Sidney Kimmel Institute for Nuclear Renaissance (SKINR) Overview

Sidney Kimmel Institute for Nuclear Renaissance
University of Missouri

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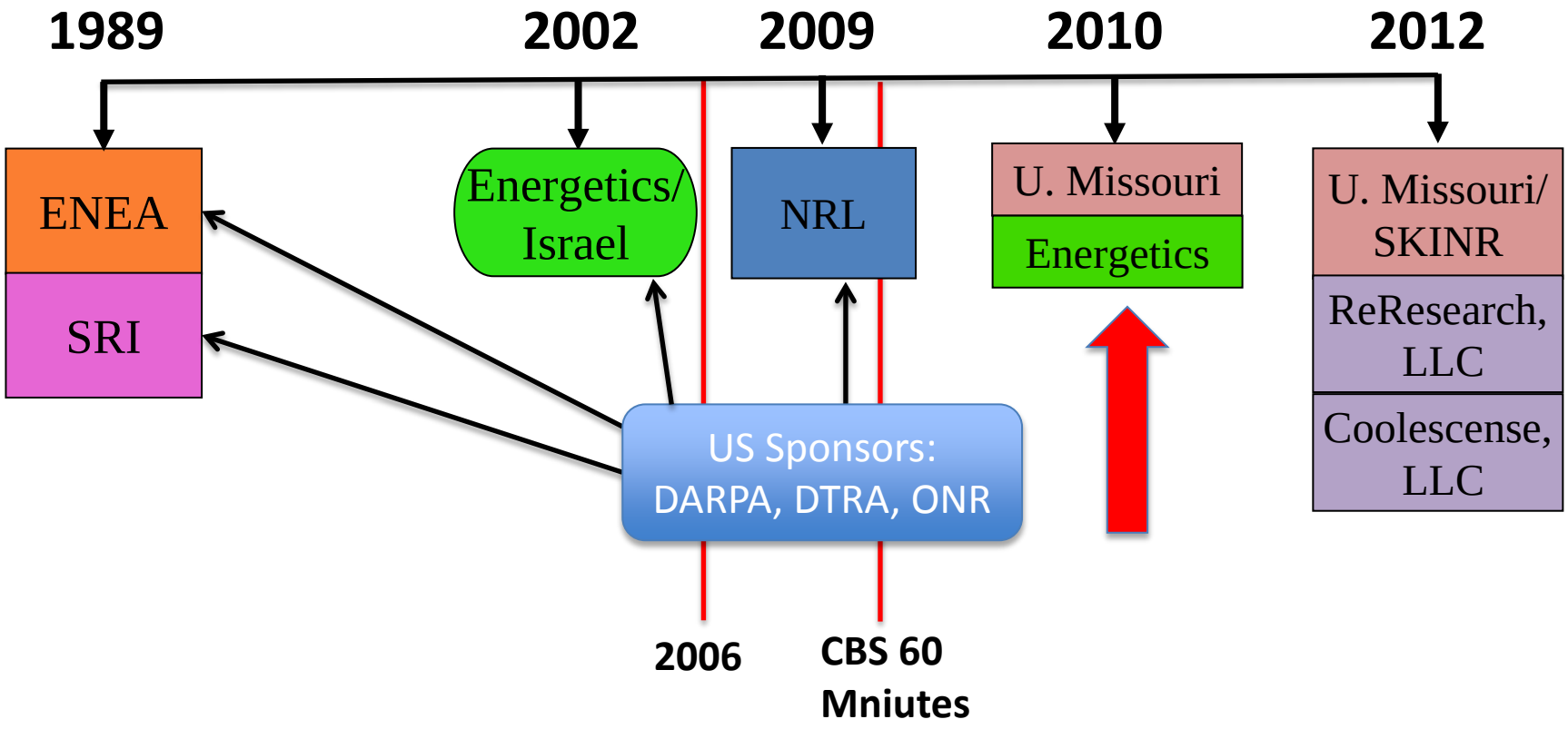
SKINR Directive: **To find the origin of the Anomalous Heat Effect (AHE) with a sound materials science approach and with no preconceptions as to the origin of the phenomenon. To publish findings in the open literature and to openly collaborate world wide with researchers in the field and in cross disciplines.**

International Collaboration and Time-Line of Partner Involvement



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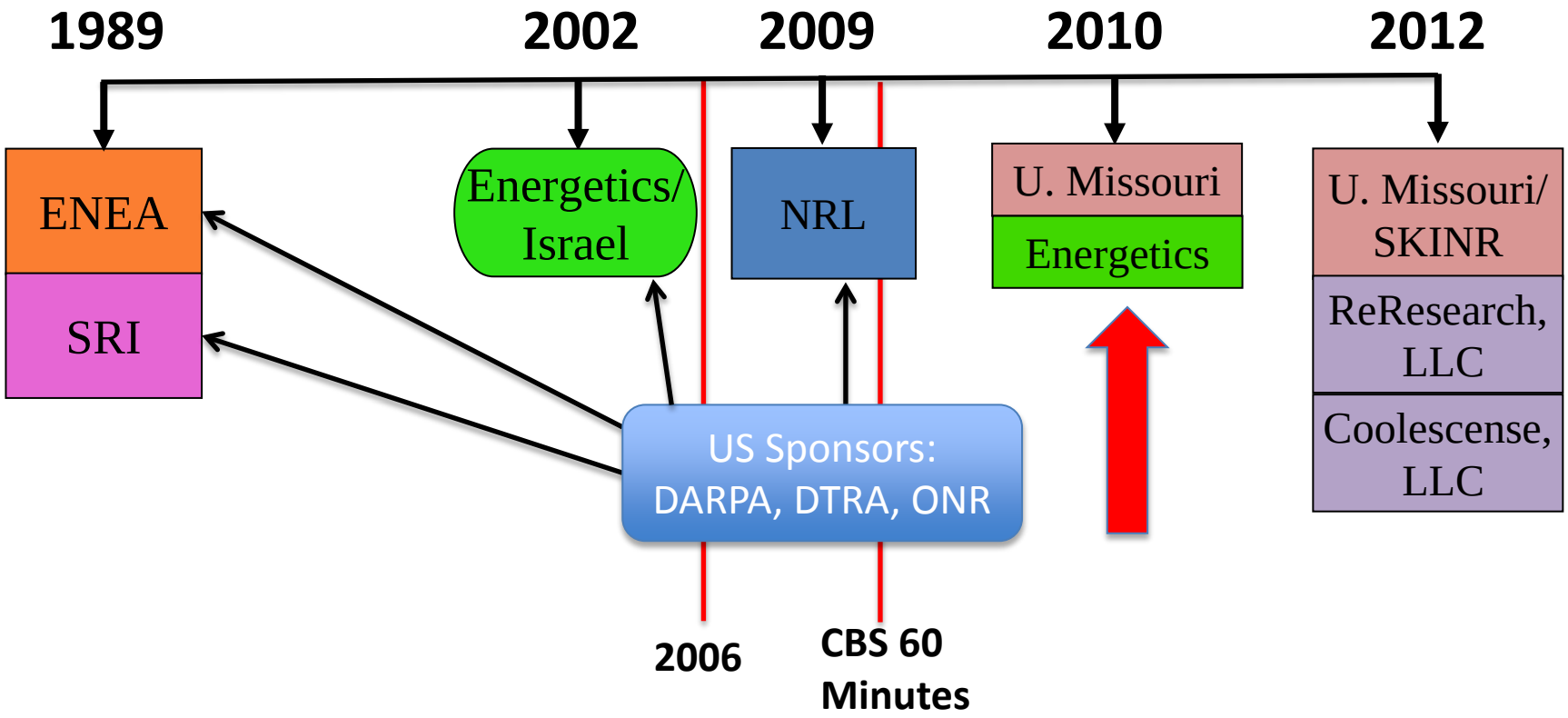

Expected Progress:

- **Improve Reproducibility**
- **Reveal Mechanism**

Rob Duncan

SKINR Staff

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Administratively located in the UM Department of Physics and Astronomy

Orchideh Azizi
Arik El-Boher (Research Group Leader)
Graham Hubler (Director)
William Isaacson
Dennis Pease
Mark Tsirlin

SKINR has Laboratory space in the Department of Physics and in the Department of Electrical Engineering – Dr. Shubra Ganghopadhyay was instrumental in donating space to SKINR

R. Duncan; UM Vice Chancellor for Research

Involvement of UM Professors in SKINR-related Activities

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J. Gahl, Electrical Engineering
-Pd(d,p); Ni(p,p) on cyclotron

S. Gangopadhyay; Electrical Engineering
-CNT; nanoporous; artificially structured cathodes; Pd deposition on membranes

H. Kaiser: Dept. of Physics & Astronomy/MURR
-neutron scattering on PdD. PdH

K. Kattie; Dept. of Radiology
-In situ nanoparticle deposition on cathodes

S. Kovaleski, Electrical Engineering
-Piezoelectric ion sources, low energy ion bombardment

M. Prelas, Nuclear Engineering
-Neutrons form thermally shocked TiDx, diamond particle detectors

P. Pfeiffer; Dept. of Physics & Astronomy
-Fundamental Hydrogen charging of metals studies

Graduate Students and Post-Docs

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Charles Weaver – M. Prelas – Nuclear Engineering
Peter Norgard – J. Gahl and S. Kovaleski – Electrical Engineering
Cherian Mathai – S. Gangopadhyay - Electrical Engineering
Somik Mukherjee - S. Gangopadhyay - Electrical Engineering
Gupta Sagar – K. Katti - Radiology
Andrew Gunn – H. Kaiser – Physics & Astronomy

Most Energetic Anomalous Heat Events by the University of Missouri (SKINR)

ENEA fabricated cathodes

40% reproducibility

Experiment	56	64a	64b	GD-141	US1-15	US3-05	US3-06	US3-21
EE, MJ	3.1	1.1	> 3.5	2.4	0.19	1.1	1.32	0.026
EP, W	3	19	> 11	14	0.25	0.8	0.9	0.13
Max COP, %	80	2500	> 1500	75	600	3000	525	650
Duration of EH, h	300	17	80	90	280	960	445	55

Many Initiatives at SKINR

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Gas Reactors:
- -Celani replication
- -High temperature reactor/calorimeter

Electrochemical cells:
- -Cathode development (many choices)
  - -Self assembled Pd nanoparticle cathodes
  - -Pd coated carbon nanotube cathodes
  - -Artificially structured Pd cathodes
  - -New alloy compositions
  - -Dealloying for nanporous Pd
- -Magnetic fields
- -In situ ultrasound surface stimulation
- -Glow discharge cleaning
- -Hydrogen permeation kinetics
- -Radiation detection

Related studies
- -Neutron scattering
- -MeV and keV bombardment of D on Pd
- -Thermal shock of TiD2
- -Hydrogen absorption thermodynamics at high pressure/temperature
- -Diamond radiation detectors
- -Theory

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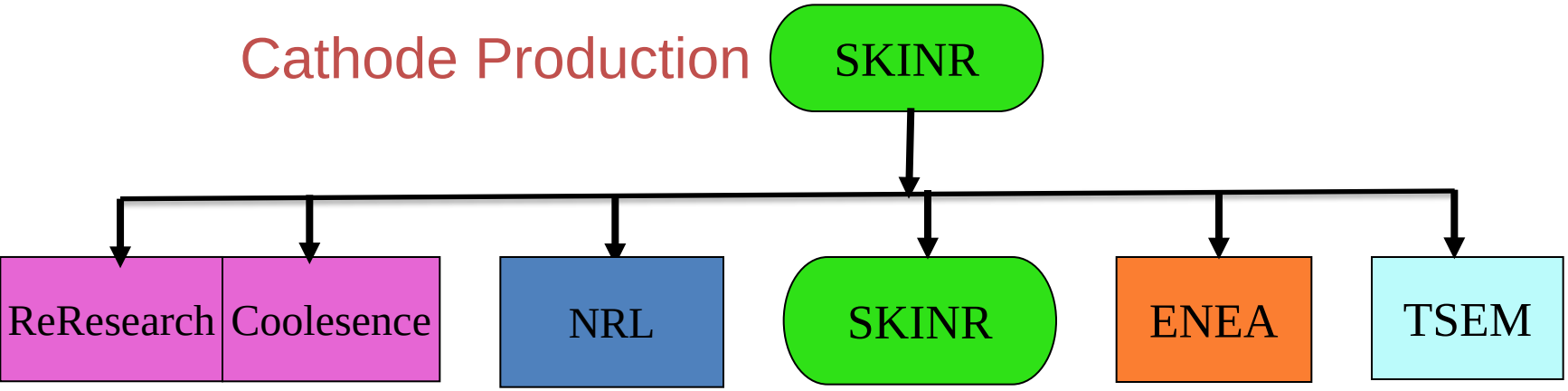
Cathode Development Plan

Empirically guided cathode modifications

Cathode Production

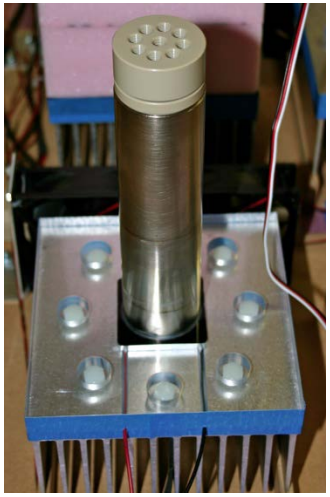


Cathode Electrolysis

With collaboration partners, run hundreds of fabricated cathodes in parallel using NRL designed *common equipment and common protocols.*

Expected Progress: Improved Reproducibility

Electrochemical cell



Cell in calorimeter

Mechanistic Experiments

Two Examples

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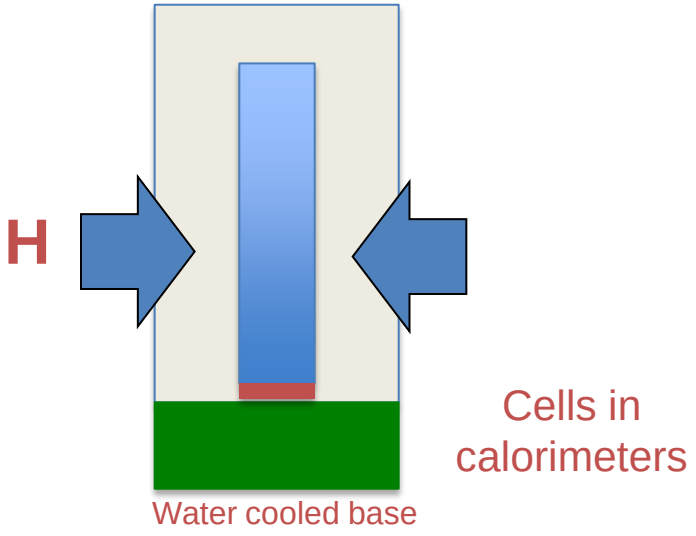
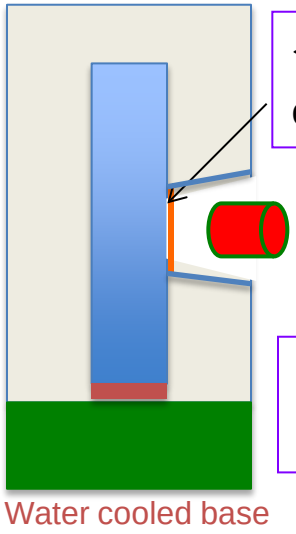
Magnetic Fields



Cells in calorimeters

Low energy gamma, particle emissions



<1 μm thick Si_3N_4 membrane on cell/calorimeter wall

X-ray, gamma, particle, IR detectors in air

Build on previous work by:
Bockris – Texas A&M
Boss & Gordon – SPAWAR
Cravens & Letts – NM
Swartz – Jet Energy

Low energy emissions have never been thoroughly investigated in REAL TIME

Expected Progress: Reveal Mechanism

Membrane Experiment Schematic

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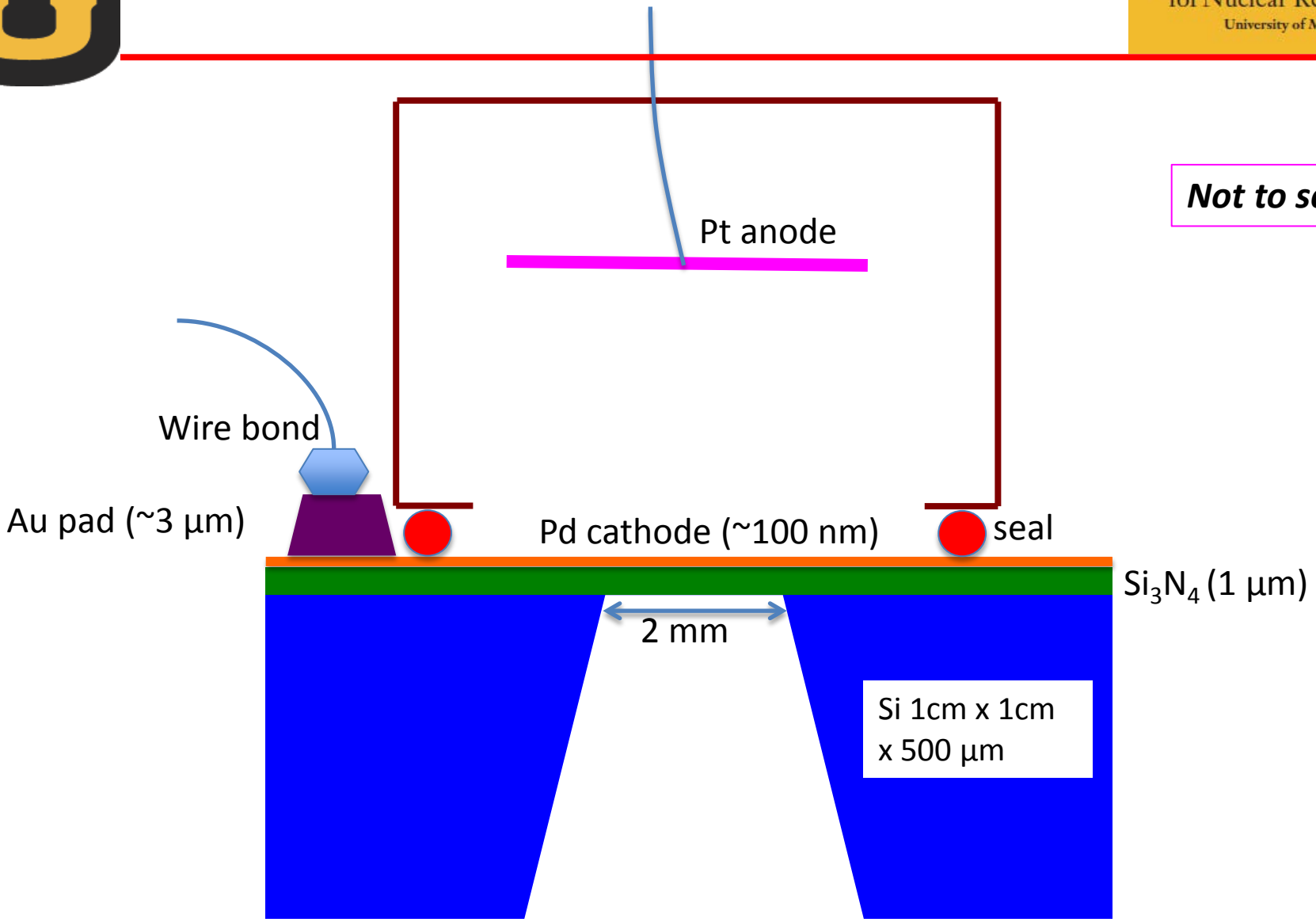
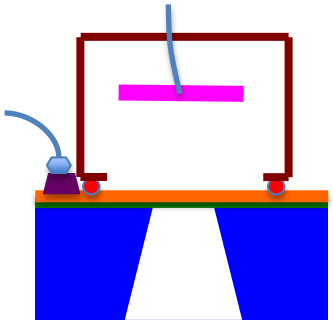


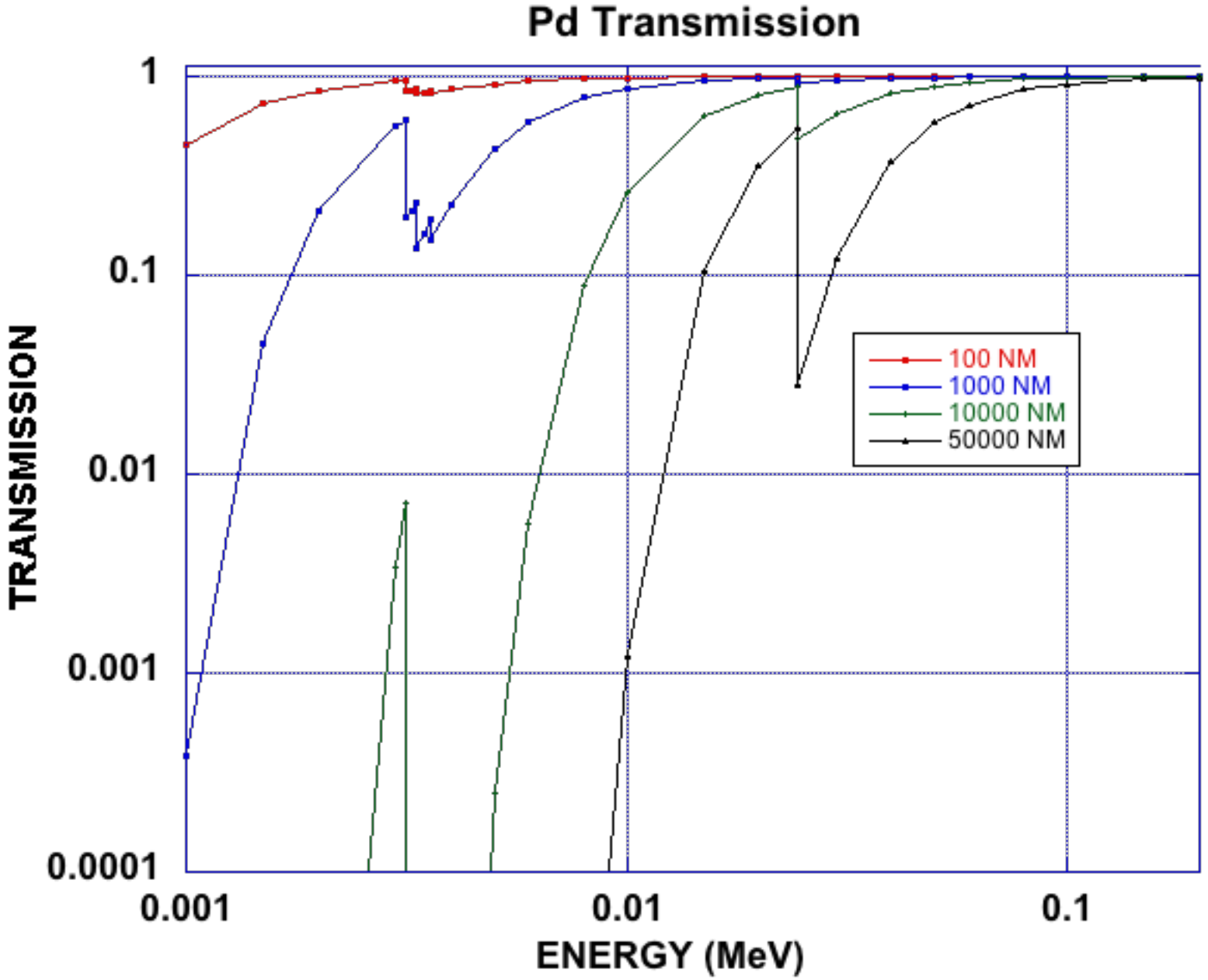
Membrane Experiment Sensitivity

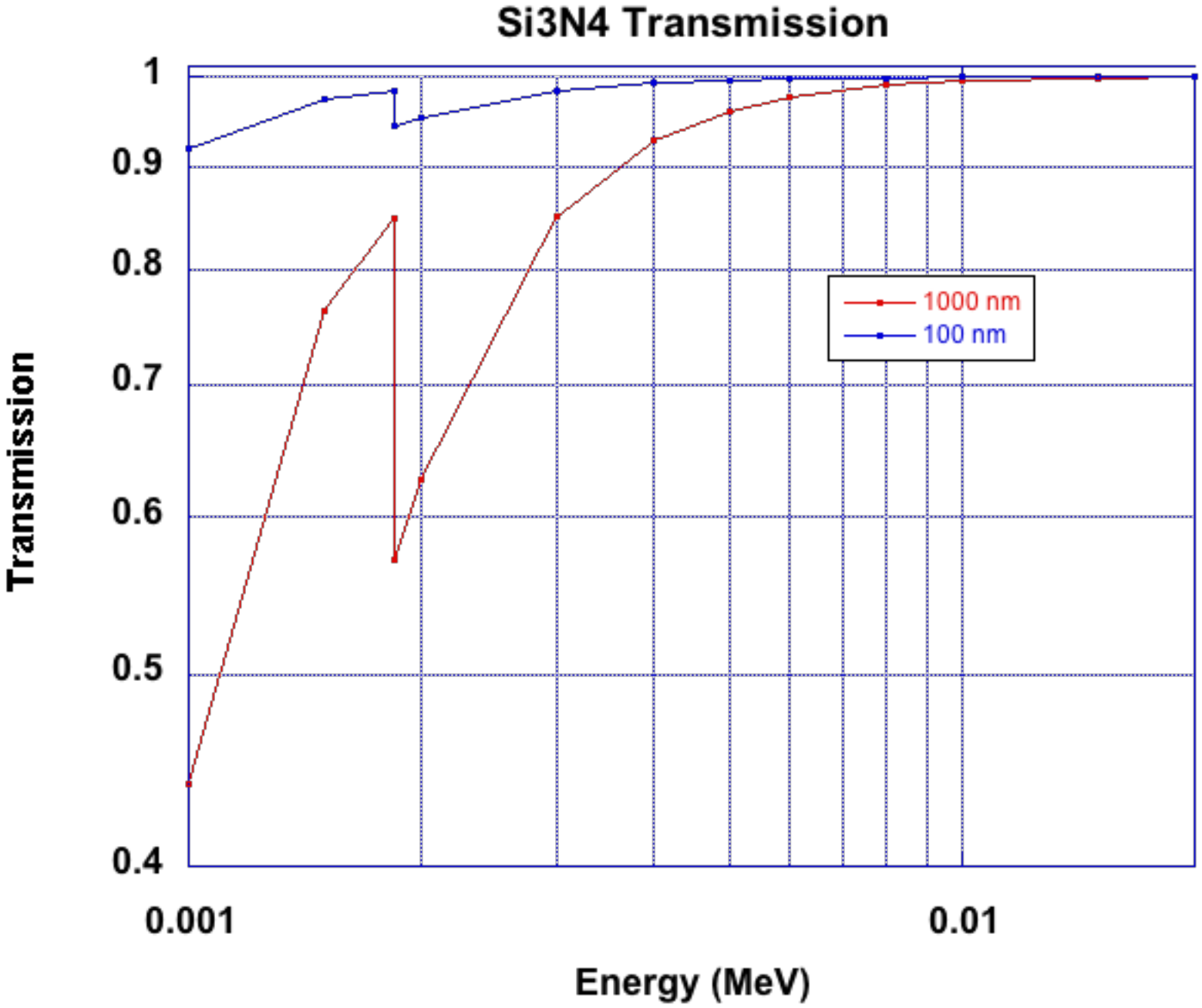


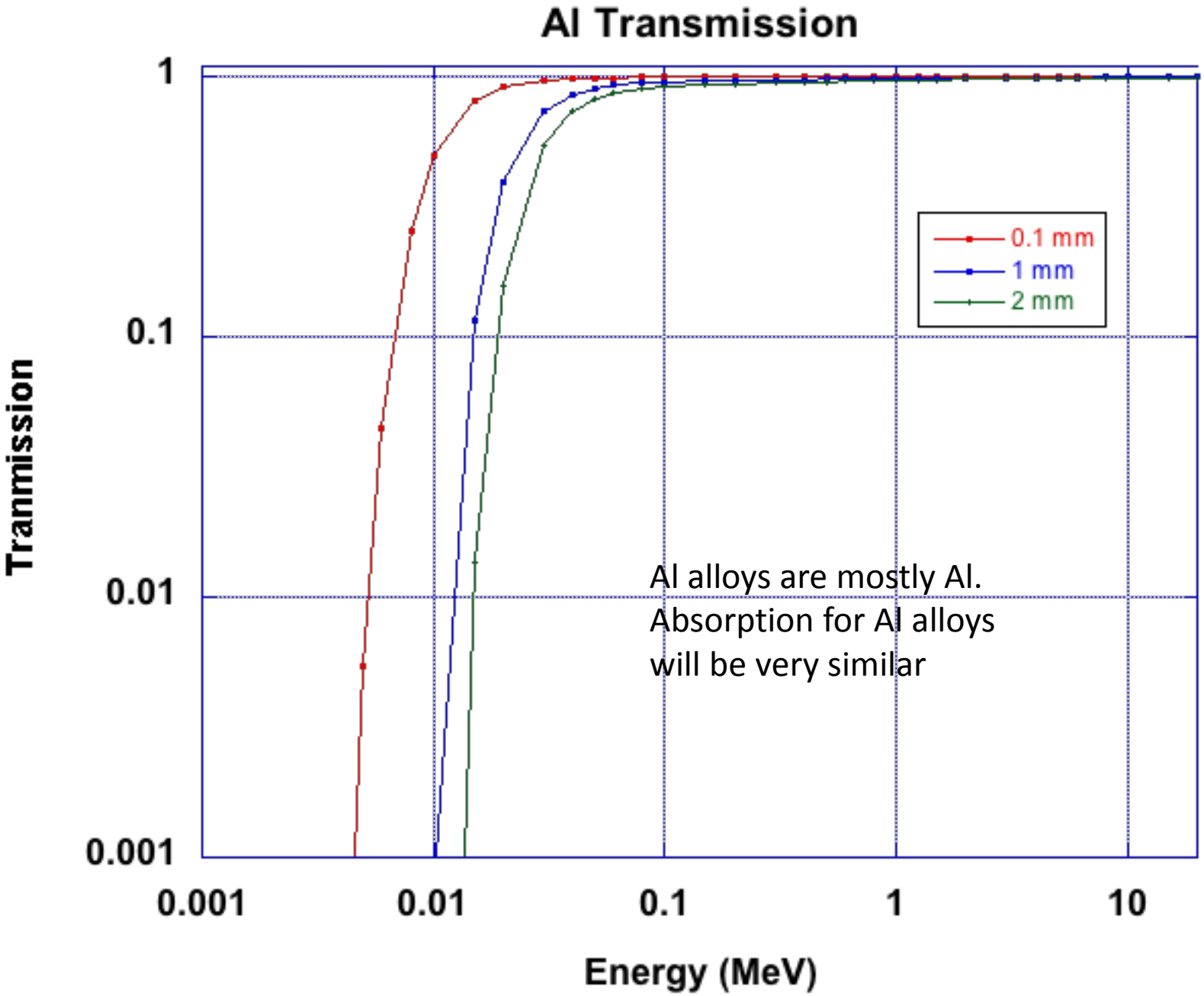
Most calorimeters have power sensitivity in the range of 1 to 10 mW

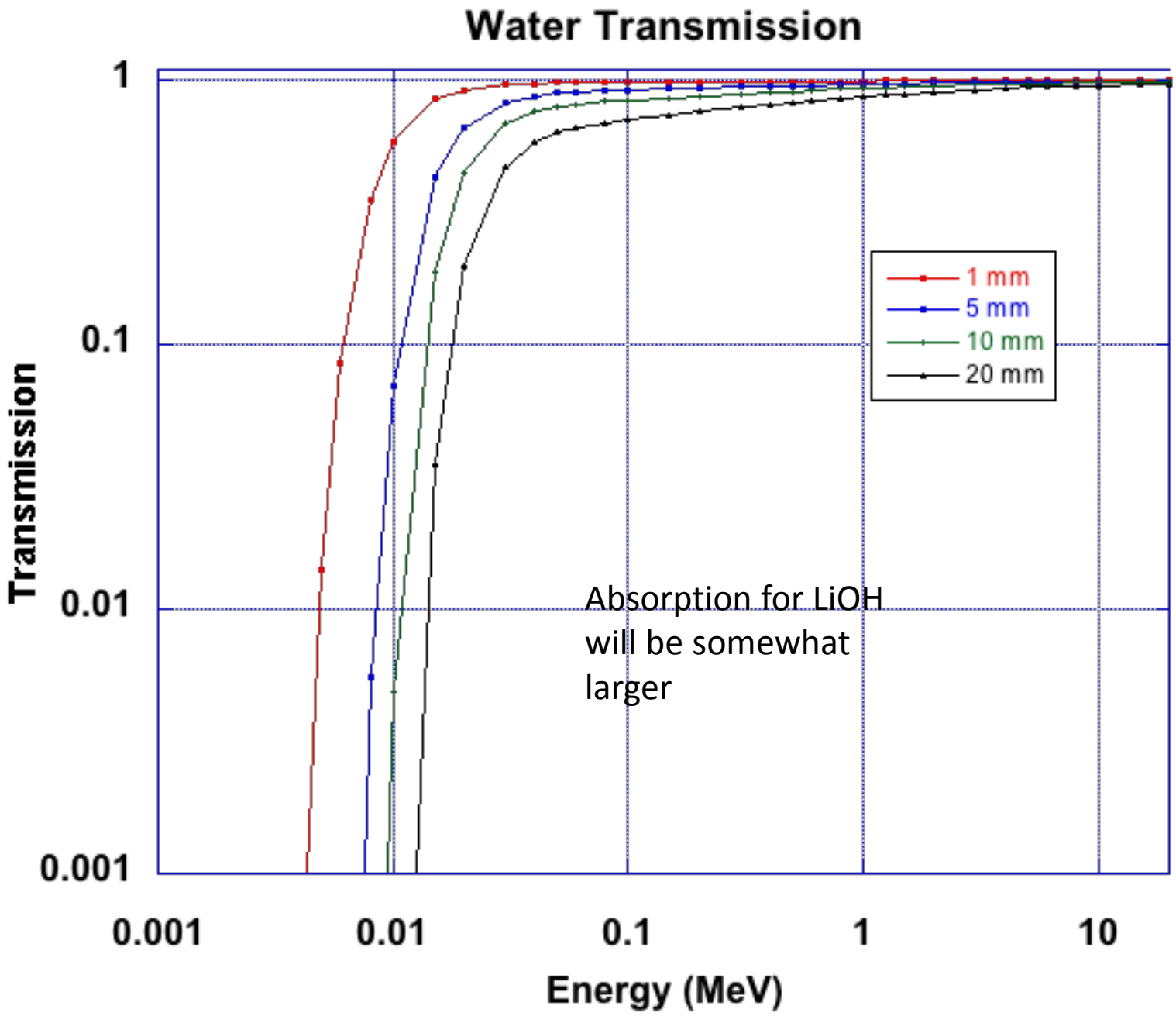
Suppose that the anomalous heat mechanism is active much of the time but at the micro-, nano-, or pico-Watt level. The the calorimeter is insensitive to this power output

If in the membrane experiment we see a 1 keV x-ray at a rate of 1 Hz, the corresponding power sensitivity is 0.2 femtowatts, an excess power sensitivity improvement of 10^{12} !


Pd Transmission
TRANSMISSION
1
0.1
0.01
0.001
0.0001
0.001
0.01
0.1
ENERGY (MeV)
100 NM
1000 NM
10000 NM
50000 NM


Si3N4 Transmission
Transmission
1
0.9
0.8
0.7
0.6
0.5
0.4
0.001
0.01
Energy (MeV)
1000 nm
100 nm


Al Transmission
1
0.1
0.01
0.001
Tranmission
0.001
0.01
0.1
1
10
Energy (MeV)
0.1 mm
1 mm
2 mm
Al alloys are mostly Al.
Absorption for Al alloys
will be very similar

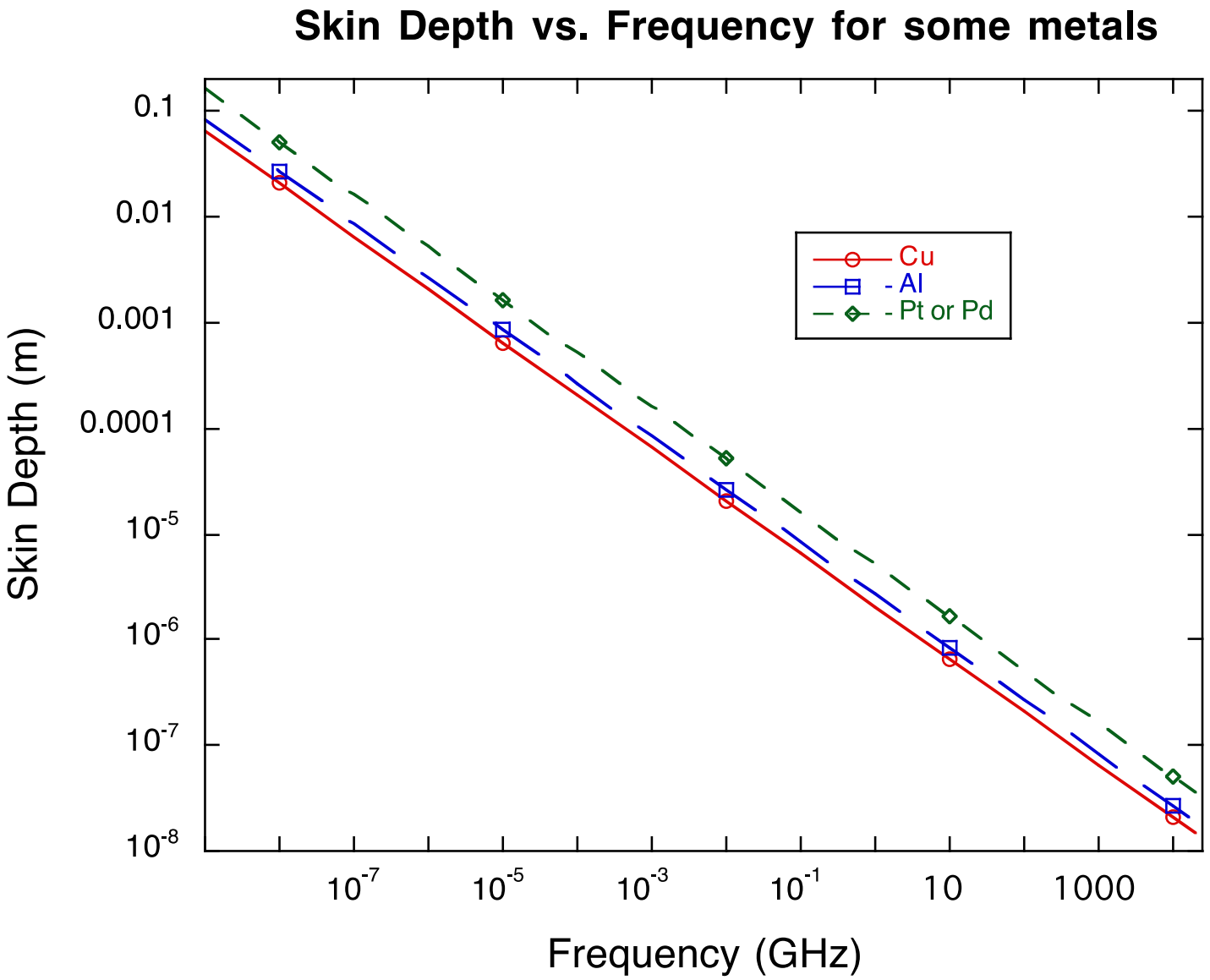

Water Transmission
Transmission
1
0.1
0.01
0.001
0.001
0.01
0.1
1
10
Energy (MeV)
1 mm
5 mm
10 mm
20 mm
Absorption for LiOH will be somewhat larger

Skin Depth (m) = SQRT((2.*Resistivity)/(2π*permeability*relative permeability*frequency (Hz)))

Resistivity: Al = 28.2 nOhm-m
Cu = 16.8 nOhm-m
Pd & Pt = 105 nOhm-m

For Al, Cu, Pt, Pd
Permeability = 12.56E-7 H/m
Relative permeability = 1.0

Si_3N_4 is transparent to E&M radiation over most of this range



Hydrogen Permeation Kinetics

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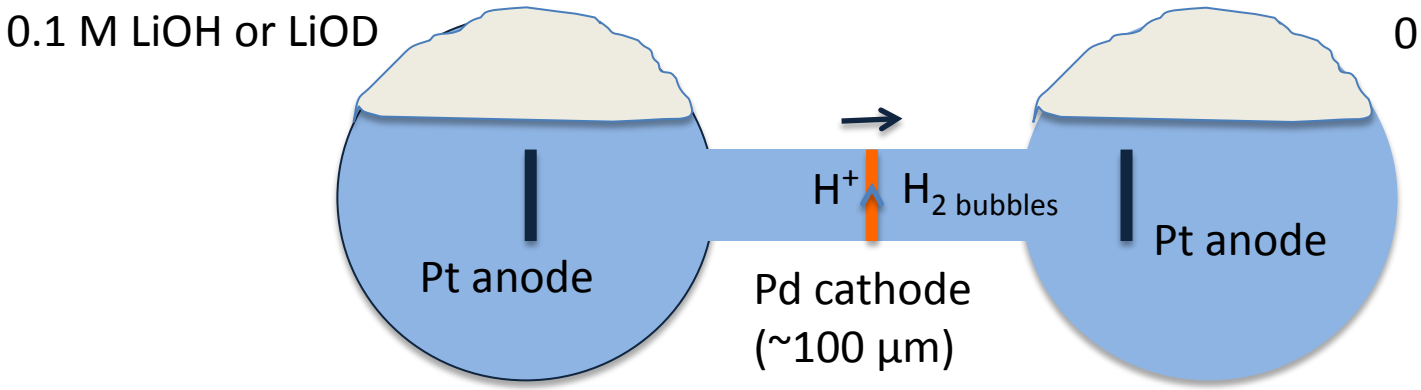

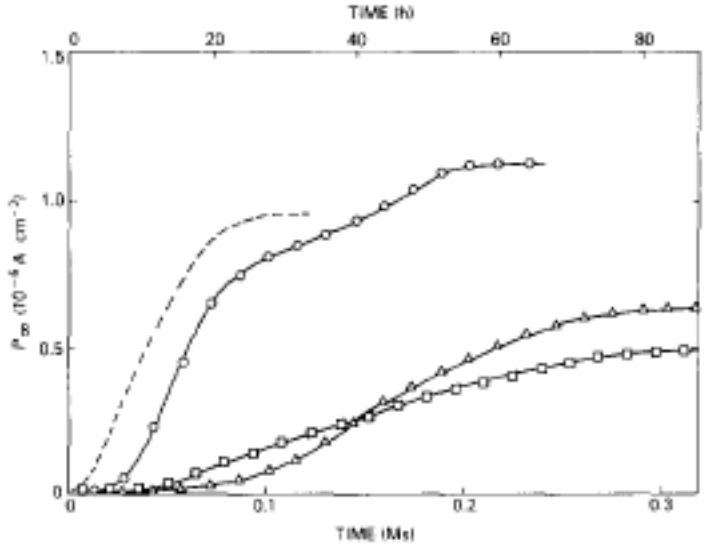

Fig. 7. Hydrogen permeation transients of nickel implanted with a fluence of 3×10^{15} Pt^{+} cm^{-2} before and after treatment with aqueous 0.2! HF: ○, $t = 0$ s; △, $t = 60$ s; □, $t = 180$ s.

$D_{lag} = L^2/6\ t_{lag}$

$P = D_{lag} \times C_H \times F / L$

Obtain:

D_{Lag} - Diffusion constant

C_H - H conc. Just below surface

P - relative surface activity

Summary

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- **SKINR owes its existence to Sidney Kimmel, Energetics, LLC, CBS news and Rob Duncan**
- **Another ~four years to run the Institute**
- **Expected to raise more funds to prolong and expand the institute**
- **Studying both electrochemical and gas loading experiments**
- **Plan for increasing reproducibility in electrolysis experiments**
- **Mechanistic studies may lead to improved understanding of the origin of anomalous heat**
- **Extensive collaborations developed and invite more collaborators**
- **Completely open research objectives, plans and results**
- **Publication of results is an objective**

Much Optimism on the SKINR Team, and, We are having fun!

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Graham K. Hubler
Director, SKINR, Department of Physics and Astronomy, University of Missouri, Columbia, MO 65211

Abstract

The Sydney Kimmel Institute for Nuclear Renaissance (SKNIR) was established in April 2012 as an entity within the Department of Physics and Astronomy at the University of Missouri (MU) that reports directly to the Vice Chancellor for Research, Dr. Robert V. Duncan. The Institute was formed through negotiations between Dr. Duncan and Philanthropist Mr. Sydney Kimmel who provided initial 5-year funding totaling $5.5 M. The nucleus of the SKINR staff originated with the company Energetics, LLC. Energetics had carried out research since 2002 in the Anomalous Heat field. Dr. Arik El-Boher is the Group Leader running day-to-day operations.

The mission SKINR laid out by Dr. Duncan was "**to find the origin of the Anomalous Heat Effect (AHE) with a sound materials science approach and with no preconceptions as to the origin of the phenomenon. To publish findings in the open literature and to openly collaborate world wide with researchers in the field and in cross disciplines.**"

Dr. Duncan began by setting up projects with seven UM professors in the departments of Electrical Engineering, Physics, Nuclear Engineering, Missouri University Research Reactor, and Radiology. The experiments set up under Institute guidance are fundamental investigations into aspects related to the Anomalous Heat Effect. The Institute funds graduate and undergraduate students as well as several post-Docs, in addition to the SKINR staff.

This talk will review this history of SKINR, describe the SKINR facilities and experiments, and describe on-going projects with University staff and external collaborators.