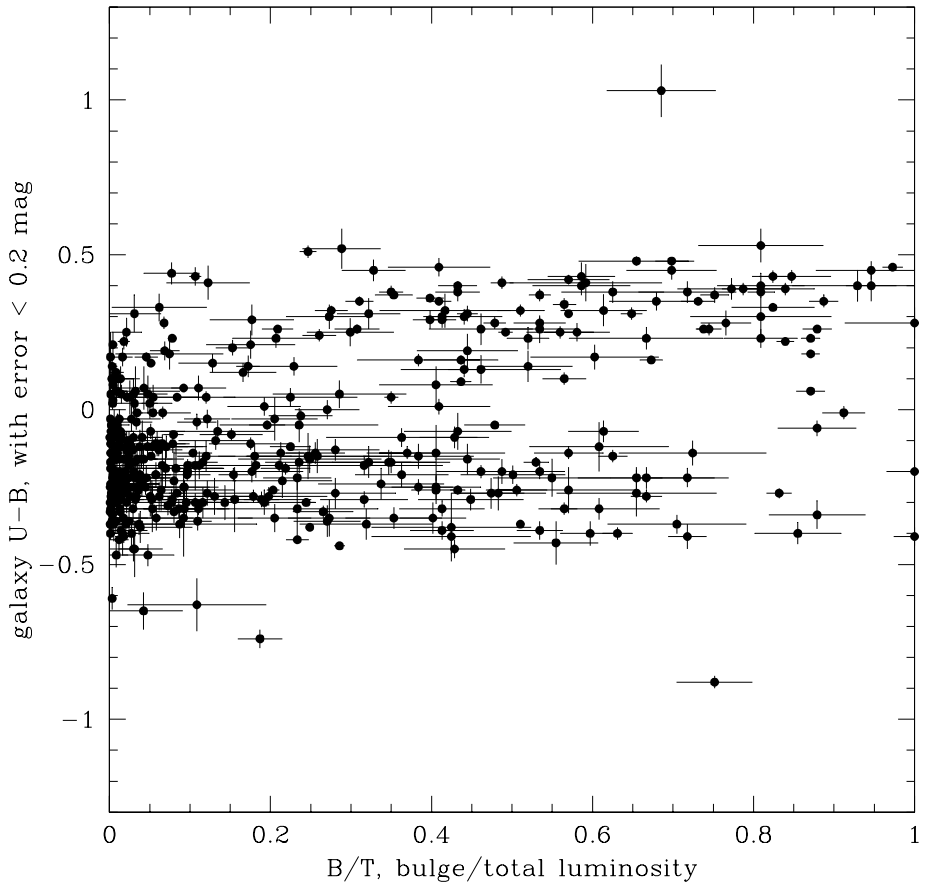
- The division is at $U - B = 0.1$, the color of an Sb galaxy.
- A similar bimodality is seen locally by the SDSS (Blanton et al 2002).
- Note also the population of very red bulges, requiring old stellar population
- Few red galaxies are as red as the bulges; the red *galaxies* are not purely red, dead ellipticals.



U-B rest color vs. central concentration, from DEEP 1 + HST

HST imaging of the Groth Strip allows bulge/disk fits ($r^{1/4}$ bulge, exponential disk, from Luc Simard's `gim2d`).

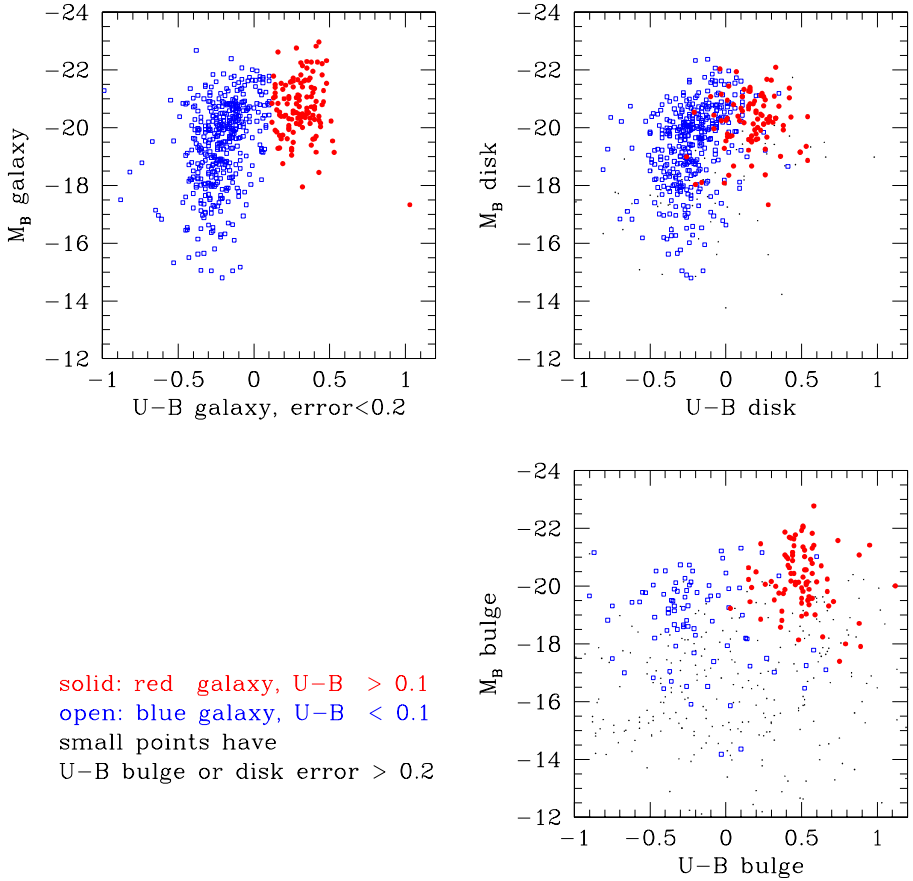
- Red galaxies are centrally concentrated, but are not necessarily bulge-dominated.
- The main body of blue galaxies are very disk-dominated.
- Visual inspection shows the red galaxies are a mix of types.



Luminosity vs. color for DEEP 1 galaxies, bulges and disks

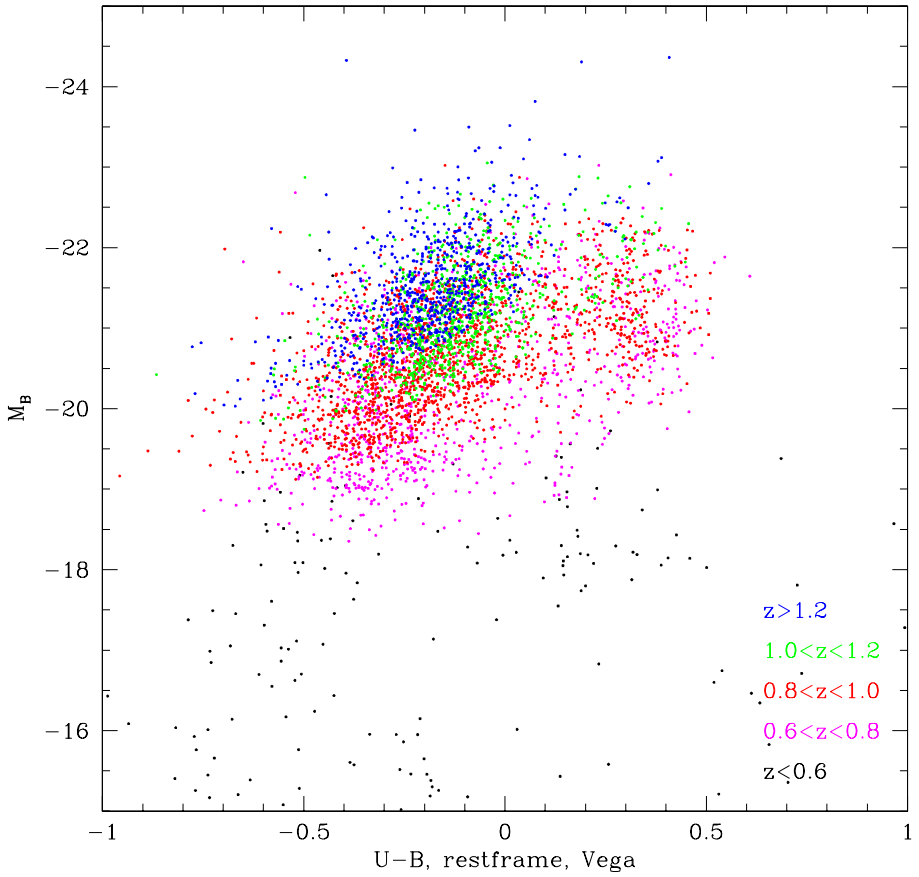
The points are color-coded by whether the *total galaxy* is blue or red.

- Red galaxies have bright, red bulges / central concentrations
- Blue nuclei in blue galaxies may be star-forming centers.
- Disks of red galaxies are redder than, but overlap with, disks of blue galaxies.



Luminosity vs. color for DEEP 2 galaxies

- There are few faint red galaxies, as in DEEP 1
- Division: lack of galaxies around $U - B = 0.15$
- Consistent with local surveys, probes quite faint
- Unlikely to be merely selection effect or lack of spectral features



Galaxy properties from the DEEP surveys

- Division in galaxy color, linked with presence of a luminous, red bulge. The division persists to high z and is similar to that seen locally by SDSS and 2dFGRS.

- Strong difference in the luminosity functions of blue/red galaxies: few faint red galaxies.

- Red galaxies exist out to at least $z = 1.2$, implying the bulk of their star formation occurred early

- The red galaxies are not purely "old, red and dead" nor purely elliptical. They are not as red as pure bulges, which have $U - B = 0.5$, the color of a 5+ Gyr old population. Bulges that red already do exist at $z = 1$.

- To come: [O II] equivalent widths, kinematic linewidths, and 10 times as many galaxies!