Polarization of Nuclei

Materials that can be polarized by DNP

List of Possible Materials

Nucleus	Spin	Mag. Moment	Abundance (%)
^{6}Li	1	0.882	7.4
^{7}Li	3/2	3.256	92.6
^{9}Be	3/2	-1.177	100
^{10}B	3	1.801	19
^{11}B	3/2	2.688	81
^{13}C	½	0.702	1.1
^{14}N	1	0.403	99.635
^{15}N	½	-0.283	0.365
^{17}O	5/2	-1.893	0.037
^{19}F	½	2.628	100
Note:			
^{1}H	½	2.793	99.986
^{2}H	1	0.857	0.014
^{3}H	½	2.979	-----
^{3}He	½	-2.127	10^{-4}

Comments

General:

- Low natural abundance -> expensive
- Low magnetic moment -> low polarization
- For past experiments mostly interested in compounds with high dilution factors for protons.
- Polarization typically proportional to B/T → $P = \tanh[uB/kT_S]$

For DNP: need to add paramagnetic centers; Chemical or irradiation doping depending on material phase

Handling: Some materials toxic or dangerous. Make "inert" compounds eg LiF.
However compounds can be dangerous, eg NH_3 (toxic), BH_3 (explodes on contact with air). Further step -> Borane ammonia (BH_3NH_3) polarizable solid.

- **Fluorine**

  Compound = LiF. Solid, Radiation doped

  P_{Li} = 60%, P_F = 80%   T = 0.7 K, B = 5.5 T

- **Oxygen**

  No data

- **Nitrogen**

  Compound = NH_3 (or ND_3), Gas, Radiation doped

  P (^{14}N, ^{15}N) ~ 20% for proton = 95%

  T ~ 1K, B = 5 T

- **CARBON**

  Compound –various, ^{13}C enhanced, Gas, liquid, TEMPO, EHBA doped. P (^{13}C) ~ 45 % at T ~1 K, B = 5T

- **Boron**

  Compound – Borane ammonia, Ethyl-amine-borane-ammonia Polarized hydrogen in these compounds, but no measurement of B polarization.

- **Beryllium**

  No data

- **Lithium**

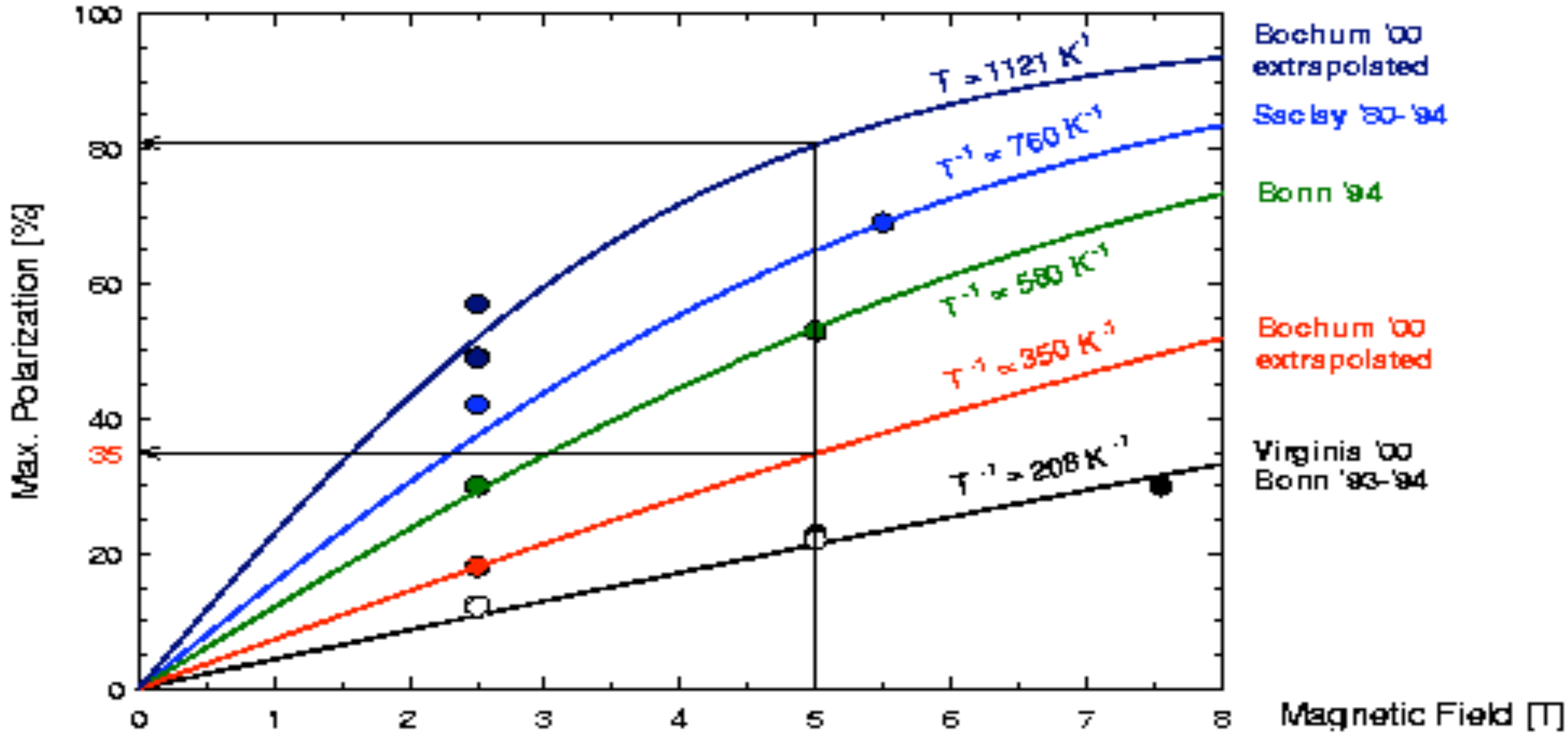
  Metal: skin depth for 140GHz is sub-micron therefore particle size needs to be prohibitively small.

  Compounds: ^{6}LiH, ^{6}LiD, ^{7}LiH, ^{7}LiD, LiF

  ^{6}LiD measured over a range of field and temperature

  $P(^{6}Li) \sim P(d)$

Inverse Spin Temperatures of the ^{6}LiD World Pol. Data



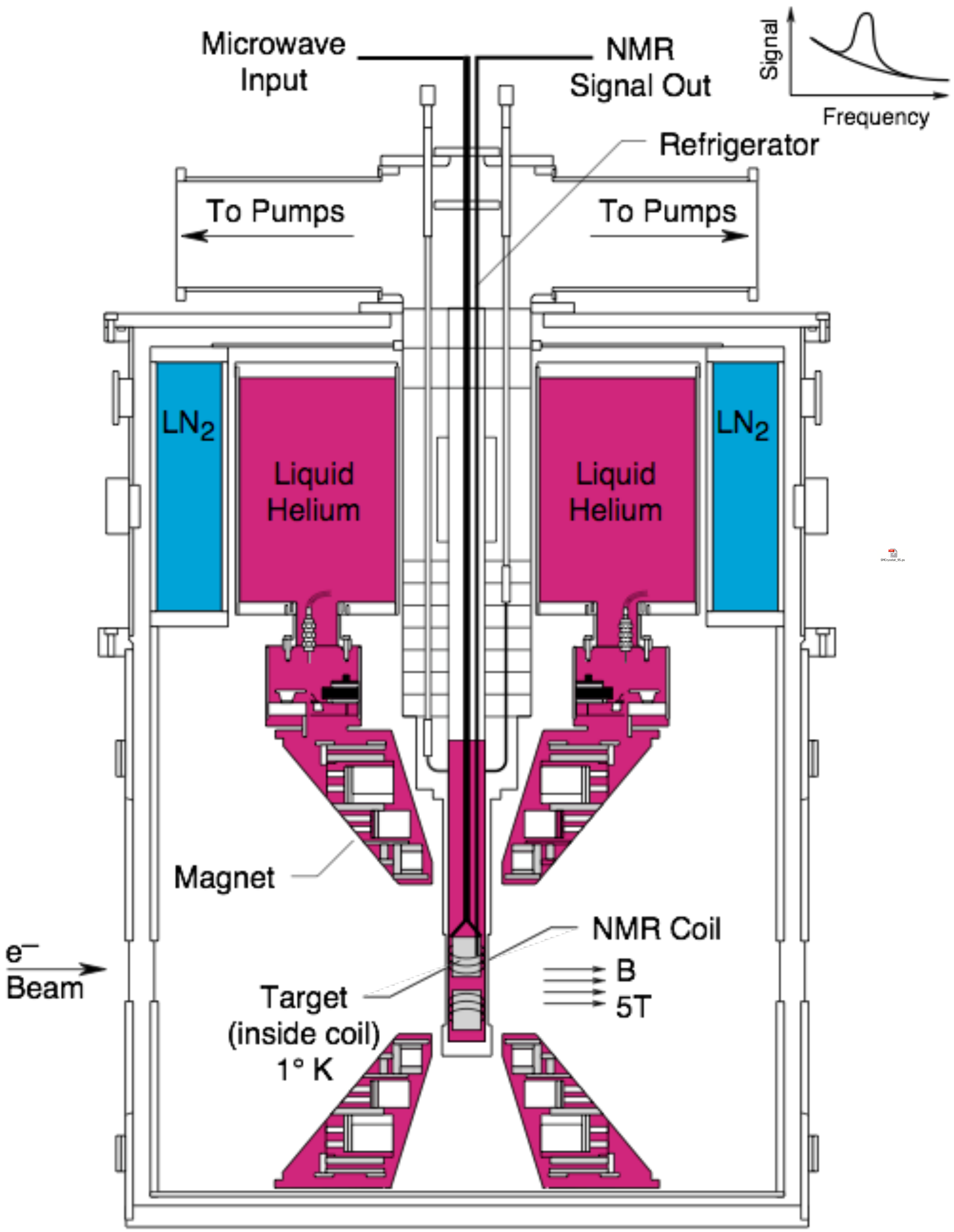
$$P = \frac{4 \tanh(g_d \mu_k B / 2kT)}{3 + \tanh^2(g_d \mu_k B / 2kT)} \sim 4/3\,(g_d \mu_k B / 2kT)$$

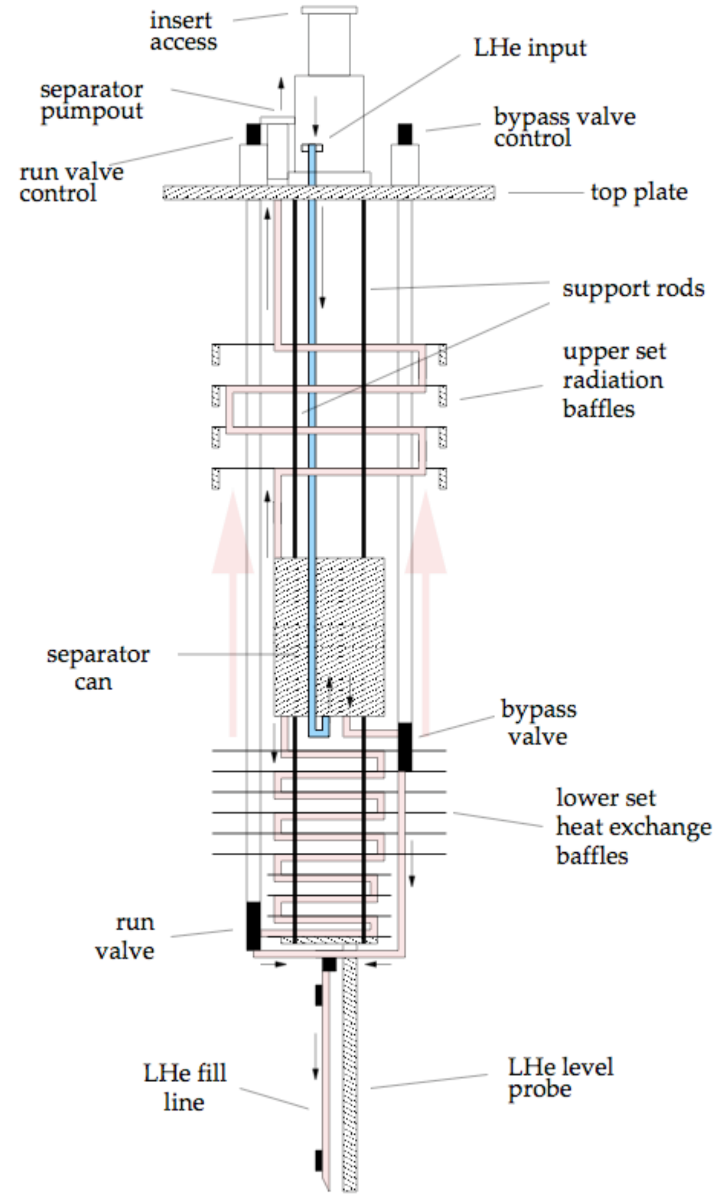
Lithium H, D Polarizations

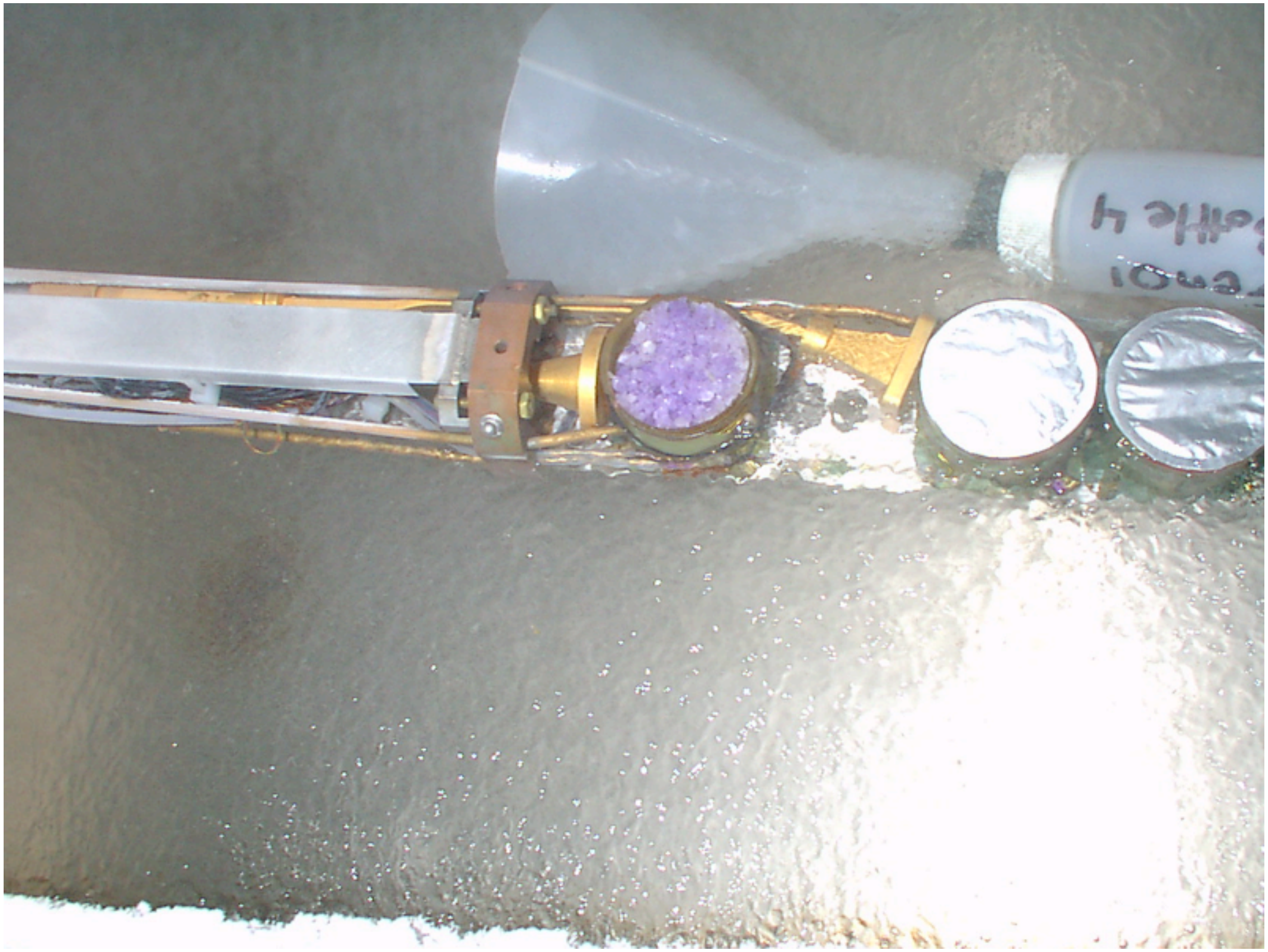
Polarizations (%)				K	T
^{6}Li	^{7}Li	H	D	Temperature	Field
+54 -49	+89* -91*		+53 -49	Dil.	2.5
	+31 -31	+42 -43		Dil.	2.5
	+44 -42	+58 -52		Dil.	2.5
	+50	+70		Dil.	5.0
	+31 -31	+42 -43		Dil.	2.5
	+46 -38			Dil.	2.5
+27	+63*		+27	1	5.0

* from impurity of ~4.5% ^{7}Li in ^{6}Li

UVA/SLAC/JLAB Target







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