Lessons Learned from the Experience of Preparing, Installing, Commissioning and Operating the Polarized 3He Target for the Gen-II experiment in Hall A – Part I:

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1. Survey and alignment (Chris Gould feedback)
   a. Line of sight is not so clear when you start with installing the first target
   b. What points need to be surveyed at the installation? (need clear plan and order of steps)
      i. Optics boards
      ii. Mirrors (oven, periscope)
      iii. Doors of shielding box
      iv. Target ladder (positions and motion)
      v. Pivot (positions and rotations to different kinematic settings)
      vi. Positioning points for optics screen for compass field measurements
      vii. Cartridge adjustment to adjust pitch and yaw
2. Person-power and time
   a. Personnel with specific onsite training was lacking.
      i. Make sure the team has all required training well in advance (laser training, radiological worker II training, etc)
      ii. Having at least four graduate students with proper training who are available to help with small scale hardware tasks would help spread out the work more evenly
      iii. People with knowledge on polarized targets, SBS magnetic field (fringe field), and polarimetry being able to be onsite would have been helpful
   b. Not enough person-power in preparation and installation. The students had too many responsibilities, overworked.
      i. Having four graduate students, one postdoc, and multiple staff and professors would make an efficient team.
   c. It would be great to have a postdoc or staff who can be dedicated to implementing monitoring systems before production running starts.
3. Cell production
   a. Have cells ready and onsite well in advance of installation
      i. Mount the cells ahead of time so that they can be installed in the hall with less notice
      ii. Have oven bottom plates, RTDs, and feedthrough mounts (= 2 x number of produced cells) manufactured in advance so that they don’t need to be reused after being contaminated
   b. Better communication with UVA target group

            i. Attendance by a JLab target group member at UVA meetings or UVA member gives an update at JLab target group
    c. Results of test on cells at UVA should be available
        i. Could help prioritize the order of cell installation
        ii. If an emergency cell transfer needs to happen, we will already have a plan
4. Cell characterization
    a. Better communication on the results from UVA.
        i. Make an electronic logbook?
    b. Prepare JLab to make measurements in order to help with cell wall thickness measurements.
        i. Could make measurements at both UVA and JLab to spread out the work.
5. Target enclosure design
    a. I-beams that support the structure restrict access to the downstream part of the enclosure.
    b. Overall, the enclosure could be bigger so that we could move around more freely during installation.
        i. This would also allow us to possibly get three or four people in the enclosure at once, which would help with the physical requirements of attaching the cell to the oven.
    c. Decision to cover up holes with lexan sheets came at the last minute. Do this ahead of time.
    d. Entrance doors were wobbly and thin. Is it possible to improve this?
    e. Make sure no laser light can potentially escape from below the doors - engineered control.
6. Optics (lasers, laser fibers, laser polarization, etc)
    a. Purchase additional laser fibers within budget and keeping in mind shipment time, procurement time, and overhead. Always have multiple spares.
    b. Laser power wattage - more input from Jack Jackson.
        i. Need to check as lasers age which means they need to be looked at during run period
    c. Difficult to integrate new lasers into Epics data stream.
        i. This was never figured out?
    d. Difficult to integrate new lasers into multistation laser controller software.
    e. Make more laser-to-interlock station cables.
    f. Decide on the optics layout ahead of time and acquire a variety of lenses that are close to what we expect we will need.
        i. Matching the optics setup in the proposal to reality takes time.
    g. Polarization of laser light decreases as it passes through pumping chamber glass when the oven is on due to birefringence.

        i. Make a glass enclosure for a polarimetry cube that is the same thickness as the pumping chamber when the oven is on.
        ii. Study circular polarization under production conditions.
        iii. Use spectrometer and look at absorption at wavelength of lasers.
    h. Have pre-made bullseye cutouts for the oven windows and mirrors.
    i. Come up with a folded path procedure ahead of time.
        i. Standardize and document procedure in order to get the optimal laser spot with the target in the polarized helium-3 target position.

7. Cell mounting and installation (alignment)
    a. Support bar for the target ladder should have a groove beveled into it to accommodate half seals.
    b. Cells need to be made closer to spec so that the transfer tubes don't push up against the inside of the holes in the oven plate.
    c. We only have two metal dowels to hold the bottom plate in the jig. This is enough to keep it still, but we need one more and should have 2-3 extra dowels as well.
    d. Add convection heater strip and support bar to mounted target BEFORE bringing it into the enclosure.
8. Beam and slow controls
    a. Good Beam = good
    b. Monitoring beam positions, raster sizes, target protections always implemented
    c. Start off with implementation of beam excursion controls.
        i. We have methods to monitor the beam from the CH, and these should be in place at the beginning of running.
9. Reference cell and cooling jets
    a. Reference cell
        i. Make sure we have multiple spares in case something happens during a cell rupture.
        ii. Use the connector tool.
            1. Use a different copper connector in the future that is smoother and easier to use so that the force required to (dis)connect the reference cell is not absorbed by the target ladder.
        iii. Have lots of spare positioning screws for reference cell mounting.
        iv. Don't tighten the screws on the reference cell too much. Leave them finger-tight.
        v. Figure out how much data to take on the reference cell before running at each kinematic. Have a more detailed run plan.
    b. Cooling jets
        i. Upstream cooling jet is in the way of magnetic field measurements and cell alignment, and it must be removed each time we do either of these tasks.

        ii. Read the instructions for cooling jet alignment before going into the enclosure.
            1. Make sure the instructions are posted and available.
        iii. Todd input?

10. Polarimetries
    a. Create a framework to document calibration measurements that can be used from the beginning of the experiment, i.e., make a wiki page with an empty table to fill out, create a place to compile all the log entries, etc.
    b. NMR
        i. The signal is different with the SBS magnet on and off, so we need separate calibrations. We don't really need them for off.
        ii. Make sure that all the signals from all the channels of the pre-amplifier are properly connected and the correct polarity direction is used.
            1. Label BNC connections so that they are always placed in the correct orientation.
        iii. The frames had to be machined to be out of the way of the target ladder.
        iv. Many software errors from LabView occurred while doing production running. They were addressed by restarting LabView.
        v. Dynamic instructions should be readily available for shift takers from the beginning of the experiment.
        vi. Hunter input?
    c. EPR
        i. Move the EPR amplifier upstairs to the counting house so that we can do EPR-NMR calibrations remotely without needing hall access.
        ii. Get plenty of spare photodiodes. These eventually break due to radiation damage.
        iii. More people should be trained in taking EPR measurements. We only had one person.
        iv. Make a wiki page with the links to the log entries for all the EPR measurements.
        v. Hunter input?

11. Magnetic field
    a. It would be nice to have a way to get rad-hard field sensors in the enclosure during production running.
    b. Compass measurements
        i. The UVA compass encountered issues and was dropped from use. It was never sent to JLab. All custom instrumentation should be working, tested, and on site before production running.

ii. The screens were built at the last minute, and we realized that survey and alignment was needed for each measurement. Knowing this far in advance would have prepared survey and alignment.
    1. Is it true that we need survey and alignment for EACH measurement?
    2. Bogdan feedback?

iii. Mounting the screen requires access to the enclosure via the small shielding door which requires additional overhead to remove the acceptance shielding plates.

iv. The vertical rod holder of the compass itself was unstable. When measurements were done, the movement of the holder sometimes caused the compass itself to tilt at an angle.
    1. A more stable way of moving the compass and holding it in place needs to be designed so that we can make measurements at the pumping chamber and transfer tubes.

v. The initial plan was to take pictures of the screen, but after the first cell rupture the target enclosure became a high contamination area and taking pictures became very difficult.
    1. There needs to be an additional person outside of the enclosure to take the picture.

c. Gradient probe measurements

i. The gradient probe apparatus should be designed such that it allows us to change the orientation of the probe while still having a stable surface to rest on. We held it in place by hand for certain orientations.
    1. The challenge here is that it would need to be incorporated at various z locations along the beam line.
    2. Pick a few z locations and add a cutout at these locations.

ii. We had to remove the pickup coils for each field measurement. This means that cables could come loose and we had to check the polarity afterwards.

iii. The apparatus to measure the gradient at the pumping chamber had slot indicators at different angle locations. They became loose and had to be tightened by Dean Spiers.
    1. It might be a good idea to have at least one spare that can be used while another one is being fixed.

iv. There were two probes and one had a tilt. Measurements had to be taken twice to average and cancel out effects due to the tilt. We should account for this beforehand and test the device with the hope that when it is used for production measurements, the tilt is fixed and/or accounted for.

v. Mark off exact z locations on the apparatus so that we can show measurements are reproducible at known z locations.

d. Magnetic shielding
    i. Install sensors at various locations near the pivot area and ensure they are calibrated before production running.
    ii. It was crucial that the acceptance shielding plates, which were initially ignored, be installed because they reduced the residual SBS field at the target location.
e. SBS and BB magnet operation
    i. Coordinating the effort needed to do the field measurements ahead of time was crucial. Only a few people are able to operate these magnets, so make sure we have the support from these people when needed.
    ii. Get the OSP approved ahead of time. Make sure that enclosure is safe after magnets are turned on.
f. Power supplies
    i. We used constant voltage mode.
    ii. If we want to consider constant current mode, we need to test and prove stability in the test lab.
    iii. Check the monitoring system for current over time to make sure that connections are stable and the field doesn't become noisy.
    iv. Get the correct size i-connections for the wires.
    v. If the work coordinator wants to lock out the power supplies, make sure to coordinate and establish the procedure.
g. Documentation
    i. Make sure that the field measurement results are clearly documented in known locations.
        1. A wiki page with compiled log entries would be helpful.
        2. Establish a documentation mode before taking any measurements.
h. Readout / EPICS / slow controls
    i. We didn't monitor the field direction variable initially. It would've been nice if we did.
        1. Is this true? We had currents the whole time but not everything is archived.
    ii. Setting up the system to monitor all the variables ahead of time would've helped.
    iii. Record all of the variables that we monitored as a starting point for future use.
    iv. David Flay made an initial version of a python script that will bring up all the necessary screens for a TO. We should look into this.
        1. "gotargetstripcharts" made by Bill

        v. Bill input?
            1. Get everything running including EPICS variables in the test lab way before prod
    i. Field rotation in LabView
        i. Where should we optimize the field direction? Pumping chamber or target chamber? This decision should be made ahead of time.
        ii. What does the software use as input to determine the field direction?
            1. Gradient probe or compass?
            2. Use both - more info from bill
        iii. The field rotation program should match any tables that are posted at the TO desk.
            1. Or don't post a table
        iv. Make configurations for different inputs ahead of time and check that they produce the correct net field.
            1. Check with spokespeople/optics about all of the different magnet configurations that might be used. We need to account for all the settings before running starts.

12. Control and software
    a. Work on software and documentation should start earlier and be fully ready for the experiment.
    b. Target and laser controls should be fully tested in *remote operations mode* prior to installation into the Hall.
    c. Is there a good way to input EPICS variables into LabView to help certain corrections happen automatically? This would be a good feedback mechanism.
13. Safety
    a. Target operator training should be done at a specific time each week.
        i. Ask RC of each week to identify the TOs for the upcoming shifts who need TO training and direct them to us.
        ii. Set up weekly training sessions so that multiple people can be trained at once.
        iii. Be prepared to make exceptions for international people who arrive onsite close to their first shift.
    b. Pay close attention, have people trained properly and remind people often.
    c. Start documents early.
    d. Include spokespeople