Status of Scaling FFAG System

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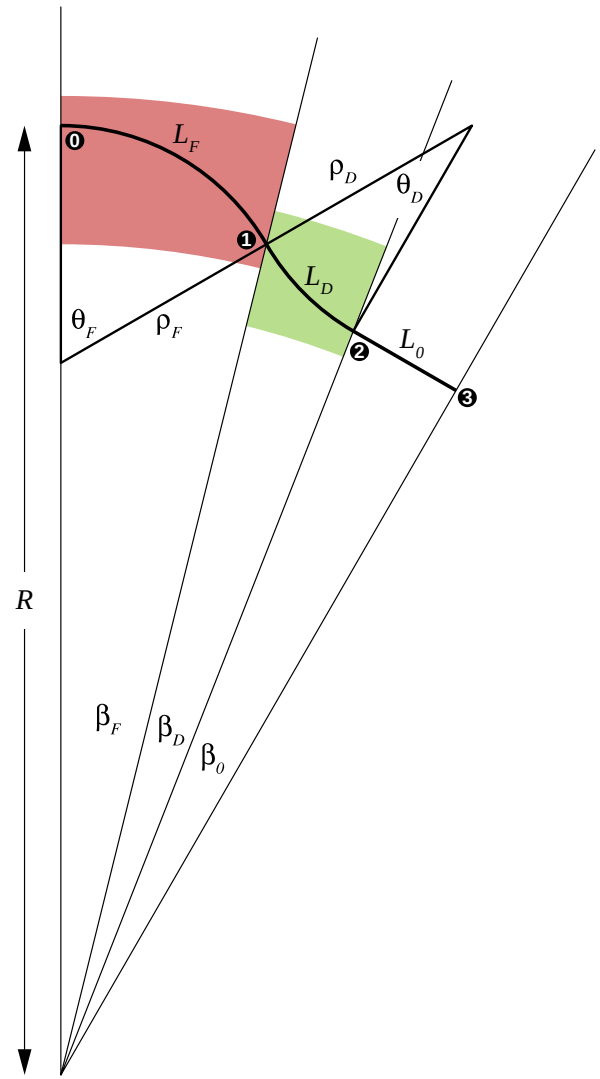
NuFactJ Parameters

- Need a description of the field in the FFAG
- NuFactJ report: description based on arcs of sector magnets, run in SAD
- Need to convert to

$$B(r,\theta) = B_0(\theta)(r/r_0)^k$$

$B_0(\theta)$ piecewise constant

- Geometry determined, only specify fields
- For some lattices, no reasonable guess works



Original Table

Lattice number	1	2	3	4	5	6
p_{min} (GeV/c)	0.3	0.3	1	1	3	10
p_{max} (GeV/c)	1	1	3	3	10	20
Cells	32	16	64	32	64	120
Field index	50	15	190	63	220	280
Average radius (m)	21	10	80	30	90	200
Field (T)	1.8	2.8	1.8	3.6	5.4	6.0
β_F (mrad)	26	52	12.7	26	12	6.7
β_D (mrad)	18	36	9.3	18	9	5.3
θ_F (deg)	17	26	10.5	16	10	6.8
Packing fraction	0.45	0.46	0.45	0.45	0.43	0.46
μ_x (deg)	120	131	132	154	157	67
μ_y (deg)	61	103	33	46	23	19
L_0 (m)	2.060	2.120	4.325	3.229	5.046	5.668
$2L_F$ (m)	1.104	1.065	2.041	1.575	2.169	2.685
L_D (m)	0.382	0.367	0.747	0.544	0.813	1.062

My Versions of NuFactJ Lattices

- Try to fit the tunes, assuming those were chosen carefully
- Can't do this by just varying fields: degeneracy due to scaling
- Vary β_F, B_D, keeping β_0 fixed

My Versions of NuFactJ Lattices Parameter Table

Lattice number	1	2	3	4	5	6
p_{min} (GeV/c)	0.3	0.3	1	1	3	10
p_{max} (GeV/c)	1	1	3	3	10	20
Cells	32	16	64	32	64	120
Field index	50	15	190	63	220	280
r_0 (m)	21	10	80	30	90	200
β_F (mrad)	27.24	57.38	13.25	27.68	12.41	8.16
$2r_0\beta_F$ (m)	1.144	1.148	2.119	1.661	2.234	3.266
B_F (T)	1.958	3.078	1.992	3.938	5.978	6.215
β_D (mrad)	16.76	30.62	8.75	16.32	8.59	3.84
$r_0\beta_D$ (m)	0.352	0.306	0.700	0.490	0.773	0.767
B_D (T)	-2.619	-3.950	-2.821	-5.525	-8.040	-11.946
$2r_0\beta_0$ (m)	2.275	2.167	4.334	3.250	5.056	5.672

My Versions of NuFactJ Lattices
Magnet Parameters and Cost

- Machine costs are huge (non-scaling FFAGs: $\lesssim$ 100 PB each stage)
- Magnet apertures are large
- Fields are very high
- Note: no cavities in cost!
  - RF system really needs to be defined
  - It looks like it will be really expensive

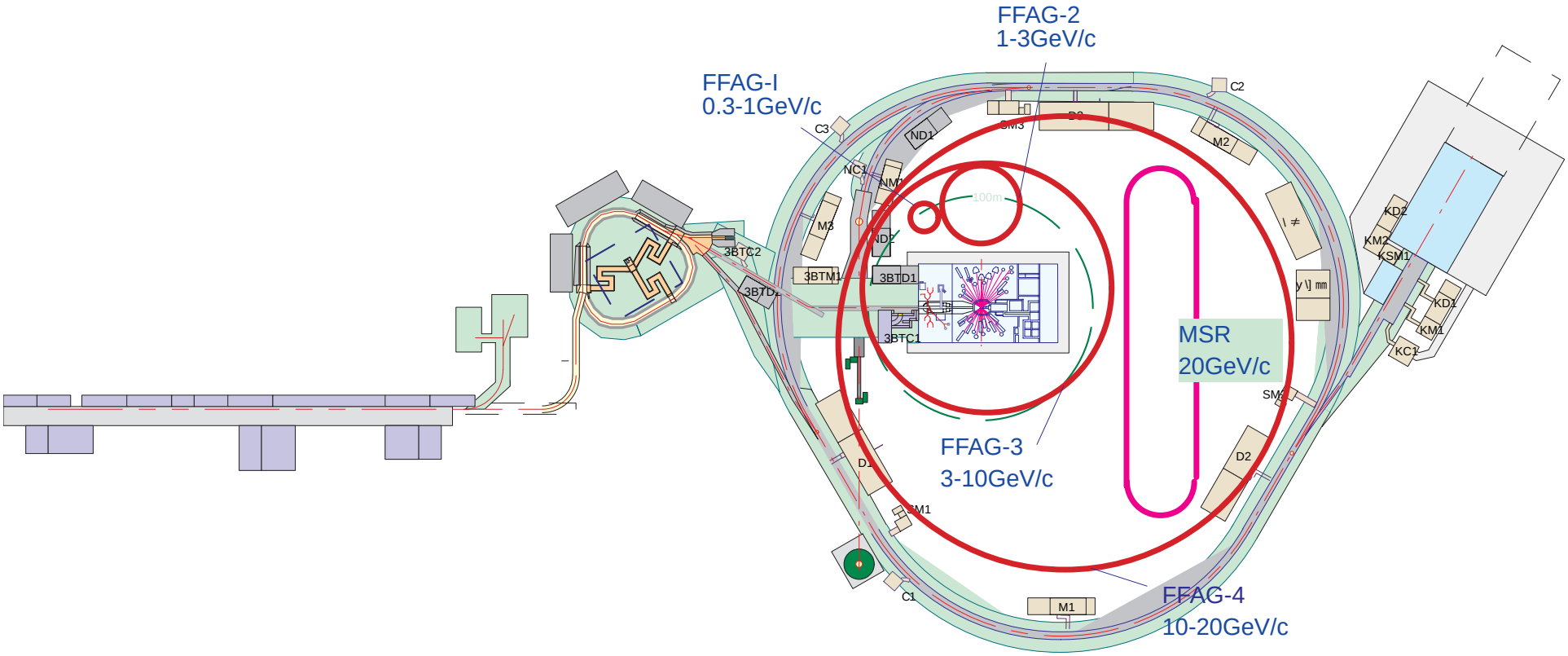
My Versions of NuFactJ Lattices
Magnet Parameters and Cost

Lattice number	1	2	3	4	5	6
L_F (m)	1.125	1.088	2.111	1.640	2.225	3.257
r_F (cm)	58.3	75.0	54.1	59.7	52.9	45.0
x_F (cm)	-35.5	-51.6	-32.9	-37.3	-34.0	-41.1
B_F (T)	3.442	4.355	3.292	6.282	9.493	6.567
L_D (m)	0.345	0.288	0.696	0.482	0.770	0.766
r_D (cm)	52.2	67.2	48.1	52.1	47.4	41.2
x_D (cm)	-40.6	-60.5	-40.4	-45.7	-41.4	-48.5
B_D (T)	-3.450	-4.368	-3.387	-6.316	-9.301	-10.783
Cost (PB)	281	355	396	527	1153	1410

My Impressions from Conversations

- These designs were just supposed to by “typical”
- Constrained to fit inside 50 GeV proton ring
- Nobody did anything beyond the SAD model
- RF systems are all R&D projects

FFAGs on Tokai Campus



Lattices from 2002 LBL FFAG Workshop

- Work was done on improving the high energy (10–20 GeV/c) FFAG lattice
  - FODO lattice
  - Two versions
    - ⋆ Same number of cells, higher field index, smaller ring
    - ⋆ Larger ring, more cells even higher field index
- I ran the lattices based on a hard edge model
  - Only one stable in my computations (120 cell)
  - Don't match on tunes
  - Cause for differences: I use hard edge, original has Enge ends
- Cost reduced significantly from NuFactJ design
  - Apertures and fields both much lower
  - Still high

Parameters from 2002 LBL FFAG Workshop

Cells	180	120
Field index	670	330
Reference radius (m)	200	120
Ends (m)	0.30	0.20
D angle (deg)	0.438	0.63
D length (m)	0.93	0.92
D field (T)	5.795	7.738
F angle (deg)	0.562	0.87
F length (m)	1.36	1.42
F field (T)	-3.636	-4.857
Drift length (m)	2.35	1.97

L_F (m)	1.420
r_F (cm)	22.9
x_F (cm)	-15.8
B_F (T)	-5.739
L_D (m)	0.919
r_D (cm)	23.0
x_D (cm)	-1.5
B_D (T)	13.970
Cost (PB)	435

Next Steps

- Examine, cost LBL soft-edge lattice
- Need to find a good working point for other lattice
  - F/D ratio, field index, number of cells
  - Insure that we have sufficient transverse aperture
  - Need to precisely define lattices
- Can then optimize cost against scale of field (and thus ring circumference)
- We won't worry about the size constraint
- Somehow the RF system needs to get defined. . .
  - Then we can examine longitudinal dynamics