Weak Lensing for Dwarf Galaxies

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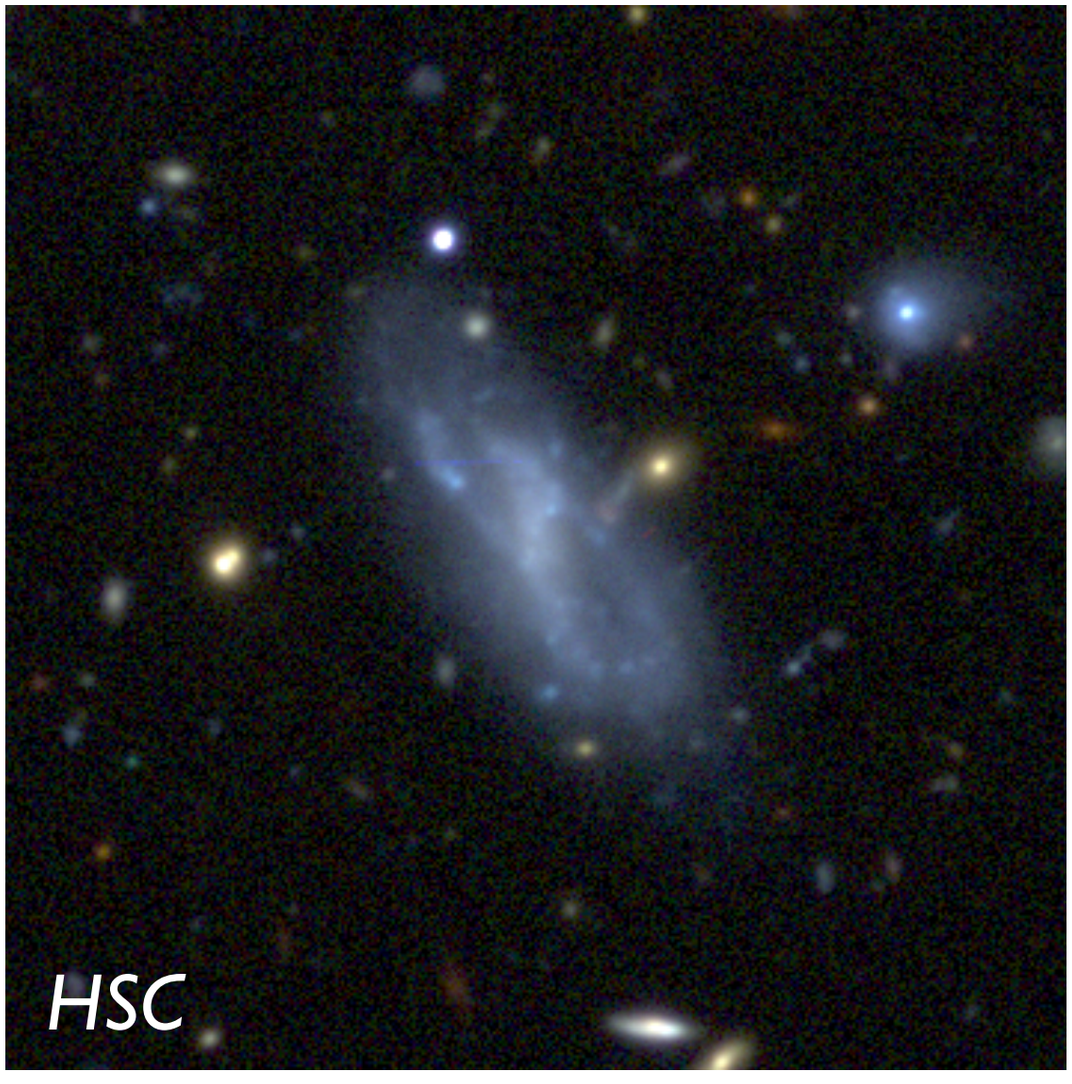
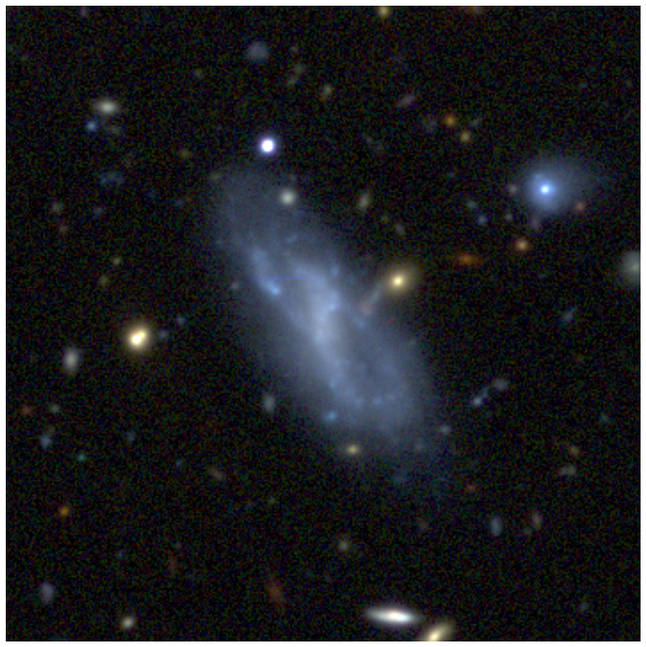


Cusp v.s Core



- Rotation curves in spirals/dwarfs at the origin of the “cusp versus core” controversy

Observational evidence for self-interacting cold dark matter

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Princeton University, Princeton NJ 08544 USA

Cosmological models with cold dark matter composed of weakly interacting particles predict overly dense cores in the centers of galaxies and clusters and an overly large number of halos within the Local Group compared to actual observations. We propose that the conflict can be resolved if the cold dark matter particles are self-interacting with a large scattering cross-section but negligible annihilation or dissipation. In this scenario, astronomical observations may enable us to study dark matter properties that are inaccessible in the laboratory.

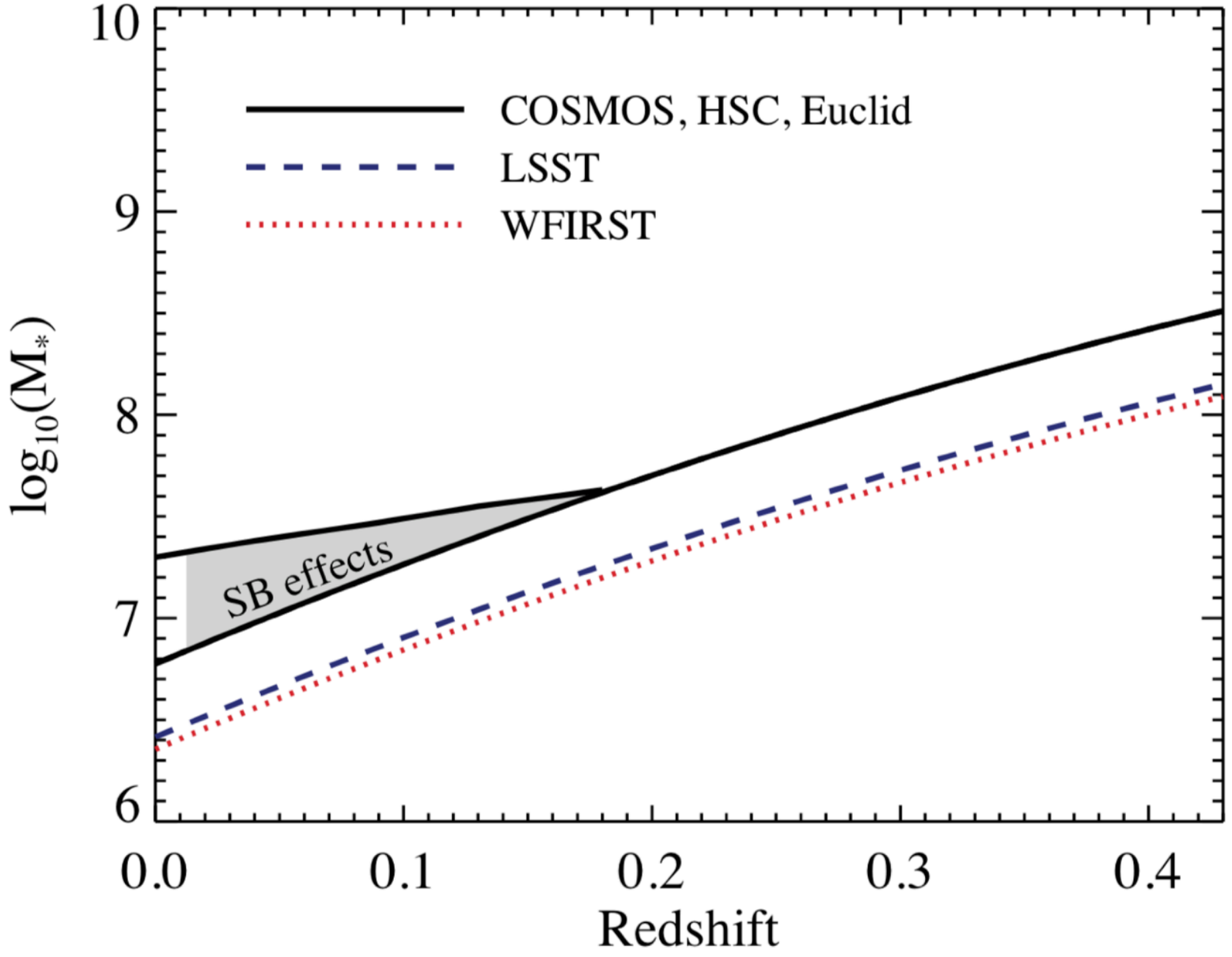
Flat cosmological models with a mixture of ordinary baryonic matter, cold matter, and cosmological constant (or quintessence) and a nearly scale-invariant, adiabatic spectrum of density fluctuations are consistent with standard inflationary cosmology and provide an excellent fit

ing cross-section may be due to strong, short-range interactions, similar to neutron-neutron scattering at low-energies, or weak interactions mediated by the exchange of light particles (although not so light as to produce a long-range force). Depending on the interaction and the mean free path, the requisite mass for the dark matter is in the range 1 MeV to 10 GeV. For the purposes of our proposal, only two-body scattering effects are important so either repulsive or attractive interactions are possible. Exchanged particles should be massive enough that they are not radiated by the scattering of dark matter particles in the halo.

We are led to consider self-interactions because ordinary astrophysical processes are unlikely to resolve the problems with standard, weakly interacting dark matter. Consider the dwarf galaxy problem. One might suppose that supernova explosions[15] could cause the galactic core density to be made smoother; but, while the explosions suppress star formation in dwarf galaxies, numerical sim-

- But rotation curves only probe a fraction of the dark matter halo (10-20 times smaller)
- Knowledge of full DM halo: probe of DM physics and baryonic effects

Deep + Wide surveys



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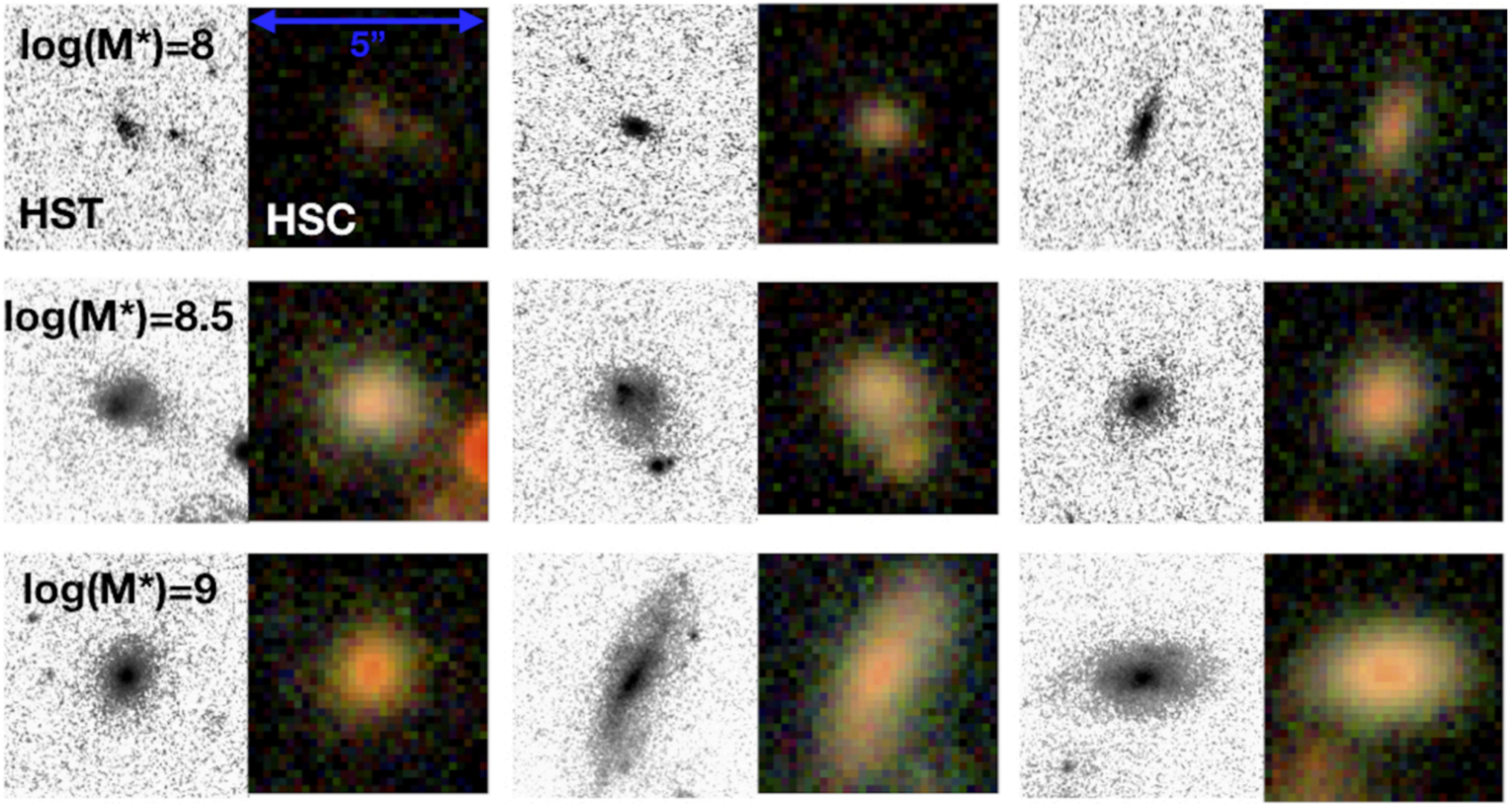
Deep + Wide surveys



Dwarfs in COSMOS, z=0.2

Lensing Predictions

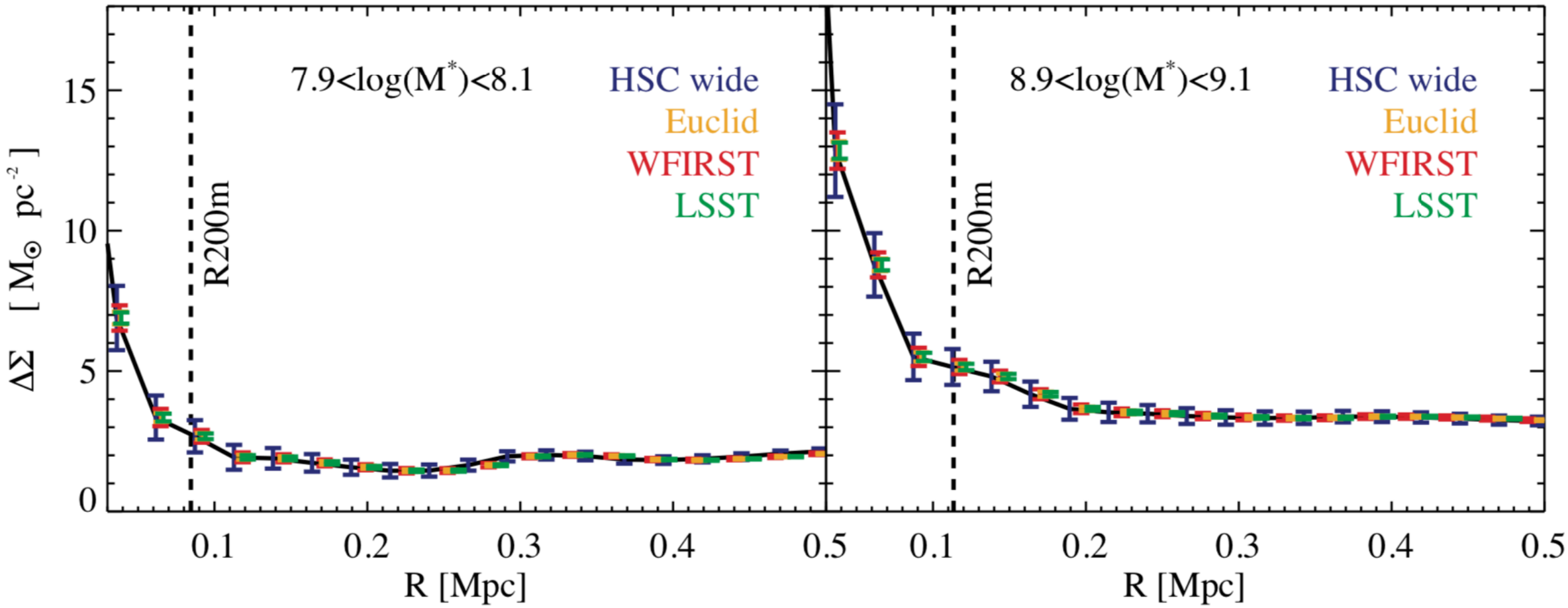


Table 2. Predicted signal-to-noise for two mass bins of width 0.2 dex and for $0 < z < 0.25$.

Survey	$\log(M^*)$=8 and $r < 500$ kpc	$\log(M^*)$=9 and $r < 500$ kpc	$\log(M^*)$=8 and $r < 84.55$ kpc	$\log(M^*)$=9 and $r < 113.44$ kpc
HSC Wide	37	46	8	15
LSST Wide	208	261	47	84
Euclid Wide	184	231	41	74
WFIRST HLS	92	153	21	37

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Take-home points

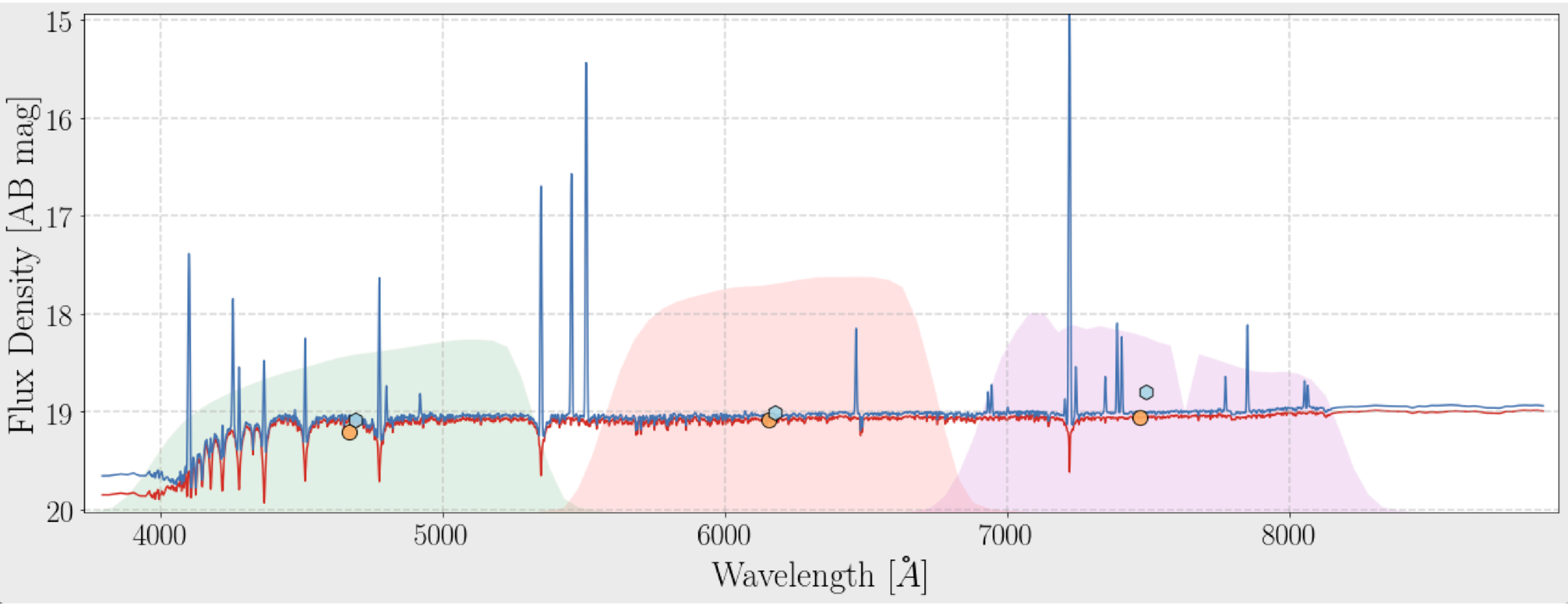
- Upcoming Lensing surveys will both be able to find low redshift dwarfs (mass complete at low z)

- They will have **ample statistical power** to measure the lensing signal for these dwarf galaxies.

- The main limitation will be **getting redshifts** for the dwarf galaxies (the lens sample). Typical 5-band photo-z's unlikely to be good enough

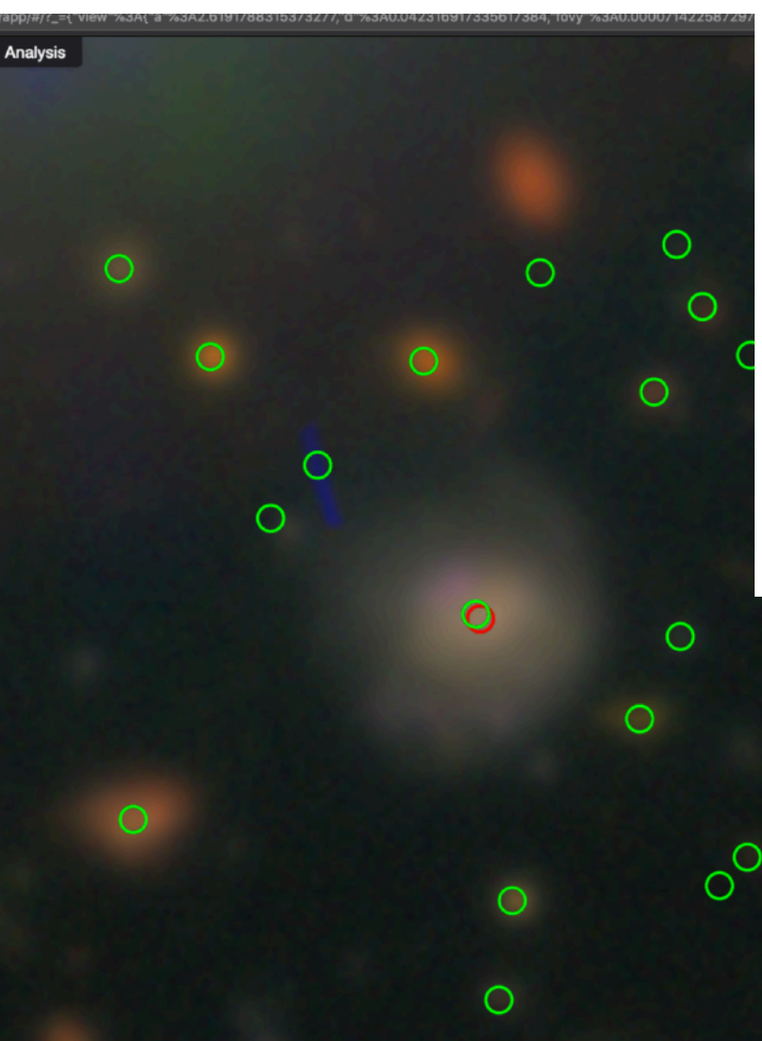
- The usual caveats apply: *weak lensing is difficult and may aspect will need further consideration (e.g. blending effects, photoz errors, etc …)*

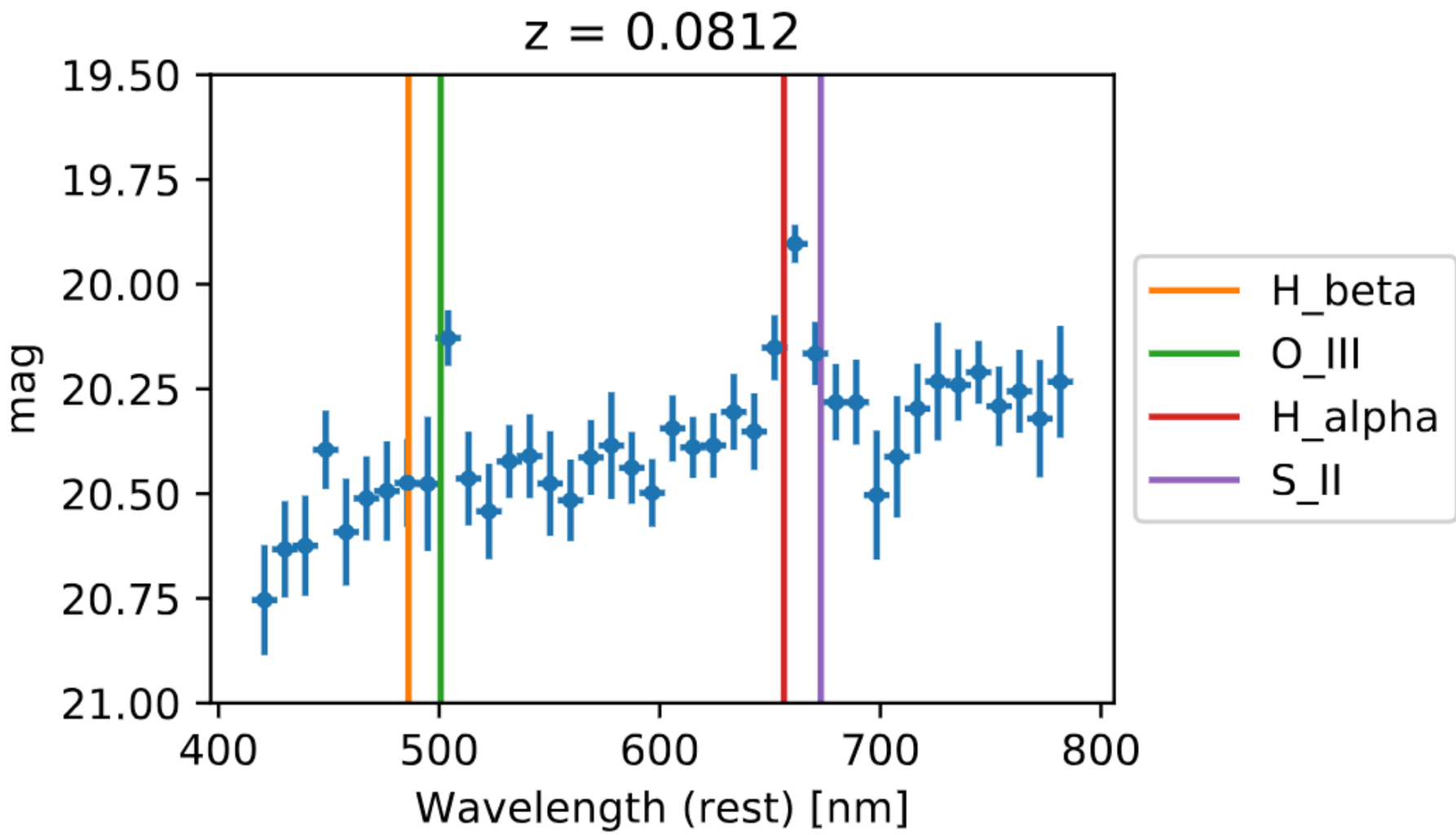
Redshifts for Dwarfs?



10^9 M_{sun} dwarf - SDSS gri bands

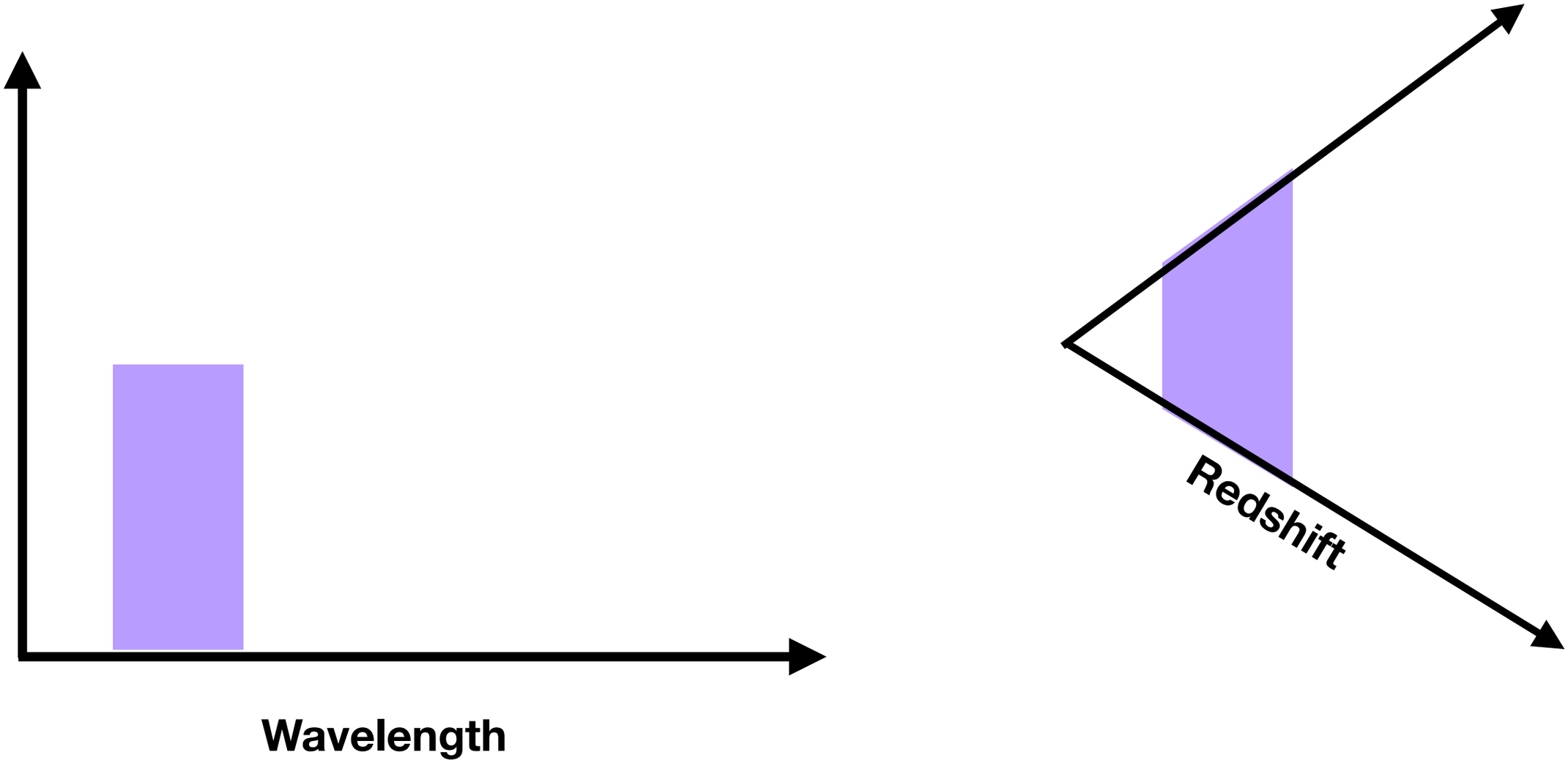
Redshifts for Dwarfs?





Photometry from the PAU survey

Filter Optimized for Lensing?



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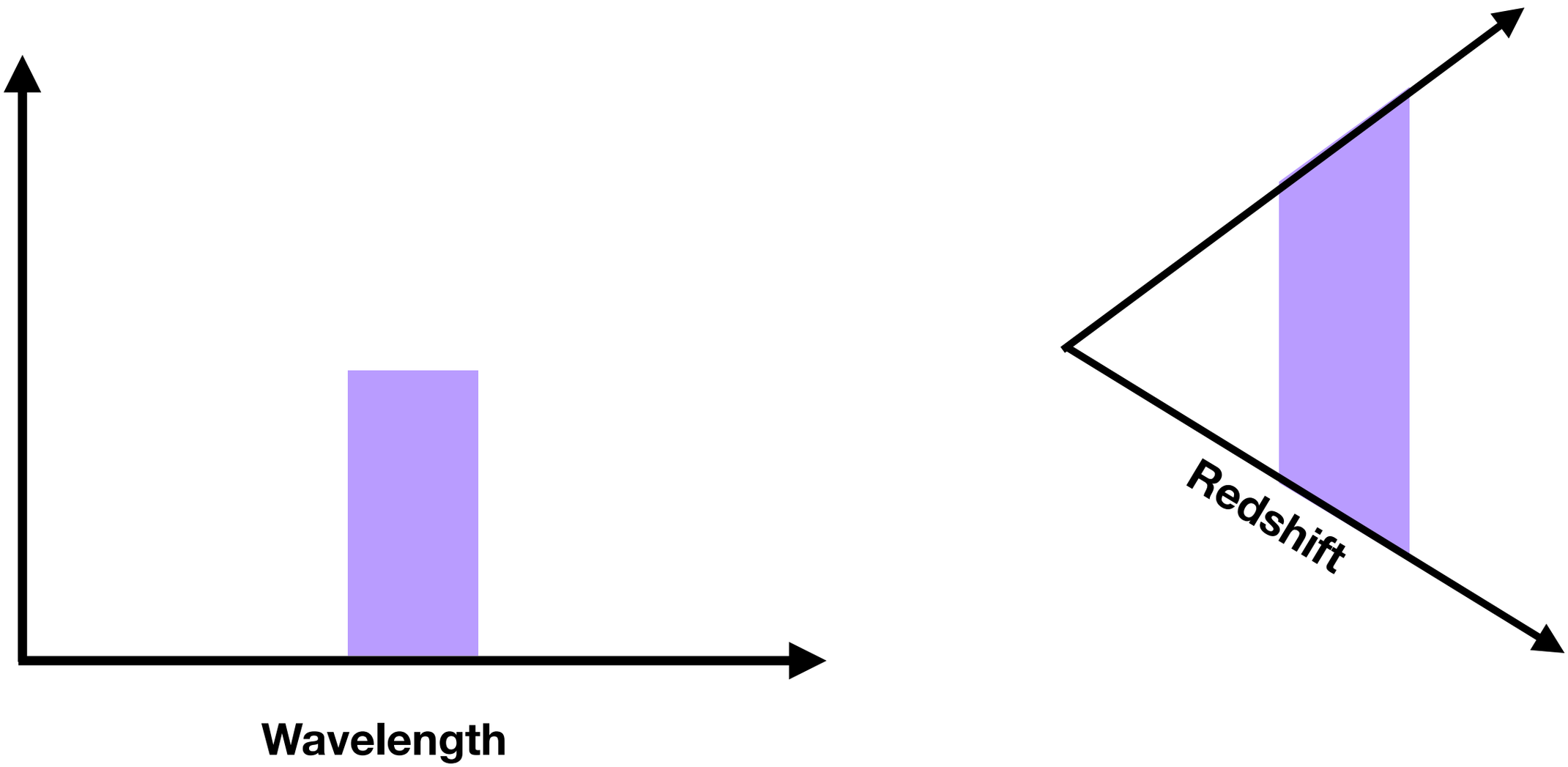
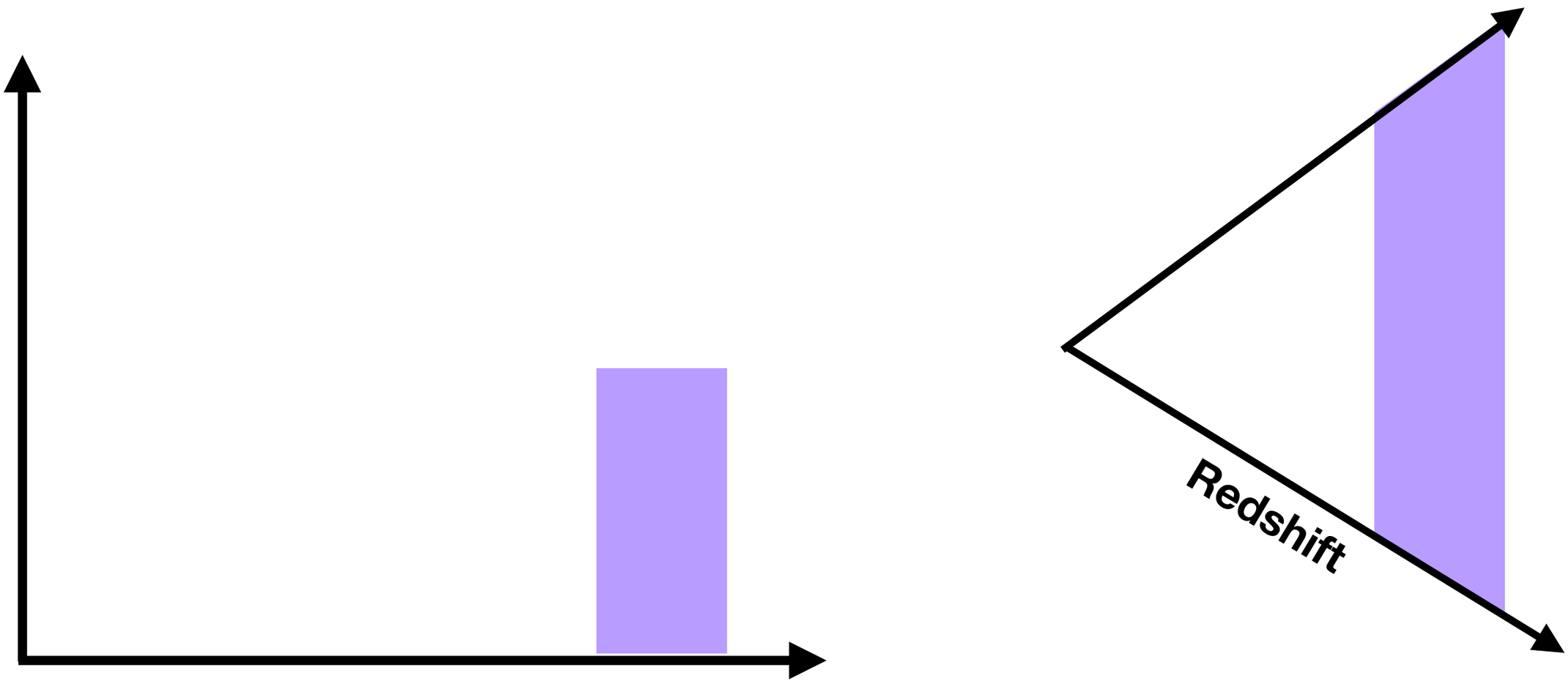


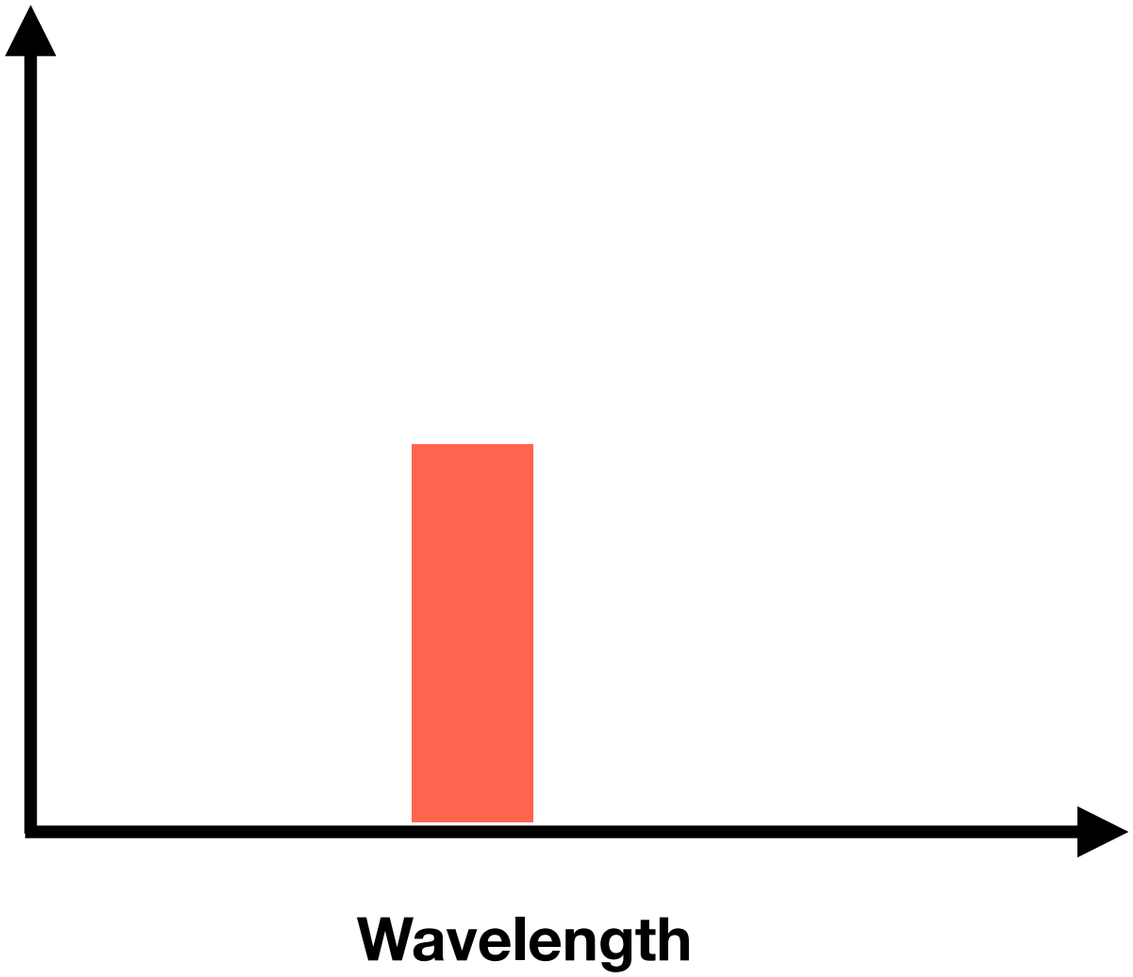
Filter Optimized for Lensing?

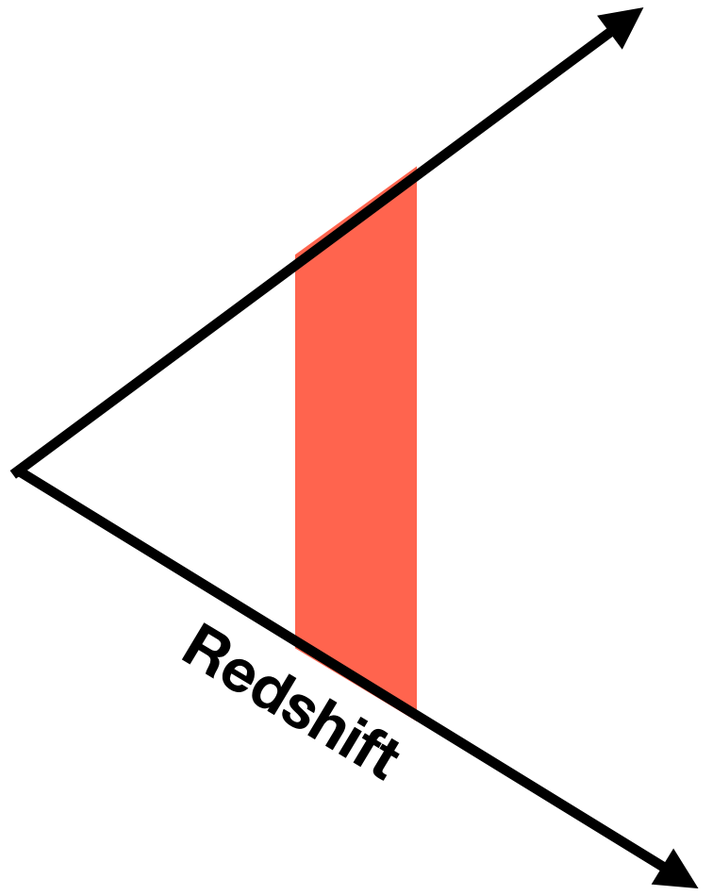


More volume = higher lensing signal to noise

Dwarfs are fainter = longer exposure time = less volume probed at fixed survey time

Filter Optimized for Lensing?





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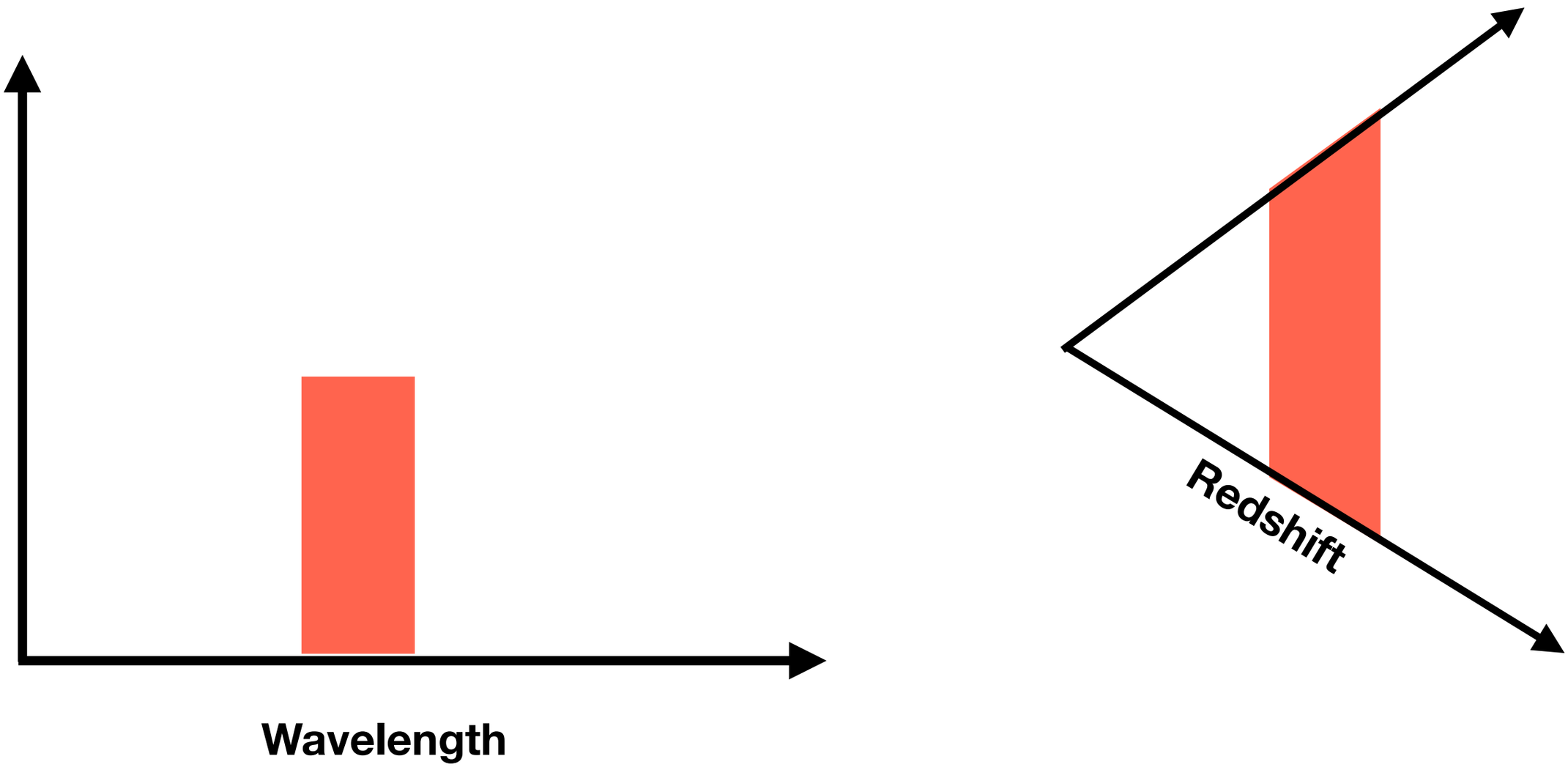

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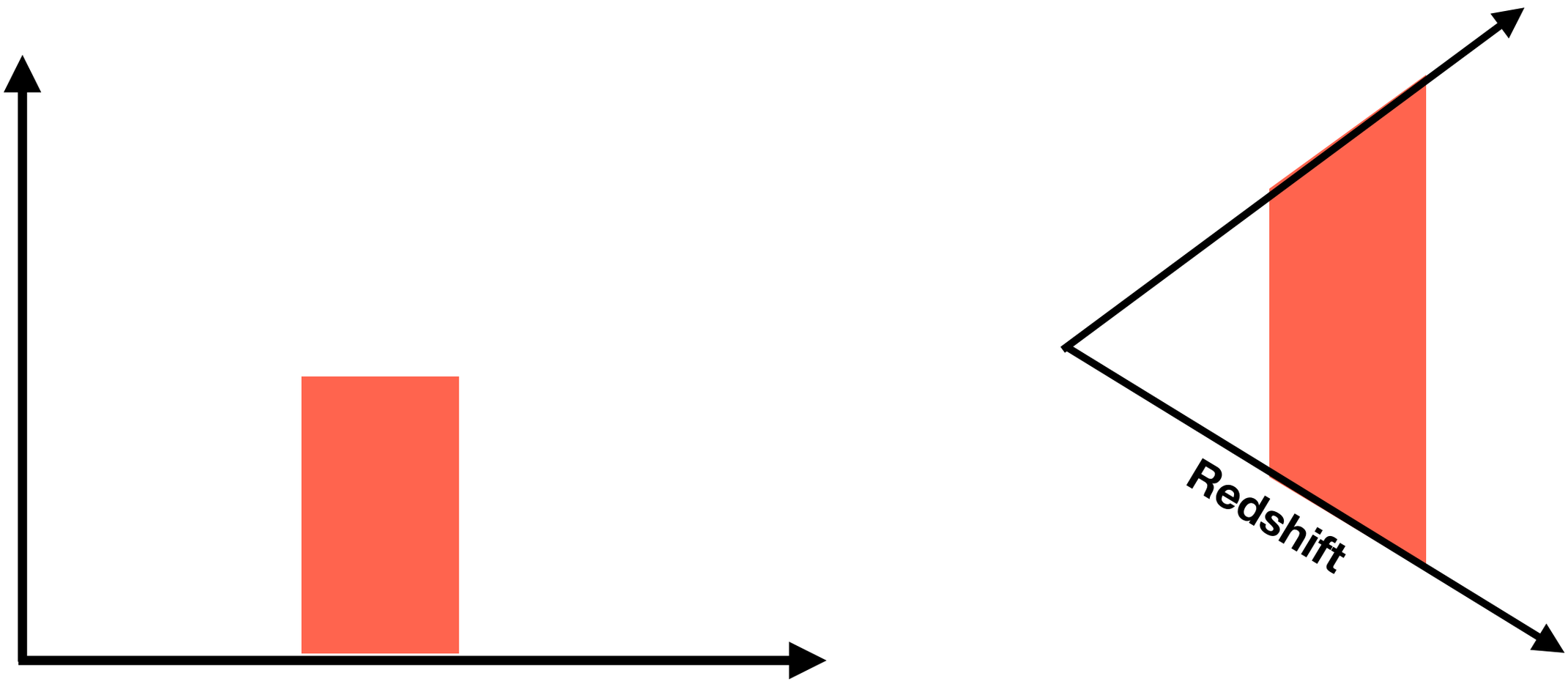
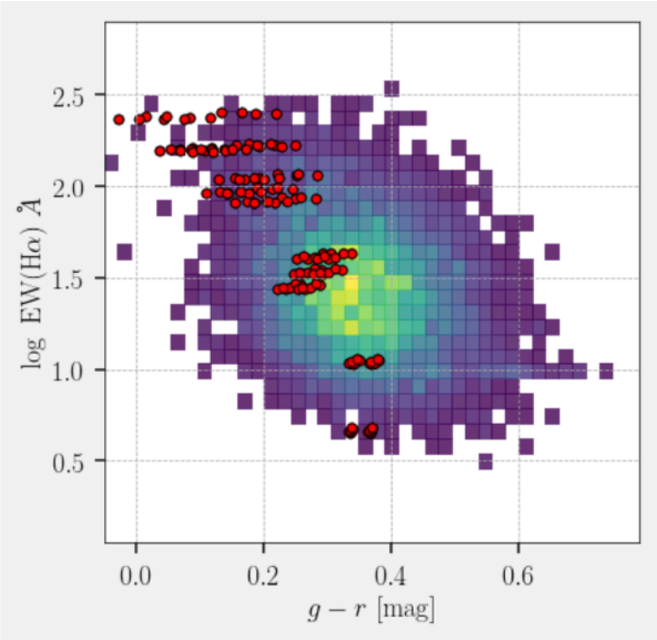
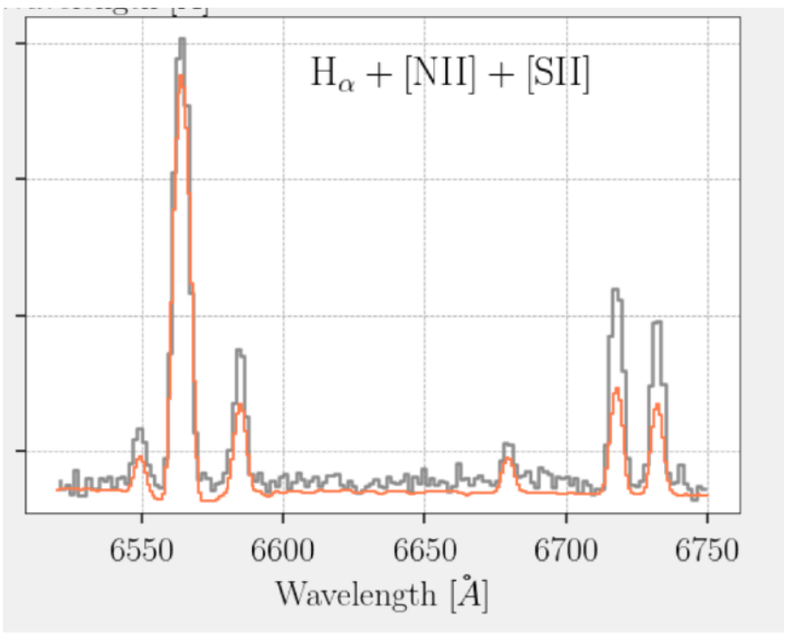


More volume = higher lensing signal to noise

Signal to noise of emission line detection weakens, fewer dwarfs detected





Mock dwarf population, FSPS mock spectra

Yifei Luo et al. in prep

Lensing S/N module →

Monte Carlo

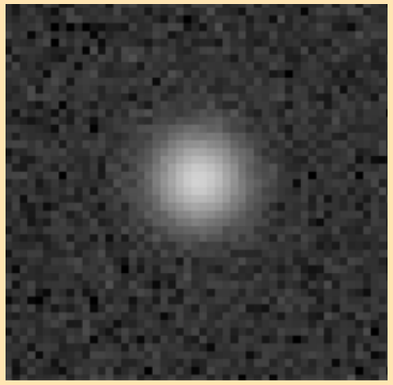
Generate galaxy images (GalSim)

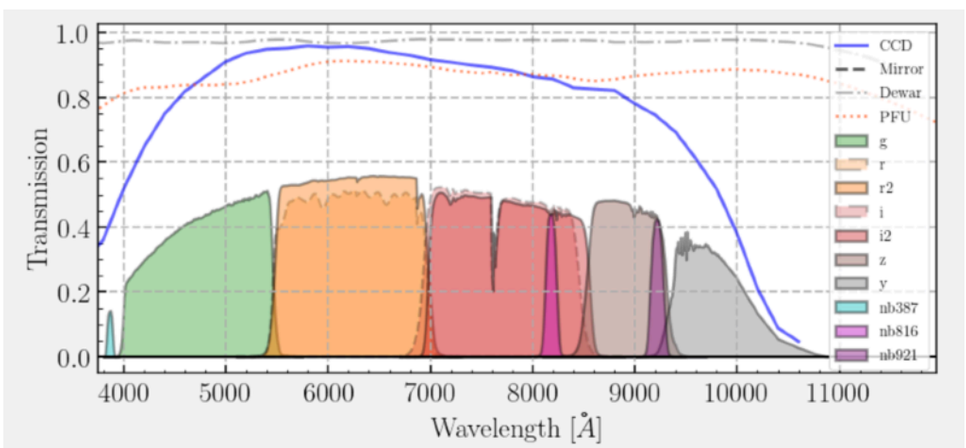
Run Source Extractor

Determine Dwarf Completeness

Require completeness > 80%

Determine exposure times, volume, lensing S/N

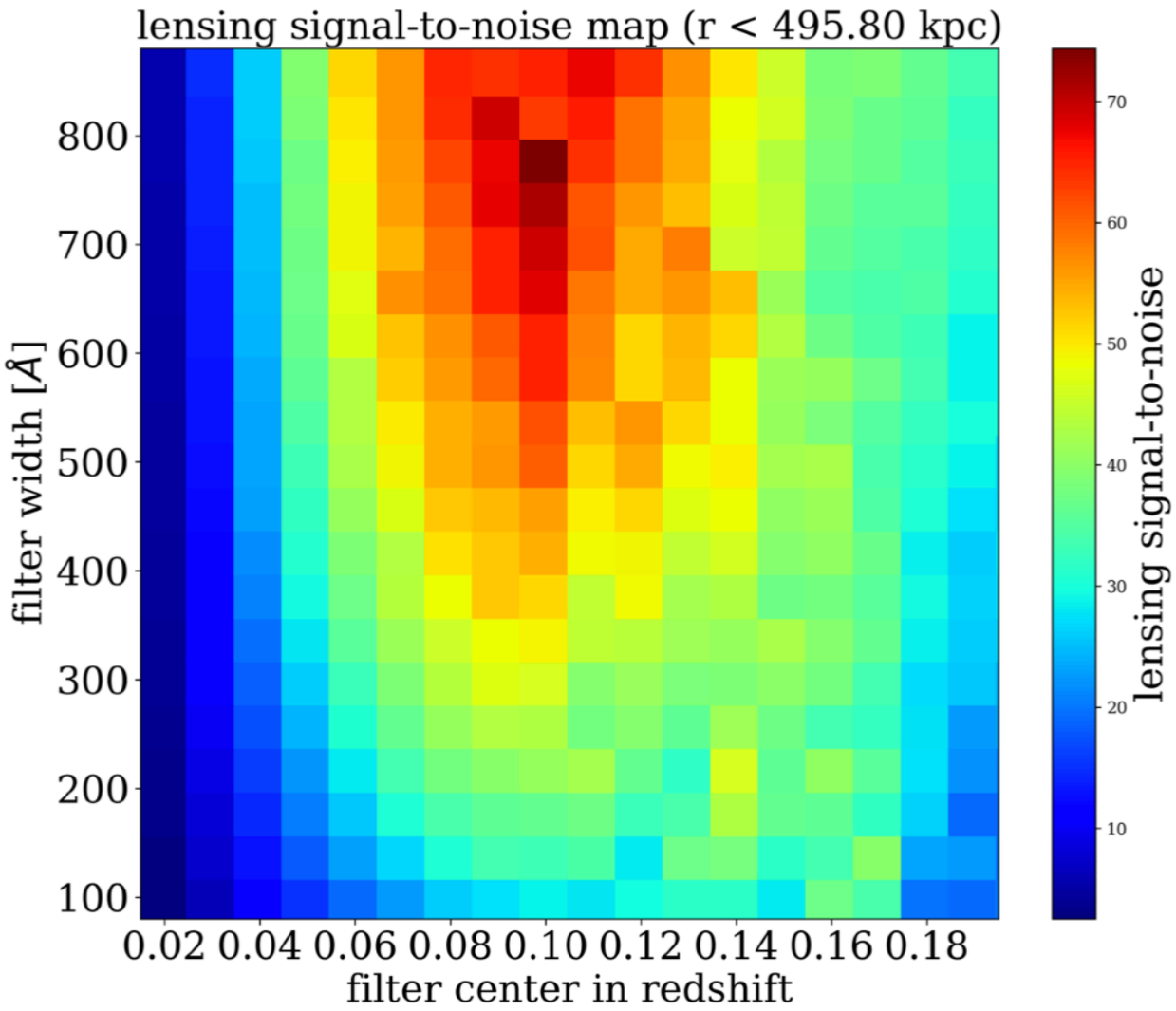


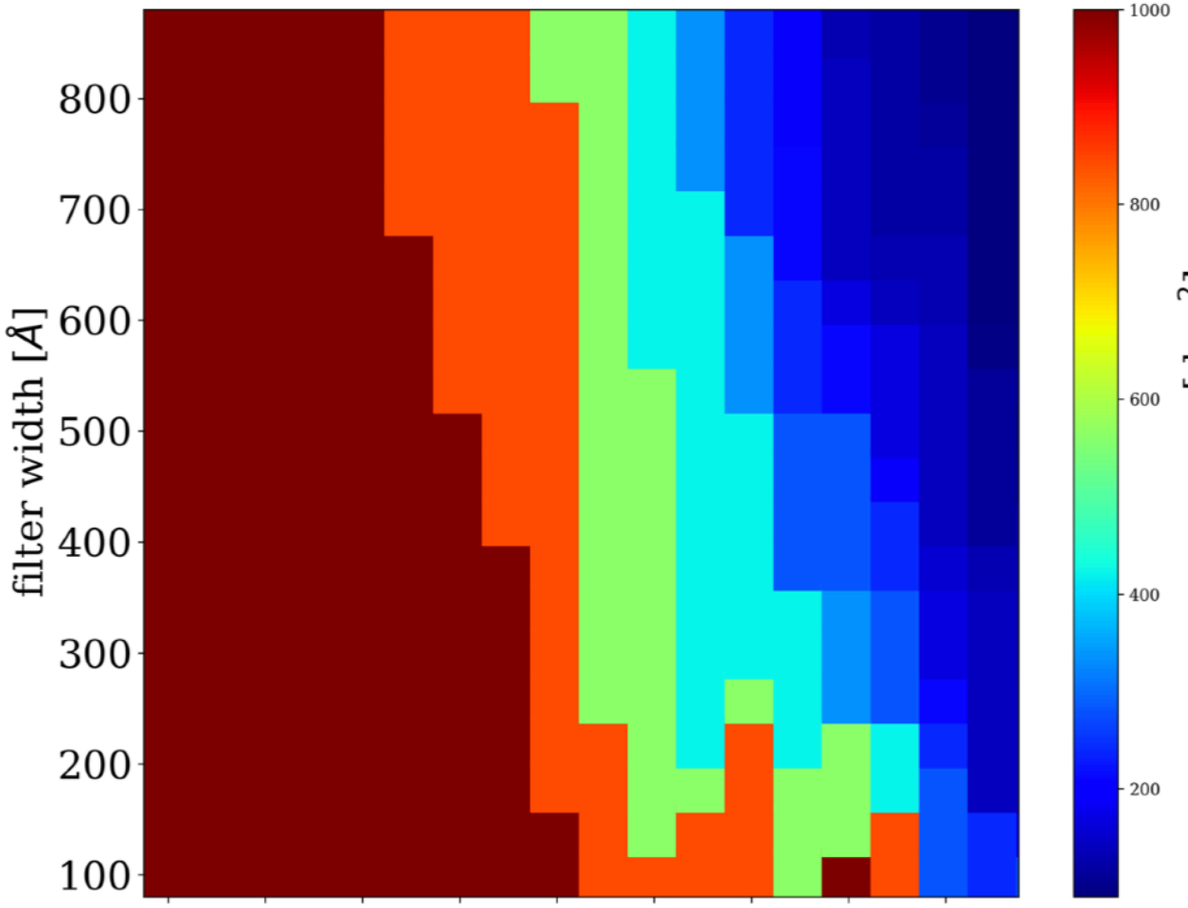


HSC broad band filter set

Filter that optimizes S/N!

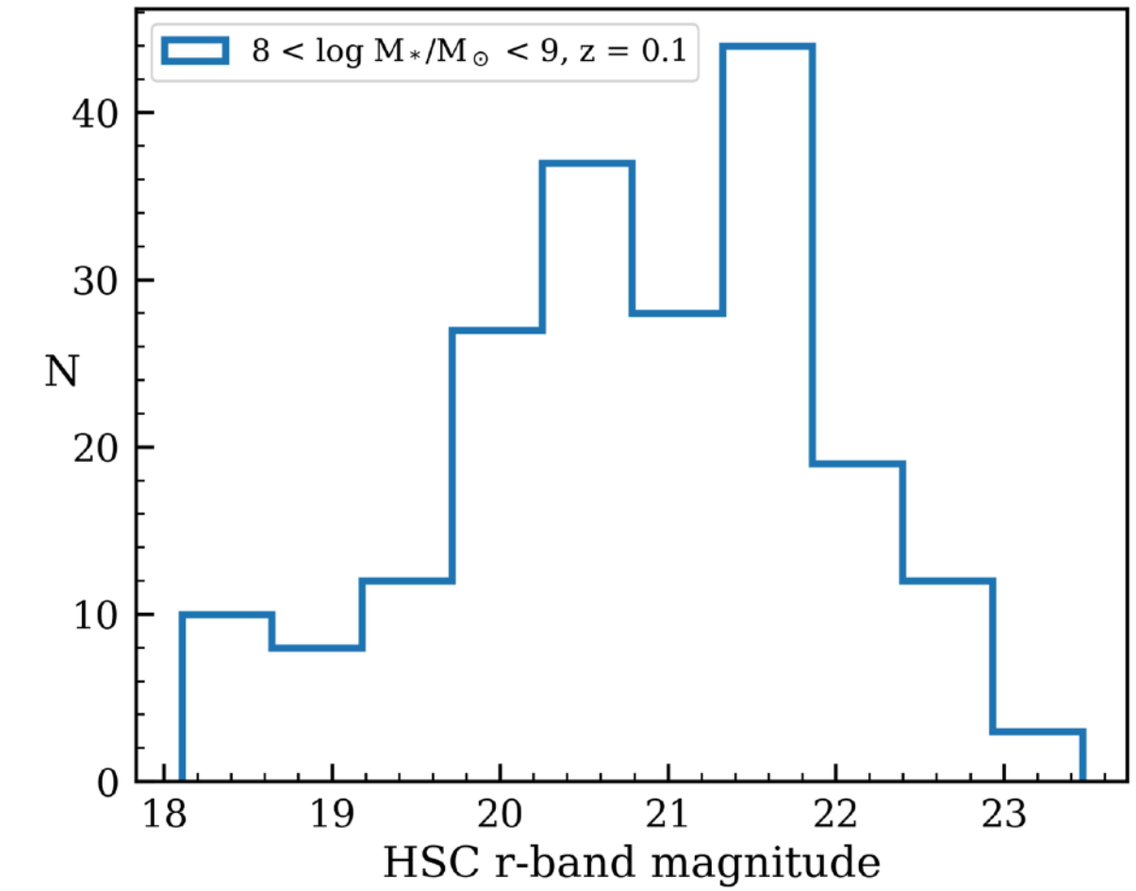
Optimization Exercice

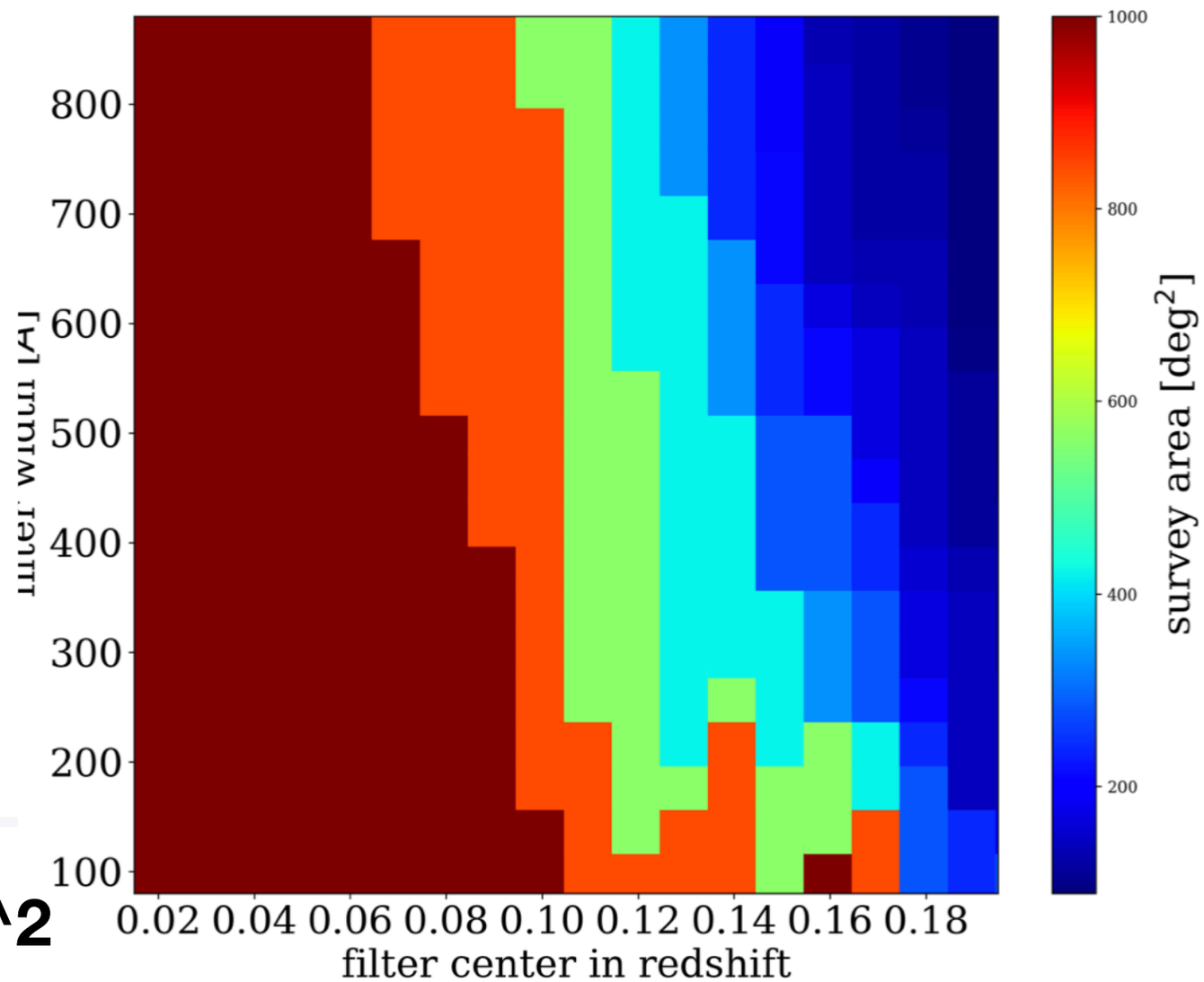




Super Preliminary!!!

General Properties





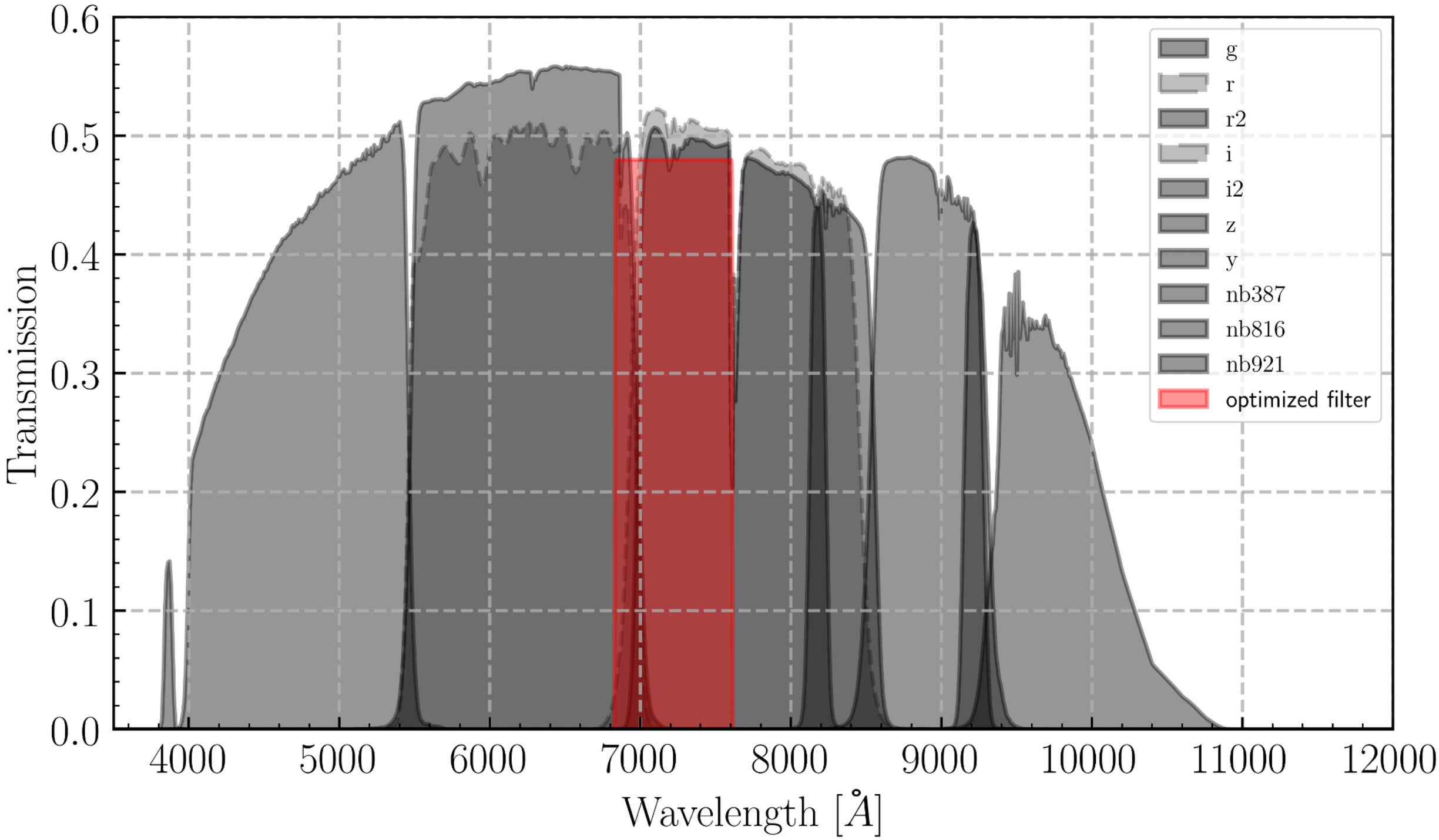
8<M*< 9. z=0.1, ~ 800 deg^2

200, 000 dwarfs, 15 nights on Subaru (?)

Super Preliminary!!!

Looking Forward

- Refine calculations (have ignored some details)
- Consider other observatories (CFHT, DECAM)
- Study mitigation techniques for contamination
- Keck data in December, ~200 galaxies at 0<z<0.2 with gas dynamics and Alpha SFR. If interested, let me know.
- Build a filter, 100k !


Transmission
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0.1
0.2
0.3
0.4
0.5
0.6
4000
5000
6000
7000
8000
9000
10000
11000
12000
g
r
r2
i
i2
z
y
nb387
nb816
nb921
optimized filter