Explaining the MiniBooNE Excess Through a Mixed Model of Oscillation and Decay[1]

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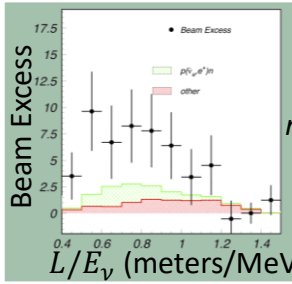
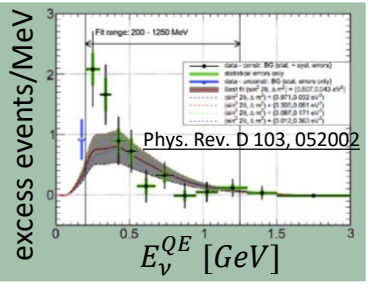
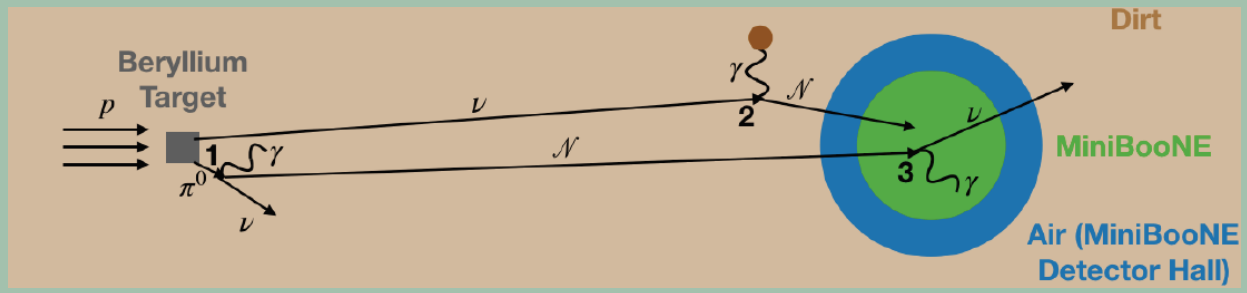
Evidences for Neutrinos Beyond Standard Model



Left: LSND excess suggested there could be more than 3 neutrinos.

Right: MiniBooNE (MB) reported an ν_e-like excess in tension with other global fits with 3 ν plus 1 sterile O(1 eV).

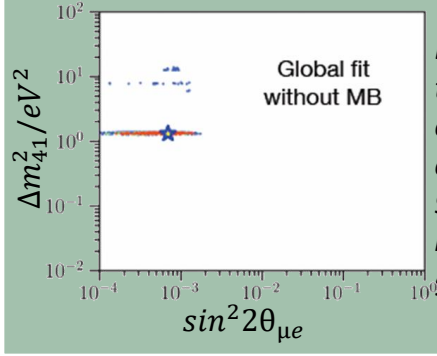




Simulated process from the creation of HNLs to their decay inside MB detector

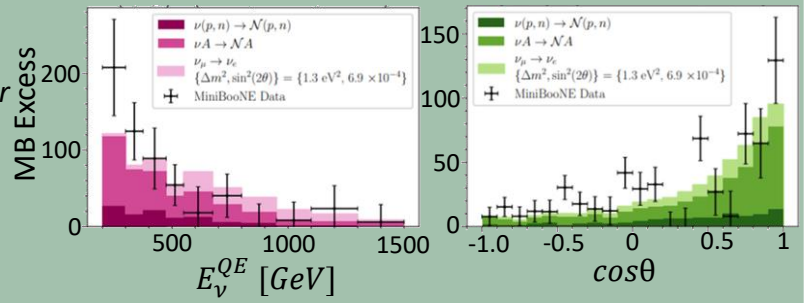
Fitting MB Excess

- We evaluate the oscillation parameters from a global fit (w/o MB) for ν_e appearance and $\nu_{\mu/e}$ disappearance: $\Delta m^2 = 1.3\ eV^2$ and $sin^2(2\theta_{\mu e}) = 6.9 \times 10^{-4}$.



Best fit region for the model 3+1 only with oscillation data. 90,95, and 99% regions in red, green, and blue.

- We remove from the excess the 3+1 global fits' results. The remaining excess is fitted with our dipole model in energy and angular distribution.



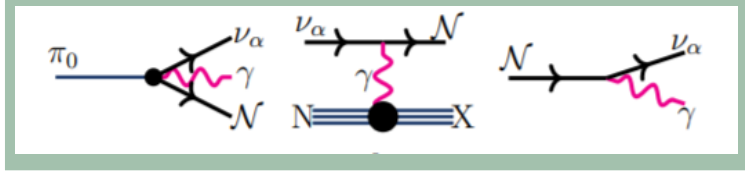
E_ν^{QE} (left) and cosϑ (right) distribution for a point in the 3+1+N model.

New Model: the Heavy Neutral Lepton Dipole

- A model 3+1+N_j is proposed, where j = 1,2,3 are sterile ν of size eV, keV, and MeV. Only $N_3 \equiv N$ can be seen in a SBL experiment.
- HNL Dipole Model couples right-handed N, γ, and left-handed ν.
- γ from HNL's decay are simulated for different dipole strengths and masses.

$$\mathcal{L} \supset \mathcal{L}_{SM} + \sum_{j=1}^{3} \bar{\mathcal{N}}_j (i\partial\!\!\!/ - M_j)\mathcal{N}_j + \sum_{i=1}^{3} (d_{i,j}\bar{\nu}_i \sigma_{\mu\nu} F^{\mu\nu} \mathcal{N}_j + h.c.)$$

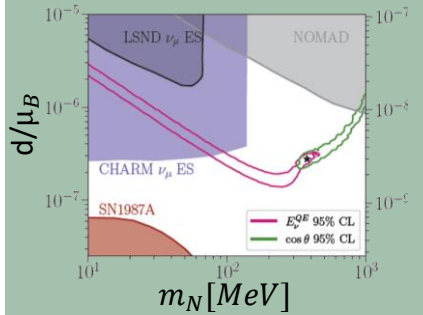
Lagrangian of the Dipole Model



HNL production channels (left and middle), decay (right)

Results and conclusion

- Removing MB data relieves tension between appearance and disappearance data in global fits.
- Dipole model 3+1+*N* gives a good fit to the energy and angular distribution of the MB excess, and it can be tested on MINERνA, NOνA, T2K, and IceCube.



Preferred regions to explain the MB excess.

Parameters $(\sin^2 2\theta, d, m_{\mathcal{N}})$	χ^2/dof			
	$3+1+\mathcal{N}$		$3+1$	
	E_ν^{QE}	$\cos\theta$	E_ν^{QE}	$\cos\theta$
(0.30, 3.1, 376)	5.7/8	32.1/18	30.5/10	86.4/20
(0.69, 2.8, 376)	7.9/8	31.4/18	27.3/10	71.8/20
(2.00, 5.6, 35)	20.2/8	36.7/18	27.6/10	40.8/20
(0, 0, 0)	34.1/10	99.4/20	same	same

χ^2/dof values for 3+1 and 3+1+N -decay models.

1 *Vergani S. et al.,* **Explaining the MiniBooNE Excess Through a Mixed Model of Oscillation and Decay**, arXiv: 2105.06470