STRANGE PARTICLE EXPERIMENTS AT PEP

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ABSTRACT

A variety of problems including inclusive hadron production cross-sections and weak interaction effects can be studied by the measurement of strange particles from e^+e^-. For example, asymmetries and polarizations of a few per cent may be present in Λ production. The measurement of Λ polarization, including a consideration of background effects is discussed. Several vertex detectors including streamer and wire chamber spectrometers with a number of magnetic field configurations merit further investigation

Experiments involving strange particles at PEP are of interest for several reasons. They allow a different approach to the study of inclusive annihilation processes, are a signature of charmed particles and provide unique tools for the study of weak-electro-magnetic interference effects. In this note we will survey these areas, discuss strange particle production mechanisms, and consider in some detail the requirements of a detector optimized for the study of strange particles.

There has been a great deal of interest at SPEAR in the ratio of $\pi^{\pm}$: $K^{\pm}$: $p^{\pm}$: ..... as a function of $x = 2p/\sqrt{S}$. In order to obtain particle separation, time-of-flight measurement and/or Cerenkov counters have been employed. These techniques are applicable only in restricted momentum regions, and in the case of the use of Cerenkov detectors, usually require either a severe sacrifice in geometrical acceptance or a very large and complex apparatus. The inclusive spectra of K^o's, Λ's, etc., are interesting in their own right, but the ratios π^+: K^o: Λ: ... contain much the same information as $\pi^{\pm}$: $K^{\pm}$: $p^{\pm}$ ...., and are far more accessible experimentally. Further, while beam-gas interactions are a severe background in $e^+e^- \to p + X$, they are much less of a problem in $e^+e^- \to \Lambda + X$. Copious production of K's and baryons is expected at PEP, and with an apparatus optimized for the detection of V's, one can have hadron separation for both particles and antiparticles over a wide range of momenta with reasonably large geometric efficiency. Since charged particle multiplicity will also be large, good geometry for vertex reconstruction is important.

If the neutral weak current which couples to hadrons has an axial vector part, then the Z^o exchange amplitude in $e^+e^- \rightarrow$ hadrons can interfere with the one photon exchange amplitude, producing parity violating effects. There are at least two such effects which can be detected in strange particle inclusive channels at PEP:

1) A forward-backward asymmetry in the production angle in single particle inclusive reactions. Calculations by Preparata and Gatto[1)] and Budny and McDonald[2)] (using the Weinberg model with $\sin^2\theta_W = .33$) indicate that an effect of

$$\frac{N_F - N_B}{N_F + N_B} \sim -3.5\% \text{ at } \sqrt{S}=30 \text{ GeV},$$

where N_F and N_B are the numbers of leading particles of a given type (e.g. Λ's) produced at $\theta < 90^o$ and $\theta > 90^o$, respectively. This asymmetry is present in any single particle inclusive channel, but the possibility of unambiguously identifying Λ's (or K^o's) over a wide range of x would seem to make them particularly well suited to tests of this sort.

Two photon effects can also lead to a forward-backward asymmetry, estimated by Gatto and Preparata to be < 1%. This contribution may be separable, in that it should be concentrated at small angles to the beam direction, and should increase as ℓn S, rather than as S.

2) The production of longitudinally polarized hadrons. This effect can best be observed in the asymmetry in the decay distribution of hyperons. This distribution is given by

$$\frac{dN}{d(\cos\theta)} \sim \frac{1}{2}\left[1 + \alpha_{eff} P \cos\theta_{cm}\right],$$

where P is the longitudinal polarization produced by weak-EM interference, and

$$\alpha_{eff} = \frac{A_W}{A_{EM} + A_W} \alpha_o ,$$

where A_W, A_{EM} are the relative numbers of Λ's (or Σ^+'s) corresponding to the production cross sections for weak-EM interference and purely electromagnetic processes respectively. α_o is the intrinsic decay asymmetry parameter for the strange particle decay in question; $\alpha_o = 0.65$ for $\Lambda \to \pi^- p$, for example.

Charmed particles, should they exist, would be expected to decay by weak interactions with a large branching ratio to strange particles. Should, as is likely, these states be too short-lived to be identified directly, an attractive signature would be a threshold effect, with beam energy, in the production of strange particles, or in the production of longitudinally polarized Λ's. Still another characteristic signature would be a strange particle accompanied by a lepton.

Our estimates of strange particle production are based on the quark-parton model, which couples parton-antiparton pairs to vector intermediate states (γ or Z^o) according to the parton charge. The subsequent probability of producing a particular hadron from a given parton-antiparton pair depends on the mechanism by which bare partons make hadrons by dressing themselves in the vacuum. Since the SPEAR data on π, K and $\bar{p}$ production are consistent with phase space distributions and a matrix element which is identical for π, K and $\bar{p}$, we assume that at PEP a parton will become a meson half the time and a baryon half the time. To then calculate the probability of producing any specific hadron, we assume the vacuum to be an SU(3) singlet, so that the freshly produced parton can combine with any pair of partons with equal probability on its way to becoming a baryon. We use a model with integer charge colored quarks.

The production processes considered are as follows:

A. Λ Production

1) One Photon Processes:

$e^+e^- \rightarrow \gamma \rightarrow \Lambda + X$:

$$\sigma_{\gamma\rightarrow\Lambda} = \frac{7}{6}\,\frac{R}{E_o^2(\mathrm{GeV})^2}\ \mathrm{nb},$$

where

$$R = \sigma_{e^+e^- \rightarrow \text{hadrons}}/\sigma_{e^+e^- \rightarrow \mu^+\mu^-}.$$

2) Neutral Weak + Electromagnetic:

$e^+e^- \rightarrow Z^o \rightarrow \Lambda + X$ interfering with

$e^+e^- \rightarrow \gamma \rightarrow \Lambda + X$:

$$\sigma_{Z\gamma\rightarrow\Lambda} = \frac{28\pi}{3}\,\frac{R}{M_{Z^o}^2(\mathrm{GeV})^2}\ \mathrm{nb}$$

3) Pair Production of Charmed Particles:

$e^+e^- \rightarrow C\bar{C}$
$\quad\hookrightarrow \Lambda + \ldots.$

$$\sigma_{C\bar{C}\hookrightarrow\Lambda} = \frac{5}{M_C^2(\mathrm{GeV})^2}\left[1 - \left(\frac{M_c}{E_o}\right)^2\right]^{3/2}\left[1 + \frac{3}{4}\left(\frac{M_c}{E_o}\right)^2\right] \times$$

$$|F(s)|^2\ B\quad \mathrm{nb},$$

where F(s) is the elastic charmed particle form factor.

If this form factor is dominated by a pole of mass ~ 1 GeV as are other hadron form factors, then

$$|F(s)|^2 \sim \frac{1}{s^4} \quad \text{for } s \gg 1 \text{ GeV.}$$

B is the branching ratio $C \rightarrow \Lambda + \ldots$, which is probably in the range $.1 \leq B \leq 1$. M_c is expected to lie between 2 and 10 GeV.

This cross section is negligibly small at PEP energies (s = 900).

4) Inclusive Production of Charmed Particles:

$$e^+e^- \rightarrow C + X$$
$$\hookrightarrow \Lambda + \ldots$$

$$\sigma_{C \rightarrow \Lambda} = \frac{21RB}{2\,E_o^2} \cdot \frac{p_c^3}{(p_c^2 + M_c^2)^{3/2}} \quad \text{nb},$$

where p_c is the momentum of M_c. This last factor is a β^3 phase space suppression factor.

5) Charged Weak + Electromagnetic

$$e^+e^- \rightarrow W^\pm \, e^\mp \nu$$
$$\hookrightarrow \text{hadrons}$$

$$\sigma_{W \rightarrow \Lambda} \sim \sigma_{e^+e^- \rightarrow \mu^+\mu^-} \quad GM_W^2 \; \frac{P_W^3}{(p_W^2 + M_W^2)^{3/2}} \quad \sin^2\theta_c$$

This cross section is negligibly small.

6) Two Photon Processes

$$e^+e^- \rightarrow \gamma\gamma \rightarrow \Lambda + X + e^+ + e^-$$

$$\sigma_{\gamma\gamma \rightarrow \Lambda} = \frac{14\alpha^2}{3} \; \frac{R}{M_{\Lambda+X}^2} \left(\ell n \frac{E_o}{m_e}\right)^2 \text{nb}$$

B. Ξ Production

$$e^+e^- \rightarrow \gamma \rightarrow \Xi + X \quad (\Xi \rightarrow \Lambda\,\pi)$$

The rate for producing S = -2 states should be at least a factor of ten less than that for S= -1 states. (In pp collisions, this factor is ~ 1/30).

$$\sigma_{\gamma \rightarrow \Xi \rightarrow \Lambda} \approx \frac{1}{10}\ \sigma_\gamma = \frac{7}{60}\ \frac{R}{E_o^2}\ \text{nb}$$

C. Σ^+ Production

$$e^+e^- \rightarrow \Sigma^+ + X$$

Cross sections for Σ^+ production are expected to be similar to those for Λ production by the corresponding mechanism.

D. K^o Production

$$e^+e^- \rightarrow \gamma \rightarrow K^o + X$$

$$\sigma_{\gamma \rightarrow K^o} = \frac{21}{12}\ \frac{R}{E_o^2}\ \text{nb}.$$

With the following set of assumptions:

$R = 6$, $E_o = 15$ GeV, $< P_c > = 3$ GeV, $M_W = 40$ GeV, $M_Z = 100$ GeV, $M_{\Lambda X} = 2$ GeV, $2 < M_C < 10$ GeV, $B = 0.5$,

we arrive at the production cross sections given in Table I. The number of events/year correspond to an integrated luminosity of $5 \times 10^{38}\,\text{cm}^{-2}$, or a peak luminosity of $10^{32}\ \text{cm}^{-2}\text{sec}^{-1}$, with a use factor of 25% and 8 months (5000 hrs) of running per year.

It should be noted that there are as many $\bar{\Lambda}$, $\bar{\Sigma}^+$, etc. as there are Λ, Σ^+, ..., so that many effects can be studied with effectively twice the rate indicated in Table I. These calculations of rates are, of course, highly model dependent and assume the validity of quark-parton ideas.

Rather than design a strange particle detector at the nuts and bolts level, we will discuss design criteria in the light of production and decay mechanisms, and illustrate certain points by a general discussion of the merits of several different types of detectors.

The signature of a Λ or K^o is, of course, a neutral vertex which points to the e^+e^- intersection region. The design of a V detector depends very crucially on the momentum spectrum one assumes for hadrons at PEP. Should the spectrum be dominated by low energies to the extent predicted by thermodynamic models, then the pions from Λ decay would be of extremely low momentum (100-300 MeV/c), and in any detector the Λ mass resolution would be dominated by multiple scattering in the detector itself, and in the beam pipe (since most decays would occur inside the beam pipe). In such a situation the use of a titanium beam pipe such as is planned for the ISR Split-Field Magnet[3] would be quite important, as it could cut multiple scattering by a factor of two. Should, as is more likely, the hadron spectrum be peaked at higher momentum, the momentum and angular resolution of the detector itself would dominate the mass resolution, and the detector's spatial resolution would become important in discriminating against accidental vertices. In either eventuality, a streamer chamber, with its low mass and excellent resolution, might be the appropriate instrument to detect V's. The streamer chamber, however, presents problems in devising a beam pipe structure of low mass which can be used in a high electric field, and in devising an appropriate trigger.

The detector need not be extremely large, as the decay lengths of strange particles in this momentum range are less than one meter (see Table II). The model of Bjorken and Kogut[4] predicts that the average momentum of hadrons at PEP will be ~ 3 GeV/c, with very few produced above 8 GeV/c.

Thus, if we require a track length of .5 meter for the charged secondaries, a sensitive volume of 1.5 x 1.5 x 1.5 m^3 in both the forward and backward hemispheres would provide an acceptance of > 90% for all decaying strange particles produced within the solid angle acceptance of the detector.

The question of detector geometry depends on several factors. While at SPEAR, hadron production appears to be isotropic, at high energies the coupling of a vector intermediate state to pairs of pointlike spin 1/2 particles (i.e., partons) results in an angular distribution of the form

$$\frac{d\sigma}{d\Omega} \sim 1 + \cos^2\theta,$$

assuming that the resulting hadron jet is limited in $p_\perp$, so as not to wash out the intrinsic parton angular distribution. In this case, more particles per unit solid angle are produced at $\theta = \pm 45^\circ$ than at $\theta = 90^\circ$. While a large cylindrical detector with end caps still maximizes the solid angle acceptance, it may no longer be the optimal detector configuration for studying V's. A more important criterion is the fraction of charged particles resulting from V's which strike the detector planes in good geometry, e.g., at less than 45° to the wire plane. Since the opening angle of V's at low momentum is large, and in Λ decay momentum is not equally shared between p and π, other geometries may have some advantages. We will consider a few alternative geometries below.

Another important criterion is spatial resolution. If we restrict ourselves to wire plane readouts, i.e., wire spark chambers, MWPC's or drift chambers, then certain geometries can be read out with better spatial resolution than others. For example, the SPEAR Magnetic Detector consists of cylindrical wire spark chambers, read out in small angle stereo. While resolution in the ϕ direction is < .5 mm, resolution in the Z direction is poor, of the order of 1 cm. Any geometry requiring small angle stereo is likely to have this problem. The recent development of two dimensional readout of drift chambers by means of delay lines[5)] is of some help in this area, as resolution of .1-.2 mm is achieved perpendicular to the 5 cm spaced wires, and 1 - 2 mm resolution along the wire direction is possible. An octagonal detector oriented along the beam direction can be read out in 90° stereo, promising good resolution in all dimensions. Two other detector configurations which sacrifice solid angle for resolution will be briefly discussed below.

The V detector is required to 1) uniquely identify Λ, $\bar{\Lambda}$ and K_S^{o} and to be able to reconstruct their decays with an over-constrained fit and 2) be able to recognize Ξ^-, Ξ^{o} and Σ^{o} decays into $\Lambda\pi$ in order to separate such events from the sample of directly produced Λ's. Separation of Σ^{o} and Ξ^{o} decays requires photon detection.

It is interesting to note that in the momentum range appropriate to PEP, separation of Λ^{o} from K_S^{o} can be accomplished very well without a magnetic field. A Λ^{o} or K_S^{o} decay is completely constrained by knowledge of the directions of the $\Lambda^{o}(K_S^{o})$ and the decay products. Since V production will be accompanied by other charged particles, will be accompanied by other charged particles, the interaction vertex position is accurately known. Detection of the charged particle directions gives the decay vertices. Then, if one charged particle has an opening angle of less than 50 mrad, it can safely be assumed to be a proton from a Λ decay. This method of separation appears to be quite clean through Λ momenta of at least 5 GeV/c. Such a technique does not, of course, distinguish between Λ and $\bar{\Lambda}$. For some physics this is not a terribly important distinction, but for weak interactions it is. Λ-$\bar{\Lambda}$ separation can be accomplished by distinguishing p and $\bar{p}$ calorimetrically by the extra 2 GeV deposited in $\bar{p}$ annihilation. This technique becomes difficult above 2 - 3 GeV/c, where the energy resolution improves as $\sqrt{E}$, while the fractional effect of the annihilation energy decreases as E.

The application of even a small magnetic field in the decay region would allow the sign of the charged particles to be distinguished, which would quite cleanly separate Λ from $\bar{\Lambda}$: a 2 kG field over the size of detector we have been discussing would produce a distinguishable sagitta on tracks up to about 5 GeV/c. Momentum measurement on the other hand could provide valuable constraints, so that we would envision a V detector to have a field of about 5 kG, if one were used at all.

The question of magnetic field geometry is closely related to detector geometry. A solenoidal field and cylindrical or octagonal detector are clearly natural partners. Planar geometries are more suited to transverse magnetic fields. We have investigated two such field configurations; others are clearly possible. The first consists of two conventional dipole magnets, separated by 30-40 cm and operated one with field up, and the other with field down. The beam can be shielded from the field by means of a superconducting tube inserted in each magnet. Since such shields are reasonably thick (~ 1 cm of Cu, Nb), they should end some distance before the interaction region. The approximate cancellation of the opposing fringe fields should be sufficient to ensure the integrity of the colliding beams, especially if small compensating dipoles are used up and downstream.

A better way to apply a transverse field to the interaction region may be the use of a split-field magnet. In this case we envision a field pointing up on the inside of the ring and down on the outside. The field should cancel exactly at the e^+e^- orbit. These magnets could be built as conventional dipoles, or with the rather low field required, they might have vanelike flux returns.

The simplest arrangement of detectors for these transverse field configurations might be a small set of cylindrical chambers (say 40 cm long) around the intersection region, which serve mainly to count multiplicity, and a series of planes transverse to the beam pipe, with a hole to clear the beams. This design would also be suited to study resonance production in two photon processes. It would allow the reconstruction of about 25% of the V's if the chamber dimensions varied from 1 m x 1 m at 20 cm from the interaction region to 2m x 2 m at 1 meter.

A more interesting design again consists of a small cylindrical polymeter around the interaction region, but has four sets of detector planes inclined at an angle of $\sim 30^{\circ}$ to the beam line. This arrangement would allow the reconstruction of about 50% of the V's, with dimensions similar to those above. In addition to covering more of the solid angle, more V's are detected in good geometry by this configuration. Both of these designs have the minor advantage that calorimetry can be built behind them in plane rather than cylindrical geometry.

The need for good spatial resolution probably dictates that the detectors be either wire spark chambers or drift chambers. While the relatively low event rates at PEP would seem to make this unnecessary, the use of MWPC's would permit the use of a V trigger in the case of transverse fields. This could be done by constructing a matrix logic circuit which verticized tracks in the non-bending projection and required an intersection at some distance from the beams. More likely, however, one would extract V's offline from a specific two particle trigger or even from a single particle trigger.

The important backgrounds to direct Λ production come from other hyperon decays: $\Sigma^0 \rightarrow \Lambda\gamma$, $\Xi^- \rightarrow \Lambda\pi^-$ and $\Xi^0 \rightarrow \Lambda\pi^0$, where the hyperons are produced either electromagnetically or by weak-electromagnetic interference. The reaction $\Sigma^0 \rightarrow \Lambda\gamma$ is a serious problem in the study of the Λ inclusive spectrum, in that it results in a source of Λ's directly from the interaction region. The rate of such Λ's would be approximately equal to that for direct Λ's. The only way to distinguish these events would be the very difficult procedure of detecting the γ energy and direction to allow reconstruction of the Σ^0 mass. This may mean that one would have to be satisfied with studying the time-like S=1 baryon spectrum without distinguishing $I=0(\Lambda)$ from $I=1(\Sigma^0)$ components. Since the Λ from Σ^0 decay is unpolarized, it does not contribute a false signal to the search for weak-electromagnetic interference by measuring Λ polarization, but it does wash out the effect.

The background for weak interaction physics comes from the $\Xi \rightarrow \Lambda\pi$ decays, since if the Ξ are produced unpolarized, the resulting Λ's are ~ 40% polarized (see Table III). It may be possible to eliminate this background topologically. In $\Xi^- \rightarrow \Lambda\pi^-$, the Λ will not, in general, point at the interaction region, and a π^- track will miss the interaction region. In some instances, the Ξ^- track will itself be seen. The $\Xi^0 \rightarrow \Lambda\pi^0$ decay is somewhat more difficult, in that the Ξ^0 decay vertex is not visible, and that the π^0 direction would be difficult to reconstruct, especially in view of the other associated π^0's in each event. The Ξ^0 lifetime, is however, relatively long, so that in most cases the Λ will not point to the interaction region. Since S= -2 particles are expected to be produced much more rarely than S=-1 particles, these handles may be sufficient to keep the Ξ background Λ's to a tolerable level.

It may be instructive at this point to discuss the relative merits of detecting Λ polarization in $e^+e^- \rightarrow \Lambda + X$ vs μ^+ polarization in $e^+e^- \rightarrow \mu^+\mu^-$ as a probe of weak-electromagnetic interference effects. The relative number of such events is dependent on R and hadron production models, but may be in the range of .2 to .6. However, while only μ^+ are useful for analysis of polarization, there are an equal number of $\Lambda \bar{\Lambda}$ events. Further, the analysing power of Λ's is twice as great as μ's: $\alpha_{o_\Lambda} = .65$, $\alpha_{o_\mu} = .33$. For $e^+e^- \rightarrow \mu^+\mu^-$, the average muon helicity is expected to be [6] $< h > \approx 7 \times 10^{-2} \times (4 \sin^2\theta_w - 1)$. The Λ helicity depends on strong interaction couplings which have not been calculated, but it may be of the same order. We have discussed the Ξ background to the Λ measurement above; the $\mu\mu$ signal appears to be background free. The size of an apparatus to measure Λ polarization, is as we have discussed, small on a PEP scale, while one μ^+ polarization experiment discussed during the summer study used an apparatus weighing 9000 tons. In sum therefore, the measurement of Λ polarization may be a more practical probe than μ polarization.

We have summarized the general characteristics of a strange particle detector for PEP in Table IV, which considers the relative merits of several geometries. In each case, the detector is 3m long and 1.5 m in transverse dimensions. Since small detector sizes and small magnetic fields are sufficient, no inordinate demands on the standard experimental areas are foreseen.

References

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2. R. Budny and A. McDonald, Physics Letters 48B, 423 (1974).
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4. J. D. Bjorken and J. Kogut, Phys. Rev. D8, 1341 (1973).
5. A. Breskin, et.al., Nucl. Inst. and Meth. 119, 1 (1974).
6. A. McDonald, Nucl. Phys. B75, 343 (1974).

Table Captions

Table I. Cross sections and PEP rates for strange particle production. One year is defined to be an integrated luminosity of 5×10^{38} cm^{-2}.

Table II. Strange particle decay lengths as a function of momentum.

Table III. Strange particle branching ratios and asymmetry parameters.

Table IV. Comparison of V detector geometries. All detectors are 3m long and 1.5 m in transverse dimensions. A 5 KG field is assumed.

TABLE I

PROCESS	σ(nb)	Events/Year*	Parity Violation
1. Electromagnetic (Λ,Σ)			
$e^+e^- \to \gamma \to \Lambda(\Sigma^+) + X$	$\frac{7}{6}\frac{R}{E_o^2} = 31 \times 10^{-3}$	1.5×10^4	No
2. Weak-EM Interference			
$e^+e^- \to {Z^o \atop \gamma} \to \Lambda(\Sigma^+) + X$	$\frac{28\pi}{3}\frac{R}{M_Z^2} = 17.6\text{x}10^{-3}$	8.4×10^3	Yes
3. Charm Pair Production			
$e^+e^- \to C\bar{C}$, $\hookrightarrow \Lambda + X$	Negligible	---	Yes
4. Inclusive Charm Production			
$e\ e \to C + X$, $\hookrightarrow \Lambda + X$	$\frac{21}{2}\frac{RB}{E_o^2}\frac{P_3^3}{(P_c^2+M_c^2)^{3/2}}$		Yes
	$= 28\text{x}10^{-2}$ $(M_c=2)$	$12.7\text{x}10^4 (M_c=2)$	
	$= 36\text{x}10^{-4}$ $(M_c=10)$	$1.8\text{x}10^3 (M_c=10)$	
5. Charged Weak			
$e^+e^- \to We\nu$, $\hookrightarrow \Lambda + X$	Negligible	---	Yes
6. Two Photon			
$e^+e^- \to \gamma\gamma \to \Lambda(\Sigma^+) + X + e^+e^-$	$\frac{14}{3}\frac{\alpha^2 R}{M_{\Lambda X}^2}\left(\ell n \frac{E_o}{M_e}\right)^2$	2×10^4	No
	$= 4.0 \times 10^{-2}$		
7. Strangeness -2, with Decay to Λ			
$e^+e^- \to \gamma \to \Xi + X$, $\hookrightarrow \Lambda\pi$	$\frac{7}{60}\frac{R}{E_o^2} = 3.1 \times 10^{-3}$	1.5×10^3	Yes**
8. Electromagnetic (K_S^o)			
$e^+e^- \to \gamma \to K_S^o + X$	$\frac{21}{12}\frac{R}{E_o^2} = 4.6\text{x}10^{-2}$	$2.3\text{x}10^4$	No

* Equal numbers of $\bar{\Lambda}$, $\bar{\Sigma}^+$, ... are also produced.

** Background for weak interaction experiments using Λ, unless tagged.

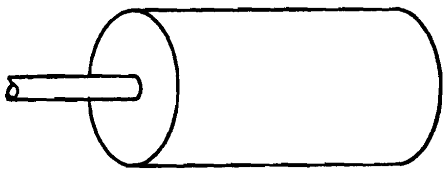
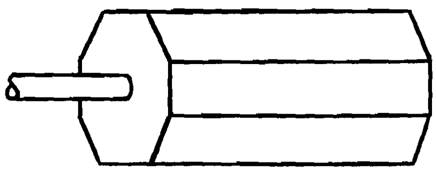
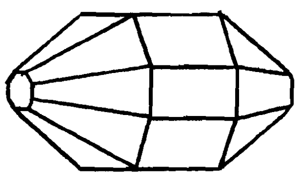
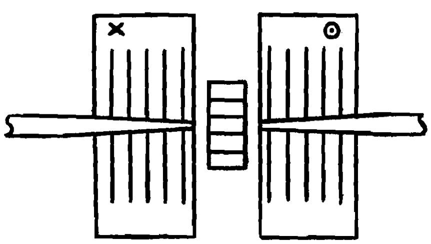
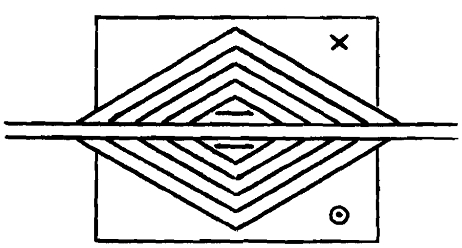
TABLE II

P(GeV)	Λ	K_S^o	Σ^+	Ξ^-	Ξ^o
1	10	3.5	3.1	6.4	12
2	16	5.3	5.0	10	18
3	25	8.6	7.7	16	29
5	35	12	11	22	40
8	54	19	17	35	62
10	68	23	21	44	78
15	101	35	31	64	118

TABLE III

Decay	Branching Ratio	α (Asymmetry)	
$K_S^o \to \pi^+\pi^-$	.69	0	
$\Lambda \to p\,\pi^-$	.64	.65	Signal
$\Sigma^+ \to p\,\pi^o$	.52	-.98	False Asymmetry in Λ Angular Distribution
$\Xi^- \to \Lambda\,\pi^-$ $p\,\pi^-$	.64	-.40	
$\Xi^o \to \Lambda\,\pi^-$ $p\,\pi^-$	.64	-.44	
$\Sigma^o \to \Lambda\gamma$	1.00	0	

TABLE IV

	Geometry	Magnetic Field	V Detection Efficiency $(1 + \cos^2\theta)$
	Cylindrical, Planar end caps	Solenoidal	80%
	Octagonal, Planar end caps	Solenoidal	80%
	Octagonal, Slanted end caps	Helmholtz Coils	80%
	90° Planar, Cylindrical Central Detector	Transverse, Two opposed Dipoles (Requires two Superconducting Tubes)	25%
	30° Planar, Cylindrical Central Detector	Transverse, Split-Field Dipole (Inside-Outside)	50%