Hall-B Beamline Commissioning Plan for CLAS12

Version 1.1

S. Stepanyan

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1 Introduction

The beamline for CLAS12 utilizes the existing Hall-B beamline setup with a few modifications and additions. The Hall B beamline is divided into two segments, the so called "2C" line, from the Beam Switch Yard (BSY) to the hall proper, see Figure 1, and the "2H" line from the upstream end of the experimental hall to the beam dump in the downstream tunnel, Figure 2. The "2C" part of the beamline features an achromatic double bend (dogleg) that brings the beam up to the hall's beamline elevation from the BSY. In the past, in 6-GeV era, instrumentation on the "2C" line was sufficient to shape the beam profile and position it. The beamline instrumentation on "2H" line is then used only for monitoring the beam properties. In the 12-GeV era, at higher passes (at 4^{th} and 5^{th} passes) the beam dispersion due to the synchrotron radiation is large and the beam spots at the CLAS12 target with use of only "2C" line optics is expected to be large, $\sigma_{x/y} \simeq 400$ μm. In order to reduce the beam size on the target for high energy beams, a new girder consisting of two corrector dipoles (horizontal and vertical) and two quadrupoles is installed ~ 10 meters upstream of the CLAS12 target. This girder, referred to as "2H00", has already been used for the HPS experiment at approximately the same location on the space frame and is fully tested.

Two other important changes that took place to the "2H" line for high energy running, compared to the past electron beam running, are use of a collimator (the Hall-B photon collimator box with ~ 30 cm long Ni collimators with 20 mm and 12.5 mm diameter holes) and addition shielding on the photon tagger dipole yoke, lead bricks right upstream and poly. blocks right downstream of the collimator. These additions serve the following purposes:

- Collimator will protect the CLAS12 SVT and MVT from direct hit from an errant beam
- The shielding is necessary to shield CLAS12 detectors and electronics when beam will be dumped in the new dump on the tagger dipole yoke [1]. This dump will play the same role as the Hall-B photon tagger dump in the past, it will be used to terminate beam during the initial beam tune and during the Möller runs. (Due to limitations of the tagger dipole field strength, beams with energies above 6.12 GeV cannot be dumped in the tagger dump). In addition a blank collimator block (Ni block without a hole) will be positioned on the beam line to prevent radiation leakage through the beamline.

The beam commissioning steps described below are for establishing physics quality beams for the CLAS12 experiments. Note that all of beamline devices involved, i.e. wire harps, optics elements, BPMs, collimators, viewers, electron dump, see the full list in Figure 3, have been used for the KPP run, as well as for the HPS and PRad experiments, and have been commissioned.

2 Commissioning with High Energy Beams

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 deflecting the beam down to an intermediate dump with the Hall B tagged photon spectrometer dipole magnet [2]. Then in the second step establishing the physics quality beam on the target. The procedure on how to establish physics beam for the CLAS12 experiments can be found in the [3]. Here we describe additional checks that will be done for beam commissioning for the first time. The total time for the commissioning is ~ 30 hours.

It is assumed that the Hall is in the “Beam Permit” state. The time allotted for each step assumes beam is available for 50% of the time.

(a) ask MCC to energize the tagger dipole magnet and set the current as needed for dumping the beam in the designated dump on the tagger yoke. MCC will ask you to change (set) the beam deliver mode. Note, the relation of the beam energy and tagger magnet current is:

$$I(A) = 43.491 \times E(GeV) - 0.076 \quad (1)$$

Energizing the tagger magnet can be done right after Hall is closed and is in “Beam Permit”. There is no need to wait until MCC is ready to send the beam and then energize the magnet, it takes 45 minutes to set the magnet

(b) position the "blank" collimator on the beam

(c) when the tagger magnet is at required setting ask MCC if they are ready to establish beam on the tagger yoke dump ($\leq$ 5 nA). Since beam will not be directed to the "tagger beam dump" in the floor, the ITV2C24 YAG viewer, controlled by MCC, can be used to make sure the beam has a reasonable shape. It will take $\sim$ 1 hour for MCC to setup and cleanly transport beam to the tagger yoke dump,

(d) perform harp scans using the 2C21 harp. Beam width in 'x' and 'y' directions energy (pass) dependent, should be $\lesssim$ 150 μm, with peak/tail $> 10^2$ (this is small due to background from tagger yoke dump). Ask MCC to retune if needed, repeat the scan. Iterate to get acceptable beam profile. Time for this study $\sim$ 2 hours,

NOTE: since the "Tagger yoke dump" is used, radiation environment will be high and the rates on some of halo counters will be higher than usual. Call RC and beamline expert if background in all halo counters will be too high to perform harp scans.

(e) continue with beam tune, perform harp scans using the 2C24 ("tagger") wire harp. This harp will measure beam width in 'x', 'y', and 45° projections. Acceptable beam profile is $\sigma_{x/y/45^\circ} < 500 - 700$ μm. Time for this study is $\sim$ 4 hours.

(f) after reasonable profile is established on 2C24 ("tagger") harp, send the beam to Faraday Cup dump (otherwise known as electron dump).

- CLAS12 detectors, solenoid current setting is at 10% its max, torus is at the required setting for the run (magnets can be energized as soon hall is in "beam permit")
- ask MCC to degauss and turn the tagger dipole off
- position 20 mm collimator on the beam and move "Chromox" screen of the downstream viewer in beam position (if it is not already)

This will take $\sim$ 2 hours (degaussing is a long procedure).

(g) when ready, ask MCC to send 5 nA beam to the Faraday cup. Closely watch the downstream viewer and the Faraday cup reading. If the beam goes through cleanly you should see a clean beam spot on the viewer and the current as reported by Faraday cup should be within a few % of the BPM readings (2C21 and 2C24). The clean transport of the beam to the dump can take up to 2 hours.

(h) study effect of the solenoid magnetic field on the beam: torus should be already up to its required field setting, the solenoid at 10% of max current. Start ramping up the solenoid to the desired current and watch the beam spot on the downstream viewer. Beam deflections of a few mm at the viewer is not a problem (on the Chromox screen tick marks are in 5 mm steps). If beam moves more than 10 mm call RC,

    This will take as long as it takes to ramp up the magnets, ~ 4 hours.

(i) position beam on the target: The cryo target cell is a 5 cm long Kapton cylinder, 20 mm in diameter, with entrance and exit windows that have a thin part in the center, 30 μm aluminum, 10 mm in diameter. Beam always should pass through the thin part. Outside of that range beam will hit the target support parts. Using position readings on 2H01, move beam up/down and left/right and find the sweet spot where rates in the downstream halo counters are the lowest. Target should be in "empty" state.

    Time for this study is ~ 1 hour.

(j) tune the beam profile using the 2H01A harp. This harp will measure beam width in 'x', 'y', and 45° projections. Acceptable beam profile is $\sigma_{x/y/45^\circ} <$ 300 μm. If needed, use quads on the 2H00 girder to adjust beam width (MCC should consult with Michael Tiefenback). Time for this study is ~ 4 hours.

(k) fill (if cryo-target is in place) and study beam halo counter and beam offset monitor (BOM) rates. Set FSD based on the halo counter and BOM rates. Two things must be set, the trip rate and the trip detection time interval. In order to limit "false positive" trips, the trip limit should be $\sim 5\sigma$ to 6σ above the nominal count rates (N), here $\sigma = \sqrt{(N)}$. The trip detection time interval, $\delta\tau$, must be selected such that $N \times \delta\tau \geq 200$. This can take up to 2 hours.

(l) test FSD system by running the harp wire through the beam and reading out rates using the Struck scaler system with a 15 μs dwell time. This will take ~ 4 hours and **must be done with beamline expert**

(m) empty the target. Turn on forward PMT detectors (EC/FTOF/LTCC), make sure rates are reasonable while running ~ 5 nA beam. Will take ~ 1 hour.

(n) rate studies with the target: fill the cryo target (LH_2) and raise the beam current. Watch the rates on the forward detectors, and occupancies and currents in DC. Stop at the beam current where rates and occupancies are still acceptable; consult with RC if needed.

This will take $\sim$ 1 hour.

(o) study DC occupancies and detector rates as a function of solenoid field. Will take $\sim$ 2 hours.

References

[1] Under "Document" at https://clasweb.jlab.org/wiki/index.php/CLAS12_Beamline, "Proposed tagger yoke dump" and "Simulation of the tagger yoke dump".

[2] D.I. Sober et al., "The Bremsstrahlung Tagged Photon Beam in Hall B at JLab", Nucl. Inst. and Meth. A 440, 263 (2000).

[3] Appendix of the beam line manual or under "Procedure" on the run wiki.

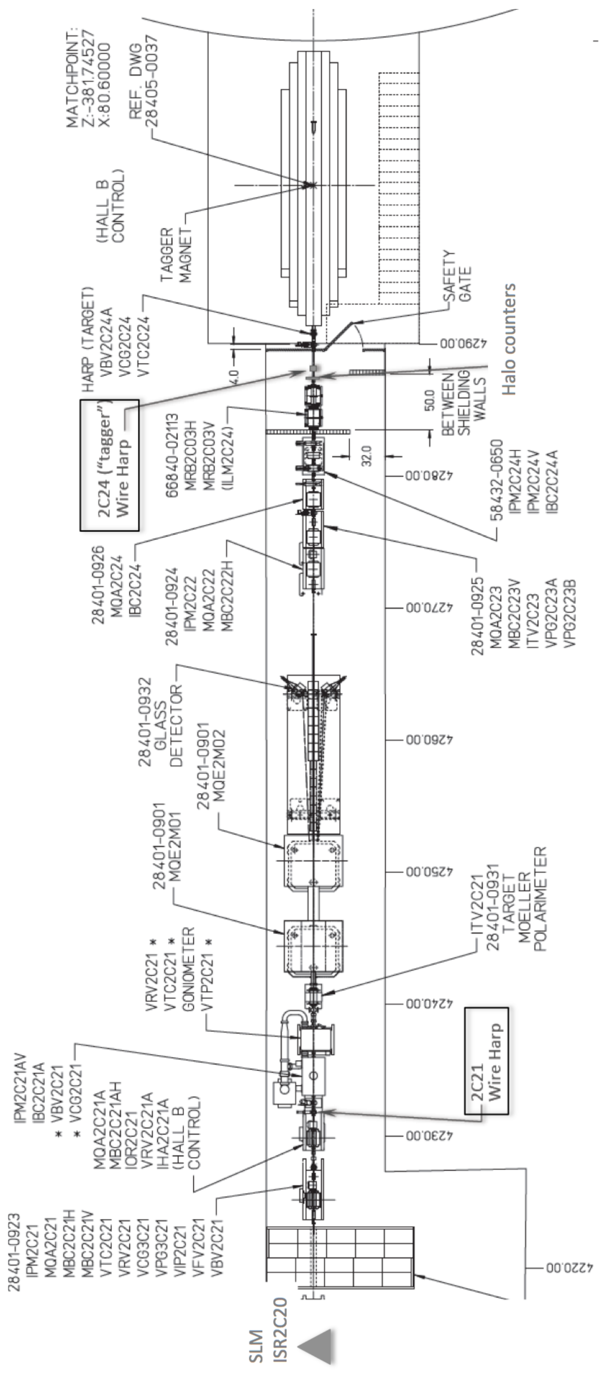


Figure 1: The “2C” line from the green shielding wall to the Hall-B tagged photon spectrometer dipole magnet. This is the part in the upstream tunnel where the beam gets to the hall beamline elevation.

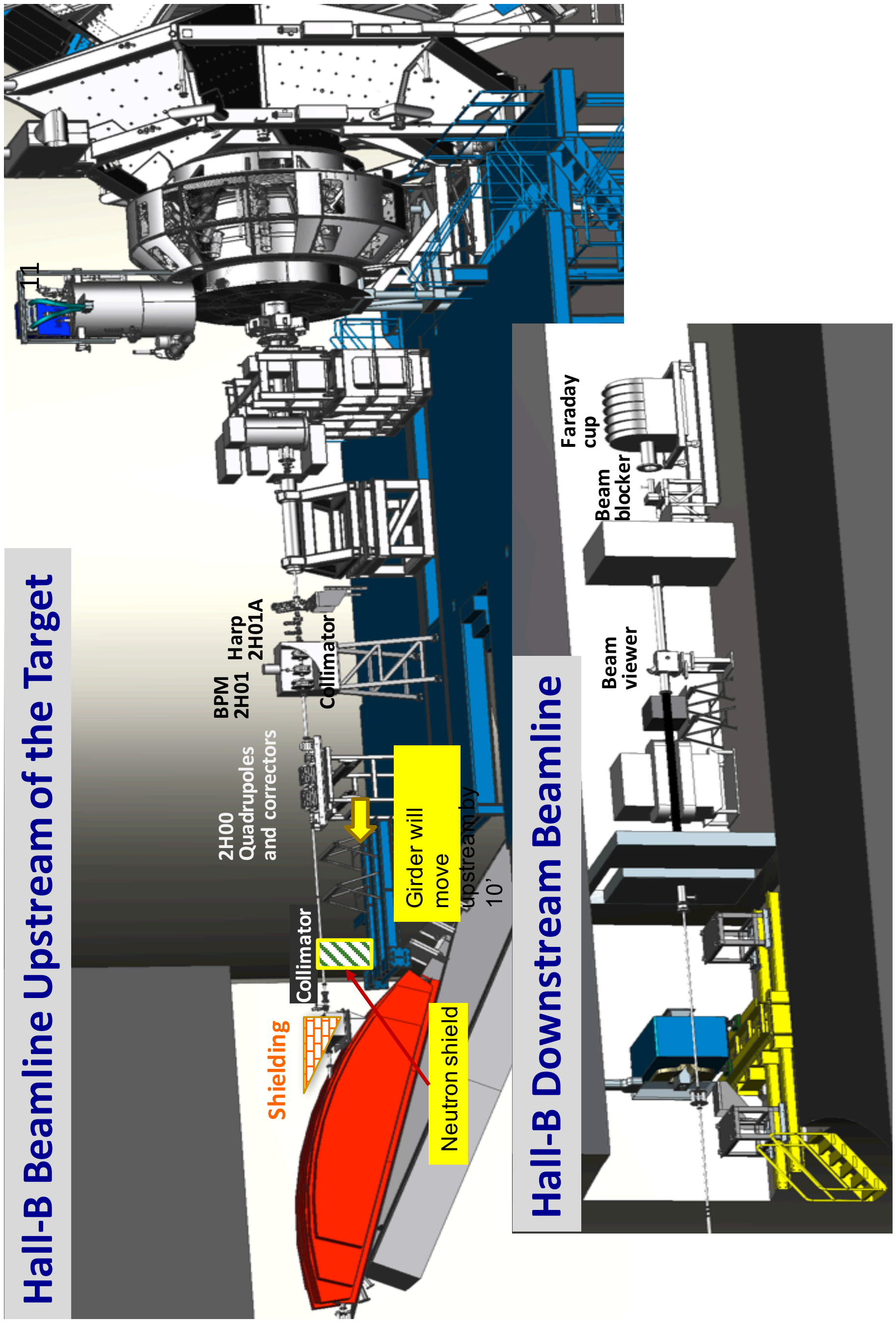
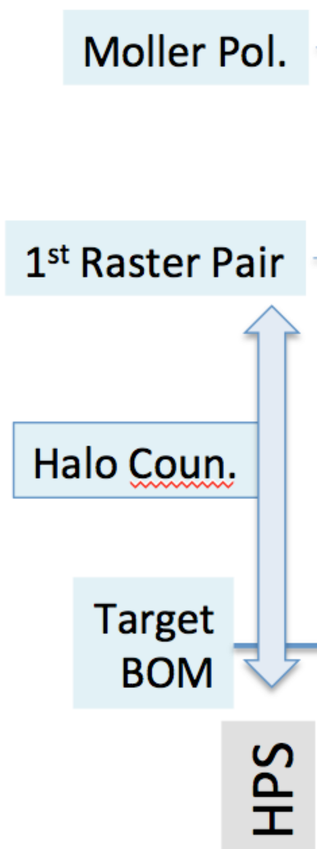


Figure 2: The “2H” line from the Hall-B tagged photon spectrometer dipole magnet to the Faraday cup dump in the downstream tunnel (electron dump).



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