
Welcome to
ICCF-18!
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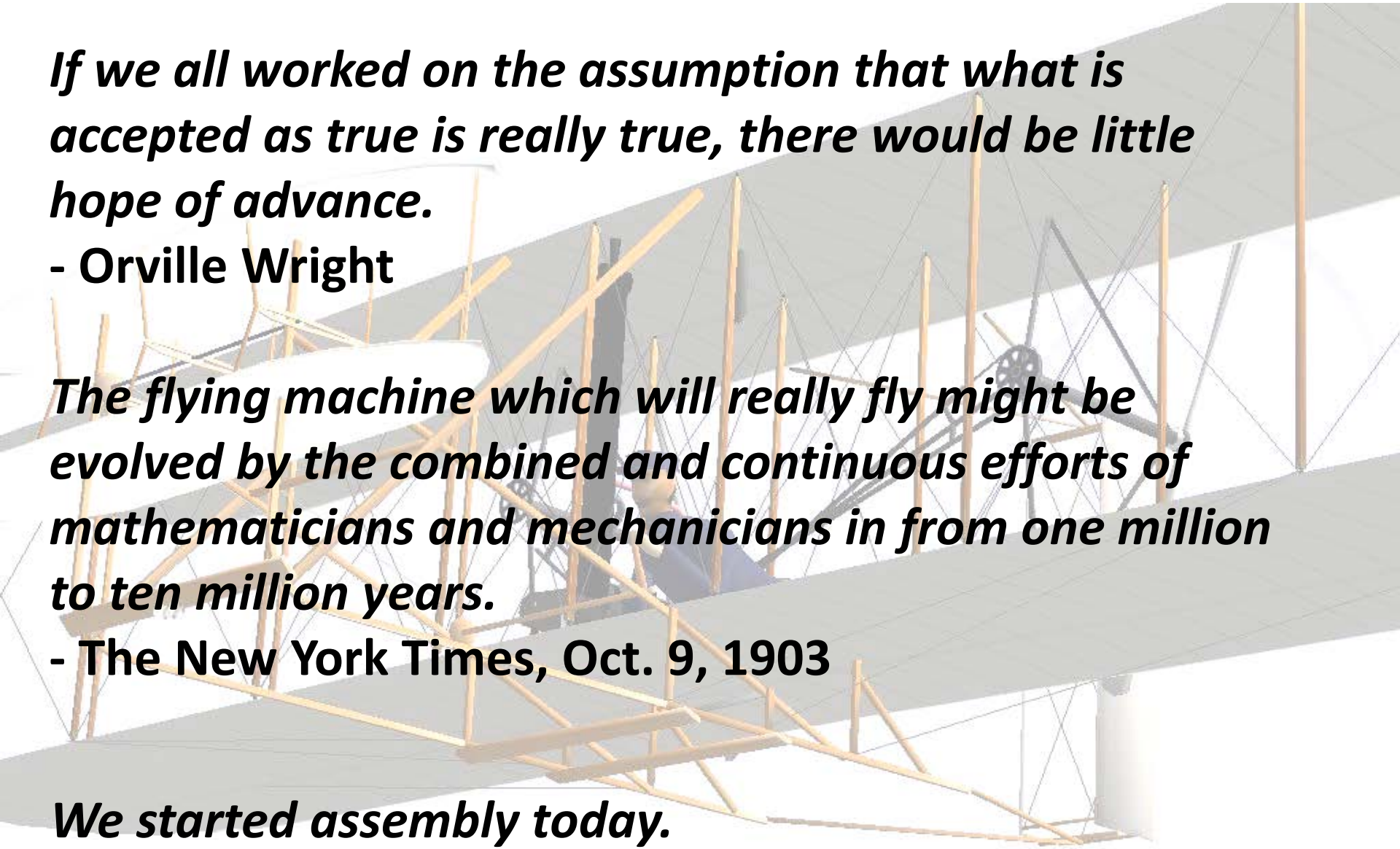
Discovery is Disruptive and Unexpected



If we all worked on the assumption that what is accepted as true is really true, there would be little hope of advance.

- Orville Wright

The flying machine which will really fly might be evolved by the combined and continuous efforts of mathematicians and mechanicians in from one million to ten million years.

- The New York Times, Oct. 9, 1903

We started assembly today.

- Orville Wright's Diary, Oct. 9, 1903

Class 1 Phenomena: Known Nuclear Process Enabled by the Condensed Matter State *Pyroelectric Fusion*

- Pyroelectric D+D crystal fusion
  - Jabon, Federovich, and Samsonenko (1997)
  - Naranjo, Gimzewski, and Putterman (2005)
- $LiTiO_3$ pyroelectric crystal accelerates D+ ions into a ErD_2 target
- About 1,000 fusions per second, confirmed
- T+D fusion achieved at LANL in 2010
- Many other reports and improvements since 2005

Other 'Class 1' Phenomena
Piezoelectric Fusion

- Piezoelectric fusion and other nuclear reactions have been demonstrated in Prof. Scott Kovaleski's Group here at MU
  - Piezoelectric acts as a huge voltage amplifier to create fields that accelerate electrons, deuterons, etc.
  - Confirmed beta and x-ray source, and confirmed fusion, but very low intensity
- Novel nuclear systems are being developed in MEMS technology today, including a 'cyclotron on a chip' and other innovative devices. For example, Prof. Amit Lal's and his group at Cornell University.

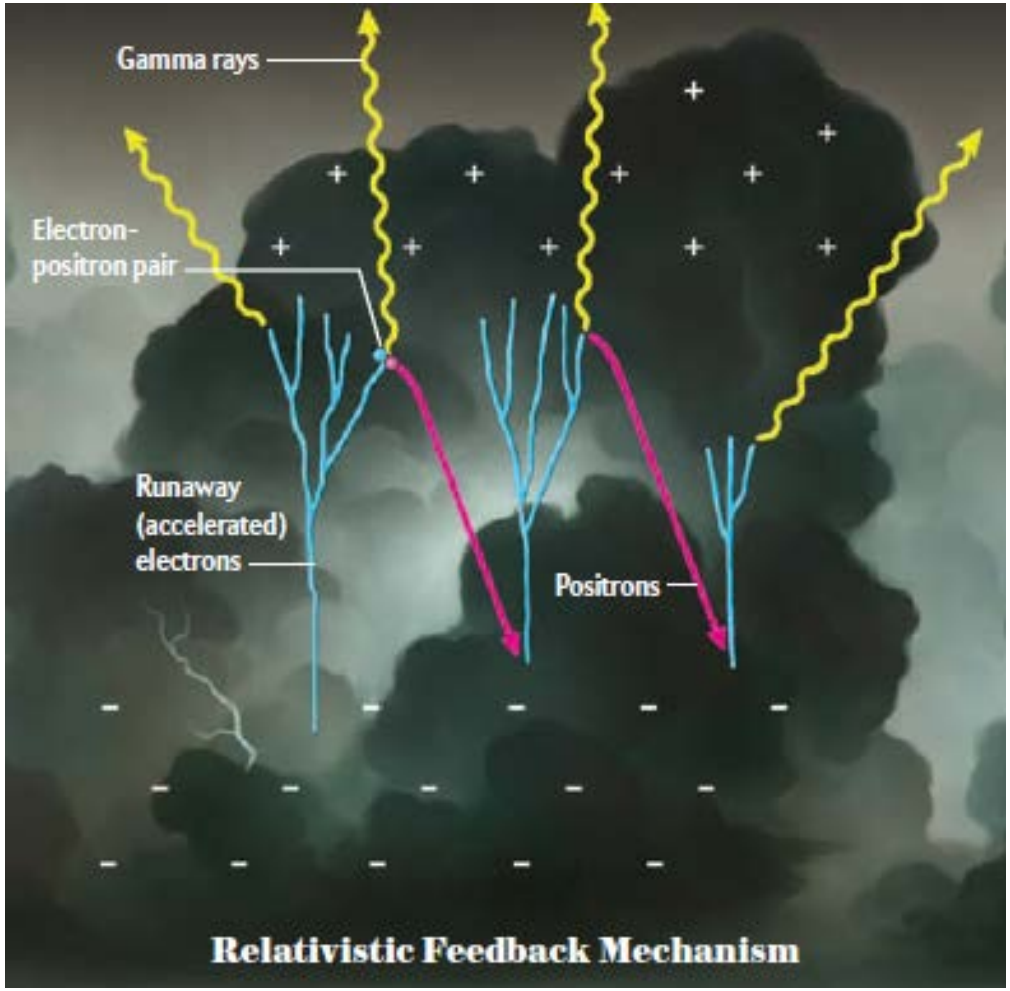
Class 2 Phenomena: Nuclear Phenomena Observed in Condensed Matter in Unexpected Ways

Fusion in Deuterium-loaded Metals

- Intense emissions of neutrons from deuterium heavily loaded on chips of Ti, Pd, and ^{238}U
  - Professor Mark Prelas and his group at MU (1990)
  - Work at BARC: Kaushik et al., Rapid Communications, Indian Journal of Technology 28, pp. 667-673 (1990)
  - China Institute of Atomic Energy, China, Email: ssjiang@ciae.ac.cn, 2 Tsinghua University, China (2012)
  - Izumida, Yamashita, and Miyadera (1990)
  - Arata and Zhang (1990)
  - Menlove, Fowler , Garcia, Miller, Paciotti , Ryan, and S. E. Jones (1990)
- Muon Catalyzed Fusion, discovered in the mid-1950's, is now very well understood

Other Class 2 Phenomena
Antimatter Production in Thunderstorms

- Production of positrons within thunderstorms



This is an excellent example of new, unexpected phenomena in a strongly interactive system driven far from equilibrium

←from Scientific American, August, 2012

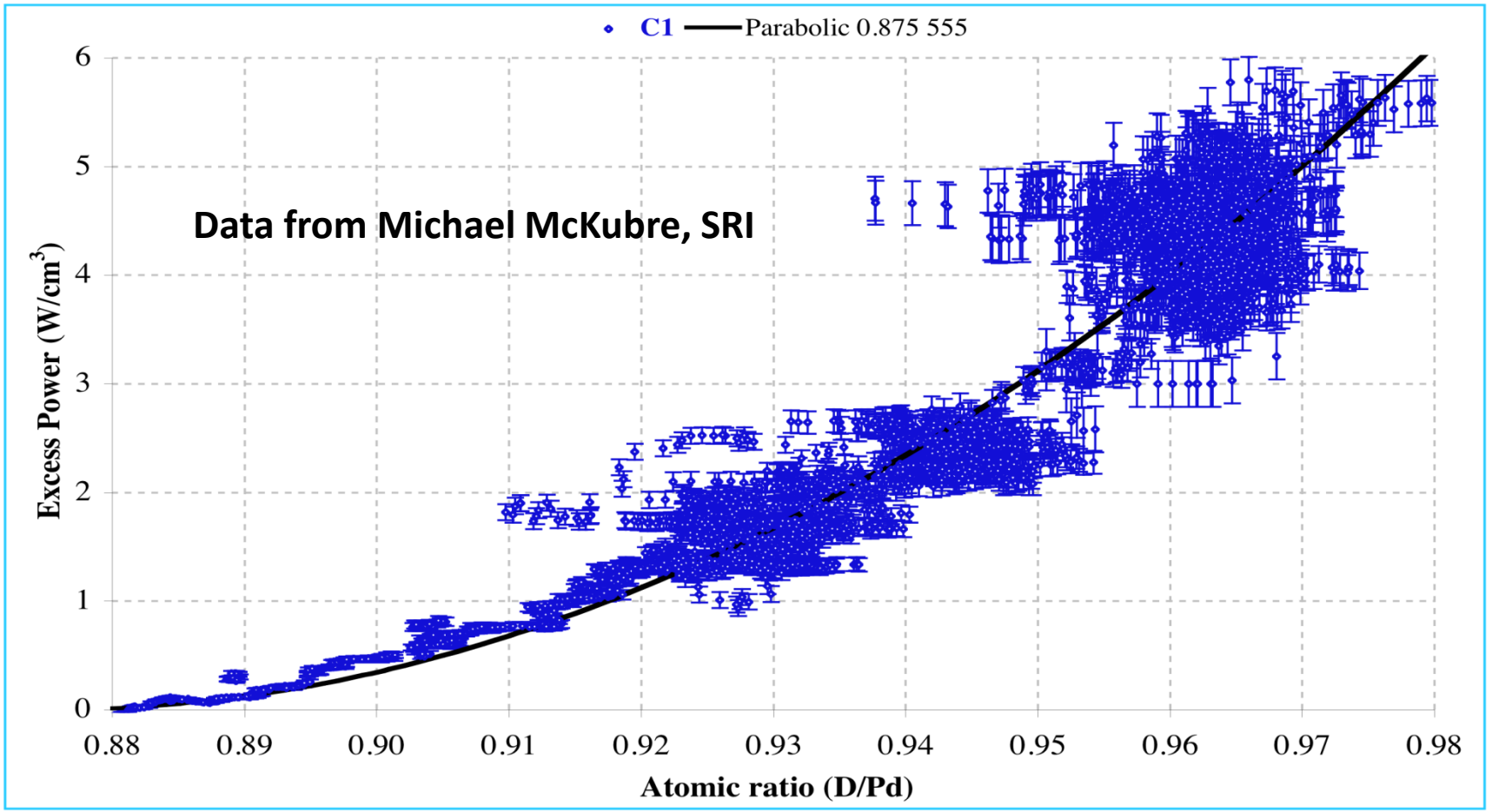
Class 3 Phenomena: Genuinely New Phenomena that Lack Current Physical Explanation

Anomalous Excess Heat (as in Fleischmann and Pons)

- There are now hundreds of confirmations of this effect by many exceptionally skilled experimentalists, including groups at BARC, NRL, ENEA, and many other major laboratories world-wide
- Despite numerous claims to the contrary, the physical origin of this effect remains uncertain
- Typically these results occur one time in 20 (NRL) to one time in 7 (Energetic Technologies), and the size of the effect varies considerably in an uncontrolled way

What is Different Now from 1990?

The loading of [D]/[Pd] must exceed 0.88 for excess heat



Anomalous Excess Heat of Unknown Origin (Con't)

- Large excess heat is achieved in high, non-equilibrium loading of D in Pd
  - Electrolytic loading techniques (like in FP)
  - Glow discharge and ion bombardment loading
- Smaller effects are observed in equilibrium loading
  - Co-deposition of D and Pd
  - Gas diffusion loading, usually of nanoparticles
- Many reports of excess heat in the Ni – H system, but we have yet to replicate these results at MU. We are attempting to do so now.

The Excess Heat Effect: far Greater than Chemical Heat Release

- The ET Pd cathode mass was 0.3 g ($2x10^{-3}$mole)
- Chemical release of heat:
  - ΔH for Pd +D → PdD is about 43 kJ/mole
    - So about 100 J if this heat release was somehow delayed
  - ΔH for $2D_2 + O_2 \rightarrow 2D_2O$ is about 242 kJ/mole
    - So about 500 J of delayed released heat
- Many measurements show:
  - Typical heat release per episode of 50,000 J
  - Occasional heat release of over 1,000,000 J
- Heat release is usually from ambient temperature to about 100 ^oC, with occasional reports of heat release at much higher temperatures

So What is Going On?

- We don't know – it will take a lot of well controlled experiments to figure this out.
- The 'excess heat' is real, and this is enough to motivate serious study to determine its origin
- A nuclear process? Probably…

  - Fusion? Look for nuclear by-products (He, T, n)

  - LENR? First electro-weak nuclear energy release? If so, look for cold neutron effects

  - I hypothesize that this is at least augmented by (d,p) and/or (d,n) reaction with the host lattice atoms, enhanced by extreme out-of-equilibrium conditions

Sidney Kimmel Institute for Nuclear Renaissance (SKINR) at MU

Sidney Kimmel FOUNDATION

$5.5 Million gift, plus equipment,
Five-year minimum duration

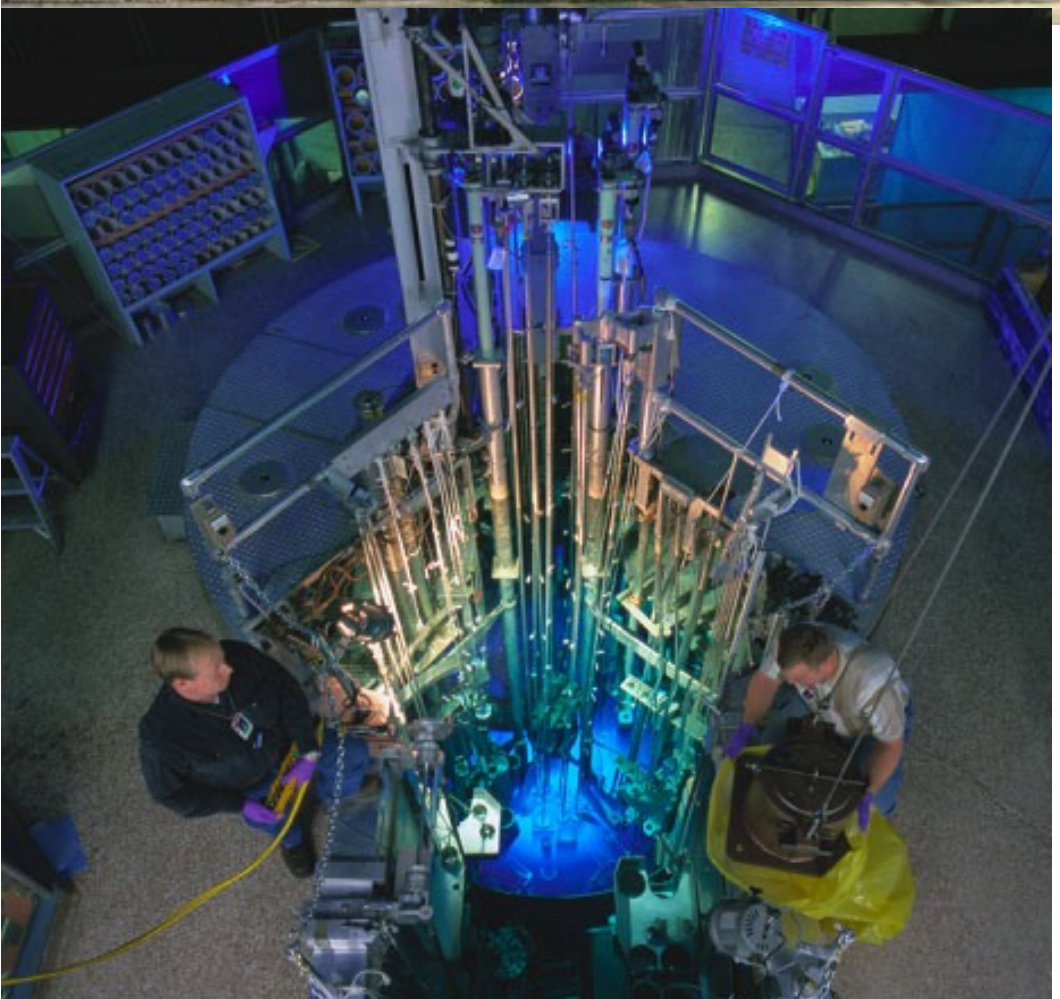
SKINR's objective is to determine the physical origin of the Anomalous Heat Effect

"I chose MU for this important gift because it is a comprehensive university, experienced in using its deep scientific research capacity across many fields with its firm commitment to serve the public good."

SKINR's Scientific Focus

- Always run careful controls (hydrogen vs. deuterium) in all experimental loading techniques, including 'electrolytic', 'glow discharge', and 'gas loading'.
- Be 'hypothesis driven' throughout. What are we trying to disprove?
- Characterize and control the Pd metal surfaces carefully at the nanometer scale, and evaluate surface changes in all samples regardless of the level of excess heat release – standardize the protocol – utilize 'top-down' fab and 'self-assembly'
- Comprehensive chemical analysis and isotope abundance determinations

MU Research Reactor



At **10 MW**, MURR is the largest neutron source on a US campus and provides a flux competitive with national user facilities. It has a total of **six beam ports**, three of which are presently dedicated to **four neutron scattering instruments**: a triple-axis spectrometer (TRIAX), a neutron reflectometer (NR) and two double-axis diffractometers (2X-C and PSD).

SKINR's Scientific Focus (Con't)

- Neutron activation analysis to search for 'cold neutron' effects (data below from Firestone, *et al*.)
- See Bush and Lagowski: *Trace Elements Added to Palladium by Electrolysis in Heavy Water, EPRI, Palo Alto, CA: 1999 (TP-108743):* $^{108}Pd/^{110}Pd$ down 28%!
- Determine ^{108}Pd /^{109}Ag stable isotope ratio

Isotope	Abundance	neutron σ_{th} (barn)
^{102}Pd	1%	0.9
^{104}Pd	11%	0.61
^{105}Pd	22%	21.1
^{106}Pd	27%	0.36
^{108}Pd	27%	7.6
^{110}Pd	12%	0.10

SKINR's Scientific Focus (Con't)

Implant Loading… Energy from 'glow discharge loading' up to the Coulomb barrier (cyclotron)

In a big radiation vault, so we bring the beam out to impinge on target

D+ on layered Pd targets
p on isotopic pure ^{64}Ni

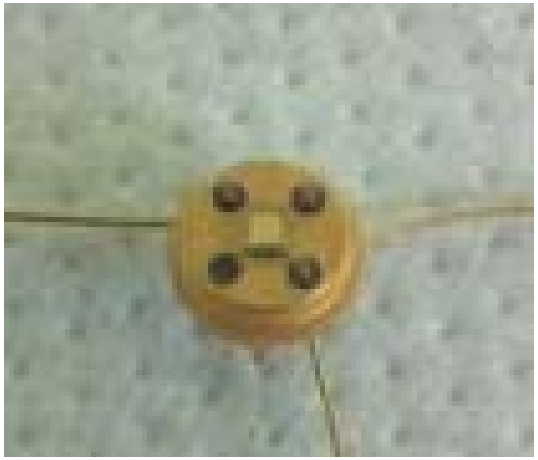
Soon…

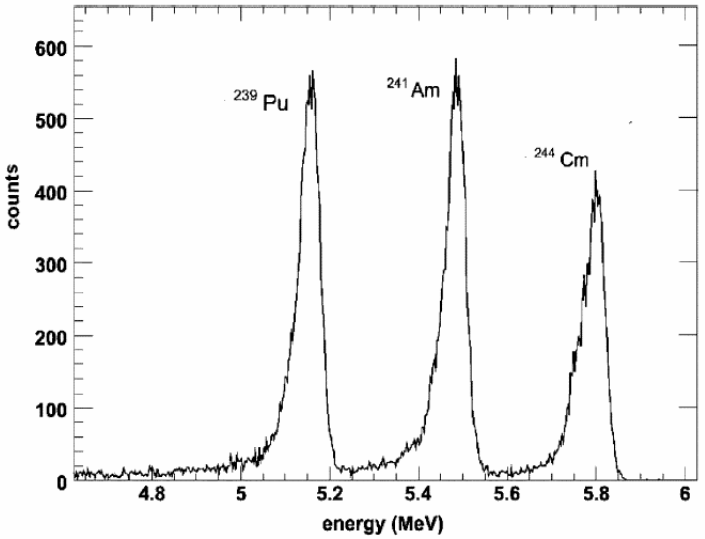
p on layered Pd targets
D+ on isotopic pure ^{64}Ni

General Electric, 16.8 MeV p accelerator (MU and Essential Isotopes, LLC)

SKINR's Scientific Focus (Con't)

- Use diamond substrate particle detectors to check for internal conversion





See Mark Prelas and Eric Lukosi for more information. Figure copied from A. Galbiati *et al.,* IEEE Transactions on Nuclear Science, Vol. 56, No. 4 (2009), 1863-1874.

Pd – D films have been co-deposited on these diamond sensors, and nuclear emissions have been observed that suggest Pd neutron capture transmutations, but this is a preliminary result. Compare / contrast SPAWAR and CR-39 results. See ICCF-17.

SKINR's Scientific Focus (Con't)

- We are developing new Pd surface self-assembly through electrolytic deposition methods that use 'activated' palladium nanoparticles in the electrolyte. Control is achieved at the nanometer scale using this 'green nanotechnology' process.
- All surfaces are characterized before and after attempts to see excess heat, regardless of the level of excess heat observed.
- Efforts on nanoparticles from Prof. Kattesh Katti and his group, and nanorod studies from Prof. Shubhra Gangopadhyay and her group.

Recommendations

- Follow the Scientific Method to establish the physical mechanism(s) as soon as possible
- Encourage all funding agencies to be more empirical and evidence-based in exploring / funding new phenomena
- Expand experimental techniques and the range of materials and physical measurements
- Create a more formal international trade organization to explore LENR, and meet to standardize techniques and terminology
- Emphasize exceptionally good measurements

Companies and Commercialization

- Many companies are working on methods to commercialize LENR as a new method of heating and/or of producing power, and they are welcome to present their results here.
- There is no peer review of commercial demonstrations, presentations, or of corporate claims regarding the performance of devices that you will see here at ICCF-18.
- MU does not endorse any company, or vouch for the validity of their claims. You are responsible for doing your own due diligence before purchasing products, or investing in any commercial entity.