Dust Effect on Electrons in LAPD

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Abstract

We calculate the effect of dust on drifting electrons for an LAPD sized volume.
We also calculate the settling time of dust for various grain sizes.
We conclude that very fine dust below 30 microns or so can be a problem. Larger grains fall down quickly enough even in the presence of the expected convection velocities.
We would welcome an independent verification of the calculations.

Assumptions

We consider a vessel of height 10 ft and diameter 10 ft (like LAPD).
For a given grain diameter and total grain mass, we calculate the electron loss fraction.
This is defined as the total grain area (x 4) / vessel cross section.
This loss is independent of electron velocity or drift time.
We assume a grain mass density of 2500 kg/m^3 and a dynamic viscosity of 0.001 Pa s (we take the water value; we hope that LAr is similar)
We assume spherical grains, and calculate the terminal fall velocity per the Stokes equation as
V = (rho-rhozero)*volume* g/b,
Where b = 6*pi*eta*radius, and eta is the dynamic viscosity

Results

An active spread sheet is attached.
The yellow fields are input values.

Examples:

For a total grain mass of 10 micro grams of 3 micron grains we get an electron loss of 0.8% and a fall time of 157 hours.
The fall velocity is 5 micron/s, hence any convection currents will keep the grains in suspension forever.

For a total grain mass of 100 micro grams of 30 micron grains we get the same electron loss of 0.8% and a fall time of 1.6 hours.
The fall velocity is 0.5 mm/s, only a bit smaller than expected convection currents.
Grains of that size and larger may eventually accumulate at the bottom of the tank

For a total grain mass of 400 micro grams of 100 micron grains we get a similar electron loss of 0.9% and a fall time of 8 minutes.
The fall velocity is now 6 mm/s, larger than the expected convection currents.
Grains of that size and larger will quickly accumulate at the bottom of the tank

Conclusions

Dust from the filters may prove a possible agent in drift electron loss.
We see that the larger grains of 100 micron and larger diameter will sink to the tank bottom quickly, even in the presence of convection currents.
Grains of 30 micron and smaller diameter may be kept in suspension for very long times.
It takes a very small total mass of dust grains (0.1 mg at 30 micron, 0.01 mg at 3 microns) to cause noticeable electron capture.
We see no obvious method of removing such very small grains from the liquid Argon.