Parameter Lists for (Electron Models of) FFAG Rings

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My WWW home directory:

`http://keil.home.cern.ch/keil/MuMu/Doc/FFAG05/FFAG_Apr05/03Apr05.pdf`

Need for Comparable Parameter Lists

- Convincing others of validity and consistency of parameters
- Cross checking by others using different programs
- Examples from my work on *isochronous* lattices with transition at centre of range at http://doc.cern.ch/archive/electronic/cern/preprints/ab/ab-2005-015.pdf
- Please add parameters needed for your favourite programs

Keil's Ring Parameters

Injection momentum p_i/MeV	10	10	11.25	11.25
Reference momentum p_r/MeV (1)	15	15	15	15
Extraction momentum p_f/MeV	20	20	18.75	18.75
Number of turns T	10	10	10	10
Approx. RF frequency f_{RF}/GHz	1.3	1.3	1.3	1.3
Calc. number of cells N_p (2)	63.95	35.97	33.09	25.97
Harmonic number h_{RF} (3)	139	78	66	52

1. Reference momentum p_r and cell parameters, given at p_r, define geometry of ring; some programs assume beam based RF phasing and require that p_r is at a zero of the time of flight
2. My procedure yields non-integral numbers
3. Some programs require that h_{RF} is an integer

Keil's Cell Parameters at p_r

Number of cells N_p	64	36	33	26
Cell length L_p/m	0.5	0.5	0.46	0.46
Hor. phase advance $\mu_x/2\pi$	0.233	0.233	0.233	0.263
Vert. phase advance $\mu_y/2\pi$	0.233	0.233	0.233	0.263
Eff. FD straight section/m	0.1	0.1	0.08	0.08
Eff. RF straight section/m	0.2	0.2	0.18	0.18
Obs. slip factor η_0	0	0	0	0
Obs. slip factor η_1	0.00976	0.0271	0.0319	0.0419
Av. acceleration ΔE/kV	15.62	20.83	22.73	28.85
RF cavity voltage V/kV	18.99	25.32	27.52	35.06

- Phase advances μ_x and μ_y at $\delta p/p \neq 0$ may be listed
- Observed slip factors η_0 and η_1 from $ct(\delta p/p)$ in tracking
- RF cavity voltage V is 21.4% larger than average acceleration

Keil's Magnet Parameters at p_r

F/D style	R/R	R/R	R/R	R/R	
F eff. length ℓ_F	100	100	100	100	mm
F angle φ_f	-20.38	-61.44	-73.10	-76.21	mrad
F gradient G_F	3.2005	3.1499	3.4916	3.8439	T/m
F field B_F	-101.9	-307.2	-365.6	-381.1	Gauss
F char. length $\vert X_F\vert$	3.18	9.75	10.47	9.91	mm
D eff. length ℓ_D	100	100	100	100	mm
D angle φ_D	118.6	236.0	263.5	317.9	mrad
D gradient G_D	-3.146	-2.934	-3.224	-3.444	T/m
D field B_D	592.8	1180.0	1317.7	1589.5	Gauss
D char. length $\vert X_D\vert$	18.84	40.22	40.87	46.15	mm

- Magnet style is either R=rectangular with entrance and exit angles equal to half the bending angle or S=sector with perpendicular entrance and exit
- The values of other entrance or exit angles should be listed

Magnet Design Issues

- Characteristic length $X = B/G$ is radial distance between reference orbit and zero of magnetic field
- Profile parameter $n/\rho = 1/X$ familiar to the elderly
- Magnets like the F magnets in my examples with $X \ll$ aperture radius A_x are essentially quadrupoles with axes displaced from reference orbit by X
- Magnets like the D magnets in my examples with $X \geq A_x$ are essentially half quadrupoles with neutral pole at distance X from reference orbit
- Transformation of rings with one zero of time of flight and $\eta_0 = 0$ to rings with two zeroes and $\eta_0 \neq 0$ implies changing bending angles, achieved by displacing the magnets radially
- Subtleties in short magnets with large bending angles and fringe fields
  - Curved vs. straight magnets?
  - Rotate magnets around vertical axes to get desired entrance and exit angles?
  - Precision alignment, measurement of bending angles of reference orbit?

Lattice Design Issues

- Doublets vs. triplets?
  - At equal L_p and N_p, triplets have at most 25% smaller ct than doublets
  - At equal N_p, doublets have 1/3 fewer magnets than triplets
  - At equal L_p, longer F magnets in doublets than triplets, fringe fields less severe
  - FODO lattices are a variant of doublet lattices with two straight sections of equal length, might be chosen when two RF cavities are needed in a cell
  - Conclusion: Adopt doublet lattice
- Two zeroes vs. one zero of ct?
  - Transform lattice with one zero into lattice with two zeroes by changing bending angles only
  - Observe that lattice with two zeroes needs more turns at the same RF voltage V and for the same range
  - Conclusion: For muons adopt lattice with one zero of ct, why do the opposite for electron model?