RCS LATTICE DESIGN

Christian Carli, Miriam Fitterer, Horst Schönauer

Acknowledgements: Bernhard Holzer

RCS as PS-Booster Upgrade

Motivation:

- new machine instead of upgrading old one
- avoid triple splitting in PS

Main Parameters:

Energy	160 MeV-2 GeV
Circumference	1/7 Circ(PS)=89.76 m (h=1, h=1+2 or h=3) or 4/21 Circ(PS)=119.68 m (h=1+2 or h=4)
Repetition Rate	10 Hz
Maximum magnetic field	1.3 T
Aperture estimates by downscaling booster acceptance:	Dipoles (Scrapers): 29.5 mm (v), 61 mm (h) Quadrupoles (vacuum chamber): 60.5 mm (v), 67.5 mm (h)

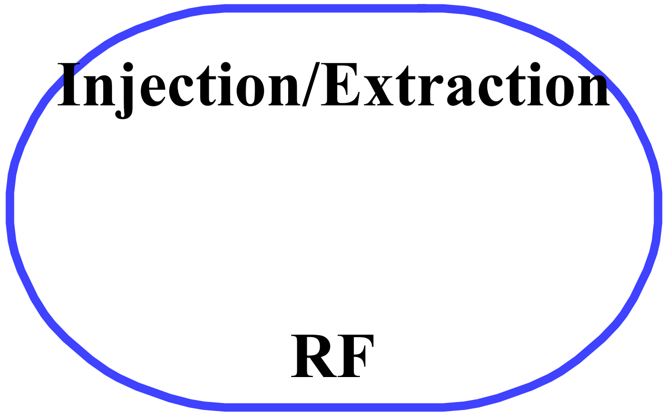
Not considered:

- nonlinearities, resonances etc.
- space charge
- Collimation

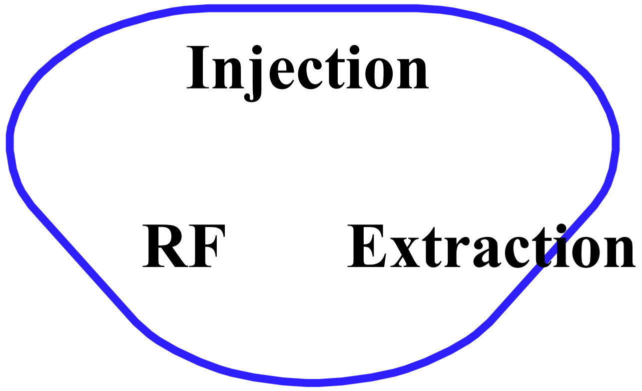
...

Basic Options

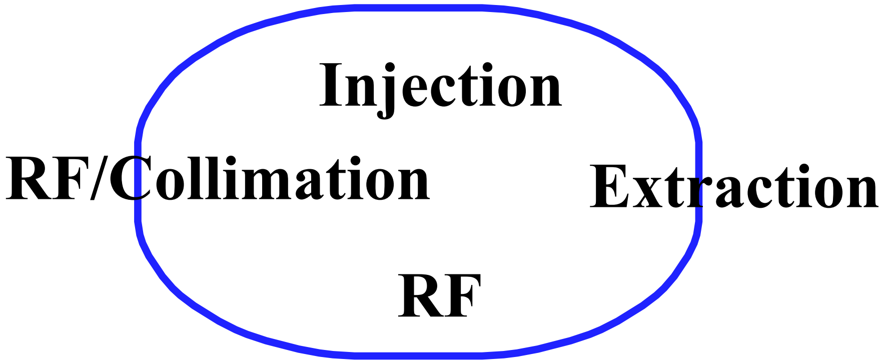
Racetrack - 2-fold symmetry:



Triangle - 3-fold symmetry:



Square - 4-fold symmetry:



Higher symmetries were not considered as the straight sections become too short to host Injection/Extraction

Some Rule of Thumbs, limits and Conclusion

Dispersion Suppression and Tune:

- n*2 Pi phase advance in the arcs (more or less determines the tune and phase advance)
- modified “missing bend” scheme

Twiss Parameters → Aperture:

Shorter (more) cells → smaller twiss functions → smaller aperture

Injection Requirements:

FODO cell with QD in straight: 2*2.6 m straight section
Straight section without QD: 6.2 m straight section

Gamma Transition:

not so clear, we considered gammat>3.6 (gamma(2GeV)=3.13)

Number of quadrupole families:

until now **2** families, more families would provide more flexibility (e.g. working point adjustment) and smaller twiss functions

1/7 CIRC(PS) (NOT MANY CHOICES)

in general:

- high dipole filling factor required

→ FODO lattice (best for lattices requiring a high dipole filling factor. E.g. doublet or triplet require higher quadrupole strength (→ longer quads, less space for dipoles) .

→ Dispersion suppression with n*2 Pi phase advance in the arcs. Other dispersion suppressor schemes require missing bends or reduced bending strength

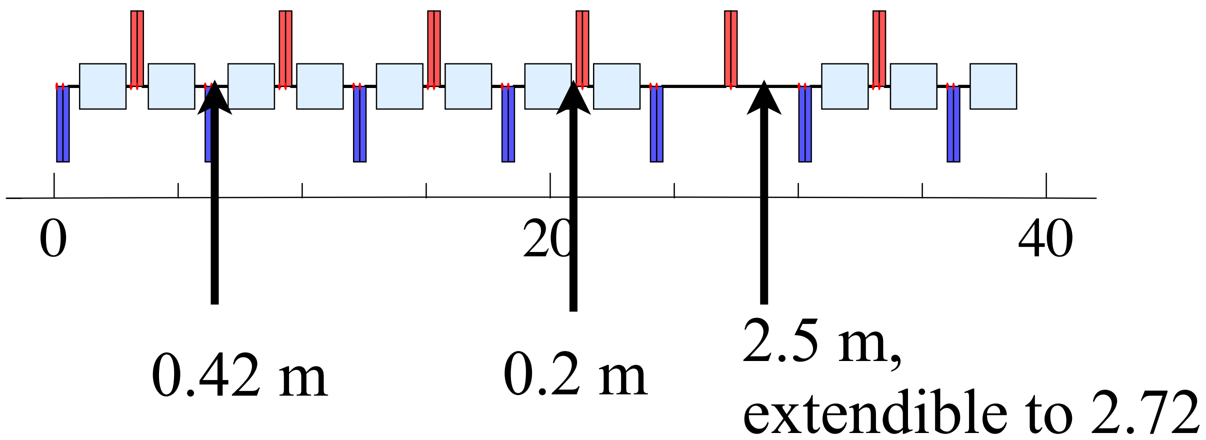
→ in our case implies three-fold symmetry (Inj./Extr./RF), other symmetries are less space efficient.

→ minimum number of cells (trade off between aperture and dipole filling factor)

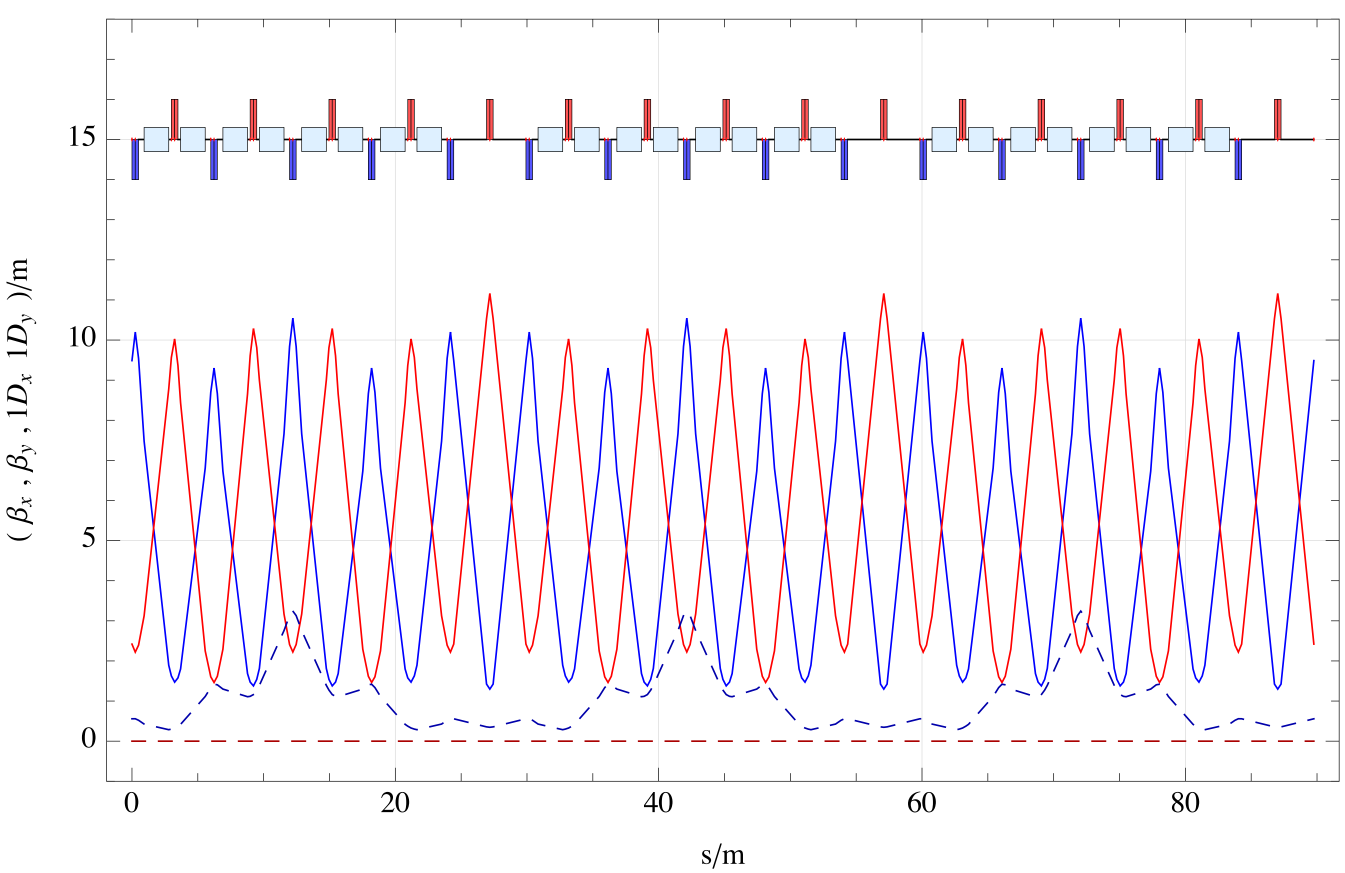
→ to reach a high enough gammat and low enough twiss functions a high phase advance is required

1/7 Circ(PS) - Triangle - FODO

15 cell FODO Lattice, Dispersion Suppression via 2Pi phase advance/arc



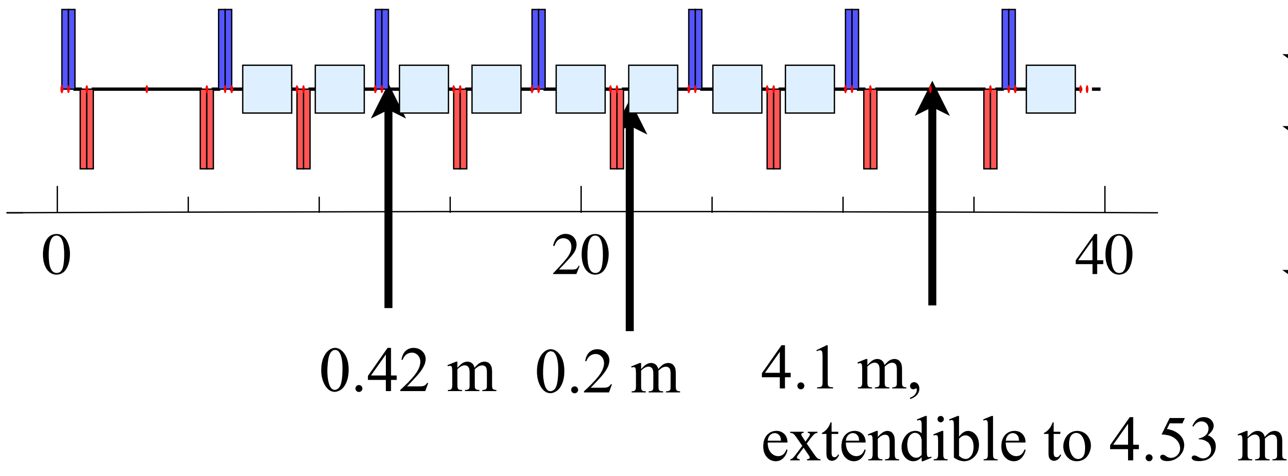
- ★ little space left for multipoles, diagnostics etc.
- ★ high phase advance per cell
- ★ residual dispersion in straight sections due to WP adjustment - dispersion matching with ind. quads next to straight section possible
- ★ tight injection/extraction using the kick of the QD



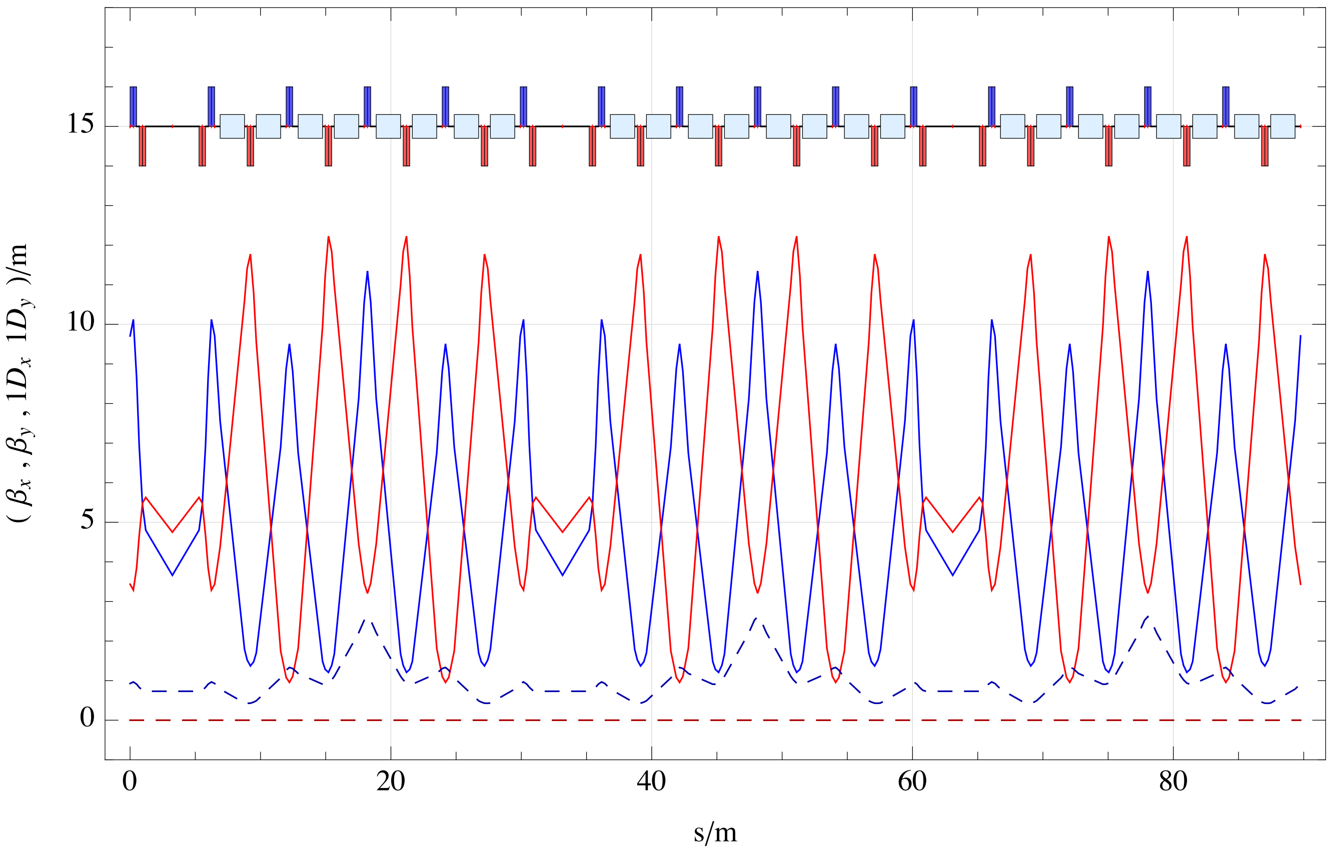
Q_H	4.2817
Q_V	3.57
Gamma	3.13
Gamma Transition	**3.79**
$D_{x,max}$(straight)	0.51
phase advance per cell (x/y)	approx. 103º/86º
$\beta_{x,max}/\beta_{y,max}$	10.04/11.06 m
$D_{x,max}$	2.97 m
QF/QD Field (0.5 m length)	10.1/8.57 T/m
Dipole field (1.87 m length)	1.3 T

1/7 Circ(PS) - Triangle - FODO+Doublet

15 cell FODO+Doublet Lattice, Dispersion Suppression via 2Pi phase advance/arc



- ★ little space left for multipoles, diagnostics etc.
- ★ high residual dispersion in straight section (maybe improvable with more ind. quads)
- ★ "free" straight section for Inj./Extr.



Q_H	4.2817
Q_V	3.57
Gamma Transition	**4.06**
$D_{x,max}$(straight)	0.88 m
phase advance per cell (x/y)	approx. 103º/ 86º
$\beta_{x,max}/\beta_{y,max}$	11.35/12.23 m
$D_{x,max}$	2.48 m
QF/QD FODO (0.5 m length)	10.7/8.73 T/m
QF/QD Doublet (0.5 m length)	14.52/9.85 T/m
Dipole field (1.87 m length)	1.3 T

4/21 CIRC(PS) (A BIT MORE FLEXIBLE)

in general:

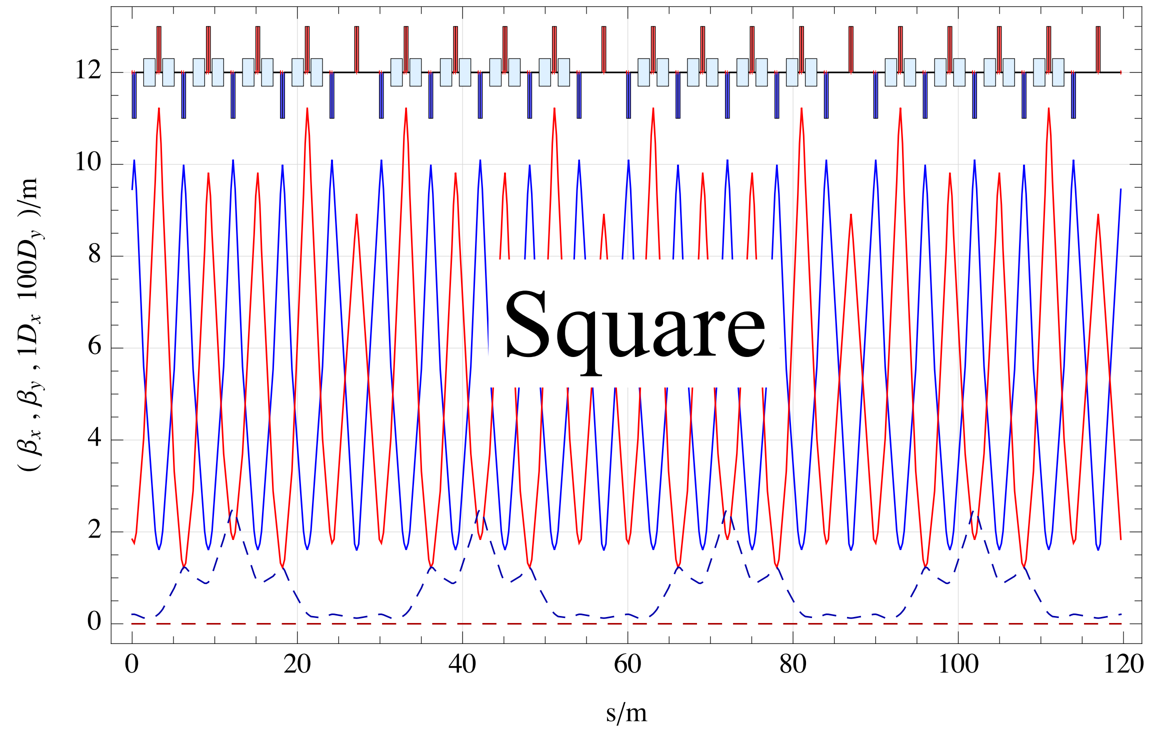
- dipole filling factor:
  → FODO and doublet lattice as basic choices
  → Dispersion suppression with n*2 Pi phase advance in the arcs or missing bend scheme
  → 2,3 or 4-fold symmetry
  → Could consider going to a higher number of cells
- aperture:
  → at least equivalent number of cells as for 1/7 PS circumference

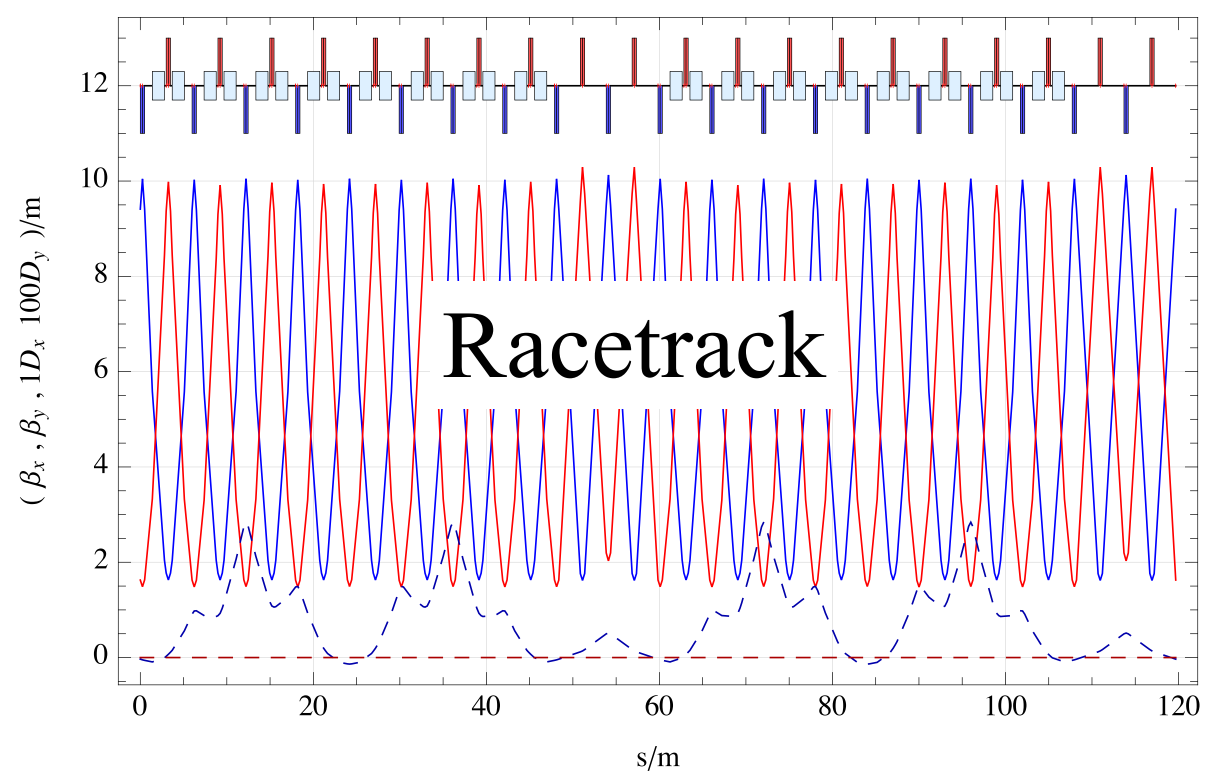
15 cells *4/3=20

4/21 Circ(PS) - Racetrack/Square - FODO

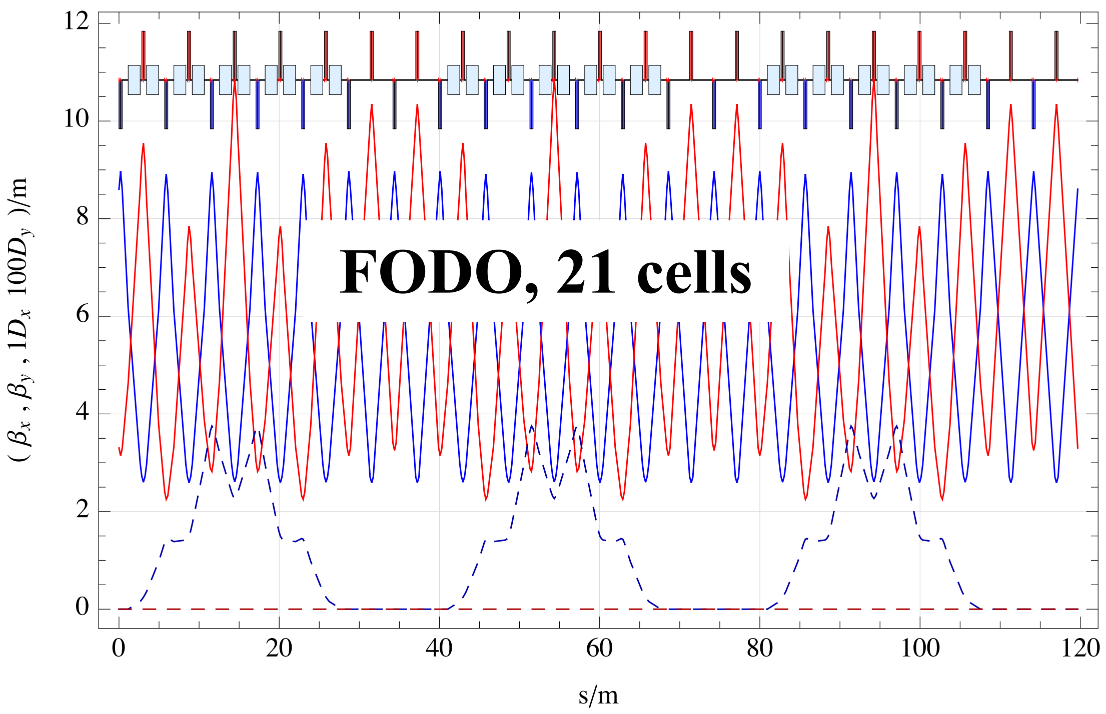
	Square	Racetrack
# cells	**20**	
# cells/straight sec.	1	2
straight section	2*2.49 m	4*2.49 m
d(Quad-Dip)	0.89 m	0.89 m
phase adv./cell (h/v)	95/98	95/98
Q_H/Q_V	5.28/5.46	5.28/5.46
γ_T	**4.96**	**4.99**
$\beta_{x,max}/\beta_{y,max}$	10.09/11.20 m	10.13/10.29 m
$D_{x,max}$	2.55 m	2.84 m
Vert. Accept. Dip.	33.5 mm	31.9 mm
Hor. Accept. Quad.	**68.0 mm**	70.2 mm

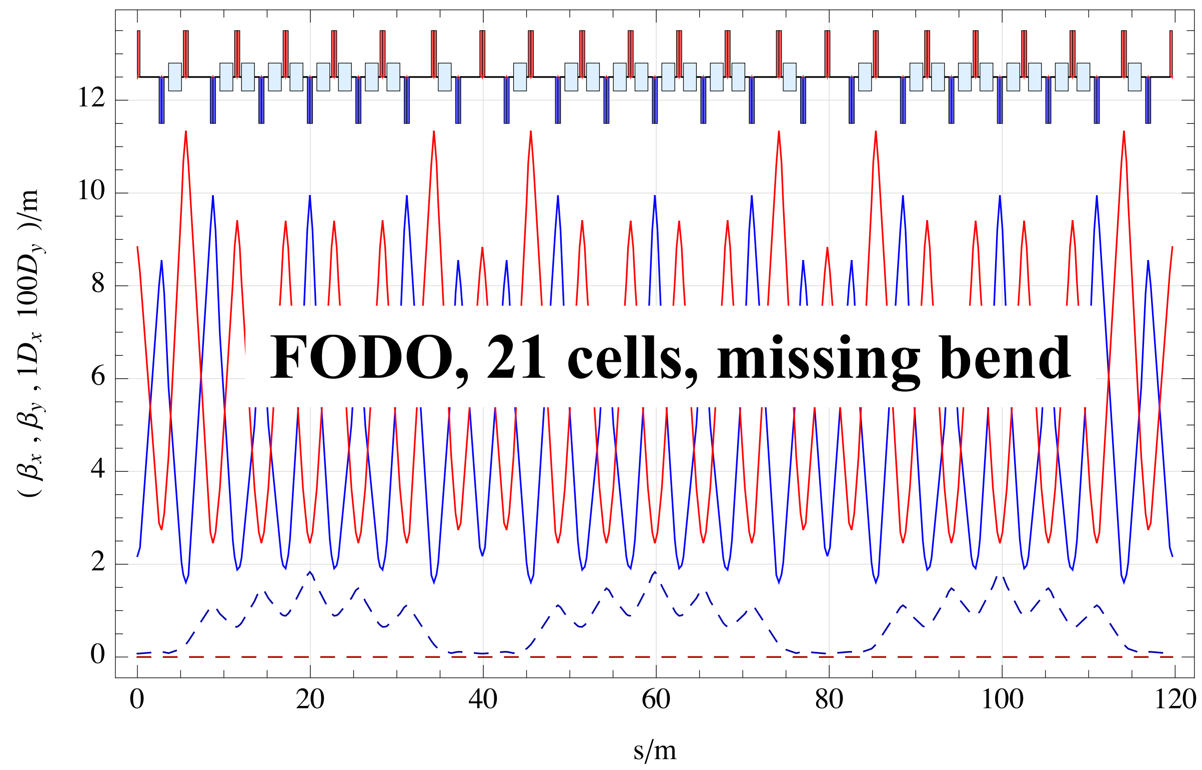
- ★ similar optics for racetrack and square
- ★ enough space for multipoles etc.
- ★ small residual dispersion with adjusted tunes
- ★ high gammat
- ★ tight for Inj./Extr.



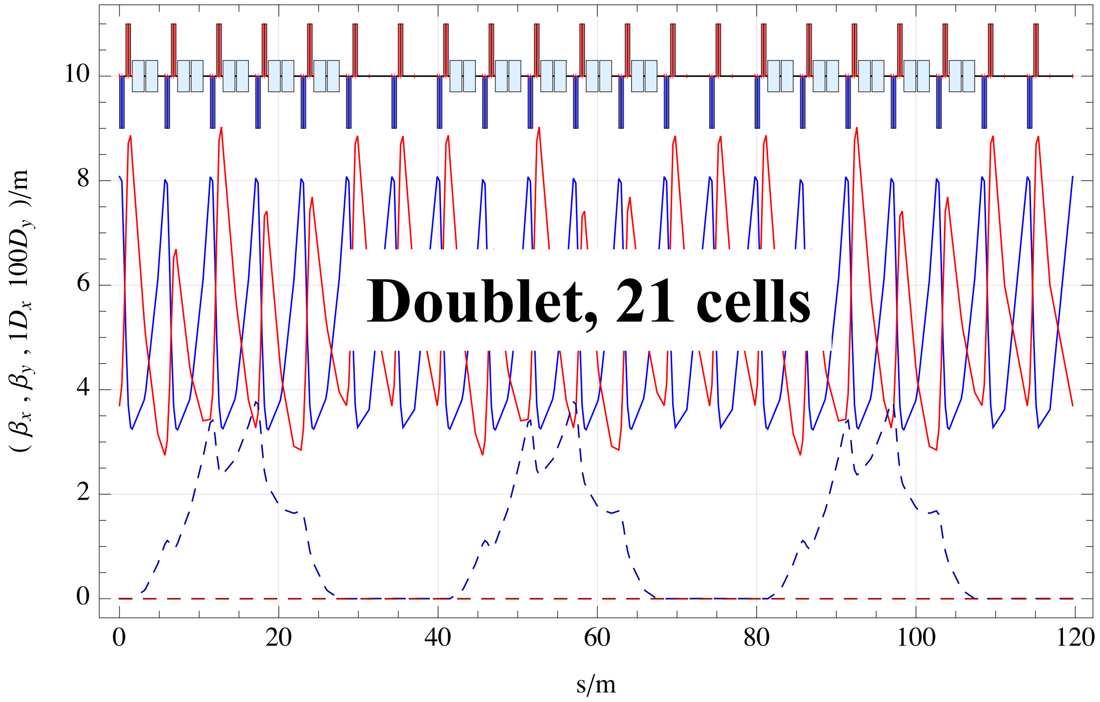


4/21 Circ(PS) - Triangle





Based on: Design of low energy ring(s), Internal Task Note, Antoine Lachaize, André Tkatchenko



- ★ higher gammat and slightly smaller aperture with doublet
- ★ tune chosen to have no dispersion in straights
- ★ no real advantage by going to 24 cells (same aperture, but smaller phase advance per cell)
- ★ dispersion suppression does reduce considerably the aperture requirements, but reduces the space in the DS free straight sections

4/21 Circ(PS) - Triangle

	FODO (QD in Straight)				Doublet	
# cells	21		24	21 (DS suppr.)	21	24
# cells/straight sec.	2	1	2	1	2	2
straight section	4*2.55 m	2*2.55 m	4*2.09 m	2*2.20 m	2*4.30 m	2*3.59 m
d(Quad-Dip)	0.75 m	0.75 m	0.65 m	0.5 m	0.90 m	0.69 m
phase adv./cell (hor.)	72	60	61	91	72	61
phase adv./cell (vert.)	68	63	59	69	70	61
Q_H	4.205	3.5	4.05	5.29	4.206	4.05
Q_V	3.95	3.7	3.95	4.05	4.05	4.05
γ_T	**3.64**	**3.32**	**3.60**	**4.8**	**3.77**	**3.66**
$\beta_{x,max}$	8.97 m	9.64 m	8.23 m	9.95 m	8.08 m	7.55 m
$\beta_{y,max}$	10.84 m	10.03 m	9.10 m	11.34 m	9.03 m	8.47 m
$D_{x,max}$	3.75 m	4.73 m	3.99 m	1.83 m	3.77 m	3.84 m
Vert. Accept. Dip.	33.6 mm	32.8 mm	31.6 mm	33.7 m	32.2 mm	31.4
Hor. Accept. Quad.	**74.6 mm**	**83.4 mm**	**74.6 mm**	**62.3 mm**	**72.1 mm**	**72.0 mm**

CONCLUSION AND OUTLOOK

Different lattices give a rough guess about the feasibility of a RCS, but more detailed studies are needed.

e.g. next step:

- play with more quadrupole families to reduce twiss functions, especially dispersion, and adjust the working point
- include multipoles, skew quads etc.
- space charge