Probing the pseudo-Dirac scenario using Solar neutrinos at JUNO

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IP3

Neutrino Masses

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↓ SM SSB via Higgs vev

$$\mathcal{L}_\nu \supset -\frac{Y_{\alpha i} v}{\sqrt{2}}\overline{\nu^\alpha}_R N_R^i + \frac{1}{2}(N_R^i)^c M_{ij} N_R^j + h.c$$

Neutrino Masses

Let's rewrite it a bit neater...

$$\mathcal{L}_\nu \supset -\frac{1}{2}\overline{\Psi}^c M \Psi$$

$$\Psi = \begin{pmatrix} \nu_L \\ N_R^c \end{pmatrix} \qquad M = \begin{pmatrix} 0_3 & \frac{Y^T v}{\sqrt{2}} \\ \frac{Y v}{\sqrt{2}} & M_R \end{pmatrix}$$

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In See-Saw scenarios, take: $M_R \gg Yv$

But what about... $M_R \ll Yv$

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Global symmetries should be broken by quantum gravity...

$$M_R \equiv 0 \quad \Longrightarrow \quad 0 < M_R \ll 1$$

The Pseudo-Dirac Scenario

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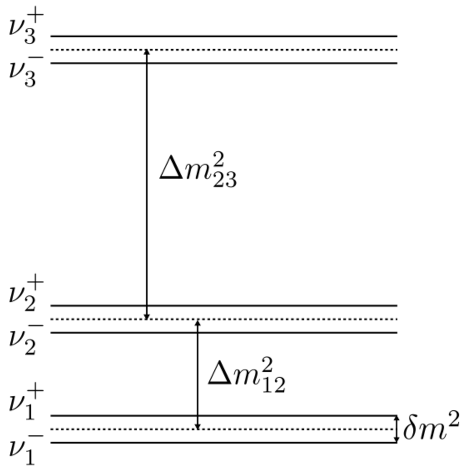

Testing the Pseudo-Dirac Nature

Majorana mass is *tiny*, basically impossible to probe with $0\nu2\beta$

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What about oscillations?

$$L_{osc} = \frac{4\pi E_\nu}{\delta m_k^2} \approx 25 \times 10^5 \mathrm{km} \left(\frac{E_\nu}{100\mathrm{keV}}\right) \left(\frac{10^{-10}\mathrm{eV}^2}{\delta m_k^2}\right)$$

Solar oscillations with PD neutrinos

Solar neutrinos are a great probe:

$$E_{pp} \leq 420\text{keV}$$

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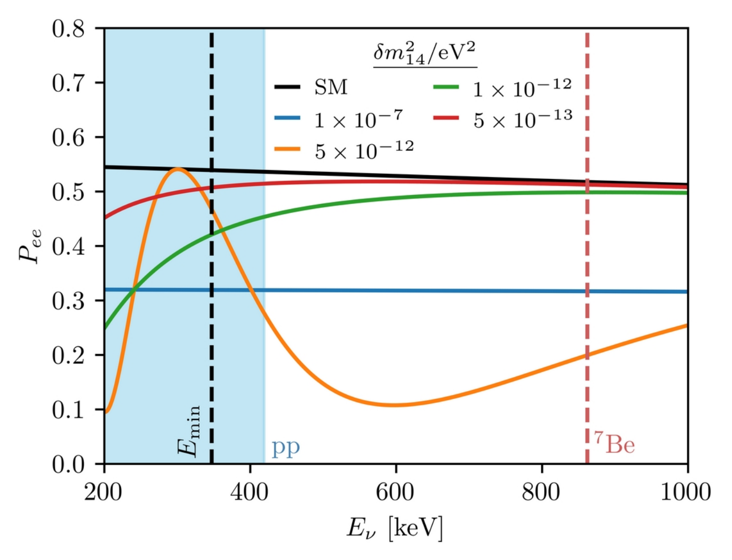

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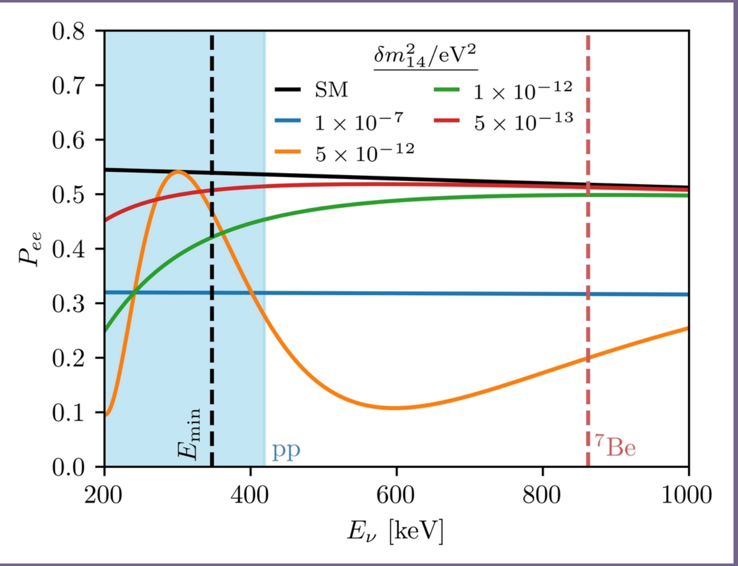
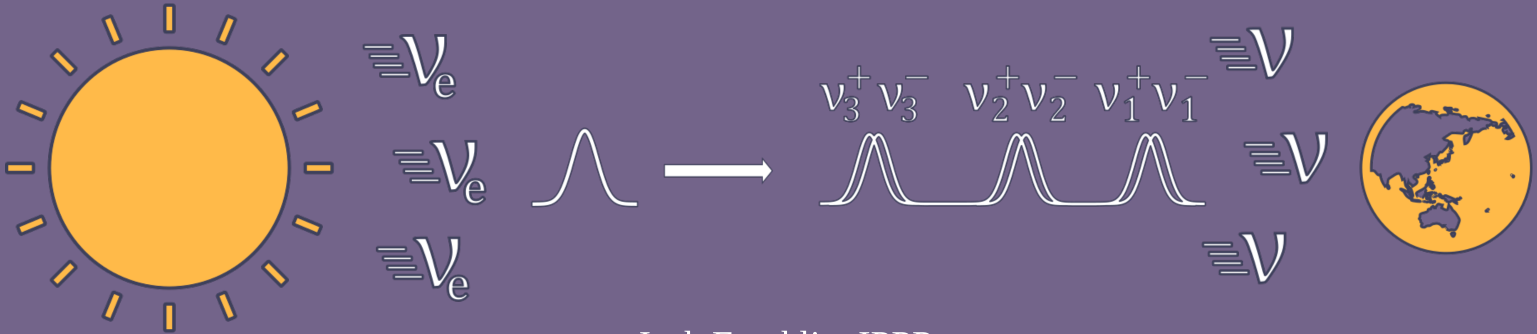
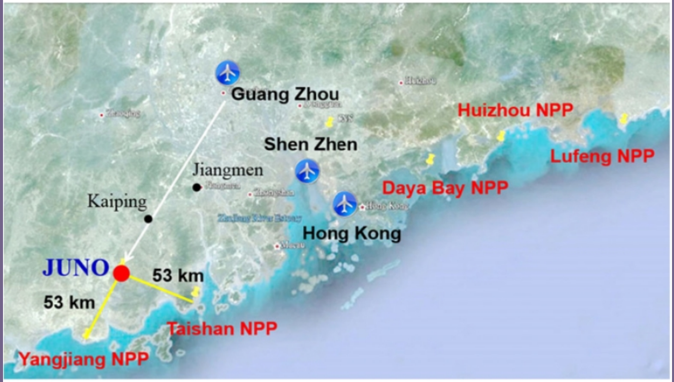
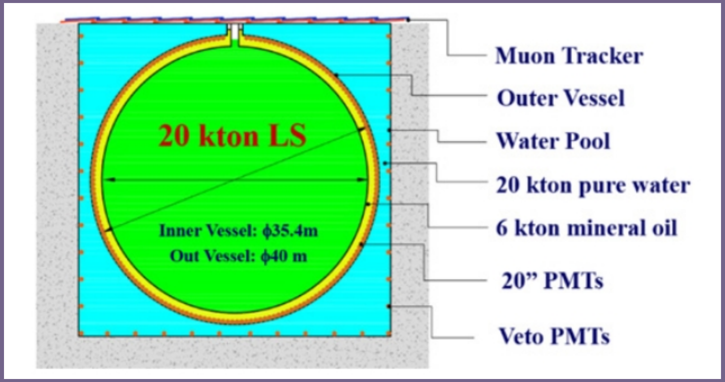




The JUNO Experiment

- Jiangmen Underground Neutrino Observatory (JUNO)
- Liquid scintillator detector





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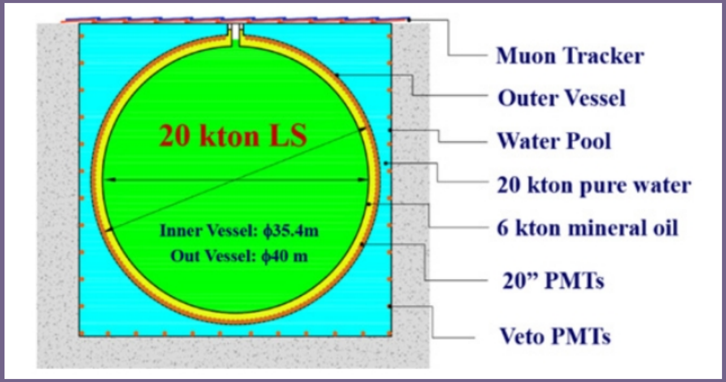

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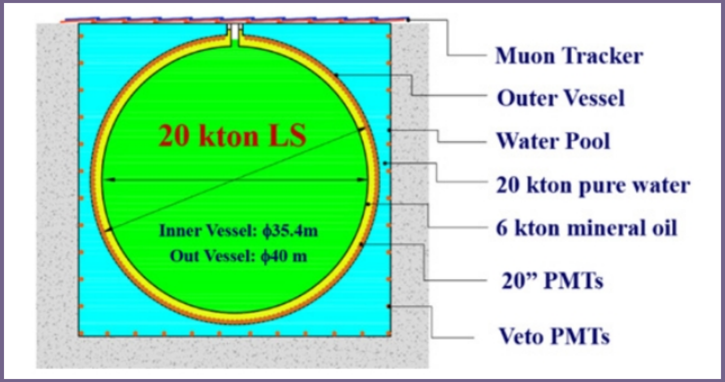

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The JUNO Experiment

- Jiangmen Underground Neutrino Observatory (JUNO)
- Liquid scintillator detector
- 20 kt fiducial volume (Borexino ~ 1kt)
- Primary goal is to determine the neutrino mass hierarchy
- Will be able to detect Solar neutrinos

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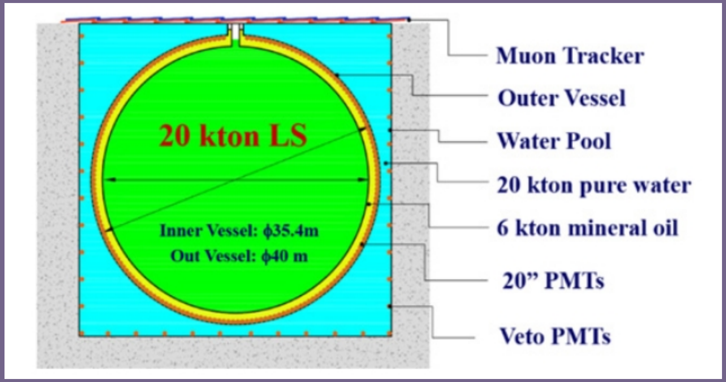
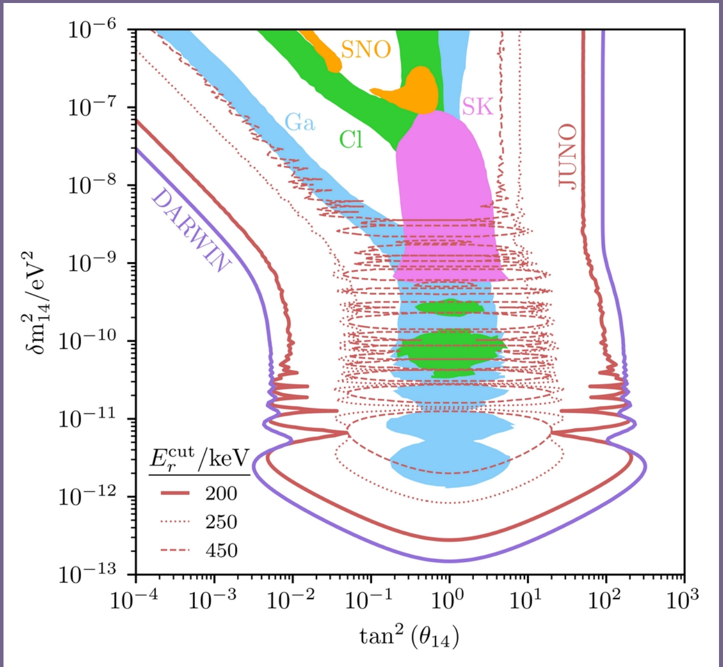


Results

Looked at two types of scenarios:

- Only one mass splitting, non-maximal mixing
  - JUNO will be able to put strong bounds on parameter space
  - May be competitive with DARWIN experiment



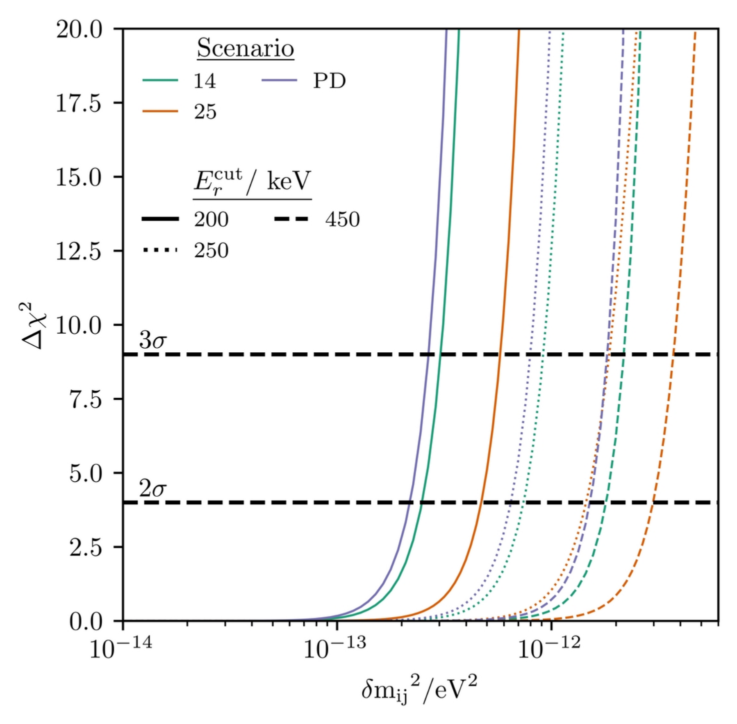
Results

- Looked at two types of scenarios:
- Maximal mixing:
  - 1 splitting only:

    $$\delta m_1^2 \lesssim 3 \times 10^{-13} \mathrm{eV}^2$$
  - 2 splitting only:

    $$\delta m_2^2 \lesssim 6 \times 10^{-13} \mathrm{eV}^2$$
  - All states:

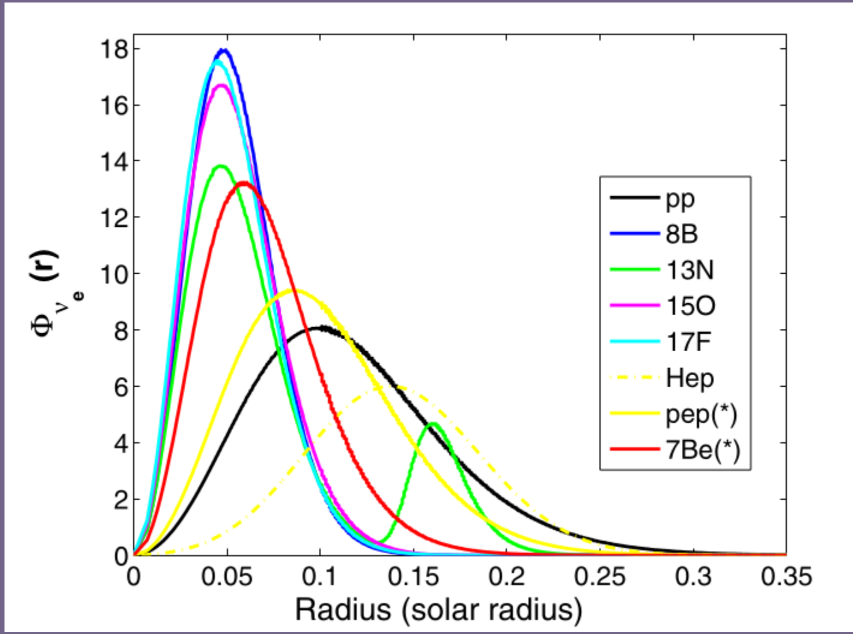
    $$\delta m^2 \lesssim 3 \times 10^{-13} \mathrm{eV}^2$$

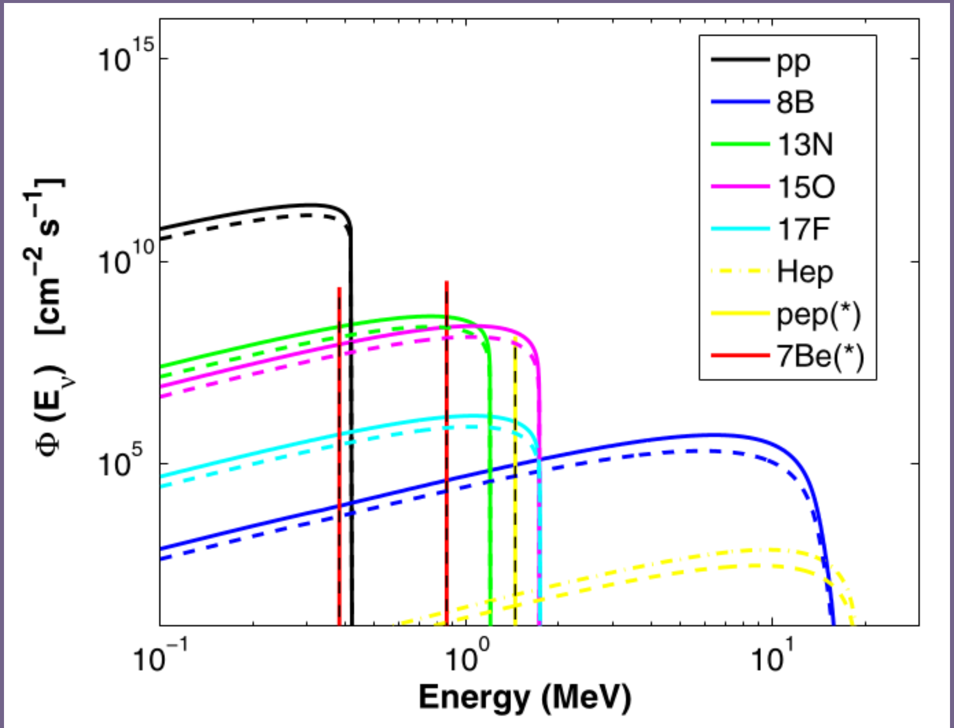


Thank you

Feel free to come by my poster if you have any questions!

Solar neutrino fluxes





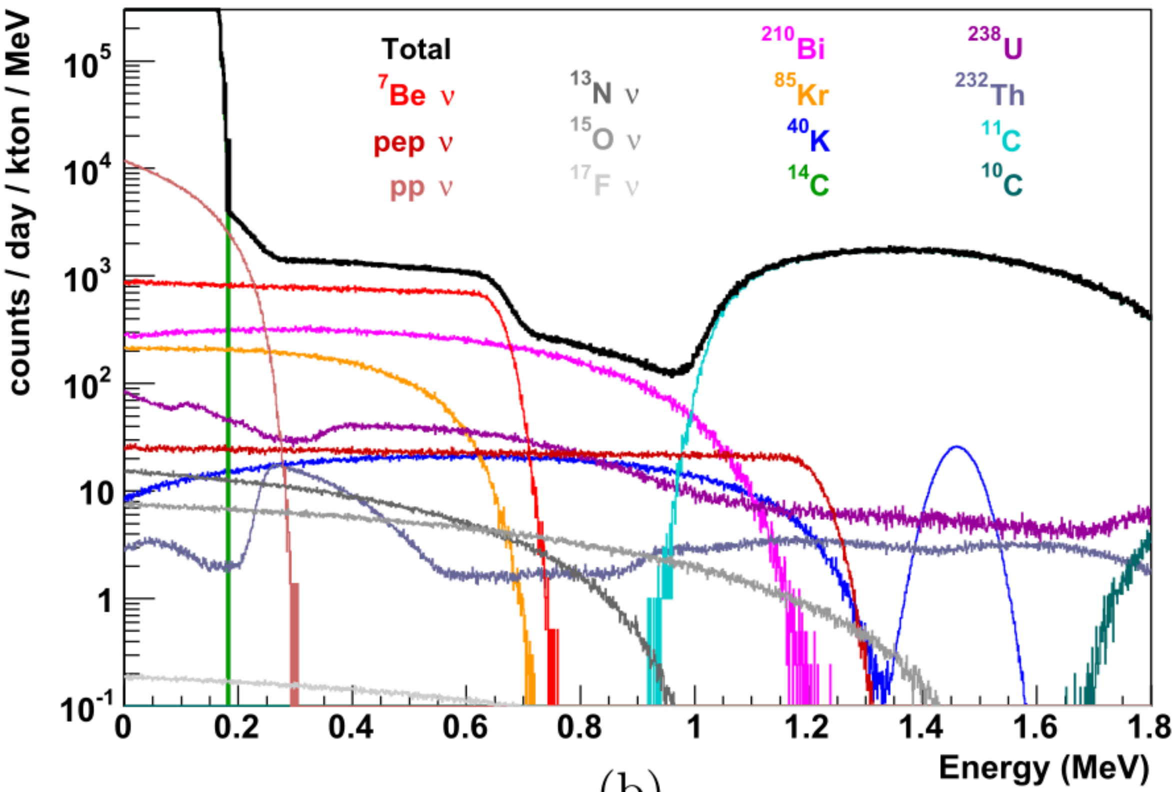
Source: Ilídio Lopes and Sylvaine Turck-Chièze 2013 ApJ 765 14

Chi-squared

$$\chi^2 = \sum_i \frac{\left(\sum_a \alpha_a N^{i,a}_{\text{theory}} + \sum_b (\alpha_b - 1) N^{i,b} - N^i_{\text{bench}}\right)^2}{N^i_{\text{bench}} + \sum_b N^i_b}$$

$$+ \sum_a \left(\frac{\alpha_a - 1}{\sigma_a}\right)^2 + \sum_b \left(\frac{\alpha_b - 1}{\sigma_b}\right)^2$$

Backgrounds at JUNO



(b)