Jefferson Lab

Hall C Ion Chamber Calibration Procedure

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Estimated Time to Perform: 1 hour

Procedure Overview

This procedure establishes the process for determining appropriate ion chamber setpoints for the six ion chambers not associated with the dump diffuser (i.e., the Compton, Transport, Target, Dump Viewer, Left and Right Dump) before CW beam delivery to Hall C. Ion chamber readback versus beam-current data is gathered up to a high-enough beam current so that ion chamber setpoints can be linearly extrapolated up to the highest beam current the Hall will be taking.

Ion chamber setpoints vary depending on beam current, beam energy, the type of physics target, and the beamline configuration. Whenever there is a significant change in at least one of these variables, new ion chamber setpoints must be entered to provide appropriate machine protection. The new setpoints can be determined using this procedure, or if existing data are available, derived from previous data sets.

Photographs of ion chamber locations can be found on the OpsWiki at:
http://opsweb.acc.jlab.org/wiki/index.php/Hall_C_Ion_Chamber_Locations

The procedure is divided into sections as follows:

Prerequisites

1. The Hall C Ion Chamber Functional Test Procedure must be performed first, before this calibration procedure, if any of the following are true:
   - Since the last functional test, the Hall C ion chamber locations have changed *or* ion chamber hardware has been replaced.
   - Since the last functional test, there have been beamline changes or other hardware changes in the hall that might shield the ion chambers.

   NOTE: Changes to the SHMS and HMS angles and changes in current to their magnets DO NOT trigger the requirement to repeat the functional test.

2. The Hall C target and all beam-interrupting devices are out of the beamline.
3. The Hall C Compton detector is in the “garage.”
4. FSD masking is set for beam delivery to Hall C.
5. All SHMS magnets are at zero current and powered OFF.
6. Tune-Mode beam transport has been optimized up to the Hall C beam dump with the SHMS magnets OFF.

   NOTE: When beam transport to the dump is optimized, Tune-Mode beam should produce very little ion chamber activity.

NEXT PAGE
BACK 1 PAGE
1ST PAGE

Procedure Steps

1.0 Setting Up for Calibration

Table 1: Ion Chamber CED Name and Name Alias

CED Name	Alias
IIC3P03	Compton
IIC3H04	Transport
IIC3H07	Target
IIC3H09	Dump Viewer (formerly Viewer)
IICD307	Left (may be right) Dump
IICD307A	Right (may be left) Dump
IICD307B	L/R Dump Diffuser
IICD307C	L/R Dump Diffuser

1. Open an FSD Overview Screen (**JMenu⇒Operations⇒FSD⇒FSD Overview**) and verify the following:
    - On FSD node **3H005**, the **HVHLCMPS1A** bit is unmasked and clear
    - From FSD nodes **ICHLCMPS1A** and **ICHLCMPS1B**, open the expert screens and verify the following (see Figure 1, below, for an example).
        - All six ion chambers are unmasked
        - All **Threshold** values have been set to 30,000
        - All **Max** values have been set to 45,000

7. On the ion chamber expert screens, set the **Bias** value for each of the six ion chambers to 4,000 (see Figure 1, below).

Figure 1: Ion Chamber Expert Screens

2. Perform an Allsave and include the comment *"Before Hall C Ion Chamber Calibration"*.
3. Start a running ELog entry with the title *"Hall C Ion Chamber Calibration for Target xx, at pass/energy xx"*.
4. Verify that the Hall C Fast Raster (**JMenu⇒Beam Setup⇒Hall C⇒Hall C Raster⇒Fast**) is OFF.

2.0 Calibrating the Ion Chambers Using iCalibrate

CAUTION: Check the Operational Restrictions for any beam-current limits for unrastered beam on the target chamber windows. Do not exceed this limit while performing the following procedure.

1. Insert the Tune-Mode dump viewer, ITV3H10, and verify that beam is making it to the Hall C dump. Capture a screenshot of the viewer image and add it to your running ELog entry.
2. Remove ITV3H10 and establish 5 μA CW beam to the Hall C dump. Verify that beam is centered on ITV3H10A, the CW dump viewer. **Continue to monitor and maintain this positive verification that beam is on the CW dump viewer throughout this procedure.**
3. Terminate beam and contact the hall. Ask them to insert the target they will be using during beam delivery. Determine the maximum current Hall C intends to run on this target. Document the target being used and the intended maximum beam current in your running ELog entry.

   NOTE: Before re-establishing beam, verify that the target, raster setup, and intended maximum current are consistent with the *Operational Restrictions*.
4. Open iCalibrate (**JMenu⇒Beam Setup⇒Hall C⇒iCalibrate**).

   NOTE: If there are any problems running iCalibrate during this procedure and the problems cannot be corrected, refer to Appendix A – Calibrating "By Hand" on page 7.
5. Select **File⇒New⇒Hall C**.
6. Determine the beam-current range to be used for calibration on this target, with the raster OFF, as follows (you'll translate this to an attenuator setting in the next step). If there is any confusion, coordinate with the Crew Chief and Hall C staff.
   - **Maximum Current ≤20 μA:** Calibrate from 1 μA to the maximum current (verify this with Hall C personnel and check the *Operational Restrictions*).
   - **Maximum Current >20 μA:** Calibrate from 1 μA to 20 μA, then extrapolate to calculate the ion chamber readbacks at the higher current.
7. Using FC2 or another current-measuring device in the injector, determine the attenuator values equivalent to the minimum/maximum of the calculation range determined in Step 6, above. Add to your running ELog entry the minimum/maximum beam-current limits and their associated attenuator settings and describe any coordination with Hall C personnel.

NEXT PAGE
BACK 1 PAGE
1ST PAGE

8. In iCalibrate, enter the desired **Min Attenuator** and **Max Attenuator** settings as determined in Step 7, above. Enter additional settings as follows.
   - **# of Attenuator Steps:** Use a sensible number of attenuator steps (no more than ~3 µA current gain/step).
   - **Settle Time:** 5 seconds
   - **# of Samples per Step:** 30 (30 samples per step entails 30 measurements, one second apart, at a given attenuator step).
9. With the attenuator set to the minimum value being used for calibration, establish CW beam to the Hall C dump, verifying that you can see the beam on ITV3H10A, the CW dump viewer.
10. Click on the **Next** button on the iCalibrate screen.
11. Verify that the **Laser**, **Beam Established**, **Target**, and **Pass** fields are appropriately populated. Add a note as needed. Click on the **Next** button.
12. Verify that all settings are correct before running the calibration, and add a screen-shot to your running ELog entry.
13. Click on the Start button. iCalibrate ramps up the attenuator and records the ion chamber readbacks at each step, averaging the samples.

    NOTE: Refer to the iCalibrate User Guide as needed: https://acc-wiki.acc.jlab.org/do/view/SWDocs/IonChamberCalibration
14. Were there any ion chamber trips during the iCalibrate run?

    NO YES **A.** Open a Stripchart for the ion chamber and look at its readback prior to tripping. With Crew Chief approval, raise the trip point such that the necessary data can be acquired. Return to Step 12, above, and run the iCalibrate process again.
15. After iCalibrate has finished successfully collecting data, terminate beam. When prompted, save the file in the appropriate directory: **~mccops/IonChambers/HallC_YYYY/**
16. Capture a screenshot of the iCalibrate results for each ion chamber (six in total), and add it to your running ELog entry.
17. Calibration data acquisition is complete. Submit your running ELog entry, and continue to Section 3.0, Entering New Ion Chamber Setpoints and Testing, below.

3.0 Entering New Ion Chamber Setpoints and Testing

1. Open iCalibrate (**JMenu⇒Beam Setup⇒Hall C⇒Expert⇒iCalibrate**).
2. Select **File⇒Open** and choose the appropriate calibration file for the run, pass, and target.
3. Call Hall C and determine the beam current they would like to run to their target. Enter the beam current in the upper-right corner in the **Current** field. Below it, enter a margin of 10%.
4. Review the Calculated Setpoints that iCalibrate will upload to the ion chambers. If the values are reasonable, go to **File⇒Export to Epics** to upload to the new settings to the control system.

5. Verify that the new setpoints were uploaded using the ion chamber expert screens (**JMenu⇒Operations⇒FSD⇒FSD Overview⇒ICHLMPS1S** and **ICHLCMPS1B⇒Expert**). The **Bias** field is the trip setpoint you are checking.
6. Establish CW beam to the Hal C dump at the intended physics beam delivery current, with the appropriate target IN and the beam raster set accordingly. Verify that your setup is consistent with the *Operational Restrictions*. Were you able to reach the desired current without an ion chamber trip?

   YES NO → **A.** Using iCalibrate, increase the Margin field by 5% (up to a total 30% if needed) and repeat Steps 5 and 6, above. If you are still unable to transport beam without tripping an ion chamber with the margin set to 30%, halt the procedure and consult with the Crew Chief.
7. Make an ELog entry that includes the Hall C Ion Chambers Expert screen showing the trip setpoints.
8. Procedure complete.

NEXT PAGE
BACK 1 PAGE
1ST PAGE

Appendix A – Calibrating "By Hand"

NOTE: This appendix is to be used only when iCalibrate does not work.

1. Complete Section 1.0, Setting Up for Calibration, on page 3 of this procedure.

CAUTION: Check the Operational Restrictions for any beam-current limits for unrastered beam on the target chamber windows. Do not exceed this limit while performing the following procedure.

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2. Insert the Tune-Mode dump viewer, ITV3H10, and verify that beam is making it to the Hall C dump. Capture a screenshot of the viewer image and add it to your running ELog entry.
3. Remove ITV3H10 and establish 5 μA CW beam to the Hall C dump. Verify that beam is centered on ITV3H10A, the CW dump viewer. **Continue to monitor and maintain this positive verification that beam is on the CW dump viewer throughout this procedure.**
4. Terminate beam and contact the hall. Ask them to insert the target they will be using during beam delivery. If they intend to run with the target raster ON, turn it ON, using the settings they will use during beam delivery. Determine the maximum current Hall C intends to run on this target. Document the raster settings, the target being used, and the intended maximum beam current in your running ELog entry.

   NOTE: Before re-establishing beam, verify that the target, raster setup, and intended maximum current are consistent with the *Operational Restrictions*.
5. Determine the beam-current range to be used for calibration as follows (you'll translate this to an attenuator setting in the following steps). If there is any confusion, coordinate with the Crew Chief and Hall C staff.
   - **Maximum Current ≤20 μA:** Calibrate from 1 μA to the maximum current (verify this with Hall C personnel and check the *Operational Restrictions*).
   - **Maximum Current >20 μA:** Calibrate from 1 μA to 20 μA, then extrapolate to calculate the ion chamber readbacks at the higher current.
6. Open the Hall C Ion Chamber Calibration Spreadsheet (an Open Office document) (**~mccops/IonChambers/ByHand/HallC_ByHand_Template.ods**).
7. Using the spreadsheet, record the present readbacks for all Hall C ion chambers (these are the baseline values without a target). Save the spreadsheet in the present directory, including your user name and the date in the file title (e.g., `HallC_ByHand_"target"_"date".ods`). You will attach the file to an ELog entry at the end of this procedure.

NEXT PAGE
BACK 1 PAGE
1ST PAGE

8. Contact Hall C and ask them
   - To insert the target they will be using during physics beam delivery. In the spreadsheet, record which target they are using.
   - Make sure you can deliver 15 µA un-rastered onto this target, referencing the *Operational Restrictions*. If not, calibrate up to the maximum current the given target can take un-rastered, or the beam current at which the hall intends to run, whichever is lower.
9. Set up **1 µA CW** to the dump.
10. Were there any ion chamber trips?

    NO YES → **A.** Open a Stripchart for the ion chamber and look at its readback prior to tripping. With Crew Chief approval, raise the trip point such that the necessary data can be acquired.

11. Record *all* of the Hall C ion chamber readbacks at 1 µA.

    NOTE: For this and all the following steps, record the readbacks for all of the ion chambers in the hall, not just the dump ion chamber readbacks.

12. Increase the beam current to **2 µA CW**.
13. Record *all* of the Hall C ion chamber readbacks at 2 µA.
14. Increase the beam current to **5 µA CW**.
15. Record *all* of the Hall C ion chamber readbacks at 5 µA.
16. Increase the beam current to **10 µA CW**.
17. Record *all* of the Hall C ion chamber readbacks at 10 µA.
18. Increase the beam current to **15 µA CW**.
19. Record *all* of the Hall C ion chamber readbacks at 15 µA.
20. Terminate beam to Hall C.
21. For each ion chamber, the spreadsheet creates a correlation plot of the beam current vs. the ion chamber readback. The graphed results should be very close to linear.

    NOTE: Although the ion chamber response should be close to linear, it is typical for the rad/hr vs. beam current to *decrease* slightly as beam current increases. If the response is non-linear and *increasing*, there may be beam transport or beam position problems. Check all beam quality indications for signs of trouble. Do not proceed if there is any indication of an undiagnosed beam quality issue.

22. Make an ELog that includes the key words "*Hall C Ion Chamber Setpoint Calibration Results"*, and attach the spreadsheet, including the plots for each ion chamber. Leave the ELog entry open for now.
23. Go to Section 3.0, Entering New Ion Chamber Setpoints and Testing, on page 5.

NEXT PAGE
BACK 1 PAGE
1ST PAGE