Prospects for Exploring New Physics in Coherent Elastic Neutrino-Nucleus Scattering

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Poster #23

CEvNS is a Standard Model process:

$$\frac{d\sigma}{d(cos\theta)} = \frac{G_F}{8\pi} {Q_W}^2 E^2 (1 + cos\theta)$$

$$Q_W = Z(4\,sin^2\theta_W - 1) + \mathrm{N}$$

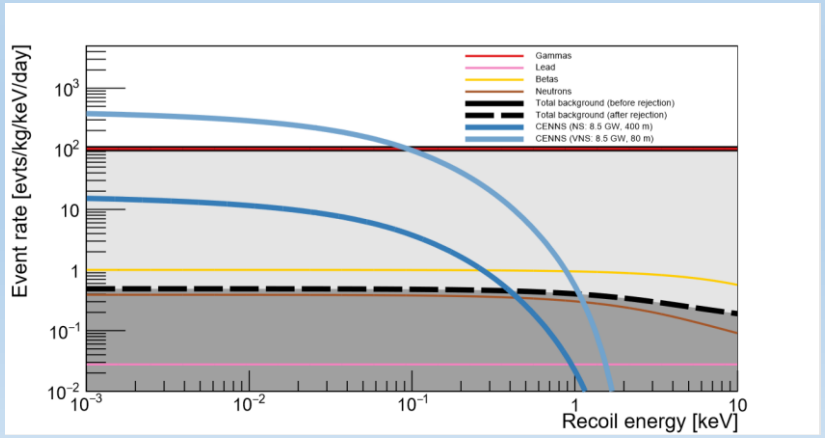
Target Nucleus	T_{Max} $E_\nu = 3$ MeV	$E_\nu = 30$ MeV
Ar	484 eV	48.3 keV
Zn	296 eV	29.5 keV
Ge	266 eV	26.6 keV
	(Reactor)	(Spallation)

- Bolometers at a reactor probe lower energies
- Consider a bolometer at the 8.5 GW Chooz reactor complex, placed at the 400m near site or 80 m very near site

Current and planned CEvNS Projects:

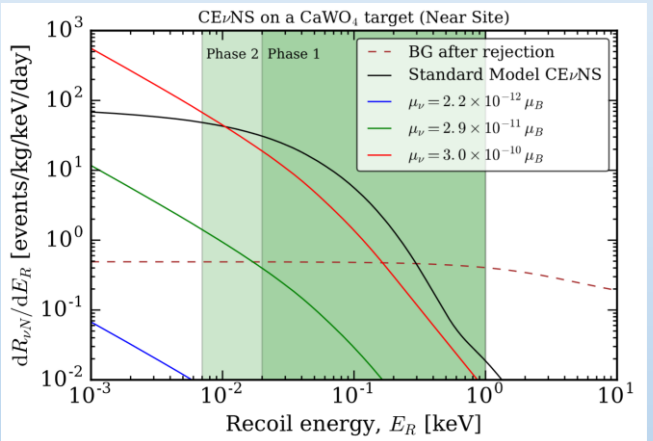
- MINER: 10 kg Si+Ge at a 1 MW, 200 eV threshold
- NUCLEUS: Several grams CaWO4 + Al2O3, 10 eV energy threshold
- Ricochet: Several kg of Zn, Ge, Si, or Os, 50 eV threshold

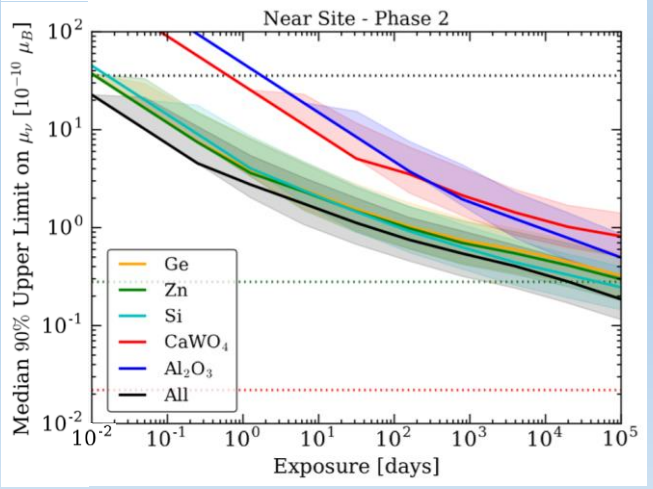
	Phase 1		Phase 2		Background reduction	
Target	E_{th} [eV]	Mass [g]	E_{th} [eV]	Mass [g]	gamma	neutron
Zn	50	500	10	5000	1000	1
Ge	50	500	10	5000	1000	1
Si	50	500	10	5000	1000	1
$CaWO_4$	20	6.84	7	68.4	1000	10
Al_2O_3	20	4.41	4	44.1	1000	10



Neutrino Magnetic Moment:
Adds a term to CEvNS

$$\frac{d\sigma_{\upsilon-N}^{mag.}}{d(E_R)} = \frac{\pi\alpha^2\mu_\nu^2 Z^2}{m_e^2}\left(\frac{1}{E_R} - \frac{1}{E_\nu} + \frac{E_R}{4E_\nu^2}\right)F^2(E_R)$$





Neutrino Coupling to Quarks

Massive Scalar Mediator:
Adds a term to CEvNS

$$\frac{d\sigma_{\phi}}{d(E_R)} = \frac{g_\nu^2 Q_\phi^2}{4\pi} \frac{E_R m_N^2}{E_\nu^2 (q^2 + m_\phi^2)^2} F^2(E_R)$$

$$Q_\phi = (15.1\, Z + 14\, N) g_q$$

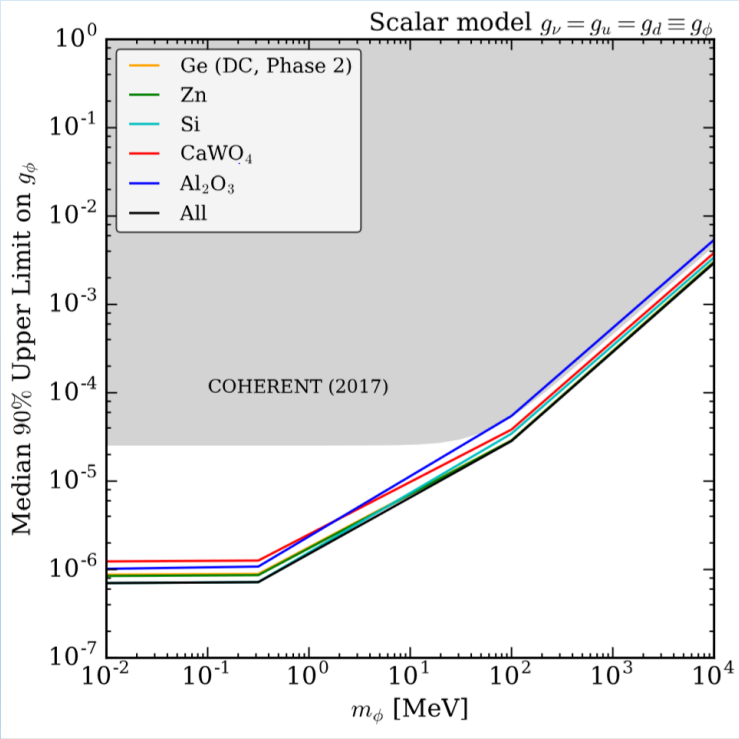
Massive Vector Mediator:
Interferes with CEvNS

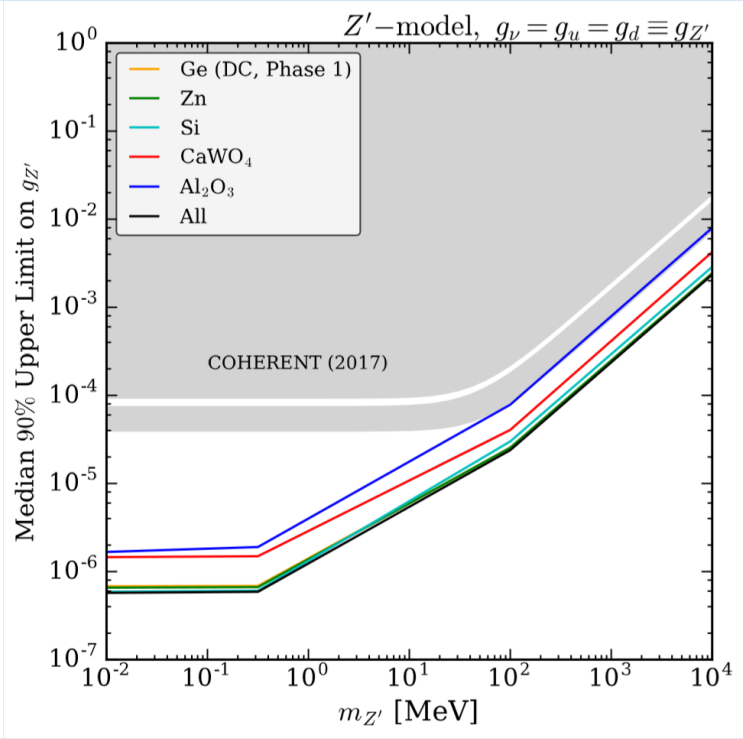
$$Q_W \rightarrow Q_{SM+NP} = Q_W - \frac{\sqrt{2}}{G_F} \frac{Q_{Z'}}{q^2 + m_{Z'}^2}$$

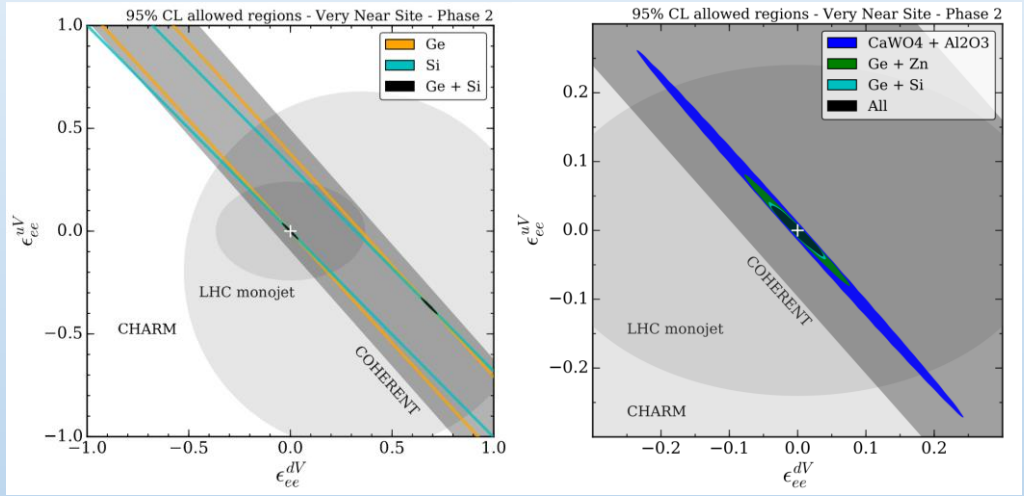
General Non-Standard Interactions:

$$Q_W = \left[4N\left(-\frac{1}{2} + \epsilon_{ee}^{uV} + 2\epsilon_{ee}^{dV}\right) + Z\left(\frac{1}{2} - 2sin^2\theta_W + 2\epsilon_{ee}^{uV} + \epsilon_{ee}^{dV}\right)\right]^2$$

$$+4\left[N\left(\epsilon_{e\tau}^{uV} + 2\epsilon_{e\tau}^{dV}\right) + Z\left(2\epsilon_{e\tau}^{uV} + \epsilon_{e\tau}^{dV}\right)\right]^2$$







- Breaking the $\epsilon_{\alpha\beta}^{uV}$ *and* $\epsilon_{\alpha\beta}^{dV}$ degeneracy is important for determining the mass hierarchy with DUNE
  (P. Coloma and T. Schwetz, Phys. Rev. D 95, 079903 (2017))
- Probing low energies places strong bounds at light mediator masses below ~ 10 MeV
- Combining multiple targets places strong NSI bounds