Seeing the dark with Cosmic shear

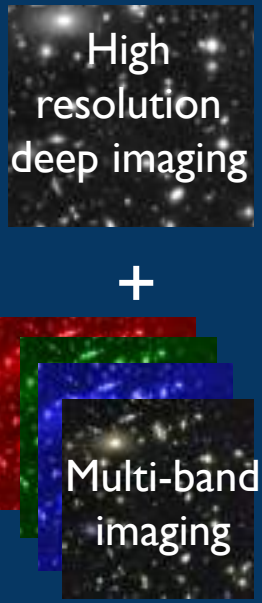
Marika Asgari

University of Hull

Gravitational Lensing and cosmic shear

Image Credit: Ruhr-Universität Bochum

Cosmic shear analysis in practice


High resolution deep imaging
+
Multi-band imaging

+

Catalogue

+

Catalogue

Galaxy
Shapes

Galaxy
redshifts

+

Catalogue

Galaxy Shapes

Calibrate!!!

Galaxy redshifts

+

Catalogue

Galaxy Shapes

Galaxy redshifts

Calibrate!!!

Signal

Divide the galaxies

+

Catalogue

Galaxy Shapes

Galaxy redshifts

Calibrate!!!

Signal

Divide the galaxies

Cosmological model

+

Catalogue

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Galaxy redshifts

Calibrate!!!

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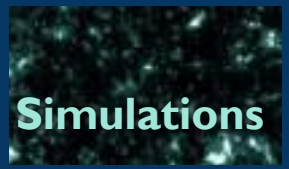
Divide the galaxies

Cosmological model



+

Catalogue

Galaxy Shapes

Galaxy redshifts

Calibrate!!!

Signal

Divide the galaxies

Cosmological model

Analytical Models

Simulations

Modelled signal and error

+

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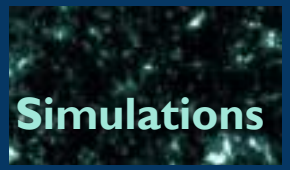

Modelled signal and error

+

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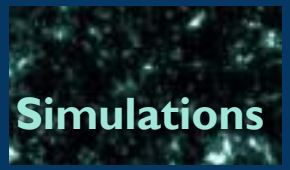
Cosmological model



Modelled signal and error

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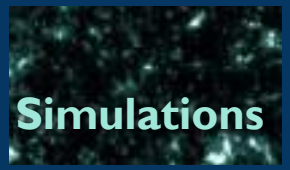
Blinding !

Cosmological model



Modelled signal and error

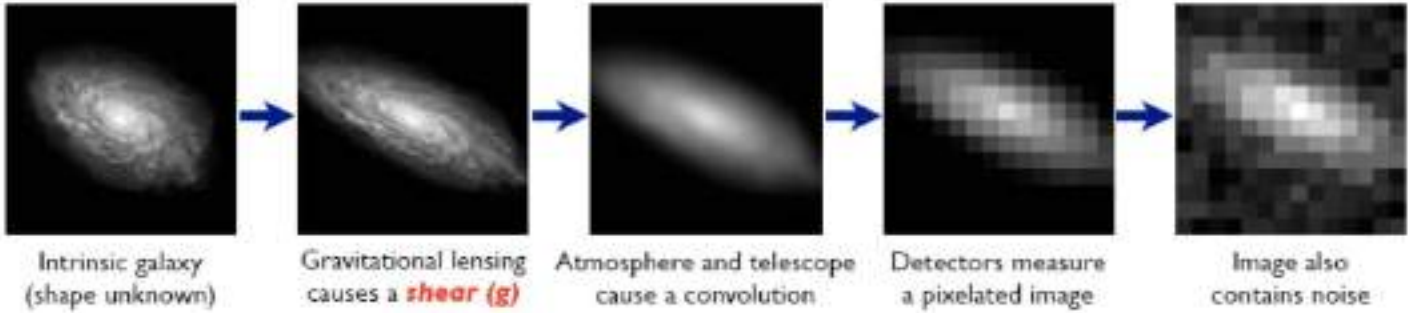
Shape measurement

Typically much weaker than this

Blending!

etc!

Needs calibration → image simulations



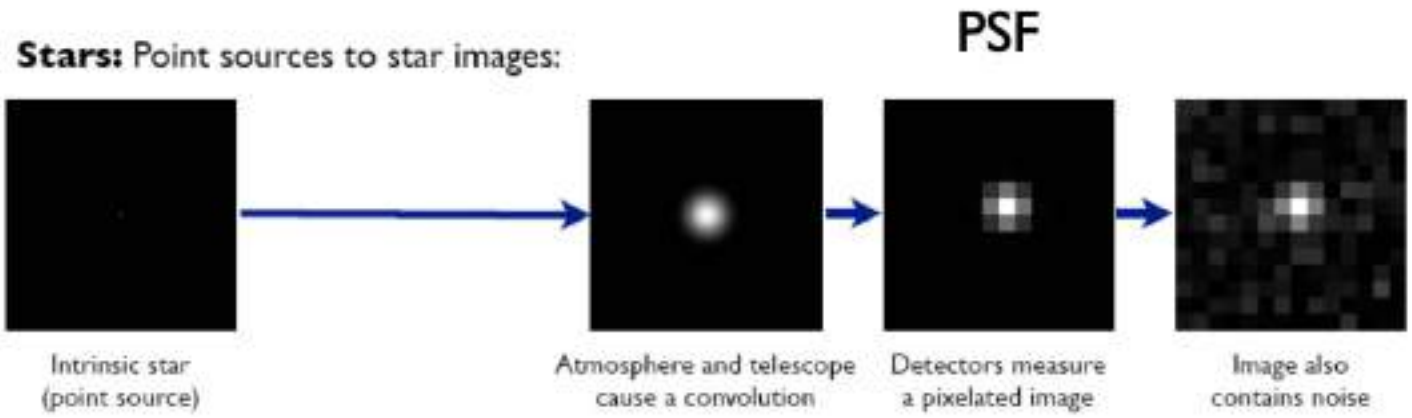
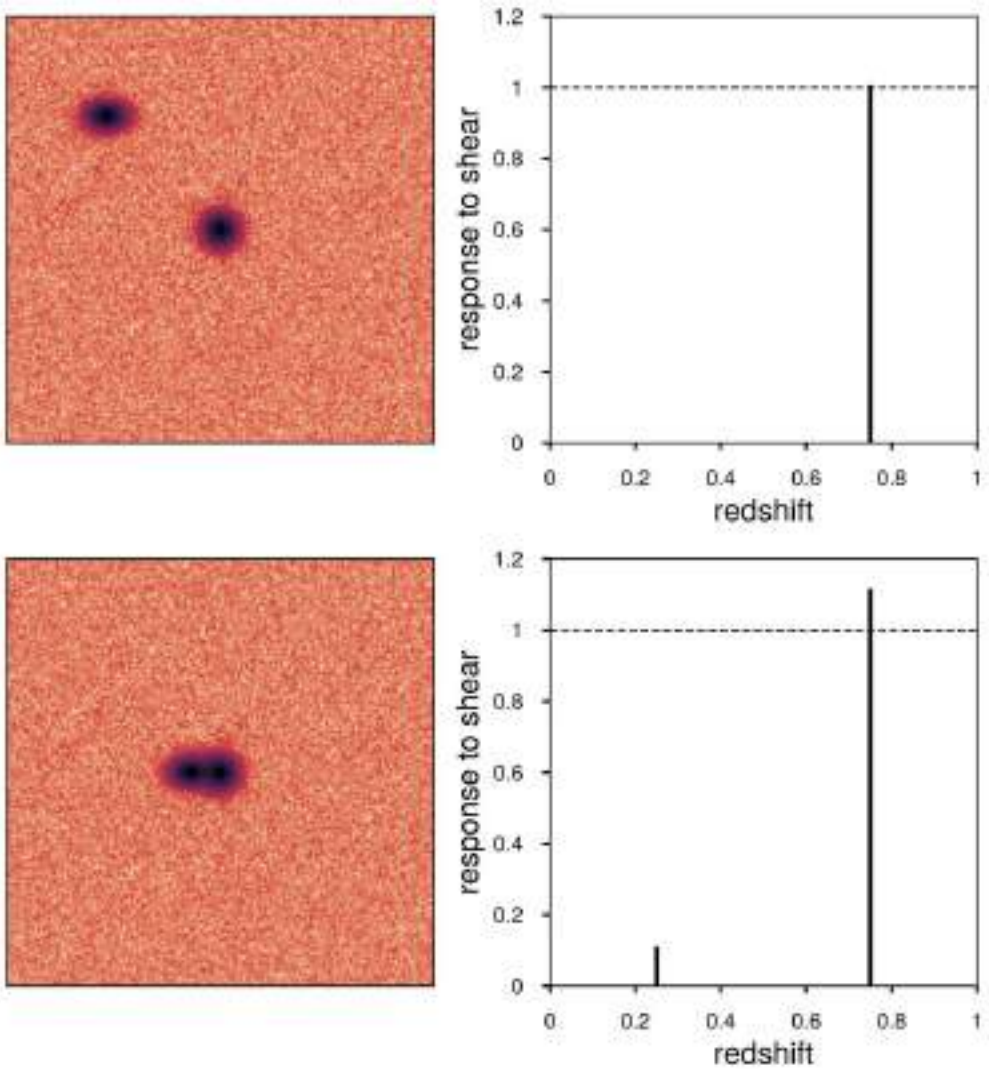


Image credit: Catherine Heymans

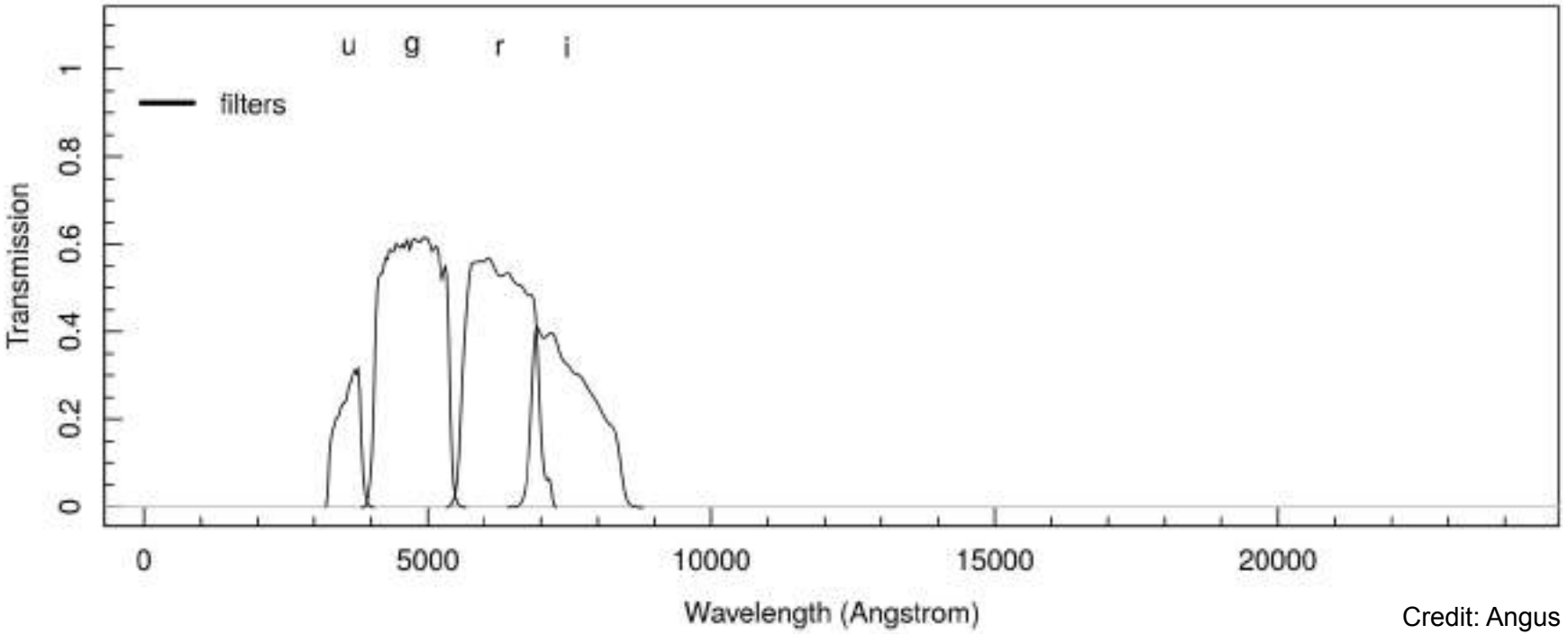
Blending

Image simulations are essential!



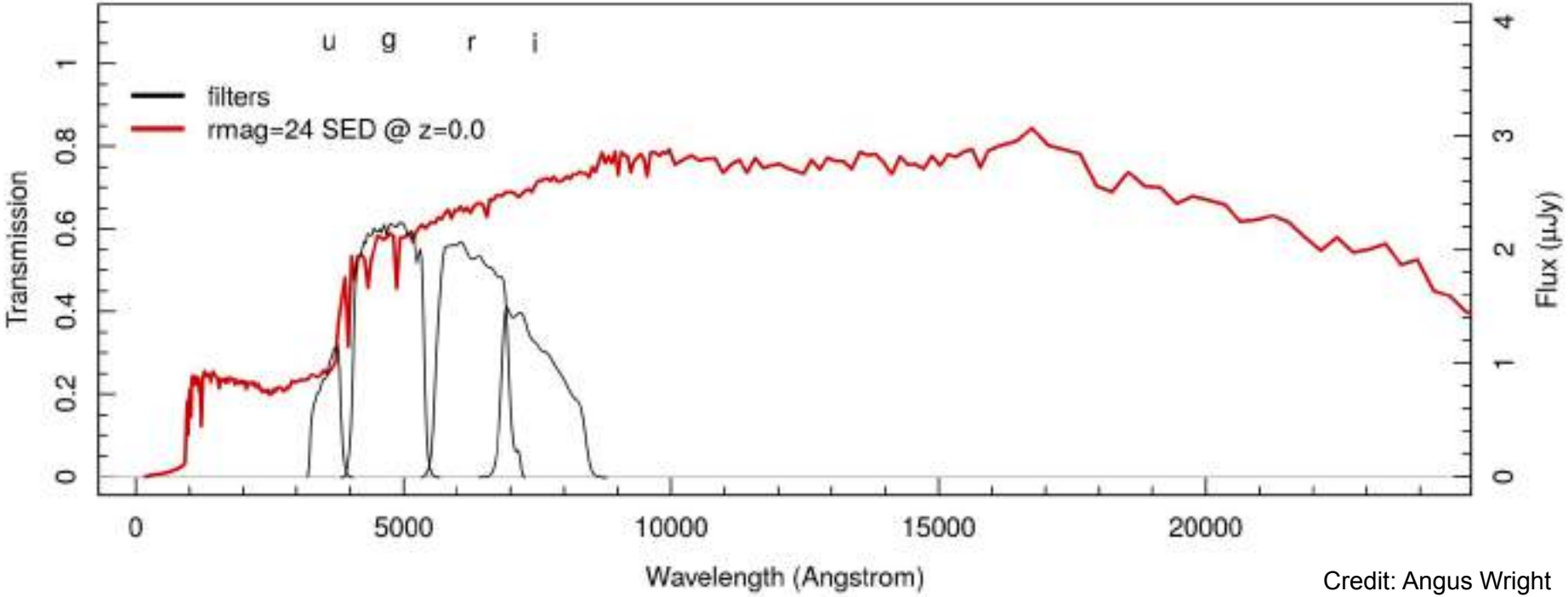
MacCrann et al. (2022)

Photometric Redshifts



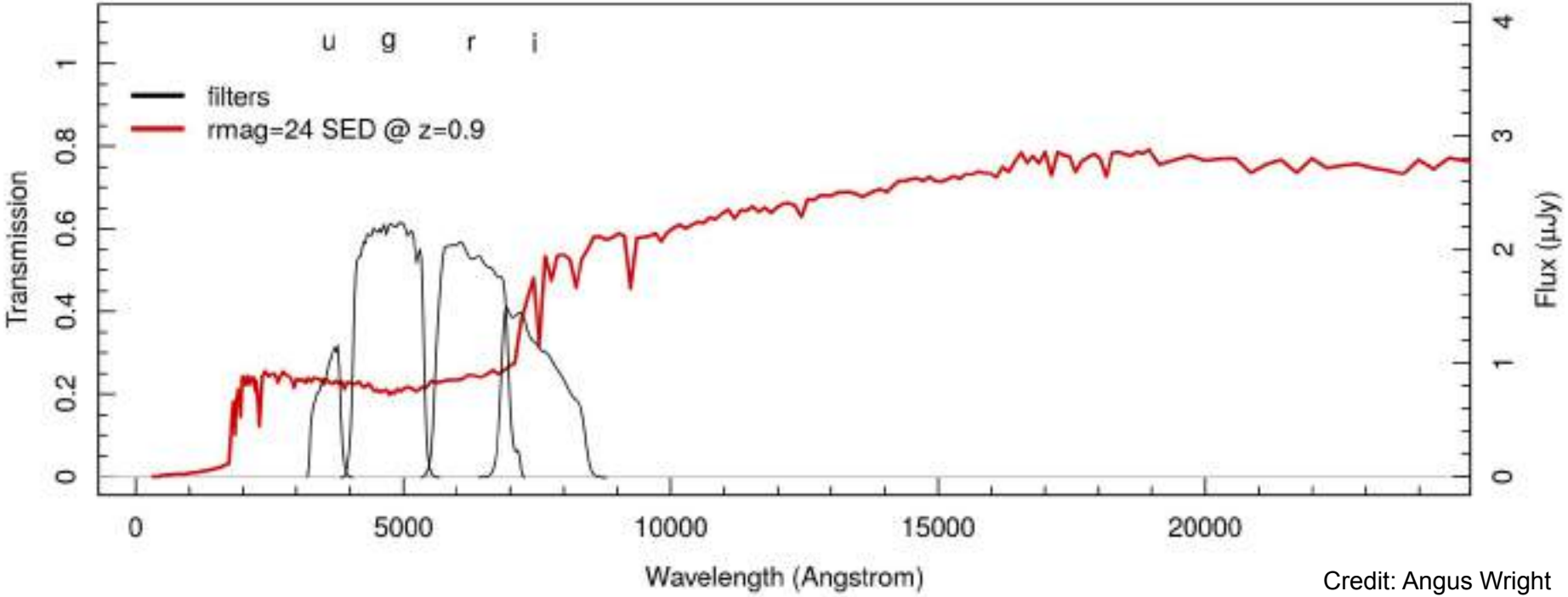
Credit: Angus Wright

Photometric Redshifts



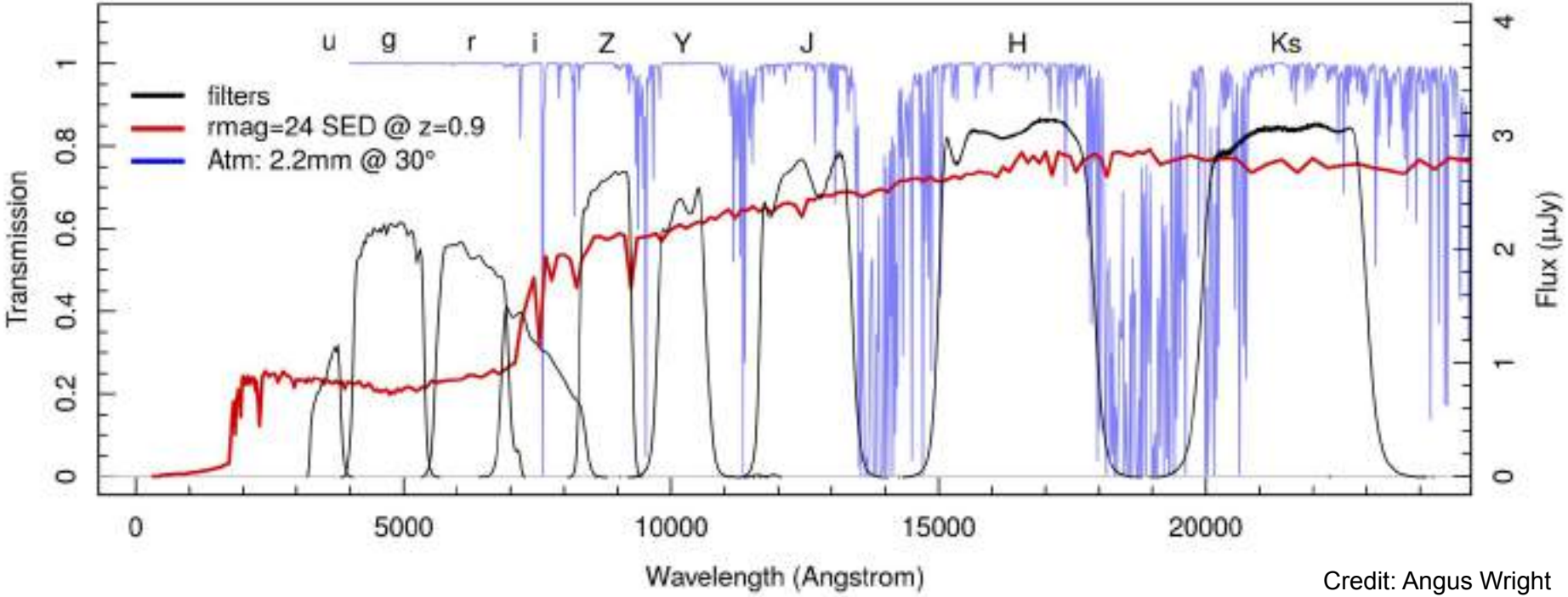
Credit: Angus Wright

Photometric Redshifts



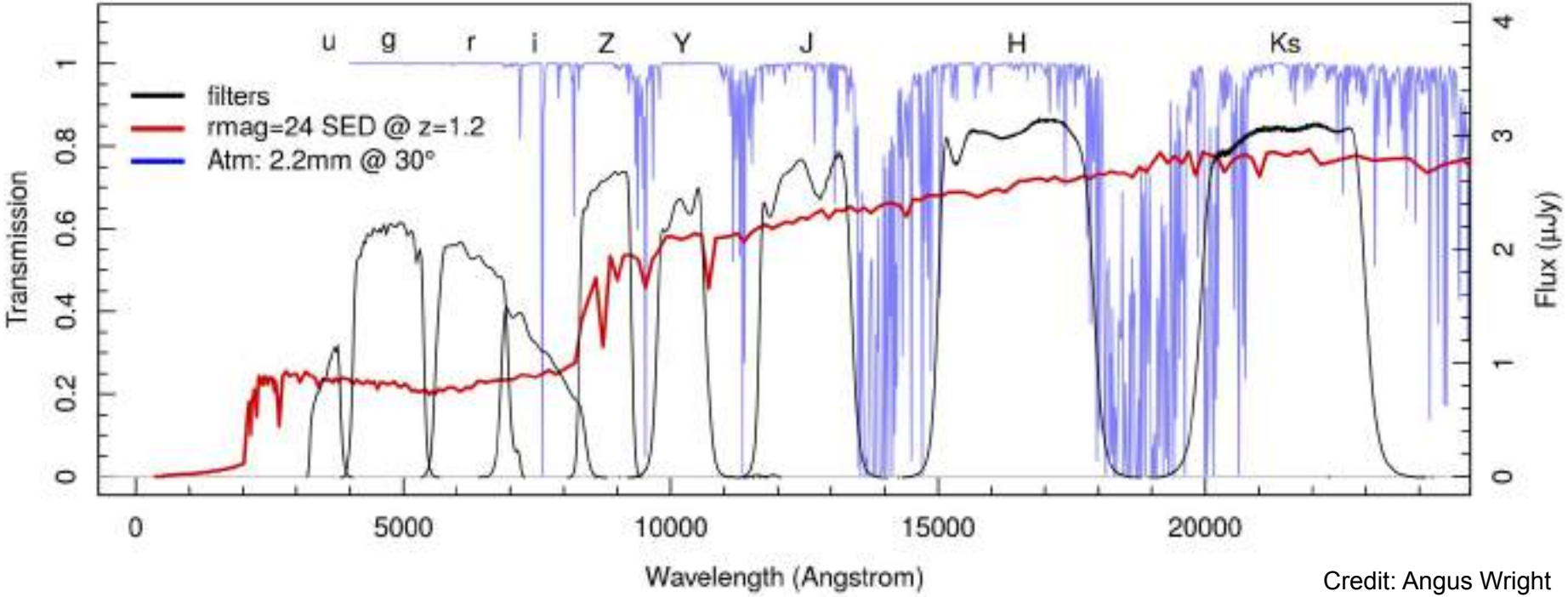
Credit: Angus Wright

Photometric Redshifts



Credit: Angus Wright

Photometric Redshifts

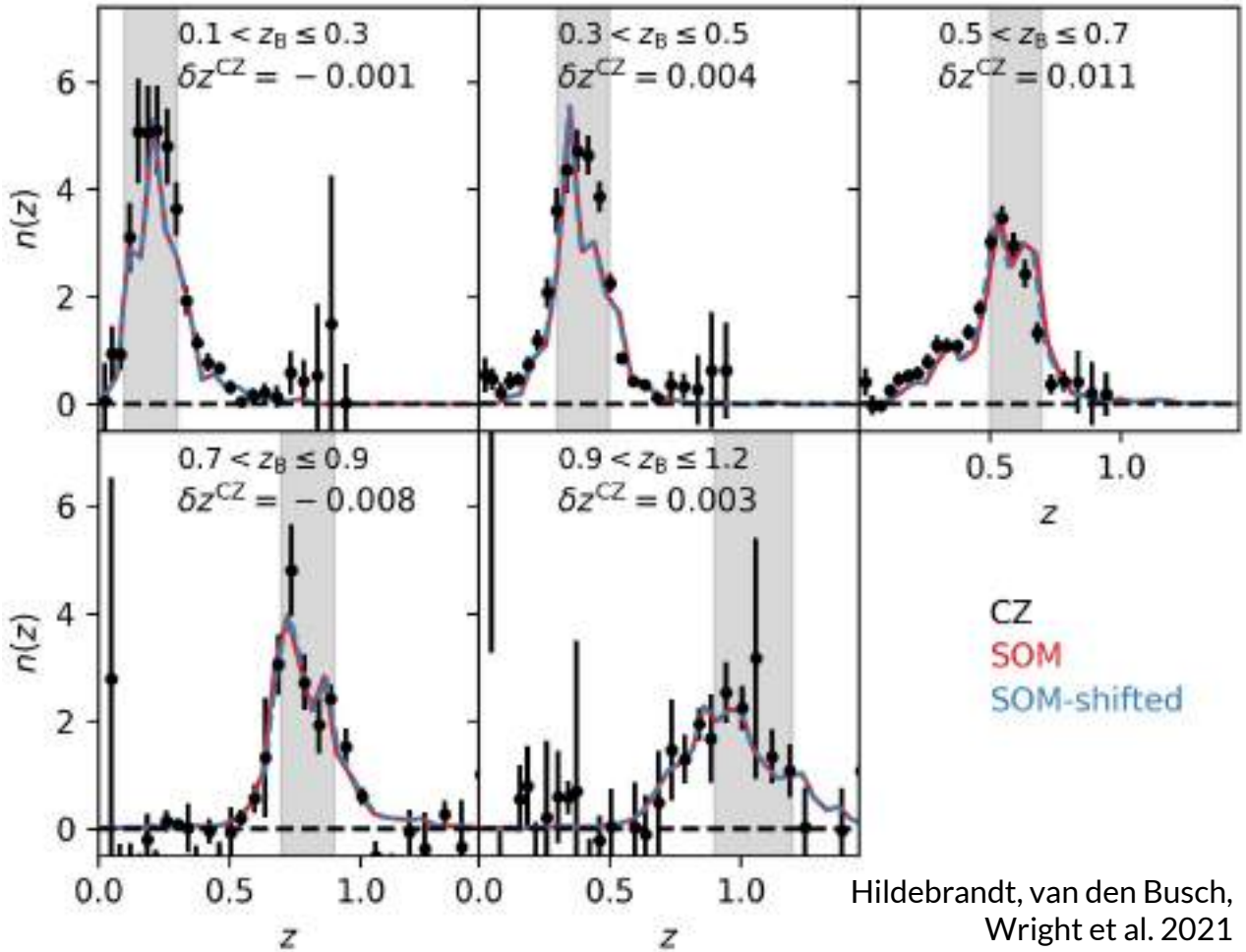


Credit: Angus Wright

Photometric Redshift Calibration

Use spec-z to calibrate photo-z

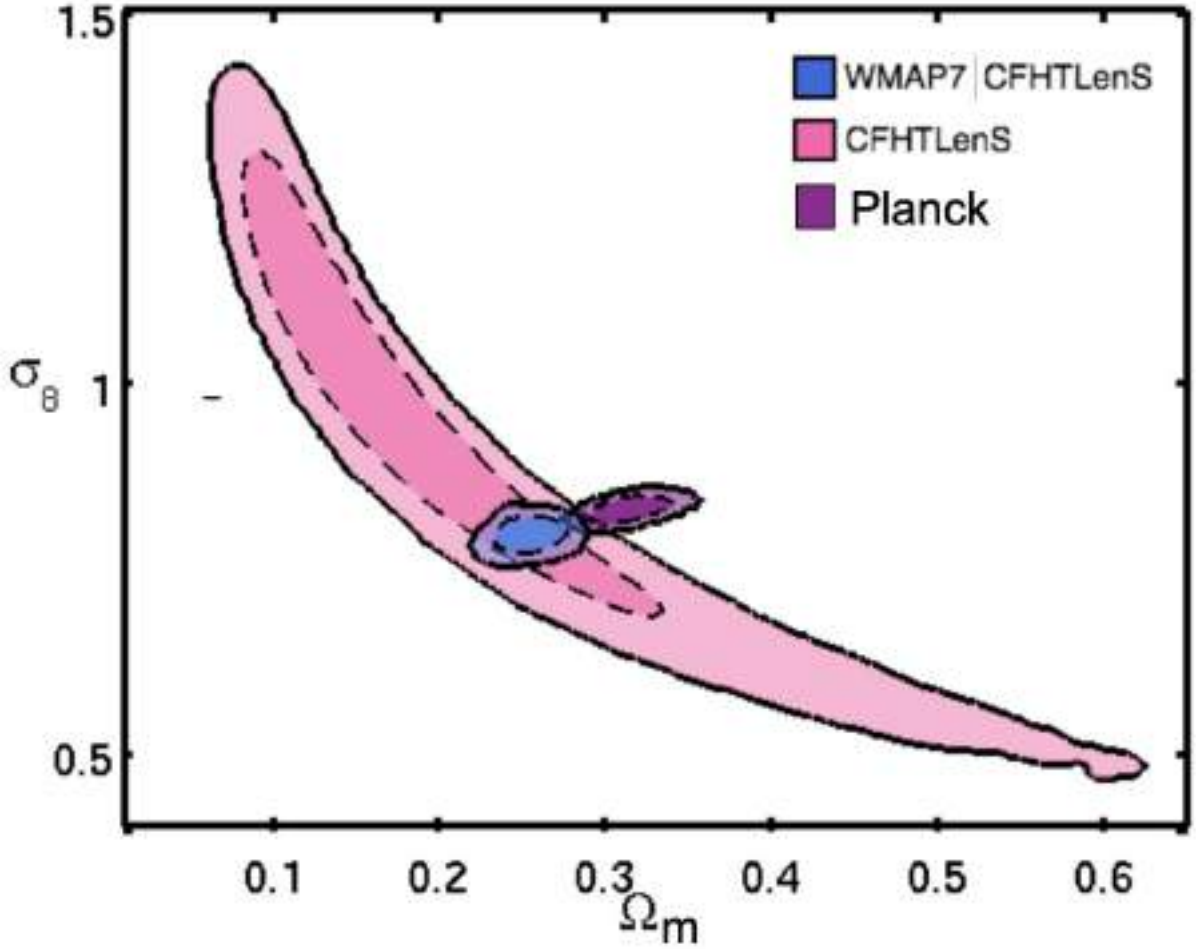
- ML methods, e.g. Self Organising Maps
- Cross-correlations: Clustering-z



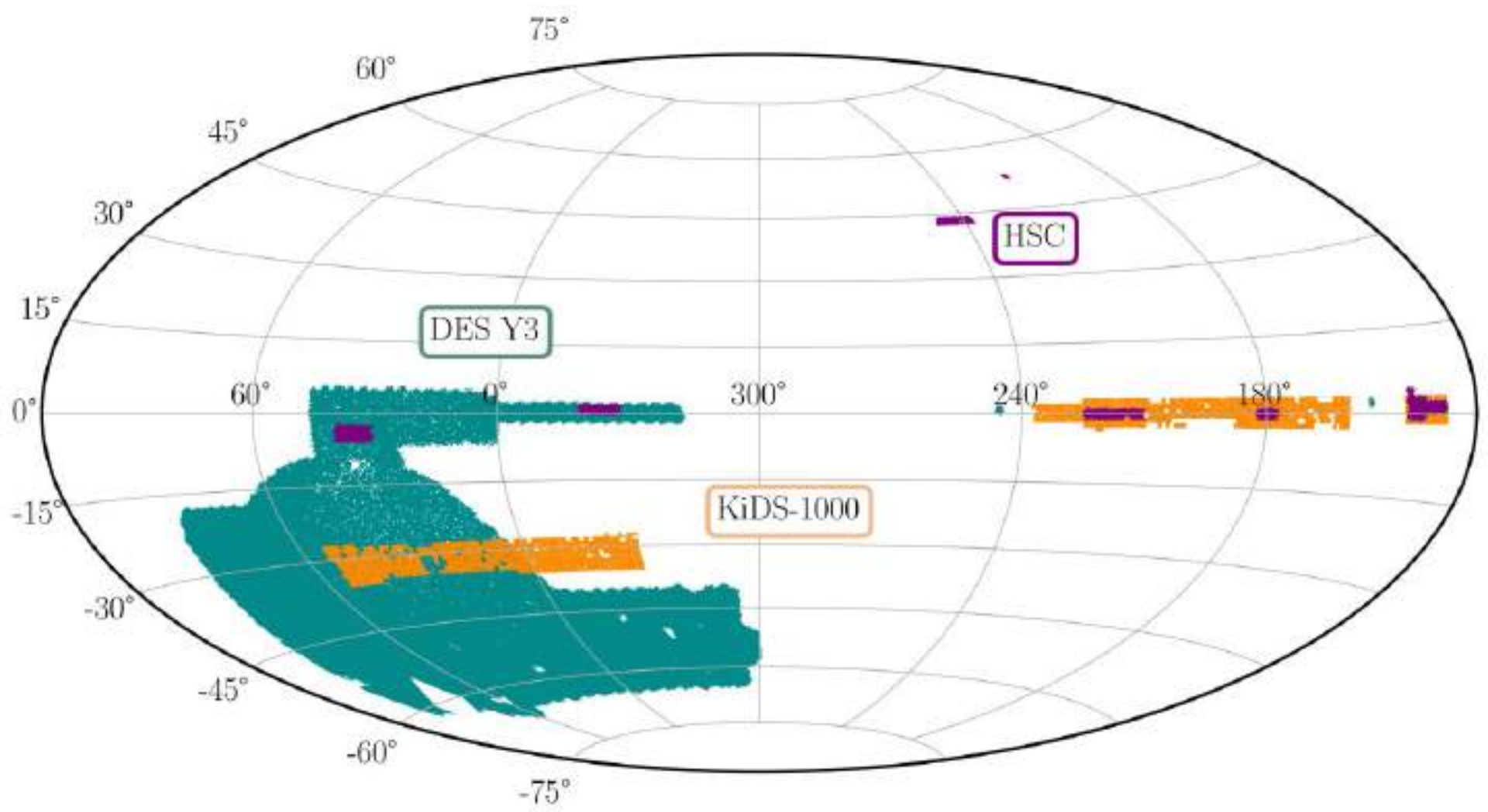
Hildebrandt, van den Busch, Wright et al. 2021

A History in Tension: CFHTLenS vs Planck

- From Ripples in the cosmos: http://astro.dur.ac.uk/ripples/programme.php

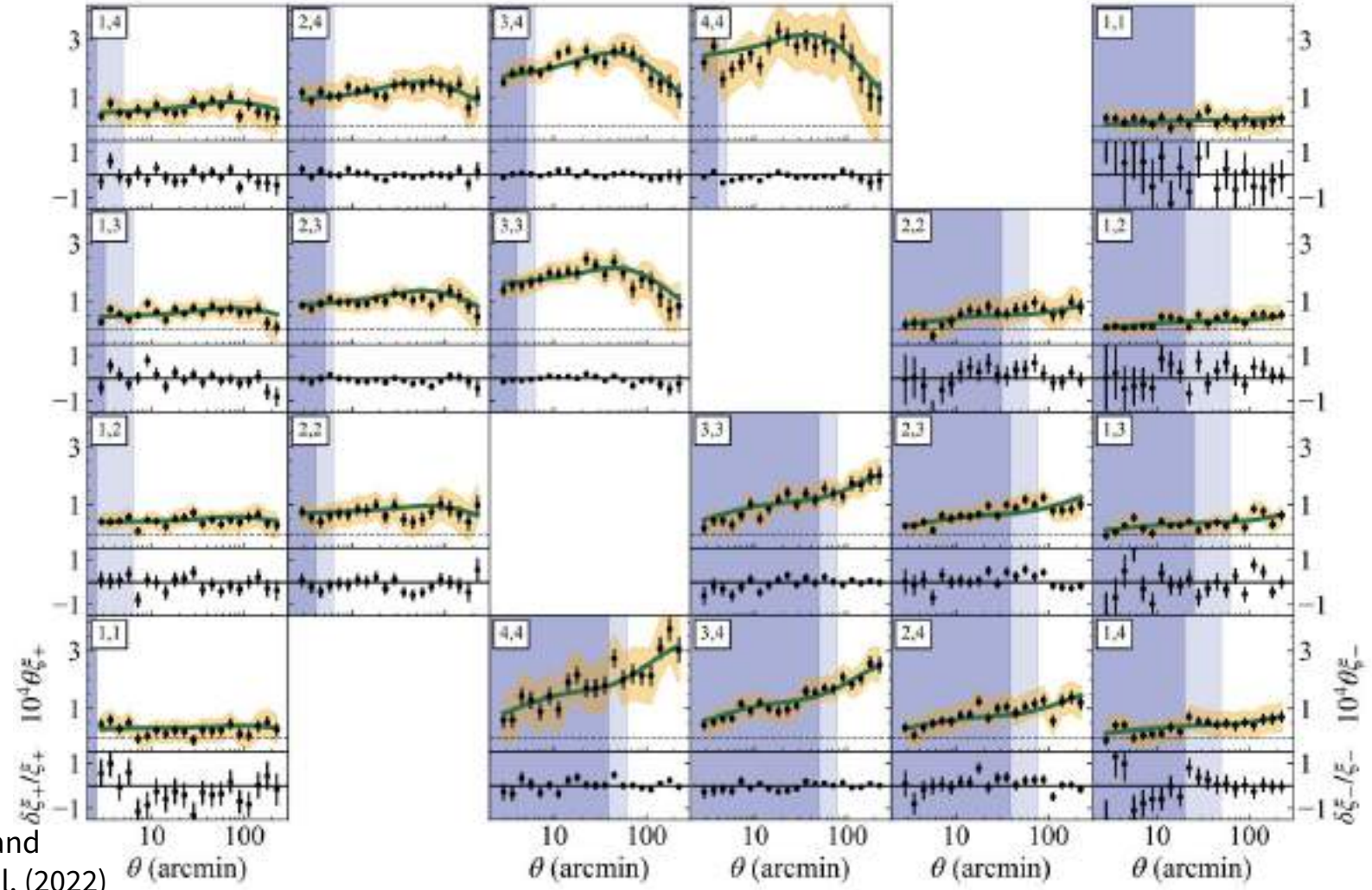


Heymans et al. (2013)


75°
60°
45°
30°
15°
0°
-15°
-30°
-45°
-60°
-75°
60°
0°
300°
240°
180°
HSC
DES Y3
KiDS-1000

2PCFs

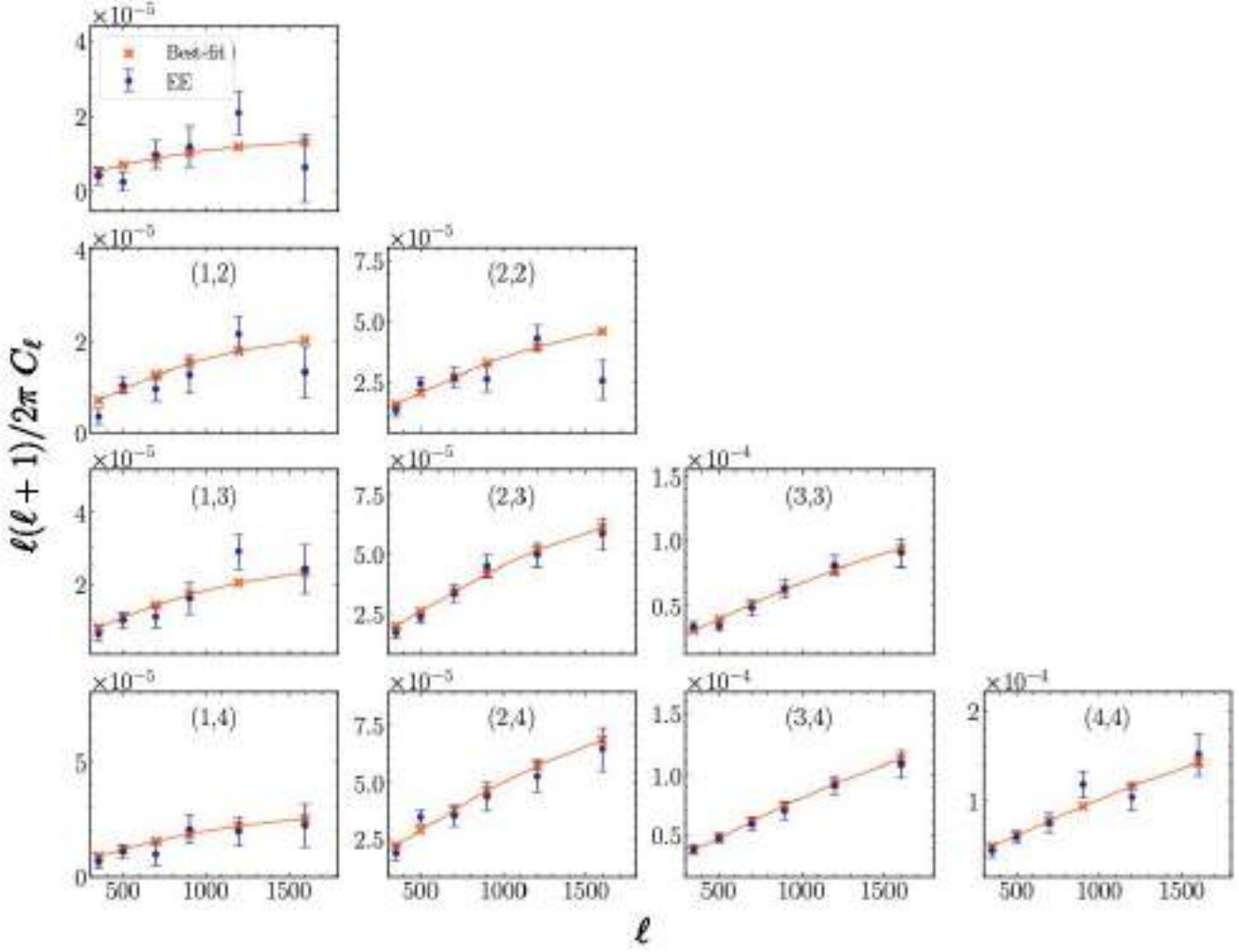
DES-Y3



Amon et al. (2022) and
Secco, Samuroff et al. (2022)

Power spectra

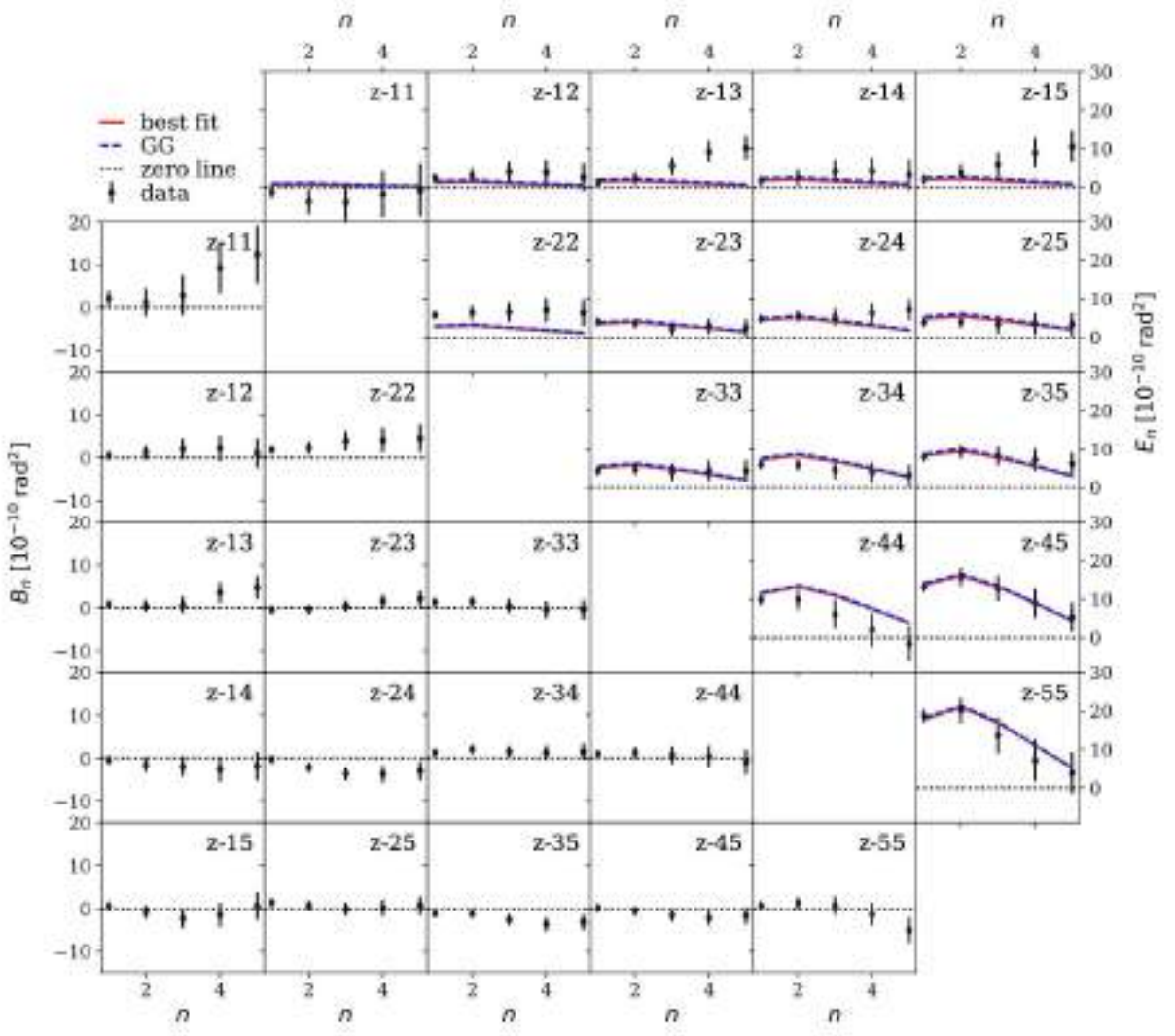
HSC-Y3



Dalal et al. (2023)

COSEBIs

KiDS-1000



Asgari et al. (2021)

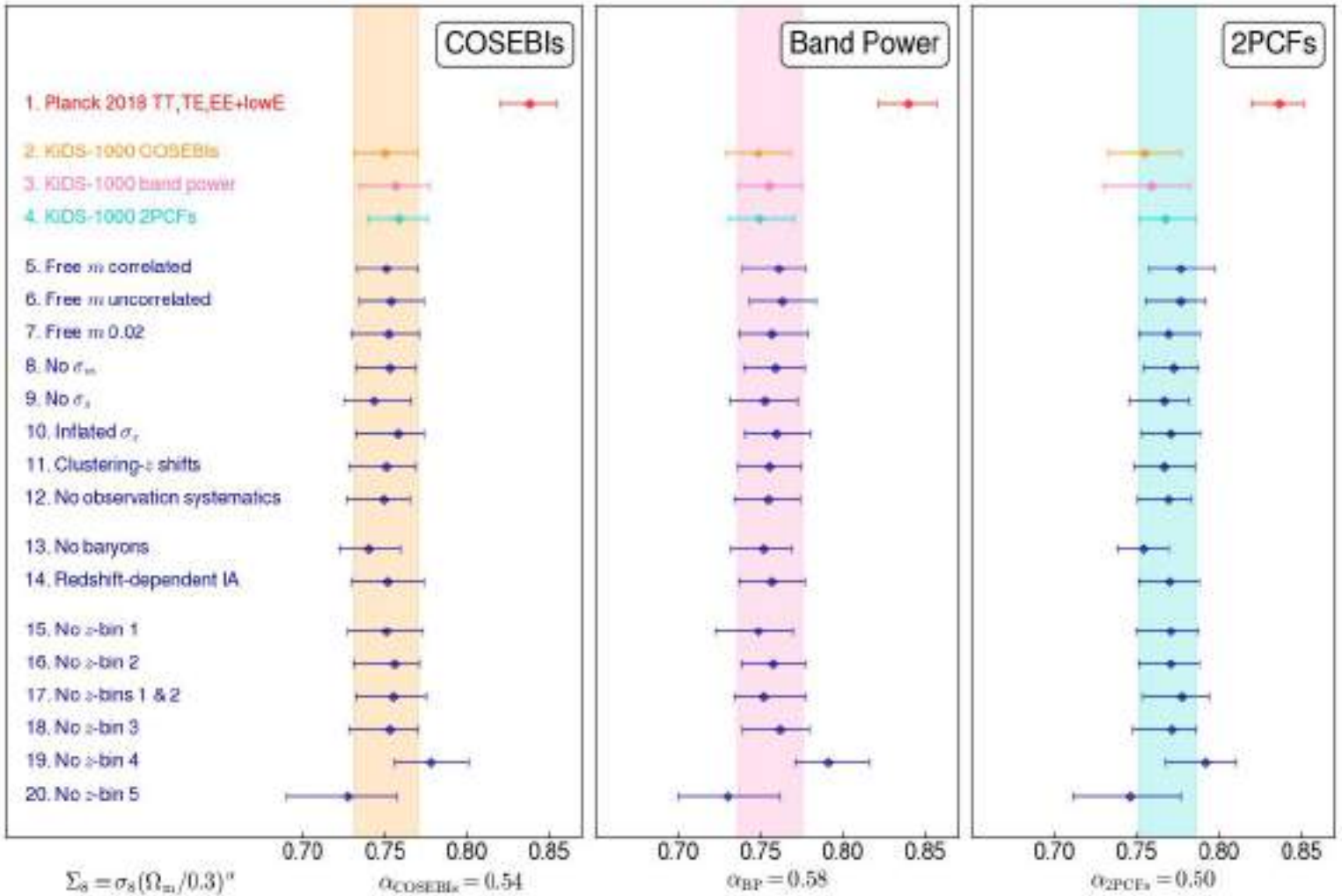
Systematic effects and S8

KiDS-1000

Observational systematics

Astrophysics

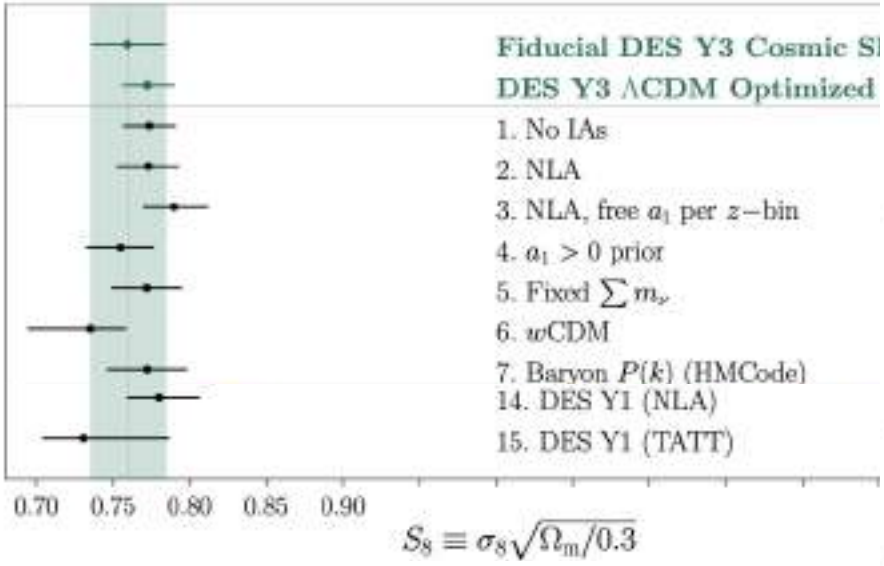
Z-bins consistency



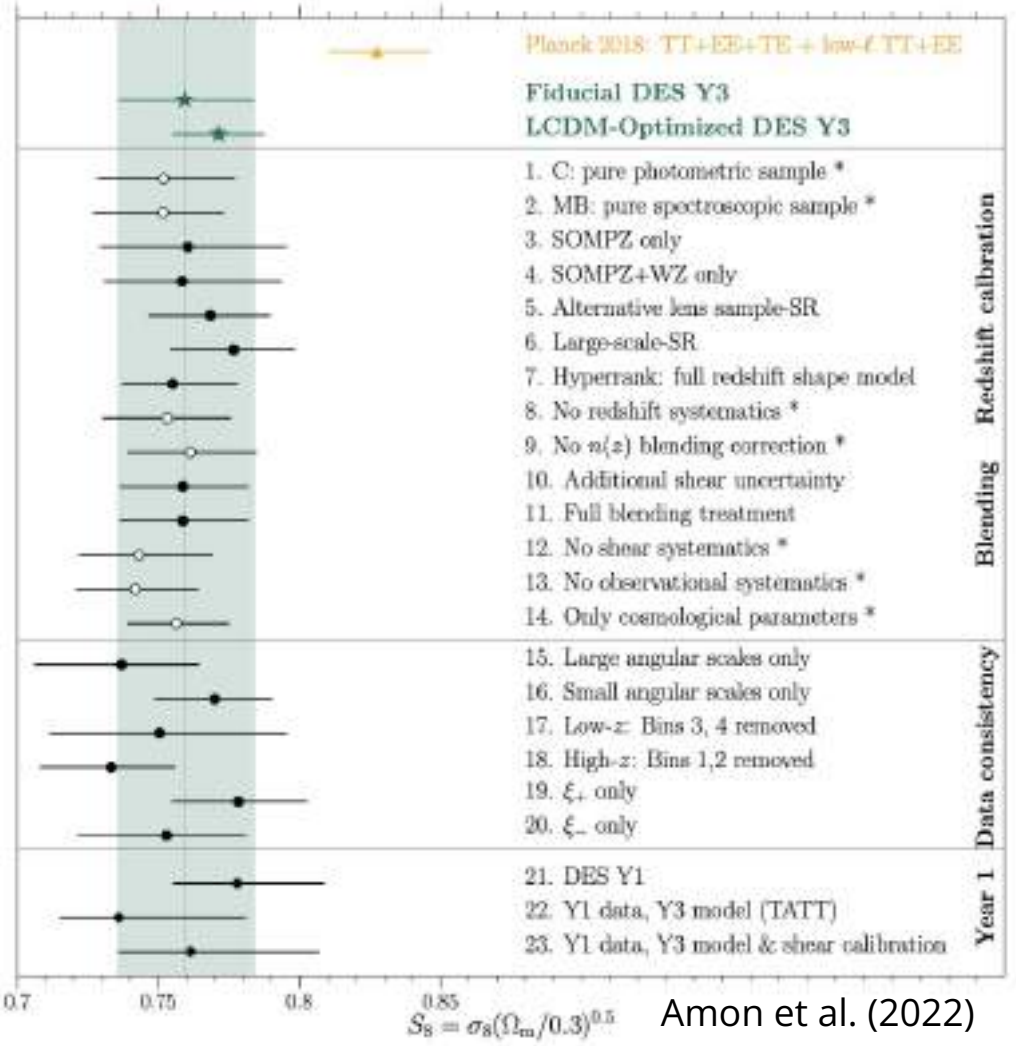
Asgari, Lin, Joachimi et al. (2021)

Systematic effects and S8

DES-Y3



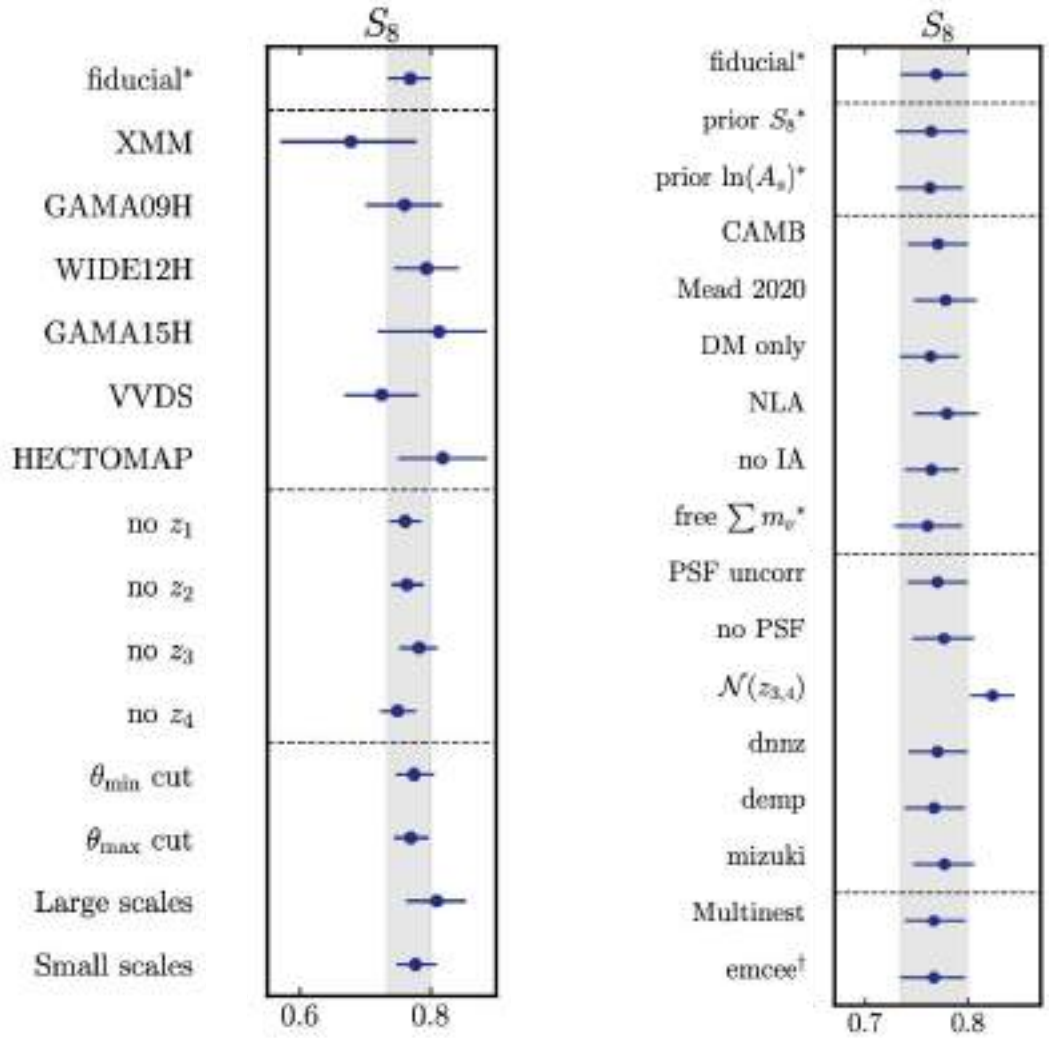
Secco, Samuroff et al. (2022)



Amon et al. (2022)

Systematic effects and S8

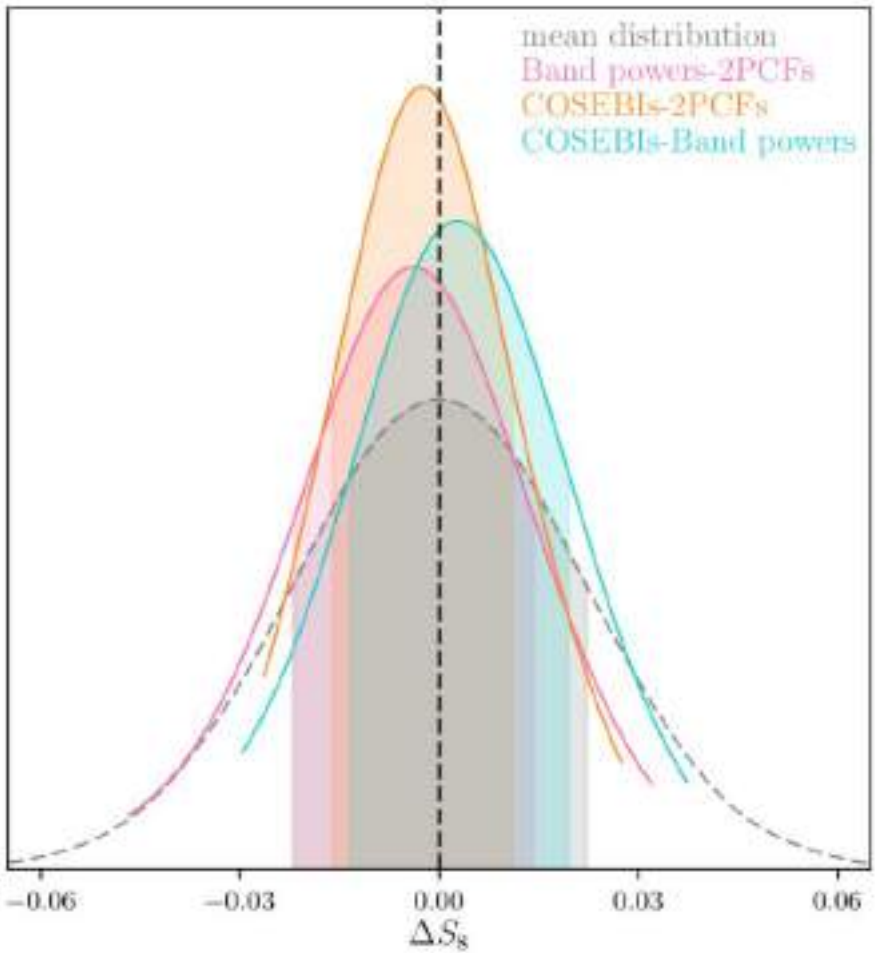
HCS-Y3



Li+ 2023

Mock data analysis: difference between 2pt Stats

- 100 mock noisy realisations
- Find Delta S8 for each pair of statistics.
- We expect to see differences of up to 0.8 sigma_S8 for 68% of the realisations.
- For KiDS-1000 we saw at most 0.4 sigma differences.

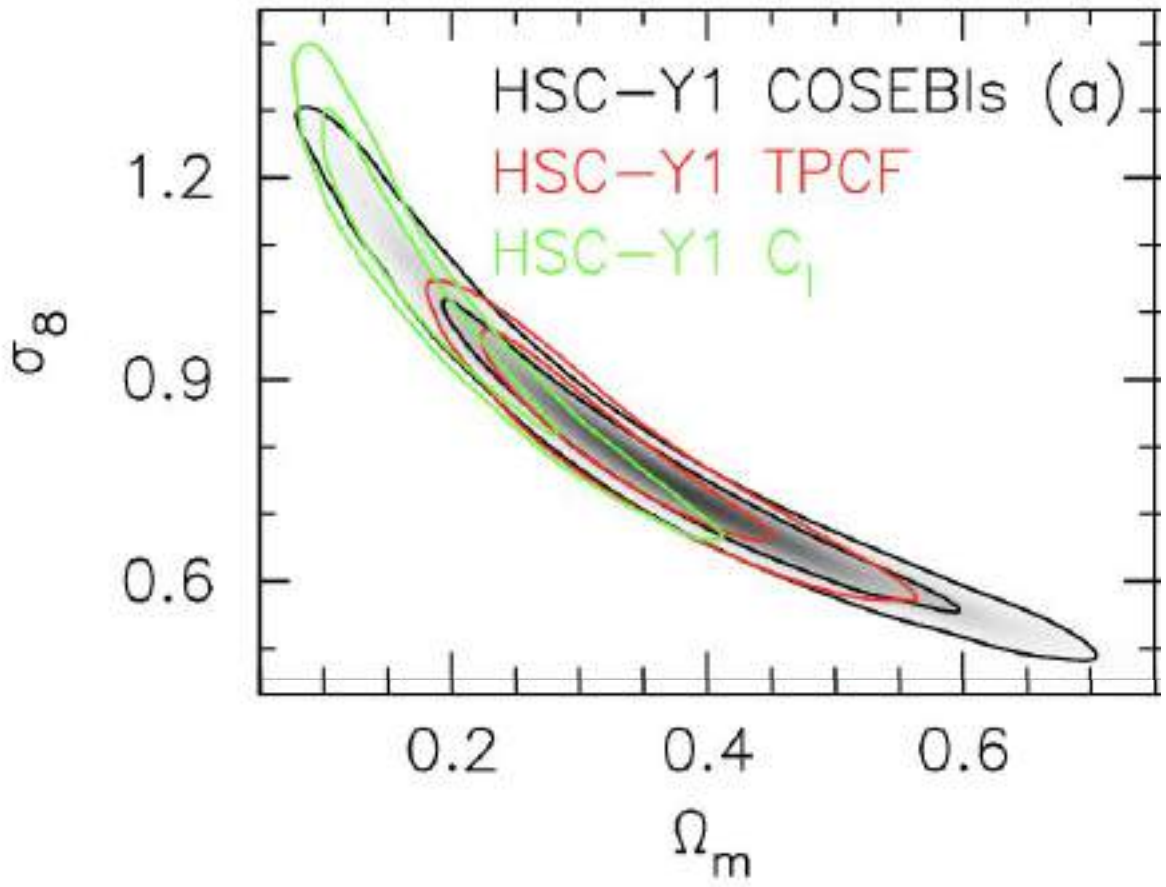


Asgari, Lin, Joachimi et al. (2021)

Comparison between 2pts

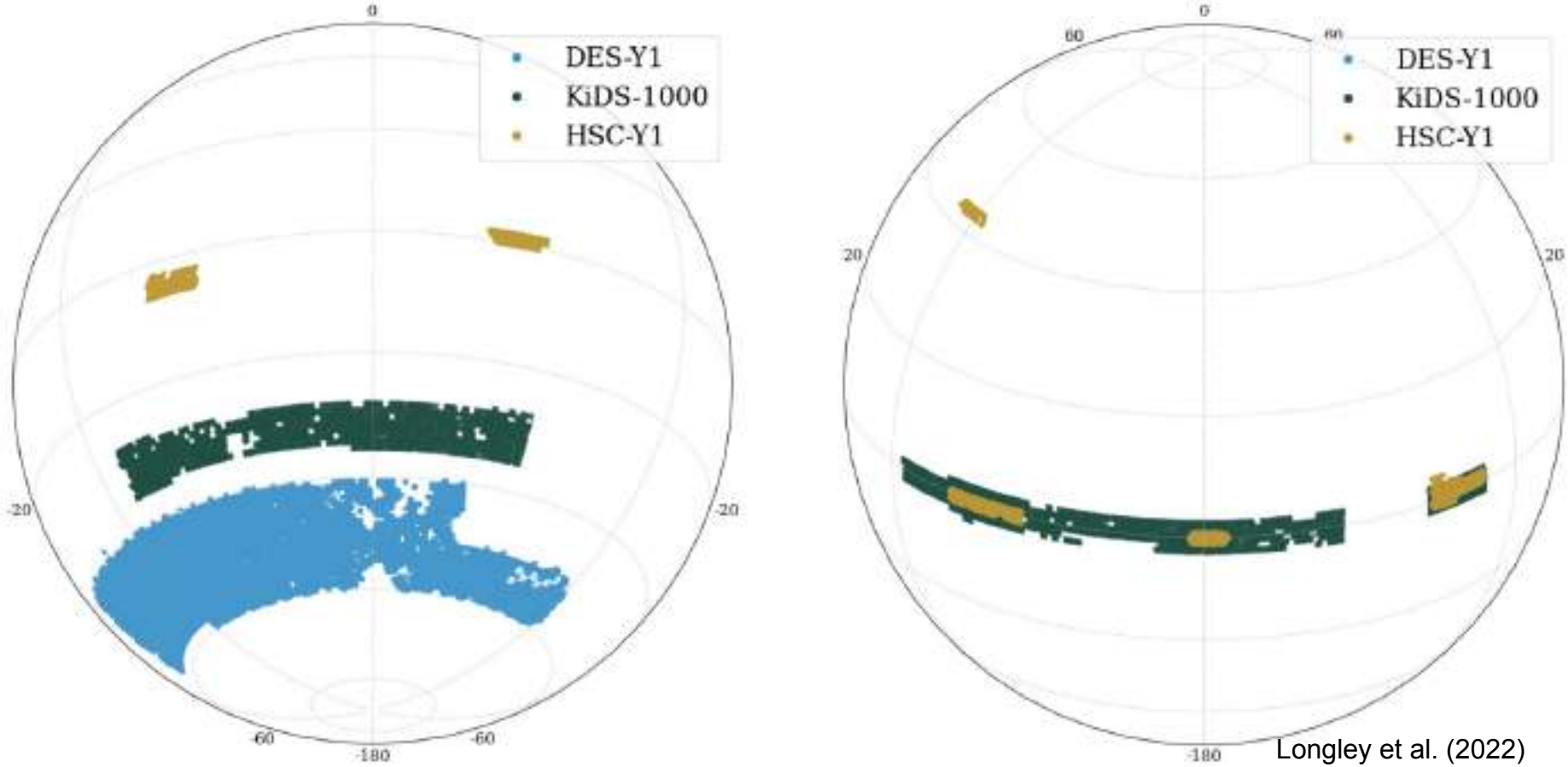
HSC-Y1 data

Good agreement between the 2pts



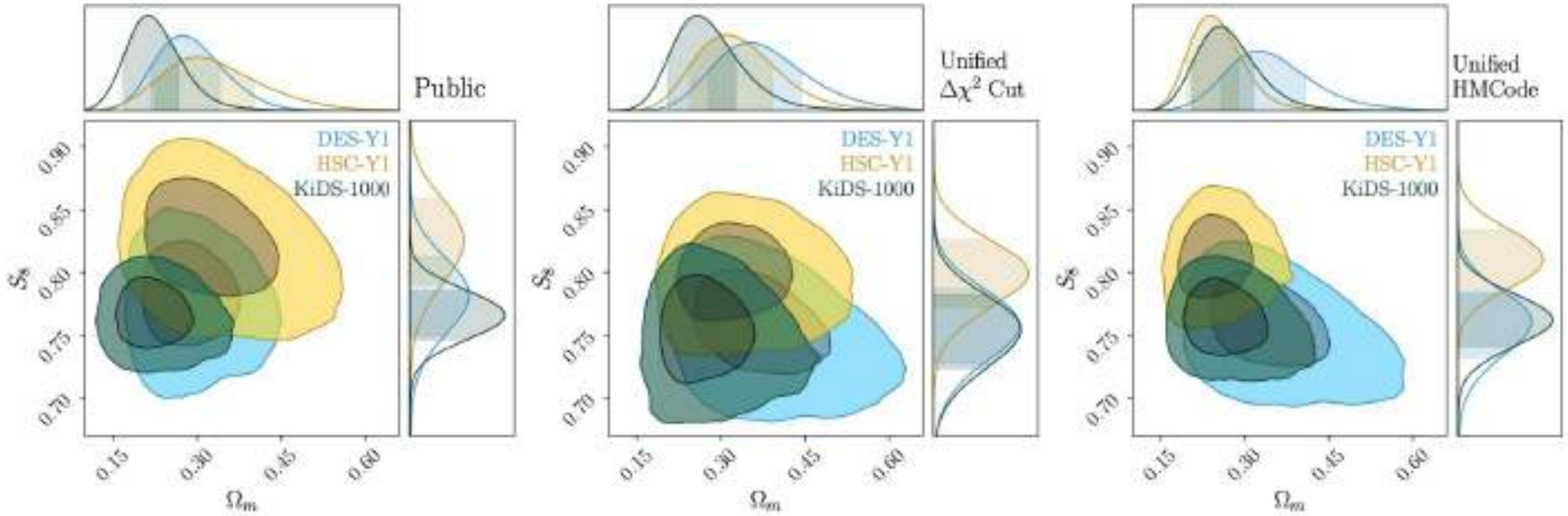
Hamana et al. (2022)

Unified DES-Y1, KiDS-1000 and HSC-Y1 using Rubin's LSST pipeline



Longley et al. (2022)

Unified DES-Y1, KiDS-1000 and HSC-Y1 using Rubin's LSST pipeline



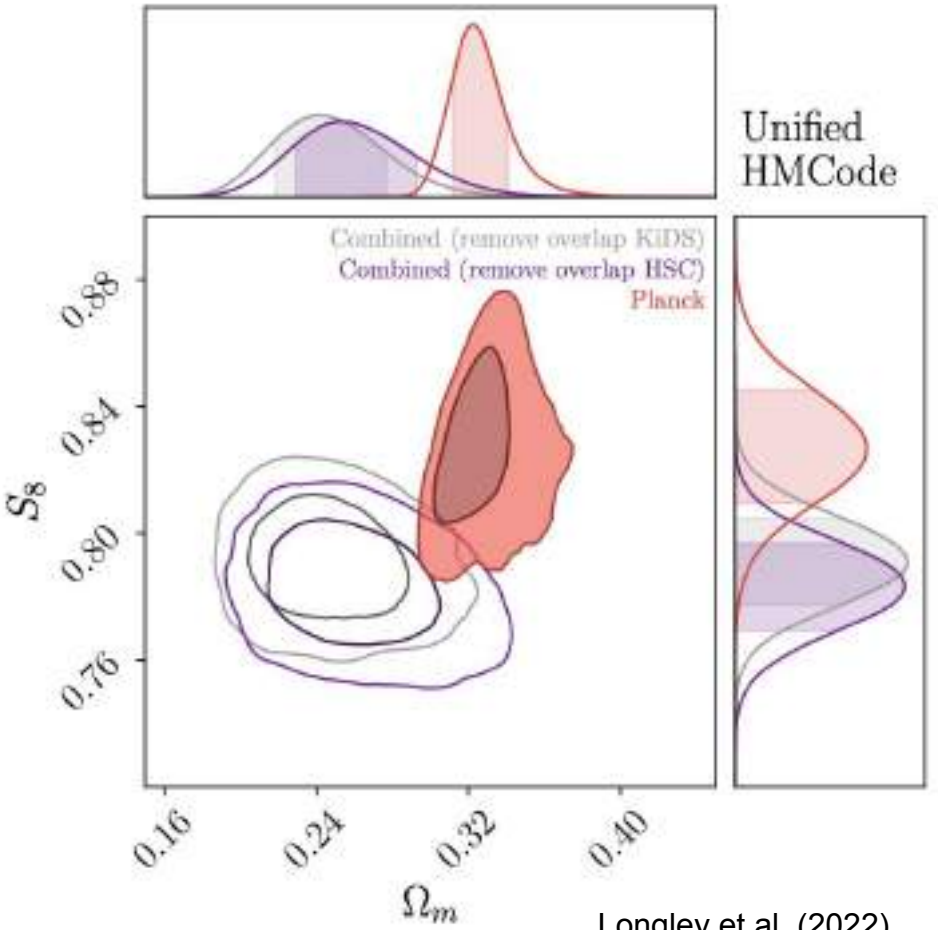
- Shapes and redshifts unchanged
- Signal: 2PCFs
- Unified angular scales
- Unified priors
- Unified model

Longley et al. (2022)

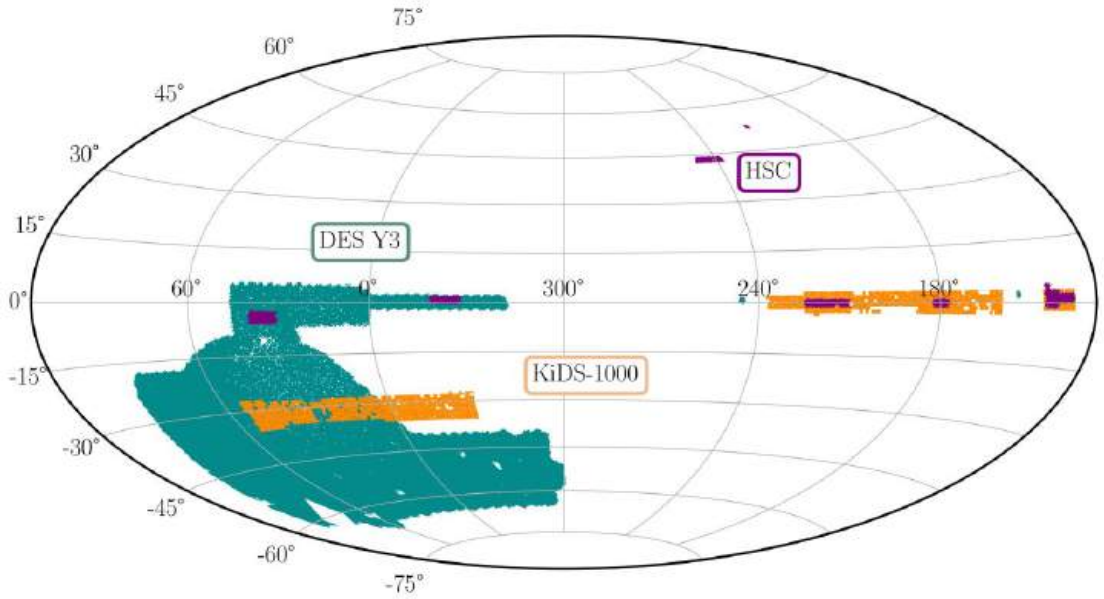
Unified DES-Y1, KiDS-1000 and HSC-Y1 using Rubin's LSST pipeline

Error on S8:

- HSC: 0.021
- KiDS: 0.020
- DES: 0.024
- Combined analysis: 0.012
- Planck (fiducial): 0.016



Longley et al. (2022)



Core team:

1. Alexandra Amon* (DES)
2. Marika Asgari (KiDS)
3. Ami Choi* (DES)
4. Catherine Heymans (KiDS)
5. Anna Porredon (DES)
6. Simon Samurrof (DES)

DES & KiDS collaborations et al. 2023

*Part of both groups but mainly active in DES.

+

Catalogue

Galaxy Shapes

Galaxy redshifts

Calibrate!!!

Signal

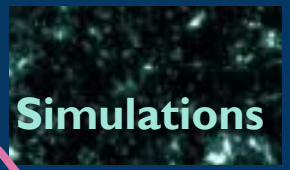
Divide the galaxies

Likelihood

Inference

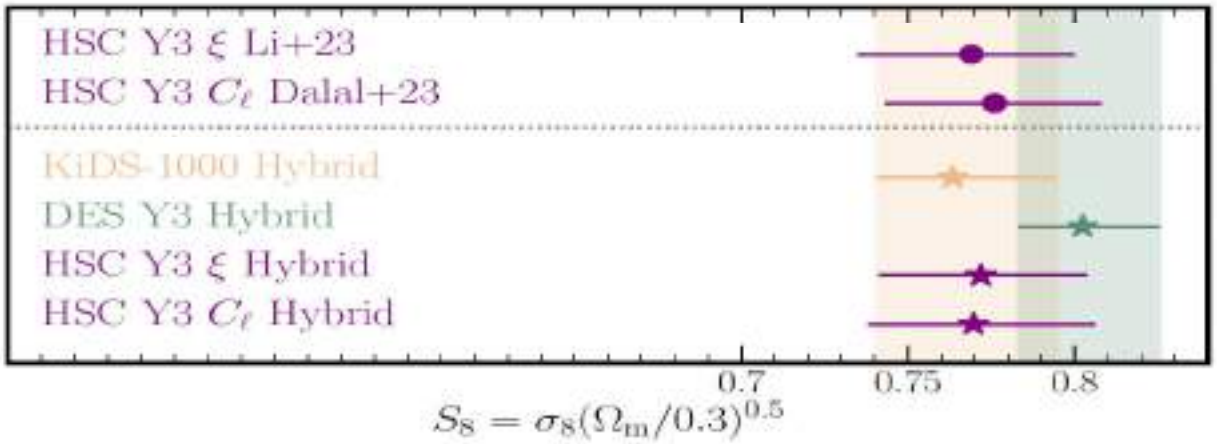
Blinding !

Cosmological model



Modelled signal and error

Re-analysis of HSC Y3

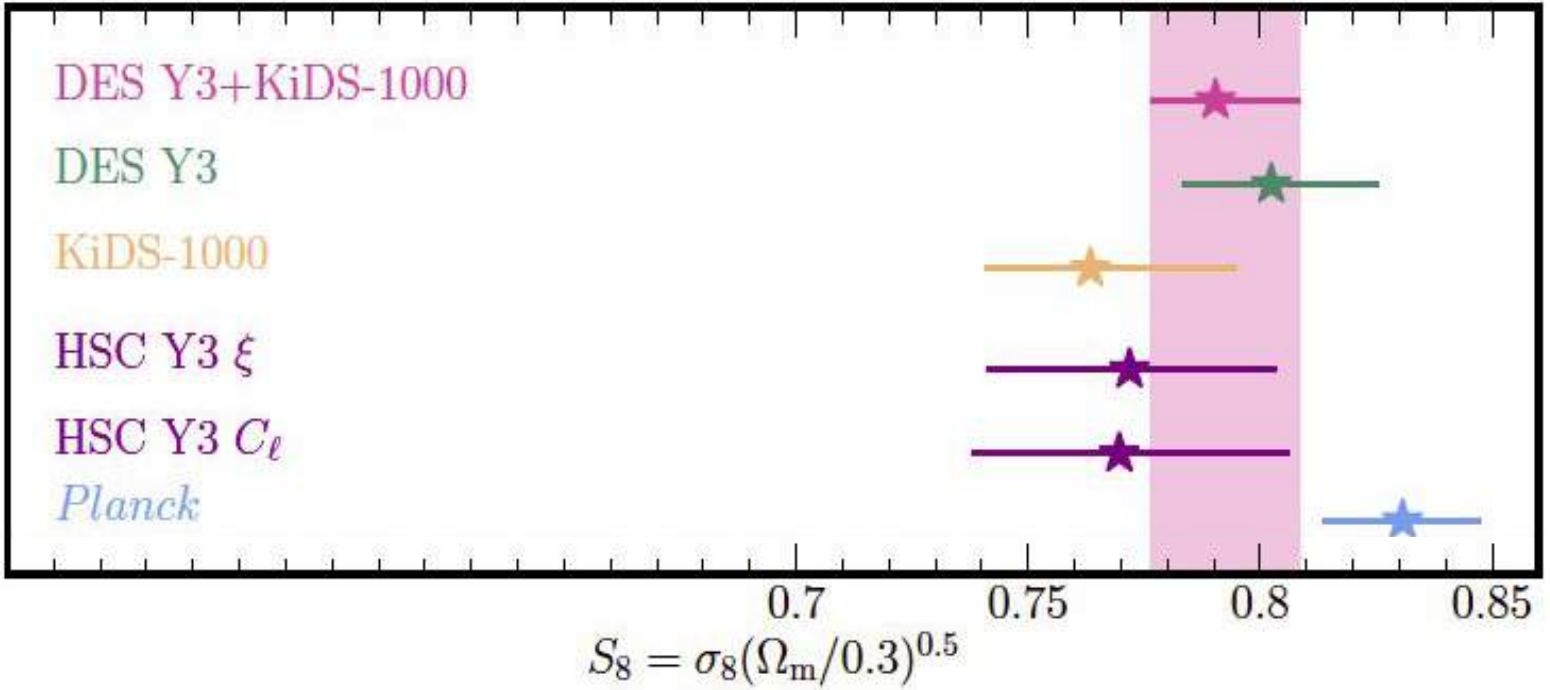


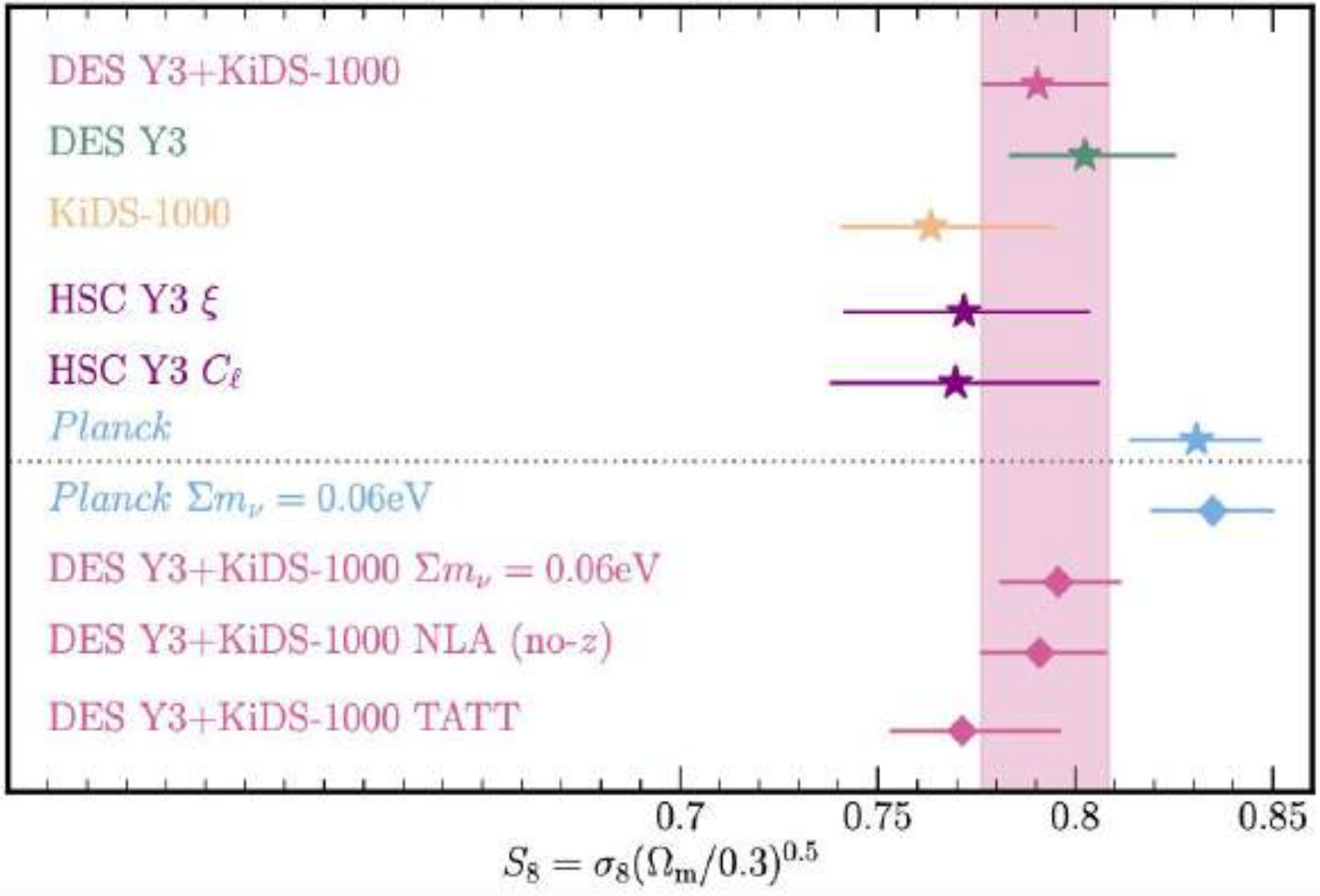
HSC Y3

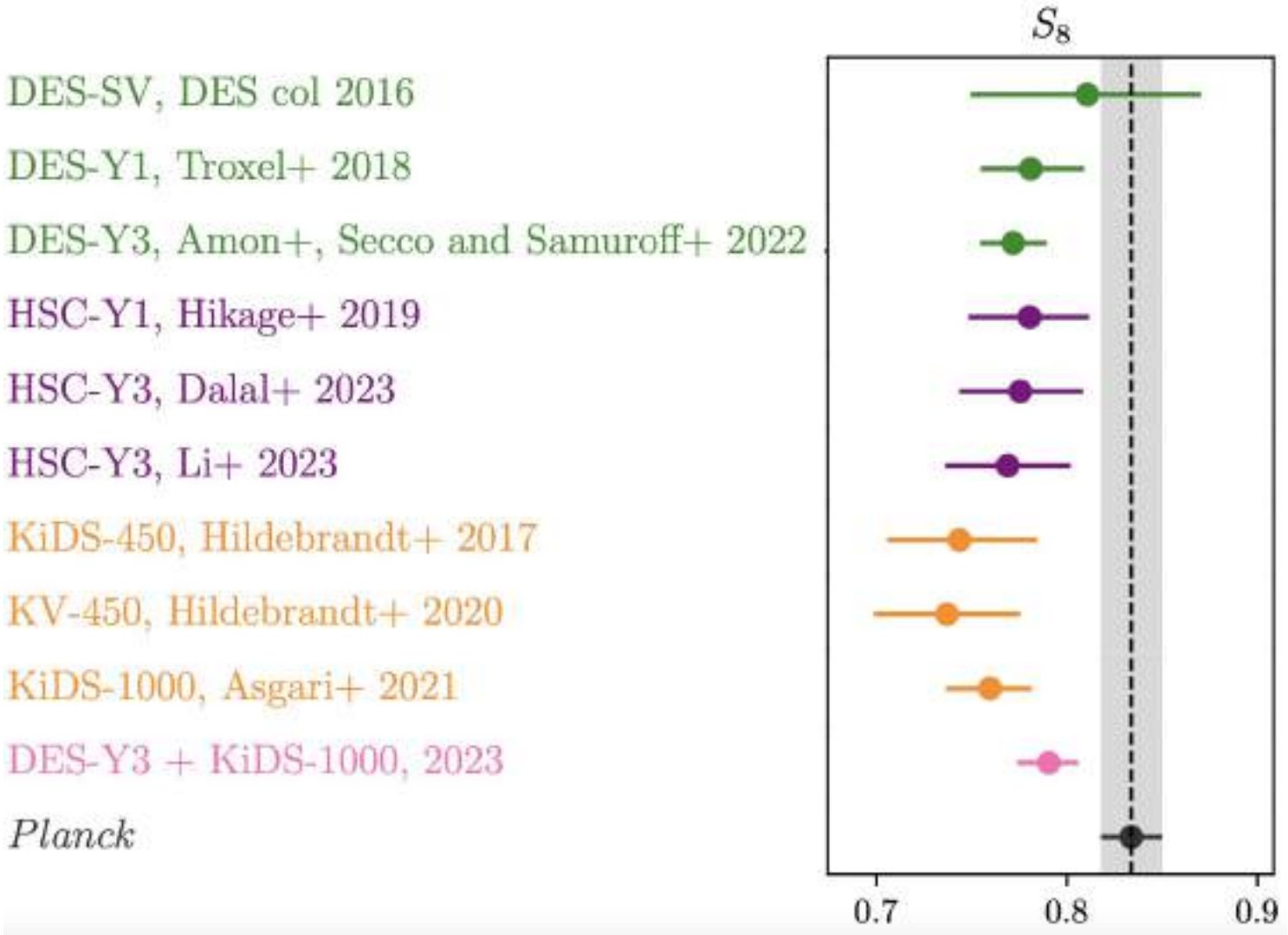
Important changes in Hybrid pipeline:

- *Pk model*
- *Baryon feedback parameter prior*
- *IA model*

With thanks to Roohi Dalal & Xiangchong Li


DES Y3+KiDS-1000
DES Y3
KiDS-1000
HSC Y3 ξ
HSC Y3 C_ℓ
Planck
0.7
0.75
0.8
0.85
$S_8 = \sigma_8(\Omega_m/0.3)^{0.5}$


DES Y3+KiDS-1000
DES Y3
KiDS-1000
HSC Y3 ξ
HSC Y3 C_ℓ
Planck
Planck $\Sigma m_\nu = 0.06$eV
DES Y3+KiDS-1000 $\Sigma m_\nu = 0.06$eV
DES Y3+KiDS-1000 NLA (no-z)
DES Y3+KiDS-1000 TATT
0.7
0.75
0.8
0.85
$S_8 = \sigma_8(\Omega_m/0.3)^{0.5}$


S_8
DES-SV, DES col 2016
DES-Y1, Troxel+ 2018
DES-Y3, Amon+, Secco and Samuroff+ 2022
HSC-Y1, Hikage+ 2019
HSC-Y3, Dalal+ 2023
HSC-Y3, Li+ 2023
KiDS-450, Hildebrandt+ 2017
KV-450, Hildebrandt+ 2020
KiDS-1000, Asgari+ 2021
DES-Y3 + KiDS-1000, 2023
Planck
0.7
0.8
0.9

Summary and Conclusions

- Cosmic shear analysis are consistent with each other and
- They (still) find lower values of S8 compared to Planck 2018
- We need all future analysis to be blinded
- Combined survey analysis requires extensive tests and unification of methods
- Alternative models and non-linear modelling and astrophysical effects
- DES+KiDS paper and cosmology talks