5048

RECEIVED BY DTIC MAR 3 1969

There is no objection from the patent point of view to the publication or dissemination of this document
Patent Group (Brookhaven)

2/27/69

By.....
GEAL-1046

MASTER

LASER-INDUCED POLARIZED PHOTON BEAM
AT THE CAMBRIDGE ELECTRON ACCELERATOR

Preliminary Report

Richard H. Milburn
Jon R. Sauer
Charles K. Sinclair
Department of Physics
Tufts University

Mircea Fotino
Cambridge Electron Accelerator

November 15, 1968

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
and HARVARD UNIVERSITY

CAMBRIDGE ELECTRON ACCELERATOR

CAMBRIDGE 38, MASSACHUSETTS

DISCLAIMER

This report was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency Thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

DISCLAIMER

Portions of this document may be illegible in electronic image products. Images are produced from the best available original document.

附註：(1) 此項試驗係在 25°C 下進行。

[illegible]

ut revivabatur

011307

10150410 106 100613 10000000

LEGAL NOTICE

This report was prepared as an account of Government sponsored work. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

A. Makes any warranty or representation, expressed or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or

B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission, or employee of such contractor, to the extent that such employee or contractor of the Commission, or employee of such contractor, prepares, disseminates, or provides access to, any information pursuant to his employment or contract with the Commission, or his employment with such contractor.

CAMBRIDGE ELECTRON ACCELERATOR

HARVARD UNIVERSITY
42 OXFORD STREET
CAMBRIDGE, MASS. 02138

CEAL-1046

November 15, 1968

LASER-INDUCED POLARIZED PHOTON BEAM

AT THE CAMBRIDGE ELECTRON ACCELERATOR*

Preliminary Report

Richard H. Milburn, Jon R. Sauer[†], and Charles K. Sinclair

Department of Physics
Tufts University, Medford, Mass.

and

Mircea Fotino

Cambridge Electron Accelerator

Introduction

The scattering of laser optical photons on extreme relativistic electrons has been proposed¹⁻⁴ as a source of high-energy photon beams possessing both a high degree of polarization and a hard energy spectrum. The theory of the process has been thoroughly discussed¹⁻³ and will not be described here.

*Work supported by the U.S. Atomic Energy Commission under Contract AT(30-1)1984 with Tufts University and Contract AT(30-1)2076 with the President and Fellows of Harvard College.

[†]U. S. Steel Fellow 1966-68

fly

Subsequent experiments at the Cambridge Electron Accelerator⁵ and the Lebedev Institute^{6,7} have detected Compton back-scattered photons and have observed a counting rate and an energy spectrum consistent with theoretical predictions.

The development of laser-induced photon beams of intensity suitable for high-energy physics experiments is presently underway at the Cambridge Electron Accelerator and at the Stanford Linear Accelerator Center^{8,9}. The present report describes the technical characteristics and status of the CEA program.

Experimental Setup

Since it is desirable to have a long photon pulse for counter experiments, the beam of a normal-mode laser was brought into head-on collision with the internal electron beam so that the two beams can undergo multiple crossings. Maximum yields from this interaction are obtained when the beams are focused to the smallest possible cross sections and are oriented in such a way as to maximize the length of the common interaction volume, located in this case in a straight section of the accelerator. The mechanical and optical components of the experimental system incorporated in the synchrotron had to be designed taking into account the high-vacuum requirements imposed by accelerator operation and the fact that the synchrotron radiation in the median plane limits the domain within which delicate optical components can be safely placed.

The experimental setup can be described as consisting of (i) the injection tank, (ii) the laser, (iii) the detection system and (iv) the logic electronics. A schematic diagram of the experimental setup is shown in Fig. 1.

Injection

The laser head is mounted in the accelerator ring tunnel adjacent to straight section #38. The injection geometry is shown in Fig. 2. Maintenance of the polarization throughout the injection optical system and space limitations required that the light beam be first directed upwards. It then passes through two lenses: divergent L1 (plano-concave, $f_1 = -3.043$ in.), and convergent L2 (plano-convex, $f_2 = 14.8$ in.), and is deflected by two plane mirrors, M1 and M2. The deflection by M1 brings the beam into a horizontal plane before being injected into the accelerator perpendicular to the electron beam direction. The light beam is focused by the second lens L2, which is also the vacuum window for the straight section tank, and is deflected into the interaction region by mirror M2. The axis of lens L2 is $3/4$ in. above the median plane of the synchrotron. Lenses L1 and L2 are AR-coated and are made of radiation-resistant crown glass (Bausch & Lomb BSC-2) and have 1-inch and 2-inch clear apertures, respectively. Mirrors M1 and M2 have a multilayer dielectric coating adjusted for maximum reflectivity at the laser light wavelength and intersect most of the beam. Mirror M2 is mounted on a rigid

support having three degrees of freedom and adjustable, through bellows, from outside the vacuum tank. The bottom edge of mirror M2 is about 0.5 in. above the median plane to clear the electron-beam envelope at injection. The dimensions of the present system are such that the laser beam is focused on the electron beam about 50 cm upstream from mirror M2. The angle of intersection between the two beams is thus about 3° .

The injection straight section tank, in addition to the lens and mirror support mentioned above, includes several access flanges for the main vacuum system pump, an ionization gauge, three titanium sublimation booster pumps, a moveable metal curtain for optical alignment, and two viewing ports. All seals are made with 1/16 in. diameter lead wire. In the case of lens L2 the sealing surface is on the flat side; an annular lead pad shaped to the convex surface eliminates pressure stresses from the covering flange. Prior to installation in the accelerator ring, the injection tank was processed and treated for high-vacuum performance. It was first chemically etched. The tank body was twice baked out in its entirety, the first time to 250°C and the second to 200°C . The body of the main 300 l/sec Drivac triode-type ion pump (model PDV-300, Consolidated Vacuum Corp.) was also baked to 250°C by means of specially installed strip heaters. The lowest pressure statically attained after this processing

with only one titanium sublimation pump (515 l/sec, model 22 TP 212, General Electric Co.), was about 6.0×10^{-10} torr. Over longer periods of time the base pressure remained at the 10^{-9} torr level without bakeout or sublimation pump. After the tank was installed in the ring and under normal dynamic conditions, including outgasing produced by magnet heating, synchrotron radiation and the electron beam itself, the pressure remained stable in the range 2×10^{-8} to 6×10^{-8} torr. It was continuously monitored by a Varian ionization gauge (model UHV-14) and an automatic Granville-Phillips control unit (model 02, series 236).

An 1/8-in.-thick steel curtain inscribed with a two-dimensional grid of thin lines 0.050-in. apart was mounted above the interaction region and normally kept out of the beam. It could be lowered to intersect the trajectory of the laser and electron beams. The magnified image of the weld mark resulting from local melting produced by a few high-power laser pulses could be inspected through the optical system and the beam spot size thus determined to within 0.010 in.

The Laser

A ruby laser consisting of a laser head (Model LH8) and a power supply (Model LPS21A) manufactured by Raytheon Co. was modified for the requirements of this experiment. A closed-

circuit water chiller was incorporated to allow continuous operation at about 1 pps. The lasing element was a Verneuil ruby crystal ($n = 1.76$), 6-5/8 in. long and 3/8 in. in diameter, having the optic axis at 60° to its geometrical axis. The front face was uncoated and the rear face was anti-reflection coated to permit use of an external reflector, in this case a high-reflectivity multilayer dielectric mirror situated a short distance behind the ruby. The optical pumping was achieved by a single FX-47B-6.5 Xenon flashlamp located together with the ruby crystal in a silverplated, elliptical cavity. A continuous flow of dry nitrogen was maintained in the cavity during operation in order to protect the silver surface. Ruby, flashlamp and cavity were cooled by filtered, demineralized water at 1.2 gal/min.

During normal operation at about 1 pps and with input energies of about 2800 joules, new flashlamps yielded laser outputs in excess of 20 joules per pulse. As the lamps aged, the laser output decreased until it was reduced to 10 to 12 joules per pulse at the end of the lamp life (typically 25,000 to 35,000 firings). Output energies were measured with a cone bolometer (TRG Model 108).

The various components of the laser system were distributed in two appropriate locations as follows:

A) Adjacent to the Injection Tank:

1. The laser-head assembly, mounted on a steerable optical bench which pivoted about the image of lens L2 in mirror M1. Remotely controlled actuators produced displacements of the optical bench in two directions resulting in displacements of the focused laser spot over a region about 0.45-in. square in a plane perpendicular to the electron beam. The pivot arrangement insured that the laser beam was always aimed at the effective aperture defined by lens L2 and mirror M2 during steering. All this mechanism was mounted in a light-tight enclosure also containing the high-power trigger generator for the flashlamp, interlocks on the laser-head temperature and purge-gas system for the cavity, a high-voltage safety switch and an exposed photomultiplier covered by an interference filter tuned to $6943 \text{ \AA}$ and used to monitor the timing and relative intensity of laser light.

2. The pulse-forming network (PFN) for the flashlamp consisting of a three-section lumped constant transmission line having a total capacitance of 1740 μfd . The cabinet containing the PFN was mounted under a ring magnet girder (#38).

B) Control Station

1. The closed-circuit water chiller and recirculator. This was connected to the laser head by 120 feet of 1-in. diameter, thermally-lagged copper tubing. The laser-head temperature was maintained at about 22°C during steady operation.

2. The PFN charging unit. This constant-current, SCR-controlled variable-voltage supply was capable of charging the PFN to about 2400 V once a second.

3. The control and monitoring equipment. Chart recordings were continuously maintained of the PFN high voltage, the laser-head temperature, and the water-chiller input and output temperatures.

An extensive system of interlocks was provided wherever necessary for high-voltage, optical and laser-head safety.

The laser operation had no deleterious effects upon the vacuum. A transient pressure rise occurred only on one occasion when the coating on mirror M2 was blown off by an un-defocussed laser beam. The continuous impact of the pulsed laser beam on components of the accelerator (ceramic vacuum chamber, metal joints and flanges, access window) had no ill effects of any sort. There is no record of any emergency situation necessitating an interruption in accelerator running.

The laser was triggered by a signal suitably delayed after $B_{\min}$ by a CEA preset interval timer. Lasing started about 700 μsec after this trigger and was up to 1500 μsec long.

Detection System

The back-scattered photons emerge tangentially to the electron orbit and perpendicularly through a thin window (0.002-in. stainless steel) in the vacuum chamber of the accelerator. They are detected by a total-absorption Cerenkov counter located about 10 m downstream from the interaction region (see Fig. 1). It consists of a square array of four identical lead glass blocks, each 8 cm x 8 cm x 70 cm. The length corresponds to about $23 X_0$. Each block is viewed through the downstream end by a photomultiplier (Amperex XP 1031) and the four outputs are mixed into a common signal. The counter is shielded on all sides with lead bricks except for a 2 in. x 2 in. aperture in front. An iron absorber, 1/8 in. thick, is placed in front of the counter for filtering the synchrotron radiation emerging from the accelerator.

The alignment of the counter was most satisfactorily carried out by using the synchrotron radiation pattern associated with the accelerator straight section. The straight portion of the electron orbit, in which no synchrotron radiation

is emitted, results in an interruption of the mark left on a sensitive material (yellow adhesive tape) oriented transversely to the median plane and situated downstream from the thin window (see Fig. 3). The two lobes correspond to the two curved portions upstream and downstream from the straight section.

Additional shielding and collimation of the photon beam is provided by an aperture (1-in. wide) in a lead block (4-in. thick) located at C (Fig. 1) and by a moveable slit (1/4-in. wide) defined by two heavimet blocks (3-in. thick) located in front of the Cerenkov counter. In each running period the slit was used for determining the straight section tangent corresponding to the maximum of the bremsstrahlung from the residual gas. At the same time a small (1/4-in. x 3 1/2-in. x 1 1/4-in.) scintillation counter situated in front of the iron absorber helped determine the location of the synchrotron radiation minimum also corresponding to the straight section tangent. The counts recorded from the Cerenkov counter and from the small scintillation counter during a slit scan are shown in Fig. 4.

Electronics System

A block diagram of the electronics required by the detection and control system is shown in Fig. 5.

The output from the Cerenkov counter must be gated to (i) reduce the high electronic background noise, (ii) insure overlap with the laser pulse, (iii) prevent short-term pile-up at the input of the pulse stretcher, and (iv) impose an adequate dead time for the pulse-height analyzer (TMC Model 404 C). The signals from the Cerenkov counter, the laser monitor, and intermediate logic components were displayed on two oscilloscopes and/or counted by scalars. In spite of all precautions, certain portions of the acceleration cycle remained unsuitable for observation. Standard EG&G and LeCroy logic components were used throughout.

The laser system was operated entirely on a parasitic basis, using 1 pulse in 64 provided by the CEA pulse-sharing system. There was no evidence of interference with other simultaneous users. During the pulse assigned to the laser experiment, no orbit distortion (beam bump) was introduced. This reduced beam instabilities. Furthermore, the accelerating radio frequency was turned off late in the cycle to delay beam dumping and make the top of the cycle available for beam interactions.

Structure of the Laser Beam

The discharge of the pumping energy stored in the PFN results in a pulse 500-1500 μ sec long consisting of many spikes, each about 1 μ sec long. The time structure of a typical laser pulse is illustrated in Fig. 6.

The spatial structure of the beam was measured experimentally by scanning the beam with the bolometer stopped down by a small aperture (0.052-in. dia) in a block of pyrolytic graphite. Although the instantaneous structure of the beam may be rather complex, the spot envelope obtained from many bolometer scans at various distances from the front face of the ruby is about 0.180 ± 0.014 inches long and 0.080 ± 0.010 inches wide. A typical scan along the major axis taken at 1.4 m from the crystal face is shown in Fig. 7. The divergence of the beam was found to be (2.3 ± 0.2) mrad in the plane of the major axis and (4.5 ± 0.2) mrad in the plane of the minor axis. The major axis of the laser spot is perpendicular to the major axis of the pumping cavity, and thus parallel to the surface of the laser optical bench.

Direct information about the size of the laser beam spot in the interaction region was obtained by using the moveable steel curtain described earlier. The mark of local melting produced by 10 to 20 laser firings at normal power levels

(12-18 joules each) could be examined visually through the optical system used as a Gallilean magnifying telescope. The typical mark (see Fig. 8) exhibits a well-defined pit 0.030-0.050 inches across, surrounded by a rough annular region of obvious surface disturbance about twice this size.

The laser yields light with a high degree of linear polarization. Preliminary measurements with a high-power glan prism have indicated the polarization to be greater than 70%.

Structure of the Electron Beam

The CEA electron beam had a filling factor of 40-70% during most of the measurements reported here. Its cross-sectional size varies through the cycle and will be discussed below.

Since the electron beam position was found to change because of various unpredictable perturbations, the alignment of the clashing beams could be prepared only to a limited extent. The final overlap was attained by horizontal and vertical displacements of the laser beam. Once back-scattered photons were detected, these displacements were adjusted until the output from the Cerenkov counter was optimized.

In order to verify that the two beams had been properly aligned, slit scans were performed with and without the laser beam. The discriminators were set at 300-350 MeV level to eliminate the low-energy background. It is seen on Fig. 9 that the peak of the laser-induced beam coincides with the peak of the bremsstrahlung from the residual gas in the straight section.

It had been suggested earlier¹⁰ that the laser beam could be used for non-destructive probing of the accelerated electron beam structure. It was found convenient to determine the electron-beam profile by displacing the laser beam across the electron beam. Horizontal and vertical scans could be taken in a few minutes with very satisfactory reproducibility. Fig. 10 shows horizontal scans taken with 500 μ sec and 1500 μ sec gates overlapping the laser pulse and centered at the peak of the acceleration cycle. It should be noted that, as expected, the profile is independent of gate width.

The vertical profile of the electron beam cannot be obtained in a simple manner because the two beams intersect in the vertical plane. The portion of the divergent (or convergent) light beam intercepted in the interaction region by the electron beam changes during the vertical scan so that the resulting photon yield reflects a simultaneous and unequal

density variation in both beams. In fact, because the electron beam size is smaller than the conical light beam outside of the focal region, such a vertical scan almost represents a vertical scan of the laser beam by the electron beam. By appropriately modifying the optical system to inject the laser beam from the side and in the orbital plane of the electron beam, it would be possible to achieve also in the vertical plane the same direct and convenient scan now obtained in the horizontal plane.

The timing of the gate allows probing the electron-beam profile at arbitrary times during the acceleration cycle. A narrower gate is preferable for this case in order to minimize energy dispersion. The two curves in Fig. 11 were taken with a 500 μ sec gate centered at the 5.65 GeV and 3 GeV levels in a 6 GeV beam. At 5.65 GeV, the beam is wider (0.100 in., FWHM) than at 3 GeV (0.070 in., FWHM), in qualitative agreement with theory and other experimental evidence, while at the same time it is displaced outward by about 0.020 in. Because at 3 GeV the cross section of the electron beam is comparable to the laser beam, it is likely that the measured FWHM represents an overestimate of the horizontal profile. It should be possible to improve this measurement by reducing the laser aperture

and thus the focal spot size, while retaining sufficient photon intensity for scanning.

Distortions of the electron orbit can also be conveniently analyzed by laser-beam scanning. Figure 12 illustrates the small modification of the orbit introduced intentionally by a quadrupole perturbation in the magnetic field.

The electron beam is characterized as occupying a certain volume of four dimensional phase space. Typically the parameters specifying this volume are electron position and angle in each of two orthogonal planes transverse to the equilibrium orbit. Generally speaking, the density of electrons in this phase volume is not uniform. In principle, by using a laser beam brought to a point focus, and an infinitely fine slit before the Cerenkov detector, one could sample the electron density at any point in this phase volume. Furthermore, by scanning the laser focus and the slit in a plane, one could map out completely the two dimensional phase area associated with that plane. In practice the laser focus was scanned through the electron beam in a horizontal plane, and the yield detected in the Cerenkov counter for each of five locations of a 1/4" slit placed before the counter 9.6m from the interaction region. The results are shown in Fig. 13, along with an inset

indicating the slit size, the laser beam spot size, and the theoretical phase ellipse in this plane. The results are suggestive, but clearly the resolution was much too poor to yield interpretable results. It is evident that it would be desirable to continue these investigations using a somewhat smaller laser focus and a considerably narrower slit, or preferably a more distant slit. If the electron beam phase volume may be represented by an uncoupled ellipse in each plane, it would appear possible to measure the degree of shearing and estimate the eccentricity by this method.

The Back-Scattered Photon Beam

As described earlier, the photons are detected in the present system by the total-absorption Cerenkov counter, and their energy determined by pulse height analysis. The dimensions of each individual lead-glass block correspond to the absorption of more than 99% of the electromagnetic shower developed axially by a 6-GeV photon. The entire counter was initially calibrated between 800 MeV and 5 GeV in a low-intensity positron beam available at CEA and its response found to be very satisfactory. For this experiment, since it was very inconvenient to move the counter to another location during data taking, the knee of the background radiation, which at the high-energy end represents very closely the bremsstrahlung from the residual

gas in the accelerator straight section, was used for energy determinations in situ. At the low-energy end the spectrum of the background radiation is higher than the normal bremsstrahlung because of contributions most likely from showers developed in the vacuum chamber by stray electrons. Most of this contribution could be eliminated by setting the cut-off level at 100-150 MeV. With circulating electrons of given energy, different values of the knee were obtained by timing a 100- μ sec gate at various times in the accelerator cycle (Fig. 14). In this way consistency checks and calibrations at lower energies were obtained (Fig. 15).

The photons obtained by back-scattering of optical photons on relativistic electrons have an energy distribution differing from normal bremsstrahlung in that it is significantly enhanced at the high-energy end.^{1,2} For the case under study, the energy of the back-scattered photons from 6 GeV electrons and 1.79 eV light photons extends up to a maximum of 848 MeV. If taken at low laser intensity, the measured spectra are in qualitative agreement with the theoretical results in that a high-energy peaking is clearly observed which falls off rapidly above the kinematically allowed value. The results shown in Fig. 16 were obtained with 2 joules per laser pulse and 5.5 mA circulating electron beam. At higher beam intensities, the

high-energy peaking disappears and the spectrum extends beyond the value permitted by kinematics (Fig. 17). Considering the discrete structures of both beams, i.e. the spikes of the light output and the rf buckets of the electron beam, this effect is probably due to an accumulation of several photons during a time shorter than the overall resolving time of the analyzing system (200 nsec) and resulting in longer or larger output pulses from the photomultiplier. This situation was confirmed by direct oscilloscope observation of pile-up in the Cerenkov counter output and by saturation of 100 MHz scalars.

Under such circumstances it becomes difficult to make the absolute rate measurements needed in scattering experiments. Improvements could be achieved by reducing the beam intensities, by decreasing the resolving time of the counter, or by integrating the detector pulses during the 1 msec laser output.

Yield

Using the relevant injection parameters, the experimentally determined values of the laser beam cross section and the electron beam dimensions, it is calculated that the back-scattered photon yield over the entire energy spectrum is:

$$Y_{calc} = 90-95 \text{ photons per mA (electron beam) per joule (laser light)}$$

The measured yield was:

$$Y_{\text{meas}} = 30-45 \text{ photons per mA (electron beam) per joule (laser light)}$$

The overall system efficiency thus appears to be 30-50% and is believed to be primarily a consequence of losses in the optical system from limited apertures.

Conclusions

This experiment represents the continuation of work initiated at CEA in 1964 with the identification of back-scattered photons⁵. It shows that it is possible to obtain routinely beams of such photons for use in certain high-energy experiments in which low intensities are compensated by a high degree of polarization and a harder energy spectrum. The present level of a few thousand photons per pulse is more than satisfactory for bubble chamber applications. The present location of this beam is unfavorable for counter experiments, due to a high background, but a workable condition can be attained by installing the counters in a well-shielded area away from the accelerator ring.

The output intensity could be increased by several approaches:

- (i) higher beam intensities, (ii) a better ruby rod giving up to 10 times greater brightness, (iii) improved cavity and

flash-lamps, (iv) use of mirrors to make the laser beam cross the interaction region several times, and (v) use of a plunging or rotating mirror (inside the vacuum tank) which could be brought closer to the orbit at the end of the accelerator cycle, thus decreasing the crossing angle of the two beams and consequently increasing the length of the interaction region.

The applicability of the laser beam as a non-destructive probe for beam studies has been demonstrated by measuring the distribution of particle densities in space and time. It would be possible to modify the present system to obtain similar scanning capabilities in vertical direction. At the same time it is concluded that measurements of electron beam angular distribution can also be conveniently performed, and that the whole electron phase space can thus be determined.

Finally attention is drawn to the applicability of this technique to similar beam studies in electron and possibly proton storage rings and particularly to the analysis of interacting beams in regions inaccessible by other methods.

REFERENCES

- ¹ Richard H. Milburn, Phys. Rev. Letters 10, 75 (1963).
- ² F. R. Arutyunian and V. A. Tumanian, Phys. Letters 4, 176 (1963).
- ³ F. R. Arutyunian, I. I. Goldman and V. A. Tumanian, Zh. Eksper. Teor. Fiz. 45, 312 (1963) translation: Soviet Physics JETP 18, 218 (1964).
- ⁴ Richard H. Milburn, SLAC Report No. 41, May 1965.
- ⁵ C. Bemporad, R. H. Milburn, N. Tanaka and M. Fotino, Phys. Rev. 138B, 1546 (1965).
- ⁶ O. F. Kulikov, Yu. Ya. Telnov, E. I. Filippov and M. N. Yakimenko, Phys. Letters 13, 344 (1964).
- ⁷ O. F. Kulikov, Yu. Ya. Telnov, E. I. Filippov and M. N. Yakimenko, Pribery i Tekhnika Eksperimenta, No. 4, 14 (1967).
- ⁸ J. J. Murray and C. K. Sinclair, private communication.
- ⁹ J. J. Murray and P. R. Klein, SLAC-TN 67-19, June 1967.
- ¹⁰ R. H. Milburn, B. F. Stearns, R. F. Walker, Jr., and M. Fotino, Proposal for Polarized Photon Beam, submitted to CEA Scientific Committee, Jan. 15, 1966 (unpublished).

NOT TO SCALE

FIG. 1 - SCHEMATIC DIAGRAM OF EXPERIMENTAL SETUP

FIG. 2 - LASER INJECTION GEOMETRY

FIG. 3 - TYPICAL SYNCHROTRON RADIATION PATTERN FROM
AN ACCELERATOR STRAIGHT SECTION (LOOKING
DOWNSTREAM)

FIG. 4 - BREMSSTRAHLUNG FROM RESIDUAL GAS AND SYNCHROTRON RADIATION AT THE LOCATION OF THE CERENKOV COUNTER

FIG. 5 - BLOCK DIAGRAM OF ELECTRONICS SYSTEM

5 μ SEC/CM

200 μ SEC/CM

FIG. 6 - TIME STRUCTURE OF THE LASER PULSE

FIG. 7 - LASER OUTPUT PROFILE ALONG THE MAJOR AXIS, TAKEN THROUGH 0.052-IN. PINHOLE IN FRONT OF THE BOLOMETER AT 1.4 M FROM THE CRYSTAL FACE

FIG. 8 - SPOT PATTERN OF THE LASER BEAM
IN THE INTERACTION REGION

FIG. 9 - SLIT SCAN AT CERENKOV COUNTER ENTRANCE

COUNTS
MA-SEC

FIG. 10-- ELECTRON BEAM PROFILE WITH DIFFERENT GATE WIDTHS

FIG. 11 - HORIZONTAL LASER SCAN OF THE ELECTRON BEAM GATED AT DIFFERENT TIMES IN THE ACCELERATION CYCLE (BACKGROUND SUBTRACTED)

COUNTS
MA-SEC

FIG. 12 - MODIFICATION OF THE ELECTRON BEAM INDUCED BY A QUADRUPOLE PERTURBATION IN THE MAGNETIC FIELD

FIG. 13 - HORIZONTAL LASER SCANS OF THE ELECTRON BEAM WITH THE SLIT IN FIVE DIFFERENT POSITIONS (BACKGROUND SUBTRACTED). BASELINE DISPLACED IN EACH CASE.

FIG. 14 - PORTIONS OF BREMSSTRAHLUNG SPECTRA GATED AT (A) 6.85 MSEC,
(B) 6.55 MSEC AND (C) 6.35 MSEC BEFORE PEAK OF ACCELERATION
CYCLE

FIG. 15 - CALIBRATION OF THE CERENKOV COUNTER BY THE KNEE OF THE BREMSSTRAHLUNG SPECTRA FROM THE RESIDUAL GAS

FIG. 16 - ENERGY SPECTRUM OF BACK-SCATTERED PHOTONS AT LOW BEAM INTENSITIES
(BACKGROUND SUBTRACTED)

FIG. 17 - ENERGY SPECTRUM OF BACK-SCATTERED PHOTONS AT HIGH BEAM INTENSITIES
(BACKGROUND SUBTRACTED)

LEGAL NOTICE

This report was prepared as an account of U. S. Government sponsored work under the auspices of the U. S. Atomic Energy Commission. Neither the United States, nor the Commission, nor any person acting on behalf of the Commission:

- A. Makes any warranty or representation, express or implied, with respect to the accuracy, completeness, or usefulness of the information contained in this report, or that the use of any information, apparatus, method, or process disclosed in this report may not infringe privately owned rights; or
- B. Assumes any liabilities with respect to the use of, or for damages resulting from the use of any information, apparatus, method, or process disclosed in this report.

As used in the above, "person acting on behalf of the Commission" includes any employee or contractor of the Commission to the extent that such employee or contractor prepares, handles or distributes, or provides access to any information pursuant to his employment or contract with the Commission.

* * * * *