

# Extraction System for the 12 GeV CEBAF Upgrade

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## Abstract

Presently used extraction scheme (6 GeV CEBAF) with the horizontal RF separation has been adopted for 1-4 pass extraction in 12 GeV CEBAF. The 6 GeV optics files for: 2T, 4T, 6T and 8T transfer lines were scaled up to appropriate energies, preserving the layout and adding stronger magnets/quads where necessary. However, the 5-pass separation scheme was altered significantly. The new optics was designed for AT line at 11 GeV. It involved cutting up the Arc A deck and pasting the middle of a scaled 4 GeV 8T deck into it. It proved possible to stack AT line dipoles and girders under those of the other arcs. Power requirements for the RF separators are increased from the 6 GeV case due to the much shorter drift. The power required is calculated from first principles, consistent with historical power levels for 5.7 GeV three-way separation.

## 1. Baseline Extraction Scheme

The RF separation system consists of warm RF cavities operating at the third sub harmonic (499 MHz) of the accelerator's micro bunch structure (1497 MHz), providing the initial transverse kick to direct the interlaced beams to one of three experimental end stations. The RF separator cavities provide the initial deflection, which is then amplified by a series of septum magnets to gain the final beam separation.

Extraction lines for the first four passes (2T, 4T, 6T, and 8T) are designed to extract beam in the horizontal plane with a combination of RF cavities and magnetic septa, dipoles and quads. All 4 passes share the same physical layout with the strength of the devices scaling with energy. Typically one of the three 499 MHz bunch trains is deflected by the RF system into the extraction path where two downstream septum magnets (YA and YB) amplify the initial transverse kick. The septa are followed by a magnetic chicane to bring the extracted beam back to the initial axis. The other two bunch trains are deflected toward the recirculation beam-line to bypass the YA and YB septa and are transported into the next arc.

On the other hand, the fifth pass extraction line (AT) facilitates simultaneous beam delivery to all three halls, so that all users can have the maximum energy. RF cavities once again initiate the time-dependent separation, while downstream magnetic septa (YA), dipoles, and quads complete the extraction process. Unlike passes 1-4, pass 5 uses vertical separation to match into the 3-way Lambertson magnet that steers the beam into the beam lines for the three existing halls.

Overall, the base line extraction system provides the capability for Halls A, B and C to have any of the first five passes while simultaneously delivering 5.5 passes to Hall D and with the additional constraints that only three Halls can be operating at the same time and only one Hall can get any particular energy.

## **2. Extraction Lines - Components**

### **2.1 2T and 4T Lines**

The first and second pass extraction magnets are capable of operating at 12 GeV settings and will remain in their present physical configuration.

Figures 1ab and 2ab illustrate the extraction region Optics and the horizontal beam separation for 2T and 4T extraction lines. The extraction lines components (RF separator cavities and magnets) are listed Tables 1 and 2.

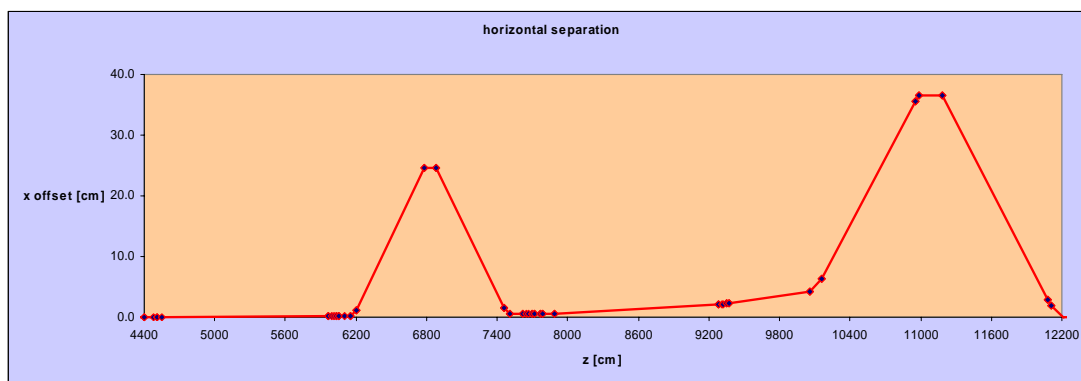
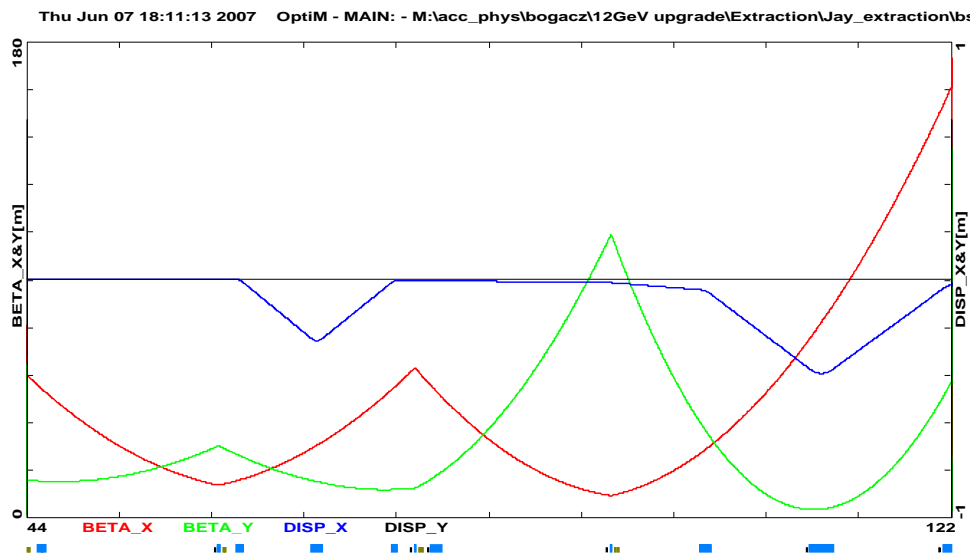


Figure 1ab

Name	L[cm]	B[kG]	G[kG/cm]	angle[Rad]
RRF2T01	70			-1.0E-04
MQB2E01	15		-0.406	-1.3E-04
MQB2E02	15		0.436	4.5E-04
MYA2T01	100	-0.102		-1.3E-03
MQB2E03	15		-0.515	-1.8E-03
MYB2T02	100	-2.595		-3.4E-02
MBP2T03	200	2.848		7.4E-02
MBQ2T04	100	-2.876		-3.7E-02

Table 1

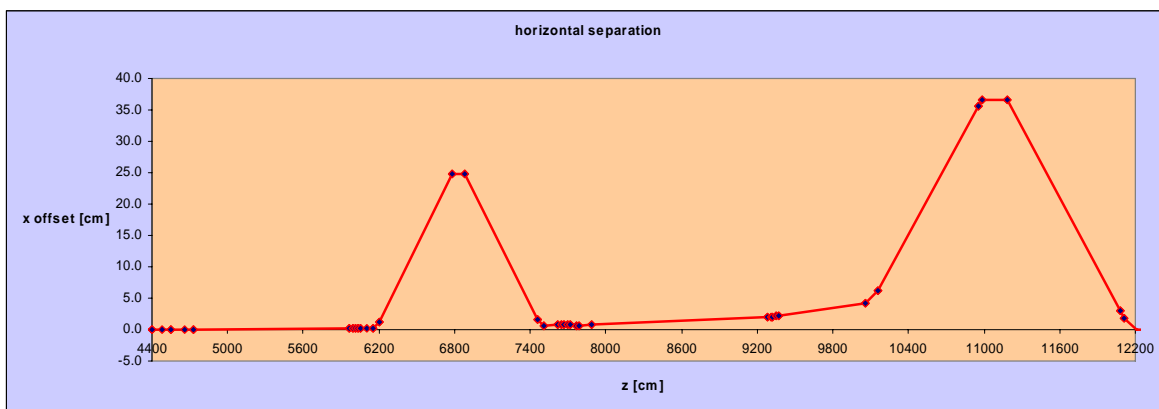
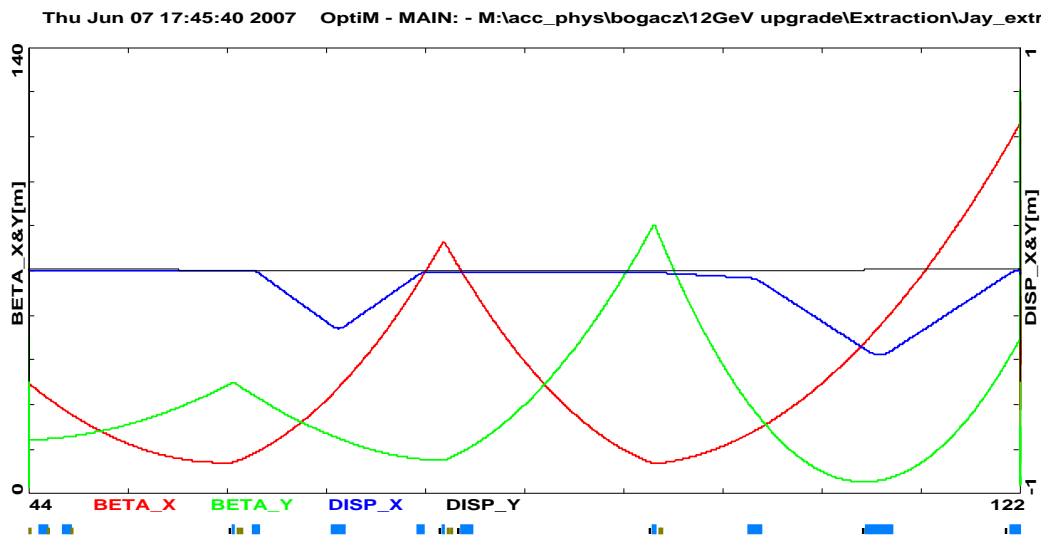


Figure 2ab

Name	L[cm]	B[kG]	G[kG/cm]	angle[Rad]
RRF4T01	70			-7.6E-05
RRF4T02	70			-7.6E-05
MQB4E01	15		-0.689	-1.6E-04
MQB4E02	15		0.881	6.5E-04
MYA4T01	100	-0.192		-1.3E-03
MQB4E03	15		-0.993	-2.1E-03
MYB4T02	100	-5.040		-3.4E-02
MBP4T03	200	5.544		7.4E-02
MBQ4T04	100	-5.598		-3.7E-02

Table 2

## 2.2 6T Line

For the third pass, a YA septum magnet will be relocated from the fifth pass and installed adjacent to the existing 3rd pass YA. Both septa will then be used to provide the required 1.33 mRad kick. The existing 1-meter YB septum magnet will be replaced by a 2-meter YR septum magnet salvaged from existing magnets to provide the necessary 34.00 mRad deflection to the extracted beam. An additional 2-meter BP dipole magnet will be installed adjacent to the existing 2-meter BP dipole magnet to provide the 75.00 mRad kick. The 1-meter BQ dipole magnet will be replaced by a single 2-meter BP dipole magnet to provide the necessary 37.00 mRad kick. The beam-line components are listed in Table 3

Figures 3ab illustrate the extraction region Optics and the horizontal beam separation. The extraction line components (RF separator cavities and magnets) are listed Table 3.

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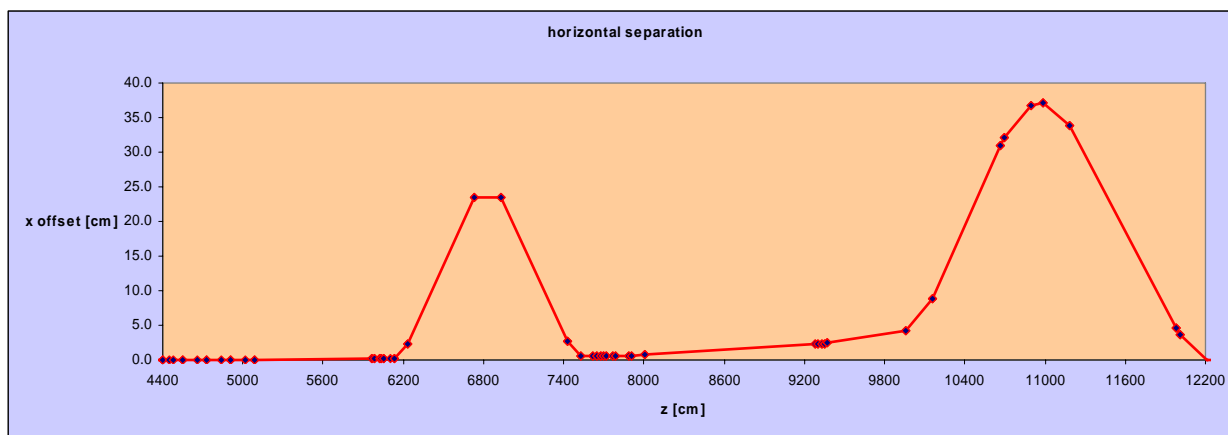
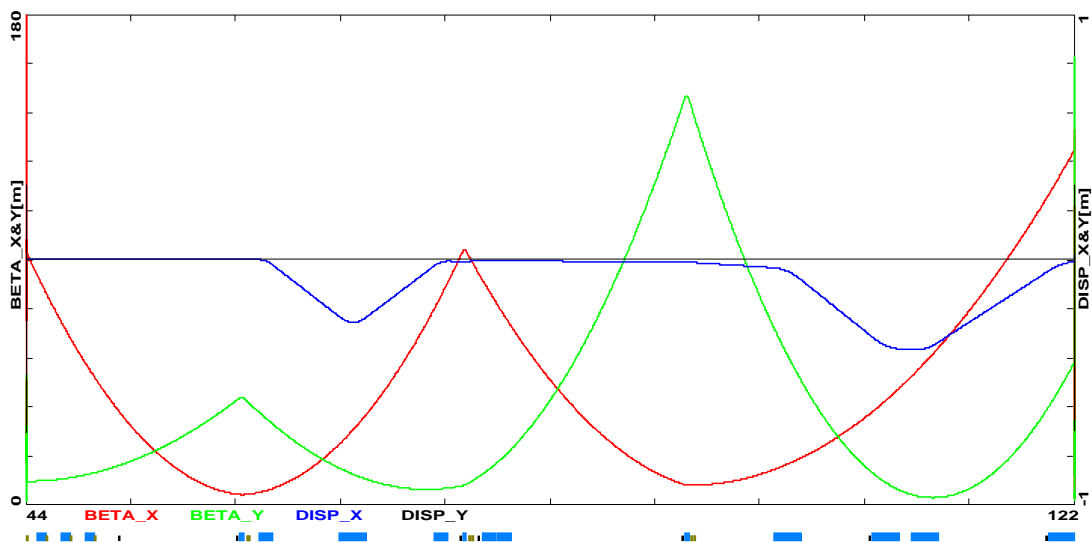


Figure 3ab

Name	L[cm]	B[kG]	G[kG/cm]	angle[Rad]
RRF6T01	70			-4.8E-05
RRF6T02	70			-4.8E-05
RRF6T03	70			-4.8E-05
MQC6E01	30		-0.826	-1.2E-04
MQC6E02	30		0.781	4.3E-04
MYA6T01A	100	-0.151		-6.8E-04
MYA6T01B	100	-0.151		-6.8E-04
MQC6E03	30		-0.740	-1.8E-03
MYB6T02	200	-4.509		-4.1E-02
MBP6T03A	200	4.452		4.0E-02
MBP6T03B	200	4.452		4.0E-02
MBQ6T04	200	-4.062		-3.7E-02

Table 3

2.3 8T Line

For the fourth pass, a YA septum magnet will be relocated from the fifth pass and installed adjacent to the existing 4th pass YA. Both septa will then be used to provide the required 1.33 mRad kick. The existing 1-meter YB septum magnet will be replaced by a 2-meter YR septum magnet salvaged from existing magnets to provide the necessary 34.00 mRad deflection to the extracted beam. An additional 2-meter BP dipole magnet will be installed adjacent to the existing 2-meter BP dipole magnet to provide the 75.00 mRad kick. The 1-meter BQ dipole magnet will be replaced by a single 2-meter BP dipole magnet to provide the necessary 37.00 mRad kick.

Figures 4ab illustrate the extraction region Optics and the horizontal beam separation. The extraction line components (RF separator cavities and magnets) are listed Table 4

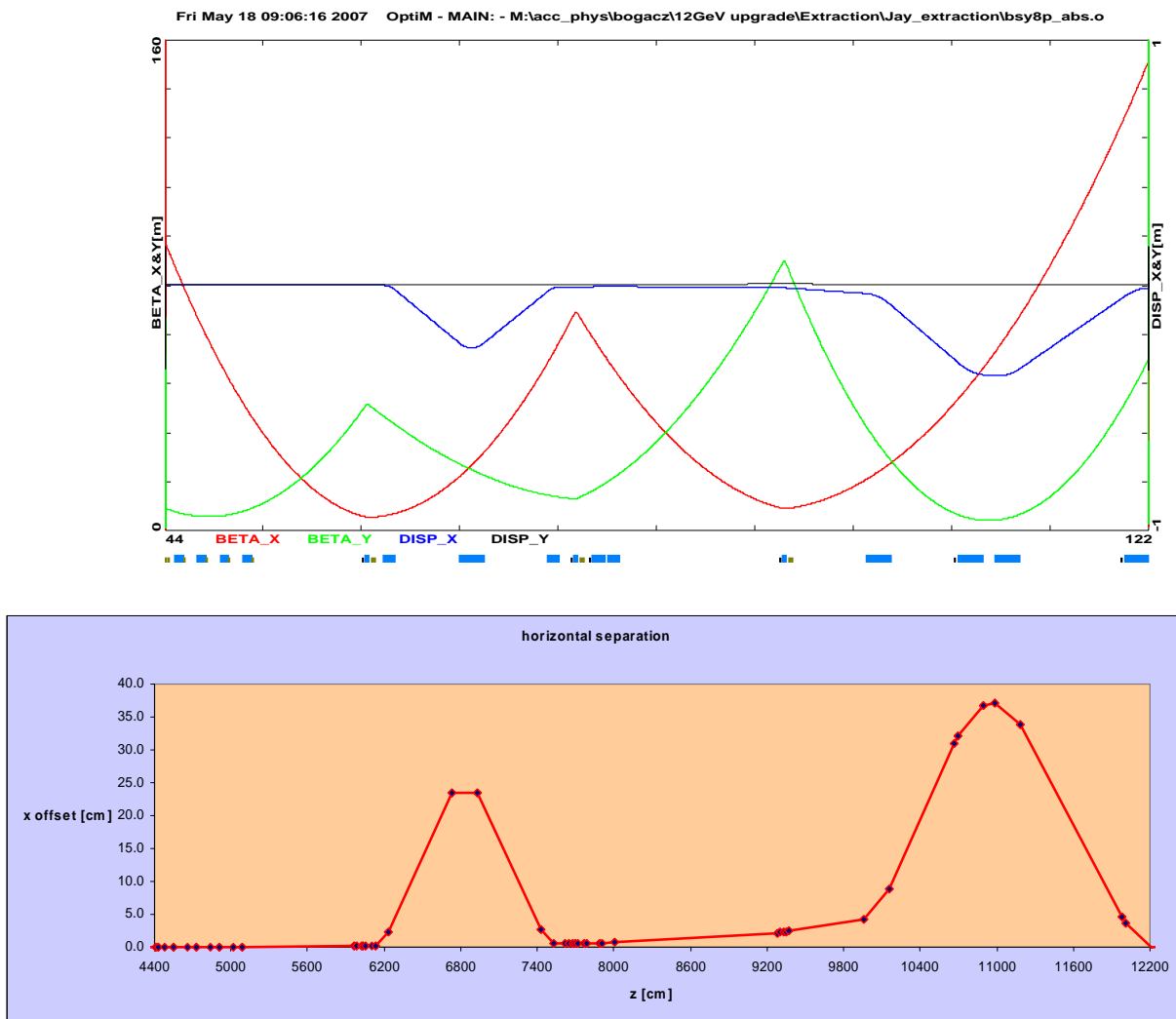


Figure 4ab



Name	L[cm]	B[kG]	G[kG/cm]	angle[Rad]
RRF8T01	70			-3.6E-05
RRF8T02	70			-3.6E-05
RRF8T03	70			-3.6E-05
RRF8T04	70			-3.6E-05
MQC8E01	30		-1.096	-1.2E-04
MQC8E02	30		1.036	4.3E-04
MYA8T01A	100	-0.200		-6.8E-04
MYA8T01B	100	-0.200		-6.8E-04
MQC8E03	30		-0.982	-1.8E-03
MYB8T02	200	-5.984		-4.1E-02
MBP8T03A	200	5.909		4.0E-02
MBP8T03B	200	5.909		4.0E-02
MBQ8T04	200	-5.390		-3.7E-02

Table 4

## 2.4 AT Line

The fifth pass upgrade design is a departure from the 4 GeV baseline due to the addition of the Arc 10 beam-line to support Hall D. The present new design will allow for transport to Hall D at 5.5 passes and one of the other halls at 5 passes. Two new 1-meter YA septa will be installed under the 4th pass septa to provide the initial 1.33 mRad kick. The balance of the upgraded 5<sup>th</sup> pass beam-line will match the 4th pass.

Figures 5ab illustrate the extraction region Optics and the horizontal beam separation. The extraction line components (RF separator cavities and magnets) are listed Table 5.

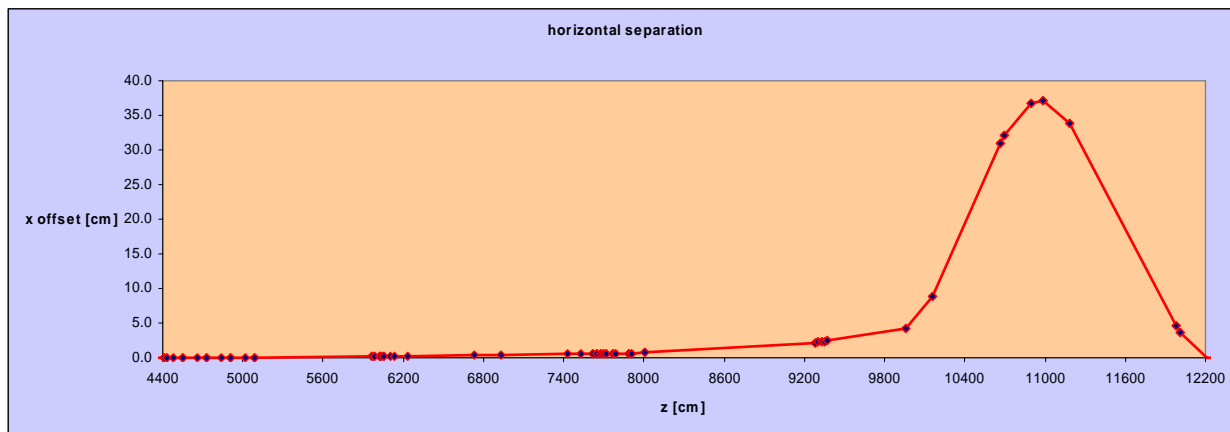
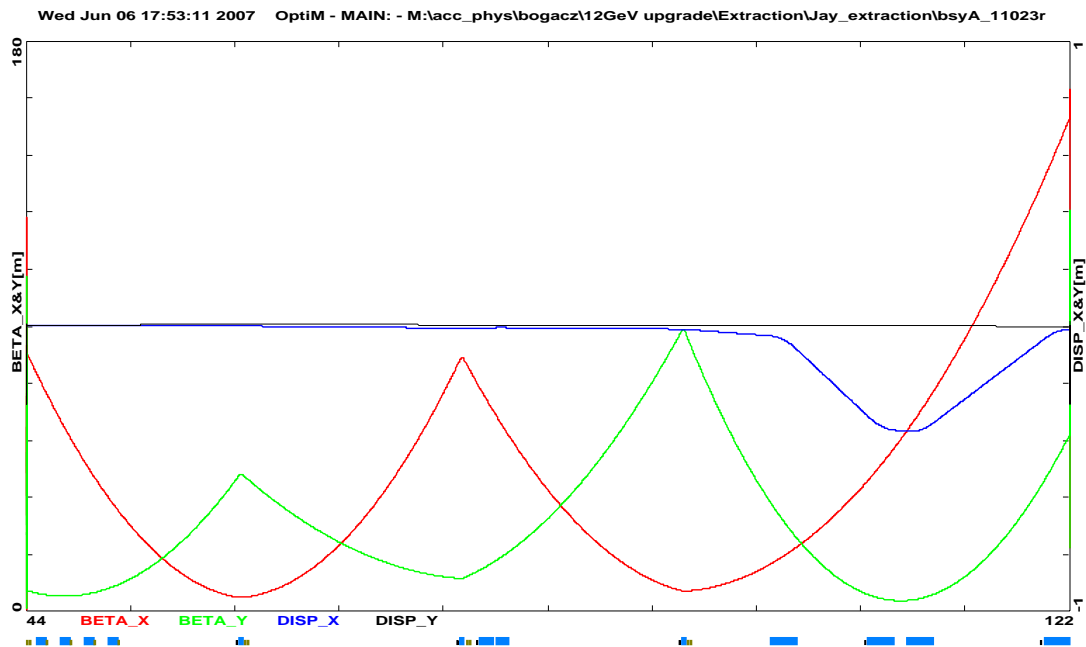


Figure 5ab

Name	L[cm]	B[kG]	G[kG/cm]	angle[Rad]
RRFAT01	70			-3.6E-05
RRFAT02	70			-3.6E-05
RRFAT03	70			-3.6E-05
RRFAT04	70			-3.6E-05
MQCAE01	30		-1.366	-1.2E-04
MQCAE02	30		1.291	4.3E-04
MYAAT01A	100	-0.249		-6.8E-04
MYAAT01B	100	-0.249		-6.8E-04
MQCAE03	30		-1.224	-1.8E-03
MYRAT02	200	-7.460		-4.1E-02
MBPAT03A	200	7.366		4.0E-02
MBPAT03B	200	7.366		4.0E-02
MBPAT04	200	-6.720		-3.7E-02

Table 5