FFAG Workshop

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My WWW home directory:
`http://keil.home.cern.ch/keil/MuMu/Doc/FFAG/ffagtalk.pdf`

Scenario I – Distributed Super-Conducting RF

- Carol Johnstone's lattice: Circular ring with 3 m long straight sections, enough for s.c. RF cavity at 200MHz and space for magnetic field decay to about 10 mGauss
- Space for up to 2*314=628 cavities and about 2km circumference.
- At 16MV/m peak voltage gradient the effective accelerating voltage is 4.5 GV/turn with RF cavities in all slots.
- Acceleration from 6 to 20 GeV needs more than 3.1 turns because of Δct
- Too large a circumference and too many RF cavities
- Unrealistic gradients can be fixed
- Muon decay not negligible

Scenario II – Distributed Normal-Conducting RF

- Compact lattice: Circular ring with 1 m long straight sections, enough for normal-conducting RF cavity.
  - Such a ring needs about 140 cells, has space for up to 280 RF cavities and about 1km circumference.
  - At 6MV/m peak RF gradient, effective accelerating voltage is 0.75 GV/turn,
  - More than 18.5 turns needed for acceleration from 6 to 20 GeV because of Δct
  - Even more unrealistic gradients can be fixed
  - Higher muon decay losses than in Scenario I
- Modified achromats cf. later foils

Scenario III – Lumped Super-Conducting RF

Racetrack-shaped ring with closely packed arcs without RF cavities, and straight sections with cells long enough for s.c. RF cavities

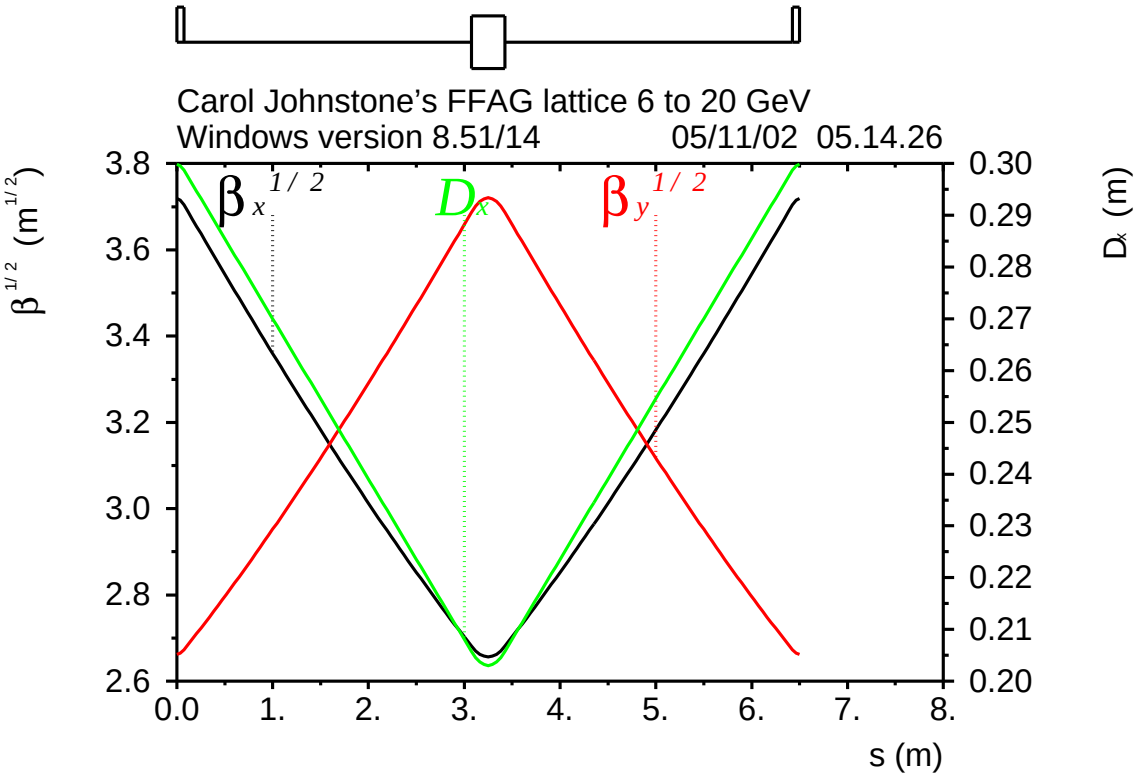
- 3m long free space accommodates single-cell cavities, 3.75 m free space double-cell cavities, and would be nearly twice as efficient.
- Transition regions adiabatically increase cell length from arc to straight section value.
- At 16MV/m peak RF gradient, about 1580 two-cell cavity traversals needed for acceleration from 6 to 20GeV.
- At 20 turns, this implies 79 two-cell cavity traversals on a turn.

Description of Carol Johnstone's Lattice oct28a

```
beam particle=posmuon energy=16.3
qf:  quadrupole l=0.15/2 k1=+1.3798
bd:  sbend l=0.35 angle=2*pi/314 k1=-0.59135
d:  drift l=3
carol:  line=(qf,d,bd,d,qf)
```

- Horizontal focusing in QF quadrupole
- Bending and vertical focusing in combined-function BD magnet
- 3 m long drift space long enough for super-conducting RF cavities

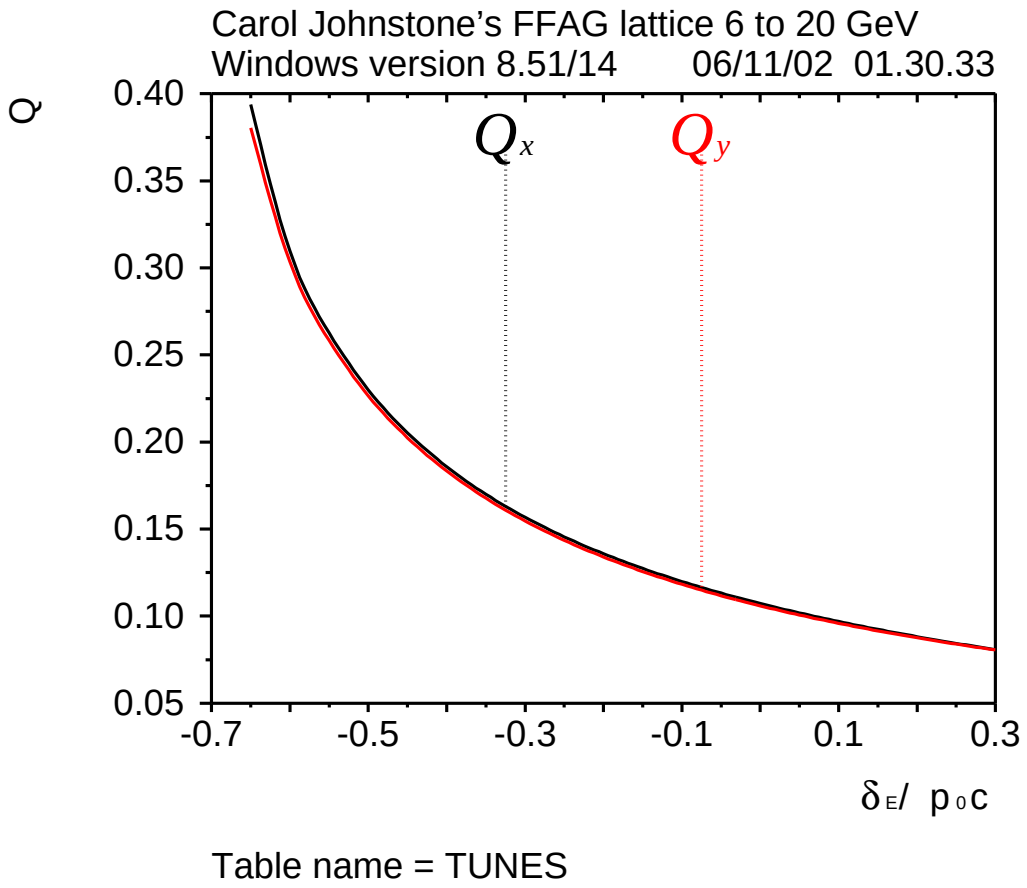
Layout and optical functions of a cell oct28a



Parameters of Johnstone's lattice oct28a

Total reference energy E	16.3	GeV
Energy range	6...20	GeV
Range of $\delta p/p$	$-0.636...0.212$	
Range of hor. offsets x	$-70.3...77.4$	mm
Period length L_p	6.5	m
Number of periods N_p	314	
Max. β-functions β_x/β_y	13.8/13.6	m
Max. Dispersion D_x	0.30	m
Phase advances μ_x/μ_y	0.107/0.105	
Chromaticities μ'_x/μ'_y	$-0.113/-0.111$	
Dipole field B	3.11	T
F quadrupole gradient G	75	T/m
Circumference C	2041	m
Path length spread	666	mm

Tune Variation with $\delta p/p$ in a cell oct28a

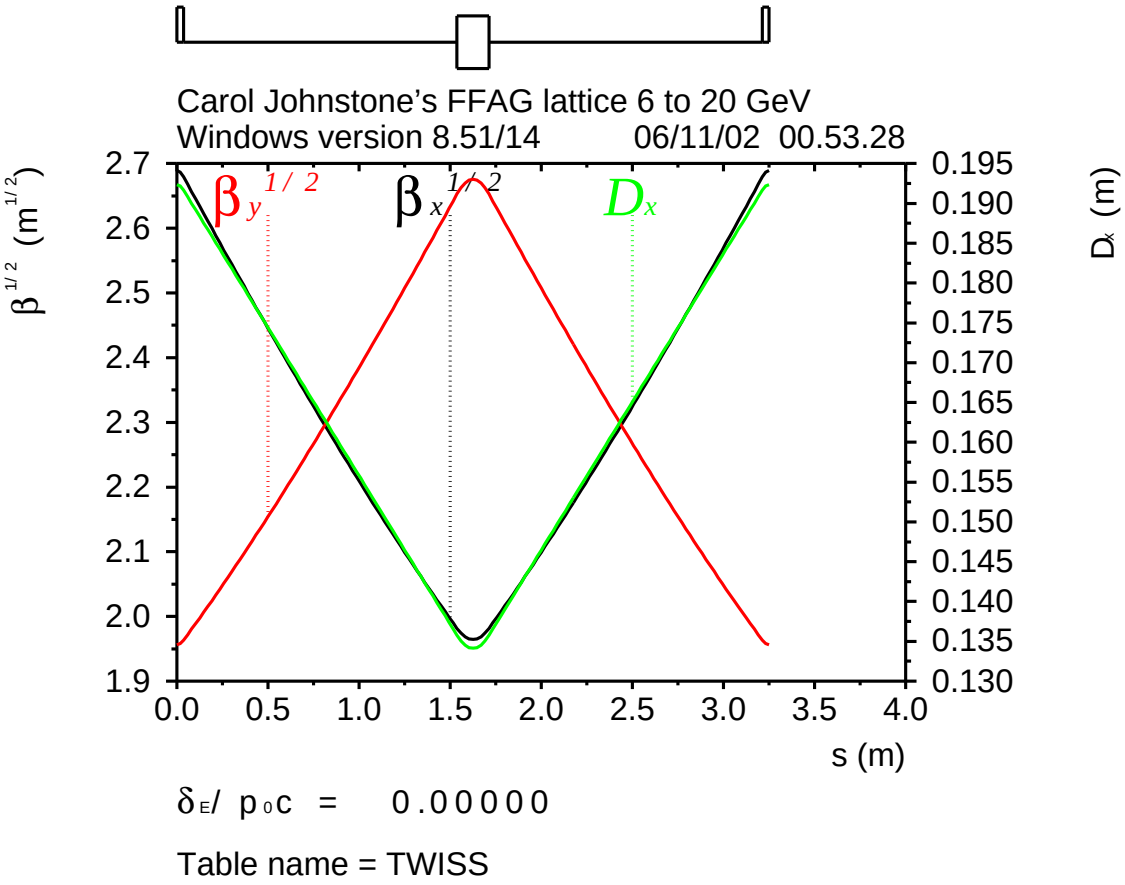


Description of Modified Johnstone Lattice oct31e

```
beam particle=posmuon energy=16
qf:  quadrupole l=0.15/4 k1=+5.1726
bd:  sbend l=0.35/2 angle=2*pi/314 k1=-2.2267
d:  drift l=3/2
carol:  line=(qf,d,bd,d,qf)
```

- Horizontal focusing in QF quadrupole
- Bending and vertical focusing in combined-function BD magnet
- 1.5 m long drift space long enough for normal-conducting RF cavities

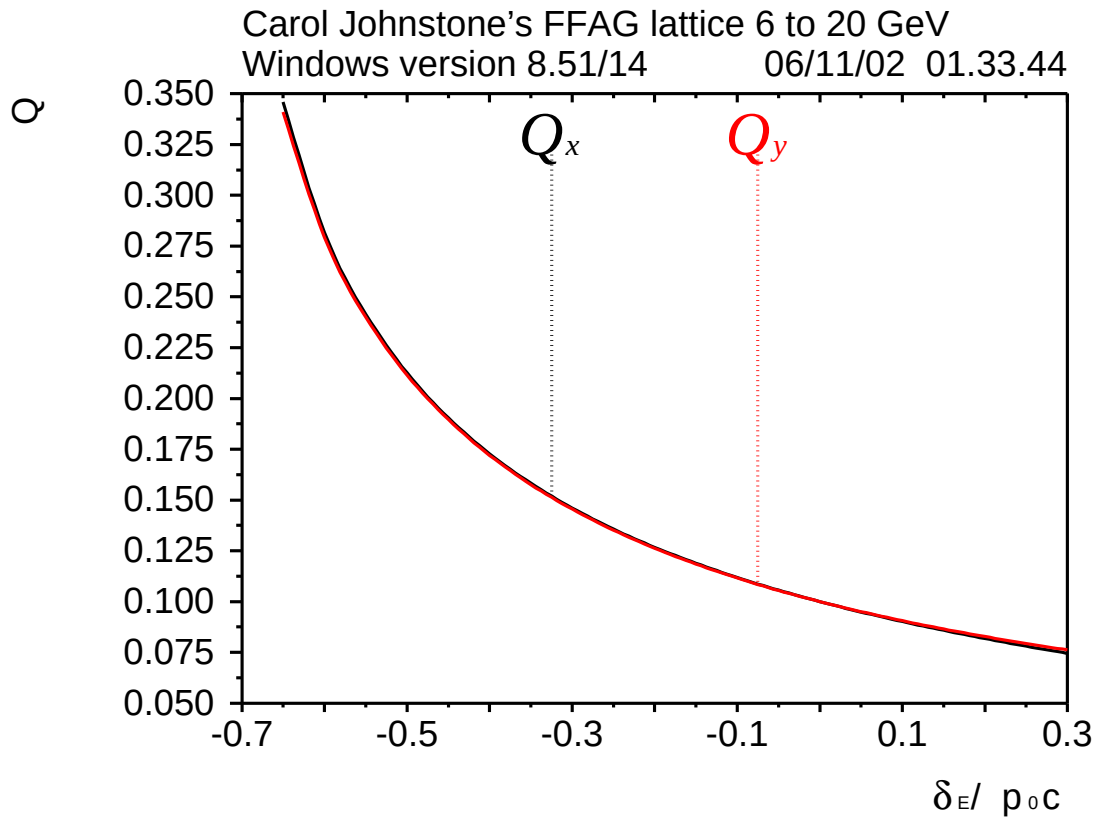
Layout and optical functions of a cell oct31e



Parameters of modified Johnstone's lattice oct31e

Total reference energy E	16	GeV
Energy range	$6 \ldots 20$	GeV
Range of $\delta p/p$	$-0.625 \ldots 0.250$	
Range of hor. offsets x	$-44.9 \ldots 50.0$	mm
Period length L_p	3.25	m
Number of periods N_p	280	
Max. β-functions β_x/β_y	7.23/7.04	m
Max. Dispersion D_x	0.17	m
Phase advances μ_x/μ_y	0.1/0.1	
Chromaticities μ'_x/μ'_y	$-0.107/-0.104$	
Dipole field B	6.8	T
F quadrupole gradient G	276	T/m
Circumference C	910	m
Path length spread	410	mm

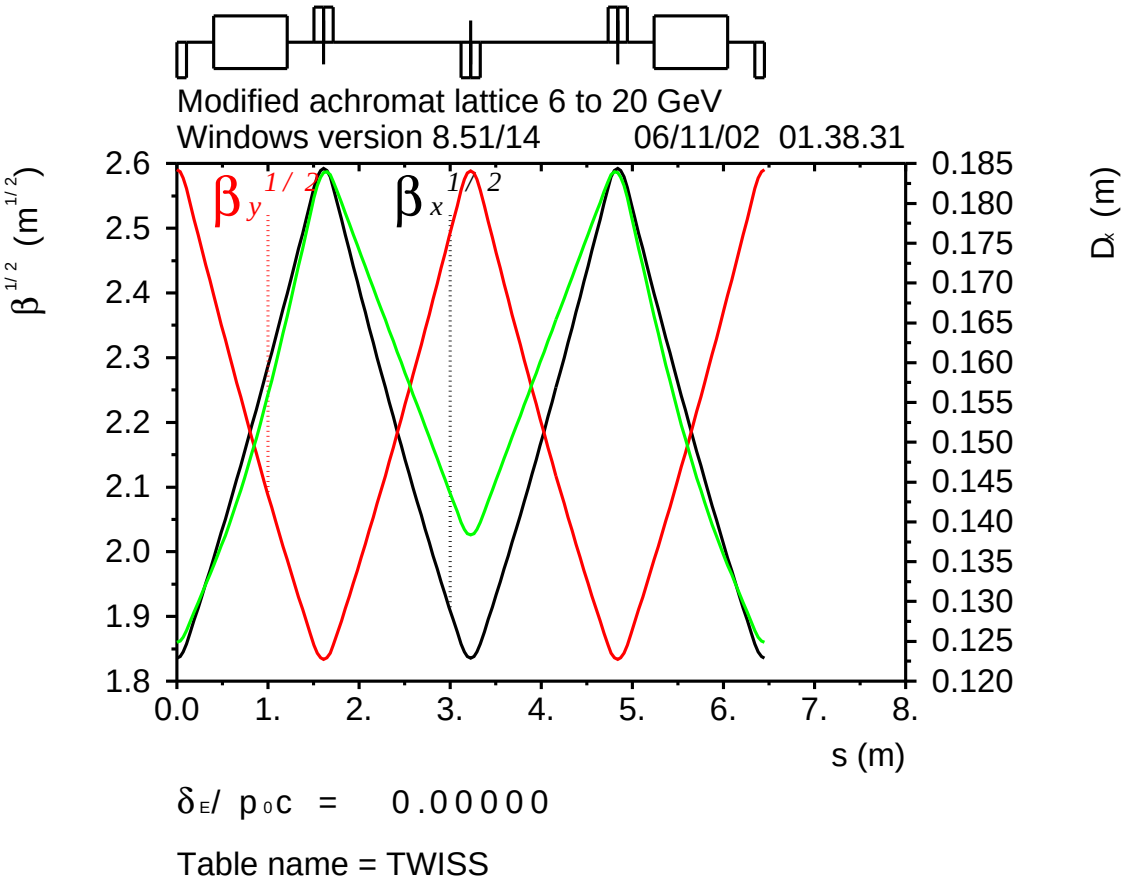
Tune Variation with $\delta p/p$ in a cell oct31e



Properties of modified achromats

- Achromats
  - used in ELFE and RLA design at CERN
  - consist of 2 FODO cells for focusing
  - have dipoles in half cells surrounding every second F quadrupole
  - D_x vanishes in every second F quadrupole
- Modified achromats
  - have opposite quadrupole polarities
  - $D_x > 0$ everywhere
  - have half cells without dipoles providing space for n.c. RF system
  - have path length spread proportional to number of achromats

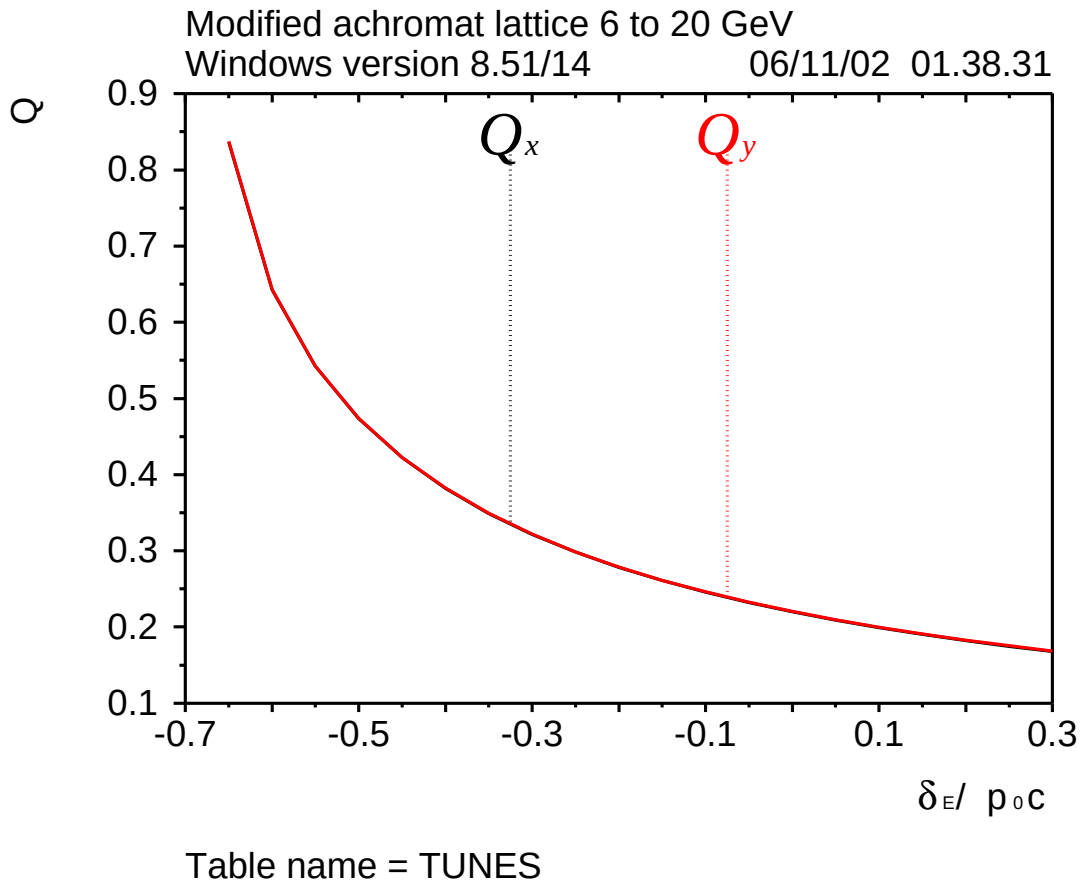
Layout and optical functions of modified achromat lattice achro6



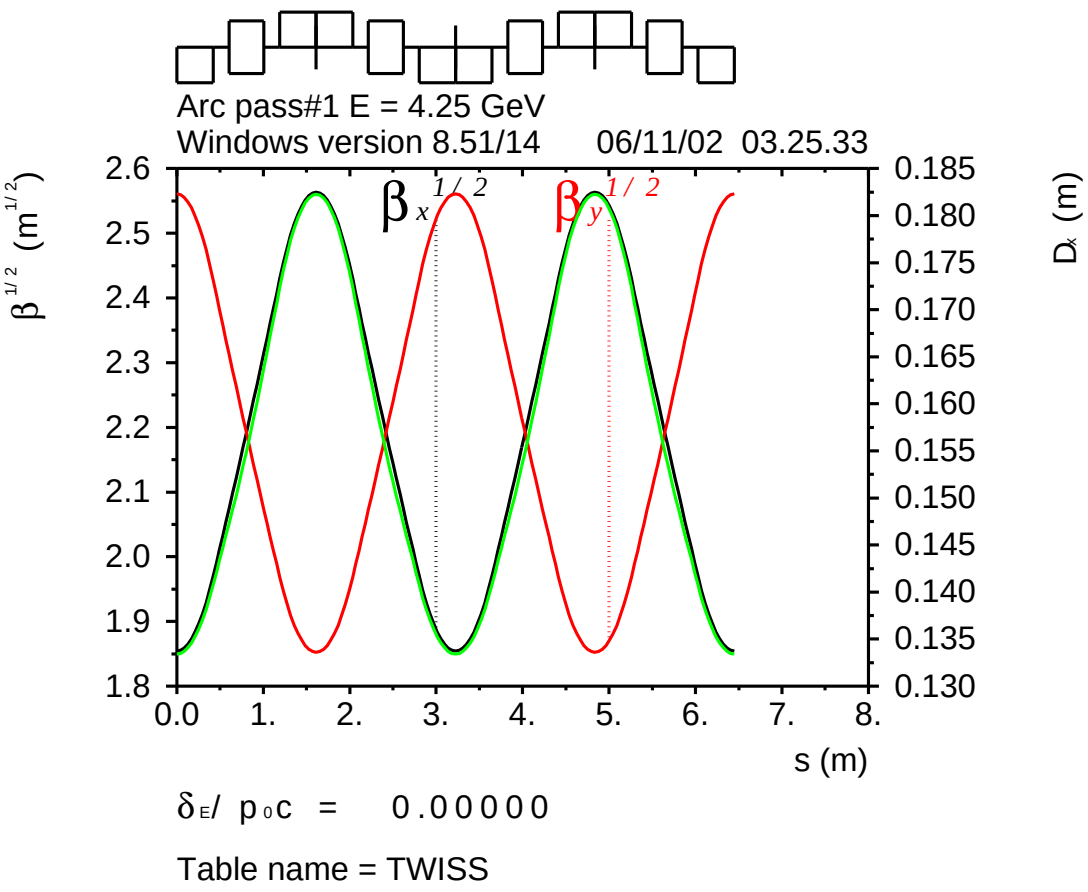
Modified Achromat Parameters achro6

Total reference energy E	16.5	GeV
Energy range	$6 \ldots 20$	GeV
Range of $\delta p/p$	$-0.636 \ldots 0.212$	
Period length L_p	6.449	m
Number of periods N_p	140	
Max. β-functions β_x/β_y	6.72/6.71	m
Max. Dispersion D_x	0.18	m
Phase advances μ_x/μ_y	0.22/0.22	
Chromaticities μ'_x/μ'_y	$-0.229/-0.229$	
Dipole field B	1.53	T
Quadrupole gradient	1.15	T/m
Circumference C	902.8	m
Path length spread/cell	397	mm

Tune Variation with $\delta p/p$ in achro6



Layout and optical functions of arc lattice achro6c



Compact Arc Lattice Parameters achro6c

Total reference energy E	17	GeV
Energy range	6...20	GeV
Range of $\delta p/p$	$-0.647...0.176$	
Range of hor. offsets x	$-52.5...37.0$	mm
Period length L_p	3.2	m
Number of periods N_p	280	
Max. β-functions β_x/β_y	6.57/6.56	m
Max. Dispersion D_x	0.18	m
Phase advances μ_x/μ_y	0.11/0.11	
Chromaticities μ'_x/μ'_y	$-0.114/-0.114$	
Dipole field B	1.6	T
Quadrupole gradient	35	T/m
Circumference C	902.8	m
Path length spread/cell	382	mm