Workshop Accomplishments

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Optimization Parameters

- Pole tip fields: 7 T, 30% buffer
- Long drifts: 2 m; short drifts, 0.5 m
- 7.5 MV acceleration per cell
- Aggressive parameters for longitudinal phase space area
- 201.25 MHz RF

Triplet FFAGs at Various Energies

E_{min} (GeV)	1.25	2.5	5	10
E_{max} (GeV)	2.5	5	10	20
w	1/4	1/6	1/8	1/12
Cells	56	59	74	93
D Length (cm)	31	56	85	128
D Radius (cm)	15.9	11.6	8.6	6.5
D Field (T)	1.9	3.5	4.1	4.5
D Gradient (T/m)	-23	-23	-27	-30
F Length (cm)	11	18	29	45
F Radius (cm)	12.1	10.1	8.3	7.3
F Field (T)	0.4	-1.8	-2.3	-2.7
F Gradient (T/m)	41	42	47	50
RF Voltage (MV)	420	443	555	698

Conclusions: Lattices at Different Energies

- 1.25–2.5 Lattice is of questionable value. Use RLA/Linac.
- 2.5–5 is borderline. Check cost, maybe go to RLA.
- Cost ber GeV definitely seems to be increasing
  - Number of cells only go down weakly
  - Apertures go up, although lengths go down
  - RF Voltage per GeV of acceleration goes up rapidly

Different Lattice Structures, 10–20 GeV

Type	FDF	FD	FODO 1 RF	FODO 2 RF
Cells	93	101	113	82
D Length (cm)	128	101	81	99
D Radius (cm)	6.5	5.3	6.1	6.4
D Field (T)	4.5	4.9	4.8	5.6
D Gradient (T/m)	-30	-36	-30	-24
F Length (cm)	45	81	60	74
F Radius (cm)	7.3	9.5	11.0	13.8
F Field (T)	-2.7	-2.2	-1.9	-2.3
F Gradient (T/m)	50	43	39	31
RF Voltage (MV)	698	758	848	1230

Conclusions: Different Lattice Structures

- FDF triplet as the least RF voltage
- Fewer cells in FDF
- Triplet has more magnets
- From RF standpoint, triplet wins
- Need to examine magnet costs to determine true winner

Electron Model Lattice: Parameters

- Goals
    - Demonstrate that nonscaling FFAG works
    - Test “gutter acceleration”
    - Do variable speed resonance crossing
- Accelerate 10–20 MeV
    - Compare to 2.5–5 GeV muon machine
- Design for $V/(\omega\Delta T\Delta E) \approx 1/4$
    - Somewhat larger than desired for muon acceleration
- Use low frequency RF and/or piezo-controlled high-frequency RF for slow acceleration
- No ends in calculation: significant effect here with short rings (Keil), but comparative results hold

Electron Model Lattice

RF Frequency (MHz)	1300	1300	1300	2856	2856	2856
Pole tip (T)	0.2	0.2	0.5	0.2	0.2	0.2
Cavity voltage (kV)	250	1000	1000	250	500	500
Long drift (cm)	25	25	25	15	15	15
Short drift (cm)	5	5	5	5	5	5
$V/(\omega \Delta T \Delta E)$	1/4	1/4	1/4	1/4	1/4	1/2
Cells	24	15	9	32	24	33
D Length (cm)	14.3	31.4	11.0	11.4	13.8	11.4
D Radius (cm)	1.52	4.27	1.67	1.31	1.36	1.29
D Field (T)	0.160	0.182	0.438	0.138	0.160	0.140
D Gradient (T/m)	-2.44	-0.30	-3.81	-3.77	-2.80	-3.73
F Length (cm)	5.0	10.5	3.2	4.0	5.0	4.0
F Radius (cm)	2.45	6.86	2.44	1.74	2.35	1.82
F Field (T)	-0.097	-0.172	-0.210	-0.074	-0.091	-0.080
F Gradient (T/m)	3.81	-0.36	9.25	6.16	4.18	5.82
RF Voltage (MV)	6	15	9	8	12	16.5

Electron Model: Observations

- Large installed RF for desired acceleration
  - Acceleration in few turns for high $V/(\omega\Delta T\Delta E)$
  - Less RF by lowering voltage per cell, but longer ring
  - Lower $V/(\omega\Delta T\Delta E)$, lower voltage requred
  - Lower voltage per cell, ring gets longer
  - Back off $V/(\omega\Delta T\Delta E)$ to get better lattice but less longitudinal phase space
- Lower frequency looks nicer for lattice
  - RF delivery higher for lower frequency more difficult
- Hardware issues
  - Kicker: better for higher β-function
  - Independent phasing of cavities with single power source
  - Component size may be too small to deal with???

Thin Lens Model of Triplet

- Find that thin lens model produces inaccurate tunes for triplet
- Most likely problem: drift between magnets short/comparable compared to magnet length
- Try constructing model using thick lenses, take power series

Proton Driver Parameters

Turns	1000
Minimum Kinetic Energy	200 MeV
Maximum Kinetic Energy	2000 MeV
Beam Power	1 MW
Circumference	500 m
Pipe aperture	50 cm × 20 cm
Maximum field	1 T
Repetition frequency	1 kHz