Polarized Target for the b_1 & A_{zz} Experiments in Hall C

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U.S. DEPARTMENT OF ENERGY | Office of Science

Jefferson Lab

Outline

- What's in a name?
- The quintessential Don Crabb target
- The past
- The g2p update
- Current status
- The schedule
- What's next

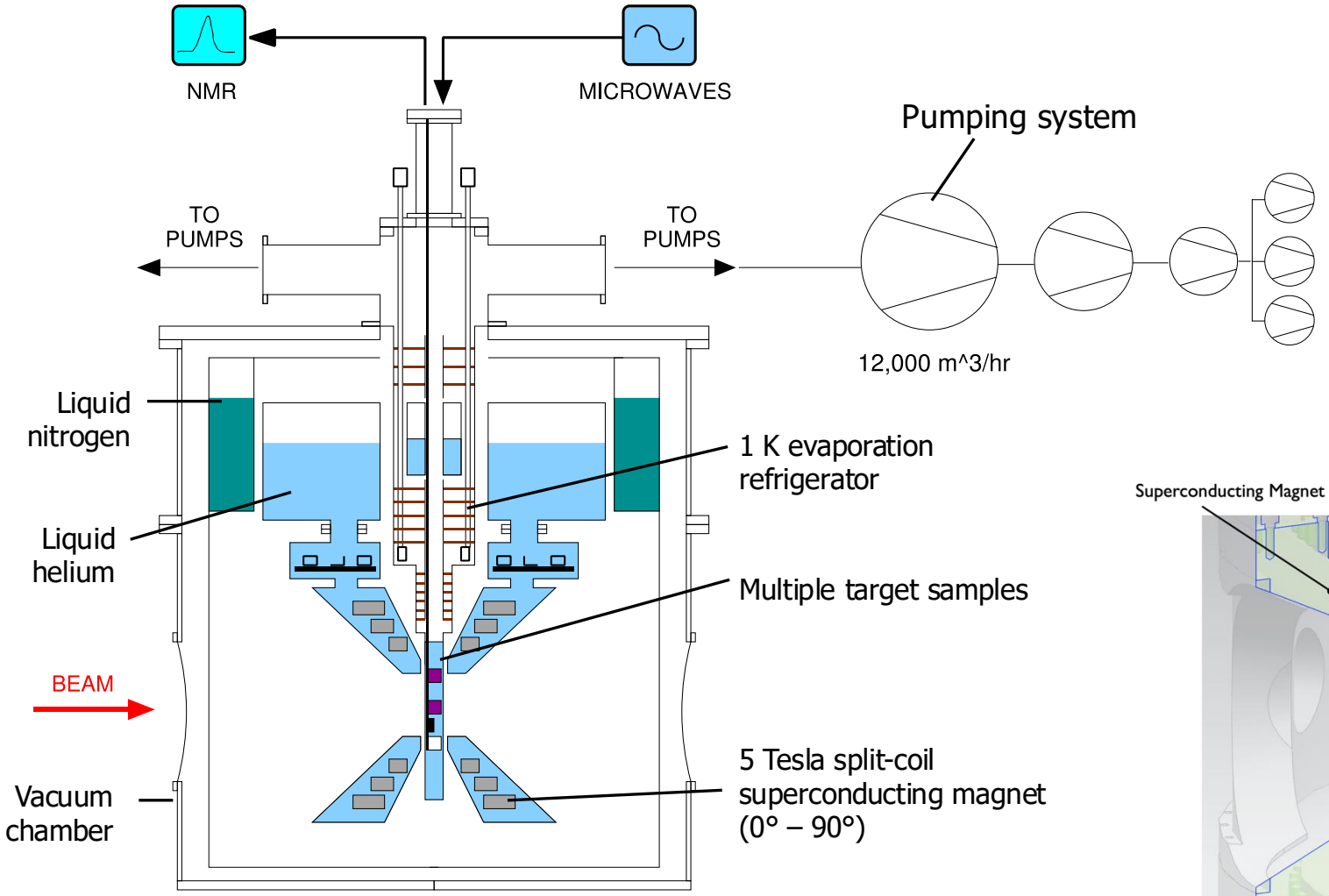
What's in a name?

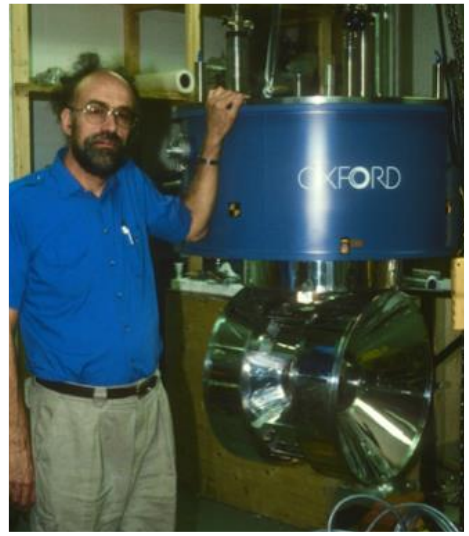
The tensor experiments in Hall C will/can/should utilize an existing polarized target system.

Like the characters in a Russian novel, it has many names….

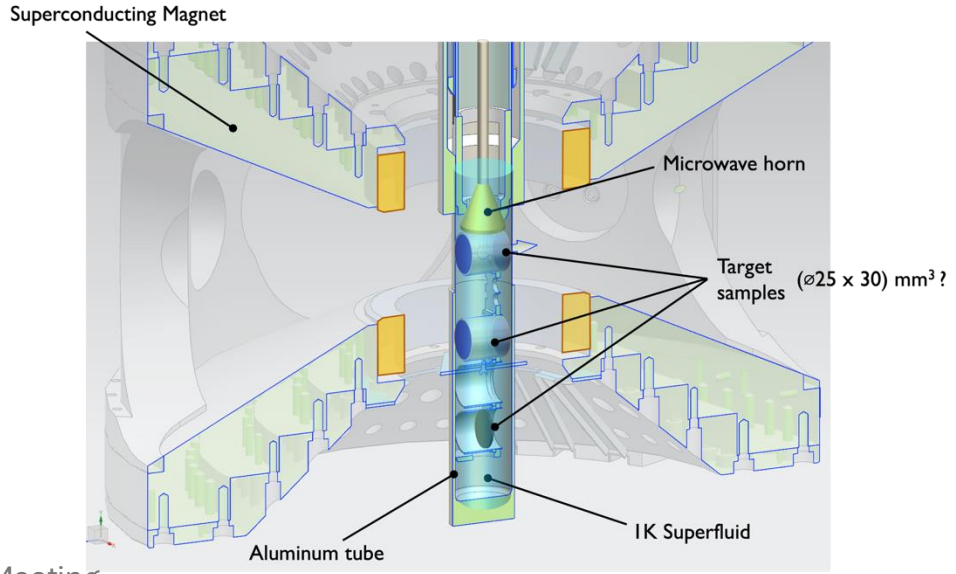
- The "SLAC" polarized target
- The "UVA" polarized target
- The "Hall C" polarized target
- The "G2p" polarized target

The quintessential Don Crabb target





Don Crabb with the SLAC target, 1992



The past

A solid polarized target for high-luminosity experiments

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The Virginia/Basel/SLAC polarized target: operation and performance during experiment E143 at SLAC

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journal homepage: www.elsevier.com/locate/nima

Design and performance of the spin asymmetries of the nucleon experiment

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

journal homepage: www.elsevier.com/locate/nima

Dynamically polarized target for the g_2^p and G_E^p experiments at Jefferson Lab

J. Pierce[a,*], J. Maxwell[b,1], T. Badman[b], J. Brock[a], C. Carlin[a], D.G. Crabb[c], D. Day[c], C.D. Keith[a], N. Kvaltine[c], D.G. Meekins[a], J. Mulholland[c,2], J. Shields[c], K. Slifer[b]

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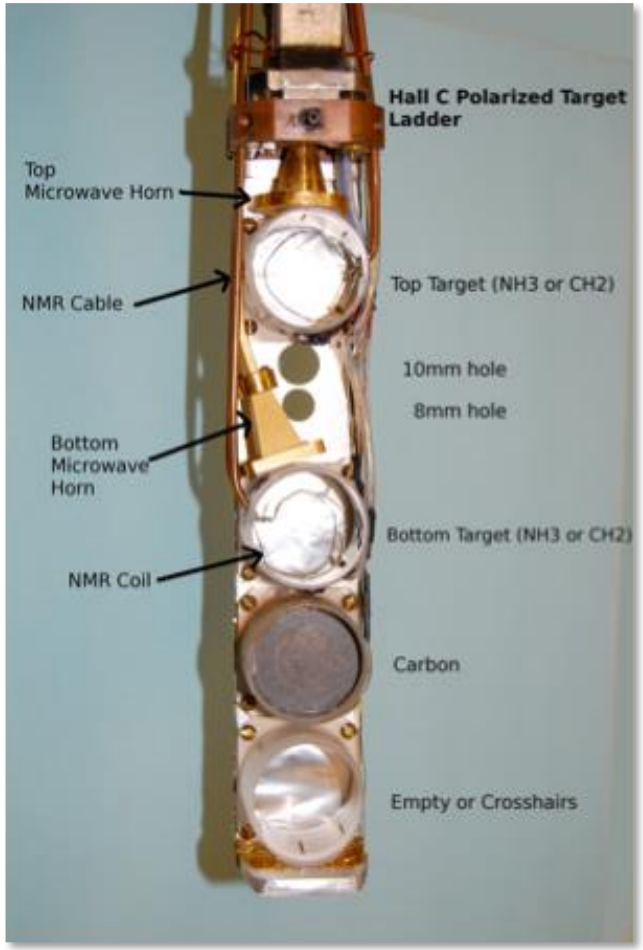
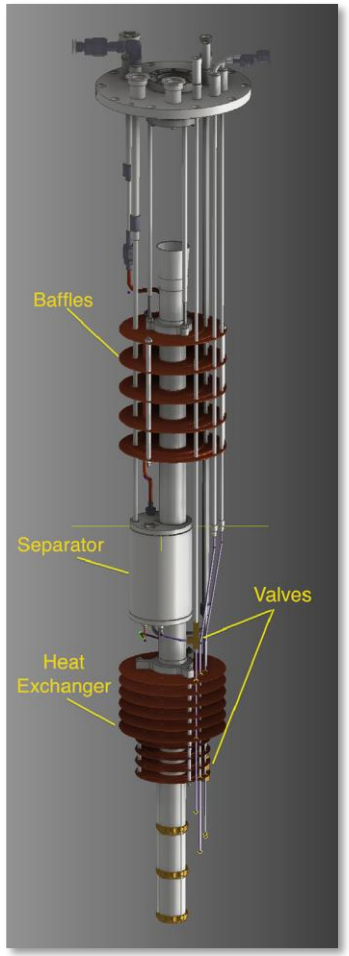


Used at SLAC on three occasions
- E143 (1993)
- E155 (1997)
- E155X (1999)

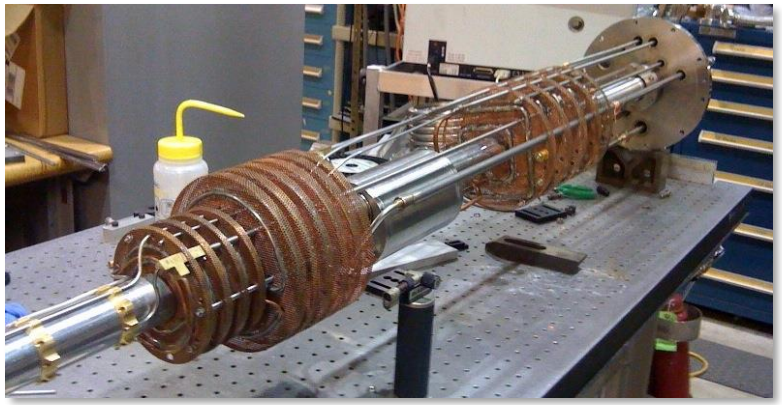
and at JLab on four occasions
- Gen (1998)
- Gen2 & RSS (2000)
- SANE (2008)
  - ➢ Major renovation
- G2p & GeP (2012)

The g2p upgrade

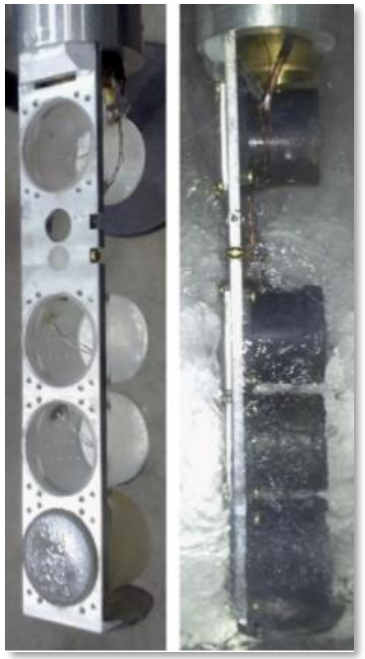
2012: Extensive upgrades were performed on numerous subsystems to improve target reliability



ASME-compliant 1 K refrigerator



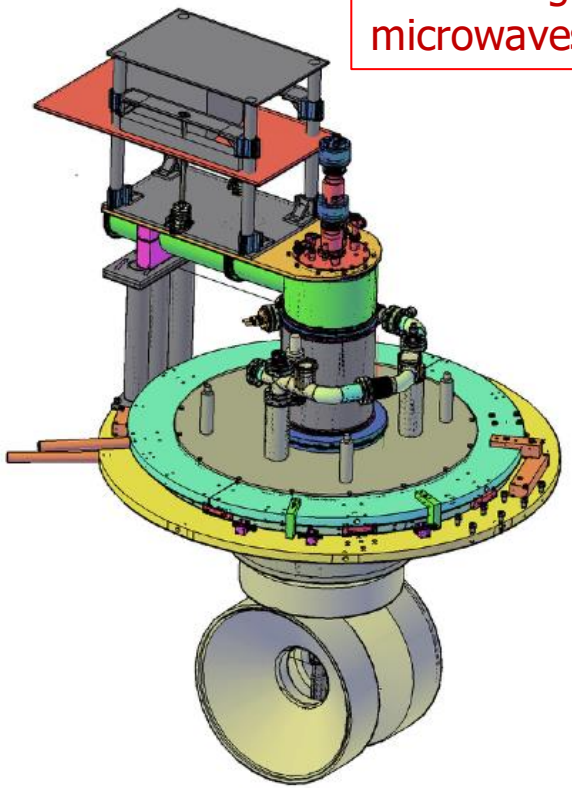
Carbon fiber target insert

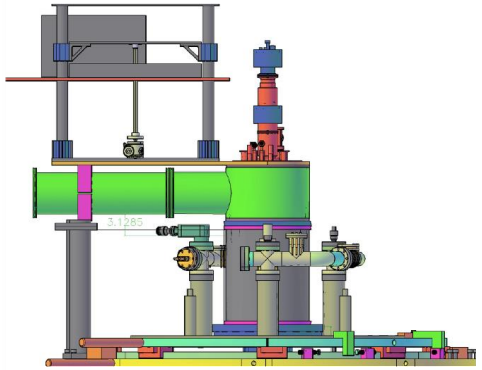


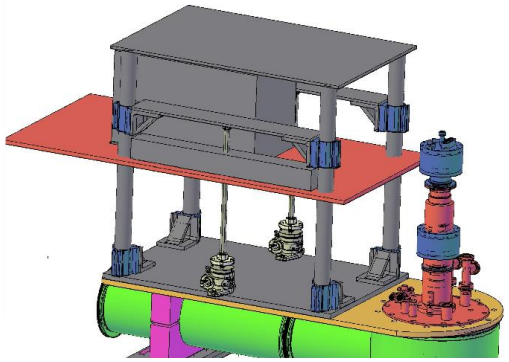
The g2p upgrade

2012: Extensive upgrades were performed on numerous subsystems to improve target reliability

New lifting mechanism for microwaves and target insert

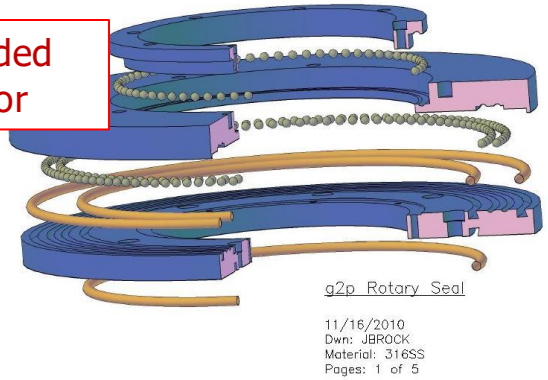






Oxford's (leaky) rubber & plastic seals replaced with metal knife edges

Rotary stage added to 1 K refrigerator

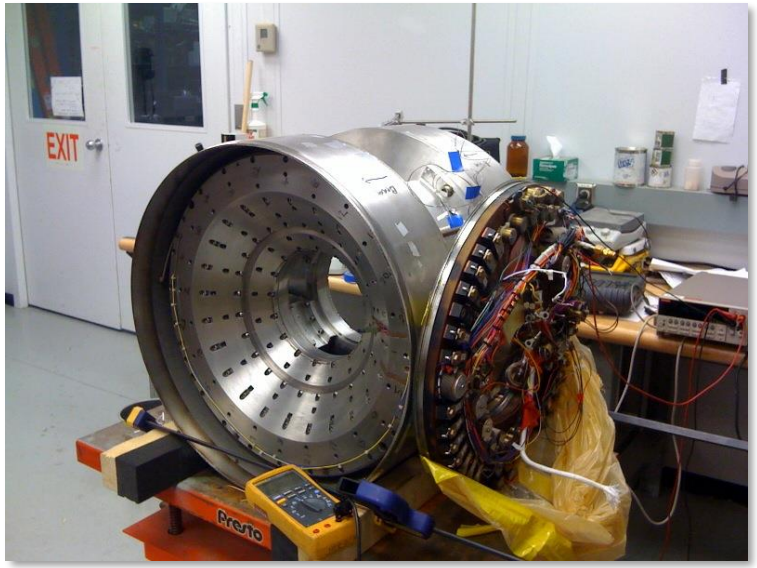


2012: Extensive upgrades were performed on numerous subsystems to improve target reliability

And a new (old) magnet

Following unstable operation during the SANE experiment, the 5 T magnet was shipped to Oxford Instruments for repairs

Upon return to JLab, it quenched (catastrophically) at 4.5 T during its first attempted ramp.

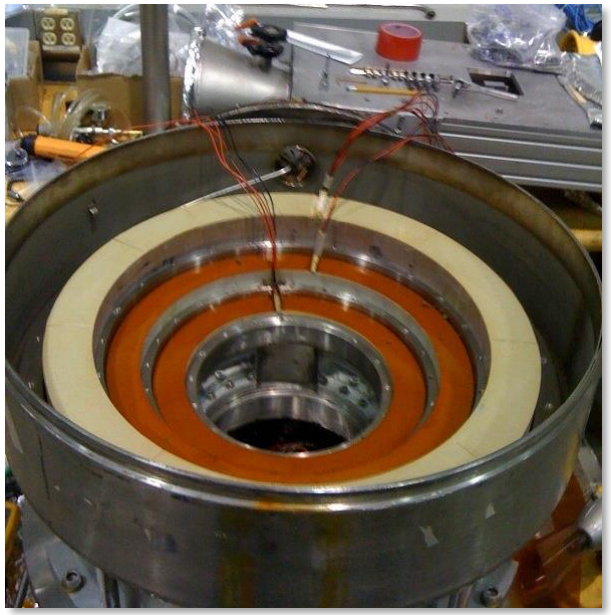


We cut it apart to find and repair the broken wire(s)

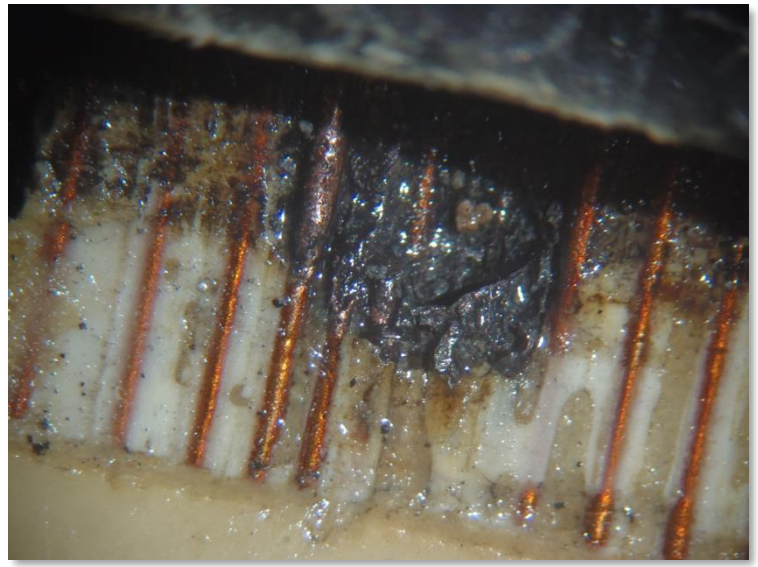
We found damage to the quench-protection circuitry…

The g2p upgrade

2012: Extensive upgrades were performed on numerous subsystems to improve target reliability



… and evidence that high-voltage arcs destroyed parts of the superconducting windings.

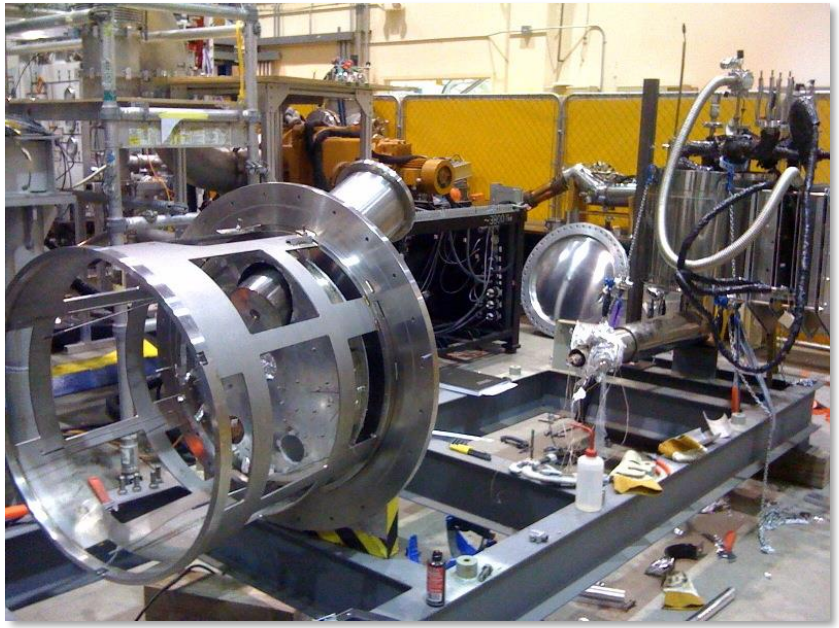


The g2p upgrade

Fortunately, we had another magnet on hand

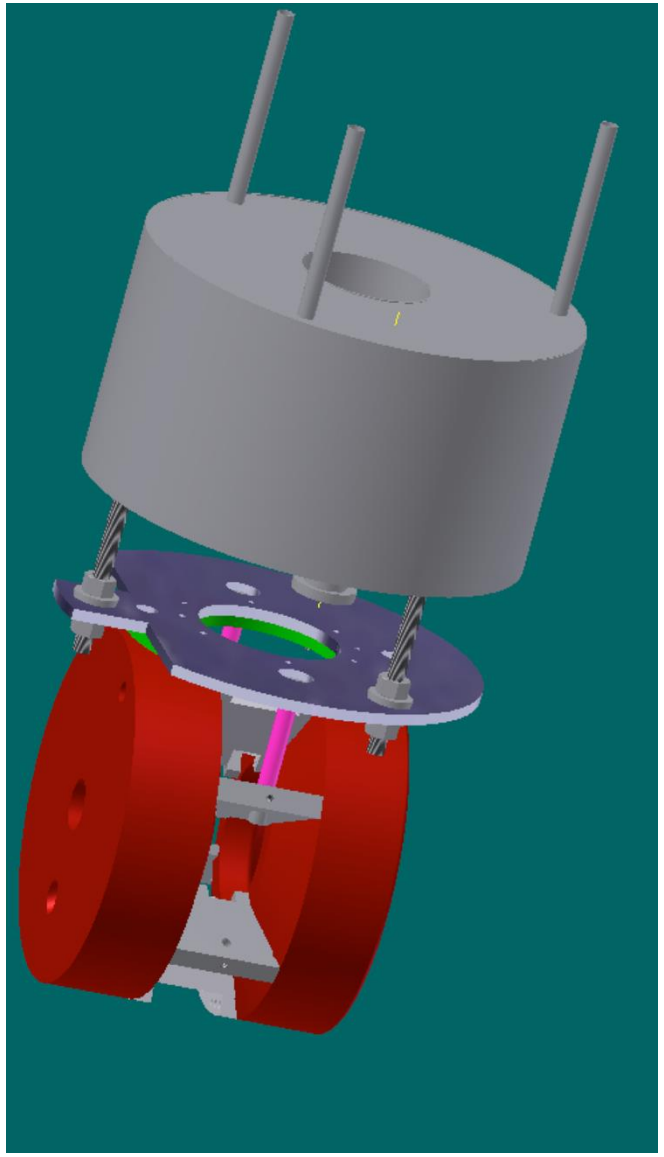
Hall B polarized target, ca. 2005

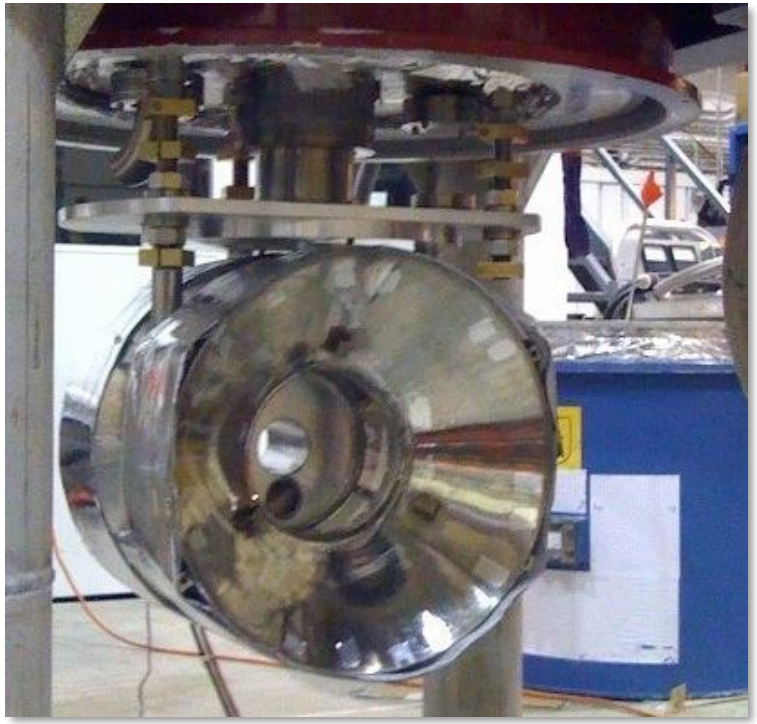
Vacuum can and heat shield removed



Magnet removed from cryostat

The g2p upgrade





The Hall B magnet in the Hall ~~C~~ ***A*** cryostat

Target performance during g2p & Gep *(J. Pierce et al, NIM A 738 (2014) 54)*

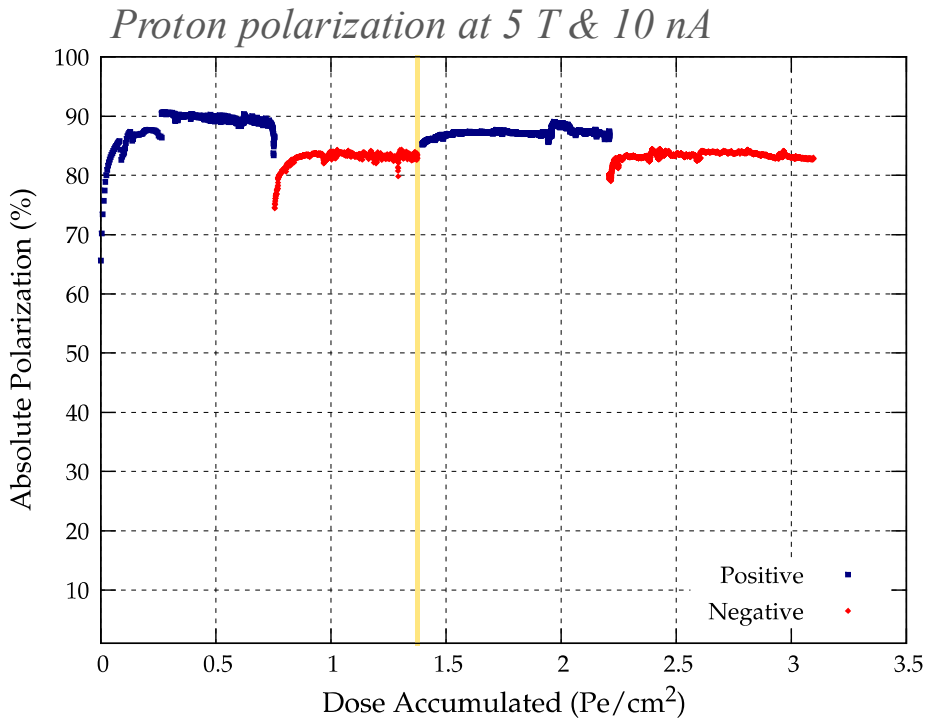


Fig. 8. Polarization vs. dose for the material which accounted for over half the total dose accumulated during G_E^p, taken with a 5 T magnet field and a 10 nA beam current. The vertical line represents removal and storage at 77 K.

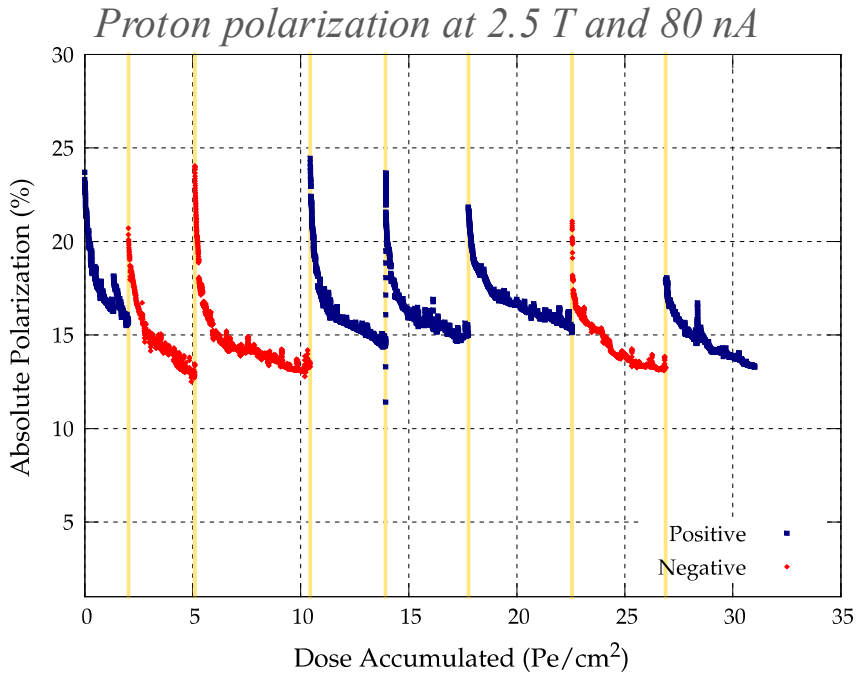


Fig. 9. Polarization vs. dose for the material which accounted for a third of the total dose accumulated during the g_2^p 2.5 T magnet field running, under a 80 nA beam current. Vertical lines represent anneals.

Current status

The polarized target was placed in the Physics Storage Building following the g2p/Gep experiments.

This warehouse is not climate-controlled and after 14 years, the condition of some of the equipment is highly suspect.

Current status

Two major capital equipment purchases have been made in the intervening years

Two sets of 6000 m^3/h roots pumps to replace the aging 12,000 m^3/h pumps
(40 y/o? 50 y/o?)

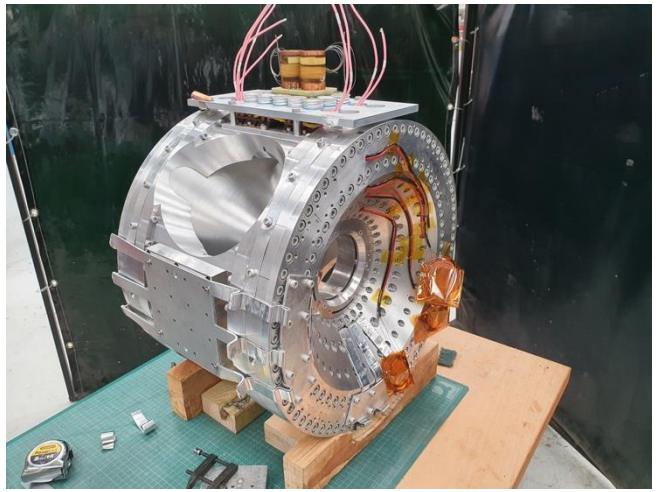
Current status

Two major capital equipment purchases have been made in the intervening years

A 5 T cryogen-free magnet for CPS, optimized for ***transverse polarization***

The opening angles for forward-scattered particles are

- Longitudinal (field || to beam): ±35° (down from ±55°)
- Transverse (field ⊥ to beam): ±25° (up from ±15°)



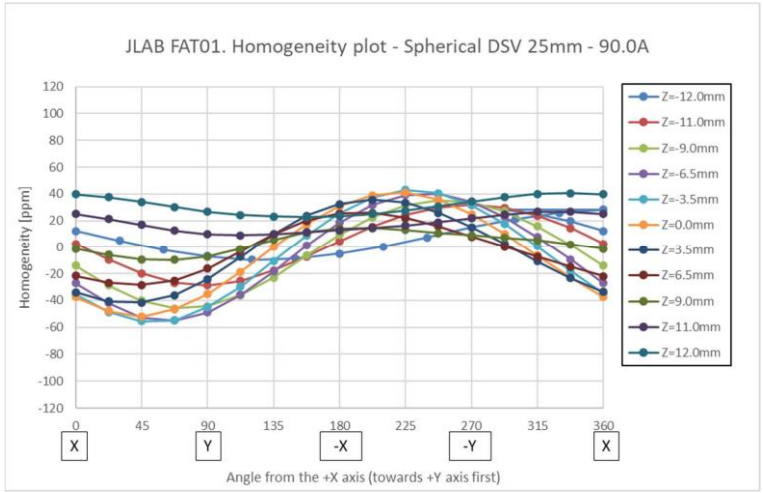
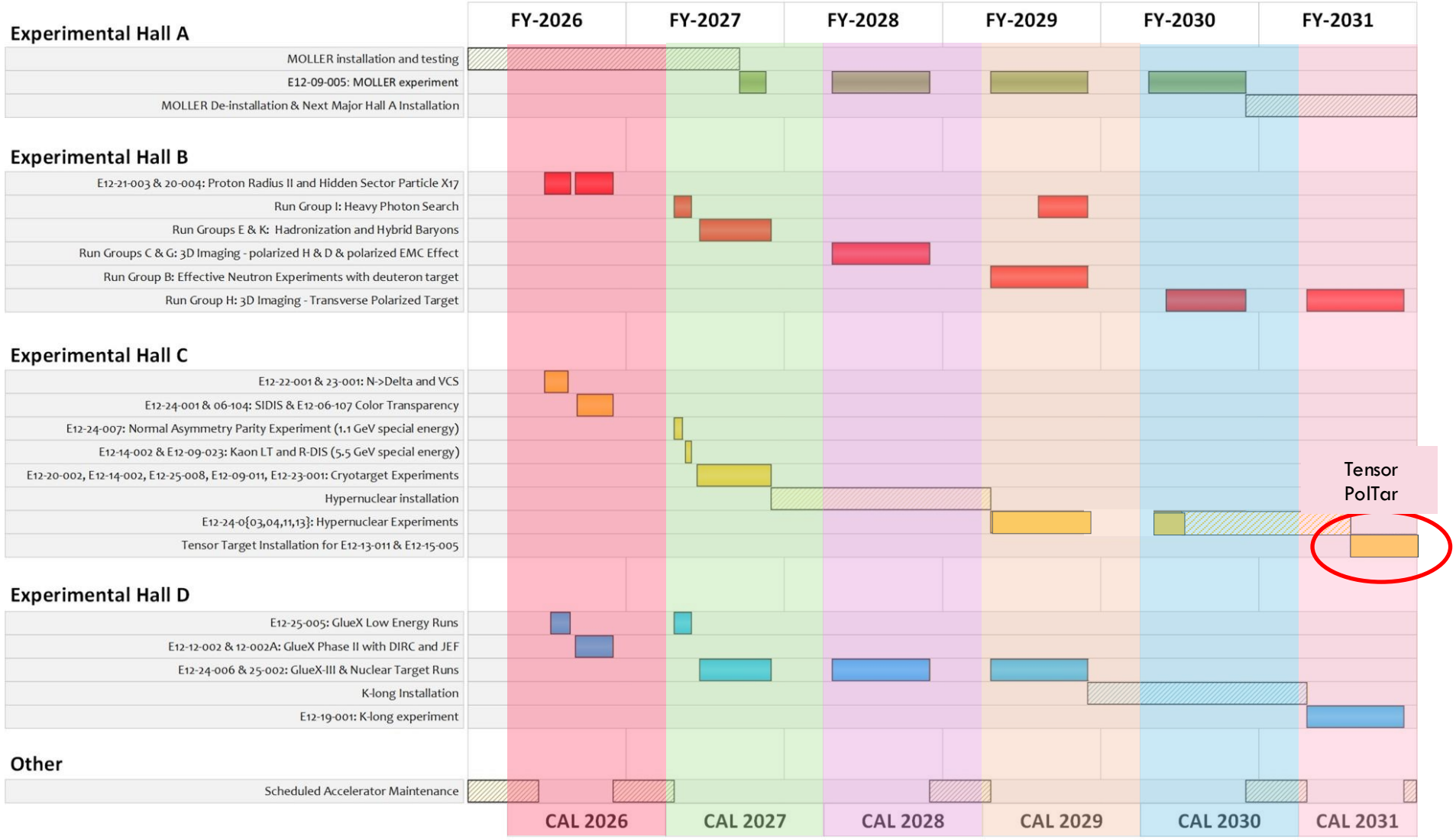


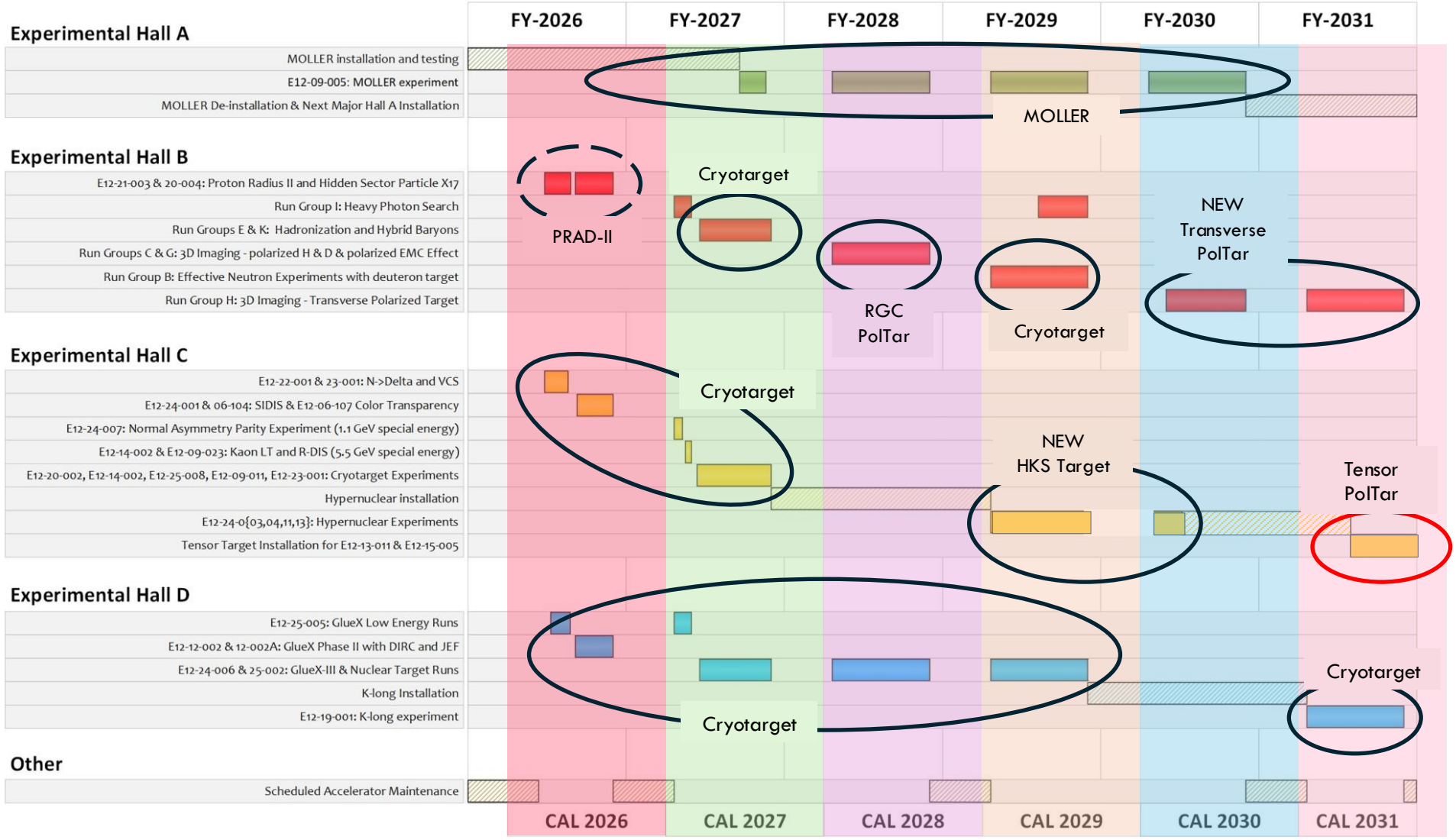
Figure 13: Plot of homogeneity on a 25mm DSV at 90.0A (max=43ppm, min=-55pm).

Homogeneity is ± 50 ppm over a 25 mm diameter spherical volume (DSV)

The schedule



The schedule



The next steps

Decide which magnet to use.

Hall B: Greater opening angle – 100° vs 70°
Operable at lower fields
Requires LHe

CPS: Larger uniform field region – 25 mm vs 20 mm
Cryogen free
Uniform only at 5.0 T

The next steps

Find a place to work:
(we might not get to choose…)

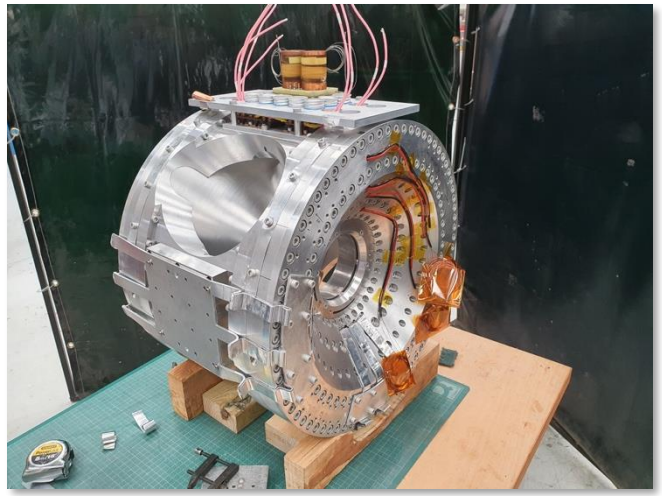
Requirements:
- 480 VAC for vacuum pumps
- Volume for ODH
- Overhead crane
- …

Experimental Staging Building

Test Lab High Bay

TED-F High Bay

Gather the equipment



The next steps

Put it together and make it work

Task	Time Est. (days)	Techs	Engineer/Scientist	Requirements
Move old Hall C PolTar to test site	2	2		Forklift, RadCon
Remove, inspect, rebuild insert lifter	10	2		Crane, RadCon
Remove 1 K fridge	1	1		Crane, RadCon
Inspect, repair 1 K fridge	10	1	1	Leak detector
Remove pumping sleeve	1	1		Crane, RadCon
Inspect pumping sleeve	1			Leak detector
Machine new nose piece x2	15	1		Designer, machinist
6	5	2		Crane, ForkLift, RadCon, Property Dept.
Assess stand qualifications	10		1	
Transport stand to test site	1	2		Crane, Forklift
Transport new magnet & vacuum can to test site	2	2		Crane, Forklift
Assemble fridge to new magnet	1	1		Crane
Leak check	2		1	Leak detector
Assemble insert lifter	5	1	1	Crane
Transport gas panel to test site	1	2		Forklift, RadCon
Recommision gas panel	5		1	
Leak test gas panel	1	1		Leak detector
Transport Roots pumps to test site	2	2		Forklift, Crane
Electrical connect pumps	20	1		Electrician
Test pumps	2	1	1	
Fabricate/connect pumping lines	30	2	1	Crane, welder, machine shop
Leak test system	5	1	1	Leak detector
Design new heat shield with approriate windows	5		1	Designer
Construct & install heat shield	10	2		Machine shop, Crane
Develop PI&D	5		1	
Develop EPICS slow control software	20		1	
Collect existing electronics	10		1	
Construct new electronics	40	1	1	
Transport electronics to test site	1	2		Crane
Connect & wire electronics	40	1	1	
Implement NMR hardware/software	40		1	
Design insert	20		1	
Fabricate insert, x2	20		1	Designer, machine shp
Assemble/test microwave system	20	1	1	Electrician
Design new transfer line for 1K fridge	10		1	
Fabricate/test transfer line	10	2		Leak detector
Cool-down #1	5	1	2	250 liters Lhe
Modify	15	2	1	
Cool-down #2	5	1	2	250 liters LHe
Modify	15	2	1	
Cool-down #3	15	1	2	250 liters LHe
Assess/Restore Vacuum chamber & windows	20	2	1	Crane, forklift, leak detector
Assess/Restore 500 L buffer dewar	20	1	1	Crane, forklift, leak detector
Transport/install in Hall C	40	4	2	Crane, forklift, leak detector
ERR #1 (prep + review)	10		2	
ERR #2 (prep + review)	10		2	
Total days	**477**	**614**	**539**	
Total weeks	**95.4**	**122.8**	**107.8**	

The end

- QUESTIONS? -