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H_0 Candidates From the Decays $\Sigma^- p$ and $\Lambda p \pi^-$, Produced in Heavy Ion Collisions *Si* Beam on *Pb* Target¹

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Abstract. We present H_0 candidate events, where $H_0(2210)$ is observed through the weak decay modes $\Sigma^- p$ and $\Lambda p \pi^-$, produced in central heavy ion collisions with $14.6 \times A$ GeV/c *Si* beam on *Pb* target. The lifetime is consistent with ~ 4 cm $c\tau$ in both channels approximately 1/3 of an $H_0(2210)$ which decays into $\Sigma^- p$ is produced per central *Si Pb* collision. The branching ratio between $\Lambda p \pi^-$ and $\Sigma^- p$ is around $11\% \pm 3\%$.

I 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].

II EXPERIMENTAL METHOD

The experimental method was described in previous publications [3]. Briefly, experiment E-810 measured charged tracks in three TPCs (Time Projection Chamber) modules in a magnetic field.

In order to search for potential H_0 's which decay into $\Sigma^- p$, a pattern recognition was developed which put together a positive negative with a negative kink vertex sharing the same negative track. We then make a fit constraining the kink vertex to be consistent with a Σ^- decaying into a π^- plus an unobserved n .

In an earlier conference report we reported a search for strange-matter decaying into $\Lambda p \pi^-$ and $\Lambda p p \pi^-$. We had processed ~ 10000 central *Si Pb* events and had seven events below the $\Lambda\Lambda$ threshold in the $\Lambda p \pi^-$.

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FIGURE 1. a) Effective mass spectrum fitted with a H_0 Gaussian plus a background curve (see Fig. b); b) Effective mass spectrum of background wrong sign Σ^-p fitted with the same background shape used in Fig. a; c) Effective mass spectrum of $\Lambda p \pi^-$ fitted with a H_0 (Gaussian with same mass as Fig. a) plus a background which describes the $\Lambda\Lambda$ continuum with small relative transverse momentum to their flight path; curves are also explained in the text.

III RESULTS

With the above pattern recognition we processed 20000 central *Si Pb* events and found 106 Σ^-p candidates with 83 of them lying below the $\Lambda\Lambda$ threshold (see Fig. 1a). We have searched for background candidates in the data by looking at the opposite charged assignment. We have found 38 background candidates where 17 are below the $\Lambda\Lambda$ threshold (see Fig. 1b). We also find 80 $\Lambda p \pi^-$ candidates with 22 lying below the $\Lambda\Lambda$ threshold (see Fig. 1c). We next performed a global fit to the three mass spectrums, assuming that there is one common H_0 plus two backgrounds. The first background is a fit to the 38 opposite sign events shown in Fig. 1b. Figure 1a show the this background scaled by 2 plus a Gaussian bump for the H_0 , where the width was free to vary. This scale factor is consistent with the more numerous $\sim$ twice positive tracks. One must note that $2 \times (38 \pm 6) = 76 \pm 12$ which is only 2σ different from 108. The second background describes the $\Lambda\Lambda$ events which contribute to the $\Lambda p \pi^-$ when the two Λ 's have relative small transverse momentum to the direction they are co-traveling. Figure 1c shows the $\Lambda p \pi^-$ mass spectrum fitted with a Gaussian bump with the same mass as Figure 1a plus a background form for the $\Lambda\Lambda$ background. From this global fit we estimate that the H_0 has a mass of 2.210 ± 0.015 GeV/ c^2 with 29 Σ^-p events and 21 $\Lambda p \pi^-$ events.

A complete Monte Carlo simulation of events was performed using GEANT. Events were generated using the HIJET model [5]. The generated TPC hits include all known effects of the detectors apertures, efficiencies, resolution, and distortions. We embedded an H_0 particle in the HIJET events file according to a simple production model.

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FIGURE 2. a) H_0 lifetime distribution in $\Sigma^- p$ channel (cut data see text) in $c\tau$ (cm); b) H_0 lifetime distribution in $\Lambda p\pi^-$ channel in $c\tau$ (cm).

$$\frac{dn}{dm_t dy} = m_t N_0 e^{-(a+b \cosh(y-y_0))m_t} \quad (1)$$

The H_0 lifetime and H_0 mass are also parameters. We see in Fig. 1a, that one can improve the signal to background by making a mass cut ($2.18 < M_{H_0} < 2.23 \text{ GeV}/c^2$). The production vertex is well determined in the perpendicular plane (x, y) at the target to within a millimeter by the over 70 charged tracks of the primary vertex. In a Monte Carlo H_0 study, H_0 's point back very well within 3 cm. If we make the mass and vertex cut we are left with 36 events with an estimated 24 H_0 's.

Using above cut $\Sigma^- p$ and the 21 low mass $\Lambda p\pi^-$ events, we can calculate the observed rapidity spectrum and the observed H_0 lifetime in both the channels determined by our experimental setup. For the Monte Carlo generated events we reconstruct H_0 's in both channels and compare them directly to the above uncorrected H_0 data. We then adjust the above parameters and regenerate, process and compare. Our final parameters give a $c\tau$ of 4 cm, mass $2.210 \text{ GeV}/c^2$ and a inverse slope of $140 \text{ MeV}/c^2$. We then generated 30,000 H_0 embedded in central *Si Pb* HIJET events. We decayed these H_0 into both modes $\Sigma^- p$ and $\Lambda p\pi^-$. The effective mass resolution was consistent with the Gaussian fits of Fig. 1. The full width at half maximum (FWHM) for the $\Sigma^- p$ was $33 \text{ MeV}/c^2$ while for the $\Lambda p\pi^-$ the FWHM was $17 \text{ MeV}/c^2$.

The acceptance corrected proper time $c\tau$ is shown in Fig. 2, where Fig. 2a is the cut $\Sigma^- p$ events and Fig. 2b is the $\Lambda p\pi^-$ events.

We (E-810) have published the rapidity distribution for the Ξ^- for central *Si* on *Pb* collisions [6]. The yield of $1/2 \Xi^-$ per central *Si Pb* event is well reproduced by the Random Event Generator [7]. The corrected rapidity distribution for the H_0 events with background subtraction is shown in Fig. 3a, where we also plot (dashed) the Ξ^- yield predicted by the Ref. [7]. Our production model described above is the solid curve in Fig. 3a. A prediction of a dibaryon $\Lambda\Lambda$ dihyperon state has been made by coalescence [8] and is a factor 25 to 50 times smaller.

FIGURE 3. a) H_0 rapidity distribution for Σ^-p decays; b) H_0 rapidity distribution for $\Lambda p\pi^-$ decays; curves are described in text.

In Fig. 3b, we show the H_0 rapidity distribution for the $\Lambda p\pi^-$ decay mode. Again the solid line is our production model where the branching ratio of $\Lambda p\pi^-$ to Σ^-p is 11%.

IV CONCLUSIONS

We have observed the $H_0(2210)$ dibaryon candidates through its weak decay modes Σ^-p and $\Lambda p\pi^-$. The signal has a 4 cm $c\tau$ in both channels. Our production model gives a central rapidity temperature of 140 MeV and cross section of a ~ 100 mb into the Σ^-p channel. This is a factor 25 to 50 times the $\Lambda\Lambda$ coalescence [8] and thus makes a bump below the $\Lambda\Lambda$ in the $\Lambda p\pi^-$ easily observable. With the production at the same level as the Ξ^- , one has to assume that the expected suppression of dibaryons coming from the quark level is gone and the only suppression is obtaining two strange quarks. This would imply free quarks feeding direct production.

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