Status of frozen−spin polarized HD targets for spin experiments*

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T. Kageya[4], C.M. Bade[3], A. Caracappa[1],
F. Lincoln[1], M.M. Lowry[1], J. Mahon[3]
L. Miceli[1], A.M. Sandorfi[1], C.E. Thorn[1]
X.Wei[1], C.S. Whisnant[2]

1. Brookhaven National Lab., Upton, NY 11973, USA
2. James Madison University, Harrisonburg, VA 22807, USA
3. Ohio University, Athens, OH 45701, USA
4. Virginia Polytechnic Institute and State University, Blacksburg, VA 24061, USA

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Motivation

Nucleon Spin Sum Rules

- Gerasimov−Drell−Hearn

$$-\frac{\alpha}{2m^2}\kappa^2 = \frac{1}{4\pi^2}\int_{m_\pi}^{\infty}\frac{\sigma_{1/2}-\sigma_{3/2}}{E_\gamma}dE_\gamma$$

  - Nucleon spin strucure at $Q^2=0$
  - LEGS covers ~65%
  - Measurement down to pion threshold is important

- Forward Spin−Polarizability

$$\gamma_0 = \frac{1}{4\pi^2}\int_{m_\pi}^{\infty}\frac{\sigma_{1/2}-\sigma_{3/2}}{E_\gamma^3}dE_\gamma$$

  - Test of chiral perturbation theories
  - LEGS covers ~90%
  - Measurement down to pion threshold is important

Multipole Amplitudes

- Double polarization observables
  - Asymmetries E and G
  - Neutron channels $\pi^o n$ and $\pi^- p$

LEGS−Spin Collaboration

- Brookhaven National Laboratory
  - *C. Cacace, A. Caracappa, S. Hoblit, O.C. Kistner, A. Kuczewski, F. Lincoln, M. Lowry, L. Miceli, A.M. Sandorfi, C. Thorn, X. Wei*
- James Madison University
  - *A. Lehmann, C.S. Whisnant*
- Norfolk State University
  - *M. Khandakar*
- Ohio University
  - *K. Ardashev, C. Bade, R. Deininger, K. Hicks, M. Lucas, J. Mahon*
- Syracuse University
  - *A. Honig*
- Universita di Roma II − Tor Vergata
  - *A. D'Angelo, A. d'Angelo, R. Di Salvo, D. Moricciani, C. Schaerf*
- Universitè de Paris − Sud, ORSAY
  - *C. Commeaux, J.−P. Didelez*
- University of South Carolina
  - *I. Danchev, C. Gibson, B.M. Preedom*
- University of Virginia
  - *A. Cichocki, B. Norum, K. Wang*
- Virginia Polytechnic Institute & State University
  - *M. Blecher, T. Kageya, H. Meyer, T. Saitoh*

LEGS (Laser Electron Gamma Source) GDH experiments

1. Compton backward−scattered polarzied γ beam

   $0.15 < E\gamma < 0.47$ GeV

   $P\gamma \sim 90\ \%$

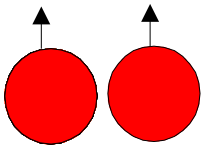
2. 4π detector

   $(\sigma_{1/2} - \sigma_{3/2})/ E\gamma$;

   Total cross sections

3. Polarized HD solid target

H_2 molecule

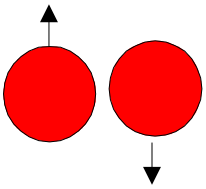


Ortho

I = 1

L = 1

Can be polarized



Para

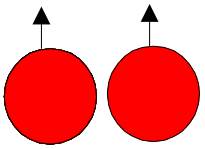
I = 1

L = 0

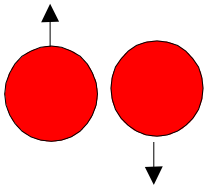
Cannot be polarized

Conversion

at low temp

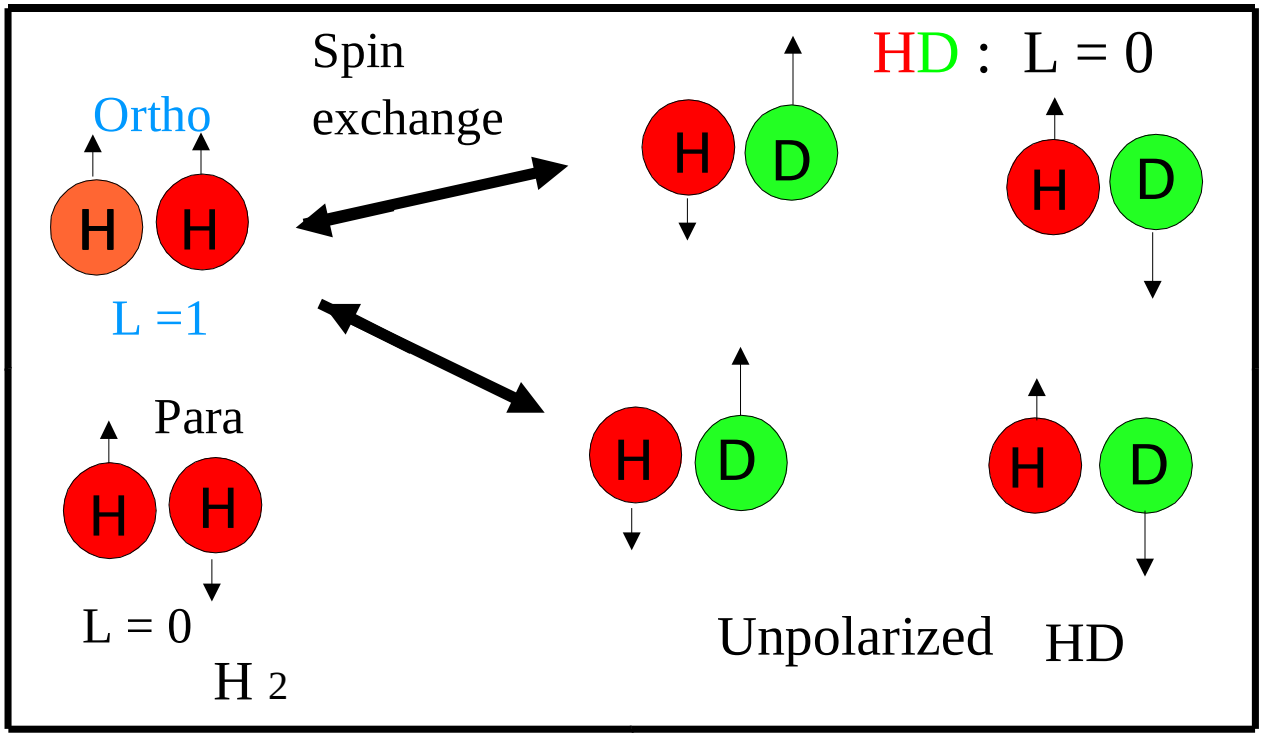


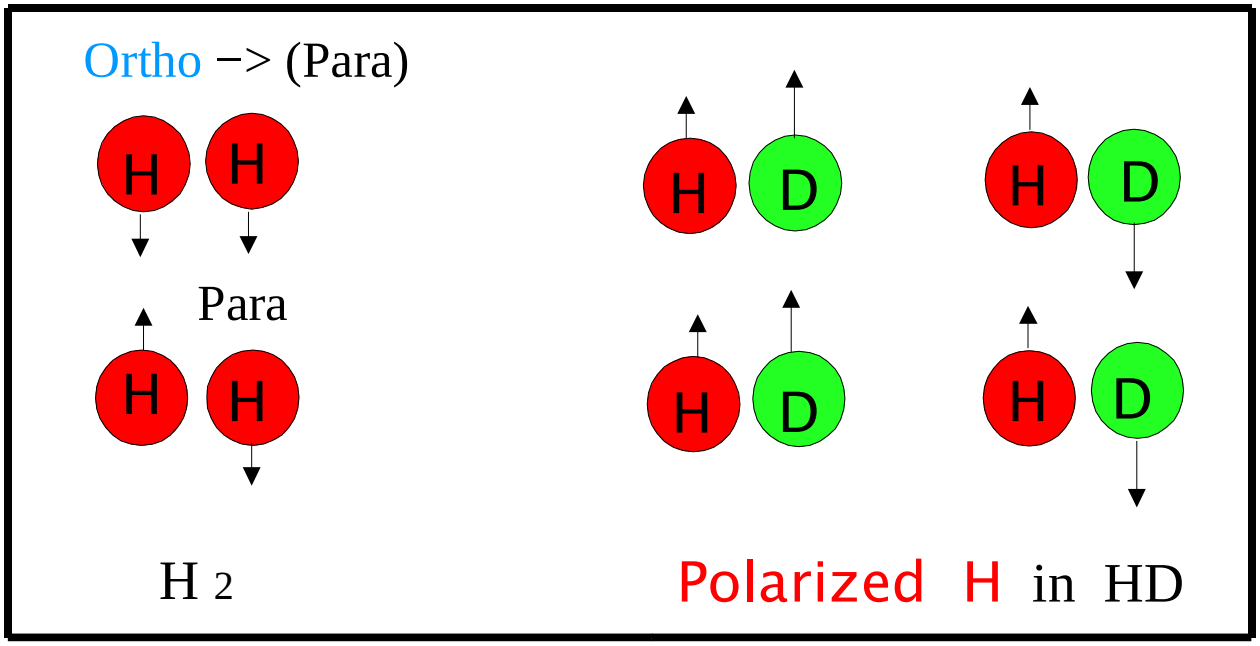
Ortho



Para

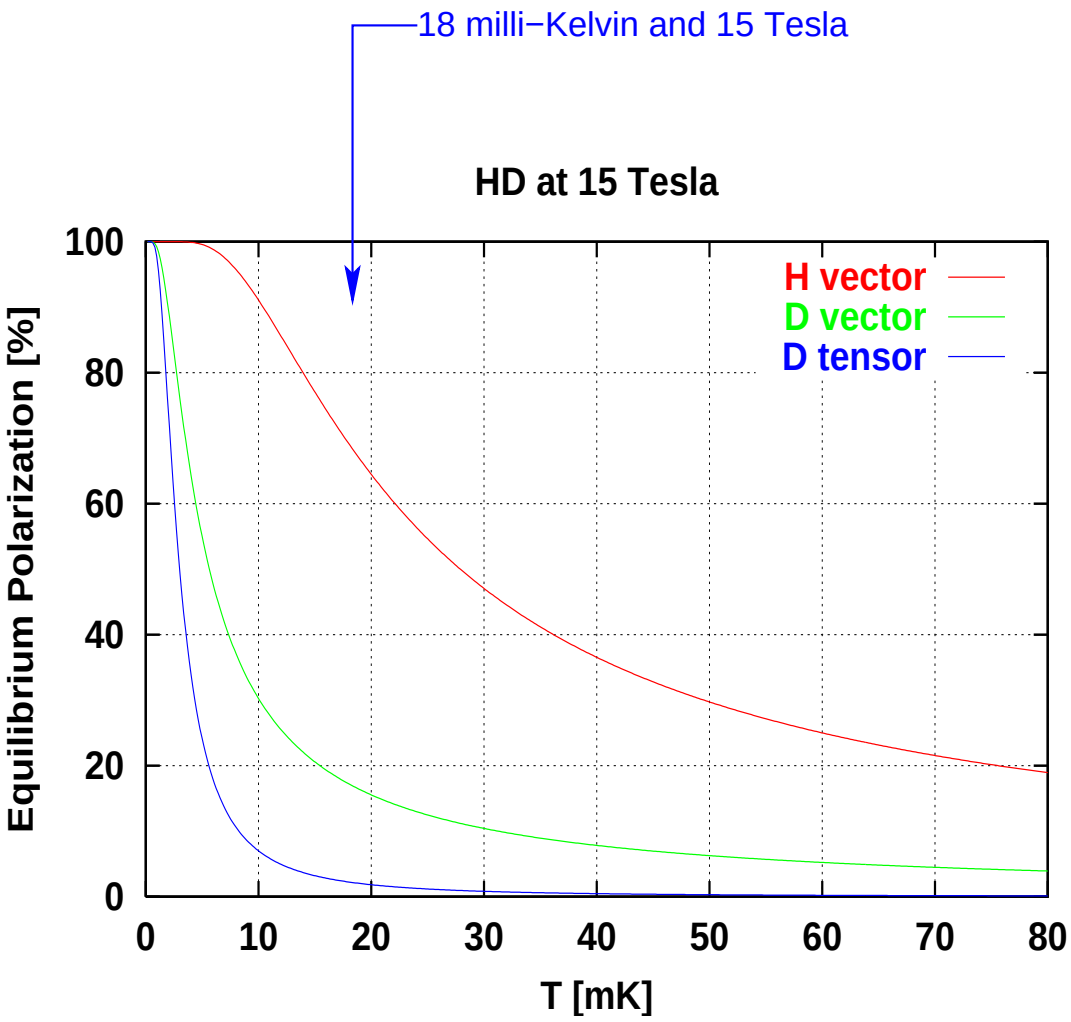
Polarize H in HD using polarized ortho $-H_2$



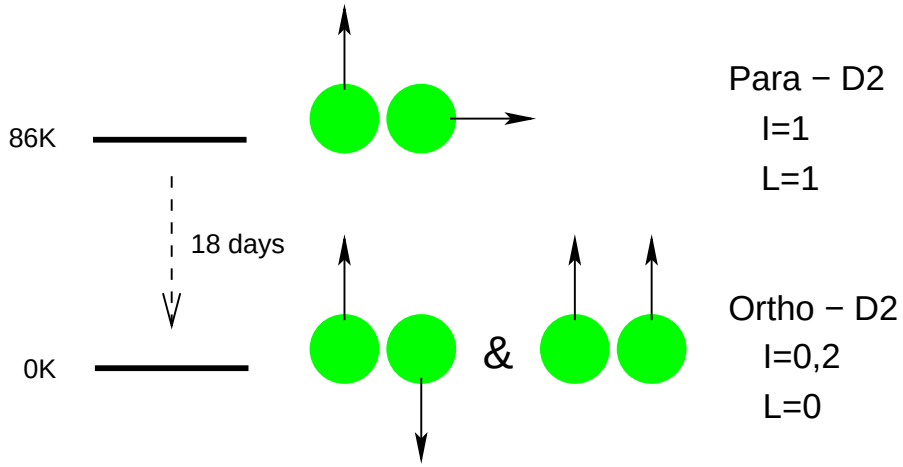


No spin exchange to HD (Frozen Spin)

Expected Polarizations



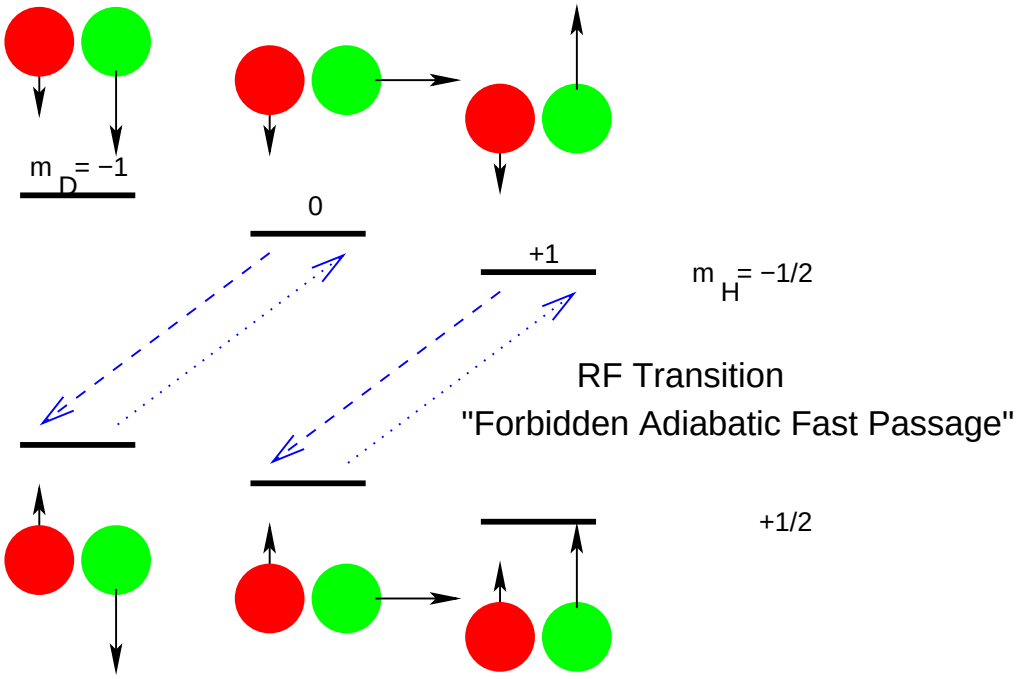
Deuterium Molecular Physics



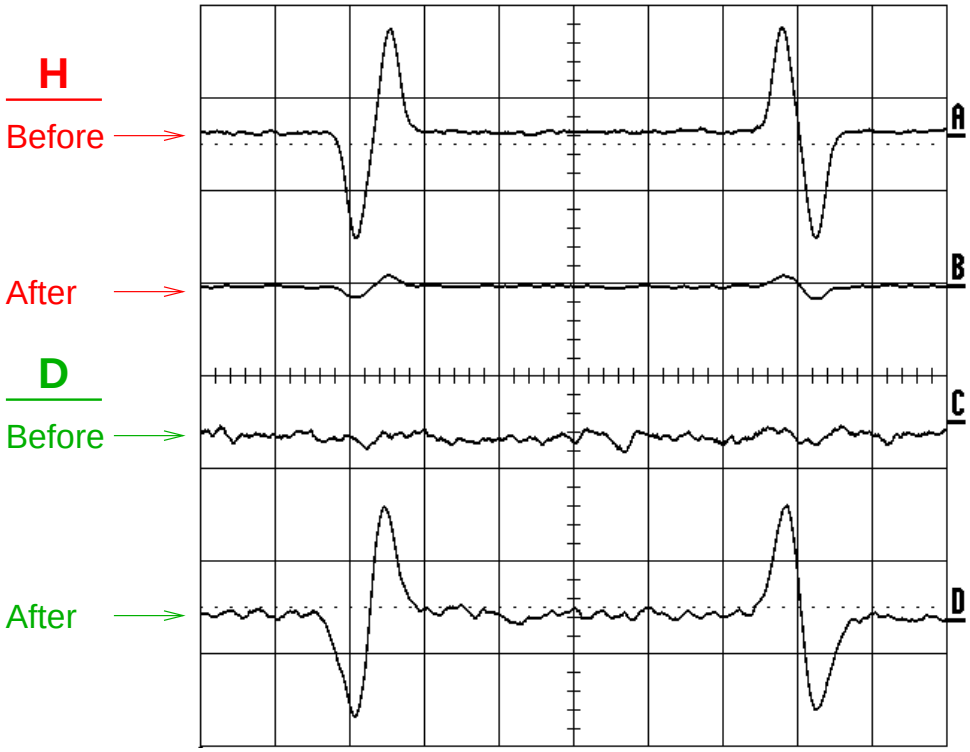
D Problem: Equilibrium Polarization low

Use FAFP to transfer from H

HD Crystal Physics

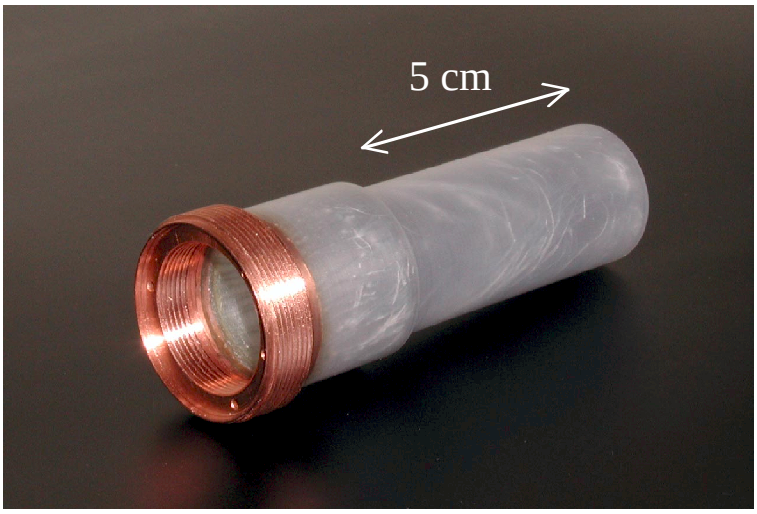


Forbidden Adiabatic Fast Passage

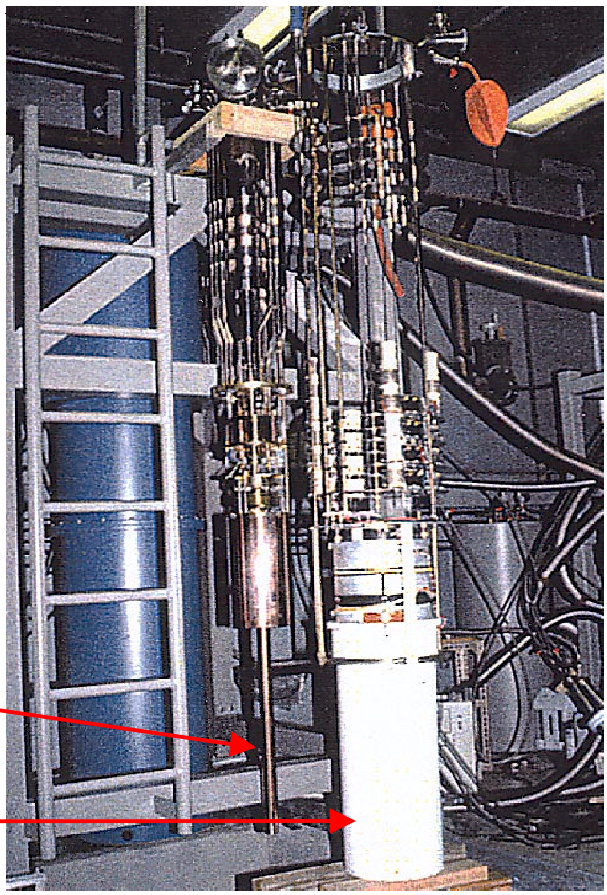


Efficiency of transfer = 67%

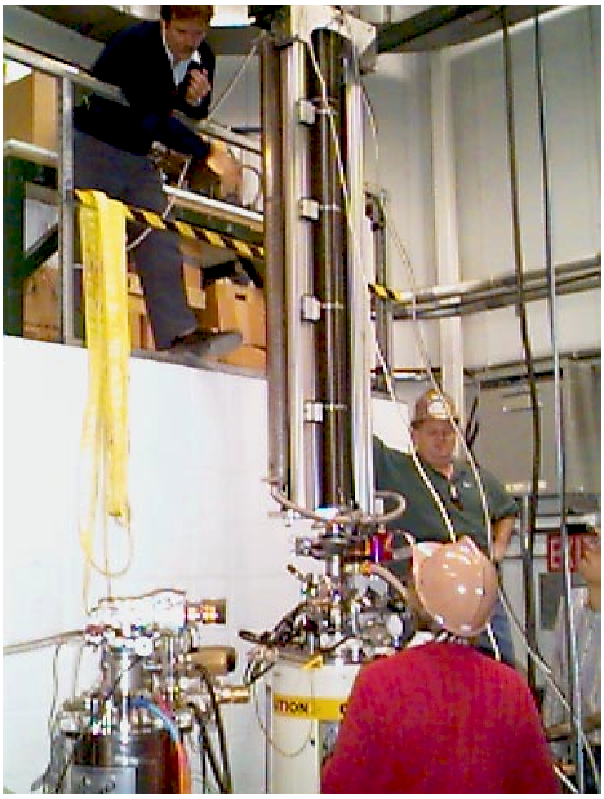
HD target cycle:



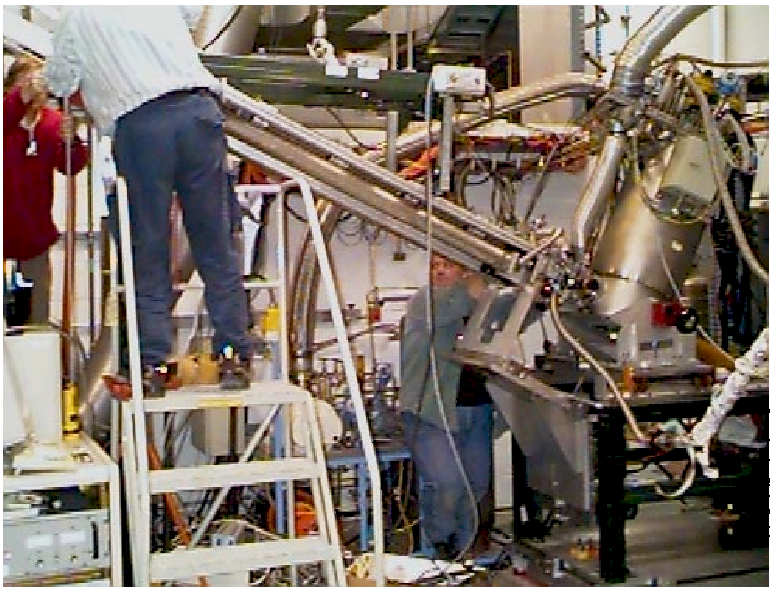
target injection into dilution fridge;
~50 to 100 days at 15 Tesla / 18 mK

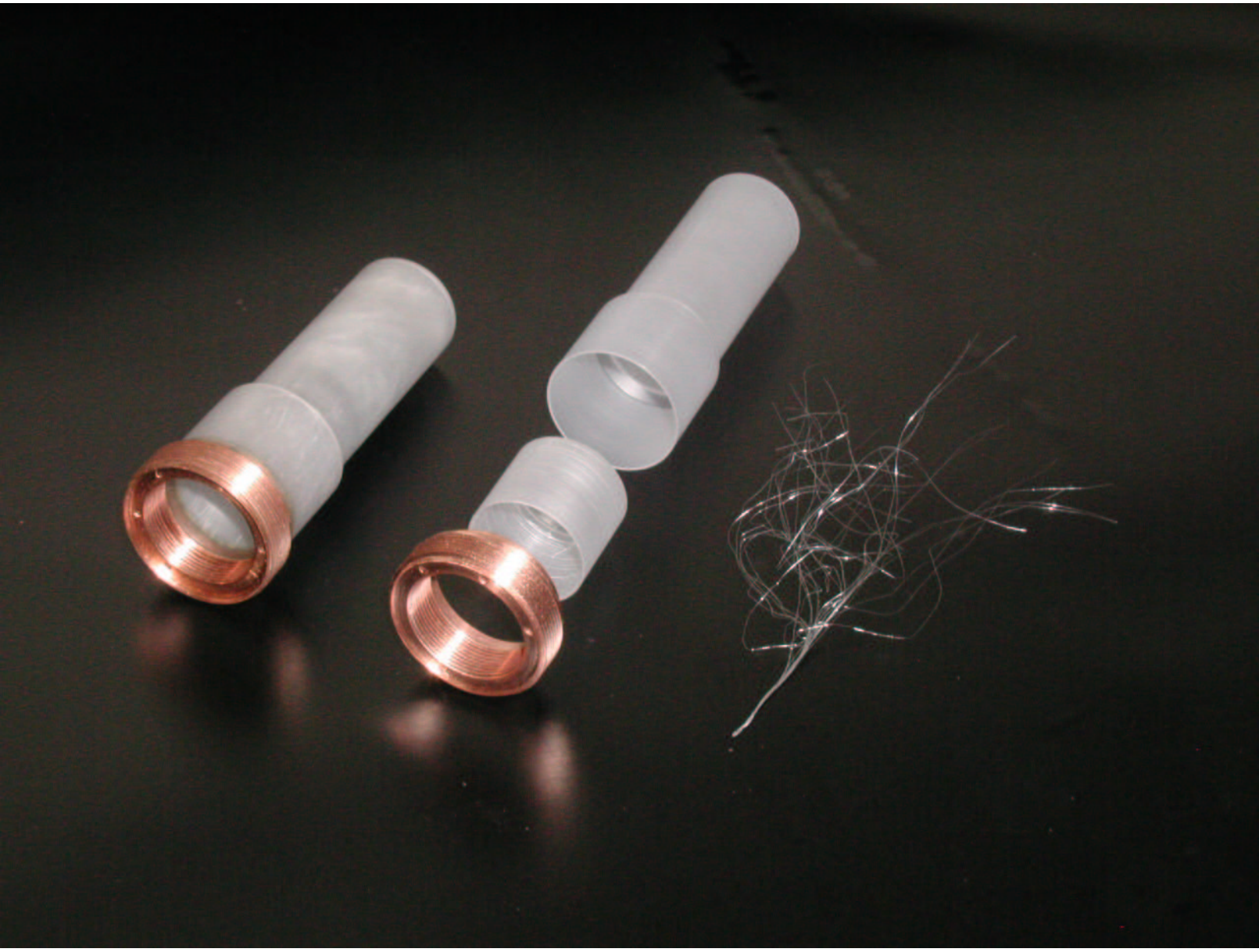


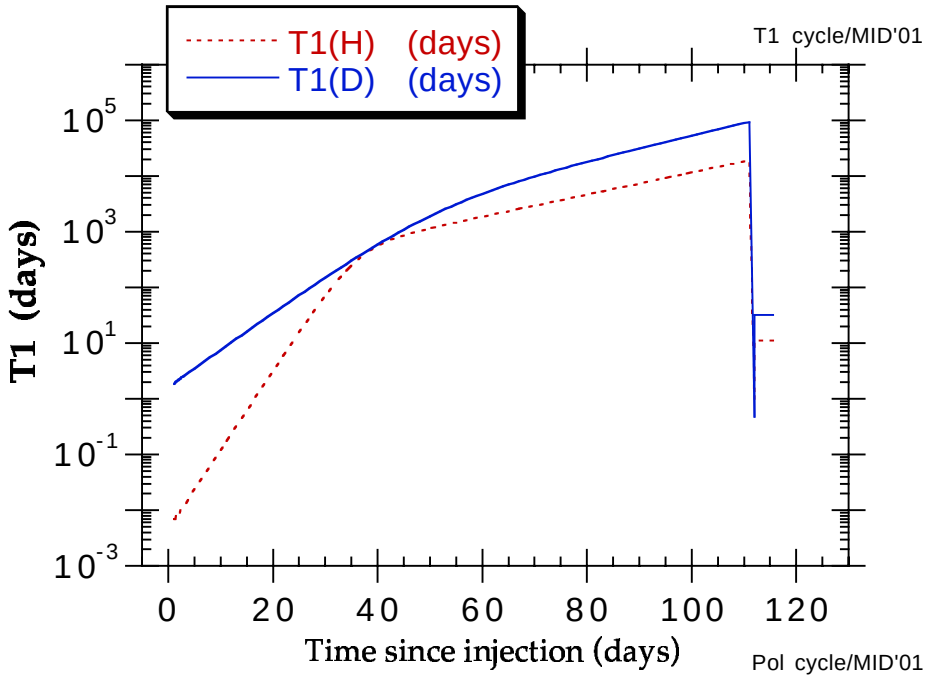
extraction at 2.5°K and 0.016 T

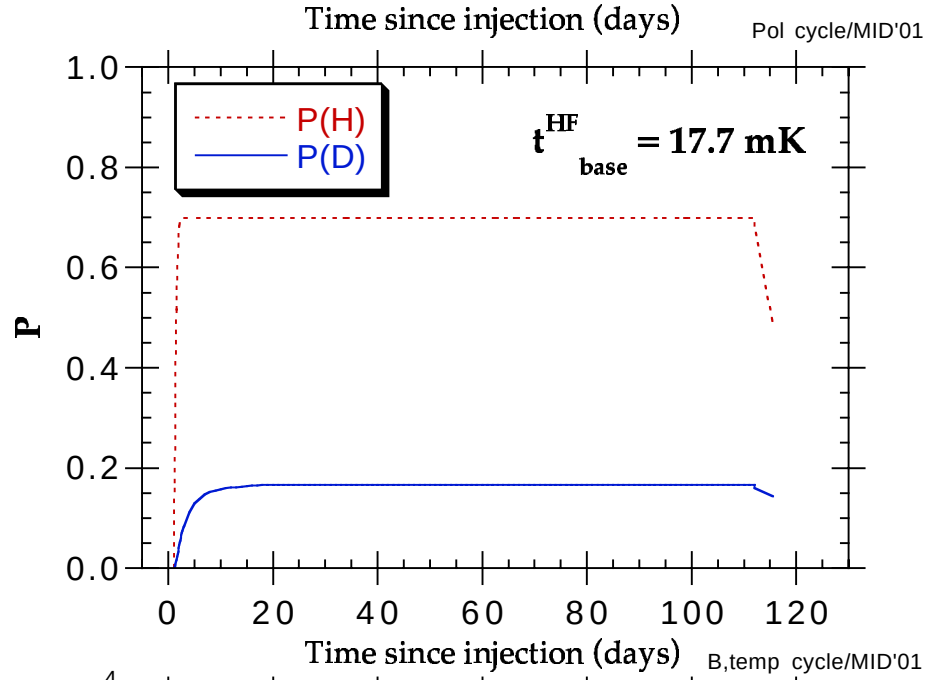


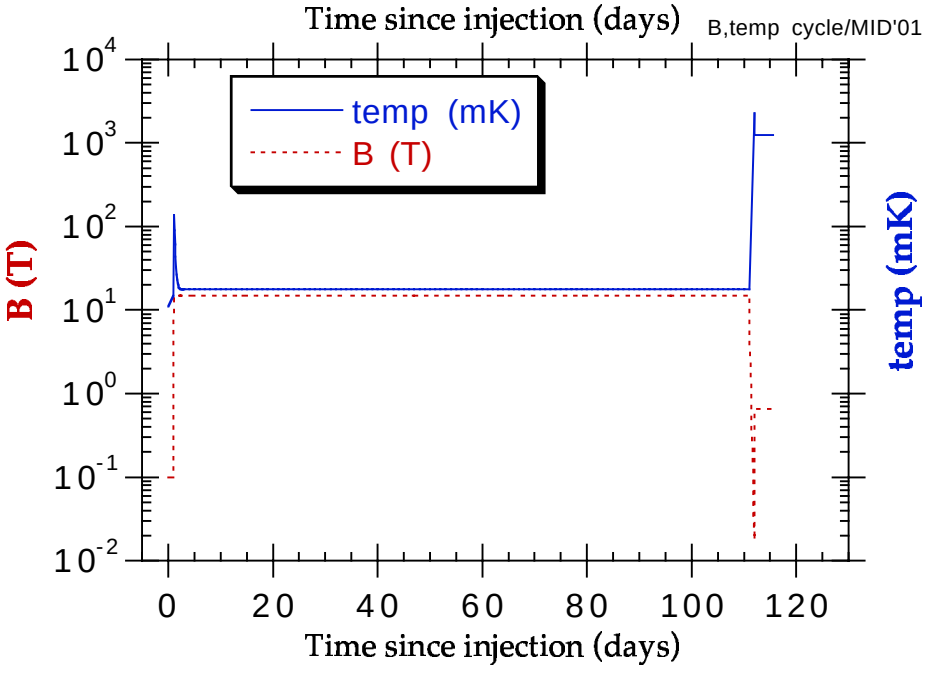
loading in-beam cryostat
(1.25°K and 0.7 Tesla)

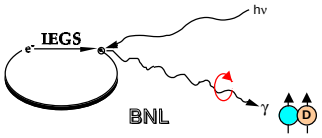





T1(H) (days)
T1(D) (days)
T1 cycle/MID'01
T1 (days)
Time since injection (days)

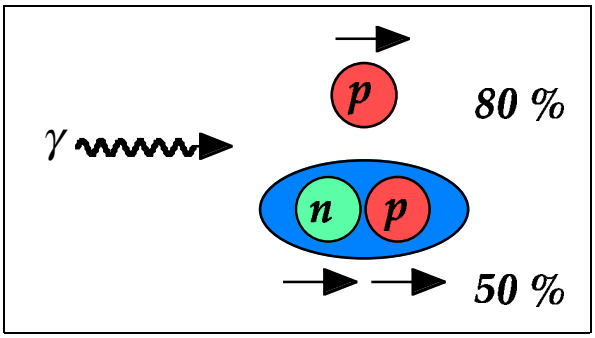

Pol cycle/MID'01
P(H)
P(D)
t^{HF}_{base} = 17.7 mK
P
Time since injection (days)

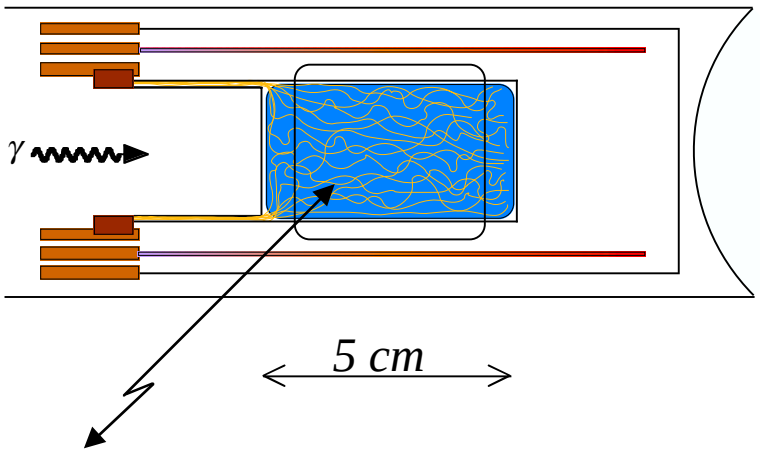

B,temp cycle/MID'01
temp (mK)
B (T)
B (T)
temp (mK)
Time since injection (days)



Strongly Polarized Hydrogen-deuteride ICE (SPHICE)

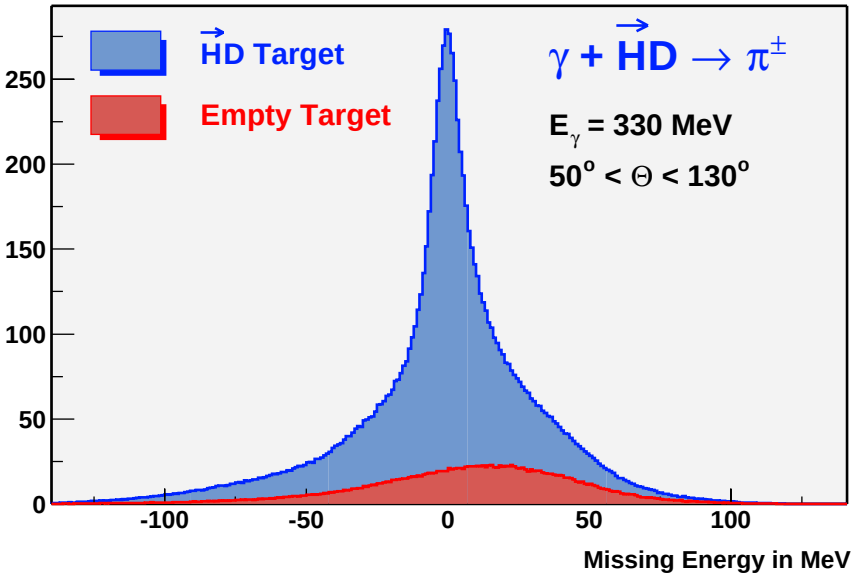
a new class of frozen-spin target for photonuclear experiments





3 gm solid HD + 20% Al by weight

(2050 × 50 μm wires)



Polarization

	P_H	P_D
Sept'01	70 %	17 %
Nov'01	30 %	6 %
goal	80 %	50 %

in-beam spin-relaxation

	T_1^H	T_1^D
Nov'01 (1.3°)	13 d	36 d
goal (0.2°)	>30 d	>100 d

Recent Progress and Plan

(1) Improve DF performance at High Field

Vibration isolation from pumping line

– reduce eddy current heating

D polarization –> 22 %

(2) Forbidden Adiabatic Fast Passage at DF

Install resonance coils in DF

D polarization –> Goal > 50 %

(3) Modifying NMR system

(4) A couple of months run for Deuteron in 2002 and 2003

Future Plans

Two new cryostats:
designing, to be fabricated, tested and installed

(1) IBC (Orsay) −−> New IBC (Quantum tech.)

1.3 K → 0.2 K

0.65 Tesla → 1 Tesla

At least twice the relaxation time

(fabricated by mid 2003)

(2) TC (Orsay) −−> New TC (BNL/Juelich)

0.016 Tesla → 0.16 Tesla

Reduce polarization losses during target transfers

(fabricated by mid 2003)