# $Ar^{39}$ Decays and Background Rates on Long Wires in a Large Liquid Argon Detector

Kirk T McDonald (kirkmcd@princeton.edu)
Princeton University
(May 12, 2006)

Liquid argon contains radioisotopes that contribute a background of low-energy ionization. The rate of this background on a given wire in a large liquid argon detector is proportional to the length of the wire, so longer wires have a larger background rate.

Here we estimate that rate based on facts from a recent paper by the WARP collaboration: http://arxiv.org/abs/astro-ph/0603131

The most troublesome radioisotopes are $Ar^{39}$ and $Kr^{85}$, which have rather similar beta-decay endpoint energies of about 600 keV. The average decay energy is about 250 keV. The combined decay rate is about 1.5 counts/sec/liter of liquid argon.

For an estimate, I take the wire spacing to be 5 mm, and each time step in the detector readout to correspond to 1.25 mm (*i.e.*, 4098 time steps for a 5 m drift distance).

Then the volume sampled during a single time step is $V$ = 6e-6 $L$ m$^2$ where $L$ = length of wire in meters. If an $Ar^{39}$ or $Kr^{85}$ decay occurs within this volume at any time during its drift over the 5-m distance, which requires about 3 ms, some 250 keV of background energy will appear in the data sample.

For example, if $L$ = 40 m, $V$ = 2.4e-4 m$^2$ = 0.24 liters. The number of decays that occur during 3 ms in this volume is therefore N = (1.5 counts/sec/liter) (0.24 liter) (0.003 sec) = 0.011. Thus, there will be about 1% channel occupancy with background counts of 250 keV or so.

For comparison, a minimum ionizing particle deposits about 250 keV in a 1.25-mm thick sample of liquid argon.

A 1% channel occupancy is not likely to be a severe problem for reconstruction of neutrino events, but it does add to the software challenge for large liquid argon detectors that use long wires.