Dogbone RLA Droplet Design

J. Scott Berg
Brookhaven National Laboratory
Muon Accelerator Group Meeting
18 June 2014

Outline

- Quick introduction
- Reveiw of previous results
- Droplet arc design update
- Conclusions

RLA to 63 GeV

- Accelerate from 5 to 63 GeV
- Use dogbone RLA
- Tolerate 10% emittance growth (original spec: 6%)

N	2×10^{12}	4×10^{12}	2×10^{12}
$\epsilon_{\parallel}$ (mm)	1.5	1.5	70

Review of Previous Results

- Beam loading limits us to 3 passes at 650 MHz, 9 passes at 325 MHz
- Emittance growth limitations require long arcs with many cells
  - Need to reduce momentum compaction
- 650 MHz preferable to 325 MHz
  - Total arc length significantly less
  - Decays for 325 MHz too high

Design Requirements

- Arise from longitudinal dynamics
- Note huge energy spread
- T_1 (frequency slip factor, in funny units) drives arc design: larger is easier

ϵ (mm)	1.5	1.5	70	70
$\omega/2\pi$ (MHz)	325	650	325	650
Linac passes	9	3	9	3
T_1 (ps/GeV)	1567	299	435	83
ϕ (deg)	7	6	25	22
σ_E (MeV)	22	50	283	647

Droplet Design I

- Avoid severe mismatch: arc beta similar to linac beta
- Arc cell lengths and cell count roughly proportional to beta
- Linac beta dependency:
  - Proportional to cell length
  - Inversely proportional to phase advance per cell
- Linac must accept full energy spread at injection
- Linac betatron phase advance at end of first pass:

$$\sin\frac{\mu_\perp}{2} \leq \frac{E_0 - k\sigma_E}{E_0 + U}$$

Droplet Design I

- Results reasonable for Higgs longitudinal emittance
- Unacceptable for collider longitudinal emittance
  - Decays too high
  - Huge energy spreads force low tunes, large beta functions in linac
  - Shorten linac cells to bring down beta functions
  - 325 MHz better, but lots of arc
  - 650 MHz, energy spread makes it crazy

Droplet Design I

ϵ (mm)	1.5	1.5	70	70
$\omega/2\pi$ (MHz)	325	650	325	650
Linac passes	9	3	9	3
$\mu_\perp$ (deg.)	51	23	32	10
Cells/cavity	2	5	2	2
Cells/droplet	16	58	65	338
Arc length (km)	4.3	3.3	24.0	32.5
Decay (%)	8.8	5.3	17.4	20.7

Droplet Design II

- Allow a beta mismatch between linac and arc
- Design arcs for maximum field (1.5 T warm, 6 T cold)
- Solutions look more reasonable
  - 325 MHz should use cold magnets for decays
  - 650 MHz could use warm or cold
    - Beta match easier with warm

Droplet Design II

$\omega/2\pi$ (MHz)	325	325	650	650
Linac passes	9	9	3	3
Arc dipole (T)	1.5	6	1.5	6
Cells/droplet	93	51	212	121
Arc length (km)	13.5	4.2	3.3	1.1

Conclusions

- 5–63 GeV RLA design straightforward for Higgs emittance alone
- Collider emittance more challenging
  - Can come up with parameters, but
  - Energy spreads are huge
  - Big linac-to-arc beta mismatch
  - Possible solutions
    - Racetrack configuration
    - Two stages (my preference)
  - Solutions need to be fully simulated
- Need to check results against longitudinal simulations