

Effect of Positron Polarization on P_{eff} , $\delta(P_{\text{eff}})$ and W-pair Background Suppression

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4. P_{eff}

When both beams are polarized, an effective polarization can be defined for A_{LR} measurements relevant for s-channel vector exchange,

$$P_{\text{eff}} = \frac{P_- + P_+}{1 + P_- P_+},$$

where P_- and P_+ are absolute values of the electron and positron polarization respectively.

The benefit of positron polarization can be seen in Table 1. If we define a Figure-of-Merit, FOM, to be $(P_{\text{eff}}/P_-)^2$, then 30% positron polarization increases the FOM by 23% (10%) for $P_-=80\%$ (90%).

Table 1: P_{eff}

| P_- | P_+ | P_{eff} | FOM |
|-------|-------|------------------|------|
| 0.8 | 0.3 | 0.887 | 1.23 |
| 0.8 | 0.6 | 0.946 | 1.40 |
| 0.9 | 0.3 | 0.945 | 1.10 |
| 0.9 | 0.6 | 0.974 | 1.17 |

5. $\delta(P_{\text{eff}})$

The uncertainty in P_{eff} is reduced compared to the uncertainty in P_- and P_+ given from the polarimeters. This is summarized in Table 2, where I assume 0.25% polarimetry uncertainties on both the electron and positron polarimeters. Substantial improvements in the precision on A_{LR} measurements is achieved with 30% positron polarization.

$$\frac{\partial P_{\text{eff}}}{\partial P_-} = \frac{1 - P_+^2}{(1 + P_- P_+)^2}, \quad \frac{\partial P_{\text{eff}}}{\partial P_+} = \frac{1 - P_-^2}{(1 + P_- P_+)^2}$$

Table 2: $\delta(P_{\text{eff}})$

| P_- | P_+ | $\delta(P_{\text{eff}})/P_{\text{eff}}$ |
|-------|-------|---|
| 0.8 | 0.3 | 0.16% |
| 0.8 | 0.6 | 0.08% |
| 0.9 | 0.3 | 0.14% |
| 0.9 | 0.6 | 0.07% |

6. W-pair Background suppression

The production cross section for W-pairs for

- i. Left-polarized electrons and right-polarized positrons, is

$$\sigma_1 \approx (1 + P_-)(1 + P_+)\sigma_{LR}$$
- ii. Right-polarized electrons and left-polarized positrons, is

$$\sigma_2 \approx (1 - P_-)(1 - P_+)\sigma_{LR}$$

A FOM for background suppression studies can be defined as $\text{FOM} = \sigma_1/\sigma_2$. Table 3 summarizes these FOM. A substantial improvement is achieved with 30% positron polarization.

Table 3: FOM W-pair background suppression

| P_- | P_+ | FOM |
|-------|-------|-----|
| 0.8 | 0 | 9 |
| 0.8 | 0.3 | 17 |
| 0.8 | 0.6 | 36 |
| 0.9 | 0 | 19 |
| 0.9 | 0.3 | 35 |
| 0.9 | 0.6 | 76 |