FFA@CEBAF Working Group|Minutes

## Meeting date | time 03/22/2024 | 11 AM EST | Meeting location <https://jlab-org.zoomgov.com/j/1614898082?pwd=TnUzMS81M2sxbDZIbERJU01tYkJCQT09>

|  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| |  |  | | --- | --- | | Meeting called by | Alex B | | Type of meeting | Weekly Meeting | | Facilitator | Alex B | | Note taker | Ryan | | Timekeeper | Alex B | | Attendees  Alex B, Ryan, Alex C, Todd, Scott, Edith, Kirsten, Nick, Donish, Stephen, Reza, Dejan, Andrei, Vasiliy, Randika, François, Georg |

# Intro Discussion

* Spring break time
* FOA – no news yet
* Next LDRD season?
* Andrei encouraging to apply for sextupole option for arcs
  + Donish “getting up to speed with DA”

# Agenda topics

## Time allotted | 45 mins | Agenda topic FFA Arc Corrections| Presenter Alex C

* A bit sick
* Some slides will change by review time
* **While including optics in appendices, scope is all about corrections**
* Using the non-sextupole lattice. Use the current baseline instead of the new stuff that’s not solidified.
  + Can update for new lattice
* **Diagram

  Description automatically generated**
* **Chart, diagram

  Description automatically generated**
* **Chart

  Description automatically generated**
  + Started with a “guess” based on beta functions – so place where non-minimal betas (not at an extremum)
  + Turns out, the optimum placement is at the trailing end (last two segments) of FFA magnets
  + Bottom right corner shows optimal placement
  + 100 BPMs and 100 Correctors
  + 25 cells, 2 correctors and 2 bpm
  + 50 cells with 1 of each
    - Place correctors on focusing magnets for this option
* **Graphical user interface, text, application

  Description automatically generated**
  + If beam comes in with significant position or momentum offset, it’s hard to correct
    - Errors in lattice seem to be easy to “disappear”
  + Recently, realized that high E beam gets lost easier
    - Low E lost easily too, but less rigid
* **Chart

  Description automatically generated**
  + **Errors of 1/5th of 1 mm**
  + Uncorrected orbits – wildly nonzero
  + Highest E most robust
* **Chart

  Description automatically generated**
  + Applied SVD algorithm
  + Scale is 1 mm +/-
    - Can deliver beam to within 10s of microns (without input offsets)
* **Text

  Description automatically generated**
  + Can’t use in CW b/c don’t know individualized orbits with multipass
  + Can apply in tune mode
  + We have 1 Hz orbit lock system – based on data pulled from machine
    - Can we have this in FFA?
* Trained a NN on a function of BPM inputs and final corrector outputs
  + Reduced inputs from 6 to 1 using the function above
    - Took charge center for each energy (x\_e) multiplied by 90%^e – about losing 10% of the pass
    - Some not-exactly linear way to get information from BPMs – used this as input for NN
* **Chart

  Description automatically generated**
* **Chart

  Description automatically generated**
* **Chart, bar chart

  Description automatically generated**
  + Initial beam offsets likely cause of beam loss
* Zooming in:
  + **A picture containing chart

    Description automatically generated**
    - **For most conditions, work out perfectly well**
* **Chart, bar chart, histogram

  Description automatically generated**
  + Looking at position
  + SVD and NN perform almost exactly the same, except the last pass where a few trials were way off target
    - Still trying to figure out why
* **Chart, bar chart

  Description automatically generated**
  + Momentum offset
* Dejan – do you have aperture limits installed?
  + Yes, horizontal apertures are ~ 5 cm total
* Nick – very interesting, couple things:
  + Way to do this in operations? Essentially SVD to correct each individual pass first?
    - Alex – not quite, but close. The SVD corrects lowest E pass, waits to the point of not being able to change the last 8 or so BPMs on the lowest E pass, then does the next higher energy, but can’t change what happens at the end
    - As you go up the passes, you can’t change what you’re doing to the end of the previous passes
  + Dejan – there is a phase difference changing for each energy. By picking up the most suitable correction element b/c of the phases. When they’re picked up, then the next pass has a different set of optimum correctors to be used. Etc…
  + Alex – worth noting that the SVD algorithm carries most of the weight of this b/c it uses the least squares ….
    - Nick – ah, so you only use some correctors for each pass
    - Alex – yes, more or less
  + Dejan – 2nd pass would ruin the first pass
  + Alex – that’s the point of “freezing” the final BPMs – make sure the last 6-10 BPMs don’t have any changes – SVD won’t skew fields in previous passes
* Ryan – basically the SVD gives you an orthogonal set of knobs for each pass
* Nick – in CW they can’t see each pass?
  + Alex – right.
  + Alex B – in pulse mode, can get individual passes
  + Alex C – but in CW, you can’t.
* Ryan – the point of looking at the CW diagnostics is to not “fly blind”
  + Alex C – hard to see how we do the orbit feedback in FFAs – have ideas from 1 Hz system in CEBAF now
  + Nick – do we need faster?
    - Not sure, but Alex C’s scheme can be used at any frequency
* Nick – Panofsky quads superimposed? Slide 3
  + They fit over the permanent magnets?
  + Dejan – the nu of the permanent magnet material is ~1.03ish – so superposition works beautifully b/c fields from correctors goes through the PMs and goes to the beam
  + Nick – does quad field also correct?
    - Yes – correct in this order: vertical steering alone, then turns off and does quads, then turns off quads and does horizontal steering
      * If there’s a better order tell him
        + Depends – magnets are much longer now. Quad correction may not be necessary
  + Nick – so you correct optics with quads?
    - Not sure what diagnostics yet. For now, been assuming “something” will work
* Dejan – distance b/w lowest and highest orbit not to be neglected
  + Used 4 button BPMs at CBETA
  + Were considering 6 button as well
* Nick – energy locks?
  + Ryan – that’s part of the FFB system – vernier in the LINACs
* Dejan – right now, only single quads in the cells. If we do triplets, how would this change? Which way would we go for the triplets?
  + Alex C – scope of dissertation doesn’t include LINACs – only thought about LINACs a bit
* Alex B – we don’t correct optics in LINACs – do it in recombiners, etc… before we get into LINACs
  + Multiplexing very useful in pulse mode when we thread beam through
  + Algorithm corrects for zeroeth order optics
* Alex B – looking into upgrading BPM system – in your scheme, what are the initial requirements?
  + How many, how many buttons, etc? Just strictly theoretically?
  + Alex C – requirement – not sure minimum req
    - Assumes that over the whole FFA arc, there is 100 button BPMs in different locations
      * In the first 10 cells after the splitter, you’d have 2 BPMs
      * Next 50 only 1
      * Last 15 have two again
    - More important for general passthrough. FFA arcs pretty robust. Important in beginning to correct input errors, and very important at end of arc to deliver very precisely
      * So doubled up at beginning and end
      * In the middle, as long as you’re coming in ok, it is really robust – correction not as needed in the middle
  + Have you done an optimization on this?
    - No, not yet. Don’t want too many, but not too few
  + Not a full optimization. Want at least 1 per pass to have an idea of what the phase is doing per pass
    - Started with 2, then reduced until the delivery at the end was flagging
* For the Panofsky quad – does this need optimization?
  + If this magnet could be a little stronger, that would be nice
  + Algorithm currently not pushing power supplies.
  + Scott – current density?
    - Can find that out
* Alex C – know smallest amount you can change by
* Scott – you could also make them longer
* Alex C – assuming beam injected close to x, xp – these are great and delivers almost perfectly
* Alex B – so headroom wouldn’t hurt?
  + Wouldn’t hurt
* There was some cooling requirements – air vs water cooled?
  + Water cooling a corrector magnet would be moderately unusual (“EXTRA”)
* Dejan – keep temperature steady. Used 80-85 F at CBETA
* Scott – what in the main part of the arc with 1/cell – are you putting them in the same place in every cell?
  + Yes. Vertical beta is a bit bigger, but they’re similar magnitudes off of zero when you take the central point of the wave
* Dejan – sqrt(beta)\*theta
  + Right – but trying to balance for both planes. So compromising and not doing at a peak of either
* **Topic got changed to CBETA? Hard to follow without inside knowledge**

|  |  |  |
| --- | --- | --- |
| Action Items | Person responsible | Deadline |
|  |  |  |
|  |  |  |

## Time allotted | 15 mins | Agenda topic AOB | Presenter All

* A lot of discussion about CBETA and other stuff. Ryan stopped taking notes at this point.
* Discussion of next LDRD cycle – sextupole arcs, DA studies, etc…
  + 5 pass vs 6 pass
  + Ryan – 5 pass is better not just for arcs, but also for Splitters/Transition
  + Alex C – if we can get the transition that works, then look at changes. Instead of changing the arcs, maybe get a finished system first
    - Not saying kill it – might not be highest priority yet
* Alex B – this is a subject we just started, and if we can get funding, it could be a useful study to do
* Dejan – main reason why this is important, if we can add sextupole and extend energy reach good
* Alex B – thorough studies need to be done to conclude
  + Good subject for LDRD
* Dejan – serious question from Hutton – why not remove splitters totally?

|  |  |  |
| --- | --- | --- |
| Action Items | Person responsible | Deadline |
|  |  |  |
|  |  |  |

## Special notes

Pathway to Repository: <https://jeffersonlab-my.sharepoint.com/:f:/g/personal/tristan_jlab_org/EqZ5MeS-nipCgPfZB5p0oS4B9Is67d3nQb9sLJI3Zyev9g>

No Meeting for Next Two Weeks