Detectors for the COHERENT neutrino experiment

R. Tayloe Indiana U. for the COHERENT collaboration

Outline

- Physics motivation
- Experimental overview
- detectors:
 - Csl
 - Nal
 - LAr
 - Ge





Coherent Elastic v-Nucleus Scattering:

"CEvNS": Coherent Elastic v-Nucleus Scattering: $vA \rightarrow vA$

Neutrino scatters with low momentum transfer coherently, elastically from entire nucleus. For large nucleus,

R_N~few fm, and:

$$E_{\nu} \lesssim \frac{hc}{R_N} \cong 50 \text{ MeV}$$



.. but recoil energy is quite small:

$$E_r^{\rm max} \simeq \frac{2E_{\nu}^2}{M} \simeq 50 \ {\rm keV}$$

The CEvNS process has yet to be observed...



Coherent Elastic v-Nucleus Scattering:

Cross section is large...
in fact largest v channel
at O(10 MeV) on heavier nuclei,
eg Ar





and has distinctive
N² dependence

$$\frac{d\sigma}{dE} = \frac{G_F^2}{4\pi} \left[(1 - 4\sin^2\theta_w) Z - (A - Z) \right]^2 M \left(1 - \frac{ME}{2E_\nu^2} \right) F(Q^2)^2$$

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Coherent Elastic v-Nucleus Scattering:

Physics of CEvNS:

- Supernovae: Expected to be important in core-collapse SN and possible SN detection channel.
- Standard Model tests: $\sin^2 \theta_w$
- Nuclear Physics: nuclear form factors
- v oscillations: A possible v_s detection channel
- Dark Matter: Important background for 10-ton searches

In next session on neutrinos:

- J. Newby for more CEvNS physics
- M. Heath on CEvNS backgrounds
- T. Thornton on sub-GeV dark matter



COHERENT experiment at SNS/ORNL

ORNL SNS is also an...

..v source

- intense (~1MWatt, 0-50 MeV)..
- pulsed (60 Hz, 600ns spill time)...





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COHERENT experiment at SNS/ORNL

- a low-background experimental area has been acquired for COHERENT
- 20-29 m from target







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COHERENT experimental strategy at SNS/ORNL

Measure N² dependence of CEvNS process

with multiple targets/detector technologies

- (event rate)/kg is high, so relatively small (10-100 kg) detectors sufficient
- radiological background requirements fairly modest, because of pulsed beam
- but, need low E thresholds !





COHERENT detectors

Nuclear Target	Technology	Mass (kg)	source distance (m)	Recoil thresh (keVnr)	Data-taking start date; CEvNS detection goal
CsI[Na]	Scint. Crystal	14	20	6.5	9/2015; 3σ in 2 yr
Ge	HPGe PPC	10	22	5	Fall 2016
Nal[Tl]	Scintillating crystal	185* /2000	28	13	*high-thresh. runs starting July 2016
LAr	Single-phase scintillation	35	29	20	Fall 2016



Csl[Na] for COHERENT

- 14kg CsI[Na] crystal (Na doping reduces afterglow seen in common TI doping)
- .. installed July 2015 in the v corridor at SNS
- ... into Pb, H2O, plastic shielding structure
- ~ 1 calendar year data has been collected











Csl[Na]

- Quenching factor measurements indicate CEvNS signal within reach
- Steady state backgrounds at the SNS installation are 10-20% of measurements at U. of Chicago.

• Expected neutrino-induced-neutron backgrounds reduced to 4% (of CEvNS) with HDPE inner shield

Stay tuned for results!



Nal [TI] for COHERENT

 discontinued DHS program has provided opportunity to use many ~7kg Nal xtals

- 185 kg prototype for initial deployment
- 2 ton next phase deployment
- Up to 9 tons available
- Also CC interaction with ν_{e}





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LAr for COHERENT

- Single-phase scintillation detector built by J. Yoo, etal at Fermilab for CEvNS effort
- 35-kg fiducial volume
- Readout: 2 × Hamamatsu R5912-02MOD PMT (8" cryogenic, highgain)
- Excellent nuclear-/electron-recoil PSD demonstrated by miniCLEAN
- SCENE has measured quenching factors¹
- ³⁹Ar controllable with PSD and duty factor
- Pb, Cu, H2O shielding structure
- Currently being installed at SNS



¹H. Cao et al., SCENE Collaboration, *Phys. Rev.* D91 (2015) 092007. arXiv:1406.4825 [physics.ins-det].

LAr for COHERENT

- Tested summer '16 at IndianaU
- Installation at SNS underway!



Ge for COHERENT

- HPGe PPC
- Excellent resolution at low energies
- Well-measured quenching factor
- Phase I: 5-10kg PPC Ge detector array:
 - Repurposing on-hand Majorana Demonstrator/LANL ^{nat}Ge detectors.
 - Copper/Lead/Poly shield with Plastic scintillator µ-veto.
 - Installation in Fall 2016
- Potential Phase II: Expansion of target with larger-mass (C4-style) point contact detectors.





Summary

- The COHERENT collaboration is employing 4 different detector technologies for an unambiguous measurement of CEvNS at the SNS in the next years.
- See talks on COHERENT in next session (00PF).
- Thanks for DOE, NSF, ORNL support!



SNS v corridor



arXiv:1509.08702



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