Costs for Different Numbers of FFAG Stages

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Three vs. Four Stages

- Accelerate from 2.5 GeV to 20 GeV
- Each stage has the same factor gain in energy
- Adjust a to be proportional to $(\Delta E)^{-1/2}$
  - Could do better with my new calculation, but not everything is in place yet
  - Results will be sensitive to this
- Using 17 MV/m gradient

Table: Three vs. Four Stages

Minimum total energy (GeV)	2.5	4.2	7.1	11.9	2.5	5.0	10.0
Maximum total energy (GeV)	4.2	7.1	11.9	20.0	5.0	10.0	20.0
a	0.20	0.16	0.12	0.09	0.17	0.12	0.08
Number of cells	34	38	46	57	50	63	82
D length (cm)	77	90	108	122	63	78	97
D radius (cm)	13.2	10.7	8.7	7.0	13.4	10.0	7.4
D pole tip field (T)	4.6	5.8	6.6	7.9	4.5	5.8	7.1
F length (cm)	98	117	137	164	96	115	141
F radius (cm)	21.4	18.6	15.7	13.2	21.2	16.6	13.1
F pole tip field (T)	2.7	3.3	3.8	4.3	2.7	3.5	4.3
Number of cavities	26	30	35	38	42	48	56
RF voltage (MV)	331	382	434	477	534	606	704
Turns	5.2	7.6	11.4	17.7	4.7	8.5	15.0
Circumference (m)	144	174	228	306	204	279	400
Decay (%)	3.6	3.8	4.4	5.4	4.2	5.1	6.5
Machine cost (PB)	53.0	56.7	61.5	68.1	74.8	78.9	88.9
. . . per GeV (PB/GeV)	31.1	19.8	12.8	8.4	29.9	15.8	8.9
Marginal decay cost (PB)	18.0	18.9	21.9	27.1	21.1	25.6	32.3
Total machine cost (PB)	239.3				242.7		
Total decay cost (PB)	85.9				78.9		

Analysis

- Total costs aren't that different
  - Machine cost is slightly higher for 4 stages compared to 3
  - More decays with 4 stages
  - With decay costs, the 3 stage machine wins
- 4-stage machines much shorter, less voltage
  - But this is washed out by having more stages
- Add transfer lines, 3 stages looks even better
- I think all things being equal, fewer stages is better than more
- Maybe I should look at 2 stages. . .
- Next: play with points of division for fixed number of stages