Enhanced Tc Superconductivity and Anomalous Nuclear Emissions in YBCO and Palladium

Lawrence Forsley, JWK International Corp, Annandale, VA, USA
Pamela Mosier-Boss, MIT, Cambridge, MA, USA

Overview

Raison d'être
PdH HTSC
Condensed Matter Nuclear Reactions
Solid State Nuclear Track Detection using CR-39
- PdD_x System
- D_xYBCO

Questions
- Is their a relationship between metal hydride superconductivity and condensed matter nuclear reactions?
- How do we diagnose what's occurring?
- How can we scale what we observe?
  - Increased J_c and T_c for superconductivity
  - Increased nuclear emissions

Raison d'être

- PdH_x metal hydride exhibits Type II Superconductivity
  - Where $x > 1$, $T_c > 77K$
- Under high deuterium loading, D_yYBCO and PdD_z, emit nuclear particles.
  - Where $y = .2$ and $z > .86$
  - 2.5 MeV and 14.1 MeV neutrons, multi-MeV alphas, 6 – 8 MeV p^+, >12 MeV p^+
- Stabilization of highly loaded, deuterided material, has allowed the *in vacuo* manipulation of these materials that previously have only been observed at low hydrogen isotope loadings.
- Two phenomena: opposite sides of the same coin?
- What are the roles of:
  - electron screening?
  - Cooper-pairs?
  - Superfluidity?
  - Hydrogen isotope spillover?
  - Lattice defects and flux pinning?
  - Grains vs grain boundaries?
  - Surface vs. bulk effects?
  - Topology

But….

- Pd doesn't superconduct
  - PdH has a T_c of 9K
  - PdD has a T_c of 11 K (inverse mass effect)
  - Yet, at high loading, PdH shows T_c > 77K
    - *(Japanese work shows signs of room temperature superconductivity)*
- Coloumb Barrier prevents nuclear reactions due to positive nuclear charges
  - How is it overcome?

Fabrication

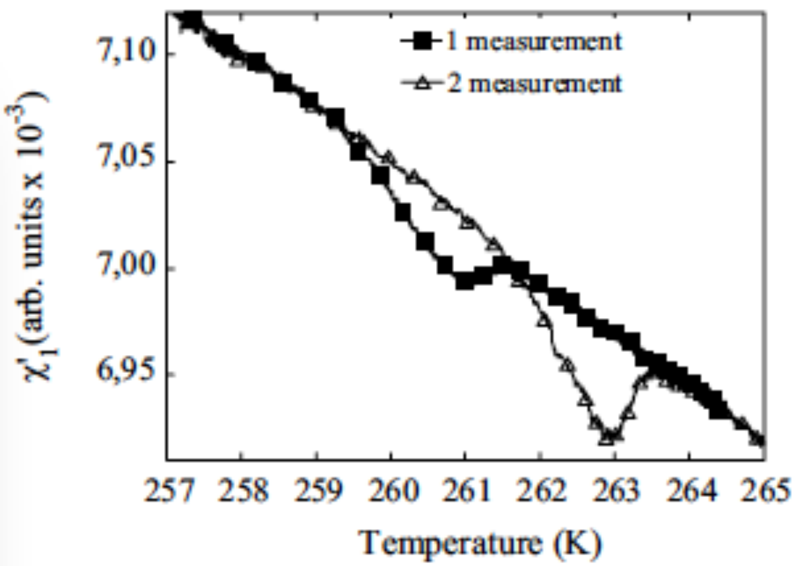
- Pd
  - Wires, foils loaded electrolytically or under high pressure gas (several bar)
  - Co-deposition electrolytically and simultaneously load Pd with H or D
    - Reduces lattice stress
    - Highly fractal surface
- D_xYBCO or H_xYBCO
  - Gas loaded

Pd:H HTSC

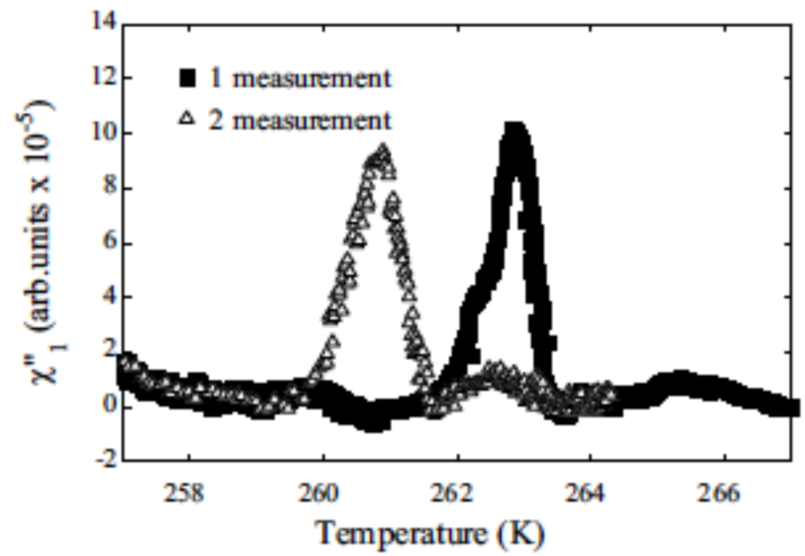
1. Tripodi, P.; “U.S. Patent No. 7,033,568” (High T_c Palladium Hydride Superconductor), (2006)
2. Tripodi, P.; Di Gioacchino, D.; Vinko, J.D., “STABILITY TEST OF HTSC PHASES IN PdH SYSTEM”, *Journal of Physics: Conference Series* **43** (2006) 690–693
3. Lipson, A.G., *et al, Phys. Rev B*. **72**, (2005) 212507
4. Lipson, A.G., *et al*. “Evidence of Superstoichiometric H/D LENR Active Sites and High Temperature Superconductivity in a Hydrogen-Cycled Pd/PdO”, *12th International Conference on Condensed Matter Nuclear Science*. 2005. Yokohama, Japan.
5. Tripodi, P.; Di Gioacchino, D.; Vinko, J.D. “Magnetic and Transport Properties of PdH: Intriguing Superconductive Observations!” *Brazilian Journal of Physics*, **34**, 3B, September, (2004).
6. Tripodi, P.; Di Gioacchino, D.; Vinko, J.D. , “Possibility of high temperature superconducting phases in PdH”, *Physica C* **388–389** (2003) 571–572
7. P. Tripodi et al., "Temperature coefficient of resistivity at compositions approaching PdH", *Physics Letters A*, **276**, pp. 122-126, Oct. 30, 2000.

Pd:H HTSC[1] AC Susceptibility

χ'



χ''



$J_c > 10^4$ A/cm^2 has been measured at 77 K with H_{DC} = 0 T.[2]

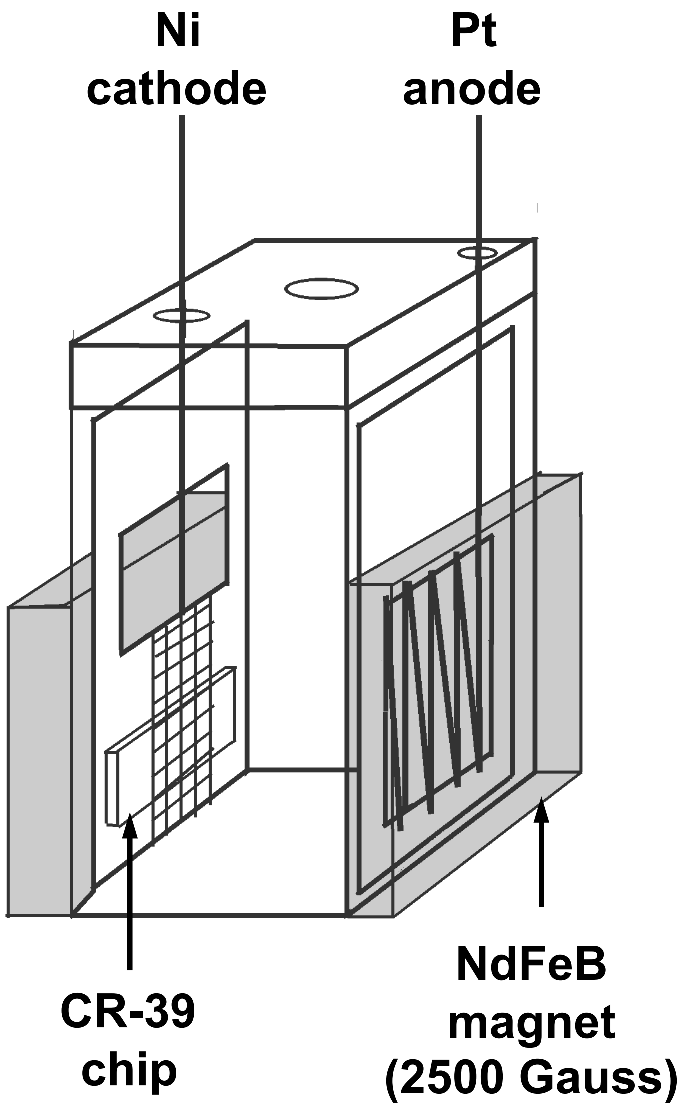
Electrolytically loaded, HgSO4 stabilized (up to two years)

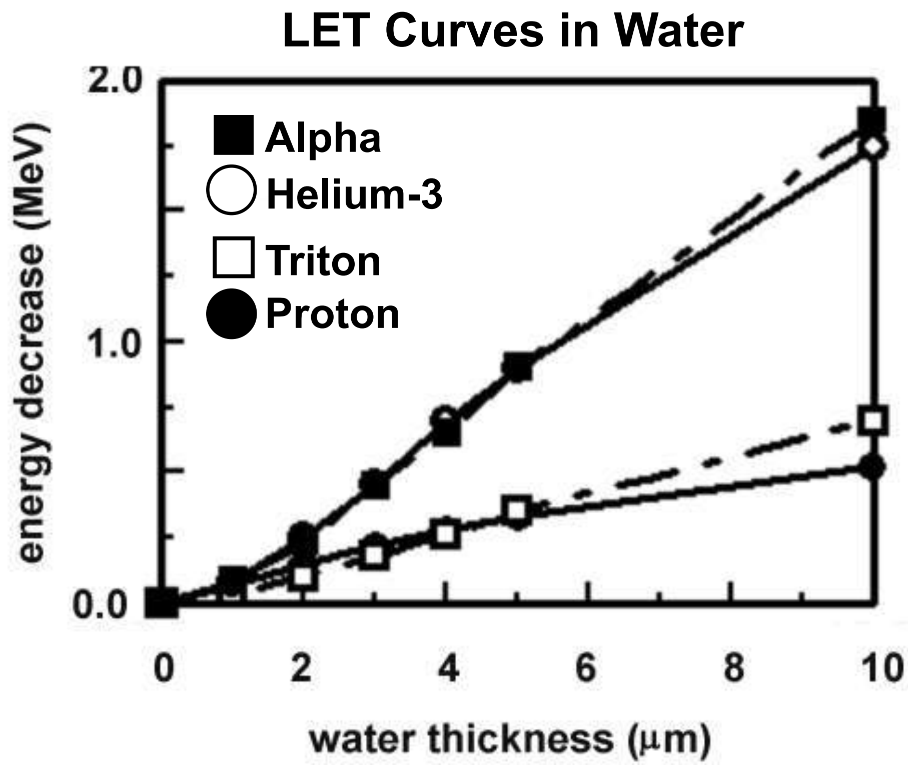
Near Room Temperature Superconductivity observed at $PdH_{1.56}$

[1]Tripodi, P.; Di Gioacchino, D.; Vinko, J.D., “STABILITY TEST OF HTSC PHASES IN PdH SYSTEM”, Journal of Physics: Conference Series 43 (2006) 690–693

[2]Tripodi, P.;Di Gioacchino, D.; Rodolfo Borelli, R; Vinko, J.D., “Possibility of high temperature superconducting phases in PdH”, Physica C 388–389 (2003) 571–572

Pd:D Co-Dep Experiment

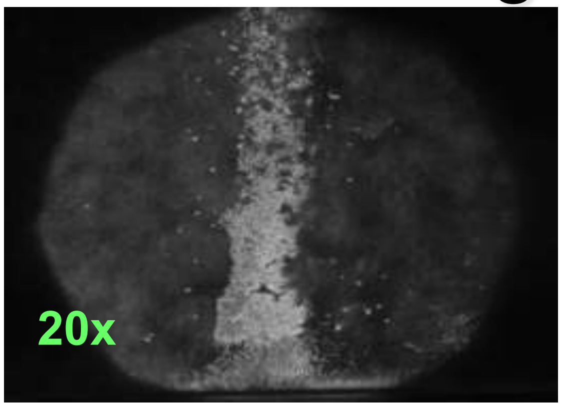


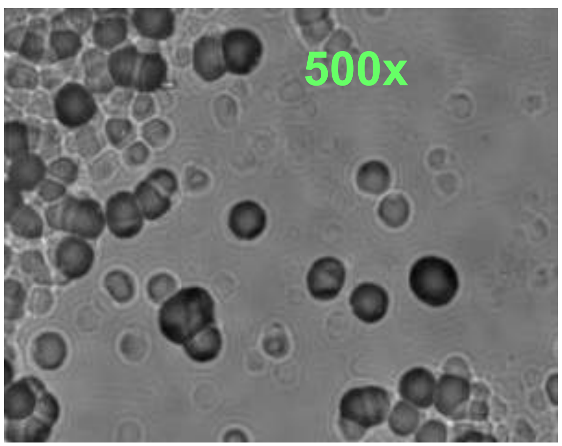


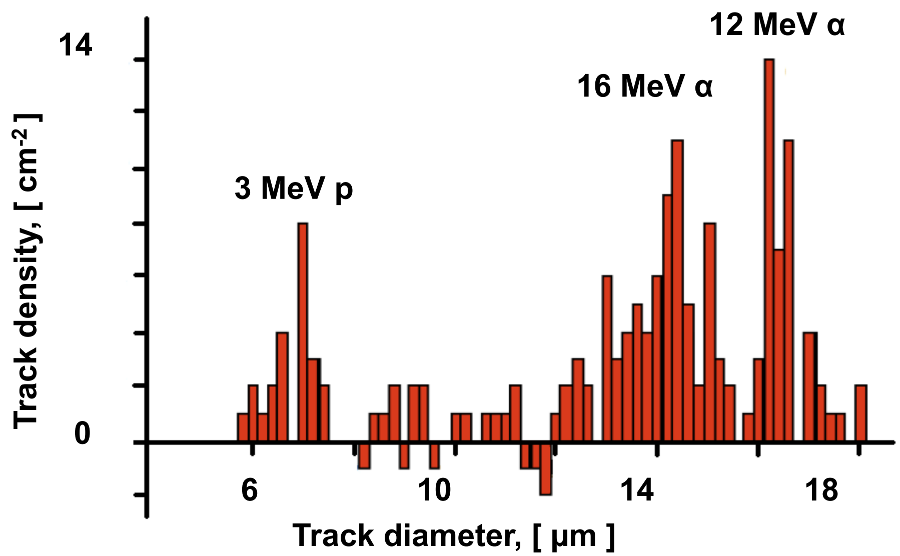
▼ CR-39 in close proximity to the cathode because high energy particles do not travel far

▼ Cathode substrates used: Ni screen; Ag, Au, Pt wires

Nuclear Particle Track Analysis: Charged Particles using CR-39







Control experiments show that the tracks are not due to radioactive contamination, impingement of the D2 gases on the detector, chemical reaction or Pd dendrites piercing into the plastic.

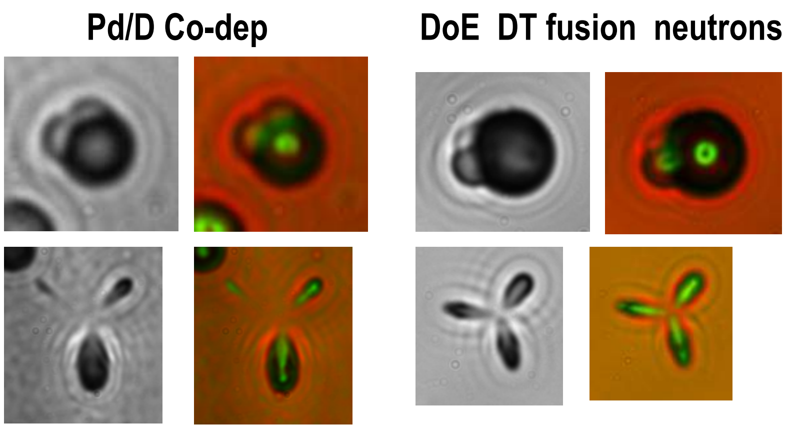
CR-39, polyallyldiglycol carbonate polymer, widely used solid state nuclear track detector

When traversing a plastic material, charged particles create ionization track sensitive to chemical etching. Etched tracks size and shape distinguish nuclear specie and energy

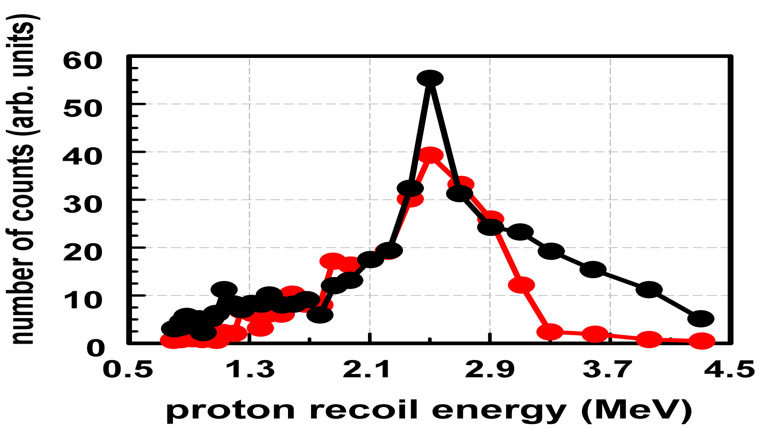
PdD Co-deposition Fast Neutrons and Charged Particles >7 nuclear channels represented

14.1 MeV DT neutrons

With DoE laboratory and NNSA funding



2.5 MeV DD neutrons

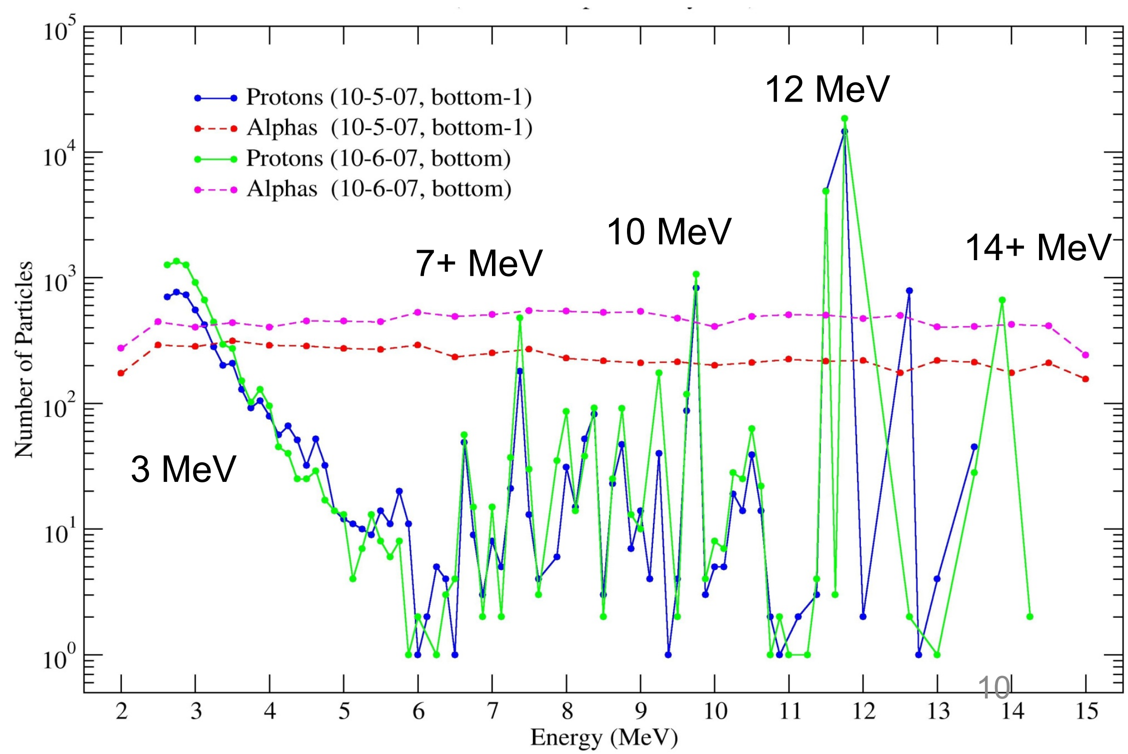


SRI replication analyzed by Dr. Lipson & Dr. Roussetski, Lebedev

Charged Particles: protons and alphas

SRI Replication of PdD co-dep protocol
LET Analysis by Dr. Zhou, NASA JSFC

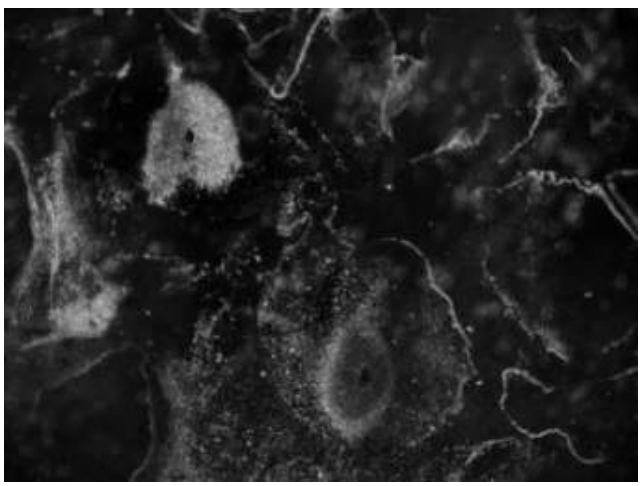
> 35,000 tracks



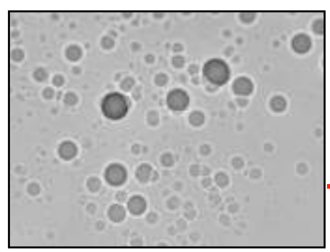
Without External B field
Ni Suppresses Nuclear Reactions in PdD

Ni/Pd-D, no external field

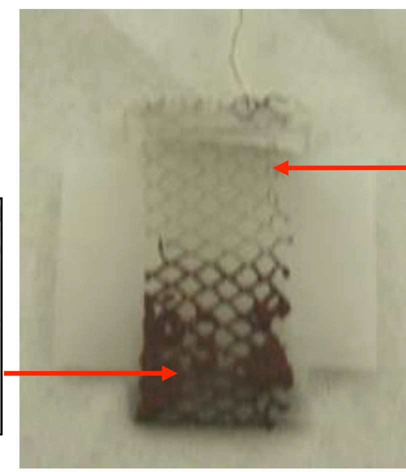
Ni/Pd-D, external B field

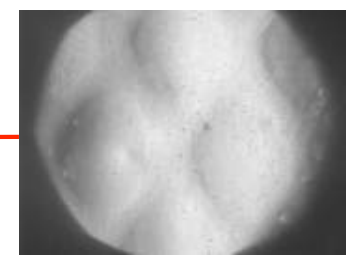


- Ni screen cathode with PdD Co-dep requires external E/B field to produce nuclear tracks
- Ag, Au or Pt wire cathodes produce nuclear tracks with or without external E/B field
- Ni Screen cathode, ½ with Au electrolyis deposition
  - Au surface -> nuclear tracks
  - Ni surface -> no tracks
  - Ferromagnetic Ni Suppresses nuclear reaction in PdD



Tracks





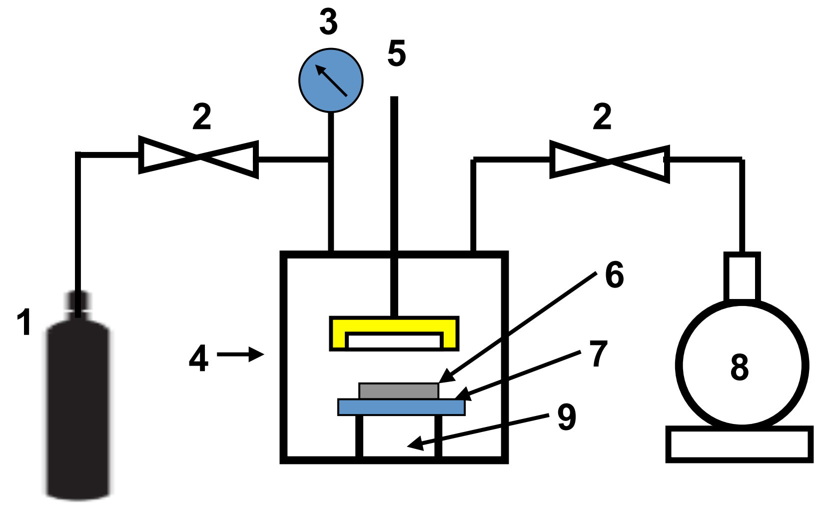
No tracks

Deuterided $YBCOD_x$ Exhibits Nuclear Effects

- Jin *et al.* report 3×10^5 tracks/cm2 in room temperature YBCO
- Lipson, *et al.* report DD fusion neutron recoil and charged particle tracks[2,3]

[1]Jin, *et al*,"YBCO High Temperature Super-conductor", EPRI. Proceedings: Fourth International Conference on Cold Fusion Volume 3: Nuclear Measurements Papers, TR-104188-V3. 1994. Lahaina, Maui, Hawaii: Electric Power Research Institute.
[2] Lipson, A.G.; Sakov, D.M.; Lyakhov, B.F.; Deryagin, B.V., "Neutron generation in high temperature superconductors YBa2Cu3O(7-delta)D(y) stimulated by the superconducting phase transition", *Rossijskaya Akademiya Nauk, Doklady* (ISSN 0869-5652), **329**, no. 3, p. 296-299.
3. Lipson, A.G., *et al*., "Generation of the products of DD nuclear fusion in high-temperature superconductors YBa2Cu3O7-deltaDy near the superconducting phase transition." *Tech. Phys.*, **40** (1995) p. 839.

YBCO HTSC Nuclear Emissions[1]

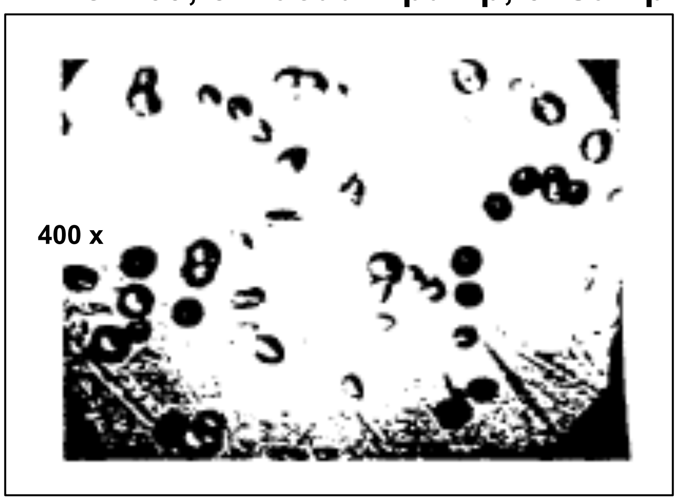


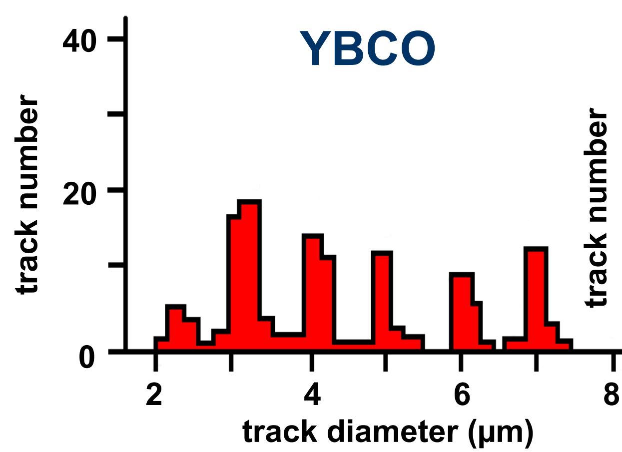
1. D_2 gas cylinder; 2. Valves; 3. Vacuum gauge; 4. Vacuum chamber; 5. SSB; 6. YBCO sample; 7. CR-39; 8. Vacuum pump; 9. Sample frame

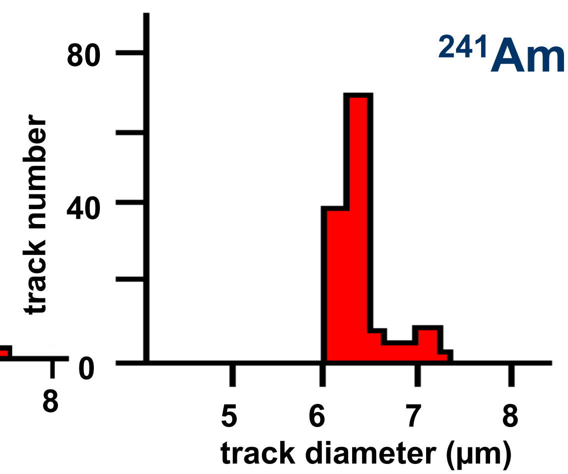
▼ $Y_1Ba_2Cu_3O_{7-\delta}$ absorbs hydrogen. Structural analysis shows absorbed H is located on the Cu-O surface

▼ Photo shown of tracks in CR-39. Track density (minus bkg) was **~ $3 \times 10^5/cm^2$**

▼ Size distribution for vertically incident tracks from D_xYBCO and ^{241}Am (perfectly circular tracks),

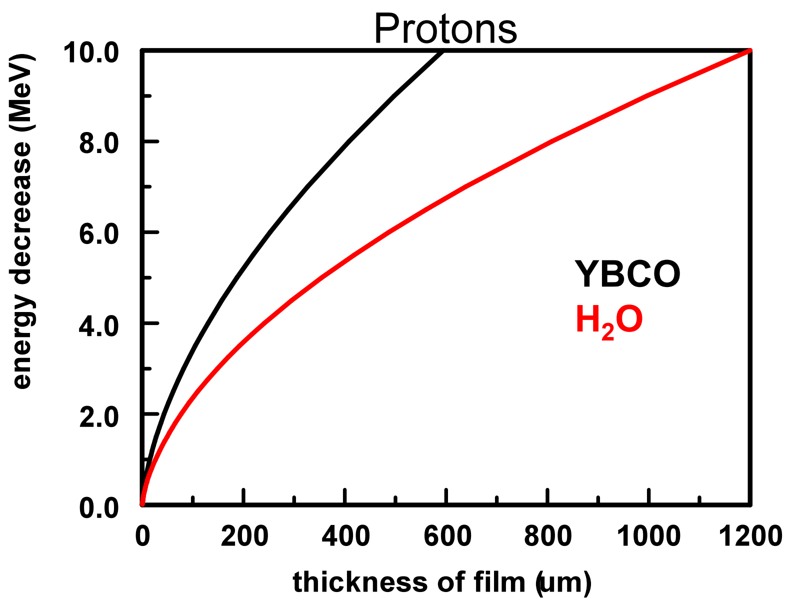


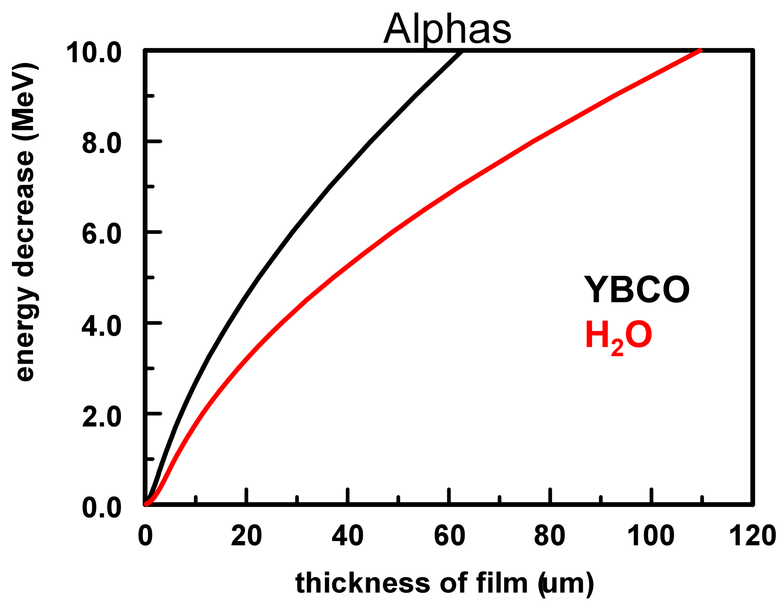




[1] Jin, *loc cit*

LET Curves





Significant energy is lost traversing the YBCO:

p+ loses 4 MeV in <120 um

alpha loses 4 MeV in < 20 um

Conclusion

- PdH and YBCO are recognized HTSC
  - High hydrogen loading in PdH has anomalously high Tc
- PdD and YBCOD produce charged particles and neutrons
  - Observed with solid state nuclear track detectors (SSNTD)
- PdD HPGe damage and SSNTD
  - At least 7 nuclear channels observed
  - 2.5 MeV and 14.1 MeV neutrons
  - Protons up to 14 MeV
  - Alphas up to 16 MeV

Questions

- What is the relationship between HTSC in these two systems and nuclear reactions occurring within:
  - the deuterided Pd lattice
  - deuterided CuO planes ($YBCOD_x$)
- What is the role of:
  - Increased PdD, PdH and YBCODx given lattice expansion?
  - Can hydrided HTSC increase T_c through lattice compression?

Acknowledgements

- Dr. Jenny D. Vinko, H.E.R.A.
- Dr. Paolo Tripodi, H.E.R.A.
- Dr. Andrei Lipson
- Dr. George Miley

Thanks…

- Mitchell, Gayle and Peter, for this, and all the previous Colloquia, and especially this year, on the 25th anniversary of Martin's and Stan's prophetic though (and, not by their doing) premature announcement.