NAL PROPOSAL No. 106

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PROPOSAL FOR A STUDY OF MULTIPARTICLE PRODUCTION AT NAL USING AN ARRAY OF WIDE-GAP TRIGGERABLE SPARK CHAMBERS

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ABSTRACT

We propose a study of particle production in p-p and π-p interactions at the highest accessible NAL energies using an LH_2 or polyethylene target with a downstream array of wide-gap chambers and an ANL type BM-111 magnet for momentum analysis. By using a triggered system the interactions of 10^5 particles per pulse may be studied; a run of 2×10^5 machine pulses is requested.

The experiment is designed to provide early information on many features of particle production; the large path length in the apparatus results in good detection efficiency for strange particle decay. In addition, specialized triggering will permit a careful examination of the rarer processes leading to particles with high transverse momenta.

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I. Justification

In recent years increasing experimental and theoretical effort has been directed towards understanding the nature of the physical processes which determine the general features of particle production at very high energies. In the original statistical model of Fermi,[1] the collision resulted in the elevation of a small volume of nuclear matter to high temperature; after achieving thermal equilibrium particles "boiled" off according to simple thermodynamic laws. The model has been increasingly refined in subsequent years; in a recent extension of the model, Hagedorn and Ranft[2] introduced a range of local temperatures depending on impact parameter. Their objective was to achieve quantitatively correct predictions with a minimum number of physically motivated parameters. When the effects of resonances are included, they find that the model can fit single-particle production spectra over a wide range of energies.

Alternatively, Benecke et al[3] have developed an intuitive model of high energy collisions in which the "hypothesis of limiting fragmentation" (HLF) plays a dominant role. They speculate that at increasingly high energies particle distributions resulting from fragmentation of either the target or projectile achieve limiting functional forms; in addition, pionization (when defined as the fraction of outgoing hadron energy below any fixed value W_f in the c.m.) approaches zero as the energy of the projectile $E_i \rightarrow \infty$. In analyzing the asymptotic properties of field theory at arbitrarily high c.m. energies W, Feynman[4] has also been led to an hypothesis of limiting distributions when expressed as functions of transverse momentum $p_\perp$ and fractional longitudinal momentum $x = p^*_{||}/p^*_i$ or $p^*_{||}/W$, where the stars denote c.m. variables. For x not too large, the distributions approach the limit $F(p_\perp)/x$; this implies that the mean total number of any kind of particle increases logarithmically with W. Feynman then speculates that when Regge-asymptotic behavior is included, cross sections for particular groups of particles moving to the right or left in the c. m. will be determined by the highest trajectory capable of exchanging the required quantum numbers (isospin, hypercharge, etc.). To develop a more detailed dynamics of multiparticle production, several versions of the multiperipheral Regge model have been studied extensively;[5] when general conclusions are available, they also suggest limiting distributions as $W \to \infty$. Although most models lead to limiting distributions for x not too large, the behavior of the distributions for $x \to 0$ (where pionization would contribute strongly) differ sharply.

Recently, Wilson[6] has summarized the general features of particle production implied by various models. He assumes that diffractive dissociation and multiperipheral production contribute in separately identifiable ways; this is important since the two processes are likely to follow different scaling laws. In an attempt to distinguish among models, Wilson has suggested a series of seven measurements. While they are not necessarily all new, taken together they form a consistent program.

1. Measure charged particle multiplicity distributions. Is there any dip in the distribution which separates low-multiplicity diffraction-dissociation events from high-multiplicity multiperipheral events?

2. Measure the single-particle distribution functions $\rho(p_\perp, p_z, E)$; vary E for fixed $p_\perp$ and x. Are limiting distributions achieved?

3. Measure backwards production in p-p and π-p collisions. Factorization (independent fragmentation of target and projectile) implies that the result should be the same.

4. Test the dx/x law for distribution functions.

5. Search for double Pomeron exchange in reactions such as $p+p \to p+p+\pi^+ + \pi^-$. Contributions of double Pomeron exchange result only in I = 0 dipion systems and cannot produce ρ mesons.

6. Measure two-particle correlation functions. For multiperipheral processes independent emission is expected at large effective dipion masses, so that in this regime the two-particle distribution function is just the product of single particle distribution functions.

7. If diffractive and multiperipheral processes are separately identifiable, test factorization in multiperipheral processes by requiring a transverse pion in the c. m. where diffractive events do not contribute.

In p-p collisions the symmetry permits an adequate study of production processes through analysis of either the forward or backward hemisphere in the c. m. system. This is not true when either π or K mesons are used as projectiles. To the extent that the collision results in the independent fragmentation of target and projectile only the forward cone in the laboratory system provides new information. Recognizing this, a number of hybrid systems have been proposed using a bubble chamber (now the ANL 30-inch) to provide local detail at the interaction vertex and a downstream detector to provide information on fast forward-going secondaries. Since neutral particles are not detected, detailed fitting of events is not possible. The downstream system, consisting of wide-gap spark chambers and counters, can, in principle, be triggered on events of specific types. However, when coupled to a bubble chamber, which must be prepulsed for sensitization, the potential increase in data rate for "interesting" events cannot be utilized. Consequently, even though studies involving fragmentation of the target particle are best done in the bubble chamber, for other studies it merely serves as a complicated and awkward hydrogen target.

To exploit the full advantages of a downstream system, we propose an alternative target-detector system consisting of a target (liquid H_2 or polyethylene) surrounded by an array of wide-gap chambers. A typical bubble chamber exposure of 10^6 pictures, each with 5 tracks yields 10 events/μb; with double pulsing the interactions of at most 10 particles will be examined each machine pulse. Since the system proposed here can examine the interactions of 10^5 particles/pulse, the detection efficiency for events which can be identified with a specific trigger is improved by 10^4. This increased sensitivity is particularly important in the study of events with transverse pions in the c. m. and in the search for 'exotics'.

II. Apparatus

The target-detector array is shown in Fig. 1. A charged particle emerging from a side of the target is observed in one of the four T-counters before entering a wide-gap chamber module. The 4" gaps in the modules yield good multitrack efficiency, as well as high position and angular resolution for track segments. The two-gap target modules are separated by 4" so that lead and/or additional counters may be inserted for γ-detection. Charged particles in the forward cone are detected in the D-counters before entering the wide-gap modules $SC_{1,2}$. The modules have been arranged to maximize the solid angle for which tracks will traverse at least one chamber with angle less than 45° since track visibility decreases rapidly at larger angles. Regions of solid angle for which this is not practical are covered by counters.

For momentum analysis, the downstream system incorporates a magnet similar to the ANL BM-111, 30"W x 72"L. At the nominal gap height of 6" and I = 2400A, it provides a transverse momentum $p_{\perp} = 1020$ MeV/c, or 100 mr deflection at 10 GeV/c. To clear the coil structure the wide-gap chamber modules SC_4 and SC_5 are separated by 108". With upstream and downstream momentum-analysis chambers displaced by comparable distances, the error in angular measurement is $\Delta\theta \simeq \pm 0.2$ mr, giving a momentum resolution of $\Delta p/p \simeq \pm 8\%$ at 400 GeV/c for tracks traversing the entire system. The 6" gap subtends an angle of $\pm$ 12 mr at the target, so that 400 GeV particles with transverse momenta less than 1.2 GeV/c are accepted without bias. The horizontal aperture of 30" is sufficient to accept the full forward c.m. hemisphere for a beam momentum of 400 GeV/c. Should increased vertical acceptance be necessary, the gap can be opened with a corresponding decrease in momentum resolution.

Use of wide-gap chambers results in a greatly simplified optical system; since it is not necessary to observe the full track length in each chamber, mirrors are the only elements required in the optical path.

Triggering is discussed in Section VI. The film would be scanned and measured at each of the three participating institutions.

The versatility of the downstream detector is significantly enhanced with the addition of a quantameter-hadrometer (Q-H) after the last wide gap chamber module, SC_6. Using alternate layers of Pb and scintillator EM showers can be distinquished from hadronic cascades since the characteristic length in the first case is the radiation length (L_{rad}= 0.58 cm in Pb) and in the second case the collision length (L_{coll} = 13.8 cm). An array 3' x 5' in area and 3' in length would be sufficient to contain 90% or more of the energy deposited by either an EM or hadronic cascade.

III. Experimental Procedure

In the spirit of an exploratory experiment, no detailed fitting of events is intended; even so, cross sections for several specific final states can be measured with sufficient accuracy so that subsequent experiments can be designed with confidence. In some cases, it will be possible to determine whether the simple power-law behavior suggested by low energy measurements persists to the highest accessible NAL energies. Backwards c.m. production will result in low energy secondaries at large angle detected in the wide-gap chambers around the target. Forward-produced charged particles will be momentum-analyzed and studied systematically in the downstream wide-gap spark-chamber spectrometer system. Some information of fast neutral hadrons and π^o's produced in the forward cone will be collected in the downstream quantameter-hadrometer.

A. Quasi-Two-Body Final States

To illustrate the use of the system, we consider the identification of several 'simple' final states. In general

$$p + p \rightarrow N_a^{*+} + N_b^{*+} \qquad (1a)$$

$$\rightarrow N_a^{*o} + N_b^{*++} \qquad (1a)$$

where N_a^{*+} is some combination of particles with B = 1, S = 0, Q = +1, moving along the beam direction in the c. m.; N_b^{*+} moves along the target direction, etc. In some cases, this will mean little more than particle production in the backward or forward hemisphere; for diffractive processes the classification relates closely to the production dynamics. Special cases are:

$$p + p \rightarrow (p\pi^o)_a + p \qquad (2a)$$

$$\rightarrow p + (p\pi^o)_b \qquad (2b)$$

Identification requires Pb sheet between the side target chambers. For (2a) the target detectors show a single charged particle and a π^o; the Q-H assures that the single fast forward particle is not accompanied by a π^o. For (2b) a single slow proton is detected in the target chambers; a single charged particle enters the downstream Q-H, but it detects both an EM shower and hadronic cascade.

$$p + p \rightarrow (p\pi^+\pi^-)_a + p \qquad (3a)$$

$$\rightarrow p + (p\pi^+\pi^-)_b \qquad (3b)$$

For (3a) three fast charged particles traverse the downstream system and for (3b) three slow particles appear in the target chambers. No π^o's are detected around the target or in the downstream Q-H.

$$p + p \rightarrow (p\pi^+)_a + n \qquad (4a)$$

$$\rightarrow n + (p\pi^+)_b \qquad (4b)$$

For (4a) two fast positive particles are observed in the downstream system; no other charged particles, and no π^o's are detected. For (4b) two slow charged particles emerge from the target, with a neutral hadronic cascade in the downstream Q-H; no π^o's are detected anywhere.

It is apparent that many configurations involving only a few particles (charged and neutral) produced by fragmentation of the target or projectile can be identified with relative certainty without precision measurement and fitting. This is possible only when adequate γ-detectors surround the target and subtend the downstream cone.

When the fragmentation (and/or) dissociation of protons has been adequately explored, pions may be used as projectiles to determine the extent to which the target fragmentation is independent of the kind of projectile used. For example

$$\pi^{\pm} + p \rightarrow \pi^{\pm} + (p\pi^{o}) \qquad (5)$$

$$\rightarrow \pi^{\pm} + (p\pi^{+}\pi^{-}) \qquad (6)$$

may be compared with (2b) and (3b), etc. Simultaneously, the downstream system serves to study the nature of the pion fragmentation process. A number of reactions may be easily identified

$$\pi^{\pm} + p \rightarrow (\pi^{\pm}\pi^{+}\pi^{-}) + p \qquad (7)$$

$$\rightarrow (\pi^{\pm}\pi^{+}\pi^{o}) + n \qquad (8)$$

$$\rightarrow (\pi^{\pm}\pi^{o}) + p \qquad (9)$$

$$\pi^{\pm} + p \rightarrow (\pi^{+}\pi^{-}) + (p\pi^{\pm}) \qquad (10)$$

$$\pi^{-} + p \rightarrow (\pi^{+}\pi^{-}) + n \qquad (11)$$

etc.

B. <u>Multiparticle Production</u>

The quasi-two-body reactions consist merely of the subset of identifiable final states. More generally, multiplicities and momentum spectra for all events may be measured and catalogued. Gamma-rays identified in the target-detector array or in the downstream Q-H permit some determination of the correlation between neutral and charged pion production.

As discussed in the next section, decays will indicate hyperon or kaon production; in many cases the initial particle can be identified and the momentum measured.

C. Hyperon and Kaon Identification

In Table I we have indicated the laboratory momenta corresponding to zero c. m. momentum for production of strange particles; the dominant decay modes and maximum transverse momenta are also listed. Note that no known hyperon decay gives a K^o, so that any V associated with a decay vertex is always a Λ unless something new (an exotic) is observed. In general, decay of neutral particles (other than directly produced Λ's or Σ^o's can be identified only by observation of a downstream V not pointing at the interaction vertex; for charged particle decay, a kink may be observed with or without an associated V.

Decay events can be convincingly identified only in the path before or after the magnet. The tabulation in Table II shows that at 100 GeV/c 25-60% of all strange particles (except $K^{\pm}$) decay before the magnet and 10-20% after; at 200 GeV/c, 10-35% decay before and 15-20% after. When the decay occurs before the magnet, and there is an associated V, the momentum and identity of the initial particle can usually be deduced from the decay kinematics; when the decay occurs after the magnet, the momentum is measured directly, but the identity can be established only when there is an associated V. When the V points to the decay vertex, the primary particle is an Ξ^-; when it points downstream of the decay vertex, the primary particle is an Ω^-.

For V's originating at the interaction vertex, a separation into K_1 and Λ decays is necessary. The primary distinction between the two decays lies in the larger angle allowed for the positively charged secondary from K_1 decay. For momenta above a few GeV/c, K_1 decays with π^+ c. m. angle $\gtrsim 30^o$ yield positively charged secondaries at larger angles than allowed for protons from Λ decays of the same initial momentum. With our expected angle and momentum resolution, we estimate that 1/2 to 2/3 of all K_1 decays before the magnet will be uniquely identified; in general, Λ decays will fit as K_1 decays. An iterative subtraction (taking into account the isotropic c.m. K_1 decay) will yield the correct relative numbers.

It is apparent that the production of antiparticles results in some straightforward modification of the above remarks.

D. Search for Exotics

By 'exotics' we mean phenomena which either cannot be inferred from present knowledge, or phenomena which may be expected on the basis of reasonable theoretical models but have not yet been observed (massive hadrons and leptons, quarks, monopoles, intermediate bosons, etc.). In the present proposal, the search for exotics can be carried out with either an LH_2 or polyethylene target as soon as any high energy beam is available. To conserve quantum numbers, it may be necessary to pair-produce massive exotics so that c.m. momenta may be low, and corresponding laboratory momenta only reflect the c.m. motion. In this case, the time dilation is about 14.6 for 400 GeV/c incident protons. For 1/3 or more of such particles to emerge downstream of the target, the lifetime must be greater than 10^{-10} sec. The target wide-gap chambers provide some sensitivity for decay of particles with shorter lifetimes; it is apparent, however, that the ability to separate vertices for production and decay within the target will depend upon the specific details of these processes. Some experience can be gained in relating forward and backward production of Σ's, Ξ's, and Ω's .

IV. Triggering

Initially, the system would be triggered when any kind of interaction was detected. To do this, a coincidence would be required between an upstream beam counter and either of the two counters D_1 (immediately downstream of the target) or D_2 (behind the last wide-gap chamber module);

small circular holes in D_1 and D_2 allow passage of the undeflected beam. Those events with no downstream particles counting in D_1 or D_2 would be identified by a coincidence between the T-counters surrounding the target and the upstream beam counter.

After recording a sufficient number of events for preliminary study, the trigger would be modified to optimize efficiency for detection of rare events. At 400 GeV/c incident proton momentum, the c. m. angle $\theta^* = 90^\circ$ transforms to a laboratory angle $\theta = 4^\circ$. Based on extrapolation of present knowledge, pionization is the only process likely to contribute significantly to particle production near $\theta = 4^\circ$. In the laboratory system, however, two groups of particles can emerge near $\theta = 4^\circ$. The first corresponds to $\theta^* = 90^\circ$ and (for pions) may be identified by $p < 2.9$ GeV/c; the second corresponds to $\cos\theta^* \simeq -1$ and by $p < 2.9$ GeV/c. Consequently, the simplest signature for exotics or rare events would be the presence of energetic particles near $\theta = 4^\circ$, since these might represent:

a) Pionization which will contribute in the region $x \simeq 0$ if it plays an important part in the miltiparticle production process.

b) Strong decay of massive short-lived systems. In this case, particles with large transverse momenta emerge from the interaction vertex.

c) Weak decay of massive particles. Here, particles near $\theta = 4^\circ$ emerge from a decay vertex downstream of the interaction vertex. Whether the decay vertex will be observed clearly depends upon lifetime and momentum.

These processes can be identified with a simple combination of counters before and after the magnet. The rare-event trigger would be utilized for most of the spill length; if no event is recorded during this period, the general trigger is added, so that a useful event is assured for each machine pulse.

V. Beam, Equipment, and Scheduling

In preliminary talks with Dr. Toohig, it appears that the apparatus would be well suited for operation in the low intensity bubble chamber beam to be built in Area 1. Since the apparatus requires only 40' along the beam line there is more than ample space just upstream of the building which will house the 30" Bubble Chamber.

All equipment with the exception of the hydrogen target and analyzing magnet will be supplied by the experimental groups involved. Because of its simplicity, the system can be ready 6 months after approval.

After tune-up, we believe that both a sensitive (10^{-34} cm^2) search for rare events and a comprehensive survey of particle production can be completed with 2 x 10^5 machine pulses equally divided between p-p and π-p studies. Triggering will always be arranged to optimize the event rate per pulse; the maximum number of allowed beam particles, however, depends upon spill length. For 1 second spill, a beam of 10^5 particles would be desirable. Compatible running with either the narrow or broad band neutrino experiment would provide the greatest flexibility.

TABLE I

	Mass	cτ	P_{min} 200 GeV	P_{min} 400 GeV	Decay Modes	p^*
$\pi^{\pm}$	139.6	781				
$K^{\pm}$	493.8	370				
K_s^o	497.8	2.59	5.14	7.37	$\pi^+\pi^-, \pi^o\pi^o$	205
K_L^o	497.8	16.4	5.14	7.37		
Λ	1115.6	7.54	11.5	16.3	$p\pi^-, n\pi^o$	100
Σ^+	1189.4	2.41	12.3	17.4	$p\pi^o, n\pi^+$	190
Σ^-	1197.3	4.47	12.4	17.5	$n\pi^-$	190
Ξ^o	1314.7	9.10	13.6	19.2	$\Lambda\pi^o$	135
Ξ^-	1321.3	4.98	13.8	19.3	$\Lambda\pi^-$	140
Ω^-	1672.5	3.90	17.3	24.4	$\Xi^o\pi^-, \Xi^-\pi^o$	290

TABLE II

	Probability For					
	Decay Before Magnet			Decay After Magnet		
	50	100	200 (GeV)	50	100	200
$\pi^{\pm}$						
$K^{\pm}$						
K_s^o	0.504	0.296	0.160	0.131	0.210	0.192
K_L^o						
Λ	0.417	0.237	0.126	0.144	0.169	0.132
Σ^+	0.834	0.592	0.362	0.011	0.088	0.193
Σ^-	0.623	0.286	0.217	0.074	0.183	0.210
Ξ^o	0.408	0.231	0.125	0.175	0.213	0.167
Ξ^-	0.625	0.288	0.218	0.076	0.186	0.210
Ω^-	0.781	0.544	0.325	0.019	0.112	0.205

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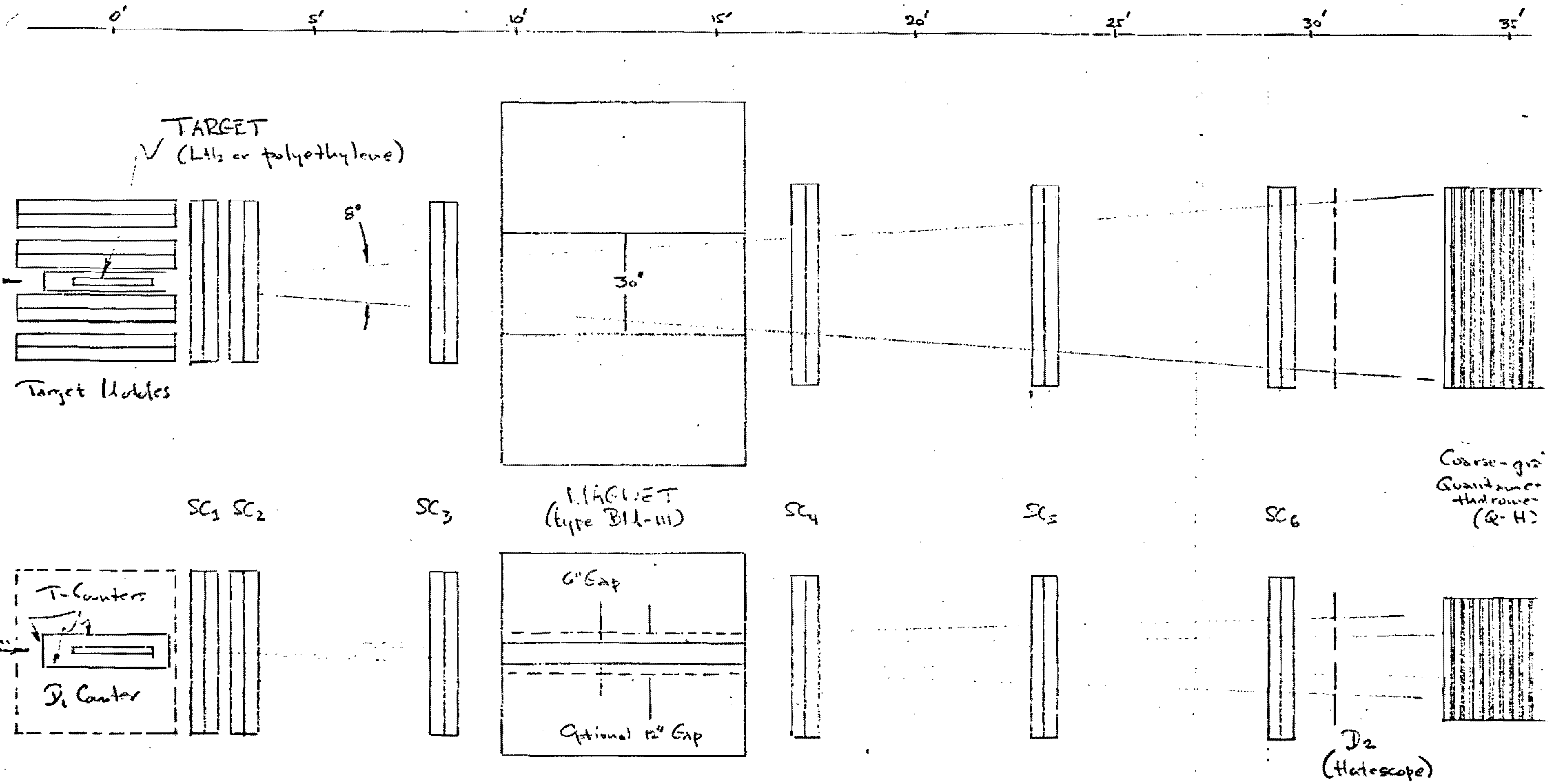
WIDE-GAP SPARK CHAMBER DETECTOR-SPECTROMETER



Donald Miller: Spokesman
Bruce Cork
Gerald Smith
May 14, 1971

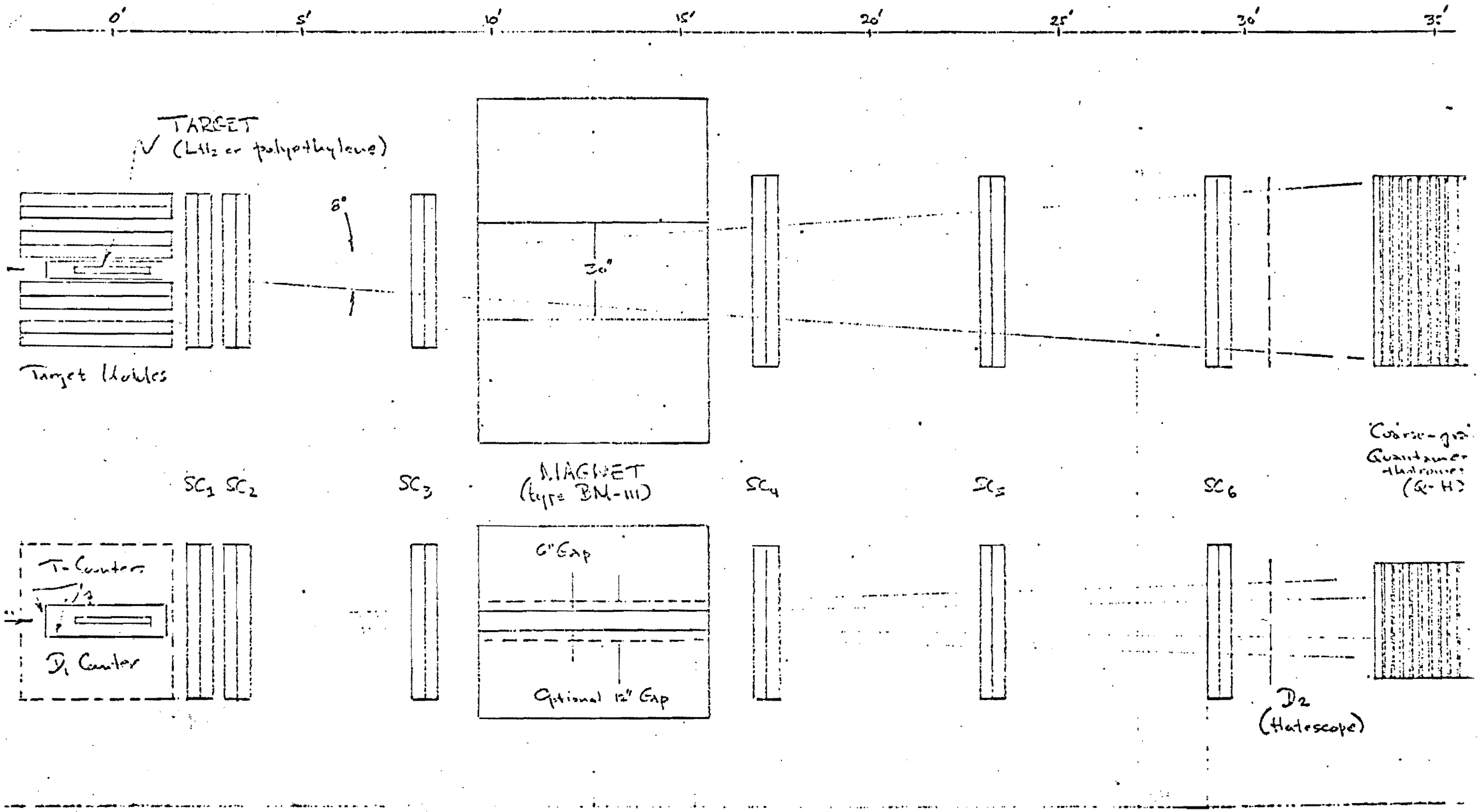
Addendum to Proposal #106.

Several questions regarding this proposal have been raised by the PAC. It is the purpose of this addendum to provide the information necessary to help the committee in its decision.

We have proposed that an array of triggerable wide-gap chambers be used at NAL in a study of multiple particle production processes and in a search for rare (exotic) events. It is apparent that the 30" bubble chamber is well-suited to investigate details of target fragmentation and backwards production in processes with cross sections of 10^{-30}- 10^{-29} cm^2; with a beam of 10^5 particles/pulse and a spill of 1 second, the wide-gap chamber array is intended to extend these studies to selected processes with cross sections as small as 10^{-34} cm^2. The most exciting result of the experiment, however, might well be the observation of unexpected structure, identified by the presence of energetic particles with large transverse momenta. In contrast to other kinds of searches, the wide-gap array allows the possibility of studying much of the event in which these particles are produced.

In addition to the study of rare processes, the experiment will yield important information on the high energy behaviour of several reactions widely studied at low energies. The apparatus is well suited to the study of charged particle fragmentation products of beam particles and there is adequate sensitivity for a measurement of strange particle yields at the highest available momenta. All these studies involve only the observation and measurement of charged secondaries. Forward-produced particles are detected in the downstream chambers and backwards-produced particles in

WIDE-GAP SPARK CHAMBER DETECTOR-SPECTROMETER



the chambers around the target. Blind regions are covered by counters, so that the existence of one or more unseen charged particles in a given event will be recognized.

An attractive feature of the basic proposal is the simplicity of the apparatus, and we intend that this remain so. Nevertheless, it was recognized that several important final states could be identified with the addition of supplementary detection equipment for neutral particles. This is a limited objective suitable only for low-multiplicity events with cross sections of 0.1 - 1.0 mb; it is <u>not</u> intended that this be a general purpose apparatus with the possibility of fitting events involving arbitrary numbers of charged and neutral secondaries. To achieve this objective with limited measurement precision it is necessary that the neutral particle detectors allow a significant statement about what an event <u>is not</u> (an event with 3 observed γ-rays is not single π^0 production, etc.); in this way the most likely hypothesis can be identified, at least on a statistical basis. Examples are given in the proposal.

To provide detection for neutrals, two modifications are necessary:

a) The downstream quantameter-hadrometer. The most straightforward version of such a device consists of a series of Pb and Fe plates interspersed with wide-gap (4") chambers. The first 6 plates are Pb as indicated in Fig. 1.

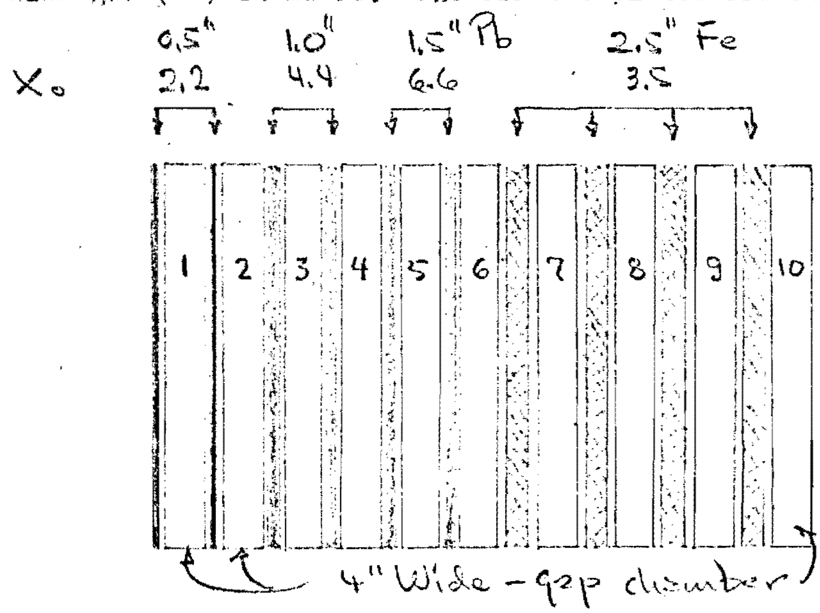


Fig. 1

Quantameter-Hadrometer

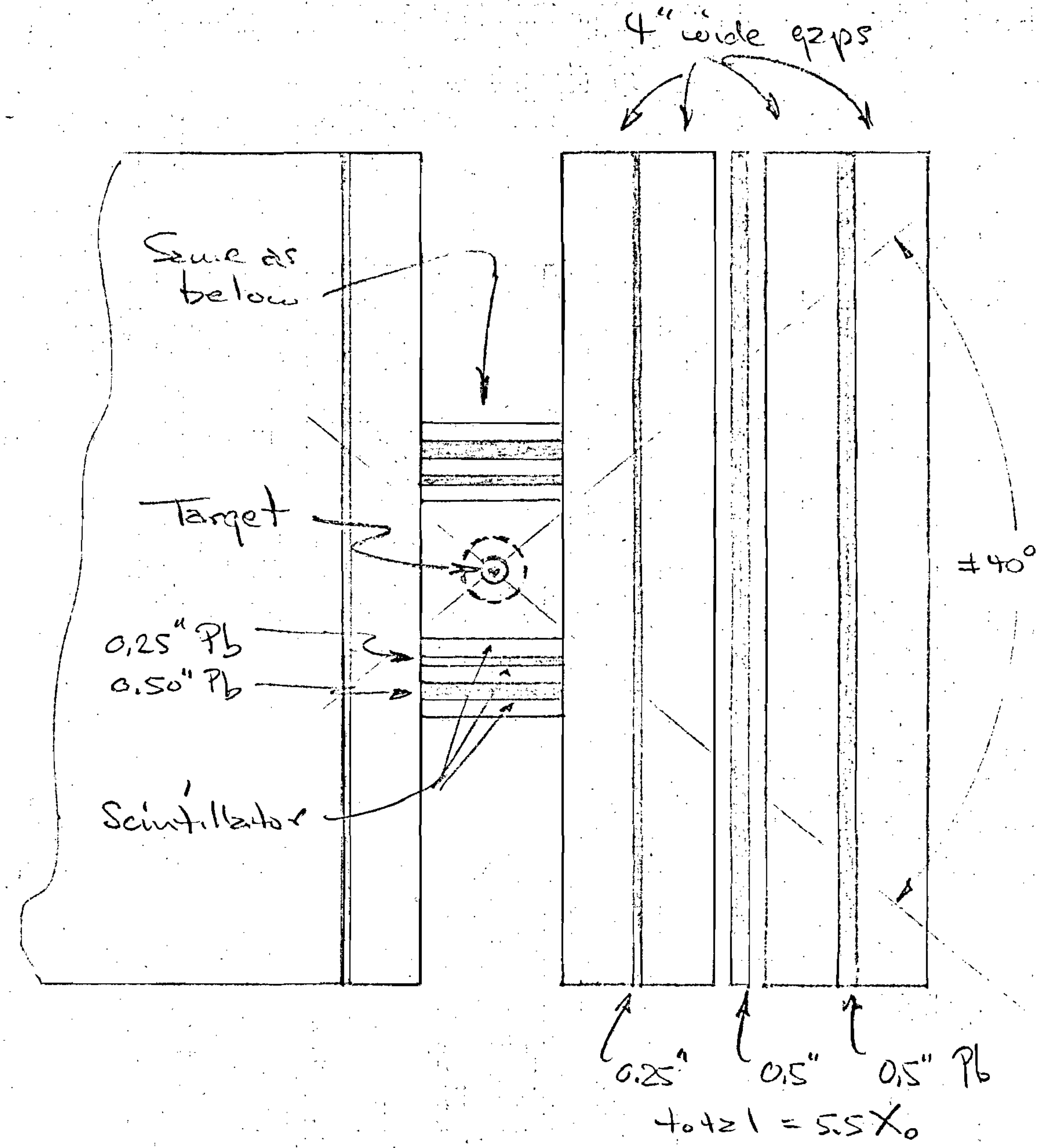


Fig. 2 Cross section of target-detector array as seen by beam.

Most γ's are converted in the first plate ($\gtrsim$ 80%) or the second ($\gtrsim$ 95%); the initial part of the shower provides some spatial resolution. Monte-Carlo calculations by U. Völkel* indicate that 98% of the shower is contained in a length $t \simeq 2.5 \ln E_\gamma$. For $E_\gamma = 100$ GeV, $t = 2.5 \ln 10^5 = 29X_0$. Consequently, less than 2% of the shower energy appears behond gap #6. But the 6" of Pb before gap #6 is only 1.1 collision lengths, so that any hadronic cascade is just getting underway. Measurements by Hofstadter and collaborators+ indicate that 80% of the hadron cascade energy will be contained in the volume specified in Fig. 1; the only significant leakage is out the back. The response for incident hadrons can be adequately studied with beam particles. It is not expected that detailed energy measurements will be attempted with this neutral particle detector. It will detect γ's with energy above 50 MeV and energetic neutrons (and antineutrons) with high efficiency. Note that this device will also provide excellent detection of muons, either those produce directly or those resulting from decay.

Adequate γ detection around the target presents a more difficult problem, and some compromise is necessary. At present the arrangement would be as indicated in Fig. 2. Over the useful length of the target the efficiency for γ detection ($E_\gamma \gtrsim 50$ MeV) is greater than 90% for most of the 4π solid angle. In identifying specific final states, such as those discussed in the proposal, it is only necessary to know whether one or more low energy π^0's originated in the target. When it is apparent that more than one such π^0 had been produced, the neutral content of the target fragmentation would not be analyzed further. The large-angle charged particles help in reconstruction of the interaction vertex in the target; the counters above and below the target are essential to determine whether

* U. Völkel, DESY 65/6 (1965)
\+ E.B. Hughes et al., Nuclear Inst. and Methods 75, 130 (1969)

all the large-angle charged particles enter the sensitive regions of the wide-gap chambers. It is apparent that such a target-detector array provides mostly statistical information about the target fragmentation process. In low multiplicity events it can be crucial in identifying specific final states.

At least two cameras are necessary for photography; however, the optical system will be calibrated periodically with non-interacting beam particles. With the magnet off, straight-through tracks are observed; with the magnet on, direct calibration to 1 GeV/c transverse momentum is accessible. By varying the beam momentum, the system can be calibrated over most of the useful range.

For initial running the trigger operates in two modes during the spill. For 80% of the time, the system waits for a rare event (energetic particles near 4^{o} lab); if nothing has happened, a loose trigger is added. The latter consists simply of the statement that the beam particle is not observed downstream, or that secondary particles are observed around the target. Unbiased triggering can be achieved with beam counters alone. Although some examination of events will be concurrent with running, it is preferable that the run be interupted after 10k pictures for a more careful examination. Optimum triggering for the remainder of the run would be determined at that time.

It is apparent that the apparatus can take interesting data for any beam intensity $\gtrsim$ 1 particle/pulse. Because of the exploratory nature of the experiment and its suitability for operation at the highest accessable beam momentum, it is desirable that it be scheduled at the earliest possible time.