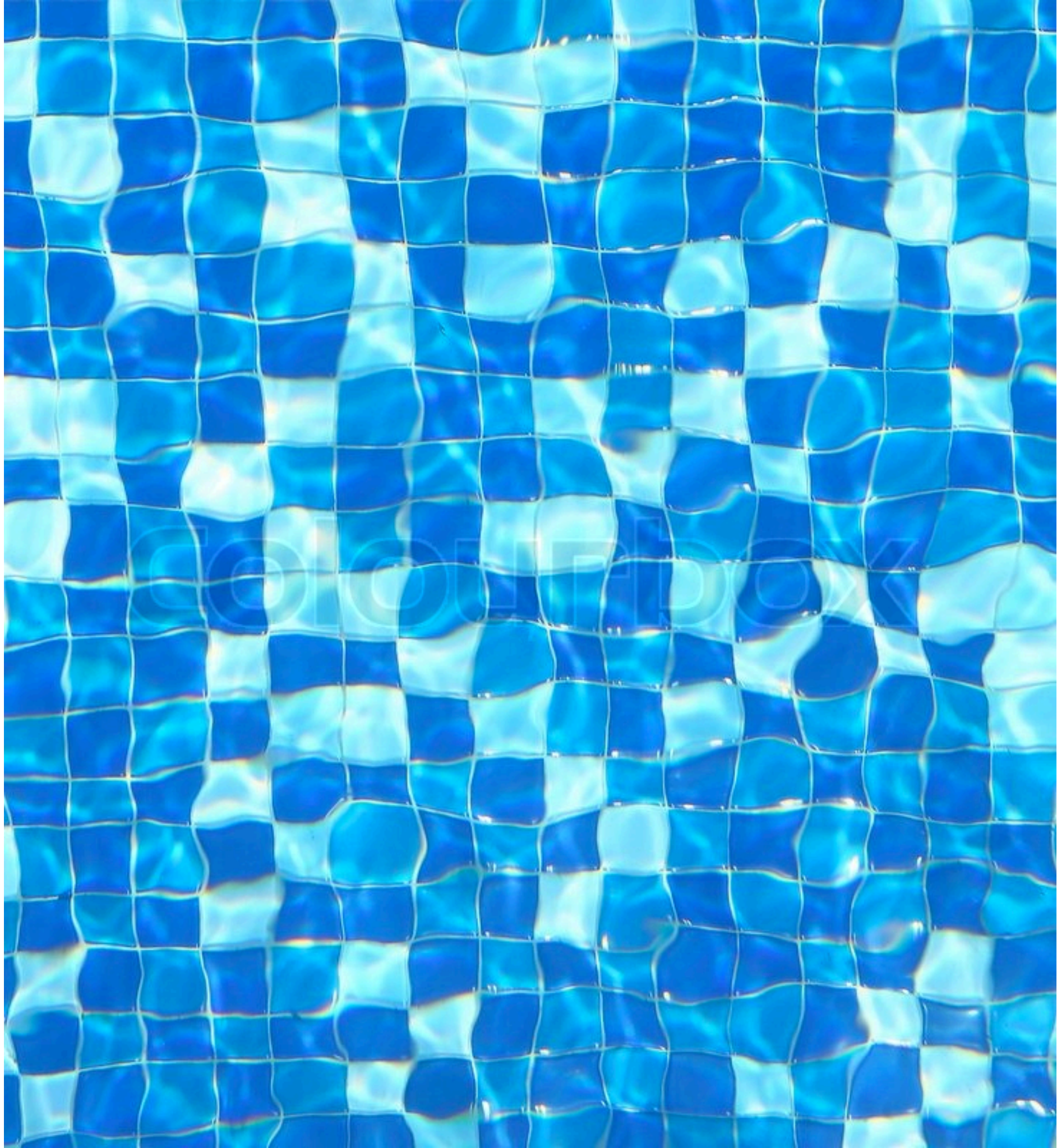


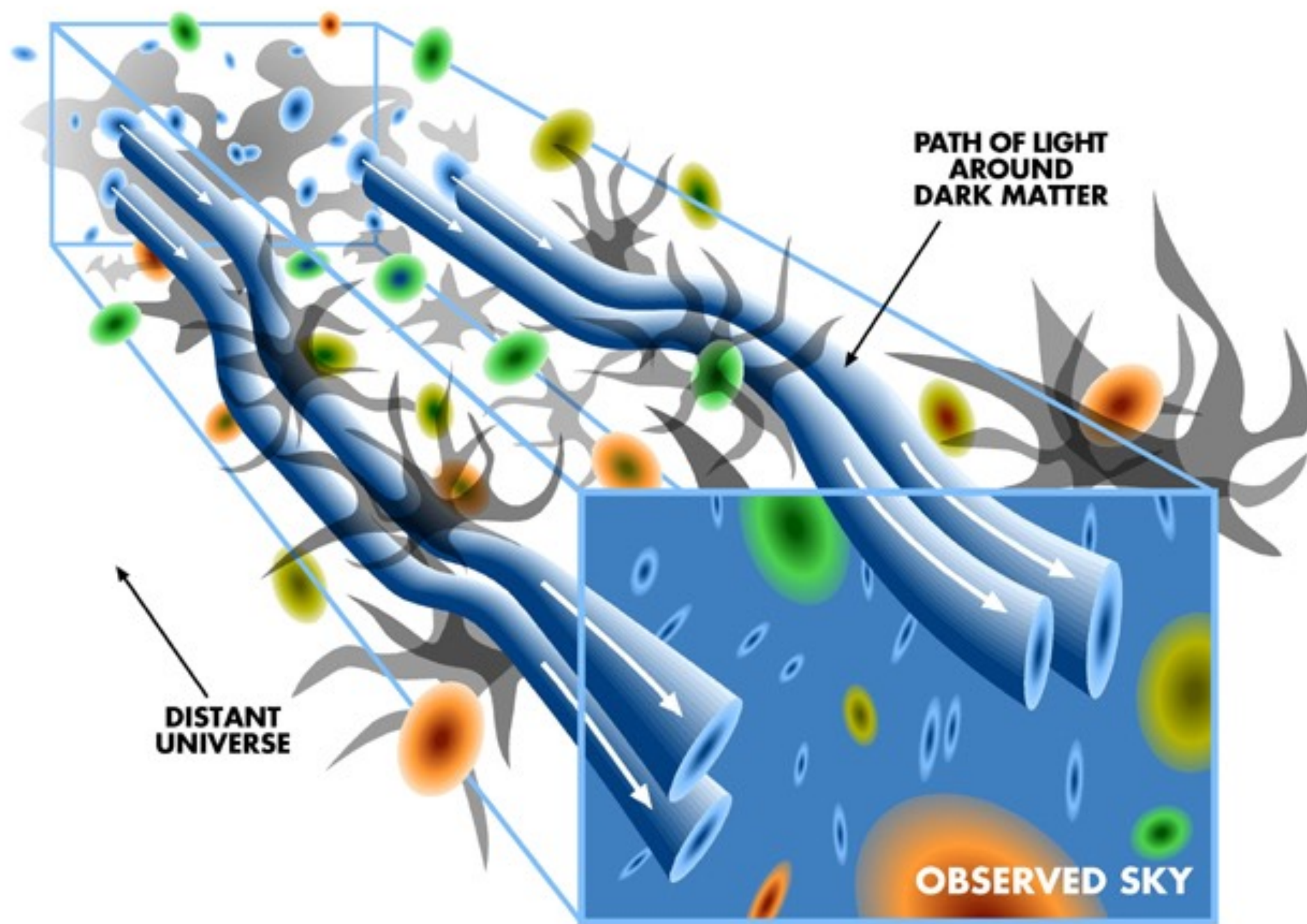
Weak lensing and tensions in Λ CDM

Hendrik Hildebrandt - Ruhr-University Bochum





Cosmic shear



Sensitive to:

- Matter distribution
- Geometry

Observables:

- Ellipticities
- Photo-z

Statistical measurement of many galaxies

Wittman et al. (2000)

Observation \rightarrow theory

$$\xi_{\pm}(\theta) = \langle \gamma_t \gamma_t \rangle (\theta) \pm \langle \gamma_x \gamma_x \rangle (\theta)$$

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$$P_{\kappa}(\ell) = \frac{9H_0^4 \Omega_m^2}{4c^4} \int_0^{\chi_h} d\chi \frac{g^2(\chi)}{a^2(\chi)} P_{\delta} \left(\frac{\ell}{f_K(\chi)}, \chi \right)$$

$$g(\chi) = \int_{\chi}^{\chi_h} d\chi' p_{\chi}(\chi') \frac{f_K(\chi' - \chi)}{f_K(\chi')}$$

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Cosmic shear systematics

1. Shape measurements
2. Redshift estimates
3. Intrinsic alignments
4. Baryon feedback

1. Shape measurements

- Measure ellipticity and correct for PSF on pristine pixel data through

- Brightness moments

- Model fitting



- Calibrate biases (noise bias, model bias) to $\sim 1\%$ (0.1%) with

- Image simulations, machine learning

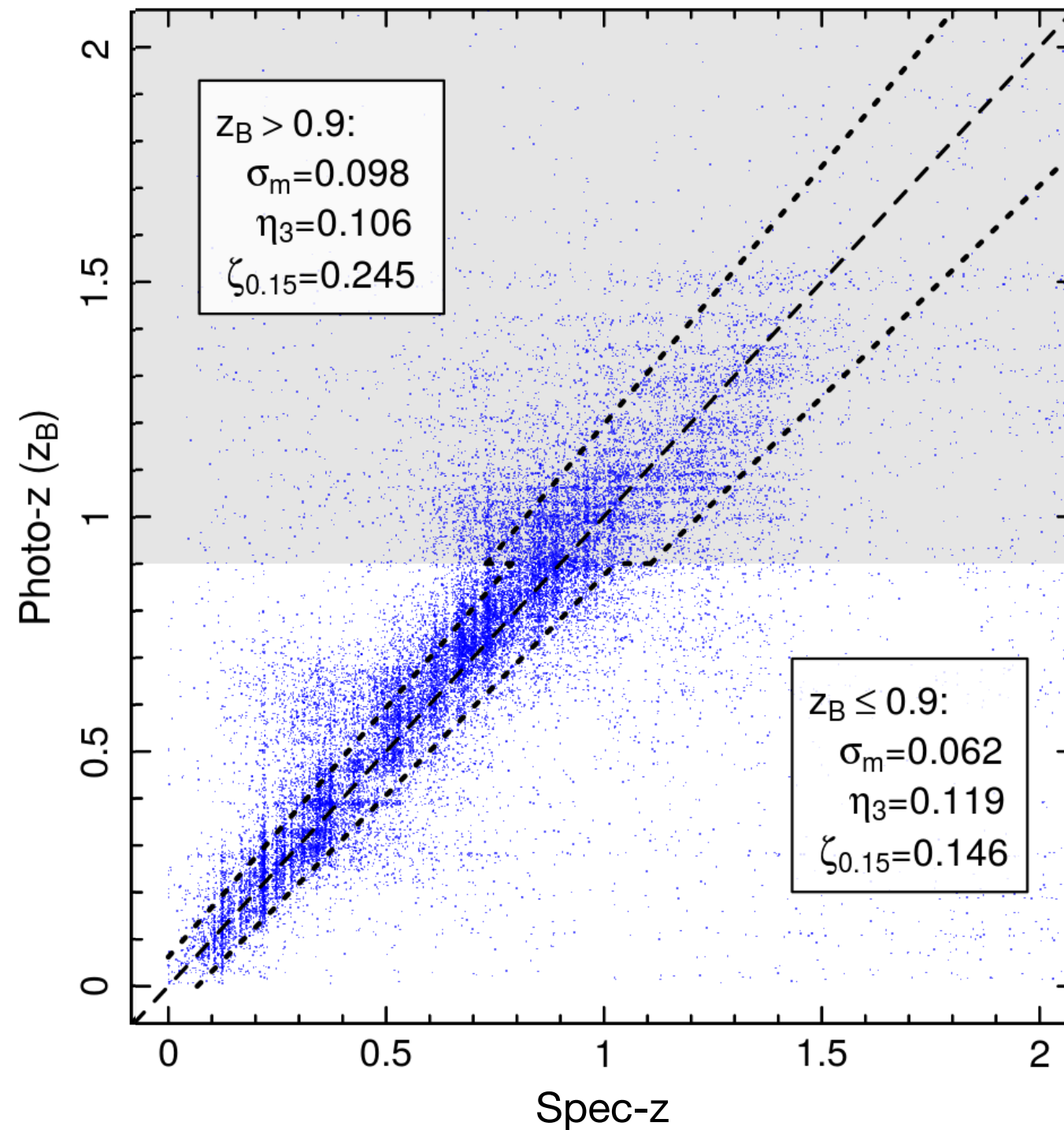
- Shearing of the images/models (Metacalibration)

- Check for residual biases via

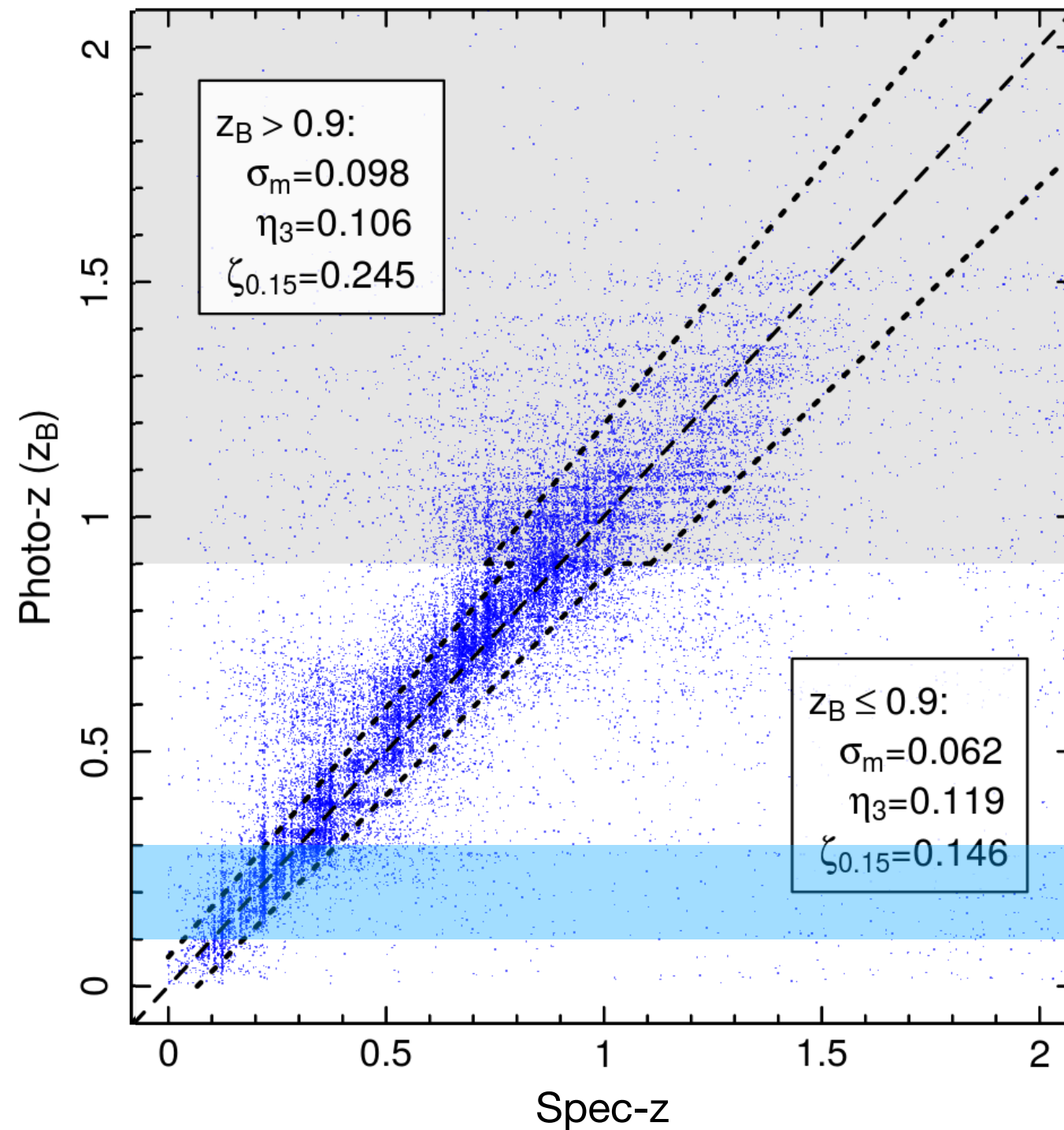
- Star-galaxy cross correlation functions

- B-mode tests

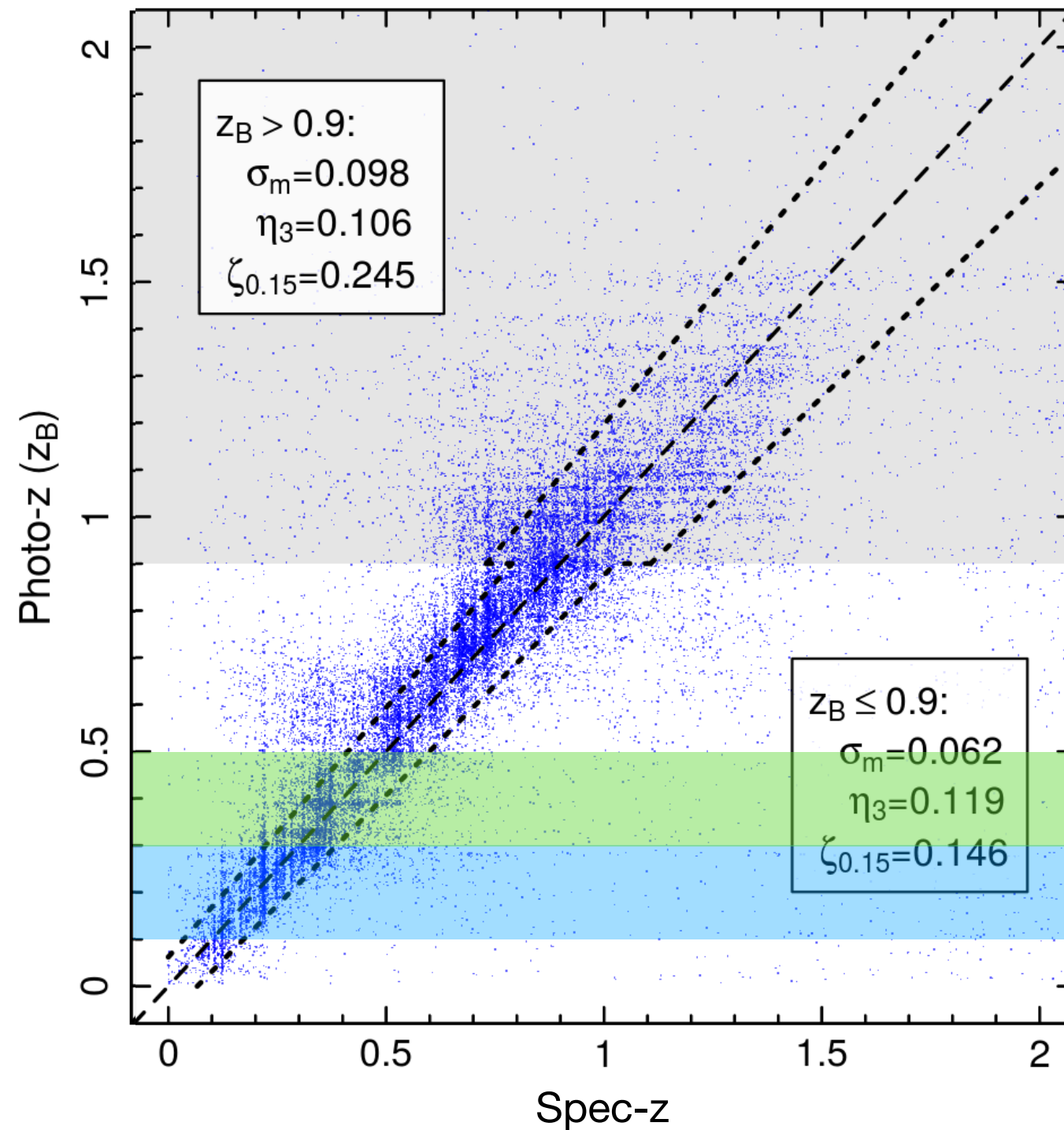
2. Photometric redshifts



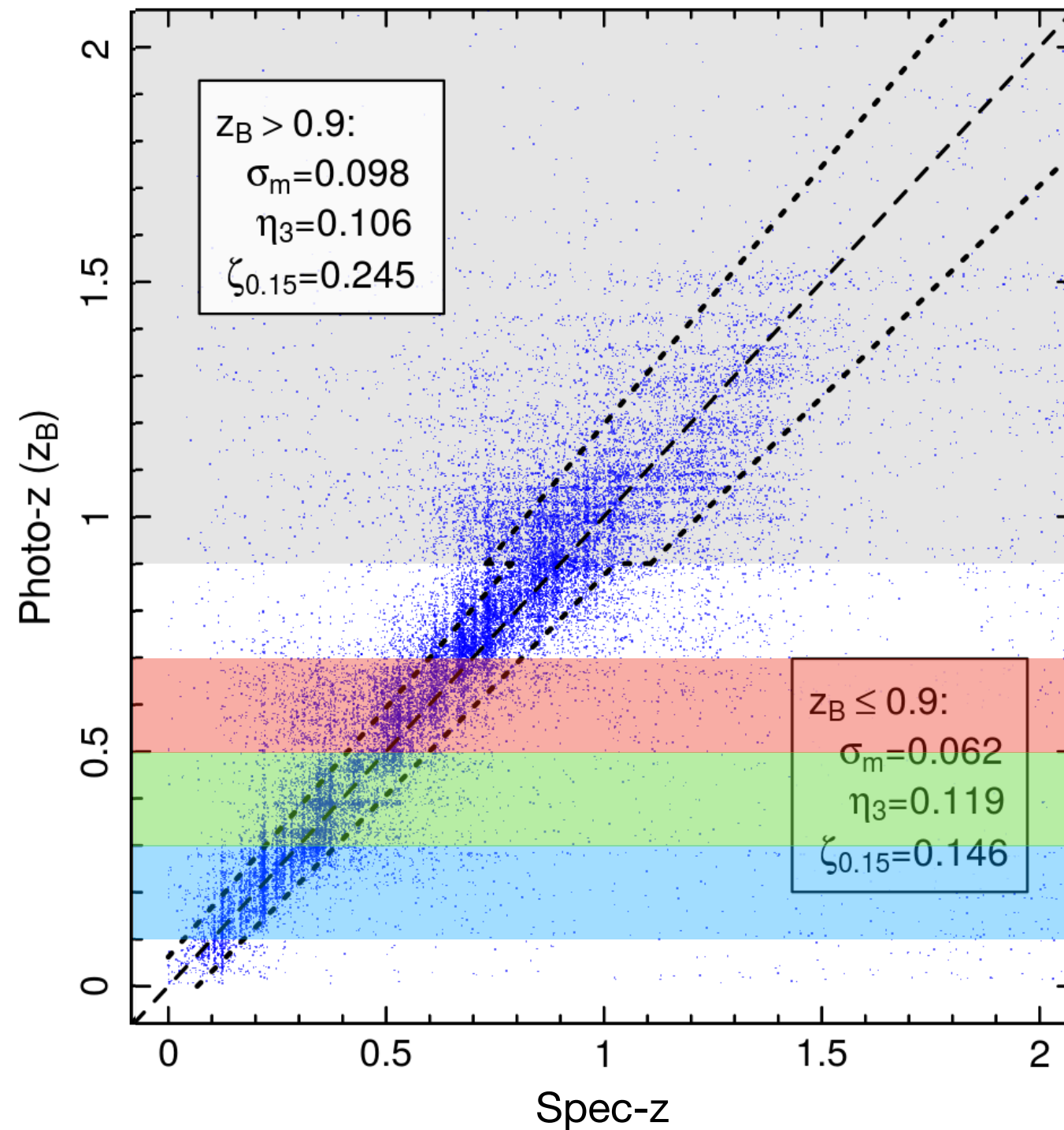
2. Photometric redshifts



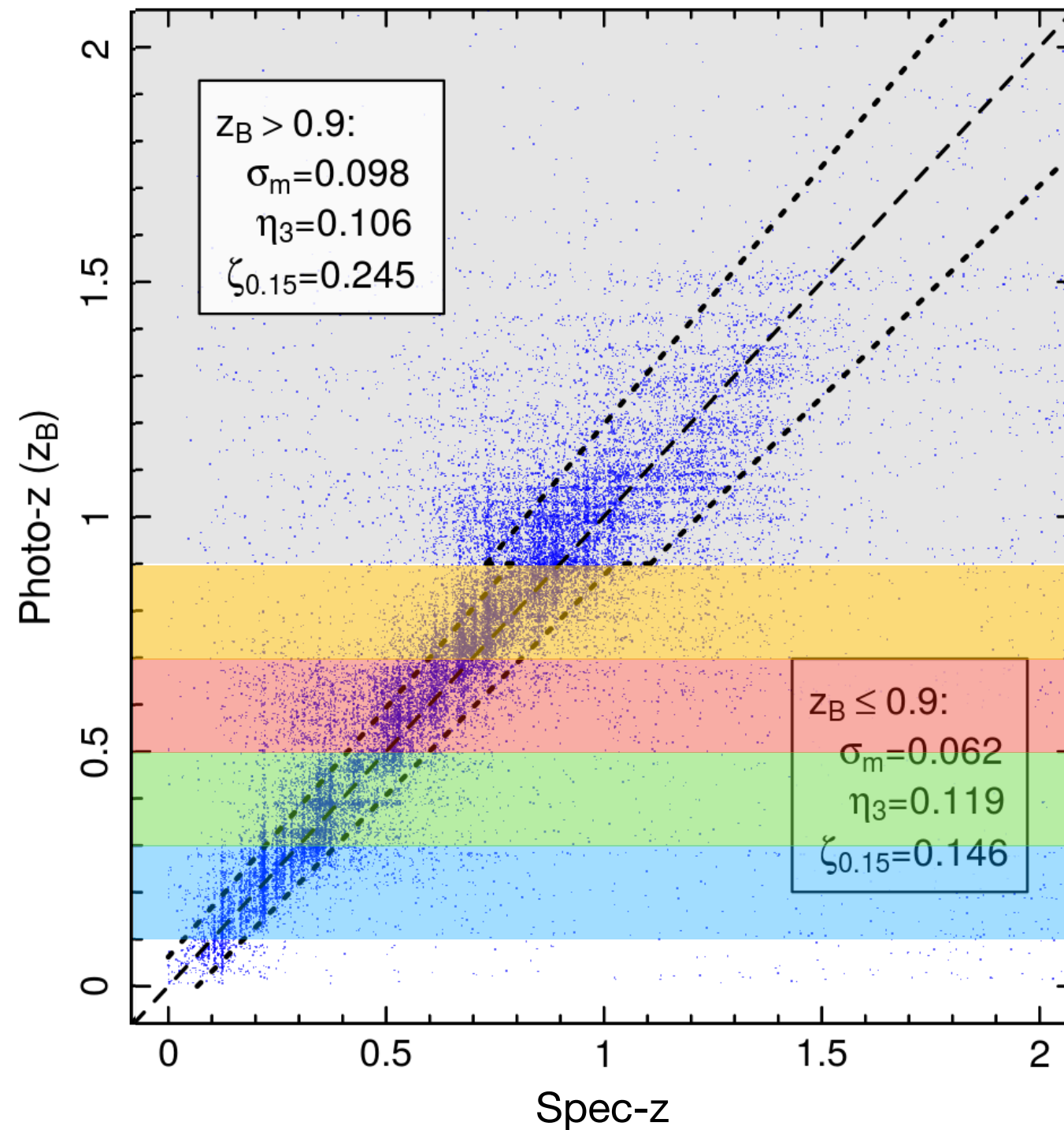
2. Photometric redshifts



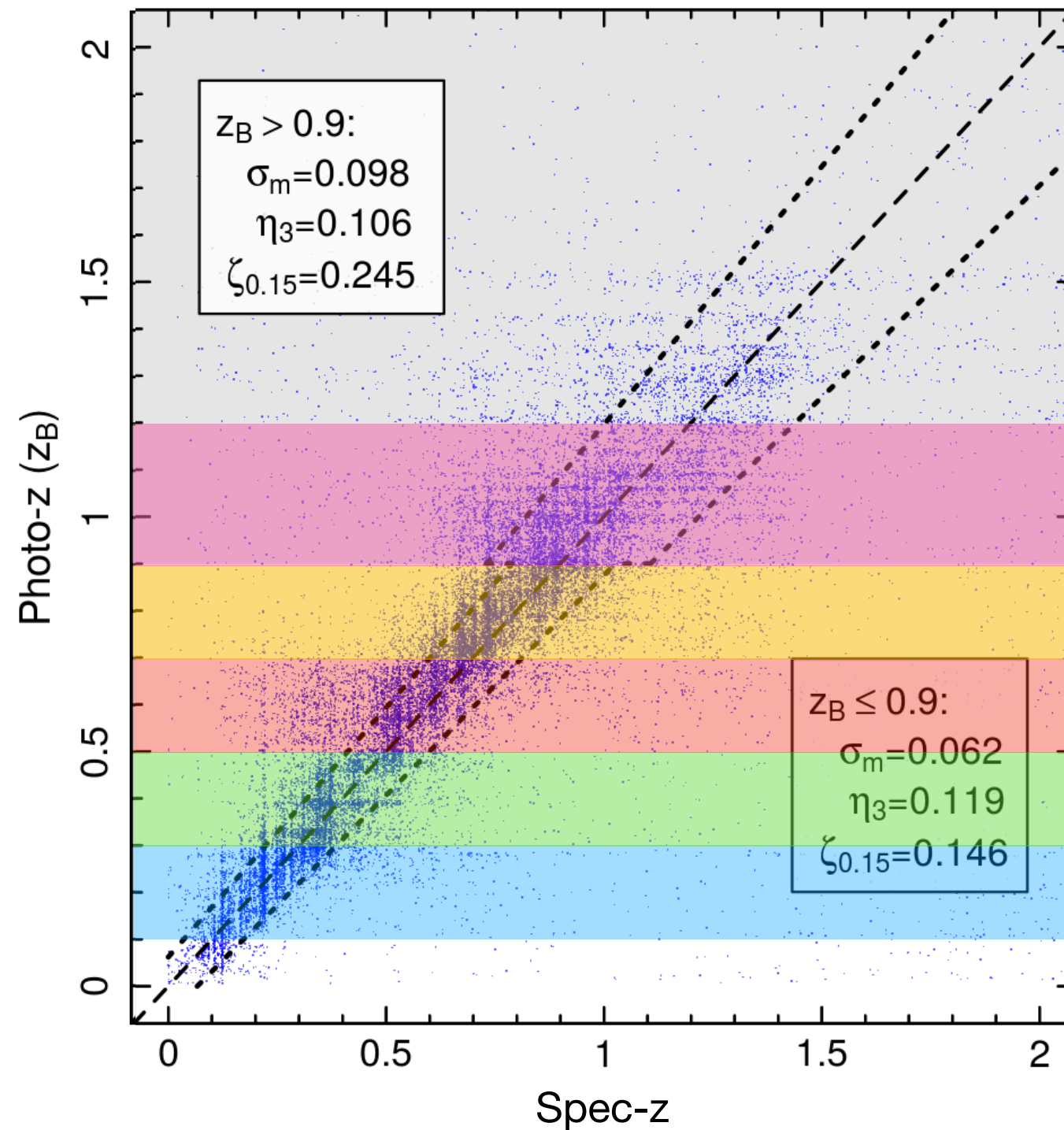
2. Photometric redshifts



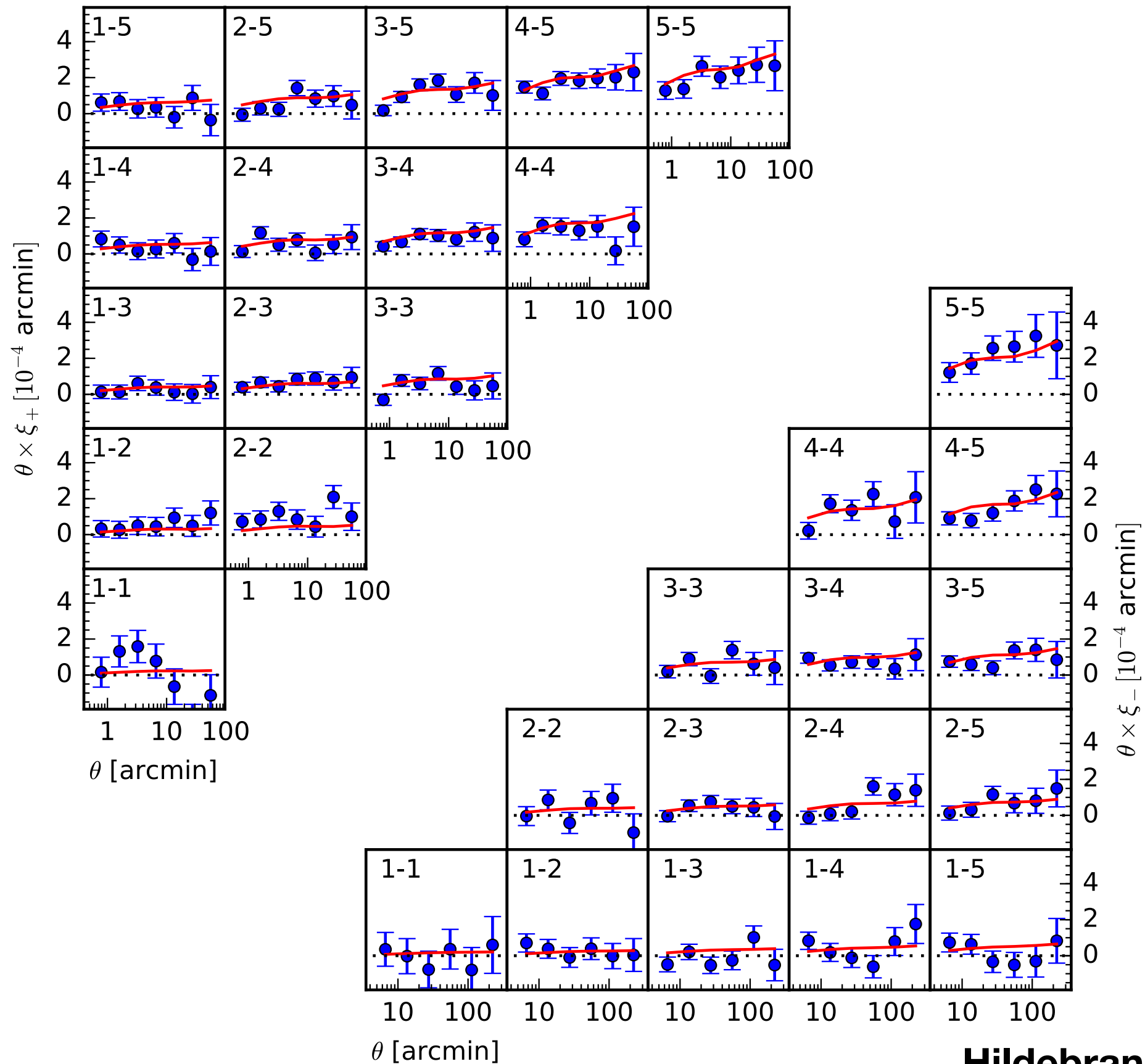
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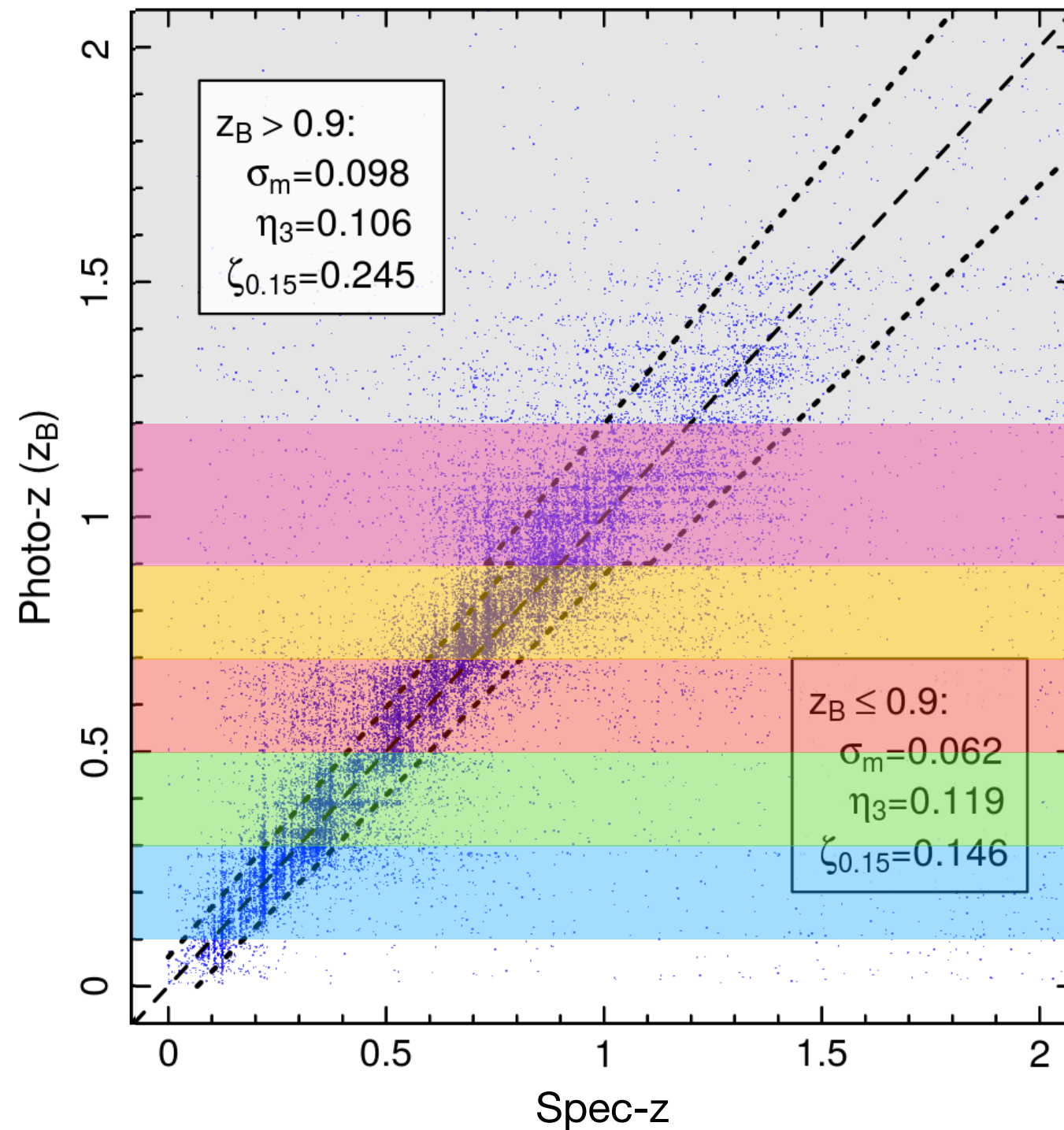
2. Photometric redshifts



2pt shear correlation functions

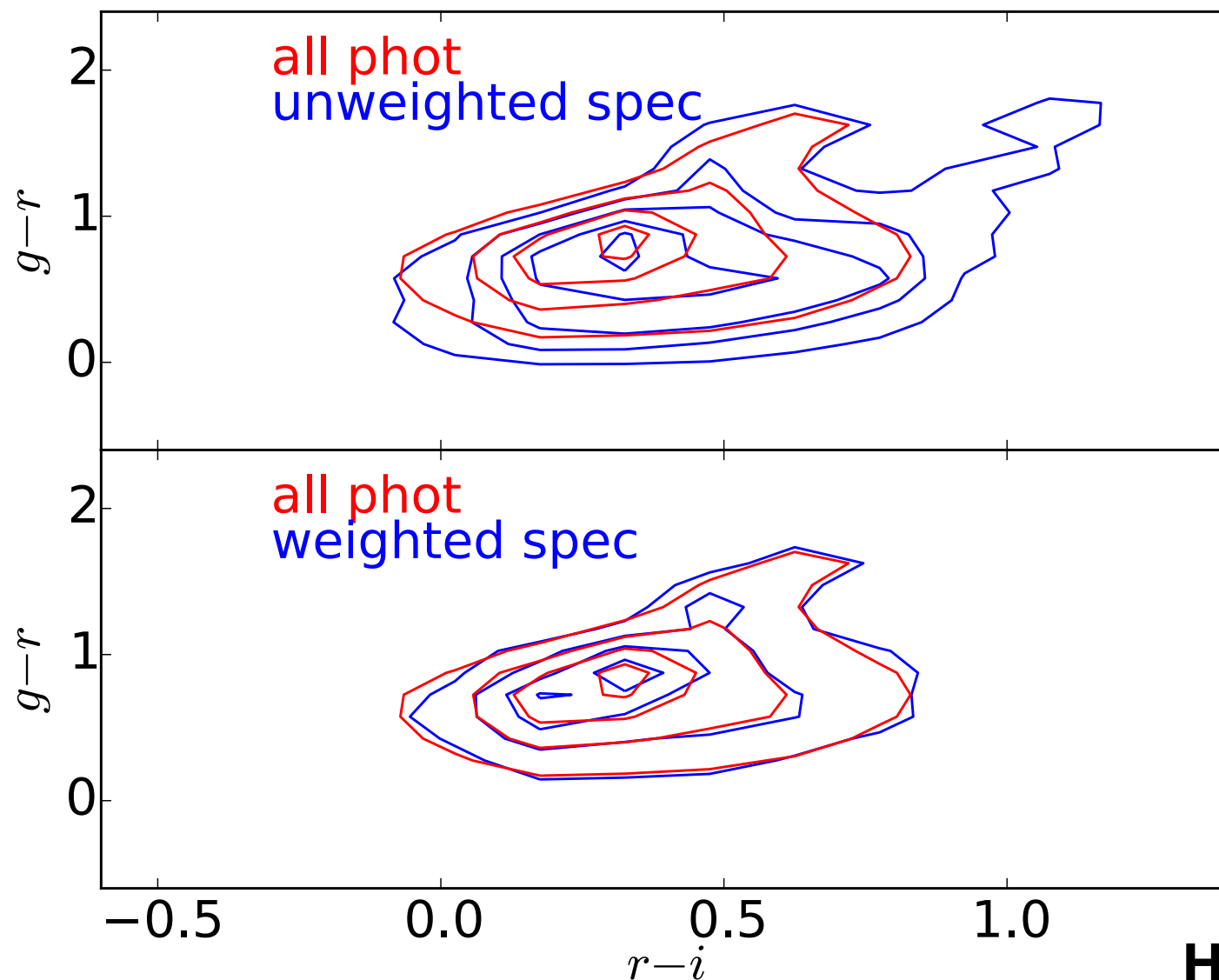


2. Photometric redshifts

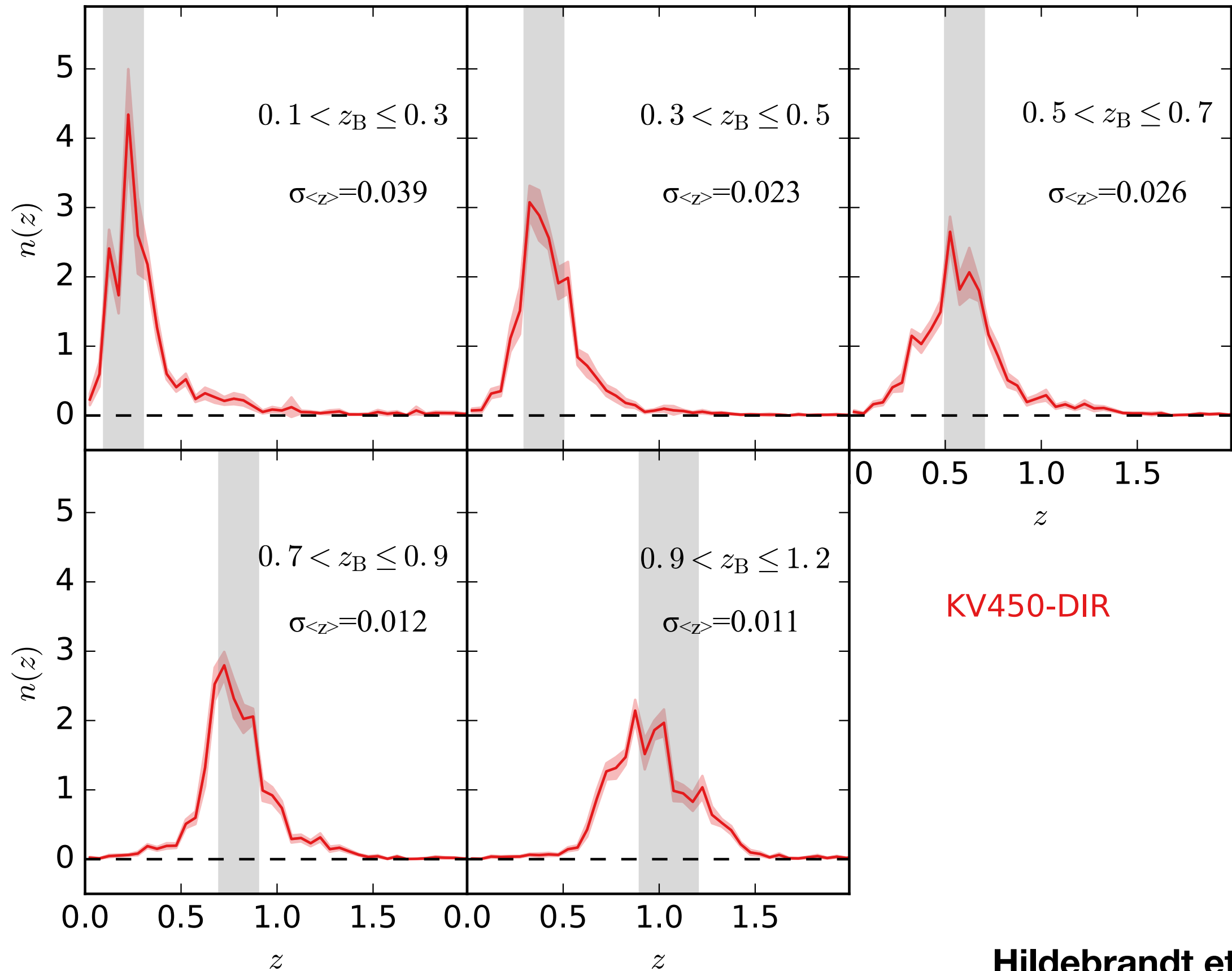


2. Redshift calibration

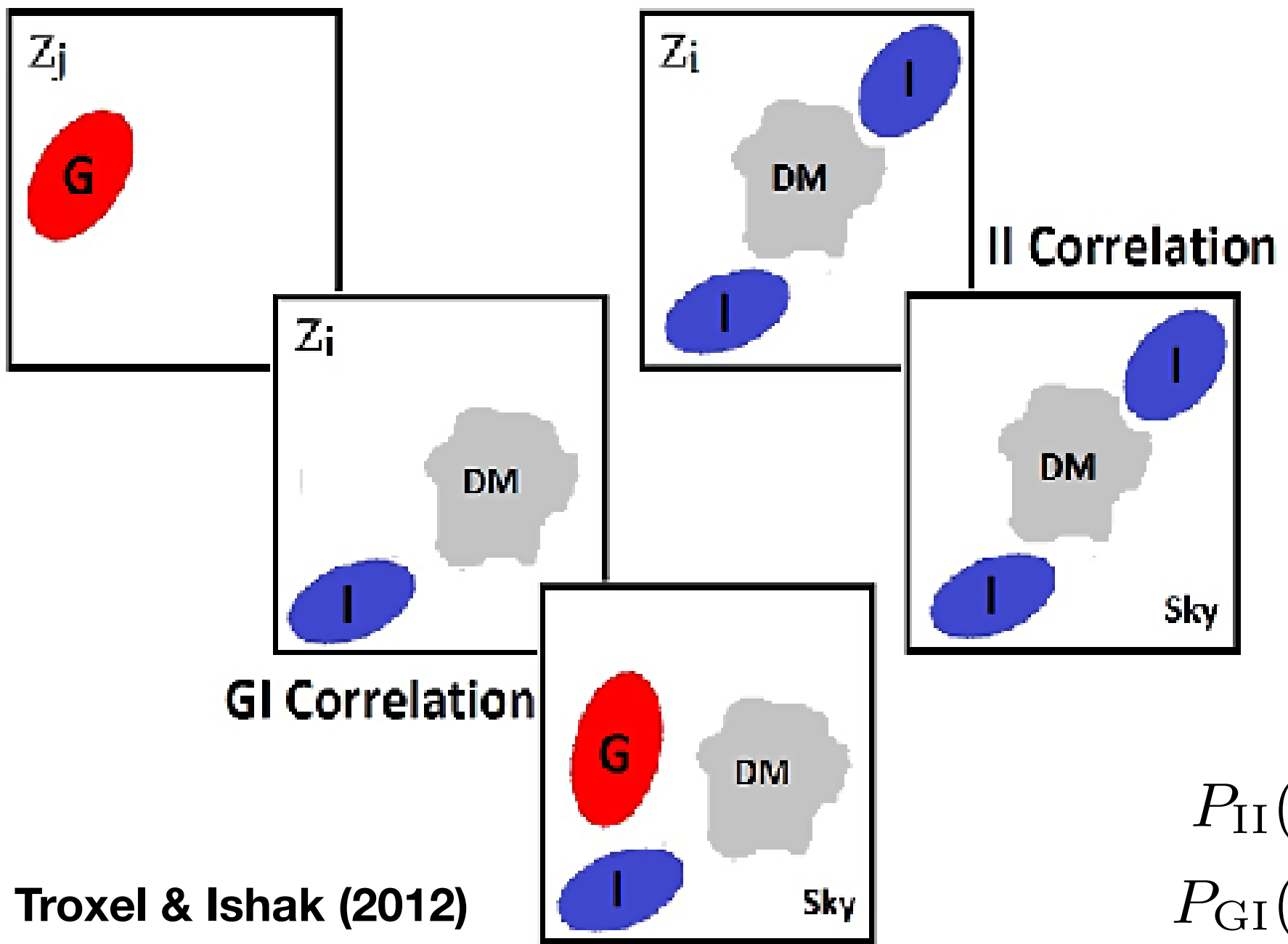
- Re-weight spec-z surveys to be more representative.
- Magnitude space needs to be fully covered.
- Requires unique relation colour-redshift relation.
- Requires extremely reliable spec-z.



2. Redshift distributions



3. Intrinsic alignments

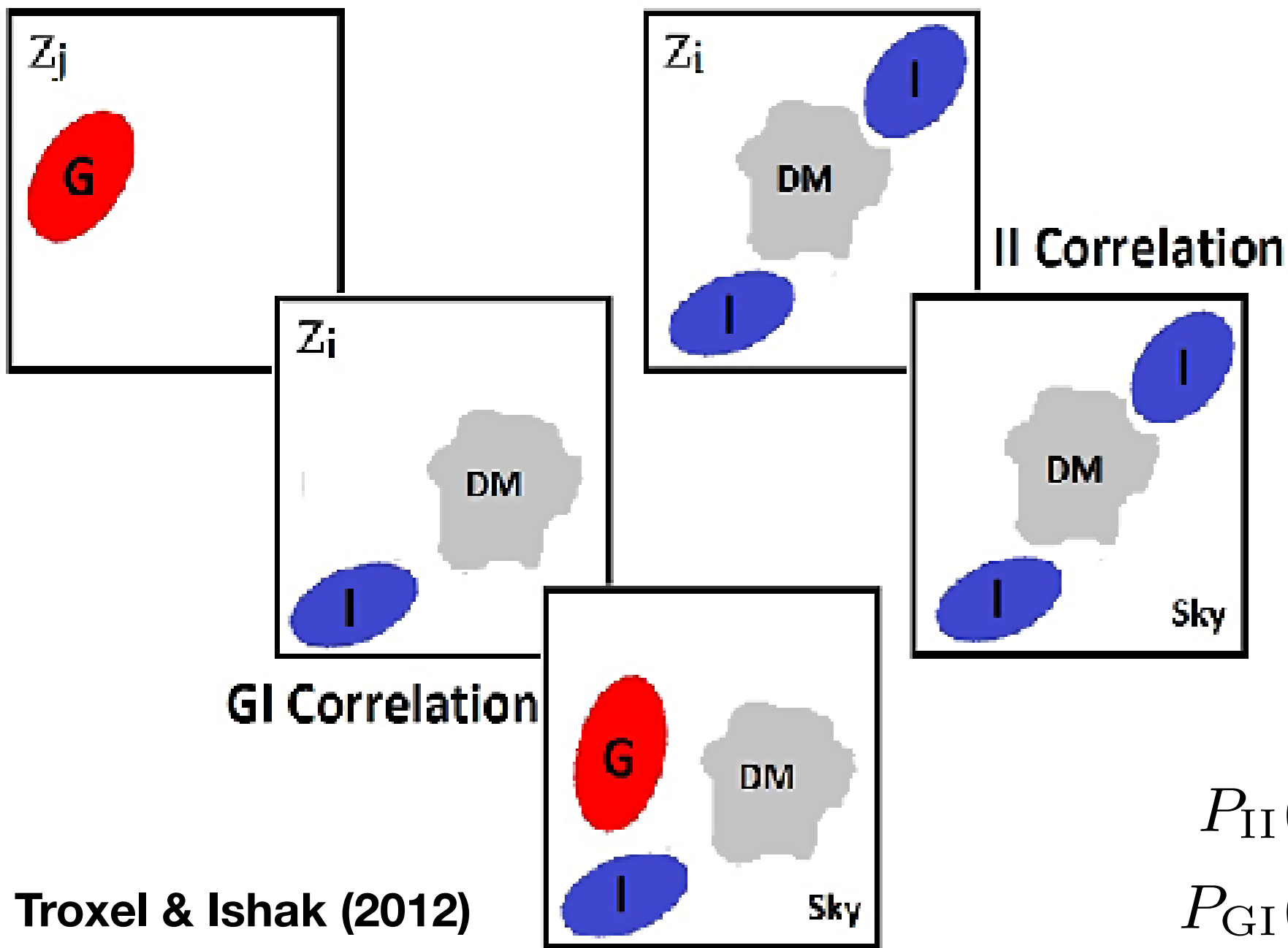


$$P_{II}(k, z) = F^2(z) P_{\delta}(k, z)$$

$$P_{GI}(k, z) = F(z) P_{\delta}(k, z),$$

$$F(z) = -A_{IA} C_1 \rho_{\text{crit}} \frac{\Omega_m}{D_+(z)} \left(\frac{1+z}{1+z_0} \right)^{\eta} \left(\frac{\bar{L}}{L_0} \right)^{\beta}$$

3. Intrinsic alignments

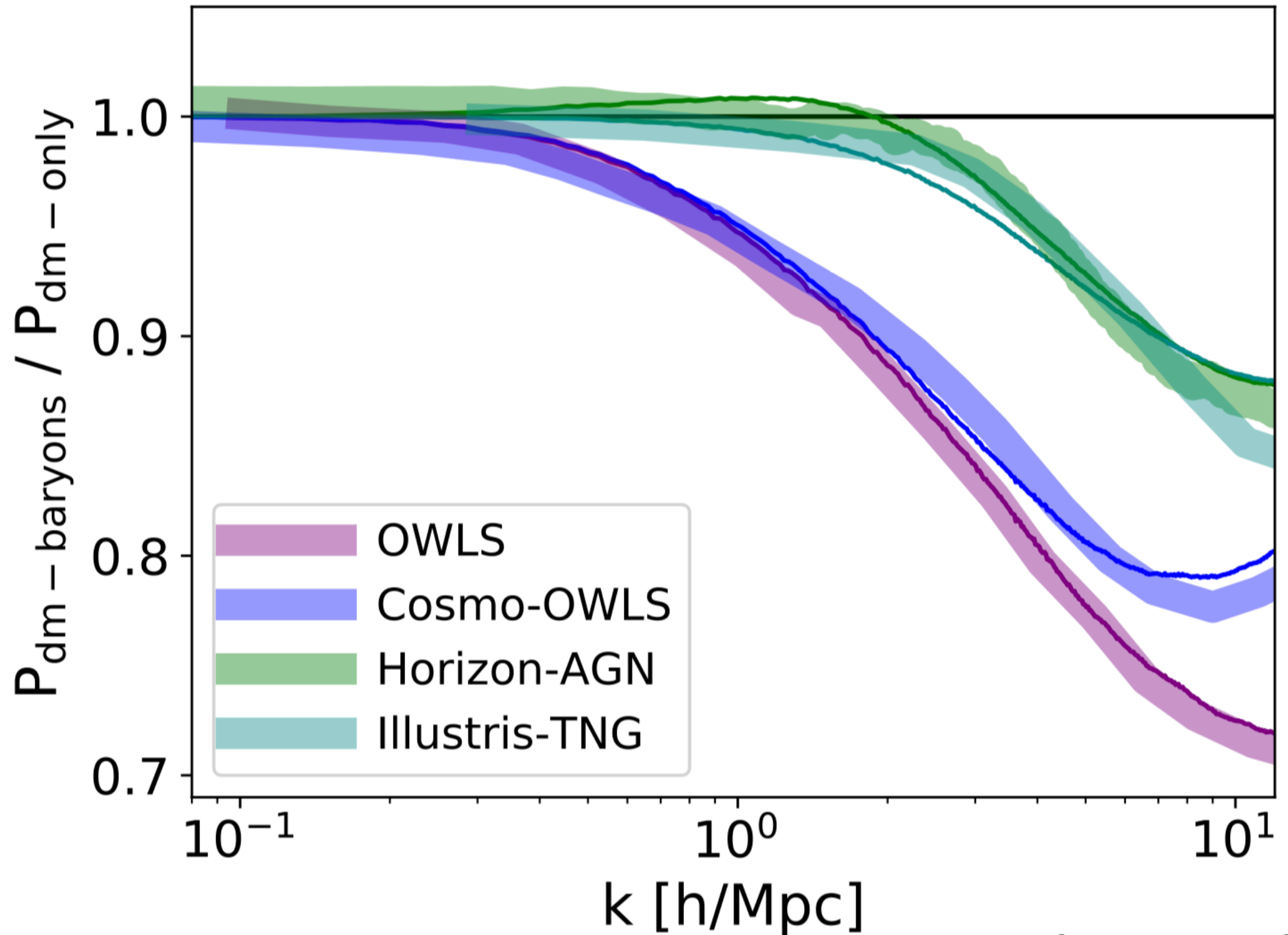


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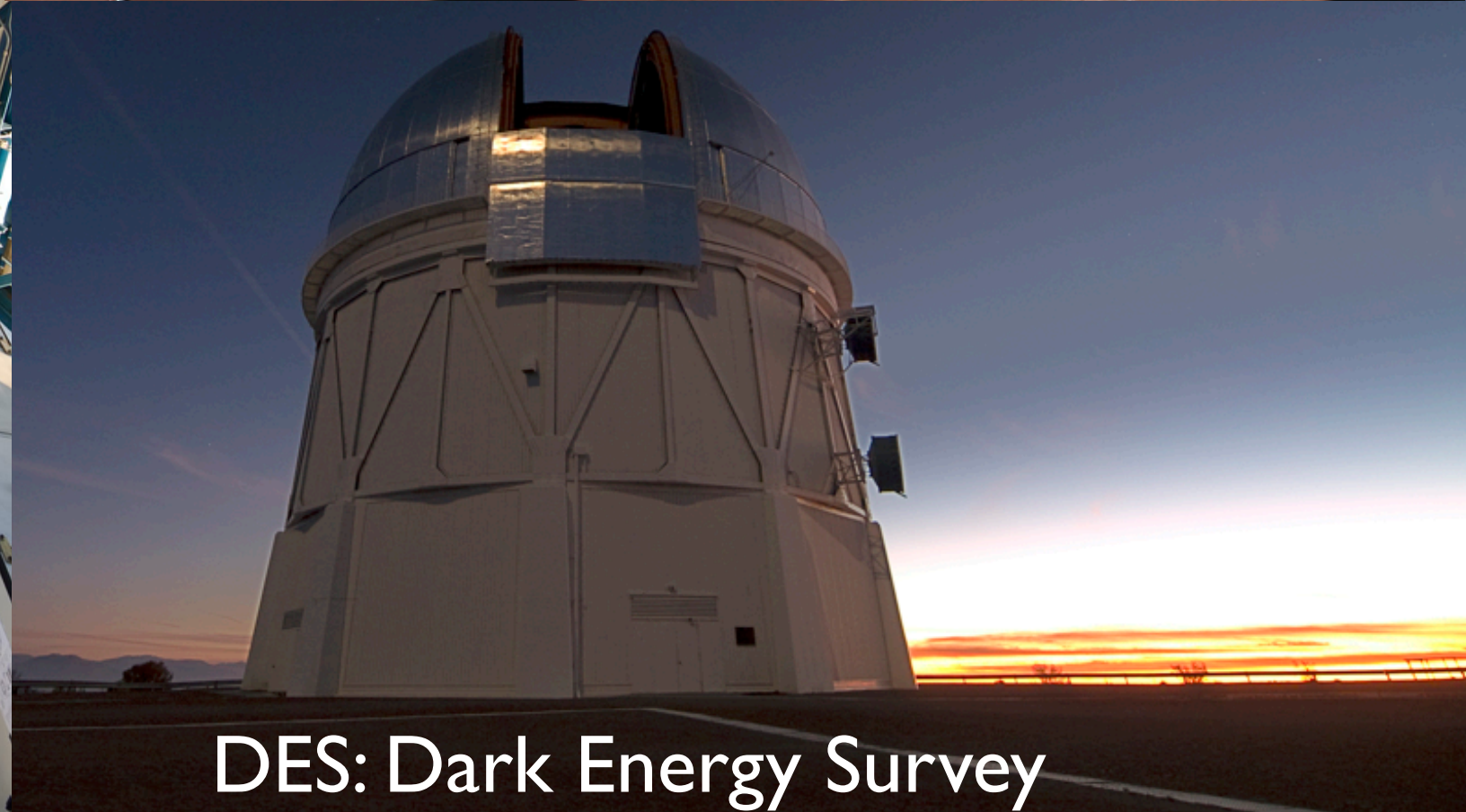
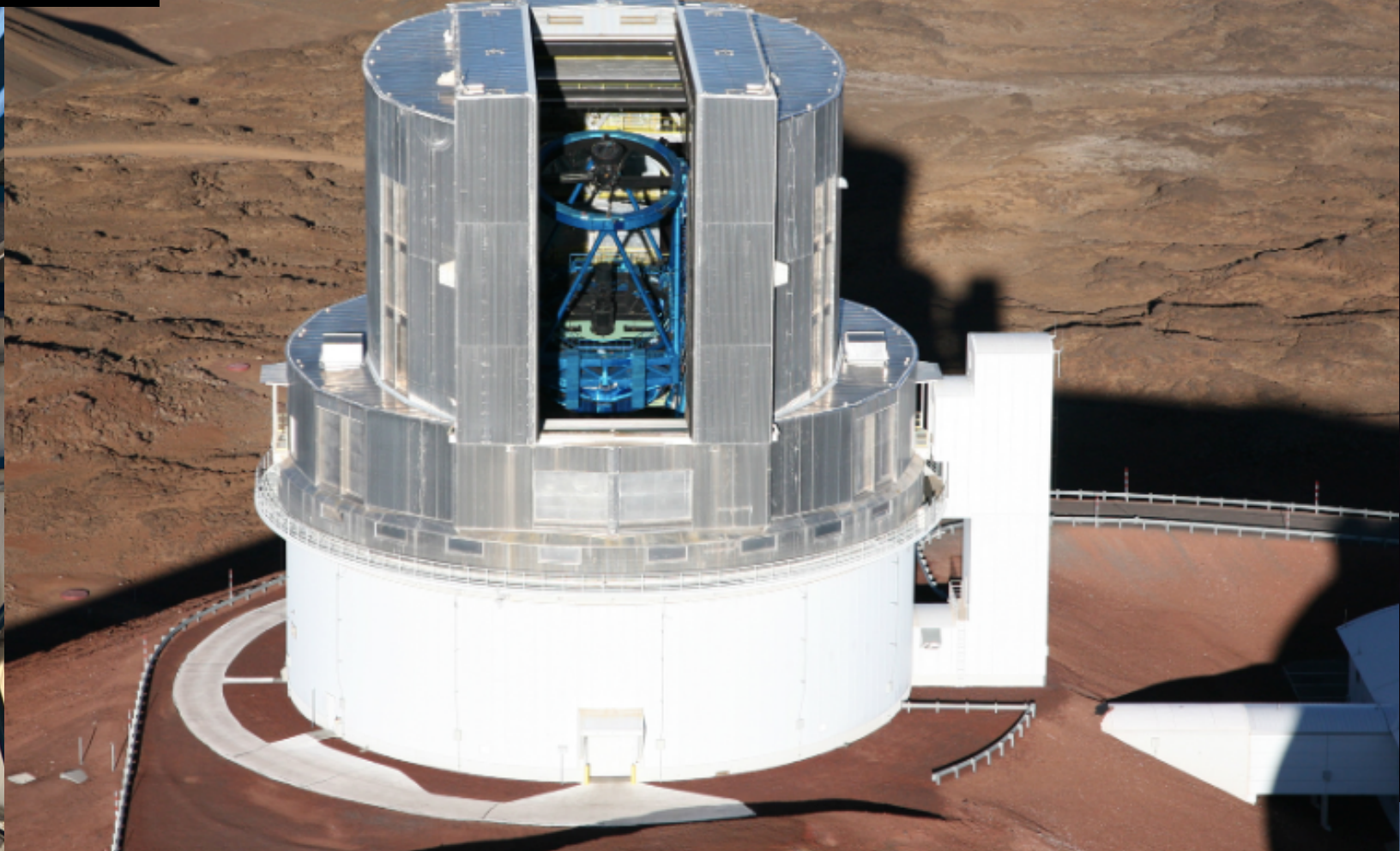
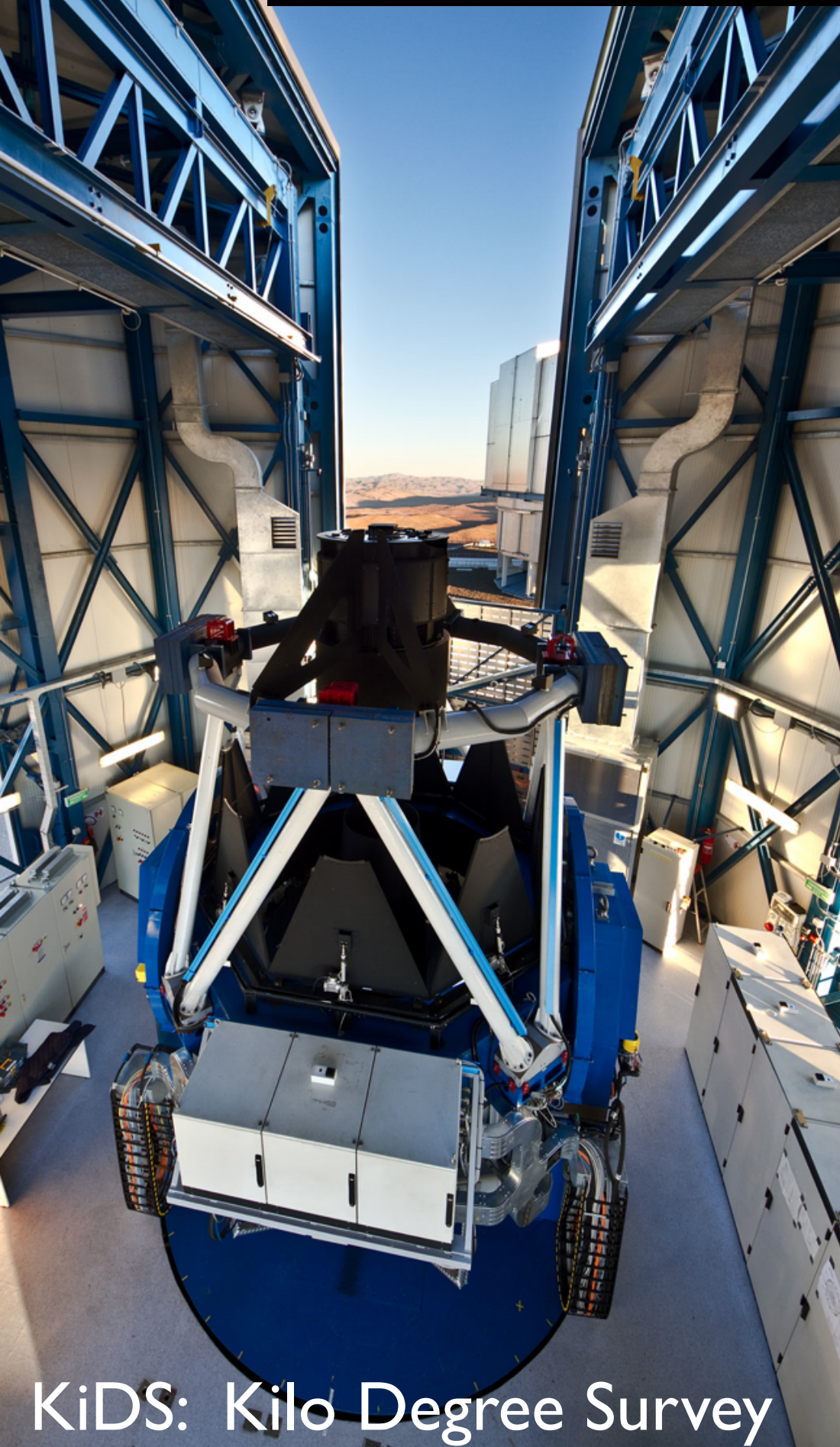
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4. Baryon feedback



Stage III Surveys

HSC: Hyper-Suprime Cam Survey



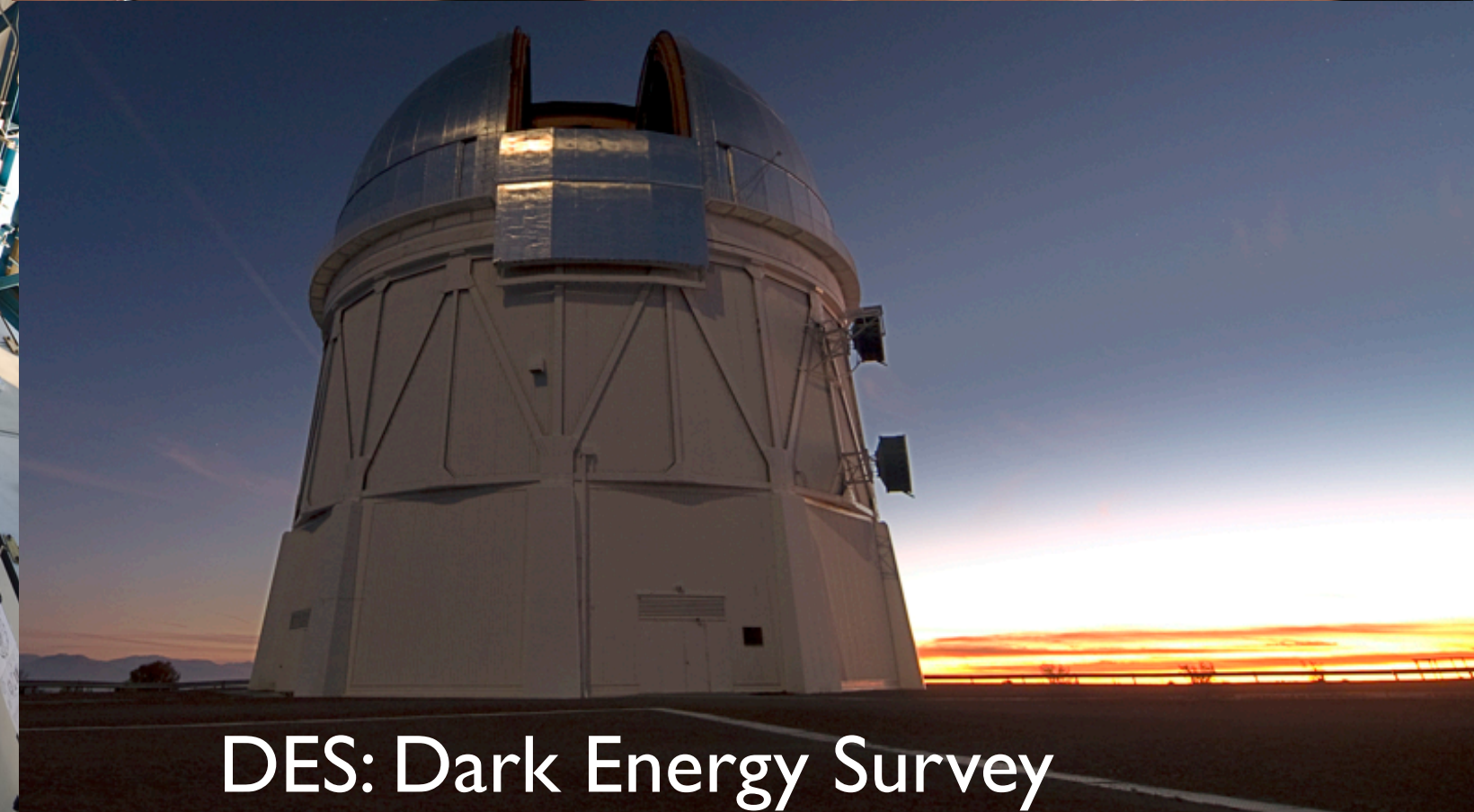
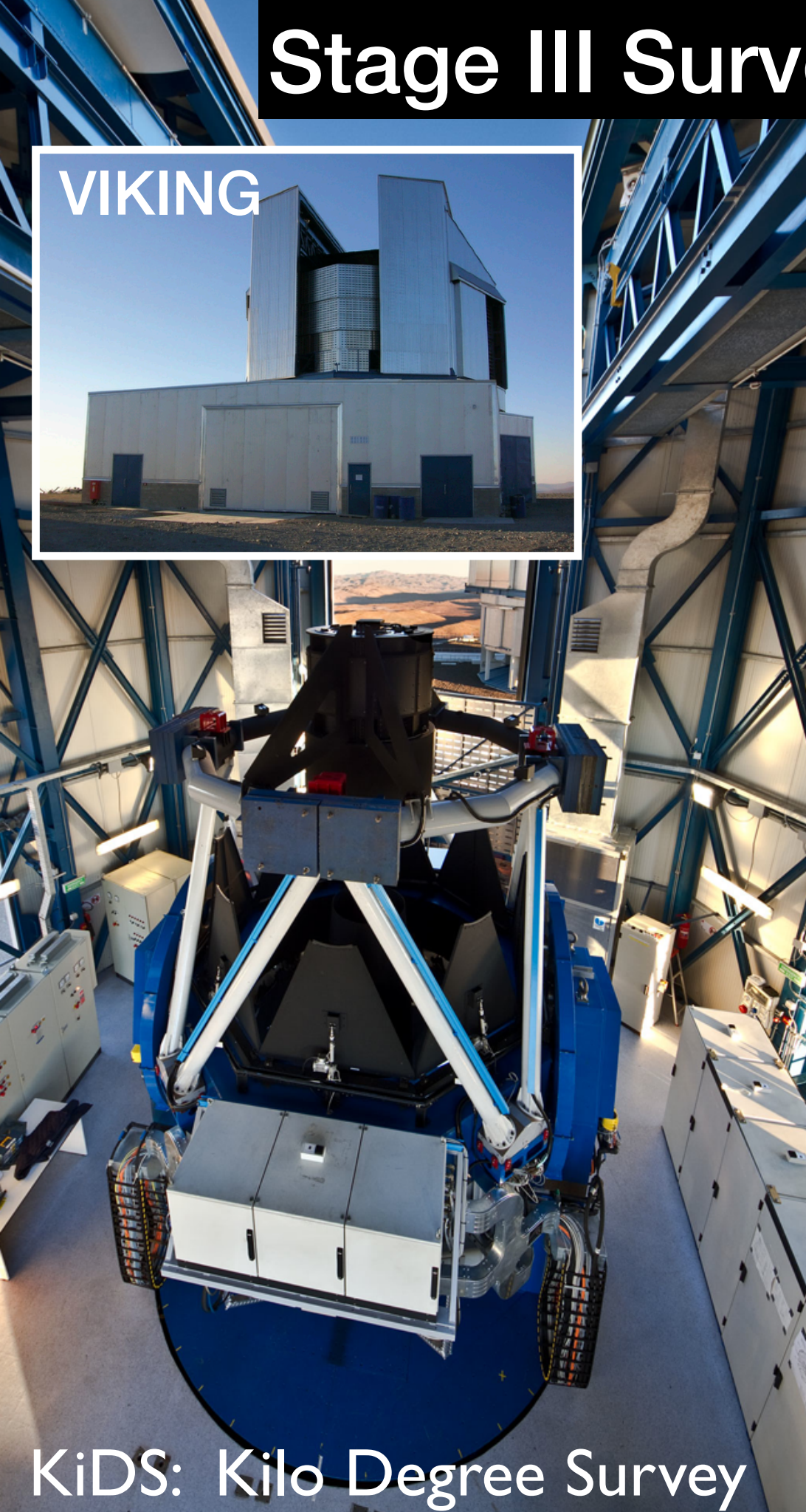
KiDS: Kilo Degree Survey

DES: Dark Energy Survey

Stage III Surveys

HSC: Hyper-Suprime Cam Survey

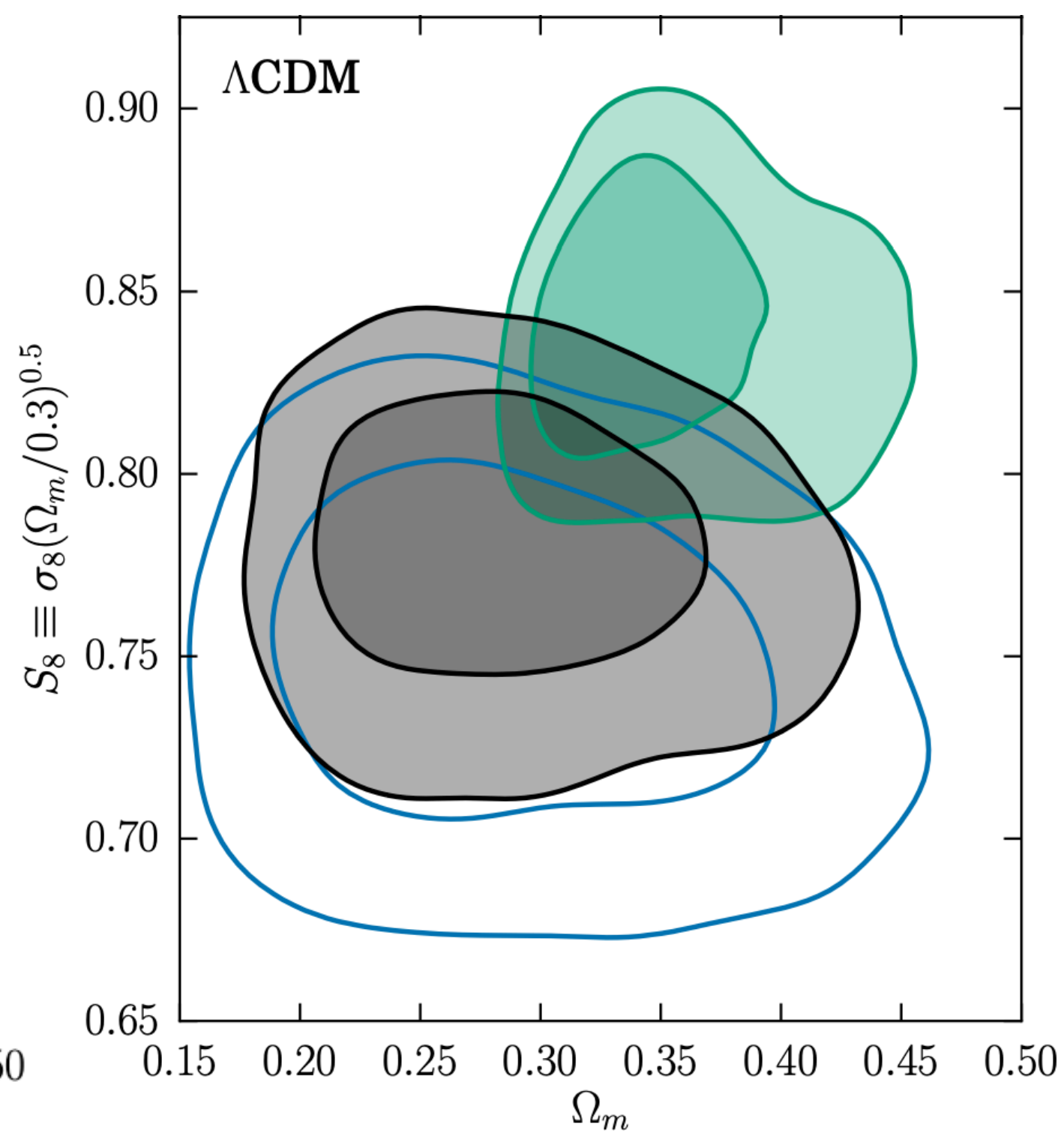
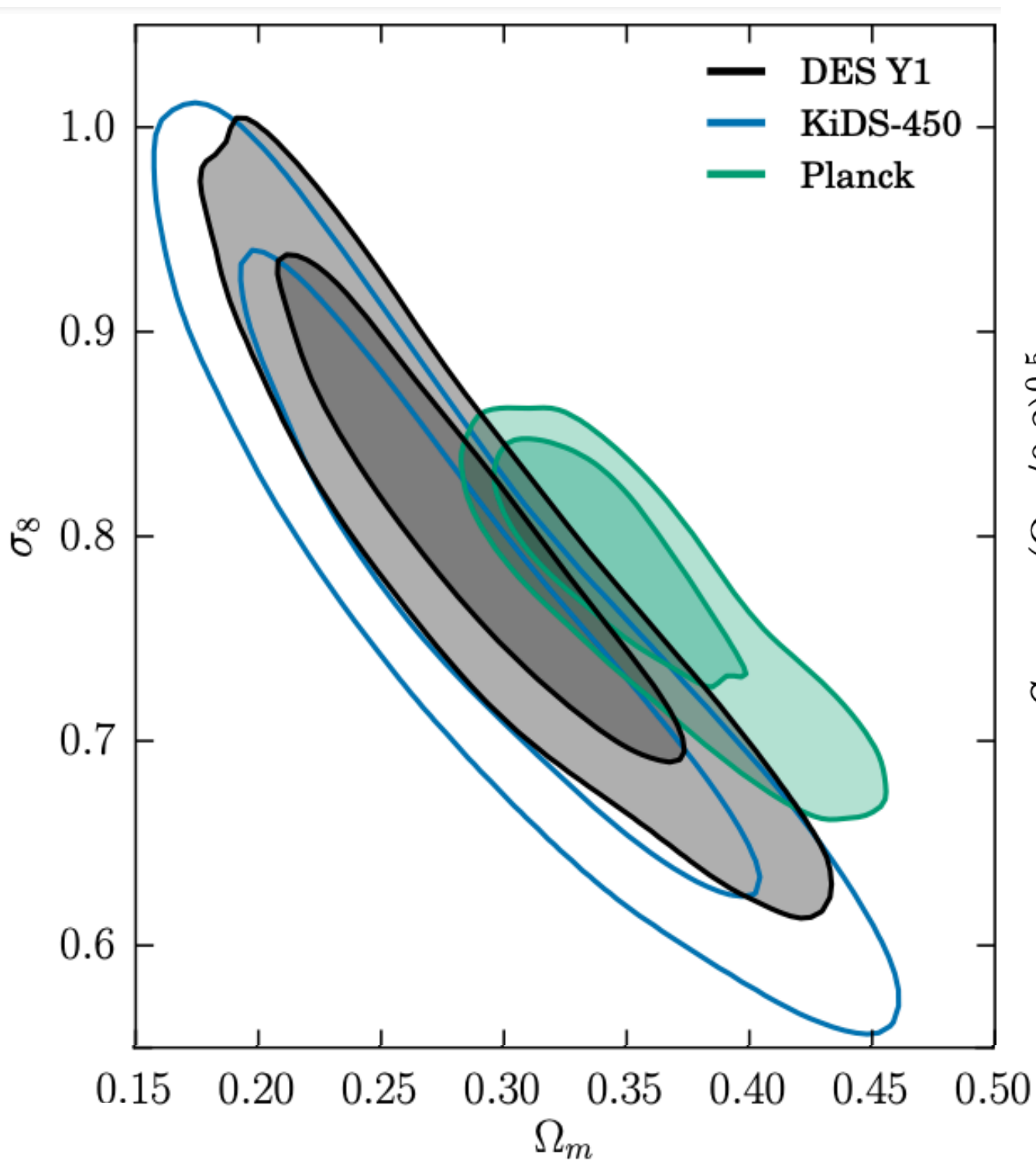
VIKING



KiDS: Kilo Degree Survey

DES: Dark Energy Survey

DES-Y1

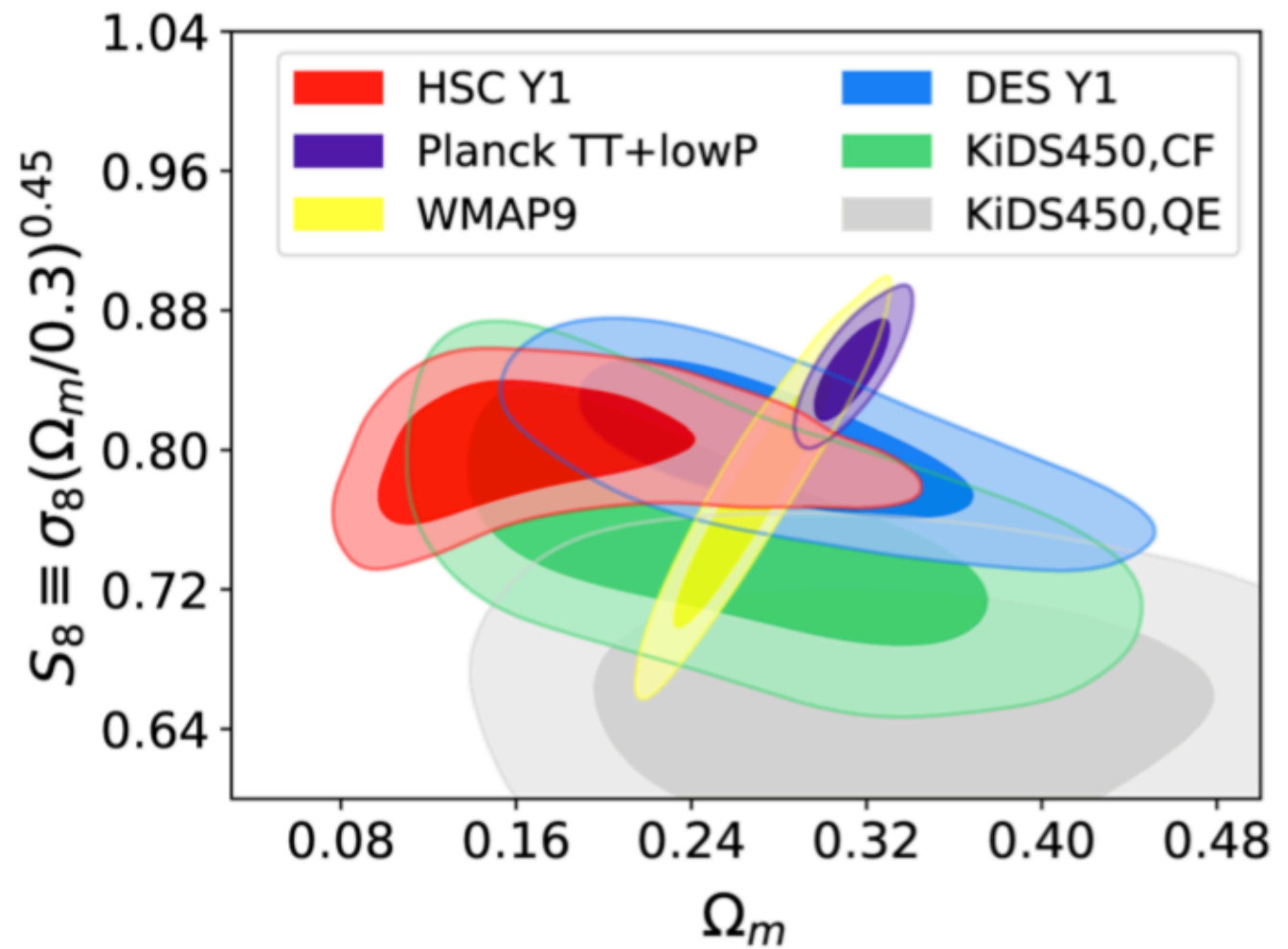
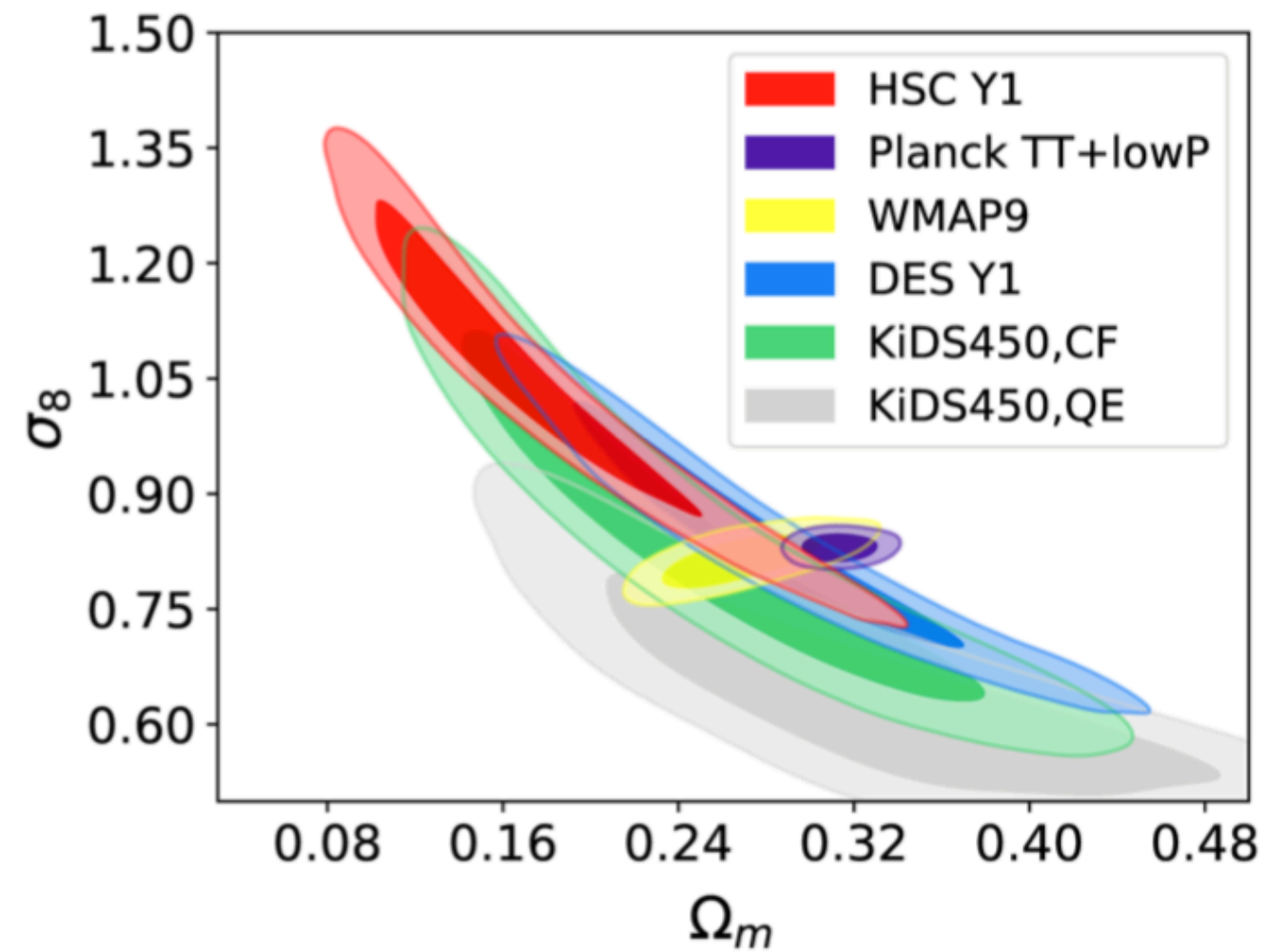


DES: 1/3 of the data, half depth

KiDS-450: 1/3 of the data, full depth, optical-only

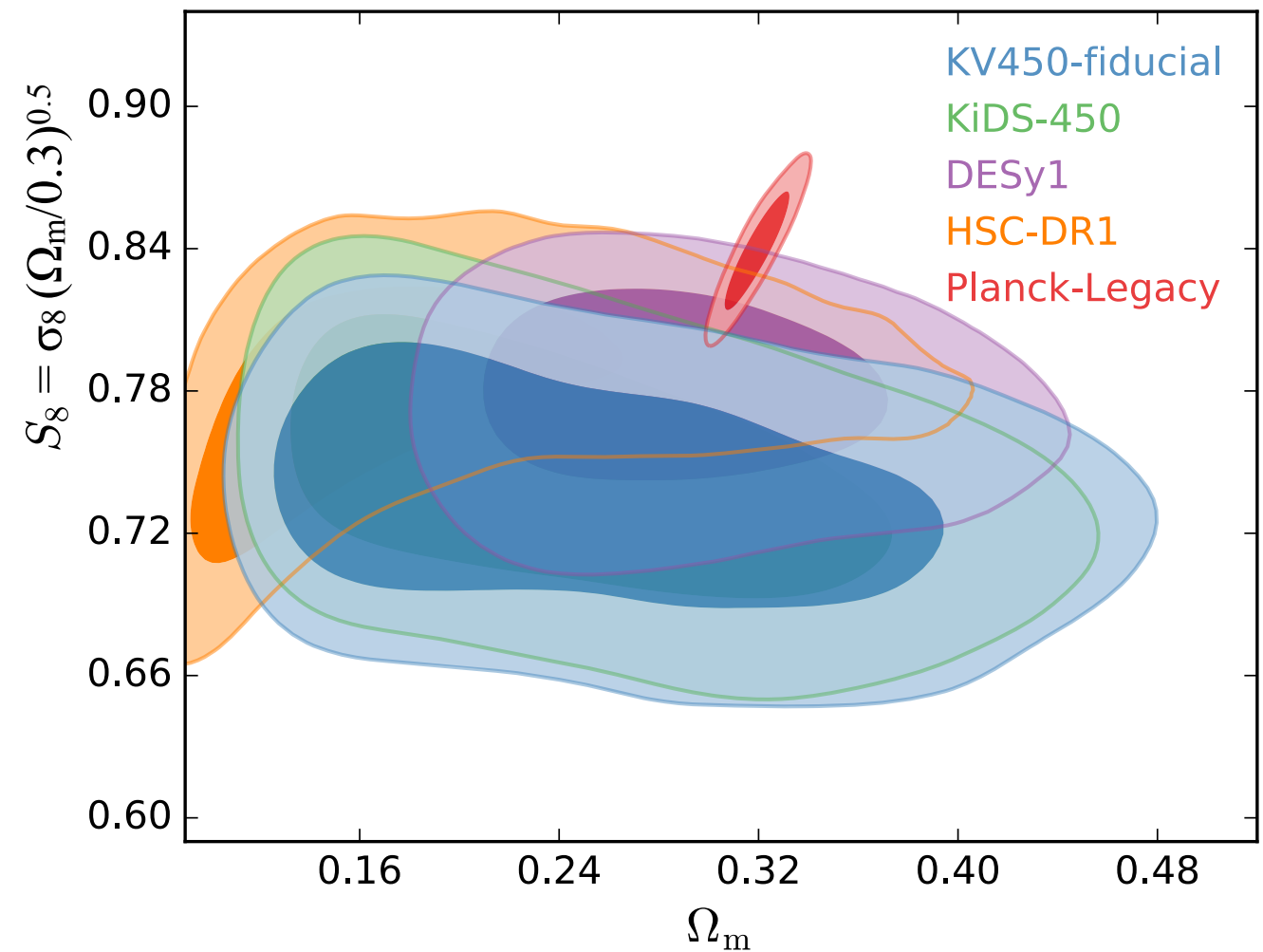
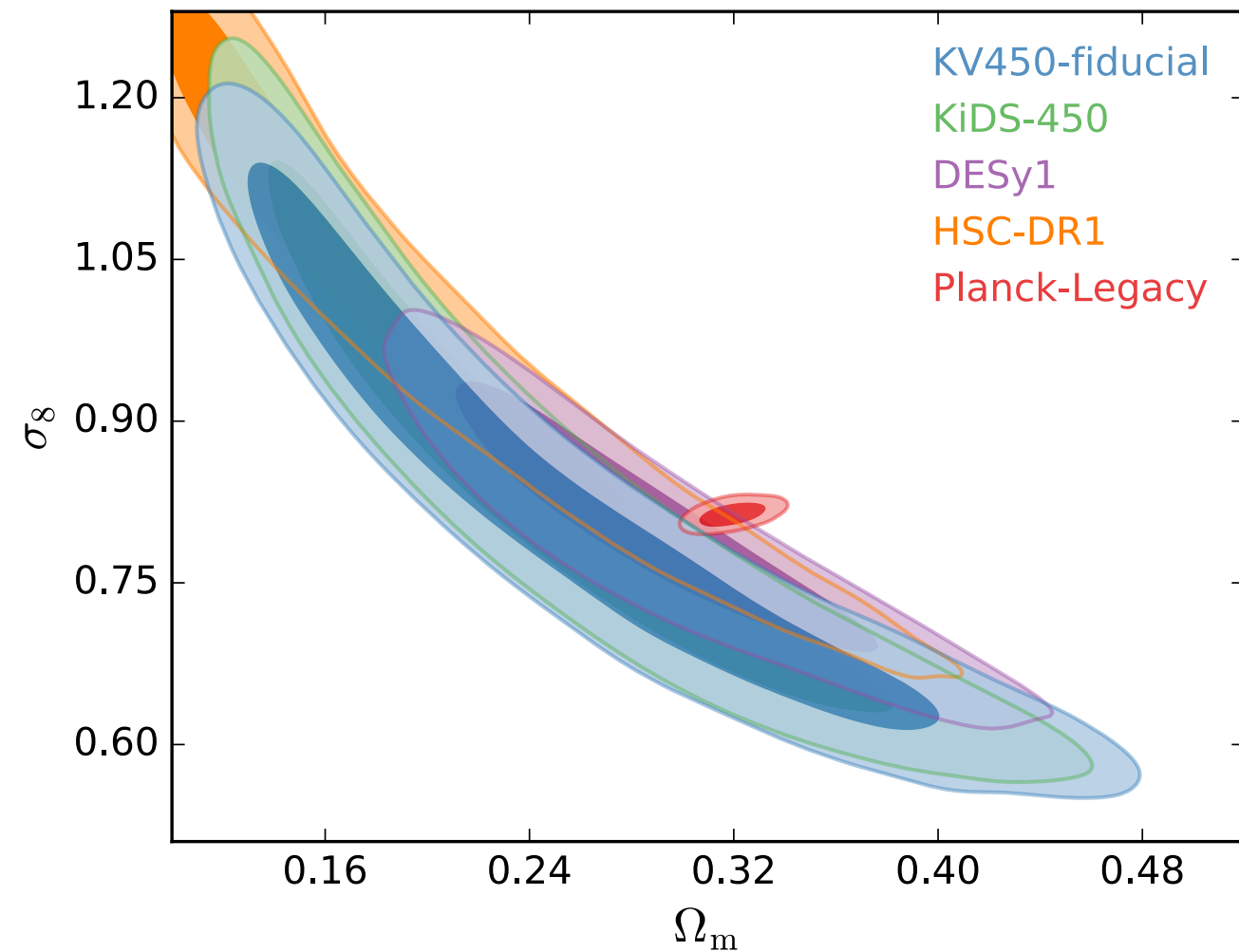
Troxel et al. (2018)

HSC-DR1

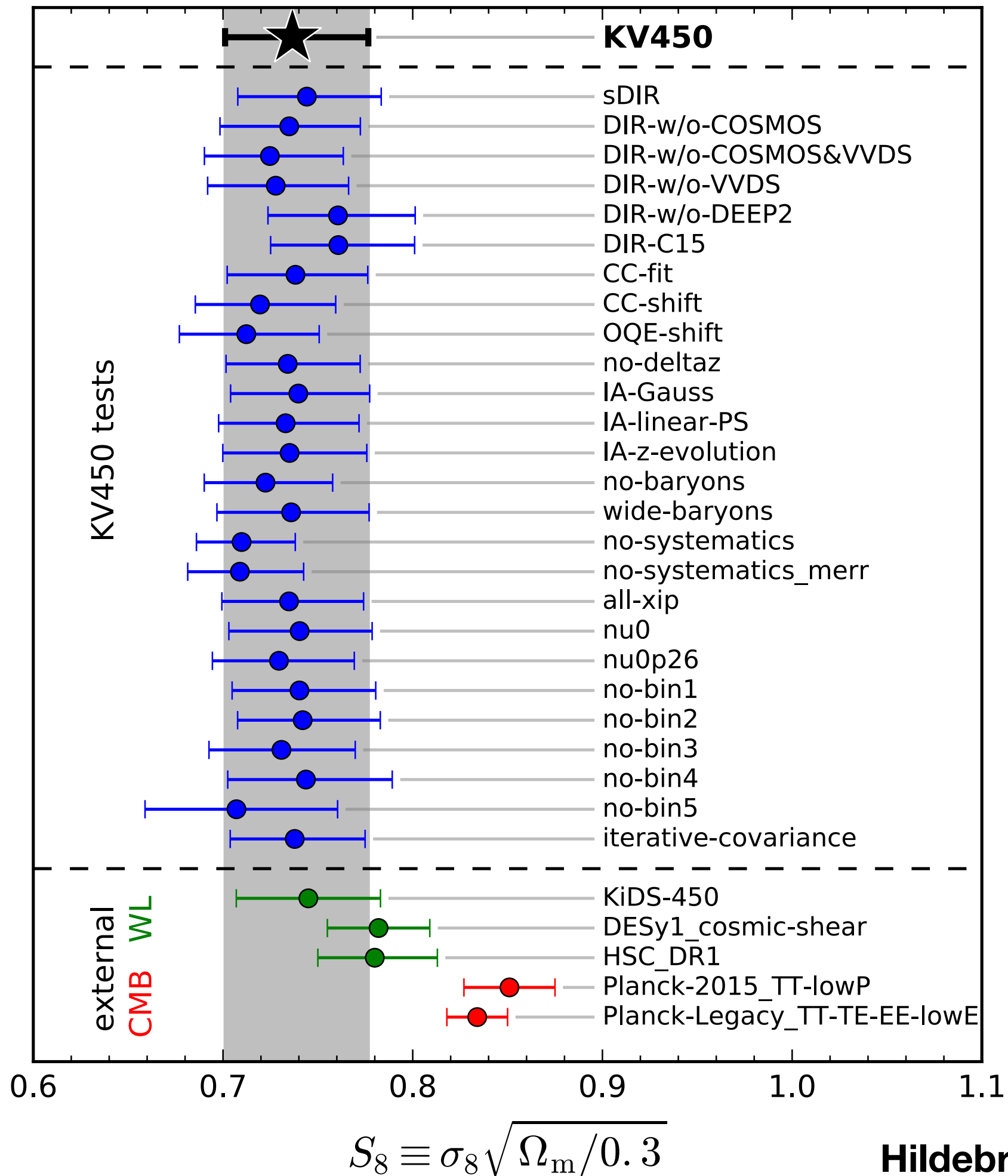


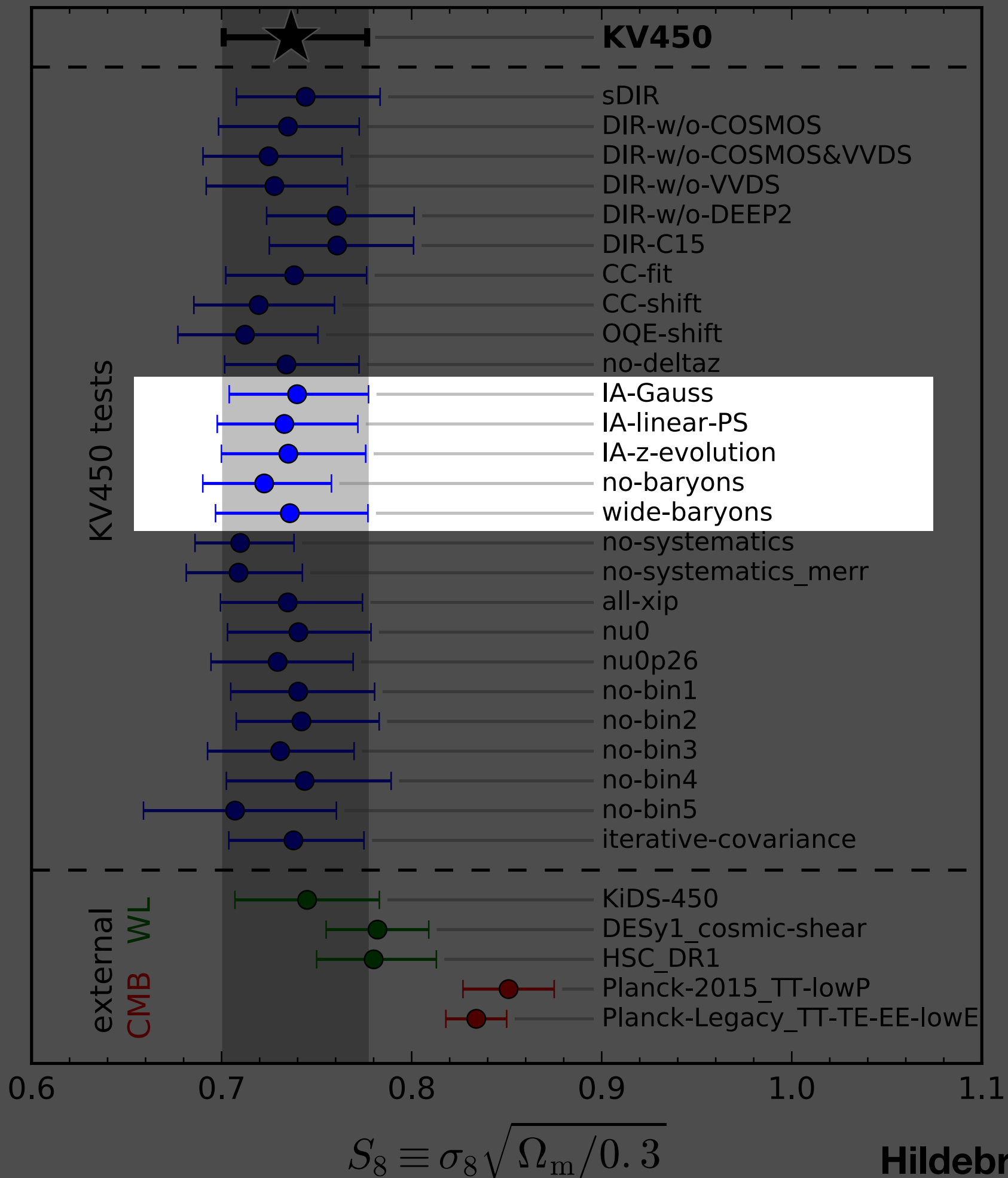
HSC: 1/10 of the data, full depth

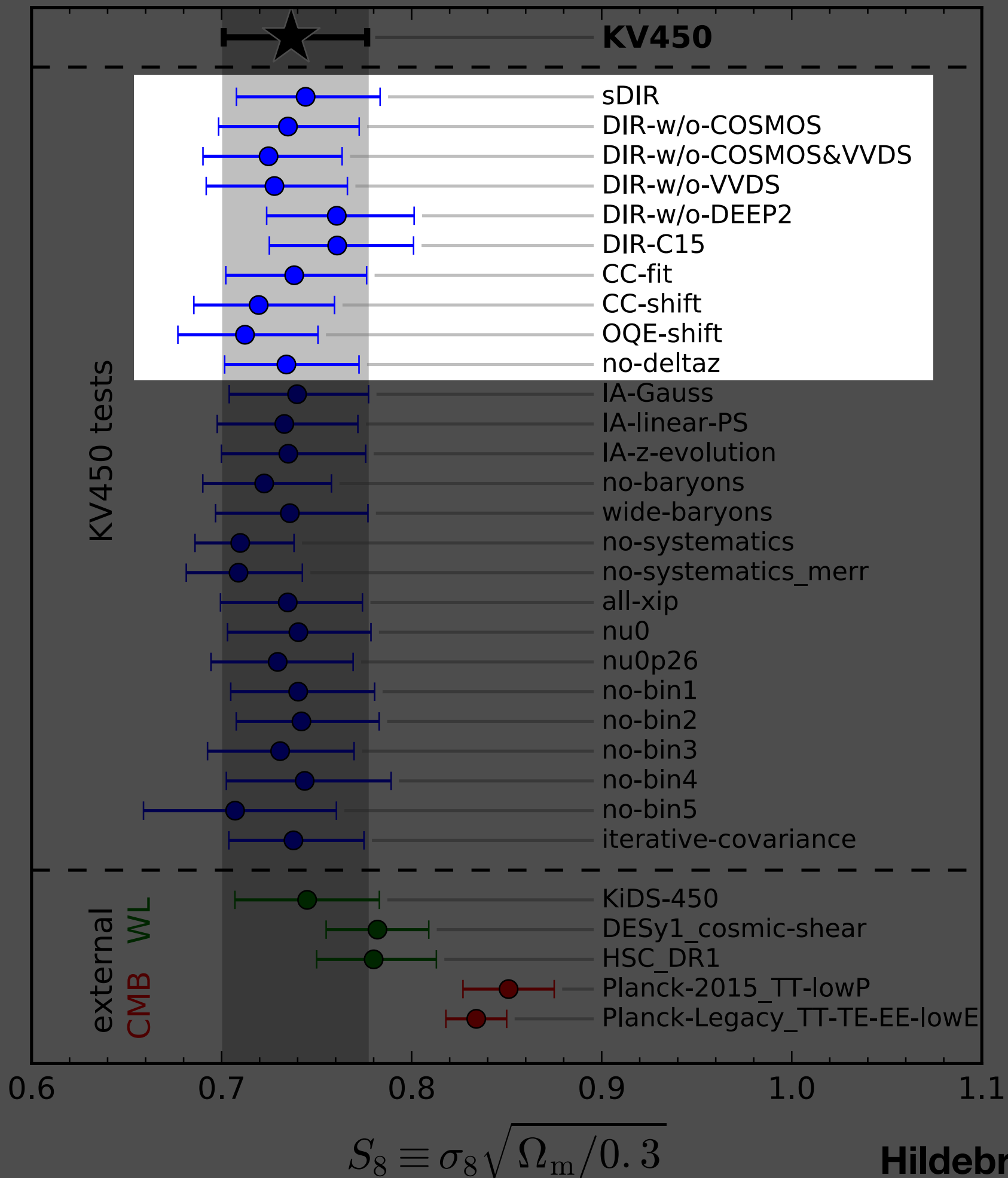
KiDS-VIKING-450

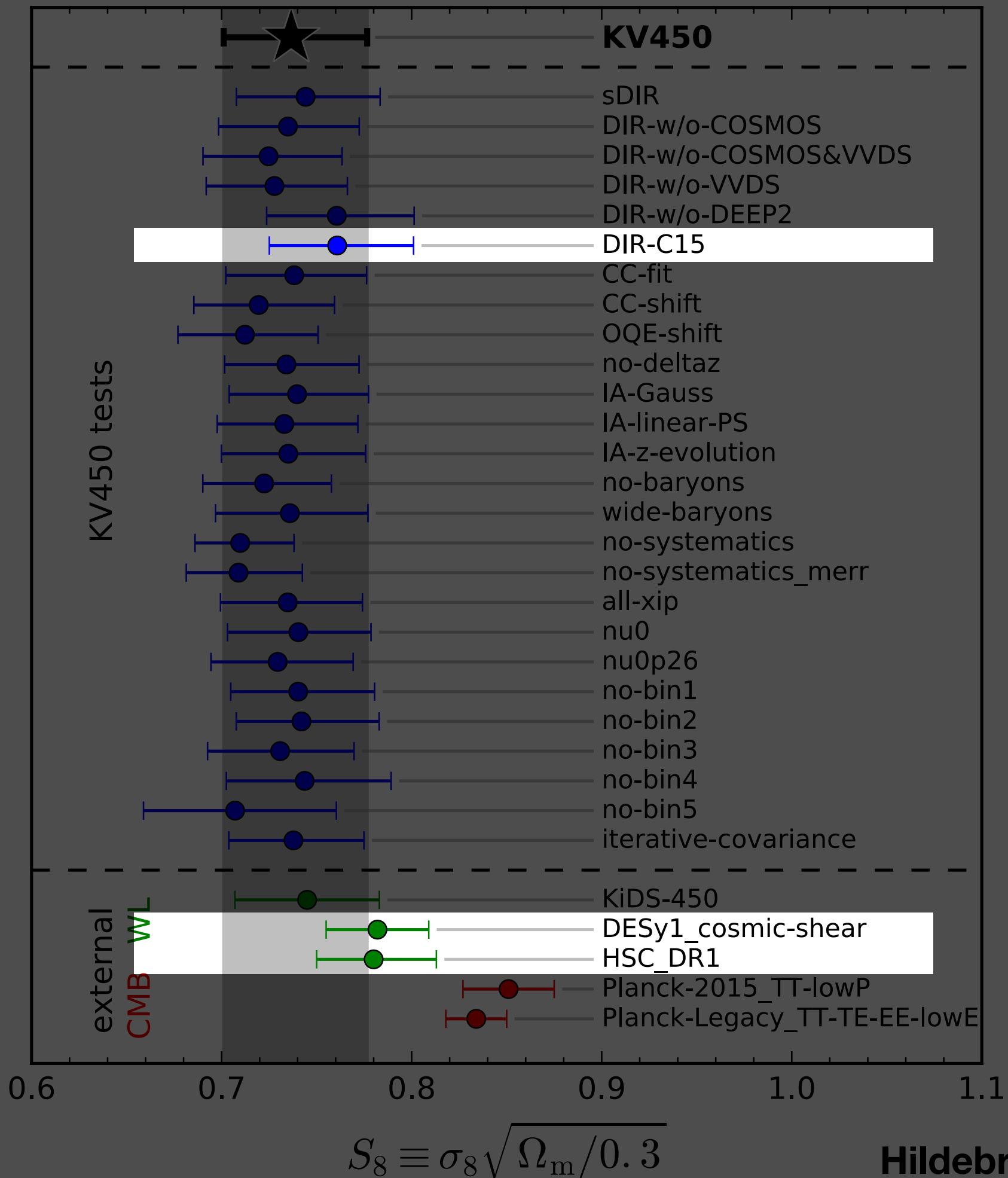


KV450: 1/3 of the data, full depth, optical+IR

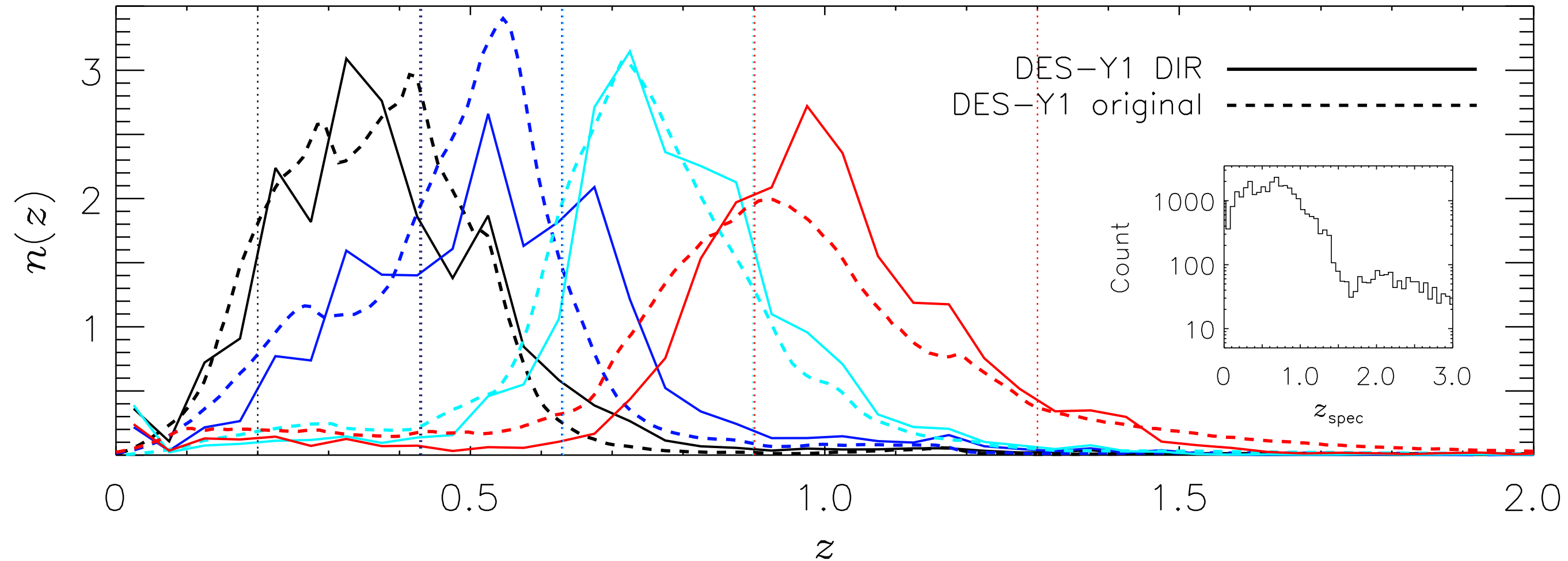








Spectroscopic calibration of DES-Y1

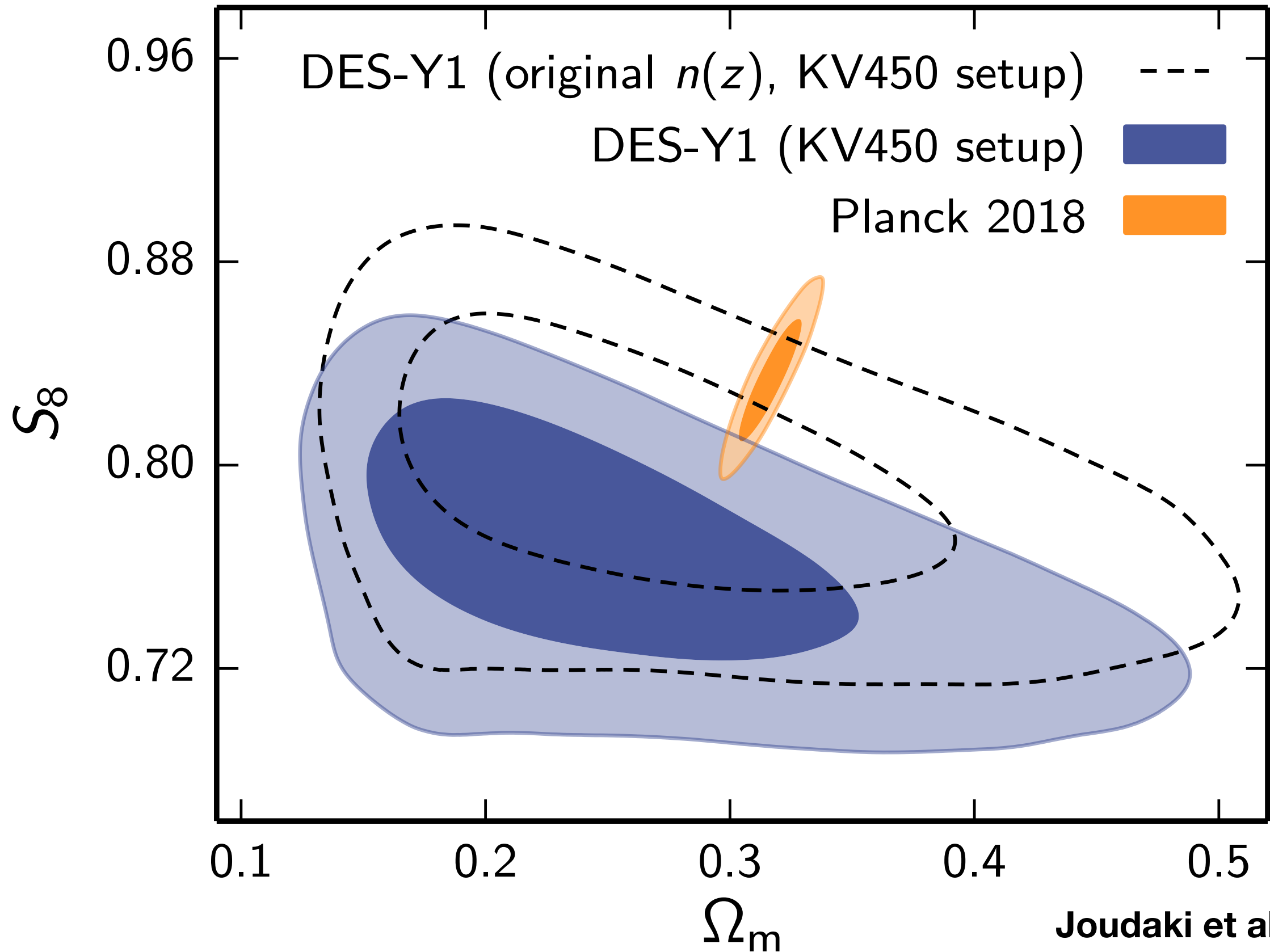


Joudaki et al. (2019), arXiv:1906.09262

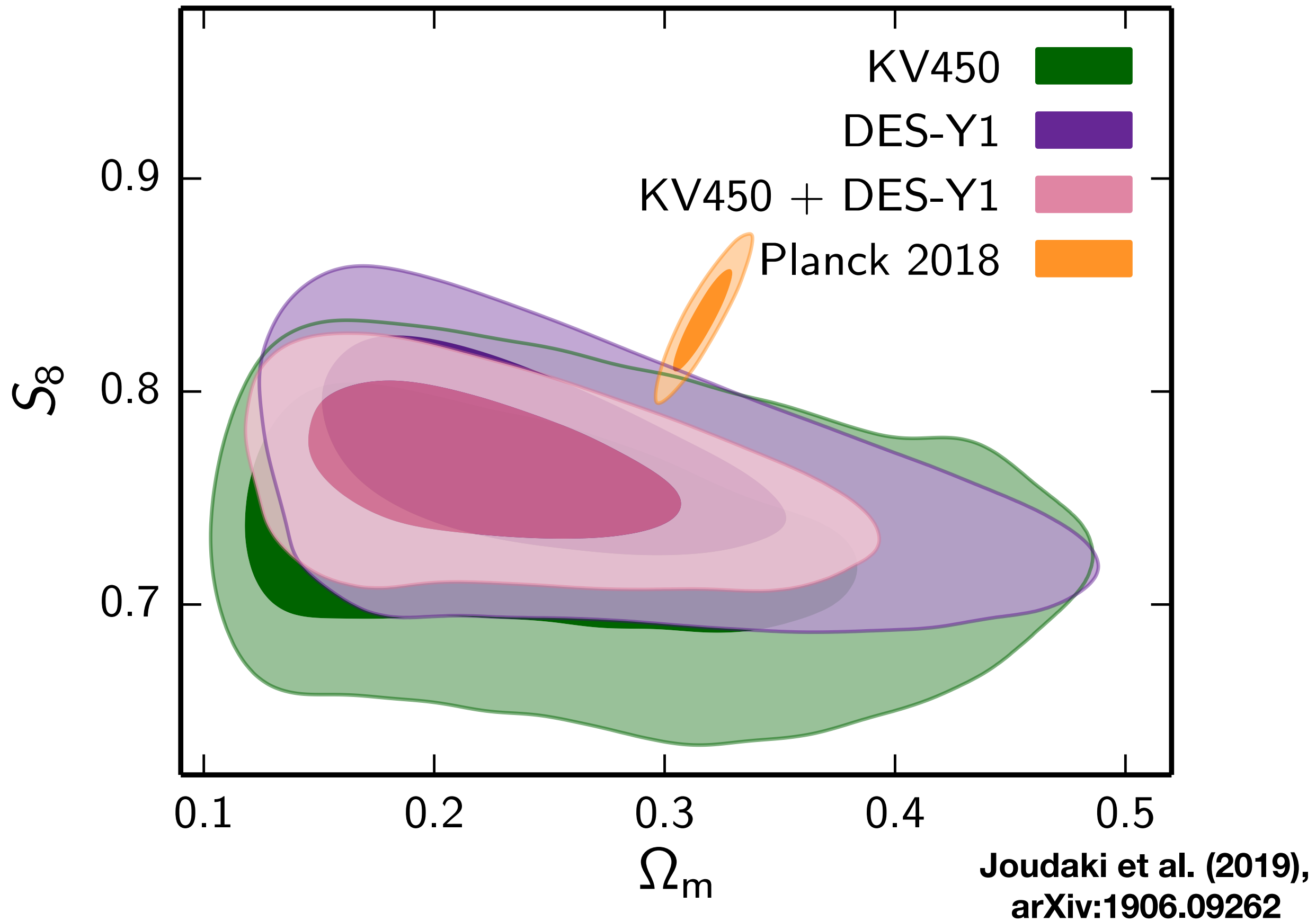
Caveat: Re-weighting done in 4D only.



S_8 constraints



KV450 and DES-Y1 combined



Problems with the redshifts

- Calibration with photo-z (e.g. COSMOS-2015):
 - Outliers => underestimate $\langle z \rangle$
 - Bias => underestimate $\langle z \rangle$
- Calibration with spec-z:
 - Magnitude-space coverage => underestimate $\langle z \rangle$
 - Uniqueness of colour-redshift relation => underestimate $\langle z \rangle$
 - Wrong spec-z => $\langle z \rangle$ drawn to the mean of all spec-z
- Clustering redshifts:
 - Evolving galaxy bias
 - Magnification effects

Summary & Outlook

- Mild $\sim 2.5\sigma$ tension in S_8 between Planck and low- z WL measurements (KV450, DES-Y1 recalibrated).
- Systematics? **Redshift calibration?**
- Other LSS probes show similar discrepancies. Related to H_0 crisis? Serious problem for Λ CDM?
- Exciting times: KiDS+VIKING and DES finished; all 3 stage-III surveys analysing more data now.
- Prepare with today's data for Euclid/LSST.