Path Length and MO Setup

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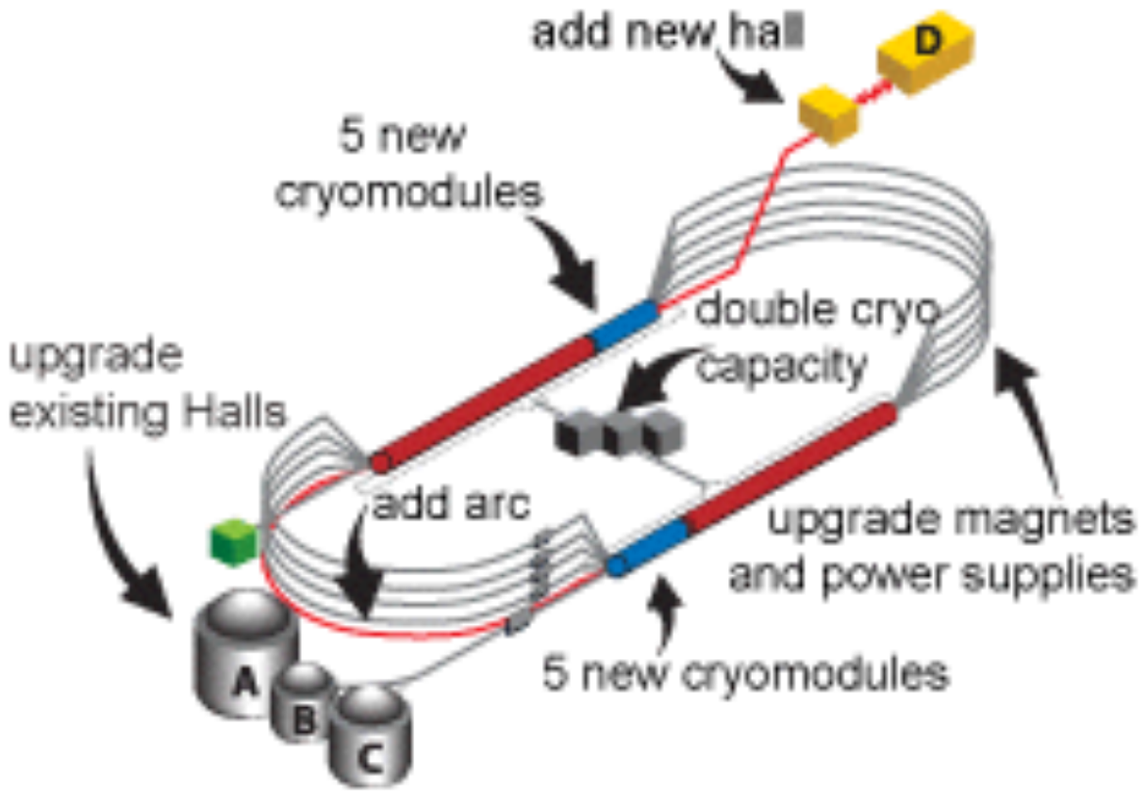
Longitudinal Issues:

- Linacs accelerate the beam
- Arcs recirculate it; timing is critical
- Circular accelerators and storage rings are phase stable; CEBAF is not



RF Acceleration

- Unstable fixed point: on-crest acceleration
- Accelerator phase stability ensures that multiple circuits remain (adequately) in synchronism
- Penalty: less than full available energy gain per circuit — off-crest acceleration
- CEBAF has up to 5.5 circuits of acceleration: cannot make up for fractional energy gain by adding a few more passes

First-Pass Regulation

- Maintain energy gain fixed on first pass
- Regulate [Gradient * cos(theta)] with locks
- Regulate [theta] with phase lock (MOMod/PID)
- Stabilize first pass energy and energy spread

Multiple Passes

- “All that remains” is to enforce synchronism: maintain the transit time per pass

- Variables:

  - Overall machine length

  - “Cutting corners” in Spreader/Recombiner setup

  - Arc steering

  - Asymmetric expansion(?)

Historical Corrections

- Control knobs
    - Path length (Dogleg) chicanes
    - Arc orbit offsets
- Diagnostics
    - “M56” cavities (RF phase comparison to MO)
    - MOMod system coupled to phase lock PID
    - Multi-pass MOMod (detects high-pass drift off-crest)

Reduced Dogleg Leverage

- Chicane delay

$$dL = (L_{drift} + L_{dipole}/3)^* (1 / \cos(\theta) - 1)$$

- Scales like (theta**2)
- Power-supply limited systems: dL ~ 1/Energy**2
- Doglegs being upgraded to improve control reach

New Knob: MO Frequency

- Integer number of wavelengths per circuit
- As machine grows, lower the frequency
- 5-cell SRF must be “on” to track MO changes
- 7-cell digital RF responds essentially instantly
- Changes must be made “slowly”

MO Generator Issues

- Rode & Schwarz generator responds ingraciously to digital change of central frequency
- Requires analog FM input port (adjustable gain) controlled by external analog DAC
- High gain induces unacceptable phase noise
- Use <= 200 Hz/volt setting
- Annual cycle ~ 7 RF degrees per arc ==> 6 kHz
- Reach end of DAC range, reset central freq. and DAC

AutoDog(?)

- Plan to re-establish MOMod with phase lock
- High arc version provides CW path length monitor
- Detect change of path and dial in new MO target
- Use (very) slow PID to slew MO with operator concurrence
- Limited autonomy (as for phase lock introduction)

Updated M56 Cavity Tool

- Provide direct tune mode M56 cavity read-back
- Feed directly into updated Dogleg Calculator as desired, advising operators on chicane changes
- Plan to validate calibrations regularly

Dogleg Calculator

- 6 GeV version by Jay and Michele was very useful
- Revision including RF frequency is overdue
- After interviewing many ops staff, we plan to shift from RF degrees to mm of Path as basic unit
- Combination of M56 report from tool and as-found configuration should enable ready re-configuration

Expected Hierarchy

- Baseline setup will probably always be manual
- Expect MO dF to be principal adjustment knob during normal run time
- Chicane adjustments (former first-line response) should be infrequent except at set-up and change of energy
- Avoid arc orbit offsets (stay centered in quads) as feasible