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Stern-Gerlach Polarimetry

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It is explained how the CEBAF 123 MeV injection line can serve as one big Stern-Gerlach (S-G) polarimeter measuring the polarization state of the injected beam. No physical changes to the line are required and (though not optimal) resonant beam position monitors (BPMs) already present in the line detect the S-G signals.

The historical Stern-Gerlach apparatus used a uniform magnetic field (to orient the spins) with (skew) quadrupole magnetic field superimposed (to deflect opposite spins oppositely) and a neutral, somewhat mono-energetic, unpolarized, neutral atomic beam of spin 1/2 particles. For the highly-monochromatic, already-polarized beams produced by Jefferson Lab electron guns, the uniform magnetic field has become superfluous, and every quadrupole in the injection line produces polarization-dependent S-G deflections.

Dual CEBAF electron beam guns produce superimposed 0.25 GHz (bunch separation 4 ns) electron beams for which the polarization states and the bunch phases are adjusted individually. The (linear) polarizations are opposite and the bunch arrival times are adjusted so that (once superimposed) the bunch spacings are 2 ns and the bunch polarizations alternate between plus and minus. The effect of this beam preparation is to produce a bunch charge repetition frequency of 0.5 GHz different from the bunch polarization frequency of 0.25 GHz. Along with low frequency modulation of the polarizations, this difference will make it possible to distinguish Stern-Gerlach-induced bunch deflections from spurious charge-induced excitations.

The paper calculates the S-G signals to be expected at each existing BPM position during routine (alternating polarization) CEBAF 123 Mev electron injection line in a "proof-of-principle" test. Once successful, this should motivate the development of a passive (non-destructive) form of high analyzing power, precision polarimetry.

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