Calibration of CENNS-10 liquid argon detector with 83mKr source

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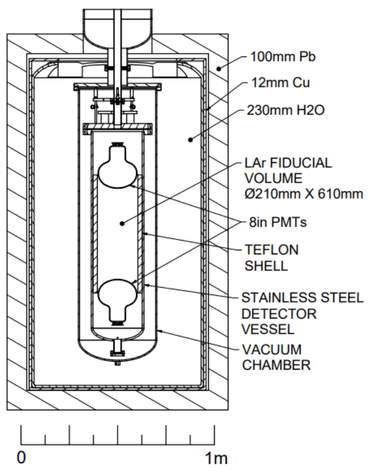
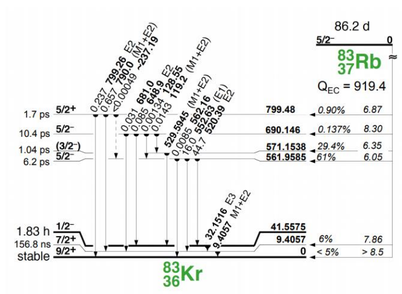
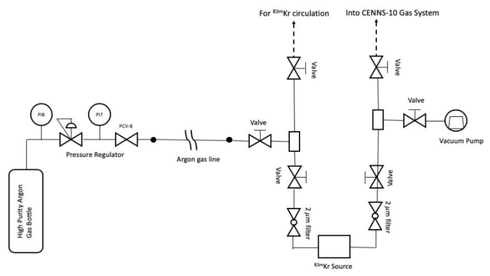
CENNS-10 detector



- CENNS-10 (COH-Ar-10) is a single-phase scintillation-only liquid argon detector
- Placed at the Spallation Neutron Source as part of COHERENT to measure CEvNS in late 2016
- The 24 kg active detection region is bounded by teflon cylinder coated with 1,1,4,4-tetraphenyl-1,3-butadiene (TPB), high-efficiency wavelength shifter that converts the 128 nm liquid argon scintillation light to the visible
- Two frosted-glass Hamamatsu R5912-02MOD are used as photodetectors
- **First detection of CEvNS on argon (2020)**
- Future plans: CENNS-750

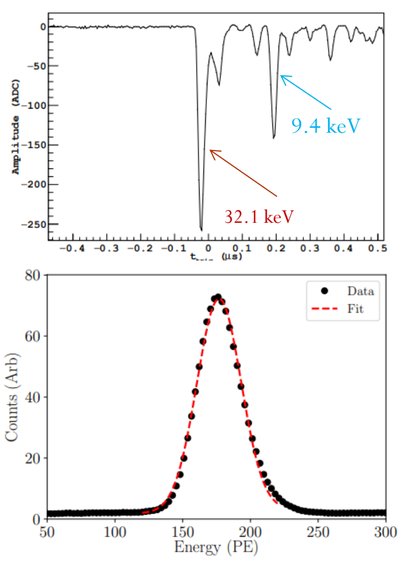
83mKr source



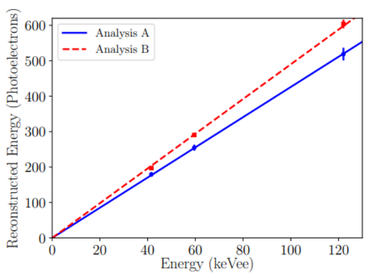


- The Rb-83 solution was used for source development
- 83Rb was infused into a matrix that adsorbs the 83Rb but release the 83mKr gas atoms to admix with the circulating argon boil-off gas from CENNS-10
- Two possible methods of operation: one-time injection or circulation (wasn't used for calibration)

Calibration results

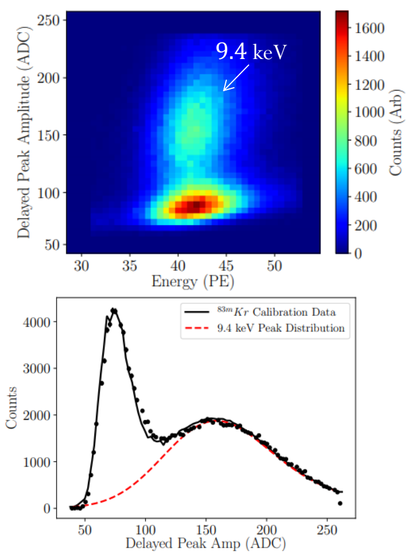


- Full energy of 41.5 keV is used (32.1+9.4 keV lines)
- Two parallel analyses were performed ("analysis A" and "analysis B")
- Main difference of analyses is determination of the value of the integrated SPE
- Mean value of the peak is near similar for both analyses
- Energy resolution for 83mKr peak is 9.3%



- Both analyses predict linear detector response
- Analysis A: = 4.3 ± 0.1 PE/keV
- Analysis B: = 4.9 ± 0.1 PE/keV
- Distinction of the values can be explained by different definition of SPE

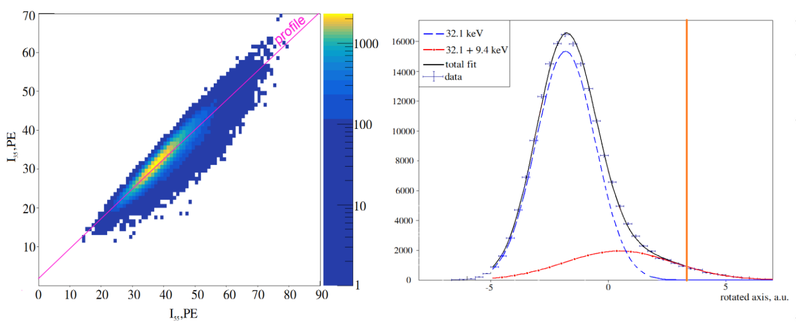
Component isolation: analysis A



- Treats both lines separately
- Events with 9.4 keV line in **>90 ns** were chosen for analysis
- For 32.1 keV mean yield measurement events with the 9.4 keV component delayed by at least 152 ns were selected
- The peak height for 9.4 keV depositions was obtained through a peak-finding analysis of the summed PMT waveforms

Energy (keV)	Method	*I* (PE)	*Y* (PE/keV)
9.4	Peak extrapolation	41.7 ± 2.2	4.44 ± 0.23
32.1	Peak extrapolation	135.7 ± 4.2	4.22 ± 0.13
41.5	Full integration	176.8 ± 3.6	4.26 ± 0.09

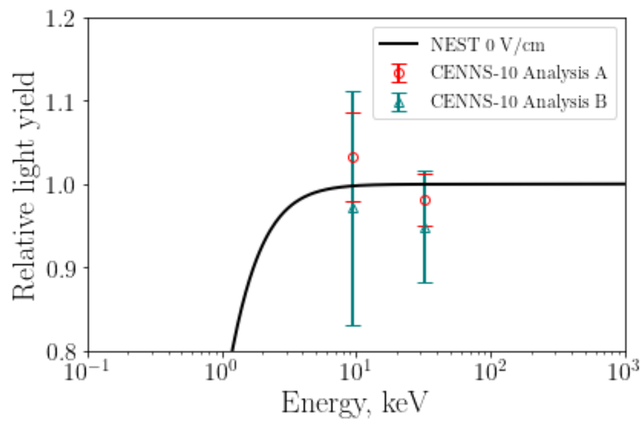
Component isolation: analysis B



Energy (keV)	*I* (PE)	*Y* (PE/keV)
9.4	44.7 ± 6.3	4.76 ± 0.67
32.1	149.2 ± 9.8	4.65 ± 0.31

- Treats both lines separately
- Events with 9.4 keV line **before** 90 ns were chosen
- The events with 9.4 keV line occurring between 35 and 55 ns are easily distinguishable and contain full light from 9.4 keV line (loss <1%)
- For selection of these events additional axis based on I35:I55 (integrals of 35/55 ns of waveform) distribution was used
- For PE calculation iterative calculation approach was used

Comparison of both analyses with predictions



- Comparison with argon version of NEST (Noble Element Simulation Technique) was performed
- Both analyses **and** NEST confirm linearity in 9.4-122 keVee region

Summary

- A 83mKr calibration source was designed, prepared and successfully installed for the calibration of COHERENT's CENNS10 (COH-Ar-10) detector
- The measured energy resolution of ~ 9% was sufficient for a CEvNS measurement with CENNS-10
- Analysis of 83mKr data shows the energy response of the detector was linear to 9.4 keV
- This result from two independent analyses agrees with NEST predictions
- This source gave the lowest-energy calibration available to CENNS-10 and was close to the energy region of interest for the primary CEvNS search analysis

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- RFBR projs. 20-02-00670_a and 18-32-00910 mol a

References:

- Development of a 83mKr source for the calibration of the CENNS-10 liquid argon detector, arXiv:2010.11258
- First Detection of Coherent Elastic Neutrino-Nucleus Scattering on Argon, arXiv:2003.10630
- NEST