SLAC NEWS

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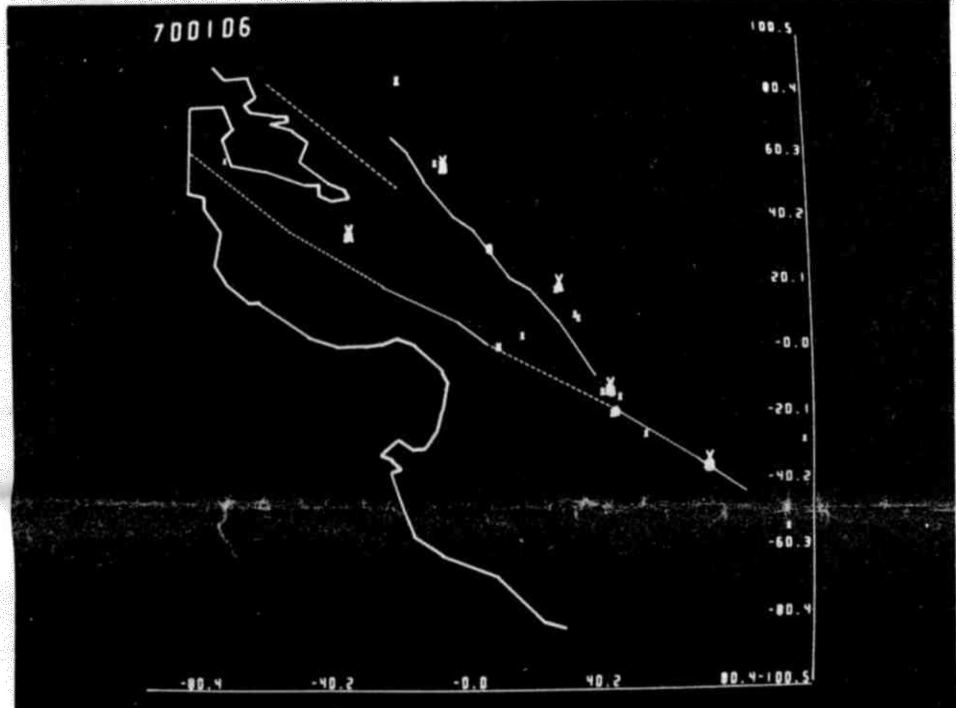
A NEW SYSTEM TO WATCH EARTHQUAKES

by K. Maddern

As a project for a Stanford Computer Science graduate course, Steve Levine in SLAC's Computation Group undertook a study of motion graphics (in this case, time-dependent data) in the spring of 1969. A colleague at the National Center for Earthquake Research (U.S. Geological Survey), Darroll Wood, had been compiling information about bay area earthquakes and was in a position to provide an organized set of data for Steve on punched cards. So began a very valuable cooperative project on earthquake data analysis carried on at SLAC. Steve currently is developing techniques for writing interactive graphics systems which could be applicable to SLAC in the design of magnetic systems, beam extraction systems, or the display of time dependent fields. The resulting computer displays from his work are particularly relevant to trial and error experiments which are applicable to the development of magnetic systems. He has considered using motion graphics techniques on the computer for a possible project of simulating parts of SLAC's accelerator in action.



IDIIOM display picture of bay area earthquake activity for the week ending January 1, 1970. The three major earthquake faults (San Andreas, Calaveras, and Hayward) can be seen. The X'x indicate earthquake activity. The scale is in kilometers.

In order to translate the earthquake data for use on SLAC's IDIIOM display, Steve used the on-line programming system developed by M.A. Fisherkeller and G.A. Robinson, and the PL/I Scope Package developed by Bob Beach (all in SLAC's Computation Group) in order to write his program. The display scope permits the viewer to see on an over-sized television-like screen (the "IDIIOM") a picture of the earthquake events which have occurred during a particular time sequence. As time goes by, the screen can represent information in two ways: (1) all the earthquakes for, say a week's time, are shown in the screen, or (2) the screen can contain a fixed number of events, no matter what length of time is involved.

For the viewers, the first item to appear on the scope screen was an aerial map outline of the Bay Area with definite lines marking the three major faults in this area, the San Andreas, Calaveras, and Hayward faults. Using the computer's capability to speed up information (up to one billion times) faster than real time, Steve set the program for one million times faster and we started watching a light show. As the program ran, different sized X's would flash on and off the screen showing where and how frequently earthquakes were occurring during a certain time period. These X's could either be viewed aerially or from an earth-profile view. It was hypnotizing to watch the occurrences, seeing how earthquakes may cluster together (a series of small ones followed by a large quake) and migrate steadily from a fault zone.

To inspect an active area more closely, the user can zoom the scope in on a particular segment of the data being displayed, separate it from the rest, and bring it even closer for detailed analysis, perhaps even changing the time compression faster at this point, and running the data either forward or backward.

Earth-tilt vector

The earth-tilt vector is a representation

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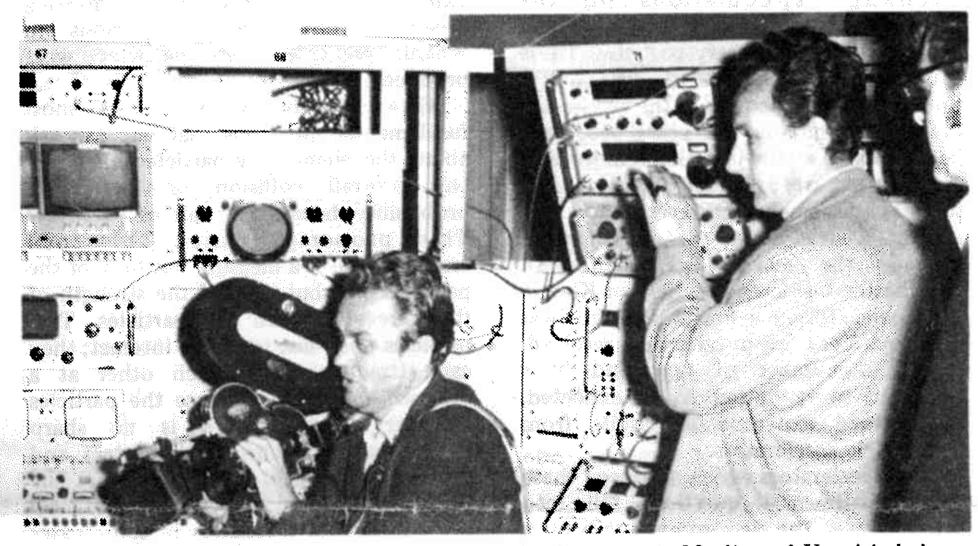
Yugoslav visitors getting the word about SLAC. From left to right, Mrs. Fortic, Danny Ibrisimovic, Joe Sodja, Greg Loew, and Steve Kociol (PIO).



Yugoslav Camera Team in CCR. From the left, Cameramen Meglic and Vranisic being aided by Danny Ibrisimovic.

YUGOSLAV FILM CREW VISITS

On November 12, 1970, SLAC hosted the Ljubljana Cooperative TV Team from Yugoslavia. They came to the United States on October 10 to begin an intensive forty-two day schedule of traveling and filming with the aim of making documentary productions on such subjects as: "America as the Americans See Her," "The American Way of Life," "The Formation of the American," and "American Efficiency."

The team, led by Mrs. Gabrijela Fortic and including cameramen Franjo Meglic and Bozo Vransisic, decided to use SLAC in their "American Efficiency" documentary (!) and shot footage inside the Central Control Building. They were accompanied by Charles Johnson of the US Information Agency.

Although Mrs. Fortic speaks excellent English, SLAC was able to provide two employees able to converse with the team in their native language. The two SLAC'ers were Danny Ibrisimovic and Joe Sodja, appropriately enough of Accelerator Operations.

Greg Loew, head of Accelerator Physics, and Vernon Price, head of Accelerator Operations, were on hand to greet the team. On duty in CCR during the visit were Tom Inman and Vern King. The visit was arranged by SLAC's Public Information Office.

Before arriving in the Bay Area on October 28, the team had visited Washington, D.C., New York City, Philadelphia, and Boston. They had filmed such diverse activities as a Sunday rock concert in Central Park (New York City) and an interview with the chief of the Boston Drug and Narcotics Unit. They filmed San Francisco City Hall during the November 3 election and had an interview with Mayor Alioto. Many other interviews were packed into their itinerary.

They did some filming down on campus and then left for home on November 18 after what must have been an interesting and exhausting trip.

EDITORS NOTE

This double issue of the paper is meant to cover the November-December period, and we will revert to the four-page format with the January issue. At that time, because of my departure from SLAC, Steve Kociol will become Editor of the paper and Doug Dupen, newly returned to SLAC, will be Associate Editor.

I would like to thank the many people here at SLAC who have helped to make this newspaper a reality through their suggestions and contributions. I would also like to thank all with whom I have had contact here at SLAC for having helped make these past seven years highly challenging, interesting and rewarding.

Jack Sanders.

Season's Greetings

IMBROGLIOS IN HIGH-ENERGY PHYSICS

by Martin Perl

(Editor's Note. This article was written by SLAC Professor Martin L. Perl, for the September 17, 1970, issue of NEW SCIENTIST, the British weekly news magazine of science and technology, and is reprinted with permission. Professor Perl was on leave at Westfield College, University of London, when this article was written. The article deals with results from the International Conference on High Energy Physics held recently in Kiev, U.S.S.R. Since last month's SLAC News dealt with results from SLAC of interest at the Conference, we have abridged Dr. Perl's article to emphasize other areas of interest.)

Every two years the world's elementary particle physicists meet to compare data, examine new theories, and exchange speculations on the fundamental constituents of matter and energy — the elementary particles. These meetings, usually called "Rochester Conferences" in honour of the city where they were initiated 20 years ago, have become large affairs in which hundreds of experiments are described and dozens of theories discussed. However, there are usually a few dominant ideas which pervade the meeting. The fifteenth "Rochester Conference", held in Kiev in the Soviet Union a few weeks ago, was different. Very few puzzles were resolved; rather, a number of new and basic questions were raised by unexpected, unexplained experimental results from the particle accelerators.

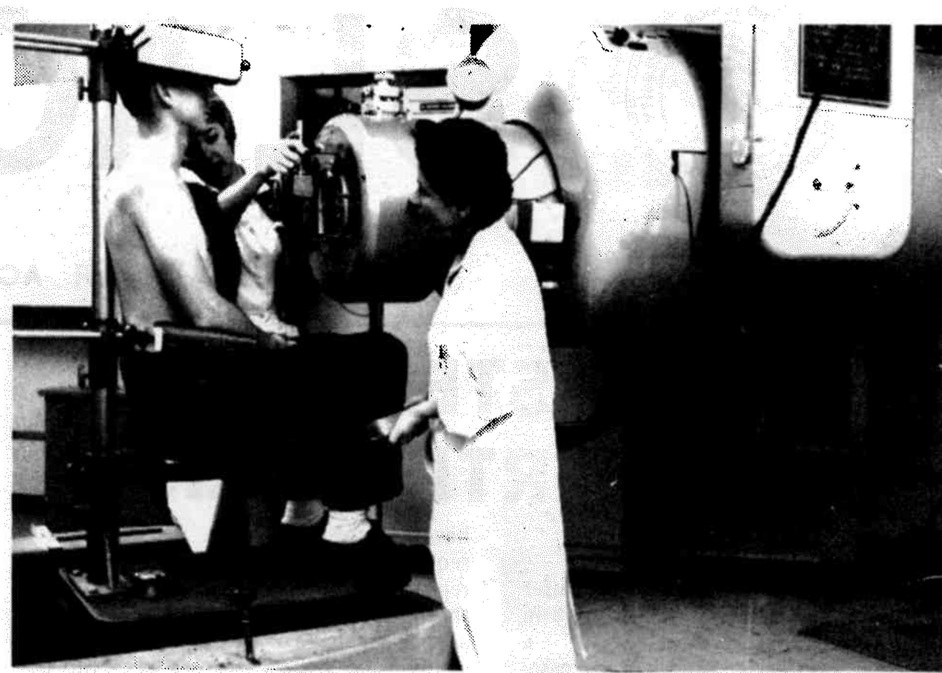
The accelerators which produced these new experimental questions fall into three groups. The first group, the proton accelerators, is led by the 70 GeV machine at Serpukov near Moscow. It is the highest energy accelerator in the world and has been in operation for about a year. The electron accelerators which comprise the second group have been in operation somewhat longer; their highest energy member is the 20 GeV linear accelerator at Stanford in the United States. In these two groups of accelerators, a very high energy particle, either a proton or an electron, collides with a stationary target proton. Then the physicist either studies the products of this collision or uses its high-energy products to make yet a further collision on another stationary proton. In the third group of new accelerators one high-energy particle is made to collide with another high-energy particle. These machines are called colliding-beam rings. The existing machines at Frascati in Italy, Orsay in France, and Novosibirsk in the Soviet Union, all have a beam of electrons colliding with a beam of positrons (anti-electrons).

Before describing the new results from these accelerators a comment on the international character of the conference may be of interest. With the world in such a troubled state, it was particularly pleasant to see the delegations from 42 nations talking and arguing in the universal language of science. As usual the Russian physicists were much better at their English than were the English-speaking physicists at their Russian. The Israeli delegation was present, and their national flag flew along with those of the other delegations in front of the conference hall. One of the major review papers was given by the Vietnamese theoretician Nguen Van Hieu of the Physical Institute of Hanoi. But such are the vagaries of international politics that there was no delegation from the People's Republic of China.

To describe the experimental results we can use the billiard ball analogy. We think of the elementary particles — the protons, mesons, electrons, photons, and so forth — as very small and fuzzy billiard balls. They are too small and too fuzzy to measure or to cut apart; we can only shoot one ball at the other and if they collide we can see what happens. Physicists often use this analogy, but we must remember that these elementary particle billiard balls have some very strange properties. Thus if an accelerator shoots a pi meson at a stationary proton, sometimes the pi meson just bounces off the proton. The pi meson and proton then recoil in different directions just as in billiards. But sometimes two completely different particles such as a K meson and a hyperon can come out of the collision. It is as though the collision of two billiard balls produced a golf ball and a croquet ball. If there is enough energy then many balls, all different in some cases, are created. Thus a number of experiments presented at the meeting described meson-proton collisions in which eight or ten particles were produced.

One of the simplest and most fundamental questions that one can ask about the elementary particles is what is the overall collision or interaction probability between a pair of particles? This property, called the total cross-section, is a measure not only of the particles size but also of the strength of the forces between the particles. Two particles need not touch to interact; they can attract or repel each other at a distance. Actually, because the particles are very fuzzy, there is no sharp distinction between actual contact and action-at-a-distance. At low energies the total cross-section depends strongly on the energy and fluctuates in some cases quite drastically with energy. It is as though the size of the billiard balls depended upon their speed or energy. At the very high energies of the Serpukov accelerator, the total cross-sections for some pairs of particles becomes constant and independent of energy (see NEW SCIENTIST, 10 September, p. 510). The elementary particle physicist had in a way always hoped to reach an energy region where total cross-sections would become independent of energy because he thinks that the theory may be simpler here. But having reached that energy for some pairs of particles (the negative pi meson and the proton, for example) but not for other pairs of particles (antiproton and proton for example) the physicist does not yet know what that theory should be. In fact, some theorists merely use a slightly sophisticated version of the billiard ball picture, regarding the radius of the billiard ball as an energy-dependent parameter that becomes constant at high energy. Other theorists suppose that the radius increases with energy. But these theorists also regard the elementary particles as being partially transparent to each other so that sometimes the particles can pass through each other without interacting. To obtain a constant total cross-section at high energy, these theorists must then assume that as the energy increases the transparency increases; the increasing transparency just compensating for the increasing radius...

We cannot say when we will receive answers to these fundamental questions raised by the new experimental data presented at the Kiev meeting. Some answers will certainly come from further experiments at existing accelerators — both those mentioned in this article and others which include the proton accelerators at CERN, at the Rutherford Laboratory in England, at the Dubna Laboratory in the Soviet Union and at Argonne, Berkeley and Brookhaven Laboratories in the United States. Other answers will come from the higher energy accelerators now under construction or proposed. These include proton machines in the several hundred GeV range being built in the United States and proposed for CERN, higher energy electronpositron colliding-beam rings being built at Hamburg, Cambridge (USA) and Stanford and a proton-proton colliding-beam ring being built at CERN. But perhaps most of all one hopes that some of the answers will come from young physicists who can take a fresh look at all these data and see new and simple explanations.



The Western Hemisphere's First Medical Linear Accelerator at the old Stanford Hospital in San Francisco.

Linacs Important In Cancer Therapy

The linear accelerator was credited recently for having liberated medical scientists to further work in radiotherapy and to develop life-saving treatment methods for cancer patients.

One of the most dramatic gains, made by the adaptation of the accelerator for medical use, has come against the malignant lymphomas, particularly the formerly fatal Hodgkin's disease.

Since 1962, according to Dr. Henry S. Kaplan, professor and chairman of the Department of Radiology at Stanford University School of Medicine, 74 per cent of all patients with various stages of Hodgkin's disease treated at Stanford have lived five years or more. The figure nationally was 36 per cent in 1960 before the advent of the medical linear accelerator developed simultaneously by research teams at Stanford and in England.

"The figures do not tell the full story," Dr. Kaplan said. "In the past three years further improvements in technique have been introduced which give strong indication we will push those survival figures in most stages of Hodgkin's disease into the 80 to 90 per cent bracket within a short time."

Dr. Kaplan made the prediction at the dedication of the $1 million Paul A. Bissinger Radiation Therapy Center at Stanford University Medical Center. Dr. Kaplan, a 1969 Atoms for Peace prize winner, has pioneered in the development of the medical linear accelerator.

He said the medical linear accelerator has now become the "work horse" of modern major radiation therapy centers, and the achievements which it has made possible have completely altered the image of radiation therapy once thought by many doctors as having essentially no curative potential.

"Radiotherapy now stands right alongside surgery as the major method for the permanent cure of many kinds of cancer," Dr. Kaplan said. "And at least 50 per cent of all cancer cases, including those in advanced stages referred to modern radiotherapy centers, have a substantial chance for permanent cure."

MAJOR CREDIT FOR THE PROGRESS, according to Dr. Kaplan, CAN BE CLAIMED BY PHYSICISTS WHO DEVELOPED THE LINEAR ACCELERATOR.

"We feel they are to be congratulated on this occasion for the very major contribution they have made to medicine," Dr. Kaplan said.

It was Dr. Kaplan who met with three other Stanford men, who formed the Microwave Laboratory Committee in the early 1950's, to look into the possibility of adopting the linear accelerator for use in radiation therapy. The committee members were Drs. Frederick E. Terman, Leonard I. Schiff, and Edward Ginzton, then laboratory director and presently board chairman of Varian Associates in Palo Alto. Work on the actual design and construction of the first medical linear accelerator was undertaken by Dr. Ginzton.

With funds from the National Cancer Institute, the American Cancer Society, and the Office of Naval Research, the new machine was completed and was installed for clinical use in January, 1956 in the old Stanford hospital in San Francisco. It was the first such device in the western hemisphere.

In addition to Hodgkin's disease, Dr. Kaplan cited other types of cancer, previously beyond the scope of the radiotherapist, which can now be treated by application of the accelerator:

CANCER OF THE PROSTATE: "One of the deep-seated tumors radiotherapists thought it was difficult to treat has turned out to be a pleasant surprise. Results to date show a five-year survival for 55 to 60 per cent of the Stanford cases. These results have made the technique widely accepted as a method of achieving cure, and in many cases, long-term control of the disease."

CANCER OF THE URINARY BLADDER: "A very prevalent and important kind of cancer, it was virtually untreatable because standard X-ray techniques caused severe skin reaction that made the treatment at appropriate doses intolerable. Today, with the aid of accelerator beams, cure rates of five years in 25 to 35 per cent of the cases have been achieved."

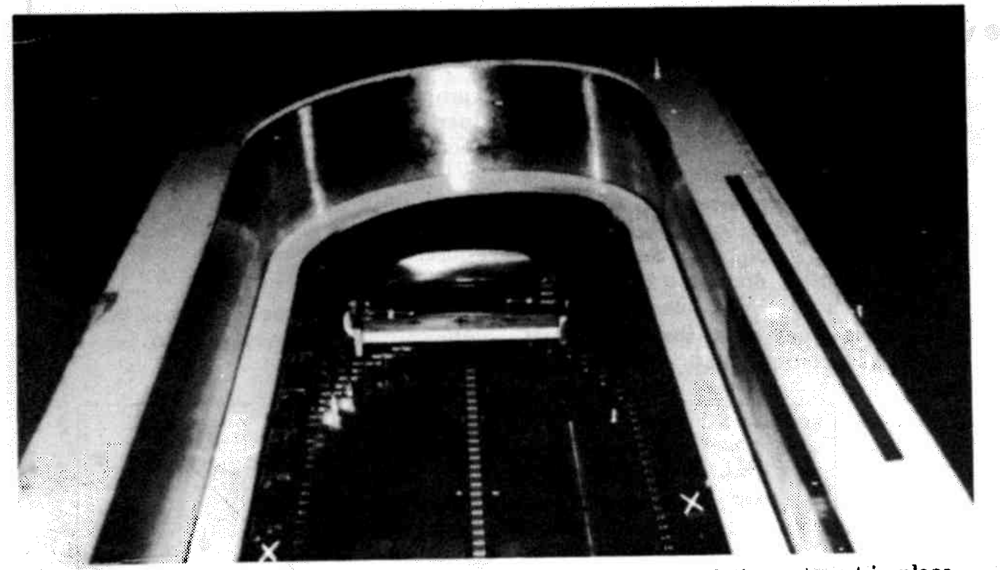
RETINOBLASTOMA: "A rare type of eye tumor, it has often been treated surgically by removal of the eye. Today in early cases, it is no longer necessary to remove the eye because the results of radiotherapy are excellent."

OVARIAN CANCER: "Numerically, cancer of the ovary is very important in women. Techniques developed through use of the linear accelerator for the first time offer hope of cure for patients with primary inoperable types of ovarian cancer.

"The same can be said for cancers of the testes that have spread to lymph nodes in the abdomen and beyond into the thorax and neck. Five-year survivals of 75 to 95 per cent have been recorded for such patients."

PURE PLATINUM USED IN EXPERIMENT

by Steve Kociol



The inside of the SLAC 82-inch buble chamber, showing the platinum target in place.

Let's eavesdrop on an imaginary conversation between John Physicist (J.P.) and a friend he is showing around the site, Interested Layman (I.L.). J.P. has already explained how the accelerator works, and something about high energy physics in general. They've just come from the beam switchyard and are standing adjacent to the building enclosing SLAC's 82-inch bubble chamber.

J.P. — This is SLAC's 82-inch bubble chamber building. Very often beams of pi or K mesons are directed into the chamber, and physicists are interested in the interactions between these particles and the protons which make up the liquid hydrogen in the chamber.

I.L. — Now, hold it right there! You said these particles only live a few billionths of a second, right?

J.P. — Right. Charged pions live for 26 billionths of a second while charged K mesons live for 12 billionths.

I.L. — But this building is well over 200 feet away from the switchyard. Looking at a pi meson going at almost the speed of light, the distance it travels until it decays would be only around 25 feet! Seems to me none of them would make it this far.

J.P. — How did you come up with 25 feet?

I.L. — Well, the speed of light is 186,000 miles per second, so the meson would travel about 5/1000 of a mile in 26 billionths of a second. Since there are 5280 feet per mile this represents about 25 or 26 feet.

J.P. — Very good! You left out one thing, however.

I.L. — What's that?

J.P. — Einstein's Theory of Relativity. Clocks moving relative to each other don't tick at the same rate. You only notice this when the relative speed is beginning to approach the speed of light. If you compare your watch with that of someone moving toward you at a high rate of speed, the other person's watch will appear to move slower. The faster the speed the slower his watch will appear to tick.

I.L. — What does that have to do with particle lifetimes?

J.P. — Well, when I gave you the lifetime, I meant the lifetime of the particle at rest with respect to the person measuring the lifetime. If you're sitting still, a pi meson with 15 billion electron volts of energy has a lifetime over 100 times longer than that of a pion at rest. Since its speed is very close to that of light, it travels over 2700 feet, on the average, before decaying.

I.L. — Okay, I understand that now. It's nice to know relativity theory has some practical uses. Now, let me ask another one.

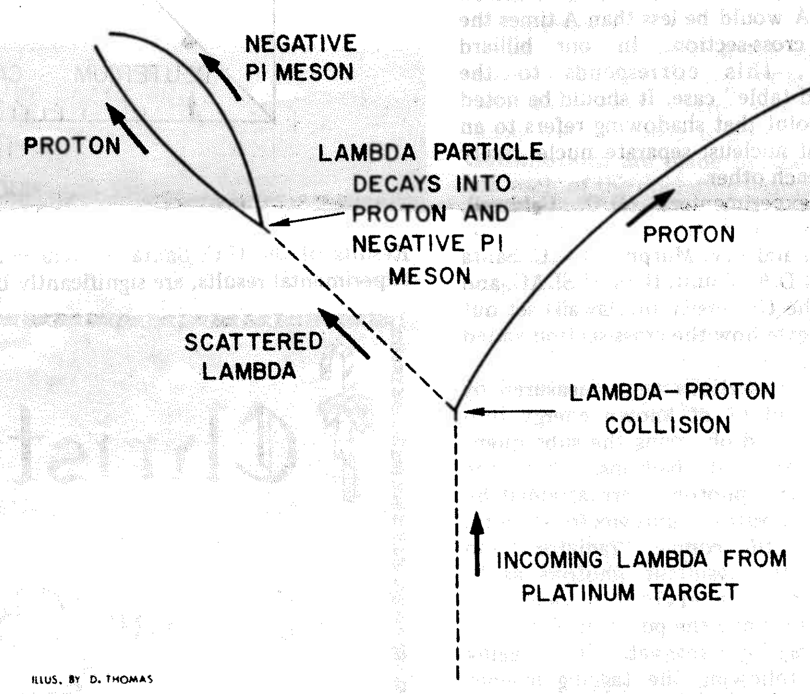
J.P. — Shoot.

I.L. — You said well over 100 short-lived particles are known.

J.P. — Right.

I.L. — How many of them live long enough to be transmitted down a few hundred feet before decaying?

J.P. — Let's see. Protons, photons, electrons and neutrinos never decay. Free neutrons live for 16 minutes. Charged pions and K mesons live long enough, as do muons and the so called long-lived neutral K mesons. All the remaining particles have lifetimes of only a few tenths of a billionth of a second or less.



Elastic scattering of lambda particles by protons as it might be seen in a bubble chamber photograph.

I.L. — How do you study these particles?

J.P. — Generally indirectly, but let me give you an example of a recent experiment done here in the 82 inch chamber to study directly the interactions of the lambda particle.

I.L. — What sort of particle is this lambda particle?

J.P. — It first appeared on the scene in 1947 in a cloud chamber photograph. It is uncharged, weighs around 1.1 billion electron volts, has a lifetime of one-fourth of a billionth of a second and decays two-thirds of the time into a proton and a pi meson. It has some interesting properties which can only be explained if we endow it with a property appropriately called "strangeness."

I.L. — What sort of an experiment was done, and by whom?

J.P. — Back in August, 1969, a group from the University of California's Lawrence Radiation Laboratory noted that fewer than 100 relatively high energy interactions lambda events had been observed. So, George Trilling, John Kadyk, Gerson Goldhaber, and J.M. Hauptman put in a proposal to do something about it here at SLAC.

I.L. — How did they get the beam of lambdas?

J.P. — In a very interesting way. Near the entrance "window" into the SLAC bathtub-shaped, 82-inch chamber, they put a 10 inch wide, 3 inch long, three-quarter inch thick plate of pure platinum. When 12 billion electron volt negative K mesons are steered into the chamber, they produce lambdas in the platinum. They found that they got one lambda for every 15 K's.

I.L. — Why Platinum? That target must be worth a fortune!

J.P. — Yes, about $70,000. Platinum was used because it is among the most dense materials known. In fact it is 21 times denser than water and almost twice as dense as lead. This minimizes the number of lambdas lost by decay before they lave the target.

I.L. — Why are there a few inches of space between the entrance window and the target?

J.P. — In this way, it is possible to see the direction of incoming K's; this permits determination of the origin of the lambdas.

I.L. — What kind of information are the experimenters after?

J.P. — Well, since there is so little data on the nature of lambda-proton interactions, the experimenters feel the pursuit of more detailed knowledge in the area is justified for that reason along. New particles will be searched for — physicists describe this by saying it is a "search for structure in the cross sections." Current information on the lambda and sigma particles will be enlarged. Half a million pictures were authorized, and 180,000 have been taken so far. The experiment is to continue in January. About 1700 interesting events should be seen in all. This might not sound like a lot, being only one event per 300 pictures, but their experiment will increase the world's present supply of data, in these particular interactions at these energies, by a factor of about 17.

I.L. — Something just occurred to me. The lambdas are neutral — they don't have an electrical charge. You can't see their tracks in a bubble chamber, can you?

J.P. — No.

I.L. — Well, then how do you know they're there?

J.P. — Indirectly. Let's consider the simplest interaction in the chamber: a lambda hits a proton and the collision changes the direction of the lambda particle and at the same time knocks the target proton off to one side. This is "elastic" scattering. A bit later on the lambda decays into a negatively charged pi meson and another proton. The whole process might look like the illustration shown.

When the film from the experiment is being analyzed, people will look for geometrics like this one, and the laws of physics will be used to distinguish between ambiguities. These laws include conservation of energy — the total energy of the system before the collision must equal the energy after. Other laws are used also.

I.L. — Well, that's a pretty good introduction to the experiment. Since you're using platinum, next you'll be telling me you use diamonds in experiments. Heh Heh!!

J.P. — Well, as a matter of fact an experiment using diamonds was just completed, and ...

I.L. — Forget it! It's time for a drink.

J.P. — Amen.

Picture taken with SLAC 82-inch bubble chamber outfitted with platinum target. An interesting lambda-produced event can be seen on the right-hand side of the target in line with the number 2.

PHOTON SHADOWING STUDIED HERE

by Steve Kociol

A series of experiments completed here by a U.C. Santa Barbara —SLAC collaboration has shown that the photon, the massless discrete quantum of electromagnetic energy, behaves partially as a strongly interacting particle (i.e., one that participates in the nuclear force). The experimental effect seen here leading to this conclusion is called "shadowing".

"Shadowing" can be easily understood in an intuitive way. Imagine an enormous billiard table on which a small number of very small billiard balls are randomly distributed. The table is so large that the average distance between balls is very large compared to their diameter. You have a distinguishable cue ball and set it in motion with a cue stick. You measure the probability of a collision being made between the cue ball and a billiard ball. You next increase the number of balls, set the cue ball in motion, and again measure the collision probability. You repeat the experiment many times with varying numbers of balls and keep track of how the collision probability varies with the number of target billiard balls.

The results are interesting, and easy to understand. As long as the table is uncrowded (the distance between balls is much larger than the balls' diameter) the collision probability is directly proportional to the number of target billiard balls. If you double the number of balls, you double the probability of a collision; if you halve the number of balls, you halve the collision probability.

This is only true, however, for the uncrowded table. As soon as the table becomes crowded the chance that a particular billard ball will be hit by the cue ball depends on how far away the ball is from the initial position of the cue ball. In a crowded situation, the nearer balls are interacted with primarily; they serve to "shadow" the balls further away. Thus doubling the number of balls would not double the chance of a collision; the probability would increase, but the increase would be much less than double. This, then, is the phenomenon of "shadowing."

Now let's relate the billiard ball analogy to the actual experiments carried out at SLAC. The cue ball is a high energy photon beam. The billiard balls are the protons and neutrons (nucleons) making up the nucleus of the atom. The experiments measured what physicists call the hadron photoproduction cross-section on nuclei of hydrogen, deuterium, carbon, copper, and lead. The hadron photoproduction cross-section is essentially the probability of a photon-nucleon collision resulting in the production of hadrons — strongly interacting particles. The use of the five different types of nucleus corresponds to varying the number of billiard balls, since the nuclei differ in the number of nucleons which make them up. If we let A stand for the number of nucleons, A for hydrogen is one (a single proton), A for deuterium is two. For carbon, copper and lead A is respectively, 12 64, and 207.

Earlier data on hydrogen had indicated that the mean distance a photon travels in hydrogen before being absorbed is hundreds of times longer than the typical size of a nucleon. This corresponds to the large billiard table with widely separated balls. Based upon the assumption of no strong interactions for the photon, the hadronic photoproduction cross-section for a nucleus of nucleon number A should be simply A times the cross-section on hydrogen.

On the other hand, suppose the photon is a hadron. What would we expect then? We can get some ideas by looking at the so-called Victor Dominance Model, built upon some similarities between photons and a class of short-lived particles called vector mesons. One such vector meson is the rho meson, and experiments done in Germany (DESY), at Cornell, and at SLAC indicate that rho-nucleus interaction take place within a distance equal to only a few nucleon radii. If, as VDM asserts, the photon essentially becomes a vector meson, we expect that the cross-section would be proportional to the nuclear area rather than the nuclear volume (A, the number of nucleons, is itself proportional to the nuclear volume). In this case, the cross-section for a nucleus of nucleon number A would be less than A times the proton cross-section. In our billiard analogy, this corresponds to the "crowded table" case. It should be noted at this point that shadowing refers to an individual nucleus; separate nuclei rarely shadow each other.

The experimenters (D.O. Caldwell, V.B. Elings, W.P. Hesse, G.E. Jahn, R.J. Morrison, and F.V. Murphy of U.C. Santa Cruz, and D.E. Yount, then of SLAC, and now at the University of Hawaii) set out to investigate how the cross-section varied with A.

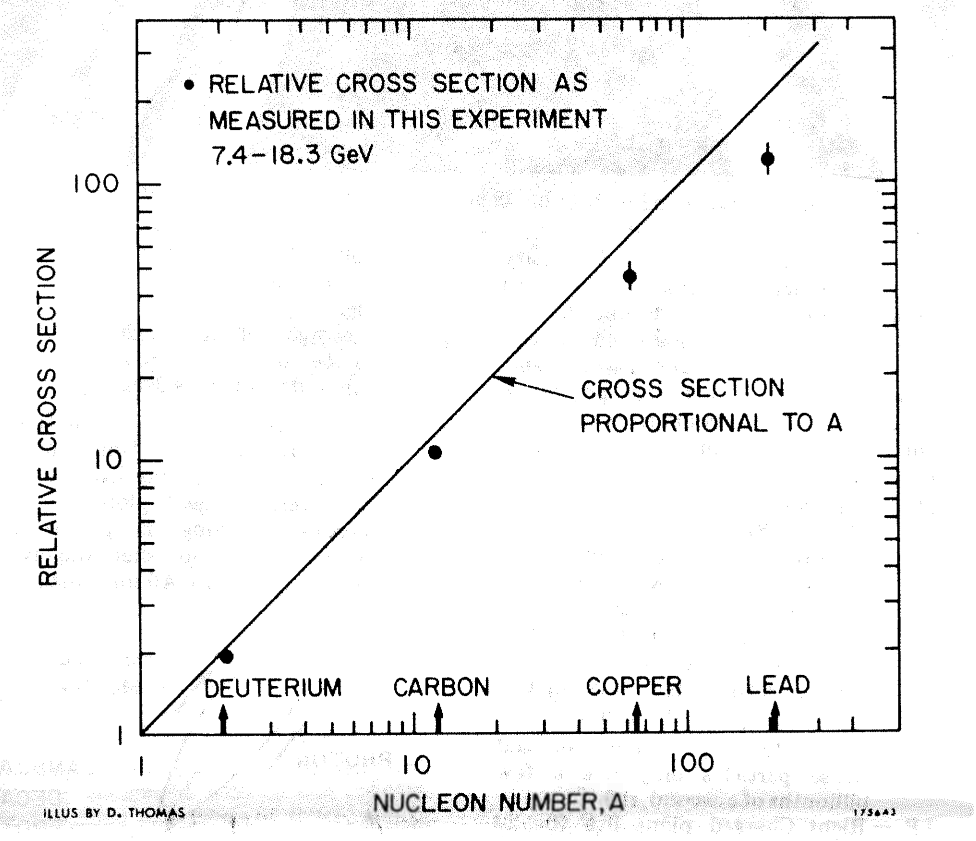
The cross-sections were measured by sending photons of known energy into the targets and observing the subsequent productions of hadrons. (See the diagram) The photons were attained by sending a positron (anti-electron) beam through a tin copper "radiator" and "tagging" the resultant photons as to energy by observing coincidences between them and the positrons deflected by a "tagging" magnet. The tagging detectors following the tagging magnet identified the deflected positron's energy. The photon produced has an energy equal to the energy lost by the positron. The photons go through the target and the hadrons produced are detected by hadron detectors.

The main experimental problem was, of course, to be sure that hadrons are identified as such and that the much more copiously produced electron pairs are not identified with the hadrons. Nearly all such electromagnetic background was "vetoed" by a lead scintillator photon beam detector.

Photons of between 7.4 and 18.3 GeV were used.

The experimenters found significant shadowing. The cross-sections were not proportional to A as can be seen in the accompanying graph. The conclusion is that the photon does not behave as a particle having only electromagnetic interactions. They claim that the general VDM assertion that the photon propagates as a strongly interacting particle is borne out. The attempt to compare these results quantitatively with VDM have not been successful; some work on the rho meson photoproduction implies that much more showing than was observed should have been observed.

In any event, the evidence showing the photon as hadron seems to be firmly established.



Results of the U.C. Santa Barbara — SLAC experiment. The black dots, representing experimental results, are significantly below the "no shadowing" line.

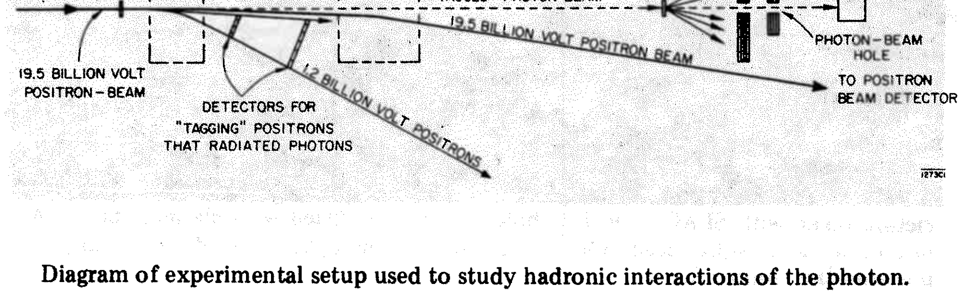
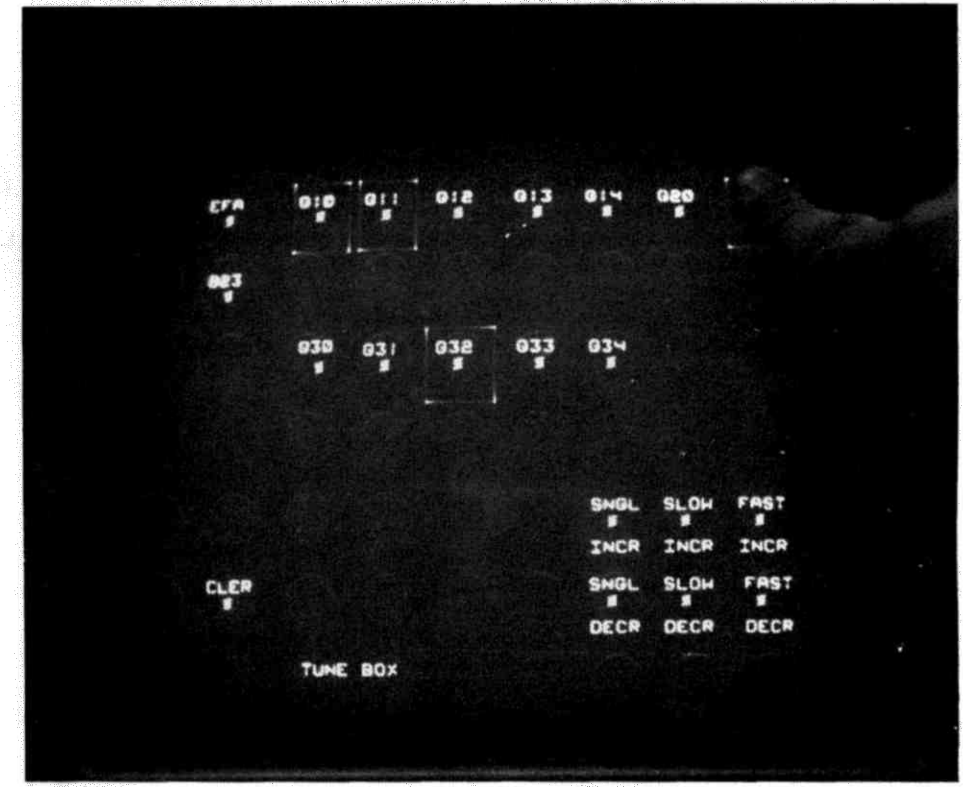


Diagram of experimental setup used to study hadronic interactions of the photon.

CONTROL ROOM CONSOLIDATION IN PROGRESS

By Warren Struven



Touch panel display in DAB. Operator controls one of the display functions simply by touch.

SLAC at present has two "control rooms" responsible for the high energy electorn beam. The Central Control Room (CCR) is located opposite Sector 27 of the Klystron Gallery and contains a PDP9 computer. In general, CCR is responsible for the beam during the two miles when it is being accelerated. After reaching the energy specified by experimenters' needs, control transfers to the second of the two control rooms located in the Data Assembly Building (DAB). DAB in general controls the pulsed magnets and other devices in the Beam Switchyard so that beam is delivered appropriately for use by experimenters. For somewhat more than two years, the Technical Division has been considering schemes to consolidate these two facilities.

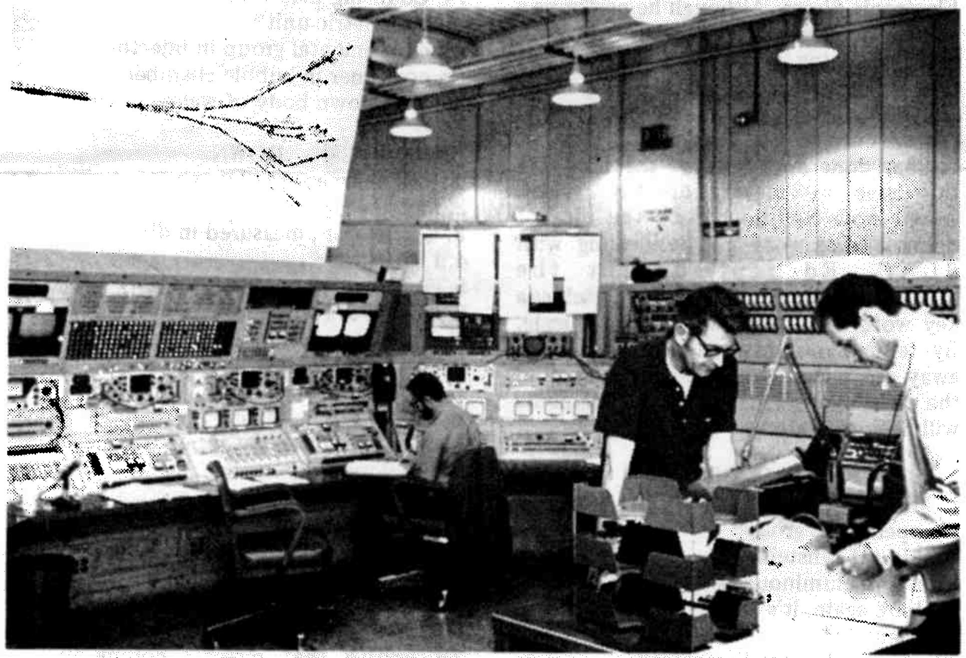
Control room consolidation started with two major decisions. The first was to make Instrumentation and Control (I/C) planning compatible with a single central control room facility for the accelerator and Beam Switchyard. This decision was announced in April 1968. The second decision was made which resulted in an October 1968 order for a Digital Equipment Corporation PDP9 computer.

In April 1968, two committees were formed to study the ways in which such a consolidation might be accomplished. The I/C Advisory Committee with Ed Seppi as chairman was asked, "to study the problems of controlling the accelerator and Beam Switchyard and recommend policies and plans which would assist in obtaining maximum research utility from the machine; to review the technical findings and recommendations of the I/C Engineering Committee and advise as to the effect of the proposed actions on research utilization and efficiency; and to review the program alternates, schedules, and estimated costs of the long range I/C plan; propose modifications as deemed appropriate and make recommendations as to a final program to the directors recommendations."

The I/C Engineering Committee under the chairmanship of Ken Mallory was asked, "to study the various technical alternatives for a combined control room complex in the Data Assembly Building (DAB) for the accelerator and Beam Switchyard and recommend a long range plan." In addition, they were asked to recommend a preferred plan, and to present a schedule and costs to implement such a plan. It was further requested that both committees complete their tasks by June 1968. It is interesting to note that no decision has been made to proceed with unification at that time.

A number of plans were considered and rejected. One early plan involved the moving of a few controls from the Central Control Room (CCR) to DAB so that the electron beams could be setup at CCR and readjusted from DAB. Other proposals involved moving the entire contents of CCR to DAB, providing control of CCR through a computer linked to DAB and to moving controls from CCR to DAB individually until no more were required. Most of these proposals were discarded as being too costly or impractical.

Operator-operator voice communications had been a constant problem since the machine was first operated but about this time the Accelerator I/C Group installed a new 'hifi" communications system not only between CCR and DAB but to and from each physics experimenter. This system worked very well and did in fact improve the situation. Computer program planning and usage was continuing during this time also. It became obvious that if the computer in DAB could be connected to the new computer in CCR, that the desired control and monitoring of the accelerator could be accomplished from DAB. The CCR computer was originally proposed as an operator aid, that is, to control and monitor the accelerator while under the complete control of the CCR operator. The installation of the link would extend this possibility to DAB. The emphasis here was to "control through the computer and not by the computer."


Central Control Room (CCR).

In July 1968 the I/C Engineering committee completed studies of the three remaining proposals: 1) move CCR totally to DAB, b) partial move of CCR controls to DAB and c) control the accelerator from DAB through a computer-computer link. The last proposal was recommended by both the Engineering and Advisory committee and was based on the following points: It was the least costly; CCR remains as a backup console area; a new control concept could be implemented (accelerator control via computer) and CCR improvements could go forward on a short term basis while still achieving the long-term plan of control room consolidation. The important point here was that each computer (DAB and CCR) could be properly connected to the appropriate signals in each control area and when local control had been achieved, linking could proceed.

At present, many of the signals have been connected to the CCR computer and some local control and monitoring using the computer is possible. Klystron substitutions are made by the computer on each of the operating beams. Focusing in the accelerator can be controlled by the PDP9 and maintenance logs of klystron gallery equipment are printed out each shift. These logs alert various accelerator groups to possible failures.

System checks are automatically initiated at regular intervals during operation to check critical gallery systems such as the modulator reference voltage (which determines the beam energy) and the status of the machine protection systems.

The CCR-DAB computer link is undergoing tests and should be ready to transmit preliminary status information from CCR to DAB in the near future.

An oscilloscope display system has been ordered for the DAB console which will display all data transmitted to it from the DAB and CCR computers. A finger-operated "touch panel" system has been developed which will fit over each of the oscilloscope displays and allow the DAB operator to request changes either in DAB or CCR.

The "touch panel" is a SLAC developed method to combine control and monitoring functions on one panel.* The monitored information is displayed on a cathode ray tube (CRT) over which has been placed a transparent sheet of plastic which has a series of finger holes. When an operator wishes to control a function, he reads the status information as displayed by the CRT and presses his finger through the appropriate hole. The DAB computer senses the location of his finger and actuates that control. Acknowledgement is made to the operator by a change in the computer displayed words on the CRT.

The present schedule predicts that accelerator control and monitoring will be possible from the DAB control console in July 1971.

*EDITOR'S NOTE: The "touch panel" idea was developed by David Fryberger of the Experimental Facilities Group and Ralph Johnson of the Beam Switchyard I & C Group. They prepared a prototype of the panel and an inventions disclosure was submitted on the device last December. The California Patent Group of the A.E.C. is presently filing patent on the panel idea.


Data Assembly Building (DAB).

WINTER DRIVING TIPS

Are you a skier? Or gambler? Or both? If so, chances are you'll be heading towards the Sierras sometime this winter. We want you to get back safely, so here are some winter driving tips, courtesy of the SLAC Safety Office and the National Safety Council.

BATTERY
Don't take it for granted that your battery will see you through another winter. Battery power goes way down in cold weather. Get a charge if you need it — or maybe it's time for a new one.

BRAKES
Faultless brakes are a "must" for winter safety. Have the equalization checked. A pull to one side can cause a dangerous skid.

TIRES
Put your snow tires on BEFORE the snows fall. Studded tires are even better, preferably on all four wheels, especially on ice. For severe conditions, tire chains are best.

WINDSHIELD
Wipers should have adequate arm tension; worn blades should be replaced. Use an anti-freeze solvent in the washer system. Make sure defrosters will do the job.

MUFFLER
Carbon monoxide is a killer and a faulty exhaust system could mean disater. Have the entire system checked for leaks.

MAKE SURE YOU CAN SEE
Keep windows clear — front, rear and both sides. Remember, danger can come from any direction. Brush snow off all around before you start out — don't be a peephole driver. Don't forget to clear the air intake in front of the windshield and free wiper blades if they are frozen.

Road spatter from slush and salted wet roads can greatly reduce visibility. Use windshield washers often, and if you're driving at night, stop occasionally to clean headlights and tail lights. Headlight efficiency can be cut in half by grime.

It's best not to drive at all in fog, sleet or heavy snow. But if you must, keep your headlights on. And use the low beam — high beams give less illumination, more glare.

Tip: If the interior of the car is cold, turn on the defroster for a few minutes after the engine is warmed up to avoid freezing or smearing of windshield washer fluid.

KNOW HOW TO STOP IN WINTER
Keep your distance in winter weather; you need a lot more room to stop. Anticipate stops and slow down gradually, especially approaching intersections. They can be doubly hazardous because of the polishing effect stopping and starting traffic has on snow and ice.

Never jam on the brakes to stop on a slippery surface — you'll only lock your wheels and go into a skid. Keep those wheels rolling by pumping and releasing the brakes in short rapid jabs.

KNOW HOW TO GO IN THE SNOW
Remember these simple tips when you're stuck in the snow. First, turn your wheels from side to side a few times to push snow out of the way. Start in drive, or second gear with a manual transmission, and a light touch on the gas. A heavy foot on the accelerator will only spin your wheels (prolonged spinning can cause overheating and transmission damage). Keep your wheels straight ahead and ease forward gently. If you try rocking a car with automatic transmission, be sure to follow the manufacturer's recommendations.

Coarse rock salt or a couple of pieces of carpeting in the trunk can come in handy when you're stuck. Use them under rear wheels for needed traction.

KNOW HOW TO STEER
Too much speed and too hard braking cause most skids, but steering errors are not far behind. Change directions gradually — no sudden movements. Anticipate turns, slow down well ahead of them, and then make them smoothly.

Warming temperatures can add to driving woes. Wet ice is like glass and at 30 degrees it's twice as slippery as when the thermometer reads zero.

Don't panic and hit the brakes if you run onto an unexpected ice patch on the road. Ease up on the gas, hold the wheel steady and roll through.

You may not have the opportunity to practice what to do if you skid. But knowing steering techniques and keeping calm will reduce your chance of accident. In sequence:

- Never hit the brakes
- Take your foot off the gas
- Steer (but don't oversteer) in the direction the rear of the car is skidding.
- When you "feel" the car regaining a grip on the road, straighten your wheels.

SLAC Dictionary

Part VII (Final)

SPARK CHAMBER: An instrument for detecting and measuring nuclear radiation. Analogous to the cloud chamber, it consists of numerous electrically charged metal plates mounted in a parallel array, the spaces between the plates being filled with inert gas. Ionizing radiation causes sparks to jump between the plates along its path through the chamber. (See also bubble chamber, cloud chamber.)

SPEAR: Stanford Positron-Electron Asymmetric Ring. An oval-shaped ring 198 to 244 feet in diameter which will store counter-rotating beams of electrons and positrons (the antiparticles of the electron). Collissions between these beams will be studied when the facility, now under construction, is completed in late 1972.

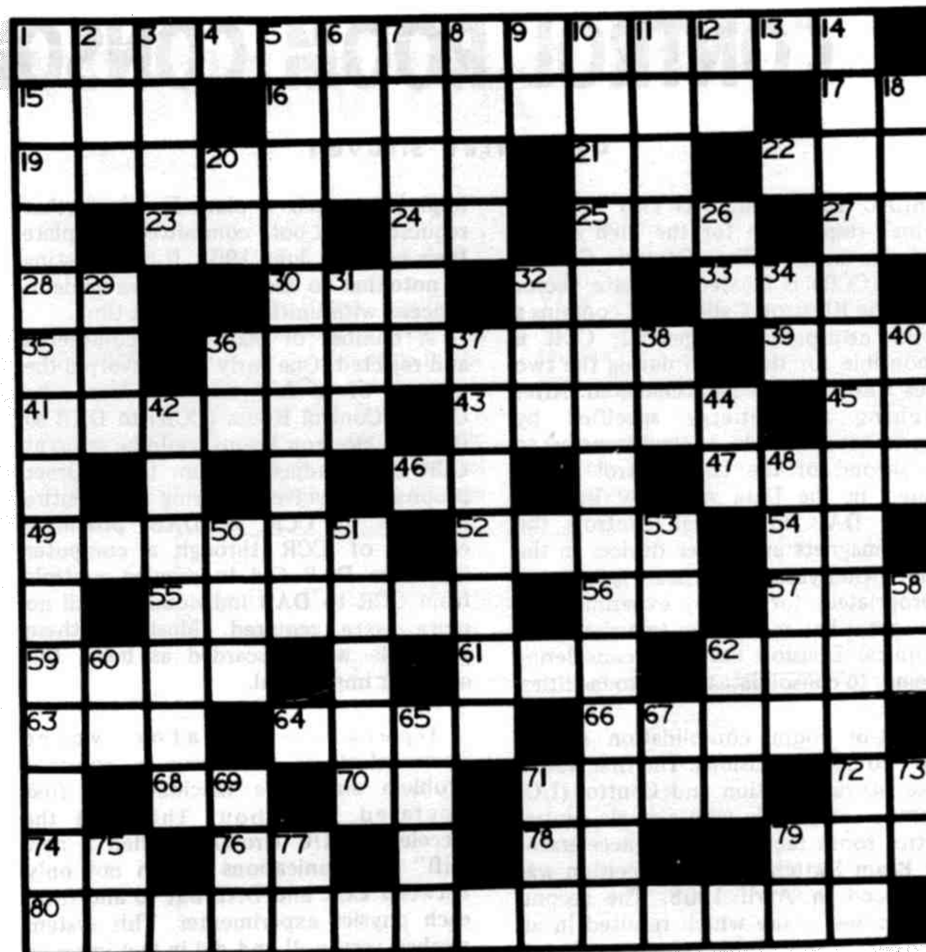
SPECTROMETER: As used in high energy physics, magnetic spectrometers are those devices especially designed for analysis of particles emanating from a target where emphasis is placed on measuring the production angles and momenta.

STRANGE PARTICLES: A class of particles to which we can semi-empirically ascribe the property of "strangeness." The K mesons have strangeness equals -1 while pions are non-strange (strangeness equals zero). Among other strange particles are the lambda hyperon (S=-1) and the omega minus hyperon (S=-3).

SUPERHEATED LIQUID: A liquid whose temperature is above boiling point. A bubble chamber operates by superheating the sensitive liquid and then allowing particles to traverse the chamber. Boiling occurs preferentially along the particle trajectories.

SYNCHROTRON: An accelerator in which particles are accelerated around a circular path of essentially constant radius by electrostatic fields. The National Accelerator Laboratory machine, the Lawrence Radiation Laboratory's Bevatron and the Brookhaven Alternating Gradient Synchrotron, AGS, are examples.

X-RAY: Penetrating electromagnetic radiation emitted when the inner orbital electrons of an atom are excited and release energy. Thus the radiation is nonnuclear in origin and is generated in practice by bombarding a metallic target with high-speed electrons.



SLACROSSWORD PUZZLE

by E.H. Austin

(Editor's Note) Ed Austin is an electronics technician in SLAC's Electronic Shops. Although he performs a variety of duties there, he generally can be found doing layouts for printed circuit boards. He has been at SLAC since 1967. He has a rather unusual hobby, however, devising crossword puzzles and crostics. He has done a number of these, and in this issue we present his first effort. Asked how he thought of the idea of doing a crossword puzzle dealing with SLAC, Ed replied that the word "paleoparadoxia" suggested itself as a key word around which to base a puzzle. By telling you this, we may have given away one word, but we think you'll find the puzzle challenging. Your comments will be appreciated.)

ACROSS

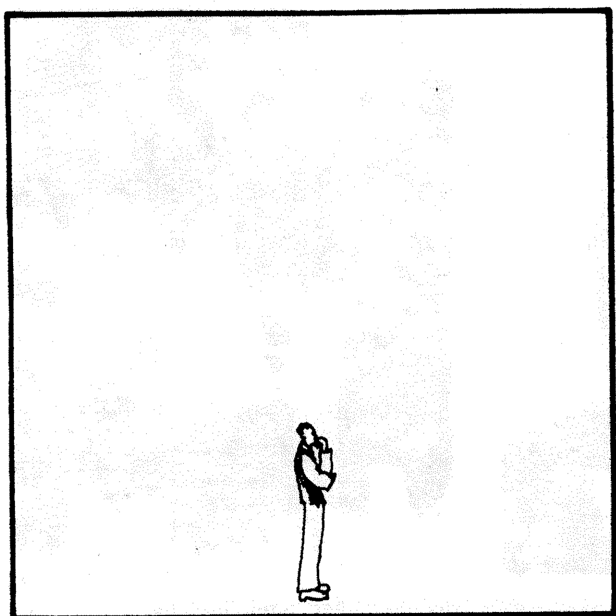
1. Miocene mascot? a leap or a paid ox.
15. operations group*
16. kin (of Einstein?)
17. unit of luminous intensity*
19. look again, it's basic.
21. rhenium*
22. against the sage timepiece?
23. — — — Francisquito Creek.
24. group found in dosimeter*
25. — — — station.
27. element in camera and aperature*
28. see 73 down.
30. a billion electron volts* (Eur.)
32. power in vacuum*
33. campus across the bay*
35. cadmium*
36. call X 2357 for these advantages.
39. federal agency*
41. alignment beams.
43. shackles at greens? on, sir.
45. small state*
46. metal in analysis*
47. if 33 across were made plural and then reversed, you'd have something covering 480 acres*
49. a light particle.
52. a kind of lab.
54. premium pay in cyclotron*
55. distant. or meet.
56. external size in modulator*
57. trig. function*
59. four quarters.
61. radio direction finder*
62. — — — — III Accelerator.
63. slick beach group*
64. (with 37 down) band — — — — — — —
66. Andrea's blame?
68. shop group in drive system*
70. — — land Stanford.
71. see 42 down.
72 old eastern campus in quadrupole*
74. Counting Electronics*
76. volumetric unit*
78. experimental group in injector*
79. container in bubble chamber*
80. a 48 down body of water.

DOWN

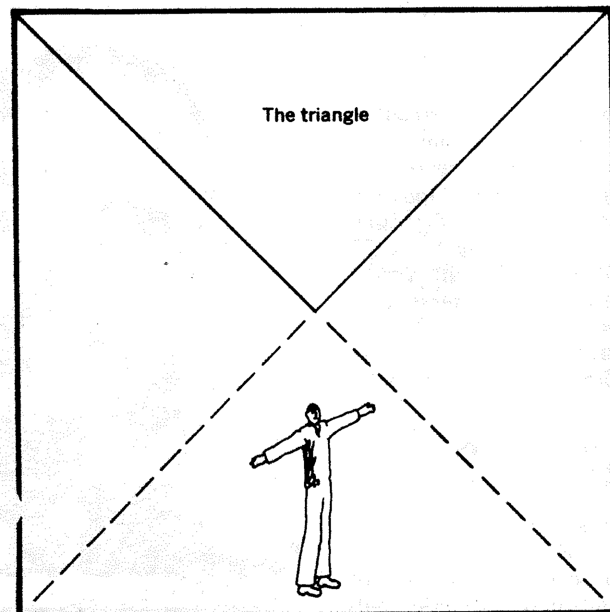
1. minute science? (2 wds.)
2. high card group*
3. deprivation, measured in db.
4. I times R*
5. citrus space? (2 wds.)
6. employee records group*
7. one is for visitors.
8. sometimes heard at games at 33 and 72 across.
9. element in betatron*
10. top administrative group.
11. enclosure for heating.
12. atomic number 54*
13 current*
14. SLAC area rapid transit? (2 wds)
18. product of 4 and 13 down*
20. experimental group in earth*
26. flows thru battery circuits*
29. group that dissects commonplace facts*
31. officer in extension*
32. mixture often compressed.
34. degree in Van de Graaff*
36. number four on the chart*
37. see 64 across.
38. tin*
40. 76 across minus one.
42. (with 71 across) circular closet? (2 wds.)
44. vessel in vessel*
48. not 55 across.
50. parame — — —
51 relating to a node.
53. score by division?*
58. tank*
60. experimental group opposite to 36 down*
62. break container. (heavy)
65. often found before a conductor.
67. Latin for 59 across*
69. PNPN device in beam scraper*
71 unit of reluctance.
73 (with 28 across) head of 10 down's long ion chamber*
75. St— —ring dipoles.
77. a shop building*
79. element named for city of 33 across*

* — indicates symbol, abbreviation, or acronym.
(watch for anagrams and puns, etc.)

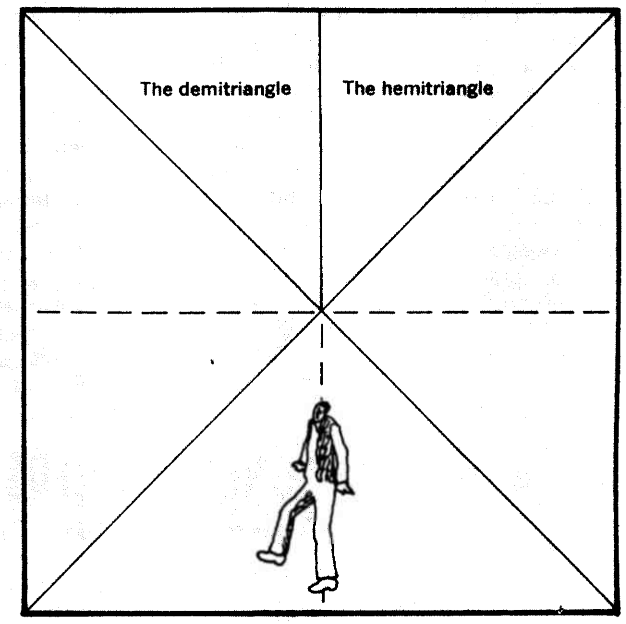
A Short History of Particle Physics?



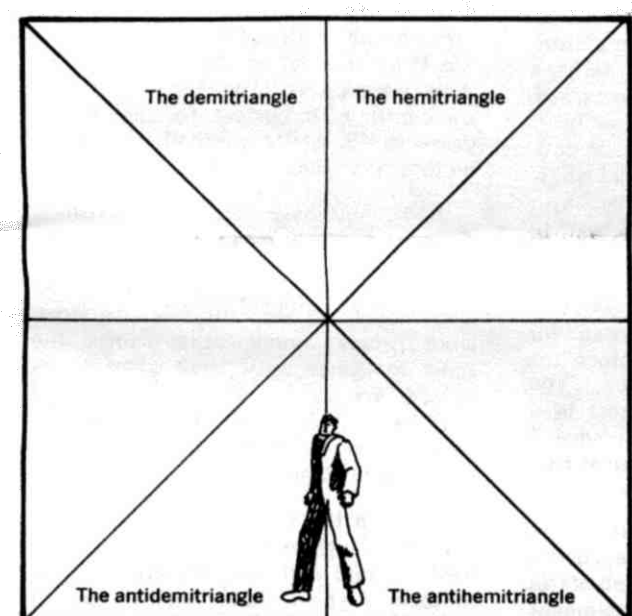
10 000 BC. The inhabitants of the paper square have no conception of the true nature of the universe they inhabit.



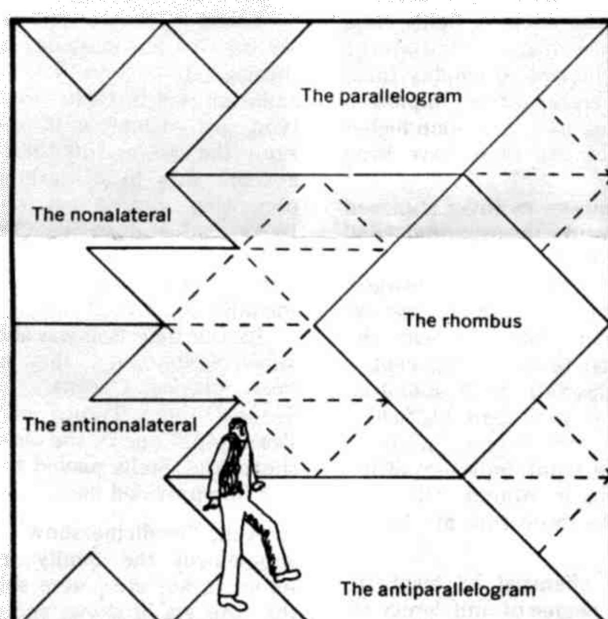
1900 AD. Physicists of the square discover a basic subdivision of their universe. They call it the "triangle" and consider it to be the fundamental building block of the universe.



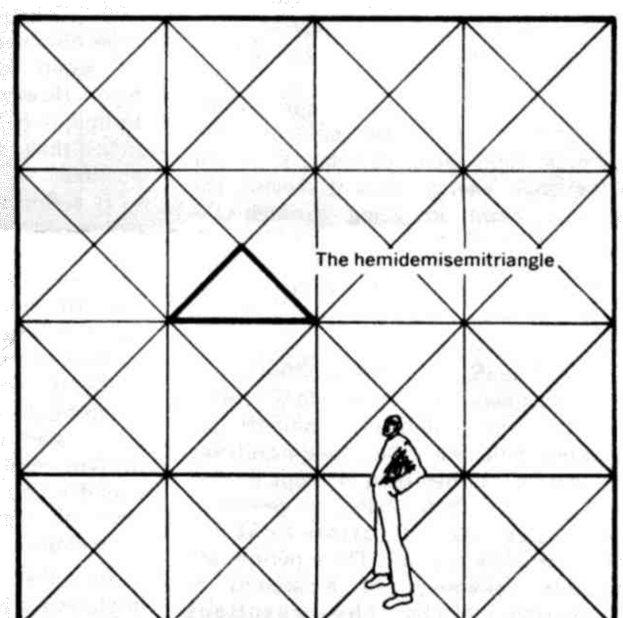
1930 AD. Physicists discover that the triangle can be split. Its parts are termed the "hemitriangle" and the "demitriangle." These are thought to be the fundamental building blocks of the universe.



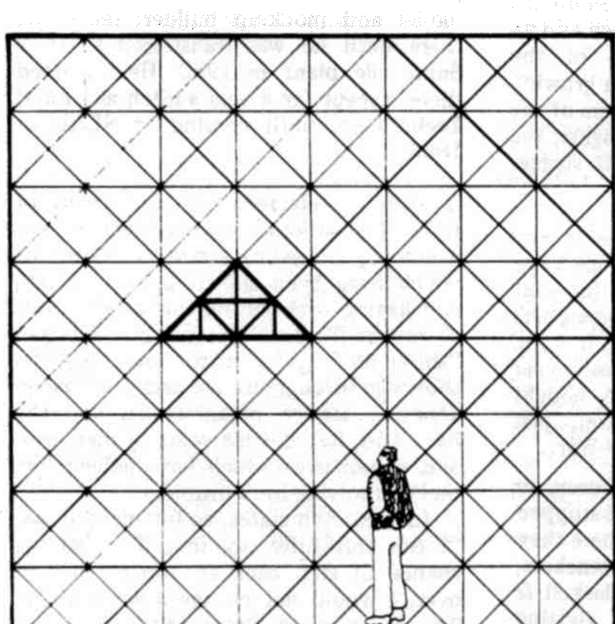
1950 AD. Mirror images of the hemitriangle and the demitriangle are discovered. These are termed "antihemitriangle" and "antidemitriangle."



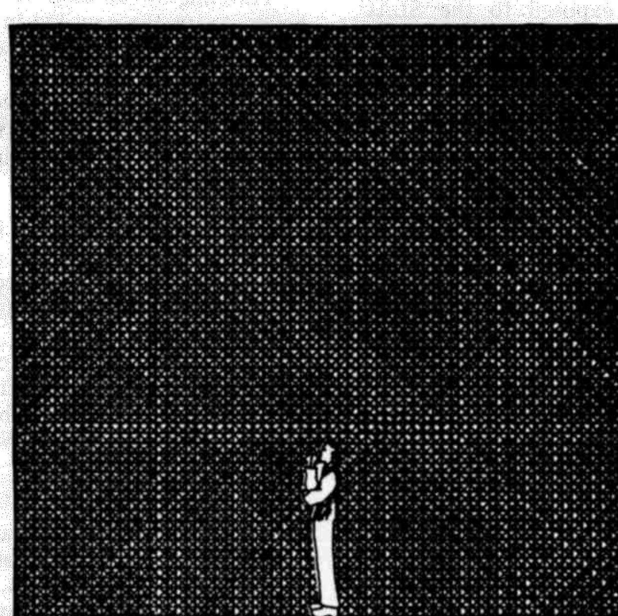
1960 AD. Physicists' conception of their universe is further clouded by new discoveries: the rhombus, the parallelogram, the antiparallelogram, the nonalateral and many others. It is unclear what these discoveries signify.



1970 AD. A new configuration, the "hemidemisemitriangle," is hypothesized, out of which all known configurations of the universe can be constructed. The hemidemisemitriangle is thought to be the fundamental building block of the universe.



1975 AD. The hemidemisemitriangle is discovered. The following year the hemidemisemitriangle is split.



2000 AD. The inhabitants of this paper square have no conception of the true nature of the universe they inhabit.

Editor's Note: This cartoon history of particle physics is reprinted with permission of Physics Today magazine from their October 1970 issue. It accompanied Geoffrey Chew's article, "Hadron Bootstrap: Triumph or Frustration," and were originated by the author's son, Berkeley Chew.

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EARTHQUAKES

Continued from Page 1

on the scope of the changing angle of the earth's surface due to various forces acting on it. The effect of the sun, moon, and tides can be represented by this vector, which is the ratio of the horizontal acceleration to the vertical acceleration of gravity, and which on the scope is a line paralleling the maximum tilt of the earth's surface (in the Bay Area the earth moves up and down about 30 centimeters each day). The tilt of the earth caused by the sun, moon and tides is predictable. There has been sufficient study of these forces to enable seismologists to understand the earth's movement from their influence. However, by removing these predictable factors from the earth-tilt occurrence, there still remains a tilt which is as yet unexplained from all available information and calculations. There is speculation that this unexplained tilt may be caused by internal activity of the earth which in turn has an effect on seismographic activity.

The first test made on the correlation between the direction of maximum tilt preceding a damaging earthquake (4.1 on the Richter scale) and the actual location of that quake was, colloquially, fantastic. (100 hours preceding the June 11, 1970 earthquake in Danville, the tilt vector recorded in Berkeley, 25 kilometers from the epicenter, pointed directly to the active area and unwaveringly continued to point in that direction until the quake occurred.)

ULTRA-HIGH MAGNETIC FIELDS AT SLAC

by Charles Oxley

Usual laboratory strong magnetic fields have a strength of about 20 thousand gauss. (In California, the earth's magnetic field strength is about ¼ gauss.) Producing fields 100 times as large increases difficulties not by 100, but by 10,000 as the square of the field strengths. A limiting difficulty is magnetic force on the field-producing elements. Another problem is the high rate of resistive heating which melts and vaporizes coils. Despite these problems fields of up to two million gauss have been produced at SLAC by a group from Illinois Institute of Technology, consisting of Fritz Herlach and Tom Erber of the IIT faculty and Robert McGroom, graduate student. The magnetic field serves as a target for the SLAC high energy election beam. The electron beam in going through the magnetic field produces gamma rays of some tens of millions of electron volts. SLAC people involved in setting up the beam and in its operation are Joe Murray and Roger Gearhart.

In obtaining million-gauss fields one first considers the tremendous forces amounting to millions of pounds per square inch on the field-producing conductors. Rather than attempt to deal with these forces statically, one resorts to brief periods of attainment in self-destructive systems. These periods are typically millionths of a second in duration. With the resultant high-frequency fields the electric current induced in the conductor by the fields resides in a thin skin on the surface of the conductor and spreads into it at a rate of a millimeter per microsecond.

In the simplest system in use, the electric energy is stored in capacitors and is switched into a one-turn copper coil through a high speed switch. The field rises to over a megagauss in two microseconds. Magnetic pressures blow the coil apart, resulting in a sharp report. Here at SLAC these loud bangs have sometimes brought accelerator operators searching for more serious catastrophies than the planned explosion of a coil in the cause of experimental physics.

More specifically, the energy is stored in low inductance capacitors at 20 thousand volts. Current is brought through many low inductance leads to a switch. The special, one-shot low inductance switch is formed by a mylar sheet pressed between steel conductors. The insulation is broken down by exploding fine wires embedded in the mylar. These are exploded electrically by a current pulse at about the time the burst of electrons starts down the accelerator. Peak fields are obtained as the beam arrives in the experimental yard.

The single turn copper coil is a simple replaceable unit with an inside diameter of 1/8 to 3/8 of an inch and a length of about 3/8 inch. Heating effects melt a thin skin of copper which carries the current. A shrapnel shield limits the damage to replacable elements.

The slow penetration of a magnetic field on this time scale into a conductor allows the compression of magnetic fields by piston-like action of chemical explosives. If a magnetic field is present within a thin cylindrical conductor and a cylinder of high explosive is placed around it the fast implosion of the cylinder on firing the explosive can compress the magnetic flux to extremely high fields. Reduction of the radius of the cylinder by a factor of ten will ideally increase the field strength by a factor of 100. Although the highest fields have been obtained by chemical explosions the IIT group was reluctant to employ them here. However, an electrical implosion technique has been used to obtain higher fields than would otherwise have been possible.

If a thin aluminum cylinder is placed within a coil and the exterior coil activated, the magnetic field through its pressure will force the cylinder inward, quickly reaching very high speeds. Ideally, if no field leaked through, the cylinder would be forced to its center. However, some magnetic field does leak in during the earlier stages and this field is compressed until the internal magnetic pressure limits the rapid implosion of the cylinder and turns it around. The flash x-ray photographs show this process of implosion.

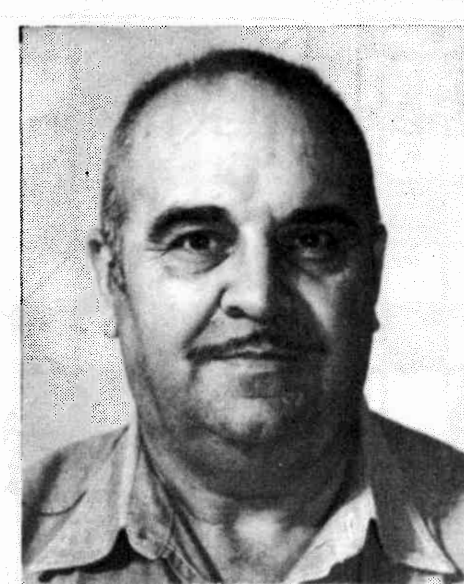
In either the chemical or magnetic implosion a high degree of uniformity all around the circumference is required. Not only the coil or explosive and its container but the imploded cylinder must be highly perfect.

Within the coils, nuclear emulsions have survived in magagauss fields and escaped damage by the subsequent destructive explosion. When the nuclear emulsions were exposed to the SLAC electron beam, tracks were seen curving even within the short distance observable under a miscroscope. The best high field observations previously had barely been able to seperate the positive from negative electrons produced in the emulsions.

The prime physics experiment is the production of gamma rays when the electron is deflected by the magnetic field, a process known as synchrotron radiation. This process of energy loss accounts for the linearity of SLAC since it limits the energy obtainable in circular electron accelerators. Energy associated with the radiation is spread over a wide range of photon frequencies from visible light on through to x-rays and even higher. The theoretical energy distribution may be calculated on a semi-classical or correspondence principle basis with sufficient precision for ordinary purpose. At extreme energies and magnetic fields the process requires more sophisticated quantum-electro-dynamic treatment and the present experiment may throw new light upon a region of quantum electrodynamics not explored by other means.

SLAC PERSONALITY-

BOB MASKELL



BOB MASKELL

Maskell Family circa 1915 with hand-cranked, gas-lighted movie projector. Bob's up front in white.

Bob Maskell, a carpenter in the Crafts Shop for the last five and a half years, is as much at home in a theater as he is in a carpentry shop. What kind of theater? Well, any kind, and there starts the story of this issue's SLAC Personality.

Born in Munising, Michigan, in 1909, to a family that owned a combination skating rink and early-day motion picture theater, Bob says that his father's ambition was to be in show business, any type, just so long as it was "show biz." From the skating rink-theater it was only a short step to a traveling road show presenting movies and vaudeville, with Bob's dad and mother having become proficient in mind-reading act. Magic, comedy skits and other acts completed the bill.

By the time Bob was about six and his sister, Stella, seven, they had joined the show, playing a scenario entitled, "The Three O'Clock Train," or, "Ghost in a Pawnshop," one of the old-time medicine show skits. Stella played the straight part and Bob provided blackface comedy.

And, "medicine show" it was, for to supplement the family income, herbs, tonics, soap, etc., were sold. Bob states that this era of shows and entertainment was very much a part of American rural life and history and was about the only entertainment available to rural communities. Some included displays of various daring feats, dogs and other trained animals, and, of course, the first of the motion pictures.

Traveling by railroad, staying in hotels, being always the new kid in town and an "actor" at that, were some of the adventures that Bob recalls as a growing boy. Also, there were the wonders of the day — steam tractors, electric lights, the early automobiles, other things to stagger the imagination.

It couldn't last all year, however, and come fall and winter, Bob and his sister would have to leave the road for that mundane life of school. He remembers attending his first one in Ingram, Wisconsin, with a different one each year after that until the family finally bought a home in Everett, Washington, just before the end of the First World War.

On the way to Everett, however, in 1917, the "Maskells Shows" had stopped to play in Ingamar, Montana, where they met the Gatewood brothers, ranchers, and formed the partnership, "Maskell & Gatewoods' Wild West Shows." Getting together the horses, cowboys, cowgirls, Indians, ring stock, steers, etc., they opened up a wagon show under a huge canvas tent. It was a short-lived adventure — going broke in less than a month, but one an eight-year-old boy would never forget for having been a part of it.

With the purchase of a Model-T Ford truck, with solid tires, in 1919, the Maskell family became even more mobile, putting all types of shows on the road, playing both indoors and out, and covering the whole of the West Coast. All didn't remain rosy, however, for a recession hit in 1923-24, and Bob's father was killed in a car accident in 1925. The show went on as "The Three Maskells," and continued in business for anoteher 15 years, until Stella married and Bob's mother remarried.

Bob continued on alone with a portable theater, which could seat 125 people, that he constructed on a large semi-trailer truck. Following the Department of Agriculture's migratory labor camps, among other things, the show continued until 1943 when it was closed for lack of equipment and supplies. At that time, Bob went to work as a steam fitter for a ship building company in Napa, California.

Back on the road after the war, Bob, wife and daughter were playing from the west to mid-west and wintering in the southeast where Bob opened several theaters in Georgia. Not satisfied without the "road," Bob became a roving cameraman for the "World in Color," shooting and producing travel and educational films.

With children growing up, by 1951 Bob decided he should settle down and joined Lockheed in Georgia as a master model and mock-up builder, remaining there until he was transferred to their Sunnyvale plant in 1960. He remained there, except for a year's hitch at United Technology, until coming to SLAC in 1965.

Having collected over 200 reels of films of all varieties, many of them one of a kind or exceedingly rare, and many of which have been shown here at SLAC, and having over several thousand photos of vintage films and posters, Bob still is in "show biz" in his spare time. He gives showings throughout the area for charity benefits, service organizations and the like. And, he's got his years of memories and experiences which have helped him much in solving life's problems.

In fact, Bob states, as few people can, "I can truthfully say that if I had the chance to step back and do my life all over, I would not change a single thing. The many good times and experiences I've had would read like fiction if I ever got them written. Also, no matter how hard the tasks of the day might have been, there's always the joy and fun and escape from everyday life in the magic words, "SHOW TONIGHT."