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Research Article

Nuclear Signature in LENR Gas Loading Experiments

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Abstract

Several types of experiments on LENR anomalies were performed at the ARGAL laboratory in Bareggio, in particular using thin films of palladium in H_2 or D_2 atmosphere at various pressures. The laboratory is equipped with instrumentation suitable for the detection of neutrons and gamma emission, with an He^3 detector, and a multichannel detector with a 3-inch NaI crystal. All the experiments carried out have been monitored with these instruments, and in many cases we have found neutron emissions attributable to nuclear events inside the reactor. Some anomalous events were short-lived; others were prolonged for several minutes. Apart from one particular case, the events were modest. In any case, the evidence found shows once again the nuclear nature of the LENR phenomena, in the past highlighted by clear episodes of nuclear transmutations in similar conditions, where it was possible to analyze the material with the appropriate techniques at the end of the experiment.

Keywords: Neutron burst, Nickel foam, Pd electroplating, Pd loading, Transmutations

1. Introduction

The ARGAL laboratory in Bareggio is equipped with several reactors used to perform experiments on LENR anomalies [1]. The configuration used in the experiments described here is depicted in Fig. 1.

The laboratory is continuously monitored with a He^3 neutron detector (Ludlum) and with a multichannel detector (Ludlum) with a 3" sodium iodide scintillator for gamma radiation, which are placed nearby the reactors.

The Ludlum 12-4 neutron meter detector (Fig. 2) is particularly well suited for neutron monitoring. This detector is interfaced to a PC that uses LabView to record the events reported by the detector. The acquisition program records the data in two different modes, one in the form of events (counts) as a function of time (Fig. 3), indicating the number of counts every minute (left axis) and every hour (right axis); and in a different screen (Fig. 4) in a normalized histogram for counts every hour. The program performs an acquisition over 8000 min, followed by a reset and the beginning of a new acquisition. The data for each complete acquisition are stored in a remote hard disk for subsequent analysis.

Figures 2–4 respectively show an example of a graph for a partial acquisition, an example of an almost complete acquisition and a histogram of an almost complete acquisition.

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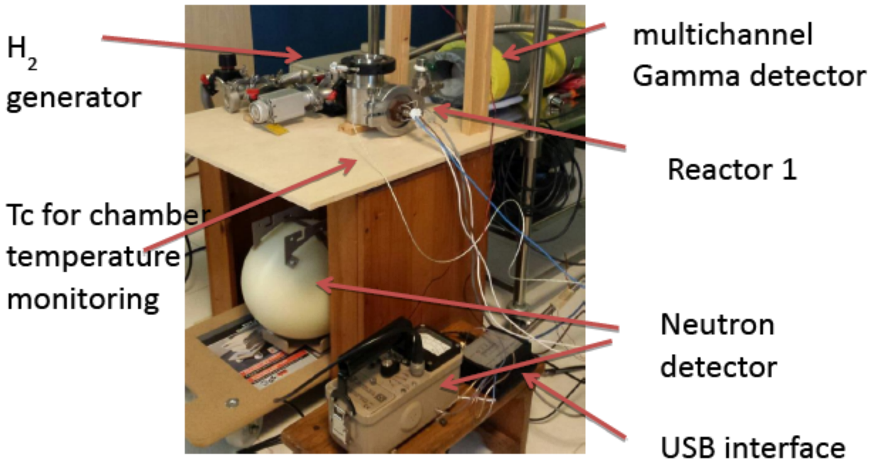

Figure 1. Configuration setup.

2. How to Read the Neutron Acquisition Graph

Figures 2 and 3 show the evolution over time of the pulses coming from the neutron detector. On the X-axis the time expressed in minutes (*bottom*) and in hours (*top*). The left Y-axis shows the neutrons in every single minute (*black points*), which for the most part are on the line $Y = 0$, with some at $Y = 1$, and relatively few for $Y = 2$; $Y = 3$ is a very rare event. The right Y-axis shows neutrons for single hour (green dots linked together by green lines). Each acquisition has a duration of about 8000 min, after which the graph is reset and a new acquisition starts. This happens for 24 h a day, every day of the year, except for a few days break for maintenance of the laboratory or other special needs.

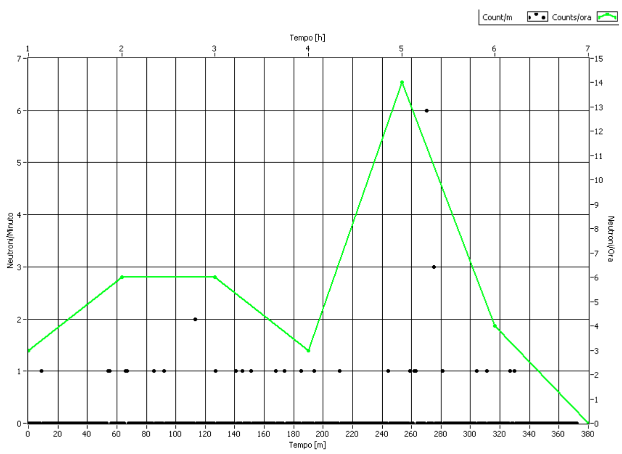

Figure 2. Evolution of the neutron count over 350 min during the experiment.

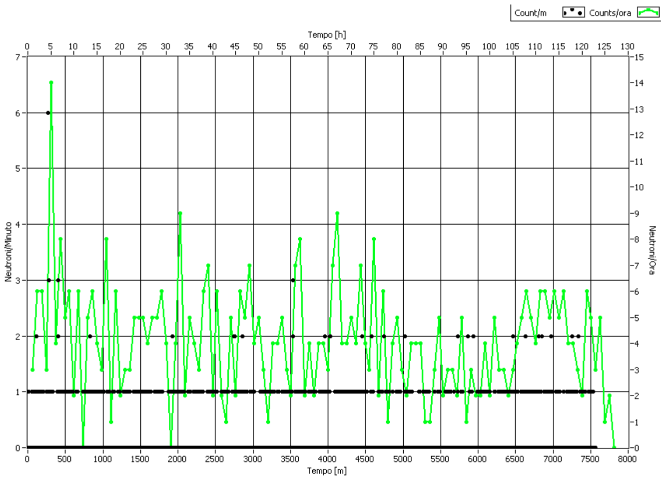

Figure 3. Changes in the neutron count included the above chart (Fig. 2), extended up to 7600 min. This also includes monitoring while trying to reproduce the neutron burst of six neutrons in 1 min, which took place around minute 270. This event is more clearly shown in Fig. 2.

In addition to neutron monitoring, to follow the course of the experiments in a complete and effective way, another PC runs a LabView program acquiring other parameters such as: the temperature of the sample inside the reactor, the pressure in the reactor, the environment temperature, the external temperature of the reactor, possible power to heat the sample and finally the value of a thin film resistance in palladium to monitor the absorption of hydrogen, when the material under test contains palladium. A typical behavior of the monitor resistance is shown in Fig. 5.

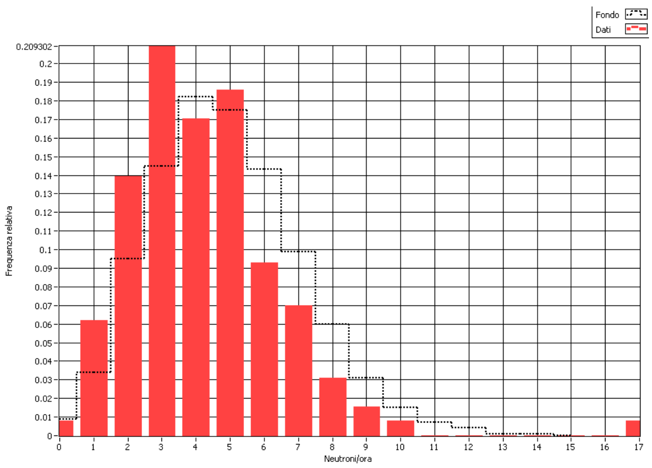

Figure 4. Histogram of the neutron count / hour for a time interval during which an experiment with Reactor 1 containing a sample with a film of palladium in hydrogen at a pressure of 1 bar showed abnormal emission of neutrons while hydrogen was admitted into the reactor (screenshot on 01 December 2014).

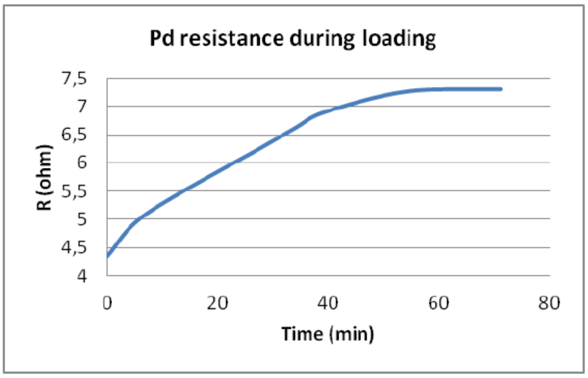

Figure 5. Trend of Pd resistance as the reactor finishes filling with hydrogen at 1 bar pressure. The graph shows the rise in resistance when the palladium was loaded for the first time. During subsequent loadings the change in resistance is faster.

3. Neutron Bursts

As can be seen in Fig. 2, around minute 270 a count of six neutrons was recorded. That is completely anomalous, as we shall see below with a statistical analysis of the performance of this type of monitoring. It is important to note that the abnormal recording of six counts in 1 min coincided with the completion of the absorption, measured by palladium resistance (the resistance value was 7.31 Ω) and that this particular palladium film was being subjected to absorption for the first time.

In the past the same abnormal emission of neutrons was recorded under practically identical conditions, using a different sample with the same structure: 250 nm of palladium on an oxidized silicon substrate. This first episode was not analyzed as closely as the current one, because it was totally isolated and unexpected, and therefore considered to be a result of the statistical fluctuation of the neutron background detection. In any case, we did suspect that an anomaly may have occurred, and we recorded it as histogram trend of neutrons (which is a cumulative figure), stored at that time (Fig. 4). Unfortunately, the graph as that of Fig. 3 was not stored by a screenshot, but it has been recovered as raw data from the external hard disk where all the acquisition data are archived. The Excel graph of this data is shown in Fig. 6.

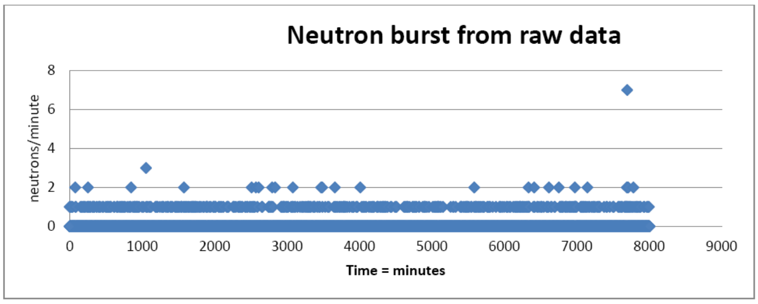

Figure 6. Neutron burst reconstruction from raw data stored on 01 December 2014. The neutron emission of seven neutrons in 1 min was in coincidence with hydrogen admitted into the reactor when the resistance of the palladium monitor resistance was rising.

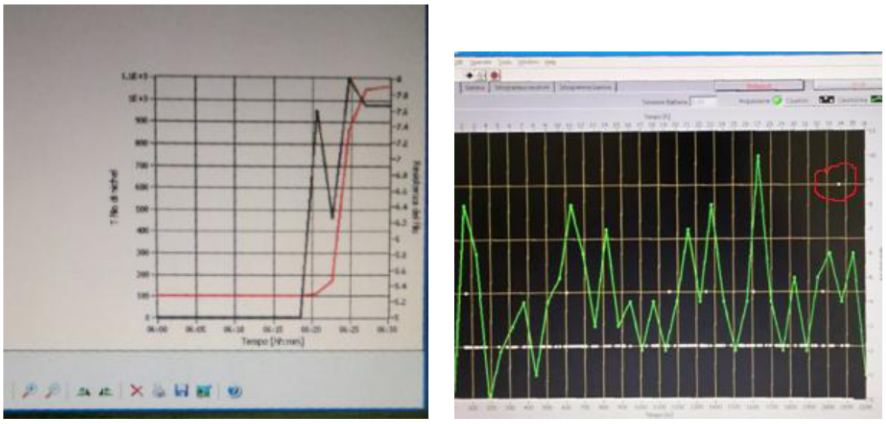

Figure 7. Anomalous neutron burst in coincidence with palladium thin film hydrogen loading (red curve on the left image).

4. Statistical Analysis

To confirm whether signals coming from the reactor are due to internal nuclear reactions, it is necessary to make a statistical analysis. So, referring to real data from a background neutrons acquisition (similar to that of Figs. 2 and 3, but without abnormalities), the events per minute for an interval of 171 min were collected. Subsequently, events over a time interval of 1470 min were collected.

In Table 1, columns 2–4 show such data in the following format: The first row indicates the events per minute that in the specific case are either zero, or 1, or 2, the second row the number of events for the three cases (0, 1, 2) for 171 min and the third row, the number of events for the three cases (0, 1, 2) for 1470 min.

In column 4 the statistic is shown in a normalized form, extending the number of cases up to 6 to determine the likelihood using the Poisson's law, because the events (neutron emissions) are independent from each other [2].

Hence, in columns 8–11 data extrapolated up to six events, as follows: Over 171 min, 10 neutrons were detected. Probability of occurrence: 0.0585 neutron/min. Over 1470 min 91 neutrons were detected. Probability of occurrence: 0.0619 neutron/min.

The two values are quite close. Let us consider $\lambda = 0.06$ n/mn (λ in the Poisson's formula). The Poisson's distribution is given by the formula:

$$P(n) = \frac{\lambda^n \, \mathrm{e}^{-\lambda}}{n!}.$$

The last line of the table shows the probabilities according to this law.

Table 1. Real data and probability table.

	Real data			Probability up to six events per minute						
Cases	0	1	2	0	1	2	3	4	5	6
n	161	9	1	0,9415	0,0526	0,0058				
n	1379	86	5	0,9380	0,0585	0,0034				
Poisson				0.9418	0.0565	0.0017	3.4 10^{-5}	5.08 10^{-7}	6.1 10^{-9}	6.1 10^{-11}

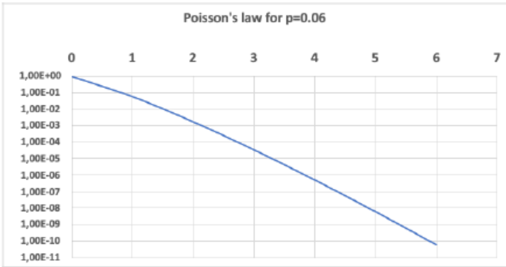

Figure 8. Curve fit for the calculation of the probability for a number "*n*" of events per minute.

Figure 8 shows the chances of cases actually observed occurring, expressed in exponential form, which we can use estimate the probability of some number of events per minute. For our purposes, this evaluation shows the probability of up to six events per minute; it is equal to 6.1 $\times 10^{-11}$, from which one can derive how often this kind of event should occur on average in the absence of abnormal emissions. The reciprocal of the probability indicates the number of minutes (on average) between one event and the next; for example for the case 1 it would be: 1 / 0.0565 = 17.7 min, which multiplied by 86 (number of events) gives us 1522 min, a value close to 1470 min, that is, the observation interval. Then: 1 / 6.1 $\times$ 10^{-11} = 16 $\times$ 10^9 min between one event and the next in the case of 6 "counts" in a minute, corresponding to 30 441 years. This allows us to state that the coincidence between the loading of palladium films and counting six neutrons in 1 min is an extremely unlikely event, and it is almost certainly an indication of a brief, real nuclear event inside the reactor.

14 May 2018 Neutron Burst: Event Probability 5.08 $\times$ 10^{-7}

5. Monitoring Neutrons with Palladium Inside the Reactor

With a sample of nickel foam on which a thin layer of palladium was deposited, tests were carried out to verify on a small scale what was reported by Mizuno with his experiments in which the samples had similar structures (nickel mesh with palladium deposited by rubbing) [3]. The thermal anomalies found by Mizuno were not confirmed, but clear neutron emission episodes were observed as described above, both in hydrogen than in deuterium. The photos in Fig. 9 show the material and the simple set-up for the palladium electroplating.

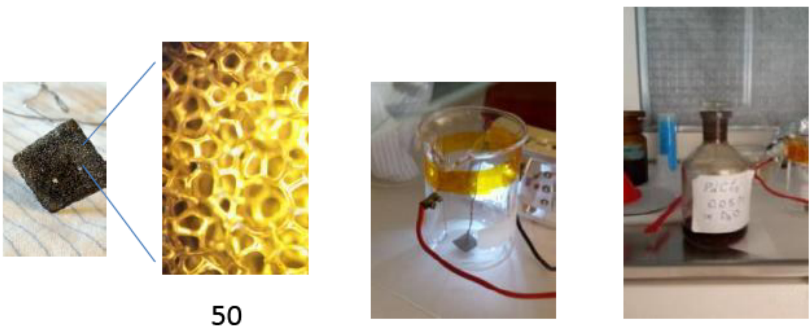

Figure 9. Nickel foam, beaker with platinum electrodes and palladium chloride solution for plating.

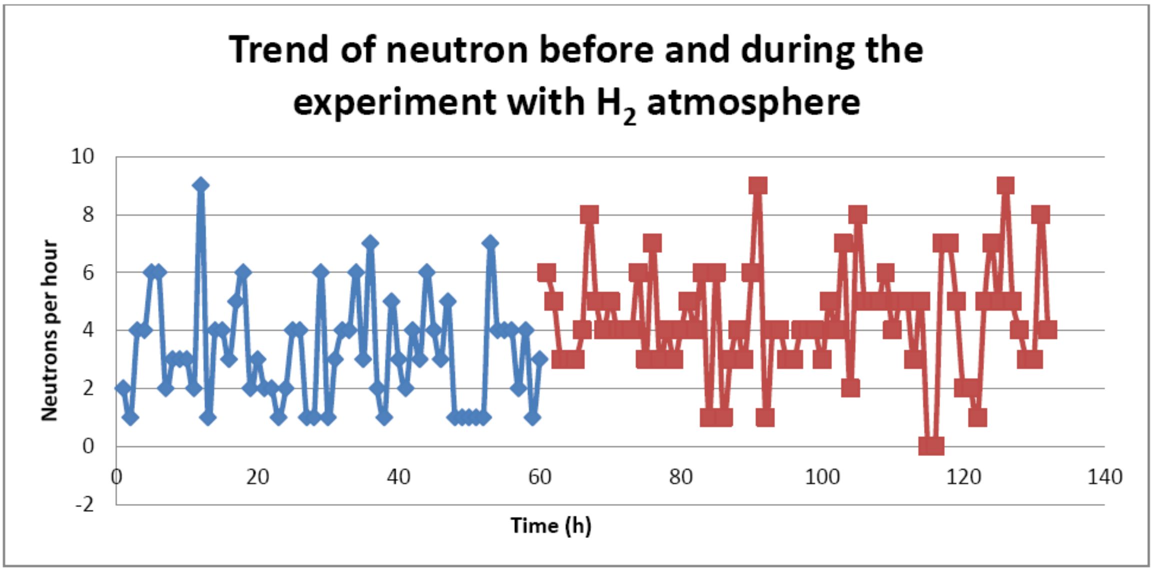

Figure 10. Neutron data with no sample in the reactor (*blue*), and with the sample under test (*red*) in hydrogen atmosphere.

Figure 10 and the followings show that slight neutron emission activity is detected when palladium is present in the reactor, both in hydrogen and deuterium atmosphere. The events that manifest themselves as bursts are instead relatively rare because in almost all cases the palladium inside the reactor was exposed to the atmosphere of hydrogen or deuterium for the first time. That was unexpected. Attempts to replicate these bursts were made immediately after each burst, but they have not produced emissions in the same form.

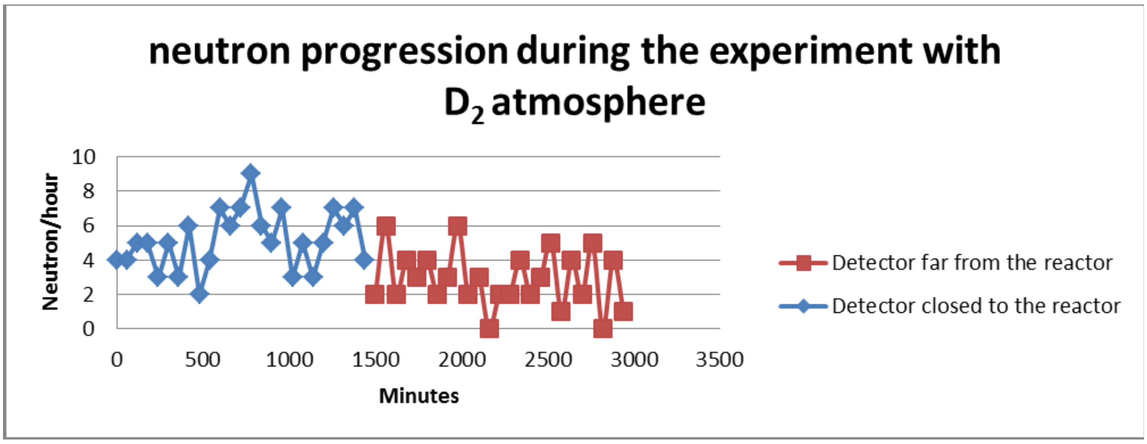

Figure 11. Another example of neutron emission in deuterium atmosphere moving the detector far from the reactor (*red*) and near the reactor (*blue*).

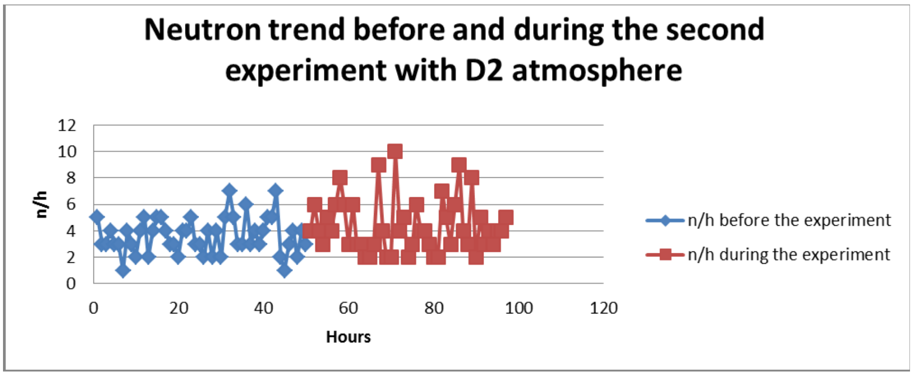

Figure 12. Neutron data with no sample in the reactor (*blue*), and with the sample under test (*red*) in deuterium atmosphere.

In the below histogram a double peak is clearly visible. This is the best sign that two different phenomena are at play. Most events are distributed almost like the background (peak=5). Some events produce a larger number of neutrons and build up an additional distribution (peak=10). Even though this is a short period of measurement with a statistically small amount of data, it confirms that bursts are taking place.

6. Massive Neutron Emission

An event with a significant neutron emission from reactor 1 was recorded in October 2014 (see Fig. 14). The continuously active monitoring system signaled a first burst lasting 3 min when the reactor was under vacuum after a thin film palladium sample irradiated with a 405 nm wavelength laser for 2 weeks was extracted from the reactor. It is important to consider that because palladium film is very reflective, the laser beam had also irradiated the internal walls of the stainless steel reactor. After a first neutron burst lasting 3 min, a few hours later, a more intense and longer second burst (17 min) was recorded. The causes of these anomalous emissions have been attributed to the desorption of the hydrogen gas from the internal walls of the reactor [4]. The reactor was at ambient temperature.

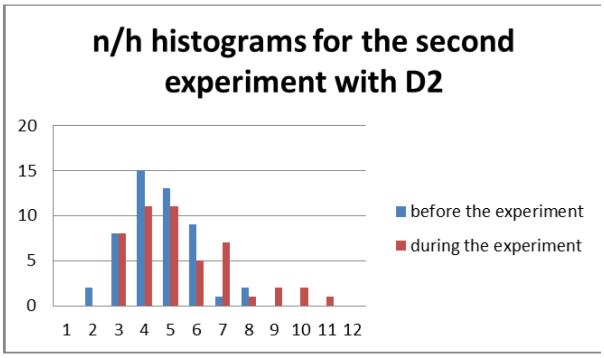

Figure 13. Histogram of the data in Fig. 12.

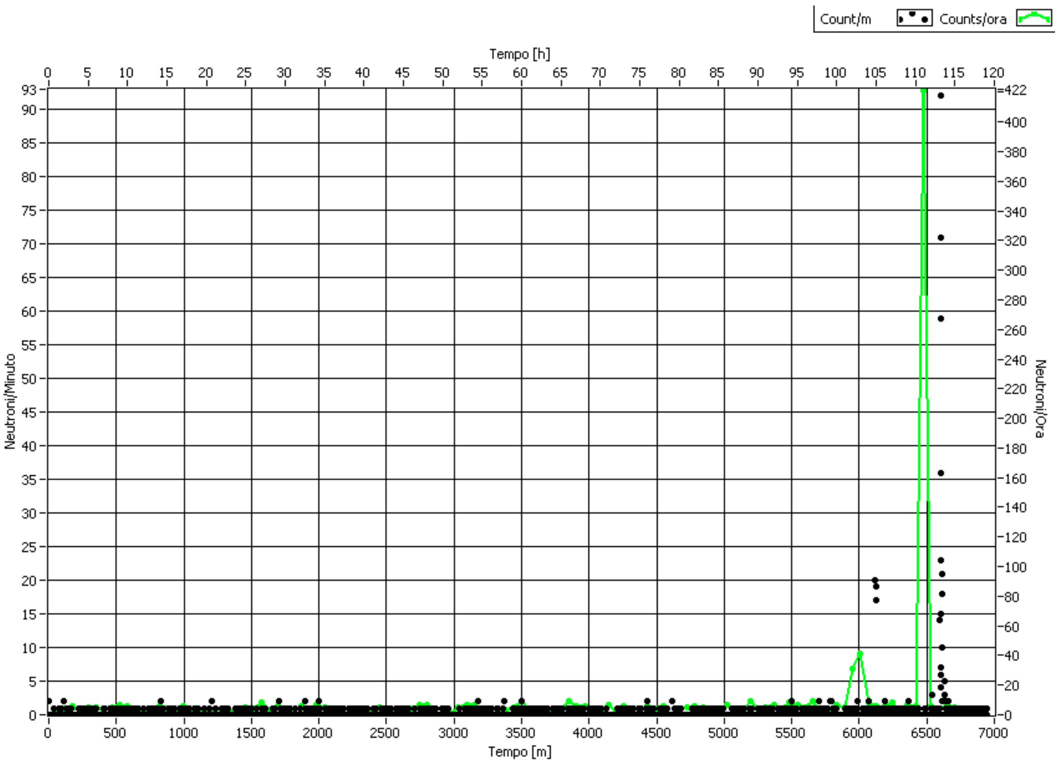

Figure 14. Screen shot of the neutron monitoring PC showing a massive neutron emission from reactor 1 after the experiment with a 405 nm laser.

6.1. Figure 14 Chart description

Figure 14 shows a chart extracted with a screen shot on 18 October 2014 at 4:05 PM.

The first burst occurred about 12 h before the screen shot and the second peak 5 or 6 h earlier.

The duration of the first burst (*black points*) was about 3 min, while the second burst, much more intense, lasted about 17 min.

The green line indicates the neutron average in 1 h, the black dots the neutrons every minute.

7. Conclusions

Abnormal neutron emissions from reactor 1 at the Bareggio ARGAL laboratory were detected several times. Unfortunately, in the most noticeable cases, we do not have a convincing explanation of the mechanism that produced them. Meticulous attempts to replicate the conditions that originally appeared suitable have produced no breakthrough. The current analysis of abnormal emission during the loading of a thin layer of palladium is not based on a mechanism or model, but instead on replication of an event already seen and reproduced in identical conditions. For this reason it is believed that the events are not random, and so the overall experimental outcome confirms that the interaction between palladium and hydrogen is actually the location where nuclear abnormalities of LENR type occur [5]. It cannot be ruled out that other metals in similar conditions also produce anomalous nuclear events.

References

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