THE OPTIMIZED BUNCH COMPRESSOR FOR THE INTERNATIONAL LINEAR COLLIDER

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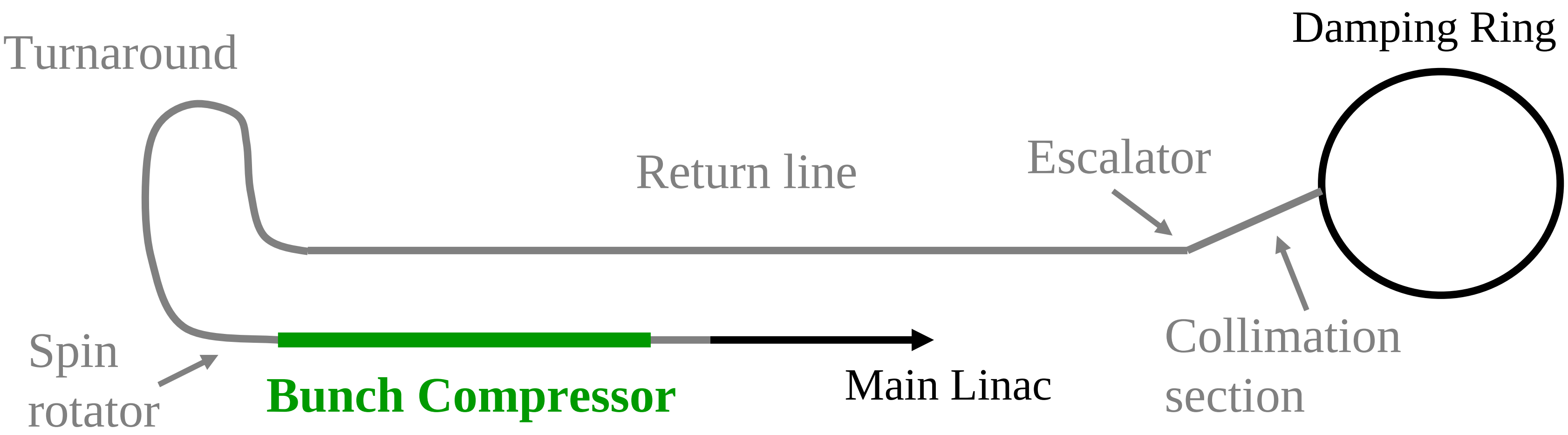
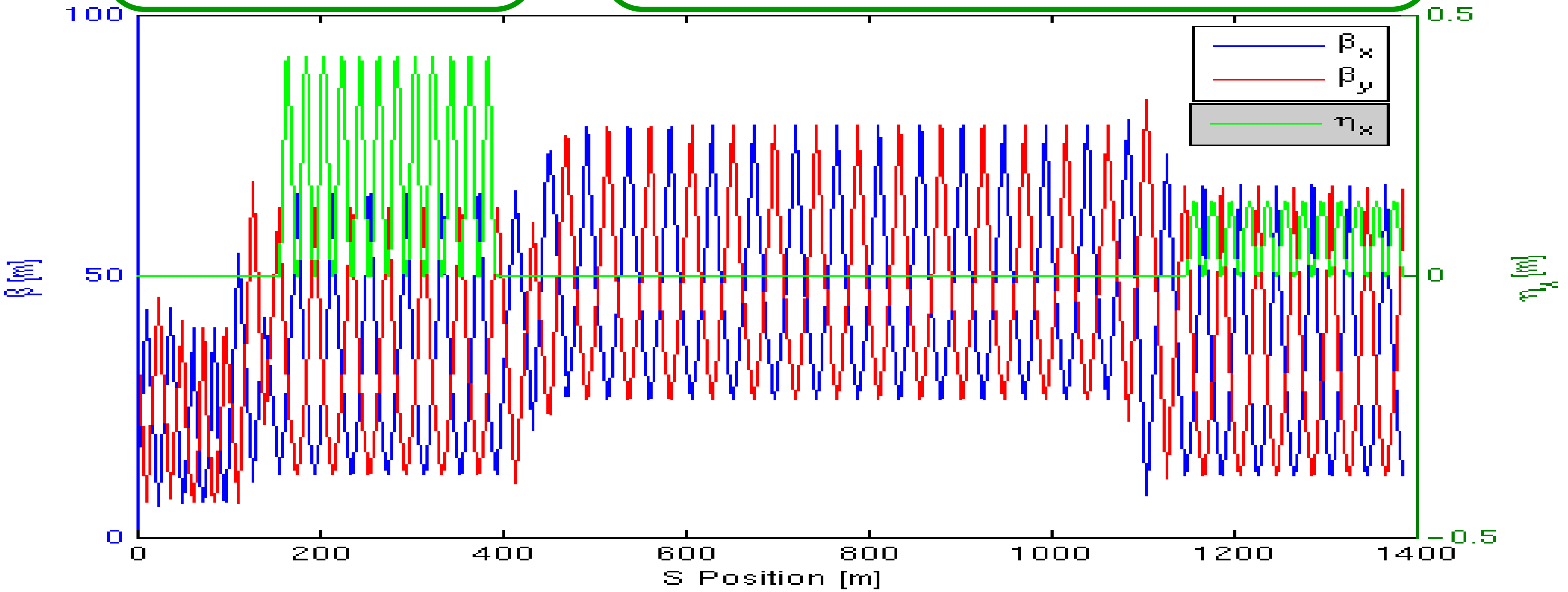
Introduction



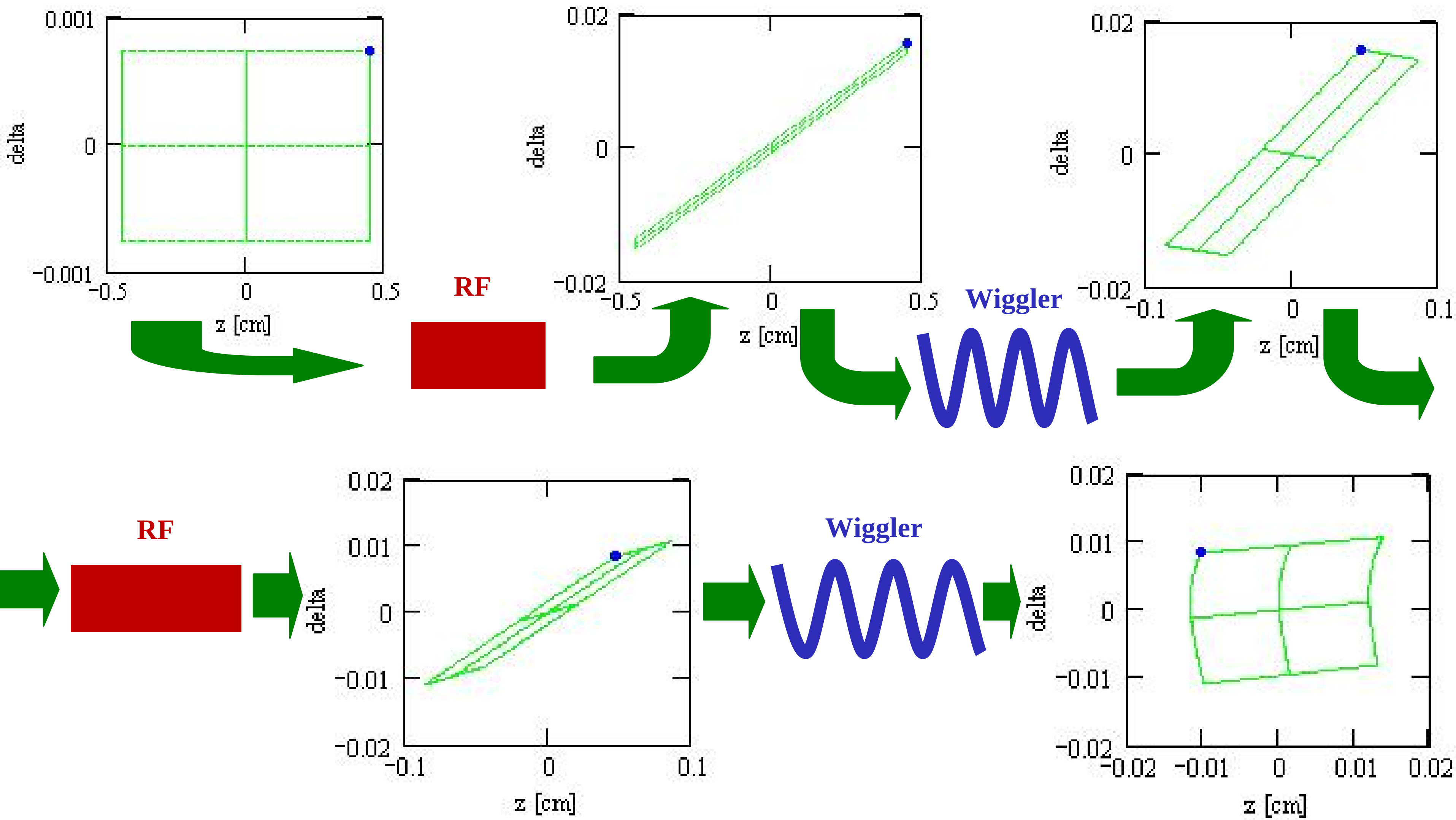
- The ILC Ring to Main Linac (RTML) transports and matches the beam from the Damping Ring to the entrance of the Main Linac.
- The RTML must perform several functions:
  - ✓ "Geometry matching" transport of the beam from the damping ring to the linac
  - ✓ Collimation of the beam halo generated in the damping ring
  - ✓ **Compression of the long Damping Ring bunch length by a factor of 30~45 to provide the short bunches required by the Main Linac and the IP**
  - ✓ Rotation of the spin polarization vector from the vertical to any arbitrary angle required at the IP

Bunch Compressor Overview

- In order to achieve the required bunch compression, a two stage system is adopted.
- The momentum compaction in both BC stages (BC1 and BC2) is produced by the wiggler

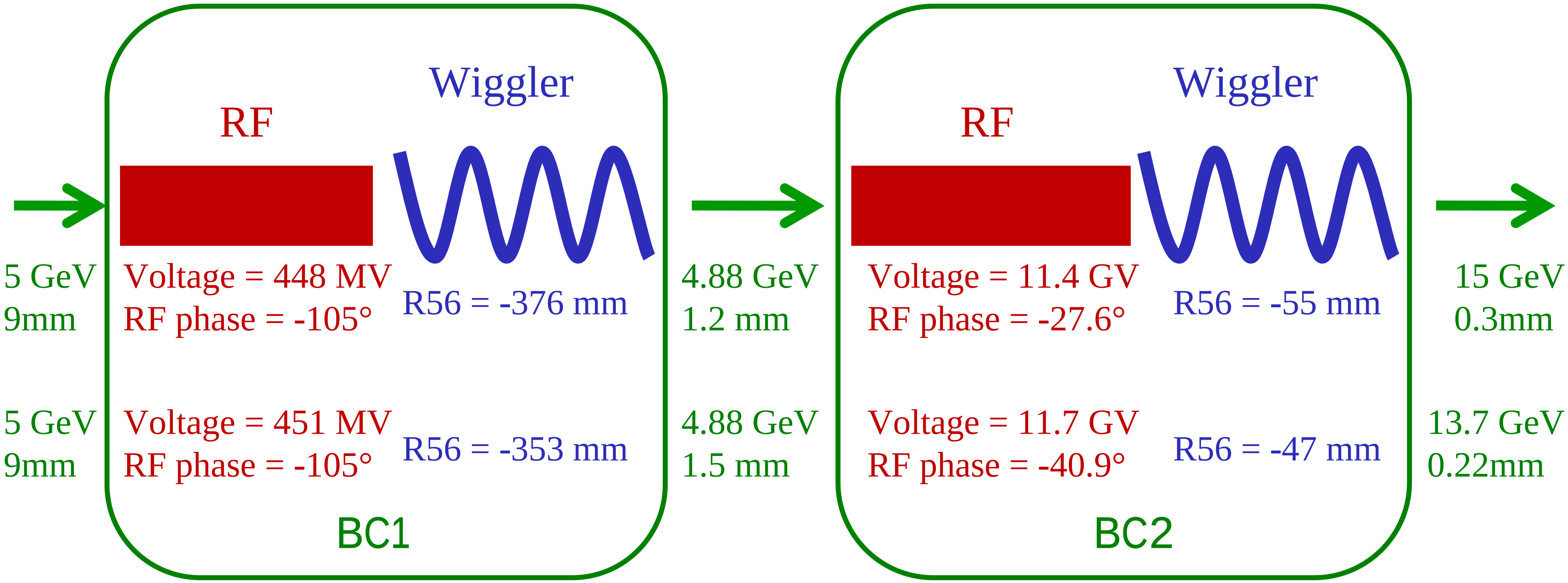


Bunch Compressor Overview



Bunch Compressor Overview

- The bunch compressor has to have enough flexibility to compress beam from 9 mm to either 300 um or 220 um.
- The maximum tolerable energy spread at the exit of the Bunch Compressor is 3.5%



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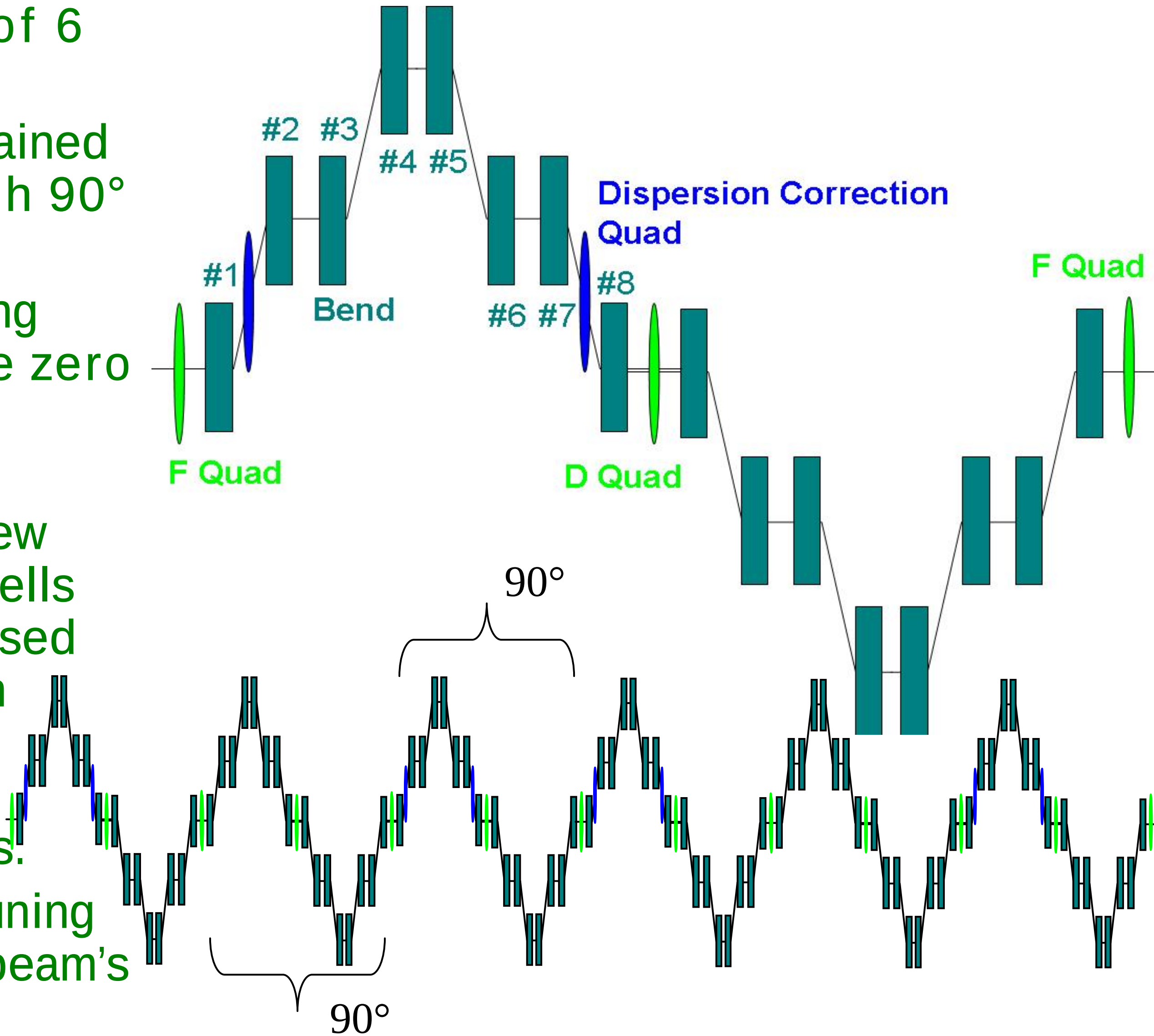
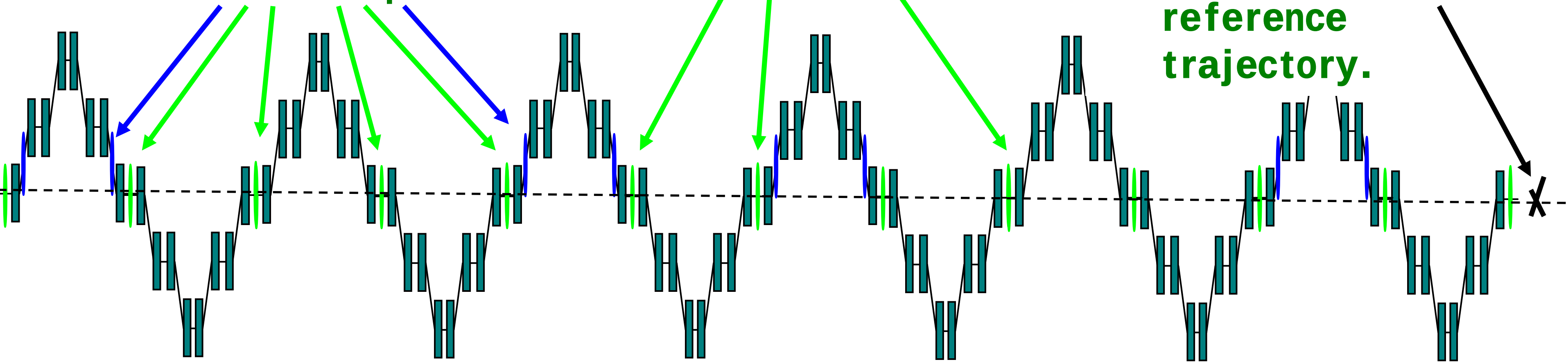
Design of the Wiggler

- Each wiggler consists of 6 identical cells
- Wiggler cells are contained in FODO structure with 90° phase advance per cell
- Focusing and defocusing quads are placed in the zero dispersion regions
- There are 4 additional normal quads and 4 skew quads per wiggler (in cells 1,3,4 and 6) that are used for possible dispersion correction without introducing betatron coupling or mismatches.
- Sixteen bends allow tuning R56 while preserving beam's trajectory in quads



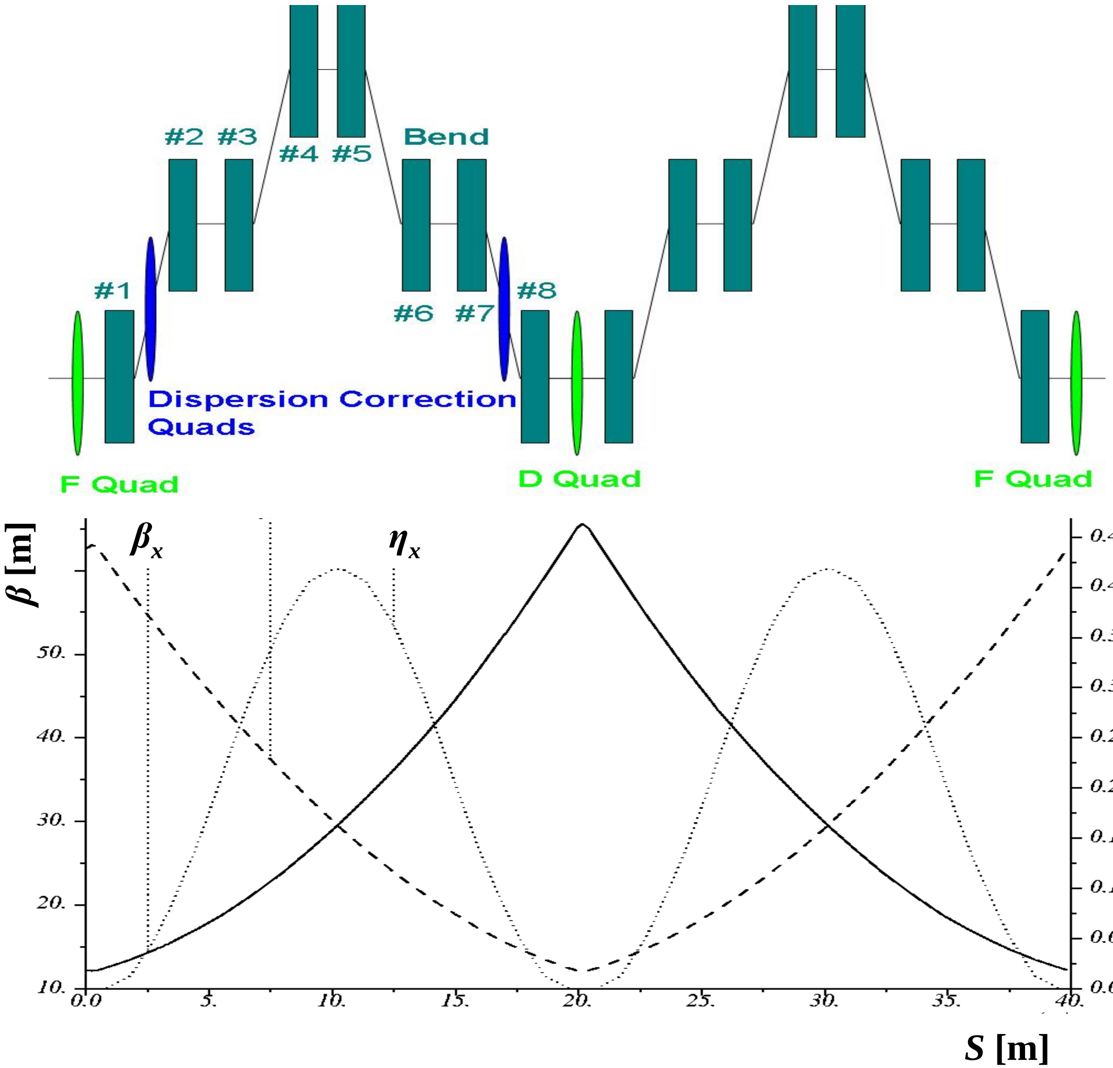
Requirements to the Wiggler

- So far we discussed 2005 version of the wigglers which were 239m long each. There is strong desire to shorten them.
- We want wigglers to be able to produce the same R56=-376 or -353 mm in BC1 and R56=-55 or -47 mm in BC2.
- **Shorter wigglers require more bending => synchrotron radiation (SR) related emittance growth.**
- We want the wigglers to switch between different R56 values and at the same time keep them tunable i.e.:
  - ✓ **The beam trajectory must be fixed in all quads**
  - ✓ **Dispersion must stay zero in FODO quads**
  - ✓ **Beam's trajectory at the exit of the wiggler must coincide with the reference trajectory.**



Requirements to the Wiggler

- How were these requirements satisfied in 2005 design?



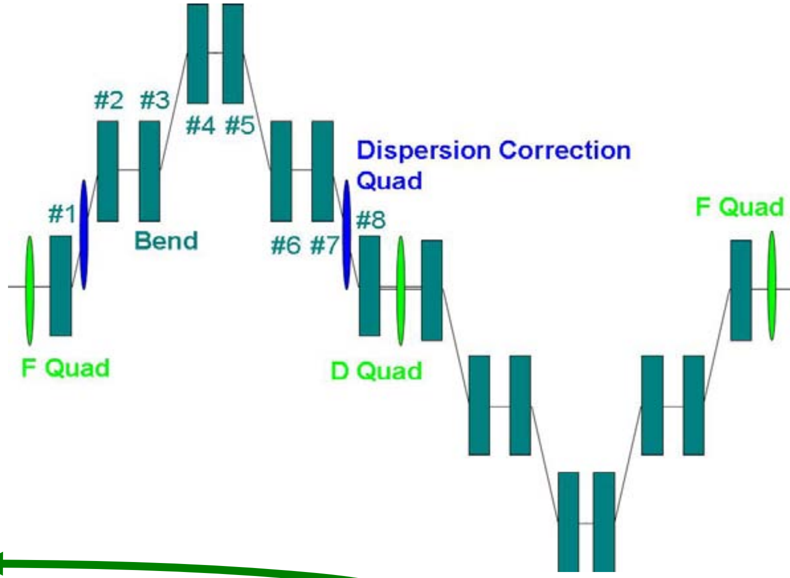
- The wiggler was designed with these requirements in mind.
- For bends 1,4,5 and 8: φ4=-φ1, φ5=- φ1, φ8= φ1
- Adjust bends 2, 3, 6, 7 to vary R56 in such way that: φ3=- φ2, φ6=-φ2, φ7= φ2.
- This natural symmetry automatically fixes the trajectory in the quads, zeroes dispersion in the middle and exit of every cell and returns trajectory to the reference one at wiggler's exit

New Wiggler’s Design

- We suggest that it is possible to reduce wiggler’s length while keeping both the required R56 values and reasonably low bending angles by introducing nonzero dispersion slope (η’) at the entrance of each cell.
- This breaks the natural symmetry of old design and makes the problem of making the wiggler tunable not easily solvable.

New Wiggler's Design

- We keep φ1, φ8 and η' constant for different R56. => Beam is not moved in quads when wiggler is tuned.
- We zero trajectory displacement over the half of the cell. => Trajectory at wiggler's exit is fixed to the reference orbit.
- We require the mirror symmetry of the first and second halves of the cell, and we require that $\Sigma_{(1..8)} \varphi_n = -2\eta'$. => Dispersion in FODO quads is zero and η' at the exit of each cell is equal to its entrance value.
- In the matching routine we explicitly constrain R56 to the required value and constrain the fifth SR integral to 0.
- We have 5 bending angles to vary.

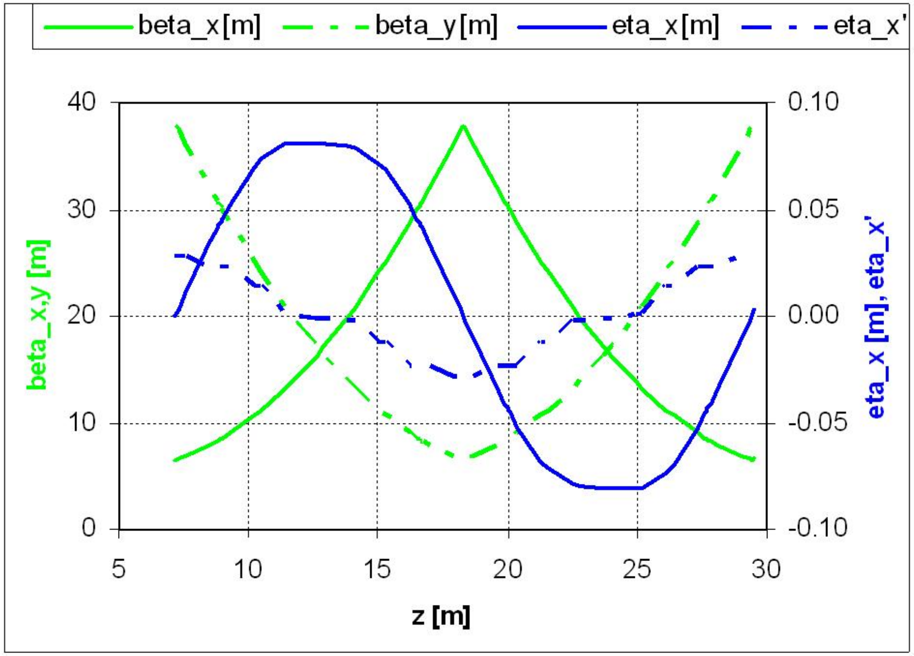


We looped through this procedure several times reducing the bends lengths and spacing and trying out different φ1, φ8 and η' for each length.

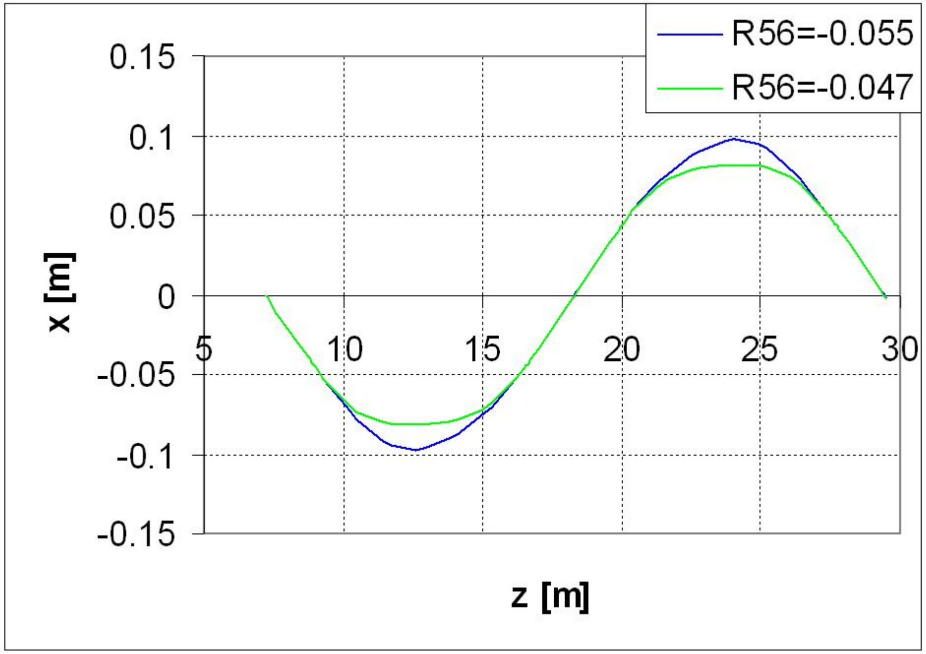
New Wiggler's Design

- The ultimate solution allowed us to reduce the total wiggler's length down to 141 m for BC1 and 147m for BC2.
- At the same time the horizontal emittance growth due to SR is below 5.5%.

Cell of the optimized BC2 wiggler



Twiss parameters in BC2 wiggler's cell

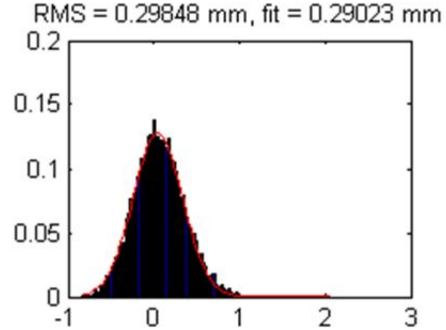


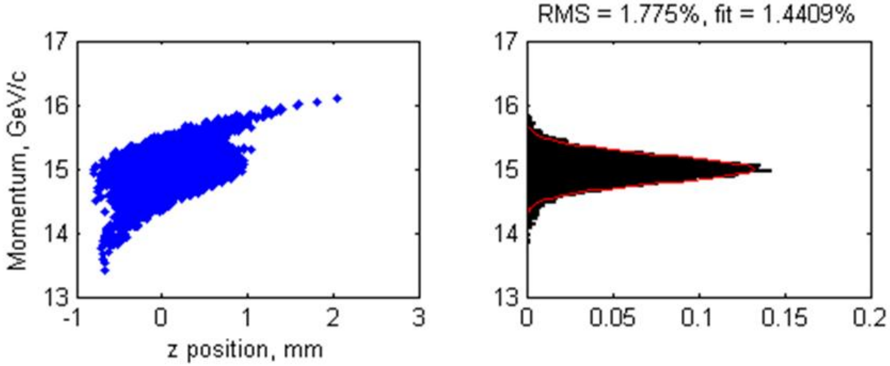
Beam trajectory in BC2 wiggler's cell

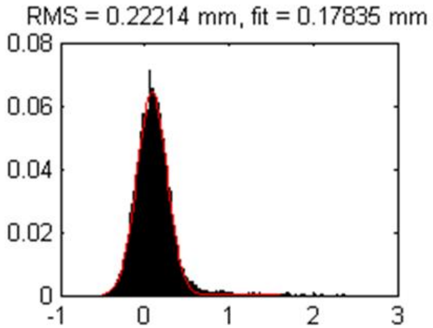
- The shift of trajectory for different R56 is below 10 nm in each of the quads.
- The trajectory returns to the reference orbit at wiggler's exit.

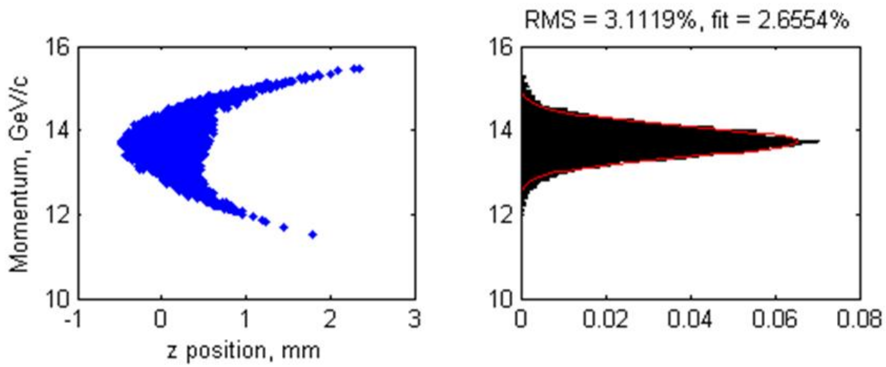
New Wiggler's Design

- Final length 0.3 mm









- Final length 0.2 mm