Polarization coordinates for $\vec{e}$p elastic

For proton scattering on an analyzer the asymmetry, ϵ, is defined as:

$$\epsilon = \frac{(\#\text{ scattering to left}) - (\#\text{ scattering to right})}{(\#\text{ scattering to left}) + (\#\text{ scattering to right})} \tag{1}$$

The coordinate system at the focal plane is defined with P_x^{fp} pointing along the +x dispersive direction, P_z^{fp} pointing along the proton momentum and P_y^{fp} defined by $\vec{z}x\vec{x}$. The azimuthal scattering angle, ϕ, is define as zero along the +y direction and rotates from +y to the +x axis. Therefore +90° is pointing along the +x axis. The asymmetry can be written as a function of ϕ as:

$$\epsilon = \epsilon_y \sin(\phi) + \epsilon_x \cos(\phi) \tag{2}$$

and $\epsilon_y = AP_y^{fp}$ and $\epsilon_x = -AP_x^{fp}$.

Now one need to relate the focal plane polarizations to the target polarizations. The coordinate system at the target is defined in the same way as the focal plane coordinate system. Assuming a simple dipole magnet then $P_x^{fp} = -P_z^{tg}\sin(\chi)$ and $P_y^{fp} = P_y^{tg}$. Therefore, $\epsilon_y = AP_y^{tg}$ and $\epsilon_x = AP_z^{tg}\sin(\chi)$.

For $\vec{e}$p elastic scattering with the electron scattering to beam right, $P_z^{tg} > 0$ and $P_y^{tg} > 0$. Therefore one expects $\epsilon_y > 0$ and $\epsilon_x < 0$ since $\chi = 270$.

Now the above assumes a certain helicity convention for the signals that we receive from MCC which indicate the flipping of the beam helicity at the source. In our code we define a variable, *helicity*, which is used to indicate the beam helicity is along it's momentum direction or the opposite. For the above *helicity* = 1 was used to tag events as beam helicity in the direction of its momentum. Using this convention we get the proper signs of the ep elastic polarizations.

Now this convention can be checked by comparison to Moller. There is a nice write-up at http://www.jlab.org/m̃oller/spin_direction.html by Eugene explaining the Moller helicity convention . For the Moller, with the half-wave plate out, the raw asymmetry is negative for a coil current of +9.0A so that means the beam helicity is positive for a logical level of 1 which is what is found for the ep elastics in the FPP. As of Dec. 2000, the FPP and Moller were using the convention for the signals so this confirms it, but it is worthwhile to independently confirm this. One way is by looking at the measure charge asymmetry for Moller and the scalers for the left arm. Of course they have to be for the same time period since the charge asymmetry changes over time. Another way is to set up a system to feed an independent signal (that is set up to be asymmetric) into both the Moller and left arm electronics and check that both measure the same asymmetry. This was done in Nov 30, 2000 as explained in halogs 52585 and 52588. At that time the Moller and FPP had opposite convention, but since then they were made the same. This is verified by the agreement between ep elastic and the Moller, but it doesn't hurt to recheck.

The Moller helicity convention can be compared to the convention at the injector. With the half-wave plate out the injector measures -73.5% (see elog 17596). With the spin precession through the accelerator we would expect to have negative polarization in the hall if we used the same helicity convention as injector. Since Moller measures a positive polarization in its helicity convention then the convention must be opposite. The injector is using PGUN3 and for Ndelta experiment it was also seen that with PGUN3 the helicity conventions are opposite (Though for PGUN2 the conventions are the same, somehow injector changes its convention with the different guns)