Status of CEvNS Search with the CENNS-10 Liquid Argon Detector

2018 APS April Meeting

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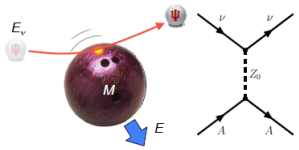
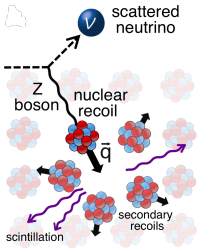
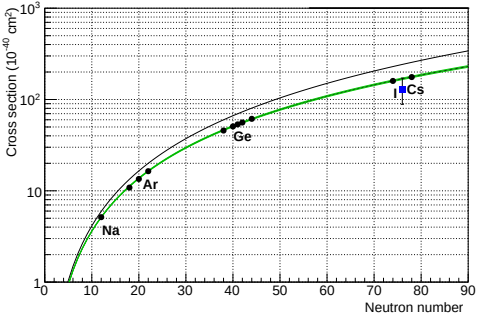
Coherent Elastic Neutrino Nucleus Scattering

- Neutrino collides with large nucleus which recoils coherently
  - $E_\nu \lesssim \frac{hc}{R_N} \approx 50\,\text{MeV}$
- Small recoil energy
  - $E_r^{max} \lesssim \frac{2E_\nu^2}{M_N} \simeq 50\,\text{keV}$
  - Difficult to detect
- Deploy a suite of detectors to measure N^2 cross section dependence
  - CsI[1], Ar, NaI, Ge



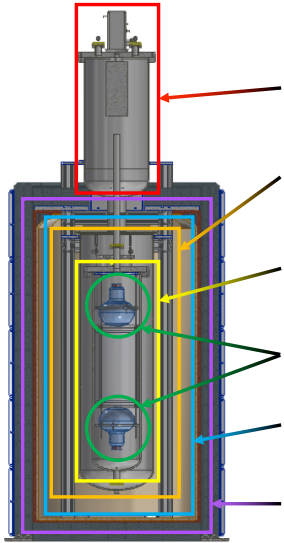


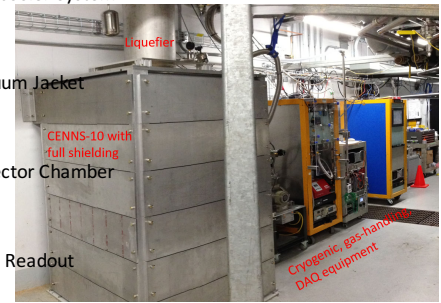


[1] DOI:10.1126/science.aao0990

Specs

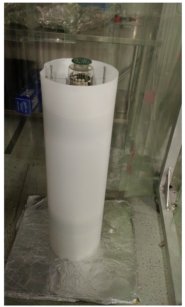
- Single phase liquid argon detector
- 2x Hamamatsu R5912-20
- Caen 1720 digitizer
- PT90 cold head
- Saes MonoTorr gas purifier
- Running at SNS 2016-present
  - "Spring 2017 Data"
  - "Summer 2017 Data"
    - After light collection upgrade

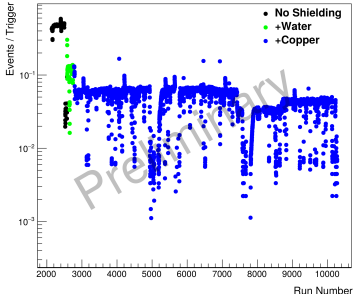


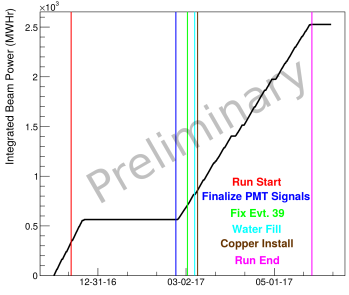


Spring 2017 Run

- 35 kg fiducial volume
- Tetraphenyl butadiene (TPB) coated acrylic cylinder backed by teflon
- TPB coated acrylic disks in front of PMTs
- Water, Cu shielding
- 1.7×10^3 MWh





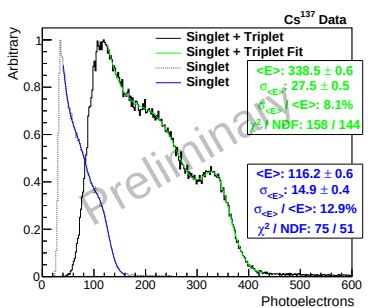


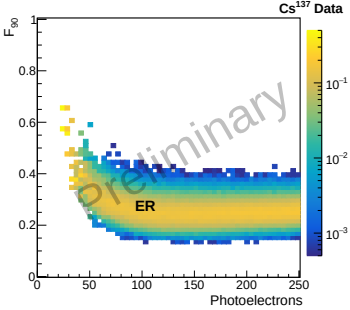
Calibrations

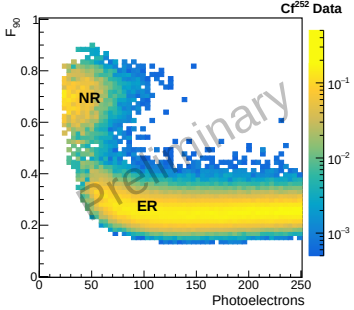
- Weekly calibration runs
  - LED for SPE calibration
  - ^{137}Cs for light yield calibration
- Monthly ^{252}Cf source for NR/ER discrimination
- Light yield ~0.5 PEs/keVee

Pulse Shape Discrimination

- Argon scintillates with 2 time constants
  1. Singlet light: ~6 ns
  2. Triplet light: ~1.6 µs
- Electronic Recoils mostly triplet light
- Nuclear Recoils mostly singlet light
- Ratio allows for PSD!

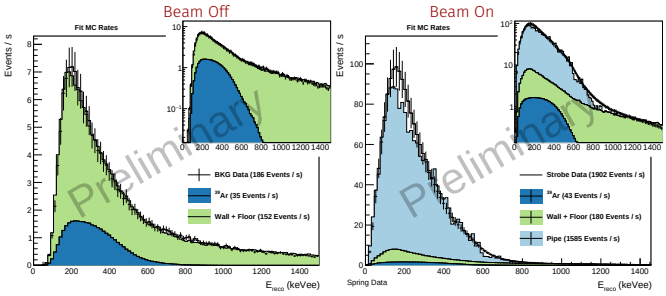






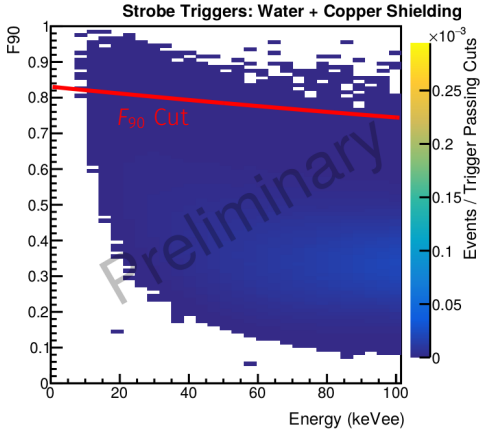
Steady State Backgrounds

- ^{39}Ar, 511 γs, wall + floor gammas dominate
- Bkg calibration runs give ^{39}Ar, wall + floor rates
- 511 γs from beam on strobe triggers
  - From beam exhaust pipe
- ~1.9 kHz steady state bkg rate



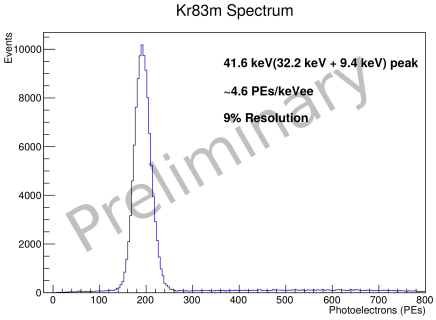
Expected Sensitivities

- F_{90} cut from calibrations to isolate ^{252}Cf neutrons
  - Apply to strobe data
- Find sensitivity to beam related events
  - CEvNS, Neutrino Induced Neutrons (NINs), Beam Related Neutrons
- Assuming 1σ background subtraction errors sensitive to ~10s of events
  - Expect ~10 CEvNS events

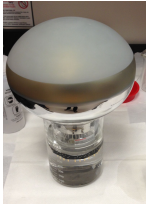


Summer 2017 Run

- Light collection upgrade Summer 2017
  - TPB coated teflon walls, PMTs
  - 22 kg fiducial volume
  - ~4.5 PEs/keVee!
- Add'l lead shielding
- 2.5×10^3 MWh
- Initial low energy Kr^{83m} results promising!

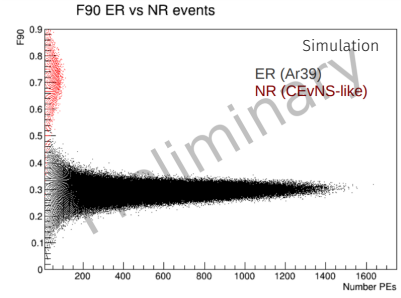


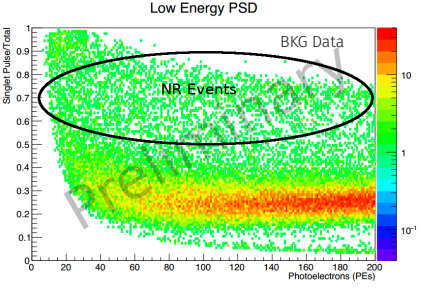
Kr^{83m} Holder



Expected Sensitivity

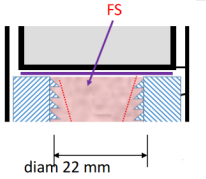
- Threshold ~20 keVnr
- Major beam unrelated background ^{39}Ar
  - ~1 Bqkg^{-1}
- Initial MC estimates indicate ^{39}Ar/CEvNS separation adequate
  - Expect ~60 ev year^{-1} (prompt) and ~80 ev year^{-1} (delayed)
  - Tuning MC to better match calibration data

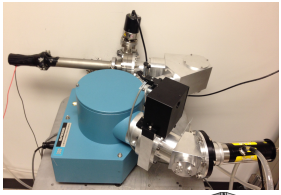


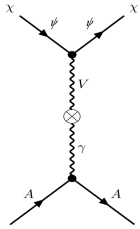


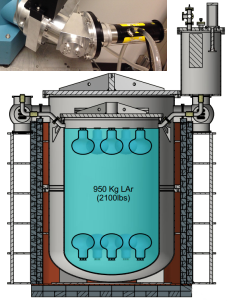
Future Prospects

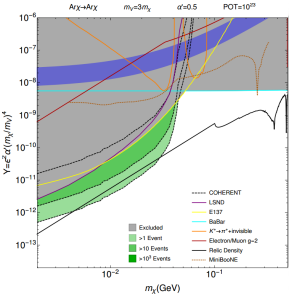
- Test chambers at IU/ITEP/ORNL for readout/WLS testing
  - TPB coatings, Xe doping, SIPMs...
- Ton scale detector farther future
  - Precision CEvNS measurement
  - Charged current measurement
  - Accelerator produced DM
  - Underground argon?
  - LNe, LXe?





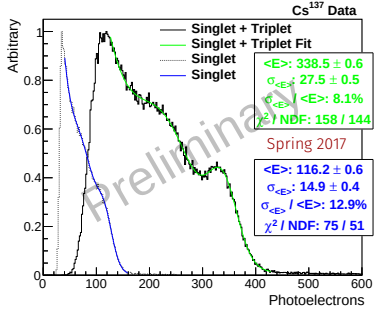


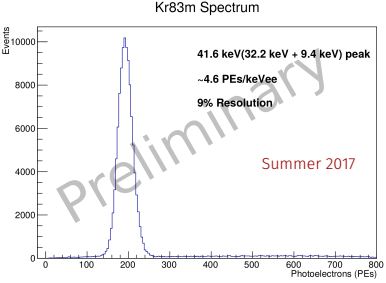




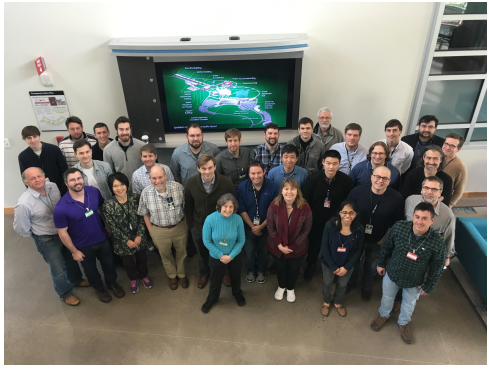
Summary

- COHERENT preparing multiple detectors to search for CEvNS
- CENNS-10 results soon!
- Longer term precision measurements in the works



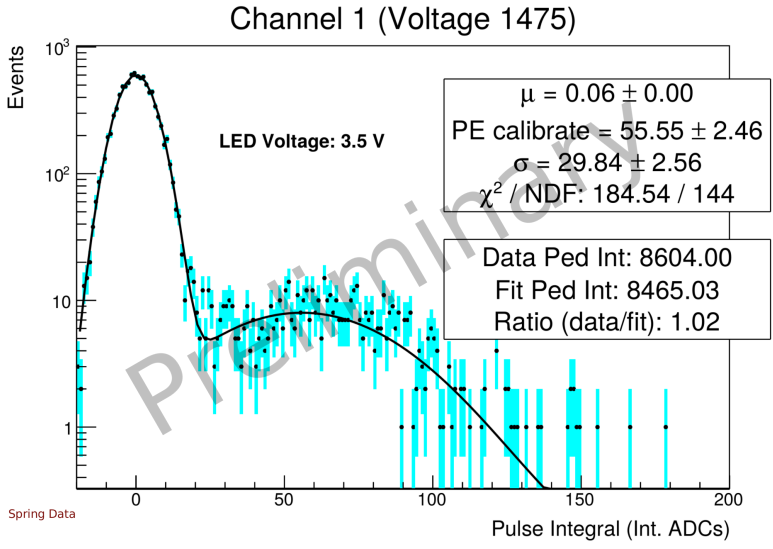


The COHERENT Collaboration



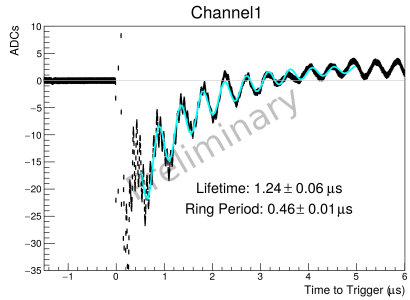
Backups

SPE Spectrum

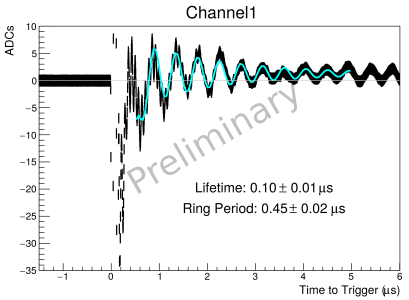


Triplet Lifetime

Pre-Doping



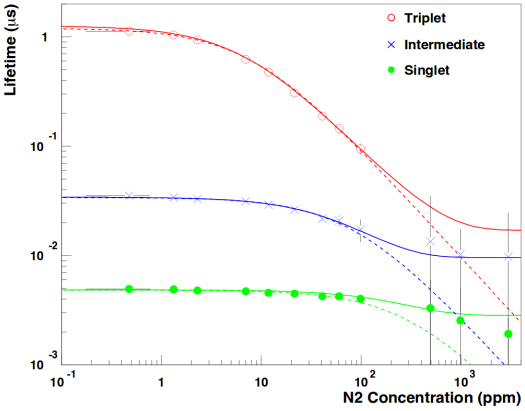
Post-Doping

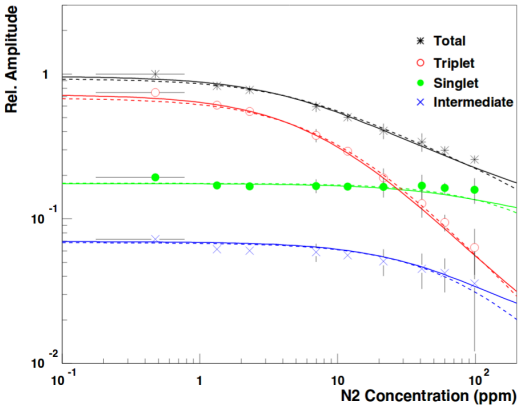


- As data quality check introduce N_2 after spring run
  - ~25 ppm
- Triplet lifetime changed from ~1.2 μs to 0.2 μs
  - Roughly 1 ppm and 20 ppm respectively[2]

[2] arXiv:0804.1217 [nucl-ex]

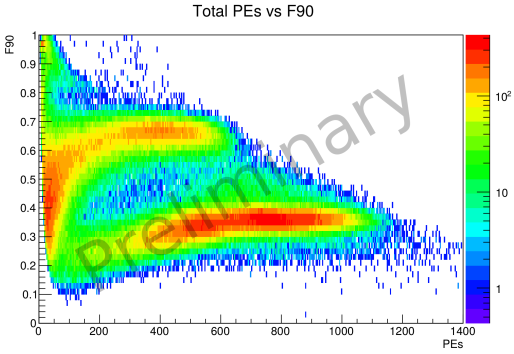
N2 Contamination



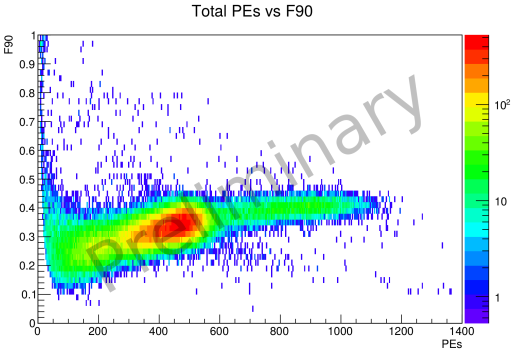


[2] arXiv:0804.1217 [nucl-ex]

Summer 2017 PSD



AmBe



^{57}Co