Establishing beam for physics

Version 2.0

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Establishing production quality electron beam for experiments in Hall B is a two step process. The initial tune is done at low currents, < 10 nA, by dumping the beam on newly established beam dump on the tagger dipole magnet yoke before hall proper. Beam is deflected down to this intermediate dump with the Hall B tagged photon spectrometer dipole magnet [1]. The tagger dipole power supply set current relates to the beam energy as [2]:

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

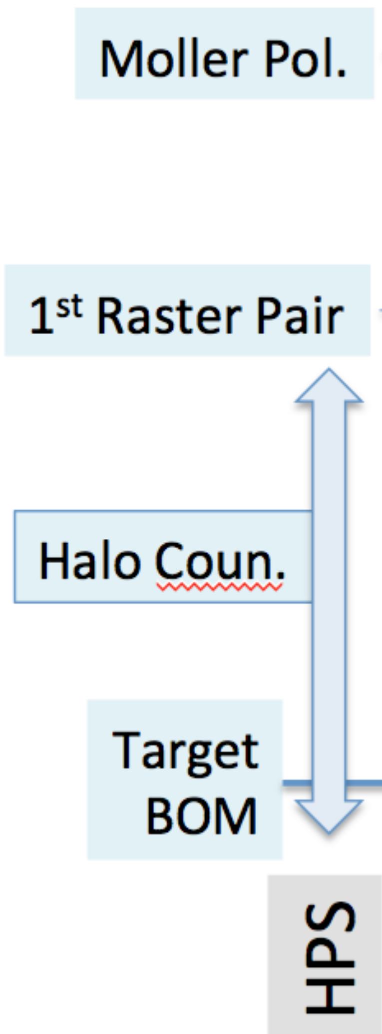
In this first step:

- the CLAS12 detectors (especially tracking detectors) must be OFF
- all halo counters must be ON
- 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 is established by MCC ops using correctors and quadrupoles on 2C line, while monitored by Hall-B shift crew 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 can also be used to verify position of the beam. Hall-B shift personnel should work with MCC operator to establish required quality 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 counting house. Typically widths at 2C21 harp $\sigma_{x,y} \leq 200$ μm, while at 2C24 (tagger) harp $\sigma_{x,y} \sim 500-600$ μm.

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

- tell MCC that beam is acceptable at the tagger
- ask to degauss and turn OFF the tagger magnet
- position 20 mm diameter collimator on the beam
- unmask halo counter FSDs and set 1 MHz trip threshold with 5 second trip time



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	-8.6
nA-BPM	IPM2H01	-8.0
Wire harp	IHA2H01A	-7.5
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.

- when ready ask MCC to send ∼ 5 nA beam straight to the electron dump, at the end of the Hall B beamline where Faraday cap is located
- verify that beam goes to the dump

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

b. make sure that Faraday cup beam current reading and the beam currents on 2C21 and 2C24 BPMs are consistent (should not be different 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 2H00 girder in the hall. The last one is the closest to the target ($\sim$ 10m upstream) and will be used to focus beam at the target location to achieve required size (preferably $< 300\ \mu$m). The profile and position of the beam on the CLAS12 target will be checked using a 3-wire harp 2H01A mounted about 5 meters upstream of the CLAS12 target and 2H01 nA BPM (stripline BPM on 2H00 will not work at low currents). The 2H01A harp measures the beam profile and its projected position along x-, y-, and 45° axes. After physics quality beam is established based on the profile, beam position on the cryo target cell must be adjusted based on the lowest rates on the downstream halo counters and on BOM. Procedure for adjusting the beam on the target is the following:

- ask MCC operator to move beam on 2H01 BPM by 0.1 mm steps up and down, vertical direction
- 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 where you started
- analyze rates as a function of position, find a position on 2H01 corresponding to the mid point of the two extreme ends where rates were highest. Ask MCC operator to position the beam on that position on 2H01 BPM
- repeat everything for horizontal alignment, moving the beam to left and right
- set orbit lock using found vertical and horizontal positions on 2H01

After high quality beam was established and properly aligned, the beam orbit lock system should be engaged. This system incorporates position readings from the BPMs (2H01 and 2H00 if currents are high enough) 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 the beam Fast Shut Down (FSD) system. If beam moves unexpectedly and gets close to an obstacles, 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 is:

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

where n_σ is how far from mean value we want the trip to acquire. For example, for $\delta t = 5$ ms, $n_\sigma = 5.$ will mean one false tripe every 5 hour. In order to avoid frequent false trips and allow some overhead in average rate and possible smaller time interval, a recommended value is $n_\sigma = 6$.

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).