Beam Requirement for the 6 GeV PVDIS Experiment E08-011

Beam Property	Nominal Value	Maximum Run-averaged Helicity-correlation	Helicity-Correlated one-day (“slug”) average
Average current	up to 105 μA	1 ppm	5 ppm
Energy	6 and 4.8 GeV	$\Delta E/E < 1$ ppm	< 5 ppm
Positiion x at target	0	50 nm	
Angle x' at target	0	50 nrad	250 nrad
Position y at target	0	50 nm	250 nm
Angle y' at target	0	50 nrad	250 nrad
Charge asymmetry	0	< 10 ppm	< 10 ppm
transverse beam polarization (vertical, up/down)	0	$< \pm 2\%$	$< \pm 2\%$
transverse beam polarization (horizontal, left/right)	0	$< \pm 20\%$ shared with Hall B	$< \pm 20\%$ shared with Hall B

- Maximum Run-averaged helicity-correlation: This refers to the maximum value of the helicity-correlated (HC) difference (or asymmetry) that can be tolerated after averaging over the entire 32-day run.

- One-day “slug” average: Due to statistical noise, it is not possible to tell in a short measurement whether a systematics offset exists which will make it impossible to reach the run-averaged HC goal (the only exception is for charge asymmetry). Averaging beam parameters over approximately one day porvides a convenient benchmark for convergence to the run-averaged HC goals, with enough statistical precision to perceive systematic offsets. These one-day average specifications are made with the assumption that the averages are statistically distributed, with no measurable offset. If the one-day averages are not distributed around a negligible systematic offset, corrective action will be necessary in order to assure convergence to the run-averaged goals.

1 Special Considerations: Transverse polarization test run

1. A transverse polarization of the beam would cause single-beam asymmetries which can affect the measurement of the PVDIS asymmetry. Single-beam asymmetry (A_T) comes mainly from TPE, for which there is no reliable calculation for inelastic scattering. Also note that although the acceptance of the HRS is approximately symmetric in the up/down direction, which would in principle minimize the effect of transverse single-beam asymmetries, this is not the case for PVDIS because we divide the focal plane into eight groups, each providing an independent asymmetry measurement and their vertical acceptances are not symmetric.

   We will spend up to two shifts (16 hours, excluding setup time) to measure the transverse beam asymmetry, preferrably during the first week of production running. For this test we will need to set the beam polarization 100% in the vertical (up/down) direction, which is very invasive to other halls and needs to be planned ahead. Within 16 hours the uncertainty on A_T we can achieve will be roughly 36% of the size of the PVDIS asymmetry A_d, which will be $\Delta A_T \approx 30$ ppm for the lower Q^2 and 60 ppm for the higher Q^2 point, respectively. With this precision it is unlikely that we will observe a non-zero asymmetry, but we can at least set an upper limit.

   The angular dependence of the asymmetry from TPE is $\propto \vec{S}_e \dot{(} \vec{k_e} \times \vec{k'_e})$. The effect on the measured asymmetry in the spectrometer would be

   $$\Delta A \;\; = \;\; \Delta A_T \left(S_H \sin\theta_{tr} - S_V \sin\theta_0 \cos\theta_{tr} \right)$$

   where S_H, S_V are fractions of the electron spin in the horizontal (left/right) and vertical (up/down) directions, respectively, θ_{tr} is the particle's out-of-plane angle in the transport coordinate, up to 30 mrad for detector groups on the edge, and θ_0 is the spectrometer central angle. Using this formula we request the alignment of the beam spin direction to be within $\pm 20\%$ in the horizontal and $\pm 2\%$ in the vertical direction, corresponding to $< 0.2\%$ systematic effects on the measured asymmetries from each component. The $\leq 20\%$ transverse polarization is also what we expect to have if the polarization is shared between Hall A and B.