

Hall D Beam Delivery Procedure

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Estimated Time to Perform: Three hours for initial setup after an energy change

Procedure Overview

This procedure describes the protocol for establishing and maintaining beam delivery to Hall D. The following outline describes the overall process used to establish electron beam to the Hall D Tagger Dump and then photon beam to Hall D.



- Begin with a robust, well-matched beam to the Arc 10 in-line dump, meeting the specifications defined in [Table 1 on page 2](#).
- Thread beam to IDA5C00 (Hall D in-line dump) and then tune optics, make rough energy/momentum corrections, and perform aperture checks.
- Establish beam to the Hall D Tagger Dump and verify its presence by seeing the beam spot on the dump viewer.
- Perform a fine beam energy/momentum correction, and correct vertical dispersion.
- Verify Hall D ion chamber functionality and calibration.
- Set the orbit and current locks to maintain beam quality using active feedback. Lock the energy to Arc 1 or Arc 2.
- Match beam to the goniometer/radiative foils.
- Establish beam through the active collimator.
- Optimize beam transport and the rates in the Hall D detectors.

This procedure is divided into sections as follows:

- Section 1.0 [Establishing Beam to Hall D](#)
- Section 2.0 [Optimizing Beam Transport](#)
- Section 3.0 [Performing a Normalization Run](#)
- Section 4.0 [Adjusting Beam Aspect Ratio at the Goniometer ???](#) *Revise this section after draft 1b8???*
- Section 5.0 [Establishing a Neutral Axis on the Hall D Target Through the Active Collimator](#)
- Section 6.0 [Maintaining Beam Delivery to Hall D](#)

Prerequisites

1. The accelerator has been optimized to meet the specifications in Table 1, below (i.e., the [Optics Restoration and Finalization Procedure](#) has been completed through the Arc 10 (AR) in-line dump.

Table 1: Accelerator Performance Specifications

Parameter	Specification
Injector	Injector has been setup per the injector setup procedure and the injector alarm handler is clear.
Linac phasing	All RF phases optimized.
Accelerator orbit	Clean transport with all relevant locks On.
Path Length	< 0.5 degree compared to baseline.
Dispersion	< 1 mm error in non-dispersive locations.
Courant Snyder Invariant	< factor 3 growth compared to Arc1. ??ORFP has ±50%??
Accelerator Aperture	> 1.5V on 30 Hz correctors ??revise voltages?? > 6V for 30 Hz RF



2. The default FSD masks are loaded for Hall D beam delivery.
3. The Hall D goniometer is set to an empty position (i.e., no target in the beam path).
4. The Experimental Hall PreOps Checklist has been completed ([MCC Operations Manual, Table 7.2](#)).
5. Hall D is ready for beam as verified using the Hot Checkout Tool (<https://acc-web.acc.jlab.org/hco/readiness>).
6. The Hall D alarm handler node and all the various sub-nodes are enabled and communicating.
7. Hall D 5.5-pass extraction is set to the appropriate energy/momentum according to the Momentum Management System (MMS) (**JTabs**⇒**Operations**⇒**Optics**⇒**MMS**⇒**MMS Symmetry Control**). Discuss any deviations with the Program Deputy.

Procedure Steps

1.0 Establishing Beam to Hall D

1. Change the BOOM state to Accelerator Configuration Change (ACC).
2. Perform an All-Save of the present machine configuration with zero-pos, labeling it as “pre-setup conditions”.
3. Insert the Hall D in-line dump (IDA5C00).
4. Set FSD masking for Hall D.
5. Open all Hall D valves.

6. Contact Hall D and verify the following:
 - The cryotarget is withdrawn or placed in a safe position.
 - The amorphous radiator is withdrawn, and the goniometer is set to a safe/empty setting.
 - The pair spectrometer target, photon harp, and other detectors are retracted.
 - All detectors that could be saturated are either off, set to a low gain, or at an appropriate voltage so as to not trip the detector off.
 - Any other checks at Hall D's discretion.
7. Use the Elegant Download Tool (eDT)(**JTabs**⇒**Operations**⇒**Optics**⇒**eDT**) to generate a file for transport to Hall D at the required energy. This file does the following.
 - Configures the Hall D quads.
 - Sets the Hall D dipole bus (MTSB5C)
8. Use CMPQ (**JTabs**⇒**Operations**⇒**Optics**⇒**CMPQ**) to download the appropriate quad/tuning limits and then cycle the boxes and correctors two times per standard cycling protocol.
9. Set the MaxJuice current limit to 8 μ A.
10. Using the [Hall D Tagger Magnet Operation Procedure](#), turn ON the Hall D Tagger Magnet to the suggested current for the specified energy (this may be done in parallel by a second operator).
11. Verify that the energy locks are running and that the energy is locked to Arc 2 or whichever hall is taking the lowest-pass extracted beam (Hall A or Hall C) and has energy locked with either FFB or the energy locks.
12. Establish 5 μ A Tune-Mode beam to the IDA5C00 in-line dump as follows.
 - a. Pull the AR02 in-line dump.
 - b. Establish 5 μ A Tune-Mode beam through the North Linac (BL) to the 1L27 $M_{5,6}$ cavity.
 - Use shunts MXXAR01 and MZAAR03 to optimize the vertical launch into the North Linac. Use MZA8R04 to corner steer if necessary.
 - Use the AR06H/AR09H and AR04V/AR08V correctors to optimize the launch across the linac.
 - c. Establish beam through the BS and BE regions, optimizing the vertical orbit in the BS region as follows.
 - Open the East Arc spreader/recombiner screen (**JTabs**⇒**Operations**⇒**Magnets**⇒**Spreader/Recombiner**⇒**East Arc**).



- Using the shunts listed in Table 1-1, below, steer to optimize the vertical orbit at the corresponding BPM.

Table 1-1: BS/BE Region Vertical Steering

BPMs	Shunts	Comment
IPMBS00	MYBBS04	Monitor Arc 9 BPM positions, particularly at 9S00.
IPMBS01	MYBBS06	Shunt is powered by Arc 7.
IPMBS02, IPMBS03, and IPMBS04	MXGBS07, MXLBS08	Shunts are powered by Arc 7. MXLBS08 also shunts MXZBS09.

- d. Establish beam to the 5C00 In-line Dump.
 - e. Capture the beam image on synchrotron light monitor ISRBS01 and post it to the ELog (assuming that the beam image is visible).
 - f. Capture the beam image on ITV5C00 and post it to the ELog.
13. Using the [Path Length Measurement and Correction Procedure](#), adjust the path length to minimize the momentum error and thus reduce the horizontal beam size. If there is a problem, check linac and cavity phasing, which can also affect the horizontal beam size.



14. Perform an All-Save with zero-pos, labeling it as “beam to 5C00”.
15. Acquire FOPT data to document the Hall D setup.

NOTE: Because of the Hall D line design, it is not possible to null vertical dispersion until later in this procedure.

16. Using the Courant-Snyder tool (**JTabs**⇒**Operations**⇒**Optics**⇒**Courant Snyder**), look at the FOPT data. Do the plots meet the Courant Snyder and Dispersion specifications in [Table 1 on page 2](#), and is the accelerator tuned to meet all other specifications in [Table 1 on page 2](#) (refer to Figure 1-1, below, for examples of good and bad matches into the hall; green trace=good match, red trace=bad match)?

YES **NO** →

Go to [Step 17](#)

- A.** Refer to the [Optics Restoration and Finalization Procedure \(ORFP\)](#) to bring beam to within specification and, also, to measure the vertical dispersion at IPMBS01 and IPMBS04.

NOTE: The optical design of the Hall D line allows for the dispersion leak from Arc 10, through the linac, and into the extraction beamline (i.e., you will not be able to manage the dispersion leak, but that is okay).

- B.** Does the vertical dispersion at IPMBS01 and IPMBS04 roughly equal the following ratio: $\frac{BS04}{BS01} = \frac{5}{3}$?

- YES** **NO** → **C.** Inform Optics On-call of the problem when you contact them in Step 18 on page 5, and ask how to proceed. Go to Step 17, below.

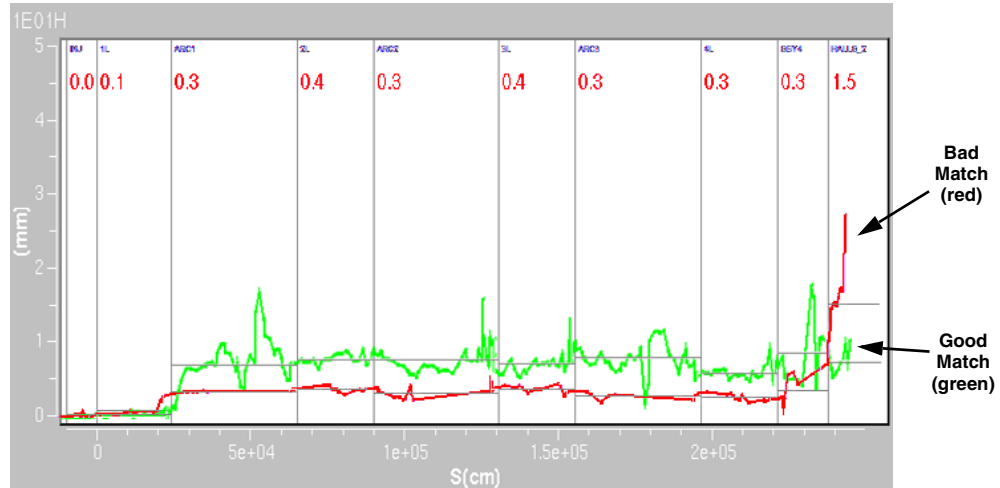
D. Go to Step 17, below.

Figure 1-1: Hall Match Example

17. Perform an All-Save of the present machine configuration, labeling it as “pre-match”.
18. Using 5 μ A Tune-Mode beam and qsUtility (**JTabs** \Rightarrow **Operations** \Rightarrow **Optics** \Rightarrow **qsUtility**), make an emittance measurement at the Hall D in-line dump (IDA5C00) using IHA5C00. Immediately contact Optics On-call and ask them to analyze the data and contact you with any recommended changes (this information will be used at Step 20, below). *??new tool allows for loading result, still need to call Optics On-Call every time??*
19. Scan harp IHA5C00 and post the results to the ELog.
20. Did Optics On-call recommend any optics changes based on the analysis of the emittance data taken in Step 18 on page 5 (you must have verbal verification of the analysis before proceeding)? *??still need to call Optics On-Call every time??*
 - NO** **YES** \rightarrow **A.** Apply the quad changes recommended by Optics On-call. Cycle any quadrupoles that have changed.
 - B.** Repeat [Step 18 on page 5](#) and work with Optics On-call to correct any problems with the beam profile. *??still need to call Optics On-Call every time??*
 - C.** Scan harp IHA5C00 and post the results to the ELog.
21. Pull viewer ITV5C00.
22. Recheck steering to the 5C00 in-line dump. The orbit in all non-dispersive regions should be 0.0 ± 0.5 mm.
23. Use the MBDBT03H/V correctors to steer to 0.0 ± 0.5 mm at IPM5C00. This corrects the launch angle into the Hall D line.



NO **YES** \rightarrow
Go to
[Step 21](#)

24. Using the 30 Hz system, demonstrate a clear aperture to the Hall D in-line dump (IDA5C00). Were you able to achieve greater than 1.5 volts of aperture for all correctors and 6 volts for RF? *??different units??*



Go to
[Step 25](#)

- A.** Make steering changes with the aid of the Hall D status screen (**JTabs**⇒**Beam Setup**⇒**Hall D**⇒**30 Hz Scraping Tool**) *??new path??* as follows.
- Turn ON the 30 Hz function generator (**JTabs**⇒**Operations**⇒**Optics**⇒**30 Hz Switch**) and open the 30 Hz BPM screen for Hall D (**JTabs**⇒**Operations**⇒**Wall Menu**⇒**INJ/Halls**⇒**Hall D**⇒**30 Hz**).
 - Make orbit corrections as necessary to improve the aperture.
25. Capture the beam image on synchrotron light monitor ISRBS01 and post it to the ELog.
26. Perform an All-Save with zero-pos, labeling it as “??”.
27. Acquire FOPT data to document the Hall D setup.
28. Stop beam delivery.
29. Using HystArea (**JTabs**⇒**Operations**⇒**Optics**⇒**HystArea**), cycle all Hall D trim channels (quads and correctors) two times.
30. Mask the Hall D BLMs.
31. Remove the Hall D in-line dump.



CAUTION: The power limit for the Hall D Tagger Dump is 60 kW (60,000 W). The maximum beam current is calculated using the following equation.

$$I = \frac{P}{E \times d.f.} = \frac{60,000 \text{ W}}{E(\text{MeV}) \times d.f.}$$

Where I is beam current measured in μA , E is voltage of beam measured in MV (MeV/e), P is beam power measured in watts, and $d.f.$ is the percent duty factor of the beam.

32. Establish 2–3 μA Tune-Mode beam to the Hall D Tagger Dump (just enough current to light up the BPMs).
33. Capture the beam image on synchrotron light monitor ISR5C00 and post it to the ELog (assuming that the beam image is visible).
34. Is the IPM5C03.YPOS value $<\pm 5\text{mm}$?



- A.** If this hall setup is the first after an accelerator energy change (not a pass change), contact the PD to determine if Optics On-call should be asked to verify that the accelerator energy is correct. If this setup is a pass change, without an accelerator energy change, adjust the Hall D dipole string bus current (MTSB5C) to zero the vertical position of the beam at IPM5C03. Cycle the box supply afterward, and make any final adjustments to minimize the error at IPM5C03.

35. Is the IPM5C03.YPOS value $< \pm 1\text{mm}$?

- YES** **NO** → A. Adjust the Hall D dipole bus current (MTSB5C) to zero the vertical position of the beam at IPM5C03. Cycle the box supply afterward and make any final adjustments to minimize error at IPM5C03.

36. Optimize the steering in the Hall D line, and use correctors to zero the absolute position at IPM5C10 and IPM5C11B (the entrance of the Tagger).

NOTE: The nA BPMs will not read Tune-Mode beam correctly. Steer to the absolute beam positions.

37. Using the [Hall D Tagger Magnet Operation Procedure](#), adjust the Tagger magnet setpoint to place the beam at the location specified by Hall D.

38. Using the Tagger magnet, zero the beam position on viewer ITVAD00, in front of the beam dump. Is beam visible on viewer ITVAD00?

- YES** **NO** → A. Is beam visible on viewer ITV5C11A?

Go to
[Step 39](#)

- YES** **NO** → B. Pull viewer ITV5C11A.

Go to
[Step E](#)

- C. Locate beam upstream using the BPM screens.
D. Verify that all prerequisites on page 2 of this procedure have been satisfied, and all steps before Step 38 have been successfully completed (do not repeat them). If beam still does not reach ITV5C11A, contact Optics On-call.

- E. Using the [Hall D Tagger Magnet Operation Procedure](#), verify that the Tagger magnet is set to the correct field strength. Is the field strength correct? ??Beam Transport Monitor will limit change of Tagger setpoint--retained comment??

- YES** **NO** → F. Correct the Tagger setpoint and repeat Step 38, above.

- G. Do the BPM spikes show that beam is present at IPMAD00?

- YES** **NO** → H. Contact Optics On-call.

- I. Using correctors [M##AD00H/V \(not presently installed\)](#) and the Tagger magnet, steer as close as possible to 0,0 at IPMAD00.

- J. Insert viewer ITVAD00. Is beam visible?

- YES** **NO** → K. Repeat Step 38, above.

- L. Scan harp IHAAD00 to verify that beam is present. Post the result to the ELog.

- M. Verify that beam current monitor IBCAD00 is registering an appropriate beam current value.

- N. Contact the Director of Accelerator Operations and advise him that beam has been successfully centered on the dump using all available diagnostics but the beam spot is still not visible on the dump viewer. He will decide if it is okay to deliver CW beam. Make an appropriate ELog entry.



- O.** Complete an OPS-PR indicating any diagnostics that need repair.
 - P.** Go to Step 39, below.
39. When tuning is complete, post an image of the beam position on ITVAD00 (the Hall D Tagger Dump viewer) in the ELog.
40. Is the beam spot on IHAAD00 acceptable (i.e., it should be elliptical, with X being the longest dimension [$\sim 3:2$ aspect ratio], and the position should not be oscillating).
- YES NO** → **A.** Contact Optics On-call.
41. Perform an All-Save labeling it as “??”.
-
42. **CAUTION:** When performing the following vertical dispersion correction steps, IT IS IMPORTANT to maintain the existing orbit in the Hall D line. Monitor the relative spike screen for changes greater than 0.5 mm in the Hall D line orbit (this may be done by a second operator). Immediately correct changes in the relative orbit by adjusting the MBD5C03H/V correctors, which are closest to the quadrupole being changed.
-

Correct vertical dispersion in the Hall D line as follows:

- a. Turn on the 30 Hz generator, and increase RF until the horizontal dispersion pattern in Arc 1 reaches 5.0mm.
- b. Open the relative BPM screens for the Hall D line, and zero the BPMs’ position offsets (these will be used to monitor the orbit, see CAUTION, above).
- c. Post images of the Hall D 30 Hz absolute spike screen, relative orbit screen, and absolute orbit screen in the ELog, labeling them with the present Bdl setting for MQA5C03.
- d. Take MQA5C03 off loop and increase the setting by +100 G-Cm.
- e. Does the 30 Hz spike screen show vertical dispersion improvement in the 5C08–5C11C region?

YES NO → **A.** Decrease the setting for MQA5C03 by –200 G-cm. Was there an improvement in the vertical dispersion pattern?

Go to
[Step f](#)

YES NO → **B.** If there is a non-zero vertical dispersion pattern in the 5C08–5C11C region, contact Optics On-call for help with correcting the dispersion leak into the hall.

- f. Continue adjusting the MQA5C03 in a positive or negative direction (as determined in Step e, above) until the vertical dispersion pattern is optimized. Post an image of the Hall D 30 Hz spike screen in the ELog, labeling it with the present Bdl setting for MQA5C03.
43. Repeat Steps 34–40, above, as necessary to correct any shift in energy or position caused by the vertical dispersion correction in Step 42.



44. Open the Beam Energy Monitor (**JTabs**⇒**Operations**⇒**Optics**⇒**BEM**). Is the ARCA dp/p bpm value $<1 \times 10^{-4}$ dp/p?

YES **NO** →

Go to
[Step 45](#)

A. Using the [Path Length Measurement and Correction Procedure](#), adjust the path length to minimize the momentum error and thus reduce the horizontal beam size. Linac and cavity phasing can also affect the horizontal beam size and should be checked if the problem persists. Were you able to reach a dp/p bpm value $<1 \times 10^{-4}$ dp/p (attempt to reach 1×10^{-5} dp/p if possible).

YES **NO** →

B. Contact Optics On-call for assistance.

45. Perform an AllSave of the current accelerator configuration, labeling it as having been made following a momentum adjustment.
46. Take FOPT data to the AD00 dump, and post the Courant Snyder data to the ELog. Make any touch ups as needed.
47. Verify that beam is still centered on the AD00 dump.
48. If beam is visible on the synchrotron light monitor ISR5C00, post an image of the spot to the ELog.
49. Perform an All-Save with zero-pos, labeling it as “??”.
50. Perform the [Hall D Ion Chamber Functional Test Procedure](#) ??need procedure/link??.
51. Use qsUtility to make emittance measurements at IHA5C11 and IHA5C11CA, and make quadrupole adjustments as necessary. Mask the goniometer ion chambers as necessary during the measurement.
52. Prepare to send CW beam as follows.
- Set the MaxJuice current limit to ?? μA. ??wasn't the limit already set in [Step 9 on page 3](#)??
 - Unmask the Hall D BLMs.
 - Unmask the Hall D ion chambers.

CAUTION: After an energy change or a pass change, new ion chamber setpoints must be established as follows before delivering CW beam for physics to Hall D.

- Perform the [Hall D Ion Chamber Calibration Procedure](#) ??add link when document available?? to determine appropriate ion chamber setpoints.
 - Establish photon beam to the Hall D active collimator using [Section 5.0, Establishing a Neutral Axis on the Hall D Target Through the Active Collimator, on page 14](#). ??test plan forthcoming??
 - Turn ON the Hall D orbit lock (**JTabs**⇒**Operations**⇒**Locks**⇒**Orbit/Energy Locks**) and calibrate the lock if necessary. Set the lock for Hall D's desired positions while maintaining beam through the active collimator.
53. Establish the requested CW-Mode beam current to Hall D, and turn ON the Hall D current lock.



54. Verify that the Hall D Faraday Cup/Dump BCM current (IBCAD00) level agrees with IPM5C11C. Is the ratio of IBCAD00/IPM5C11C = 0.98–1.02? ??Mike M. to discuss w/ Trent whether comparing a nA BPM to an MPS BCM is effective??
- YES NO** → A. Ensure that the BCM has been calibrated using the [Hall D BCM Linearity/Cross Calibration Procedure](#) ??new procedure??. If it has, submit an OPS-PR for IPM5C11C.
55. Verify that the Hall D fast feedback system (FFB) can be turned ON as follows:
- Send beam to the Hall D Tagger Dump at the current intended for physics running.
 - Turn OFF the Hall D orbit locks.
 - Select the FFB coils/BPMs of interest from the *Hall D FFB Calibration Response* screen (JTabs⇒Tools⇒Hall D FFB Control (expert)⇒Hall D Control (New Expert)⇒Calibration Response (BPM Selection)). Select “used” for the two BPMs to control on in each plane, and “unused” for the balance of the BPMs (see Table 1-2, below)

Table 1-2: Hall D Fast Feedback Coils/BPMs

Magnets (horiz.)	Target	Magnets (vert.) ^a	Target
MCNBS04H	IPM5C03	MCNBS04V	IPMBT02
MCN5C00H	IPM5C07	MCN5C00V	IPM5C11A
MCN5C04H	Active Collimator	MCN5C04V	Active Collimator

- The vertical targets are not identical to the horizontal targets due to the high vertical dispersion region on the ramp coming into the hall.
 - Turn ON the Fast Feedback system using the [Fast Feedback Restoration Procedure](#).
 - Document beam stability by posting the horizontal, vertical, and wire sum FFT data for IPM5C11C to the ELog (JTabs⇒Tools Screen⇒Expert⇒Hall D Fast Feedback Control⇒Expert⇒BPM/Corrector Waveform⇒FFT). ??Original Comment: “This is a nA BPM. Can’t have FFT . . . too slow.” Markup: “11B?” Need final resolution.??
 - Turn ON the Hall D orbit locks.
56. Perform an AllSave of the present accelerator configuration with **zero pos**, and label it as the initial setup conditions.
57. Take FOPT data and document the results with the Courant-Snyder tool.
58. Ask Hall D to turn on their detectors and insert the radiator. Do the detectors remain on without tripping and are the downstream counts acceptable?
- YES NO** → A. Work with Optics On-call (if necessary) and the Crew Chief to make the necessary adjustments using [Section 2.0, Optimizing Beam Transport, on page 11](#), then return to Step 59, below.
59. Complete [Section 3.0, Performing a Normalization Run, on page 11](#) if requested by Hall D.



60. Verify that beam is present on the Hall D photon dump and make an ELog entry with pictures of the Hall D screen from the video wall, the absolute BPM positions, the orbit lock targets, the BEM screen.
61. Restore the BOOM state.
62. PROCEDURE COMPLETE.

2.0 Optimizing Beam Transport

NOTE: [Section 1.0, Establishing Beam to Hall D, on page 2](#) should be performed before executing this procedure section.

1. Turn off the Hall D current lock.
2. Ask Hall D to insert the radiator they will use for physics running.
3. Ask Hall D to perform a Pair Spectrometer scan. Is the photon beam position acceptable to the user?

YES NO → A. Optimize the photon beam position using [Section 5.0, Establishing a Neutral Axis on the Hall D Target Through the Active Collimator, on page 14](#).

4. Establish the requested current to Hall D, and turn ON the current lock.
5. Perform an AllSave.
6. Restore the BOOM state.
7. PROCEDURE COMPLETE.



3.0 Performing a Normalization Run

1. Verify that the beam is locked to the desired positions, with at least 1 nA of CW beam to Hall D.
2. Turn OFF the orbit lock and current locks, FFB, and the active collimator.

NOTE: During normalization runs Hall D would like to be informed of all machine state changes.
3. Establish 100 pA of CW-Mode beam to the Hall D Tagger Dump.
4. PROCEDURE COMPLETE:

4.0 Adjusting Beam Aspect Ratio at the Goniometer **??**”Revise this section after draft 1b8”??

NOTE: This section should be used to make adjustments when the beam is too wide or tall as seen on the last two harps in the hall, IHA5C11 and IHA5C11A. The following steps assume that you’ve already matched beam to the Hall D in-line dump, IDA5C00, per [Section 1.0, Establishing Beam to Hall D, on page 2](#). Make adjustments with the following basic guidance in mind:

- Quads set to a negative current/Bdl are vertically focusing and horizontally defocusing.
- Quads set to a positive current/Bdl are horizontally focusing and vertically defocusing.

- Using two alternating quads in a lattice achieves an overall net (or strong) focusing effect.

1. Mask the Goniometer ion chambers and the Shield Wall ion chambers.
2. Scan harps IHA5C11 and IHA5C11A and post your scans to the ELog.
3. Is the beam size acceptable to Hall D (i.e., does the spot size fall within the limits specified in the *Hall D Experiment Binder* in the control room)?

NO YES → A. PROCEDURE COMPLETE.

4. Perform an AllSave, noting the present beam conditions. Reference the harp scans by ELog number in your save notation.
5. Use the primary quads (and if necessary the secondary quads) listed below to achieve the desired aspect ratio (SmartKnobs may also be used). If adjusting quads by hand, use one of the two knobs noted to focus the beam in the plane of interest to minimize the size of the beam spot.
 - **Primary Quads:** MQP5C10 (set –) & MQP5C11(set +) (upstream of Goniometer/radiator).
 - **Secondary Quads:** MQP5C08 (set –) & MQP5C09 (set –) (upstream of goniometer/radiator).

NOTE: Make a dramatic change to begin with (perhaps 10–15% of the quad strength) in the “wrong” direction to ensure the quad is behaving as you would expect. If, for example, the beam is too wide in Y, relax the current on the negatively valued primary quad, and expect it to blow up worse in Y.

6. Did the adjustments bring the beam aspect ratio within spec?

NO YES → A. Cycle the changed quads to make sure that the change is reproducible. Is the aspect ratio still within spec?
Go to [Step 7](#)

NO YES → B. Perform an AllSave.

C. PROCEDURE COMPLETE.

D. Proceed to Step 7, below.

7. Back out the previous quad changes and cycle the quads in question.
8. Perform an FOPT to the Tagger Dump, and examine the path length.



- Using the Courant-Snyder tool (**JTabs**⇒**Operations**⇒**Optics**⇒**Courant Snyder**), look at the FOPT data. Do the plots meet the Courant Snyder and Dispersion specifications in [Table 1 on page 2](#) (refer to Figure 4-1, below, for examples of good and bad matches into the hall; green trace=good match, red trace=bad match)?

YES NO →
 ↓
 Go to
[Step 5](#)

- Refer to the [Optics Restoration and Finalization Procedure \(ORFP\)](#) to bring beam to within specification and, also, to measure the vertical dispersion at IPMBS01 and IPMBS04.

NOTE: The optical design of the Hall D line allows for the dispersion leak from Arc 10, through the linac, and into the extraction beamline (i.e., you will not be able to manage the dispersion leak, but that is okay).

- Is the vertical dispersion at IPMBS01 and IPMBS04 roughly equal (within ±15%)?

YES NO → **C.** Contact Optics On-call.

- Go to Step 5, below.

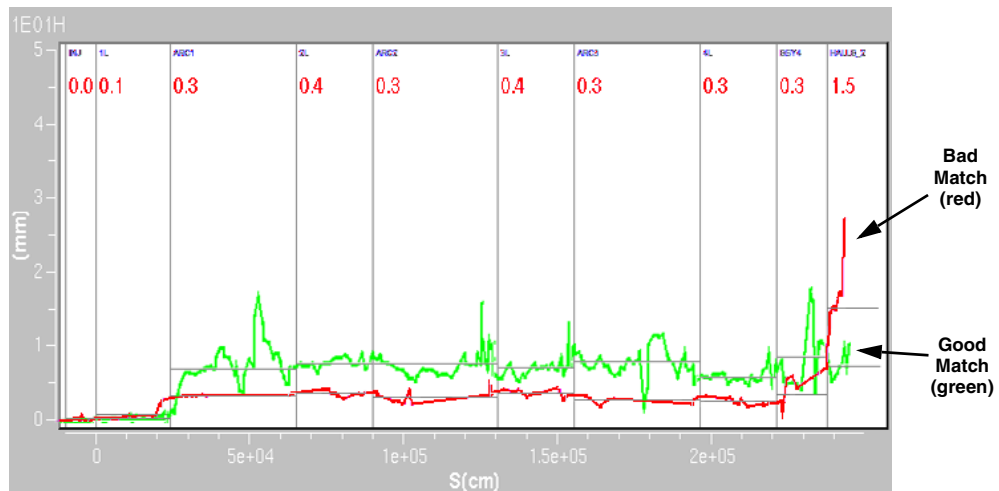


Figure 4-1: Hall Match Example

- Using 3 μA Tune-Mode beam and qsUtility (**JTabs**⇒**Operations**⇒**Optics**⇒**qsUtility**), make an emittance measurement at the Goniometer/Radiator using harps IHA5C11 and IHA5C11A. Immediately contact Optics On-call and ask them to analyze the data and contact you with recommended changes.
- Apply the quad changes recommended by Optics On-call. Cycle any quadrupoles that have changed.
- Repeat Steps 10 and 11, above, as many times as necessary, working with Optics On-call to correct the beam profile. Use all available tools as necessary.
- Did the adjustments bring the beam aspect ratio within spec?

YES NO → **A.** Inform the Program Deputy and ask how to proceed.

- Insert viewer ITV5C11A and reduce the attenuator as necessary to prevent blooming on the viewer. Capture the image, and post it to the ELog, labeling it as “Beam Profile After Matching to IHA5C11 and IHA5C11A”.



15. Perform an AllSave.
16. PROCEDURE COMPLETE.

5.0 Establishing a Neutral Axis on the Hall D Target Through the Active Collimator

1. Verify that all quads and correctors in the Hall D line are cycled and on loop.
2. Using correctors MBD5C10H/V, steer beam to the zero the orbit at IPM5C11B.
3. Insert a radiator of Hall D's choosing.
4. Using correctors MBD5C11H/V, steer beam onto the face of the active collimator, and center it using the X_{\pm} and Y_{\pm} readbacks from the collimator as a reference (when centered, $X_{+} = X_{-}$ and $Y_{+} = Y_{-}$).

NOTE: The Pair Spectrometer is located approximately 80 meters downstream of the Tagger Magnet. Steer beam such that the average counts on both channels are equal.

5. Remove the radiator.
6. PROCEDURE COMPLETE.



6.0 Maintaining Beam Delivery to Hall D

1. The Fast Feedback System or energy lock should be ON.
2. The optimum angle and position at the radiator are defined by the beam positions at IPM5C11B, C, and the active collimator. Maintain the ideal values as defined by Hall D. Maintain these positions as described in [Section 5.0, page 14](#).
3. Refer to the *Hall D Experiment Binder* in the control room for beam specifications associated with the present physics run. The PD Shift Plan may also provide beam specification guidance to meet the physics goals.