Building a ν mag moment signal model for LZ

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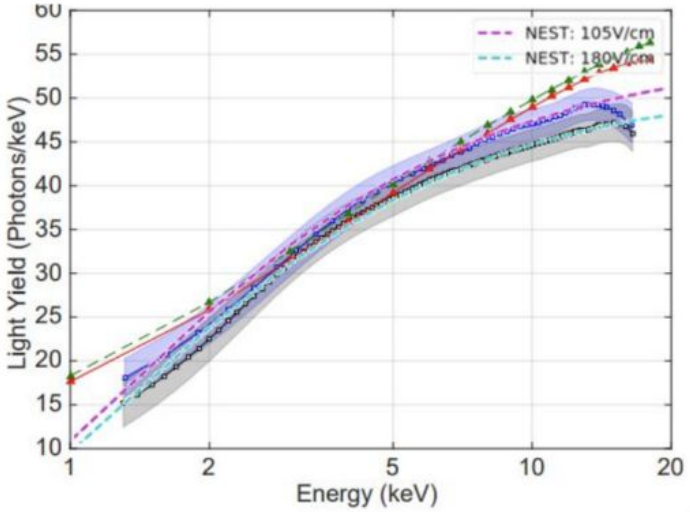
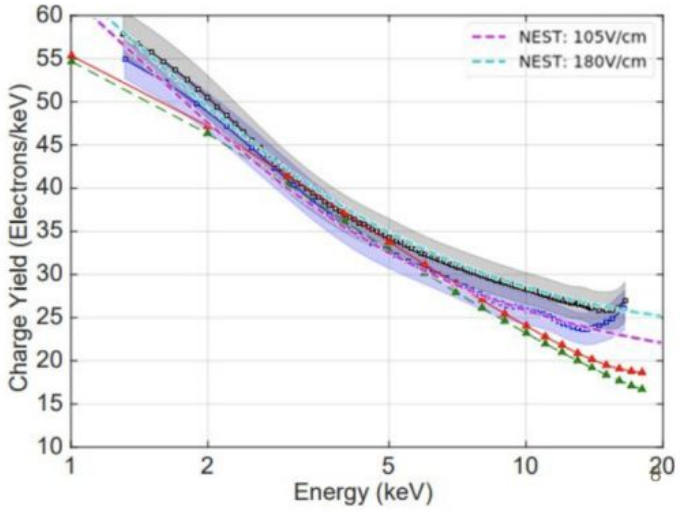
Noble Element Simulation Technique (NEST)

A comprehensive simulation specifically focused on understanding how noble fluids produce signal quanta (i.e. scintillation and charge)

This program pools data from multiple experiments to build response models, but allows for detector-specific inputs (efficiencies, field amplitudes, etc.)





Combining scintillation, charge to reconstruct energy spectrum

W: Work function (recoil energy per signal quantum produced)

S1: scintillation signal observed (unit in photons)
S2: electron signal observed (unit in photons)

g1: 'S1 gain', photons detected per photon produced
g2: 'S2 gain', photons detected per electron produced

Combining all variables give equation for reconstructed energy:

$$E_{recon} = W\left(\frac{S1}{g_1} + \frac{S2}{g_2}\right)$$

LZ threshold set by S1: g1 (0.119) and a 3 PMT coincidence requirement

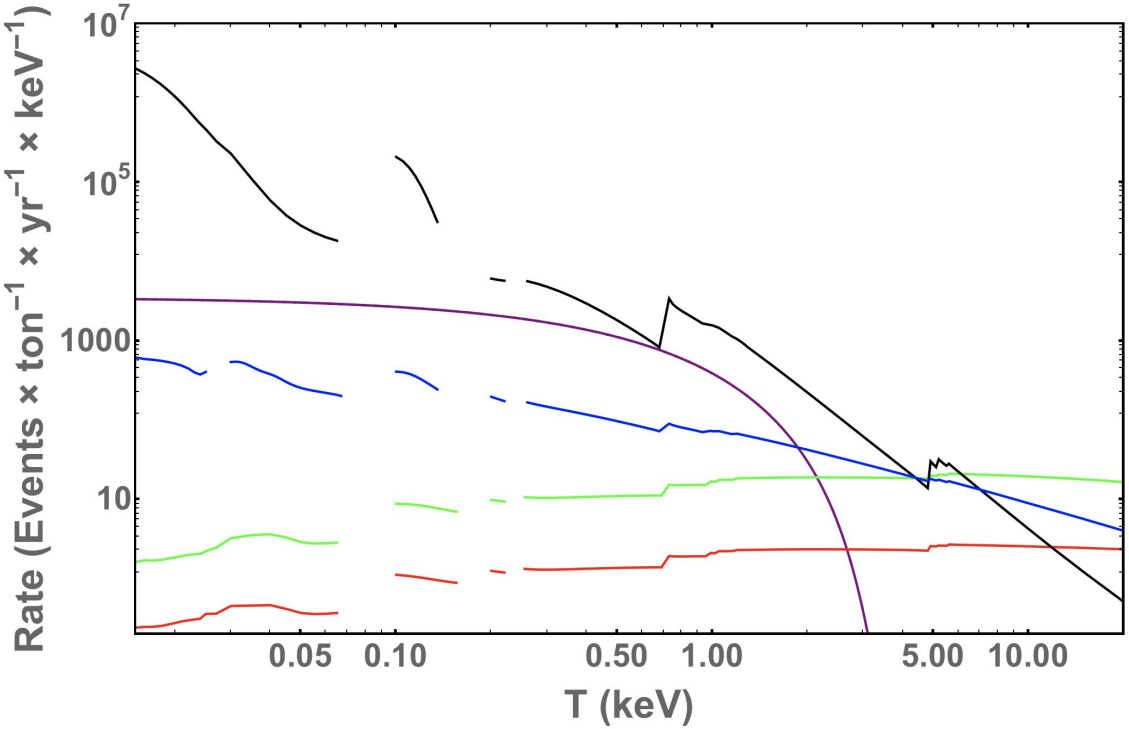
NMM Spectrum Data

Specific to Xe atomic electron shells
Provided by Jiuun-Wei Chen from National Taiwan University

Noted by blue line:

$$\mu_{\nu_S}^{\text{eff}} < 2.8 \times 10^{-11} \mu_B$$

(Current best limit, from Borexino)



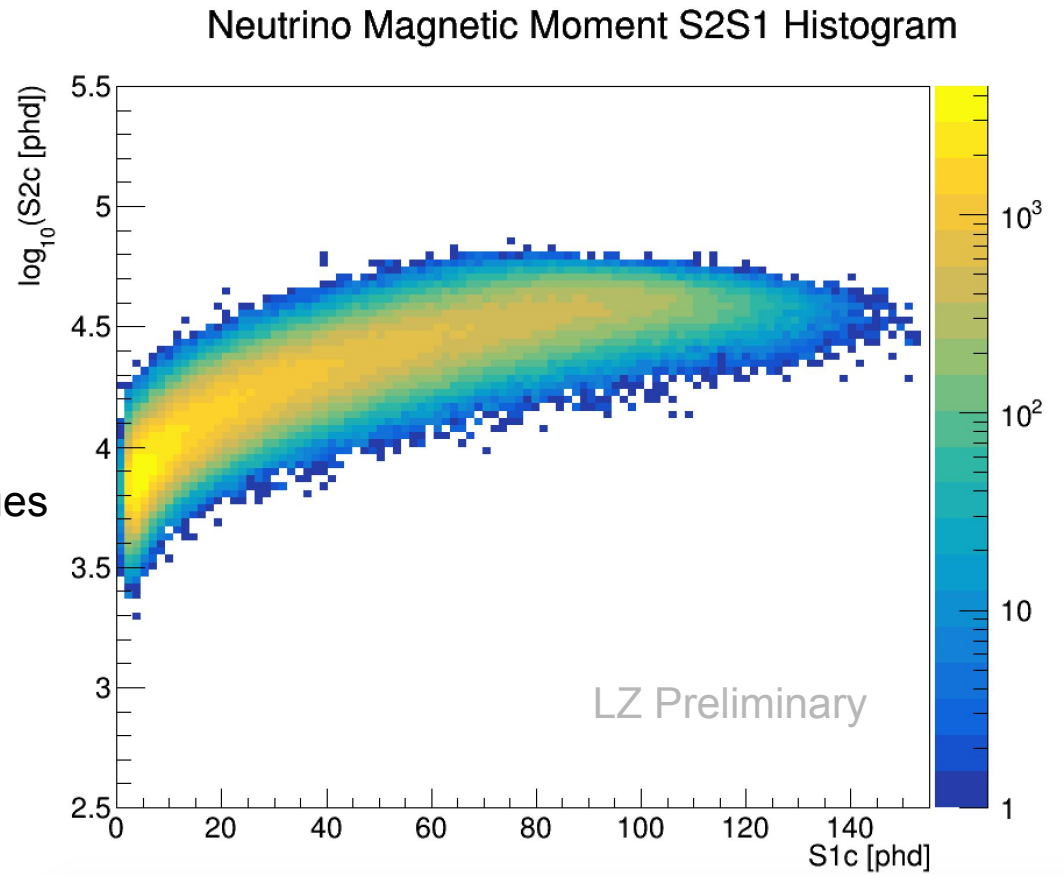
log(S2) vs. S1 Plot

`True' recoil spectrum is interpolated, then run through LZ-specific NEST.

1 million neutrino recoils simulated

For each recoil, record expected S1, S2 values

(In this plot, color scaling is arbitrary)



Reconstructed energy

Following previous LZ sensitivity studies (arXiv:1802.06039):

- Exposure assumed as 5.6tons x 1000days
- Background is ~15 counts/keV/t/y (Rn-dominated)

Reconstructed energy histogram:

- Energy of electron recoils assumed from E_recon expression
- Histogram constructed with 1keV wide bins
- Rate is then normalized by exposure in detector

Vertical error bars: simple Sqrt(n), where n=number of samples per bin

Reconstructed energy plot

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Takeaways:

1) Effective threshold is ~1keV

2) LZ expects world-leading solar-neutrino magnetic moment sensitivity

Next steps:

1) Practice making statistical statements using profile likelihood ratios

2) Repeat for other non-standard interactions