CEBAF Upgrade Injector Location Debate
Jay Benesch (11 September 2025 1600 version)

LERF advantages

1. It exists
2. Positron source development work will be done there
3. Digging the tunnel to convey beam to the West Arc is straightforward
4. 2K cold box supplying the LERF and South Linac **may** have enough capacity to support the additional cryomodules required.

LERF disadvantages

1. It's 70 m by 13 m, constraining layout. Ceiling is low.
2. Floor is several meters above that of the CEBAF tunnel, generating vertical dispersion which must be suppressed within sloping tunnel to West Arc, complicating optics.
3. It has less than 2 m shielding as FELs are radiologically benign. Soil overburden has shifted and must be repaired for its use in cryomodule testing, much less as a positron source.
4. Too small to allow both 123 MeV positron and 650 MeV electron production simultaneously, ending positron program if energy upgrade is approved.
5. Requires a transfer line ~800 m long hanging from ceiling to convey beam to North Linac
6. Simulations suggest 10-20% of positrons are lost in transiting that line.
7. Transfer line must cross tunnel and descend to meet injection point in a crowded region without violating life safety code egress requirements.
8. Facilities has installed convective cooling system hanging from the ceiling in the arcs, reducing options for beam line placement or requiring complete cooling system replacement.
9. Facilities will install groundwater intrusion collection system throughout the CEBAF tunnel during SAM 25 and 26, again hanging from the ceiling. Another likely interference.
10. Fire suppression system also hangs from ceiling over the aisle as it was deemed too expensive to replace the pipe behind the magnet stands. That pipe was installed before any technical equipment was installed in the tunnel.
11. Existing LERF RF and cryo provisions are poorly placed to service positron acceleration after creation. User labs may have to be pressed into service.
12. Precludes other uses of LERF, for instance for an ongoing low energy nuclear physics program, as is being discussed in a November 2025 workshop, if used as CEBAF injector.

Adjacent to existing injector: disadvantages

1. This would be a more extensive and expensive construction project than the LERF tunnel. Care must be taken to avoid damage to existing structures and the vault is much larger.
2. Many utilities run through the ground that would be disturbed.
3. External architecture and engineering firm should be engaged to examine feasibility and estimate cost. Suresh Chandra expressed the opinion that it could not be built without damaging existing facilities. Steve Suhring was of the opinion that sheet piles could be driven next to the existing service building and tunnel to prevent damage.
4. A review of the 2024 estimate, which is missing most transfer line magnets, suggests the TPC will increase about 5%. I assume $5K per square foot construction costs, same as BDX hall. The 5% estimate assumes everything in LERF will be moved to the new vault.
5. A modern 2K cold box would be required to supply the additional cryomodules as the existing, 30 year old North Linac cold box is at capacity. The cryogenics groups has submitted a proposal to replace it with one identical to that supplying the South Linac as cold compressor failure in the existing unit is a concern.

Adjacent to existing injector: advantages

1. The grassy area inside the site fence from the service buildings to the fence next to the ESH building is about 20 m wide, half again as wide as LERF. Fence and drainage ditch could be moved to gain a bit more width.
2. From the fence by the guard shack to the start of the North Linac is about 70 m, the same length as the LERF. From the fence to the start of cryomodule NL05 is about 100 m. The transition from the FFA arcs to the linac requires about 50 m; removing the first three cryomodules provides 45 m for this optics function.
3. A 20 m by 100 m vault is feasible in this location, 2.2x the area available in LERF. A longer vault yet could be built if desirable. Pillars are necessary and must be located in concert with accelerator components. Perhaps a 5 m grid, three rows of eighteen columns? 24" I-beams span the 20 m width? Or two rows 7 m apart, 6 m from walls.
4. Vault would be at the same depth as the CEBAF tunnel - no vertical dispersion to deal with.
5. Overburden and shielding would be at least the same and it could be greater than that of the CEBAF tunnel given skyshine from the positron source. AKA thicker concrete roof.
6. A 20 m by 100 m vault is sufficient to contain the positron source, a parity quality electron source, and a ring to take either to 650+ MeV, the injection energy needed for the energy upgrade. This would allow the positron program to continue indefinitely at 9.5 GeV interleaved with 20+ GeV electrons. 9.5 GeV will be the capability of the four electromagnetic passes if the energy upgrade is built. (Positrons cannot be circulated through the permanent magnets without rotating them about their vertical axes, not practical.)
7. Once civil construction is concluded, CEBAF operation can resume while the new equipment is installed in the vault and the new surface service buildings. Interruption to CEBAF will be no longer than and could be shorter than that required for LERF tunnel construction and transfer line installation.
8. Optics from new injector vault to North Linac would be very simple. Transfer line perhaps 8 m versus ~800 m for LERF. Particle loss can be minimized.
9. No change to then-existing Facilities infrastructure in CEBAF tunnel: everything hanging from the ceiling remains as is or will be.
10. ESR2 will have spare capacity after MOLLER. A temporary LHe transfer line to a Roots-blower based 2K system with warm return might allow commissioning of the new injector while CEBAF is running a 12 GeV electron program. Only after the new 123 MeV injector is debugged would the wall between the new vault and the CEBAF tunnel be breached. The cryo feed to the existing CEBAF injector would be diverted to the new vault and the beam pipes joined. Existing injector would remain in place until the energy upgrade when all the magnet stands come down. CTF is another possible temporary 2K source. Road clearance would be an issue for either transfer line. If Hall D is shut down as I recommend in TN-24-054, that system could be moved and upgraded to 2K.
11. Under Disadvantages (4) I assumed that all the equipment in LERF would be moved to the new vault. If it were retained there as a low energy electron-positron experimental facility, requiring duplication of all gear, TPC would increase about 10% over the cost of the project estimated in 2024. This would significantly expand the range of physics that can be done at JLab.