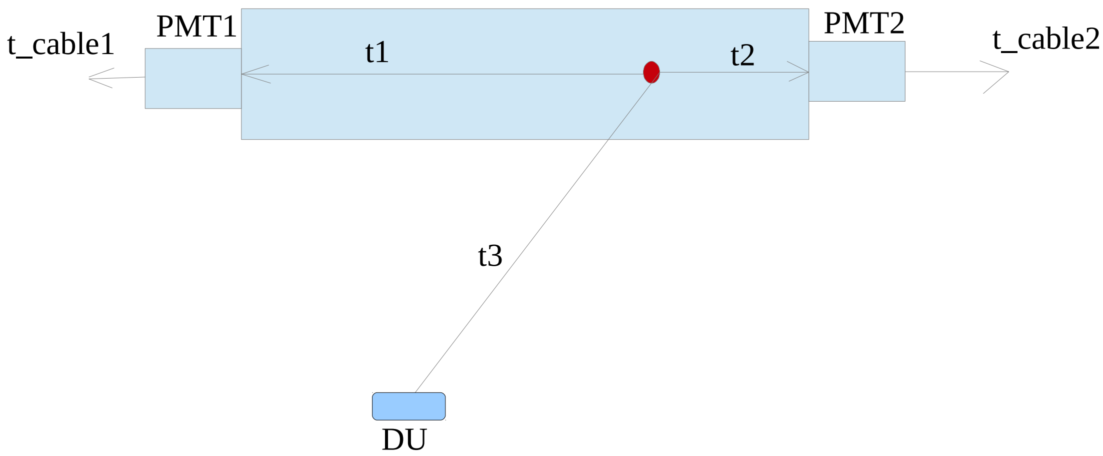
Time t1 and t2 definition.

In the experiment we had neutrons created in the target (DU in this case). After the neutrons escaped the target they traveled some distance within time t_3 (see the sketch below) before they hit the neutron detector.



The total time-of-flight of a neutron seen by PMT1 and measured in the experiment is $TOF_1 = t_3 + t_1$ (see picture above). The total time of flight seen by PMT2 and measured in the experiment is $TOF_2 = t_3 + t_2$. The time that the light needs to pass 100 cm of the detector material (the standard length of our neutron detectors) is $t_{tot} = t_1 + t_2$. We need to get the information on t_1 and t_2 in terms of TOF_1 and TOF_2, hence, we need to eliminate t_3, the time that neutron needs to get to the detector. It should be noted the times t_1 and t_2 will include the delay time due to the finite length of the signal cables t_{cable1} and t_{cable2} which were not measured and are unknown.

First equation can be written as $TOF_1 - TOF_2 = (t_3 + t_1) - (t_3 + t_2) = t_1 - t_2$. The second equation is $t_{tot} = t_1 + t_2$. Solving these equations we find that

$$t_1 = \frac{1}{2}\left[t_{tot} + (TOF_1 - TOF_2)\right]$$

$$t_2 = \frac{1}{2}\left[t_{tot} + (TOF_2 - TOF_1)\right] \ ,$$

where t_{tot} was measured in the separate experiment for each of the neutron detector using Co-60 source and known source position.

The data obtained for Det E with Co-60 source shown in Fig 1 and 2.

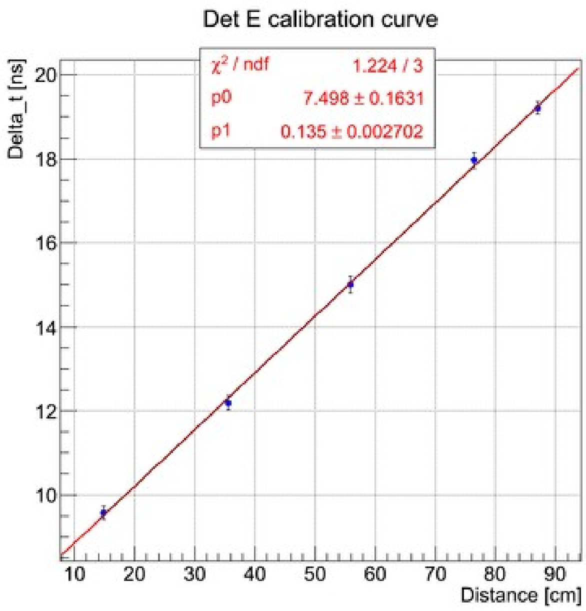


Fig 1. Det E speed of light v' = 7.41 cm/ns

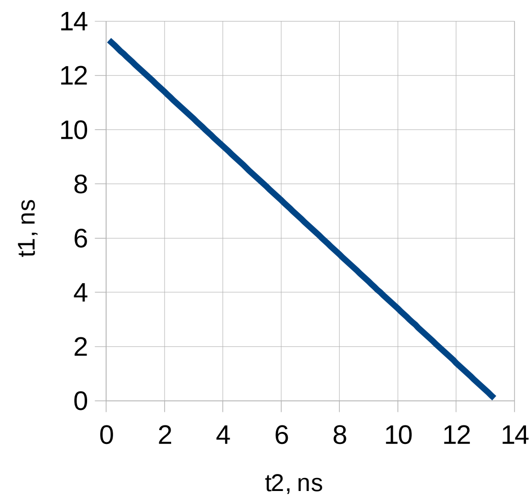


Fig 2. Det E time of light propagation toward PMT left (t1) vs the time towards PMT right (t2).

As can be seen from the Fig. 2. the total time that light needs to travel through the total length of the Det E is equal to 13.5 ns.

The scatter plot of neutron time-of-flight detected by the PMT1 and PMT2 with respect to the corresponding zero time (center of the photon peak) in the neutron ToF spectra is shown on the right in Fig. 3. Only neutron region is used in the data analysis and each point in the plot corresponds to the event that was detected by both PMTs (coincidence mode between the PMTs).

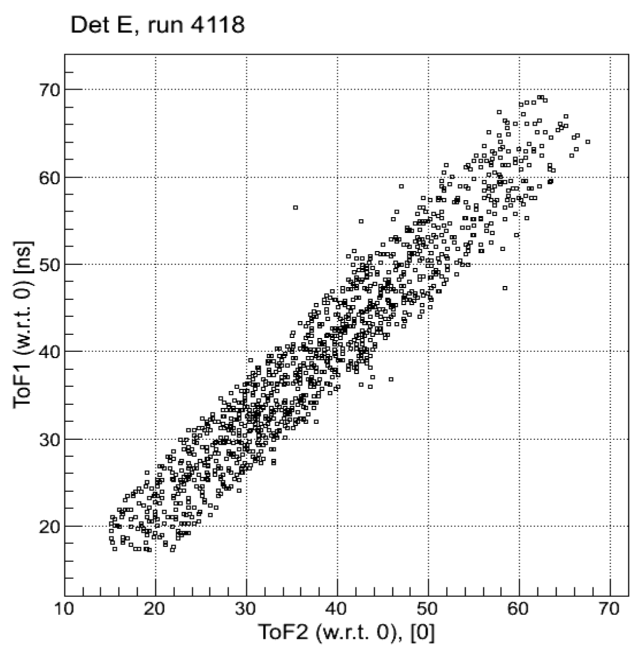


Fig. 3. Scatter plot of the neutron time-of-flight detected by PMT1 and PMT2 obtained for Det E.

Using the equations for t_1 and t_2 and the data from Fig. 3 it is possible to plot the dependence of t_1 vs t_2. This dependence is shown below in Fig. 4.

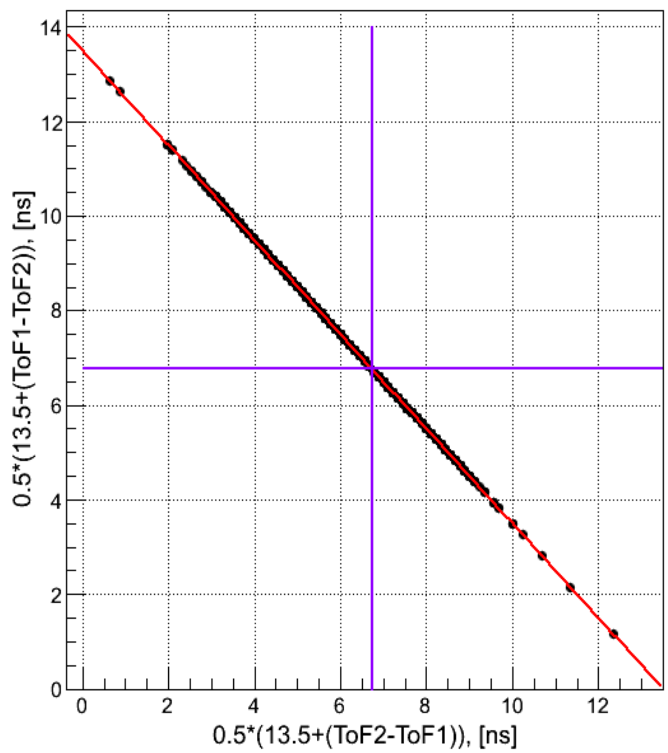


Fig. 4. t_1 vs t_2 obtained for Det E (run 4118). The plot should be symmetric around 6.75 ns.

It can be seen that when $TOF_1 = TOF_2$, i.e. when the hit is in the middle of the detector the times t_1 and t_2 are equal and the plot is symmetric around 13.5/2 = 6.75 ns. The line fit equation is $y = -x+13.5$.