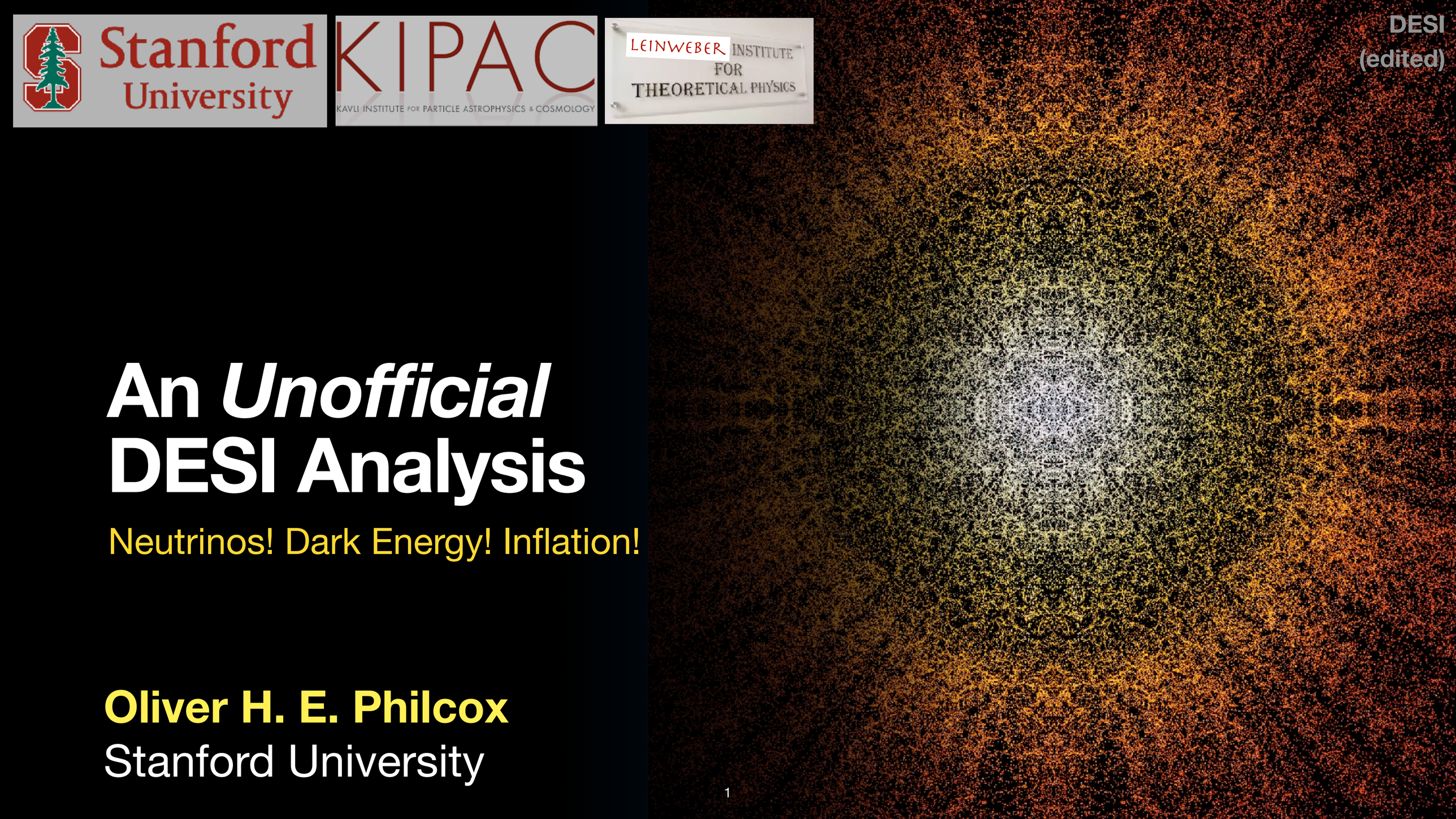
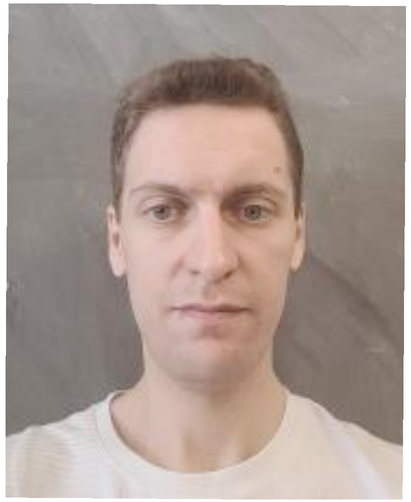


An *Unofficial* DESI Analysis

Neutrinos! Dark Energy! Inflation!

Oliver H. E. Philcox
Stanford University

Acknowledgements



Anton Chudaykin

Mikhail Ivanov

PAPERS

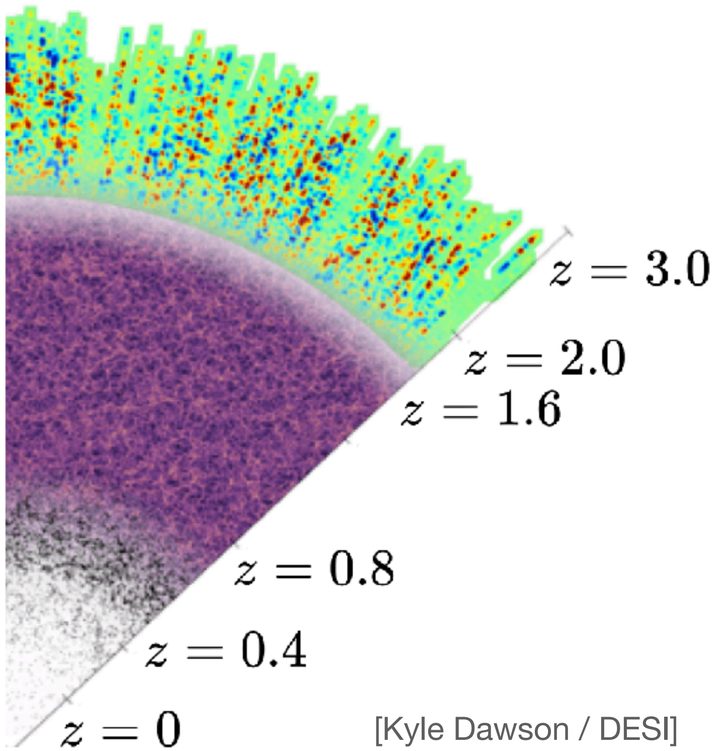
arXiv:2507.13433 (ΛCDM)
arXiv:2511.20757 (Extensions)
arXiv:2512.04266 (PNG)
arXiv:2601.16165 (Everything)

+ Stephen Chen, Mark Maus, Jamie Sullivan

and, of course, the **DESI collaboration!**

Reanalyzing DESI

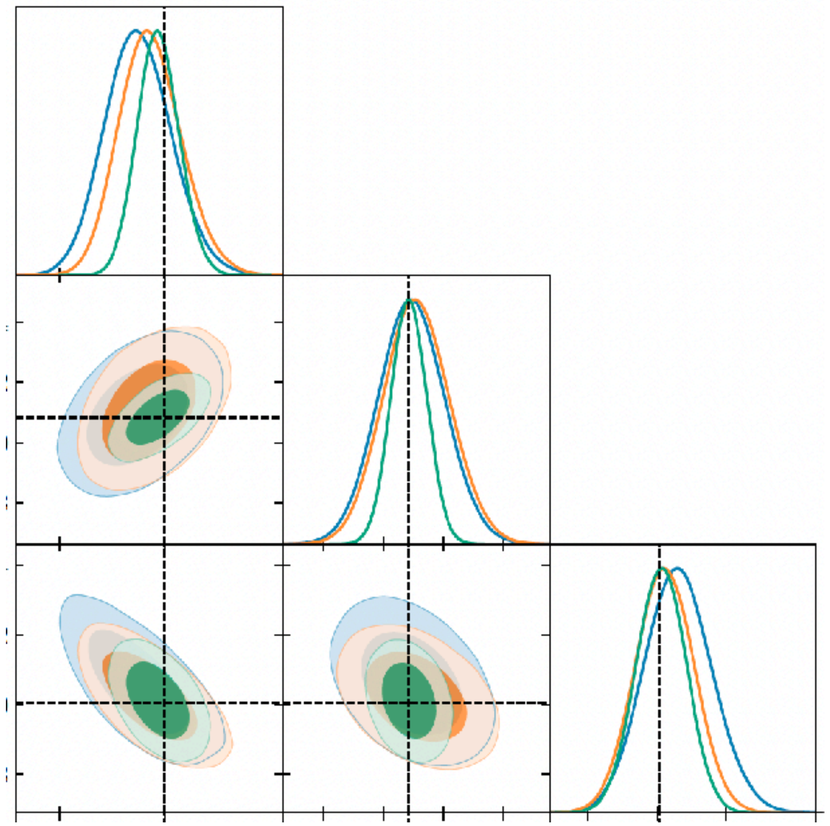
DESI Galaxies



[Kyle Dawson / DESI]

???

Cosmological Parameters



DESI 2024 II, V, DESI Data Release 1, Chudaykin, Ivanov, **Philcox**, Sullivan, Maus, Chen

Reanalyzing DESI

DESI Data Release 1 (LRGs)

TARGETID	Z	NTILE	RA	DEC	...
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39627546853115304	0.5559672054059013	1	159.28855963426028	-9.955979493106813	...
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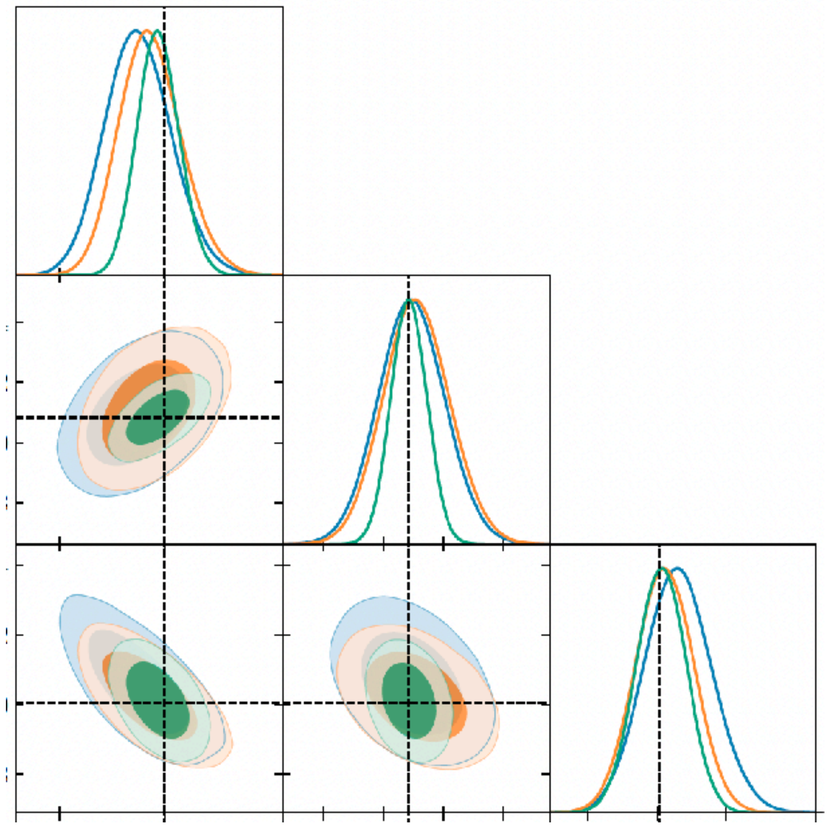
39627546853115682	0.9274570688680336	1	159.30835543527493	-10.106935803496164	...
...	...	...	...	...	...

???

Cosmological Parameters



DESI 2024 II, V, DESI Data Release 1, Chudaykin, Ivanov, **Philcox**, Sullivan, Maus, Chen

Reanalyzing DESI

DESI Data Release 1 (LRGs)

TARGETID	Z	NTILE
int64	float64	int64
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39627546844726593	0.835471640017949	
39627546848921194	0.8148312339778753	
39627546848922139	0.7200341373651288	
39627546848922621	0.7606337242857438	
39627546848922874	0.7198972751282844	
39627546848923188	0.7210857282186207	
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39627546848923415	0.8891288789150124	
39627546848923493	0.9513285375888253	
39627546848923519	0.7212784017696859	
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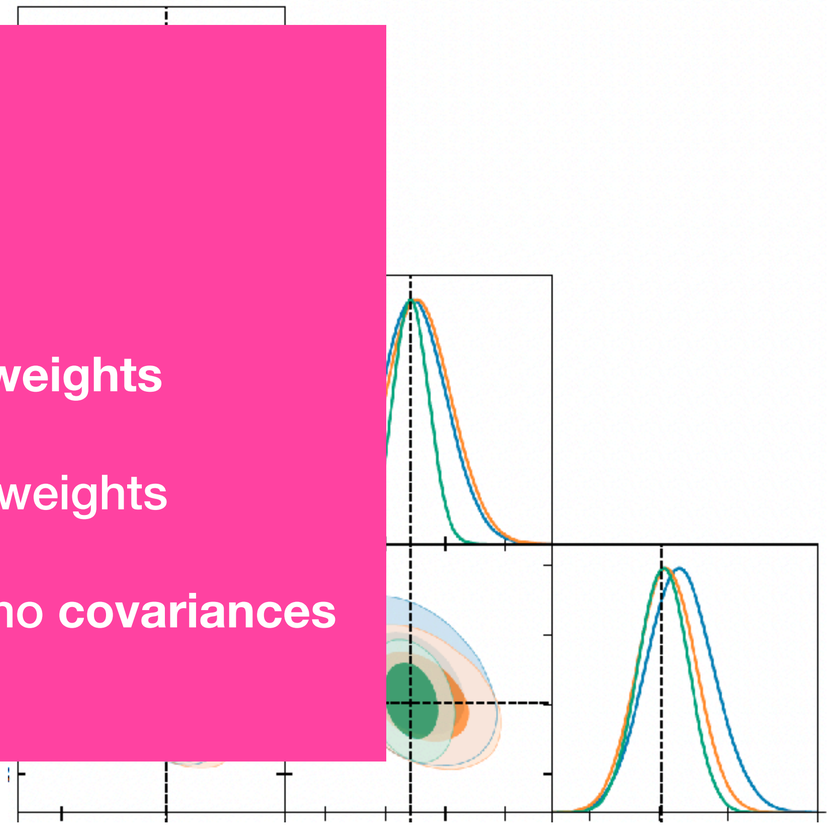
...	...	...

Cosmological Parameters



This is hard

Initially, the data release **only** contained:

- Galaxy **positions, redshifts** and **systematic weights**
- Random positions, redshifts and systematic weights

There are no **simulations***, no **power spectra** and no **covariances**

[= now added!]*

DESI 2024 II, V, DESI Data Release 1, Chudaykin, Ivanov, **Philcox**, Sullivan, Maus, Chen

Reanalyzing DESI

DESI Data Release 1 (LRGs)

TARGETID	Z	NTILE
int64	float64	int64
39627540901396844	0.42060841162467566	
39627546836338876	0.8668980715716706	
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39627546840533707	0.7646678553759423	
39627546840534067	0.88129590000311	
39627546840534396	0.6646155566176719	
39627546844725593	0.7619120932610688	
39627546844726132	0.8129116729090922	
39627546844726593	0.835471640017949	
39627546848921194	0.8148312339778753	
39627546848922139	0.7200341373651288	
39627546848922621	0.7606337242857438	
39627546848922874	0.7198972751282844	
39627546848923188	0.7210857282186207	
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39627546848923493	0.9513285375888253	
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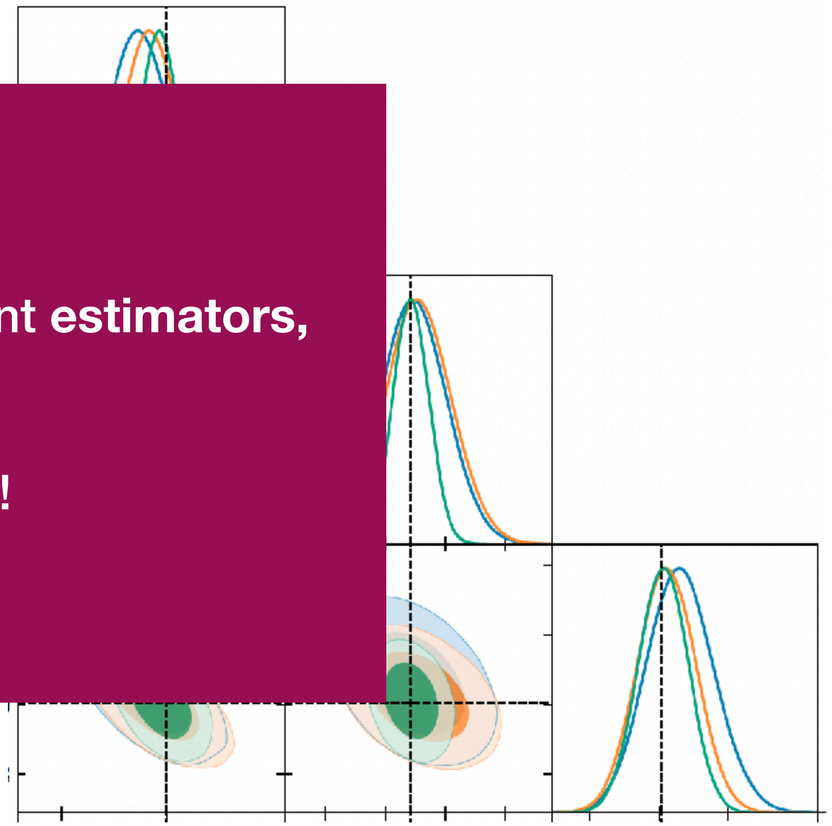
...	...	...

Cosmological Parameters



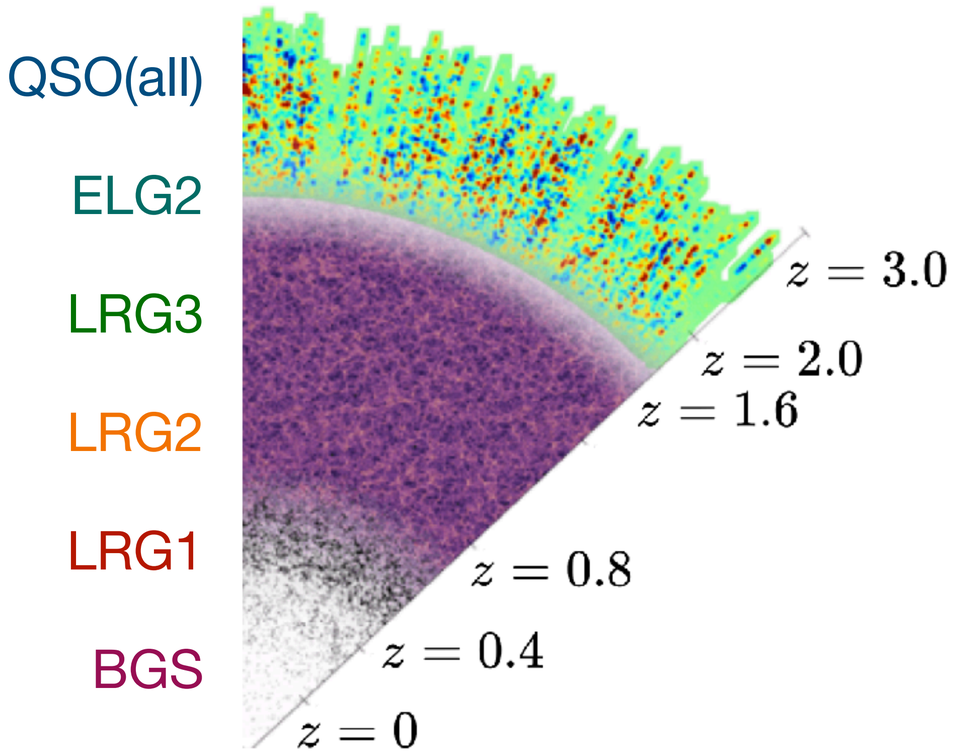
This is <u>important</u>

We develop an **independent** pipeline, using different **estimators, covariance estimates**, and **theory codes**

We can include **more statistics** with **new methods**!

DESI 2024 II, V, DESI Data Release 1, Chudaykin, Ivanov, **Philcox**, Sullivan, Maus, Chen

The Unofficial DESI Dataset



Fiducial

- Power Spectra: $P_\ell(k)$ $\quad 0.01 \leq k/[h^{-1}\mathrm{Mpc}] \leq 0.2$
- Bispectra: $B_\ell(k_1, k_2, k_3)$ $\quad 0.01 \leq k/[h^{-1}\mathrm{Mpc}] \leq 0.16$
- Baryon Acoustic Oscillations (from DR2): $\alpha_{\|}, \alpha_{\perp}$

Just released

Cross-correlations!

- (CMB lensing) x (spectroscopic galaxies): $C_\ell^{\kappa g^{\mathrm{spec}}}$
- (CMB lensing) x (photometric galaxies): $C_\ell^{\kappa g^{\mathrm{phot}}}$

- (Photometric galaxies) x (Photometric galaxies): $C_\ell^{g^{\mathrm{phot}} g^{\mathrm{phot}'}}$

DESI 2025, DESI Data Release 1, Chudaykin, Ivanov, **Philcox**, Sullivan, Maus, Chen

Modeling Choices & Challenges

QSO(all)

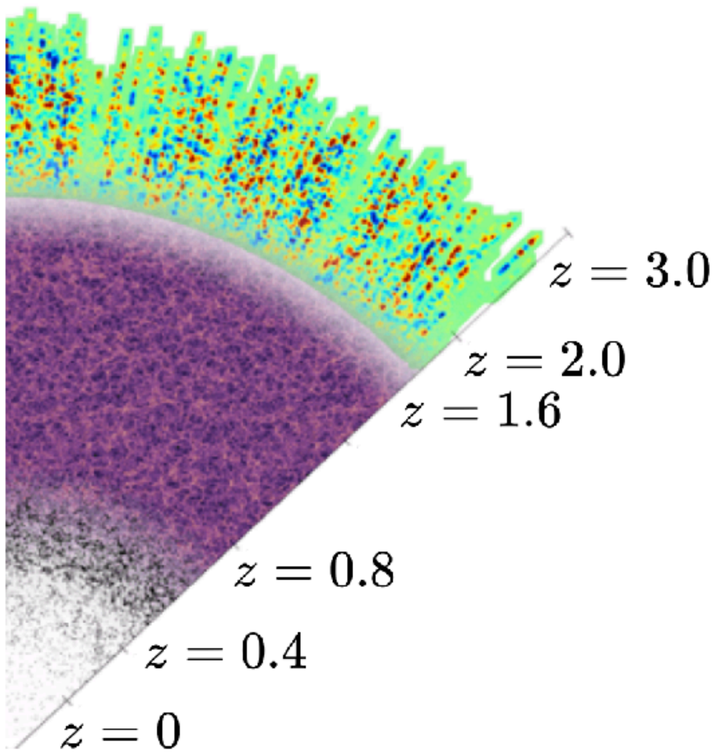
ELG2

LRG3

LRG2

LRG1

BGS



- New estimator: **PolyBin3D**
- New statistics: power spectrum **hexadecapole** + **bispectrum**
- New theory model: **one-loop** for all statistics
- **Analytic** covariances (including masks)
- **Systematic** corrections (**wide-angle**, **masks**, **fiber-collisions**, and **integral constraints**)
- New **conservative** priors (with rescaling)

e.g., $b_1 \to b_1\sigma_8$, $\qquad P_{\rm shot}(k) \sim \dfrac{(a + bk^2)}{\bar{n}}$

DESI 2025, DESI Data Release 1, Bakx, Floss, Vlah, Chudaykin, Ivanov, **Philcox**, Sullivan, Maus, Chen

Constraints on ΛCDM

Bound on σ_8 gradually tightens with **more** datasets

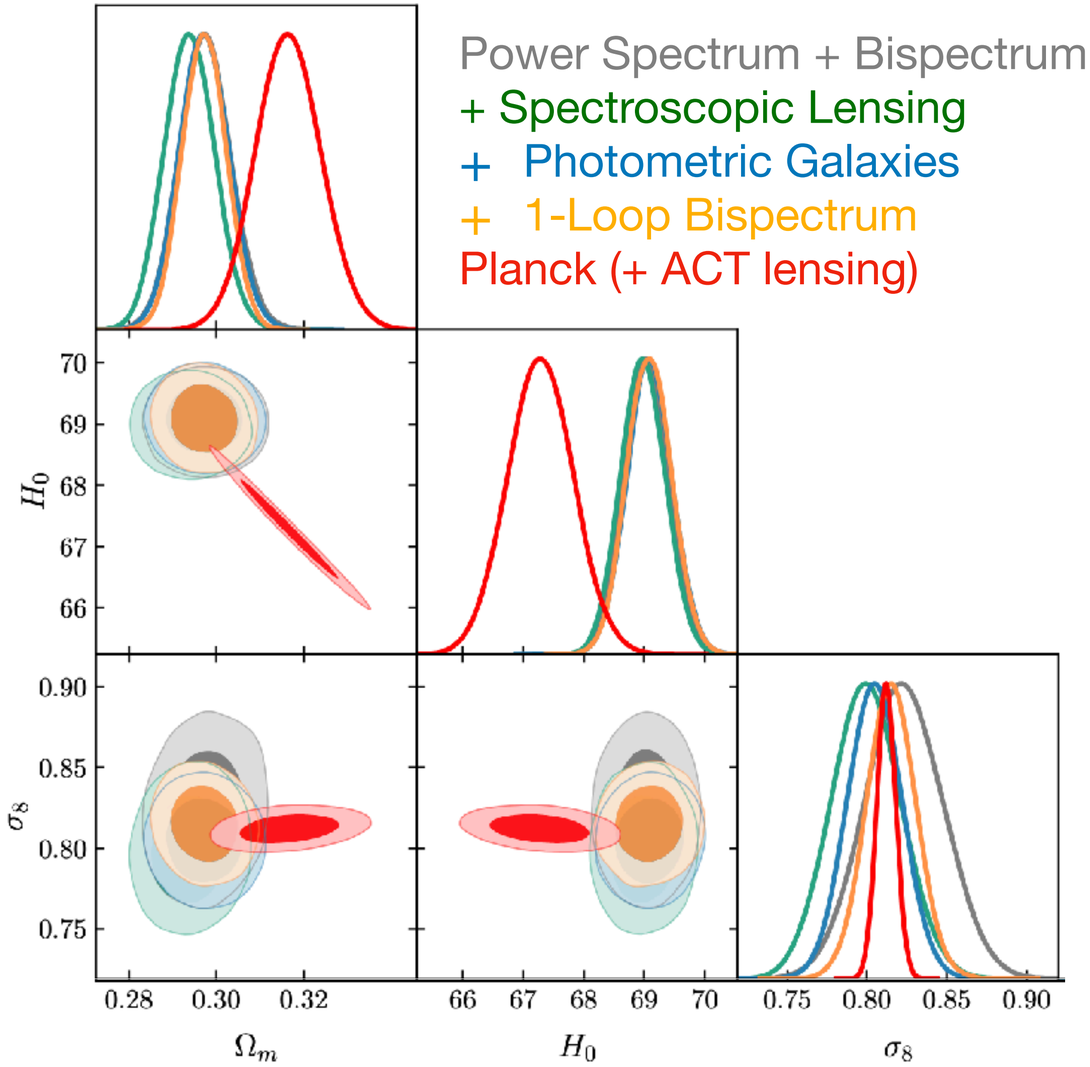
- $+15\,\%$ from lensing cross-correlations
- $+30\,\%$ from photometric data
- $+7\,\%$ from one-loop bispectra ($+15\,\%$ on Ω_m)

Our constraints are **broadly consistent** with Planck

- $P + B + \mathrm{BAO}$ dataset matches CMB to 2σ (1.8σ with PR4)
- No evidence for H_0 tension or S_8 tension ($S_8 = 0.811 \pm 0.016$)

Overall constraint:

$$\Omega_m = 0.297 \pm 0.005,\ H_0 = 69.1 \pm 0.4,\ \sigma_8 = 0.815 \pm 0.016$$

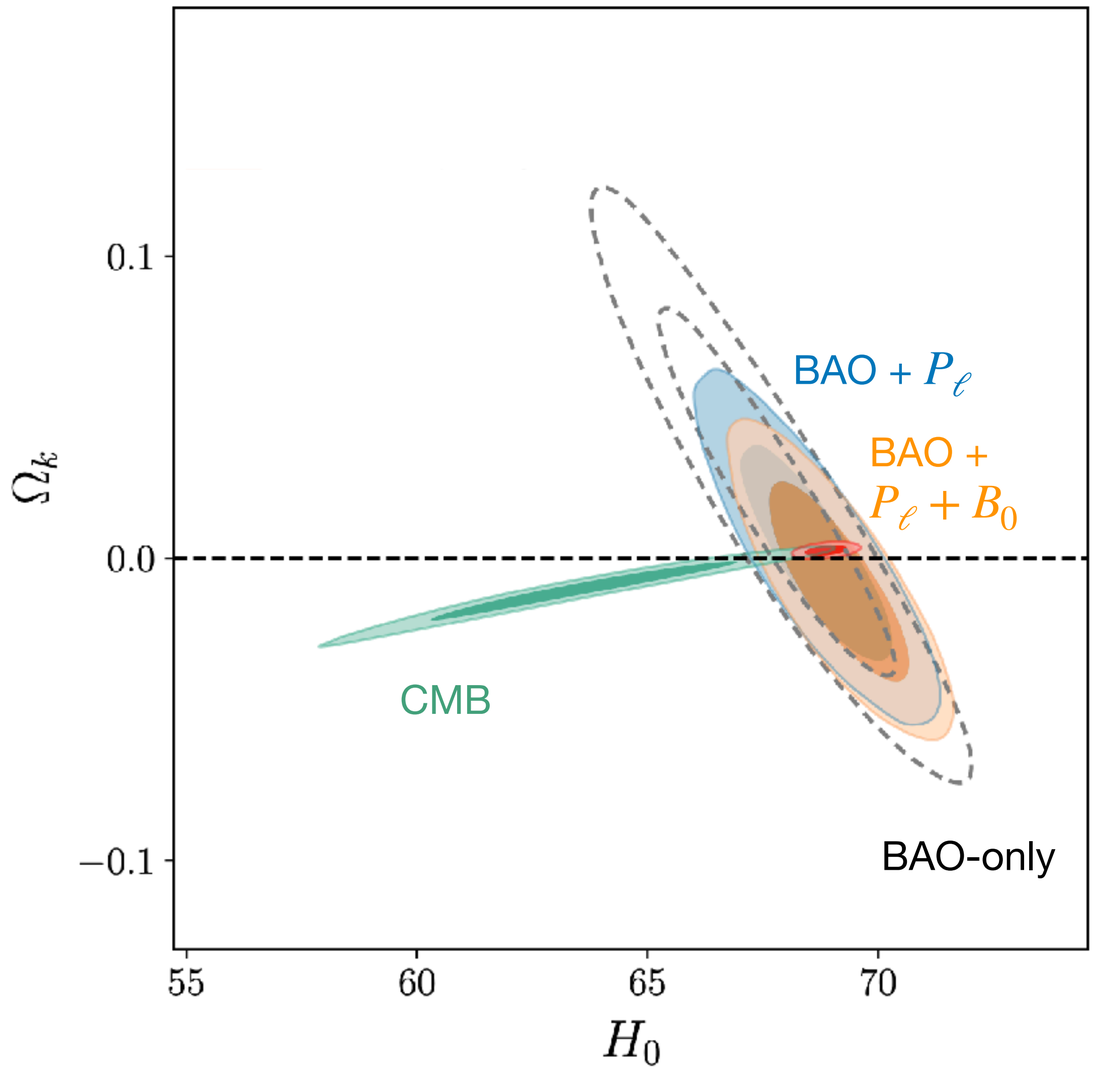


Ivanov, Sullivan, Chen, Chudaykin, Maus, **Philcox** 2026

Constraints on Alternatives to ΛCDM

We can constrain **curvature**:

- Bound from BAO improves by **2x** when adding $P_\ell + B_0$
- CMB + $P_\ell + B_0$ agrees with CMB + BAO



Chudaykin, Ivanov, **Philcox** 2025b

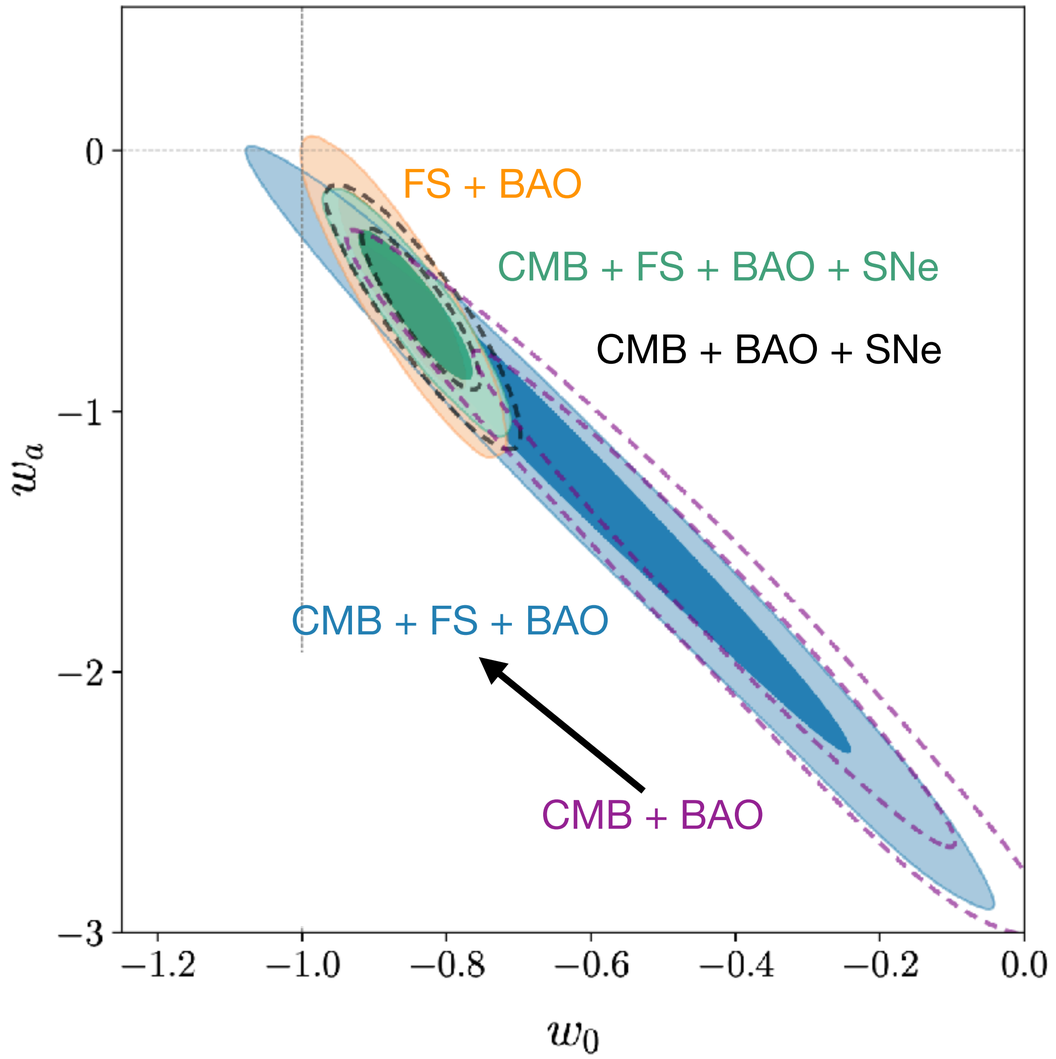
Constraints on Alternatives to ΛCDM

We can constrain **curvature**:

- Bound from BAO improves by **2x** when adding $P_\ell + B_0$
- CMB + $P_\ell + B_0$ agrees with CMB + BAO

We can constrain **dynamical dark energy**:

- Evidence for $w_0 w_a$ increases from $1.7\sigma \rightarrow 2.6\sigma$ when adding **full-shape** to DESI BAO + SNe.
- Using CMB, we find a preference at 2.8σ
- The kitchen sink improves the **figure-of-merit** by $18\,\%$



Ivanov, Sullivan, Chen, Chudaykin, Maus, **Philcox** 2026

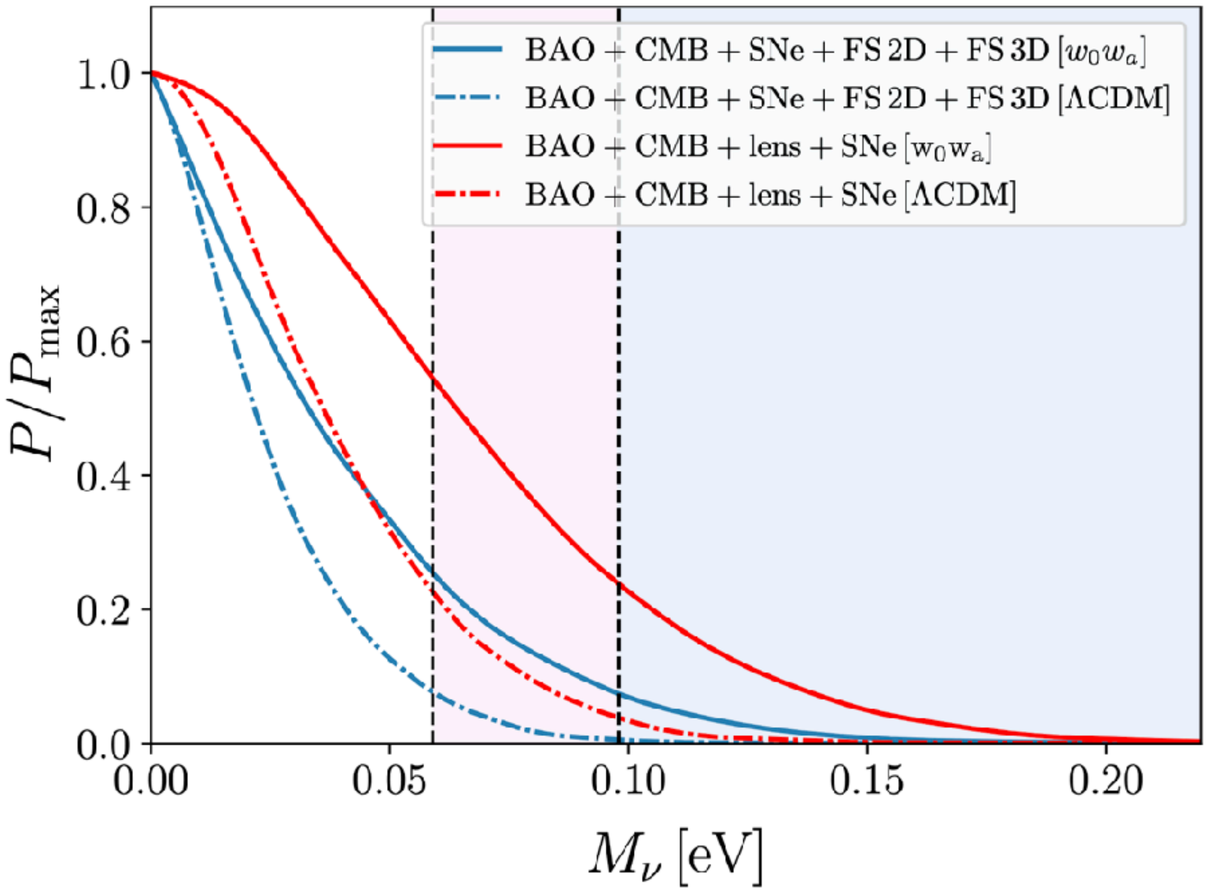
Constraints on Neutrinos

DESI + CMB + SNe constrains the neutrino mass

- $\sum m_\nu < 0.057\,\mathrm{eV}$ in ΛCDM (95% CL)
- $\sum m_\nu < 0.095\,\mathrm{eV}$ in $w_0 w_a$CDM (95% CL)

Full-shape improves constraints by $\approx 25\,\%$

We disfavor the inverted hierarchy at $> 2\sigma$ for both ΛCDM **and** $w_0 w_a$CDM!



Ivanov, Sullivan, Chen, Chudaykin, Maus, **Philcox** 2026

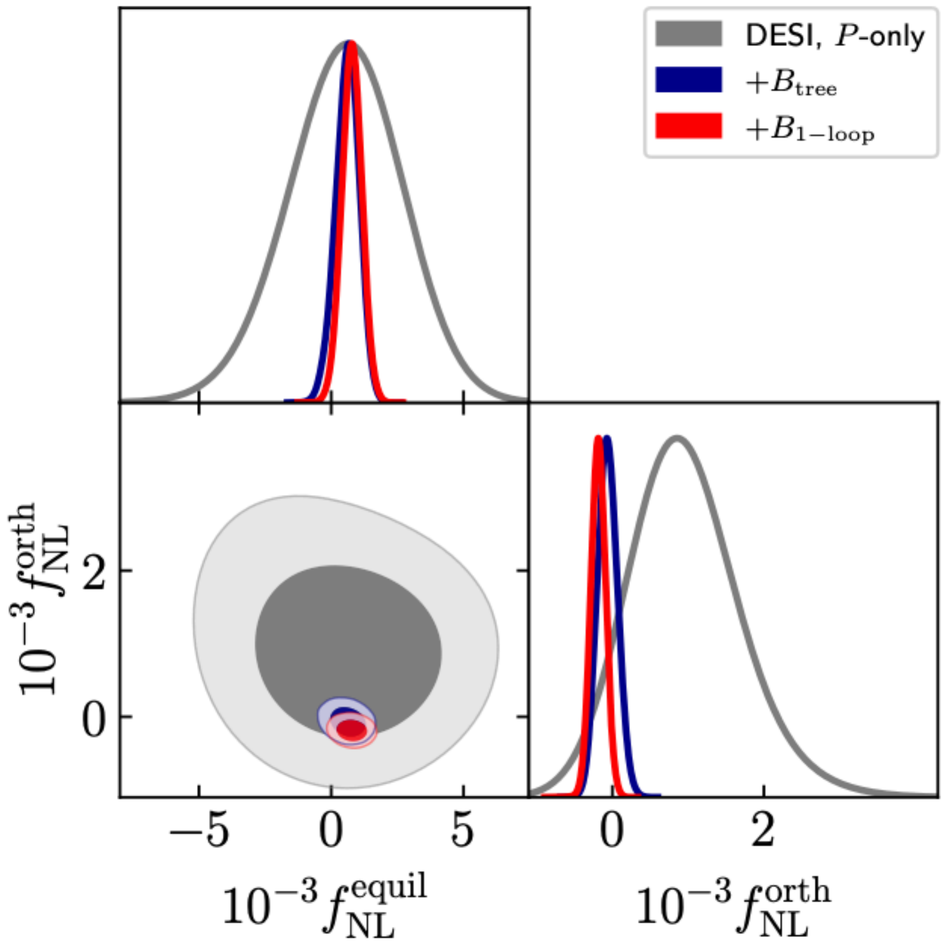
Constraints on Inflation

We can constrain **primordial non-Gaussianity**

From DESI $P_\ell + B_\ell$ (including $z > 2$ quasars):

- **Single-Field**: $f_{\rm NL}^{\rm eq} = 200 \pm 230,\ f_{\rm NL}^{\rm orth} = -24 \pm 86$
- **Multi-field**: $f_{\rm NL}^{\rm loc} = -0.1 \pm 7.4$

Single-field constraints are much weaker than the CMB, but will improve soon!



Chudaykin, Ivanov, **Philcox** 2025c

Constraints on Inflation

We can constrain **primordial non-Gaussianity**

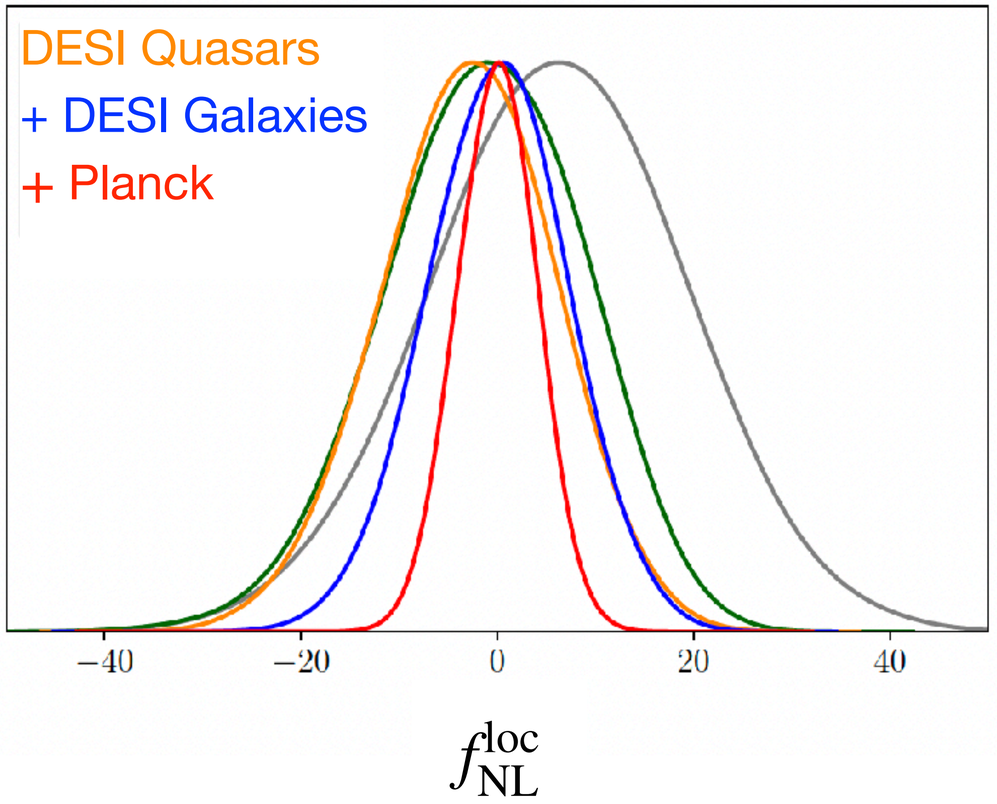
From DESI $P_\ell + B_\ell$ (including $z > 2$ quasars):

- **Single-Field**: $f_{\rm NL}^{\rm eq} = 200 \pm 230, \;\; f_{\rm NL}^{\rm orth} = -24 \pm 86$
- **Multi-field**: $f_{\rm NL}^{\rm loc} = -0.1 \pm 7.4$

Almost as strong as the CMB!

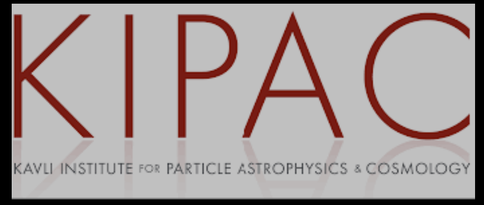
Adding **Planck**, we obtain the **tightest** constraint on local PNG yet!!

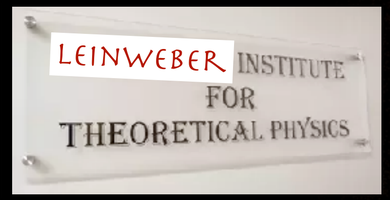
$$f_{\rm NL}^{\rm loc} = 0.0 \pm 4.1$$



The bispectrum improves by $\approx 20\,\%$ ***!***

Chudaykin, Ivanov, **Philcox** 2025c, see also Chaussidon+24





DESI
(edited)

Summary

- We perform a **full renalysis** of the **public** DESI DR1 (full-shape), using independent *estimators*, *theory codes*, and *covariances*!

- For the first time, we include power spectra, bispectra, BAO, lensing cross-correlations, and photometric galaxies

- We find **strong** constraints on parameters including:
  $\Omega_m, H_0, \sigma_8, w_0, w_a, \Omega_k, \sum m_\nu, \ldots$

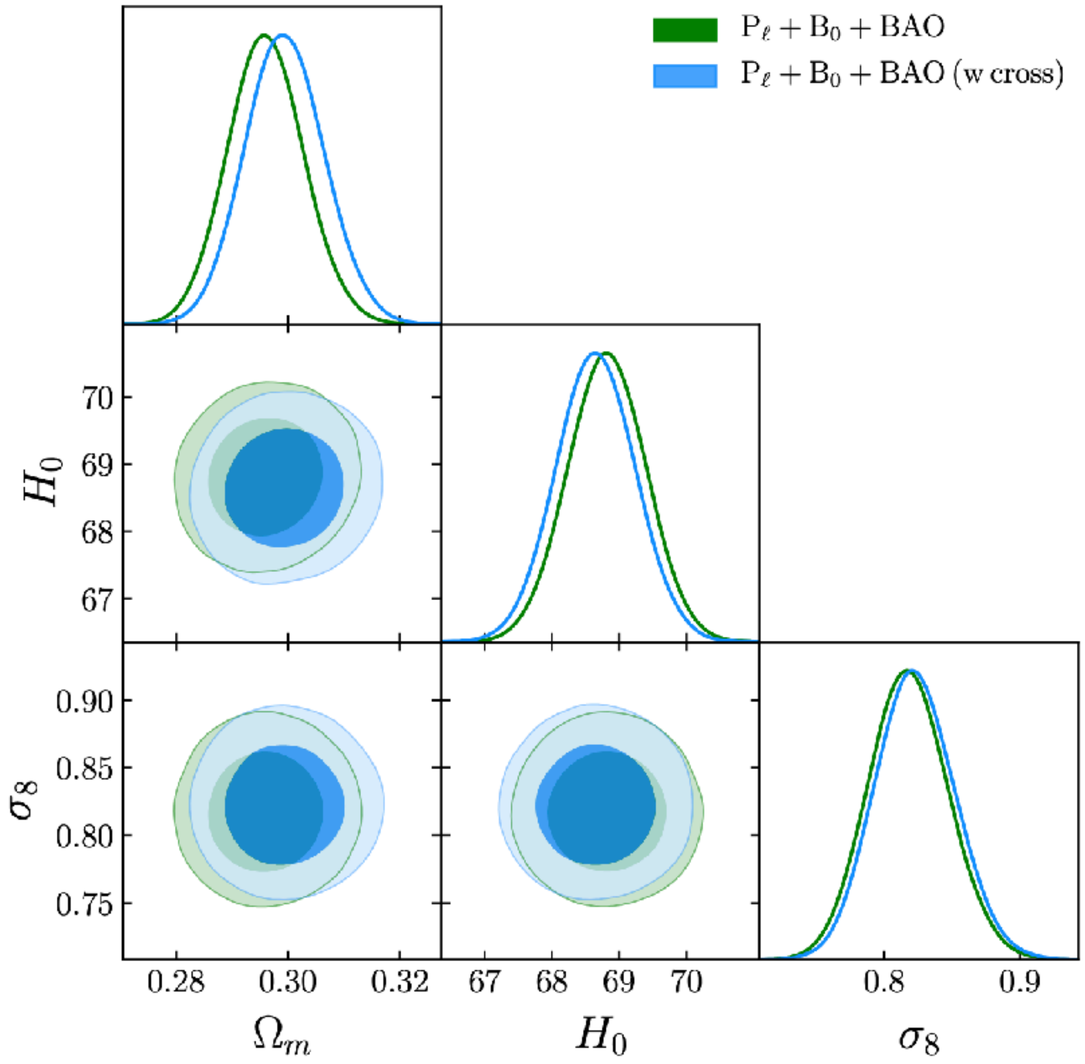
Contact: ohep2@cantab.ac.uk

Can you ignore the covariance of Full-Shape and BAO?

- Due to reconstruction, cross-correlations between $\alpha_{\parallel}, \alpha_{\perp}$ and $P_{\ell}(k)$ are usually quite weak.

- They're *much* weaker for us, since we use **DR2** BAO and **DR1** full-shape.

- Two tests (see paper 1 appendices):
  - Add an approximate cross-covariance ⇒ small shifts
  - Perform a joint **DR1** BAO — FS analysis ⇒ similar constraints! (but weaker H_0)



Chudaykin, Ivanov, **Philcox** 2025