2 PR12-20-009 and PR12-20-012

These experiments propose to measure DVCS beam charge asymmetries in HallB (-009) and HallC (-012) respectively using a CEBAF accelerator with a positron beam. The feasibility of these experiments heavily depends on the properties and qualities of the positron beam provided by the accelerator.

2.1 Positron Beam in CEBAF

The baseline design of the CEBAF accelerator expects a beam emittance of 4 nm at the injection to the main accelerator with a momentum spread of 10^{-3}. This is crucial since for the first two passes in the machine there is a damping effect taking place that reduces the beam emittance to about 0.22 nm (before arc 5) in both dimensions. From this point on the beam emittance will increase with increasing beam energy due to synchrotron radiation. At the end of Arc 9 the emittance will have grown by almost a factor of 10 in the horizontal bending direction and about a factor of 4 in the vertical direction.

Therefore, independent of the design choice for a positron beam source, in order for the existing CEBAF accelerator to successfully accelerate the beam, the positron beam needs to have the following characteristics at the point of injection into the main machine:

- Bunch length $< 500\mu m$. This is critical to keep the momentum dispersion at acceptable levels throughout the machine.
- $\Delta p/p < 2 \cdot 10^{-3}$ before ARC 1. This is critical with regards to acceptance and chromatic effects. This value is currently routinely around 0.1% during beam operations.
- Total beam current $>$ 500 nA with multi-hall operations.
- For currents near the 500 nA lower end of this range, beam diagnostics must be upgraded in many regions of the machine to monitor position and beam loss. The beam loss accounting system now ignores differences of less than 1 μA from injector to the sum of the four halls.

Fig. 3 in PR12-20-012 and Fig. 8 in PR12-20-009 are only sketches and many of the important details of the setup are missing. In particular, the injector area is already crowded and the area shown in the figure with the collection and energy selection system likely will require civil construction to be added. Also, the details of all the new magnets required need to be listed and shown. Thus, to really understand the impact and cost of this system to the injector requires detailed CAD drawings.

While there are several conceptual ideas available for a positron source, there is currently no sufficiently detailed design that meets the required operating parameters listed above. Given the large investment in time and money needed to construct and operate a positron injector, as well as the previous investment in the 12 GeV upgrade, it is reasonable to require that a positron injector be capable of flexible multi-hall operation. In that case, two positron energies will be needed. Sending positrons to Hall B with at least 60% polarization requires selection of positrons with at least 50 MeV. But at this positron energy, the yield is so low that it would require a MWatt scale facility to simultaneously send 5 μA of unpolarized positrons to Hall C. Thus, without energy recovery or an improvement in positron production efficiency by orders of magnitude, a second, lower positron energy will be needed to provide μA scale currents to the high luminosity halls as well as 300 nA beam to the Hall D tagger. These two bunch trains with different timing, charges and energies will then have to be independently accelerated to 123 MeV/c and interleaved so as to form one train compatible with 1497 MHz accelerating cavities and the existing RF separators at 499 and 748.5 MHz. A practical positron injector is an FEL-scale facility.

In addition to these considerations there is also the task of making the accelerator itself compatible with a positron beam as all the magnetic fields need to be reversed.

- Magnet polarity change can be accomplished with polarity reverse switches, however for the 120 shunt modules there is not enough space available in the buildings to do this. As a consequence this will be a manual polarity change by swapping lead contacts. Building additions in six locations are a second option, given the scale of the work required for this project. These would provide space for polarity reversing switches for the shunts.
- The 45 box supplies can be equipped with polarity reversal switches but could require some investment.
- Depending on the available equipment, a polarity change of the magnets and shunts alone will take between two and four weeks.
- All beam lines leading up to the experimental halls will also need to be made compatible with a positron beam.

In conclusion, while a positron beam upgrade is a major upgrade which will require substantial accelerator physics development, a detailed cost and implementation plan, and expensive changes to the CEBAF accelerator, a multi-Hall positron beam capability could have great potential for a future JLAB 12-GeV science program.