Spin Discussion

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Spin and Luminosity at RHIC

$$A_L = \frac{\sigma_+ - \sigma_-}{\sigma_+ + \sigma_-}$$

Beam is not 100% polarized. We measure a combination of σ_+ and σ_-:

Counts (for 100% acceptance): also use $L^+ = L^- = L$

$$C^+ = L^+_+ \sigma_+ + L^+_- \sigma_- \qquad (L = \int L' dt)$$

— for beam polarized in + direction

$$C^- = L^-_+ \sigma_+ + L^-_- \sigma_-$$

— beam pol. in − direction

... algebra

$$\boxed{A_L = \frac{1}{P_{avg}} \frac{C^+ - C^-}{(C^+ + C^-) - (C^+ - C^-)\frac{P_{dif}}{P_{avg}}}}$$

$$P_{dif} = \frac{P^+ - P^-}{2}$$

$$P_{avg} = \frac{P^+ + P^-}{2}$$

$$P^+ = \frac{L^+_+ - L^+_-}{L^+_+ + L^+_-} \qquad P^- = \frac{L^-_- - L^-_+}{L^-_- + L^-_+}$$

P^+ and P^- can be calculated from the polarization of individual bunches:

$$P^+ = \frac{B_+^+ - B_-^+}{B_+^+ + B_-^+}$$

B_+^+ = number of beam protons with pol = + for a + pol. sign bunch; $L_+^+ = \text{const.} \times B_+^+$

$$= \frac{\sum (B_{+i}^+ - B_{-i}^+)}{\sum (B_{+j}^+ + B_{-j}^+)}$$

sums over crossings for + polarized bunches

$$= \frac{\sum B_i P_i^+}{\sum B_i}$$

$$P_i^+ = \frac{B_{+i}^+ - B_{-i}^+}{B_{+i}^+ + B_{-i}^+}$$

$$\boxed{P^+ = \frac{\sum L_i^+ P_i^+}{\sum L_i^+}}$$

$$\boxed{P^- = \frac{\sum L_i^- P_i^-}{\sum L_i^-}}$$

P^+ and P^- are the weighted avg.s of the bunch polarizations, weighted by the luminosity of the crossings.

Case for a = acceptance $\neq 100\%$, $L^+ \neq L^-$:

$$C^+ = \frac{N^+}{a^+ L^+} \qquad C^- = \frac{N^-}{a^- L^-}$$

$$A_L = \frac{1}{P_{avg}} \frac{C^+ - C^-}{(C^+ + C^-) - (C^+ - C^-)\frac{P_{dif}}{P_{avg}}}$$

For some signals (jets), $N = N^+ + N^- \approx 10^6$

$\Rightarrow \Delta N/N \approx 10^{-3}$

$\Rightarrow$ need relative luminosity

$$\frac{\Delta L}{L} \approx 10^{-4}$$

$\Rightarrow$ statistics for $\Sigma L \approx 10^8$

and want systematics for measuring L to 10^{-4}.