CORRELATING CME WITH NET LAMBDÁ HELICITY

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LOCAL PARITY VIOLATION SHOULD SHOW UP IN THE DIFFERENCE OF
(LEFT HANDED LAMBDAS – RIGHT HANDED LAMBDAS) EVENT TO EVENT.

THIS COULD BE SEARCHED FOR AS “UNEXPECTEDLY LARGE” EVENT-BY-EVENT
FLUCTUATIONS IN THE NET HELICITY OF LAMBDAS. THIS IS DIFFICULT AND THE
BACKGROUND MURKY.

THIS COULD BETTER BE SEARCHED FOR AS “LEFT HANDED CME EVENTS SHOULD HAVE
AN EXCESS OF LEFT HANDED LAMBDAS”. THIS IS EASIER AND HAS A CLEARER
EXPECTATION.
CME and lambda helicities

- In the chiral limit...

$$\left( N^u_L - N^u_R \right) = \left( N^d_L - N^d_R \right) = 2Q = \left( N^s_L - N^s_R \right)$$

Q is event-wise quantity applies to both

Some Goes into net helicity for Hyperons

Most Goes into CME for pions
SIMULATION: LOOKING AT JUST LAMBDA HELICITIES

Averaged over many events, net lambda helicity should be zero, but we could look for “Large” event-by-event fluctuations in $N_L^\Lambda - N_R^\Lambda$.

Assume:

\[ \Lambda \text{ spin (helicity)} \text{ completely determined by spin (helicity) of s quark.} \]
SIMULATION: LOOKING AT JUST LAMBDA HELICITIES

Averaged over many events, net lambda helicity should be zero, but we could look for "Large" event-by-event fluctuations in $N_L^\Lambda - N_R^\Lambda$

$\sigma_Q$ is the assumed width of the event-by-event distribution of $Q$

Different curves represent different efficiencies for finding a $\Lambda$

Need a LOT of events to see a signal in the ideal (no backgrounds) case.
Each event is characterized by its $Q$ value:

**positive $Q$ value**
- Excess of left-handed $\Lambda$
- Charge separation OPPOSITE to magnetic field ($[a_+ - a_-] < 0$)

**negative $Q$ value**
- Excess of right-handed $\Lambda$
- Charge separation ALONG the magnetic field ($[a_+ - a_-] > 0$)

LOOK FOR THESE CORRELATIONS (Need 1st order reaction plane information)
FIRST QUESTION-COULD WE SEE THIS EFFECT?

SIMULATION:

• Assume: all signal measured by STAR in charged particle correlations in 200GeV Au+Au 30-60% centrality bin is due to chiral magnetic effect.

• This implies a particular average $Q$ value in this collisions – assume $Q$ according to Gaussian distribution with $\sigma_Q = 2 \rightarrow$ this actually gives “$a$” of about .025 (a bit bigger than the STAR measurement)

• If that $Q$ also manifests itself in $\Lambda$ helicities, how many events for a measurable correlation signal?

• Assume 1st order rxn plane resolution is 45%
QUANTIFYING THE SIGNAL FROM THE SIMULATION

EACH EVENT GOES INTO THIS PLOT:

IF CHARGE DIPOLE POINTS ALONG MAGNETIC FIELD, PLOT \( N_L^\Lambda - N_R^\Lambda \)

IF CHARGE DIPOLE POINTS OPPOSITE TO MAGNETIC FIELD, PLOT \( N_R^\Lambda - N_L^\Lambda \)

LOOK AT THE STATISTICAL SIGNIFICANCE OF THE MEAN BEING NON-ZERO and NOTE: THE SIGN IS MEANINGFUL
In simple simulation, how much signal in 10M events?

Vary \( \Lambda \)'s efficiency from 2\% to 30\%.

Need few millions of events (in that centrality range) in these cases.
TO DO

• Improve parameters of simulation (assumptions of s quark being massless, s quark helicity determining lambda helicity, change assumptions about Q)

• Redo with event generator

• Worry about backgrounds
SUMMARY

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Thanks to SCSU undergraduate Hang Pham