RG-C Report

CLAS Collaboration Meeting

March 2, 2021

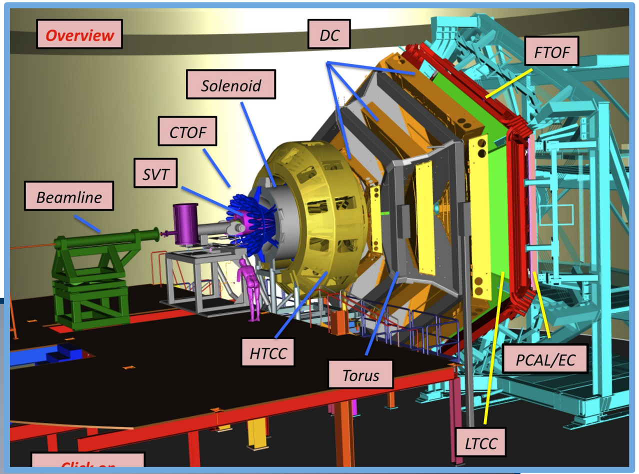
Victoria Lagerquist

Outline

- Target Status
  - Refrigerator
  - Trolley
  - NMR
- RGC Status
  - Beamline
  - Simulations
- Wrap-Up

Polarized Target - Apollo

Ammonia
POLarized
LOngitudinally

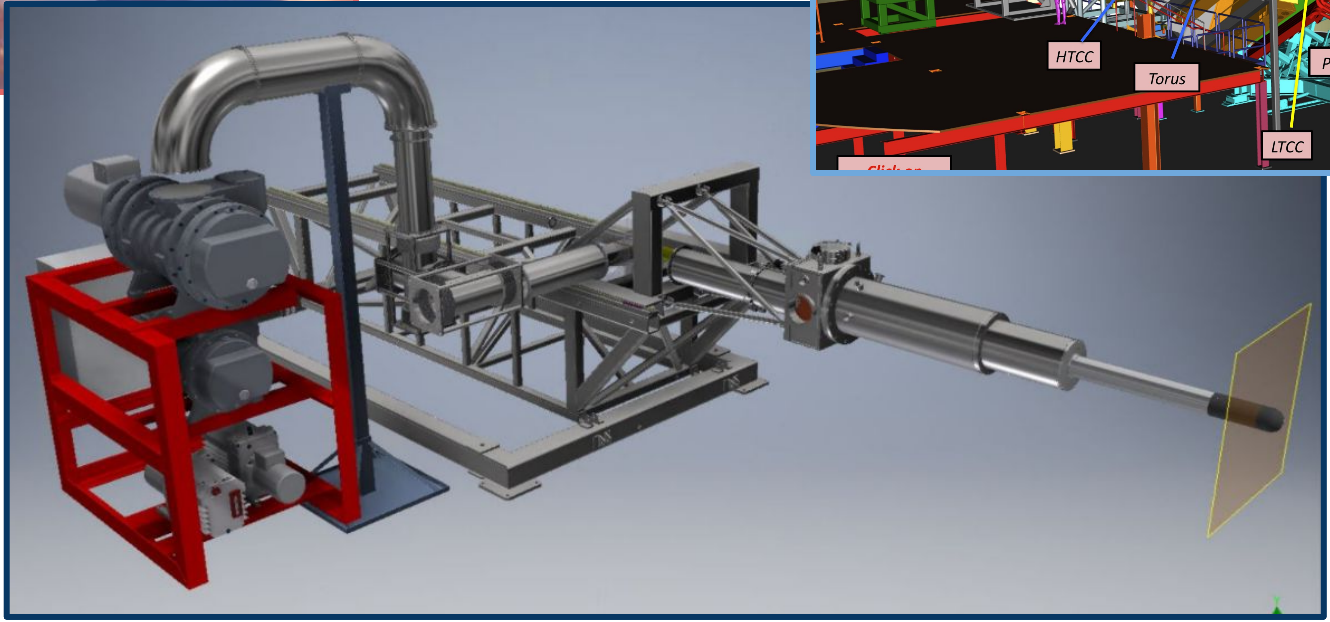


Polarized Target for CLAS12

Solid Ammonia / Deuterated Ammonia Targets

Improved Target Cell Loading

New NMR System



Dynamic Nuclear Polarization

Material
(Free Radicals)

Low Temperature
(1K)

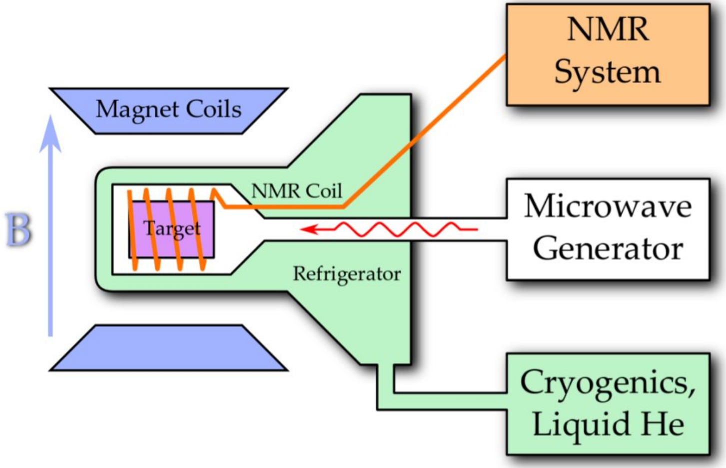
Magnetic Field
(5T)

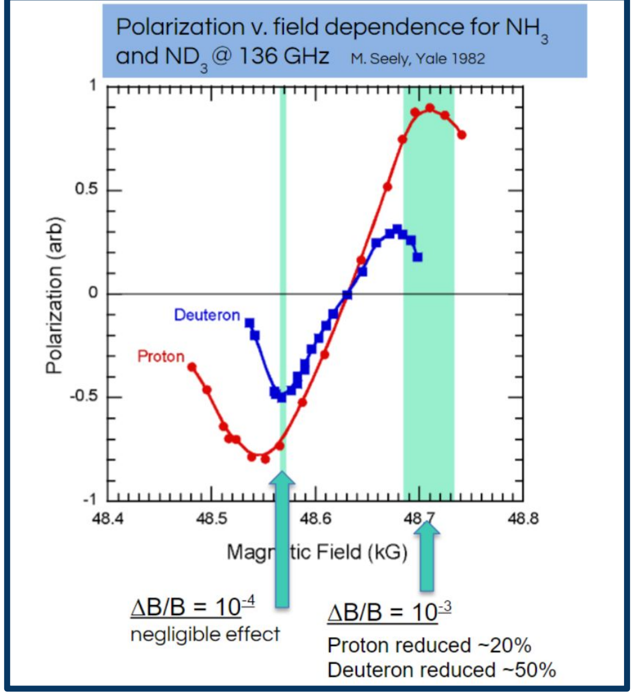
Microwaves
(140 GHz)

Monitoring (NMR)

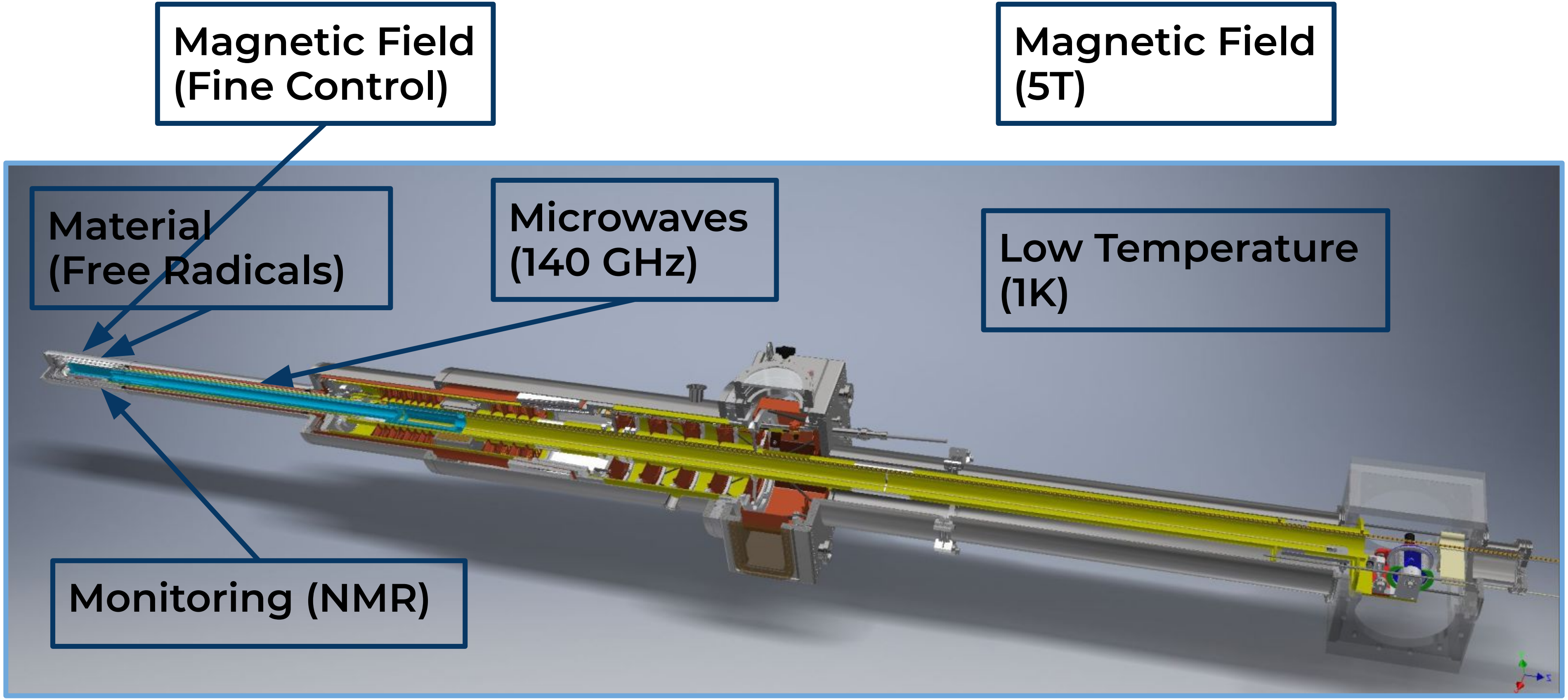
P_{proton} > 90%

To achieve hyperpolarization via DNP, target samples must be very cold, in a strong magnetic field, and irradiated with microwaves.

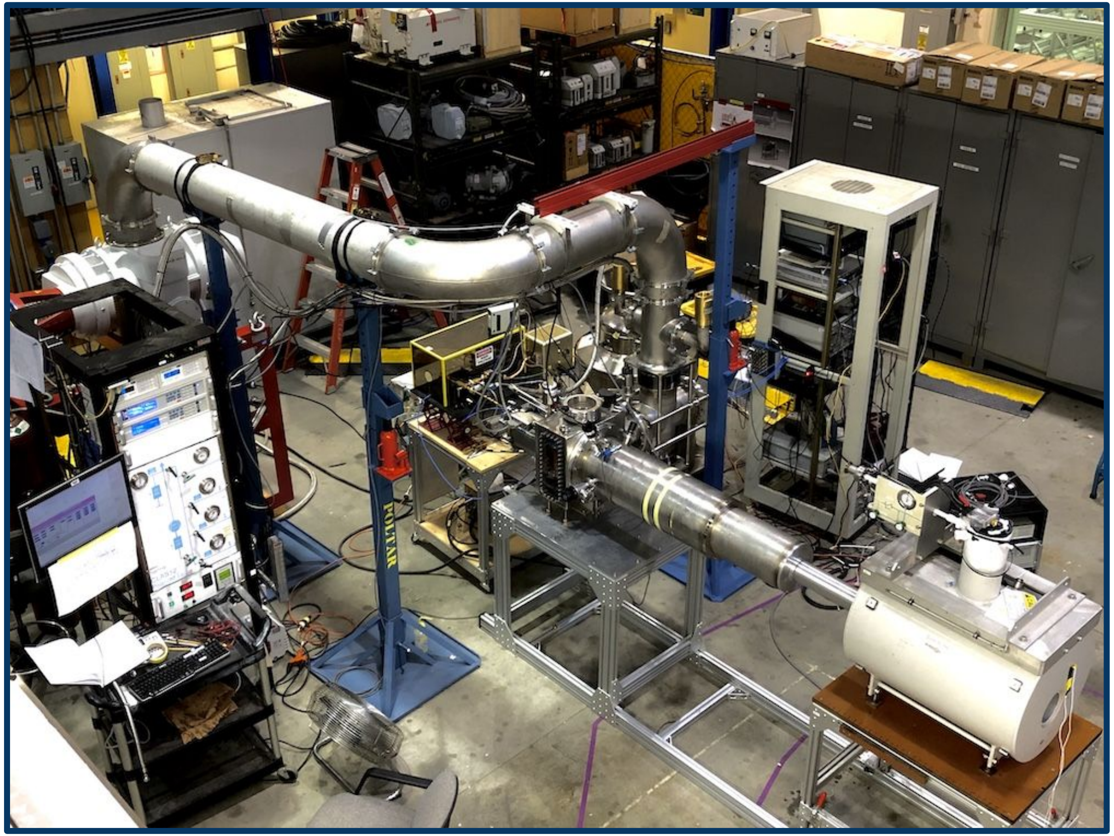




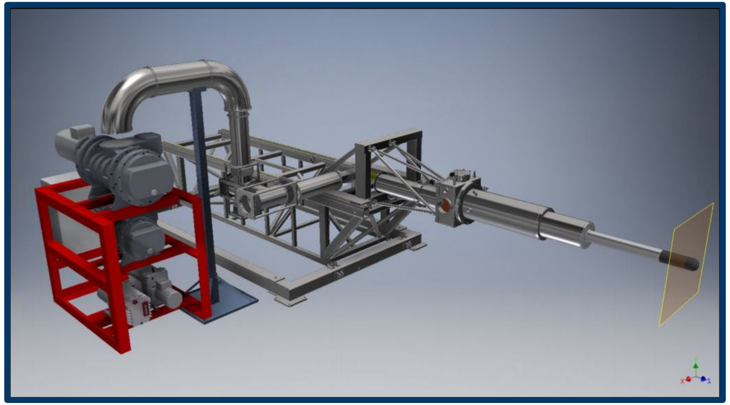
Target Overview



Testing in the EEL



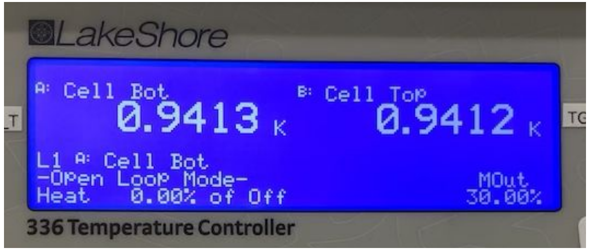
Previous cooldowns used loose equipment racks. Final design will have a single packaged ‘Target Cart’

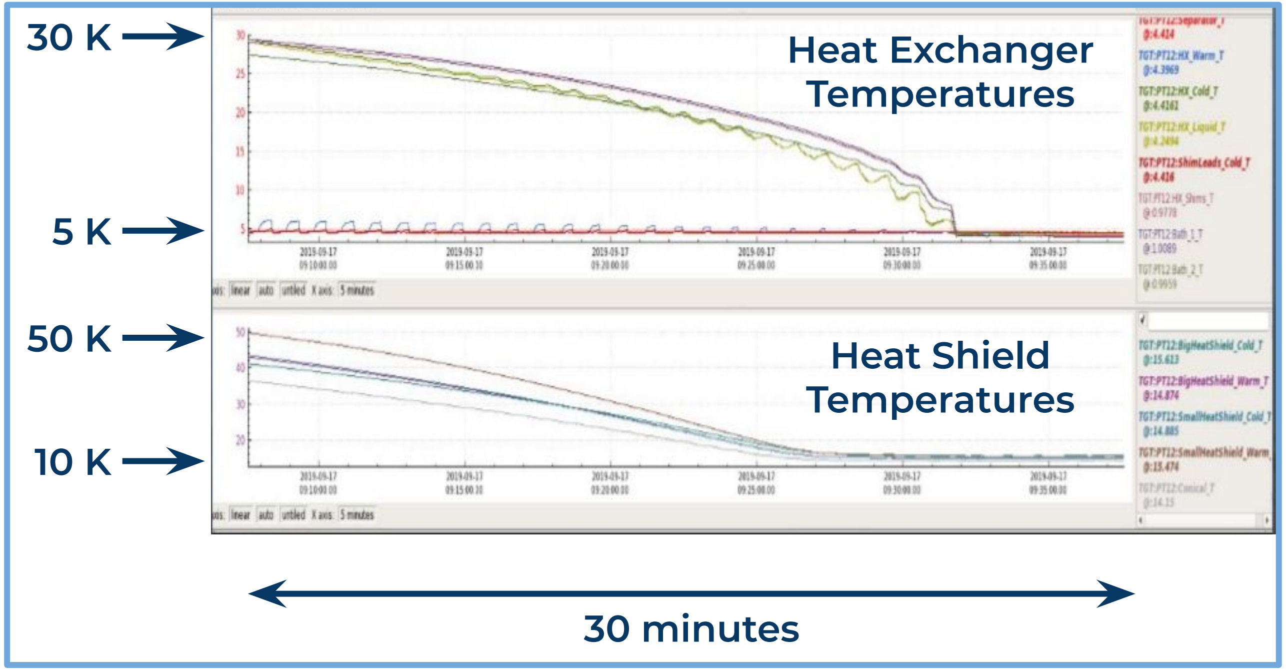


Testing in the EEL

Refrigerator

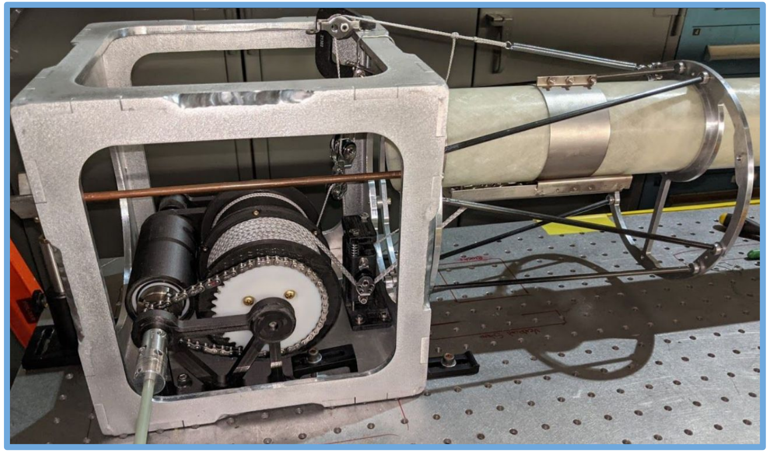
Refrigerator easily reaches required temperature and maintains it while under heat load.

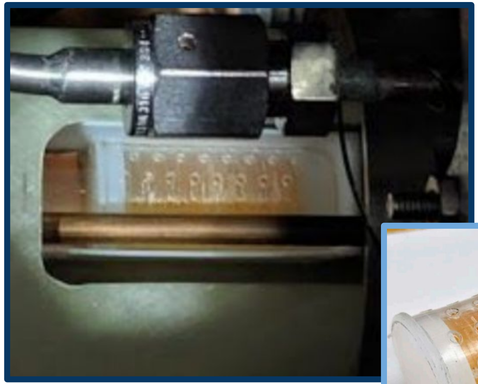




Most recent test successfully incorporated a capacitance level probe for automated PID running. System automatically controlled helium flow rate to change / maintain cryostat temperature.

Trolley Mechanism





As material takes beam, it depolarizes and eventually needs to be replaced. Previous experiments required partial disassembly of target to do so. Apollo will use a trolley system to transport target cell away from cold bath, minimizing downtime. The prototype trolley was successfully tested last cooldown. The updated model is ready for upcoming cold test.

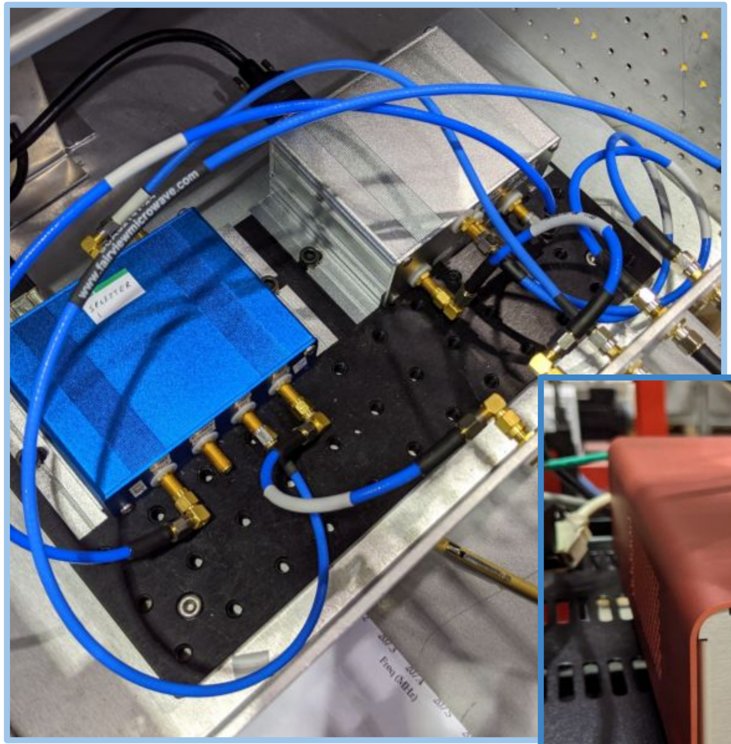
New NMR System

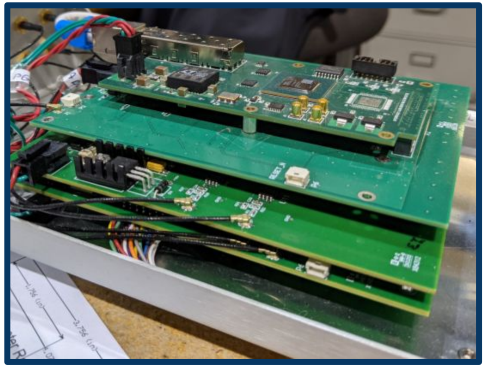
Completely new NMR system!

Previously developed new Q-meter and cold tank circuit.

New bespoke DAQ system: Upgraded from old National Instruments DAQ to custom board with FPGA firmware.

Many times faster communication to RF supply.





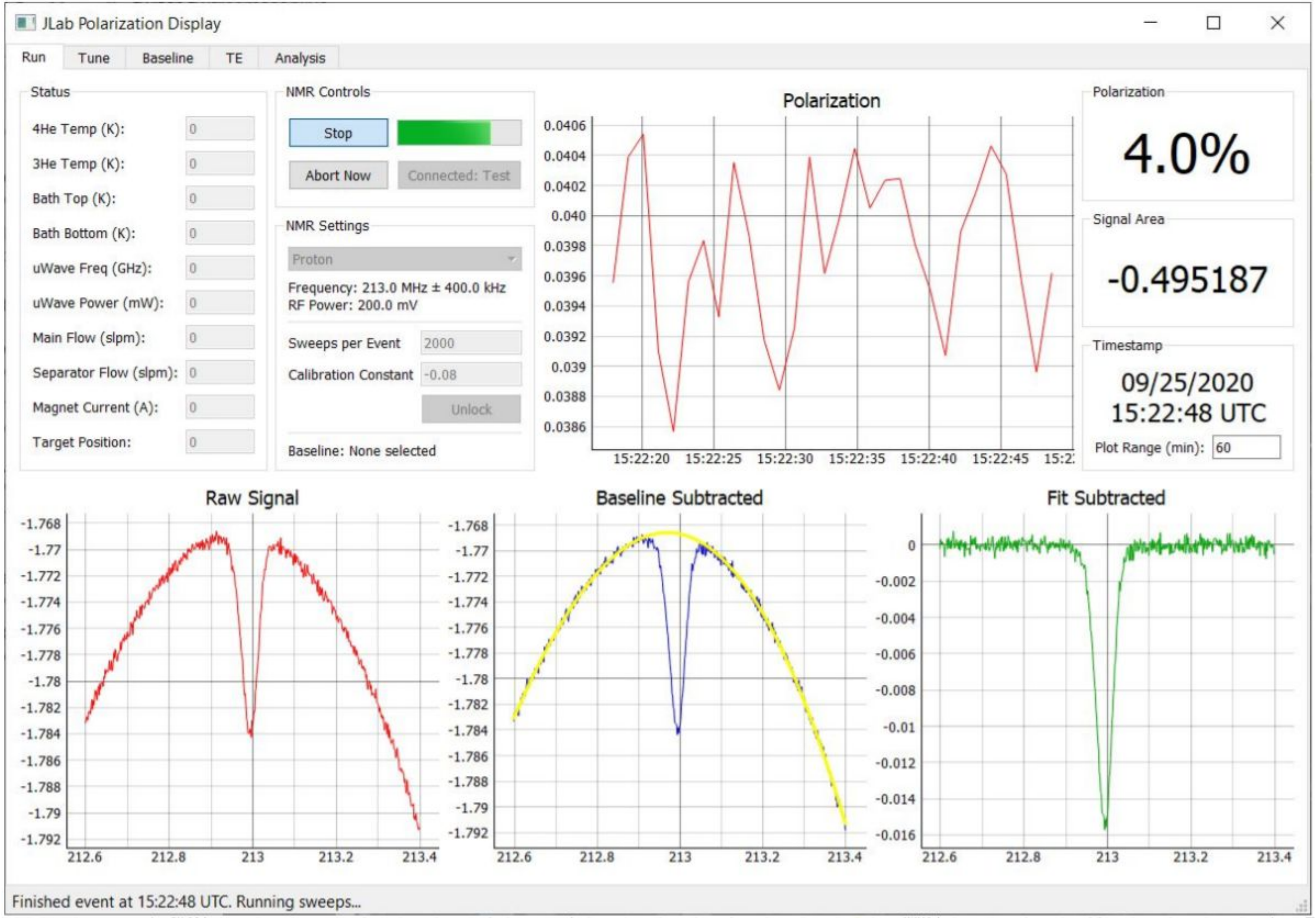
New NMR System

New software has been developed using python.

Will be tested during upcoming cool down.

Complete suite of NMR utilities.

No proprietary components.



Next Steps

Upcoming Cooldown:

Goals

1. Demonstrate loading & unloading of cold target samples
2. Demonstrate high DNP of butanol+TEMPO
3. Check stability of NMR
4. Demonstrate loading and polarization of NH3
5. Demonstrate NMR & DNP of *deuterated* butanol

Precool Tasklist

1. Confirm all slow controls (thermometer, heater, pressure level probe, etc);
2. Confirm NMR;
3. Assemble cryostat and re-check slow controls and NMR;
4. Order LN2 for 5 T magnet;
5. Pump on target OVC & FROST magnet OVC
6. Leak check target cryostat
7. Order LHe
8. Cool FROST magnet with LN2

Cooling Tasklist

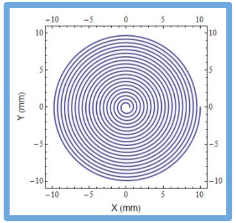
1. Load epoxy test samples in sample holder #1
2. Blow out LN2, cool FROST magnet with LHe
3. Start cooling 1 K refrigerator overnight
4. Tune 1K refrigerator
5. Ramp FROST magnet to 5 T

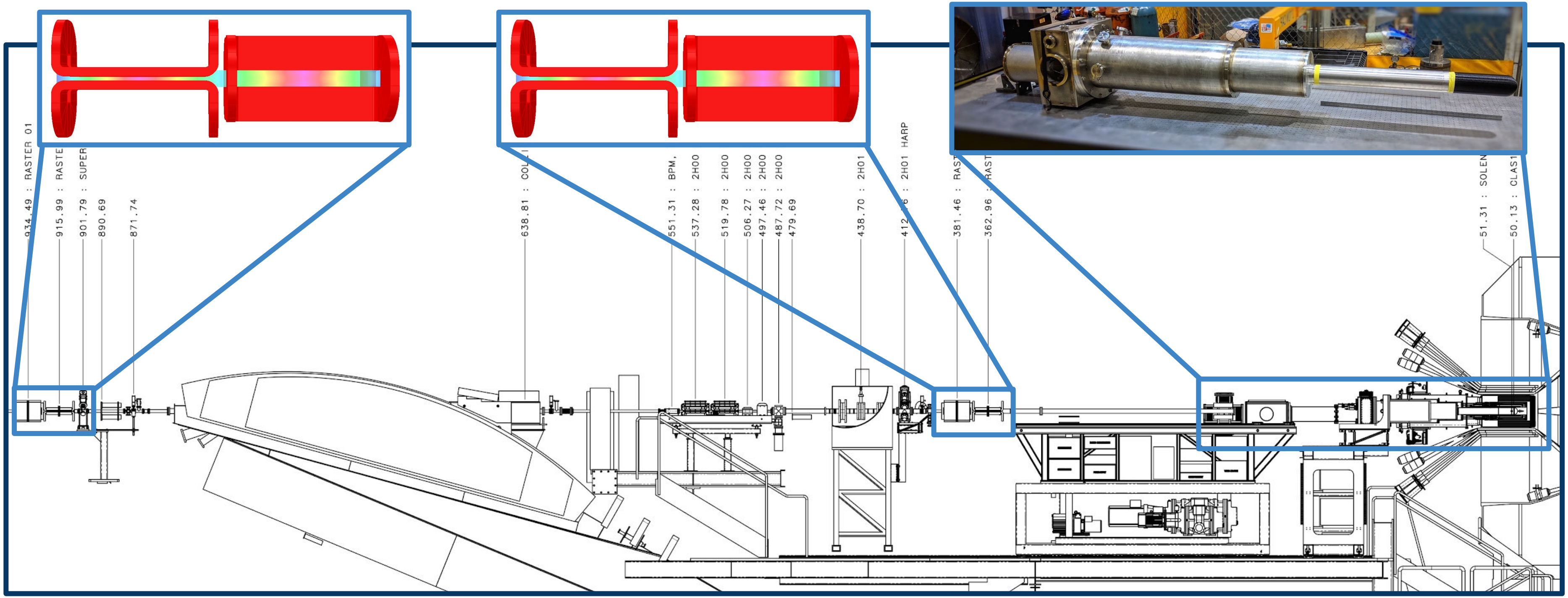
TEST Plan

1. TE epoxy (3 – 4 temperatures) & DNP Epoxy #1
2. Repeat TE after target motion, 3x
3. Replace with Epoxy in sample holder #2
4. TE + DNP Epoxy #2
5. Replace w/ Butanol in sample holder #3, TE + DNP
6. Replace w/ Butanol in holder #4, TE + DNP
7. Replace w/ Ammonia loaded in sample holder #2, TE + DNP
8. Load Epoxy #1, repeat TE & DNP of step 1
9. TE & DNP of Butanol w/ double aluminum endcaps
10. Load d-butanol (use sample holder #4), TE + DNP
11. Unload d-butanol and warm up

Beamline - Raster Magnets

Models of the raster magnets have been analyzed to confirm a maximum raster radius of ~1 cm is achievable. The magnets are currently being inspected and tested by the magnet group.





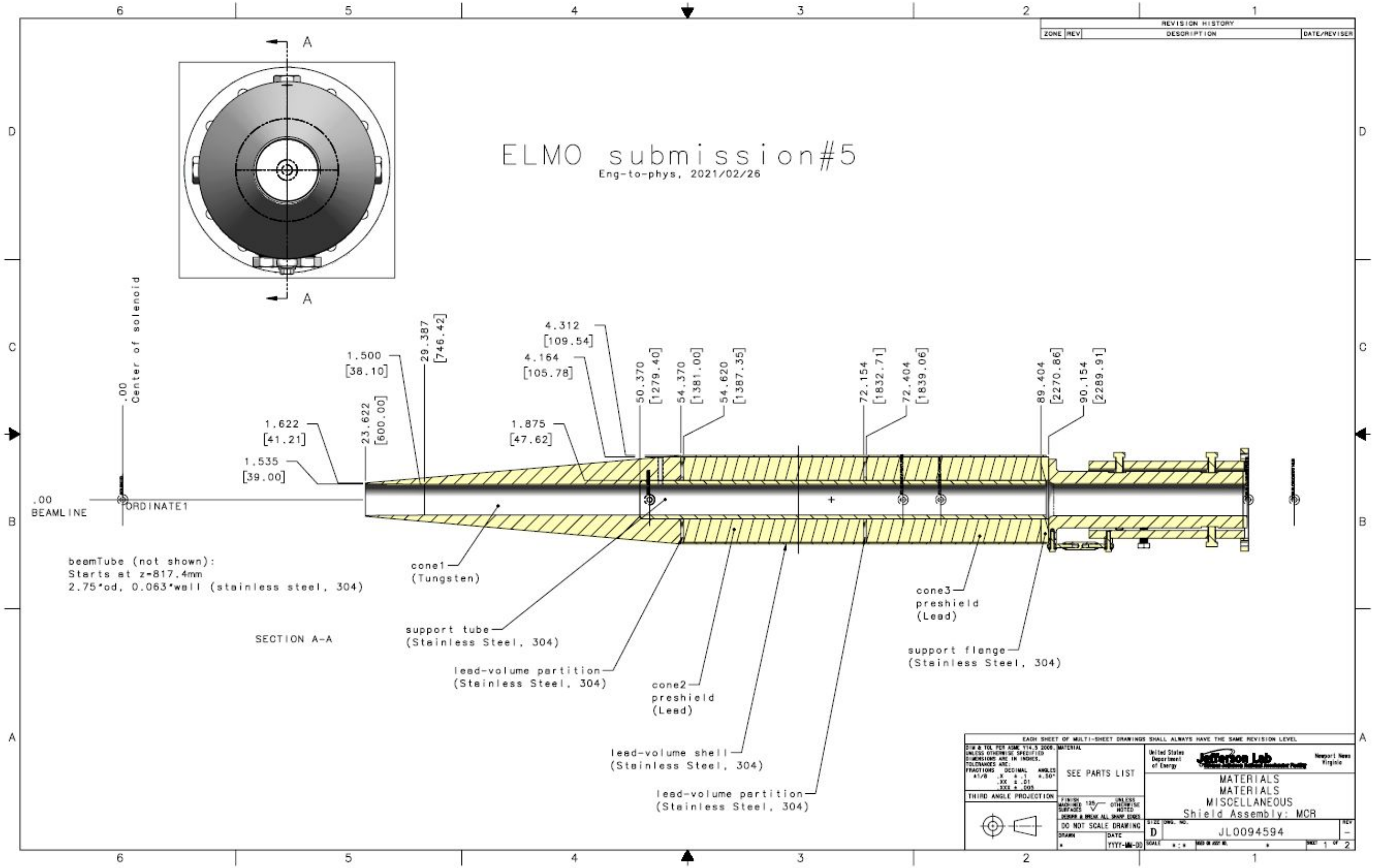
RGC Status

Beamline - ELMO Møller Shield

New engineering drawing is complete and awaiting review.

Lead portions will have stainless-steel case around them, and stainless-steel internal structural partitions.

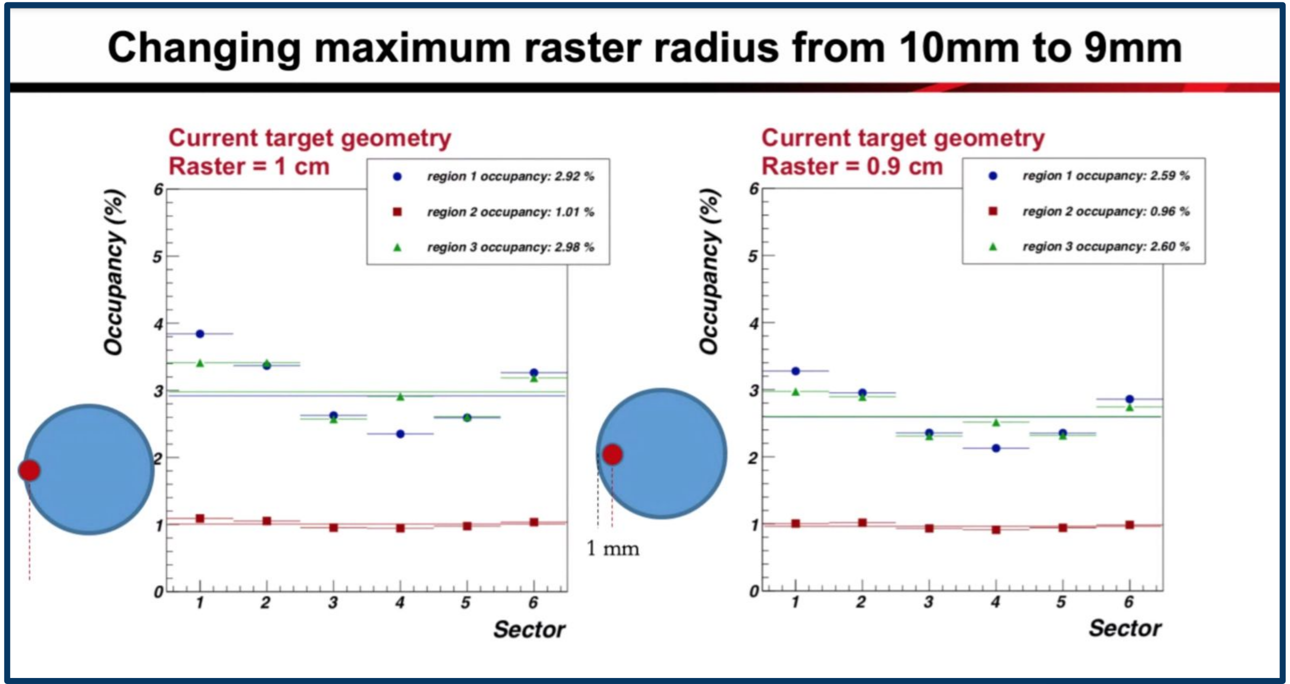
Cone material will be Tungsten 92W-NiFe.



Simulations

It was discovered that simulations involving the rastered beam were inadvertently over-rastering and scraping the target cell walls due to finite width beam.

Reducing the simulated raster radius to compensate has improved occupancies.



V. Burkert

Simulations

Additionally, errors with the geometry of the thin windows were discovered and corrected.

Simulations for pDVCS with beam background and varying raster positions are now underway in order to check the variation of tracking efficiency.

SIDIS simulations, as well, are currently being rerun.

pDVCS simulations for RG-C

In preparation for the RG-C run plan:

- **Acceptance comparison** for ELMO and FTOn configurations for pDVCS
- Effect of **beam background** and **raster size** on the **reconstruction** of the pDVCS final state

Event generator: **genepi** (DVCS/BH and exclusive π^0 on proton and deuterium targets)
Reaction: **ep→epγ**
Conditions: proton target, vz = -3 cm, beam energy = 10.6 GeV

gcards (provided by Raffaella):

- APOLLO+ELMO configuration (with and without « rastered » background)
- APOLLO+FTOn configuration

GEMC 4.4.1, COATJAVA 6.5.13, jobs ran on JLab farm
Location of scripts: **~silvia/scripts_clas12/**
Analysis done with CLAS12ROOT + pDVCS selection code by Orsay group

S. Niccolai

Simulations

To-do list

Analyze single-electron simulations with background done in RGA setup (already ran), to compare with Stepan's efficiency measurements with data

pDVCS simulations:
- More statistics for all settings
- Check different beam currents/luminosities

Precise estimate of minimum necessary fraction of data with FTOn (4D binned study)

Do the whole study for nDVCS as well (efficiency reduction could be less)

S. Niccolai

Task Force

RG-C taskforce run by Volker Burkert has been greatly beneficial in ensuring the completion of task list items in a timely manner.

See: Hall B Group Round Table Meeting Minutes: February 24, 2021

Summary

- The RGC TF effort is well underway and is on schedule for the given timeline when the experiment would need to be fully operational.
- The installation procedure in Hall B has been defined in detail in terms what is required to prepare Hall B for the installation of the polarized target
- A preliminary plan has been defined by the target group for the installation of the polarized target, including the procedure to have the target fully polarized and ready for beam.
- Simulations of the Moller cone have been completed and a satisfactory configuration has been reached. Full design is in preparation, and will have to be reviewed by Bob before going to procurement.
- Further simulations for RGC w/o FT focus on the downstream area of the Torus magnet to understand better the source of background in DC R3 and possibly FTOF.
- As the next step, simulations of the RGC configuration FT-ON will begin. This is a more challenging task and may require significant changes to the shielding concept.
- Beam raster magnets and PS to be tested to reach full beam energy of 10.6 GeV.
- Defining additional slow controls and other readout channels ongoing.

Goal: Support the hardware and software integration of RGC into CLAS12

Task Force	**RG-C Polarized Target**
PI	**V. Burkert**
Members	**R. Miller (equipment integration), N. Baltzell (software & slow controls), R. De Vita (simulations), C. Keith (Target Group)**

Tasks/Subtasks	2020		2021									
	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct
1. In coordination with RGC team and Target Group develop an integration plan to install and operate a longitudinally polarized target in CLAS12												
1.1 Define Hall B Configuration			M1.1									
1.2 Buffer Dewar				M1.2								
1.3 Define power requirements				M1.3								
1.4 Space requirements				M1.4								
1.5 Polarized target installation				M1.5.1							M1.5.2	M1.5.3
2. In coordination with RGC team define beam line components and special requirements												
2.1 Raster magnets install, operational, tested			M2.1.1		M2.1.2					M2.1.3		
2.2 New Moller shield				M2.2.1		M2.2.2					M2.2.3	M2.2.4
2.3 Forward Micromegas			M2.3.1		M2.3.2					M2.3.3	M2.3.4	
~~2.4 Beam Offset Monitor (BOM)~~ (EP)			~~M2.4.1~~		~~M2.4.2~~					~~M2.4.3~~		
2.5 Fast Shut Down system (EP)			M2.5.1								M2.5.2	
3. In coordination with RGC team define and support the experiment related simulations, monitoring, and reconstruction framework												
3.1 Simulate Effect of Moller shield				M3.1.1		M3.1.2		M3.1.3				
3.2 Simulate physics reaction with background (SN)										M3.2.1		
4. In coordination with RGC team define the integration of RGC FE and DAQ into CLAS12 framework												
4.1 Read back of raster position into DAQ					M4.1.1				M4.1.2			
4.2 Other FE readout specific to RGC					M4.2.1							
5. In coordination with RGC team check the integration of slow controls into CLAS12 framework												
5.1 Define and implement Slow Controls needs for RGC beyond normal CLAS12 operation				M5.1.1	M5.1.2				M5.1.2			
6. In coordination with RGC team define and support the integration of the RGC trigger into CLAS12 framework												
6.1 Define special trigger needs for RGC operation			M6.1.1								M6.1.2	

Wrap-Up

- Initial tests with polarized target successful
- Tests continue in the EEL building
    - Replacing prototypes with beam ready components (thin windows etc.)
    - Addition of magnet shim coils
- Raster control being finalized
- ELMO design vetted and fabrication should start soon
- Simulation issues resolved
- On track for run in 2022

Thank You