What Really Happened With Cold Fusion and Why Is It Coming Back?

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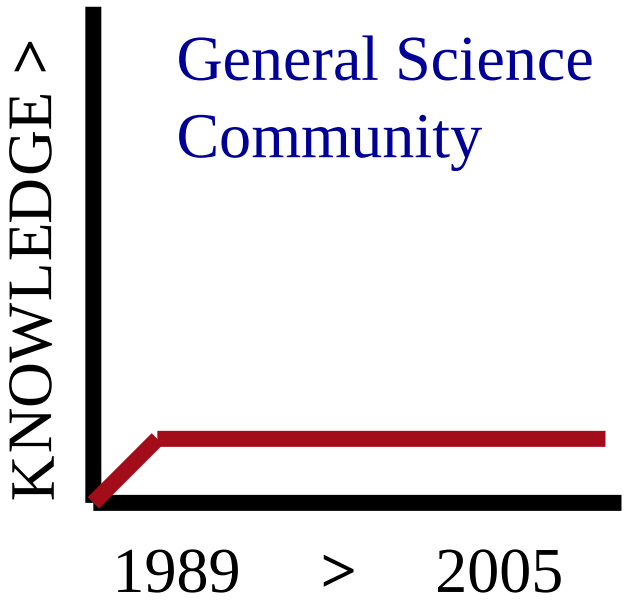
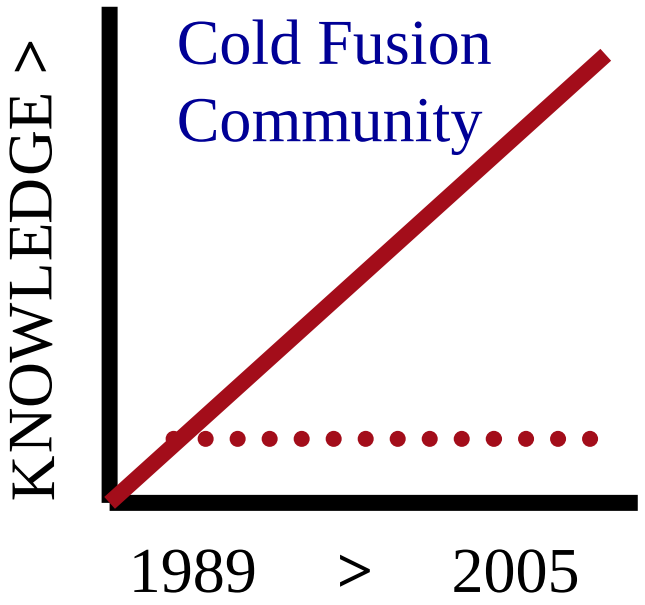
Knowledge Gap

"Cold Fusion Is Dead"

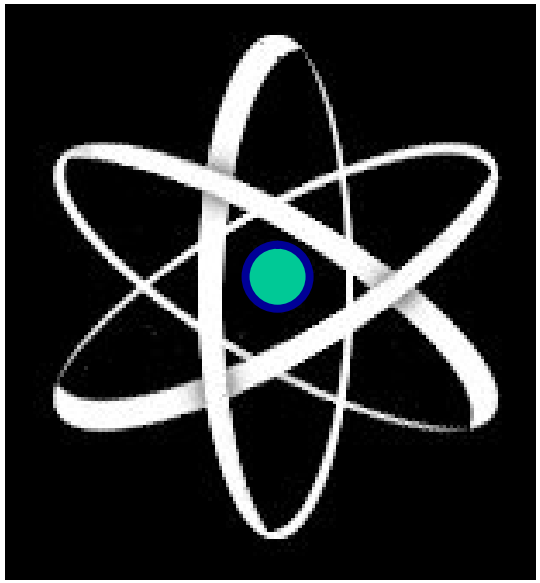


"Cold Fusion Is Alive"

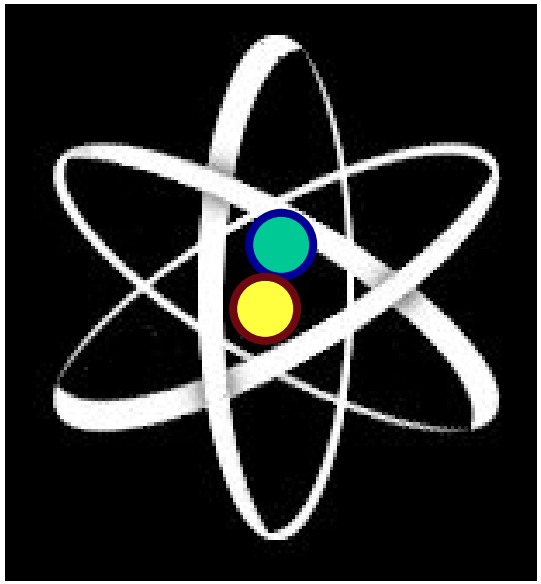


Hydrogen: Cold Fusion's Fuel

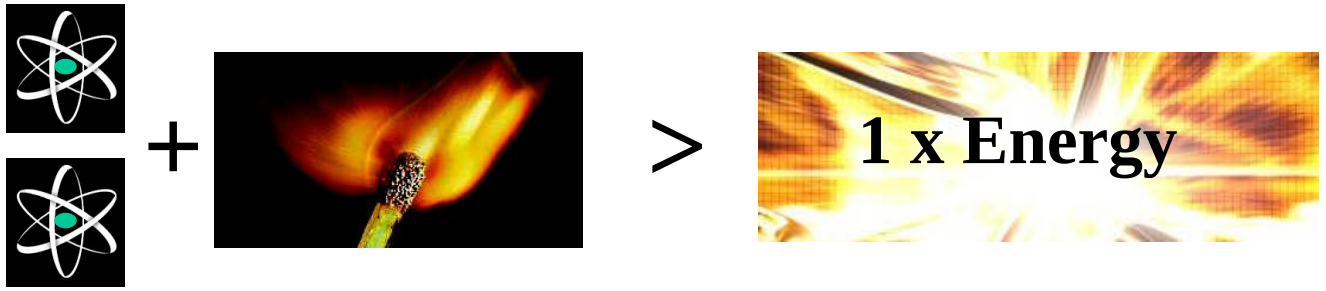
Normal Hydrogen
(one proton)



Hydrogen Isotope: Deuterium
(one proton, one neutron)

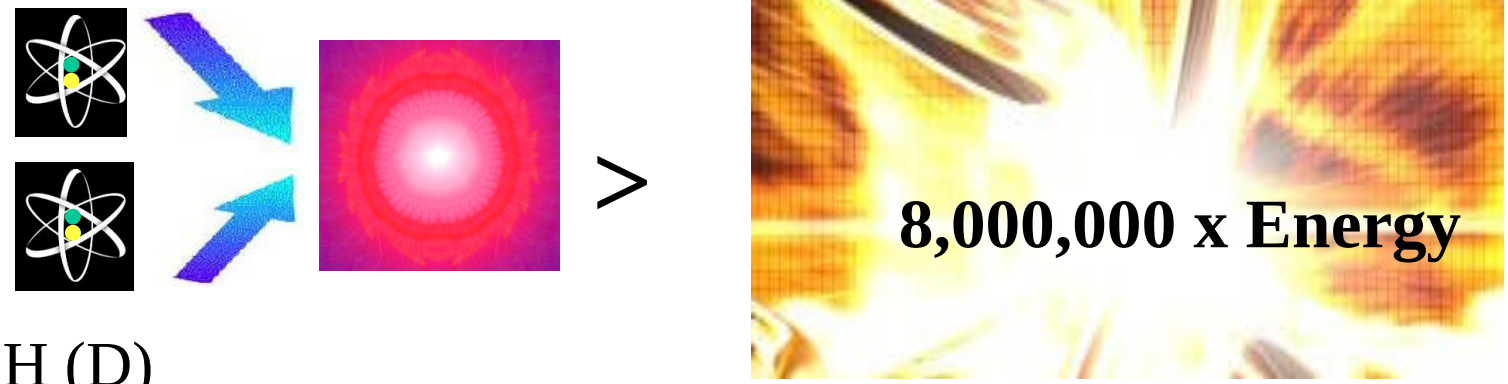


Hydrogen Energy Release



H

Chemical Reaction



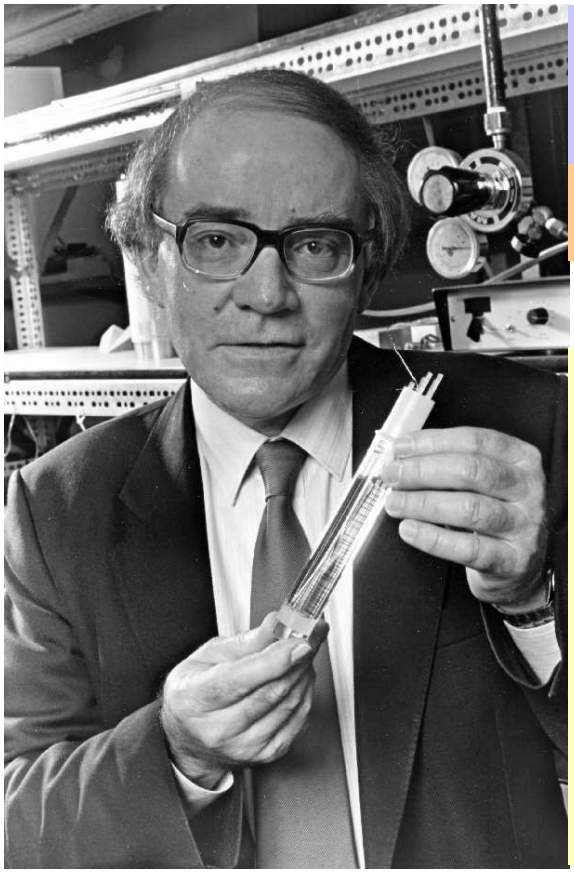
H (D)

Nuclear Fusion Reaction

Hydrogen Fusion Energy Density

One drop of heavy water contains the equivalent energy of 48 gallons of gasoline.

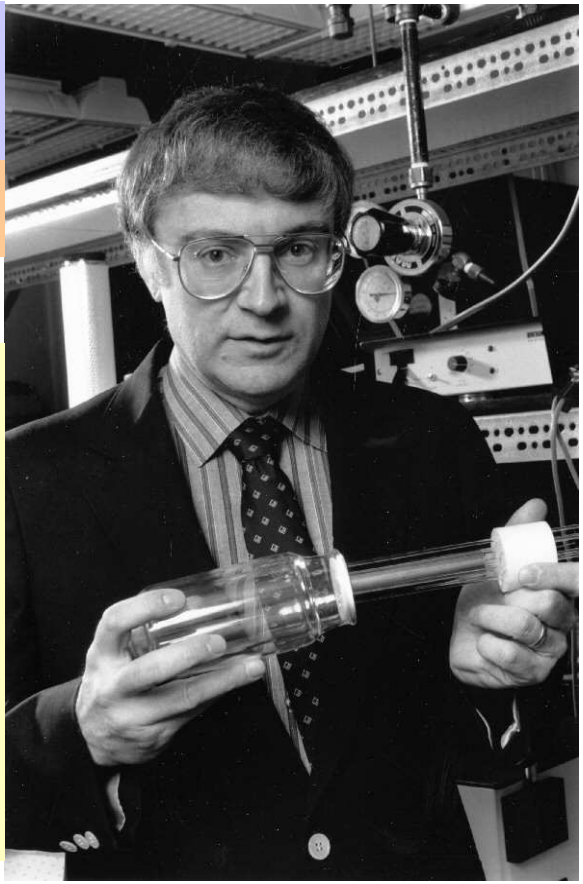
Cold Fusion Is Announced



University of Utah Press Conference

March 23, 1989

1. Deuterium-Deuterium Fusion Reaction
2. Low Temperature
3. Low Neutrons
4. Low Gamma



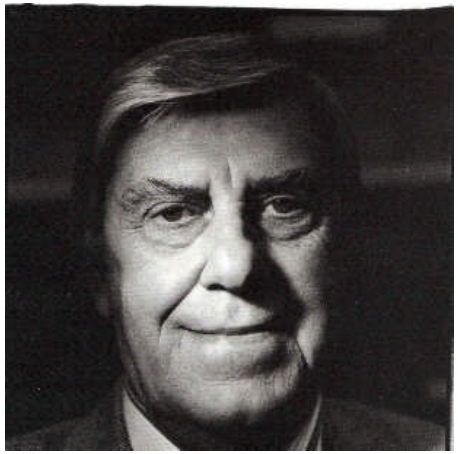
Martin Fleischmann
University of Southampton

Stanley Pons
University of Utah

Cold Fusion Is Discredited and Disproved

Nathan Lewis
Caltech
"No Evidence"

Ronald R. Parker
MIT
"It's Fraud"

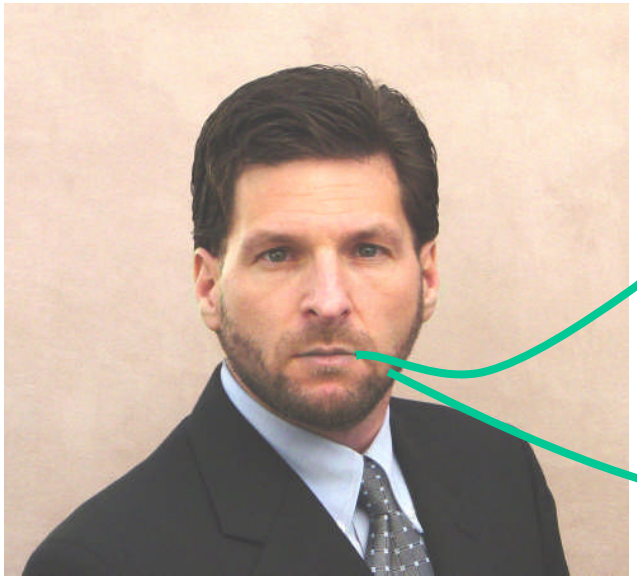


John Huizenga
1989 Dept. of Energy
Cold Fusion Panel
"Cold Fusion: The Scientific Fiasco of the Century"

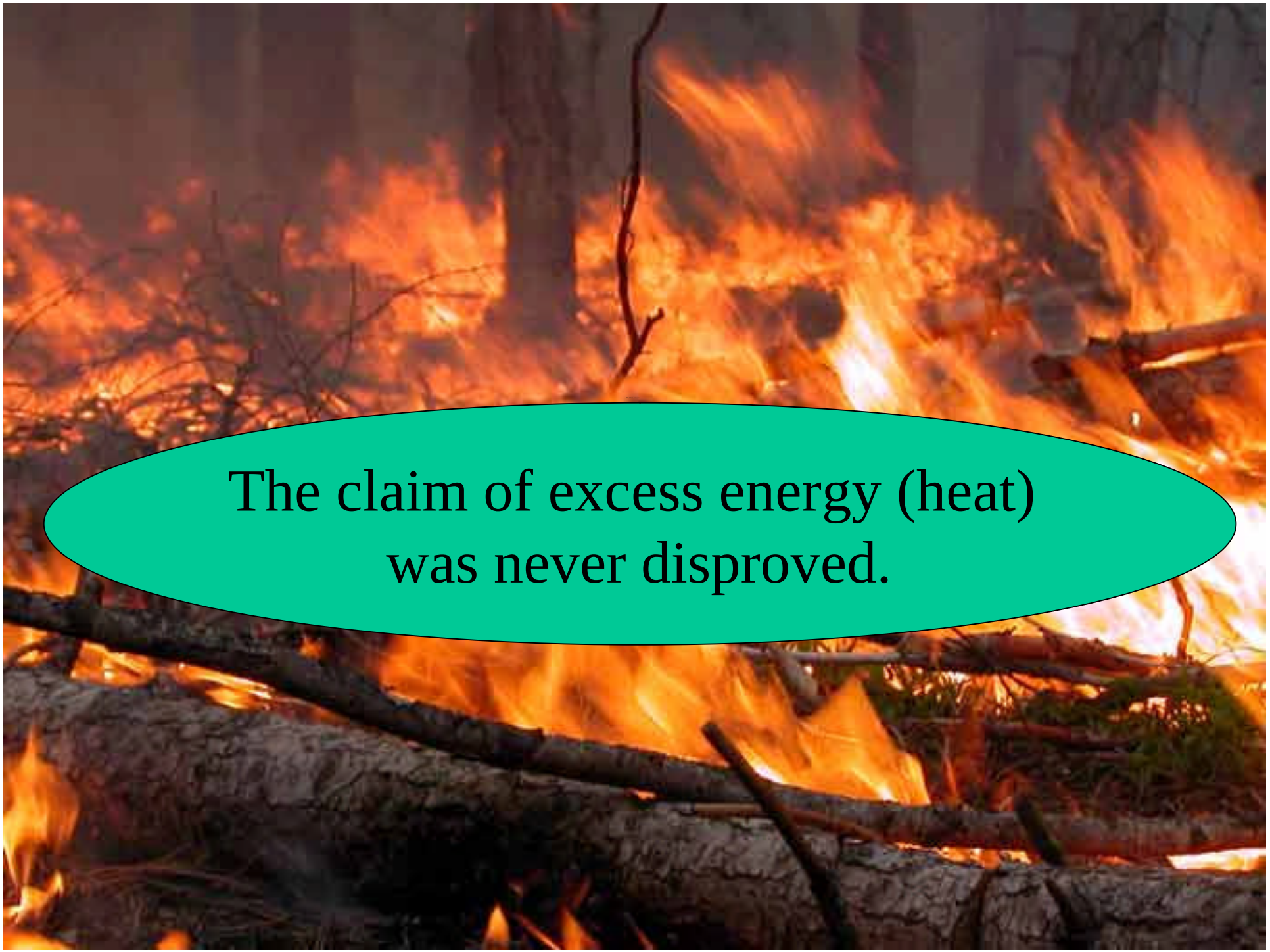
The New York Times : "The Utah claim is dead."

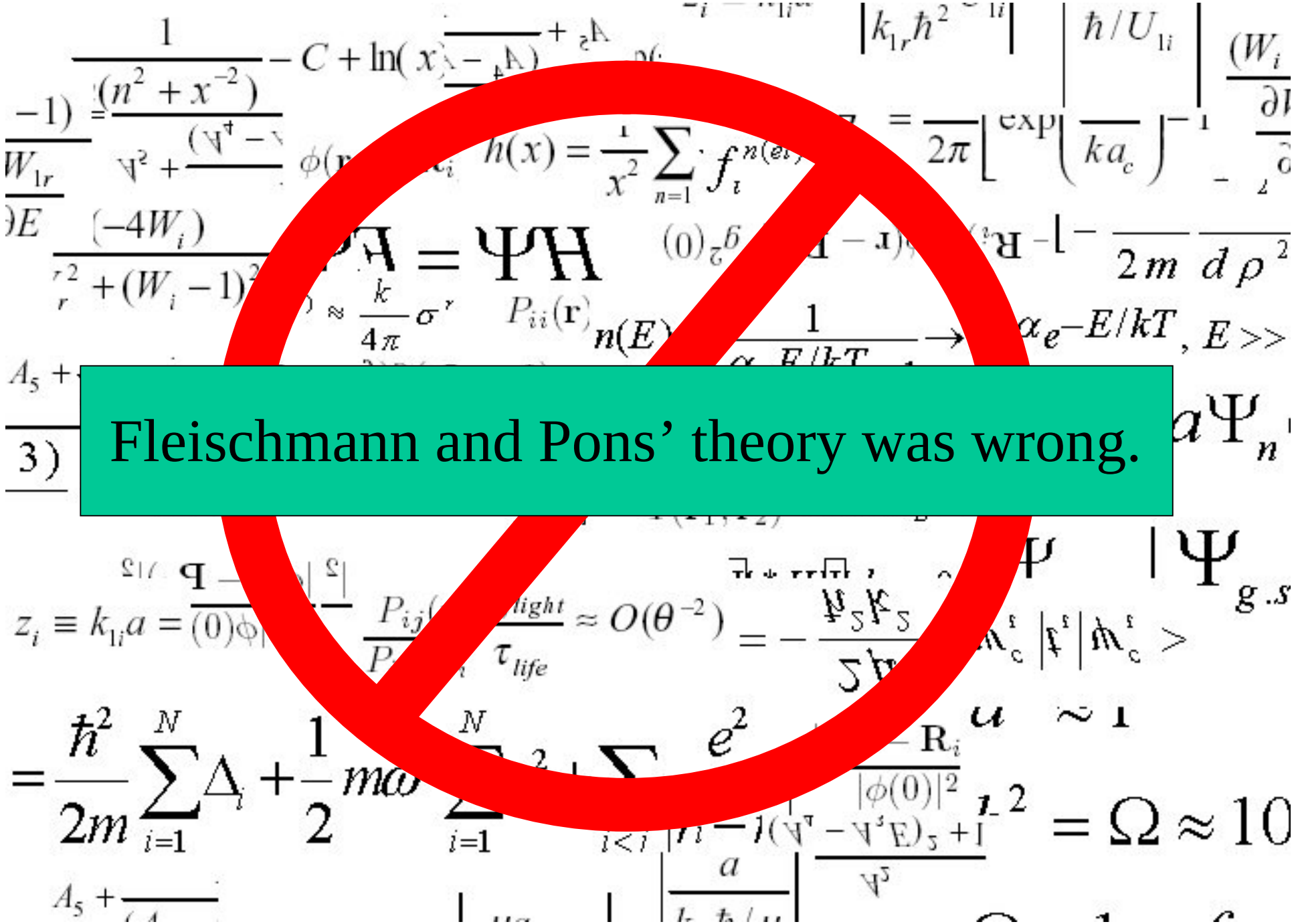
May 3, 1989

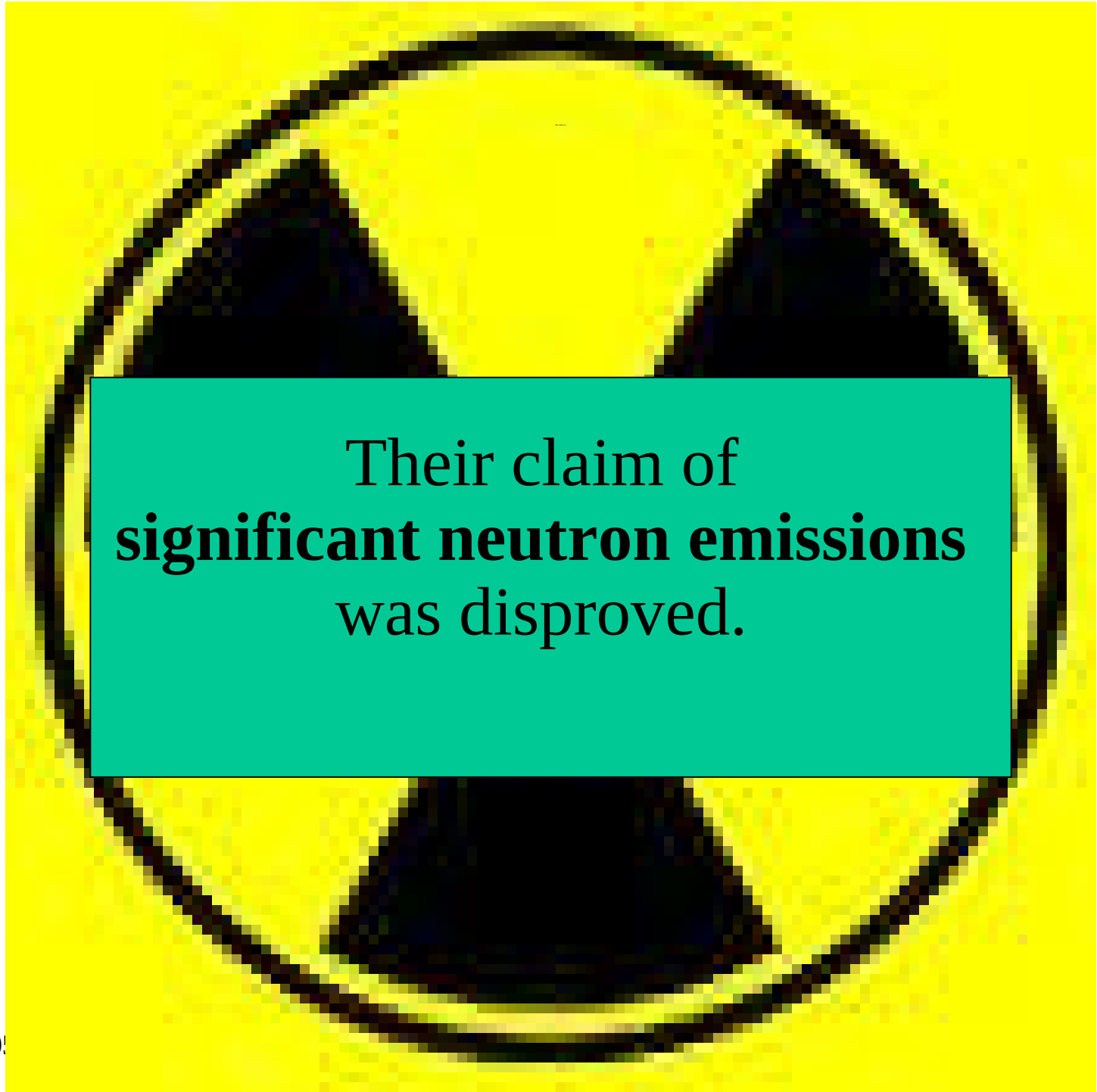
The Question



Considering this history, how can cold fusion be considered real?


The claim of excess energy (heat)
was never disproved.


Fleischmann and Pons' theory was wrong.



False Negatives: Retrospective Reviews

- Eight retrospective reviews performed by 13 scientists.
- Analysis of 1989 work at Caltech, Harwell, M.I.T.
  - –Interviewed Original Research Teams
  - –Inspected Raw Data
- Two Types of Problems Found:
  - Sloppy calorimetry (heat measurements)
  - Experimenter bias

False Negatives: Two Trends

	Number of Studies Reporting		
	Caltech	**M.I.T.**	**Harwell**
Major Errors	**6**	**4**	**3**
Possible Excess Power	**3**	**2**	**1**

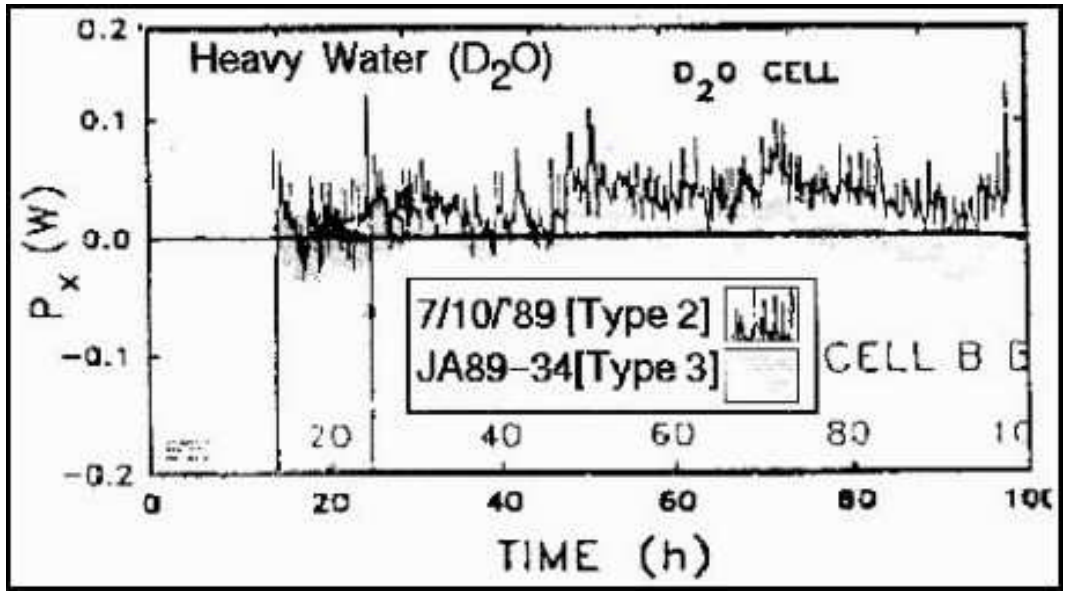
Audit of Caltech Heat Measurements

Caltech “changed their calibration constant every day."

Melvin Miles
University of La Verne

Michael McKubre
SRI International

Data Adjustment at M.I.T.

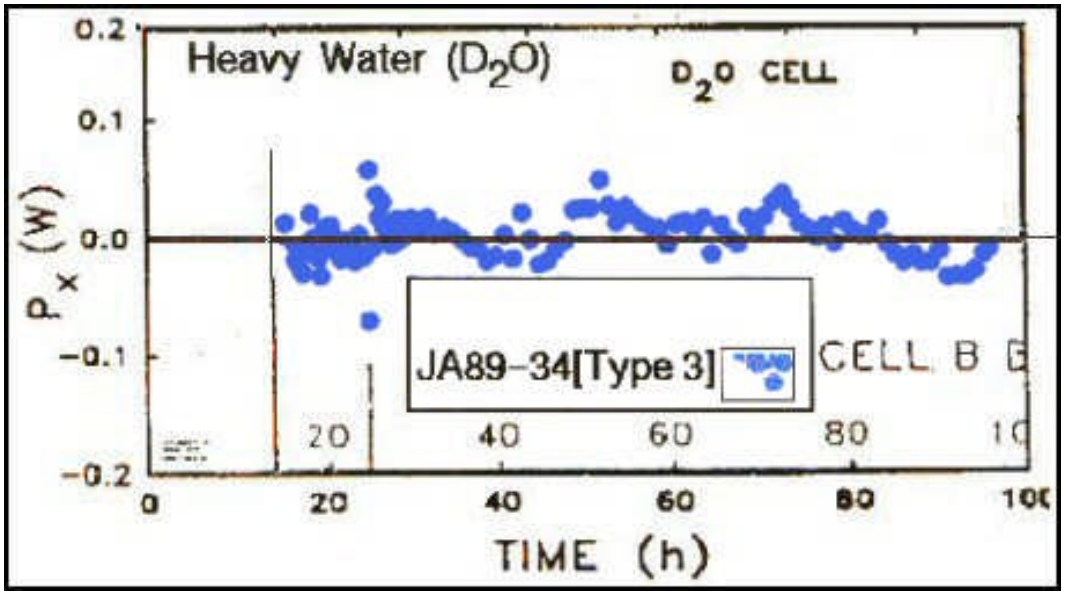


Original data shows possible excess heat (unpublished report).

Eugene Mallove, Chief Science Writer, MIT News Office

Philip Morrison, MIT Professor, Manhattan Project Member

Data Adjustment at M.I.T.



Adjusted data, shown in blue, indicates zero excess heat (published report).

Eugene Mallove, Chief Science Writer, MIT News Office

Philip Morrison, MIT Professor, Manhattan Project Member

Conclusion of Analysts Performing Retrospective Reviews

None claimed that these laboratories showed proof of cold fusion.

- HOWEVER -

The experiments **were more likely to have replicated rather than disproved** the claims of Martin Fleischmann and Stanley Pons.

Unknown Positives: Early Confirmations

- March 25-26, 1991:

  Alan J. Bard, Howard Birnbaum, Charlie Barnes

  Audit SRI International cold fusion experiment;
  Privately report evidence of excess heat to EPRI.

- October 19, 1993:
  Richard Garwin, Nathan Lewis
  Audit SRI International cold fusion experiment;
  Privately report evidence of excess heat to EPRI and Pentagon.

Unknown Positives: Early Confirmations

Amoco Oil - 1994

Shell Oil - 1995

Early Confirmations: Summary

Number of Studies	Reporting
8	**Excess Power**
0	**Major Errors**
4	**Helium-4**
2	**Tritium**
3	**A chemical origin of the excess heat was impossible**

Not a Chemical Reaction!

Richard Garwin,
receiving presidential award

"... on cells L3 and L4, we note that a chemical reaction involving the Pd at perhaps 1.5 eV per atom would **correspond to about 3.5 kJ of heat**; this is to be compared with the **3 Mj of "excess heat" observed**, so such an excess could not possibly be of chemical origin."

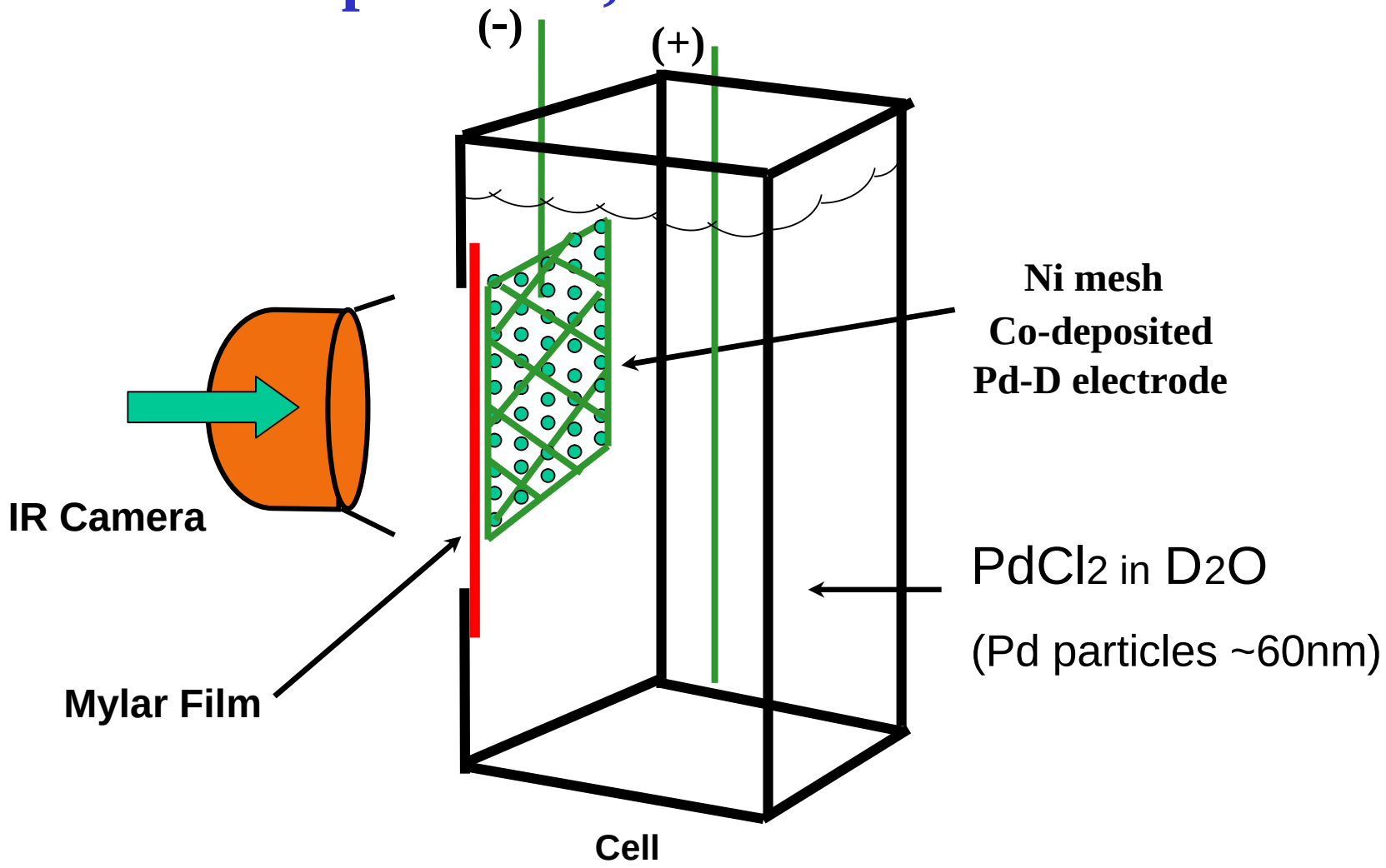
1993 Private Report to EPRI and the Pentagon

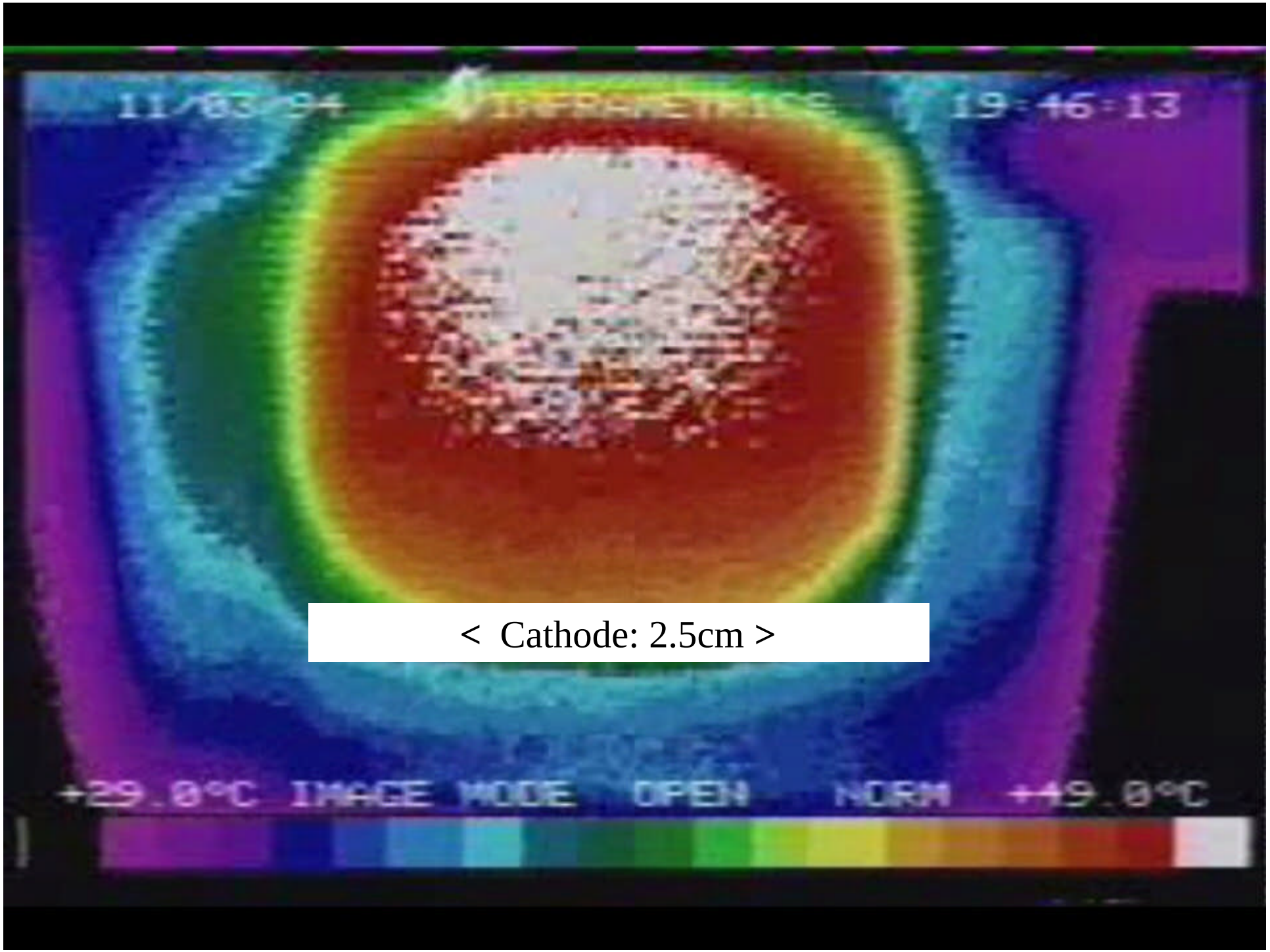
Cold Fusion
Research Developments

- A Brief Sample -

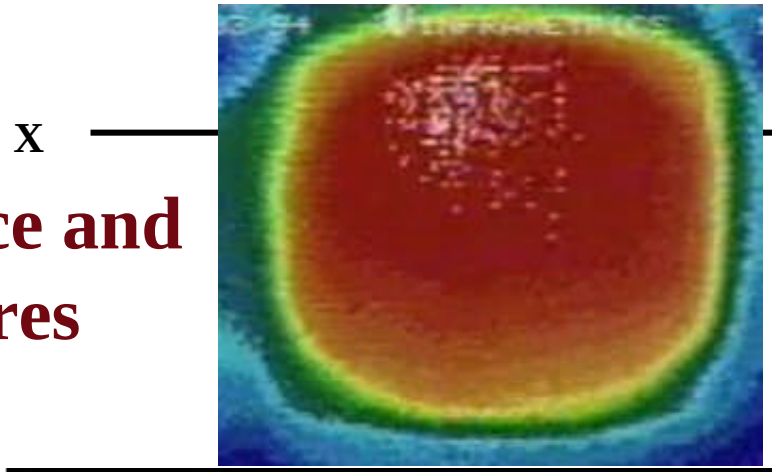
“Hot Spots” on the Palladium Cathode

Szpak et al., SPAWAR

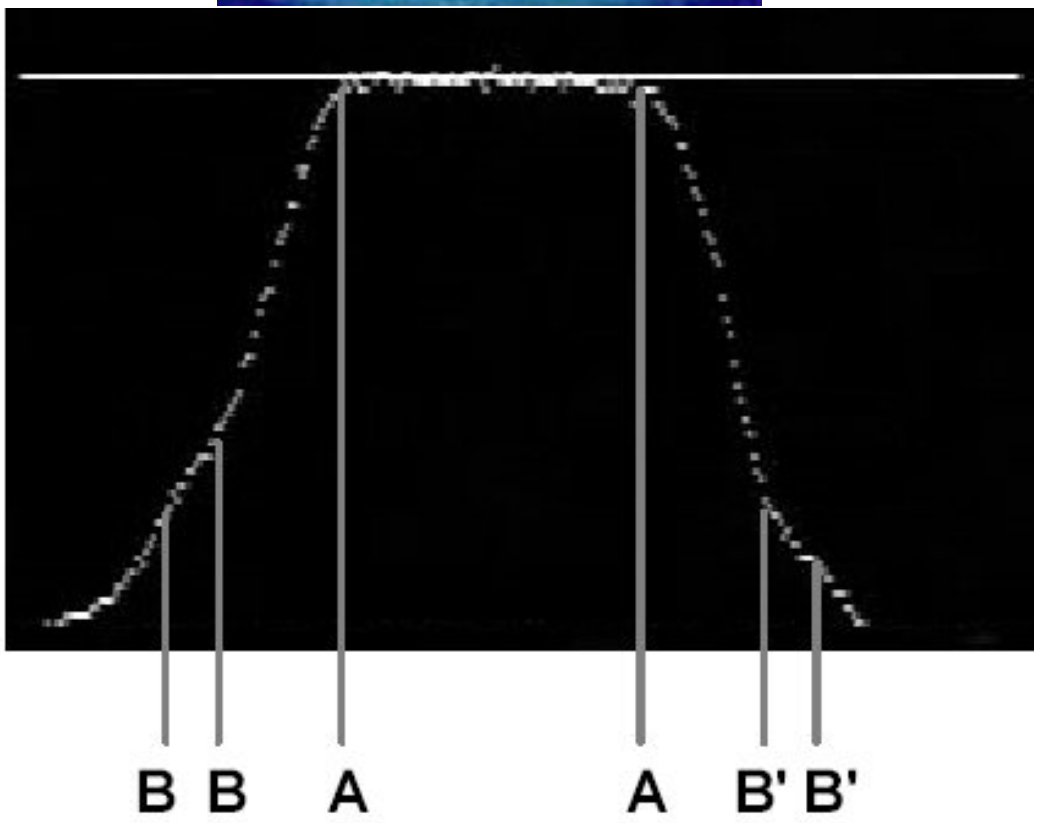



19:46:13
< Cathode: 2.5cm >
+29.0°C IMAGE MODE OPEN NORM +49.0°C

Plot of Electrode Surface and Solution Temperatures



Electrode > 60 C
Solution ~ 30 C



A = Electrode Surface T; B = Solution T

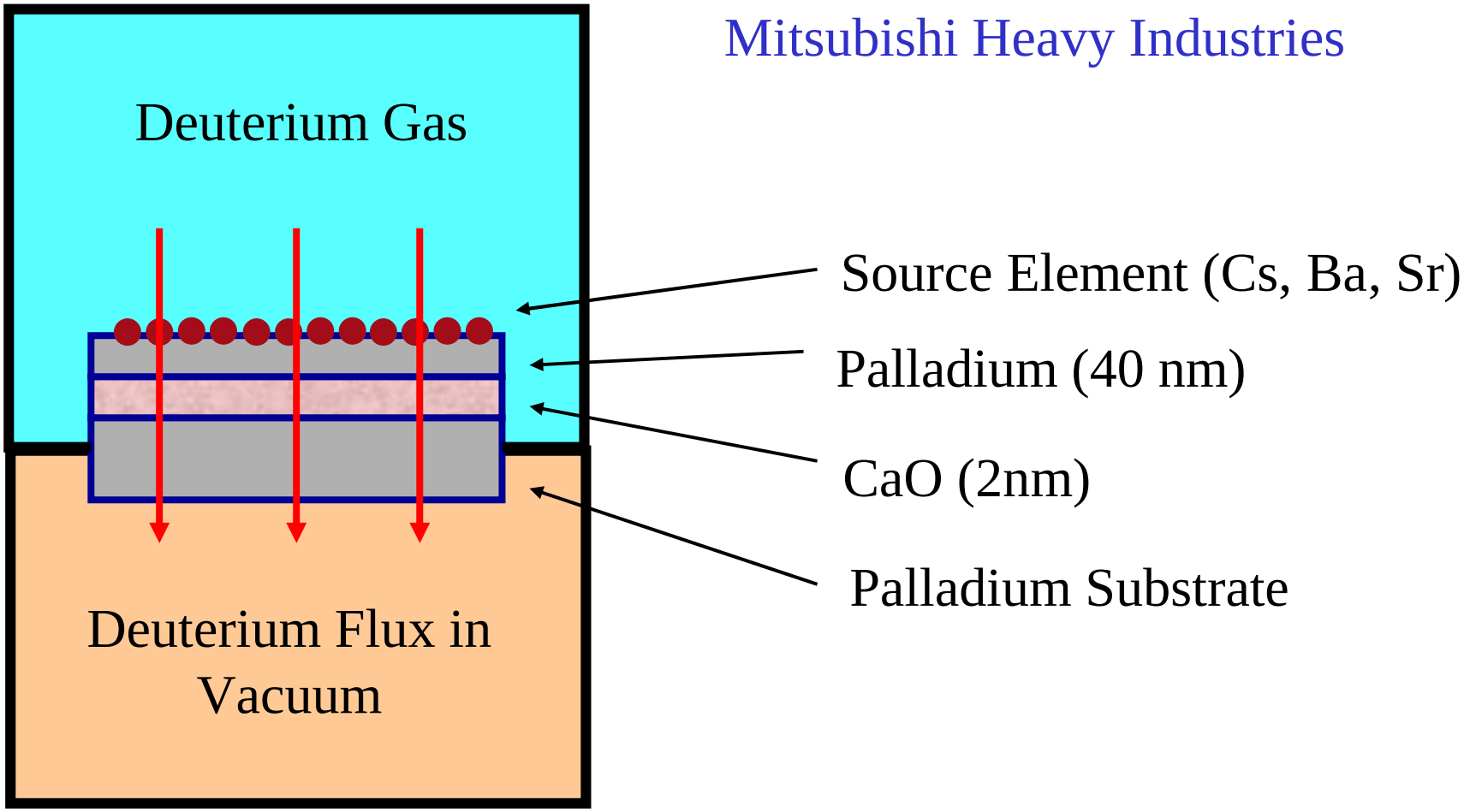
“Hot Spots” on the Palladium Cathode

Observation: Electrode is hotter than the electrolytic bath, the opposite of Joule heating.

Significance: No known explanation exists. New, unexplained science is revealed.

Nuclear Transmutation at Low Energies Using Gas Permeation

Iwamura et al.,
Mitsubishi Heavy Industries



Nuclear Transmutation at Low Energies Using Gas Permeation

Observation: Evidence of decreasing Cesium and generation of Praseodymium, a rare-earth element.

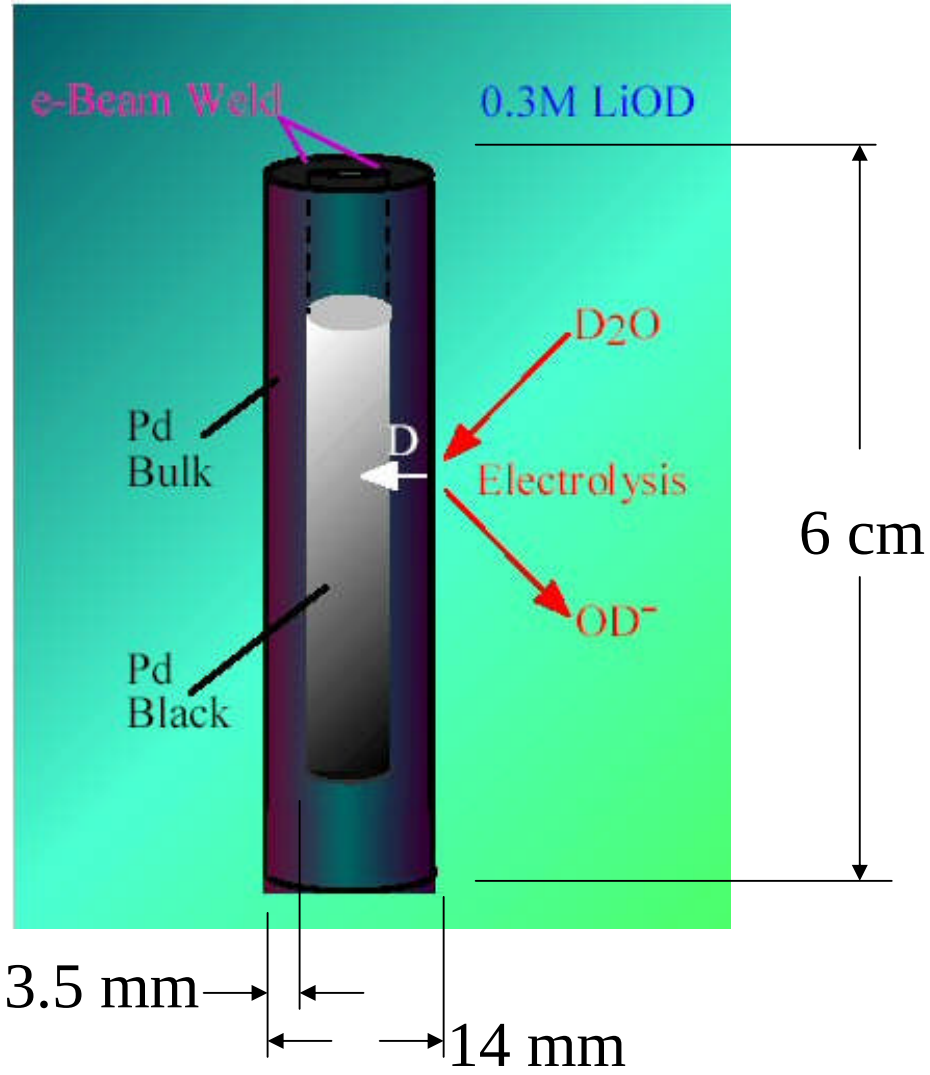
Significance: New, low-energy method for creating nuclear reactions and initiating nuclear transmutations.

Excess Energy and Helium from Double-Structure Cathode

Arata/Zhang, Osaka University

McKubre et al.
SRI International

"Pd-Black," fine nano-powders of about 20nm diameter, are placed into void inside Pd bulk.



Excess Energy and Helium from Double-Structure Cathode

Observation:

Maximum excess power generated: 10%.

Excess energy: 64 Mj

Significance:

New source of clean nuclear energy.

Concerns About Cold Fusion

Destructive Applications or Weapons

Disruptive Technology

IAEA and UN - ???

What's Needed: Going Forward

100 % Repeatable by Non-Rocket Scientists

Higher Power Levels

Hopes and Expectations

Cold Fusion,
also known as
Condensed Matter Nuclear Science
demonstrates the potential for:

New Substances

New Technologies

A New Source of Clean Nuclear Energy

For Further Information:

- *The Rebirth of Cold Fusion*, by Krivit & Winocur
  - ISBN 0976054582
- *Excess Heat* by Charles G. Beaudette
  - ISBN 0967854830
- New Energy Times ™ Web Site www.newenergytimes.com
- New Energy Times™ Newsletter
- Cold Fusion Library: www.lenr-canr.org
- International Society of Condensed Matter Nuclear Science: www.iscmns.org
- International Conference on Condensed Matter
  - www.iccf12.org

Acknowledgments

- Eugene Mallove, for his pioneering work in cold fusion journalism.
- Charles Beaudette, author of *Excess Heat & Why Cold Fusion Research Prevailed*, 2002, 2nd Ed.
- Edmund Storms and Jed Rothwell, for the LENR-CANR.org cold fusion library.

Martin Fleischmann

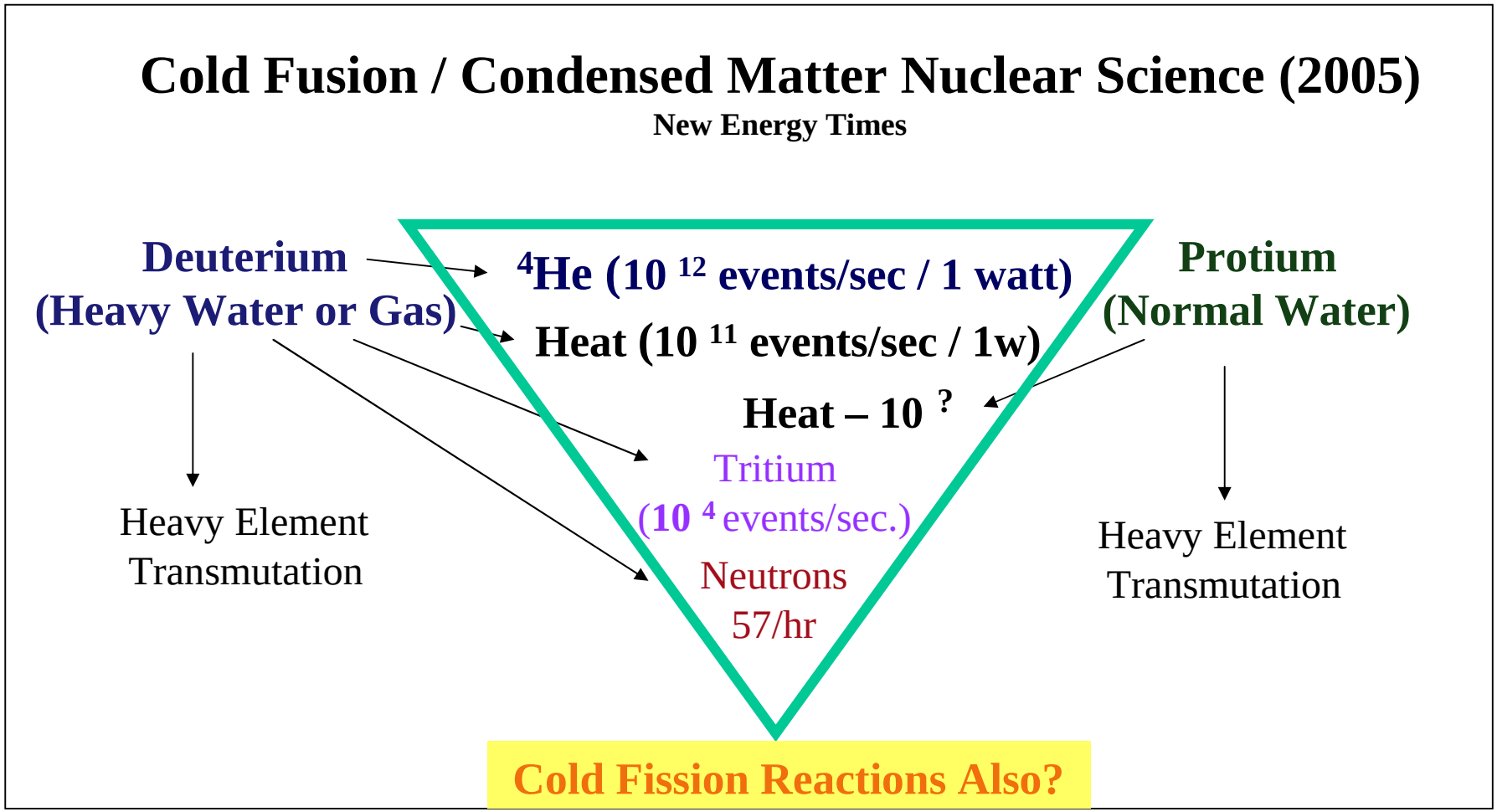
Stanley Pons

Supplemental Slides

Overview of Reaction Products

"Work in progress … represents general agreement but not consensus."

http://newenergytimes.com/Library/2004StormsE-ICCF11Class-AnUpdateOfLENR.pdf
http://www.newenergytimes.com/Reports/TheColdFusionEffect.htm



Review of Transmutation Reactions in Solids

http://www.lenr-canr.org/acrobat/MileyGHreviewoftr.pdf

Research performed in this field at the following institutions:

Hokkaido University, Japan - Mizuno et al., Notoya et al.
Mitsubishi Corporation, Japan - Iwamura et al.
Osaka University, Japan - Takahashi et al., Arata et al.
University of Leece, Italy - Vincenzo et al.
Frascati Laboratory, Italy - De Ninno et al.
SIA "LUTCH", Russia - Karabut et al., Savvatimova et al.
Tomsk Polytechnical University, Russia - Chernov et al.
Lab des Sciences Nucleaires, France - Dufour et al.
Beijing University, China - Jiang et al.
Tsinghua University, China - Li et al.
University of Illinois, Urbana, USA - Miley et al.
Portland State University, USA - Dash et al.
Texas A & M University, USA - Bockris et al.
Shizuoka University, Japan - Kozima et al.
Iwate University, Japan - Yamada et al.

Selected Transmutation Studies

Iwamura, Y., et al., "Elemental Analysis of Pd Complexes: Effects of D2 Gas Permeation," Jpn. J. Appl. Phys. Vol. 41 (2002) pp. 4642–4650
http://lenr-canr.org/acrobat/IwamuraYelementalaa.pdf

Higashiyama, T., "Replication Of MHI Transmutation Experiment…"
http://lenr-canr.org/acrobat/Higashiyamreplicatio.pdf

Iwamura's Presentation at ICCF-11 Short Course October 31, 2004

"Nuclear transmutation induced by deuterium permeation through the Pd complexes detected by surface and bulk analysis methods."

http://newenergytimes.com/Library/2004IwamuraY-ICCF11Class-NuclearTransmutation.pdf

http://newenergytimes.com/Library/2004IwamuraY-ICCF11Class-PdComplex.pdf

http://newenergytimes.com/Library/2004IwamuraY-ICCF11-TheRoleOfCaO.pdf

Yasuhiro Iwamura, Mitsubishi Heavy Industries

Appendix A – False Negatives

Studies of Work That Supposedly Disproved Cold Fusion

Year	Analysts (Qty on Team)	Cal Tech	MIT	Harwell
1991	1st China Lake Team (2)	**Excess Power (1)** Major Errors(1)	Major Errors(1)	Major Errors(1)
1991	Noninski & Noninski		**Excess Power (2)**	
1992	Melich & W. Hansen			**Excess Power (3)**
1993	Noninski & Noninski	**Excess Power (4)** Major Errors(4)	Major Errors(4)	
1993	2nd China Lake Team (5)	**Excess Power (5)** Major Errors(5)		
1993	Swartz & Mallove	Major Errors(6)	**Excess Power (6)**	
1994	Melich & W. Hansen	Major Errors(7)		Major Errors(7)
1994	3rd China Lake Team (3)	Major Errors(8)	Major Errors(8)	Major Errors(8)

Appendix A (2)

Studies of Work That Supposedly Disproved Cold Fusion

1. Miles, Melvin, et al., "Calorimetric Principles and Problems in Pd-D2O Electrolysis, The Third International Conference on Cold Fusion," Nagoya, Japan:, Universal Academy Press, Inc., Tokyo: (1991), p. 113
2. Noninski, V.C. and Noninski, C.I., "Comments on 'measurement and analysis of neutron and gamma-ray emission rates, other fusion products, and power in electrochemical cells having palladium cathodes,' Fusion Technology, Vol. 19, (1991), p. 579
3. Melich, Michael E. and Hansen, W.N., "Some Lessons from 3 Years of Electrochemical Calorimetry, "Third International Conference on Cold Fusion," Nagoya Japan: Universal Academy Press, Inc. (1992)
4. Noninski, V.C. and Noninski, C.I., "Notes on Two Papers Claiming No Evidence for the Existence of Excess Energy During the Electrolysis of 0.1 M LiOD/D2O with Palladium Cathodes," Fusion Technology, Vol.23, (July 1993,) p. 474
5. Miles, Melvin, et al., "Correlation of excess power and helium production during D2O and H2O electrolysis using palladium cathodes," Journal of Electroanalytical Chemistry, Vol. 346, (1993), p. 99 Also similarly published 1994, Fusion Technology, Vol. 25, (1994), p. 478
6. Swartz, Mitchell, "Some Lessons from Optical Examination of the PFC Phase-II Calorimetric Curves, Vol. 2," Fourth International Conference on Cold Fusion, sponsored by EPRI and the Office of Naval Research, December (1993)
7. Melich, Michael E. and Hansen, W.N., "Back to the Future, The Fleischmann-Pons Effect in 1994," Fourth International Conference on Cold Fusion, Lahaina, Maui: Electric Power Research Institute, (1993)
8. Miles, Melvin, et al., "Calorimetric principles and problems in measurements of excess power during Pd-D2O electrolysis," Journal of Physical Chemistry, Vol. 98, (1994), p. 194

Appendix B – Unknown Positives

Early Successful Excess Power Analyses & Experiments

Year	Analysts	Fleischmann & Pons	China Lake - U.S. Navy	Amoco Oil Co.	Shell Oil Co.	SRI International
1991	**Wilford Hansen** (Analysis)	**EP (1)** Not chemistry(1)				
1991	**Alan J. Bard, Charlie Barnes, Howard Birnbaum** (Analysis)					**EP (2)** No major errors (2)
1993	**China Lake Team (5)** (Experiment)		**EP (3)** Correlated heat & Helium-4 (3)			
1993	**Richard Garwin & Nathan Nathan Lewis** (Analysis)					**EP (4)** No major errors (4) Not Chemistry(4)
1994	**Melich & Hansen** (Analysis)	**EP (5)**		**EP (5)** Tritium (5)		
1995	**Shell Oil (DuFour, Foos, Millot)** (Experiment)				**EP (6)** He-4 (6)	
1995	**Amoco Oil (Lautzenhiser, Eisner, Phelps)** (Experiment)			**EP (7)** Tritium (7) Not chemistry (7)		

Appendix B (2)

Early Successful Excess Power Analyses & Experiments

1. Hansen, Wilford. N., "Report to the Utah State Fusion/Energy Council on the Analysis of Selected Pons Fleischmann Calorimetric Data," Second Annual Conference on Cold Fusion, Como, Italy: Societa Italiana di Fisica, Bologna, Italy, (1991)
2. Bard, Alan J., Barnes, Charlie, Birnbaum, Howard, "Comments on SRI RP-3170 Review Meeting 25-26 March 1991", Unpublished private report, (1991)
3. Miles, Melvin, et al., "Correlation of excess power and helium production during D2O and H2O electrolysis using palladium cathodes," Journal of Electroanalytical Chemistry, 1993. 346: (1993), p. 99 Also similarly published Fusion Technology, Vol. 25, (1994), p. 478.
4. Garwin, Richard L., Lewis, Nathan, "Report from SRI Visit October 19, 1993," Unpublished private report, (1993)
5. Melich, Michael E., Hansen, Wilford N., "Back to the Future, The Fleischmann-Pons Effect in 1994," Fourth International Conference on Cold Fusion, Lahaina, Maui: Electric Power Research Institute, (1993)
6. Dufour, Jacques, et al., J. Foos, J.P. Millot, Shell Research/ CNAM Laboratoire des Sciences Nucléaires 2 rue Conté 75 003 Paris, 9 April 1995, Excess energy in the system Palladium/Hydrogen isotopes, Measurements of the excess energy per atom hydrogen, Listed in index as ICCF5 paper # 604, but unpublished
7. Lautzenhiser*, T., Phelps*, D.W., Eisner**, M., (* Amoco, ** University of Houston,) Cold Fusion: Report on a Recent Amoco Experiment, Amoco Production Company, Report T-90-E-02, 90081ART0082, 19, March 1990, Private Report

Energy Production: Selected Reports of Excess Heat

See Appendix C for References

Ref	Name	Year	Max.Excess Heat	% Excess Heat	Time	Excess Energy
1	Arata	1999	10w	No data	2000h	No data
2	El-Boher #56	2004	3.5w	80%	300h	3.1Mj
2	El-Boher #64a	2004	34w	2500%	17h	1.1Mj
2	El-Boher #64b	2004	32w	1500%	80h	4.6Mj
3	Stringham	2004	40w	No Data	No Data	No Data
4	Takahashi	1992	130w	70%	1440h	No Data

Appendix C

Energy Production

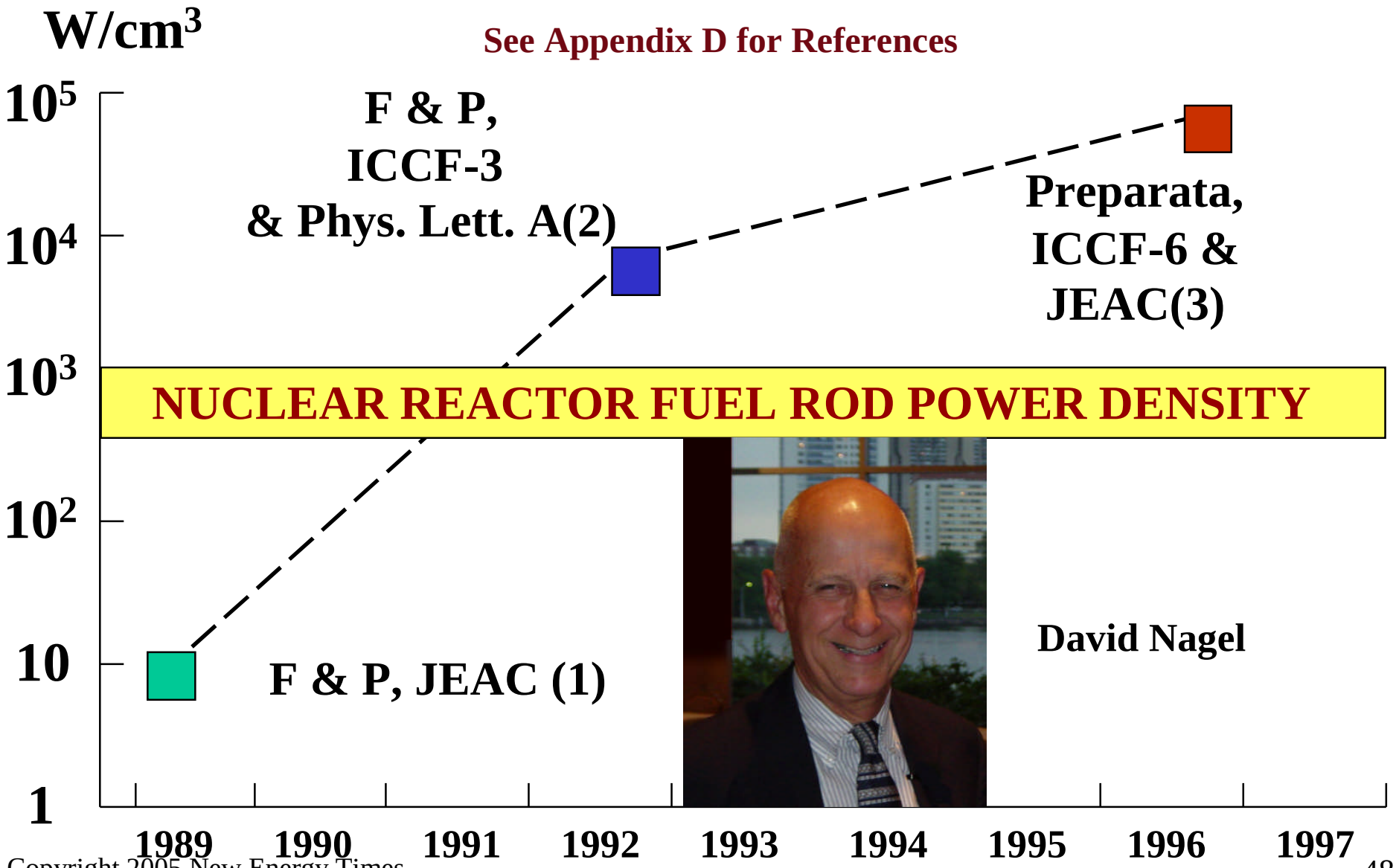
1. Arata, Yoshiaki, Zhang, Yue-Chang, "Anomalous production of gaseous 4He at the inside of 'DS cathode' during D2O-electrolysis," Proc. Jpn. Acad., Ser. B, 75: p. 281 (1999)
http://newenergytimes.com/Library/1999ArataY-AnomalousProduction.pdf

2. El Boher et al., "Excess Heat In Electrolysis Experiments At Energetics Technologies," (to be published Proceedings of 11th International Conference on Cold Fusion, Marseilles, France, 2004)
http://newenergytimes.com/Library/2004ElBoher-ExcessHeatInElectrolysis.pdf

3. Stringham, R., "1.6 MHz Sonofusion Device," (to be published Proceedings of 11th International Conference on Cold Fusion, Marseilles, France, 2004)
http://newenergytimes.com/Library/2004StringhamR-1.6MHzSonofusion.pdf

4. Takahashi, A., et al., "Anomalous Excess Heat by D2O/Pd Cell Under L-H Mode Electrolysis," Third International Conference on Cold Fusion, Nagoya, Japan: Universal Academy Press, Inc., Tokyo, Japan. (1992)
http://newenergytimes.com/Library/1992TakahashiAAnomalousExcessHeat.pdf

Cold Fusion Volumetric Power Densities



Appendix D

Cold Fusion Volumetric Power Densities

1. Fleischmann, M., S. Pons, and M. Hawkins, "Electrochemically induced nuclear fusion of deuterium," Journal of Electroanalytical Chemistry, Vol. 261, p. 301 and errata in Vol. 263 (1989)
2. Fleischmann, M. and S. Pons, "Calorimetry of the Pd-D2O system: from simplicity via complications to simplicity," Physics Letters A, Vol. 176, (1993), p. 118
3. Preparata, Giuliano, et al., "Isoperibolic calorimetry on modified Fleischmann-Pons cells," Journal of Electroanalytical Chemistry, 411, 9 (1996)

Comparison of Hot and Cold Fusion

See Appendix E for References

U.S. Government-Sponsored Research	Hot Fusion	Cold Fusion
Years Studied	54	16
Estimated U.S. funding to date	$16 Billion [1]	$25 Million [2]
Committed worldwide government funding	> $12 Billion	None
Experimental Qualities		
Shows potential for large-scale power generation	Yes	No
Potential for power production at point of consumption	No (too big)	Yes
Demonstrates self-sustaining nuclear reaction	Never	Yes [3]
Peak Experimental Power Levels		(Conservative Values)
Peak output power levels / Duration	16 Megawatt / 1 Sec.	10 watts / 2000 hrs [4]
Ratio of power out/power in (break-even =1.0)	0.6	> 1.1 [4]
Typical Experimental Power Levels		(Conservative Values)
Typical excess power levels	0	1 watt
Duration	n/a	5-600 hours [5]
Fuel		
Fuel required	D + T + Lithium	Deuterium
Dangerous and/or radioactive fuel	Yes	No
Commercialization Expectations		
Earliest estimated commercialization	2050	2010
Requires power distribution grid	Yes	No
Potential use: fixed, mobile terrestrial, air, and space	No	Yes
Single point of failure for large service area	Yes	No
Security risk	Yes	Yes

Appendix E – Fusion Compared

Comparison of Hot and Cold Fusion

1. Nagel, David J., "Fusion Physics and Philosophy," *Accountability in Research*, 8, (2000), p.137
2. Estimates based on miscellaneous reports of DARPA and Navy funding.
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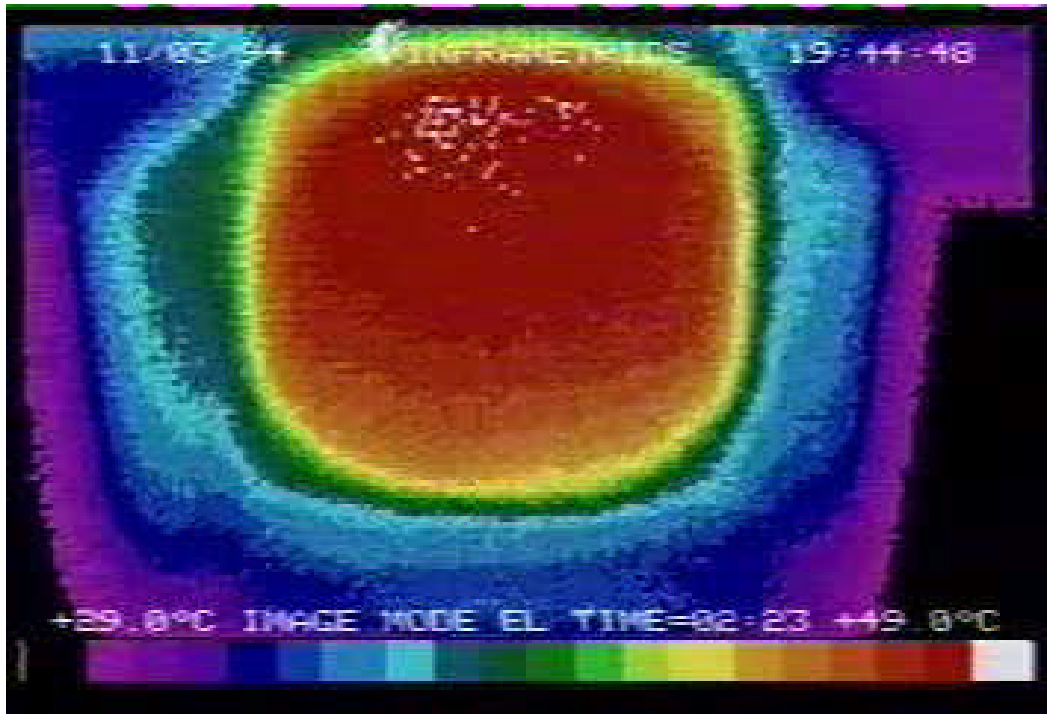
4. NOTE: The listed value of 10 watts is conservative. Arata, Yoshiaki, Zhang, Yue-Chang, "Anomalous production of gaseous 4He at the inside of 'DS cathode' during D_2O-electrolysis," *Proc. Jpn. Acad.*, Ser. B, 75: p. 281 (1999); Arata, Yoshiaki, Zhang, Yue-Chang, "A new energy caused by 'Spillover-deuterium,'" *Proc. Jpn. Acad.*, Ser. B, 70 ser. B: p. 106, (1994); Takahashi, A., et al. Anomalous Excess Heat by D2O/Pd Cell Under L-H Mode Electrolysis in Third International Conference on Cold Fusion, "Frontiers of Cold Fusion". 1992. Nagoya Japan: Universal Academy Press, Inc., Tokyo, Japan.
5. Storms, Edmund, "A Critical Review of the "Cold Fusion" Effect", *Journal of Scientific Exploration*, 10, #2, p. 185, (1996)

Hot Spots on Cathodes

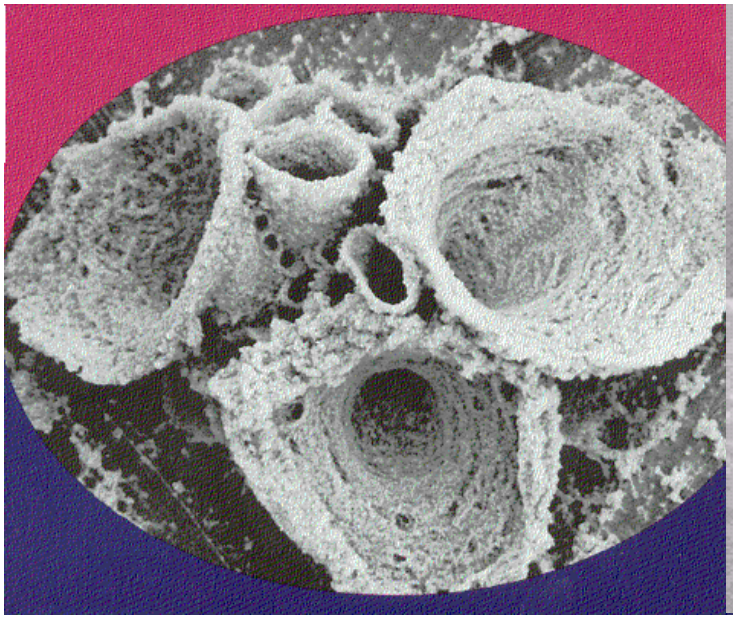
Calculations by David Nagel, Research professor; George Washington University
Specialist in micro- and nano-technologies



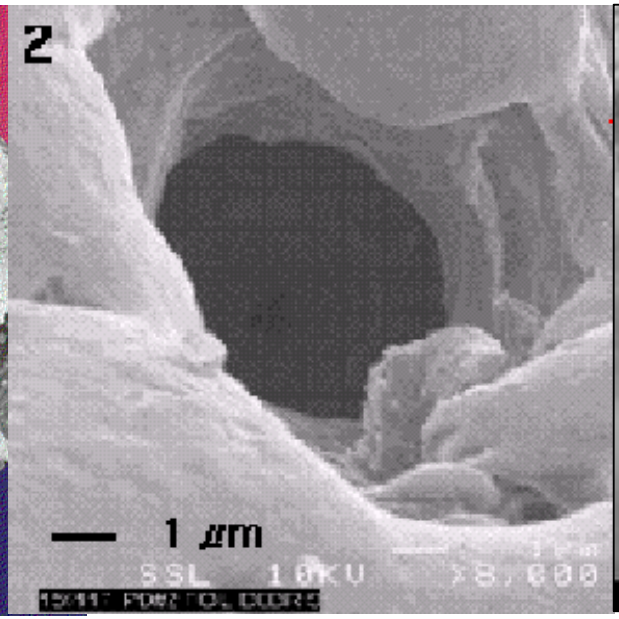
S. Szpak, P. A. Mosier-Boss, J. Dea and F. Gordon
SPAWAR Systems Center (ICCF-10 in 2003)

Release of 1 Mev in a cube of Pd 100 nm on a side gives a temperature (T) rise of
ΔT = 380 K using 3 k $\Delta T/2$ as the increase in vibrational energy, or
ΔT = 55 K using the specific heat for Pd = 26 J/K mole

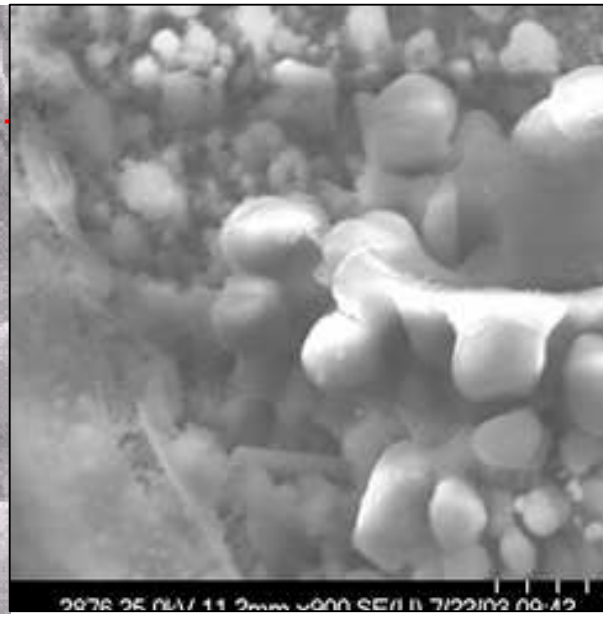
Craters in Cathodes



Mizuno



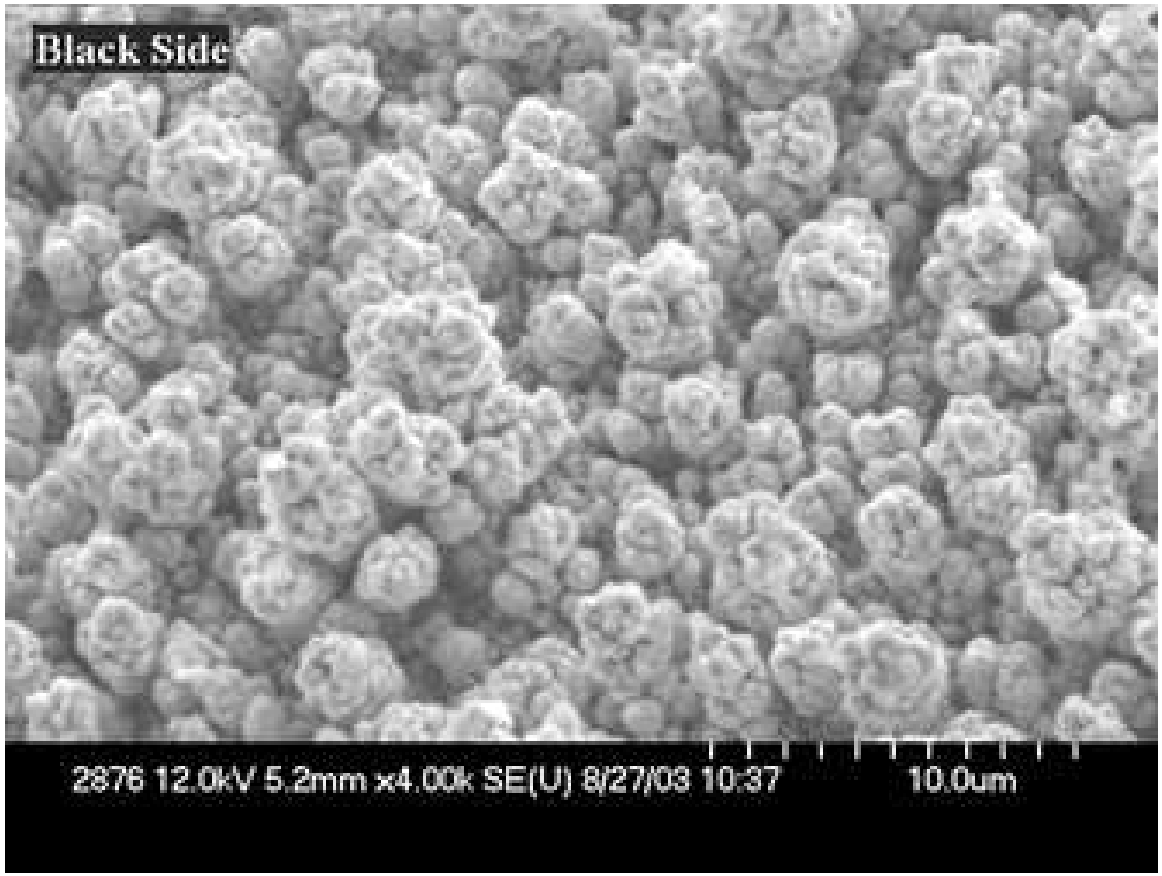
Stringham



Szpak

Chemical energies are insufficient to cause the craters that have been observed on cathode surfaces in many “cold fusion” experiments

Szpak et al., Morphology Changes (BEFORE)

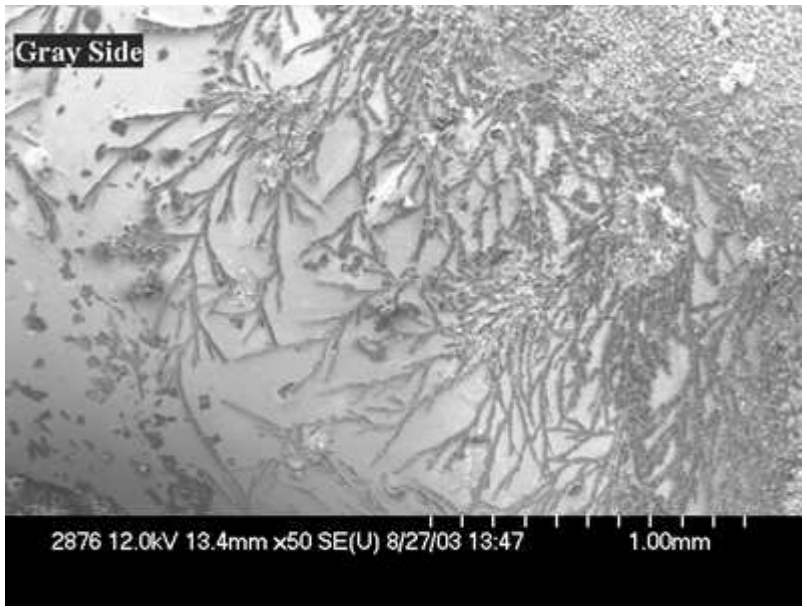


Pd/D structure before Application of external Electric field.

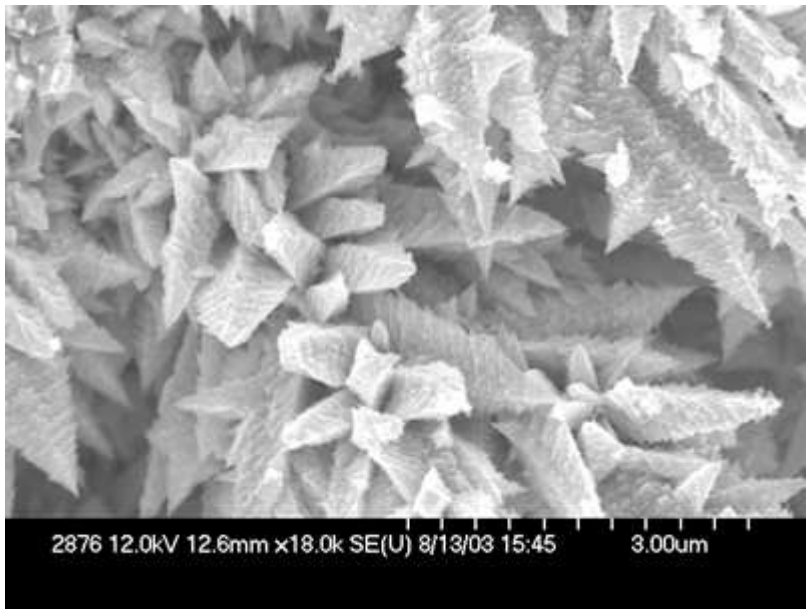
Shows uniform, 'cauliflower-like' morphology of globules

Szpak et al., Morphology Changes (AFTER)

Formation of fractals (branches)



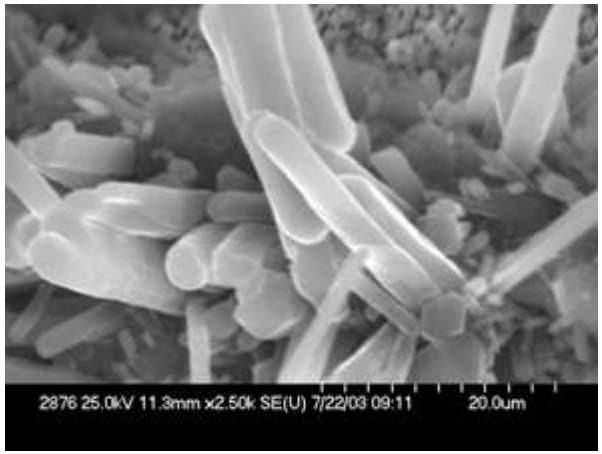
Production of dendritic growth



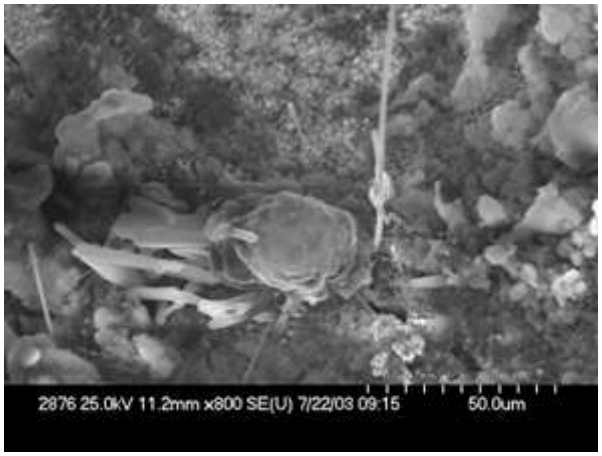
These features are the result of the combined action of:

(1) Current flow through a porous structure
(2) Evolving deuterium
(3) The electric field on the separated micro-globules suspended in the electrolyte and restricted by the porous structure

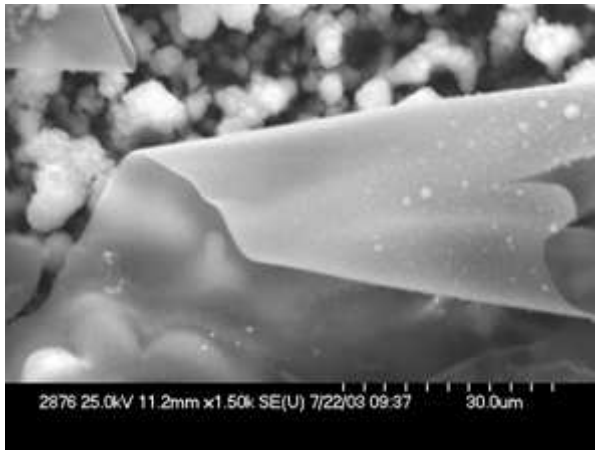
Szpak et al., Morphology Changes (AFTER)



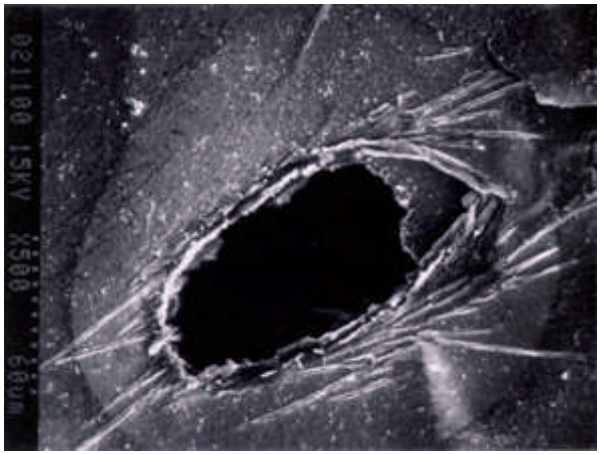
Rods (circular and square)



Long wires



Folded thin film



Crater

Worldwide Effort

- 200+ Researchers
  - Primarily from University and Government Labs
- 13 Countries
- 3,000+ Papers
- 16 years
- 12 International Conferences, 5 in Italy, 12 in Russia, 6 in Japan