LONGITUDINAL POLARIZED TARGET

Design Issues

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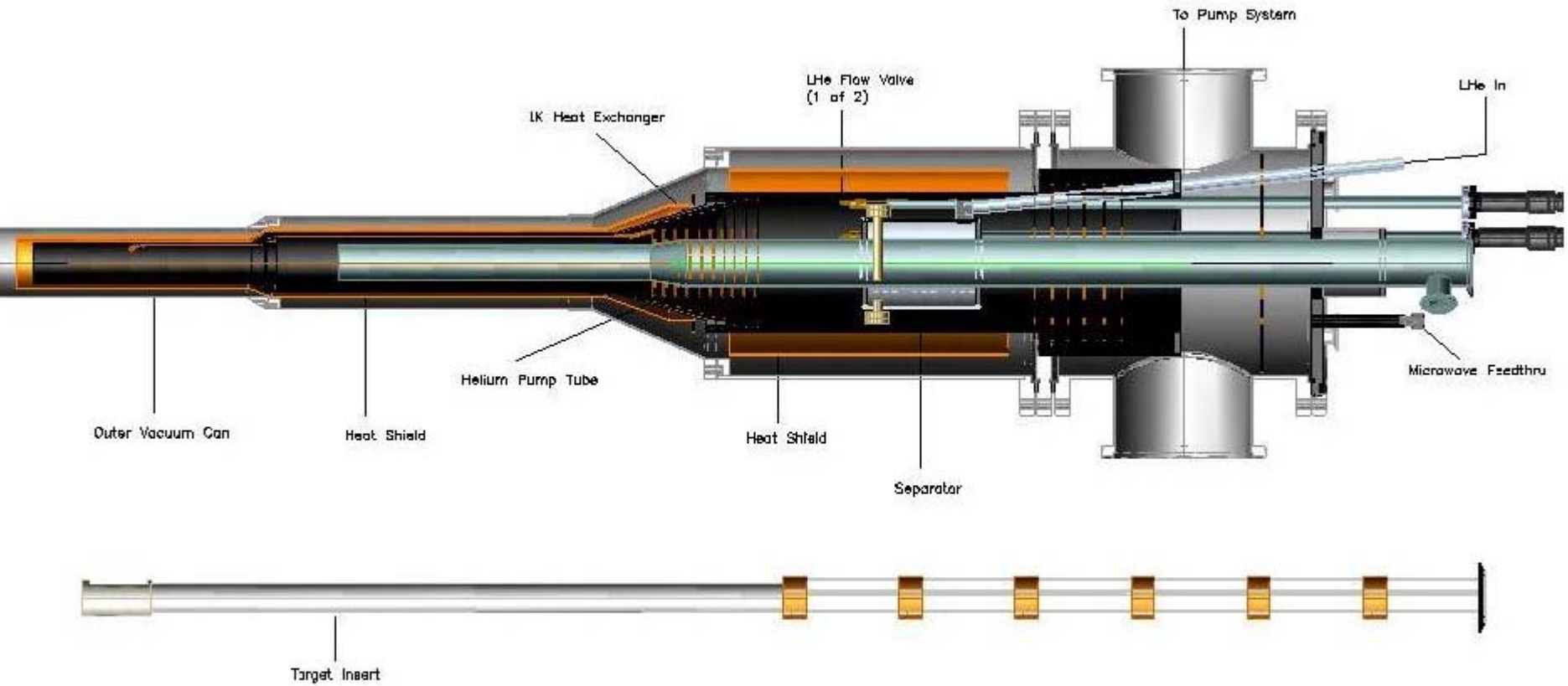
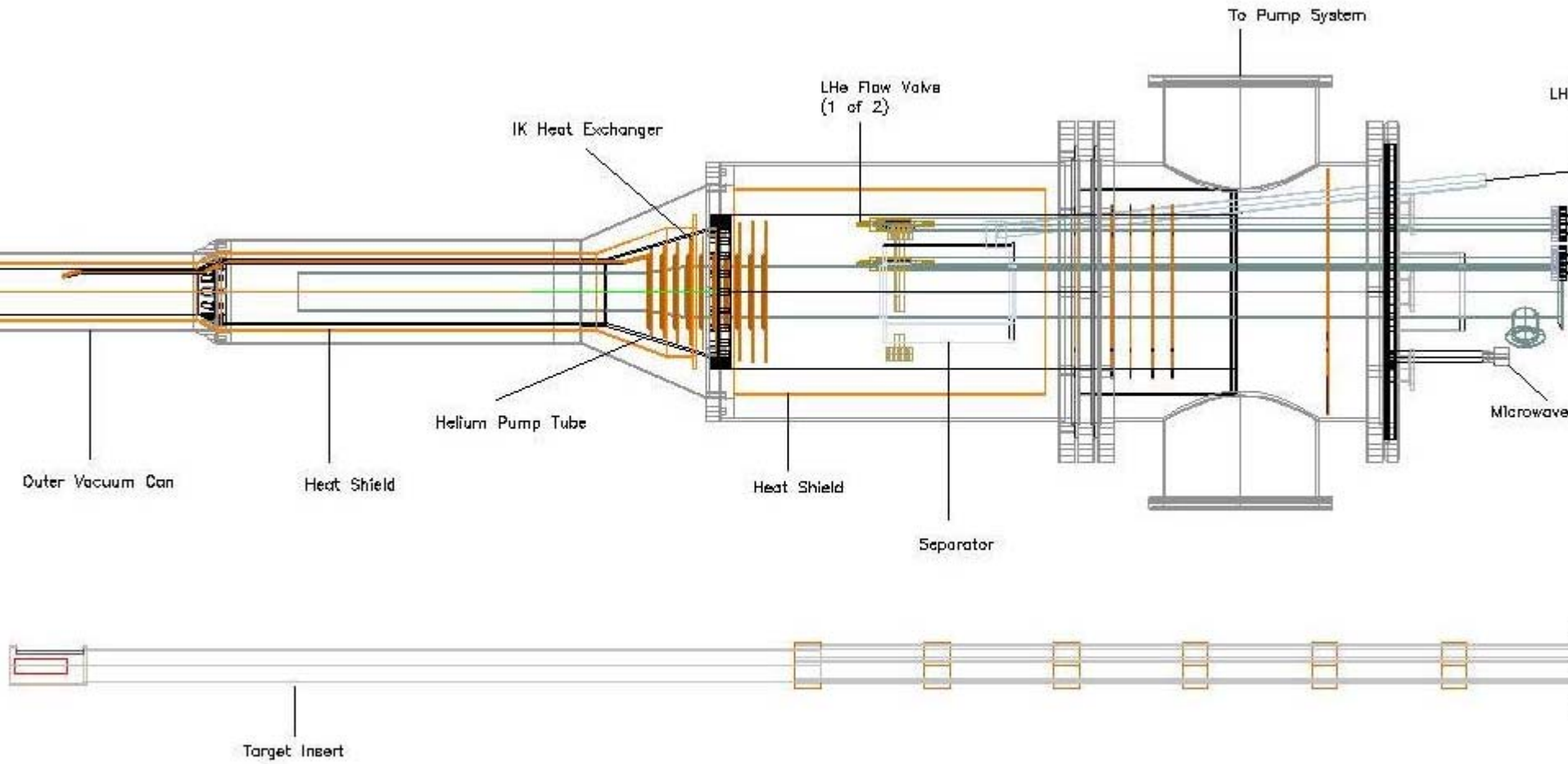
Design Parameters

Field provided by 5T Warm Bore Solenoid

- Horizontal DNP Polarized Target
- Beam along axis of Refrigerator – one target
- Surrounded by detectors – require 10cm diameter hole at center of solenoid to fit refrigerator.
- ^{4}He Evaporation Refrigerator
  - Microwaves and Beam Intensity
  - Pumping requirements
  - Polarization – radiation damage
  - Annealing
- Tentative Conclusions


To Pump System
LHe Flow Valve
(1 of 2)
LHe In
LK Heat Exchanger
Helium Pump Tube
Microwave Feedthru
Outer Vacuum Can
Heat Shield
Heat Shield
Separator
Target Insert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Beam on Target

- (L)uminosity = I (beam intensity)* N_N (number of Target Nucleons)
- 10^{35} = I x 0.6 x 3.3 x 0.91 x 6. 10^{23}
- I = 9.25 10^{10} electrons/sec = 15 nA (approx)

Can run with CLAS at about 4 nA with a I cm long target

- With 10 x L and 3.3 cm target I = 12.1 nA
- Beam Heating assume 2 MeV $g^{-1}cm^2$ energy loss

  H = 0.053 W for target material only

Microwaves

- For 5 T need 140 GHz EIO Tube

  Power delivered to target = 0.75 W

  Need 40 mW/g. Target is 14g

  Therefore need >560 mW delivered

  Coupling of microwaves to target?

- Bandwidth 1.5% central frequency

  If solenoid field < 5 T, will have to specify tube with different central frequency.

Pumping Requirements

- Total Power = 0.8 W

For liquid helium at 1K, **L_{evap} = 80 J/mole** requires a pumping displacement of **0.01 mole/sec.**

At 1 K **VP = 160 mbar**

Pump Displacement is about **5000 m^3h^{-1}**

Need at least a **6000 m^3h^{-1}** pumping system

Caution: Actual pumping speeds may differ from nominal specifications

For example: Hall B system is a nominal **4000 m^3h^{-1}**

Measured pumping speed is about **3300 m^3h^{-1}.**

Pumping Requirements

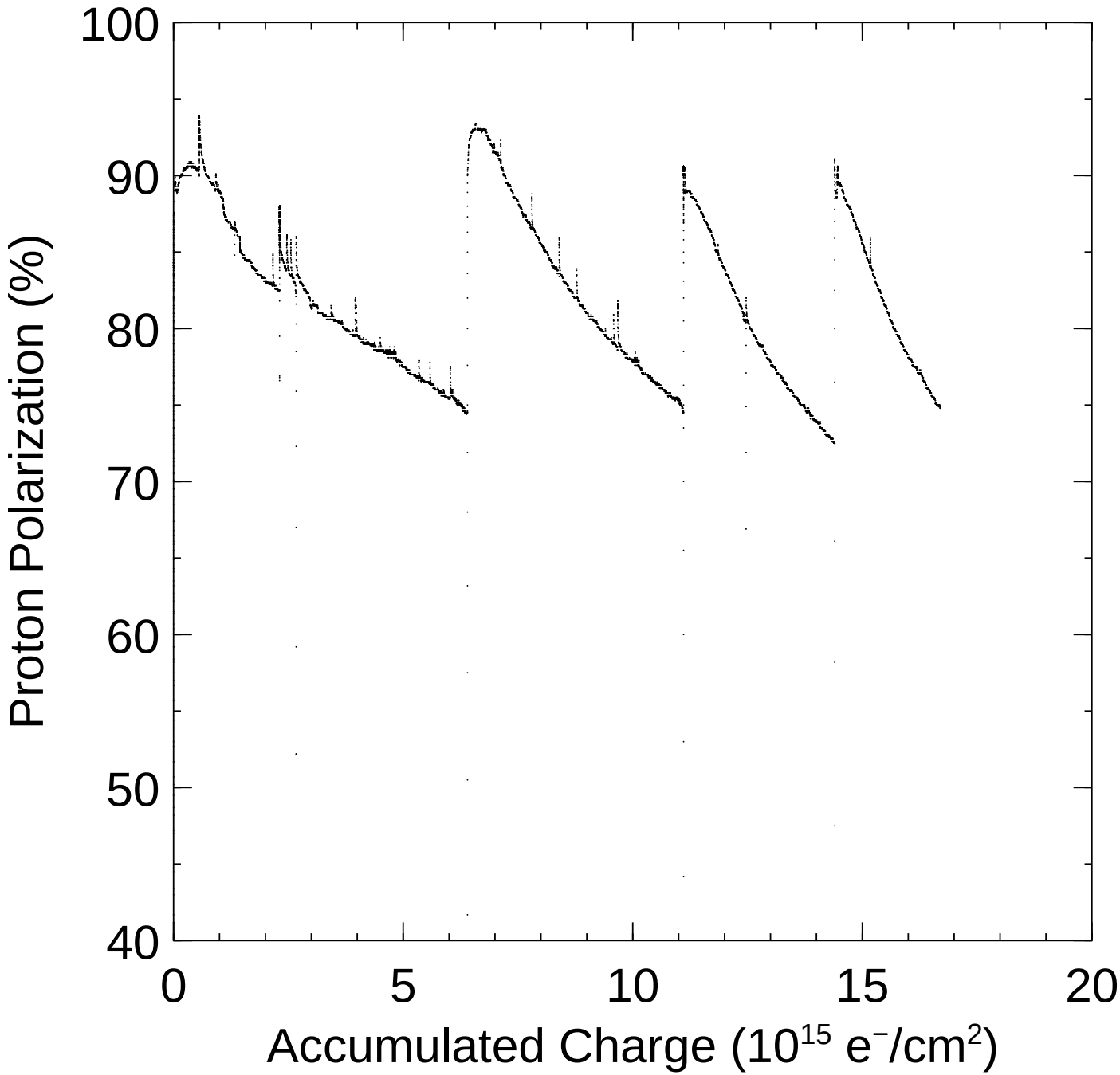
- Typically are pumping through “orifices”, heat exchangers and pumping tubes of various sizes. Also helium pumping less efficient than for air

Typically, pumping speed → D^4/L

- Hall B with 4000 system pumps through the first tube (looking at LHe surface) of D = 3.18 cm diameter and runs at 1.15 to 1.2 K.
- Hall C/SLAC system with 12000 pump can maintain about 1.05K

Annealing

- Polarization decreases with beam dose (units of electrons/ cm^{-2})
- Polarization can be recovered by heating target to 80 – 100 K for up to 1 hour
- Polarization decay gets faster during the lifetime of target
- Eventually change target.


100
90
80
70
60
50
40
Proton Polarization (%)
0
5
10
15
20
Accumulated Charge (10^{15} e^{-}/cm^{2})

Annealing

- Annealing will take place every 2 10^{15} electrons cm^{-2} (90% -> 80%)

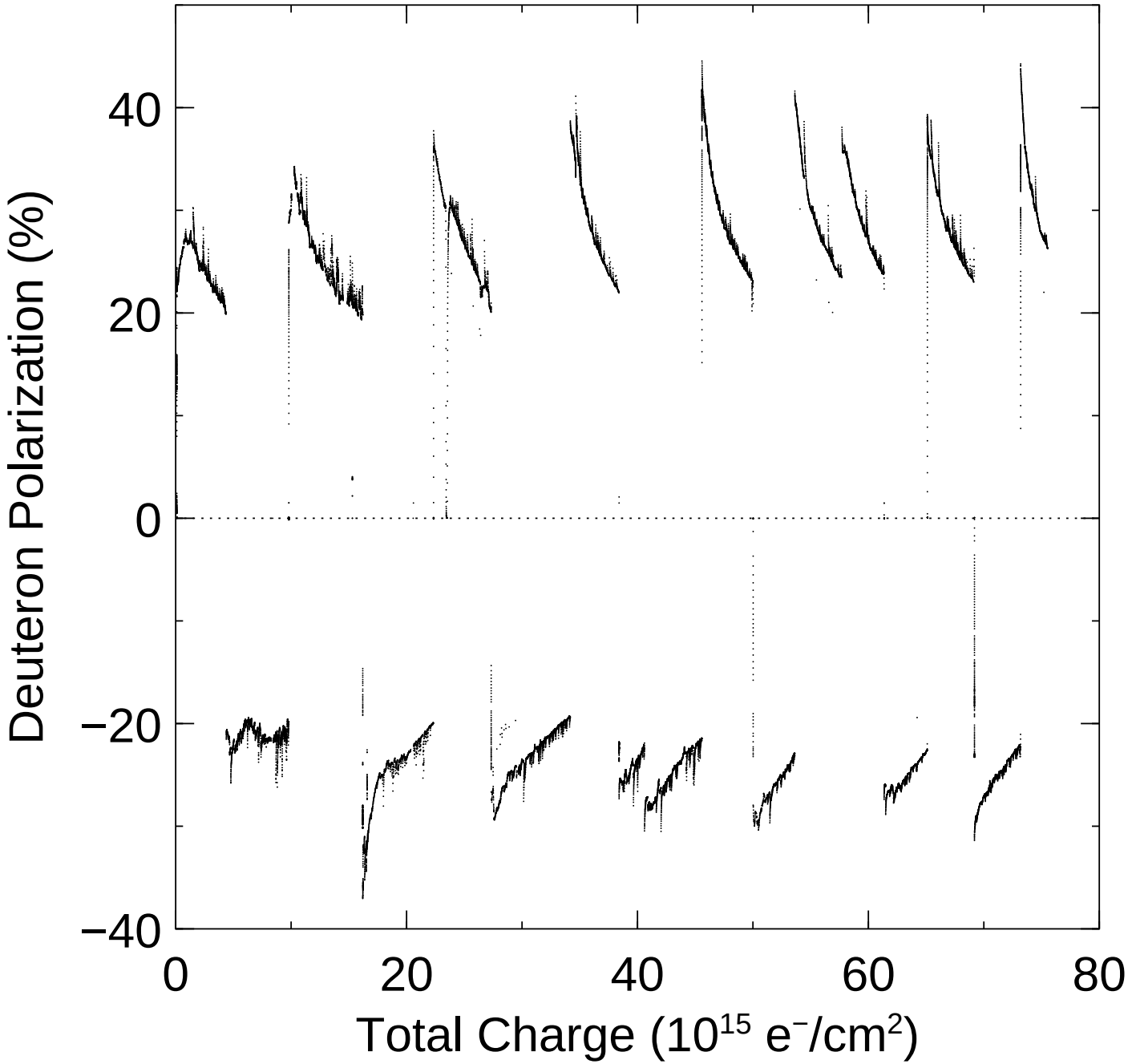
Beam of **10^{11}** electrons/sec, target area = **7 cm^2**

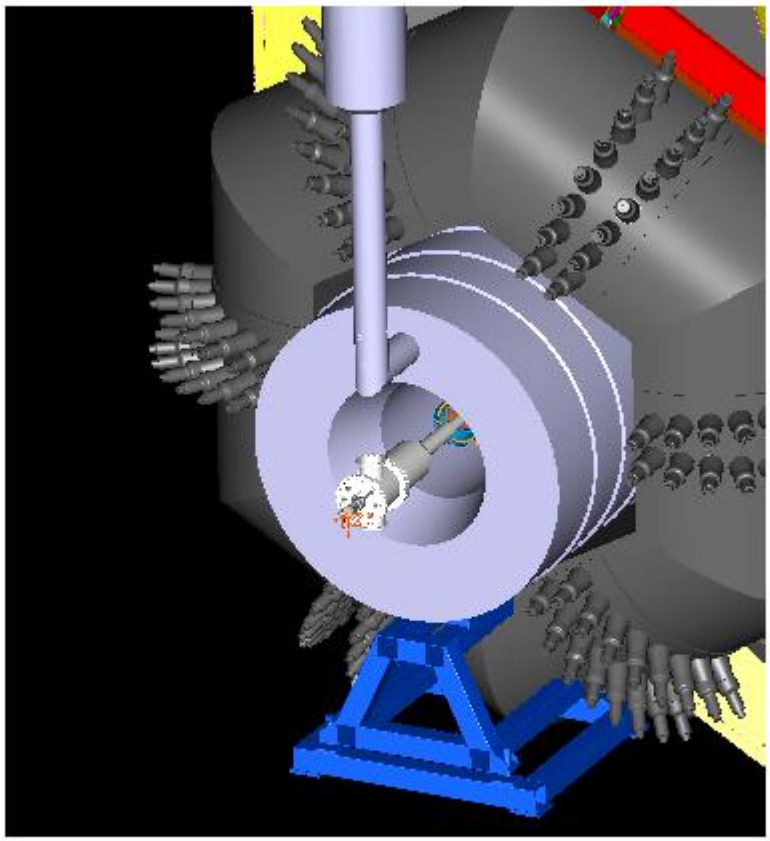
At **1.4 10^{10}** electrons $s^{-1}cm^{-2}$ will take about **40 hrs** before an anneal is necessary

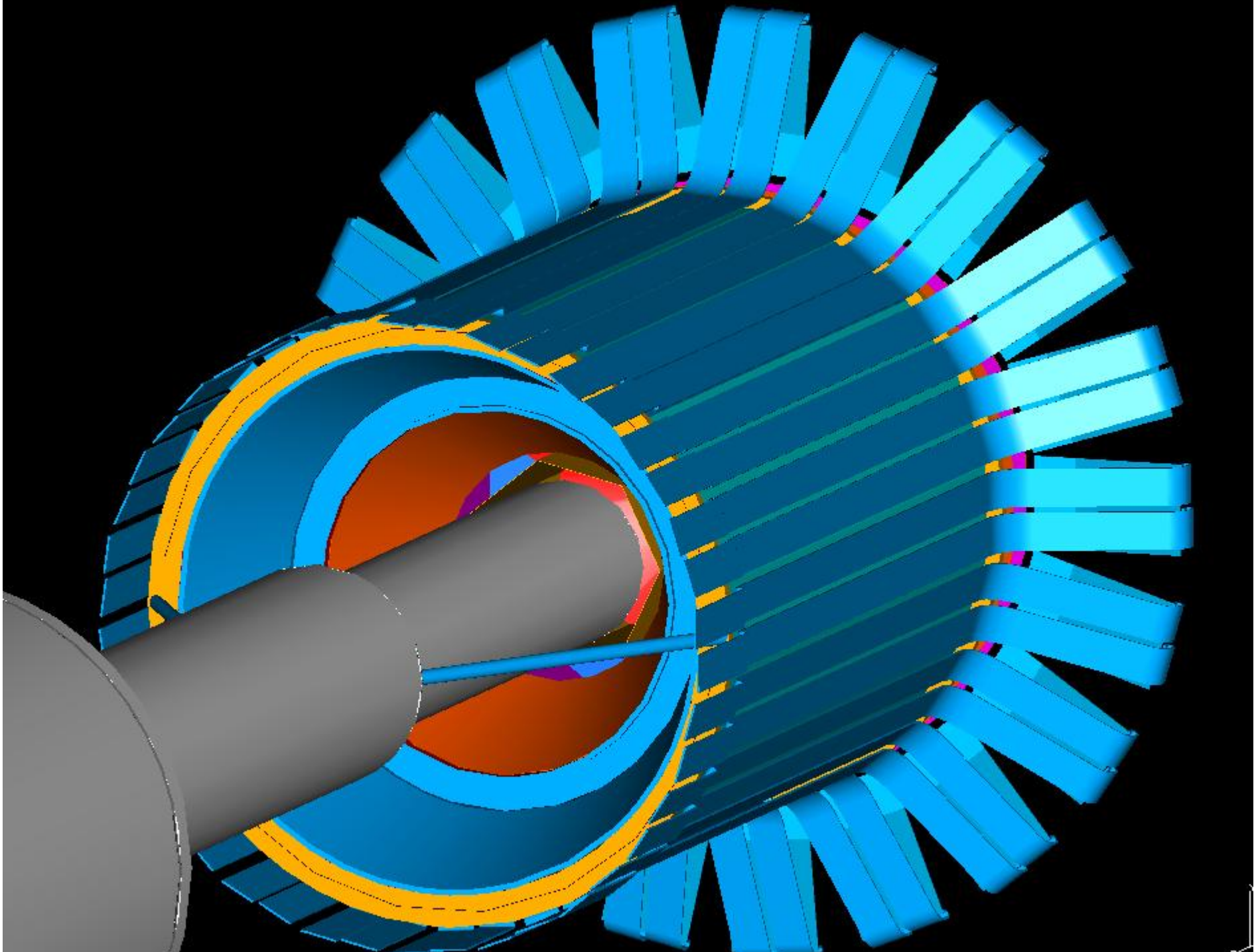
Target changed about every 400 hours

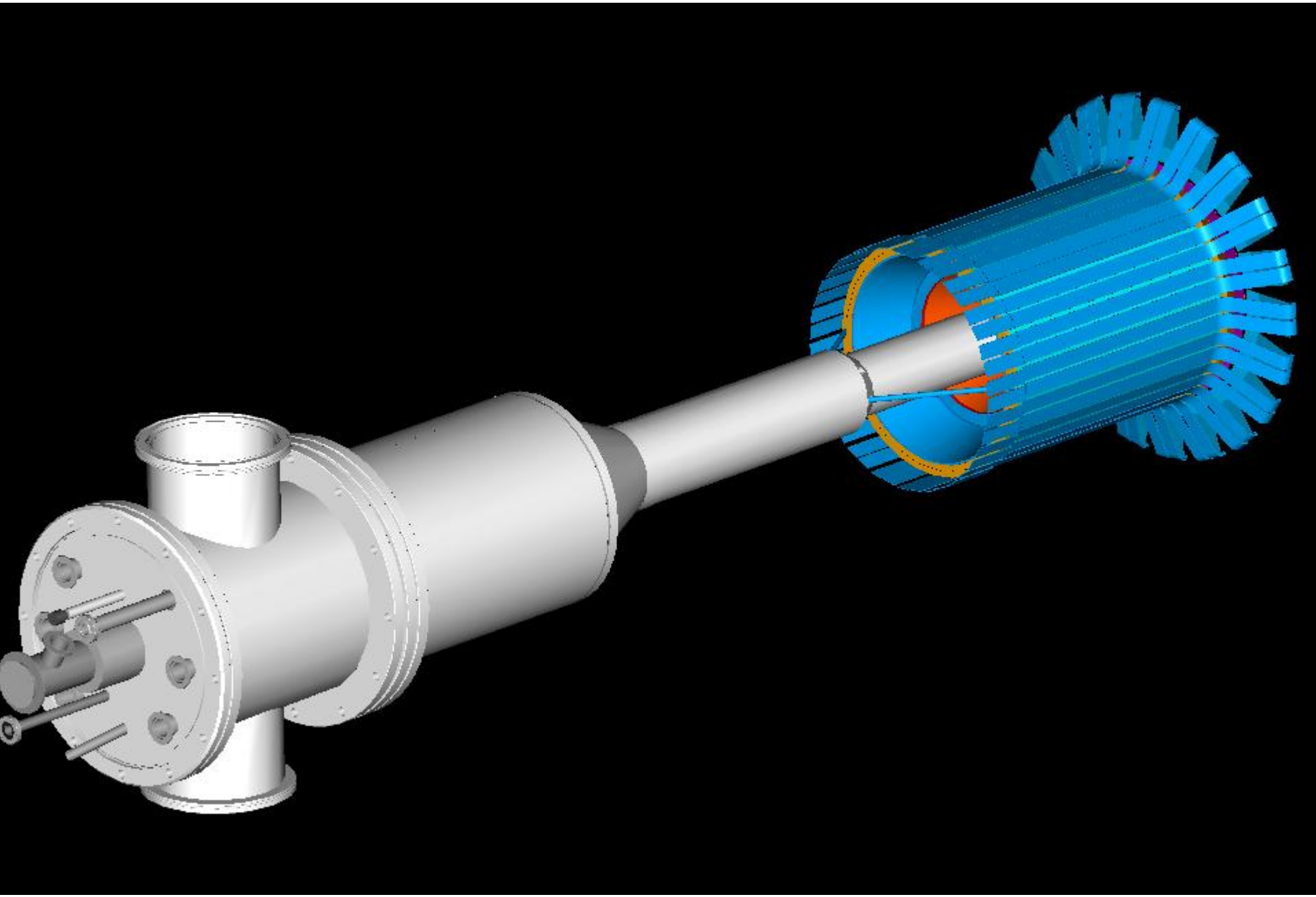
- Anneal with heater coil near target, or with “oven” into which target must be pulled

Either one is effective, but must be done remotely


Deuteron Polarization (%)
40
20
0
−20
−40
0
20
40
60
80
Total Charge (10^{15} e^{-}/cm^{2})







Budget

Procurement:

			2010	2011	2012
Cryostat	Dewar	Vacuum jacket	6		
		Helium space		4	
		Service ports	2		
		Instrumentation		4	
	Refrigerator	Separator	2		
		Insert		4	
		Heat exchanger		2	
		Inner vacuum jacket	4		
		Outer vacuum can	2		
		Instrumentation		14	4
Pump System		Pumps	100		
		Vacuum manifold	14		
		Vacuum components	10	2	
		Pump skid		8	
		Pump electrical			6
		Chiller			5
Instrumentation	Microwave	EIO Tube		85	
		Power Supply		65	
		Waveguide Comp		12	2
		Frequency counter		14	
		Power meter		5	
	NMR	Frequency generator		14	
		Q meter		5	2
		Interface/Computer		2	6
Target Positioning		Target mounting skid		6	
Cryogen Supply		Buffer dewar			10
		Transfer line			4
Total			140	246	39

Total $425 k

Conclusions

- Horizontal ^{4}He Evaporation Refigerator
- Target Material: Ammonia and Deuterated Ammonia. ^{15}N ammonia? LiD(H)?
- Pumping: At least 6000 m^3h^{-1} Roots system . Sealed. Dry Backing Pumps
- Microwaves: Some detailed design of target Cup
- NMR: Design under control
- Space and Compatibility: To be negotiated
- Cost $500K