$H_0$ candidates from the decay $H_0 \rightarrow \Sigma^-p$, observed in heavy ion collisions with $14.6 \times A$ GeV/c Si beam on Pb target.

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We present $H_0$ candidate events, where the $H_0$ is observed through the decay $H_0 \rightarrow \Sigma^-p$. These decays are reconstructed in the three TPC modules of E810 while triggering on central Si Pb events at $14.6 \times A$ GeV/c Si beam.

1. INTRODUCTION

There is considerable interest in searching for strange quark matter (strangelets)[1]. The lowest strangelet state is thought to be a six quark dibaryon singlet spin zero state called the $H_0$ predicted by R.L.Jaffe[2]. A major decay channel predicted by Ref. 2 is $H_0 \rightarrow \Sigma^-p$. This channel is detectable if one only measures the charged particles that come from the decay.

2. EXPERIMENTAL METHOD

The experimental method was described in previous publications[3]. Briefly, experiment E-810 measured charged tracks in three TPC (Time Projection Chamber) modules in a magnetic field. The trigger, as described in Ref. 3, selected centrally enriched events for data recording. For the final data sample we selected the most central events using a cut on the highest multiplicity of the negatively charged tracks within our good acceptance (300 mb ~10% of total cross section).

In order to search for potential $H_0$'s, a pattern recognition was developed which put together a positive negative track vertex with a negative negative kink vertex sharing the

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same negative track. We then make a fit constraining the kink vertex to be consistent with a \( \Sigma^- \) decaying into a \( \pi^- \) plus an unobserved \( n \). We processed several thousand Si Pb central events and much to our surprise we found a handful of candidates whose track length was greater than 30 cm. This implied that we were only observing a small percentage of the actual \( \Sigma^- \) decays. In order to check this point we improved our pattern recognition to find short negative tracks.

3. RESULTS

With the improved pattern recognition we processed 5000 central Si Pb events and found 44 candidates. From this sample, we have 33 candidates whose effective mass lies below the \( \Lambda \bar{\Lambda} \) threshold (see Fig. 1). This represents a factor five increase in yield. We have searched for background candidates in the data by looking at the opposite charge assignment. In the same 5000 central events we have found 10 candidates with 5 above the \( \Lambda \bar{\Lambda} \) threshold and 5 below. Using this 50-50 split we can estimate that of the 33 candidates, 11 are background. Figure 2, shows a typical \( H_0 \) decay in the TPC modules.

The full width at half maximum (FWHM) for the threshold \( \Sigma^-p \) bump is 52 MeV/c\(^2\). In order to check the mass resolution and determine the lifetime and the acceptance, a complete Monte Carlo simulation of events was performed using GEANT. Events were generated using the HIJET model[4]. The generated TPC hits included all the known effects of the detector apertures, efficiencies, resolution, and distortions. We embedded an \( H_0 \) particle produced according to a simple production model.

\[
\frac{dn}{dm dy} = m_t N_0 e^{-(a + b \cosh(y - y_0))m_t} \tag{1}
\]

The \( H_0 \) lifetime and \( H_0 \) mass are also parameters. From the 33 \( H_0 \) events we calculate the observed rapidity spectrum and the observed \( H_0 \) lifetime, which is determined by our acceptance. For the Monte Carlo generated events we reconstruct \( H_0 \)'s and compare this directly to the uncorrected \( H_0 \) data. We then adjust the above parameters and regenerate, process and compare. Our final parameters give a \( cT \) of 10 cm, mass of 2.18 GeV/c\(^2\) and an inverse slope of 150 MeV/c\(^2\). We then generated 10000 \( H_0 \) events in order to get our preliminary acceptance. The effective mass spectrum of the generated \( H_0 \) has a FWHM of 56 MeV/c\(^2\) which is consistent with the data (see Fig. 3). The \( H_0 \) lifetime with acceptance corrected proper time(\( cT \)) is shown in Fig. 4. The fit gives 9.4 cm \( cT \) consistent with 10 cm finally used. Figure 5, shows the lifetime distribution for the \( \Sigma^- \), where the line is the 4.44 cm \( cT \) of the \( \Sigma^- \). A study of candidates whose mass is greater than \( \Lambda \bar{\Lambda} \) (11 such) or who are found using directly the opposite charged tracks (10 such) also have a \( \Sigma^- \) lifetime consistent with 4.44 cm. However, these background candidates have an \( H_0 \) lifetime of 5.4 cm, which is one half of the \( H_0 \) data.

Recently we (E-810) published the rapidity distribution for \( \Xi^- \) for Si on Pb collision[5]. The yield of 1/2 \( \Xi^- \) per central Si Pb event is well reproduced by the Random Event Generator[6]. If we assume \( \Xi^-p \) is the only decay channel, the corrected rapidity distribution for our \( H_0 \) events is shown in Fig. 6, where we also plot the \( \Xi^- \) yield predicted by the Ref.[6]. This implies that the yield of \( H_0 \)'s is equal to or greater than the \( \Xi^- \) yield in central Si Pb events. A prediction of a dibaryon \( \Lambda \bar{\Lambda} \) hypernucleon state has been made by coalescence[7] and is a factor 50 smaller. If our \( H_0 \) signal is established it would
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require some other production mechanism (like Quark Gluon Plasma (QGP) \(\rightarrow\) Strange Matter \(\rightarrow\) \(H_0\)).

The production vertex is well determined in the perpendicular plane \((x, y)\) to within a fraction of a millimeter by the over 70 charged tracks of the primary vertex in a central collision. In order to determine the point back accuracy, one has to make an event by event correction because the beam spot wanders by 5cm in \(z\) direction during the AGS spill. For the Monte Carlo we find that 86% of the \(H_0\)'s are within 3 cm of the primary vertex. For the \(H_0\) data 70% of the candidates are within 3cm, which is consistent with the 33% background in the data \((11/33)\). For the 21 background candidates mentioned above 46% are within 3 cm and the whole distribution is very flat running out to 10 cm. All three distributions are plotted in Fig. 7. The distribution in the lowest 3 cm of the data is completely different and quite the opposite of the Monte Carlo. The Monte Carlo at the 40% level is within 1 cm while the data at the 40% level is outside 2 cm. We are thus faced with two possibilities. The fact that 70% of the \(H_0\) candidates were within 3 cm was just a statistical fluke (implying the \(H_0\)'s are fake). \(H_0\)'s are produced from the decay of metastable strange matter a few cm away from the target and thus cause an offset for the \(H_0\) projection (implying QGP \(\rightarrow\) Metastable Strange Matter \(\rightarrow\) \(H_0\)).

4. CONCLUSIONS

We have observed 33 \(H_0\) candidates on a estimated background of 11. Many of the properties of the candidates are not inconsistent with the \(H_0\), but its production properties make this signal extraordinary and thus one has to be cautious at this stage. We will continue to process our data and see what a factor of five in statistics will bring.

REFERENCES

Figure 1. Effective mass spectrum of $\Sigma^- p$.

Figure 2. Typical $H_0$ candidate ($\pi^-, \Sigma^-, p$, labeled)
Figure 3. Effective mass spectrum of Monte Carlo $H_0 \rightarrow \Sigma^- p$.

Figure 4. $H_0$ lifetime distribution in $cr$ (cm) (see text).

Figure 5. $\Sigma^-$ lifetime distribution in $cr$ (cm) (see text).
Figure 6. $H_0$ rapidity distribution (curve see text).

Figure 7. Distance from projected $H_0$ to the target in cm.
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