DEFENSE THREAT REDUCTION AGENCY
8725 JOHN J. KINGMAN ROAD, STOP 6201
FORT BELVOIR, VA 22060-6201

John Greenewald
[redacted]

August 16 2018

Re: FOIA Case No.: 17-021

Dear Mr. Greenewald:

This is our final response to your Freedom of Information Act (FOIA) request perfected on December 14, 2016 and assigned FOIA Case 17-021 by the Defense Threat Reduction Agency (DTRA). You requested a copy of the slide presentations made by Lewis Larsen, Allan Widom, Mitchell Swartz, David Nagel and Michael Melich for the Dec. 12, 2006 DTRA/ASCO High Energy Science and Technology Workshop at Ft. Belvoir Virginia.

Enclosed is a copy of the records deemed responsive to your request; totaling 165 pages. These records are being released to you in part. Portions of these records are exempt from release under FOIA Exemption 4. FOIA Exemption 4 protects trade secrets, commercial, or financial data that is privileged or confidential and which, if released, would result in competitive harm to the company.

Another record, totaling 50 pages, was located and deemed responsive to your request. Upon review, it was determined that the information originated with the Department of the Navy. Since that organization operates their own FOIA program, we referred your request to them at the address below for further action and direct response to you.

Department of the Navy
ATTN: Office of the Chief Naval Operations
Washington, D.C. 20350-2000

No fees are due as the assessable costs total $25.00 or less. Determinations on behalf of DTRA were made by the Initial Denial Authority (IDA), Mr. Joseph J. Urgese, Deputy General Counsel. If you consider this decision to be an adverse determination, you may file a written appeal that is postmarked no later than 90 days after the date of this letter to the Deputy Director, Defense Threat Reduction Agency, Office of the General Counsel (FOIA/PA), 8725 John J. Kingman Road, MSC 6201, Fort Belvoir, Virginia 22060. The appeal should reference the FOIA case number, contain a concise statement of the grounds upon which the appeal is brought, and a description of the relief sought. A copy of this letter should also accompany your appeal. Both the envelope and your letter should clearly identify that a Freedom of Information Act Appeal is being made.

Should you have additional questions or concerns regarding this case, you may seek dispute resolution services from the DTRA FOIA Public Liaison or the Office of Government Information Services (OGIS). The DTRA FOIA Public Liaison, Ms. Pamela Andrews, may be contacted by phone at (703)767-1792 or by email at dtrafoiaprivacy@mail.mil. The contact information for OGIS can be found at www.archives.gov/ogis.

Sincerely,

JerHean Ross
Government Information Specialist,
Freedom of Information/Privacy Act Office

Enclosures:
As stated

EXCESS HEAT IN ELECTRIC-FIELD LOADED DEUTERATED METALS

DTRA Advanced Systems and Concepts Office Workshop
on High Energy Science and Technology 12/12/06

Dr. Mitchell Swartz
JET Energy, Inc.
Wellesley Hills, MA 02481

EXCESS HEAT IN ELECTRIC-FIELD LOADED DEUTERATED METALS

Research and Development

BRIEF SUMMARY OF RESULTS:

SIGNIFICANT EXCESS HEAT OBSERVED IN PALLADIUM HEAVY WATER (PdD) SYSTEM, PALLADIUM HEAVY WATER (PdD) CODEPOSITIONAL SYSTEM, SOME NICKEL LIGHT and HEAVY/LIGHT WATER SYSTEMS

EXCESS HEAT NOT OBSERVED IN IRON, ALUMINUM, OR DAMAGED PALLADIUM NICKEL SYSTEMS

DIFFERENT CONFIGURATIONS AND MATERIALS EXAMINED (1989-2006)

- **Heavy Water** – inc. low paramagnetic, 99.99%, Volume generally ~30-40 cubic centimeters.
  Codeposition - $PdCl_2$ [palladium (II) chloride 99.9%, Pd 60.2%, ~8.2 mM
  prepared anaerobicly as bluish gray color, rather than reddish brown aerobic color.
- **Light Water** - distilled or double deionized Na ~1 millieq/l K ~0.3 meq/l $TC0_2$ ~5 mmole/l pH 7.4

- **Anodes** - Platinum, Gold, Graphite, Nickel, Titanium, Palladium
  Cathodes – Palladium, Platinum, Graphite, Iron, Nickel, Titanium, Niobium, Aluminum

- **Phusor Design**:
  Palladium cathode [nominally preprocessed 1.0 mm diameter, 99.98+%]
  active area ~ 6.4 - 6.7 square centimeters; active volume 0.17 (to 0.47) cm^3
  Platinum anode [1.0 mm diameter, 99.998%] active area of ~3 cm^2; active volume ~0.077 cm^3

- **Electrode configurations** - Parallel Opposed Electrodes, Single And Paired; Coaxial Systems, Wires, Rods, Spiral, Foil or Plate, Mesh, Screen, Woven, Fibrex (Ni), Phusors, Multi-gang electrodes.

- **Maximum cleanliness** – High density polypropylene.
  Parafilm, Paraffin, and other seals minimize contamination, inc. humidity, light, and water.
  Neither silicates nor glasses were used.

- **Select Material Studies** – Experimental studies include:
  Role of Catastrophic Active Media [capable of sudden desorption]
  Role of Fukai-defect creation (~2-3 Megagray deposited by e- beam 2MV irradiation)
  Corrosion Issues, recently stress corrosion cracking, Hydridation issues
  Irradiation Studies- Synchronous Ultrasound and Laser irradiation of loaded cathodes

Improved Thermometry and Calorimetric Controls to Increase the likelihood of reliability of measured XSE

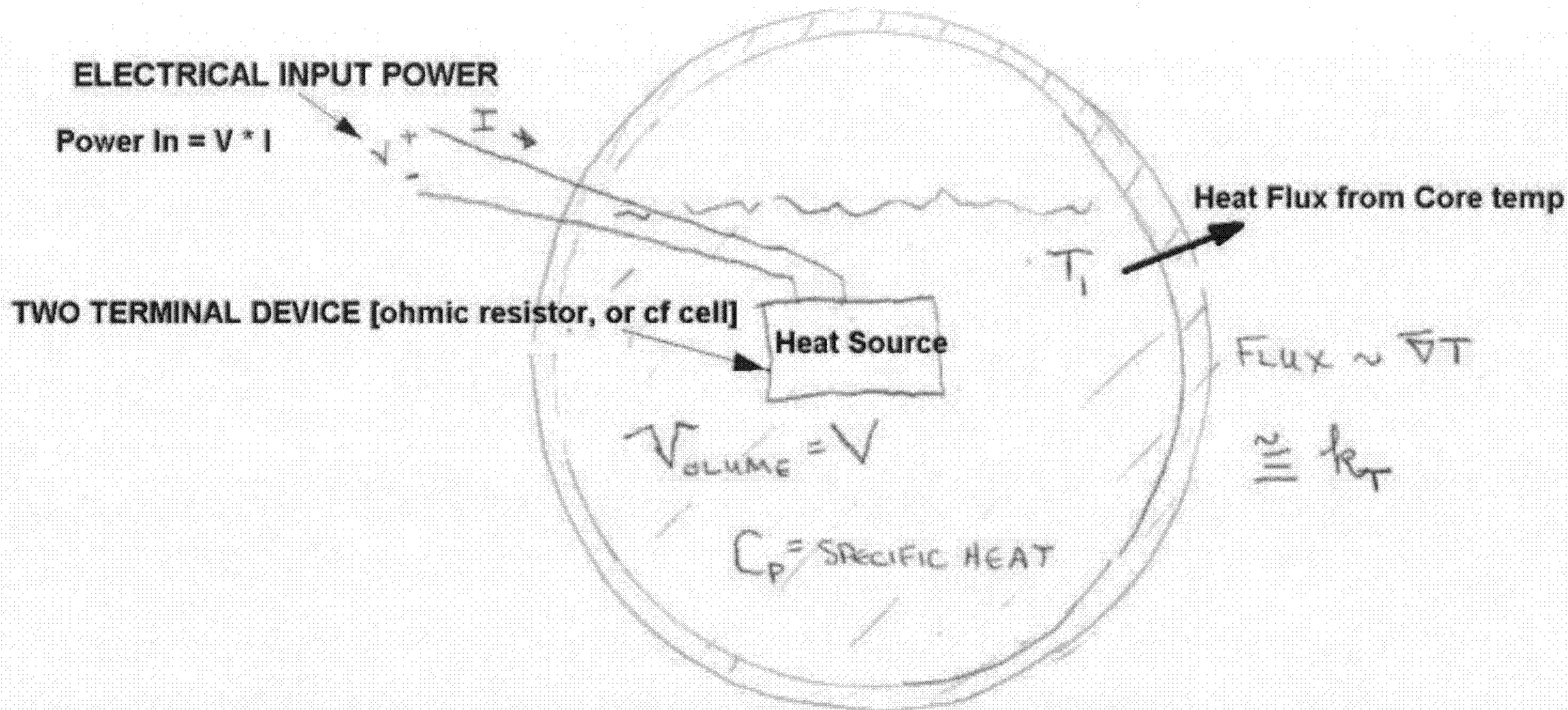
Thermometry - Temperature Probes prescreened

- Thermocouples, Thermistors, and other temperature sensors and their coatings, were pre-selected for linearity, minimal dispersion, zero sensitivity to applied electric fields.
- Then matched for multipoint, multi-ring system after dual point calibration including by an Omega Ice-Point Cell.
- Developed Solution- and Current-Insensitive Probes for Core.
  Accuracy <+/- 0.6 - 1.0 deg K; Precision <+/- 0.6 deg K

In the reaction container core, temperature measurements by modified corrosion-type fully-electrically insulated thermocouples
Accuracy of +/- 0.8 degrees K, precision of +/-0.1 degrees K

EXPT: Solutions are heated by Electricity (DC) through two electrodes.

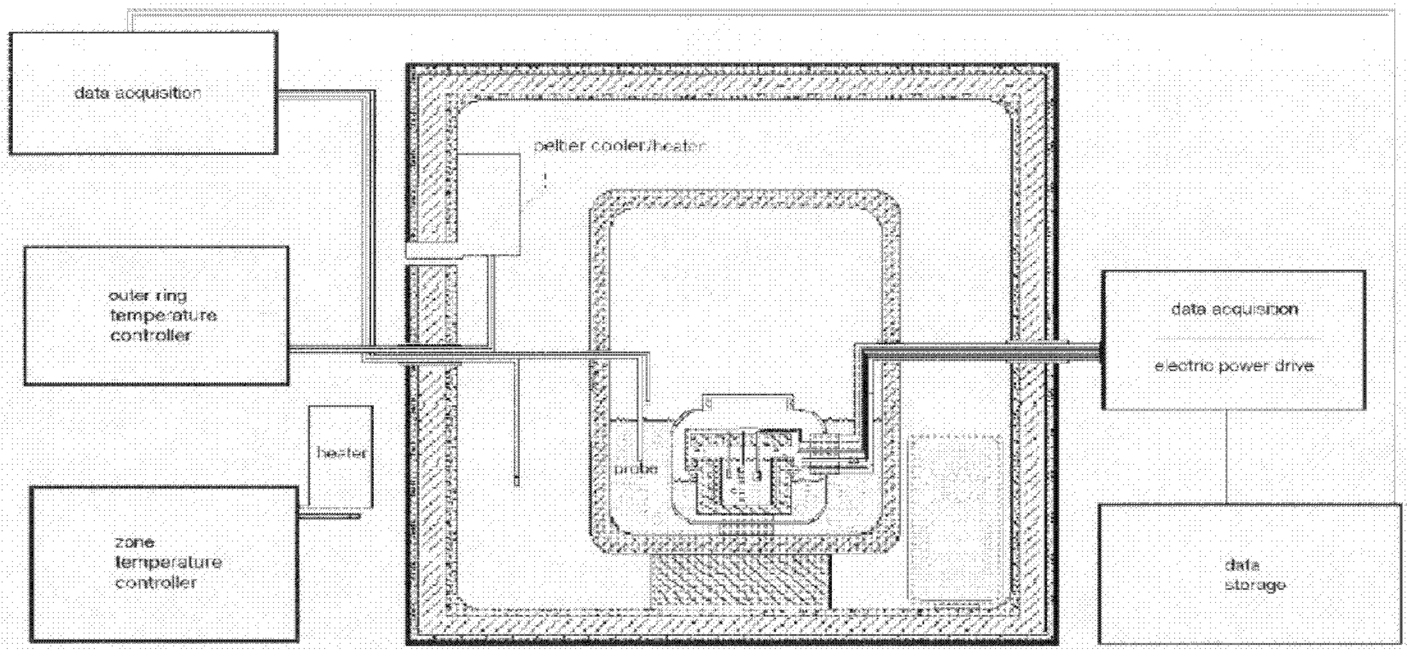
- For most semi-quantitative experiments, there was a single container. The reaction container contains two electrodes to produce entry of hydrogen from a liquid solution in the metal electrode.
- The amount of output energy is interfered from the temperature rise, which is compared to the input energy (V*I, with no reduction for thermo-neutral potential).



Input Energy -> ~ loading, electrolysis, water heating, heat loss through wall

Possible errors include: radiative loss; variables f(time, T), wall has mass also: possible lead loss, inhomogeneity, etc.

Multi-ring Calorimetry with Waveform Reconstruction to Increase the likelihood of reliability of measured XSE



Multiple Ring Calorimetry System

Modified isoperibolic calorimetry with controlled low exit Heat Flow.

Single Or Dual Feedback Temperature-Controlled Multiple Ring System

Yellow Spring Thermal controller [e.g. Model 72 [bandwidth of 0.2 K]

Time Integration, Nyquist-sufficient sampling and Noise Measurement Increase the likelihood of reliability of measured Excess Energy

- Data Acquisition: 22+ Bit Resolution
  Spatial and Multi-ring redundancy

- Nyquist issues: 1-10 Hertz Sampling
  100 Hz for Motor rotation studies; ~300 kHz for vibration studies.

- Time-integration of Input electrical and semi-quantitatively derived output power
  Rules/out peaks, and false positives.

- Noise Power Measurement – Rules out false positives

Improved Thermometry and Calorimetric Controls to Increase the likelihood of reliability of measured XSE

Full controls - Ohmic thermal, metallic, and calorimeter controls

- **Thermal Controls** (ohmic Control – *in situ*) - Used to calibrate for power and energy.
  Adds a square wave pulse of fixed energy for calibration, metachronously and synchronously.
  Used to check for square-wave reproducibility and time invariance of the calorimeter.
  Electrical current either goes through the Phusor cell OR the joule (ohmic) control.
  Ohmic resistor hermetically protected, impedance ~solution [60-220 kilohms]

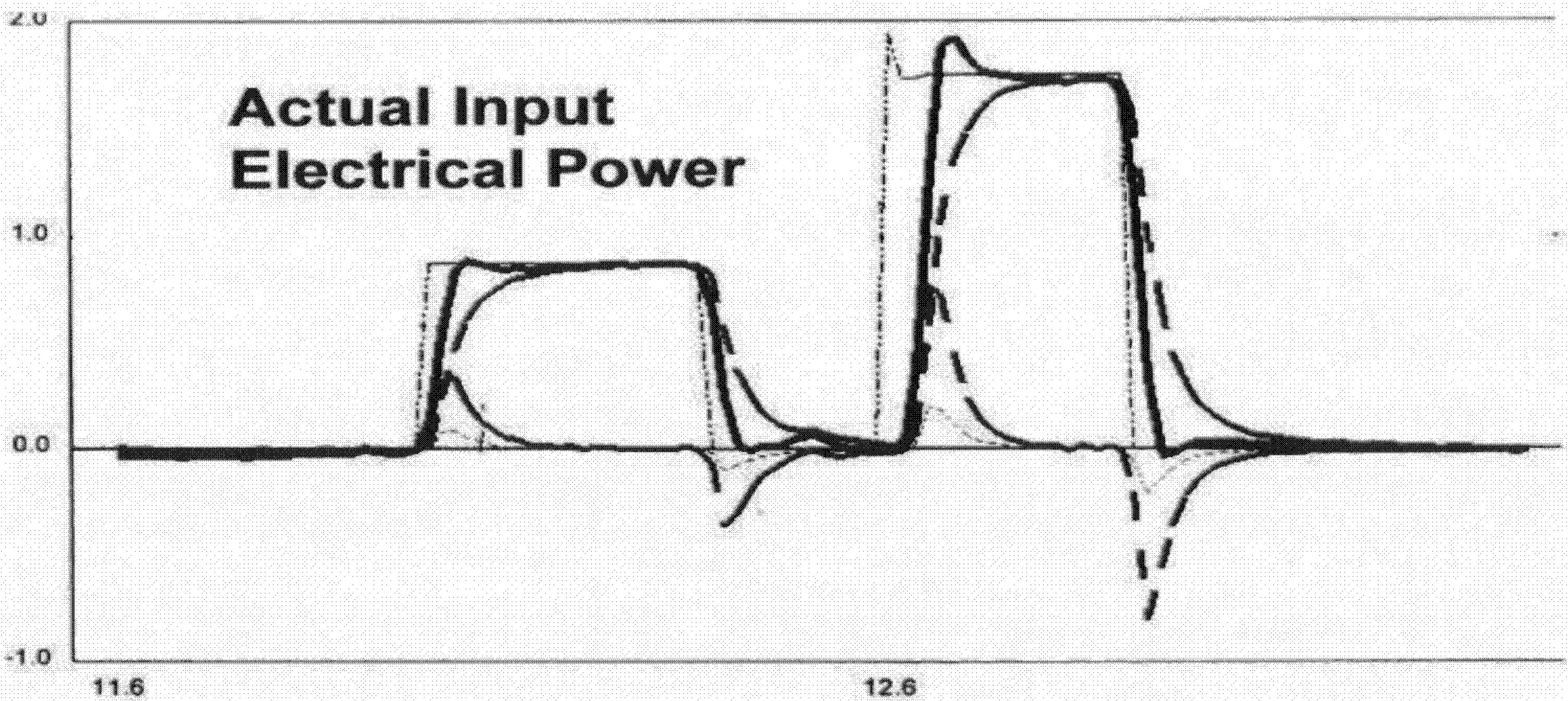
- **Dual Ohmic Controls** - Two Controls – *in situ* and in a complete second calorimeter
  Two thermal ohmic controls calibrate for time-variance of the calorimeter, without interfering with the measurement. Second ohmic control is immersed in a different, but equivalent, volume of water in a second calorimeter (further DAQ & sensors required).
  Usually the electrical current either goes through the operational Phusor cell and then the second (ohmic) control in the second calorimeter in electrical series.

- **Metallic Cathodic Controls** - non-active aluminum, iron; inactivated cathodes (Ni)

Improved Thermometry and Calorimetric Controls to Increase the likelihood of reliability of measured XSE

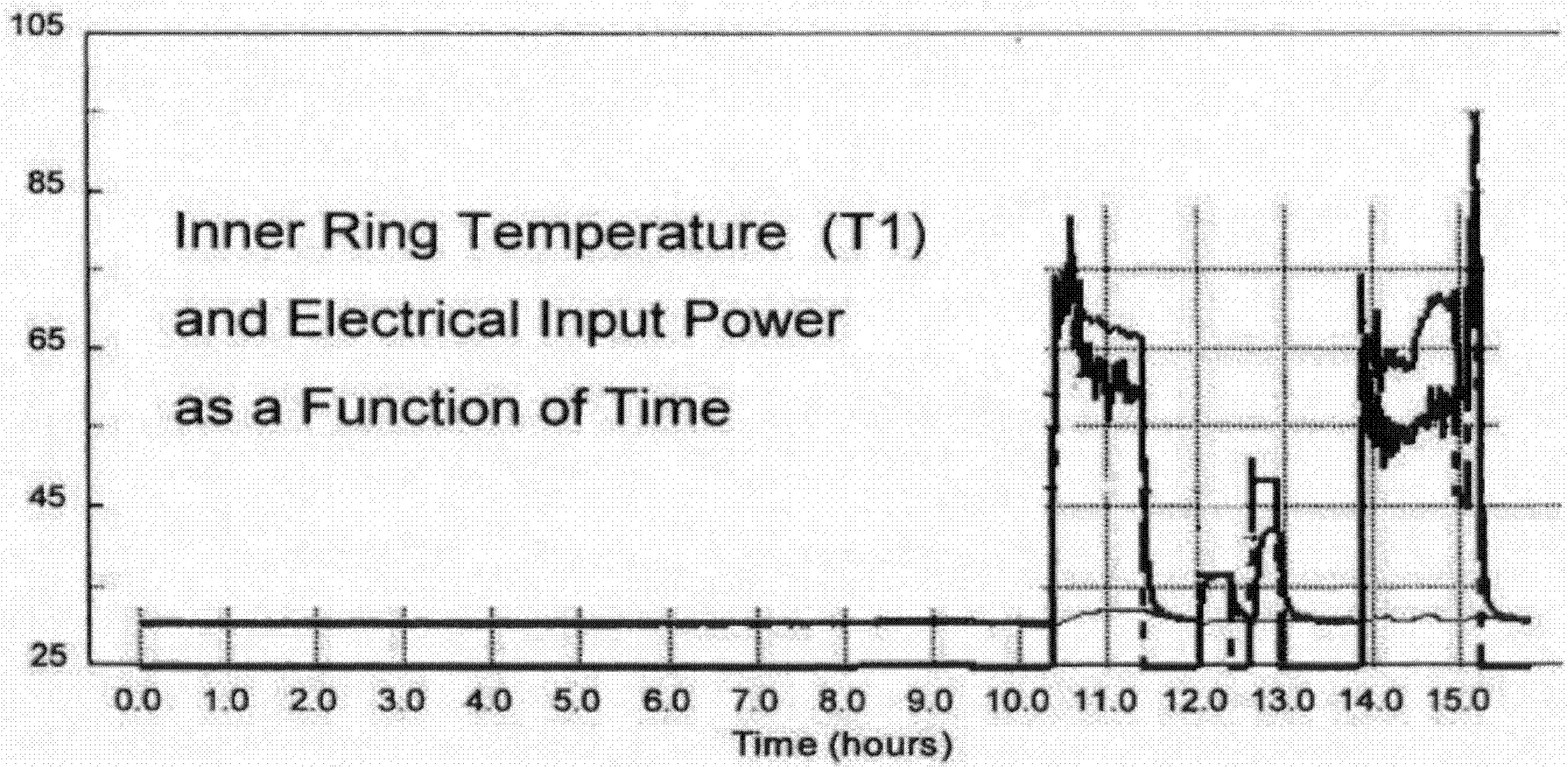
Additional control – Check of Paradigm

- **Calorimeters Characterized by Thermal Waveform Reconstruction**
  Square wave response of the calorimeter to measured input through ohmic control.
  Correct For Barrier Terms augmented T1-T2 Terms by Barrier Heat Storage T1+T2 Terms



Methods used to improved Test Setups and Analyses

- Maximize Delta-Ts (~20-135 Centigrade)
- Maximize Long Initial Baselines and Cooling Off Periods



Methods Used to Improve Analyses

- Maximize Analytical Calculations - Correct For Barrier Terms augmented T1-T2 Terms by Barrier Heat Storage T1+T2 Terms

- Minimize Analytical Errors and Artifacts

  Avoid flawed calorimetry techniques

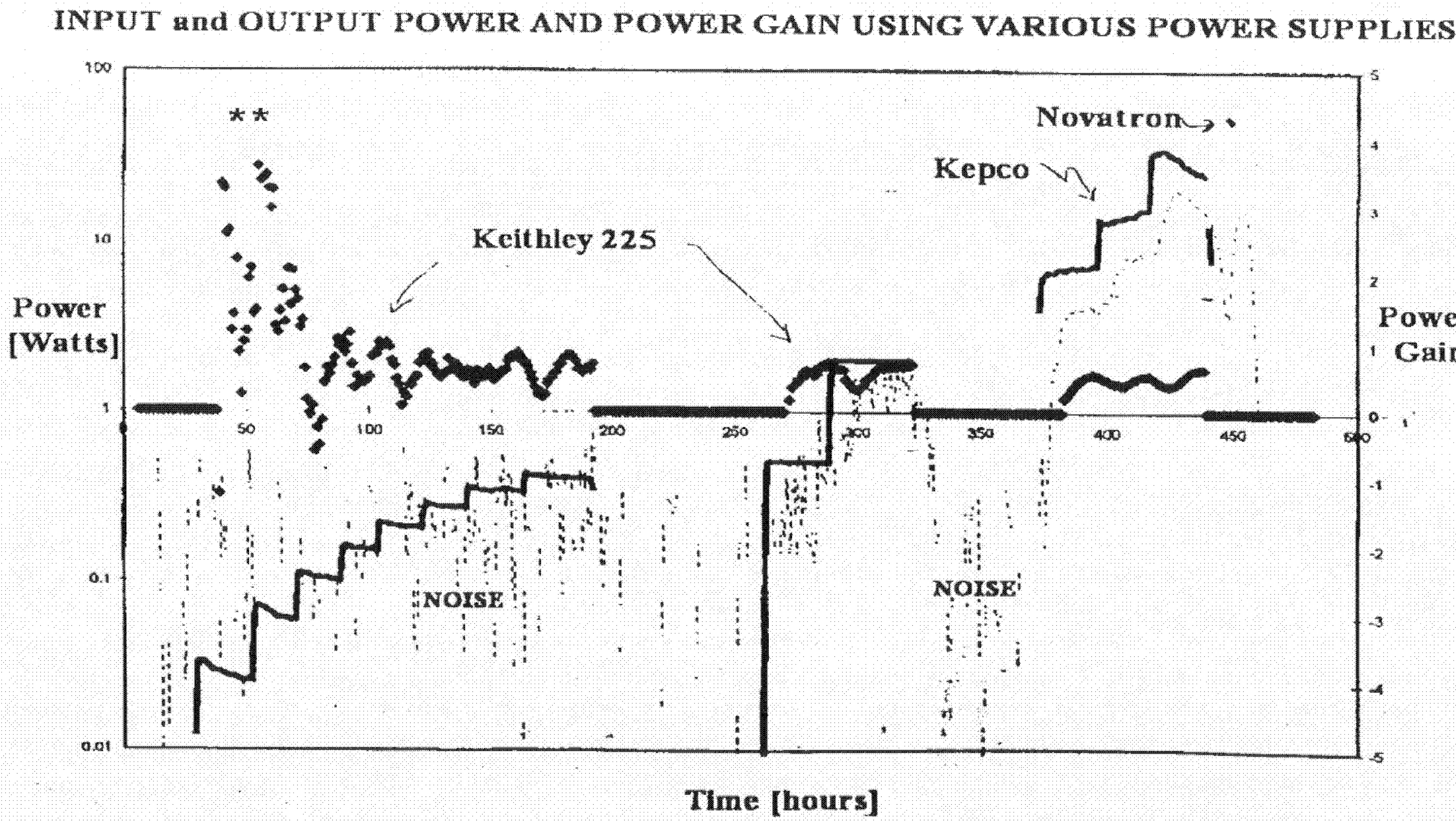
  [e.g. vertical positional flow technique with Bernard instability].

- Minimize Noise Errors and Artifacts – Failure to calibrate and measure the background noise levels can result in false positive 'excess heat'.

  [Swartz. M., "Patterns of Failure in Cold Fusion Experiments", Proc. 33RD Intersoc.Eng.Conf. Energy Conversion, IECEC-98-I229, (1998).

- Data presented as power-time thermal spectroscopy, with ohmic and calorimeter controls and time-integration

Methods used to improved Analyses
Importance of Noise Measurement



- Usually electric current controlled. 20 micro- to 0.1 A/cm^2
- Loading by Keithley 225, HP 6177c, Lambda 340A, LLS3040, LG531,HP722AR, HP/Harrison 6525A, Nobatron DCR-150, Fluke 412B.
- Voltage measurement by Keithley 610C Electrometers, 160B microvoltmeter, Dana Electronics 5900 multimeter, Fluke 8350A multimeter, HP 412, 3465A or 3490A voltmeters.
- Voltage accuracy: <0.015 $^{+/-0.005}$ volts or ~+/-0.5%

Improved Calorimetric Noise Measurement to Increase the likelihood of reliability of measured XSE

- Input electrical power defined as V*I.

No thermo-neutral correction in denominator.

- Input energy = time-integral (V(t) * I(t)).

  The excess energy is defined and derived as time integral of [Poutput(t) – Pinput(t)].

- The instantaneous power amplification factor (nondimensional) is defined as Pout/Pin, as calibrated by at least one electrical joule control [ohmic resistor].

Dual Ohmic Control (DOC) Calorimetry with Time Integration

- Dual ohmic control (DOC) calorimetry uses a second external ohmic control.

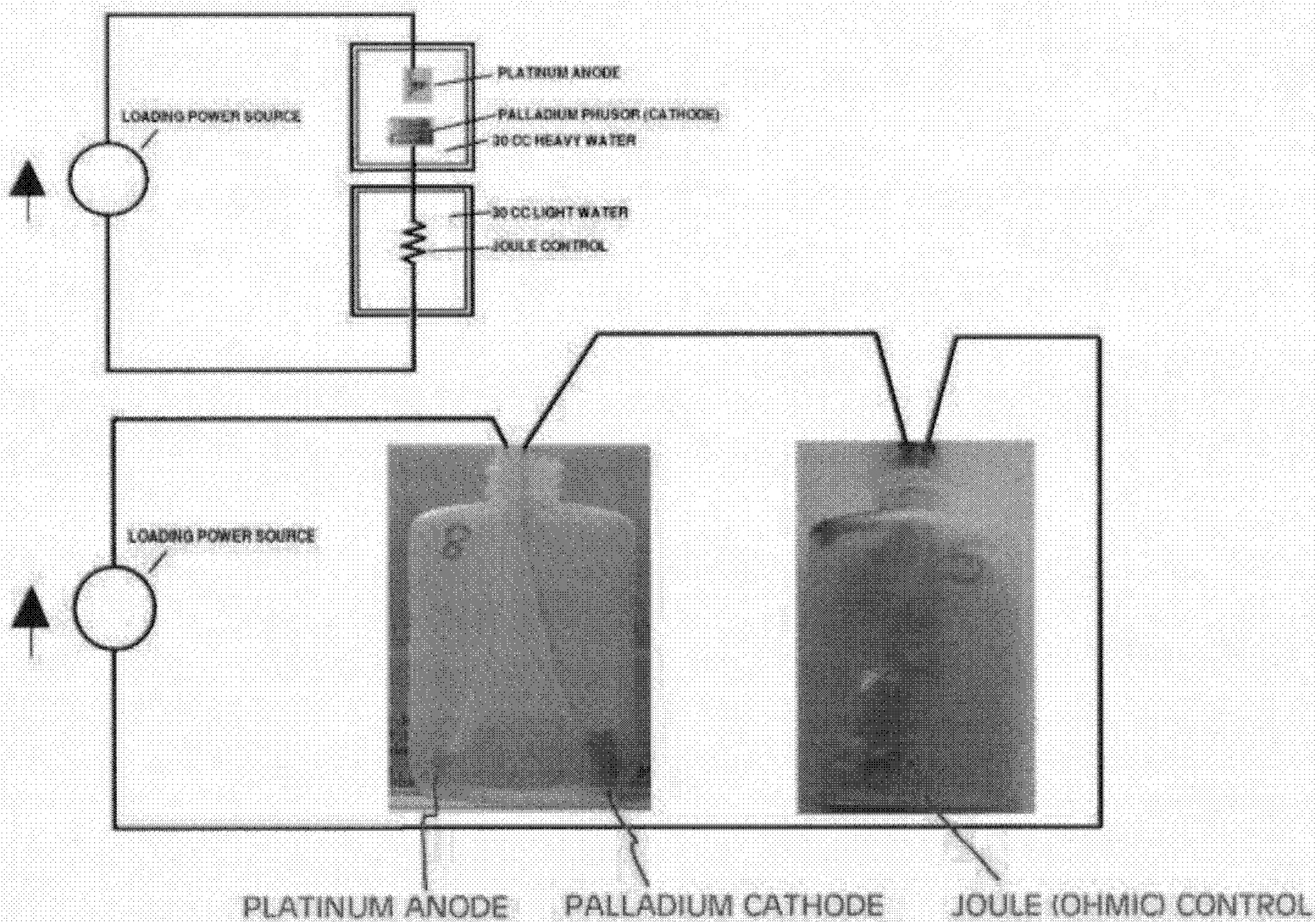
  1) an ohmic thermal control next to the Phusor, and

  2) a second ohmic thermal control in an identical reaction container.

- Calorimeter cool-off and heat-storage effects are eliminated by the (redundant) DOC calorimetric system.
- Time integration also measures loading energy and tardive thermal power (TTP).

EXPT: Solutions are heated by Electricity (DC) through two electrodes.

- In most, palladium is the cathode and platinum the anode. Also included in the container is an electrical ohmic resistor which serves as a thermal (joule, ohmic) control.
- Temperatures were sampled from several sites within, and from several sites around the core container containing about 30-40 cc of solution, using thermocouples, singly and in surfaces to also measure heat flow.
- For most recent experiments, there are two containers, and two complete calorimeters. Such paired solutions in separate calorimeters are Dual Ohmic Control experiments.



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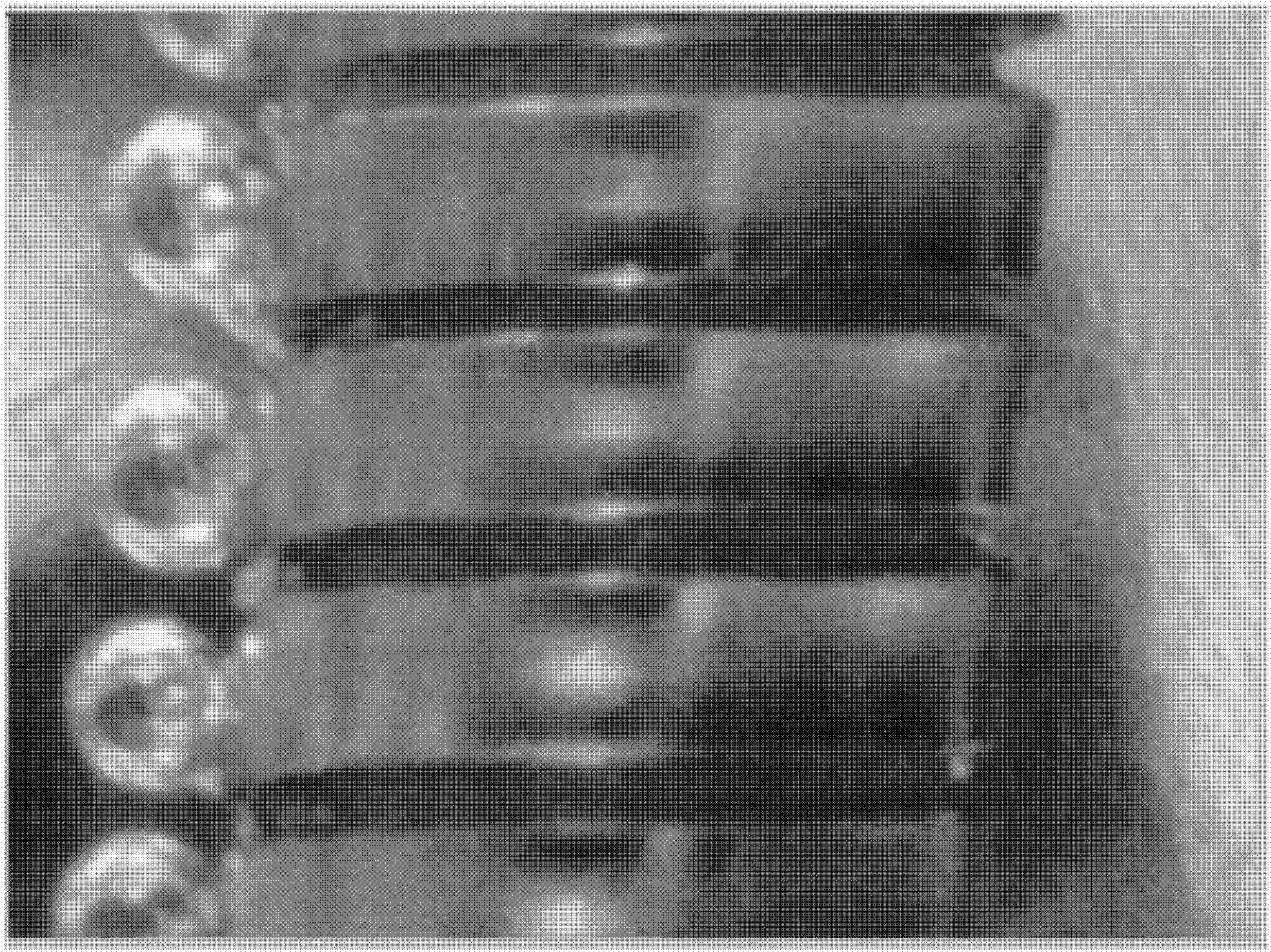


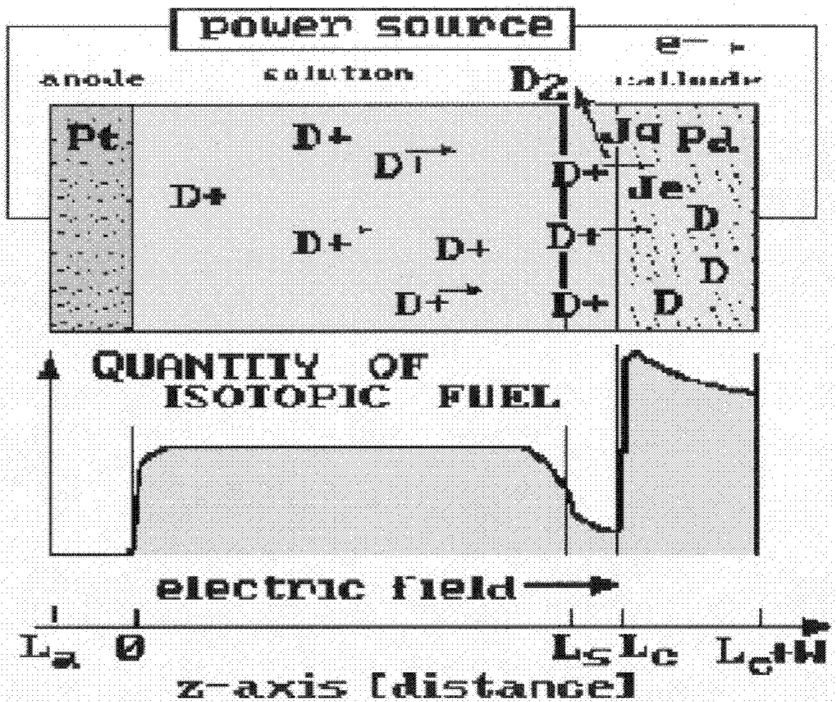
Close-up of Phusor cathode
Note bubbles on only one side

The anode is to the left (not shown)

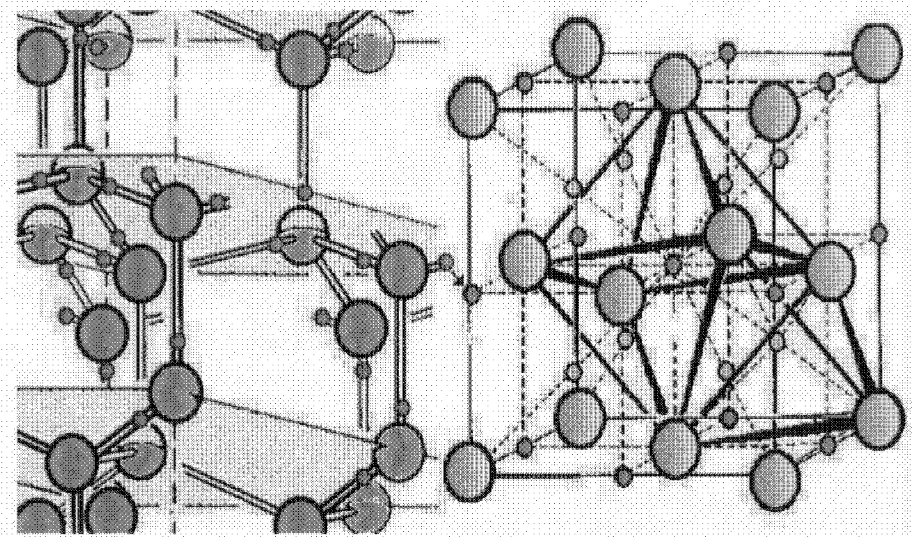
Swartz. M., G. Verner, "Excess Heat from Low Electrical Conductivity Heavy Water Spiral-Wound Pd/D2O/Pt and Pd/D2O-PdCl2/Pt Devices", Condensed Matter Nuclear Science, Proceedings of ICCF-10, eds. Peter L. Hagelstein, Scott, R. Chubb, World Scientific Publishing, NJ, ISBN 981-256-564-6, Pages 29-44; 45-54, and 213-226 (2006).

QUASI-1-DIMENSIONAL CONTINUUM ELECTROMECHANICAL DERIVATION OF LOADING FLUX

ROLE OF APPLIED ELECTRIC FIELD INTENSITY



- Cold fusion requires small pure pieces of palladium to absorb and to fill ("load") with hydrogen (heavy hydrogen or deuterium from water), and begins after a sufficient time of maintaining the loaded metal.



"Quasi-One-Dimensional Model of Electrochemical Loading of Isotopic Fuel into a Metal", *Fusion Technology*, 22, 2, 296-300 (1992)

"Codeposition of Pd and Deuterium", *Fusion Technology*, 32, 126-130 (1997)"

Excess Heat from Low Electrical Conductivity Heavy Water Spiral-Wound Pd/D2O/Pt and Pd/D2O-PdCl2/Pt Devices", *Proceedings of ICCF-10*, (2003)

QUASI-ONE-DIMENSIONAL (Q1D) MODEL OF HYDROGEN ISOTOPE LOADING

-Has yielded theoretical predictions of codeposition and Optimal Operating Point behavior, and Phusor technology.

QUASI-1-DIMENSIONAL CONTINUUM ELECTROMECHANICAL DERIVATION OF LOADING FLUX

ROLE OF APPLIED ELECTRIC FIELD INTENSITY

In the absence of solution convection, molecular flux (J_D) results from both diffusion down concentration gradients and electrophoretic drift from an applied electric potential $[\Phi]$.

$$J_D = -B_D * \frac{d[D(z,t)]}{dz} - \mu_D * [D(z,t)] * \frac{d\Phi}{dz} \qquad (1)$$

The equation describes and predicts the distribution of deuteron species in the bulk solution, $[D(z,t)]$; and describes the result of the cathodic flow of deuterons. These equations are complex because they include the deuteron diffusivity (B_D), electrophoretic deuteron mobility (μ_D), and have parameters which vary with temperature. The mathematical solutions are determined both by the boundary conditions and by conservation of mass,

$$\kappa_e = (\mu_D * E) - (\kappa_g + \kappa_f) \qquad (2)$$

K_e is the rate at which deuterons physically enter the palladium cathode. K_g is the rate of deuteron loss to the gas phase (or on the electrode surface) as diatomic deuterium (D_2). K_f is the bulk rate of the desired reactions which cause loss of deuterons. A very important result is heralded by the quasi-1-dimensional analysis of loading and the Einstein relation.

$$k_e = \frac{B_D * qV}{L * [k_B * T]} - (\kappa_g + \kappa_f) \qquad (3)$$

This indicates that the loading rate is a competing process of gas loss.

QUASI-1-DIMENSIONAL CONTINUUM ELECTROMECHANICAL DERIVATION OF LOADING FLUX

ROLE OF APPLIED ELECTRIC FIELD INTENSITY

- Briefly, the applied electric field intensity produces migration in the electrolyte and loading of the metal. Q1D models have successfully predicted that the loading of hydrogen isotopes into the metal is an effect which is actually **opposite** the generation of bubbles which are classically associated with electrolysis and generally associated with cold fusion.

- Another important result, which was applied, is that if insufficient voltage is used, or if the metal is defective (like a balloon with a moderate leak) it may simply never adequately fill.

- Another important result is that codeposition generates excess heat more quickly. The optimal operating point behavior of codeposition was confirmed, and its excess heat has been independently confirmed (Szpak et alia).

Role Of Electrical Conductivity Upon The Loading Flux

Compared to the other deuteron fluxes, the deuteron loss to fusion is very small. Therefore, for this analysis it is reasonably assumed that $\kappa_{fus} \approx 0$. Assuming a Faradaic efficiency for gas formation of per electron, and accounting for the Faraday, F, then substituting the electrical admittance and electric field intensity, comprised of an electrical conductivity with geometric factors, yields

$$k_e \cong \frac{B_D * qE}{k_B T} - (\kappa_g) \qquad (4)$$

Assuming a Faradaic efficiency for gas formation of ξ_g per electron, and accounting for the Faraday ratio to the mole, F, then

$$\kappa_g \approx \frac{\xi_g * I}{F * A * [D^+]} \qquad (5)$$

QUASI-1-DIMENSIONAL CONTINUUM ELECTROMECHANICAL DERIVATION OF LOADING FLUX

ROLE OF APPLIED ELECTRIC FIELD INTENSITY

$$\mathrm{K}_g \approx \frac{\xi_g * \sigma_{D_2O} * V}{\mathrm{F} * \mathrm{L} * [D^+]} \qquad (6)$$

Using this with the original loading equation,

$$k_e \cong \frac{B_D * qV}{\mathrm{L} * k_B T} - \frac{\xi_g * \sigma_{D_2O} * V}{\mathrm{F} * \mathrm{L} * [D^+]} \qquad (7)$$

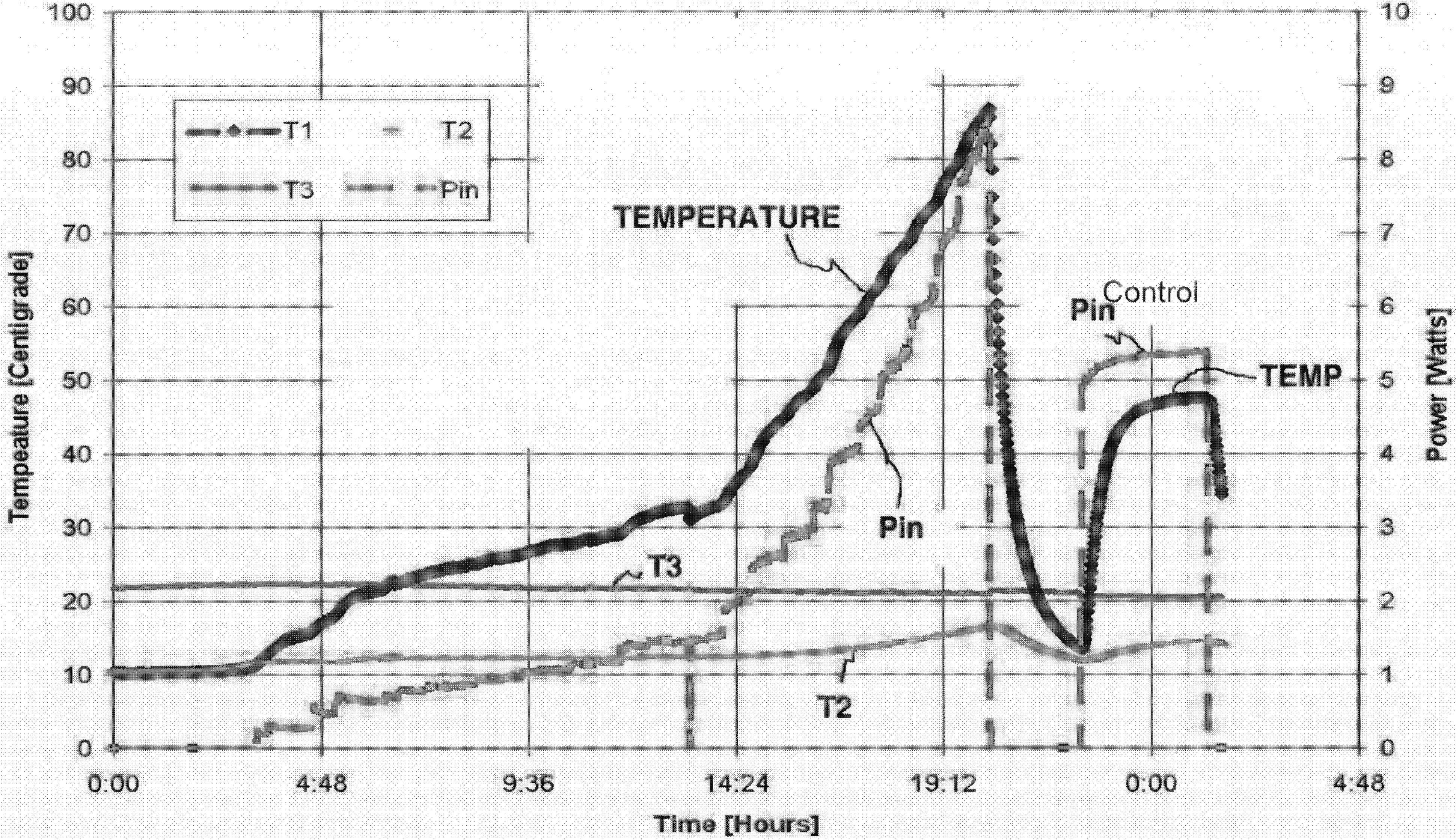
This is a second important equation. It shows the relations of first order loading rate to, and decreasing, with, solution electrical conductivity. That was tested in this series of experiments reported in the present paper. Using ultrapure heavy water, σ_{D_2O} was kept to a minimum for optimum loading of the palladium.

Metal Deuteride Research and Development

RESULTS:

Temperature as a function of Time.
Input-Power-Normalized delta-T In core.
Input-Power-Normalized Heat flow from core.
Wave Reconstruction Calorimetry yielding Power-Time Thermal Spectrograms.
Input-Power-Normalized Electric Generation, powered from core.
Input-Power-Normalized delta-T at Engine, heat from core.
Motor Function, powered by core.

TEMPERATURE AND INPUT POWER
PALLADIUM PHUSOR AND CONTROL



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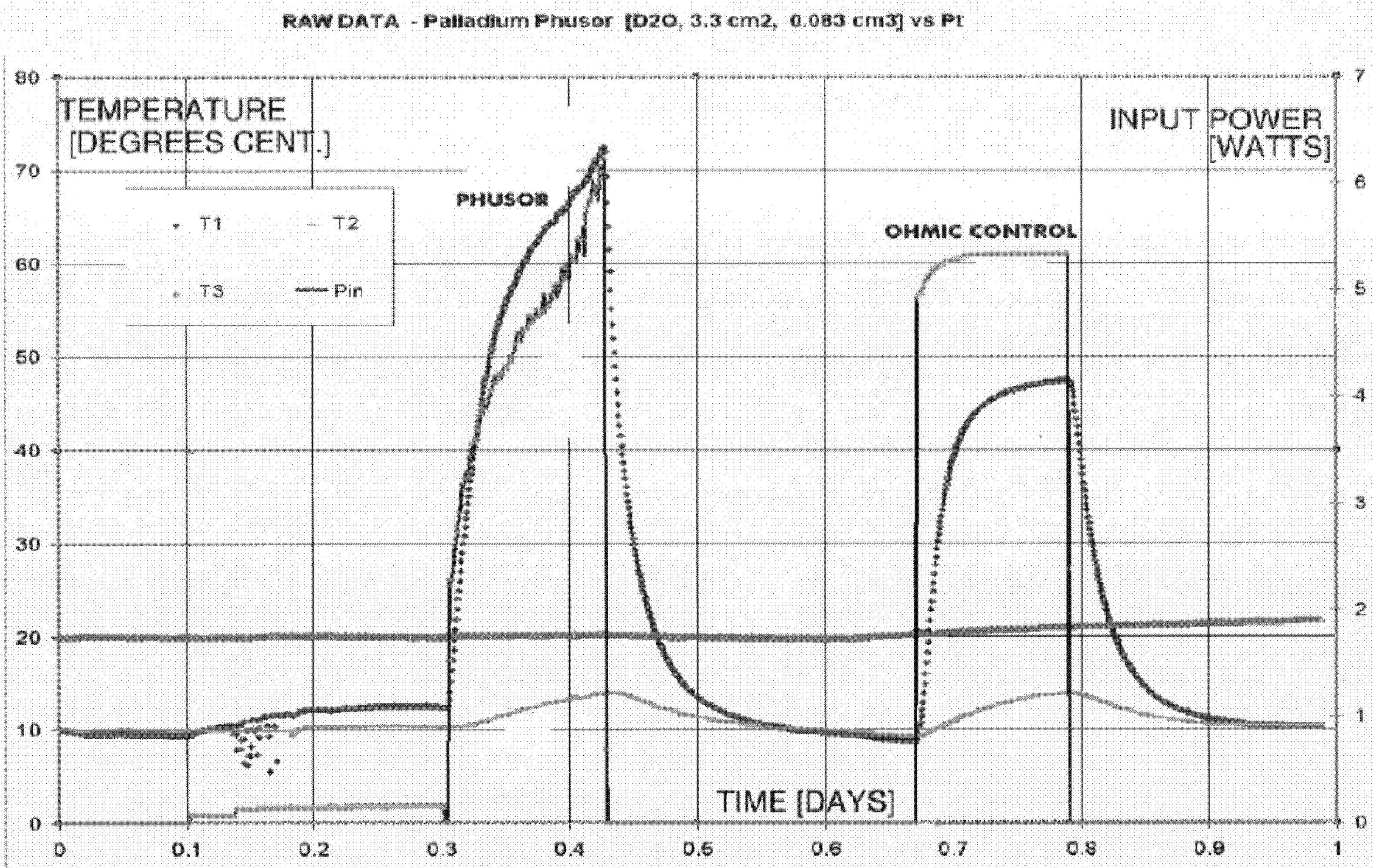
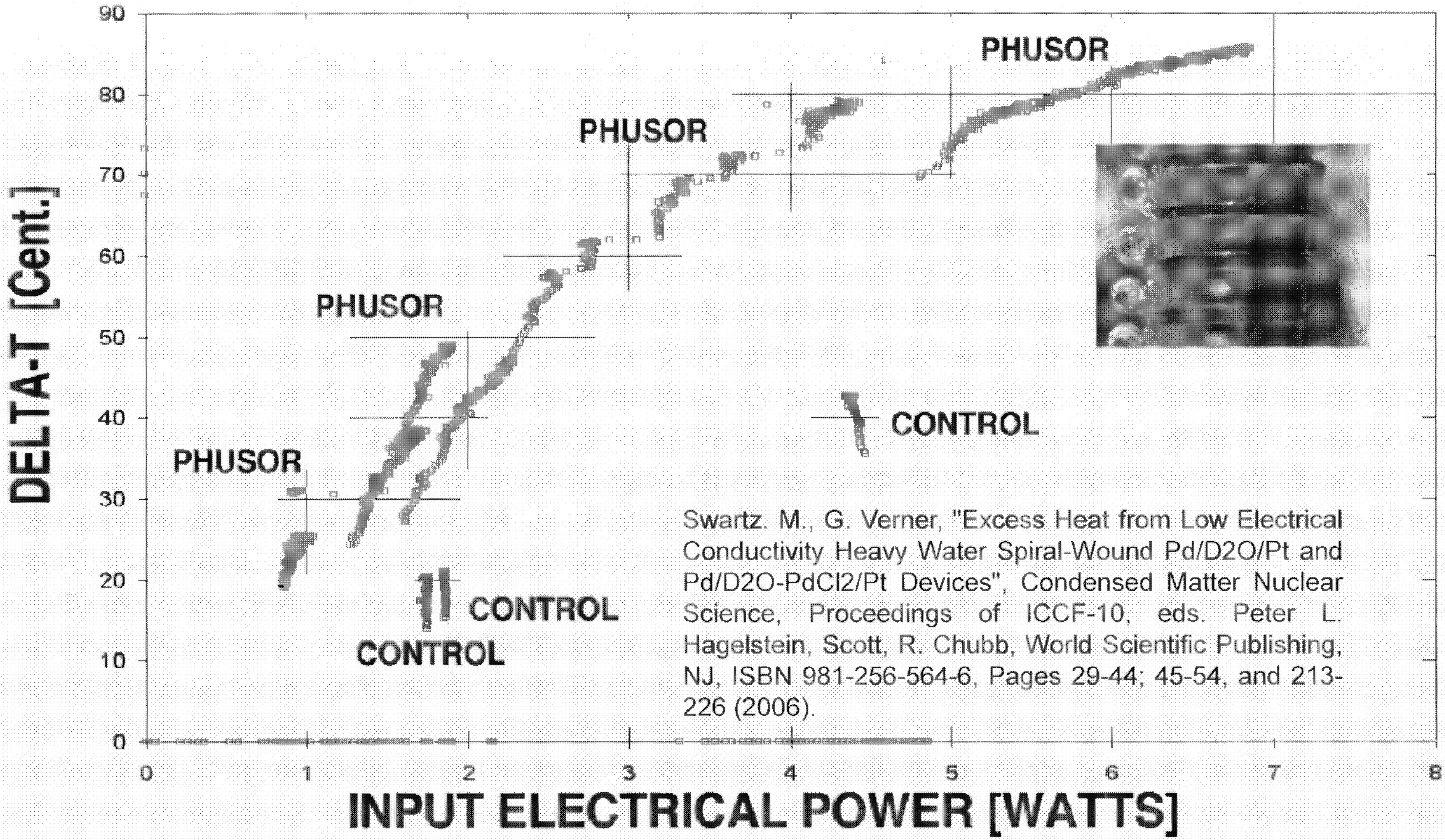
Dec. 12, 2006



RAW DATA - Palladium Phusor [D2O, 3.3 cm2, 0.083 cm3] vs Pt
TEMPERATURE
[DEGREES CENT.]
INPUT POWER
[WATTS]
T1
T2
T3
Pin
PHUSOR
OHMIC CONTROL
TIME [DAYS]
0
10
20
30
40
50
60
70
80
0
1
2
3
4
5
6
7
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

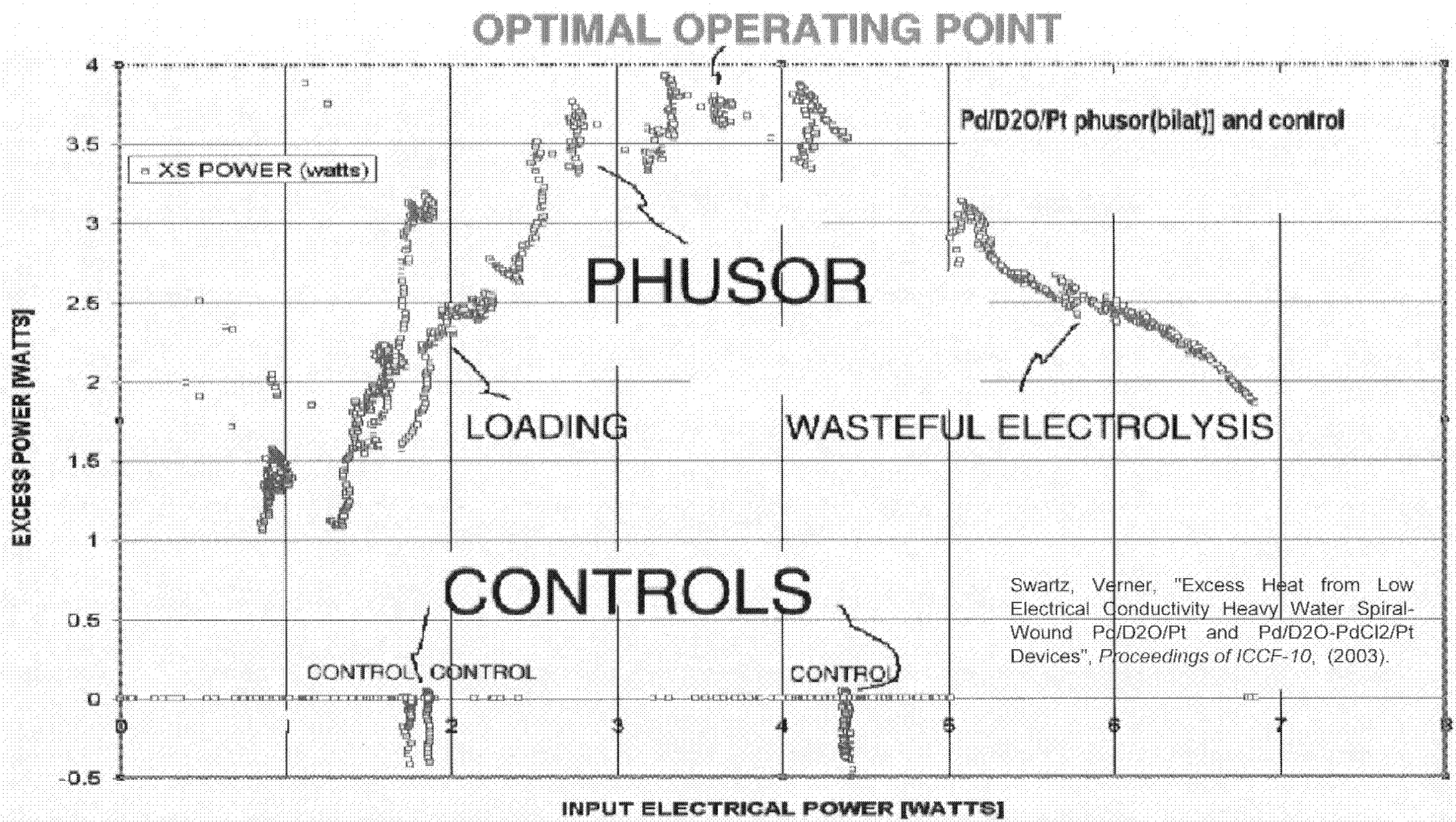
DELTA-T ACHIEVED AS A FUNCTION OF INPUT POWER

Pd PHUSOR [D2O, Pt spiral wound) and ohmic control

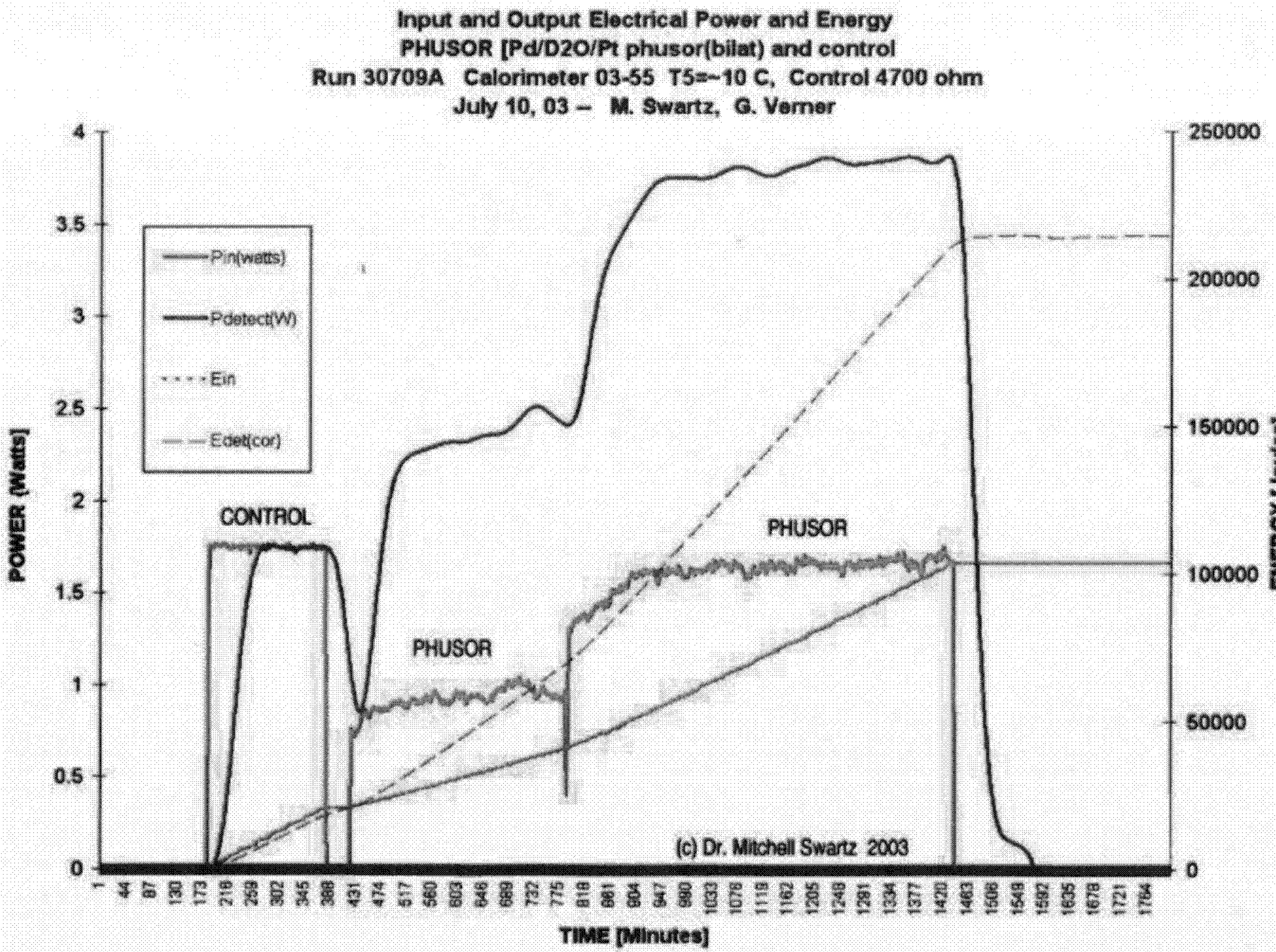


Optimal Operating Point Manifold

EXCESS POWER [WATTS] as a function of INPUT POWER

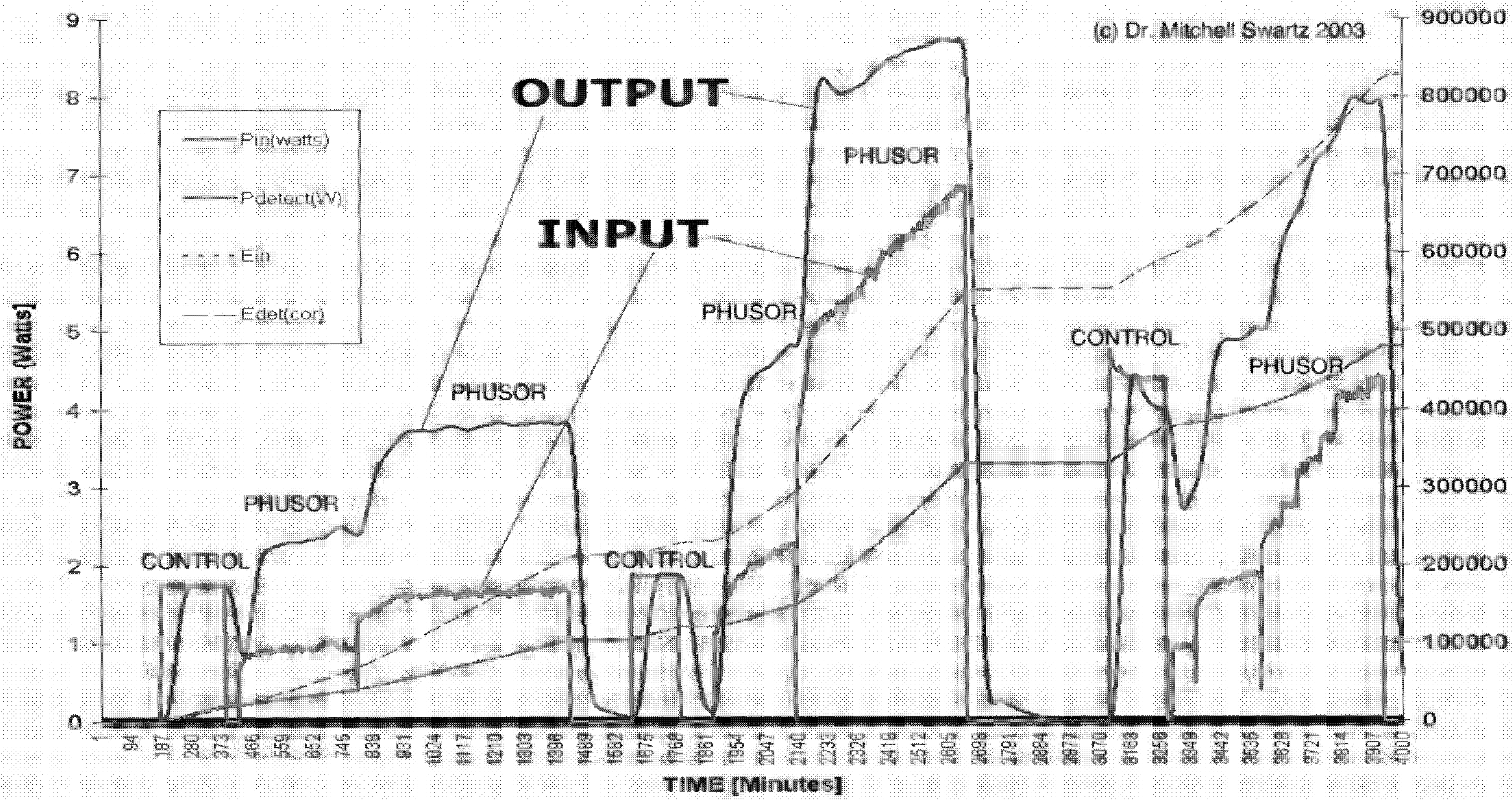


EXCESS ENERGY in the Pd/D2O/Pt System



EXCESS ENERGY BEYOND OHMIC CONTROL AT DIFFERENT POWER LEVELS
in the Pd/D2O/Pt System

Input and Output Electrical Power and Integrated Energy
PHUSOR [Pd/D2O/Pt phusor(bilat)] and control



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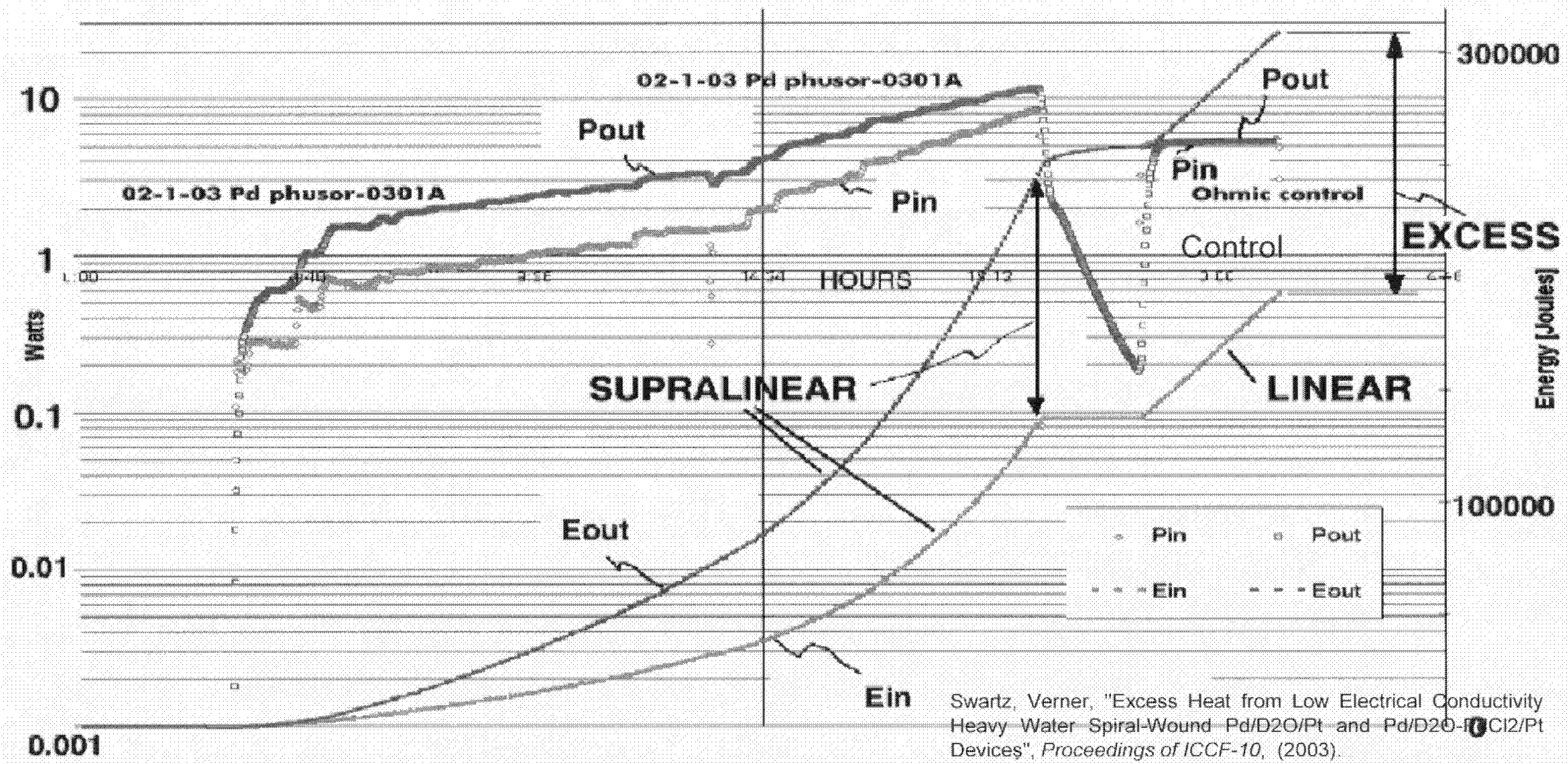
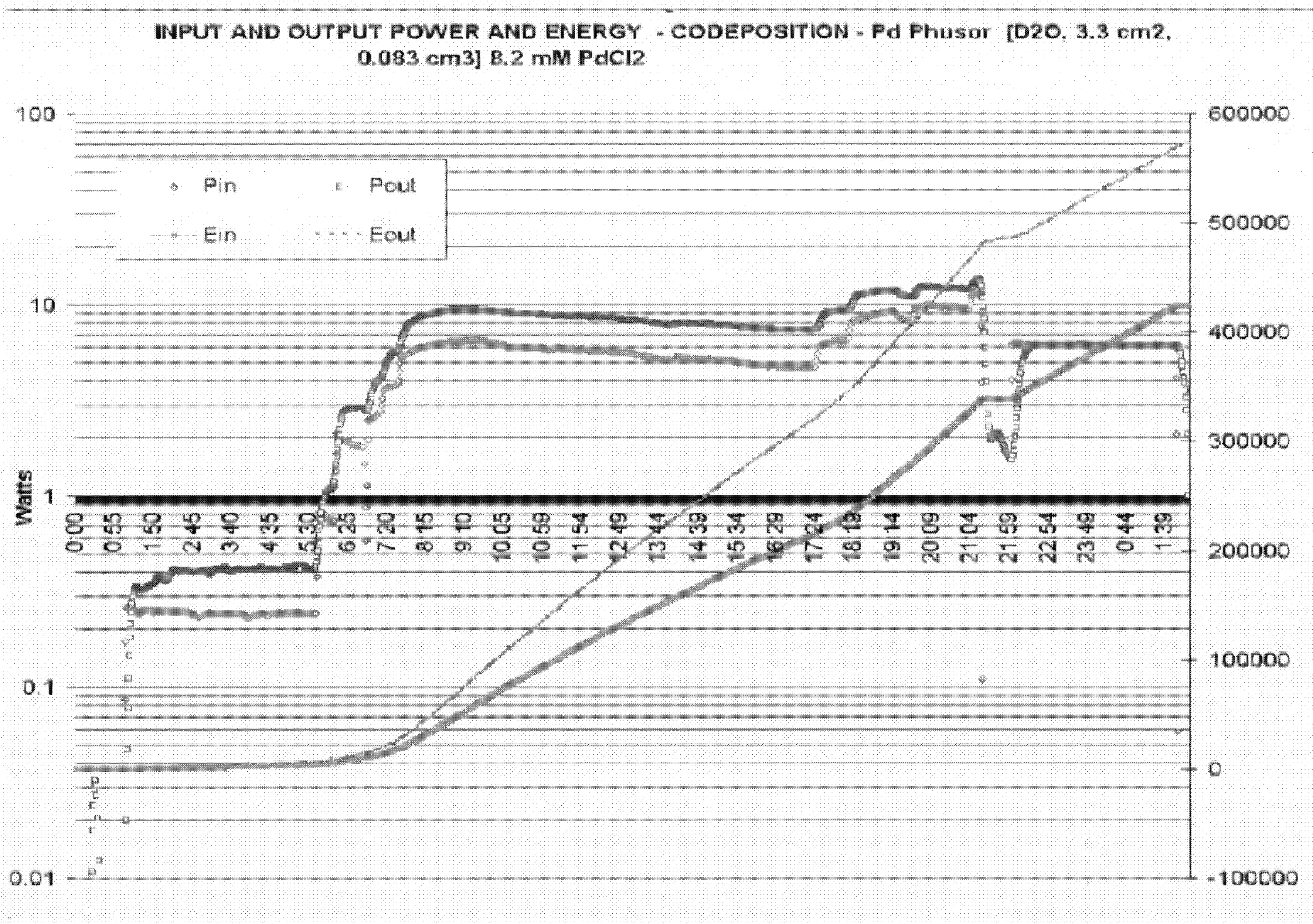
Dec. 12, 2006

EXCESS ENERGY BEYOND OHMIC CONTROL AT DIFFERENT POWER LEVELS
in the Pd/D2O-PdCl2/Pt System

INPUT AND OUTPUT POWER AND ENERGY of PALLADIUM PHUSOR [D2O, Pt]



Swartz, Verner, "Excess Heat from Low Electrical Conductivity Heavy Water Spiral-Wound Pd/D2O/Pt and Pd/D2O-PdCl2/Pt Devices", *Proceedings of ICCF-10*, (2003).



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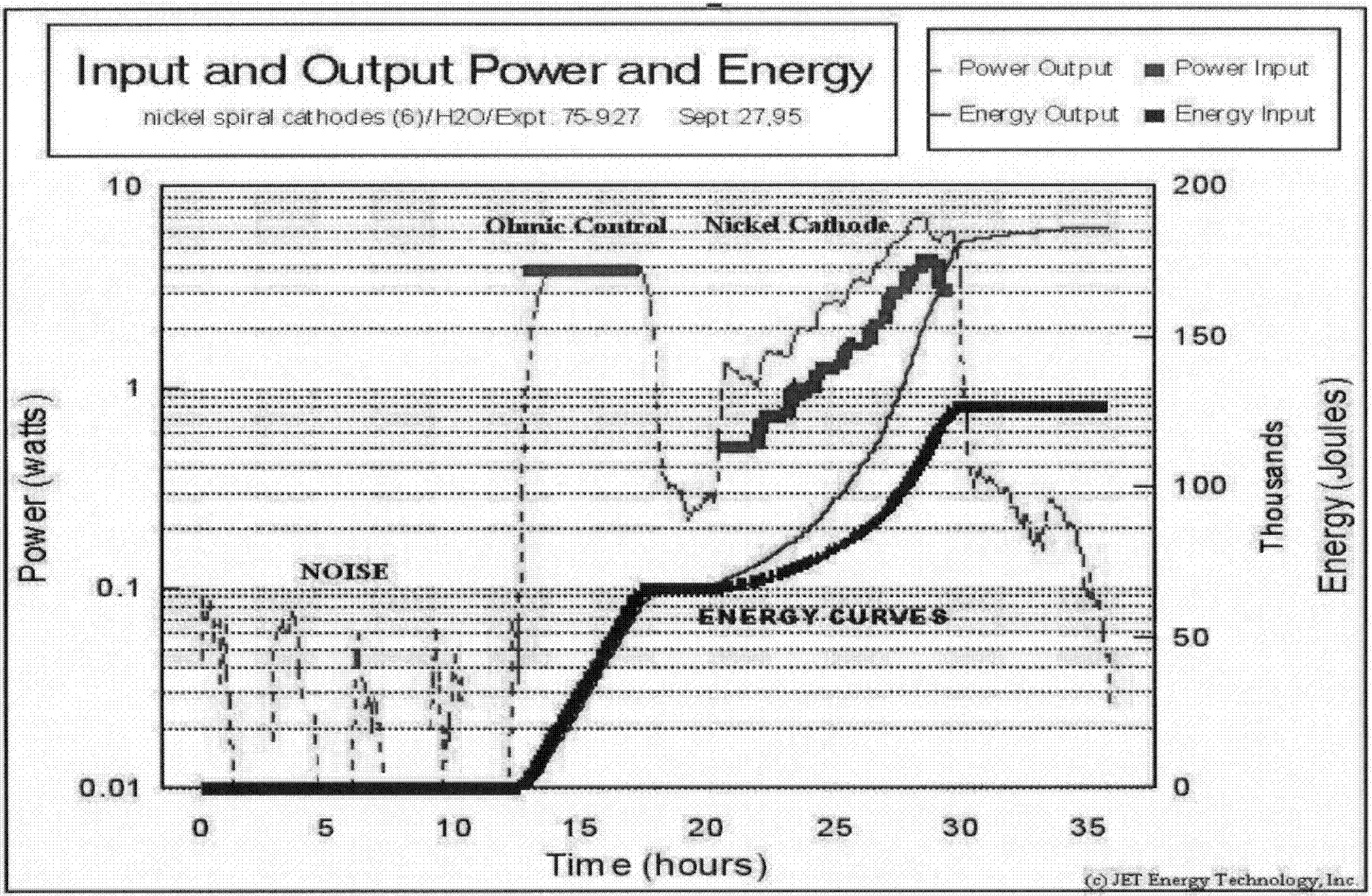
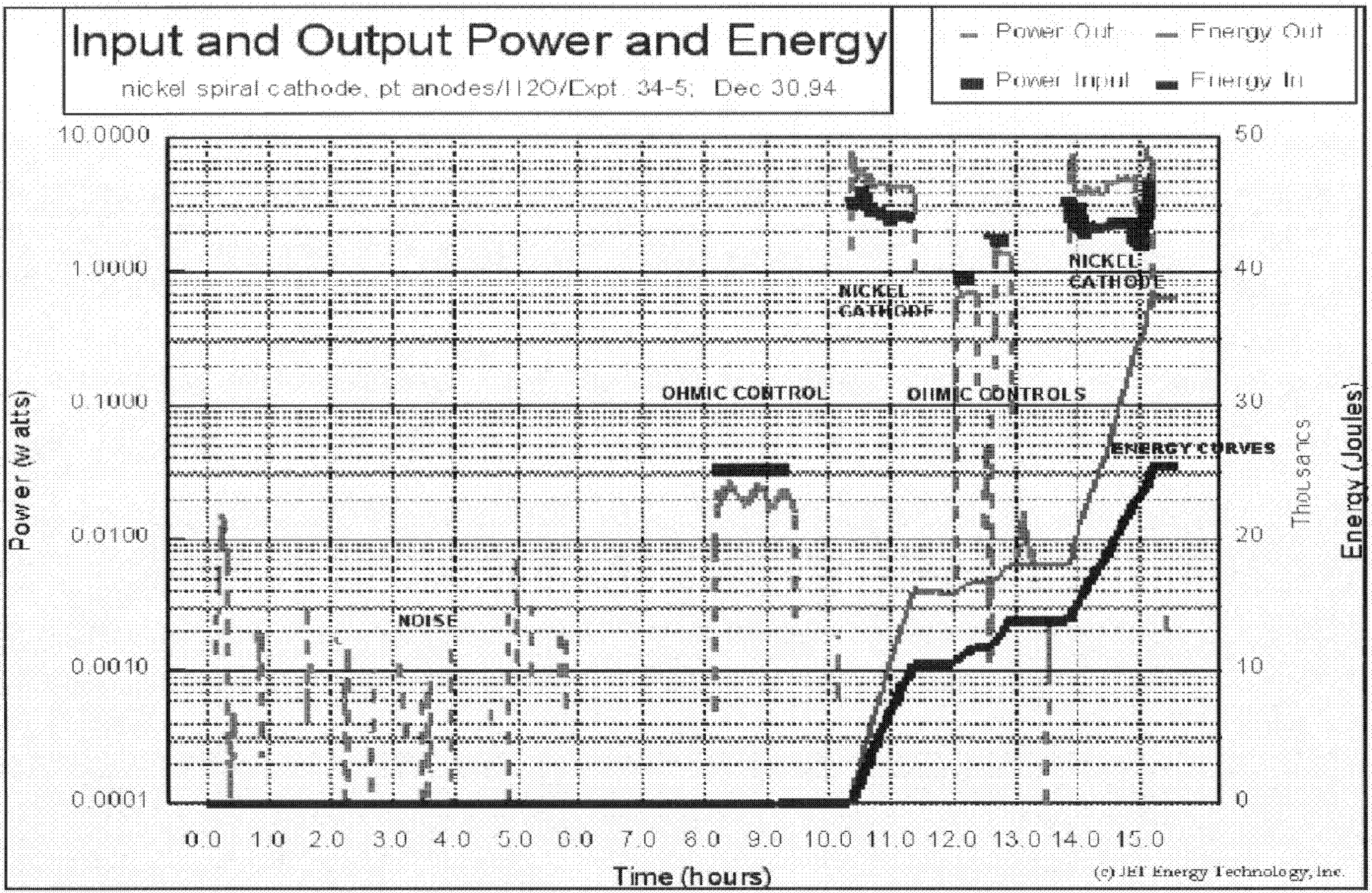
EXCESS ENERGY BEYOND OHMIC CONTROL in the Ni/H2O/Au System



EXCESS ENERGY BEYOND OHMIC CONTROL in the Ni/H2O/Pt System



EXPT: Solutions, Core, Container, Barriers, Calorimeter, Electric Producer, and Motor Engine are all heated by Electricity (DC) through two electrodes.

Input Power-Normalized delta-T at core

↓

Input Power-Normalized Heat Flow from core with NIST calibrated Sensors

↓

Dual Ohmic Control calorimetry with Time Integration

↓

Input Power-Normalized delta-T at Engine

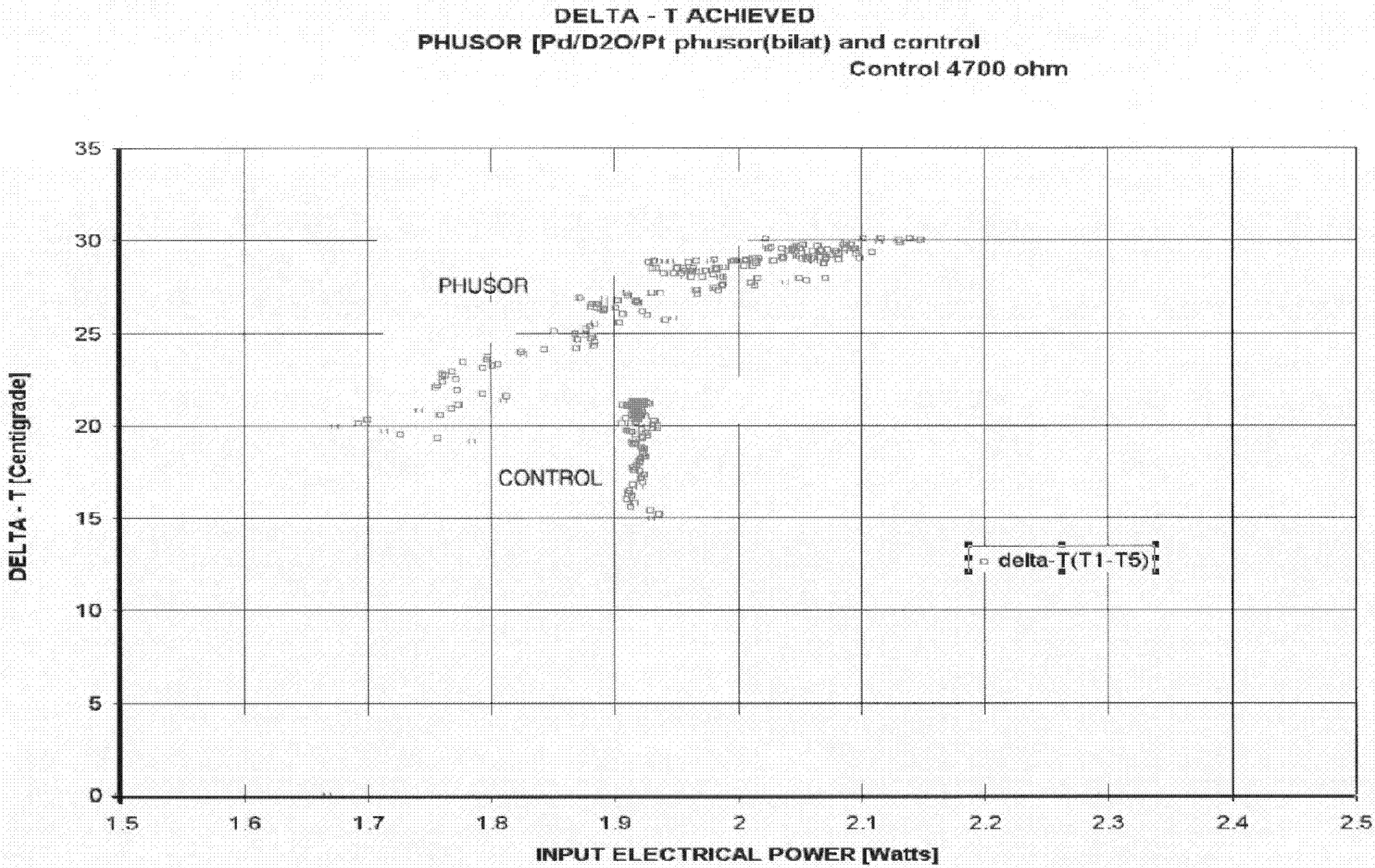
↓

Input Power-Normalized Electricity Generation

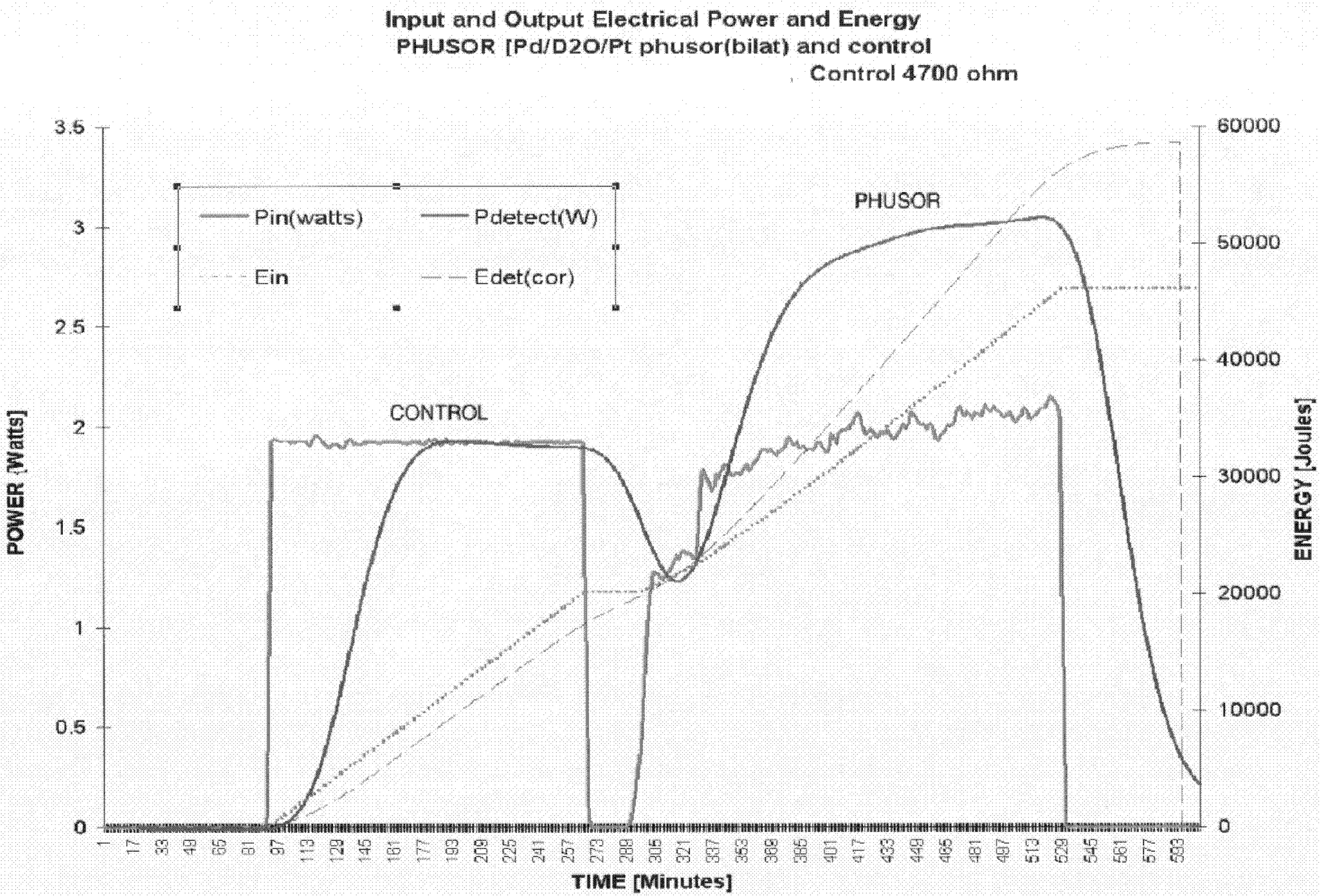
↓

Input Power-Normalized Motion from Engine

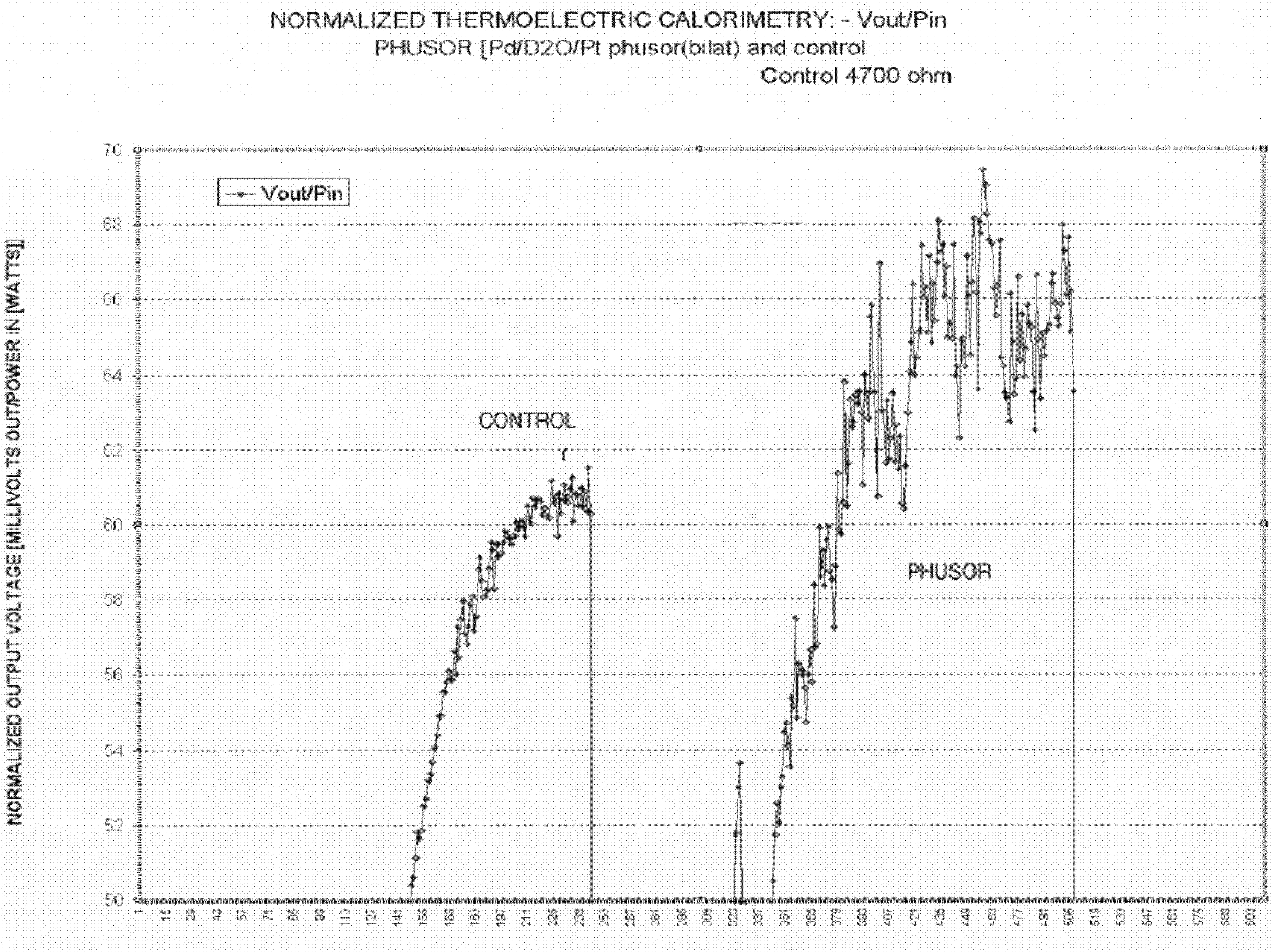
3 WAYS OF CONFIRMATION



3 WAYS OF CONFIRMATION



3 WAYS OF CONFIRMATION



4 WAYS OF CONFIRMATION

Palladium Phusor (moderate power) Run 29, E60823A
Pd Phusor (Ti) vs. Pt, lp-D2O and Ohmic Control (paraffin,3ply),
10K Driver,Dual Engines - Vertical Block Dr. Swartz 8/24/06

Brief Procedure Note

Pd Phusor (Ti)-D2O Phusor
10K Driver mod. 4
10K Driver Current by HP Harrison
Ohmic control driven by Keithley 225
Pd /D2O/Pt (fl-Ti) Phusor
(dual wrap parafilm)
Paired NIST-calib Heat Flow Sensors
Control - 7.2K ohms parafilm

Run 8/20-23/06 AB
Total run time: hours [Max I = 2.6 mA]
Total Phusor run time: 16 hours
Phase: Phusor Operational
Plan: Increasing low power.
Show excess energy four ways ☑

Recommendations/Observations

Operators: Dr. Mitchell Swartz
Guests:
Aug. 24, 2006 Dr. Mitchell Swartz

Results

Pin(max) = ~500 milliwatts
Ein(total) = ~18,000 Joules
R(Phusor) = 25,000 -> 21,000 ohms

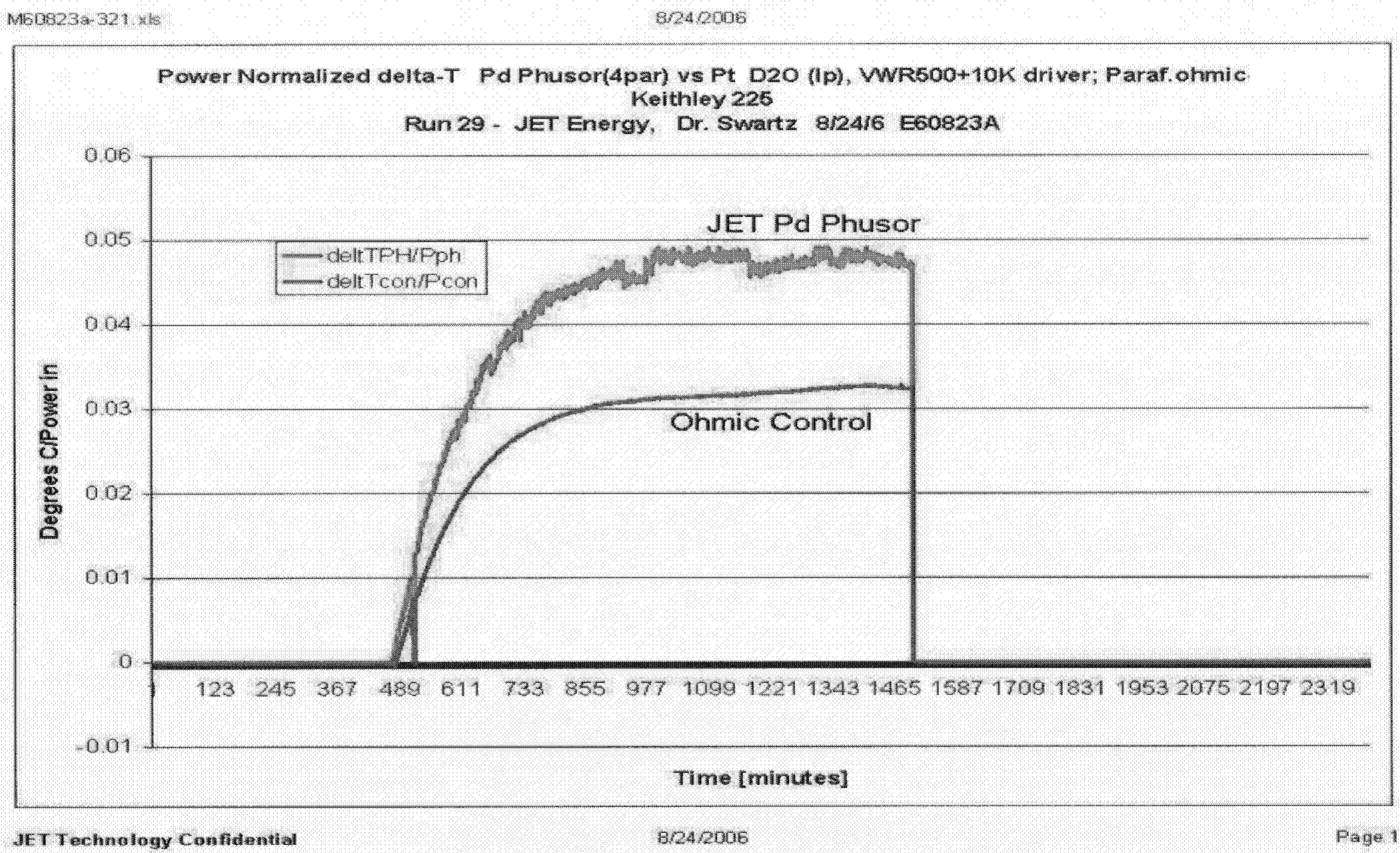
☑ Pgain = 149% (by delta-T/Pin)
☑ Pgain = ~225% (by normalized HF)
☑ Pgain engine = 180%
(by power normalized delta-T only)
☑ Pgain = 149% (by time-integrated, calorimetry with controls, waveform analysis)

ENERGY gain = ~149% (by calorimetry)
IntegXS Energy = ~8,200 J
<Power Gain>= 1.5-2.2

XS Pout[(max)] = ~125 mw
Loading Energy =
IntegHAD energy = ~ 800Joules
Voc = Pd = 1.75 v
Vinterelectrode (Pd-Ti) = n.a.

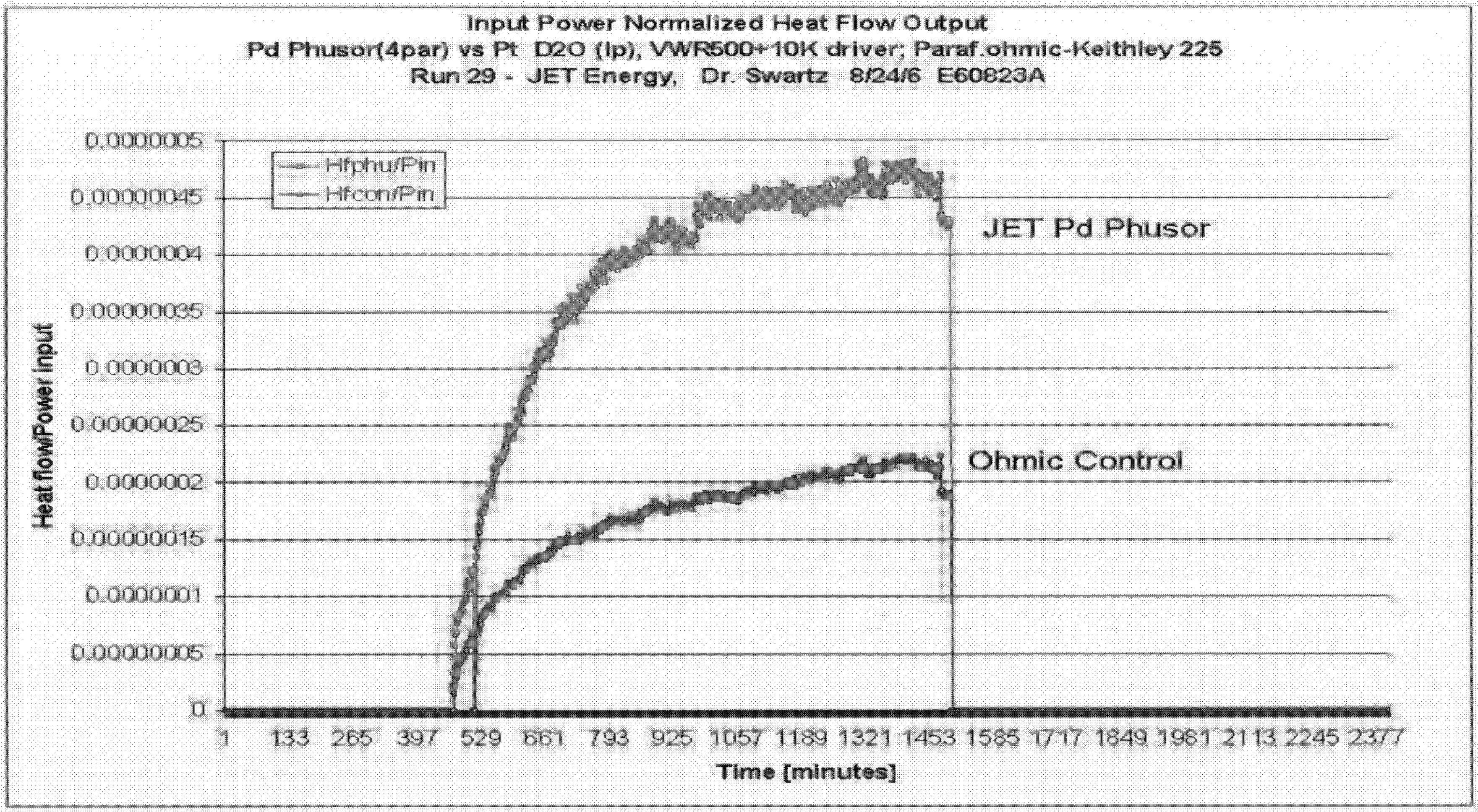
Complications/Findings: Added graph of all four power gains as f(t)

4 WAYS OF CONFIRMATION



4 WAYS OF CONFIRMATION

8/24/2006M60823a-321.xls



JET Technology Confidential 8/24/2006 Page 1

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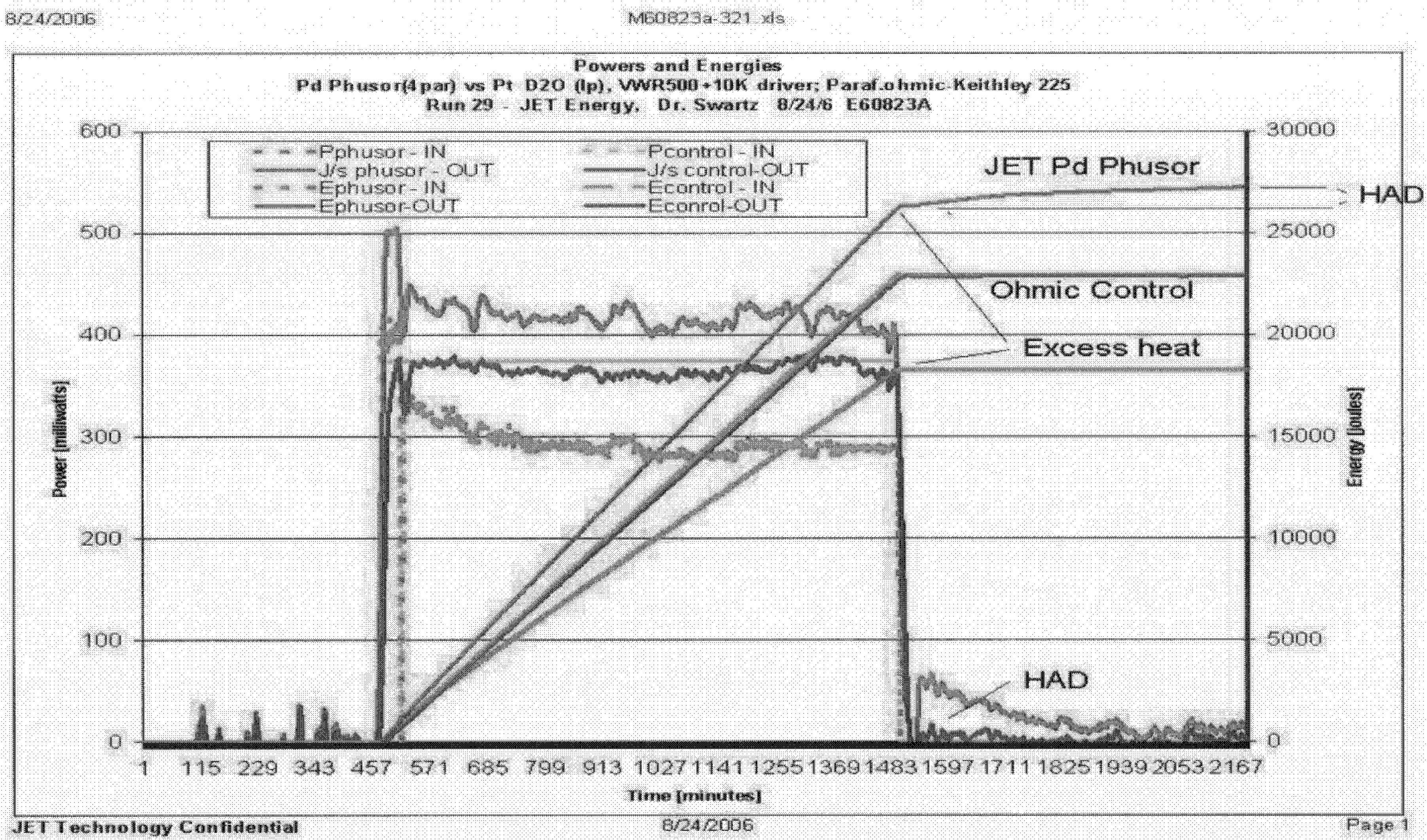
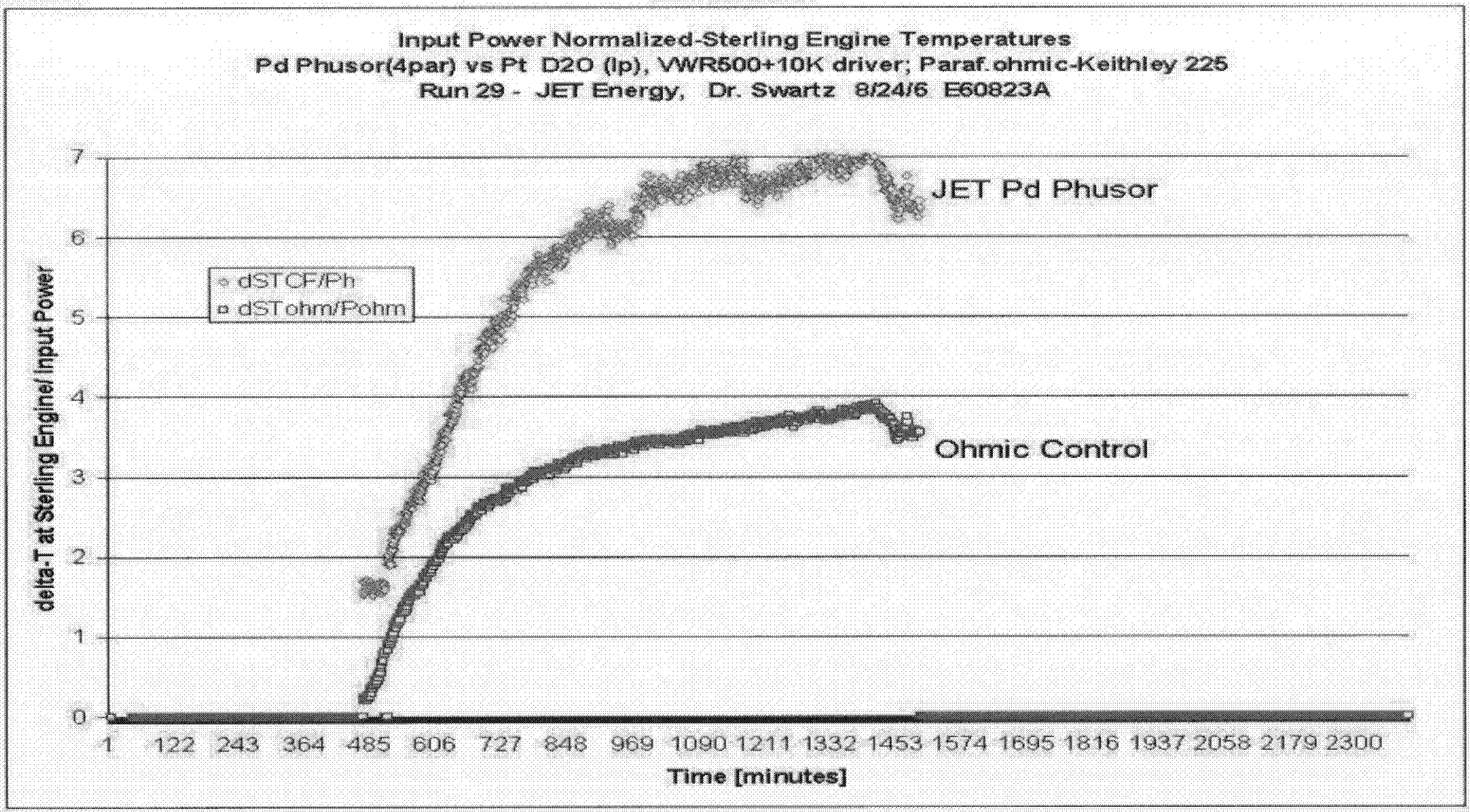
4 WAYS OF CONFIRMATION



4 WAYS OF CONFIRMATION

8/24/2006 M60823a-321.xls



JET Technology Confidential 8/24/2006 Page 1

4 WAYS OF CONFIRMATION

Palladium Phusor Run 30, E60825-26AB
Pd Phusor (Ti) vs. Pt, lp-D2O and Ohmic Control (paraffin,3ply),
10K Driver,Dual Engines - Vertical Block Dr. Swartz 8/27/06

Brief Procedure Note

Pd Phusor (Ti)-D2O Phusor
10K Driver mod. 4
10K Driver Current by HP Harrison
Ohmic control driven by Keithley 225
Pd /D2O/Pt (fl-Ti) Phusor
(dual wrap parafilm)
Paired NIST-calib Heat Flow Sensors
Control - 7.2K ohms parafilm

Run 8/24-27/06 AB
Total run time: hours [Max I = 8.88 mA]
Total Phusor run time: 24 hours
Phase: Post-preparation power increase
Plan: Show excess energy four ways ☑

Recommendations/Observations

Operators: Dr. Mitchell Swartz

Aug. 27, 2006 Dr. Mitchell Swartz

Results

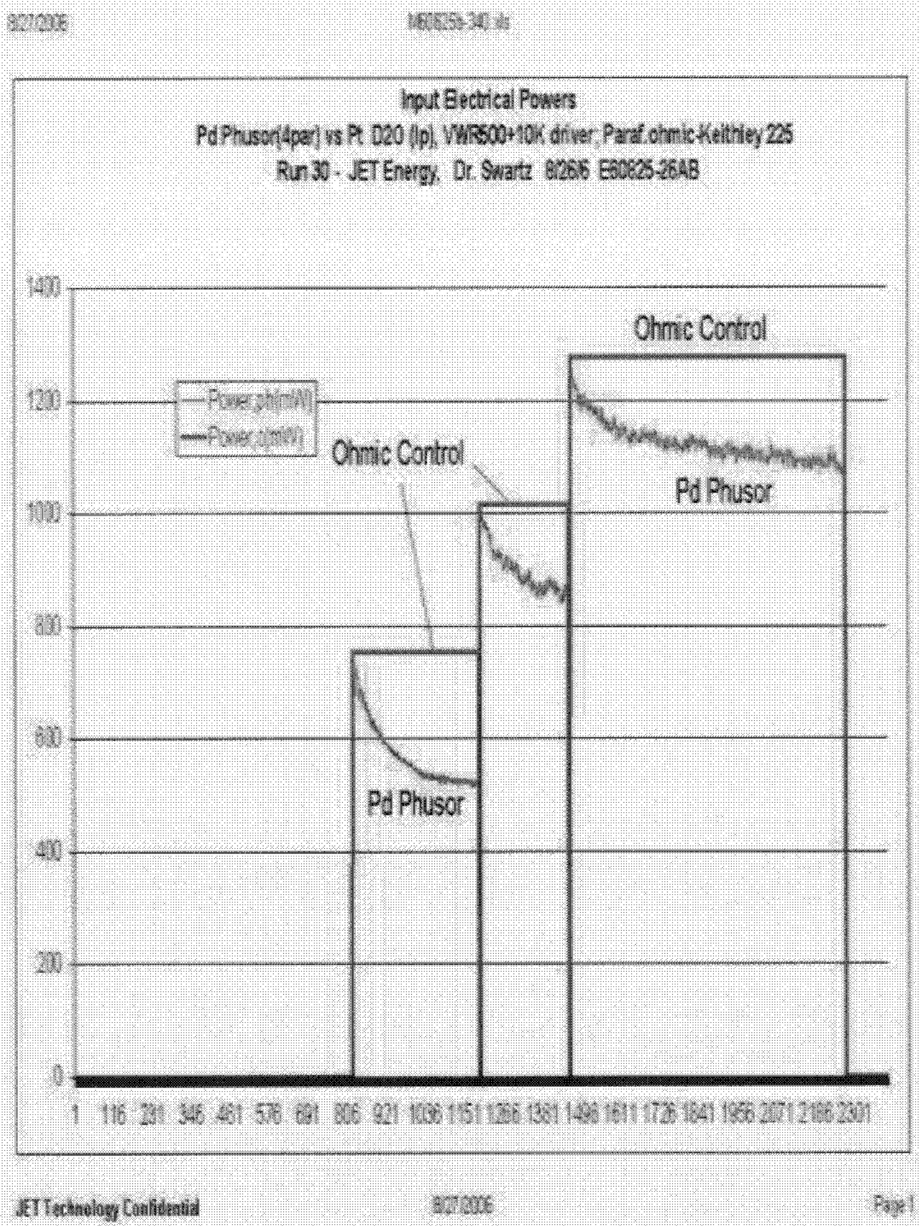
Pin(max) = ~1013 milliwatts
Ein(total) = ~81,434 Joules
R(Phusor) = 25,000 -> 14,000 ohms

☑ Pgain = 152% (by delta-T/Pin)
☑ Pgain = ~197% (by normalized HF)
☑ Pgain engine = 154%
(by power normalized delta-T only)
☑ Pgain = 143% (by time-integrated, calorimetry with controls, waveform analysis)

ENERGY gain = ~143% (by calorimetry)
IntegXS Energy = ~31,015 J
<Power Gain>= 1.4-2.0

XS Pout[(max)] = ~521 mw
Loading Energy = 39 Joules
IntegHAD energy = ~ 3383 Joules
Voc = Pd = 1.82 v
Vinterelectrode (Pd-Ti) = n.a.

Complications/Findings: Added graph of all four power gains as f(t)


Input Electrical Powers
Pd Phusor(4par) vs Pt D2O (lp), VWR500+10K driver; Paraf.ohmic-Keithley 225
Run 30 - JET Energy, Dr. Swartz 8/26/6 E60825-26AB
Ohmic Control
Ohmic Control
Pd Phusor
Pd Phusor
1400
1200
1000
800
600
400
200
0
1 116 231 346 461 576 691 806 921 1036 1151 1266 1381 1496 1611 1726 1841 1956 2071 2186 2301
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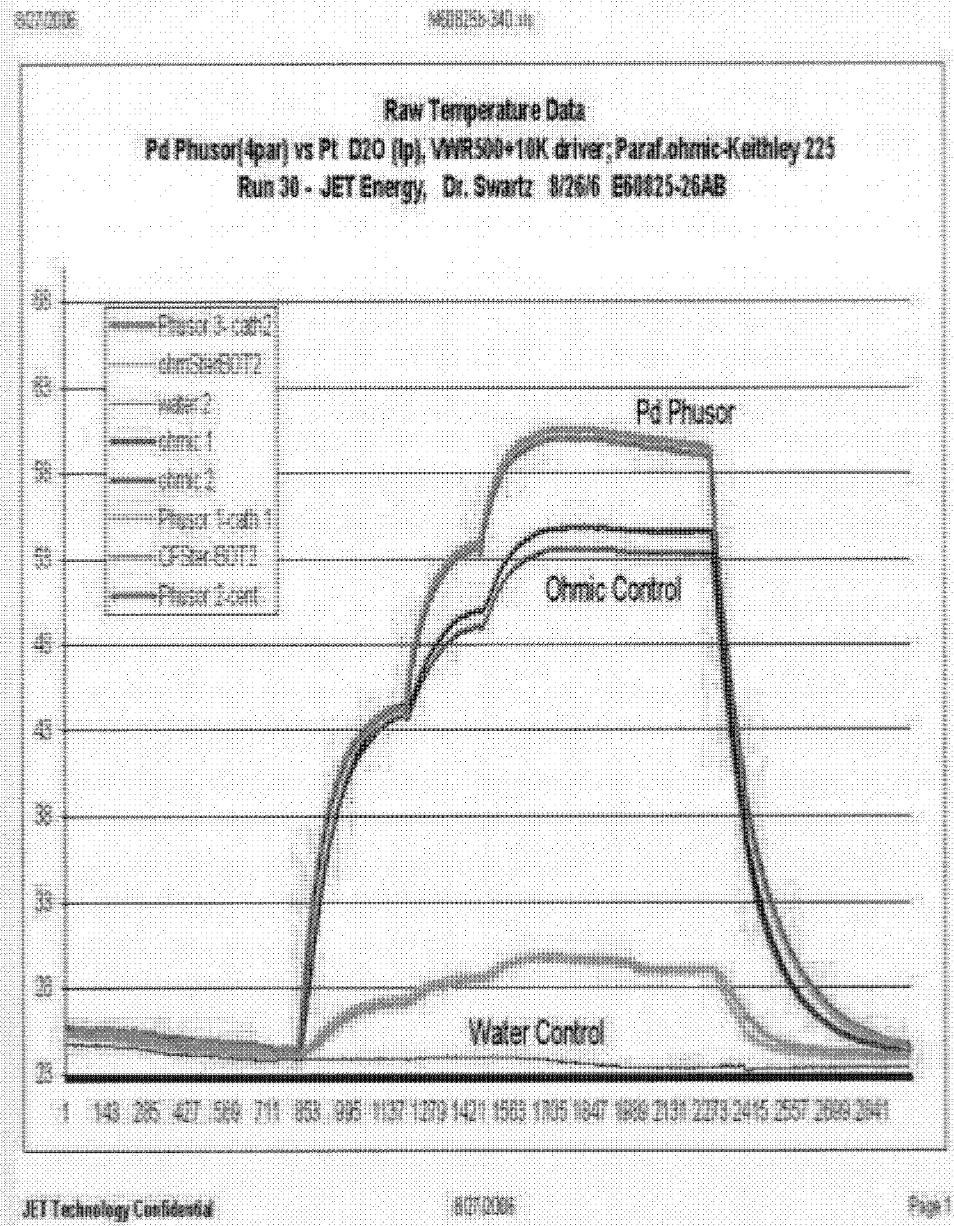
Raw Temperature Data
Pd Phusor(4par) vs Pt D2O (lp), VWR500+10K driver; Paraf.ohmic-Keithley 225
Run 30 - JET Energy, Dr. Swartz 8/26/6 E60825-26AB
Phusor 3-cath2
ohmStarBOT2
water 2
ohmic 1
ohmic 2
Phusor 1-cath 1
CFStar-BOT2
Phusor 2-cent
Pd Phusor
Ohmic Control
Water Control
68
63
58
53
48
43
38
33
28
23
1 143 285 427 569 711 853 995 1137 1279 1421 1563 1705 1847 1989 2131 2273 2415 2557 2699 2841
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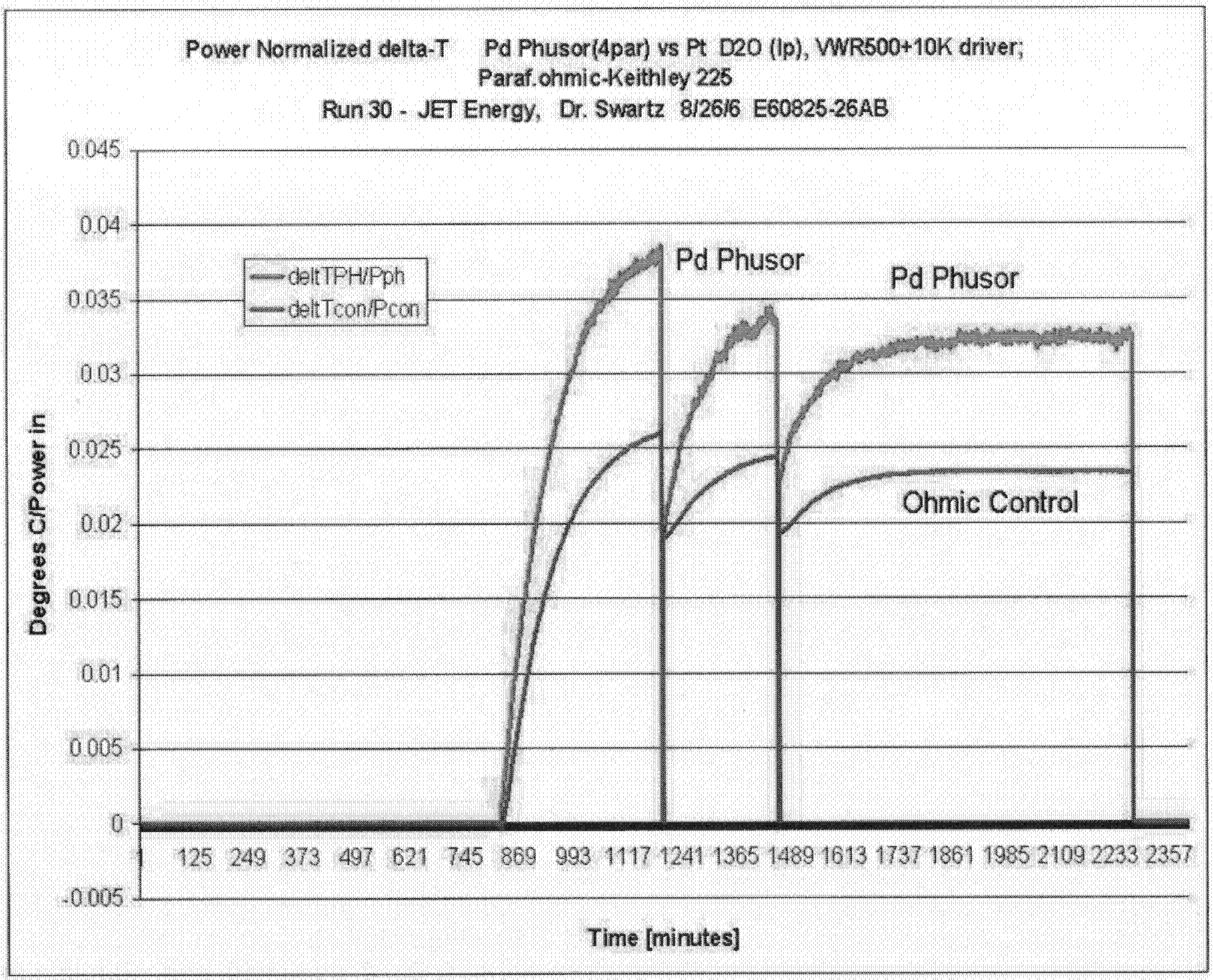
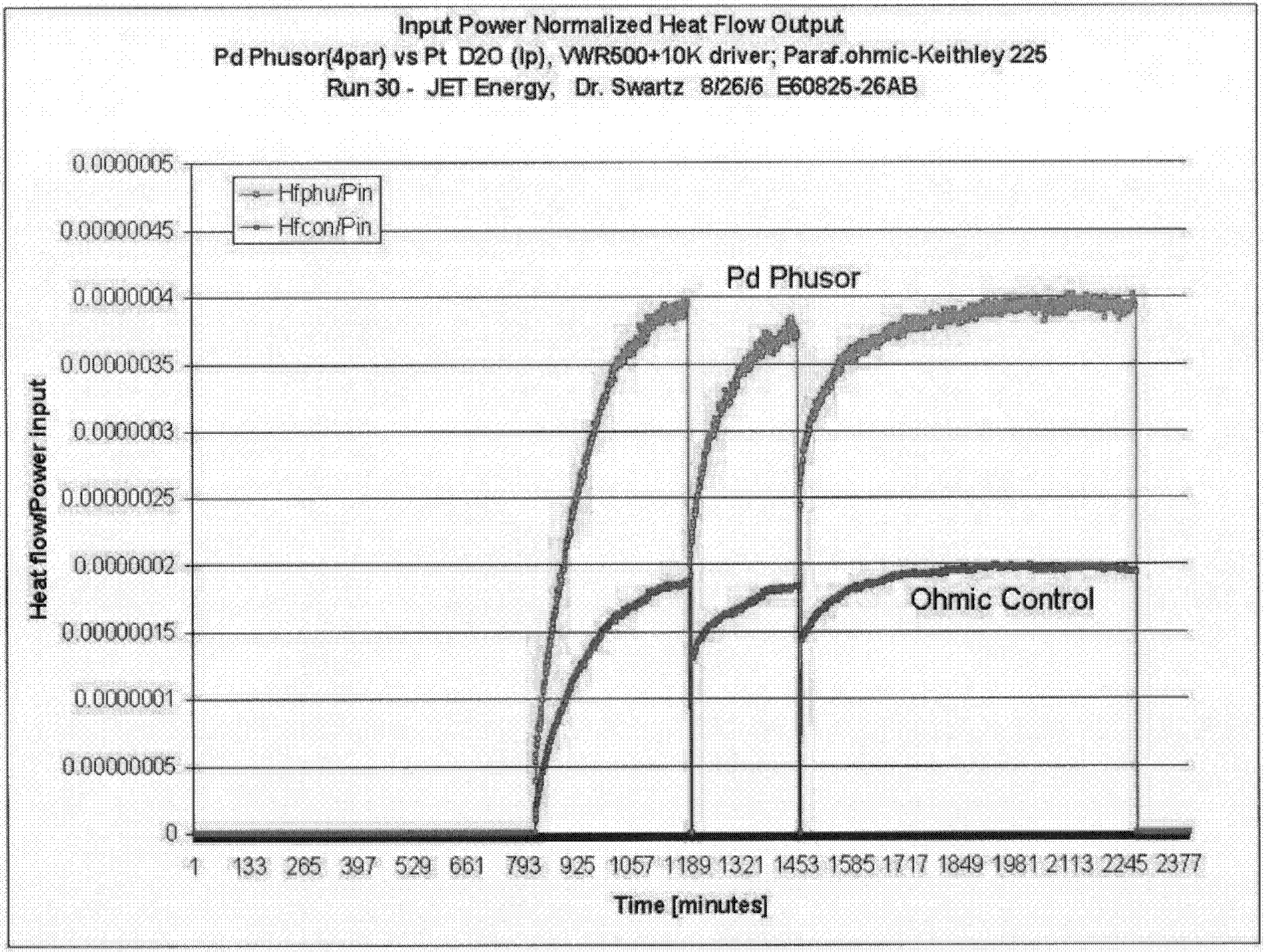
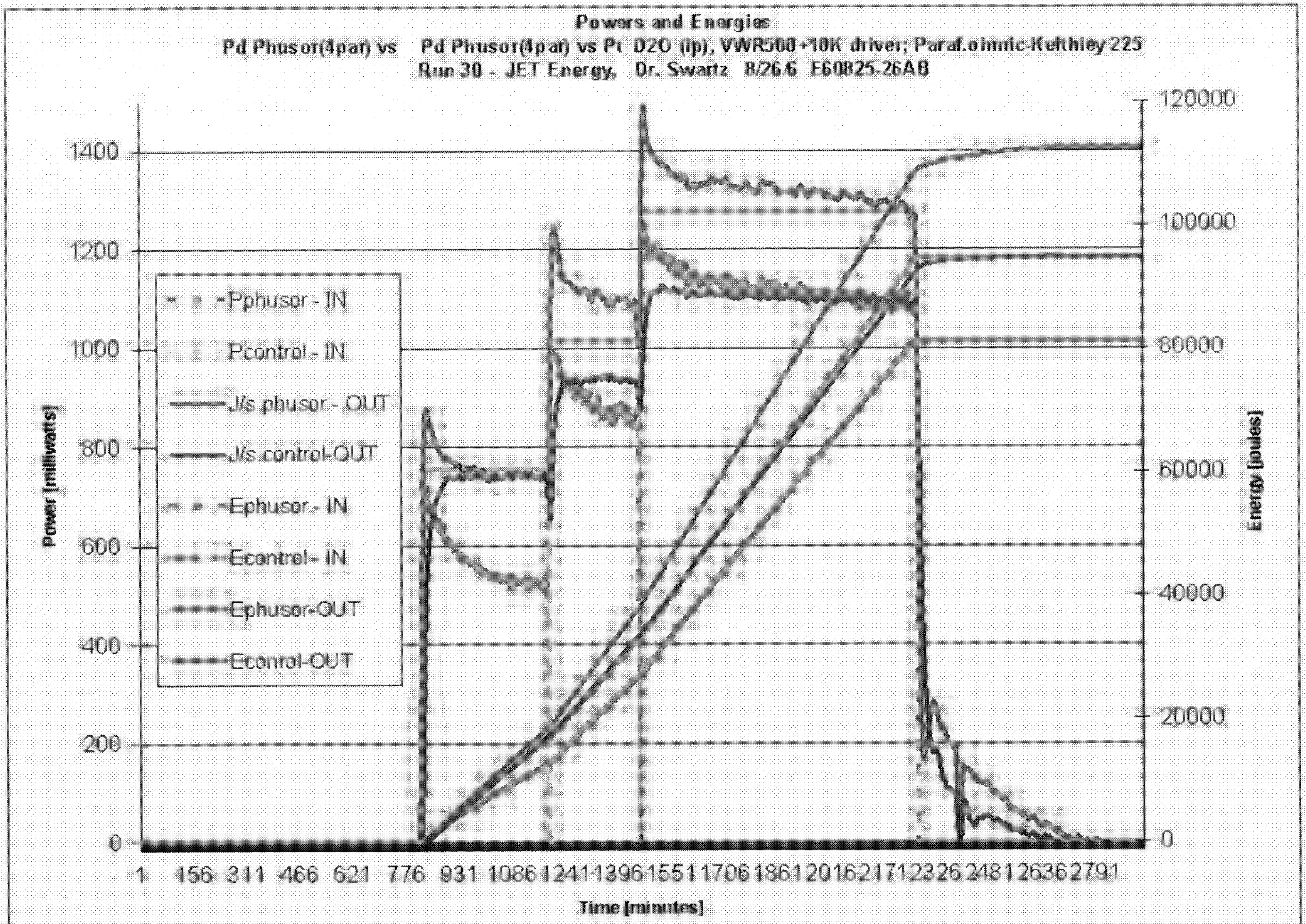
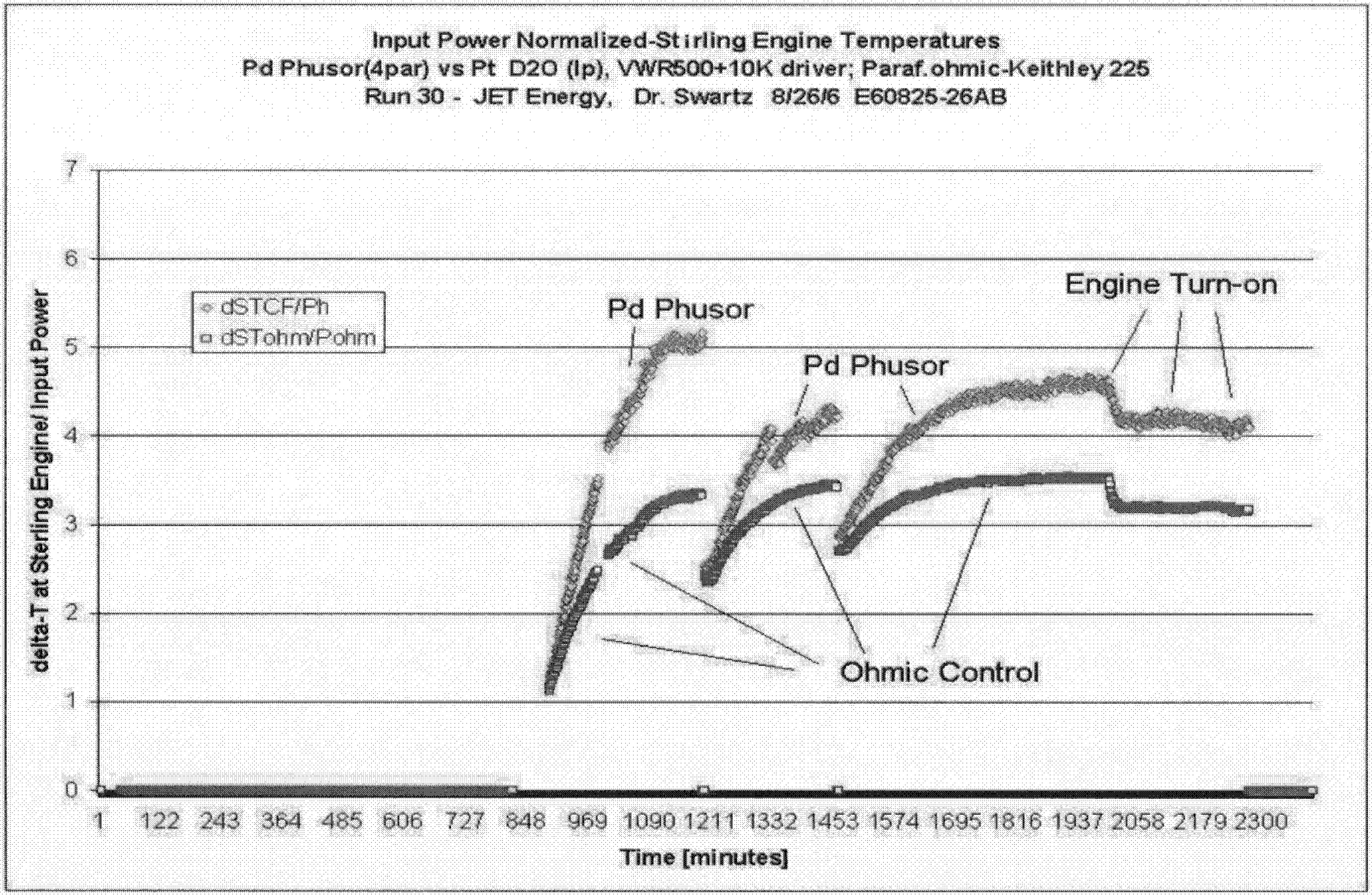


Power Normalized delta-T Pd Phusor(4par) vs Pt D2O (lp), VWR500+10K driver;
Paraf.ohmic-Keithley 225
Run 30 - JET Energy, Dr. Swartz 8/26/6 E60825-26AB
deltTPH/Pph
deltTcon/Pcon
Pd Phusor
Pd Phusor
Ohmic Control
Degrees C/Power in
Time [minutes]
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
-0.005
1 125 249 373 497 621 745 869 993 1117 1241 1365 1489 1613 1737 1861 1985 2109 2233 2357


Input Power Normalized Heat Flow Output
Pd Phusor(4par) vs Pt D2O (lp), VWR500+10K driver; Paraf.ohmic-Keithley 225
Run 30 - JET Energy, Dr. Swartz 8/26/6 E60825-26AB
Hfphu/Pin
Hfcon/Pin
Pd Phusor
Ohmic Control
Heat flow/Power input
0.0000005
0.00000045
0.0000004
0.00000035
0.0000003
0.00000025
0.0000002
0.00000015
0.0000001
0.00000005
0
1 133 265 397 529 661 793 925 1057 1189 1321 1453 1585 1717 1849 1981 2113 2245 2377
Time [minutes]



Powers and Energies
Pd Phusor(4par) vs Pd Phusor(4par) vs Pt D2O (lp), VWR500+10K driver; Paraf.ohmic-Keithley 225
Run 30 - JET Energy, Dr. Swartz 8/26/6 E60825-26AB
Power [milliwatts]
Energy [joules]
Time [minutes]
Pphusor - IN
Pcontrol - IN
J/s phusor - OUT
J/s control-OUT
Ephusor - IN
Econtrol - IN
Ephusor-OUT
Econrol-OUT
0
200
400
600
800
1000
1200
1400
0
20000
40000
60000
80000
100000
120000
1 156 311 466 621 776 931 1086 1241 1396 1551 1706 1861 2016 2171 2326 2481 2636 2791


Input Power Normalized-Stirling Engine Temperatures
Pd Phusor(4par) vs Pt D2O (lp), VWR500+10K driver; Paraf.ohmic-Keithley 225
Run 30 - JET Energy, Dr. Swartz 8/26/6 E60825-26AB
delta-T at Sterling Engine/ Input Power
Time [minutes]
dSTCF/Ph
dSTohm/Pohm
Pd Phusor
Pd Phusor
Engine Turn-on
Ohmic Control
7
6
5
4
3
2
1
0
1 122 243 364 485 606 727 848 969 1090 1211 1332 1453 1574 1695 1816 1937 2058 2179 2300

5-6 WAYS OF CONFIRMATION

- We now go further, with corroboratory measurements made by multiple methods [we now use up to 5 to 6 independent methods to evaluate excess heat as we will discuss in our next ICCF paper].

Palladium Phusor Run 35, E60912-16AB
Pd Phusor (Ti) vs. Pt, lp-D2O and Ohmic Control (paraffin,3ply),
10K Driver, Dual Engines - Vertical Block Dr. Swartz 9/16/06

Brief Procedure Note

Pd Phusor (Ti)-D2O Phusor
10K Driver mod. 4
10K Driver Current by Keithley 225
Ohmic control driven by HP Harrison
Pd /D2O/Pt (fl-Ti) Phusor
(dual wrap parafilm)
Paired NIST-calib Heat Flow Sensors
Control - 7.2K ohms parafilm

9/12-16/6 AB
Total run time: 89 hours [Max I = 8.6 mA]
Total Phusor run time: 60 hours
Phase: Phusor (Ti exp)
Plan: Show excess energy five ways including engine ☑

Recommendations/Observations

Operators: Dr. Mitchell Swartz
Gayle Verner

Sept. 16, 2006 Dr. Mitchell Swartz

Results

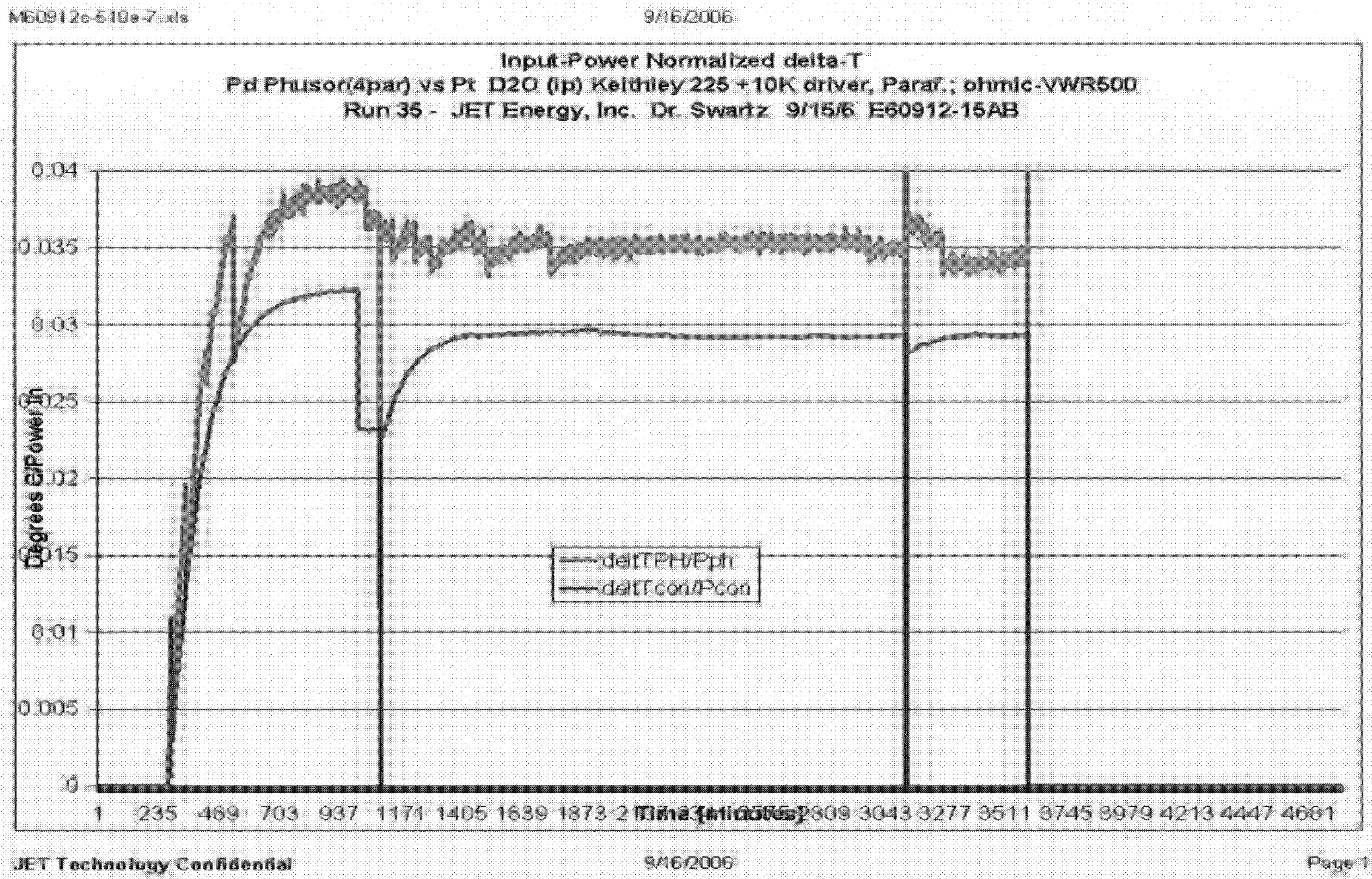
Pin(max) = ~1.098 watts Ein = ~192.25 kJoules
R(Phusor) = 25,000 -> 15,000 ohms
☑ Pgain by input-power-normalized delta-T
189% max , ave. 120%
☑ Pgain by input-power-normalized HF
238% , min. 166%
☑ Pgain by max.area corr. in-power-nlzed HF
155%
☑ Pgain by input-power-normalized delta-T at engines 159%
☑ Pgain by time-integrated multiring calorimetry with controls, waveform analysis 142% (cal1)
☑ Pgain by time-integrated multiring calorimetry with NIST-cal flow 181% (cal2)
ENERGY gain = ~142% (by calorimetry 1)
IntegXS Energy = ~41,528 J
<Power Gain>= 1.4-2.4
XS Pout[(max)] = XS Pout[(ave)] =
Loading Energy = 142 Joules
HAD energy = 12.9 kjoules (cal1) 10.3 kJ (cal2)

Voc Pd = 1.83 v Vinterelectrode (Pd-Ti) = n.a.

Complications/Findings: none

5-6 WAYS OF CONFIRMATION

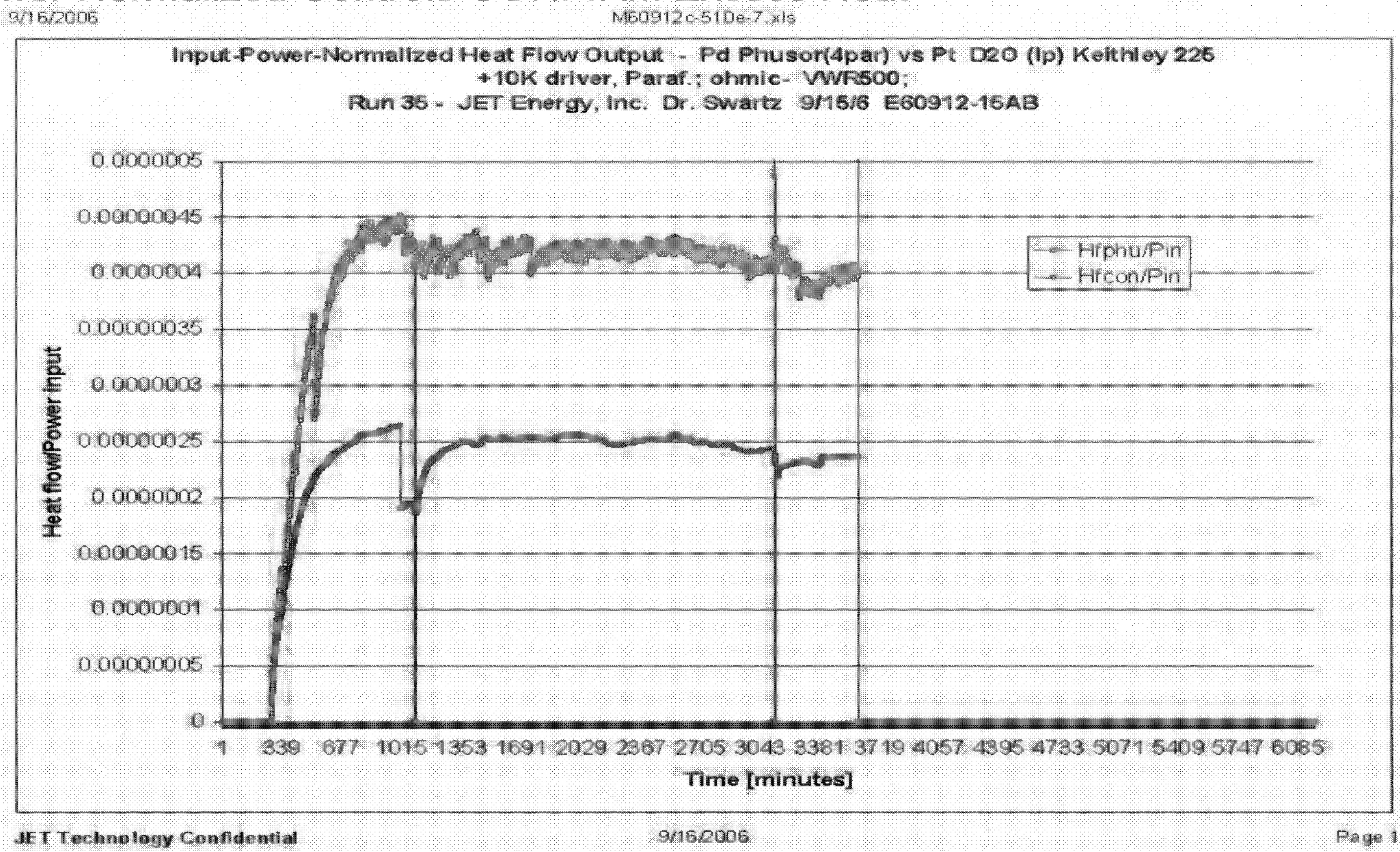
Power Normalized Controls CONFIRM Excess Heat



Input Power-Normalized delta-T at core

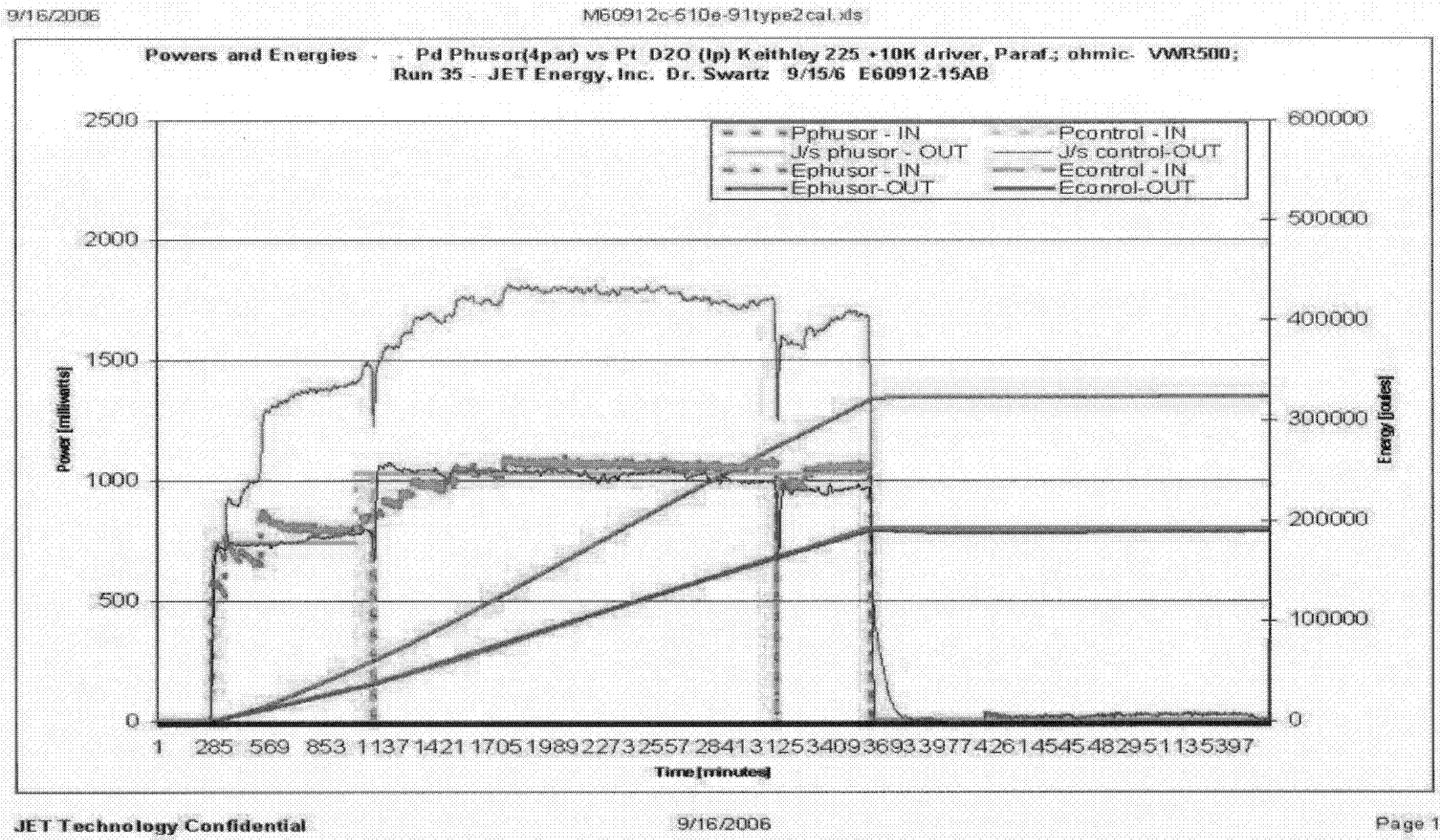
5-6 WAYS OF CONFIRMATION

Power Normalized Controls CONFIRM Excess Heat



Input Power-Normalized Heat Flow from core with NIST calibrated Sensors

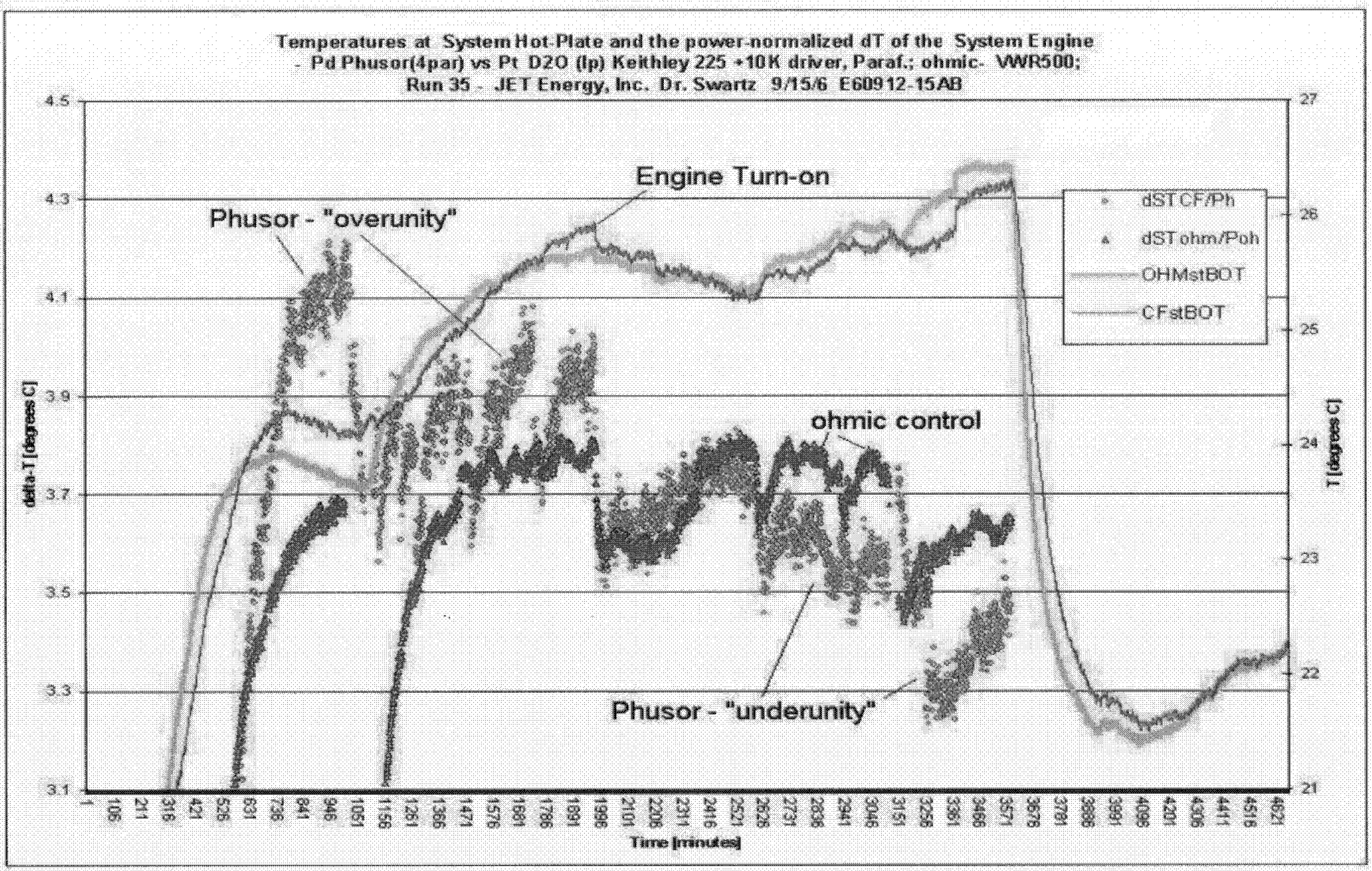
5-6 WAYS OF CONFIRMATION



Dual Ohmic Control Calibrated calorimetry with Time Integration

5-6 WAYS OF CONFIRMATION

"Excess" Energy Is Conserved between Compartments



5-6 WAYS OF CONFIRMATION

MECHANICAL ROTATION FOR DAYS at LOWER INPUT POWER LEVELS THAN OHMIC CONTROL

September–October 2006 – Runs 35 and 44:

The CF Device went an equivalent 11.6 miles vs. 0.0 for the ohmic control; with loss of “Excess Energy” from delta-T measured at the engine site.

JET THERMAL PRODUCTS - Procedure 40428
Three day run of Demo X-1 with replaced Control

Brief Procedure Note

Pd-D2O Phusor 10K-1 run 4

18.2K ohmic control.

Vapplied = 100, 150, then 230v

Run duration 4/27-29/04

Guests on 4/28/4 Jeff Tolleson
Bruce Nappi

Results

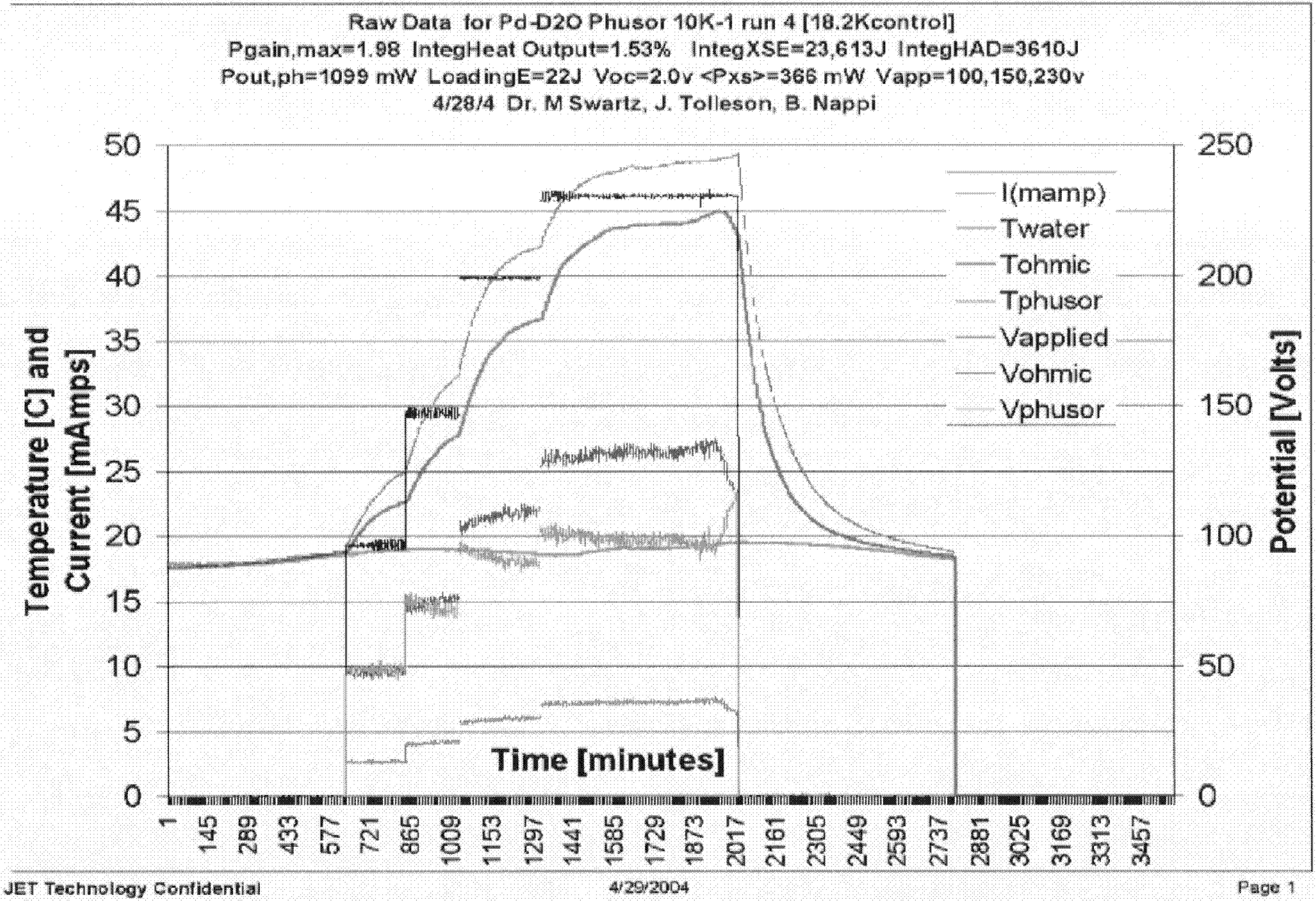
Pout,phusor = 1099 mWatts
Voc = 2.0 volts

Pgain, max = 1.98
<Pxs> = 366 mWatts
IntegHeat Output=1.53%
IntegXS Energy = 23,613 Joules

IntegHAD energy = 3610 Joules
Loading Energy = 22 Joules

Recommendations

Power, sensitivity OK
Ready for transfer with arrival of control box and when Manual ready.



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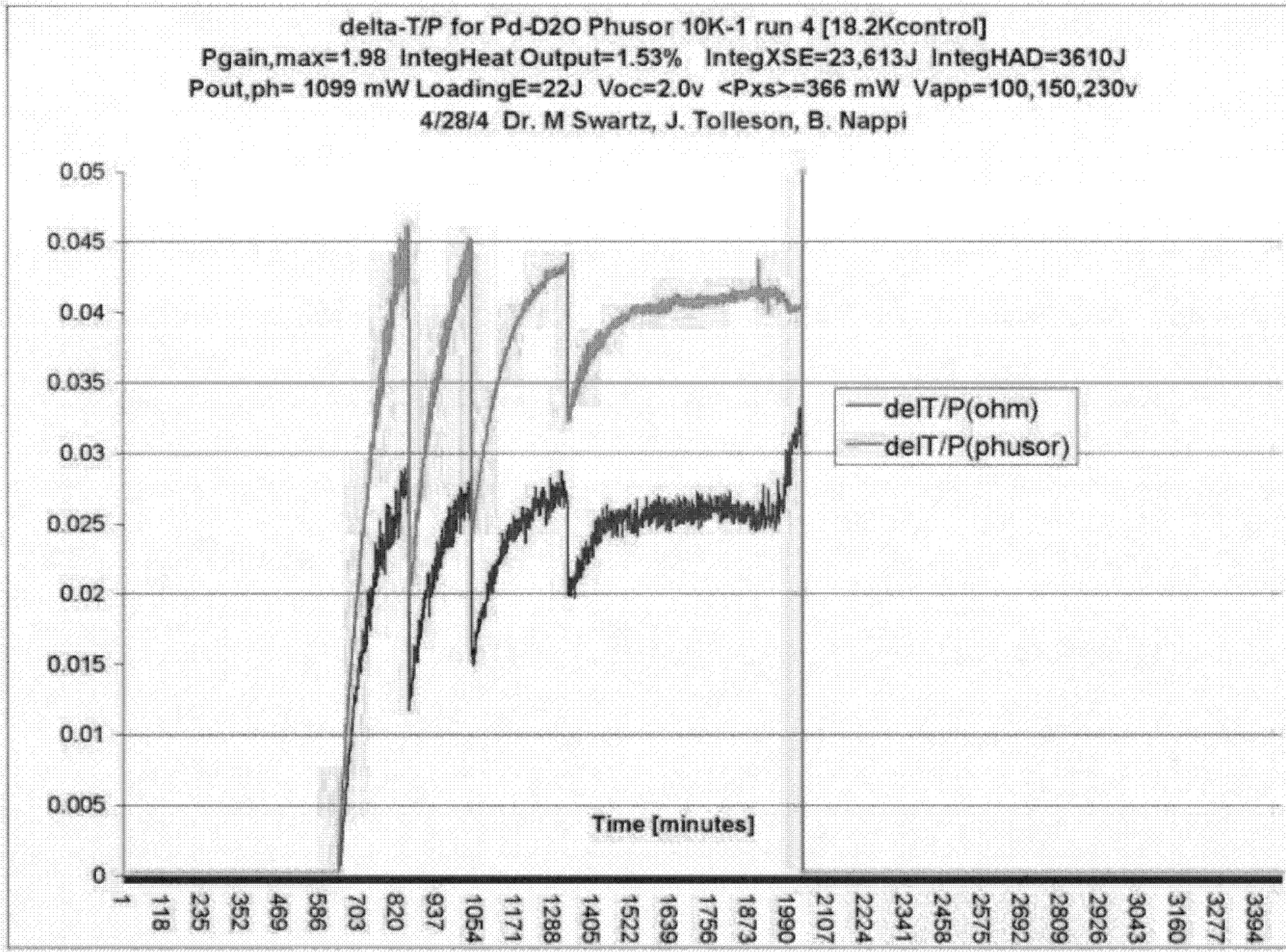
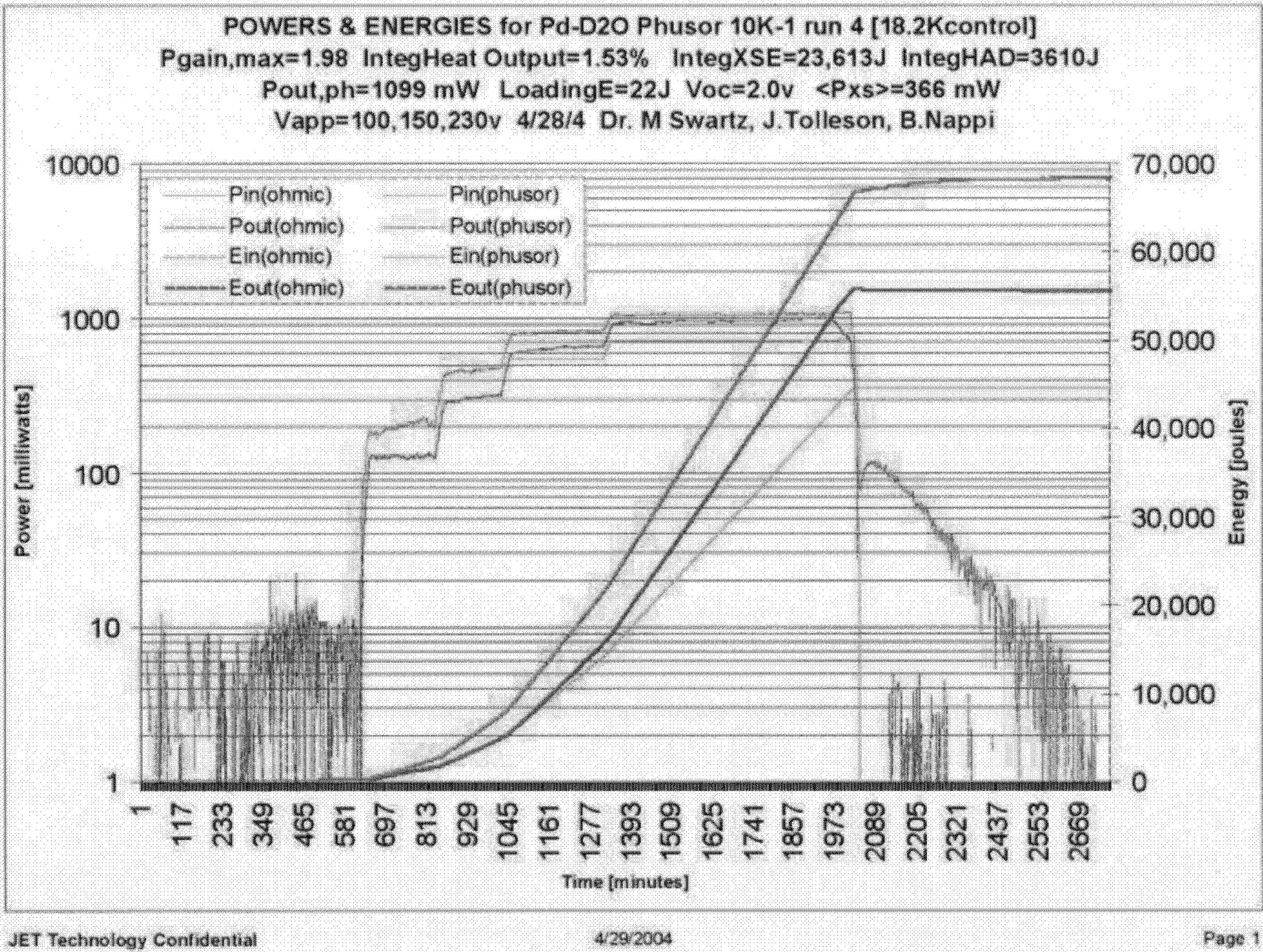
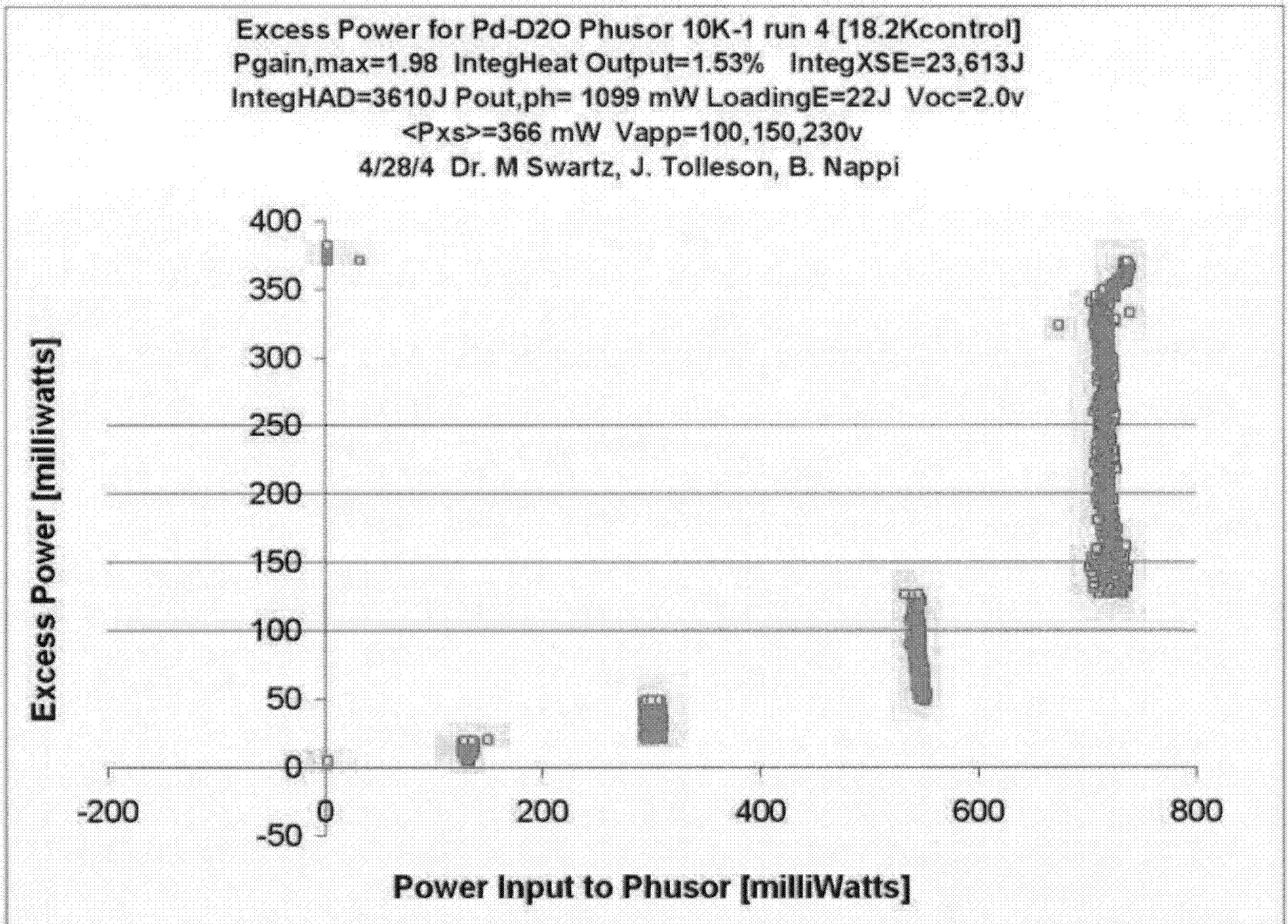


JET Technology Confidential 4/29/2004 Page 1



POWERS & ENERGIES for Pd-D2O Phusor 10K-1 run 4 [18.2Kcontrol]
Pgain,max=1.98 IntegHeat Output=1.53% IntegXSE=23,613J IntegHAD=3610J
Pout,ph=1099 mW LoadingE=22J Voc=2.0v <Pxs>=366 mW
Vapp=100,150,230v 4/28/4 Dr. M Swartz, J.Tolleson, B.Nappi
Pin(ohmic)
Pin(phusor)
Pout(ohmic)
Pout(phusor)
Ein(ohmic)
Ein(phusor)
Eout(ohmic)
Eout(phusor)
Power [milliwatts]
Energy [Joules]
Time [minutes]
10000
1000
100
10
1
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
1
117
233
349
465
581
697
813
929
1045
1161
1277
1393
1509
1625
1741
1857
1973
2089
2205
2321
2437
2553
2669
JET Technology Confidential
4/29/2004
Page 1


Excess Power for Pd-D2O Phusor 10K-1 run 4 [18.2Kcontrol]
Pgain,max=1.98 IntegHeat Output=1.53% IntegXSE=23,613J
IntegHAD=3610J Pout,ph= 1099 mW LoadingE=22J Voc=2.0v
<Pxs>=366 mW Vapp=100,150,230v
4/28/4 Dr. M Swartz, J. Tolleson, B. Nappi
Excess Power [milliwatts]
400
350
300
250
200
150
100
50
0
-50
-200
0
200
400
600
800
Power Input to Phusor [milliWatts]

JET THERMAL PRODUCTS - Procedure 40509
Four day run of JET Phusor 10K Driver

Brief Procedure Note

Pd-D2O JET Phusor 10K Driver Run 8
18.2K ohmic control
Vapplied = 200v

Run duration 5/9-12/04

Guests: Jeff Tolleson
Bob Weber
Steve Olasky

Operators: Dr. Mitchell Swartz
Gayle Verner

Results

Pout,phusor = 949 milliwatts
Voc = 1.97-2.1 volts (at end)

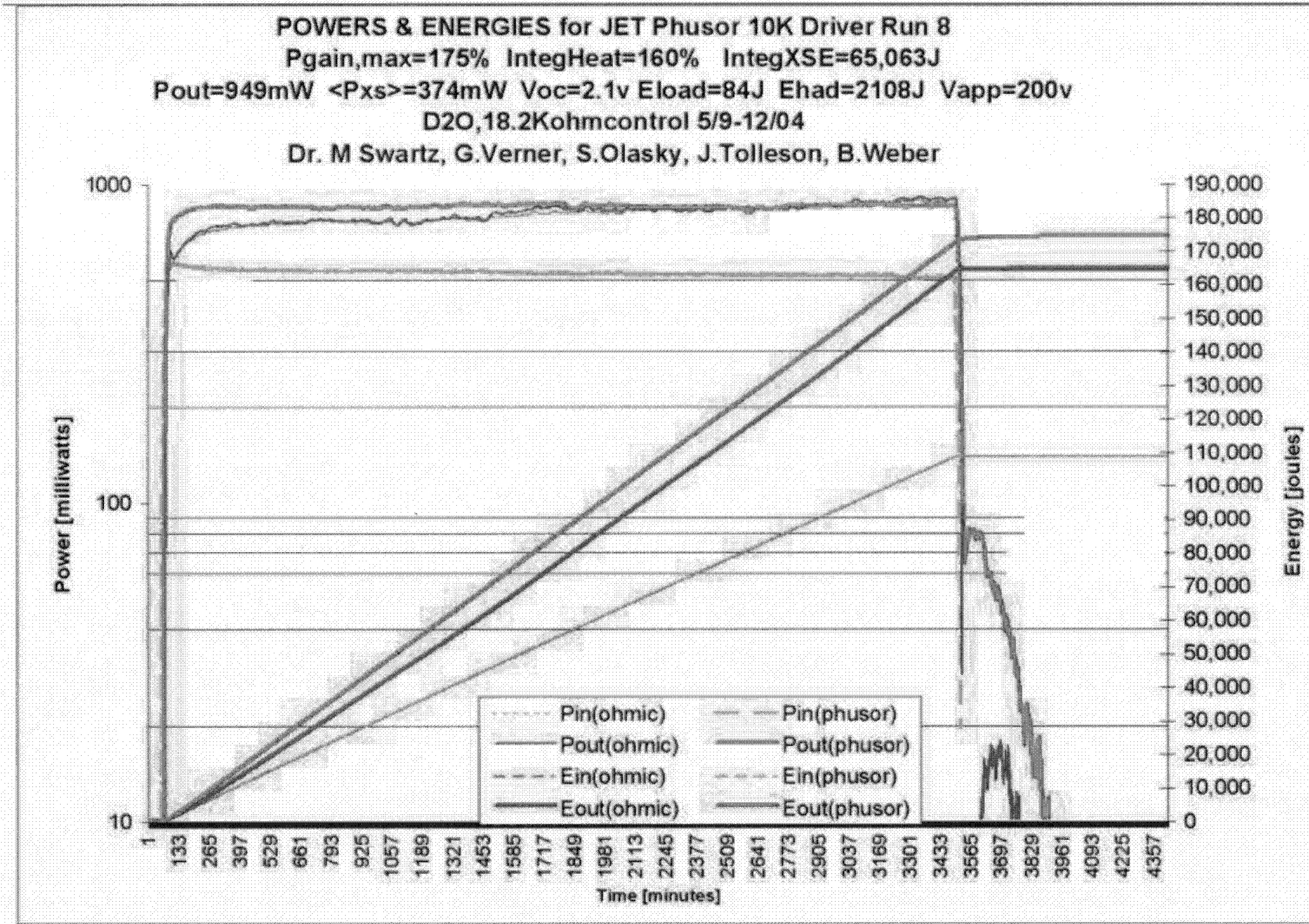
Pgain, max = 175%
<Pxs> = 374 milliwatts
IntegHeat Output=160%
IntegXS Energy = 65,063 Joules

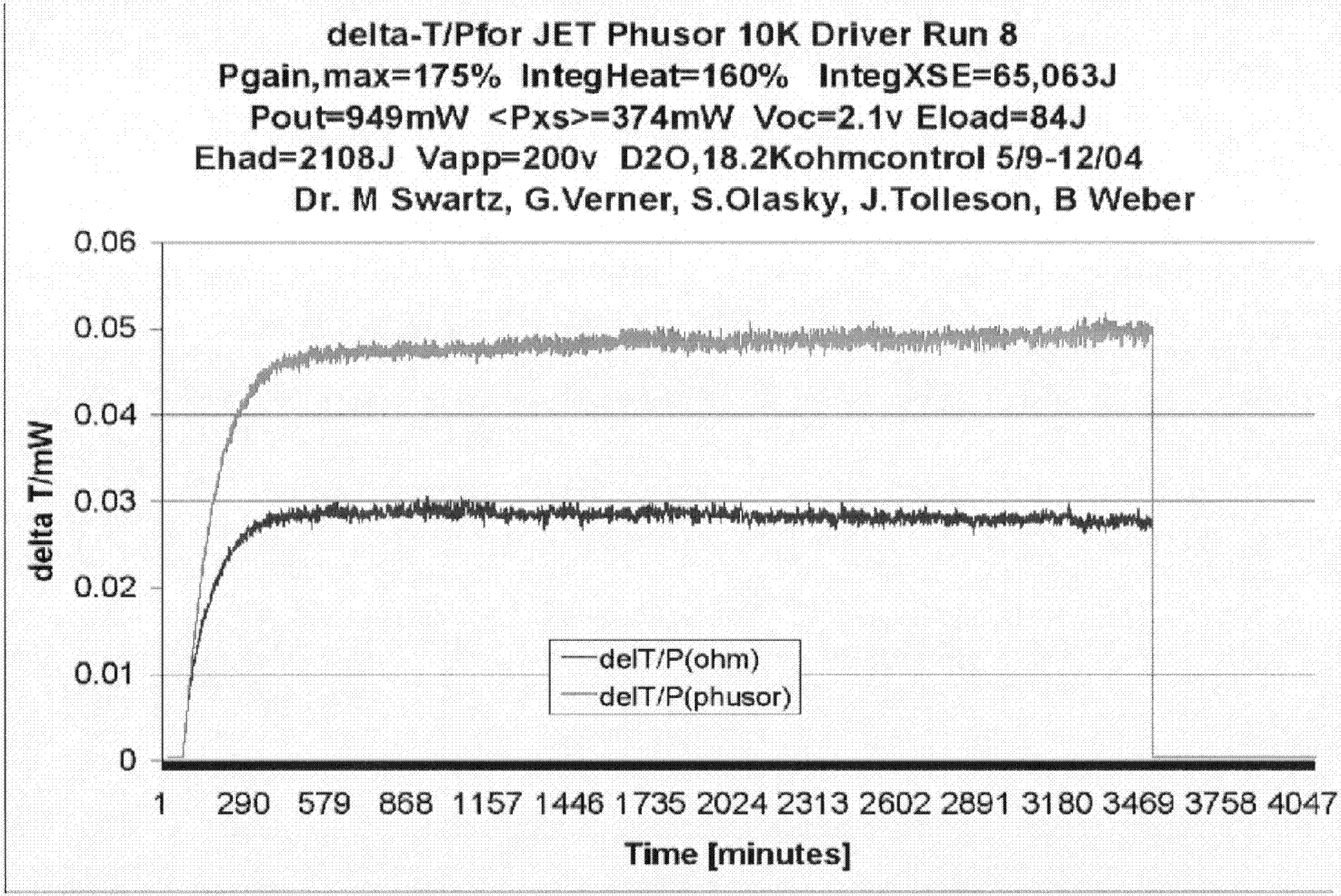
IntegHAD energy = 2108 Joules
Loading Energy = 84 Joules

Recommendations/Observations

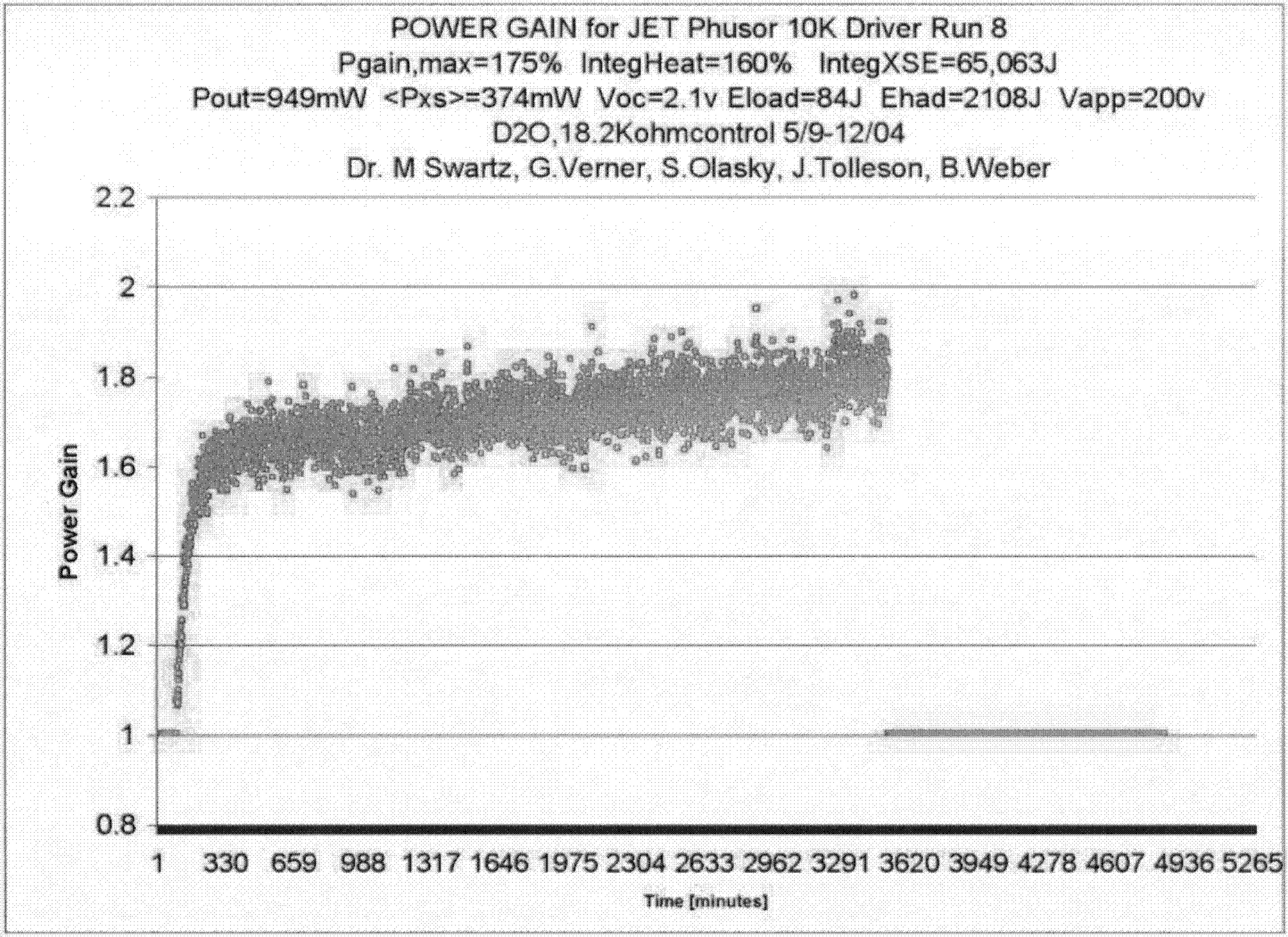
Power gain improved throughout expt
JET Phusor 10K Driver box has really improved the ease of setup

May 12, 2004 Dr. Mitchell Swartz


POWERS & ENERGIES for JET Phusor 10K Driver Run 8
Pgain,max=175% IntegHeat=160% IntegXSE=65,063J
Pout=949mW <Pxs>=374mW Voc=2.1v Eload=84J Ehad=2108J Vapp=200v
D2O,18.2Kohmcontrol 5/9-12/04
Dr. M Swartz, G.Verner, S.Olasky, J.Tolleson, B.Weber
Power [milliwatts]
Energy [joules]
Time [minutes]
Pin(ohmic)
Pin(phusor)
Pout(ohmic)
Pout(phusor)
Ein(ohmic)
Ein(phusor)
Eout(ohmic)
Eout(phusor)



JET Technology Confidential 5/12/2004 Page 1


POWER GAIN for JET Phusor 10K Driver Run 8
Pgain,max=175% IntegHeat=160% IntegXSE=65,063J
Pout=949mW <Pxs>=374mW Voc=2.1v Eload=84J Ehad=2108J Vapp=200v
D2O,18.2Kohmcontrol 5/9-12/04
Dr. M Swartz, G.Verner, S.Olasky, J.Tolleson, B.Weber
Power Gain
2.2
2
1.8
1.6
1.4
1.2
1
0.8
1 330 659 988 1317 1646 1975 2304 2633 2962 3291 3620 3949 4278 4607 4936 5265
Time [minutes]

JET THERMAL PRODUCTS - Procedure 40522 Run 10
Three day run of JET Phusor 10K Driver

Brief Procedure Note

Pd-D2O JET Phusor 10K Driver Run 10
First Refilling Ever of Cell 8 (filled 8/03)
18.2K ohmic control
Vapplied = 200, 150, 100 v nominal
Run duration 5/22-24/04
(terminated for electrical thunderstorm)

Results

Pout,phusor = 729 milliwatts
Voc = 1.9 - 2.3 volts

Pgain, max = 190%
IntegHeat Output=139%

<Pxs> = 200 milliwatts
IntegXS Energy = 24,161 Joules
IntegHAD energy = 270 Joules
Loading Energy = 91 Joules

Recommendations/Observations

First refilled (recharged) phusor system [CIL 99.9% D2O (DLM-11)].

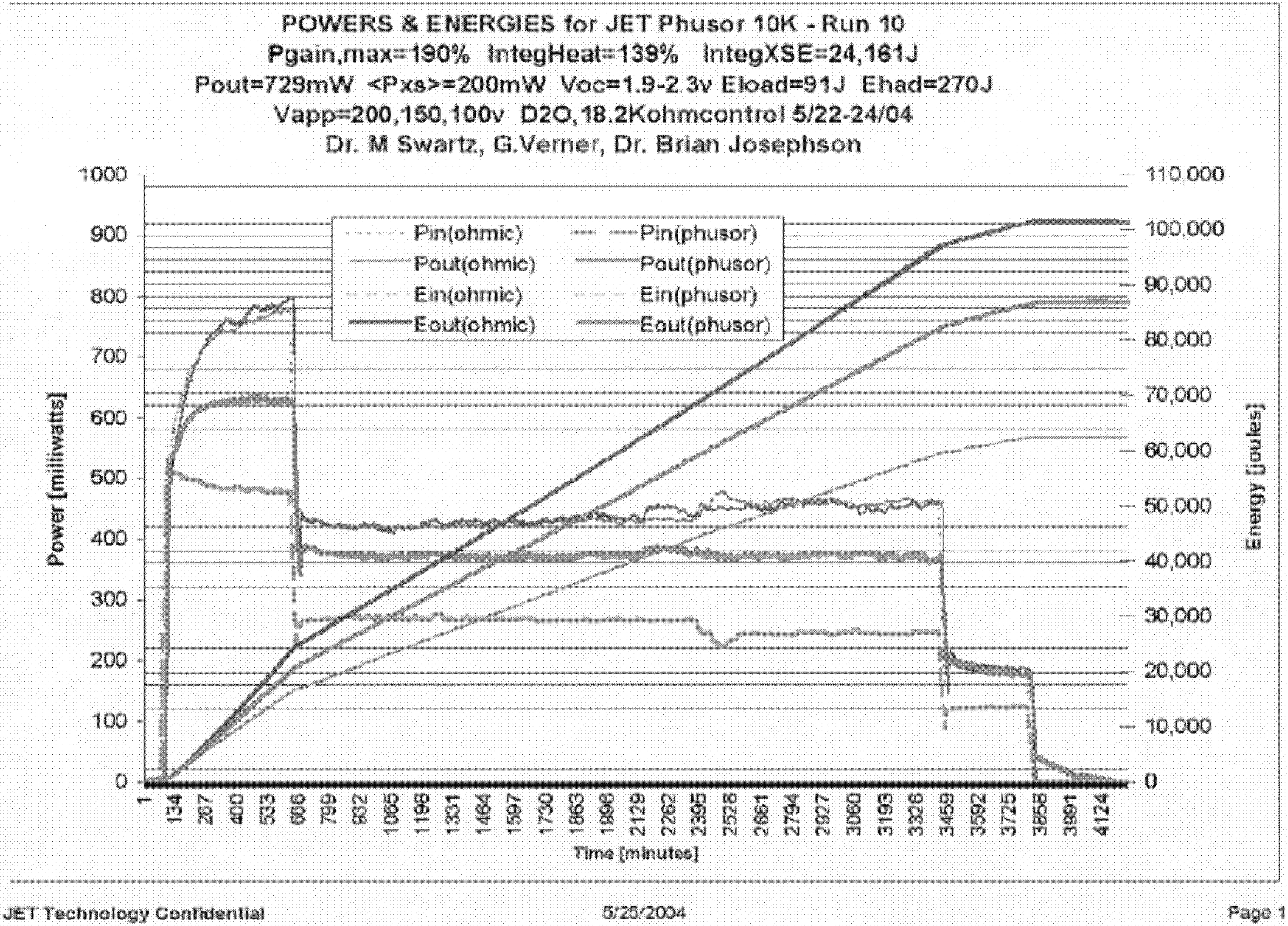
10K Driver, dual DAQ improves setup consistently.

Logout

Operators: Dr. Mitchell Swartz
Gayle Verner

Guest: Dr. Brian Josephson

May 24, 2004 Dr. Mitchell Swartz



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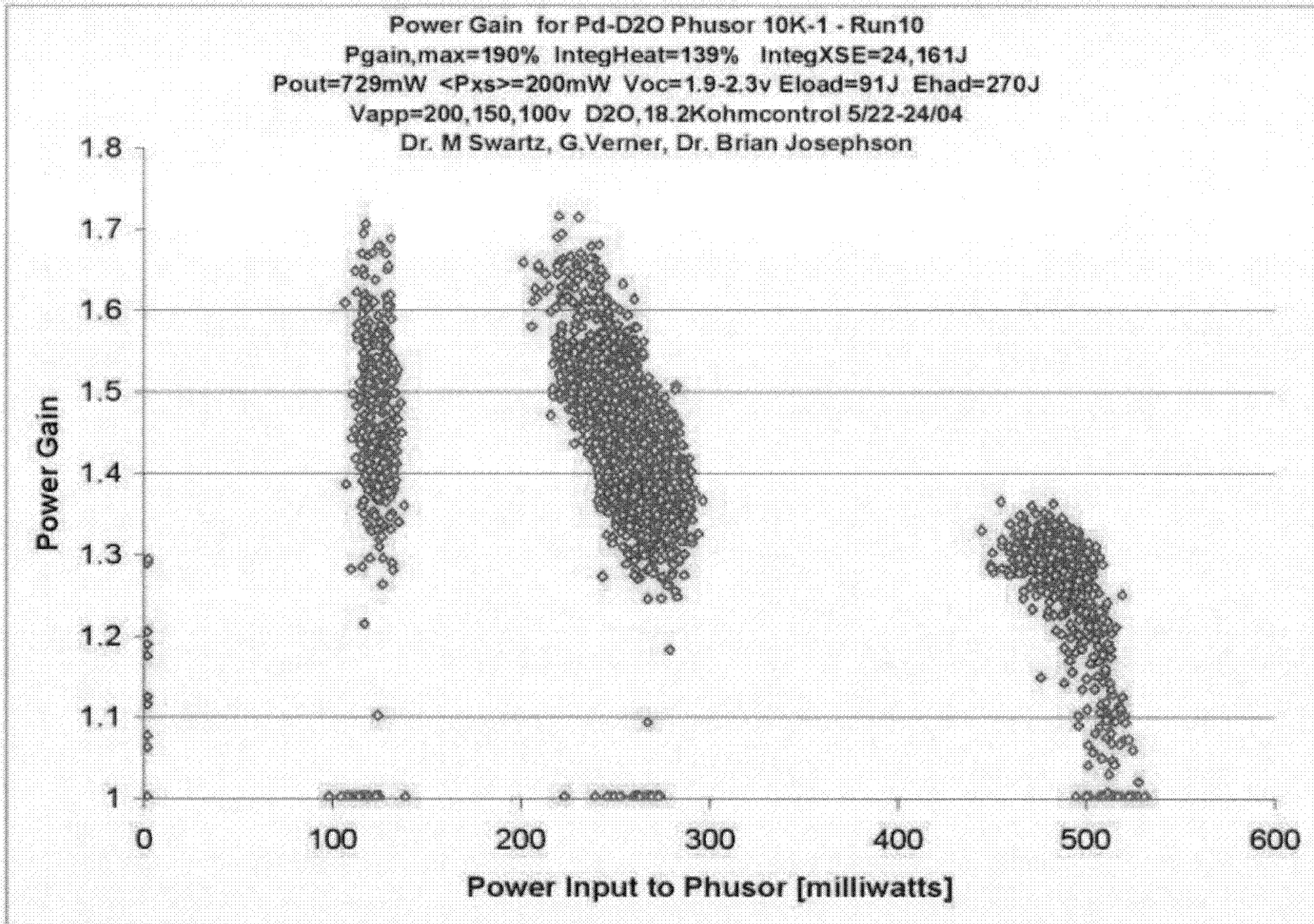

Power Gain for Pd-D2O Phusor 10K-1 - Run10
Pgain,max=190% IntegHeat=139% IntegXSE=24,161J
Pout=729mW <Pxs>=200mW Voc=1.9-2.3v Eload=91J Ehad=270J
Vapp=200,150,100v D2O,18.2Kohmcontrol 5/22-24/04
Dr. M Swartz, G.Verner, Dr. Brian Josephson
Power Gain
1.8
1.7
1.6
1.5
1.4
1.3
1.2
1.1
1
0
100
200
300
400
500
600
Power Input to Phusor [milliwatts]

EXCESS HEAT IN ELECTRIC-FIELD LOADED DEUTERATED METALS

RESULTS:

EXCESS HEAT OBSERVED IN PALLADIUM HEAVY WATER (PdD) SYSTEM

EXCESS HEAT OBSERVED IN PALLADIUM HEAVY WATER (PdD) CODEPOSITIONAL SYSTEM

EXCESS HEAT OBSERVED IN SOME NICKEL LIGHT and MIXED WATER SYSTEMS

EXCESS HEAT NOT OBSERVED IN IRON, ALUMINUM, DAMAGED NICKEL SYSTEMS

INFREQUENT BORDERLINE EXCESS HEAT in CONTAMINATED Au, Pd, Ni, Pt systems

EXCESS HEAT OBSERVED IN PALLADIUM HEAVY WATER (PdD), PALLADIUM HEAVY WATER (PdD) CODEPOSITIONAL, AND NICKEL LIGHT WATER (NiH) SYSTEM

EXCESS HEAT OBSERVED IN PALLADIUM HEAVY WATER (PdD) SYSTEM

- Excess energy significant after full loading and early processing; depends upon loading rate, flux, purity, contamination, confinement time, and operating point.
- Peak excess power: 0.5 to 1.5 watts (occasionally higher)

- Activation energy ~ 60.7 kilojoules/mole.
- Activity quenched by many things.
- Critical input electrical current density of this configuration 1.5 $^{+/- 0.3}$ milliamperes/cm^2
- May exist threshold voltages before adequate loading is achieved.
- Open Circuit Voltage: 2.4 volts heralds good activity; 1.85 fair activity

- Power Gain Pd/D2O/Pt 1.4 – 3.4
- Peak Excess Volume Power Density (*) 62-65 watts/cm^3 based upon 60 microns active depth
  5.3 - 14.7 watts/cm^3 full volume
- Peak Excess Surface Power Density 0.37 - 0.39 watts/cm^2

EXCESS HEAT OBSERVED IN PALLADIUM HEAVY WATER (PdD) CODEPOSITIONAL SYSTEM

- Excess Enthalpy Observed for 8.2 mM $PdCl_2$ Poorer performance the regular system.

EXCESS HEAT OBSERVED IN PALLADIUM HEAVY WATER (PdD), PALLADIUM HEAVY WATER (PdD) CODEPOSITIONAL, AND NICKEL LIGHT WATER (NiH) SYSTEM

EXCESS HEAT OBSERVED IN SOME NICKEL LIGHT WATER SYSTEMS

- Excess energy significant for some samples for a limited period of time depending upon operation
- Damaged by high current and D2O [Swartz ICCF-11]
- Peak Excess Volume Power Density 7.0 wattslcm3
- Peak Excess Surface Power Density 0.088 wattslcm2

Power Gain Ni/H2O/Pt 1.3 - ~ >3 Ni Phusor [Swartz Fusion Technology '97]

Power Gain Ni/H2O/Pt 1.1 - ~ 2.4

Power Gain Ni/H2O/Ni 0.96 - 2.1

Power Gain Ni/H2O/Au 2 - 5 Ni Phusor [Swartz Fusion Technology '99]

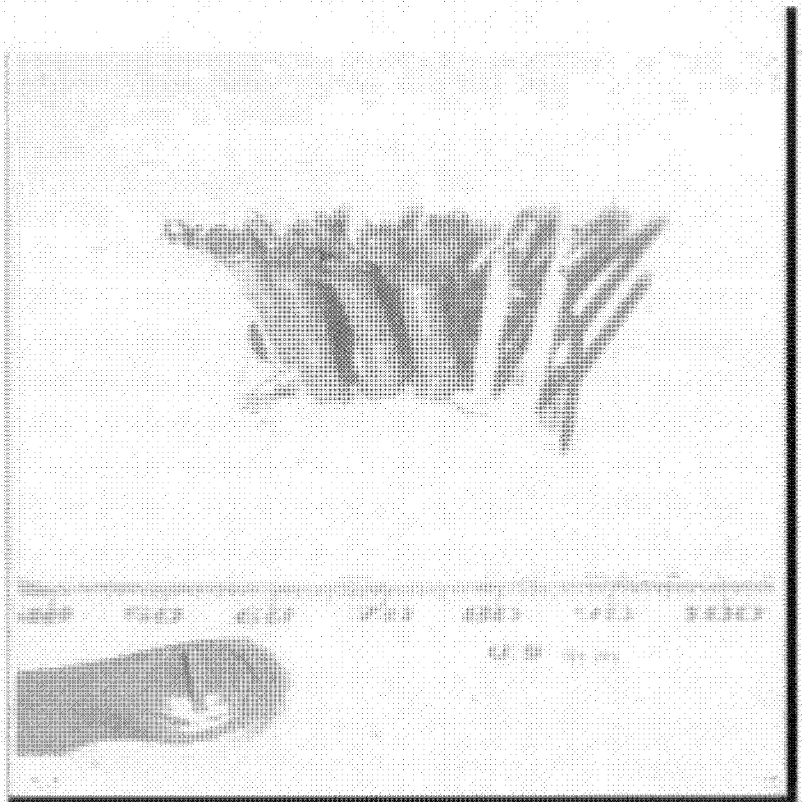
- **EXCESS HEAT NOT OBSERVED IN IRON, ALUMINUM, DAMAGED NICKEL SYSTEMS**
- Excess heat NOT seen with Iron, Aluminum, or damaged Nickel(*) as Cathodes

Power Gain Al/H2O/Pt 0.7 – 0.8

Power Gain Fe/H2O/Fe 0.61 – 0.79

- **INFREQ. BORDERLINE EXCESS HEAT OBSERVED in CONTAMINATED Au, Pd, Ni, Pt** Power Gain 0.73 – 1.19 [Swartz LENR-2 1996]

- **BORDERLINE EXCESS HEAT MIGHT BE OBSERVED CONTAMINATED Au, Pd, some Pt systems** [reported LENR-2 (1996)]



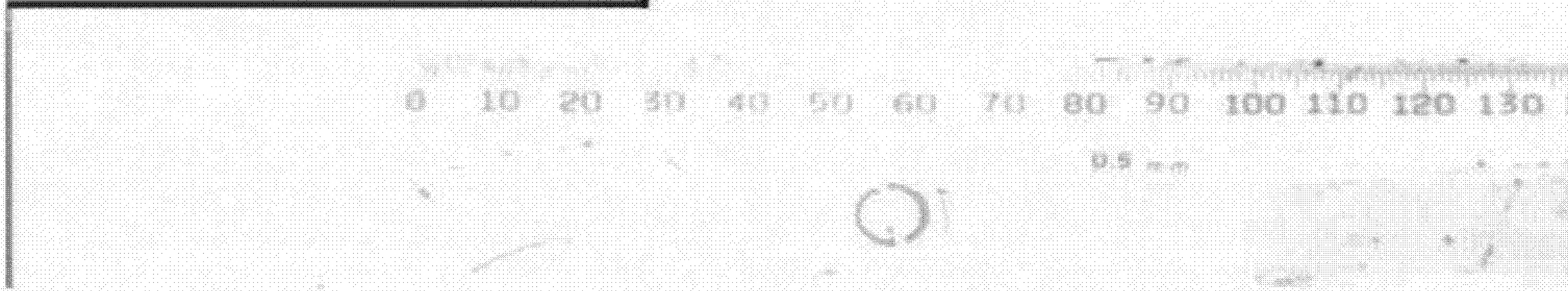
JET Technology

Side view of Octet cathode mandril

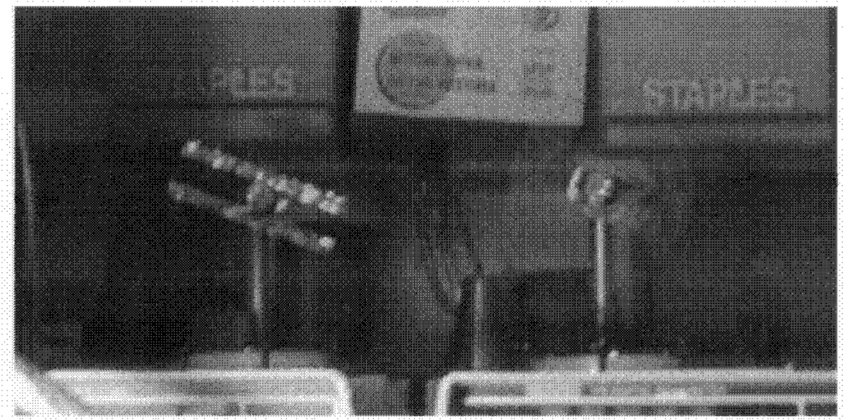
Gold anode was used at up to 100 volts yielding auric hydroxides as precipitate and electrodeposition on side of polyethylene base

Metal is nickel wound around mandrils. Several have been removed for examination by electron emission spectroscopy

August 7, 1996



Cold Fusion-Driven Stirling Engine Calorimeters with(Input Power Normalized) Core Temperature Monitoring, Heat Flux Measurements, Electric Output, Multiring Calorimetry, delta-T measurement at engine, with Dual Ohmic Control and Time-Integration

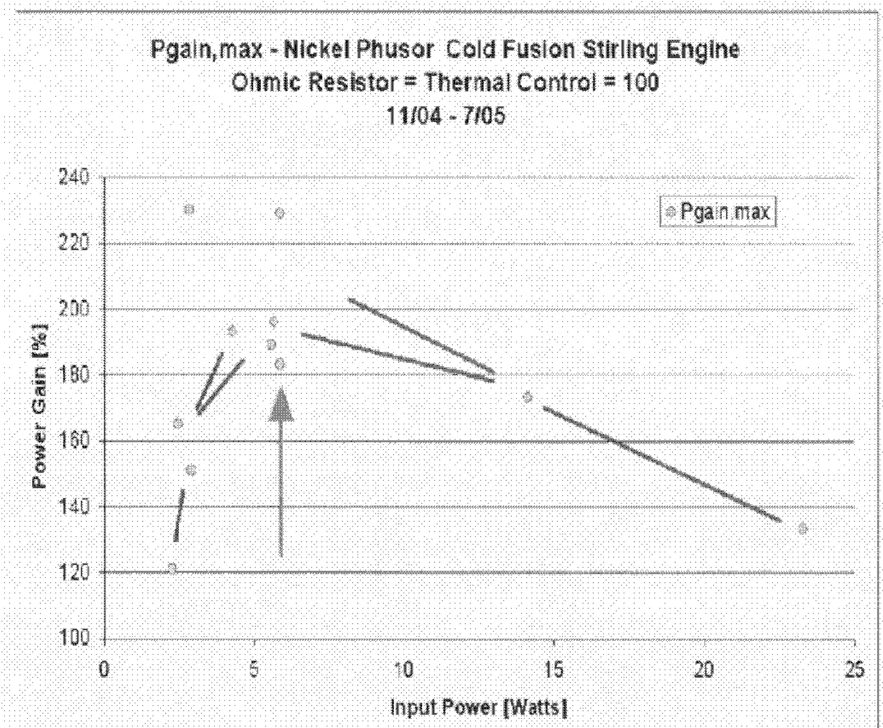


2004 Phase II -- Stirling Motor Results

11 Experiments using JET Thermal Products Pd and Ni Phusors™ with full ohmic controls, matched Stirling engines

Average Gain **170%** +/- 22%
Time-Integrated Gain **152%** +/-31%

<Pin> = 3.6 watts <Pout> = ~4.5 watts
(and Motion on Phusor side)



2005-2006 Phase IV

Improved Calorimetry Motor Results
Excess Power of ~180 - 220% at 237 watts input
Excess Power of ~130% at 23 watts input
Confirmed by Multiple Input Power Normalized Methods

In recent one run, CF Motor went an equivalent 11.6 miles vs. 0.0 for the ohmic control

EXCESS HEAT IN ELECTRIC-FIELD LOADED DEUTERATED METALS

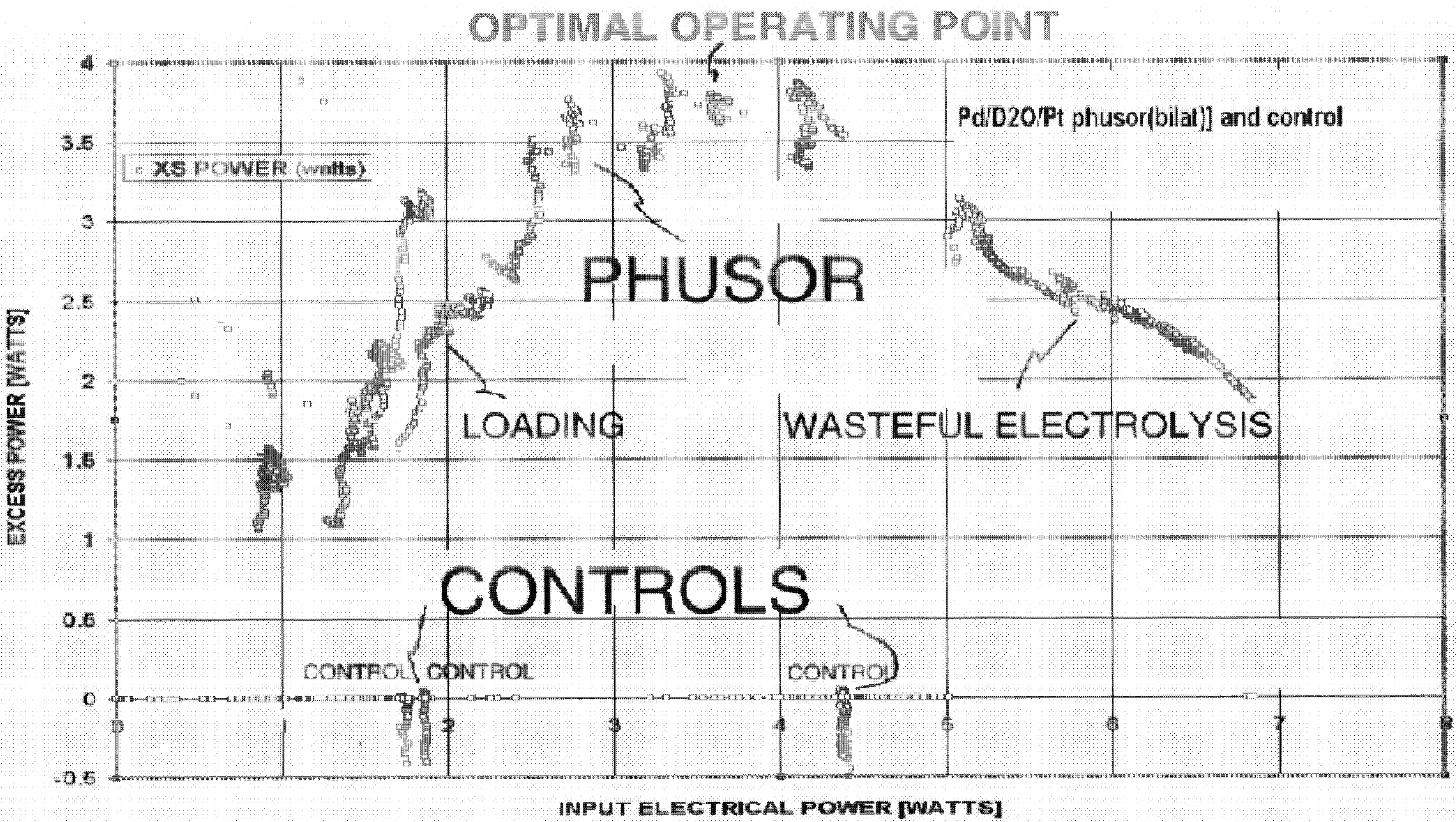
OPTIMAL OPERATING POINTS

COHERENT IRRADIATION OF CATHODE
QUASI-1-DIMENSIONAL LOADING EQS.

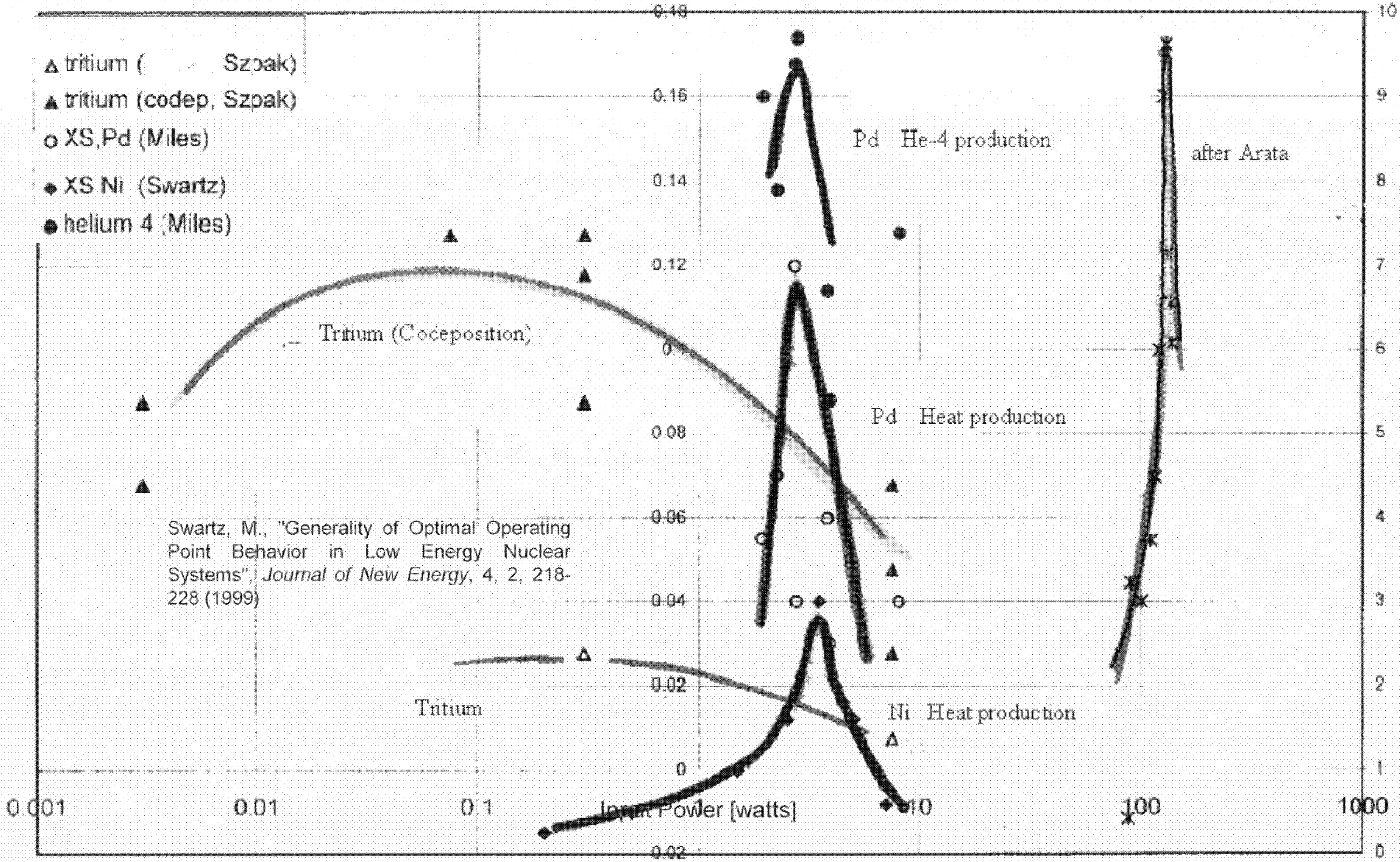
Dr. Mitchell Swartz
JET Energy, Inc.
Wellesley Hills, MA 02481

Optimal Operating Point Manifold

EXCESS POWER [WATTS] as a function of INPUT POWER

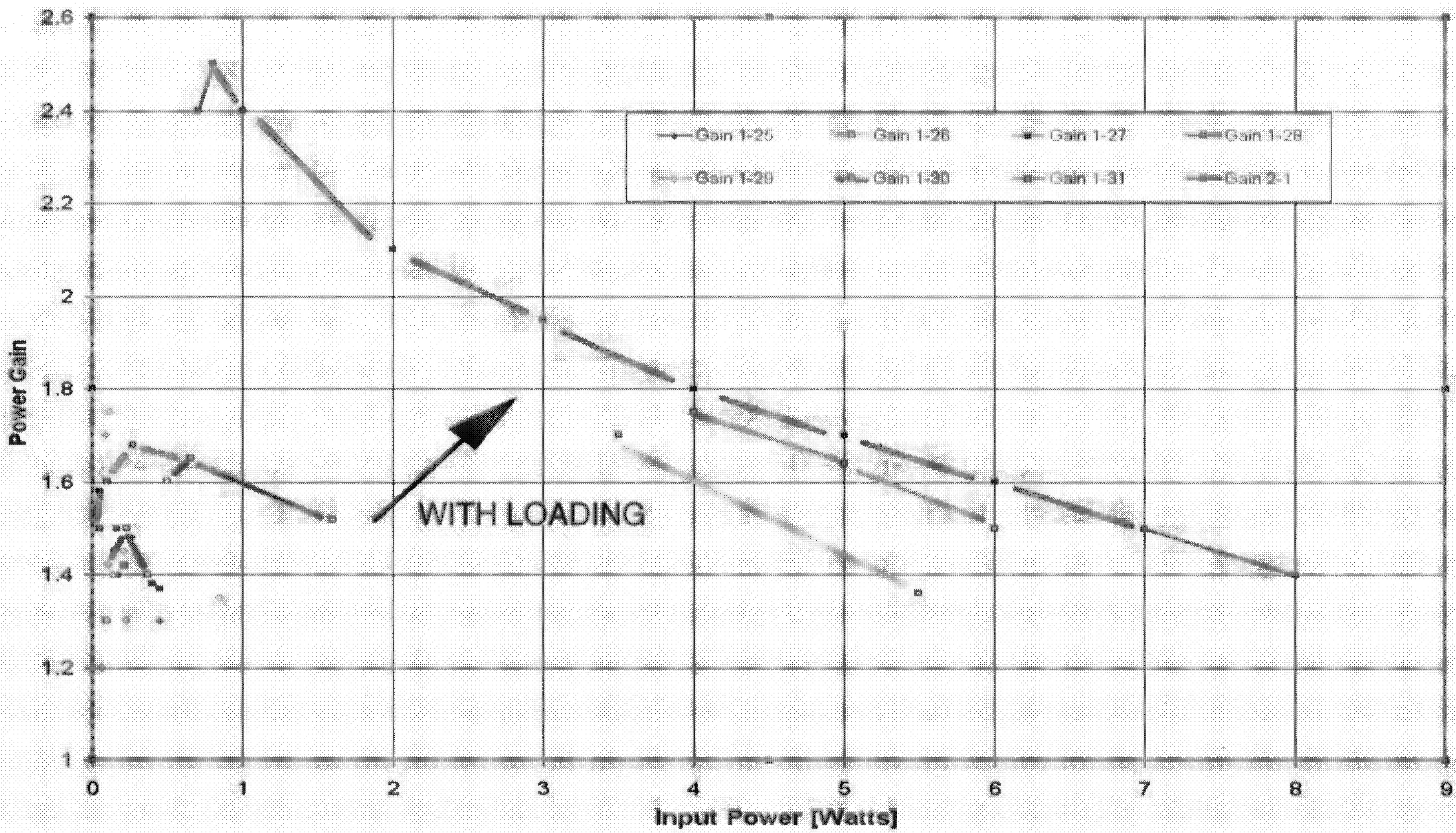


Optimal Operating Point Manifolds are Generally Applicable

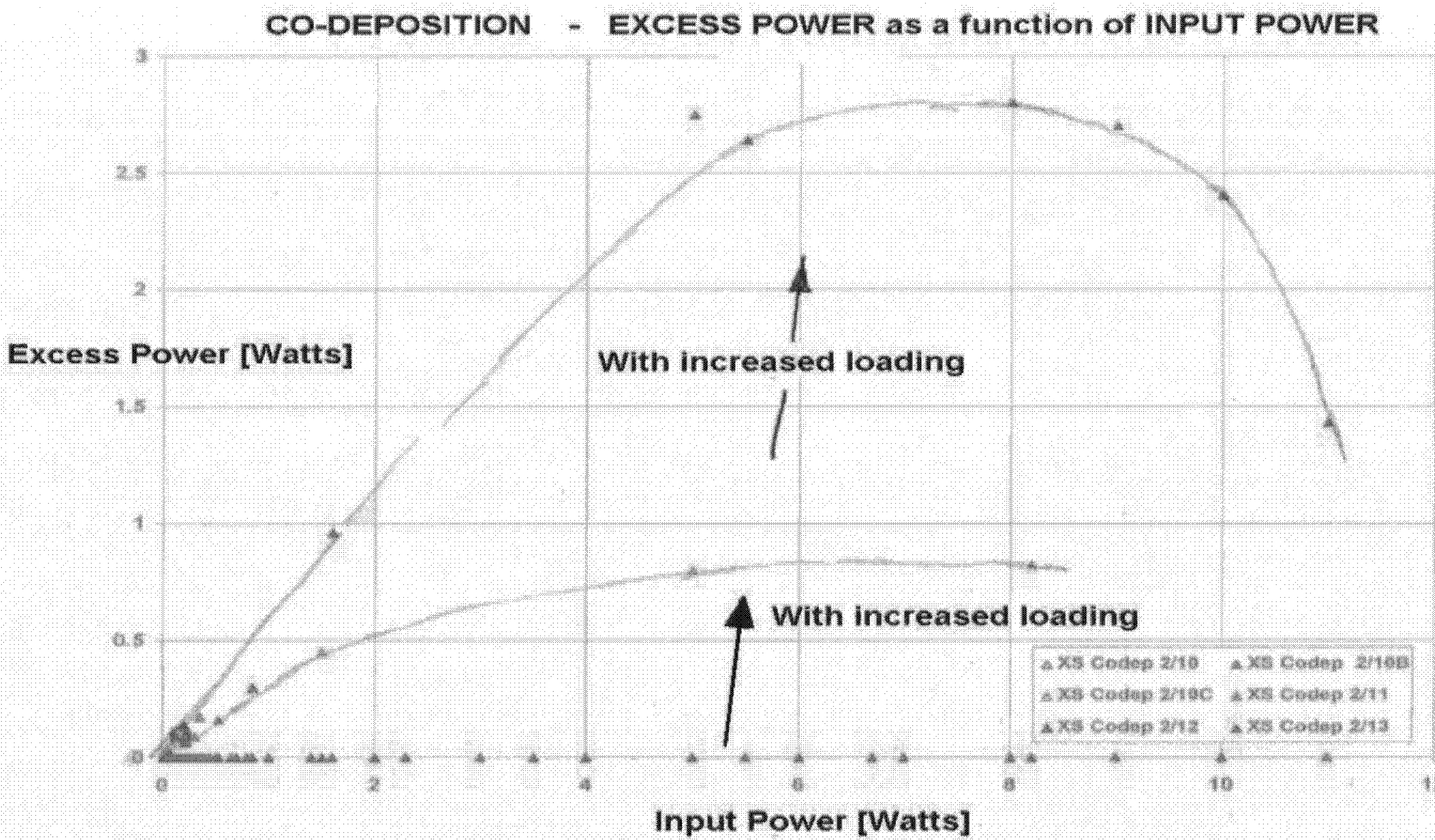


OPTIMAL OPERATING POINT MANIFOLDS in Pd/D2O/Pt SYSTEMS ARE TIME-VARIANT

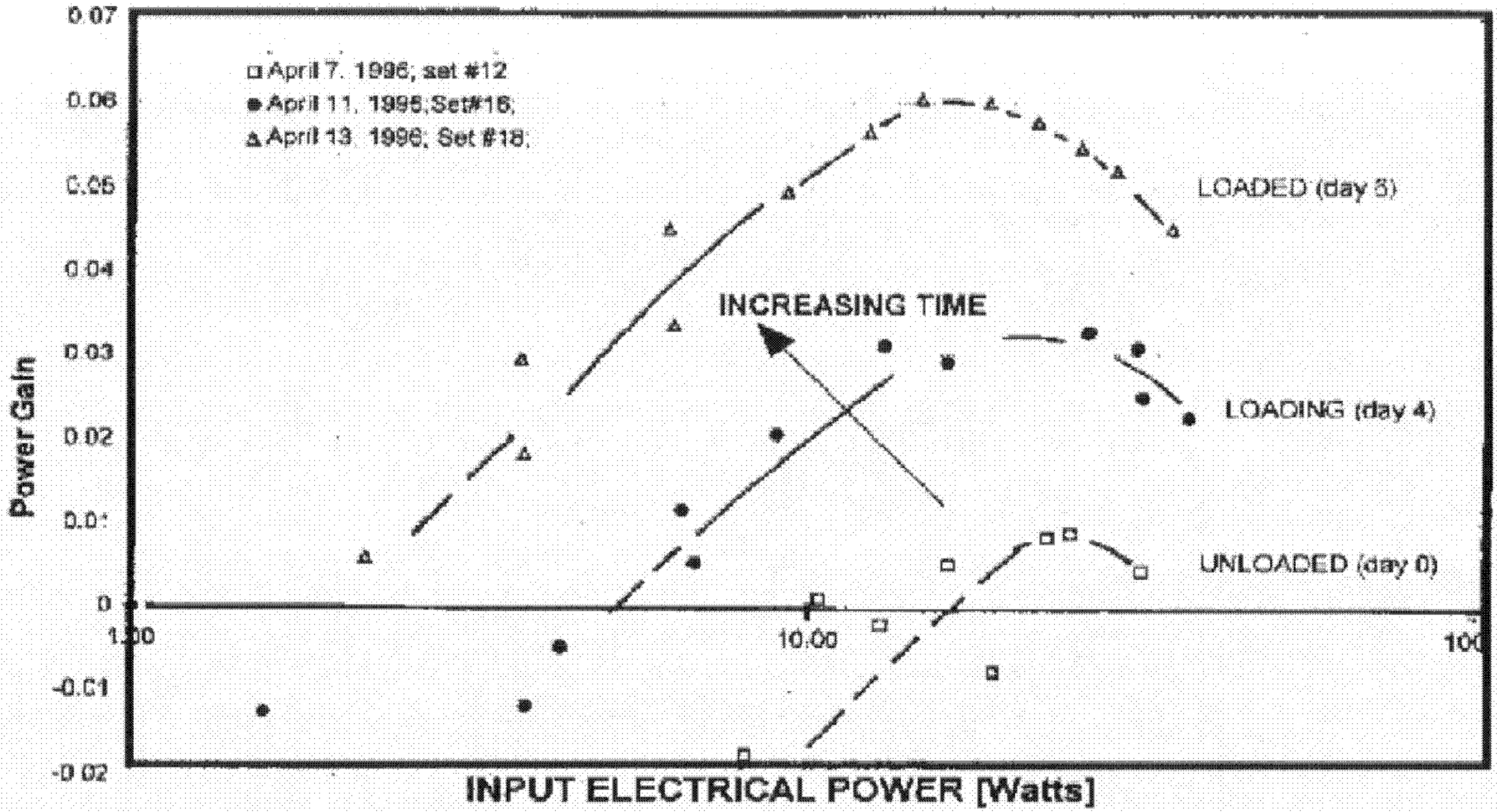
Impact of Loading -- Power Gain as a Function of Applied Input Power
Pd Phusor [D2O, 3.3 cm2, 0.083 cm3]



OPTIMAL OPERATING POINT MANIFOLDS ARE TIME-VARIANT IN CODEPOSITION

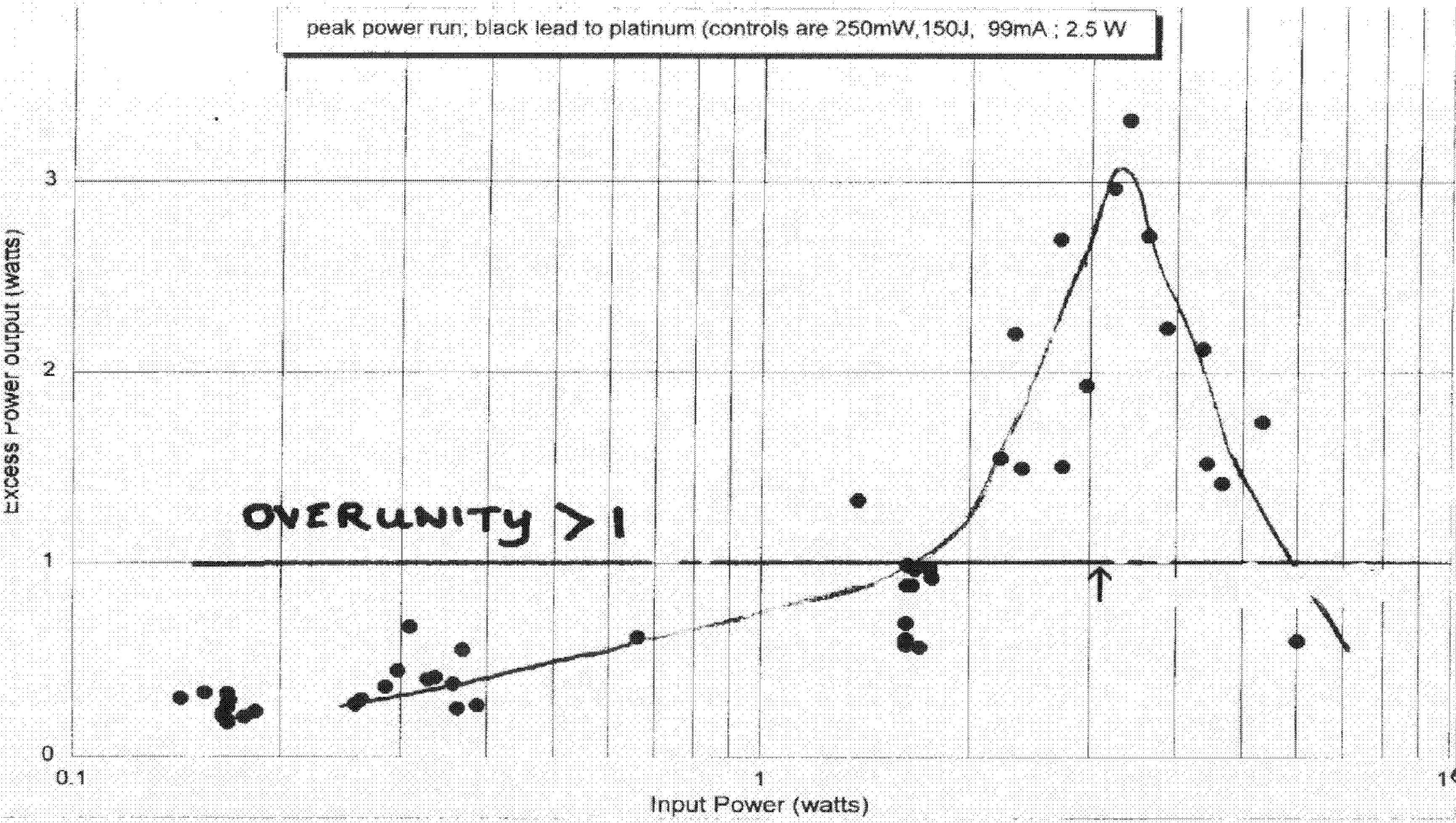


OPTIMUM OPERATING POINT MANIFOLDS ARE TIME-VARIANT

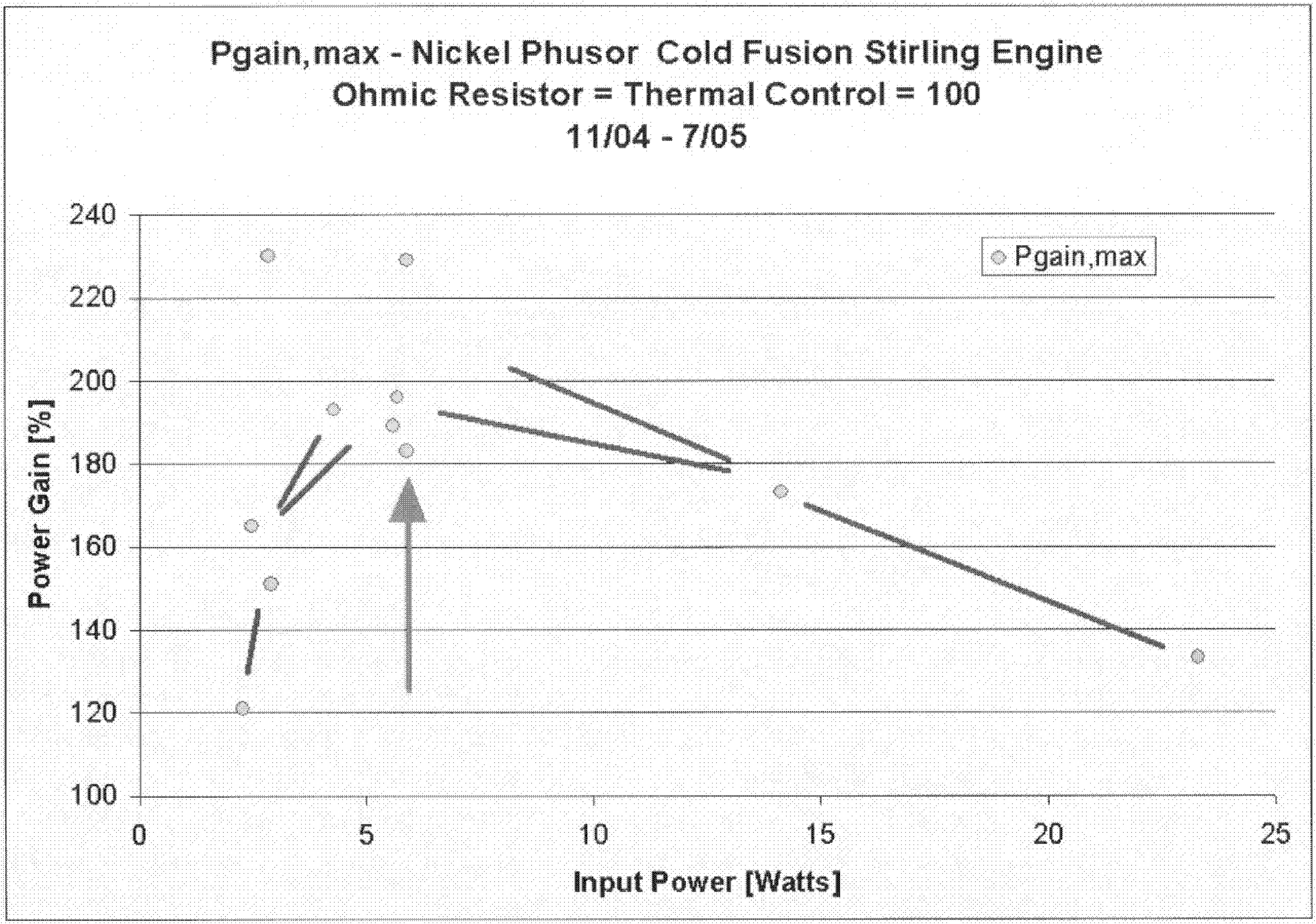


OOP manifold maturation during loading. Power gain curves of a $Pd/D_2O/Pt$ system as a function of input electrical power. Curves are shown before, during, and after 7 days of loading of the palladium with deuterium as it is polarized as the cathode [After Storms; IMRA No. 42 (Refs. 7 and 14)]. This palladium sample in heavy water had previously demonstrated excess heat of ~4 W. The biphasic character of power gain as a function of applied input power can be seen. The lower data are from the unloaded sample. The intermediate curve was at partial loading, midway in time after beginning the loading (dates listed inset). The upper data are the sample fully loaded (upper curve).

EXCESS OUTPUT POWER (WATTS)
AS A FUNCTION OF INPUT POWER WATTS



JET Energy Technology, Inc.


Pgain,max - Nickel Phusor Cold Fusion Stirling Engine
Ohmic Resistor = Thermal Control = 100
11/04 - 7/05
Pgain,max
Power Gain [%]
240
220
200
180
160
140
120
100
0
5
10
15
20
25
Input Power [Watts]

Optimal Operating Point Manifold

Optimal Operating Points and the Manifolds. What are they?

OOP Manifolds appear to show the way to relatively reproducible products (Excess heat, helium, tritium).

For CF, CMNS, or LENR systems --for each desired product– there are only narrow loci of functional activity along the input electrical power axis.

OOP Manifolds are located at low to moderate input power levels for present configurations.

OOP Manifolds appear to be generalized behavior for Pd and Ni loaded systems (including co-deposition)

OOP Manifolds have similar qualitative shapes along the input power axis, and reflect the apparent biphasic production curves for the products (e.g. heat and helium-4 for Pd loaded with D) as a function of input electrical power.

Optimal Operating Point Manifold

What is the role of OOP-Manifold behavior in CF, CMNS, or LENR systems?
Knowledge of the OOP-manifolds may improve the reproducibility and efficacy of CF, CMNS, or LENR systems in several ways.

1. Optimal operation for each product appears to be at a OOP-manifold peak.
2. Undershooting the OOP-manifold Peak produces many "negative" results by insufficient loading.
3. Overshoot of the OOP-manifold peak, by driving with electrical input power beyond the peak optimal operating point wastes input electrical power, lowers desired product yield, produces a diminished power gain and may terminal activity to below ohmic control, despite increasing input electrical power.
4. OOP-manifold peaks may herald breakpoints in system behavior.
5. Many "negative" occur due to a failure to operate the system at, or near, the optimal operating point.

below OOP: surfaces and diffusion control and limit hydridation; insufficient energy in applied electric field intensity (cf. Einstein formulation in loading eq.)

above OOP: increased competition with other reactions (may quench the desired reaction(s).

Optimal Operating Point Manifold

What is its role of OOP-Manifold behavior in CF, CMNS, or LENR systems?

Optimal Operating Points and the Manifolds.

The height of the OOP-manifold peaks differ between samples and are time-variant dependant upon sample history.

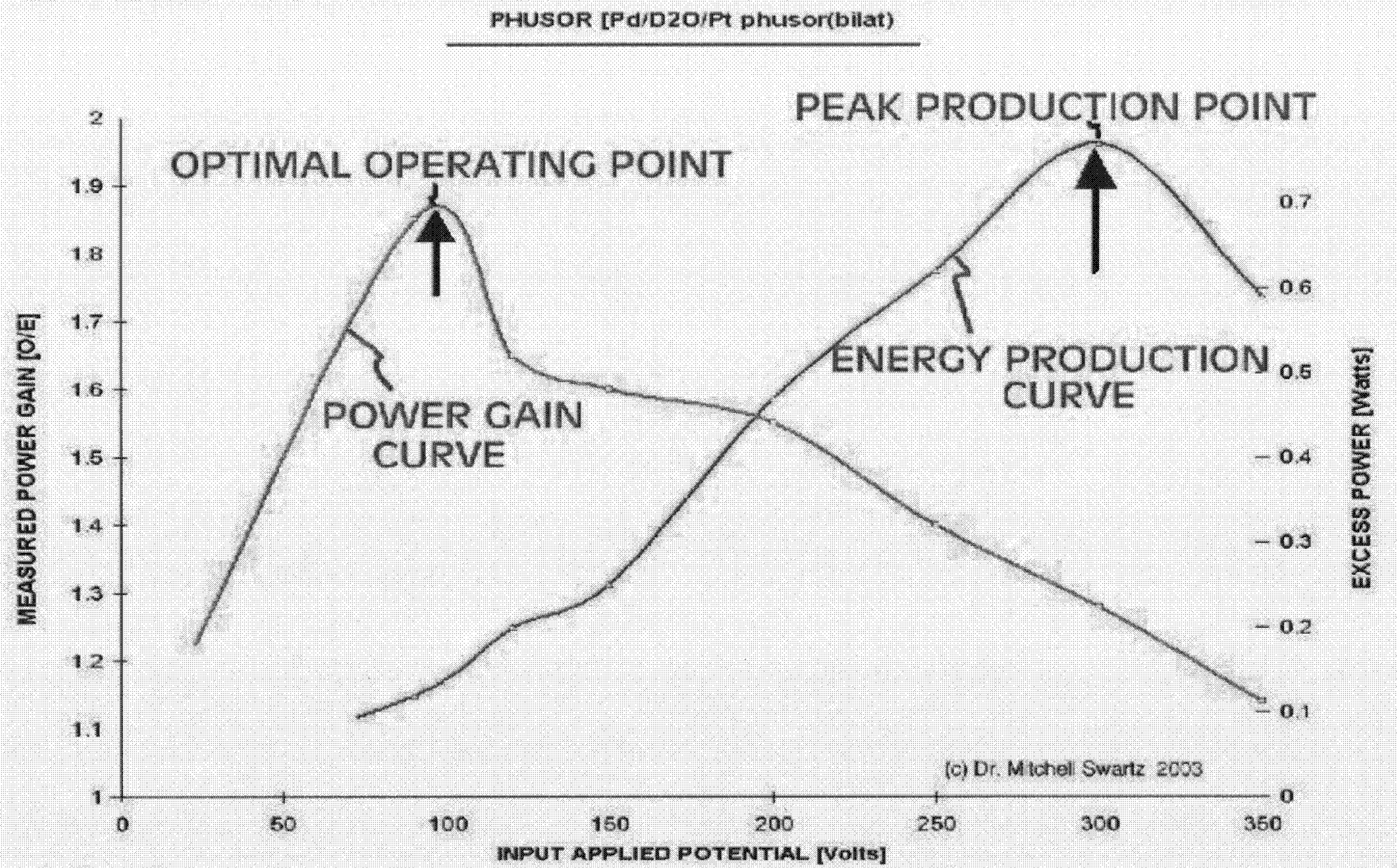
The height of the OOP-manifold peak grow in height with loading, heralding increased sample activity.

Summary regarding Optimal Operating Points

Success of CF, CMNS, or LENR systems appear to require control of loading, operation in the OOP-manifold, and both material purity and integrity.

Along with metallurgy, engineering, control of noise and phonons, control of the sample behavior within the OOP-manifold may improve reproducibility, efficiency of the desired reaction(s), and thus system performance.

OPTIMAL OPERATING AND PEAK PRODUCTION POINTS



Swartz, [illegible] "Excess [illegible] Low Electrical Conductivity [illegible] D2O-PdCl2/Pt Devices", *Proceedings of ICCF-10*, (2003).

JET THERMAL PRODUCTS - Procedure 40522 Run 10
Three day run of JET Phusor 10K Driver

Brief Procedure Note

Pd-D2O JET Phusor 10K Driver Run 10
First Refilling Ever of Cell 8 (filled 8/03)
18.2K ohmic control
Vapplied = 200, 150, 100 v nominal
Run duration 5/22-24/04
(terminated for electrical thunderstorm)

Results

Pout,phusor = 729 milliwatts
Voc = 1.9 - 2.3 volts

Pgain, max = 190%
IntegHeat Output=139%

<Pxs> = 200 milliwatts
IntegXS Energy = 24,161 Joules
IntegHAD energy = 270 Joules
Loading Energy = 91 Joules

Recommendations/Observations

First refilled (recharged) phusor system [CIL 99.9% D2O (DLM-11)].

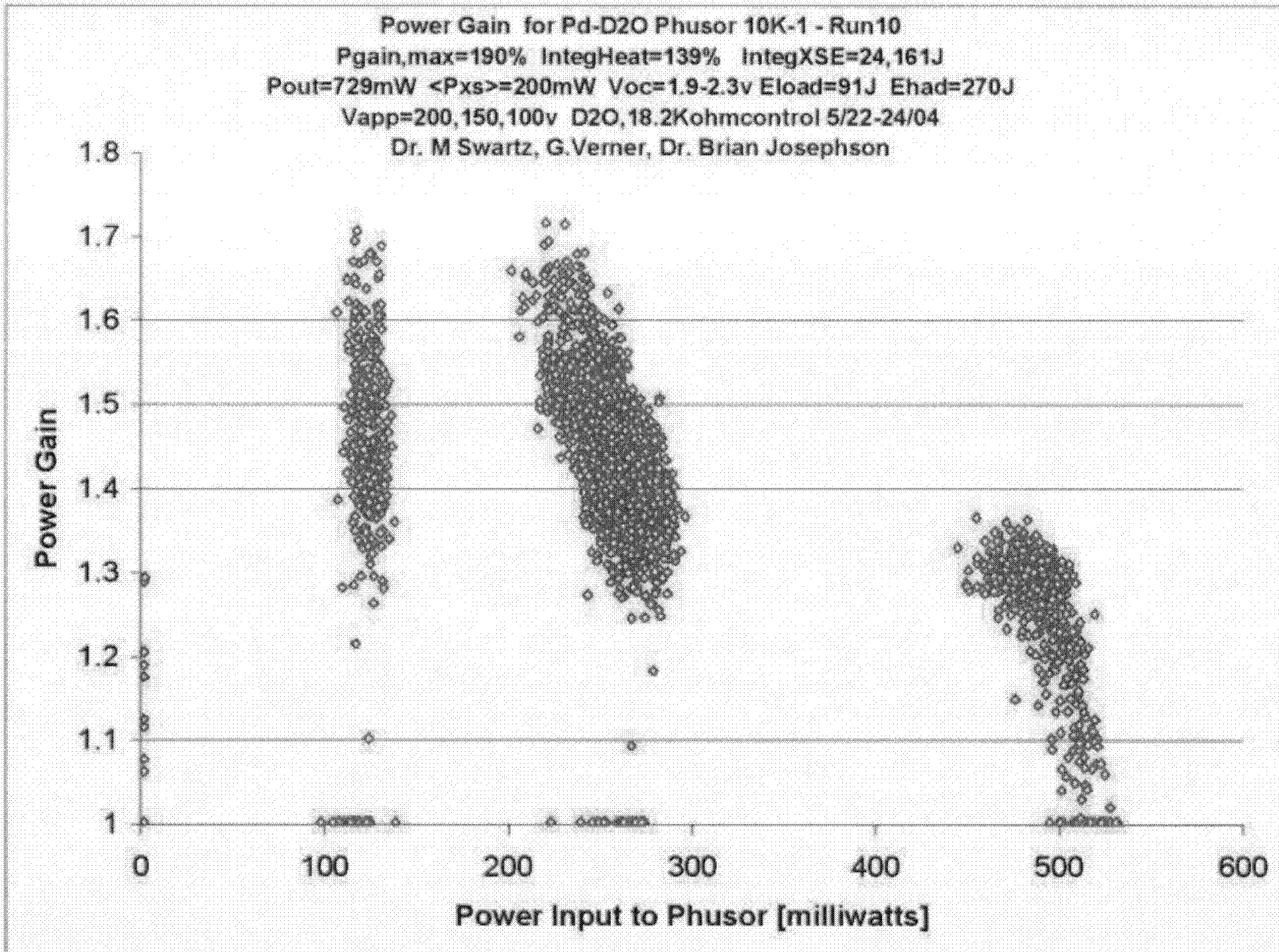
10K Driver, dual DAQ improves setup consistently.

Logout

Operators: Dr. Mitchell Swartz
Gayle Verner

Guest: Dr. Brian Josephson

May 24, 2004 Dr. Mitchell Swartz



JET Technology Confidential 5/25/2004 Page 1

EXCESS HEAT IN ELECTRIC-FIELD LOADED DEUTERATED METALS:

TARDIVE THERMAL POWER

Dr. Mitchell Swartz
JET Energy, Inc.
Wellesley Hills, MA 02481

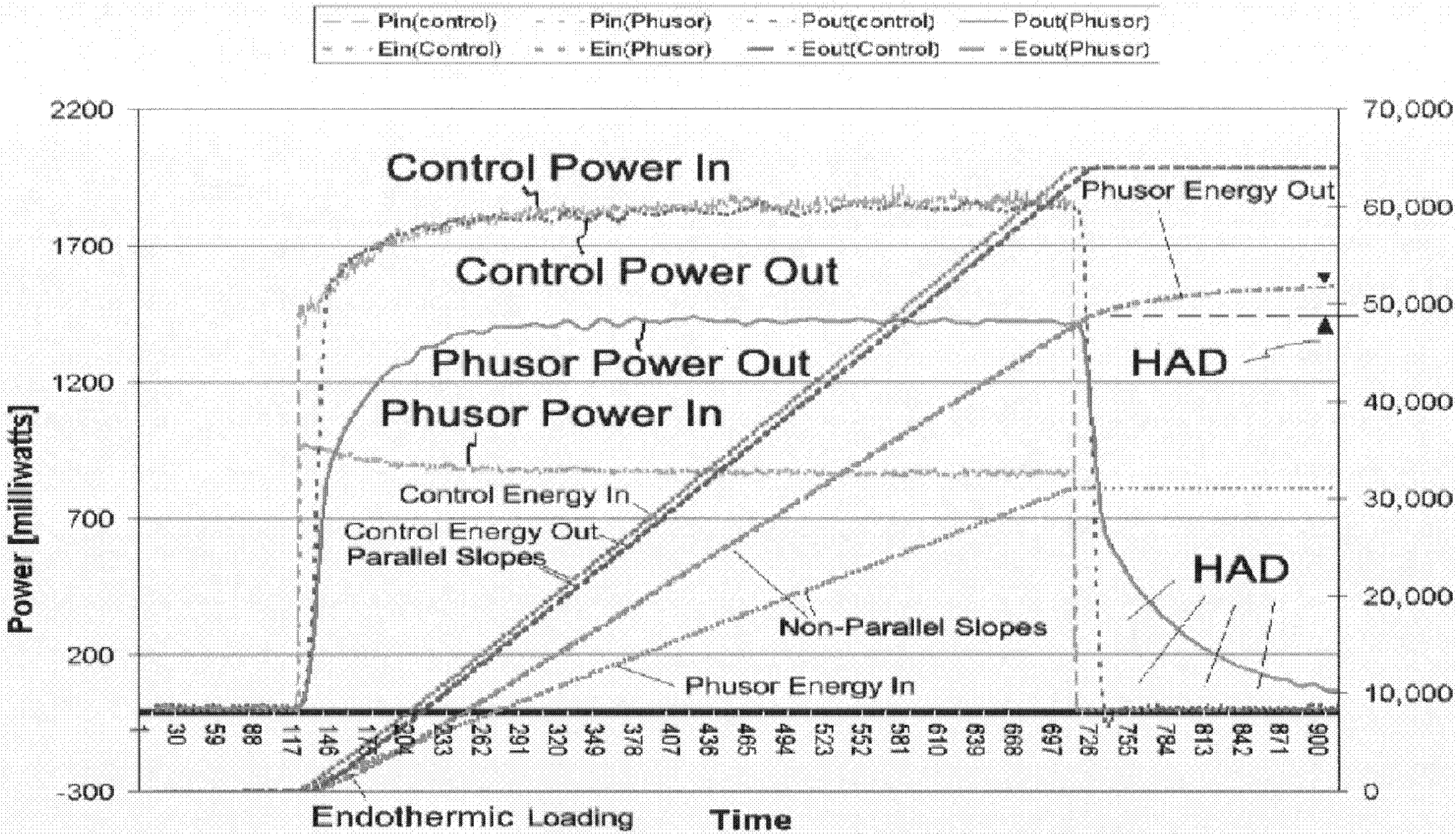
MEASUREMENT AND CONTROL OF TARDIVE THERMAL POWER

- After being driven to excess heat conditions, Phusors continue to produce significant (excess) tardive thermal power (TTP) long after the termination of input electric power.

  Tardive → Time Delayed

- The time-integral of TTP has been called "heat after death" (HAD).

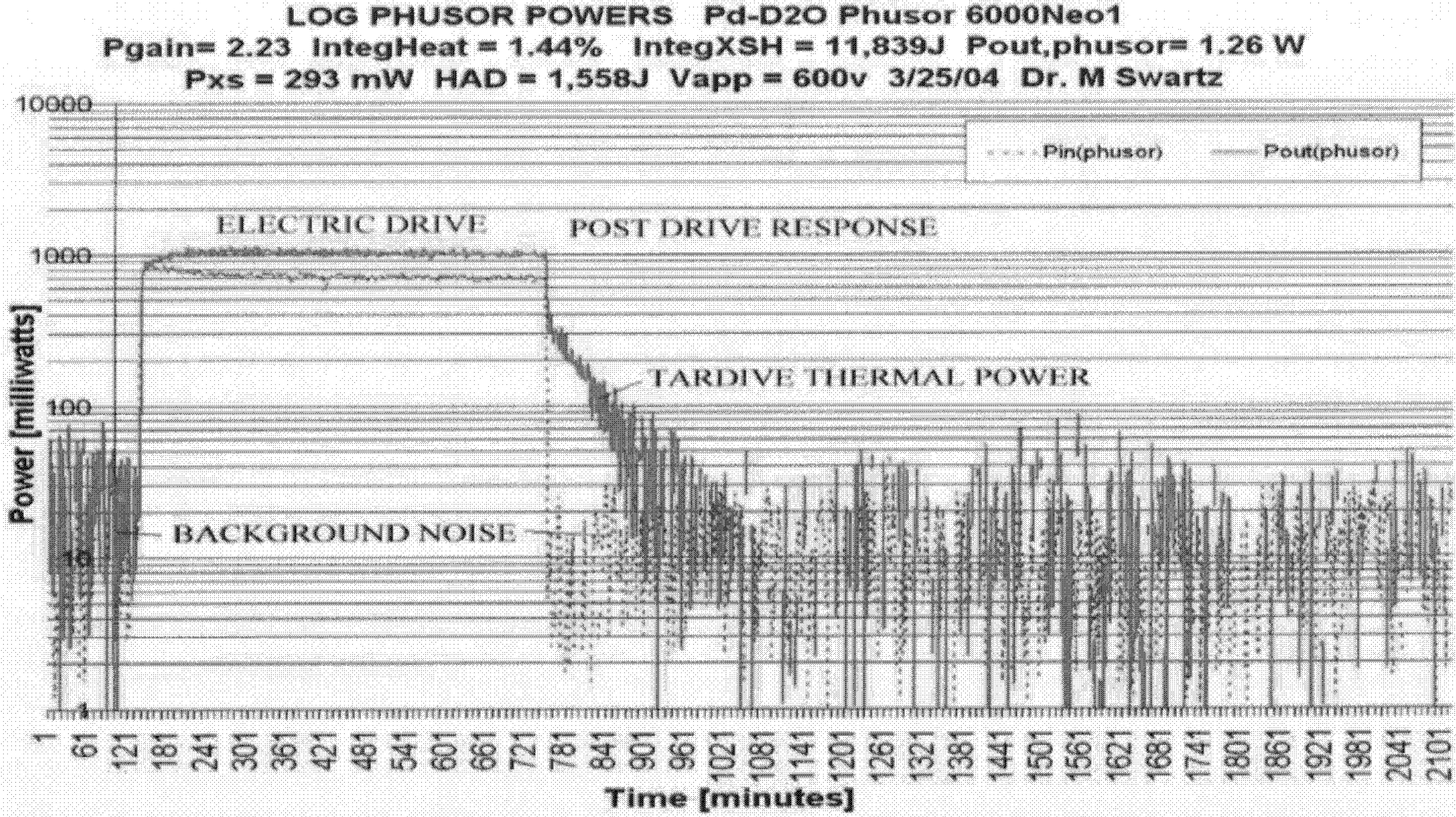
Semi-quantitative Determination of Tardive Thermal Power Using Dual Ohmic Controls



Swartz, M., G. Verner, "Dual Ohmic Controls Improve Understanding of "Heat after Death", Transactions, American Nuclear Society, vol. 93, ISSN 93 1-988, 891-892 (2005).

Figure shows the input electrical and observed output thermal powers (and energies) for both the Pd/D2O/Pt cell and joule control. HAD is the time-integral of tardive thermal power.

DISCHARGE FUSION SPECTROSCOPY INDICATES POSSIBLE SHALLOW AND DEEP POPULATIONS



JET THERMAL PRODUCTS - Procedure 40527 Run 11
Five day run of JET Phusor 10K Driver

Brief Procedure Note

Pd-D2O JET Phusor 10K Driver Run 11
Recharged Cell 8 [filled 8/03,
recharged CIL 99.9% D2O (DLM-11 5/04)]
Run duration 5/27-31/04

Results

Vapplied = 50,100,130,155,170v nominal
Voc = 1.7 - 2.1 volts

Pout,phusor = 460 milliwatts
<Pxs> = 140 milliwatts

Pgain, max = 170%
IntegHeat Output=134%

IntegXS Energy = 12,681 Joules
IntegHAD energy = 1011 Joules
Loading Energy = 8 Joules

Recommendations/Observations

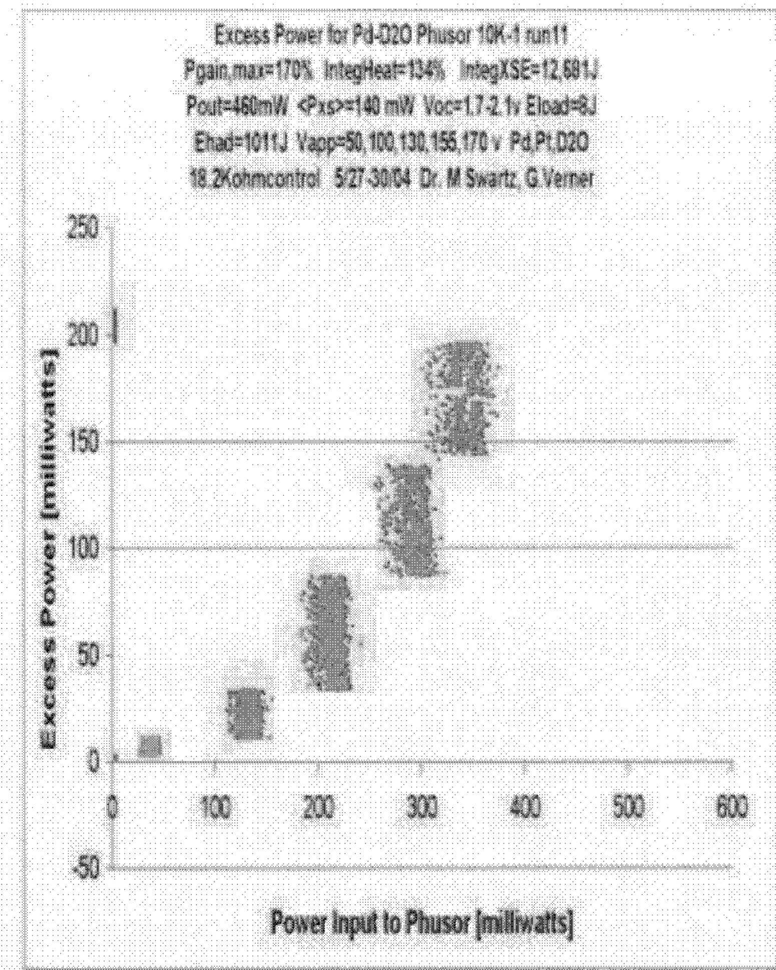
10K Driver, dual DAQ (12 bit V tested). Data loss (of the E and V a,b,c,d,e,f,g,h,j,k data sets, of 20 sets, lost Vg). f merged with h. Therefore, this is a qualitative, not semiquantitative experiment. Also, this expt. may underestimate device output.

FIRST USE OF HAD in 10K FOR WORK

At end of drive portion, inadvertently left HAD-performing phusor electrically connected to the ohmic control. Therefore, the expt shows the HAD-performing phusor dissipating thermal energy at a second location --heating the control. The control input power rises above the background noise (bottom-right, log power curves).

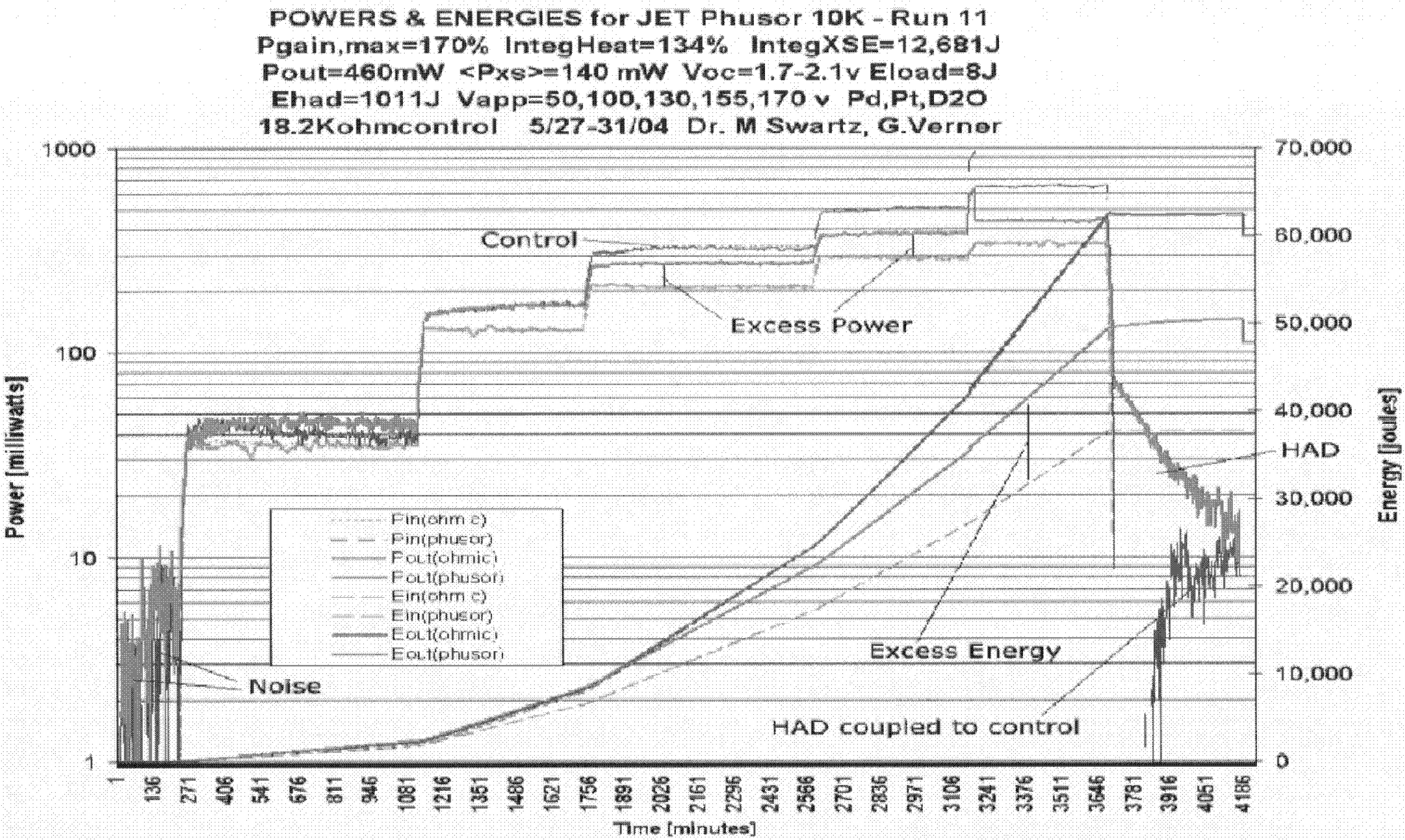
Logout

Operators: Dr. Mitchell Swartz
Gayle Verner
May 31, 2004 Dr. Mitchell Swartz



Technical Milestone - First Use of TTP for Work

May 2004 –The 10K-Driver used with Phusor Technology resulted in the first known use of tardive thermal power (TTP) to produce work. The time-integral of TTP is know as "heat after death".



B4

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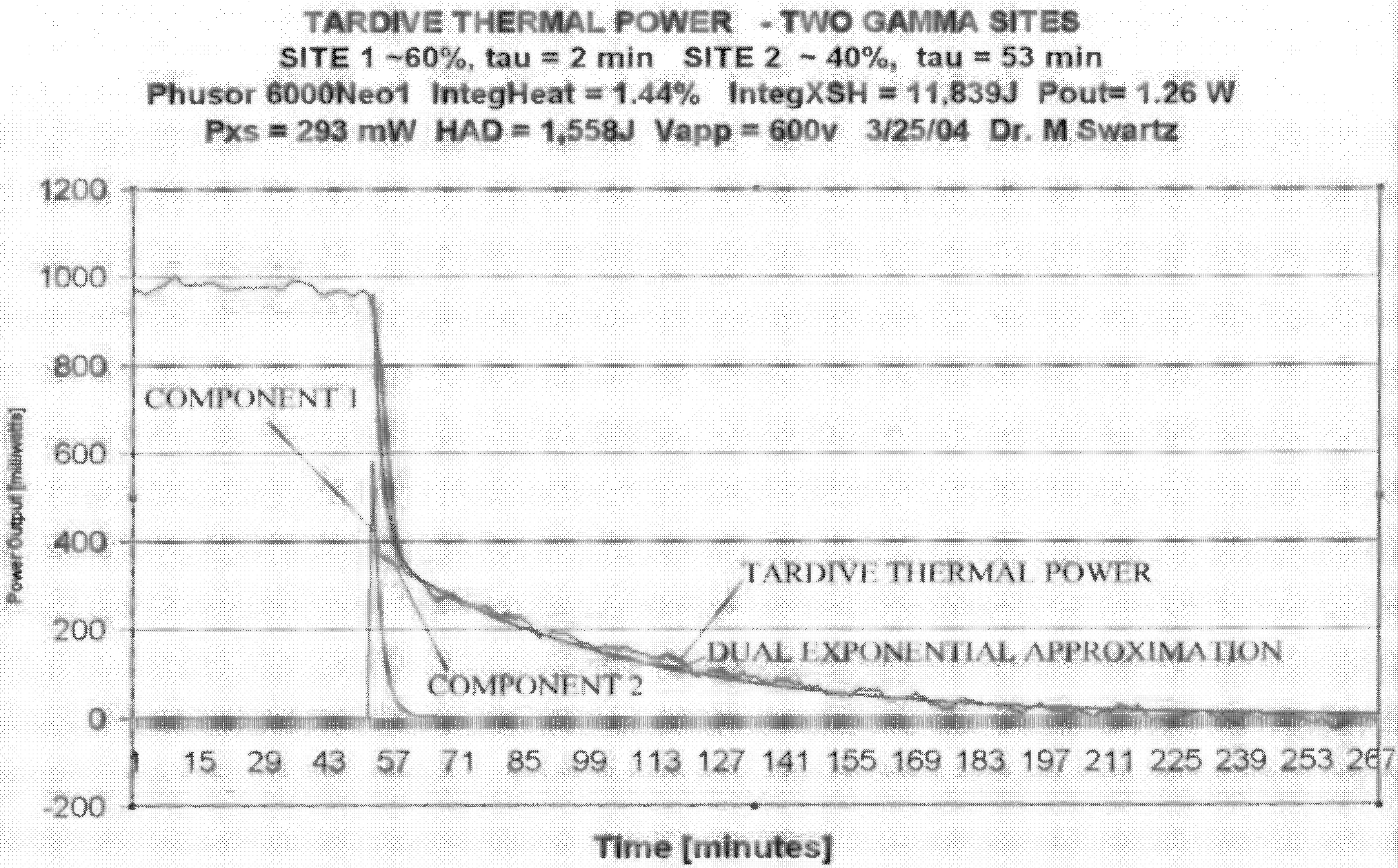
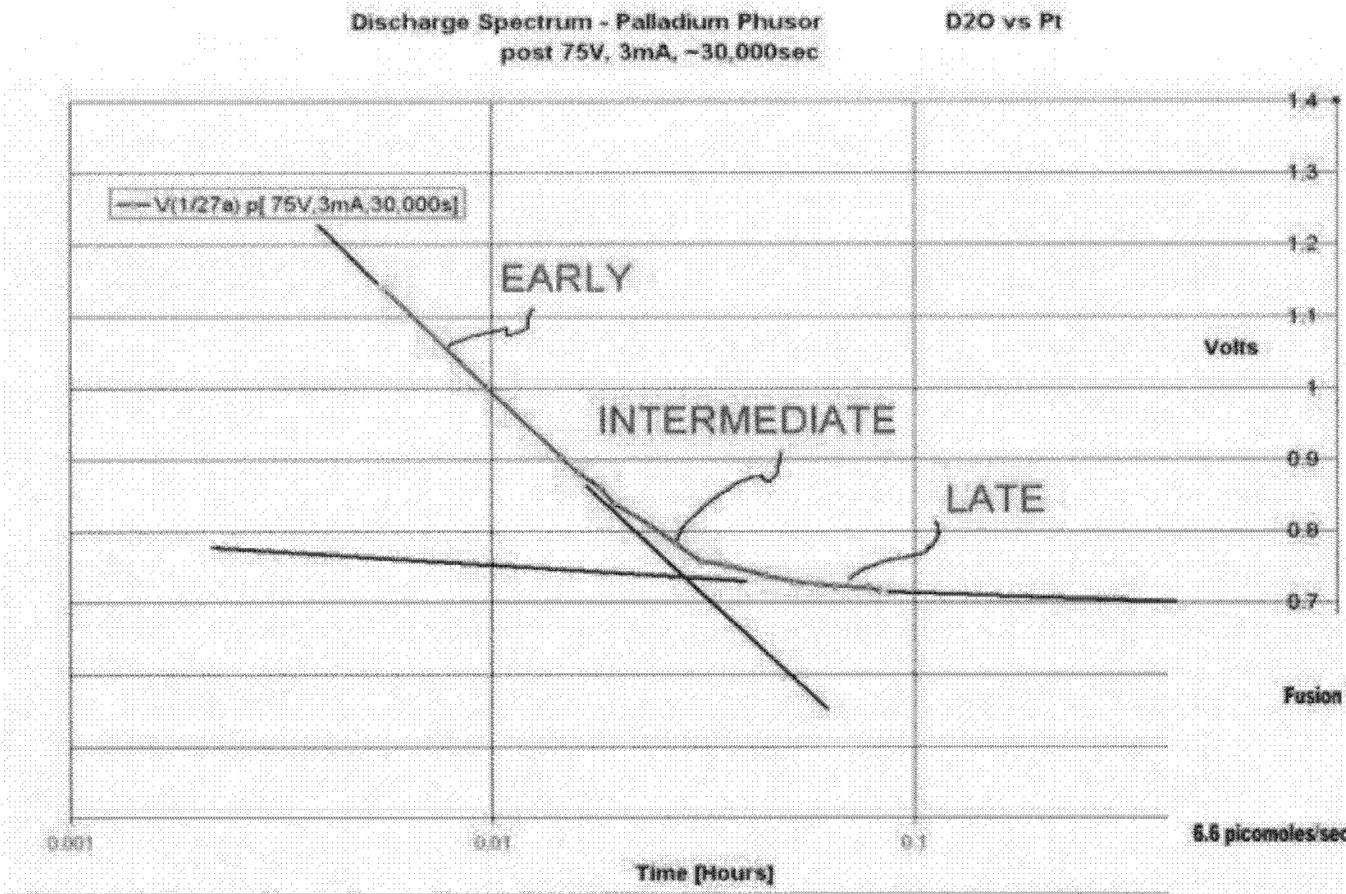
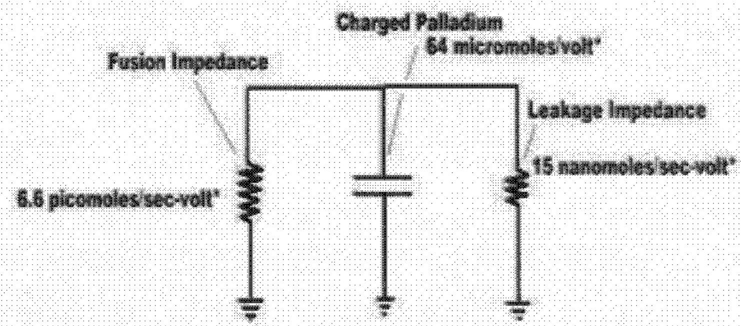
DISCHARGE FUSION SPECTROSCOPY
# INDICATES POSSIBLE SHALLOW AND DEEP POPULATIONS



DISCHARGE FUSION SPECTROSCOPY
# INDICATES POSSIBLE SHALLOW AND DEEP POPULATIONS





Implications of TTP/HAD Measurement

- 1) Characterization and Optimization of sample behavior necessarily has a new dimension because of utilization of TTP/HAD.

- 2) Our previous reports of obtainable Phusor power gain are lower limits of what we have, and can be, achieved.

This is important because the effective excess power generated is further greatly increased (up to an additional ~410% beyond that obtained without tardive thermal power operation).

In addition, these systems have revealed further insight into the kinetics of the desired condensed matter reactions.

Implications of TTP/HAD Measurement

- 3) Complete sample characterization requires knowledge of the optimal operating point AND consideration of TTP/HAD.

- 4) Cold fusion systems and devices can be made more efficient by utilizing TTP/HAD effects.

- 5) The advantages and roles of gold (Swartz) and boron (Miles) alloys must now be considered in the light of this new information because they may change the ratio of the two hydridation admittances, thus improving the efficiency of the desired reaction(s).

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- 9. Swartz. M., "Control of Low Energy Nuclear Reactions through Loading and Optimal Operating Point", *Transactions of ANS/2000 International Winter Meeting*, Nov. 12-17, 2000, Washington, D.C., (2000).
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Wellesley Hills, MA 02481

Lattice Energy LLC

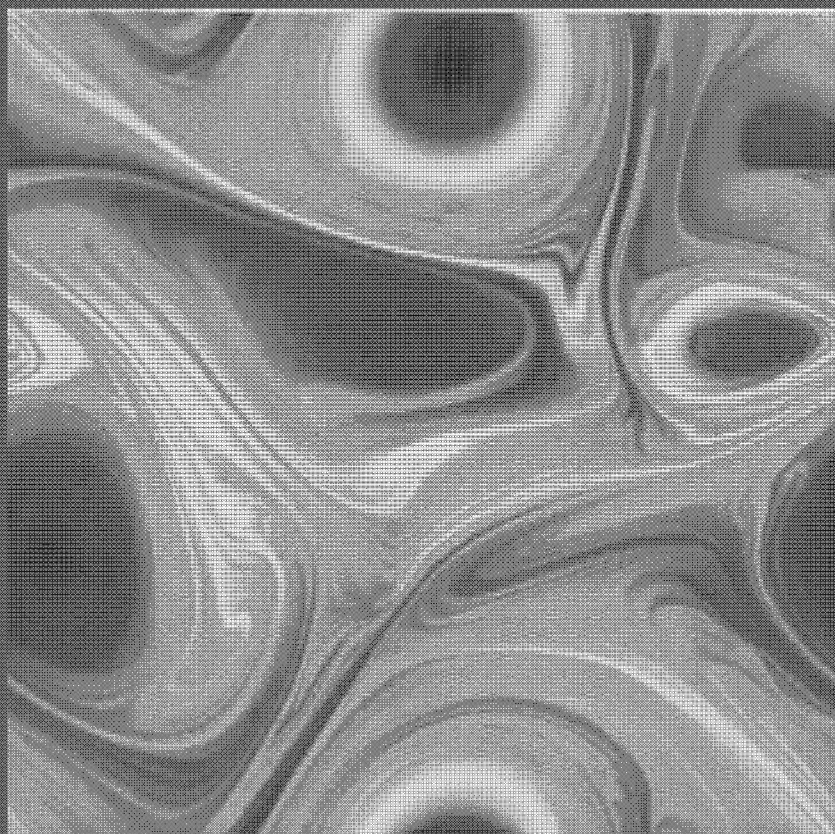
Commercializing LENRs:
A “Green” Next Generation Energy Source
For Dense, Long Lived Portable Power

Lewis G. Larsen
President and CEO, Founder

Prof. Allan Widom
Consultant and Member of Lattice Energy LLC
Northeastern University, Dept. of Physics

DTRA/ASCO High Energy S&T Workshop
December 12, 2006

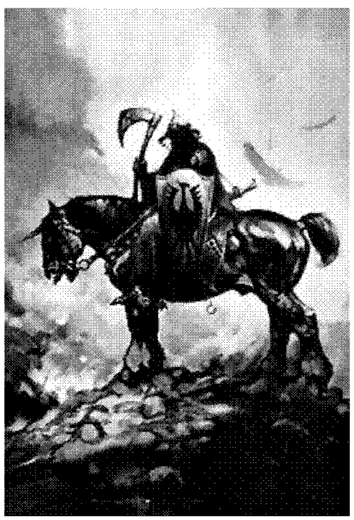
Low Energy Nuclear Reactions in Condensed Matter Systems



L. Larsen
A. Widom

Low Energy Nuclear Reactions Controversial Research I

- Experimental results don't fit well with presently accepted knowledge of nuclear physics, particularly fusion reactions.
- According to accepted nuclear theory, many LENR researchers should have been killed by lethal fluxes of neutrons or hard radiation.



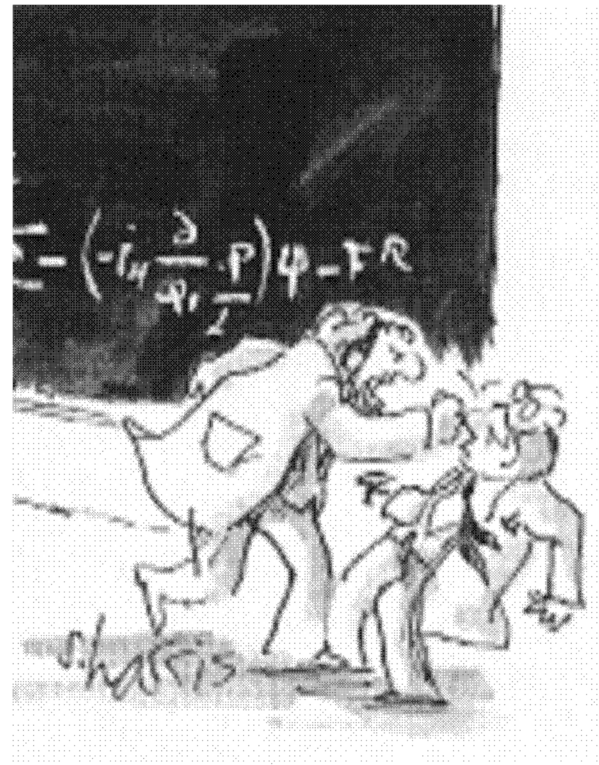
Yet We Live

- Many researchers working in field continue to insist that LENR's are some form of "cold" fusion.
- Reproducibility of many aspects of LENR's is poor, *especially* regarding excess heat.
- Critics have argued that LENR's are "junk" science.

Fact: There is a large residue of experimental data on LENR's that is quite solid and *cannot* be explained away simply as experimental error.

Low Energy Nuclear Reactions Controversial Research II

- **Fact:** Although the quality of experimental work varies greatly, a significant body of experimental observations are well done.
- **Fact:** To date, no LENR researchers have been killed by radiation.
- **Problem:** Standard model nuclear theory was not applied to explain the results.
- **Solution:** Develop a theory of LENR's which explain the data without invoking "new physics" beyond the standard model.



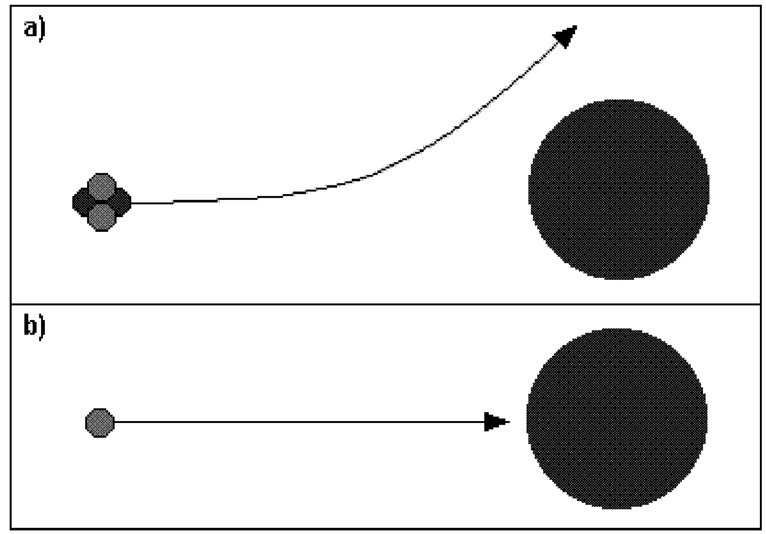
You want proof! I'll give you proof!

Widom-Larsen Theory I

- Explains a broad range of experimental data in H- and D-based systems.
- Answers why there are not energetic neutrons typically produced.
- Answers why there are not significant amounts of hard radiation.
- Answers why there are not Coulomb barriers to the required reactions.
- Explains production of helium isotopes observed in certain experiments.
- Explains production of excess heat observed in certain experiments.
- Explains complex product spectra seen in transmutation experiments.
- Enables calculations of reaction rates in agreement with experiments.
- Creates a road map that solves previous reproducibility problems.
- Predicts new LENR phenomena and also explains anomalous data and phenomena in other fields of weak interaction nuclear physics.

Widom-Larsen Theory II

- LENR's primarily involve the weak interactions (creation of neutrons, neutrinos and beta decays).
- LENR's are not "cold fusion" or other forms of pure strong interactions.
- Explains LENR's in terms of the accepted high energy Standard Model.
- Extends existing electroweak model to include condensed matter collective effects.
- Does not employ any microscopic "new physics".
- Does not involve penetration of a Coulomb barrier. Neutrons have no charge. Electrons and protons attract.

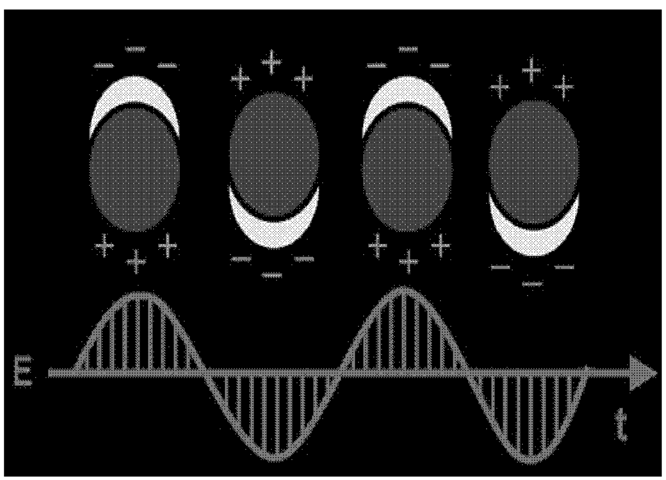


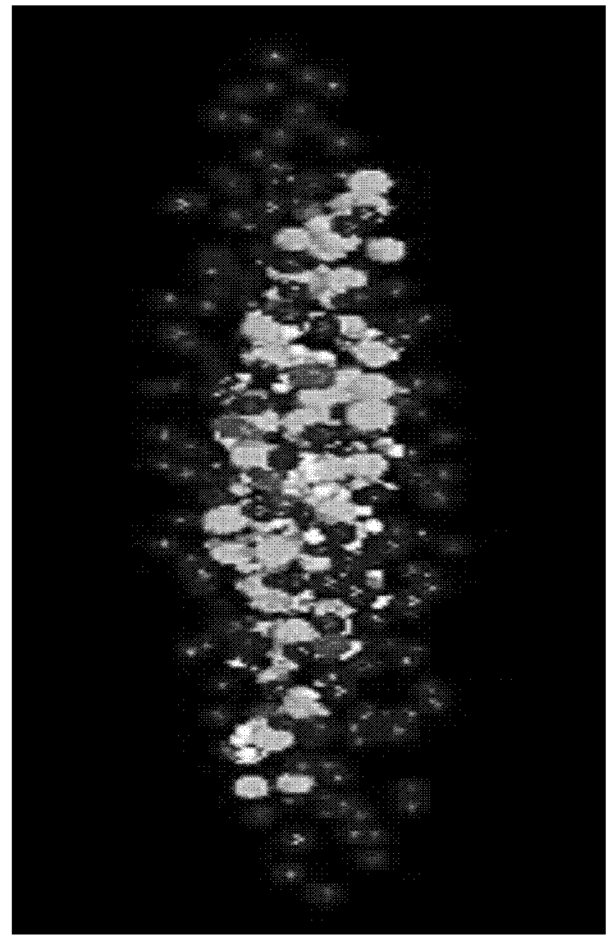
Nucleus bombarded with the a) alpha particle
b) neutron

Only like charges deflect from a Coulomb barrier.

Widom-Larsen Theory III

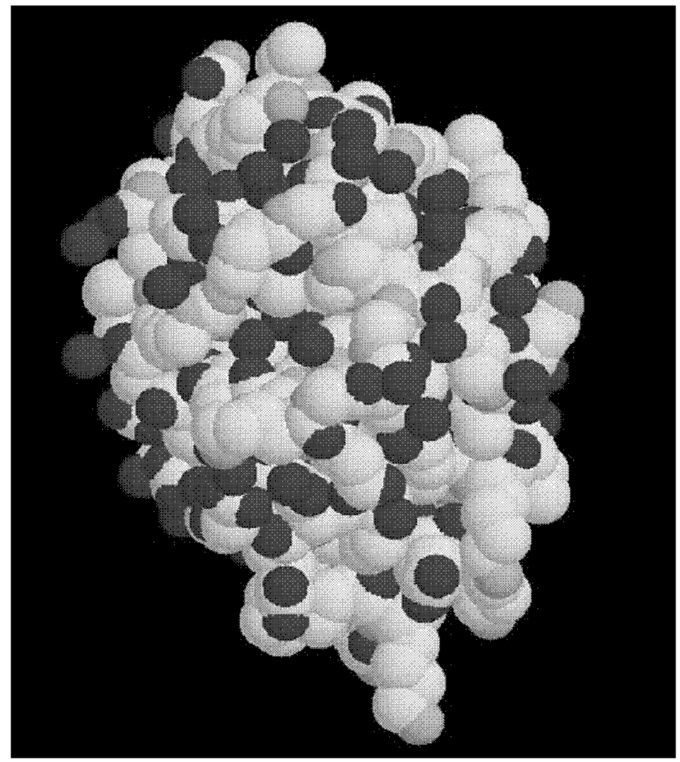
- Does not violate any conservation laws.
- It Is unusually multidisciplinary –it incorporates accepted concepts from a number of different areas of physics, including collective many-body effects.





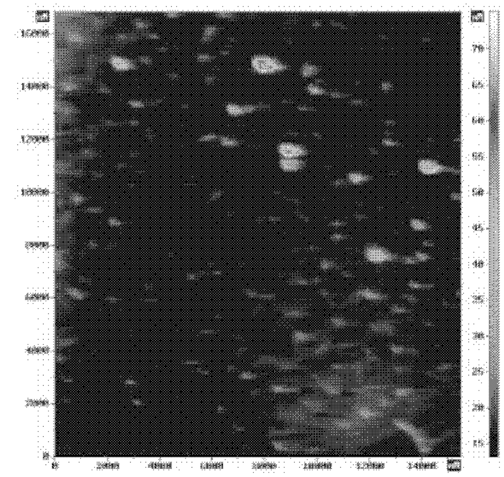
Widom-Larsen Theory IV

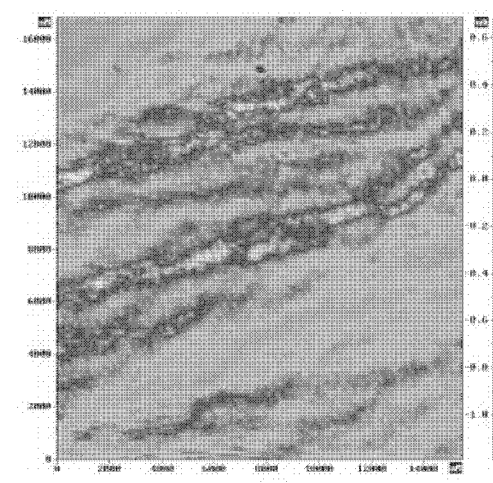
1. Many-body "patches" of collectively oscillating protons or deuterons form on metallic hydride surfaces "loaded" with hydrogen isotopes.
2. Then, the Born-Oppenheimer approximation breaks down in the local region "above" the patches; collective oscillations of the protons or deuterons start to couple loosely to the collective oscillations of nearby Surface Plasmon Polariton electrons (SPPs) commonly found on surfaces of metals.



Widom-Larsen Theory V

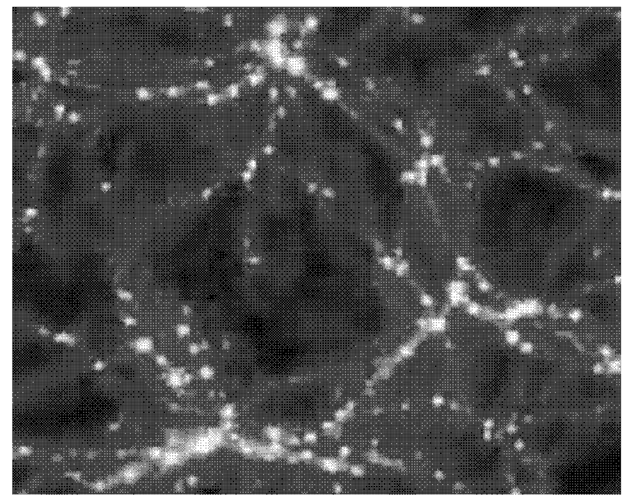
1. Coupling between SPP's and the patches of protons or deuterons increases the local electric field to values > 10^{11} volts/meter (roughly the same magnitude as Coulomb fields seen by inner electrons by nuclei).
2. Intense local radiation field raises effective mass of SPP electrons so that they can react spontaneously with nearby protons or deuterons to create neutrons.
3. Neutrons created collectively have huge quantum mechanical wavelengths (microns) and are almost always absorbed locally by nearby nuclei.





Widom-Larsen Theory VI

- Heavy-mass SPP electrons in condensed matter systems have the unique ability to directly absorb a gamma photon and reradiate it as a collection of much lower-energy infrared and soft X-ray photons (conservation of energy applies).
- Thus, when expected prompt hard gamma photons are emitted as a result of neutron absorption by local nuclei or beta decays, gammas are intercepted by heavy SPP electrons and reradiated as much "softer" electromagnetic energy.
- As a result, LENR systems have built-in "gamma shields" that preclude external emission of hard radiation in the form of MeV + gamma- and X-rays.
- Since there is internal absorption of gammas, no significant shielding is required for conducting safe laboratory experiments with LENR systems.



Widom-Larsen Theory VII

Beginning in May 2005, four papers have appeared on the non-proprietary aspects of the Widom-Larsen theory.

1. "Ultra Low Momentum Neutron Catalyzed Nuclear Reactions on Metallic Hydride Surfaces", ***Eur. Phys. J. C*** **46, 107 (2006)**
2. "Absorption of Nuclear Gamma Radiation by Heavy Electrons on Metallic Hydride Surfaces", **cond-mat/0509269**
3. "Nuclear Abundances in Metallic Hydride Electrodes of Electrolytic Chemical Cells", **cond-mat/0602472**
4. "Theoretical Standard Model Rates of Proton to Neutron Conversions Near Metallic Hydride Surfaces", **nucl-th/0608059**

Ultra Low Momentum Neutron Catalyzed
Nuclear Reactions on Metallic Hydride Surfaces

A. Widom
Physics Department, Northeastern University, Boston MA 02115

L. Larsen
Lattice Energy LLC, 175 North Harbor Drive, Chicago IL 60601

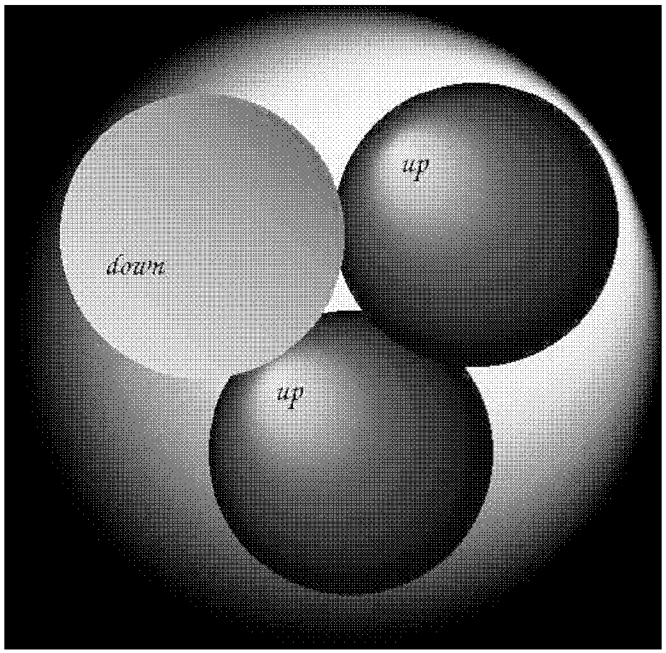
Ultra low momentum neutron catalyzed nuclear reactions in metallic hydride system surfaces are discussed. Weak interaction catalysis initially occurs when neutrons (along with neutrinos) are produced from the protons which capture "heavy" electrons. Surface electron masses are shifted upwards by localized condensed matter electromagnetic fields. Condensed matter quantum electrodynamic processes may also shift the densities of final states allowing an appreciable production of extremely low momentum neutrons which are thereby efficiently absorbed by nearby nuclei. No Coulomb barriers exist for the weak interaction neutron production or other resulting catalytic processes.

Future papers with new collaborators are in preparation.

Low Energy Nuclear Reactions

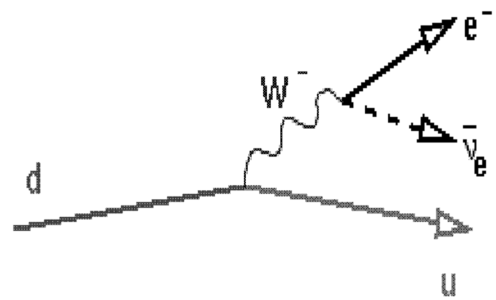
- Standard Model
- Energy Sources
- Weak Interactions
- Chemical Cells
- Nuclear Transmutations and Abundances
- Exploding Wires
- Total Rates
- Conclusions

Standard Model



The Neutron

The Proton



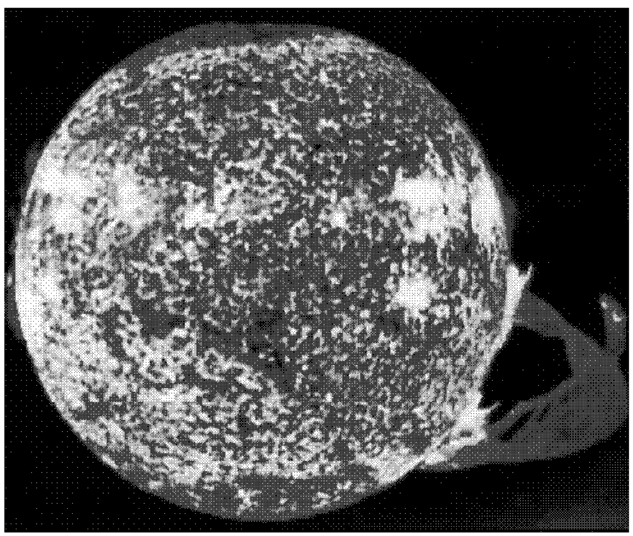
Weak Interaction
Decay of the Neutron

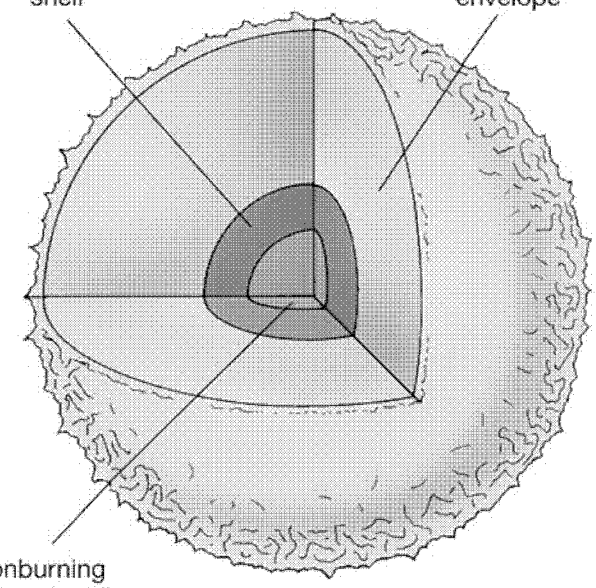
$$n \rightarrow p^{+} + e^{-} + \overline{\nu}_{e}$$

Energy Sources I

"Burning" Hydrogen in the Sun via Weak Interactions. The "seed" reaction is

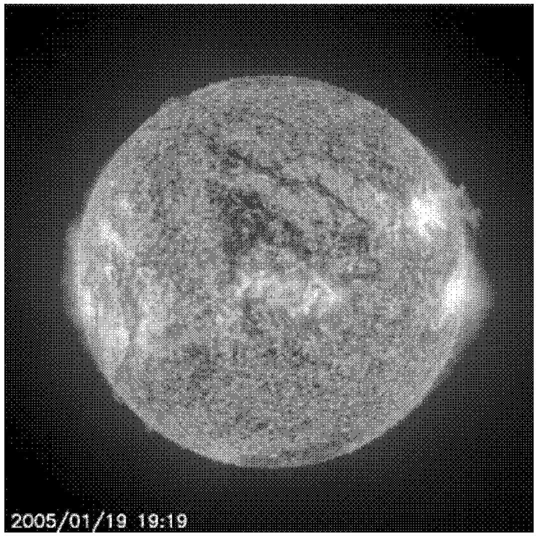
$$p^{+} + p^{+} \rightarrow d^{+} + e^{+} + \nu_{e}$$





Optical Picture and Theoretical Model of the Sun

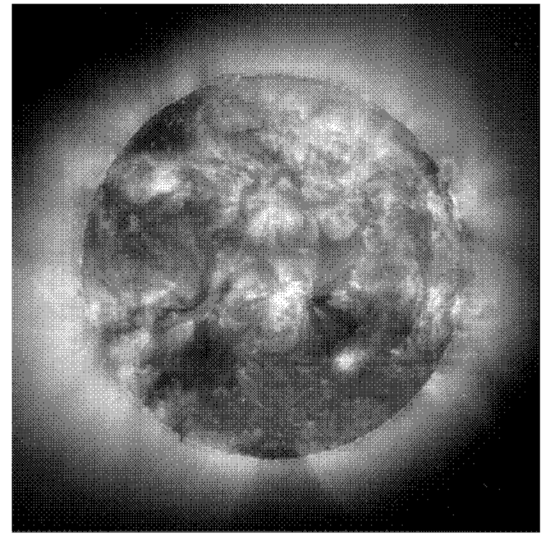
Energy Sources II



Optical Picture

Simultaneously Taken Pictures of the Sun

Outside X-ray Temperatures in the Solar Corona are from Nuclear Reactions of Unknown Origin



X-ray Picture

Our suggested "seed" corona weak interaction is the following:

$$(\text{collective radiation energy}) + e^- + p^+ \rightarrow n + \nu_e$$

Weak Interaction Energy Source

A. Widom and L. Larsen, *Eur.Phys.J.C* **46**, 107-111 (2006)

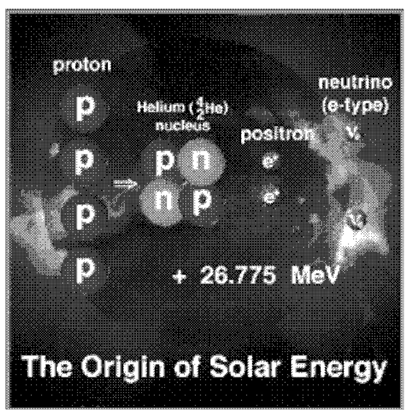
$$\text{(collective radiation energy)} + e^- \rightarrow \text{(mass renormalized electron) } \tilde{e}^-$$

$$\tilde{e}^- + p^+ \rightarrow n + \nu_e$$

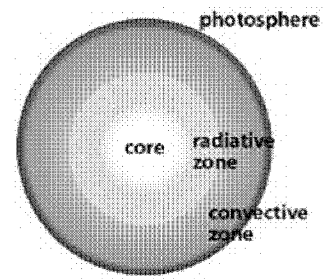
$$\text{net neutron producing reaction}$$

$$\text{(collective radiation energy)} + e^- + p^+ \rightarrow n + \nu_e$$

If there is a large enough neutron flux, then nuclear transmutations yield chemical abundances.



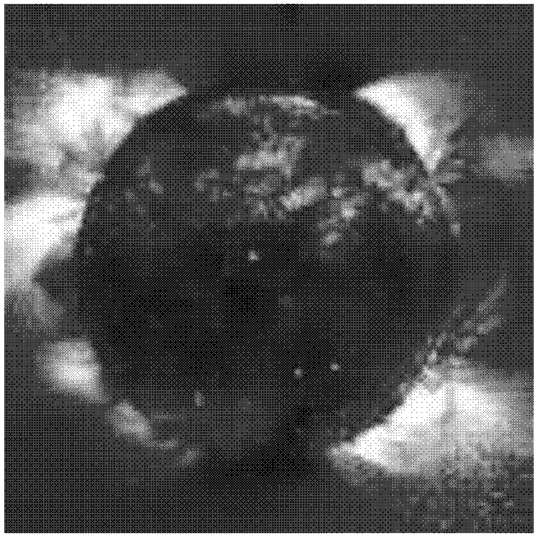
The Origin of Solar Energy



$$\tilde{e}^- + p^+ + p^+ \rightarrow d^+ + \nu_e$$

Possible Seed Reaction

Weak Interaction Energy Source



Nuclear Net Reaction for Burning in the Sun

$$2e^- + 4p^+ \rightarrow \alpha^{++} + 2\nu_e$$

Coulomb Barrier Intermediate Reaction

$$2p^+ \rightarrow e^+ + d^+ + \nu_e$$

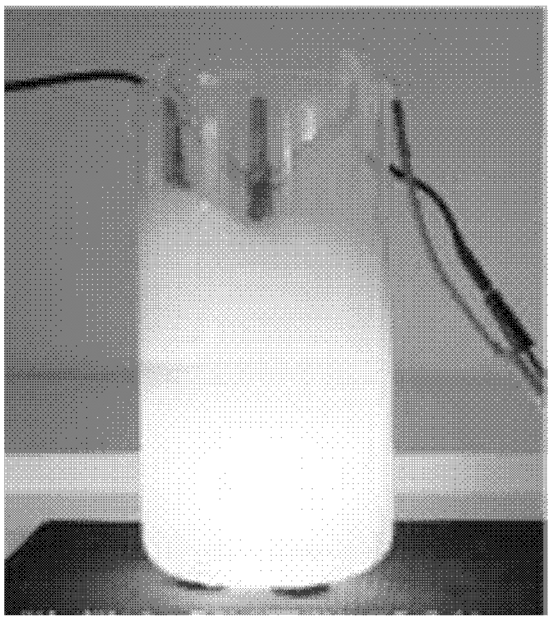
Intermediate Reactions *without* the Coulomb Barrier

$$e^- + p^+ \rightarrow n + \nu_e$$
$$n + p^+ \rightarrow d^+$$

There is always a neutrino flux with weak interactions.

$$e^- + p^+ \rightarrow n + \nu_e$$
$$n + p^+ \rightarrow d^+$$
$$n + d^+ \rightarrow t^+$$
$$n + t^+ \rightarrow \alpha^{++} + e^- + \overline{\nu}_e$$

Chemical Cells I



$$(\text{radiation}) + e^- \rightarrow \tilde{e}^-$$

$$\tilde{e}^- + p^+ \rightarrow n + \nu_e$$

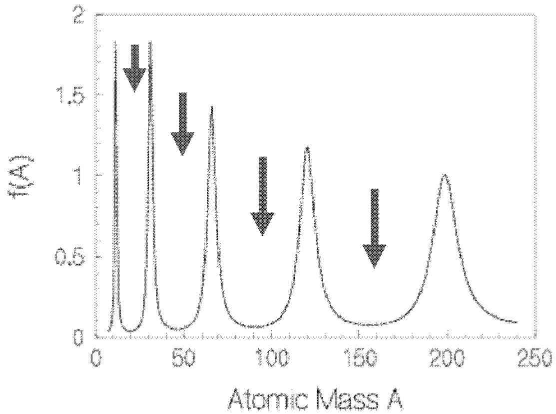
$$n + (Z, A) \rightarrow (Z, A+1)$$

$$(Z, A+1) \rightarrow (Z+1, A+1) + e^- + \bar{\nu}_e$$

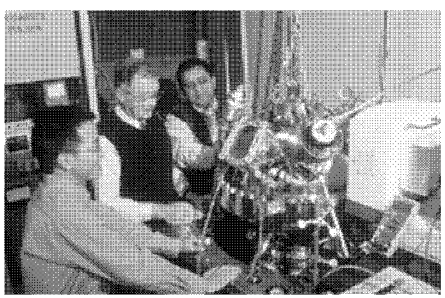
$$\cdots\cdots\cdots\cdots\cdots\cdots$$

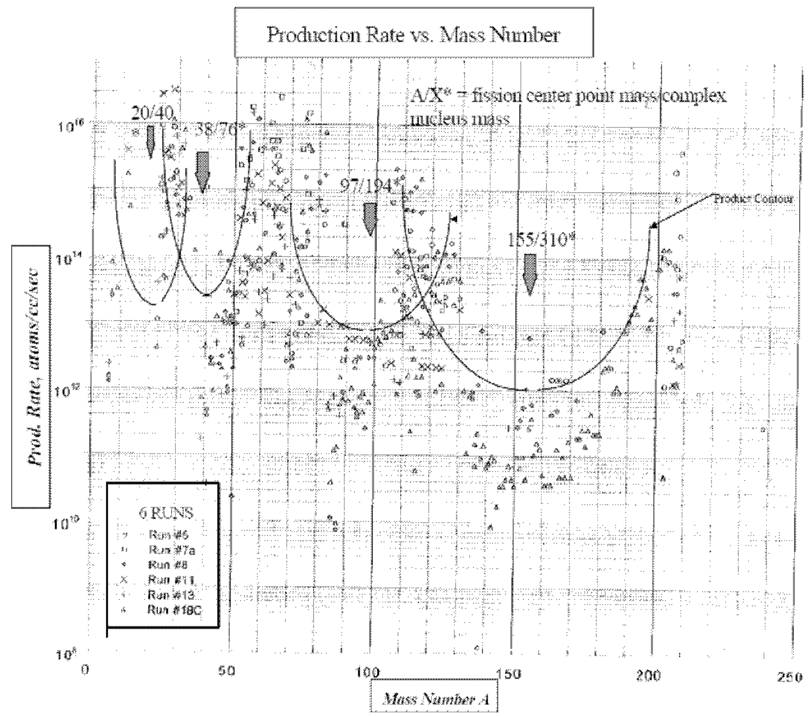
Chemical Cells II

Neutron Cross Section Strengths



Resonances in σ(A)



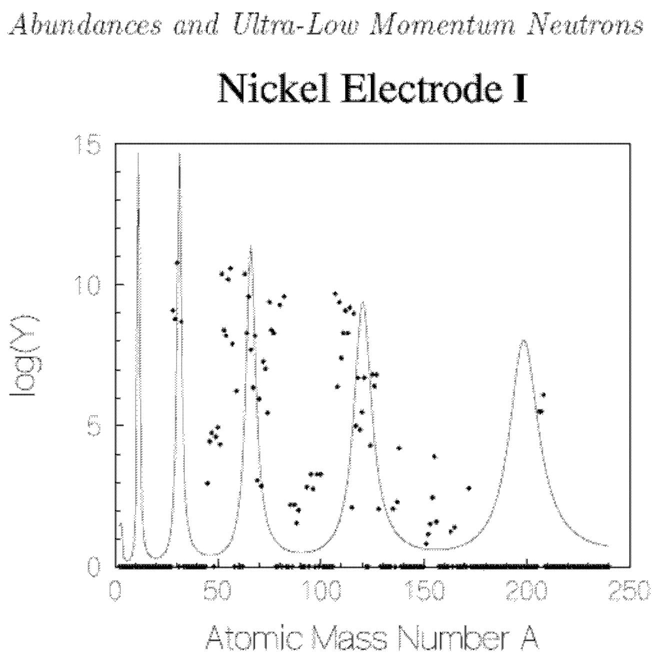


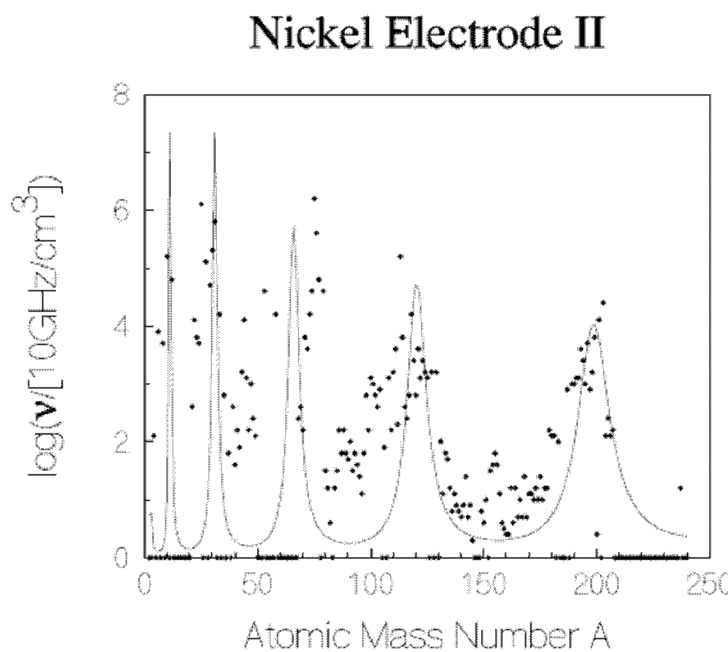
Experimental Abundances

Chemical Cells III

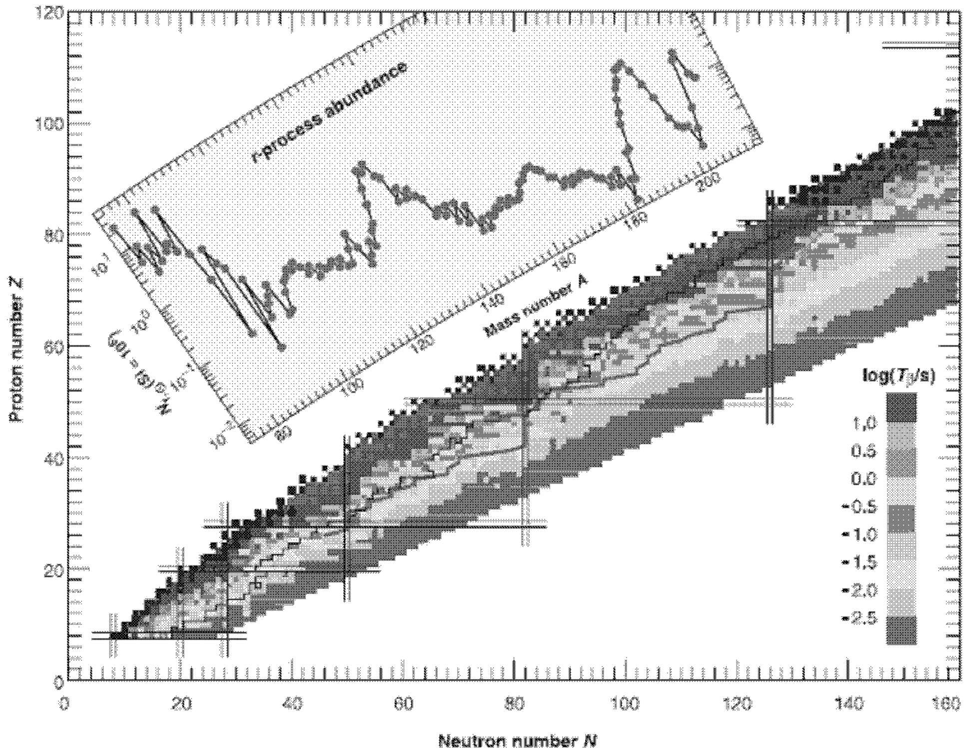
Nuclear Transmutations in Chemical Cells with Light Water and Nickel Electrodes

Abundances taken from the experiments of G. Miley et. al.





Nuclear Abundances I



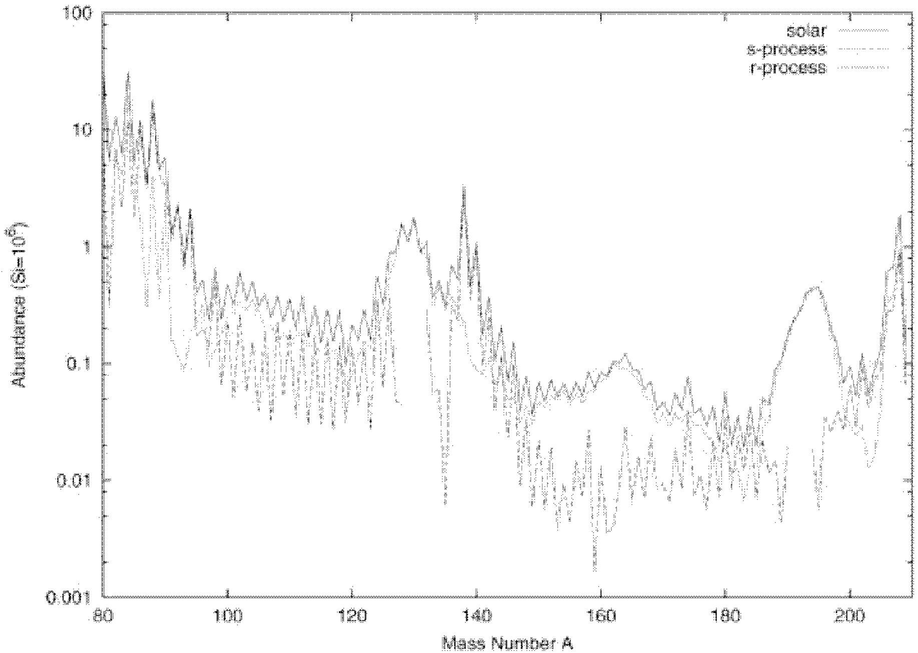
C. Sneddon & J.J. Cowen

"Genesis of the Heaviest Elements in the Milky Way Galaxy"

Science, **299**, 70 (2003)

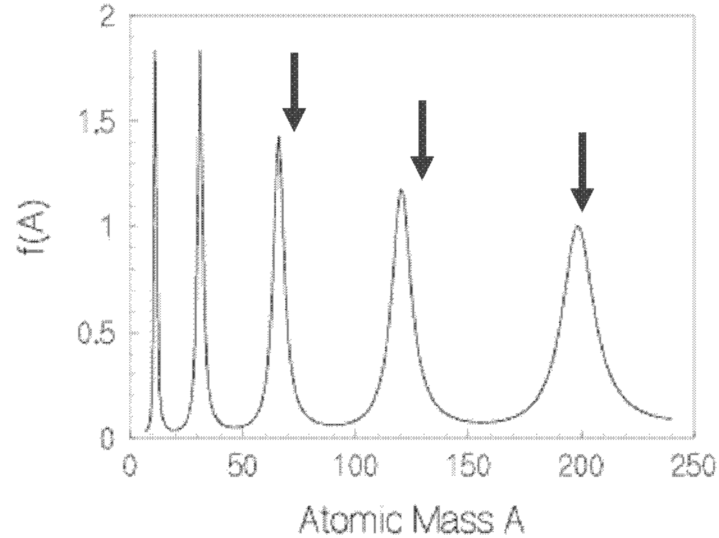
The peaks in the solar system abundance distribution around A=88, 138, 208 are formed in the s-process, whereas the broader companion peaks shifted to slightly lower mass number are r-process peaks.

Nuclear Abundances II



Maxima around A=88, 138, 208 are formed in the s-process.

Neutron Cross Section Strengths



Exploding Wires I

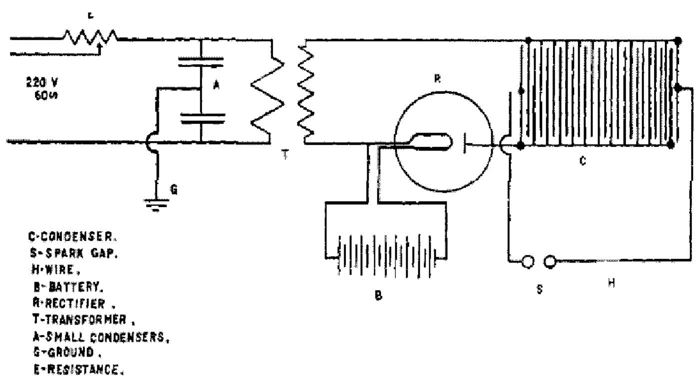
DECOMPOSITION OF TUNGSTEN 1887

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

EXPERIMENTAL ATTEMPTS TO DECOMPOSE TUNGSTEN AT HIGH TEMPERATURES

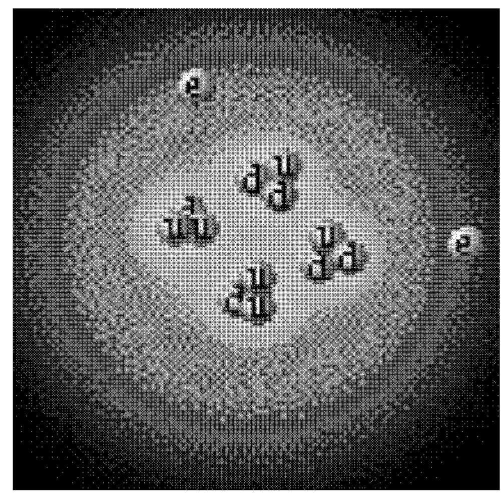
BY GERALD L. WENDT AND CLARENCE E. IRION

Received May 8, 1922



Published In Science

Spectroscopic Detection of α-particles, i.e. Helium atoms



Exploding Wires II

DECOMPOSITION OF TUNGSTEN 1887

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

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BY GERALD L. WENDT AND CLARENCE E. IRION

Received May 8, 1922

[1] Sir Ernest Rutherford, in *Nature*.

it is to be anticipated that the additional heating effect due to this liberated energy would be a much more definite and more delicate test of disintegration of heavy atoms into helium than the spectroscope.

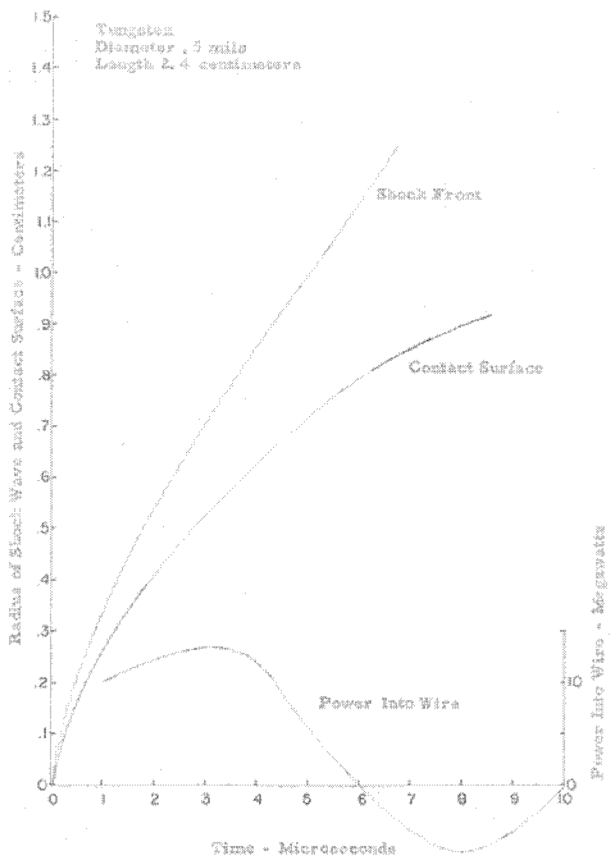
....

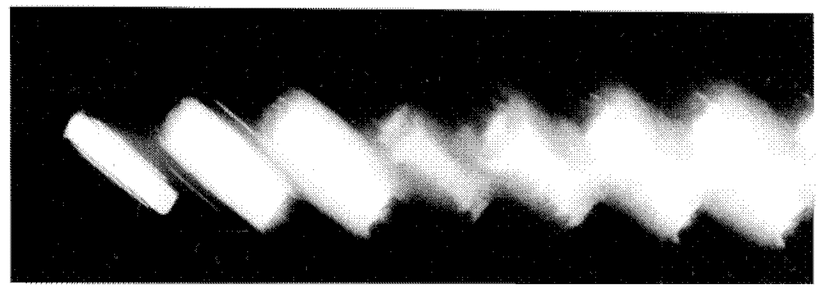
particular, in Coolidge tubes an intense stream of electrons of energy about 100,000 volts is constantly employed to bombard a tungsten target for long intervals, but no evolution of helium has so far been observed.

Rutherford has a big voltage but small current. One poor electron arrives at a time. Rutherford sees nothing.

Wendt and Irion have a small voltage but big current. Many electrons arrive at a collectively. Wendt and Irion see transmutations.

Exploding Wires III





From "A Study of Exploding Wires"

by Ben Robert Turner. Ph. D. Thesis,

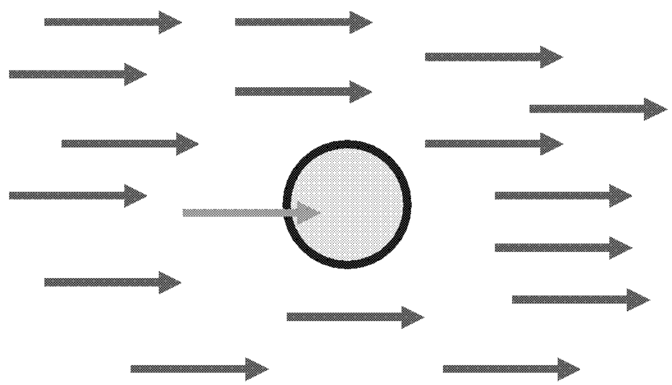
California Institute of Technology (1962)

Power input positive for times $0 < t < 6$ μsec.

Power output positive for times 6 μsec. $< t < 10$ μsec.

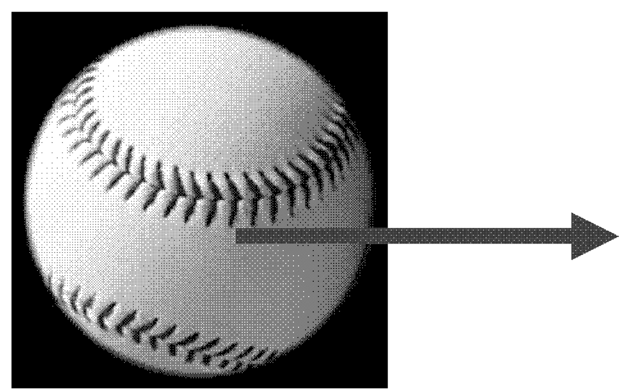
For transmutations in exploding wires also see "Investigation of Arcing in Electrical Fuses" by Robert Ernest Brown. Ph.D. Thesis, School of Engineering, Sheffield Hallum University.

Exploding Wires IV



When many electrons arrive at a proton, only one electron may pierce into the proton's inside. That electron dies. All of the other electrons have but donated a little energy. The plasma modes are collective and in synchronization.

It is not hard to throw a baseball at a target with an energy of 10^{23} electron volts, but (as did *not* Rutherford) one will *not* see transmutations. The electrical currents must be collective and the electrons must transfer energy coherently and all together.



General Theoretical Formulation I

From conservation law arguments, for every new neutron created (by destroying an electron and a proton) there will be neutrino created. One thereby counts new neutrons by counting new neutrinos. That was the game played in counting neutrinos from the sun. Power sources are derived from weak interactions.

$$S_{weak} = \hbar \int \left(\overline{\nu}(x)\eta(x) + \overline{\eta}(x)\nu(x) \right) d^4x$$

$$-i\gamma^{\mu}\partial_{\mu}\nu(x) = \eta(x)$$

$$i\partial_{\mu}\overline{\nu}(x)\gamma^{\mu} = \overline{\eta}(x)$$

Weak Interaction for Neutrinos

General Theoretical Formulation II

$$S_{week} = \hbar \int \left(\bar{\nu}(x)\eta(x) + \bar{\eta}(x)\nu(x) \right) d^4 x$$

$$S_{effective} = \frac{i}{2\hbar} \left\langle S_{week}{}^2 \right\rangle_+$$

Weak Interaction for Neutrinos

$$P = \left| e^{iS_{effective}/\hbar} \right|^2 = e^{-(1/c)\int \varpi \, d^4 x}$$

$$\int \varpi \, d^4 x = \frac{2c}{\hbar} \Im m S_{effective}$$

$$\frac{1}{c} \int \varpi(x) \, d^4 x = \Im m \int \int \left\langle \bar{\eta}(x_1)\nu(x_1)\bar{\nu}(x_2)\eta(x_2) \right\rangle d^4 x_1 d^4 x_2$$

$$\left\langle \nu(x_1)\bar{\nu}(x_2) \right\rangle = C(x_1 - x_2) = \text{vacuum neutrino correlation}$$

$$\left\langle \bar{\eta}(x_1)\eta(x_2) \right\rangle = K(x_1, x_2) = \text{condensed matter source correlation}$$

$$\varpi(x) = c \Im m \int C(y) : K\left(x + \frac{y}{2}, x - \frac{y}{2} \right) d^4 y$$

Creation Probability for Neutrinos

$$\varpi(x) = \text{neutrino production rate per unit time per unit volume at } x$$

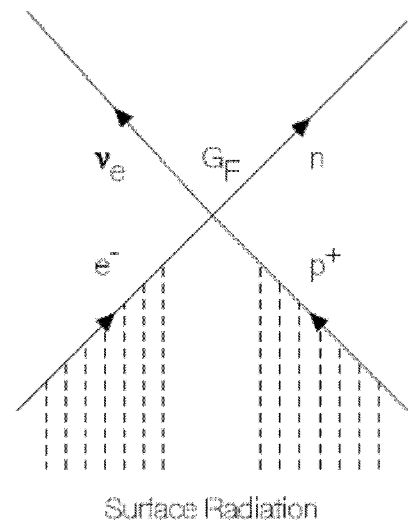
General Theoretical Formulation III

The rigorous source correlation function yielding the total production rate which does not depend on a "two body" correlation function is

$$K(x_1, x_2) = \langle \overline{\eta}(x_1)\eta(x_2) \rangle$$

$$\eta(x) = \frac{1}{\sqrt{2}} \gamma^{\mu} W^{+}{}_{\mu}(x) \psi_{left}(x)$$

$$\overline{\eta}(x) = \frac{1}{\sqrt{2}} \overline{\psi}_{right}(x) \gamma^{\mu} W^{-}{}_{\mu}(x)$$



which allows for the calculation of very high order non-linear electromagnetic processes

Conclusion I

- **Weak interactions allow for many of the observed low energy nuclear transmutations.**
- **Collective surface plasma modes yield the required renormalized electron properties.**
- **Nuclear transmutation distributions near surfaces can be largely understood.**
- **Total rates from weak interactions appear to be in reasonable agreement with many observations.**

Conclusion II

This laboratory was only funded to the extent that base metals could be converted into pure gold!

Low Energy Nuclear Reactions: Problems, Progress & Prospects

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The George Washington University
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Defense Threat Reduction Agency
High Energy Science and Technology Workshop
12 December 2006

Major Implications for Energy Production

Diverse Applications (Civil & Military)

Major Implications (U. S. & Foreign)

It may be possible to provide both electricity and hot water in homes, offices, factories and other buildings……..safely.

There would be no need for large centralized power stations or for major electrical power distributions systems.

LENR result in little radiation or radioactivity

Major Implications for Alteration of Elements

Production: Many Possibilities (Critical Materials)

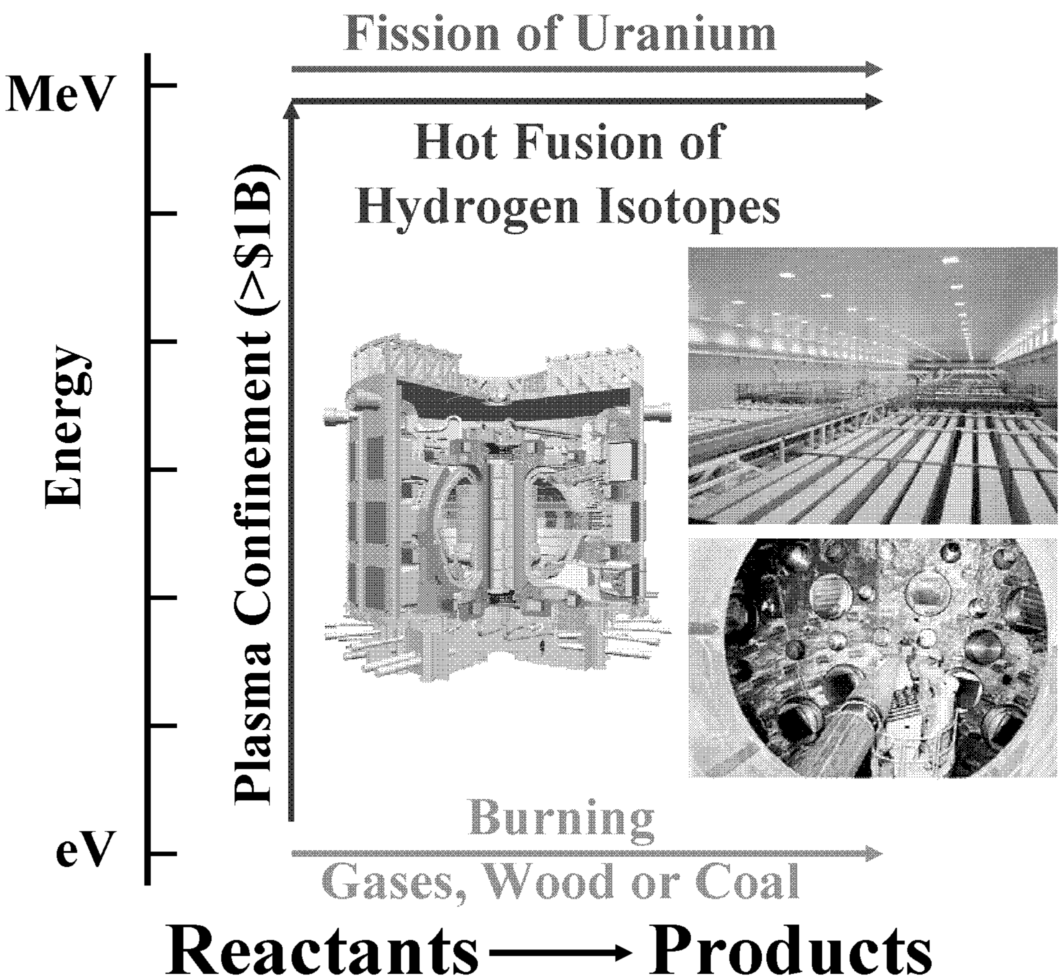
Destruction: Radioactive Materials (Nuclear Waste)

It may be possible to produce many elements across the periodic table on demand, so countries and their industries would not be constrained by geological circumstances or global markets in elemental materials.

Some people think that it might be possible to deactivate nuclear waste from fission reactors.

LENR result in little radiation or radioactivity

Chemical and Nuclear Reactions



<u>Basic Question for LENR</u>

How to get from the chemical to the nuclear energy regime in order to initiate reactions?

PROBLEMS

Potential Importance
for Energy, Materials and Weapons

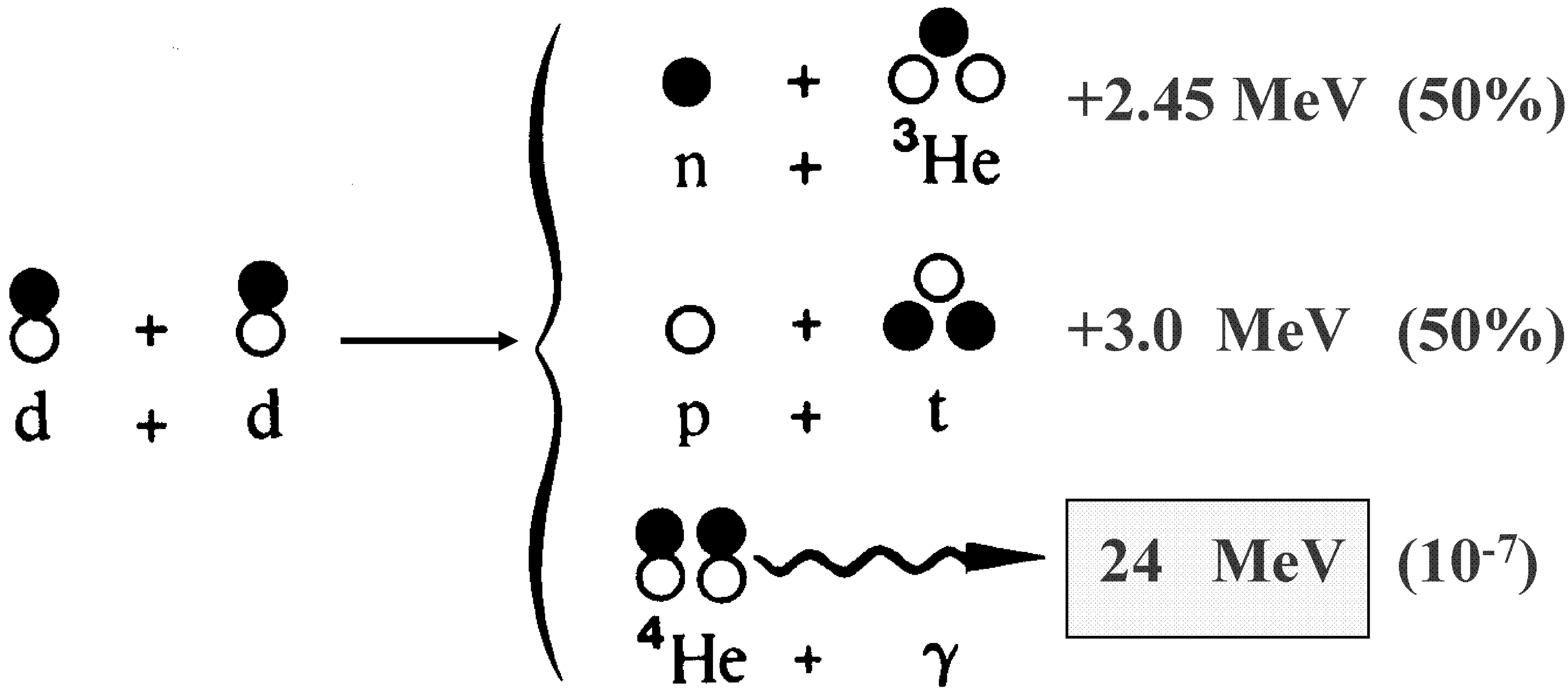
Polarization of Scientists

Diverse Mistakes

Technical Complexity

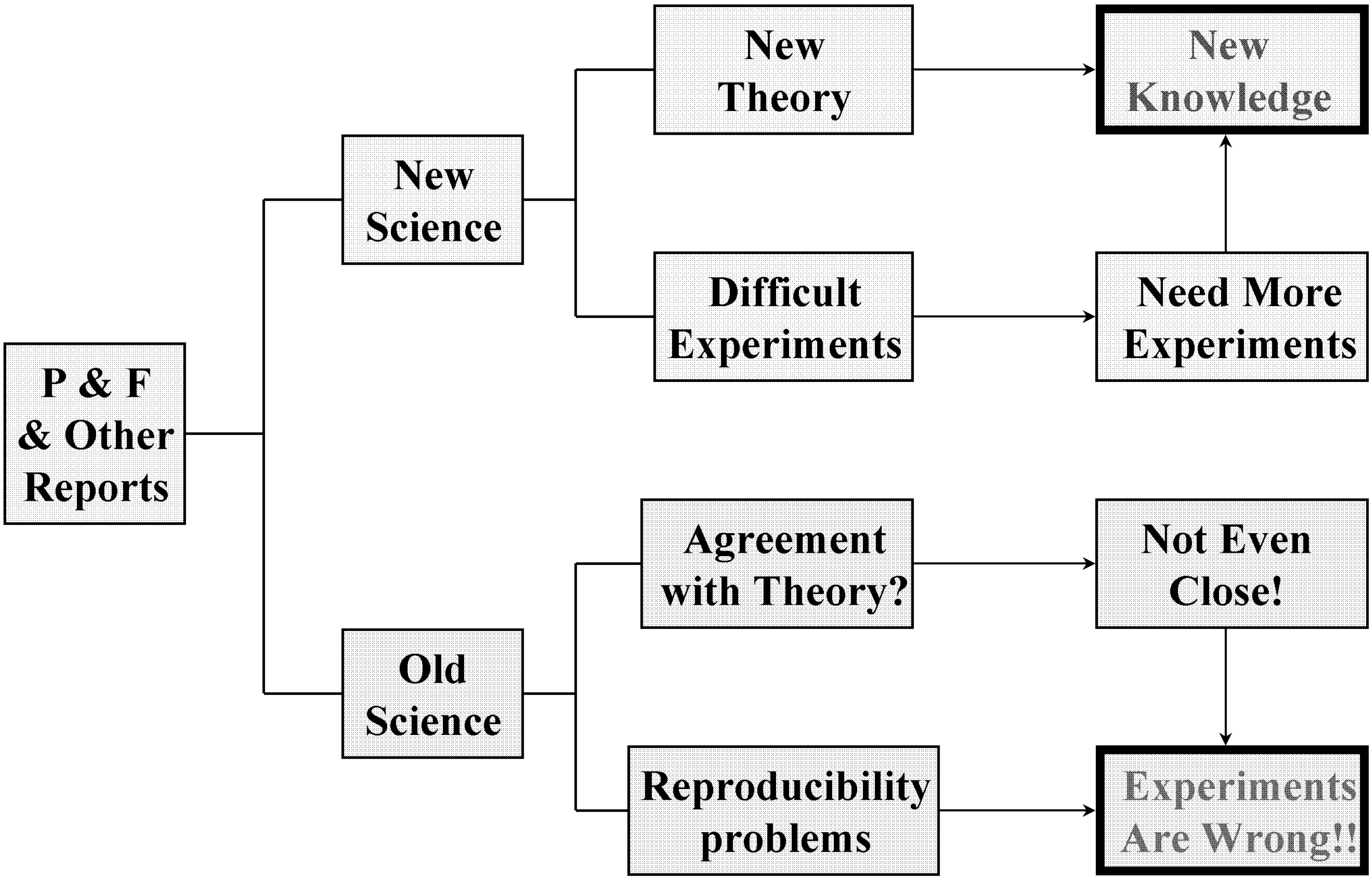
Flows of Money and Information
Disrupted Early & Remain Poor

Hot D-D Fusion



Ignition Temperature Near 400 x 10^6 ^{0}C
(about 40 keV)

A Major Problem with "Cold Fusion"



LENR Experiments are
Intrinsically, Inescapably, Inevitably
Inter-disciplinary

Physics | **Chemistry**

Nuclear Physics | **Electrochemistry**

Solid-state Physics & Chemistry

Materials Science

Instrumentation Science & Technology

Electrical, Mechanical & Thermal Engineering

Statistics & Data Analysis

PROGRESS

Continuous Activity & International Conferences

Better Instrumentation, Calibration and Controls

Some Systematics Found & Verified for Heat Generation Experiments

Nuclear Ash Measured & Correlated with Heat Production

More Attention to Materials

New Experiments Performed

Some Inter-lab Reproducibility

The ICCF Series of Conferences

AMERICA	EUROPE	ASIA
1. Salt Lake City	2. Como Italy	3. Nagoya Japan
4. Maui Hawaii	5. Monaco	6. Sapporo Japan
7. Vancouver	8. Lerici Italy	9. Beijing China
10. Cambridge	11. Marseilles France	12. Yokohama Japan
14. Washington DC	13. Sochi Russia	

Other Conferences

12 in Russia, 6 in Japan, 5 in Italy and many sessions at various society conferences

Books

Proceedings of the ICCF (11 volumes)
Beaudette "Excess Heat & Why Cold Fusion Research Prevailed"
Krivit and Winocur "The Rebirth of Cold Fusion"
Rothwell "Cold Fusion and the Future"
and several others

Useful Web Sites

lenr-canr.org	Library of papers on LENR**
newenergytimes.com	Online Magazine
theworld.com/~mica/cftsci.html	Diverse useful information

**Reviews by Ed Storms

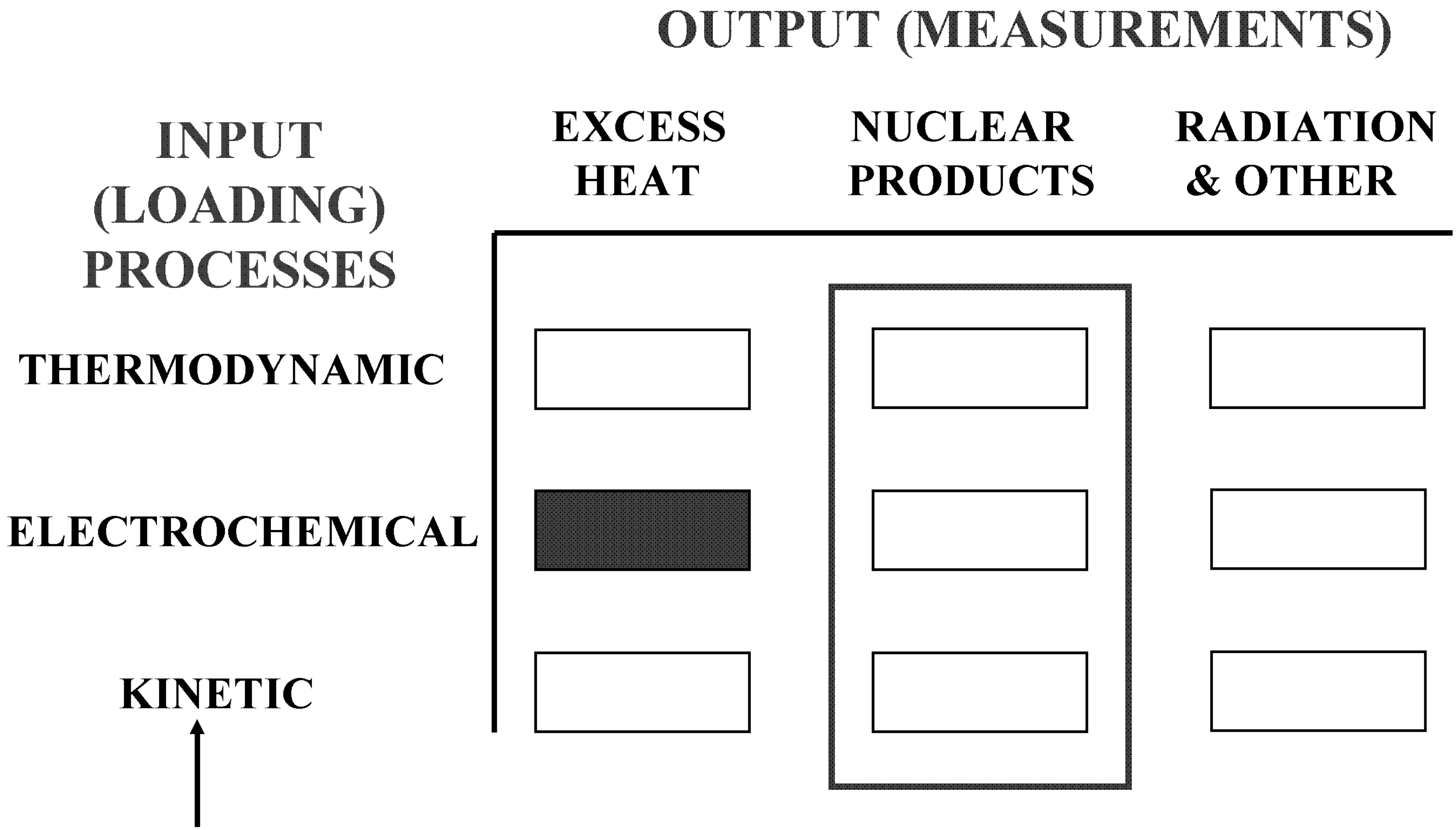
Japan CF Research Society

wwwcf.elc.iwate-u.ac.jp/jcf/indexe.html

International Society for Condensed Matter Nuclear Science

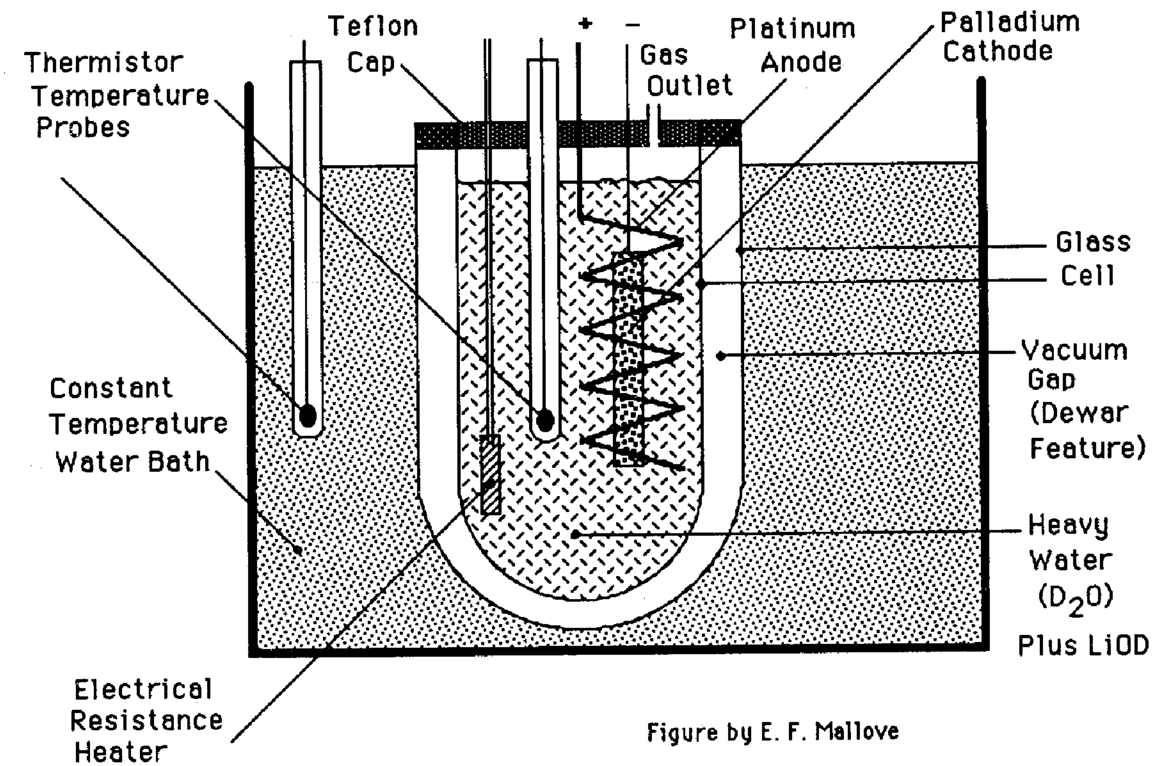
iscmns.org

Input-Output Organization for LENR Experiments



Includes SonoFusion but not Bubble Fusion, which involves high temperatures

Electrochemical Loading & Heat Measurements



CELL DESIGN: TYPE, OPEN or CLOSED,…

CALORIMETER: HEAT or MASS FLOW, CALIBRATION, …..

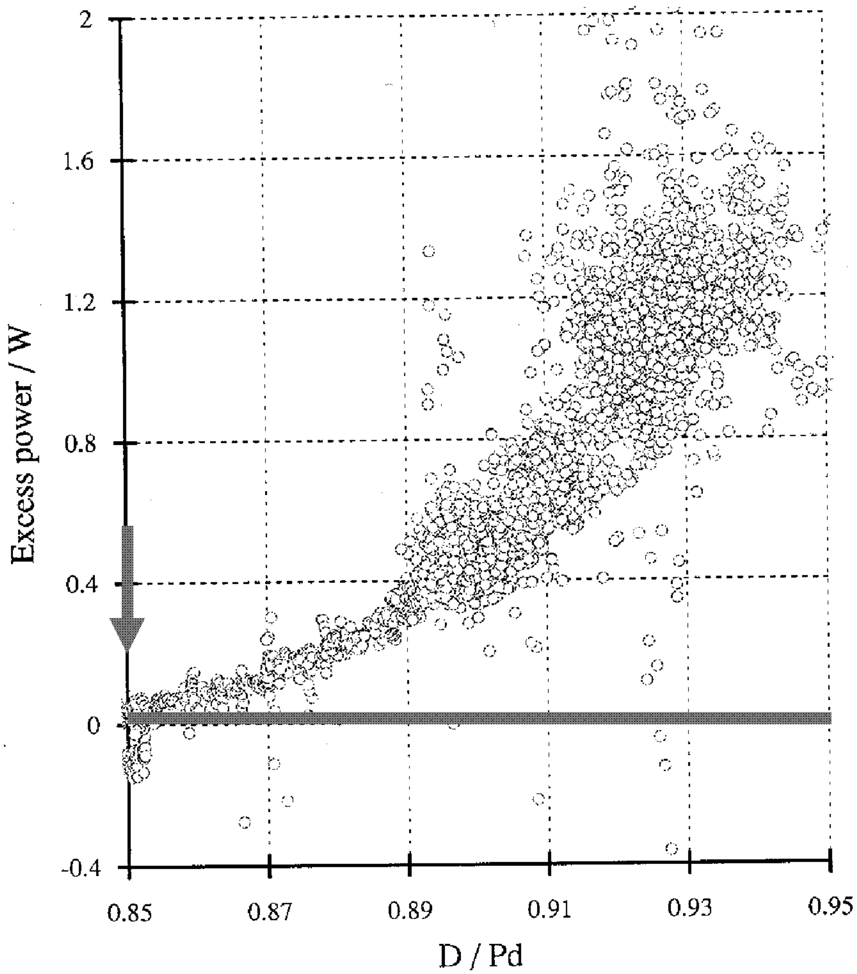
ELECTROLYTE: D_2O or H_2O, BASIC or ACIDIC, SOLUTE, ….

MATERIALS: COMPOSITION, STRUCTURE, GEOMETRY, …

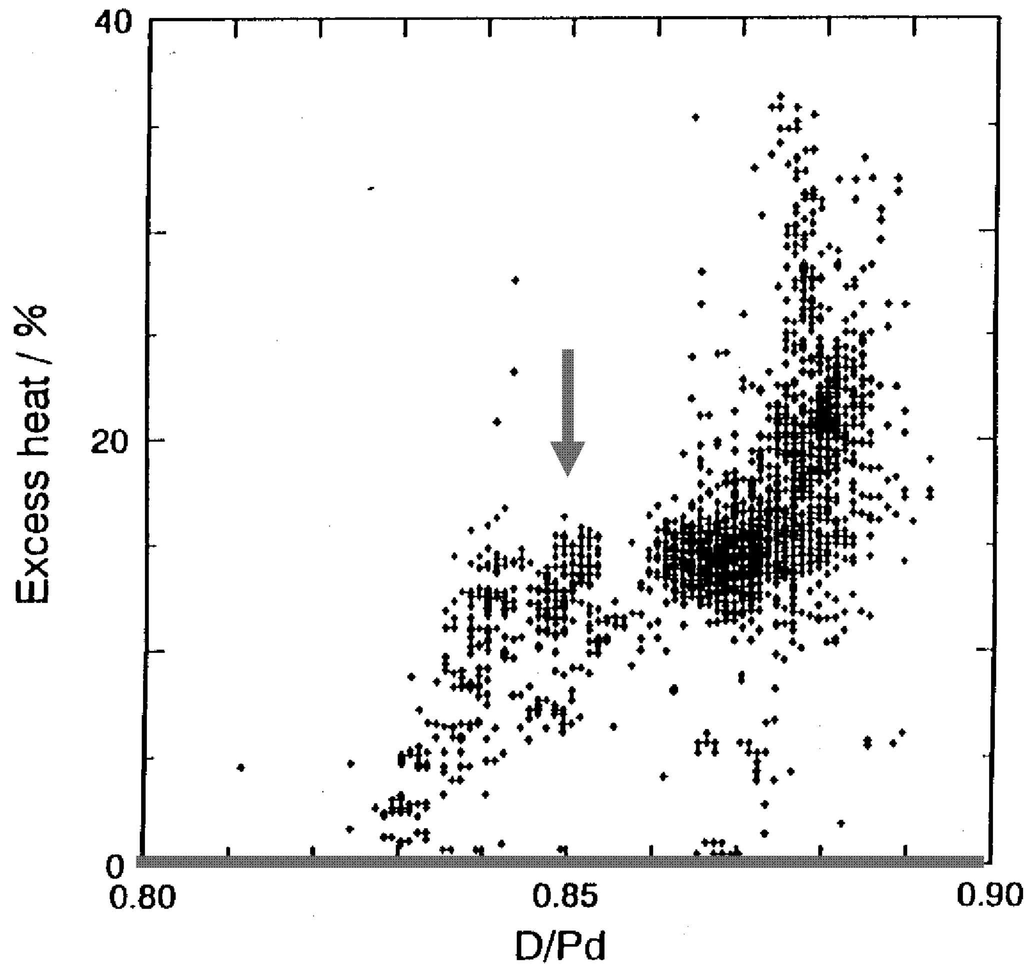
ANALYSES: CHEMICAL & DATA

OTHER FACTORS: DURATION OF EXPTS, RECOMBINATION….

Excess Heat Depends on the Loading



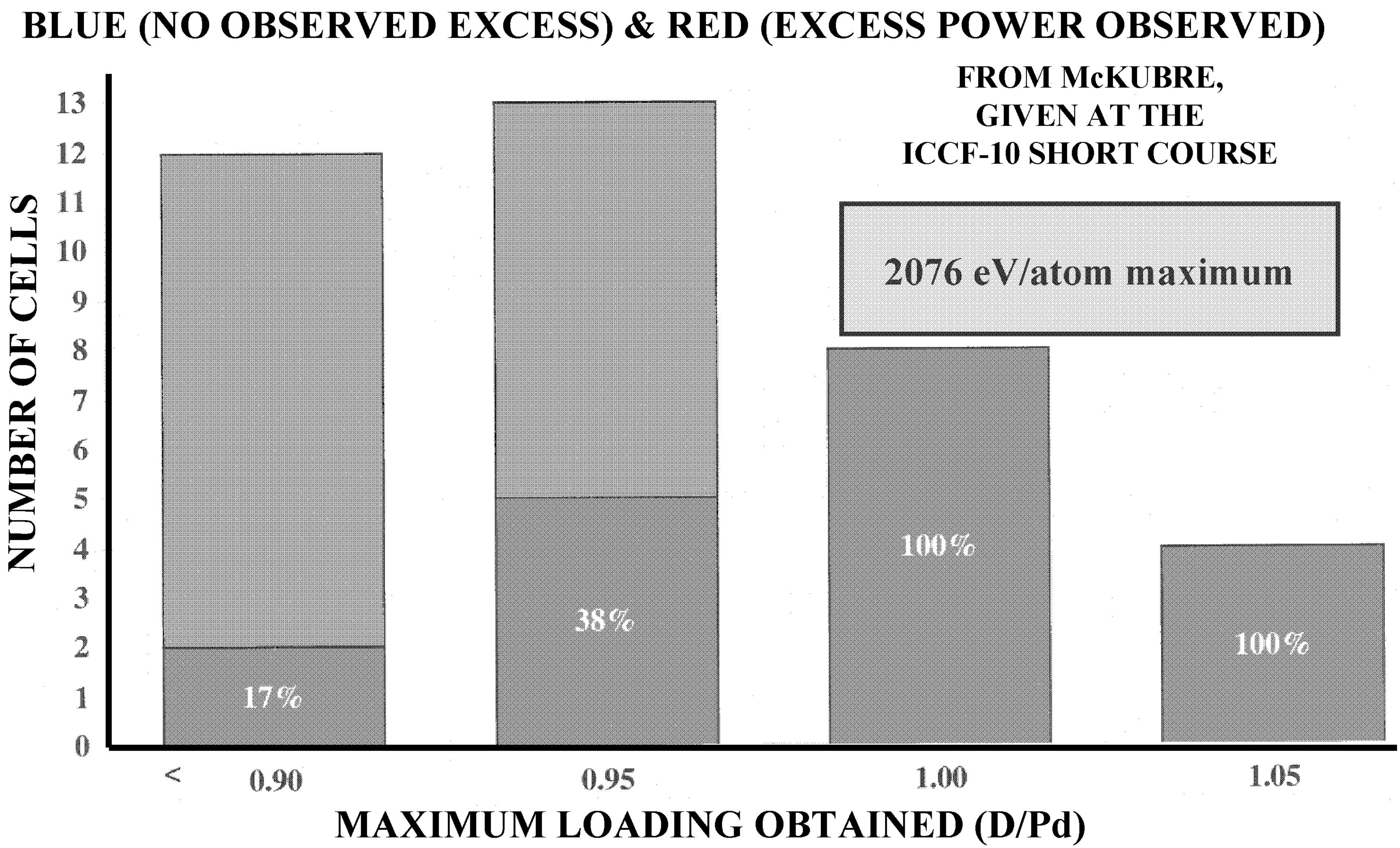
McKubre et al



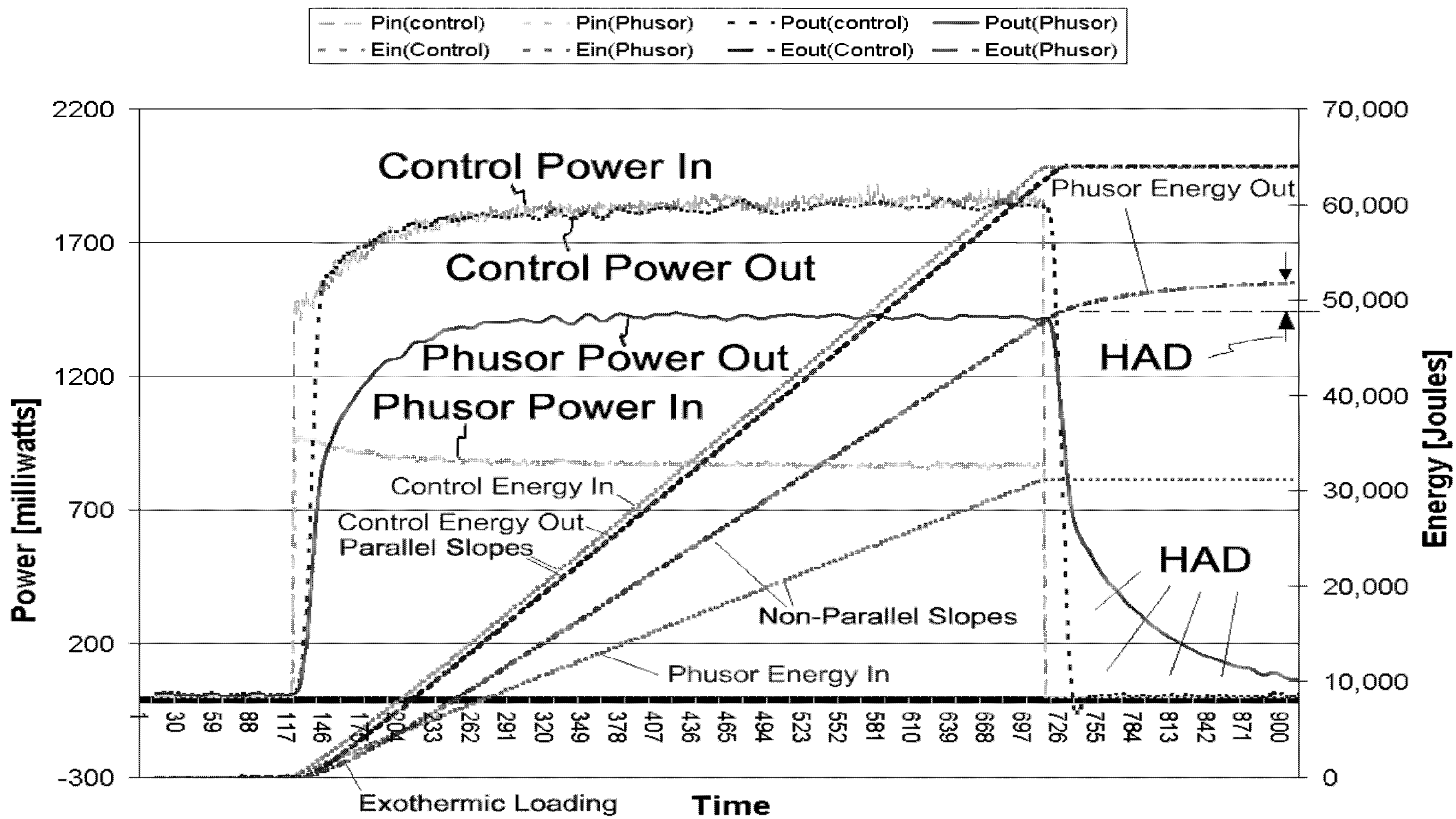
Kunimatsu et al

$P_{XS} \sim [X - X_O]^2$ where $X = D/Pd$

SRI did 100K hours of calorimetry & found: Excess Heat Depends On Level Of Loading

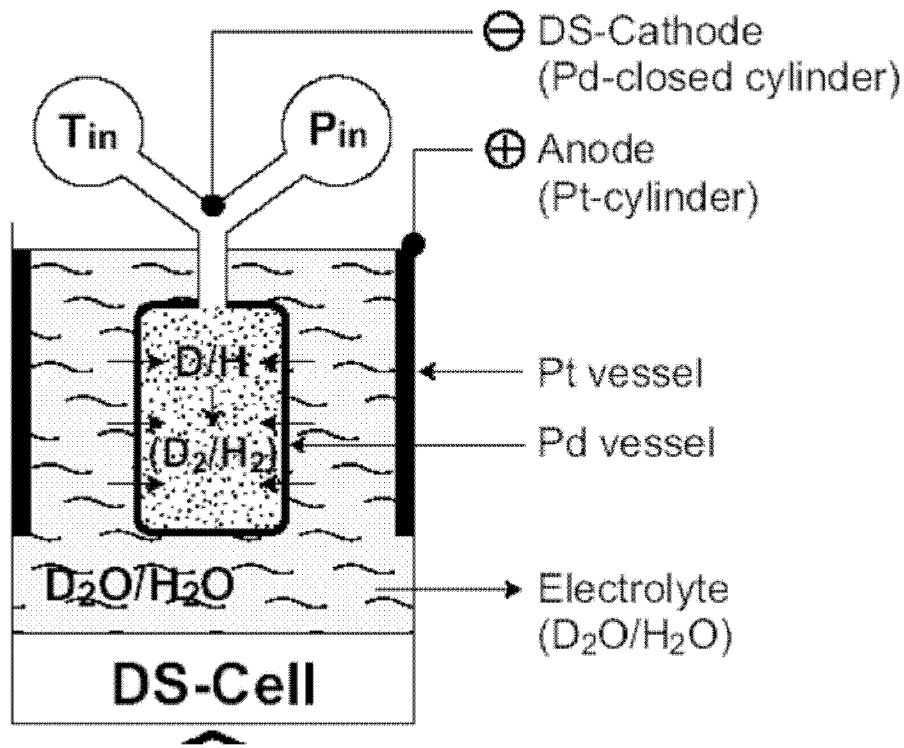


Determination of Excess Thermal Power using Dual Ohmic Controls



M. Swartz and G. Verner, Dual Ohmic Controls Improve Understanding of "Heat after Death", Transactions, American Nuclear Society, Vol. 93, 891-892 (2005).

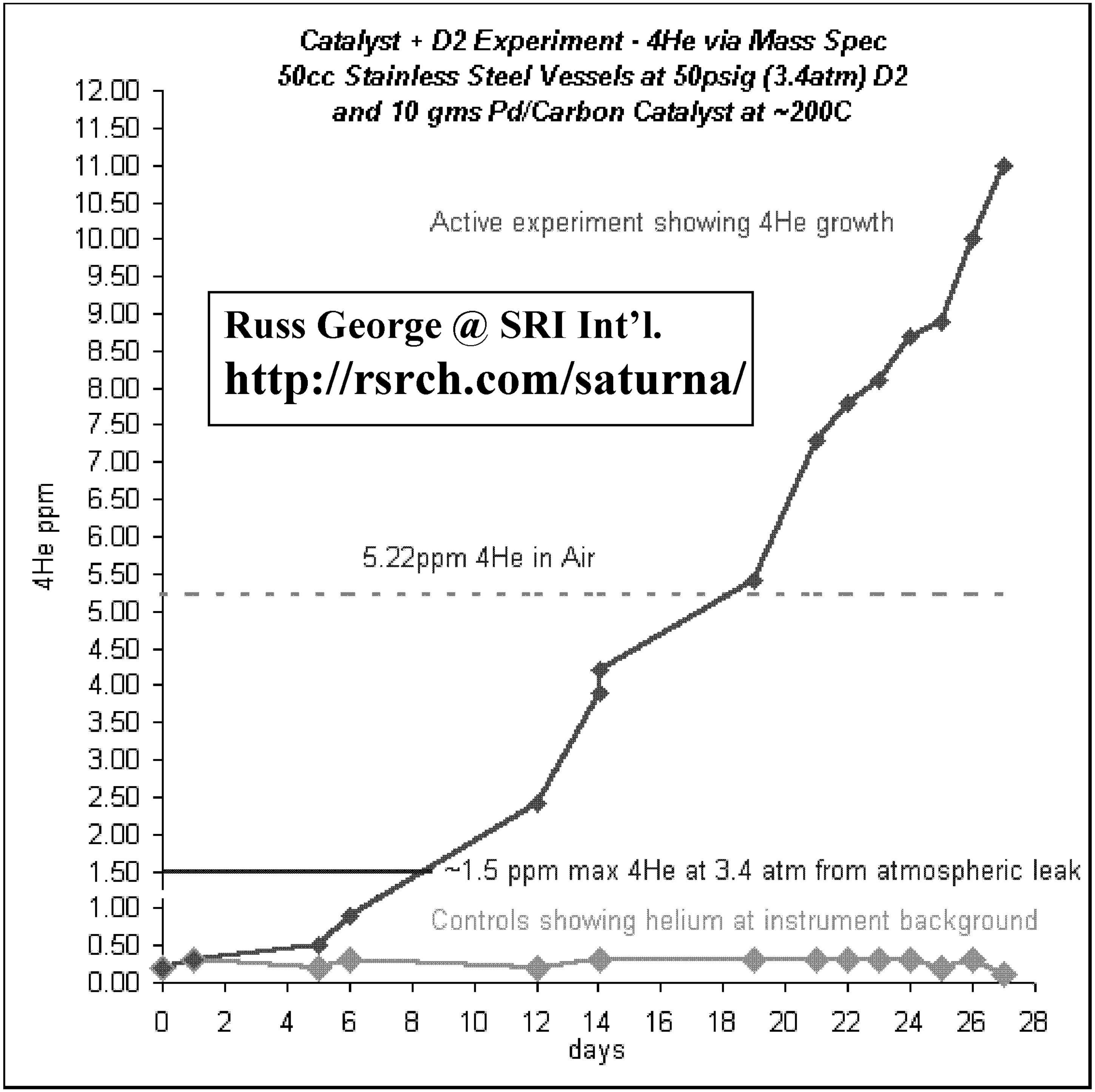
Arata-Zhang Double Structure Cathode



Noteworthy Features and Results:

The cathode structure and Nano-crystalline Pd powder

Heat and helium generation and Odd He-3 to He-4 ratios


Catalyst + D2 Experiment - 4He via Mass Spec
50cc Stainless Steel Vessels at 50psig (3.4atm) D2
and 10 gms Pd/Carbon Catalyst at ~200C
Active experiment showing 4He growth
Russ George @ SRI Int'l.
http://rsrch.com/saturna/
5.22ppm 4He in Air
~1.5 ppm max 4He at 3.4 atm from atmospheric leak
Controls showing helium at instrument background
4He ppm
days
0.00
0.50
1.00
1.50
2.00
2.50
3.00
3.50
4.00
4.50
5.00
5.50
6.00
6.50
7.00
7.50
8.00
8.50
9.00
9.50
10.00
10.50
11.00
11.50
12.00
0
2
4
6
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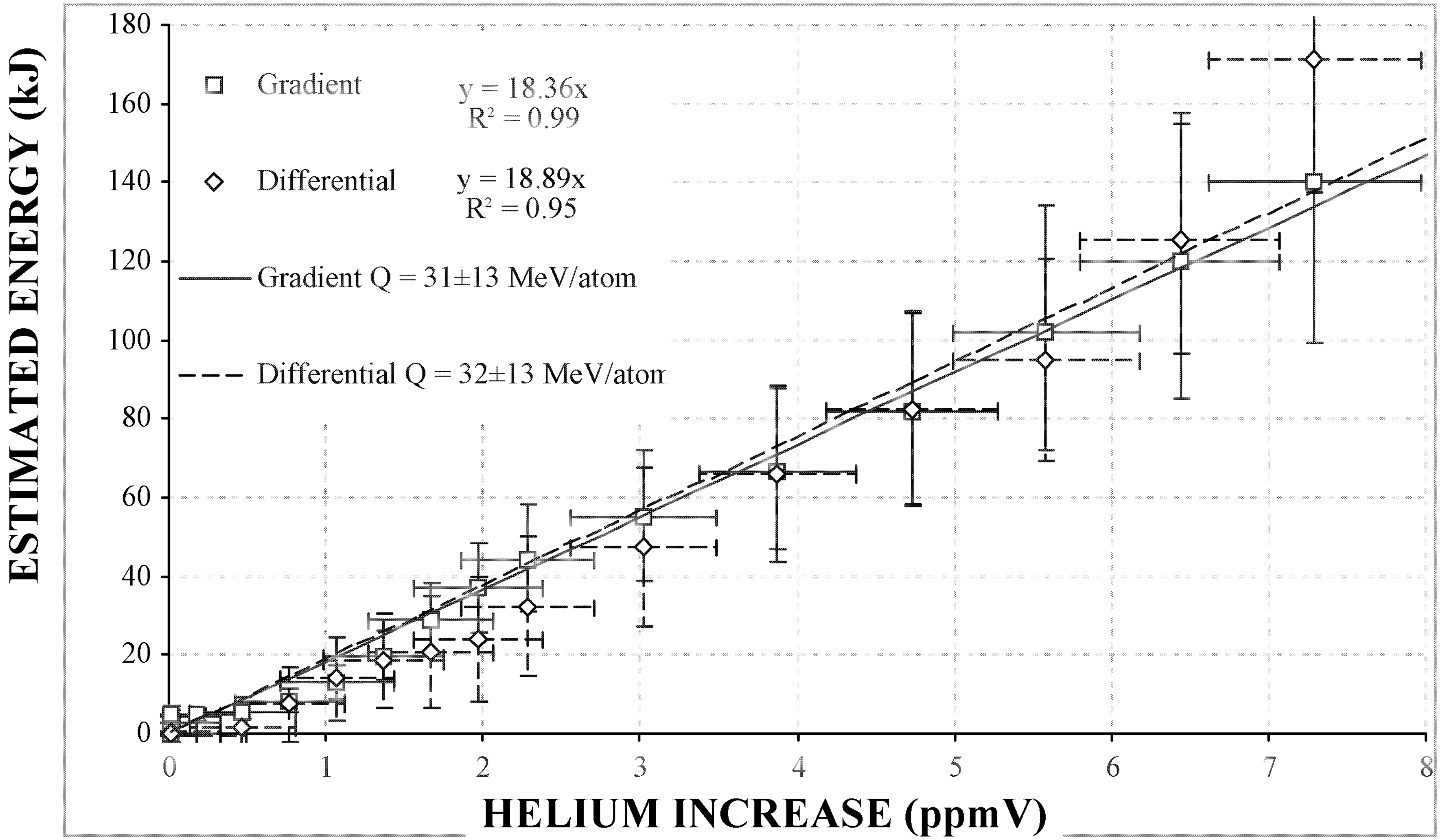
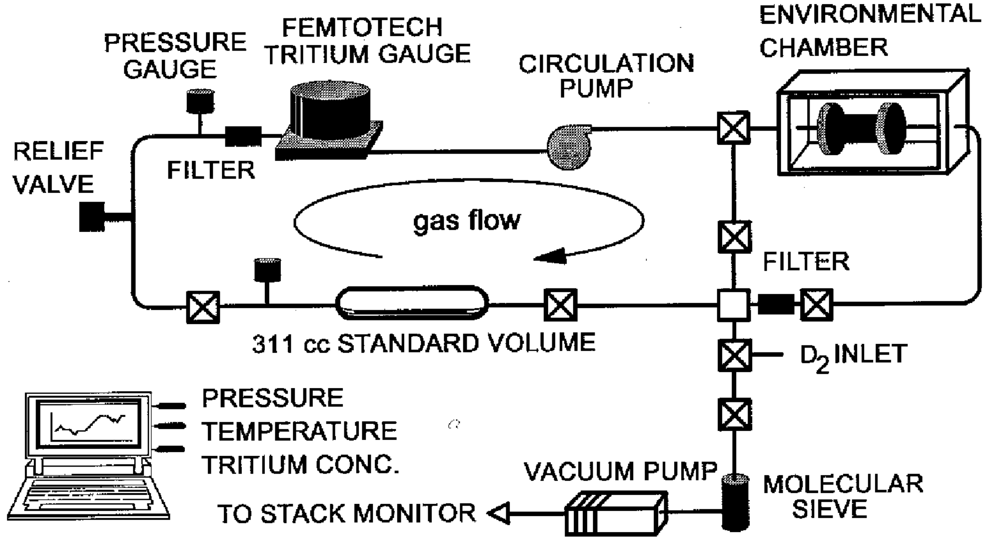
28

Heat-Helium Correlation



McKubre et al, SRI International

Production of Tritium



GOOD INSTRUMENTATION

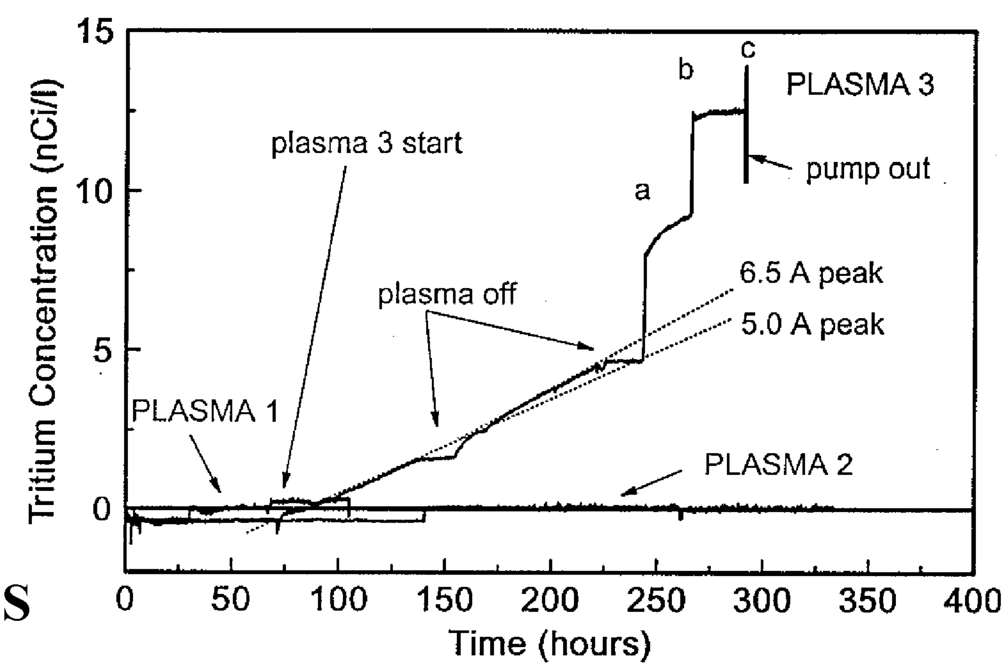
TWO TECHNIQUES
TO MEASURE TRITIUM

BASELINE FOR
SOME EXPERIMENTS

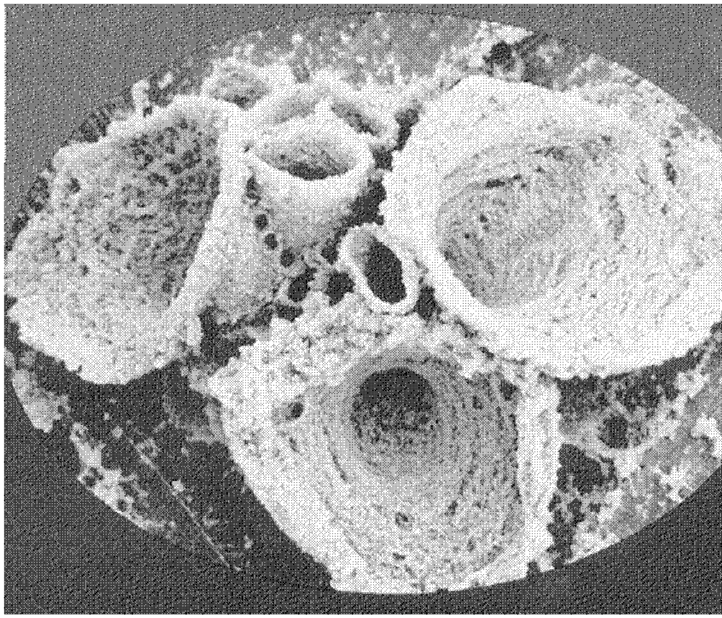
GOOD SIGNAL TO NOISE

RESPONSE TO VARIATIONS

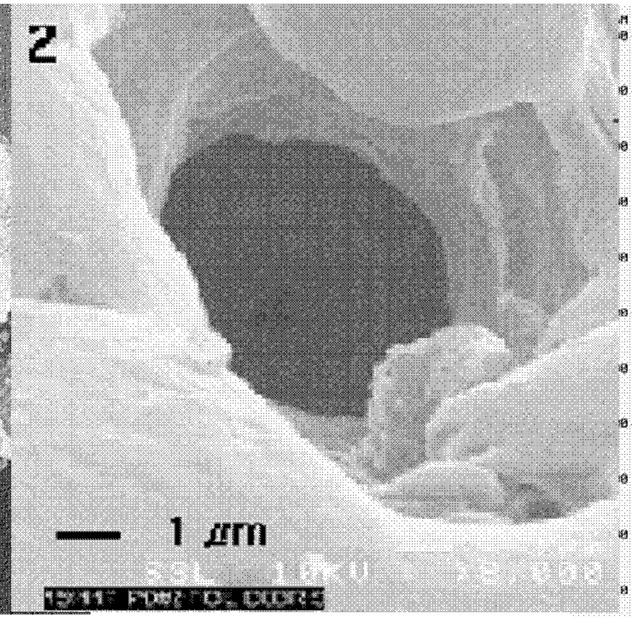
CLAYTOR ET AL @ LOS ALAMOS



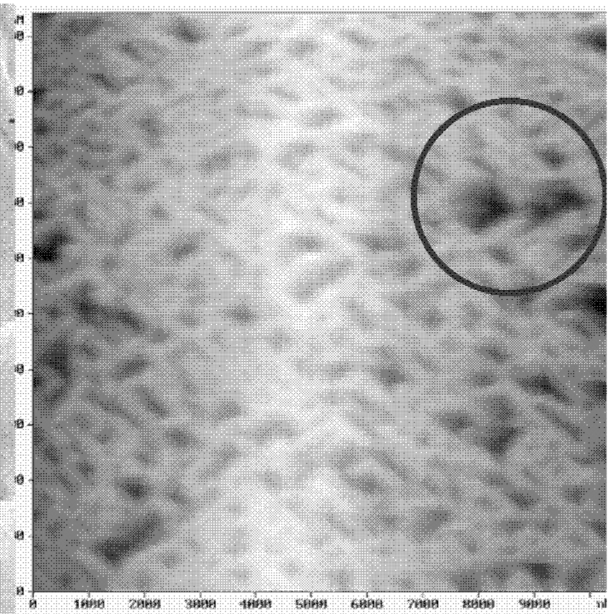
Craters in Cathodes



Mizuno



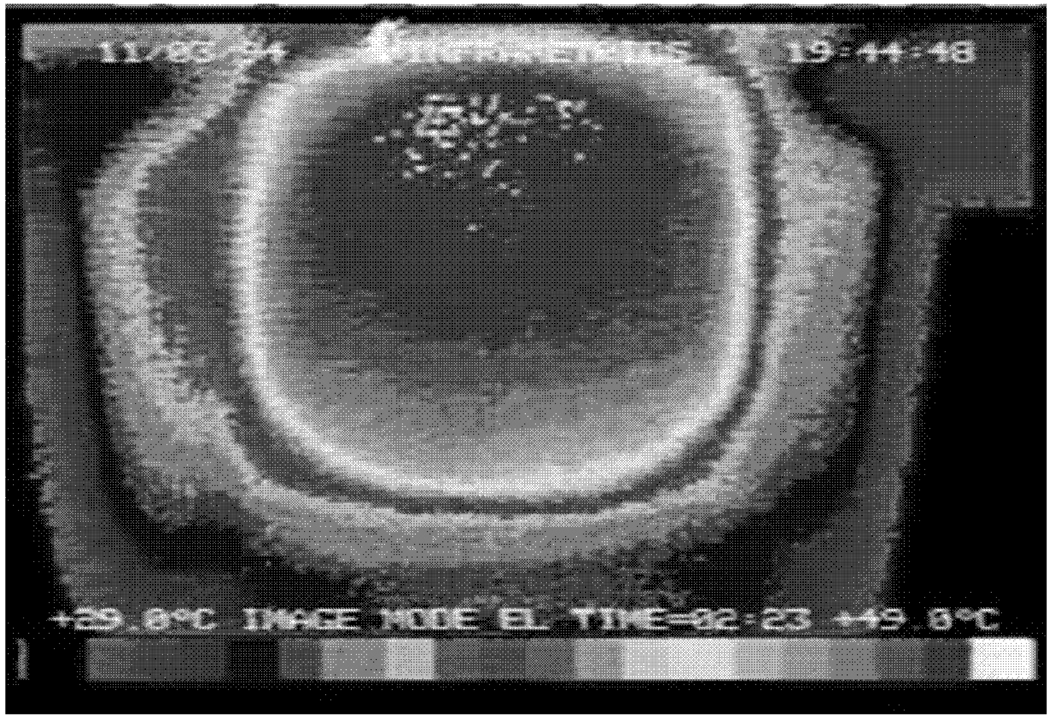
Stringham



Violante

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

Hot Spots on Cathodes



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

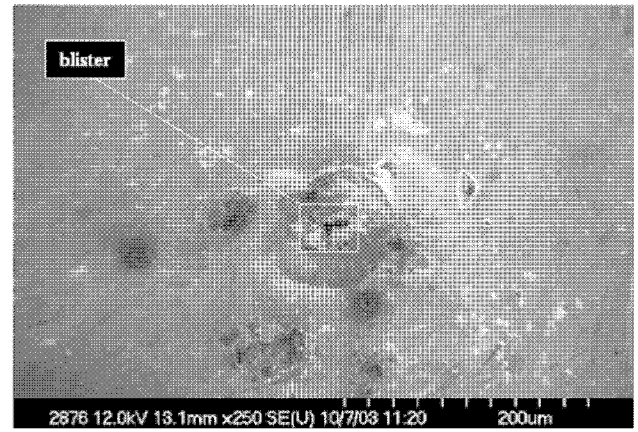
Release of 1 Mev in a cube of Pd 100 nm on a side gives a temperature (T) rise of $\Delta T = 380$ K using 3 k $\Delta T/2$ as the increase in vibrational energy, or $\Delta T = 55$ K using the specific heat for Pd = 26 J/K mole

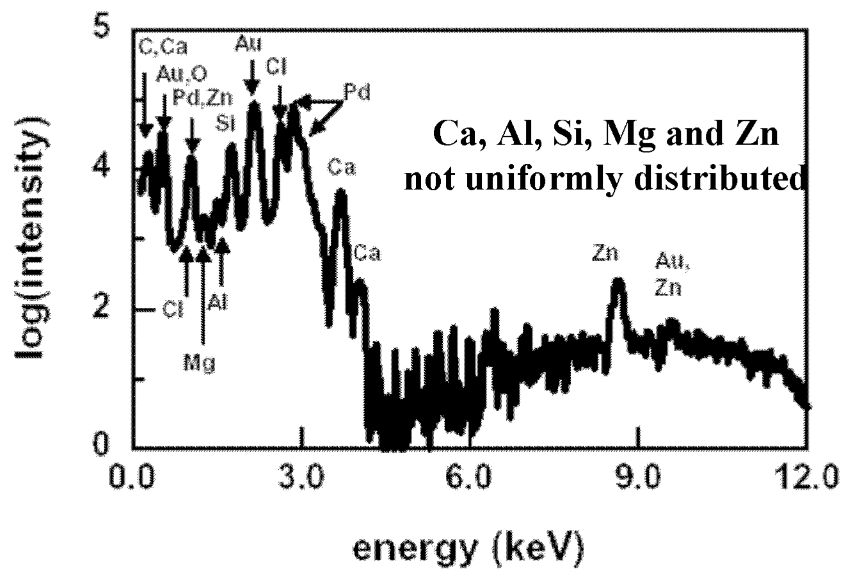
Observations of Unexpected Elements

Labs Reporting Transmutation Results
(Compilation by Miley)

Hokkaido Univ., Japan - Mizuno et al.; Notoya et al.
Mitsubishi Corporation, Japan - Iwamura et al.
Osaka University, Japan - Takahashi et al; Arata et al.
University of Lecce, Italy - Vincenzo et al.
Frascati Laboratory, Italy – De Ninno et al.
SIA "LUTCH", Russia - Karabut et al; Savvatimova et al
Tomsk Polytechnical Univ., 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, USA - Miley et al.
Portland State University, USA – Dash et al.
Texas A&M University, USA - Bockris et al.
Schizuoka University, Japan – Kozima et al.
Iwate University, Japan – Yamada et al.

S. Szpak et al
SPAWAR Systems Center





Types of Evidence for Nuclear Reactions

Large Excess Heat

Production of Helium

Heat-Helium Correlation

Production of Tritium

Observations of Neutrons

Observations of X-Rays

Observations of Gamma-Rays

Craters in Cathodes

Hot Spots on Cathodes

Observations of New Elements

Each of these <u>types</u> of results individually indicates that nuclear reactions occur in diverse experiments at modest temperatures.

Taken together, the case for LENR is robust, far stronger than the evidence for anomalous new effects in the early stages of other important fields of science.

Experimental Summary

Many experiments have been performed by credentialed scientists using diverse approaches, with appropriate equipment and techniques, including calibrations and controls. Although reproducibility is still a problem, anomalous effects have often been recorded. They have been presented and discussed at conferences, and documented in papers that are now widely available.

Excess energies measured by many experimenters are many times the noise in the experimental recordings. Excess energies exceeding 1000 eV / Pd atom in the experiments have been seen by several researchers.

Helium, Tritium, Neutrons, X-Rays and Gamma-rays are not due to chemistry. Elemental transmutations cannot be caused by chemistry.

Some systematics have been observed and confirmed by different investigators.

The database is robust and the observed effects must be due to nuclear reactions !!

Two Major Problems

Imperfect Reproducibility:
Difficult and Contentious Experiments

Lack of a Complete Theory:
Little Substantive Theoretical Guidance

Two Major Needs

Significant Funding:	**DARPA and Angels Now**
Protection of IP:	**US PTO Policy Problem**

Theoretical Summary

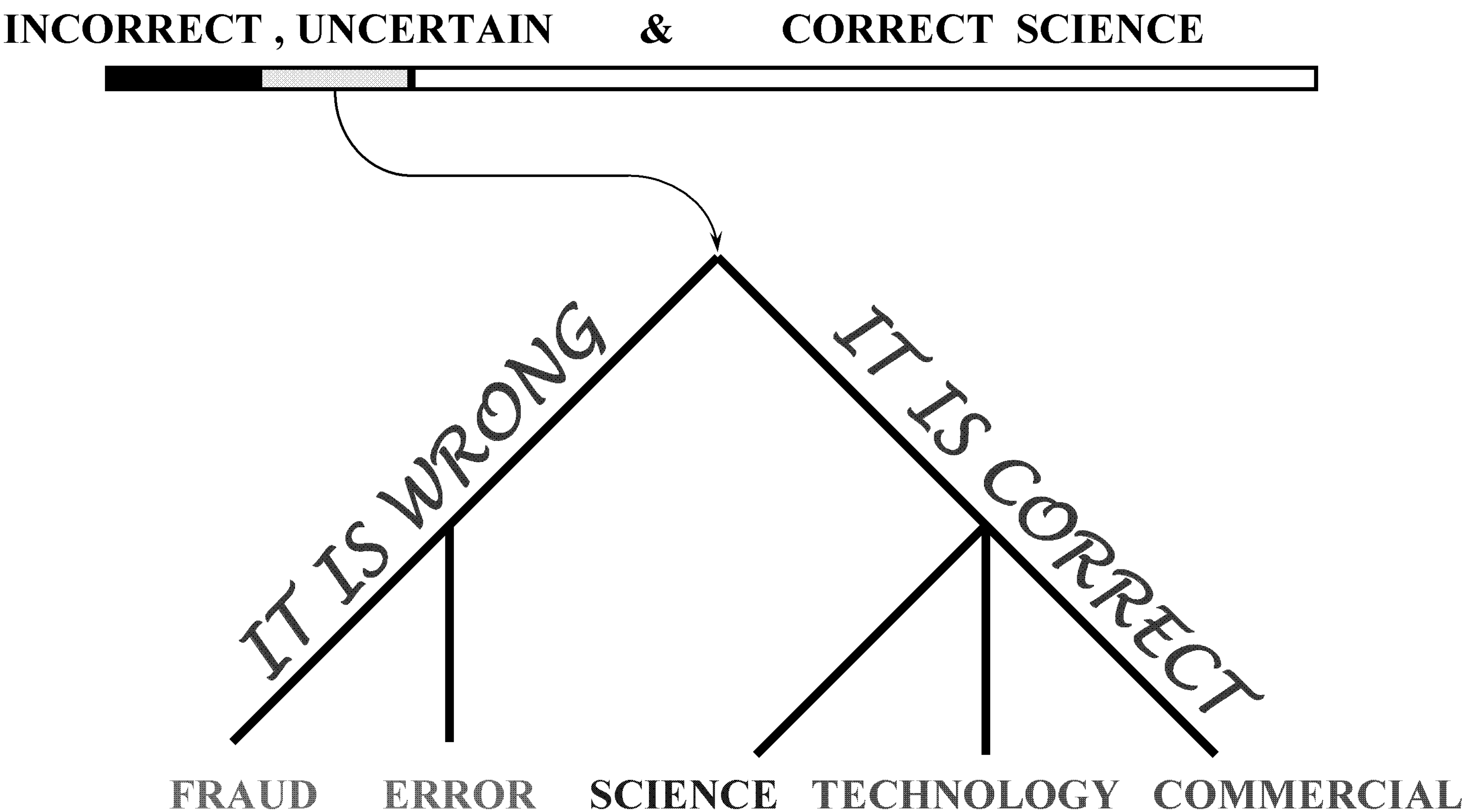
DAUNTING PROBLEMS WITH:

- **Energy Concentration**
- **Timing of Excitation and Decay**

MY QUESTIONS FOR THEORISTS:

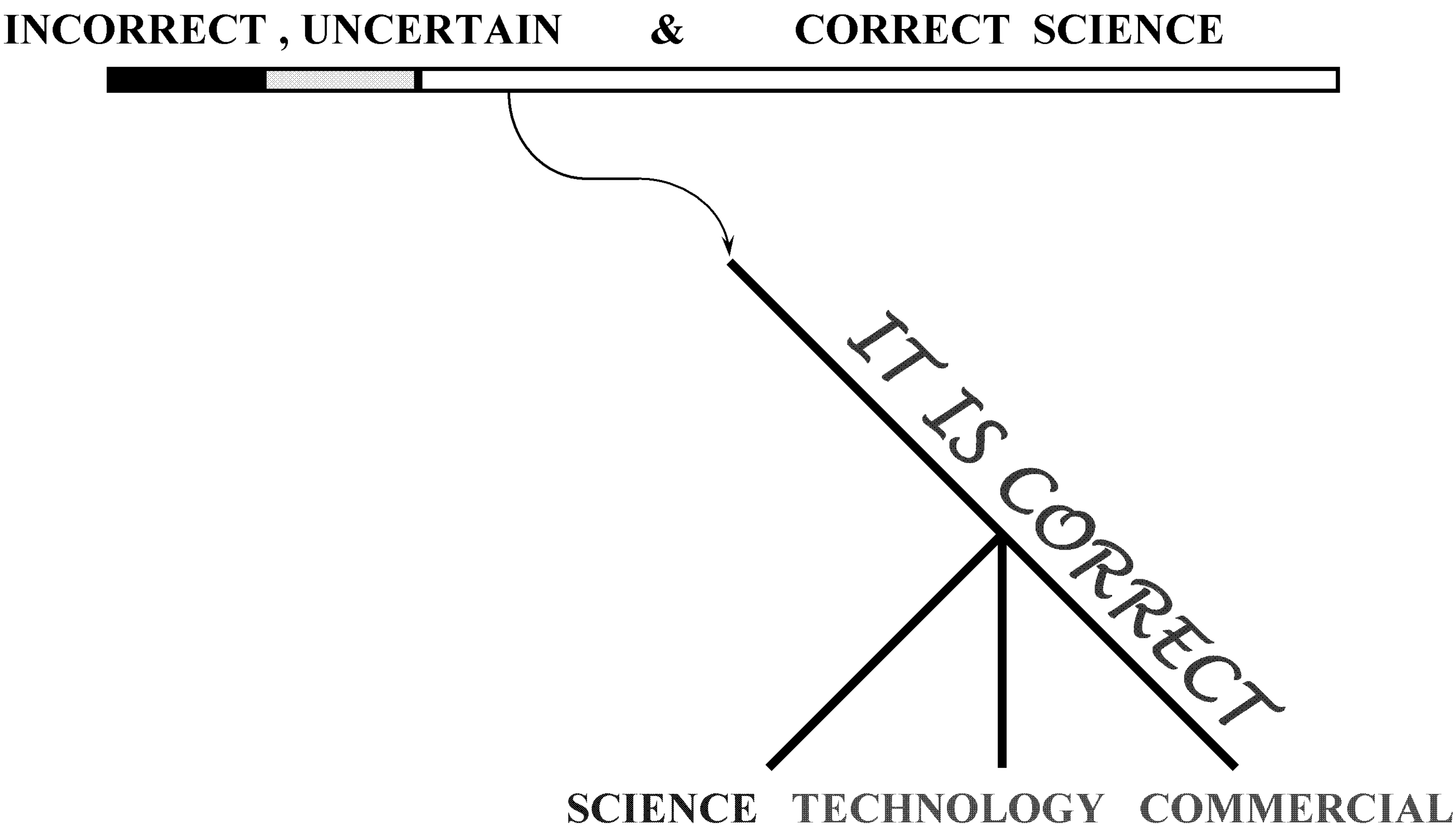
- **What is the Key Concept?**
- **Has it been Written Out for Examination?**
- **Has it been Reduced to Numbers?**
- **Have They Been Compared to Data?**
- **Can the Theory Handle the Variety of Effects Seen?**
- **What Else Does It Predict??**

PROSPECTS



INCORRECT , UNCERTAIN & CORRECT SCIENCE
IT IS WRONG
IT IS CORRECT
FRAUD
ERROR
SCIENCE
TECHNOLOGY
COMMERCIAL

Status !!


INCORRECT , UNCERTAIN & CORRECT SCIENCE
IT IS CORRECT
SCIENCE
TECHNOLOGY
COMMERCIAL

What Should Be Done, and When??

		POTENTIAL ACTIONS			
		NOTHING	EXPERIMENTS	THEORY	ENGINEERING
ASSESSMENT	NOTHING NEW				
	UNCERTAIN NOW				
	NEW SCIENCE				

Program Strategy for LENR

David J. Nagel, Infinite Energy, Issue 69, 2006

Enough is known to give early consideration to possible applications

Engineering Estimates for Applications

Repeat Old Experiments	Perform New Experiments

Instrumentation | **Materials** | **Theory**

Reproducibility remains a major challenge, especially between laboratories

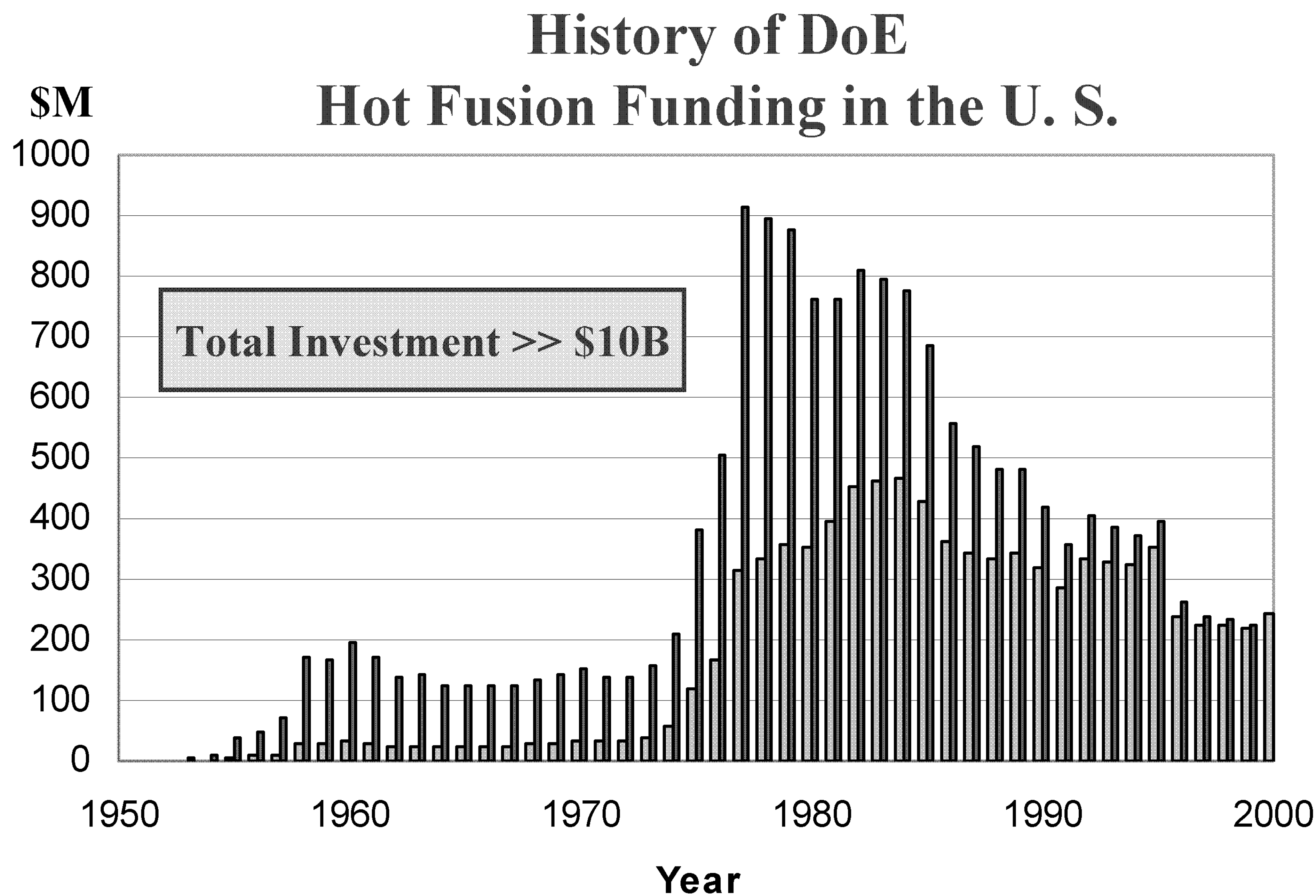
Vary equipment, materials and protocols. Do totally new experiments.

Improve and integrate instrumentation. Use new types of instrumentation.

Vary important materials characteristics and properties, including their geometries. Analyze for impurities!

Challenge, calculate and test both old and new theories.

At least $10M annually for 5 Years would be an appropriate investment


History of DoE
Hot Fusion Funding in the U. S.
$M
1000
900
800
700
600
500
400
300
200
100
0
Total Investment >> $10B
1950
1960
1970
1980
1990
2000
Year

Cold Fusion Start-Ups in the U. S. and Canada

Company	Location	Principal
Coolescence	Boulder CO	Rick Cantwell
D2Fusion **	Foster City CA	Russ George
First Gate Energies	Kilauea HI	Roger Stringham
Jet Tech., Inc.	Wellesley Hills MA	Mitchell Swartz
Lattice Energy, LLC.	Chicago IL	Lewis Larsen
L.E.N.R., Inc.	Elkhart IN	David Cappelletti
Monti America Corp.	Agassiz, BC, Canada	Eleonora Anderson
Spindletop Corp.	Palo Alto CA	Michael McKubre & Peter Hagelstein
Eneco	Salt Lake UT	Harold Brown
MARI	Ann Arbor MI	Frederick Mayer

**D2Fusion was acquired by the Canadian company Solar Energy Ltd

Significant interest by large companies

The Field of LENR has Diverse Needs

Science	Technology	Engineering

Intellectual Property

Programmatics   Investments

Public Relations   Politics

The Field of LENR has Incredible Promise

Nuclear energy sources that are distributed and safe

Production of elemental materials

Augmented or new weapons ?????