New Insights into Dark Energy from DESI DR2 with CMB and SNIa

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Based on: arXiv:2507.09981

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Outline

- Background
- Dataset
- Results
- Conclusions

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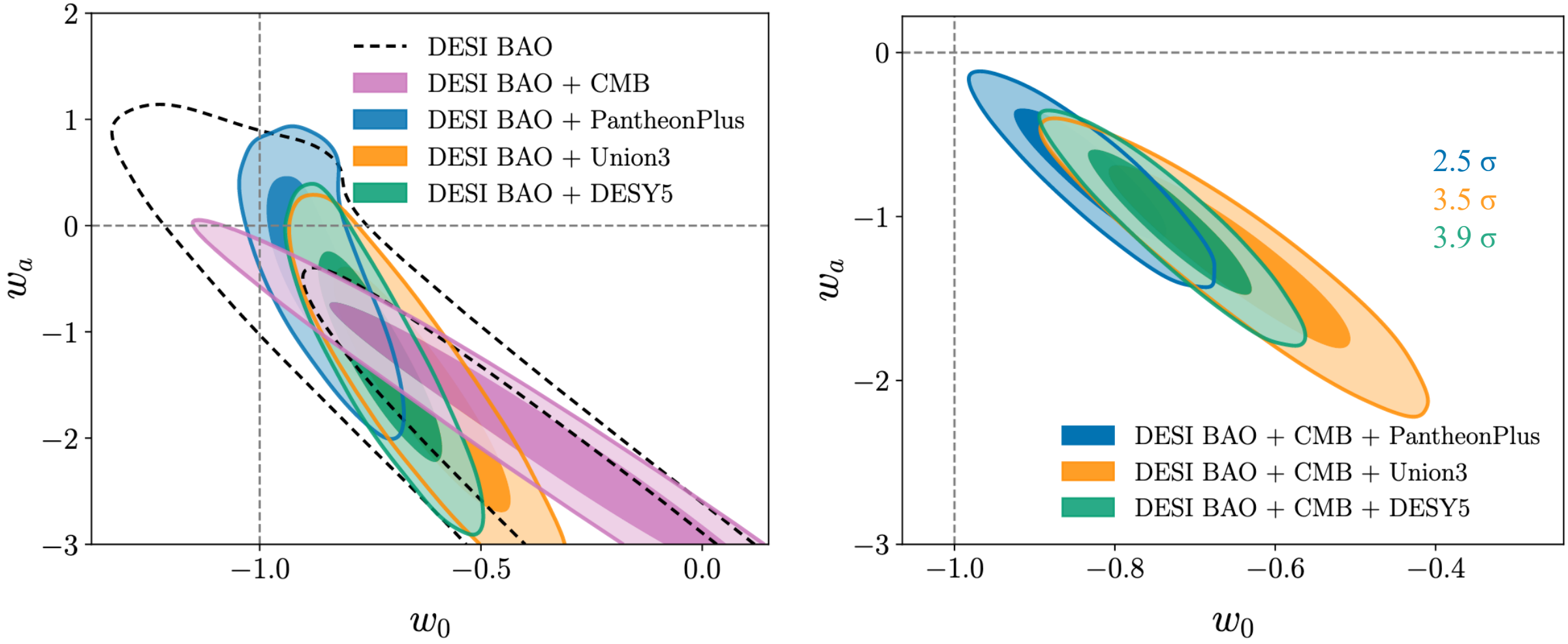
The significant deviation from the ΛCDM

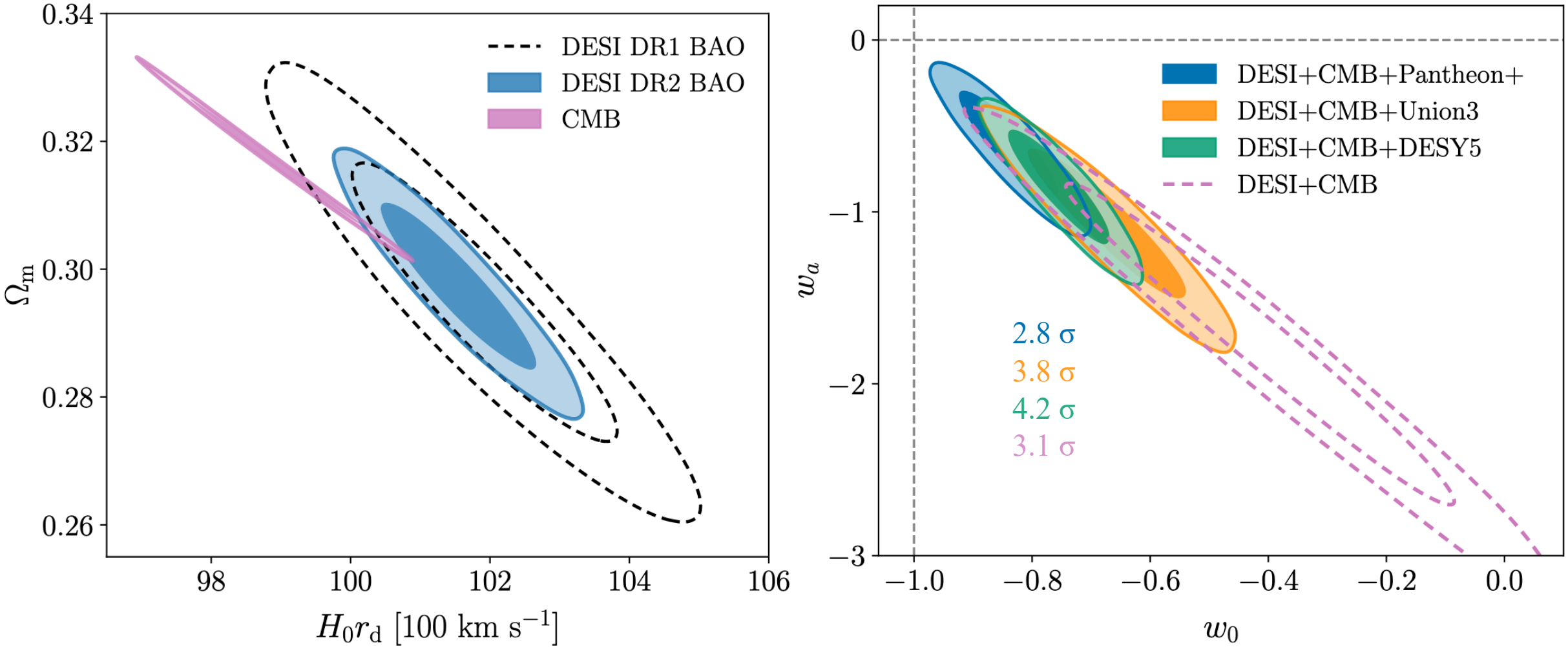
DESI DR1 BAO



DESI Collaboration, JCAP 02 (2025) 021

The significant deviation from the ΛCDM

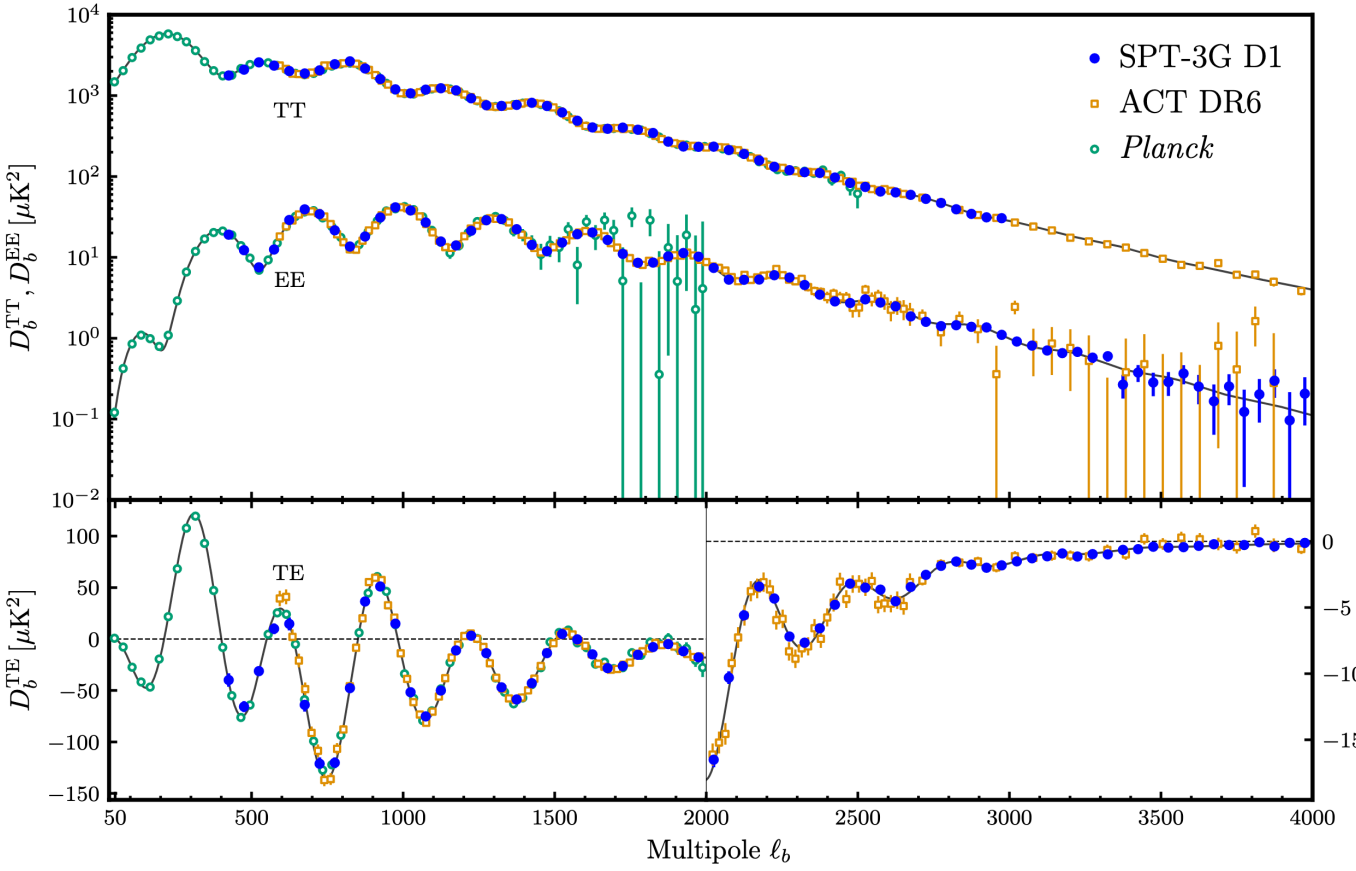
DESI DR2 BAO



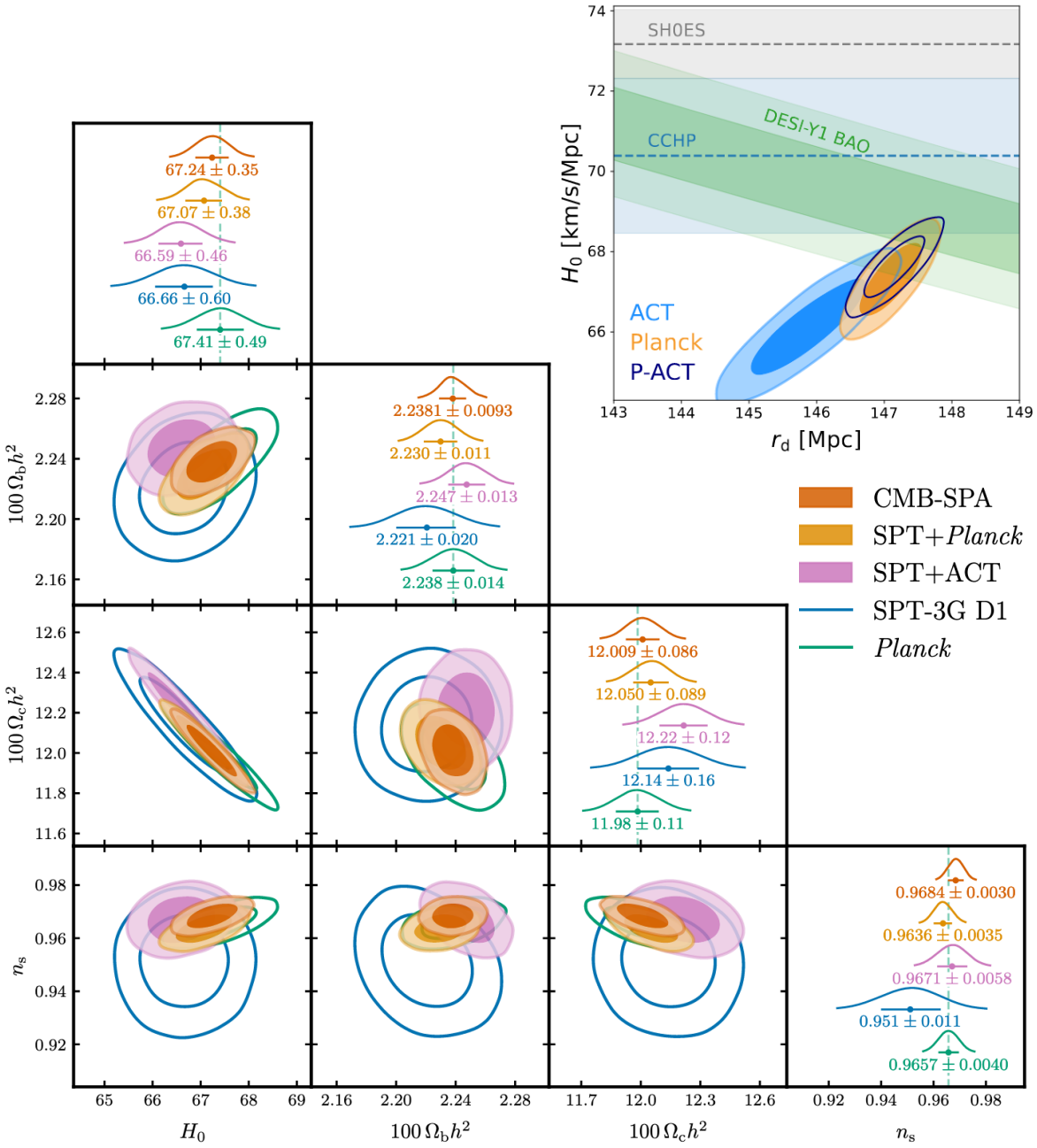
DESI Collaboration, PRD 112 (2025) 8, 083515

CMB Side -- Differences among CMB Datasets

ACT--Acatama Cosmology Telescope
SPT--South Pole Telescope

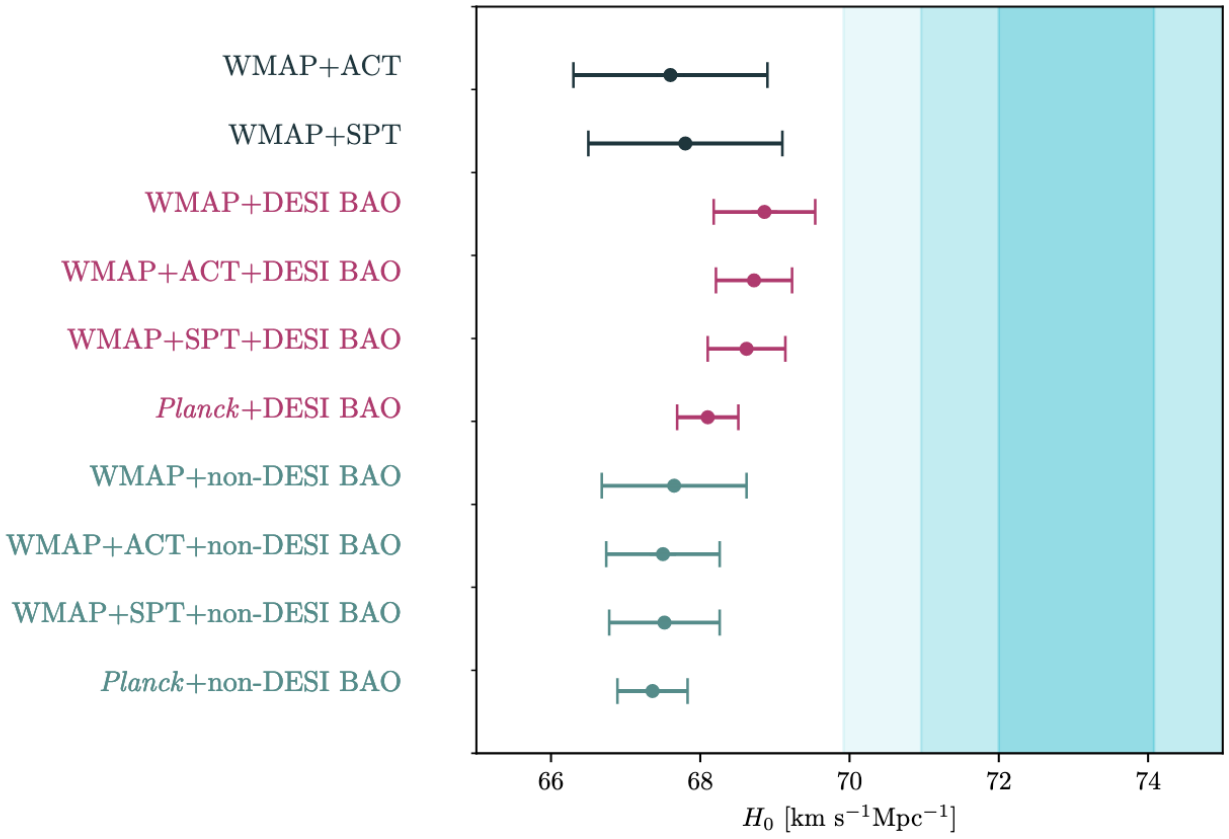


Thibaut Louis, et al., arXiv:2503.14452

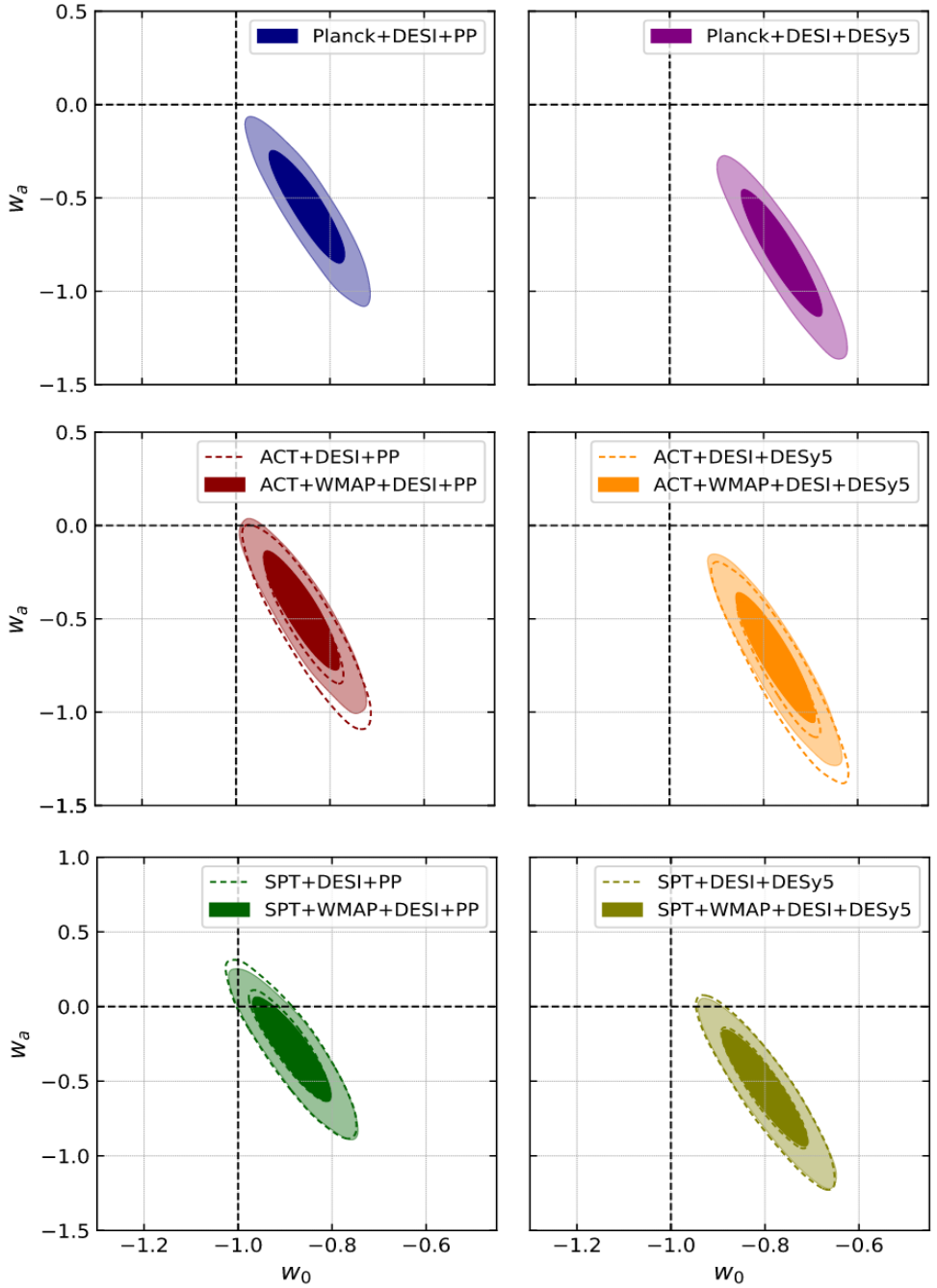


SPT-3G Collaboration, arXiv:2506.20707

CMB Side -- Differences among CMB Datasets

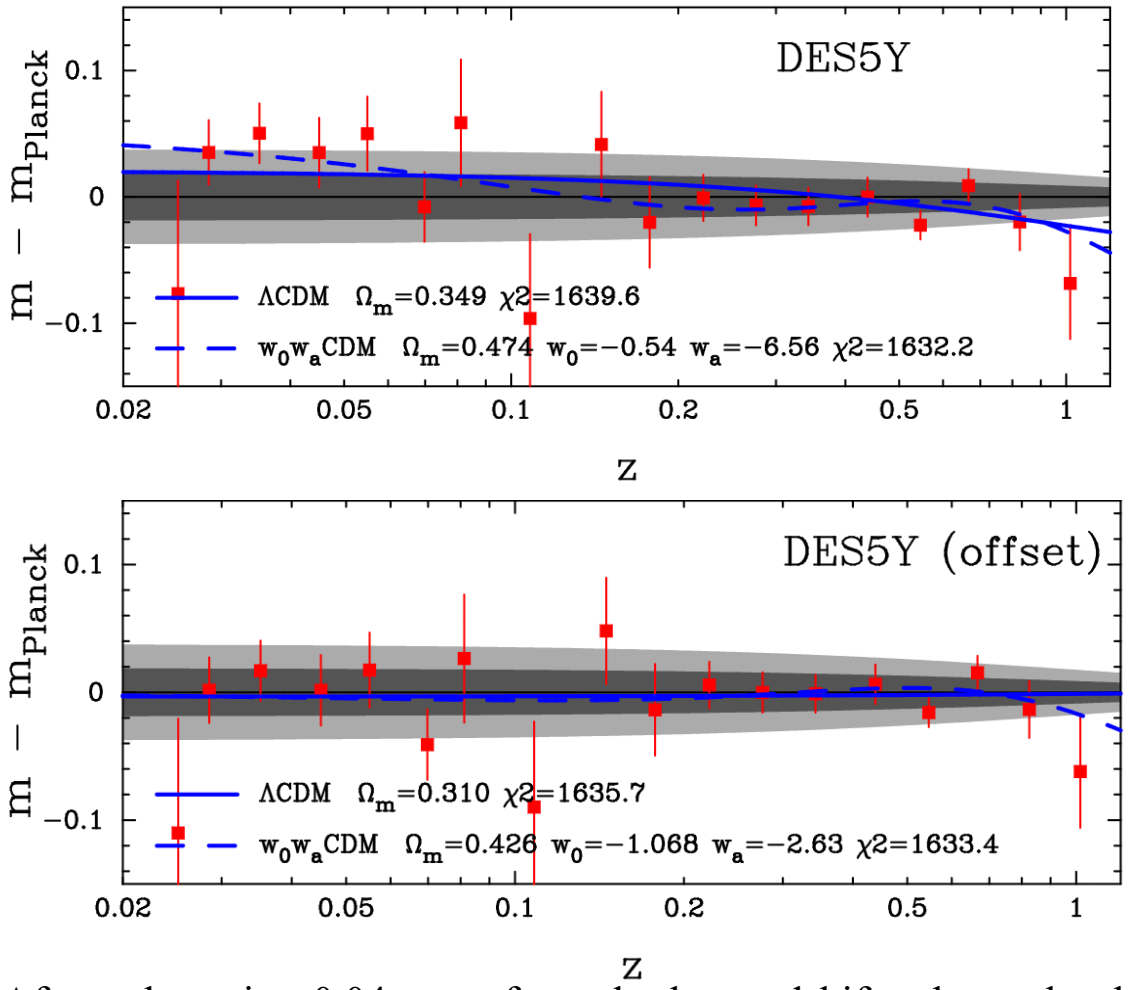


Ye-Huang Pang, Xue Zhang, Qing-Guo Huang, JCAP 04 (2025) 057

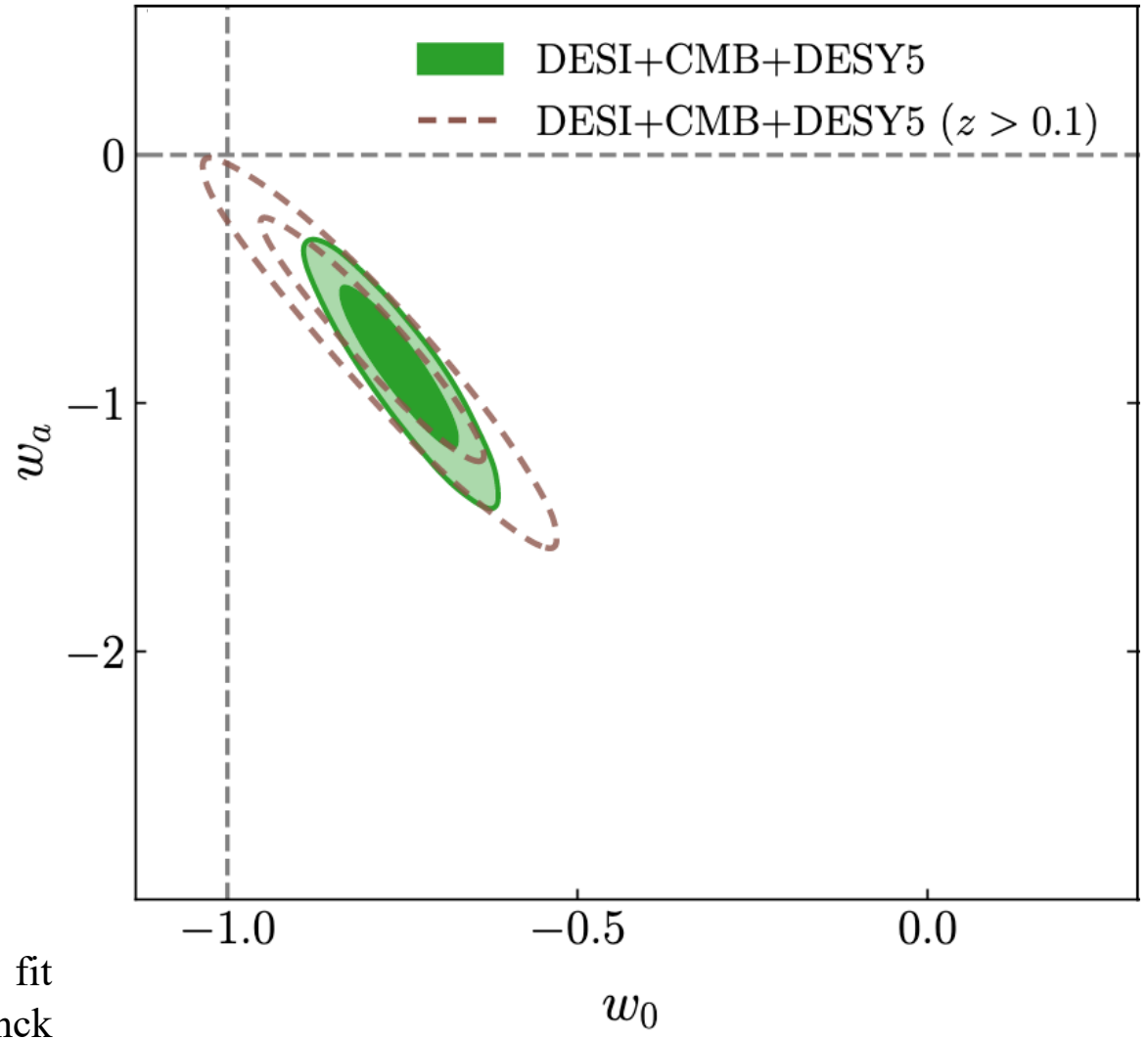


William Giarè, PRD 112 (2025) 2, 023508

SNIa Side -- Potential Systematics in the DESY5



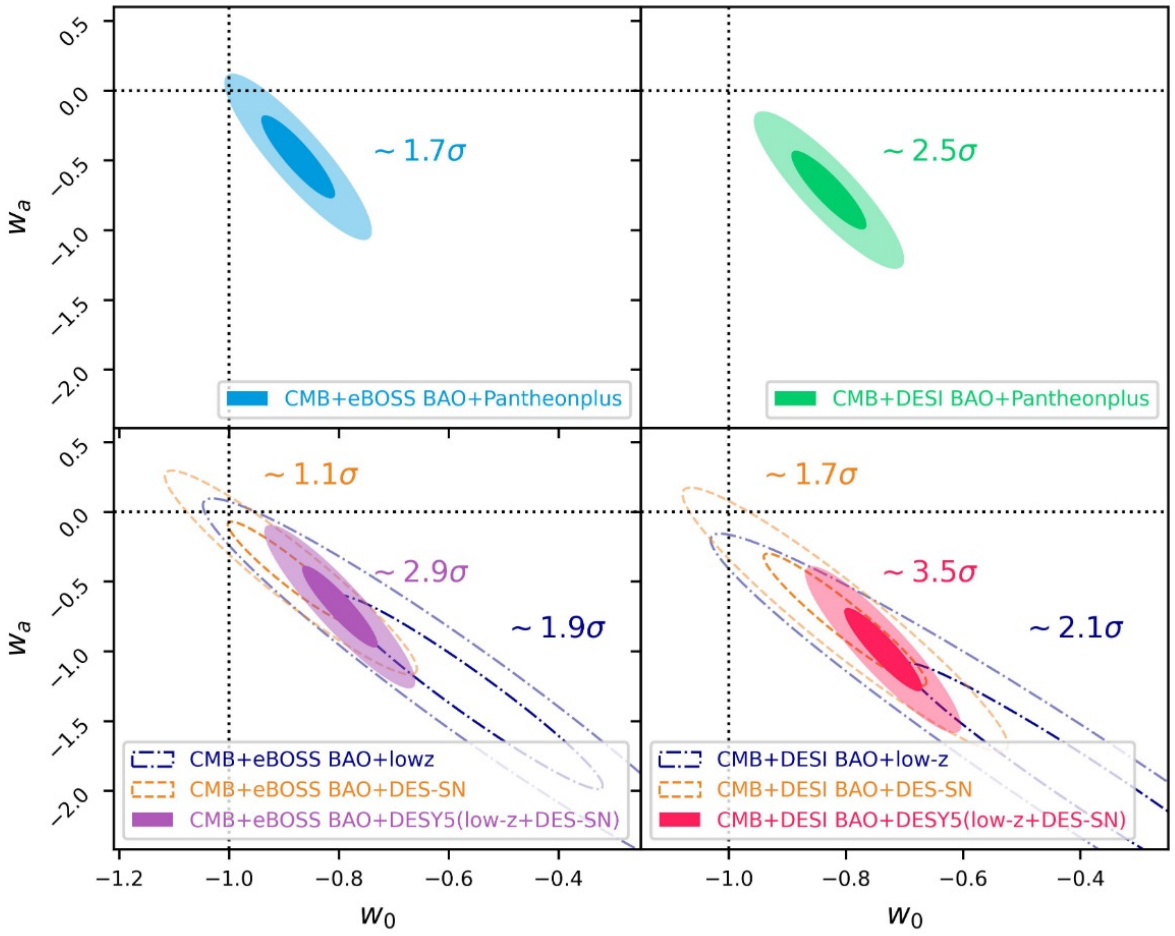
After subtracting 0.04 mag. from the low redshift subsample, the best fit ΛCDM cosmology is now indistinguishable from the best fit Planck ΛCDM cosmology and there is no preference for evolving dark energy.

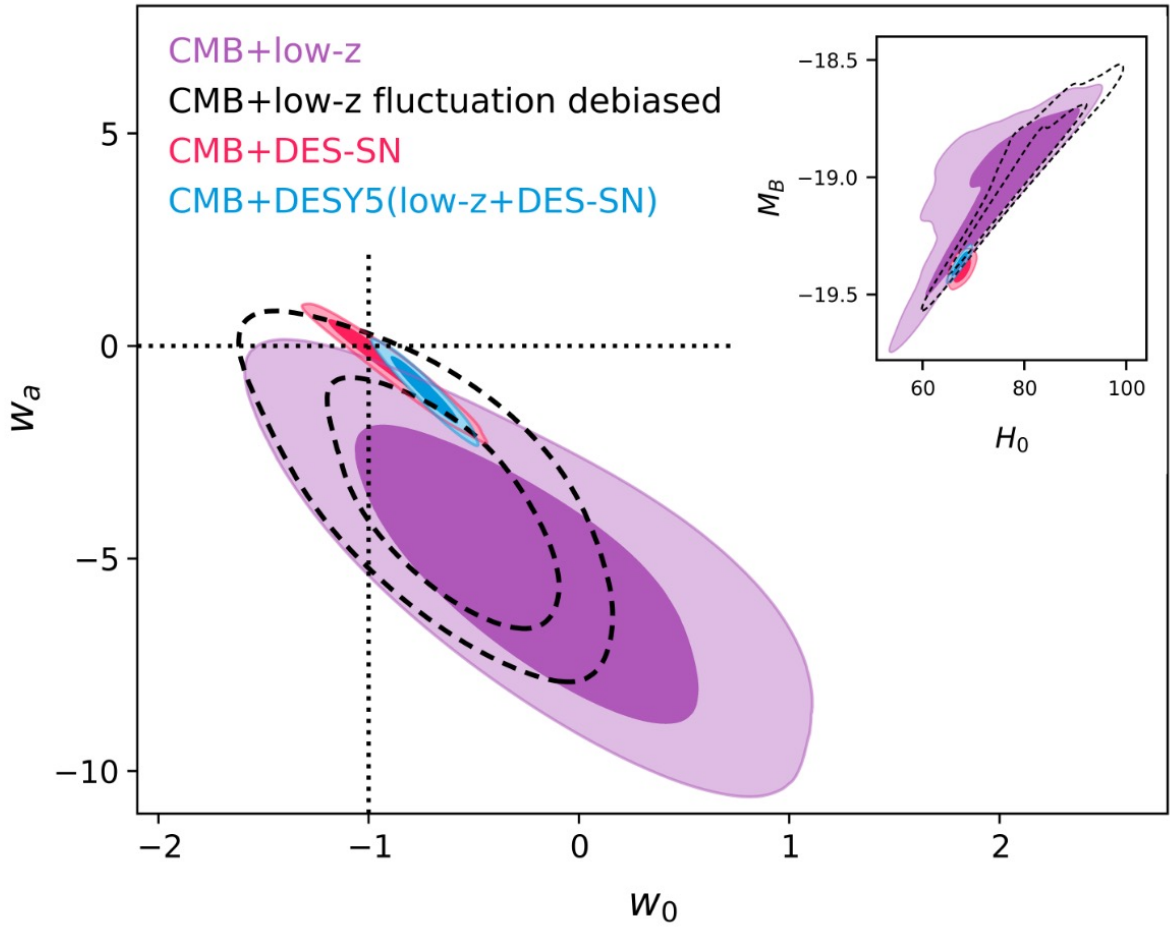


DESI Collaboration, PRD 112 (2025) 8, 083515

 George Efstathiou, MNRAS 538 (2025) 2, 875

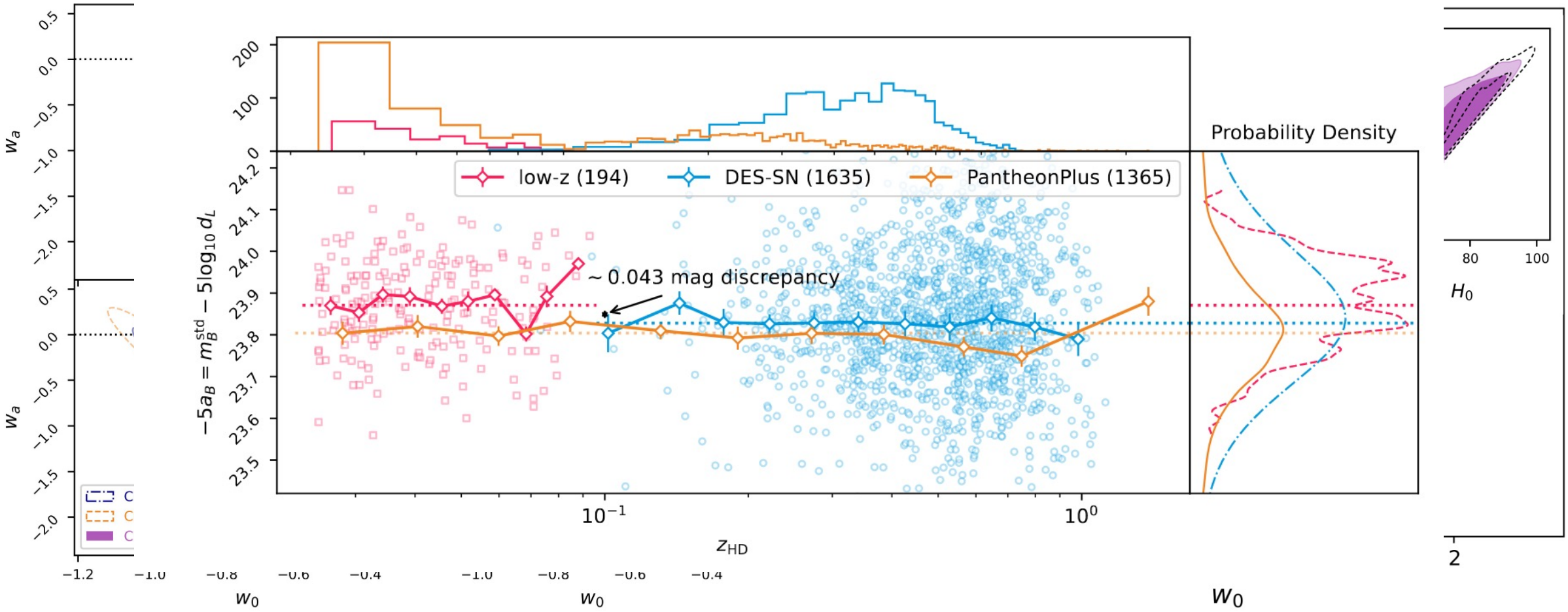
SNIa Side -- Potential Systematics in the DESY5





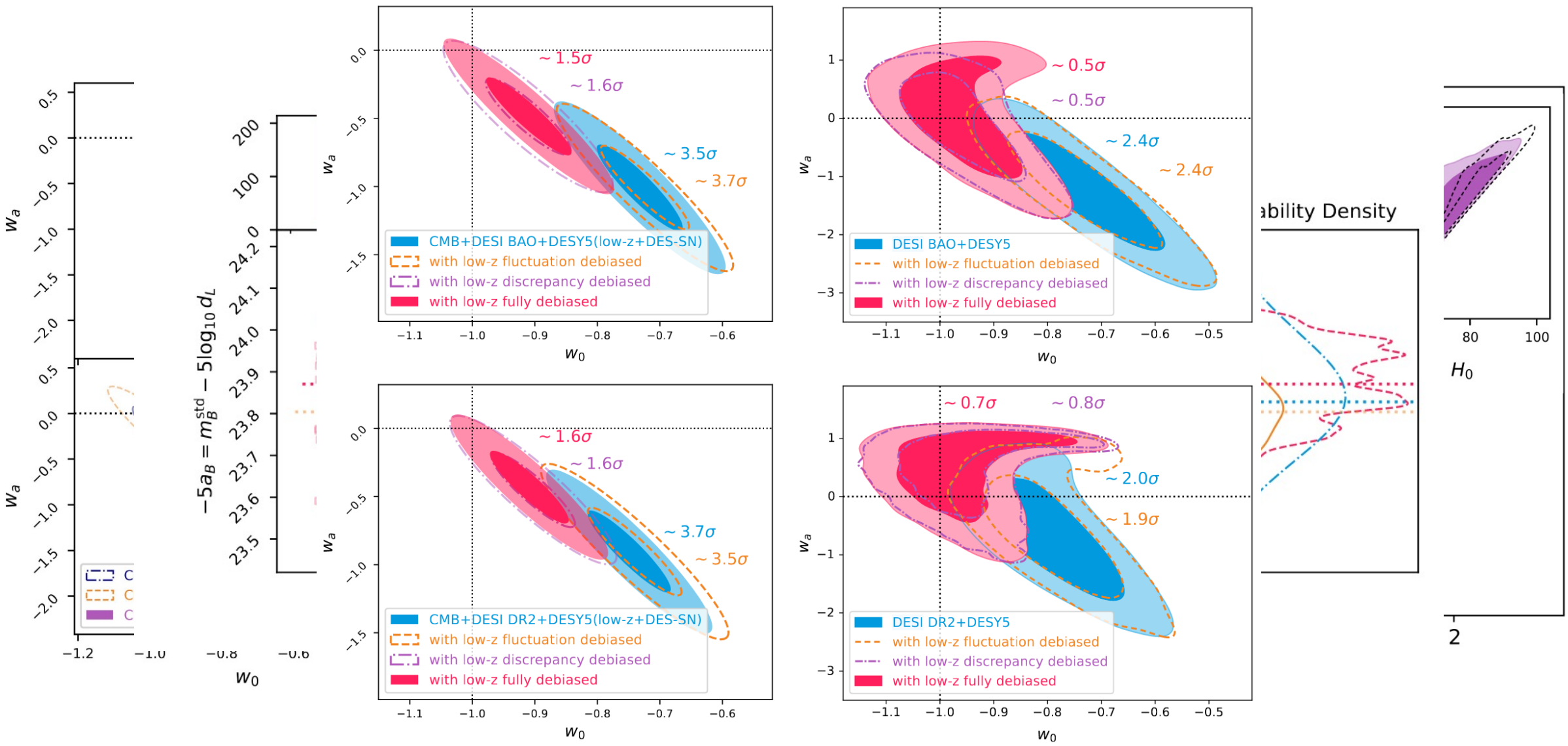
Lu Huang, Rong-Gen Cai, Shao-Jiang Wang, SCPMA 68 (2025) 100413

SNIa Side -- Potential Systematics in the DESY5



Lu Huang, Rong-Gen Cai, Shao-Jiang Wang, SCPMA 68 (2025) 100413

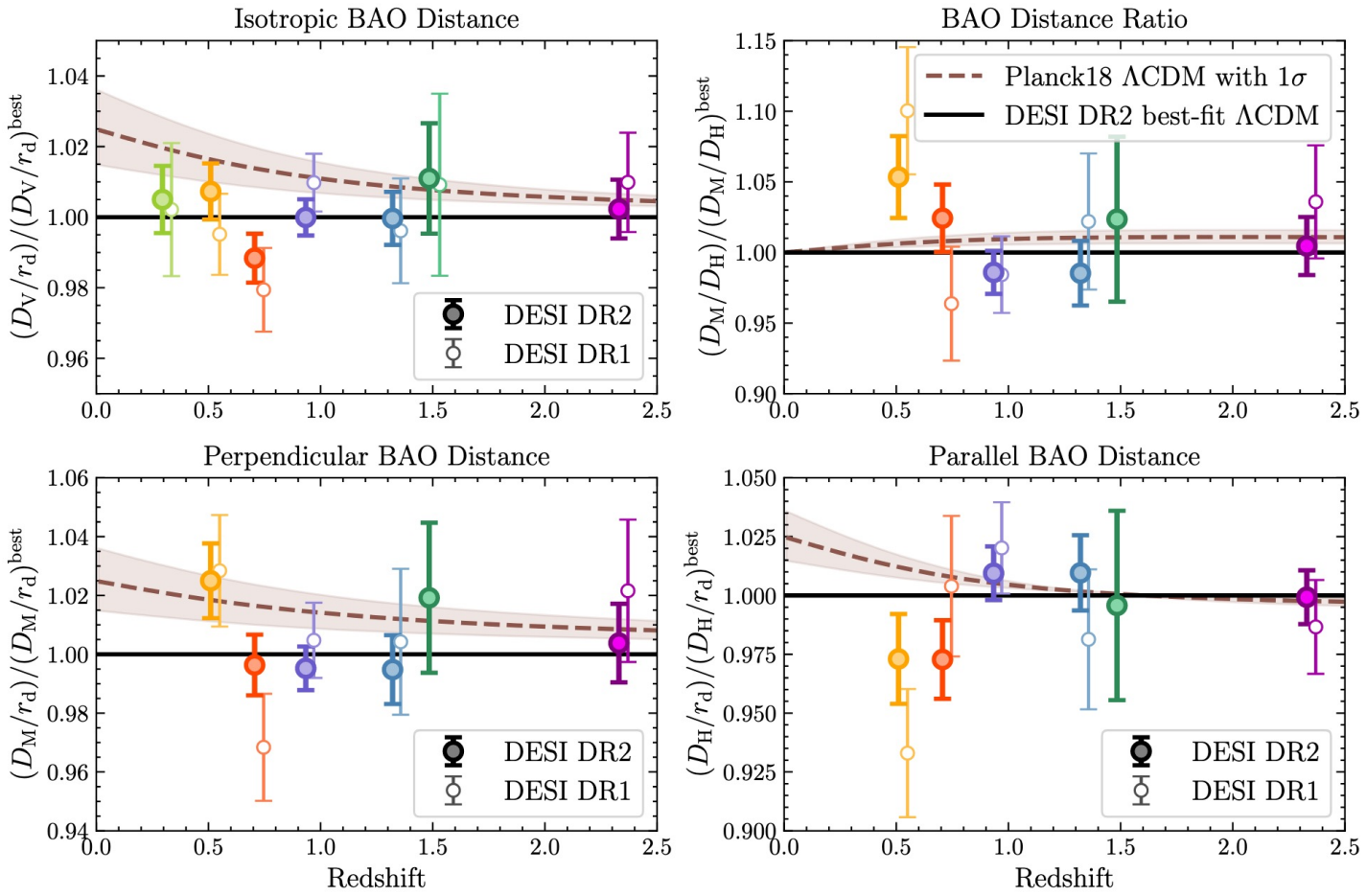
SNIa Side -- Potential Systematics in the DESY5



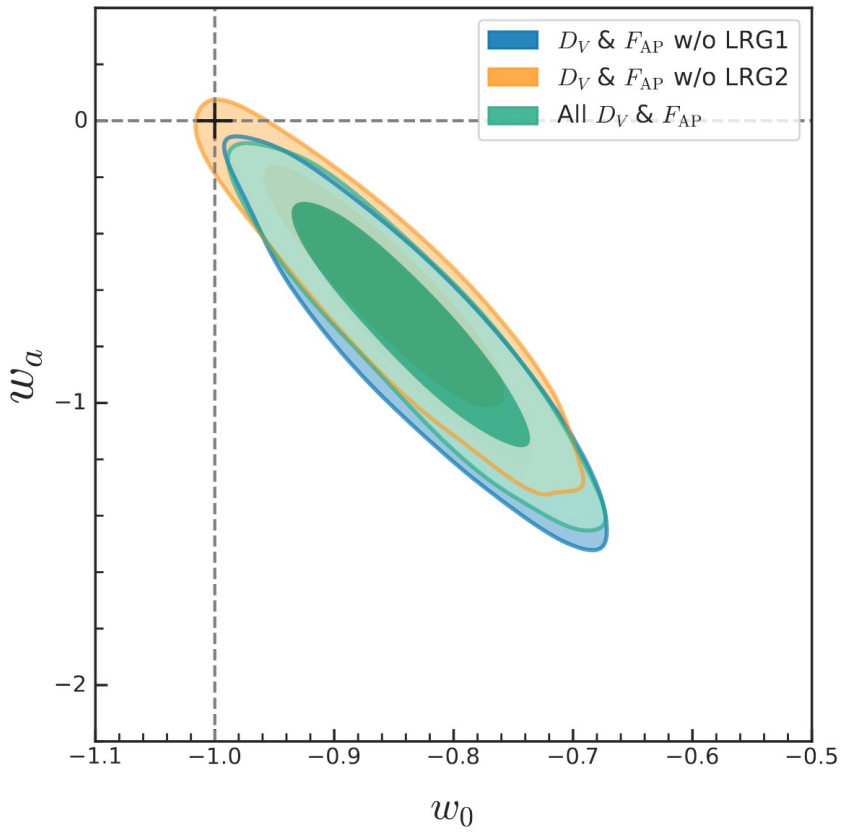
Lu Huang, Rong-Gen Cai, Shao-Jiang Wang, SCPMA 68 (2025) 100413

BAO Side -- Problem in DESI BAO

Tracer	BGS	LRG1	LRG2	LRG3+ELG1	ELG2	QSO	Lya



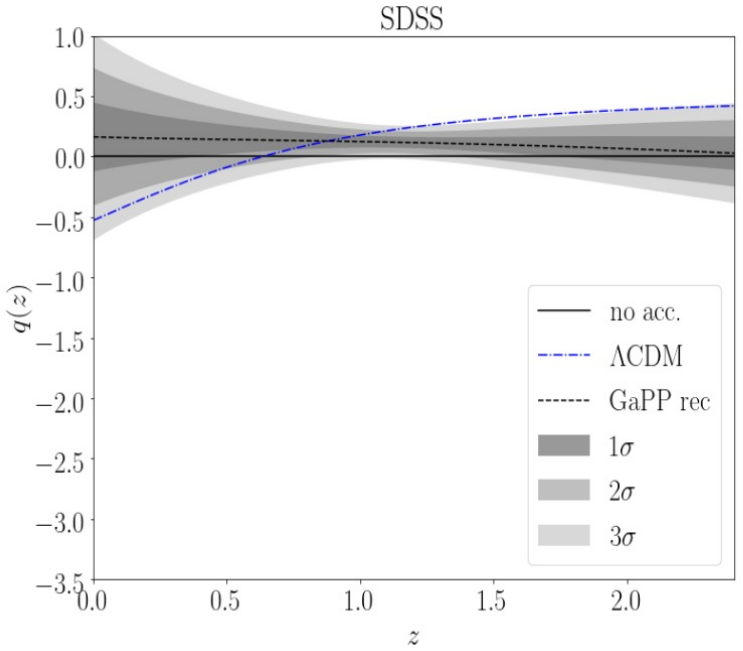
DESI Collaboration, PRD 112 (2025) 8, 083515

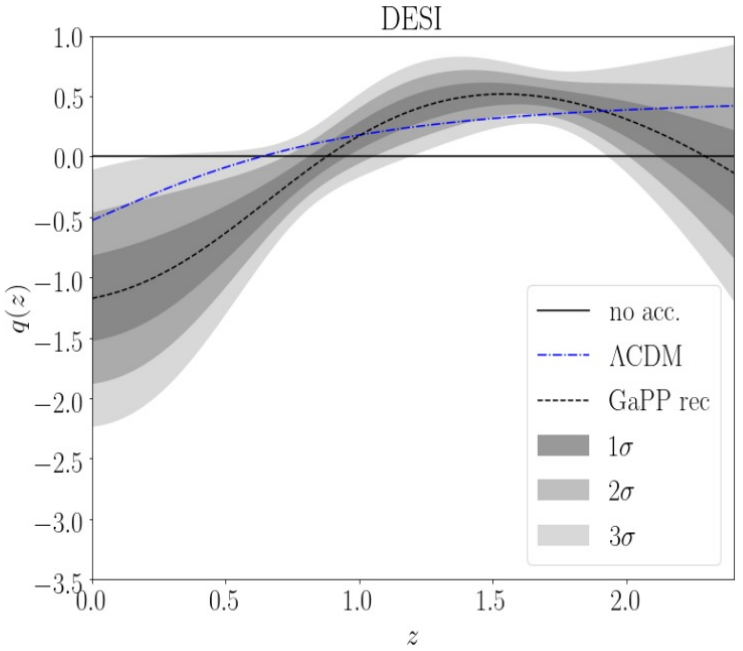


Zhengyi Wang, et al., MNRAS 534 (2024) 4, 3869

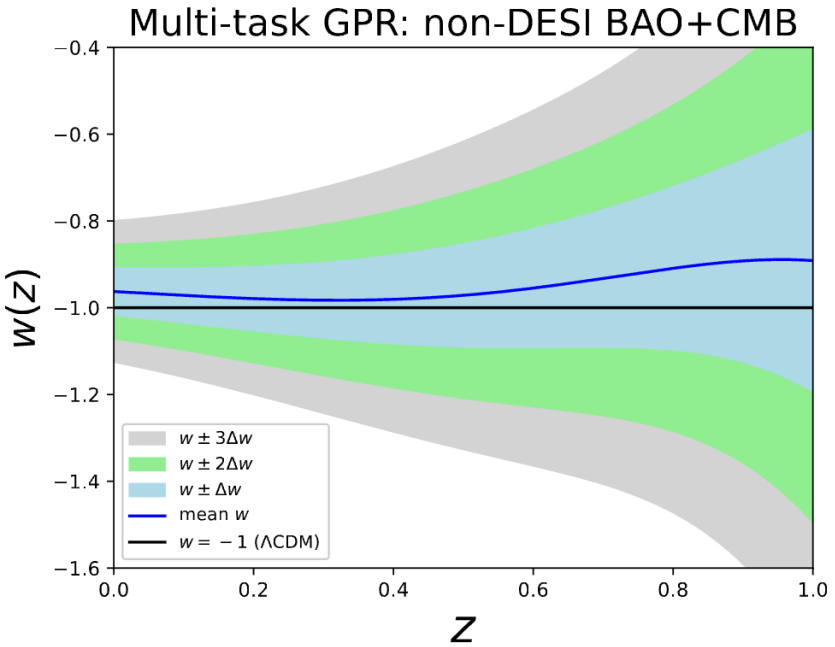
BAO Side -- Discrepancy between SDSS and DESI

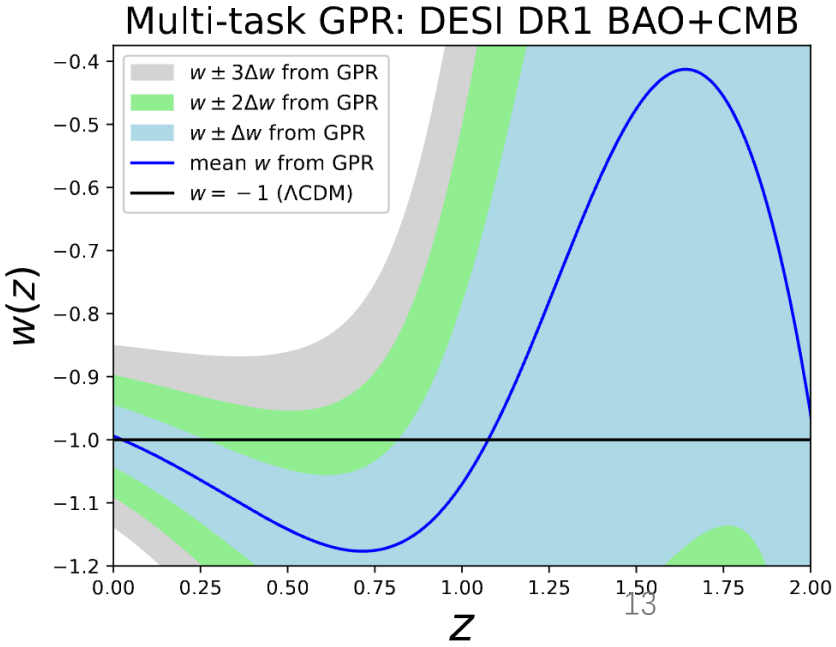
Basundhara Ghosh, Carlos Bengaly,
PDU 46 (2024) 101699





Bikash R. Dinda, Roy Maartens,
JCAP 01 (2025) 120





Where does the dominant issue lie?

Can the combined constraints from CMB, SNe Ia, and BAO truly not favor ΛCDM?

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Dataset

Name	Likelihood
ACT-DR6	`act_dr6_cmbonly`[1]
ACT-DR6-Lensing	**ACT-DR6** + `act_dr6_lenslike.ACTDR6LensLike`[2]
Planck	`planck_2018_lowl.TT`[3]
	`planck_2018_lowl.EE`[3]
	`planck_NPIPE_highl_CamSpec.TTTEEE`[3]
Planck-Lensing	**Planck** + `planckpr4lensing.PlanckPR4Lensing`[4]
SPT	`spt3g_2022.TTTEEE`[5]
WMAP	`wmaplike.WMAPLike`[6]
SDSS BAO	`bao.sdss_dr7_mgs`[7]
	`bao.sdss_dr12_lrg_bao_dmdh`[7]
	`bao.sdss_dr16_lrg_bao_dmdh`[7]
	`bao.sdss_dr16_bao_elg`[7]
	`bao.sdss_dr16_qso_bao_dmdh`[7]
	`bao.sdss_dr16_baoplus_lyauto`[7]
	`bao.sdss_dr16_baoplus_lyxqso`[7]
DESI DR2	`bao.desi_dr2`[7]

DESY5: 194 low z SNe (DES-lowz) and 1635 SNe (DES-SN) collected during the full five years of the Dark Energy Survey Supernova Program.

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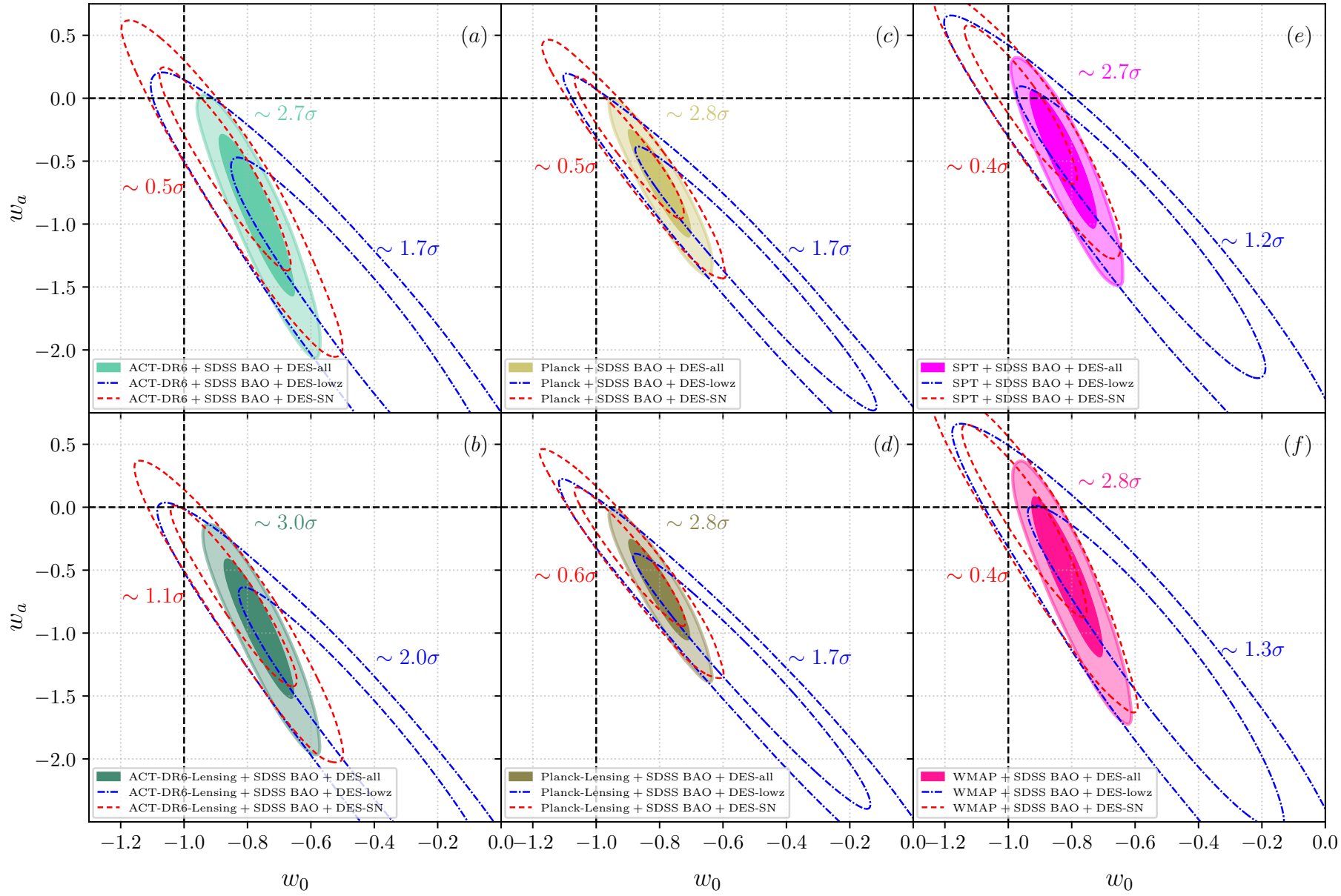
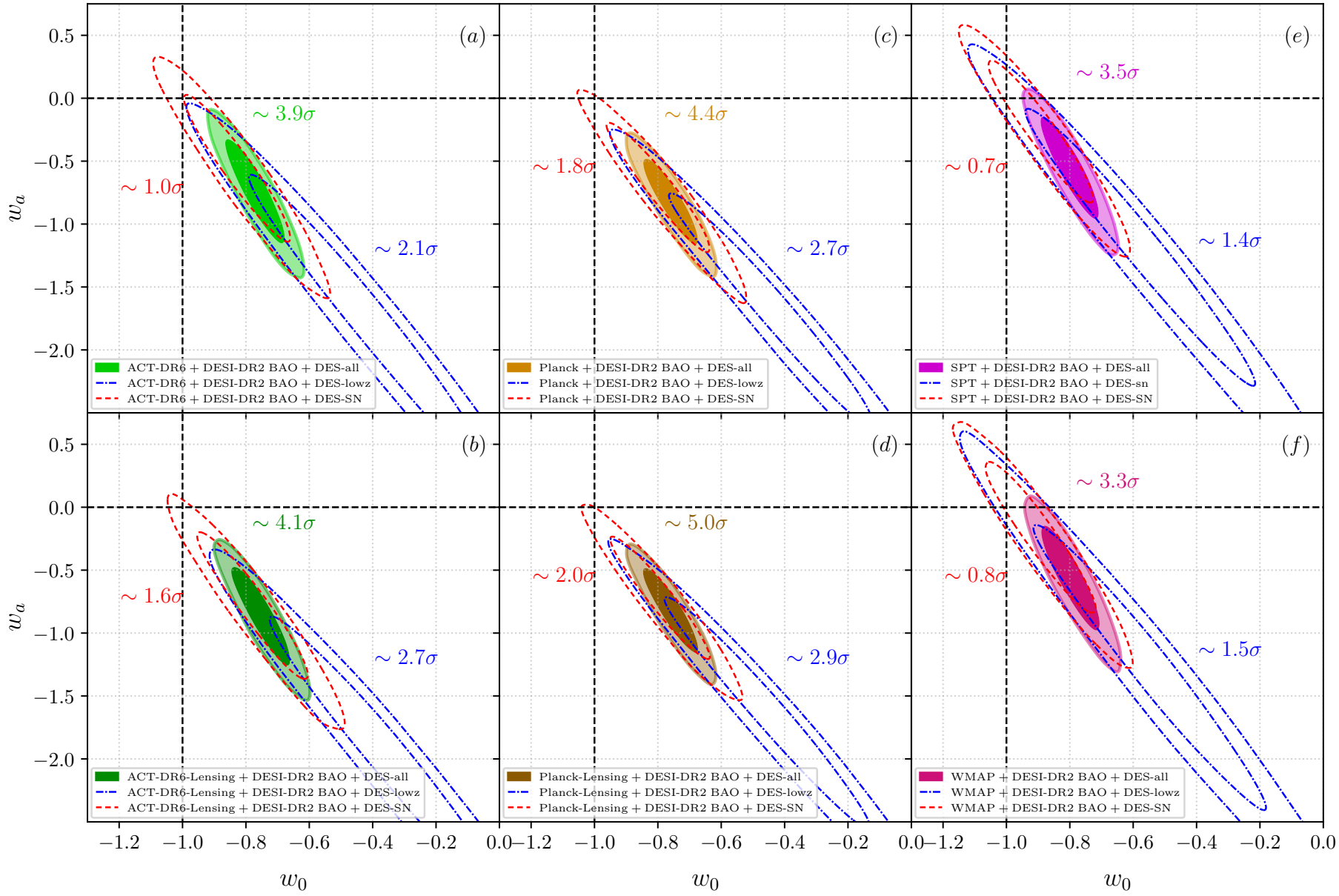
CMB + SDSS BAO + DESY5

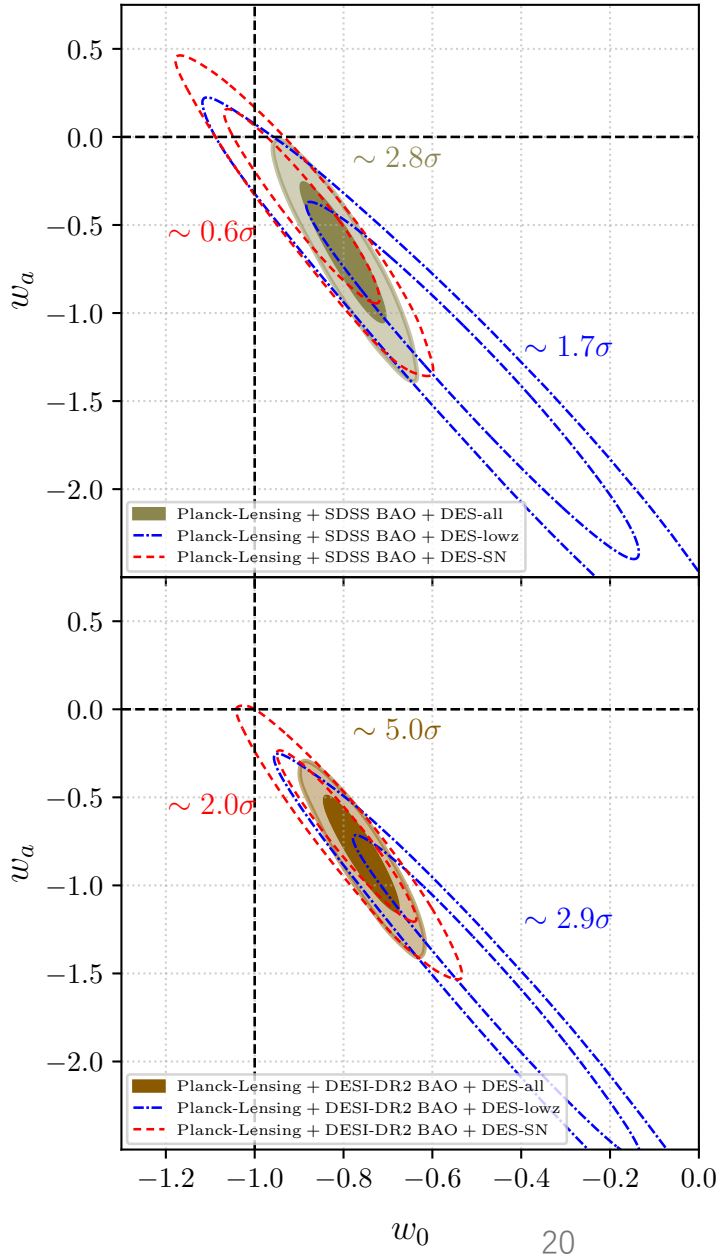


CMB + DESI DR2 BAO + DESY5



Compare SDSS and DESI DR2

Parameter	Planck-Lensing+					
	eBOSS BAO+			DESI-DR2 BAO+		
	DES-lowz	DES-SN	DES-all	DES-lowz	DES-SN	DES-all
w_0	-0.50 ± 0.24	-0.88 ± 0.12	-0.797 ± 0.065	-0.45 ± 0.20	-0.79 ± 0.10	-0.757 ± 0.057
w_a	-1.41 ± 0.65	$-0.42^{+0.39}_{-0.34}$	$-0.67^{+0.29}_{-0.25}$	$-1.63^{+0.62}_{-0.55}$	$-0.74^{+0.33}_{-0.30}$	$-0.83^{+0.23}_{-0.21}$
$\Omega_b h^2$	0.02220 ± 0.00013	0.02219 ± 0.00013	0.02219 ± 0.00013	0.02221 ± 0.00013	0.02224 ± 0.00013	0.02223 ± 0.00012
$\Omega_c h^2$	0.11965 ± 0.00096	0.11971 ± 0.00095	0.11972 ± 0.00096	0.11937 ± 0.00084	0.11894 ± 0.00082	0.11903 ± 0.00082
τ_{reio}	0.0506 ± 0.0071	0.0514 ± 0.0072	0.0509 ± 0.0072	0.0509 ± 0.0069	0.0530 ± 0.0070	0.0525 ± 0.0069
$\log(10^{10} A_s)$	3.033 ± 0.014	3.035 ± 0.014	3.034 ± 0.014	3.033 ± 0.014	3.037 ± 0.014	3.036 ± 0.014
n_s	0.9639 ± 0.0038	0.9635 ± 0.0039	0.9635 ± 0.0038	0.9645 ± 0.0036	0.9655 ± 0.0037	0.9653 ± 0.0036
H_0	$63.5^{+2.0}_{-2.4}$	67.1 ± 1.0	66.40 ± 0.64	$63.9^{+1.7}_{-1.9}$	67.00 ± 0.97	66.72 ± 0.56
r_{drag}	147.39 ± 0.23	147.38 ± 0.23	147.38 ± 0.23	147.45 ± 0.21	147.52 ± 0.21	147.51 ± 0.21
Ω_m	0.355 ± 0.025	0.317 ± 0.010	0.3234 ± 0.0066	0.350 ± 0.020	0.3161 ± 0.0096	0.3188 ± 0.0056
Tension	$\sim 1.7\sigma$	$\sim 0.6\sigma$	$\sim 2.8\sigma$	$\sim 2.9\sigma$	$\sim 2.0\sigma$	$\sim 5.0\sigma$



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Conclusions

1. We find that the combination of non-Planck CMB, BAO, and DES-SN remains consistent with the ΛCDM.
2. The low-redshift portion of the DESY5 sample is identified as the primary contributor to deviations from ΛCDM.
3. Planck CMB data is also a key factor driving the constraints away from ΛCDM.
4. Both ACT-DR6 lensing and Planck PR4 lensing have only minor, yet non-negligible, impacts.
5. The choice of BAO data may has a substantial impact: replacing SDSS BAO with DESI-DR2 BAO not only tightens the constraints but also shifts the best-fit values of w_0 and w_a, thereby enhancing the deviation from ΛCDM.

Thank You !