The Big Picture of Low-Energy Nuclear Reaction Research

American Nuclear Society – Winter 2012

Steven B. Krivit
Publisher and Senior Editor, *New Energy Times*
San Diego, CA, November 14, 2012

Big Nuclear:
A Mature, Stable Industry

Science:	**Clearly Understood**
Technology:	**Expanding and Improving**
Scale:	**Big**
Cost:	**High**


commodore
PET
2001 Series
personal
computer

LENR is a Young Science

Hints at a Revolutionary Energy Technology

Science:	**Poorly Understood**
Technology:	**Not Yet**
Scale:	**Small**
Cost:	**Low**

March 11,1922 – Wendt and Irion
American Chemical Society

[CONTRIBUTION FROM THE KENT CHEMICAL LABORATORY, UNIVERSITY OF CHICAGO]

EXPERIMENTAL ATTEMPTS TO DECOMPOSE TUNGSTEN AT HIGH TEMPERATURES

BY GERALD L. WENDT AND CLARENCE E. IRION

Received May 8, 1922

... one cubic centimeter of helium from half a milligram of tungsten wire ...

Oct. 22, 1926 – Paneth and Peters

Die Naturwissenschaften

"On the Transmutation of Hydrogen into Helium"

Über die Verwandlung von Wasserstoff in Helium[1]).

Von FRITZ PANETH und KURT PETERS, Berlin.

(Aus dem Chemischen Institut der Universität.)

1. Der Grundgedanke der Arbeit.

In den modernen Fassungen der PROUTschen Hypothese, in den astro-physikalischen Berechnungen der Lebensdauer der Fixsterne und in den radioaktiven Überlegungen über den Ursprung der HESSschen Strahlung wird stets auf die theoretisch zu fordernde Verwandlungsmöglichkeit von Wasserstoff in Helium hingewiesen. Dieses Element

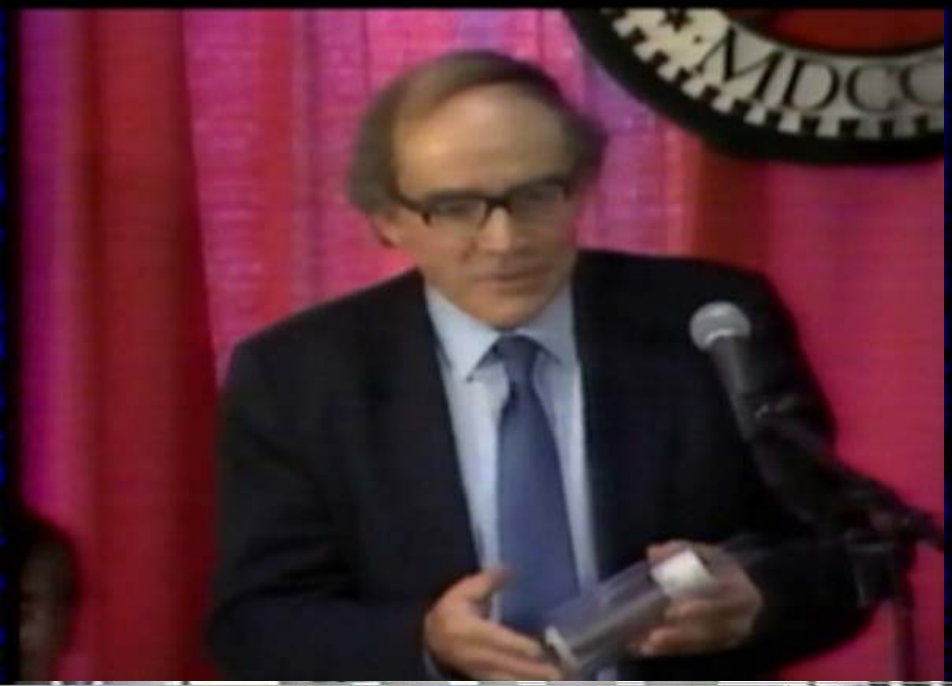
Arten elektrischer Entladungen unter Zufuhr großer Energiemengen daran gearbeitet worden ist.

Nun ist die Reaktion selber vermutlich in höchstem Maße energieliefernd; aus der Massenabnahme der 4 Grammatome Wasserstoff beim Übergang in Helium berechnet sich eine Wärmetönung von $6{,}4 \times 10^{11}$ cal. Es ist daher gar nicht sicher, daß überhaupt Energie zugeführt werden

Feb. 9, 1927: "For the rest of the positive tests even today we cannot give an explanation. But since the majority of our experiments have explained themselves in a 'natural' way, we think it probable will also happen for our outstanding (unexplained up to now) experiments."


Martin Fleischmann ~ Age 22
Bockris ~ Age 23
University of London, Imperial College ~ 1949

March 23, 1989 – Fleischmann and Pons



Low-Energy Nuclear Reactions

Fusion? — No
Nuclear? — Yes
Potentially High Reaction Rates? — Yes

1. Fusion Versus LENR Distinction
2. Theory
3. Experimental Approaches
4. Energy Density

Huizenga's "3 Miracles" of "Cold Fusion"

1. How to overcome the Coulomb barrier
2. Lack of strong neutrons
3. Lack of gamma rays

Theoretical Argument Doesn't Disprove
Huizenga Only Shows Why it is Unlikely

Empirical Distinction

D-D Fusion Versus "Cold Fusion"

THEY LOOK NOTHING LIKE EACH OTHER

D-D Fusion Branches

D+D > **3He** (0.82 MeV) + **n** (2.45 MeV) [~50%]
D+D > **T** (1.01 MeV) + **p** (3.02 MeV) [~50%]
D+D > **4He** (0.08 MeV) + **gamma ray** (23.77 MeV)

Input Inconsistencies

	What Goes In
D-D Fusion	Deuterium Gas
LENR	Deuterium in heavy water or gas, Hydrogen in normal water or gas, Li, C, Pt, Pd, Ti, Ni, Al, W

Some Output Inconsistencies

	D-D FUSION	LENR
Neutrons: Tritium	1:1	**1**: 1,000,000
Neutrons: 4-Helium	10,000,000: **1**	**1**: 10,000,000

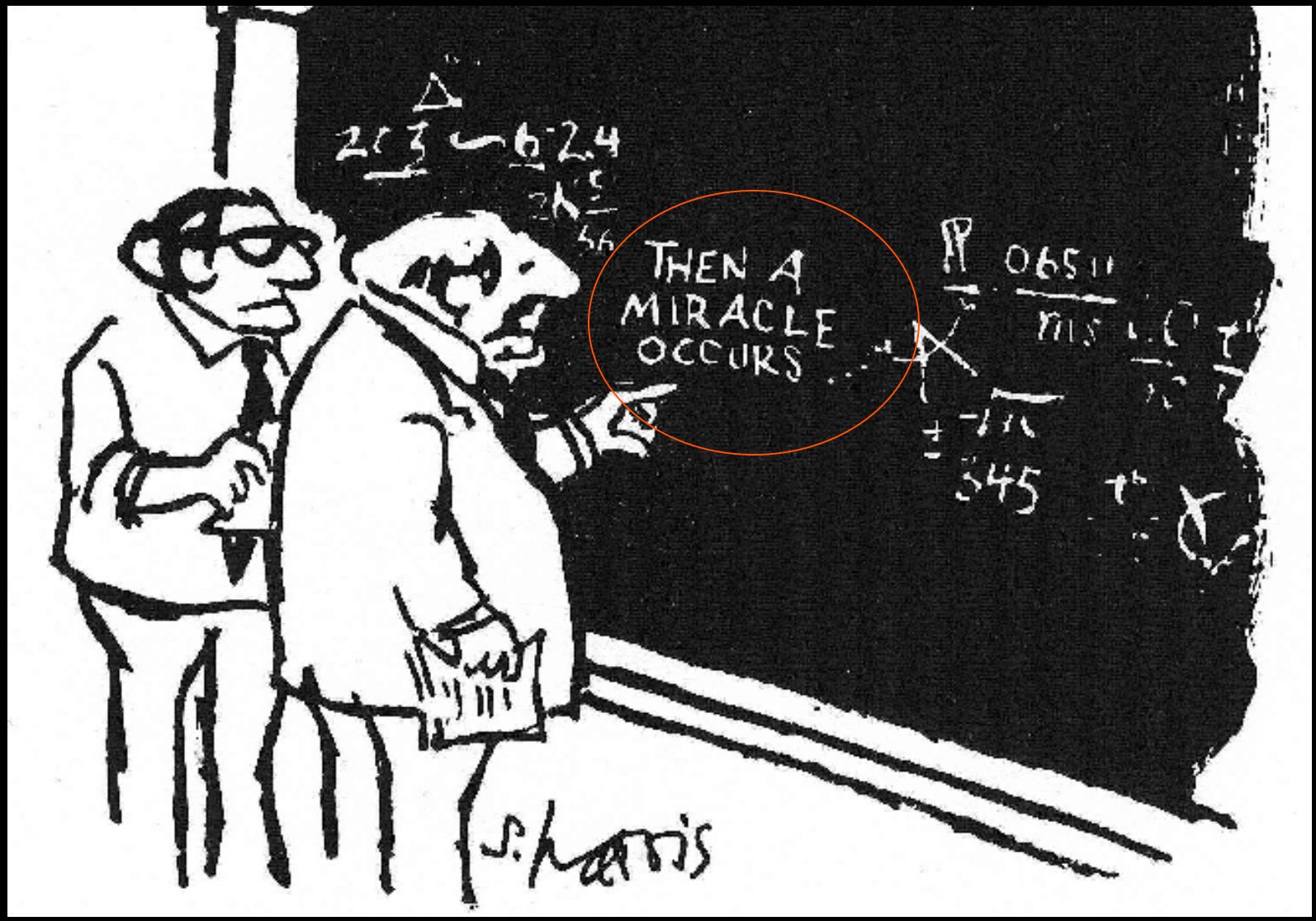
“Cold Fusion” Hypothesis

~1989 “Maybe it favors and mimics the third branch.”

D+D > 4He (0.08 MeV) + [????] (23.77 MeV)

Only D goes in
Only 4He comes out
???? = “New Physics”

Then a Miracle Occurs



"I think you should be more explicit here in step two."

Lots of Assumptions

D+D > 4He (0.08 MeV) + [????] (23.77 MeV)

Solve Hiuzenga's 3 Miracles
???? ("New Physics")
No Other Products or Emissions

Other Products and Emissions

Energetic Alphas [1] **+ Tritium** [2] **+ Low-Flux Neutron Emissions** [2] **+ Isotopic Shifts** [3] **+ Heavy Z Transmutations** [4]

1. Lipson, A.G., Roussetski, A. S., Miley, G. H., Saunin, E. I., "Phenomenon of an Energetic Charged Particle Emission From Hydrogen/Deuterium Loaded Metals," Tenth International Conference on Cold Fusion. 2003. Cambridge, MA

2. BARC Studies in Cold Fusion Government of India Atomic Energy Commission April - September 1989 Edited by P.K. Iyengar and M. Srinivasan December 1989

3. Bush, Ben F. and Lagowski, J.J., "Trace Elements Added to Palladium by Electrolysis in Heavy Water," EPRI TP-108743, November 1999

4. Y. Iwamura, M. Sakano and T. Itoh, Elemental Analysis of Pd Complexes: Effects of D2 Gas Permeation, Japanese Journal of Applied Physics A, 2002, 41, 4642–4648.

It Doesn't Balance

~~D+D > 4He (0.08 MeV) + [????] (23.77 MeV)~~

+ Energetic Alphas [1] **+ Tritium** [2] **+ Low-Flux Neutrons** [2] **+ Isotopic Shifts** [3] **+ Heavy Z Transmutations** [4]

"Cold fusion" believers ignored data the conflicted with their hypothesis.

The Data Disproves “Cold Fusion”

1. Missing or suppressed gamma
2. Wrong neutron to tritium ratios
3. Wrong 4He to neutron ratios
4. Missing 1st branch
5. Missing 2nd branch
6. Invalid “24 MeV” energy balance
7. Heavy Element transmutations
8. Protium-based experiments

LENR Products Observed

Isotopic Shifts - Strongest Scientific Evidence
Tritium
Heavy Z Transmutations
Low-Flux Neutrons
Energetic Alpha Particles
Helium-4
Excess Heat - Weakest Scientific Evidence
Highest Commercial Interest

17 of the 66+ LENR Theories

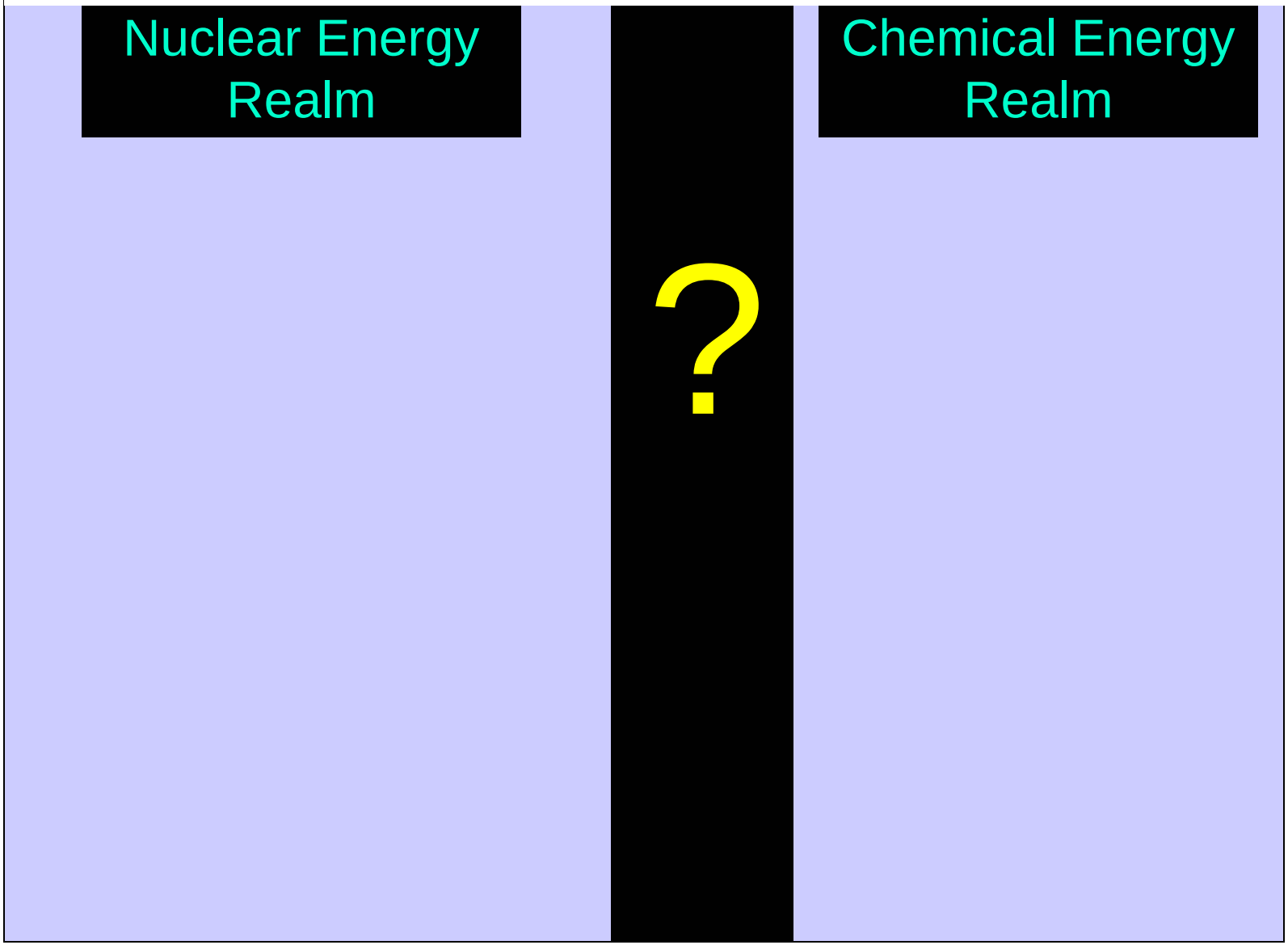
Bazhutov-Vereshkov Theory
Chubb (Scott) Theory
Chubb (Talbot) Theory
Fisher Theory
Gareev Theory
Hagelstein Theory
Hora-Miley Theory
Kim-Zubarev Theory
Kirkinskii-Novikov Theory
Kozima Theory
Li Theory
Preparata Theory
Sinha-Meulenberg Theory
Storms Theory
Szpak Theory
Takahashi Theory
Widom-Larsen Theory

In A Class of Its Own
Widom-Larsen Theory

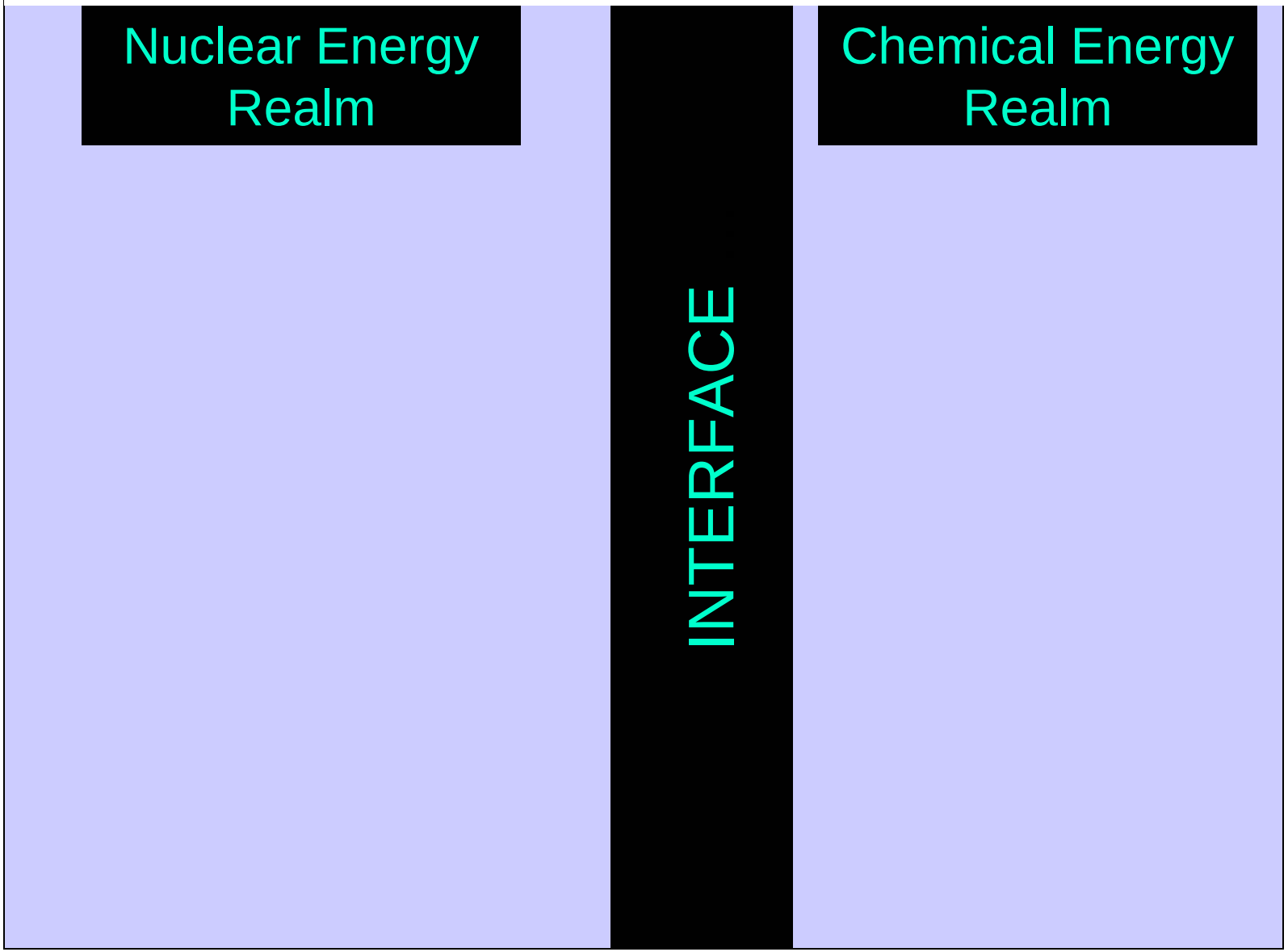
1. No “miracles” to overcome and no “new physics.”
2. Explains most of the better experiments; both deuterium- and hydrogen-based.
3. Larsen can explain concept, from start-to-finish, in plain English, without math.
4. Widom and Larsen can also support their theory with a complete set of mathematics.
5. WLT is the only LENR theory to get any independent endorsement. (DTRA, CERN, SPAWAR, NASA, others)
6. Only LENR theory to show visual examples of data correspondance.

How Do You Get From Chemical to Nuclear in LENRs?

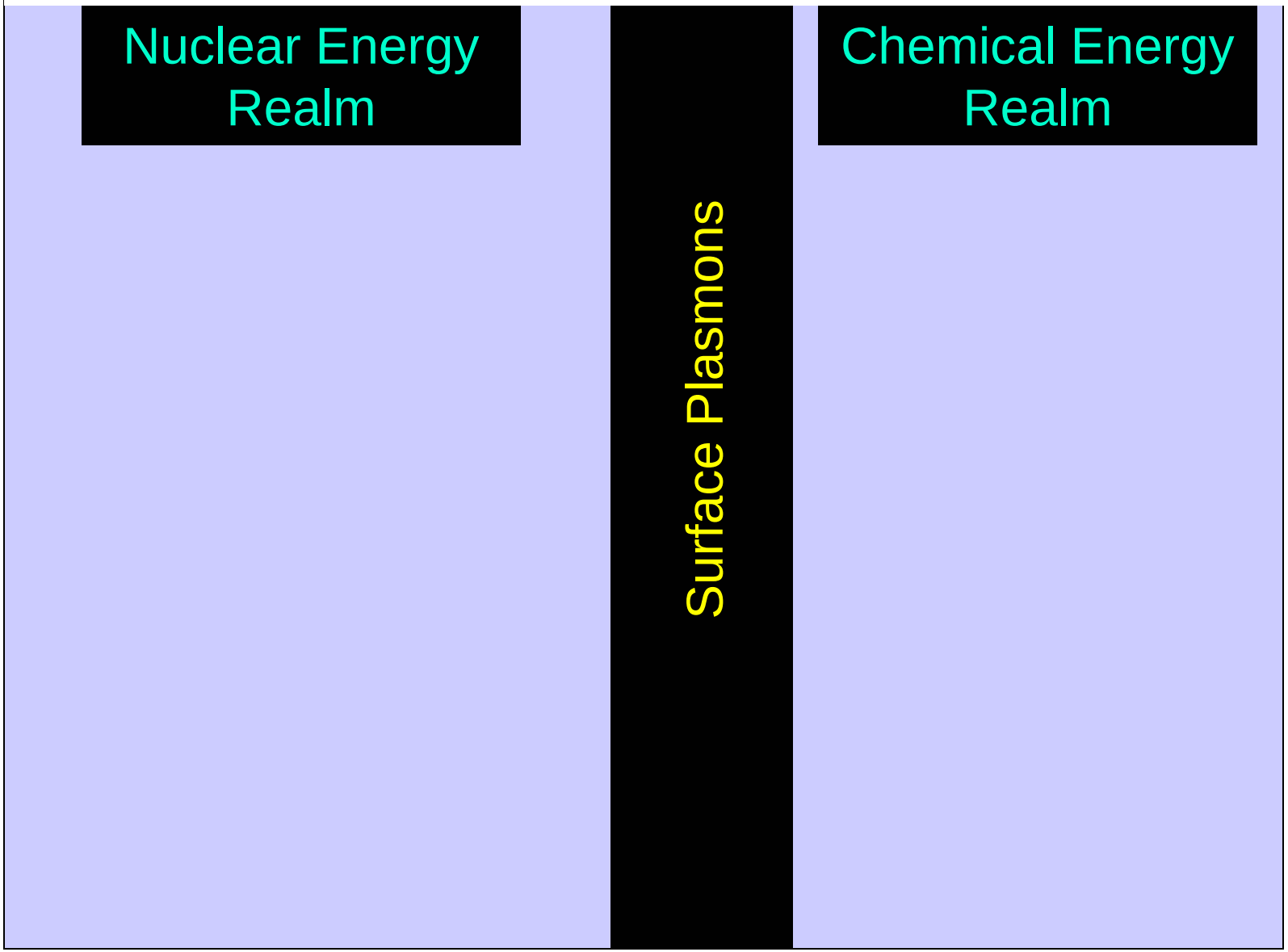
Based on Original Diagram by Lewis G. Larsen



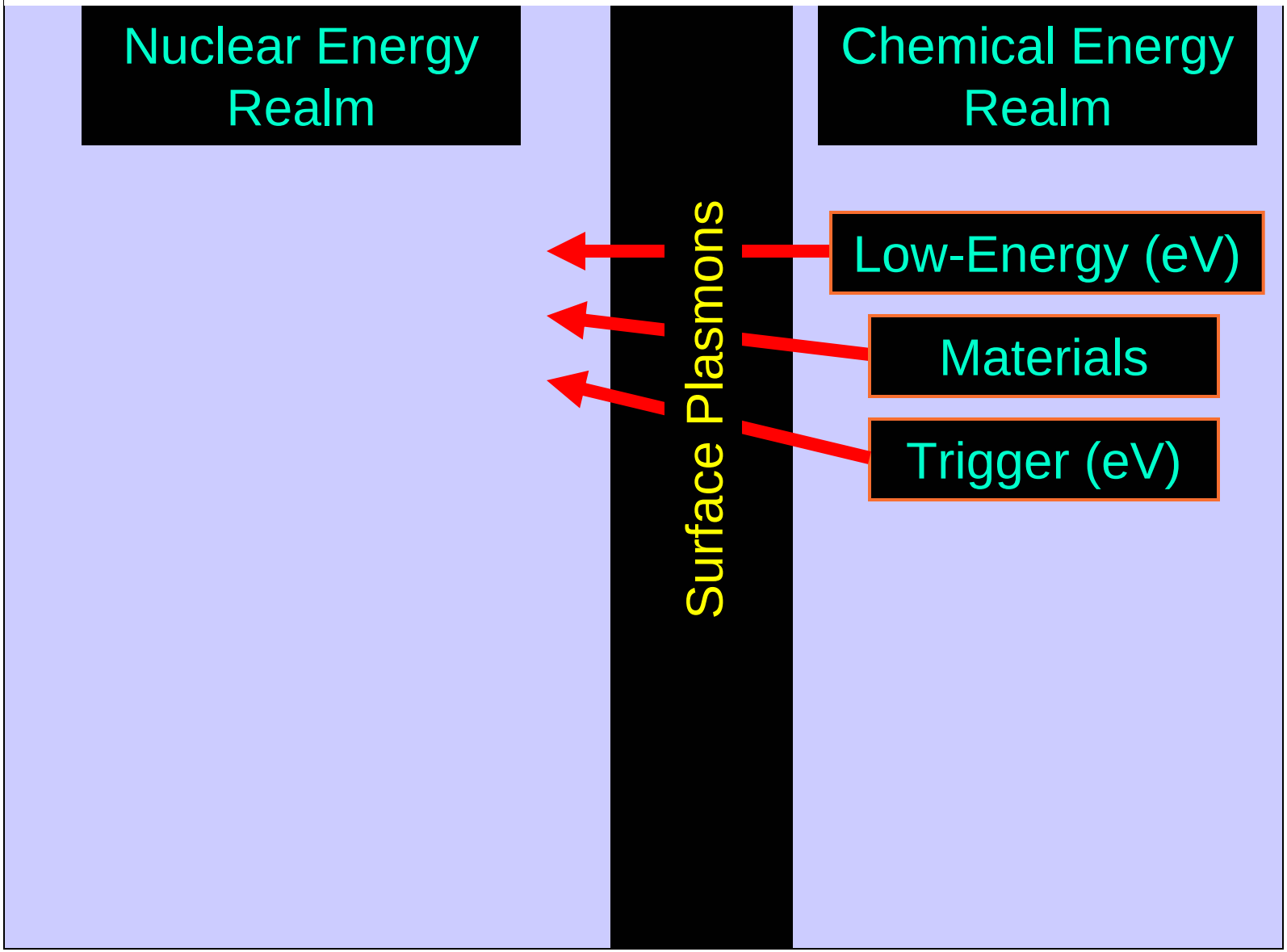
Through an Interface....



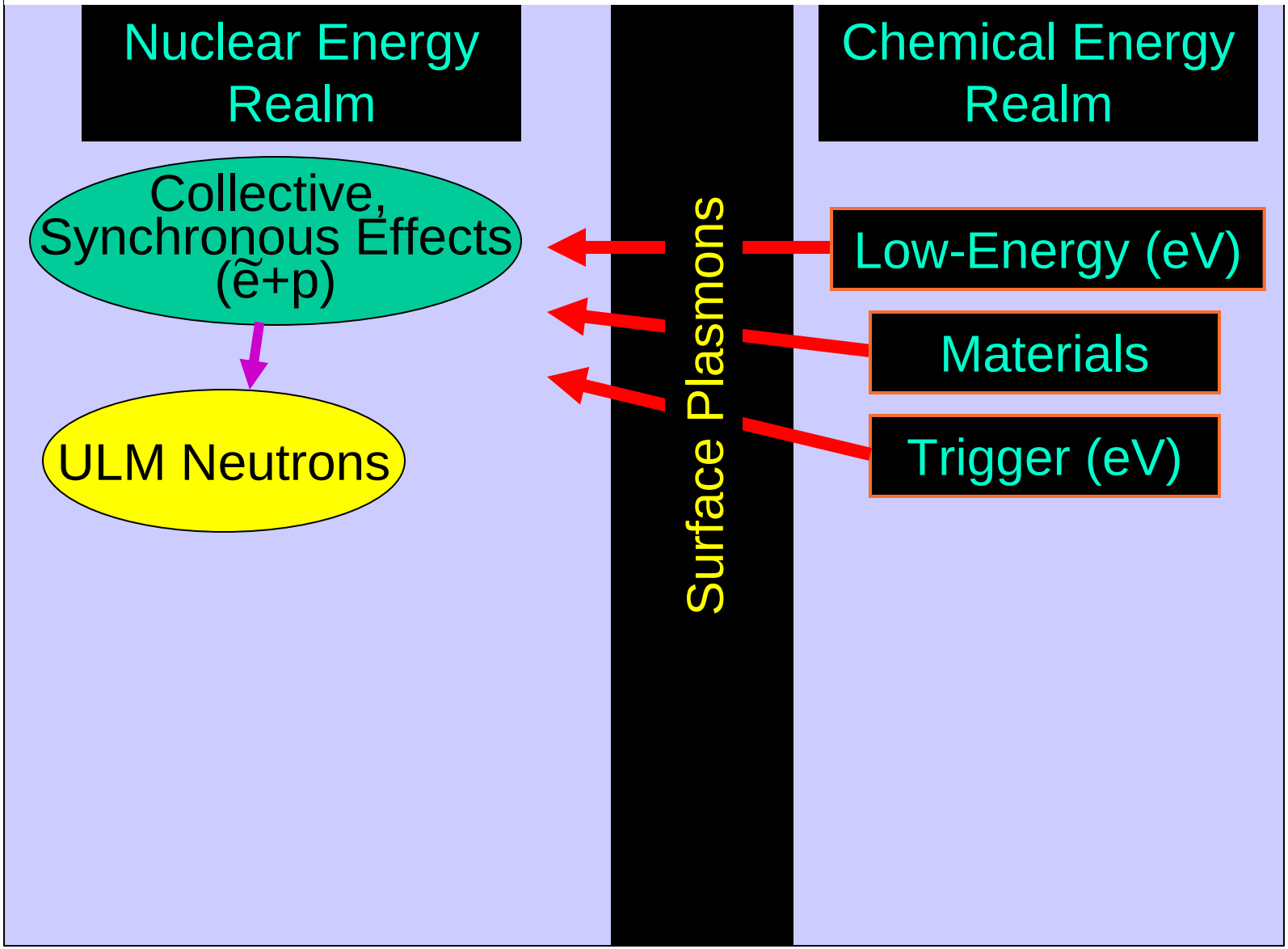
Surface Plasmons Create That Bridge



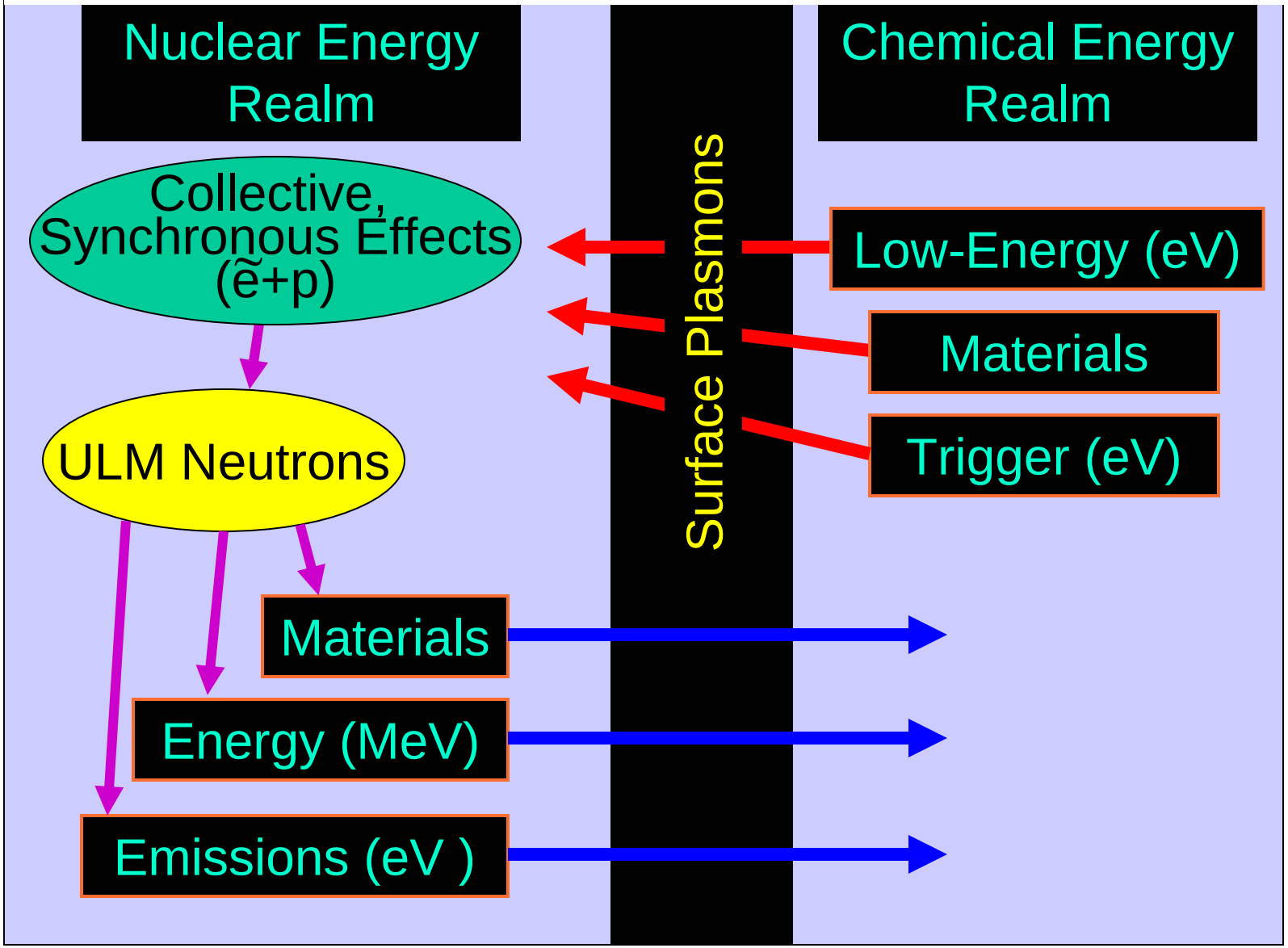
Begin in the Low-Energy Chemical Realm...



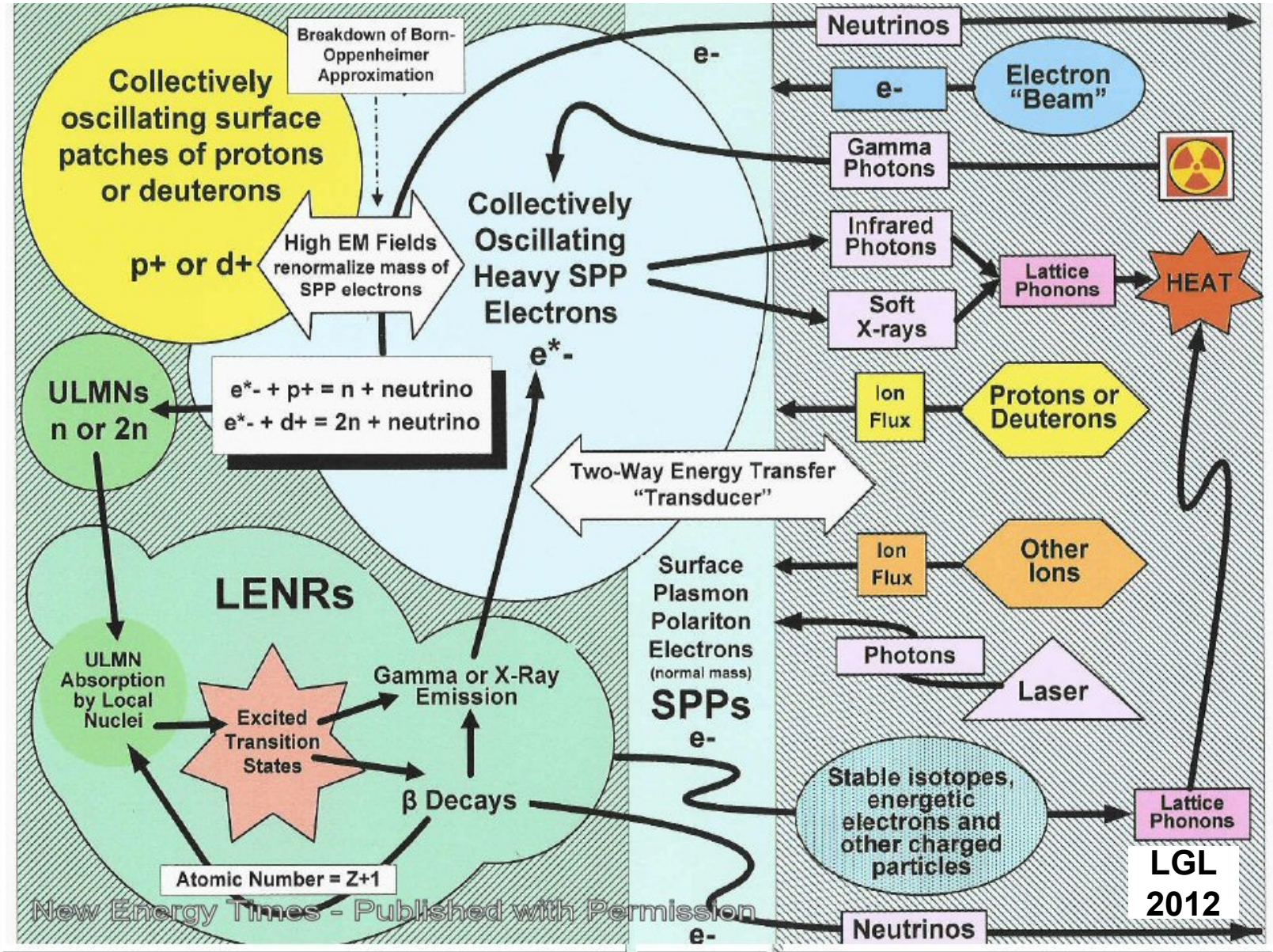
Collective, Synchronous Effects Create Ultra-Low-Momentum Neutrons (Not a 2-Body Interaction)



Once you have available neutrons in the system ...

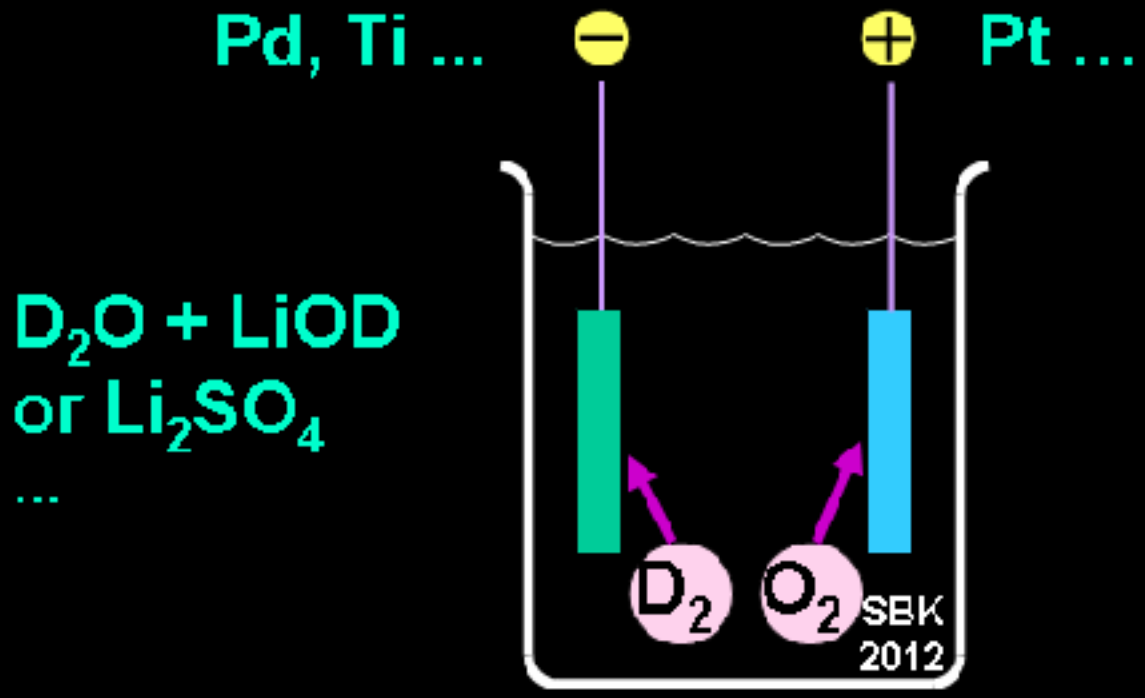


Conceptual Overview of Widom-Larsen Theory of LENRs



A Myriad of Approaches

Electrolysis in Heavy Water



Input and Duration
Less than 5 Watts
Weeks to Months

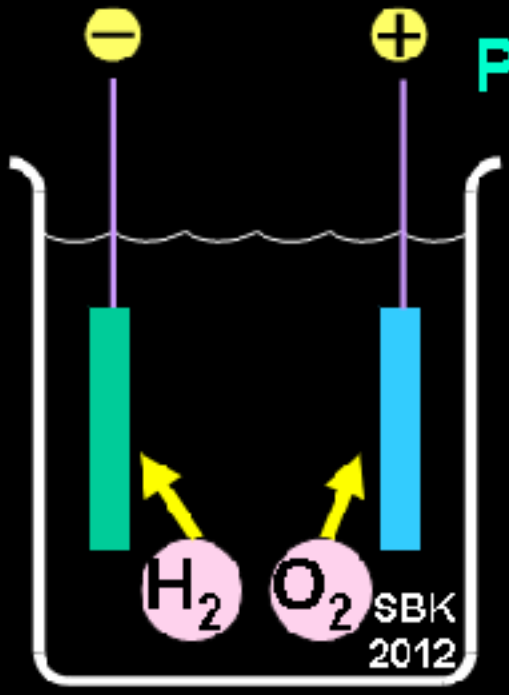
Typical Search
Excess heat

Martin Fleischmann, Stanley Pons, Many Others

Electrolysis in Light Water

Ni, Pd ...

Pt ...



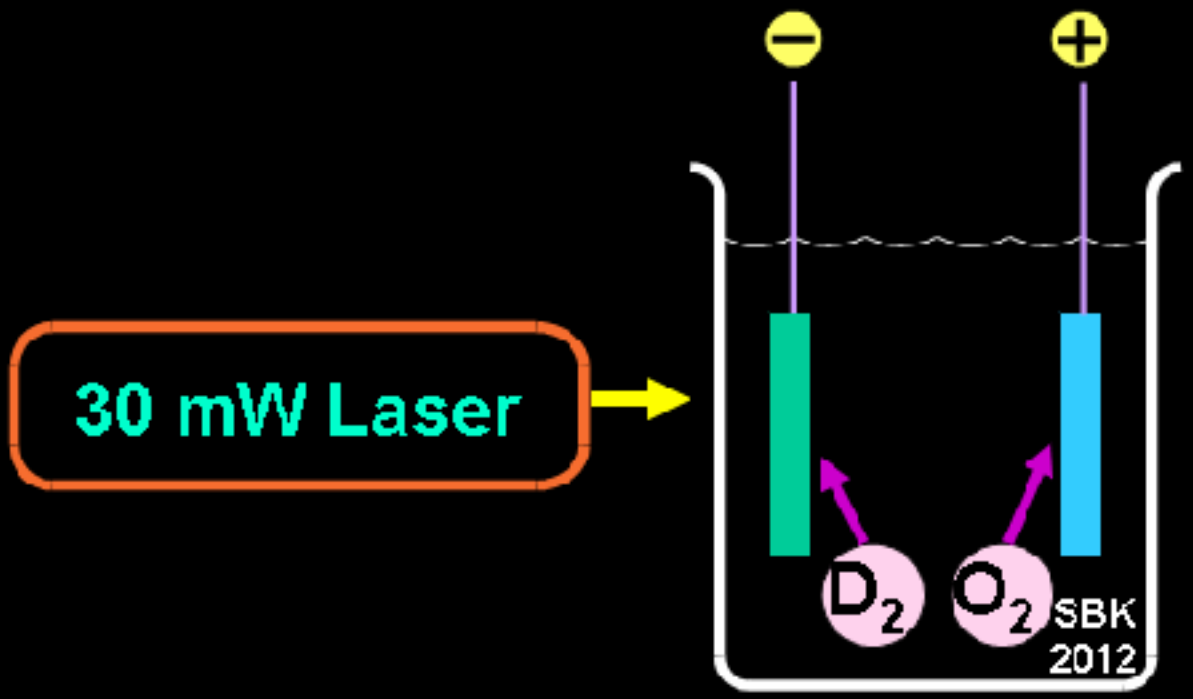
$H_2O + K_2CO_3$
or LiOH or
H_2SO_4 or
$LiSO_4$

Input and Duration
Less than 6 Watts
Days to Weeks

Typical Search
Excess heat, nuclear emissions and transmutations

Randy Mills, John Dash, George Miley, Many Others

Electrolysis with Low-Power Laser



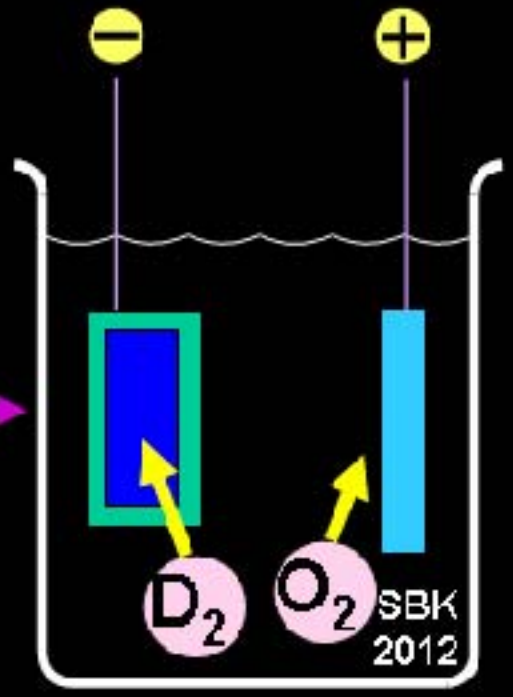
Input and Duration
Less than 5 Watts
Days to Weeks

Typical Search
Excess heat,
nuclear emissions

Dennis Letts, Dennis Cravens, Others

Electrodiffusion

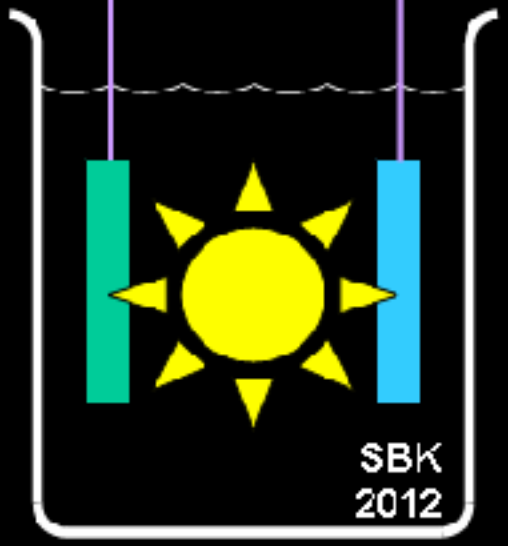
Hollow Core Cathode
Welded Closed After
Filled with Pd Black



Yoshiaka Arata & Yue-Chang Zhang (Japan)

High-Voltage Plasma Electrolysis in D_2O or H_2O

W ... ⊖ ⊕ Pt mesh, C, Steel ...

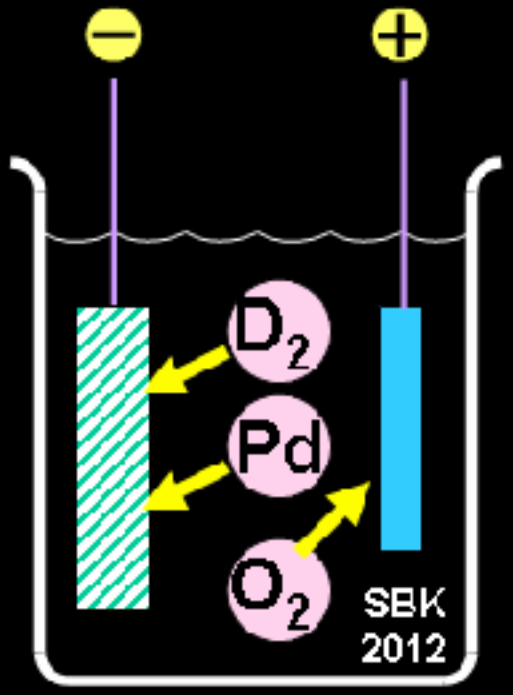


Input and Duration
100 to 800 Watts
Minutes to Hours
Typical Search
Excess heat, nuclear emissions and transmutations

Tadahiko Mizuno (Japan), Domenico Cirillo (Italy)

Electrolytic Co-Deposition

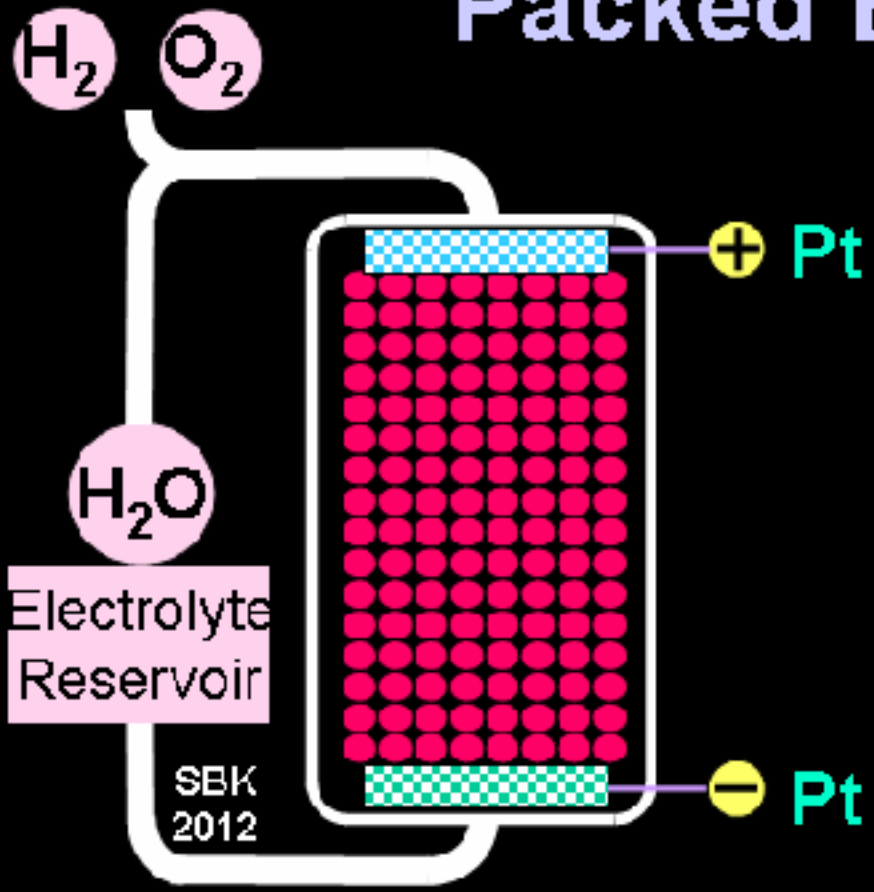
Substrate:
Pt, Au, Ag, Cu



Input and Duration
Less than 5 Watts
Days
Typical Search
Nuclear emissions and transmutations

Stan Szpak, Pamela Mosier-Boss, Melvin Miles (USA)

Thin-Film Electrolysis in Packed Bed



Microspheres coated with Ni or Pd

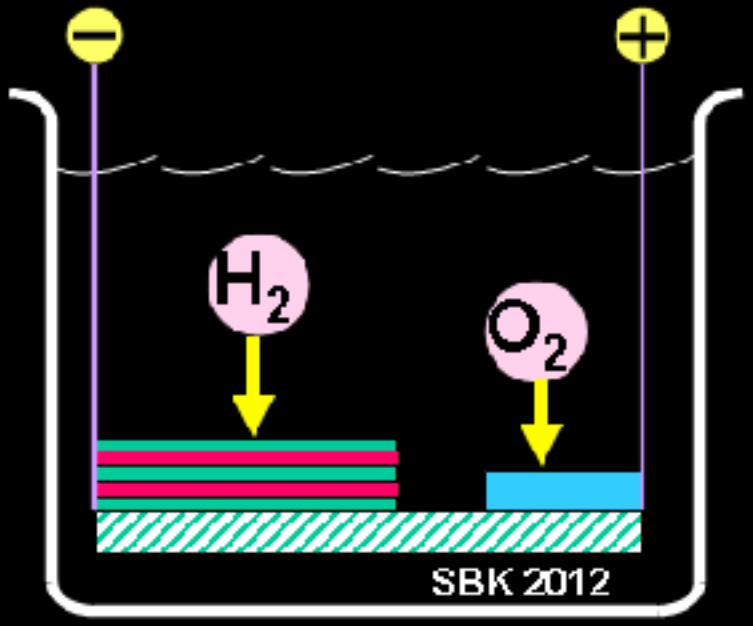
Input and Duration
Less than 6 Watts
Hours to Days
Typical Search
Excess heat, nuclear emissions and transmutations

James Patterson, George Miley (USA)

Thin-Film Electrolysis on Substrate

Substrate: Glass/Quartz

Films: Pd, Ni …

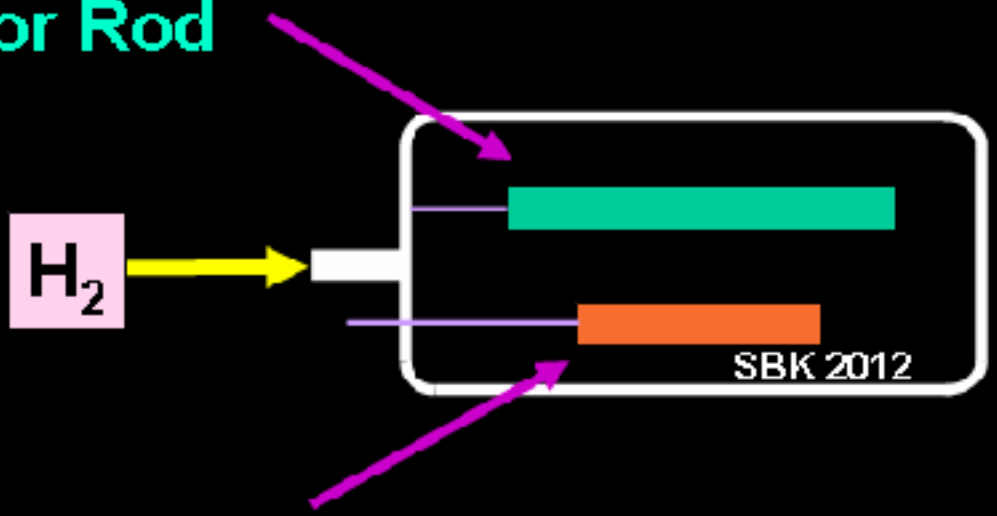


Input and Duration
Less than 6 Watts
Hours to Days
Typical Search
Excess heat, nuclear emissions and transmutations

George Miley (USA)

Gas Loading on Bulk Metal

Treated Ni or Ni Alloy
Wire or Rod



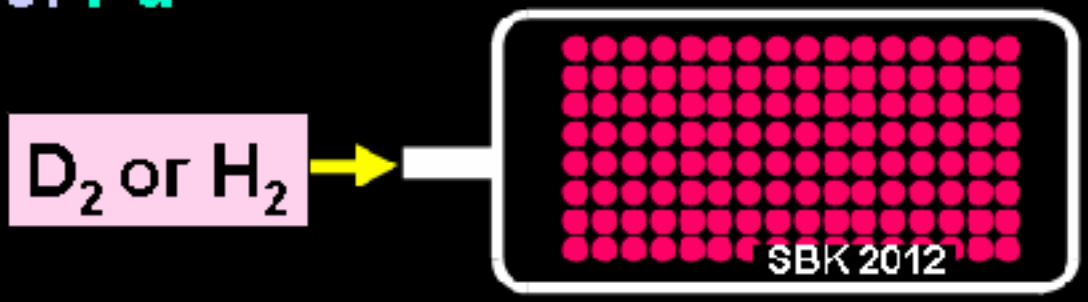
Resistance Heater

Input and Duration
Tens of Watts
Days to Months
Typical Search
Excess heat, nuclear emissions and transmutations

Francesco Piantelli, Francesco Celani (Italy)

Gas Absorption into Nano-Powder

1926: Pd



2012: PdNiZr or NiCuZr Alloy

Input and Duration
Gas Pressure Only
Hours to Days
Typical Search
Excess heat, nuclear emissions and transmutations

Paneth & Peters (Germany) Yoshiaka Arata & Yue-Chang Zhang (Japan), Akira Kitamura (Japan), Brian Ahern (USA)

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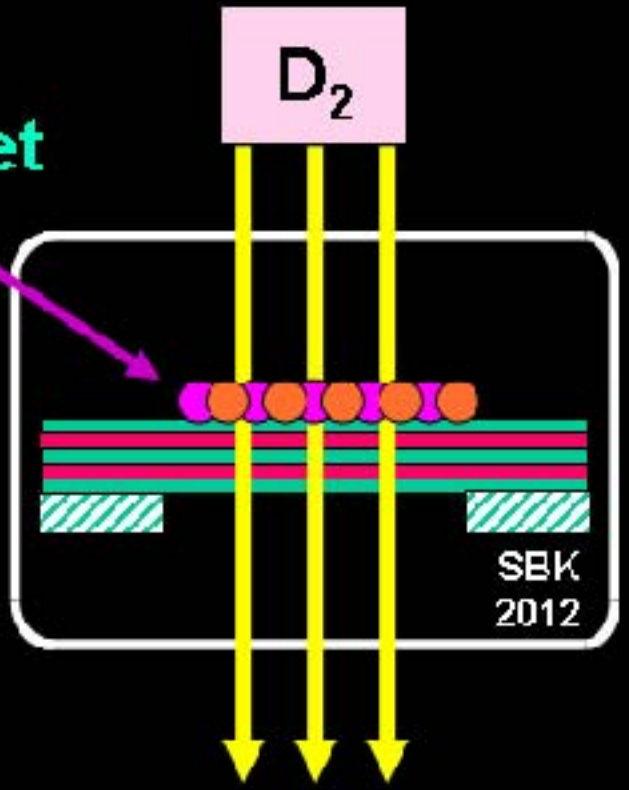
Gas Plasma – Glow Discharge

Cathode: Pd Foils

Input and Duration
6 to 100 Watts
Hours to Days
Typical Search
Excess Heat, Nuclear Emissions and Transmutations

Irina Savvatimova (Russia)

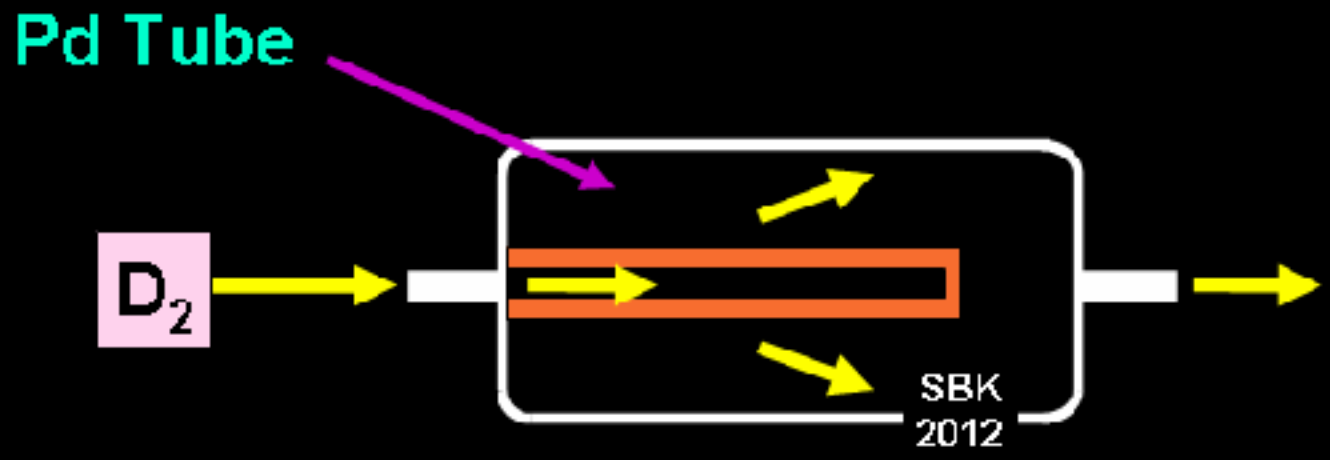
Gas Permeation Through Thin Films



Input and Duration
Gas Pressure, Small Heater
Hours to Days
Typical Search
Nuclear emissions and transmutations

Yasuhiro Iwamura (Japan), Others

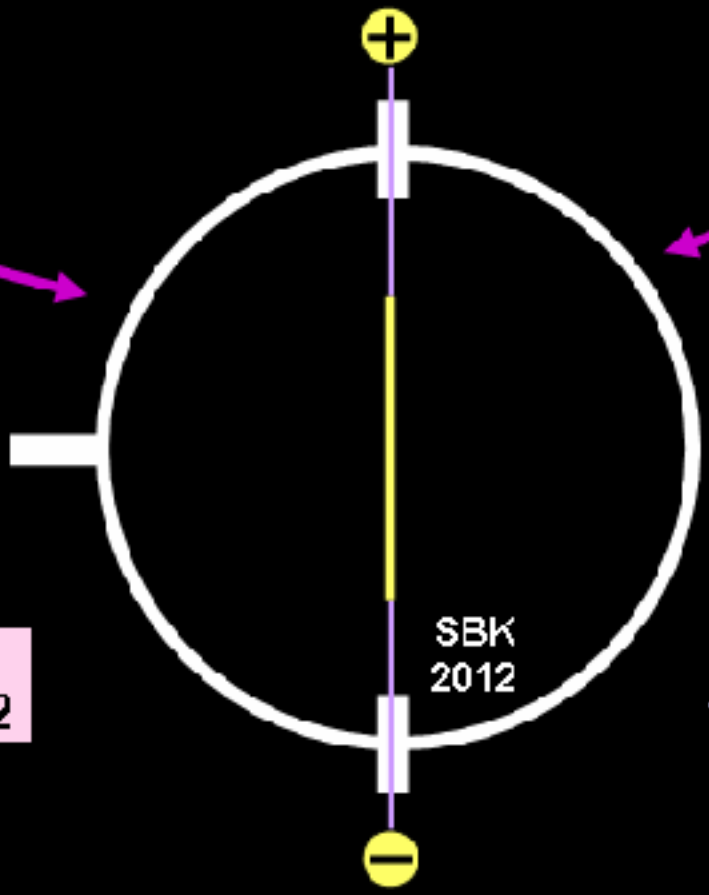
Gas Permeation Through Thin Metals



Input and Duration
Gas Pressure
Days
Typical Search
Excess Heat
and Nuclear emissions

Jean-Paul Biberian (France), Gustave Fralick (USA),
Xing Zhong Li (China)

Exploding Wires



Tungsten Wire

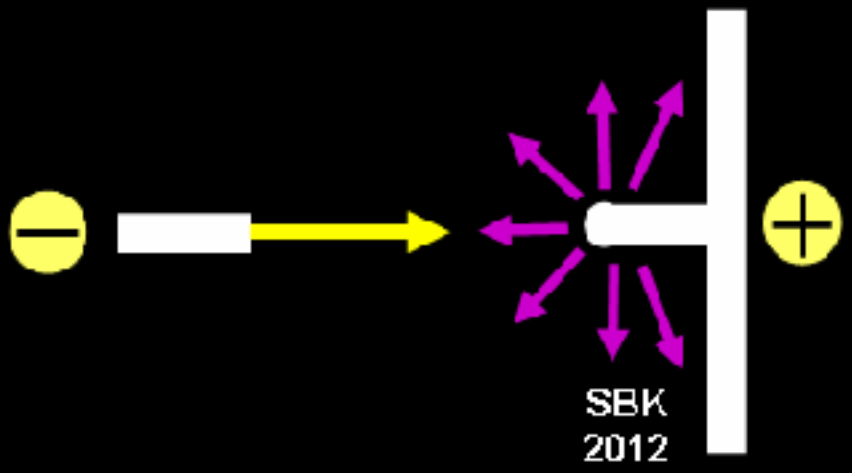
Bulb

Vacuum or Filled with D_2

Input and Duration
Tens or hundreds of Watts
Seconds to minutes
Typical Search
Nuclear Emissions and Transmutations

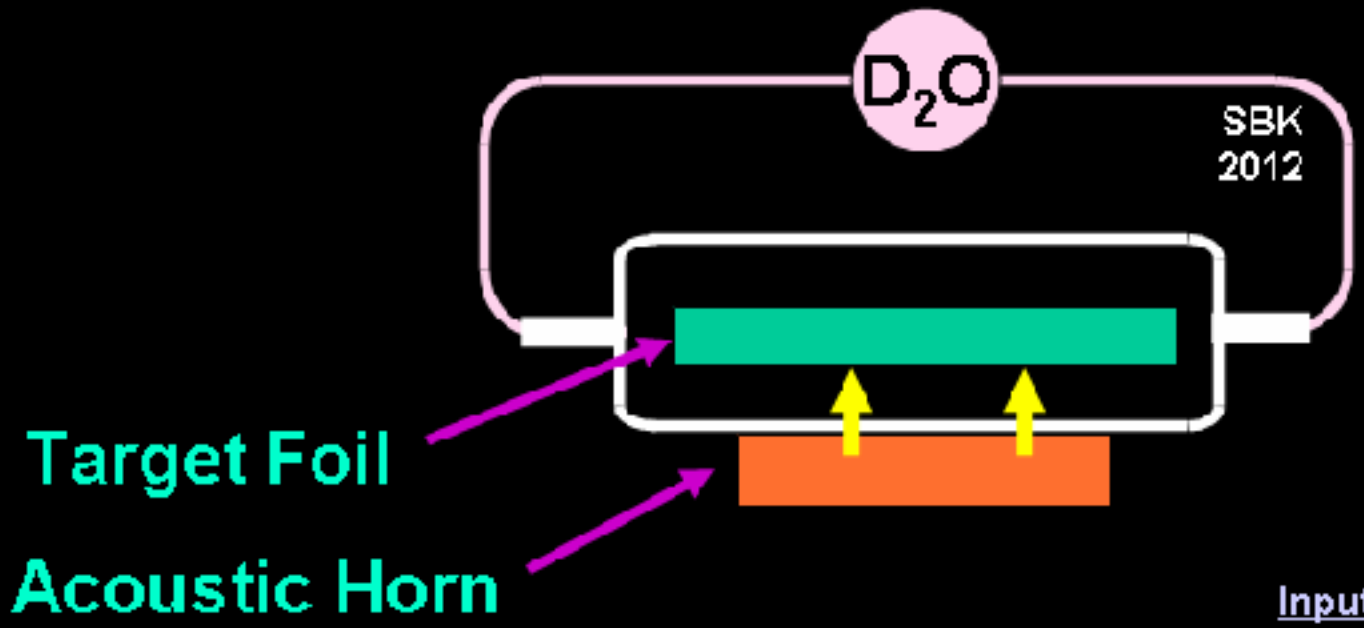
Gerald L. Wendt and Clarence E. Irion (USA, 1922)
Urutskoev, Leonid (Russia, 2002)

Electron Beam Impact



Input and Duration
200J - 2000J
15ns -100 ns
Typical Search
Nuclear Emissions and
Transmutations

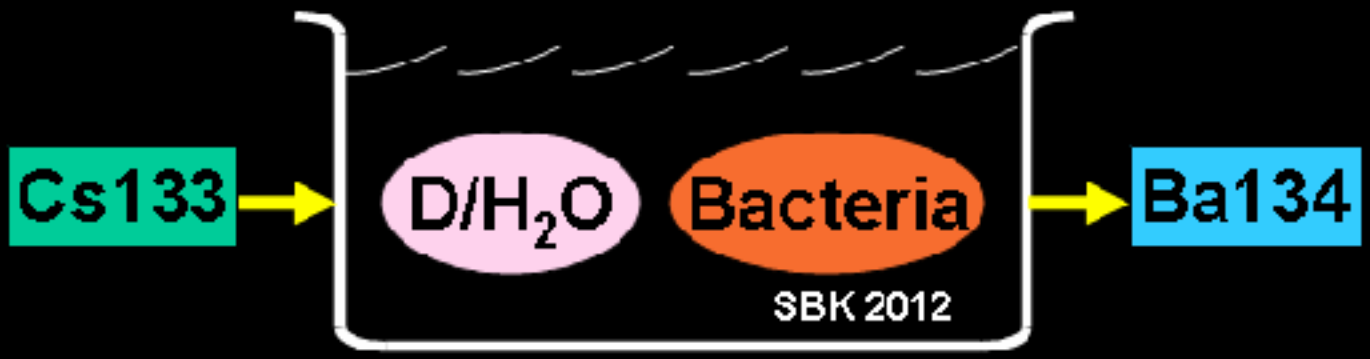
Acoustic Cavitation



Input and Duration
16 Watts
Hours
Typical Search
Excess Heat and
Transmutations

Roger Stringham (USA)

Biological Processes

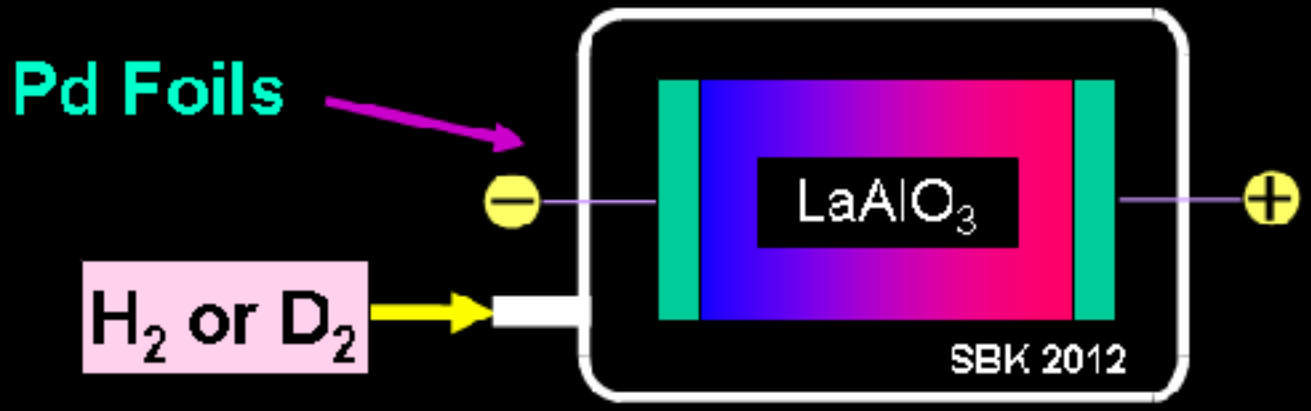


Also: Mn55 → Fe57

Input and Duration
No Input Power
1-100 Days
Typical Search
Nuclear Transmutations of Stable and Radioactive Isotopes

Vladimir Vysotskii and Alla Kornilova (Ukraine and Russia)

Electromigration Through Solid-State Proton Conductors

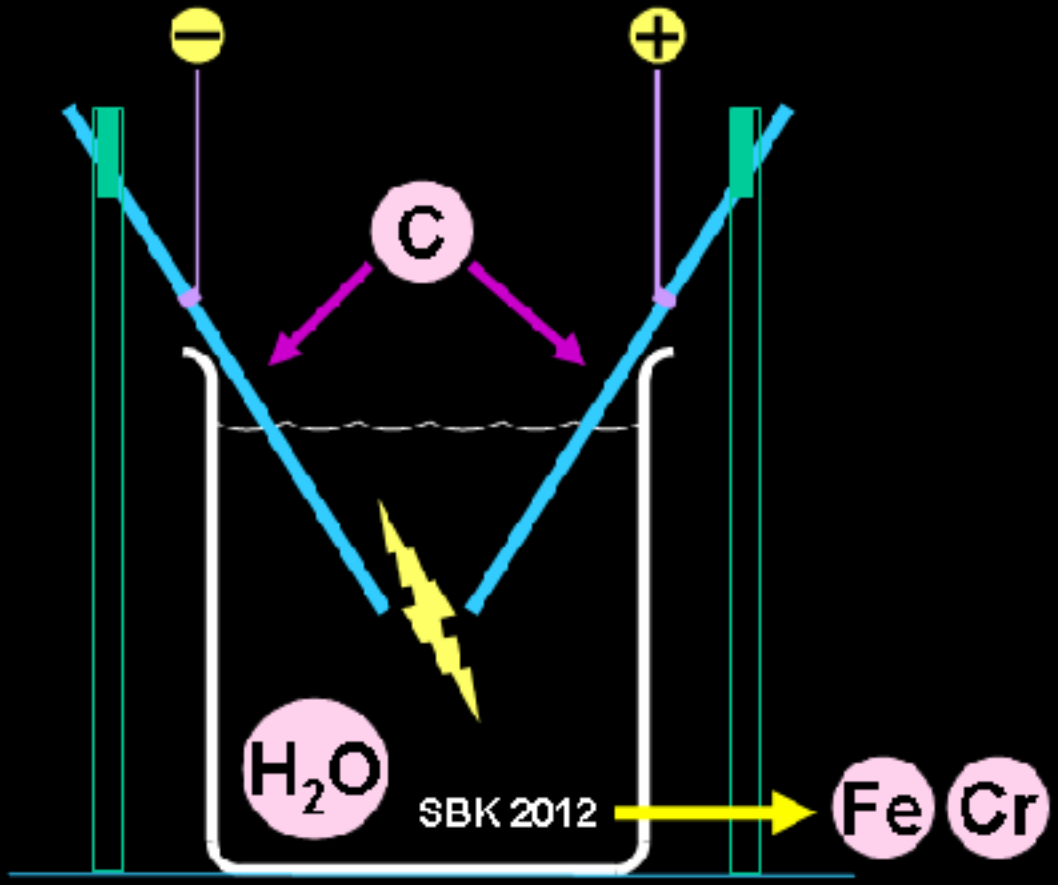


Input and Duration
0.1 – 10 Watts
Minutes to hours
Typical Search
Excess Heat

Mizuno, Tadahiko (Japan), Jean-Paul Biberian (France)

18

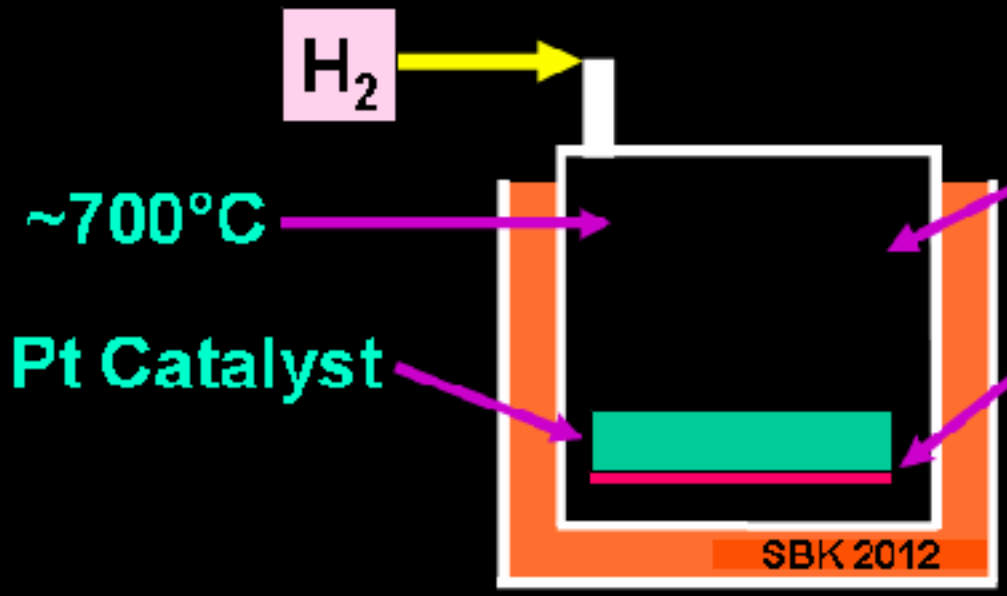
Carbon Arc Experiments



Singh (India), Sundaresan and Bockris (USA)

Input and Duration
10-30 Amps
Hours
Typical Search
Excess Heat and
Transmutations

Petronuclear Hydrogen Loading of Phenanthrene



>5,000x Energy From Coal or Bitumen Without Combustion

Input and Duration
500-1000 Watts
Hours
Typical Search
Excess Heat, Nuclear Emissions and Transmutations

Mizuno, Tadahiko (Japan), Lewis G. Larsen (USA)

Effectiveness of Materials

Original Concept by Peter Gluck

HEALTHY

SICK

DEAD

Energy Density – B. Ahern

2012 H2 Gas Absorption Experiment:

- 21 Watts Excess Heat
- 5 Days
- < 1g Hydrogen Gas (5 Grams CuNiZr Nanopowder)
- 9 Mj Energy Produced
- 9,000 kj/gram of hydrogen gas

DIESEL: 40 kJ per gram

Ahern LENR Experiment = 225x DIESEL

Energy Density – T. Mizuno

1991 D_2O + Pd Closed-Cell Electrolysis:

- 17.5 Liters Vaporized, Zero Input Power
- 8 Days, 120 Watts Heat
- 400 grams D_20
- 8.2×10^4 kj Energy Produced
- 2,050 kJ/gram of D_2O

OCTANE: 48.3 kJ per gram

Mizuno LENR Experiment = 42x OCTANE

Tadahiko Mizuno – "Nuclear Transmutation" pg. 66

Energy Release Per Reaction Type

Data Courtesy Lewis G. Larsen

Reaction Type Data Courtesy L. Larsen – SBK 2012	Typical Avg. Energy Release	Reaction Family	Relative Energy Release
U-235 Conventional Fission	220 MeV	Strong Interaction	1000
H+H Fusion in Stars	27 MeV	Strong Interaction	123
D+T Fusion Reactors	17.6	Strong Interaction	80
Heavy-Water LENRs	~ 22 MeV	Weak Interaction	91
Conservative Value LENRs	0.5 MeV	Weak Interaction	2.25
Light-Water LENRs	~ 0.1 MeV	Weak Interaction	0.45
Blacklight Power "Hydrinos"	Max 0.02 MeV	?	0.09
Hydrogen Fuel Cells	0.0002 MeV	Chemical	0.0001
Combustion of Gasoline	0.0001 MeV	Chemical	0.00005

Energy Density Per Source

Image and Data Courtesy Lewis G. Larsen

LENRs Versus Chemical Energy Sources: Batteries, Fuel Cells, and Microgenerators	
Source of Energy	**Approximate Energy Density (Watt*hours/kg)**
Alkaline Battery	164
Lithium Battery	329
Zinc-Air Battery	460
Direct Methanol Fuel Cell (35% efficient)	1,680
Gas Burning Microgenerator (20% efficient)	2,300
100% Efficient Combustion of Pure Methanol	5,930
100% Efficient Combustion of Pure Gasoline	11,500
LENRs (based on an assumption of an average of 0.5 MeV per nuclear reaction in an LENR system)	**57,500,000** (maximum theoretical energy density – only a fraction would be achievable in practice) **LGL 2012**

0.5 MeV LENR = 5,000x GASOLINE

Promising Energy Source

- No carbon emissions
- No long-term radionuclides
- No strong prompt radiation
- Potential raw materials:
  Nickel, Hydrogen, Oil, Coal, Bitumen

Uncertainties:
Correct material conditions; surface preparations, nanostructure geometries,
Process control
Fabrication costs

New Energy Times

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steven1@newenergytimes.com