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SUMMARY OF RESEARCH OPERATIONS
AT THE CAMBRIDGE ELECTRON ACCELERATOR
M. Stanley Livingston, Director

January 20, 1966

RELEASED FOR ANNOUNCEMENT
IN NUCLEAR SCIENCE ABSTRACTS

MASSACHUSETTS INSTITUTE OF TECHNOLOGY
and HARVARD UNIVERSITY

CAMBRIDGE ELECTRON ACCELERATOR

CAMBRIDGE 38, MASSACHUSETTS

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CAMBRIDGE ELECTRON ACCELERATOR

HARVARD UNIVERSITY
42 OXFORD STREET
CAMBRIDGE 38, MASS.

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A. Scheduled Accelerator Operating Time for Prime Users (in hrs.):

Scientific Users:	<u>No. of groups:</u>	<u>Calendar 1964:</u>	<u>Calendar 1965:</u>	<u>(Estimated) 1966:</u>
Mass. Inst. of Tech.	5	1121	669	(1200)
Harvard University	5	1085	685	(1200)
Bubble Chamber(joint)	1	196	-	-
Other Universities*	5	820	23	(1000)
CEA Res. & Develop.	-	521	547	(600)
Totals	16	3743	1924**	(4000) hrs

* Other user groups come from Yale, Northeastern, Tufts, Southeast. Mass. Tech. Inst., and CEA scientific staff.

** Operations were suspended from May 6-26 and from July 5 to December 31 due to a fire in the linac on May 6 and a bubble chamber explosion on July 5.

B. Scientific Users of the CEA:	<u>1965</u>	<u>(Estimated) 1966</u>
Professors	29	(26)
Post-Doctoral	38	(28)
Graduate Students	<u>61</u>	<u>(50)</u>
Total Professionals	128	(104)
Technicians and Undergrad.	<u>59</u>	<u>(60)</u>
Total in user groups	187	(164)

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SUMMARY

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C. Number of Publications, etc. (1964-1965):

Publications in scientific journals	- 24
Papers at Conferences and Meetings (published in the proceedings)	- 34
Doctoral Theses	- 12
	<hr/>
Total	- 70
Number of scientists' names on published papers	- 108

D. Experimental Program at the CEA (1964-1965):

1. Electron-Proton Scattering. Profs. Richard Wilson,
N. F. Ramsey et al.

The purpose of this experimental program is to determine the charge and magnetic distributions within the proton and neutron, through studies of elastic scattering of electrons in hydrogen and deuterium targets. The incident energy and scattering angle are varied to cover a wide range of momentum transfer. Results show the charge and magnetic distributions to be uniform and continuous through the center of the proton; with the neutron the magnetic distribution is uniform and the charge is zero. These studies confirm the conclusion that the proton has no central charge or magnetic core. An interesting and as yet unexplained result is that the ratio of the electric to the magnetic form factor is equal to the magnetic moment of the proton. Further studies are planned of inelastic scattering to identify and measure the excitation states of nucleons, and to study the pion form factor.

Publications:

"Electroproduction of Protons at 1 Bev and 4 Bev", K.W. Chen, J.R.Dunning, Jr., J.R.Rees, W.Shlaer, J.K.Walker, R.Wilson, Physical Review, -- 135, B1030, Aug. 1964.

"Elastic and Inelastic Electron Scattering from the Proton and Deuteron", K.W.Chen, A.A.Cone, J.R.Dunning, Jr., G.Hartwig, N.F.Ramsey, J.K.Walker, R.Wilson, Internat. Conf. Hi.En. Phys. Dubna, Aug. 1964.

"Inelastic Electron-Proton Scattering at High Momentum Transfers", A.A.Cone, K.W.Chen, J.R.Dunning, Jr., N.F.Ramsey, J.K. Walker, R.Wilson, G. Hartwig, Bull. Am. Phys. Soc. II-9-4, April, 1964.

"Electromagnetic Structure of the Neutron and Proton", J.R.Dunning, K.W.Chen, A.A.Cone, G.Hartwig, N.F.Ramsey, J.K.Walker, R.Wilson, Phys. Rev. Letters, 13, #21, 23 November, 1964.

"Baryon Spectroscopy by Inelastic Electron-Proton Scattering", A.A.Cone, K.W.Chen, J.R.Dunning, Jr., G. Hartwig, N.F.Ramsey, J.K.Walker, R.Wilson, Phys.Rev.Letters, 14, #9, 1 March, 1965.

"Quasi-elastic Electron-Deuteron Scattering and Neutron Form Factors", J.R.Dunning, Jr., K.W.Chen, A.A.Cone, G.Hartwig, N.F.Ramsey, J.K.Walker, R.Wilson, Phys.Rev., January 1966 (in print).

"Nucleon Form Factors and their Interpretation", J.R.Dunning, Jr., K.W.Chen, A.A.Cone, G.Hartwig, N.F.Ramsey, J.K.Walker, R.Wilson, Phys. Rev., January 1966 (in print).

"Measurement of Proton Electromagnetic Form Factors", J.R.Dunning, Jr., K.W.Chen, A.A.Cone, G.Hartwig, N.F.Ramsey, J.K.Walker, R.Wilson, Phys. Rev., January 1966 (in print).

2. Photoproduction of Electron Pairs. Prof. F.M. Pipkin et al.

This experiment is designed to test the validity of quantum electrodynamics (QED) at very short interaction distances, by observing wide-angle, symmetrical electron pairs produced by photons in a carbon target. High incident energy and wide angles (5° to 8°) are needed for large momentum transfers. Observation of symmetrical pairs with coincidence techniques simplifies the theoretical analysis. With a carbon target having zero spin only

the electric form factors are involved in the theoretical prediction of cross section. Early studies suggested a 50% increase of cross section above that predicted from QED at the largest momentum transfers. Further studies are required to determine whether this result is valid. Other experiments are planned for studies of mu mesons, K-mesons, and other particles.

Publications:

"A Deviation from Simple Quantum Electrodynamics", R.B.Blumenthal, D.C.Ehn, W.L.Faissler, P.M.Joseph, L.J. Lanzerotti, F.M. Pipkin, D.G.Stairs, Phys. Rev. Letters, 14, #16, April 19, 1965.

"High Energy Photoproduction of Neutral Rho Mesons", L.J.Lanzerotti, R.B.Blumenthal, D.C.Ehn, W.L.Faissler, P.M.Joseph, F.M.Pipkin, J.K.Randolph, J.J.Russell, D.G.Stairs, J.Tenenbaum, Phys.Rev. Letters, 15, #5, August 2, 1965. (also Hamburg Conference, 6/65)

"Nucleon Form Factors and Evidence for the Validity of QED at Small Distances", F.M.Pipkin, Oxford Conference, Sept. 19, 1965.

"Wide Angle Electron Pair Production", R.B. Blumenthal, D.C.Ehn, W.L.Faissler, P.M.Joseph, L.J.Lanzerotti, F.M.Pipkin, D.G.Stairs, Physical Review (submitted October 1965).

3. Photoproduction of Mesons. Prof. L.S. Osborne, et al.

Cross sections for the photoproduction of pions and other mesons from a hydrogen target have been measured over a wide range of photon energy and angular distribution. The overall behavior of the cross sections is a rapid decrease with increasing energy and increasing angle, complicated by peaks and shoulders due to resonances and multi-particle production. Four of the known resonances (at 1.69, 1.92, 2.19 and 2.36 Gev) can be identified. A higher energy resonance is observed at 2.75 Gev, interpreted as leading to the production of η -mesons, which then decay into three

pions. The primary reaction for incident energies from 1 to 2 Gev is the production of single π^0 -mesons; $\pi^\pm$ -mesons are also produced with high yields. Analysis of the η -meson production suggests further experiments to confirm the predictions of special unitary group theory.

Publications:

"Photoproduction of π Mesons between 0.9 and 4.0 Bev", R.Alvarez, Z.Bar-Yam, W.Kern, D.Luckey, L.S.Osborne, S.Tazzari, R.Fessel, Phys.Rev. Letters, 12, #25, June 22, 1964.

"Evidence for Two New Resonances in the π -Nucleon System", R.Alvarez, Z.Bar-Yam, W.Kern, D. Luckey, L.S.Osborne, S.Tazzari, R.Fessel, Phys. Rev. Letters, 12, #25, June 22, 1964.

"Photoproduction of Charged and Neutral π Mesons", J.R.Uglum, R.Alvarez, Z.Bar-Yam, D. Garelick, S.Homma, W.Kern, R.Lewis, D. Luckey, L.S. Osborne, R.Fessel, Bull. Am. Phys. Soc. II-10-4, April 1965.

"Photoproduction of Neutral Pions at Gev Energies", R.Alvarez, Z.Bar-Yam, D. Garelick, S.Homma, W.Kern, R.Lewis, W.Lobar, L.S. Osborne, J.Uglum, R.Fessel, Hamburg Conference, June 1965.

"A Photoproduction Experiment Using a Small Computer", R.Alvarez, Z.Bar-Yam, D.Garelick, S. Homma, W. Kern, R. Lewis, D.Luckey, L.S. Osborne, J.Uglum, R.Fessel, IEEE Transactions, NS-12-4, August 1965.

4. Electron-Deuteron Scattering. Profs. J.I. Friedman, H.W.Kendall et al.

High Energy electrons which are elastically scattered by the deuteron as a whole, as distinguished from scattering from the individual nucleons, have been studied to determine the form factor of the deuteron. This work was done with a liquid deuterium target in the synchrotron ring and a spectrometer arm in the Target Area. The data over the entire range of four momentum transfer agree with theoretical prediction based on a neutron-proton interaction with a repulsive core.

The equipment was also used to search for a heavy electron (e-particle) in the inelastic scattering of electrons from hydrogen, which was suggested as a theoretical possibility by Prof. F.E.Low; the result was negative.

Publications:

"Wide Angle Photoproduction of MU Pairs", J.K.dePagter et al, Phys. Rev. Letters, 12, June 29, 1964.

"Determination of the Branching Ratio for the Decay of Rho Mesons into Muon Pairs", J.K.dePagter et al, Phys. Rev. Letters, 16, January 3, 1966.

"Wide Angle Photoproduction of Mu Pairs", J.I.Friedman, Internat. Conference on High Energy Physics, Dubna, 1964.

"Elastic Electron-Deuteron Scattering", H.W.Kendall, Internat. Conference on High Energy Photon and Electron Interactions, DESY, Hamburg, 1965.

5. Photoproduction with 12-inch Liquid Hydrogen Bubble Chamber.

Cambridge Bubble Chamber Group.

In the spring of 1964, over 800,000 useful photographs were taken of the 12-inch hydrogen bubble chamber exposed to a photon beam containing photons with energy from .05 to 6 BeV. All of the interesting events contained in these pictures have been analyzed, and as a result we now have an overall picture of the photon-photon interaction, including the previously unexplored 1-6 BeV region. The two charged pion production process proceeds mainly through isobar production below 1.5 BeV, and through ρ -meson production above this energy. ω -meson production is considerably lower than ρ -meson production. The cross section for strange particle production is about 10% of the overall cross section of 100 μ barns for observed events. Detailed information on energy

dependence, angular distribution and polarization of the ρ -mesons has been obtained which is consistent with diffraction production but not with one-pion exchange production.

Publications:

by Cambridge Bubble Chamber Group: H.R.Crouch, R.Hargraves, B.Kendall, R.E.Lanou, A.M.Shapiro, M.W.Shapiro, G.E.Fischer, C.Bordner, A.E.Brenner, M.E.Law, U.Maor, T.A.O'Halloran, Jr., K.Strauch, J.C.Street, J.J.Szymanski, D.Rudnick, R.Bastien, B.T.Feld, V.K.Fischer, I.A.Pless, A.Rogers, C. Rogers, E.E.Ronat, L.Rosenson, T.L.Watts, R.K. Yamamoto, G.Calvelli, F.Gasperini, L.Guerriero, J.Massimo, G.A.Salandin, L.Ventura, C.Voci, F.Waldner, A.Bradstetter, Y.Eisenberg, A.Levy.

"N* and Rho-Zero Production by High Energy Photons", Phys. Rev. Letters, 13, 640 November 1964.

"Gamma-Ray Proton Interactions Between 0.5 and 4.8 BeV", Phys. Rev. Letters, 13, 636, November 1964.

"Three-Pion Production in a 5-GeV Bremsstrahlung Beam", Bull. Am. Phys. Soc. II-9, 1964.

"Pion-Pair Production in a 5-GeV Bremsstrahlung Beam", Bull. Am. Phys. Soc., II-9, 1964.

"Photonucleon Interactions in a 5-GeV Bremsstrahlung Beam", Bull. Am. Phys. Soc., II-9, 1964.

"Multiple Pion and Strange Particle Production in Gamma Ray-Proton Interactions between 0.5 and 4.8 GeV", Dubna Conference, Aug.1964.

At 1965 Hamburg Conference on Electron and Photon Interactions at High Energies:

- (1) "Cross Sections and Particle Distributions"
- (2) "Strange Particle Production"
- (3) "Vector Meson Production"
- (4) "Nucleon Isobar Production"
- (5) "Multipion Production and other Complex Reactions"

"High Energy Photoproduction of nucleon and pionic Resonances", Athens Conference on Resonant Particles, June 1965.

Invited Papers on "Photon-Hydrogen Interactions in the Range 0.5-5 BeV", 1965 Washington Meeting, Am. Phys. Soc.

- (1) "Cross Sections and Particle Distributions", J.Szymanski
- (2) "Production of Baryon and Meson Resonances", E.Ronat, Bull. A. Phys. Soc. II-10, 1965.

"The ρ and ω Meson Photoproduction at CEA", invited paper, Yerevan Summer School, Yerevan, Armenia, K. Strauch, 1965.

"Photoproduction of N^{**} and Eta Mesons", Invited paper, Yerevan Summer School, Yerevan, Armenia, I. Pless, 1965

"Photoproduction of Particles at High Energy", Invited paper, Yerevan Summer School, Yerevan, Armenia, V.K. Fischer, 1965.

6. Photoproduction of Mu-Pairs. Prof. R. Weinstein, et al.

A study of the photoproduction of mu-pairs from a carbon target using a 5-Gev bremsstrahlung beam provides a test of the validity of quantum electrodynamics (QED) for large momentum transfers. The yield of mu-pairs was observed as a function of incident energy, muon energy and angle of emission up to $\pm 15^\circ$. The results are in agreement with the predictions of QED at values of momentum transfer about 10 times larger than had previously been attained in pair-production processes.

Publications:

"Wide-angle Photoproduction of Mu-pairs", J.K.dePagter, A.Boyarski, G.Glass, J.I.Friedman, H.W. Kendall, M.Gettner, J.F.Larrabee, R. Weinstein, Phys. Rev. Letters, 12, #26, June 29, 1964.

"Search for Rho-meson Decay into Muons", A.Boyarski, G.Glass, R.C.Chase, M.Gettner, Phys. Rev. Letters, 13, #21, Nov. 22, 1965.

"Determination of the Branching Ratio for the Decay of Rho-mesons into Muon Pairs", J.K.dePagter, J.I.Friedman, G.Glass, R.C.Chase, M. Gettner, E.von Goeler, R. Weinstein., Phys. Rev. Letters, 16, #1, January 3, 1966.

7. Photoproduction of Charged Pions and K-mesons. Prof. V.W. Hughes, et al.

Studies have been made of photoproduction cross sections of charged pions and kaons with incident energies of 3 to 6 Gev, at relatively large laboratory angles of 5° to 10° . The associated photoproduction of K^+ mesons shows evidence for neutral Y^* states with masses greater than 1900 Mev. Continuation of the experiments with improved apparatus is planned, to study the masses and energy widths of excitation states up to 2.7 Gev.

Publications:

"Photoproduction of Charged Pions in H and C at 4.5-6 Gev," R.C. Minehart, W.A. Blanpied, J.S. Greenberg, V. W. Hughes, P. Kitching, D.C. Lu, Bull. Am. Phys. Soc. II-10-1, January 29, 1965.

"Photoproduction of Charged K-mesons in Hydrogen", P. Kitching, W.A. Blanpied, S. Greenberg, V.W. Hughes, D.C. Lu, R.C. Minehart, Bull. Am. Phys. Soc. II-10-1, 29 January 1965. Also presented at Hamburg Conference, August 1965.

8. Production of Pions by Tagged Photons. Prof. D.O. Caldwell, et.al.

Photoproduction of Pions has been studied for both elastic and inelastic processes by using photons of known energy. In such interactions the "missing mass" of the particles produced with the pion, and the momentum transfer from the photon to the pion, can both be determined with good accuracy. Analysis provides information on the mechanisms of the production processes. Photon energy is determined by an apparatus in which monoenergetic positrons impinge on a thin radiator and the recoiling positrons are momentum-analyzed and detected in a 19-counter hodoscope. Coincidence measurements of the recoil positron momentum with the pion produced in a hydrogen target by the photon are used to identify the incident photon energy.

Publications:

"Tagging System for High Energy Photons", D.O.Caldwell, J.P.Dowd, K.Heinloth, M.D.Rousseau, Rev. Sci. Instr. 36, 283 (March 1965).

"Production of Charged Pions by Tagged Photons in the 2 - 5 Gev Range", D.O.Caldwell, J.P.Dowd, K.Heinloth, T.R.Sherwood. Hamburg Conference, June 8, 1965.

"Production of Charged Pions by Tagged Photons of 2 to 5 Gev". D.O.Caldwell, J.P. Dowd, T.R.Sherwood, Bull. Am. Phys. Soc., Honolulu Meeting, Sept. 2, 1965.

9. Production of Polarized Photons with a Laser. Prof. R.H.Milburn, et al.

A beam of red light from a ruby crystal laser (2 ev) is directed by a thin mirror to make head-on interactions with high energy electrons of the circulating beam in the CEA. With 6-GeV electrons the Compton scattered photons have a peak energy of 0.85 Gev and are highly polarized in the plane of polarization of the laser light; they emerge (through the mirror) in a tangential direction within a narrow cone. The high-energy and presumably polarized photons have been detected, using a laser delivering about 0.2 joules in pulses coinciding with peak energy in the synchrotron, at 60 cps. Plans involving a much higher power laser are in process, to produce photon intensities sufficient for experimental studies. Polarization provides a new dimension to the use of energetic photon beams in the study of elementary particle properties and interactions.

Publications:

"Laser Beams: The Production of Polarized and Monochromatic Gamma Radiation by Means of Compton Scattering at Electron Synchrotrons and Linear Accelerators", R.H.Milburn, SLAC Report #41, May 1965.

"High Energy Photons from Compton Scattering on Relativistic Electrons" R.H.Milburn, C.Bemporad, M. Fotino, Bull. Am. Phys. Soc. II-10-1, Jan. 1965.

"High Energy Photons from Compton Scattering of Light on 6-Gev Electrons: C.Bemporad, R.H.Milburn, N. Tanaka, M.Fotino. Phys. Rev. 138, B1546 (1965)

"Laser-induced Polarized photon Beams above 0.5 Gev", R.H.Milburn, Hamburg Conference, July 1965.

10. Wide Gap Spark Chamber Studies. Prof. K. Strauch et al.

Studies are under way to exploit the possibilities of the wide gap spark chamber, developed by Alikhanian and coworkers, for experimental use. Chambers with plate separations of 40 cm have been constructed and tested, both with and without a superposed magnetic field. Spark tracks have been studied to determine displacement or distortion in uniform and nonuniform electric and magnetic fields and to measure the sensitive time. Results indicate that wide gap spark chambers will be a promising research tool in high energy physics. An experimental system utilizing tagged photons and a wide gap spark chamber in a large-volume magnetic field is being assembled to study a variety of photo-produced processes such as the wide angle electron-positron pair production.

Publications:

"Properties of Wide-Gap Spark Chambers", J.P. Garron, D. Grossman, K. Strauch, Rev. Sci. Instr. 36, 264, 1965.

"The Sensitive Time of a Wide-Gap Spark Chamber", B.Eisenstein, D. Grossman, R. Sah, and K. Strauch, Nucl. Instr. and Meth. (in print).

"Innovations in Visual Spark Chamber Detectors" K.Strauch, Invited Paper, 1965 Purdue Conference on Instrumentation for High Energy Physics, published Proc. I.R.E., 1965.

"Properties of Wide Gap Spark Chambers", K. Strauch, Invited Paper, 1965 Erevan Summer School, Erevan, Armenia, U.S.S.R.

"The Use of Bubble Chambers and Spark Chambers at Electron Accelerators", K. Strauch, Invited Paper, 1965 Hamburg Symposium on Electron and Photon Interactions at High Energies, published Springer Tracts in Modern Physics, vol. 39, 1965.

11. Bremsstrahlung Studies with a Pair Spectrometer. Dr. H. Winick
et al.

The detailed shape of the high-energy end of the bremsstrahlung spectrum produced by monoenergetic high energy electrons is not fully understood, either theoretically or experimentally. A program to study this spectrum has been initiated by members of the CEA staff. The apparatus includes a magnetic pair spectrometer and detection equipment for observing electron-positron pairs produced in a target by the bremsstrahlung beam. Parts of the experimental equipment have been used to study the pair production total cross-sections, and the results have been reported. Further experiments are planned to study the polarization and monochromaticity of bremsstrahlung produced in monocrystalline targets such as diamond.

Publication:

"Pair Production by 5 Gev Photons in Carbon". CEAL-1024, Dec. 1, 1965
J.K. Walker, M. Wong, R. Fessel, R. Little, H. Winick.

12. Positron Scattering in Hydrogen, Profs. L. Hand, E. Engels, et al.

The elastic scattering of high energy positrons by protons has been studied, for comparison with electron-proton scattering. Differences, other than those calculable for the positive charge, would indicate a deviation from the laws of quantum electrodynamics. Analysis of the results shows no such differences or deviations.

13. Proton Compton Effect. Prof. M. Deutsch, et al.

This study of the energy and angle of high energy photons scattered elastically from protons in a hydrogen target has demonstrated the existence of Compton scattering from protons for the first time.

E. Apparatus Development at the CEA (1964-1965)1. Emergent electron beams:

Two emergent electron beams have been brought out into the Experimental Hall and are in use for experiments. The beams have high efficiency (70% of the circulating beam), excellent collimation and optical properties (focused to $2 \times 0.5 \text{ mm}^2$ at 100 ft), and an energy resolution of 0.1% for short spill-times (0.5 millisecc), at the peak of the cycle. Longer spill-times (up to 2 millisecc) are available when needed, with somewhat larger energy spread and broader collimation. Scientists have been pleased with the high quality beam and the improved geometry for experiments.

2. Target engagement and sharing:

A system of magnetic "beam bumps" allows the circulating beam to be diverted against targets in any one of four bremsstrahlung beam channels, on a pulse-to-pulse basis. This provides a few pulses per second for experiments needing low intensities for tune-up of equipment, with most of the pulses going to the prime user. The beam bumps can provide spill-times of any length up to a maximum of 3.5 millisecc (duty cycle 20% of total time).

3. Intensity control:

Intensity limiting devices have been installed to provide essentially identical intensities on each pulse. These can be programmed on a pulse-to-pulse basis to give high intensity to one user and lower intensities, if desired, to others. Very few experimenters chose to use the maximum available intensities.

4. Counting Room

A new Counting Room located above the accelerator tunnel, with minimal-length cable runs from experiments in the Experimental Hall, was completed early in 1964 and the available 9 bays are allocated to research groups. A second floor was completed in 1965, with 5 bays assigned to research users and 4 bays to house the data-analysis computer system.

5. On-line data analysis computer system:

A program has been developed in conjunction with the Harvard Computing Center to provide on-line analysis of data from experiments. An IBM 360/50 computer will be installed at the Center, with data transmission cabling from the CEA. The CEA has ordered 4 systems of SDS-92 computers to be used as interface equipments to program the data for the IBM computer; two have been received and installed. The output data from 4 experiments (prime user plus 3 parasitic users) can be analyzed simultaneously by the IBM computer.

6. Storage ring proposals:

CEA staff and local scientists prepared a proposal for a 3-GeV electron-positron storage ring to provide a colliding beam facility, and submitted it to the Atomic Energy Commission in April, 1964. Modified alternate proposals for either a 3-GeV or a 1.5-GeV storage ring were prepared and submitted in April, 1965. A similar proposal was submitted by the SLAC laboratory at Stanford. The AEC conducted a review and recommended the Stanford proposal.

7. Synchrotron Colliding-Beam Facility:

New concepts developed by the CEA staff show promise of providing a colliding-beam capability at the CEA by using the synchrotron itself for filling with and storage of counter-rotating beams. After filling with multi-cycle injection of both electrons and positrons (less than 1 minute), the CEA magnet will be switched to dc operation to store the beams for significant periods (20 to 30 minutes). These stored beams will then be switched into a bypass sector of dc magnets with a long straight section for experiments, in which the beams will be focused to small cross-sections to obtain high luminosities with relatively small currents (100 milliamps). A sequence of technical developments will be required to provide a suitable positron source, damping of radiation induced oscillations, beam switching systems, etc. A major first technical step has been accomplished by demonstrating that the circulating beam in the CEA can be captured and stored in dc magnetic fields as the ac magnet excitation is removed.

Publications:

"Beam Storage in the Cambridge Electron Accelerator:", M.S. Livingston et al, Science, submitted for publication, January 1966.

F. CEA Laboratory Reports and Memoranda: (1964-1965)Reports:

<u>Number</u>	<u>Title</u>	<u>Author</u>	<u>Date</u>
CEAL-1008	Design of a 6-BEV Faraday Cup	P.H. Burr	1/2/64
CEAL-1009	Semi-Annual Report (7/1-12/31, '63) A.E.C. Contract AT (30-1) - 2076	M.S. Livingston	1/17/64
CEAL-1010	Stability of Beam in Radiofrequency System	K.W. Robinson	2/27/64
CEAL-1011	Semi-Annual Report Jan. 1 - June 30, 1964	W.A. Shurcliff	7/21/64
CEAL-1012	Research with 6-GeV CEA	M.S. Livingston	10/6/64
CEAL-1013	Vacuum Design Problems of High Current Electron Storage Rings	G.E. Fischer R.A. Mack	10/20/64
CEAL-1014	High-energy Photons from Compton Scattering of Light on 6.0 GeV Electrons	C. Bemporad R. Milburn N. Tanaka M. Fotino	1/30/65
CEAL-1015	A Precision Energy Calibration for the Cambridge Electron Accelerator	H. Winick	2/65
CEAL-1016	Magnetic Bottle for Producing Positrons and Polarized Electrons	K. Robinson	2/19/65
CEAL-1017	On Synchrotron Radiation Produced Photo-electrons from Chopper	G. Fischer	2/28/65
CEAL-1018	A 475.76 MHz Linac Chopper	G. Voss G. Nicholls	3/22/65
CEAL-1019	Frequency Dependence of the Resistance and Inductance of Solid Core Magnets	G.R. Gonzalez A. Brambilla	3/29/65
CEAL-1020	Beam Bump Method of Target Engagement	R.J. Averill	4/23/65

Number	Title	Author	Date
CEAL-1021	An Accurate Current Integrator in the Range 10^{-5} to 10^{-9} Amperes	L. A. Law J. Weinstein	5/14/65
CEAL-1022	Beam Monitor Calibration Measurements with the 6-GeV External Beam	J. dePagter M. Fotino	6/30/65
CEAL-1023	Semi-Annual Report Jan. 1 through June 30, 1965	M.S. Livingston	9/22/65
CEAL-1024	Pair Production by 5 GeV Photons in Carbon	R. Fessel, R. Little H. Winick J.K. Walker M. Wong	12/1/65

Technical Memoranda:

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