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Dear Leon,

At a recent wine and cheese seminar Roland Winston of the University of Chicago reported on the latest measurement of the electron asymmetry parameter in sigma- beta decay. The current experimental situation is summarized in Figure 1 (ref 1). A total of four measurements have been made. They all agree with each other and all disagree with the predictions of the Cabibbo model. The magnitude of the disagreement is greater than four standard deviations for the latest measurement and almost six standard deviations for the combination of the four measurements. It is significant to note that the current measurements are consistent with the measured magnitude of the form factor ratio (g1/f1) if the sign is taken to be opposite to the prediction of the Cabibbo model.

Each of these measurements used the same basic experimental technique. In all of them a low energy meson beam was used to produce sigma-. The polarization of the sigmas was inferred from a phase shift analysis. Two hydrogen bubble chamber experiments and the latest electronic detector experiment were done at the Y*(1520) resonance in K- P scattering. The fourth electronic experiment was done with associated production in PI- P scattering. All are low statistics experiments.

Clearly something is wrong with either these experiments or with the Cabibbo model. This disagreement has been with us for over ten years. There is no fault that can be found with the current measurements. On the other hand, the Cabibbo model has been so successful everywhere else, and forms the groundwork for so much new physics, that it is unthinkable to many that it might be wrong.

My colleagues and I would like to resolve this issue by performing this measurement by a radically different technique.

As I will describe in some detail below, the current charged hyperon beam apparatus, which we used for E-497, can in one week of running collect more than ten times the current world sample of polarized sigma- beta decay events. With such a large sample of events we will be able to study possible systematic errors with techniques unavaliable to the low statistics measurements.

The only modification of the apparatus required is to reconfigure the lead glass array to provide greater pion rejection. The lead glass which we used in E-497 was borrowed from E-400 (originally from E-288) and has been returned. However, preliminary checking around the lab indicates that borrowing a sufficient quantity of appropriate lead glass will be no problem.

We know from our E-497 data that at a production angle of 3 mrad and 250 GeV/c hyperon momentum, sigma-'s are produced \#ith significant transverse polarization. Our analysis of the sigma- polarization is incomplete, so for purposes of this discussion I will use P = 0.20 which is the measured value of sigma+ polarization at the same kinematics (ref 2). We can reverse our polarization by reversing the targeting angle. The beam polarization is monitored by the sigma- --> N + PI- decay mode for which we have excellent statistics. We can, if necessary, reverse the beam polarization every pulse in order to average over any drifts in the apparatus which could cause systematic effects. Our ability to measure the beam polarization in the E-497 data clearly demonstrates that systematic errors are well under control.

In this discussion I will restrict myself to measured numbers in order to estimate rates and sensitivity. As the result of this WORST CASE analysis will show, we can make a definitive measurement in a single very short run. The apparatus is shown in Figure 2 and a summary of the discussion below can be found in Table 1.

At 3 mrad production angle with 3E10 protons on target and 250 GeV/c hyperon momentum our sigma- trigger rate in E-497 was 5000/pulse. These triggers are mainly sigma- decays with a small contamination of cascade- and K- decays. Table 1 shows the rates per pulse for the four decay modes contained within the sigma- trigger. Following in the table are the various efficiencies for each of the decay modes. The rates at the electron TRIGGER and OFFLINE electron stage are shown as well as the final ANALYZED rates. The leptonic trigger we will use will require an electron signal from the lead glass array. The lead glass has a hole in the middle for the decay neutron and a geometrical efficiency of 46% for decay electrons. Assuming a rejection factor of 50 for pions relative to electrons at the trigger level yields a trigger rate of 38/pulse. At the electron TRIGGER stage leptonic decays are 4.4% of the events.

OFFLINE I assume we can achieve the same PI-/E- rejection factor as E-400, i.e. 200/1 (ref 3). More than 70% of the sigma- triggers survive our track finding algorithm. Most of the 30% which fail are in fact sigma- decays upstream of our fiducial volume. 97% of events which survive track finding make good fits to either the sigma- or cascade- hadronic decay modes. 46% of the leptonic events also make acceptable fits to the sigma- or cascade- hadronic decay modes. Defining an ANALYZED event as one which fits neither hadronic decay mode yields a sample which is 74% leptonic decays. The rate of analyzed leptonic decay events is 0.56/pulse.

In addition to the electron trigger described above we will also take approximately 50 sigma- triggers per pulse. These events allow us to monitor the sigma- beam polarization.

The result of the above trigger and analysis scheme is 0.56 good sigma beta decays per pulse or 1.7E4 in a typical week (3.0E4 pulses/week). In addition there will be 1.0E6 good N PI- events from the sigma- triggers.

For the purposes of this estimate the electron alpha parameter (α_e) is calculated from the up - down asymmetry (A_e) for leptonic events. Since the N PI- and leptonic decay modes are kinematically similar many systematic errors will cancel in the ratio of the up - down asymmetries for these two modes.

$$\alpha_e = \left(\frac{A_e}{A_{N\pi^-}}\right) \alpha_{N\pi^-} \qquad (1)$$

The absolute normalization of the asymmetry scale is given by the known value of the alpha parameter in the N PI- decay mode ($\alpha_{N\pi^-} = -0.068$ +/- 0.008). After correcting the alpha parameter for the N PI- backround a 3.4E4 event sample will yield an uncertainty in asymmetry of +/-0.09. This is to be compared to the current world average value of 0.27 +/- 0.18.

Recall from figure 1 that two possible values of the electron alpha parameter are consistant with the measured value of the magnitude of g1/f1. The value predicted by the Cabibbo model is -0.768; the other is +0.352.

The table below, shows the values of the up - down asymmetry we would observe for the N PI- decay mode and the two possible electron alpha parameters.

MODE	ASYMMETRY	BEAM POL	EVENTS
N PI-	0.0087 +/- 0.001	0.20	1000k
N E- NUE	0.0261 +/- 0.005	0.20	34k
N E- NUE	-0.0487 +/- 0.005	0.20	34k

We believe that systematic errors in the observed asymmetry are of the order of 0.001.

We would run 3.0E4 pulses each for positive and negative targeting angles to collect equal samples with the sigma- polarization up and down. We would also take a point at zero targeting angle as a check of systematics.

Thus a three week run will yield a 3.4E4 event sample of sigma- leptonic decays and a measurement of the alpha parameter to +/-0.09. At this level of precision we can distinguish between the two possible values of the electron alpha parameter by more than 12 standard deviations.

The only externally measured number we must use in our analysis is $\alpha_{n\pi}$. The measured sign of this parameter is not generally considered in question but if this beta decay effect is confirmed this issue may need to be reopened. However, even if we were to question the validity of the sign of this measurement we can distinguish between the two possible vaules by more than 4 standard deviations by comparing the absolute value of our measured alpha parameter to the absolute value of the values predicted by figure 1.

There are several possible improvements for the design sketched above. The apparatus should easily handle twice the beam on target (6E10 instead of 3E10). This will almost double the yield. The pion rejection in the lead glass can be made significantly better than 200/1 (ref 4), thus reducing the backround even further.

The following institutions and physicists are committed to this proposal:

Yale University	P.S. Cooper, L.J. Teig
Fermilab	C. Ankenbrandt, A. Brenner, J. Lach, J. Marriner
Iowa State Univ.	W. Anderson
University of Iowa	E. McCliment
Leningrad Nuclear Physics Institute	3 Physicists
Univ. of Chicago	R. Winston

There is the possibility of a graduate student from Yale, a graduate student from the University of Iowa, and a research associate from Fermilab also participating.

We would like to make this measurement in the spring 1982 running cycle, after the completion of E-630 in Proton Center. The hyperon apparatus can be installed and checked out in three to four weeks; data taking will require three weeks of beam. The online and analysis programs required for these data already exist. If given the opportunity to take these data in the spring of 1982 we should be able to publish a final result within one year.

We are able to accomplish this measurement in such a short time because most of the experiment is presently set up, but not installed, in Proton center. The fast electronics and online computer are still largely intact from our E-497 run. The effort required to install this experiment is modest compared to the installation of a totally new experiment. Furthermore, our time estimates should be quite realistic since this will be the third time we have installed and checked out this apparatus. THe only major new work we must do is to assemble the lead glass array. We propose to do this in the lab before the run. We will be able to gain-balance the lead glass with a light pulser system before the run so that only the absolute calibration need be determined from the data while we are running. We believe that even if the total Fermilab 1982 HEP run is less than 20 weeks we will be able to accomplish this significant piece of physics.

A resolution of this question is of major significance. If the Cabibbo model is truly incorrect then the implications are far reaching. Alternatively if the previous experiments are in error then the sooner this heresy is laid to rest the better.

Sincerely yours,

Peter S. Cooper

Peter S. Cooper
Assistant Professor
of Physics

References

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   D. Bogert, et.al. Phys Rev D 2 6,(1970).
   R.J. Ellis, et.al. Nuclear Physics B 39 77,(1972).
   ANL-CHI-OSU 1981 - to be published

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3. J. Butler, Private Communication

4. J.A. Appel, et.al NIM 127 495,(1975).

Figure Captions

1. The current world data for the electron alpha parameter in sigma- beta decay is summarized. The solid curve is alpha as a function of the form factor ratio g1/f1. Recoil and weak magnetism corrections are included. The values of the electron alpha parameter consistent with the measured magnitude of the form factor ratio are shown together with the four existing measurements (ref 1) and their average. The abscissa for the measurements is not significant. Also shown for comparison is the size of the error bar which will be produced by this measurement.

2. A schematic layout of the experiment is shown. This is identical to the configuration used for E-497 and all the apparatus is the same except for the lead glass array which is reconfigured.

Worst Case Rate Calculation

Primary beam:	400 GeV/c	momentum
	3E10	protons per pulse
	1 sec	spill length

Hyperon beam:	250 GeV/c	momentum
	300k	backround muons per pulse
	25k	beam particles
		PI- / K- / SIG- / CASC-
		19k / 800 / 5000 / 200
	5k	SIGMA- triggers
		PI- / K- / SIG- / CASC-
		150 / 50 / 4700 / 100

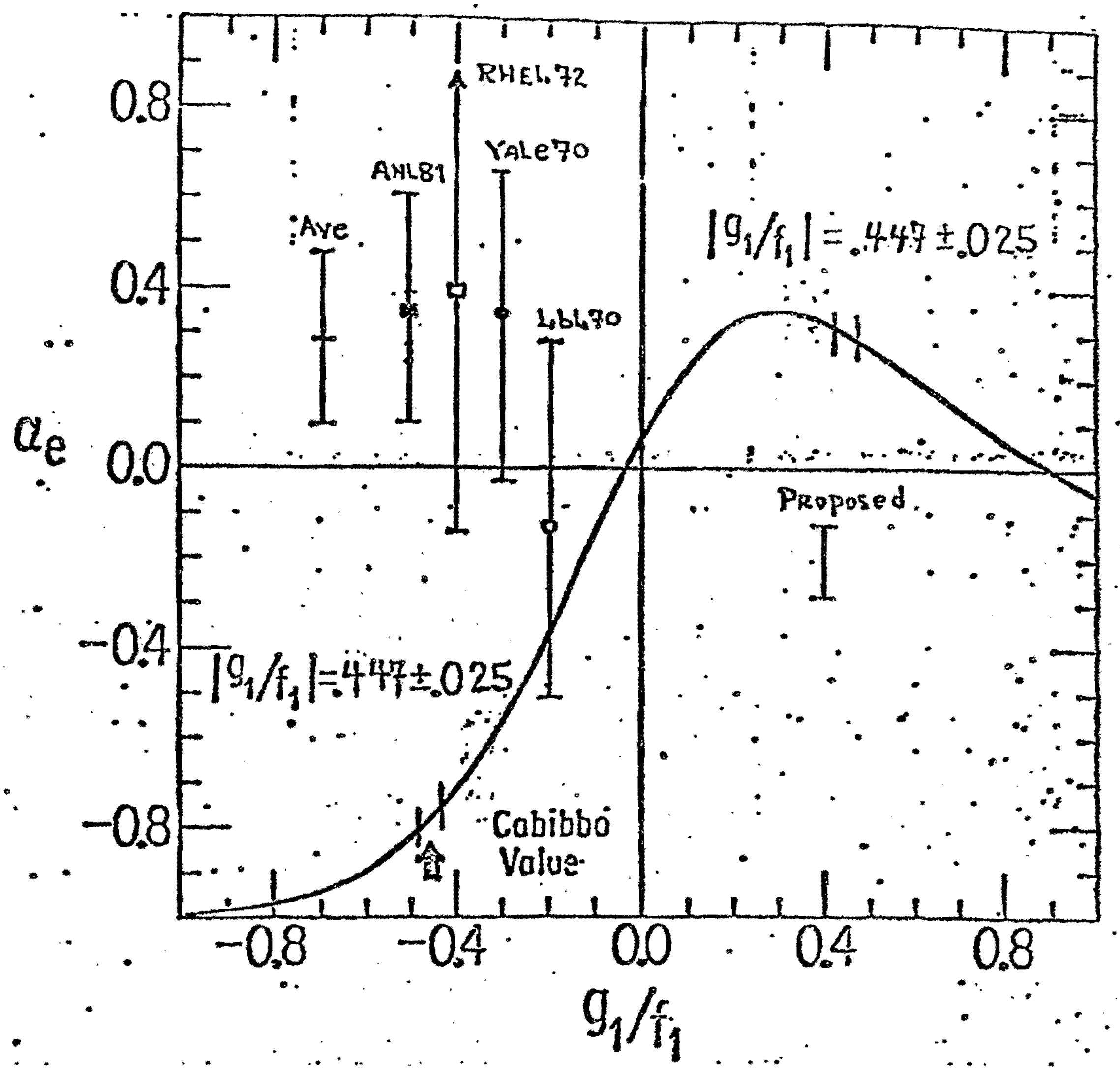
Decay modes:				B.R.
KE3	K-	--->	PIO + E- + NUEBAR	4.8%
SNPI	SIG-	--->	N + PI-	100%
LEPT	SIG-	--->	N + E- + NUEBAR	1.08E-3
CASC	CASC-	--->	LAMBDAO + PI-	100%
			|---> N + PIO	35.8%

Rates:	KE3	SNPI	LEPT	CASC
SIG- trigger	0.25	4700	5.0	35.8
Lead glass eff				
trigger	0.90	0.02	0.90	0.02
geometry	0.24	0.48	0.46	0.48
deadtime	0.80	0.80	0.80	0.80
TRIGGER	0.04	36.10	1.66	0.27
offline PbG	0.90	0.25	0.90	0.25
OFFLINE	0.04	9.03	1.49	0.07
track eff	0.70	0.70	0.70	0.70
kinematic eff	0.43	0.03	0.54	0.03
ANALYZED	0.01	0.19	0.56	0.00

notes

1. all rates are per pulse
2. track efficiency is the probability that an event passes track finding
3. kinematic efficiency is the probability that an event does not fit either the SNPI or the CASC decay hypothesis.

TABLE 1



Summary of $\Sigma^- \to ne\bar{\nu}$ Form Factor Experiments

Experiment	Year	No. of Events	$\lvert g_1/f_1 \rvert$
Maryland	1969	49	0.23 ±0.16
Heidelberg	1969	33	0.37 +0.26 −0.19
Columbia-Stony Brook	1972	35	0.29 +0.28 −0.29
Yale-Fermilab-BNL	1973	3507	0.435 ±0.035
CERN SPS	1981	4740	0.458 ±0.035 (±0.020)

Polarized Σ^- Experiments

			α_e
LBL	1970	53	−0.13 ±0.41
Yale-BNL-U. of Mass.	1970	63	0.36 ±0.39
RHEL	1972	43	0.39 +1.9 −0.53
ANL-CHI-OSU	1981	193	0.35 ±0.25
Ave			0.27 ±0.18
Proposed		34 K	? ±0.09

FIGURE 1

HYPERON APPARATUS

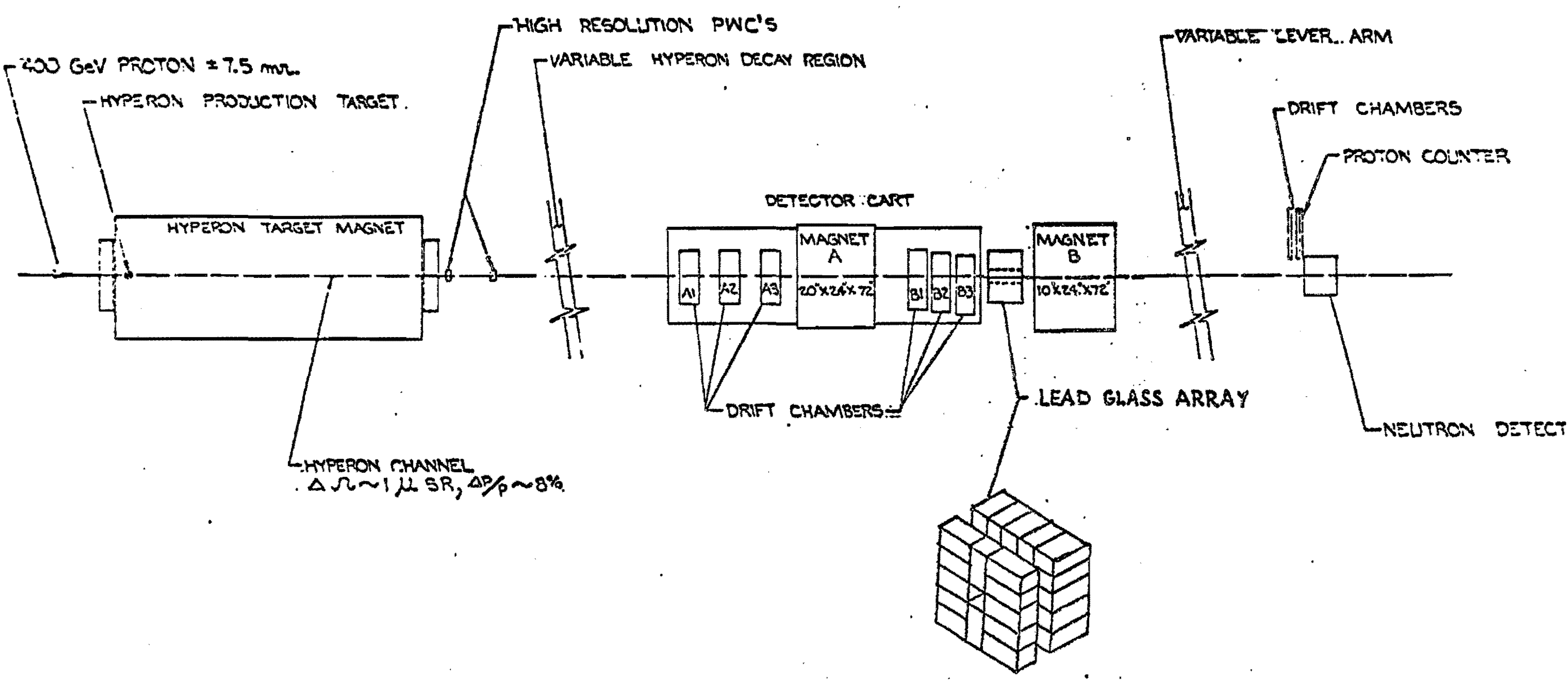


FIGURE 2