Conference Proceedings Vol. 33
«The Science of Cold Fusion»
T. Bressani, E. Del Giudice and G. Preparata (Eds.)
SIF, Bologna 1991

COLD FUSION RESEARCHES IN JAPAN

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ABSTRACT

Positive results as well as some negative results from cold fusion research in Japan are reviewed with some comments. Out of 11 research groups taken up in the present review, three groups are mainly working on excess heat calorimetry, and the rest of the eight groups are involved in the detection of nuclear fusion products.

INTRODUCTORY REVIEW

There are more than 100 scientists at present working on cold fusion in Japan, spanning more than 40 universities and institutions. They are organized into about 20 research groups which collaborate to carry out the experiments. Only three groups -- Yokohama National University, Tokyo University of Agriculture and Technology, and IMRA Japan, are working exclusively on excess heat, while the others mostly study fusion products (neutrons and charged particles such as tritium, proton, and helium-3).

A sort of steady-state, excess enthalpy output at 20 percent of the input power was observed only by IMRA Japan in a closed system, but the other two groups could not produce any definitive excess heat results in their closed cells. Large heat bursts of the kind observed by Fleischmann and Pons have never been observed, nor reported in Japan.

Successful neutron detection cases have, however, been quite abundant, although the events are not yet controllable. In order to clearly observe the neutron events in a multi-channel analyzer in the scaler mode, the dwell time must be properly chosen/adjusted in relation to the efficiency of the neutron detector. Since the neutron emission in cold fusion is still a rare event under the present uncontrollable experimental situation, if the dwell time is toolong, the neutron count rate will be observed to deviate only slightly from the background level. On the other hand, for a too short dwell time, what we would observe is rather frequent one-neutron, or two-neutron, events, unless under a condition of considerably, suppressed neutron background. However, if the dwell time is properly chosen, neutron signals can often be observed as "bursts", as shown by the Tokyo Institute of Technology group and also by the National Institute for Fusion Science.

Neutron energy spectra with a peak at 2.45 MeV are obtained with NE213 by three groups; Osaka University, Hokkaido University, and Tokyo Institute of Technology, which is a clear indication of the d-d fusion reaction.

As to the d-d fusion products other than neutrons, tritons are detected by three groups; Hokkaido University and Osaka University group, both of which claim an anomalous production rate (t/n) of 10^4-10^5, and NTT Basic Research Laboratories, which detects 1 MeV tritons, as well as concomitant 3 MeVprotons. Those protons are also detected by the Osaka City College group. Another group at Osaka University even claims its careful detection of helium-3, but no helium-4 has been detected.

These experimental results of verified d-d fusion products at their expected energies have now established the conclusion that cold fusion definitely exists, and that its fusion products are somewhat like those of the ordinary d-d fusion reactions, whatever the fusion mechanism may be. It must also be noted, however, that the amount of those fusion products are by orders of magnitude far too small to account for any detectable excess heat, or enthalpy.

Obviously the most important, key issue of cold fusion (the d-d fusion reaction and the excess enthalpy generation in/on deuterated metals) involves the base material itself, and the electrolysis, for example, would be no more than a means of charging deuterons onto the metal. In order to make it easier for researchers toexperiments and evaluate their results, in Japan, palladium rods and plates are supplied free of charge to those cold fusion groups by Tanaka Precious Metals Co. (Tanaka Kikinzoku Kogyo) according to the user's individual specifications. Most of the palladium and its alloy materials are strongly cold worked through various processes.

Some other works, which will not be presented in the present review are fracto-fusion experiments, carried out by crashing deuterated materials, which has been done at both Chuo University and Kyoto University. Neither eventually could show any positive results to account for the cold fusion phenomena.

EXCESS HEAT CALORIMETRY

1. Yokohama National University (K. Ohta, et al)

Calorimetric studies with powerstat electrolysis detected no steady state, excess heat. Sometimes small bursts of excess heat were detected during the electrolysis of heavy water, but they were at the marginal error.

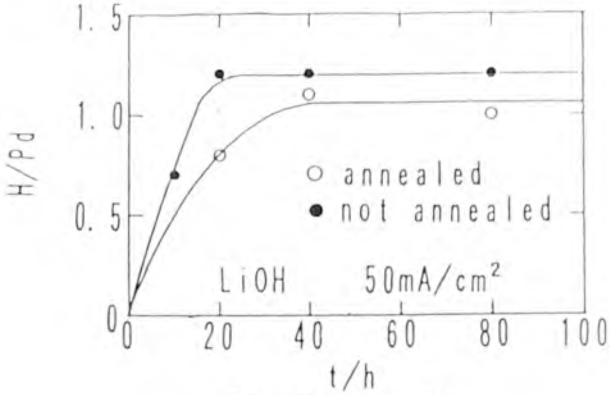


Fig. H/Pd ratio

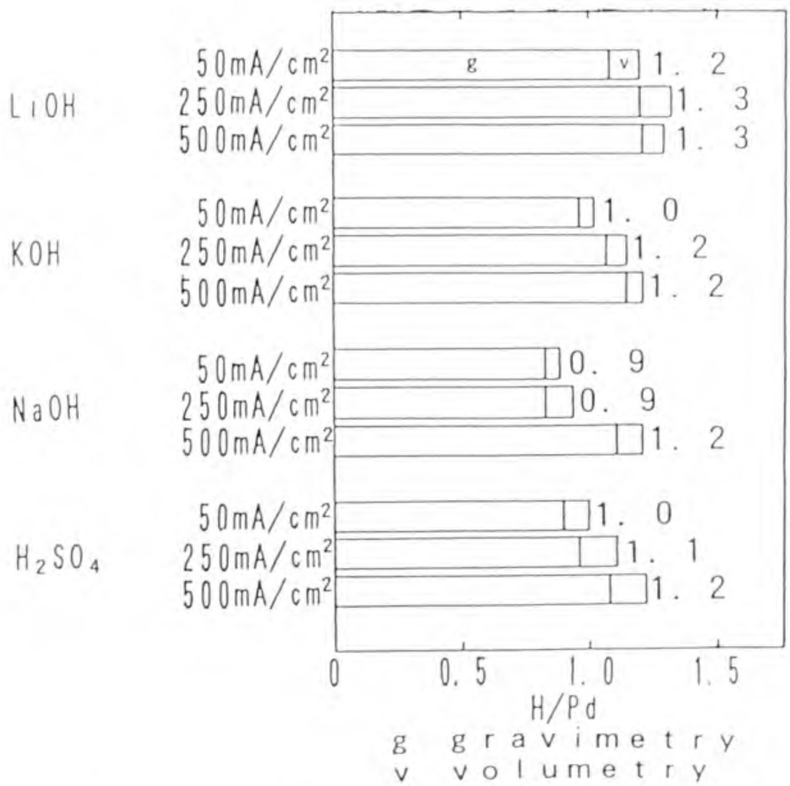


Fig. Total amount of hydrogen absorbed by Pd

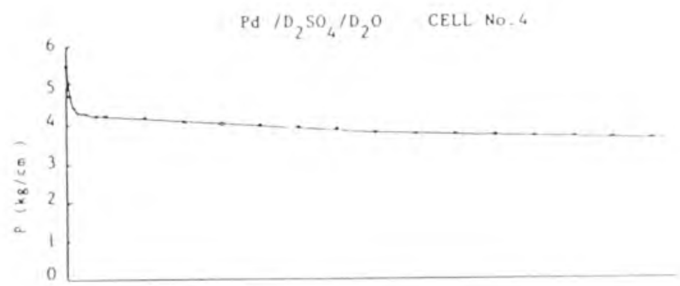
Extensive studies are being made of the ratios of hydrogens to palladium atoms absorbed into a thin palladium plate (0.1x10x10 mm) It is shown in the figures above that without any special treatment, H/Pd = 1 can be attained irrespective of not only the electrolyte, but also of the current density, if it isabove 50mA/cm^2

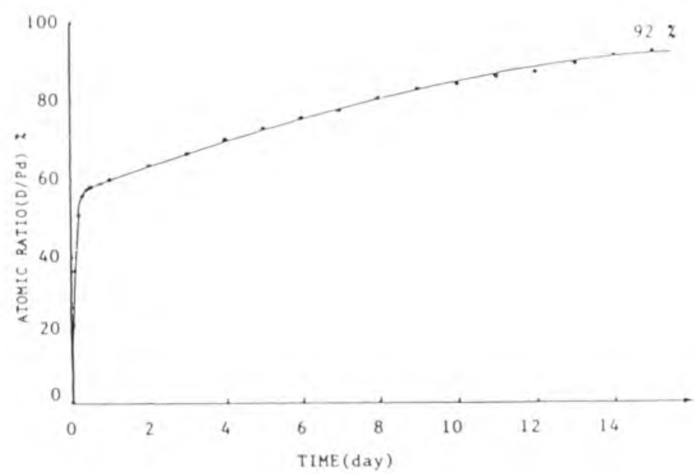
2. Tokyo University of Agriculture and Technology (N. Oyama, et al)

An open cell system with constant current electrolysis is observed to generate excess heat up to 40 % of the input power, associated with neither neutrons, nor tritium detectable.

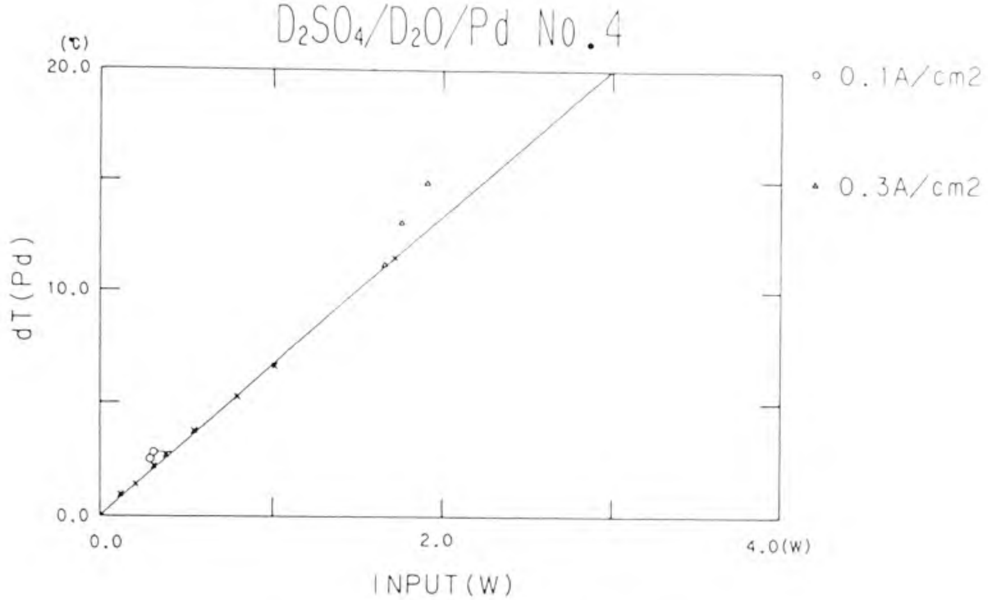
3. IMRA Japan (K. Kunimatsu, et al)

1. Electrolysis of 2.8 M -D_2SO_4 with a pair of rod palladium cathode (5o x 30 mm) and gas permeation anode can achieve D/Pd = 0.9 or above.





2. Steady excess heat of 5-20 % is observed to generate in a closed system above a certain current density.

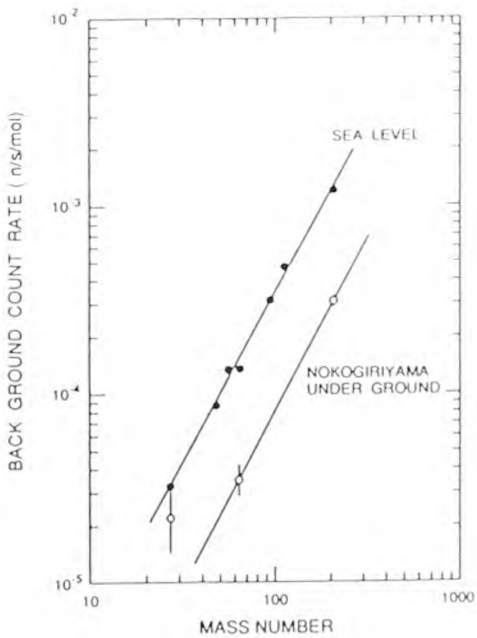


DETECTION OF FUSION PRODUCTS

4. Institute of Nuclear Study, University of Tokyo (T. Shibata, et al)

With a high sensitivity, low background, neutron detection system in the underground, no enhancement of neutron, nor tritium generation was observed. In the experiments, D/Pd ranges from 0.7 to 0.9, which is also significant.

Neutron counts per 10 min. tend to show a deviation from the Poisson distribution on the higher count rate side, which may indicate a very low rate of neutron bursts observable only if the dwell time is chosen properly in the MCS setting. It may be instructive to note that the cosmic ray induced neutrons, which determine the background level, are strongly1 influenced by the mass number of the surrounding construction elements as shown in the figure.



5. Tokyo Institute of Technology (M. Okamoto, et al)

Neutron bursts exceeding 3 are simutaneously detected by three counter channels each time approximately 5-6 hours after starting the electrolysis.

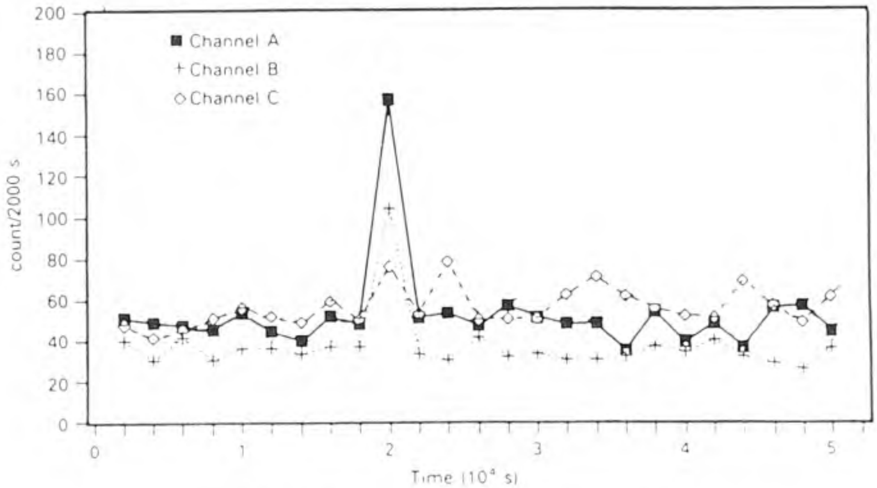


Fig. Neutron counts of each channel in run 2

6. Osaka University (G. Adati, et al)

Generation of helium-3 was observed in the process of deuterium absorption and desorption by La-Ni ingot. The detection reliability was ensured by comparing the ratio of helium-3 to helium-4 with blank cases rather than by measuring the absolute value of helium-3 generated. It is, however, hard to conclude that the detected helium-3 is due to d-d fusion activities as expected, since other possible fusion products are not studied.

Table Contents and isotopic ratios of He, Ne, Ar, Kr and Xe

Sample	^{3}He ($\times 10^8$)	^{4}He ($\times 10^{14}$)	^{3}He/^{4}He ($\times 10^{-6}$)	^{20}Ne ($\times 10^{14}$)	^{36}Ar ($\times 10^{14}$)	^{84}Kr ($\times 10^{12}$)
A	1.57(0.08)	1.45(0.07)	1.08(0.02)	2.38(0.12)	111(5)	15.1(0.7)
B	0.422(0.025)	0.561(0.027)	0.752(0.026)	0.336(0.017)	0.499(0.023)	0.479(0.023)
C	10.8(0.5)	7.08(0.34)	1.52(0.02)	10.7(0.5)	15.3(0.8)	7.21(0.34)
Air			1.399(0.013)[13]			

The noble gas contents are given in number of atoms existing in the reaction vessel.
Sample A was extracted from the $LaNi_5$ ingot by heating at 1123K.
Sample B was obtained from the applied D_2 gas.
Sample C was obtained from the D_2 gas absorbed in $LaNi_5$.
The measurement was performed twice for sample C.

7. National Institute for Fusion Science (H. Ikegami, et al)

Multiple neutron bursts displayed in MCS mode are shown in the figure. The signals are from two independent, helium-3 neutron counter systems (A and B), whose efficiency is 1 % and 0.5 %, respectively, with the dwell time setting of 100 seconds. Every large burst from the two independent system, accumulated in 100 seconds, shows remarkable time coincidence as shown in the figure, and its constituent pulse heights are checked to fall within a specified range of the helium-3 neutron detector. This observation eliminates any possibility of errorneous signals other than neutrons.

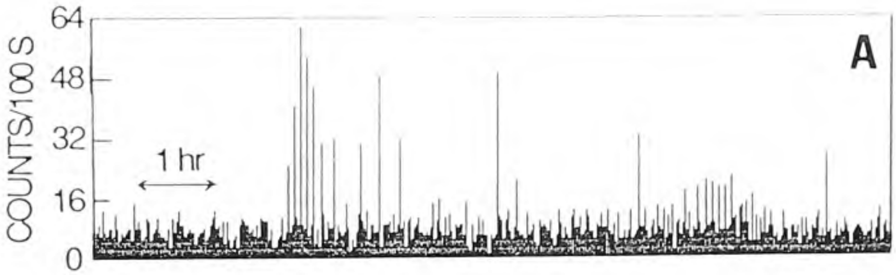


Fig. (a) Neutron Bursts of Exp.-I Measured with Sys.A(6-8 Spt. 1990).

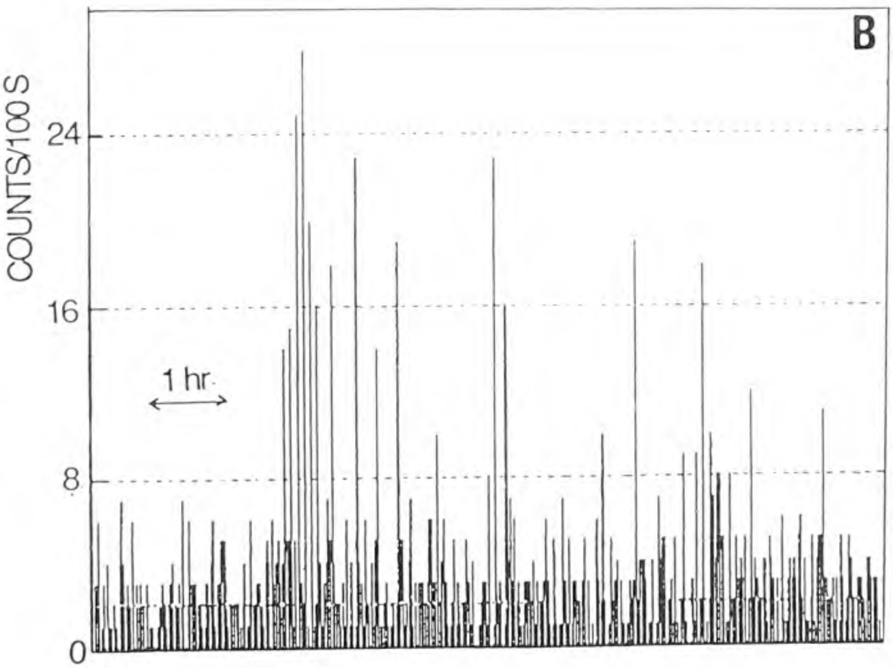


Fig. (b) Neutron Bursts of Exp.-I Measured with Sys.B(6-8 Spt. 1990).

When the bursts are seen with the dwell time, or accumulation time, of one second interval, each burst is observed to consist of frequent one-, or two-neutron events, so that those signals are due to random neutron emission rather than one big burst of neutrons in microseconds. On the other hand, if the dwell time is as long as several hours or so, it would be also difficult to see this sort of neutron emission clearly.

8. <u>Hokkaido University</u> (T. Mizuno, et al)

With the electrolysis of 0.5M LiOD with a large, palladium rod cathode (10ox100 mm), so-called typical cold fusion phenomena were observed and the experimental results/observation may be summarized as follows.

1) Neutron energy spectrum with 2.45 MeV peak was obtained.
2) Tritum anomaly such as t/n greater than 10^4 was observed.
3) Excess enthalpy detected was as much as 0.1 MJ/cm^3-Pd.

Density profiles of hydrogen and deuterium during zirconium cathodic discharging with 0.5M Na_2SO_4 were measured as shown in the figure below, which shows behavior of pre-absorbed hydrogens within the material.

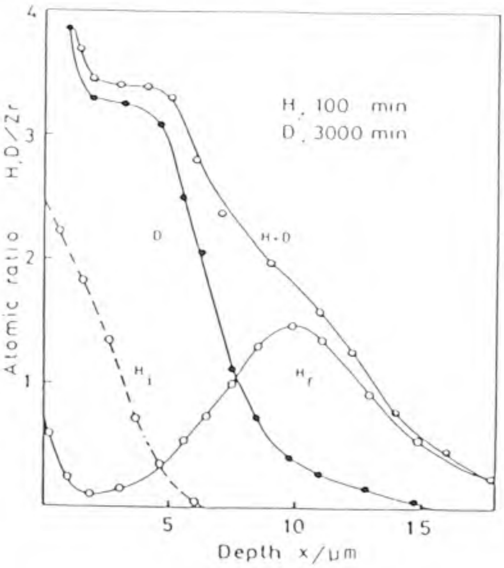
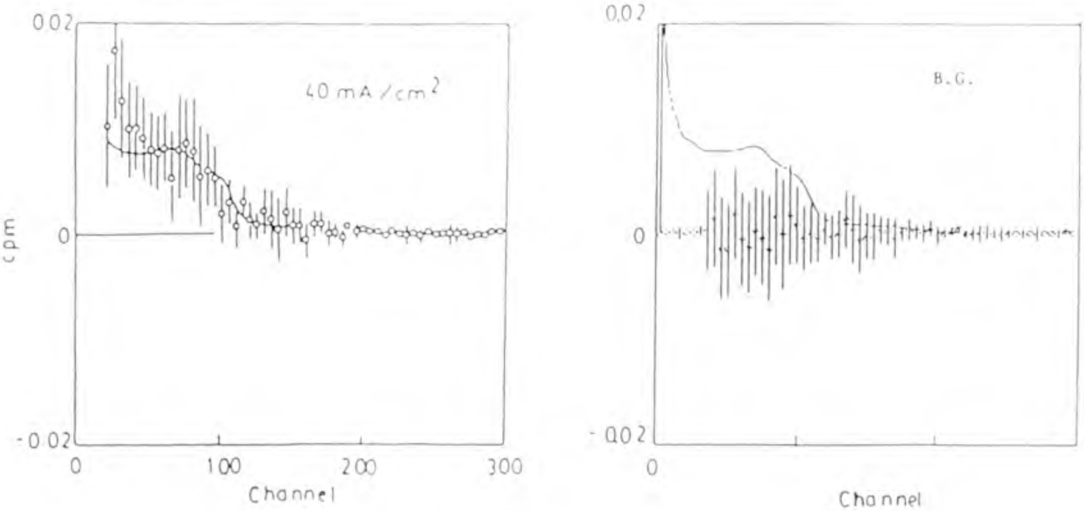


Fig. Change of a thin hydride layer profile after discharged in D_2O solution

9. Tokyo Institute of Technology (H. Numata, et al)

Neuton energy spectrum before unfolding was compared with that for the 2.45 MeV mono-energy neutrons (solid curve in the figure below). Clear indication of d-d fusion neutrons associated with the cold fusion is shown in the figure below.



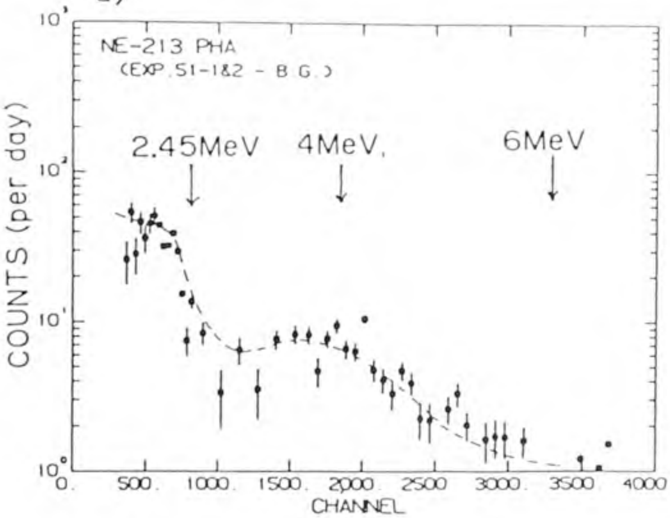
10. Osaka University (A. Takahashi, et al)

With the electrolysis of 0.3M LiOD with a large, palladium rod cathode (20ox30 mm), the cold fusion results/observation may be summarized as;

1) Neutron energy spectra with two components (2.45MeV and 3-7MeV),

2) Tritium anomaly, $t/n = 10^5$.

a)



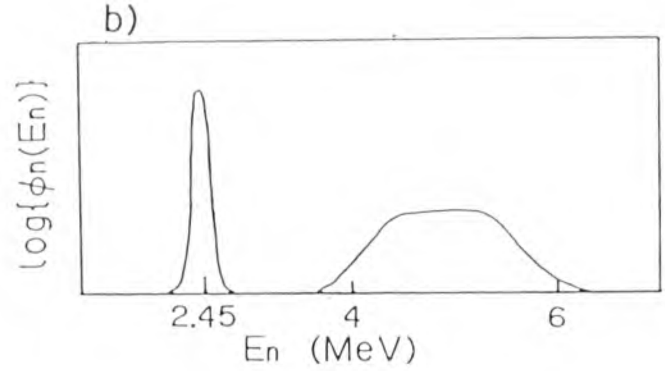
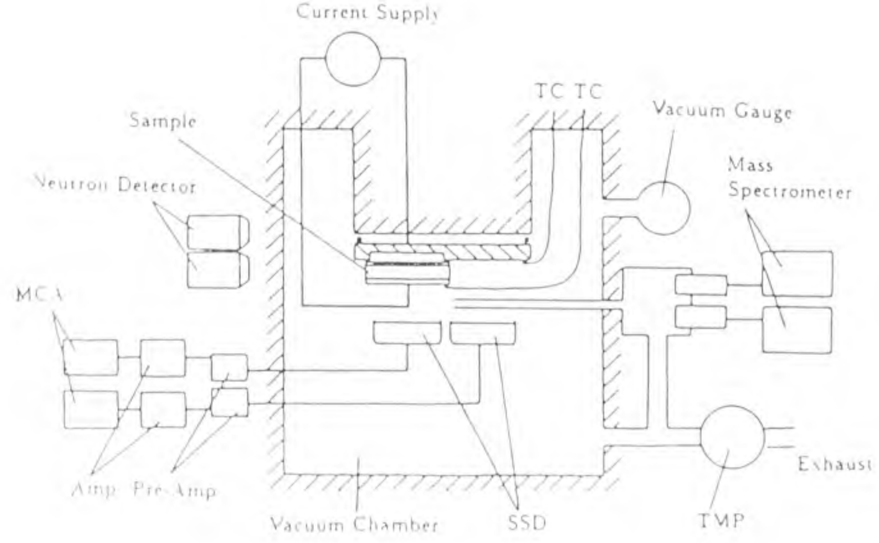
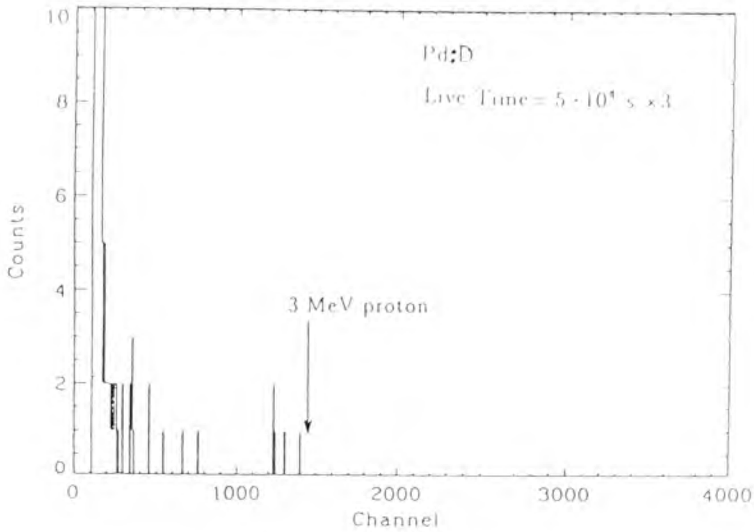


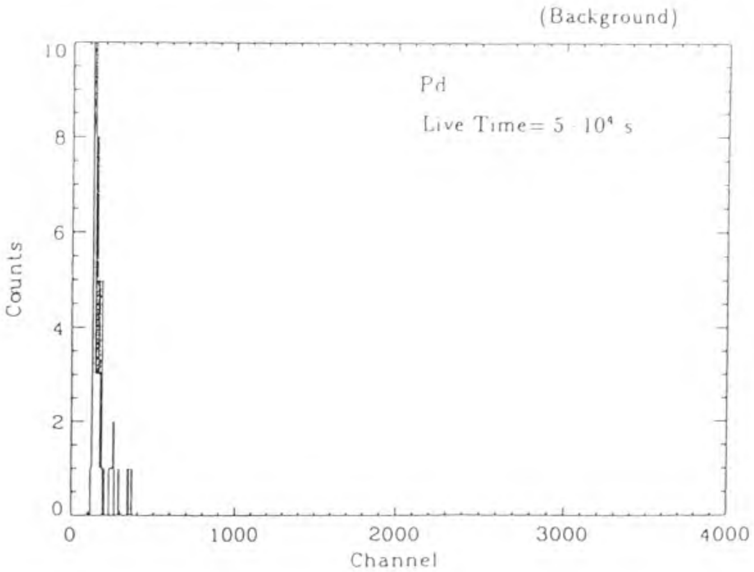
Fig. Fast neutron spectra obtained in Exp.51;
(a) pulse height spectrum of recoil protons for excess neutron counts
(b) approximate neutron spectrum which is obtained by differentiating smoothed curve (broken line in (a)) of pulse height spectrum.

11. NTT Basic Research Laboratories (E. Yamaguchi and T. Nishioka)

These are gas phase experiments with Oxides/Pd:D/Au thin, square plates (30 x 30 x 1 mm). After loading deuterim in the palladium plate, the cold fusion is triggered by a sudden creation of a vacuum in the chamber and by applying electrostatic potential of 2 volts or so across the plate surface, between the oxide layer (positive) and the gold plating (negative). The schematic diagram is as shown below, where TC refers thermocouple for temperature measurement and SSD means solid state detector for charged particle detection.







The major experimental results may be summarized as follows:

1) With deuteron implanted palladium plates, large neutron bursts (10^6n) are detected in association with a high heat flux (800℃).
2) By applying the voltage, medium heat flux (100-200℃) is observed to generate, however, it is irrespective of the use of hydrogen, or deuterium.
3) Concomitant with the events above, charged particles from d-d fusion, say 3 MeV protons and 1 MeV tritons, are detected, which is shown in the above figure.