KiDS+VIKING-450: Cosmic shear tomography with optical+infrared data

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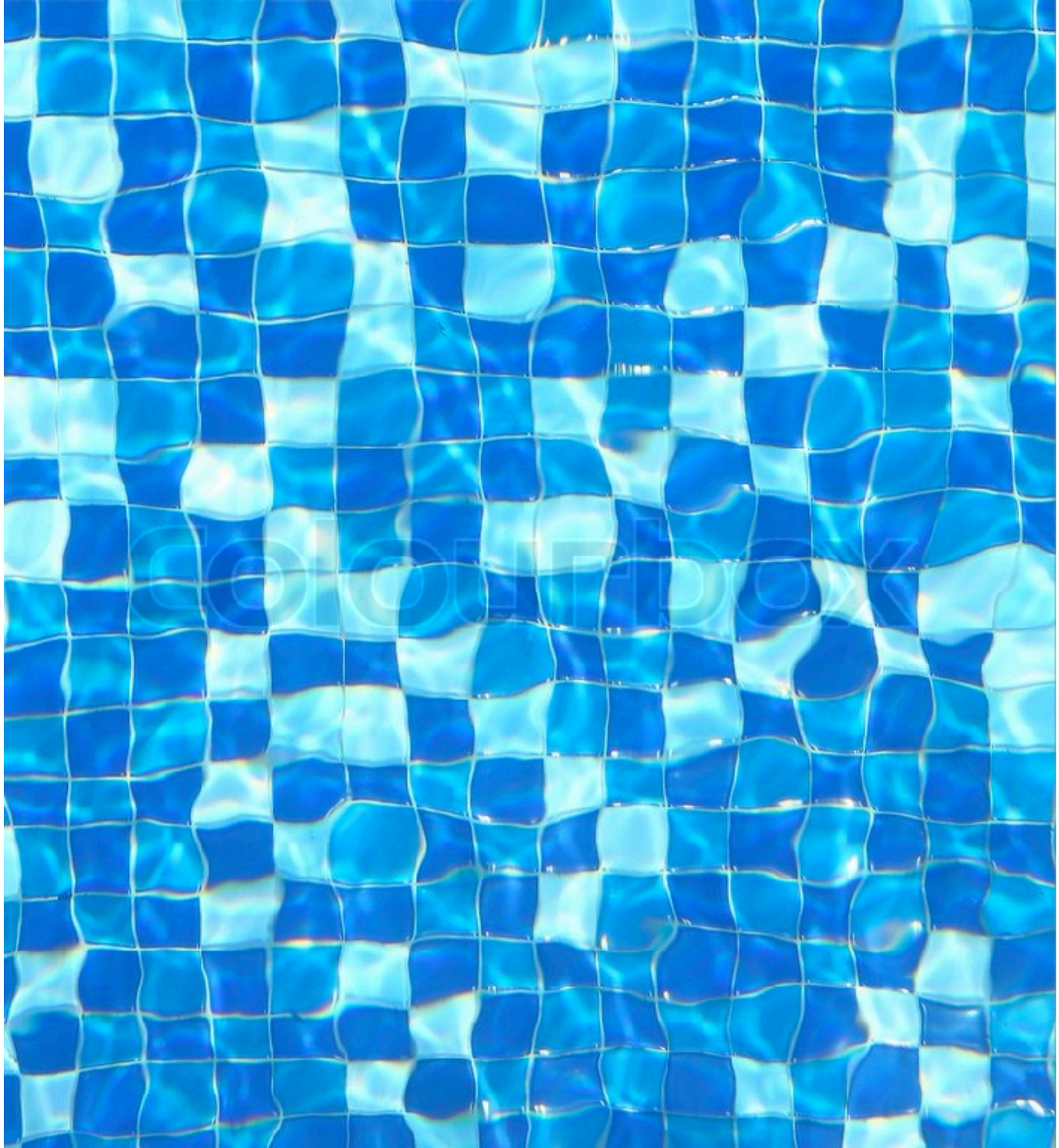
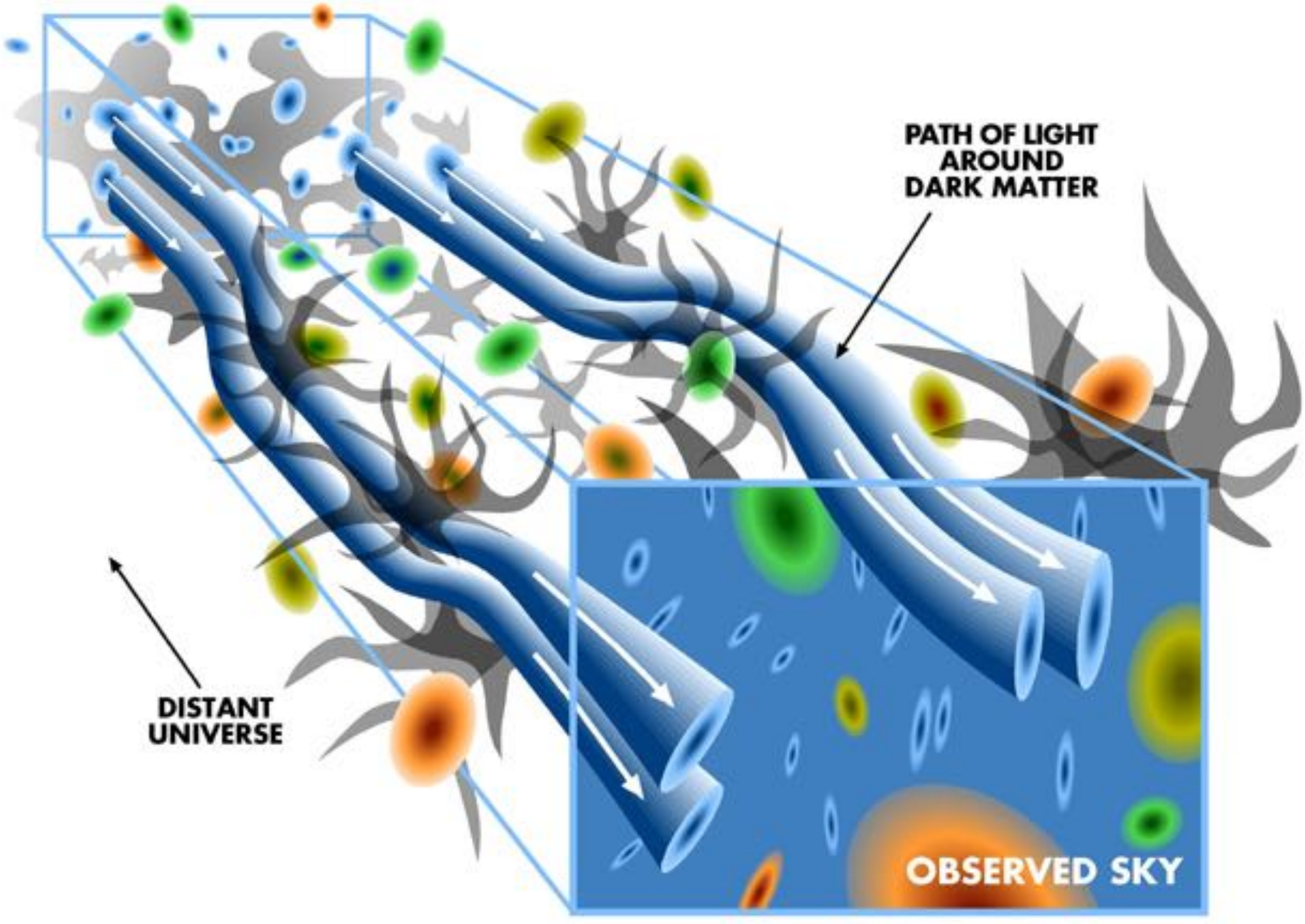
on behalf of the KiDS collaboration

7th March 2019



Cosmic shear



Wittman et al. (2000)

Sensitive to:

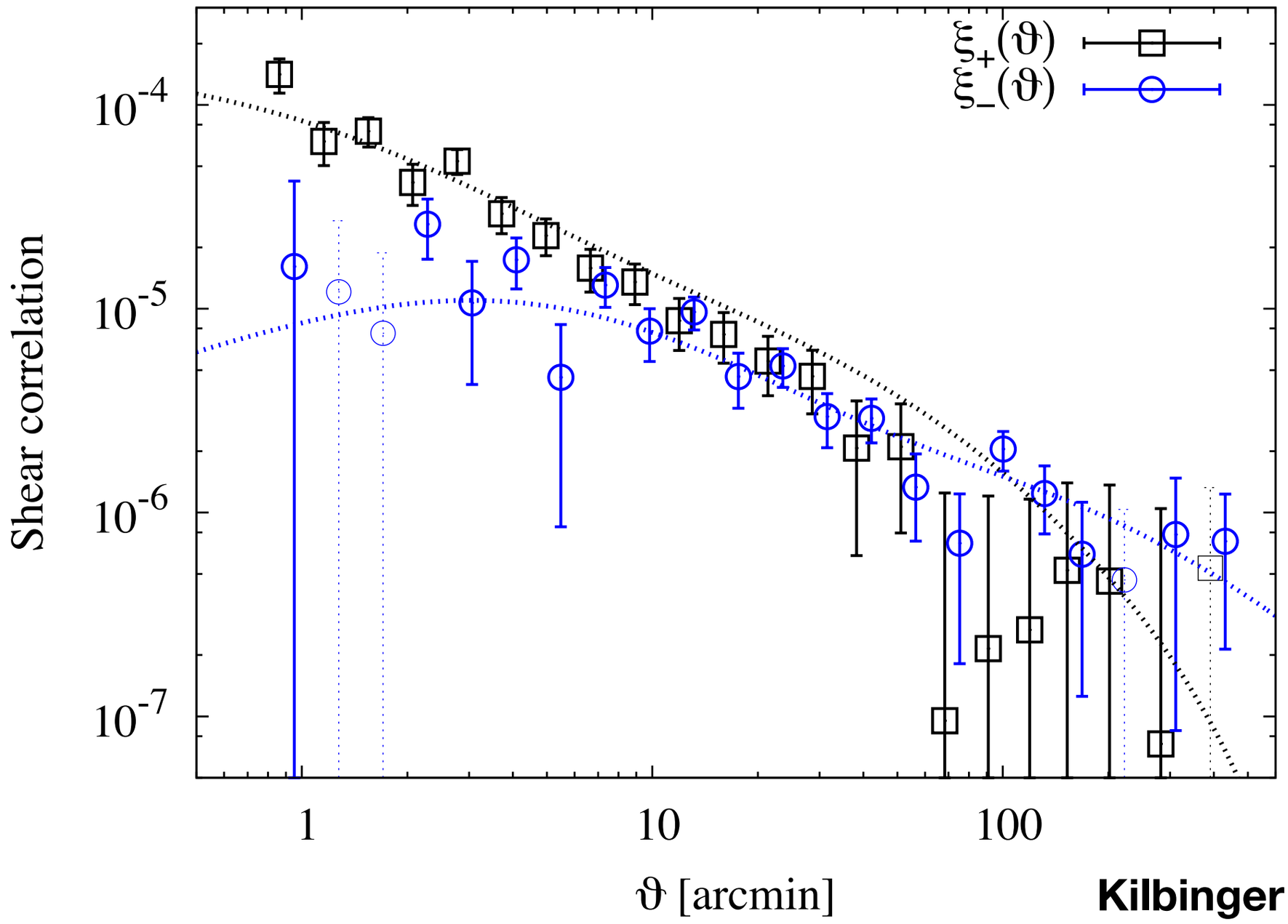
- Matter distribution
- Geometry

Observables:

- Ellipticities
- Photo-z

Statistical measurement of many galaxies

2pt shear correlation functions



Kilbinger et al. (2013)

Very directly related to the matter power spectrum P_δ.

Observation -> theory

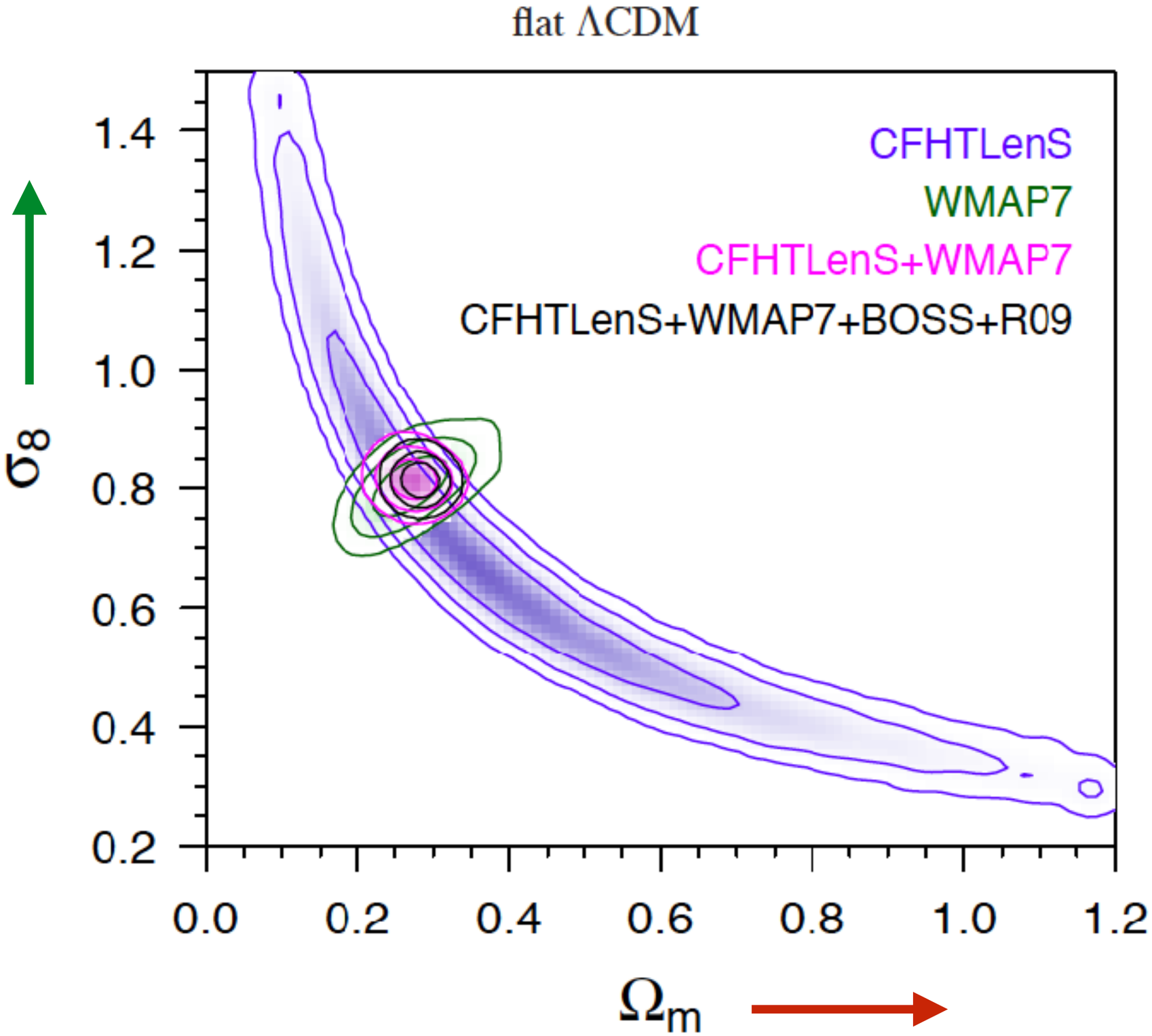
$$\xi_{\pm}(\theta) = \langle \gamma_{\rm t}\gamma_{\rm t} \rangle (\theta) \pm \langle \gamma_{\times}\gamma_{\times} \rangle (\theta)$$

$$\xi_{+}(\theta) = \int_0^{\infty} \frac{{\rm d}\ell\,\ell}{2\pi} {\rm J}_0(\ell\theta)\, P_{\kappa}(\ell)\;;\quad \xi_{-}(\theta) = \int_0^{\infty} \frac{{\rm d}\ell\,\ell}{2\pi} {\rm J}_4(\ell\theta)\, P_{\kappa}(\ell)$$

$$P_{\kappa}(\ell) = \frac{9H_0^4\Omega_{\rm m}^2}{4c^4} \int_0^{\chi_{\rm h}} {\rm d}\chi \frac{g^2(\chi)}{a^2(\chi)} P_{\delta}\left(\frac{\ell}{f_K(\chi)}, \chi\right)$$

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

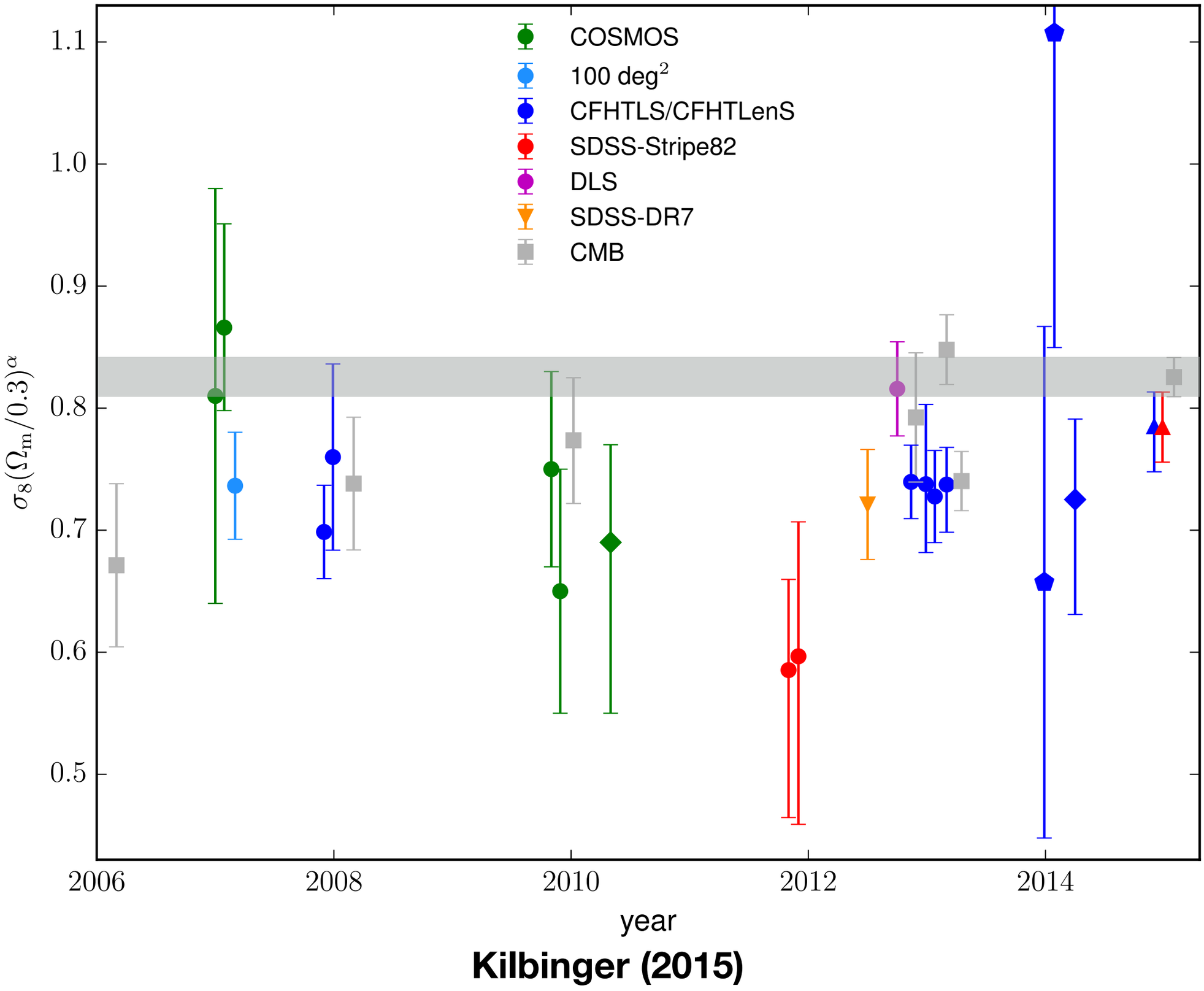
Cosmological constraints



Kilbinger et al. (2013)

- Measure **amount** of **clustered** matter
- $S_8 = \sigma_8 (\Omega_m/0.3)^{0.5}$

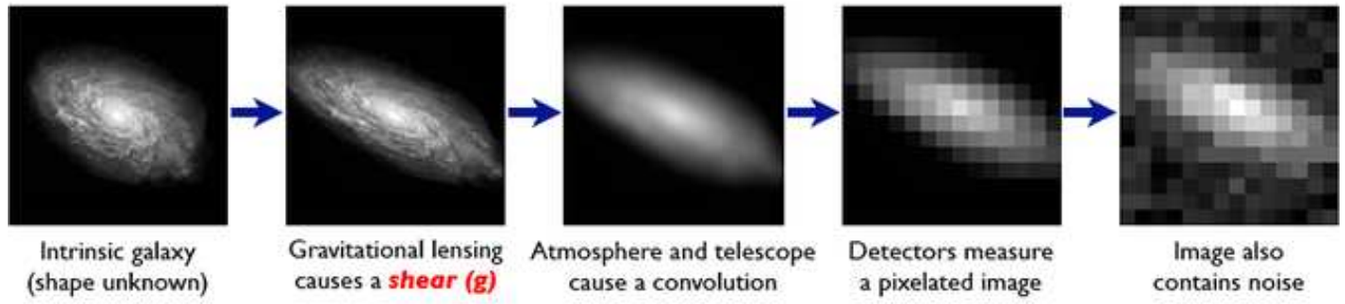
S_8 results over the years



Kilbinger (2015)

Systematic errors

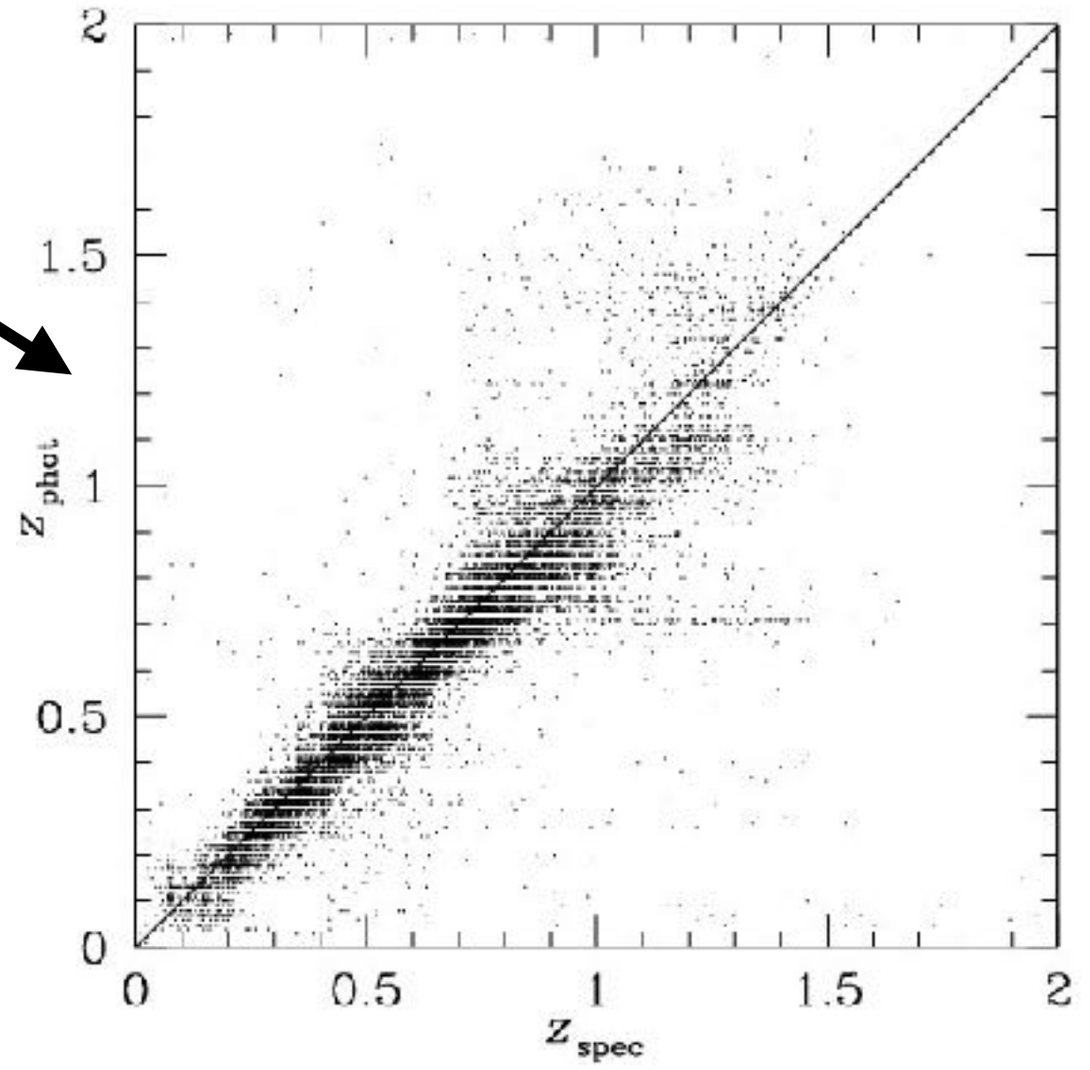
- **Shapes measurement systematics:**
  - PSF residuals
  - B modes
  - Multiplicative and additive biases

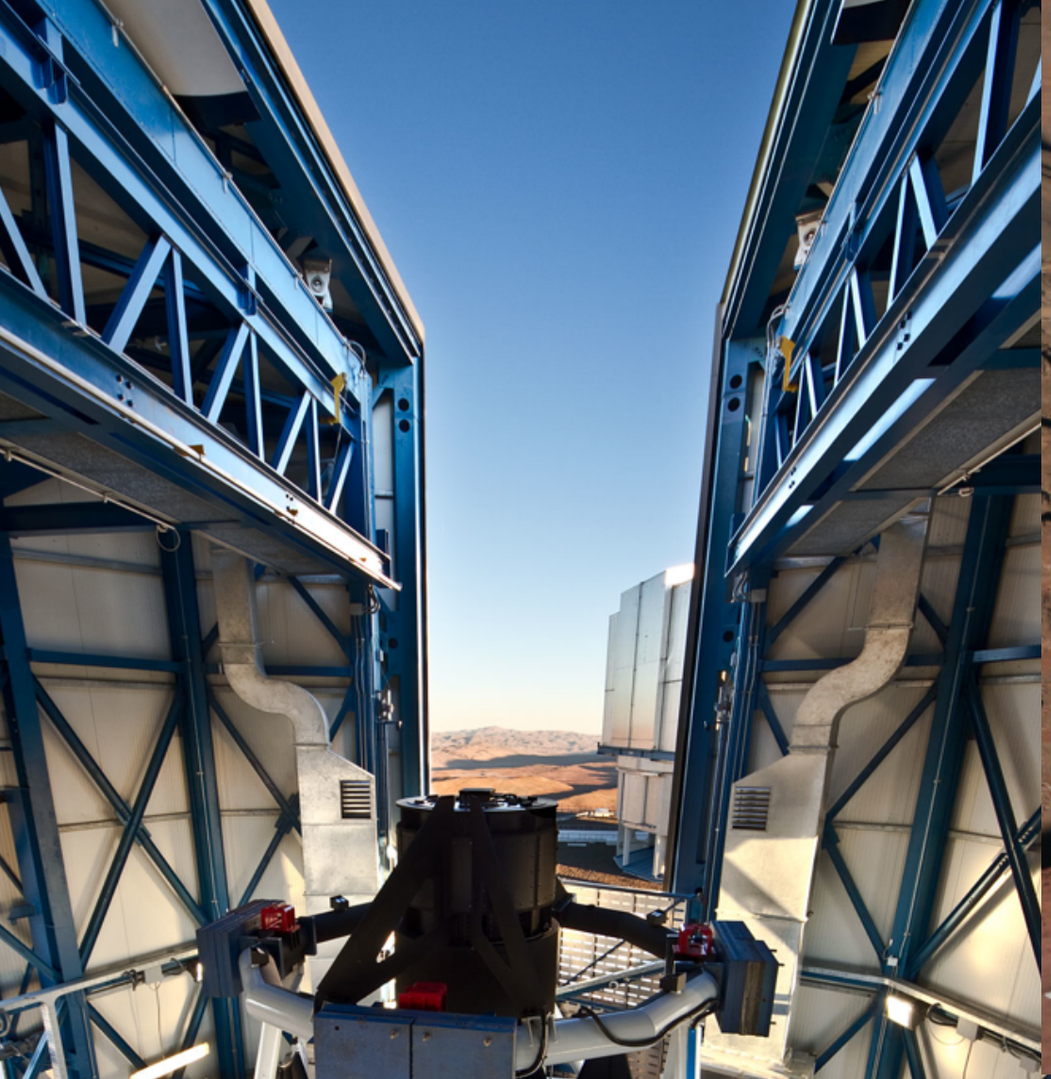


- **Photo-z systematics:**
  - Calibration sample and technique
  - Inhomogeneous multi-band data

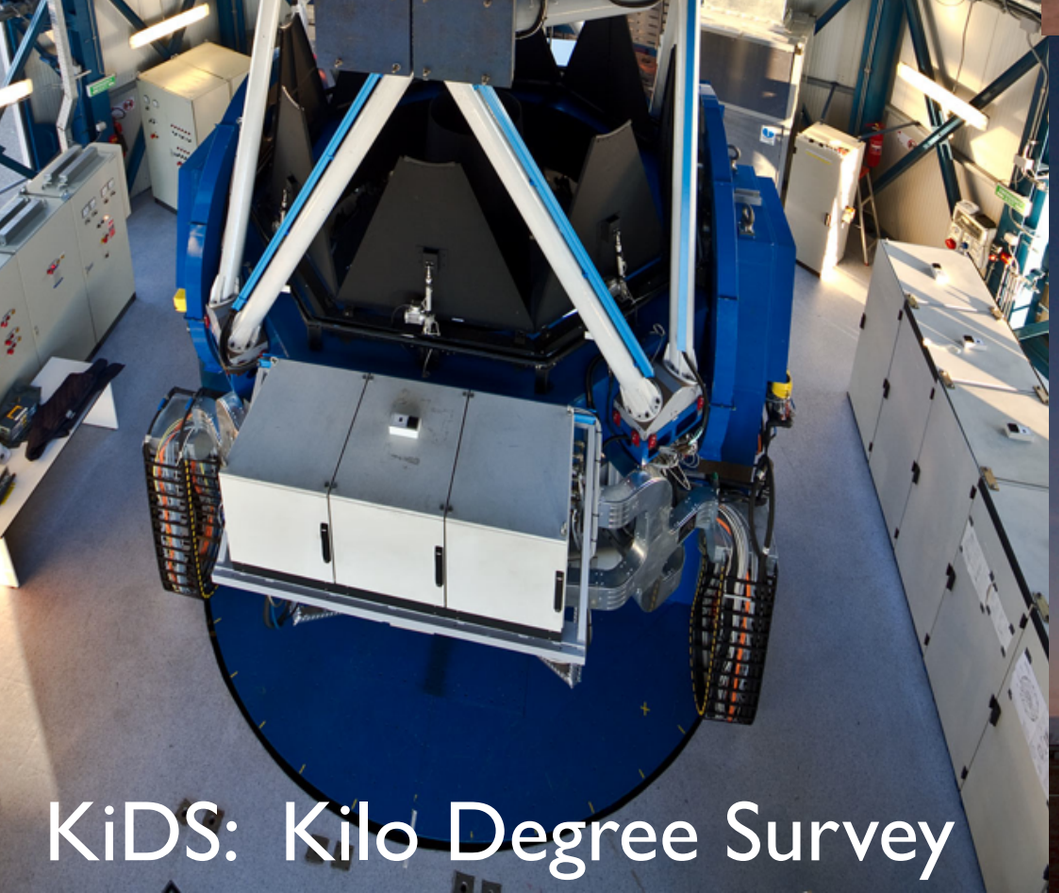
- Theoretical “systematics”:
  - Intrinsic alignments
  - Baryon feedback
  - Neutrinos
  - WDM

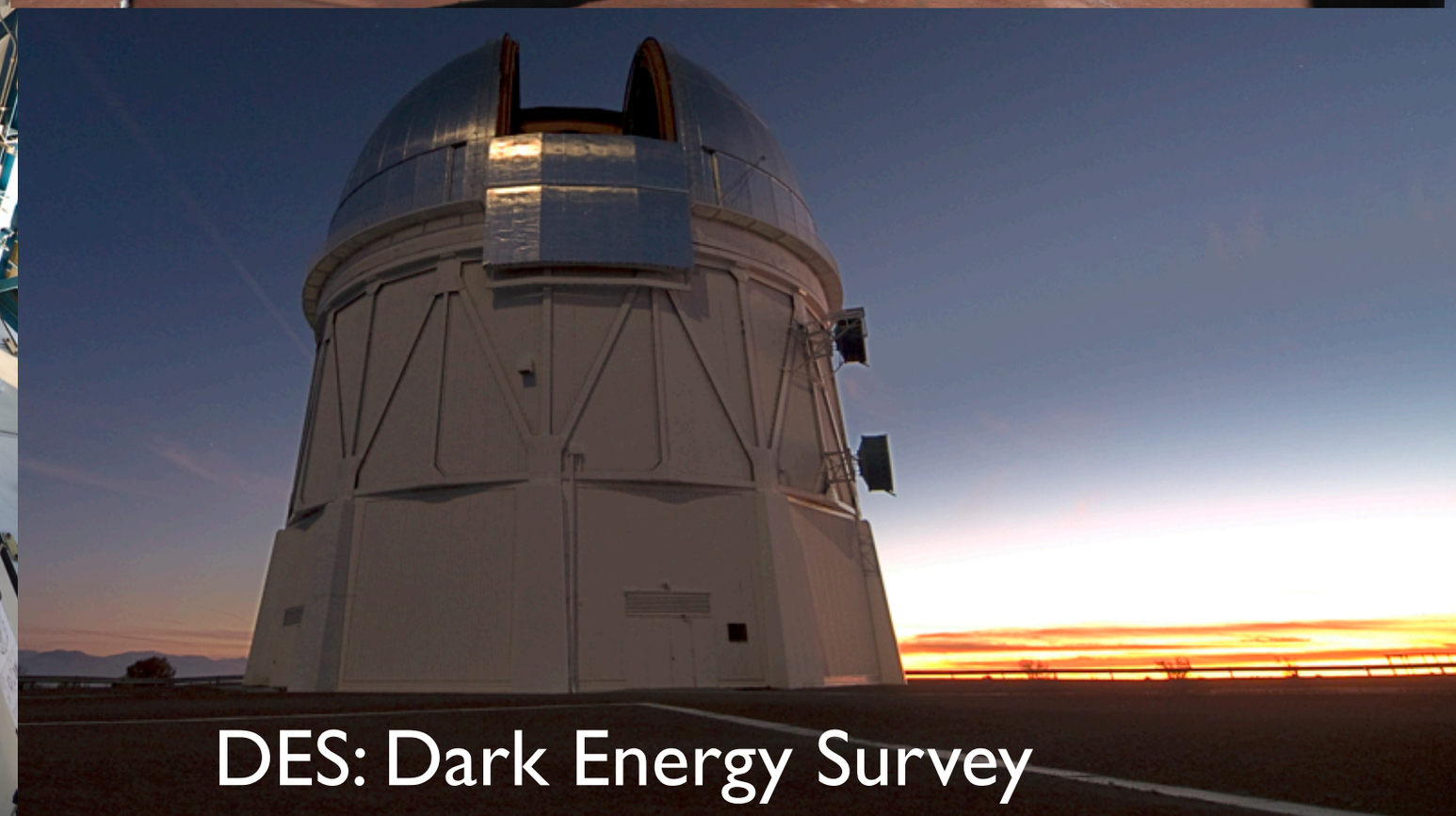
- Psychological systematics:
  - Blinding






HSC: Hyper-Suprime Cam Survey


KiDS: Kilo Degree Survey

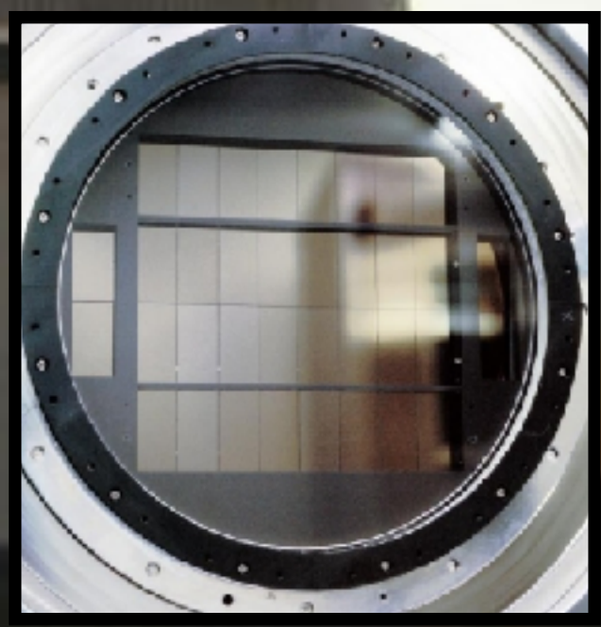

DES: Dark Energy Survey

KiDS vs. HSC vs. DES

	KiDS+VIKING	HSC	DES
Mirror [m]	2.6 + 3.9	**8.2**	4.0
Focus (optical)	**Cassegrain**	Prime	Prime
FOV [deg²]	1.0	1.8	**3.0**
Area [deg²]	1350	1400	**5000**
Filters	***u****gri*+*ZY****JHKs***	*grizy*	*griz(y)*
Seeing [arcsec]	**0.7**	**0.6**	0.9
Source density [gal/arcmin²]	~9	**~22**	~7
Depth	***r*~24**	*i*~24.5	***r*~23.5**

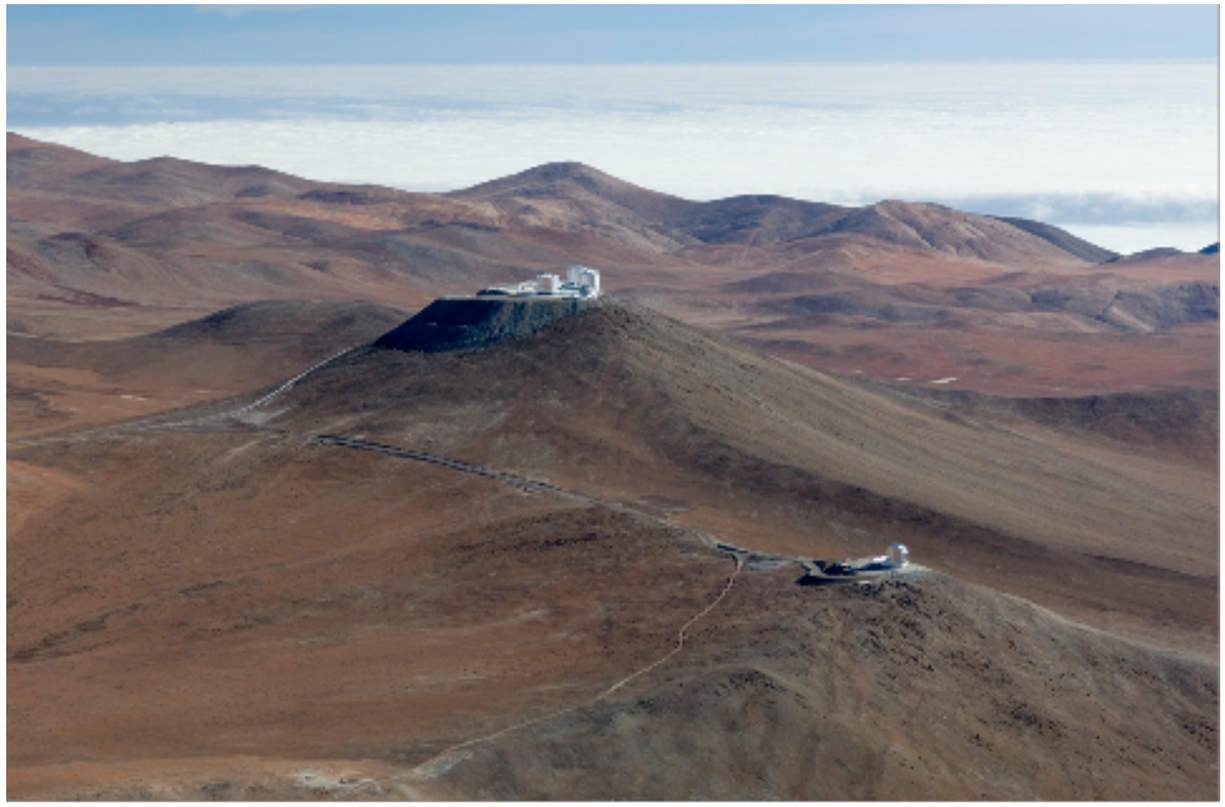
KiDS

- 1350deg^2 survey
- VLT Survey Telescope (VST)
- Four optical bands: *ugri*
- Shapes down to *r*~24
- ~8.5 gal/arcmin^2

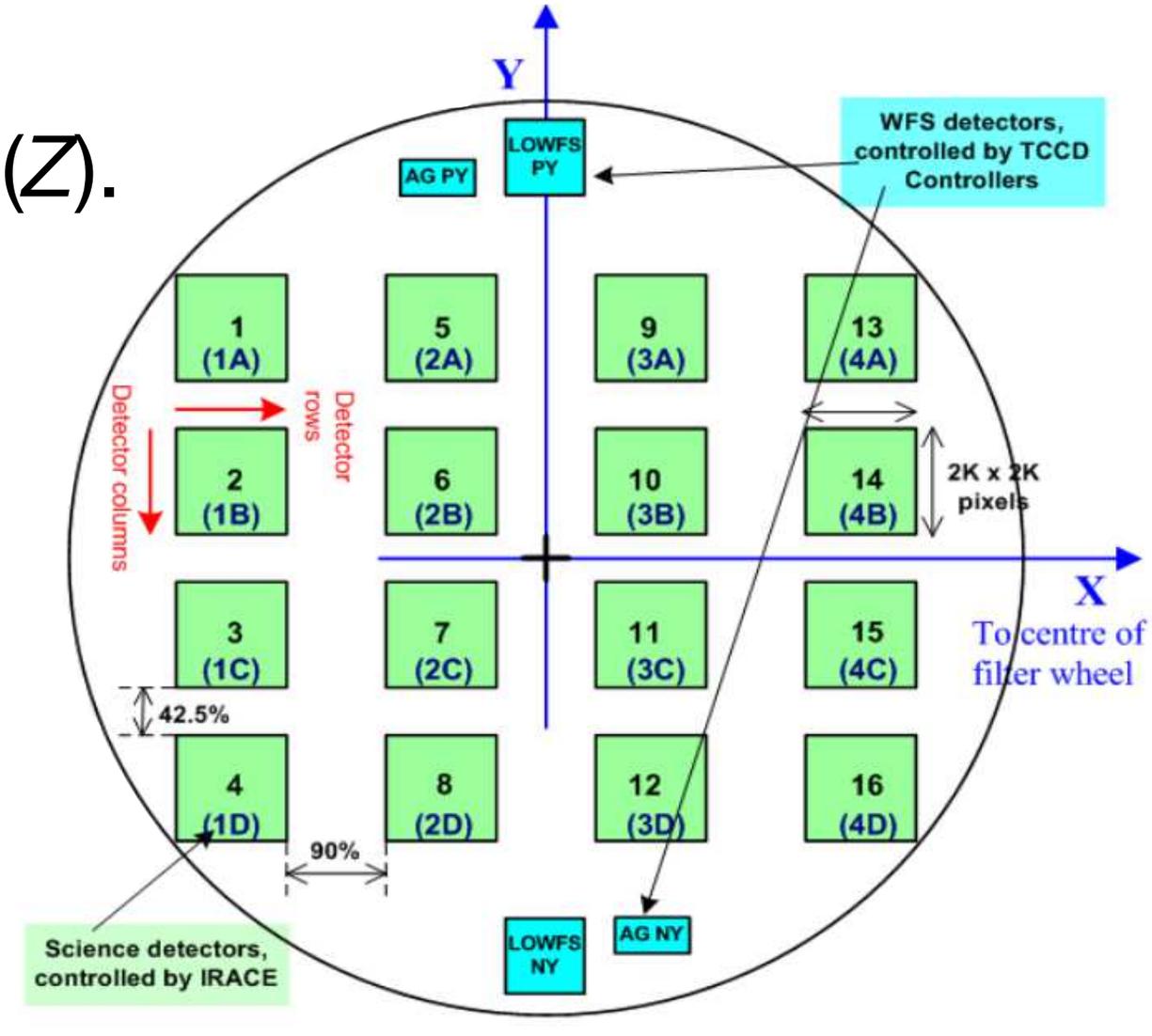


VIKING@VISTA

- Same footprint as KiDS.
- Already finished (1350deg^2).
- *ZYJHK*$_s$ images.



- 5σ depths of 21.2 (K_s) to 23.1 (Z).



KiDS-VIKING 450

- Same source catalogue as KiDS-450.

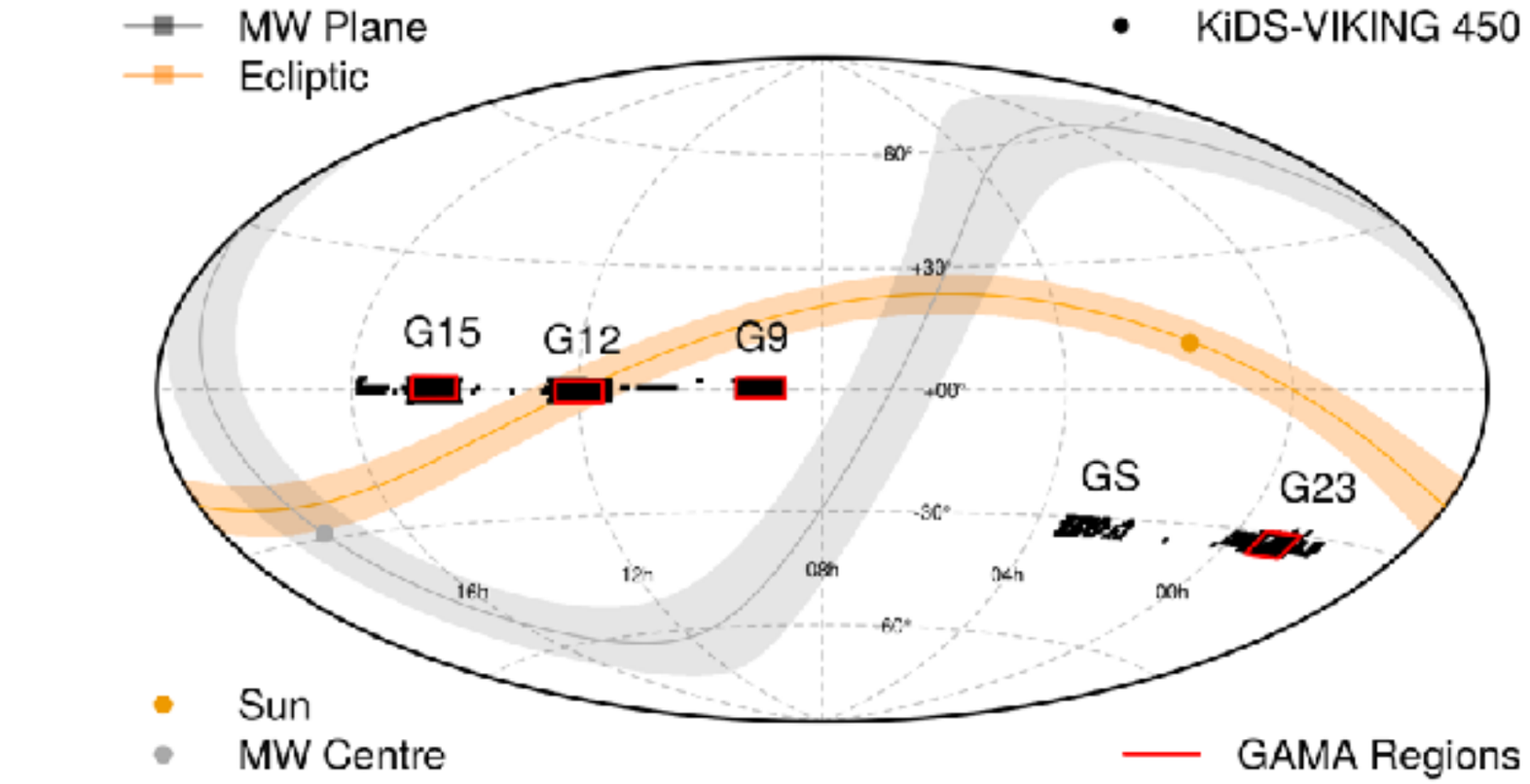
- Add VIKING $ZYJHK_s$-bands to KiDS-450 *ugri*-bands.
  => Improved photo-z.

- Define five new tomographic bins ($0.1 < z_{phot} < 1.2$).

- Leverage large-area spec-z surveys for CC.

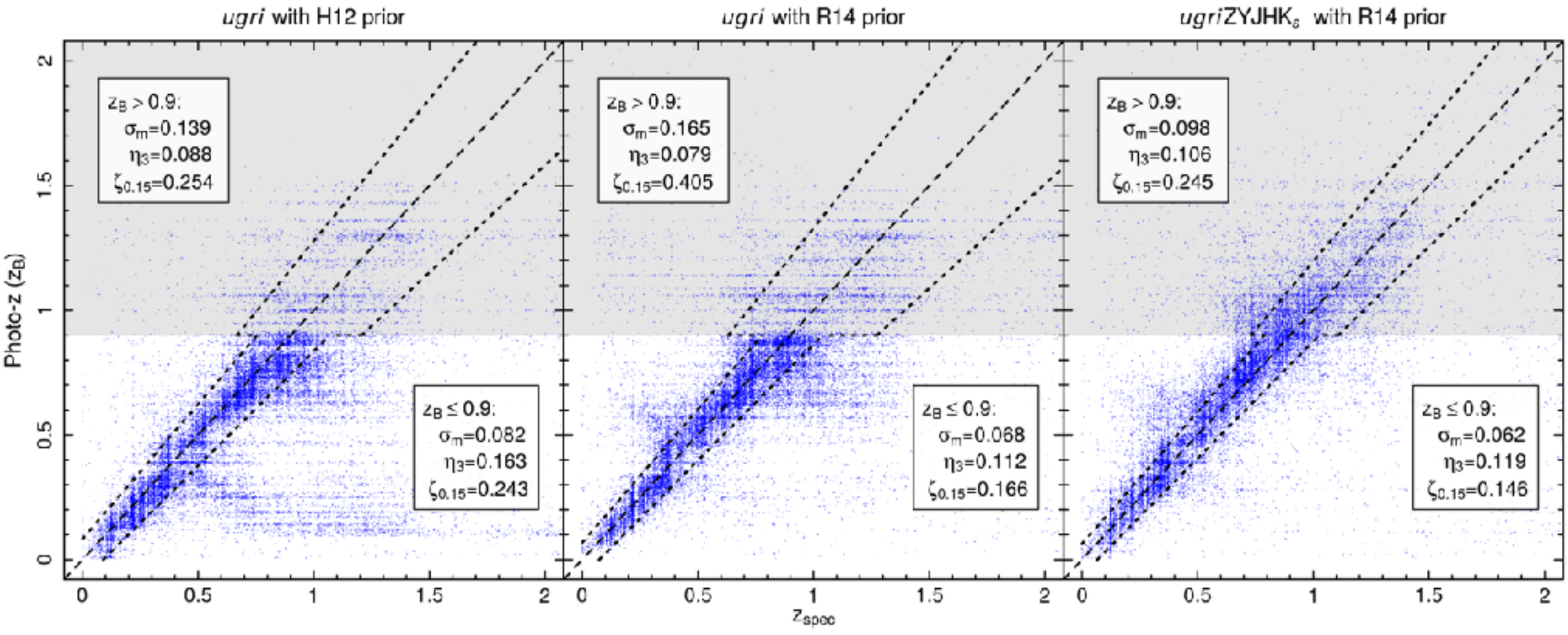
- Include a lot of lessons learned in the last couple of years.

- Expectation: More precise and systematically more robust cosmological results.



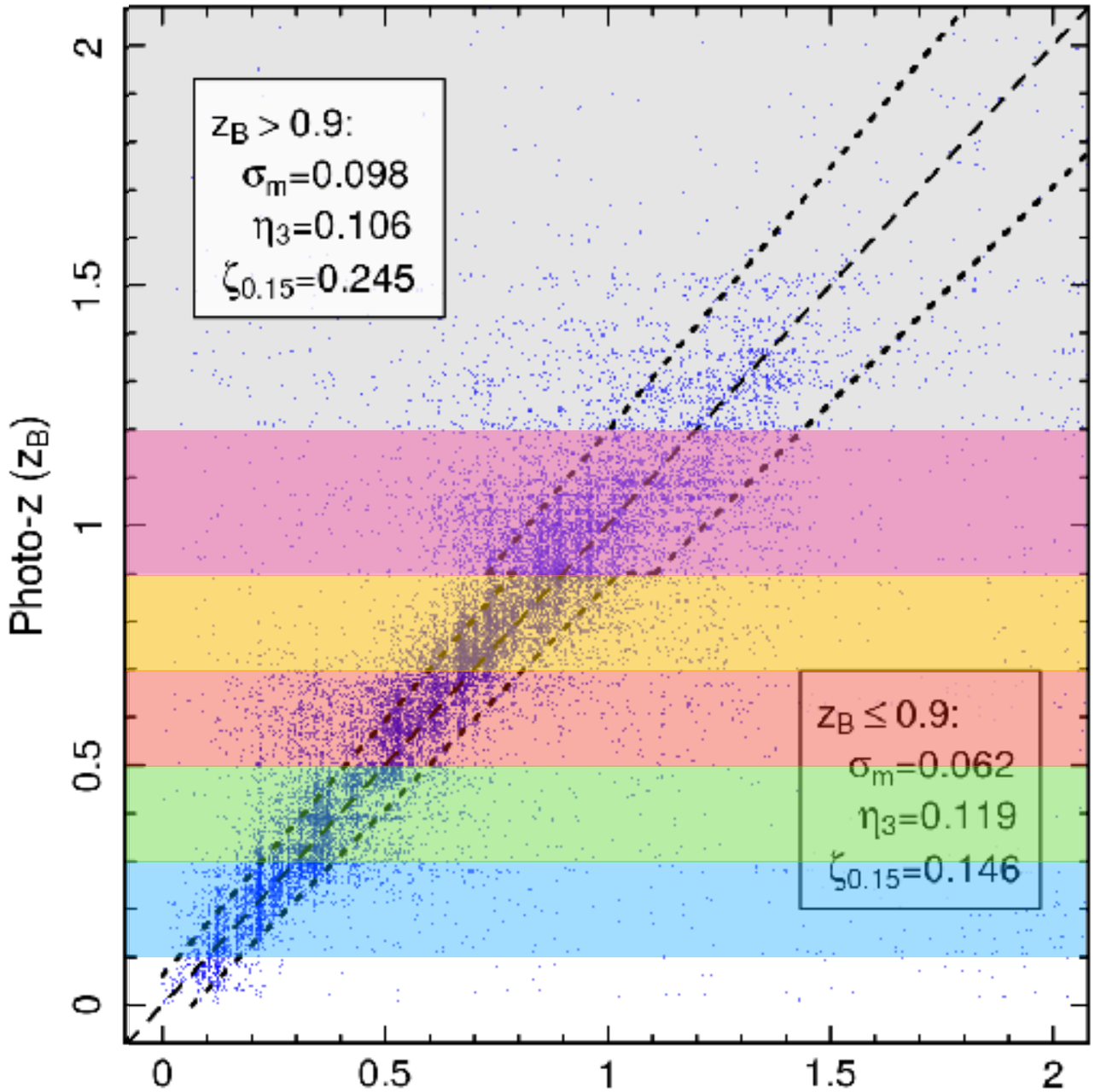
Wright et al. (2018)

Benefits of NIR



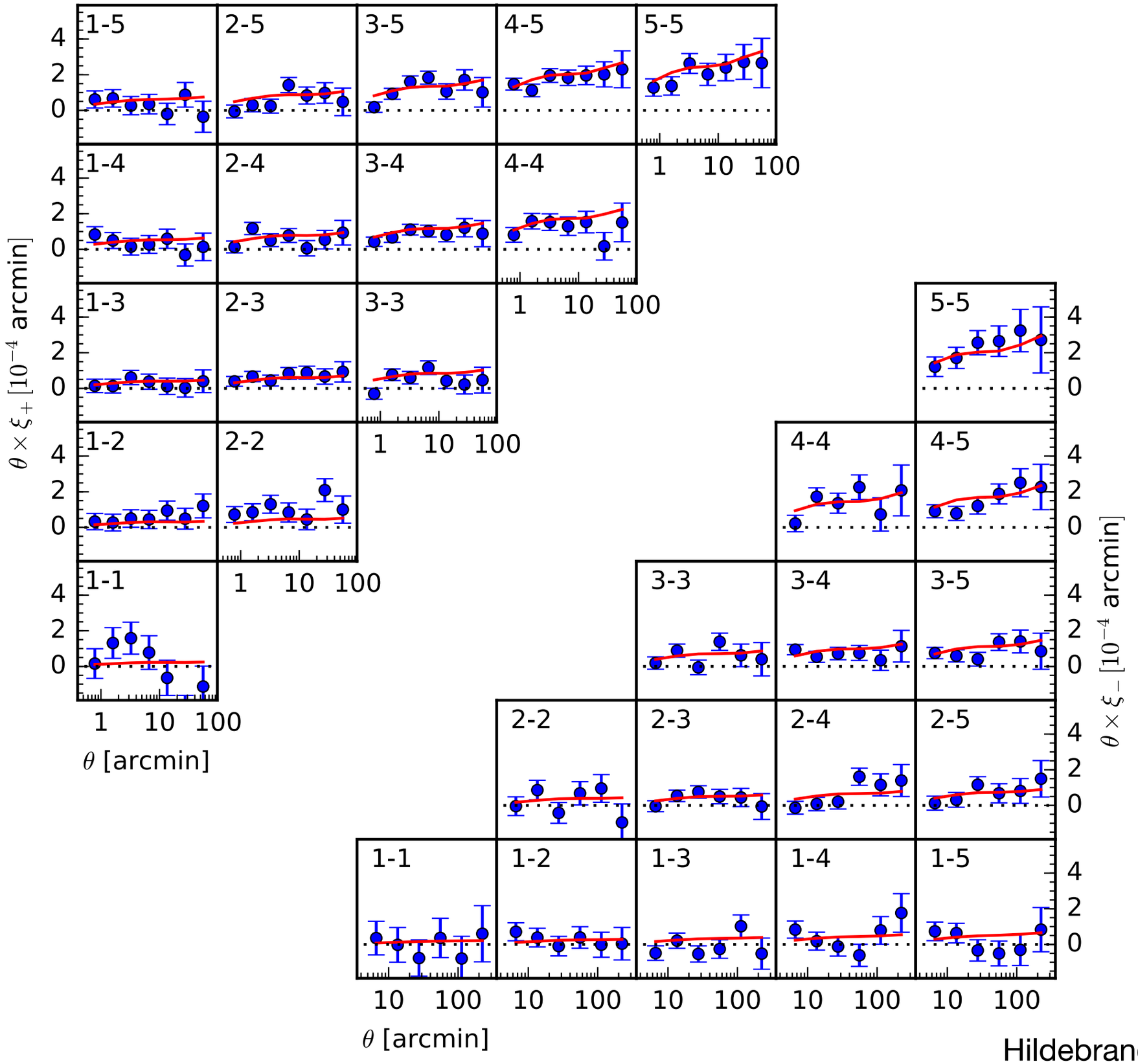
Wright et al. (2018)

Tomographic bins



Wright et al. (2018)

2-point shear corr. fct.



Hildebrandt et al. (2018)

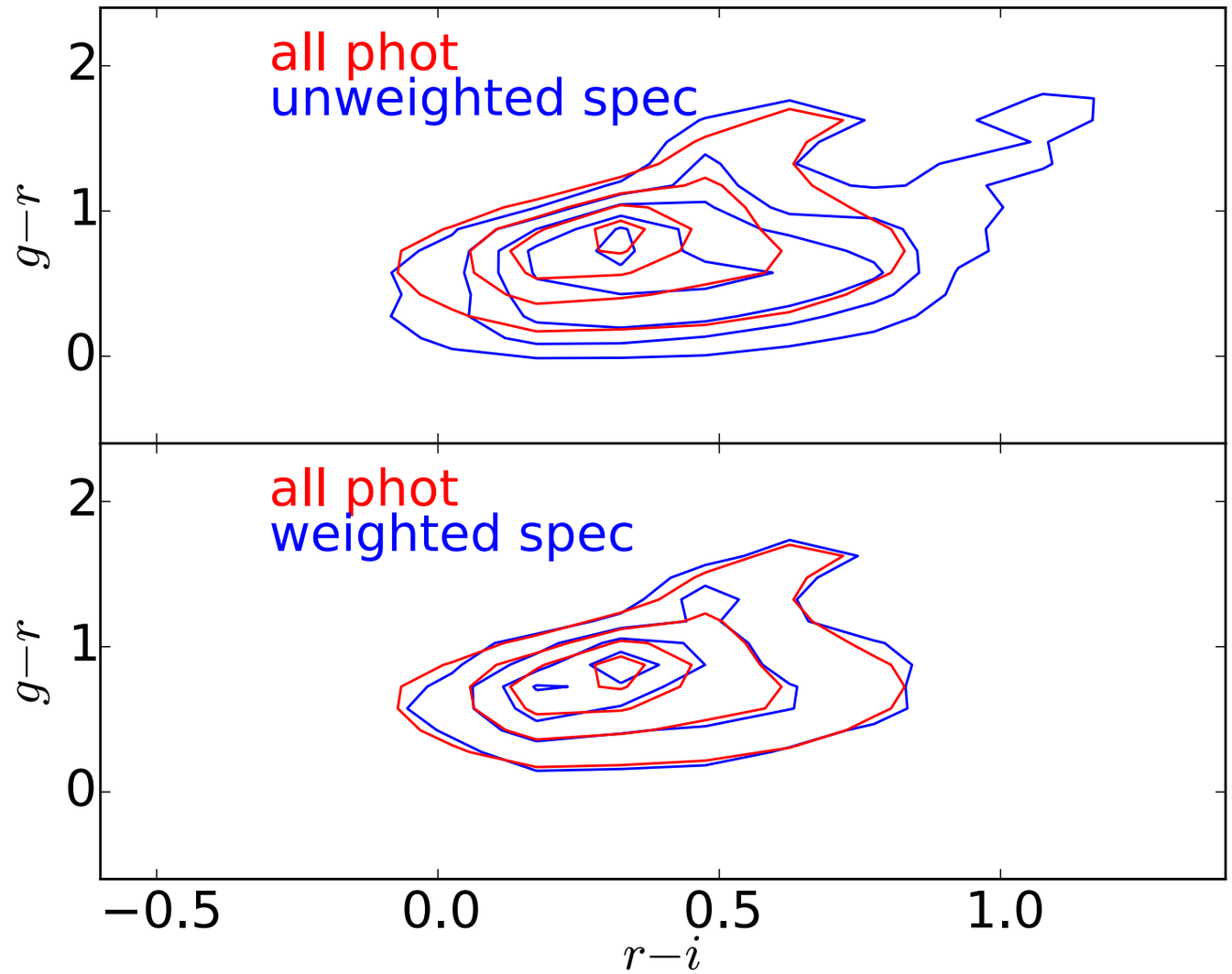
Spec-z calibration sample

Survey	Area [deg^2]	No. of spec-z	z-max	$r_{\rm lim}$	Used for
SDSS*	119.2	15564	0.7		CC/OQE
GAMA*	75.9	79756	0.4	19.8	CC/OQE
2dFLenS*	61.2	3914	0.8		CC/OQE
WiggleZ*	60.1	19968	1.1		CC/OQE
zCOSMOS	0.7	9930	1.0	24	CC/DIR
DEEP2	0.8	6919	1.5	24.5	CC/DIR
VVDS*	1.0	4688	1.3	25	CC/DIR
G15Deep*	1.0	1792	0.7	22	DIR
CDFS	0.1	2044	1.4	25	DIR

Hildebrandt et al. (2018)

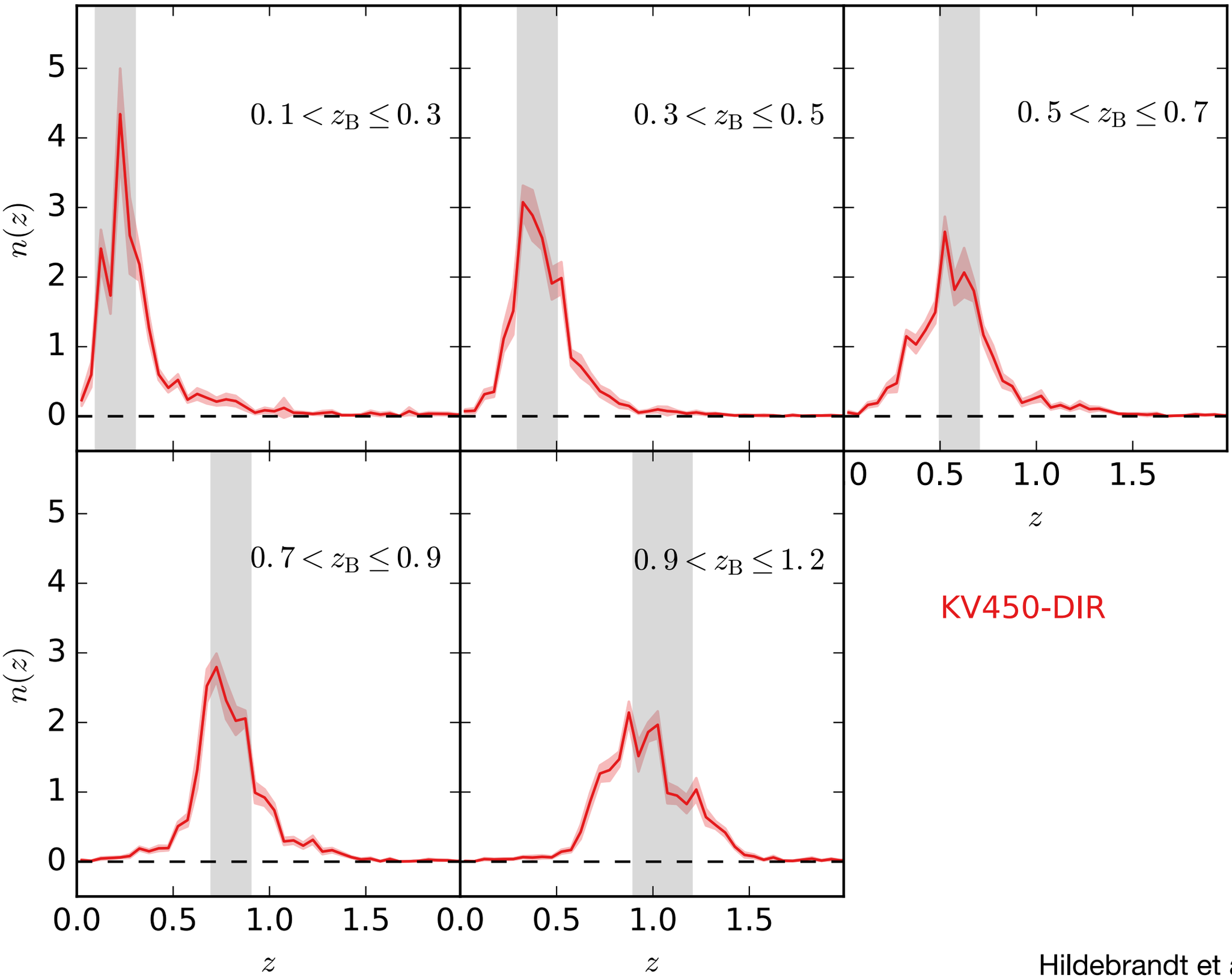
Direct photo-z calibration

- Re-weight spec-z surveys to be more representative (Lima et al. 2008)
- Only works if:
  - Magnitude space is fully covered (*r*<~24; C3R2).
  - Unique relation between magnitudes and redshifts (VIKING).



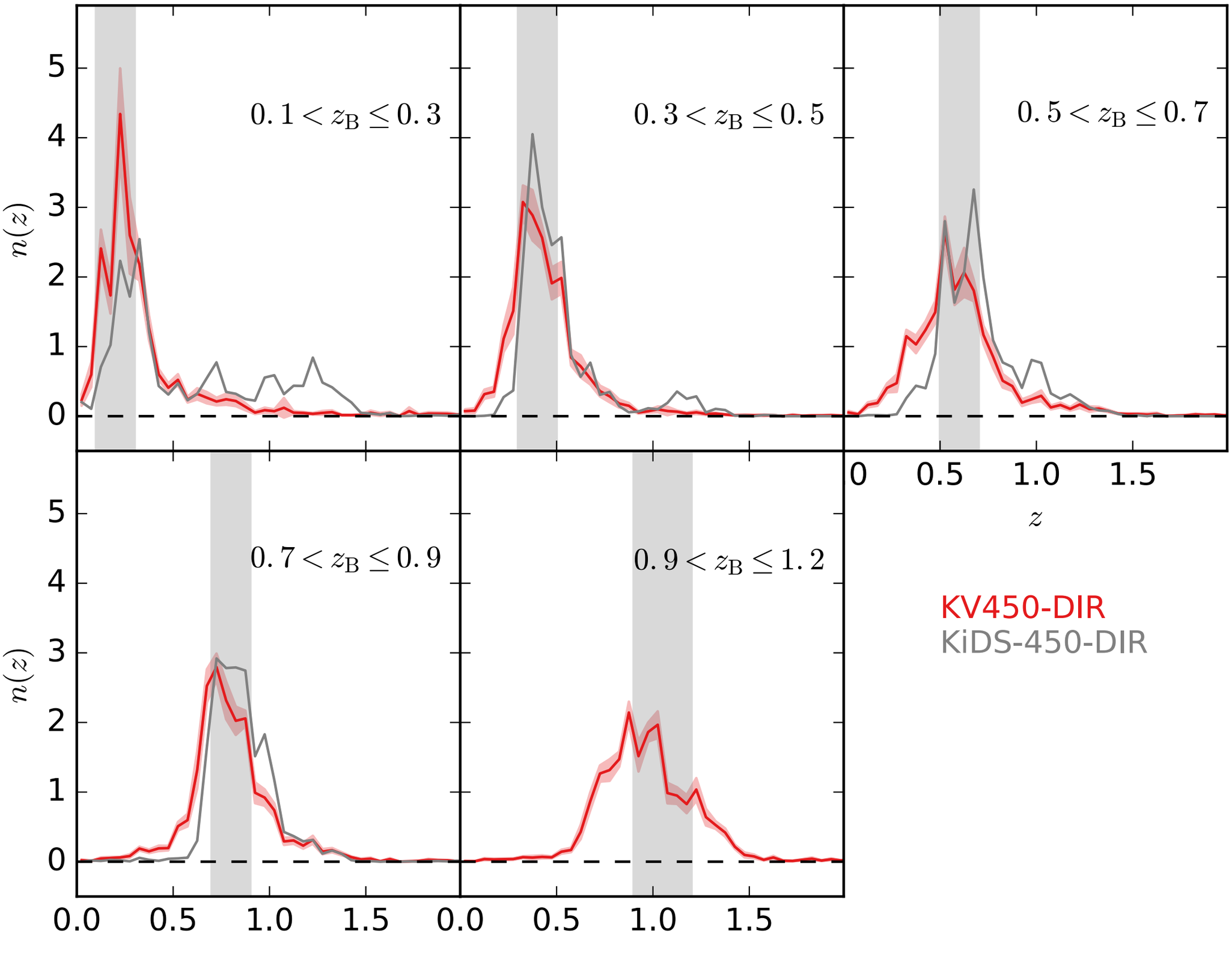
Hildebrandt et al. (2017)

KV450 - *n(z)*



Hildebrandt et al. (2018)

KV450 - *n(z)*



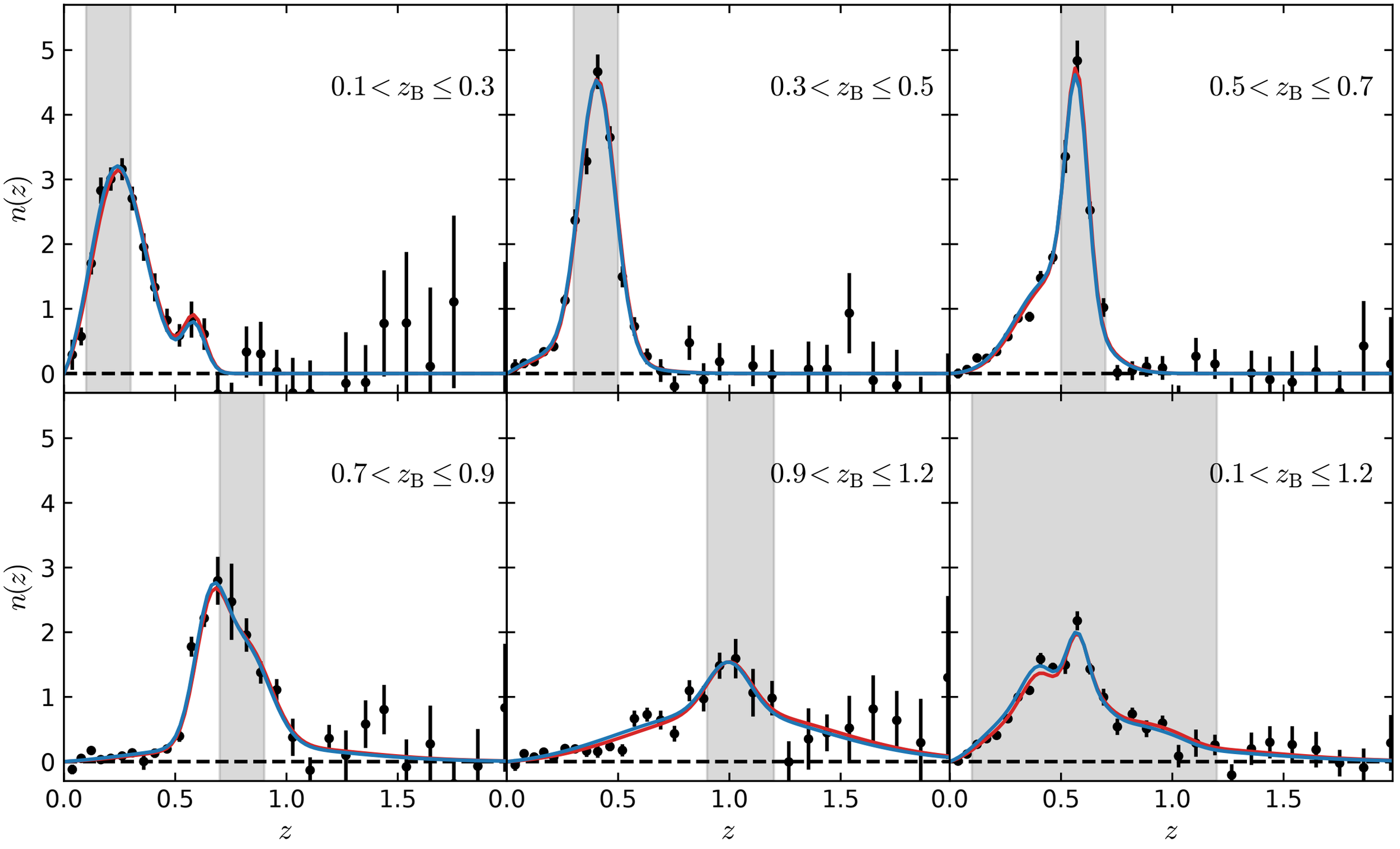
Hildebrandt et al. (2018)

Tomographic bins

Bin	z_B range	No. of objects	$n_{\rm eff}$ H12 [arcmin^{-2}]	σ_ϵ	$\langle z_{\rm DIR} \rangle$
1	$0.1 < z_B \leq 0.3$	1 253 582	0.88	0.282	0.399 ± 0.039
2	$0.3 < z_B \leq 0.5$	1 985 201	1.33	0.281	0.490 ± 0.023
3	$0.5 < z_B \leq 0.7$	3 450 970	2.04	0.291	0.669 ± 0.026
4	$0.7 < z_B \leq 0.9$	2 792 105	1.49	0.287	0.834 ± 0.012
5	$0.9 < z_B \leq 1.2$	2 444 597	1.26	0.297	1.002 ± 0.011
all	$0.1 < z_B \leq 1.2$	11 926 455	6.93	0.288	0.713 ± 0.027

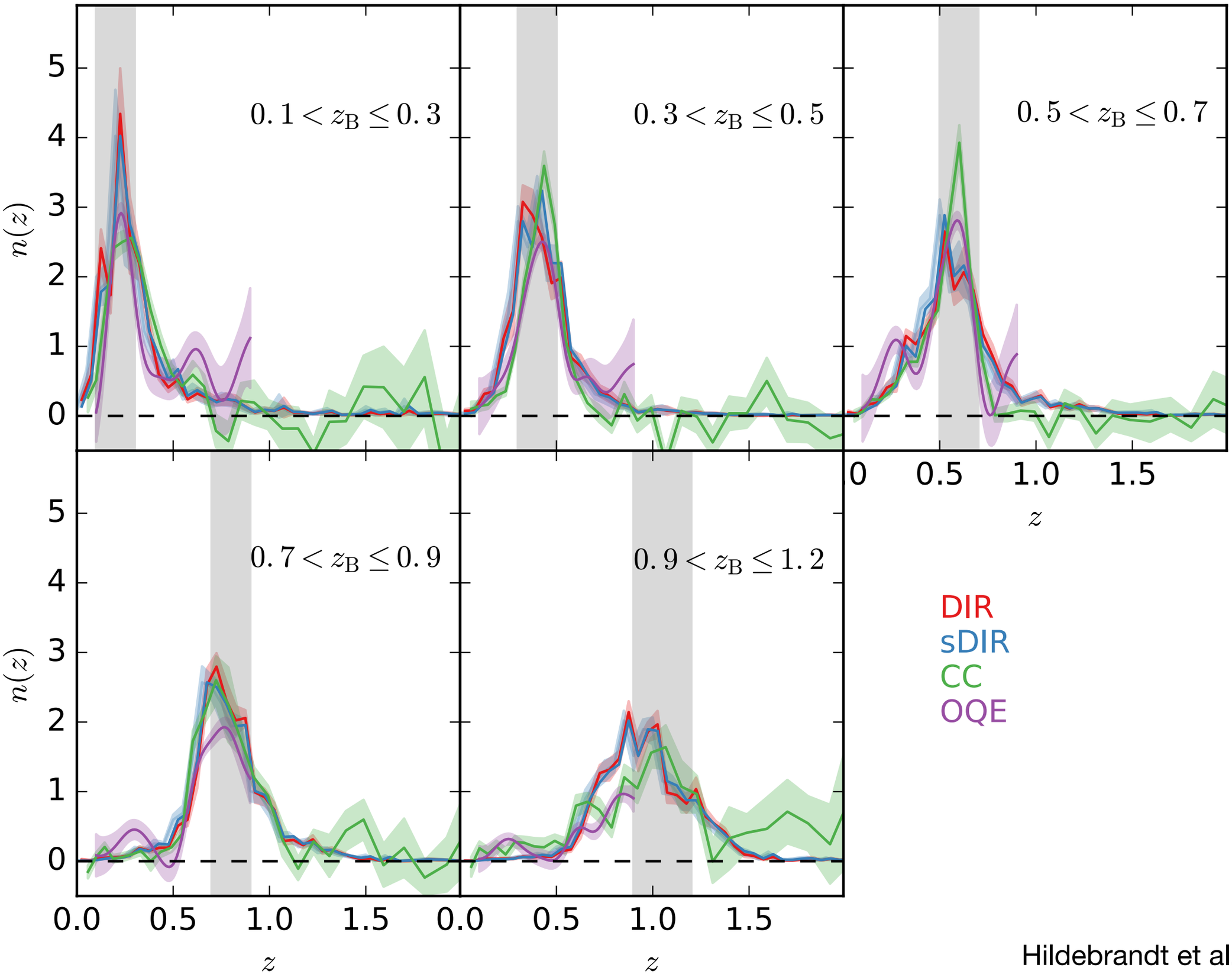
Hildebrandt et al. (2018)

KV450 clustering-z



Hildebrandt et al. (2018)

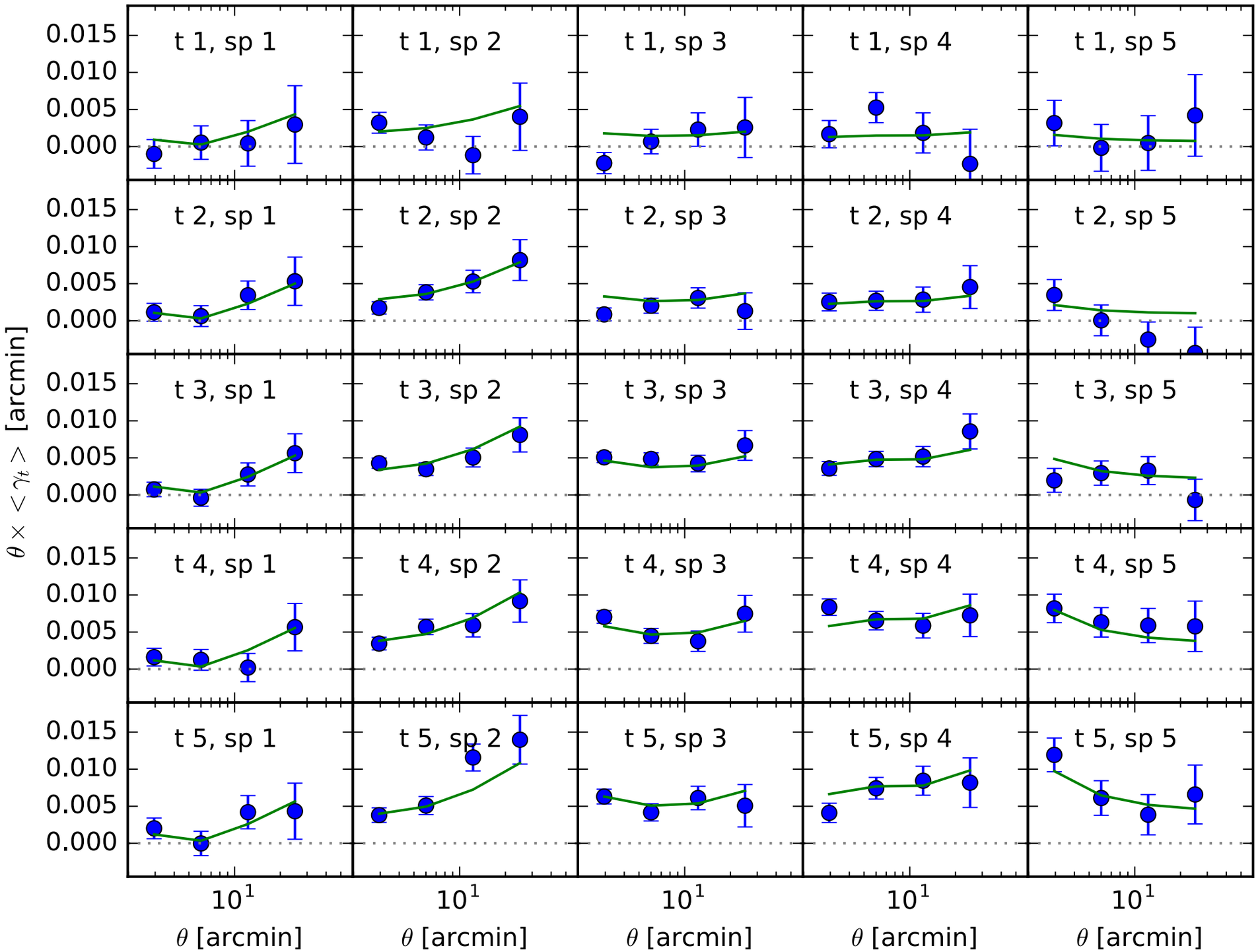
KV450 *n(z)*



Hildebrandt et al. (2018)

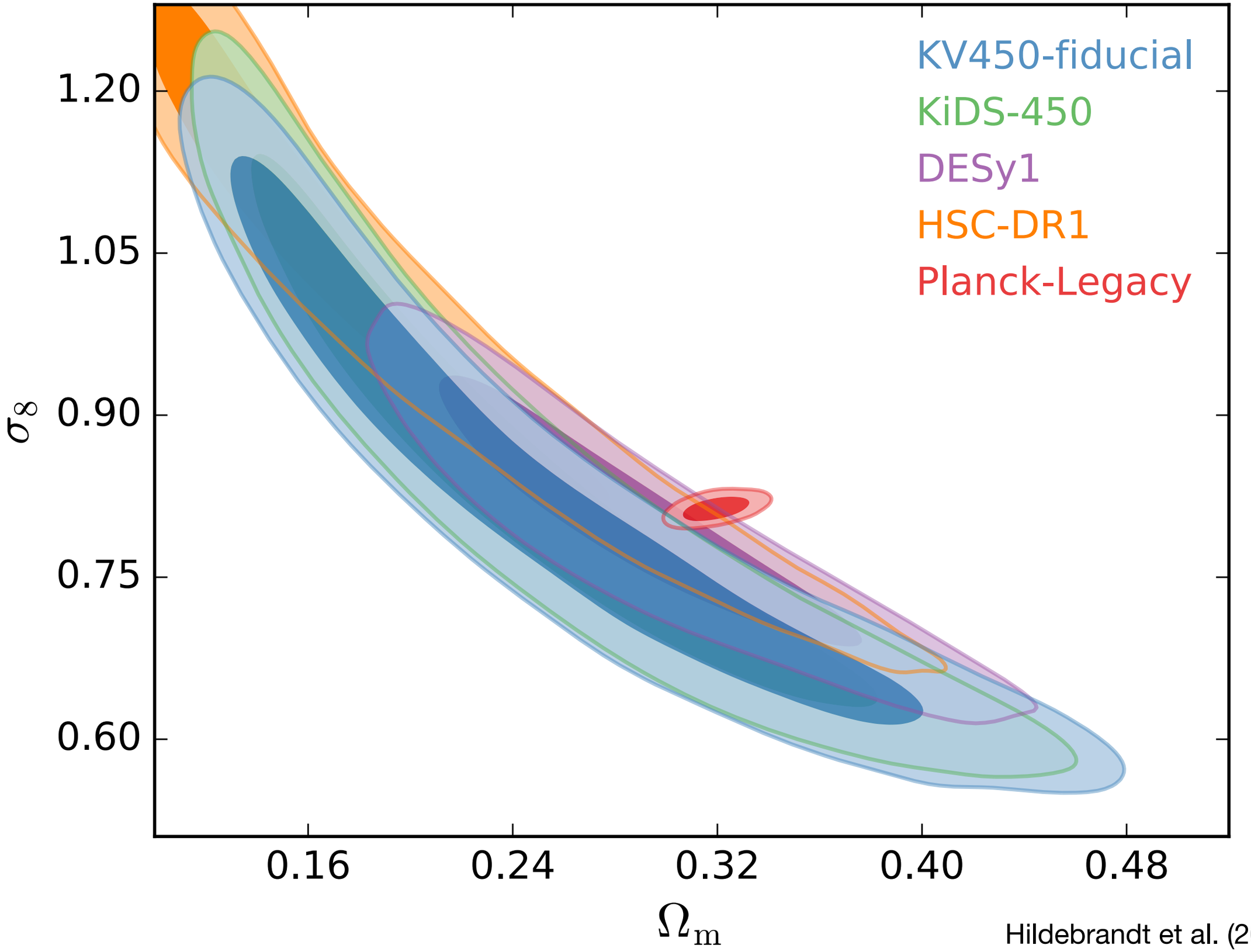
KV450 shear ratio test

GAMA lenses, KV450 sources, χ^2/dof=1.05, p=35.3%



Hildebrandt et al. (2018)

Cosmological constraints



Hildebrandt et al. (2018)

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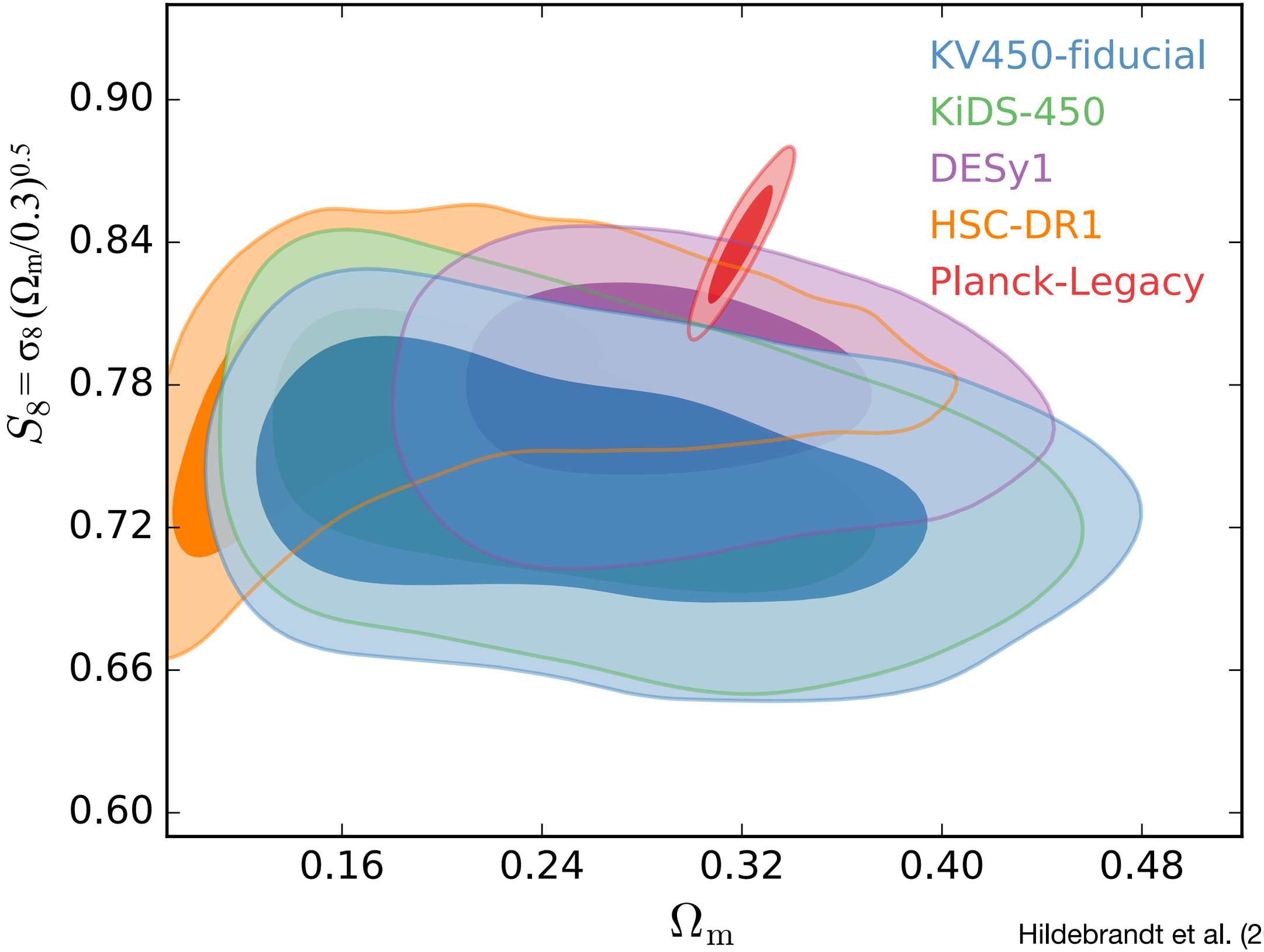
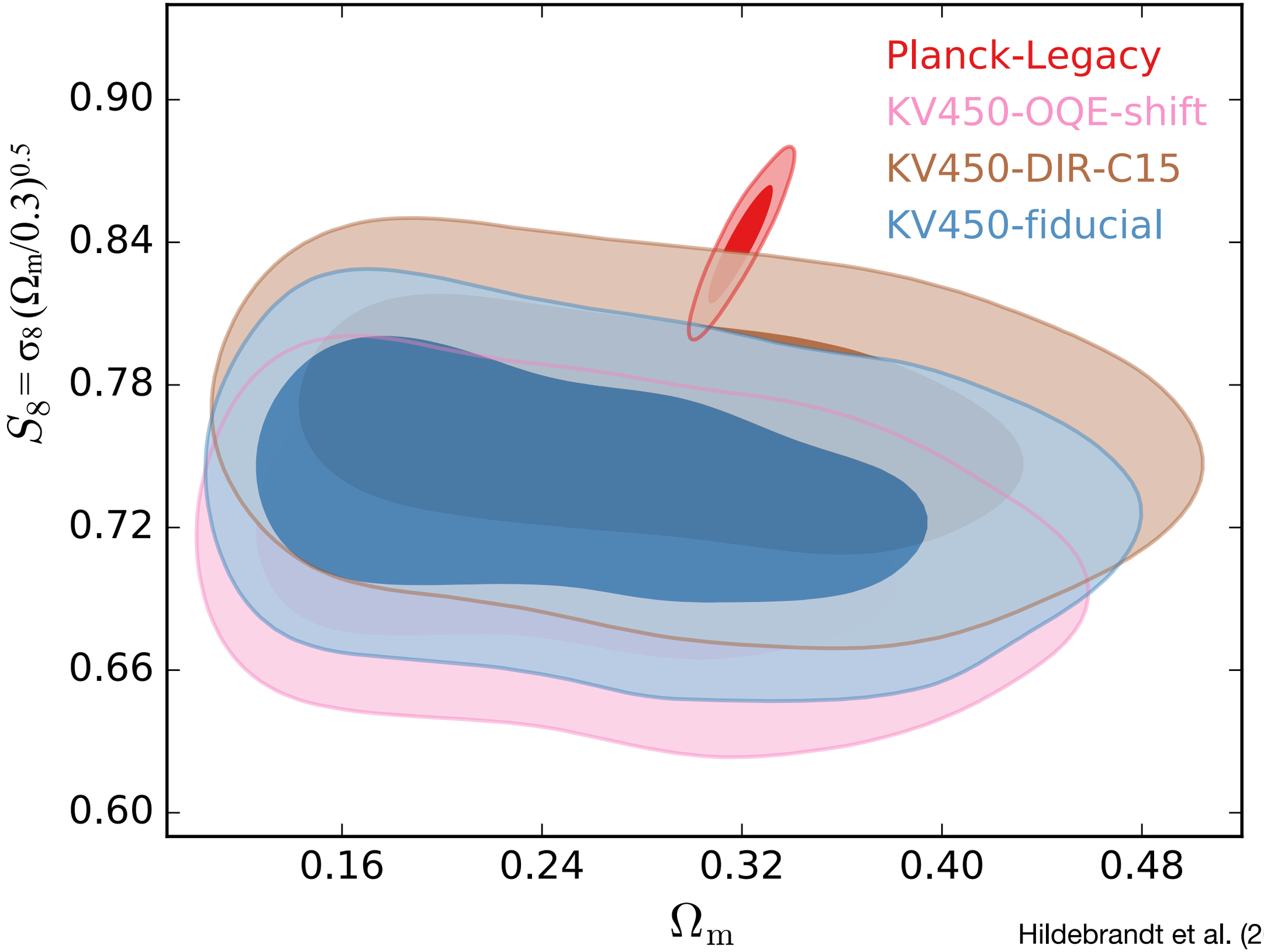


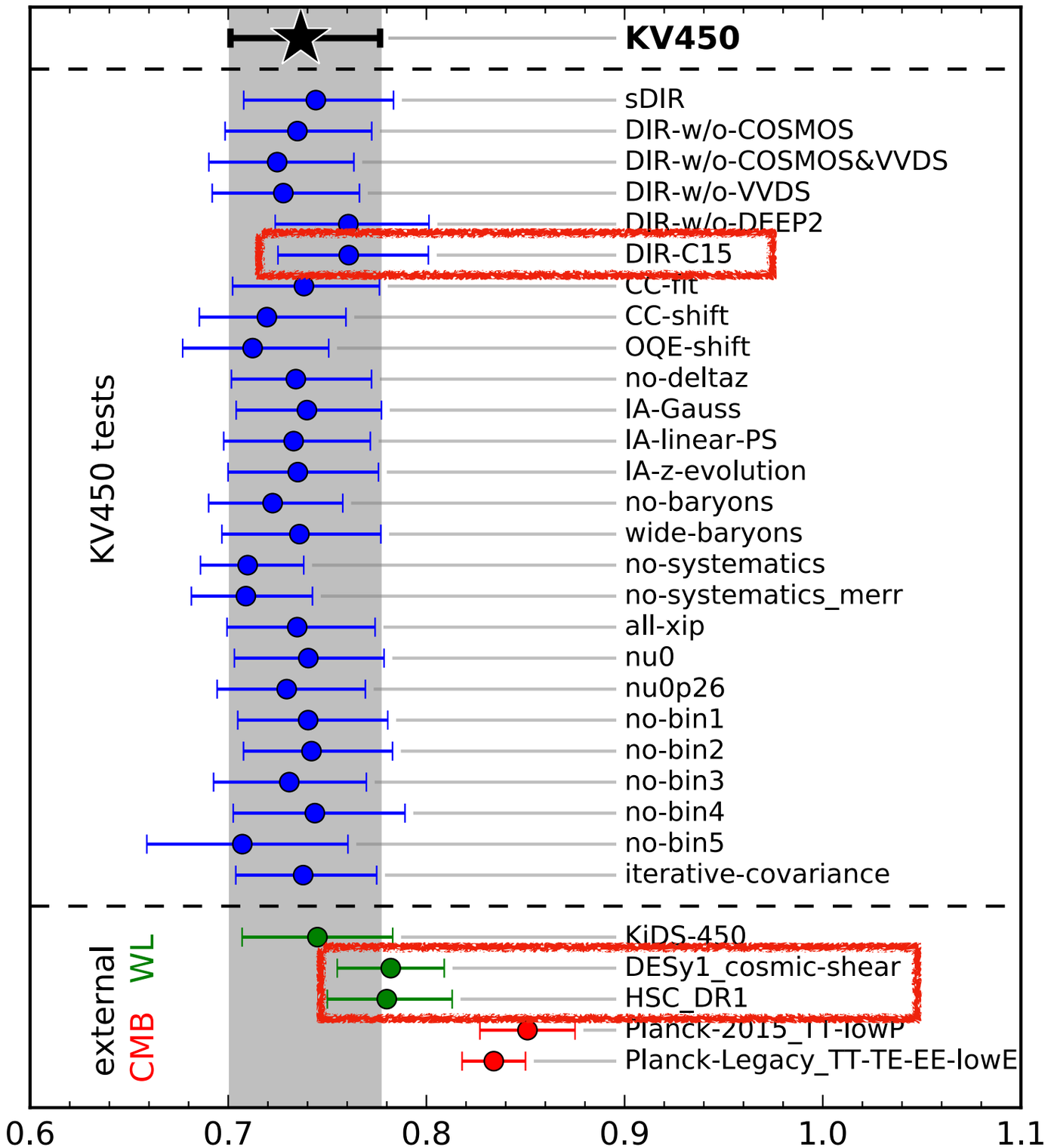
Hildebrandt et al. (2018)

Cosmological constraints



Hildebrandt et al. (2018)

S_8 posterior



$$S_8 \equiv \sigma_8 \sqrt{\Omega_\mathrm{m}/0.3}$$

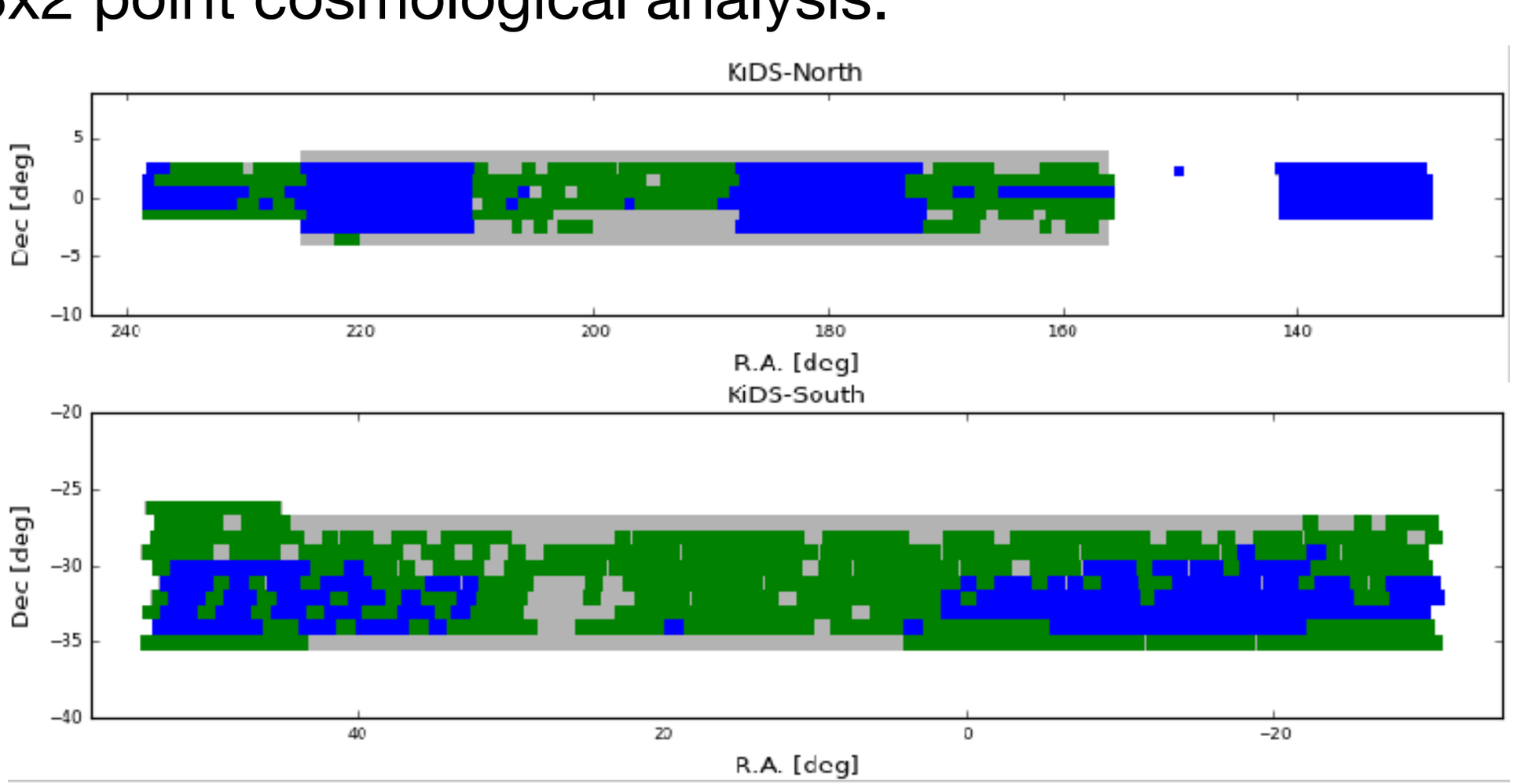
Hildebrandt et al. (2018)

KV450 other improvements

- Covariance with more realistic shape noise -> better χ^2
- More realistic image simulations
- New priors for IA and baryon feedback
- Pre-defined data splits (à la Efstathiou & Lemos 2018)

KiDS-1000

- More than 1000deg^2 released to ESO.
- Improved 9-band photometry.
- Running new lensfit version. Calibration with **KiDZ**.
- 3x2 point cosmological analysis.



Summary & Outlook

- Added VIKING NIR data to KiDS optical data.
- More robust analysis with extensive spec-*z* calibration.
- Tension with Planck persists in KiDS+VIKING-450.
  Systematics? New physics? Evolving dark energy?
- Indications for bias through COSMOS-2015 photo-*z*.
- Very exciting times: Work started on 1000deg^2 analyses.
  Survey completion (1350deg^2) in spring 2019.
  Perfect dress-rehearsal for Euclid.

Survey progress as of today