The Impact of Priors in a Neutrino Hierarchy Analysis

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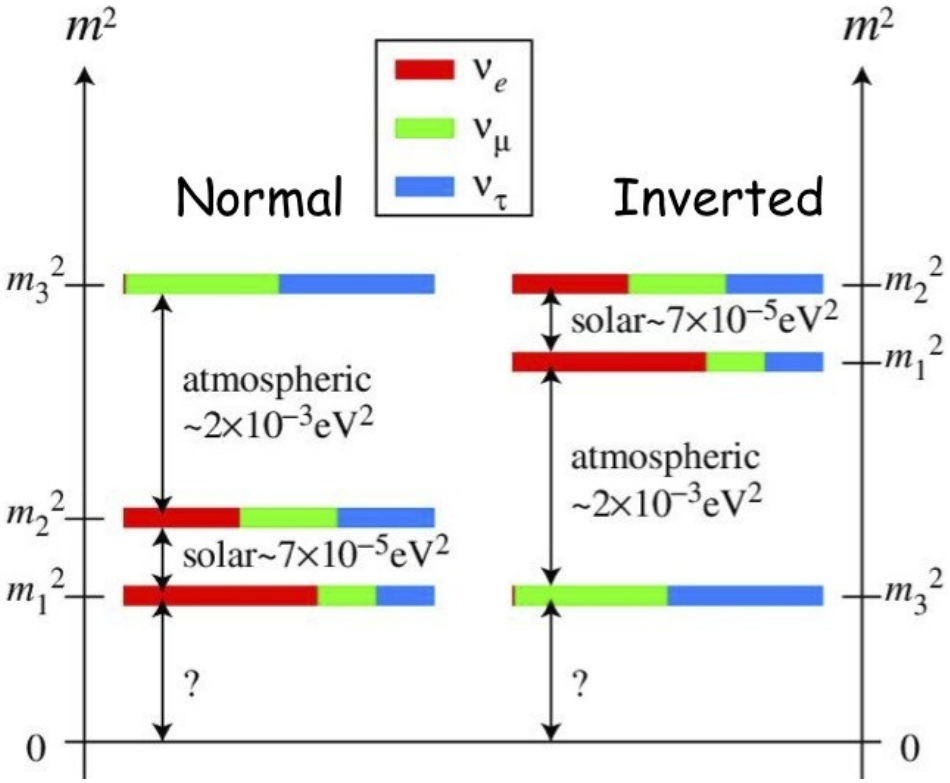
Introduction

Aim: construct a prior to be used in a joint analysis of neutrino oscillation and cosmology data which does not favour either hierarchy

- Why is a joint analysis desirable?
- Why is an equal odds prior required?

Mass squared splittings



$$\Delta m^2_{21} = (7.53 \pm 0.18) \times 10^{-5}\,\mathrm{eV}^2$$

$$\Delta m^2_{32} = (-2.51 \pm 0.05) \times 10^{-3}\,\mathrm{eV}^2$$

$$\Delta m^2_{32} = (-2.56 \pm 0.04) \times 10^{-3}\,\mathrm{eV}^2$$

Upper limit on sum of the masses

CMB: $\sum m_\nu < 0.72\,\mathrm{eV}$

CMB + BAO: $\sum m_\nu < 0.21\,\mathrm{eV}$

CMB + CMB lensing + Lyman-α: $\sum m_\nu < 0.12\,\mathrm{eV}$

Minimum sum of masses allowed by oscillations

Normal $\sum m_\nu \sim 0.06\,\mathrm{eV}$

Inverted $\sum m_\nu \sim 0.1\,\mathrm{eV}$

Choice of Prior

Bayes theorem

$$P(\theta \mid x) = \frac{P(x \mid \theta) P(\theta)}{P(x)}$$

Two difficulties

1. Neutrino data is not currently very constraining
2. Joint parameter space is complex

Literature

Normal : Inverted

42:1 (Simpson et al. 1703.03425)

3:2 (Hannestad and Schwetz. 1606.0469 & Gerbino et al. 1611.07847)

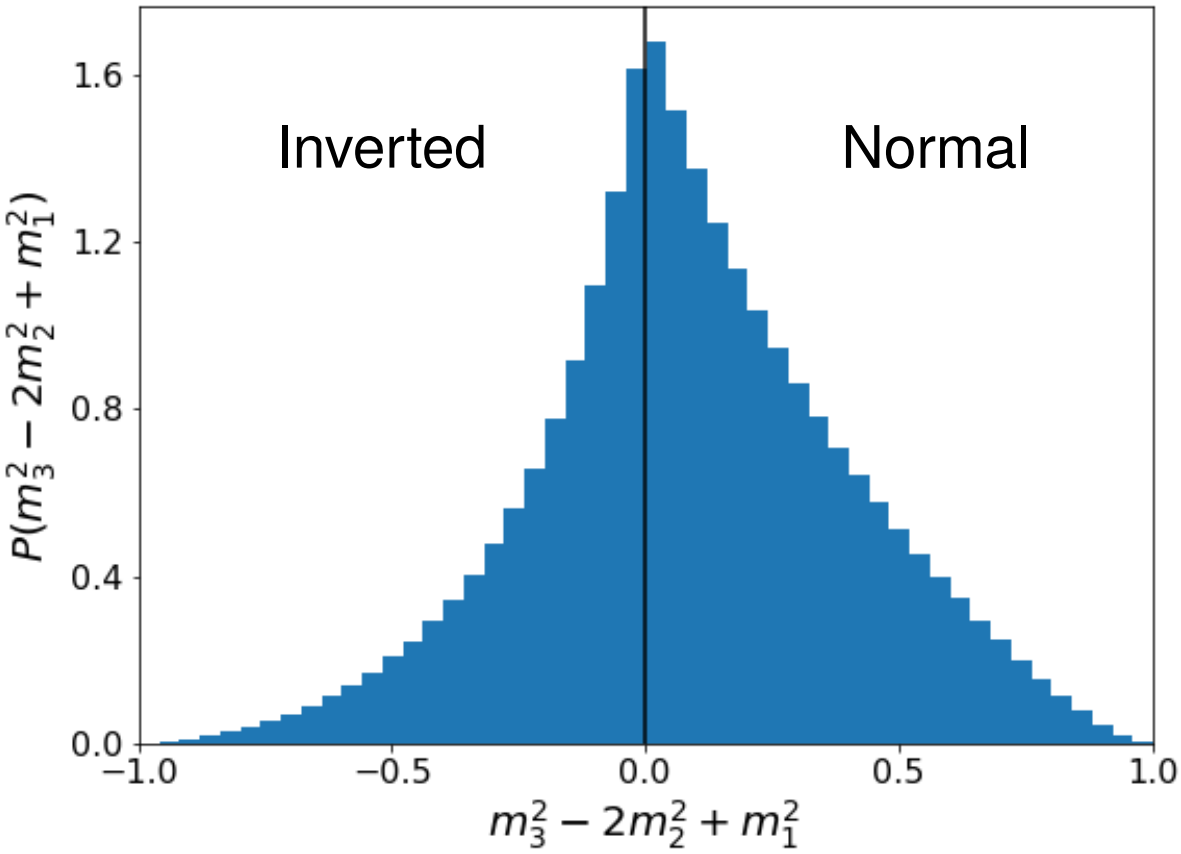
9:5 or **10:3** (Vagnozzi et al. 1701.08172)

130:1, **19:1**, **470:1** (Long et al. 1711.08434)

5:1 (Heavens and Sellentin. 1802.09450)

Example Prior

Uniform prior on the log masses



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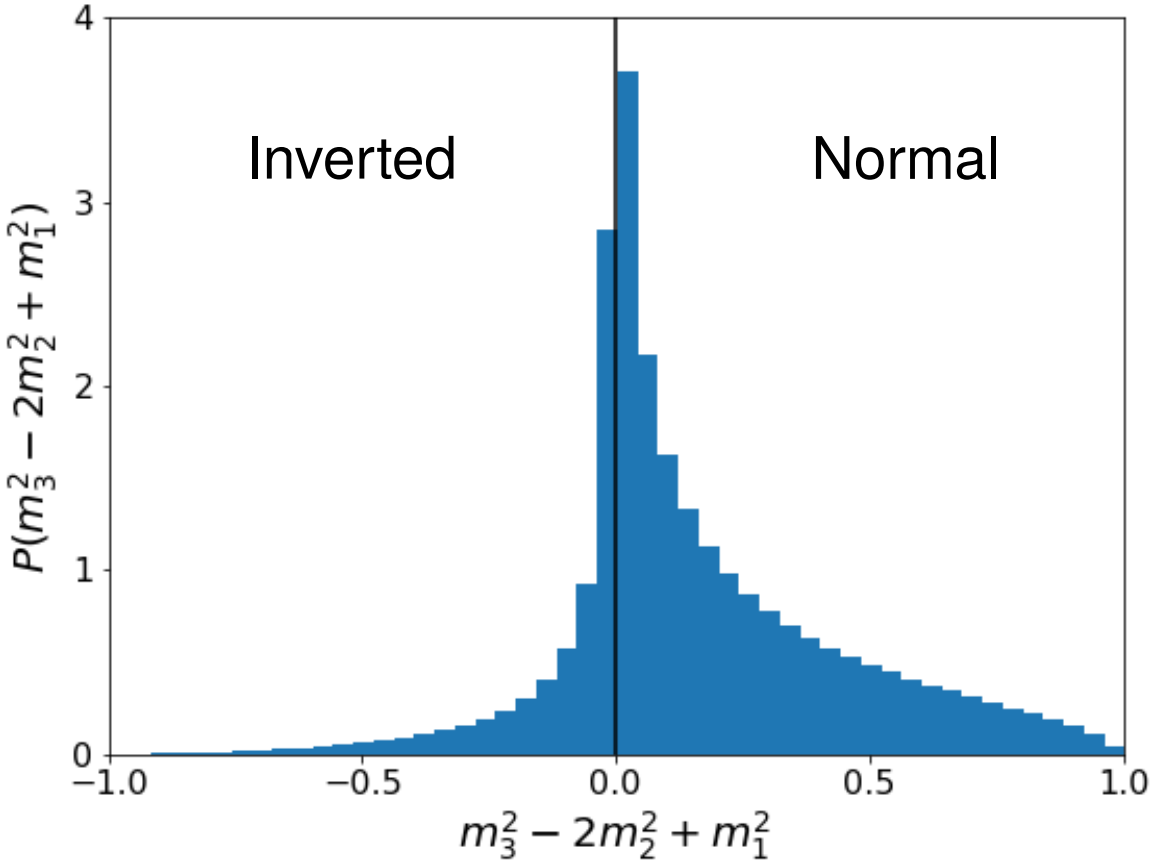

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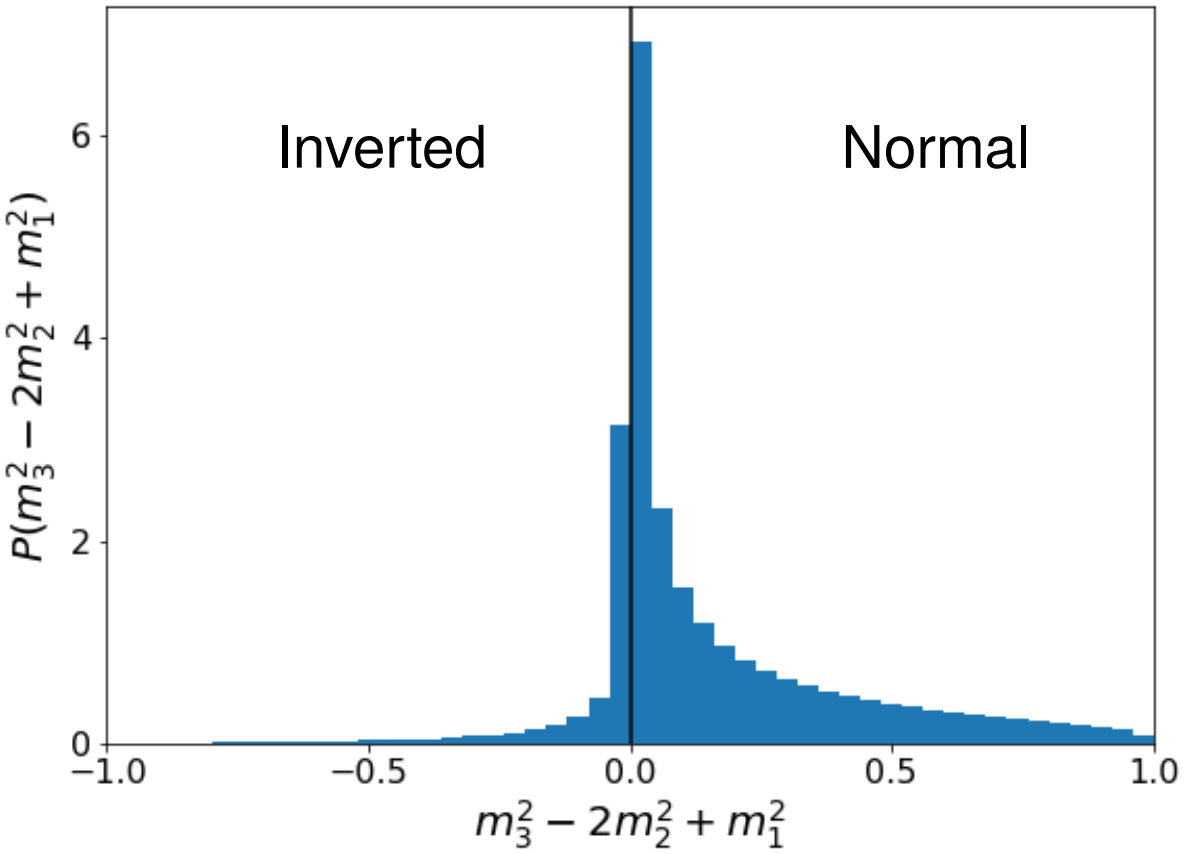

Our Approach

Construct a prior with equal odds

Rejection Sampling

1. Sample prior
2. Sample odds ratio from prior
3. Keep prior if results in equal odds