NEUTRAL CURRENT DETECTION IN DILUTED HEAVY WATER

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Our Monte Carlo code has been slightly modified to investigate the effect of additional H_2O in the D_2O. Light water has ~ 500 times greater thermal neutron absorption cross section than heavy water and thus will severely impact the neutral current detection. The H_2O content has been varied, from to 9.6%, and three scenarios have been calculated:

1) 2500 Kg of NaCl dissolved in the "heavy water"
2) Lattice of ^{3}He containing tubes
3) Lattice of tubes containing saturated NaCl.

The calculation assumptions were:

1) Acrylic vessel - 6 meter radius, 4 cm thick
2) All neutrons are born thermal (no "Fermi" length)
3) 10,000 Monte Carlo starts

In addition, for the cases with tubes placed in a lattice the additional assumptions were:

4) Tube radius = 2 cm
5) Tube wall thickness = 1/8 inch of acrylic
6) Lattice spacing = 75 cm

Neutrons were propagated until they captured in one of the following:

1) The light water external to the acrylic
2) The acrylic vessel walls
3) The "heavy" water
4) The tube walls (when present)
5) The neutral current detection substance

The results are presented in Figures 1-3.

Figure 1. 2500 Kg of NaCl dissolved in the "heavy" water. The capture on the Cl varies from 87% for 100% D_2O down to about 30% for D_2O containing 9.6% H_2O. It should be stressed that this is only the capture probability of a thermal neutron by the Cl. For neutral current detection the efficiency of converting the prompt photon deexcitation into Čerenkov radiation and measuring it with the PM array must be folded onto the capture probability. The figure also explicitly shows the capture probability on the deuterium (in the heavy water). This varies from 3% to 1% over the calculated range.

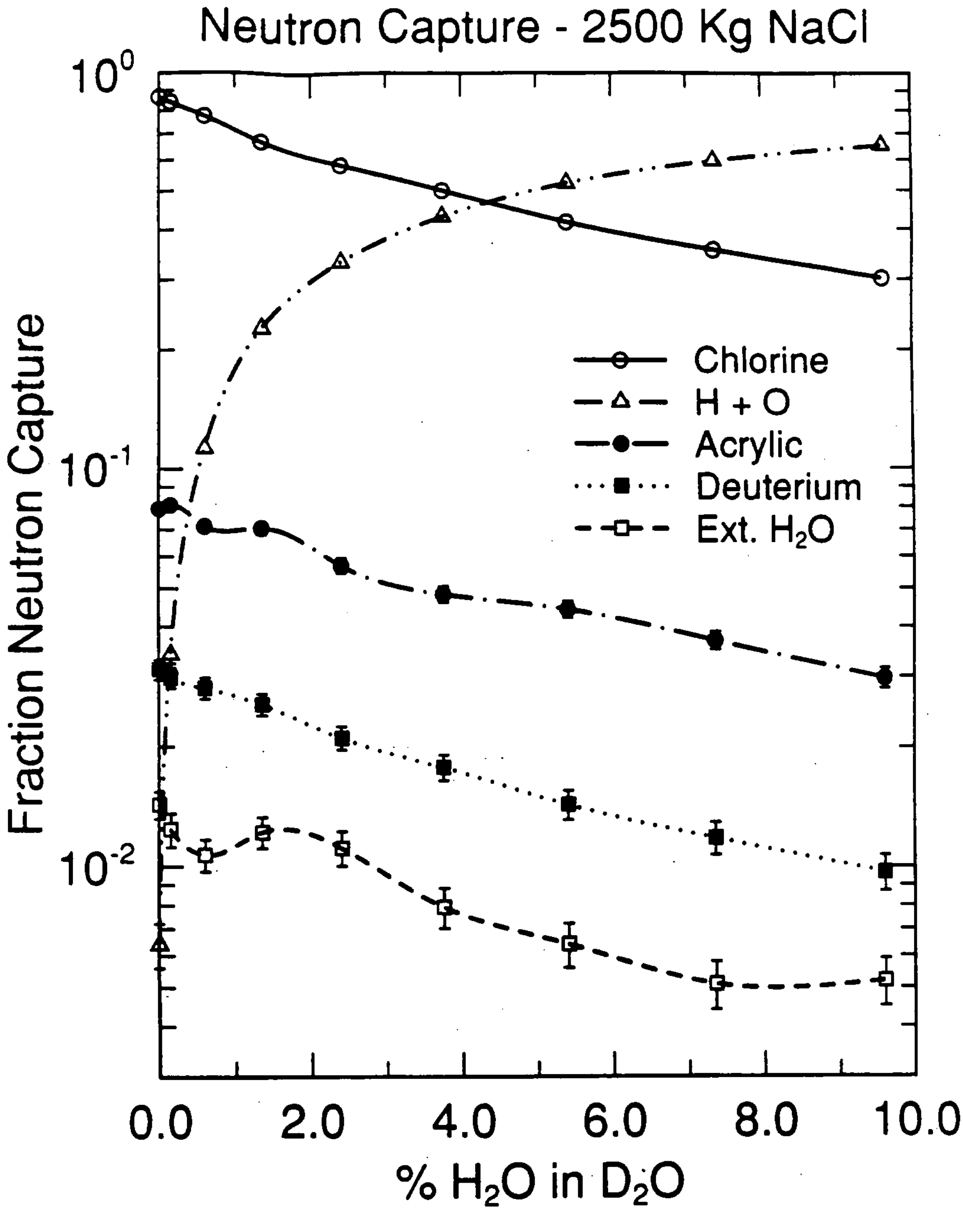
Figure 2. Neutron capture using ^{3}He tubes. For this case the effect of the H_2O impurity is more dramatic. The ^{3}He capture goes from 57% to 5% as the H_2O goes from 0% to 9.6%. The "heavy" water capture becomes equal to the ^{3}He rate for 0.5% H_2O in D_2O. The implicit assumption is that every neutron capture on ^{3}He leads to a measurable event.

Figure 3. Neutron capture using a saturated solution of NaCl (in D_2O) in tubes. The saturated concentration of NaCl in heavy water was taken to be 0.357 g/cm^3. With these assumptions the Cl capture falls from 50% to 4% over the calculated concentration range. Again it should be stressed that this is for the capture probability only. The probability of converting this capture into Čerenkov radiation and measuring it with the PM array must be folded in.

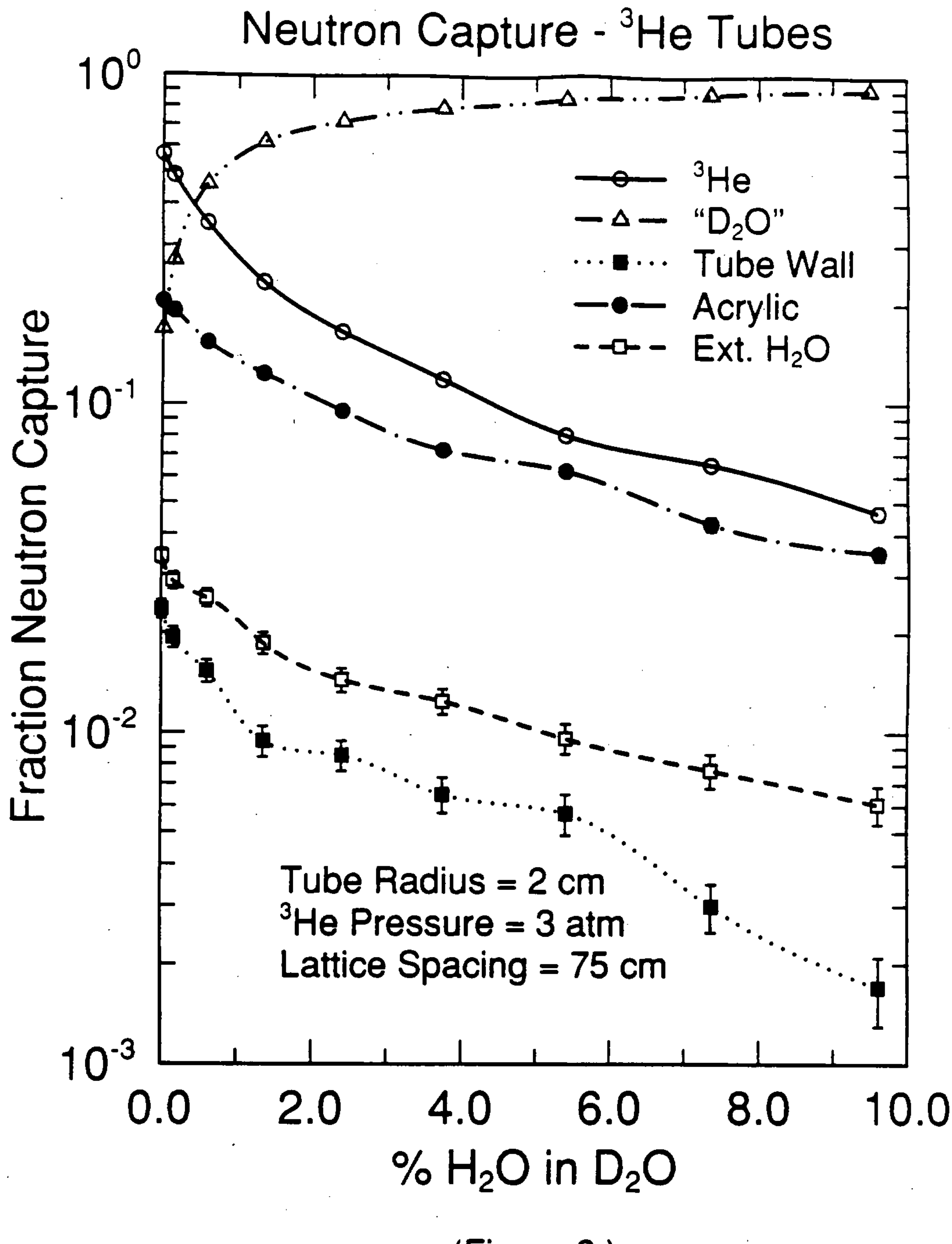
YE OLD BOTTOM LINE

The highest purity D_2O is very desirable. It is most important when the neutrons have to be transported over a finite range before encountering a high cross section capturing medium (i.e. the material in our tube arrays). The use of NaCl in a tube array is a poor choice unless very high efficiency is obtained for detection of Čerenkov light (i.e. high geometric PM coverage and a low background "wall").

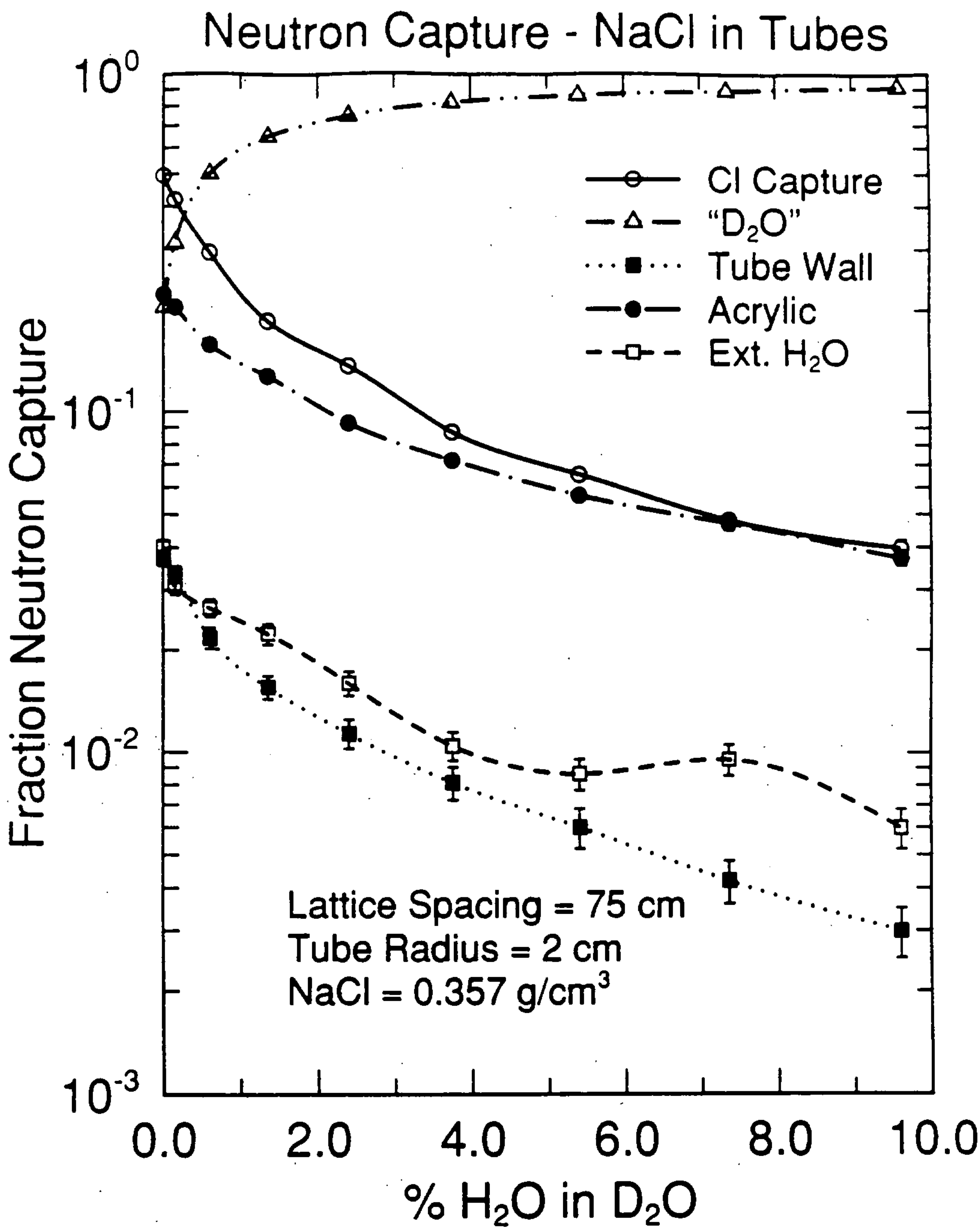
Another very important consideration for neutral current detection is the ability to make the measurement 100% of the time. With a Čerenkov scheme it will be hard (or impossible) to differentiate the charged current events from the neutral current ones. This will necessitate the requirement for an undesirable series of runs (with and without the neutral current detection media) to permit subtraction of the CC events from the NC signal. A neutral current detection scheme, which either has a separate readout capability or generates sufficient isotropic light output to allow unambiguous PM reconstruction, is very desirable for obtaining the maximum physics output from SNO.


Neutron Capture - 2500 Kg NaCl
Fraction Neutron Capture
10^0
10^{-1}
10^{-2}
Chlorine
H + O
Acrylic
Deuterium
Ext. H_2O
0.0
2.0
4.0
6.0
8.0
10.0
% H_2O in D_2O

(Figure 1.)


Neutron Capture - ^{3}He Tubes
10^0
10^{-1}
10^{-2}
10^{-3}
Fraction Neutron Capture
^{3}He
"D_2O"
Tube Wall
Acrylic
Ext. H_2O
Tube Radius = 2 cm
^{3}He Pressure = 3 atm
Lattice Spacing = 75 cm
0.0
2.0
4.0
6.0
8.0
10.0
% H_2O in D_2O

(Figure 2.)



Neutron Capture - NaCl in Tubes
Cl Capture
"D2O"
Tube Wall
Acrylic
Ext. H2O
Lattice Spacing = 75 cm
Tube Radius = 2 cm
NaCl = 0.357 g/cm3
Fraction Neutron Capture
% H2O in D2O

(Figure 3.)