# *Triggered Energy Release From Palladium Deuteride*

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***Presented at ICCF15***
***Rome***
***October 7, 2009***

# *Outline*

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- Research Plan
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- Cryogenic Calorimeter and Reaction Stimulation
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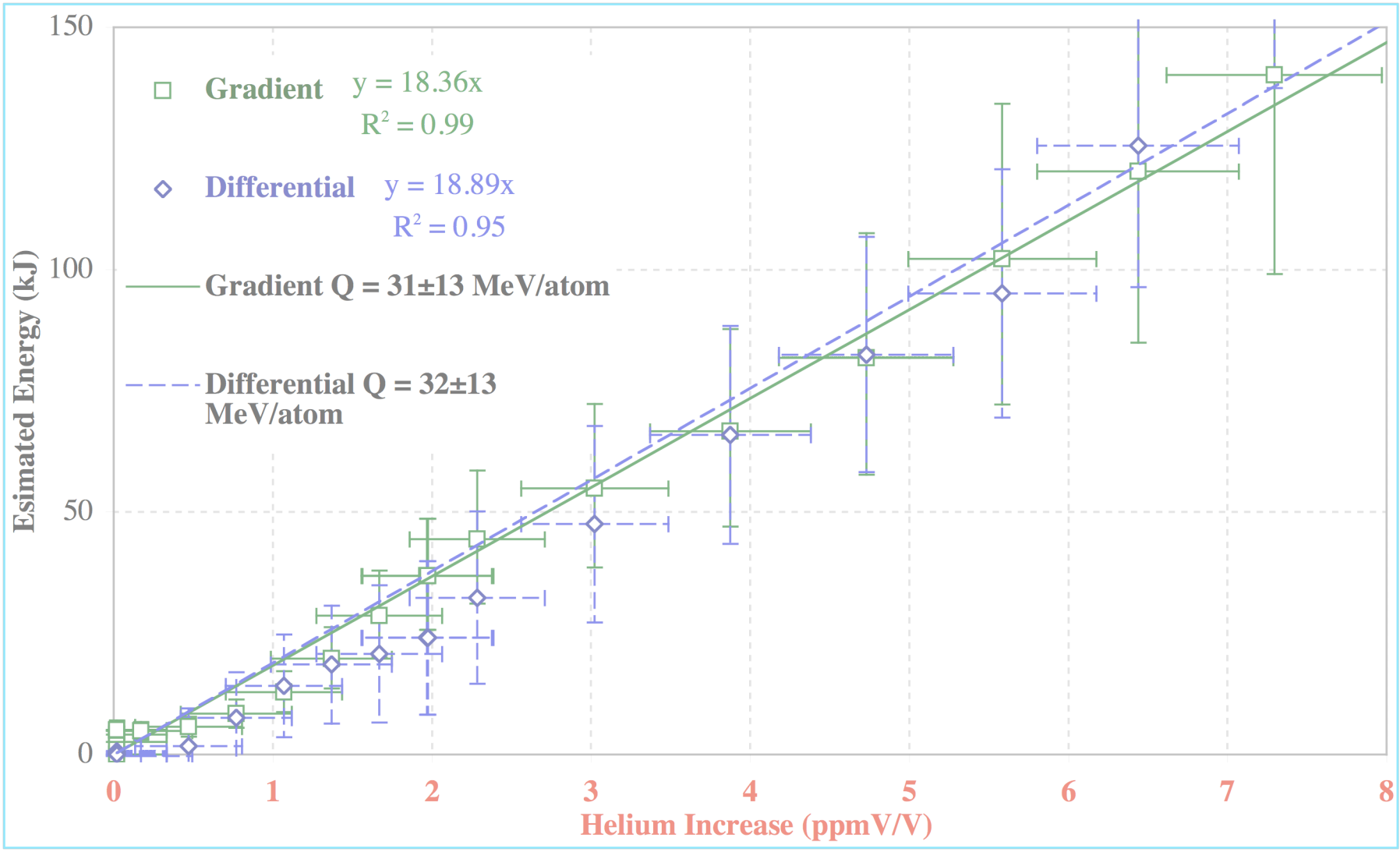
## *Research Objective*

- To understand what limits the rate of energy release (power) from the FPE in intentionally destructive experiments employing small, safe samples of ~1:1 PdD in a novel low temperature calorimeter.
- To search for evidence of potential products of nuclear reaction.
- To understand underlying reaction processes and mechanisms (theory).
- To generate, measure, and understand nuclear-level heat effects:
  - in small, safe samples of ~1:1 PdD
  - electrochemically formed from fine, short $PdD_x$ wires with various known He content
  - stimulated electrically and/or by laser pulse
  - measure heat in a novel calorimeter
  - verify nuclear effects by analyzing the wires for changes in their $^3He$ and $^4He$ content and ratio.

# *Background: Observations*

- Effect Evidenced on numerous occasions (*>70 at SRI*)
- Up to 90σ observation of excess power effect
- $P_{XS}$ >1kW/cm$^3$ (transient)
- $P_{XS}$ ~150W/cm$^2$ (1 month)
- $P_{Out}/P_{In}$ > 50
- $E_{Out}/E_{In}$ > 30
- $E_{XS}$ > 100 MJ
- 100 – 10,000 eV/ Pd Atom (100's or 1,000's times known chemical effects)
- Positive Temperature Coefficient
- Effect observed up to 650°C
- Effect has been reported after "mild" electrical stimulation at room temperature

# Background: Observation of Energy vs. $^4He$



# Background: Correlations

- Necessary conditions:
  - Maintain High Average D/Pd Ratio (*Loading*)
  - For times >> 20-50 times $\tau_{D/D}$ (*Initiation*)
  - At electrolytic i >250-500mA $cm^{-2}$ (*Activation*)
  - With an imposed D Flux (*Disequilibrium*)

- Heat correlated with:
  - electrochemical current or current density
  - D/Pd loading or
  - $V_{ref.}$ surface potential
  - Pd metallurgy
  - Laser stimulus

- For 1mm dia. Pd wire cathodes:

$$P_{xs} = M\,(x-x°)^2\,(i-i°)\,|i_D|$$

$x = D/Pd$, $x° \sim 0.875$, $i° = 50\text{-}400 mA\ cm^{-2}$, $i_D = 2\text{-}20\ mA\ cm^{-2}$, $t° > 20\ \tau_{D/D}$

# *Research Plan*

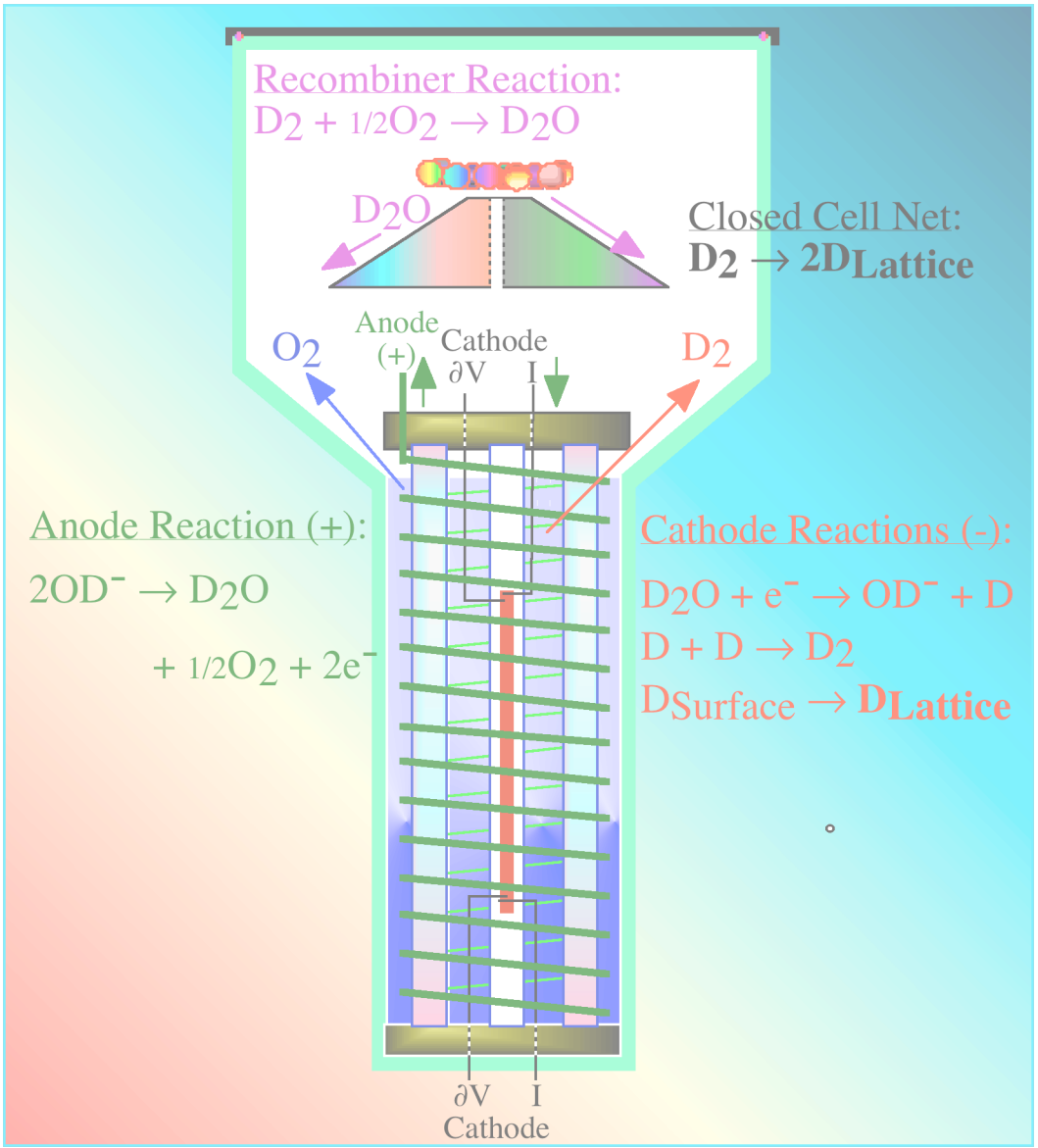
- Electrode Preparation:
  - $^4$He implantation or in-diffusion
  - **Electrochemical loading**
  - **Surface barrier sealing (transport to calorimeter)**

- Reaction Triggering:
  - **Axial current (dc,** pulse, sine wave**) – $10^5$** to $10^7$ **A cm$^{-2}$**
  - Surface laser
  - Exotic

- Heat Measurement:
  - **Mass displacement at low temperature (LN)**
  - Mass flow at room temperature

- Reaction Products:
  - **Analyze wires and emitted gases for changes in their $^3$He and $^4$He content and ratio**
  - Search for isotope effects
  - Neutrons and Gammas.

# Electrochemical $PdD_x$ Formation




## Loading Cell and Reactions.

Wires:

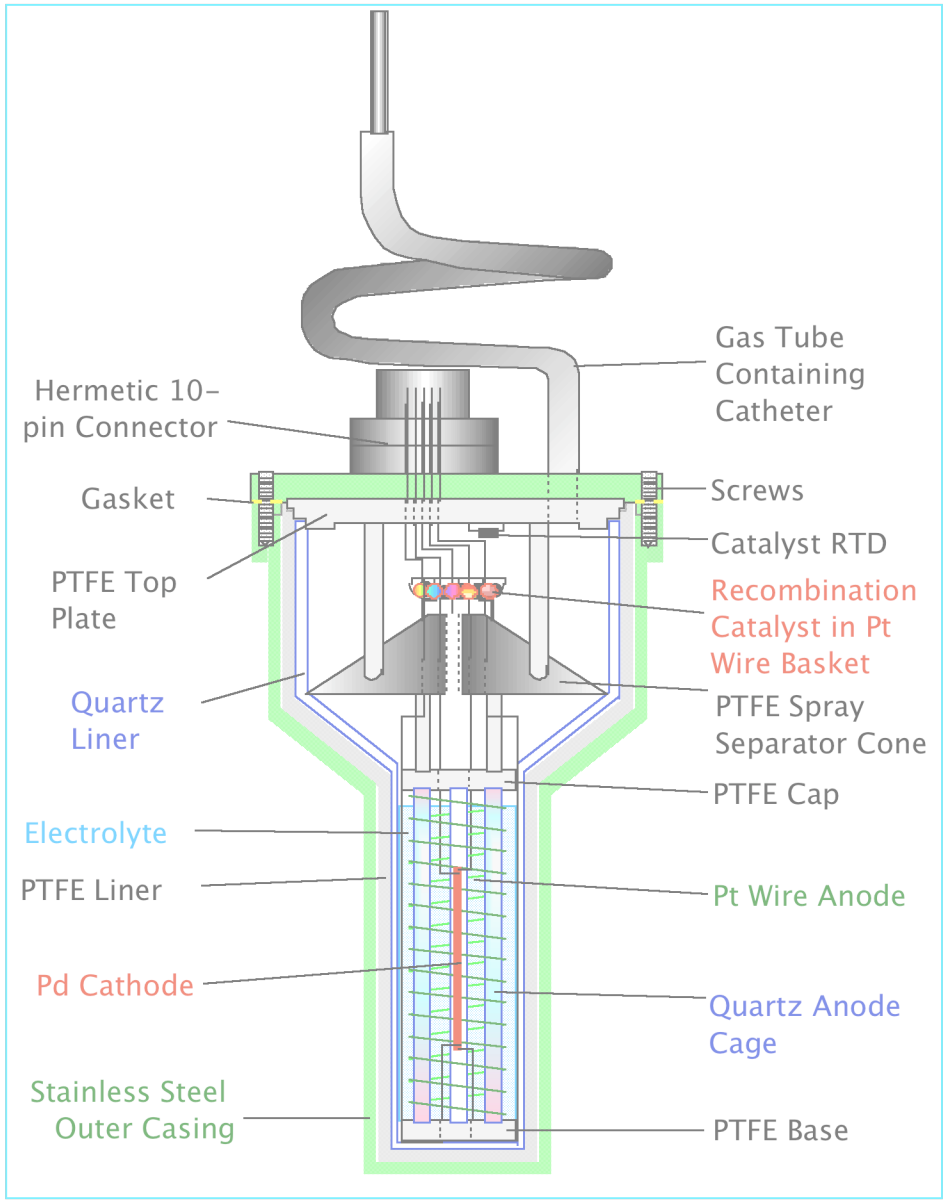
25 – 250 μm in dia.

3 – 5 cm in length.

LiOD and low temperature $CD_3OD$ (or $CH_3OD$) Electrolytes

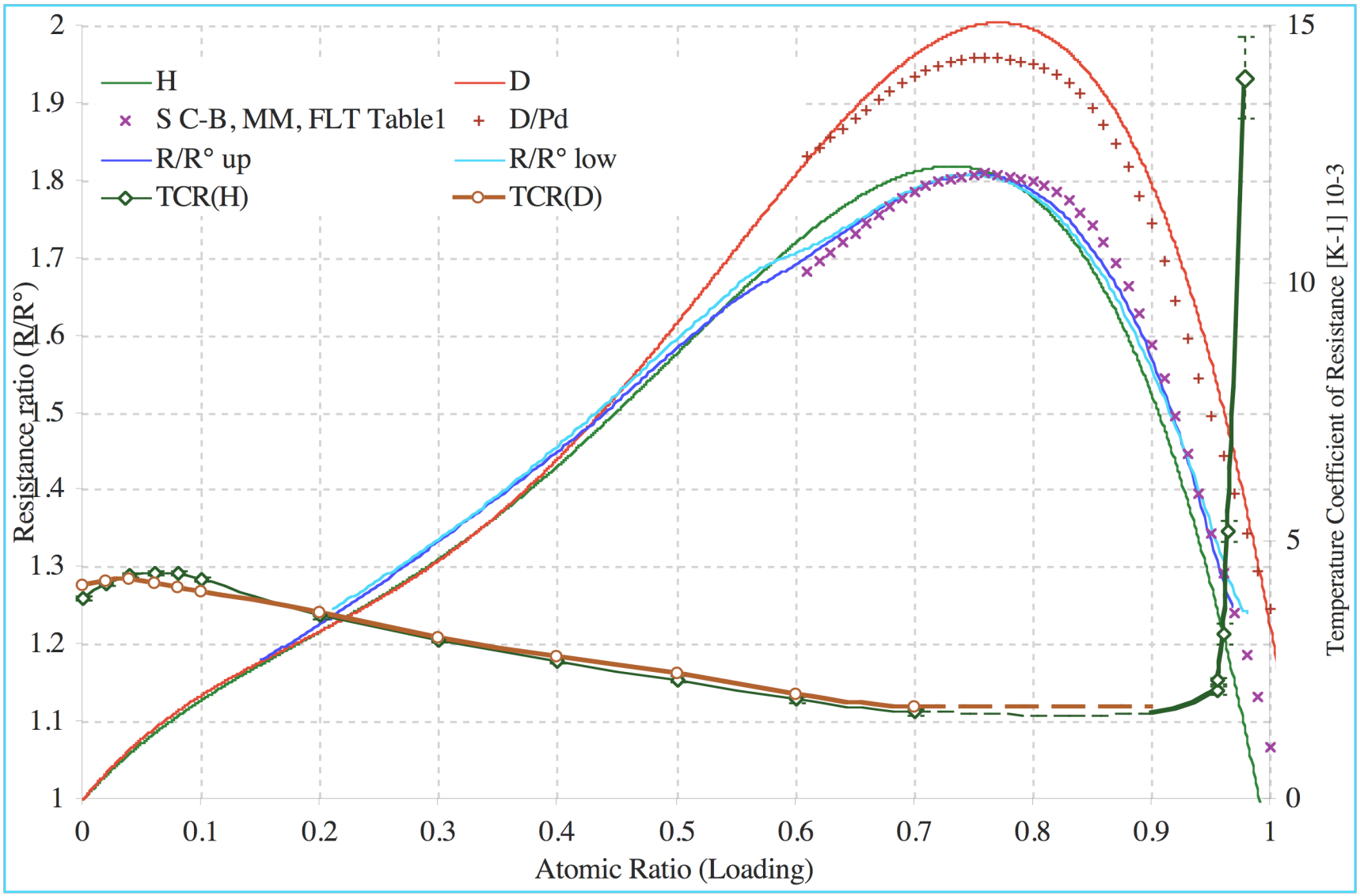
Hg (or Pb) to seal loading

# Electrochemical $PdD_x$ Formation



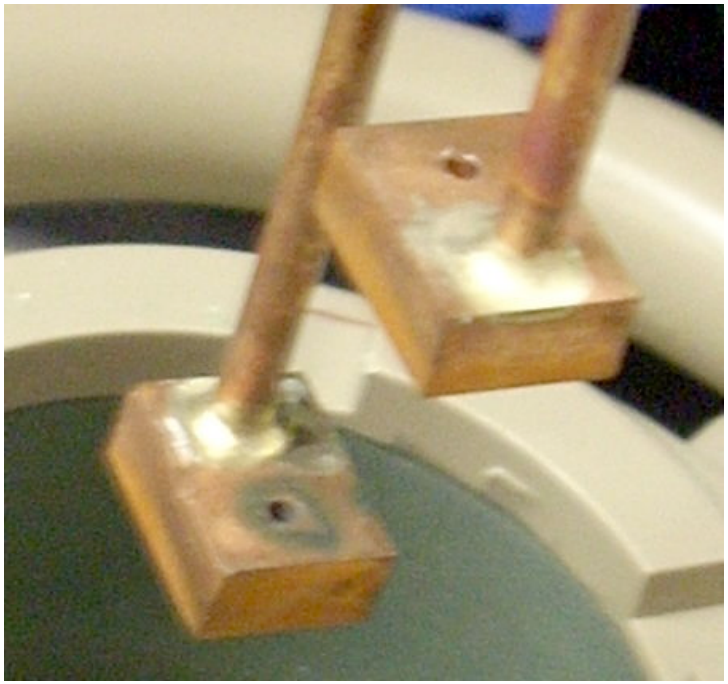

## SRI Degree of Loading (DoL) Cell

# Electrochemical $PdD_x$ Formation
# Loading and Temperature coefficient of Resistance

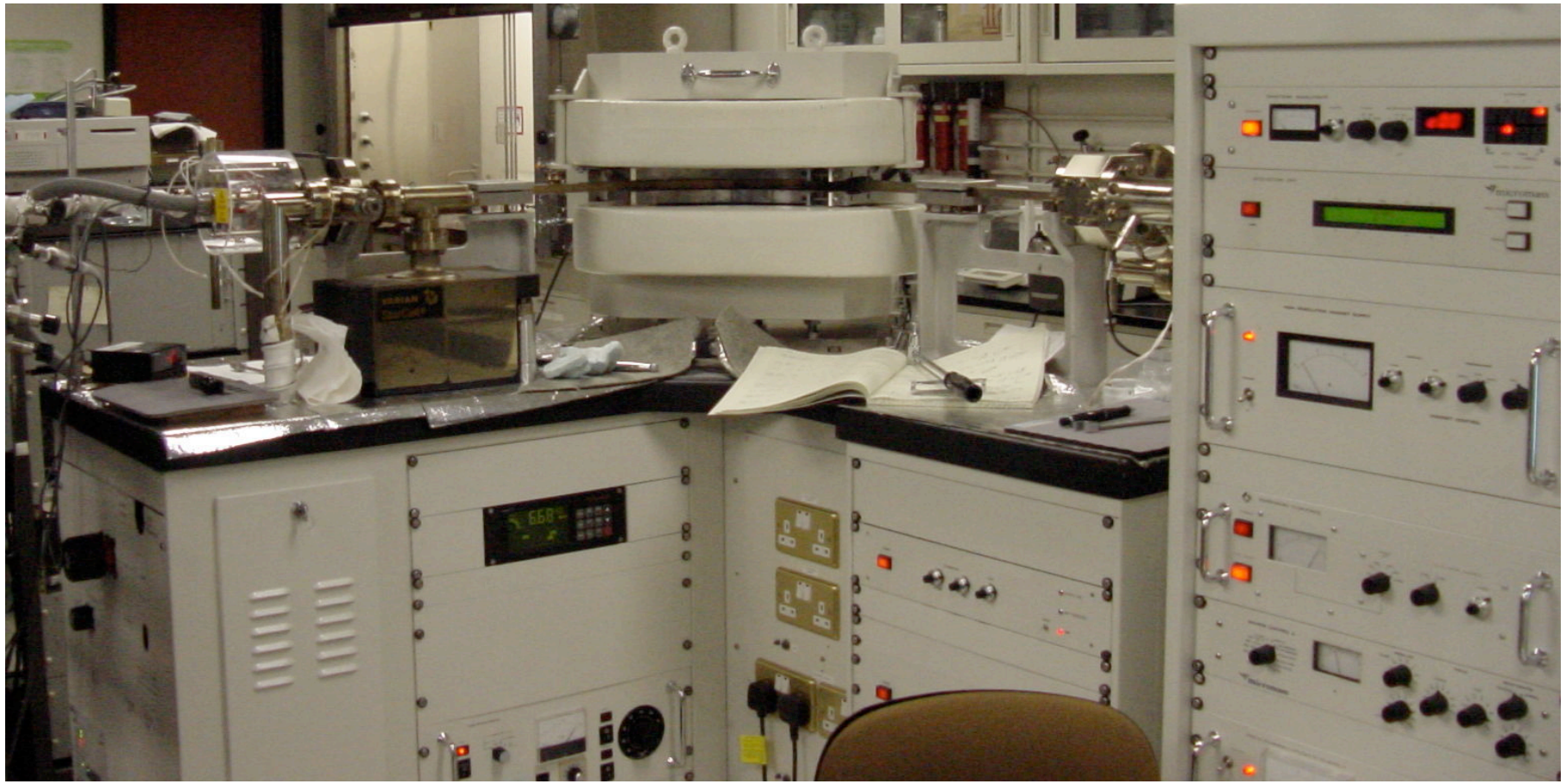


# Cryogenic Nitrogen Calorimeter and Reaction Stimulation

- Hg (or Pb) coated cathodes attached to Current Blocks and dipped in liquid $N_2$
- High current (<=125A) short pulse destructively stimulates $PdD_x$ to initiate reaction
- Measure current, voltage, and total $N_2$ gas evolved
- Laser or EMF/RF Stimulation in later studies

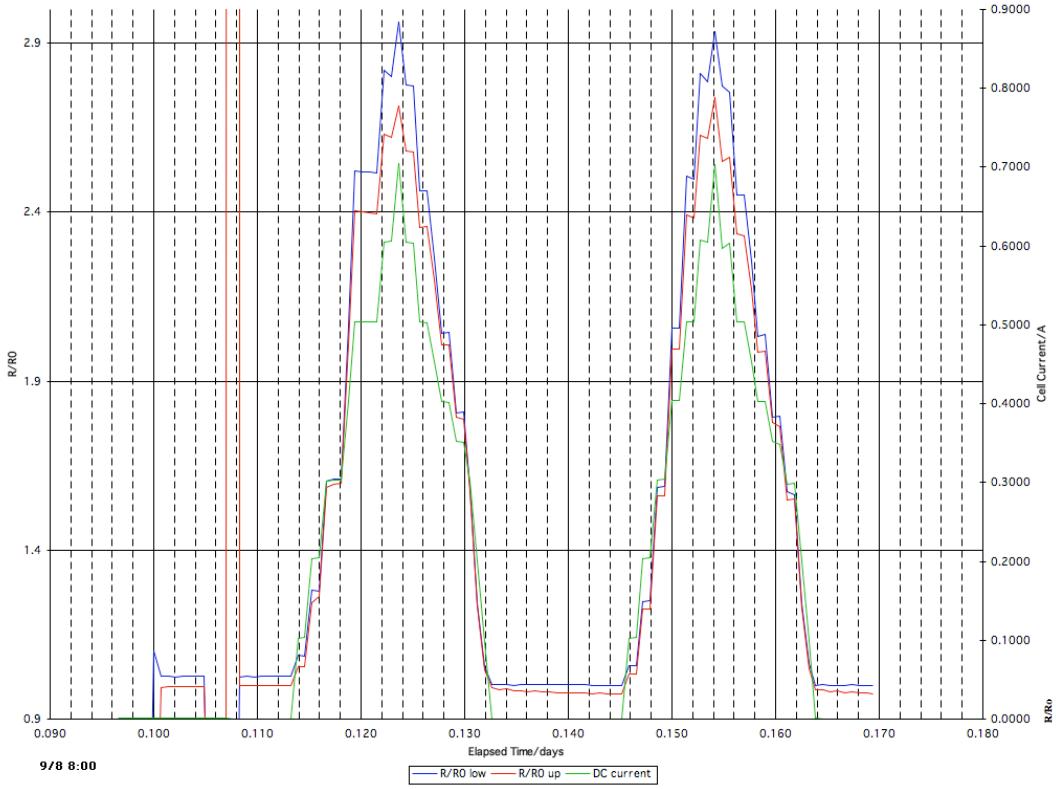


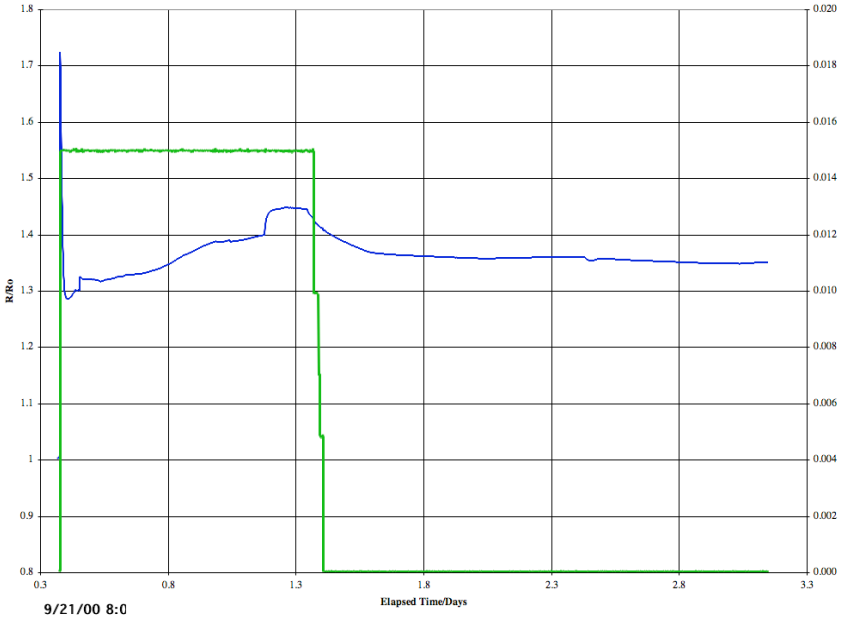
# He Isotopic Ratio Determination
# MicroMass 5400 Noble Gas Mass Spectrometer



77K activated charcoal trap/metal getters for hydrogen isotopes
1400°C inlet for He absorbed in Pd

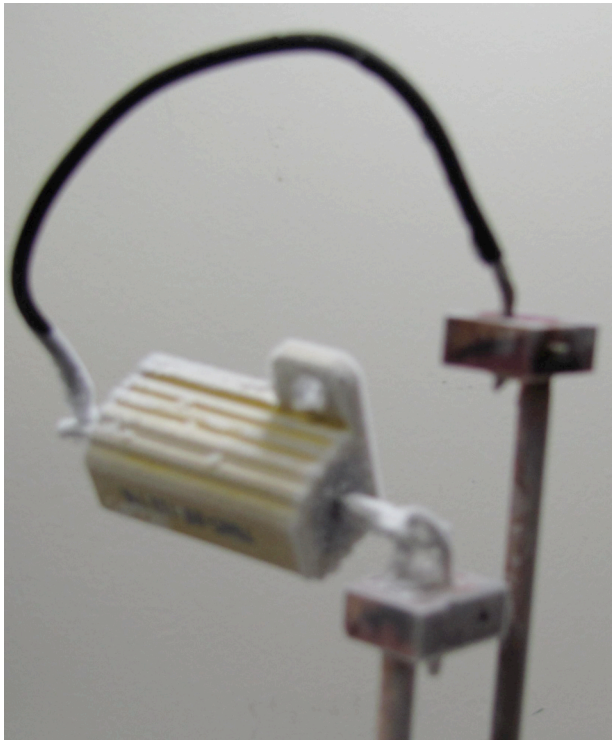
# Preliminary Results: Electrochemical $PdD_x$ Formation In Situ Annealing and Loading Procedure



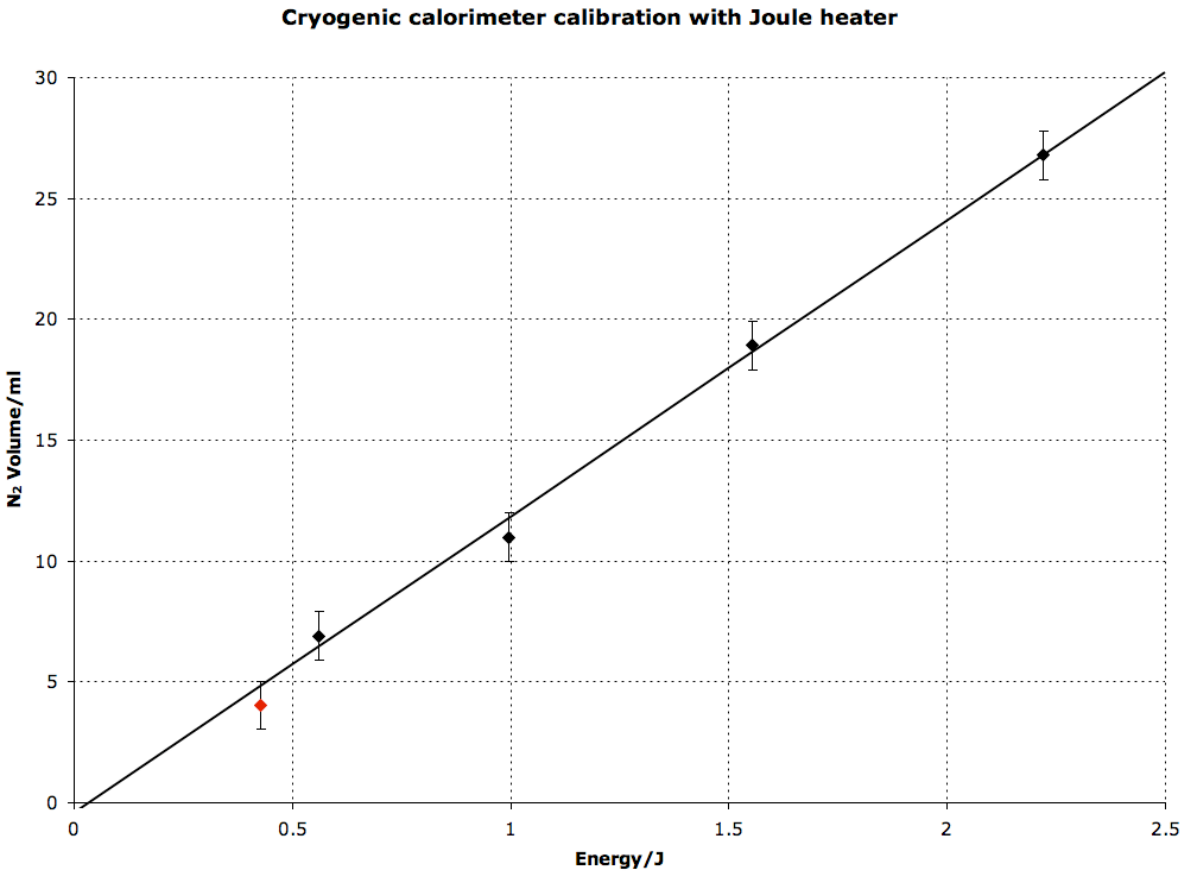




*In situ annealing and high voltage electrochemical loading and sealing as per:*
*P.Tripodi, et al., Phy.Lett.A, 276, 122-126 (2000).*

# Preliminary Results: Cryogenic Calorimeter Calibration



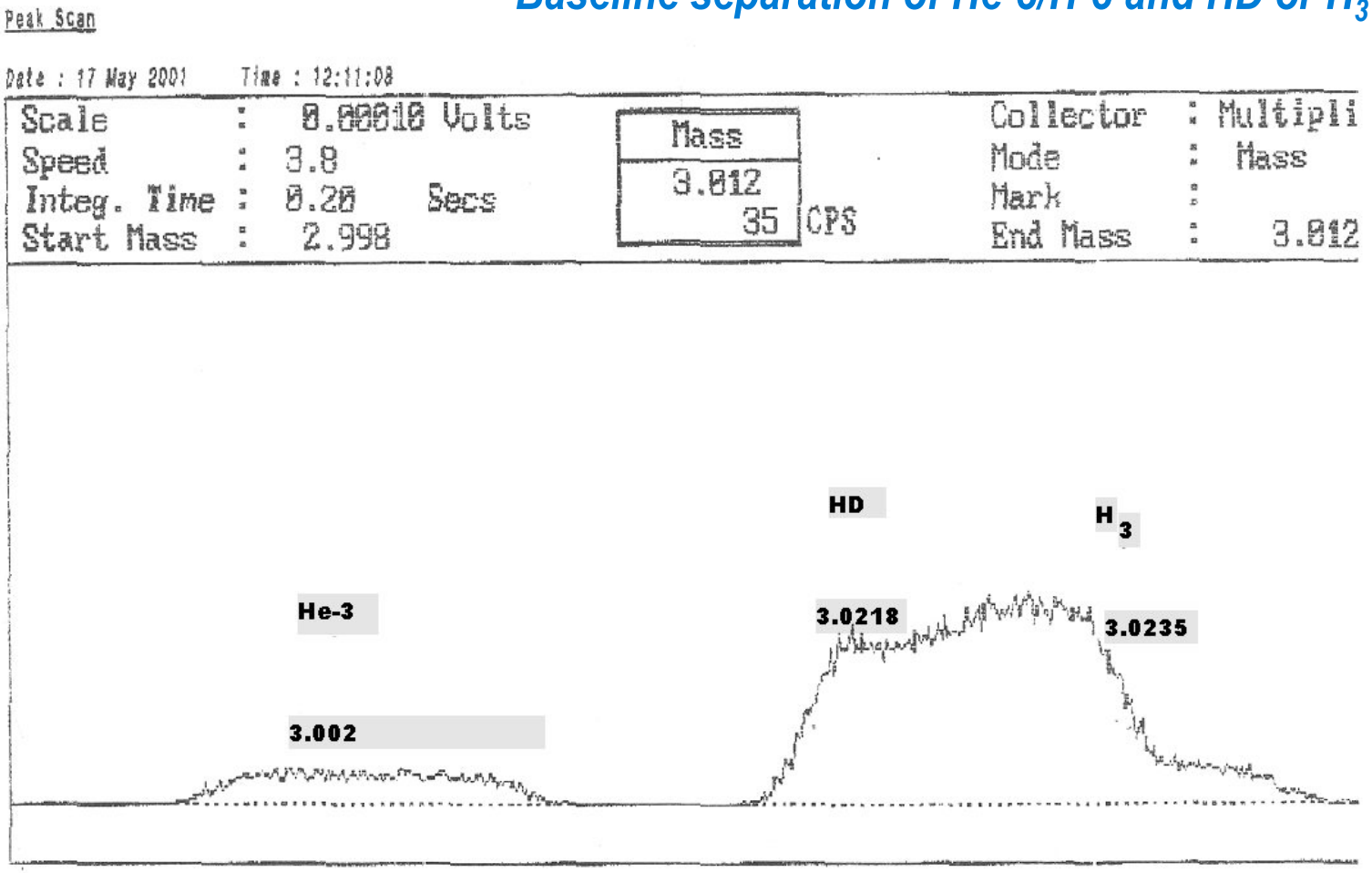
*1.008Ω at 298K, 0.988Ω at 77K*




*Red Point is for 50μm Pd wire*

# Preliminary Results: Mass Spectrometer Performance
# He-3 separation from HD and $H_3$

*Sensitivity: $10^6$ atoms He-4, $10^3$ atoms He-3*
*Baseline separation of He-3/H-3 and HD or $H_3$*



# *Conclusions*

- High energy releases seen in several LENR experiments
- Some LENR reactions stimulated by axial electrical pulses
- Pd:D (1:1) wires formed using Tripodi technique
- Pd:D (1:1) wires can be sealed and transferred to calorimeter
- Cryogenic calorimeter can detect ~0.4J from “exploding” Pd wire
- Mass Spectrometer can detect He-4 and He-3 in gas and metal samples

# *Future Work*

- Electrode Preparation:
  - $^{4}$He implantation or in-diffusion
  - **More Electrochemical loading**
- Reaction Triggering:
  - **More Axial current (dc,** pulse, sine wave**) – $10^{5}$** to $10^{7}$ **A cm$^{-2}$**
  - Surface laser
  - Ultrasonic(?), TeraHertz(?) stimulation
- Heat Measurement:
  - **More Mass displacement at low temperature (LN)**
  - Mass flow at room temperature
- Reaction Products:
  - **Analyze wires and emitted gases for changes in their $^{3}$He and $^{4}$He content and ratio**
  - Search for isotope effects
  - Neutrons and Gammas.

Acknowledged Funding Support
Basic Research Program - DTRA
Bill Wilson, Program Manager