A_{LR} with Positron Polarization (Comment)

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Abstract. This is a short comment to call your attention to the usefulness of positron polarization in reducing the systematic error on A_{LR} as described in our old note [1].

The usefulness of the positron polarization has already been mentioned at least twice [2,3] in this conference. In particular, we have heard a very professional talk by P.C. Rowson detailing experimental issues in the A_{LR} measurement. It is thus probably unnecessary to make this comment, but for T. Omori's sake I will do it anyway.

The use of positron polarization in the A_{LR} measurement was first discussed in [4], where the significant improvement of measurement errors through the reduction of error propagation was pointed out. Define the combined polarization (which is sometimes called effective electron polarization) by

$$P_{comb} \equiv \frac{P_- - P_+}{1 - P_- P_+}, \tag{1}$$

where we have adopted the right-handed helicity bases, so $P = -1$ means 100% left-handed. Then the observed left-right asymmetry will be given by

$$A_{obs} \equiv \frac{N_L - N_R}{N_L + N_R} = -P_{comb} A_{LR}, \tag{2}$$

which leads us to the following expression for the measurement error on A_{LR}:

$$\frac{\Delta A_{LR}}{A_{LR}} \simeq \sqrt{\left(\frac{\Delta P_{comb}}{P_{comb}}\right)^2 + \frac{1}{N(P_{comb} A_{LR})^2}}, \tag{3}$$

where $N = N_L + N_R$[1]. In the high statistics limit, the systematic error on P_{comb} will thus dominate the error on the left-right asymmetry. The key point T. Omori made in [1] is the use of linear error propagation:

[1] In this toy calculation, I ignored other error sources such as energy measurement, which can be dominant [3]

$$\Delta P_{comb} = \left(\frac{\partial P_{comb}}{\partial P_-}\right)\left(\frac{\Delta P_-}{P_-}\right)P_- + \left(\frac{\partial P_{comb}}{\partial P_+}\right)\left(\frac{\Delta P_+}{P_+}\right)P_+. \tag{4}$$

This is based on the observation that identical apparatuses will be used for both electron and positron polarization measurements, and therefore the relative systematic error on the positron polarization will be equal to that on the electron polarization in both size and sign:

$$\frac{\Delta P_-}{P_-} = \frac{\Delta P_+}{P_+} \equiv \frac{\Delta P_\pm}{P_\pm}. \tag{5}$$

Equation (4) then reduces to

$$\frac{\Delta P_{comb}}{P_{comb}} = \frac{1 + P_- P_+}{1 - P_- P_+}\left(\frac{\Delta P_\pm}{P_\pm}\right). \tag{6}$$

The combined polarization and the reduction factor for its relative error are plotted as a function of the magnitude of the positron polarization in Fig.1. We can see

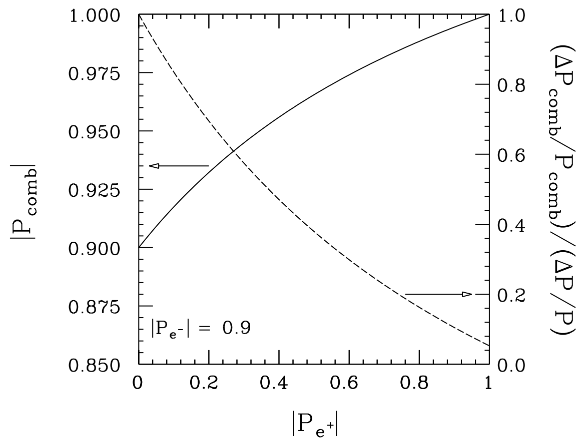

FIGURE 1. Combined beam polarization (solid) and error reduction factor (dashed) as functions of positron beam polarization when $|P_{e^-}| = 0.9$.

that already at $P_+ = 0.5$, the relative systematic error on P_{comb} can be significantly reduced.

REFERENCES

1. K. Fujii and T. Omori, KEK Preprint 95-127.
2. K. Mönig, these proceedings.
3. P.C. Rowson, these proceedings.
4. K. Flöttmann, DESY 95-064.