Experimental overview of neutrino magnetic moment measurements

June 21, 2023

1 Direct muon (anti)neutrino magnetic moment measurements

1.1 NOvA (Biao's thesis)

- ν_μ only
- Only comparing total event counts - 25 events observed and 23.78 expected
- Put an upper limit (90% C.L.) of $\mu_{\nu_\mu} < 1.58 \times 10^{-9} \mu_B$ with 10.9% systematic uncertainty on the standard model background
- Used 3.62×10^{20} POT of data (6.74×10^{23} POT for MC) with $T\theta^2 < 0.003\mathsf{GeV} \times \mathsf{Rad}^2$, $0.3 < T < 0.9\mathsf{GeV}$

1.2 MiniBooNE

- ν_μ only
- Observed excess of events (seems a bit too high)

1.3 E734 at the Alternating Gradient Synchrotron (AGS) of the Brookhaven National Laboratory

- **Both ν_μ and $\overline{\nu}_\mu$**
- $\mu_{\nu_\mu} < 8.5 \times 10^{-10} \mu_B$

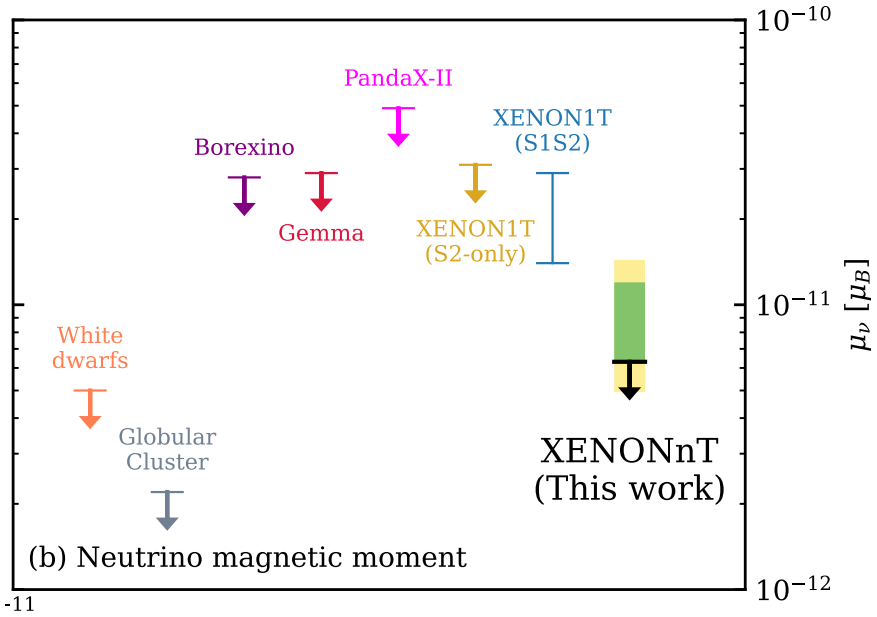

Figure 1: 90% C.L. upper limit on solar neutrinos with an enhanced magnetic moment.

1.4 LSND

2 Direct electron (anti)neutrino magnetic moment measurements

3 Solar neutrino magnetic moment measurements

3.1 XENONnT

First results published in arXiv:2207.11330[1] on 22 July 2022.

- 5.9 tonne dual-phase liquid xenon TPC dark matter detector
- Region Of Interest is (1,140) keV
- Very low background (5 times lower than XENON1T)
- Tritium excluded as the potential background (also in XENON1T)
- No excess found - XENON1T excess excluded with 4σ
- The 90% C.L. upper limit on solar neutrinos with an "enhanced" magnetic moment is $\mu_{\nu_{sol}} < 6.3 \times 10^{-12}\mu_B$, the strongest non-astronomical limit so far (see fig.1)

Amir Khan used[2] XENONnT's results and derived limits on electromagnetic properties for the three SM neutrino flavours (see fig.2). For ν_μ they

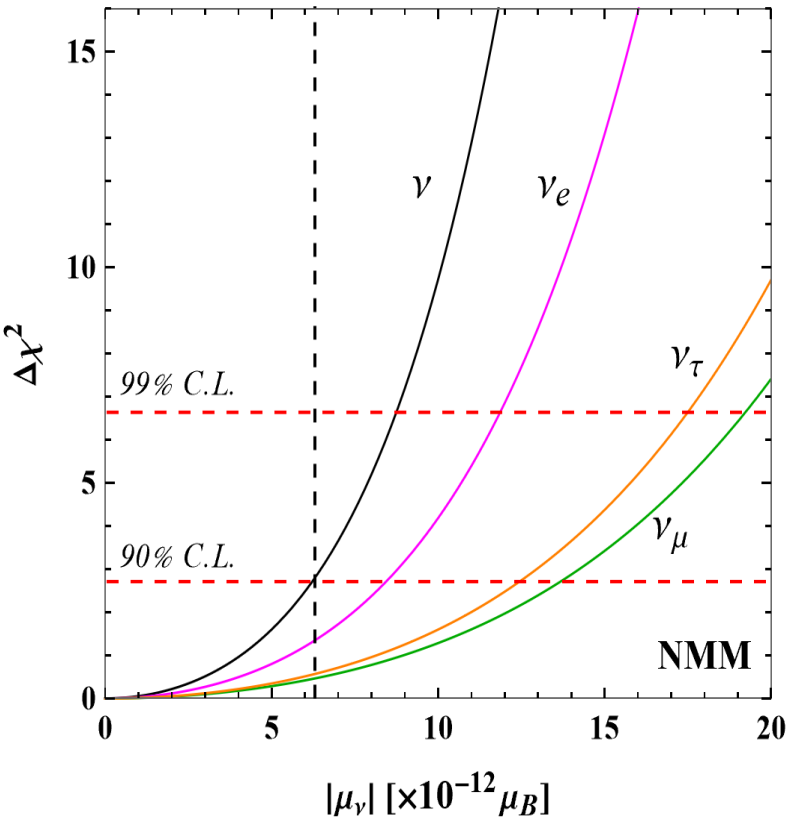

Figure 2: One-dimensional $\Delta\chi^2$ distribution with 90% and 99% C.L. boundaries of neutrino magnetic moments. The distribution in black corresponds to the effective flavor independent magnetic moment

3.2 XENON1T

3.3 BOREXINO

4 Other

4.1 LHC Forward Physics Facilities

Preliminary sensitivity studies for future experiments (namely for FLArE and FASERν2)

- LHC's Forward Physics Facilities study high energy (TeV) neutrinos of all flavours from the ATLAS interaction point.
- Large opportunity to study tau neutrinos in more detail

References

[1] E. Aprile et al. Search for New Physics in Electronic Recoil Data from XENONnT. 7 2022. arXiv:2207.11330.

[2] Amir N. Khan. New limits on neutrino electromagnetic interactions and light new physics with XENONnT. 8 2022. arXiv:2208.02144.