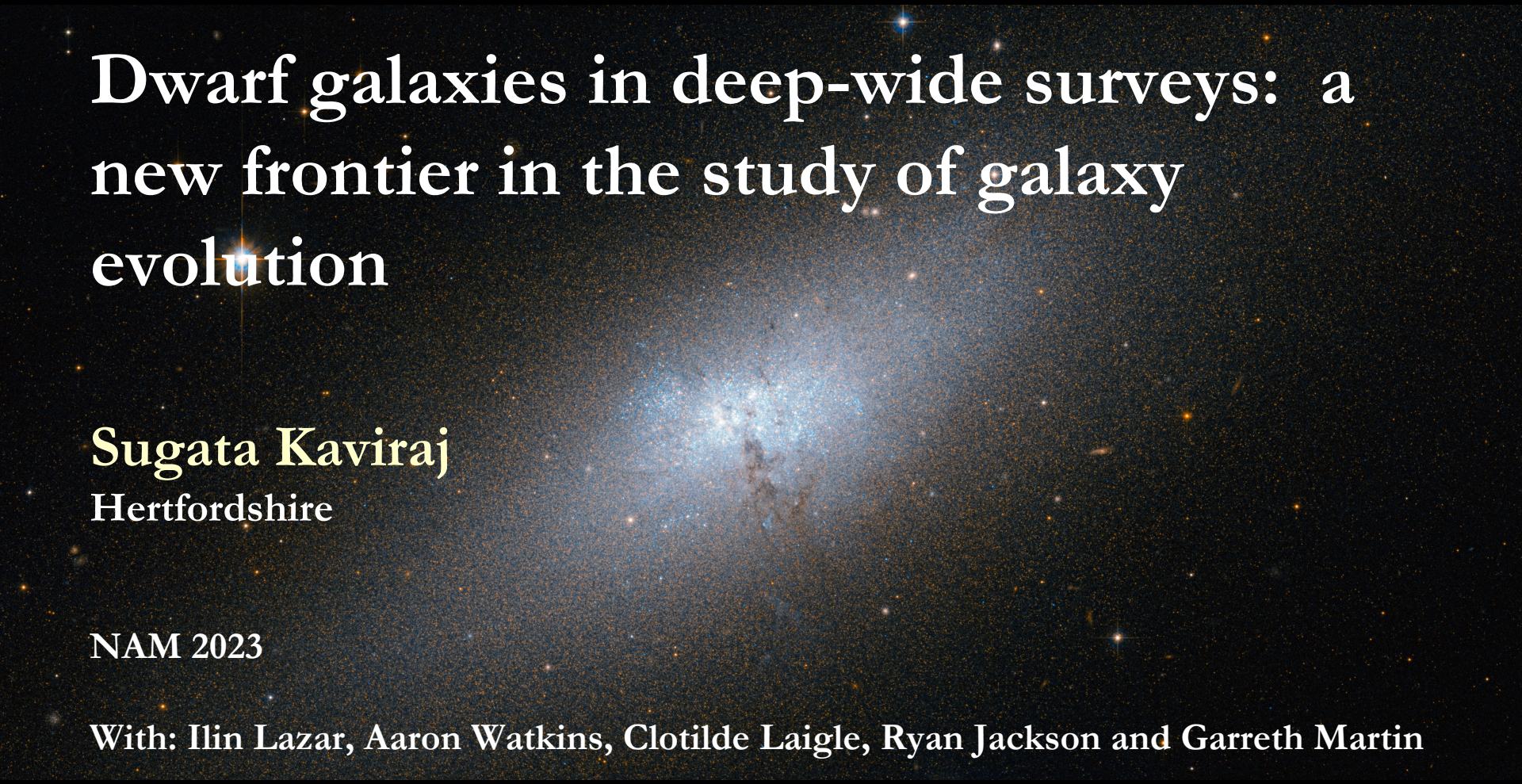

Dwarf galaxies in deep-wide surveys: a new frontier in the study of galaxy evolution

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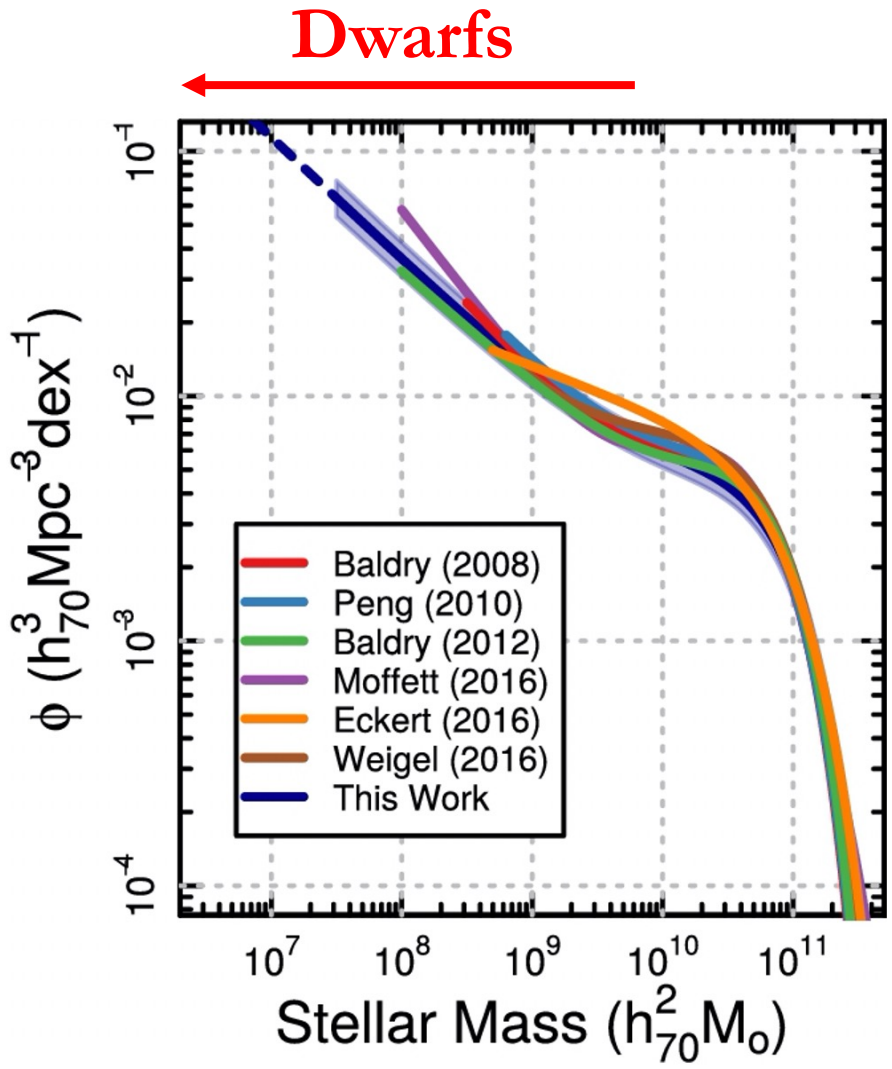
With: Ilin Lazar, Aaron Watkins, Clotilde Laigle, Ryan Jackson and Garreth Martin

Plan for talk

- Strong biases in the dwarf regime in past shallow surveys (e.g. SDSS)

- The view from deep-wide surveys:
  - Red and quenched fractions in nearby dwarfs ($10^8\,M_{SUN} < M_* < 10^{9.5}\,M_{SUN}$ and $z < 0.3$)
  - What quenches dwarf galaxies?

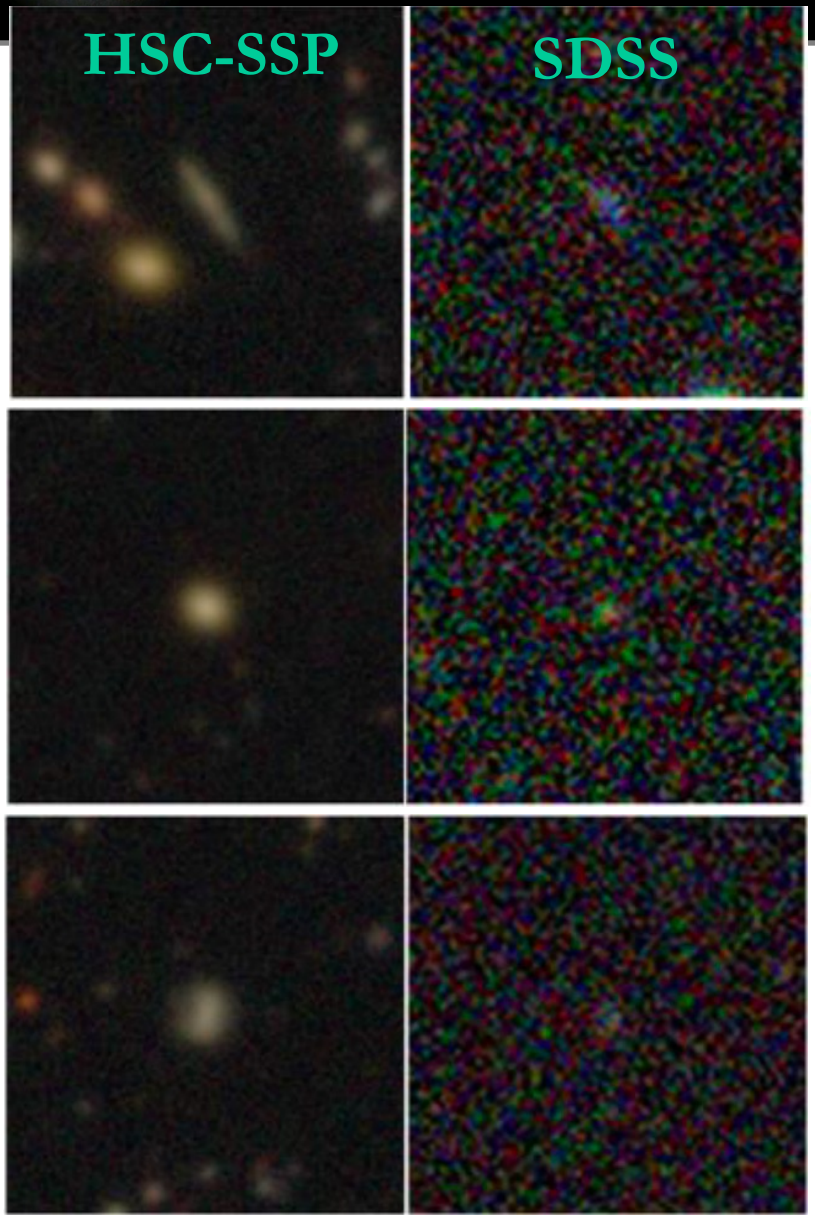
The importance of dwarf galaxies



Wright +17

- Dwarfs dominate the galaxy number density
- Need to understand dwarfs to understand galaxy evolution
- **Dwarfs have been studied in detail only in the very local Universe - typical dwarfs at cosmological distances too faint to be detected in past large surveys (e.g. SDSS)**

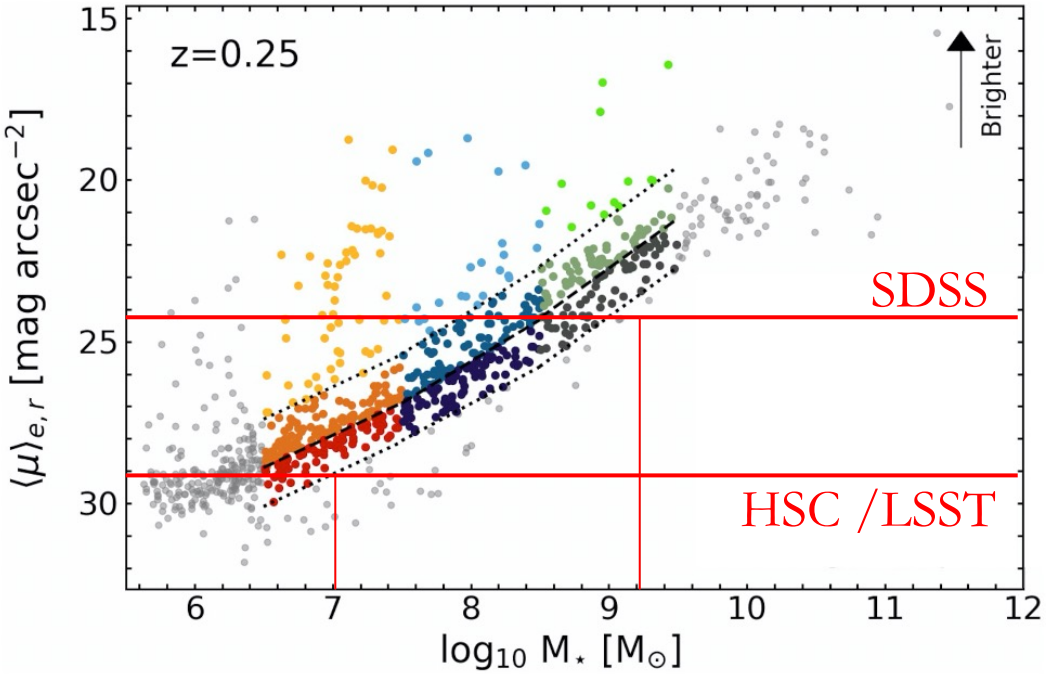
Strong biases in past surveys



- HSC surveys and LSST have the depth to reveal typical dwarf galaxies outside the local group
- Also surveys like LIGHTS (**Trujillo +21**), SAGA (**Geha +17**), MATLAS (**Duc +15**) – but these focus on environments around nearby massive galaxies

Dwarfs with $M_{\star}$ ~ 10^8 M_{SUN} at z~0.3)

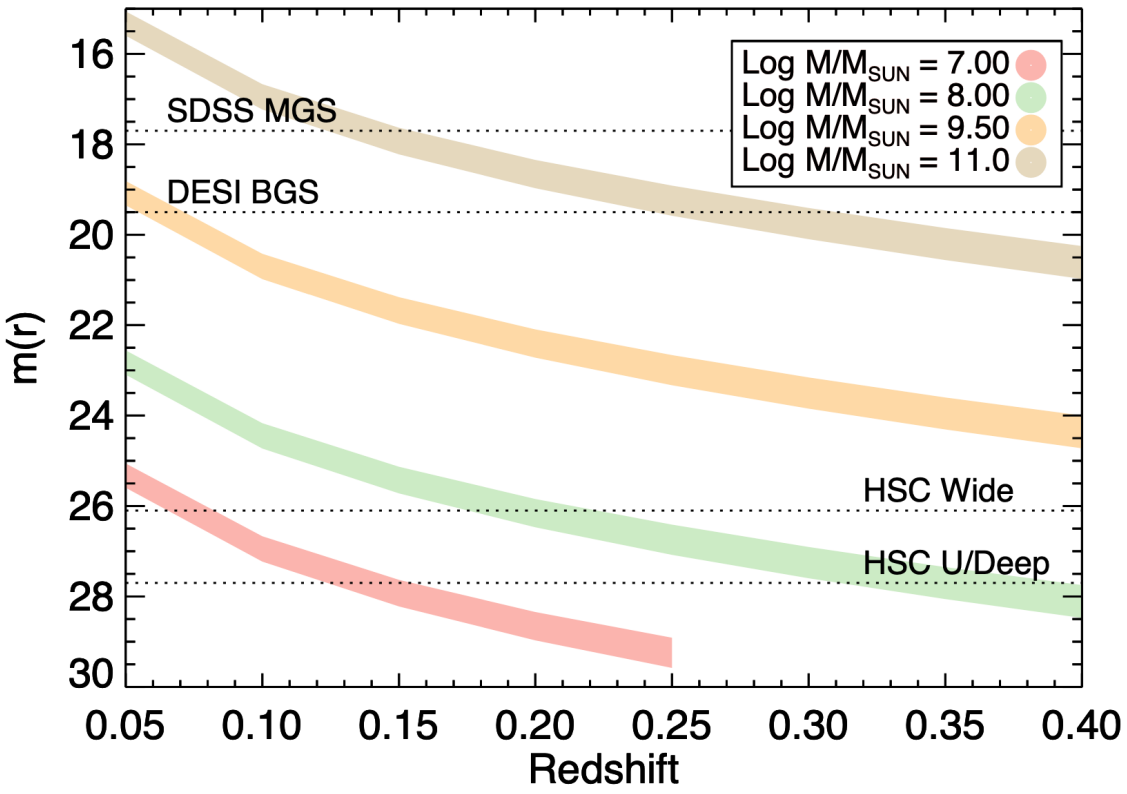
Strong biases in past surveys



Jackson +21

- Our current statistical knowledge is entirely based on massive galaxies…

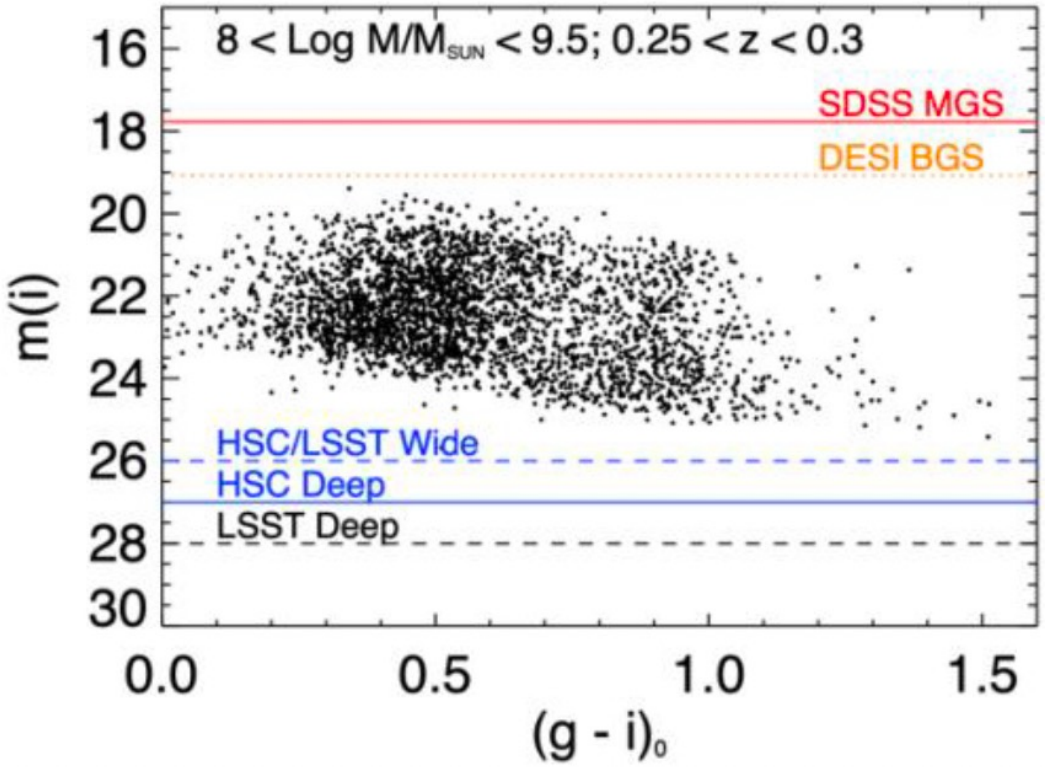
Strong biases in past surveys



- Our current statistical knowledge is entirely based on massive galaxies…

Strong biases in past surveys

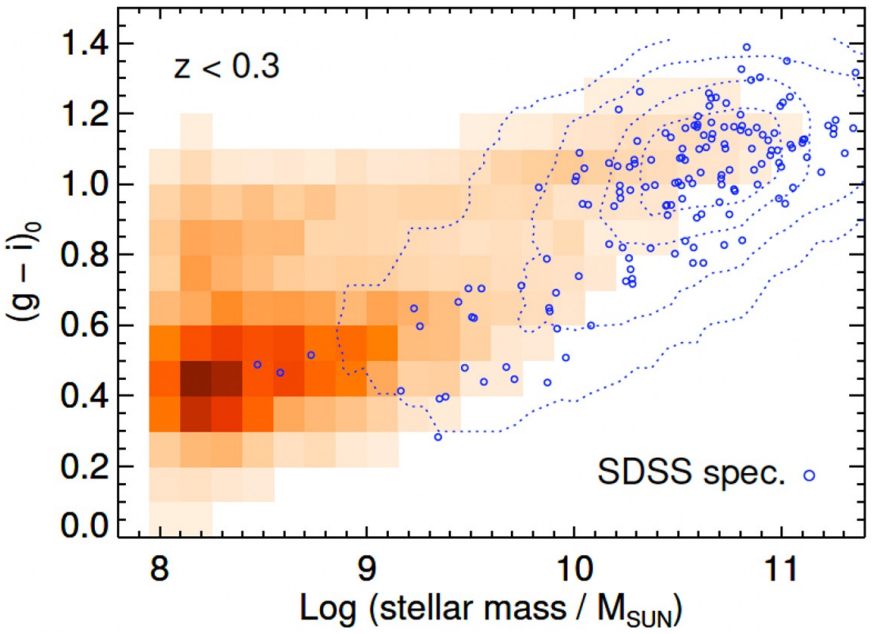
COSMOS vs shallow surveys



- COSMOS field has deep broadband photometry including HSC U/Deep **(Weaver +22)**
- Mass complete down to 10^8 M_{SUN} out to z~0.4
- Spectroscopy of dwarfs at cosmological distances will remain scant
- **Prototype for how dwarfs can be studied using photometric data in the LSST era**

Strong biases in past surveys

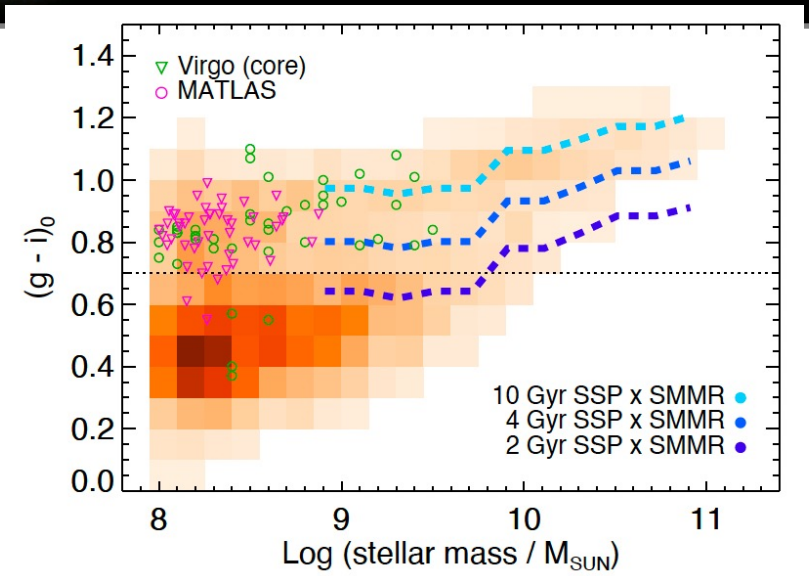
Comparison of SDSS to COSMOS

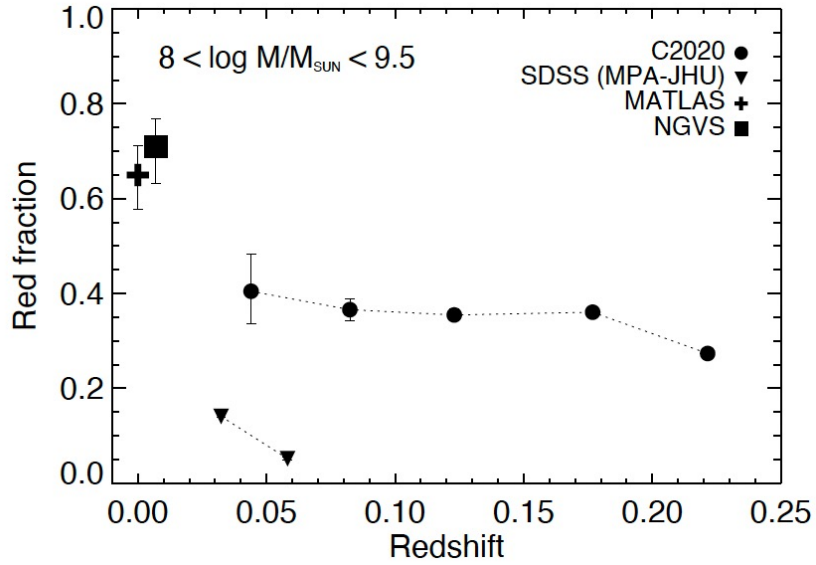


- SDSS spectroscopic objects are either massive or blue if they are low mass (because bluer objects are brighter)
- **Red (quenched) dwarfs are largely missing in SDSS**
- **All results on dwarfs derived from shallow surveys are strongly biased (e.g. Geha +12)**

Nearby (z<0.3) dwarfs in COSMOS

Colours and star formation main sequence

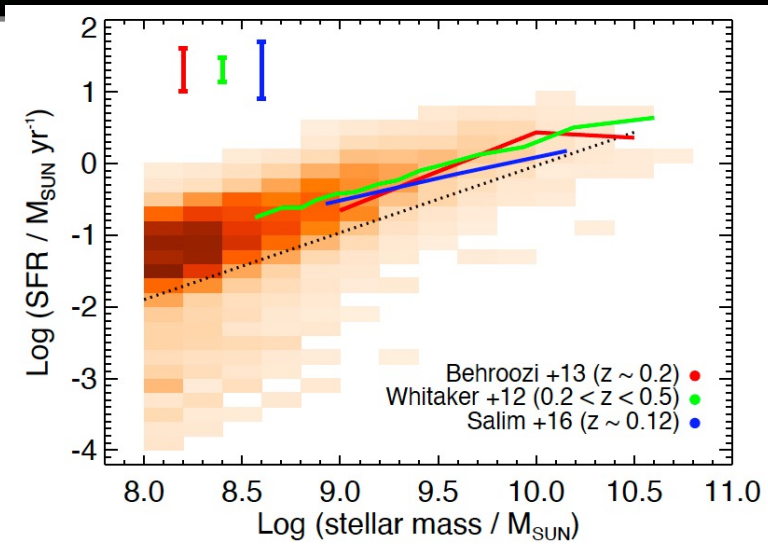


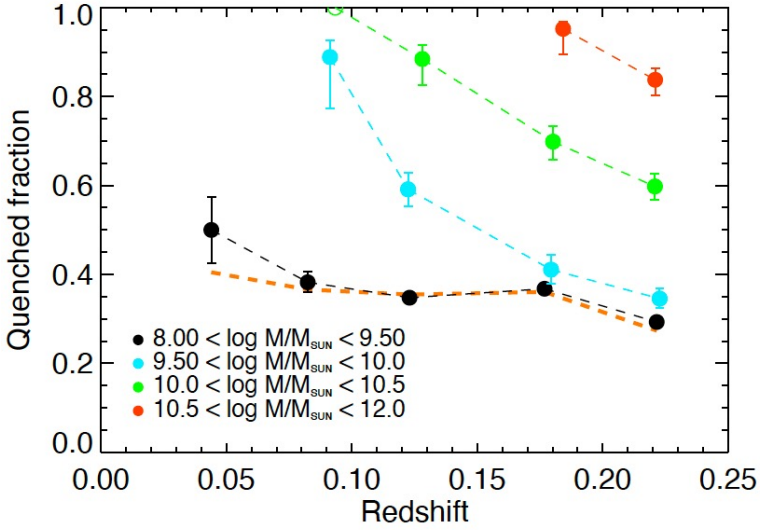


- Red fraction in nearby dwarfs is around 40%
- Red fractions are higher in dense environments
- Red fractions derived using SDSS are severely underestimated

Nearby (z<0.3) dwarfs in COSMOS

Colours and star formation main sequence

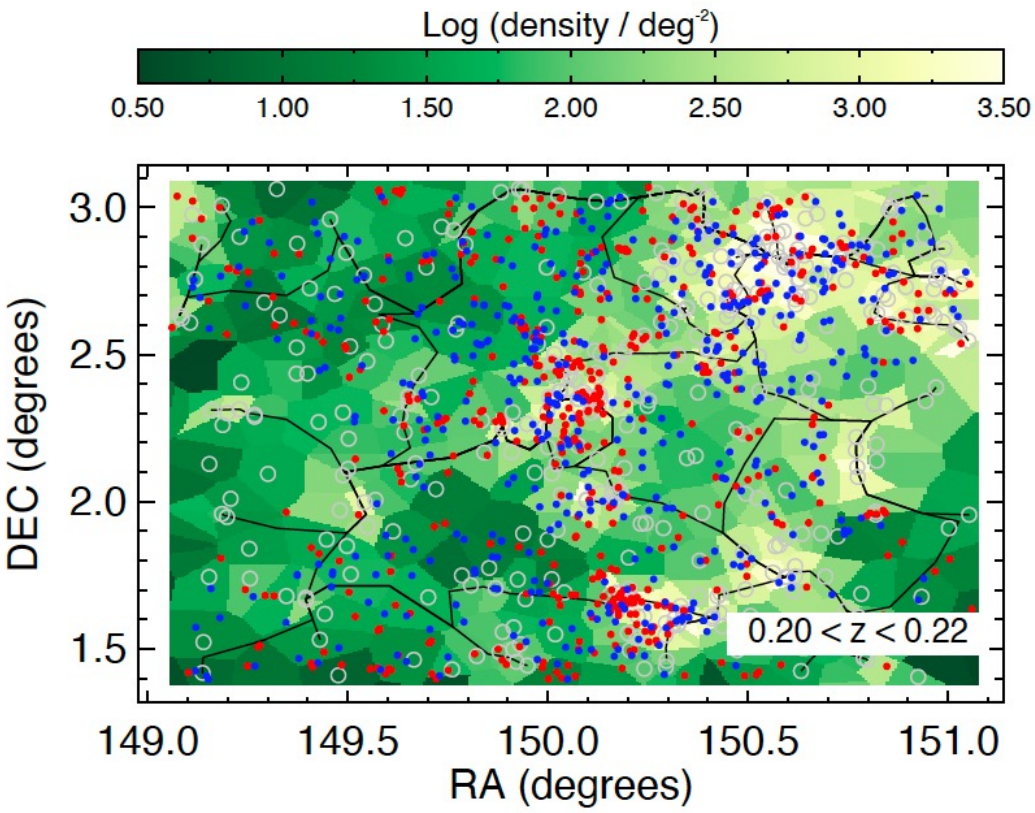




- Quenched fractions are similar to red fractions (as might be expected)

Nearby (z<0.25) dwarfs in COSMOS

The role of environment

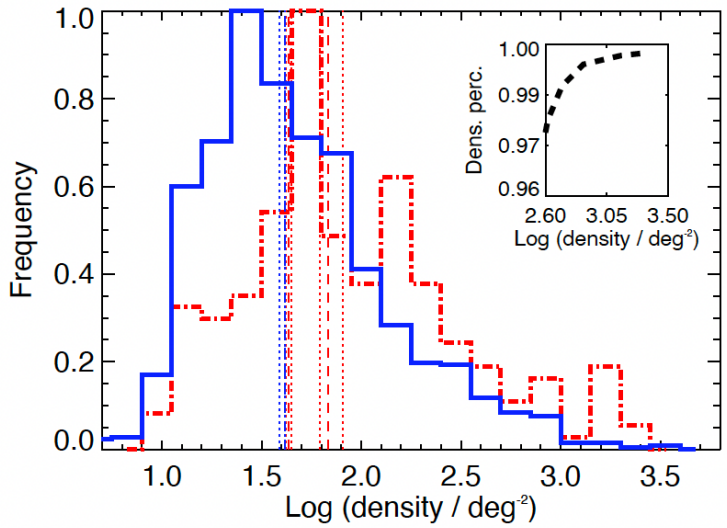


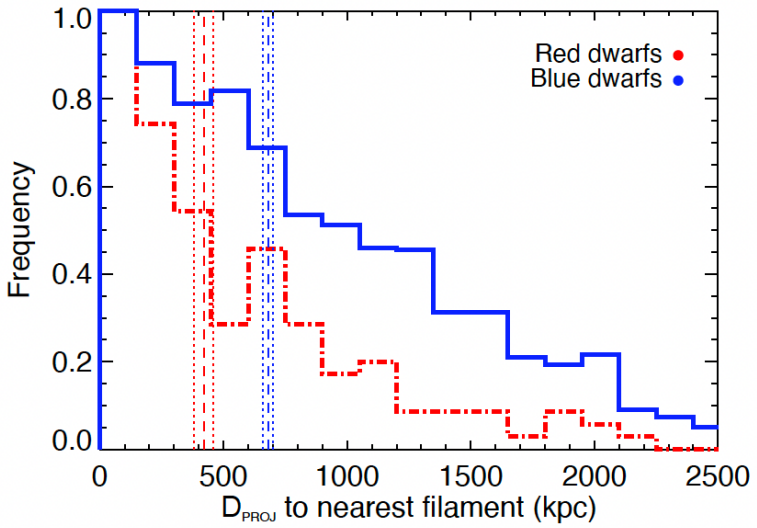
- Photometric redshift errors from deep data like in COSMOS is smaller than 1% for massive galaxies

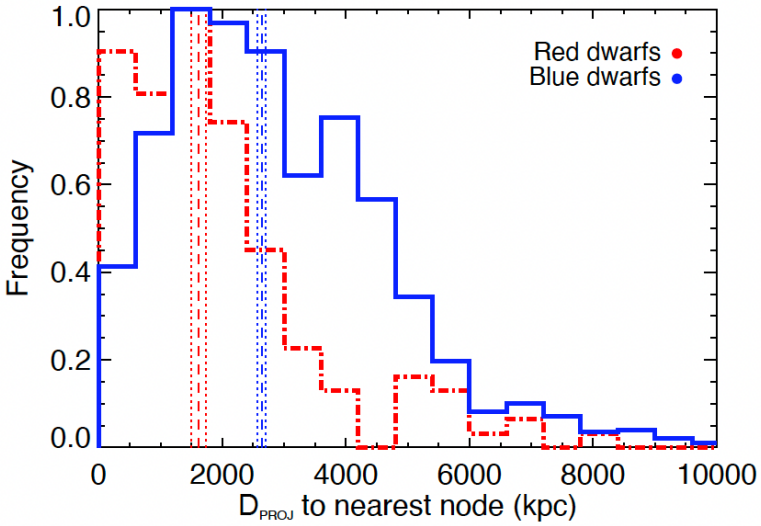
- Create density and topological maps using DisPerSE (**Sousbie +11**)

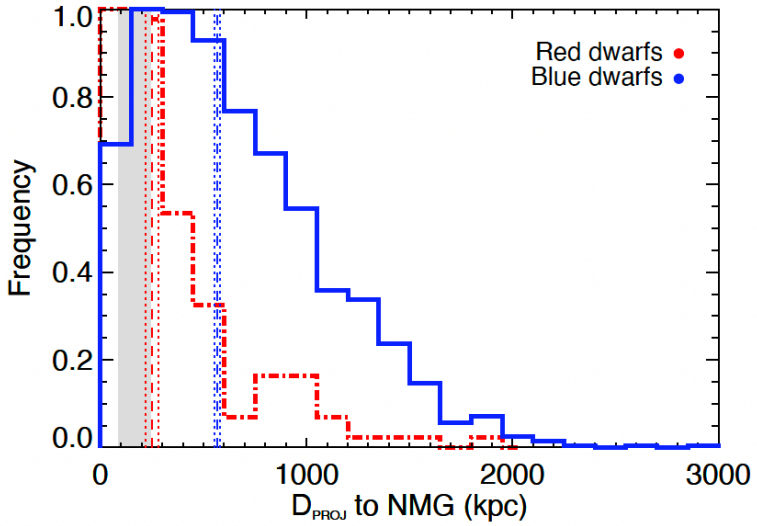
Nearby (z<0.3) dwarfs in COSMOS

Red dwarfs are closer to nodes, filaments and massive galaxies









Nearby (z<0.25) dwarfs in COSMOS

Red dwarfs are closer to nodes, filaments and massive galaxies

	Red med.	Blue med.	Med. ratio (blue/red)	Red FWHM	Blue FWHM	FWHM ratio (blue/red)
Log density (deg^{-2})	1.83	1.62	0.88	0.90	1.05	1.00
Proj. dist. to nearest node (kpc)	1611	2639	1.64	2515	4207	1.67
Proj. dist. to nearest filament (kpc)	420	682	1.63	415	876	2.11
Proj. dist. to nearest massive galaxy (kpc)	248	568	2.29	386	974	2.52

- Red dwarfs are closer to nodes, filaments and massive galaxies
- Distance to massive galaxies seems to be the most important factor (many red dwarfs at distances to NMG < typical virial radii)
- But many dwarfs in low density environments are red/quenched
- **High-density environments not a pre-requisite for dwarf quenching – internal processes like SF and AGN feedback are just as important**

Summary

Kaviraj et al. in prep.

- Strong biases in the dwarf regime in shallow surveys – virtually all red dwarfs outside local Universe are missing (because they are not bright enough)

- Deep surveys (e.g. HSC/LSST) can reveal *typical* dwarfs down to M ~ 10^8 M_{SUN} out to at least z~0.4

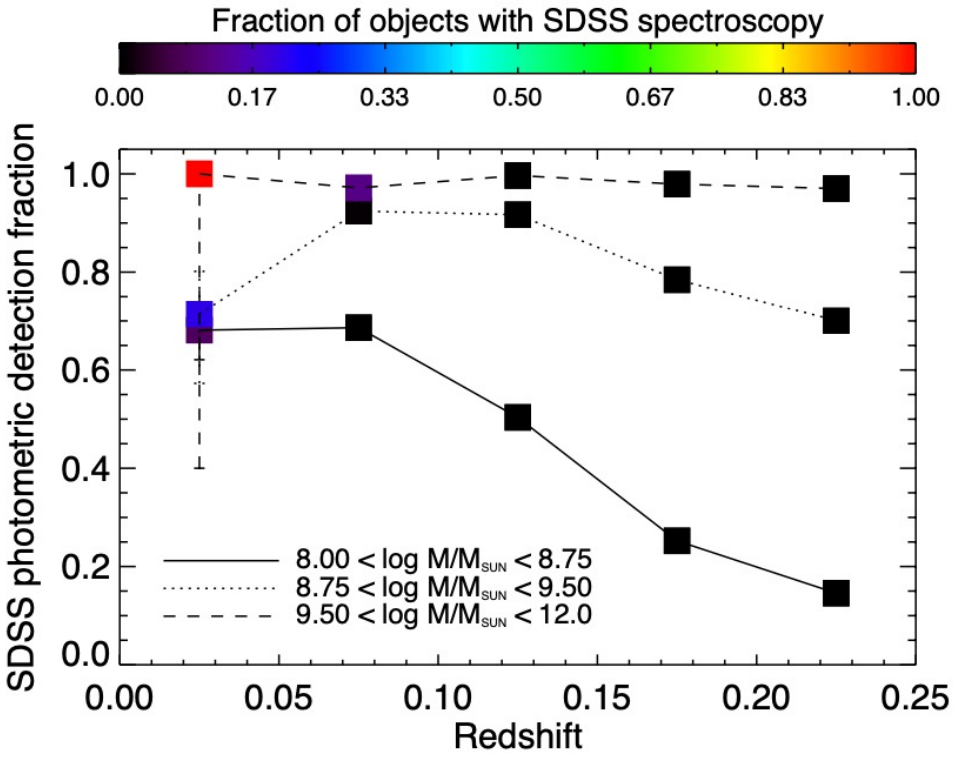
- 40 (50) % of relatively luminous dwarfs (10^8 M_{SUN} < M_* < $10^{9.5}$ M_{SUN}) in average/low density environments are red (quenched)

- Red dwarfs live closer to nodes, filaments and massive galaxies - proximity to a massive galaxy appears to be most important

- But many dwarfs are quenched by internal processes (e.g. SF/AGN feedback)

Strong biases in past surveys

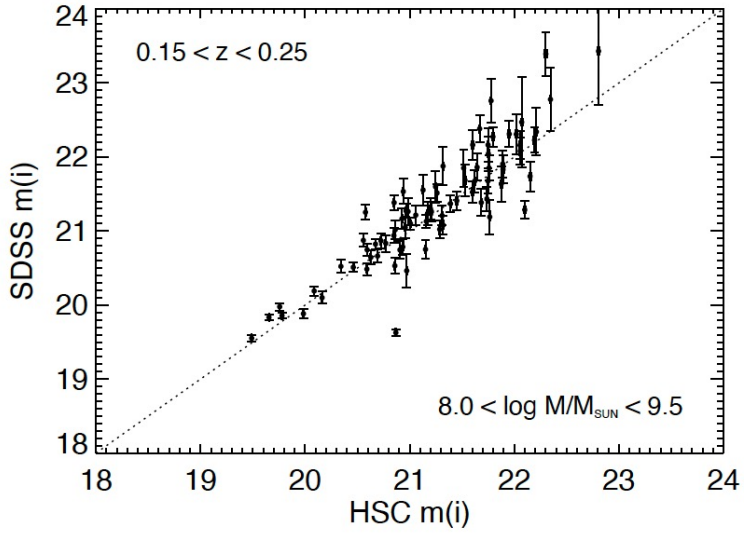
Comparison of SDSS to COSMOS

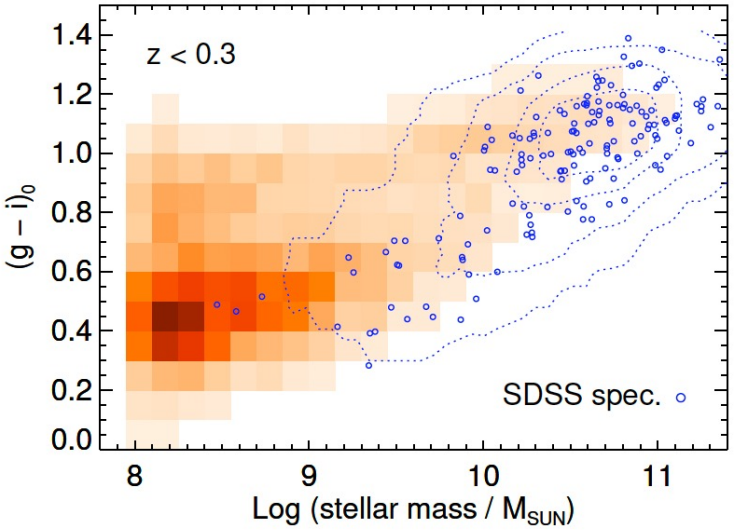


- SDSS photometric objects exist for sources detected in HSC U/Deep
- But spectroscopic detections are rare outside the local Universe (esp. in galaxies that are not massive)

Strong biases in past surveys

Comparison of SDSS to COSMOS





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