Establishing beam for physics

Version 2.9

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Establishing production quality electron beam for experiments in Hall B is a two step process. First, beam is delivered and tuned in the Hall-B upstream tunnel, using a special dump before hall proper. Then it is sent to the downstream electron dump and tuned on physics targets. Both stages require close cooperation between Hall-B shifters and MCC ops.

Note: For RG-F (BONus) run, when performing a harp scan while beam is on Faraday cup, Section 2, BOM FSD must be masked. The rest of halo FSDs should be configured as described below (1 MHz/50 ms)/

1 Establishing beam in the upstream tunnel

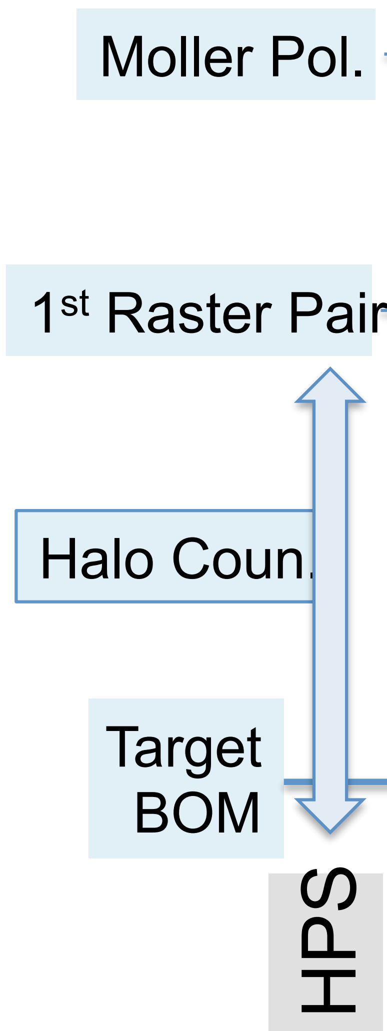
Initial beam tune is done at low currents, < 10 nA, with dumping the beam on the "tagger-yoke dump", a dump in the tagger dipole magnet yoke. Beam is deflected down to this intermediate dump by the tagger dipole magnet [1]. The tagger dipole power supply set current relates to the beam energy as [2]:

$$I(A) \; = \; 43.491 \times E(GeV) - 0.076 \tag{1}$$

In this first step:

- the CLAS12 detectors (especially tracking detectors) must be OFF
- all halo counters (upstream, midstream, BOM and downstream) must be ON and masked in beam Fast Shut Down (FSD) system
- the "blank" collimator with no hole is on the beam
- the CLAS12 solenoid and torus magnets are energized (or can be be energized while beam tune is in progress)

The beam with required profile and trajectory will be established by MCC ops using correctors and quadrupoles on 2C line. Hall-B shift crew must monitor the progress using the wire harps and the nanoamp (nA) BPMs [3] at 2C21 and 2C24 girders in the upstream tunnel (see Figure 1). There is a Yag viewer, ITV2C24, upstream of the tagger dipole, controlled by MCC, that may be used by MCC to verify the position and the profile of the beam. All harp scans must be properly analyzed and logged into logbook. The beam tune is good when required parameters for the profile (x/y widths) and trajectory (x/y positions on various monitors) are achieved. These parameters will be written on the run wiki and/or on the white board in the counting house. Typically, widths at 2C21 harp $\sigma_{x,y} \leq 200\ \mu$m, while at 2C24 (tagger) harp $\sigma_{x,y} \leq 500-600\ \mu$m. At this stage (beam on the tagger[yoke] dump) the trajectory is defined by the x/y positions at the "tagger" harp and 2C24A BPM. The relation between the positions measured by the harp and BPM is $X_{harp}(Y_{harp}) = X_0(Y_0) - X_{2C24A}((Y_{2C24A})$, where $X_0(Y_0)$ are run dependent and will be posted on the run wiki. In general it is a good practice to check newly measured beam parameters against last good/acceptable tune.



Description	Name	L (neters)
SLM	ISR2C20	-44.3
Green shield walll		
Stripline BPM	IPM2C21	-41.4
Quadruple	MQR2C21	-41.1
Horizontal corrector	MBC2C21H	-40.6
Vertical corrector	MBC2C21V	-40.1
Quadruple	MQA2C21A	-39.6
Horizontal corrector	MBC2C21AH	-39.1
Beam viewer	ITV2C21	-38.9
Wire Harp	IHA2C21	-38.8
nA-BPM	IPM2C21A	-37.6
Stripline BPM	IPM2C22	-26.9
Quadruple	MQK2C22	-26.5
Horizontal corrector	MBC2C22H	-26.2
Quadruple	MQK2C23	-25.8
Vertical corrector	MBC2C23V	-25.5
Quadruple	MQK2C24	-24.9
nA-BPM	IPM2C24A	-24.5
Wire Harp	IHA2C24	-22.0
Beam viewer	ITV2C24	-21.8
Hall-B tagger dipole	TAGGERB	-17.6
Hall-B collimator	ETA2H00	-17.0
Stripline BPM	IPM2H00	-12.3
Quadruple	MQA2H00	-11.9
Quadruple	MQA2H00A	-11.6
Horizontal corrector	MBD2H00H	-11.3
Vertical corrector	MBD2H00V	-11.1
Quadruple	MQB2H01	-6.2
nA-BPM	IPM2H01	-5.8
Wire harp	IHA2H01A	-5.2
Center of the hall		0
Stripline BPM	IPM2H02	13.5
SVT collimator	ETA2H02	14.1
Wire harp	IHA2H02A	14.8
Dipole 1	MFC2H02A	15.3
HPS target	ETA2HHPS	17.0
Spectrometer Dipole	MFC2H02B	17.5
Dipole 2	MFC2H02C	19.7
Beam viewer	ITV2H04	24.0
Dump, Faraday cup	IFY2H04	27.0

Figure 1: Bemaline elements from the green shield wall to Faraday cup dump.

2 Beam to Faraday cup

The second step of establishing a physics quality beam for the experiment starts after acceptable beam parameters have been achieved on the tagger-yoke dump. The following are steps for sending the beam to CLAS12:

- tell MCC that beam is acceptable at the tagger
- ask to take the beam away, degauss and turn OFF the tagger magnet
- position 20 mm diameter collimator on the beam
- ask ops to unmask halo counter FSDs and set the halo counter FSD thresholds as defined in the run wiki and with the integration time interval to 5 milliseconds
- when ready ask MCC to send $\sim$ 5 nA beam straight to the electron dump (downstream end of the Hall B beamline where Faraday cup is located). **Note: upstream and midstream halo counter rates should not exceed 100 Hz**.
- verify that beam goes to the dump cleanly:

  a. make sure beam is clearly visible on the downstream viewer, use Chromox screen[1]. Beam should be within 10 mm (2-tick marks) around the center

  b. make sure that beam current reading on the Faraday cup and the currents on 2C21 and 2C24 BPMs are consistent (difference should not be more then few %)

The beam profile and position adjustments on the target will be done using correctors and quadrupoles on 2C22/2C23/2C24 girders in the upstream tunnel and on the 2H00 girder in the hall (if needed). The last one is the closest to the target ($\sim$ 12m upstream) and will be used to focus beam at the target location to achieve required size (preferably < 300 μm in both x and y directions). Profile and the position of the beam on CLAS12 target will be checked using a 3-wire harp 2H01A, mounted about $\sim$ 5 meters upstream of the target, and the 2H01 nA BPM (stripline BPM on 2H00 will not work at low currents).

Use 2H01A harp to measure beam profile and its projected positions along x-, y-, and 45° axes. Before preforming the harp scan with 2H01A or also 2C21 and 2C24 (tagger) harps **ask ops to unmask halo counter FSDs and set the halo counter FSD thresholds to 1 MHz and the integration time interval to 50 milliseconds**

After physics quality beam is established based on the profile, beam position either on the target must be adjusted based on symmetry of rates in the detector (e.g. FT-Cal) or the lowest rates on the downstream halo counters and on BOM.

For adjusting the beam position to get symmetric rates on a detector, e.g. FTcal, move beam with small steps in x- and/or y- on 2H01 nA BPM until desired symmetry is achieved.

If setup has not been changed (much) from previous run and downtime was short, the following beam position adjustment on the target cell windows will not be needed - consult with RC.

Procedure for adjusting the beam on the target is the following:

- ask MCC operator to move the beam vertically on 2H01 nA BPM in 0.1 mm steps up then down
- record rates on halo counters and on BOM for each step. Stop moving in the given direction when rates go more more than $\times 10$ from the previous position

[1] At low energies beam spot may not be clearly visible at 5 nA

- analyze rates as a function of position, find a position on 2H01 corresponding to about the mid point of the two extreme highest rate ends. Ask MCC operator to position the beam on that position on 2H01 nA BPM
- repeat everything for the horizontal alignment, moving the beam to left and right
- find the best horizontal position
- set orbit locks using the found vertical and horizontal positions on 2H01 nA BPM

After high quality beam was established and properly aligned, the beam orbit lock system should be engaged. This system incorporates position readings from BPMs (either 2C24 and 2H01, or 2H01 and 2H00 if currents are high enough for 2H00) to regulate currents in the horizontal and vertical corrector dipoles to minimize beam motion at the target. The final step in establishing the production running conditions is setting limits on the halo counter and BOM rates for FSD system. If beam moves unexpectedly and gets close to an obstacle, e.g. collimator walls or to the thick parts of the target cell, count rates on the beam halo monitors and on the BOM will increase. The appropriate rate limits will depend on actual run conditions and the target, and will be noted on the white board in the counting room and/or on the run wiki. General prescription for setting a limit for FSD input rate of N(Hz) for a trip time interval of δt (ms) is:

$$N_{thr} = N + n_\sigma \times \sqrt{\frac{N}{\delta t}}$$

where n_σ is how far from the mean value we want the trip to acquire. For example, for $\delta t = 5$ ms, the value $n_\sigma = 5$ will mean one false tripe every 5 hours. In order to avoid frequent false trips and allow some overhead in average rate and possible smaller time interval, a recommended value is $n_\sigma = 6$. Note, when beam is cleanly transported to Faraday cup, "Upstream" and "Midstream" halo counters should count $<$ 10 - 15 Hz, for those FSD threshold should be set to 1000. High rates ($\sim$ 100 Hz) on these counters will indicate bad beam transport or a bleed-through from other halls and must be corrected.

References

[1] D. Sober et al., Nucl. Inst. and Meth. A 440, 263 (2000).

[2] https://clasweb.jlab.org/wiki/images/9/97/Beam_on_tagger.pdf

[3] M. Piller, et al., JLAB-ACC-99-30 (1998).