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LIQUID SCINTILLATOR DETECTION AND MULTIPARAMETER DATA AQUISITION FOR NEUTRON DETECTION IN COLD FUSION EXPERIMENTS

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Abstract

We have designed a low level neutron detector for cold fusion experiments with titanium and deuterium gas. The basic principle of the system is to monitor as many relevant parameters as possible and store them event-by-event and analyze the data afterwards. The result of the experiment was that no significant excess of neutrons was observed. We also discuss the cosmic radiation that may influence low level measurements of neutrons.

Introduction

During the spring of 1989 two American research groups reported different signs of fusion at room temperaure in metal lattices by way of electrolysis.[1,2] Later experiments with titanium exposed to deuterium gas under pressure and cooled to the temperature of liquid nitrogen showed positive results as far as the detection of neutrons goes.[3,4] The work presented here is an attempt to confirm some initial positive results with the latter kind of experiment.

To detect the neutrons a neutron detection system based on a liquid scintillator and pulse shape analysis[5] was designed. Its basic principle is to monitor as many relevant parameters as possible and store them event-by-event and analyze the data afterwards. The system also takes into account the problem of cosmic radiation that may influence measurements of this kind.

The detector system

One of the signs of cold fusion would be the 2.45 MeV neutrons from the following reaction:

$$d + d \Rightarrow \begin{cases} {}^3He\ (0.82\ MeV) + n\ (2.45\ MeV) & (42\ \%) \\ p\ (3.02\ MeV) + t\ (1.01\ MeV) & (58\ \%). \end{cases} \qquad (1)$$

The detector system, shown in figure 1, is especially designed to detect neutrons above an energy of 1 MeV and separate them from the background gamma radiation. In the center the neutron detector is placed. It is a liquid scintillator, NE-213, which has the property to separate gamma rays from neutrons by pulse shape analysis. The experimental vessel, which contains the Ti/D_2-sample, is placed in a central well. The detector is shielded from background gamma radiation and, to some extent, background neutrons with lead and solid paraffin, which has advantages and disadvantages that we will come back to later.

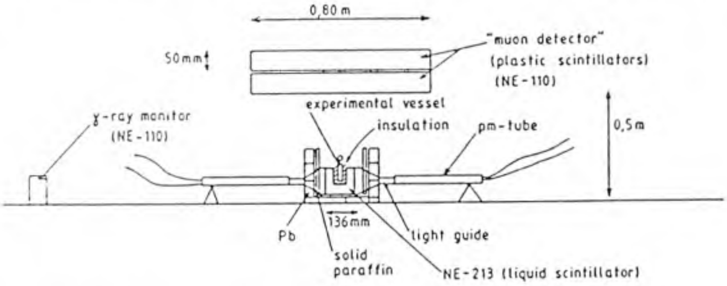

Figure 1. The experimental arrangement.

Above the neutron detector two layers of muon scintillation detectors (NE-110) are placed, which have about a 90 % geometri for cosmic muons. An additional plastic scintillator is placed a distance away in the same experimental room to monitor the variation in the overall gamma ray background.

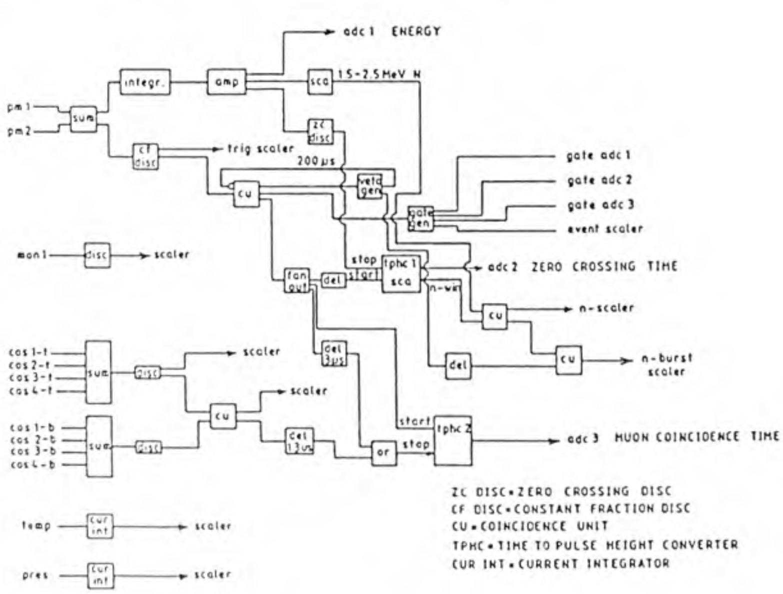

Figure 2. Block diagram of the detector system.

The block diagram of the electronics of the detector system is shown in figure 2. The two PM-tubes of the neutron detector are added and processed to give the energy to

ADC 1, the zero-crossing time to ADC 2 and the muon coincidence time, i.e. the time between an event in the muon detector and an event in the neutron detector, to ADC 3. For each trigger all three ADCs were read out consecutively and stored event-by-event.

The system also contains several scalers, e.g. the number of triggers, the number of accepted events, the number of hardware defined neutrons, the so called neutron burst watch (the number of neutron events during the dead time of the system (0.3 ms)), the gamma ray monitor and the digitalized values of the temperature and the pressure in the experimental vessel. The scalers were read out once every second and the values stored together with the ADC-data.

Energy calibration of the system was performed with gamma ray sources and pulse shape analysis calibration with a PuBe-source. To check the stability a pulser was put into the system before and after every run. Figure 3a shows a 2-dimensional diagram of the zero-crossing time, the energy and the intensity for a PuBe-calibration. The separation is good down to an energy of approximately 0.8 MeV neutrons. This type of PuBe-calibration was performed twice every day to check the stability of the system during the two weeks the experiments were in progress (figure 3d).

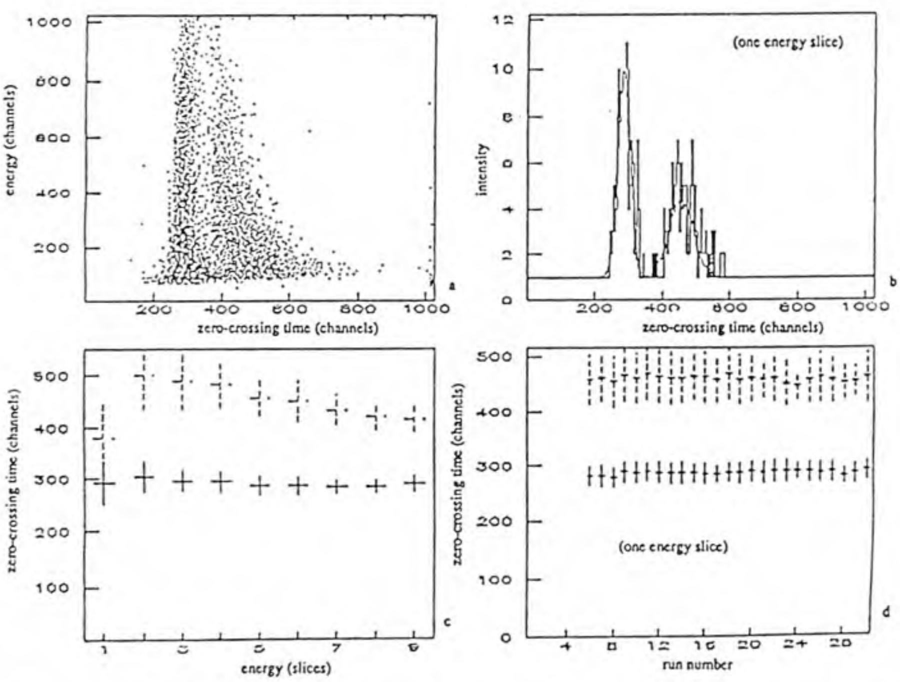

Figure 3. a) 2-dimensional diagram of energy vs zero-crossing time and intensity. b) Separation for one energy slice. A double gauss fit has been made. (For practical purposes unity has been added.) c) A parametrization of a). d) Zero-crossing stability for the experimental period (two weeks).

Experiment

The kind of experiment that the effort was concentrated on during this first running period was the so called gas experiment when titanium shavings under high D_2-pressure was temperature cycled. The deuterium gas pressure varied between 35 and 65 bar, the cooling time between 5 and 10 minutes. The system was back to room temperature after approximately 90 minutes. The amount of Ti was between 10 and 50 g. We performed three to four cycles before changing the titanium.

We performed three types of experiments: 1) 99.8 % pure titanium in the shape of shavings (1 x 1 x 0.1 mm^3): 15 runs for totally 79 h. 2) The same titanium, but evacuated, heated to 300 °C, cooled, deuterium filled, reheated to 300 °C, recooled, refilled: 7 runs for totally 51 h. 3) The titanium alloy Ti-662 (92 % Ti, 6 % Fe, 2 % Zn) in the shape of threads: 3 runs for totally 12 h.

In addition to the runs described above we ran two types of background experiments between the D_2-experiments: a) As 1) above, but with hydrogen instead of deuterium: 3 runs for totally 20 h. b) Totally empty detector: 9 runs for totally 89 h.

Results

The analysis of the collected data was performed after finishing all data-taking. The PuBe-calibrations were used to establish where the neutrons are situated in the E-t-plot (figure 3c). Hence by using this parametrization we got a neutron energy spectrum for each run. Figure 4 shows the energy spectra for the sum of the three kinds of experiments subtracted by the corresponding background (normalized to time). Nothing significant is observed, and that goes for every single experiment as well.

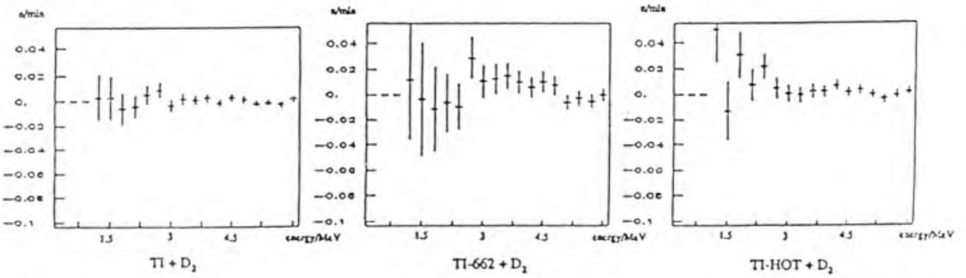

Figure 4. The energy spectra for the three kinds of experiment subtracted by corresponding background.

Cosmic radiation

In our experiments we could see that about 10 % of the observed neutrons are related to cosmic muons. They are produced in the shielding lead and other materials in the room when high energy muons collide with it, so called spalding. Lead is especially hard to deal with in this sense, because it has a very large neutron content.

Figure 5 shows the time between a muon is detected in the muon detectors and a gamma ray or neutron event in the neutron detector. Note that the gamma ray and the neutron time peaks have significantly different shapes. The tail of the neutron peak lasts for some 600 ns, which corresponds to a flight path for MeV neutrons of several meters.

This indicates that the neutrons can go around the room, maybe hitting the roof or the walls, and then go back into the neutron detector.

Nucleons also enter from the atmosphere. The rate of neutrons at the earth surface is dependent of temperature, wind, solar activity etc. But the the main factor is the air pressure. The fluctuation is 0.7 %/mbar from its avarage; i.e. quite large an effect as the air pressure can vary very much.[6]

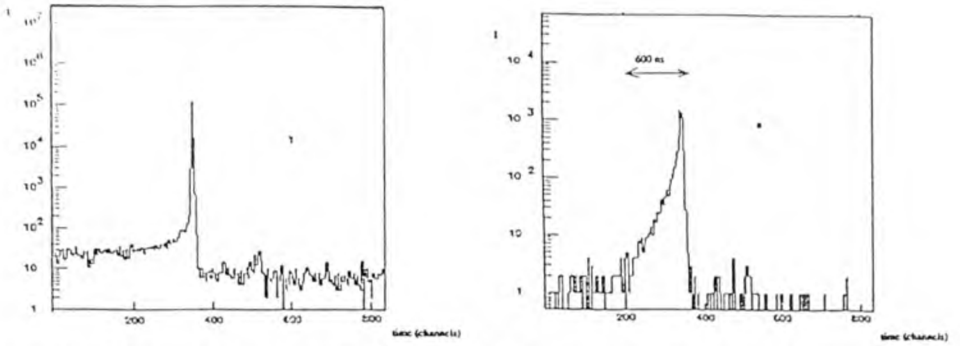

Figure 5. The time between a muon is detected in the muon detectors and a gamma ray (left) or a neutron (right) is detected in the neutron detector.

Conclusions

A low level neutron detector system has been constructed for cold fusion experiments. We conclude that:

1) It is possible to perform low level neutron measurements with this system in a reliable way.

2) No significant excess of neutrons was observed. The calculated detectable fusion rate was approximately 10^{-24} per deuteron pair and second.

3) The cosmic radiation should be paid attention to when performing low level neutron experiments. One way to deal with the problem is to have two similar systems in the experimental room to observe the neutron fluctuation.

References

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