TAGGED HIGH ENERGY \( \bar{n} \), HYPERON AND ANTI-HYPERON BEAMS AT NAL

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With the advent of high-energy high-intensity accelerators it becomes reasonable to discuss the production of relatively high-energy exotic beams. In particular the availability of nearly monochromatic \( \Lambda \) and \( \bar{\Lambda} \) beams would open up a new class of hadron interactions (i.e. the comparison of \( \Lambda p \) and \( \bar{\Lambda}p \) total cross sections at high energy; \( I = 1 \) meson exchange being forbidden for these processes might lead to equal cross sections at a lower momentum than for \( \bar{p}p \) and \( pp \)).

In addition, it should be possible to obtain high-intensity partially separated \( \bar{p} \) beams (\( \sim 10^6 \)/pulse with \( 10 \)-\( 40 \) BeV/c) at the thin target stations. Using these beams, it should be possible to obtain adequate \( \bar{n} \) or \( \bar{\Lambda} \) beams for counter, streamer-chamber or rapid-cycling bubble-chamber experiments.

Although it seems possible to obtain high-energy \( \Sigma^- \) beams using the highest energy negative particles coming from a target, the production of \( \Lambda \), \( \bar{\Lambda} \) and \( \bar{n} \) beams is intrinsically more difficult.

One possible technique is to use the characteristic properties of the diffraction dissociation processes to produce fast \( \Lambda \), \( \bar{\Lambda} \) and \( \bar{n} \)'s with these processes being tagged using mesons produced in the dissociation process. The processes to be used are...
\[ p + A \rightarrow N^*(1400) + A \]
\[ \rightarrow n + \pi^+ \]
\[ \bar{p} + A \rightarrow \bar{N}^*(1400) + A \]
\[ \rightarrow \bar{n} + \pi^- \]
\[ p + A \rightarrow N^{*+}(1700) + A \]
\[ \rightarrow \Lambda + K^+ \]
\[ \bar{p} + A \rightarrow \bar{N}^{*+}(1700) + A \]
\[ \rightarrow \bar{\Lambda} + K^- \]

with \( A \) being a nucleus of atomic number \( A \). The characteristic features of these process are

1. The \( N^* \) 's are produced strongly forward on protons and should be even more sharply forward on nuclei \( A \). The baryons from the \( N^* \) decay carry essentially all the beam momentum.
2. The \( N^* \rightarrow \pi n \) is most likely isotropic in the center of mass. \( \rightarrow \Lambda K \)
3. The cross section for \( N^*(1400) \) [and possibly \( N^*(1700) \)] is substantially larger than that either of charge exchange or for other \( N^* \) production with incident nucleons above a momentum of \( \sim 10 \text{ BeV}/c \). [At low momentum the production of \( \Delta (1238) \) is large.]
4. The cross section for these \( N^* \) production is presumably almost constant with energy.
5. The decay of \( N^*(1700) \rightarrow \Lambda K \) might give polarized \( \Lambda' \) 's at certain angles in the \( N^* \) center of mass.
Unfortunately, only fragmentary experimental evidence exists concerning the \( N^* (1700) \) production and even less information is available concerning the \( \Lambda K \) decay of this object. However, there exists some evidence that the reaction \( \pi^- p \rightarrow \Lambda K \) couples strongly to an \( N^* \) with mass in the 1700 region. In addition \( pp \rightarrow \Lambda K p \) experiments below 8 BeV/c see a strong accumulation of \( \Lambda K \) events near 1700 with a low momentum transfer to the nucleon.

It would be extremely useful if experiments were performed at the AGS to measure the \( \Lambda \) flux associated with a \( K^+ \) using high energy protons.

The scheme for making such a beam is shown below.

![Diagram of beam making process](image)

If the \( N^* (1700) \) production followed by a subsequent decay into \( \Lambda K^+ \) does dominate the \( N^* \) production process for very high momentum \( p' \)s, then a crude momentum measurement of the \( K^+ (\sim 20\%) \) should define
the $\Lambda$ momentum to much better than 20%. Using the same set up but with incident $\vec{p}$'s and tagging outgoing $\pi^-$ should provide an $\bar{n}$ beam of relatively high intensity (i.e. at 10 BeV/c with $10^6 \vec{p}$/pulse, $-10^2 - 10^3 \bar{n}$ might be obtained in a small solid angle). If the outgoing baryon momentum from the $N^*$ decay is strongly correlated to the pion or kaon momentum it might be possible to use a larger solid angle hyperon or $\bar{n}$ beam. The $\Lambda$ flux available by such techniques would surely be one to two orders of magnitude down from the $\bar{n}$ flux.

Finally, using a monochromatic neutron beam with the same device it should be possible to make tagged $\Sigma^-$ beams using the process

$$n + A \rightarrow N^* (1700) + A \rightarrow \Sigma^- K^+. $$

In this case, the first sweeping magnet is used to deflect the $\Sigma^-$ through the hole in the shielding wall. Some further momentum analysis could be used beyond the hole.