How to Use UITF

Irradiation of Polarized Target Materials

Chris Keith
Target Group

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Irradiation of Polarized Target Materials

- Solid ammonia (NH_3 and ND_3) is the most frequently utilized polarized target material at JLab
- Used in all three halls during 6 GeV era, and intended for use in multiple, approved experiments in A, B, & C at 12 GeV.
- For successful *dynamic* polarization, the sample must receive a dose of ionizing radiation (creates $\dot{N}H_2$ radicals)

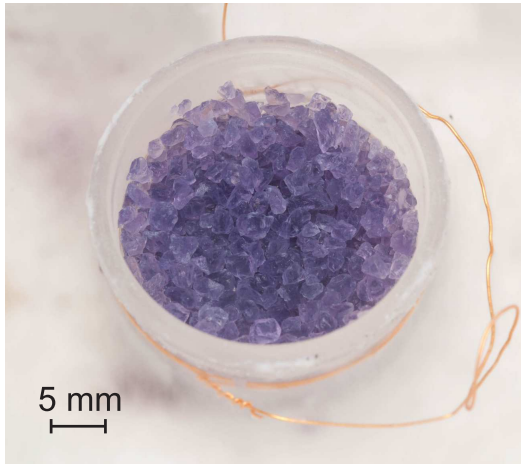
- The optimum dose is about 10^9 Rad, or $3 \cdot 10^{16}$ e^-/cm^2
  - This is 1.3 hr/cm^2 at 1 μA

- A typical 25 g sample size for irradiation

might be 5 cm dia. x 2 cm long

  - 24 hrs @ 1 μA (or 2 ½ hrs @ 10 μA)

Heretofore, all ammonia samples were irradiated and provided by Don Crabb at UVa, but he's retired now…



Irradiation of Polarized Target Materials

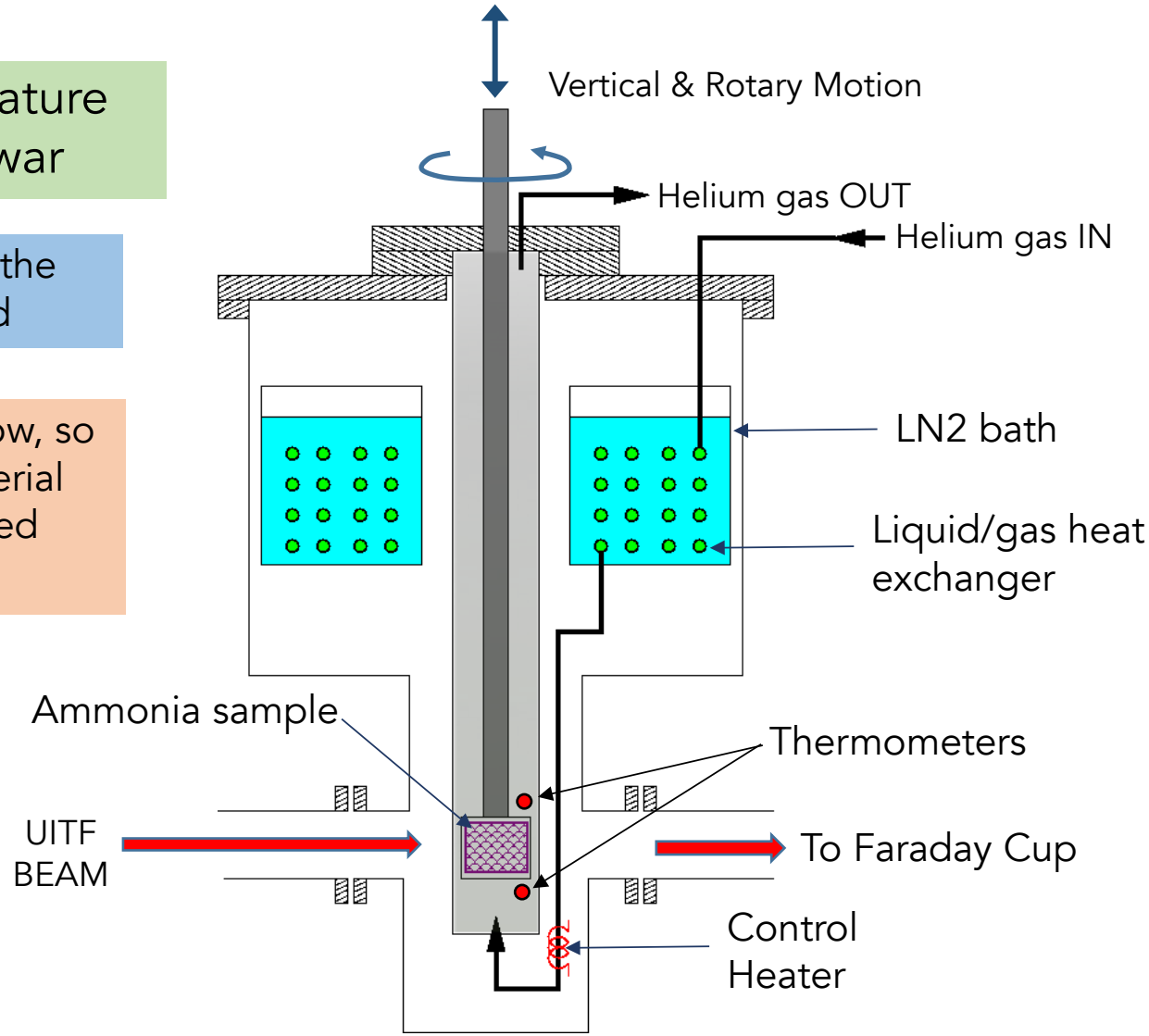
- Ammonia freezes at 196 K, and the $N\dot{H}_2$ radicals recombine at ~130 K, so the irradiation has to be performed at cryogenic temperatures, usually under liquid argon (90 K).
- In addition to ammonia, other polarized target materials can be prepared by electron-irradiation:
  - LiH and LiD
  - Butanol and propanediol
  - Polystyrene and PMMA
  - Nuclear targets (^{19}F, ^{23}Na…)?
- Different materials may benefit from irradiation at different temperatures (e.g. LiH @ 180K), so a variable temperature cryostat is desirable.

Irradiation of Polarized Target Materials

Variable Temperature Irradiation Dewar

Either the beam, or the sample is rastered

The beam energy is low, so all unnecessary material should be minimized (windows, etc)



What about DNP of HDice?

DNP of irradiated solid HD was tried once before, in 1973.

- ~3% polarization;
- Poor sample quality
- Low field, 1.3 T
- Modest temperature, 1.5 K

This is the perfect time and place to try it again.

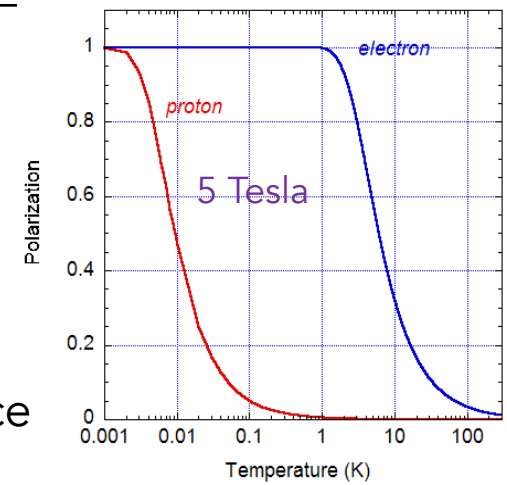
- High quality HD
- 5 T field (FROST Solenoid)
- Lower Temperature, < 0.5 T
- Experts in both fields
- ➢ We only need to add microwaves to the HDice cryostat…

- BACK-UP SLIDES -

Dynamic Nuclear Polarization in a Nutshell

Unpaired electrons are implanted in the target sample and polarized at low temperature and high field.

eg At 1K and 5 T: $P_e \sim 100\%$, $P_p < 1\%$



Microwaves near the electron resonance frequency induce a simultaneous electron-proton "flip-flop" (or "flip-flip")

- The electron quickly relaxes back to its original, polarized ground state
- The proton relaxes slower, stays in its new spin state