Hall C line at 22 GeV (FFA)
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Abstract

The initial Hall C line work discussed in TN-22-016 is brought to completion. Details are found in the accompanying spreadsheet and optim file. The dipole settings are not perfect: the Pivot location is off by -1.33 mm in X and 0.06 mm in Z. Nothing that correctors can't handle, but annoying. Arc quadrupole setting are based on the 1.9 m dispersion arc optics provided by Alex Bogacz.

Magnets

One new quadrupole type is required: QRP, a 52 cm long quad with the QR profile and same maximum gradient per cm of length, 5.33 kG/cm. This is used at 3C04 and 3C05 in addition to locations where the focusing is nominally needed as they will be used with qsUtility to measure beam properties. The harp is moved to the 3C06 girder to get greater throw. PSS equipment was moved downstream by one girder to allow this. I have not examined cooling options for the QRP.

The new Lambertson is discussed in TN-22-041. Center plate is thicker so the C beam must be lower coming out of the transport recombiner. The dispersion from the Lambertson is closed via a new 180 cm dipole, detailed in TN-23-008. The eight arc dipoles are discussed in TN-21-051. The new 180 cm dipoles were designed for use in the Compton chicane as there would have been no space for its detectors if the 200 cm dipoles previously contemplated had been used. The differential pumping station was removed to provide drifts within altered Compton chicane. The 2.62 cm vertical chicane at the end of the line uses the existing BE dipoles.

ME should check the layout with the new, wider dipoles to ensure I didn't hit the tunnel wall. FFB magnet (MCN) locations must be checked after this layout is done. Shorter FFB magnets may be required. Shorter BPM assemblies are required; those have been designed for the MOLLER beam line. The harps at 3C12 were removed, no longer peak dispersion. There is likely room at the 3C11 or 3C13 girders, dispersion peaks, for synchrotron light monitors or interferometers or one each.

Fast raster requires 100 A to provide 6 mm square at the pivot with two pair of coils. It is my understanding that the existing coils can accept 100 A. MOLLER requires ~80 A so JLab will gain experience with higher power circuits well before the upgrade.

Initial Conditions

Energy 22 Gev, dp/p 0.1%
BetaX=BetaY=20 m as usual
AlphaX=AlphaY=0 as usual
geometric emittanceX 3.6E-7 cm, twice what Kirsten calculates for the perfect FFA arcs
geometric emittanceY 1.8E-7 cm as the ratio is typically 2:1 x:y and no calculation has been done
initial dispersion and its derivative zero

Plots

The plots on the following pages end at S=145m, just beyond the Pivot which is at S=144.6 m

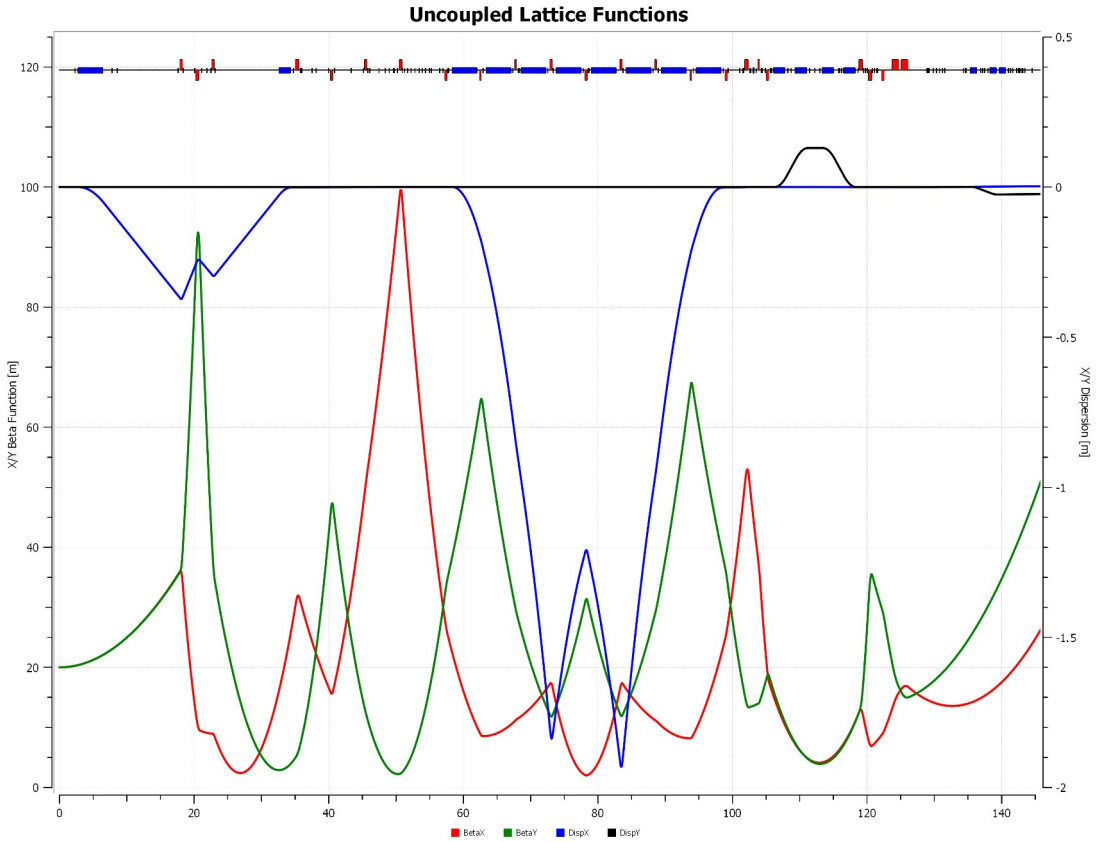

Figure 1. Lattice functions

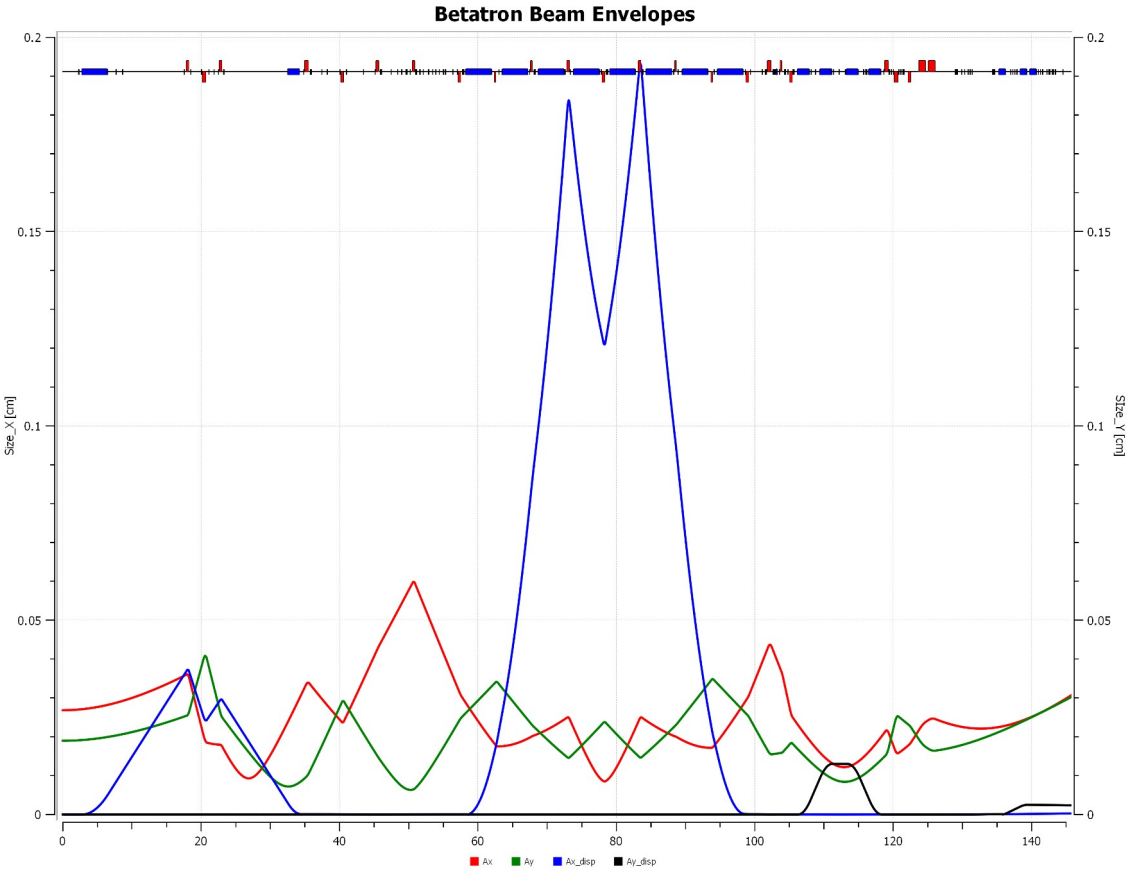

Figure 2. Beam envelopes with initial conditions specified on page 1

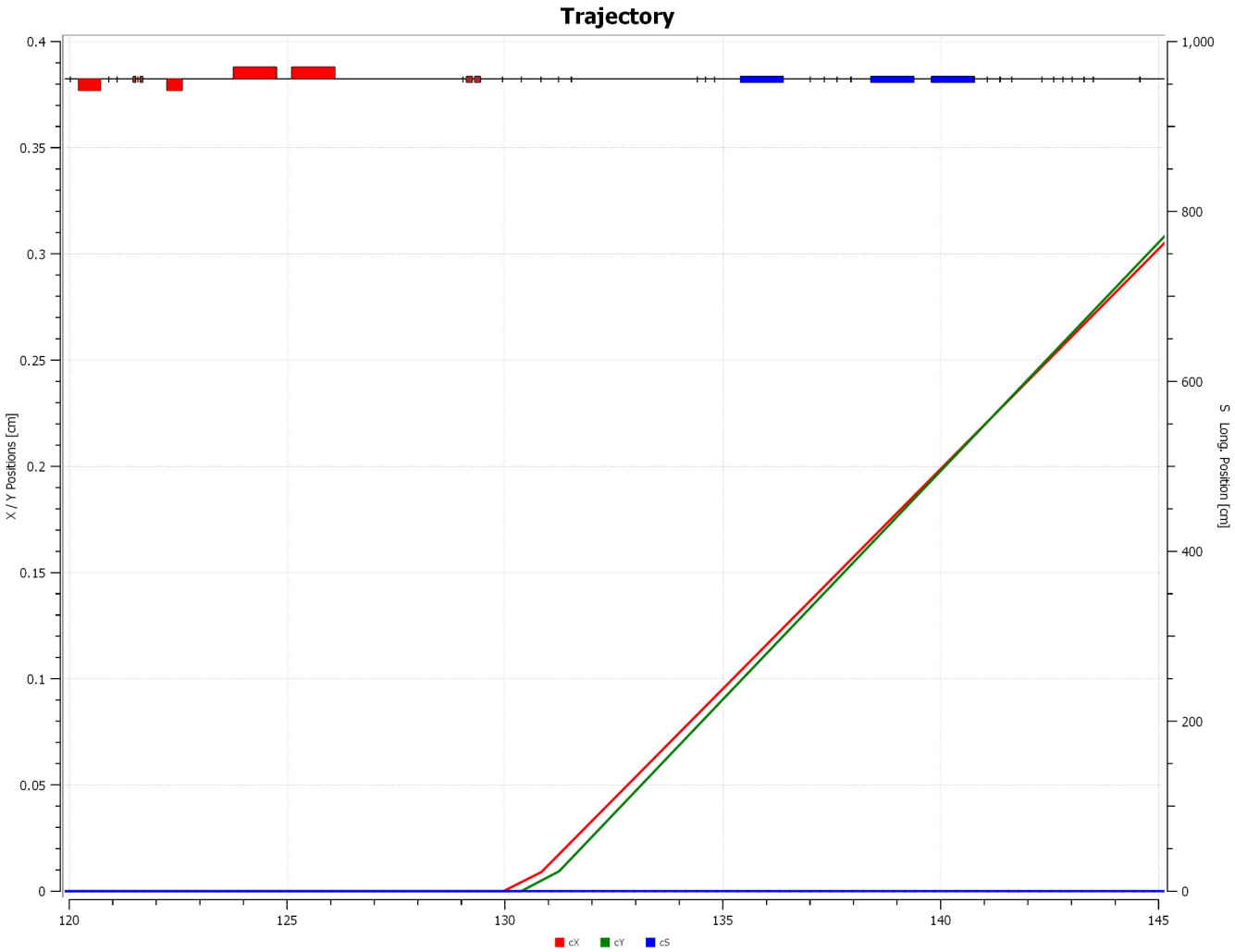

Figure 3. Raster providing 6 mm square at pivot 94 A in horizontal coils, 98 A in vertical coils

Design Robustness

In order to check design robustness I used the fractional factorial (Taguchi) matrix I devised for the 12 GeV upgrade. This is a four variable, three level array with nine trials. "scale" implies a multiplier, diff an addend. Quads 4-8 were used to match the betas and alphas at the start of the first arc dipole. Ten plots of beta envelopes follow. No matching was done after quad 8 at the entrance to the arc.

trial	xbscale	ybscale	xaldiff	yaldiff
T1	0.5	0.5	-1	-1
T2	0.5	1	0	0
T3	0.5	2	1	1
T4	1	0.5	0	1
T5	1	1	1	-1
T6	1	2	-1	0
T7	2	0.5	1	0
T8	2	1	-1	1
T9	2	2	0	-1
orig	1	1	0	0

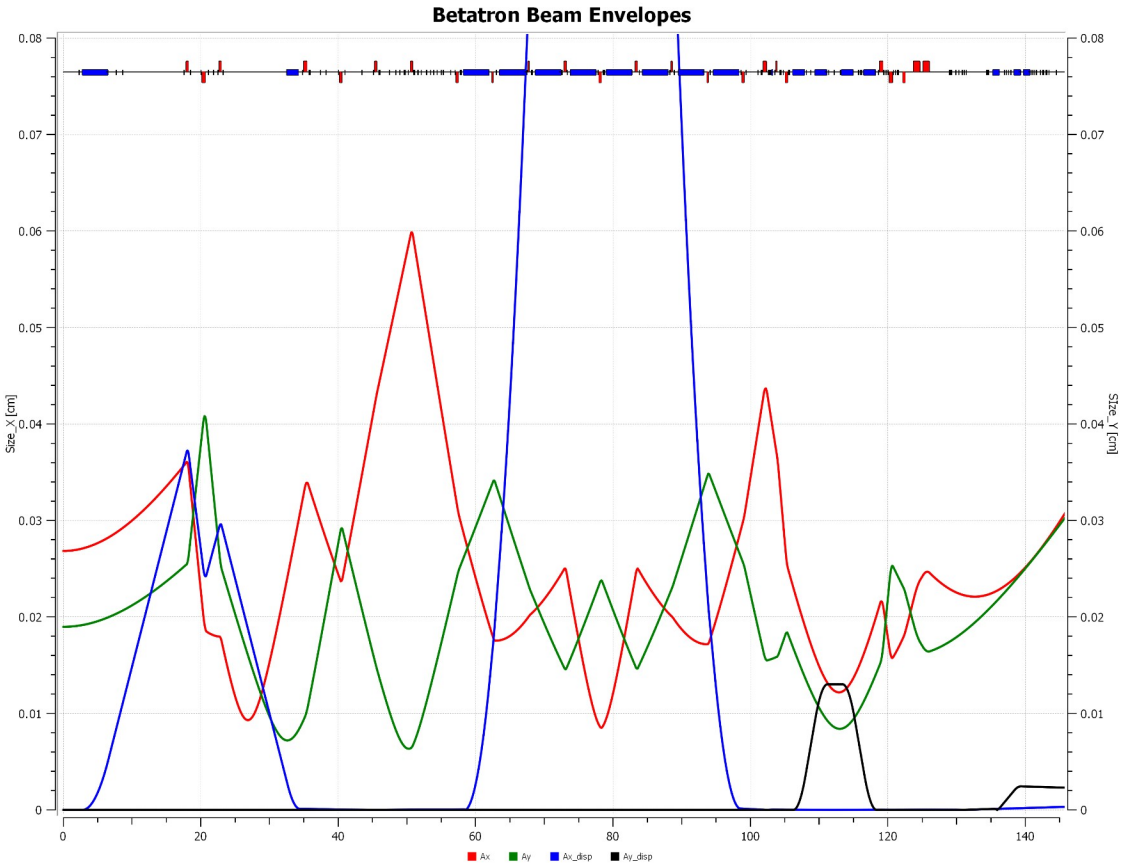

Figure 4. Original quad values, same as Figure 2 except vertical scale.

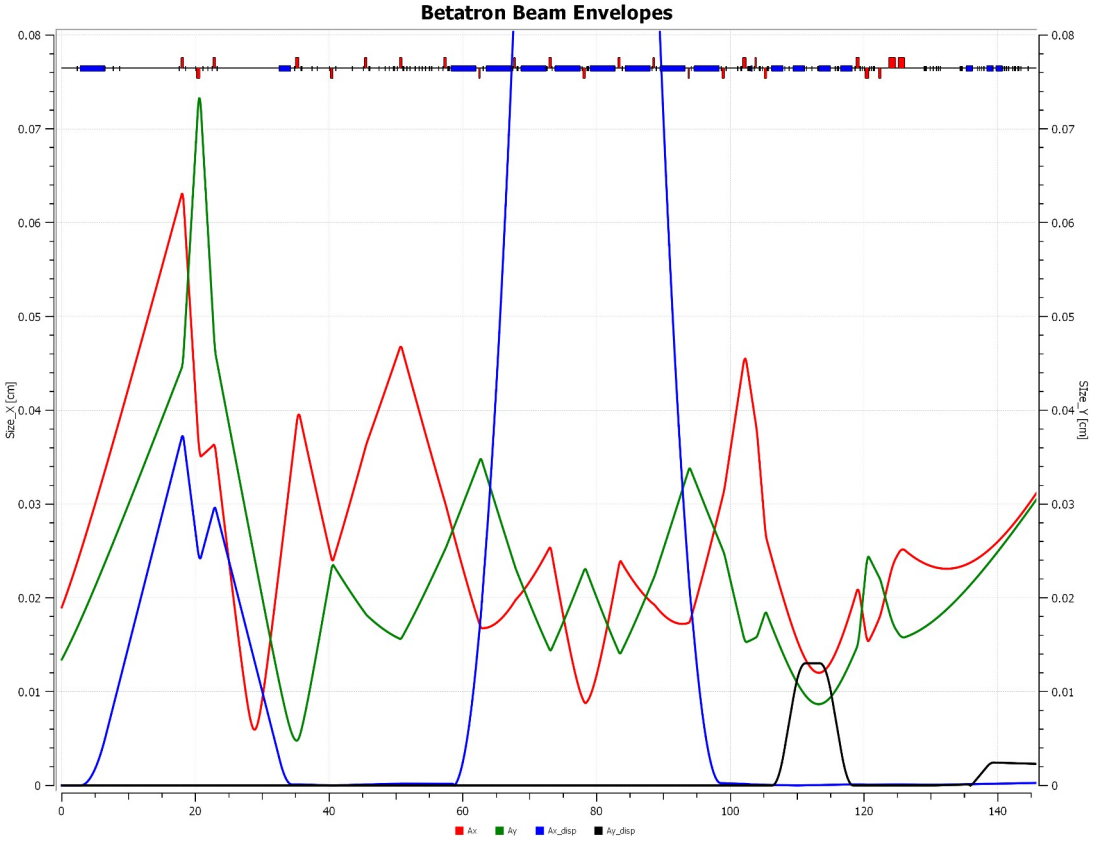

Figure 5. Trial T1 after match in non-dispersive region

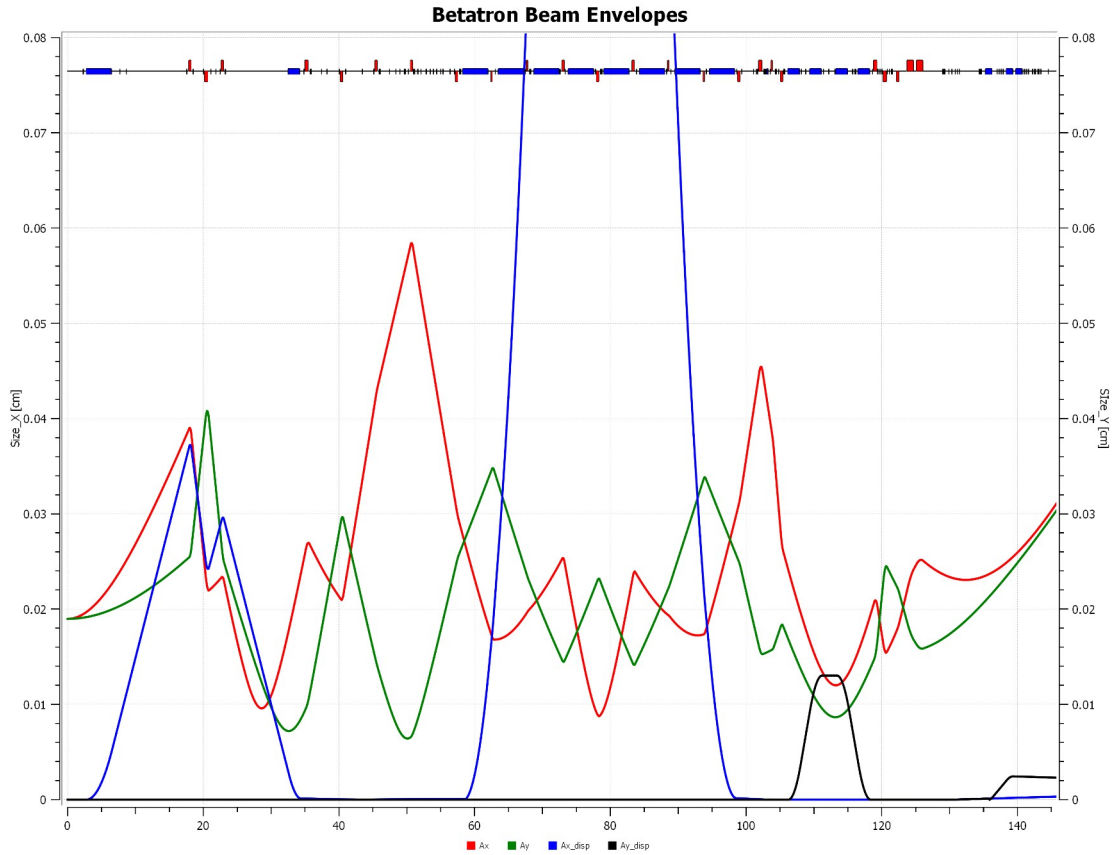

Figure 6. Trial T2 after matching

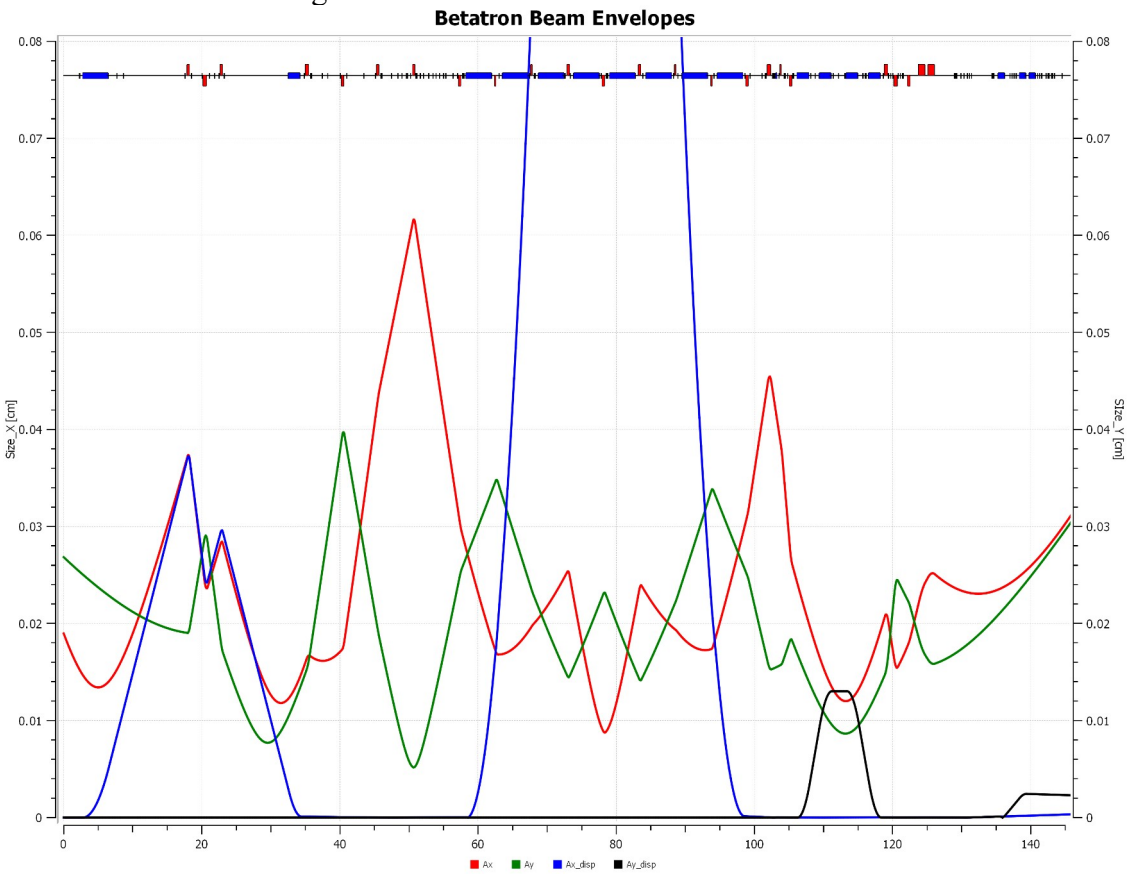

Figure 7. Trial T3 after matching

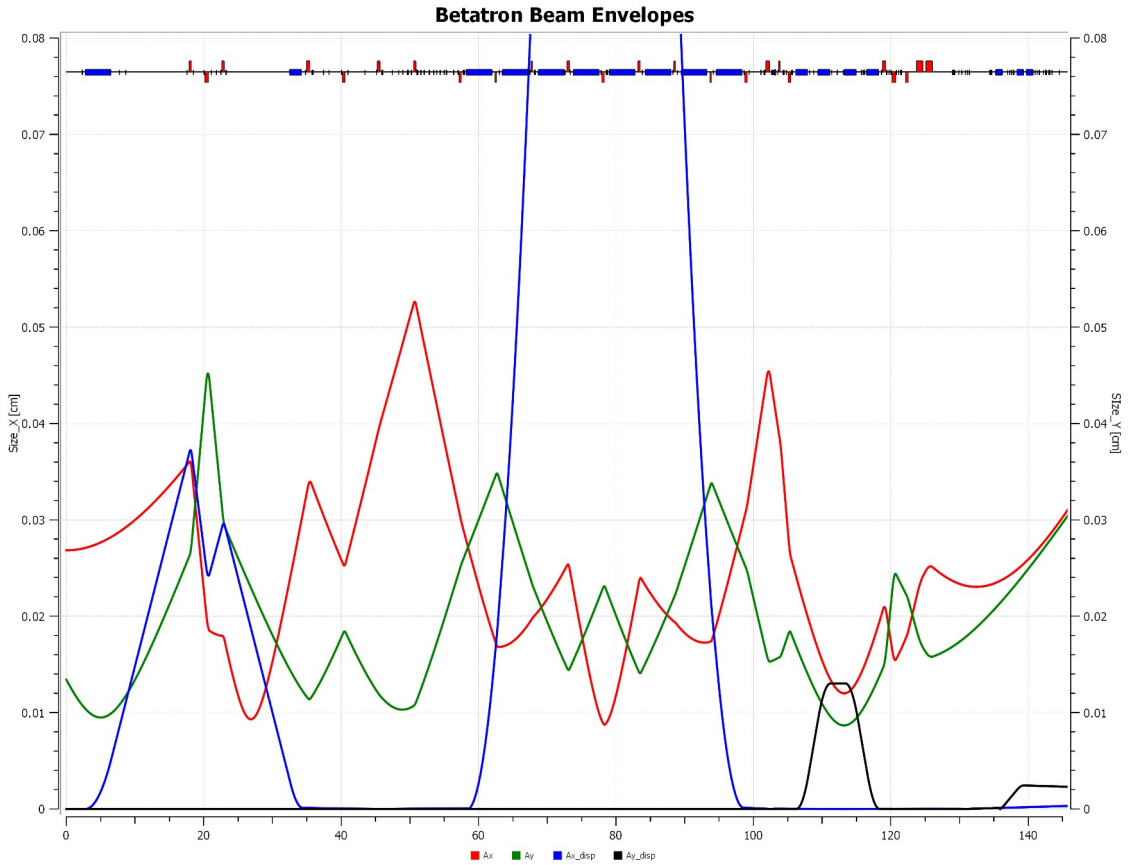

Figure 8 Trial T4 after matching

Figure 9 Trial T5 after matching

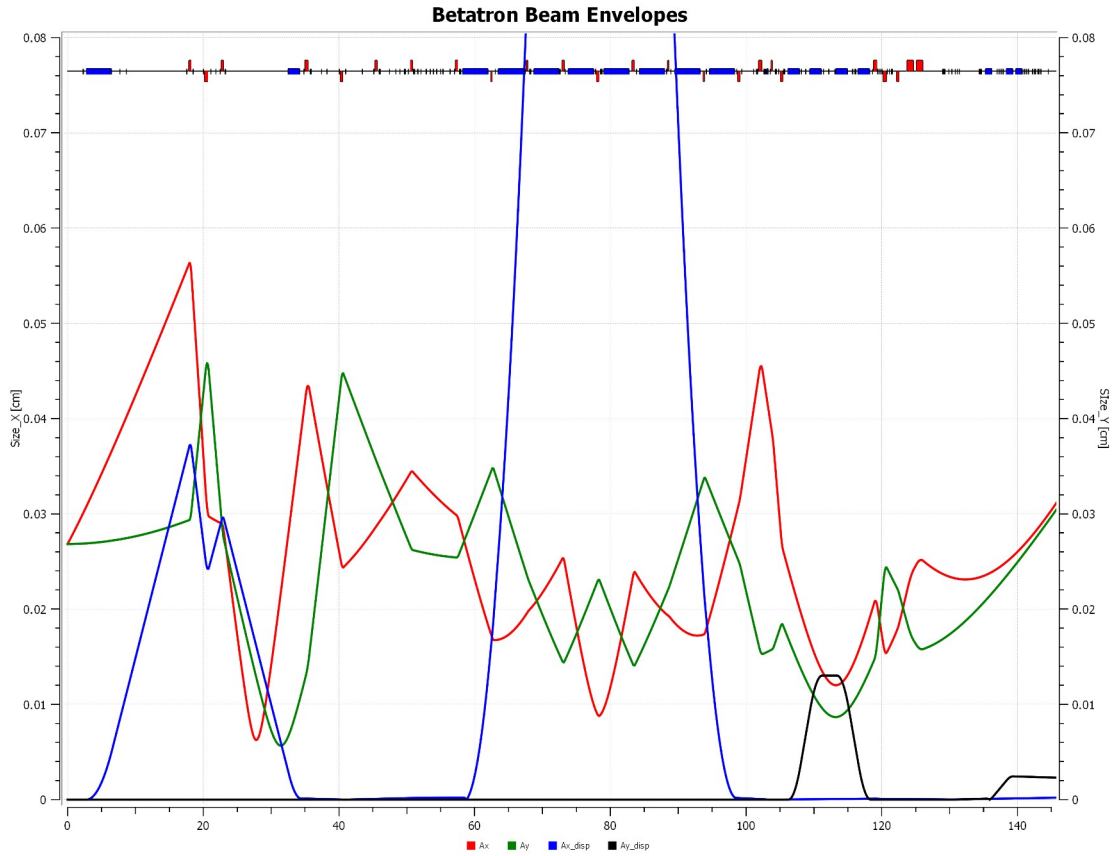

Figure 10 Trial T6 after matching

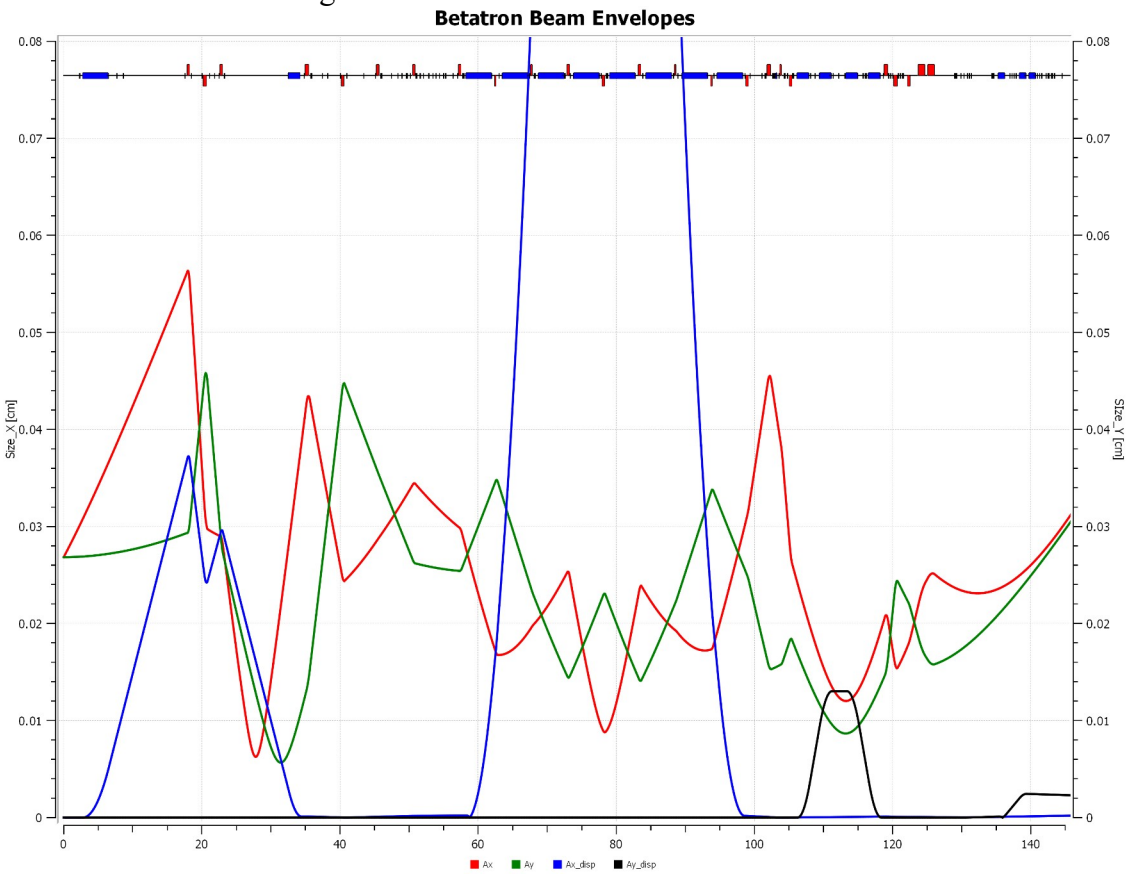

Figure 11 Trial T7 after matching

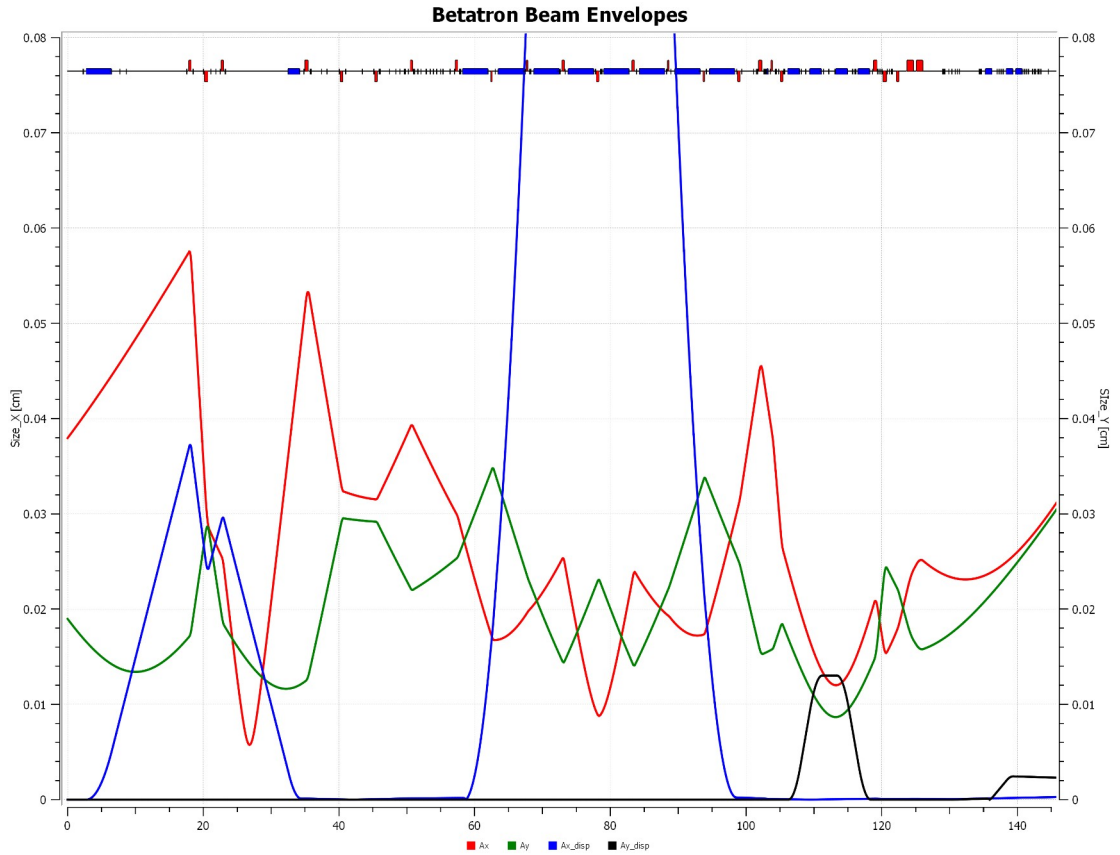

Figure 12 Trial T8 after matching

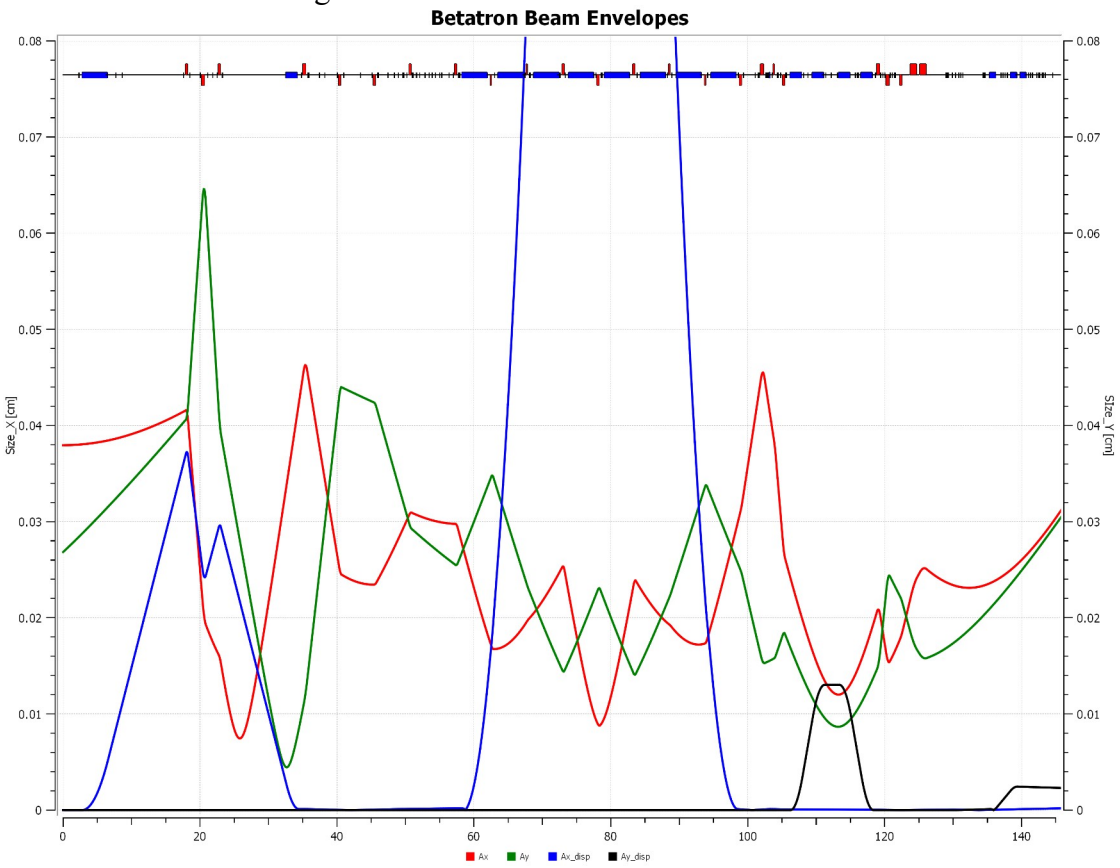

Figure 13 Trial T9 after matching

Conclusions

A viable redesign of the Hall C beam line has been completed. Two quads are lengthened, 3C04 and 3C05, specifically to allow qsUtility or its successor to be used to measure incoming beam parameters. This is not possible on fifth pass in CEBAF now as there is insufficient quad capability at these locations. (qsUtility did not exist when I defined quads for 12 GeV.) Fine tuning will be required, including a closer look at diagnostics and vacuum valves. The stronger MCG correctors designed for MOLLER are used throughout. There are details I didn't pay attention to because I wanted to get the functionality squared away.

Per Optim, about 54 MeV is lost to synchrotron radiation. The arc S is ~40 m and maximum current at 22 GeV ~40 uA so the power on the vacuum vessel wall is ~54 W/m. Cooling hasn't been considered. If dump heat removal capacity is re-evaluated and increased as may be possible per TN-06-022 and TN-13-051, perhaps 65 uA and ~90 W/m. A new Environmental Assessment will be required for the energy upgrade; beam power limit increase to 1500 kW/hall should be considered in the EA to allow for high luminosity. SRF will be limiting unless there are major changes there.

This line will be used as the basis for the Hall A line up to the start of its Compton polarimeter. The 180 cm dipoles will be used there as well.