Electron Storage Ring Version 5.1

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Contents

- Differences from Version 5.0
- Geometry comparison with existing Blue and Yellow rings
- Averaged FODO cell in the ARCs
- Solenoid modules

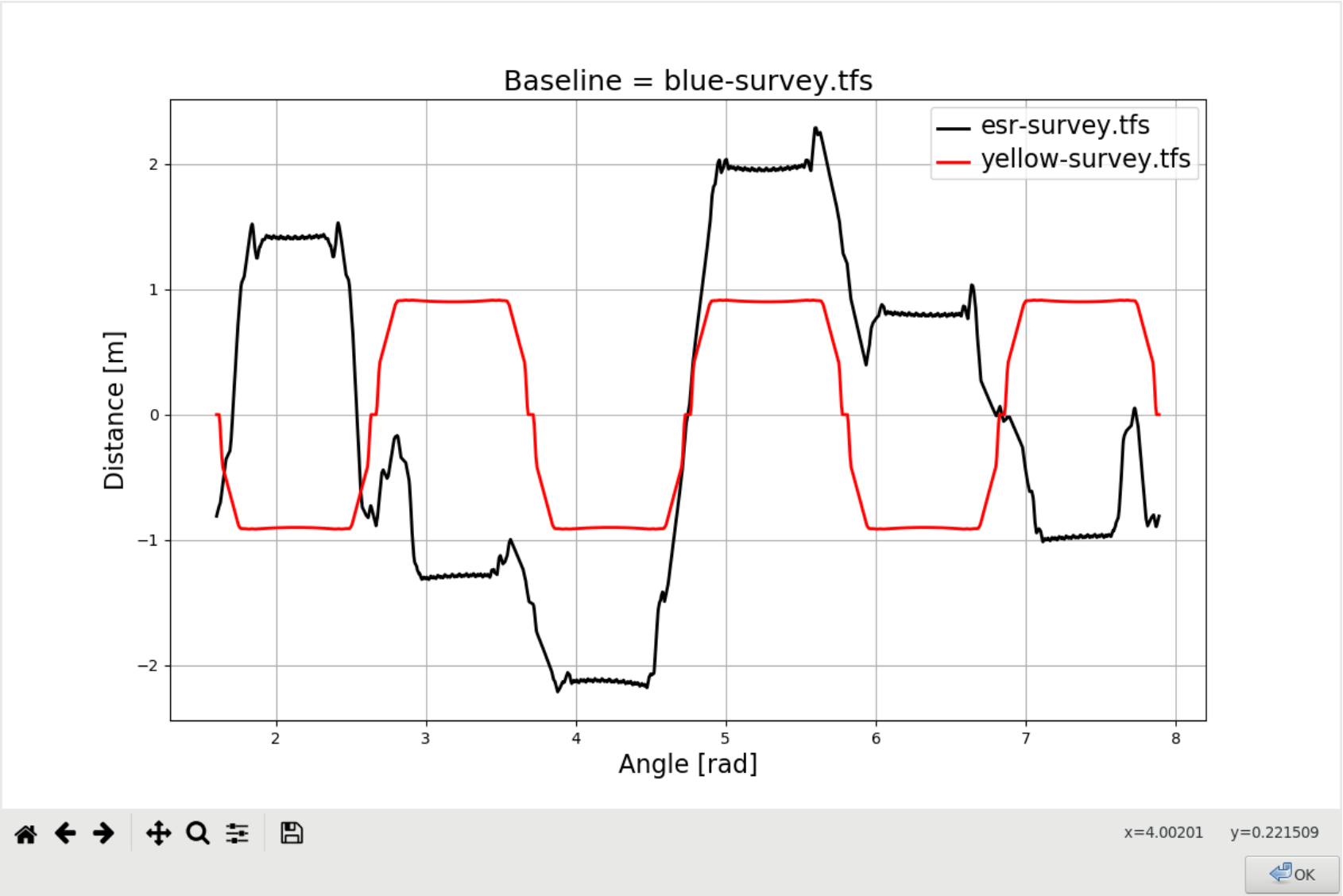
Following, both 10 GeV and 18 GeV are presented:

- Two Colliding sections (IR8 in non-colliding mode)
- Four straight sections
- Full ring
- Radiation parameter behavior with average momentum shift

Differences from Version 5.0

- Reduced quadrupole strength in the solenoid modules
  - Simplified solenoid modules (to 5 quadrupoles)
  - Horizontal dispersion can be non-zero through the module
- Fewer quadrupoles in the spin rotator dipole modules
- Geometry rematch
- IP12 (for injection) is not a zero dispersion straight section
- Matching the $\partial\eta_x/\partial\delta$ to the arcs.
  - Improves the emittance behavior with momentum
- Phase advance across the colliding IRs to be 360°.
- Some additional quadrupoles in the straight sections
  - More may be needed to reduce the β values
- Updated the IR quadrupoles from B. Palmer

Ring Geometry – Relative to the current Blue ring



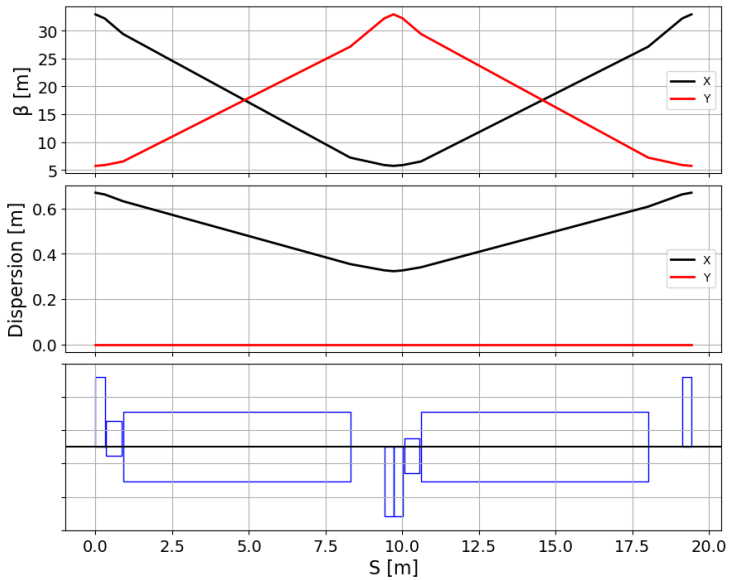
Ring Geometry – Position change from current RHIC IP

IP	Shift [m]	Angle [mrad]
IP6	-0.81	8.00
IP8	-0.81	8.00
IP10	-1.50	-1.26
IP12	0.00	-12.00
IP2	1.25	-5.12
IP4	0.00	8.31

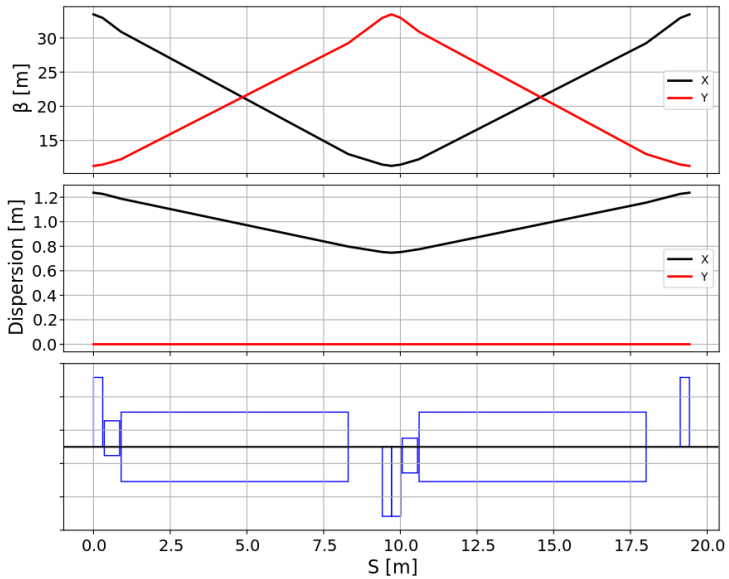
- Circumference $= 3833.940\,m$
- Path length from IP6 to IP8 $= 640.940\,m$

Average length FODO FCell: 90° and 60°

90°



60°



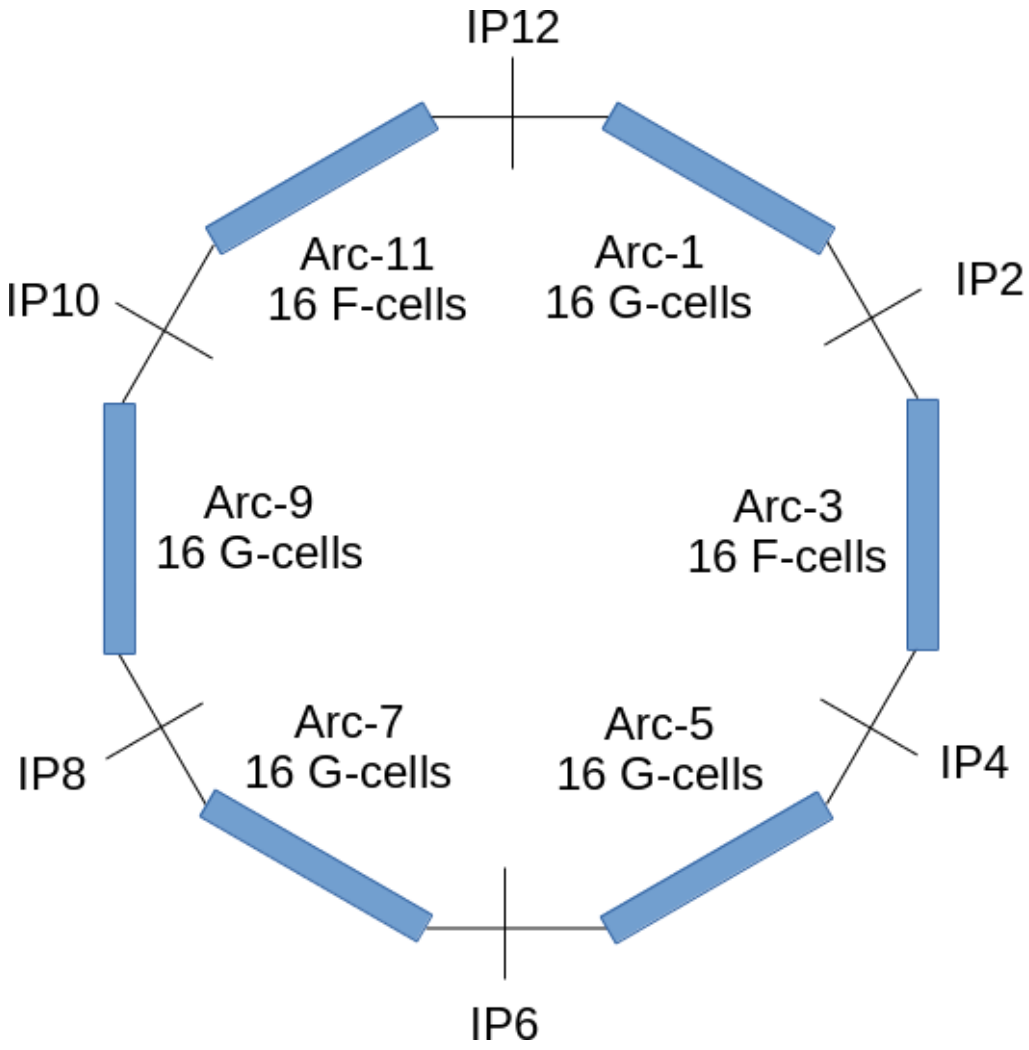
- The corresponding GCell is the mirror image of the FCell.
- Drift space between dipole and quad varies from ARC to ARC
- BPMs are between the sextupole and quadrupole

FCell/GCell parameters

Cell length [m]	19.423
Dipole length [m]	7.400
Quadrupole length [m]	0.600
Sextupole length [m]	0.500
Corrector length [m]	0.250
Dipole bending radius [m]	289.906

- Cell length varies for the arcs giving different average radii
- The drift space which will hold the orbit corrector is changed
- Room to increase the dipole length.

Arcs distribution through the ring

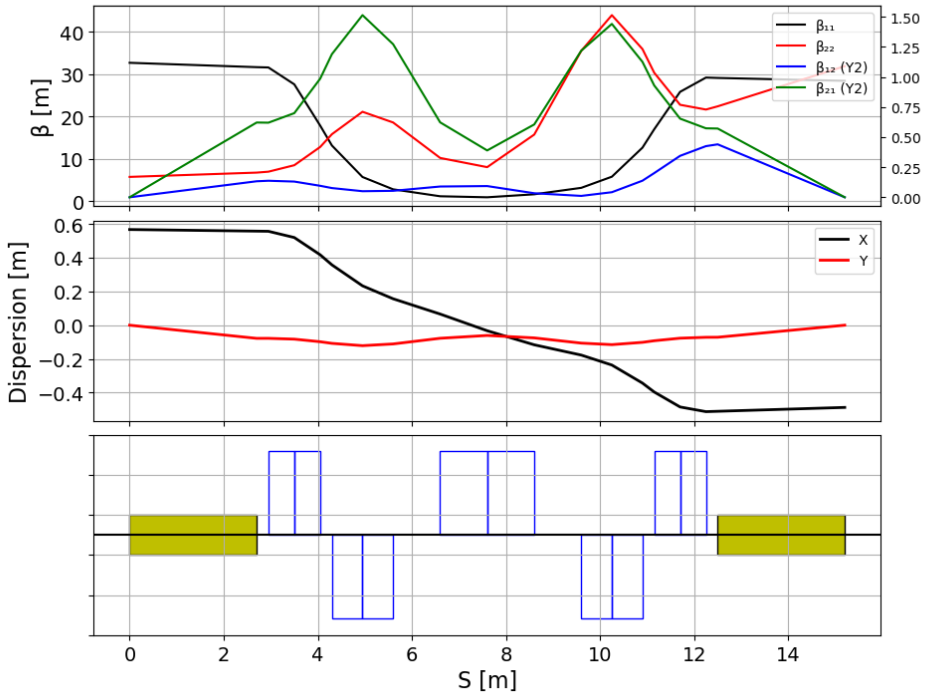


Short Solenoid Module, using 18 GeV solenoid strengths

Quad	Length [m]	Strength $[m^{-2}]$
QB15	1.10	0.42069
QB16	1.45	-0.47319
QB18	2.30	0.48933
QB22	1.45	-0.47319
QB23	1.10	0.42069

$\mu_x = 0.81864$ $\mu_y = 0.44148$

$Length = 14.8\ m$

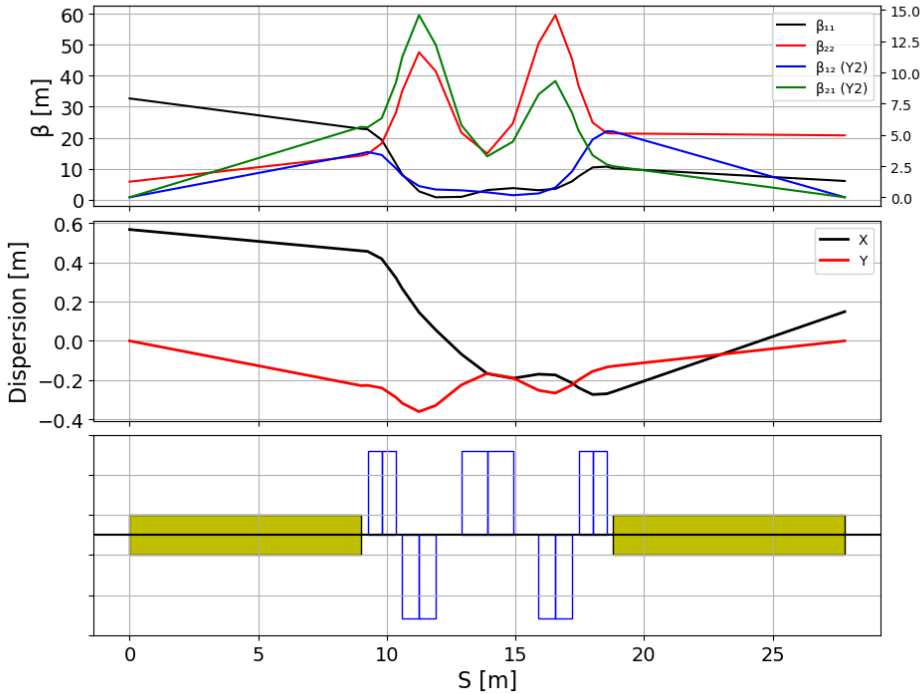


Long Solenoid Module, using 18 GeV solenoid strengths

Quad	Length [m]	Strength $[m^{-2}]$
QA15	1.10	0.46869
QA16	1.45	-0.49901
QA18	2.30	0.47028
QA22	1.45	-0.49901
QA23	1.10	0.46869

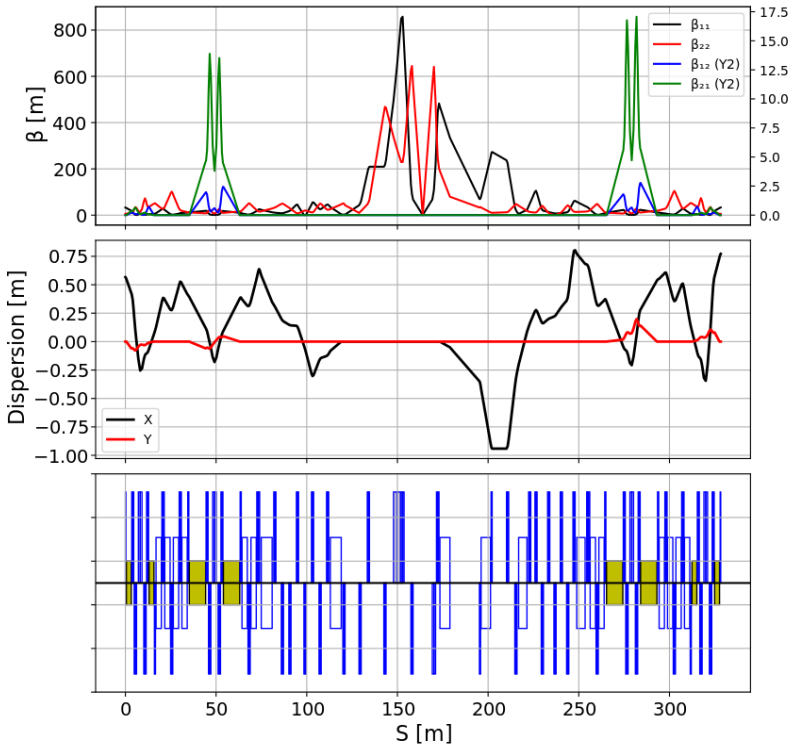
$\mu_x = 1.10276$ $\mu_y = 0.51994$

$Length = 28.1\ m$

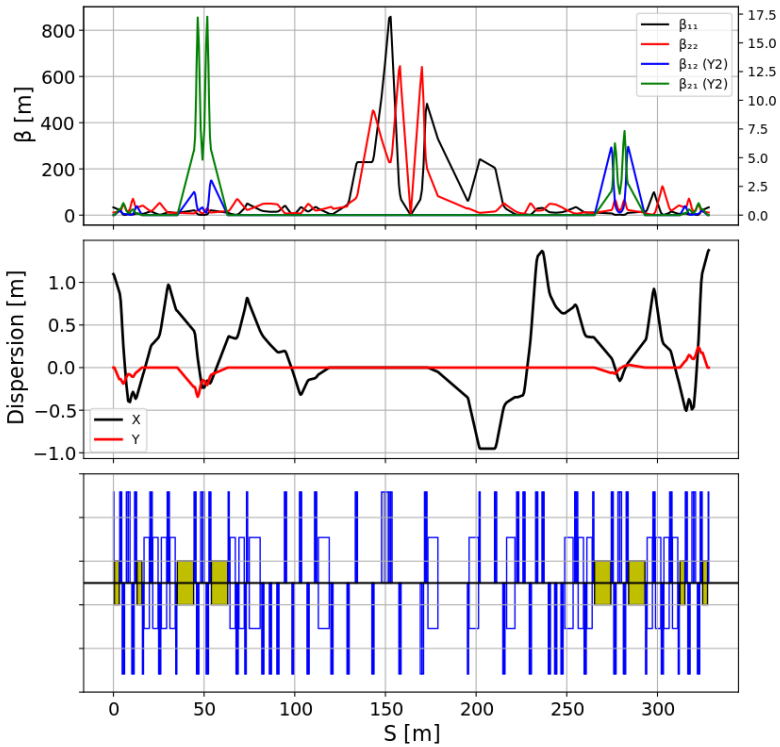


IR6 $\rightarrow$ $\beta_{max} = (860\,m, 645\,m)$ with $\beta^* = (42\,cm, 5\,cm)$

18 GeV

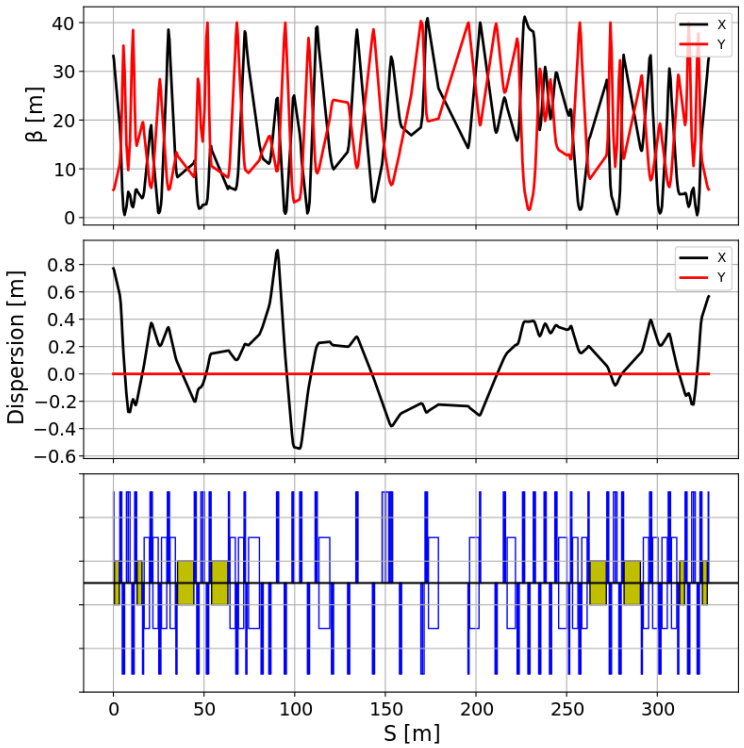


10 GeV

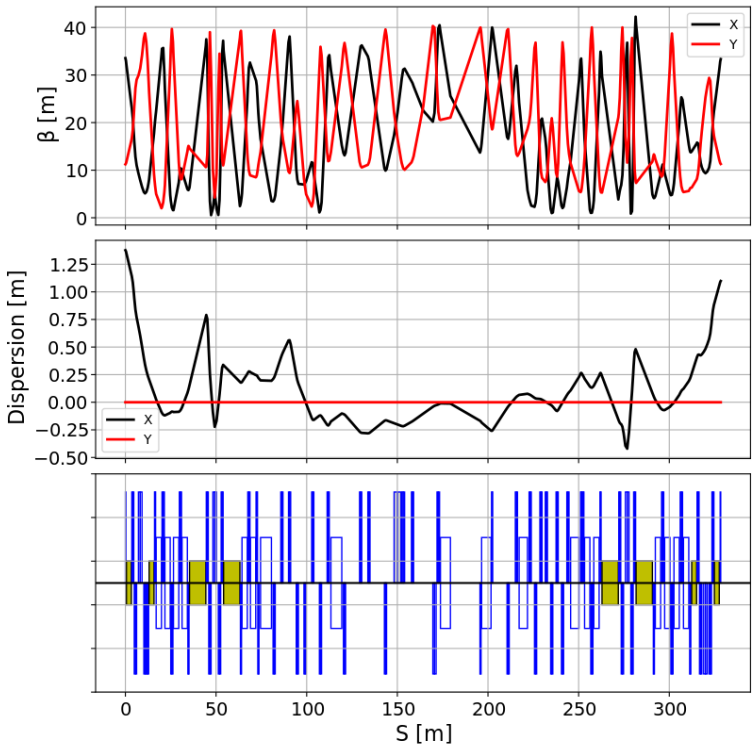


IR8 – Non-colliding mode (solenoids are off, $\beta_{max} \lessapprox 40\,m$)

18 GeV

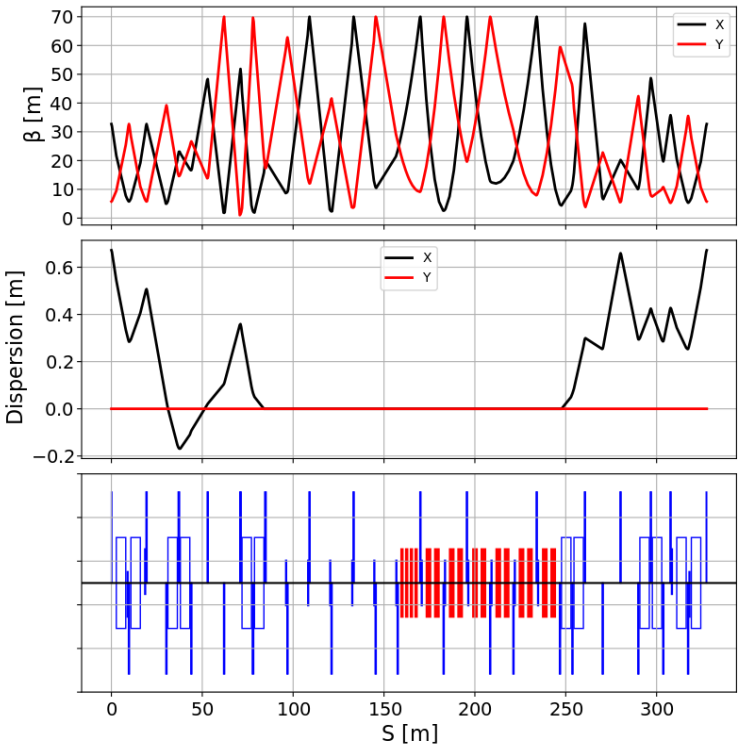


10 GeV

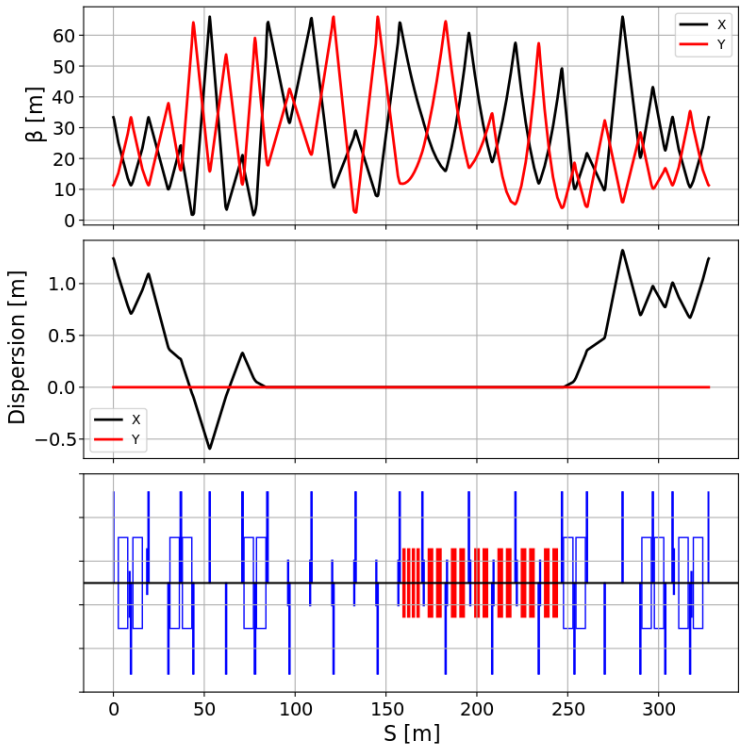


IR10 – Straight Section with RF cavities

18 GeV

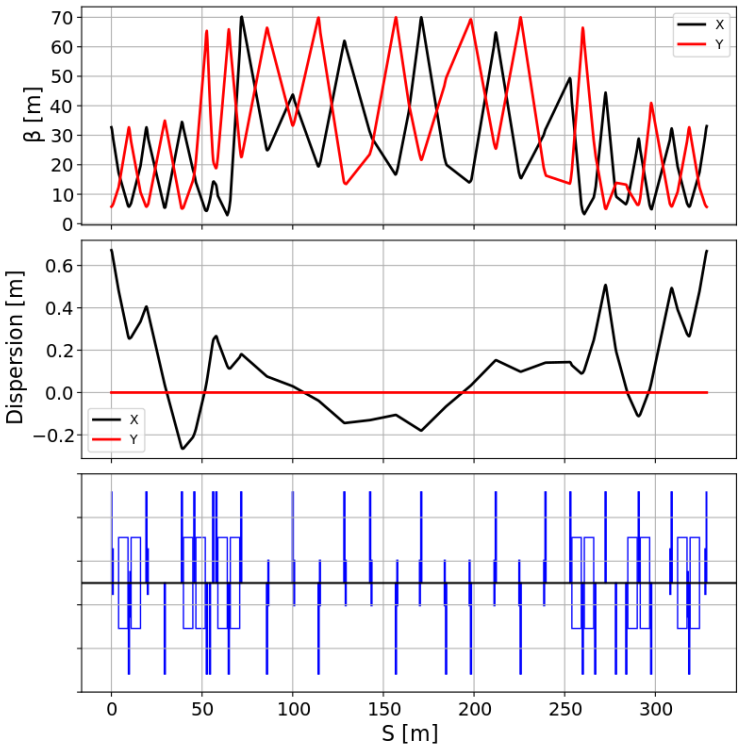


10 GeV

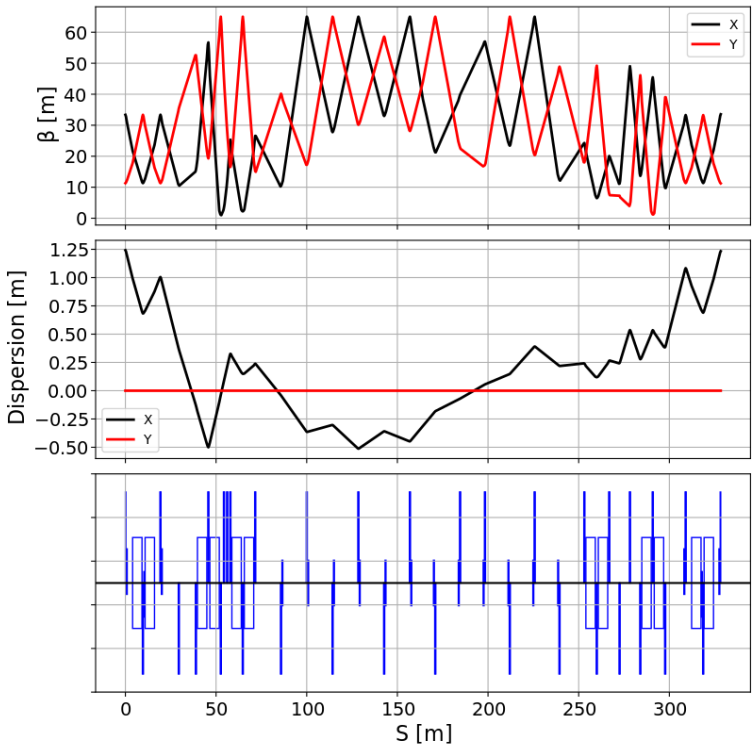


IR12 – Straight section will include the injection system

18 GeV

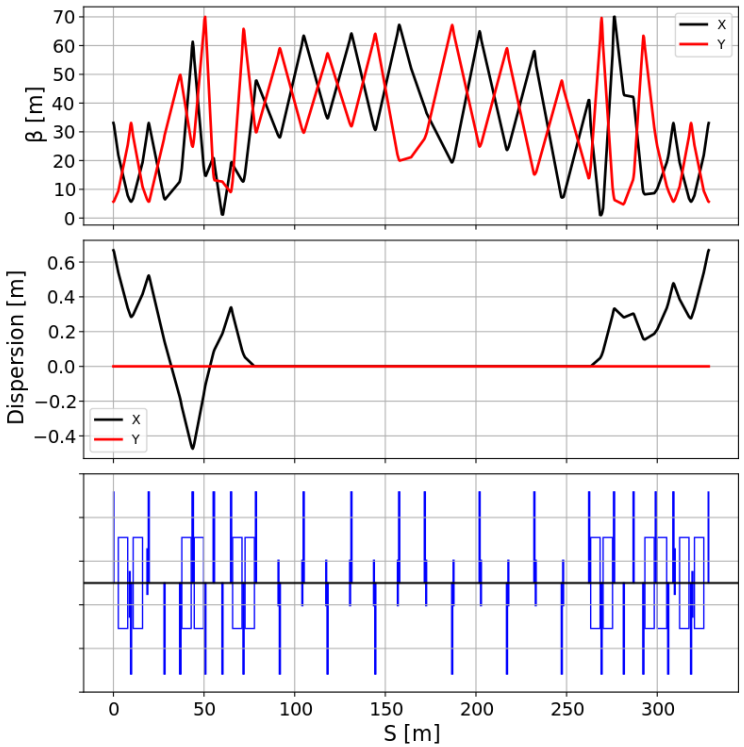


10 GeV

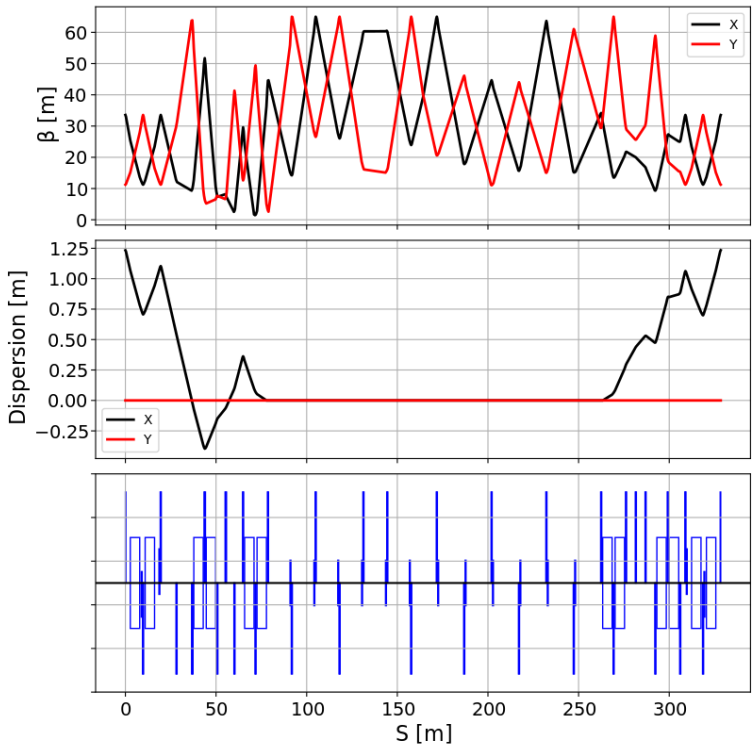


IR2 – Straight Section

18 GeV

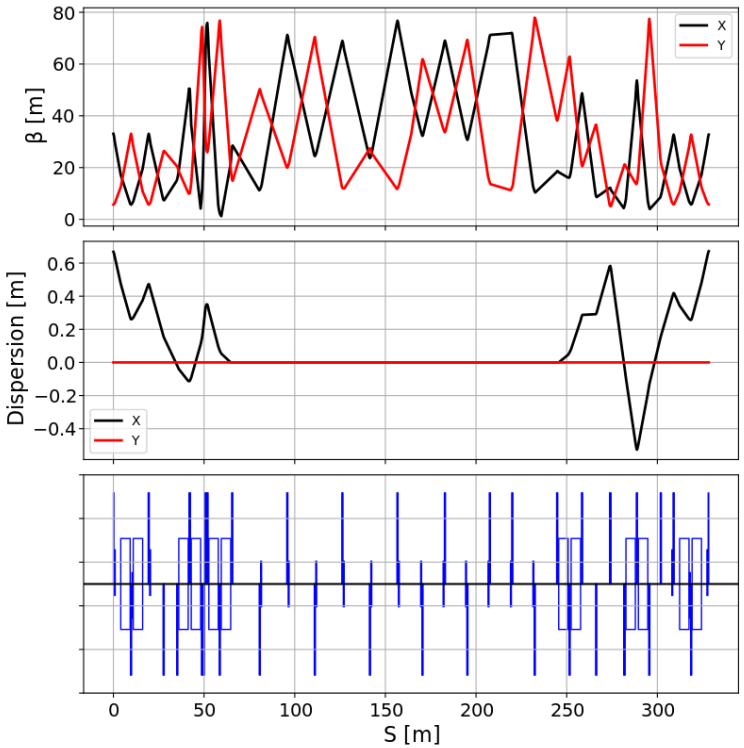


10 GeV

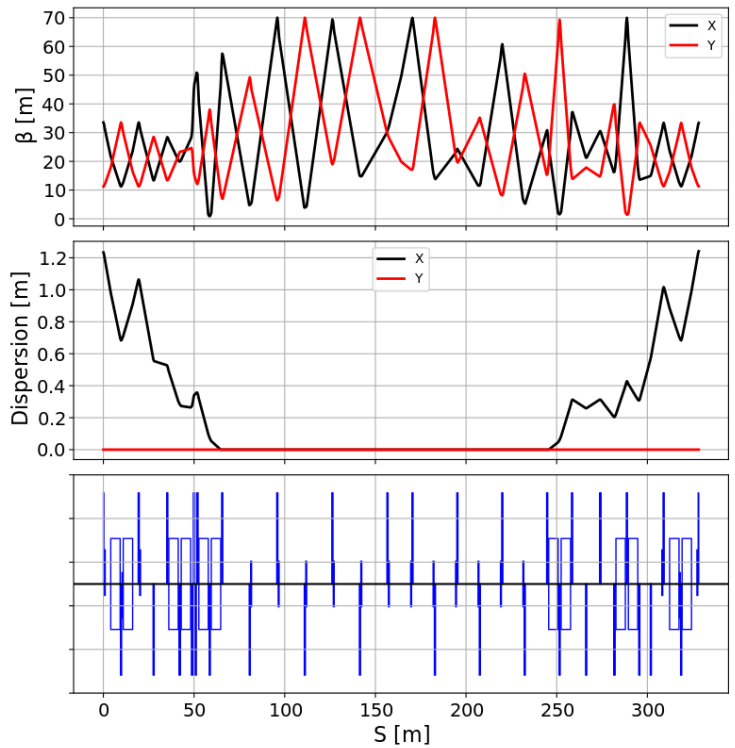


IR4 – Straight Section

18 GeV

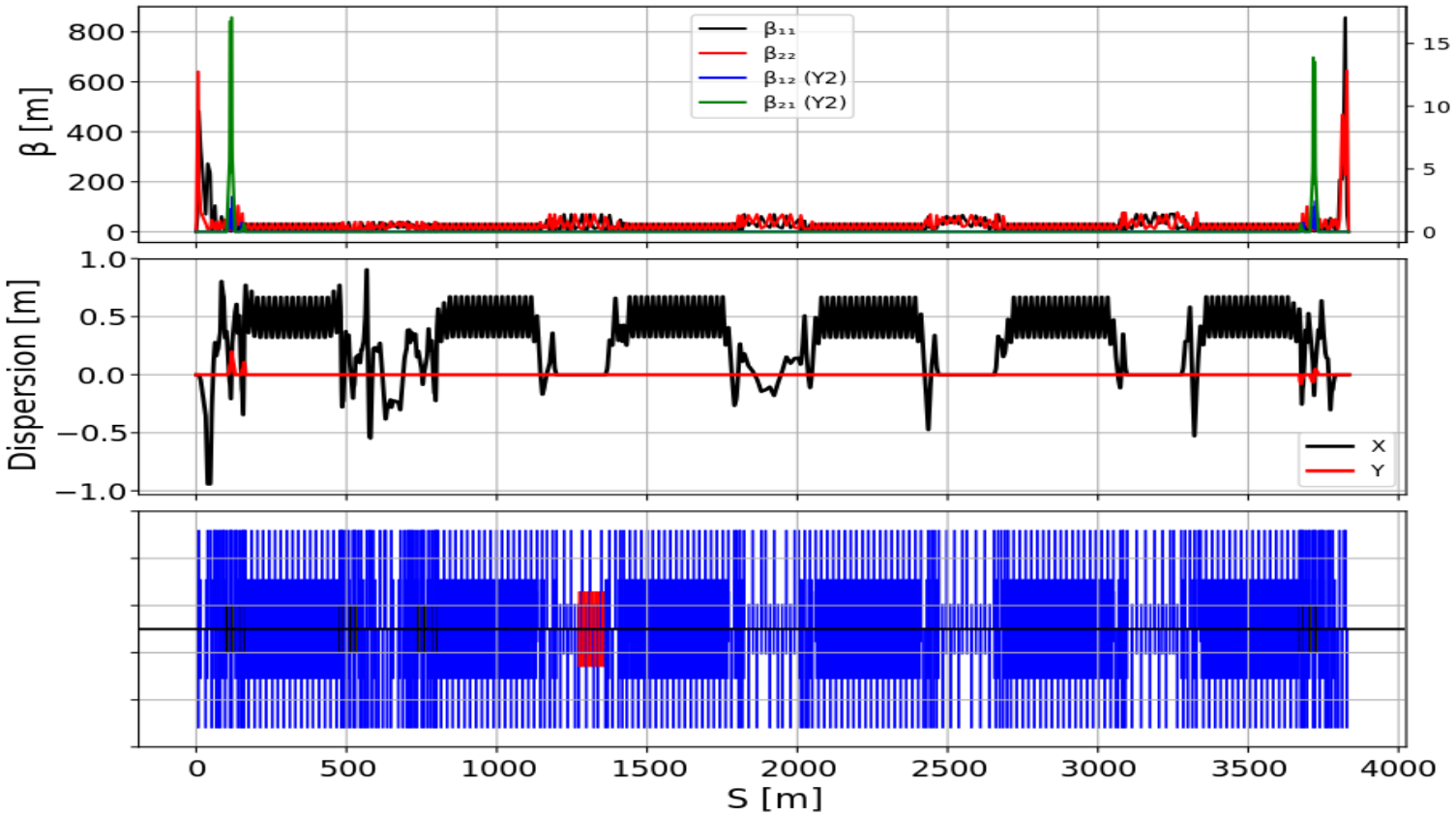


10 GeV

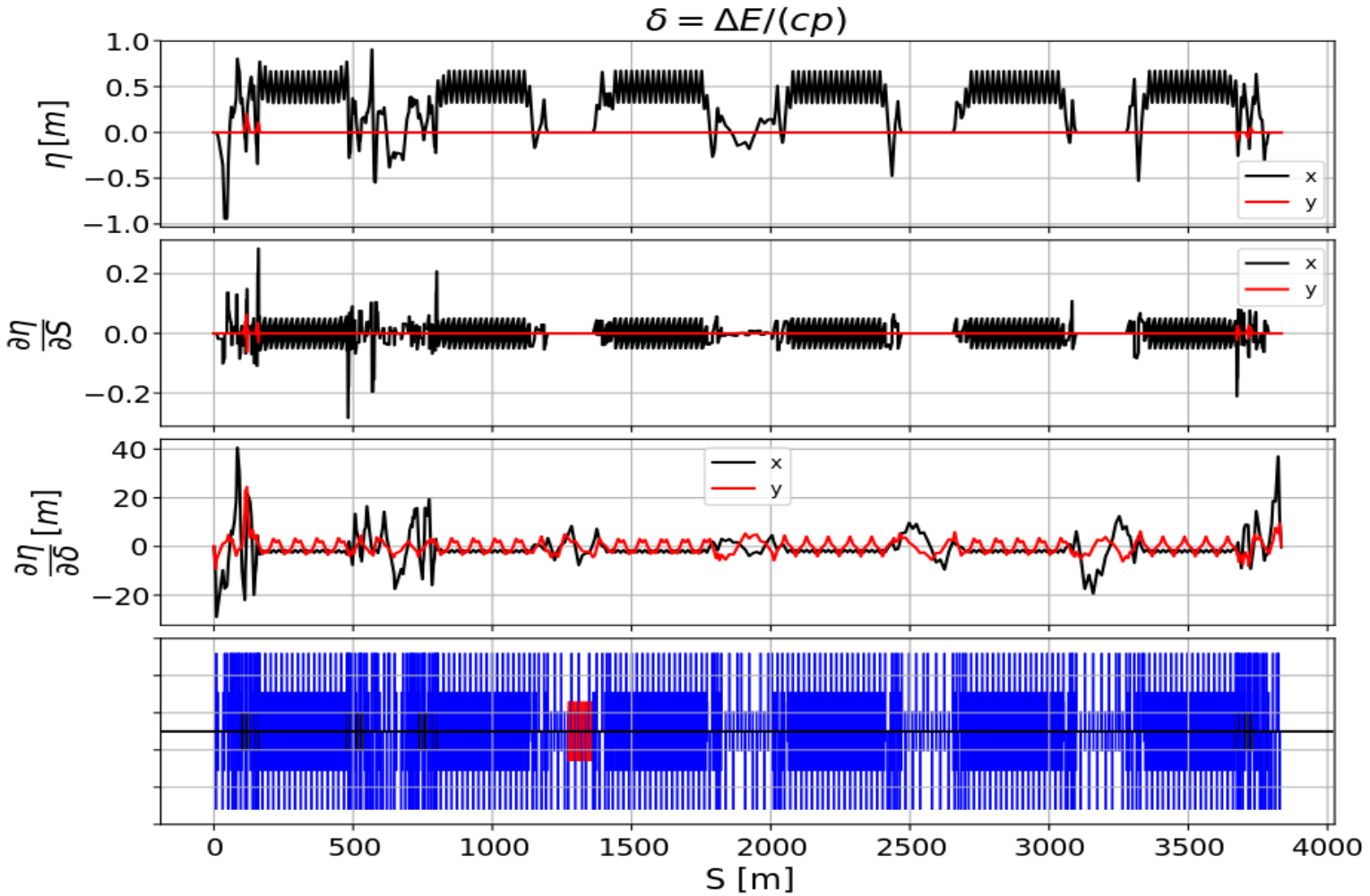


18 GeV: Full ring, $Q_x = 53.12$, $Q_y = 43.1$, 90° cells

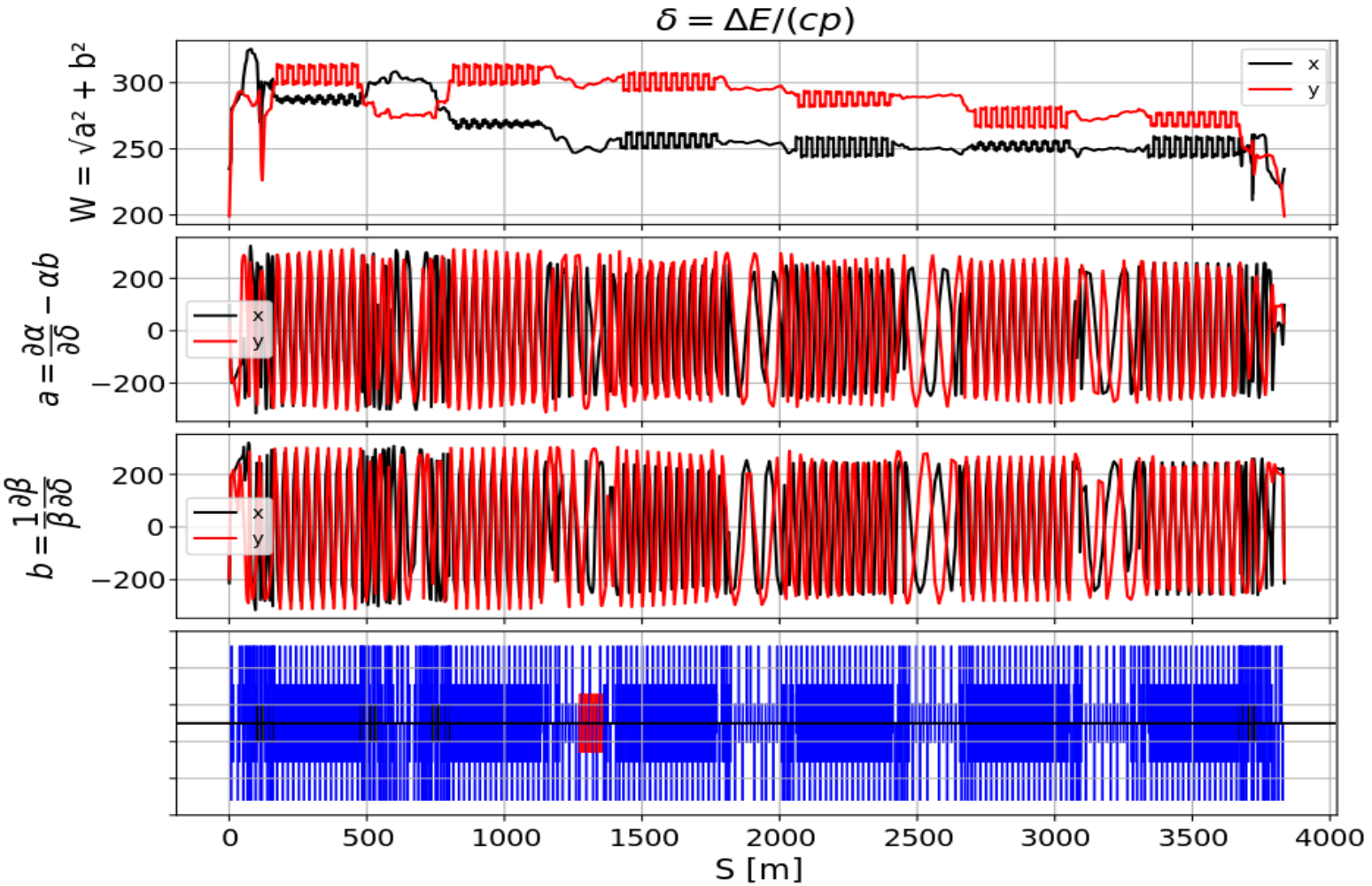
36.582 *MeV/turn*, Emittance = 33.9 *nm* and $\beta_{max} = 860\ m$



18 GeV: Dispersion functions

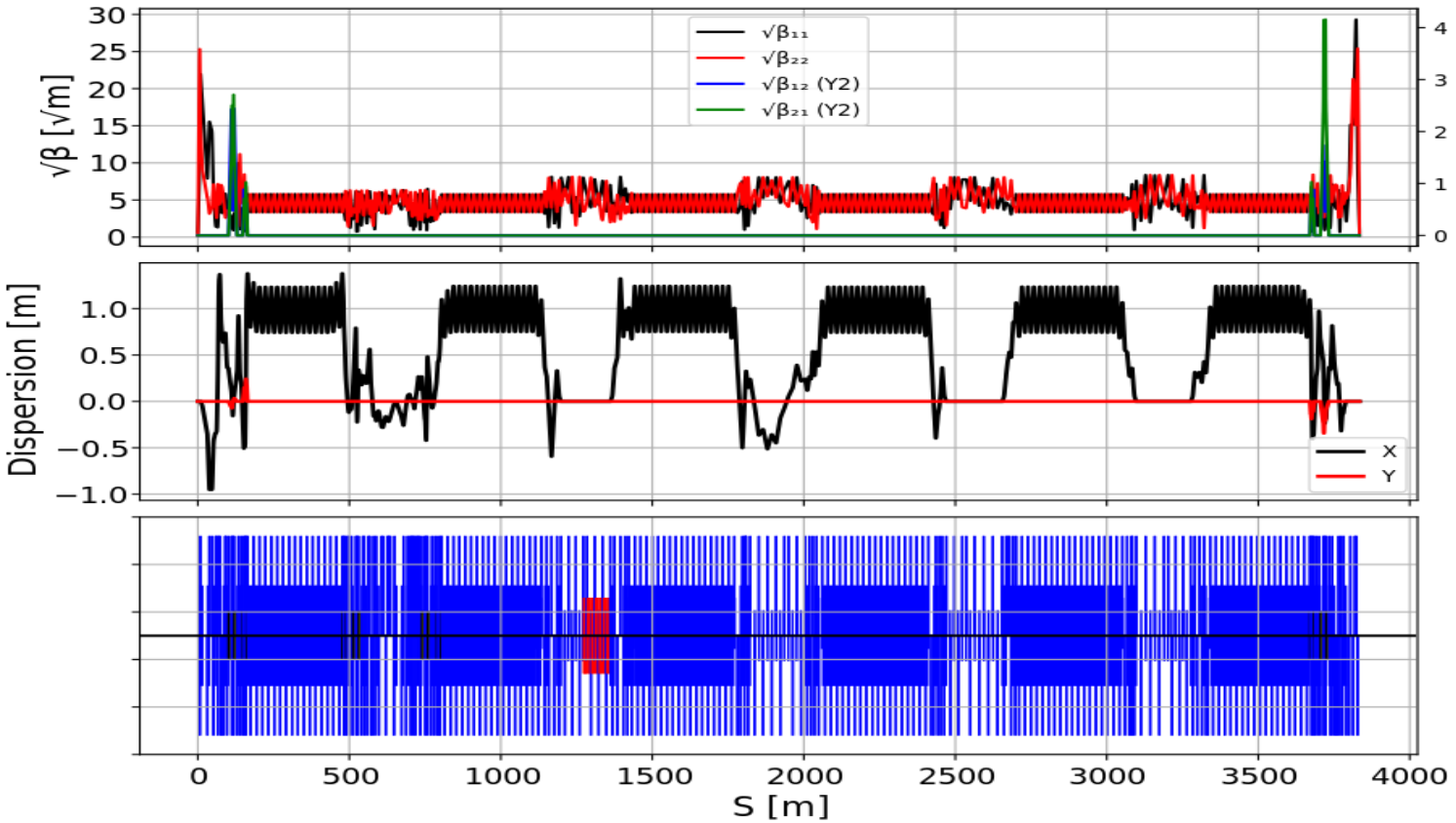


18 GeV: Chromatic functions

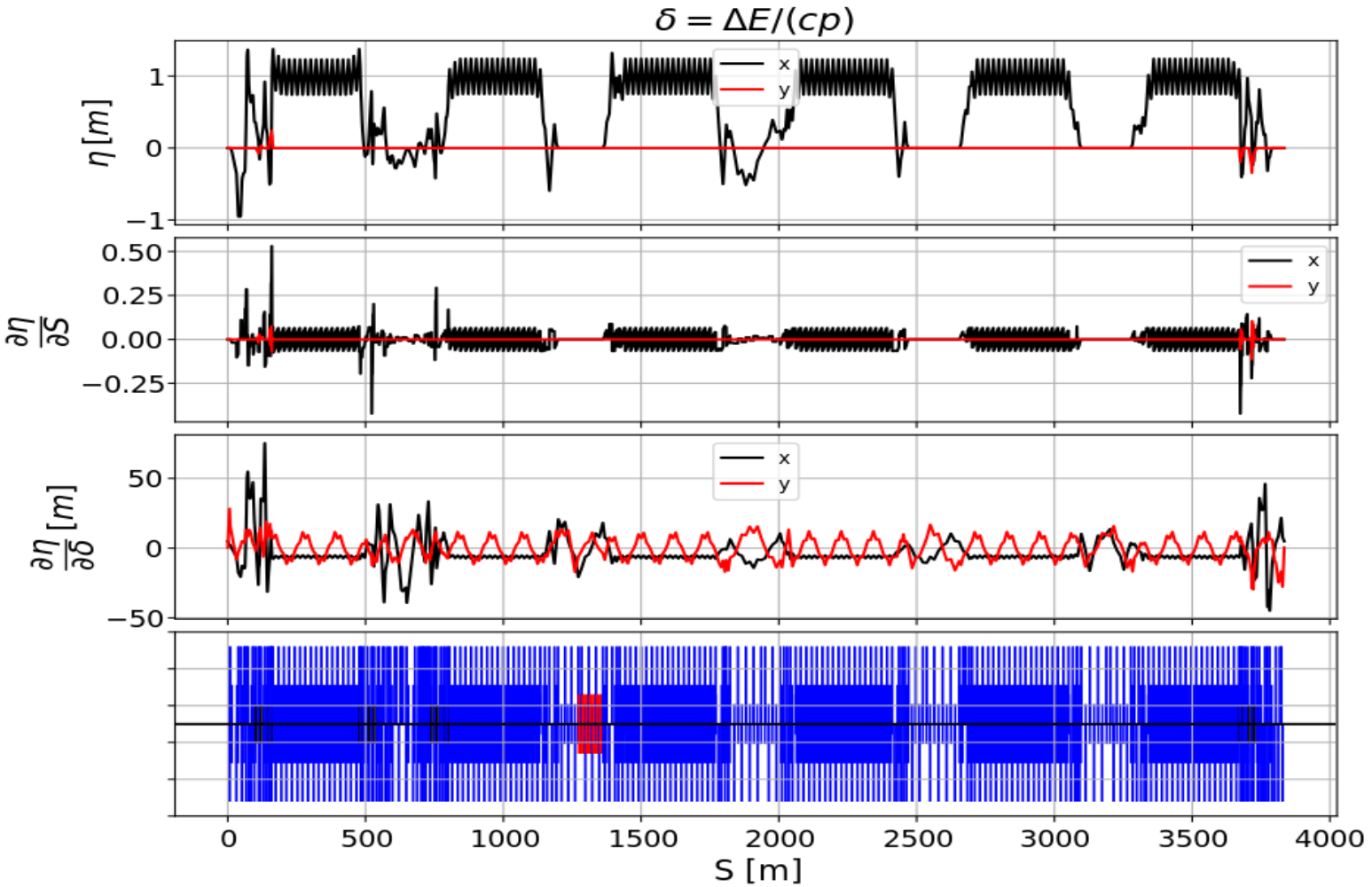


10 GeV: Full ring, $Q_x = 42.12$, $Q_y = 35.1$, 60° cells

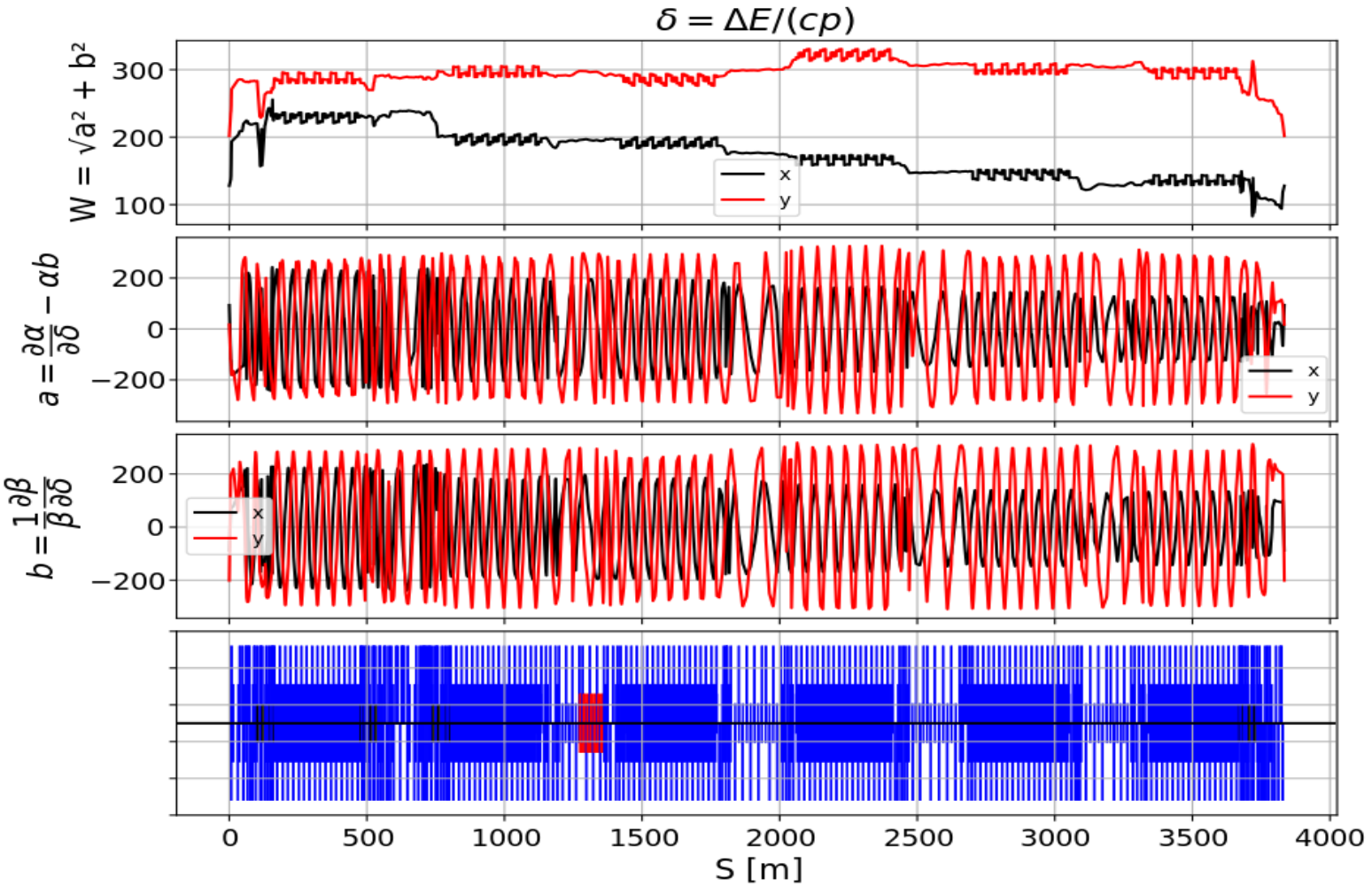
3.485 *MeV/turn*, Emittance = 23.0 *nm* and $\beta_{max} = 860\ m$



10 GeV: Dispersion



10 GeV: Chromatic functions



Nonlinear tune dependence, from PTC in MADX

18 GeV

Order	Chrom X	Chrom Y
0	0.120	0.100
1	0.909	0.941
2	-7420	-4663
3	-1.717×10^5	3.767×10^6
4	-6.113×10^8	-1.240×10^9

$$\alpha_{xx} = -938.0$$
$$\alpha_{xy} = \alpha_{yx} = -8947.9$$
$$\alpha_{yy} = 951.4$$

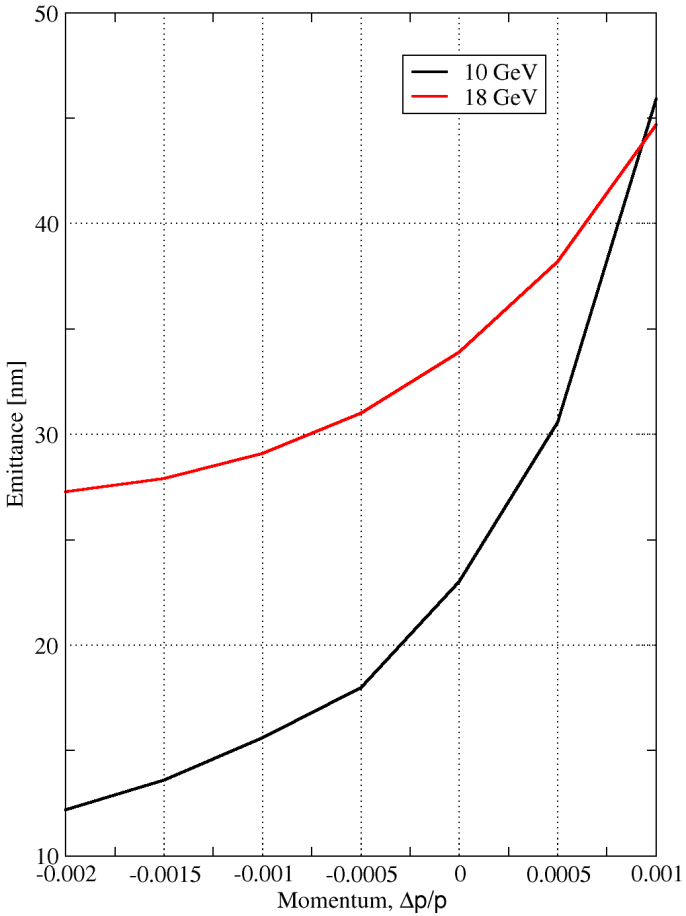
10 GeV

Order	Chrom X	Chrom Y
0	0.120	0.100
1	0.883	0.915
2	-2590	-5406
3	1.666×10^5	4.225×10^6
4	2.364×10^8	-3.329×10^9

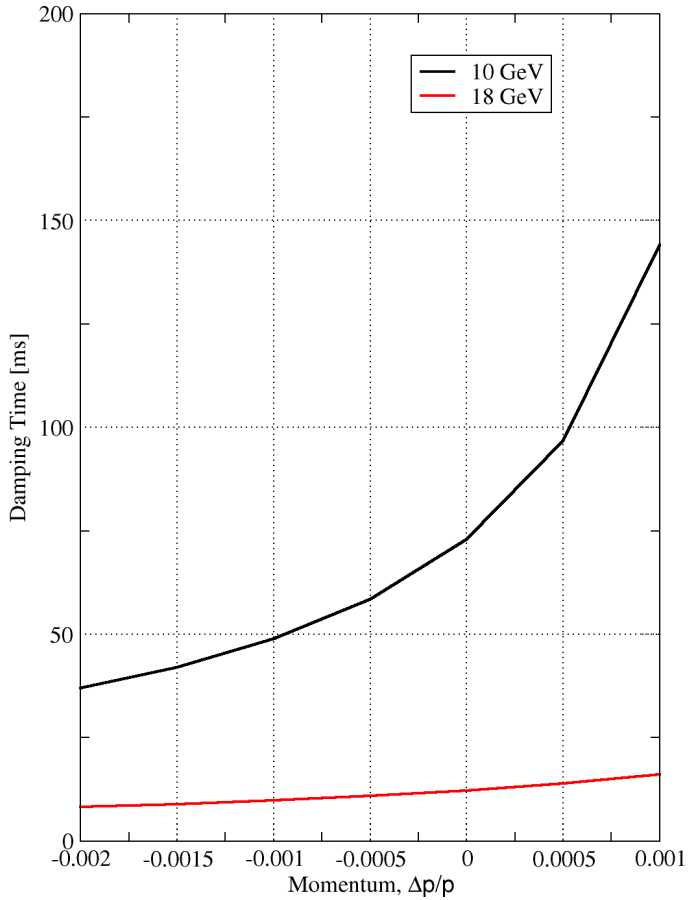
$$\alpha_{xx} = -1628$$
$$\alpha_{xy} = \alpha_{yx} = -5226$$
$$\alpha_{yy} = -1344$$

Emittance and Damping Time vs Momentum

Emittance



Damping Time



TODO for future versions...

- More quadrupoles in all the *IRs/straights* are needed
  - Provides enough parameters to vary to meet the constraints
  - Some quadrupoles need to be lengthened (18 GeV)
- Phase changes in *IRs/straights* to improve momentum aperture
- Additional work on the geometry (Ring fits in tunnel):
  - Additional dipoles due to the cryo-chambers in IP12 and IP4
  - Push IP2 to the tunnel wall due to the hadron cooling system
  - Preserve the Blue ring
- Add the super-bends
- Add BPMs and orbit correctors
  - There is 0.77 m space available in the Arcs. If this can be reduced the dipole length can be increased