Interim Internal Background Studies
SNO-STR-91-31

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Introduction

The importance of being able to use the main detector to provide information about the uranium and thorium content of the heavy water and whatever neutral current detection system that might be used has been strongly emphasized recently. The following note is intended to summarize the information presently available at Queen's about the possibility of being able to determine the U/Th content of the heavy water.

Calculations

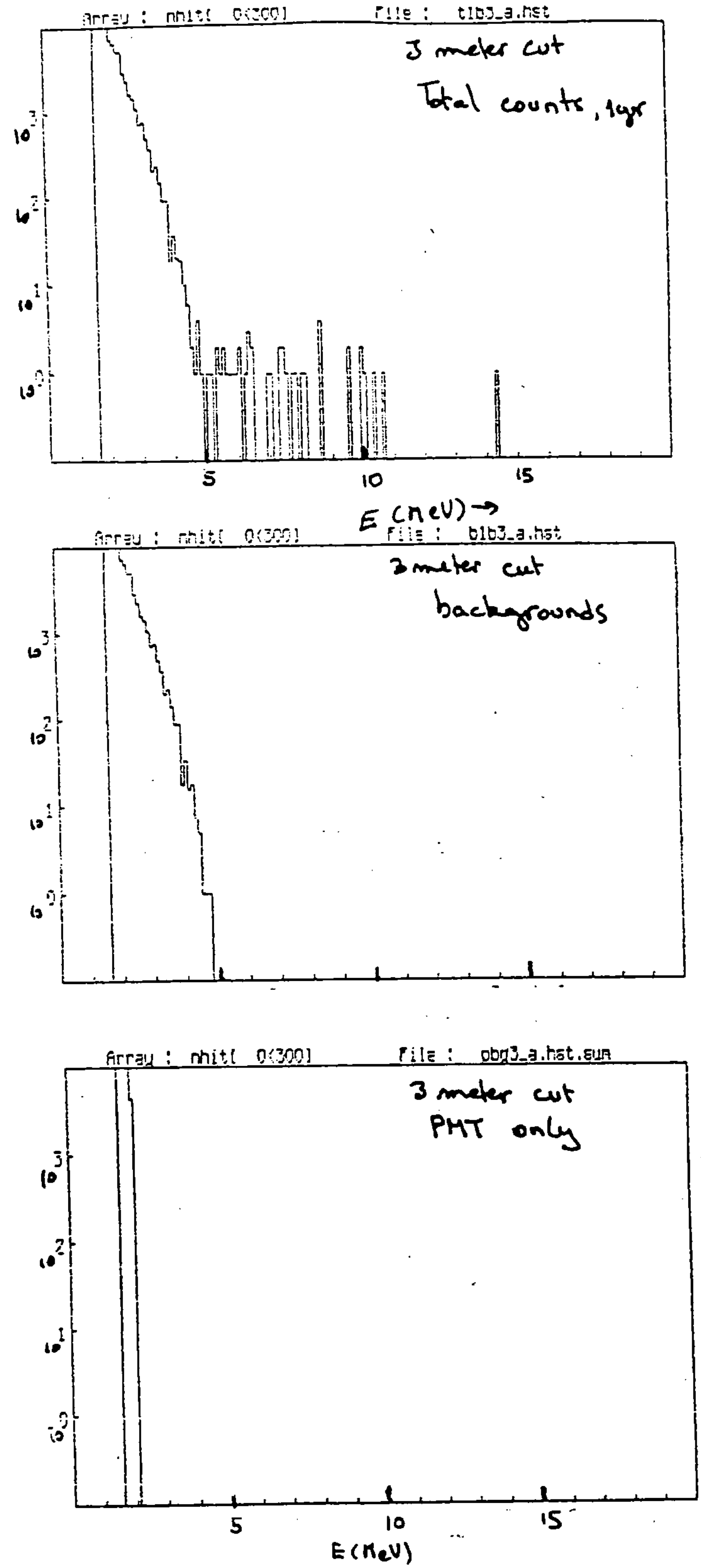
In order to minimize the PMT β-γ background contribution a 3 meter fiducial cut was made. This effectively removed the PMT β-γ background above 2 MeV (Fig 1.), although it is difficult to be confident about this because of the poor statistics and questions of fitter systematics. In the region above 2 MeV both the uranium and thorium backgrounds at the White Book level (1.1×10^{-14} g/g) generate about 17 events per day. In the same energy region the CC signal would be about 0.2 events per day so that it does not produce a significant "background" for the internal β-γ "signal". The major contamination of the internal β-γ signal is the β-γ background from the acrylic, at less than about 10% of the signal.

The raw hit distribution for uranium and thorium are similar in shape, with the uranium spectrum peaking about 700 keV lower than the thorium spectrum does (Fig. 2). The detector response to these sources is shown in Fig.3. There is clearly a difference between the two spectra. Fig. 3 shows that the detected Th spectrum is starting to turn over before reaching 2 MeV, whereas the U spectrum still shows no peak right down to the 2 MeV cutoff. (The peak in the raw hit distribution for Th indicates that the peak in the detected spectrum should be at 16 hits.) However the specific decay rate of the uranium is about ten times that of thorium, so that for comparable U and Th content the thorium spectrum effectively lies on the upper slope of a much more intense uranium one. This makes it difficult to separately extract uranium and thorium yields without a separate, accurate, determination of the uranium content of the heavy water.

The possibility of distinguishing between U and Th on the basis that the U signal is more like a (pointlike) electron source and the Th signal is mainly from a (distributed) γ ray source has been considered. However because of the low number of hits involved in such events there is very little to distinguish between the two types. This can be seen in Fig. 4 where a 3 MeV electron spatial distribution is compared with one for a 2.6 MeV γ ray. This characteristic does not look promising as a means to separate the U and the Th component of the activity.

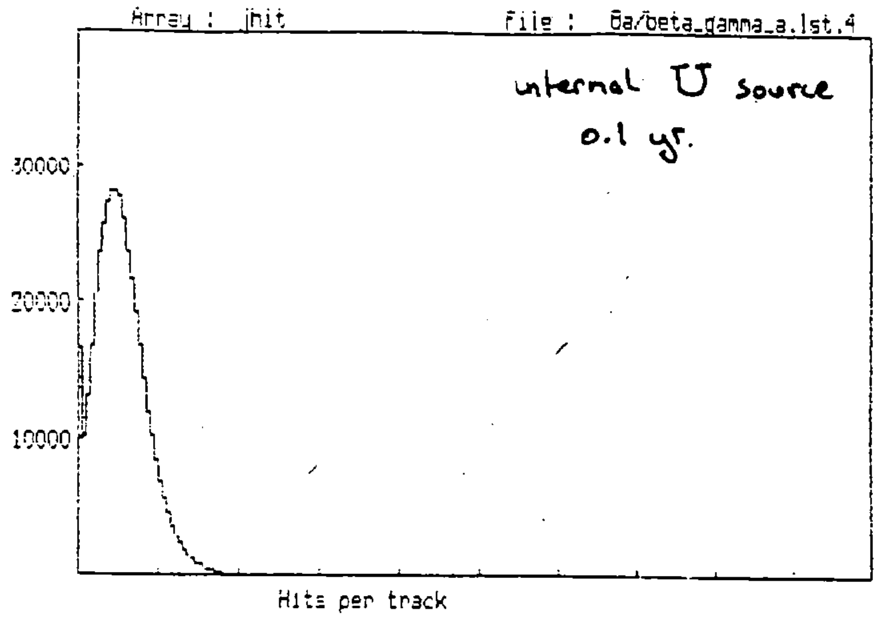
These estimates were made for a detector without tubes in the heavy water. The effect of tubes would to be to spoil the resolution by about 20%, which would make it somewhat more difficult to separate the uranium from the thorium yields.

Initial estimates indicate that potassium could give yields of the same order as the uranium and thorium, so this will have to be considered in more detail. It has also been found that the effect of noise rate is much greater for these low-hit events than for the main signals previously considered. It is also clear that the details of the fitter would have to be reevaulated to optimally extract information in the low energy region.



Array : nhit(0:300)
File : t1b3_a.hst
3 meter cut
Total counts, 1yr
10^3
10^2
10^1
10^0
5
10
15
E (MeV) →
Array : nhit(0:300)
File : b1b3_a.hst
3 meter cut
backgrounds
10^3
10^2
10^1
10^0
Array : nhit(0:300)
File : pbg3_a.hst.sum
3 meter cut
PMT only
10^3
10^2
10^1
10^0
5
10
15
E (MeV)

Fig 1


Array : jhit
File : 8a/beta_gamma_a.lst.4
internal U source
0.1 yr.
30000
20000
10000
Hits per track

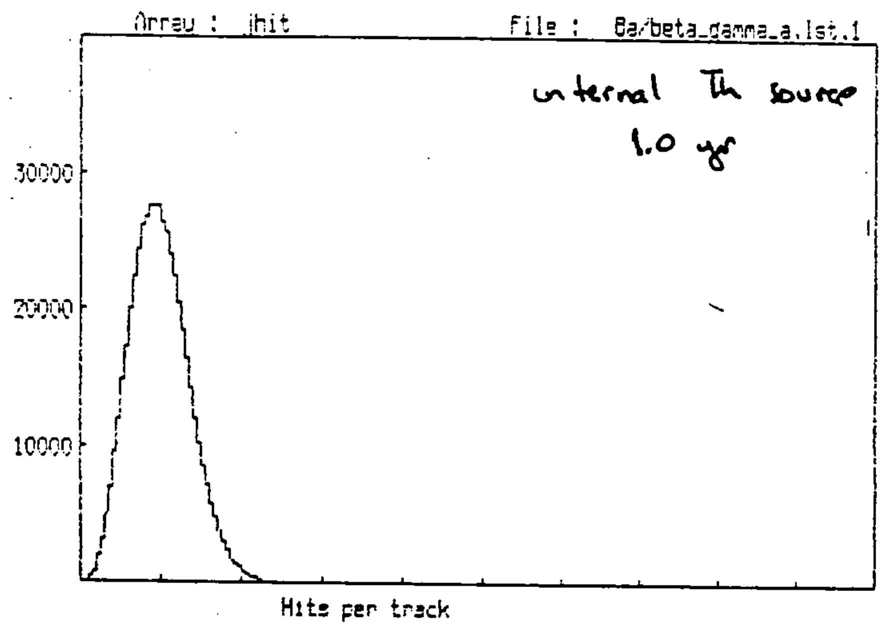
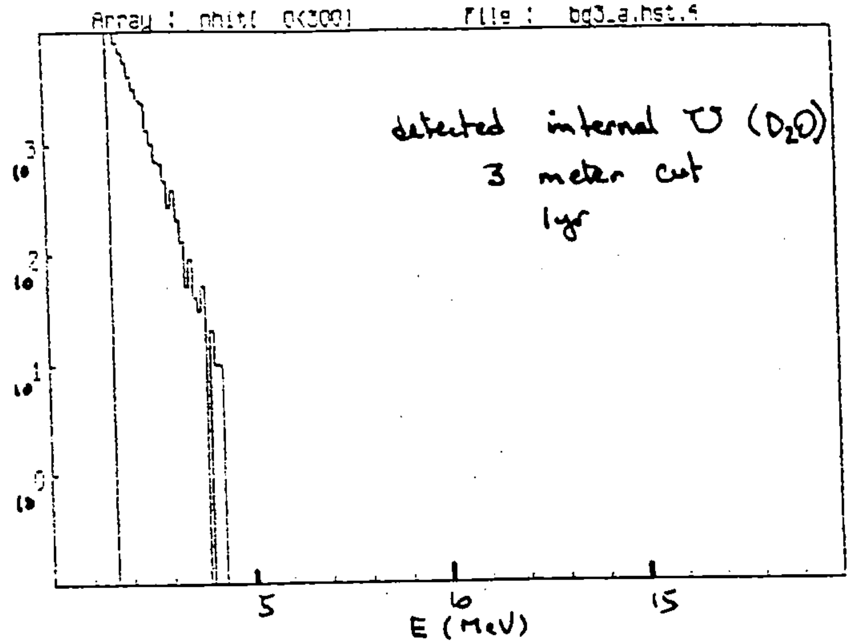
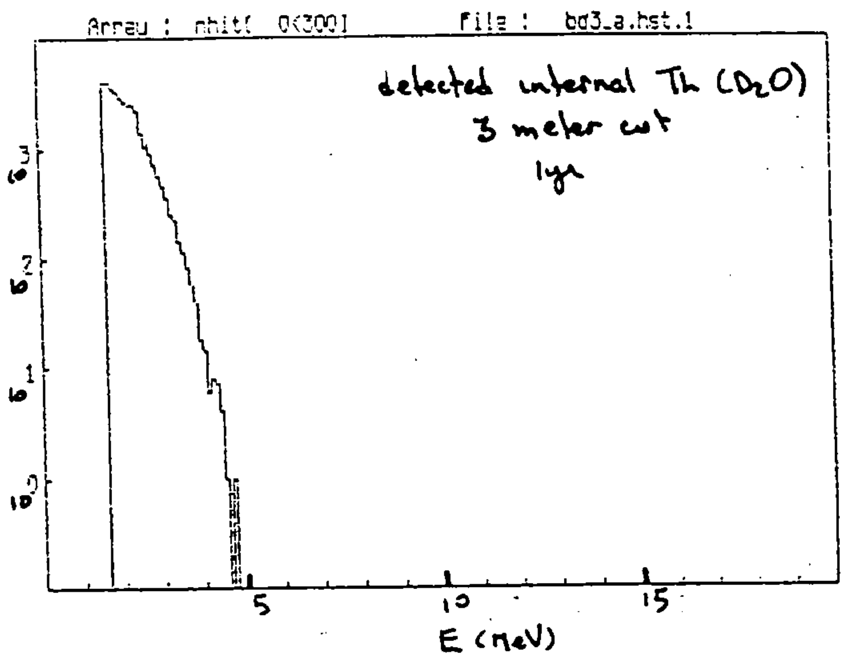

Array : jhit
File : 8a/beta_gamma_a.lst.1
internal Th source
1.0 yr
30000
20000
10000
Hits per track

Fig.2.

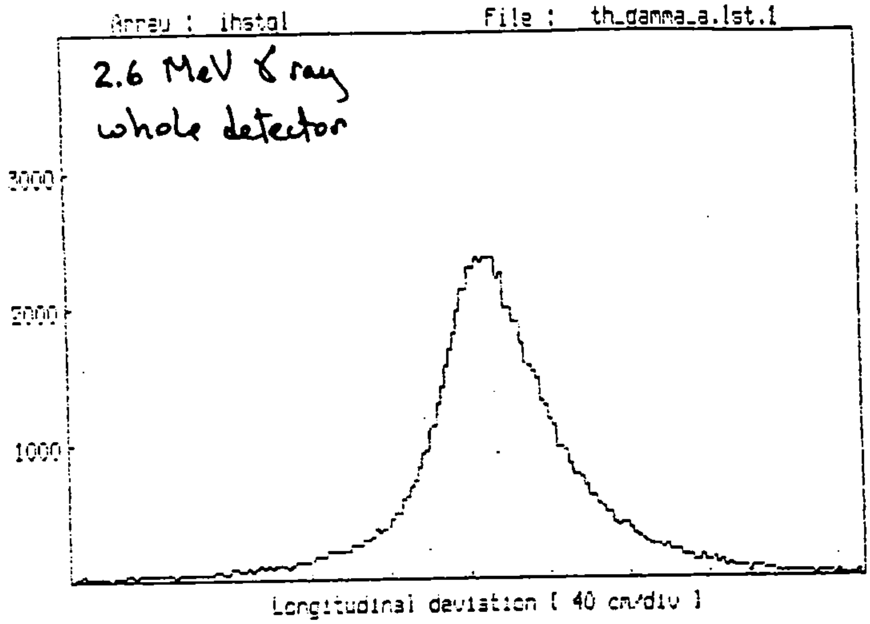


Array : nhit(0(300)
File : bd3_a.hst.4
detected internal U (D_2O)
3 meter cut
1yr
E (MeV)



Array : nhit(0(300)
File : bd3_a.hst.1
detected internal Th (D_2O)
3 meter cut
1yr
E (MeV)

Fig 3.


Array : ihstgl
File : th_gamma_a.lst.1
2.6 MeV γ ray
whole detector
3000
2000
1000
Longitudinal deviation [40 cm/div]

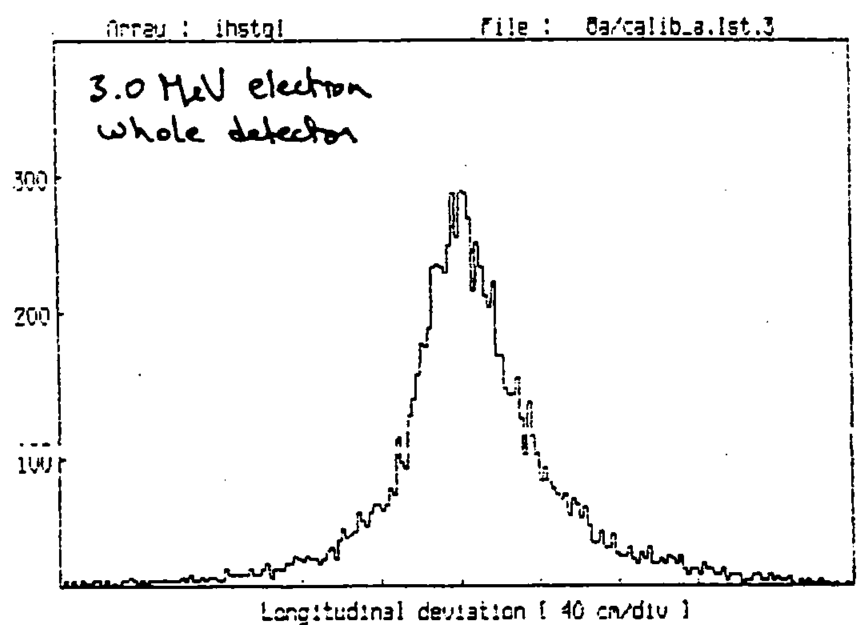

Array : ihstgl
File : 8a/calib_a.lst.3
3.0 MeV electron
whole detector
300
200
100
Longitudinal deviation [40 cm/div]

Fig. 4