

Results from the DESI DR2 BAO analysis

Héctor Gil-Marín - Institut de Ciències del Cosmos (U. Barcelona)

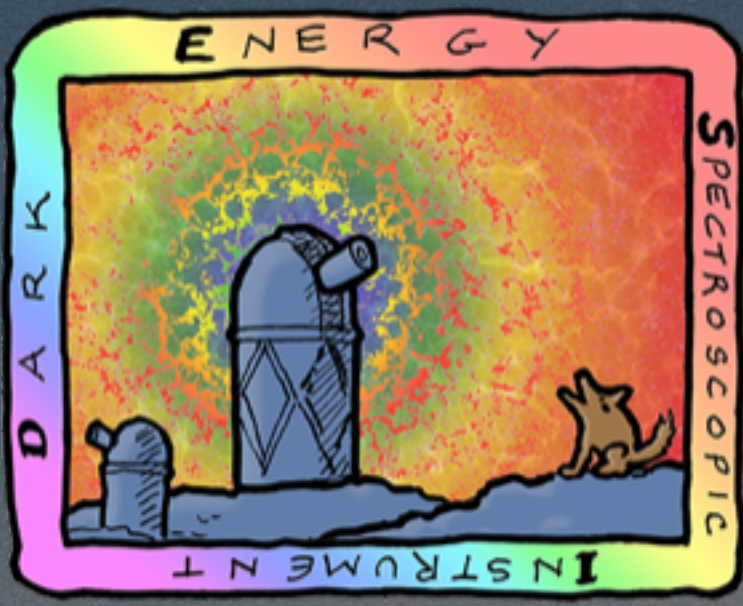
On behalf of the DESI Collaboration and
the DESI-ICCUB team



Institut de Ciències del Cosmos
UNIVERSITAT DE BARCELONA



Seminar at the IHE Brussels (6th of March 2026)

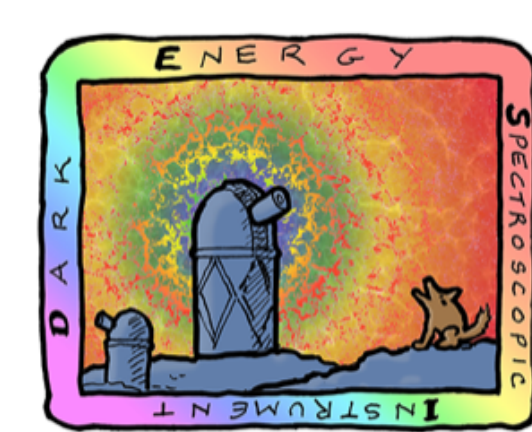


DARK ENERGY SPECTROSCOPIC INSTRUMENT

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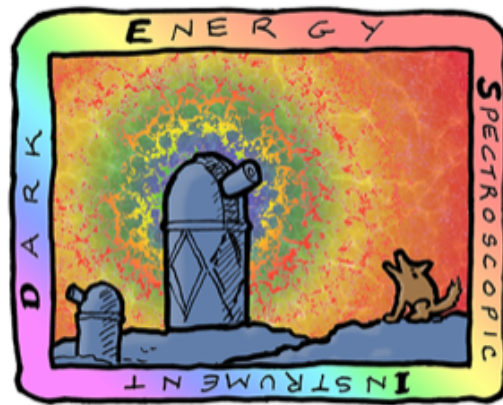
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Press Release on March 2025

U.S. Department of Energy Office of Science

New DESI Results Strengthen Hints That Dark Energy May Evolve





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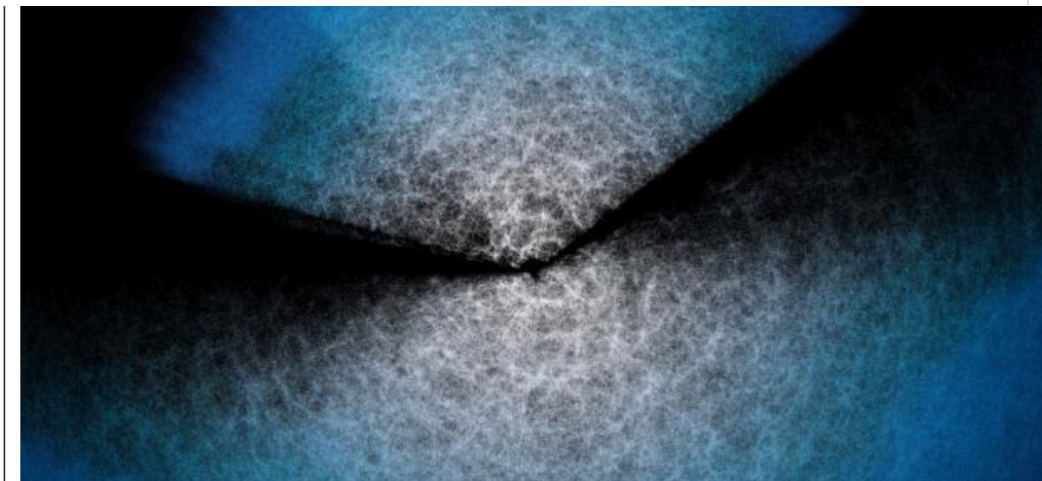
Press Release on March 2025

New DESI Results Strengthen Hints That Dark Energy May Evolve

Is dark energy destined to dominate the universe and lead to the 'big crunch'?

Few universes may emerge in due course, says scientist at Dark Energy Spectroscopic Instrument in Arizona

Dark energy: mysterious cosmic force appears to be weakening, say scientists



El proyecto DESI está creando el mapa 3-D del universo más detallado que existe // Colaboración DESI y KPNO

Revolución cosmológica

Nuevos datos indican que la energía oscura que expande el universo se está frenando

El descubrimiento, basado en observaciones de 15 millones de galaxias, puede revolucionar la comprensión del universo, ya que la teoría actual presupone que la

ara

CIÈNCIA I MEDI AMBIENT ASTRONOMIA

Astronomia

Troballa inèdita: l'energia fosca de l'Univers podria canviar amb el temps

Cosmologists intrigued by signs the universe might stop expanding

The "dark energy" field that has fueled the expansion has been weakening over the past 4 billion to 5 billion years, new data shows.

Yesterday at 6:00 p.m. EDT

6 min 24



La energía oscura podría estar evolucionando y eso cambiaría la física tal y como la conocemos

Los datos recogidos por DESI parecen sugerir que la energía oscura está debilitándose con el tiempo

DESI, el cartógrafo de la energía oscura, apunta a que esta cambia con el tiempo

Por Newsroom Infobae

19 Mar, 2025 11:16 p.m. ESP



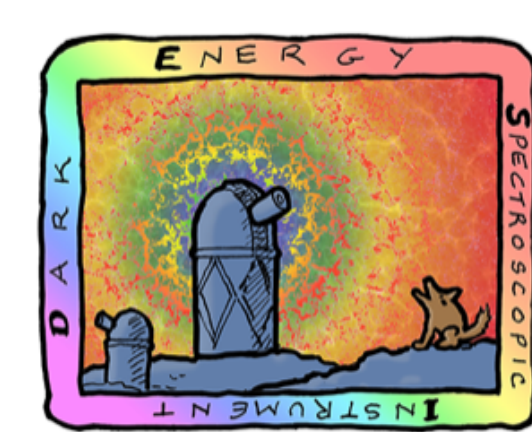
Guardar

Madrid, 19 mar (EFE).- La colaboración internacional DESI ha publicado un nuevo análisis de sus tres primeros años de datos, con cerca de 15 millones de galaxias y cuásares, y observa indicios de que la energía oscura, que se pensaba que era una

PUBLICIDAD

DARK ENERGY SEEMS TO BE CHANGING, RATTLING OUR VIEW OF UNIVERSE

Seminar in Brussels - H. Gil-

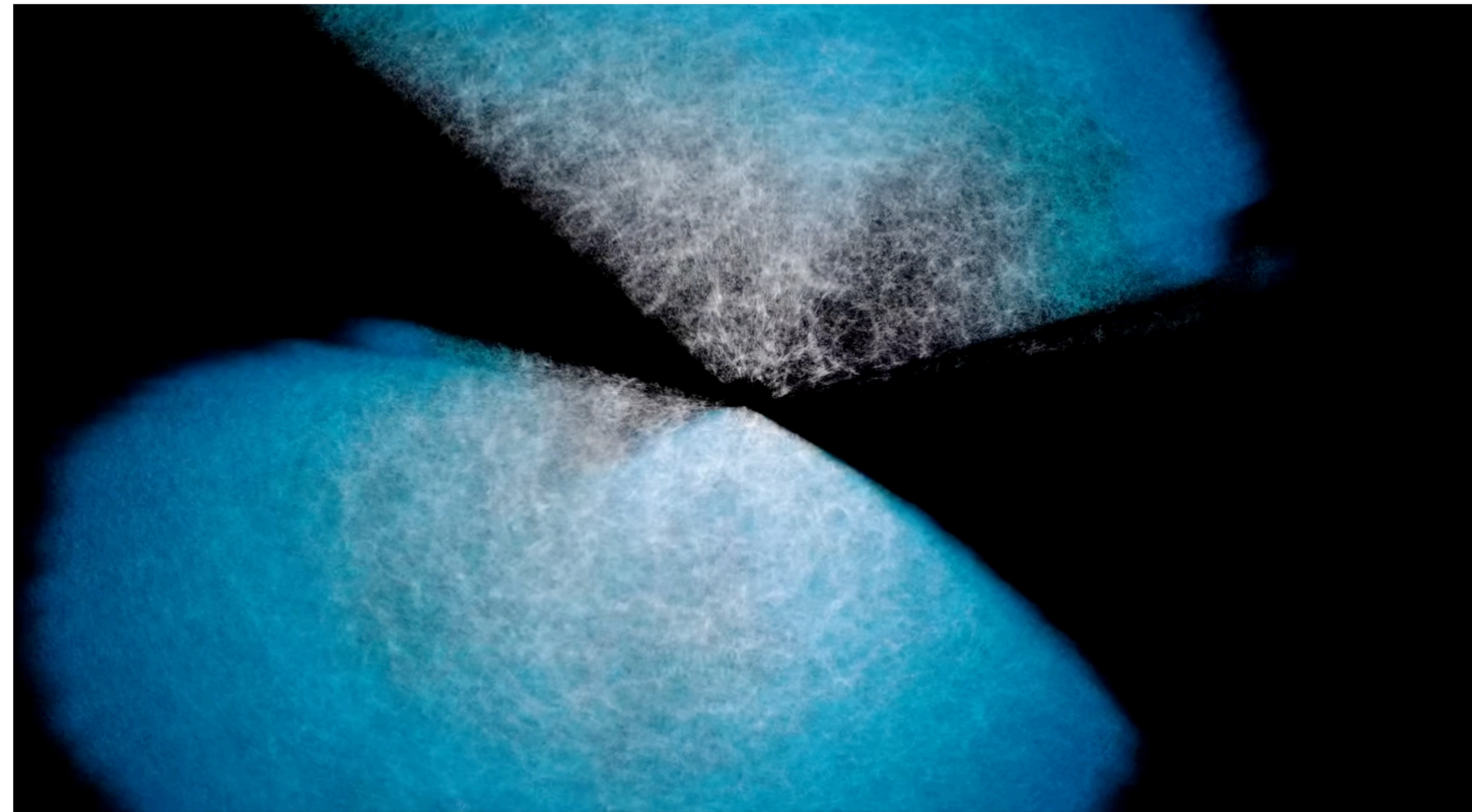


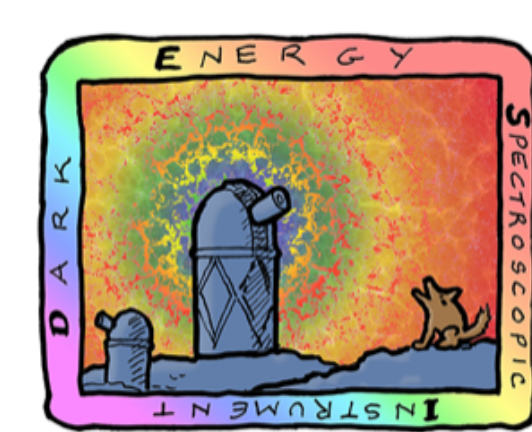
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Largest 3D map of the galaxy to date

U.S. Department of Energy Office of Science

Tracer	Number	Volume (Gpc ³)
BGS	1,118 M	3,8
LRG	4,467 M	22,3
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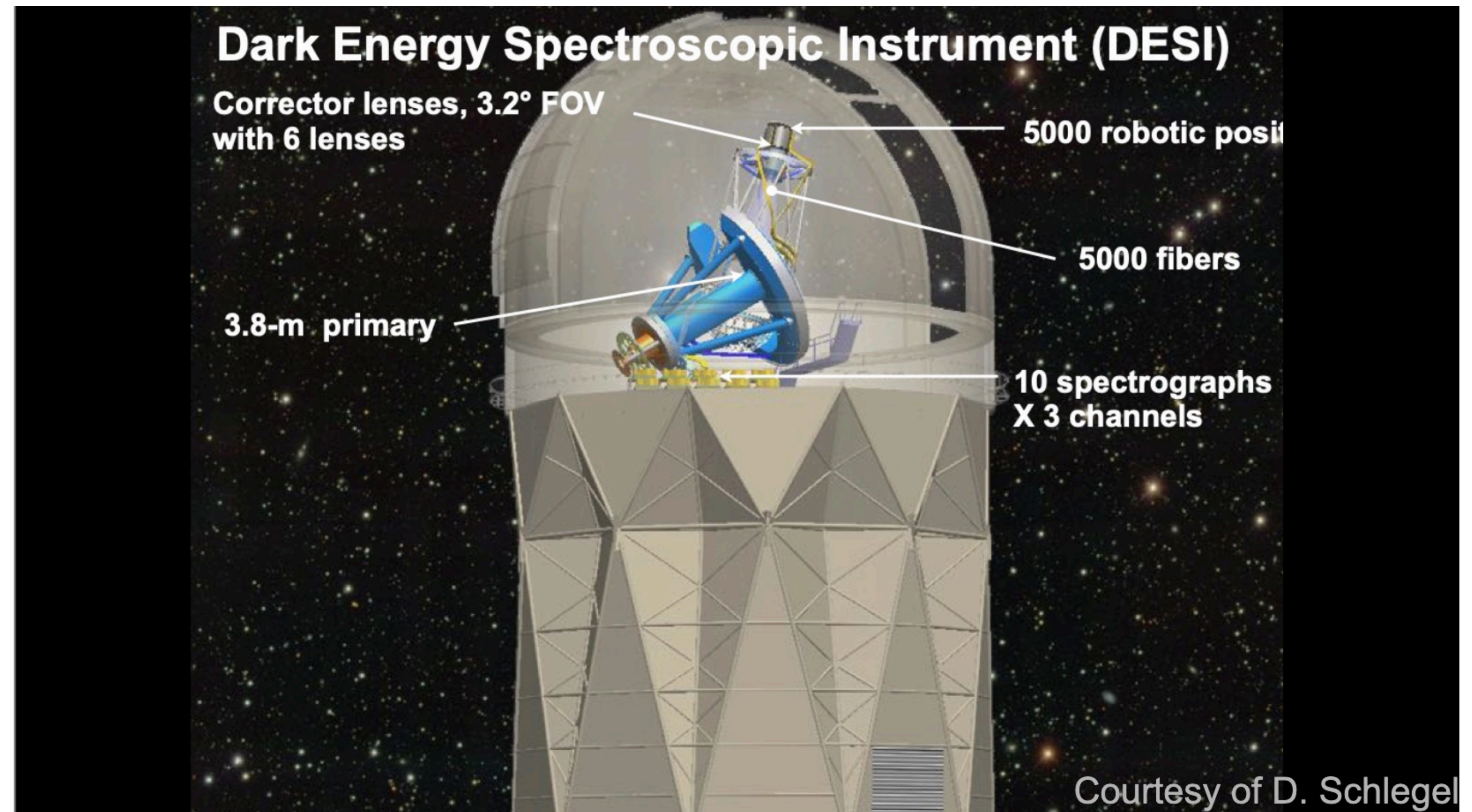


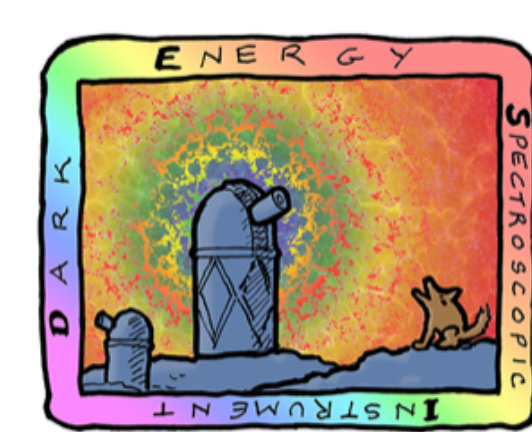
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The Dark Energy Spectroscopic Instrument

U.S. Department of Energy Office of Science

Located at the Mayal 4-m
Telescope @ Kitt Peak (AZ)



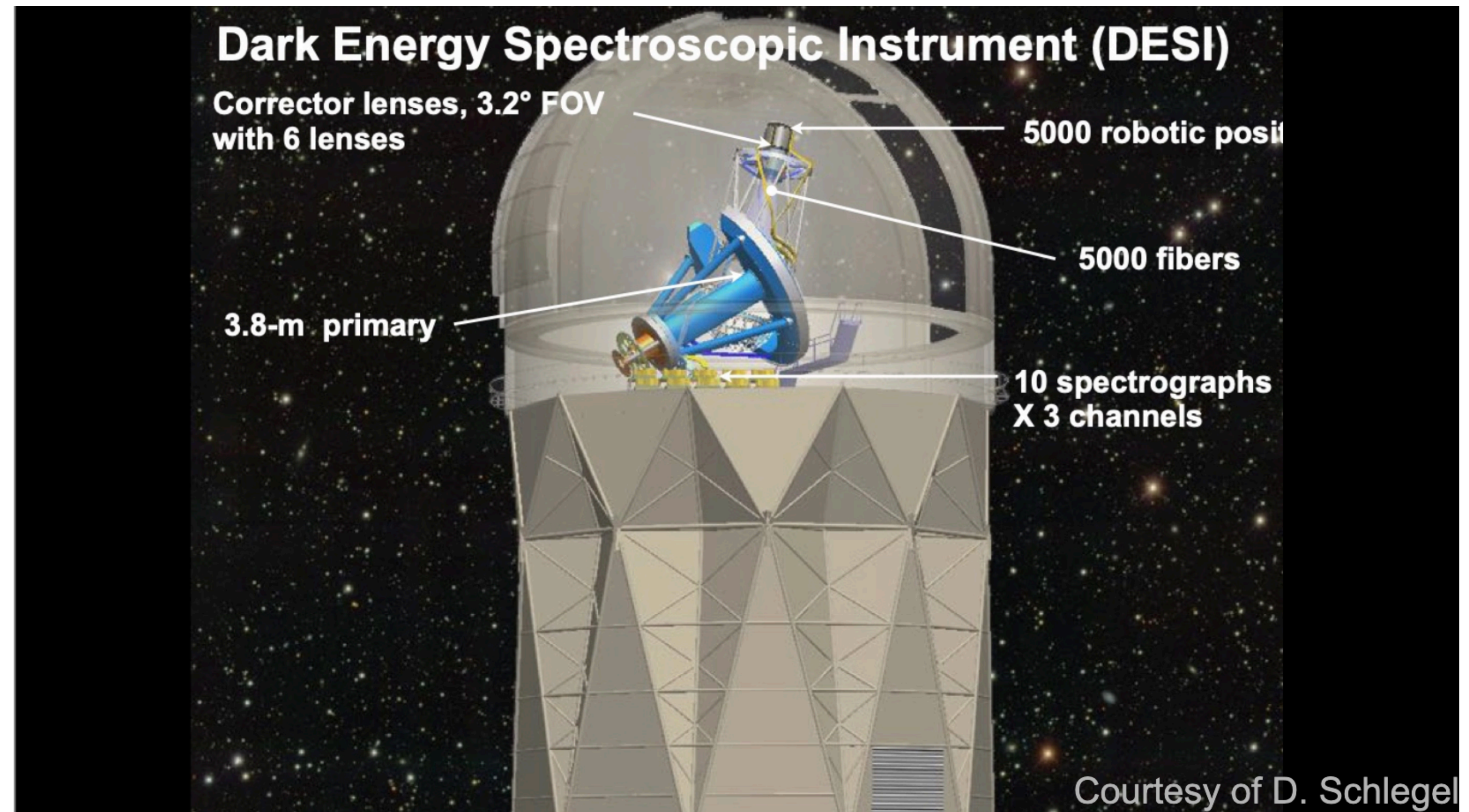
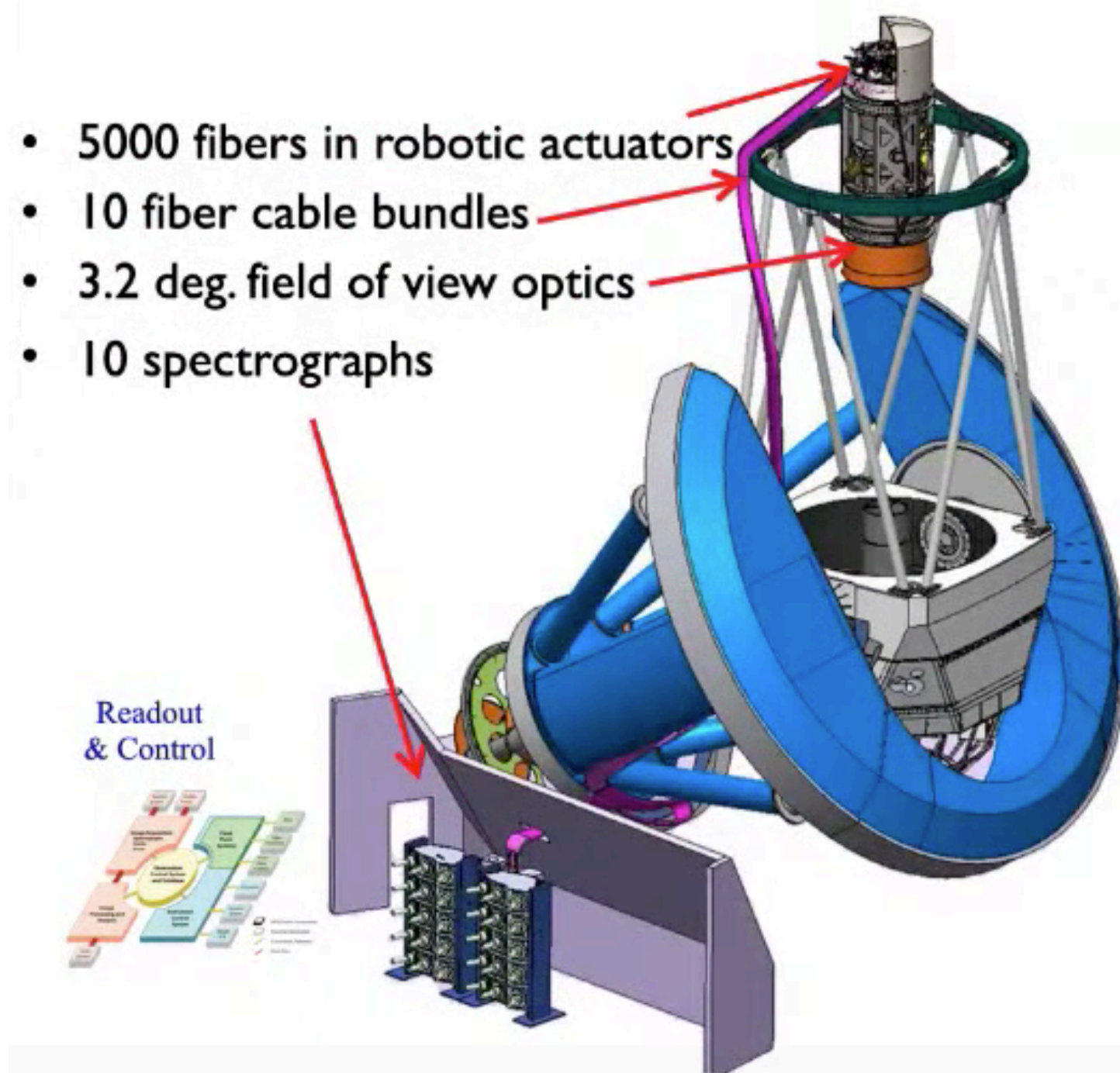


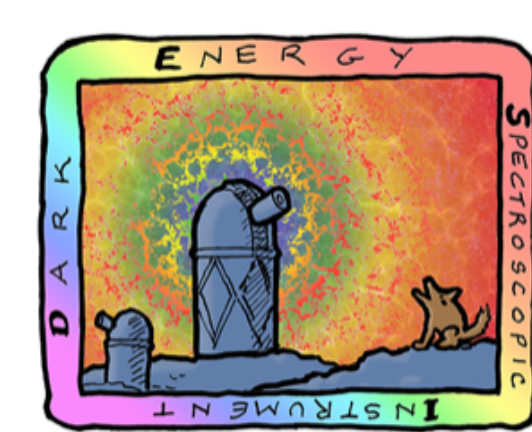
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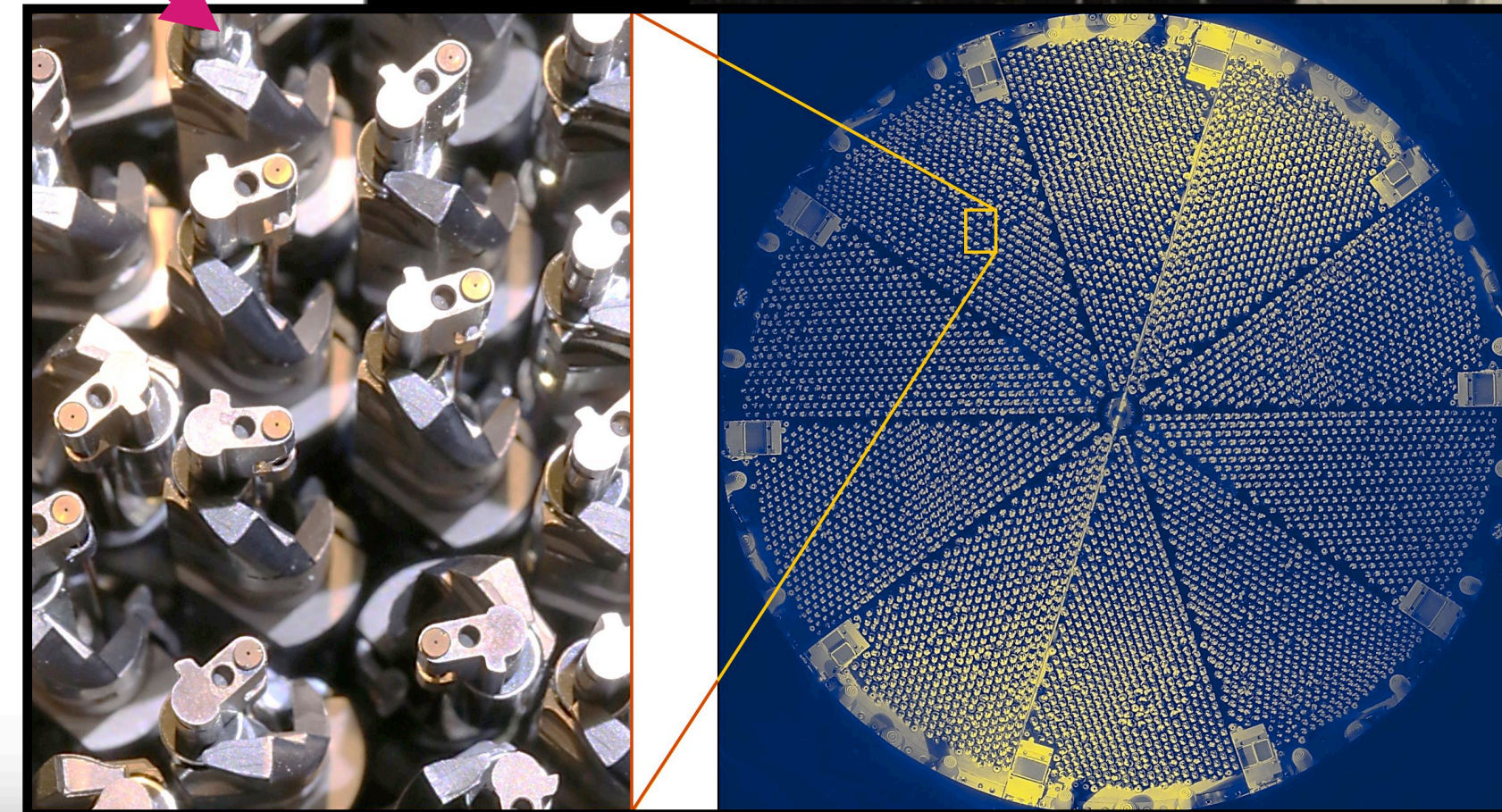
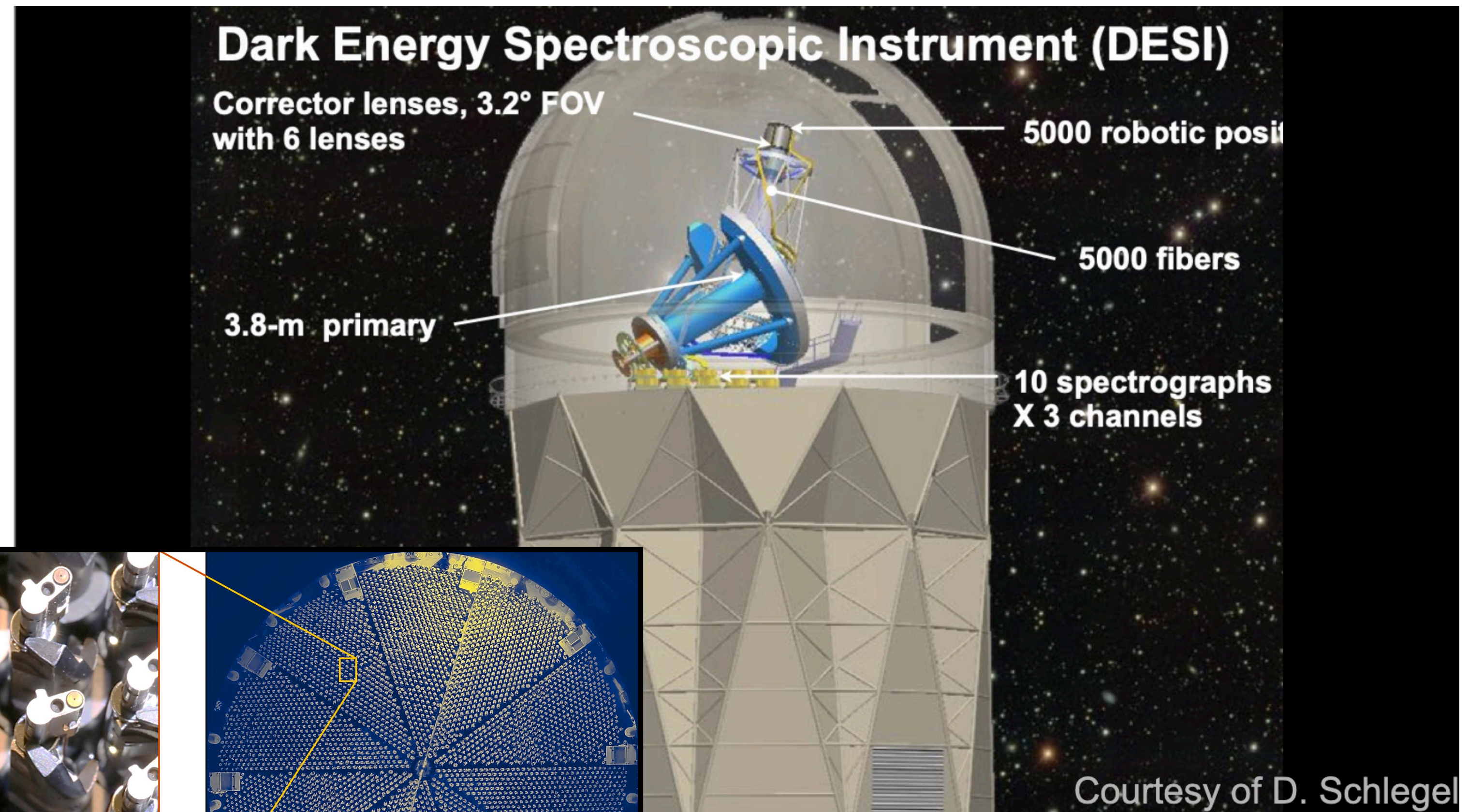
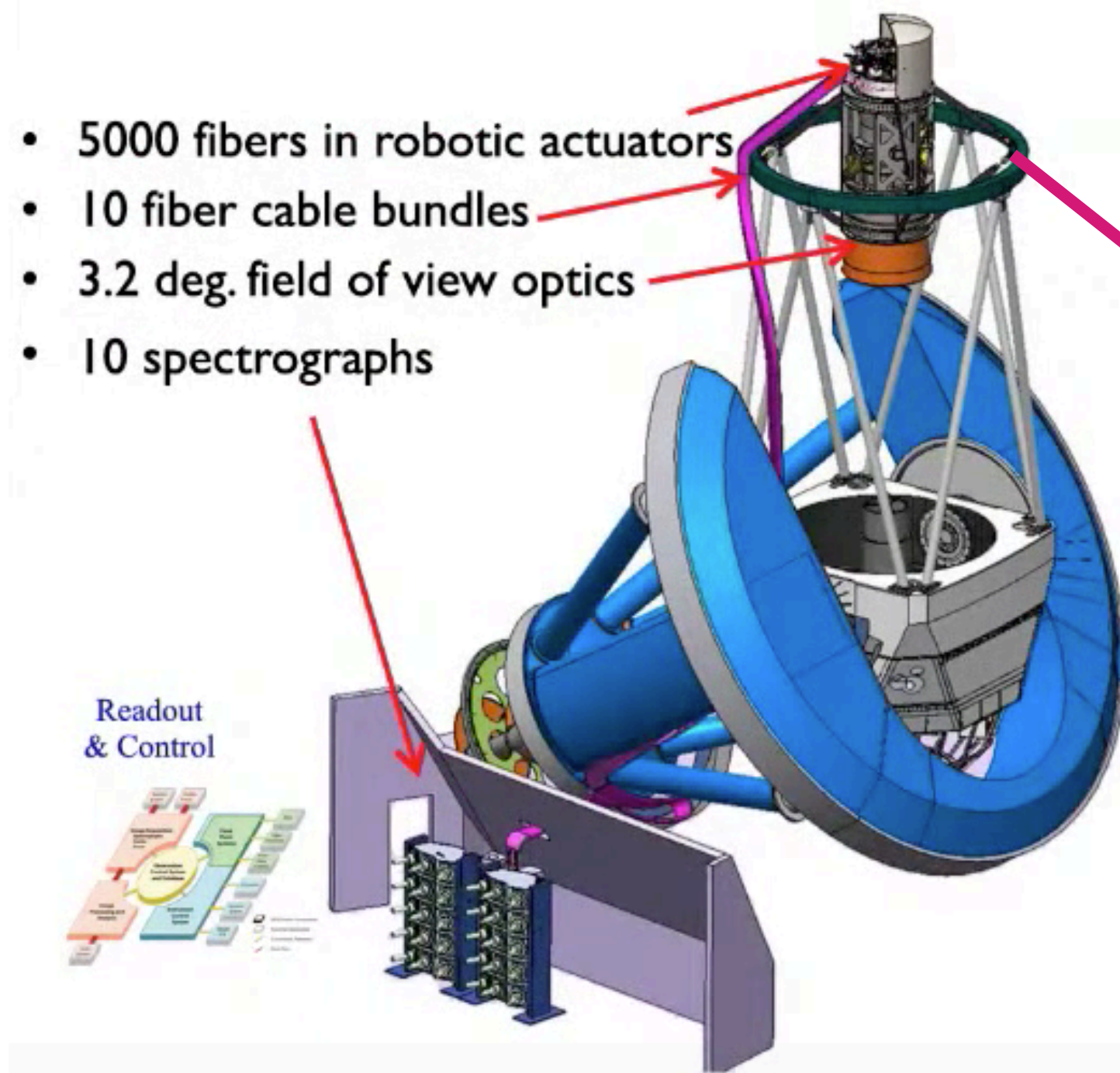


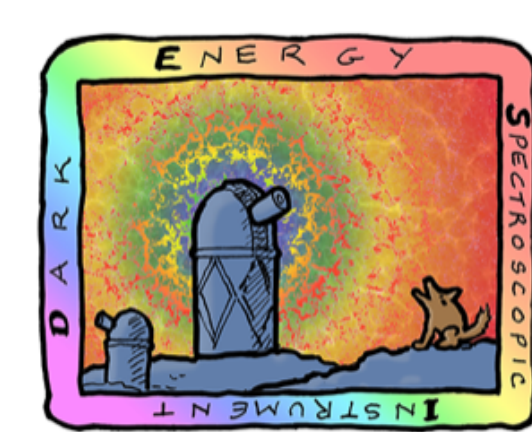
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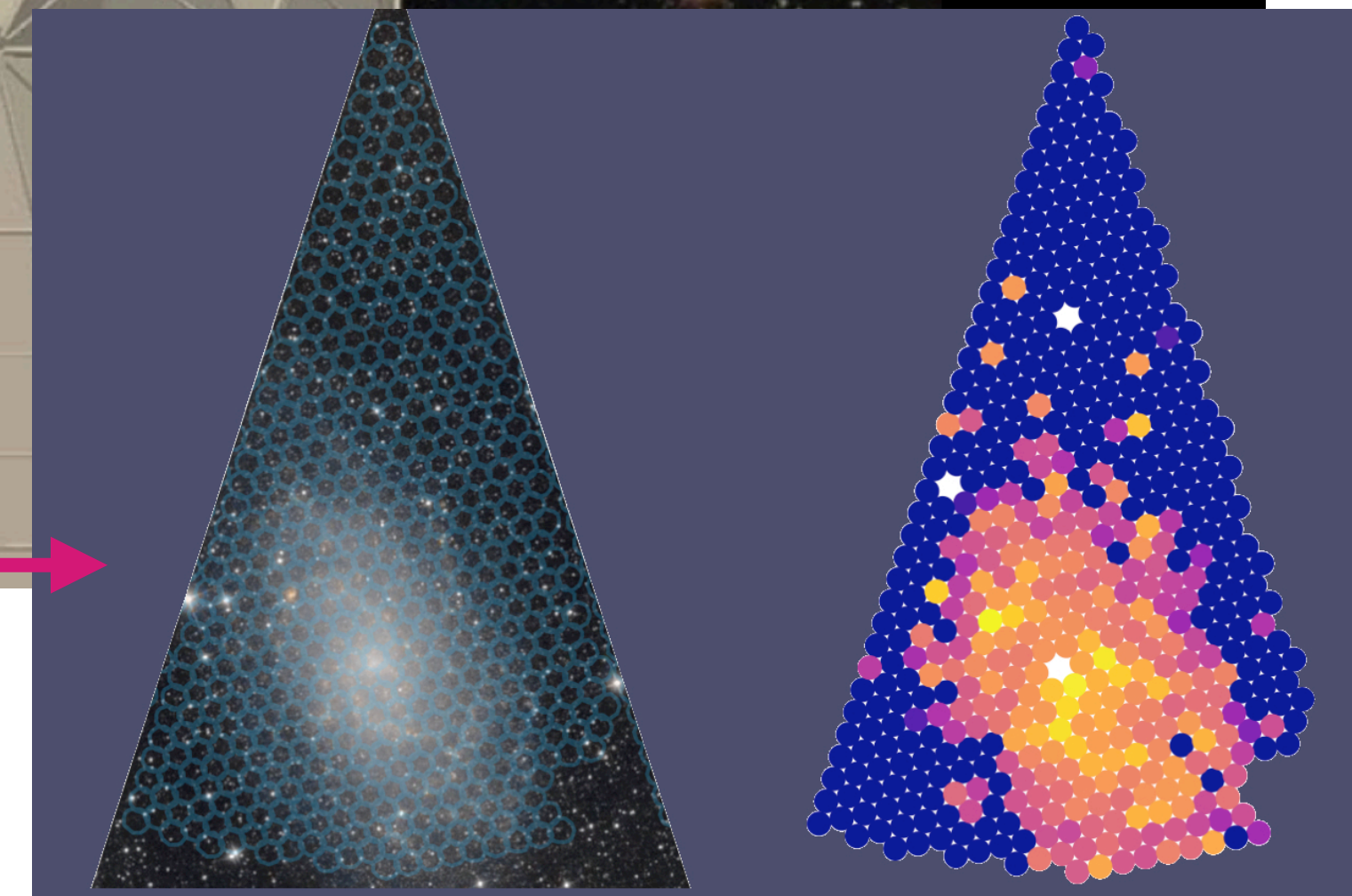
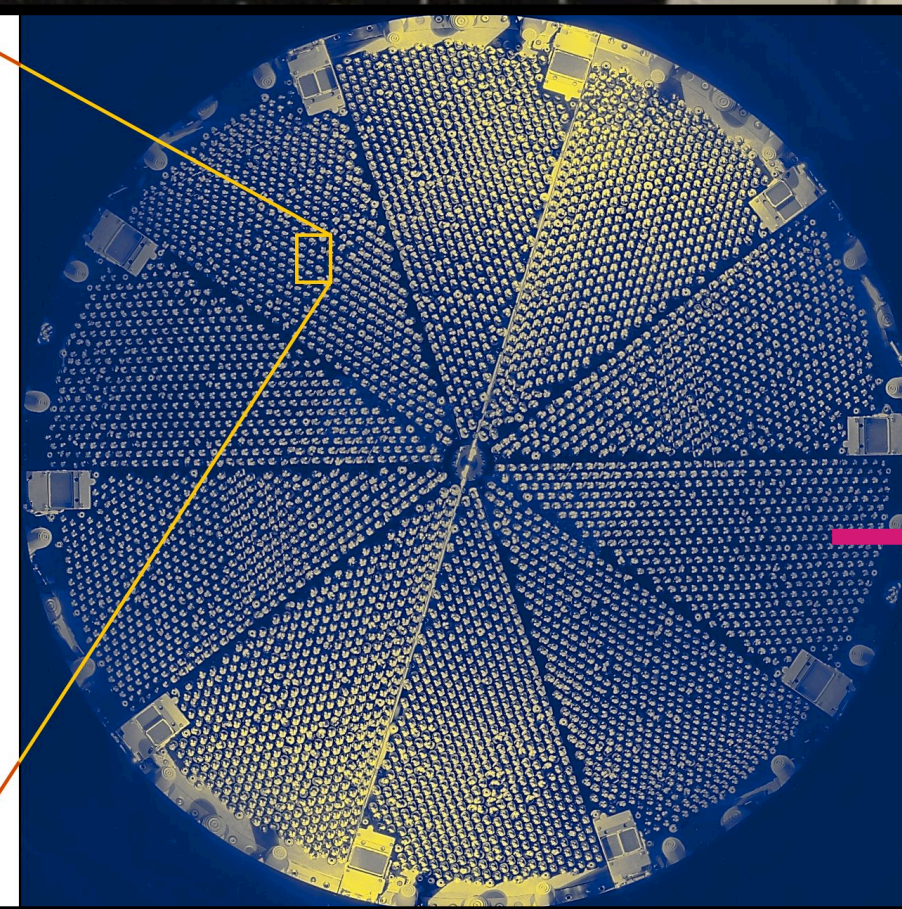
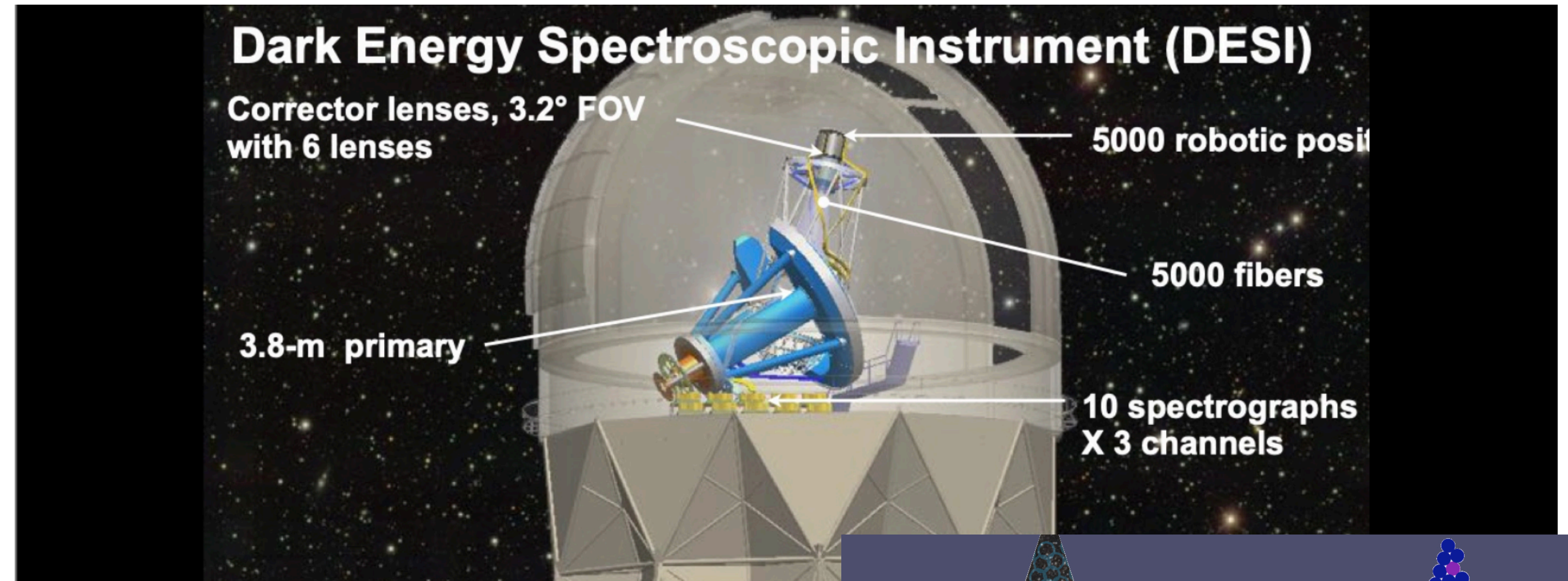
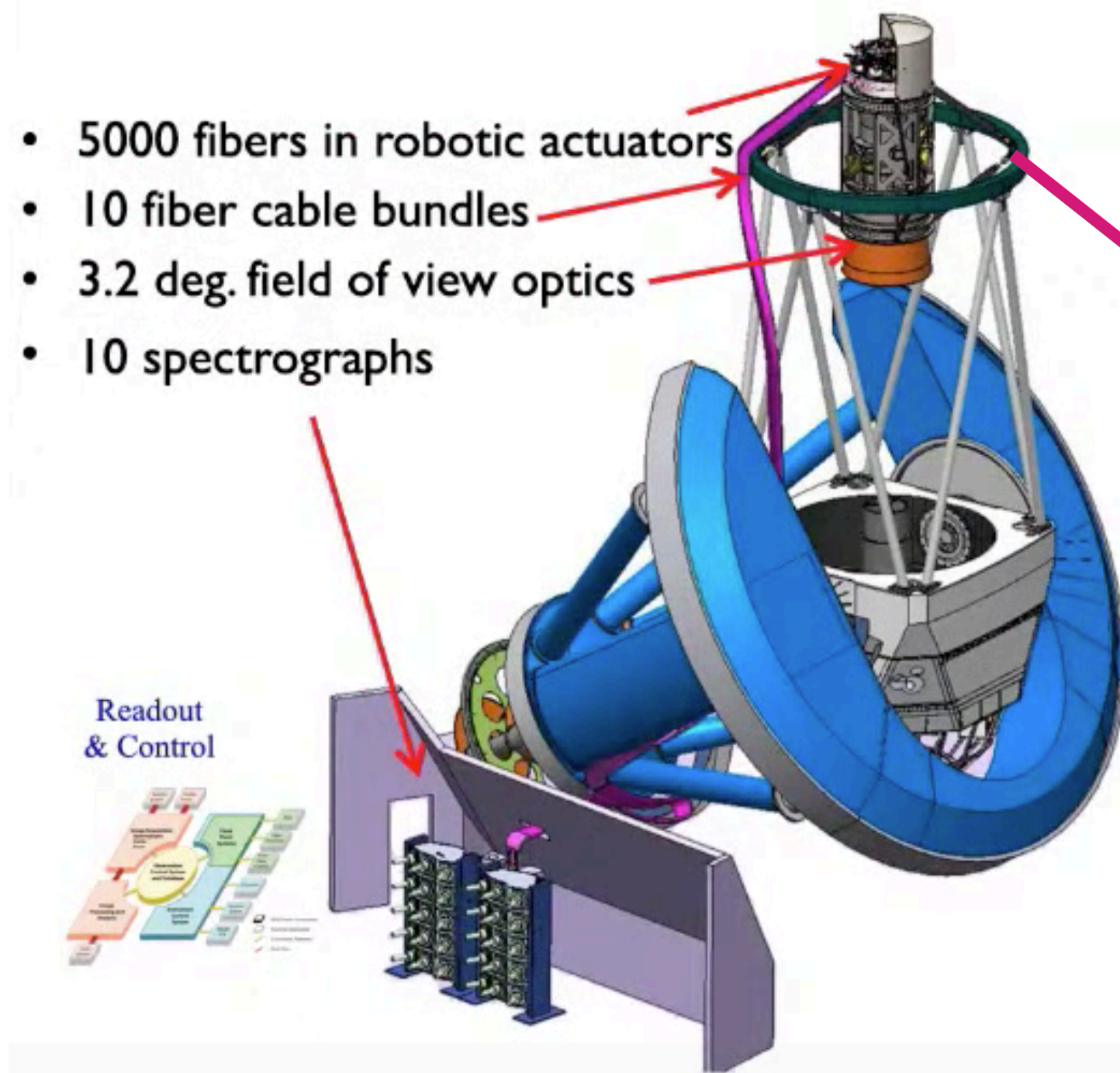


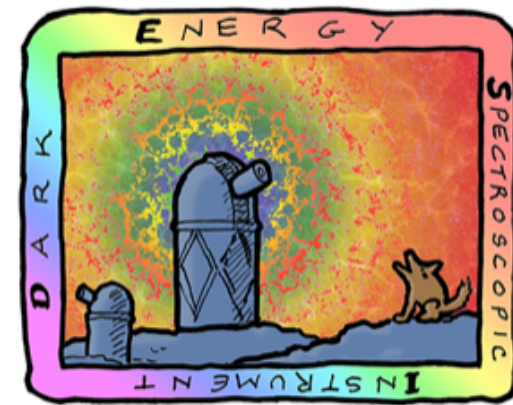
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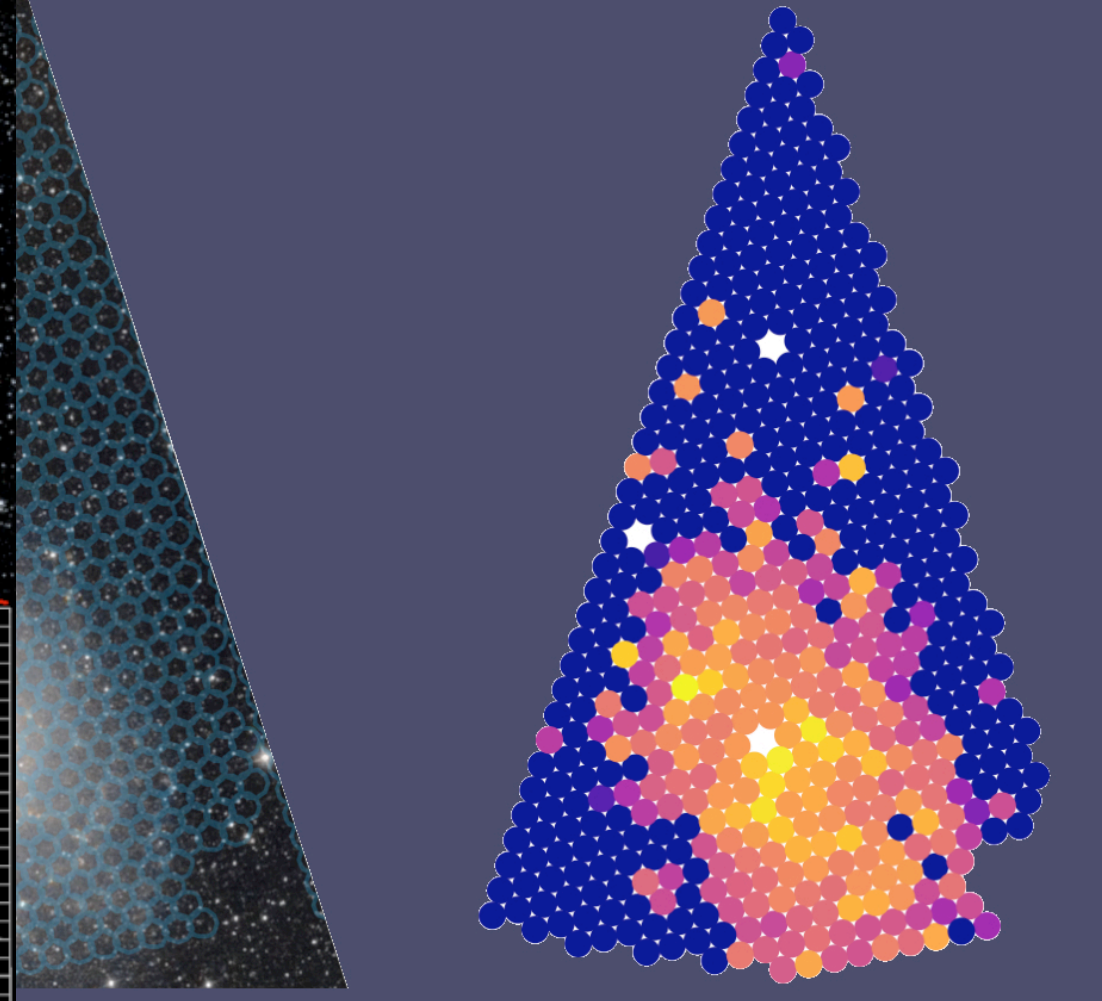
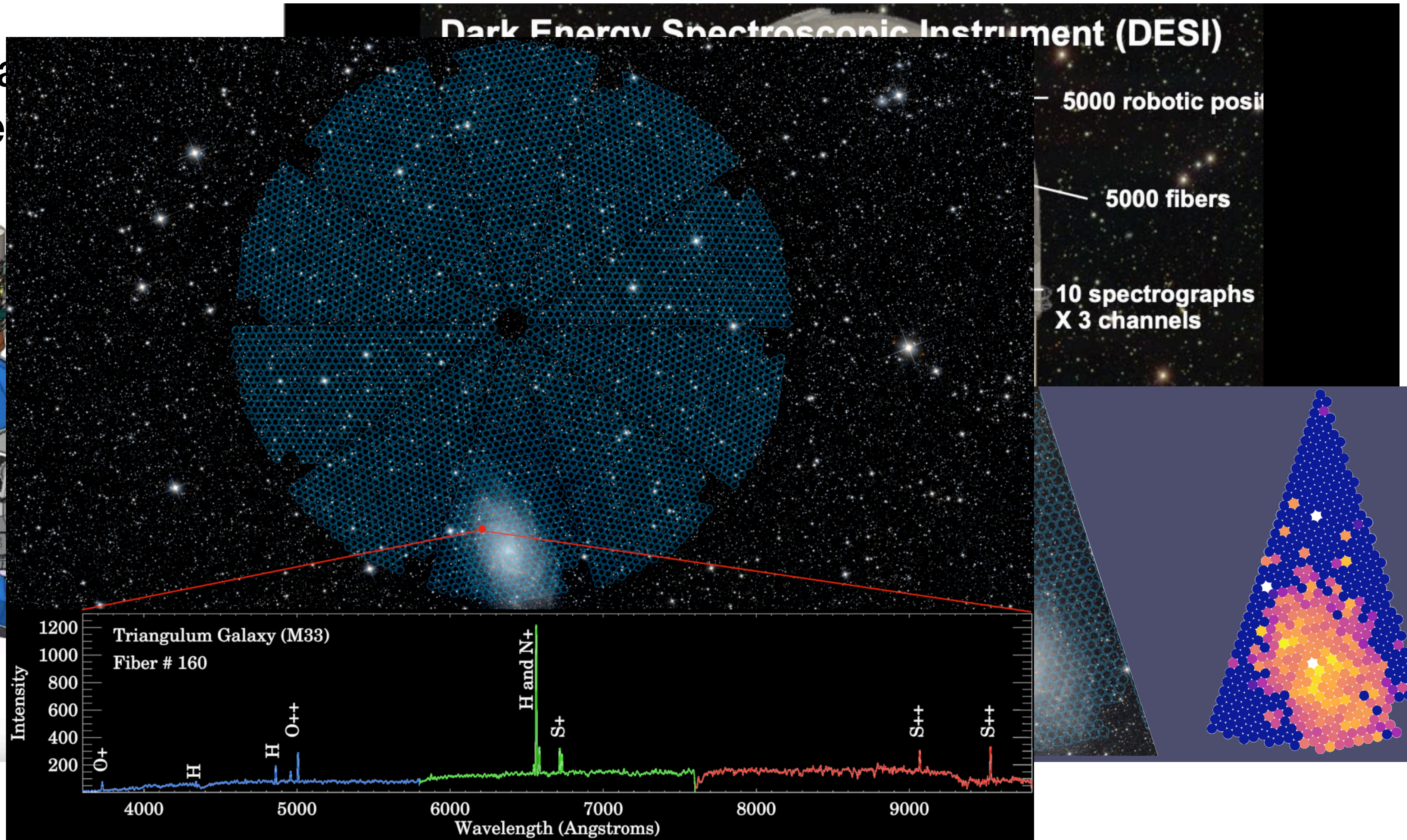
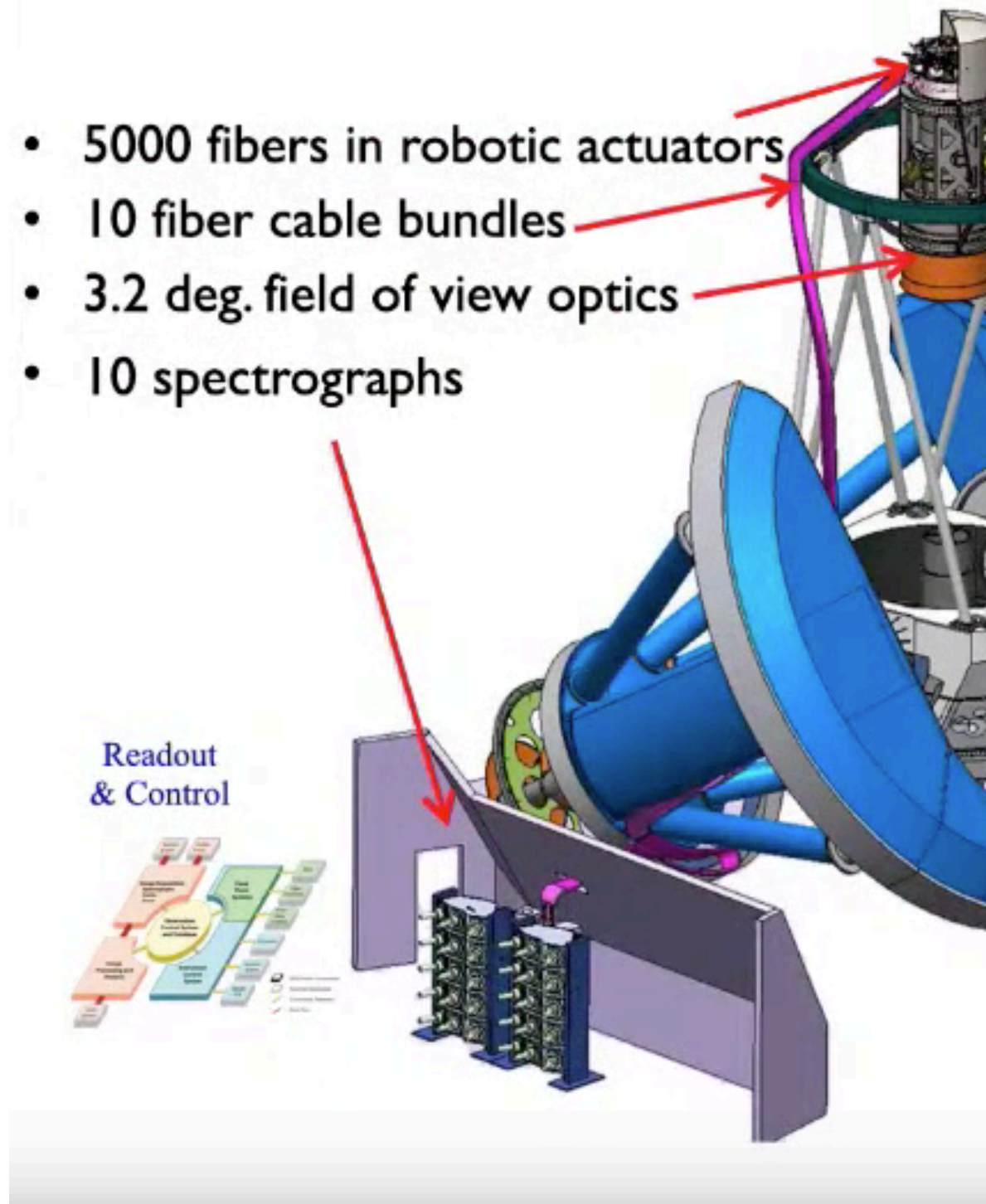


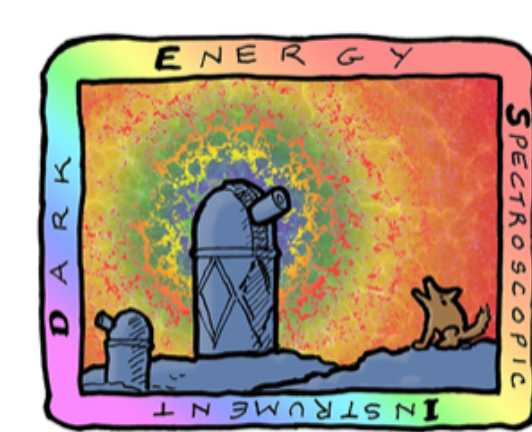
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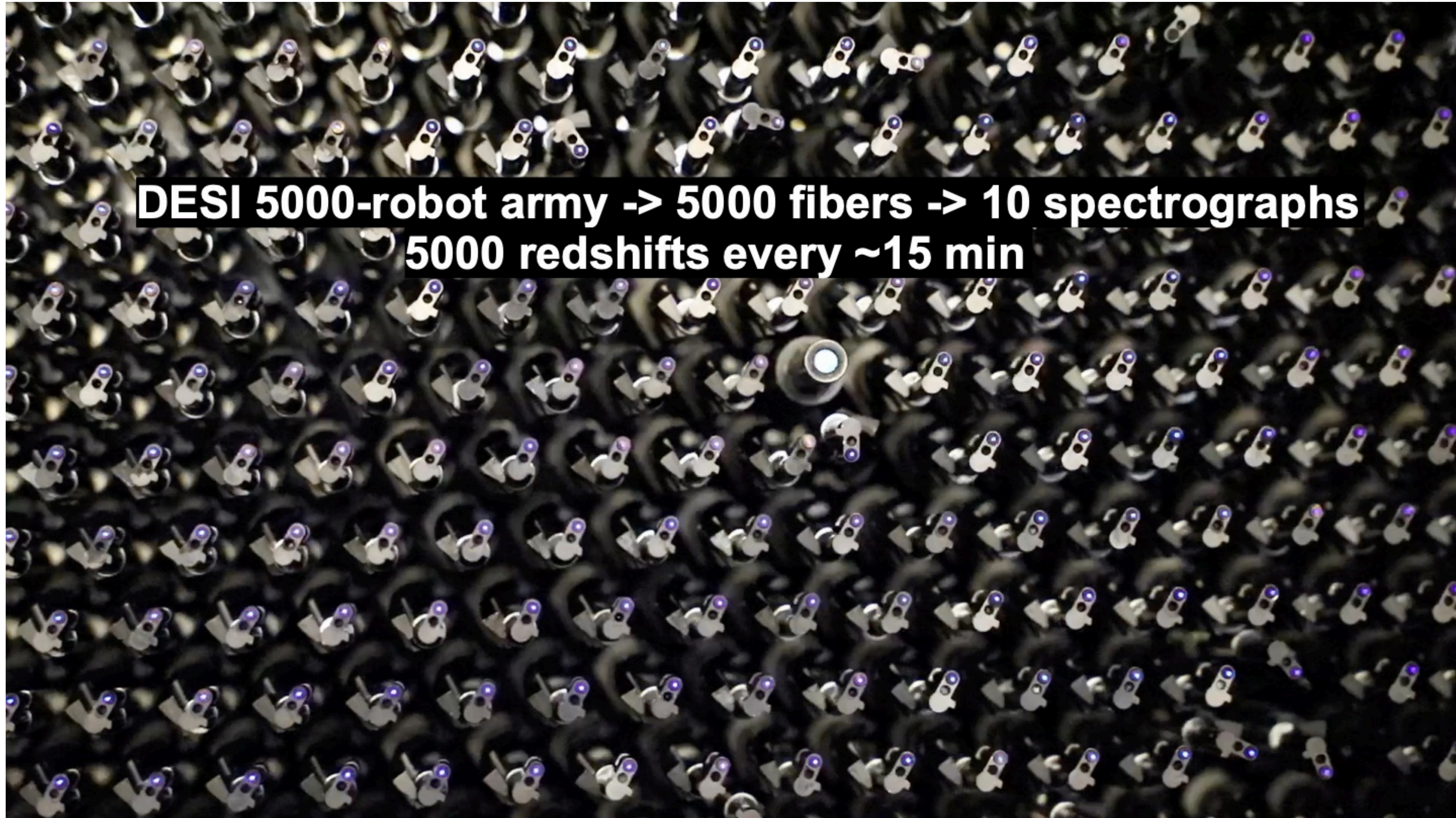


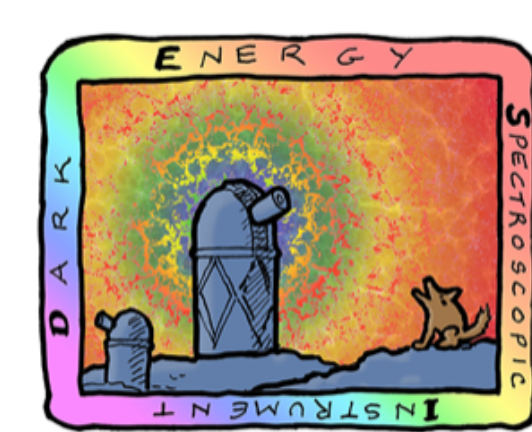


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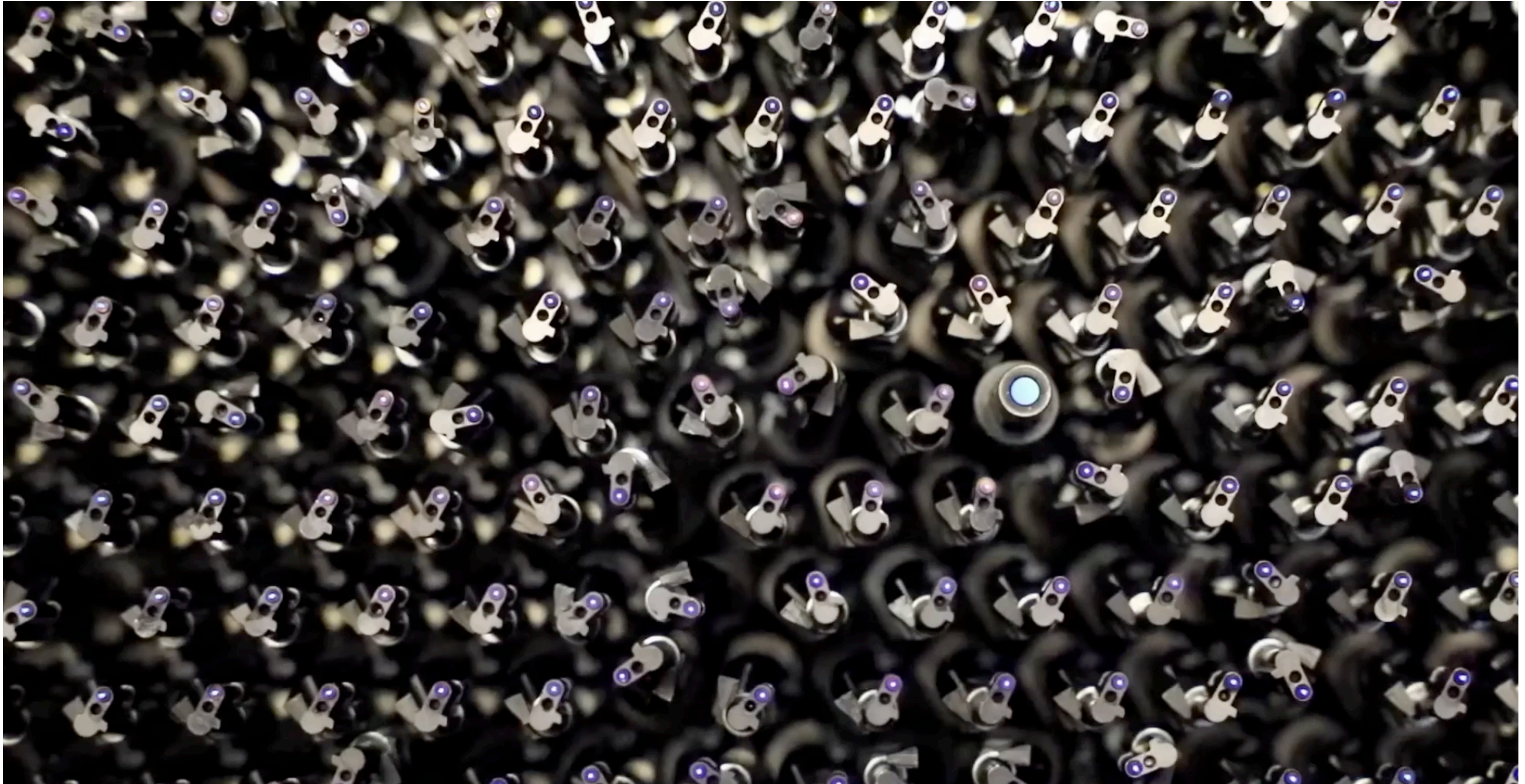




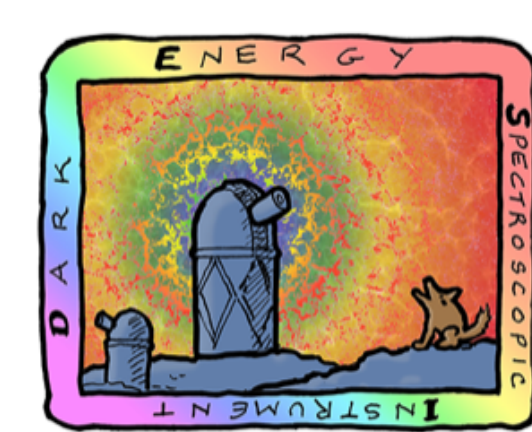
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Seminar IIHE Brussels - H. Gil-Marín

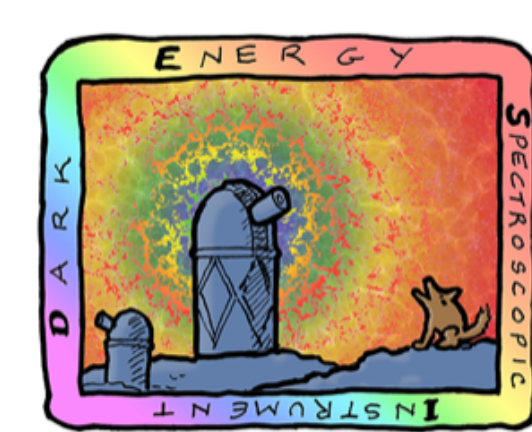


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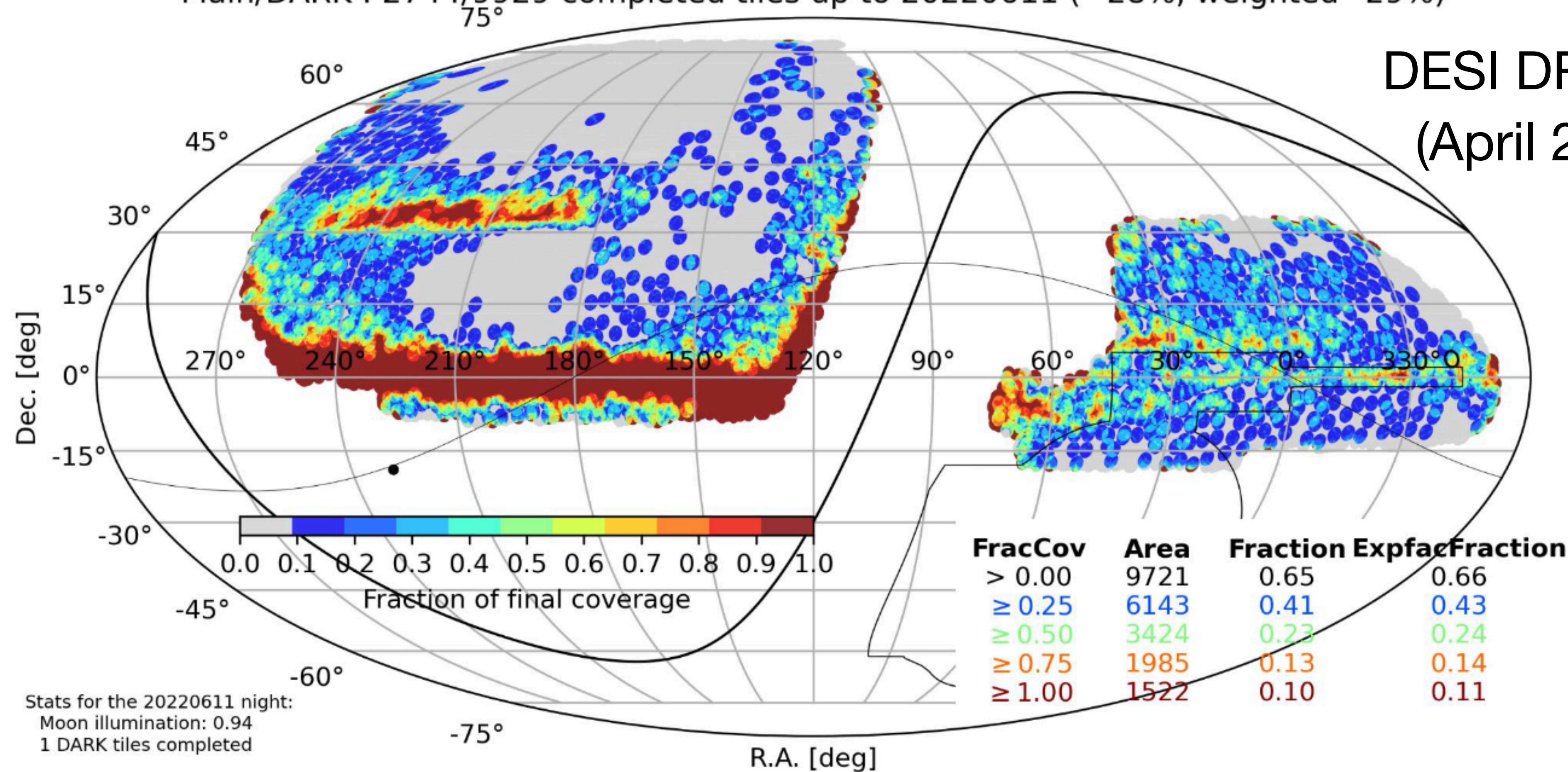


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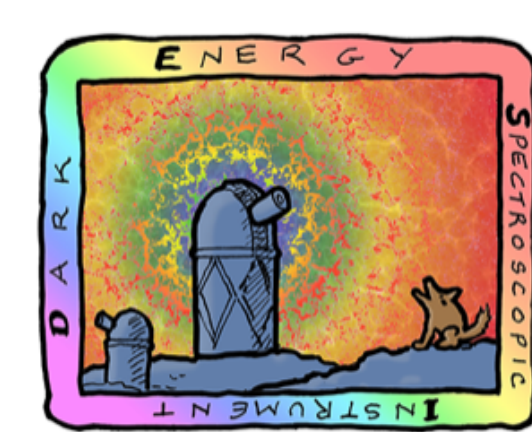
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Main/DARK : 2744/9929 completed tiles up to 20220611 (=28%, weighted=29%)



DESI DR1 Footprint
(April 2024, DR1)

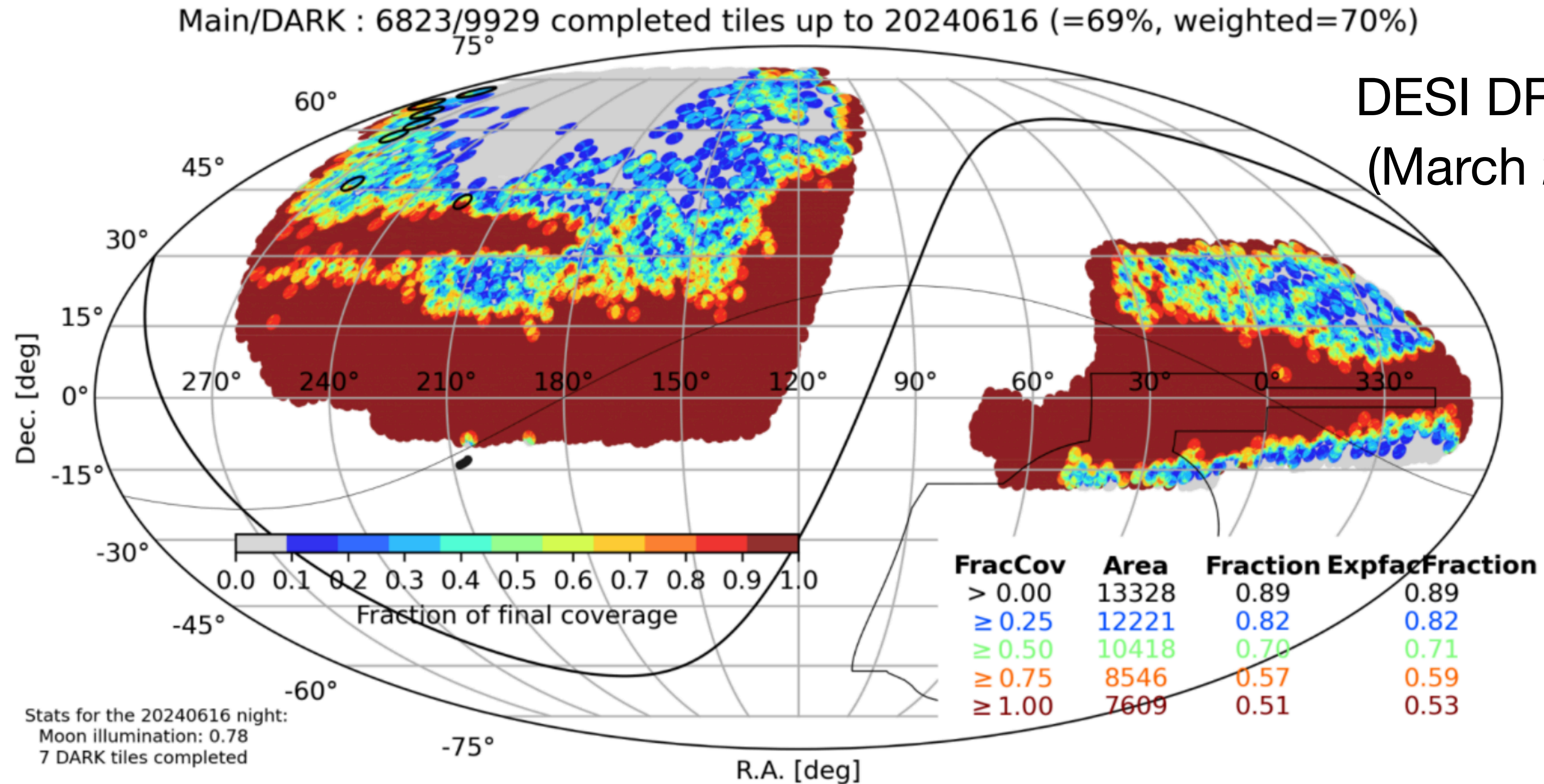
Stats for the 20220611 night:
Moon illumination: 0.94
1 DARK tiles completed



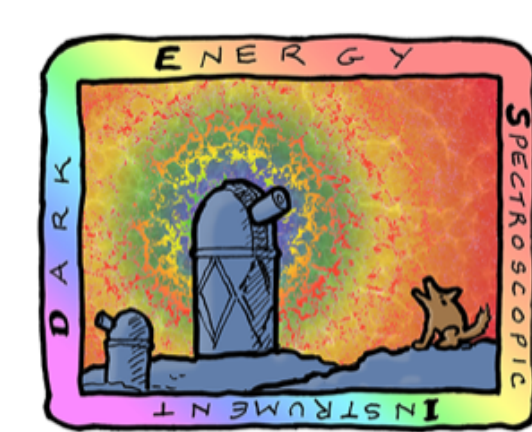
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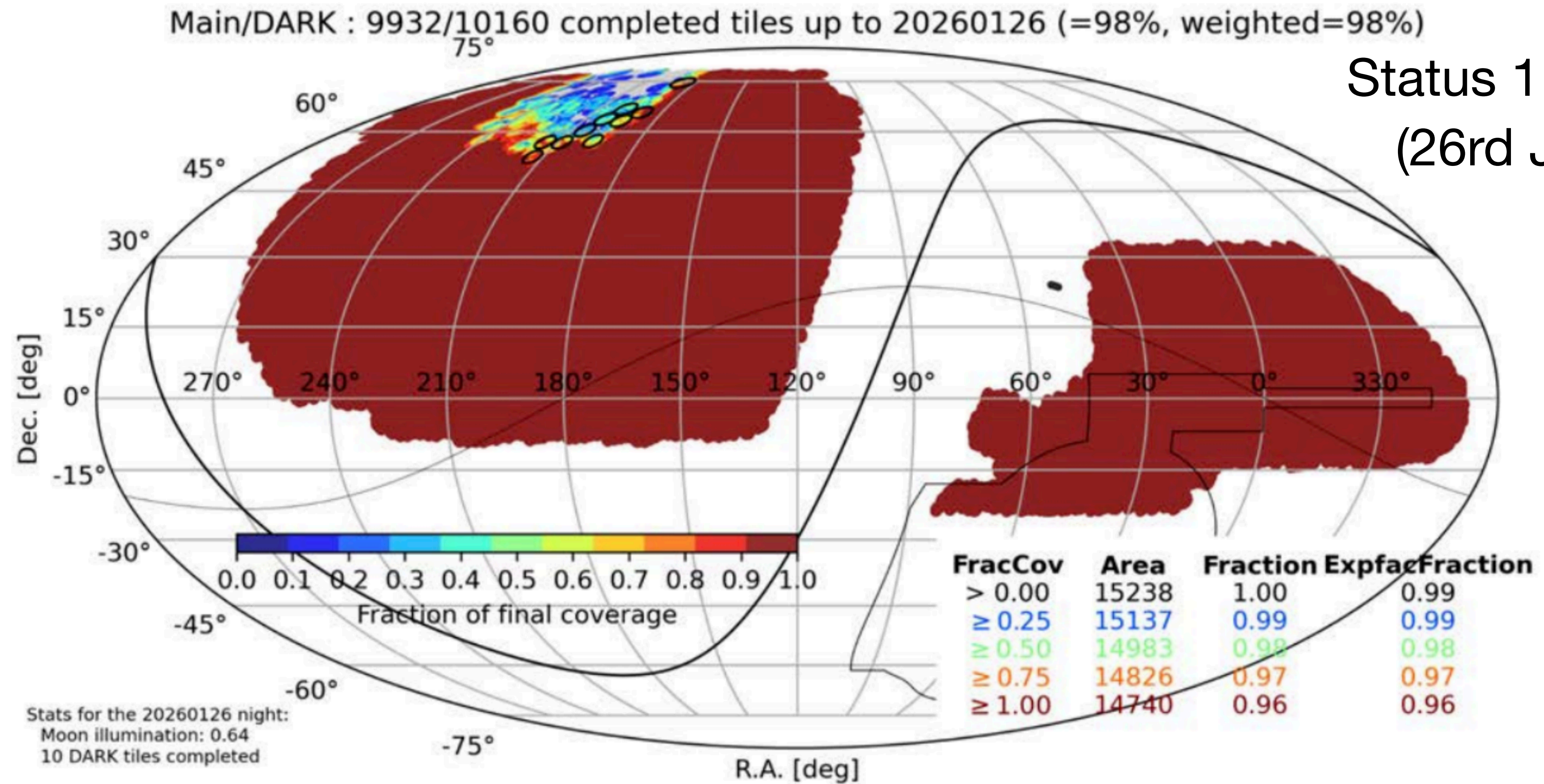
DESI DR2 Footprint
(March 2025, DR2)

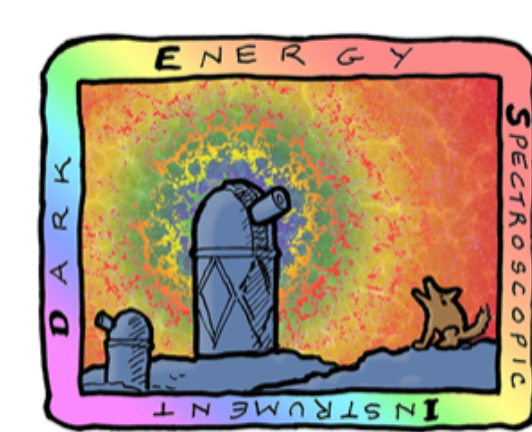


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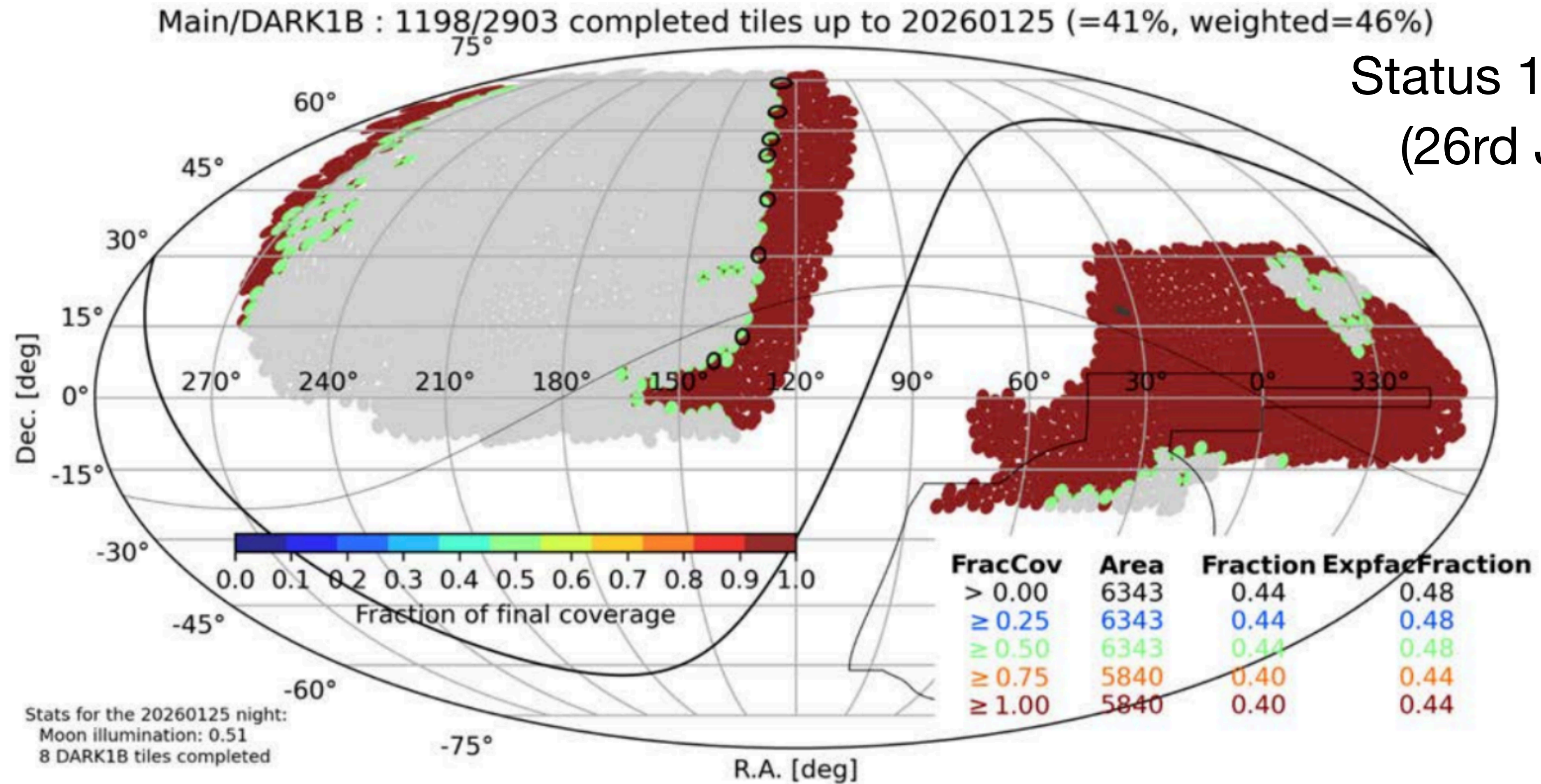


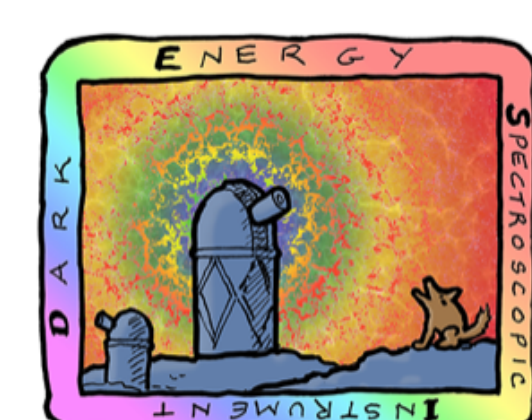
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DESI 1b → 2026 - 2028

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The Dark Energy Spectroscopic Instrument

Status on 26th Feb 2026
Already 98% completion!

DESI DR1 (1 year)

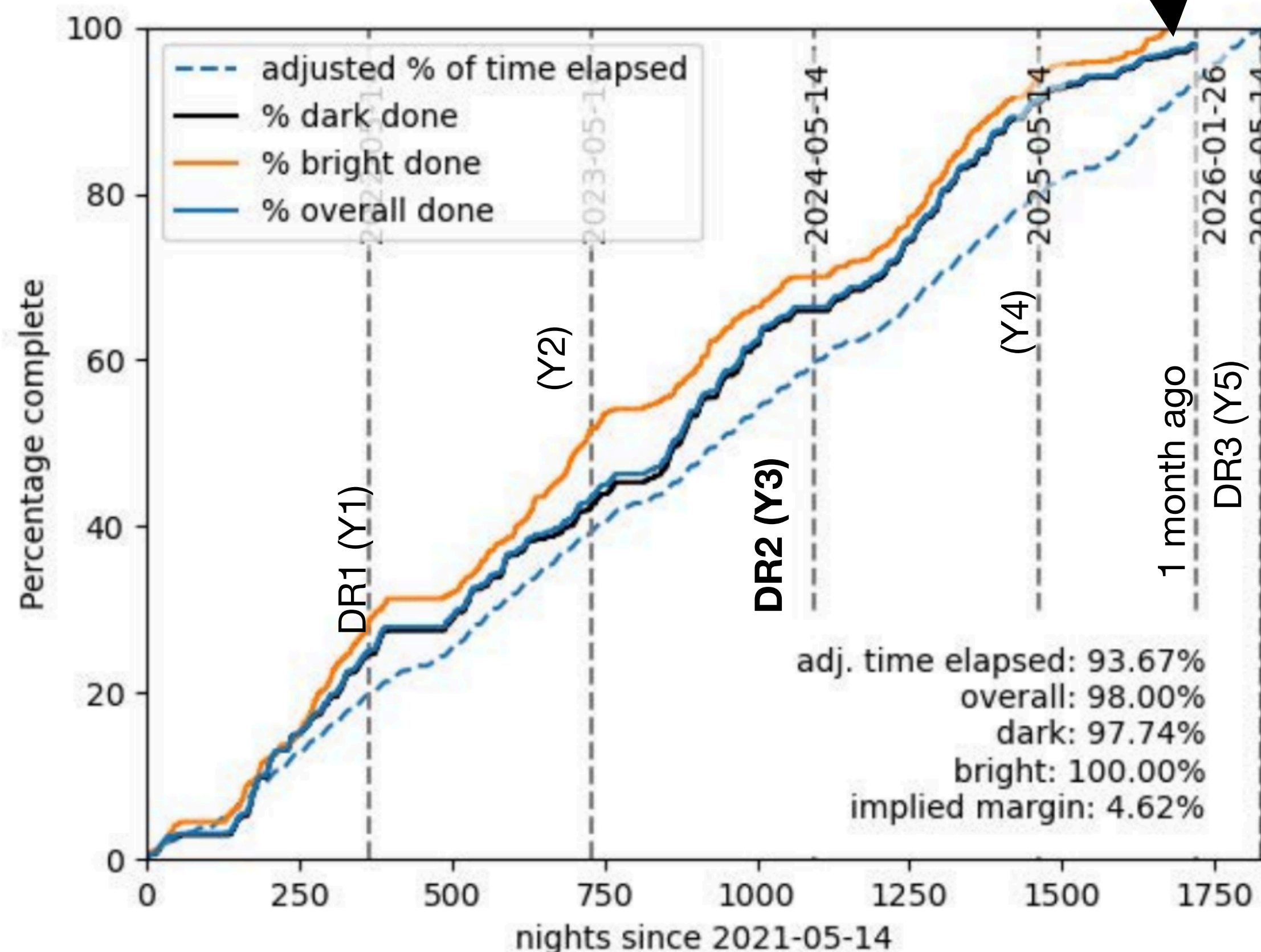
Observations from 14/05/2021 to 12/06/2022
(Results released on April 2024. Data released **Feb 2025**)

DESI DR2 (3 years)

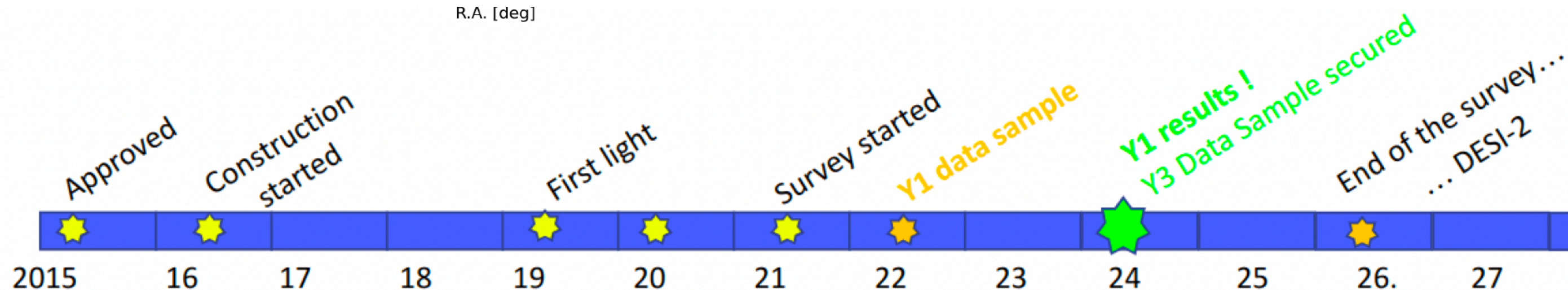
Observations from 14/05/2021 to 14/05/2024
(Results released **Feb 2025**)

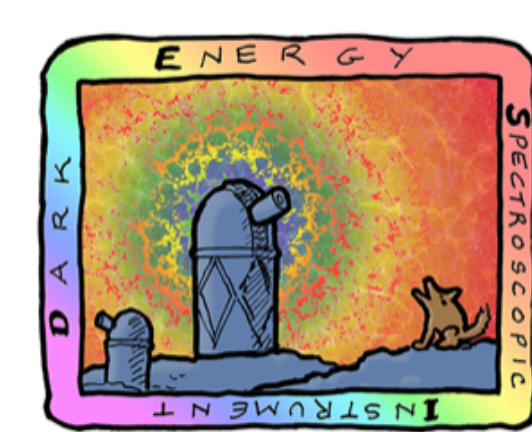
DESI DR3 (5 years)

DESI-1b DR5 (~7.5 years)



R.A. [deg]



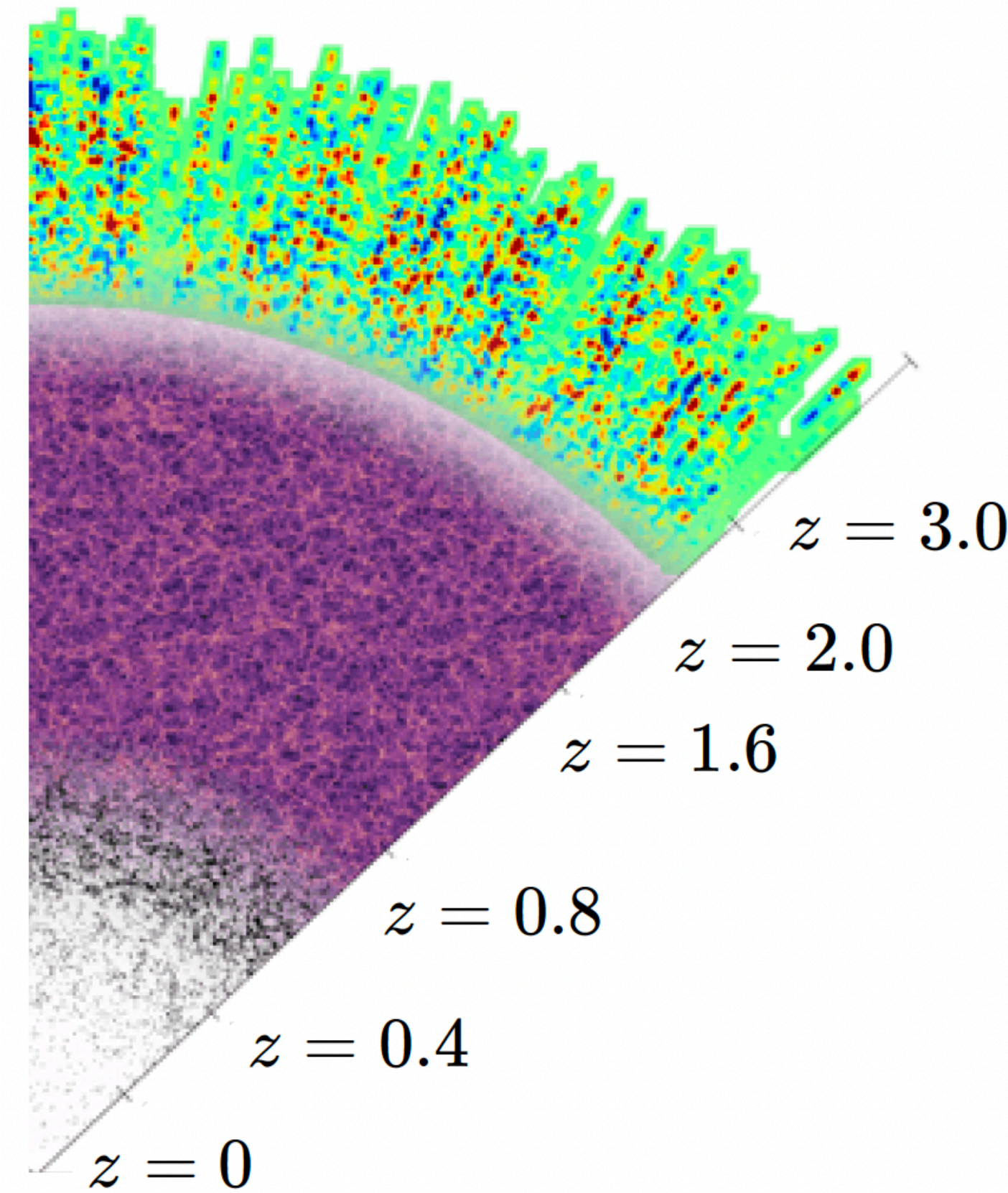
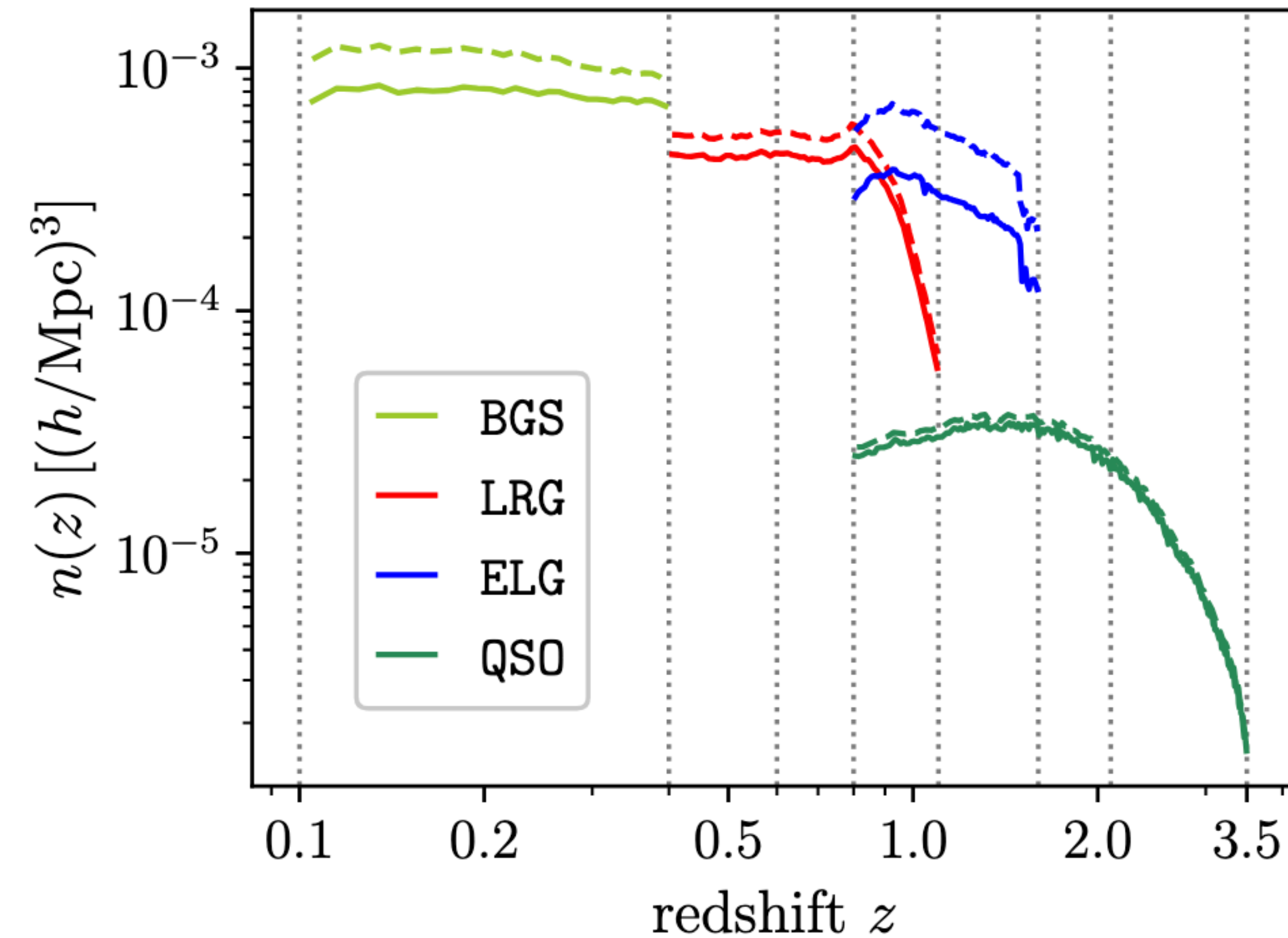


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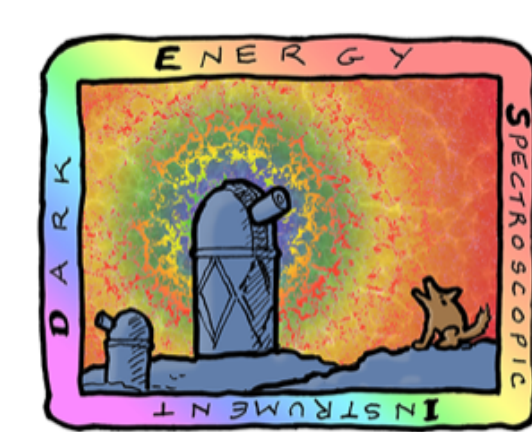
The Dark Energy Spectroscopic Instrument

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DESI DR2 samples



Tracer	Number	Volume (Gpc ³)
BGS	1,118 M	3,8
LRG	4,467 M	22,3
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DESI DR1 and DR2 Key Papers

<https://data.desi.lbl.gov/doc/papers>

DR1 Sample definitions:

(Nov. 2024, Winter 2025)

DESI 2024 I: First year data release

DESI 2024 II: Sample definitions and 2-point clustering statistics

DR1 BAO analysis:

(April. 2024)

DESI 2024 III BAO from Galaxies and Quasars

DESI 2024 IV: BAO from the Lyman-Forest

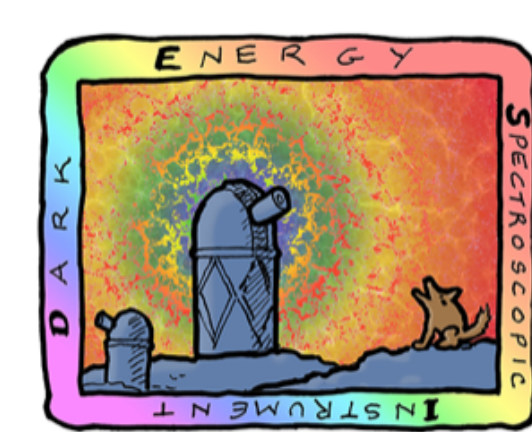
DESI 2024 VI: Cosmological constraints from BAO measurements

DR1 Full-Shape Analysis:

(Nov. 2024)

DESI 2024 V: Full Shape measurements from Galaxies and Quasars

DESI 2024 VII: Cosmological constraints from Full Shape measurements



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DR1 Sample definitions:

(Nov. 2024, Winter 2025)

DESI 2024 I: First year data release

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This talk

DR2 BAO analysis:

(March. 2025)

DESI DR2 Results I: Baryon Acoustic Oscillations from the Lyman Alpha Forest

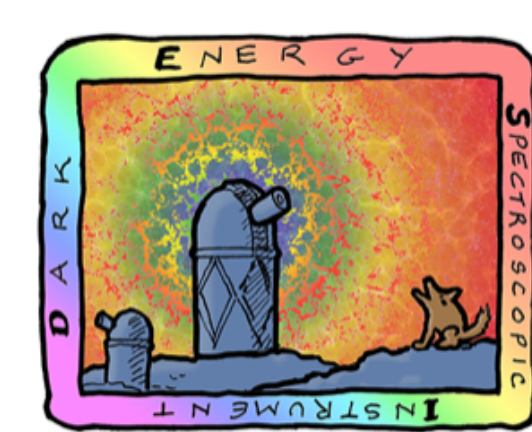
DESI DR2 Results II: Measurements of Baryon Acoustic Oscillations and Cosmological Constraints

DR1 Full-Shape Analysis:

(Nov. 2024)

DESI 2024 V: Full Shape measurements from Galaxies and Quasars

DESI 2024 VII: Cosmological constraints from Full Shape measurements



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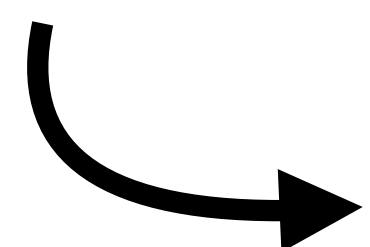
DESI DR2 Results II: Measurements of Baryon Acoustic Oscillations and Cosmological Constraints

DR1 Full-Shape Analysis:

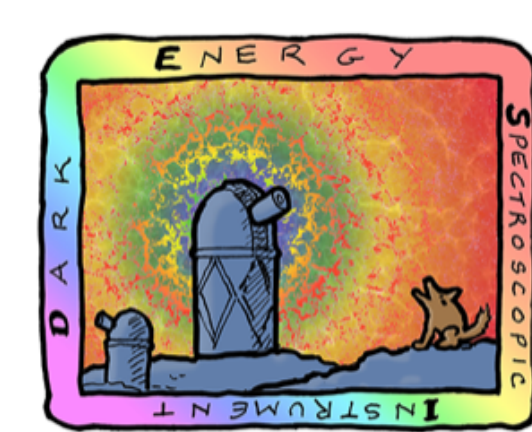
(Nov. 2024)

DESI 2024 V: Full Shape measurements from Galaxies and Quasars

DESI 2024 VII: Cosmological constraints from Full Shape measurements



... end of 2026 DR2 Full-Shape Analysis



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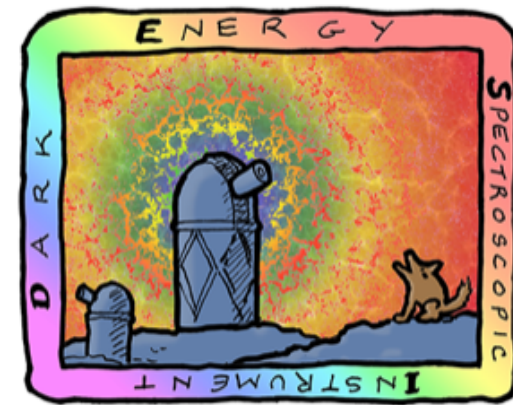
The BAO as a standard ruler

Distances in cosmology are hard. We need calibrators!



Standard Candles

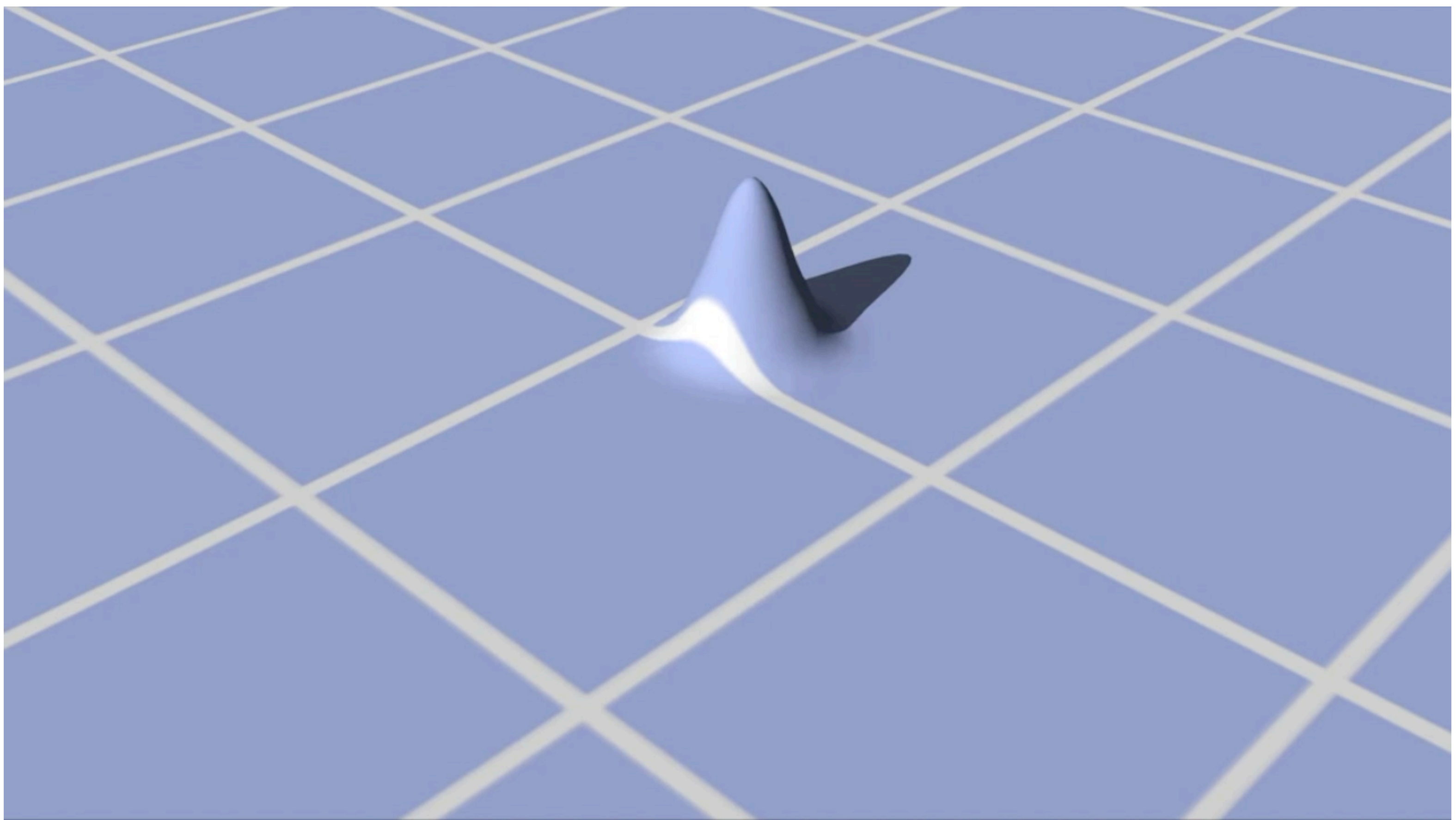
Standard Rulers



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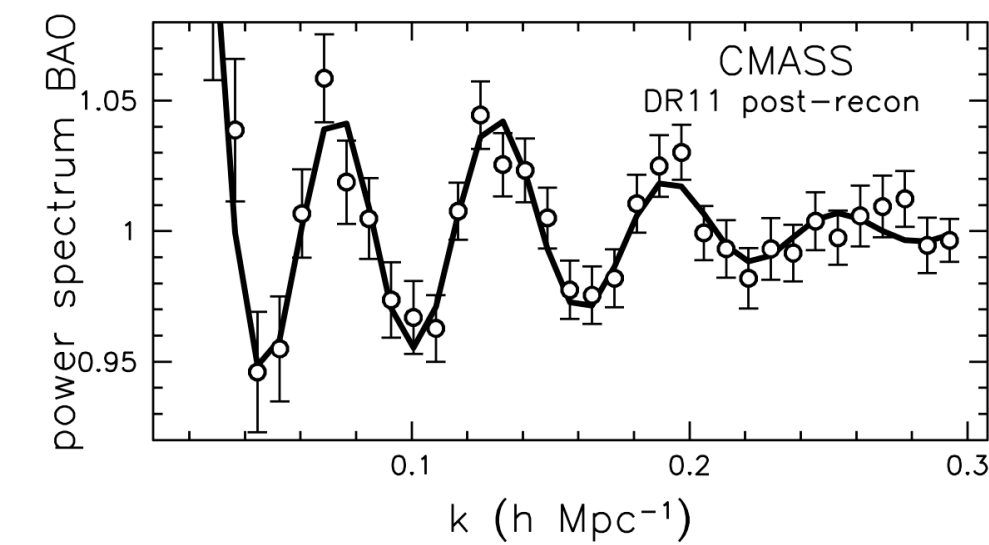
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The BAO as a standard ruler

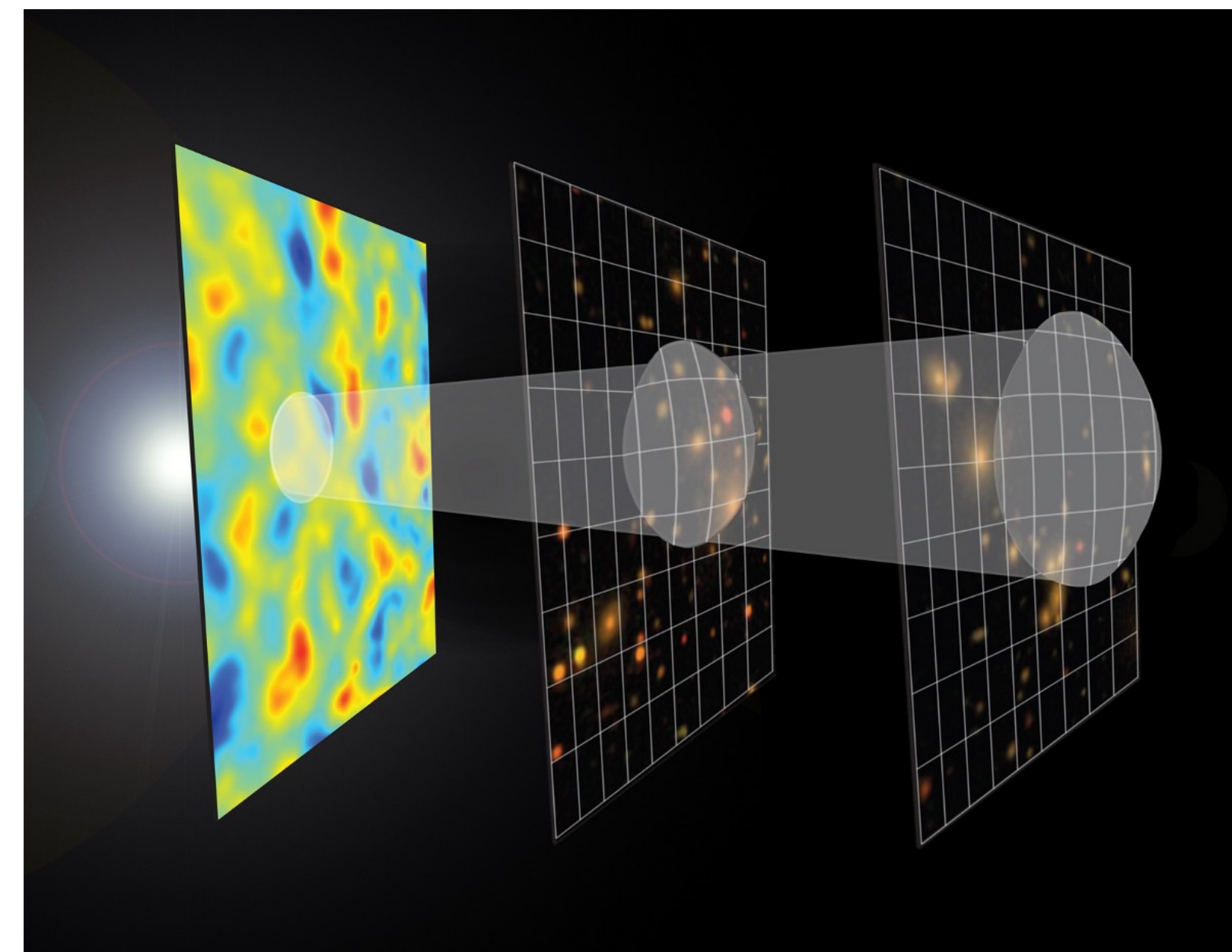
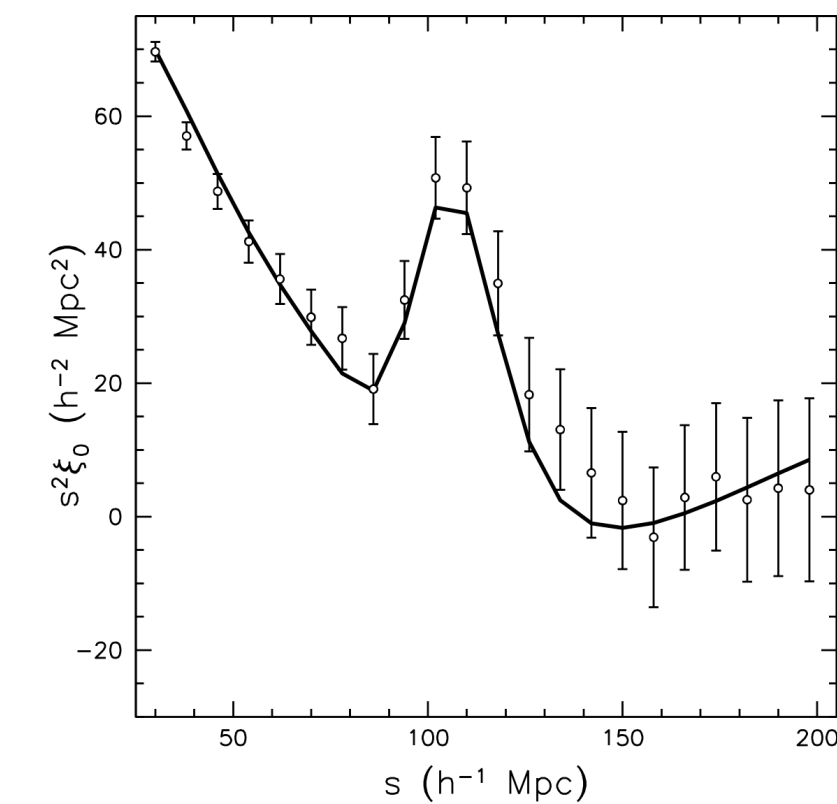


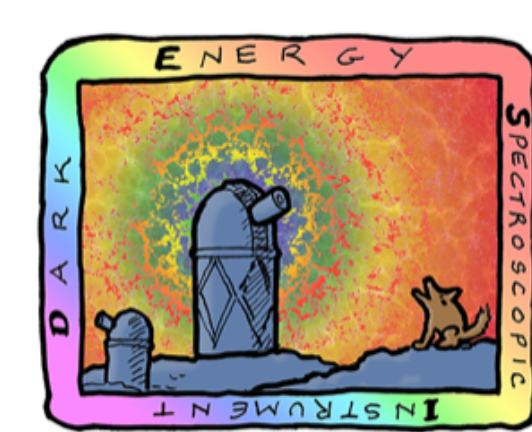
Credit CAASTRO

Fourier-space



position-space



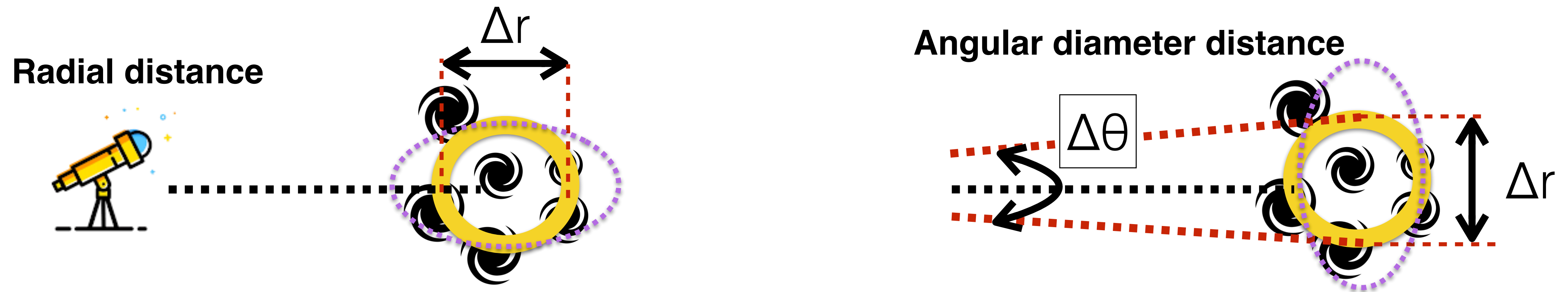


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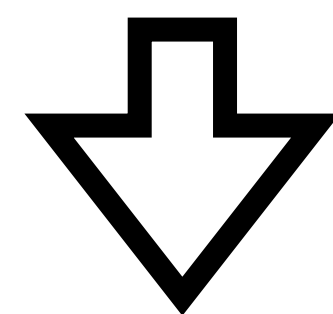
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The BAO as a standard ruler

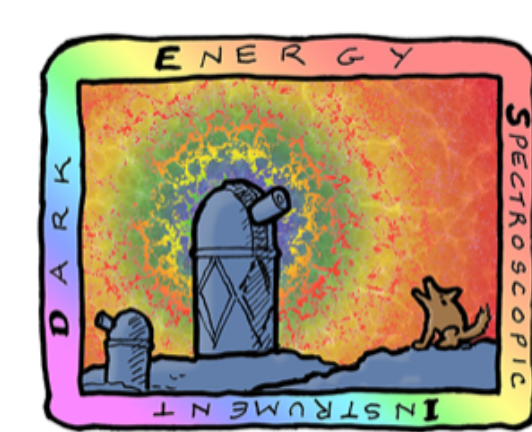
The arbitrary choice of reference cosmology distorts **all** the measured angular and radial scales.



The distortion is different in the line-of-sight direction and in the transverse direction.



Introduces an anisotropy if the **reference or fiducial cosmology** differs from the actual cosmology: Alcock-Paczynski effect



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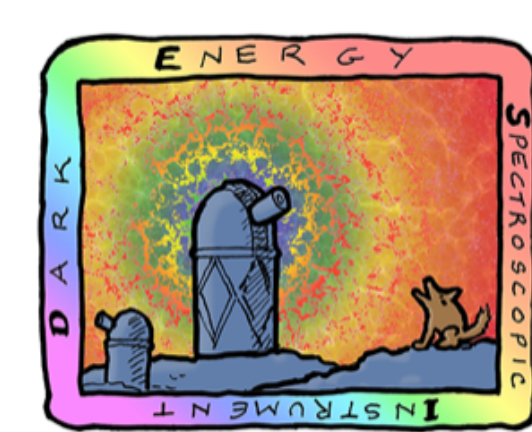
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The BAO as a standard ruler

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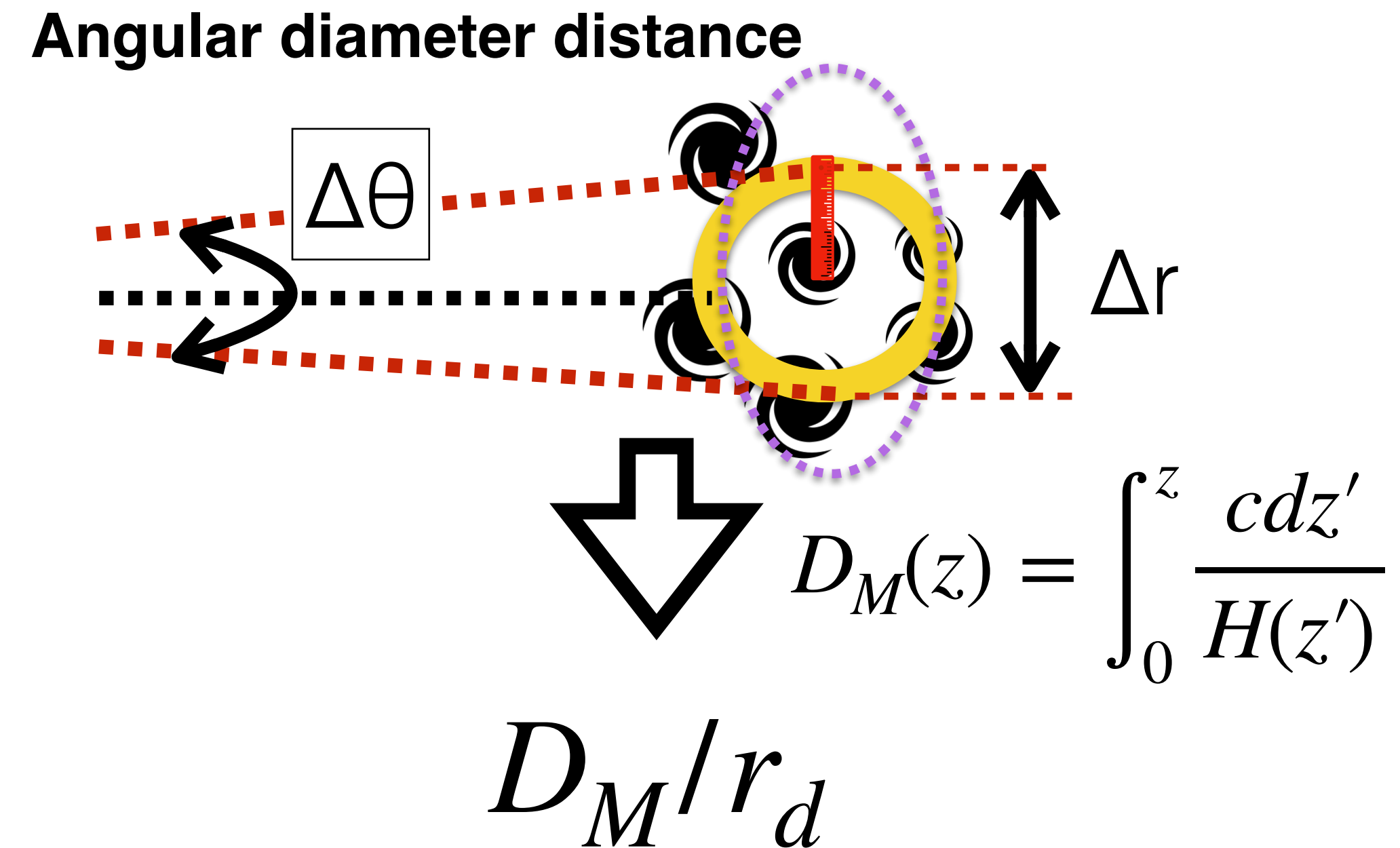
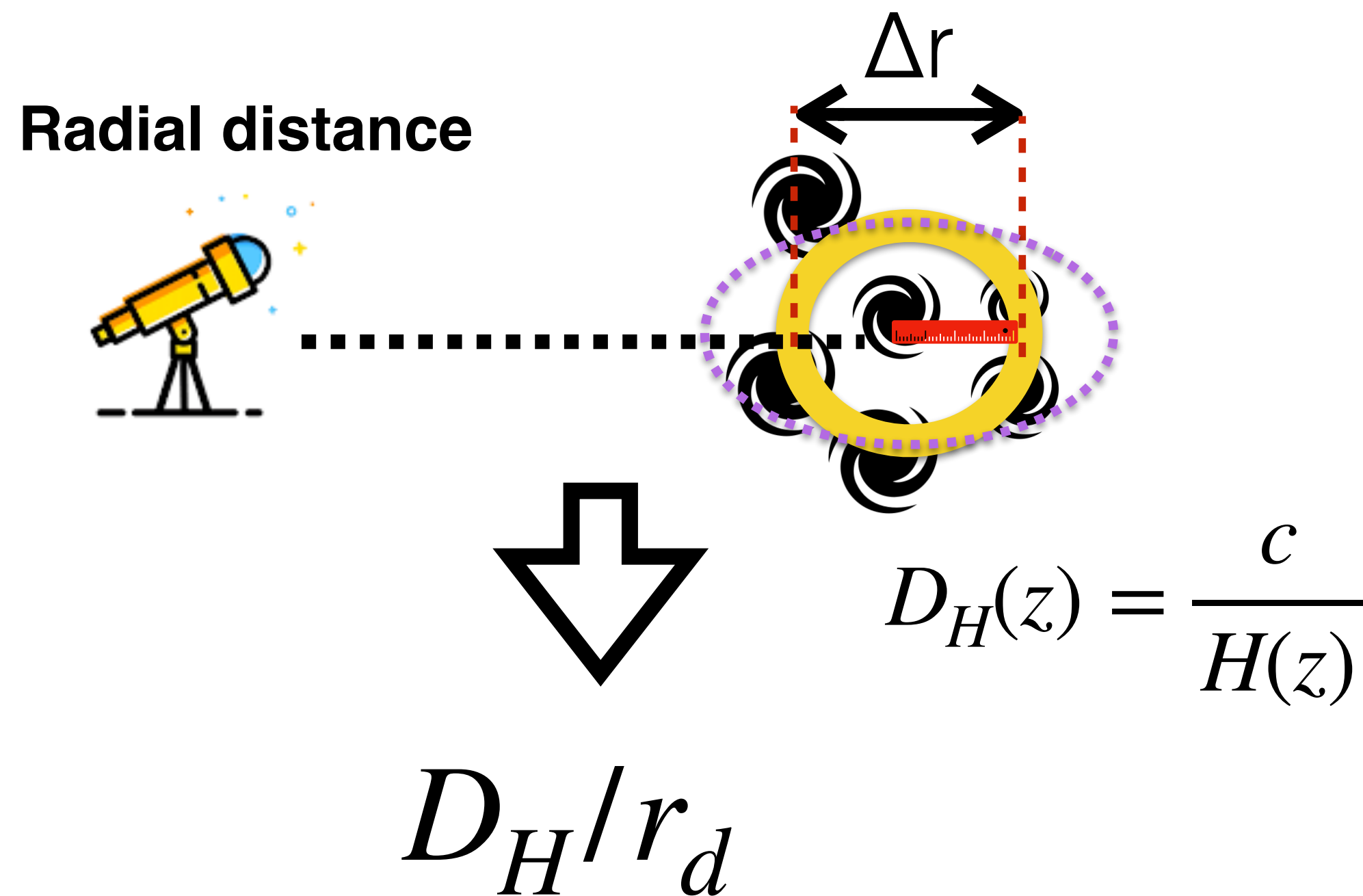


In particular, it's true for the BAO scale: the sound horizon scale at drag epoch: r_d



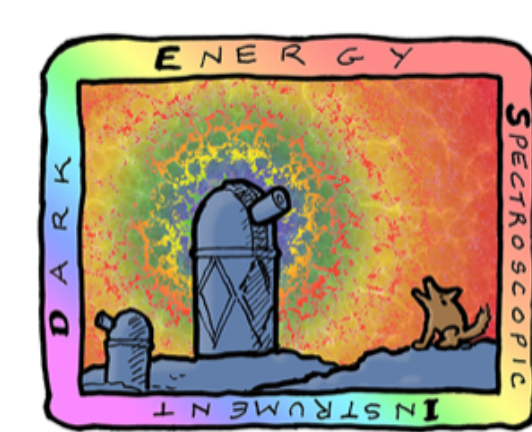
The BAO as a standard ruler

The arbitrary choice of reference cosmology distorts **all** the measured angular and radial scales.



For aficionados \longrightarrow $\alpha_{\parallel} = [D_H/r_d]/[D_H/r_d]^{\text{fid}}$
(dilation parameters)

$\alpha_{\perp} = [D_M/r_d]/[D_M/r_d]^{\text{fid}}$

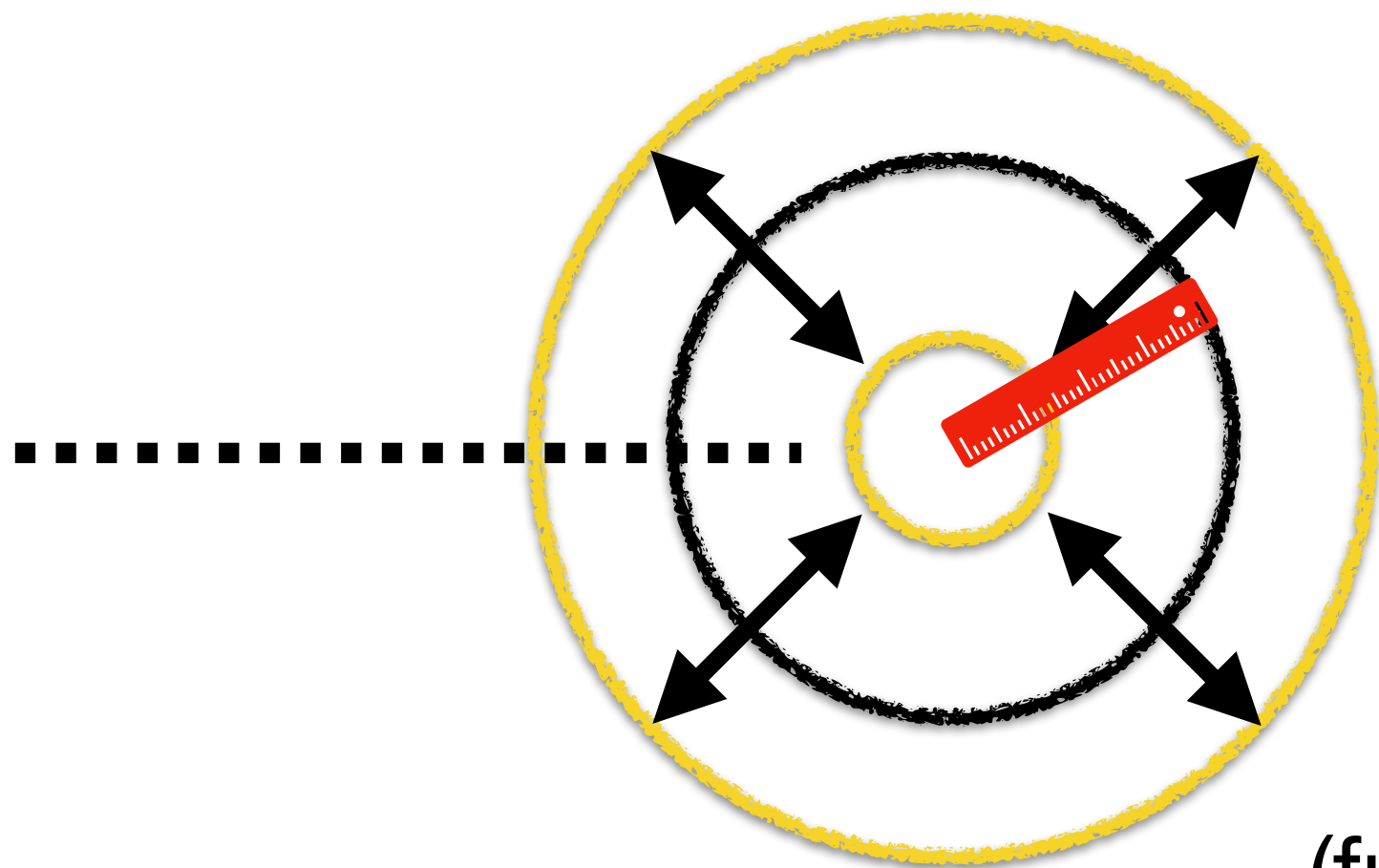


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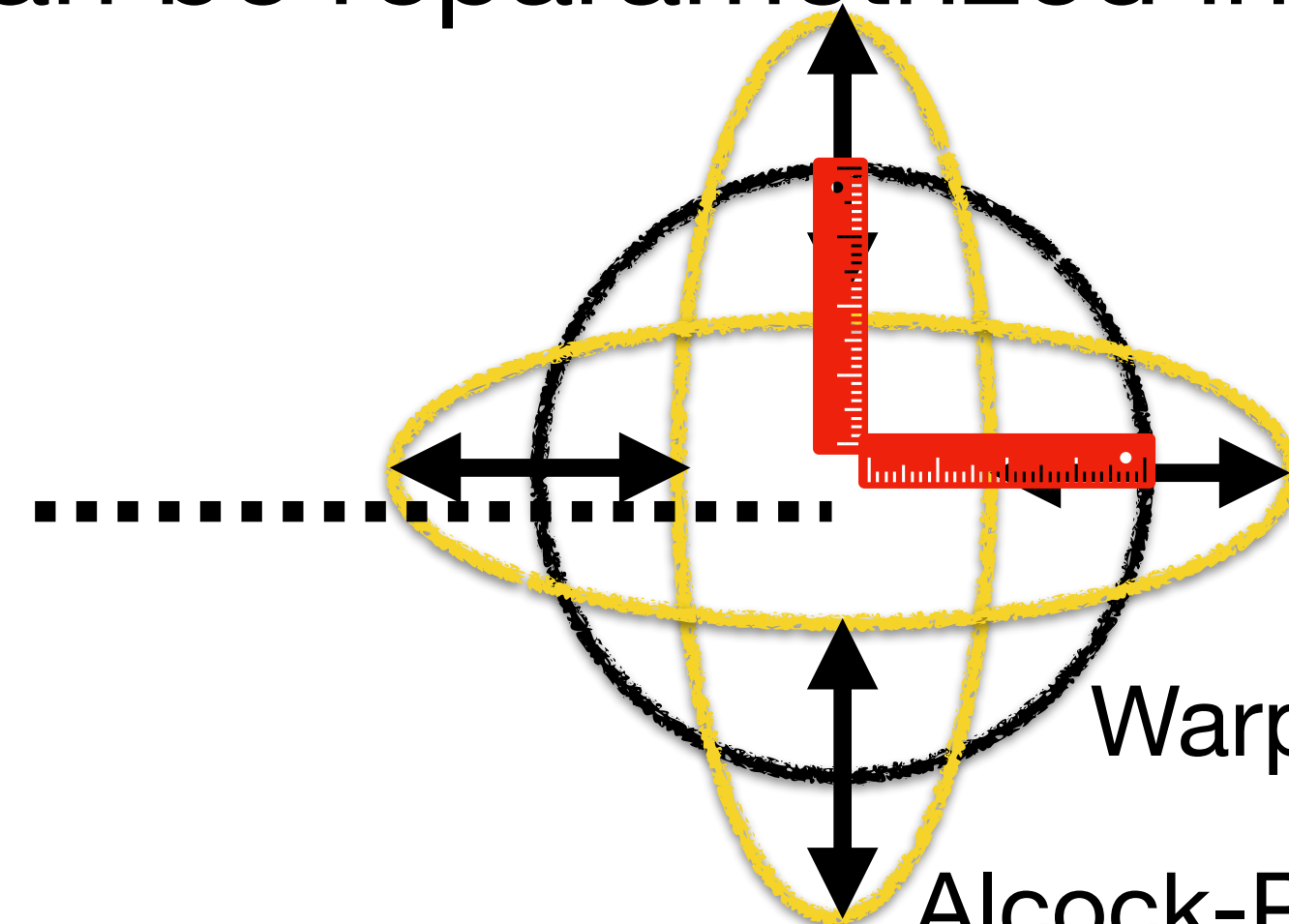
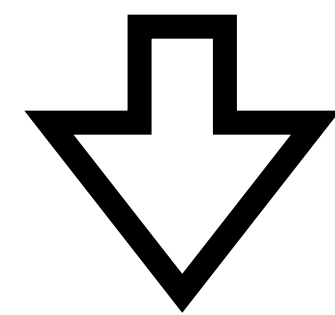
The BAO as a standard ruler

The along and across LOS BAO distortions can be reparametrized in



Isotropic re-scaling
(fully degenerate with r_d)

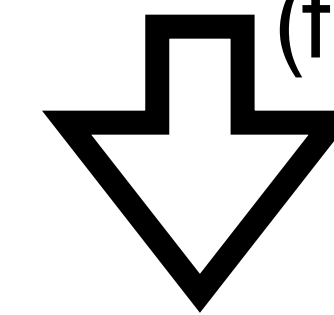
$$\{z[D_M(z)/r_d]^2 D_H(z)/r_d\}^{1/3} \equiv D_V(z)/r_d$$



Warp of scales

Alcock-Paczynski effect
(fully independent of r_d)

$$D_M(z)/D_H(z)$$

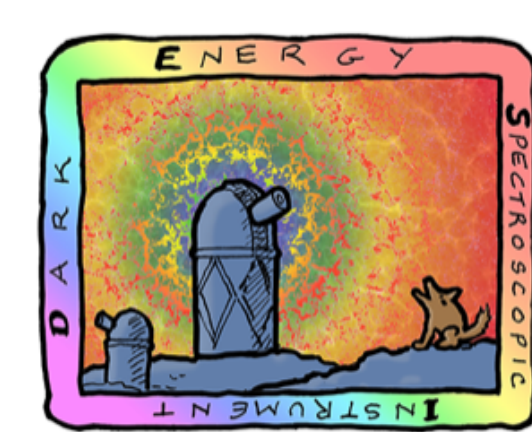


For aficionados →

$$[\alpha_{\parallel} \alpha_{\perp}^2]^{1/3} \equiv \alpha_{\text{iso}}$$

$$\alpha_{\parallel} / \alpha_{\perp} \equiv \alpha_{AP}$$

Alcock-Paczynski
parameter



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The BAO as a standard ruler

Exploiting BAO-only at different redshifts...

Uncalibrated BAO (r_d unknown)

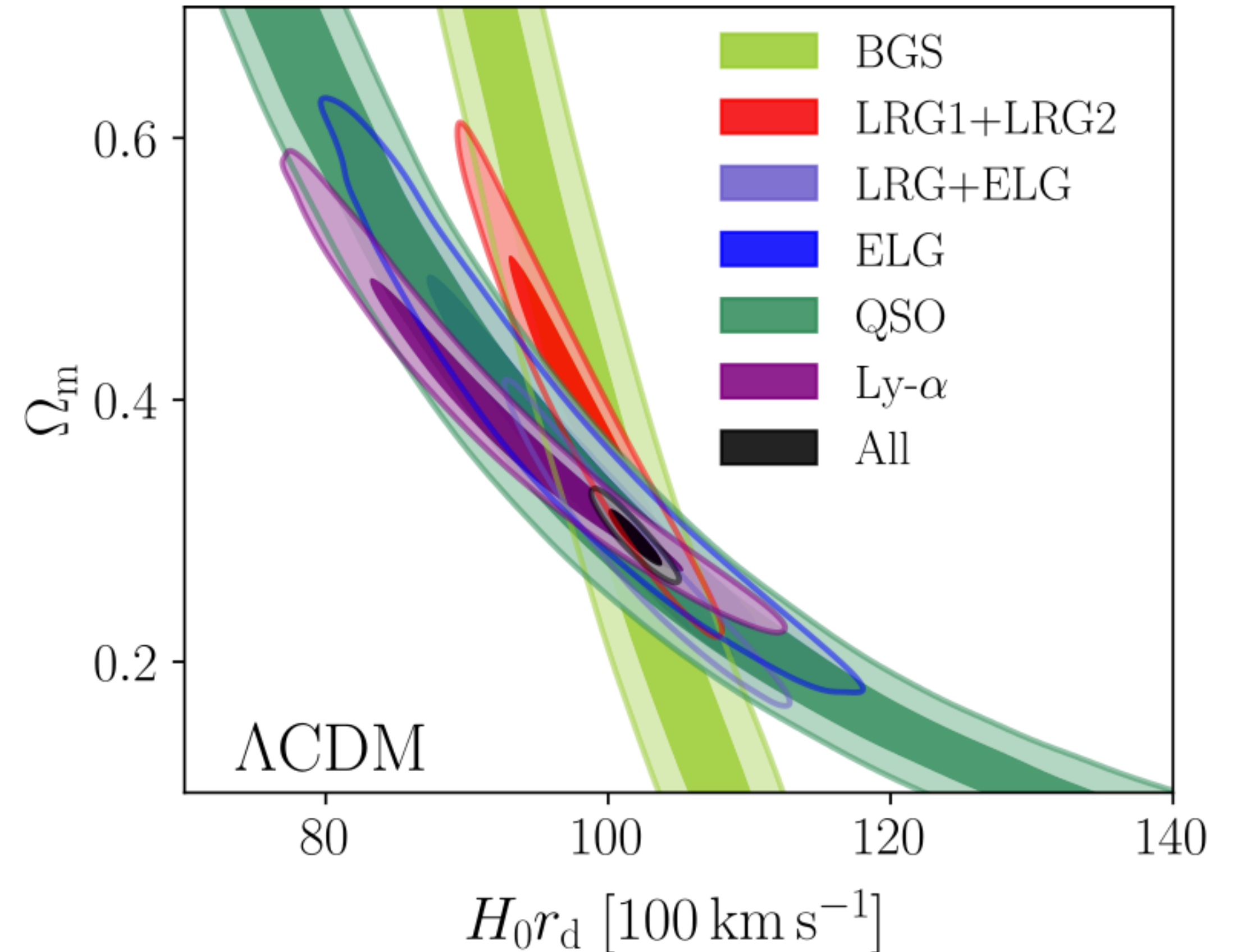
Expansion history $\frac{D_V(z_1)/D_V(z_2)}{H_0} \equiv E(z) \longrightarrow$ eg. Ω_m in Λ CDM

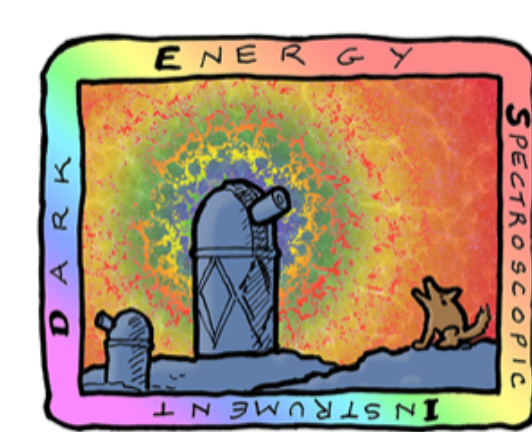
H_0 in (distance) units of $r_d \longrightarrow H_0 r_d$

Calibrated BAO (r_d known)

If r_d is given by external datasets $\longrightarrow H_0$ & r_d

(old DR1 data)

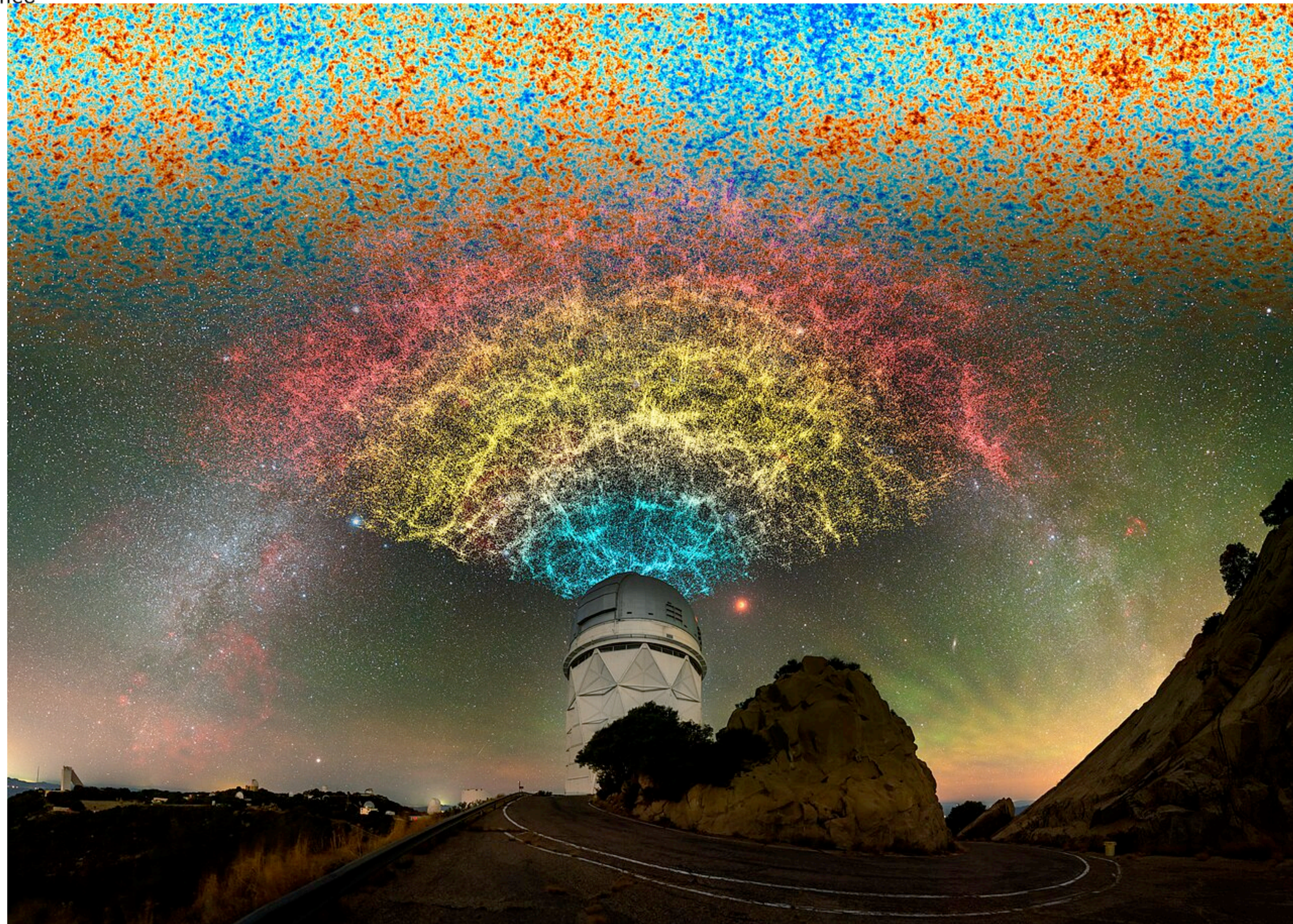




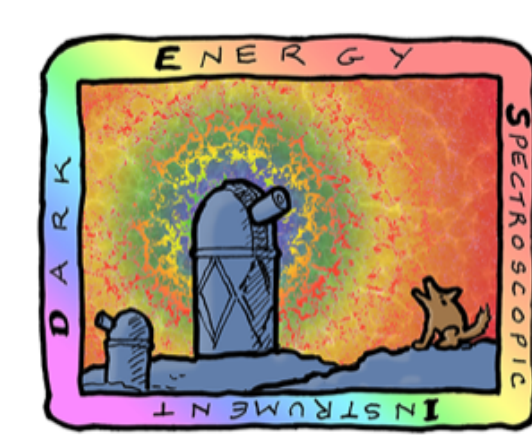
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The DESI BAO DR2 results



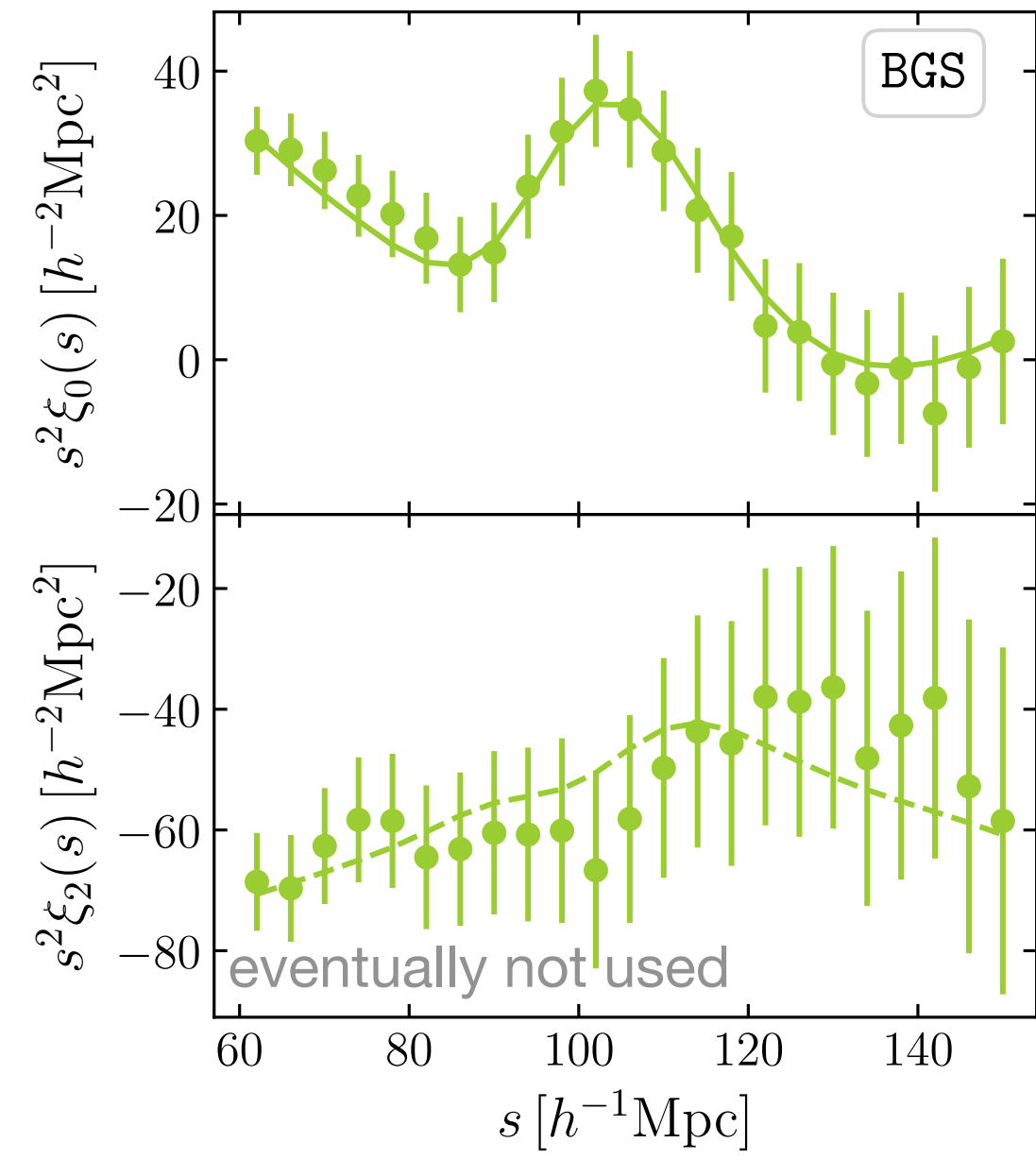
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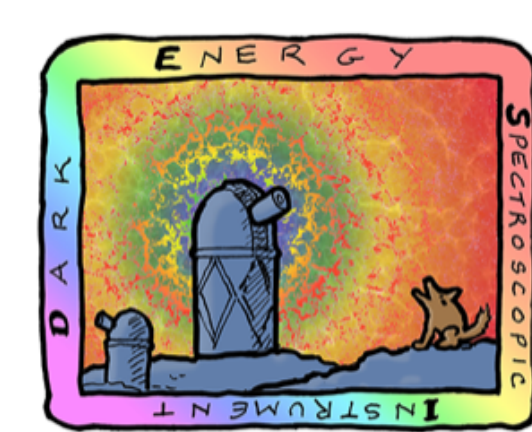


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The DESI BAO DR2 results

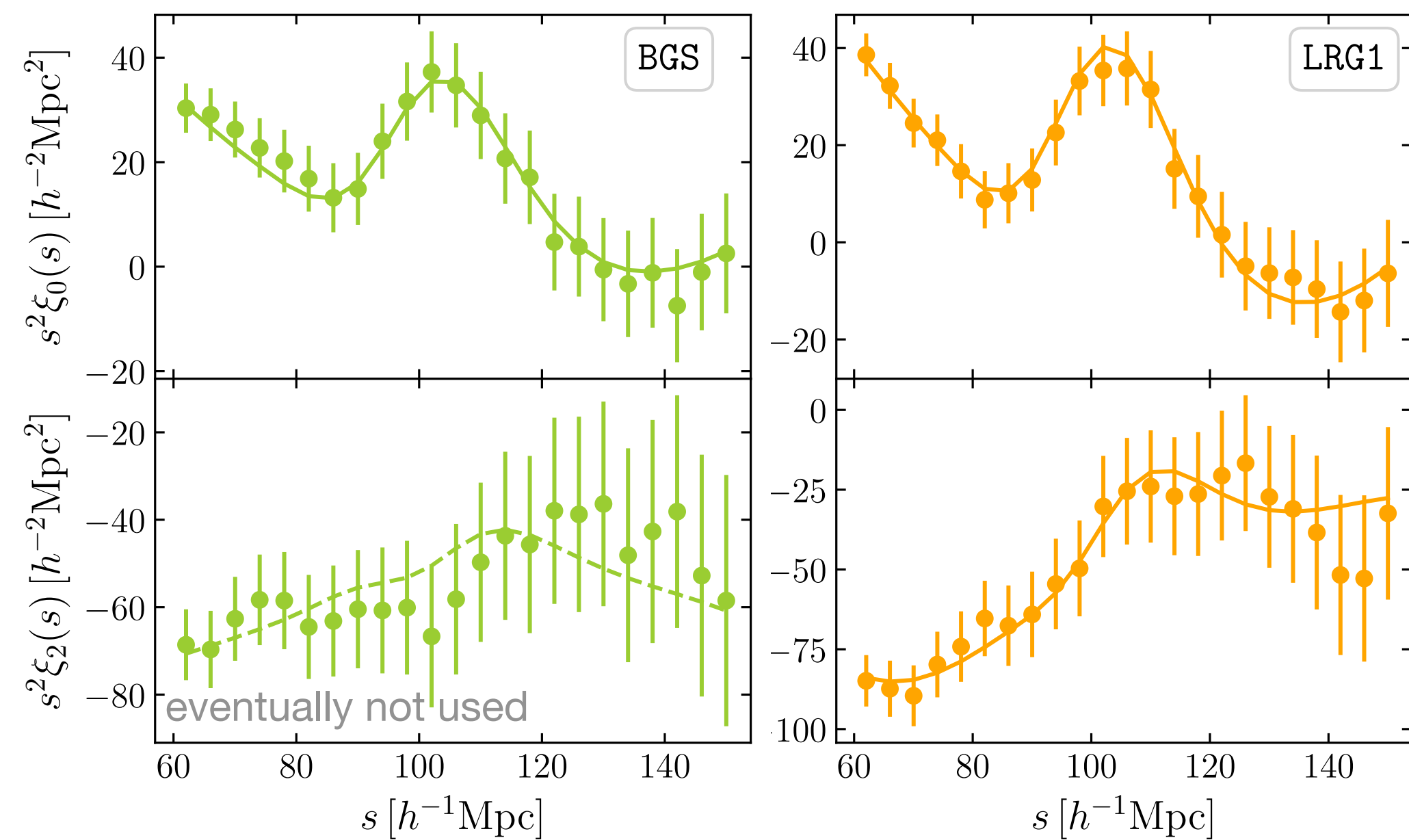


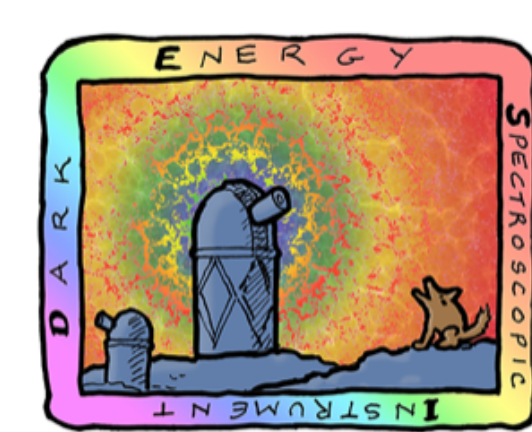


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The DESI BAO DR2 results

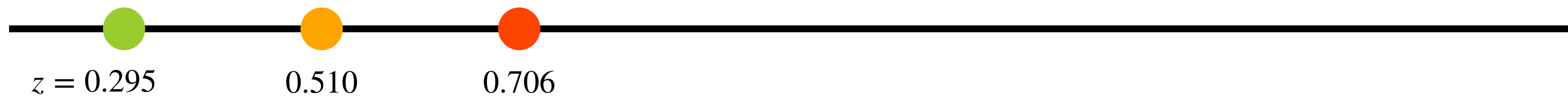
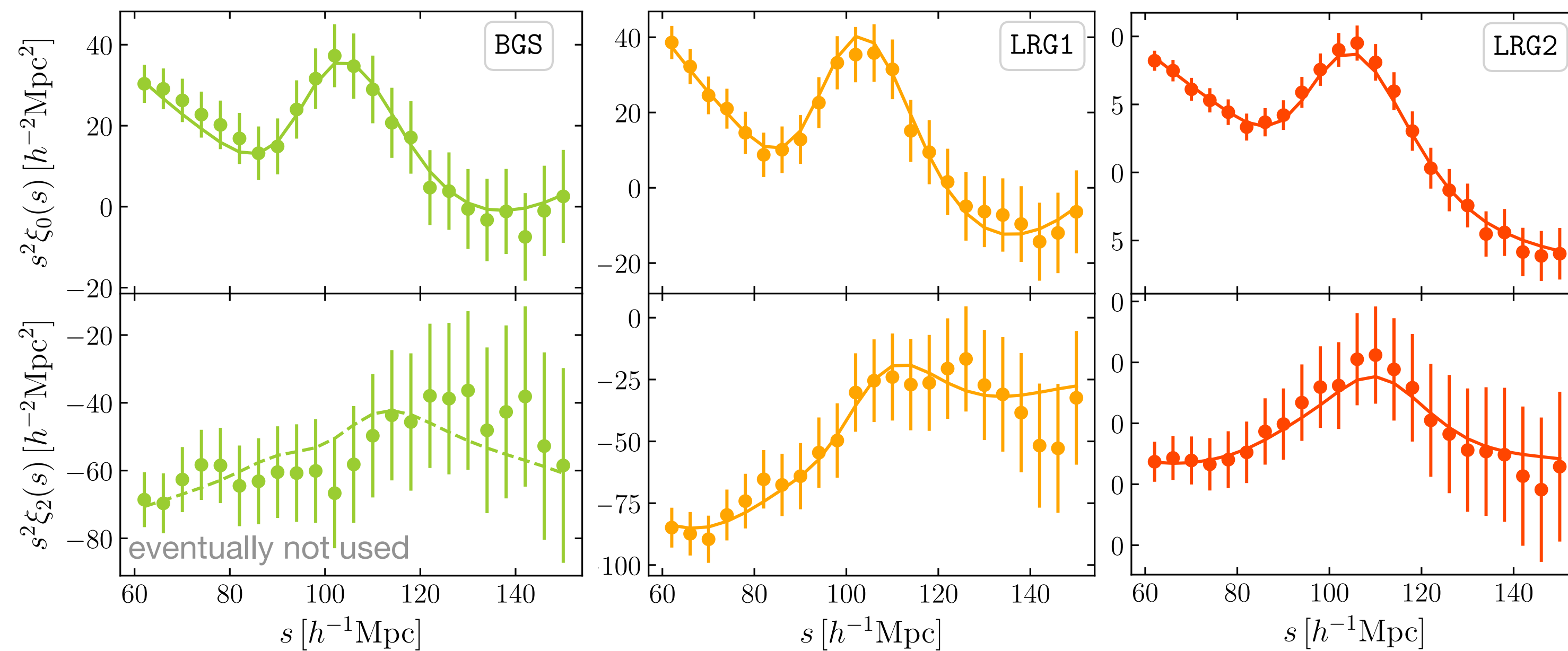


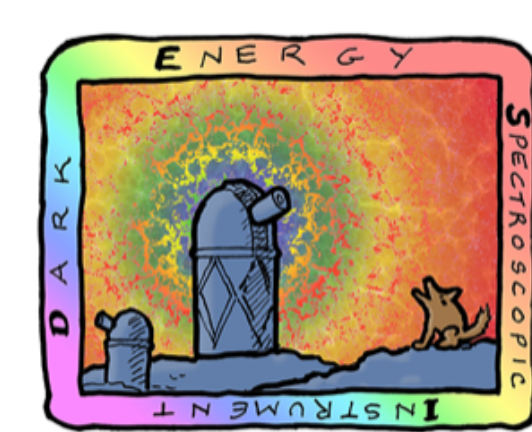


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The DESI BAO DR2 results

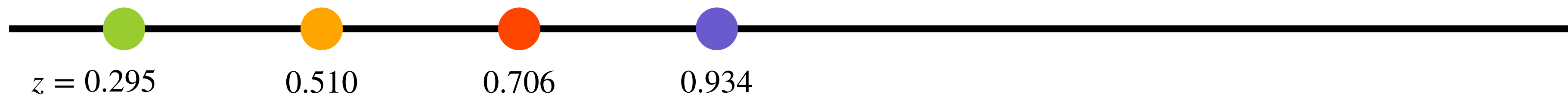
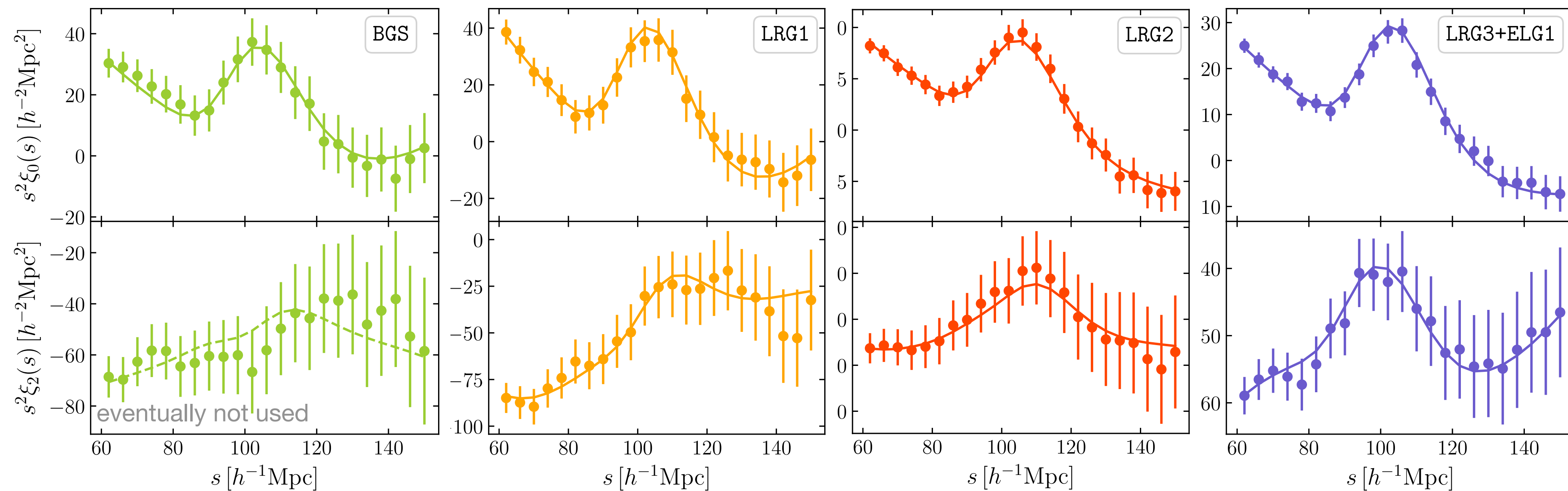


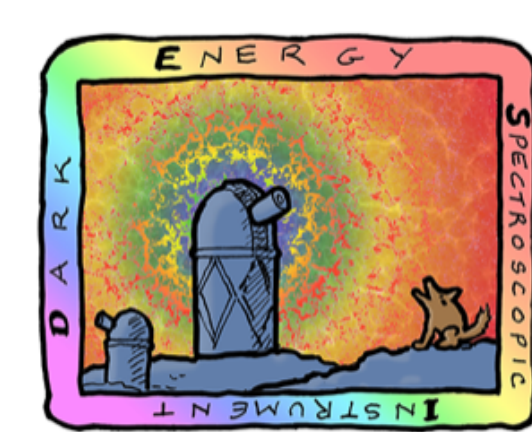


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The DESI BAO DR2 results

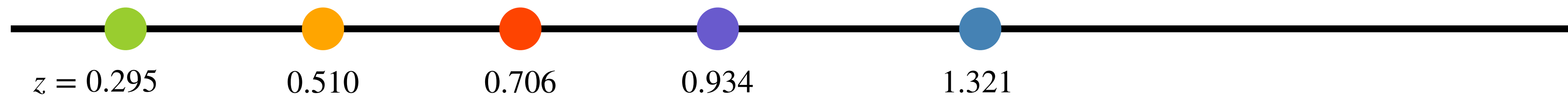
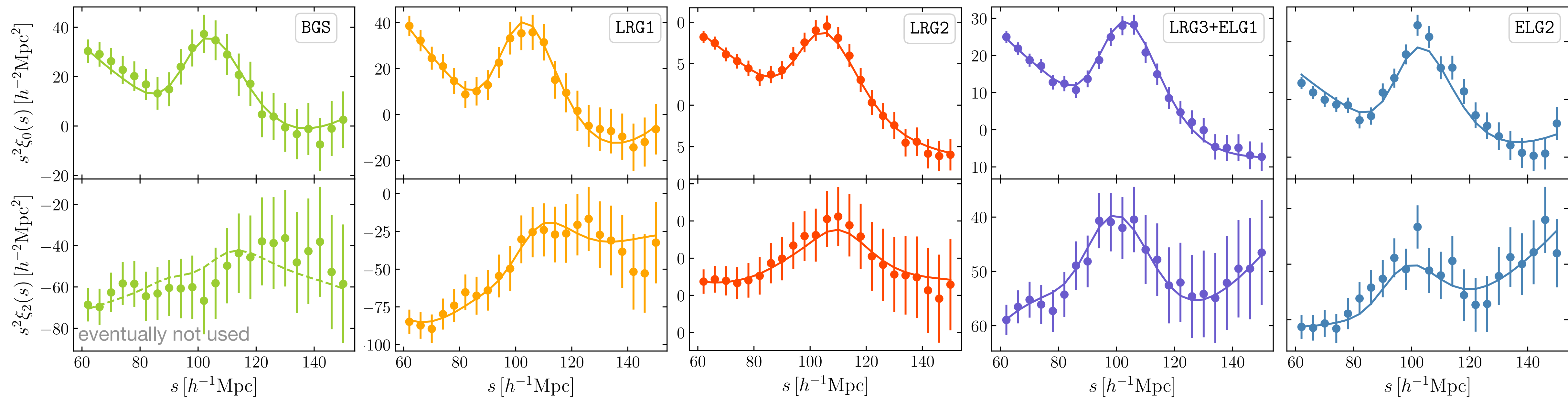


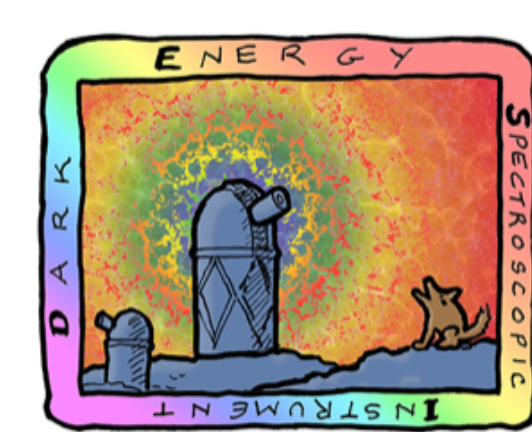


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The DESI BAO DR2 results

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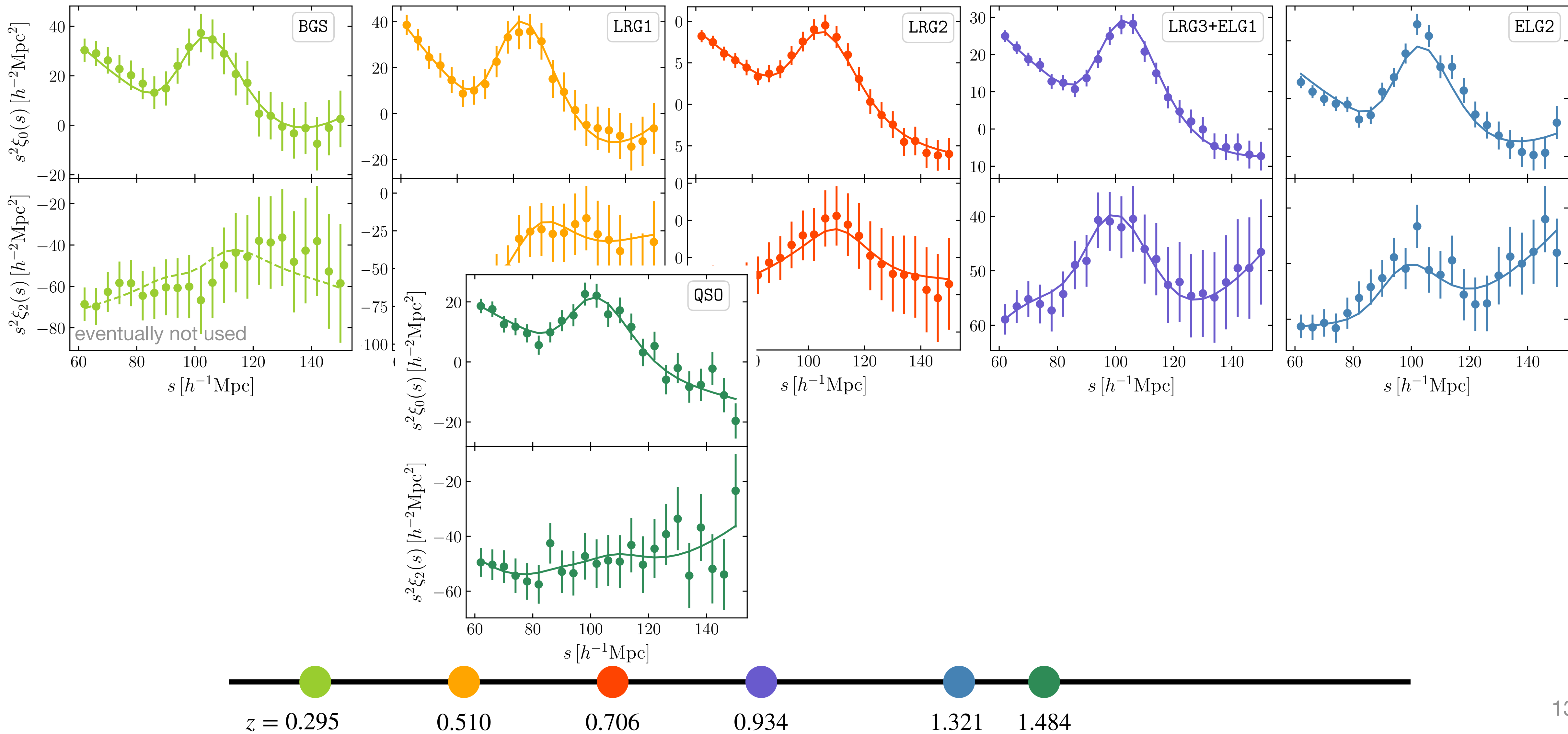


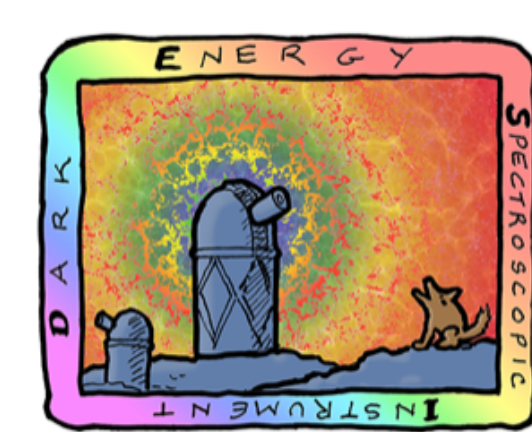


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The DESI BAO DR2 results

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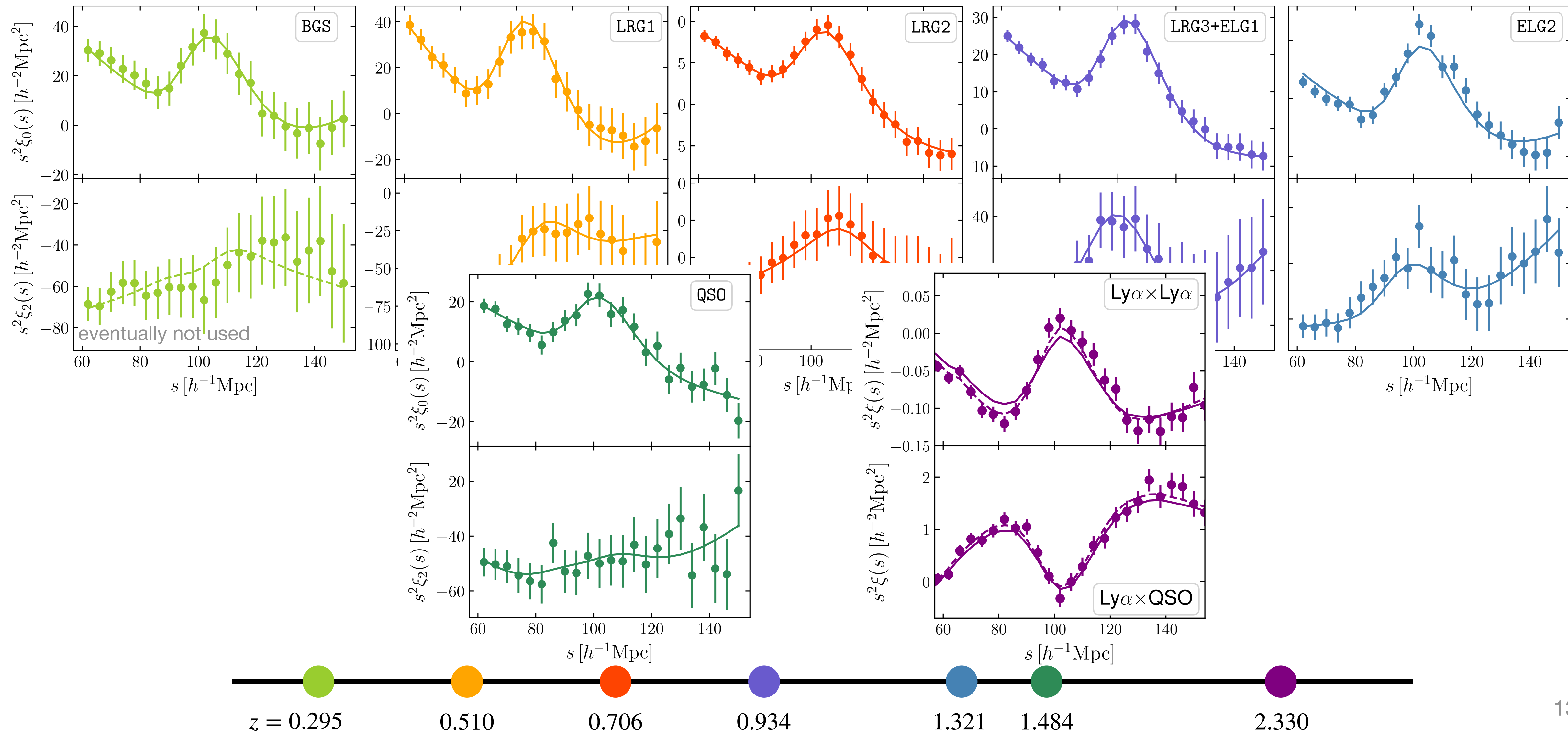


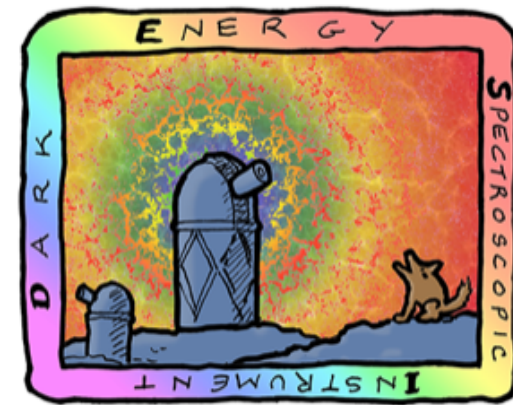


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The DESI BAO DR2 results

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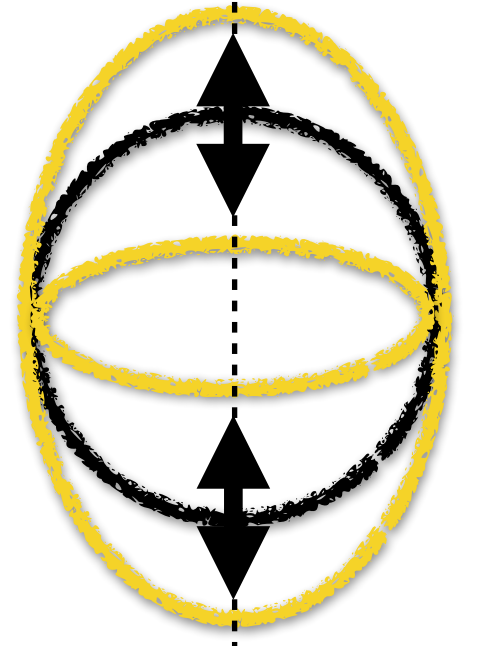
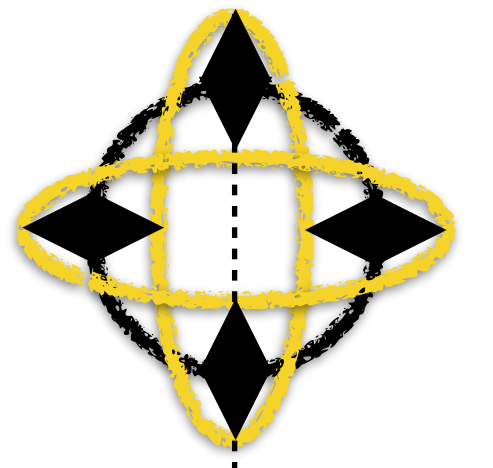
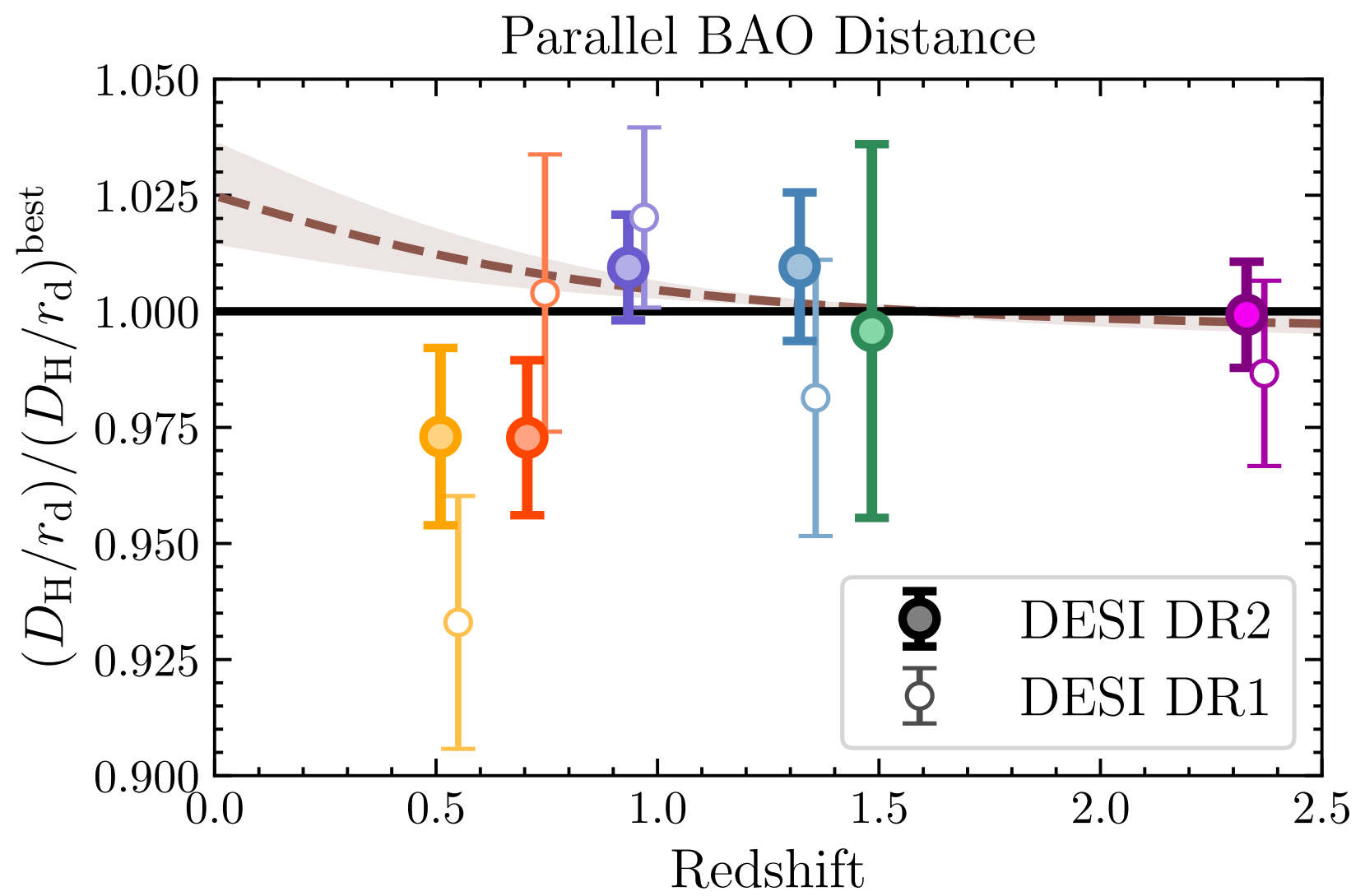
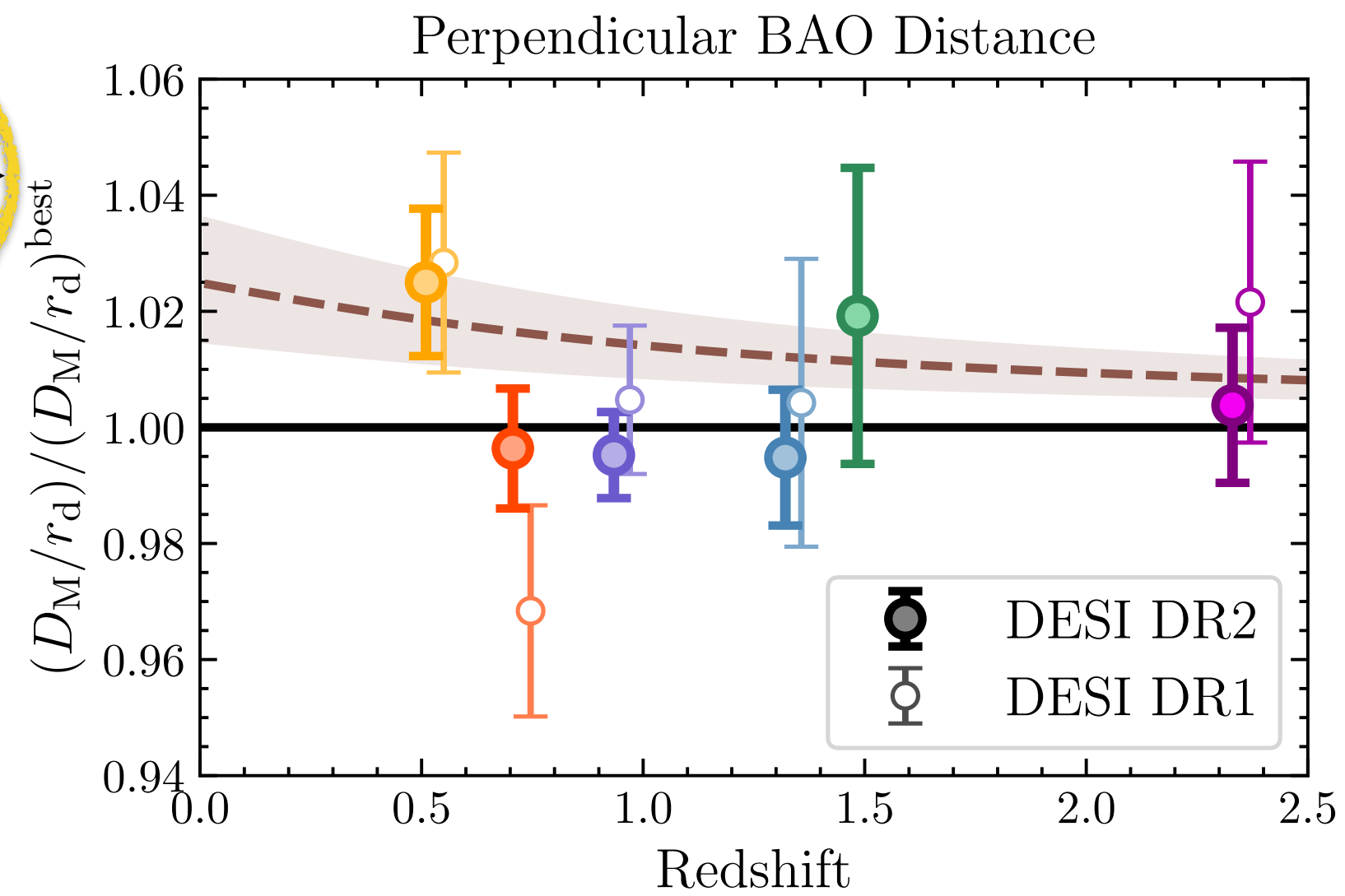
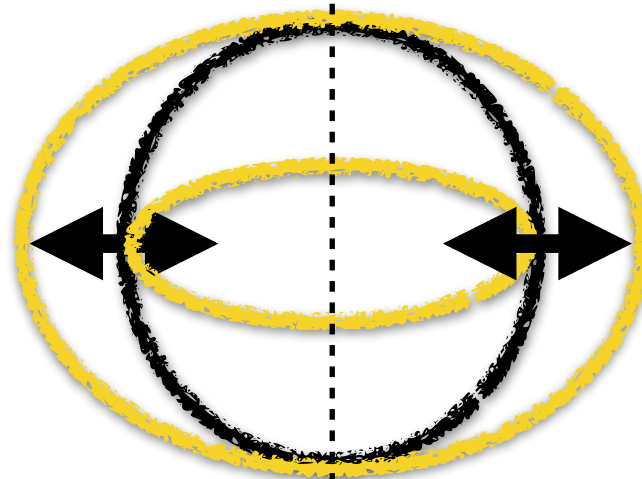
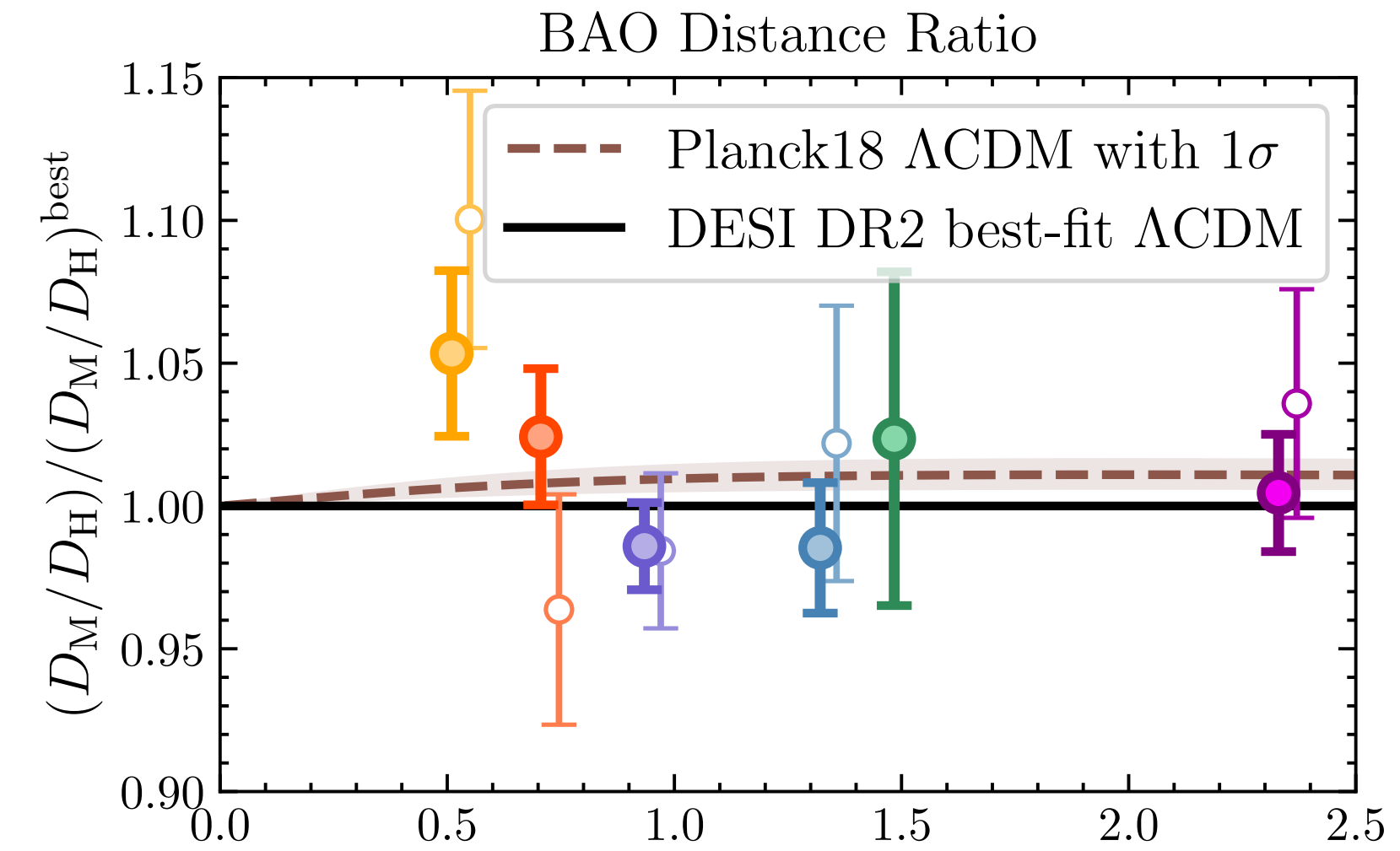
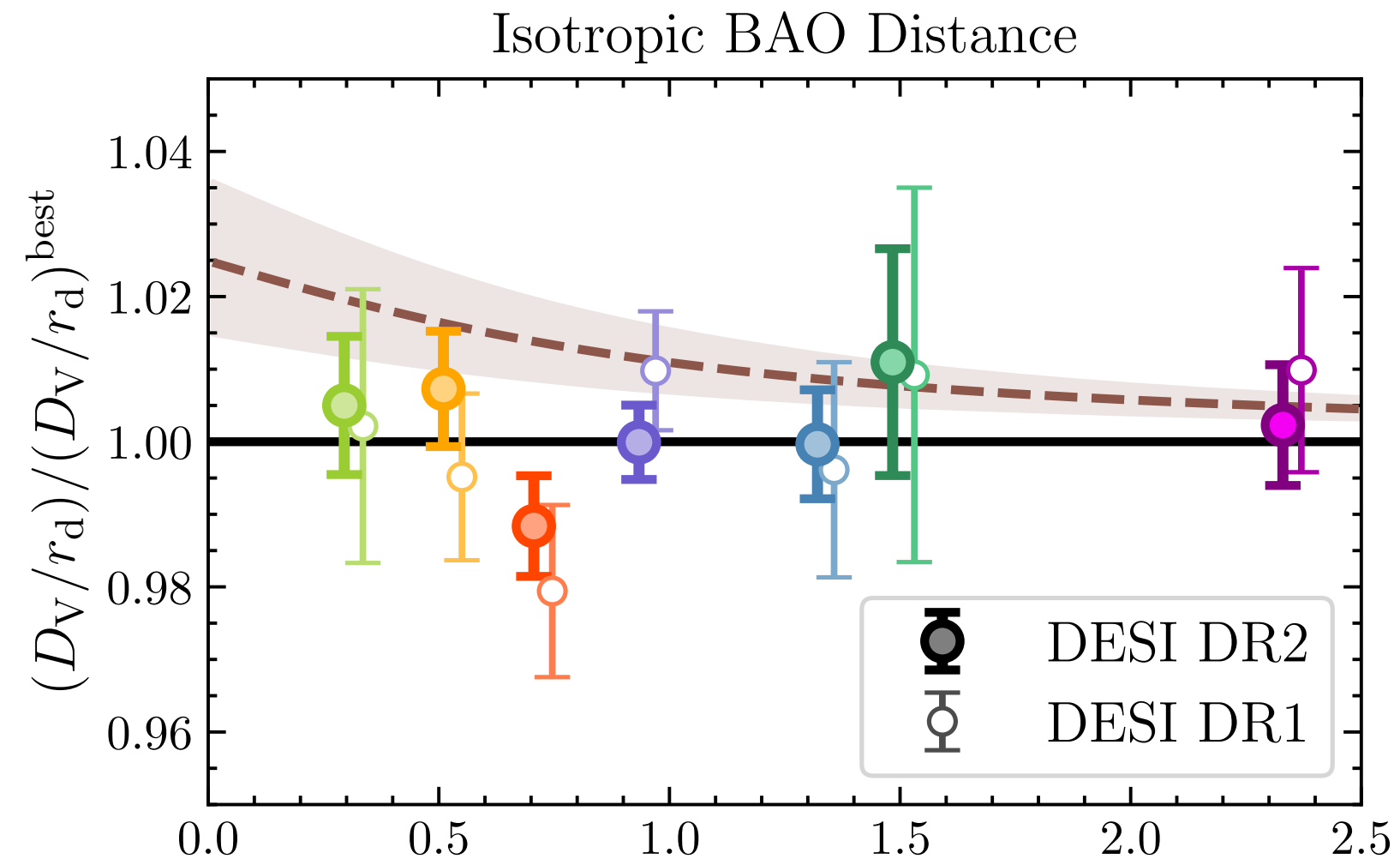
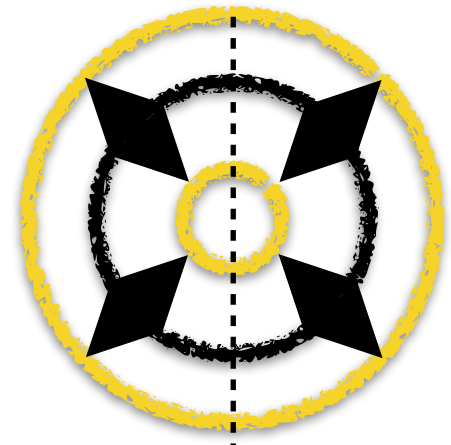


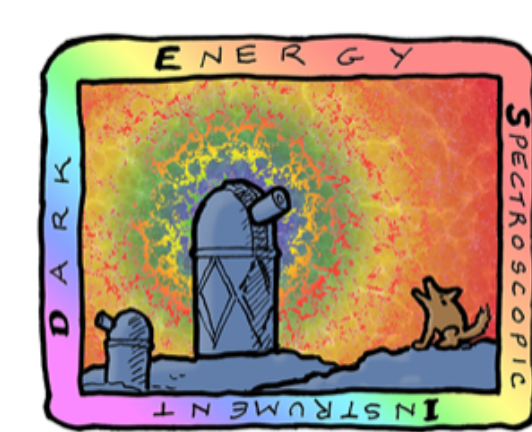


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The DESI BAO DR2 results vs. DR1



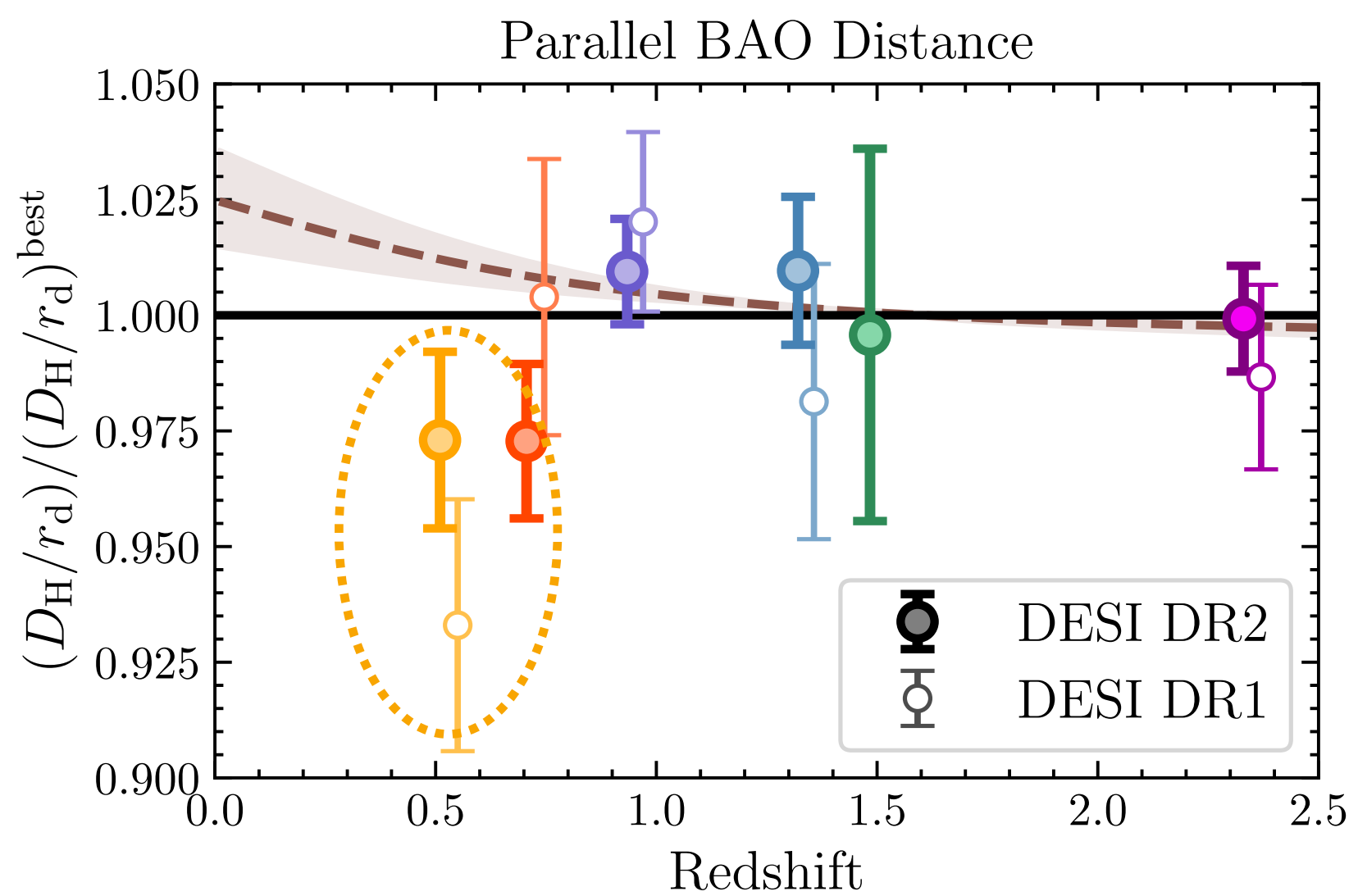
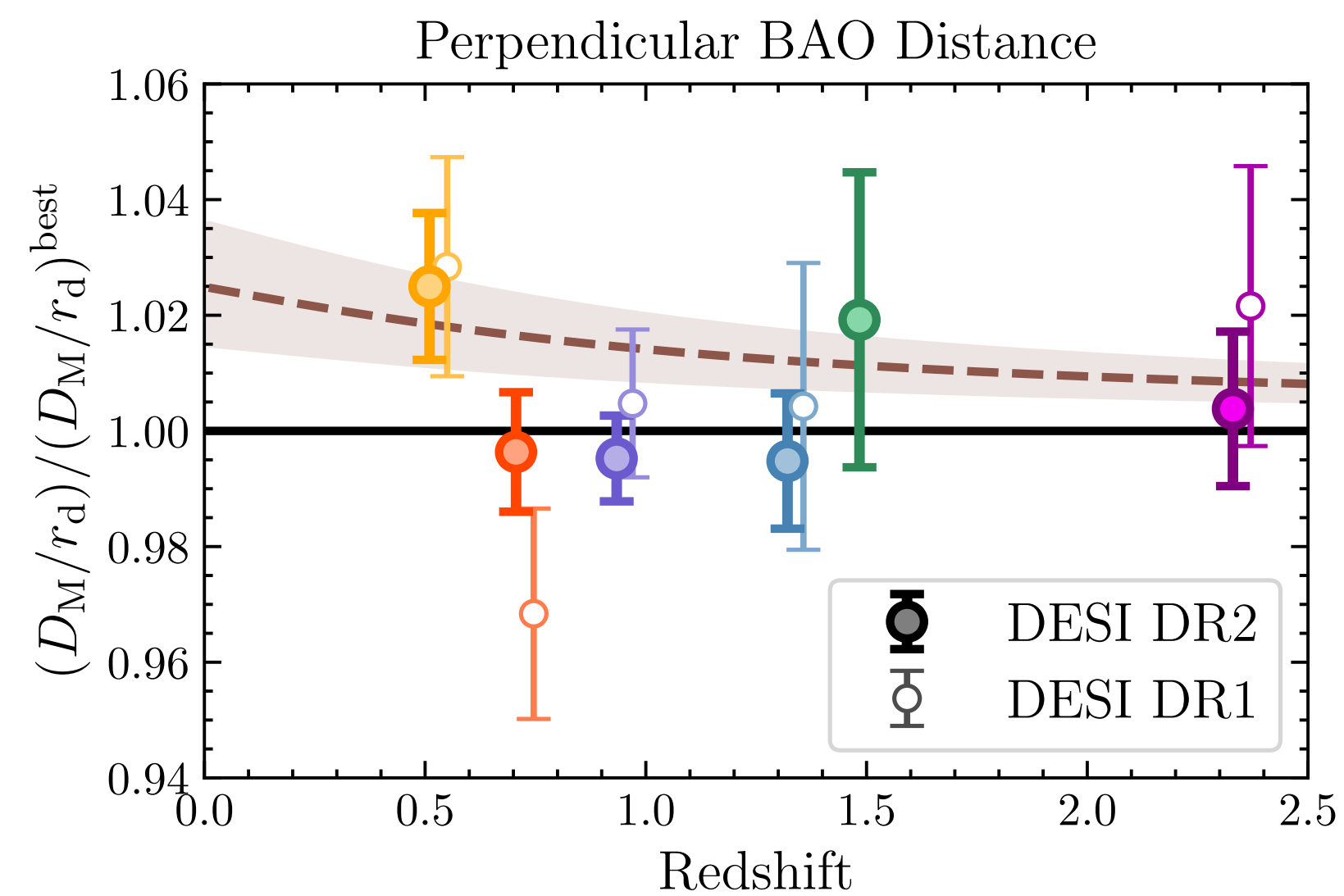
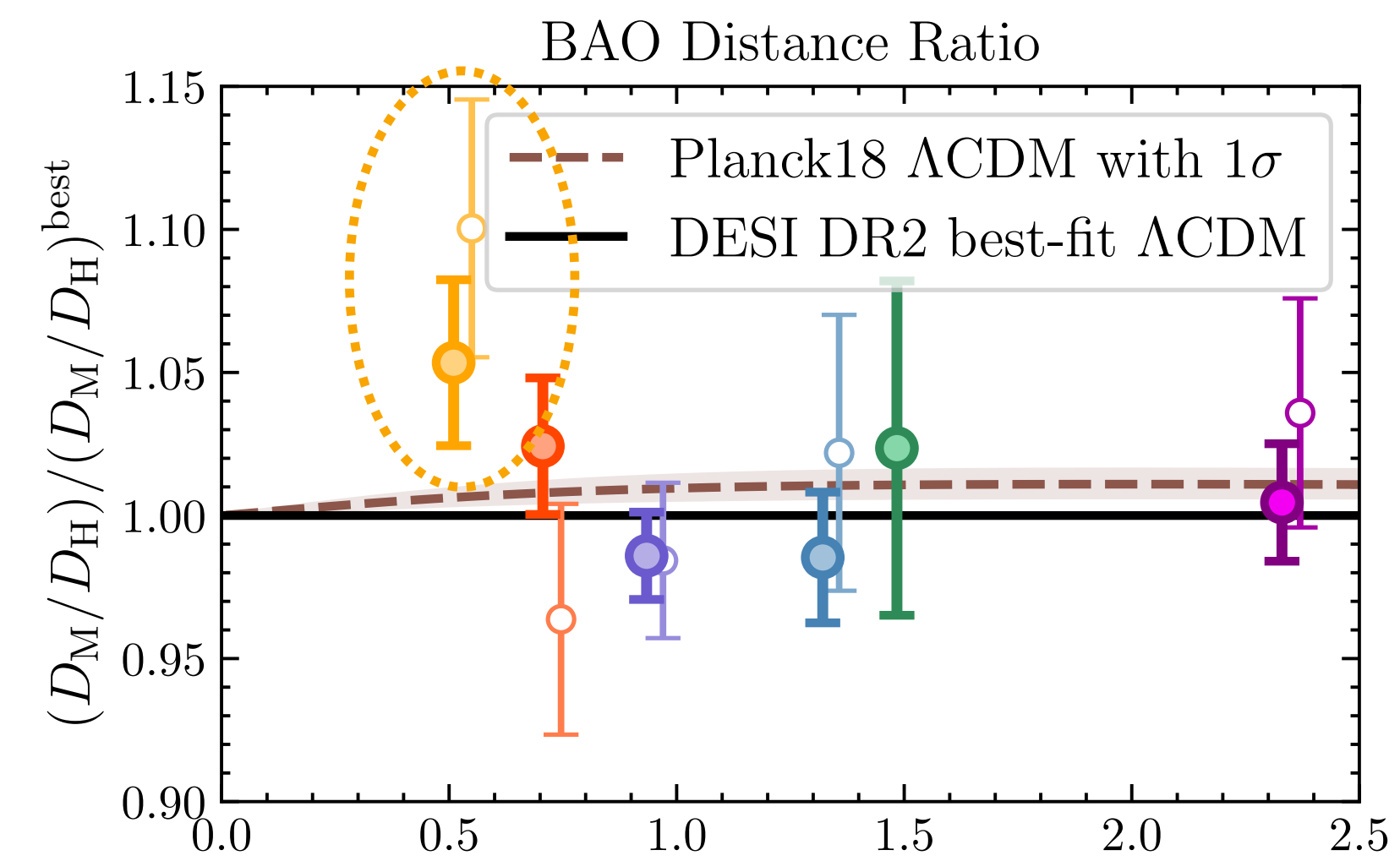
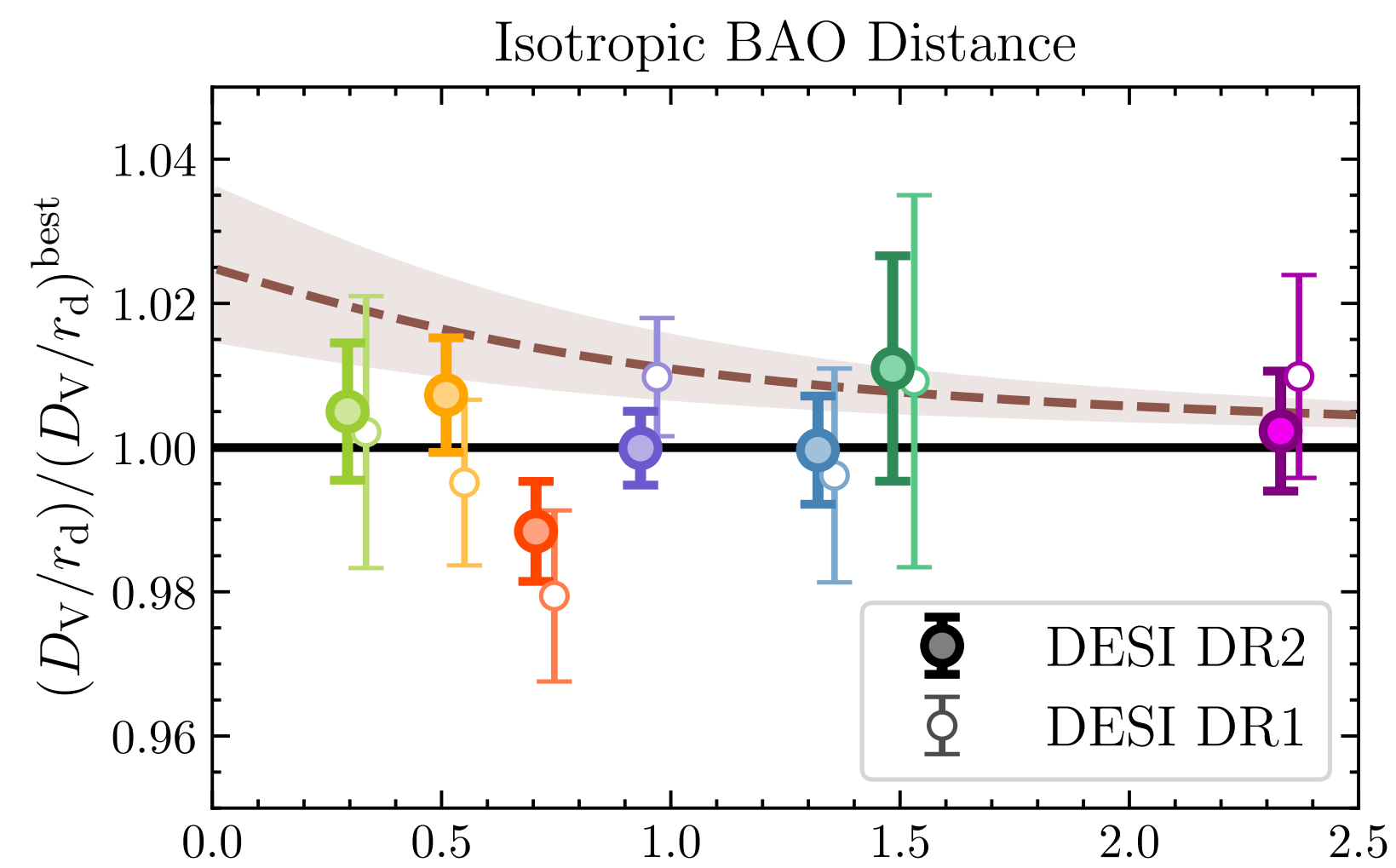


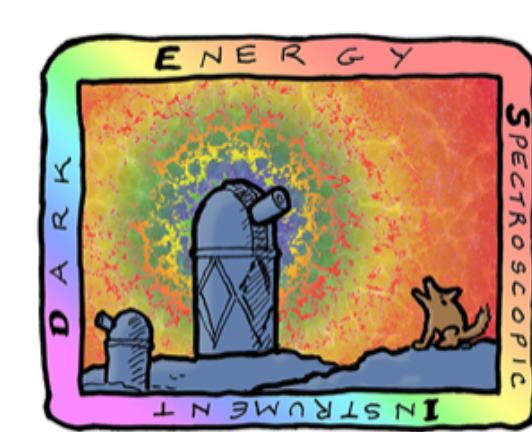
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The DESI BAO DR2 results vs. DR1

LRG1 bin $z=0.51$



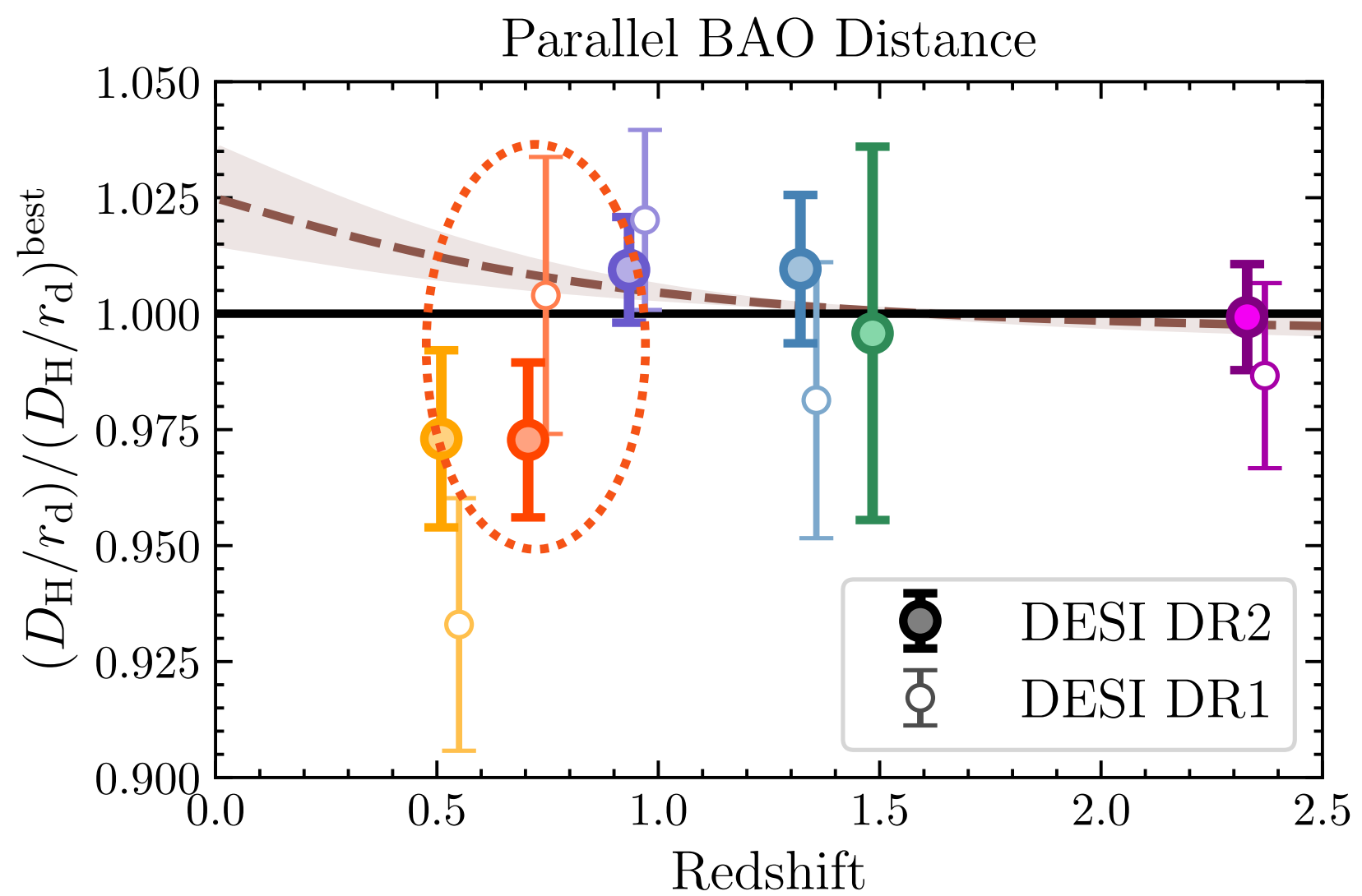
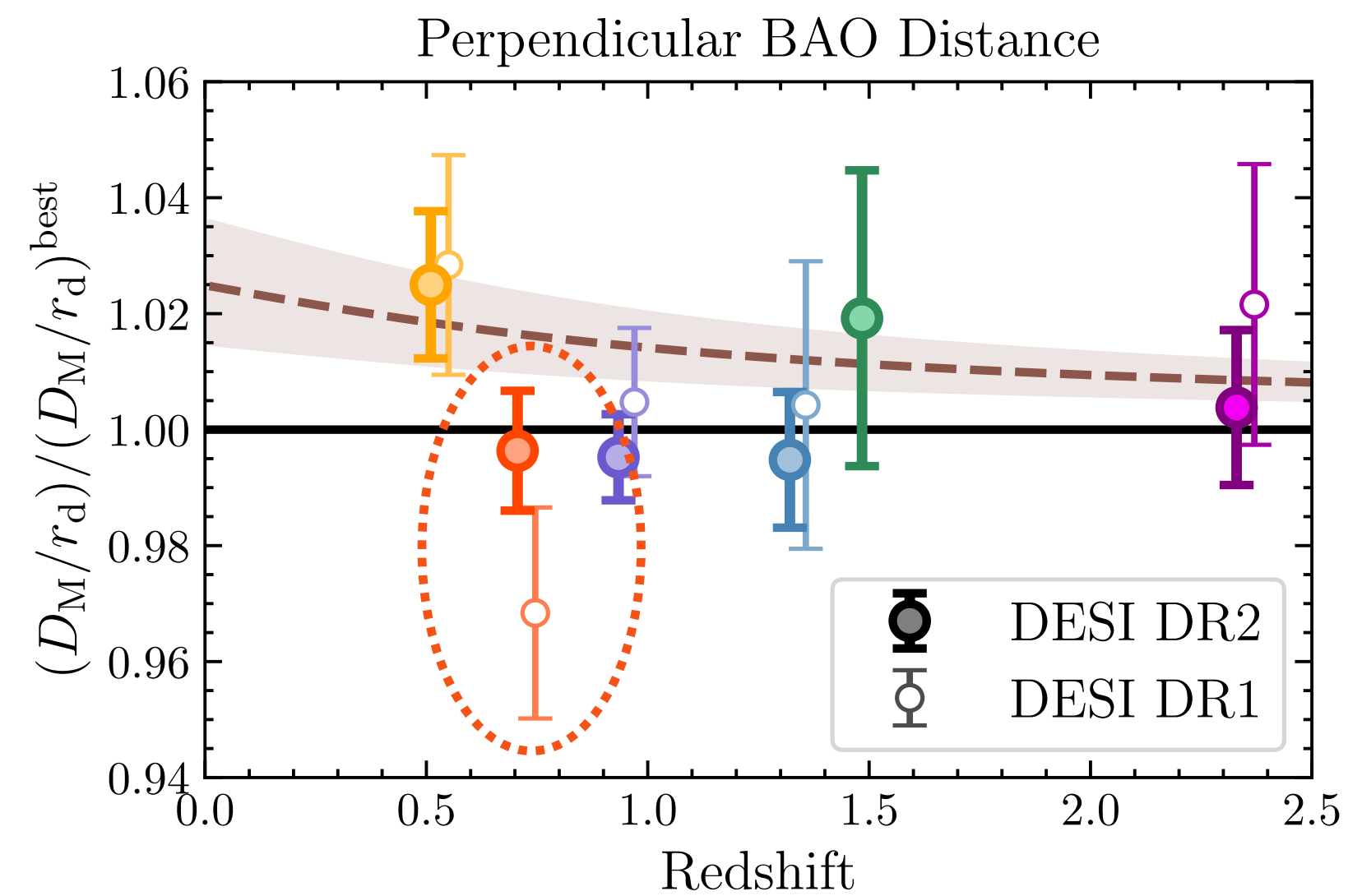
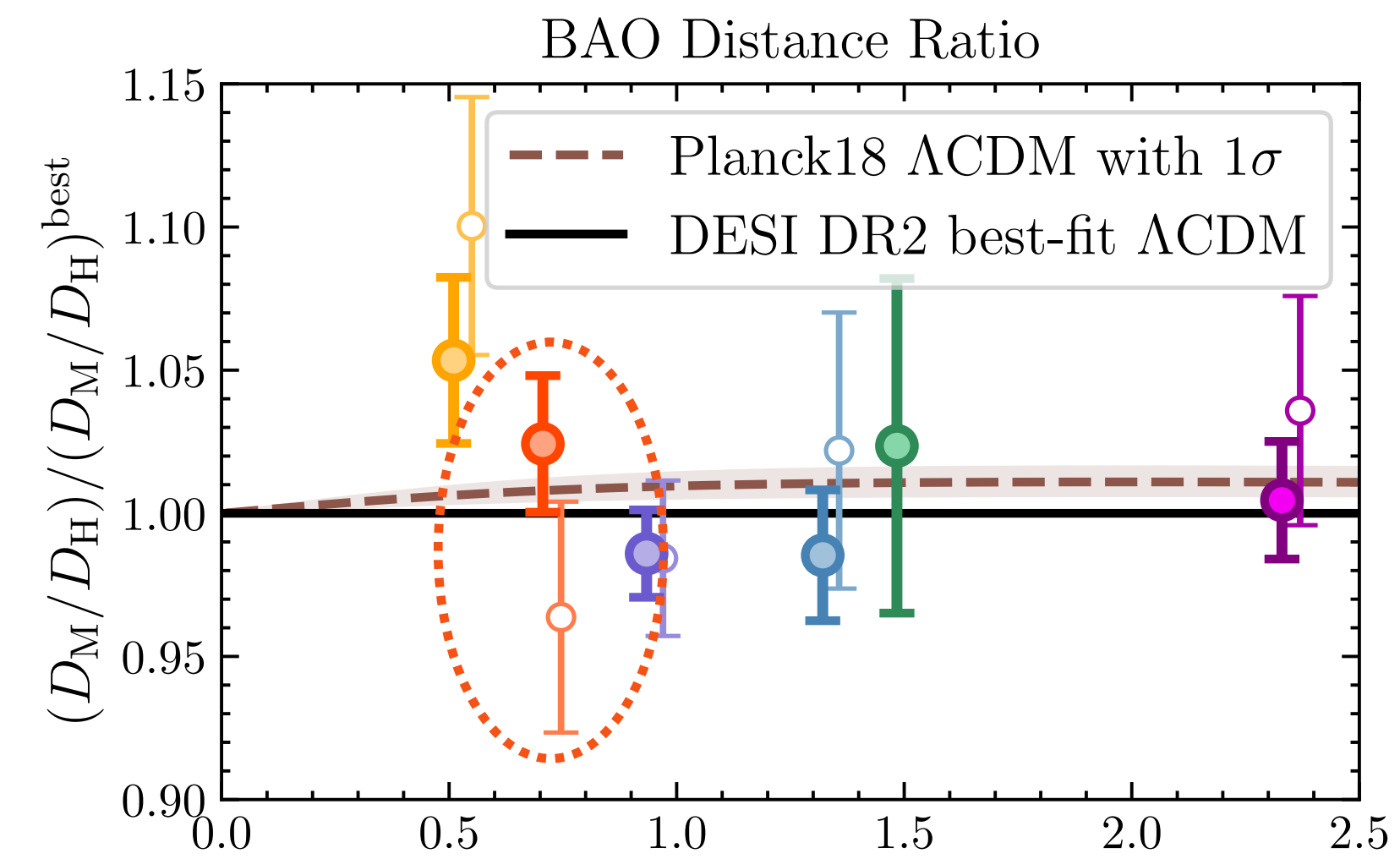
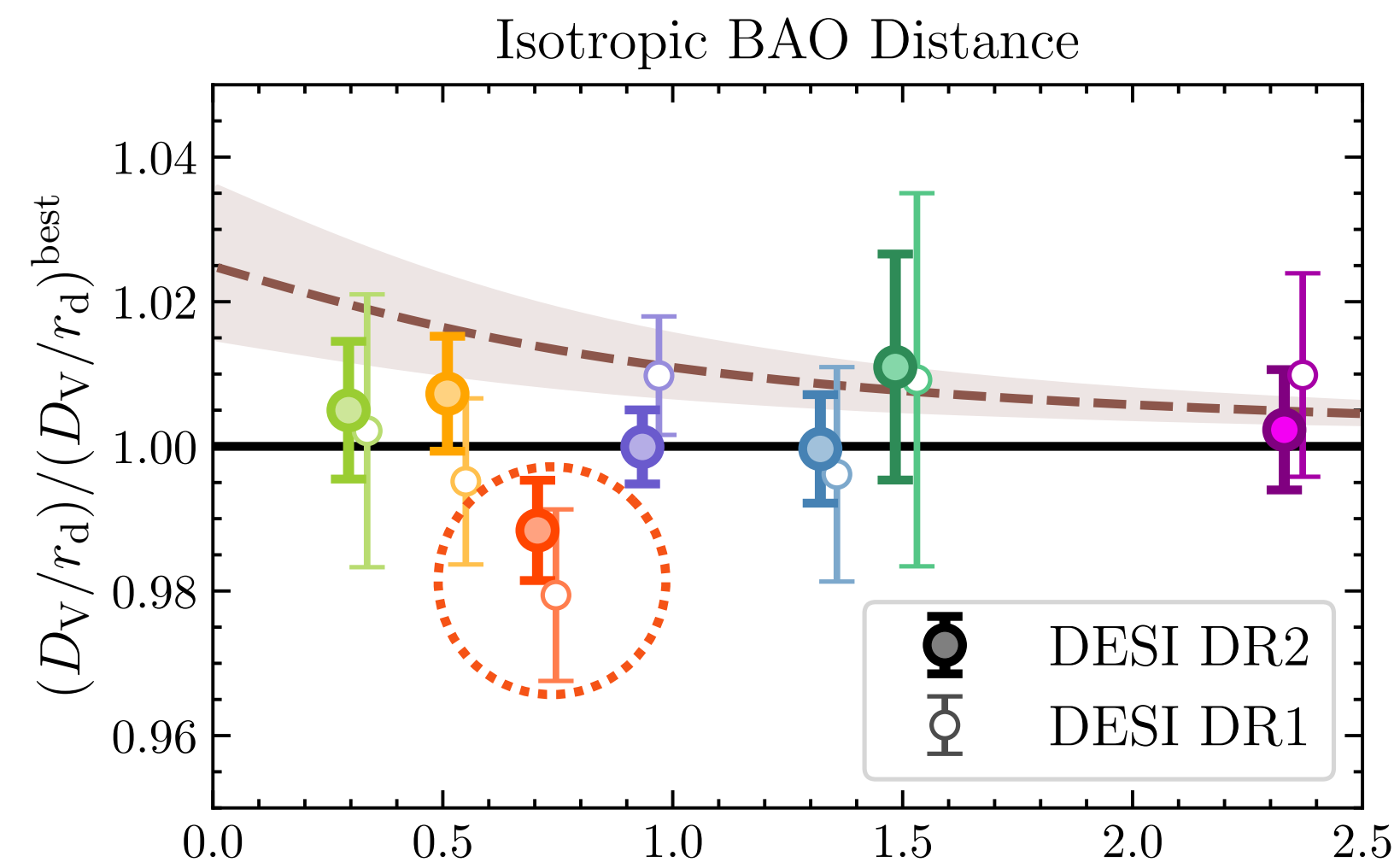


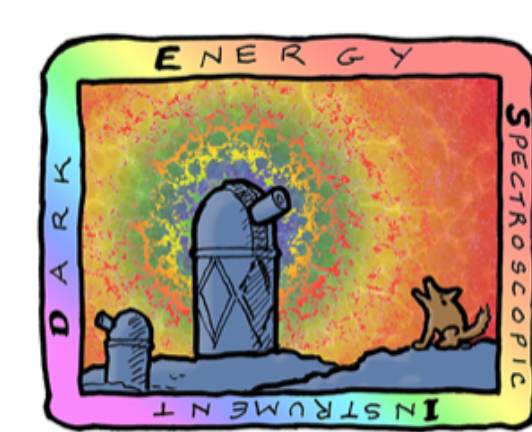
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The DESI BAO DR2 results vs. DR1

LRG2 bin $z=0.71$





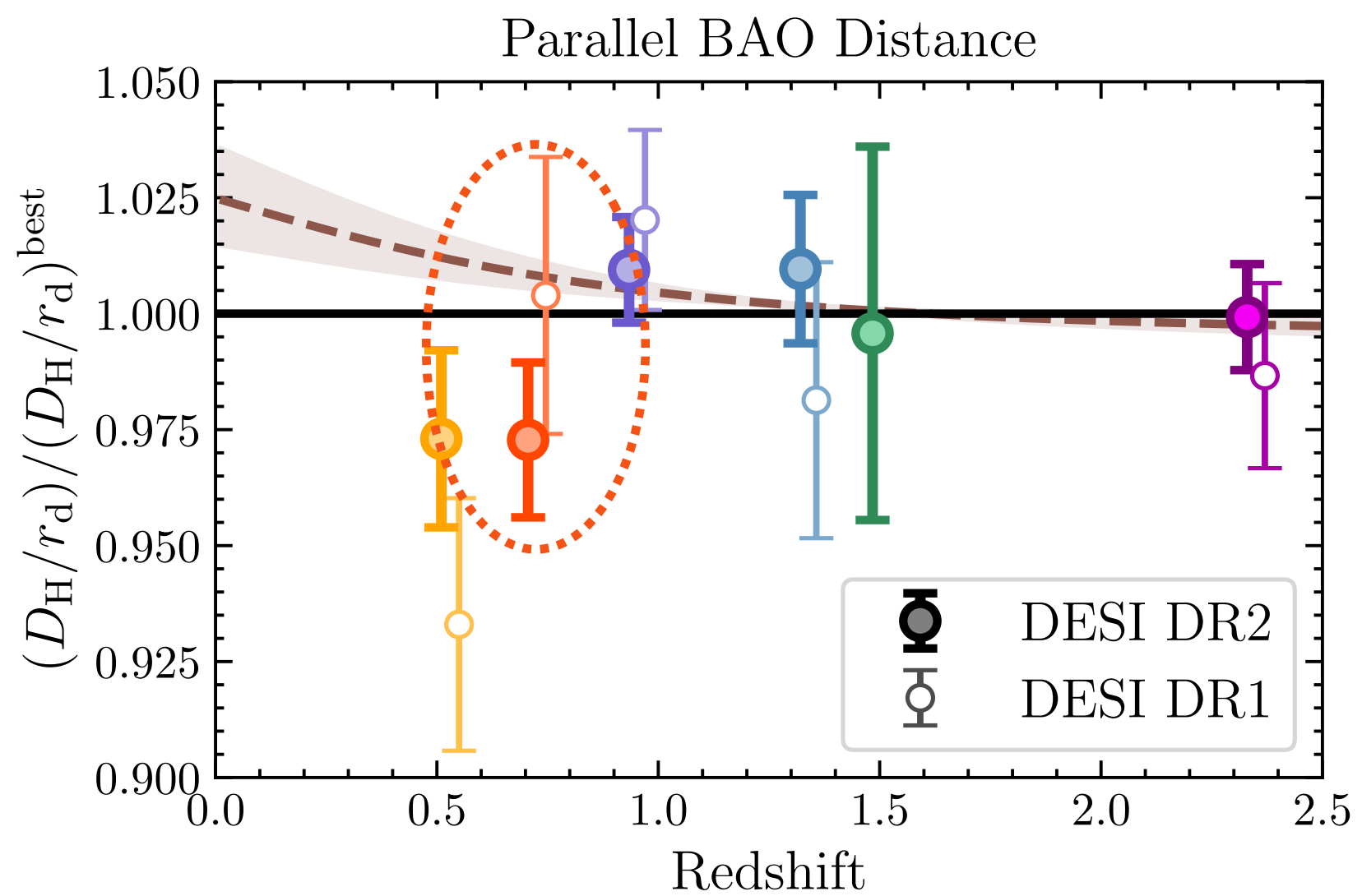
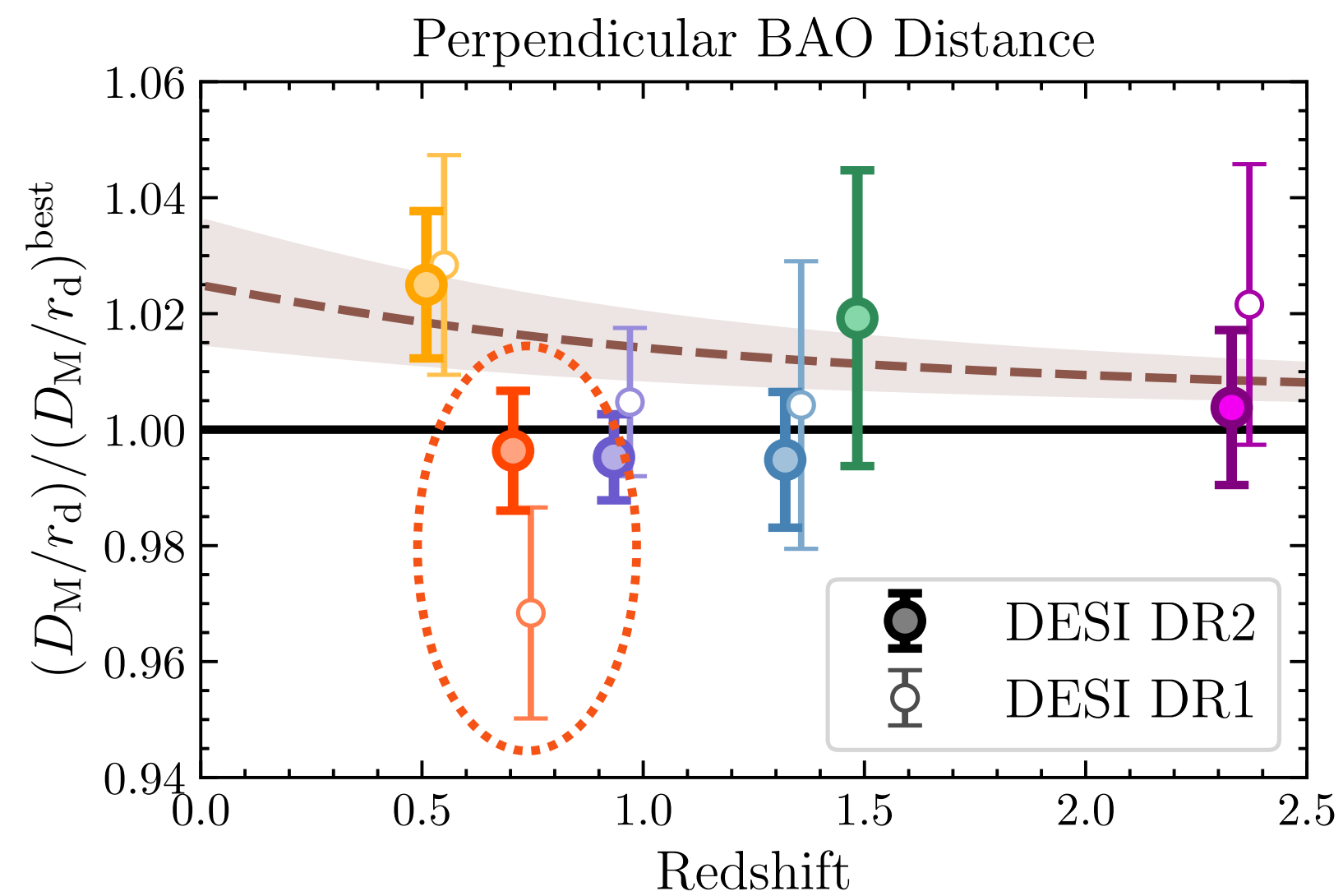
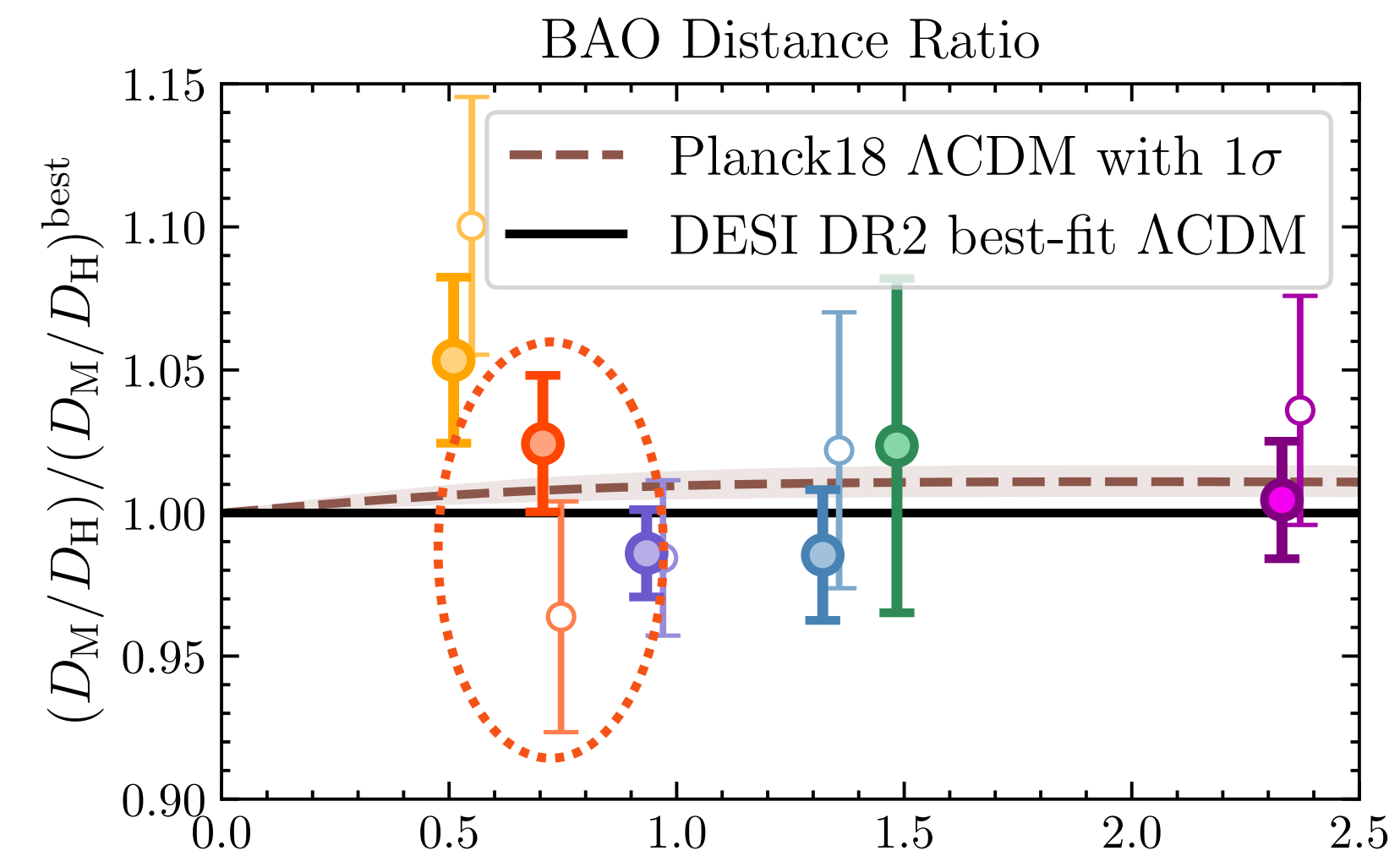
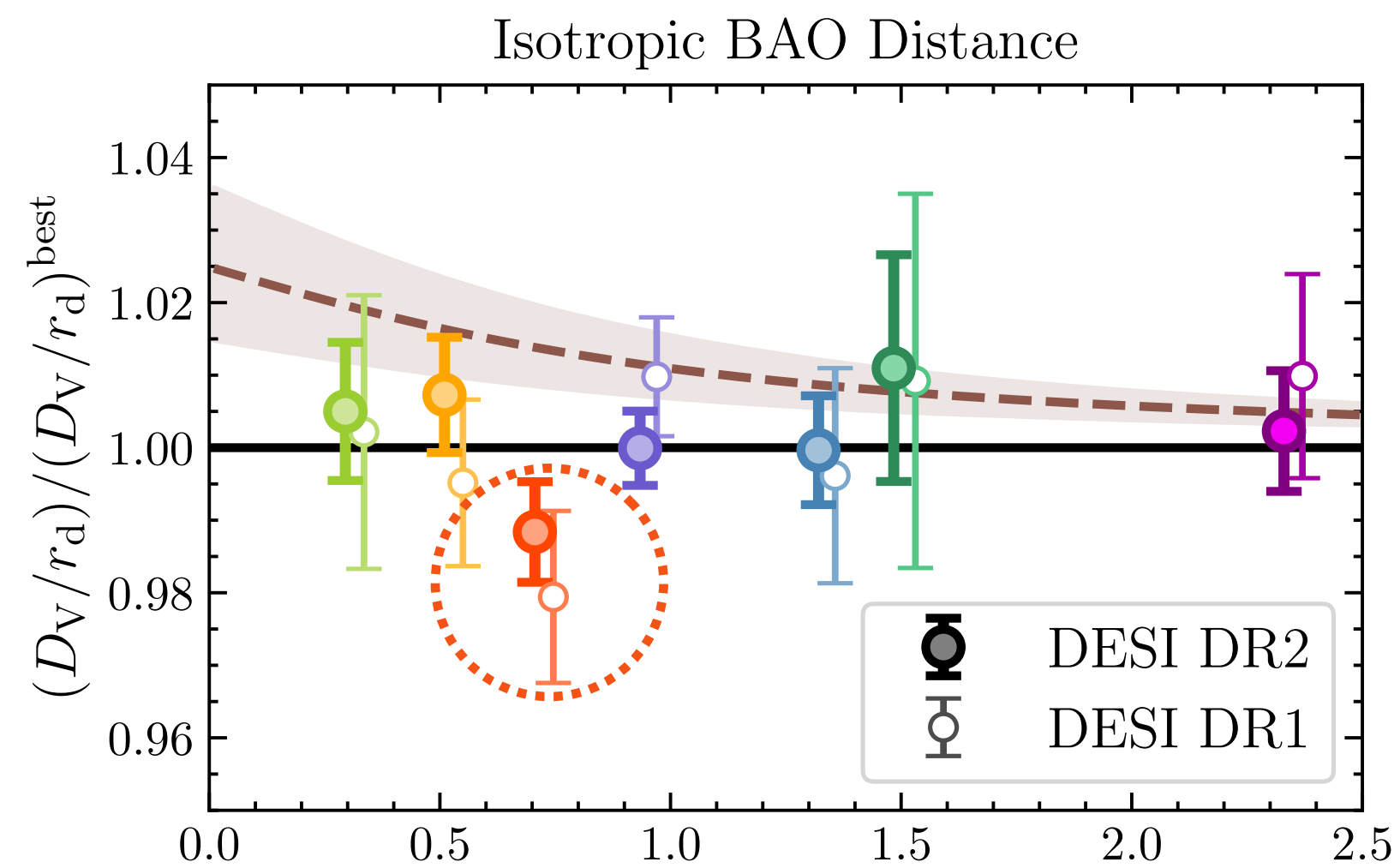
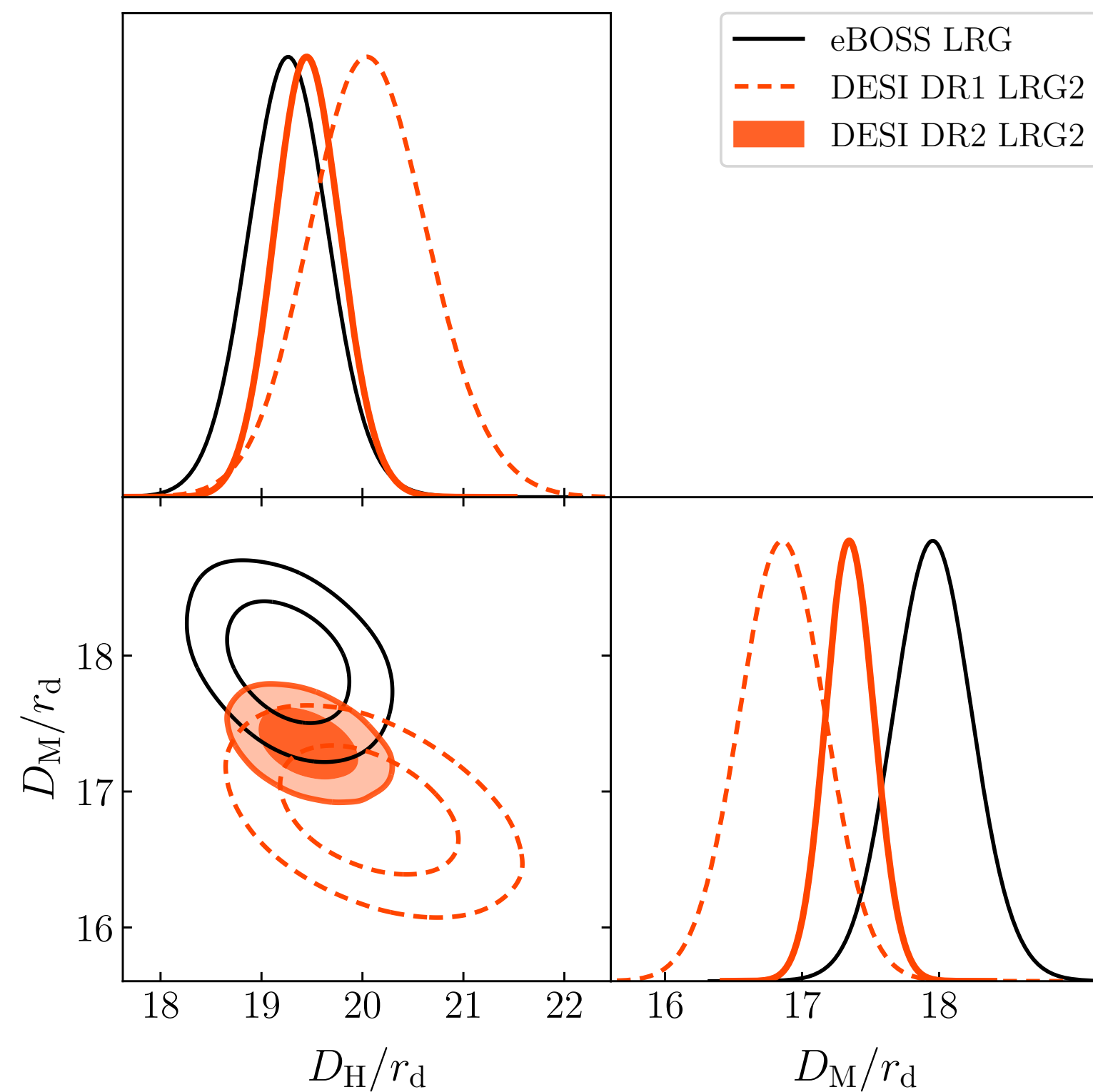
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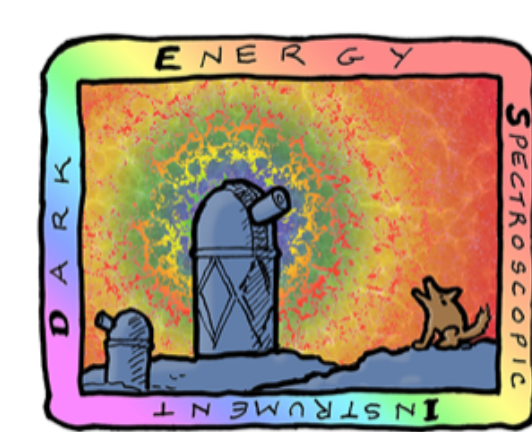
The DESI BAO DR2 results vs. DR1

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LRG2 bin $z=0.71$

Better agreement with previous SDSS





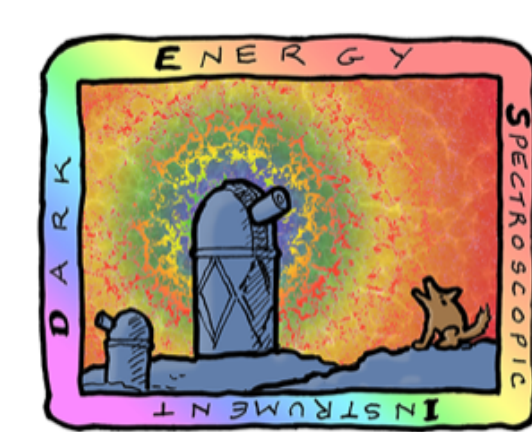
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Implications for Cosmology



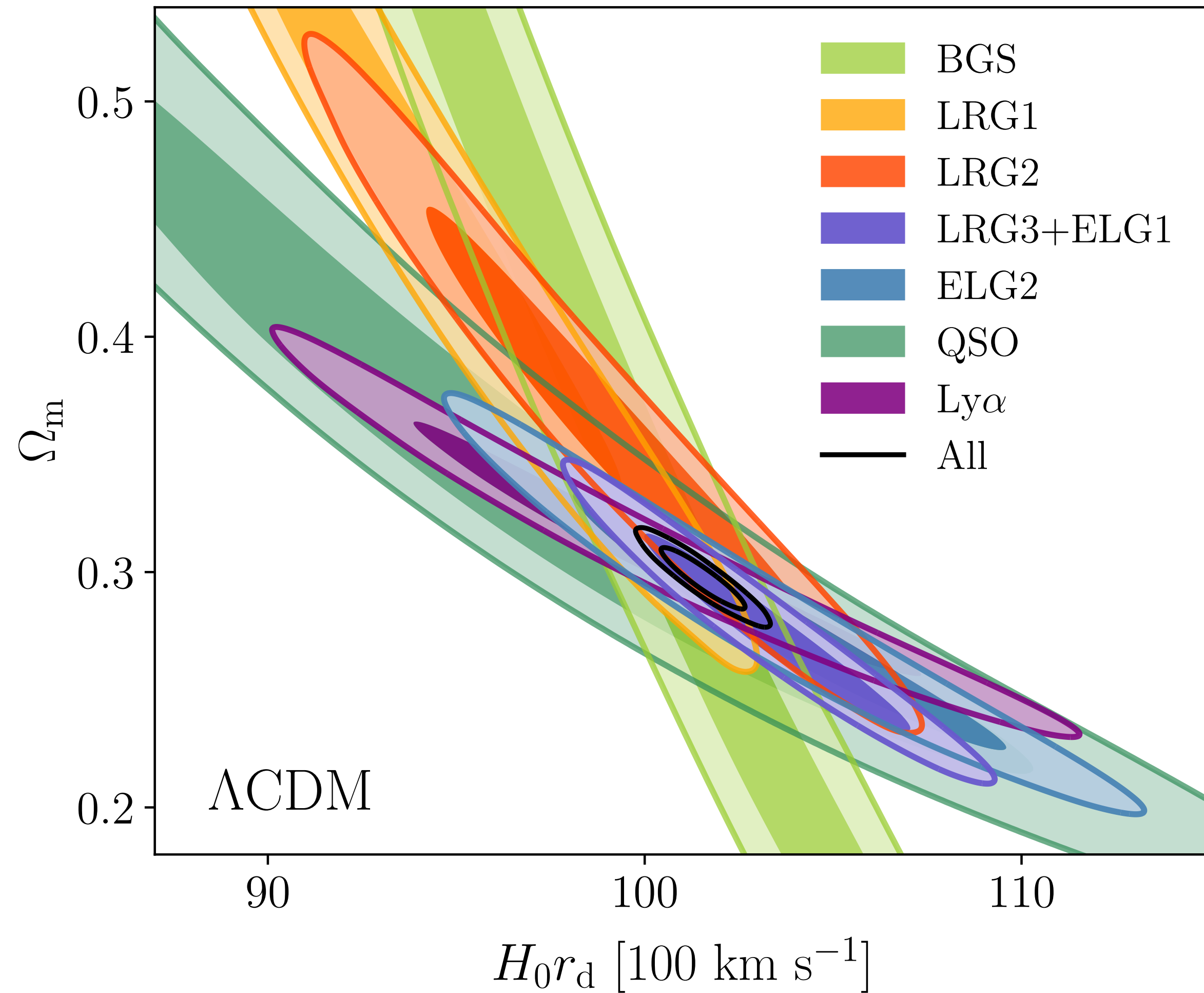
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ΛCDM model



- DESI data alone

$$\Omega_m = 0.2975 \pm 0.0086$$

$$hr_d = (101.54 \pm 0.73) \text{ Mpc}$$

- DESI data + **BBN prior** $\Omega_b h^2$

$$\Omega_m = 0.2977 \pm 0.0086$$

$$h = 0.6851 \pm 0.0058$$

(independent of any CMB data)

- DESI data + **BBN prior** $\Omega_b h^2 + \theta_*$

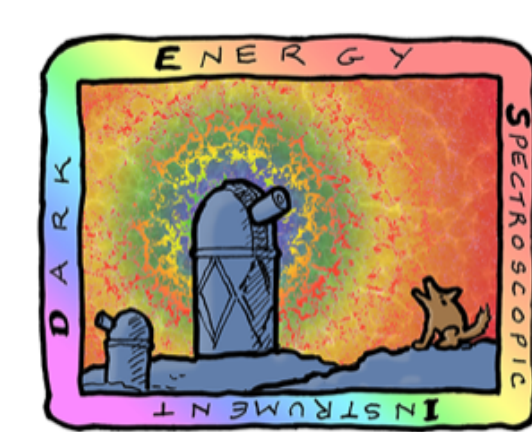
$$\Omega_m = 0.2967 \pm 0.0045$$

$$h = 0.6845 \pm 0.0047$$

(more precise than CMB alone)

Primordial abundances

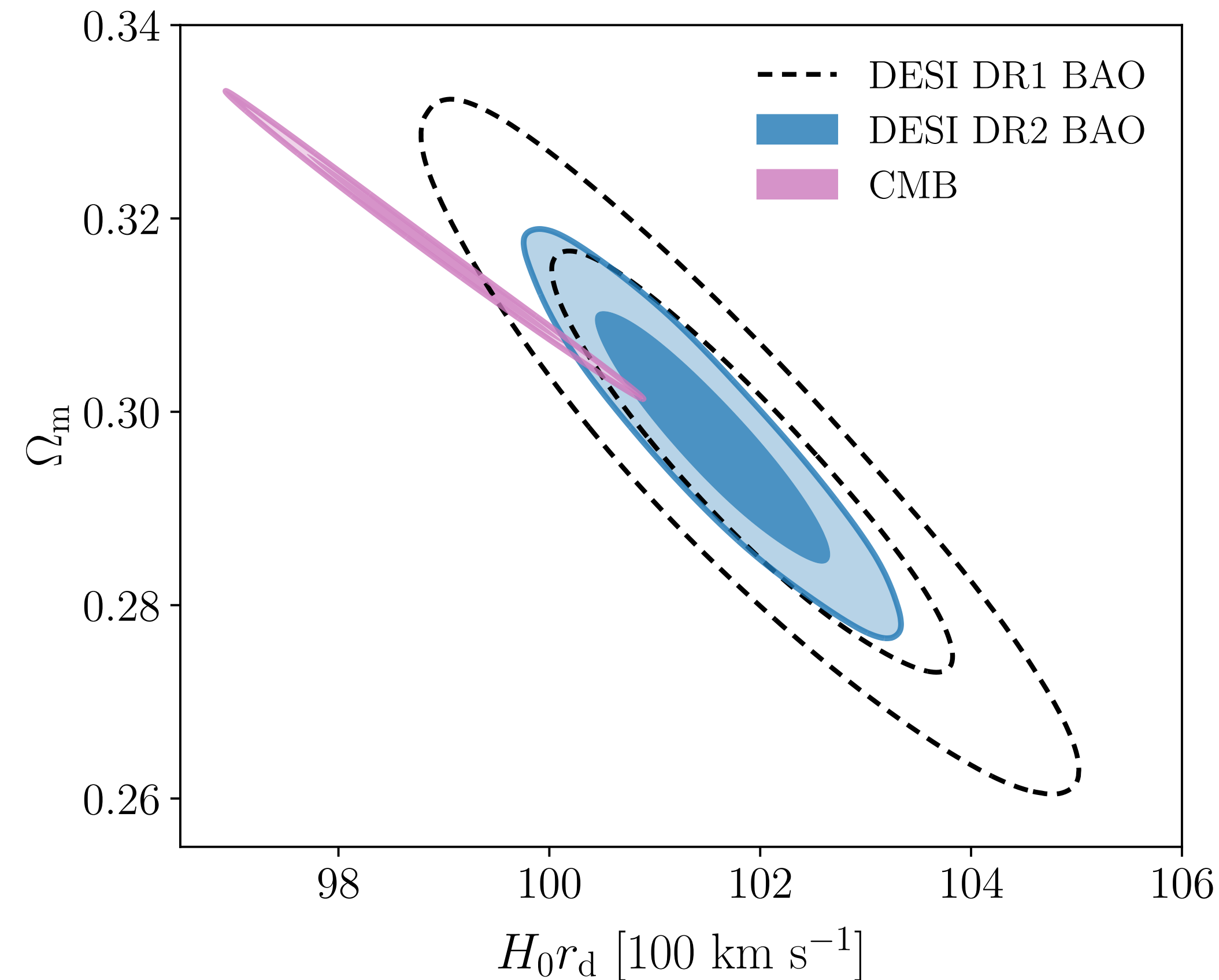
angular BAO on CMB



ΛCDM model

Planck (TT, TE, EE) + ACT (high ℓ & lensing recon)

- Is DESI compatible with Planck CMB within ΛCDM?

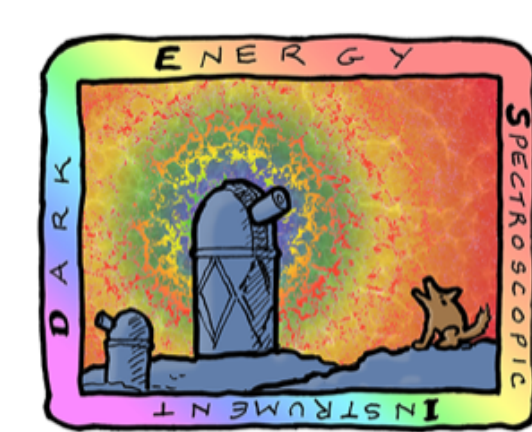


2.3 σ discrepancy between BAO and **CMB** in ΛCDM

- 2.0 σ if CMB lensing excluded
- 1.9 σ in DR1
- Reason why more-flexible than ΛCDM are preferred (come to this in few slides)

We conclude that CMB and DESI BAO can be combined within ΛCDM.

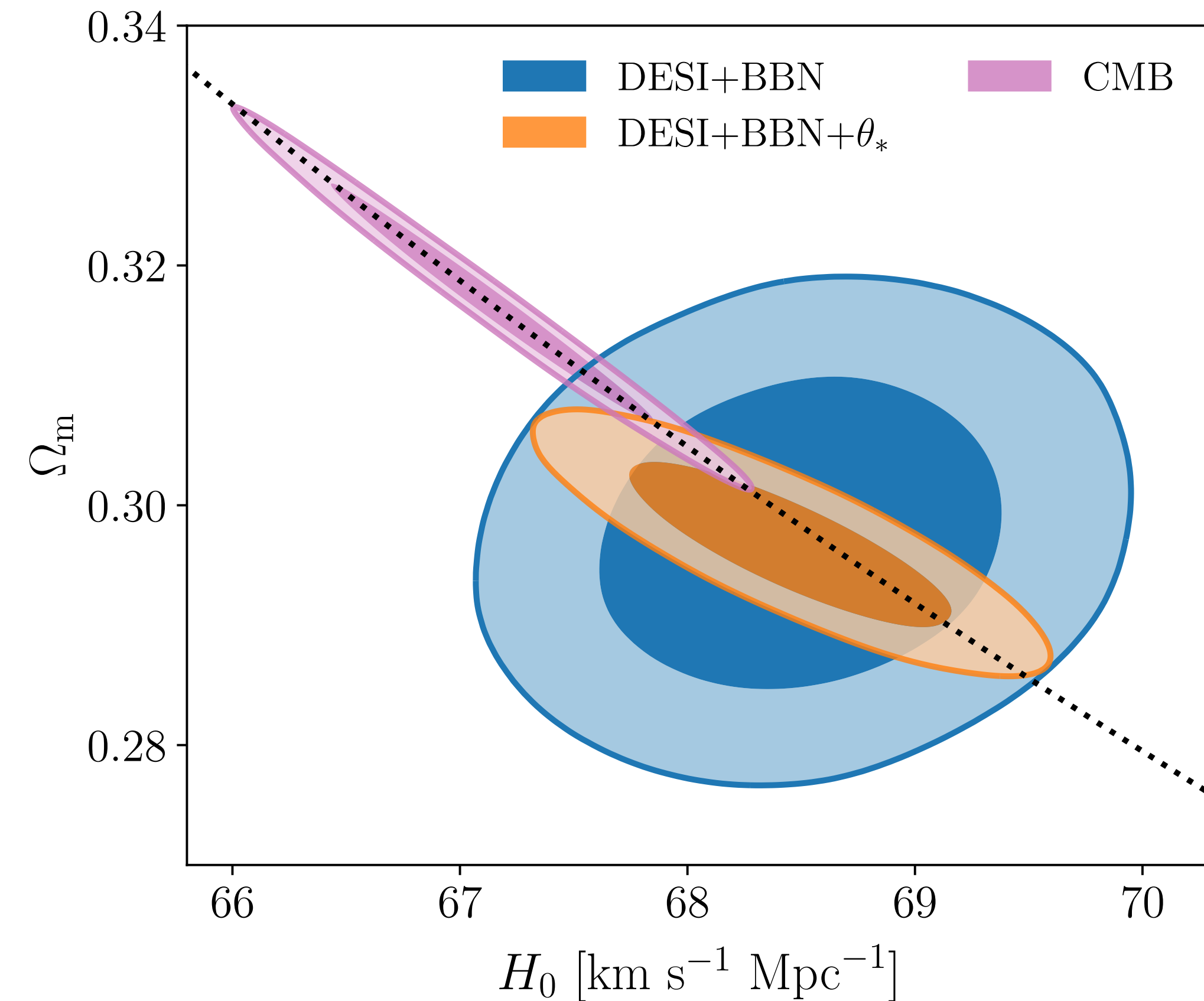
$$\Omega_m = 0.3027 \pm 0.0036$$



ΛCDM model

Planck (TT, TE, EE) + ACT (high ℓ & lensing recon)

- Is DESI(+BBN) compatible with Planck CMB within ΛCDM?



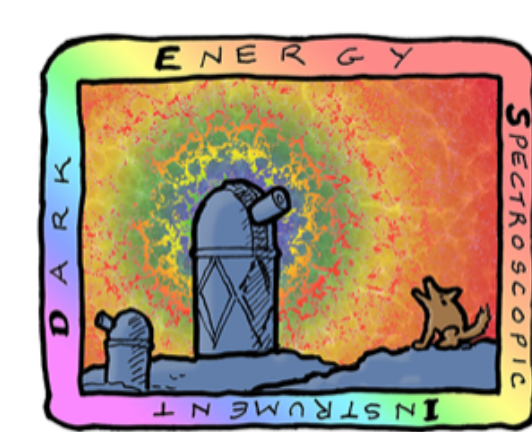
2.3 σ discrepancy between BAO and **CMB** in ΛCDM

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- 1.9 σ in DR1
- Reason why more-flexible than ΛCDM are preferred (come to this in few slides)

We conclude that CMB and DESI BAO can be combined within ΛCDM.

$$\Omega_m = 0.3027 \pm 0.0036$$

$$h = 0.6817 \pm 0.0028$$



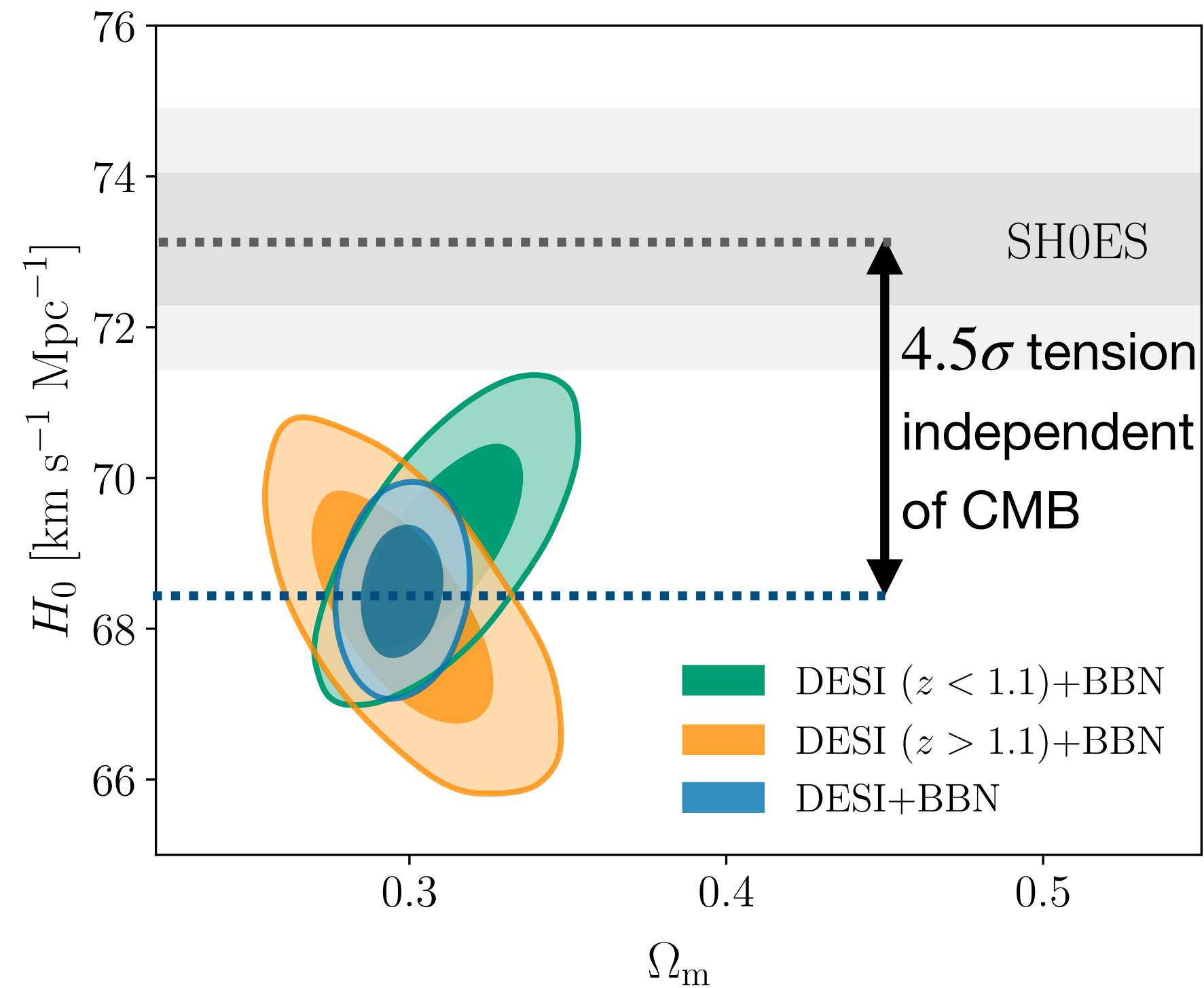
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ΛCDM model

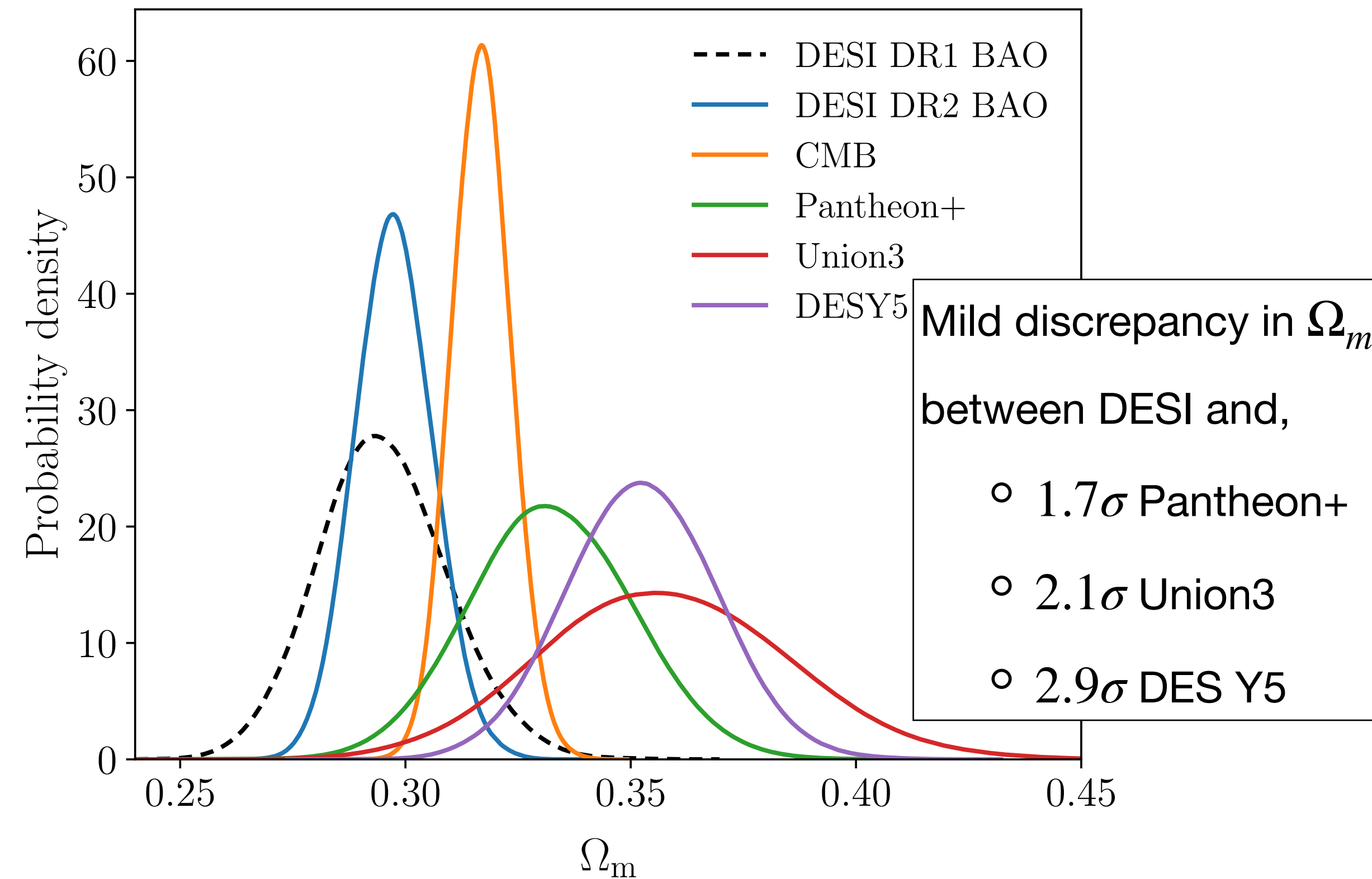
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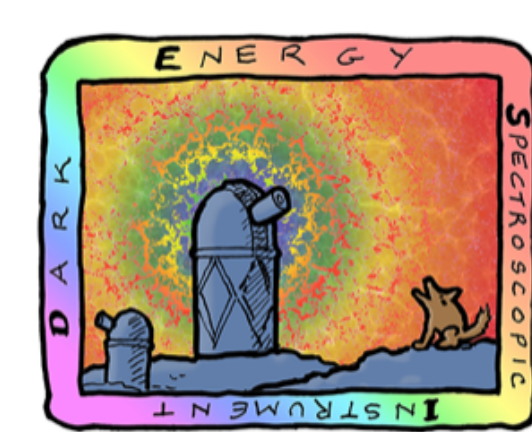
- Is DESI compatible with (un)calibrated SNe data in ΛCDM?

Calibrated



Uncalibrated





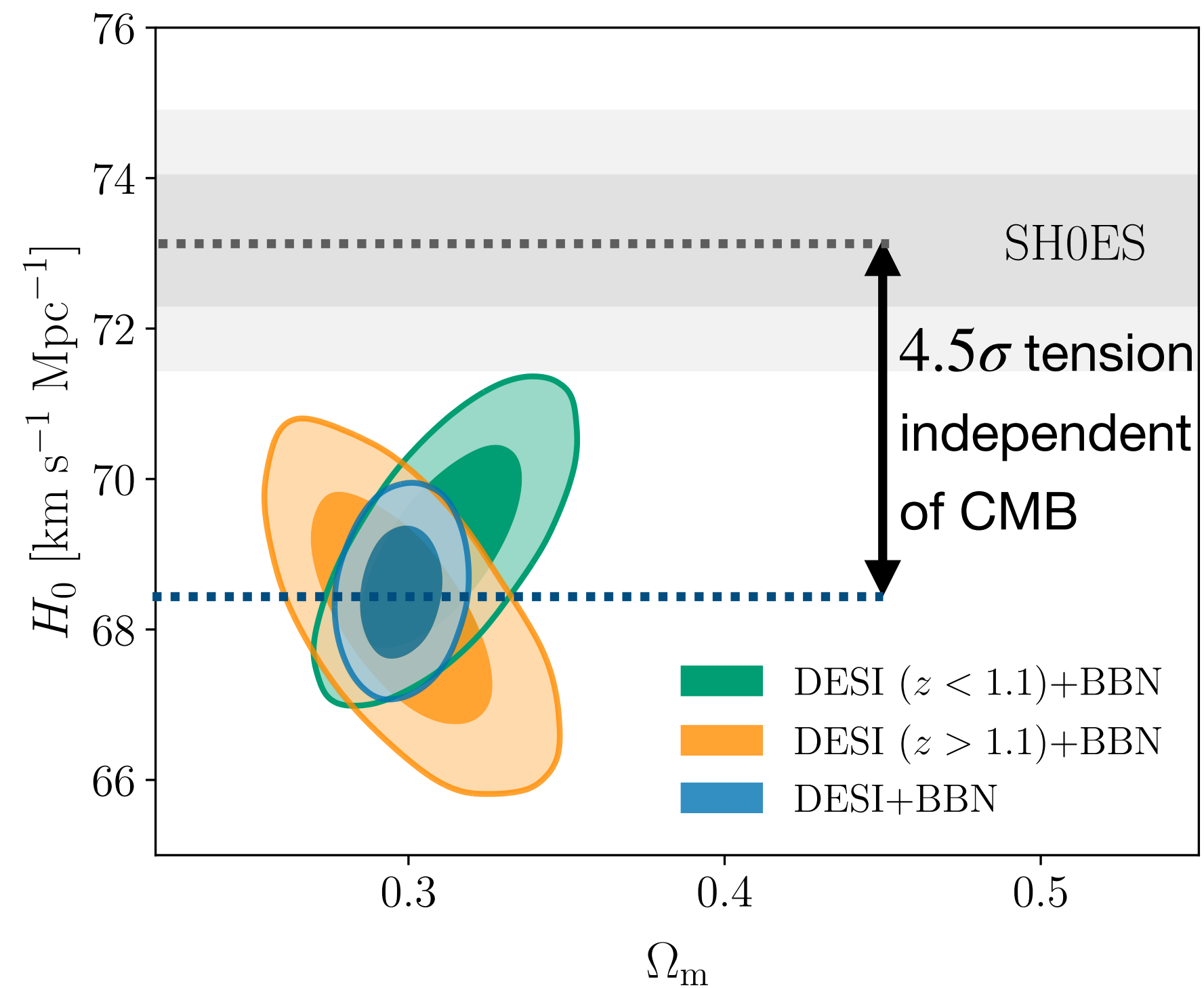
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ΛCDM model

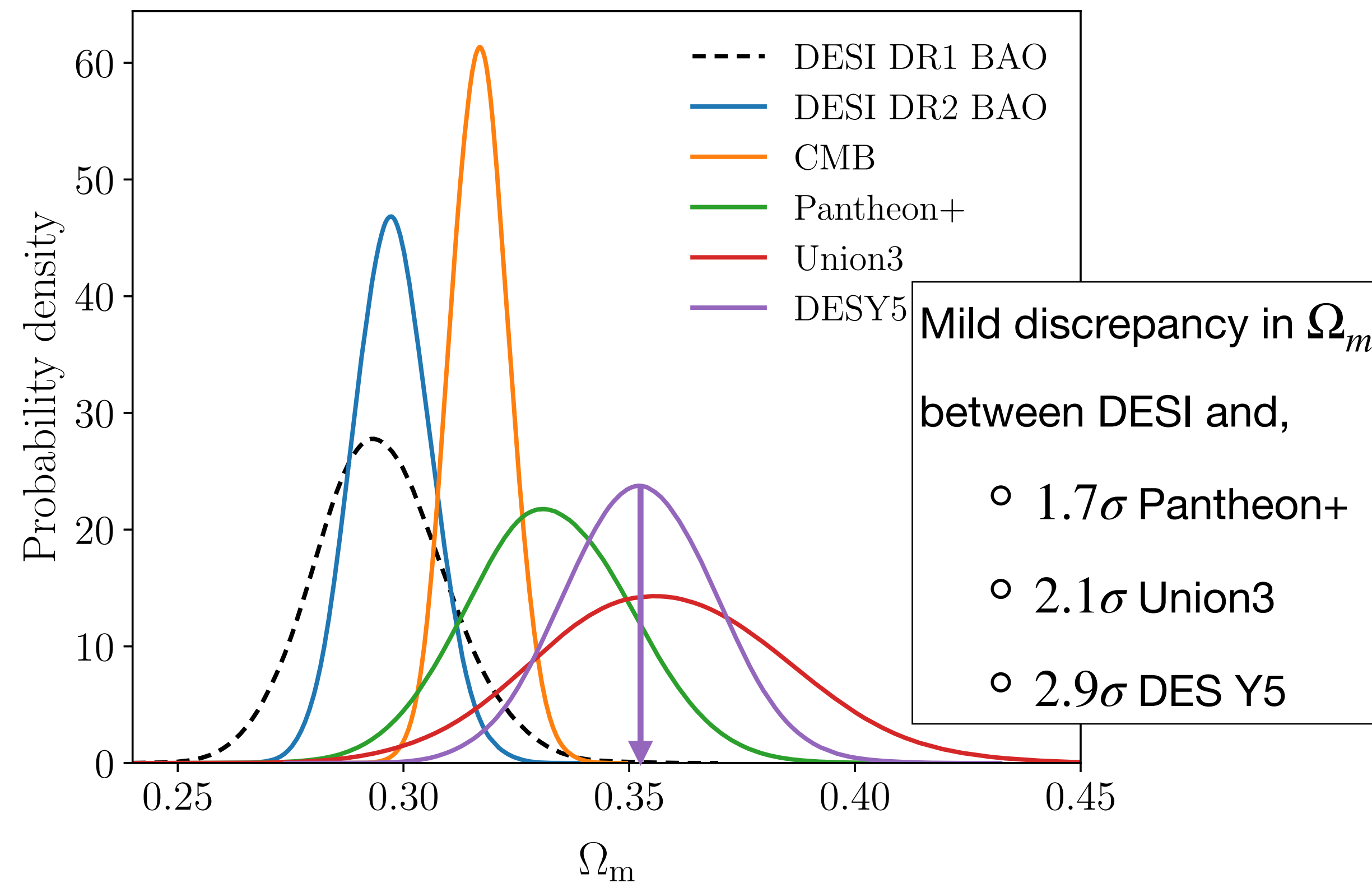
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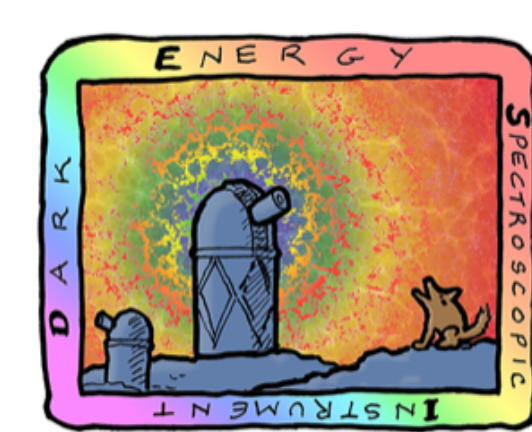
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Calibrated



Uncalibrated





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ΛCDM model

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- Is DESI compatible with (un)calibrated SNe data in ΛCDM?



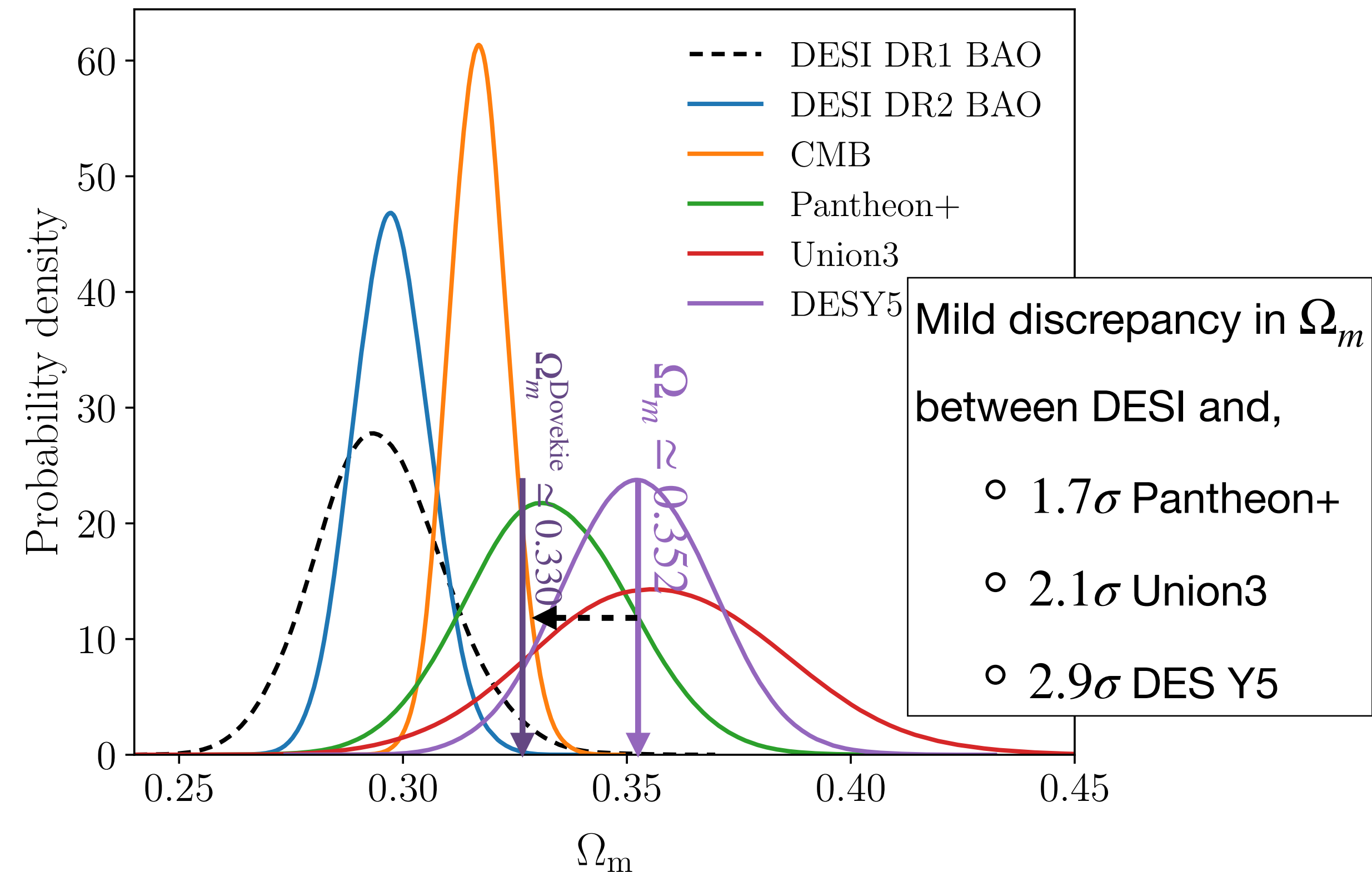
November 2025

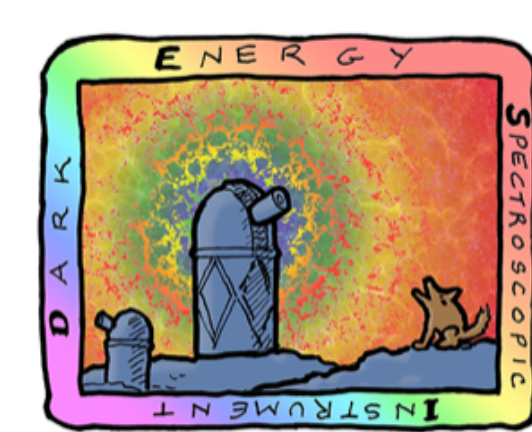
2511.07517

New DES "Dovekie" re-analysis

- Original DES Y5 SNe calibration had a slight redshift-dependent bias.
- In Popovic et al DA White Dwarfs are employed as absolute color standards.
- The team corrected a systematic error that was being misinterpreted as a cosmological signal.
- $\Delta\Omega_m = -0.022$

Uncalibrated





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ΛCDM model

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- Is DESI compatible with (un)calibrated SNe data in ΛCDM?



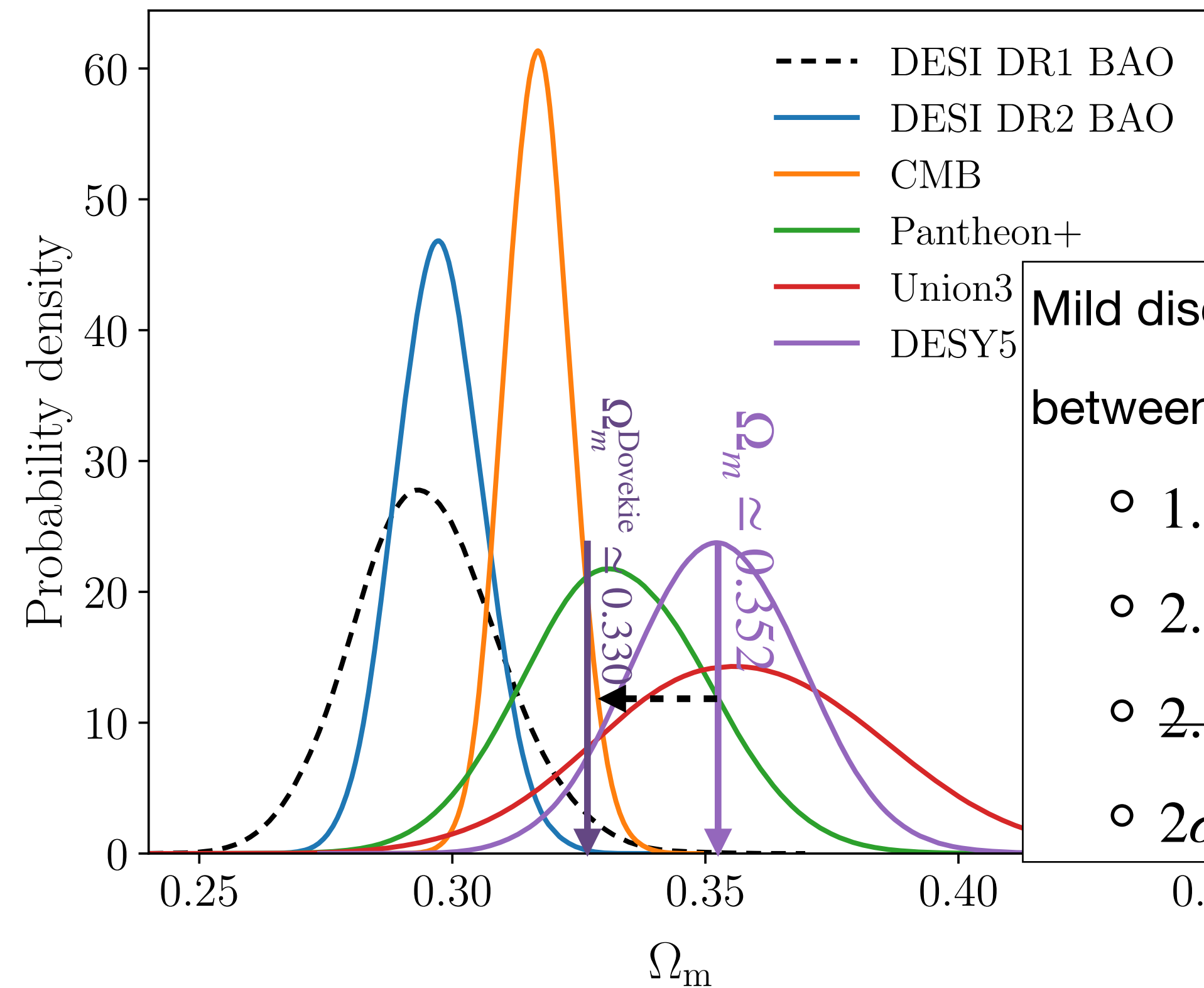
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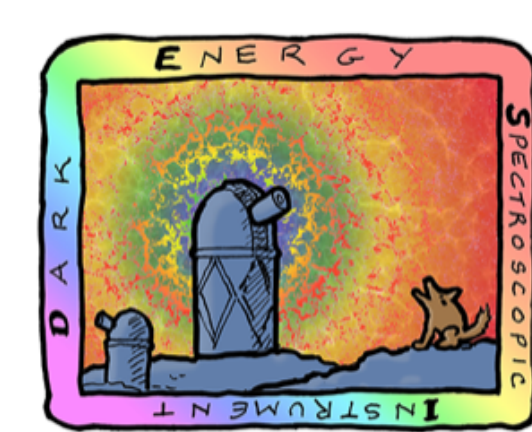
Uncalibrated



Mild discrepancy in Ω_m

between DESI and,

- 1.7σ Pantheon+
- 2.1σ Union3
- ~~2.9σ DES Y5~~
- 2σ DES Y5 Dovek.



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$w_0 w_a$ CDM model

ΛCDM: Dark Energy is a cosmological constant. $w \equiv P/(c^2\rho) = -1$

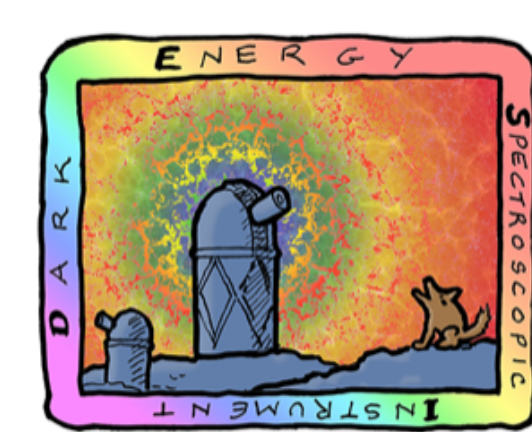
w CDM: Dark Energy is *something* with a fixed equation of state $w < -1/3$

$w_0 w_a$ CDM: Dark Energy is *something* with a time-evolving equation of state $w(z)$

$$w(a) = w_0 + w_a(1 - a)$$

Present day value

Time-dependence variable

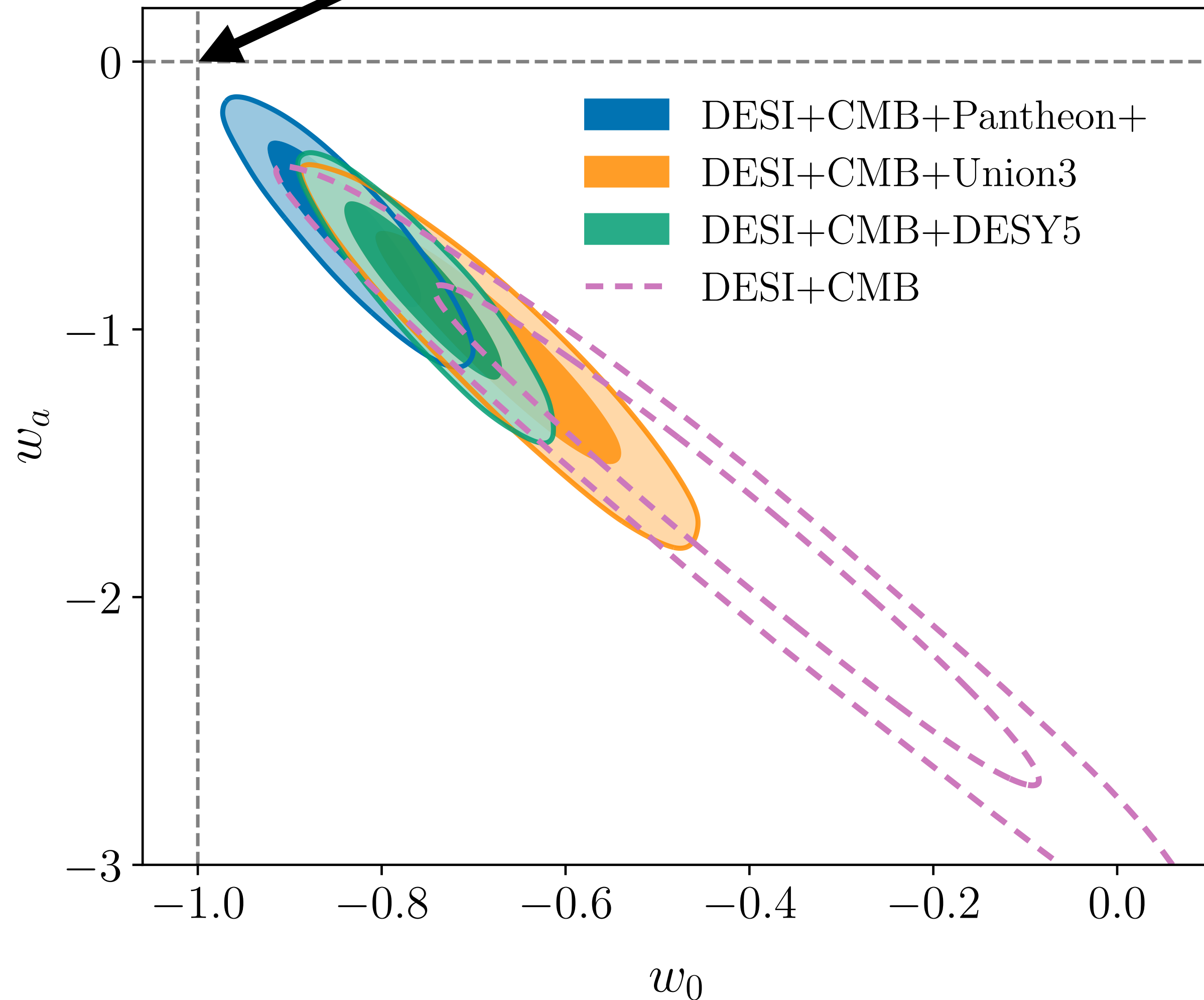


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w_0w_a CDM model

LCDM is here

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DESI alone is consistent with LCDM.

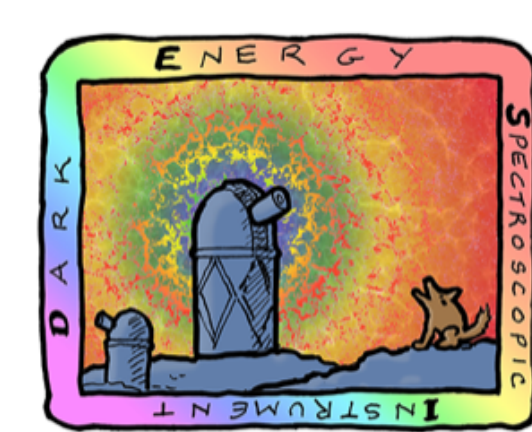
DESI + external data prefers w_0w_a CDM at,

3.1 σ DESI + (full) CMB

2.8 σ DESI + (full) CMB + Pantheon+

3.8 σ DESI + (full) CMB + Union3

4.2 σ DESI + (full) CMB + DES Y5

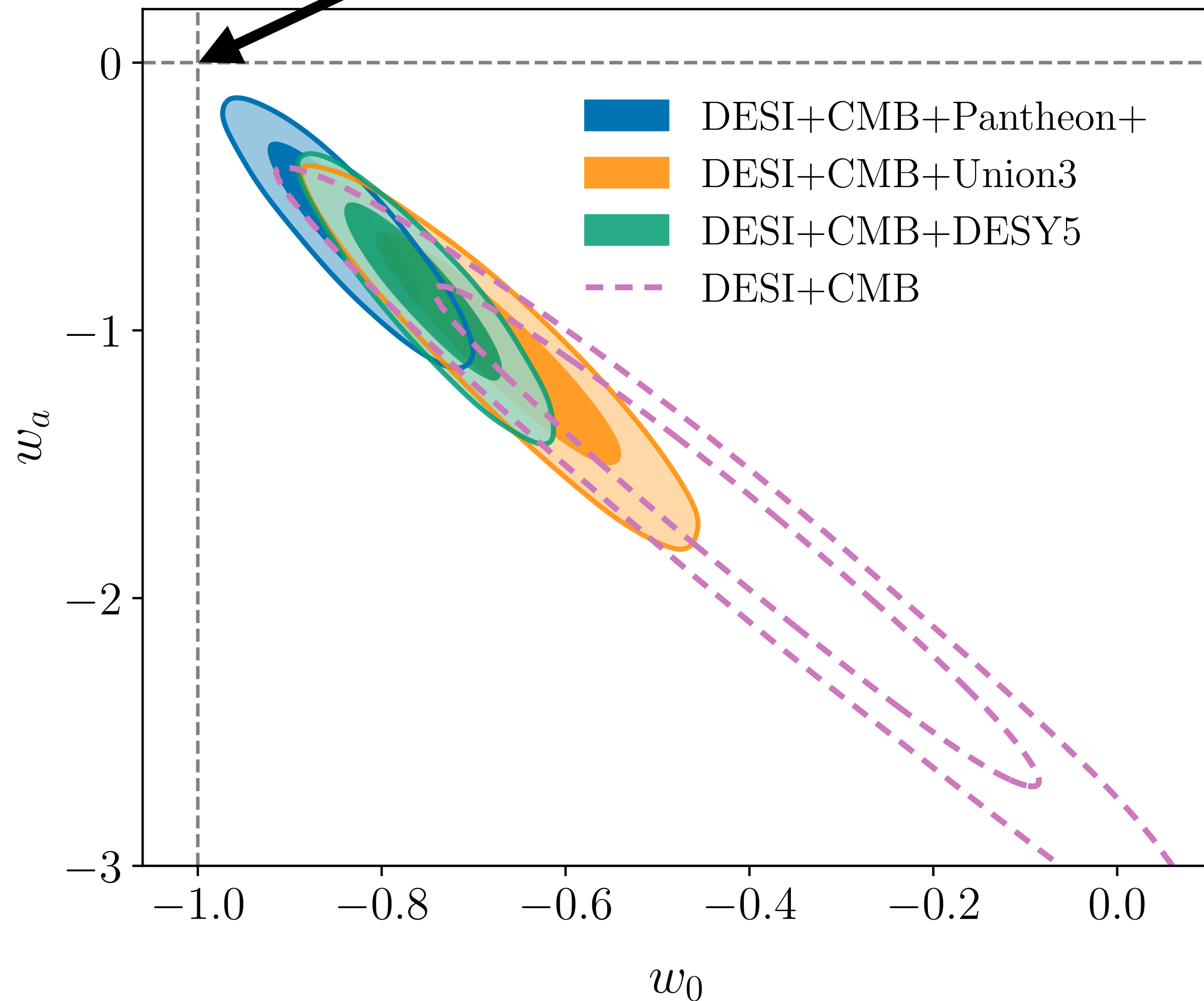


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w_0w_a CDM model

LCDM is here

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DESI alone is consistent with LCDM.

DESI + external data prefers w_0w_a CDM at,

3.1 σ DESI + (full) CMB

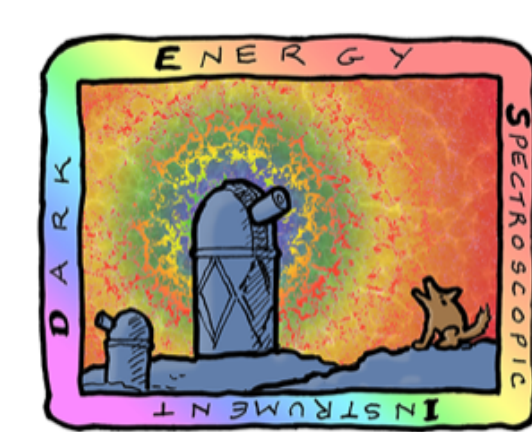
2.8 σ DESI + (full) CMB + Pantheon+

3.8 σ DESI + (full) CMB + Union3

~~4.2 σ DESI + (full) CMB + DES Y5~~

3.2 σ DESI + (full) CMB + DES Y5

w. Dovekie recalibration

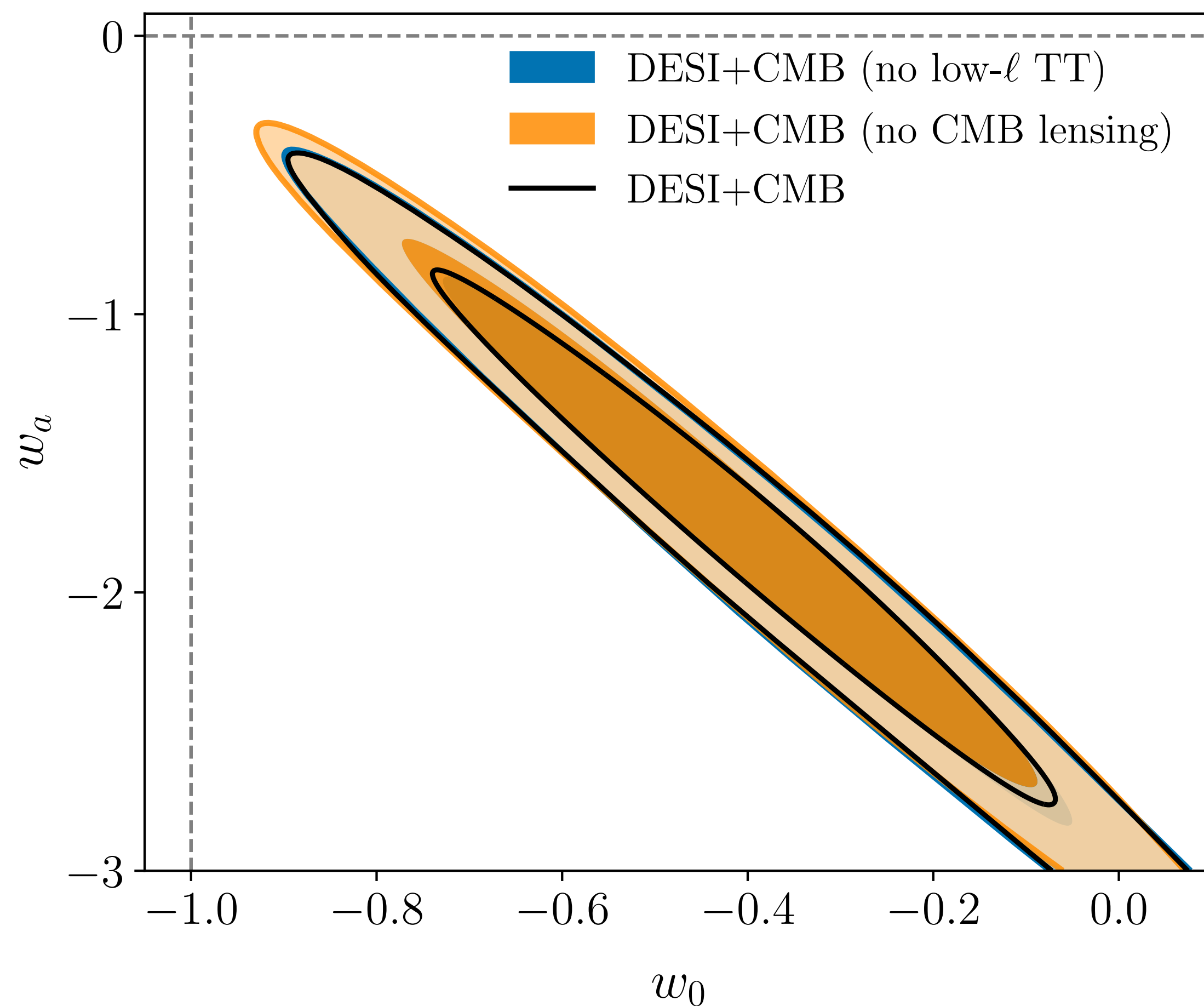


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w_0w_a CDM model

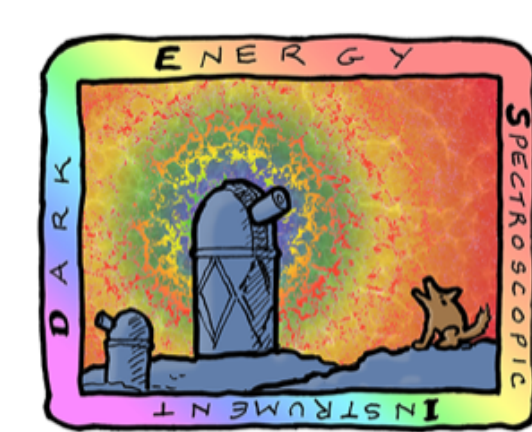
DESI + CMB type



DESI + CMB selection prefers w_0w_a CDM at

3.1σ DESI + (full) CMB

2.7σ DESI + CMB (no-lensing)

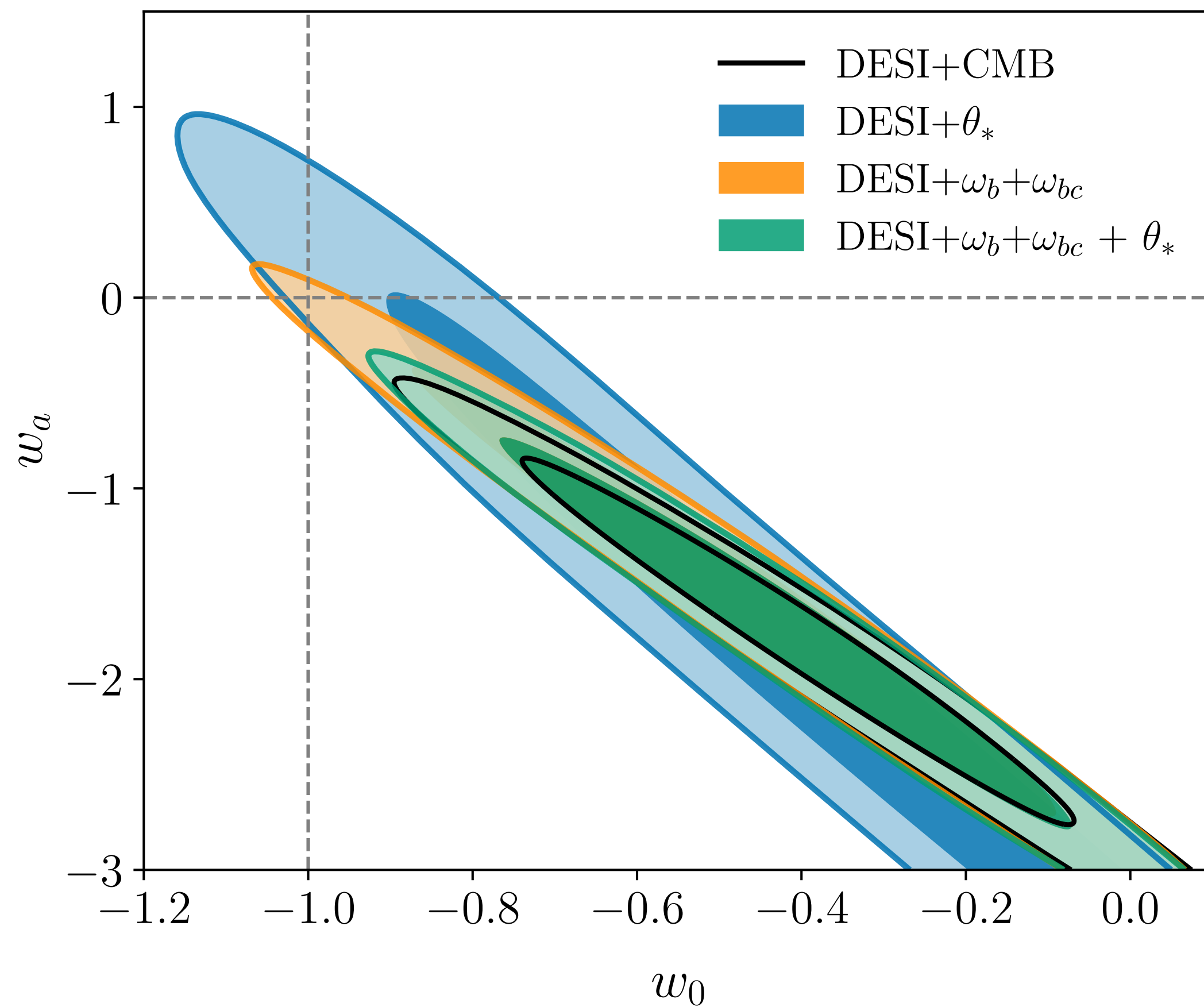


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w_0w_a CDM model

DESI + CMB type



DESI + CMB selection prefers w_0w_a CDM at

3.1 σ DESI + (full) CMB

2.7 σ DESI + CMB (no-lensing)

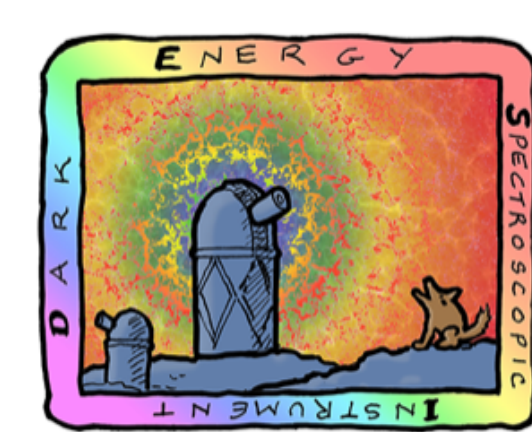
1.7 σ DESI

DESI + θ_*

DESI + $\omega_b + \omega_{bc}$

2.4 σ DESI + $\omega_b + \omega_{bc} + \theta_*$

late-time cosmo (no ISW)
Independent of

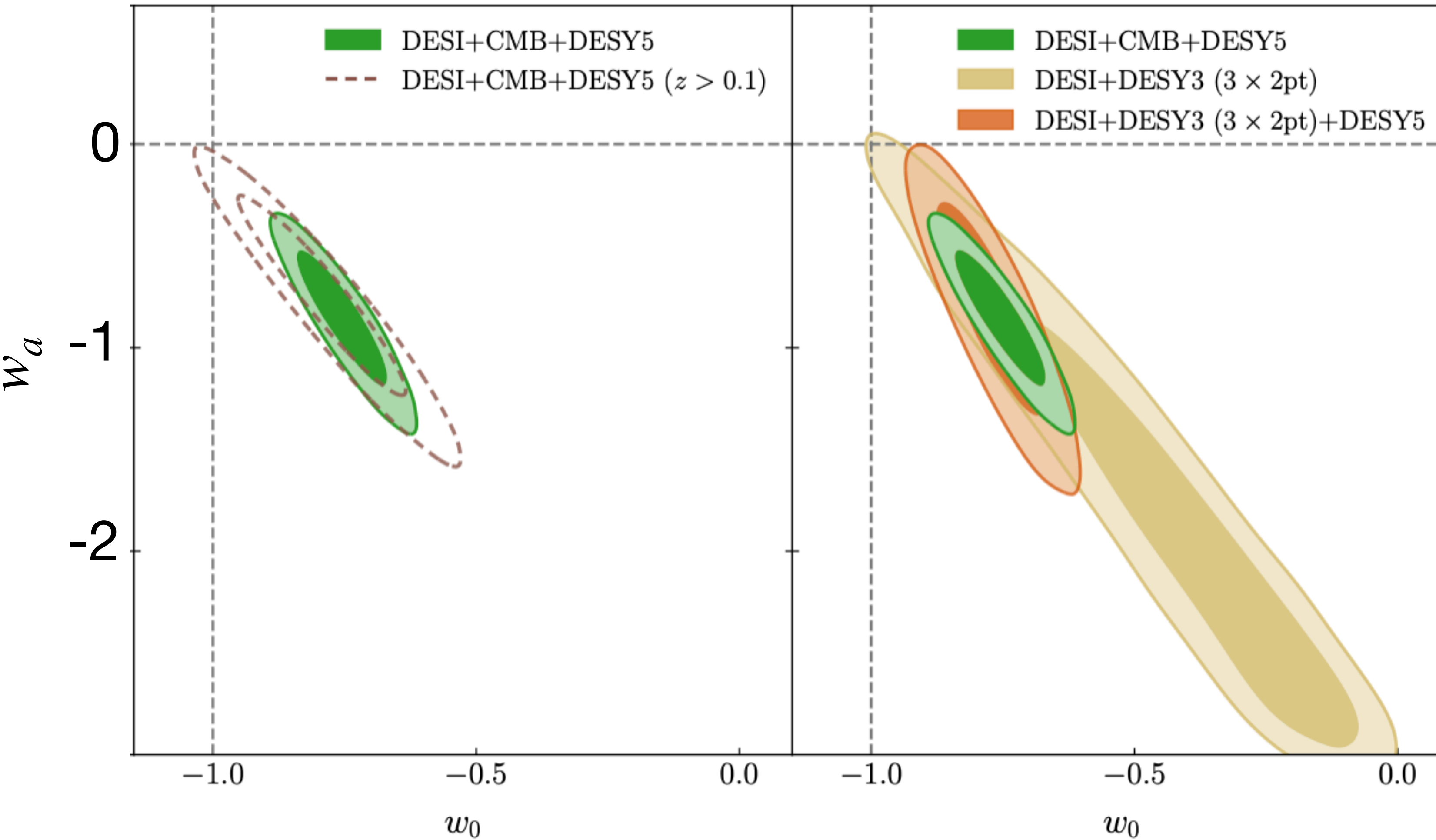


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w_0w_a CDM model

DESI + other. Where is the w_0w_a CDM signal coming from?

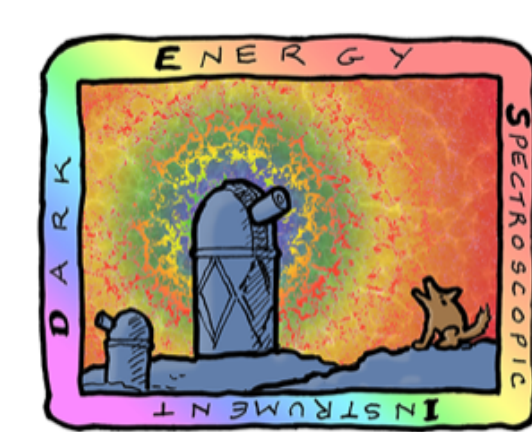


- Removing $z < 0.1$ data reduces significantly the tension.

- Using DESI+DES Y3 (3x2pt) results in just 2.2σ

Gravitational lensing from DES

Only low- z (no CMB) and no-SNe

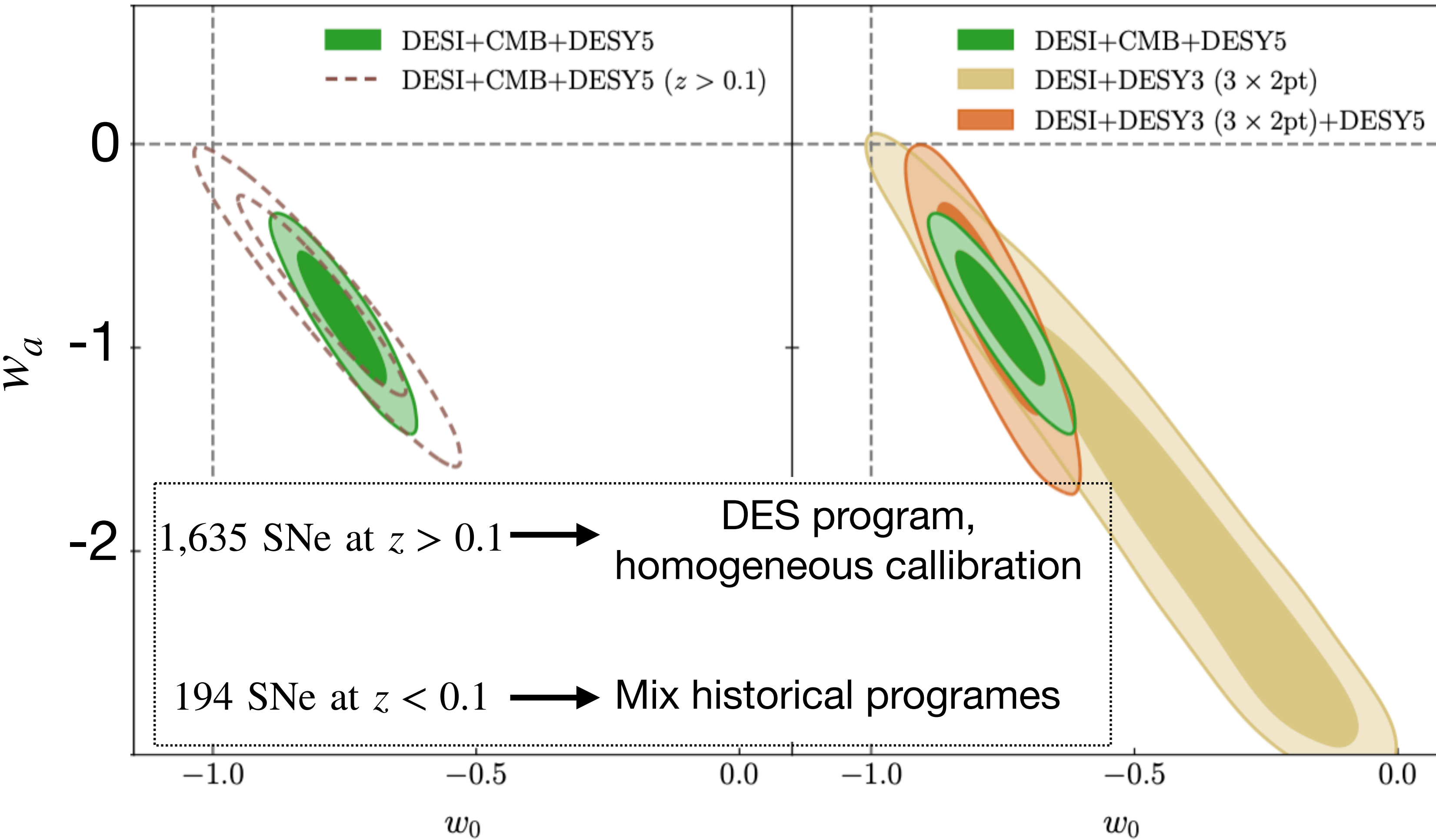


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w_0w_a CDM model

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DESI + other. Where is the w_0w_a CDM signal coming from?

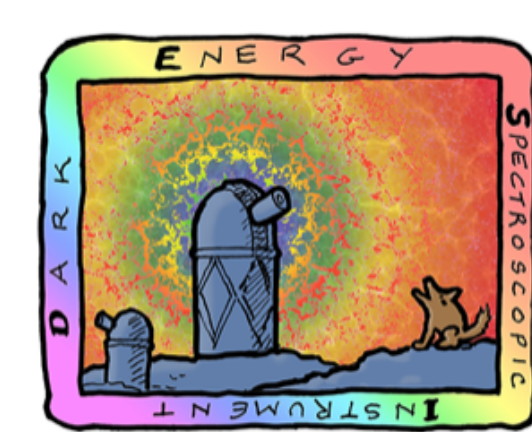


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Gravitational lensing from DES

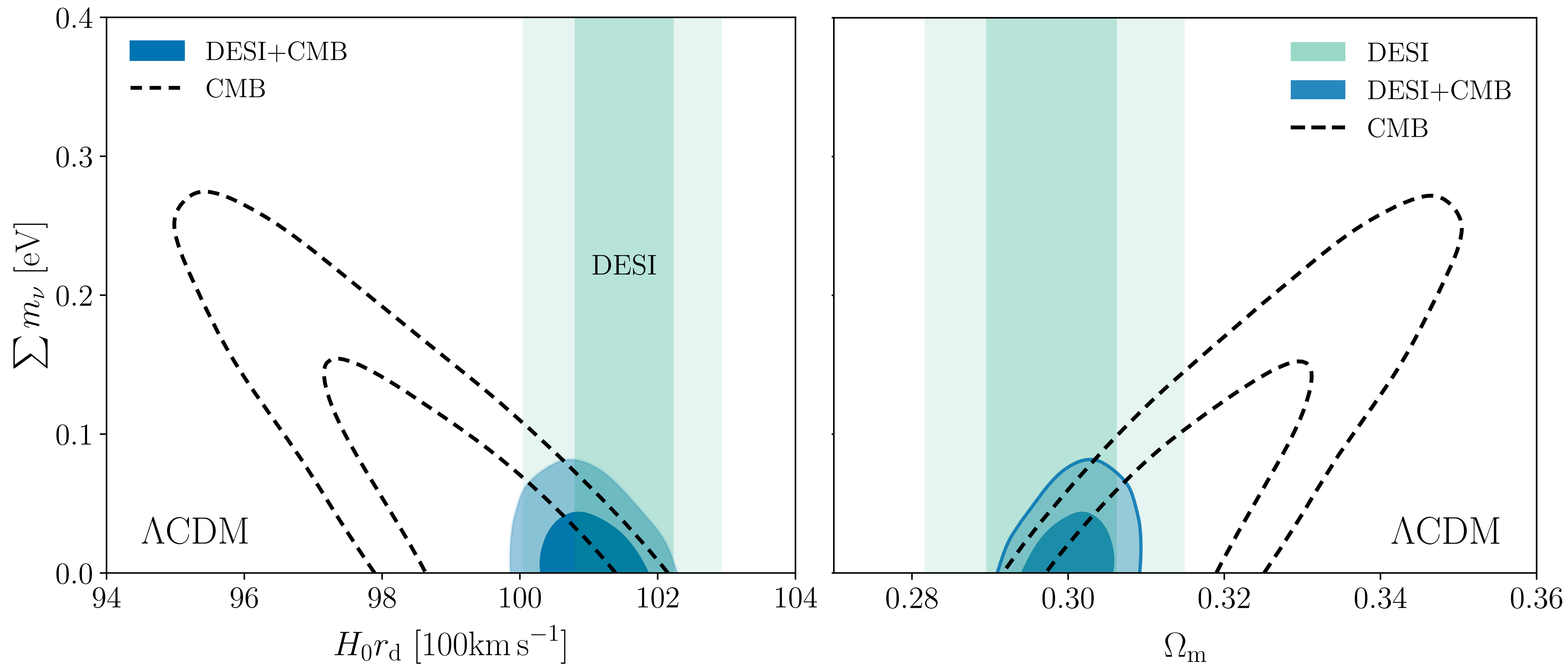
Only low- z (no CMB) and no-SNe

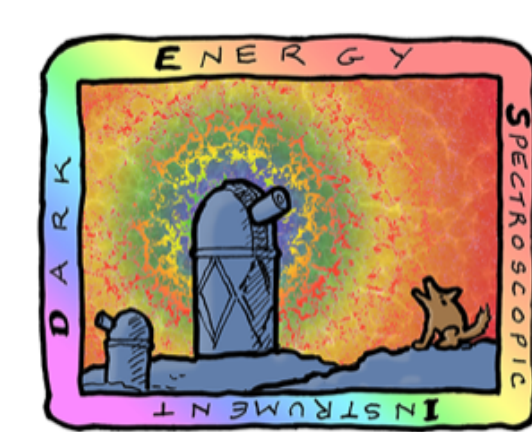


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Neutrinos in LCDM

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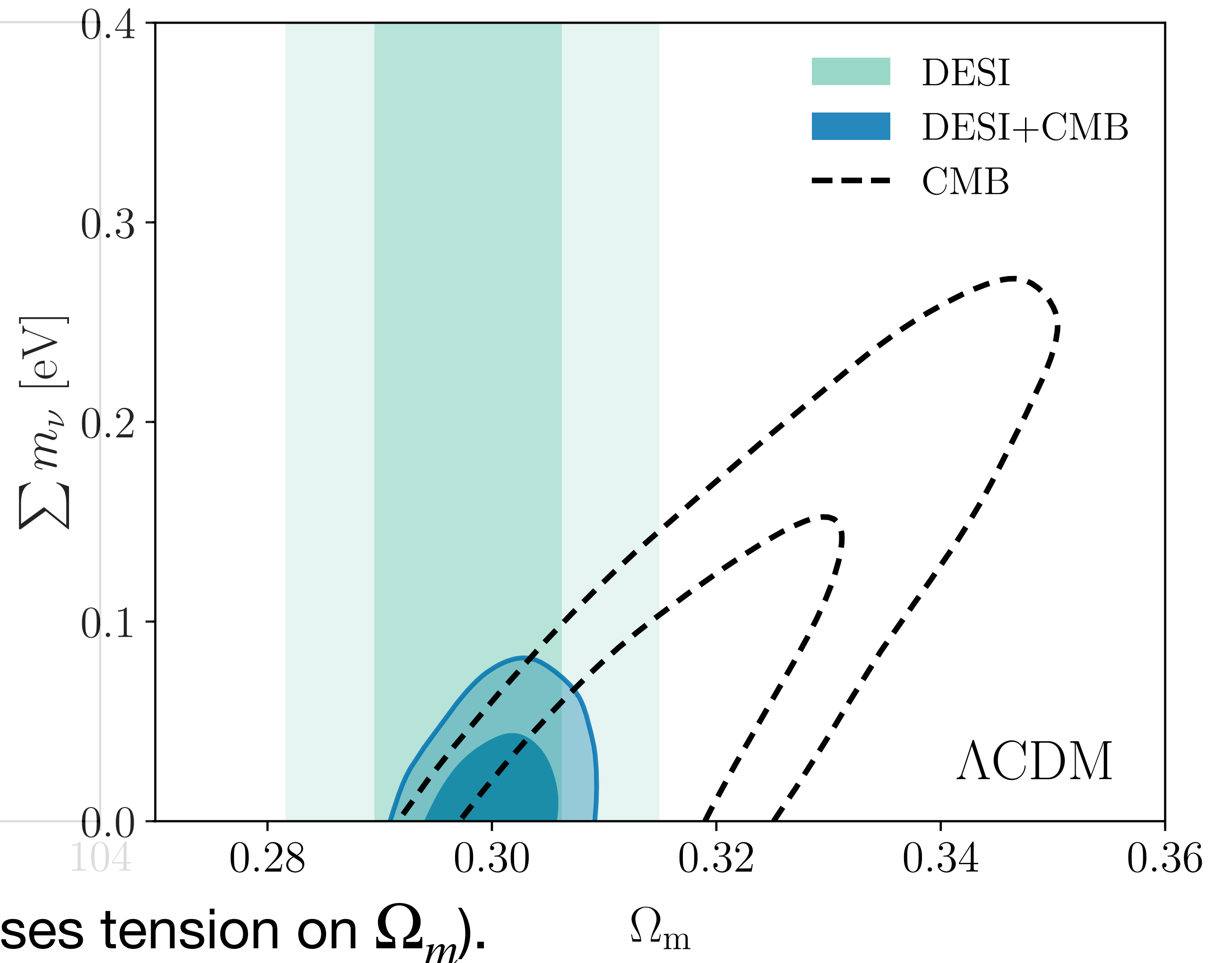
Neutrinos in LCDM

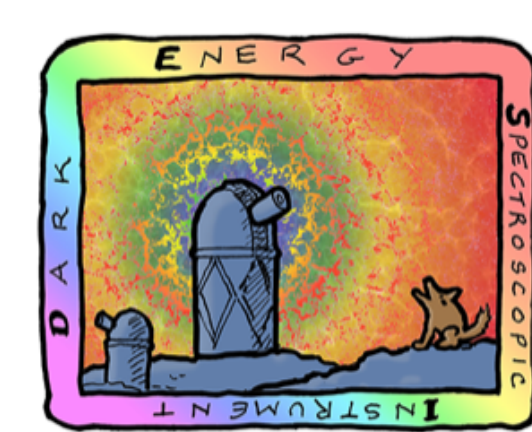
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- DESI BAO alone can't constrain any Σm_ν
- Adding CMB data allows to break that degeneracy.
- Here we use *CamSpec*. Results mildly depend on likelihood used (Plik, L-H) because of effect on lensing power
- Close to the 0.06 eV bound from neutrino oscillations.

$$\Sigma m_\nu < 0.064 \text{ eV (95\%)} \quad \Lambda\text{CDM}$$

- $\Sigma m_\nu > 0$ prior. Otherwise peak at $\Sigma m_\nu < 0$ and 3σ with the 0.06 eV bound (but decreases tension on Ω_m).

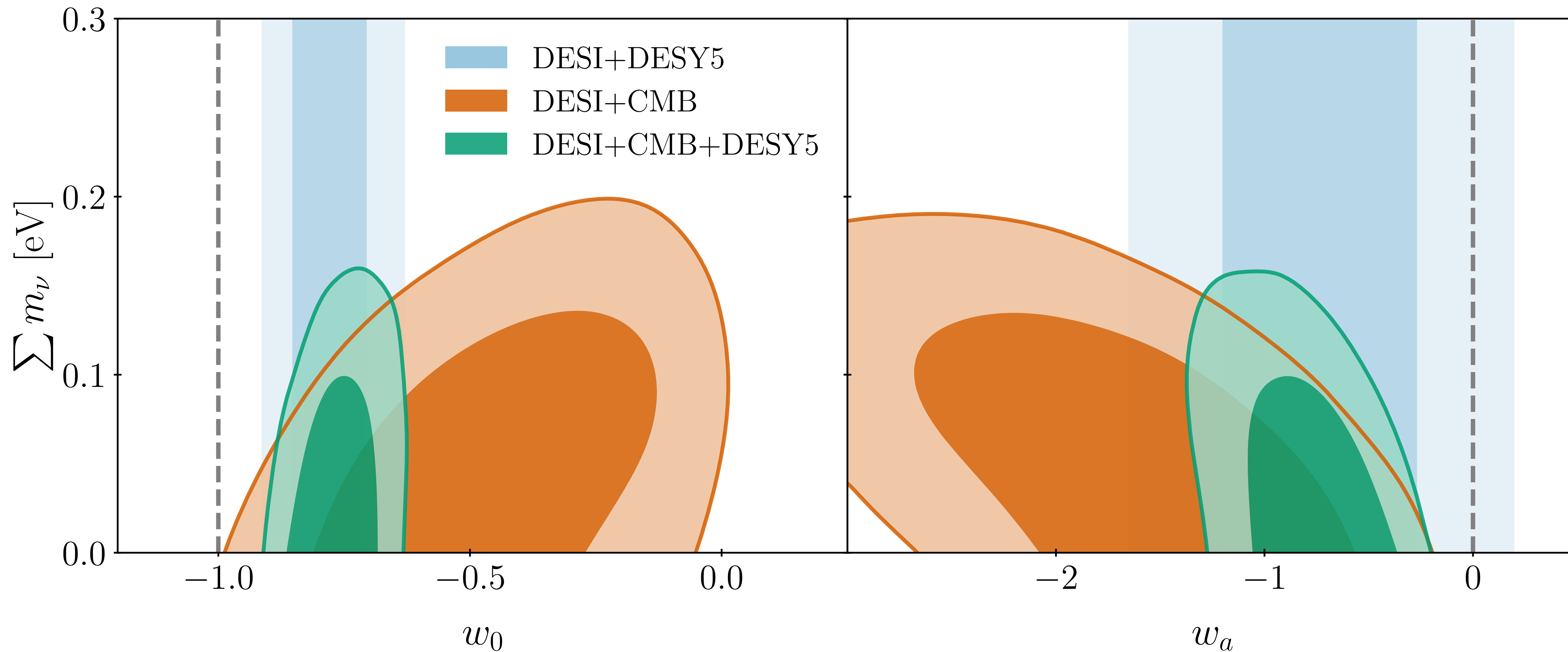


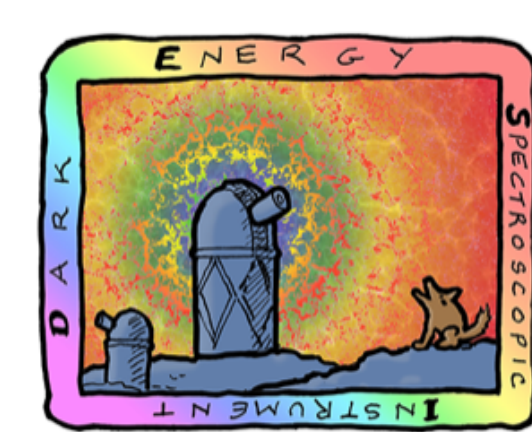


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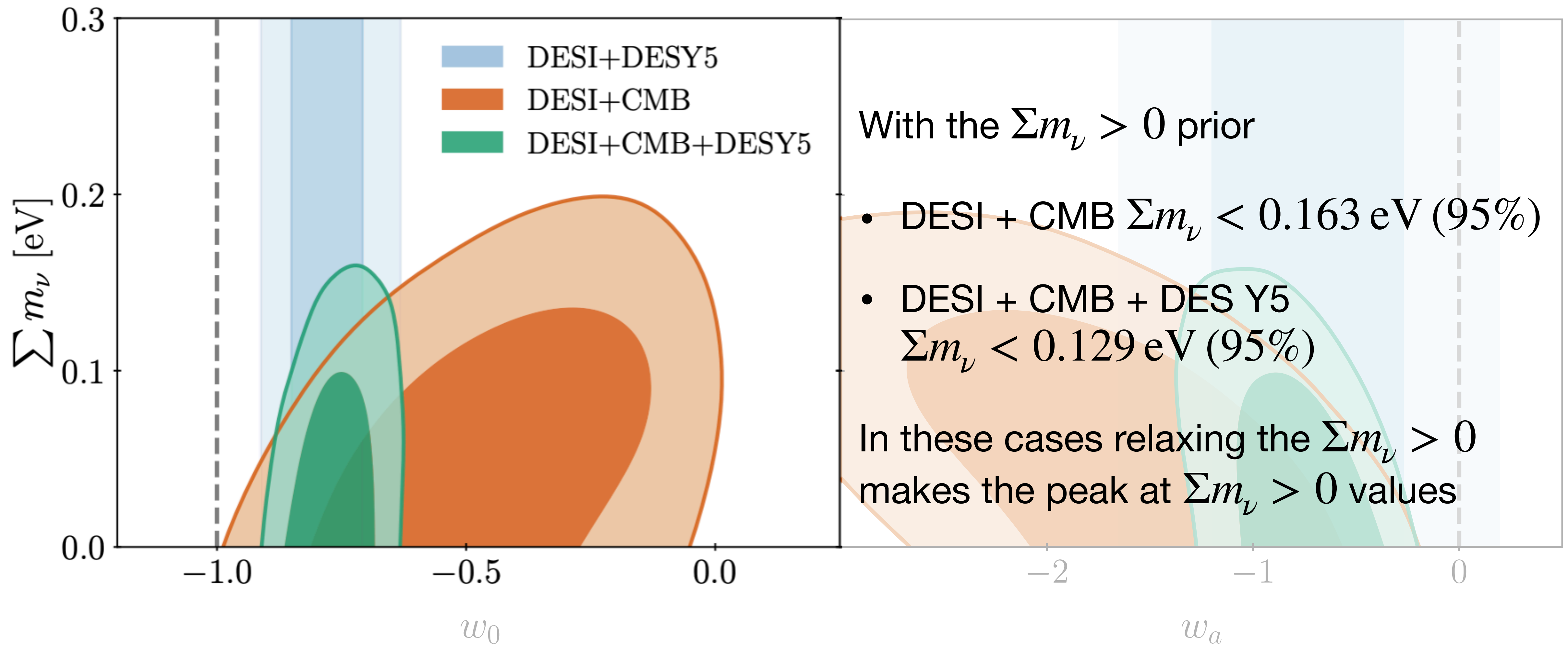
Neutrinos in w_0w_a CDM

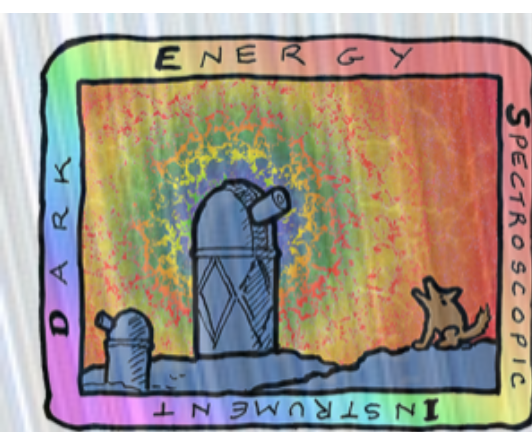
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Neutrinos in w_0w_a CDM

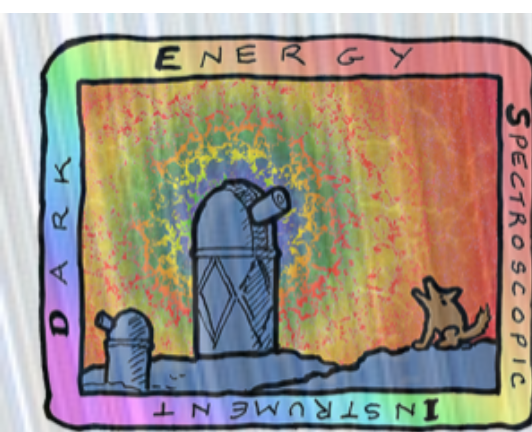




Some take-away messages

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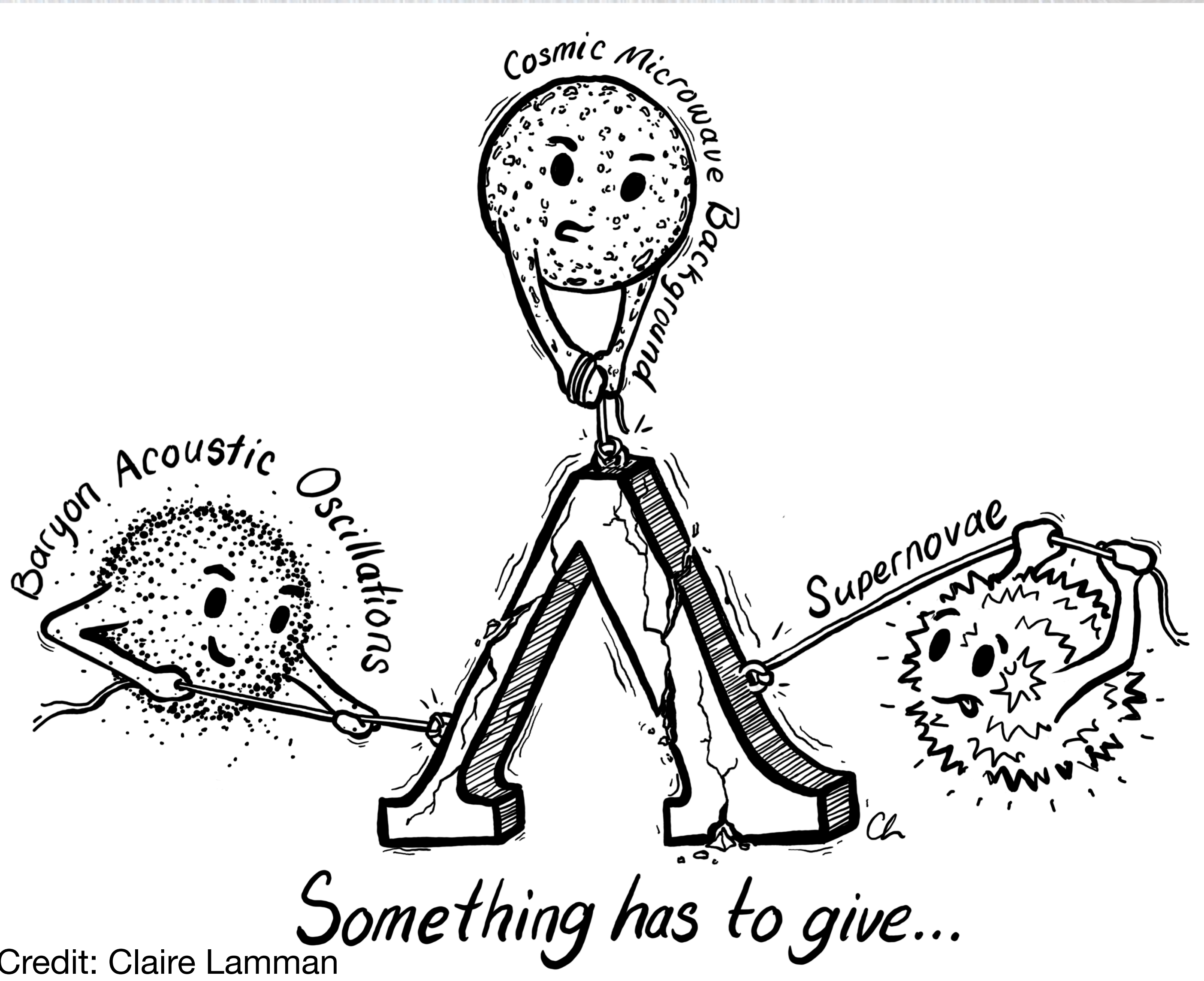
- DESI alone is consistent with a Λ CDM model
- DESI Λ CDM model is 2.3σ discrepant with Planck CMB, and to 2.0σ if lensing is excluded
- Allowing $w_0 - w_a$ to vary we find that DESI + full CMB is in 3.1σ mild tension with Λ CDM ($w_0 = -1, w_a = 0$). This is reduced to 2.4σ if only $\{w_{bc}, w_b, \theta_*\}$ are used (no late-time effects).
- For DESI+CMB+SNe we obtain: $2.8\sigma, 3.8\sigma, 4.2\sigma(3.2\sigma)$ for **P+**, **U3**, **DES Y5(Dovekie)**. This is significantly reduced if $z < 0.1$ data are excluded, but ellipse does not shift.
- $\Sigma m_\nu < 0.064$ eV (95%) for DESI+CMB in Λ CDM peaking at $\Sigma m_\nu < 0$ if prior is not applied. $\Sigma m_\nu < 0.163$ eV (95%) in $w_0 w_a$ CDM



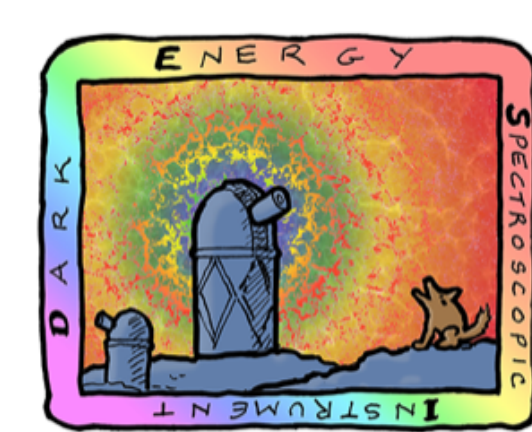
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Thank you!



Credit: Claire Lamman

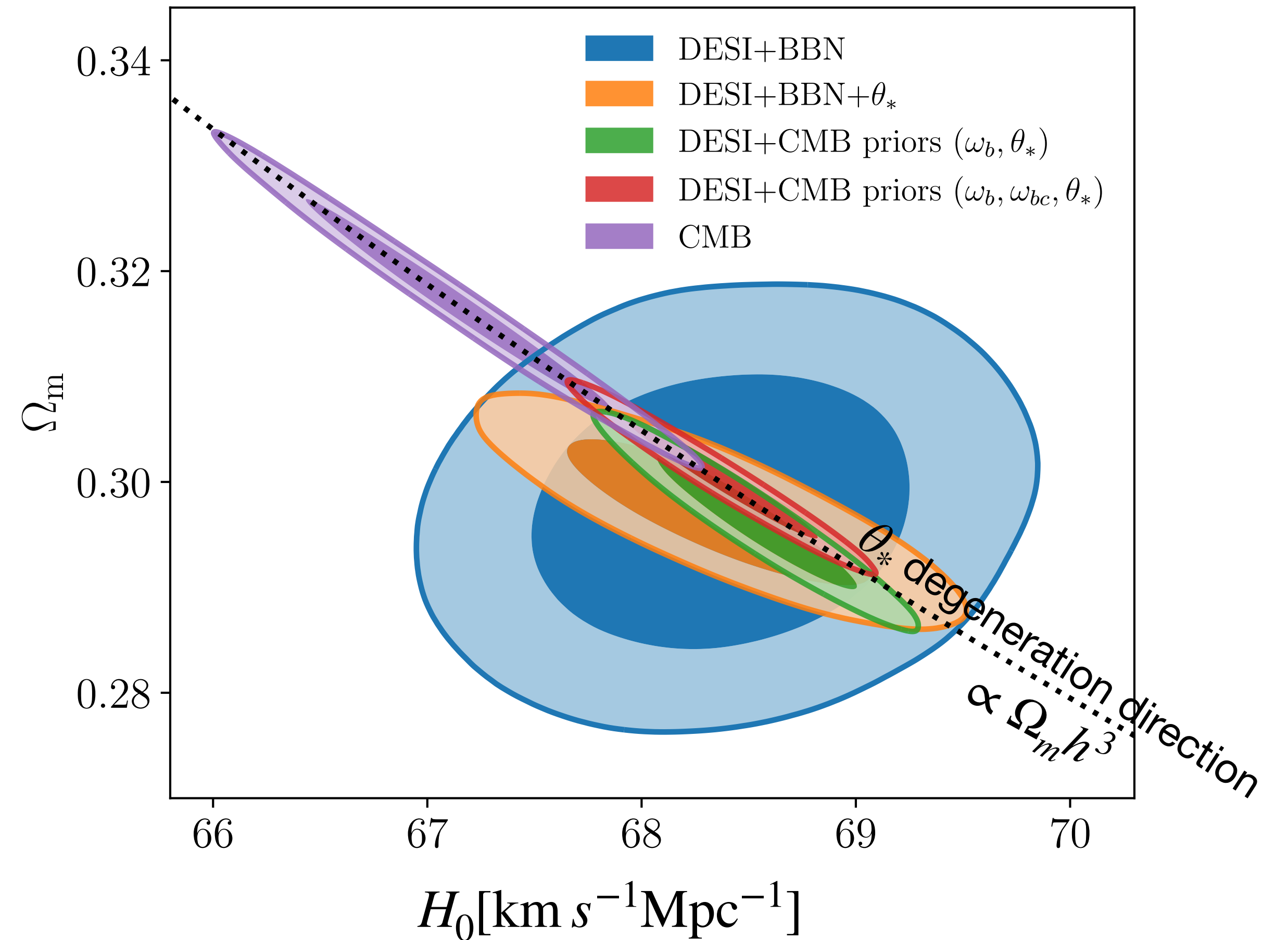
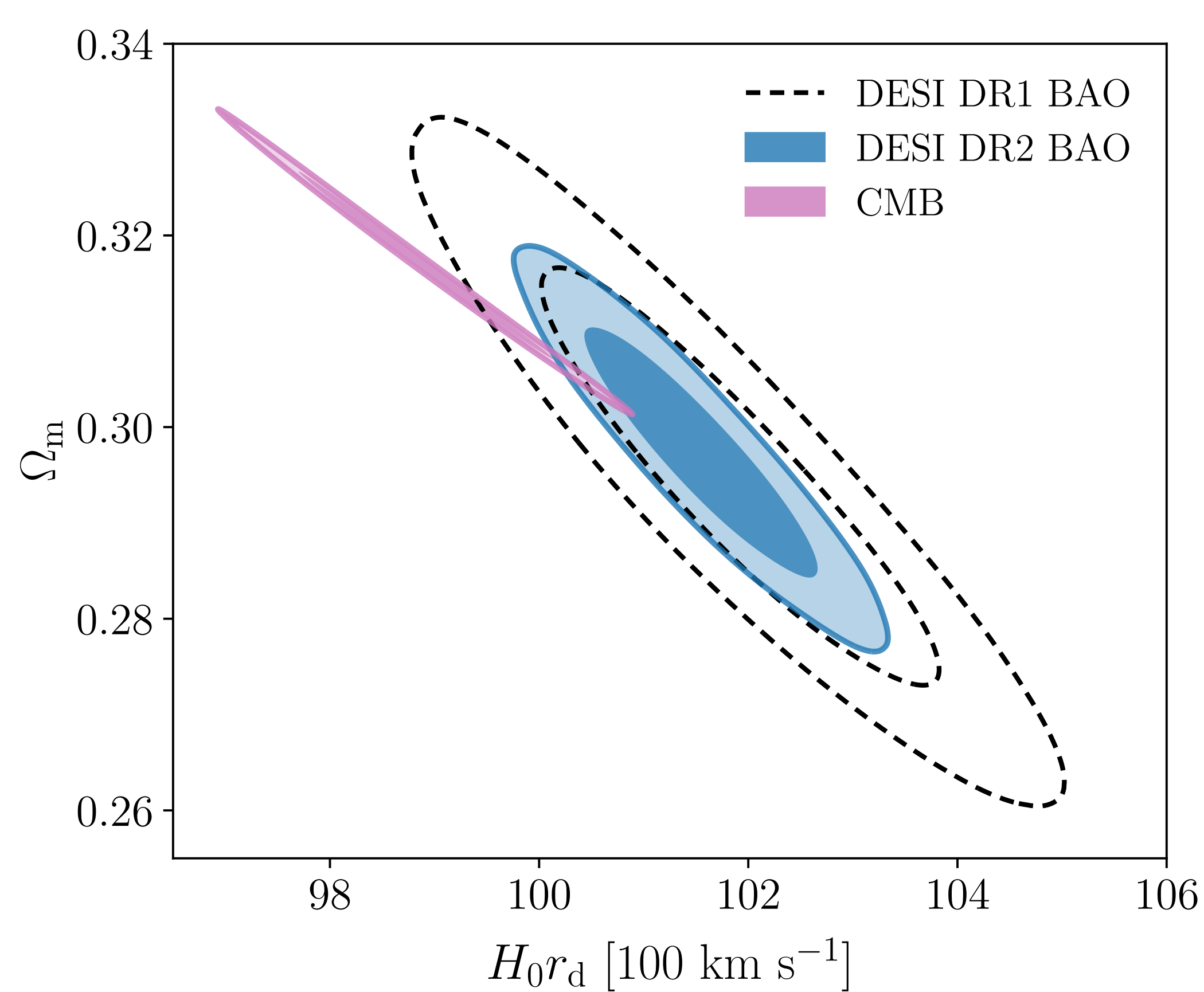


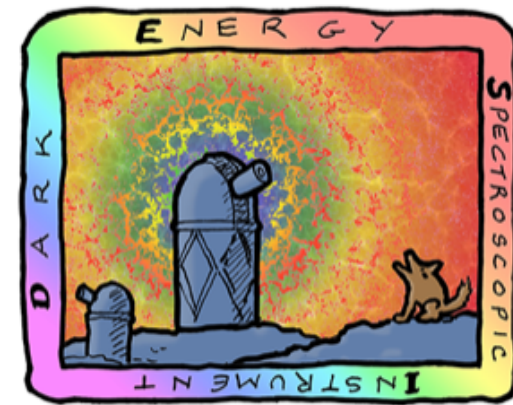
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Extra Slides

- Is DESI(+BBN) compatible with Planck CMB within LCDM?

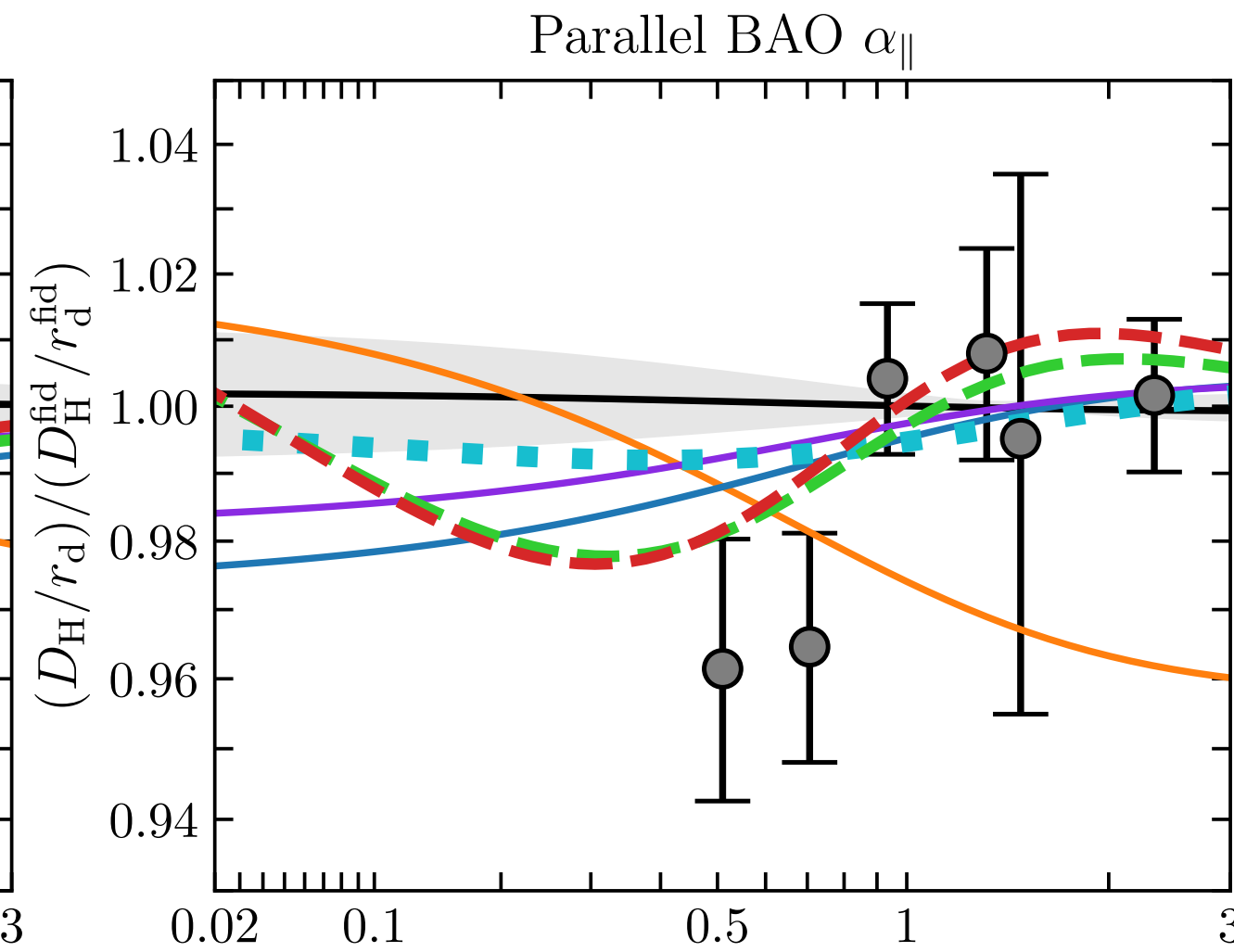
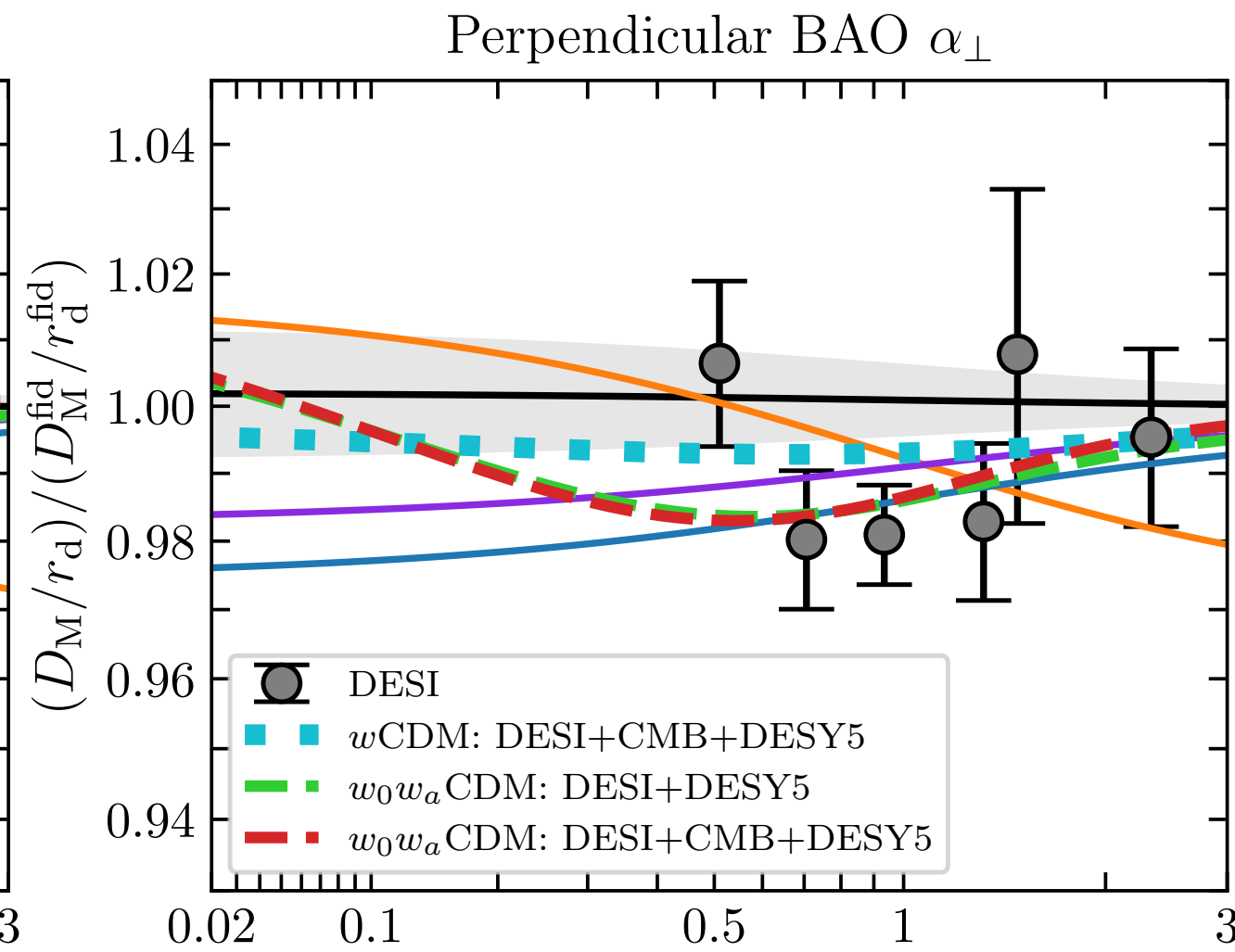
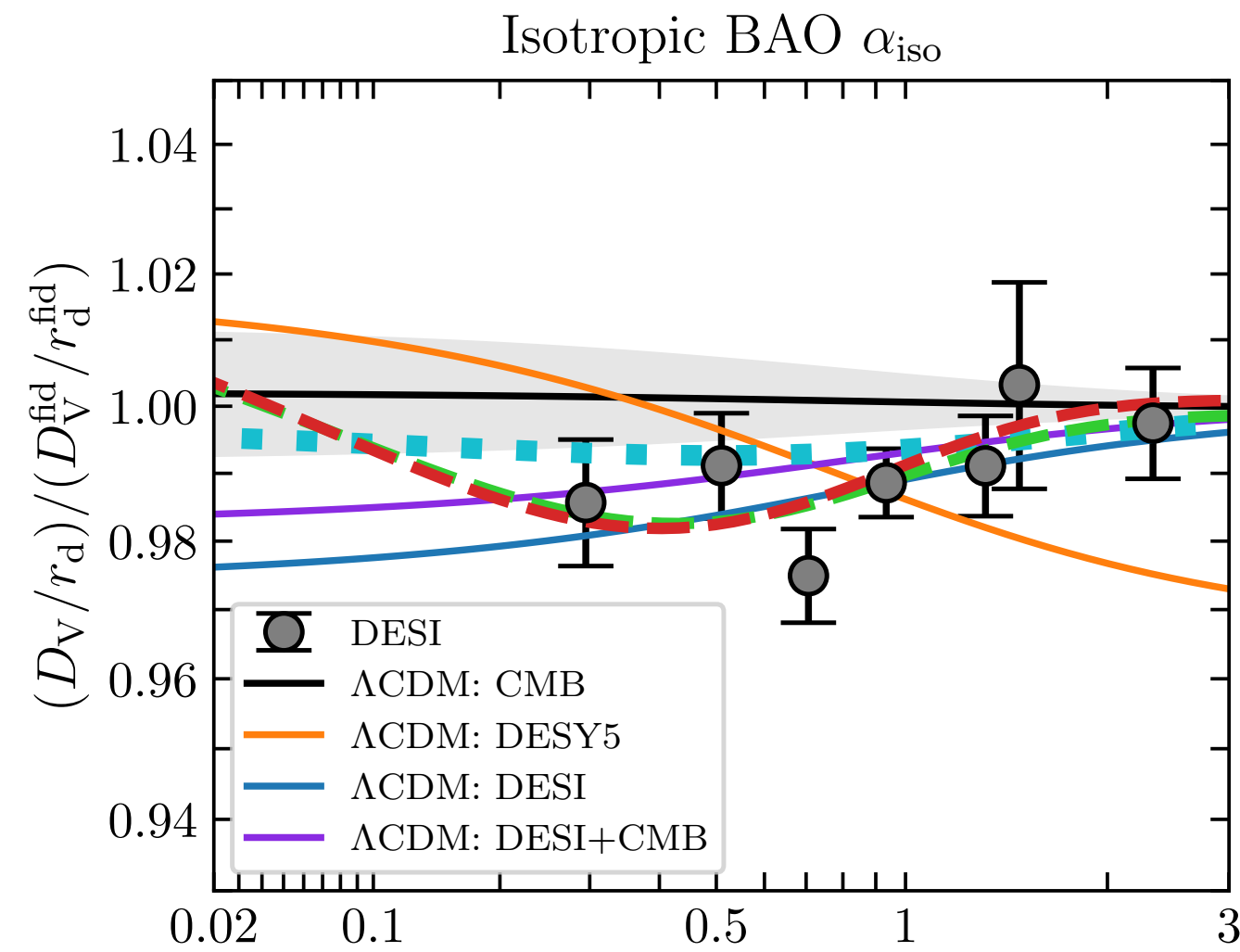




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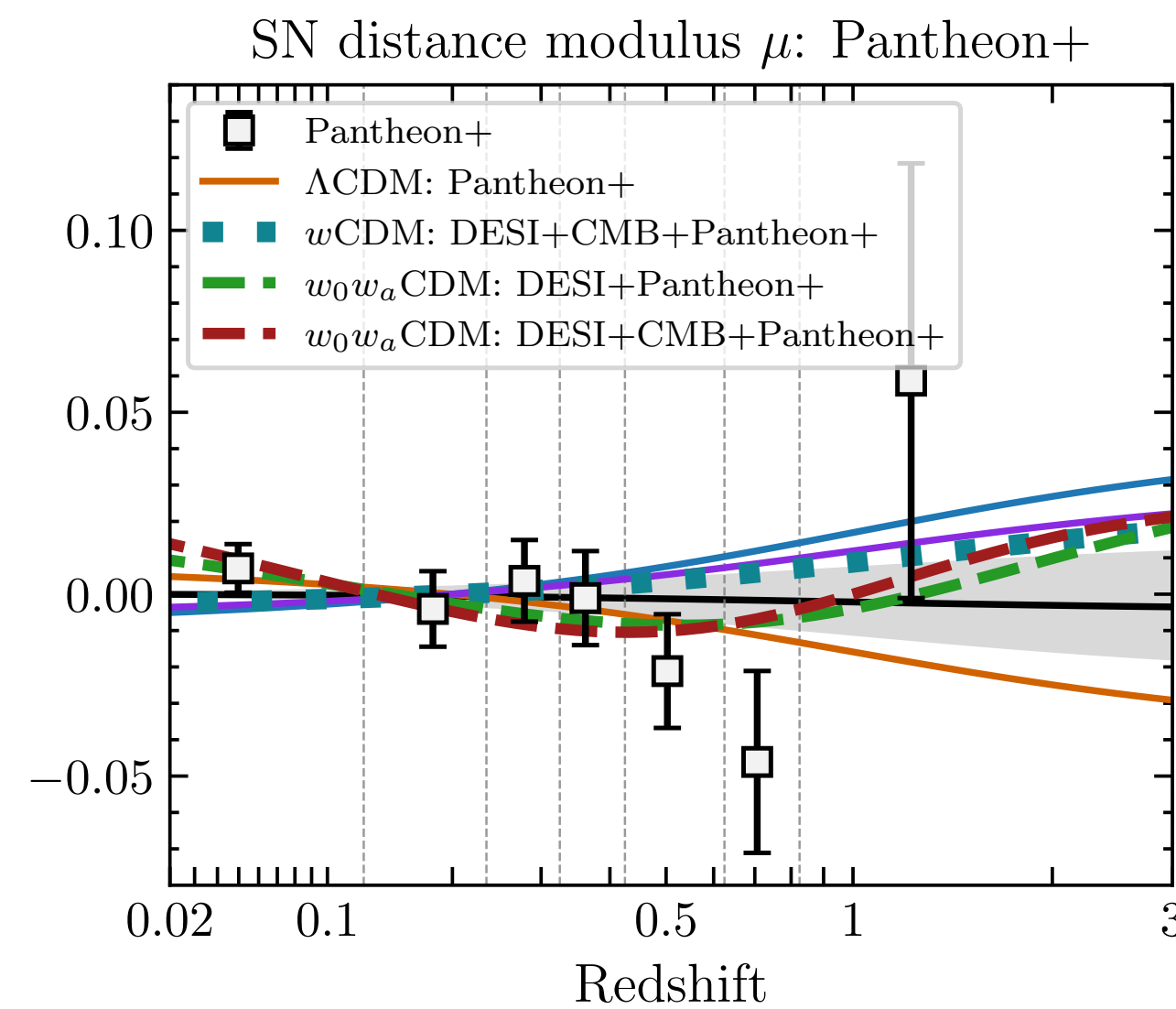
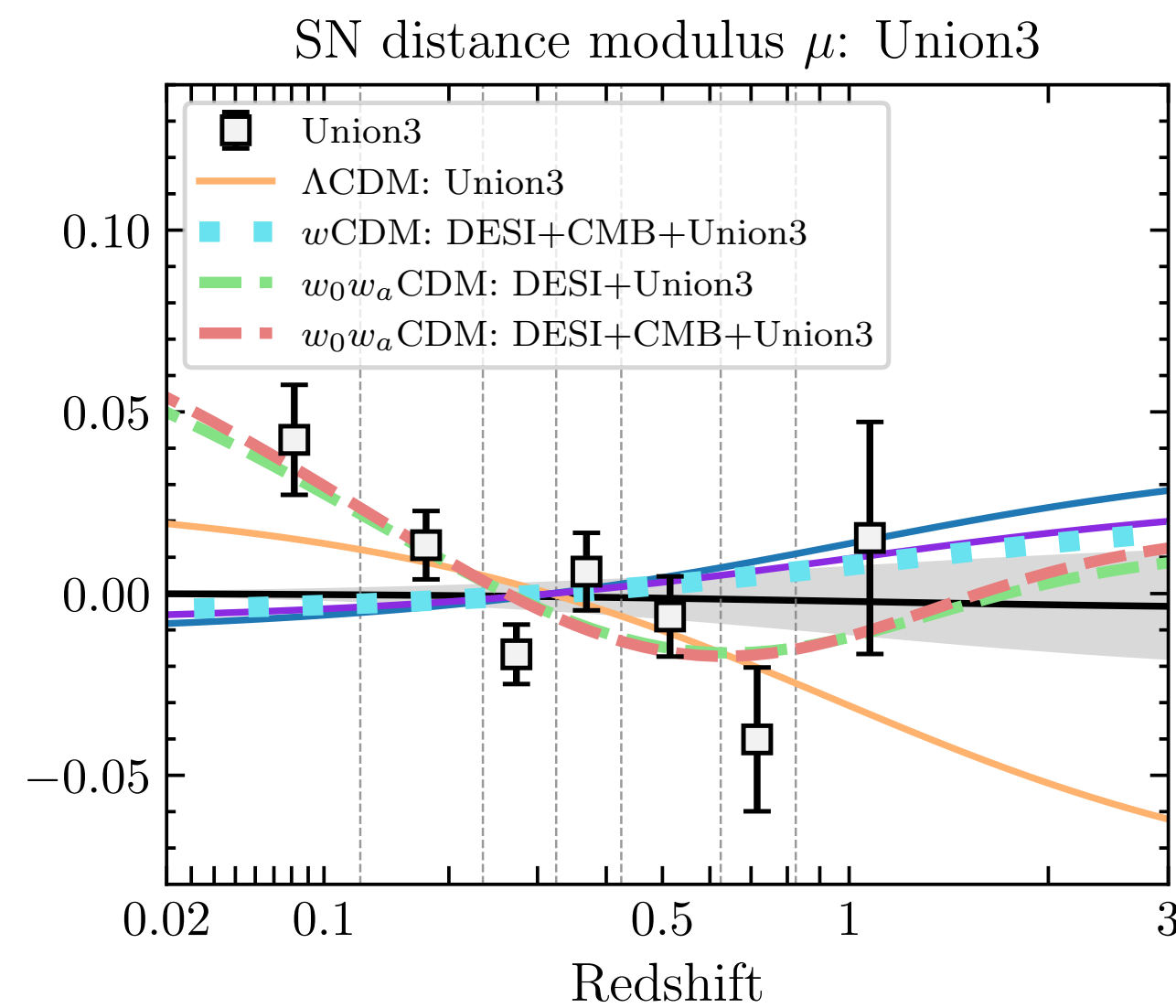
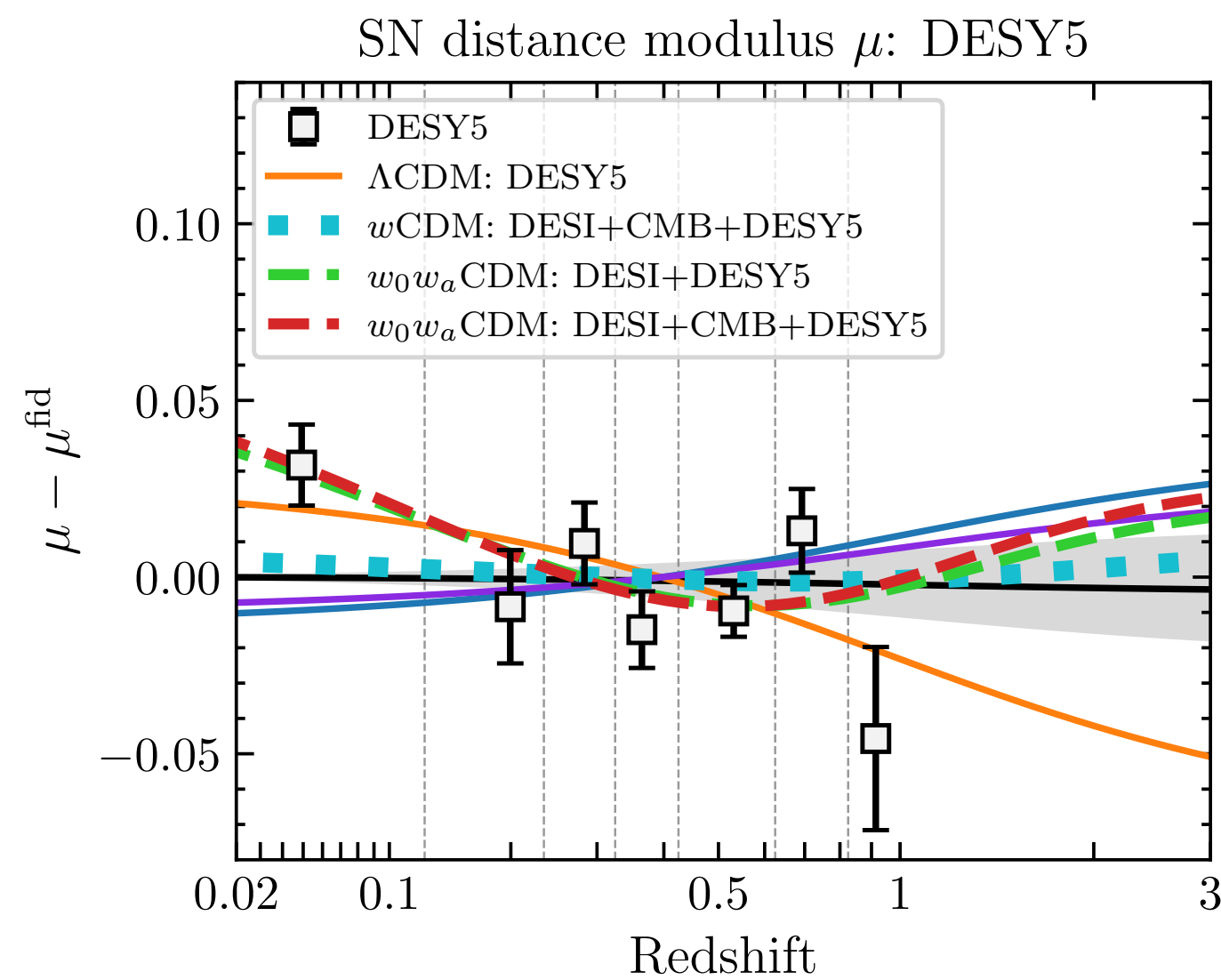


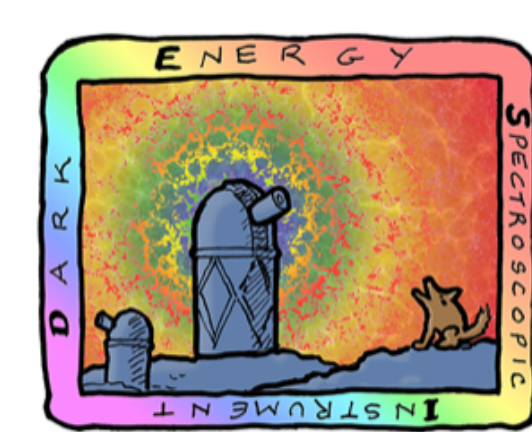
Visual Guide

Λ CDM

w CDM

w_0w_a CDM

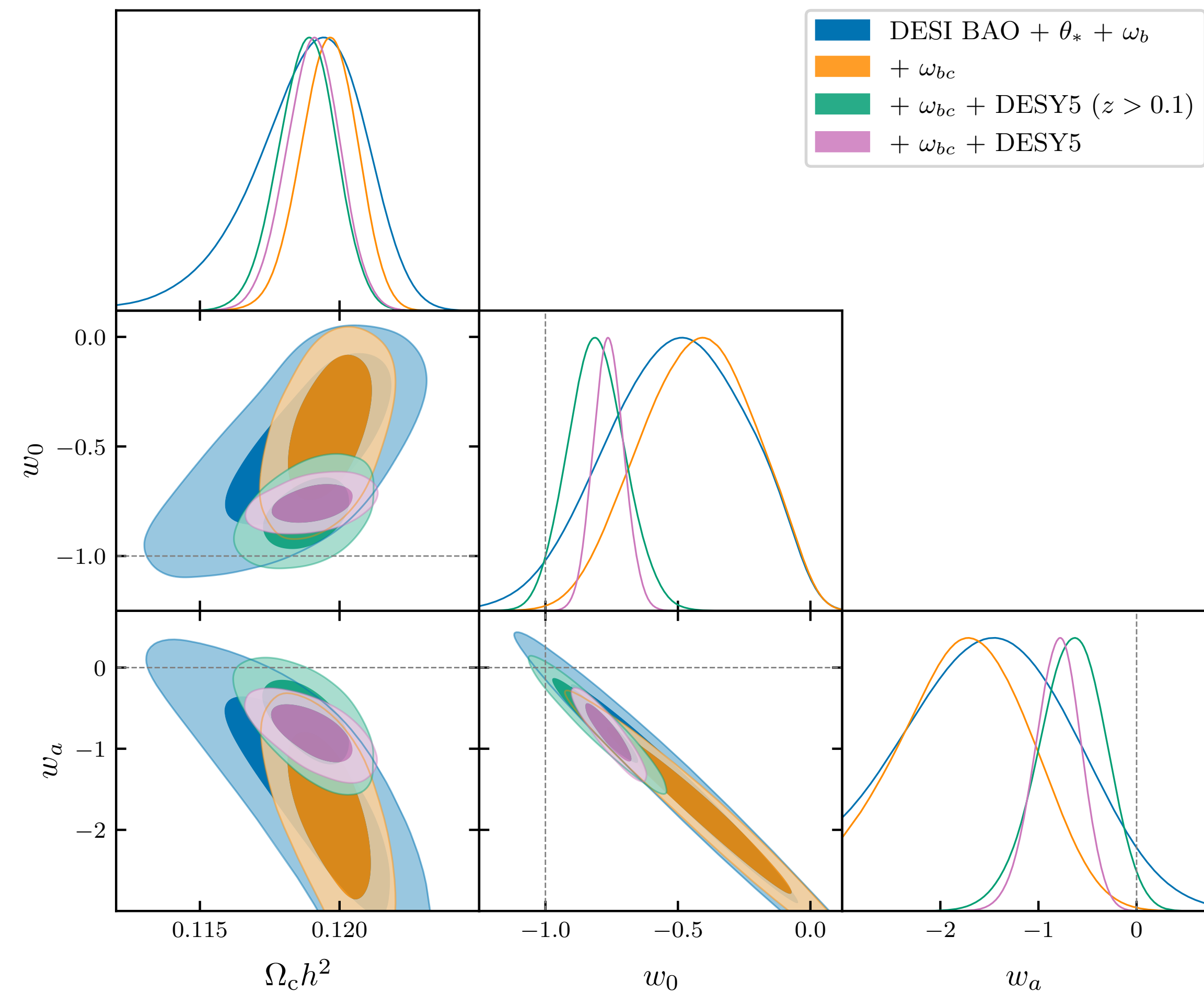
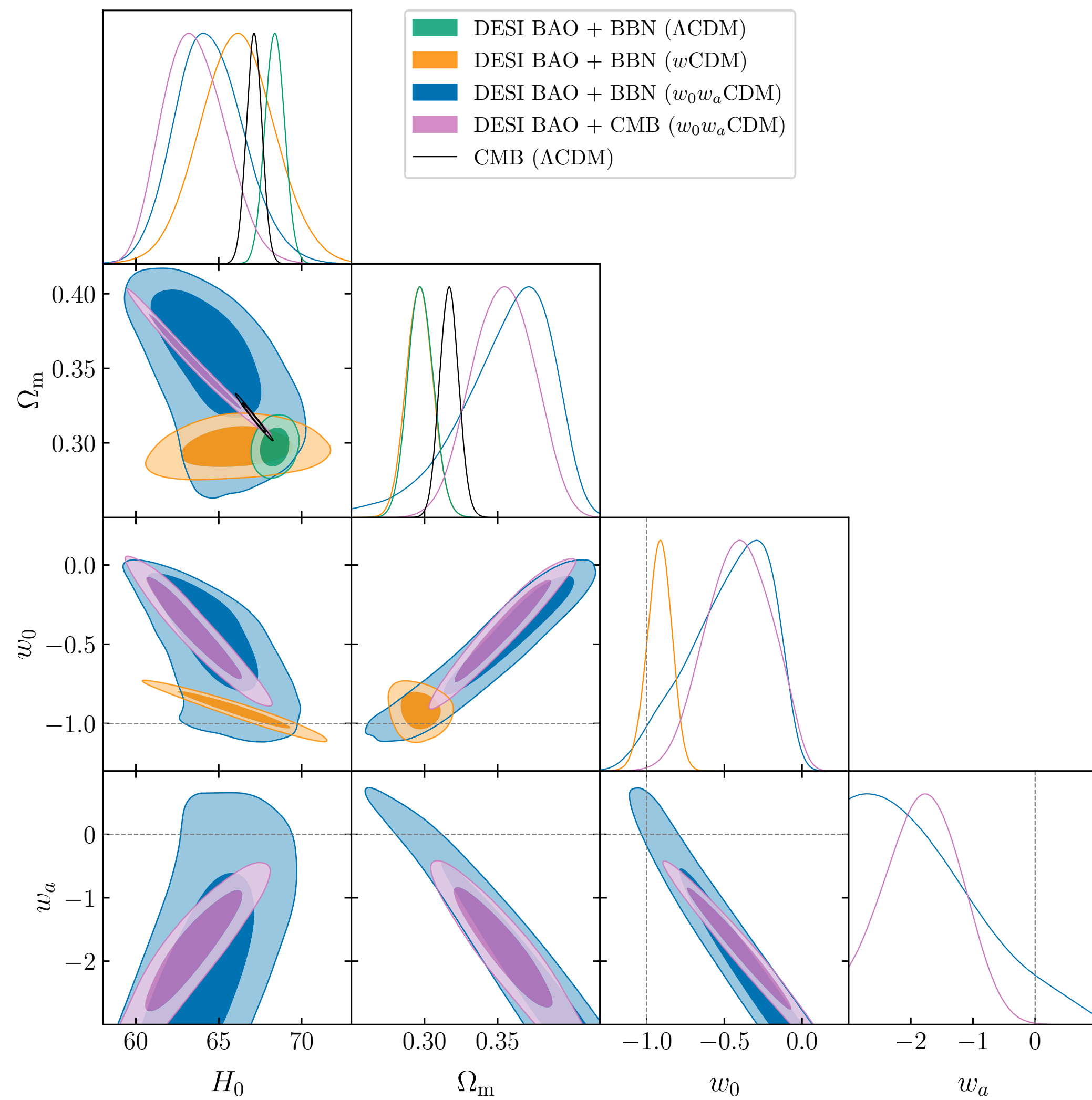


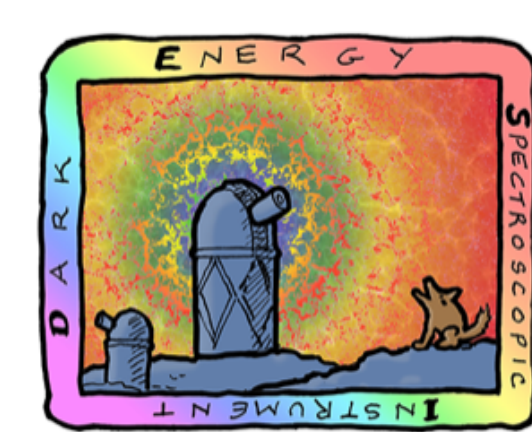


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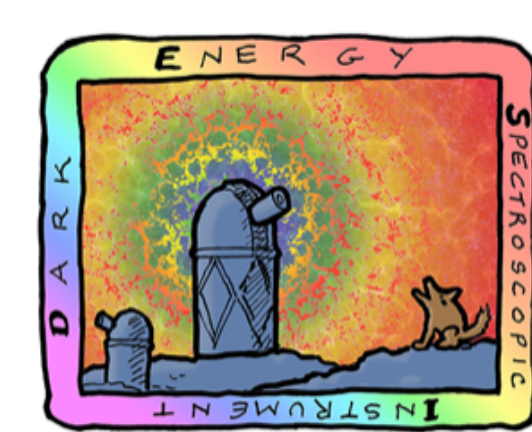
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Datasets	$\Delta\chi^2_{\text{MAP}}$	Significance	$\Delta(\text{DIC})$
DESI	-4.7	1.7σ	-0.8
DESI+ $(\theta_*, \omega_b, \omega_{bc})_{\text{CMB}}$	-8.0	2.4σ	-4.4
DESI+CMB (no lensing)	-9.7	2.7σ	-5.9
DESI+CMB	-12.5	3.1σ	-8.7
DESI+Pantheon+	-4.9	1.7σ	-0.7
DESI+Union3	-10.1	2.7σ	-6.0
DESI+DESY5	-13.6	3.3σ	-9.3
DESI+DESY3 ($3\times 2\text{pt}$)	-7.3	2.2σ	-2.8
DESI+DESY3 ($3\times 2\text{pt}$)+DESY5	-13.8	3.3σ	-9.1
DESI+CMB+Pantheon+	-10.7	2.8σ	-6.8
DESI+CMB+Union3	-17.4	3.8σ	-13.5
DESI+CMB+DESY5	-21.0	4.2σ	-17.2

TABLE VI. Summary of the difference in the effective χ^2_{MAP} value (defined as twice the negative log posterior at the maximum posterior point) for the best-fit $w_0w_a\text{CDM}$ model relative to the best ΛCDM model with $w_0 = -1$, $w_a = 0$, for fits to different combinations of datasets as indicated. The third column lists the corresponding (frequentist) significance levels given 2 extra free parameters, and the final column shows the results for $\Delta(\text{DIC}) = \text{DIC}_{w_0w_a\text{CDM}} - \text{DIC}_{\Lambda\text{CDM}}$. As a rule of thumb, $\Delta(\text{DIC})$ values < -5 indicate a ‘strong’ preference for $w_0w_a\text{CDM}$ and values < -10 a ‘decisive’ preference [144].

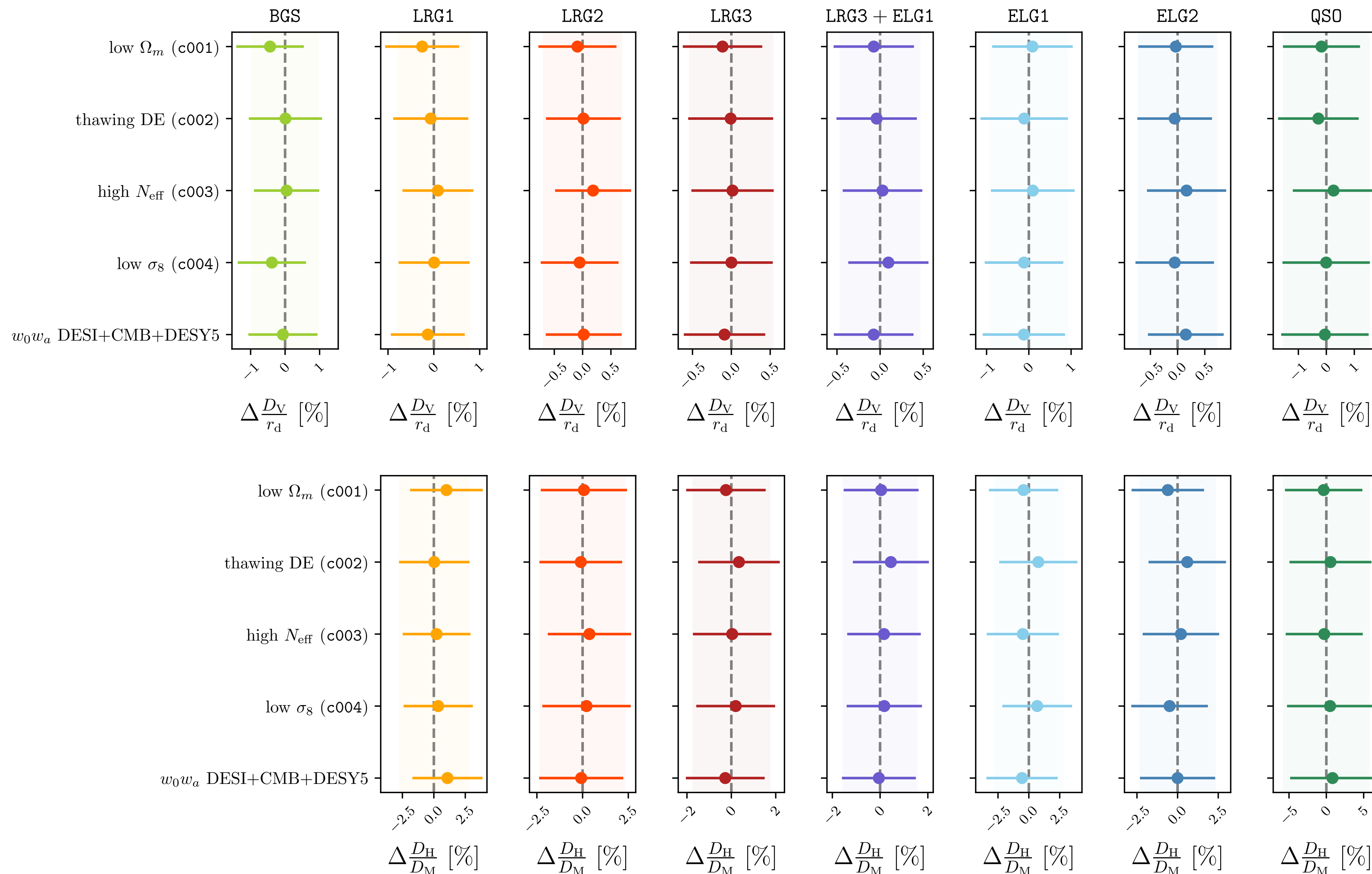


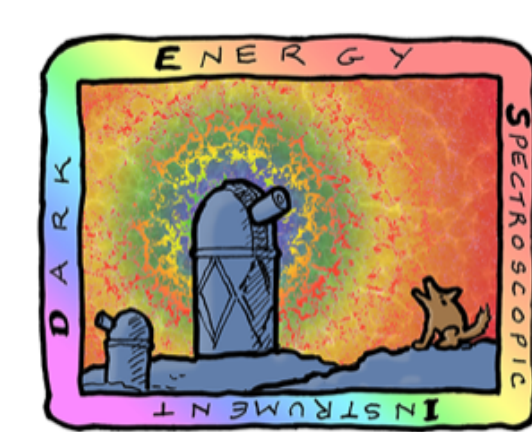
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Different
cosmology
assumptions

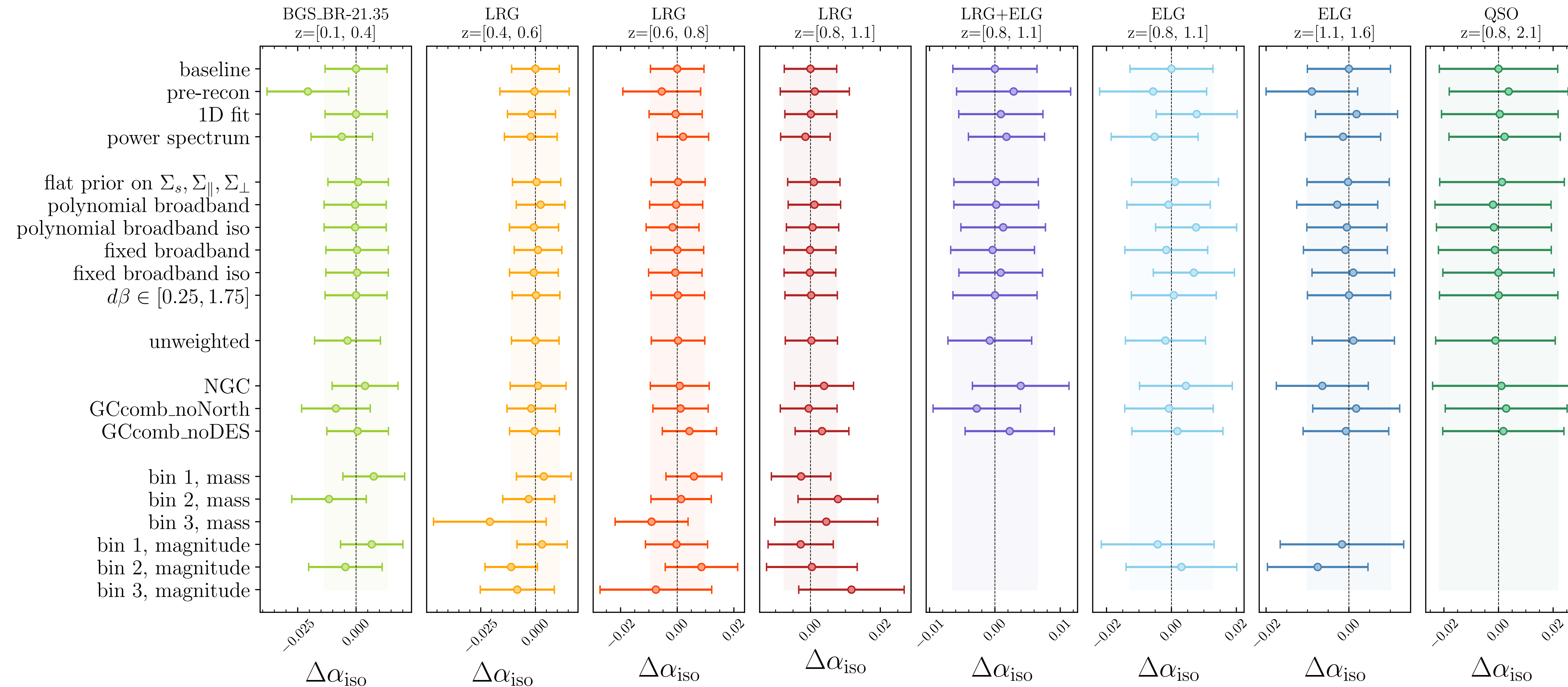


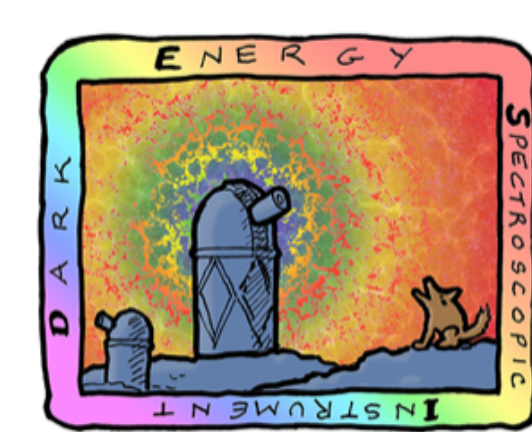


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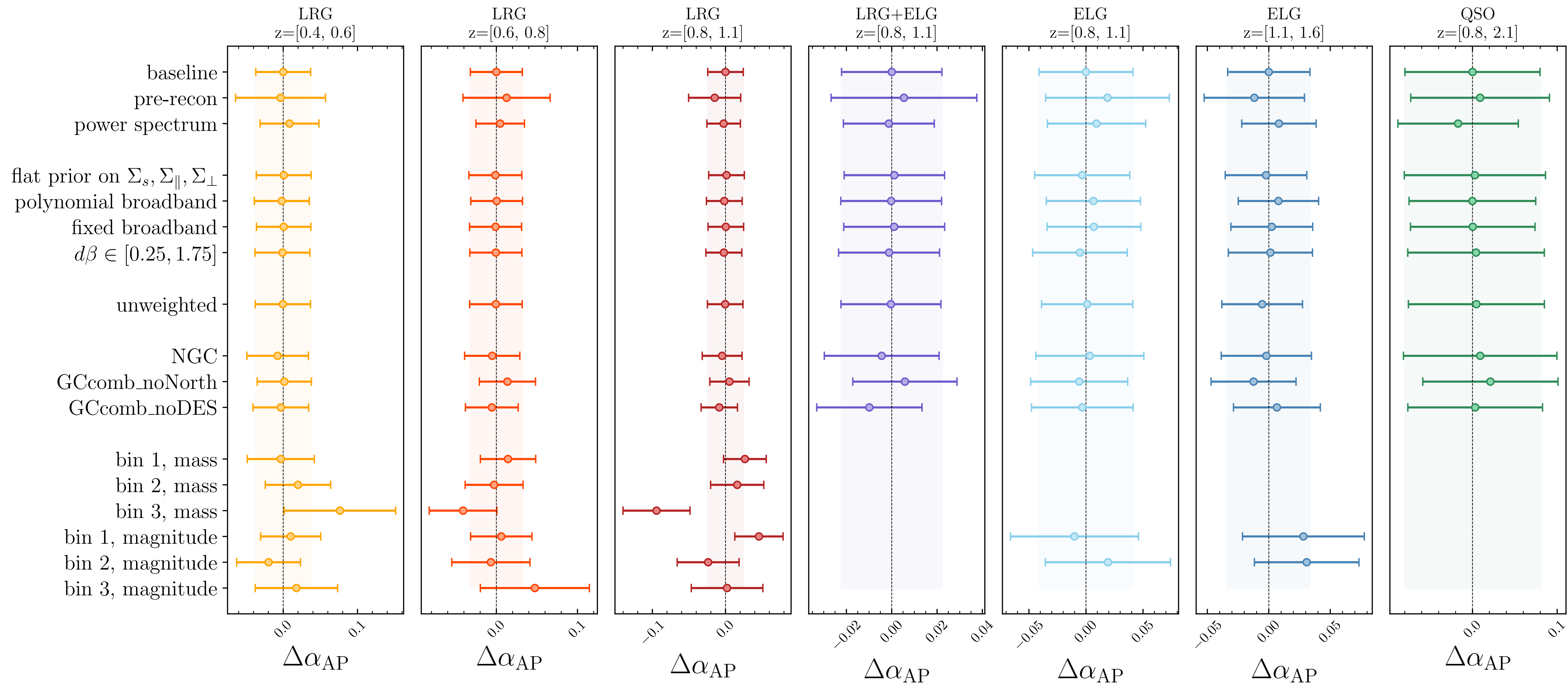


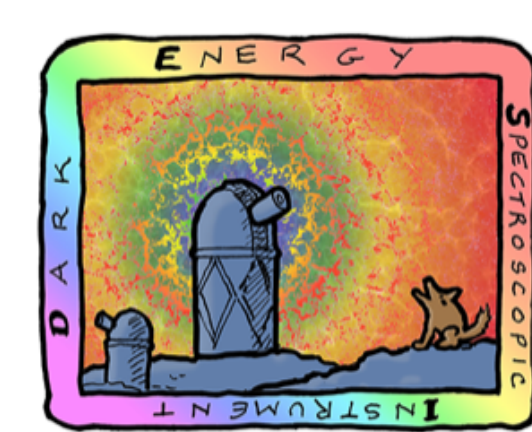


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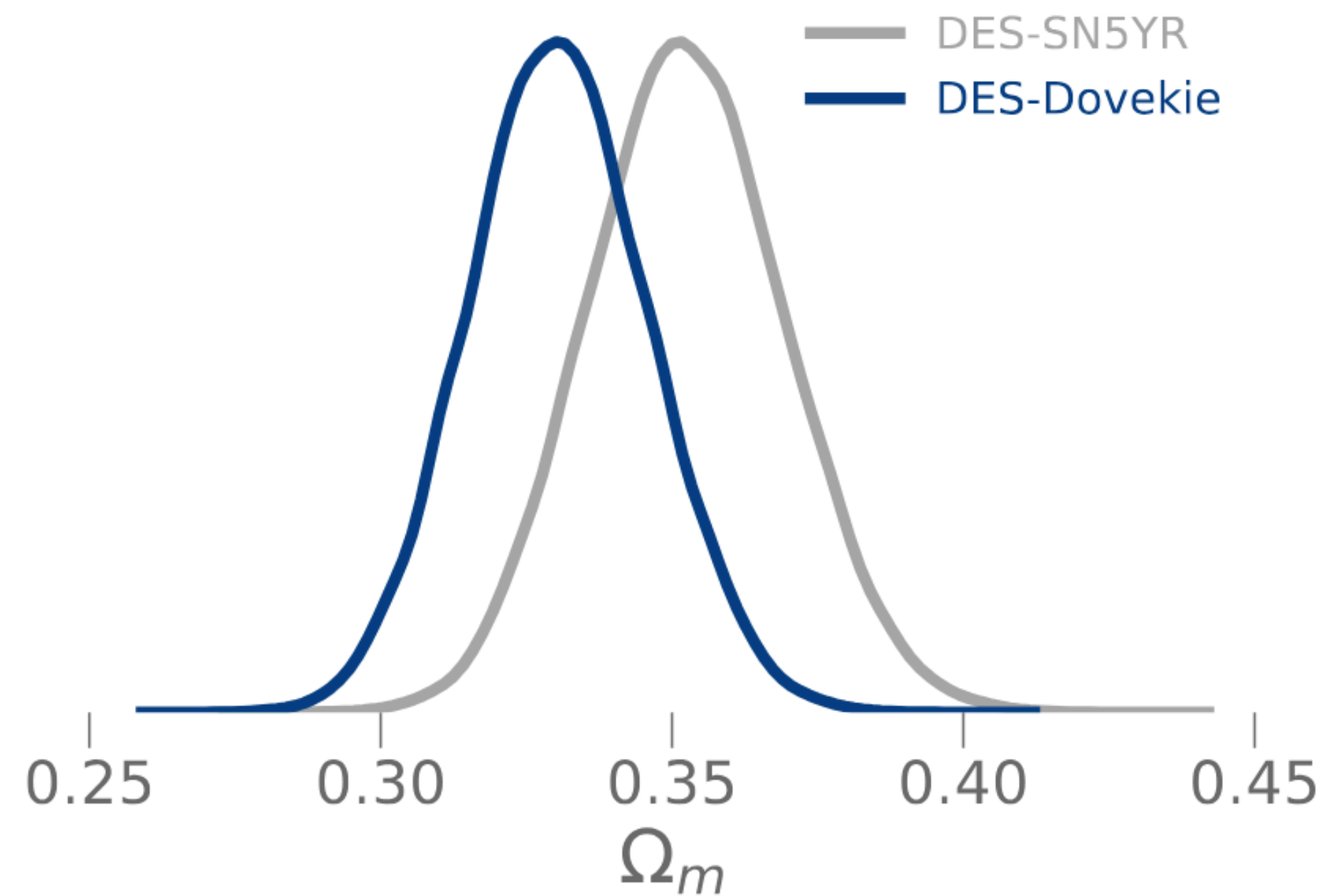


Figure C1. Ω_m posteriors for Flat Λ CDM for the original DES-SN5YR (grey) and DES-Dovekie (dark blue).

[Popovic et al. 2026](#)

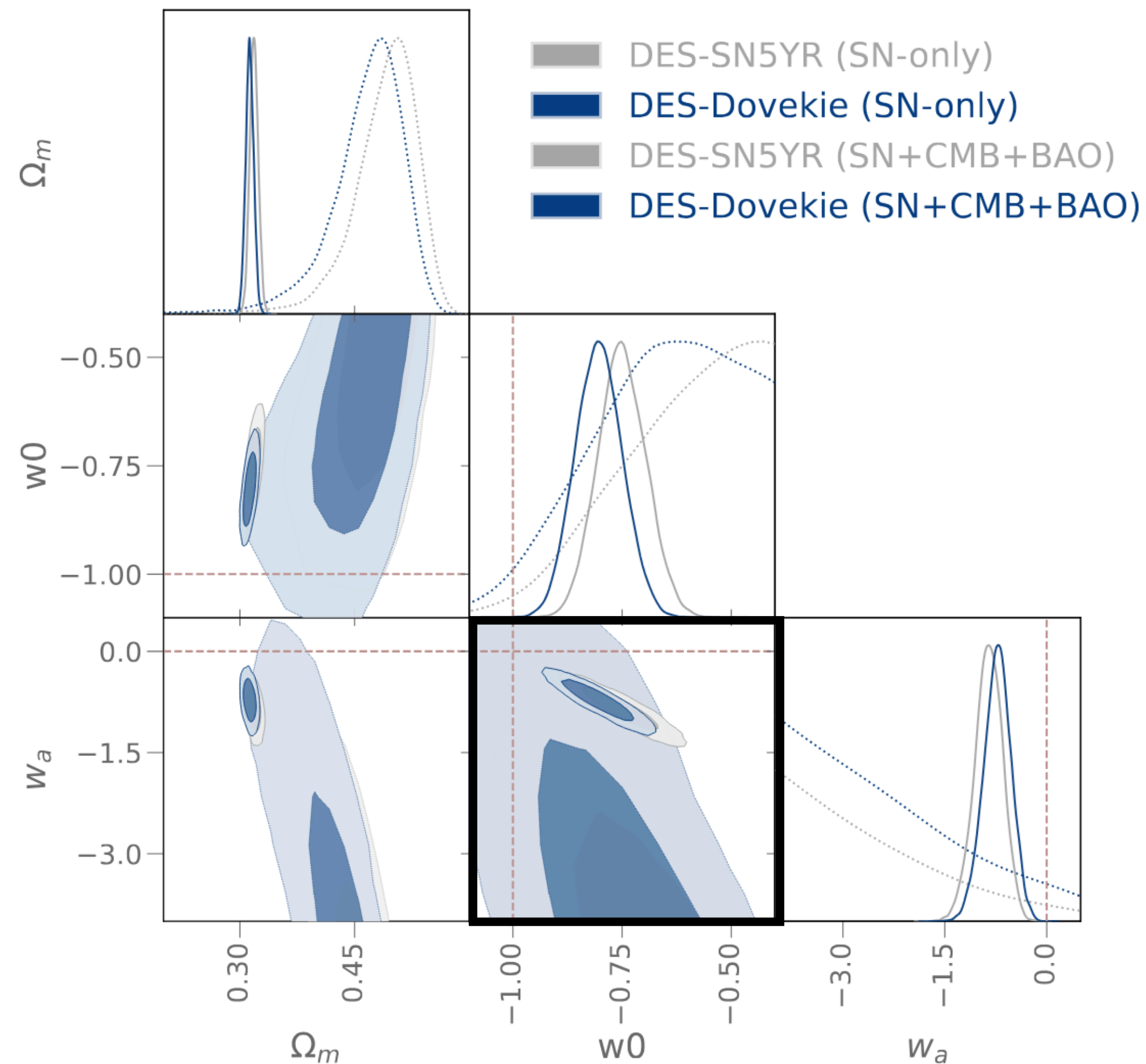


Figure C3. Ω_m , w_0 , and w_a posteriors for SN+CMB+BAO with SN as DES-SN5YR (grey) and DES-Dovekie (dark blue). We present the SN-only posteriors for each in high-transparency.