How large are alignments for lensing source galaxies?

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Galaxy shape statistics and cosmology
YITP, Dec 2021

The “NLA” and “TATT” models

$$\gamma_{ij}^I = C_1 s_{ij} + C_2 (s_{ik} s_{kj}) + C_\delta (\delta s_{ij}) + C_t t_{ij} + \cdots$$

JB+ 2019

$$C_1(z) = -A_1(z) \left(\bar{C}_1 \rho_{\rm crit}\right) \Omega_m G(z)^{-1}$$

$$A(z) = A \left(\frac{1+z}{1+z_0} \right)^\alpha$$

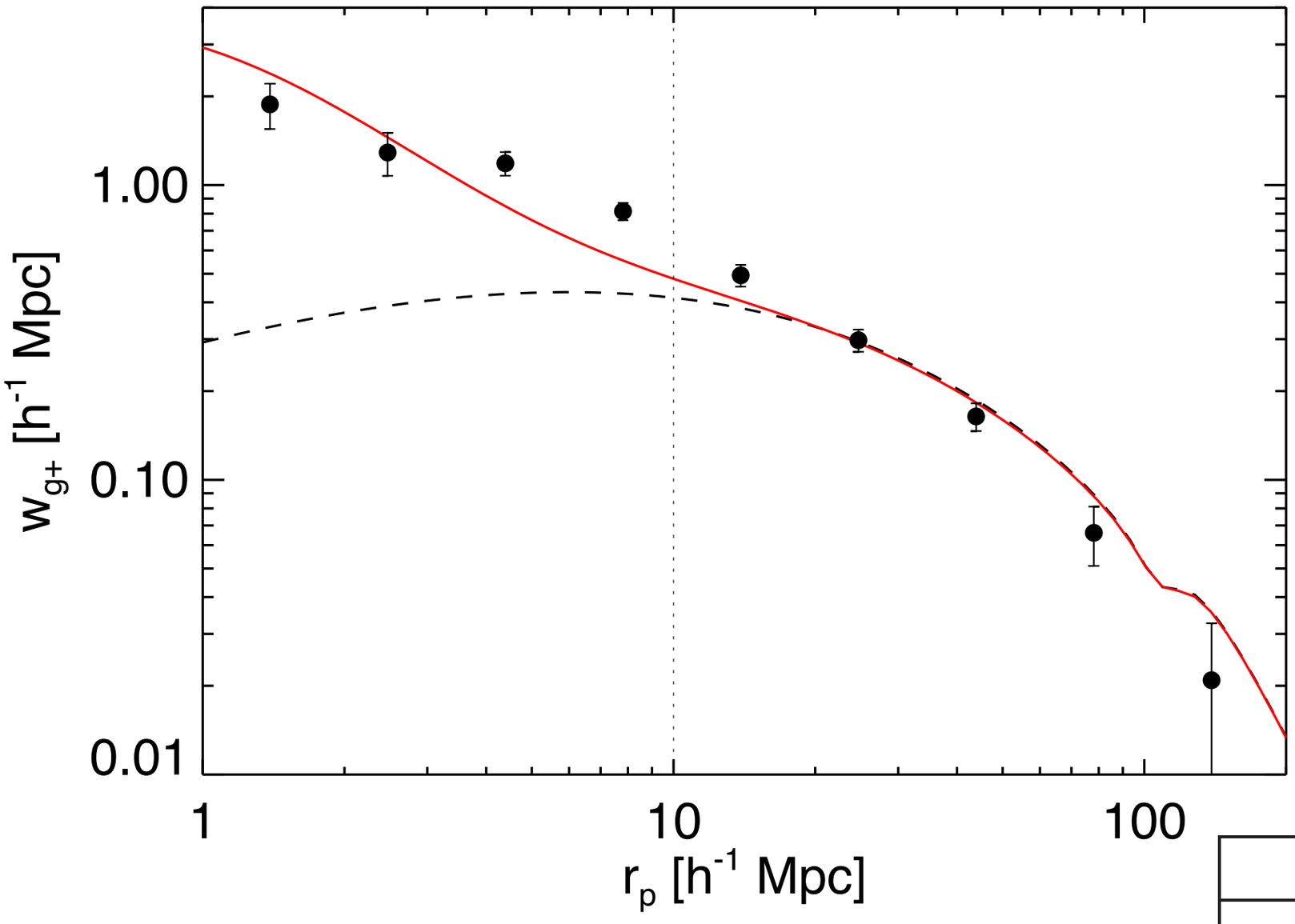
$$C_{1\delta}(z) = -A_{1\delta}(z) \left(\bar{C}_1 \rho_{\rm crit}\right) \Omega_{\rm m} G^{-1}(z)$$

$$C_2(z) = A_2(z) \left(\frac{5 \bar{C}_1 \rho_{\rm crit}}{\Omega_{\rm m,fid}} \right) \Omega_{\rm m}^2 G(z)^{-2}$$

$$A_\delta(z) = b_{\rm ta} A_1(z)$$

$$\bar{C}_1 \rho_{\rm crit} \approx 0.014$$

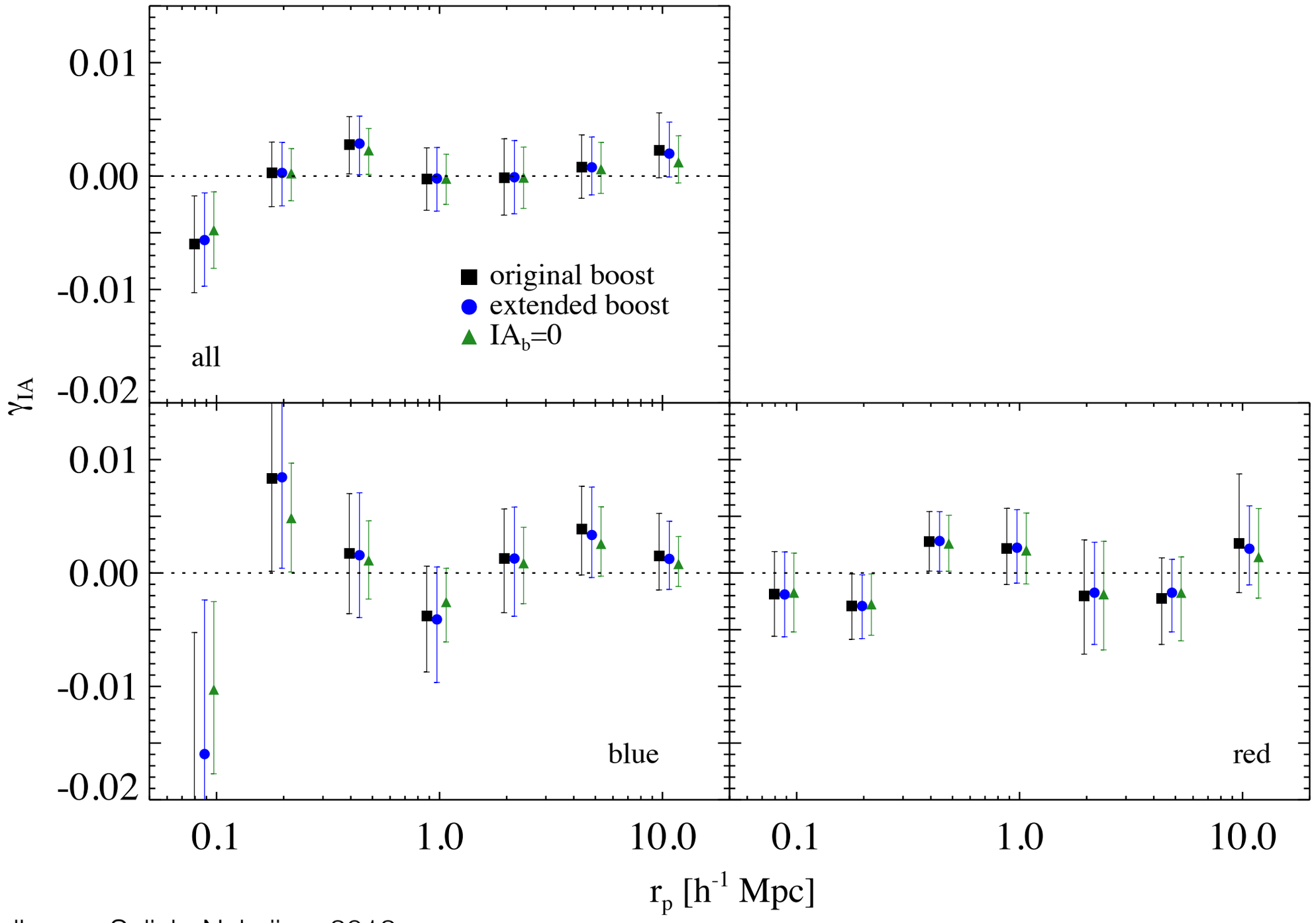
We know (roughly) IA for luminous, red (elliptical) galaxies



Test	$C_1\rho_{\rm crit}$
w_{g+}	0.125 ± 0.007
w_{++}	0.123 ± 0.014

SDSS LRGs: Okumura & Jing 2009; JB+ 2011

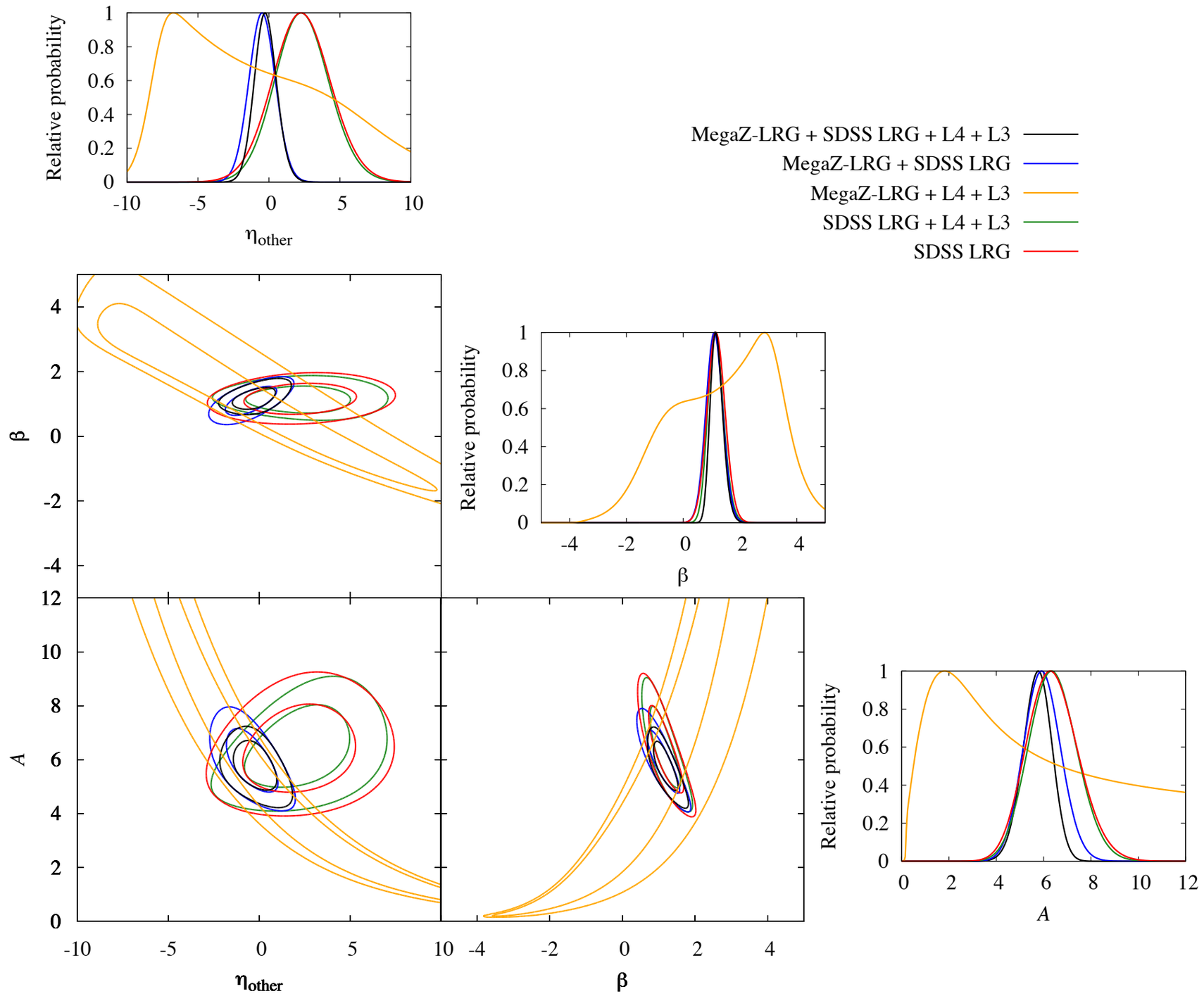
More “typical” lensing sources?



JB, Mandelbaum, Seljak, Nakajima 2012

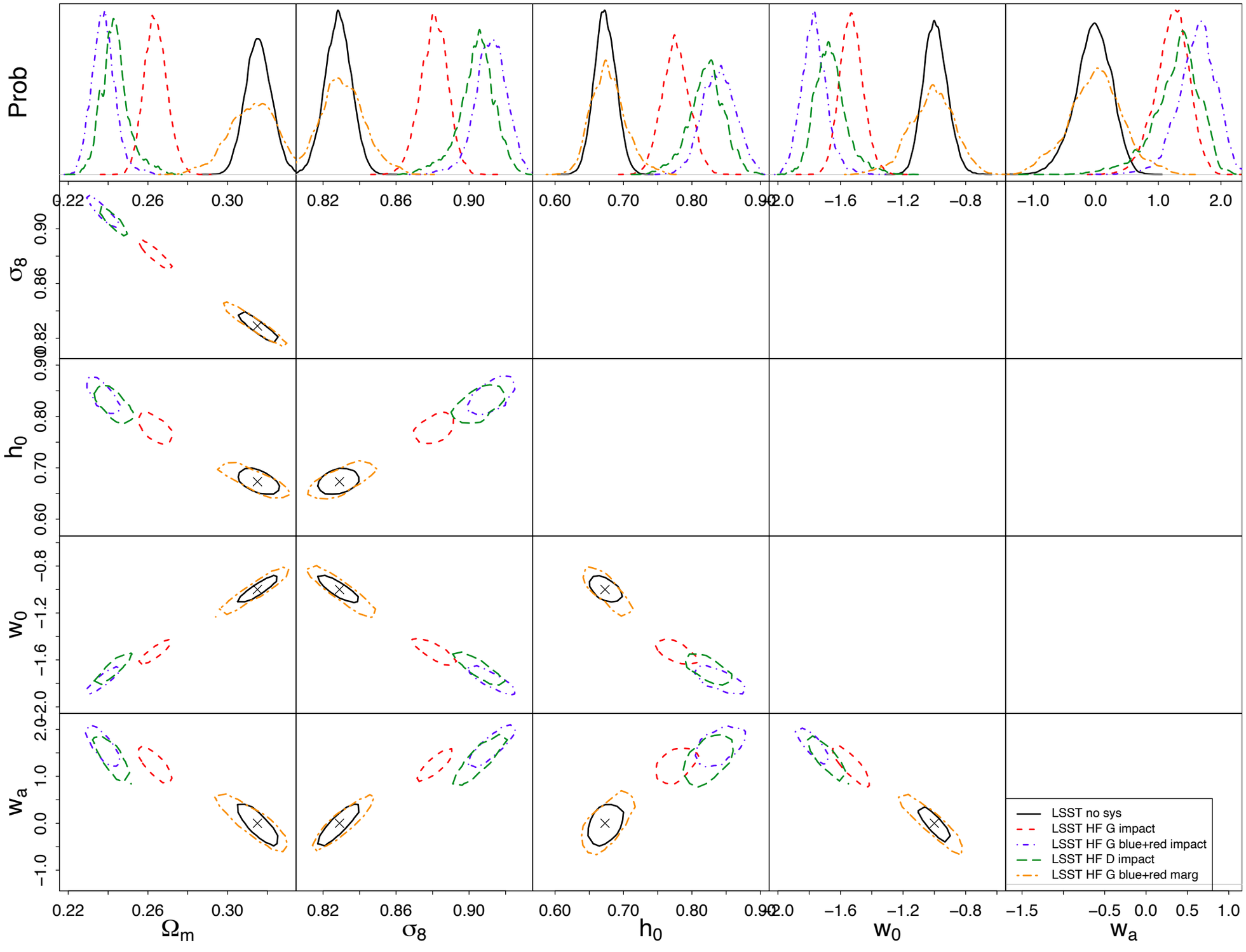
Extrapolation with power laws

$$P_{\mathrm{gI}}^{\mathrm{model}}(k,z,L) = A\; b_{\mathrm{g}}\; P_{\delta \mathrm{I}}(k,z) \left(\frac{1+z}{1+z_0}\right)^{\eta_{\mathrm{other}}} \left(\frac{L}{L_0}\right)^{\beta}$$



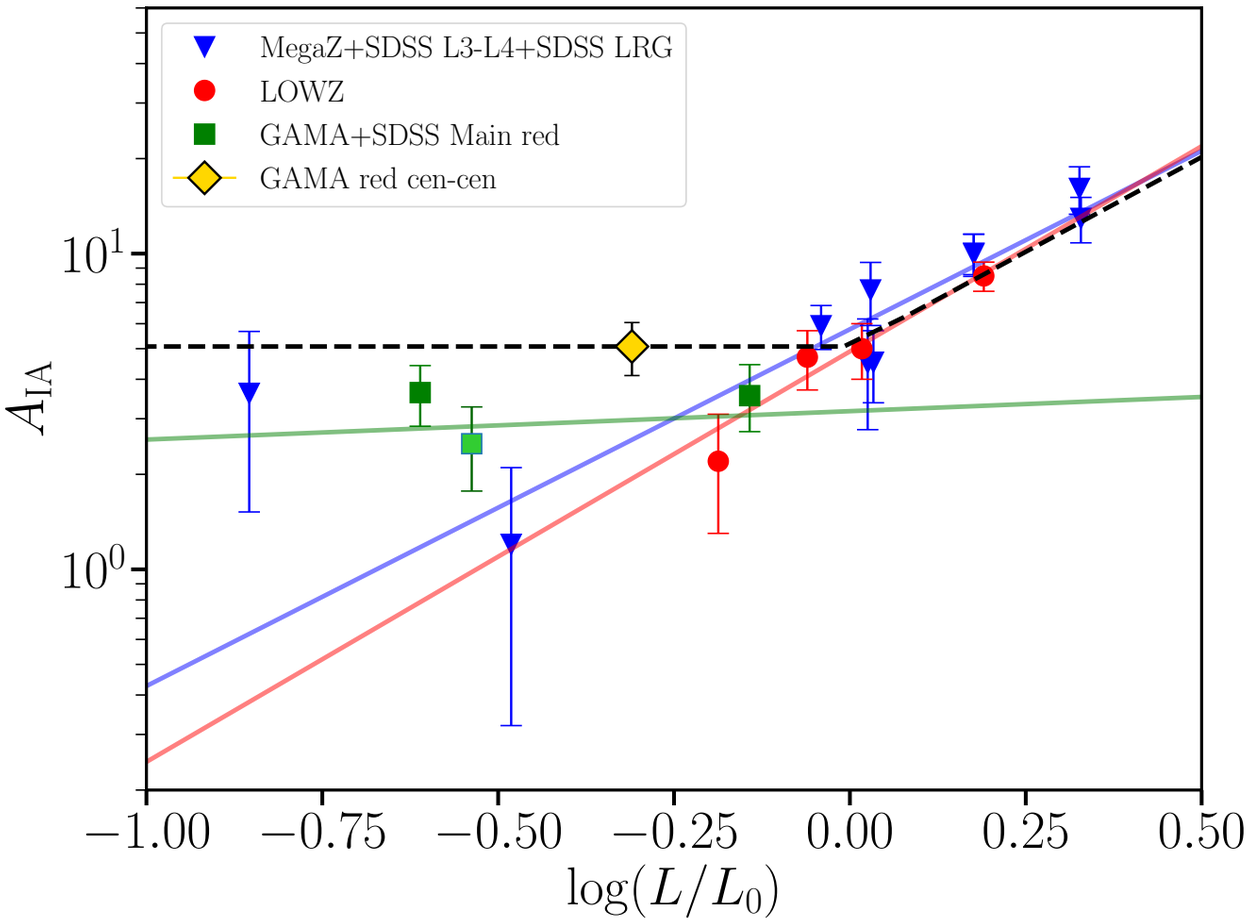
Joachimi+ 2011

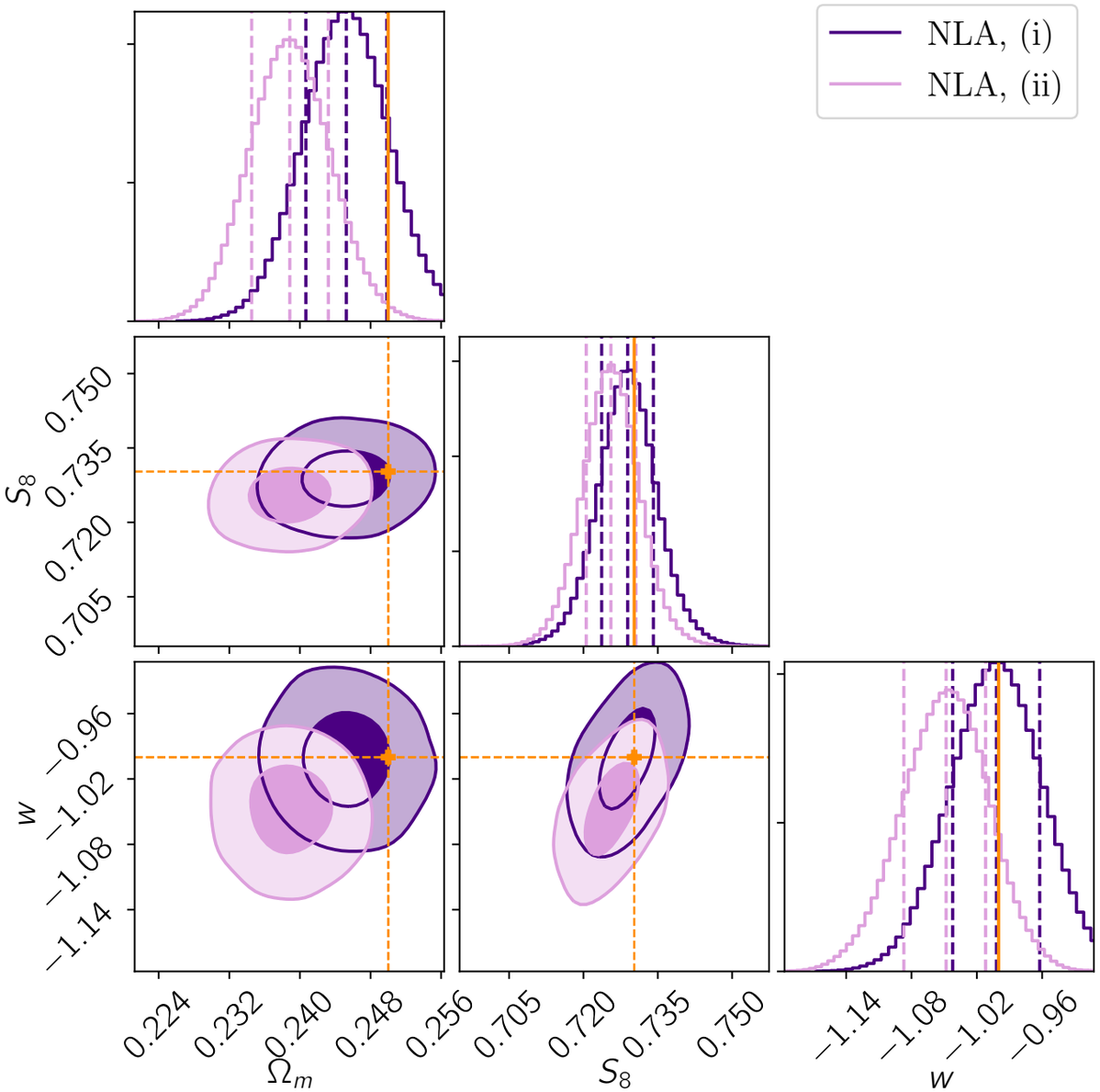
Resulting forecasts



Krause, Eifler, JB 2016

The extrapolation is important!

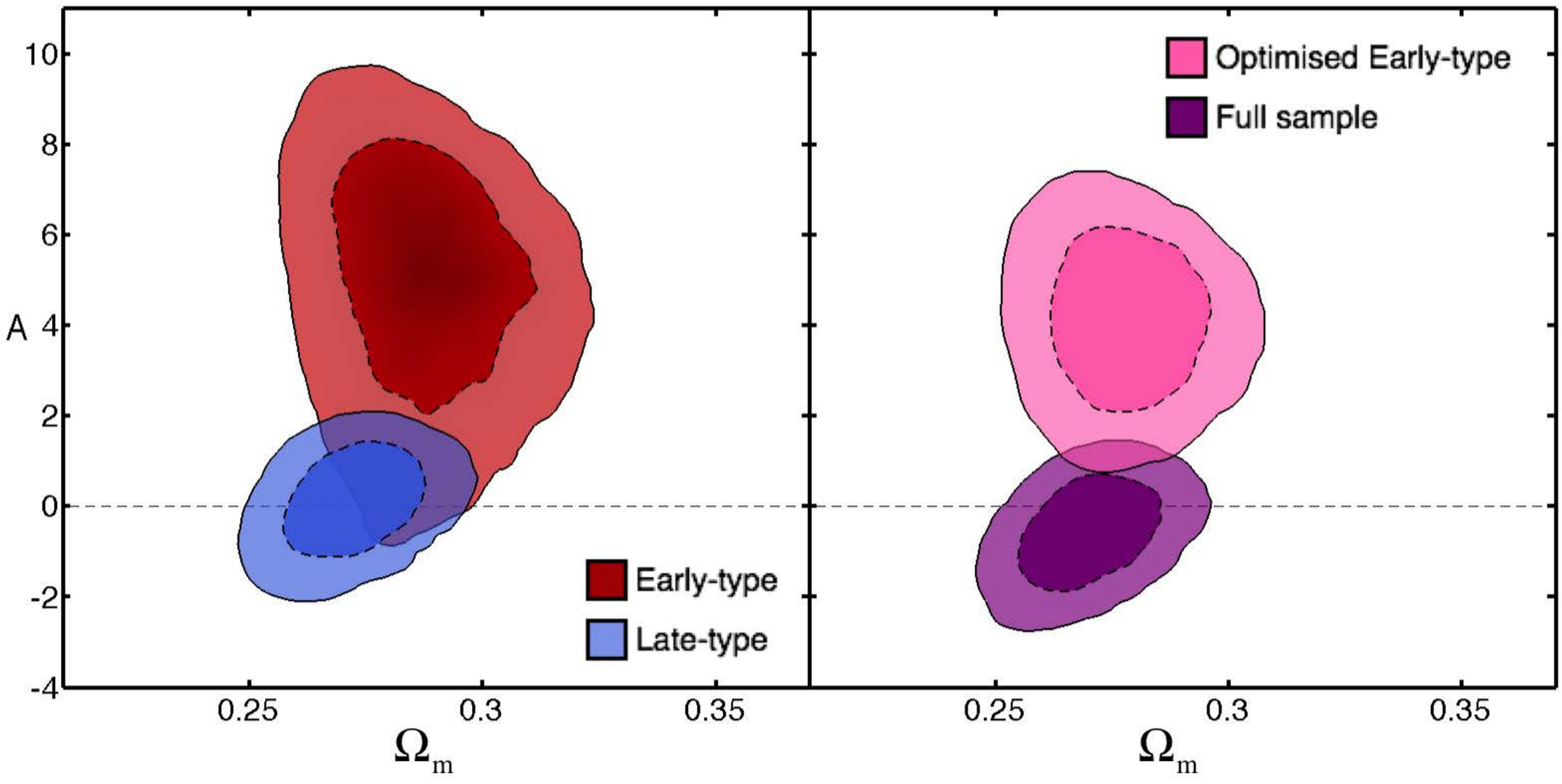




IA halo model: Fortuna+ 2021

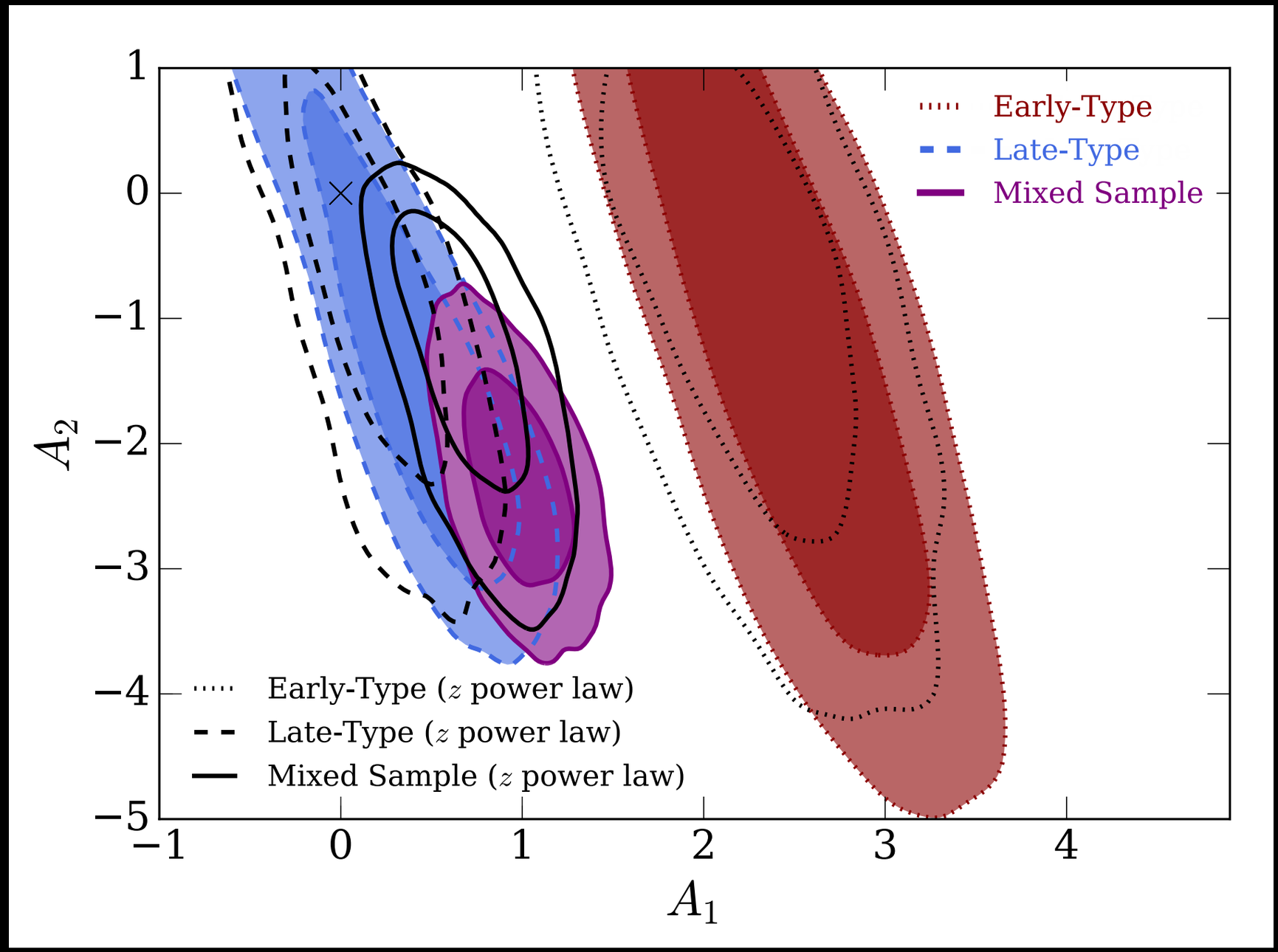
Inference from weak lensing

CFHTLenS: 154 sq. deg.



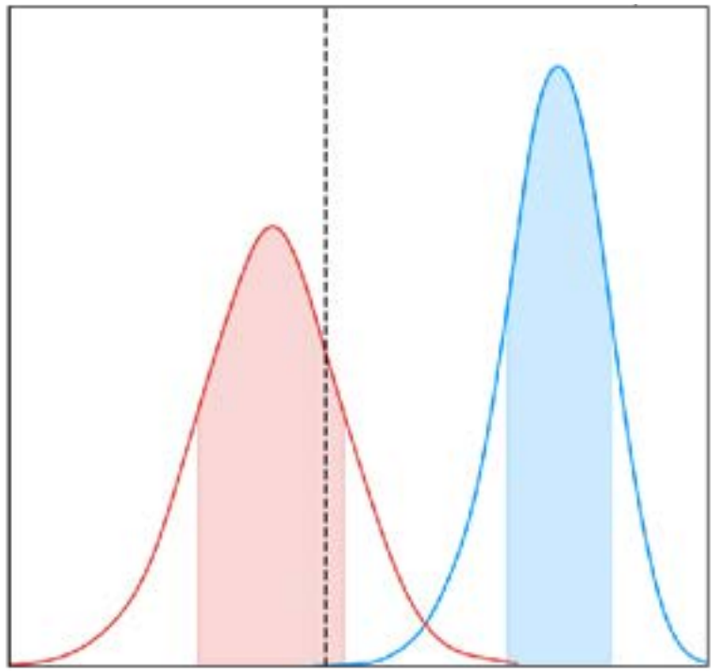
Heymans+ 2013

Dark Energy Survey Y1



Samuroff, JB+ 2018

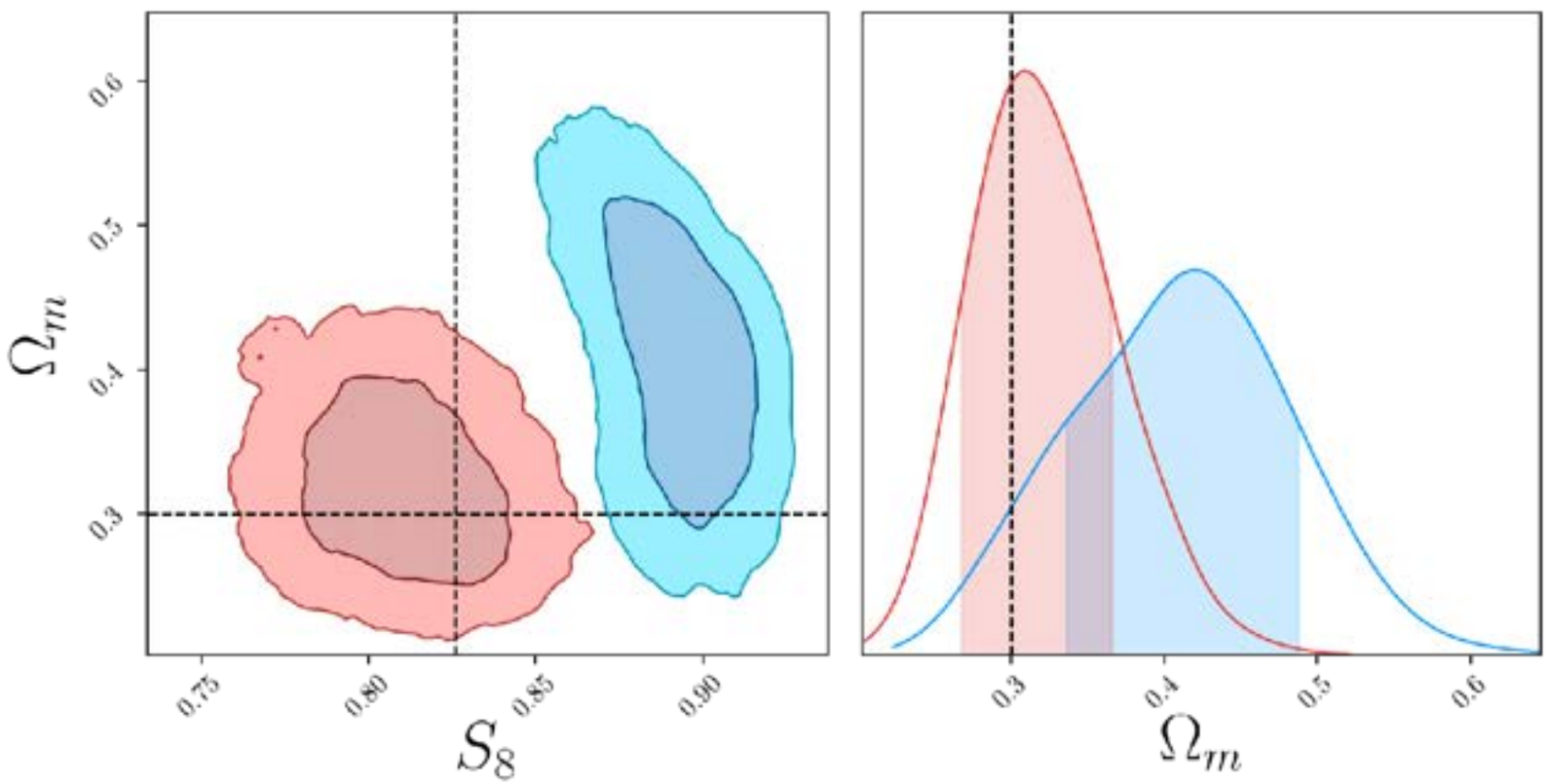
Preparing for DES Y3



Cosmic shear (lensing-lensing)

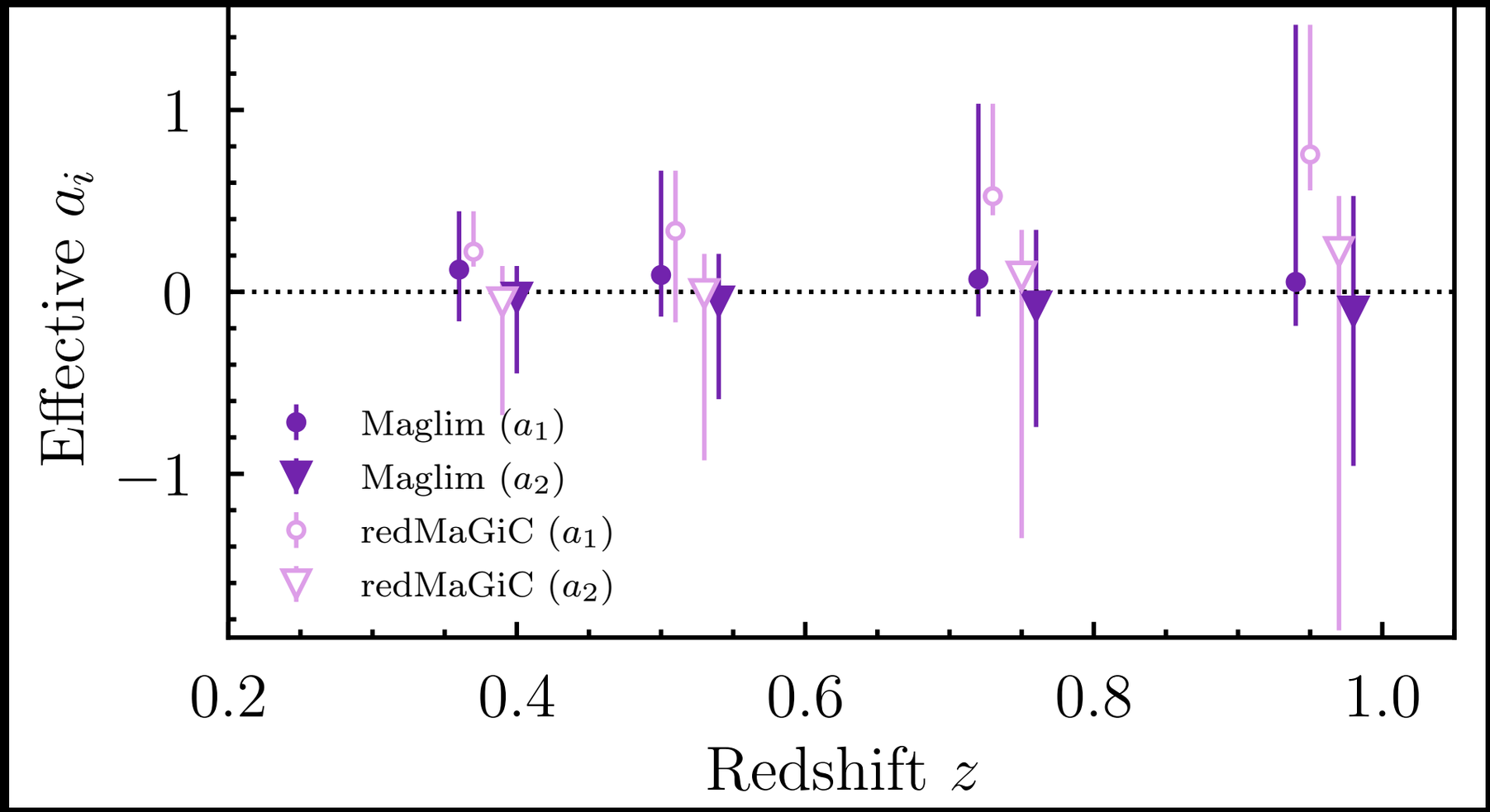
Full nonlinear IA

linear IA (NLA)



Simulated data: Secco, Samuroff+ 2021

Y3: galaxy alignments



Amplitude consistent with Y1 results, but notably lower.

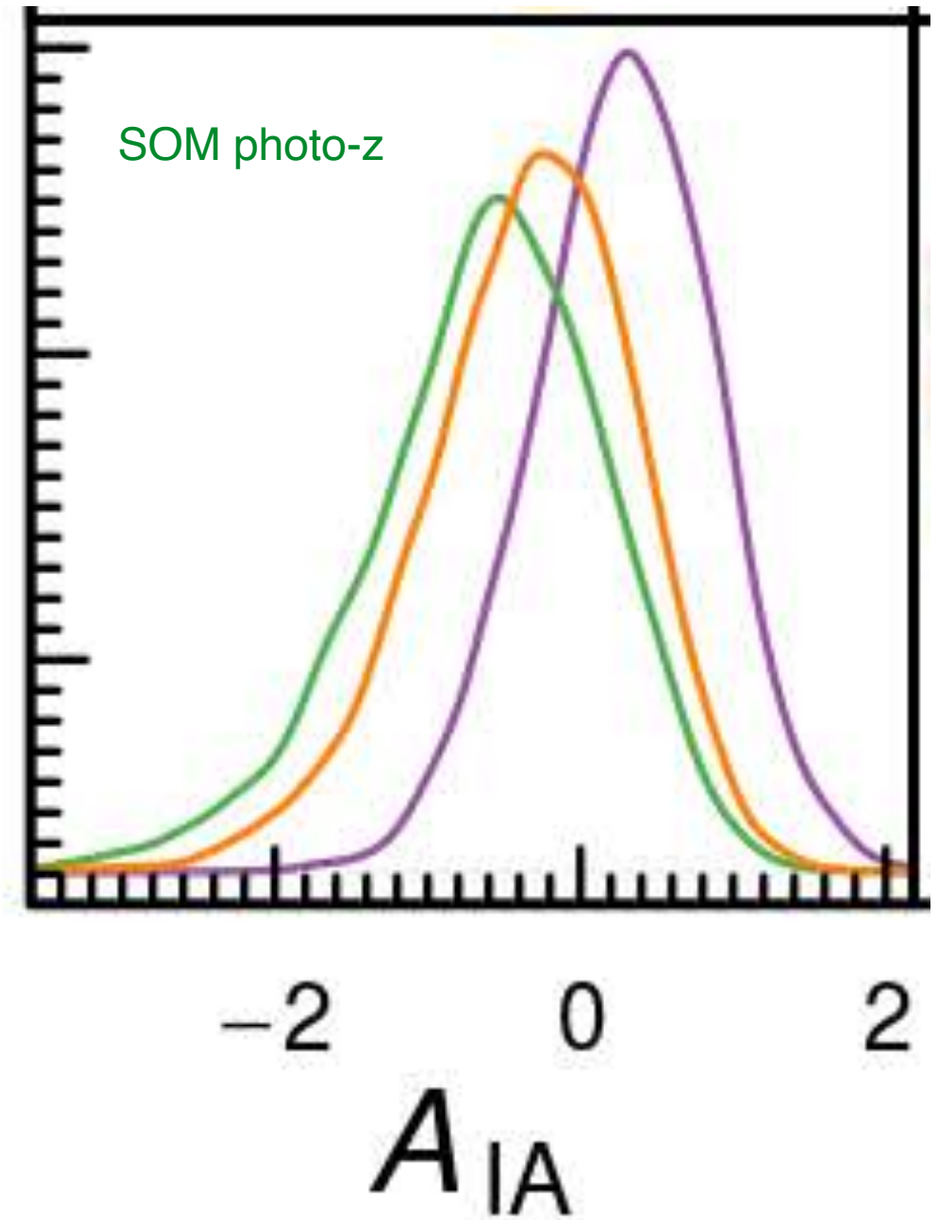
IA model selection

(cosmic shear only)

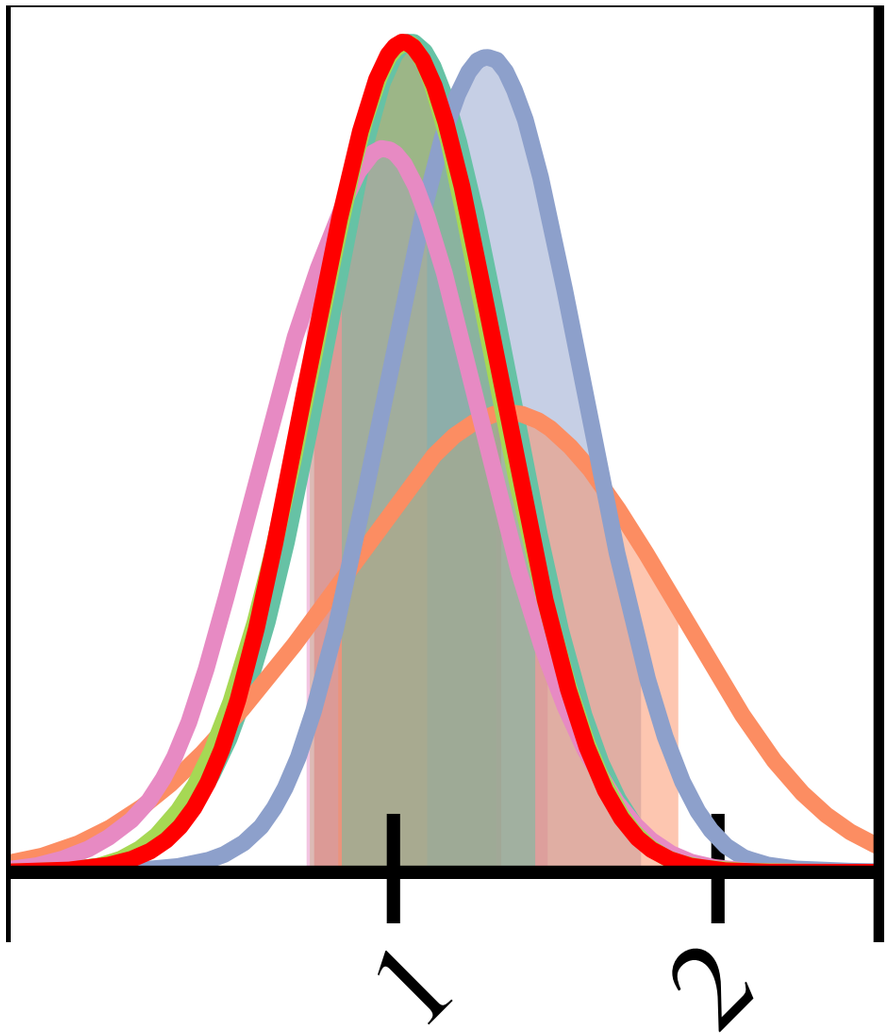
IA Model (free parameters)	χ^2/d.o.f	log Evidence	R (w.r.t. TATT)	R (w.r.t. above)	a_1	η_1	a_2	η_2	$b_{\rm TA}$
No IAs	240.6 / 225	3215.79 ± 0.11	9.48 ± 1.66	N/A	-	-	-	-	-
NLA no z-evo. (a_1)	238.6 / 224	3213.89 ± 0.12	1.42 ± 0.30	0.18 ± 0.03	$0.34^{+0.25}_{-0.23}$	-	-	-	-
NLA (a_1, η_1)	238.3 / 224	3214.07 ± 0.13	1.70 ± 0.36	1.19 ± 0.24	$0.36^{+0.43}_{-0.36}$	$1.66^{+3.26}_{-1.05}$	-	-	-
TA (a_1, η_1, $b_{\rm TA}$)	238.8 / 224	3213.87 ± 0.13	1.38 ± 0.25	0.81 ± 0.14	$0.27^{+0.35}_{-0.31}$	$2.10^{+2.89}_{-0.71}$	-	-	$0.83^{+0.31}_{-0.82}$
No z-evo. (a_1, a_2, $b_{\rm TA}$)	238.6 / 223	3211.81 ± 0.14	0.17 ± 0.03	0.12 ± 0.02	$0.18^{+0.21}_{-0.30}$	-	$0.10^{+0.55}_{-0.57}$	-	$0.80^{+0.29}_{-0.78}$
No a_2 z-evo. (a_1, η_1, a_2, $b_{\rm TA}$)	238.2 / 223	3212.09 ± 0.14	0.23 ± 0.04	1.32 ± 0.26	$-0.02^{+0.71}_{-0.31}$	$2.17^{+2.82}_{-0.70}$	$-0.27^{+0.59}_{-0.50}$	-	$0.87^{+0.38}_{-0.83}$
TATT (a_1, η_1, a_2, η_2, $b_{\rm TA}$)	233.1 / 222	3213.54 ± 0.13	1	4.28 ± 0.83	$-0.24^{+0.98}_{-0.41}$	$2.38^{+2.62}_{-0.61}$	$0.63^{+1.93}_{-1.89}$	$3.11^{+1.77}_{-0.31}$	$0.87^{+0.38}_{-0.84}$

- Simpler IA models are sufficient in Y3 data.
- What is going on (compared to previous results)? Photo-z? Fluctuation or projection?

KiDS

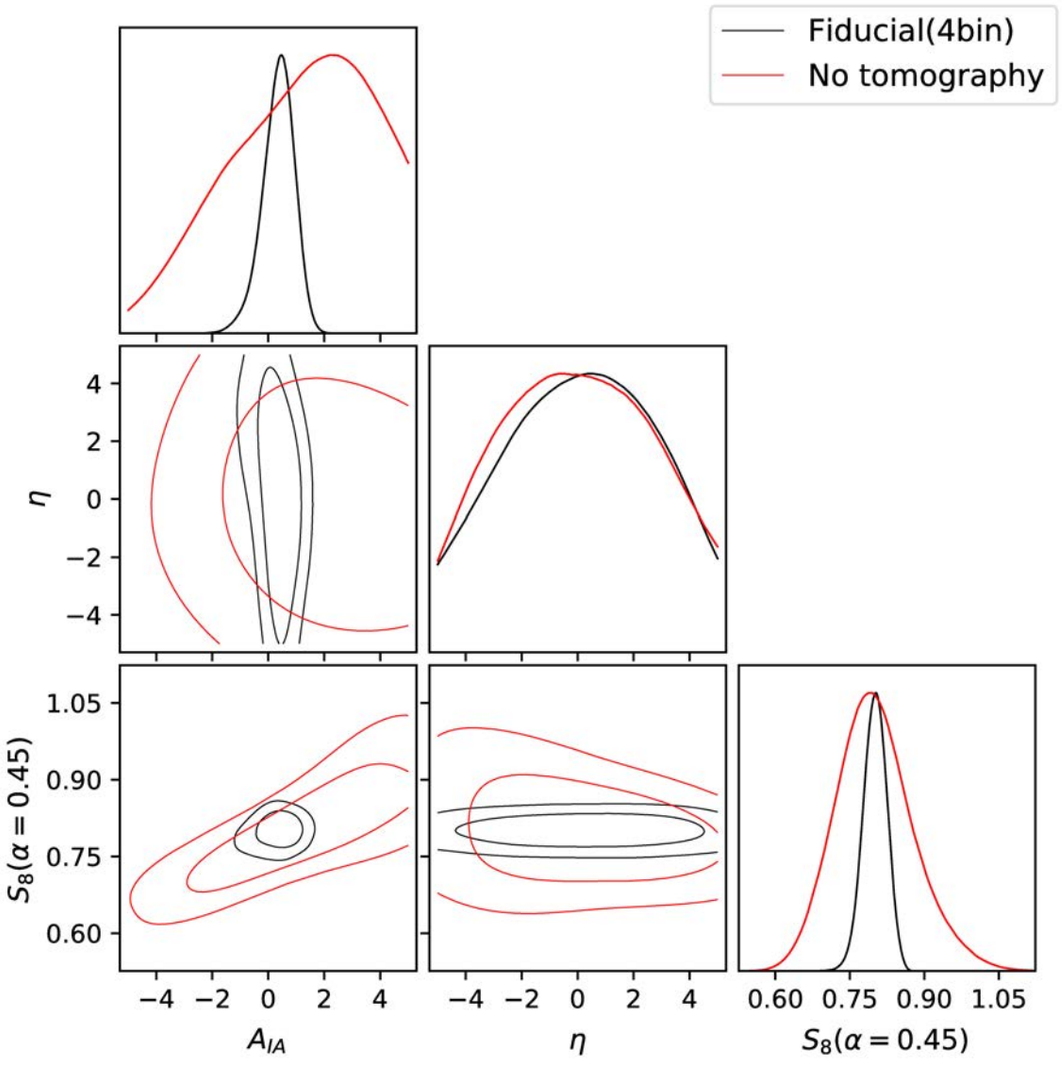


KiDS 450 cosmic shear:
Hildebrandt+2017; Wright+ 2020

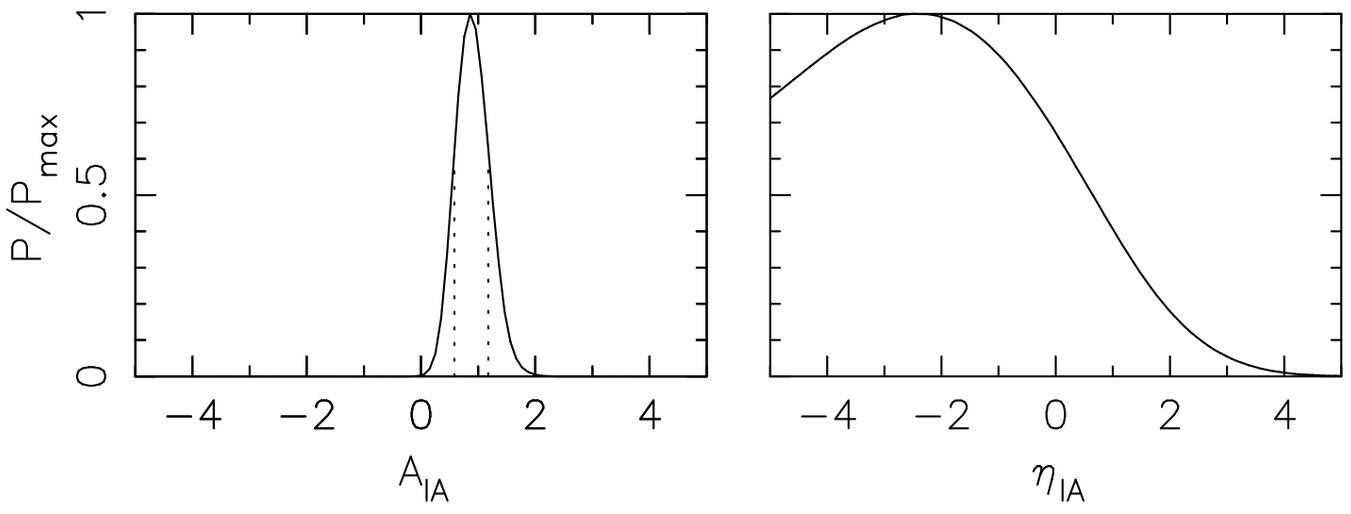


KiDS 1000 3x2:
Heymans+ 2021

Hyper Suprime-Cam

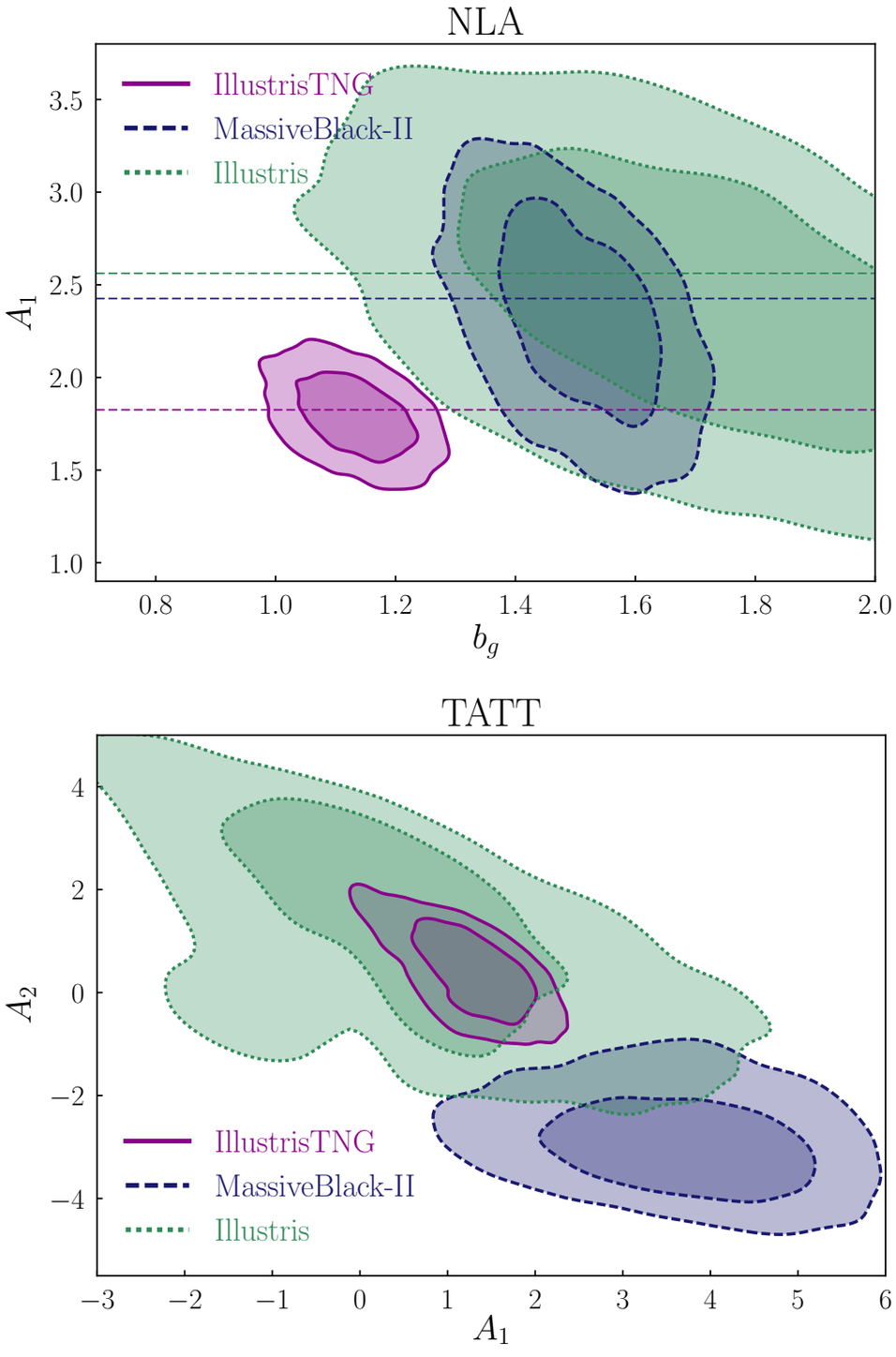


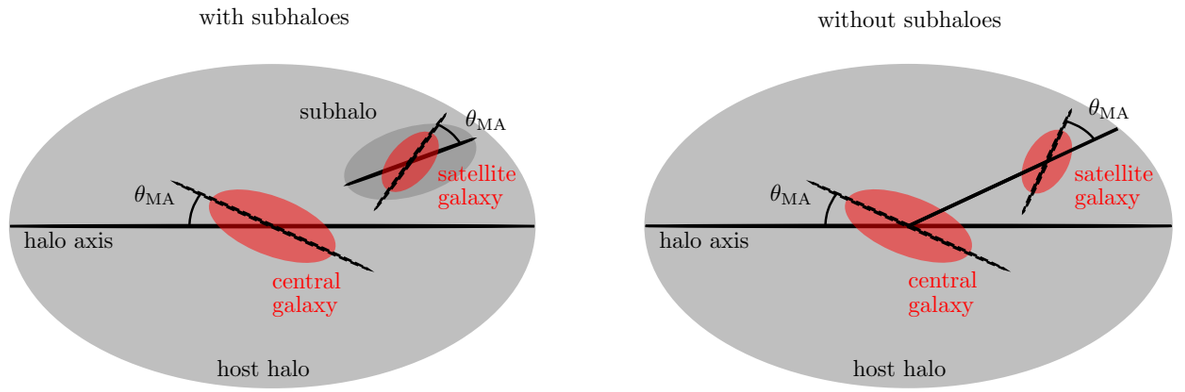
HSC power spectra
Hikage+ 2019

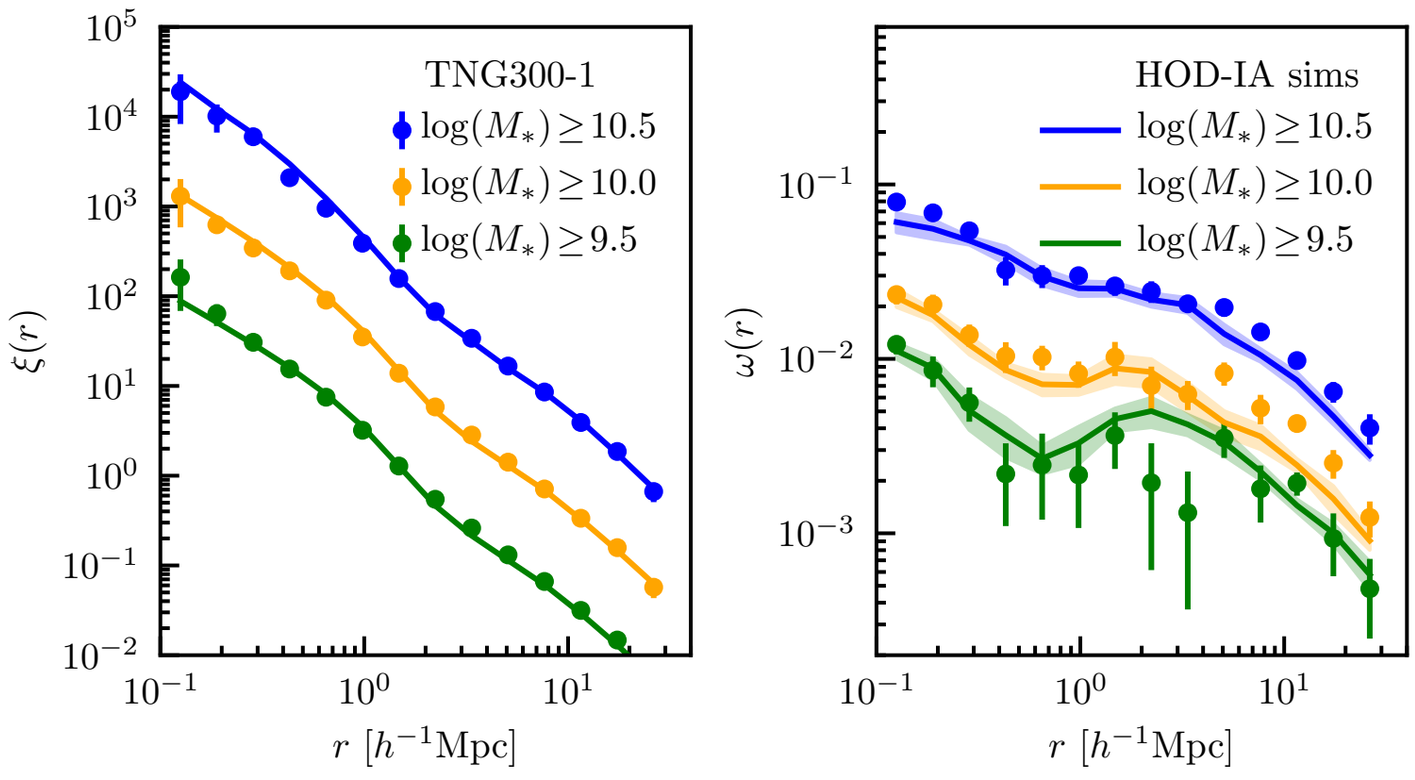


HSC correlation functions
Hamana+ 2019

Simulations?



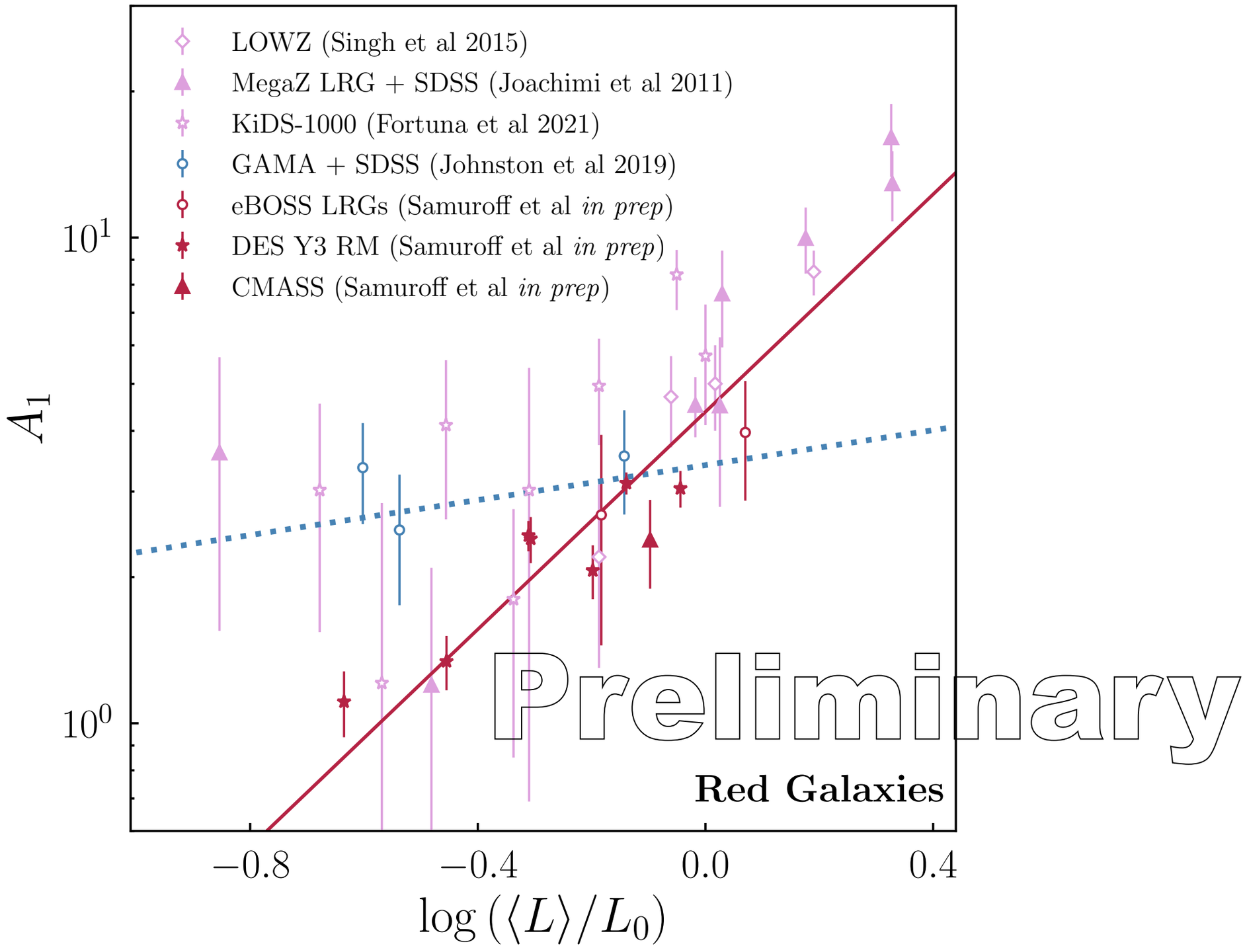




Samuroff, Mandelbaum, JB 2021

Campbell, Van Alfen, Blazek+ in prep

What next?



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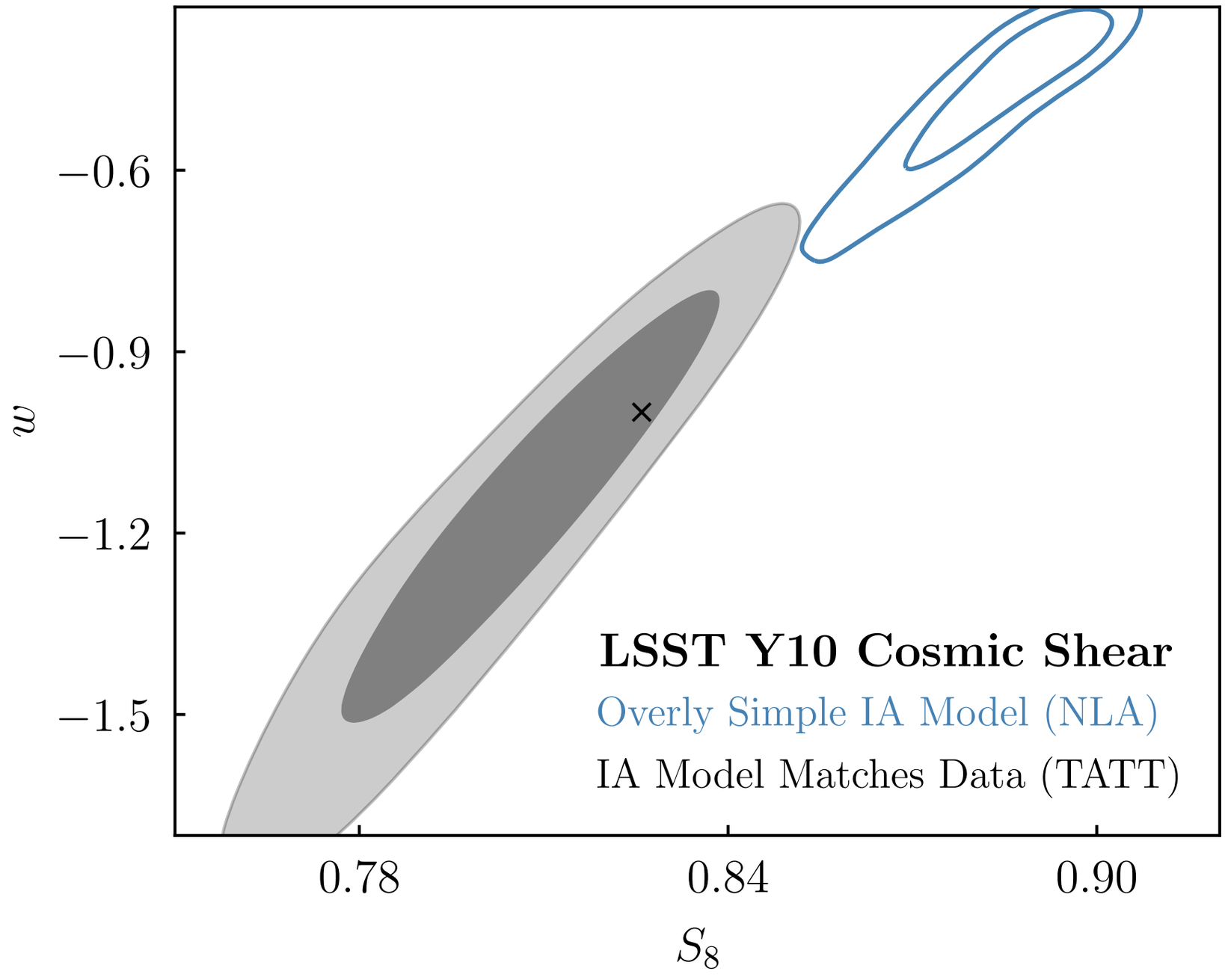

Mock analysis for LSST using TATT IA consistent with DES Y3

echoIA

Enabling Cosmology with Homogenized Observations of IA

- Remote workshop organized with Benjamin Joachimi for Stage-IV preparations
- Feb 7-9, half-day sessions
- Common modeling framework, galaxy properties, etc
- Joint analysis of new and recent measurements
- **Announcement soon!**