

# FFA@CEBAF Working Group | MINUTES

Meeting date | time 05/05/2023 | 11 AM EST | Meeting location <https://jlab-org.zoomgov.com/j/1614898082?pwd=TnUzMS81M2sxbDZlbERJU01tYkJCQT09>

Meeting called by Alex B

Type of meeting Weekly Meeting

Facilitator Alex B

Note taker Donish

Timekeeper Alex B

## Attendees

Alex B, Dejan, Scott, Alex C, Randika, Edy, Donish, Andrei, Vasiliy

## INTRO DISCUSSION

Final look at IPAC23 contributions. Scott, Ryan, Kirsten, Todd are going from FFA crew.

## AGENDA TOPICS

Time allotted | 45 mins | Agenda topic *Parametric Resonance Optics* | Presenter Vasiliy

The screenshot shows a presentation slide with the title "NL High-Power Hadron Accelerator Concept". The slide contains several sections:

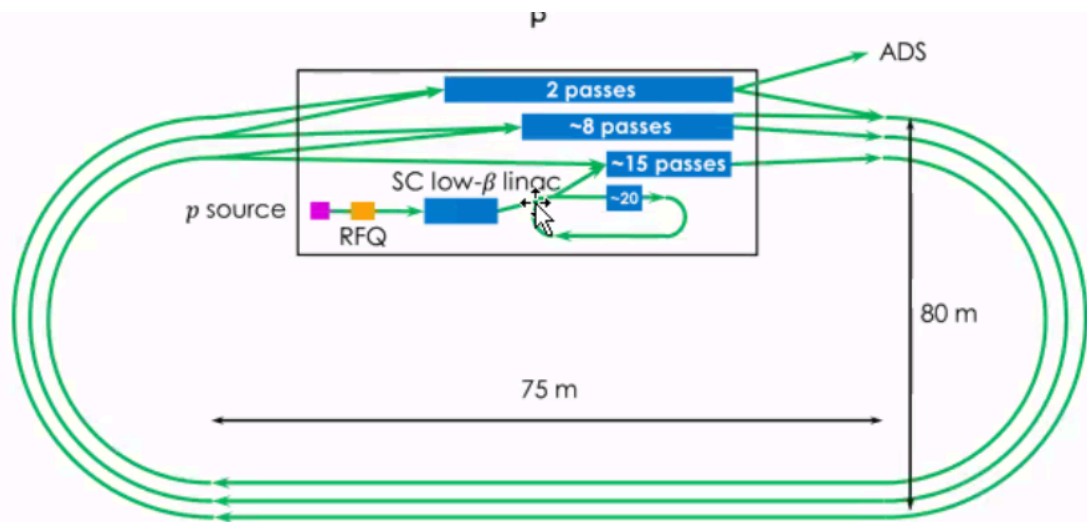
- Assumptions:** Assume the maximum RF power that can be provided by cavity to the recirculating beam of 300 kW. Assume each FFA arcs covers a momentum ratio of 2. Potential reduction in cavity number from ~160 to ~40. Same bend allows for efficient tunnel use. Short cryogenic and RF power lines. Total circumference of ~400 m.
- Table:**

	0.18	0.67	2.35	6.74 MW
$\Delta p_{beam}$	$\times 2$	$\times 2$	$\times 2$	$\times 2$
T	6	24	91	326
	1000 MeV			

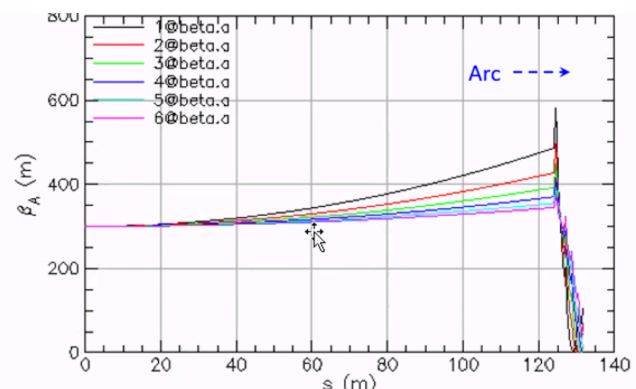
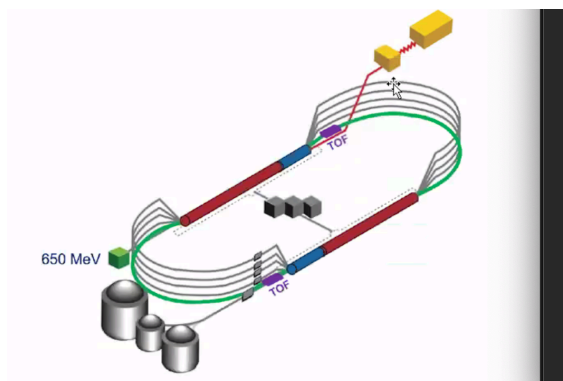
Below the table, there are labels for RLA 1, RLA 2, RLA 3, and RLA 4.

- Diagram:** A diagram of a circular accelerator layout showing a 650 MeV beam entering a linac, then a series of arcs and straights. A "Current limit" is indicated.
- Text:** "CEBAF energy to 22 GeV". "Constraints of the existing tunnel must be considered".
- Graphs:** Two graphs showing the Twiss  $\beta$  at the end of each resonance. The top graph shows  $\beta$  (m) vs Period number (0 to 40). The bottom graph shows  $\beta$  (m) vs  $\Phi_r$  (-3 to 2).
- Text:** "modulation cannot exceed the tune separation between the different energies". "Linear model where the resonance tune offset from betatron tune by  $\Delta \nu_r$ ; Twiss  $\beta$  at the end of each".
- Text:** "Linac straights are long and provide little focusing to the highest energy passes". "Twiss  $\beta$  must be expanded significantly from the arcs to the linac entrance". "Example linac optics, 0 is at the linac center".
- Acknowledgements:** A section at the bottom right.

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- Vasiliy goes through poster concepts
  - Dejan: Essentially 3 papers/concepts in 1 poster

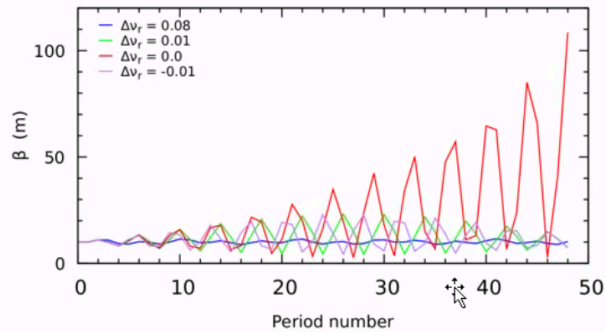


- Hadron accelerator concept
- Alex B: This is first design of proton recirculating linac with FFA arcs; 25 passes
- Still under work, have an idea of timing and can make it work
- Multiple rings for freedom from factor of 2 momentum increase
- FFA cell here is similar for FFA cell in CEBAF
  - Lower beta functions than CEBAF because linacs are designed from scratch

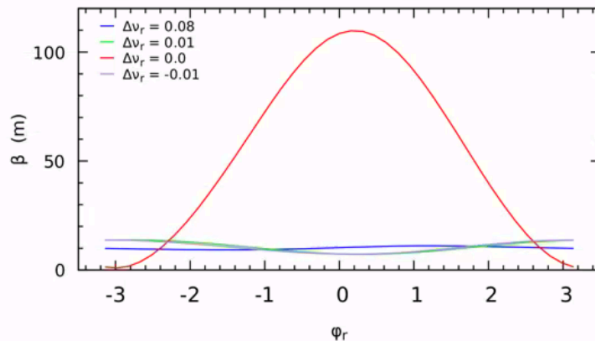


- Now, for FFA@CEBAF
- CEBAF very little focusing in the linacs for higher energies
- Not real solution (right plot), just an attempt
  - Takes space to match because lose periodicity from fodo cell with energy variation

- Linear model where the resonance tune offset from the betatron tune by  $\Delta\nu_r$ ; Twiss  $\beta$  at the end of each period



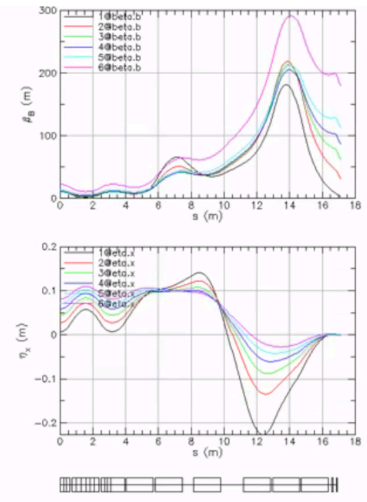
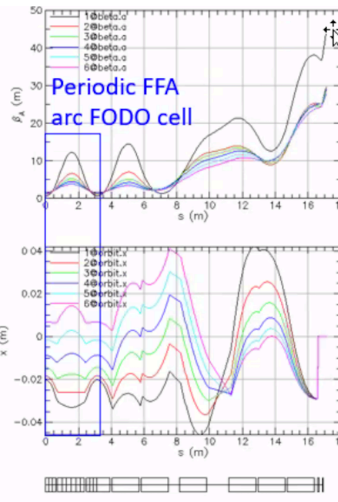
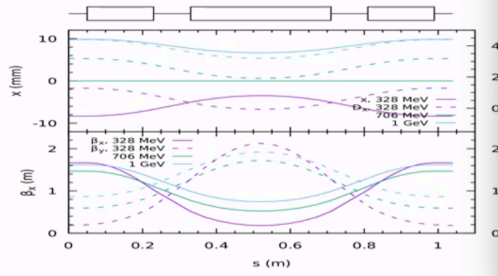
- Twiss  $\beta$  at the end as a function of the resonance phase



- Parametric resonance & excitation of beta functions
  - Periodic cell with linear matrix
  - Differences between passes/energies: beta function and **tunes**
  - Use the different tunes to control the passes independently
- At the end of each period, put thin quadrupole kick
  - Modulation of EM quadrupole current or kick element
  - Phase advance of kick = 2\*phase advance of betatron motion
- No optimization presented here. With optimization could save space.
- Dejan: Apply this to FFA by placing quad at specific phase advance positions for each particular pass.
  - Dejan & Stephen did similar to fix path length in FFA (parabolic)
  - Allows you to have equal betatron functions for all energies at the end of matching section
  - Best for straight parts not so much in arcs
  - Two knobs in quads: strength and phase

## Arc Optics & Adiabatic Match of ORNL Concept

- Arc FODO cell using combined function dipole magnet with quadrupole field components
- Maximum field of 1 T at 20 mm radius
- Consistent with permanent magnet technology



- Betatron phase does not change along channel; could apply parametric resonance to the betatron tunes
- Orbits and dispersion will not be in resonance anymore

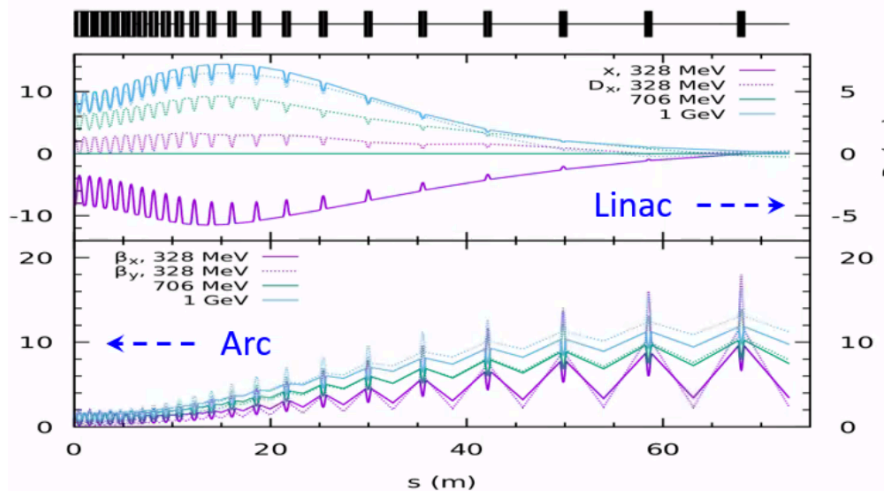
adiabatic match of arcs to linacs using 22 cells

parameters scale as

$$f(i) = 1 - 3[i/(n_T + 1)]^2 + 2[i/(n_T + 1)]^3$$

$$= f(i)\theta_a, l_i = l_s[l_a/l_s]^{f(i)}, k_1^i = k_1^s[k_1^a/k_1^s]^{f(i)}$$

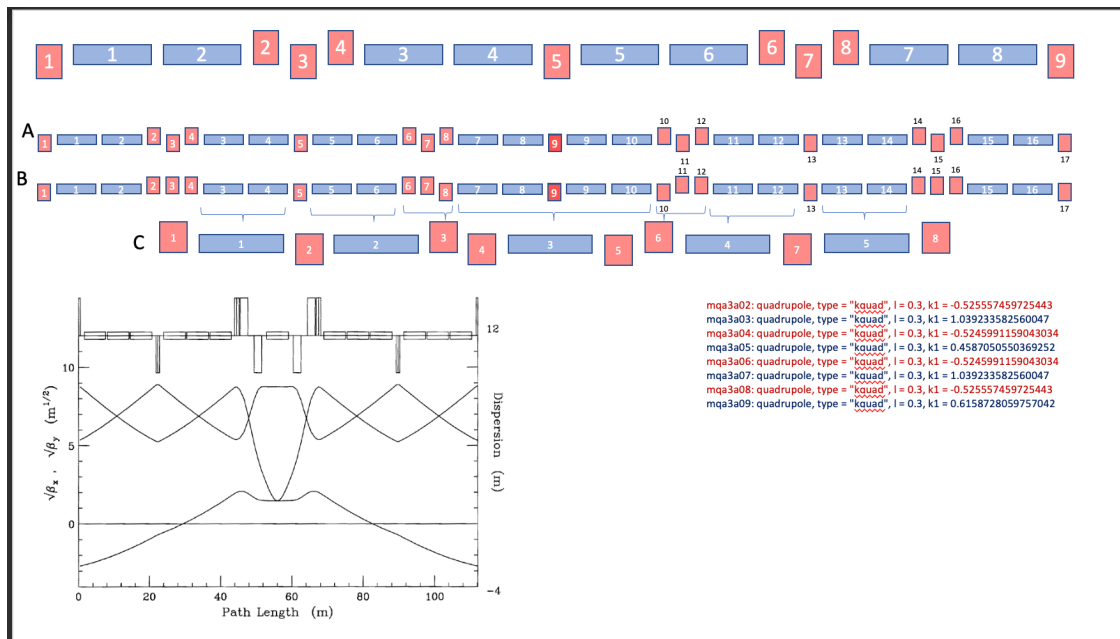
requires sufficient space to maintain adiabaticity



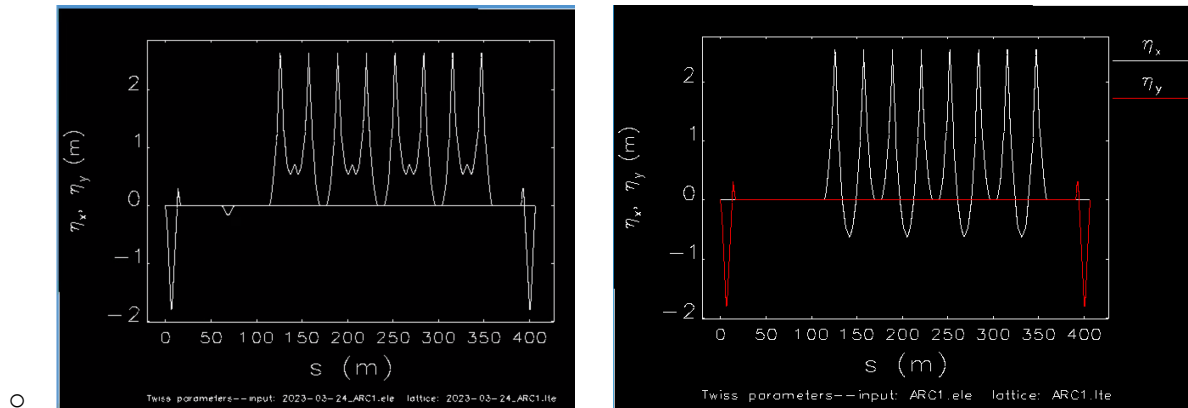
- Scaling law  $f(i)$  in the power of length and strength
- Vasily: Got from example, doesn't know where the scaling law came from
- Scott: Stumbled on good idea

## AGENDA TOPICS

Time allotted | 15 mins | Agenda topic *Dejan's Transitionless Lattice For CEBAF ARC* |  
Presenter *Donish*



- Dejan sent ideas for modification of ARC optics
  - Will reduce dispersion
  - Have null momentum compaction in ARC proper
  - Need to account for non-zero momentum compaction in spreader/recombiners
- Donish: Applied the idea but not getting good beta functions
- Dejan: troubled about combining central dipoles (7,8,9,10) might be too long
- Top cell is nominal ARC optics
  - Cell A: Two fold symmetry
  - Cell B: Two fold symmetry; different quadrupole polarity
  - Cell C: Completely different design
- Dejan: Switching phase of betatron function with the doublets
  - No correction applied to this either, so this is simply what happens from ISR/CSR
- Scott: What problem are we trying to solve?
  - Dejan: Applying transitionless lattice concept to ARC1 optics, the dispersion function was not minimized



- Left is nominal optics, right is ARC1 proper with transitionless concept ( $R_{56}=0$ )
- The peak of dispersion is not decreased by substantially with transitionless concept
- Dejan: Let me take a look at this, could decrease dispersion by factor of 4

## Action Items

## Person responsible Deadline

## Special notes

Pathway to Repository: [https://jeffersonlab-my.sharepoint.com/:f:/g/personal/tristan\\_jlab\\_org/EqZ5MeS-nipCgPfZB5p0oS4B9Is67d3nQb9sLJI3Zyev9g](https://jeffersonlab-my.sharepoint.com/:f:/g/personal/tristan_jlab_org/EqZ5MeS-nipCgPfZB5p0oS4B9Is67d3nQb9sLJI3Zyev9g)