How to Use UITF

Irradiation of Polarized Target Materials

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**IRRADIATION OF POLARIZED TARGET MATERIALS**

- Solid ammonia (NH₃ and ND₃) 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 NH₂ radicals).

  - The optimum dose is about 10⁹ Rad, or 3·10¹⁶ e⁻/cm²
    - This is 1.3 hr/cm² 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…
Ammonia freezes at 196 K, and the NH$_2$ 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)

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Vertical & Rotary Motion

Helium gas OUT

Helium gas IN

LN2 bath

Liquid/gas heat exchanger

Ammonia sample

UITF BEAM

To Faraday Cup

Control Heater

Thermometers
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…
IRRADIATION OF POLARIZED TARGET MATERIALS

- 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. 

\[ P_e \approx 100\%, \ P_p < 1\% \]

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