CEBAF TN-90-258
Revision A
January 2, 1991

Injector Low Energy Beamline Design

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I have redesigned the injector beamline between the electron gun and the cryounit entrance to provide better performance, additional room for beam diagnostics, and additional operational flexibility. The layout of the injector elements as they will be installed on the injector girder is given below. Additional remarks about some features of this layout are appended after the dimensional information.

Beamline Element Description	Length of Element (inches)	Downstream Flange Face (inches)	Critical Longitudinal Dimension
Gun Exit Flange	-.-	0.0	Gun exit flange coincident with start of girder.
4-Way Cross	6.68	6.68	
Adaptor Flange	0.75	7.43	
Spool with Lens #1 and Steering #1	14.00	21.43	
Bellows	3.34	24.77	
VAT Valve	1.38	26.15	
6-Way Cross APERTURE #1 and Viewscreen #1	4.93	31.08	APERTURE #1 (1 mm diameter) at 726.8 mm.
Spool with Lens #2	4.93	36.01	
Spool with steering #2	17.25	53.26	
Bellows	3.34	56.60	
4-Way Cross APERTURE #2	4.93	61.53	APERTURE #2 (2 mm diameter) at 1500.3 mm.
CHOPPER #1 with Lens #3	9.10	70.63	CHOPPER #1 at 1678.4 mm.

Tee	4.93	75.56	
Spool with Steering #3	6.75	82.31	
Bellows	3.34	85.65	
Spool with Lens #4a	4.93	90.58	
Cube with CHOPPER APERTURE Viewscreen #2	2.75	93.33	CHOPPER APERTURE at 2335.7 mm.
Spool with Lens #4b	4.93	98.26	
Spool with Steering #4	6.75	105.01	
Bellows	3.34	108.35	
Tee	4.93	113.28	
Chopper #2 with Lens #5	9.10	122.38	CHOPPER #2 at 2992.9 mm.
Spool with Steering #5	4.93	127.31	
6-Way Cross Viewscreen #3	4.93	132.24	
BUNCHER	4.96	137.20	BUNCHER at 3421.9 mm.
Spool with Lens #6 and Steering #6	18.00	155.20	
Bellows	3.34	158.54	
6-Way Cross Viewscreen #4 Faraday Cup	4.93	163.47	
Spool with Steering #7	4.93	168.40	
CAPTURE SECTION	18.01	186.41	CAPTURE SECTION midpoint at 4506.1 mm.
Bellows	3.04	189.45	
30° Dipole Chamber	7.05	196.50	
6-way Cross Viewscreen #5	4.93	201.43	
Kapton double gasket	0.08	201.51	
Spool with Aperture #3, Lens #7 and Steering #8	8.25	209.76	APERTURE #3 (3 mm diameter) at 5154.9 mm.
Kapton double gasket	0.08	209.84	

VAT valve	1.41	211.25	
Differential Pump Pot	11.74	222.99	
Bunch Length Cavity	4.57	227.56	BUNCH LENGTH CAVITY center at 5702.0 mm.
Kapton double gasket	0.08	227.64	
Spool with Aperture #4 and Steering #9	5.00	232.64	APERTURE #4 (6 mm diameter) at 5818.6 mm.
Kapton double gasket	0.08	232.72	
Bellows	2.98	235.70	
VAT Valve	1.38	237.08	WBS 1 Component
Pump Drop	3.88	240.96	WBS 1 Component
CRYOUNIT MIDPOINT	48.19	289.15	CRYOUNIT midpoint at 7344.4 mm.

Several remarks are in order:

1. For those interested in modelling from the gun cathode or anode, these elements are located at: Anode Center at −74.6 mm; Control Electrode at −226.3 mm; and Cathode Surface at −228.8 mm.

2. The separation of apertures #1 and #2 defines the acceptance of the system, since lens #2 is normally NOT powered. This separation is 773.5 mm, which transmits a phase space area of $2.67 \times \pi/4$ mm-mrad, or 2.1 mm-mrad, significantly smaller than the 3.14 mm-mrad design goal. Cf. also TN-90-261 by George Neil.

3. Both apertures #1 and #2 are mounted on linear motion devices. This permits the removal of either aperture without breaking vacuum. Removal of one or both apertures, and/or powering lens #2 may be employed to deliver increased beam current, (with poorer emittance), through the system for cavity testing at higher currents.

4. The separation between the chopper cavities and the imaging lenses 4a and 4b has been increased from 513 mm (as in the 5 MeV tests) to 569.8 mm. This results in reduced RF power demand in the chopper cavities, to 81% of the former requirement.

5. Vacuum pumping is provided directly at the location of apertures #1, #2, the chopper aperture, the exit of chopper #1, the entrance and exit of chopper #2, and the entrance of the capture section. These vacuum system changes will provide maximum pumping speed directly at the gas sources, and should give better overall vacuum performance. Additional correctly sized pumping is provided directly on the capture section.

6. The region between the Capture Section and the cryounit has been expanded to include a small 30° momentum analysis dipole and Yao's bunch length measurement

cavity, providing much needed diagnostic capability in this region. The 30° arm from the momentum analysis dipole has a viewscreen located a nominal 1108 mm from the magnet center, and a one-dimensional harp located at 1235 mm from the magnet center. The beam dump on this spectrometer arm is electrically isolated, to permit its use as a Faraday cup.

7. The chopper aperture has been redesigned to provide setup slits, a narrow slit (11.5 degrees FWHM in phase) for Yao's bunch length measurement scheme, and normal "safe" operation where removal of RF power to chopper #1 will prevent beam from passing through the system.

8. The diameters and separations of Apertures #3 and #4 prevent any beam which passes through Aperture #3 from striking the bellows upstream of the cryounit, or any niobium surface inside the cryounit. Thus, the only steering coil which can cause beam to strike niobium surfaces inside the cryounit is the final steering coil, #9. Once an operating range for this coil is established, software and/or hardware interlocks and limits will be imposed to prevent beam from striking the niobium surfaces.

9. Although dimensions in the table above are given to the nearest 0.1 mm, it should be clear that absolute element positions are not known with this precision. In general, critical elements have been located with some precision in the early part of the injector, and are so noted in the "comments" column. While it is reasonable to use pairs of numbers from the table above to better than a millimeter for the separation of important elements (e.g. chopper #1, chopper aperture, and chopper #2; apertures #1 and #2; chopper aperture to buncher; etc.) the general overall tolerance which should be applied is about ± 3 mm.

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