Optimization of the Combiner Rings for the CLIC DB

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Outline

Motivation

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Goal

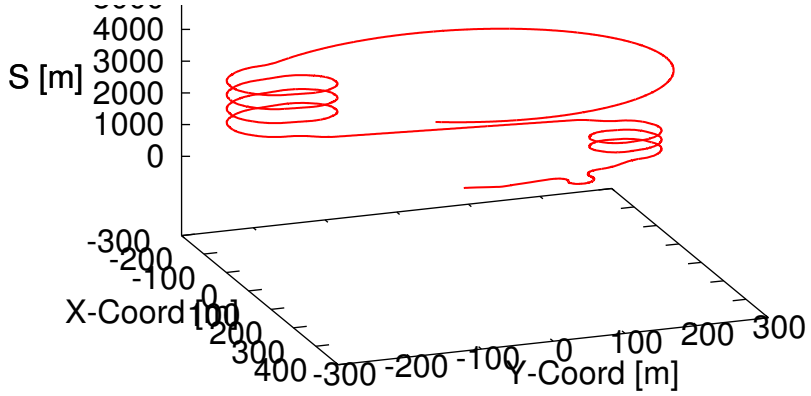
- Design the Drive Beam Recombination Complex (DBRC) capable of transporting a beam with an energy spread of 1% (rms)
- Keeping $\Delta\epsilon \leq 50\%$ at the entrance of the deccelerator

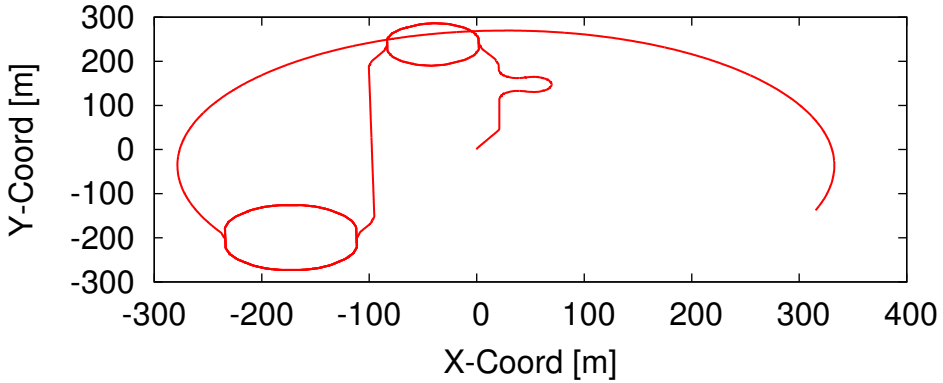
Strategy

- To replace arc cells of CR1 and CR2 based on TBA by the Chassman-Green cell [1]
  - offers lower emittance than TBA
  - requires weaker quadrupoles $\rightarrow$ smaller chromatic aberrations
  - R_{56} is easily tunable thanks to the short dipole

[1] Huang, N. Y. et al. in Proc. 2nd IPAC 2011 (SPAIN), http://accelconf.web.cern.ch/accelconf/IPAC2011/papers/wepc036.pdf

Sketch of DBRC





DL $\Rightarrow$ **TL1** $\Rightarrow$ **CR1** $\Rightarrow$ **TL2** $\Rightarrow$ **CR2** $\Rightarrow$ TTA

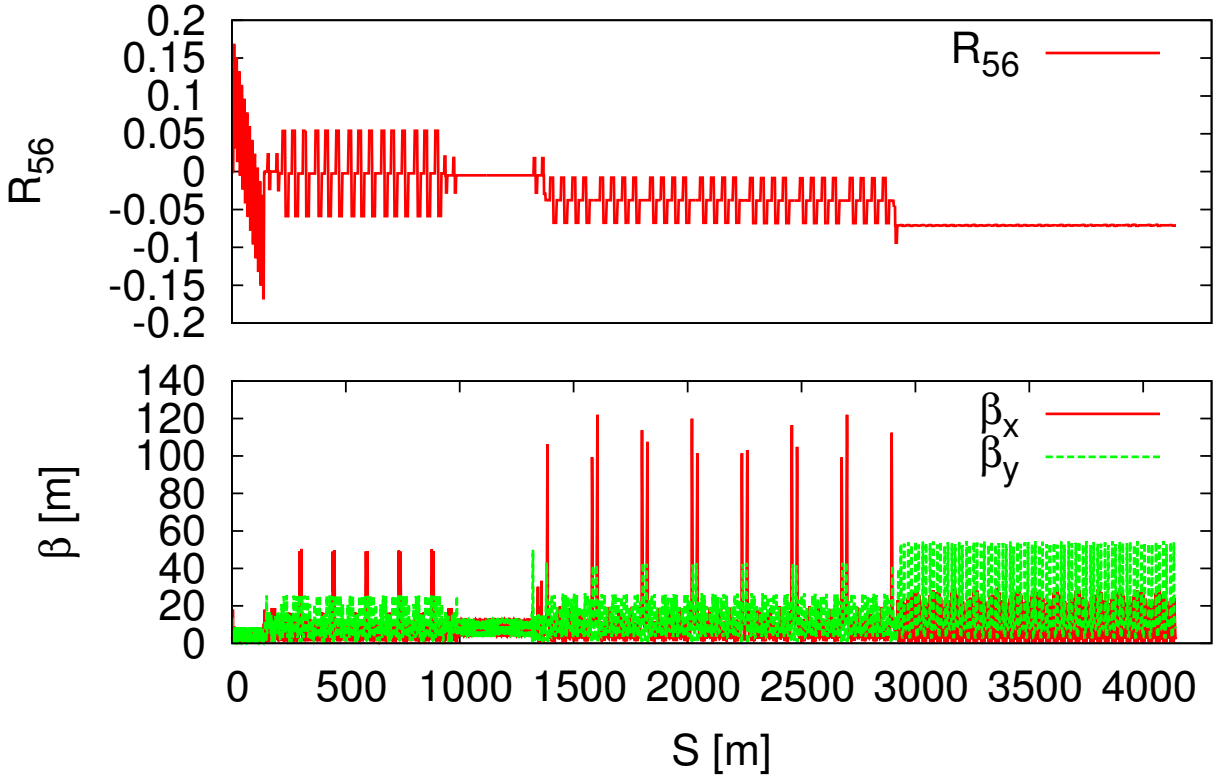
DBRC Parameters

Parameter	Units	DL	CR1	CR2	LTA
Energy	[GeV]	2.38	2.38	2.38	2.38
Norm. Emittance	[μm]	150	150	150	150
Energy spread (rms)	%	1	1	1	1
Length	[m]	146	293	439	1216
Combination factor		2	3	4	-
Average current	[A]	8.4	25	100	100
Bunch length	[mm]	1	1	1	1
RF deflector freq.	[GHz]	1.5	2	3	-

Previous Design

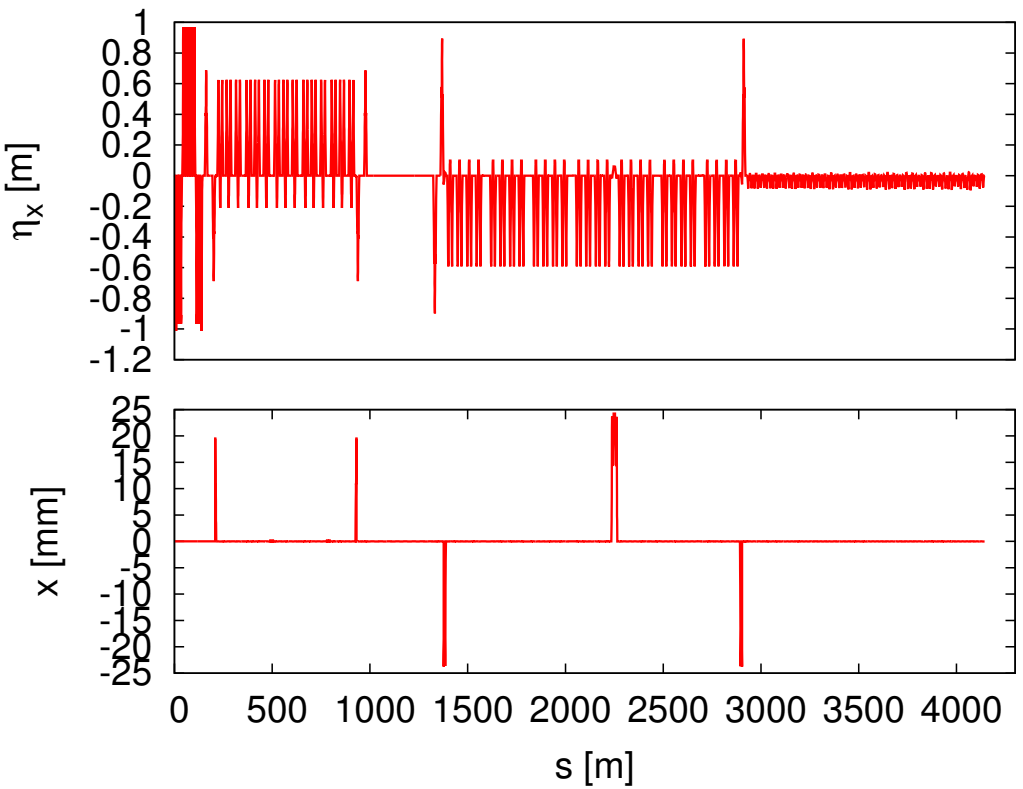
β and R_{56}

Combiner rings 1 and 2 are based on a TBA cell
Delay Line and transfer lines are based on the Chassman-Green cell

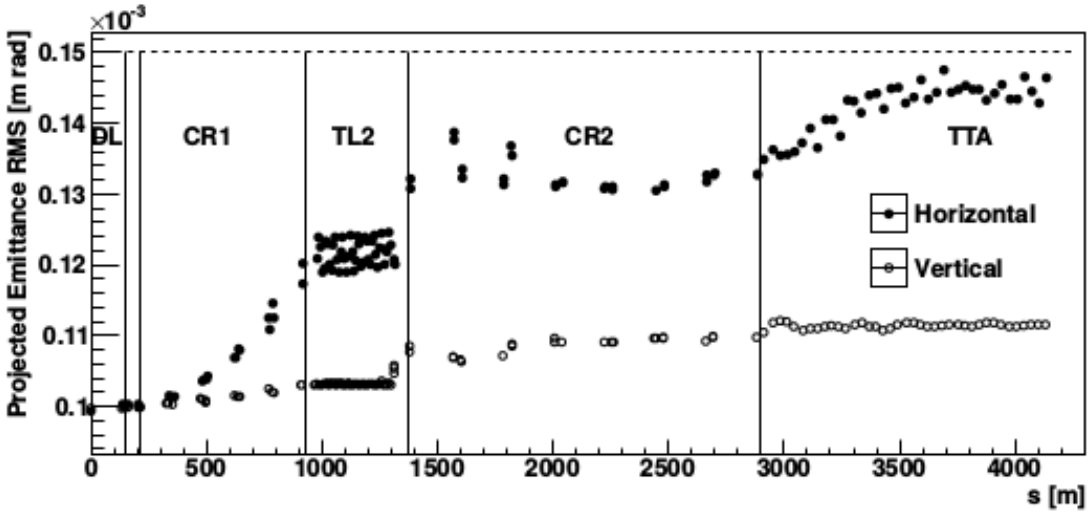


Orbit and Dispersion

Isochronous tolerance $R_{56} = \pm 1$cm
Injection into CRs is based on bump offset of 2-3 cm (maximum kick from RF kickers)
η and η' after bump $\approx \pm 0.05$ m and ± 0.01, respectively



Emittance growth



Section	$\Delta\epsilon_x$ [%]	$\Delta\epsilon_y$ [%]
DL	1	1
TL1	1	1
CR1	16	3
TL2	30	8
CR2	31	10
LTA	43 [2]	12

[2] assuming an initial $\delta p/p$=0.35% (rms) and σ_z=2 mm.

Values obtained from CLIC-CDR v1

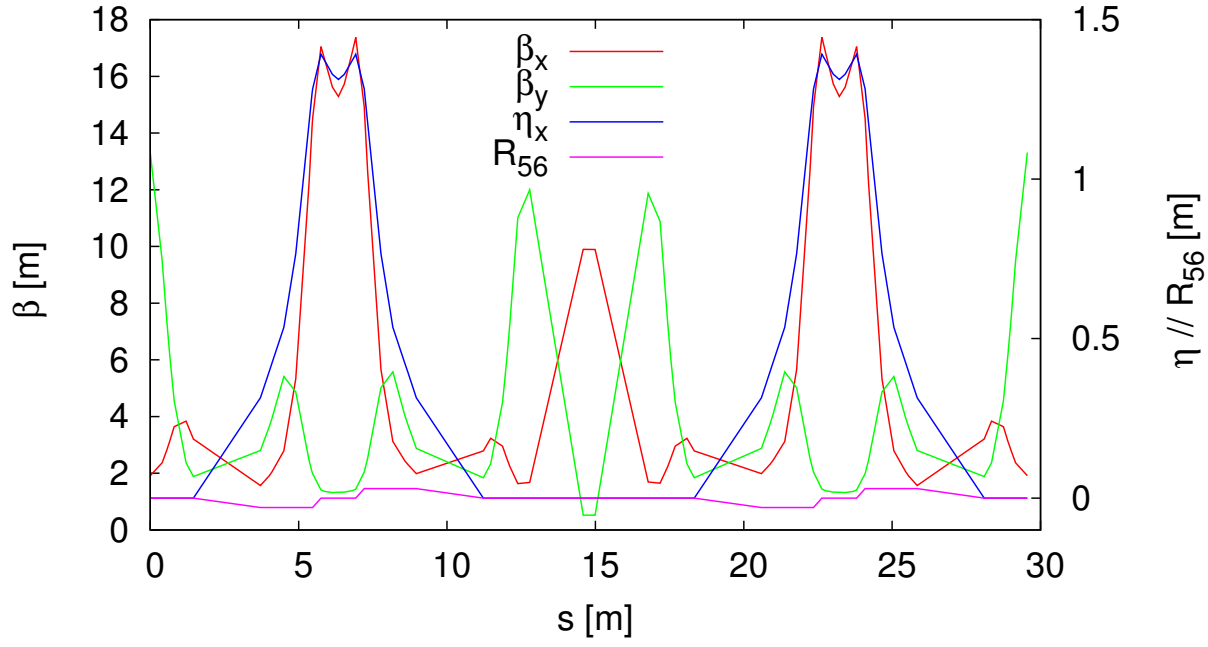
http://project-clic-cdr.web.cern.ch/project-CLIC-CDR/

New Designs

CR1

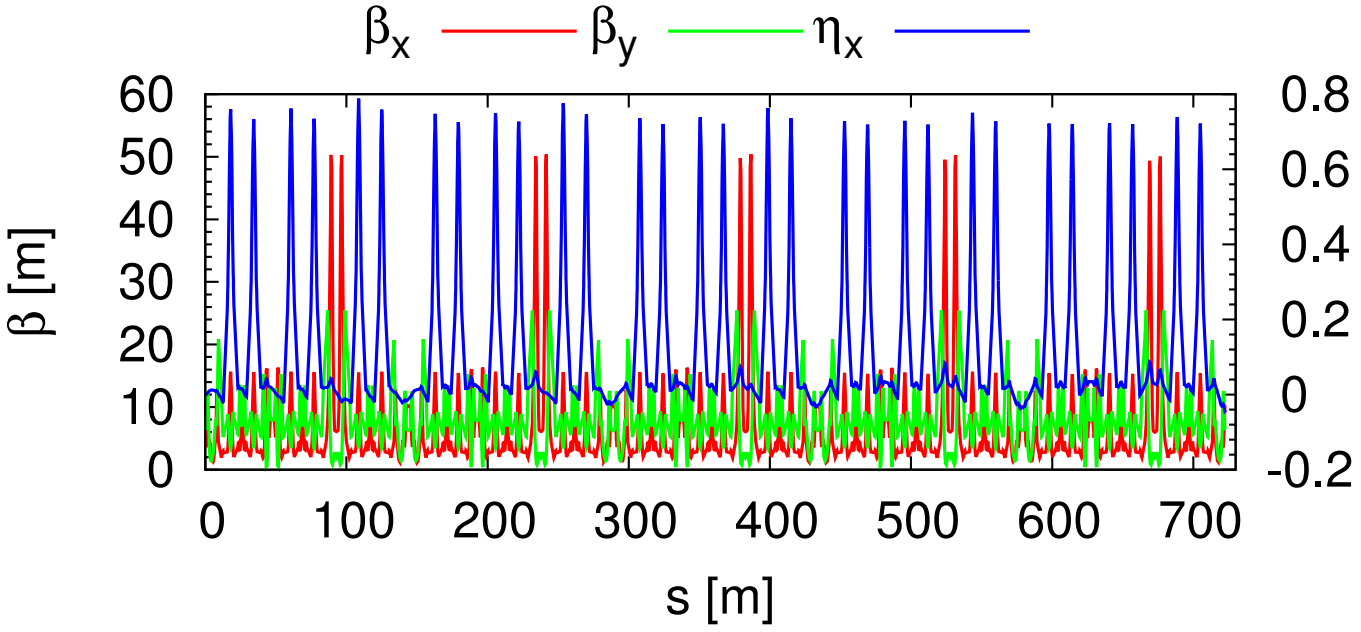
Arc Cell

The TBA cell is replaced by a 2 DBA cells connected by 3 quadrupoles to match the Twiss parameters
Length of dipoles is adjusted to set $B = 0.8$ T (1 T in CDR)



$\Delta\epsilon_{x,y} \leq 5\%$ per arc cell @ $\Delta p/p$=1%

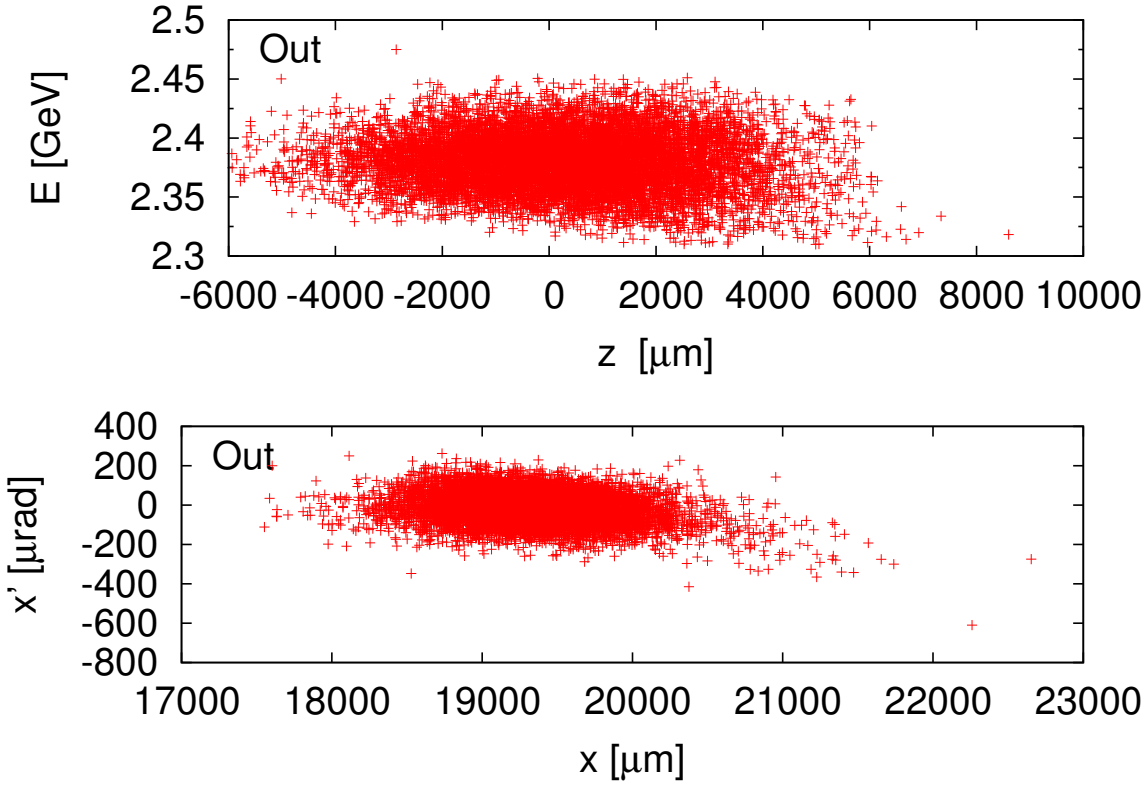
Twiss functions



	β_x [m]	α_x [rad]	β_y [m]	α_y [rad]	η_x [mm]	R_{56} [mm]
PLACET	10.01	0.10	6.37	0.17	-4.1	-0.7
CDR	9.92	0.10	6.40	0.17	-2.8	-2.4

Emittance Growth CR1

Initial Beam: $\Delta p/p = 1\,\%$ $\sigma_z = 2$ mm $\gamma\epsilon_{x,y} = 100\ \mu$m



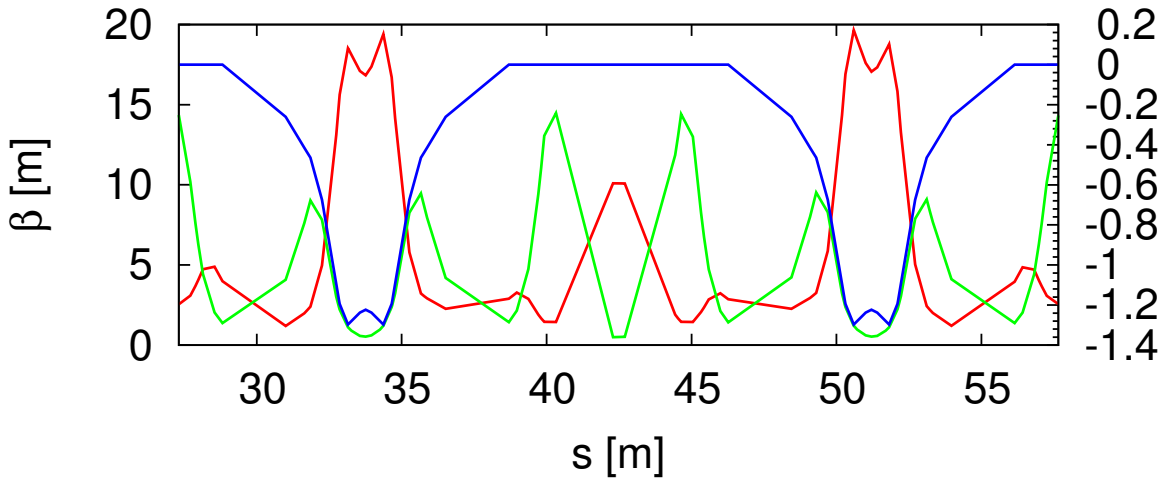
Final Emittances (2.5 turns): $\gamma\epsilon_x = 111\ \mu$m, $\gamma\epsilon_y = 107\ \mu$m

(PLACET simulation with 5 10^4 e^-. Synchrotron radiation ON)

CR2

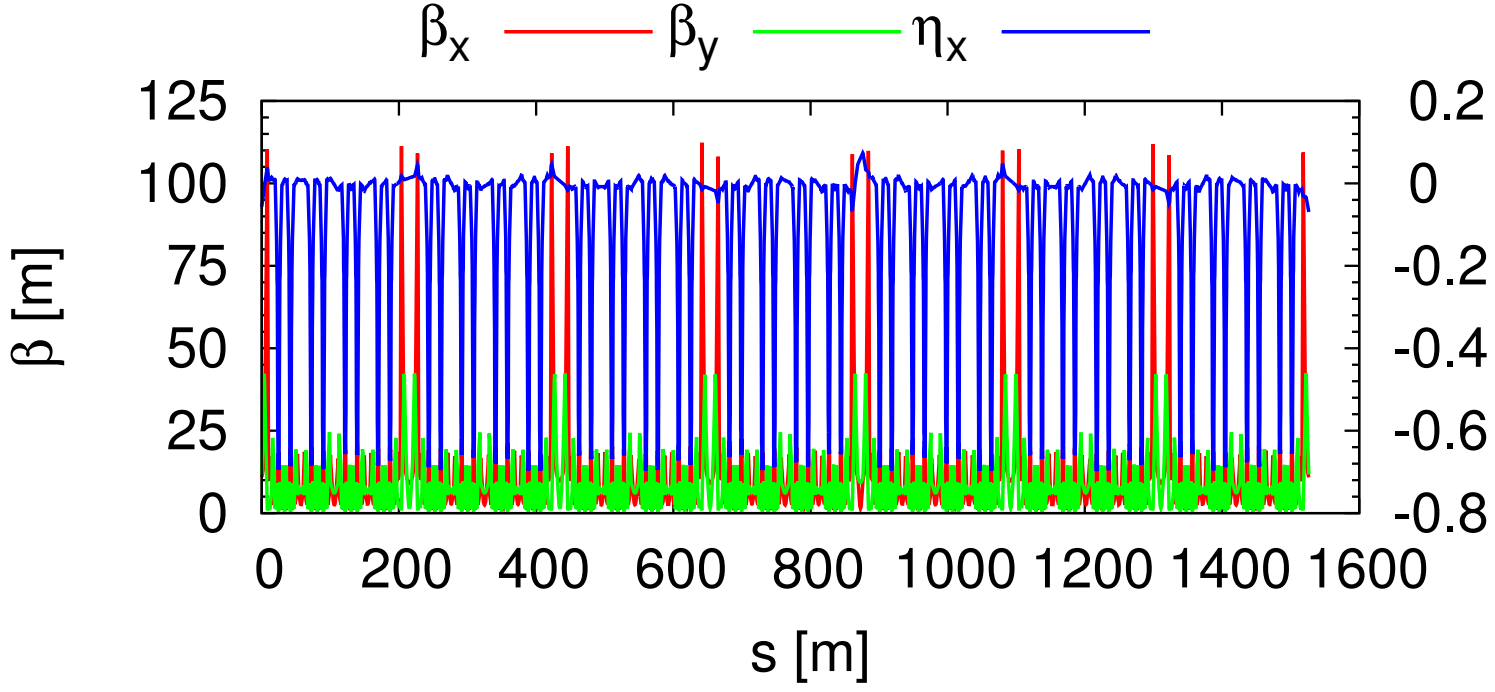
Arc Cell

The TBA cell is replaced by a 2 DBA cells connected by 3 quadrupoles to match the Twiss parameters



$\Delta\epsilon_{x,y} \leq 3\%$ per arc cell @ $\Delta p/p$=1%

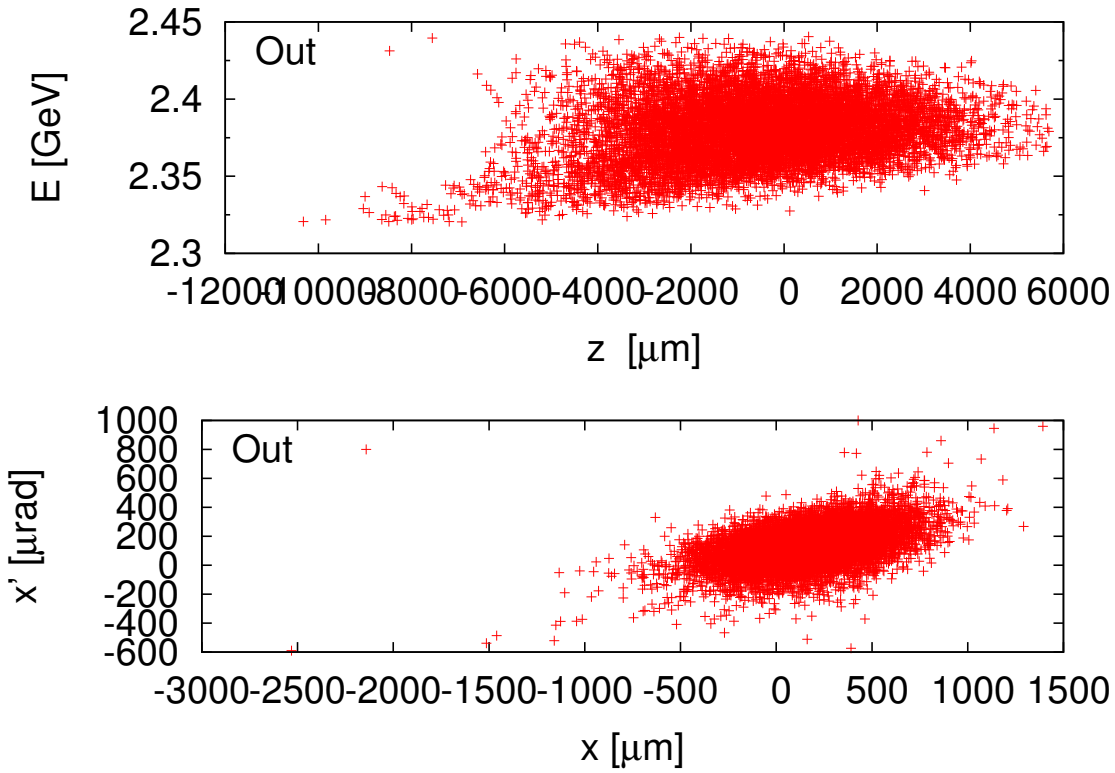
Twiss functions



	β_x [m]	α_x [rad]	β_y [m]	α_y [rad]	η_x [mm]	R_{56} [mm]
PLACET	10.8	-0.39	11.81	2.76	-70	-5.2
MAD-X	11.6	0.48	11.60	2.71	-57	-3.9

Emittance Growth

Initial Beam: $\Delta p/p$=0.9 % $\sigma_z = 2$ mm $\gamma\epsilon_{x,y} = 100\ \mu$m

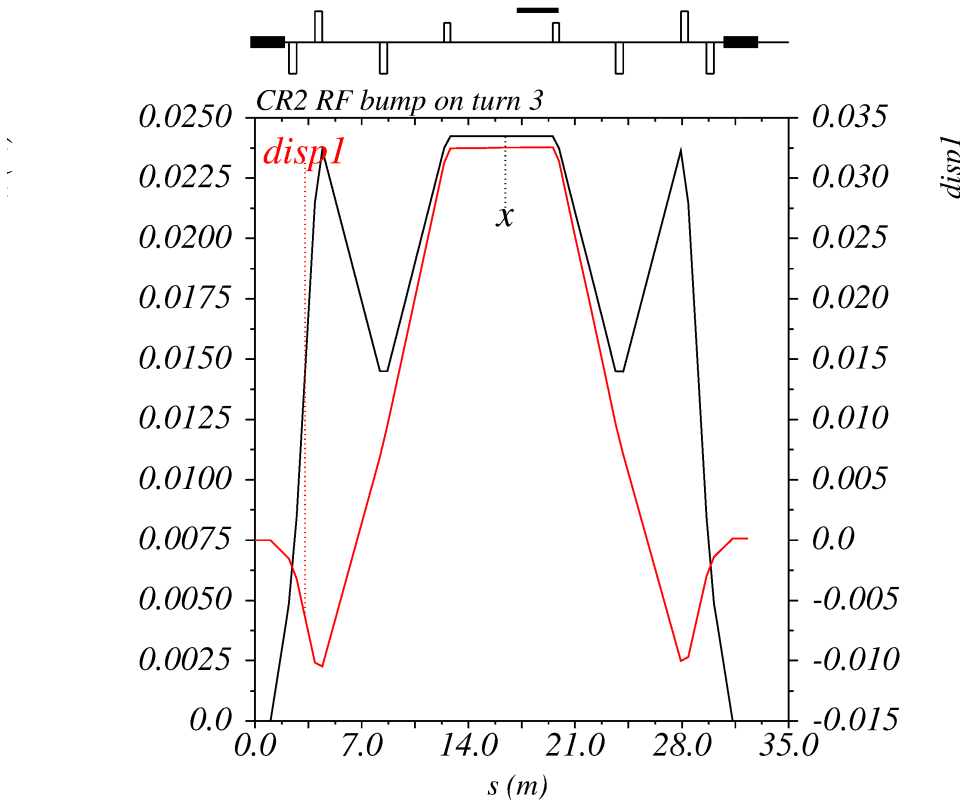


Final Emittances: $\gamma\epsilon_x = 133\ \mu$m $\gamma\epsilon_y = 110\ \mu$m

(assuming no kickers: $\gamma\epsilon_x = 123\ \mu$m $\gamma\epsilon_x = 106\ \mu$m @ $\Delta p/p$=1%)

Orbit Bump Turn 3

Orbit and dispersion are closed by means of a pair of sextupole magnets



S-2-E Simulations

Twiss

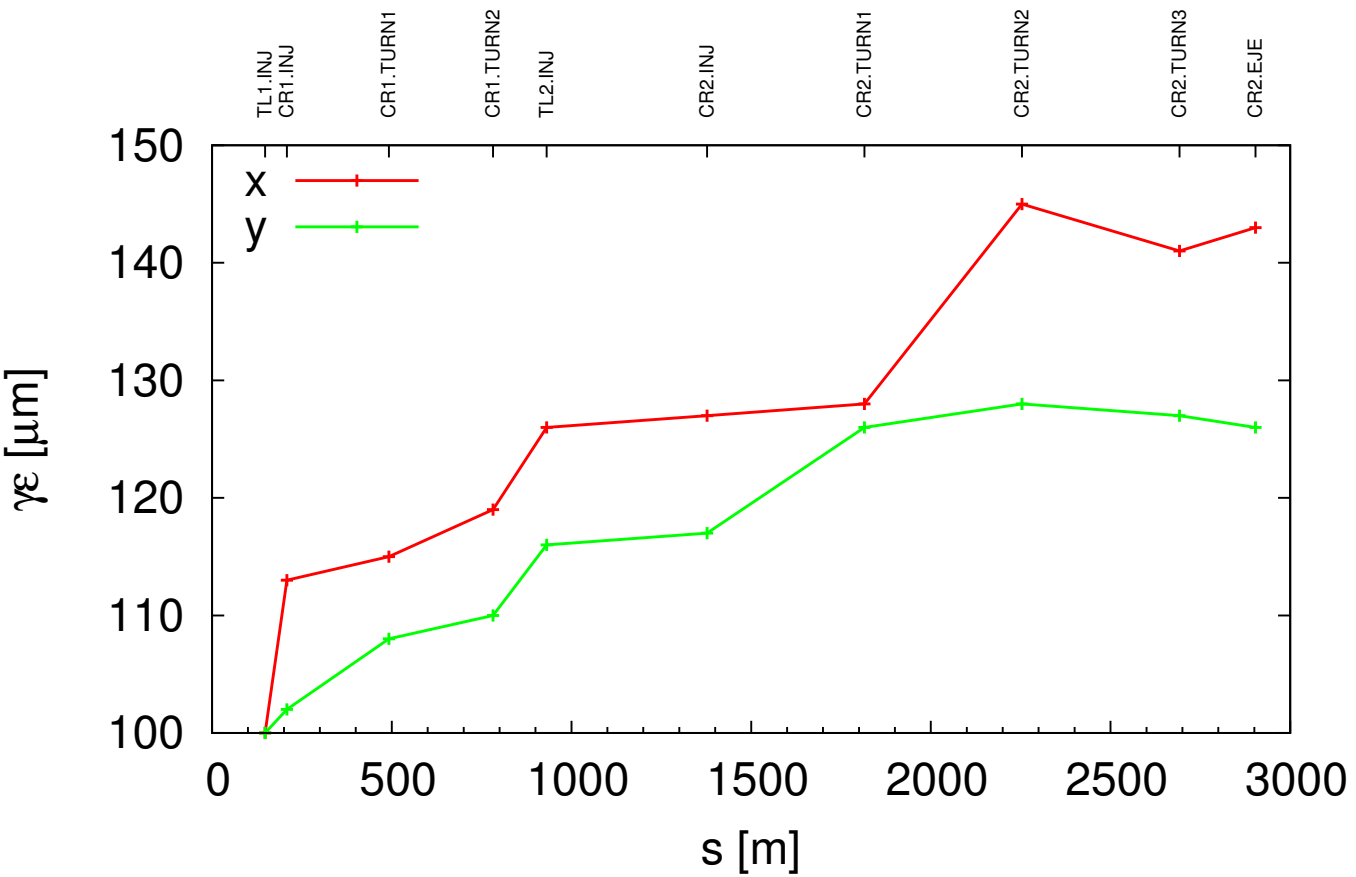
Propagation of Twiss functions along DBRC
PLACET values obtained from beam distribution ($5 \cdot 10^4$ e^-)
MADX values obtained by PTC code

	β_x [m]	α_x [rad]	β_y [m]	α_y [rad]
TL1				
PLACET	9.28	-0.19	7.65	-0.16
MAD-X	10.20	-0.09	6.37	-0.16
CR1				
PLACET	1.88	-0.080	12.74	-1.57
MAD-X	1.89	-0.086	13.34	-1.60
TL2				
PLACET	9.89	1.04	10.39	2.4
MAD-X	9.92	1.03	11.85	2.8
CR2				
PLACET	7.3	-0.6	11.6	2.7
MAD-X	9.9	0.48	11.6	2.7
TTA				
PLACET	7.8	0.8	7.96	0.00
MAD-X	2.1	-0.1	8.0	0.01

β_x, α_x, η and η'_x are miss-matched at the entrance of TTA

Start-to-End Simulation

- Beam with 0.9% energy spread (rms)
- Orbit and Dispersion deliberately optimized against final emittance @ entrance of each section



Summary

- Obtained new designs of

  CR1 (1%) and CR2 (0.9%)
- First results Start-to-end simulations are obtained for a beam with $\Delta p/p$=0.85%
- Calculated emittance growth @ exit of CR2:

  $\Delta\epsilon_x$=42%, $\Delta\epsilon_y$=26%
- x, p_x -offsets and η_x, η_{p_x} artificially introduced at the entrance of CR1 and CR2

Outlook...

- Design a matching line to provide the expected dispersion at the entrance of CRs
- Further investigation of TL3 and the Turn around loop is required to better understand the source of observed miss-matched