How to Cause Nuclear Reactions at Low Energy and Why Should You Care

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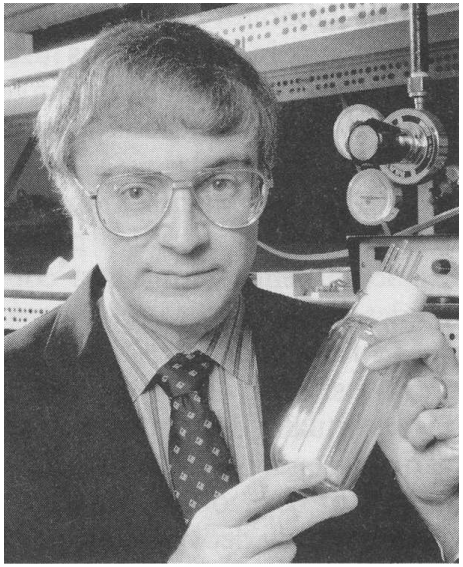
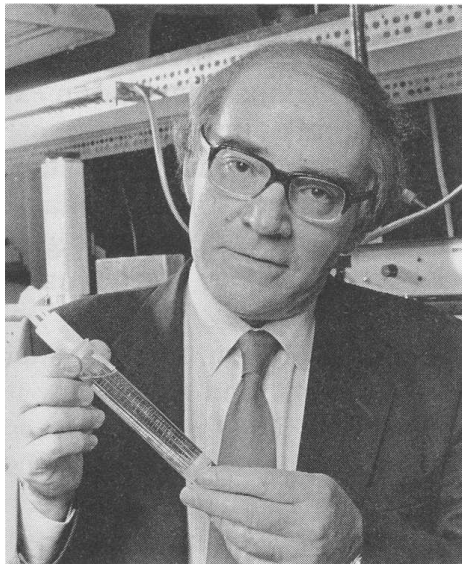
These slides are from this video lecture:

http://www.youtube.com/view_play_list?p=3B79262131CA1BCF

Profs. Pons and Fleischmann

(Courtesy Univ. of Utah)





What is Cold Fusion?

- Cold Fusion = popular name
- Low Energy Nuclear Reaction = LENR = General description
- Chemically Assisted Nuclear Reaction = CANR = LENR
- Condensed Matter Nuclear Science = CMNS = Field of study

Work is Being Done at Laboratories in Many Countries

1. Japan,
2. Italy,
3. Russia,
4. Ukraine,
5. Israel,
6. U.S.A.,
7. China,
8. France

What Reactions Occur?

Detected

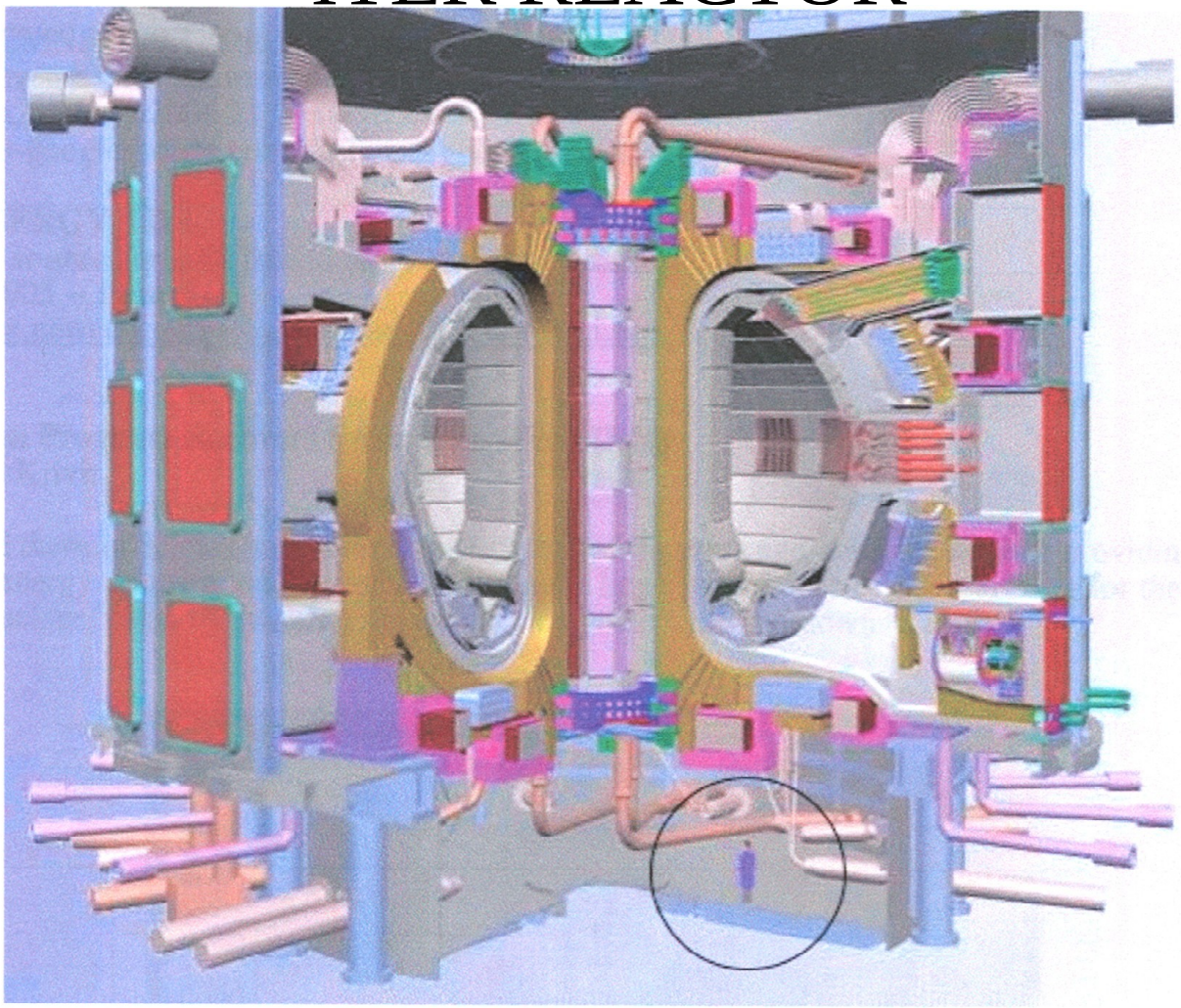
- d + d > ^{3}He(0.82 MeV) + n(2.45 MeV)
- d + d > p(3.02 MeV) + t(1.01 MeV)
- d + d > ^{4}He + (23.8 MeV) (No gamma)

- n*d + M > fusion or fission (transmutation)

Not Detected

- d + t > n(14.01MeV) + ^{4}He(3.5 MeV)
- d + p > ^{3}He + gamma (5.5 MeV)

ITER REACTOR



How does Cold Fusion Compare to Hot Fusion?

Cold Fusion

- Occurs in a special solid materials at low applied energy.
- Produces mainly helium-4 and heat
- Small, simple devices can make useful power
- Involves fusion of deuterium and many other nuclear reactions.
- Has been studied for 18 years and is not understood.
- Is a clean energy source.
- Is difficult to replicate.

Hot Fusion

- Occurs in a plasma or upon application of high energy.
- Produces neutrons, tritium and heat.
- A very large reactor is required to make useful power.
- Involves fusion of tritium and deuterium.
- Has been studied for 60 years and is well understood.
- Is a radioactive energy source.
- Is difficult to make useful.

Kinds of Evidence

- Anomalously large heat production,
- Helium production consistent with heat production,
- Occasional tritium production,
- Production of anomalous isotopes,
- Consistent patterns of behavior,
- Energetic particle and gamma emission.

How is Cold Fusion Initiated?

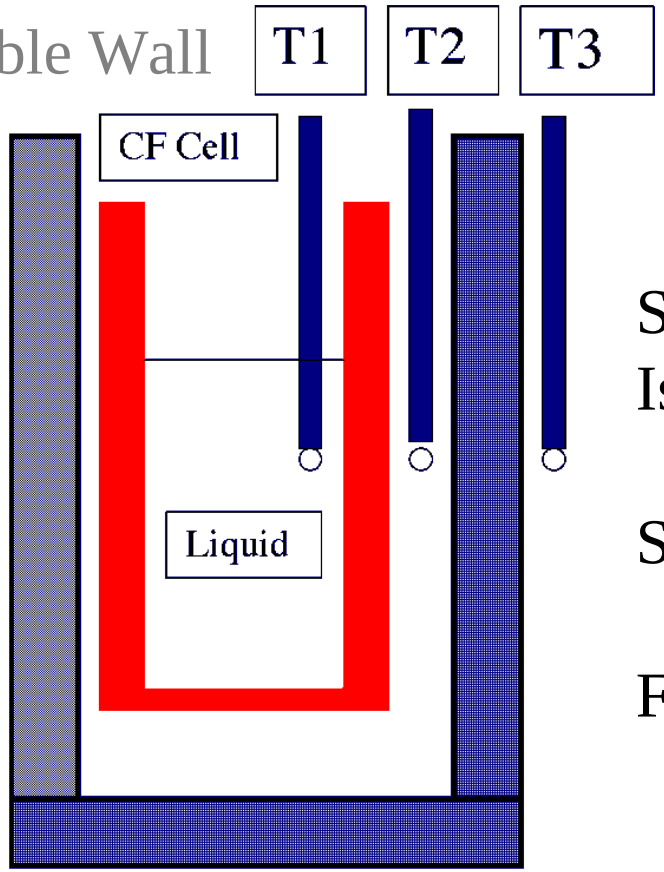
- Electrolysis
- Ambient Gas

- Liquid Plasma
- Gas Plasma
- Proton Conductor
- Sonic Implantation
- Laser Light

Representation of Calorimeter Methods

Single Wall

Double Wall



Open method

Closed method

Single and Double Wall

Isoperbolic

$E_P = \Delta T*C - V*I$, (<0.1 W)

Seebeck

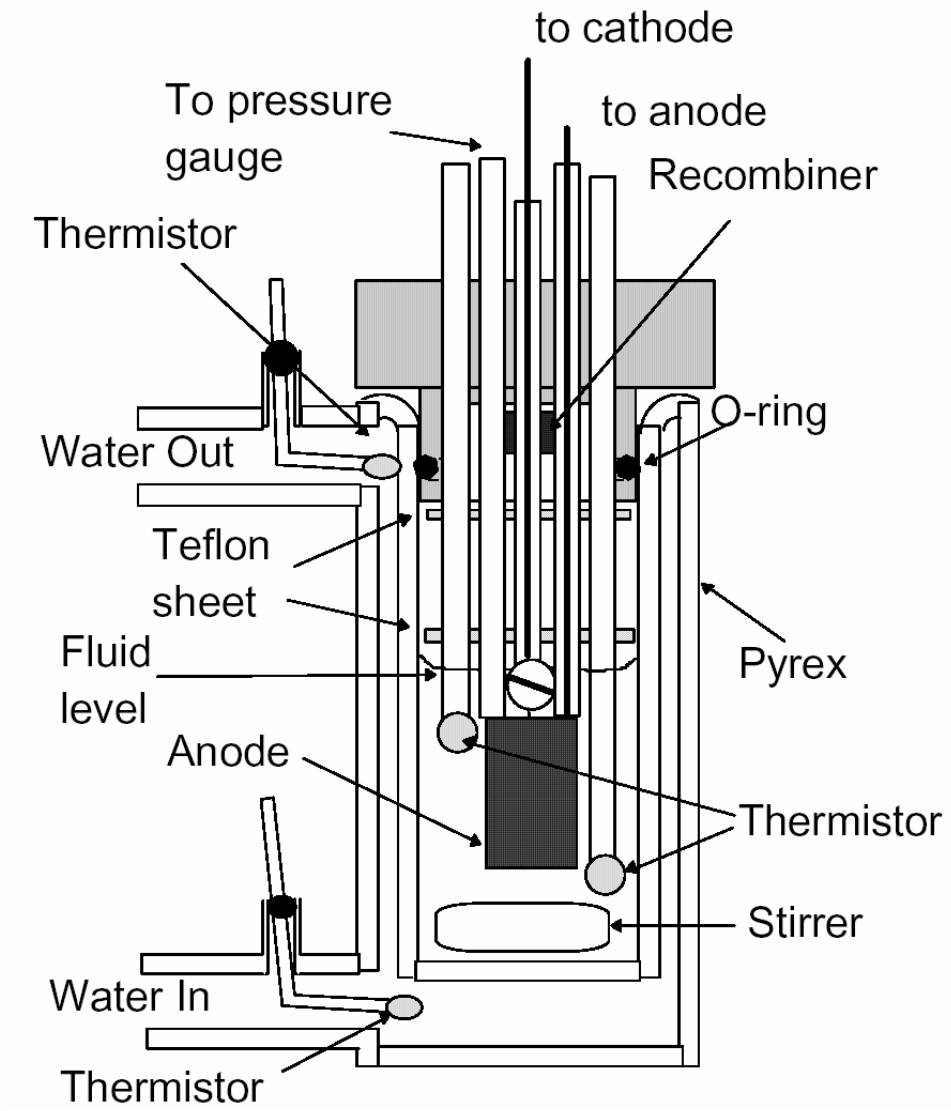
$E_P = V_s*C - V*I$, (<0.02W)

Flow

$E_P = \Delta T*(F*C_p + C) - V*I$, (±0.05 W)

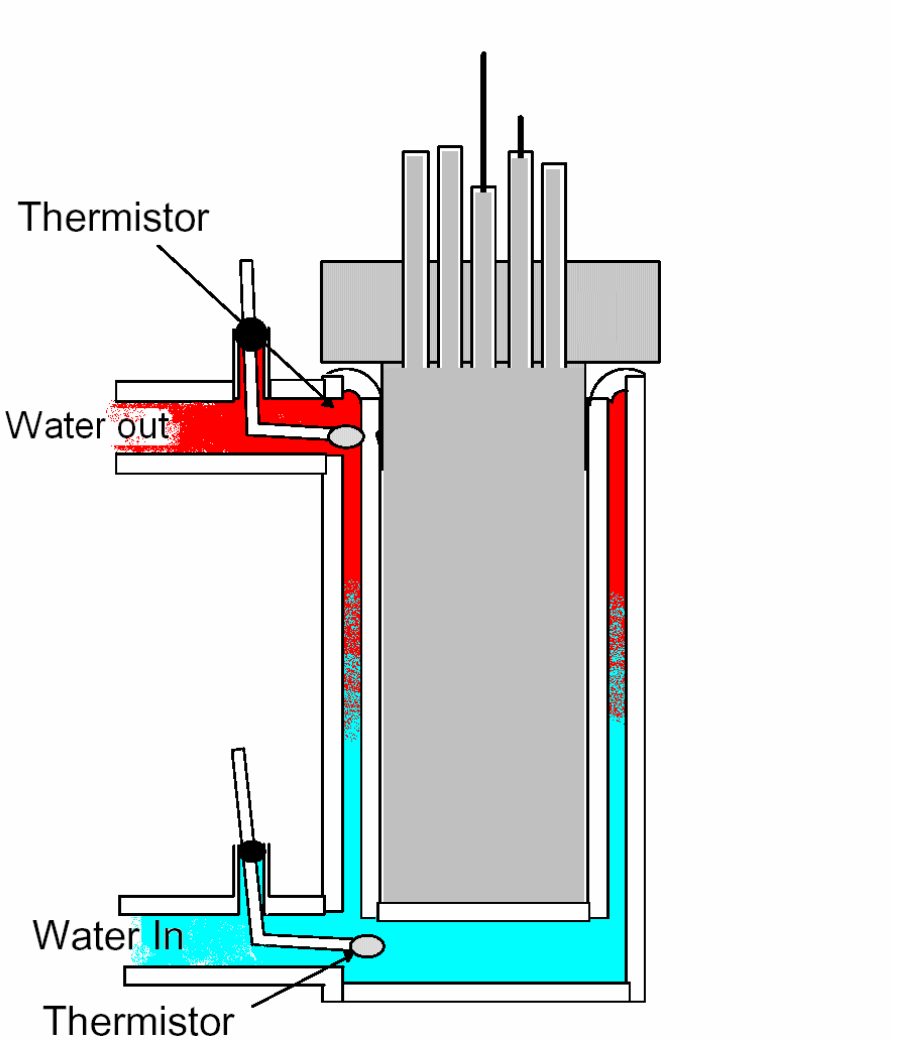
Flow calorimeter schematic

(This slide not included in video)

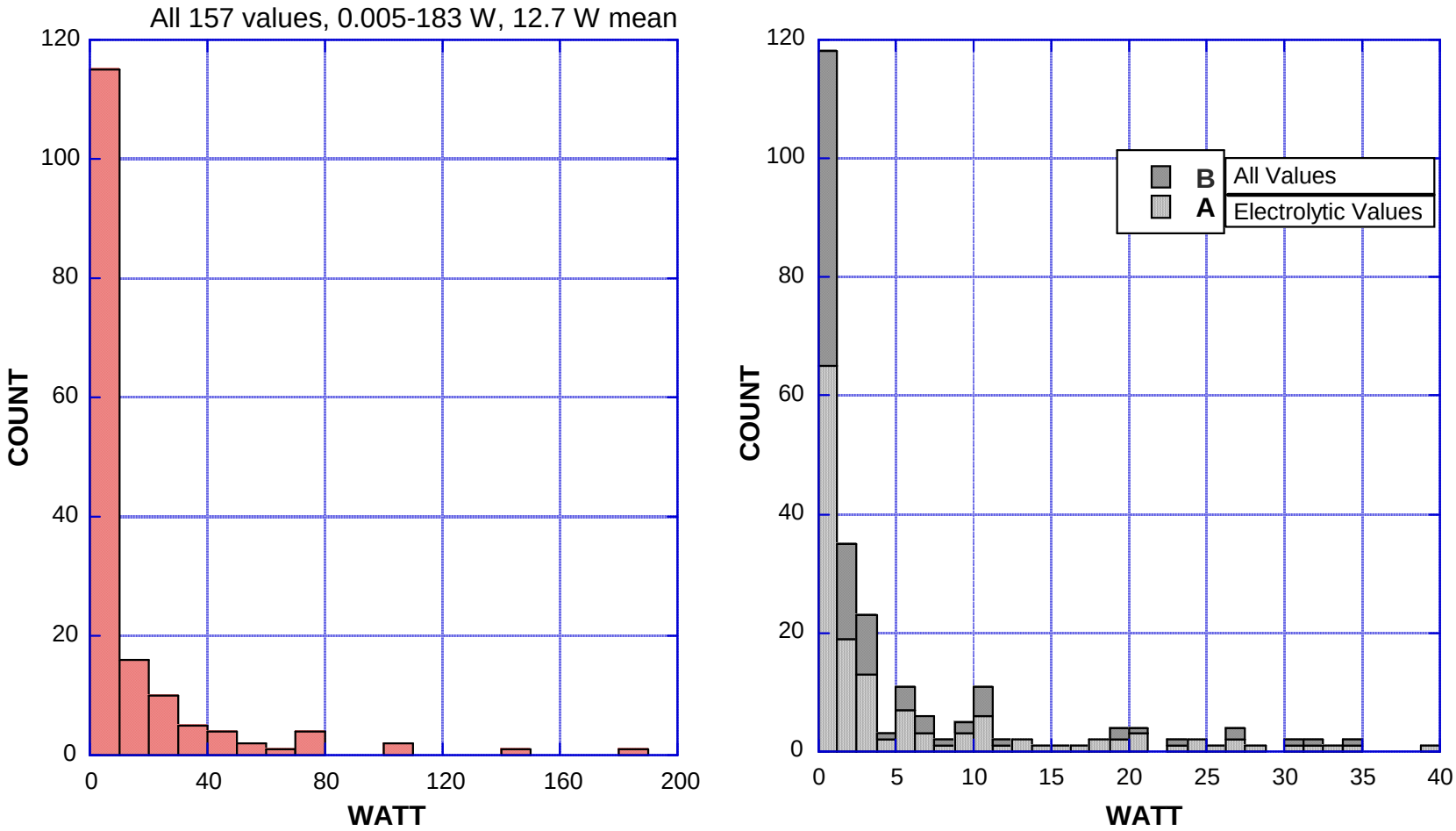


Simplified flow calorimeter schematic showing only the cooling water in the outer jacket

(This slide not included in video)



How Much Power is Produced?



Power based on 157 reported studies

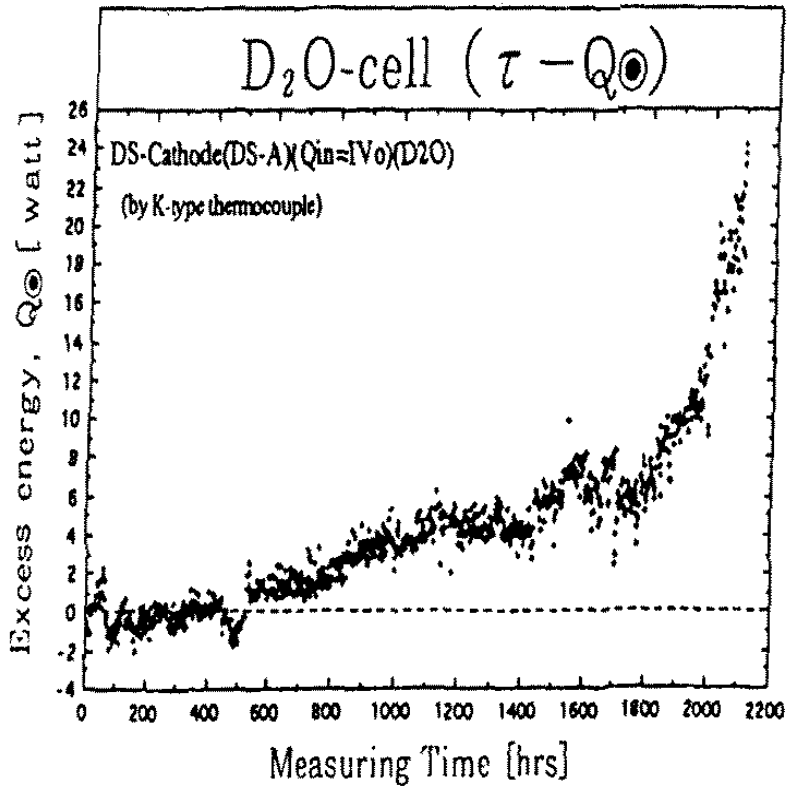
Recent Example of Significant Power using Electrolysis

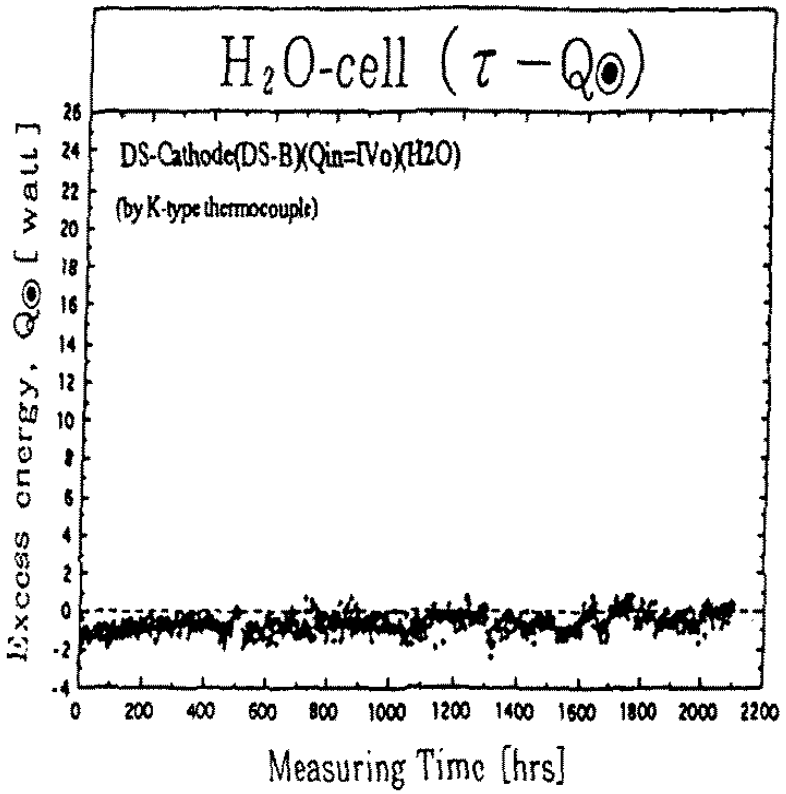
(Dardik et al., Energetics Technologies, Israel)

Excess Power of up to 34 watts; Average ~20 watts for 17 h

Example of Significant Power using Gas Loading

(Arata and Zhang, Osaka Univ., Japan)



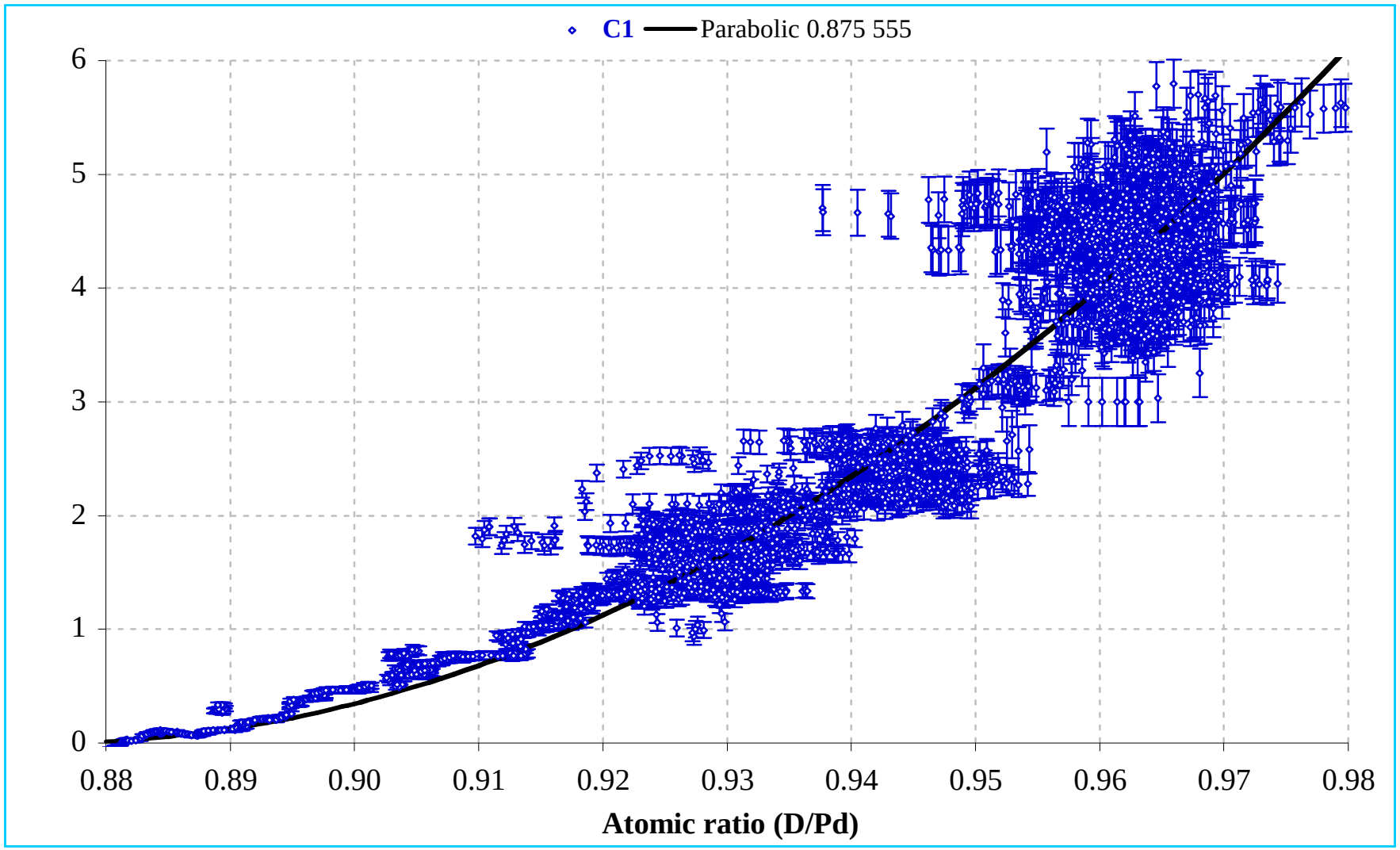


Consistent Patterns for Heat Production When Pd is used during Electrolysis

- Effect of average D/Pd ratio
- Effect of applied current
- Effect of batch of Pd
- Effect of temperature
- Effect of electrolysis time
- Effect of cracking of the metal

Effect of D/Pd ratio on excess power

(McKubre et al., SRI)

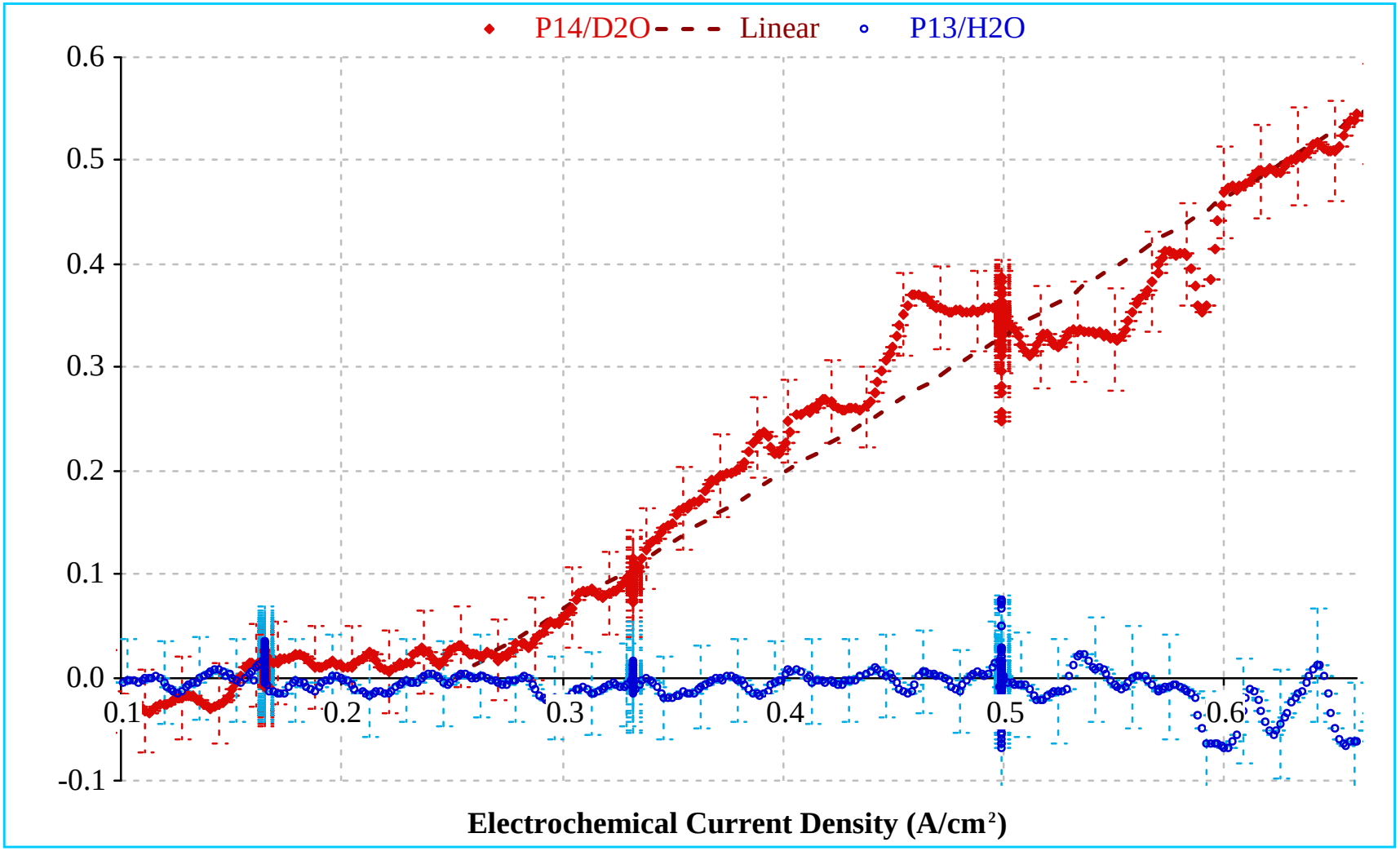


Summary of Heat Production (McKubre et al., SRI)

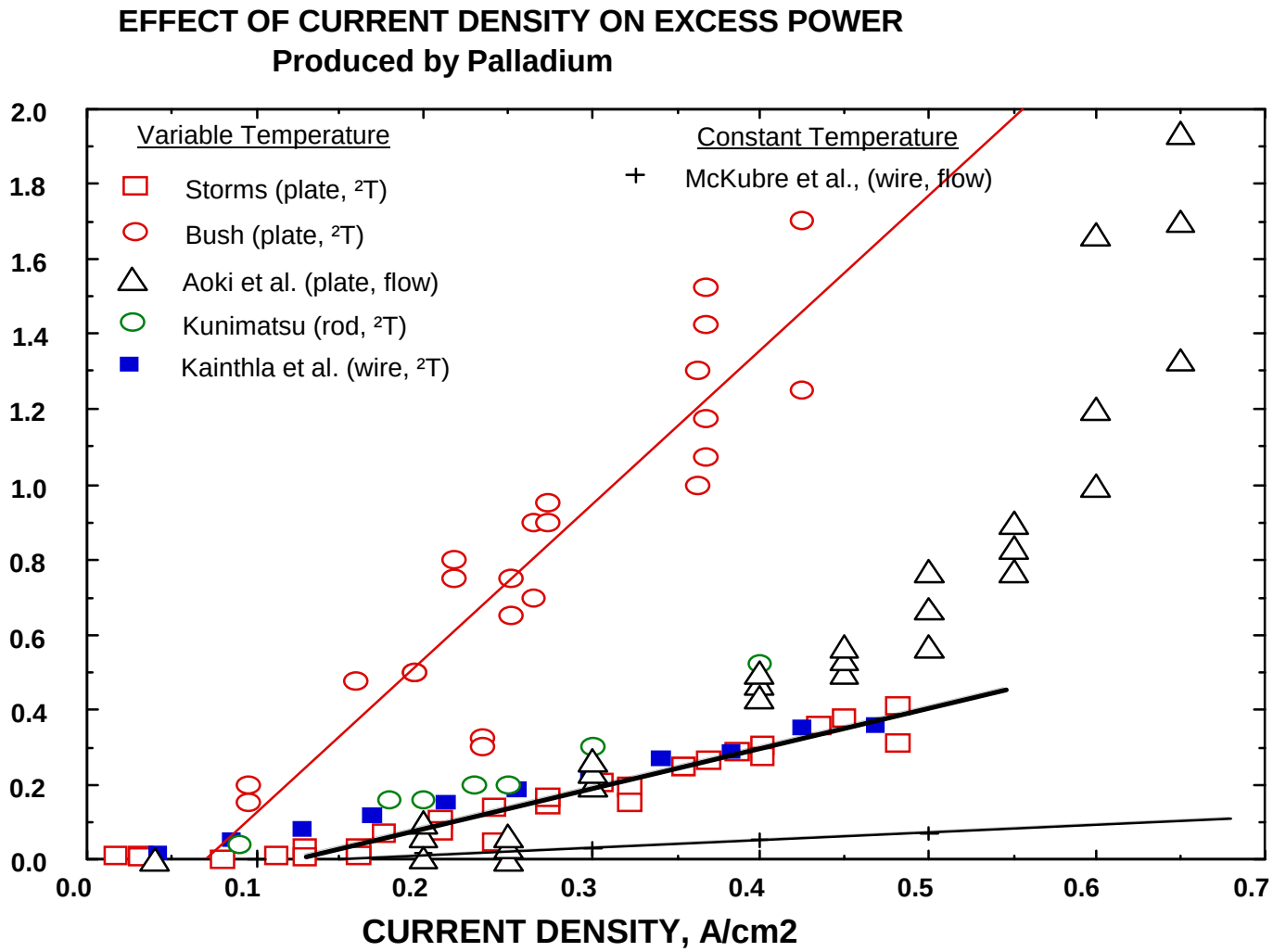
- D/Pd = 0.70 to 0.90 17 no heat
- D/Pd = 0.90 to 0.95 9 no heat, 6 heat
- D/Pd = 0.95 to 1.05 15 heat

Example of a Consistent Pattern (McKubre et al., SRI)

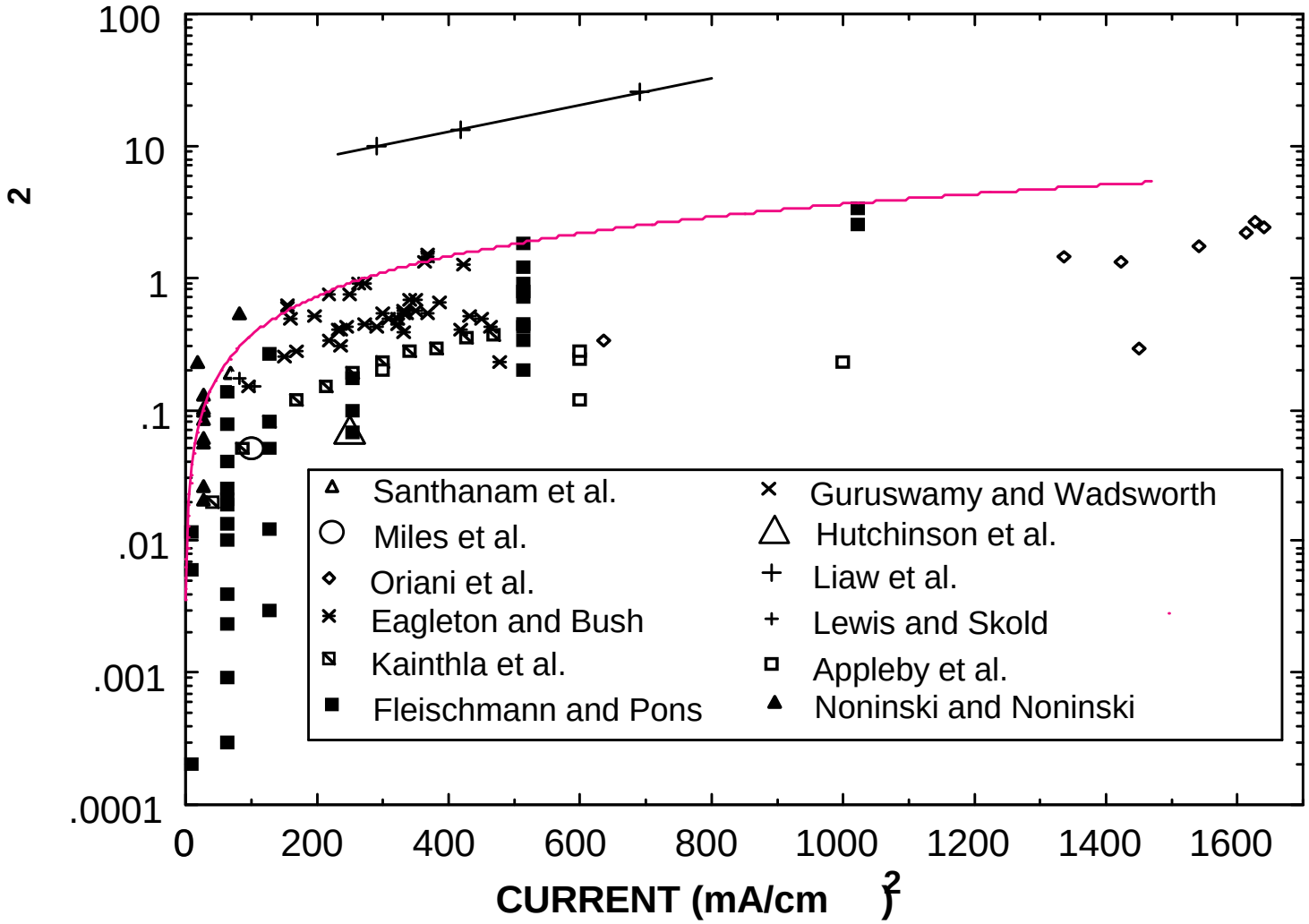
Light & Heavy Water Cells; *Excess Power vs. Current Density*



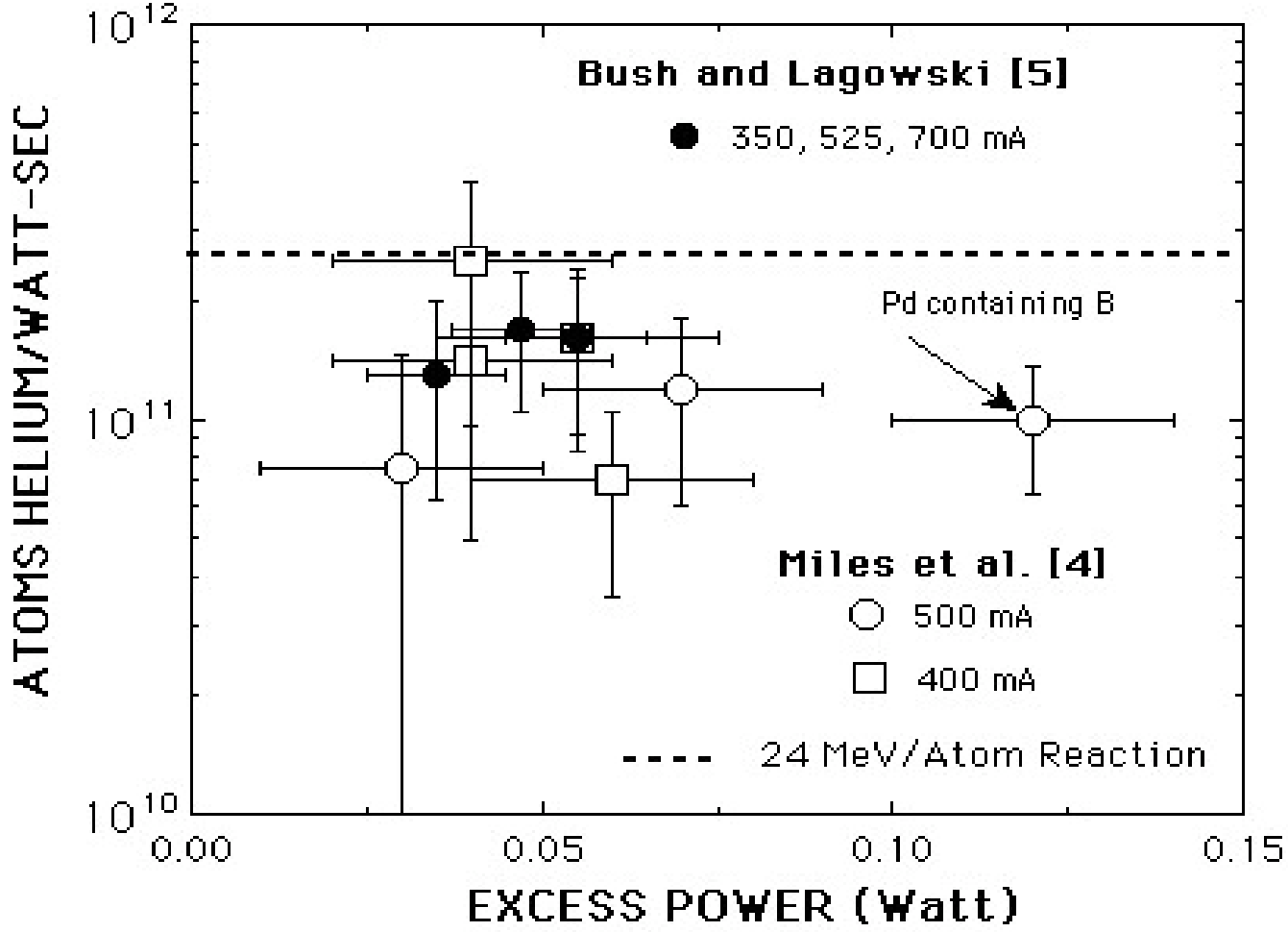
Effect of Current on Excess Power



Effect of Applied Current on Excess Power

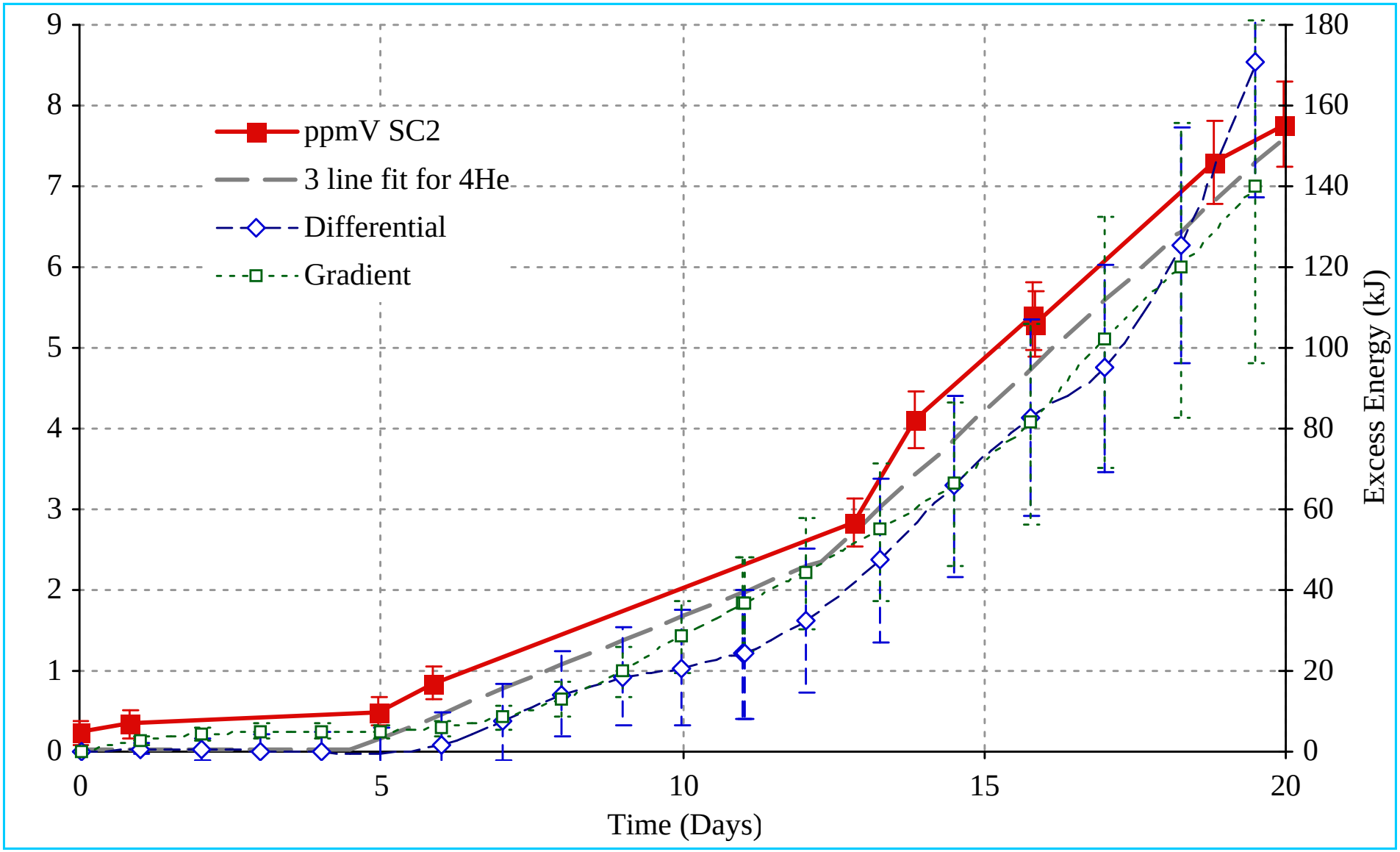


Example of relationship between helium and heat production

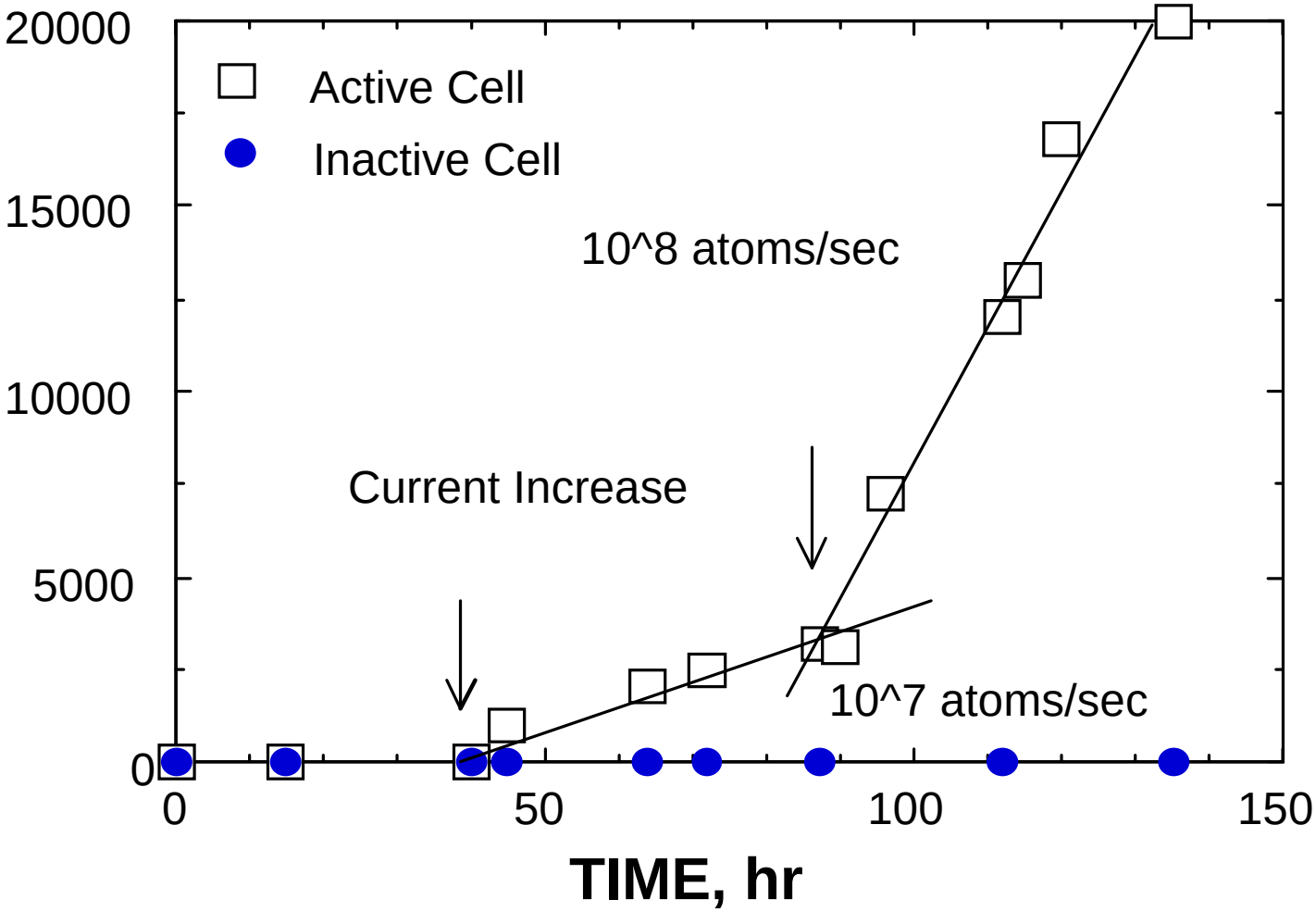


Growth of heat and helium

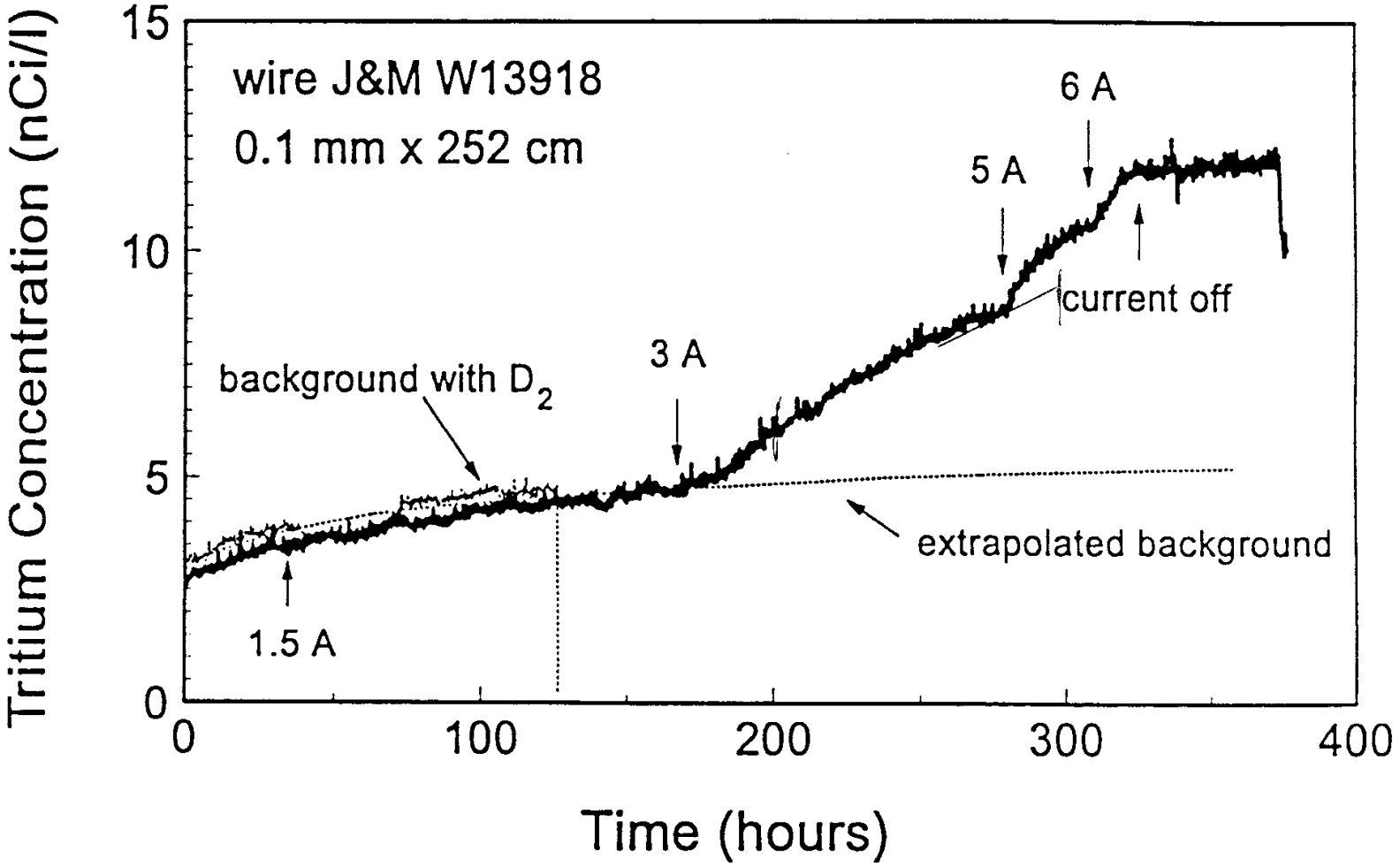
(McKubre et al., SRI)



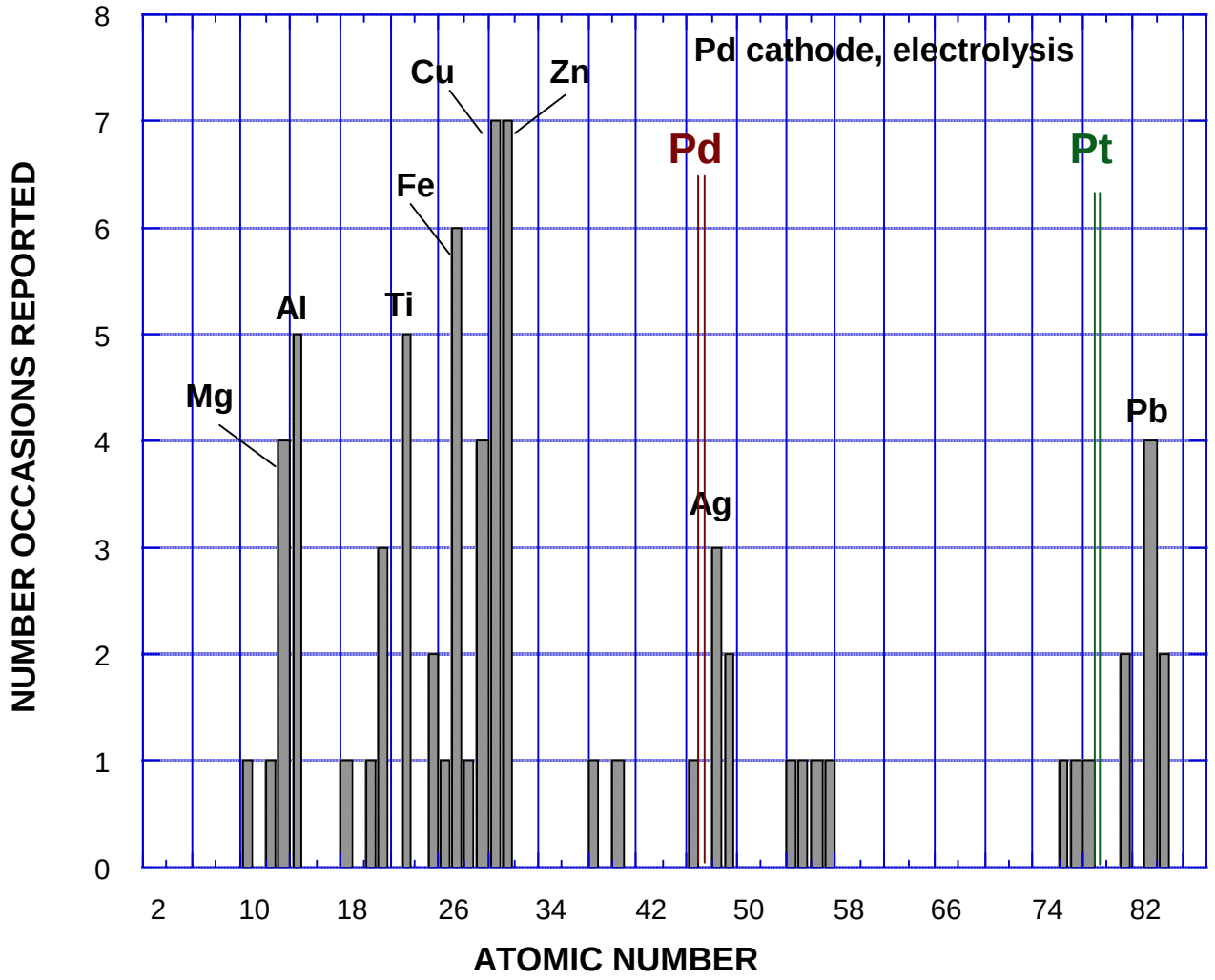
Grown of Tritium during Electrolysis (Bockris et. al, Texas A&M)



Growth of Tritium during Gas Discharge (Claytor et al., LANL)



Extra Elements Commonly Found



Iwamura et al., Mitsubishi, Japan

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

  $4D + {}^{133}Cs_{55} = {}^{141}Pr_{59} + ?$

  $4D + {}^{88}Sr_{38} = {}^{96}Mo_{42} + ?$

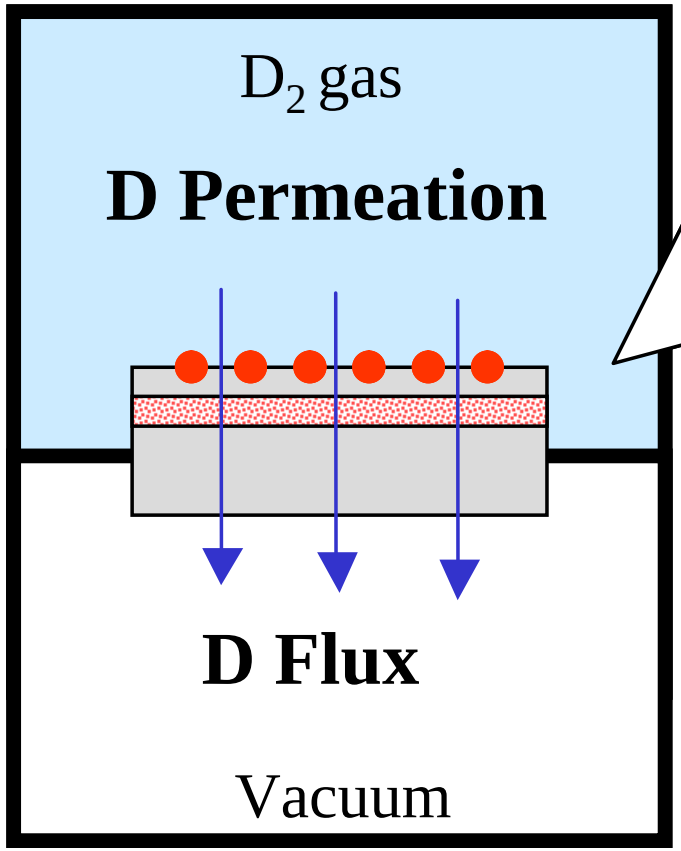
  $6D + {}^{138}Ba_{56} = {}^{150}Sm_{62} + ?$

- Measured target loss and product gain using XPS, SIMS, XANES, ICP-MS, and X-ray Fluorescence.
- Basic process replicated in Italy (INFN-LNF) and Japan (Osaka Univ.).

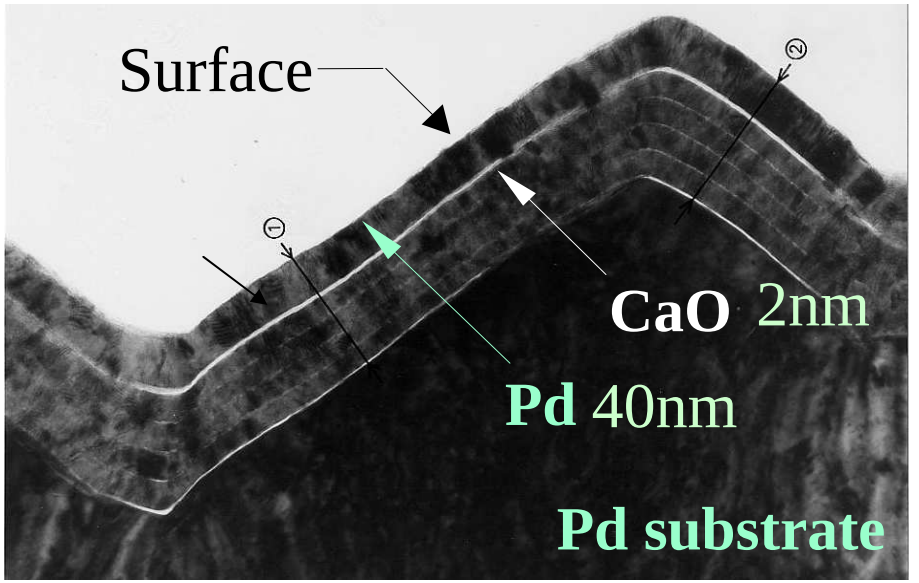
Active Region

(Iwamura et al., Mitsubishi Heavy Industries, Japan)

D_2 gas permeation through the Pd complex

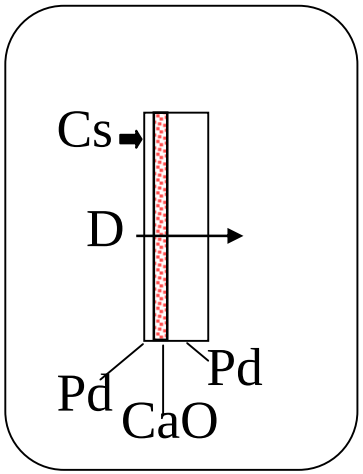


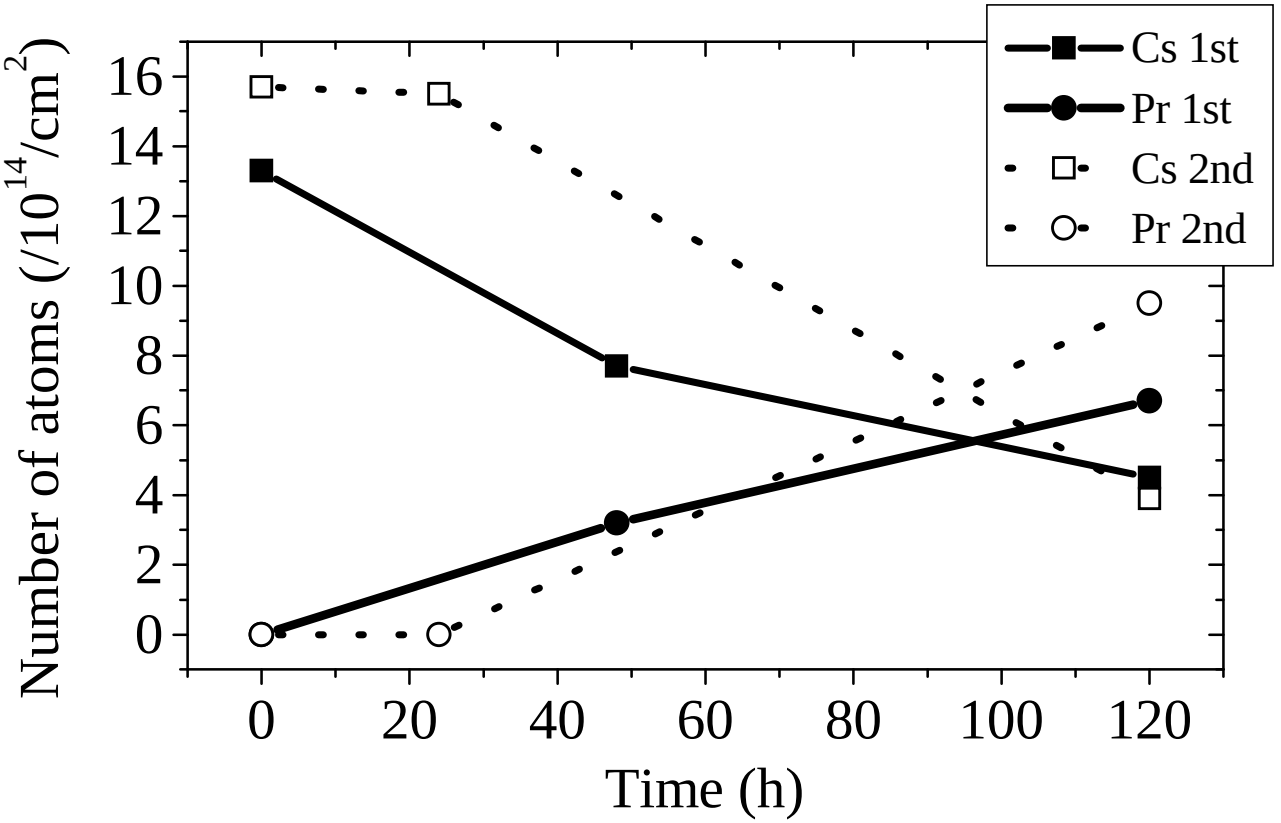
Cross Section of Pd Complex



Decrease of Cs and Emergence of Pr

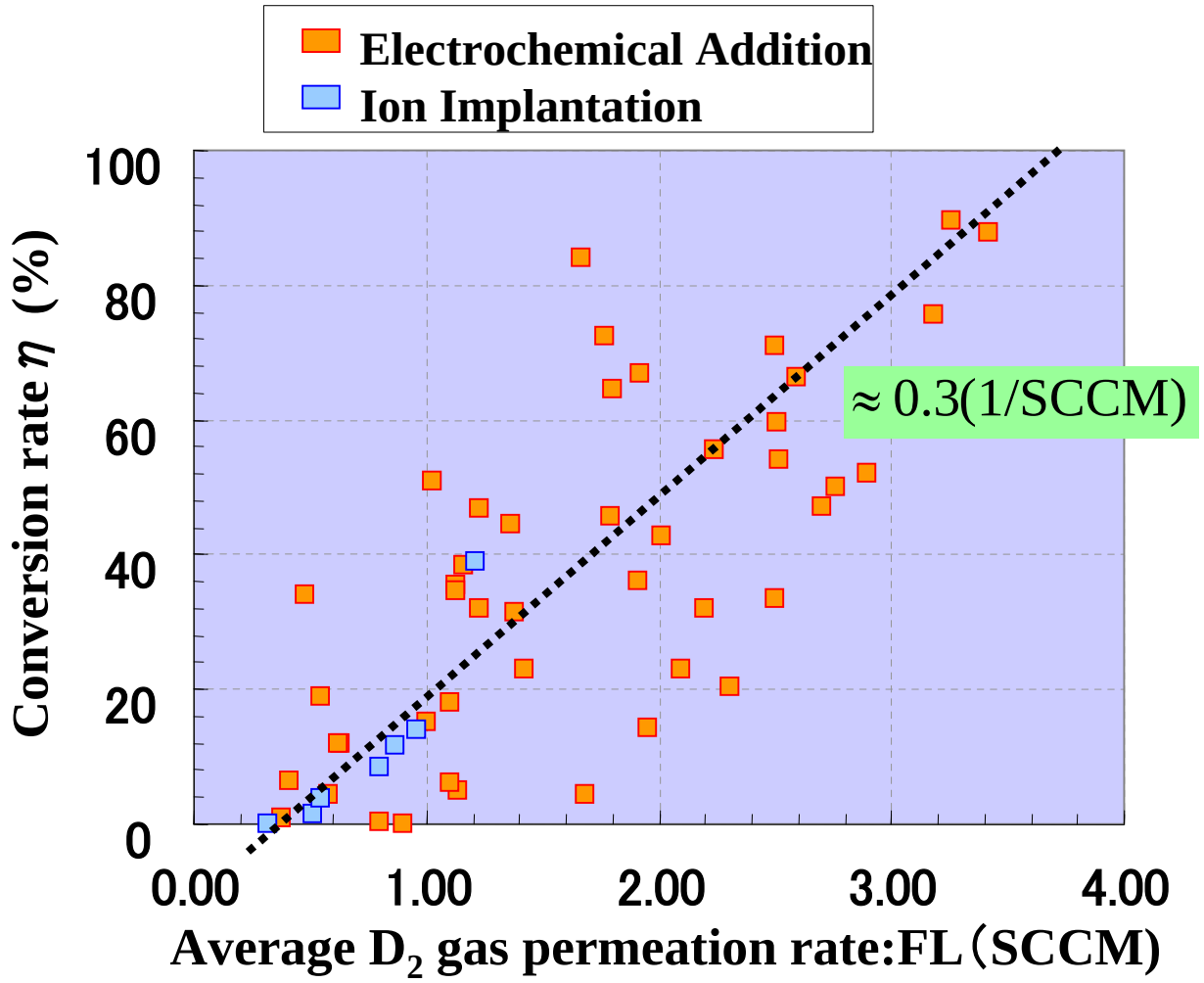
(Iwamura et al., Mitsubishi Heavy Industries, Japan)





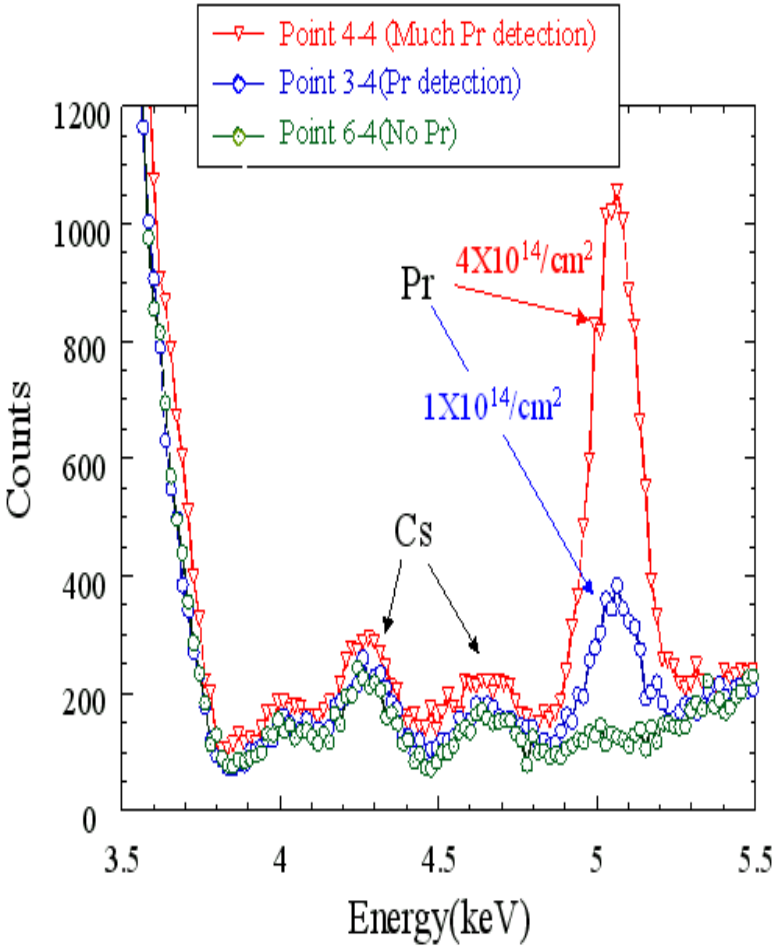
Conversion of Cs to Pr

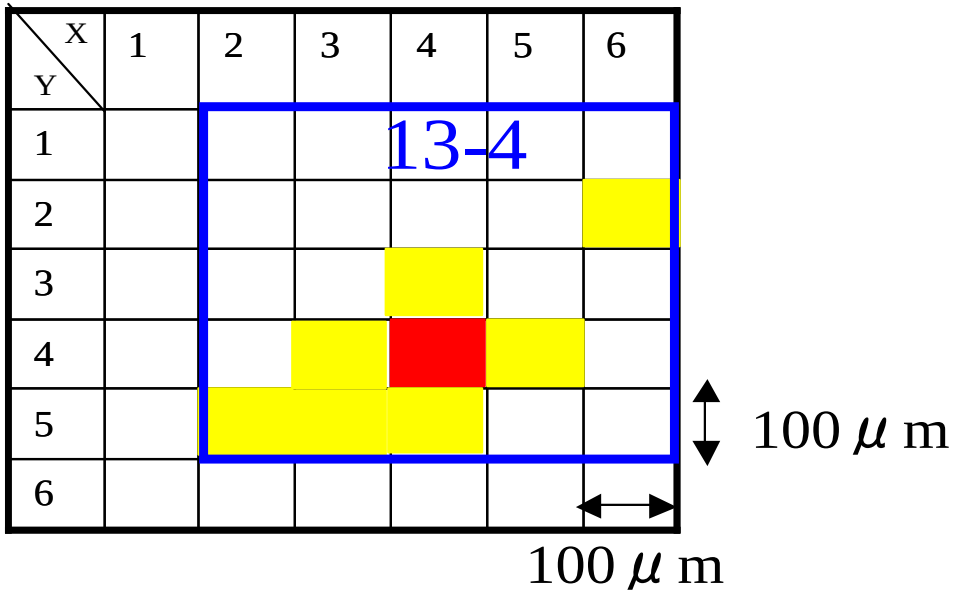
(Iwamura et al., Mitsubishi Heavy Industries, Japan)



Production of Pr from Cs

(Iwamura et al.. Mitsubishi Heavy Industries, Japan)





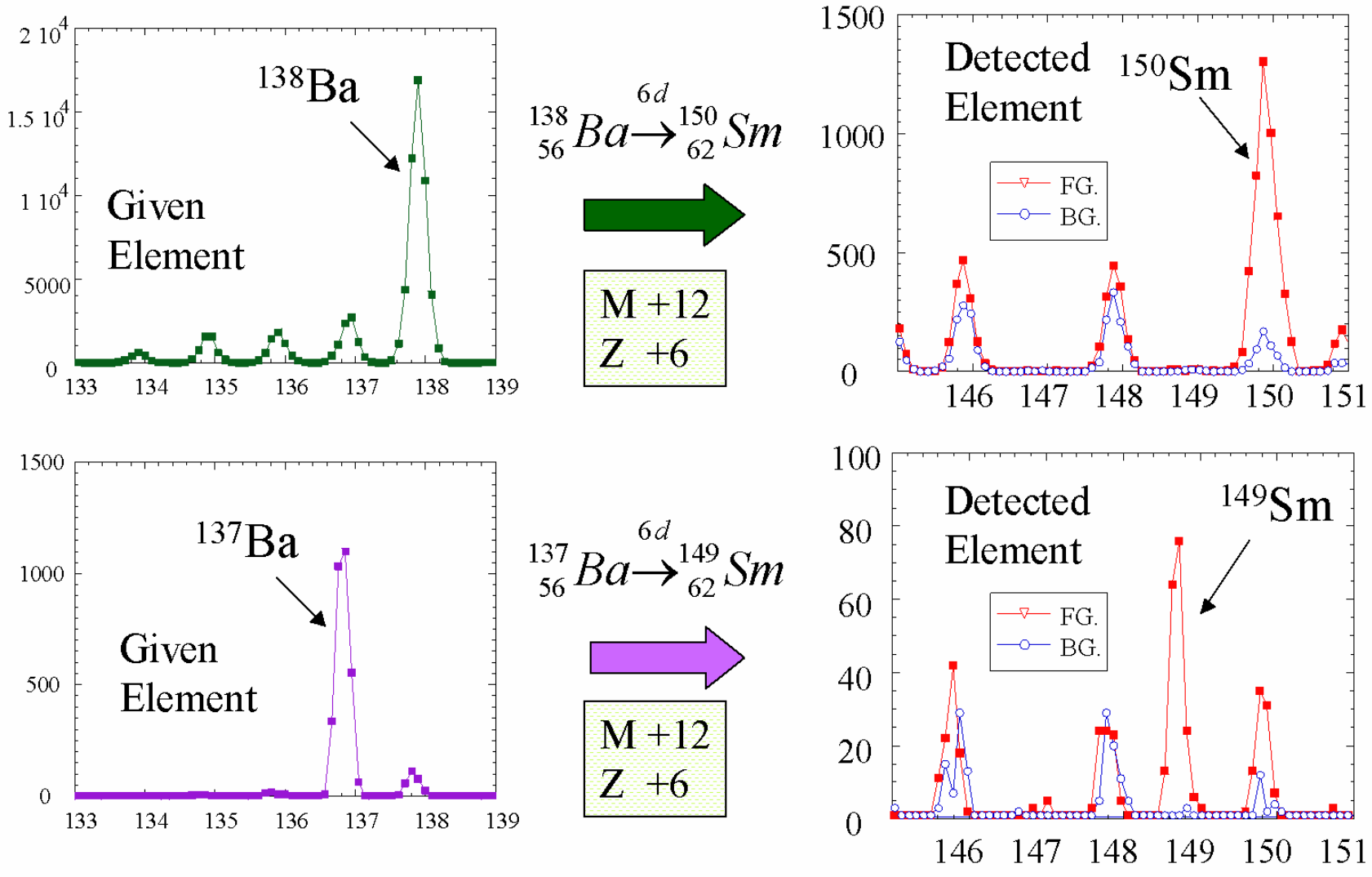
Much Pr detection

Pr detection

No Pr

Mass Correlation between Given and Detected Elements

(Iwamura et al., Mitsubishi Heavy Industries, Japan)



Why is LENR Hard to Replicate?

- Active material is present only in very small regions,
- Active material is a complex alloy with an unknown structure and composition,
- Active material rarely forms.

(The challenge is to make the alloy on purpose and in large amount.)

What Do We Know?

* 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 detected outside of apparatus.
* Significant radiation is detected inside of apparatus along with the nuclear products.
* Nuclear reactions can occur at rates that make significant heat energy.
* Nuclear reactions can be initiated many different ways.

Requirements of a Theory

- The nuclear charge of the deuteron or proton must be lowered, but not by neutron formation.
- The deuterons must form a cluster of 2, 4, or 6 d after this lowering process has occurred.
- The reactions must produce very little gamma radiation and few radioactive isotopes.
- The process must occur spontaneously without significant energy being applied.
- The mechanism must occur only under very special conditions in unique solid materials.

Conclusions

- The LENR phenomenon is real and has the potential to be an ideal energy source.
- Significant energy can be produced using several methods and with simple devices.
- The effect requires use of a special solid material.
- The challenge now is to identify this special material and manufacture it in large amount.

For more information read the book

“The Science of Low Energy Nuclear Reaction”
available at www.worldscientific.com

and

consult the website

www.LENR-CANR.org