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April 8, 1952

Berkeley, California

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Radiation Laboratory, Department of Physics
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April 8, 1952

Meeting of January 10

I. An Experiment to Detect Direct Pair Production by Electrons. R. F. Post

This experiment had been performed at Stanford University by the speaker and N. S. Shiren. It is to be the subject for an article in the Physical Review in the near future. The following summary is quoted from the BULLETIN of the American Physical Society covering its 1952 annual meeting at Columbia University, New York City, held Jan. 31, Feb. 1 and 2, 1952:

"25-Mev electrons from a linear electron accelerator have been used in an experiment to detect direct pair production by electrons. Care was taken to obtain a beam uncontaminated by x-rays. The targets used were thin enough to make indirect effects negligible. The experimental method consisted of the identification of 511-kev annihilation radiation produced by positrons in a Be stopper placed at various angles with respect to the beam incident on the target. Identification was accomplished by using a "positron counter" described elsewhere, (R. F. Post, Phys. Rev. 83, 886, 1951) which used NaI scintillation counters and operated by establishing the simultaneity, 180° angular correlation, and energy of the radiation from the stopper. Using a 0.006 inch Al target, measurements at 25° and 35° indicated the presence of positrons, but in an amount not statistically significant compared to background. However, from these data a statistically significant limit on the cross section may be deduced. Depending on the angular distribution assumed for the positrons, an upper limit is found for the total cross section which is equal to or less than theory."

Meeting of January 17

I. Electron Radiation in the Synchrotron. J. W. Mather

Subsequent to the time of this talk the author has submitted a report covering the subject; UCRL-1742 entitled "Experimental Evidence for Classical Electron Radiation", March 28, 1952. By way of a summary the introductory paragraph and other passages are quoted as follows:

"In a recent paper, Parzen has given reasons for expecting quantum deviations from the well-known classical radiation calculations of Schwinger at high electron energies. An experiment, using the 320 Mev Berkeley synchrotron, was proposed by E. M. McMillan to determine whether the quantum mechanical correction, as suggested by Parzen, should be made to the classical radiation formula at electron energies of about 300 Mev. The method involves measuring a particular time on the decreasing portion of the magnetic cycle, after the radio frequency accelerating voltage has been turned off, when the rate of shrinkage of the electron orbit (which is due to electron radiation) is just compensated by an expansion of the electron orbit caused by the negative rate of change of magnetic field.

"..... Thus, by varying the r.f. turn off, and therefore the electron energy, it is possible to reach a particular time (in the magnetic cycle) when the gain in radius due to the change of magnetic field just cancels the loss in radius because of radiation. The cancellation of these orbit motions occurs at the internal target radius r_o at a particular time and can be interpreted as a turning point in the electron trajectory. The time at which the turning point is observed furnishes information from which the rate of radiation can be computed. .....

"The total rate of energy loss ..... involves

(a) Radiation loss by a relativistic electron in a circular orbit moving with constant velocity, as given by the classical expression

$$\dot{E}_{Radiation} = \frac{2\,e^2\,c}{3\,r^2}\left(\frac{E}{mc^2}\right)^4 \qquad (3)$$

where E is the total electron energy, m is electron rest mass and r is orbit radius.

(b) Coherent radiation due to electrons bunching in the orbit. ...

(c) Betatron action resulting from field flux linking the orbit. ...

"..... From the results ..... there seems little doubt of the validity of the classical expression, eq. (3), for electrons in the 300 Mev energy range."

II. Rochester High Energy Conference. L. Alvarez, C. Richman

Both L. Alvarez and C. Richman of UCRL attended the Rochester High Energy Conference sponsored by the University of Rochester, N. Y., on Jan. 11 and 12, 1952. Dr. Alvarez spoke using his notes mostly on the various theories and experiments presented at the conference on V particles. The details are not given here since the proceedings of the conference and the papers presented there are to be published.

Meeting of January 24

I. Rochester High Energy Conference. L. Alvarez, C. Richman

Both L. Alvarez and C. Richman of UCRL attended the Rochester High Energy Conference sponsored by the University of Rochester, N. Y., on Jan 11 and 12, 1952. Last week Dr. Alvarez spoke mostly on V particles. This week Dr. Richman spoke on the progress reported in meson physics and the theories submitted. The details are not given here because the proceedings of the conference and the papers which had been presented are to be published.

II. Gamma Ray Scintillation Spectroscopy. D. F. Martin

The following will be a short summary of the work carried on by the chemistry department during the last year. Since the greater majority of isotopes can be produced only in fairly small amounts the ideal device for the examination of gamma ray spectra is one that possesses inherently high absorption characteristics as well as high energy definition.

The gas proportional counter and the crystal diffraction spectrometer both have high energy definition but require very large amounts of activity. With the advent of scintillation counters the answer to the need of large amounts of activity was found but at a definite loss in energy definition. The following will serve as a comparison of the relative merits of each system. At 100 kev a gas proportional counter, filled with 40 cm of xenon and having an active length of 20 cm, counts approximately 10 percent of the incident gamma rays; while a 1 cm thick NaI crystal counts essentially 100 percent of the incident gamma rays. Furthermore at 750 kev the gas proportional counter yields less than 0.1 percent of the incident events while the NaI crystal counts around 24 percent of the events. In the region of 100 kev the proportional counter gives approximately 10 percent resolution while the scintillation counter gives about 20 percent resolution.

A few details concerning the component parts of the scintillation counter system are also given. The crystal used is NaI with a 0.1 percent thallium activator added. The crystals are cubic in nature and can be grown from a melt to yield large optically clear single crystals, which are easily cleaved to the right size. The crystal is composed of 85 percent iodine by weight and is very hydroscopic. The crystals oxidize slowly in air to liberate free iodine. These conditions demand protective measures to preserve the crystal surface.

The crystal emits a pulse of 0.25 μ sec duration and 4400Å wave length. The most difficult problem is that of energy resolution and how to improve it. There are three separate factors involved. The first is the optical coupling of the crystal to the photomultiplier. The light pulse is degraded due to multiple reflection from the reflector. If the reflector is aluminum this amounts to about 6 percent per reflection; if MgO is used it is about 3 percent per reflection. Since an optical interface exists between the crystal, the photomultiplier and the reflector (the index of refraction being 1.77 for NaI and about 1.5 for mineral oil and glass) a loss is suffered due to Fresnel transmission at the interface. Since this is

a function of the angle of incidence of the light a large portion of the light is lost due to internal reflection, especially in the region of the critical angle, 34.4° to the normal in the case of a crystal-air interface. Since there exists a small but definite loss in transmission due to absorption each internal reflection thus suffered degrades the pulse to a greater degree and contributes to the over all loss in definition of the system.

The second factor to be considered is the non-uniformity of the photosensitive surface. The average variation being around 10 percent over the surface. The correction of this defect is attempted either by using a crystal of a small size or by making the crystal surface diffused. The third factor is the inherent statistical variation of the electron multiplier, which is dependent upon the number of electrons incident.

There are two schools of thought with regard to the optical arrangement and it seems quite natural that they should be diametrically opposed. The system employing the optically clear cleaved crystal with a hemispherical reflector is due to R. Hofstaker and co-workers of Stanford; while P. R. Bell and co-workers of Oak Ridge advocate the use of a crystal that has been quite liberally sanded to give a diffused surface. The crystal is then surrounded with MgO as a reflector. Both systems and their variations seem to yield about the same results with the major exception that the diffused system allows the employment of larger crystals, a definite advantage at high energies.

It may be concluded that much remains to be learned concerning the systems' ideal coupling arrangement, and, that at the moment it is an art rather than a science.

Meeting of January 31

I. Neutral Meson Gamma Ray Spectra from Proton Bombardment of Carbon. W. E. Crandall

For this talk the speaker used his thesis of the same title and published as report UCRL-1637, Jan. 8, 1952. An abstract of this work which had been

published earlier as a separate report UCRL-1521, entitled "Analysis of Neutral Meson Gamma Ray Spectra From Carbon" by W. E. Crandall, K. Crowe, B. J. Moyer, W. K. H. Panofsky, R. Phillips and D. Walker, is quoted as follows:

"The gamma ray spectra for angles of observation of 0°, 47°, 90°, 133° and 180° from C targets bombarded by 345-Mev protons have been measured with a multichannel pair spectrometer (Aamodt, Hadley, and Panofsky, Phys. Rev. 81, 565 (1951)), and the spectrum obtained by averaging over all angles is compared with the expected spectrum arising from the decay of a neutral pion into two gamma rays. Uncertainties in the low-energy portion of the spectrum make a precise assessment of the symmetry properties difficult, but the contribution to the spectrum from nonneutral pion decay radiation does not need to be more than 2 percent of the observed radiation. If it is assumed that only decay of neutral pions contributes to the radiation observed, then the energy distribution of the neutral pion is derivable from the spectrum. The spectra for lower-energy proton bombardments have been measured for two supplementary angles of view of the target and, based on the observed angular dependence of the spectra for 345-Mev protons, the excitation function for neutral pion production is deduced."

II. Report on Synchrotron. G. M. McFarland

Certain operational characteristics of the synchrotron were described. The time rates of change of current in the magnet current and field are proportional, giving a peak current of 3000 amp and a field of 11,000 gauss. The magnet is biased to get away from starting transients. Boosters are used at 60, 75 and 90 microseconds after the oscillator is turned on to prevent early firing by taking care of the fact that the flux bars saturate too soon. However, some betatron beam is still seen. The oscillator is turned on for 8 milliseconds and then turned off. The magnet windings total 32 turns. There are two banks of capacitors totalling 1600 microfarads but only about 800 microfarads effective capacity with 20 kv across them.

The betatron phase of acceleration is the most critical of the three stages: injector, betatron and synchrotron. Radial oscillation is depended on to get the beam past the injector. At this point the use of a contractor and displacer has increased the beam intensity by a factor of two by aiding the beam to pass the injector.

When the oscillator is turned on the particles accelerate to full energy in various oscillating orbits due mostly to increasing mass in the synchrotron phase. The peak beam intensity signal shifts and varies, which necessititates a continual manual manipulation by the operator to keep the machine tuned at peak intensity. Everyone is interested in getting a more intense and steadier beam but this ultimately will involve more study of the early phases of the acceleration. An unusual incident occurred once when an operator obtained a signal three or four times larger than normal, but there was no beam.

A number of experiments are going on with injectors. Work is continuing to find why some injectors are better and give different patterns than others of identical construction.

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