Karlsruhe Institute of Technology

Deutscher Akademischer Austauschdienst
German Academic Exchange Service

Constraining neutrino transition magnetic moments at DUNE*

@ Inivisibles 2021

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*Work done in collaboration with Thomas Schwetz and Jing-Yu Zhu in [arXiv:2105:09699]

Introduction

- Lagrangian:

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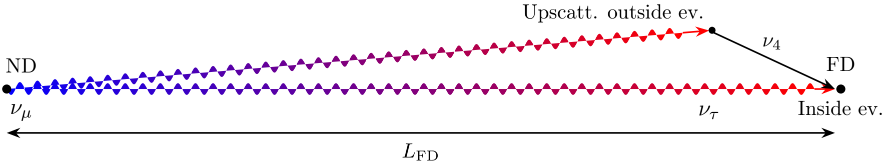

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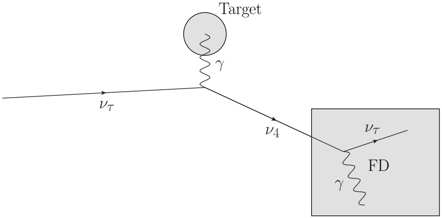
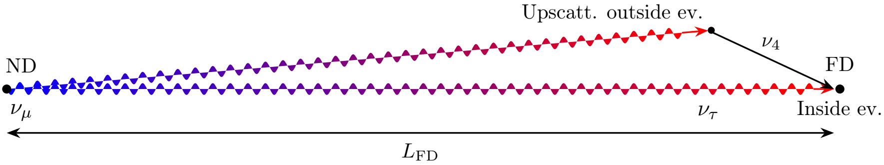
- Can also use intrinsic beam flux at near-detector.





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- **Inside events, coherent:** The coherent scattering on the nucleus leaves a nuclear recoil of low energy, which is difficult to observe in the detector. The decay leaves a single-photon signature.
- **Inside events, incoherent:** The incoherent scattering on nucleons leads to a signature similar to NC neutrino events, whereas the scattering on electrons results in a single electron. In addition, there is a coincidental displaced single-photon event from the heavy-neutrino decay.

Results (decomposition by target and event-type)

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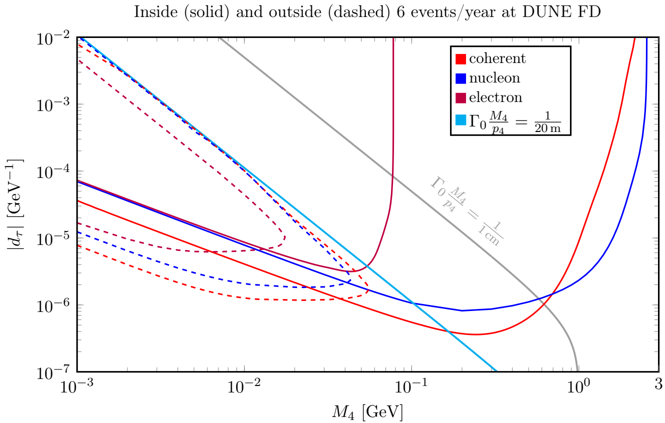
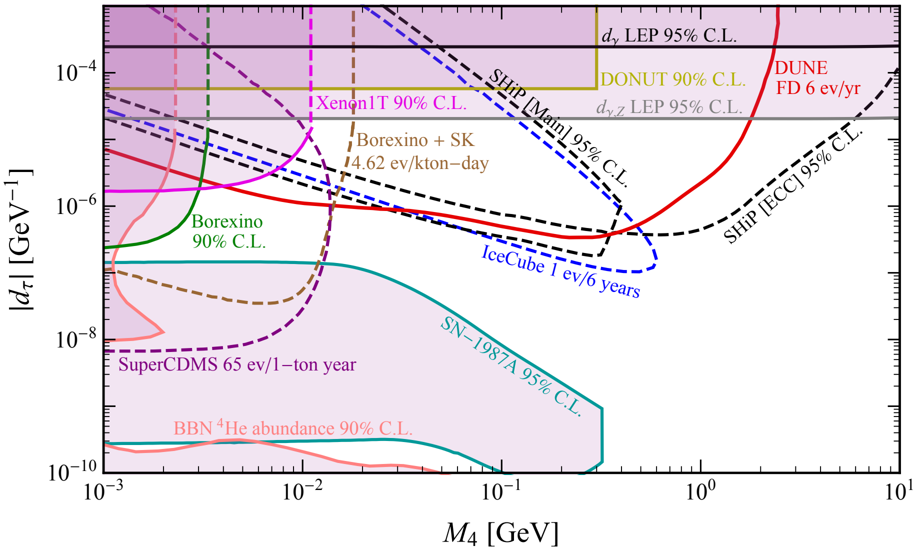
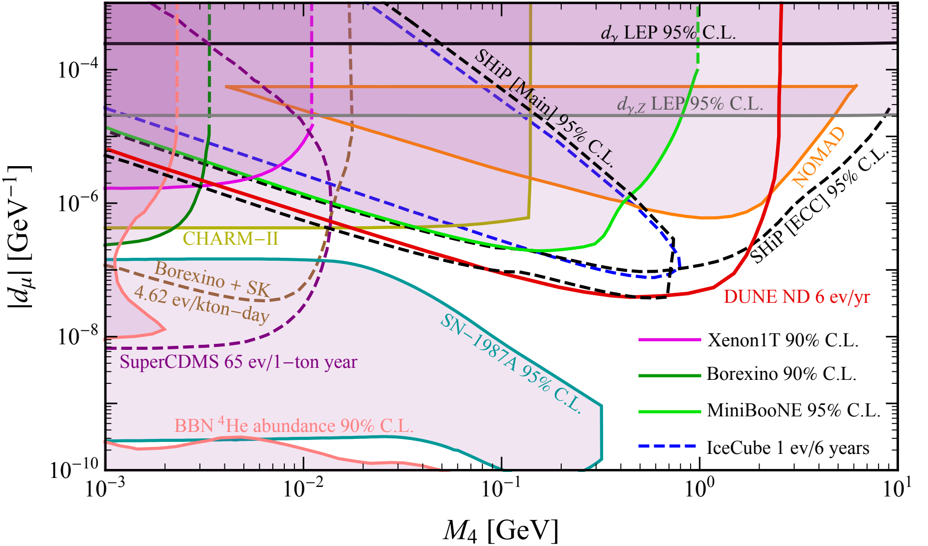


6-events/year curves for inside (solid) and outside (dashed) events at the DUNE FD for coherent scattering on nuclei (red), incoherent scattering on nucleons (blue) as well as electrons (purple). Our approximations for outside events break down at the upper curve, as decays occur very close to the detector (cyan line). This effect is negligible as inside-events will dominate. In grey is indicated when the decay-length is of the order of DUNE's spatial resolution.

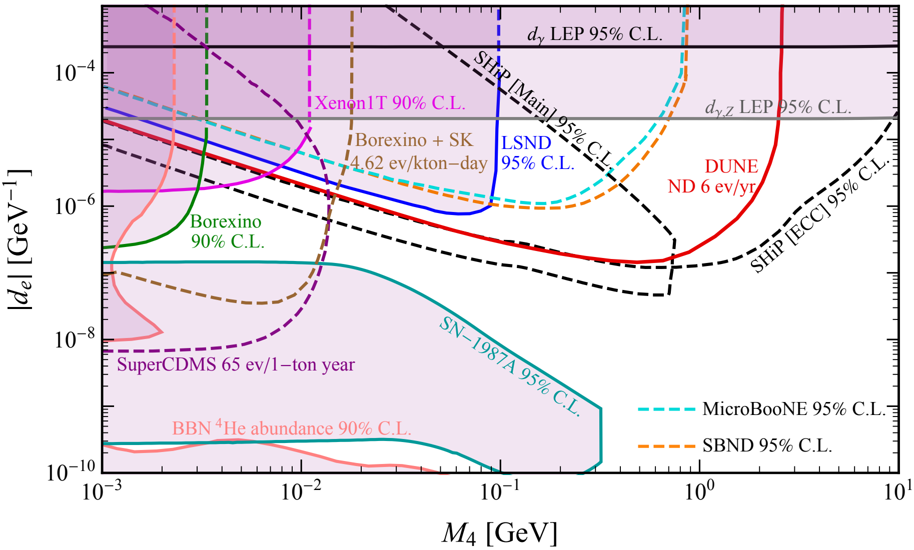
Global picture (d_τ)



Global picture (d_μ)



Global picture (d_e)



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- The intrinsic flux can constrain $d_{\mu,e}$ at the near detector.
- Meson decay ignored though.
- Background studies needed for proper sensitivity curve.

Signal (equations)

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Outside events (no detector geometry):

$$\frac{\mathrm{d}N}{\mathrm{d}E_4} = N_{\text{mod}} \frac{\rho_N}{2\pi} \int_0^{\theta_b^{\text{max}}} \sin\theta_b \mathrm{d}\theta_b \int_{r_{\text{min}}}^{r_{\text{max}}} L_{\text{ND}}^2 \mathrm{d}r_p$$

$$\sum_{M_T} \left[\frac{\mathrm{d}^2\Phi}{\mathrm{d}\Omega_b \mathrm{d}E_\nu} \frac{\mathrm{d}E_\nu}{\mathrm{d}E_4} P_{\text{osc}} \cdot \varepsilon_{\varphi_b} \cdot P_{\text{decay}}(\ell) \frac{\mathrm{d}\sigma}{\mathrm{d}\cos\theta_s} \Delta\Omega_s \cdot \varepsilon(p_4) \right]_T .$$

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Inside events (only detector geometry):

$$\frac{\mathrm{d}N}{\mathrm{d}E_\nu} = N_{\text{mod}} \frac{L_{\text{ND}}^2}{L_{\text{FD}}^2} \rho_N A_{\text{det}} \left. \frac{\mathrm{d}\Phi}{\mathrm{d}\Omega \mathrm{d}E_\nu} \right|_{\theta_b=0} P_{\text{osc}} \left(\frac{L_{\text{FD}}}{E_\nu} \right)$$

$$\sum_{M_T} \int_0^{L_d} \mathrm{d}z \int_{-1}^{1} \mathrm{d}\cos\theta_s \frac{\mathrm{d}\sigma_T}{\mathrm{d}\cos\theta_s} \Pi\left(\ell_d^0\right) P_{\text{dec}}(\ell_d^0) \varepsilon(p_4) .$$

Signal (example differential spectra)

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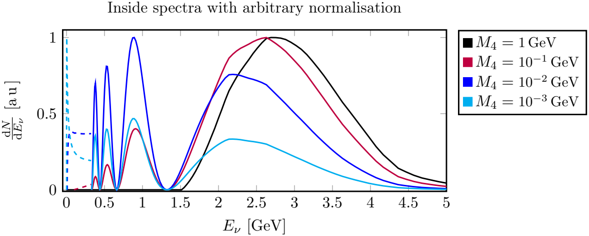
Spectra for inside, outside events at various masses, normalised so that the peak is 1. At low energies (dashed), we replace the oscillation probability with 1/2 to account for the averaging of fast oscillations. This is purely cosmetic for inside events.



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