

### Search for Nuclear Reaction Products in Gas Phase Experiments - Deuterium Permeation and Absorption -

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Employing both *in situ* and *ex situ* accelerator analyses, we have tried to replicate the nuclear transmutation [1] of Sr to Mo under deuterium permeation through a variety of multilayered CaO/Sr/Pd samples. Apparently positive results have been obtained in 8 runs out of 14, although the identification of Mo peaks in the PIXE analysis are not definite. It is implied that sputtering loss of the atoms could be responsible for the observed tendency that areal density of Sr decreases in most cases, while there is a modest increase in Mo. In addition to the accelerator analyses,  $\gamma$ -ray detection is tried for samples implanted with W atoms in expectation of transmutation from <sup>183</sup>W to radioactive <sup>191</sup>Pt.

As another series of experiments, we intended to confirm heat and <sup>4</sup>He generation by deuterium (D) absorption in nano-sized Pd powders reported by Arata and Zhang [2], and to investigate the underlying physics. The experimental procedure and the results on the heat measurements will be discussed in detail in the following two presentations [3,4]. As will be explained there, nano-sized powder of mixed Pd and Zr oxides fabricated by Santoku Corp., Kobe, Japan, have revealed not only interesting mesoscopic effects but also large isotope effects both in the first phase (zero-pressure interval) and the second phase (with the pressure increasing up to the stationary value) of gas filling.

In the latter half of the present paper, we discuss a possible cause of the large isotope effects mentioned above. For this purpose, detection of possible nuclear ash including charged particles as well as neutrons and gamma rays are tried.

- [1] Y. Iwamura, M. Sakano and T. Itoh: Jpn. J. Appl. Phys. 41 (2002) 4642-4650; Y. Iwamura *et al.*: Proc. ICCF12, 2005, Yokohama, Japan, (World Scientific Publishing Co. Pte. Ltd, 2006) 178-187.
- [2] Y. Arata and Y. Zhang: The special report on research project for creation of new energy, J. High Temperature Society, 2008, No. 1; Y. Arata, and Y. Zhang: *Condensed Matter Nuclear Science, Proc. 12<sup>th</sup> Int. Conf. on Cold Fusion* (ed. A. Takahashi, Y. Iwamura, and K. Ota, World Scientific, 2006) pp.44-54.
- [3] Y. Sasaki, A. Kitamura, Y. Miyoshi, T. Nohmi, A. Taniike, A. Takahashi, R. Seto, and Y. Fujita: Anomalous Heat Generation in Charging of Pd Powders with High Density Hydrogen Isotopes, (I) Results of absorption experiments using Pd powders, this meeting.
- [4] A. Takahashi, A. Kitamura, Y. Sasaki, Y. Miyoshi, T. Nohmi, A. Taniike, R. Seto, and Y. Fujita: Anomalous Heat Generation in Charging of Pd Powders with High Density Hydrogen Isotopes, (II) Discussions on Experimental Results and Underlying Physics, this meeting.

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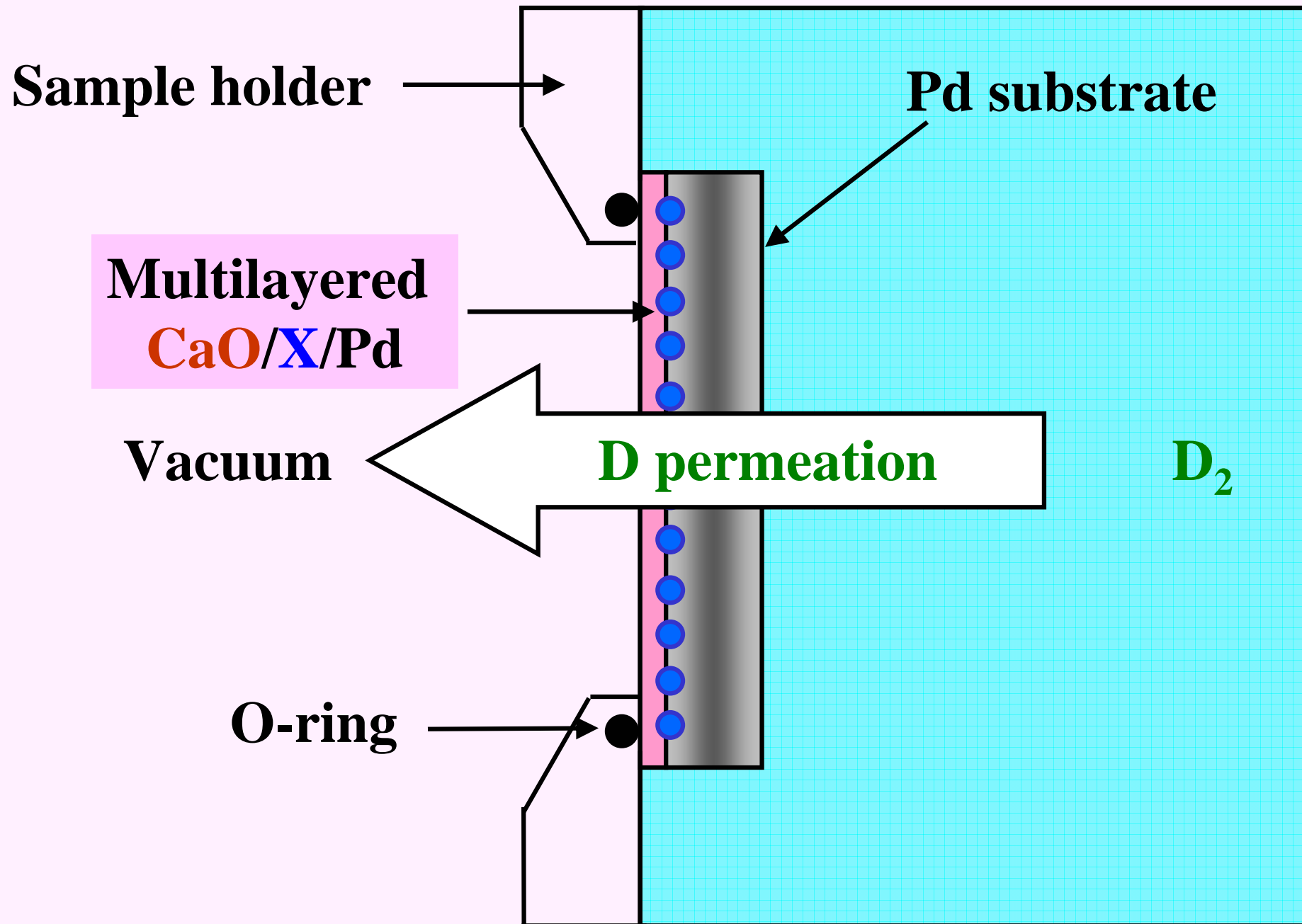
## [A] Elemental analysis of CaO/X/Pd multilayered samples subjected to deuterium permeation

- Iwamura *et al.* claimed<sup>[1]</sup> that nuclear transmutation occurs during forced **permeation** of deuterium (D) through a multi-layered film of X/CaO/Pd, with X being an element to be transmuted, *e.g.*,  $^{133}\text{Cs}$  transmuted to  $^{141}\text{Pr}$ ,  $^{88}\text{Sr}$  to  $^{96}\text{Mo}$ , *etc.*

[1] Y. Iwamura, M. Sakano and T. Itoh; *Jpn. J. Appl. Phys.* 41 (2002) 4642.

- In addition to the modified version of the sample **exposure system with reversed flow direction** installed at a beam line of a tandem electrostatic accelerator 5SDH2, **a stand-alone D permeation system** was used to examine the phenomenon by *in situ* or *ex situ* PIXE/ERD analysis, respectively.

[2] T. Yamaguchi, *et al.*; Paper 28, ICCF14, Washington D. C. Aug. 10-15, 2002.



## [A-1] Summary of PIXE analysis

- We tried to replicate the nuclear transmutation of **Sr** ( $2 - 50 \times 10^{15} \text{ cm}^{-2}$ ) **to Mo** under deuterium permeation through a variety of multilayered **CaO/Sr/Pd** samples.
- Apparently positive results were obtained in **8 runs out of 14**, although the identification of Mo peaks in the PIXE analysis was **not definite**.
- It has been implied that **sputtering loss** of the atoms could be responsible for the observed tendency that areal density of Sr decreases in most cases, while there is a modest increase in that of Mo.

## [A-2] Summary of radioactivity measurements

- Tungsten was also tested as the element X. Assuming the regularity in transmutation that (atomic number, mass number) increase by (4, 8), we expected production of radioactive nuclei  $^{191}\text{Pt}$  ( $T_{1/2} = 2.86 \text{ d}$ ) from  $^{183}\text{W}$ .
- An NaI(Tl) scintillation probe and a HPGe detector were employed to detect **0.538-MeV gamma rays** from  $^{191}\text{Pt}$ .
- The result of the measurement for the first sample was not always positive; the areal density of  $^{191}\text{Pt}$  is smaller than  $10^7 \text{ cm}^{-2}$ , if any.

## [B] Deuterium absorption by Pd nanoparticles

- The second subject is to confirm heat and  $^4\text{He}$  generation by D absorption in nano-sized Pd powders reported by Arata and Zhang [2], and to investigate the underlying physics.
- We have performed **calorimetry** during  $\text{D}_2$  or  $\text{H}_2$  absorption by micronized powders of Pd, Pd-black, and **Pd-Zr oxide compounds (Santoku Corp.)** using a twin system [3].

[3] *Y. Arata and Y. Zhang; The special report on research project for creation of new energy, J. High Temperature Soc., No. 1, 2008.*

[4] *A. Kitamura, T. Nohmi, Y. Sasaki, A. Taniike, A. Takahashi, R. Seto, and Y. Fujita; Anomalous Effects in Charging of Pd Powders with High Density Hydrogen Isotopes, Phys. Lett. A, 373 (09) 3109.*

- The experimental procedure and the results on the heat measurements have been and will be discussed in detail in the following two presentations [5,6].

[5] A. Takahashi, et al.: paper S2\_O4, this meeting.

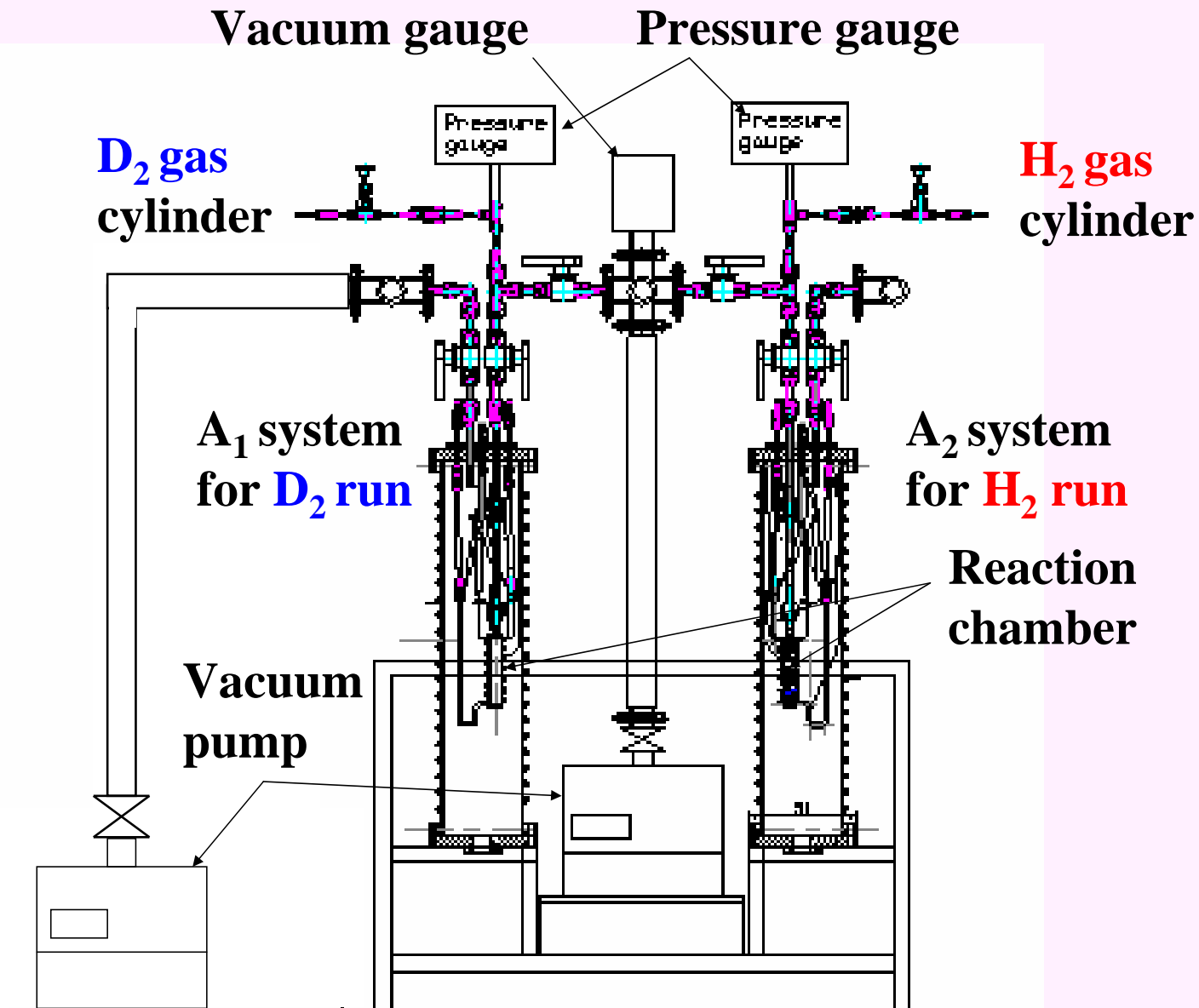
[6] Y. Sasaki, et al.: paper S7\_O5, this meeting.

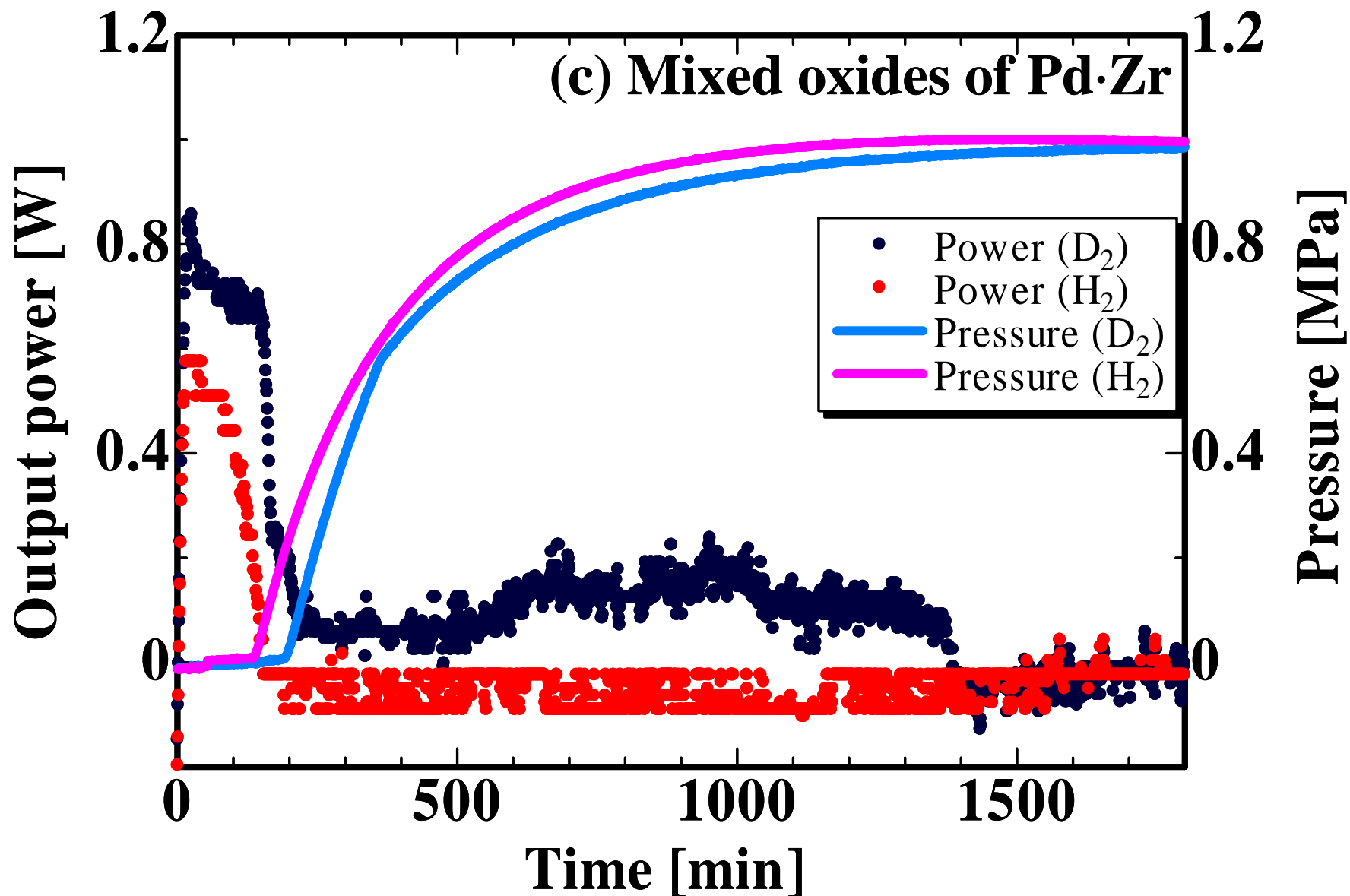
- As explained there, nano-sized powder of mixed Pd and Zr oxides fabricated by Santoku Corp., Kobe, Japan, have revealed not only interesting **mesoscopic effects** but also large isotope effects both in the first phase (zero-pressure interval) and the second phase (with the pressure increasing up to the stationary value) of gas filling.

- In the latter half of the present paper, we discuss a possible cause of the **large isotope effects** mentioned above. For this purpose, detection of possible nuclear ash including charged particles as well as neutrons and gamma rays are tried.



# A twin system for D/H absorption experiments





**Fig. 3.** Evolution of heat and pressure in the vessel after introduction of  $D_2$  gas (blue/light blue) or  $H_2$  gas (red/pink); (c) mixed oxides of Pd and Zr (D-PZ1#1 and H-PZ2#1).

## Conclusions for heat measurements

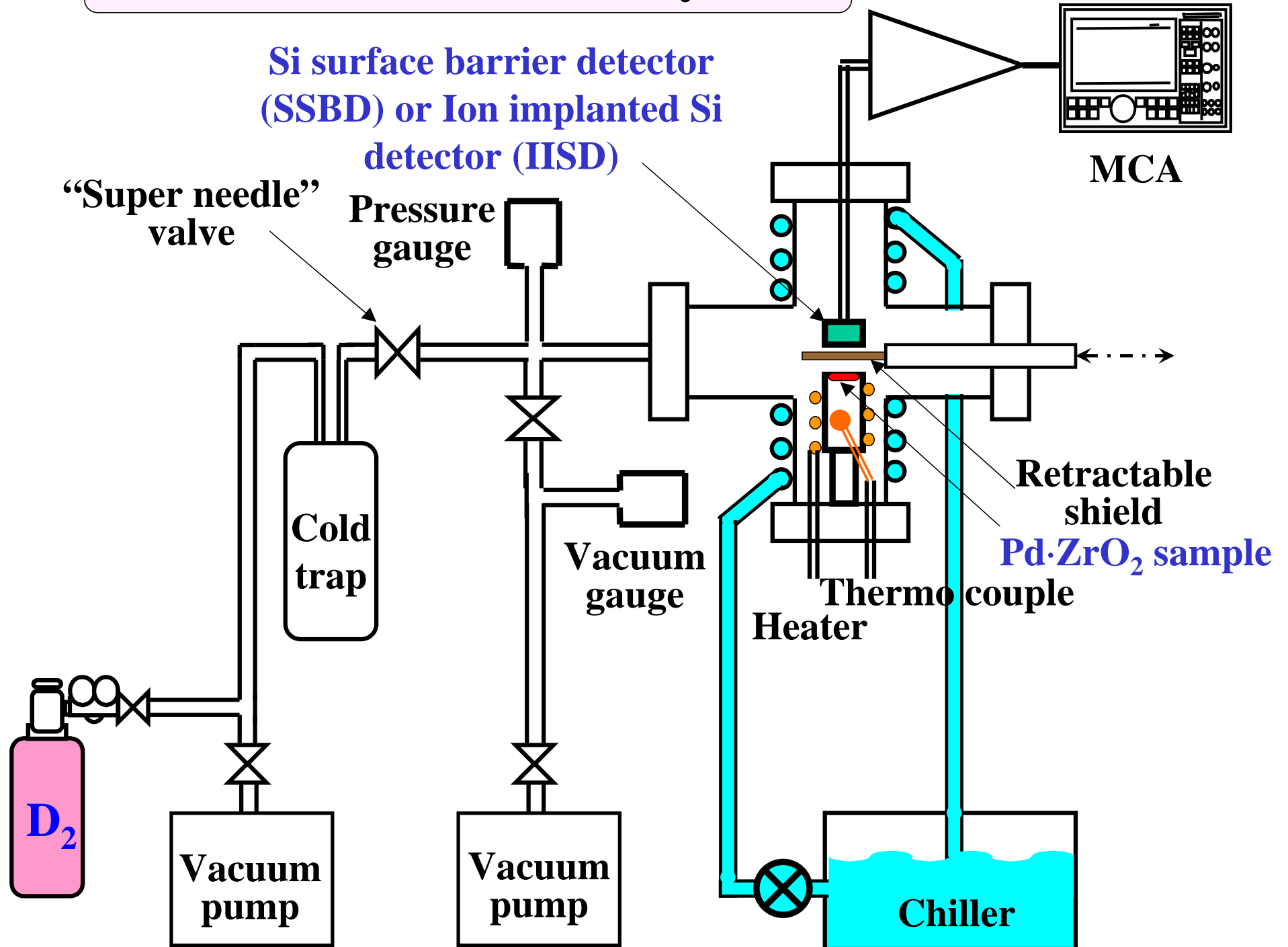
**-For Pd·Zr oxide nano-powders, anomalously large energies of hydrogen isotope absorption,**

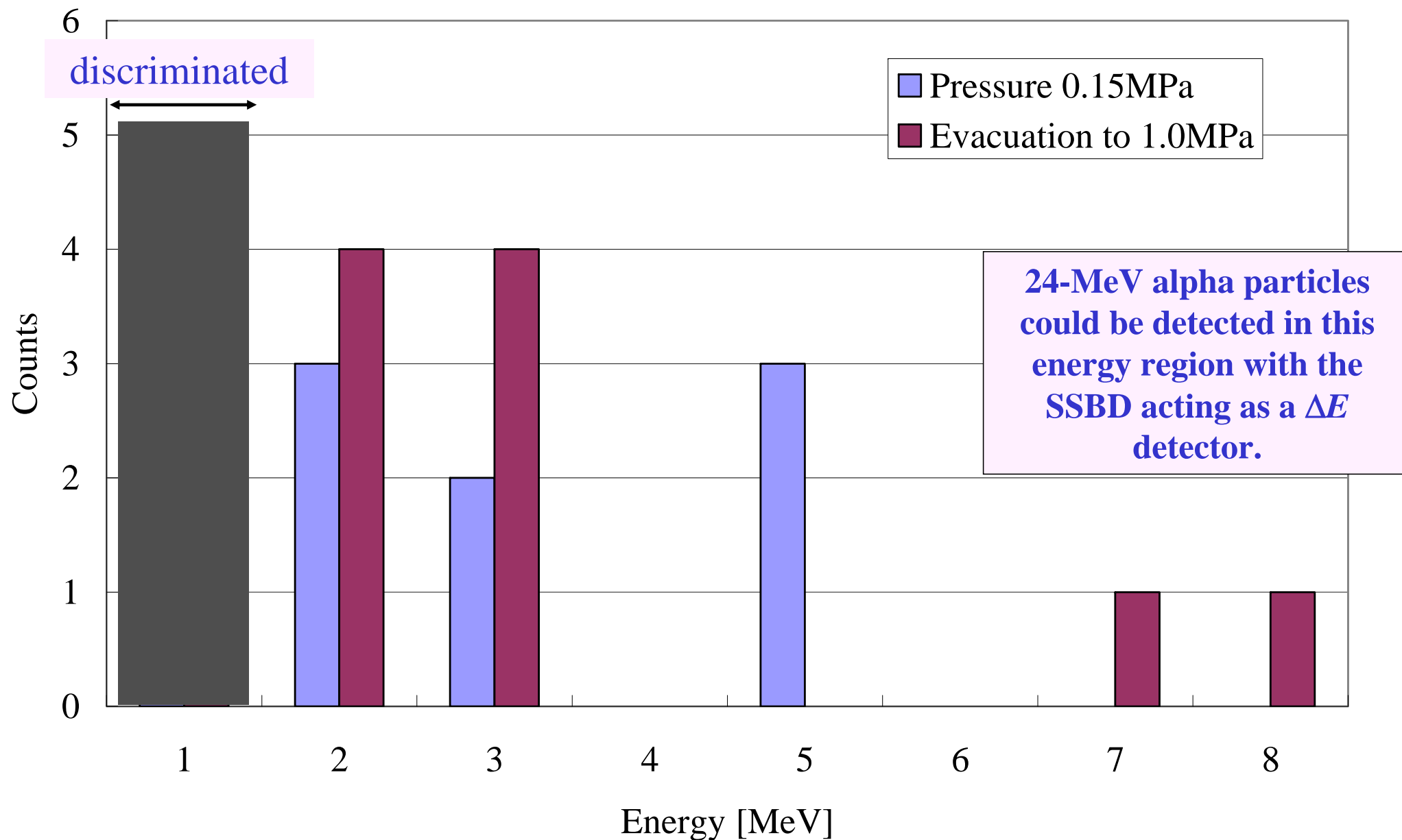
**2.4 ±0.2 eV/D-atom** and **1.8 ±0.4 eV/H-atom**,  
as well as large loading ratio of

**D/Pd =1.1 ±0.0** and **H/Pd =1.1 ±0.3**, respectively,  
were observed in the phase of deuteride/hydride  
formation (the first phase).

**-The sample charged with D<sub>2</sub> showed significantly positive output energy in the second phase after the deuteride formation.**

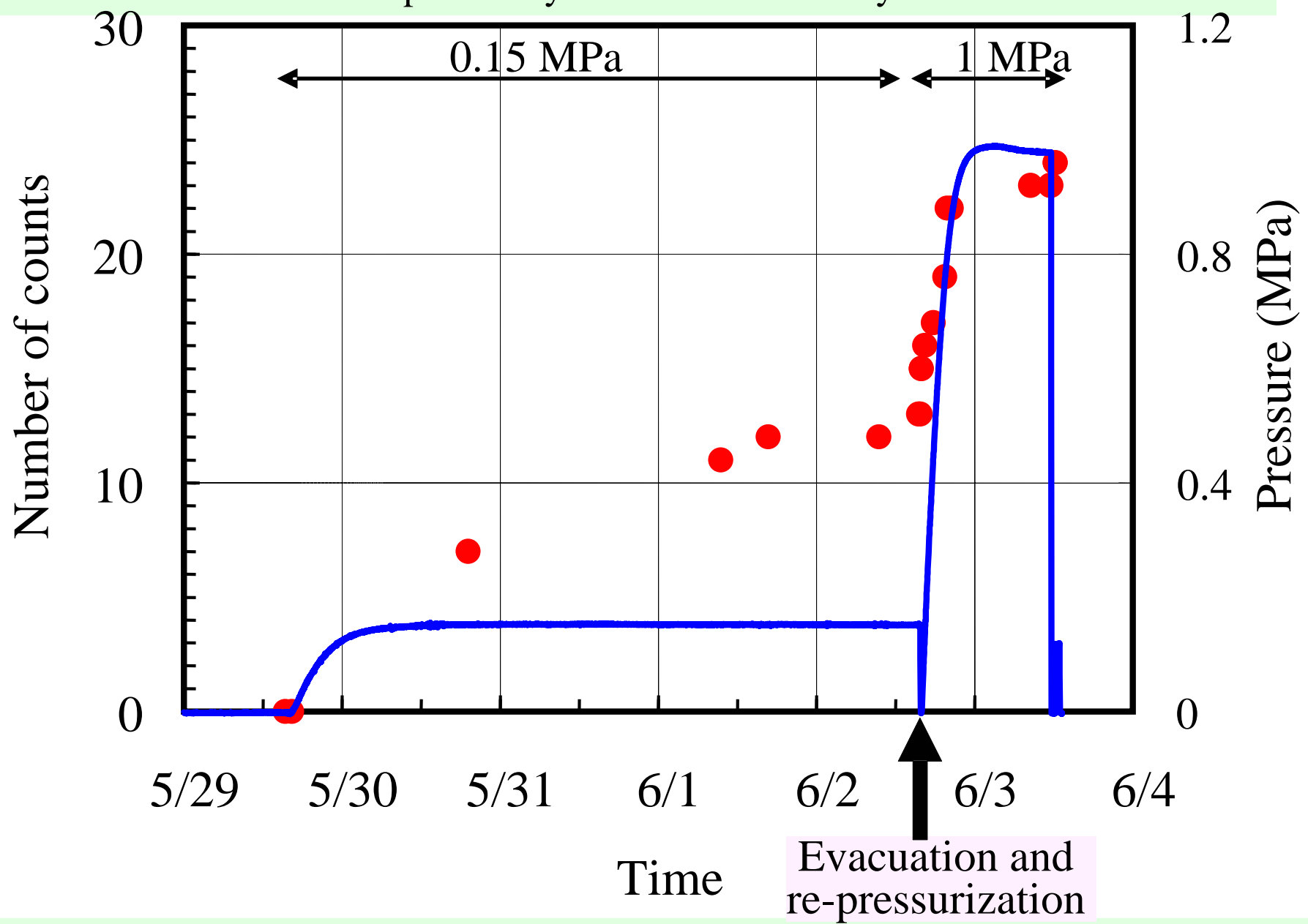
# Functional view of the B system



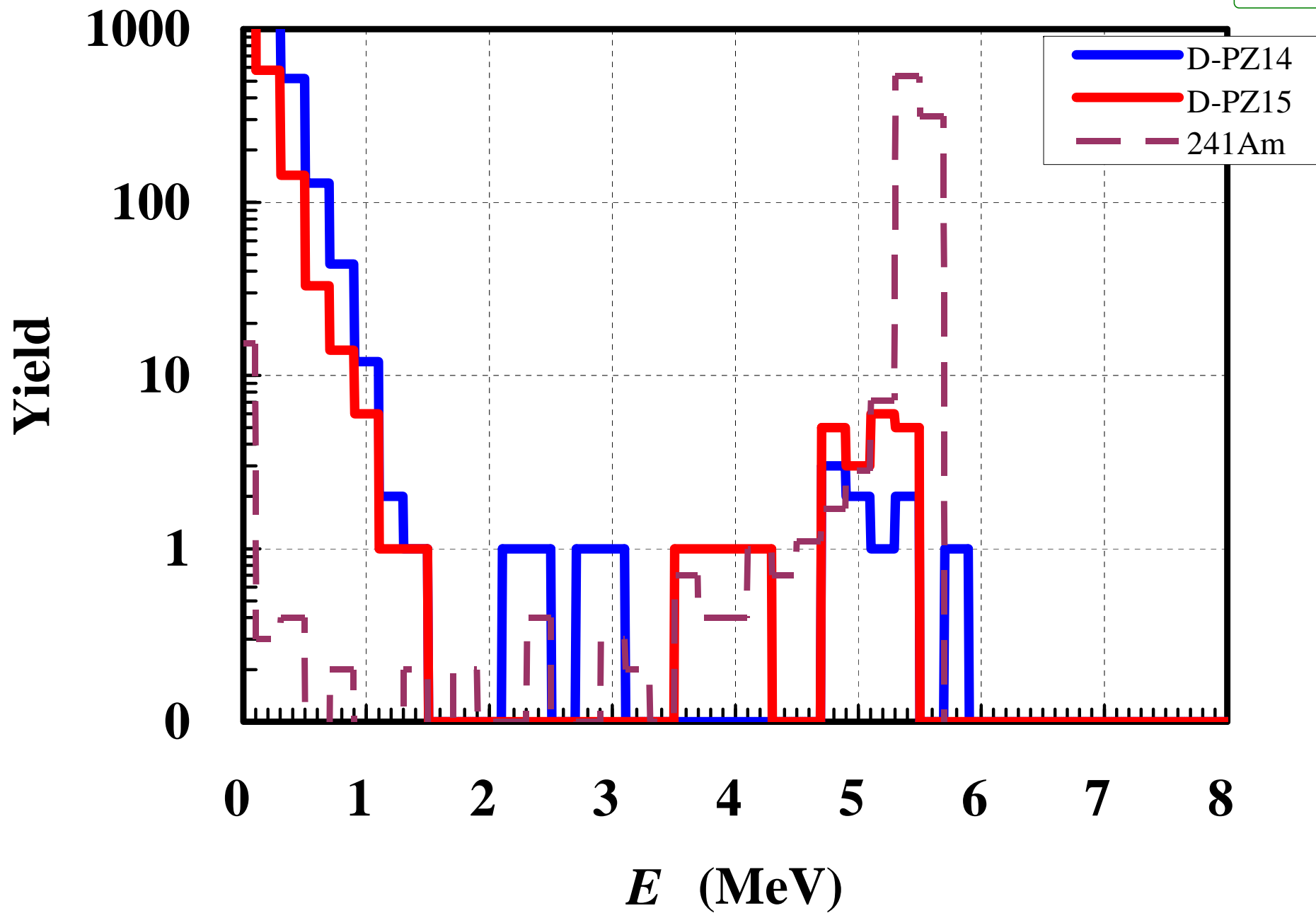


Spectra recorded by the SSBD with a 200- $\mu$ -thick depletion layer for D-PZ1#3B

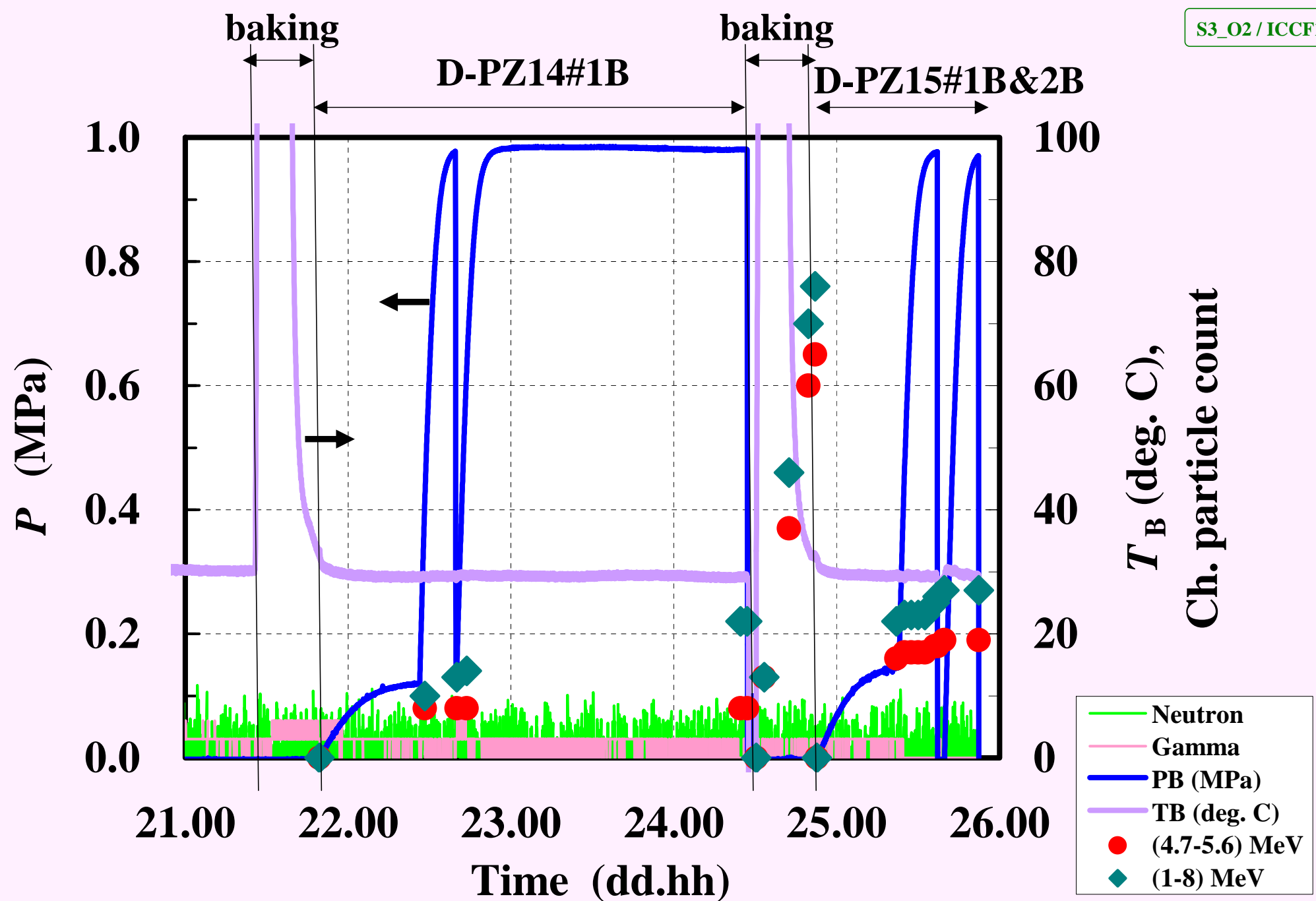
Counting could be alphas of 5.75, 9.95, 12.8 MeV by minor branch of 4D fusion. But we cannot rule out the possibility of electrical noise by mechanical oscillation.



**Evolution of total counts in the “1-12 MeV” range of the spectra measured by the SSBD (D-PZ1#3B)**



Spectra recorded by the IISD with a 500- $\mu$ -thick depletion layer in runs D-PZ14#1B and D-PZ15#1B-#2B.



Evolution of pressure and IISD counting and other radiations during the runs D-PZ14#1B through D-PZ15#2B.



-It has been turned out that the upper surface of the retractable shield has a  $^{241}\text{Am}$  contamination, and the IISD could see the spot in case of insufficient retraction.

-However, if the countings were of charged particles, we can estimate possible range of particle energy.

	$p$ (MPa)		0.15	0.6
	$pl$ (mm·atm)		22.5	90
$E_2 =$ 4.7 MeV	$p$	$E_1$ (MeV)	4.74	4.85
	$d$		4.77	4.97
	$t$		4.79	5.07
	$^3\text{He}$		5.05	6.01
	$^4\text{He}$		5.12	6.26
$E_2 =$ 5.6 MeV	$p$	$E_1$ (MeV)	5.63	5.73
	$d$		5.66	5.83
	$t$		5.68	5.92
	$^3\text{He}$		5.91	6.80
	$^4\text{He}$		5.98	7.02

Estimation of energy for assumed particles.

**[B] Summary of reaction product measurements in the system B for gas charging of PZ samples.**

- **We have observed several to several tens of counts in the 1 – 10 MeV range, which appeared to be emitted coincidentally with pressure change.**
- **However, we cannot rule out the possibility that they are due to electronic noise or contamination of  $^{241}\text{Am}$ .**
- **Up to now, we have got no firm evidence of charged particle emission.**
- **We are planning detection of X-rays as one of the candidates for the reaction products.**