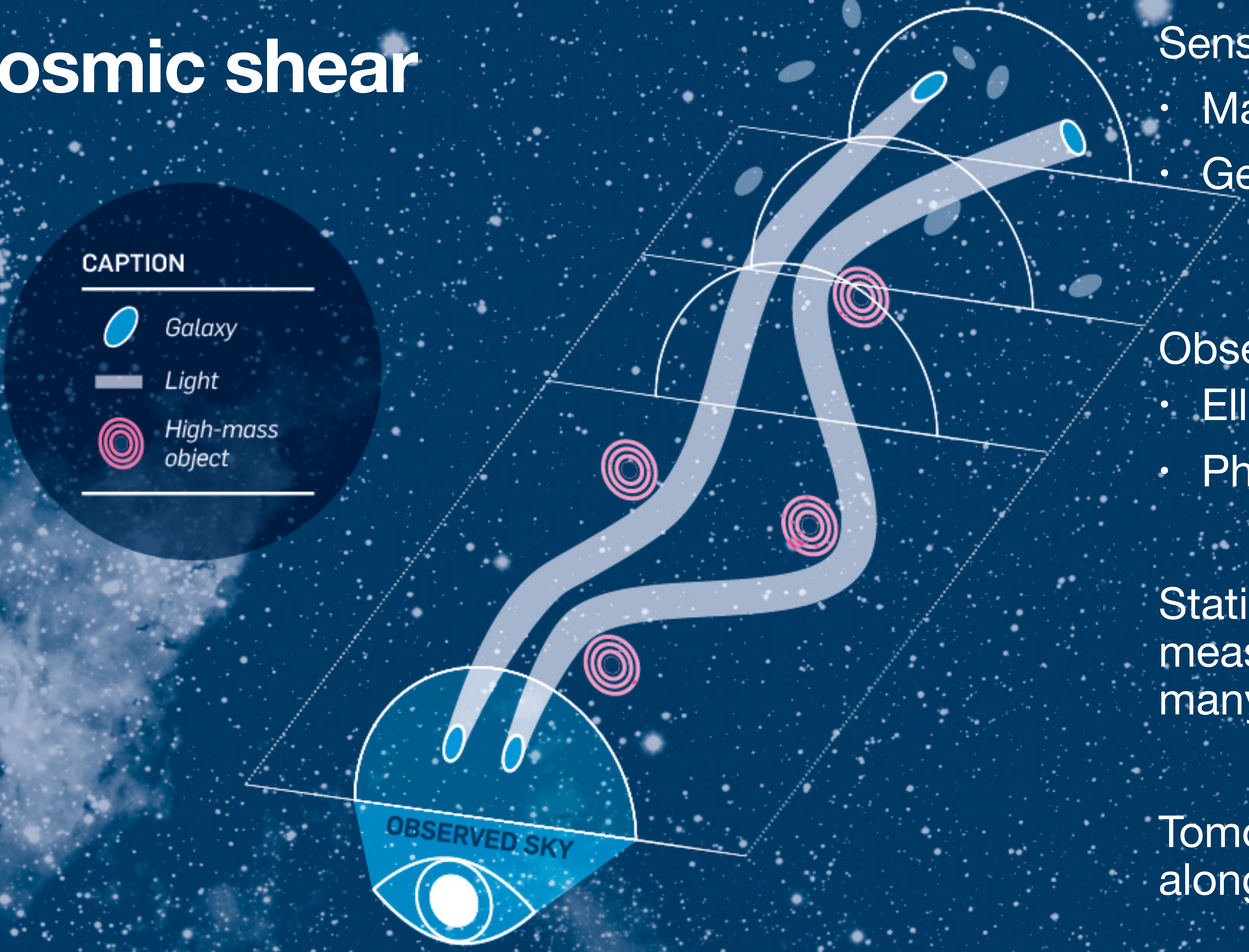
Redshift calibration for weak lensing

Hendrik Hildebrandt - Ruhr University Bochum

Heisenberg-Programm
DFG Deutsche Forschungsgemeinschaft
erc European Research Council
Established by the European Commission
GCCL
GERMAN CENTRE FOR COSMOLOGICAL LENSING
RUB

Cosmic shear



Sensitive to:

- Matter distribution
- Geometry

Observables:

- Ellipticities
- Photo-z

Statistical measurement of many galaxies

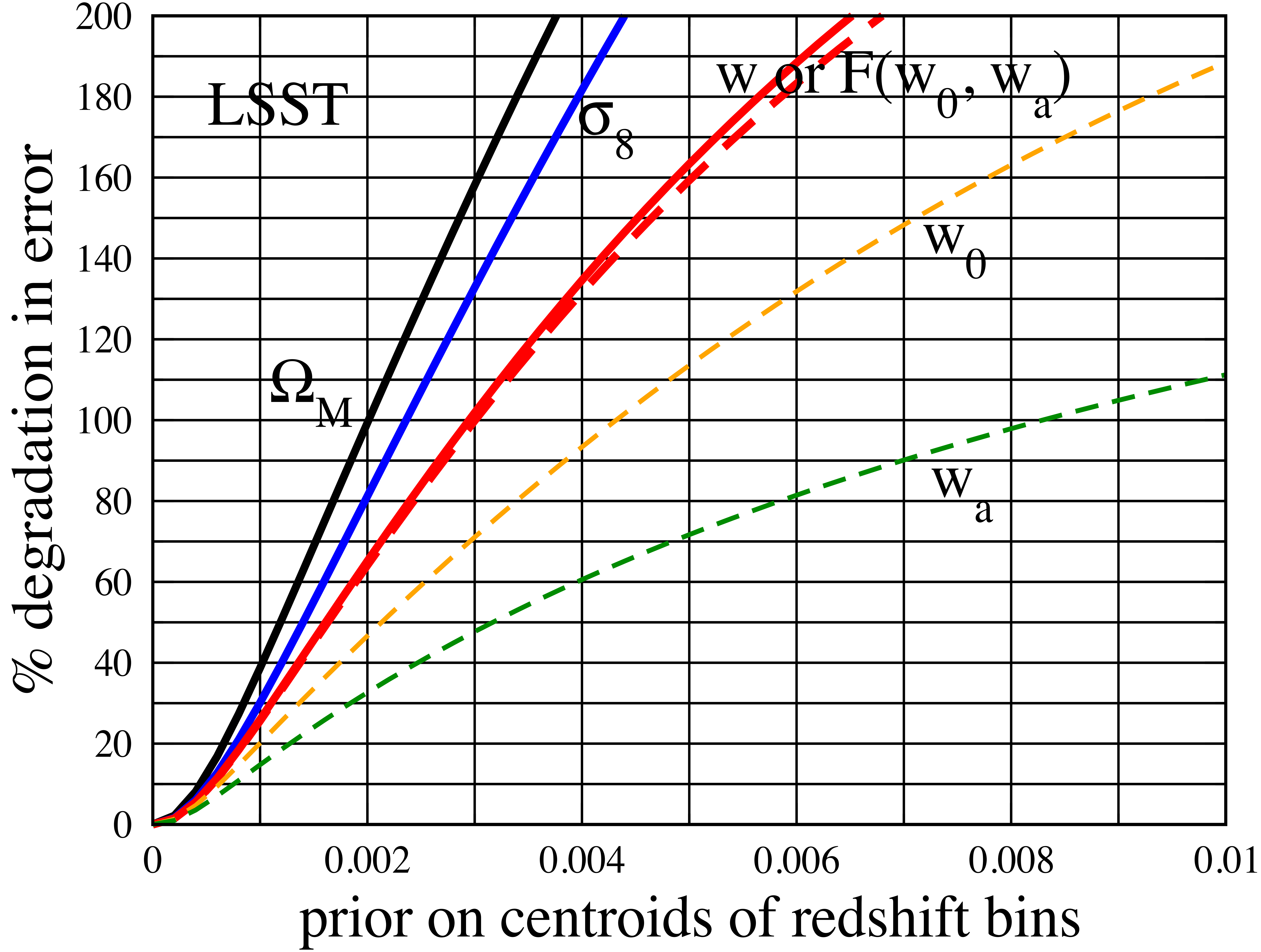
Tomographic binning along the line-of-sight

Redshift dependence of cosmic shear

$$\langle \gamma^2 \rangle \propto \sigma_8^2 \; z_s^{1.7} \; \Omega_m^{1.7} \; \theta^{\left(\frac{n-1}{2}\right)}$$

van Waerbeke et al. (2006)

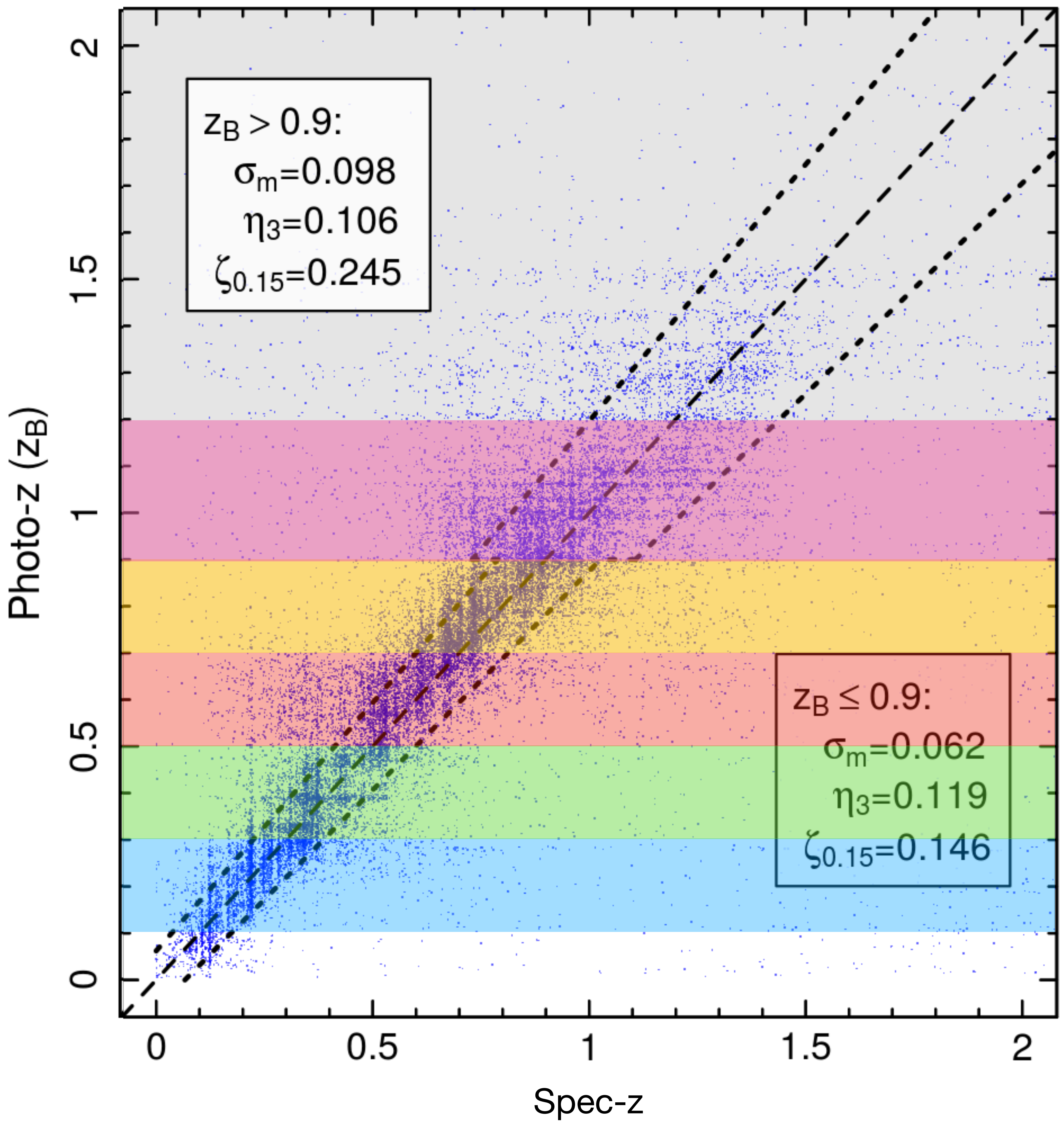
Redshift dependence of cosmic shear

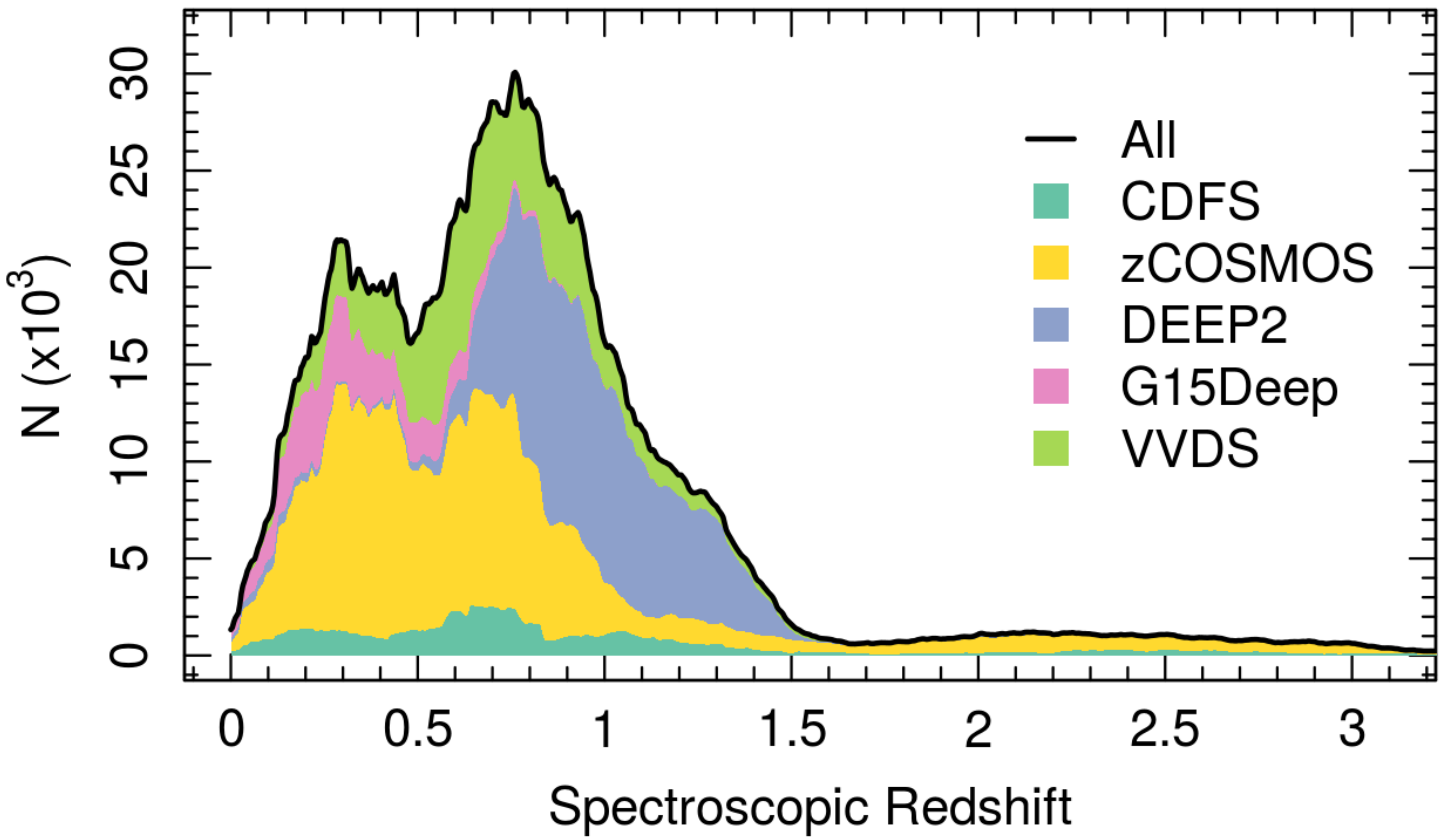


Stage-III surveys are a factor of 5-10 less sensitive to redshift errors.

Huterer et al. (2005)

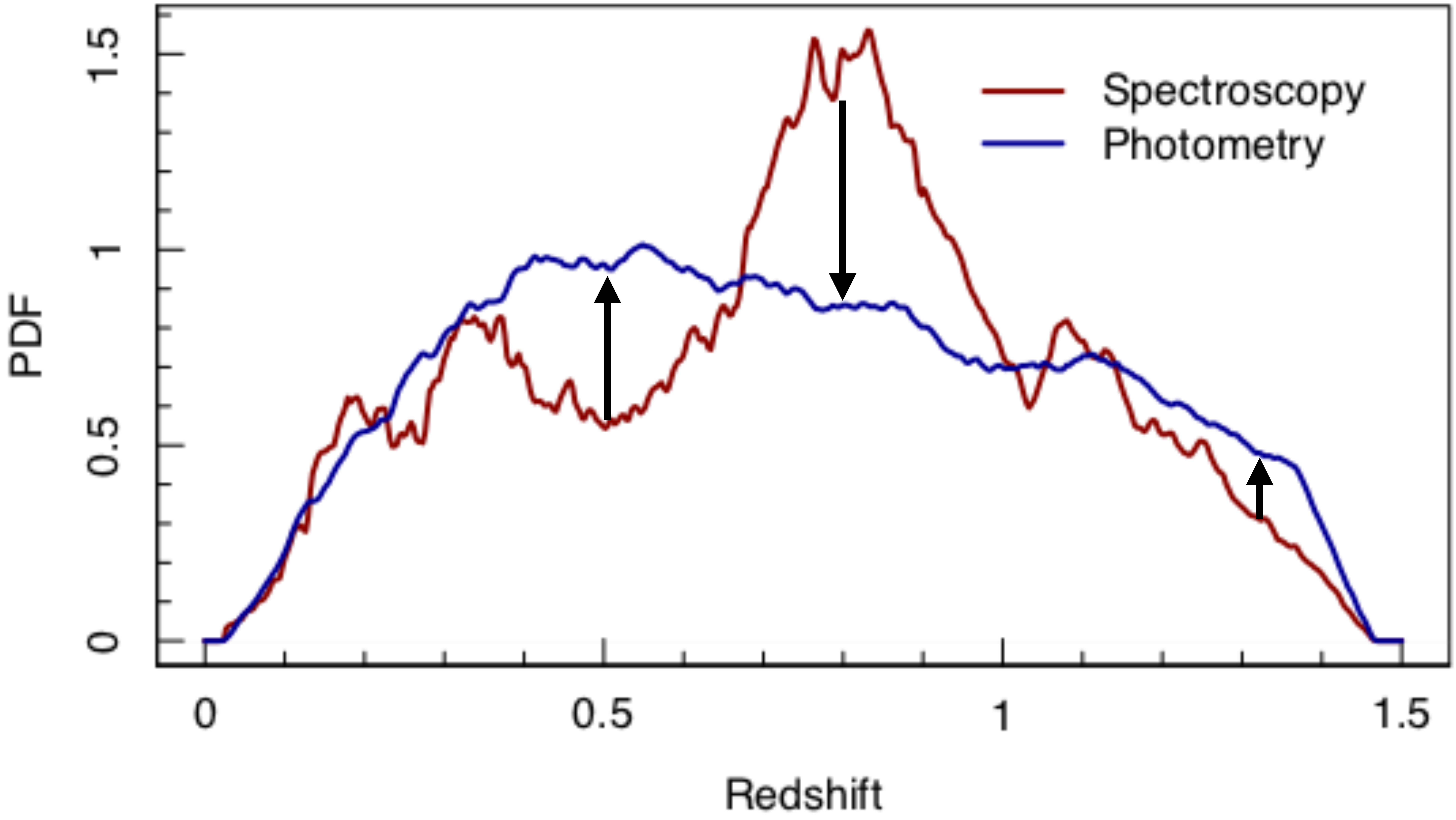
Photometric redshifts





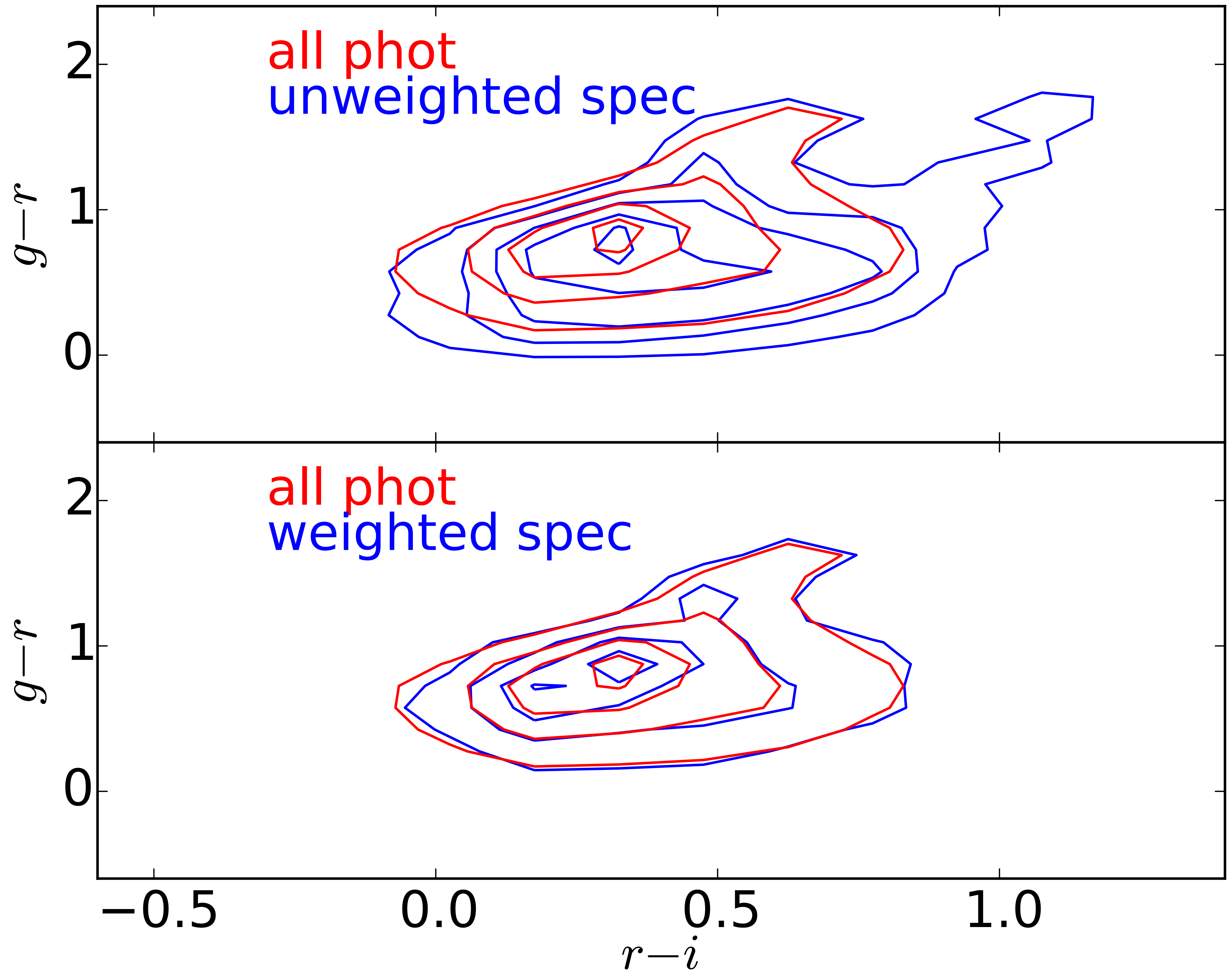
Wright et al. (2018)

Re-weighting the calibration sample



Redshift calibration with *k*NN weighting

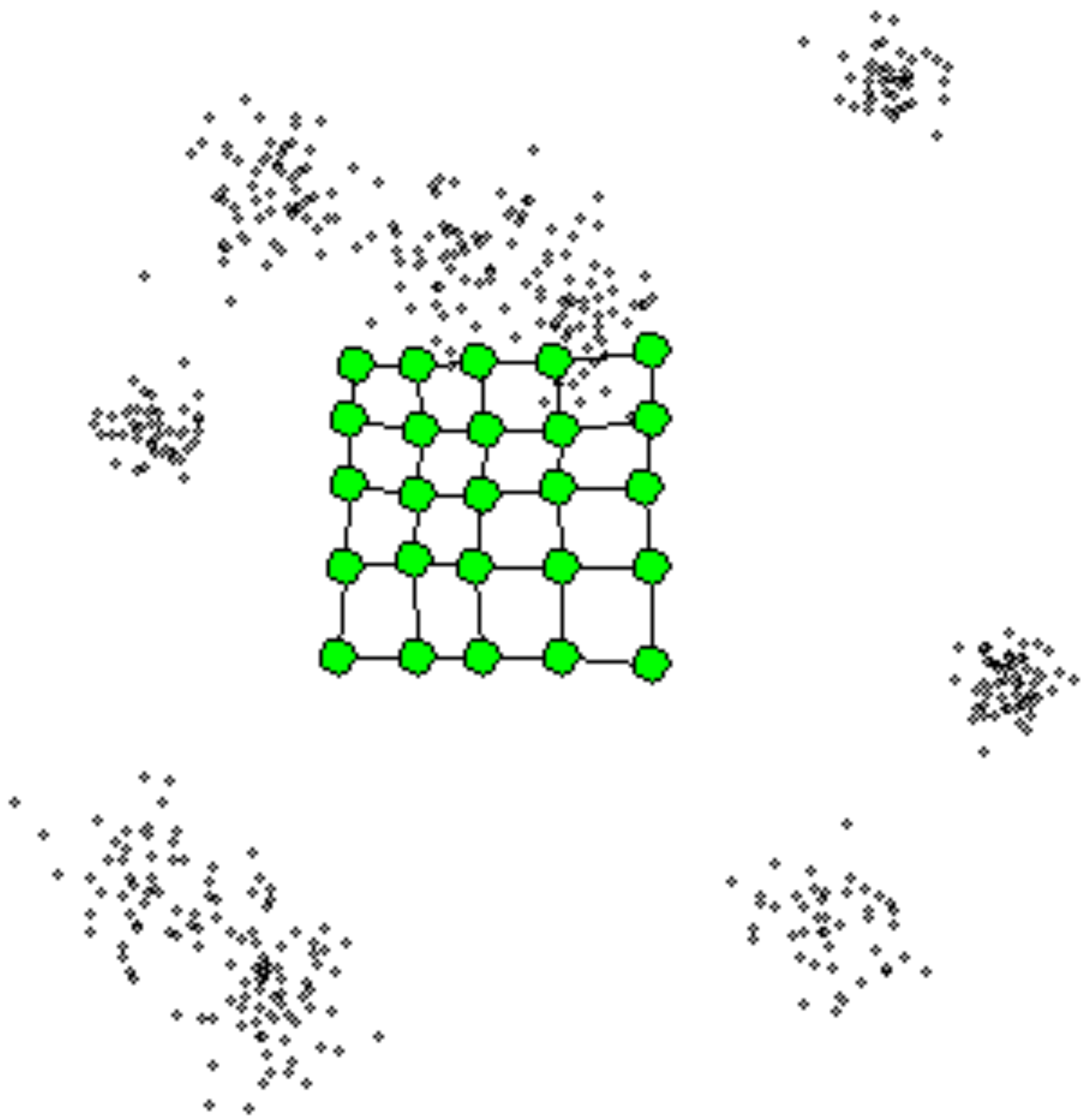
Re-weight spec-*z* surveys to be more representative.



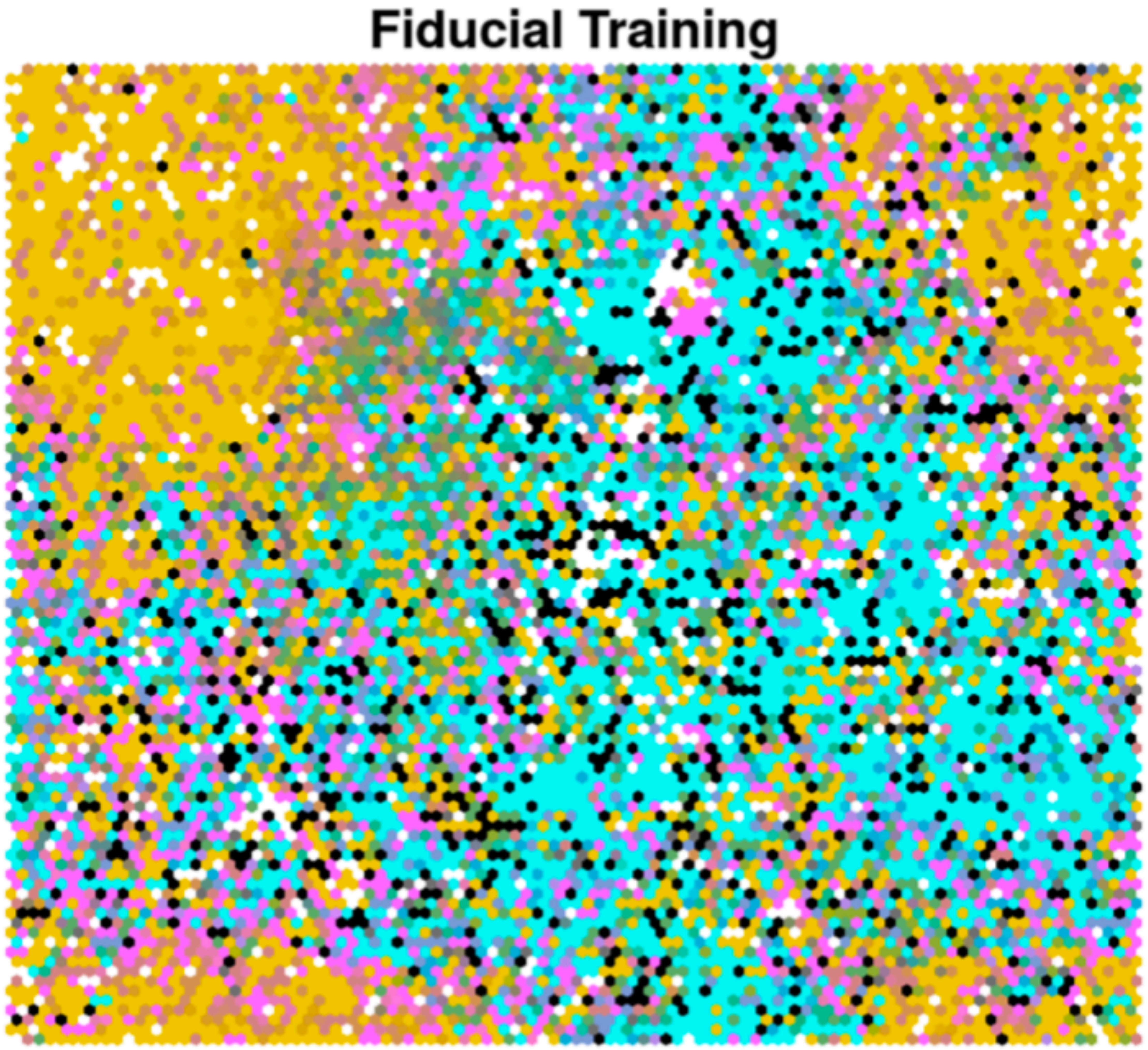
1. Magnitude space needs to be fully covered.
2. Requires unique relation colour-redshift relation.

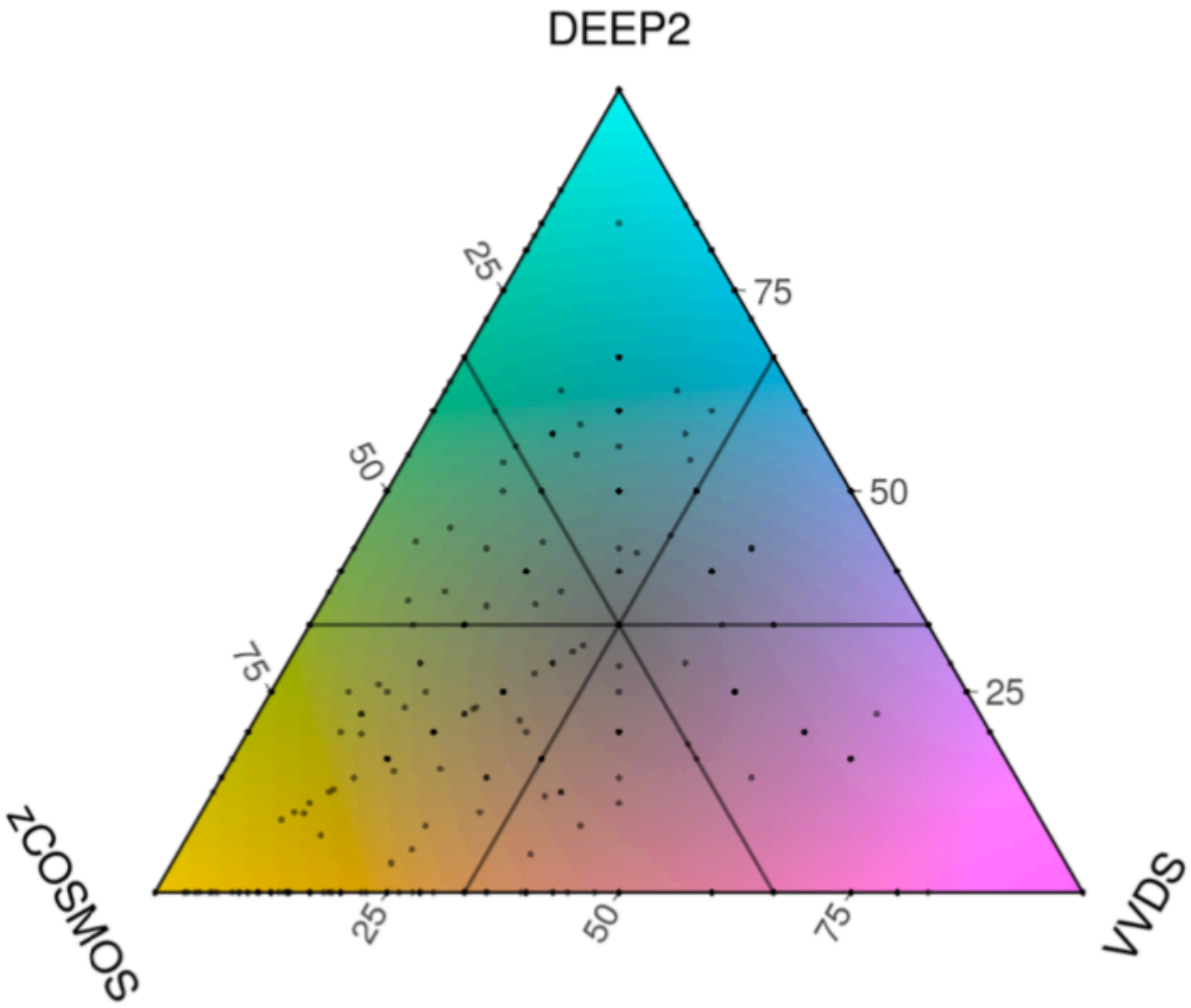
Hildebrandt et al. (2017)

Self-organising map



Self-organising map of mag space





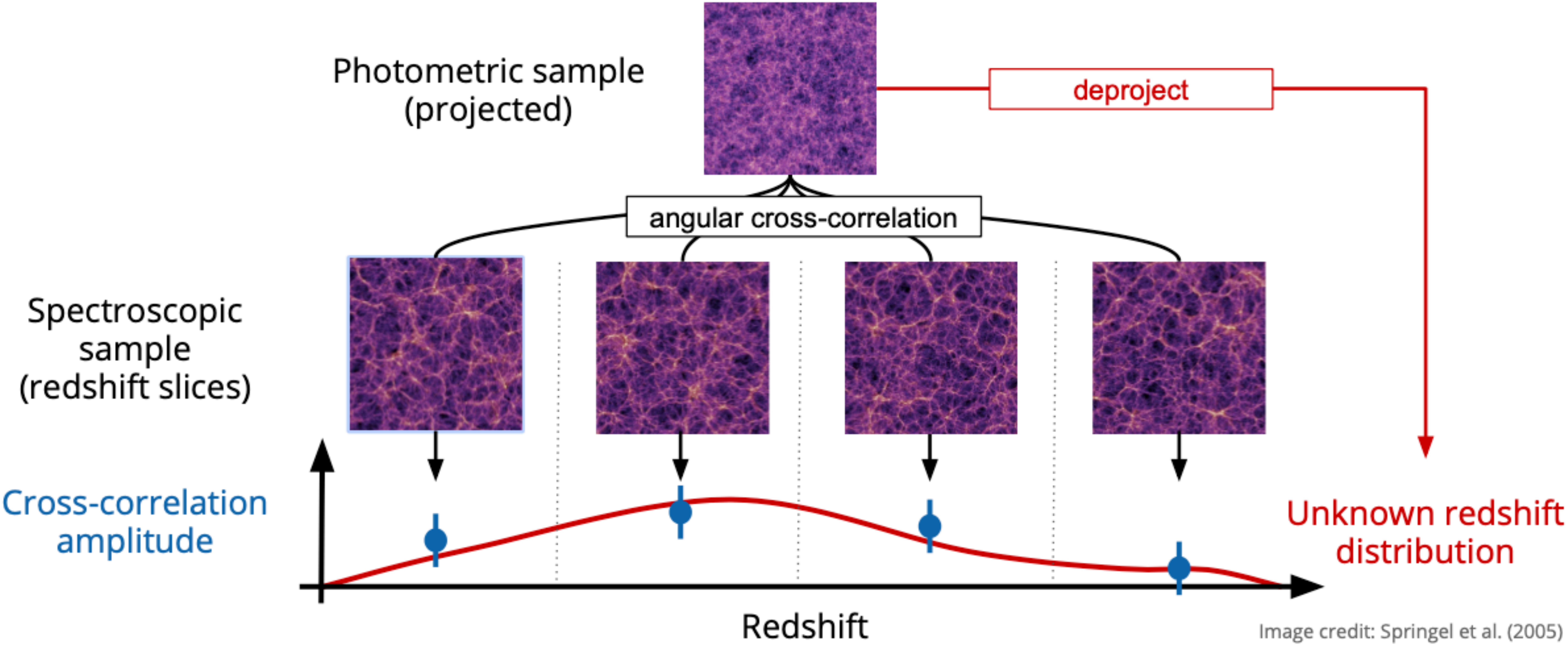
~99% coverage of 9D mag space in KV450.

Wright et al. (2019)

KiDS-1000 SOM <z> accuracy

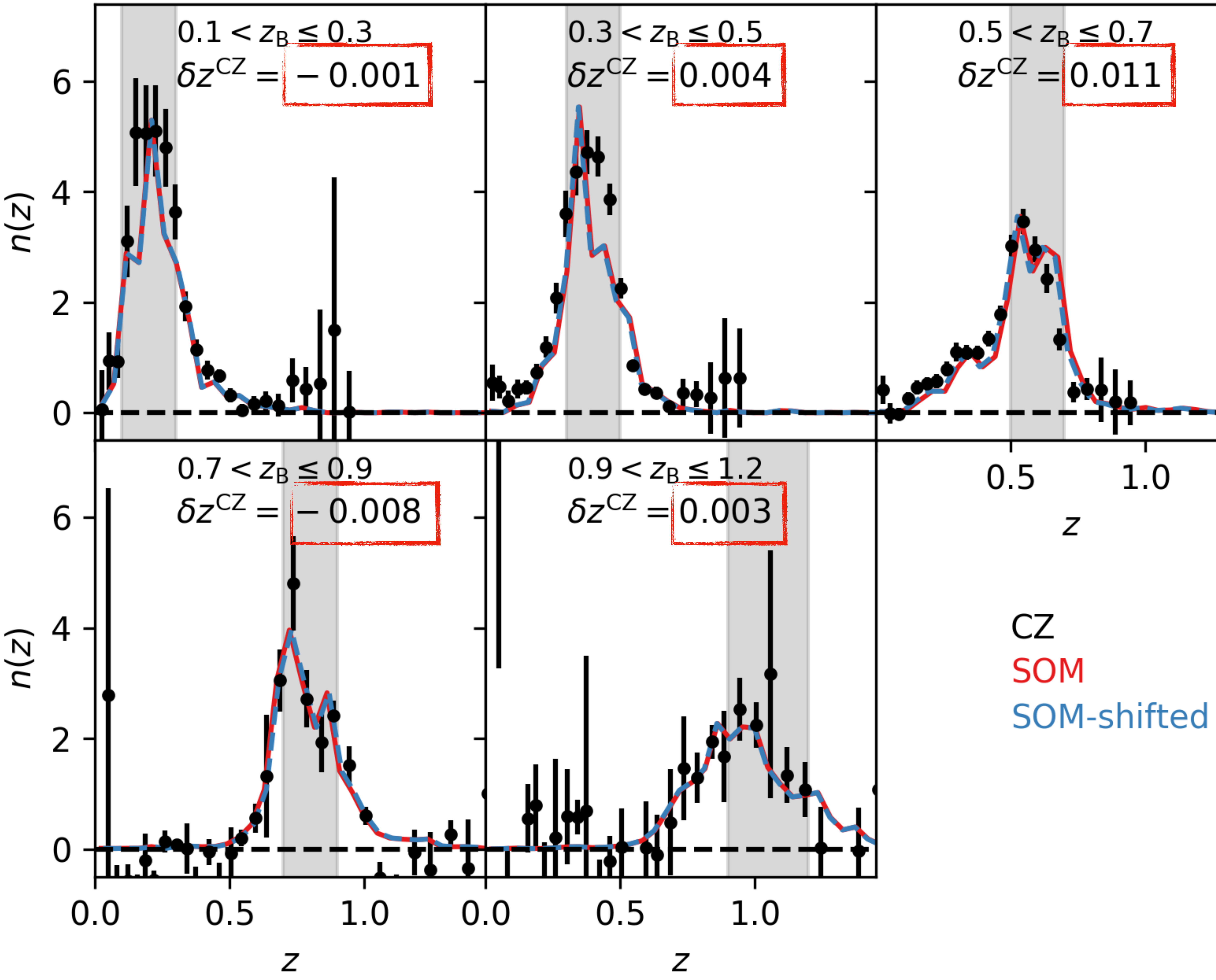
Wright et al. (2020a)

Clustering-z



- Spec-z sample does not have to be representative
- Correct for evolution of galaxy bias

KiDS-1000, clustering-z



Clustering-z inherit the uncertainty from the SOM $n(z)$ in this way.

Hildebrandt et al. (2021)

The role of ATLAS

- Redshift calibration of weak lensing is one of ATLAS' core science goals.
- Deep, dense, and wide spectroscopic sample.
- Might make redshift calibration for *Roman* weak lensing unnecessary.
- 3D lensing instead of tomographic binning.
- For all other overlapping projects it will be the definitive calibration resource.

Summary

- Complementary approaches for *n*(*z*) calibration (SOM, clustering-z, and more). Can be combined, e.g. Hierachical Bayesian Model.

- Colour-based SOM can achieve $\sigma_{<z>} <\sim 0.01$. Needs to improve by factor 5-10.

- Clustering-*z* competitive and consistent, but additional development needed.

- Galaxies and also galaxy surveys are complex beasts
  => sophisticated simulations indispensable.

- ATLAS will provide redshifts for weak lensing with *Roman* (no need for calibration?) and exquisite calibration for *Euclid* and *LSST@Rubin*.