

# Beam sizes in crab cavities

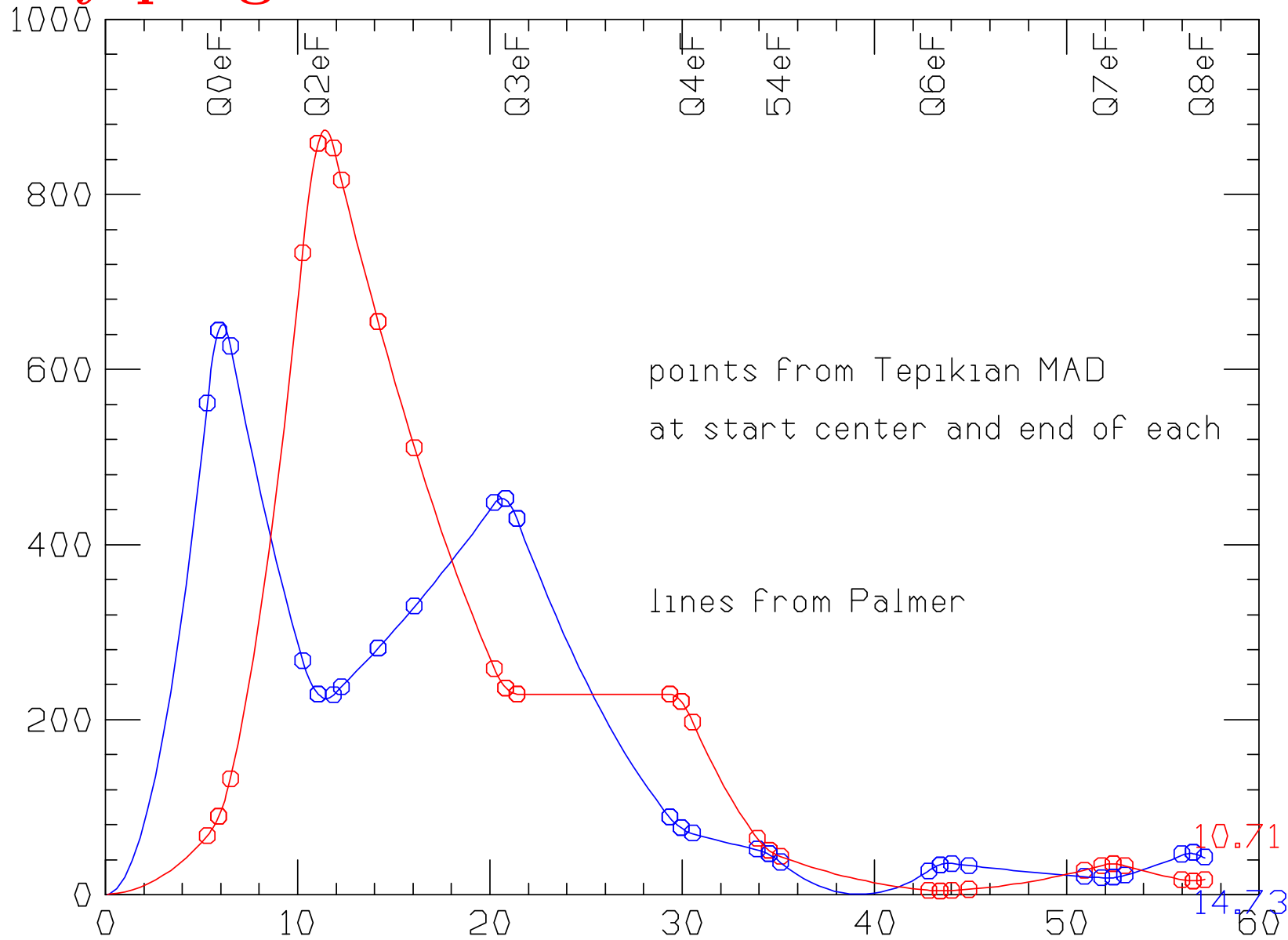
At IR meeting

9/20/19

Bob Palmer

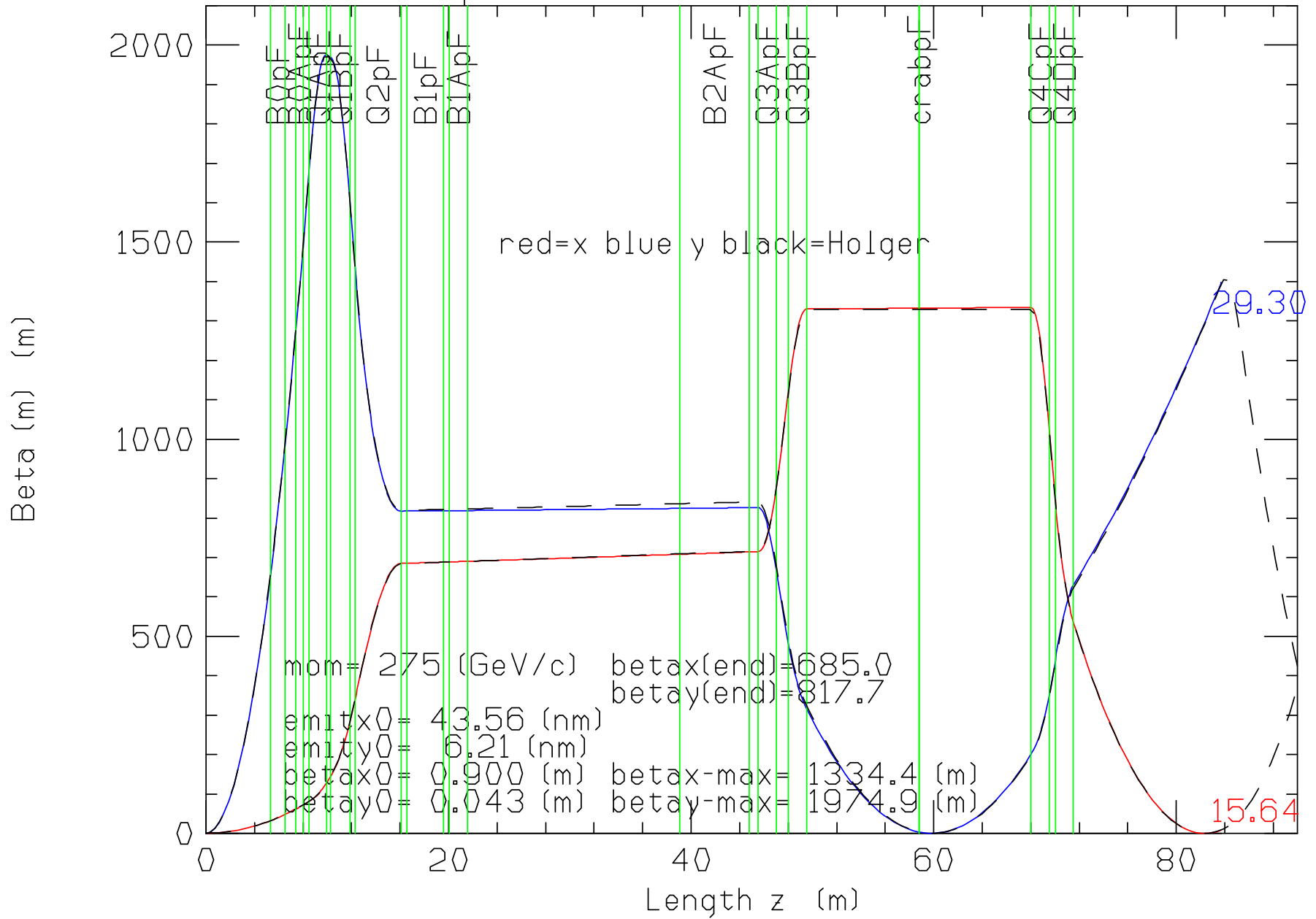
- Comparisons of my and MAD/BMAD simulations
- Beam sizes in proton crabs
- Still working on layout, but current DRAFT shown

# My prog vs MAD and BMAD



# Hadrons

TB30c(h) .9 bpFh352b



# Machine parameters v6

## Initial HD

PARAMETERS	Proton	Electron		Proton	Electron		Proton	Electron		Proton	Electron		Proton	Electron
energy, GeV	275	18		275	10		100	10		100	5		41	5
relativistic factor	293.1	35225.1		293.1	19569.5		106.6	19569.5		106.6	9784.8		43.7	9784.8
bunch_intensity,E10	10.014	2.099		9.789	22.02		7.64	22.02		6.145	22.02		6.892	22.02
number_of_bunches	290			290			290			290			290	
beam_current,A	0.36	0.076		0.36	0.8		0.28	0.8		0.22	0.8		0.25	0.8
rms_normaliz_emittance,h/v_um	5.9/2.50	845/96.6		5.9/2.50	391/96.6		3.1/2.50	391/100.0		2.7/2.50	196/100.0		2.5/2.50	196/113.3
rms_emittance,h/v_nm	20.3/8.5	24.0/2.7		20.3/8.5	20.0/4.9		29.2/23.5	20.0/5.1		25.4/23.5	20.0/10.2		57.2/57.2	20.0/11.6
emittance_y/emittance_x	0.421	0.114		0.421	0.247		0.805	0.256		0.922	0.511		1	0.579
beta,h/v_cm	90/5.9	76/18.4		90/5.9	91/10.2		90/16.2	131/74.6		90/16.2	115/37.3		118/39.6	338/195.9
IP_beam_size,h/v_um	135/22.4	135/22.4		135/22.4	135/22.4		162/61.7	162/61.7		151/61.7	151/61.7		260/150.6	260/150.6
K=sgm_y/sgm_x		0.166			0.166			0.381			0.408			0.579
IP_rms_ang_spread,h/v_urad	150/380	178/122		150/380	148/220		180/380	123/83		168/380	132/166		220/380	77/77
beam-beam_parameter,h/v	0.001/0.000	0.046/0.066		0.008/0.003	0.096/0.065		0.013/0.006	0.063/0.095		0.014/0.006	0.100/0.080		0.014/0.008	0.100/0.100
long_bunch_area,evs	0.8			0.8			0.6			0.6			0.5	
rms_bunch_length,cm	9.9	0.85		9.9	0.83		11	0.83		11	0.85		13	0.85
rms_energy_spread,e-4	4.7	10.9		4.7	5.8		8.7	5.8		8.7	6.8		14.9	6.8
max_space_charge	0.001	neglig.		0.001	neglig.		0.004	neglig.		0.004	neglig.		0.021	neglig.
Piwinski_angle,rad	8.1	0.7		8.1	1.6		7.5	1.4		8	1.5		5.5	0.8
Longit_IBS_time,h	8			8			8.28			9.44			17	
Transv_IBS_time,h	18.6			18.61			8			8			8	
lumi_factor	0.83			0.81			0.89			0.88			0.9	
luminosity,E33	0.1			1.05			0.27			0.23			0.06	

Initial Scope-HD Moderate Lumi Scope-HA Moderate Lumi Scope-HD Fu ...

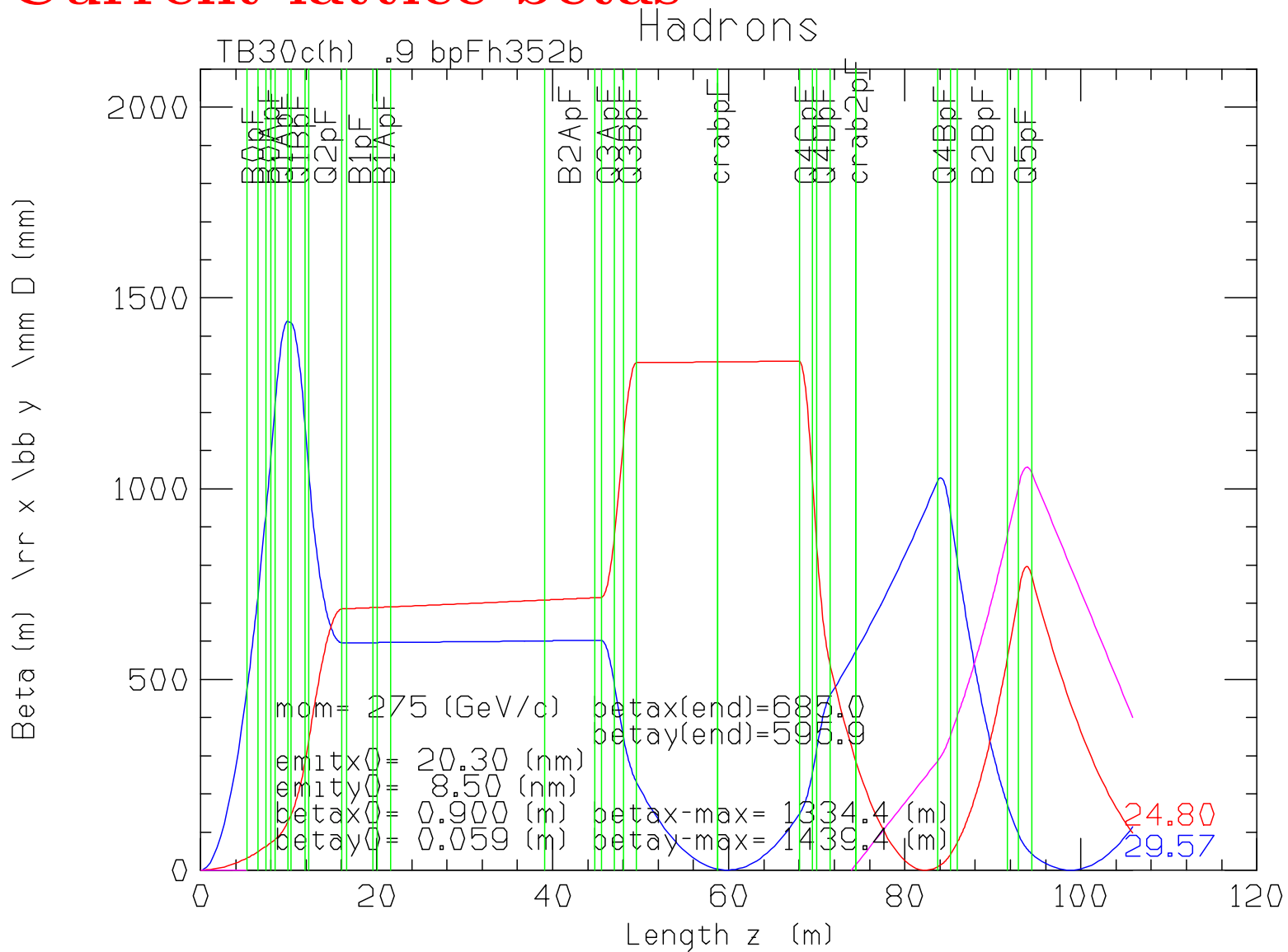
# Medium HD

PARAMETERS	Proton	Electron	Proton	Electron	Proton	Electron	Proton	Electron	Proton	Electron	Proton	Electron
energy, GeV	275	18	275	10	100	10	100	5	41	5		
relativistic factor	293.1	35225.1	293.1	19569.5	106.6	19569.5	106.6	9784.8	43.7	9784.8		
bunch_intensity,E10	15.782	7.294	10.357	34.407	7.64	26.365	6.028	26.365	6.892	24.256		
number_of_bunches	290		580		580		580		580			
beam_current,A	0.57	0.265	0.75	2.5	0.56	1.916	0.44	1.916	0.5	1.762		
rms_normaliz_emittance,h/v_um	5.9/2.50	845/100.9	4.7/2.50	391/96.6	3.1/2.50	391/100.0	3.1/2.50	196/99.5	2.5/2.50	196/113.3		
rms_emittance,h/v_nm	20.3/8.5	24.0/2.9	16.1/8.5	20.0/4.9	29.2/23.5	20.0/5.1	29.2/23.5	20.0/10.2	57.2/57.2	20.0/11.6		
emittance_y/emittance_x	0.421	0.119	0.53	0.247	0.805	0.256	0.805	0.509	1	0.579		
beta,h/v_cm	90/5.9	76/17.6	90/5.9	72/10.2	90/16.2	131/74.6	90/16.2	131/37.5	118/39.6	338/195.9		
IP_beam_size,h/v_um	135/22.4	135/22.4	120/22.4	120/22.4	162/61.7	162/61.7	162/61.7	162/61.7	260/150.6	260/150.6		
K=sgm_y/sgm_x	0.166		0.186		0.381		0.381		0.579			
IP_rms_ang_spread,h/v_urad	150/380	178/128	134/380	166/220	180/380	123/83	180/380	123/165	220/380	77/77		
beam-beam_parameter,h/v	0.003/0.001	0.072/0.100	0.015/0.005	0.100/0.076	0.015/0.007	0.063/0.095	0.015/0.007	0.100/0.075	0.015/0.009	0.100/0.100		
long_bunch_area,evs	0.8		0.8		0.6		0.6		0.5			
rms_bunch_length,cm	7	0.9	7	2	11	2	11	2	13	2		
rms_energy_spread,e-4	6.6	10.9	6.6	5.8	8.7	5.8	8.7	6.8	14.9	6.8		
max_space_charge	0.002	neglig.	0.001	neglig.	0.004	neglig.	0.003	neglig.	0.021	neglig.		
Piwinski_angle,rad	5.7	0.7	6.4	1.8	7.5	1.4	7.5	1.4	5.5	0.8		
Longit_IBS_time,h	8		10.7		8.28		10.5		16.98			
Transv_IBS_time,h	9.67		10.3		8		10.14		8.05			
lumi_factor	0.91		0.9		0.39		0.88		0.9			
luminosity,E33	0.63		4.28		0.54		0.51		0.14			

# Full Scope HD

PARAMETERS	Proton	Electron		Proton	Electron		Proton	Electron		Proton	Electron		Proton	Electron
energy, GeV	275	18		275	10		100	10		100	5		41	5
relativistic factor	293.1	35225.1		293.1	19569.5		106.6	19569.5		106.6	9784.8		43.7	9784.8
bunch_intensity,E10	20.444	7.294		6.881	17.203		6.881	17.203		4.658	17.203		2.639	13.294
number_of_bunches	290			1160			1160			1160			1160	
beam_current,A	0.74	0.265		1	2.5		1	2.5		0.68	2.5		0.38	1.932
rms_normaliz._emittance,h/v_um	4.6/0.74	845/71.2		2.8/0.45	391/23.9		4.0/0.22	391/25.4		2.7/0.27	196/20.0		1.9/0.45	196/34.2
rms_emittance,h/v_nm	15.8/2.5	24.0/2.0		9.6/1.5	20.0/1.2		37.1/2.1	20.0/1.3		25.1/2.6	20.0/2.0		43.6/10.3	20.0/3.5
emittance_y/emittance_x	0.159	0.084		0.158	0.061		0.056	0.065		0.102	0.102		0.236	0.175
beta,h/v_cm	90/4.0	59/5.0		90/4.0	43/5.0		90/4.0	167/6.4		90/4.0	113/5.0		90/7.1	196/21.0
IP_beam_size,h/v_um	119/10.1	119/10.1		93/7.8	93/7.8		183/9.1	183/9.1		150/10.1	150/10.1		198/27.1	198/27.1
K=sgm_y/sgm_x	0.084			0.084			0.05			0.067			0.137	
IP_rms_ang_spread,h/v_urad	133/251	201/201		103/195	215/156		203/227	109/143		167/253	133/202		220/380	101/129
beam-beam_parameter,h/v	0.004/0.002	0.100/0.100		0.014/0.007	0.073/0.100		0.010/0.009	0.075/0.057		0.015/0.010	0.100/0.066		0.015/0.009	0.053/0.042
long._bunch_area,eva	0.68			0.68			0.4			0.4			0.2	
rms_bunch_length,cm	6	0.9		6	2		7	2		7	2		7.5	2
rms_energy_spread,e-4	6.6	10.9		6.6	5.8		9	5.8		9	6.8		10.4	6.8
max_space_charge	0.006	neglig.		0.003	neglig.		0.028	neglig.		0.019	neglig.		0.05	neglig.
Piwinski_angle,rad	5.5	0.8		7.1	2.4		4.2	1.2		5.1	1.5		4.2	1.1
Longit._IBS_time,h	2.1			3.41			2			2.6			3.8	
Transv._IBS_time,h	2			2			2.32/2.36			2/4.8			3.4/2.1	
lumi_factor	0.86			0.86			0.85			0.83			0.93	
luminosity,E33	1.93			10.05			4.35			3.16			0.44	

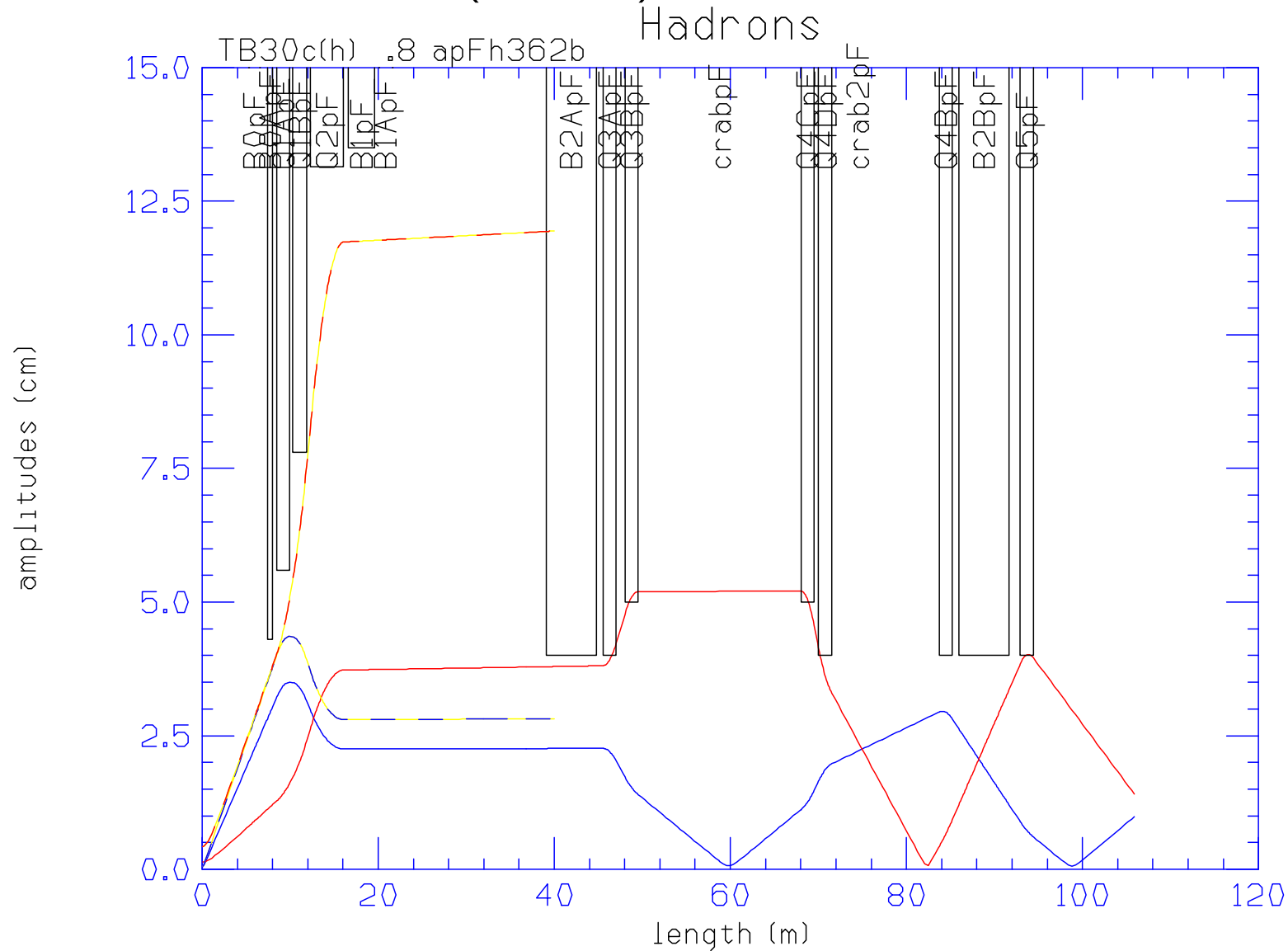
# Current lattice betas



For  $\beta_x^*=0.9$  m:  $\beta_{crab}=1332$  m

# Beam size in crabs

Worst 275 GeV case (max  $\epsilon_x$ ) Moderate HD 140 GeV 20.3 nm



10 sig in Crab = 5.2 cm ????



## Sizes for other cases

$E_p$ GeV	case	Div	$E_{com}$ GeV	$\beta_{crab}$ m	$\epsilon$ nm	10 sig cm	ok?
275	Mod	HD	140	1332	20.3	5.2	???
275	Mod	HD	105	1332	16.1	4.6	ok
100	Full	HD	63	1332	37.1	7.03	no
100	Full	HD	63	$\leq 729$	37.1	$\leq 5.2$	???
41	Mod	HD	28	1332	57.2	8.7	no
41	Mod	HD	28	$\leq 473$	57.2	$\leq 5.2$	???

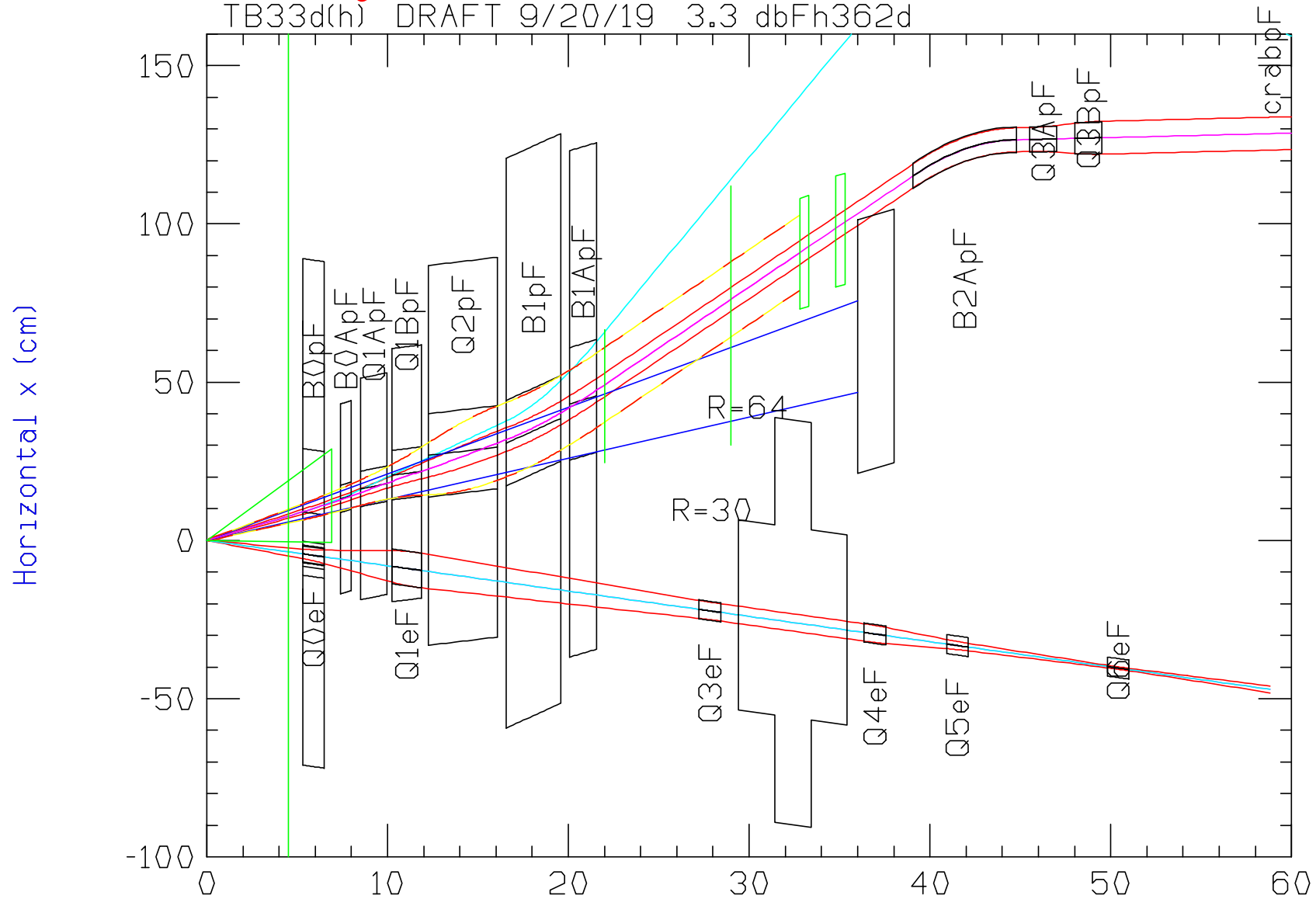
More comfortable if 275 GeV p crab beta x lowered from 1332 to 1200 m giving maximum beam size of 4.9 cm

But in any case, lattices must be modified to keep the beam sizes in the crabs for 100 and 41 GeV cases. Lower betas in crab at lower energies ok because:

$$V_{crab} = \frac{\theta_{crab} E[eV] c}{2\pi f_{crab} \sqrt{\beta_{crab} \beta^*}}$$

# DRAFT Layout

TB33d(h) DRAFT 9/20/19 3.3 dbFh362d



p magnet outlines, when shown, are of the yoke dimensions.