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123 MeV Injection Line and Its Compatibility with Global Optics for 12 GeV CEBAF

Overview

This note describes the most basic design of the 123 MeV section of the CEBAF 12 GeV upgrade. The section starts from the exit of the 2nd Injector cryomodule and ends at the entrance to the North Linac. With the newly added Arc 10 for 12 GeV, major changes are introduced to this line to clear physical interferences. The new design consists of a 5-quad matching section after the cryomodule, followed by a horizontal chicane with 4 BL dipoles. More detail is given in the following.

With this change of configuration upstream of the first pass North Linac, a question of global consistency needs be answered. This is because the global 12 GeV optics has been determined through an optimization procedure [1] that relied on a specific setting of the quadrupole 1L02. Initial matching efforts from the new Injector into North Linac appeared difficult without significant change to the 1L02 strength, which would in turn invalidate the entire 12 GeV global optics. Fortunately with the use of more realistic input beam condition generated by Parmela simulation, as well as more extended search in solution space, it was possible to match the optics from this region to the North Linac without significant impact to global optics. This will be discussed in more detail later.

The 123 MeV Injection Line

The primary driving factor in arriving at the 123 MeV section design is physical clearance from other beam lines and fixtures in this quite congested area. In addition to these concerns, it was highly desirable to retain the existing matching capability in this area for 6 GeV CEBAF, and reasonable chromatic behavior. These constraints led to a 5-quad matching section in the dispersion free line after the cryomodule, followed by a Chicane that is longer than the existing one with 9 quads (2 more than existing) to keep the beta functions below 120 m. The large number of quads in the Chicane provides good flexibility for alternative optics, and can potentially enhance the capability of the upstream matching quads.

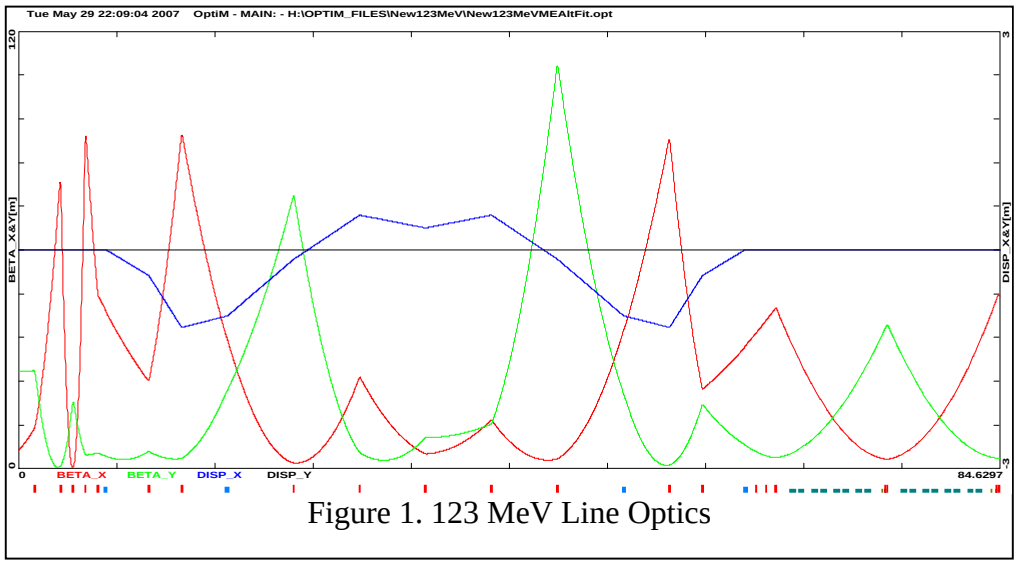

Figure 1. 123 MeV Line Optics

Figure 1 shows the optics of this section, including the first few sections of the North Linac. Specs for magnetic elements are listed in Table 1. A conceptual schematic showing this line is given in Figure 2.

Name	L[cm]	B[kG]	G[kG/cm]	BendAng[deg]
MQD0L06	15	0	-0.140345	
MQD0L07	15	0	0.350915	
MQD0L08	15	0	-0.376134	
MQD0L09	15	0	0.33484	
MQD0L10	15	0	-0.0848177	
MQD0R01	15	0	-0.117192	
MQD0R02	15	0	0.0750768	
MQD0R03	15	0	-0.0603919	
MQD0R04	15	0	0.0803106	
MQD0R05	15	0	-0.0573067	
MQD0R06	15	0	0.0803106	
MQD0R07	15	0	-0.0603919	
MQD0R08	15	0	0.0750768	
MQD0R09	15	0	-0.117192	
MBL0R01	30	-1.31331	0	-5.49998
MBL0R02	30	1.31331	0	5.49998
MBL0R03	30	1.31331	0	5.49998
MBL0R04	30	-1.31331	0	-5.49998

Table 1. 123 MeV Line Magnet Elements

Figure 2. Schematic of 123 MeV Line

Compatibility with Globally Optimized Optics

The optimization procedure [1] for the 12 GeV global optics assumed that all linac quads, with the possible exception of 1L28 that is not part of the periodic lattice, are all running at their first-pass constant-phase-advance strengths. With the introduction of the new Injection Chicane, we must ensure that it does not force the front end focusing in the North Linac to deviate too much from its periodic behavior. Indeed in one version of the preliminary design the quad 1L02 was complemented by two more matching quads in order to accept beam from the Injection Chicane, and its strength was much stronger than the periodic value. Such deviation would completely invalidate the globally optimized optics cited in [1] that served as the backbone of the 12 GeV optics design.

Fortunately, the most recent revision of the design in this area, taking into account more realistic input beam at 123 MeV based on Parmela simulation, as well as further search in the solution space, was able to accomplish the following:

- Elimination of the two matching quads
- Reduced beam profile (β below 120 m)
- Quad 1L02 undergoing a five-fold strength reduction to within 30% of its nominal periodic strength while still matched to the Chicane

The last improvement allows us to continue relying on results from global optimization [1], knowing that they are not in gross contradiction to the optics further upstream. The global optimization program was re-run with the new 1L02 quad strength matched to the 123 MeV Chicane. Figure 3 shows the outcome of this optimization, including passes 2-6 North Linac β functions and 1L00 and 1L01 quad strengths corresponding to the optimal solution. Comparison between is made in Figure 4, with previous optimization cited in [1] with the 1L02 quad at

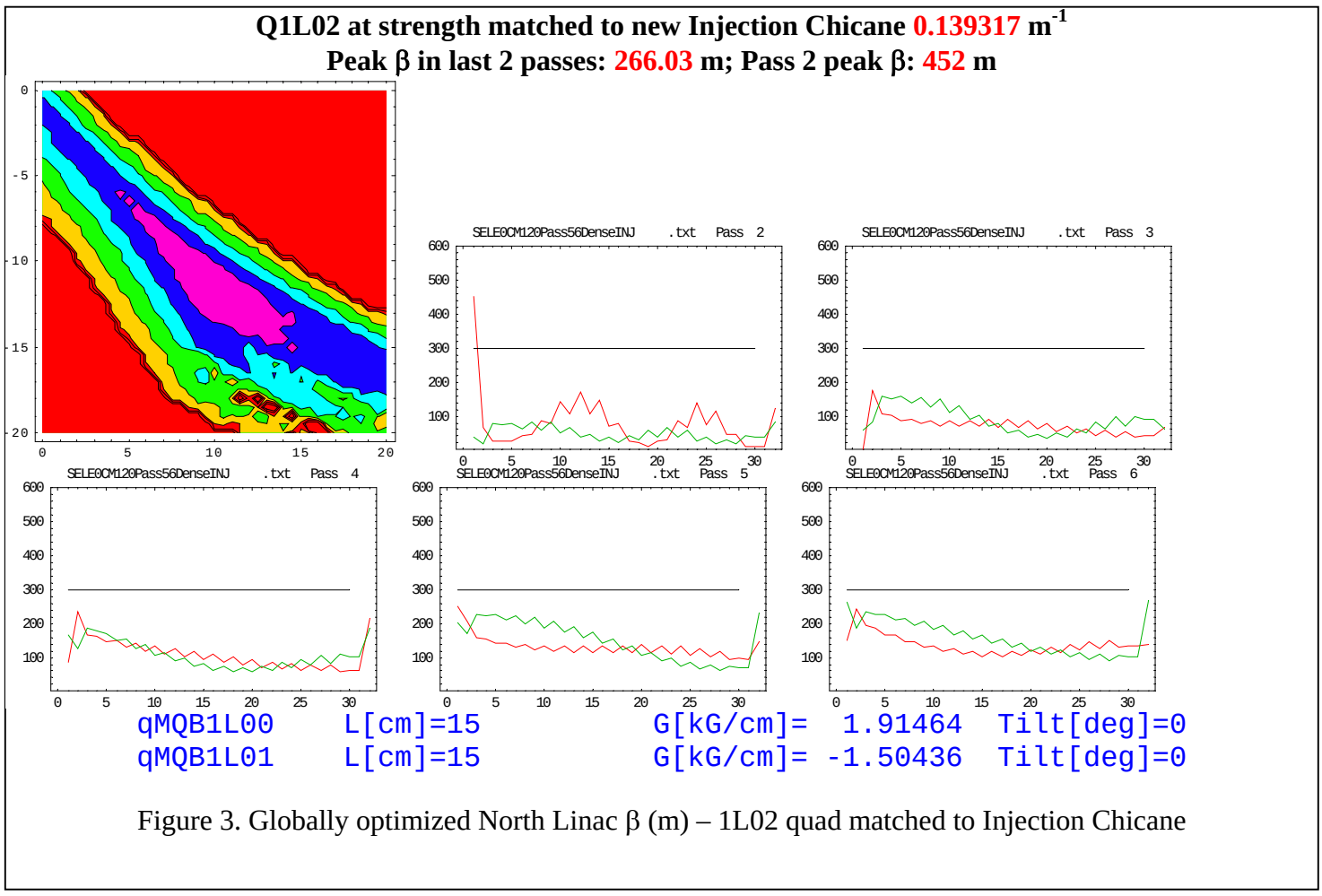

Figure 3. Globally optimized North Linac β (m) – 1L02 quad matched to Injection Chicane

its nominal periodic focusing strength. The new, more realistic solution is comparable, if not better, than the previous one.

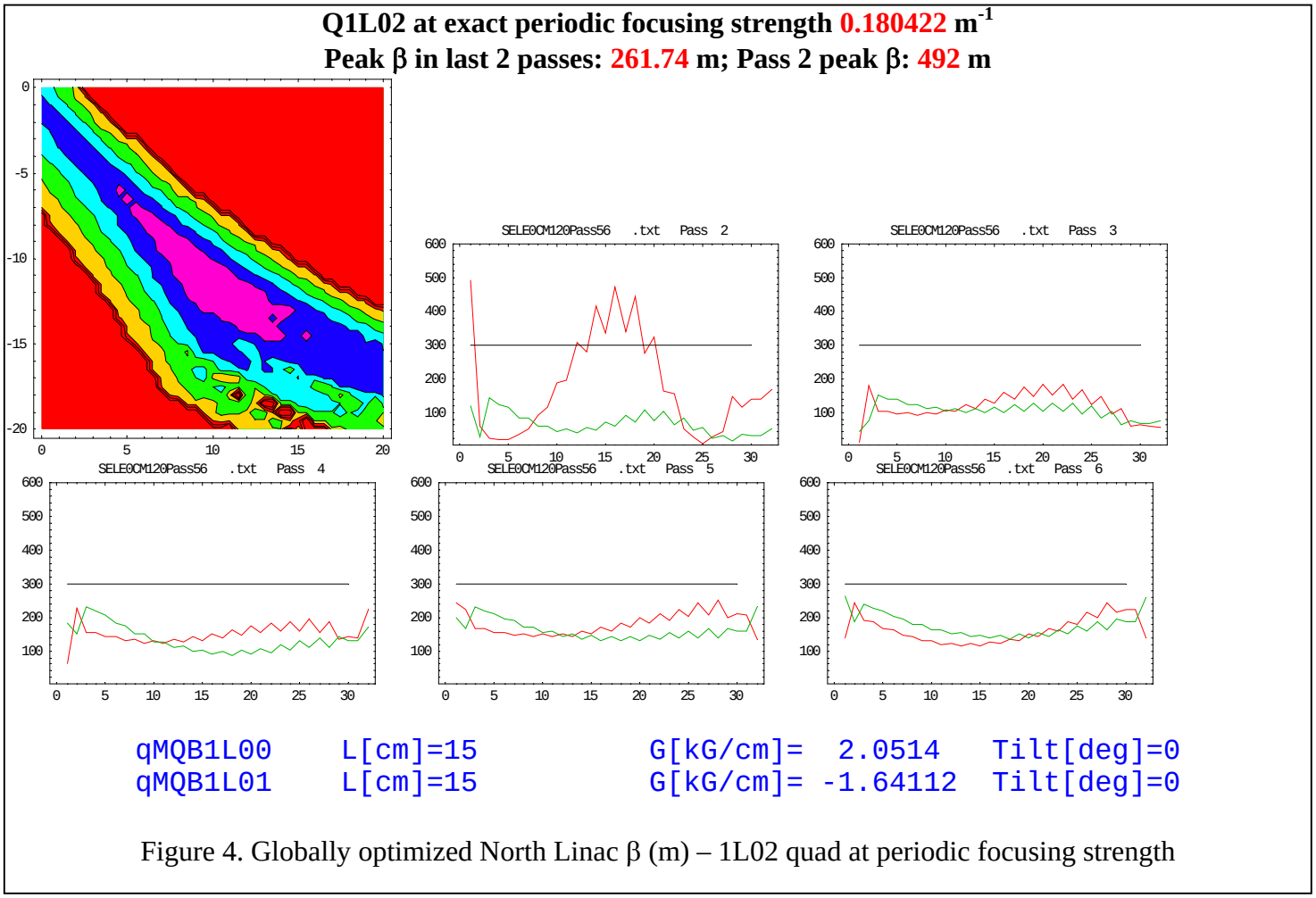

Figure 4. Globally optimized North Linac β (m) – 1L02 quad at periodic focusing strength

Reference

[1]. Y. Chao, “Improved Optimization of North Linac Momentum Profile for CEBAF 12 GeV Upgrade”, Jlab-TN-05-004