SCENE Run Report

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All Experimenter’s Meeting
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On Behalf of SCENE Collaboration: Scintillation and Ionization Efficiency of Noble Elements

Member Institutions:
Liquid Argon (LAr) as WIMP Target

Scintillation / S1: Excellent pulse shape discrimination (PSD) of nuclear (NR) versus electron recoils (ER)

Single-phase
S1 only

Ionization / S2: enables position reconstruction and additional ER discrimination

Dual-phase
S1+S2

DEAP
CLEAN

DarkSide
ArDM

AEM, Nov. 25, 2013
Scintillation and Ionization Yield for Nuclear Recoils

- Knowledge of those quantities is required to convert a NR signal to the deposited energy
- They decide the energy threshold of LAr detectors and inferred WIMP mass

Scintillation:
Yield for low energy (<25 keV$_r$) NR has not been precisely determined in the literature (the famous L$_{eff}$ parameter)

Effects of applied electric field (both on PSD and quenching factor) need to be characterized for two-phase Ar time projection chamber (LAr-TPC)

Ionization:
No comprehensive measurement of the ionization yield has been published

The Challenges

1. Compact LAr detector to minimize multiple scatterings

2. Unambiguously select NRs of a known energy
SCENE setup

~ $10^{-4}$ neutrons per beam pulse through LAr-TPC

- period = 101.5 ns or its multiples
  used 203 ns
- max current = 300 nA
  used ~50 nA

- beam angle spread at target < 0.006 deg
- ±1 keV mean uncertainty
- ±2 keV spread
- 10 MeV maximum
Experimental Layout

EJ301: Organic Liquid Scintillator Detector from Eljen Technology

Note: Polyethylene shielding between LiF and EJ301 omitted for clarity

200 μg/cm²

25.4°
SCENE Schedule

May 20-27, 2013 - Scheduled beam run canceled after 1-2 days due to beam failure

June 17 - July 2, 2013 - Two week beam run dedicated to S1 light - Results in first physics publication, now accepted to PRD
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Oct. 21 - Nov. 4 - Two week beam run dedicated to S2 measurements
Run statistics

200 ug/cm² LiF target

TPC trigger rate (alone) between 1 kHz-4 kHz during run
  -Important to keep overall rate down to protect the PMTs

Three proton energies
  2.305, 2.921, 3.600 MeV

5 Nuclear recoil energies
  7.5, 16.5, 26.1, 35.7, 57.6 keV

5 drift fields at each energy S2 runs
  50, 100, 200, 300, 500 V/cm

~500 NR events per setting (per NR energy per drift field)
Run statistics

30-70 microsecond drift lifetime
  - Slow degradation throughout the run, could be recovered by circulating through the purification loop for several hours

5-6 photoelectrons/keV light yield
  - Top PMT single photoelectron and collection efficiency sagged with time
  - Collection efficiency monitored continuously with external LED
  - Light yield monitored via $^{83}$Kr beta source (~40 keV, continuously injected into chamber)
Results (10.8 keV, $E_{\text{drift}} = 1000$ V/cm)

TPC\textsubscript{tof}: time difference between the proton-beam-on-target and the TPC signal

N\textsubscript{tof}: time difference between the proton-beam-on-target and the neutron detector signal

F90: PSD parameter in LAr the fraction of light detected in the first 90 ns of an event

N\textsubscript{psd}: peak over area in the neutron detector
Future Plans

- Finish analysis of both June and October data leading to a second paper on LAr ionization yield from nuclear recoils (including $L_{\text{eff}}$)

- Liquid Xe run in March with new TPC under construction at UCLA
  - Hugely relevant for low mass WIMP controversies, particularly in light of the LUX result
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