Neutrino mass bounds from DESI 2024 are relaxed by Planck PR4 and cosmological supernovae

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Sensitivity of Cosmology to Neutrino Mass

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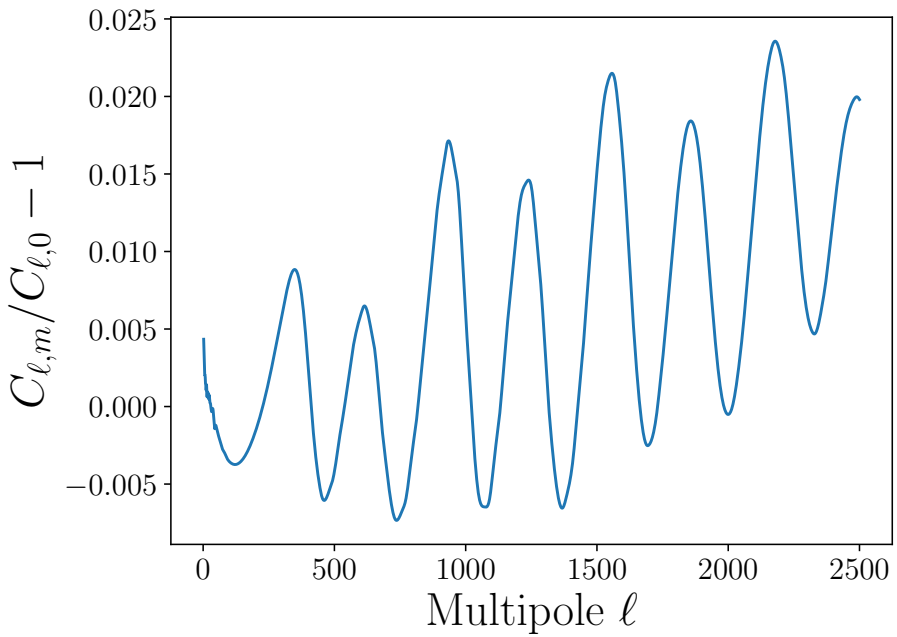

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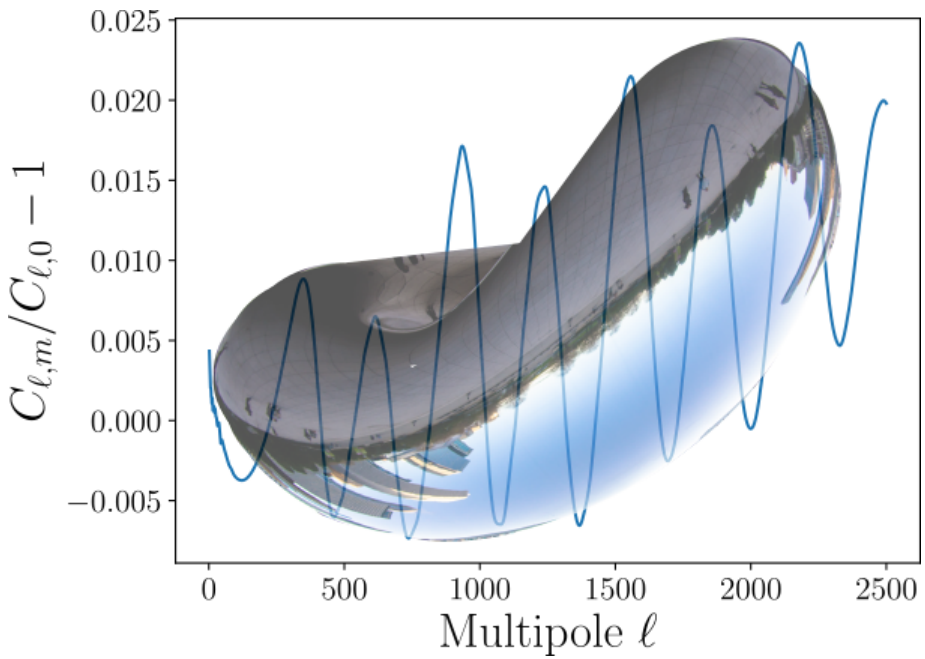

Constraints from CMB and BAO

Fitting to cosmological data can provide a strong upper bound on the sum of neutrino masses

- Assuming the ΛCDM+$\sum m_\nu$ model
- Using cosmic microwave background data from Planck 2018 (Aghanim et al 2020)
- and baryon acoustic oscillations measurements from SDSS BOSS DR12 (Alam et al 2017)

$$\sum m_\nu < 0.12 \text{ eV (Planck18 + SDSS DR12)} \quad (1)$$

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Data Analysis

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Evaluate $\sum m_\nu$ upper bounds with broad set of cosmological data

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Cosmologies are computed with Einstein-boltzmann solver `CLASS`: (Blas + Lesgourgues + Tram 11)

Markov Chain Monte Carlo analysis using `MontePython` (Audren et al 12, Brinckmann + Lesgourgues 18) and `Cobaya` (Torrado + Lewis 20)

Planck PR4 Likelihoods

Final release (PR4) Planck data has new likelihoods, including Hillipop+Lollipop ($P20_H$)

(Tristram et al 24)

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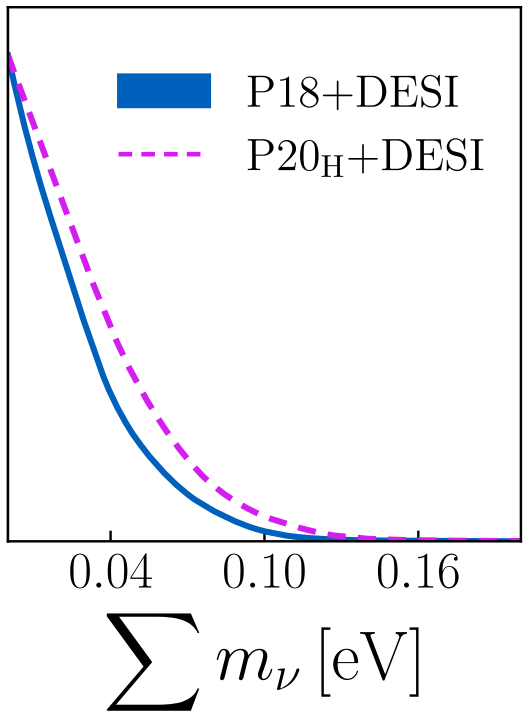

Comparing to Planck 2018 data, bounds are significantly relaxed

$$\sum m_\nu < 0.086 \text{ eV (DESI + P20}_H\text{)} \quad (3)$$

Supernovae Datasets

Cosmological supernovae not included in original DESI analysis

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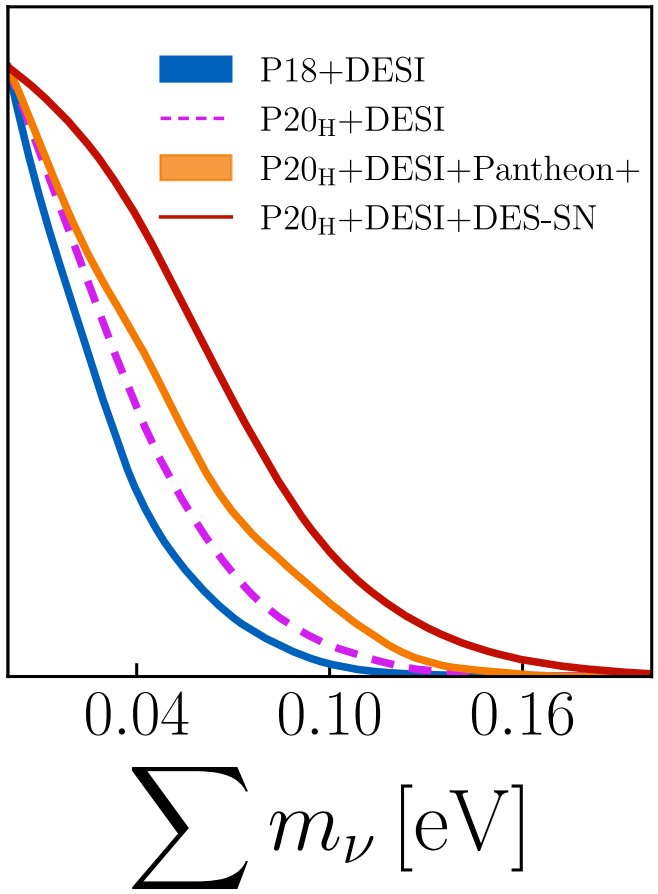

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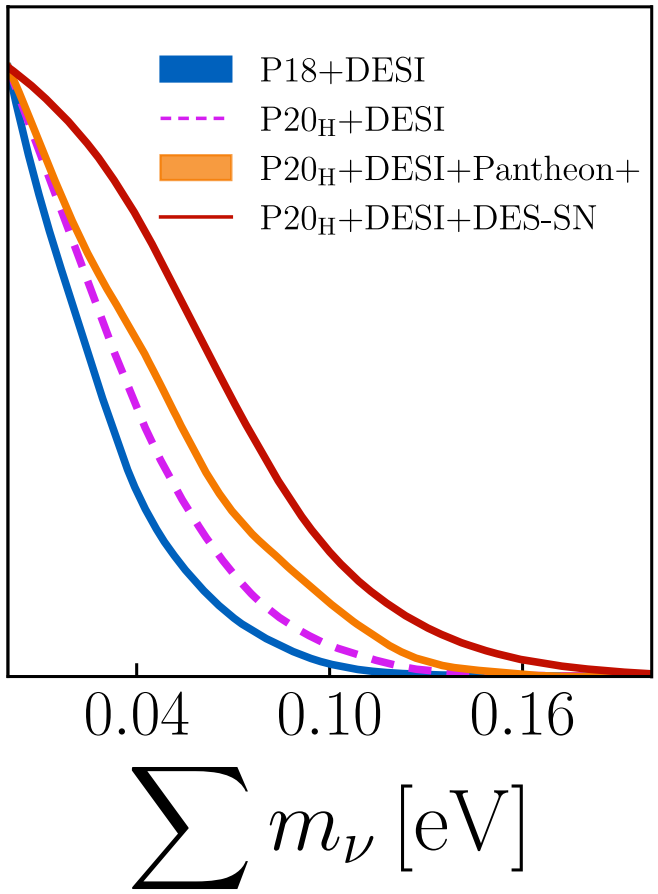
$$\sum m_\nu < 0.099 \text{ eV} \quad (4)$$

(DESI + P20$_H$ + Pantheon+)

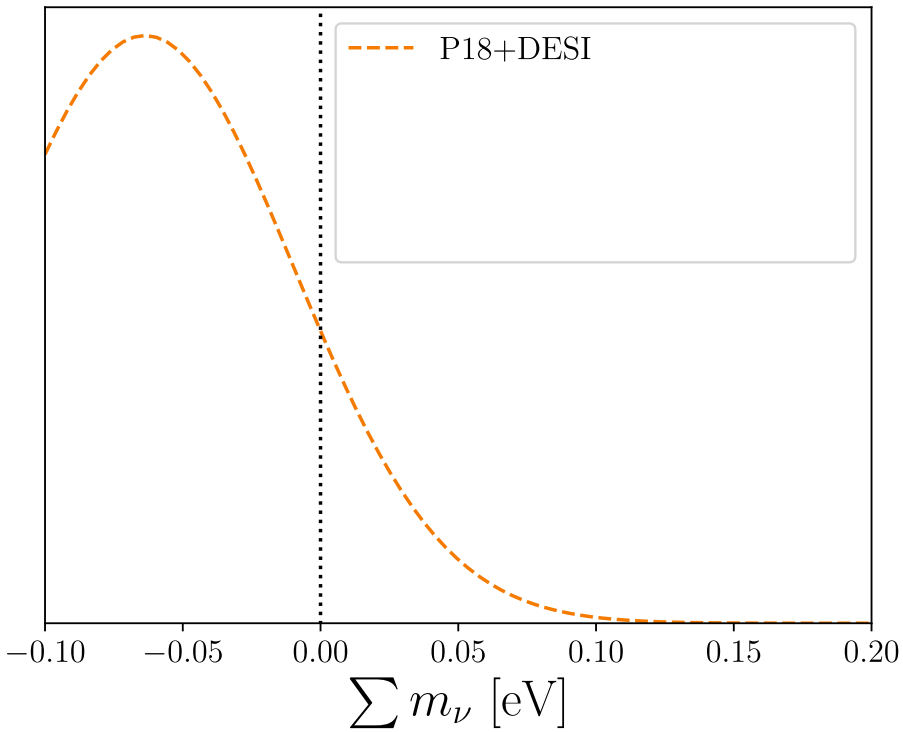


$$\sum m_\nu < 0.12 \text{ eV (DESI + P20}_H \text{ + DES-SN5YR)} \quad (5)$$

Fitting Distribution Peaks

CMB + BAO data has shown mild preference for effectively "negative" neutrino masses

(Alam et al 21; Craig et al 24)



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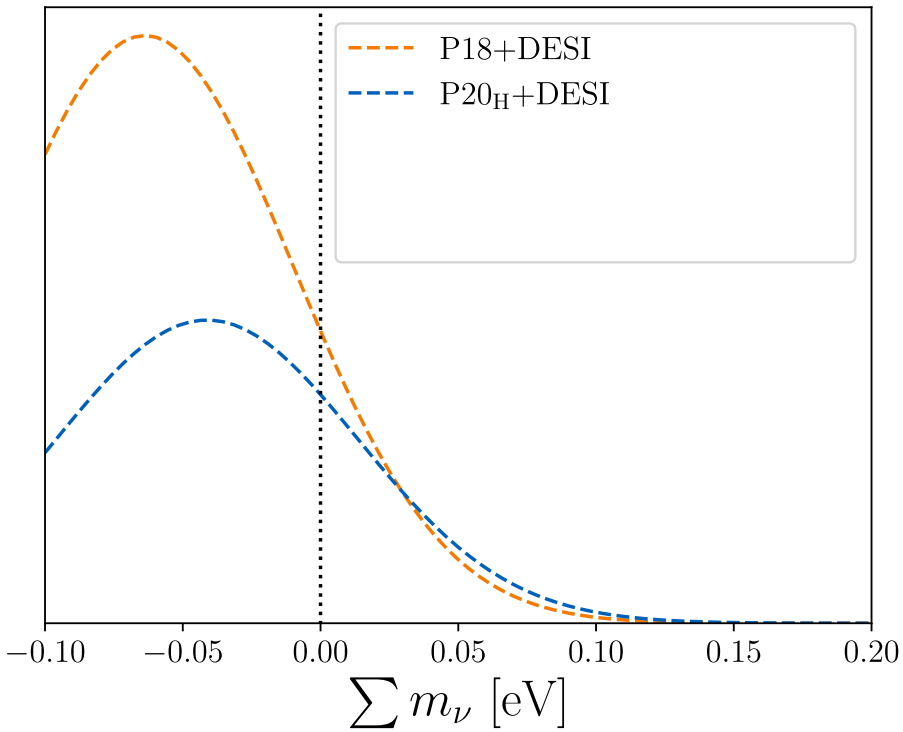

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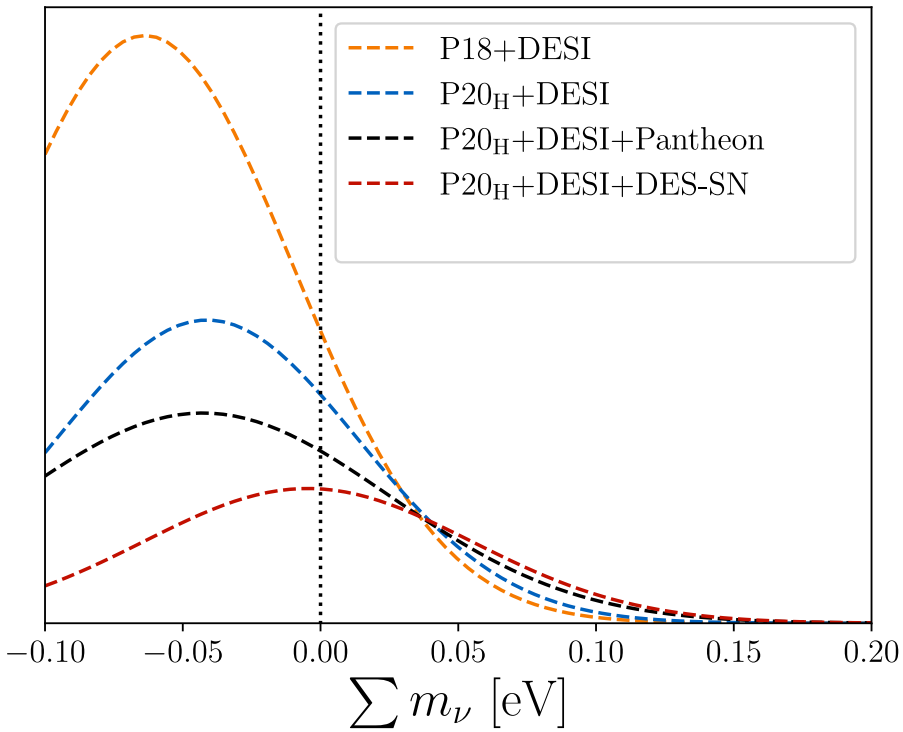

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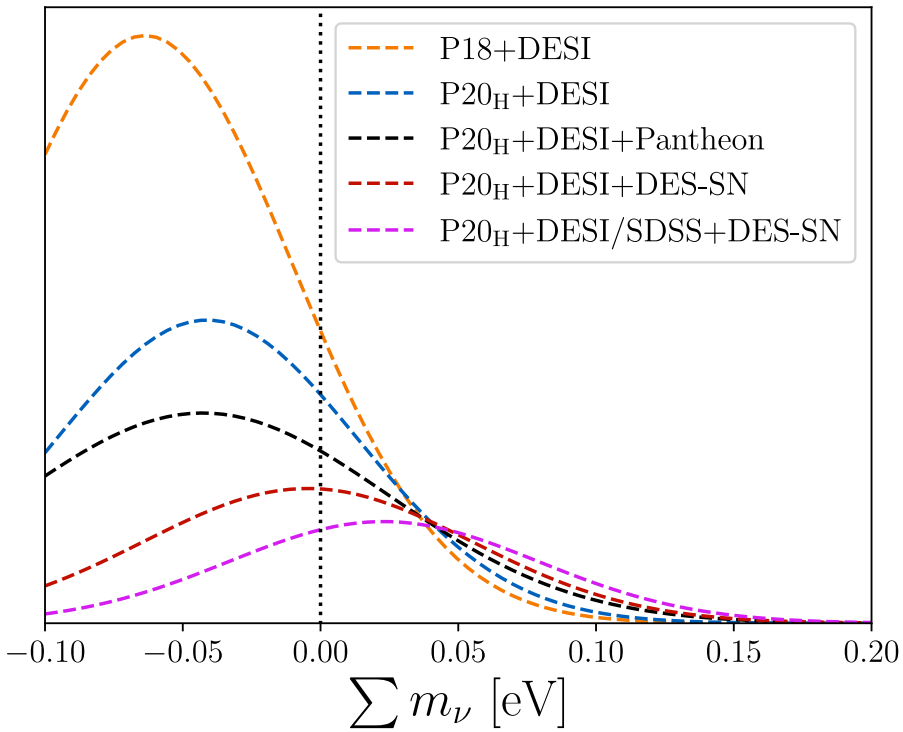

Beyond ΛCDM+$\sum m_\nu$: Fluid Dark Radiation Model

Simple extended model beyond ΛCDM: dark radiation (DR)

- One-parameter extension $\Delta N_{\rm eff}$
- Example: Fluid-like DR (self-interacting)
- In light of DESI, potential resolution to Hubble tension

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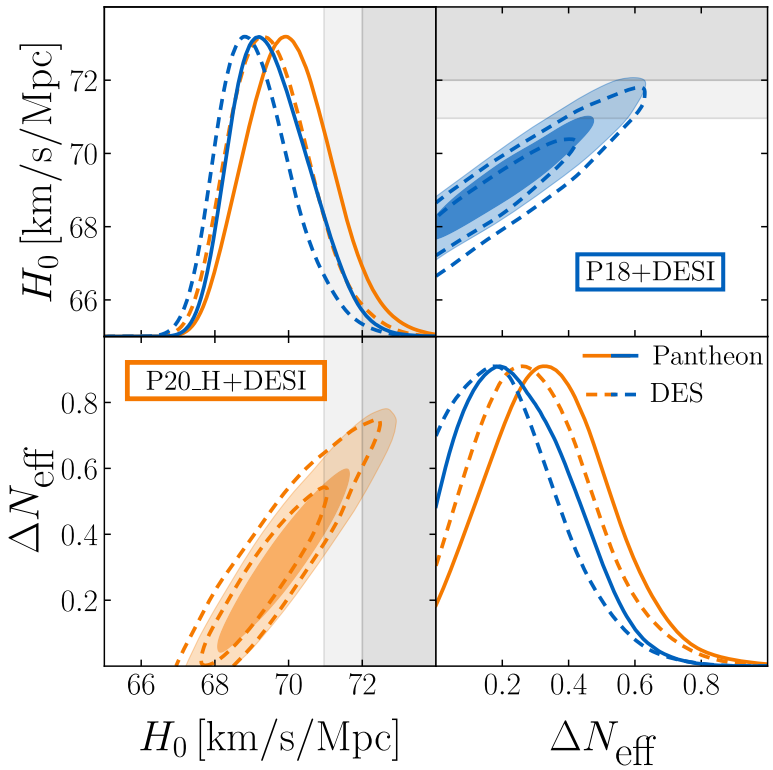
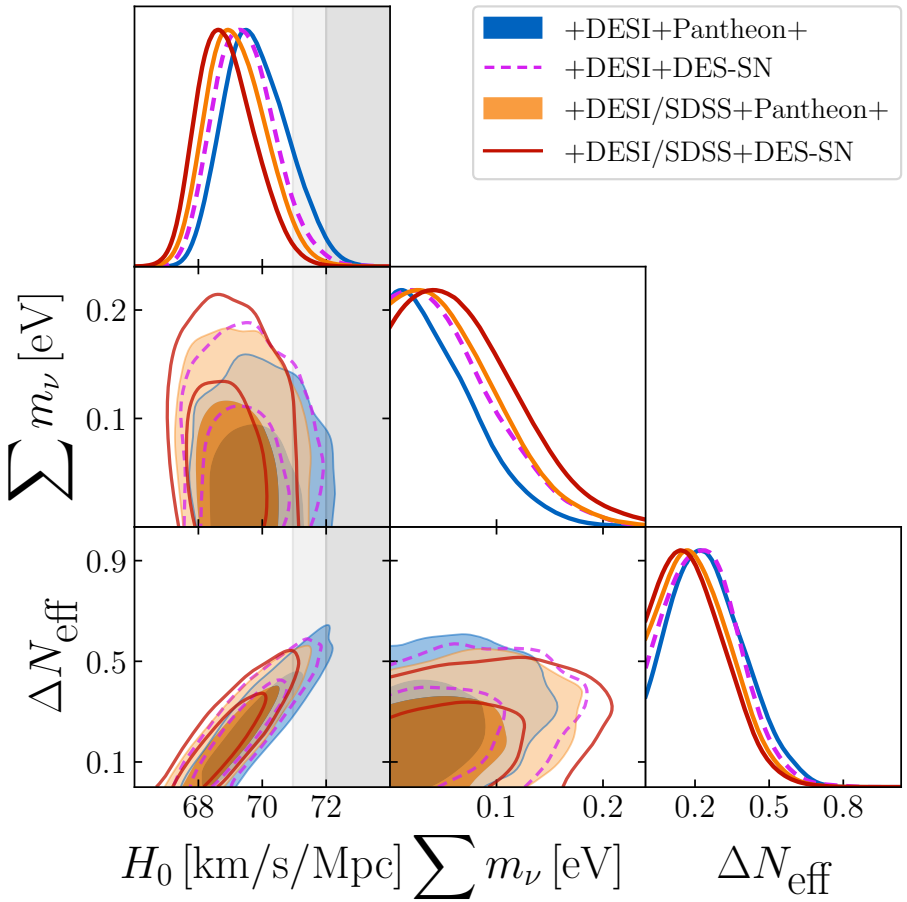


$\sum m_\nu$ Constraints with Fluid DR



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+**Pantheon**	< 0.13
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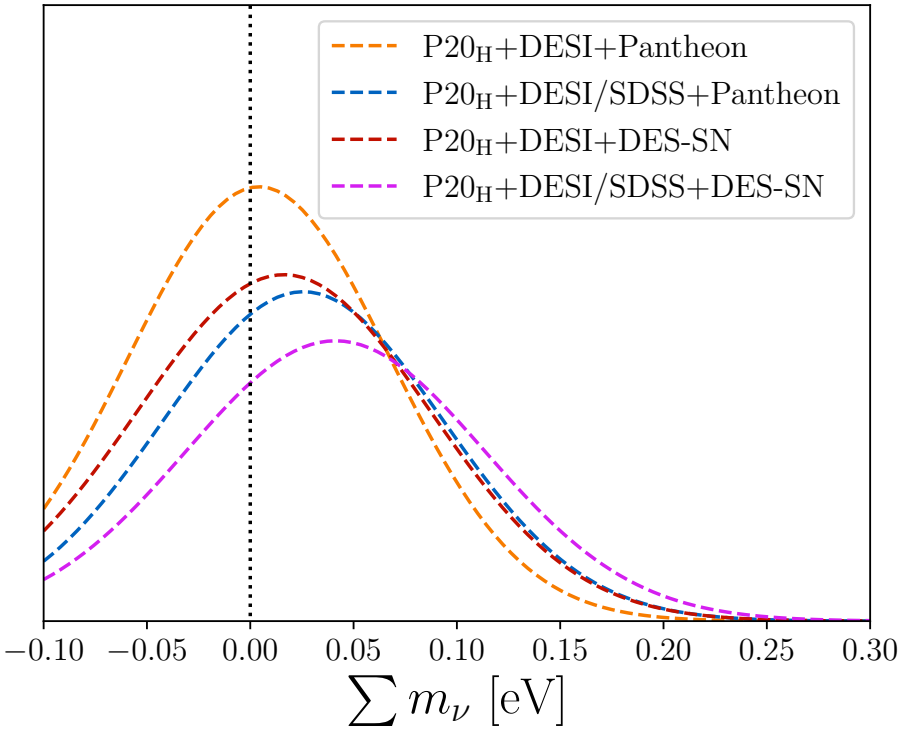

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Summary

- Claims about neutrino mass constraints are highly dependent on choice of data
- Planck PR4, supernovae datasets relax constraints
  - $\sum m_\nu < 0.072$ eV (P18+DESI)
  - $\sum m_\nu < 0.12$ eV (P20$_H$+DESI+DES-SN5YR)
- Not yet able to rule out inverted mass hierarchy
- Showing signs of future detection with more data, especially in ΛCDM+$\sum m_\nu$+DR