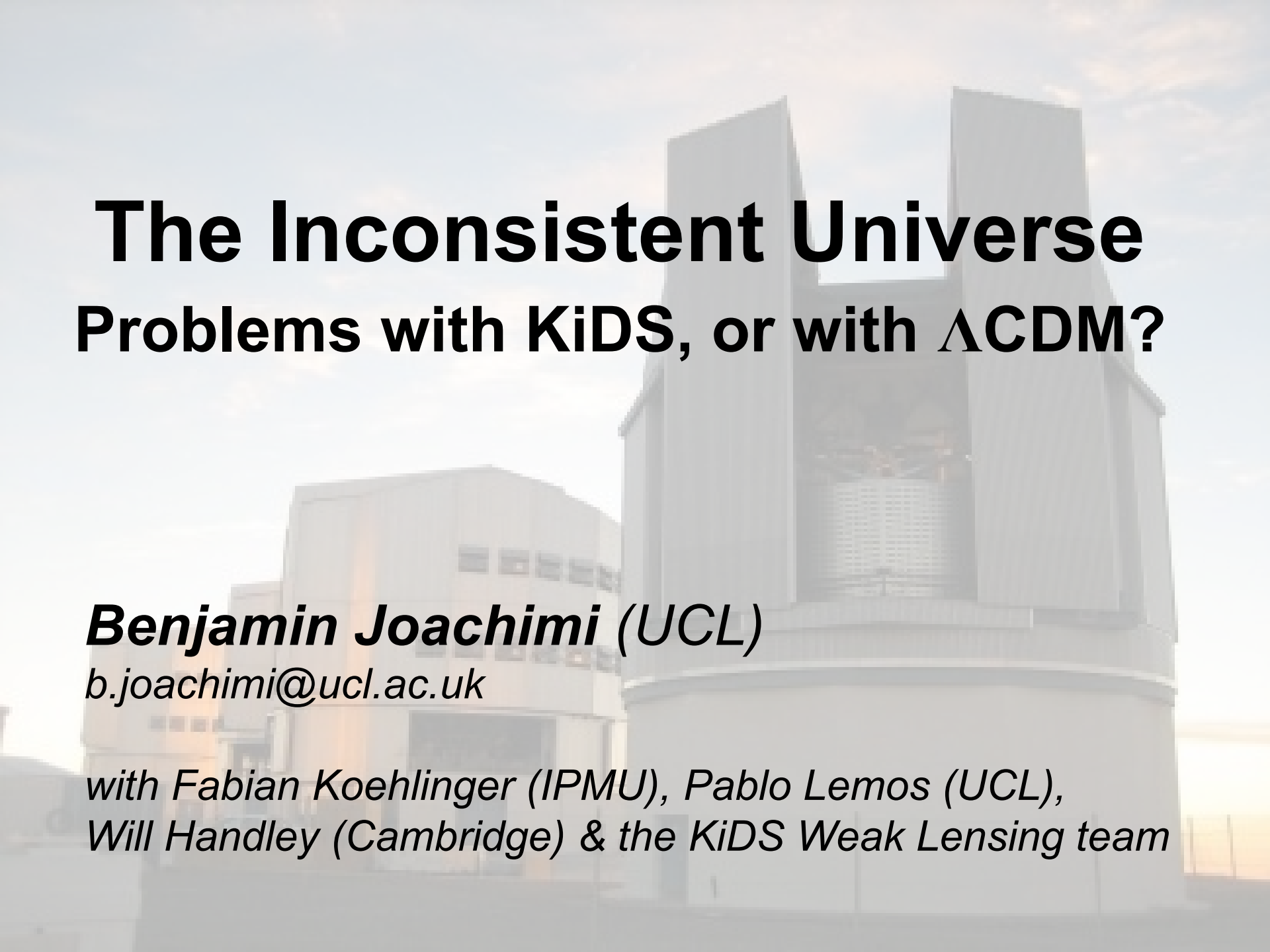

The Inconsistent Universe

Problems with KiDS, or with ΛCDM?

Benjamin Joachimi *(UCL)*
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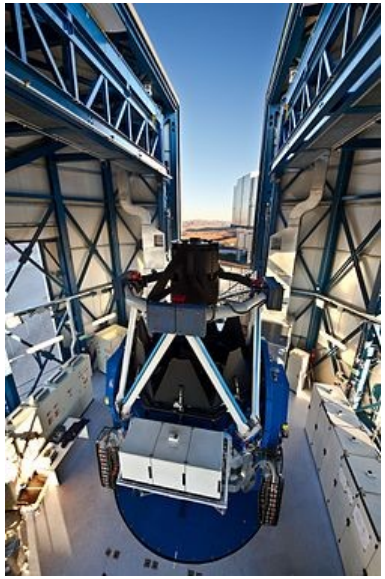
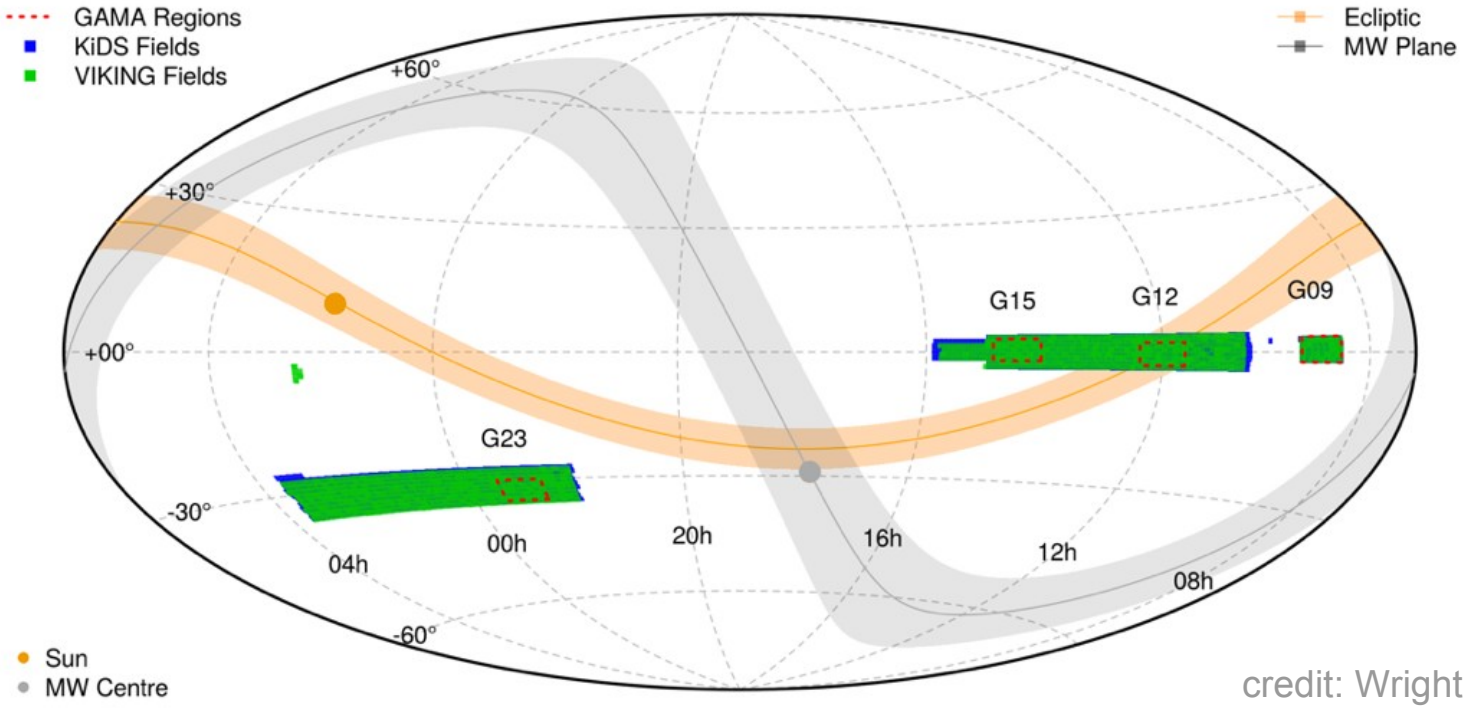
with Fabian Koehlinger (IPMU), Pablo Lemos (UCL),
Will Handley (Cambridge) & the KiDS Weak Lensing team

KiDS + VIKING

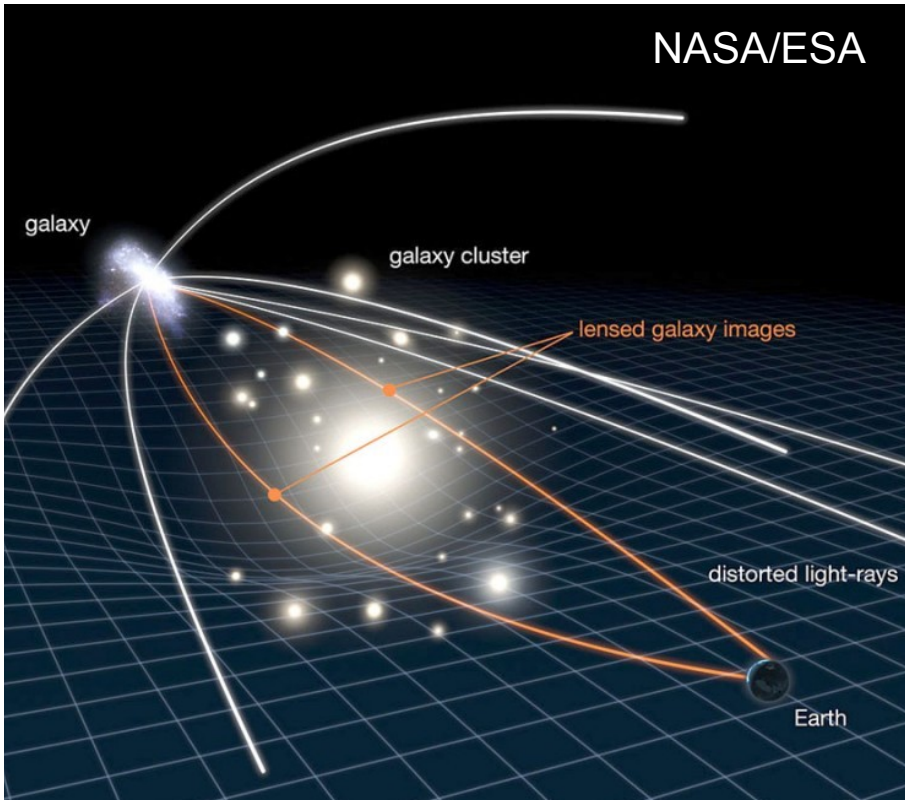


- on the 2.6m VST and 4.1m VISTA
- ugri (KiDS) + zYJHK (VIKING)
- ~1400 deg^2 (completed spring 2019)
- current papers based on 450 deg^2

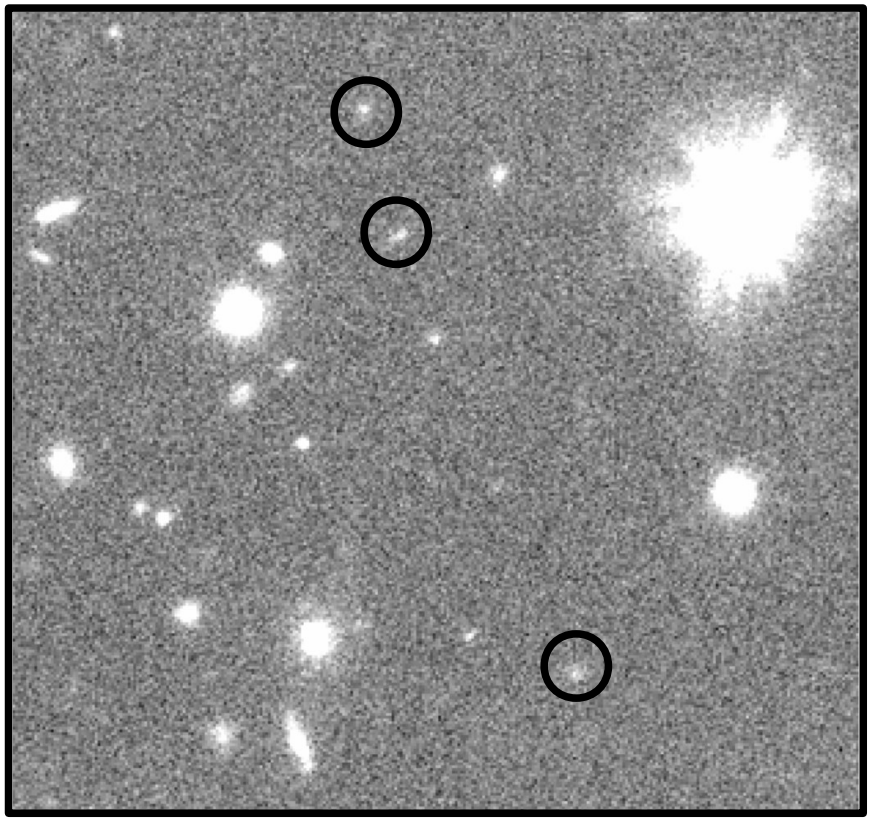


credit: Wright

Cosmology with weak lensing



Theory

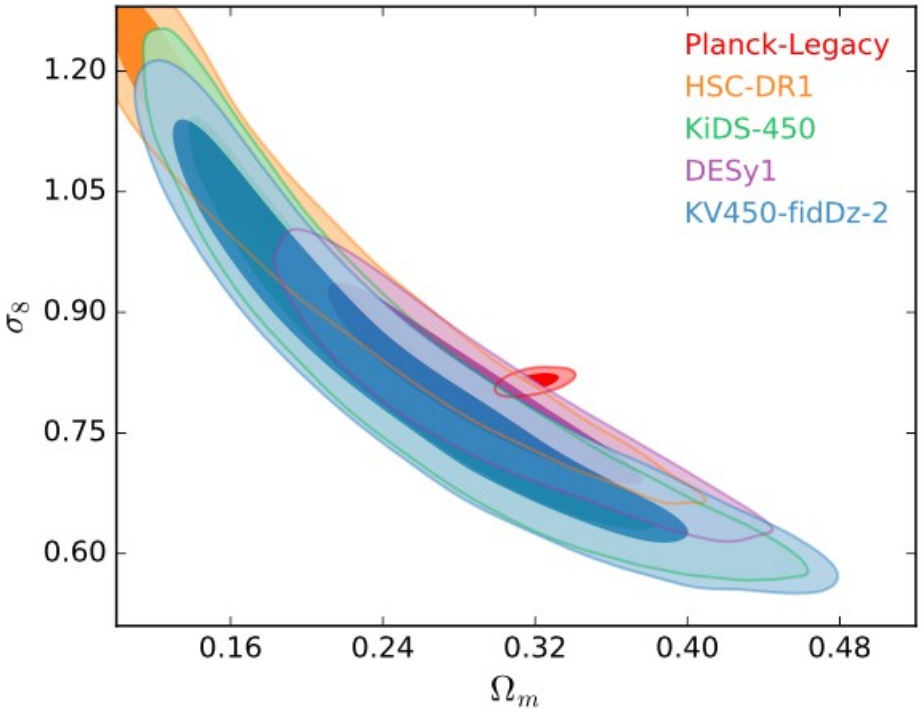


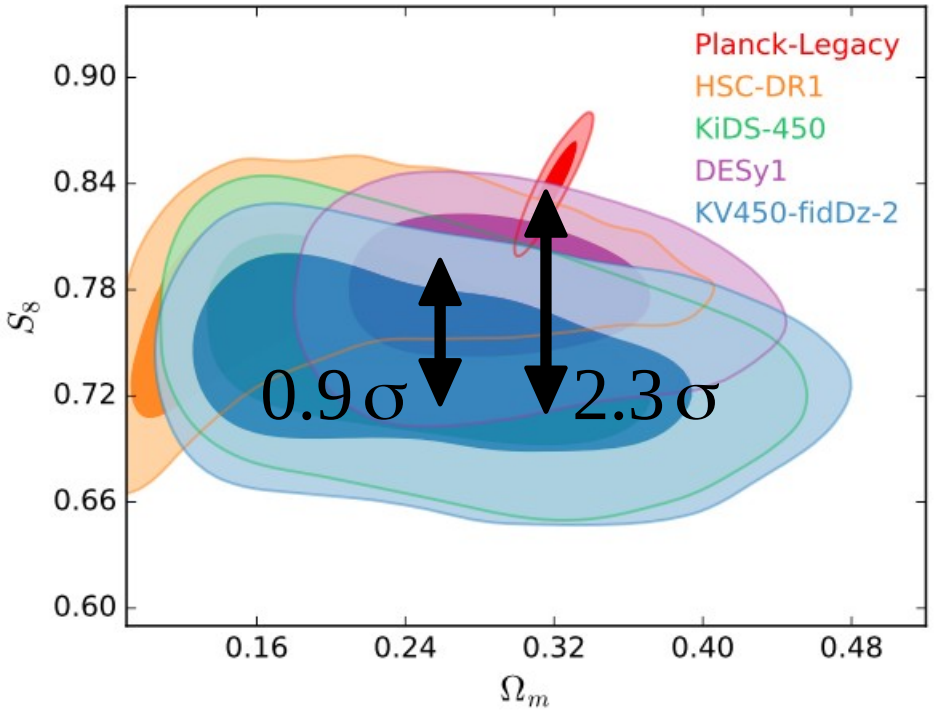
Reality

- Infer coherent lensing image distortions from galaxy ellipticities
- Infer galaxy redshifts from multi-band colours
- Model weak lensing signals in non-linear, baryon-filled universe

The state of the art for cosmic shear

Hildebrandt+ (2019)

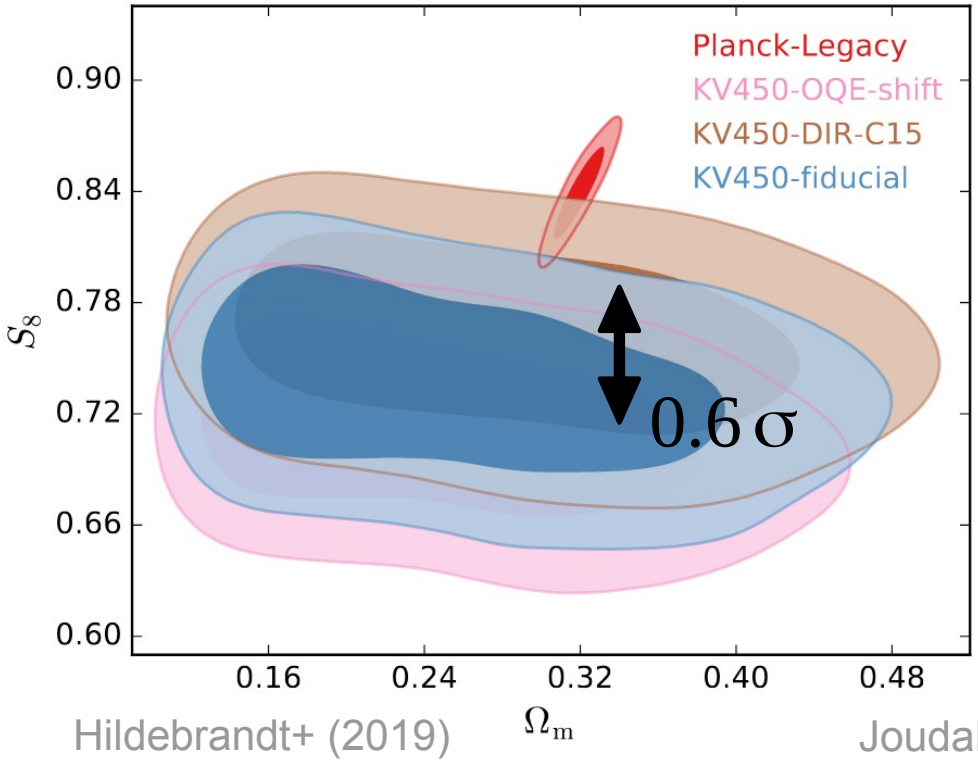




$S_8 = \sigma_8 \sqrt{\Omega_m / 0.3}$ measures constraints across the banana

Key analysis challenge: redshift calibration

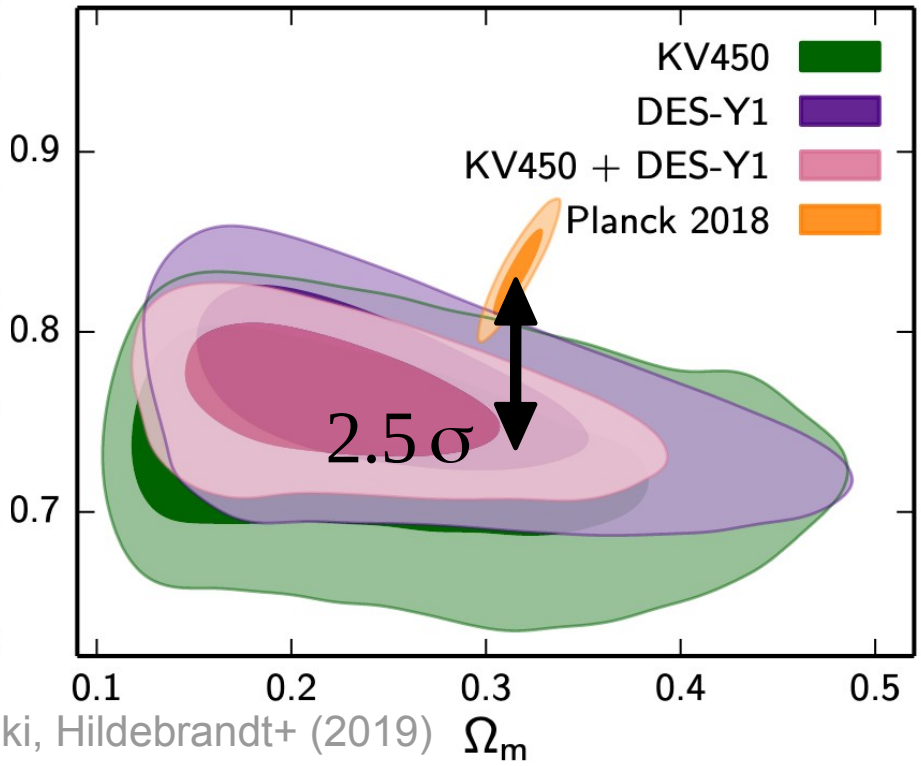
using COSMOS-30 photo-z
[DES and HSC rely on this]



Hildebrandt+ (2019)

KiDS fiducial: direct calibration
with spectroscopic redshifts

DES-Y1 re-analysed with KiDS
inference setup and calibration

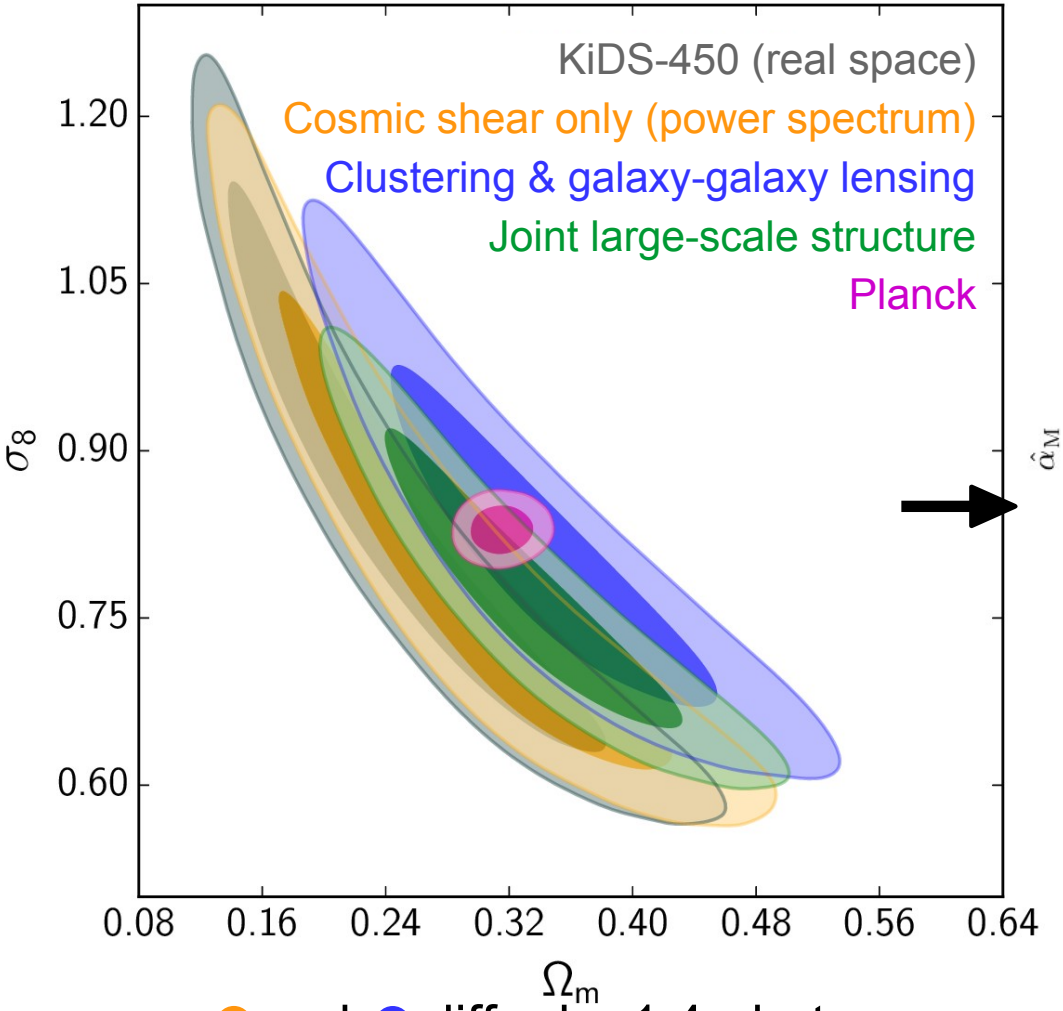


Joudaki, Hildebrandt+ (2019)

Joint KiDS-Viking and DES-Y1

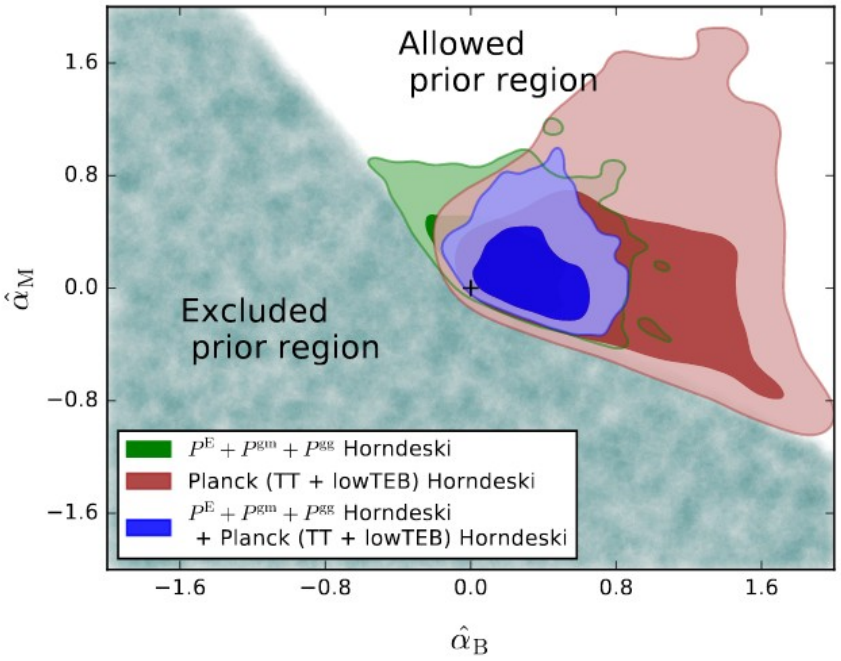
Beyond cosmic shear

van Uitert, BJ+ (2018)



● and ● differ by 1.4σ but are quasi-independent

Constraints on Horndeski gravity



Spurio Mancini, Koehlinger, BJ+ (2019)

See Alessio's poster

Is there a problem?

MNRAS **000**, 000–000 (0000) Preprint 4 July 2017 Compiled using MNRAS LATEX style file v3.0

Problems with KiDS

George Efstathiou and Pablo Lemos
Kavli Institute for Cosmology Cambridge and Institute of Astronomy, Madingley Road, Cambridge, CB3 OHA.

3 tiers of consistency checks

1. Global summary statistic

→ ~~Bayes factor~~

→ Suspiciousness

2. Posterior-level check

→ pdfs of difference in duplicated parameters

3. Data domain check

→ data vs. posterior predictive distributions

- use a Bayesian formalism
- designed for correlated datasets
- analytic solutions for Gaussian data
- intuitive tension definitions

Koehlinger, BJ+ (2019)

Handley & Lemos (2019)

Lemos+, in prep.

Tier 1: Bayes factor ++

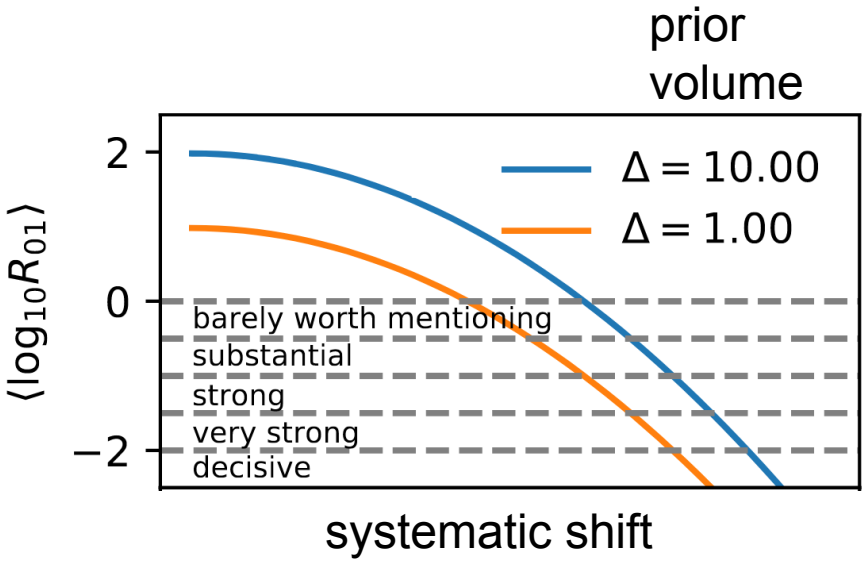
$$\underbrace{\Pr(\boldsymbol{d} \mid \mathrm{H})}_{\text{Evidence}} = \int \mathrm{d}^M \boldsymbol{p} \underbrace{\Pr(\boldsymbol{d} \mid \boldsymbol{p}, \mathrm{H})}_{\text{Likelihood}} \underbrace{\Pr(\boldsymbol{p} \mid \mathrm{H})}_{\text{Prior}}$$

Bayes factor

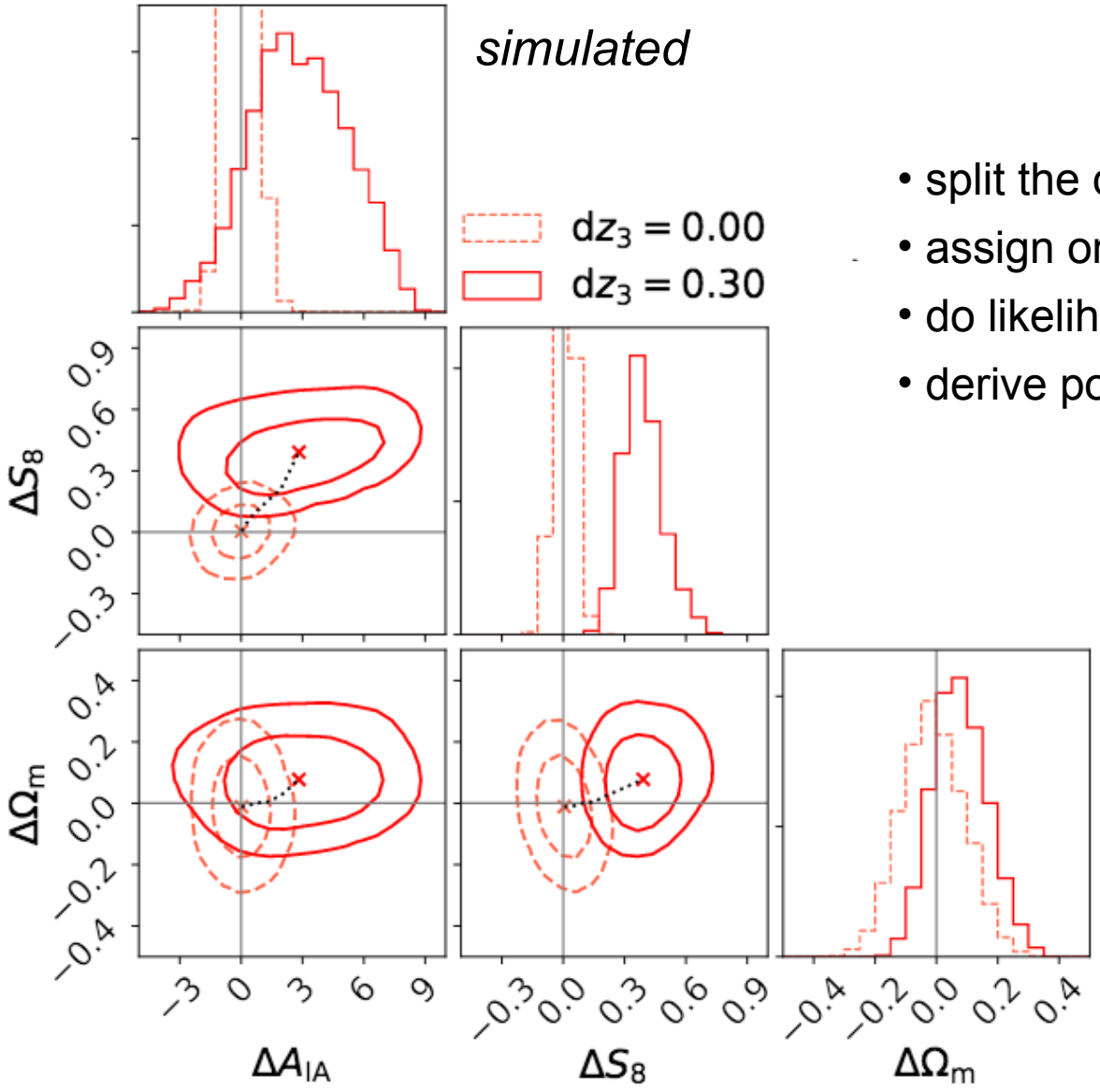
$$R = \frac{\text{Evidence(joint dataset)}}{\text{Evidence(split data w/ duplicate parameters)}}$$

Suspiciousness

$$S = \frac{R}{\text{prior volume effect}}$$

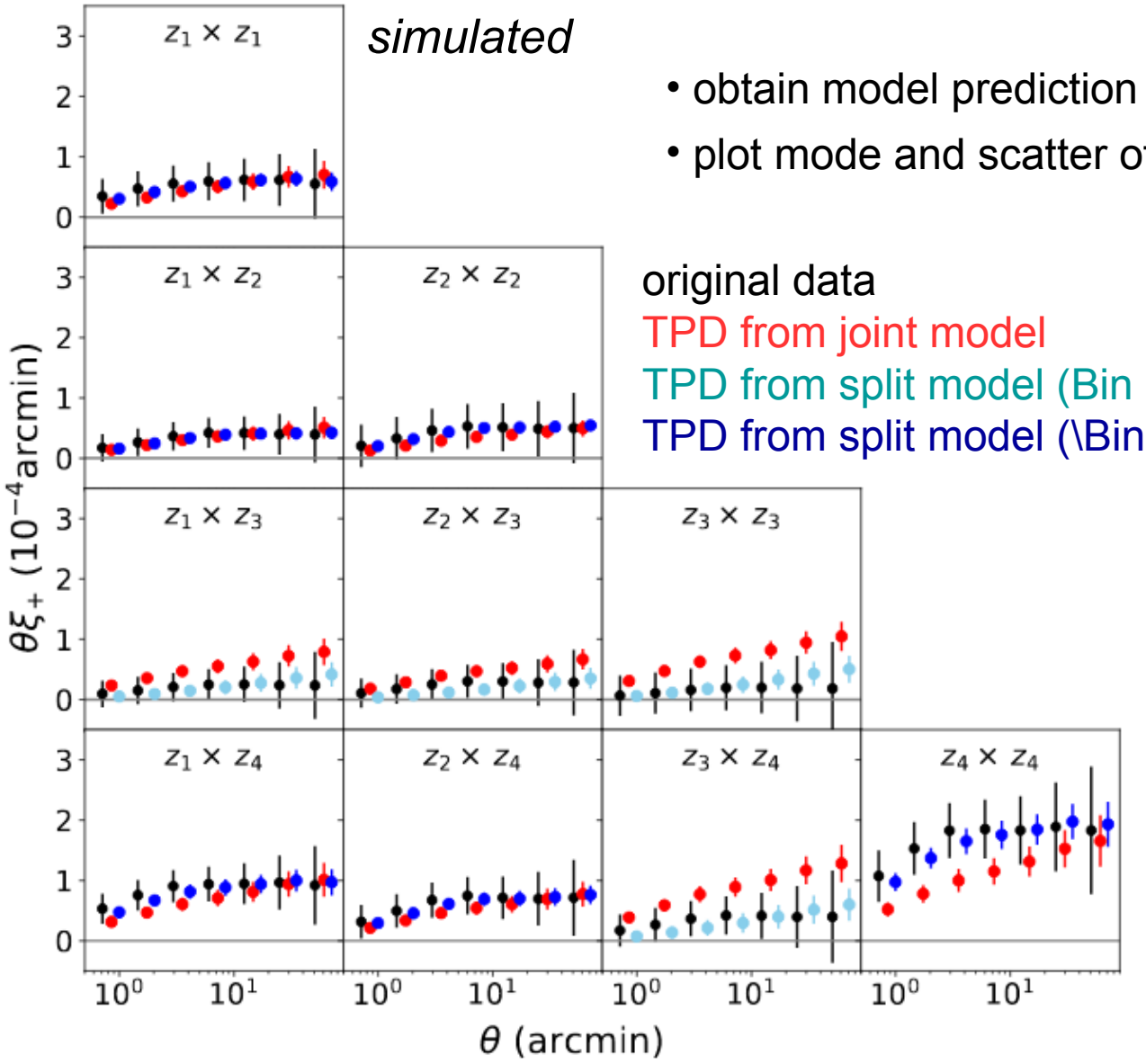


Tier 2: posterior-level check



- split the dataset
- assign one parameter set to each split
- do likelihood analysis
- derive posterior of parameter differences

Tier 3: data domain check



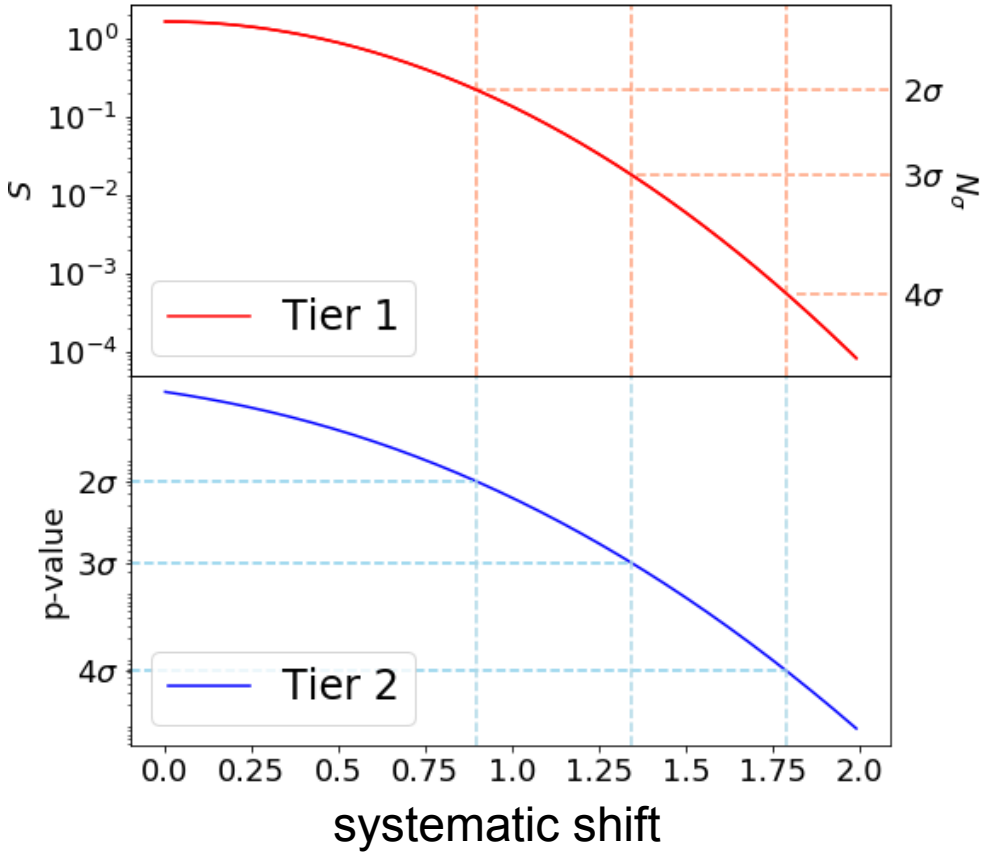
- obtain model prediction from each posterior sample
- plot mode and scatter of resulting distribution

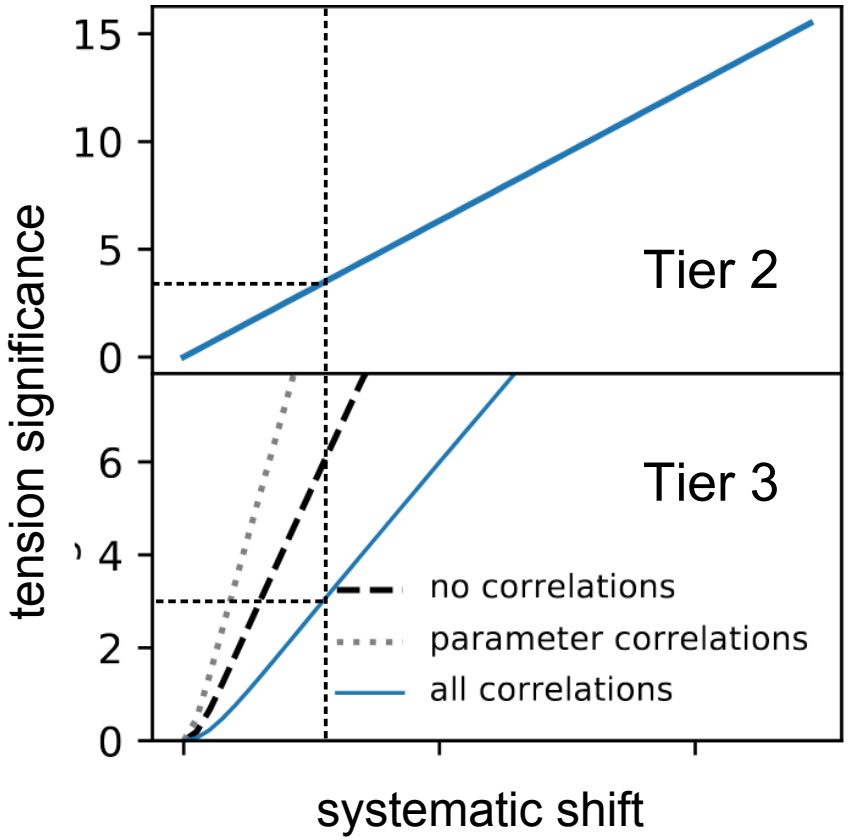
original data
TPD from joint model
TPD from split model (Bin 3)
TPD from split model (\Bin 3)

black vs blue:
→ goodness of fit

blue vs red:
→ consistency

Consistent assessment of tension

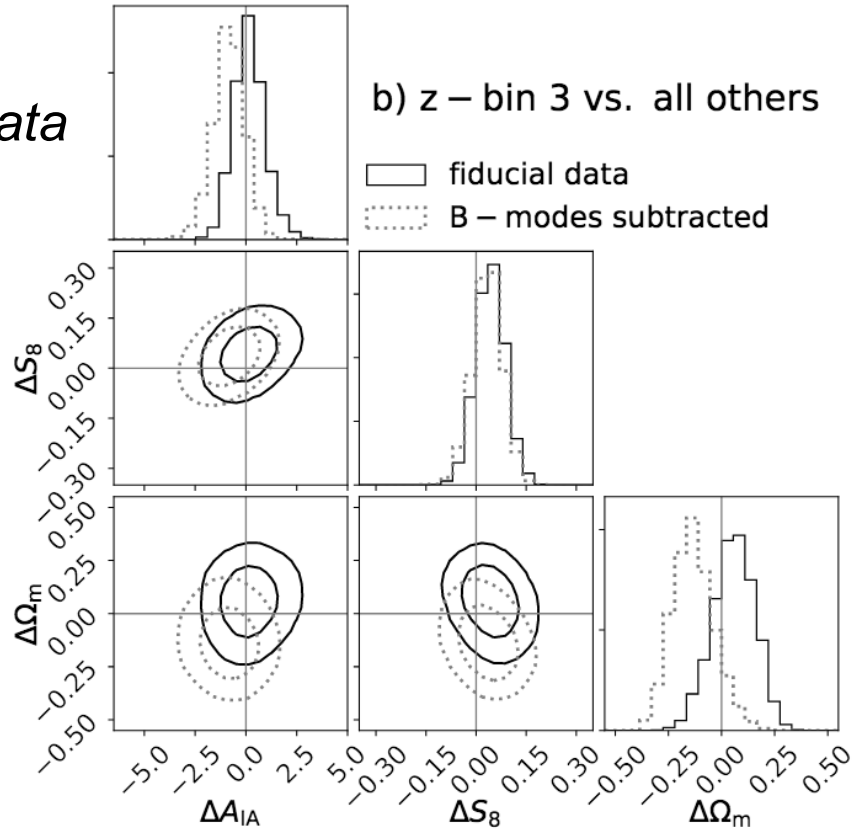




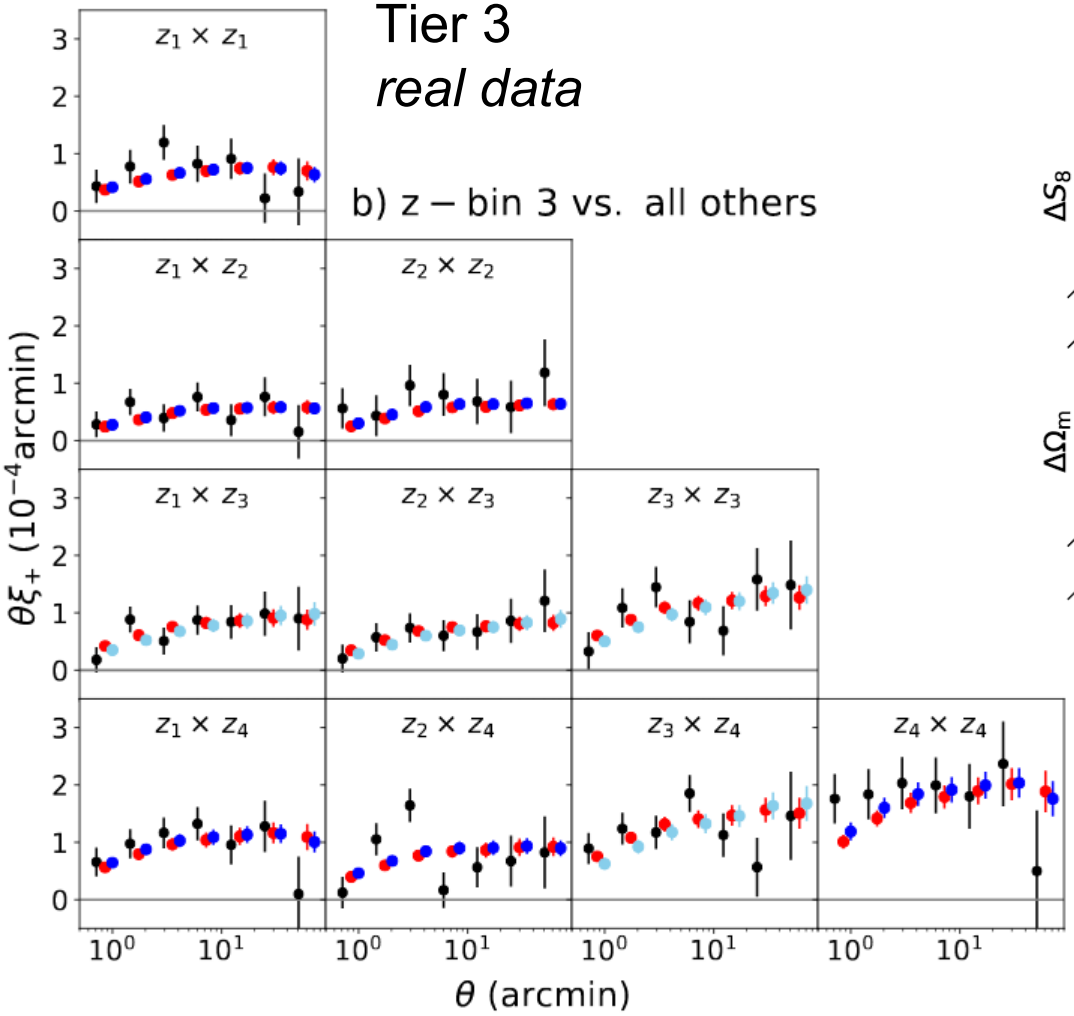
All tiers yield consistent tension significance for Gaussian likelihoods.

Problems with KiDS?

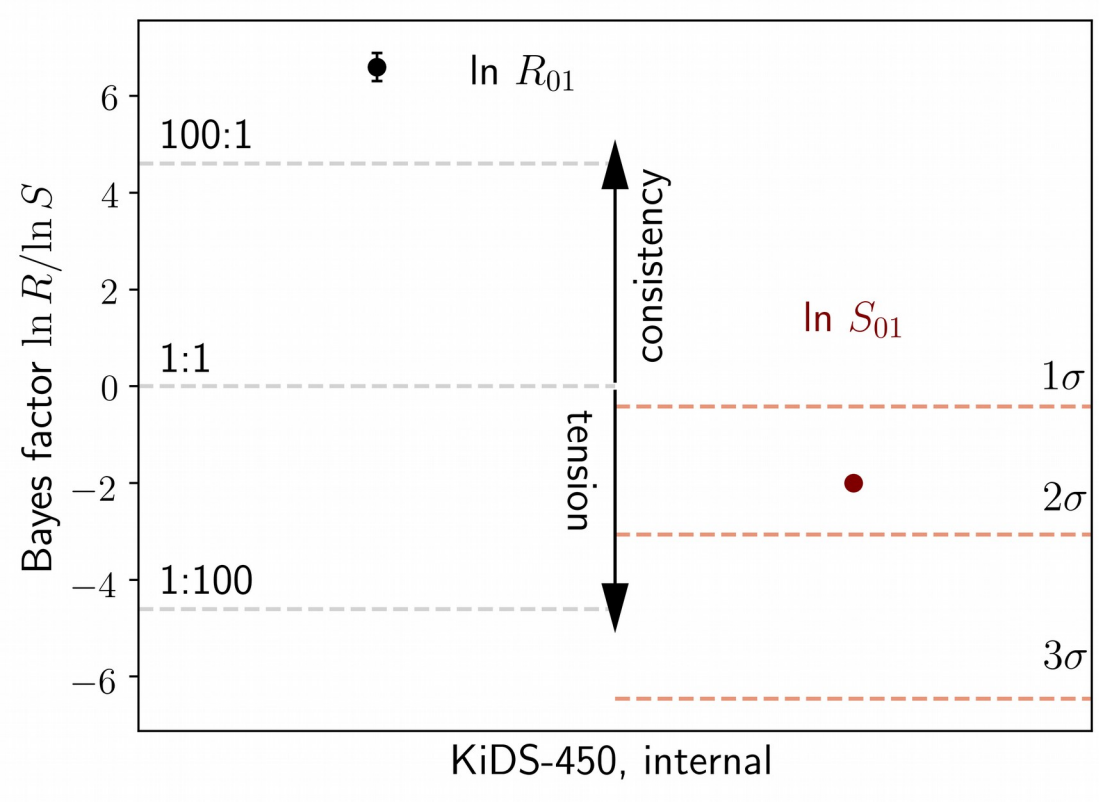
Tier 2
real data



Tier 3
real data



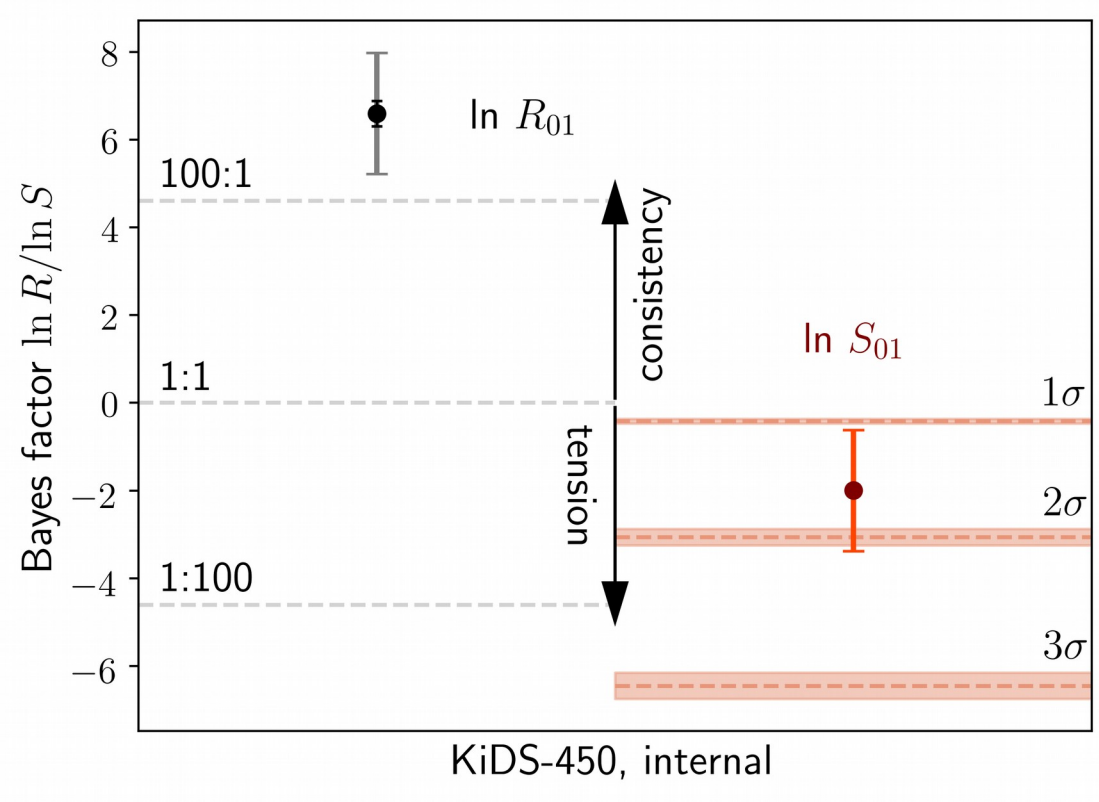
Problems with KiDS?



Tier 1
real data

BJ+, in prep.
See also Jenkins & Peacock (2010)

The limits of Bayesian decision-making



Tier 1
real data

Beware when making decisions based on Bayesian evidence – it‘s noisy!

BJ+, in prep.
See also Jenkins & Peacock (2010)

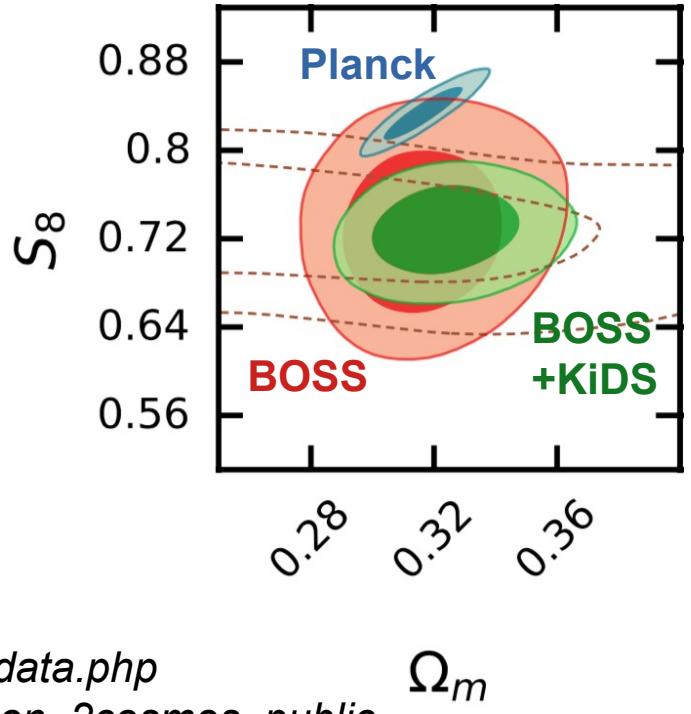
Conclusions

- KiDS weak lensing is ***internally consistent***.
- Galaxy weak lensing is in ***mild tension with Planck***.
- No known weak lensing systematics can drive the discrepancy; photometric redshift calibration is the limiting systematic.

- Independent lensing data and other LSS probes yield very similar tension with Planck.

- New Bayesian tools for quantifying tension at your disposal:

Troester+, in prep.



KiDS measurements: *http://kids.strw.leidenuniv.nl/sciencedata.php*
Data split inference: *https://github.com/fkoehlin/montepython_2cosmos_public*
***S, R,* and more:** *https://github.com/williamjameshandley/anesthetic*