PROPOSAL: NEUTRAL BEAM EXPERIMENTS

A. INTRODUCTION:

We propose to construct, through a series of stages, a neutral beam facility at SLAC to provide a flux of relatively energetic K_2^0's and anti-neutrons. At an early point in this program we would like to carry out a careful measurement of the expected intensities of these particles as a function of energy and production angle and determine the branching ratios

$$\frac{K_2^0 \to \pi^+ + \mu^- + \bar{\nu}}{K_2^0 \to \pi^- + \mu^+ + \nu} \quad \text{and} \quad \frac{K_2^0 \to \pi^+ + e^- + \bar{\nu}}{K_2^0 \to \pi^- + e^+ + \nu}$$

B. PERSONNEL:

This experimental program will be carried out by a joint group composed of personnel from the Lawrence Radiation Laboratory, SLAC, and the Stanford Physics Department. The senior members of this group will include:

K. Crowe - LRL

D. Dorfan - SLAC

D. Miller - LRL

M. Schwartz - Stanford

S. Wojcicki - Stanford

It is expected that one or two graduate students will participate in this program. Engineering and technical assistance is being arranged at SLAC and LRL.

C. PLANS OF THE PROGRAM:

1. Target Studies and Crude Flux Measurements

Preparatory to undertaking any flux measurements on the particles of interest, we would like to study the problems associated with targeting and cleaning up background in the beam. The tentative design for the targeting arrangement is shown in figure 1. We expect that a target of 1/10 radiation length with a beam average of one microampere will be adequate for allowing us to photograph one K_2^0 decay per second. The electron beam is allowed to enter a 20 kW beam dump as shown. The neutral beam will be taken at 3° to the electron beam and as a result should be fairly clean of gammas. Preliminary target studies will be carried out by placing a variable amount of converter as shown, followed by a bending magnet and a shielding wall with a beam hole through it. We propose to make crude measurements of strongly interacting flux and gamma background by placing an existing small spark chamber behind the shielding wall.

2. Detailed Flux Measurements for K_2^0's and Asymmetry Experiment

At a distance of 200 feet from the target we propose to construct the shielded entrance shown in figure 2. The necessary thickness of the front wall will be determined through measurement of general muon background in phase 1. A hole of about one square foot will penetrate the front wall for the passage of the beam. Inside of the room we expect to have the experimental arrangement shown. This arrangement consists of the following sequence of instruments:

a) An anti-coincidence counter to cover the beam hole and insure that no entering charged particle be counted.

b) A vacuum tank enclosing the decay region, the latter being 1' x 1' x 6'. Approximately one per cent of the K_2^0's will decay here.

c) An array of twelve thin counters logically connected so as to signal the arrival of two charged particles.

d) A thin-walled spark chamber 2' high and 3' wide.

e) The large Sagane magnet, on loan from LRL with a spark chamber inserted.

f) A thin-walled spark chamber 3' x 6'.

g) A large range chamber consisting of 44 plates of aluminum, each 8' x 8' x 1" interspersed with 12 inches of steel.

We expect our typical K_2^0's to be of the order of 3-6 BeV/C yielding pions, muons, and electrons with average energy of 1-2 BeV. Muons in this energy interval will all penetrate the entire range chamber whereas pions will have only about one chance in 500 of doing so. Thus we can separate the $\pi^+ \mu^- \bar{\nu}$ mode from the $\pi^- \mu^+ \nu$ mode with essentially no bias. Electrons will be recognized as characteristic showers in the same direction as the incoming track.

Flux measurements as a function of energy can be carried out on the same pictures by measuring the apparent energies of some fraction of the events.

As a result of the Fitch-Cronin experiment, one expects a charge asymmetry of the order of one per cent. Therefore it would be desirable to eventually obtain of the order of 100,000 $\pi^\pm \mu^\mp \nu$ events requiring about 400,000 K_2^0 decays. Our efficiency for collecting these events should be close to unity.

Recent calculations by Y. S. Tsai indicate that we should obtain one decay per second with the above-mentioned beam parameters (1/10 radiation length target and 1 microampere of beam). This leaves us a fair safety factor through increase of target thickness and offers the possibility of 30,000 events per day.

Of course, every K_2^0, neutron or anti-neutron that enters the large chamber will interact there and so we need to insure that we have no more than about one such particle entering per pulse. If the beam pulse length is .1 μsec, then we can exclude all particles leaving the target region with $\beta \leq 2/3$ by timing the chamber firing. This excludes neutrons with kinetic energy less than about 900 MeV. Neutrons and antineutrons with energy higher than this amount should not be any more abundant than the K_2^0's. Thus the average number of interactions in the range chamber, if we are observing one decay per second will be of the order of one. This seems to be no problem.

It should be pointed out that this experiment seems more readily done here than at any other existing accelerator. In order to distinguish a muon from a pion with the required certainty, it seems quite valuable to be able to work with K_2^0's of energy greater than 3 BeV. Furthermore, the high-energy neutron background at SLAC is much lower than at a comparable energy proton machine leading to a clean detector arrangement with higher solid angle than would be otherwise possible.

3. Detailed Flux Measurement for Anti-Neutrons

We propose to carry out this measurement by placing a hydrogen target in the middle of what was previously the K_2^0 decay region. Counters S_{1-12} will now trigger the chambers on the arrival of three or more particles and energy measurements will be carried out in the magnet system as before. We believe that we can obtain an anti-neutron spectrum to about 10 per cent in this way.

D. ACCELERATOR OPERATION:

1.	Beam Energy	-	20 BeV or as high as possible
	Current	-	1 microampere
	Pulse Length	-	0.1 microseconds
	Pulse Rate	-	180 per second or higher on phases 1 and 2; 1 per second on phase 3
2.	Target	-	0.1 rad length of Be

E. EXPERIMENTAL EQUIPMENT:

1. Bending magnet for cleaning up the beam with 8" gap and 72" length to be supplied by SLAC.
2. Beam dump--20 kW--supplied by SLAC.
3. Shielding as shown on figure 1.
4. Spark chambers
   a) Thin plate--to be constructed
   b) Range chambers--to be taken on loan from Columbia
5. Analysis Magnet

   Either the Sagane magnet on loan from Berkeley or an equivalent which is available.
6. Hydrogen target, for phase 3--to be constructed.

F. TIME TABLES:

1. All of the equipment for phase 1 of the experiment is currently available.

2. Equipment for phases 2 and 3 should be ready by January 1967.

G. MACHINE TIME:

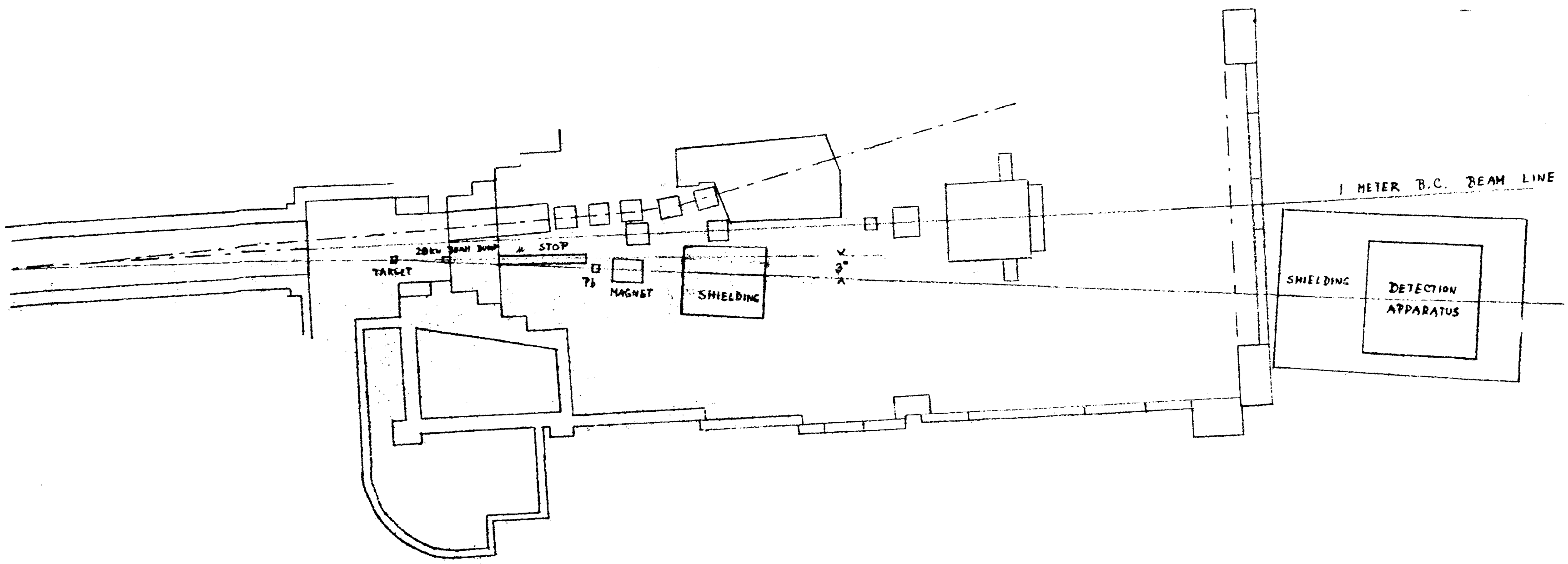
1. Phase 1 - 4 days to study background

2. Phase 2 - 10^8 pulses for 400,000 K_2^0 decays

3. Phase 3 - 10^5 seconds

H. DATA ANALYSIS:

Adequate facilities are available at both LRL and SLAC for the analysis of the film.



END STATION B

SCALE 1" = 20'

FIG 1

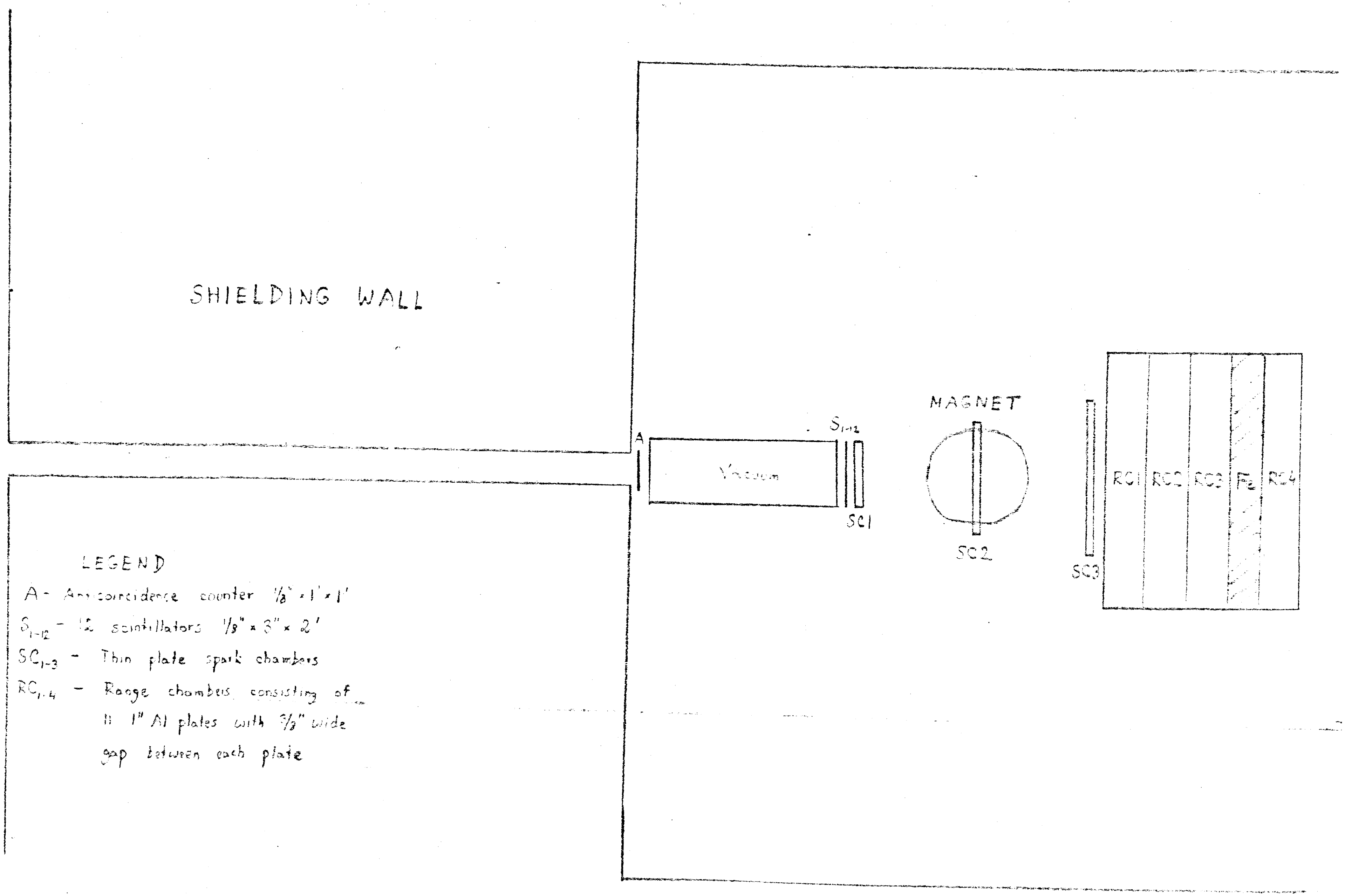


FIG. 2

SCALE 1" = 4'

No. 15

September 16, 1966

E R R A T U M

to

SLAC PROPOSAL NO. 15

and

ADDENDUM TO SLAC PROPOSAL NO. 15

The "official title" of SLAC Proposal No. 15 has been changed

From: "Proposal: A Neutral Beam Facility for SLAC"

To: "Neutral Beam Experiments"

Please make this correction on your copies of the Proposal and Addendum.

Supplement No. 2
to SLAC Proposal No. 15

May 15, 1967

ADDENDUM TO PROPOSAL NO. 15

By May 20, 1967, we expect to have completed our allotted time toward the measurement of the charge asymmetry in K_2^0 leptonic decay. We will have logged a total of about 450,000 events by that time, giving us a statistical accuracy of about 0.35%. At present we have observed a total of about 276,000 decays with an asymmetry which is consistent with either of the theoretically expected solutions ($\frac{\mu^+}{\mu^-}$ = 1.006 or 1.000). Small corrections are expected to the data from a scanning of the sample pictures taken, but we expect that these corrections should amount to less than several tenths of a percent.

We propose at this time a continuation of the experiment along the following lines:

1. We would like to take about 60 hours of running time to make a thorough check of our systematics. In this time we propose to carry out the following tests:

   a. Check of asymmetry due to anti-coincidence inefficiency. By putting the anti-counter in coincidence we magnify the effect here by at least a factor of 50. Accordingly, only about 2 hours are necessary. This test was already carried out when we had iron absorber and showed a null result. It will be repeated with the new lead absorber.

   b. A carbon block will be placed in the beam to magnify any effect due to the helium bag. About 3 hours of running here will check the systematics adequately.

c. We will systematically alter the efficiencies of counters in our first bank in synchronism with magnet reversals. This should exaggerate enormously any bias induced through such means during actual running. About 10 hours should suffice.

d. We will cycle our magnet asymmetrically to see if this is a possible source of bias. About 10 hours should suffice here.

e. We will reduce the voltage on individual counters to bring them out of plateau and see if this induces an asymmetry. About 20 hours should suffice here.

2. If all of the above tests indicate an absence of systematic difficulty down to the 0.1% level, then we would like an extension of our running time by 300 hours to permit us to go to 10^6 events. At this level it should be possible to distinguish the two solutions with some precision.

ADDENDUM TO NEUTRAL BEAM EXPERIMENTS PROPOSAL

We would like to make the following remarks relevant to our proposal:

a. It seems as though the experiment can be set up in the central beam facility as an alternative to the "B" area. There are some advantages to this possibility from the point of view of extensive parasitic running and it appears quite feasible to have the facility operating for our purposes by March or April of 1967.

b. The apparatus has been modified somewhat, as shown in the accompanying figure. In place of the rather unwieldy Sagane magnet, we have put one of the Berkeley "Atlas" magnets with 29" x 36" pole face, opened to an 18" gap. Only two thin plate chambers are used and they can be photographed with the same camera as views the large chamber. All photographic equipment with the exception of film is on hand at Brookhaven and will be brought out along with the large chambers. An additional set of 12 counters has been added, as shown, and provision will be made for inserting lead sheet in front of same.

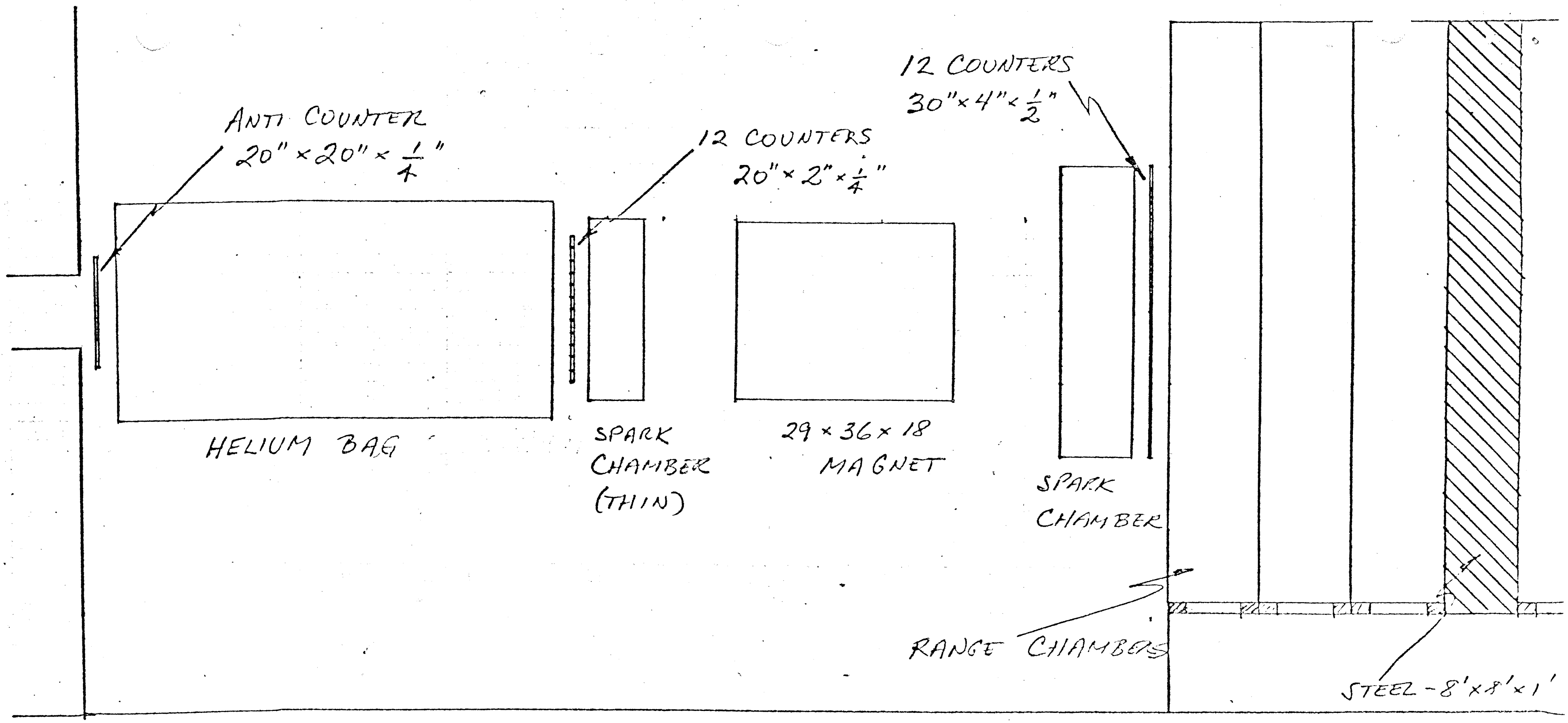
c. While awaiting arrival of the magnet from Berkeley, (tentatively scheduled for April 1, 1967) we can test all trigger systems and carry out an incidental measurement of the branching ratios of K_2^0 into $2\pi^0$ and 2γ. As is obvious from the proposal, we are uniquely suited to these measurements by virtue of our large solid angle and low neutron background.

d. We would like to request immediate approval of phases 1 and 2 of the experiment subject to reconsideration if phase 1 should show the program to be unfeasible. (We should point out that many of the experiments which have already been approved will be equally unfeasible if ours should turn out to be so.) The reasons for requiring immediate approval are the following.

1. It will give LRL the assurance it needs to schedule the loan of the Atlas magnet and to pay for its share of the experiment.

2. It gives us the priority necessary to obtain the rigging time at SLAC and to carry out the work required to set up the experiment.

e. We believe that we can shake down the experiment by running parasitically for awhile, testing our trigger system and investigating background. After that time we will insert the magnet and begin to take data. If, for political reasons, we cannot obtain all of the required running time next spring, we do feel that several days should give us enough to get us on our way.



FRONT VIEW - NEUTRAL BEAM FACILITY.