Targets for 12 GeV Upgrade

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Workshop on Physics Opportunities with 12-GeV Electrons
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I. Overview of beam properties and target limitations

II. Unpolarized targets

III. Polarized targets

Limitations on Targets

12 GeV electrons => minimum ionizing

I <= 100 microamps

Beam Heat Load

Hydrogen:	4 W/(g/cm^2-uA)
Deuterium:	2 W/(g/cm^2-uA)
⋮	
Iron:	1.5 W/(g/cm^2-uA)

Max length for <u>1000W</u> beam heat load:

LH2: 35 cm

LD2: 28 cm

Maximum beam current limited significantly for polarized targets

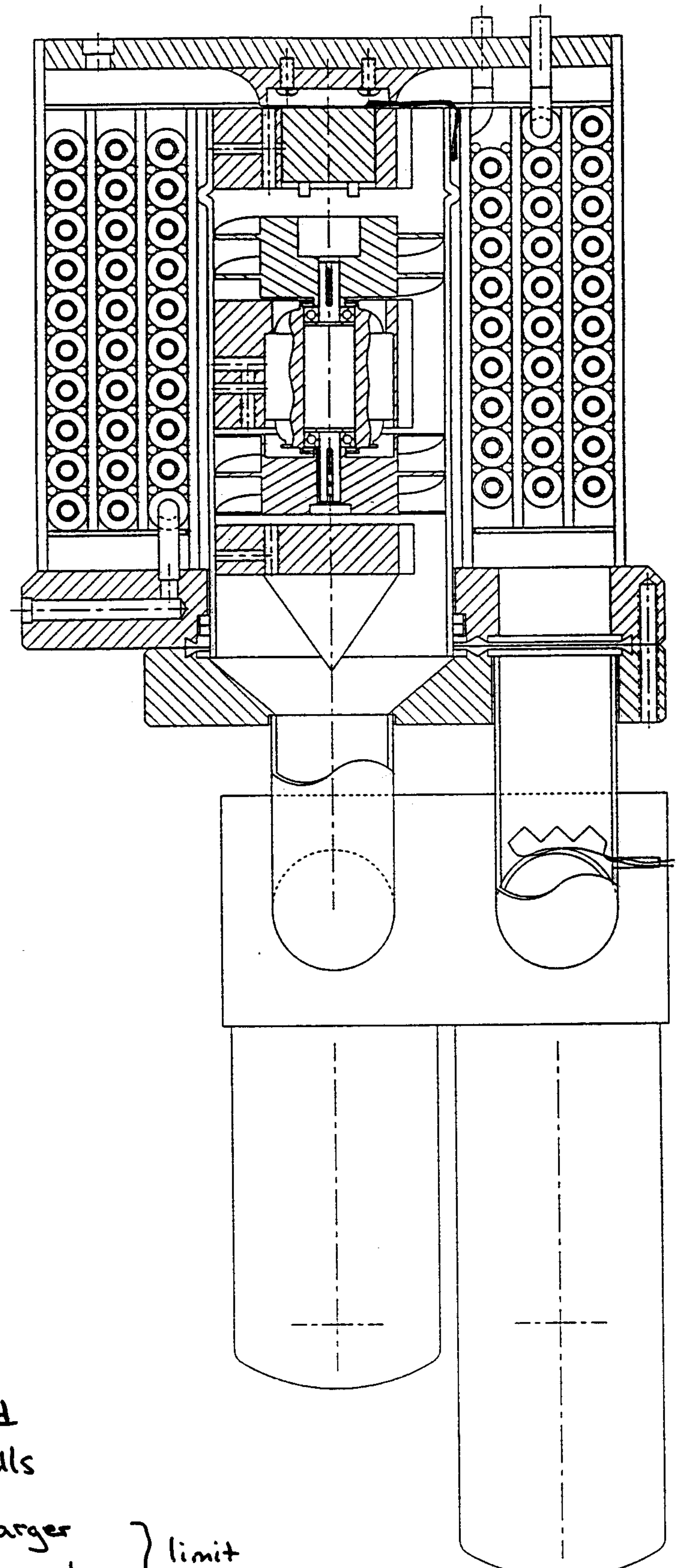
I. Unpolarized Targets

Hall A, C Targets

length ~ 4 cm & 14 cm

$I_{max} \approx 120 \mu A$

(700 W heat exchange)



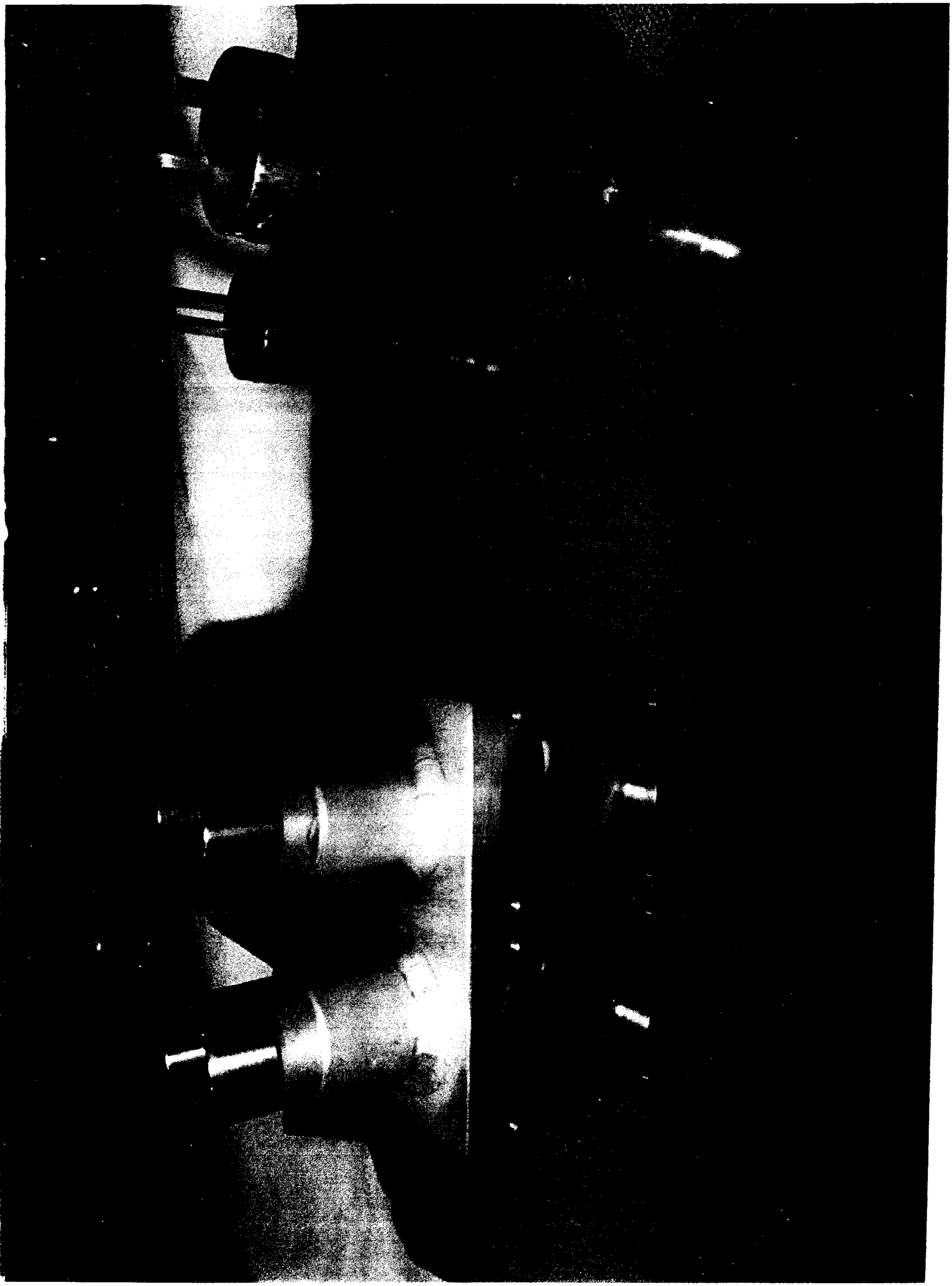
Limitations

Poor flow in end of targetcells

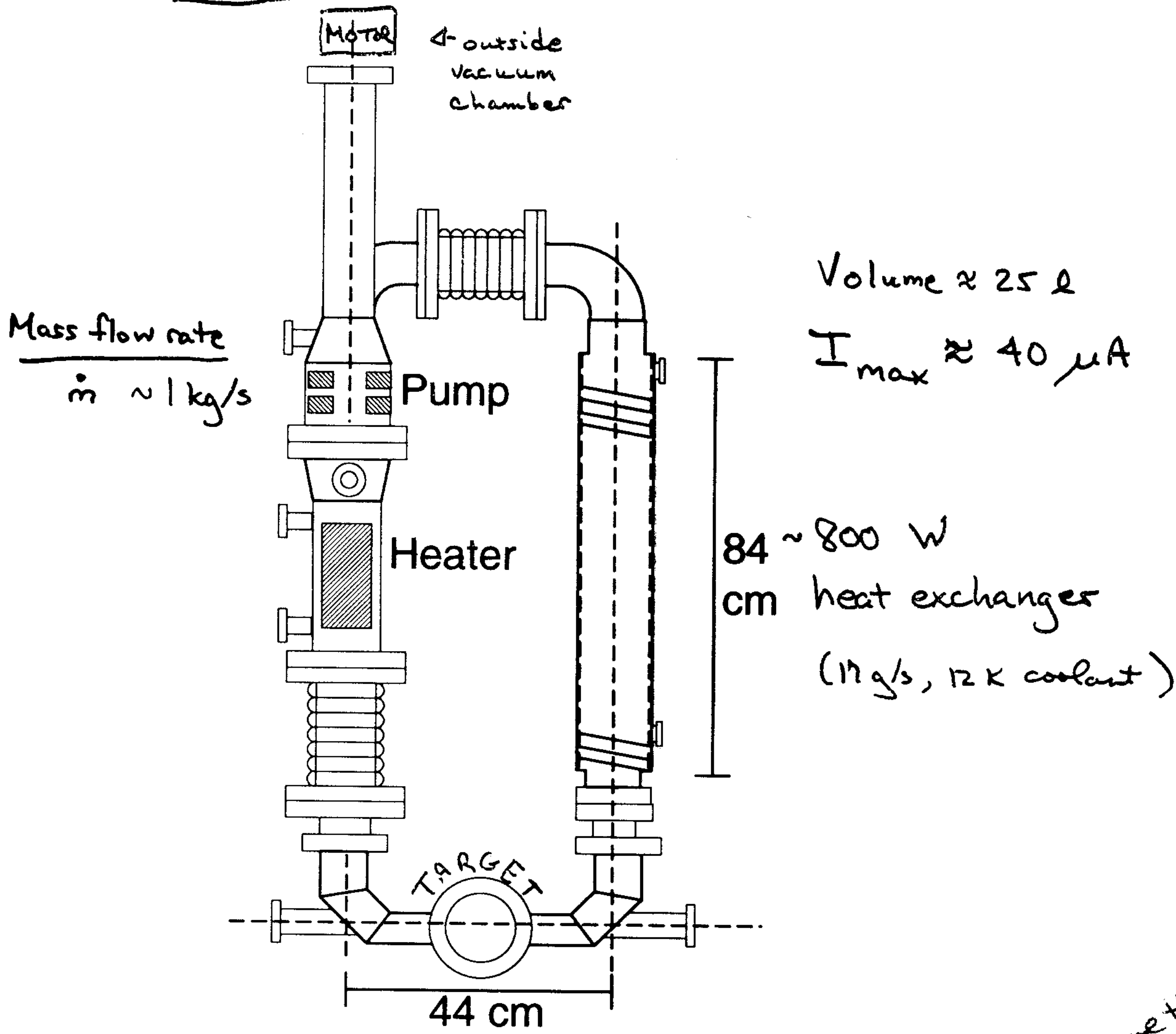
Compact design ⇒ larger pressure drops in loop } limit flow velocity

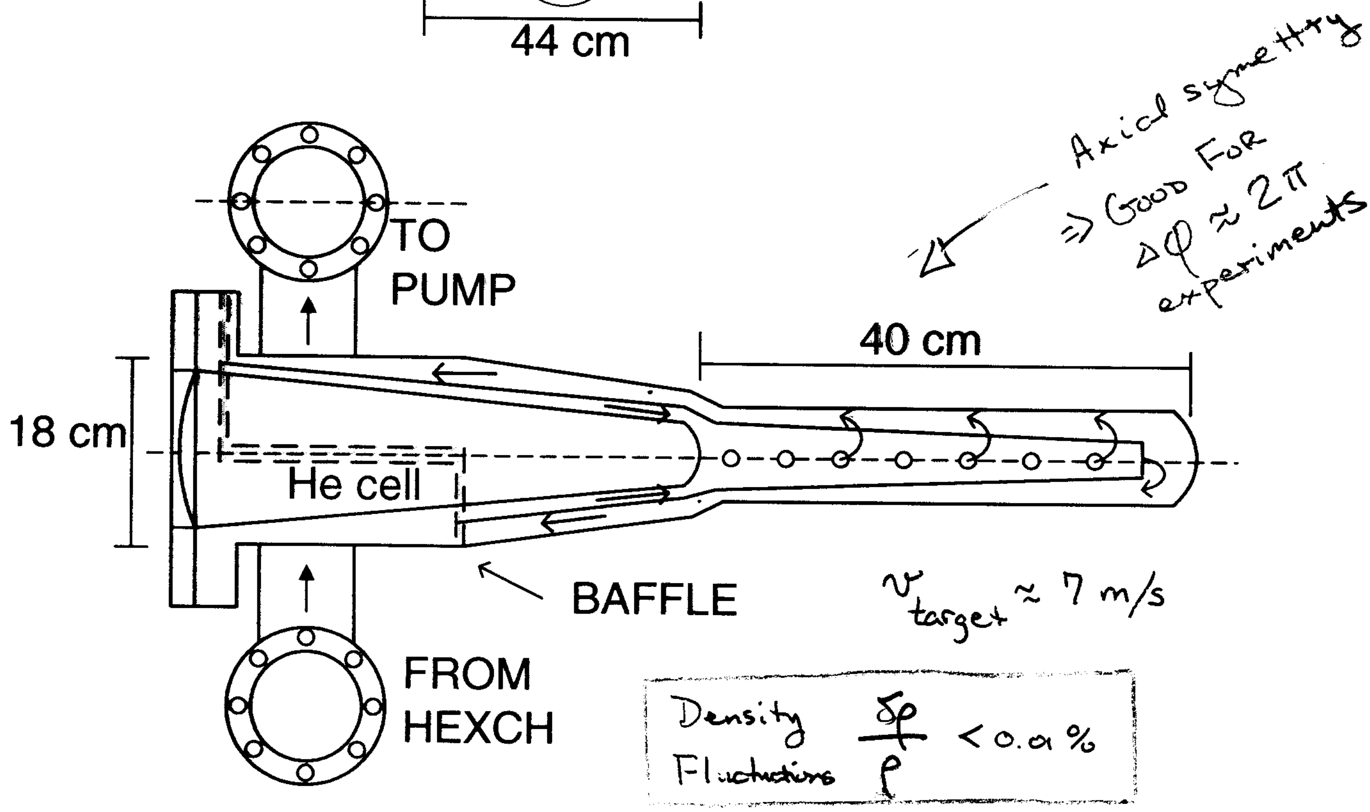
Small motor } limit flow velocity

Motor in loop ⇒ additional load on heat exchanger

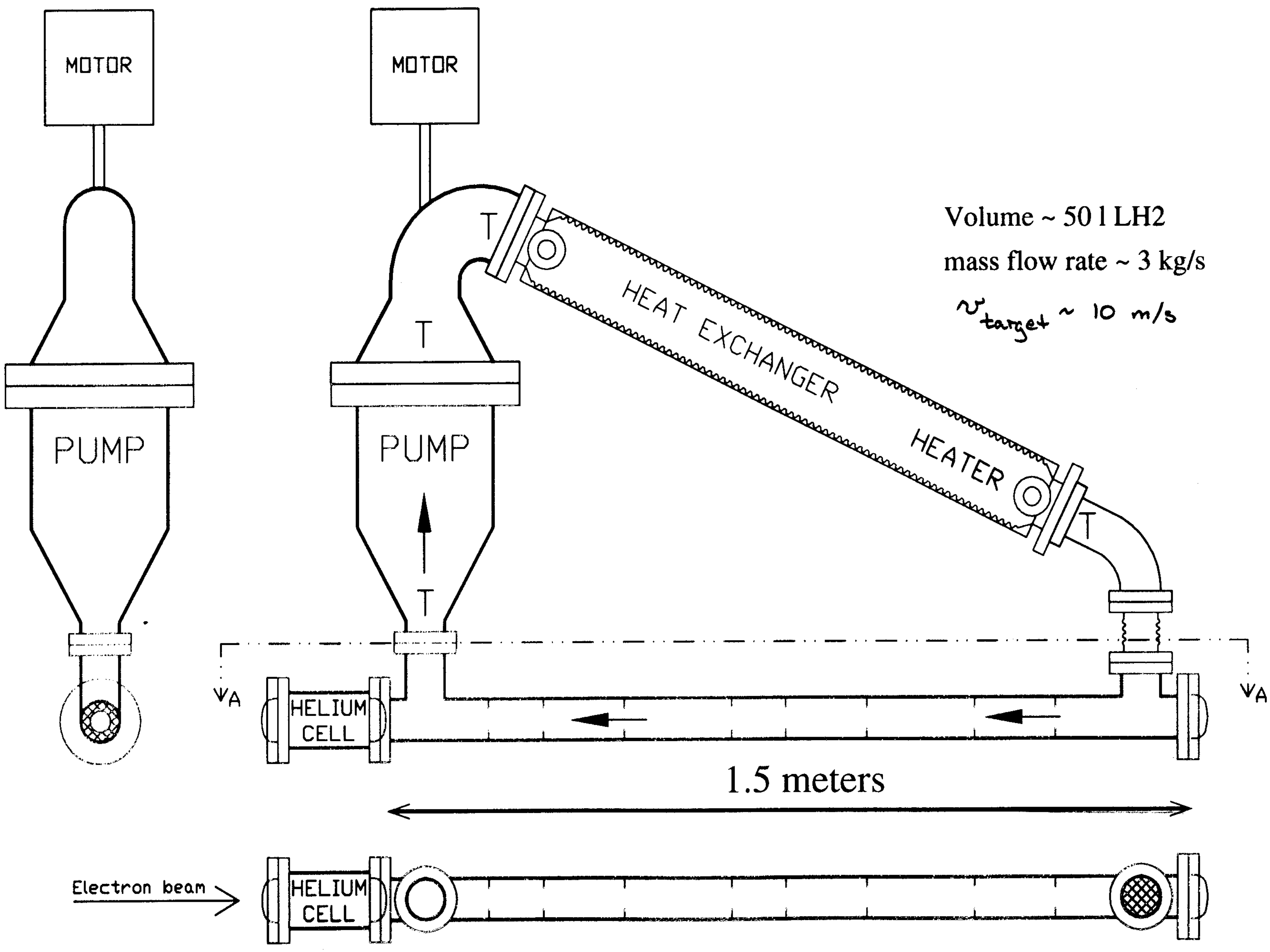


SAMPLE LH2/LD2 TARGET





SLAC E158 Liquid Hydrogen Target



Unpolarized Tritium Target

gaseous tritium target (~40 K, 200 psi)

target length = 40 cm

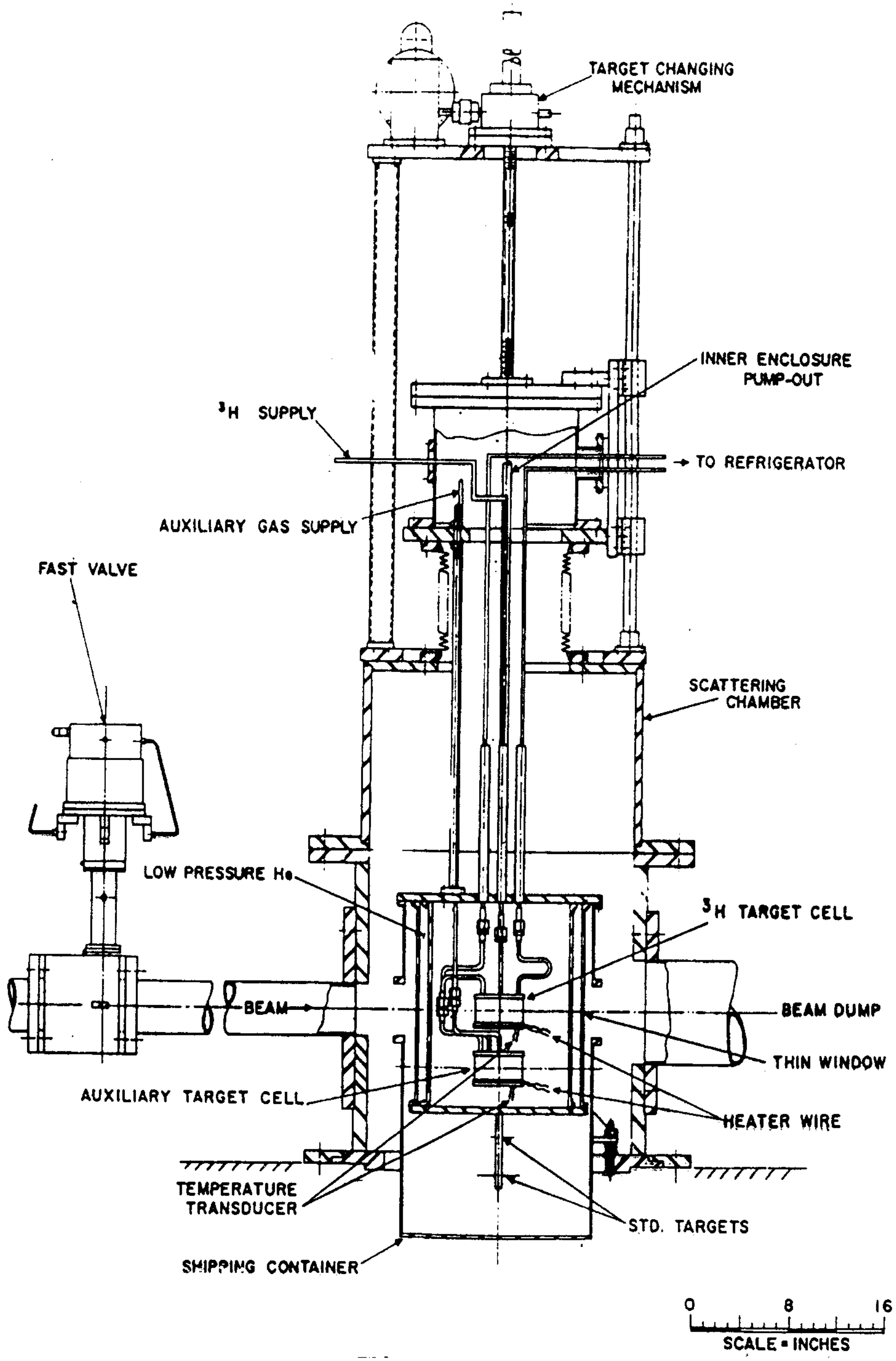
target density $2.5 \times 10^{21} /cm^3$

Maximum beam current ~ 80-100 microamps

Tritium Inventory ~ 10-20 kCi

$\mathcal{L} \approx 5 \times 10^{36}$

Bates 170 kCi Tritium Target



II. Polarized Targets

Dynamic Nuclear Polarized Hydrogen and Deuterium Targets

Ammonia : NH_3, ND_3

$I_{max} = 100$ nA

Attained

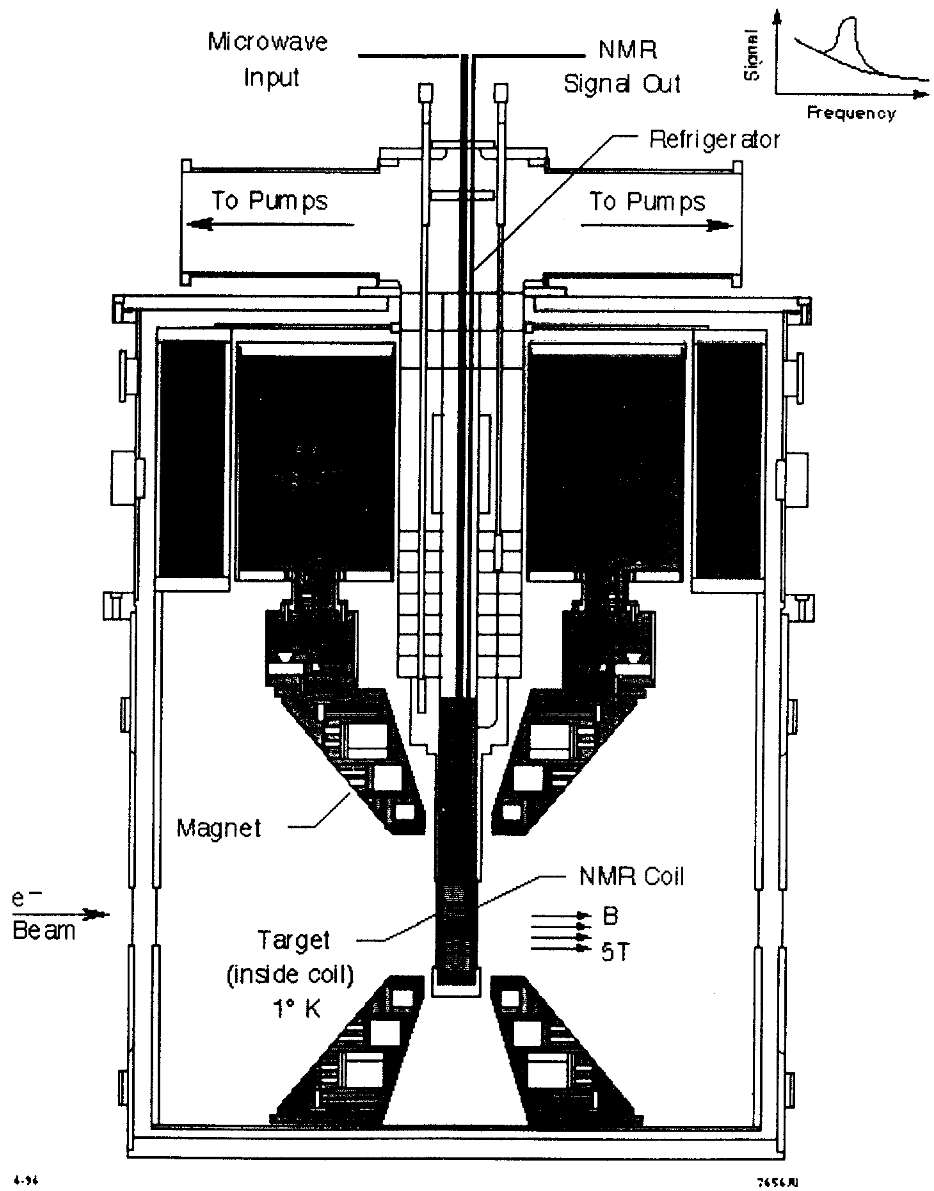
$P_H \approx 80\%$ (95%)

$P_D \approx 25\%$ (45%)

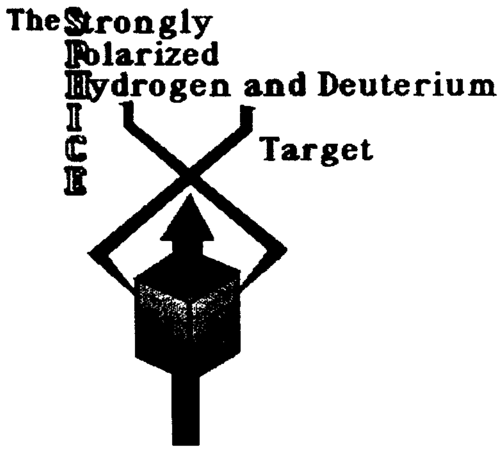
Lithium : LH, LD

UVa Attained $P_D \simeq 30\%$ @ 7T, 1K in lab [D. Crabb]

$P_H \sim P_D \sim 60-70\%$ limit



Low-Power Polarized H/D Target for Photon Experiments



for LEGS/Brookhaven

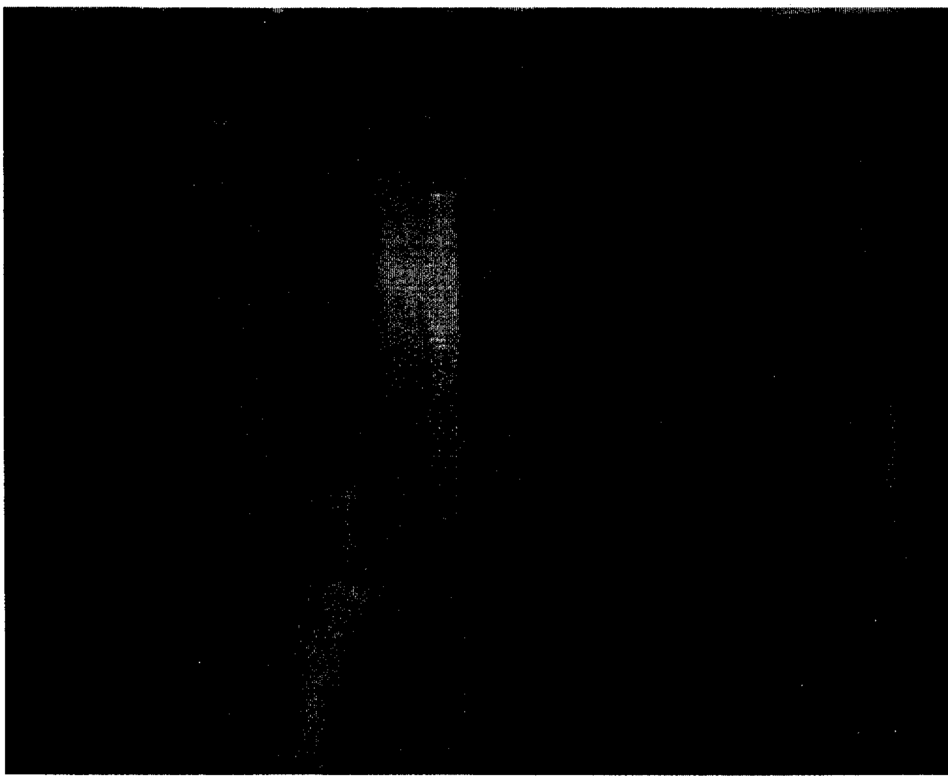
Can take no heat load

Brute force polarization of H in HD molecules at ~15 mK, 15 Tesla
with polarization transfer to D via rf transitions

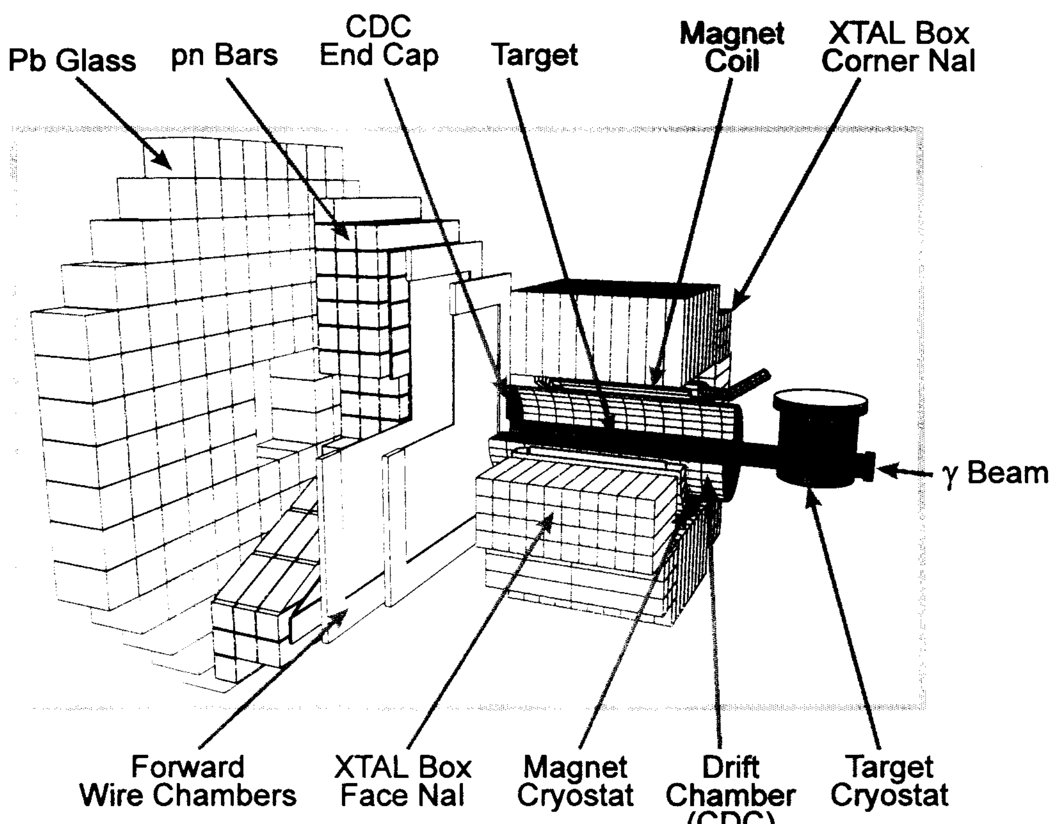
Target volume ~ 20 cm^3

Hydrogen polarization ~ 80%

Deuterium polarization ~ 60%



SPHICE in SASY at LEGS



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Spin-Exchange Optical Pumping with Rubidium

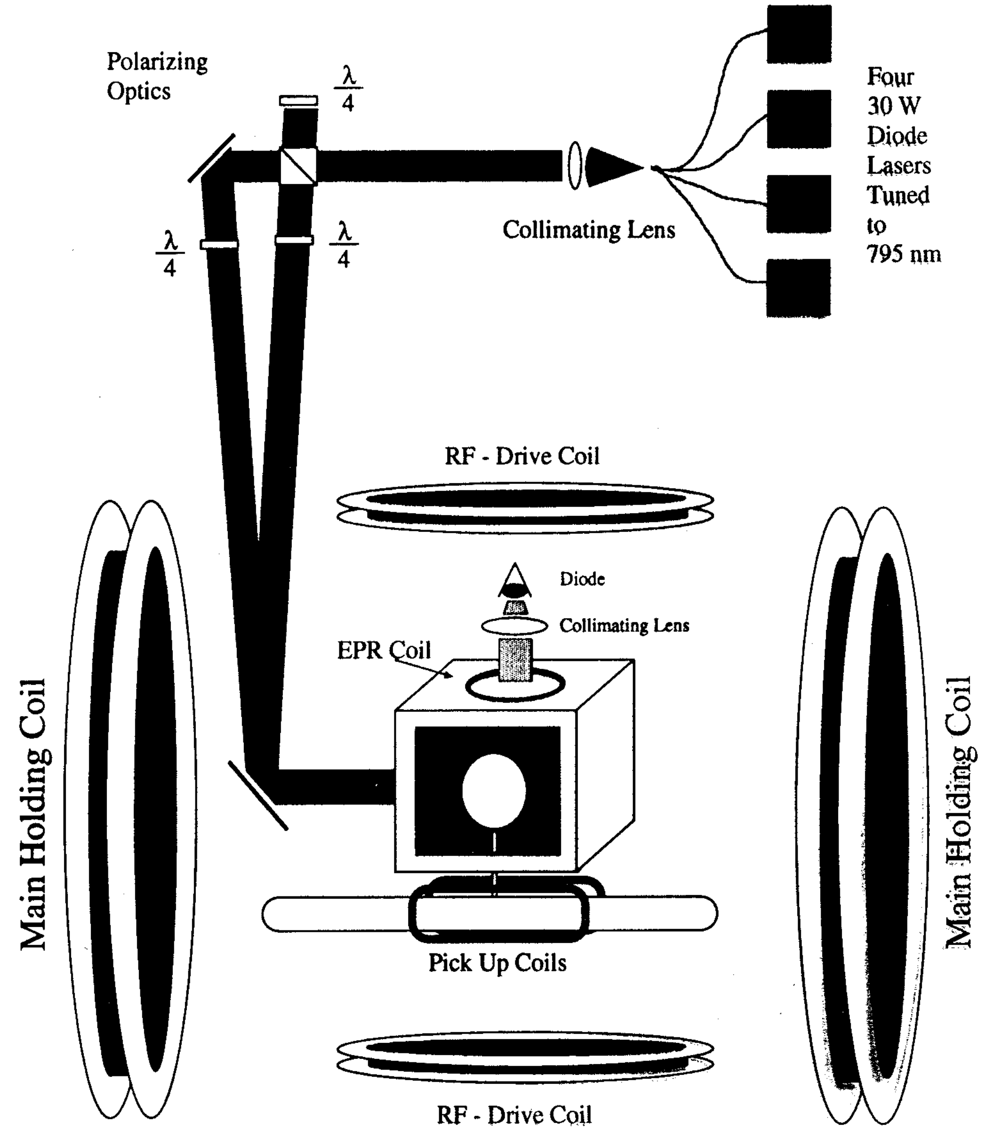
Polarization ~ 30-40%

(Improvable to 50% for low currents)

Target thickness ~10^{22}

Maximum beam current ~ 15 microamps

JLab Polarized ^{3}He Target Schematic



Speculation:

Polarized Tritium Target

Best Option for lab is LiT Dynamic Nuclear Polarized Target

Worry - heating from ^3H decay ($E_\beta \approx 18$ keV)

$\Rightarrow$ Limited to ~1 g of tritium

$P_T \approx 60 - 70\%$

Should optimize geometry to remove heat of decay from target

Really speculative ...

...another possibility????

Lyman- α Laser

==> *direct optical pumping of tritium ground state @ 121.5 nm*

Proposal of Henry Kapteyn and Margaret Murnane of JILA

Use non-linear optics techniques
to get near 100% frequency conversion to VUV

frequency quadrupling of Ti:sapphire laser amplifier
seeded by external-cavity diode laser

Estimated power output: 100 mW power
Need ~1 W for pumping; 10 mW useful as atomic polarimeter

Repetition rate: 1-10 kHz
Need at least 10 kHz rep rate and 10 GHz linewidth

Could give a pure tritium target of low density, high polarization