An Update of LENR for ICCF-11

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What does “Cold Fusion” Mean?

- Cold Fusion = D + D fusion in a solid
- LENR = transmutation and cold fusion
- LENR = CANR
- CMNS = General field of study

Reaction Paths for Fusion

- d + d ⇨ ^{3}He(0.82 MeV) + neutron(2.45 MeV)
- d + d ⇨ proton(3.02 MeV) + tritium(1.01 MeV)
- d + d ⇨ ^{4}He + “energy”(23.5 MeV)

- p + d ⇨ ^{3}He + “energy”(5.6 MeV)

Kinds of Anomalous Effects

- Anomalous heat production
- Energetic particle emission
- Transmutation
- Radiation,

  Conventional- X-ray, Gamma

  Anomalous - Matsumoto (Japan,1990)

  Ivoilov et al. (Russia, 2004)

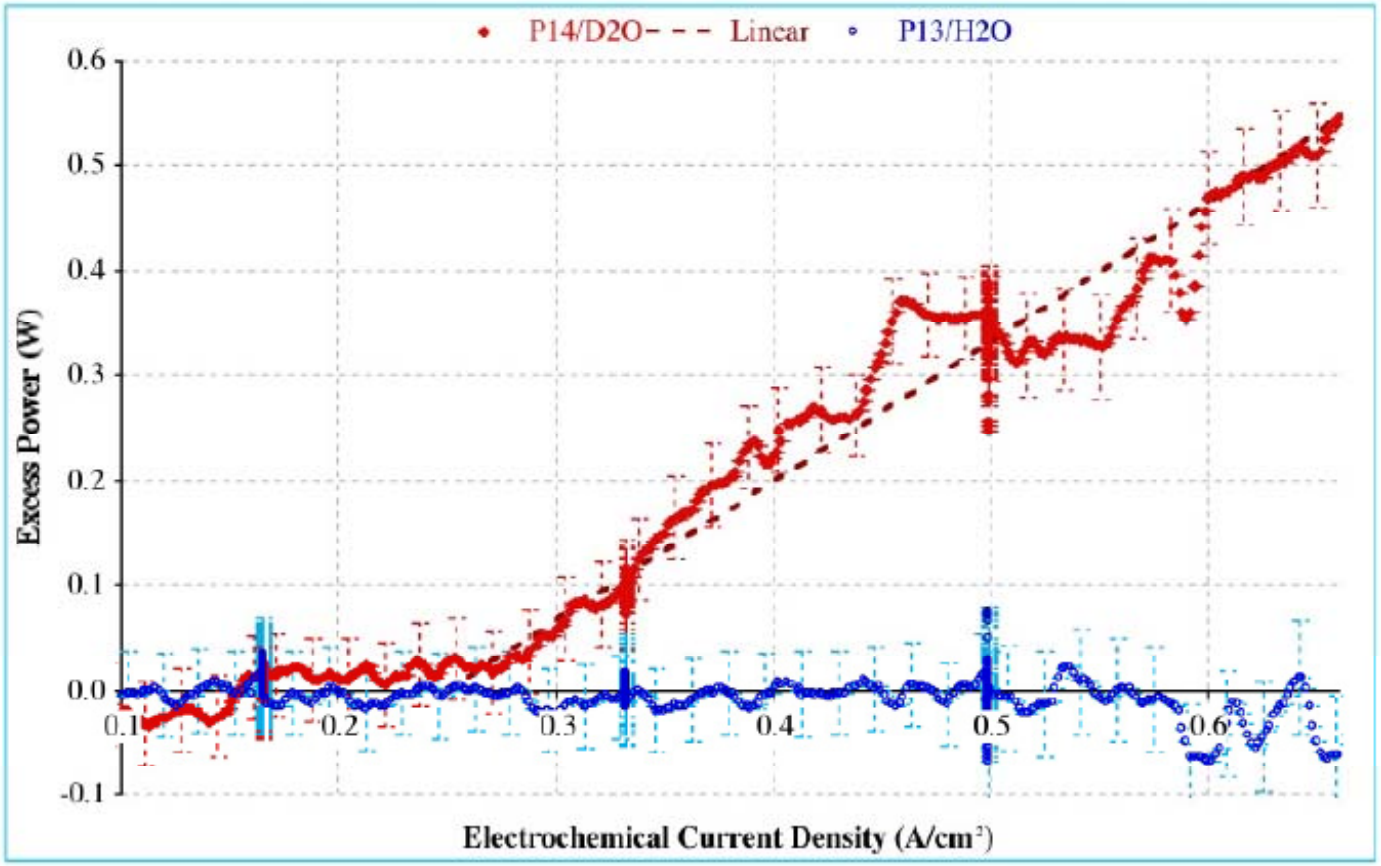
Methods Used to Produce Heat

- Electrolysis
- Plasma Discharge in a Liquid
- Gas Discharge
- Ambient gas
- Deuteron electromigration
- Sonic Implantation

Anomalous Heat Production

Effect of applied current

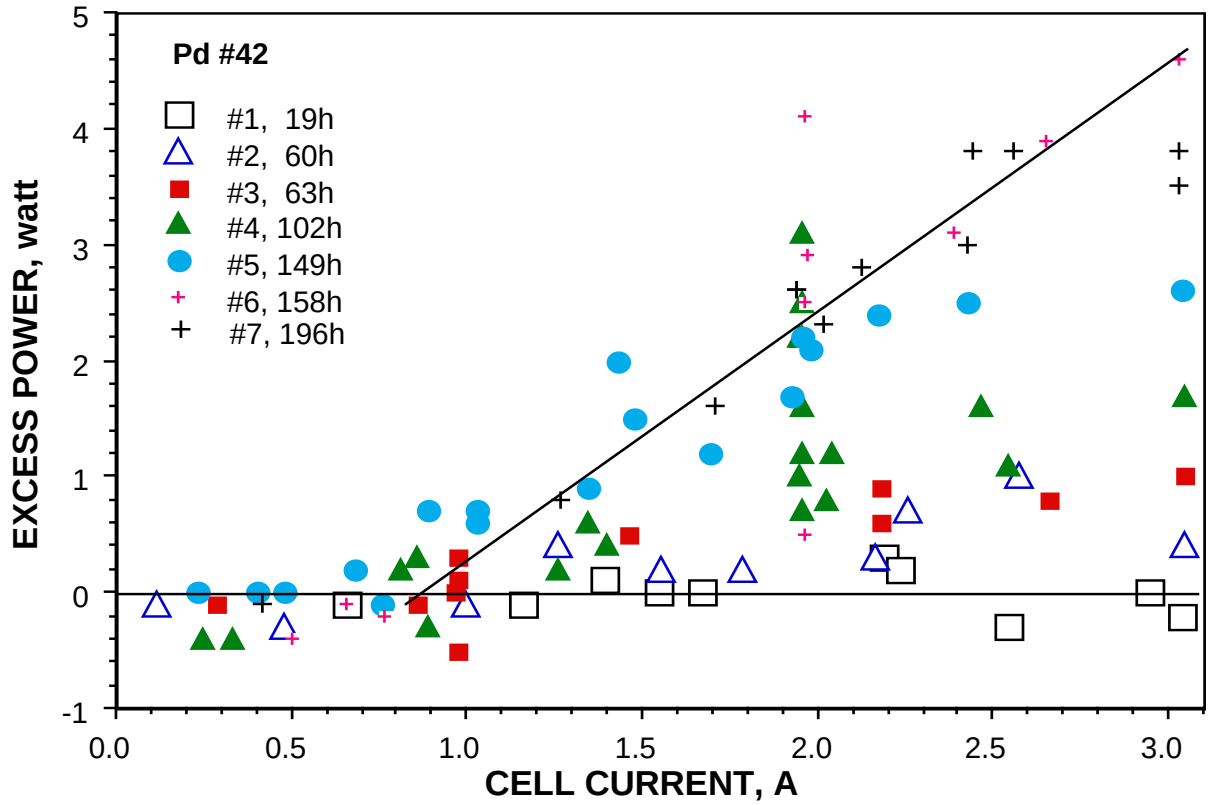
Work done at SRI



Anomalous Heat Production

Effect of time and applied current

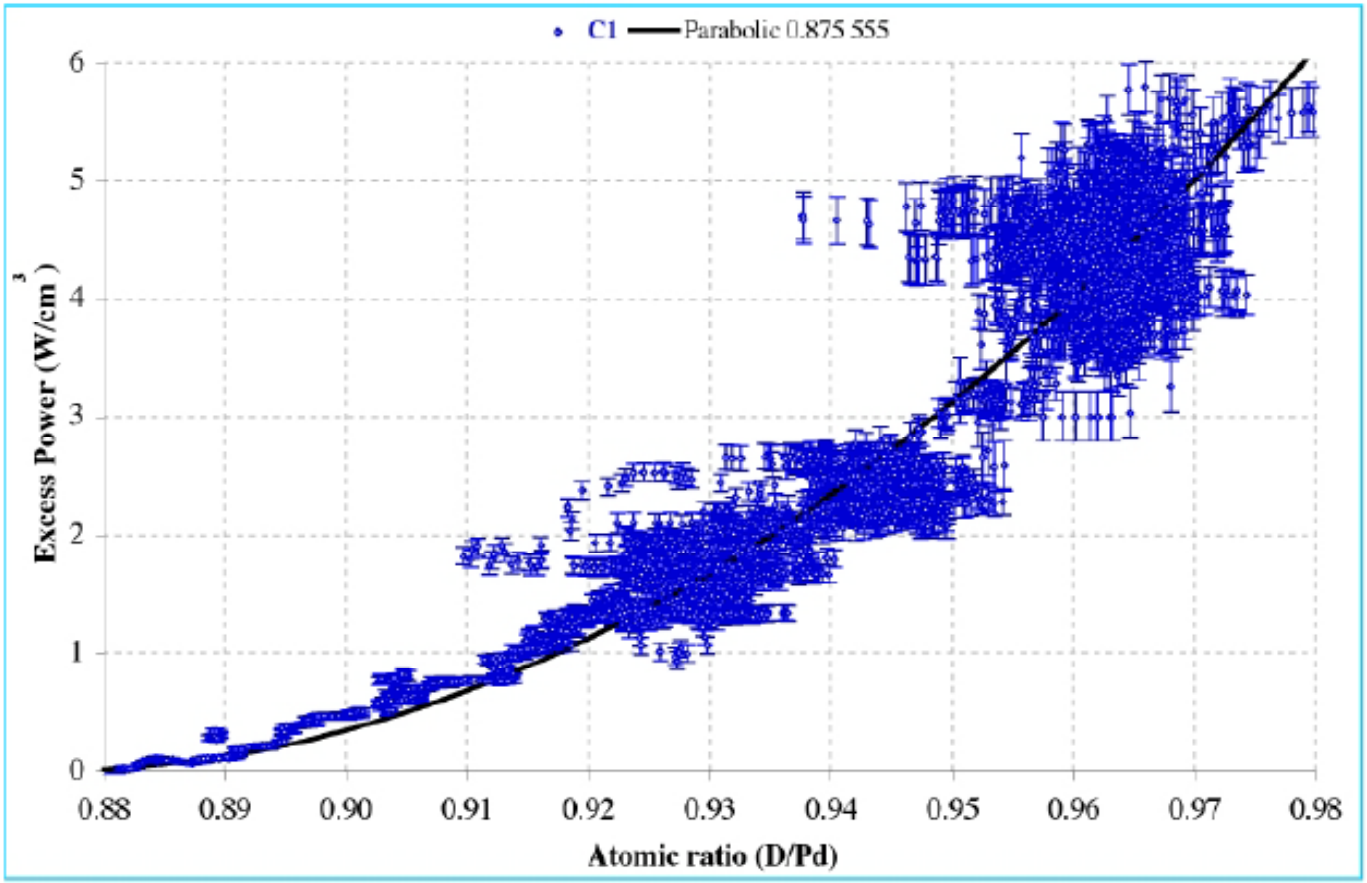
Work done at EKS, Inc



Anomalous Heat Production

Effect of D/Pd

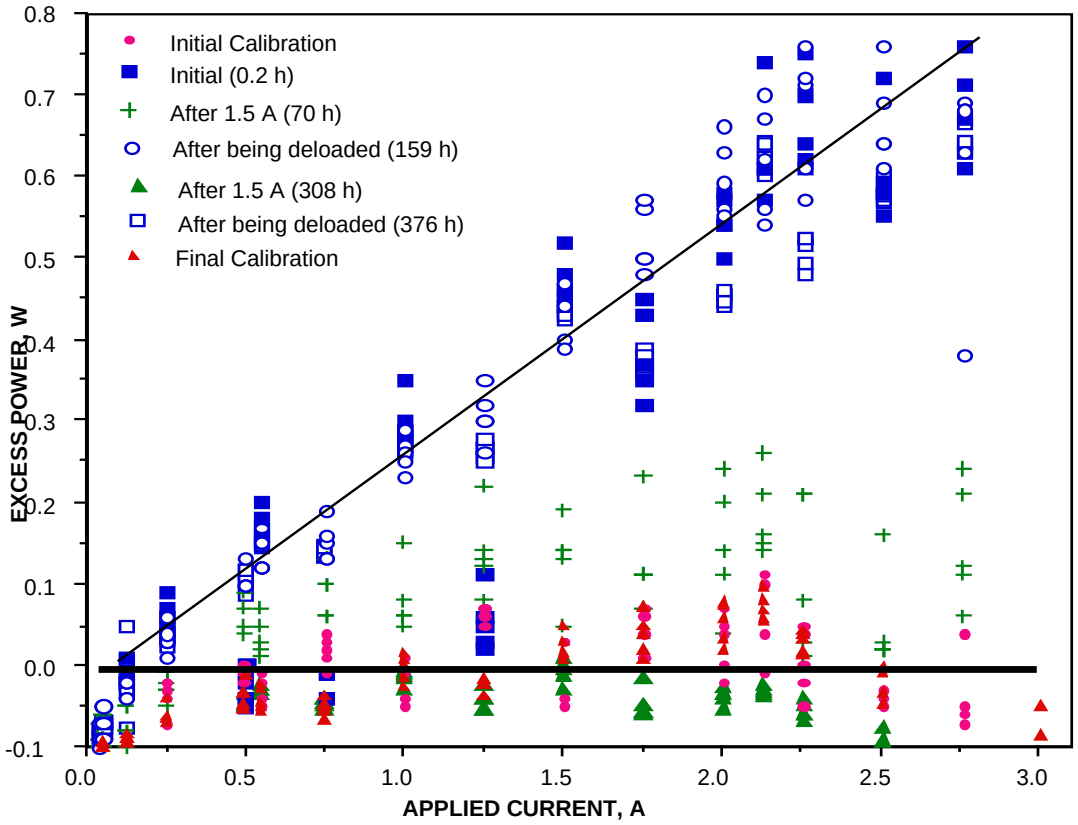
Work done at SRI



Anomalous Heat Production

Effect of active deposit on Pt

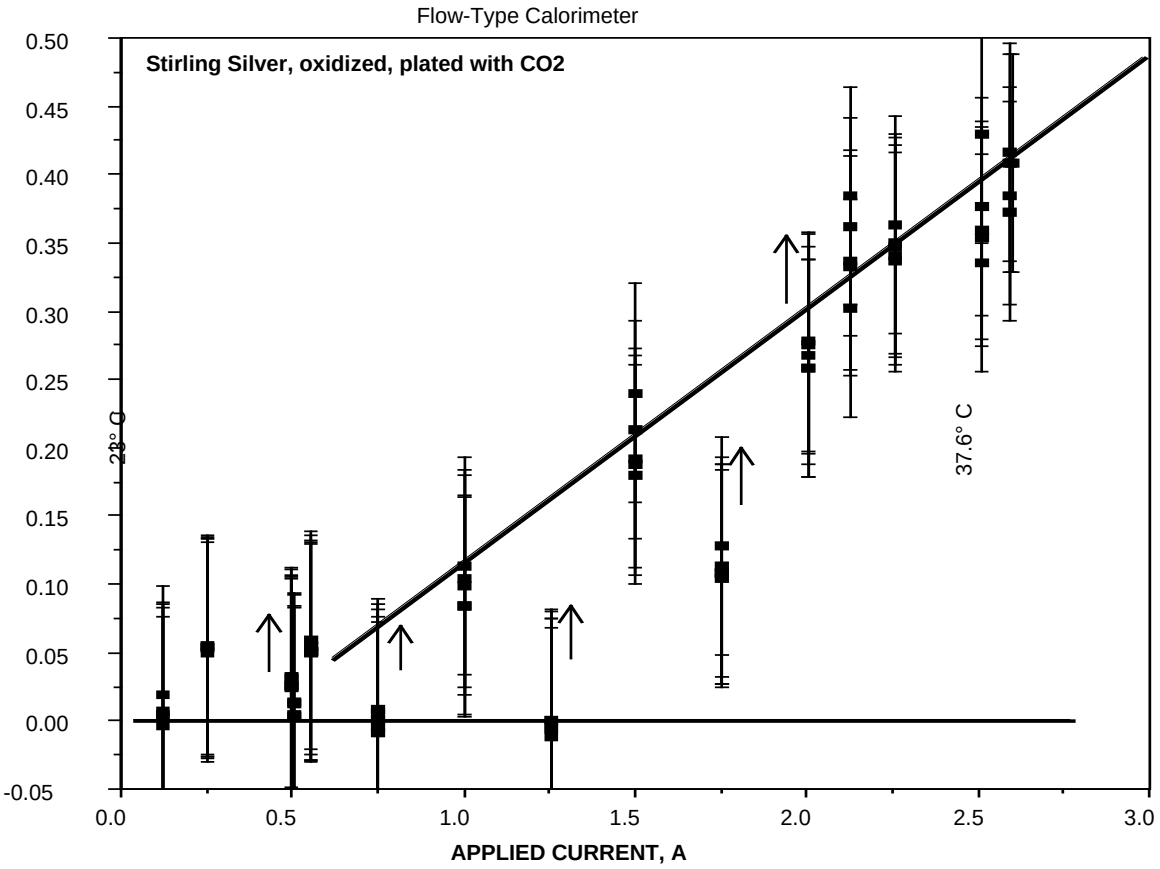
Work done at EKS, Inc.



Anomalous Heat Production

Effect of active deposit on silver

Work done at EKS, Inc



Particle Emission

- Neutron (energetic)
- Proton (energetic)
- Alpha (energetic+ambient[^{4}He])
- Triton (energetic+ambient[^{2}T])

Do energetic particles result from the same mechanism and NAE as does anomalous energy?

What is Known About Particle Emission?

1. A. The measured energy implies reaction rates of about 10^{11} events/sec.

   B. Measured particle emission rarely exceeds 1 event/sec except during bursts.

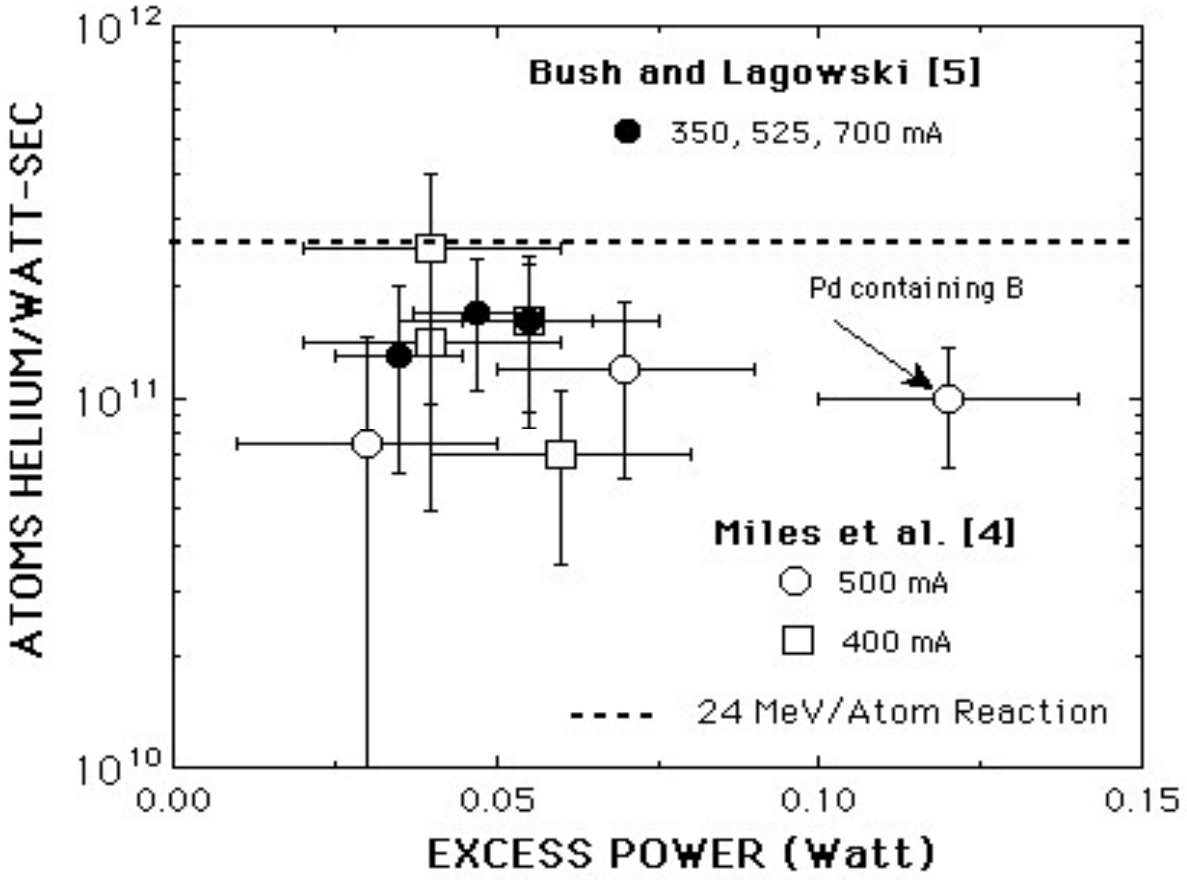
2. A. The energy produced by heat producing reactions is mainly coupled to the lattice, as evidenced by absence of corresponding X-ray and/or gamma emission rates.

   B. The energy of measured particles is consistent with a D-D fusion reaction without significant loss to the lattice.

3. A. Particle emission occurs in the absence of measurable heat production.

   B. Particle emission rate is not proportional to the amount of heat being generated.

Source of Energy When Deuterium is Used



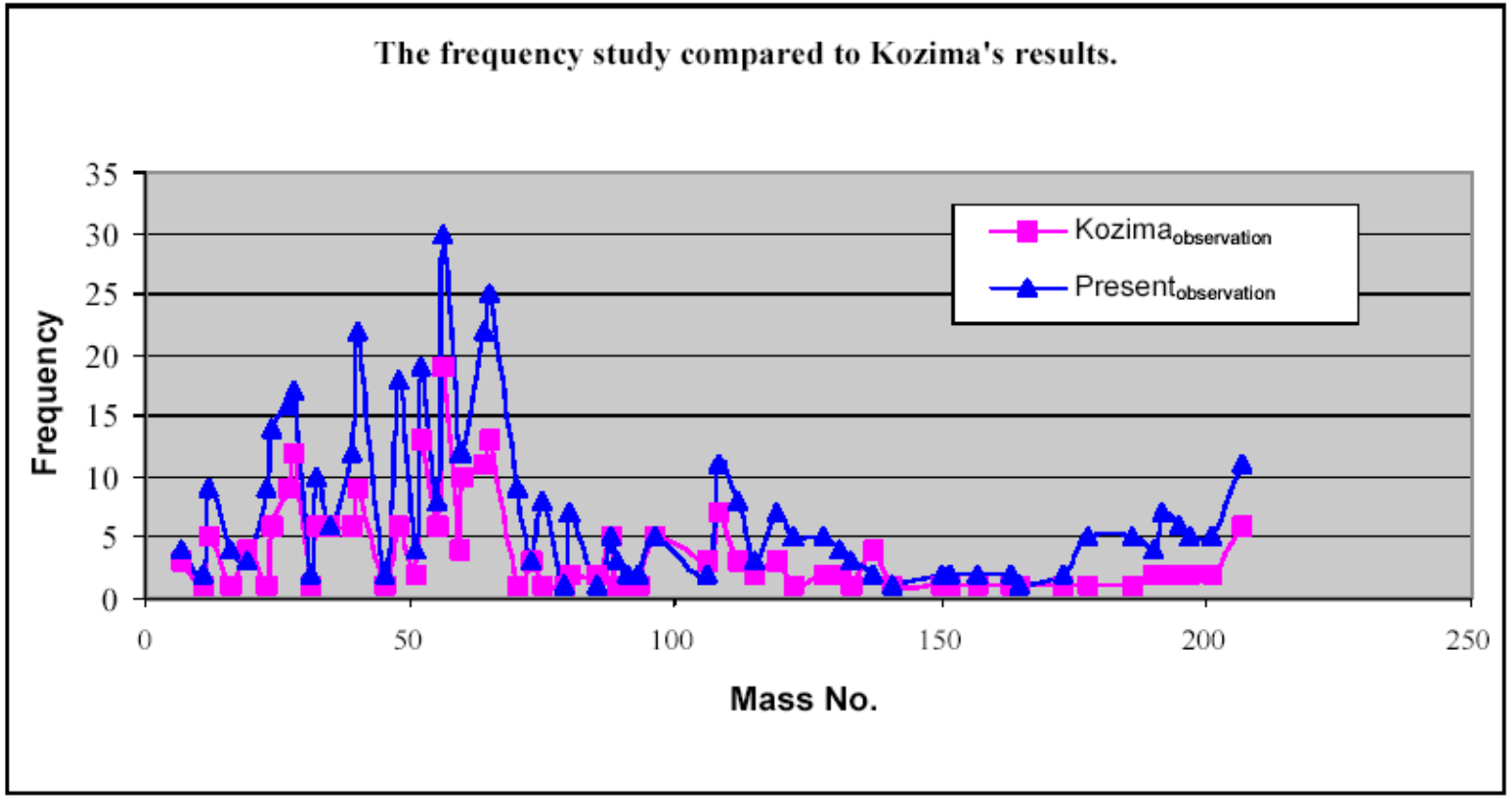
Transmutation

Methods to Initiate

- Electrolysis
- Plasma discharge in a liquid
- Diffusion through Pd assembly
- Ion bombardment
- Sonic implantation
- Living cells

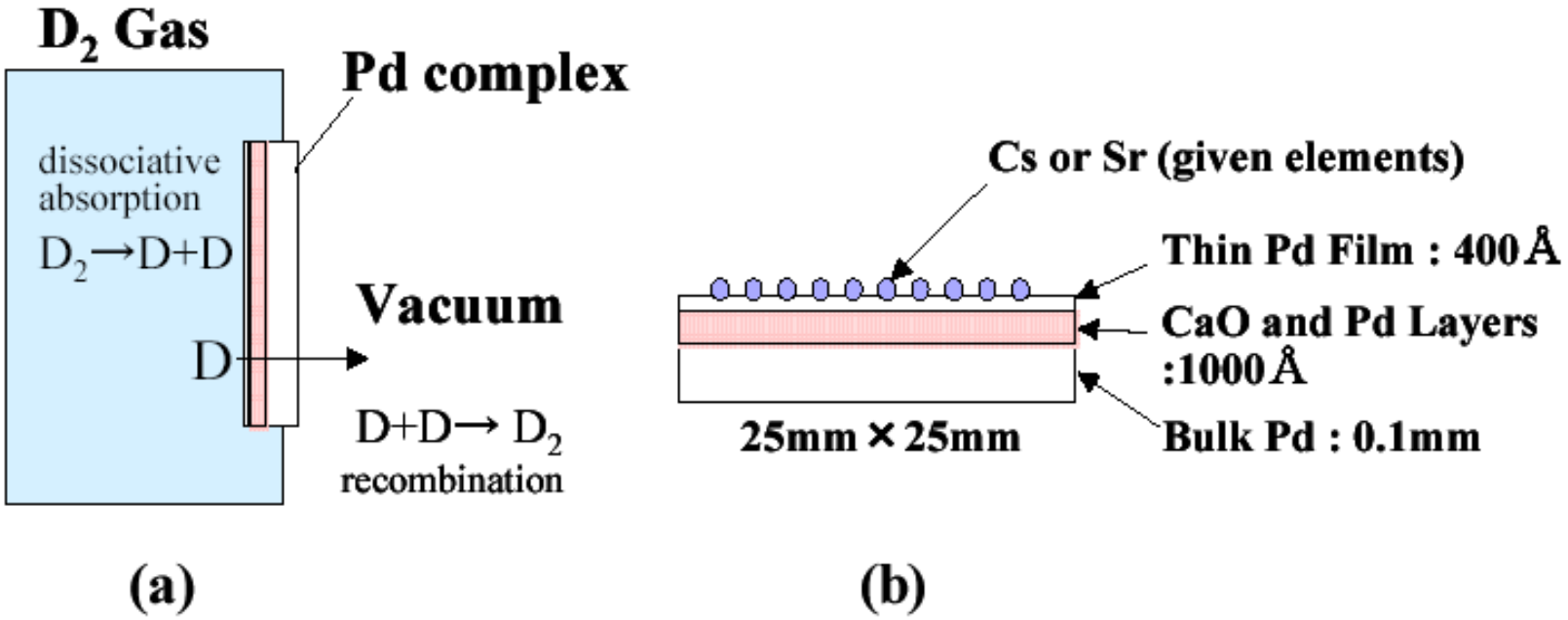
Anomalous Isotope Production

Prof.George Miley: Univ. of Illinois
(Ca, Cu, Zn, and Fe most common)



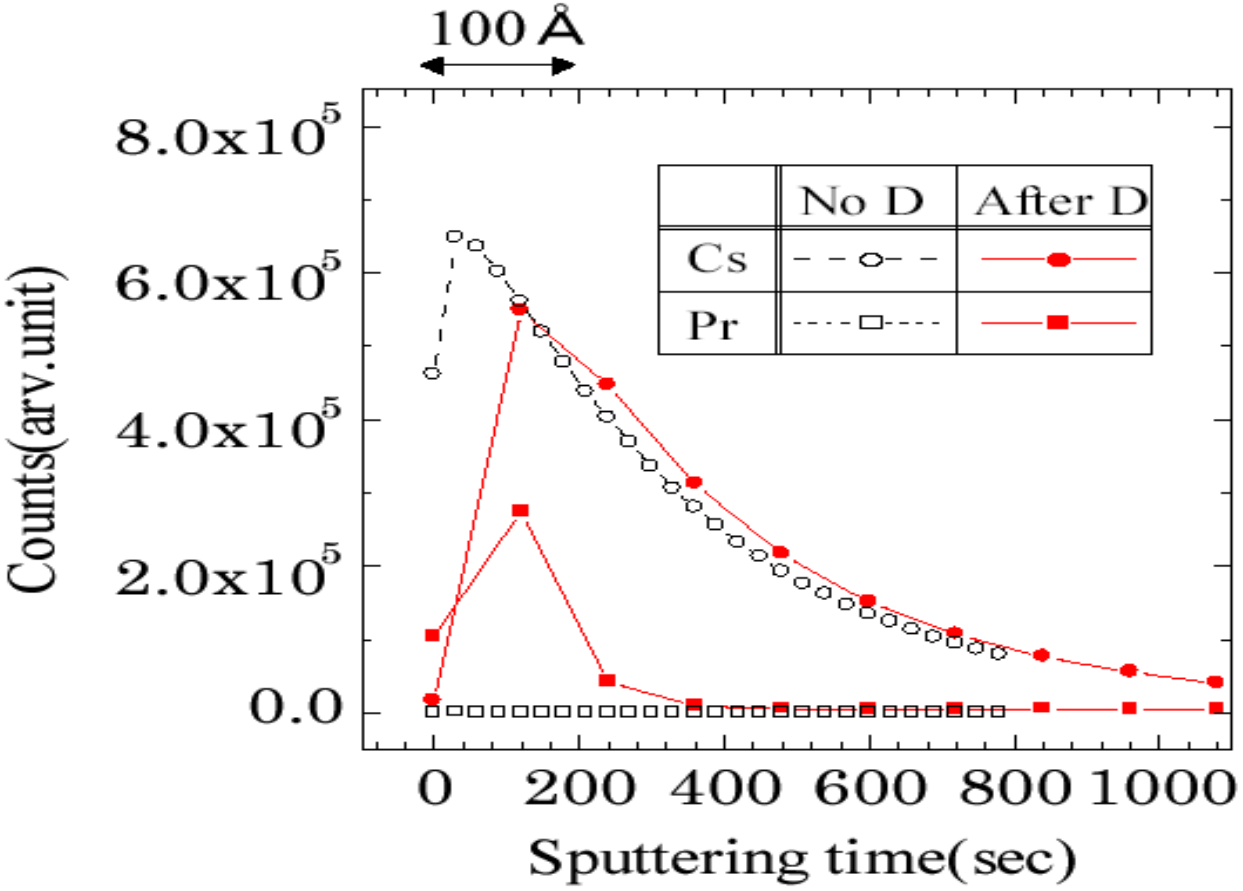
Transmutation Study

Iwamura et al. ICCF-10



Transmutation study

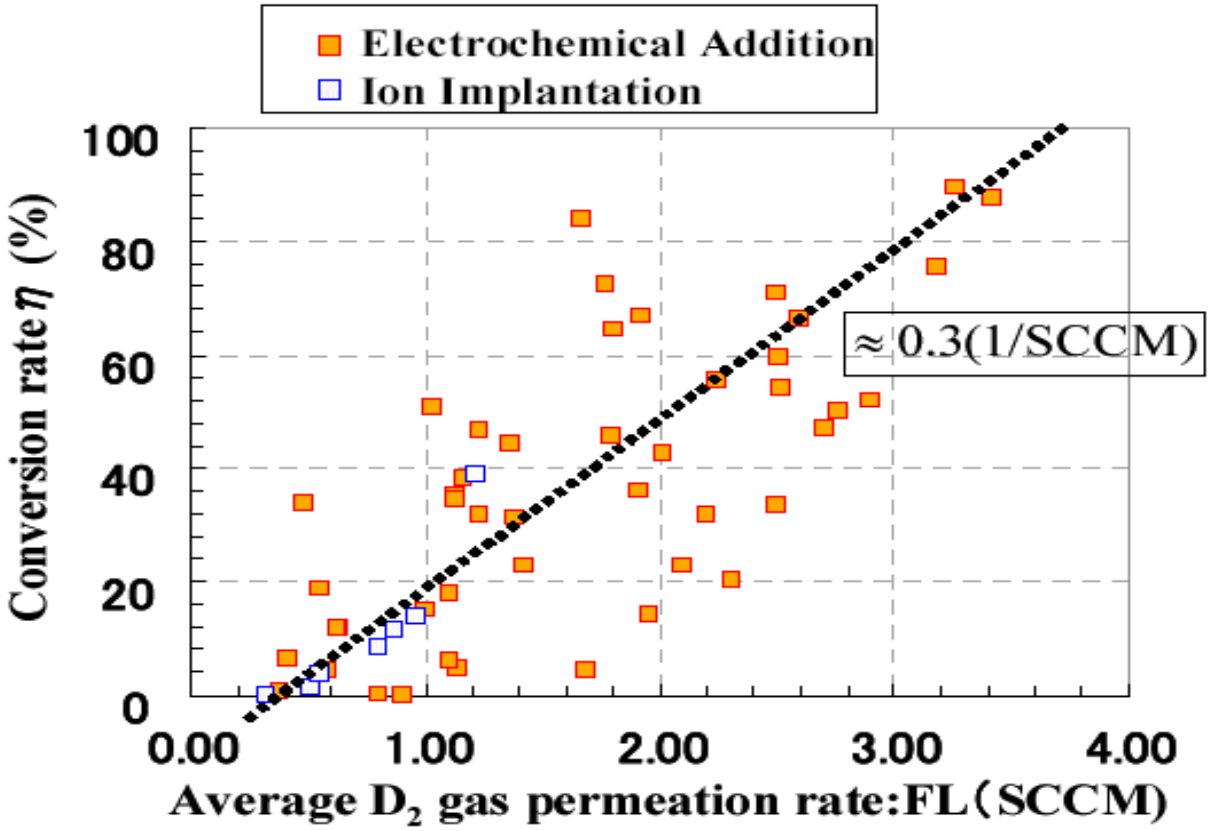
Iwamura et al. ICCF-10



Transmutation study

Iwamura et al. ICCF-10

Conversion rate of Cs to Pr



Transmutation Summary

Iwamura et al.: Mitsubishi, Japan

- Caused the following reactions by passing D_2 through Pd-CaO-Pd layers.

  $4D + {}^{133}Cs_{55} = {}^{141}Pr_{59}$ [within 100Å of surface]

  $4D + {}^{88}Sr_{38} = {}^{96}Mo_{42}$[isotope ratio transfer]

  $6D + {}^{138}Ba_{56} = {}^{150}Sm_{62}$[isotope ratio transfer]
- Measured target loss and product gain using XPS, SIMS, XANES, ICP-MS, and X-ray Fluorescence.
- Basic process replicated in Italy and Japan.

  The LENR reactions involve clusters of hydrogen isotopes and do not require high D/Pd ratio.

Energy Produced by Reactions Involving Deuterium

Deuterium	Target	Product	Total MeV	MeV/D
D	Mn	Fe	15.61	15.61
2D		He	23.84	11.92
4D	Sr	Mo	53.41	13.35
4D	Cs	Pr	50.49	12.62
6D	Ba	Sm	67.61	11.27

Biological Transmutation

- Kervran, (France, 1963-1980) Seeds or Eggs
- Komaki (Japan, 1967-1993) Bacteria, Molds, or Yeasts

  Mg, Ca, K, and Fe produced by transmutation
- Vysotskii et al. (Russia, 2000-2004) Bacteria or Yeasts

  $Mn^{55} + D^{2} = Fe^{57}$ Mossbauer

  $Na^{23} + P^{31} = Fe^{54}$ Mass Spectrometer

Nuclear reactions can occur in living cells. All elements did not originate from the “Big Bang”.

What material supports the nuclear reactions?

- Bulk palladium
- Surface region of palladium
- Deposits on surface of cathode material,

    A. Deposit is a complex alloy,

    B. Alloy has an unknown structure and composition,

    C. Alloy rarely forms and only very slowly.

Nuclear-Active-Environment (NAE)

Nuclear-Active-State (NAS)

Reproducibility

- Basis for belief
- Required for study
- Involves creating NAE
- Presently NAE is created by random chance

Application of LENR requires NAE be created on purpose and in large amounts.

Energy Production Rate

- Based on entire sample: ~100 W/g
- Based on surface deposit: ~1,000 W/g
- Based on active part of surface deposit: ~100,000 W/g

How high can energy density go?

Relationship to other observations

- Fusion in solids sensitive to chemical environment

  Kasagi et al., and Takahashi et al. [Japan]

  Czerski, et al., and Raiola et al. [Germany]

  Lipson, et al. [US]

- Radioactive decay rate sensitive to chemical environment

  Ohtsuki et al. [Japan] ^{7}Be in C_{60}

  (0.83% decrease in half-life)

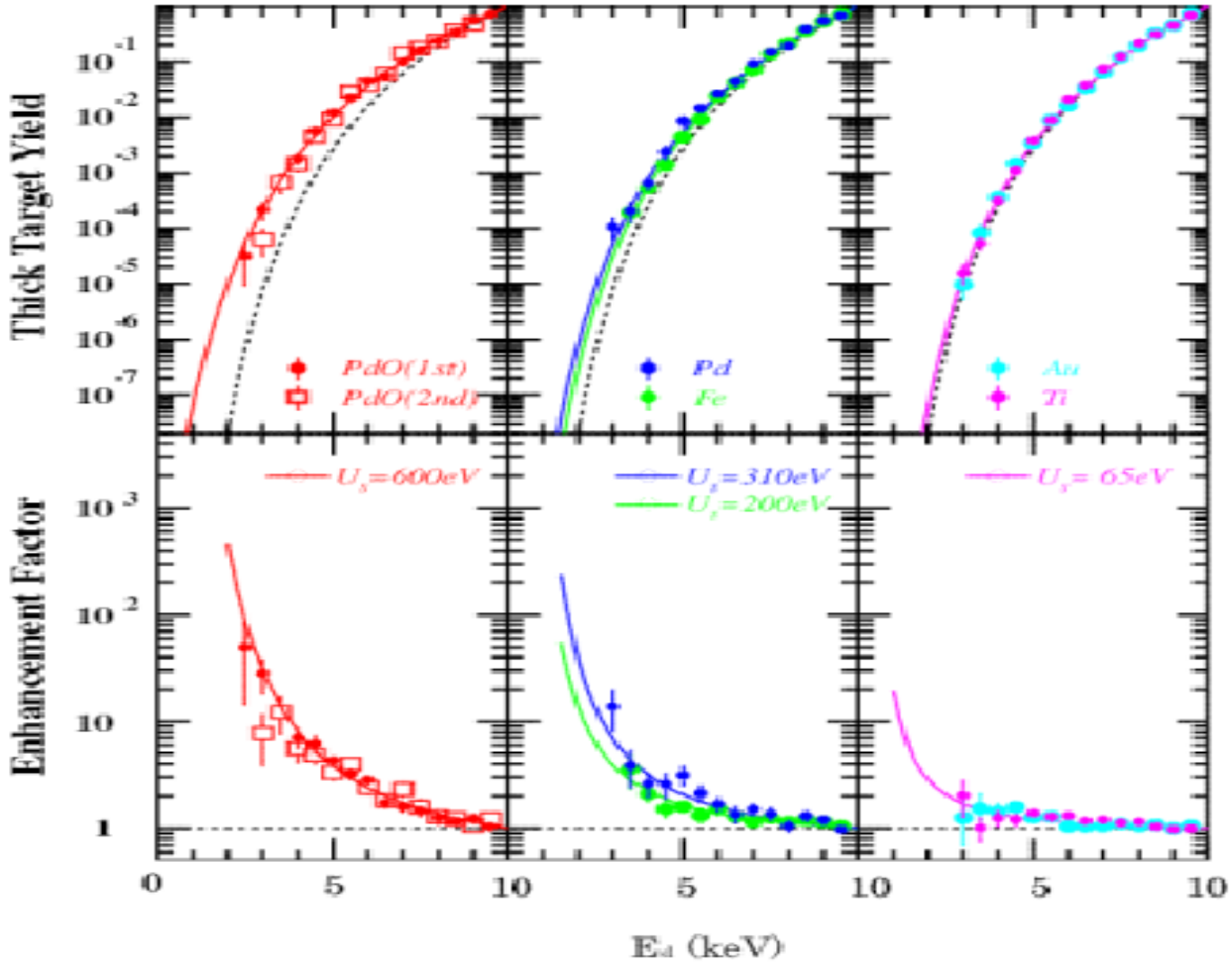
  Reifenschweiler, [Netherlands] tritium in Ti

  (40% increase in half-life)

Some Nuclear reactions are not independent of chemical environment.

Effect of Environment on D(d,p)T Reaction

Kasagi et al. ICCF-7 and ICCF-8



Theory Requirements

- Explain ^{4}He production at rates in excess of 10^{12} events/sec.
- Explain occasional production of tritium up to 10^{4} events/sec.
- Explain transmutation reactions involving up to 6 deuterons at one time.
- Explain how energy is coupled to lattice.
- Explain the nature of the NAE and why it exists in several kinds of chemical environments.
- Explain how energetic particles can form.

What We Know To Be True

- Nuclear reactions involve 1, 2, 4, and 6 deuterons that add to a variety of nuclei.
- Nuclear reactions involve both H and D.
- Nuclear reactions occur only in special solid environments (NAE).
- Nuclear reactions produce little if any radiation or energetic particles.
- Nuclear reactions can occur at rates that make significant heat energy.
- Nuclear reactions can be initiated using many different methods.

What We Hope Will Be True

- Energy from LENR will replace all present sources of energy.
- Mankind will be wise enough to introduce the energy source slowly.
- Mankind will be wise enough not to use the energy to destroy.