IR Update

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6/2/2017

1. Latest parameters
2. Magnets for No Cool High Divergence

Parameters

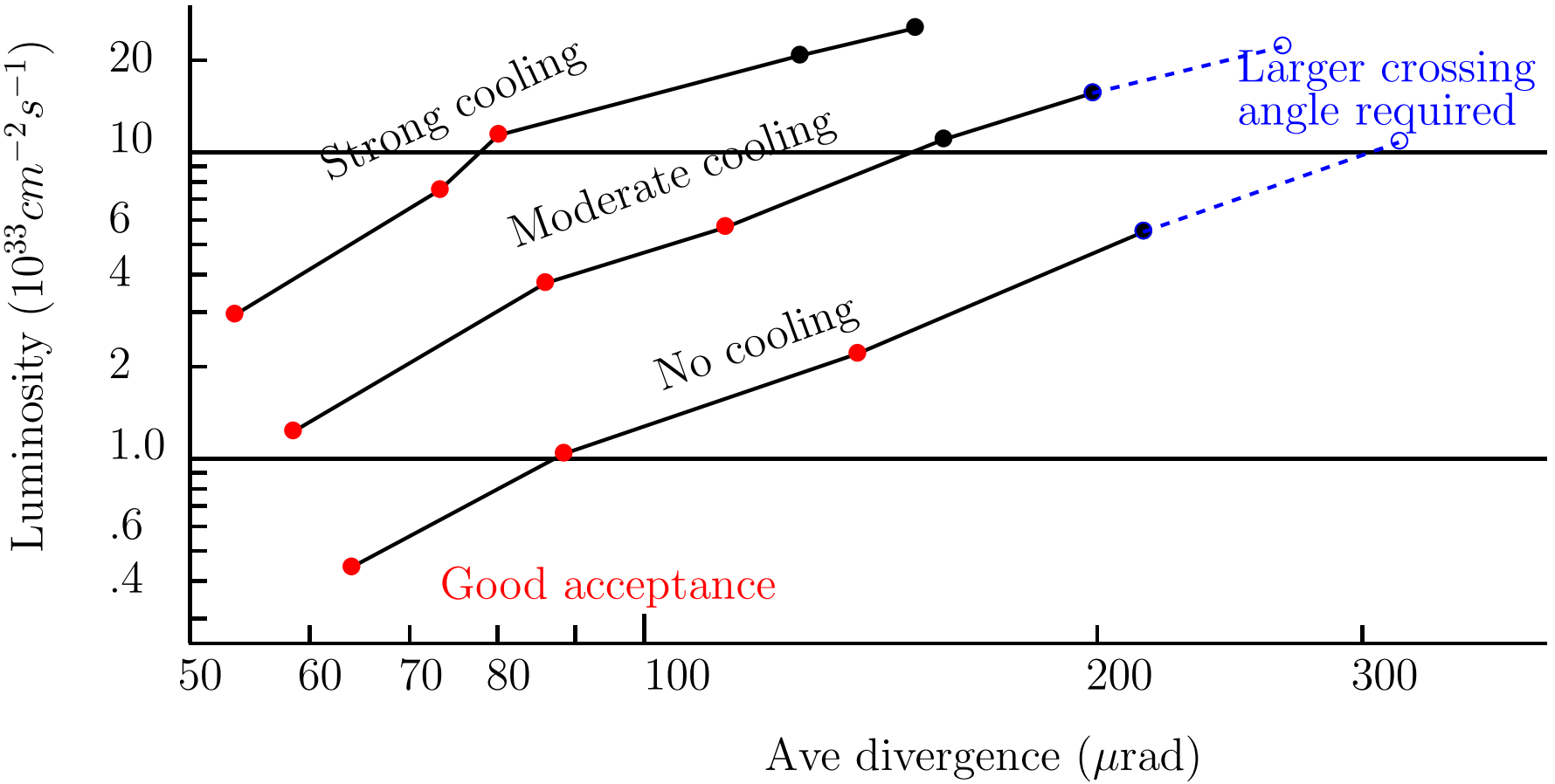
Parameters found for multiple divergence choices assuming 3 cooling assumptions:

1. No Cooling (NC) assuming normalized emittances down to 1.8 μm
2. Moderate cooling (MC) assuming normalized emittances down to 0.4 μ
3. Strong cooling (SC) with normalized emittances down to 0.1 μm

Divergences chosen:

1. With no real limit
2. Only limited by aperture in current IR
3. With hadron x divergence to give good acceptance of forward protons with Pt=200 MeV/c
4. With all divergences lowered to reduce uncertainties in initial state

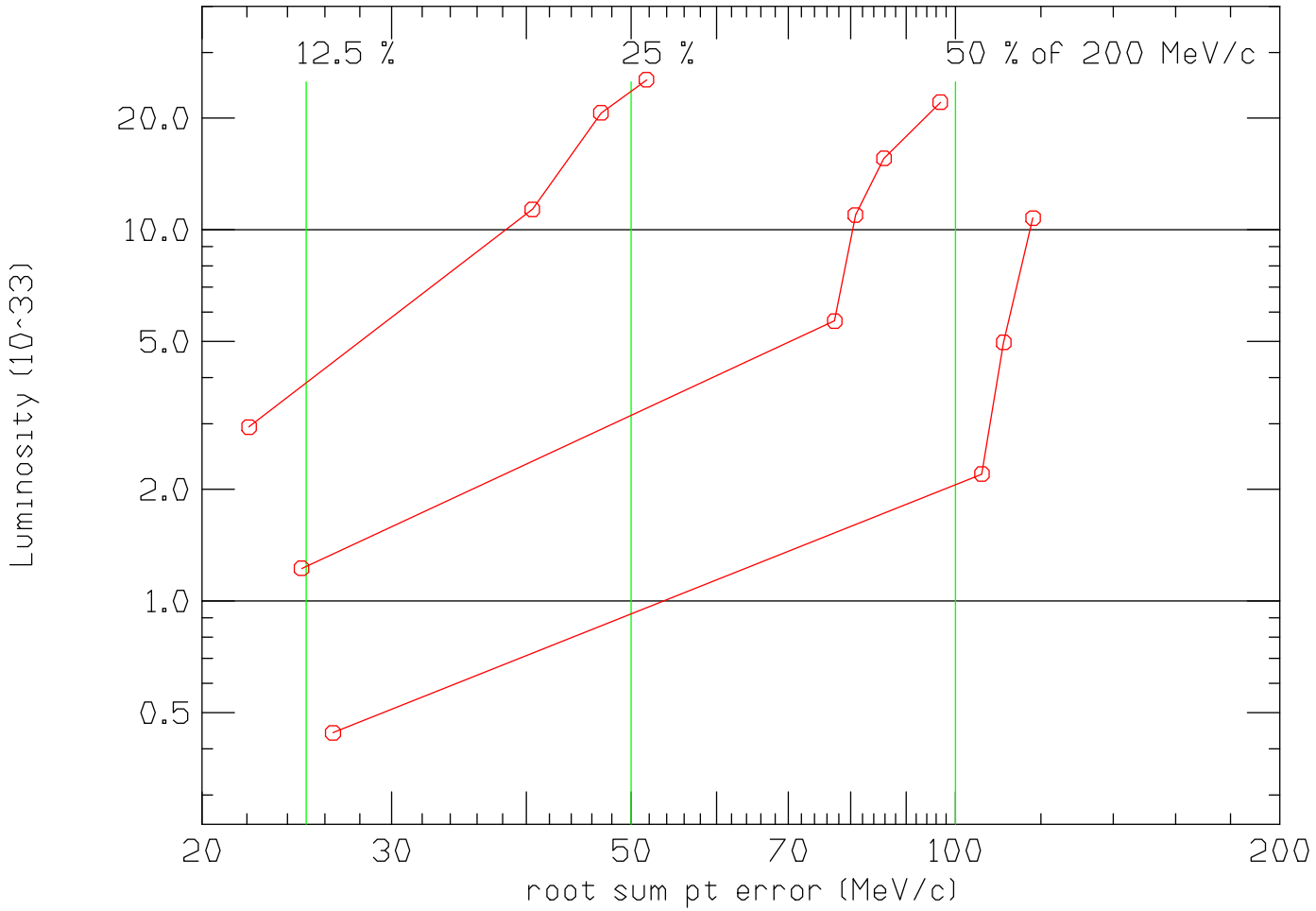
Lum vs. Ave Divergence



For this plot, for comparison, even with No Cooling, beam currents are assumed double those in baseline

All are for com energy 105 GeV (275 GeV p on 10 GeV e)

Luminosities vs $P_\perp$ error



For this plot, for comparison, even with No Cooling, beam currents are assumed double those in baseline

All are for com energy 105 GeV (275 GeV p on 10 GeV e)

New electron horizontal Emittances

- The above calculations used ideal electron emittances chosen by me
- Steve has given me approximate realizable emittances that I have used for what follows
- More accurate values will have to be used later

No Cooling High Divergence

New parameters for No Cooling High Acceptance (NC-HA) and No Cooling High Divergence (NC-HD) solutions using the new electron emittances as given below

Ep GeV	Ee GeV	Ecom GeV	emit$_{xe}$ nm	Lum HA 10^{33}	Lum HD 10^{33}
50	5	32	37.5	.16	.16
100	5	45	37.5	.47	.51
100	10	63	24.7	.64	.78
275	10	105	24.7	1.16	2.37
275	18	140	17.3	.34	.78

The 5 GeV electrons assume a 60 deg advance giving 3 x 16.0 = 48 nm

The 10 GeV electrons assume 60 deg advance giving 3 x 9.0 = 27 nm

The 18 GeV electrons assume 90 deg advance giving = 24.4 nm

High Acceptance Parameters

		E	N	Nb	$\epsilon_x(\epsilon_{Nx})$	$\epsilon_y(\epsilon_{Ny})$	β_x	β_y	σ_x	σ_y	σ'_x	σ'_y	ξ_x	ξ_y	ΔQ	σ_s	I	SR	HG	lum
		GeV	10^{10}		nm(μm)	nm(μm)	cm	cm	μm	μm	μrad	μrad				cm	A	MW	%	10^{33}
1	com	31.6																		
	p	50	10.7	330	111.1(5.9)	33.8(1.8)	130.0	22.0	380	86.2	292	392	.010	.008	.022	17.8	0.44		75	0.16
	e	5.0	31.1	330	48.0(470)	9.20(90)	301.0	80.9	380	86.3	126	107	.083	.098	.000	1.0	1.28	0.3		
2	com	44.7																		
	p	100	11.6	330	55.6(5.9)	16.9(1.8)	151.6	10.6	290	42.3	191	399	.011	.005	.008	13.2	0.48		78	0.47
	e	5.0	31.1	330	48.0(470)	7.58(74)	176.3	23.9	291	42.6	165	178	.097	.090	.000	1.0	1.28	0.3		
3	com	63.2																		
	p	100	12.8	330	39.1(4.2)	16.9(1.8)	119.7	11.6	216	44.2	181	382	.015	.007	.009	13.2	0.53		76	0.64
	e	10.0	30.5	330	27.0(528)	5.97(117)	172.5	32.7	216	44.2	125	135	.090	.083	.000	1.0	1.26	4.8		
4	com	104.9																		
	p	275	12.2	330	18.0(5.3)	6.1(1.8)	631.9	4.2	337	16.0	53	381	.013	.002	.002	8.0	0.50		83	1.16
	e	10.0	29.9	330	27.0(528)	3.47(68)	418.4	7.4	336	16.0	80	217	.099	.037	.000	1.0	1.23	4.7		
5	com	139.9																		
	p	275	15.0	330	16.1(4.7)	6.1(1.8)	566.4	4.2	302	16.0	53	381	.003	.000	.003	7.0	0.62		86	0.34
	e	17.8	6.2	330	24.2(843)	3.46(121)	375.0	7.4	301	16.0	80	216	.076	.028	.000	1.0	0.26	9.8		

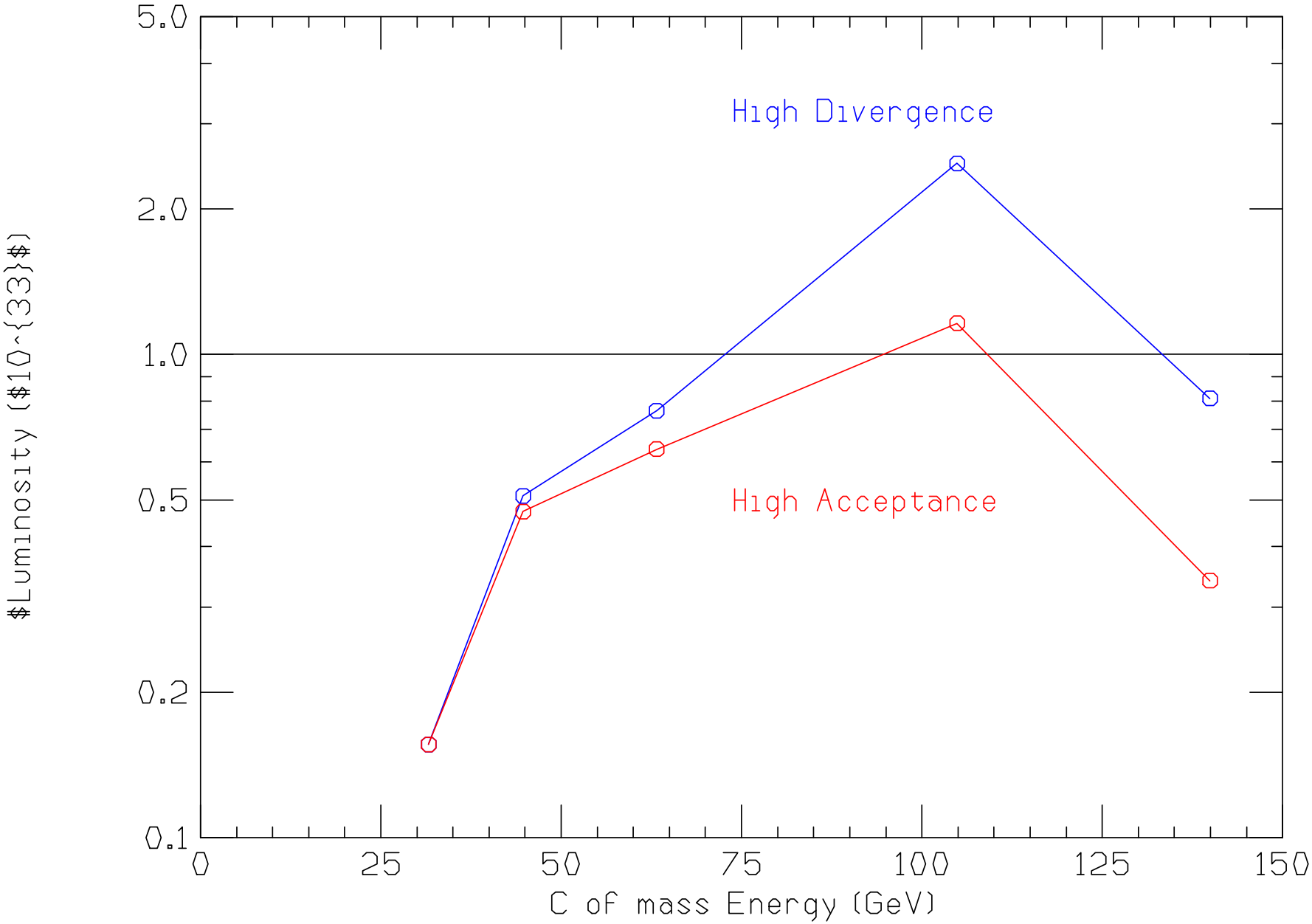
	γ	N_b	freq	Volts	ϵ_{xN}	ϵ_{yN}	σ_z	dp/p	evsec	N_p	$\tau_\parallel$	$\tau_\perp$	Q_{100m}	β^4_{crab}	f_{crab}	V^5_{crab}	HG	Lum	eff	lum*eff
			MHz	MV	μm	μm	cm	10^{-4}	eV sec	10^{11}	hr.	hr.	nC	m	MHz	MV	%	10^{33}	%	10^{33}
1	53	330	394	2.11	5.92	1.80	17.8	14.00	0.80	1.1	16.5	24.4	4.7[1]	225	336	4.57	75	0.16	69[4]	0.11
2	107	330	394	4.18	5.92	1.80	13.2	9.50	0.80	1.2	11.8	18.6	28[2]	450	336	5.98	78	0.47	66[4]	0.31
3	107	330	394	4.18	4.16	1.80	13.2	9.50	0.80	1.3	8.7	11.5	24[2]	640	336	5.65	76	0.64	60[4]	0.38
4	293	330	394	15.20	5.26	1.79	8.0	6.50	0.92	1.2	10.9	12.3	196[3]	1392	336	4.58	83	1.16	62	0.72
5	293	330	394	19.86	4.72	1.79	7.0	6.50	0.80	1.5	7.3	7.7	224[3]	1553	336	4.58	86	0.34	55	0.19

High Divergence Parameters

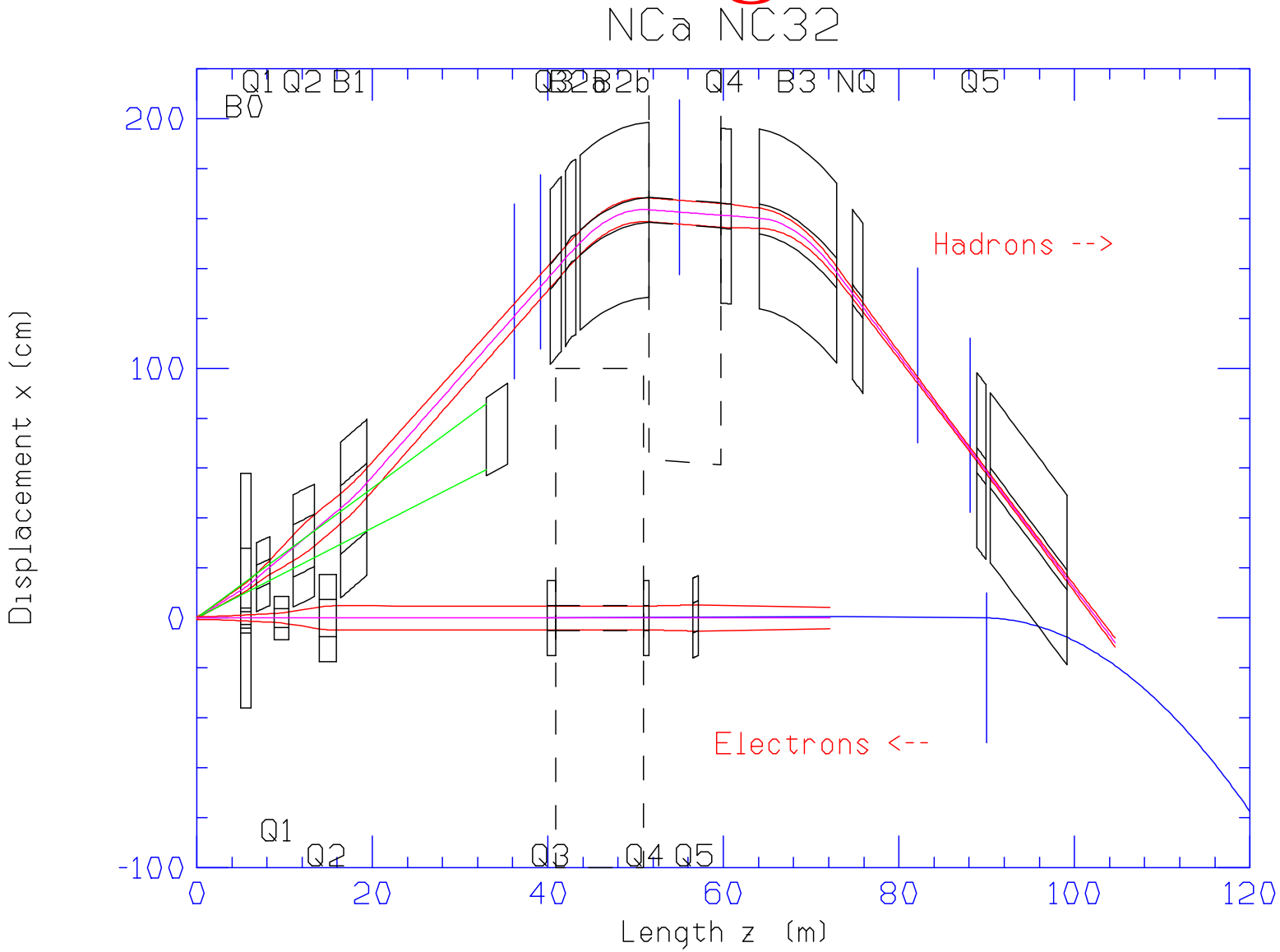
		E	N	Nb	$\epsilon_x(\epsilon_{Nx})$	$\epsilon_y(\epsilon_{Ny})$	β_x	β_y	σ_x	σ_y	σ'_x	σ'_y	ξ_x	ξ_y	ΔQ	σ_s	I	SR	HG	lum
		GeV	10^{10}		nm(μm)	nm(μm)	cm	cm	μm	μm	μrad	μrad				cm	A	MW	%	10^{33}
1	com	31.6																		
	p	50	10.7	330	111.1(5.9)	33.8(1.8)	130.0	22.0	380	86.2	292	392	.010	.008	.022	17.8	0.44		75	0.16
	e	5.0	31.1	330	48.0(470)	9.20(90)	301.0	80.9	380	86.3	126	107	.083	.098	.000	1.0	1.28	0.3		
2	com	44.7																		
	p	100	10.9	330	55.6(5.9)	16.9(1.8)	107.2	10.6	244	42.3	228	399	.011	.006	.008	13.2	0.45		76	0.51
	e	5.0	31.1	330	48.0(470)	7.58(74)	124.5	23.9	245	42.6	196	178	.088	.097	.000	1.0	1.28	0.3		
3	com	63.2																		
	p	100	12.8	330	39.1(4.2)	16.9(1.8)	79.8	11.6	177	44.2	221	382	.015	.008	.009	13.2	0.53		73	0.76
	e	10.0	31.1	330	27.0(528)	5.97(117)	115.0	32.7	176	44.2	153	135	.087	.098	.000	1.0	1.28	4.9		
4	com	104.9																		
	p	275	11.1	330	18.0(5.3)	6.1(1.8)	105.3	4.2	138	16.0	131	381	.013	.004	.002	8.0	0.46		79	2.48
	e	10.0	30.5	330	27.0(528)	3.47(68)	69.7	7.4	137	16.0	197	217	.084	.076	.000	1.0	1.26	4.8		
5	com	139.9																		
	p	275	15.0	330	16.1(4.7)	6.1(1.8)	94.4	4.2	123	16.0	131	381	.003	.001	.003	7.0	0.62		82	0.81
	e	17.8	6.3	330	24.2(843)	3.46(121)	62.5	7.4	123	16.0	197	216	.071	.064	.000	1.0	0.26	10.0		

	γ	N_b	freq	Volts	ϵ_{xN}	ϵ_{yN}	σ_z	dp/p	evsec	N_p	$\tau_\parallel$	$\tau_\perp$	Q_{100m}	β^4_{crab}	f_{crab}	V^5_{crab}	HG	Lum	eff	lum*eff
			MHz	MV	μm	μm	cm	10^{-4}	eV sec	10^{11}	hr.	hr.	nC	m	MHz	MV	%	10^{33}	%	10^{33}
1	53	330	394	2.11	5.92	1.80	17.8	14.00	0.80	1.1	16.5	24.4	4.7[1]	225	336	4.57	75	0.16	69[4]	0.11
2	107	330	394	4.18	5.92	1.80	13.2	9.50	0.80	1.1	12.6	20.0	26[2]	450	336	7.12	76	0.51	67[4]	0.34
3	107	330	394	4.18	4.16	1.80	13.2	9.50	0.80	1.3	8.7	11.5	24[2]	640	336	6.92	73	0.76	60[4]	0.46
4	293	330	394	15.20	5.26	1.79	8.0	6.50	0.92	1.1	12.0	13.5	178[3]	1392	336	11.23	79	2.48	63	1.57
5	293	330	394	19.86	4.72	1.79	7.0	6.50	0.80	1.5	7.3	7.7	224[3]	1553	336	11.23	82	0.81	55	0.45

Luminosity vs. Energy



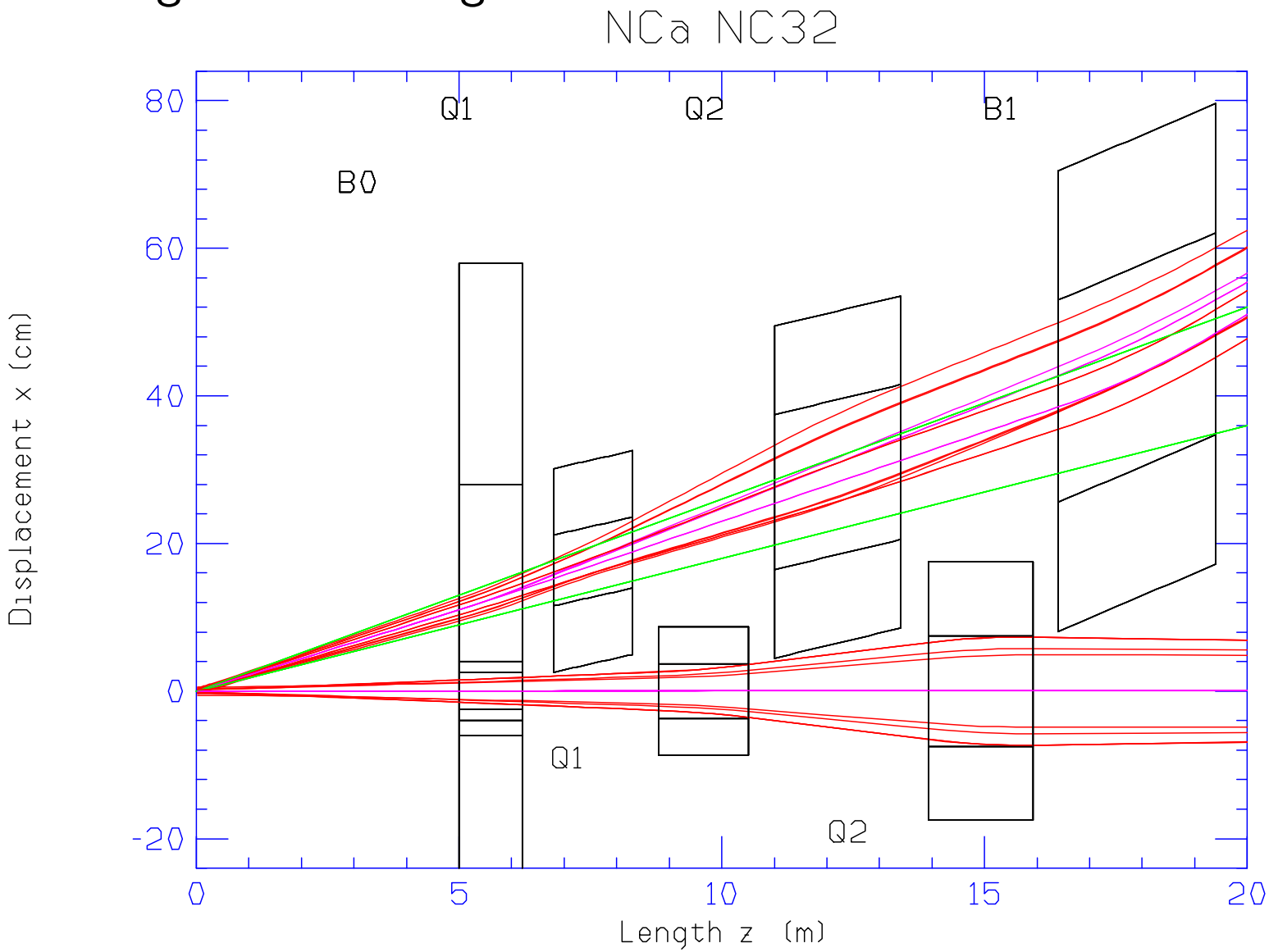
IR Forward Magnets



Dashes indicate space for Crab Cavities

Forward Magnets Detail

Showing 10 and 15 sigma of beams for all 5 cases



Forward Proton Magnets

and fields for Ecom=105 GeV - fields for other cases below

Protons mom=275 GeV/c

		L1	DL	gap	x	θ	IR	OR	B	Grad)
		m	m	m	cm	mrad	cm	cm	T	T/m
B0	3	5.00	1.20	0.60	11.0	0.00	17.00	47.0	1.70	0.00
Q1	5	6.80	1.50	2.70	16.4	16.00	4.80	13.8	6.69	-139.35
Q2	7	11.00	2.40	3.00	26.9	17.00	10.50	22.5	4.62	44.02
B1	9	16.40	3.00	20.90	39.3	30.39	13.70	31.2	5.50	0.00
Q3	11	40.30	1.20	0.50	136.6	42.22	5.00	35.0	0.57	11.46
B2a	13	42.00	1.20	0.50	143.8	39.21	5.10	35.1	-3.02	0.00
B2b	15	43.70	7.80	8.20	150.3	16.71	5.00	35.0	-4.58	0.00
Q4	17	59.70	1.20	3.20	161.1	-2.79	5.00	35.0	1.78	35.65
B3	19	64.10	8.80	1.80	159.9	-24.79	6.00	36.0	-4.58	0.00
NQ	21	74.70	1.20	13.00	129.6	-46.77	4.00	34.0	2.93	-73.33
Q5	23	88.90	1.00	0.50	63.2	-46.78	5.00	35.0	2.75	55.00
H1	25	90.40	8.75	5.50	56.2	-46.78	4.00	34.0	0.00	0.00

forward protons

E_{com}	P_p	B0	Q1		Q2		B1	Q3		B2a	B2b	Q4		B3	NQ		Q5	
		B	B	grad	B	grad	B	B	grad	B	B	B	grad	B	B	grad	B	grad
GeV	GeV/c	T	T	T/m	T	T/m	T	T	T/m	T	T	T	T/m	T	T	T/m	T	T/m
NC32	50	1.0000	1.2944	-26.9676	1.1363	10.8218	0.5833	0.0694	-1.3889	-0.4667	-0.8333	0.2894	5.7870	-0.8333	0.2667	-6.6667	0.5000	10.0000
NC45	100	1.7000	2.5778	-53.7037	2.1632	20.6018	1.3533	0.0231	-0.4630	-1.1000	-1.6667	0.5787	11.5741	-1.6667	0.5333	-13.3333	1.0000	20.0000
NC63	100	1.7000	2.5778	-53.7037	2.1632	20.6018	1.3533	0.0231	-0.4630	-1.1000	-1.6667	0.5787	11.5741	-1.6667	0.5333	-13.3333	1.0000	20.0000
NC105	275	1.6958	6.6886	-139.3460	4.6220	44.0191	5.5000	0.5729	11.4583	-4.5833	-4.5833	1.7824	35.6481	-4.5833	2.9333	-73.3333	2.7500	55.0000
NC140	275	1.6958	6.6886	-139.3460	4.6220	44.0191	5.5000	0.5729	11.4583	-4.5833	-4.5833	1.7824	35.6481	-4.5833	2.9333	-73.3333	2.7500	55.0000

Forward Electron Magnets

and fields for Ecom=105 GeV - fields for other cases below

		L1	DL	gap	x	θ	IR	OR	B	Grad)
		m	m	m	cm	mrad	cm	cm	T	T/m
Q1	3	8.79	1.72	3.42	19.3	0.00	3.70	8.7	0.14	-3.70
Q2	5	13.93	2.00	24.00	30.6	0.00	7.50	17.5	0.17	2.23
Q3	7	39.93	1.00	10.00	87.8	0.00	5.00	15.0	0.03	-0.51
Q4	9	50.93	0.60	5.00	112.0	0.00	5.00	15.0	0.05	-1.07
Q5	11	56.53	0.60	15.00	124.4	16.20	6.00	16.0	0.10	1.71

Forward electrons

E_{com}	P_e	Q1		Q2		Q3		Q4		Q5	
		B	grad	B	grad	B	grad	B	grad	B	grad
GeV	GeV/c	T	T/m	T	T/m	T	T/m	T	T/m	T	T/m
NC32	5	0.0685	-1.8506	0.0766	1.0208	0.0011	-0.0214	0.0268	-0.5350	0.0514	0.8561
NC45	5	0.0685	-1.8506	0.0858	1.1443	0.0185	-0.3692	0.0268	-0.5350	0.0514	0.8561
NC63	10	0.1369	-3.7012	0.1620	2.1603	0.0150	-0.2996	0.0535	-1.0701	0.1027	1.7121
NC105	10	0.1369	-3.7012	0.1713	2.2838	0.0364	-0.7277	0.0535	-1.0701	0.1027	1.7121
NC140	18	0.2465	-6.6622	0.3089	4.1193	0.0636	-1.2713	0.0963	-1.9262	0.1849	3.0819

Discussion

L1 is the distance from IP to the start of the magnets, DL is the magnet length, the gap follows that magnet. There are no combined function magnets. When the gradient is zero, the B indicates its field. If not, B indicates the nominal pole tip field (grad times IR).

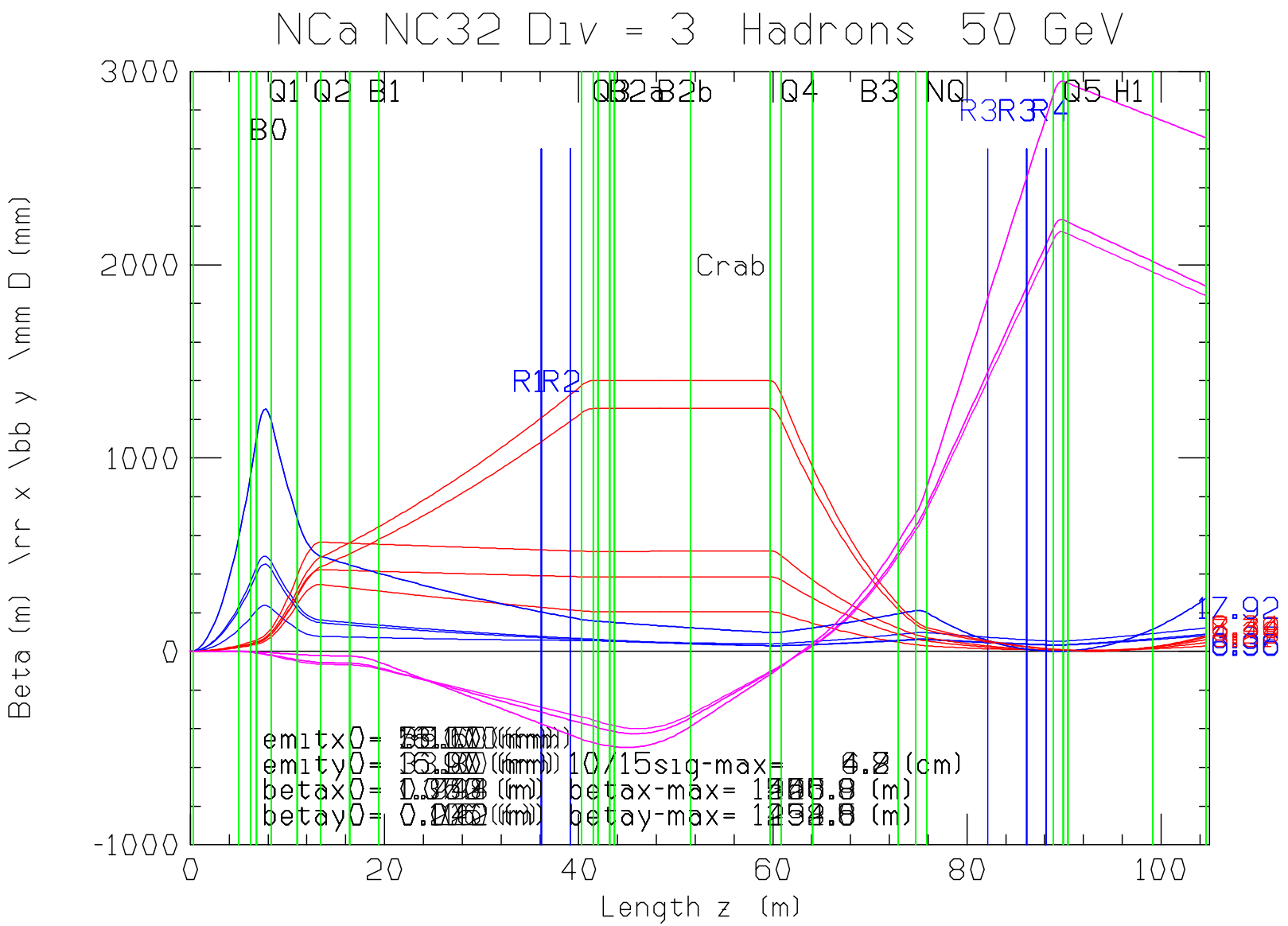
The horizontal displacements x and the angles θ are with respect to the electron direction at the IP.

Magnet locations are fixed independent of beam momenta or settings. For proton magnets Q3 and beyond, the beam center should follow the magnet centres and angles θ, but for the earlier proton magnets this is sometimes far from true.

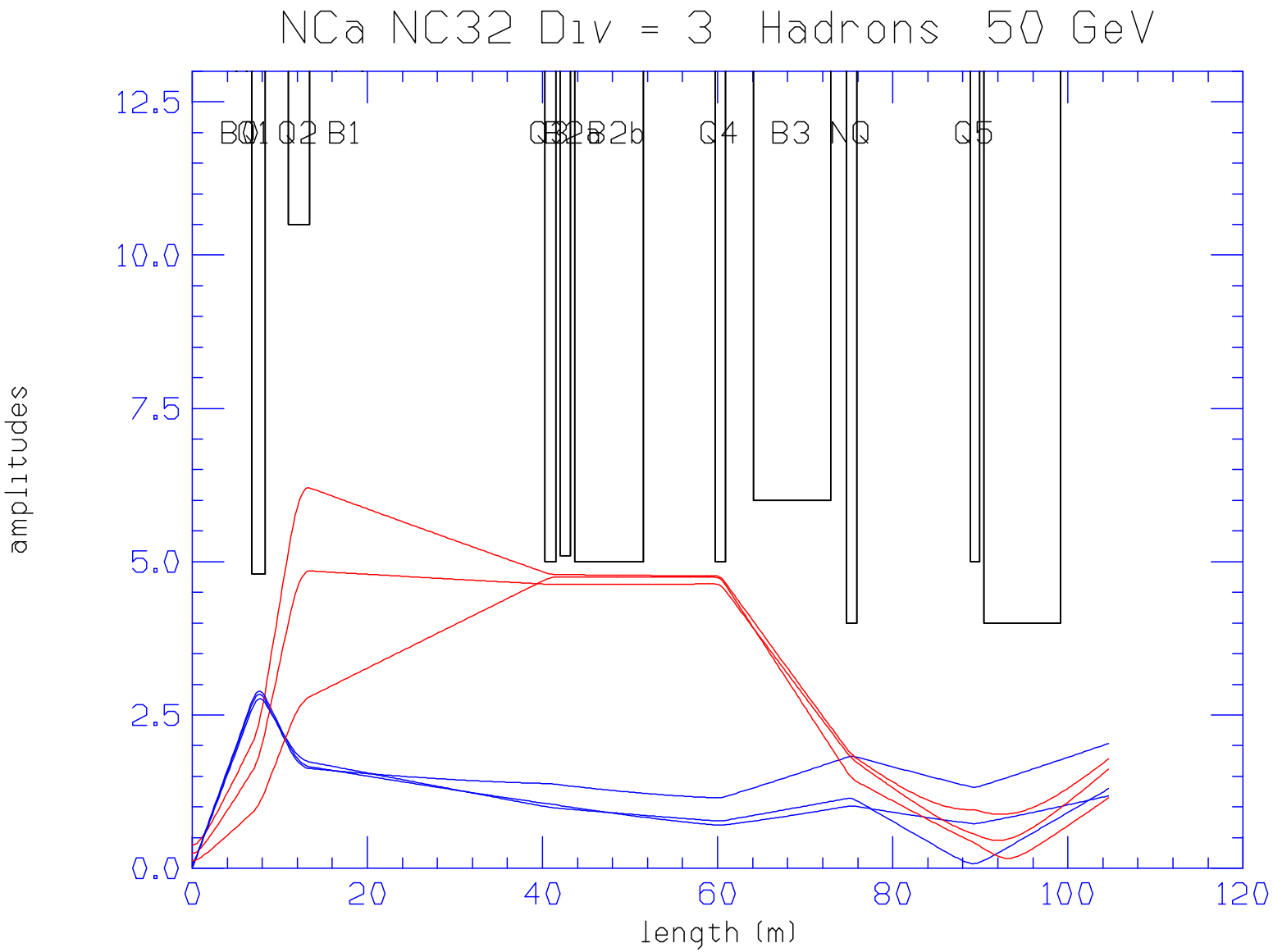
Protons are moving left to right. Electrons right to left.

Gradients and fields in the above tables are for 275 GeV p on 10 GeV e.

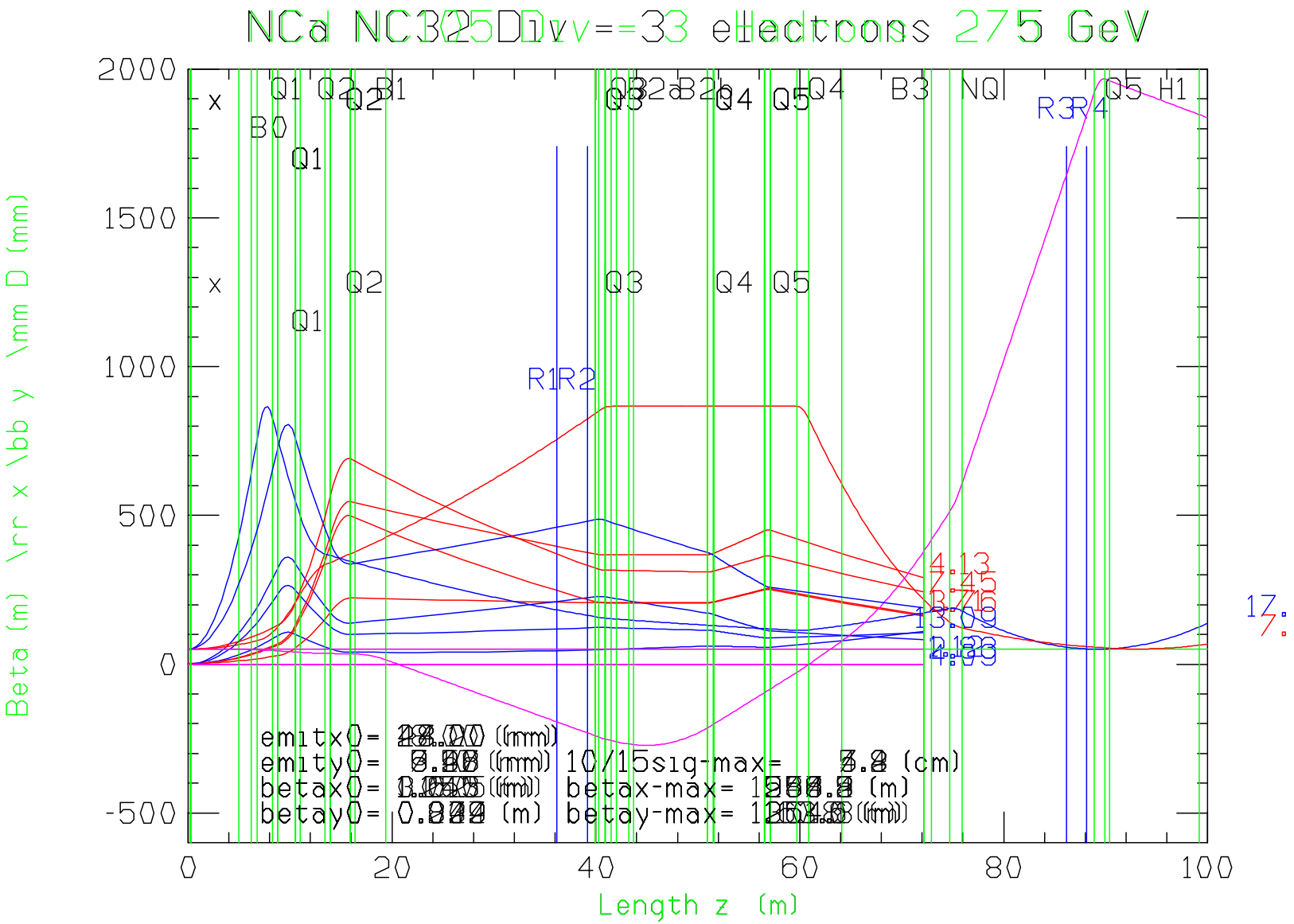
Forward hadron betas



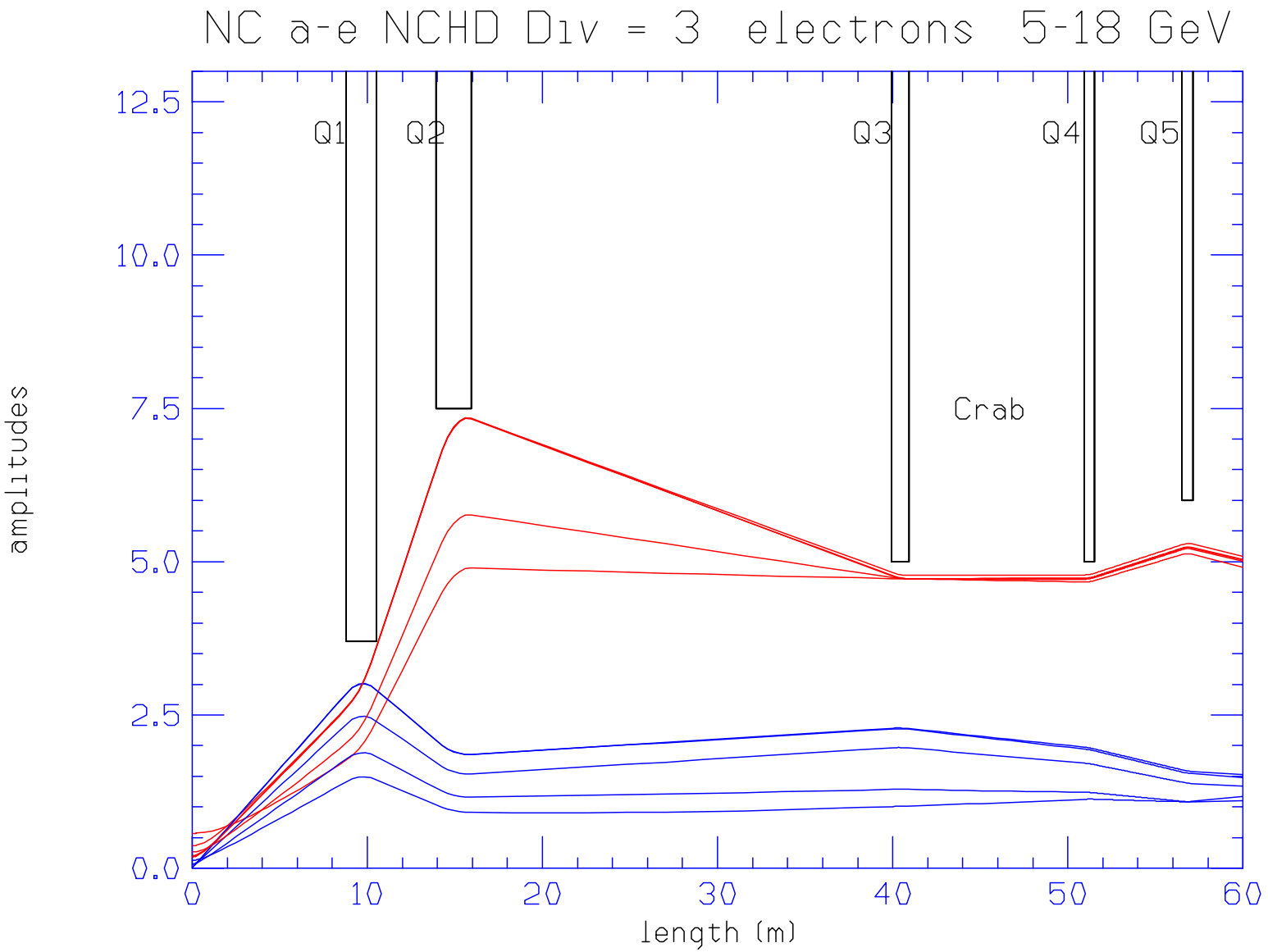
Forward hadron beam sizes



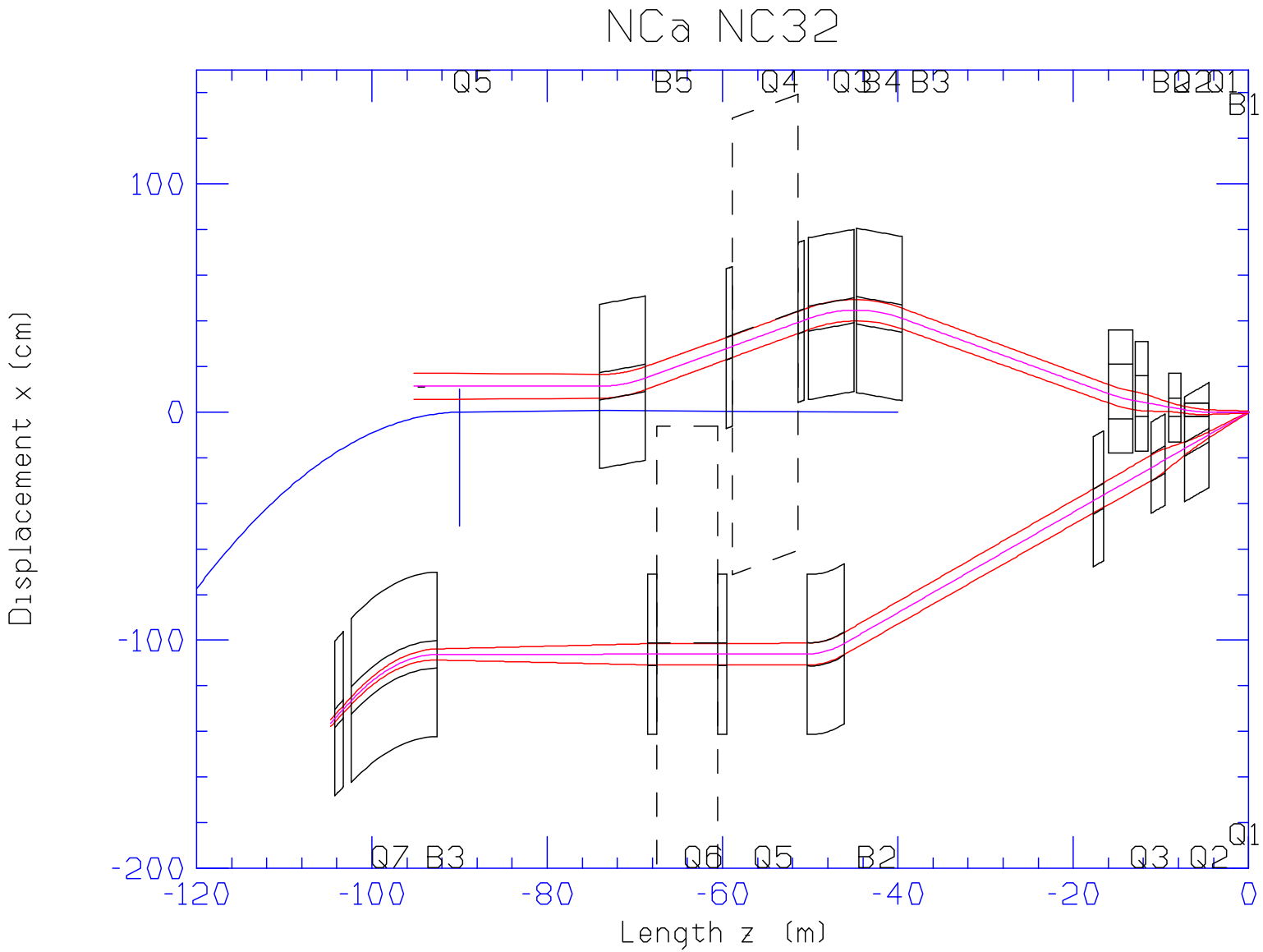
Forward electron betas



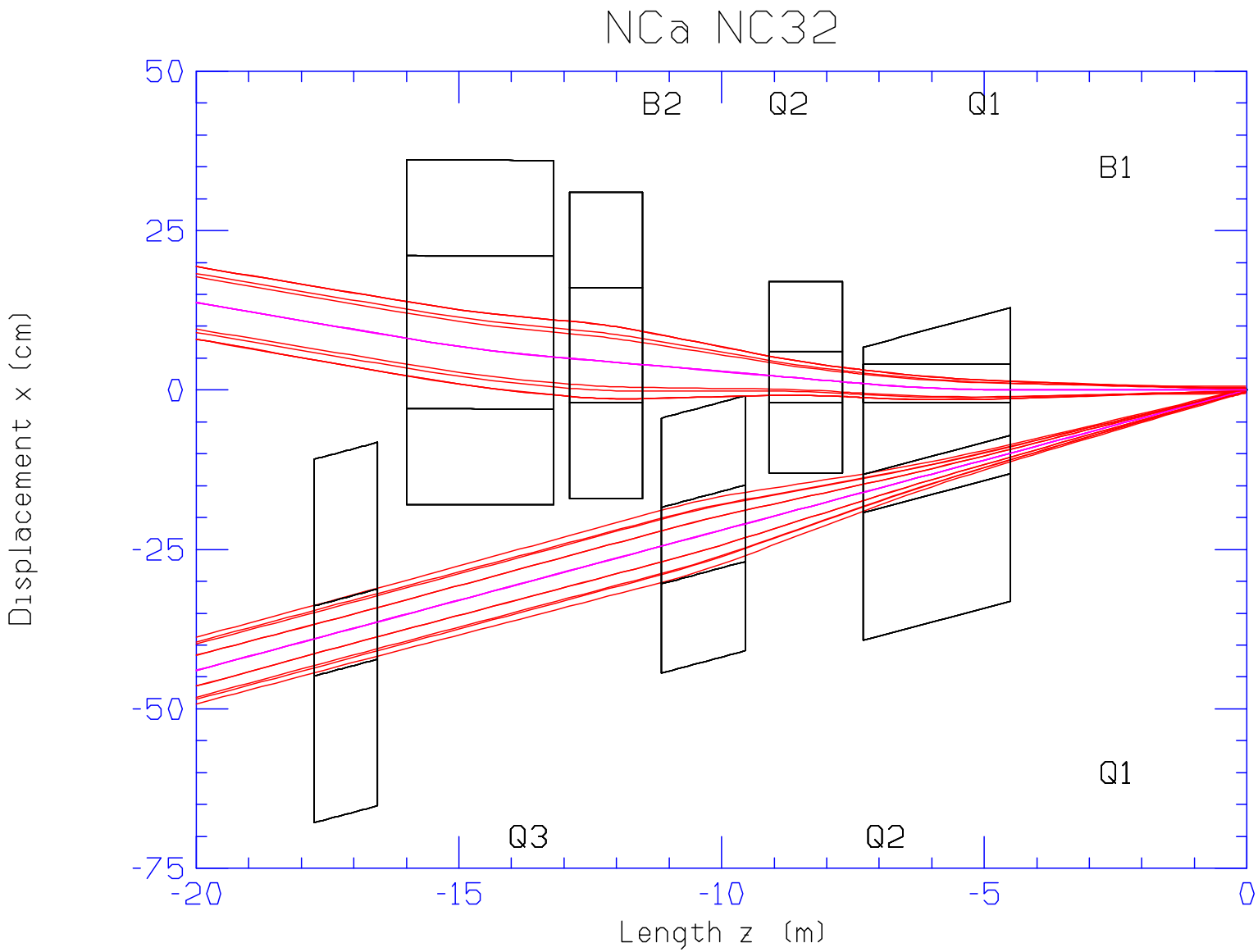
Forward electron beam sizes



Rear Magnets



Rear Detail


NCa NC32
B2
Q2
Q1
B1
Q1
Q3
Q2
50
25
0
-25
-50
-75
-20
-15
-10
-5
0
Displacement x (cm)
Length z (m)

Rear Proton Magnets

Protons mom = 275 GeV/c

		L1	DL	gap	x	θ	IR	OR	B	Grad)
		m	m	m	cm	mrad	cm	cm	T	T/m
Q1	3	4.50	2.80	2.25	-10.1	-22.00	3.00	23.0	2.89	-96.25
Q2	5	9.55	1.60	2.20	-20.9	-22.00	6.00	20.0	6.11	101.75
Q3	9	16.55	1.20	21.90	-36.7	-22.00	5.50	28.5	1.59	-28.88
B2	13	46.15	4.19	9.20	-101.5	-11.00	5.10	35.1	4.81	0.00
Q5	15	59.54	1.00	7.00	-106.1	-0.03	5.00	35.0	0.55	11.09
Q6	17	67.54	1.00	24.00	-106.2	-0.03	5.00	35.0	0.92	18.33
B3	19	92.54	9.80	0.90	-106.2	-20.62	6.00	36.0	-3.85	0.00
Q7	21	103.24	1.00	0.50	-130.2	-41.18	4.00	34.0	0.73	-18.33

rear protons

E_{com}	P_p	Q1		Q2		Q3		B2	Q5		Q6		B3	Q7	
		B	grad	B	grad	B	grad	B	B	grad	B	grad	B	B	grad
GeV	GeV/c	B	T/m	B	T/m	B	T/m	B	B	T/m	B	T/m	B	B	T/m
32	50	0.5500	-18.3333	1.1100	18.5000	0.0642	-1.1667	0.8740	0.0167	-0.3333	0.1667	3.3333	-0.7000	0.1333	-3.3333
45	100	1.1000	-36.6667	2.0400	34.0000	0.0275	0.5000	1.7480	0.0167	0.3333	0.3333	6.6667	-1.4000	0.2667	-6.6667
63	100	1.1000	-36.6667	2.1400	35.6667	0.1283	-2.3333	1.7480	0.0550	1.1000	0.3333	6.6667	-1.4000	0.2667	-6.6667
105	275	2.8875	-96.2500	6.1050	101.7500	1.5881	-28.8750	4.8070	0.5546	11.0917	0.9167	18.3333	-3.8500	0.7333	-18.3333
140	275	2.8875	-96.2500	6.1050	101.7500	1.5881	-28.8750	4.8070	0.5546	11.0917	0.9167	18.3333	-3.8500	0.7333	-18.3333

Rear Electron Magnets

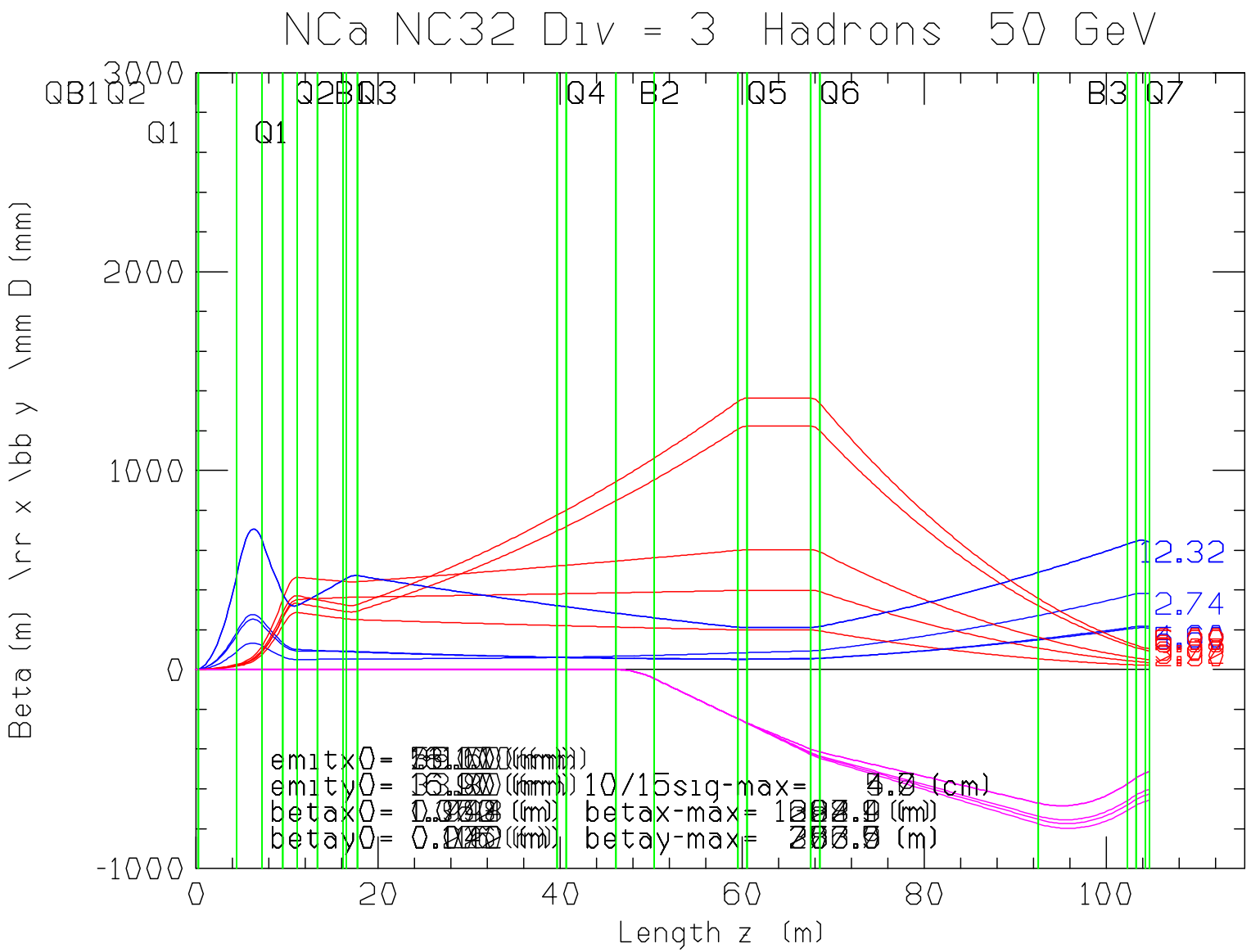
mom = 10 GeV/c

		L1	DL	gap	x	θ	IR	OR	B	Grad)
		m	m	m	cm	mrad	cm	cm	T	T/m
B1	3	4.50	2.80	0.40	10.9	0.00	3.00	3.0	0.01	0.00
Q1	5	7.70	1.40	2.40	18.9	0.00	4.00	15.0	0.22	-5.53
Q2	7	11.50	1.40	0.30	32.3	0.00	9.00	24.0	0.35	3.90
B2	9	13.20	2.80	23.50	38.0	0.20	12.00	27.0	0.01	0.00
B3	11	39.50	5.20	0.30	127.9	6.97	6.00	36.0	-0.01	0.00
B4	13	45.00	5.20	0.50	143.6	-7.00	5.50	35.5	-0.01	0.00
Q3	15	50.70	0.70	7.50	151.8	-13.99	5.00	35.0	0.01	-0.27
Q4	17	58.90	0.70	9.20	158.3	-13.99	5.00	35.0	0.01	-0.27
B5	19	68.80	5.20	20.00	166.3	-6.99	6.00	36.0	0.01	0.00
Q5	21	94.00	0.70	0.50	218.1	0.00	0.00	0.0	0.00	-0.03

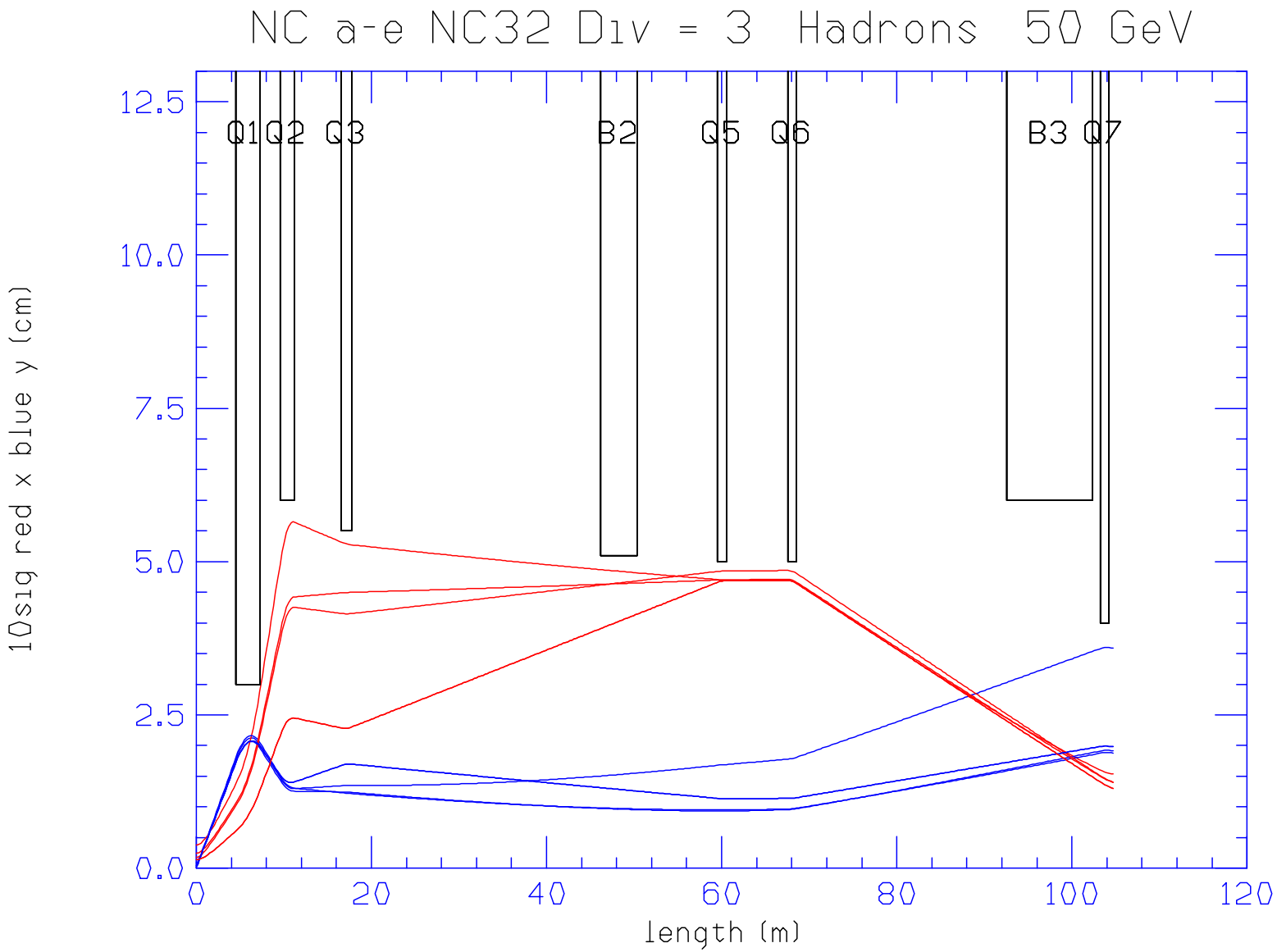
rear electrons

E_{com}	P_e	B1	Q1		Q2		B2	B3	B4	Q3		Q4		B5
		B	B	grad	B	grad	B	B	B	B	grad	B	grad	B
GeV	GeV/c	T	B	T/m	B	T/m	B	T	T	B	T/m	B	T/m	T
32	5	0.0030	0.1107	-2.7667	0.1620	1.8000	0.0030	-0.0032	-0.0032	0.0067	0.1333	0.0067	-0.1333	0.0032
45	5	0.0030	0.1107	-2.7667	0.1755	1.9500	0.0030	-0.0032	-0.0032	0.0067	-0.1333	0.0067	-0.1333	0.0032
63	10	0.0060	0.2213	-5.5333	0.3390	3.7667	0.0060	-0.0065	-0.0065	0.0008	0.0167	0.0133	-0.2667	0.0065
105	10	0.0060	0.2213	-5.5333	0.3510	3.9000	0.0060	-0.0065	-0.0065	0.0133	-0.2667	0.0133	-0.2667	0.0065
140	18	0.0108	0.3984	-9.9600	0.6318	7.0200	0.0108	-0.0116	-0.0116	0.0240	-0.4800	0.0240	-0.4800	0.0116

Rear Protons Betas

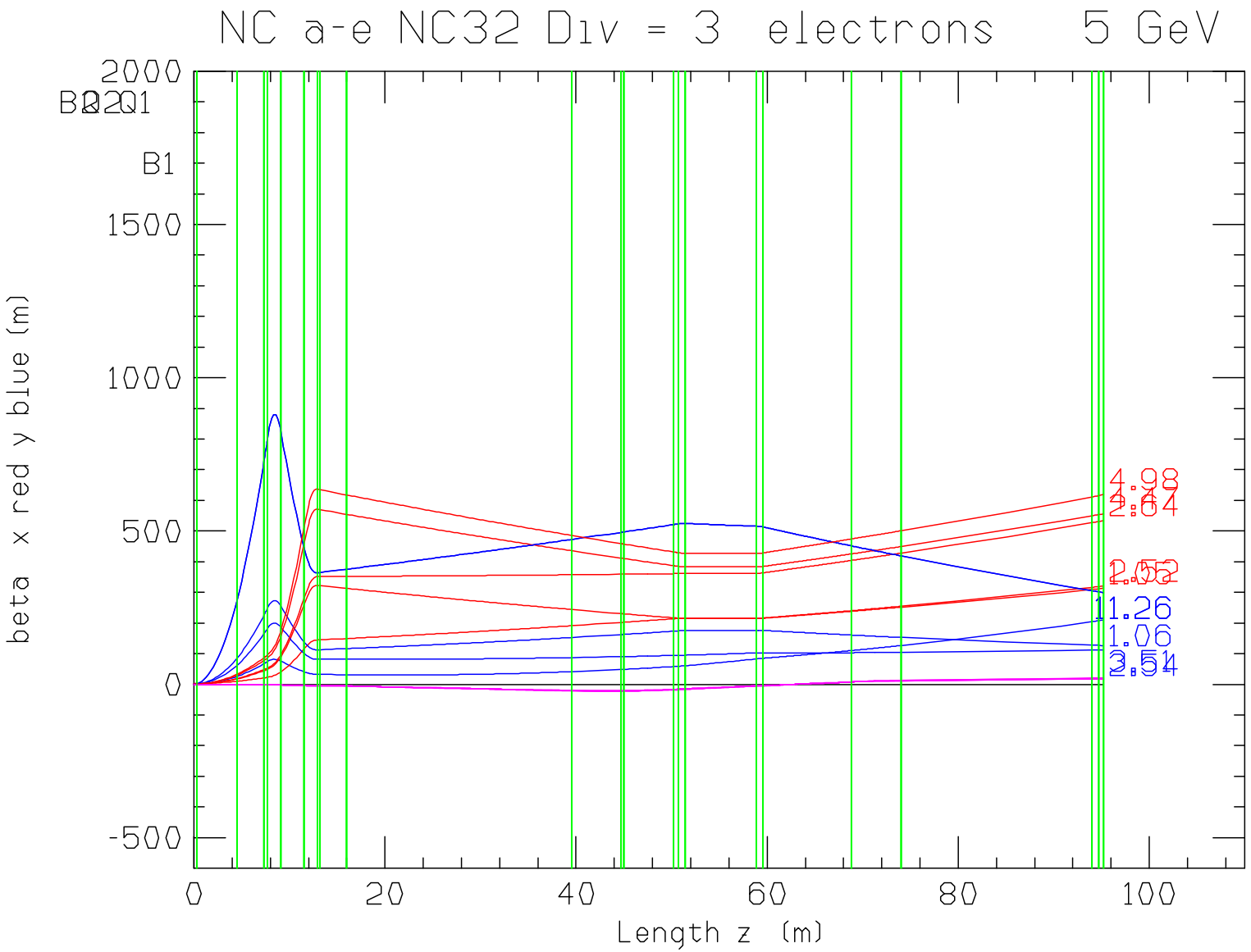


Rear proton beam sizes (all)

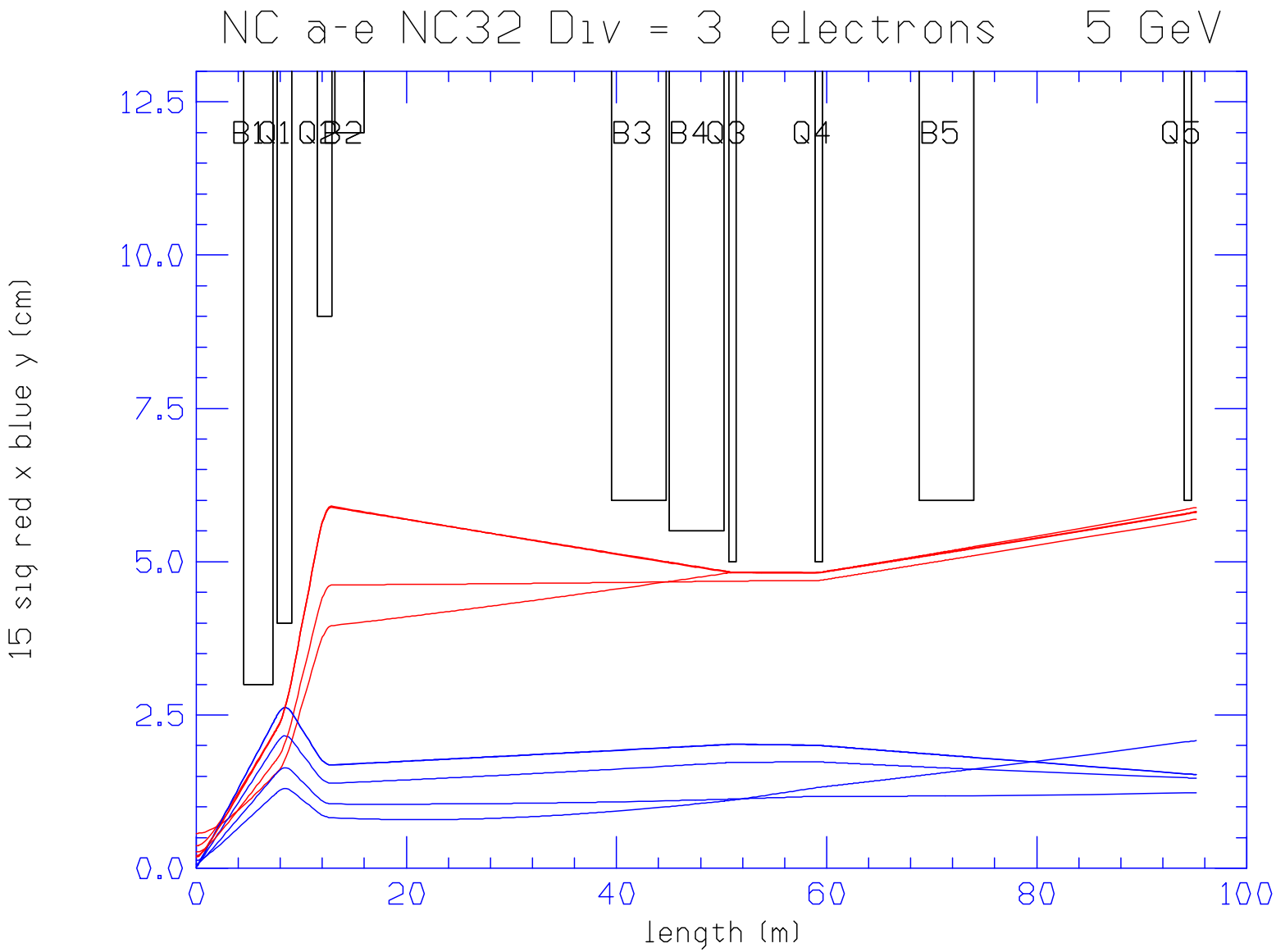


Beam size at crab cavity between Q5 abd Q6 is set just below 5 cm for all cases.

Rear electrons betas



Rear electrons beam sizes



To Be Done

- Find my errors
- Clean up the figures
- Re do the work on 105 GeV luminosities vs. divergence using the new electron emittances
- Do cases for HA and HD with moderate and strong cooling
- Write this all up
- Re-visit use of Roman Pot data