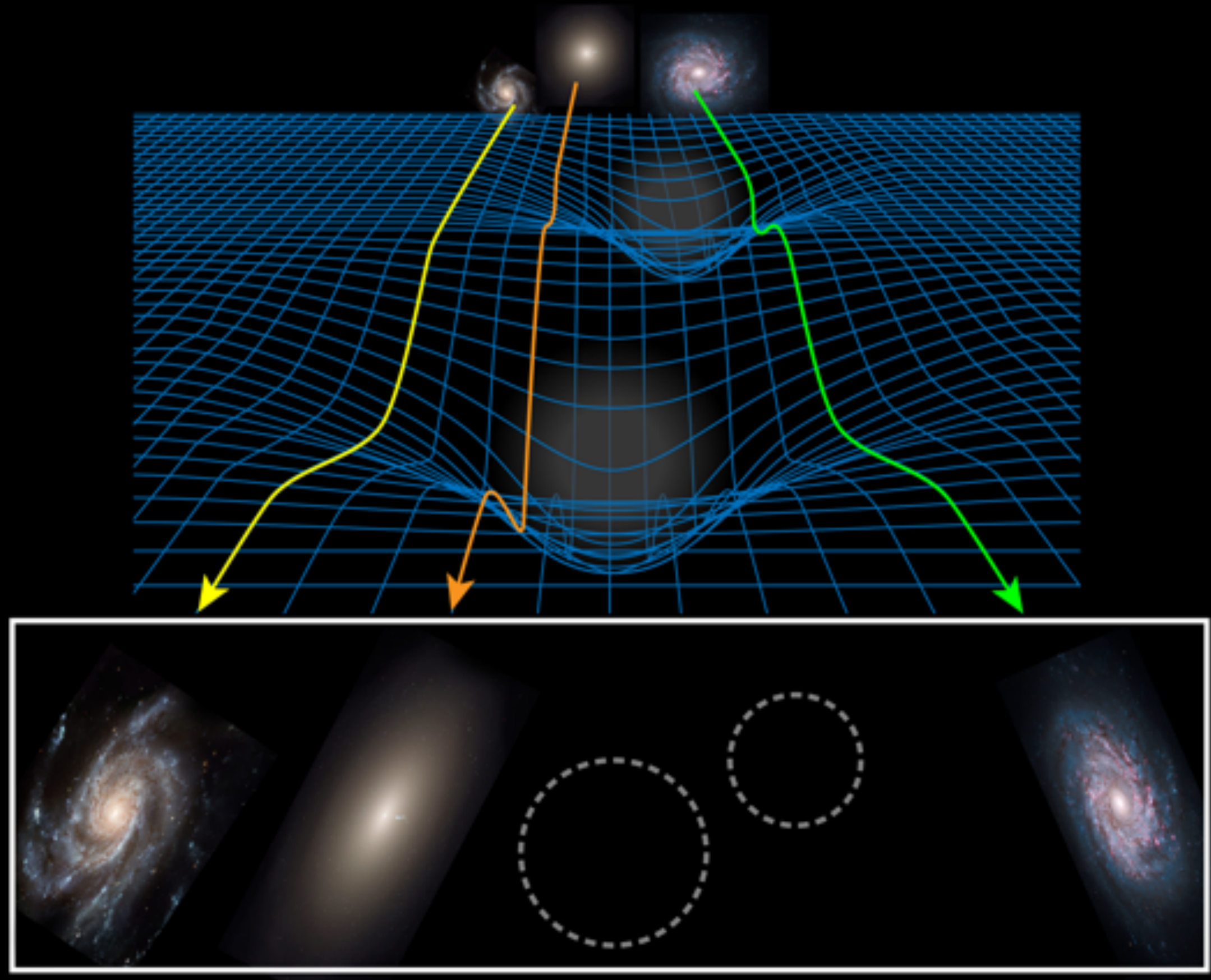
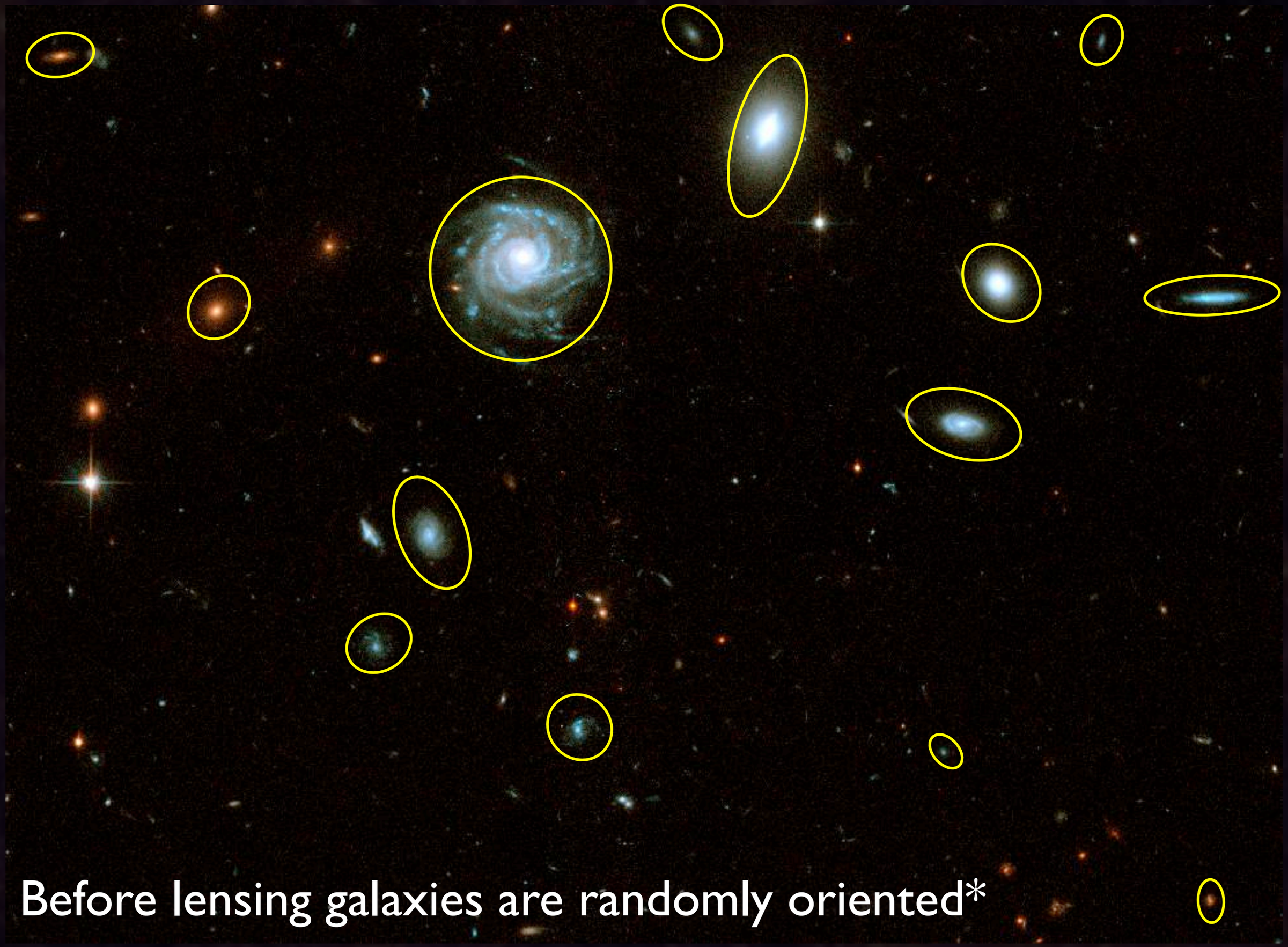
Cosmology with the Kilo-Degree Survey

Catherine Heymans
Edinburgh

Hildebrandt et al 2017
Joudaki et al 2017
van Uitert et al 2017



Credit: Stonebraker, APS


Before lensing galaxies are randomly oriented*

Gravitational Lensing by large-scale structure

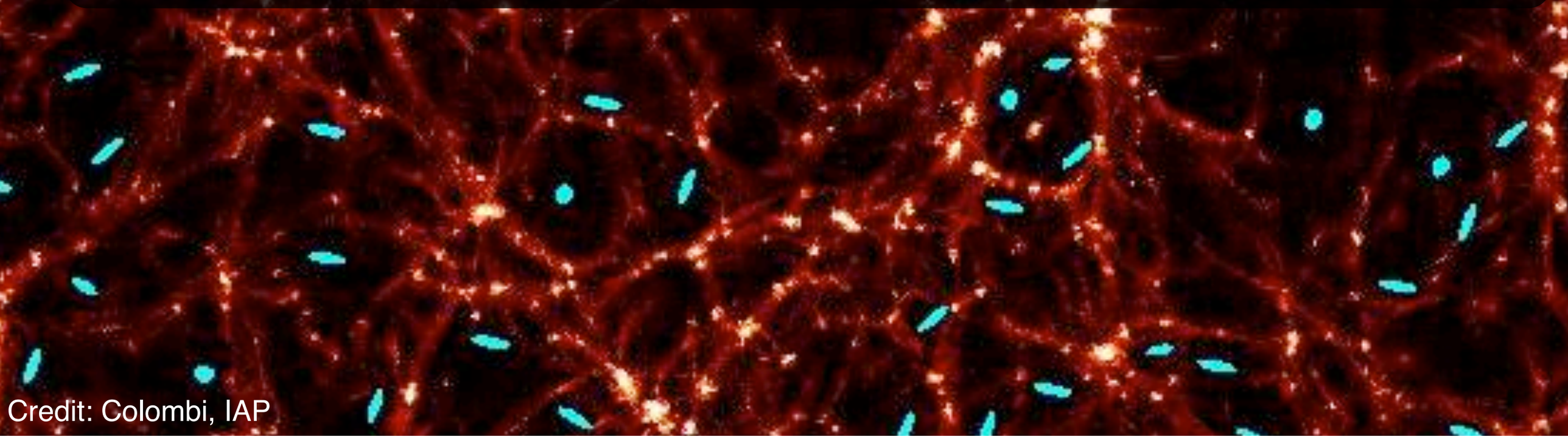
$$\xi_+(\theta) = \frac{1}{2\pi} \int d\ell\, \ell\, P_\kappa(\ell)\, J_0(\ell\theta)$$

Credit: Colombi, IAP

Gravitational Lensing by large-scale structure

$$\xi_+(\theta) = \frac{1}{2\pi} \int d\ell\, \ell\, P_\kappa(\ell)\, J_0(\ell\theta)$$

$$P_\kappa(\ell) = \int d\chi\, Q(\chi)\, P_\delta\left(\frac{\ell}{\chi}, \chi\right)$$



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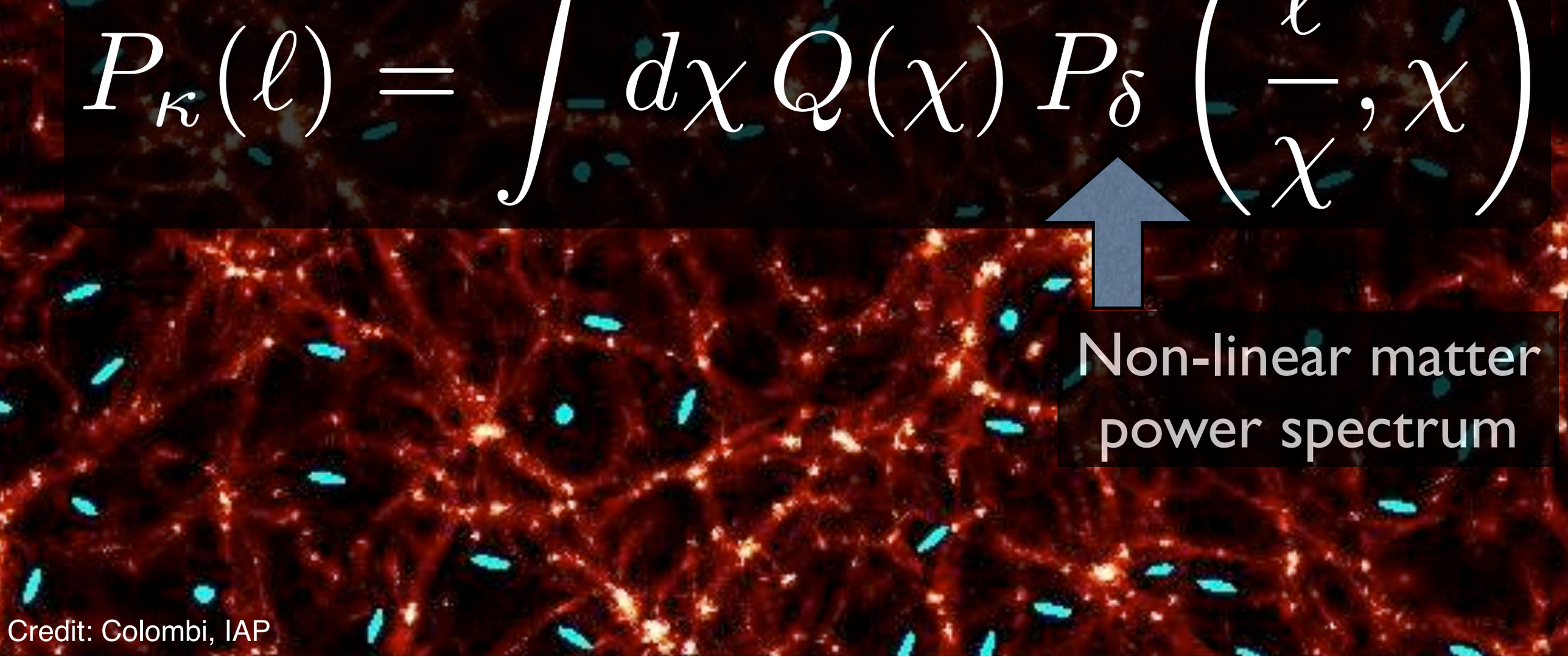
Non-linear matter power spectrum



Credit: Colombi, IAP

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Lensing efficiency + survey depth

Non-linear matter power spectrum

Credit: Colombi, IAP

Gravitational Lensing by large-scale structure

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Lensing efficiency + survey depth

Non-linear matter power spectrum

Observables

Credit: Colombi, IAP

Gravitational Lensing by large-scale structure

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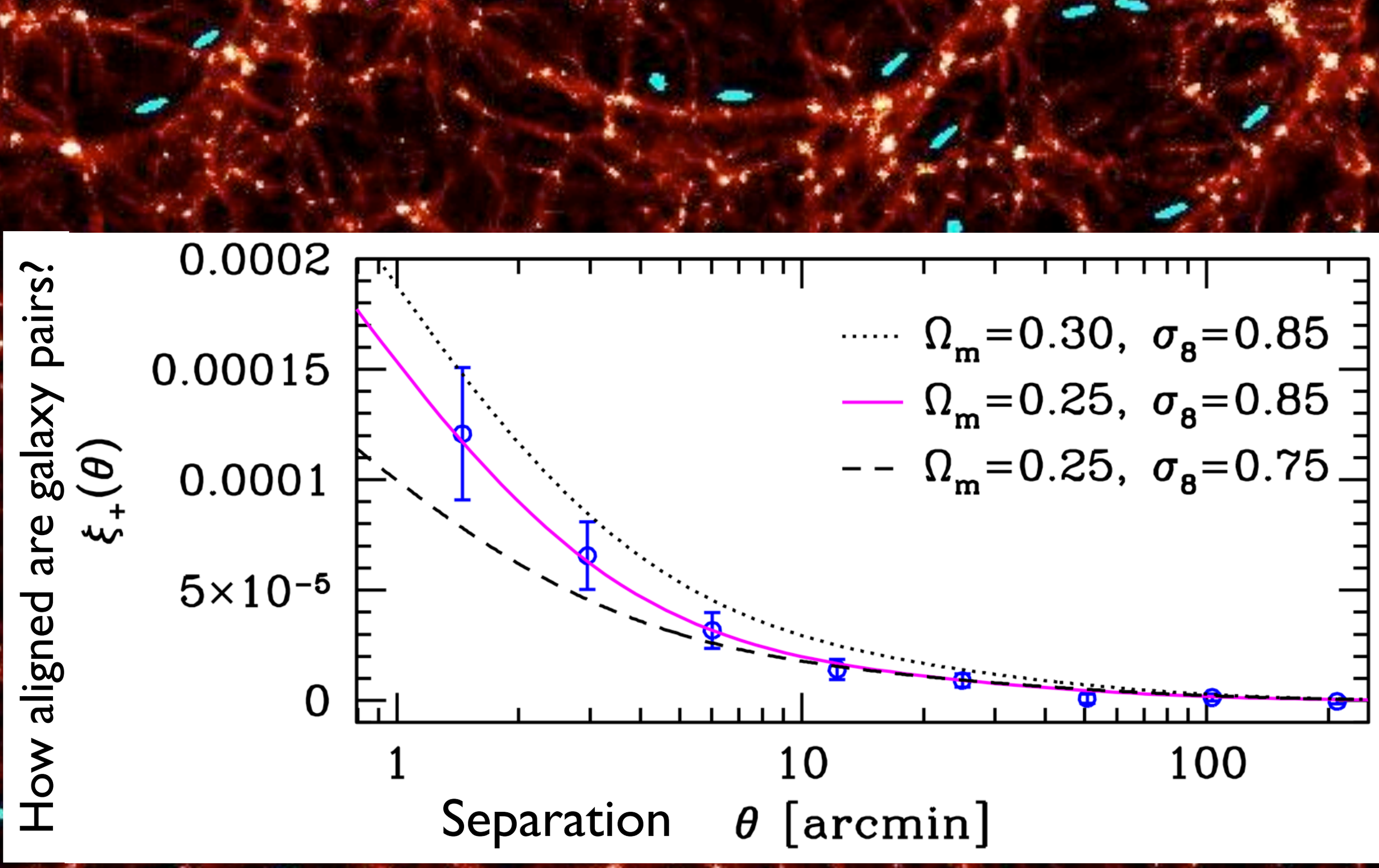
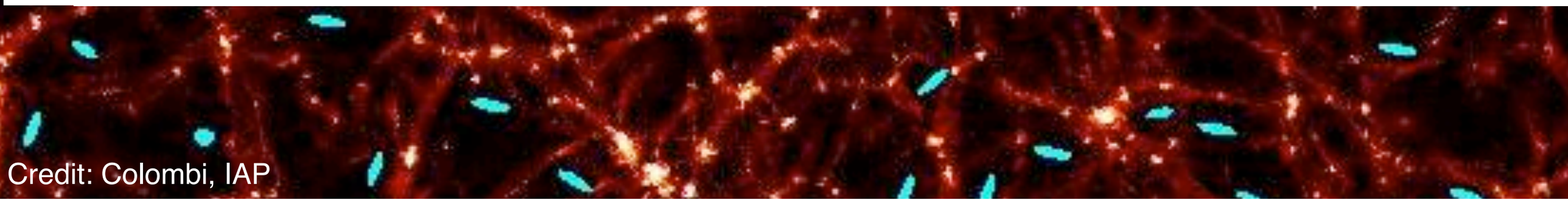
Lensing efficiency + survey depth

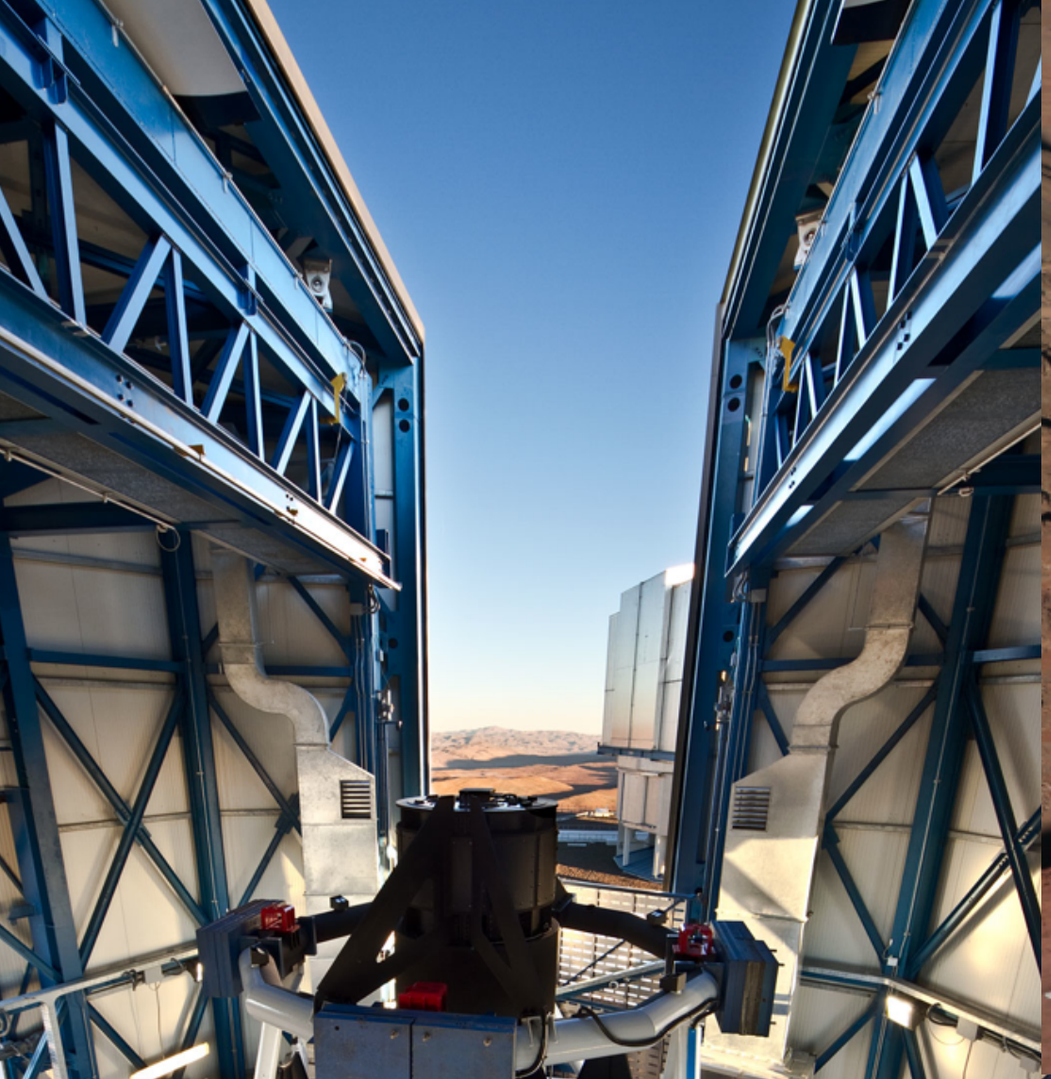
Non-linear matter power spectrum

Observables → Cosmology and Gravity

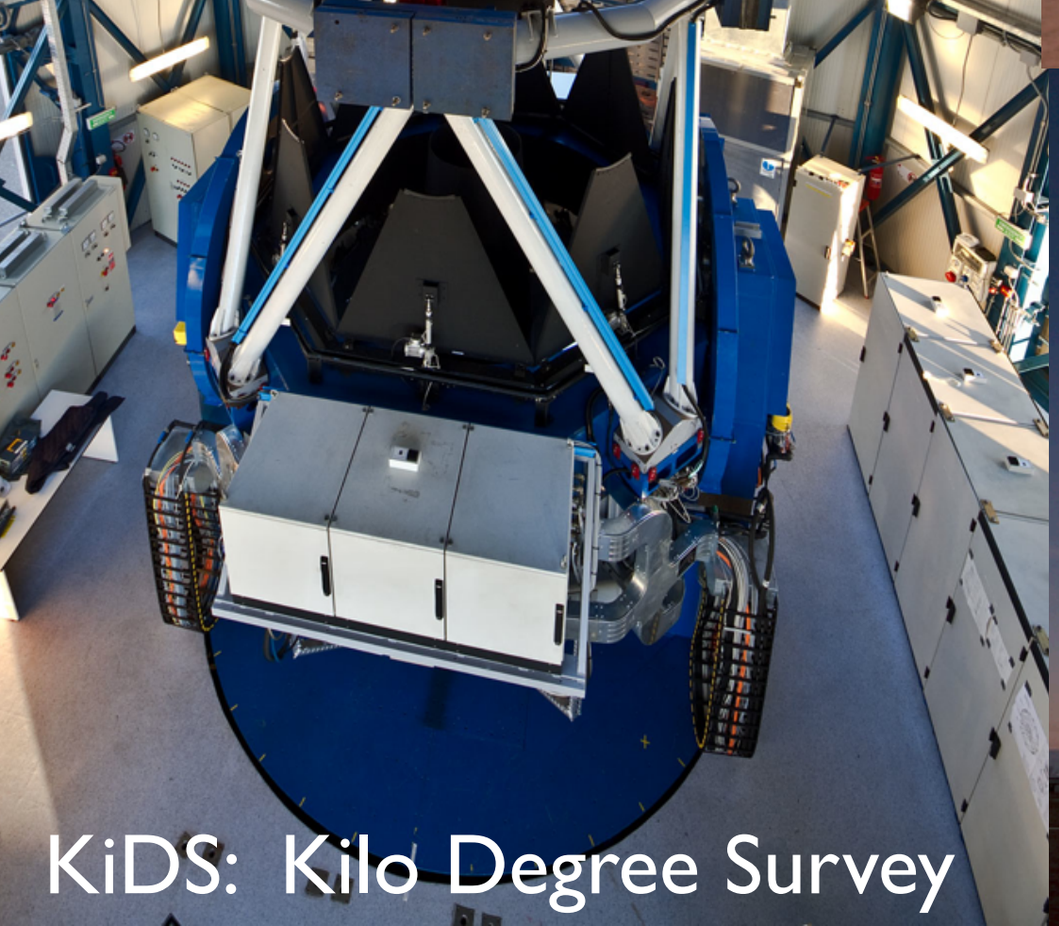
Credit: Colombi, IAP

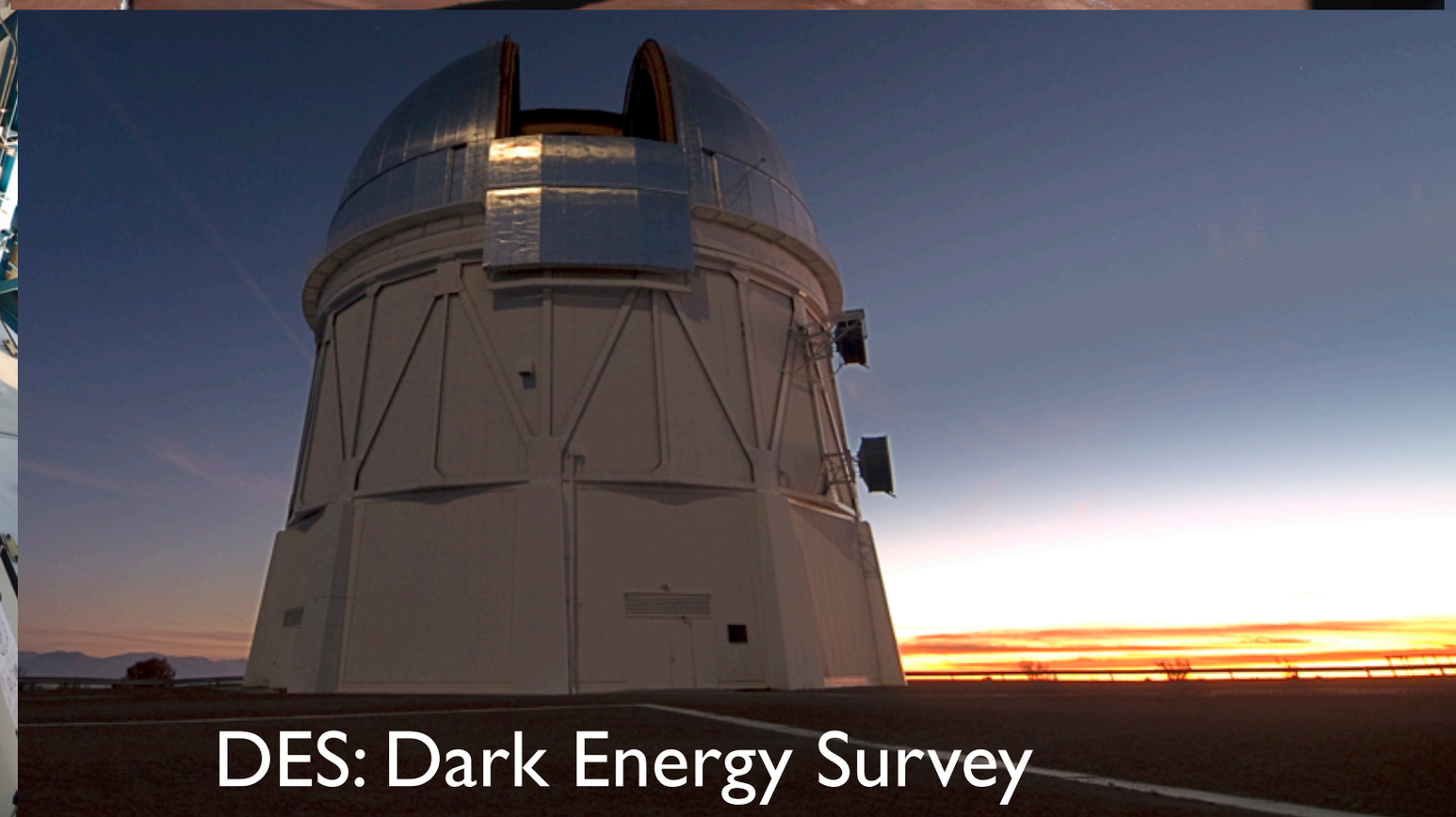

How aligned are galaxy pairs?
$\xi_+(\theta)$
0.0002
0.00015
0.0001
5×10^{-5}
0
Ω_m=0.30, σ_8=0.85
Ω_m=0.25, σ_8=0.85
Ω_m=0.25, σ_8=0.75
1
10
100
Separation θ [arcmin]


Credit: Colombi, IAP

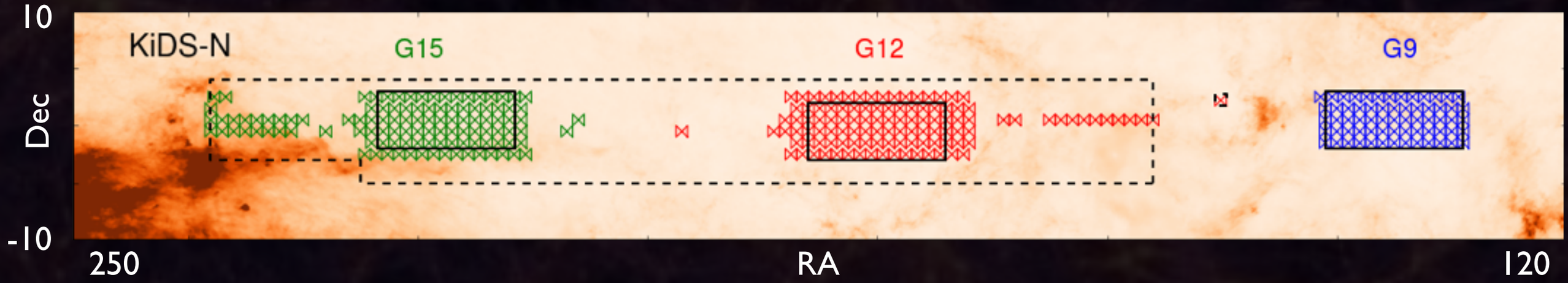


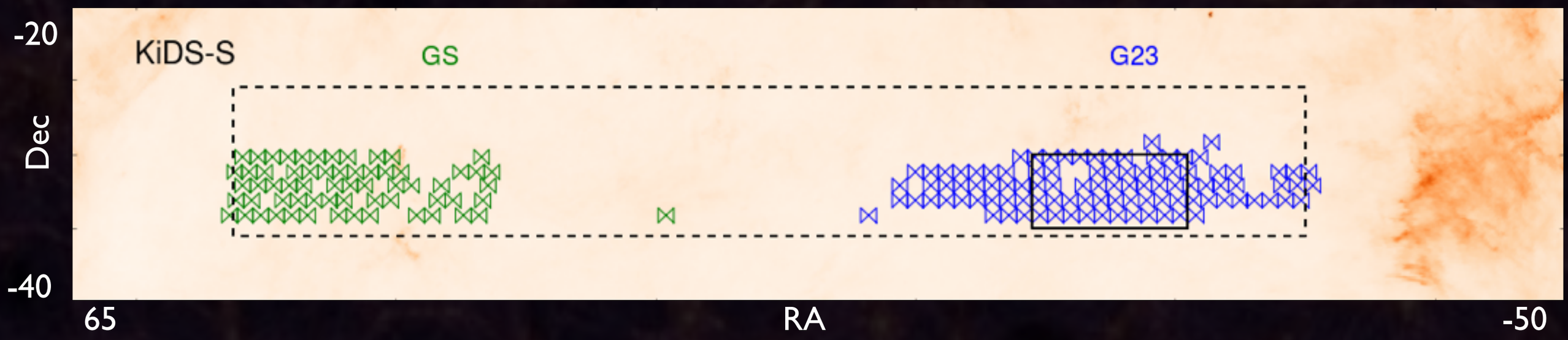

HSC: Hyper-Suprime Cam Survey


KiDS: Kilo Degree Survey

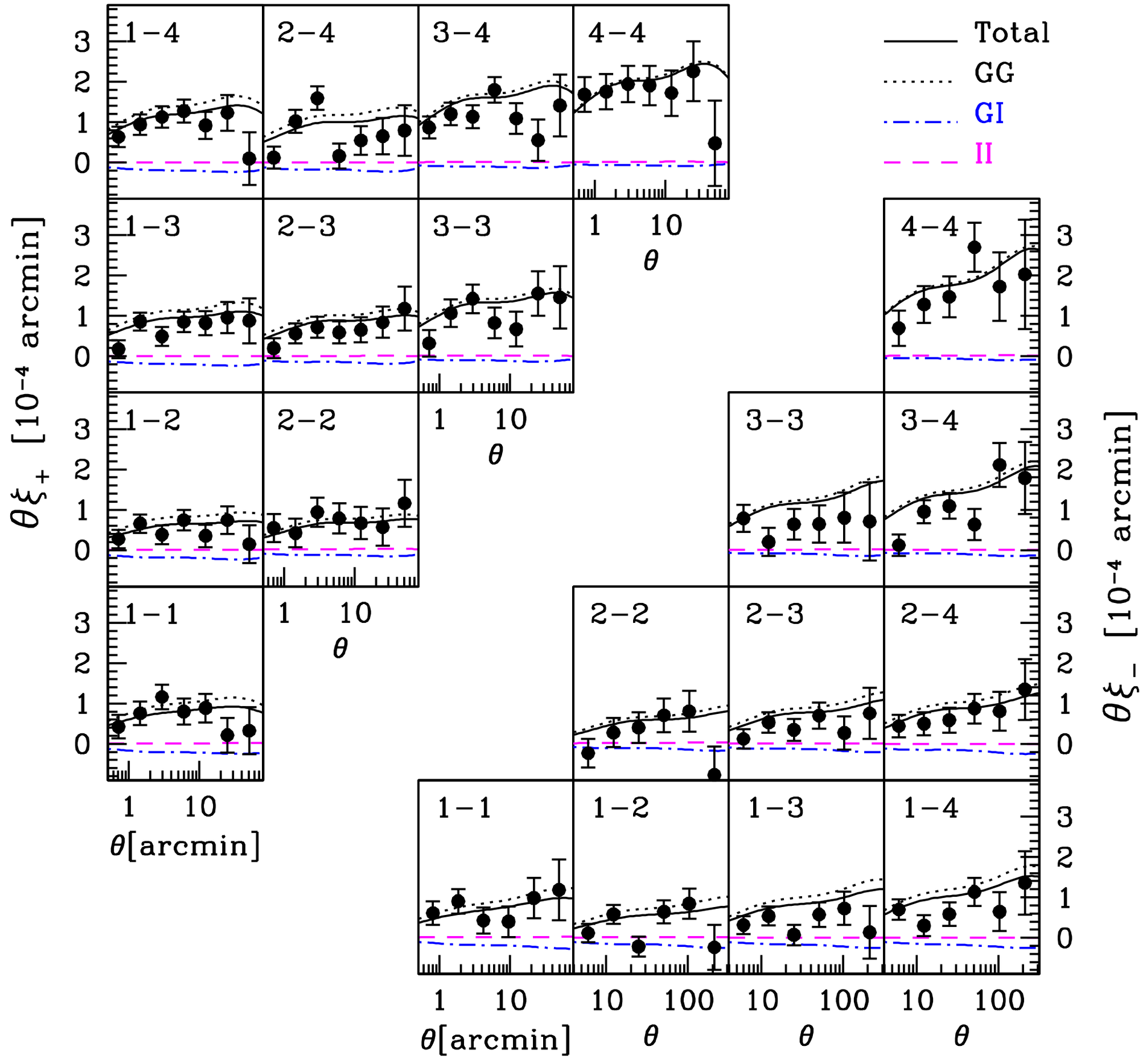

DES: Dark Energy Survey

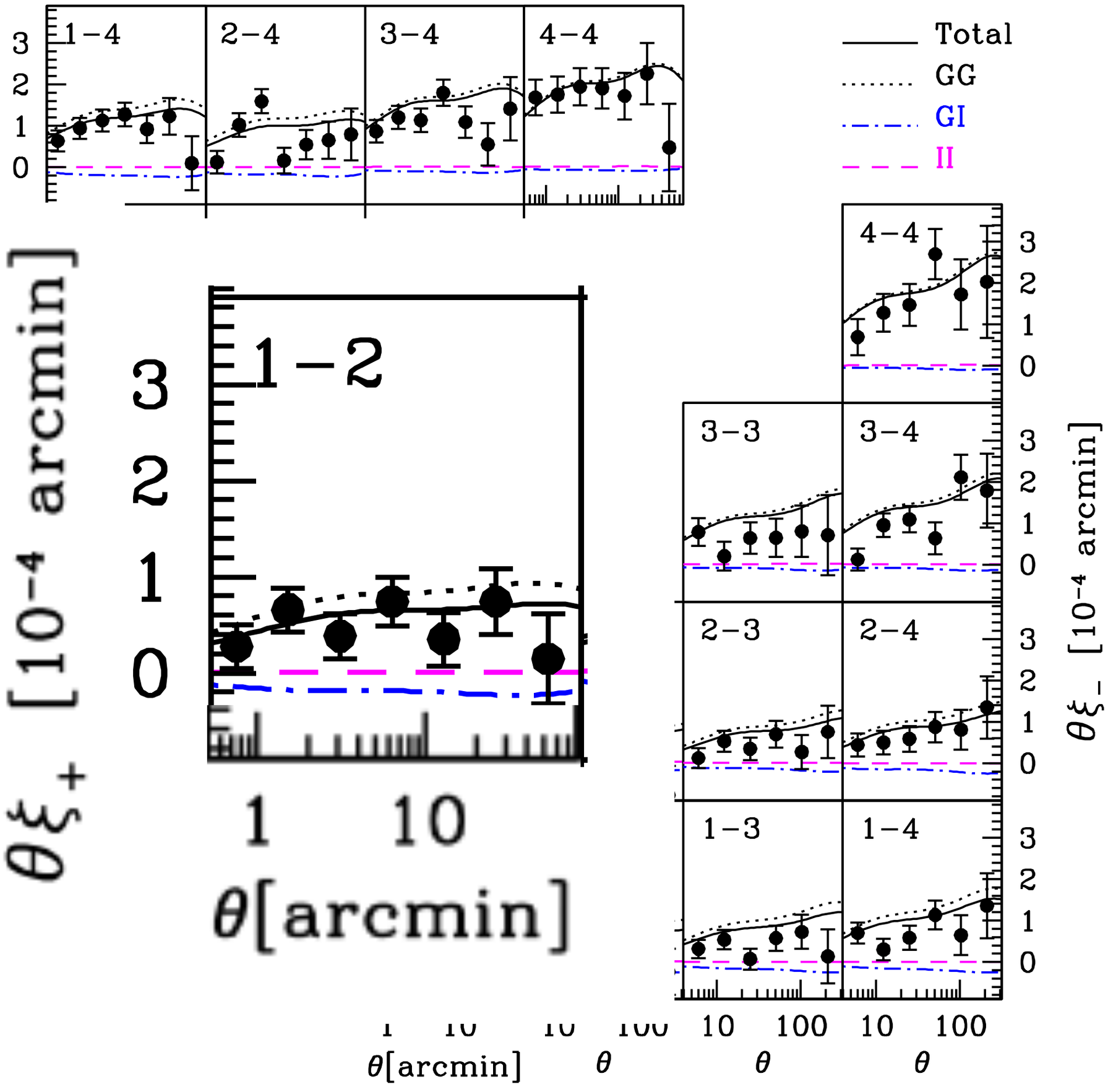
VST Kilo-Degree Survey (KiDS)

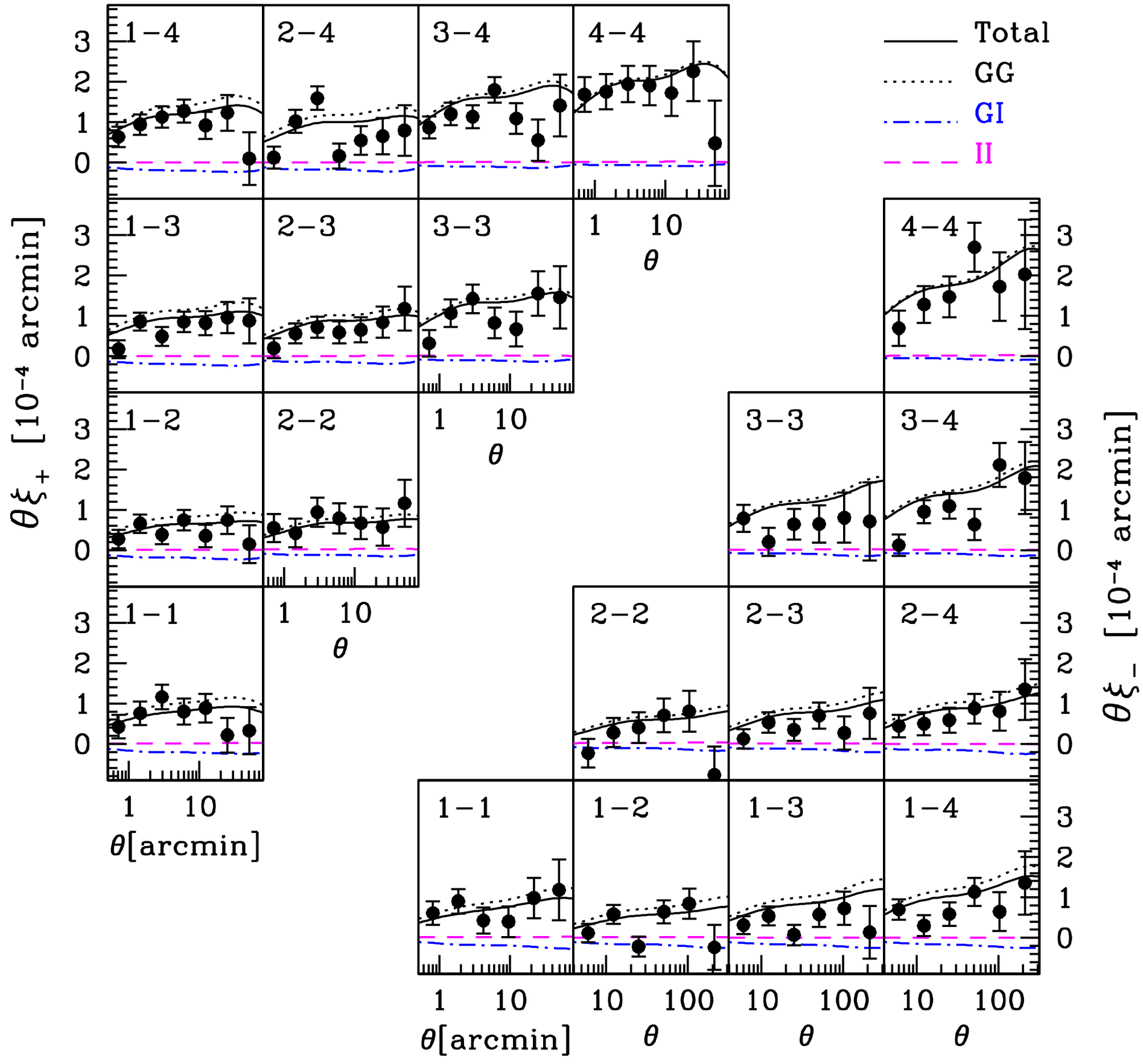




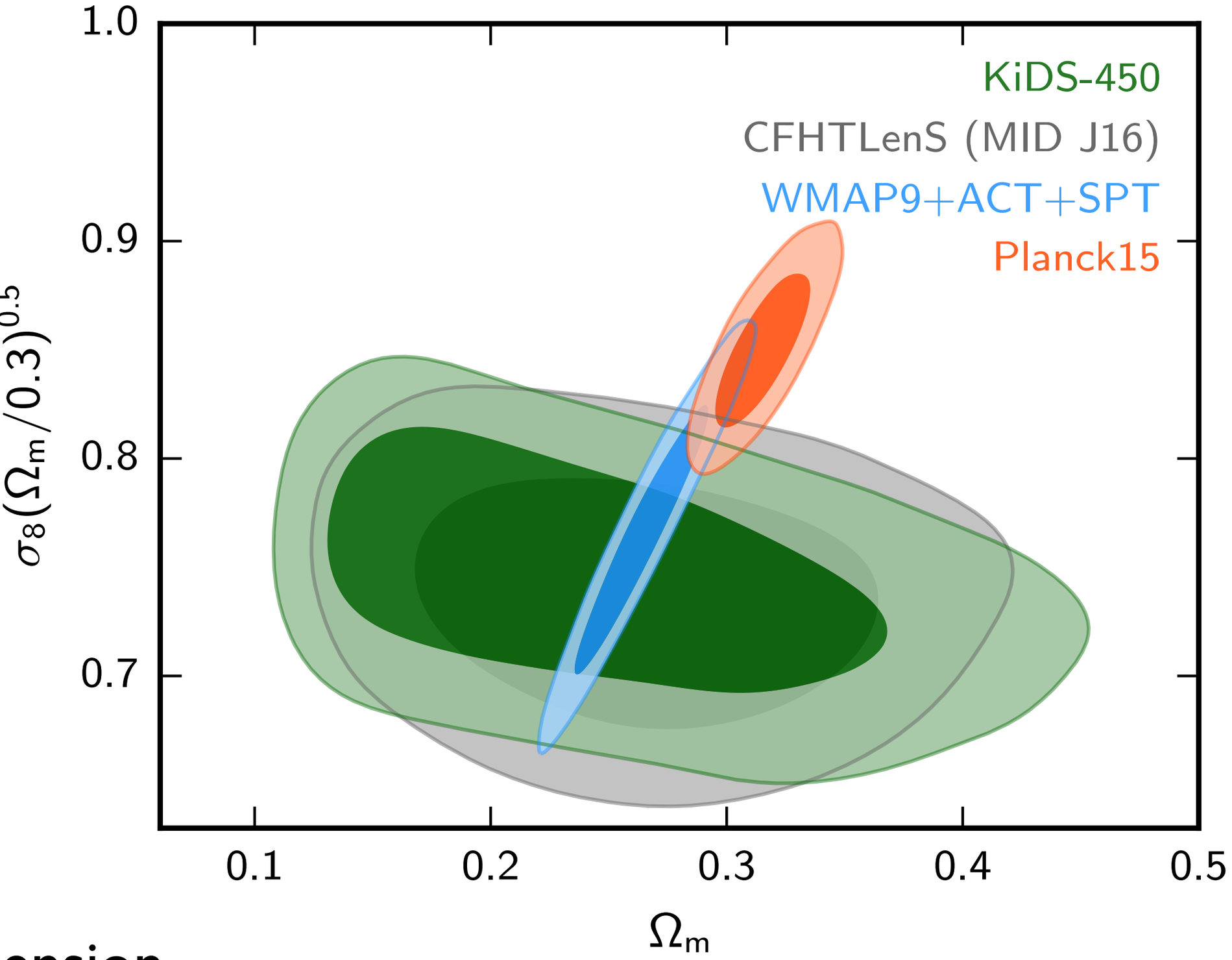
- All data until July 2015: 450 sq degrees in *ugri*
- Shapes and photometric redshifts for 15 million resolved galaxies
- neff = 8.5 gals per sq arcmin (excellent seeing)
- z_{median} = 0.66 (deep data), <z>=0.77


Total
GG
GI
II
1−4
2−4
3−4
4−4
1−3
2−3
3−3
1−2
2−2
1−1
θξ+ [10−4 arcmin]
θξ− [10−4 arcmin]
θ[arcmin]
θ
1
10
100
0
1
2
3


1−4
2−4
3−4
4−4
Total
GG
GI
II
1−2
3−3
3−4
2−3
2−4
1−3
1−4
$\theta\xi_+$ [10^{-4} arcmin]
$\theta\xi_-$ [10^{-4} arcmin]
θ[arcmin]
θ

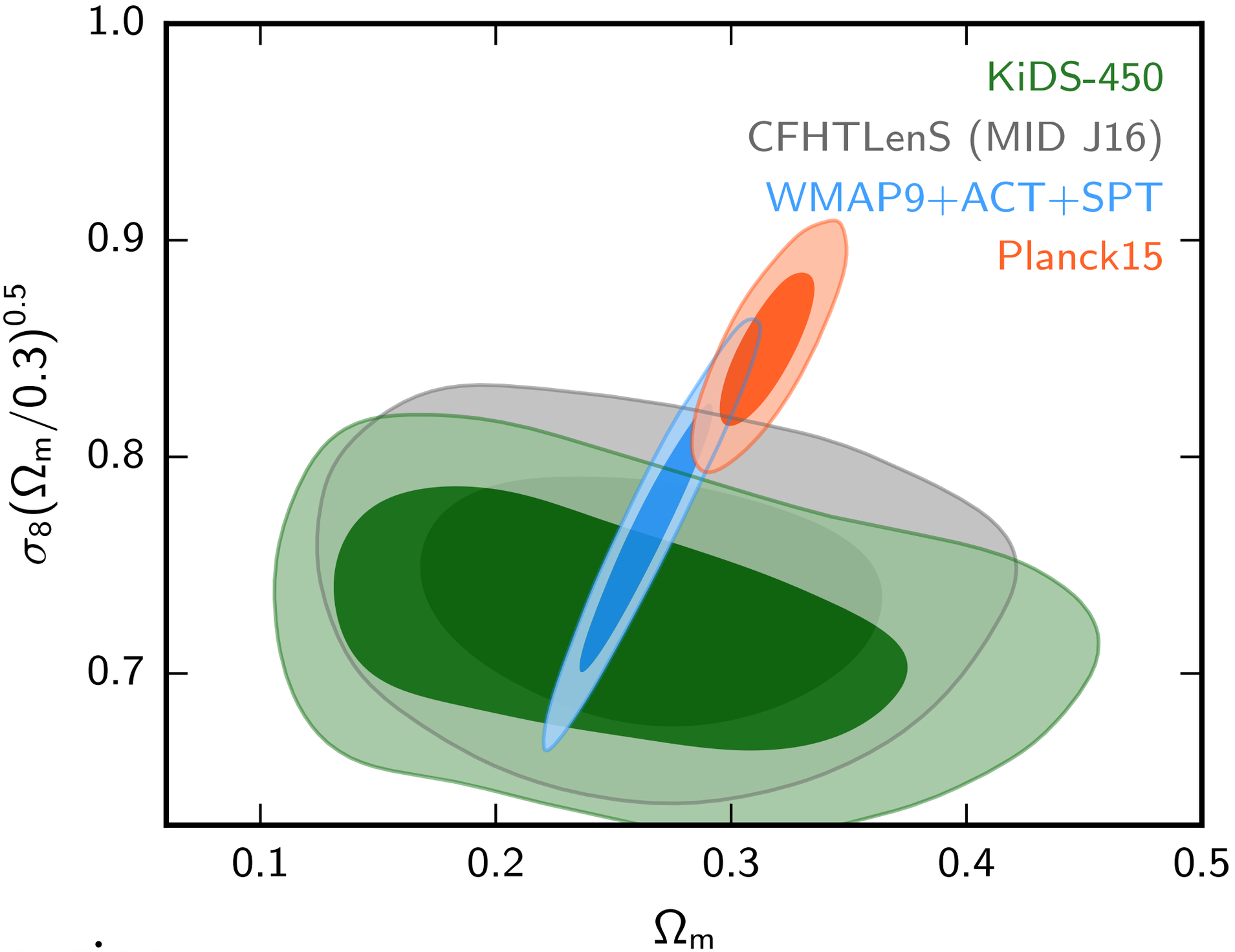

Total
GG
GI
II
1−4
2−4
3−4
4−4
1−3
2−3
3−3
1−2
2−2
1−1
θξ+ [10−4 arcmin]
θξ− [10−4 arcmin]
θ[arcmin]
θ
1
10
100
0
1
2
3

Blind I



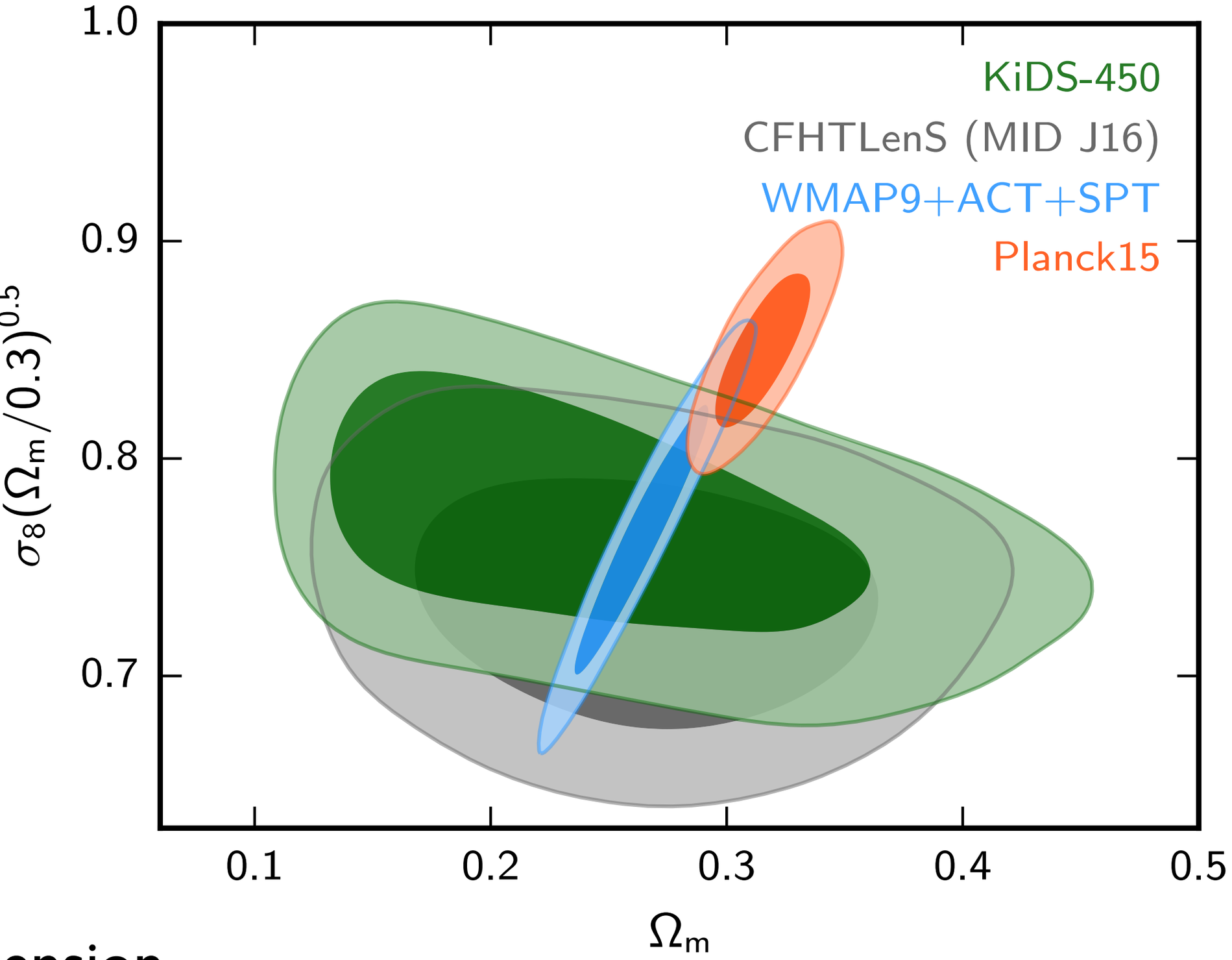
2.3 σ tension

Blind 2



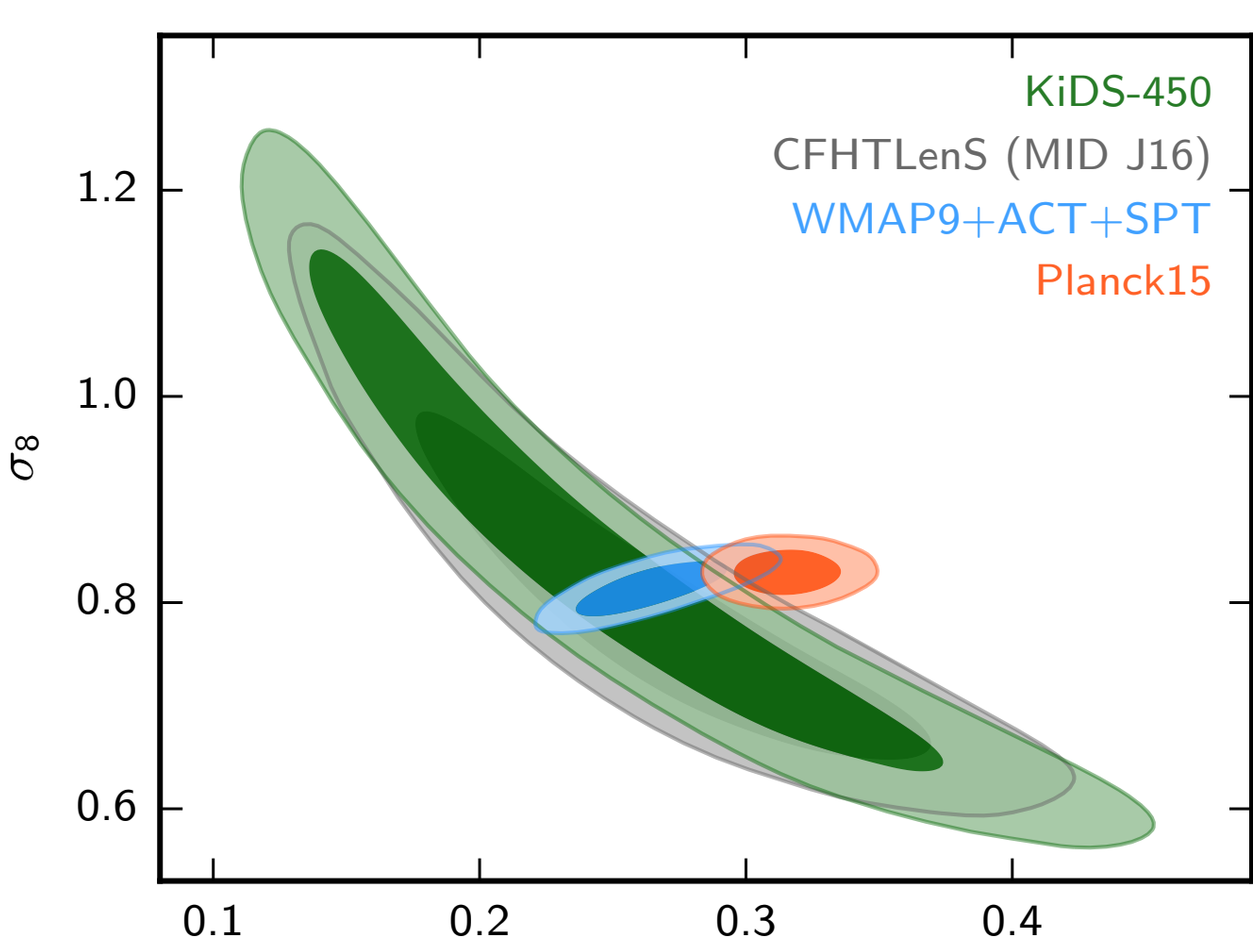
3.0 σ tension

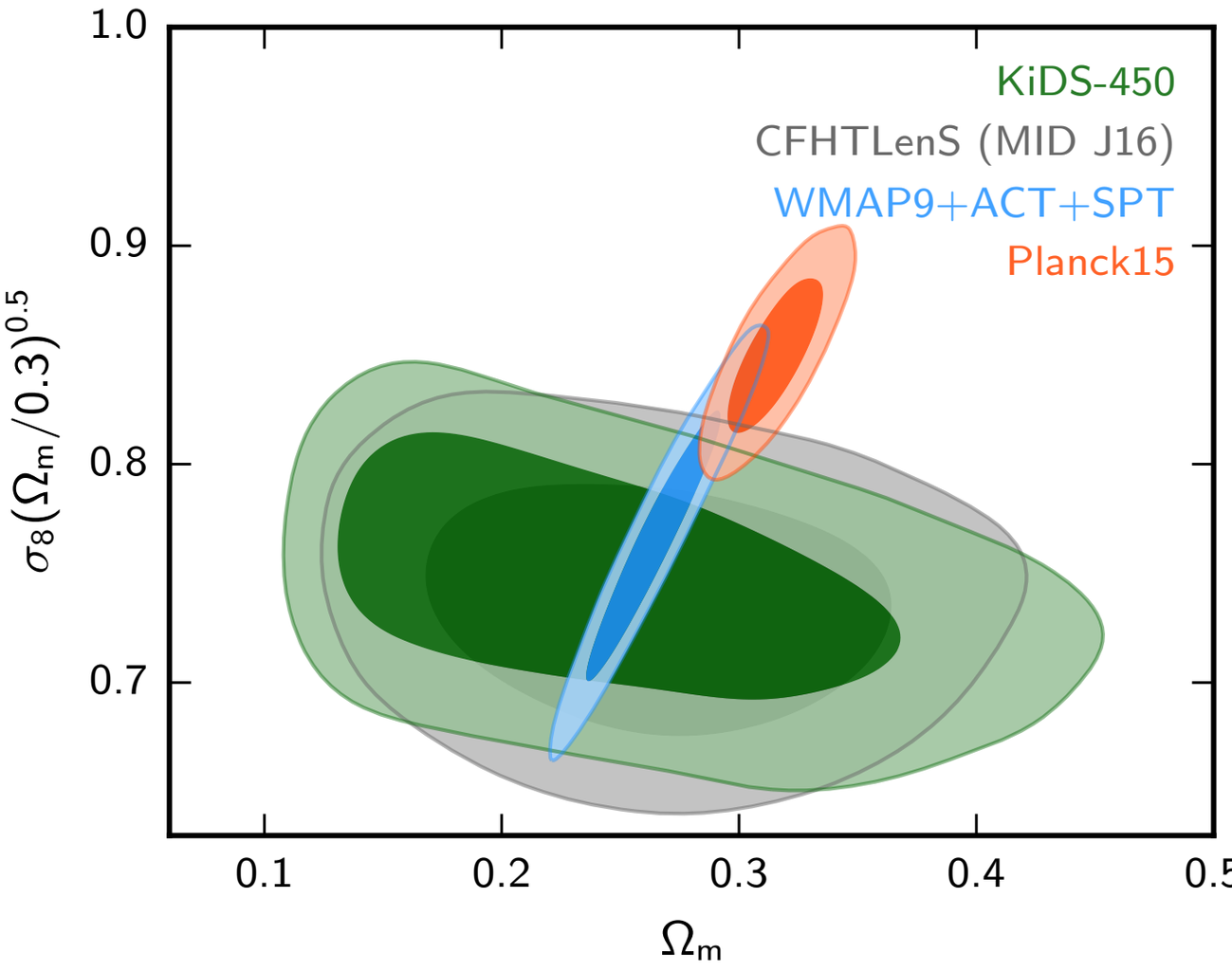
Blind 3



1.5 σ tension

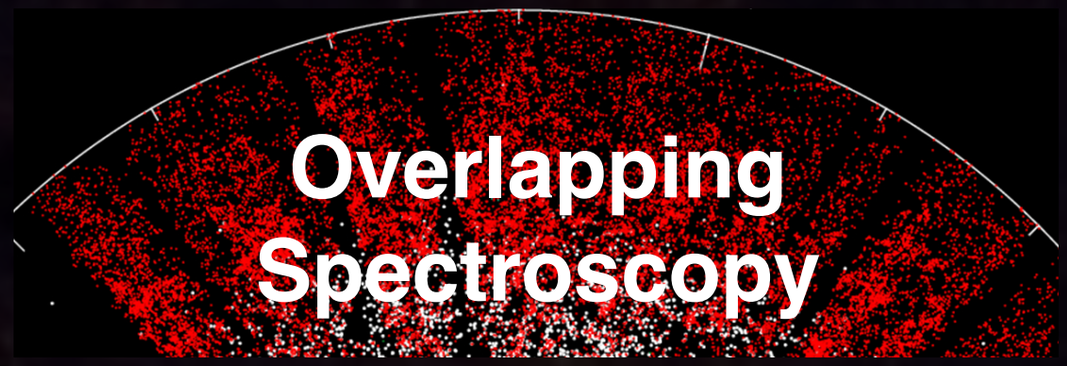
The truth.....





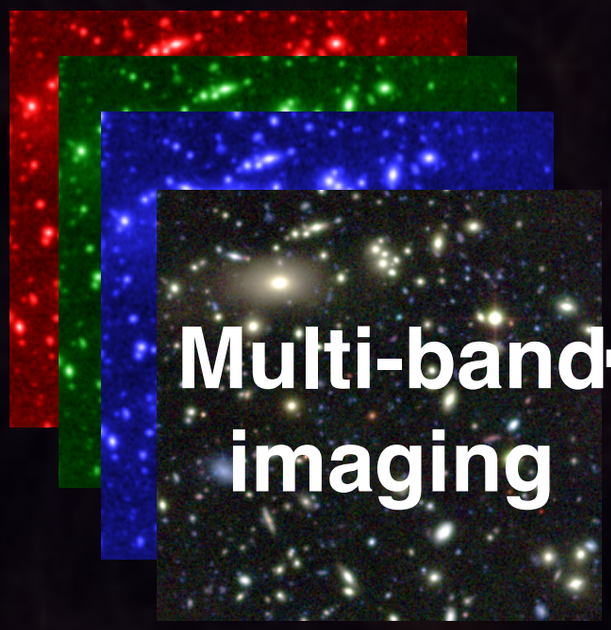
2.3 σ tension

Cosmic Shear



Object Catalogue

+



Colours

Calibration

Galaxies

Stars

P(z)

γ

Your Favourite Statistic

Errors/Models

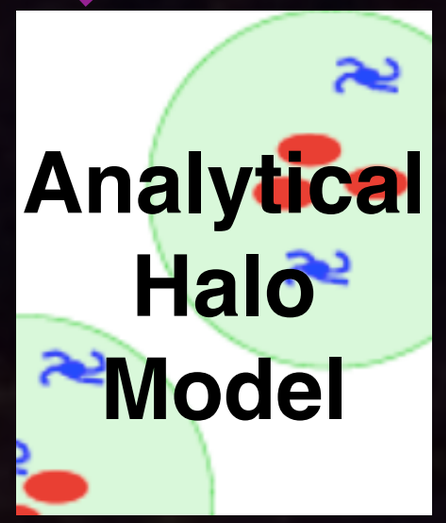
Nuisance

$\mathcal{L}$

Cosmology

Errors/Models

Calibration



Cosmology Recipe

Audience Poll

I am most sceptical about.....

A. Accuracy of Photometric Redshifts

B. Accuracy of Shear Measurements

C. Accuracy of Intrinsic Alignment Models and/or accurate non-linear matter power spectrum models

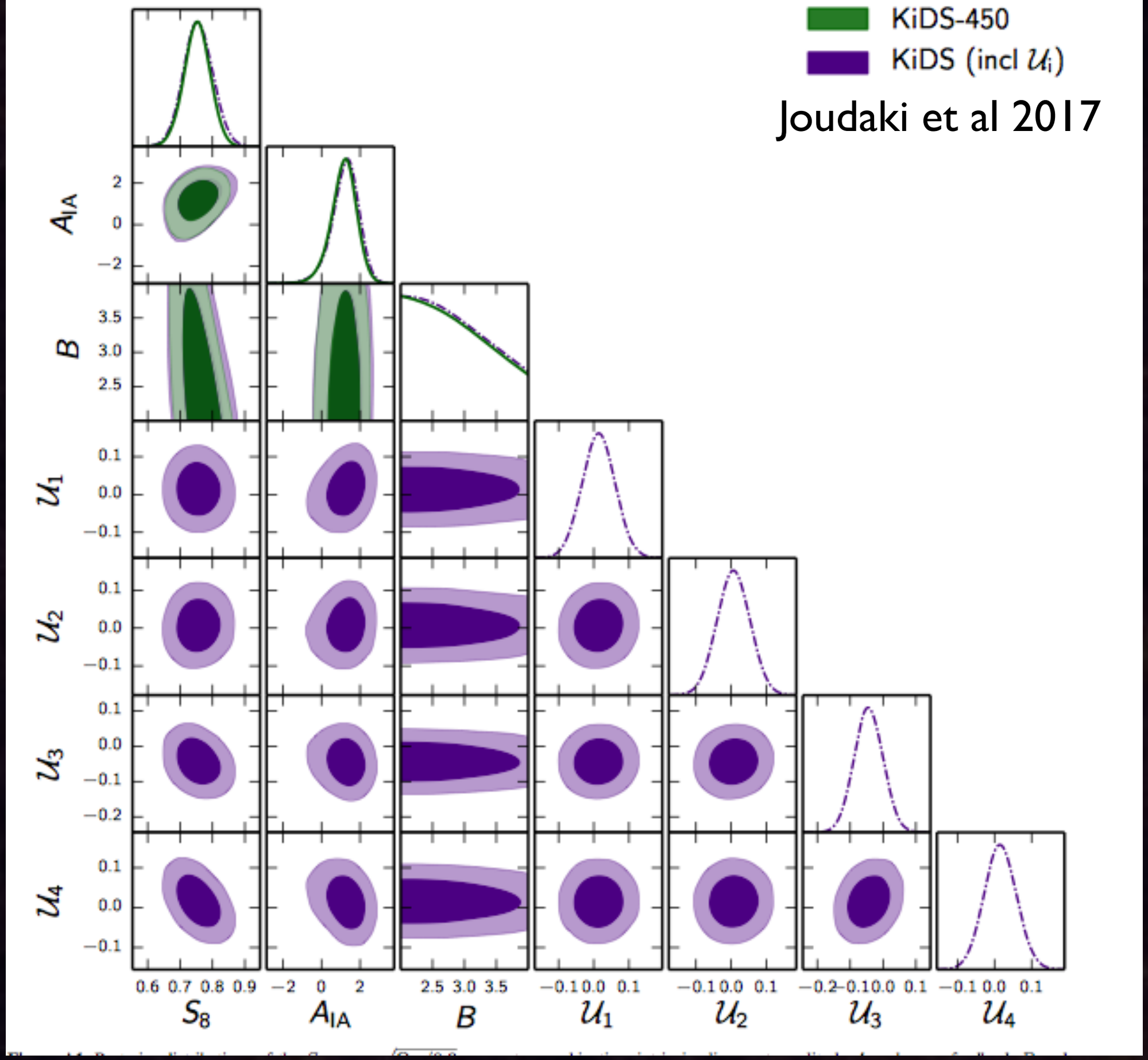
George votes for #A

Problems with KiDS

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

4 July 2017

ABSTRACT
The Kilo-Degree Survey (KiDS) has been used in several recent papers to infer constraints on the amplitude of the matter power spectrum and matter density at low redshift. Some of these analyses have claimed tension with the *Planck* ΛCDM cosmology at the $\sim 2-3\sigma$ level, perhaps indicative of new physics. However, *Planck* is consistent with other low redshift probes of the matter power spectrum such as redshift space distortions and the combined galaxy-mass and galaxy-galaxy power spectra. Here we perform consistency tests of the KiDS data, finding internal tensions for various cuts of the data at $\gtrsim 3\sigma$ significance. Until these internal tensions are understood, we argue that it is premature to claim evidence for new physics from KiDS.



Joudaki et al 2017

KiDS-450

KiDS (incl $\mathcal{U}_i$)

Joudaki et al 2017

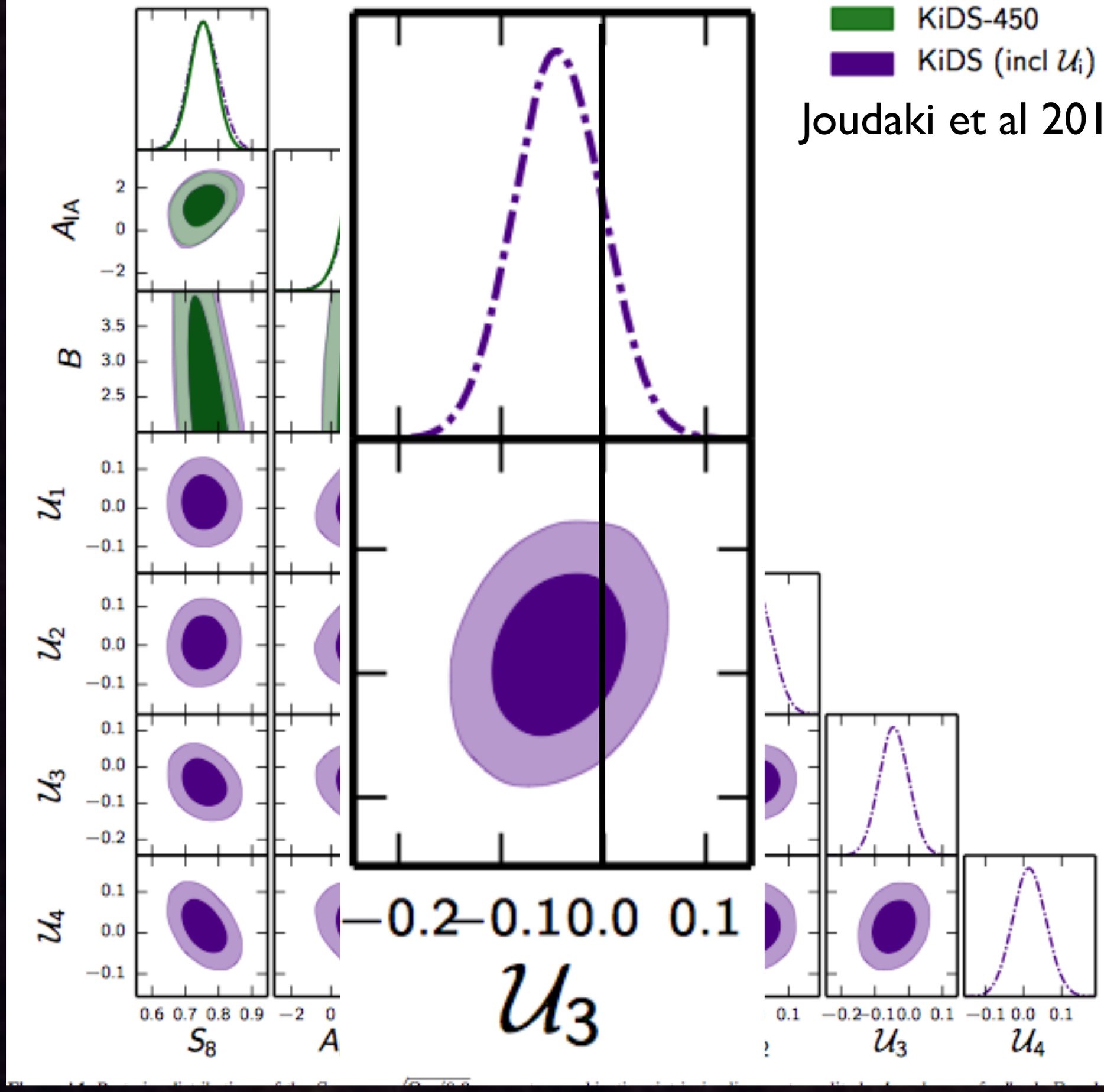
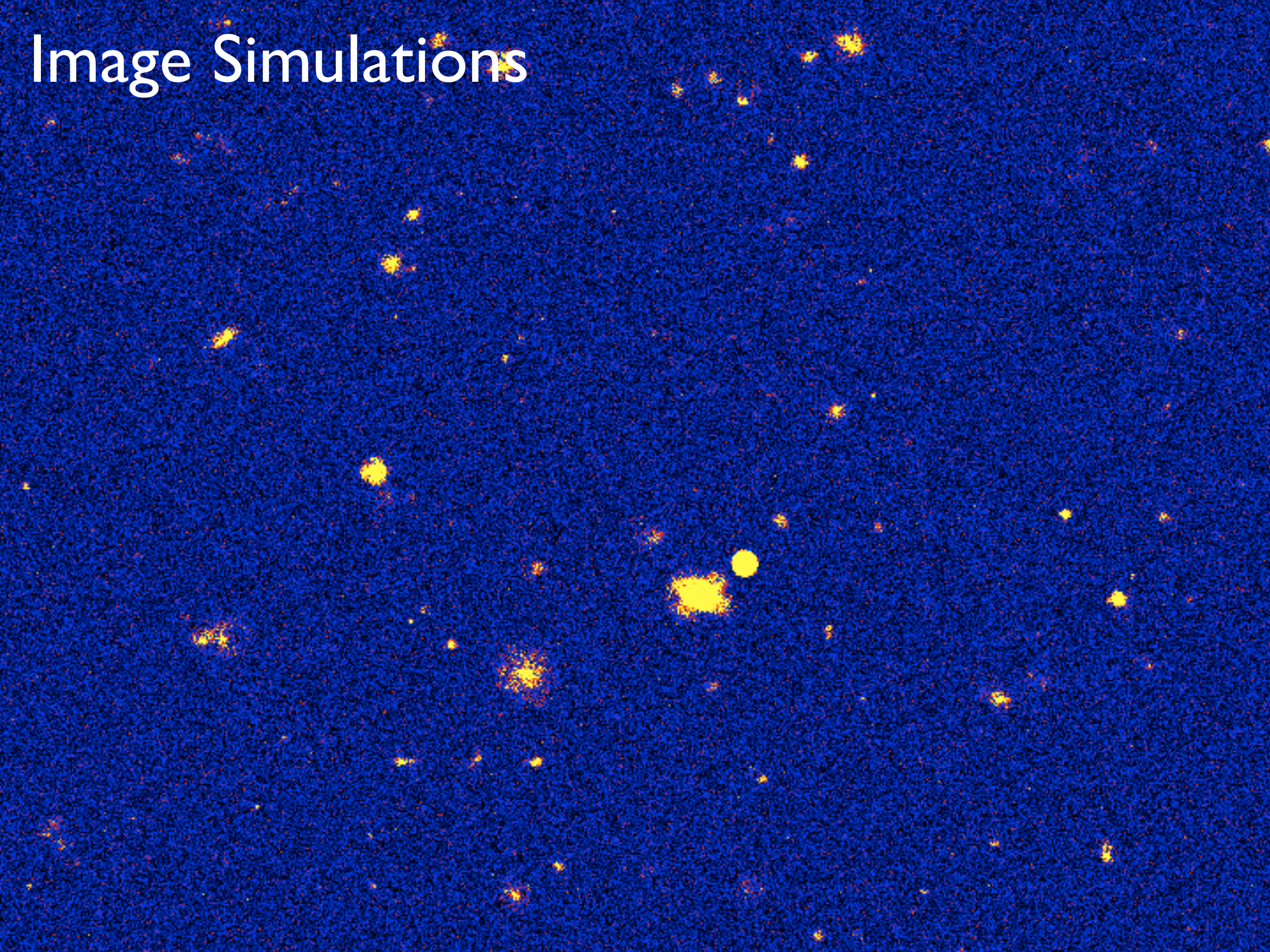
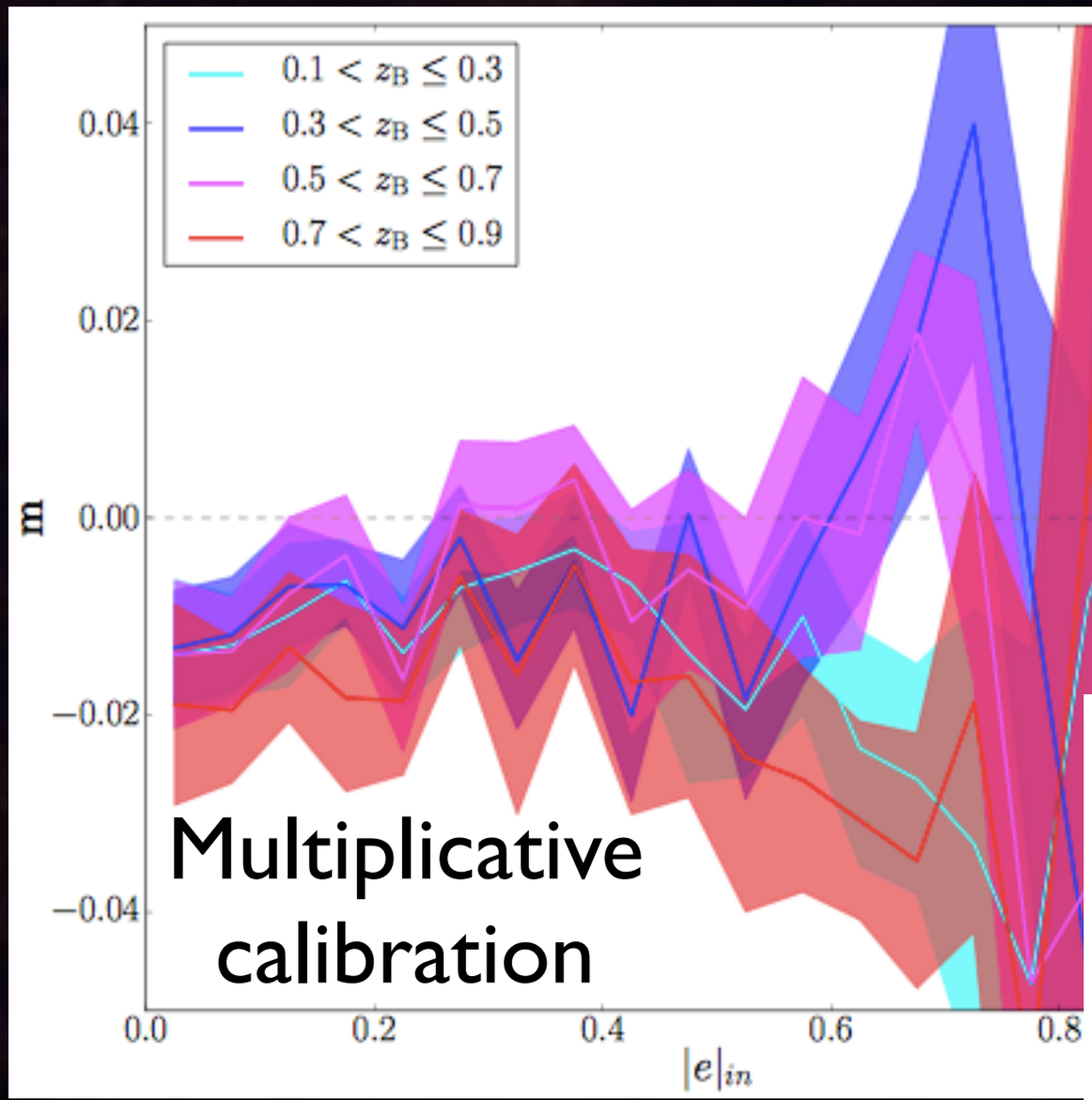


Image Simulations

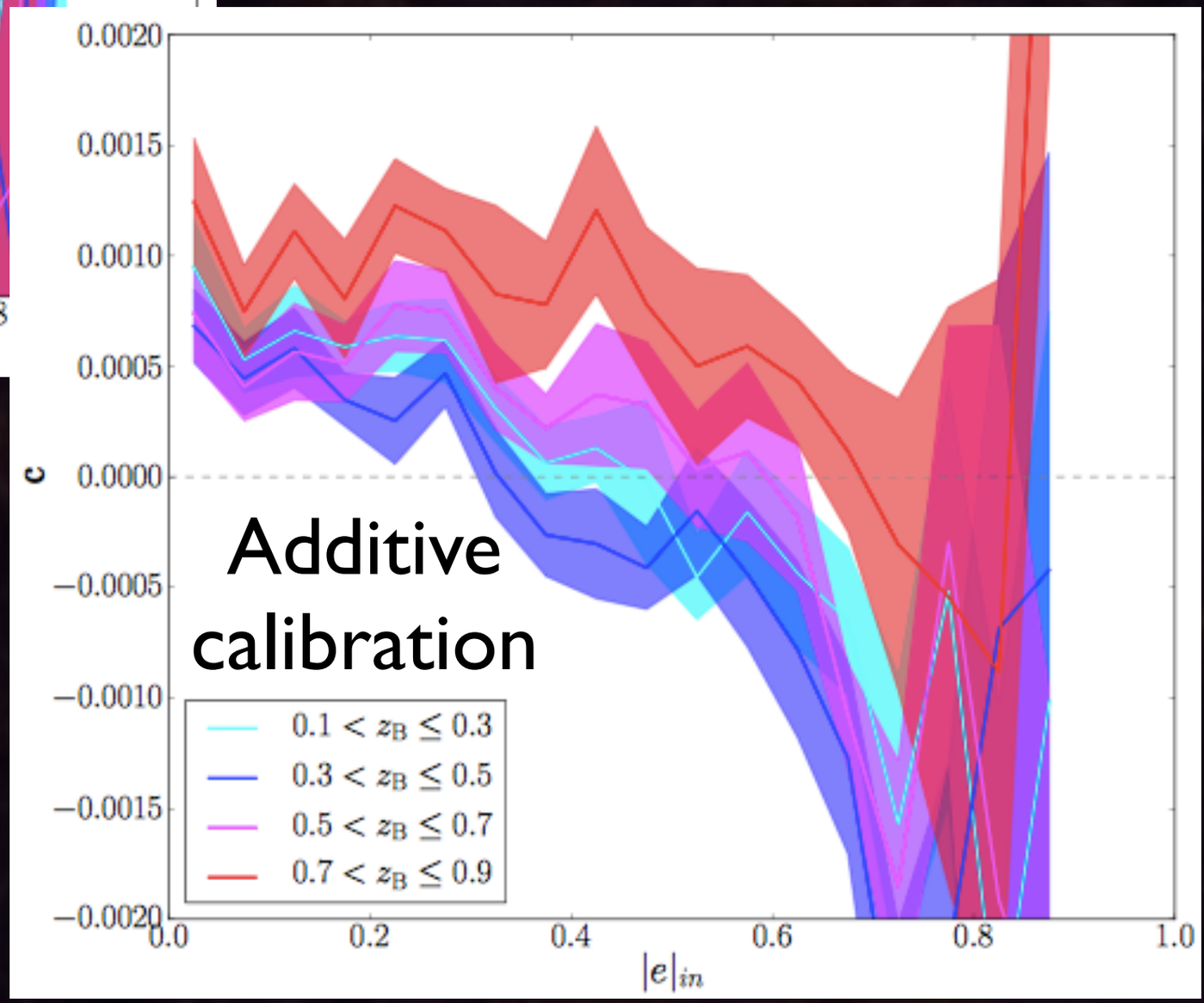


Shear Calibration

$$\epsilon^{\rm true} = (1+m)\epsilon^{\rm obs} + c$$



Multiplicative calibration



Additive calibration

Fenech-Conti et al 2017

Nuisance: intrinsic galaxy alignments

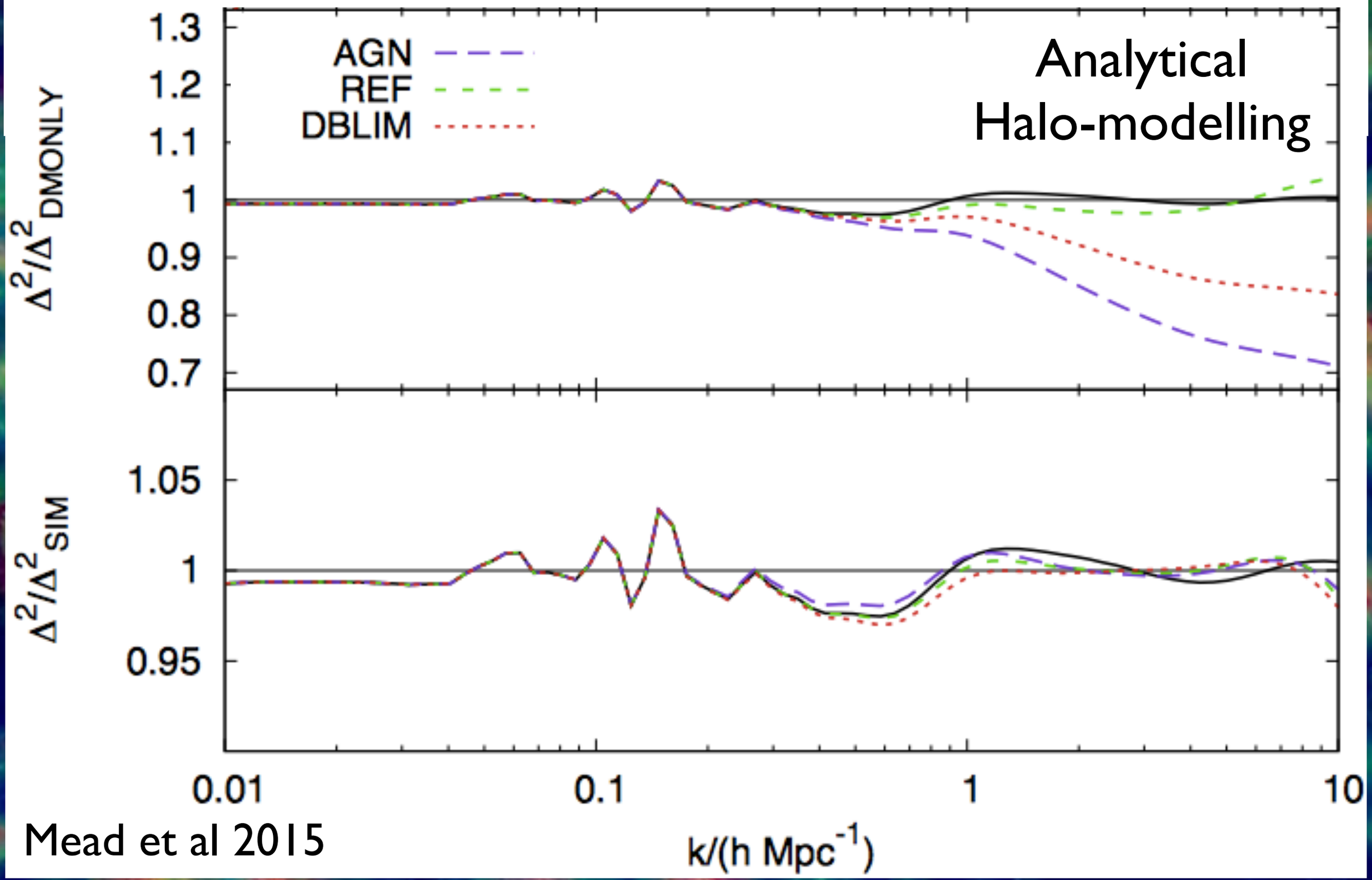
HORIZON Simulation

Codis et al 2015

Nuisance: baryon feedback

EAGLE Simulation

Schaye et al 2015



Mead et al 2015

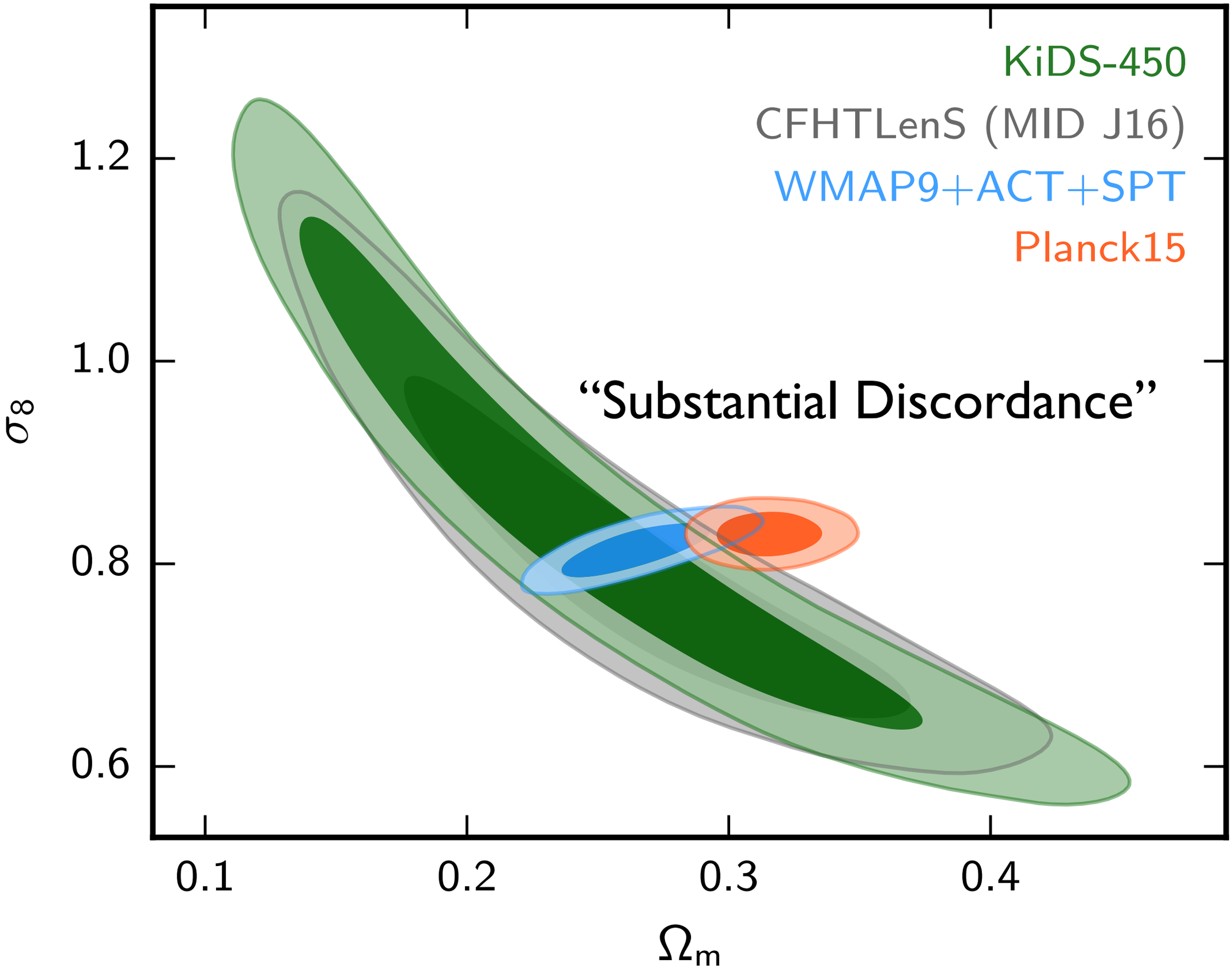
Audience Poll

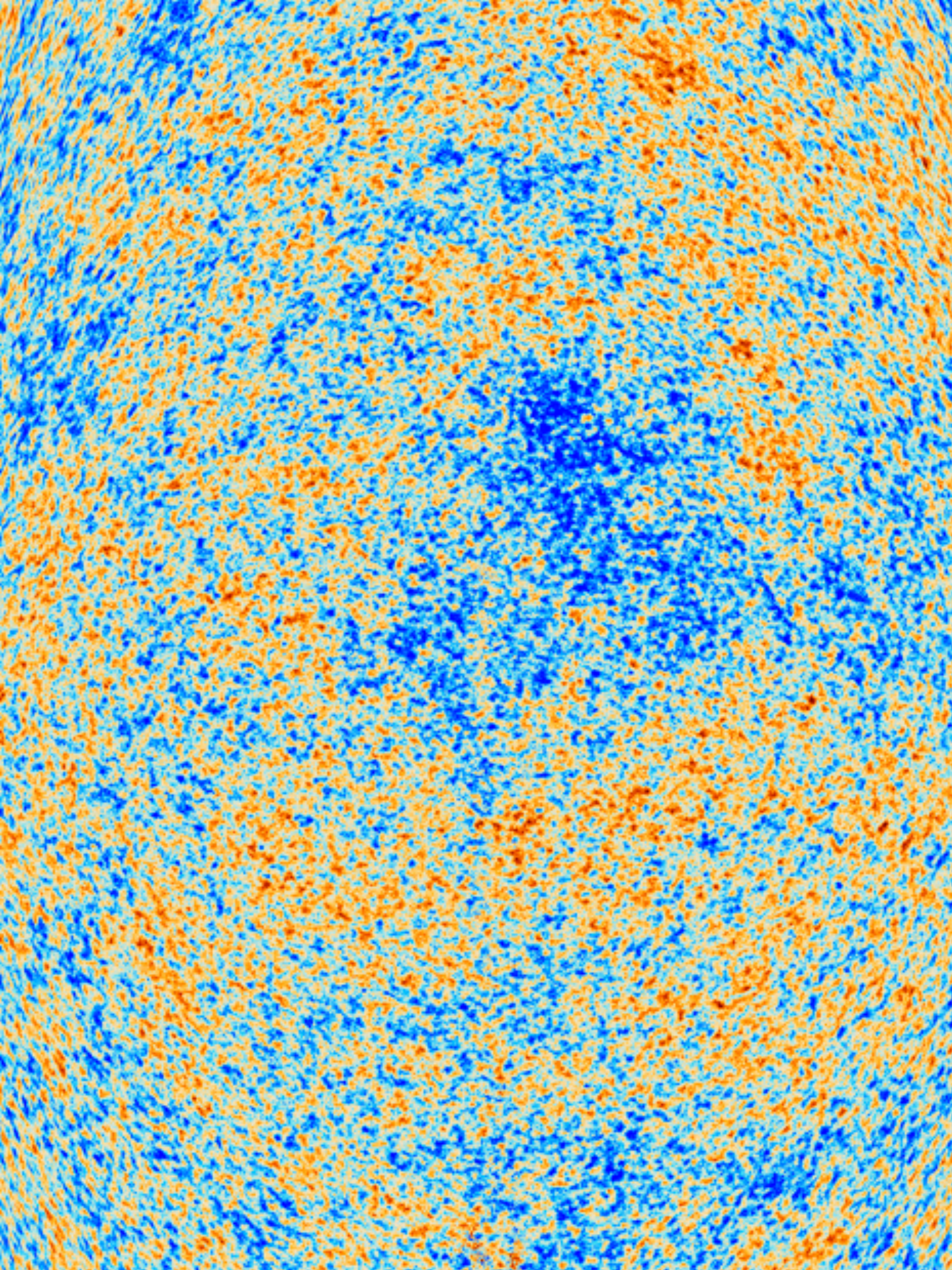
I am .....

A. Still very sceptical about this analysis.

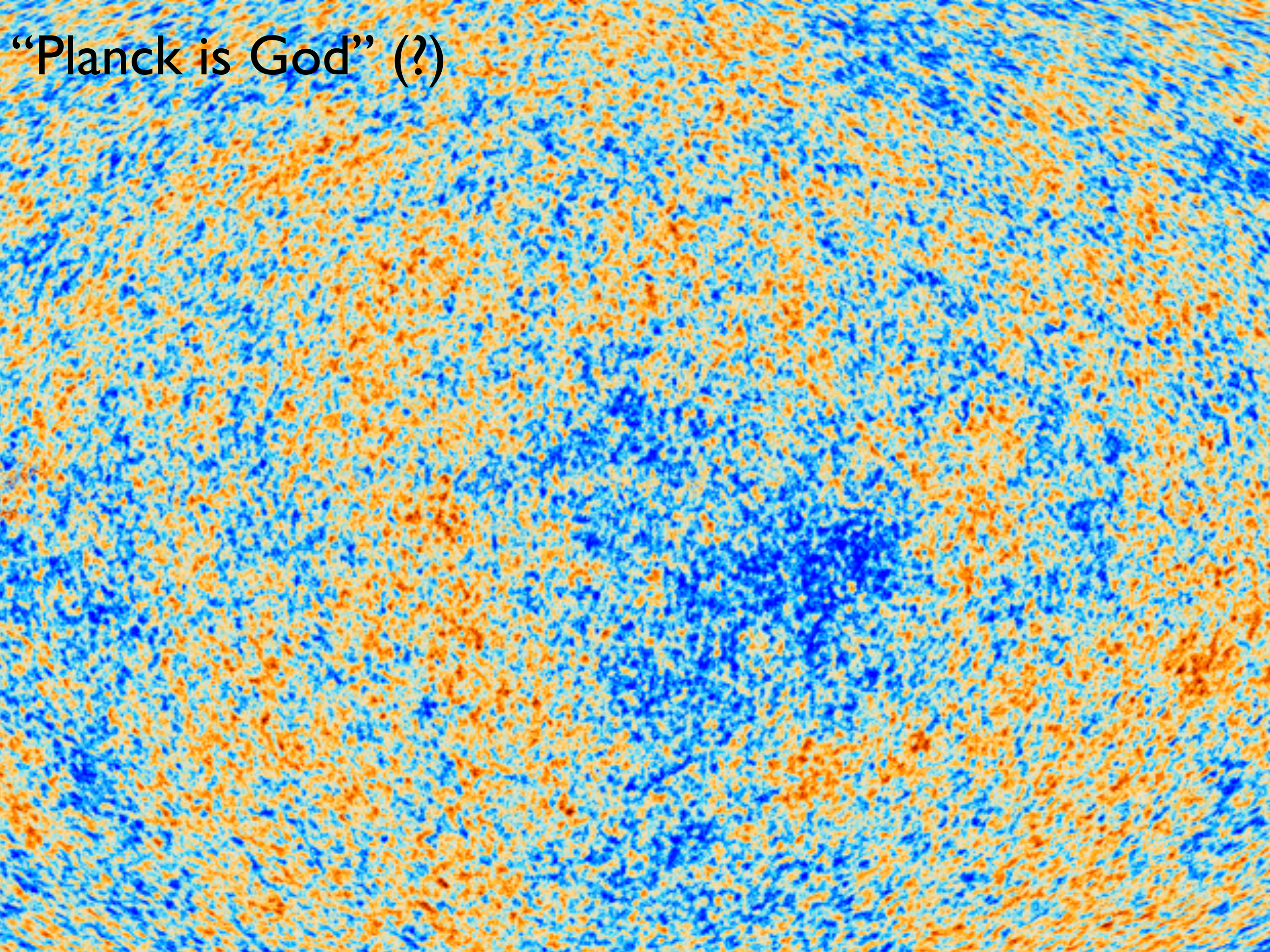
B. Much less sceptical than I was 5 mins ago....

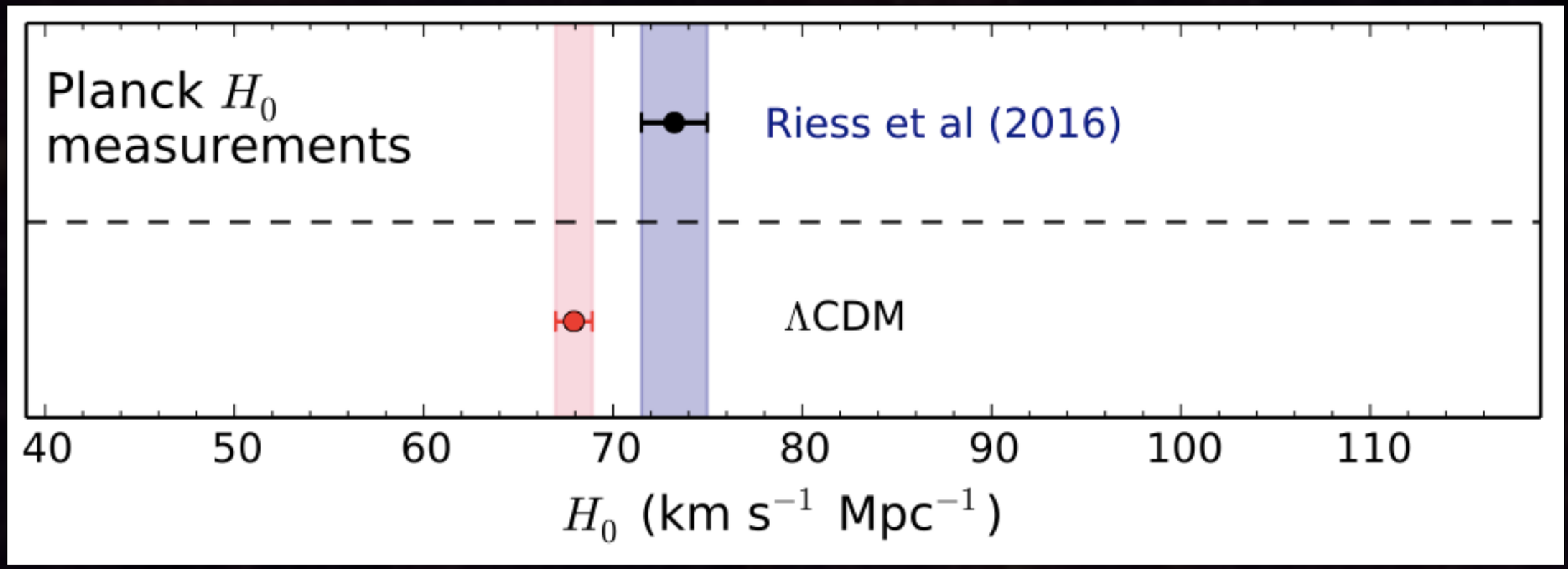
C. Convinced you've accounted for every systematic that you can think of!


KiDS-450
CFHTLenS (MID J16)
WMAP9+ACT+SPT
Planck15
"Substantial Discordance"
1.2
1.0
0.8
0.6
σ_8
0.1
0.2
0.3
0.4
Ω_m

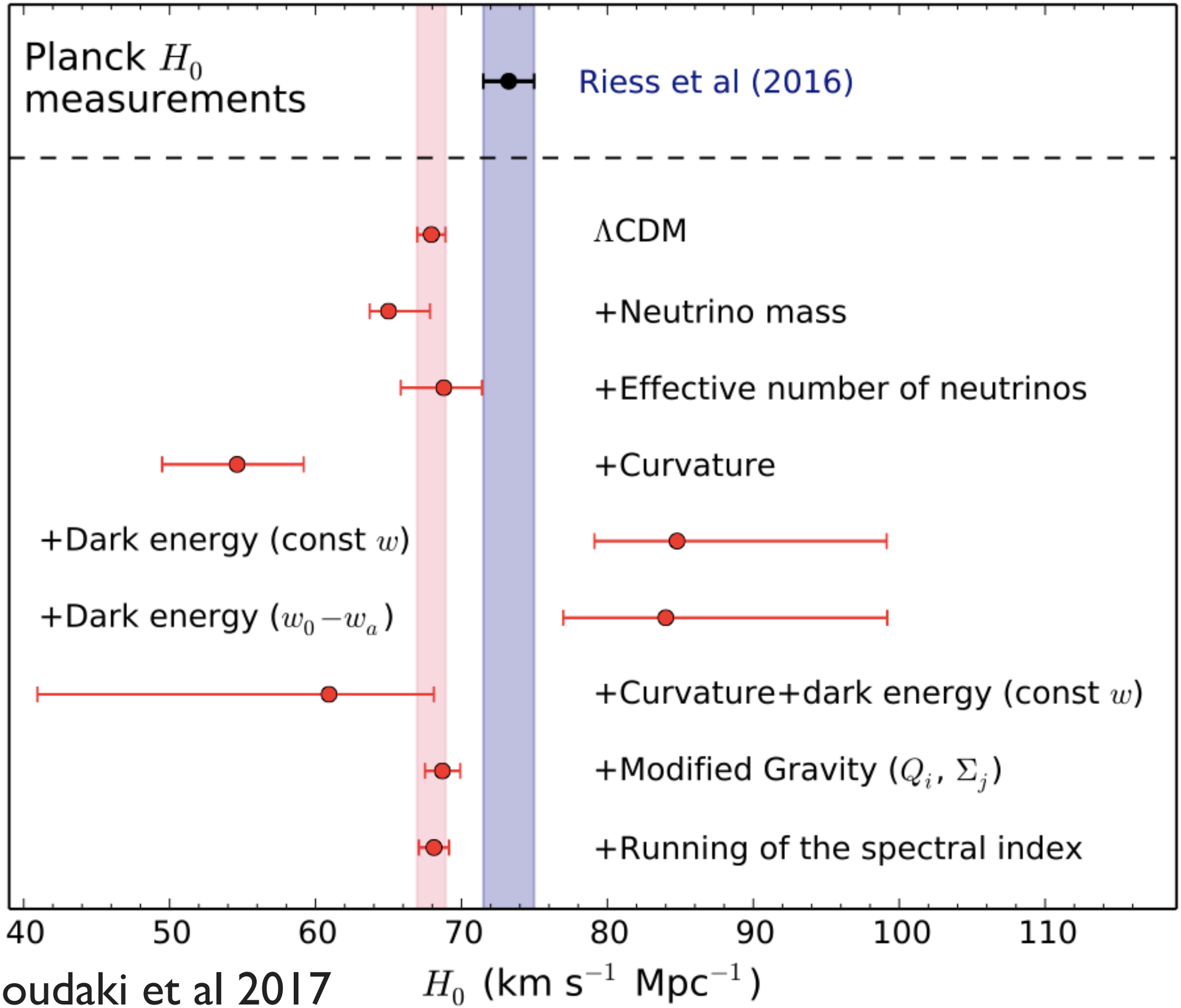


“Planck is God” (?)

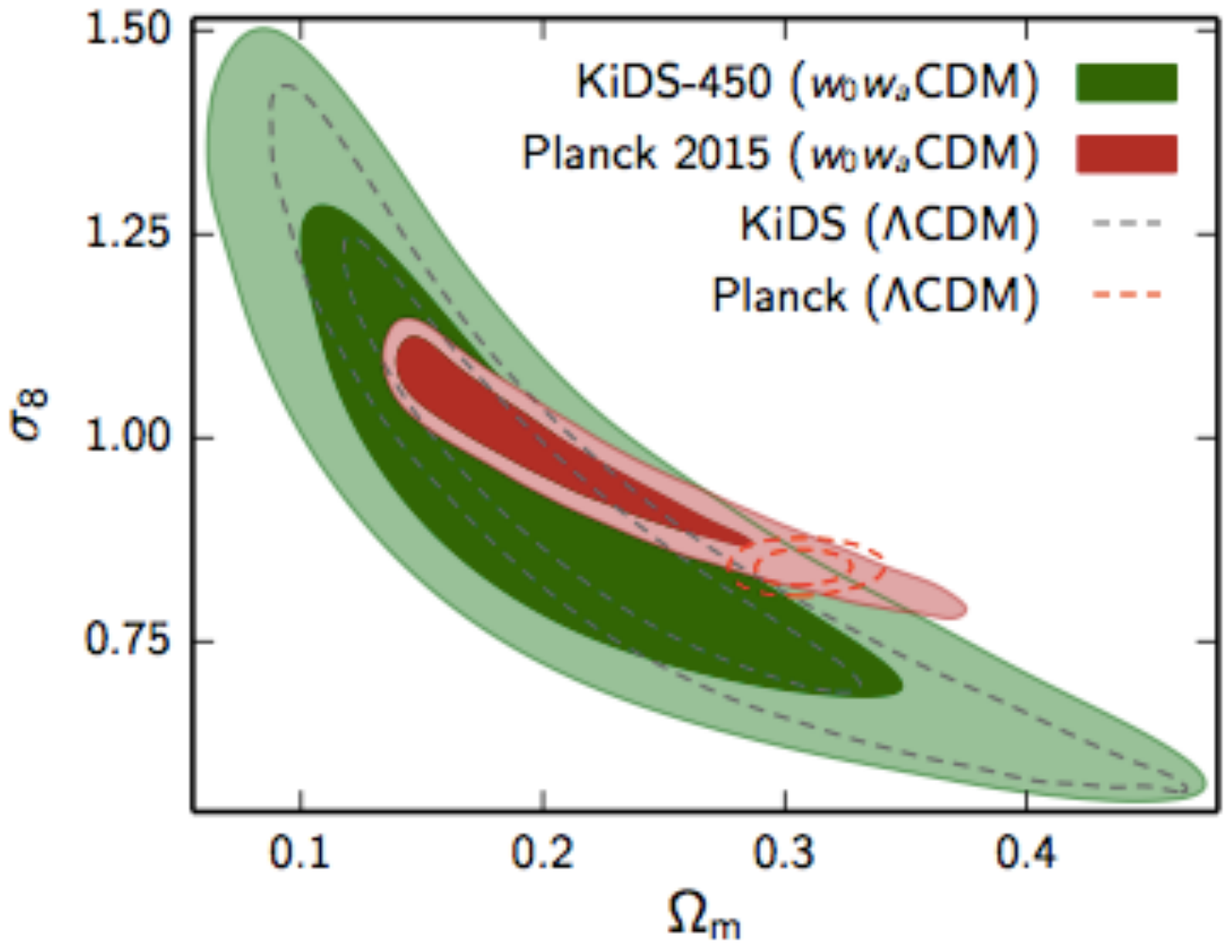


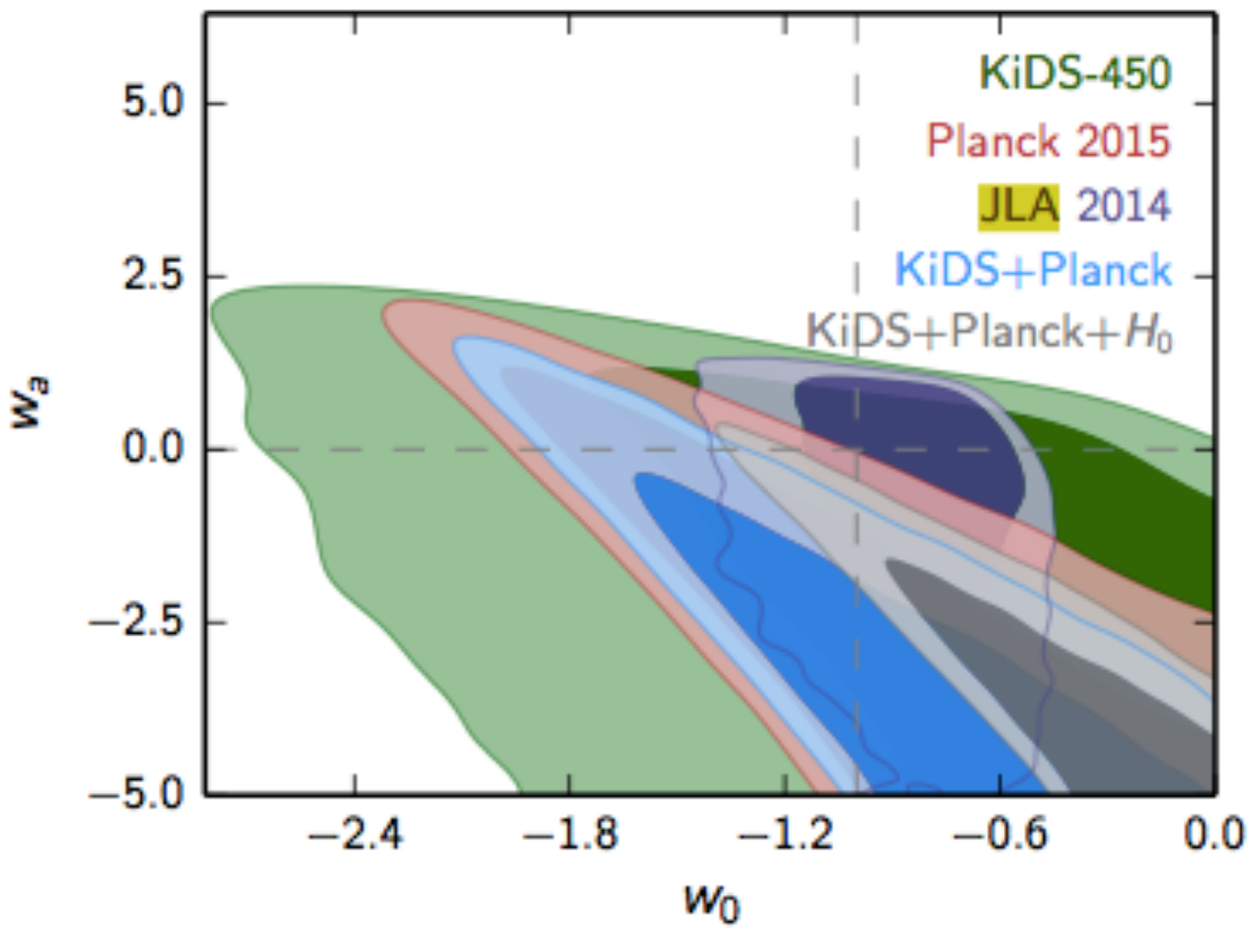


Joudaki et al 2016

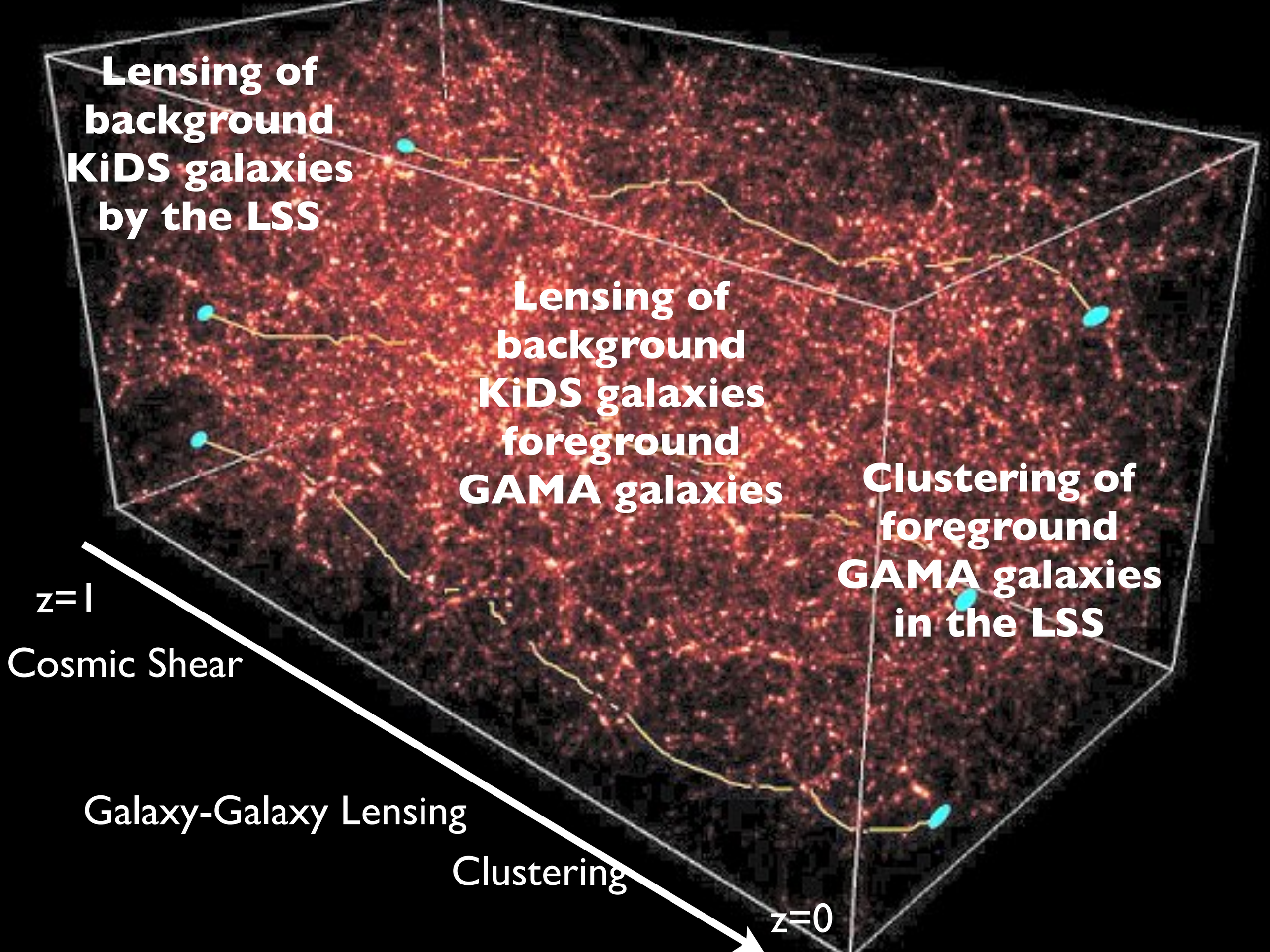


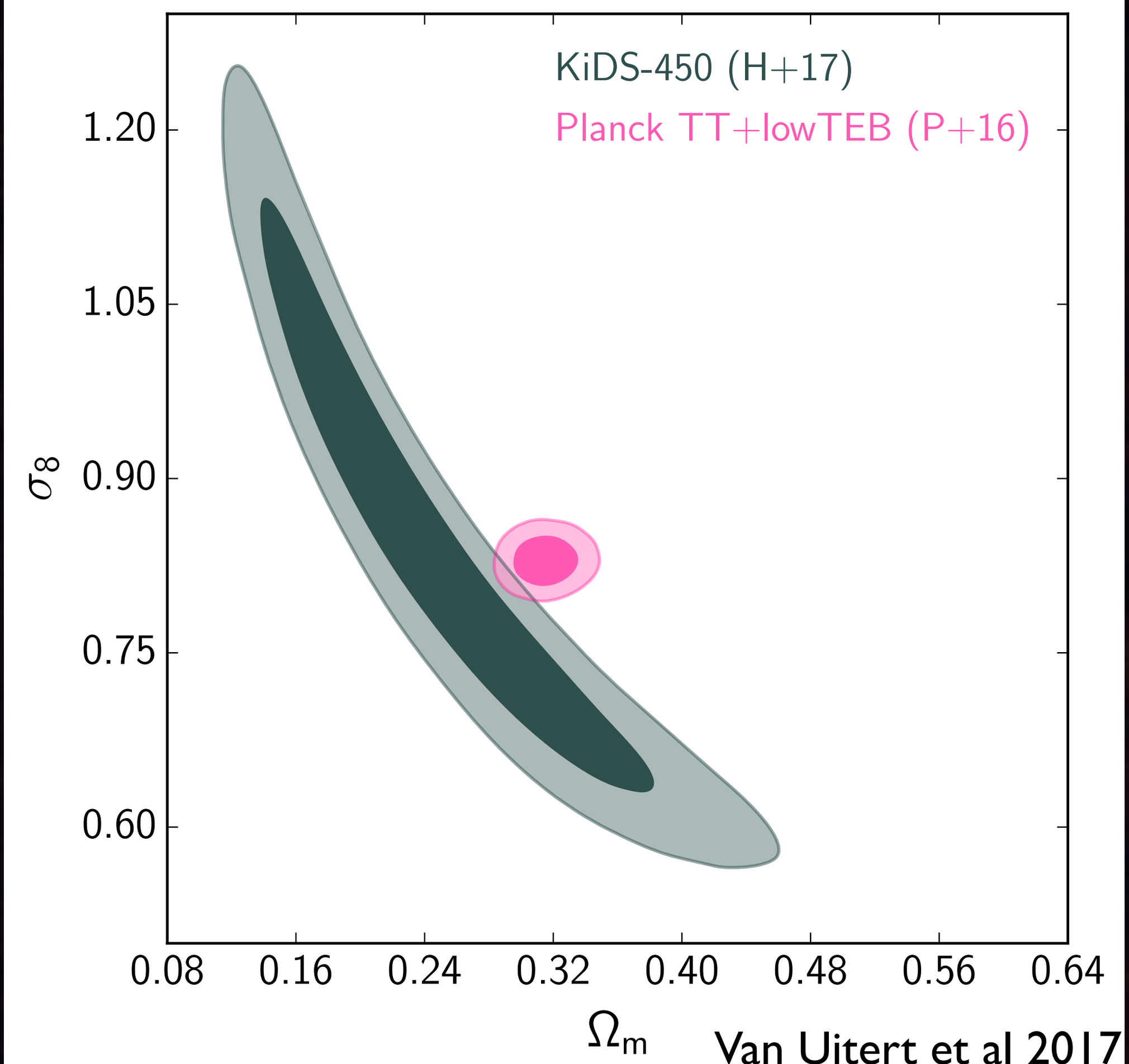
Joudaki et al 2017



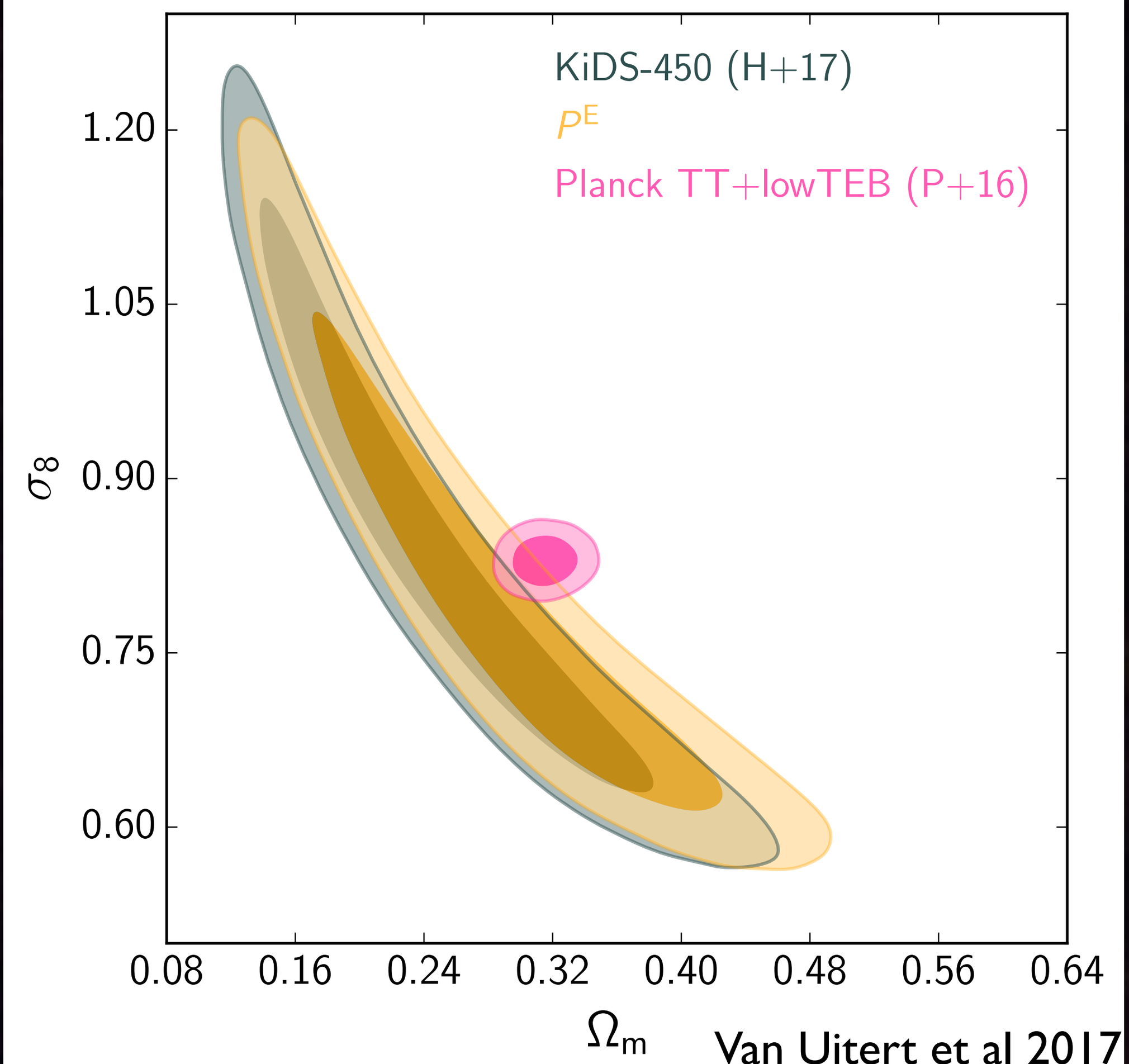


Joudaki et al 2017

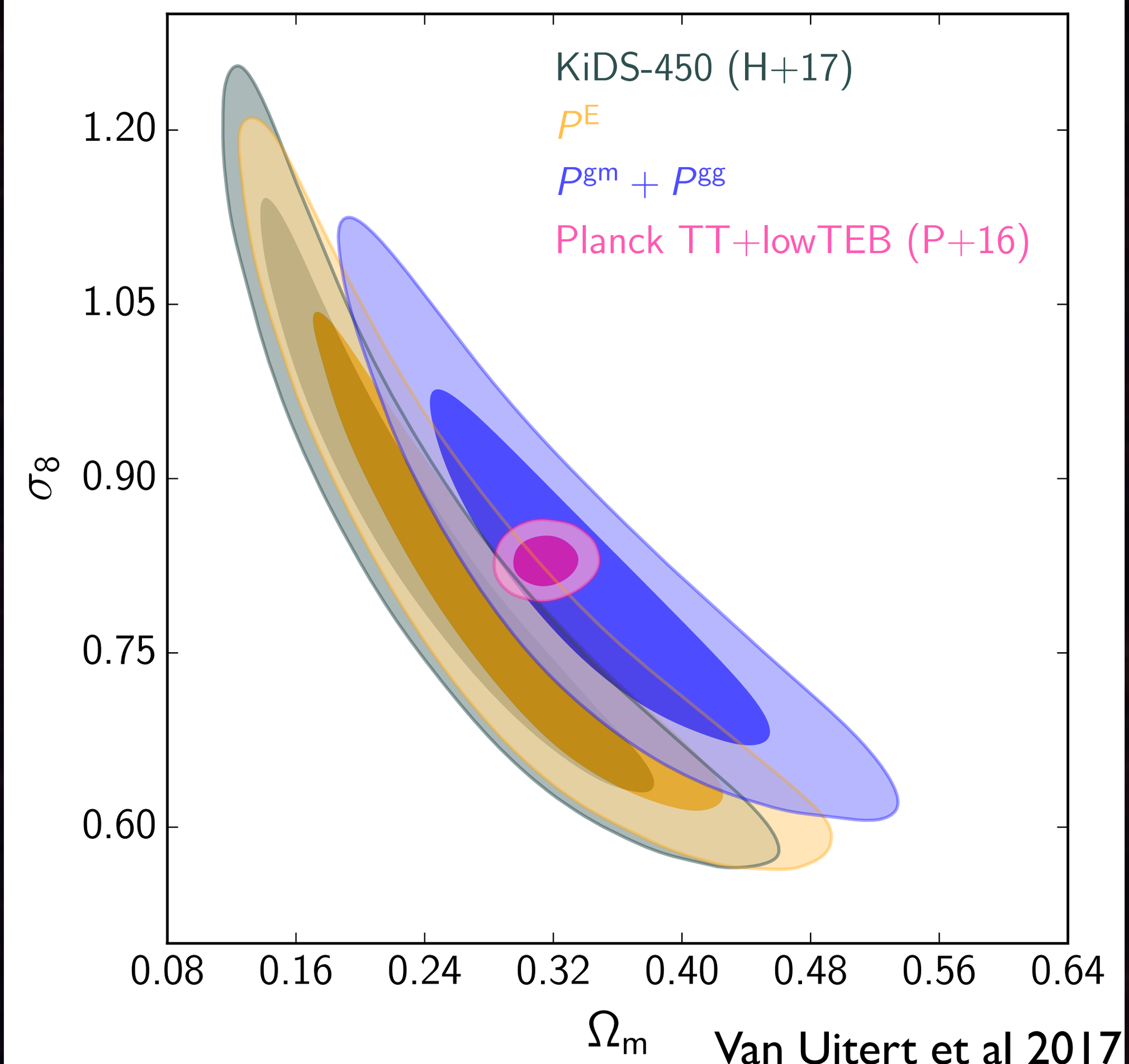

Lensing of background KiDS galaxies by the LSS
Lensing of background KiDS galaxies foreground GAMA galaxies
Clustering of foreground GAMA galaxies in the LSS
z=1
Cosmic Shear
Galaxy-Galaxy Lensing
Clustering
z=0



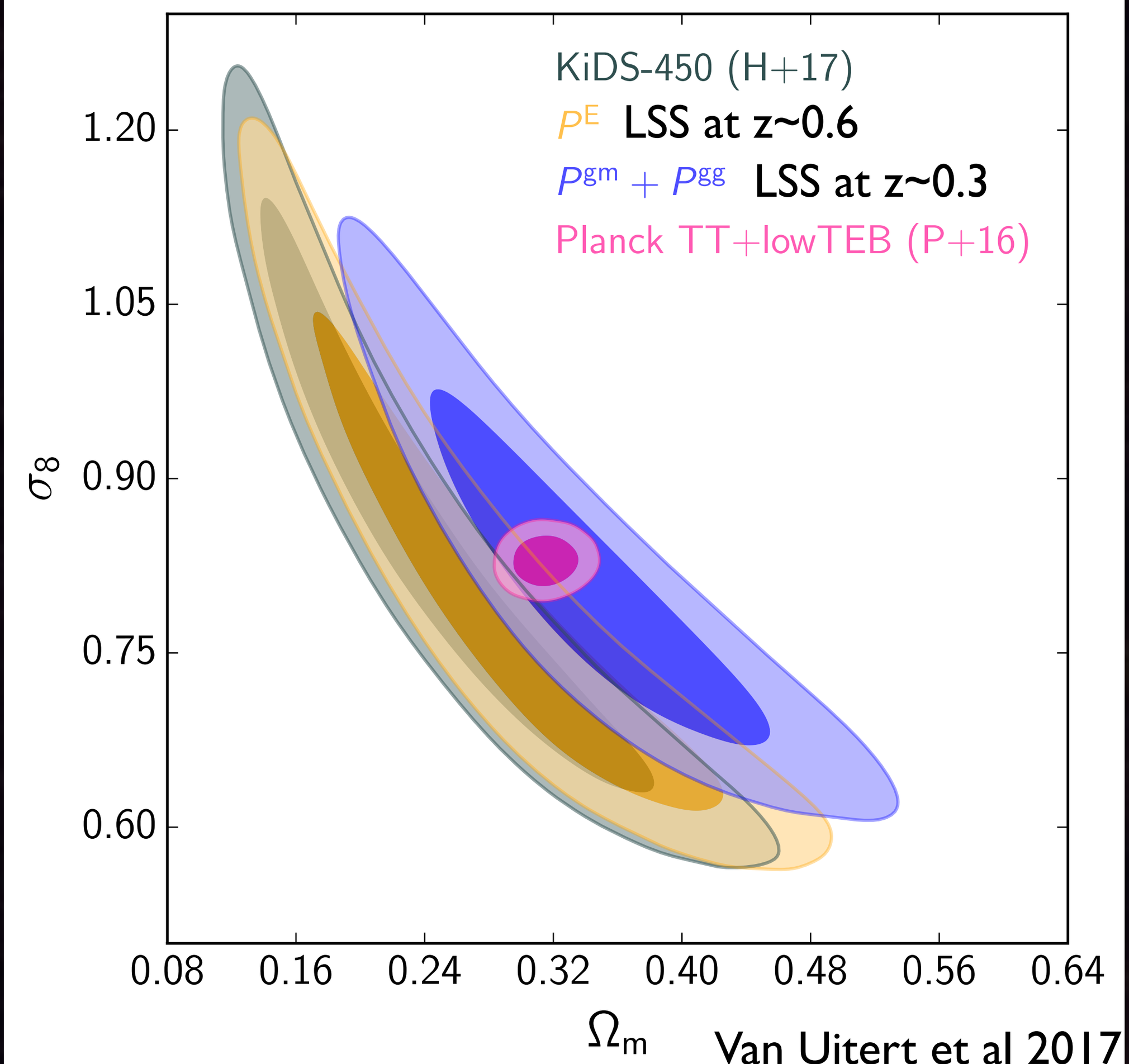
Van Uitert et al 2017



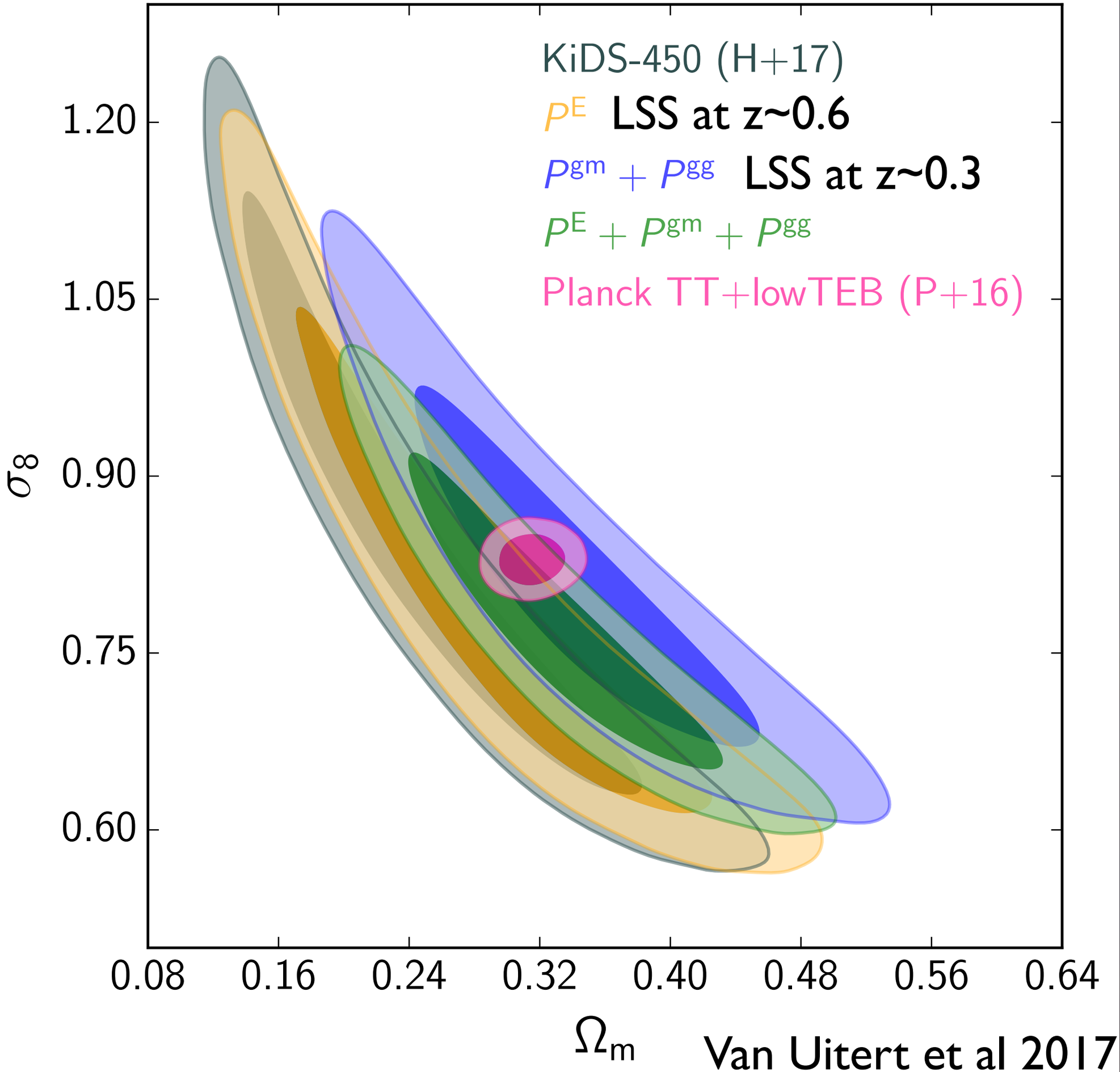
Van Uitert et al 2017



Van Uitert et al 2017



Van Uitert et al 2017



Van Uitert et al 2017

Coming soon...

- **This summer:**
- KiDS-VIKING-450: what happens when you add NIR data into the mix? (Hildebrandt et al 2017)
- KiDS-i-800: what happens when you observe in different wavebands and seeing conditions (Amon et al 2017 - arxiv today)
- **Early 2018**
- KiDS-900: what happens when you double your survey area

Conclusions

- We are confident about our KiDS-450 analysis
  - Advances in photometric redshift calibration
  - Advances in shear calibration
  - Advances in data quality
  - No data rejection (cp to 25% lost in CFHTLenS)
- Are we seeing “cracks in the LCDM cosmic egg”? or just cosmic variance?