Baseline HLS photo-z calibration plan

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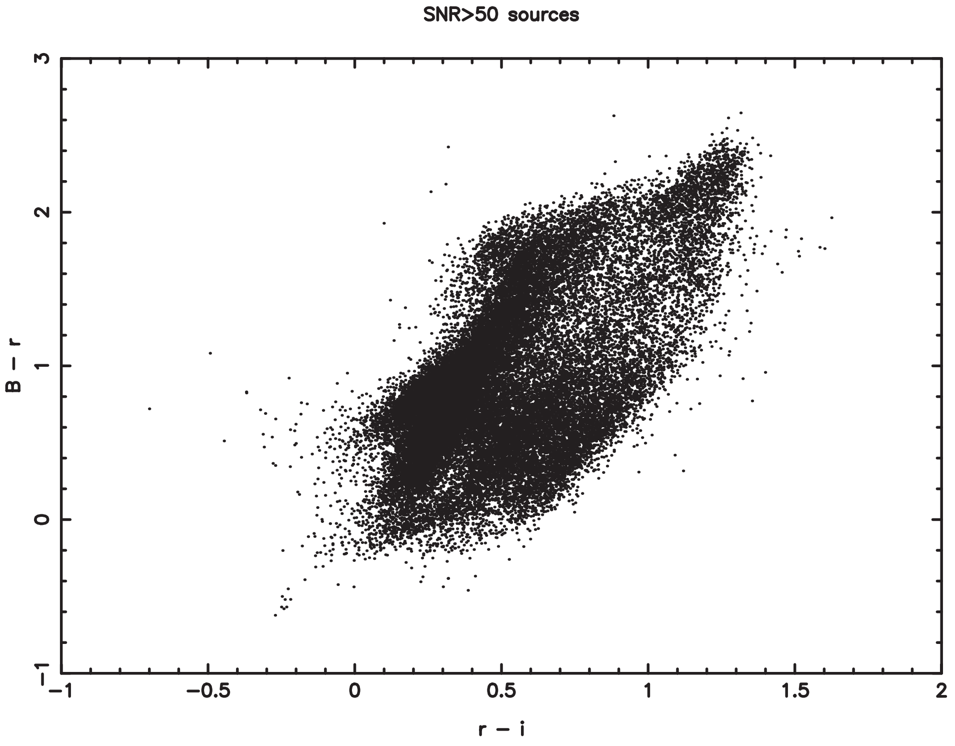
Outline

- Why do photo-z's work
- How to use them for cosmology
- Mapping the color-redshift relation
- Importance of deep fields

Why Do Photometric Redshifts Work?

- Galaxies are very similar in many ways
  - Same physics
  - Cluster in color space
- Photo-z is a map of the color space manifold to redshift
  - High dimensionality
  - Complex manifold
  - Lots of ways to do this mapping
- Error distributions and systematics are important



Why cosmology photo-z is different

- For cosmology we do not need all objects
  - Only using the lensing sample, not all galaxies
  - Need a method to define objects with well constrained redshift distributions
    - Reject the rest
    - Forget those faint red galaxies at z~2 we are not using them for cosmology because they are rare and hard to get redshifts to
- Need an accurate redshift distribution for samples of objects
  - Individual objects don't matter
  - Should be selecting objects from color space rather than photo-z space
    - Think of this as an optimal binning problem
  - May still have estimates of P(z) for each object

Philosophy Based On Euclid Experience

- Need multiple equally powerful methods to calibrate and verify photo-z and determine the errors
  - Need set of tertiary calibrators to triple check systematics
- Two methods identified as primary calibrators
  - Color-Redshift manifold calibration (e.g. Masters et al. 2015)
  - Clustering-cross correlations (e.g. Newman et al. 2015, Menard et al. 2013)
  - Should be viewed as complementary with same final result
- Tertiary methods to validate binning and co-variance
  - Photo-z/Photo-z clustering cross-correlation
  - Density field re-construction

Mapping the Color-Redshift relation (Masters et al. 2015)

- We adopt a widely-used technique known as the Self-Organizing Map (SOM), or Kohonen Map
- Easy to visualize
- Easy to understand

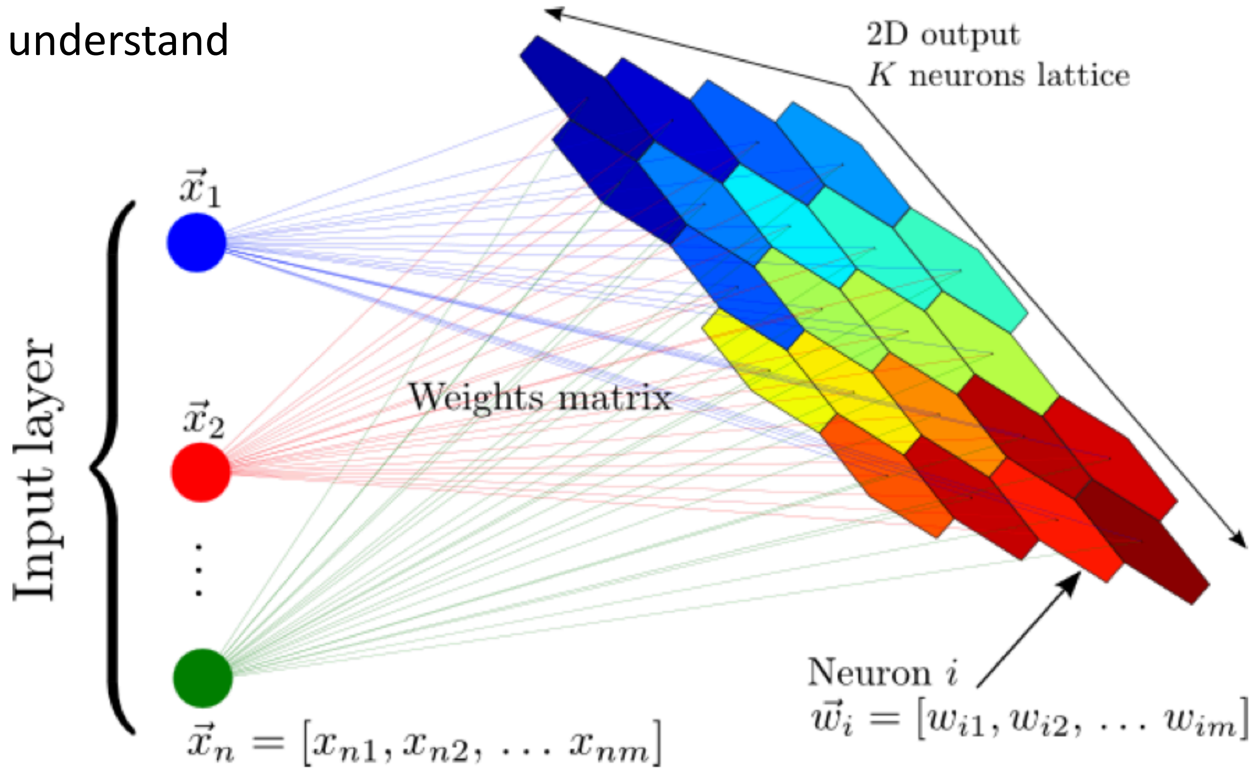
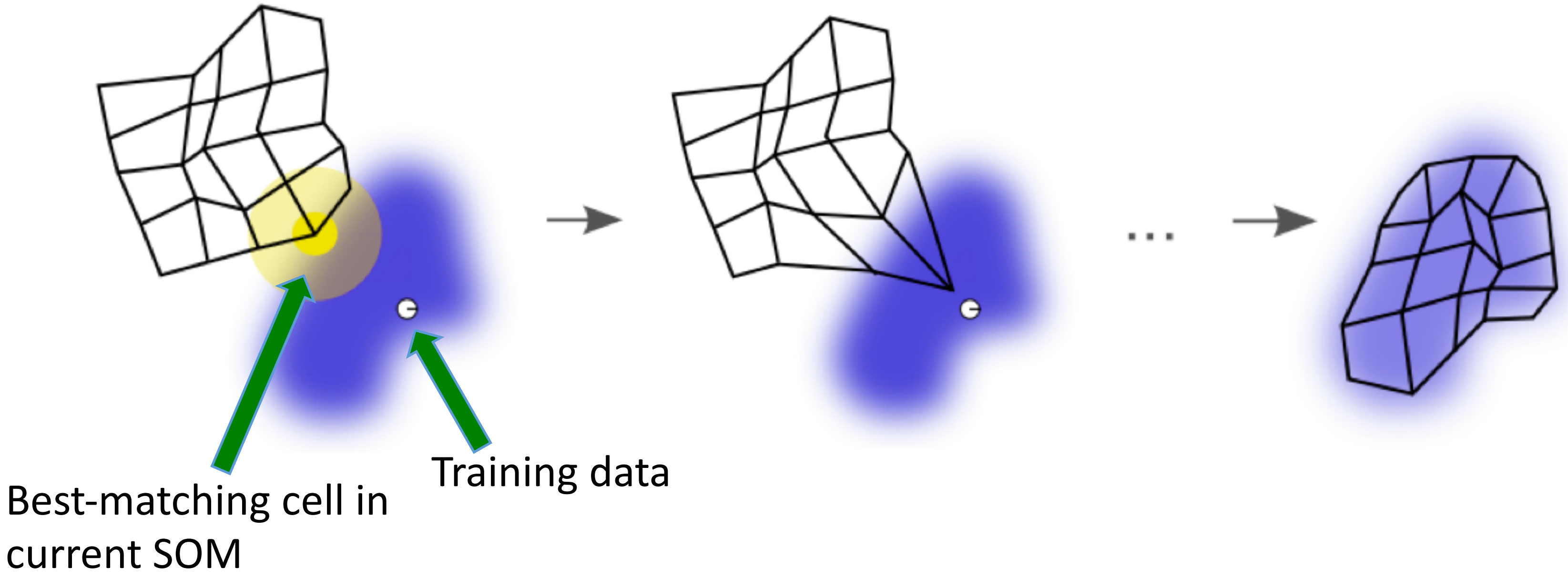


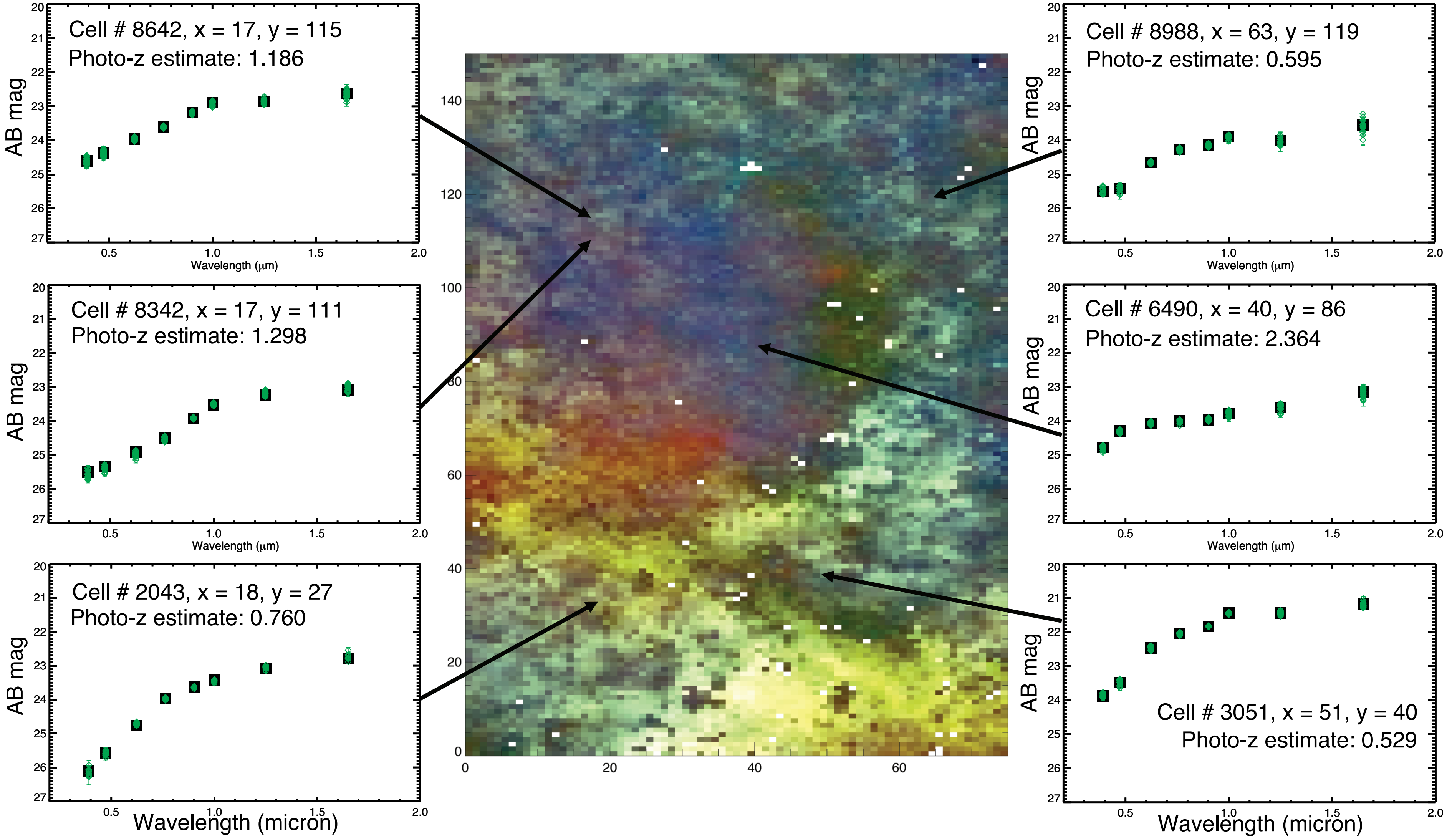
Illustration of the SOM (From Carrasco Kind & Brunner 2014)

Mapping the Color-Redshift relation (Masters et al. 2015)



1. Initialized map is presented with training data, i.e. the colors of one galaxy from the overall sample.
2. Map moves towards training data, with the closest cells being most affected.
3. Process repeats many times with samples drawn from training set until the map approximates the data distribution well.

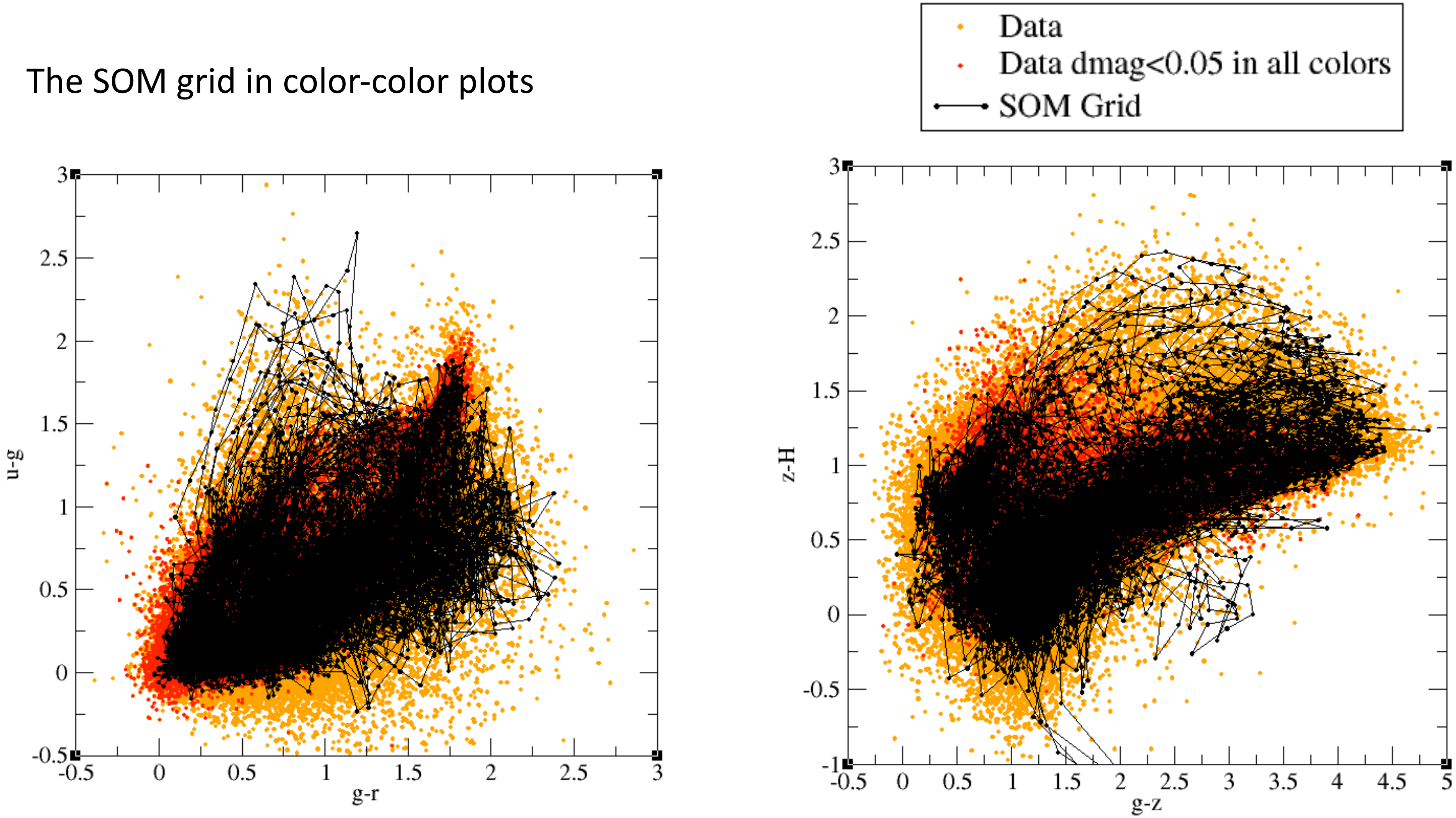
Mapping the Color-Redshift relation



Masters et al. 2015

Mapping the Color-Redshift relation

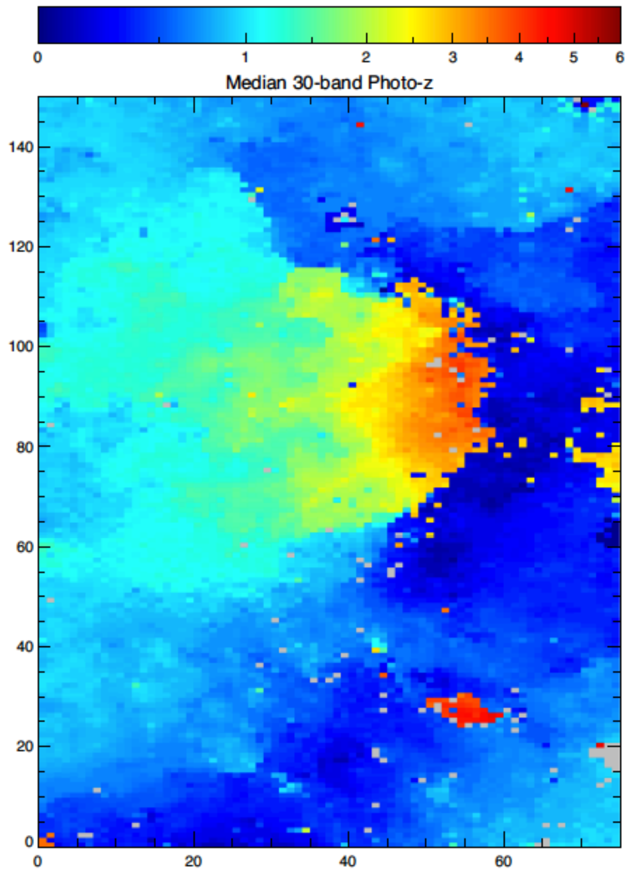
The SOM grid in color-color plots



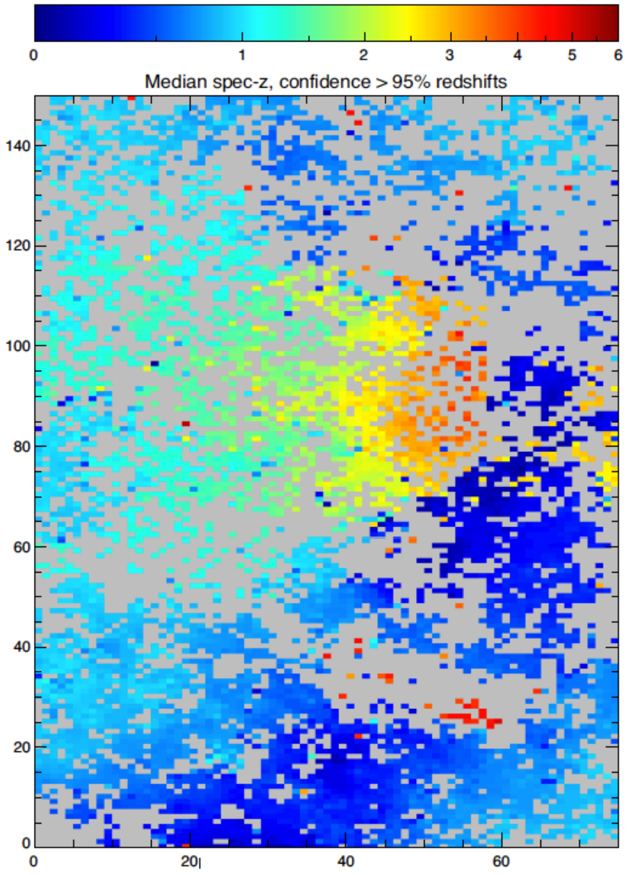
Mapping the Color-Redshift relation

- Can visualize the 7-dimentional color data
- Test if the analytic model fits
- Test where the data driven model is valid
- Target grey areas with spectroscopy

Analytic (Template) Model



Data (spectra) Driven Model

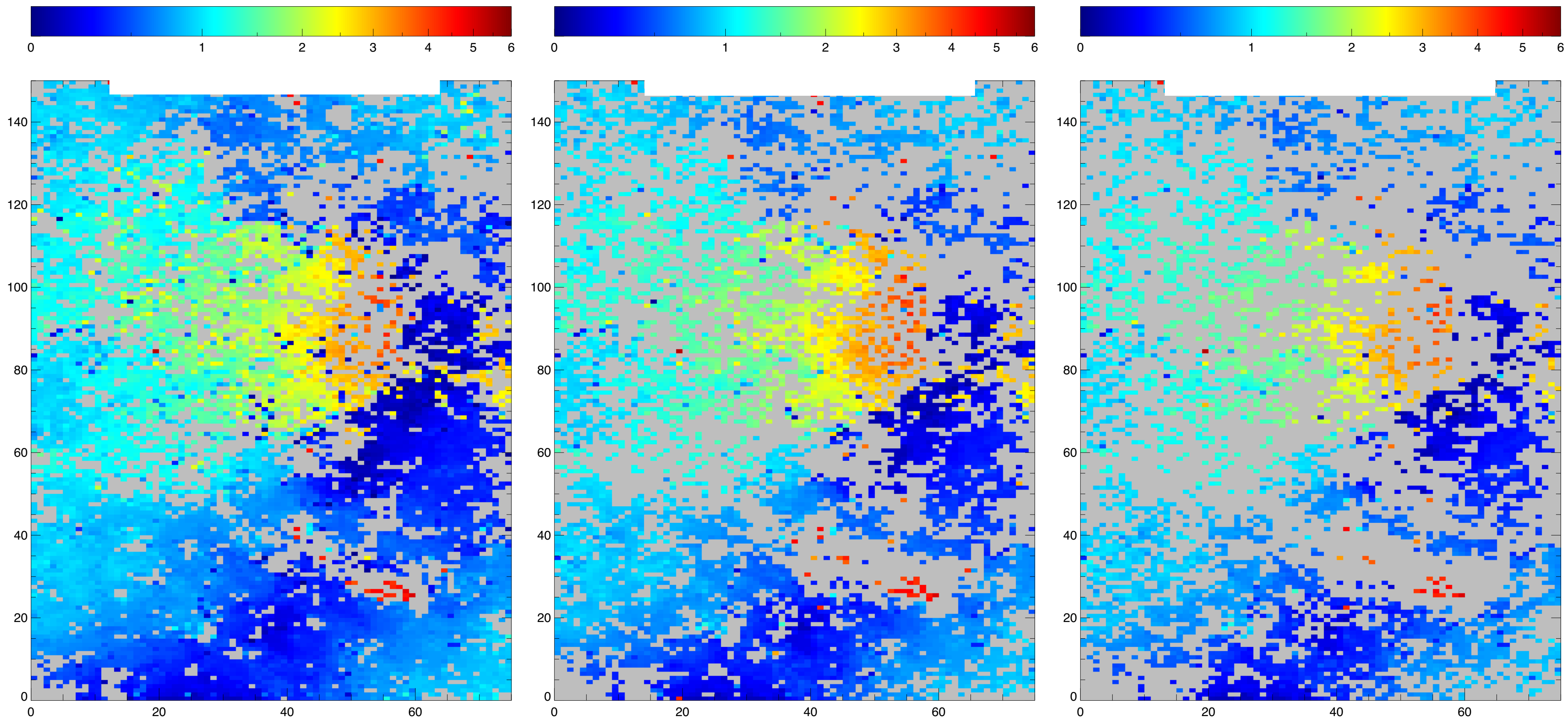


Spec-z’s across the shallower *Euclid* map at different confidence levels

Conf. ≥ 2 redshifts
31% un-sampled

Conf. ≥ 3 redshifts
51% un-sampled

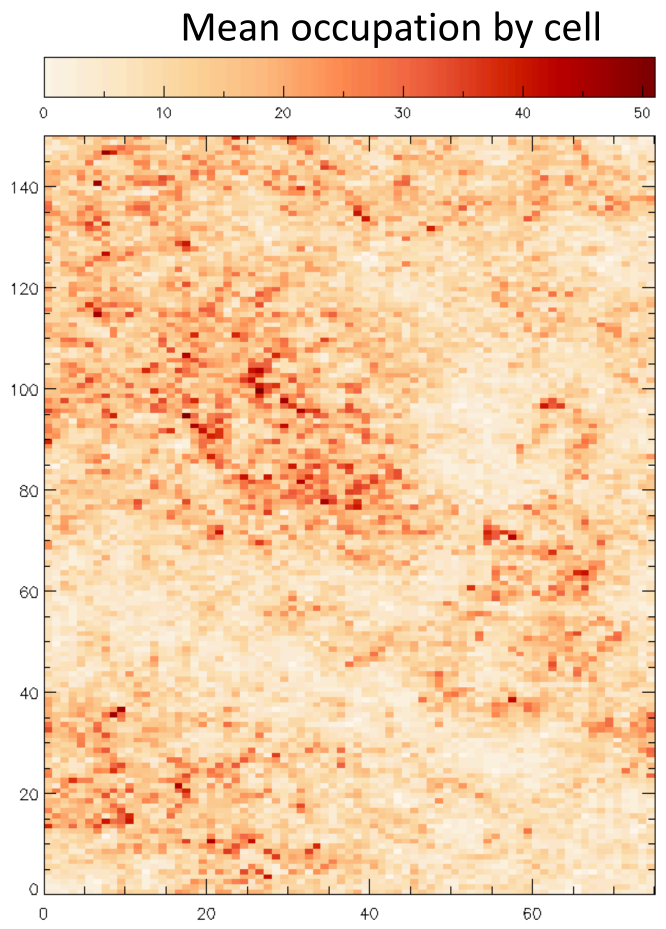
Conf. = 4 redshifts
64% un-sampled



At low confidence there appear to be very few Unknown-Unknowns. Main problem is getting high-confidence redshifts.

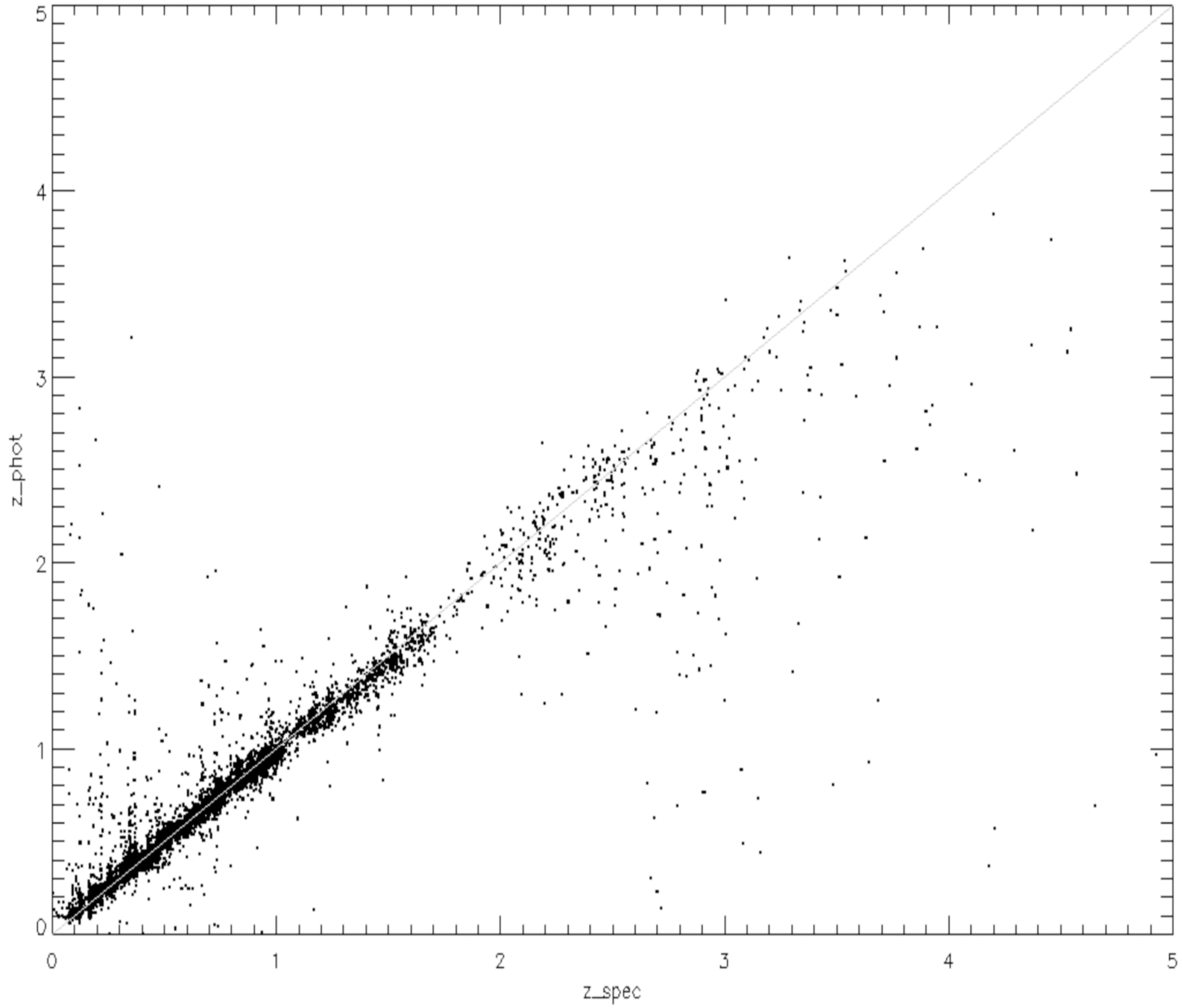
Mapping the Color-Redshift relation

- The SOM map also encodes P(color) and cosmic variance
- P(color) is important because it allows you to use the whole sample to estimate the likelihood of degeneracy
- Cosmic variance encoded in density at level of photometry
    - Typical cell has dz~0.02



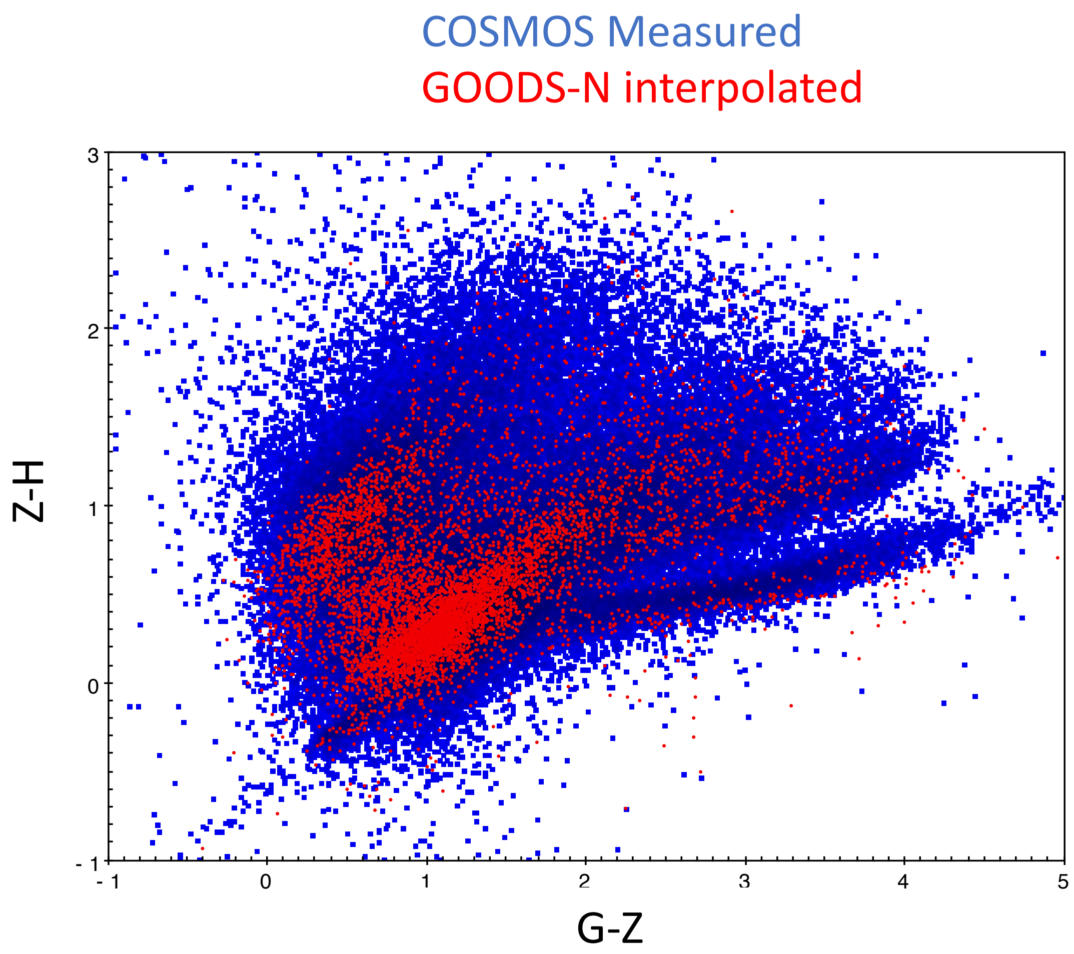
Preliminary test of SOM calibration

- Preliminary test
  - Use median photo-z + existing spec-z
    - Ones shown here not used for calibration
  - Using only u,g,r,I,z,Y,J,H photometry
  - Integrate photometric errors across SOM
- Can define a sample with an outlier fraction of 1.5% vs >10% for COSMOS
- Sigma_NMAD=0.02 vs 0.04 for COSMOS
- Overall very promising



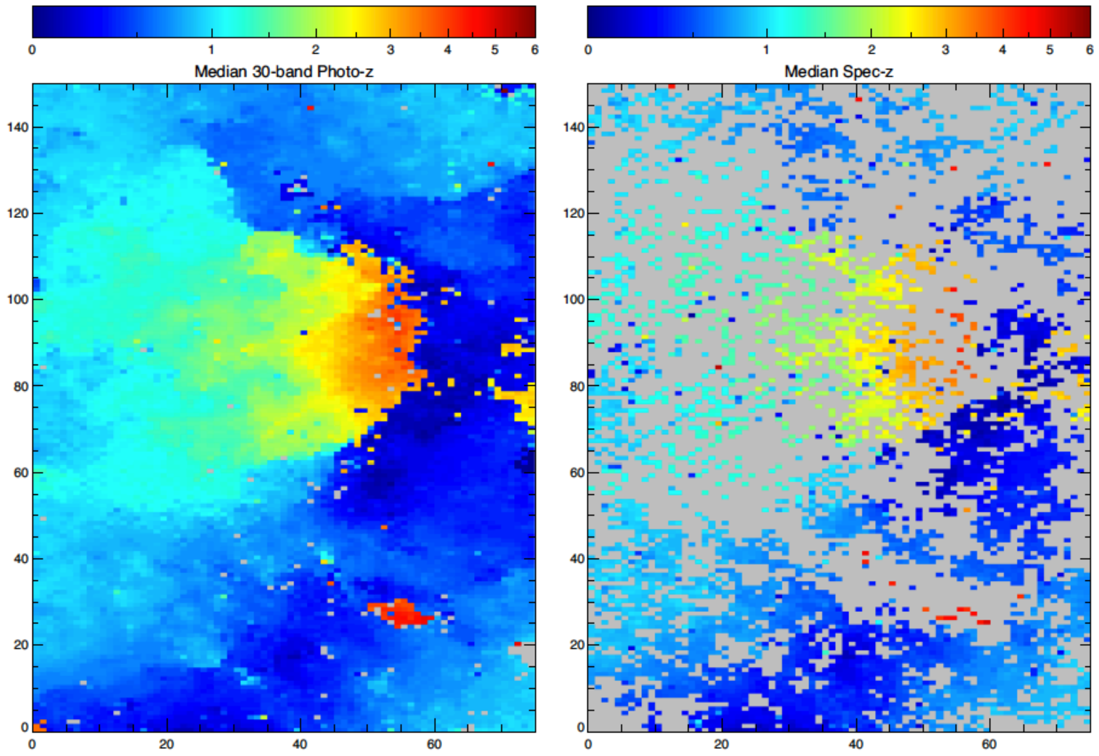
Application to WFIRST/LSST

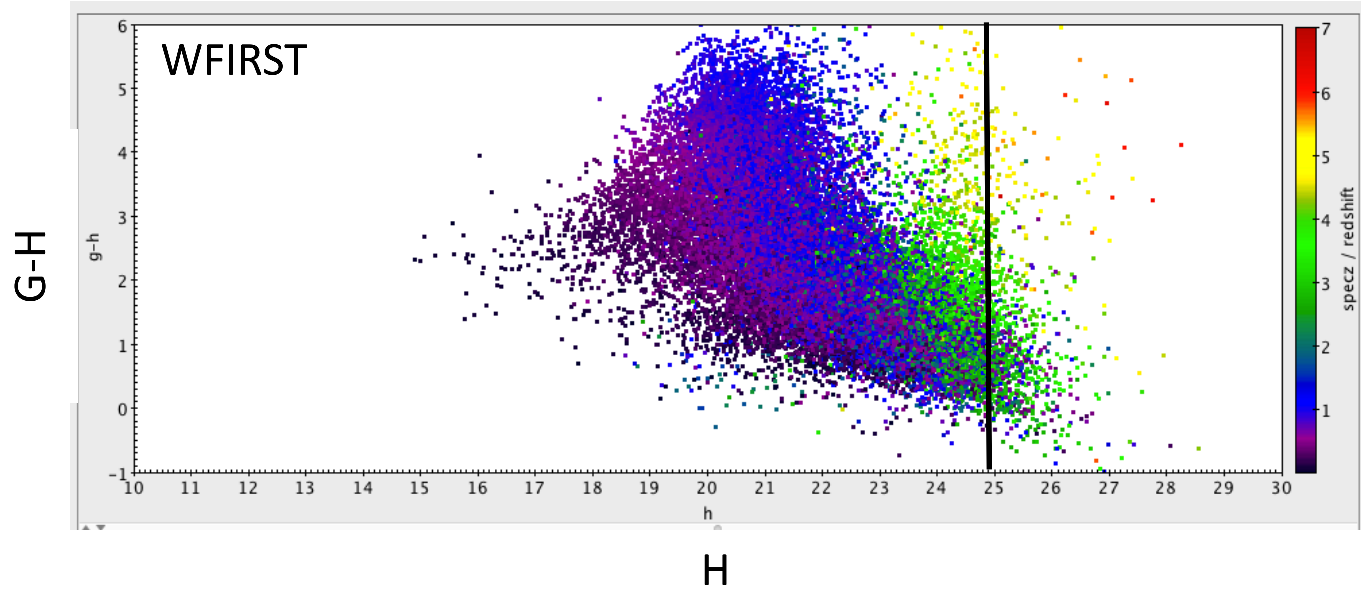
- Used CANDELS data to simulate a real WFIRST lensing sample
  - Interpolated to LSST/WFIRST bands based on existing CANDELS photometry
- Matches actual CFHT-LS + VISTA data
- Collected ~50k high-quality redshifts across CANDELS + COSMOS + SXDS + VVDS fields
- Single CANDELS field samples only a small fraction of CFHT-LS + VISTA color space

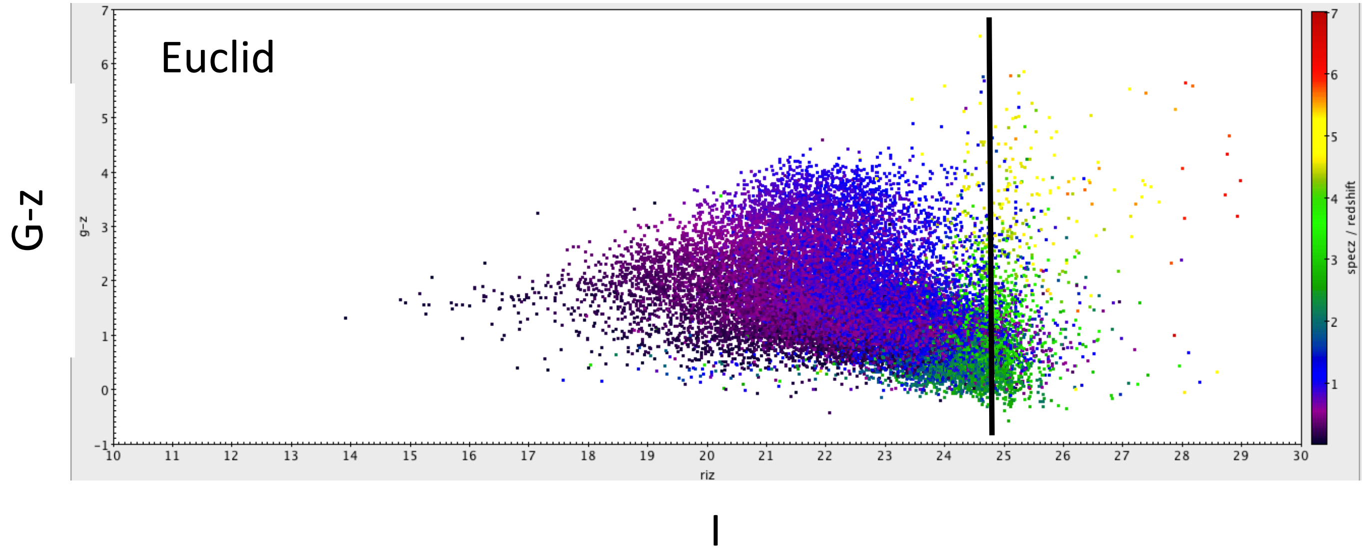


Application to WFIRST/LSST

- Euclid samples ~90% of LSST/WFIRST Color space
- WFIRST will require more z>3 spectroscopy than Euclid

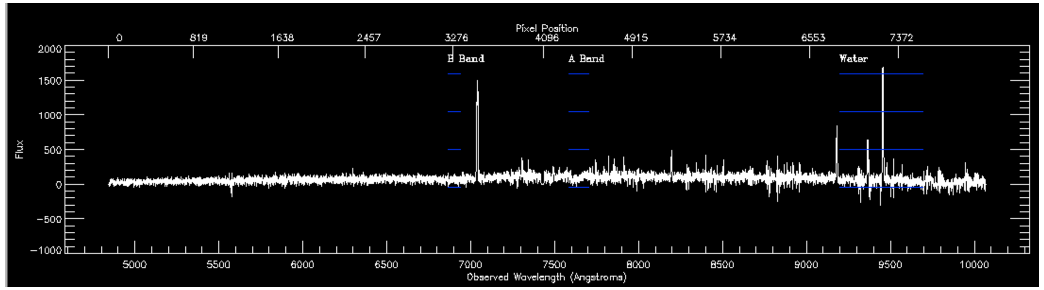


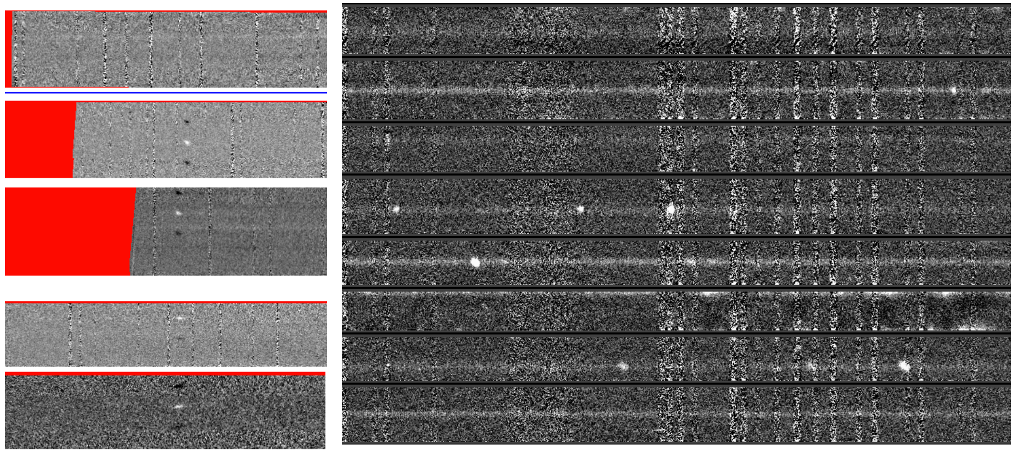




C3R2

- Aim to fill in the color-redshift map for Euclid
- Not a typical redshift survey
  - Have an expectation of what we are looking for
  - Multiple instruments, variable exposure times
  - Keep going until we have a redshift
- ~40 nights on Keck with multiple instruments
- Will go a long way to measuring the LSST/WFIRST mapping





Conclusions

- Need multiple methods to measure and verify the redshift distribution of the tomographic bins and the errors
  - Color redshift and clustering methods most promising
  - Different requirements on spectroscopy
- Spectroscopy hard but not impossible for lensing
  - Does not need to sample entire galaxy population, just lensing sample
  - Needs to be well thought out
  - Not blind targeting like previous redshift surveys