SLAC BEAM LINE

Volume 5, Number 2 *August 1974*

From The Editor

With this issue the *SLAC Beam Line* begins a new career, with a new format and a new cast of characters, and with plans for the future that are glorious but not very firm. We start with only two convictions about the kind of publication the *Beam Line* should be: regular and interesting. Our plan--or at least our hope--is that "regular" will mean once a month, but it remains to be seen whether the part-time efforts of a few people will be enough to sustain that kind of a schedule. As for "interesting," that will depend partly on us and partly on you. What we need is a steady flow of interesting material coming in from many different people on many different subjects. This material can be technical information, news, comment, opinion, announcements, or whatever. It can be written as polished prose, or a draft, or just a bunch of notes. Or simply tell us about it and maybe we'll do the writing.

So far the new *Beam Line* crew consists of the following volunteers:

Harry Hogg (x2441), whose general province will be SLAC accelerator matters: operations, components and systems, development work, future possibilities, and so on. He will do some writing himself, try to talk others into writing, and gratefully receive any unsolicited material or ideas.

Herb Weidner (x2521), who will do the same sort of thing for the research area, the experimental facilities, and the physics experiments.

Dorothy Ellison (x2723), who will be looking for input from such SLAC-connected groups as SERA, the Credit Committee, and the sport, hobby and garden clubs. She will also look out for people topics: promotions, retirements, awards, community activities, etc.

George Owens (x2411), who will handle most of the production and distribution chores and also help out with illustrations and editing.

Bill Kirk (x2605), who will do most of the editing and, to start with, the layout *(help!)*.

During the next few months we expect to be struggling through a slow learning process that will undoubtedly lead to some changes. Our readers can help this process along in at least two different ways: by telling us what's good and bad about this and future issues of the *Beam Line;* or by volunteering to take on some part of the job themselves. It's plain that the present *Beam Line* crew will not be able to cover all the interesting things that come up at SLAC--not by a long shot. So if you feel like appointing yourself as reporter for the Crafts Shops, or sportswriter, or cost-of-living expert, go to it. But whether you volunteer or not, your comments on and criticism of the new *Beam Line* will be appreciated.

-- Bill Kirk

Minority & Women's Committee

The Minority and Women's Committee (MWC), appointed by the Director of SLAC, gives minority and women employees an opportunity to bring up any job-related problems which they feel result, directly or indirectly, from their minority or woman status. MWC also assists the Director by carrying out assignments that provide information about the relationships between minorities and non-minorities, and by suggesting ways to improve these relationships. Any employee who feels hesitant about approaching the Committee as a whole may contact members on an individual, person-to-person basis. The Committee members and their telephone extension numbers are listed below:

Viola Belton	2223	Paul Regalado	2472
John Brown	2284	Mario Smalls	2784
Tiana Hunter	2328	Joe Sodja	2163
Dick Jeong	2451	Ken Stewart	2739
Marie LaBelle	2748	Anthony Tilghman	2488
Frankie McLaughlin	2864	John Valverde	2371
Lucy Wilson	2681		

SUMMER INSTITUTE ON PARTICLE PHYSICS

The second annual Summer Institute on Particle Physics is being held at SLAC during the period from July 29 to August 10. Approximately 200 physicists are attending the Institute, many from overseas. The topic selected as the focal point for this year is *The Strong Interactions*, and the program is designed primarily for post-doctoral experimental physicists. The format of the Institute is the same as last year: an initial eight-day school, during which participants are brought up to date on the field of strong-interaction physics; followed by an intensive three-day topical conference in which workers active in the field report on their current studies.

David Leith and Richard Blankenbecler of SLAC have coordinated the Institute's program, with Martha Zipf handling the bulk of the logistical load. The lecturers during the eight-day school session include Dennis Sivers, Michel Davier and Fred Gilman of SLAC (in addition to Leith and Blankenbecler), as well as Henry Abarbanel of NAL and Roger Cashmore of Oxford--both former SLACers.

During the topical conference on August 8-10 there will be a total of 18 talks which range broadly over the whole field of strong-interaction physics.

Person wanted: To work on nuclear fissionable isotope molecular reactive counters and three phase photosynthesizers. No experience necessary.
--*Adv. in the Toronto Star*

Just another entry-level job.

EXEMPT-74

Exempt-74 is an informal organization of employees at SLAC, open to anyone in the "exempt" classification. Our aim is to ensure equitable treatment for exempt employees, and, by our efforts, to make SLAC a better place to work. We intend to work with management and not against it. It is our hope that, by identifying areas of employee concern (if they exist), we can work together to improve the SLAC environment and our job satisfaction.

The present membership is approximately 70, of whom some 30 to 40 regularly attend membership meetings. The elected steering committee consists of Ken Crook - Moderator, Bob Vetterlein - Moderator Alternate, Leroy Schwarcz - Treasurer, Charlie Hoard - Membership, Joe Jurow - Secretary, Jack Truher - Publicity.

We intend to concentrate on the following program for this year:

A. *Salary Improvement*
   1. Cost of living
   2. Salary equity

B. *Job Security*
   1. Attrition
   2. Layoffs

C. *Personnel Administration*
   1. Salary review procedures
   2. Review of SLAC classification system
   3. Grievances

Our efforts to date have resulted in a letter to the Laboratory Director pointing out the problems of exempt salaries under the stress of the present inflation rates. We are currently debating a follow-up letter which will contain some concrete proposals to alleviate the salary problem.

In addition, we have made a proposal on "attrition management" which was sent to the Director in late July. We are also collecting salary information from the Personnel Department in the hope of gaining a better understanding of the SLAC salary structure.

We alternate general membership meetings and steering committee meetings on Wednesdays at 12:10 PM in the Orange Room (Central Lab Room R-140). All meetings are open to the public, and new members are welcome.

--Ken Crook & Joe Jurow

DRELL AND BALLAM NAMED TO HEPAP POSTS

Sid Drell, SLAC's Deputy Director, has recently become the Chairman of the High Energy Physics Advisory Panel (HEPAP) to the U. S. Atomic Energy Commission. HEPAP is the principal source of scientific advice for AEC-supported research in high-energy physics. Drell replaces Victor Weisskopf of MIT, who had been the Panel's Chairman since its inception in January 1967.

Joe Ballam, Associate Director for SLAC's Research Division, has recently been appointed a member of HEPAP for the period through June 30, 1975. HEPAP appointments are made for a period of one year, with the members often asked to continue for a second one-year term.

No matter where you live, it's always the same side of the street. . . Every knot has a couple of loose ends. . . Gravity likes rocks. . . Sex is hereditary. If your parents never had it, chances are you won't either. . . There is a fifty-fifty chance of anything, because either it will or it won't. . . If you know the answer, then you don't know the question. . . Ninety-nine percent of everything is bullshit. . . There's a rubber duck in your future.
--Reprinted from Harper's, July 1974

Friday Noon Informal Discussions

Those of you who haven't yet been to one of the Friday Noon Informal Discussions have been missing out on some lively times. In recent meetings we've chewed up some of SLAC's salary review procedures, learned some new information about this year's budget and about the chances for the proposed PEP project to be approved, talked about the electron scattering experiments that are done in End Station A, and heard a number of SLAC's women workers tell it like it is about their jobs and the subtle (and not so subtle) kinds of discrimination they run into.

In case you haven't got the word, these informal discussions happen every Friday, from 12:10 to 1:00 PM. They are usually held in the Auditorium, but there's always advance notice if a different room is being used (the August 2 and August 9 discussions will be in the Orange Room of the Central Lab because of the Summer Physics Institute). The general schedule for the discussions goes this way:

1st & 3rd Friday of each month - Pief is there for a general question and answer session.

2nd, 4th (&5th) Friday - different SLAC people come to discuss a variety of topics.

As an example of the many subjects we get into on Fridays, here's a list of the people and topics for those Fridays when Pief is not on the program:

Bernie Lighthouse: Staff benefits at SLAC.
Dick Taylor, David Leith, Burt Richter: Future physics at SLAC.
Fred Pindar: SLAC's Business Services Division.
Bob Moulton: SLAC's Salary Review Committee.
John Brown, Lew Keller, Ken Crook: Salary review and promotion from a Group Leader's point of view.
Hobey DeStaebler: Electron scattering experiments.
Jim Ketcher: SLAC's Affirmative Action Program.
Frankie McLaughlin: Women at SLAC.
Dick Neal, Bob Moulton: General question and answer session.

During the next few weeks the following discussions are scheduled:

August 9, Ted Jenkins: SLAC's Training Programs.
August 30, Sid Drell: What theoretical physicists do.
September 13, Dick Fuendeling: The budget process at SLAC.

So if you have any questions or opinions or gripes, why not drop in and lay it on us sometime? It's true that the discussions sometimes get a little warm, but then whose kitchen is it around here? Ours? Or "theirs?"

AN INTRODUCTION TO COLLIDING BEAM STORAGE RINGS - PART I

This is the first of a two-part series on storage rings that will include some Stanford-SLAC history, a brief review of conventional accelerators, a look at the "Why?" of colliding beams, some background and a report on the early physics results from SPEAR, and a description of the proposed PEP storage-ring facility. Part II of this article will appear in next month's Beam Line.

This Month

This article is intended primarily for non-technical readers. Although we plan to cover some of the basic technical information about storage rings, we'll try to stick to fairly simple explanations, and we'll also sneak up on some of the topics slowly enough so that, hopefully, no one will get the bends.

Some Stanford-SLAC History

SLAC has a special interest in colliding-beam storage rings for several reasons. One of the earliest colliding-beam devices, an electron-electron ring, was built as a collaborative effort between physicists from Stanford and from Princeton University at the High Energy Physics Laboratory on the Stanford campus. This early project (first experimental results in 1965) served as a training ground for some of the people who are now active in the SLAC storage-ring work. SLAC's present colliding-beam facility, SPEAR, has operated very successfully since its turn-on date of April, 1972, and the early physics results from SPEAR have been received with great interest by the international high-energy-physics community (more on this later). Its present prominence makes it easy to forget that SPEAR very nearly didn't get built. The SPEAR facility was first proposed to the AEC as a full-blown $20 million construction project as far back as 1964. This proposal was revised and resubmitted in 1965. And the year after that. And the year after that. . . . Finally, in 1970, we decided that some form of SPEAR was so important that we asked for, and got, the AEC's approval to reprogram some of our regular funding in order to put together a stripped-down version of SPEAR. (Burt Richter was getting so hard to live with that we had to do *some*thing.) That decision cost SLAC some pain, since we had to shift about $5 million away from other activities during a two-year period. But you would be hard-pressed now to find a physicist at SLAC who doesn't think it was well worth it.

PEP--a SuperSPEAR. The final reason for SLAC's special interest in storage rings is the proposal we have recently made, jointly with the Lawrence Berkeley Laboratory, for construction at SLAC of a much larger electron-positron colliding-beam storage ring facility. Since the proposed facility can accommodate the possible future addition of a storage ring for protons, the name *PEP* was chosen to represent the combination of *P*ositron-*E*lectron-*P*roton. This proposal requests construction authorization for Fiscal Year 1976 and forecasts a construction schedule of about 3½ years, with a total facility cost estimated at $62 million. Since the PEP proposal has received excellent support from the scientific community, SLAC is cautiously optimistic about its chances for authorization. The "cautious" part of this optimism is based on the fact that no large new high-energy accelerator project has been authorized in the United States since the National Accelerator Laboratory, in FY 1968, and also by the generally declining levels of support (in real purchasing power) during the same period.

Conventional Accelerators

The best way to understand the importance of storage rings is to compare them with conventional accelerators, so let's begin by reviewing the two most significant characteristics of a conventional accelerator: *beam energy* and *beam intensity*.

Beam energy for better "seeing." Higher beam energy makes possible what a physicist might call "greater resolution of structure." That is, higher energy is needed to observe smaller things, or to make out the ripples and bumps in something that seemed smooth when it was studied at lower energy. As an example, the higher energy "light" that is used in electron microscopes or x-ray microscopes can be used to see things, such as viruses, that are much too small for an optical microscope. Going farther, the 1 GeV Mark III accelerator at Stanford was able to detect the sizes and shapes of the various clusters of protons and neutrons that form the nuclei of atoms. And recently the 20 GeV SLAC accelerator has been used to discern a kind of clustering, or internal structure, within the individual protons and neutrons themselves.

Beam energy for creating particles. When an electron of relatively low energy, say 100 MeV, collides with a stationary (target) proton, the energy carried into the collision by the electron can appear after the collision in only two different ways: as the kinetic energy (energy of motion) with which the two particles recoil from the collision; or partly as recoil motion and partly as bursts of radiation (gamma rays) that either the proton or, more likely, the electron emits. When the electron energy is increased to about 300 MeV, a third alternative becomes available ("a new channel opens up") in which some of the energy creates, or knocks out of the proton, a new kind of particle called a pion. When the electron beam energy becomes as large as the 20 GeV of SLAC's beams, then the number of possible

events or open channels is greatly increased: one pion, three pions, particle-antiparticle pairs, showers of 4 or 6 or more assorted particles--literally hundreds of different combinations are possible.

Beam intensity for practical experiments. Whether or not the potential advantages of higher beam energy for better seeing and for particle production are actually realized in practical experiments depends very strongly on the intensity of an accelerator's beam. Intensity is a measure of how many particles an accelerator can deliver in a given period of time, and it is usually expressed as the number of particles per second, or as the average flow of electrical current carried by the beam (generally in microamperes). Beam intensity is the main factor in determining how much time will be needed to carry out an experiment, and therefore in setting limits on the kinds of experiments that are practical. As an example, during the inelastic electron scattering experiments at SLAC, a measurement was made on a certain extremely rare kind of particle interaction--so rare, in fact, that only one out of every 10^{18} beam electrons caused it to occur. And even though the intensity of SLAC's electron beam is considerably greater than that of any other high-energy accelerator, this particular event occurred on the average only once in every 90 minutes or so of high-current running. Thus high beam intensity makes it possible to study the rare (and often critically important) "needle in the haystack" events that would require a prohibitively long time at lower current machines.

Why Storage Rings?

We move on now to a discussion of the differences between conventional accelerators and colliding-beam storage rings. There are three such differences,

1. *Center-of-mass energy* (instead of beam energy)
2. *Luminosity* (instead of beam intensity)
3. *Particle-antiparticle annihilation*

that are especially important, for the following reasons.

1. Center-of-mass energy--more bang for a buck. With a conventional accelerator, the amount of energy that is actually useful (for detecting structure or for creating new particles) is always less than the energy of the beam. This useful part of the energy is usually called "center-of-mass energy," but the names "effective collision energy" and "available reaction energy" mean the same thing. At SLAC, with a 20 GeV electron beam striking target protons, the highest possible center-of-mass energy is about 6 GeV. Why? What happens to the other 14 GeV? The answer is that the rest of the energy is used up in giving a strong forward push to the recoiling electron and proton, and to any other particles that may be created. This forward push is something like what happens when a bowling ball strikes the pins. The energy carried by the moving ball can be distributed among the pins in many different ways. It is even possible, on rare occasions, for one or two of the pins to be knocked "backward" (toward the bowler). But the *overall* motion of the ball and pins after the collision is *always* in the same general forward direction in which the ball was initially rolling. And the same is true for a high-energy beam particle hitting a stationary target particle--one or two particles may occasionally move backward, but the whole collection of colliding and created particles always moves generally forward.

If we want to have more useful, center-of-mass (let's call it "CM" for short) energy available in particle collisions, it might appear that the simplest way to get it is simply to increase the total beam energy. This method works, to a degree, but it has a limitation that becomes progressively more serious as we go to higher and higher energies. This problem is illustrated in the following table, where the figures shown are based on either electron or proton beams striking stationary target protons.

Accel.	Beam Particle	Beam Energy (GeV)	CM Energy (GeV)	% of Beam Energy Avail. As CM Energy
DESY	electrons	6	3	50%
SLAC	electrons	20	6	30%
CERN PS	protons	28	7	25%
Serpukhov	protons	76	12	16%
NAL	protons	400	28	7%

As the table shows, the brute-force method of using higher beam energy is an increasingly inefficient way to achieve more CM energy as you go farther up the energy scale. It is also a very expensive method, and for this reason there has been a strong incentive to find a better way. And that better way turns out to be to get rid of the *stationary* target, which was too easy to push around, and to replace it with a collection of particles that will push back against a high-energy beam just as hard as the beam pushes them--in short, with *another* high-energy beam that is traveling in the opposite direction. Then, with two beams of equal energy colliding head-on, there is no "forward" or "backward" in the collision, and the result is that *all* of the energy carried by *both* of the beams is available as useful center-of-mass energy.

The importance of this colliding-beam method is illustrated in the next table, which shows several storage rings, actual or proposed, and which is similar to the previous table except for the last column.

Storage Rings	Beam Particles*	Single Beam Energy (GeV)	CM Energy (GeV)	Conv. Accel. Energy Required To Equal CM Energy**
SPEAR I	$e^- - e^+$	2.5	5	17 GeV
SPEAR II	$e^- - e^+$	4.5	9	50 GeV
PEP	$e^- - e^+$	15	30	500 GeV
CERN ISR	p - p	28	56	1,800 GeV
ISABELLE	p - p	200	400	85,000 GeV

* e^- = electrons, e^+ = positrons, p = protons
**For the electron-positron machines the last column is misleading because the figures shown assume that a proton target is used with the conventional accelerator. The correct comparison for SPEAR and for PEP would call for an electron target, but electrons in a stationary target have so little mass that even very high beam energies do not produce a very forceful collision (it's like punching a balloon). For example, to equal PEP's CM energy a conventional accelerator would have to produce a positron beam with an energy of almost 1,000,000 GeV--a SLAC-like machine that could achieve this beam energy would be about 80,000 miles long.

To summarize, then, colliding-beam storage rings provide a first-class solution to the problem of how to get very high center-of-mass energies, and thus very violent particle collisions, without going bankrupt in the process. That's the good news. Now let's go on to the bad news.

2. *Luminosity--ain't (hardly) nobody here but us chickens.* The separate box on this page gives an exact definition of luminosity and a long description of what it means. But for our purposes it wouldn't hurt much just to settle for a simpler definition--*Luminosity is a measure of the rate at which the beam particles in a storage ring collide*--and then go right on to some of the problems connected with luminosity by asking this question: If the center-of-mass energies attainable with colliding beams are such a big deal, then why haven't storage rings made conventional accelerators obsolete? There are two answers to this question, and although both are important, we'll cover the first answer only to the extent of saying that conventional accelerators are generally more versatile research instruments than storage rings because of their ability to provide many different kinds of particle beams to many different experimental locations.

The second answer comes directly from the most serious limitation of storage rings: the "target" material in a colliding-beam storage ring is a moving beam of particles, and such beams contain so little actual "stuff" that they are about a billion times less dense than an ordinary target (such as liquid hydrogen). In fact, the density of a typical storage ring beam is not much greater than the density of gas molecules in an ultrahigh vacuum. (It seems difficult to reconcile this low density with the fact that the average flow of electrical current in one of SPEAR's beams is about one ampere --enough current to light a 100-watt bulb very brightly. Well, life is complicated.)

The low density of particle beams is just something that has to be lived with in storage rings. In order to minimize the problem, designers try to pack as many particles as possible into the two beams. The limits on beam packing are set by the amount of radiofrequency power you can afford to keep the beams circulating, and sometimes by the onset of what are called "instabilities," which cause the beams to drive themselves or each other out of stable circulating orbits and thus be lost. The effective beam density can also be increased somewhat by certain tricks: squeezing the beams down to the shape of thin ribbons, and colliding the beams exactly head-on rather than at a small angle. But these tricks are beyond our present purpose, so let's end the discussion of luminosity and its problems and move on to an area where electron-positron storage rings really shine.

3. *Particle-antiparticle annihilation--the "pure energy" state.* It is a well-established rule in nature that each form of basic matter (particles) has an "antimatter" equivalent (antiparticles). A particle and its antiparticle have opposite or complementary properties; an electron, for example, has a negative electric charge, while an anti-electron has a positive electric charge (which is why it is given the special name *positron*). Because of this oppositeness or complementarity, a collision between a particle and its antiparticle can have a unique result called *annihilation*, in which the two particles disappear and a state of pure energy is formed. This pure-energy state is a unit of gamma radiation or a *photon* (symbol γ), and under the right circumstances this energy can, in turn, be converted back into certain combinations of new particles.

To see the significance of annihilation for our

What Is "Luminosity?"

The technical definition is this: *Luminosity is the number by which the cross section for a particular reaction channel is multiplied in order to get the reaction rate in events per second.* Some physicists seem fond of definitions of this sort, but since they tend to drive the rest of us crazy, let's go back to Square One and see if we can work up to an understanding of what this definition means.

Let's suppose we're planning an experiment for the SPEAR storage ring that has two objectives: (1) the only "reaction channel" we'll observe is the one in which an electron-positron collision creates a pair of pions; (2) we have to observe one million of these pion-pair events in order to learn something new. The first step in planning this experiment is to figure out how long it will take to accumulate our million events. We know that for each electron-positron collision in SPEAR there is a certain probability that the two-pion result will occur; and although it may seem peculiar, this kind of probability is thought of in particle physics as an *area*. (The probability of hitting the side of a barn with a thrown rock is larger than the probability of hitting the barn door.) So the probability of pion-pair production is given as a cross-sectional area, or just a *cross section* for short, and let's suppose that this area for the two-pion process is equivalent to a very small square which has sides that are only 10^{-15} centimeters long. Then the area of this little square, and the cross section for pion-pair production, is 10^{-30} square centimeters (cm^2).

Now suppose we ask what the luminosity of SPEAR is, and the answer we get is the following funny looking number: $10^{31} cm^{-2} sec^{-1}$. This is exactly the same as $10^{31}/cm^2 sec$, and in words it would read "10 to the 31 per square centimeter per second." The formal definition of luminosity given above can also be written as an equation:

Cross section × Luminosity = Rate per second

We put into this equation the actual values we now have for the pion-pair cross section and for the luminosity of SPEAR:

$$10^{-30} cm^2 \times \frac{10^{31}}{cm^2 sec} = 10 \text{ per second}$$

So the rate at which SPEAR will produce pion-pair events is ten per second, and if our experimental apparatus is able to detect all of these events, then the time required to accumulate one million of these events will be 100,000 seconds, or about 28 hours of running time. Since most experiments require several hundred hours of running time, our pion-pair experiment would thus be quite modest, and we might even consider adding other kinds of interactions to our study to make a more complete experimental proposal.

purposes, let's compare two processes that are apparently quite similar: the production of a pair of pions (π^+,π^-) with a conventional accelerator and with an electron-positron storage ring such as SPEAR. In physics language, what happens is

$$e^- + p \rightarrow e^- + p + \pi^- + \pi^+ \quad \textit{(Conv. Accel.)}$$

$$e^- + e^+ \rightarrow \gamma \rightarrow \pi^- + \pi^+ \quad \textit{(}e^-e^+\textit{ Storage Ring)}$$

In words, the second process would read *"Electron plus positron goes to virtual gamma, which then goes to pi-minus plus pi-plus."* Note that in the first process the original particles are still present *after* the collision, whereas in the second process they have disappeared. The reason for this difference is explained in the separate box on this page, but it is the effect of the difference that we are mainly concerned with here. As stated before, the second process consists of an electron and positron annihilating to form an intermediate state of pure energy, which then materializes into a pair of pions. The great virtue of this method of creating particles is the fact that *the original particles are not around after the collision to complicate the analysis of what is happening.* In contrast, if our purpose is to study the way in which two pions interact with each other, then the conventional production process is limited by the fact that there will always be one or more "spectator" particles hanging around which may interfere with the two-pion interaction. (Perhaps a better name for the interfering spectators would be "kibitzers" or "chaperones.")

The Conservation of Leptons and Baryons

Electrons are one of the members of a small family of particles called *leptons*, and protons are one of the members of a large family called *baryons*. The "lepton-ness" of an electron is one of its intrinsic properties: just as an electron has a definite amount of electric charge (one unit of negative charge, or simply "minus one"), so it also has a definite amount of "lepton-ness" which is called its *lepton number*, and which has a value of plus one. As might be guessed, the anti-electron, or positron, has a lepton number of minus one.

This same description also applies to the baryon family, where the proton has a *baryon number* of plus one, and the antiproton has a baryon number of minus one.

The significance of these numbers comes from the following observed fact: No matter how many particles are created in a collision, *the total lepton number and the total baryon number will be the same after the collision as they were before the collision.*

A physicist would say that "lepton number is conserved" and "baryon number is conserved," and these two general conservation laws of nature serve to explain the difference between electron-proton collisions and electron-positron collisions referred to in the text. In e^-p collisions, at least one lepton and one baryon must be left as spectators after the collision. In e^-e^+ collisions, there need be no spectators because the baryon number is zero (no baryons are involved) and the lepton number is also zero (plus one and minus one add up to zero).

Two other points about annihilation are worth mentioning. First, the pure energy intermediate state can materialize into *any* particle-antiparticle pair. (It would be more accurate, but less understandable, to say "any combination of particles which has the quantum numbers of the photon.") Thus

$$e^- + e^+ \rightarrow \gamma \rightarrow \textit{Anything}$$

which includes all the funny names that are variously used to identify the different families of particles: leptons, mesons, nucleons, baryons, hadrons, hyperons --and so ons and so ons.

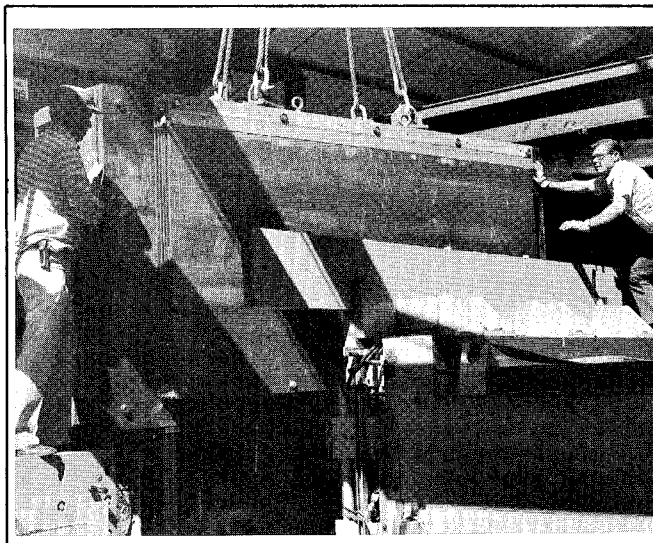
The second point about colliding-beam annihilation is that it is unique to electron-positron machines. A storage ring with colliding beams of protons and antiprotons is possible in principle, and the idea has been explored at the CERN European laboratory and at Novosibirsk in the Soviet Union. But getting an antiproton beam of sufficient intensity seems so difficult a problem that the prospects for such machines do not look bright. *(End of Part I)*

Next Month

Some Physics Background
- The idea of simplicity
- Electron scattering and partons

The SPEAR Physics Results
- Quarks and colored quarks
- The electron as hadron

The PEP Proposal
- Where PEP fits
- The prospect for approval



Jim Nolan (left) and Ernie Stevens of SLAC's Rigging Crew are shown removing a stack of steel shielding from the East experimental pit at SPEAR. This shielding was a part of Experiment SP-8, which was carried out as a collaborative effort among physicists from Princeton, Maryland and Pavia (Italy) Universities.

SPEAR shares with all other colliding-beam facilities the limitation that--since you can't bring the beam to the experiment--you have to bring the experiment to the beam. This makes for a lot of heavy moving, and the activity at SPEAR has been particularly intense this summer. The road to the East pit has been regraded and repaved in order to ease the access problems for heavy equipment. The first use of the new road was the removal of the 60-ton Princeton magnet, using a rented 160-ton crane, from the East pit to a storage area.

1974 SPORTS SPECTACULAR AUGUST 29

The third annual Long Distance Run and Bicycle Race around the accelerator will be held on Thursday, August 29, starting at noon. All interested SLAC employees are welcome to participate, with a special invitation to students who are working here during the summer months.

The starting line will be at Sector 30. Please be there by 11:50 so we can start promptly at noon. The distances are 3.8 miles for the run, and 7.6 miles for the bike race.

The Long Distance Run looks like a wide-open contest this year, since 1973 winner Dave Cuthiel has gone back to Cornell University. Two runners to keep an eye on are Bill Divita and Gerrard Putallaz, both of whom have run the 26-plus mile marathon in under 3 hours this year. Alex Gallegos will also be a hard man to beat; he presently holds the second fastest time for a SLAC runner on the 3.8 mile course --21 minutes and 24 seconds.

Other contenders include Alan Schmierer, who may be able to clip another minute off last year's 23:15; and Ed Dally, a newcomer to the race but not to SLAC, who had done four miles in under 22 minutes and the marathon in 2 hours and 45 minutes. (Not bad for a 40-plus guy, Ed. I'd say you're definitely a threat!) Of course we always have to look out for the "ringer" too, the guy who shows up looking lean and hungry on race day and runs off with all the marbles.

There will be a refreshment booth set up at Sector 30 with cold drinks for sale for those who would like to watch the action. See you at the starting line.

-- Ken Moore

spearwocky

(Dedicated to the SPEAR operators)

'Twas brillig, and the slithy beams
Did gyre and gimble in the ring:
All mimsy were the cavities,
And the Sigma-5 did sing.

"Beware the Physicist, my son!
The jaws that bite, the claws that tweak!
Beware the Engineer, and shun
The frumious Vacuum Leak!"

He took his vorpal switch in hand:
Long time the manxome beams he sought--
So rested there with a can of beer,
And stared awhile in thought.

And, as in uffish thought he stared,
The Physicist, with eyes of flame,
Came whiffling through the tulgey yard,
And burbled as it came!

One, two! One, two! And through and through
The vorpal switch went snicker-snack!
He left it dead, and with its head
He standardized right back.

"And hast thou slain the Physicist?
Come to my arms, my beamish boy!
O frabjous day! Callooh! Callay!"
He chortled in his joy.

'Twas brillig, and the slithy beams
Did gyre and gimble in the ring:
All mimsy were the cavities,
And the Sigma-5 did sing.

-- Roger McConnell

PEP SUMMER STUDY MEETS AT LBL

SLAC and the Lawrence Berkeley Laboratory (LBL) are jointly sponsoring a summer study program for interested physicists with the goal of contributing to the design and specification of the experimental facilities and of the major experimental equipment that would be used with the proposed PEP project. The PEP proposal requests authorization for construction at SLAC, beginning in FY 1976, of a 15 GeV (each beam) electron-positron colliding-beam storage ring facility at an estimated cost of about $62 million and with a construction period of 3½ years.

Like the present SLAC accelerator, the proposed PEP storage-ring project would become a national facility for research in high energy physics, available to all qualified users; and for this reason the two laboratories believe that early involvement of the potential user community in planning the experimental facilities would be of great benefit.

The 1974 summer study program will be held at LBL from August 5 to August 30. The program is being organized by a Steering Committee, which is composed of the following people: Karl Strauch (Chairman), CEA-Harvard; Barry Barish, CalTech; M. L. Goldberger, Princeton; David Cline, Wisconsin; John Kadyk, LBL; Richard Lander, UC-Davis; and Burt Richter, SLAC. Professor Lander will also represent the interests of the Associated Users of Western High Energy Accelerators (AUWHEA), an organization that was formed about two years ago.

The study will consist of two parts. During the first week, all those who expressed an interest in the study (an estimated 200 of the 800 or so physicists who were contacted) will attend meetings designed to familiarize them with the proposed PEP facility and with its broad potential for experimental research. During the latter three weeks, a smaller group of 40 to 50, including about 10 each from SLAC and LBL, will begin the more detailed studies that will eventually lead to specific design of PEP's experimental areas and some of the major research equipment. This work cannot be completed in a single summer, and for this reason the Steering Committee hopes to persuade many of the members of the smaller working group to commit themselves to continuing activity on specific design problems for a year or more into the future.

The summer study programs and the follow-up activities that were carried out at Stanford from 1958 through 1964 proved to be very valuable for the SLAC two-mile accelerator and its eventual research program. Given the size, interest and talent of the group that is now beginning work at LBL, it seems likely that PEP will benefit in a similar way.

Safety Notes

SERIOUS ACCIDENT AT CERN

Recently, at CERN, a summer student was seriously burned in an accident involving isobutane. Here is a [partial] account of the accident, provided by G. H. Hampton of CERN:

> A mixture of argon and isobutane was being used in a drift chamber installation under test in our West Hall. After awhile . . . the Group concerned transferred the gas installation together with the electrical control equipment to a small hut inside the Hall [for modification]. Mr. Rocek, the man injured in the accident, had been working . . . on the installation and had returned to the hut. When he entered, he found that a pipe had become disconnected from the union on the pressure-reducing valve on the butane cylinder, and that butane was being released into the hut. He firmly reconnected the pipe but took no other precautions. After operating the electrical control for some 15 seconds there was an explosion in which he suffered serious burns.
>
> When the equipment was tested . . . it was found that the pressure gauge on the reducing valve was faulty and that the pressure in the system was somewhat higher than the gauge indicated. However, the installation itself was perfectly safe for the maximum pressure of some 4 atmospheres that could have existed in the system, *provided* that all the gas connections were properly made.. . . We concluded that at some time during the modifications to the equipment the pipe in question had been incorrectly connected to the union and had later become disconnected.

Even though the use of heavy flammable gases is not yet common at SLAC, everyone has had some experience with somewhat similar materials through their use of laboratory solvents such as acetone, ether, natural gas (mostly methane and ethane but with some propane and butane), liquified petroleum gas (mostly propane and butane), or gasoline. Because these are in common use does not mean that they are not hazardous. Various safety manuals typically describe these as *"highly flammable, dangerous fire and explosion risk."* Common commercial gas has been especially odorized to make leaks much easier to notice, but the gases we use at SLAC typically have only a faint odor.

In the past year or two, the Hazardous Experimental Equipment Committee (HEEC) has reviewed equipment which uses propane or isobutane in several experiments in the Research Area. These cases were brought to HEEC's attention by the experimenters or the engineers involved--which is the usual way HEEC finds out about such things. It is worth emphasizing that HEEC's effectiveness depends on being informed by responsible people who are involved with potentially hazardous experimental equipment. Small, temporary laboratory setups can be just as dangerous as the larger and more permanent experimental setups. HEEC will be happy to review or advise on any setup, although a HEEC review of course does not guarantee safety. I hope that no one avoids HEEC because it seems like too much unproductive red tape. If it does seem that way, I'd appreciate hearing about it.

--H. DeStaebler
X2416, Bin 96

NAL BECOMES FNAL

Official dedication ceremonies were held at the National Accelerator Laboratory, in Batavia, Illinois on May 11, 1974. At that time the name of the lab was formally changed to the Fermi National Accelerator Laboratory, in honor of the Italian physicist, Enrico Fermi, who did some of his most notable work at the University of Chicago. The proton synchrotron at FNAL is the largest accelerator now operating, having achieved a maximum beam energy of about 400 GeV. This machine has also recently attained a beam intensity near its design value, and a broad program of experimental research is now in full swing.

Want Ads

Note: The Beam Line is scheduled to appear each month, hopefully on about the 10th day. We'll try to have a regular Want Ad section. Please send ads to Dorothy Ellison, Bin 20, x2723. If possible, the ads should be short, two- or three-liners.

NEW COMPUTATION CENTER CONSTRUCTION BEGINS

Construction of the new $2.9 million SLAC Computation Center began in July. The Comp Center will be a three-storey building of approximately 50,000 square feet, and it is expected to be ready for occupancy in September 1975. Located just east of the temporary structures which presently house SLAC's main computers, and directly across the loop road from the Central Lab Addition, the new Center will be the permanent home for the SLAC Triplex system (two new IBM 370/168 computers plus the older 360/91), for peripheral equipment and some smaller computers, and for the staff from the Stanford Center of Information Processing (SCIP) who are assigned to SLAC. The members of SLAC's own Computation Group will also move into the new building from their present quarters in the Central Lab.

The new Comp Center has been designed so that the first floor will be the "public" area, with dispatch, keypunch and storage facilities. The second floor will contain most of the computer machinery (more than $20 million worth), and access to this area will be on a controlled basis. The third floor will be mostly offices, with provisions for some of the smaller equipment.

SCIP's Mel Ray was responsible for much of the functional planning and conceptual design of the building. SLAC's Plant Engineering Department coordinated the overall design and also carried out the detailed mechanical and electrical engineering work. The PE people involved include Glenn Tenney, Project Engineer; Morris Beck, mechanical design; Alex Tseng, electrical design; and Fred Hall, general supervision. PE is also managing the actual construction.

Letters to the Editor

Note: We'd like to get Letters to the Editor. If we have space, we'll print anything that seems interesting. There's only one ground rule: we'll print anonymous letters, but only if the Editor knows who the writer is. We'd prefer SLAC rather than non-SLAC topics, and criticism or opinion rather than straight fact. But try us anyhow--Bill Kirk, Bin 80.