A CEBAF Energy Upgrade that MAY be Feasible

Jay Benesch

3 December 2024

1. Linac energy variable 1000-1100 MeV for polarization optimization and CM degradation.
2. Linac quads under 3.7 kG/cm gradient with 40 mm physical aperture (A) vs 48 mm now.
3. Four electromagnetic and five permanent magnet passes
4. Splitters may cover full tunnel width so beams remain in good field regions. (B)
5. Aluminum platform over splitters with 3° ramps fore and aft for material movement.
6. Repurpose Hall D as a permanent Physics high bay assembly and test area during positron run.
7. Baseline separation assumption: RF separation on electromagnetic passes, magnetic separation on permanent magnet passes via (normally off) extraction magnets. ABC all get same energy.
8. For vertical separation to ABC, consider LN2-cooled copper or aluminum RF cavities.
9. Explore separation concepts which would allow ABC to get different energies > 9.5 GeV.

An A&E firm should be engaged to determine if it is feasible to excavate, construct and then bury a 4 m by 20 m by 70 m vault adjacent to the existing tunnel with minimal damage to the tunnel and surface buildings. This is large enough that both the planned positron injector at 123 MeV and a ring to take either electrons or positrons to 650 MeV could be housed therein. This would allow the positron program to continue at 9.5 GeV, alternating with an electron program at 18-20 GeV, if the energy upgrade is approved. Many facility services pass through this volume and would have to be temporarily re-routed during construction. If energy upgrade is not approved, positron and electron programs would continue at 11 GeV indefinitely, leaving part of the new vault empty.

Positron source development would be done in LERF as now planned including acceleration to 123 MeV. The long transfer line from LERF to the NW corner of CEBAF would not be built. Either the positron source from LERF or a derivative would be installed in the new vault.

(A) https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-291479/24-053.pdf
(B) https://jlabdoc.jlab.org/docushare/dsweb/Get/Document-277999/23-069.pdf
Figure 24 look at beam locations versus edges of dipoles

Why is the present scheme infeasible?

1. It is impossible to build steel quads to provide the strong focusing linac triplet optics in the space available between cryomodules. (A) Hybrid quads are not an option because the aperture will be too small to steer through, only 8.5% of present area vs 69.4% with (A) EM quad design
2. Six-pass splitters do not work with the weak focusing linac optics. (Five-pass might)
3. Six pass splitters assume the C dipole field is uniform to the edge of the pole: not physical (B)
4. Acceptance of the first and sixth passes in the permanent magnet arcs is very small even after correction, as Alex Coxe's dissertation shows. Five passes: adequate.
5. No design for transition between FFA arcs and the rest of the machine.
6. Synchrotron radiation induced horizontal emittance at 22 GeV increases beam size to the point that the beam tubes in the A and C line girders will be activated by beam edges (not halo, edges). Increase in emittance in the splitters exacerbates this.
7. Halls A and C lines physically do not allow more than nine dipoles and nine quads at 22 GeV even if all BPMs and correctors are eliminated. Without BPMs and vertical correctors Ops is unlikely to get beam to the halls. Online energy measurement will be impossible. Minimum dispersion 1.7 m per A. Bogacz with eight dipoles/quads.