APPENDIX B

SUMMARY OF SOIL STUDIES TO DATE

In the summer of 1973, when engineering studies for a large, colliding-beam storage ring started in earnest, soil studies were begun to determine the nature of earth materials where tunneling might be undertaken. The initial ring concept, a 2100-m oval, was investigated by drilling seventeen test holes with a truck-mounted 15-cm auger drill rig. These holes were roughly logged to determine the general nature of the site's materials, but no laboratory testing was undertaken to determine engineering characteristics. The drilling indicated a heterogeneous, unsystematic arrangement of gravels, sand, clay, claystone and shale in the upper levels, with sandstone occurring at depths 6 to 20 m below the surface.

In an effort to determine systematic arrangement of the site's sedimentary deposits, the 1973 drilling program was followed by seismic refraction geophysical surveys.[40] Such surveys, by measuring velocities of seismic waves at varying depths, can indicate densities and competence of subterranean formations and can provide some indication of the speed of tunnel advances. The survey indicated that upper levels have relatively low compressional wave velocities between 360 and 540 m per second. These are in desiccated adobe and sandy clay. Underneath these surface materials, wave velocities varied from 700 to 1000 m per second in fine-grained sandstone, shale and clay with gravel. These velocities, comparable to earlier refraction studies of SLAC materials, indicate materials having bearing values of at least 20,000 kilograms per sq. m. Structures below these materials showed wave velocities in excess of 1500 m per second. Thus, the refraction surveys, as might be expected, indicated increasing competence of materials with depth.

In 1974, five more deep holes were drilled in order to determine the nature of materials at key points where the ring (by now conceived as hexagonally shaped) was anticipated to be located. No unusual differences from those of the earlier samplings were disclosed by these borings.

The geologic composition of the SLAC site consists of materials of three geologic ages: Eocene, Miocene and Pliocene-Pleistocene. SLAC's original construction had disclosed that Eocene formations could be troublesome, sometimes being composed of expansive clays, shales and siltstones. Miocene formations, although younger than the Eocene, are more dependable, being composed generally of fine-grained, loosely-consolidated sandstones having excellent engineering characteristics. Little contact with Pliocene-Pleistocene formations occurred in the original construction.[41, 42, 43]

Subdivision developments immediately north of the PEP site in Menlo Park have experienced serious construction problems caused by highly-expansive Eocene clays. In that area, such clays are generally overlain by adobe soils. Areas of Regions 12, 1 and 2 of PEP's ring (Fig. 1 of the design report) are likewise overlain with expansive adobes. In that same PEP area, a 1967 geological report[43] postulated a Pliocene-Pleistocene formation which could create engineering problems for construction. Because of this, a detailed geologic, soils-mechanics study of Regions 12, 1 and 2 was undertaken in the summer of 1975.[44] Trenching, drilling and materials testing was done in order to ascertain accurately the geologic structure and engineering characteristics of soils and rock. It was found that the Eocene formations so troublesome to the north do not extend into PEP's construction area, and that expansion characteristics of the claystones found should not create serious difficulties. That same summer, an interim report of the general geological structure of the entire PEP site was made.[45]

A test-drilling program continues, with extensive materials testing along the perimeter of the PEP ring. This program should provide the information necessary to determine methods and design of tunnels as well as basic design of the interaction area research halls.

APPENDIX C

COOPERATIVE BASIC AGREEMENT

BETWEEN

THE BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY

AND

THE REGENTS OF THE UNIVERSITY OF CALIFORNIA

This Cooperative Basic Agreement is entered into effective this 25th day of February, 1974, by and between the BOARD OF TRUSTEES OF THE LELAND STANFORD JUNIOR UNIVERSITY (hereinafter called "Stanford") and THE REGENTS OF THE UNIVERSITY OF CALIFORNIA (hereinafter called "UC").

RECITALS

I. INTRODUCTION

A. The Ernest Orlando Lawrence Berkeley Laboratory (LBL) is a National Laboratory operated by UC under contract W-7405-ENG-48 with the U.S. Atomic Energy Commission (AEC). The Director of LBL reports to the President of UC. The Stanford Linear Accelerator Center (SLAC) is a National Facility for High Energy Physics Research operated by Stanford under contract AT(04-3)-515 with the AEC. The Director of SLAC reports to the President of Stanford.

B. For several years LBL and SLAC have been collaborating in the study of a novel high-energy particle accelerator system consisting of a ring containing counter-rotating persistent beams of electrons and positrons, and a second intersecting ring containing a persistent rotating beam of protons. Collision between these beams will permit studies of elementary particles at higher energy, and therefore in finer detail than ever before.

C. The concept of the system, called PEP for "proton-electron-positron," has been developed to the point where design and construction of an accelerator can take place. It appears desirable to accomplish the realization of this concept in stages. The first stage will consist of a single ring of approximately 300 meter radius able to contain counter-rotating beams of electrons and positrons with energies up to 15 GeV at full interaction rate. These particles will be injected into the ring by the existing linear accelerator at SLAC. Provision will be made in the construction of PEP to maintain full compatibility with the later addition of a superconducting proton ring for protons of energies up to about 200 GeV and/or a second electron ring to provide for collision of electrons with electrons and positrons with positrons. Provision will also be made for the future installation of experimental facilities for the full PEP Project. Meanwhile, the single ring will comprise a unique tool for conducting experiments involving electron-positron collisions, and by itself will be the basis for a front line experimental program for many years. For ease of reference, the term "PEP Project" as used hereafter in this Agreement means the design, construction and operation of the PEP accelerator system as finally funded, built, and operated.

D. In consideration of the foregoing facts, and being keenly aware of the potentialities of the PEP Project for advancing mankind's knowledge of the constitution and nature of matter, and in appreciation that the task is of such challenge as to warrant the marshalling of the combined resources and talents of Stanford and UC, with a consequent sense of the historical importance of this act the parties hereto enter into this Cooperative Basic Agreement.

AGREEMENTS

II. CONSTRUCTION PROPOSAL

A. It is agreed that LBL and SLAC will collaborate in the preparation of a construction proposal to be submitted to the Atomic Energy Commission for commencement of construction in Federal fiscal year 1976 of a high energy electron-positron ring to be constructed at SLAC and to be operated jointly by SLAC and LBL as a national physics facility as described in Articles III. and IV. of this agreement. Provision will be made in the construction of PEP to maintain full compatibility with the later addition of a superconducting proton ring for protons of energies up to about 200 GeV and/or a second electron ring to provide for collision of electrons with electrons and positrons with positrons. Provision will also be made for the future installation of experimental facilities for the full PEP Project.

B. The technical and scientific justification for this construction proposal will be based specifically on the electron-positron colliding beam device. The parties agree that both scientific interest and current technical knowledge are such as to justify the construction of an electron-positron storage ring in its own right; they also emphasize that the scientific goals of the full PEP Project provide good reasons to include in the design those features essential to permit realization of the full PEP Project in the future.

C. As contained in the "5-year Budget Assumption" for 1976-1980 which was submitted by LBL and SLAC on November 13, 1973 to the AEC, the construction cost of the first stage of the PEP Project is estimated to be between $50 and $60 million.

III. MANAGEMENT PLAN

A. It is agreed that the goal of the project management is a true collaboration between LBL and SLAC. the PEP Project will have a senior scientific and technical staff drawn in a balanced way from the two Laboratories. These persons, while working on the PEP Project, will remain employees of their respective Laboratories. In particular the Project Director and Deputy Director will be appointed by the Directors of LBL and SLAC so that one comes from each Laboratory. The Project Director will report to the Directors of LBL and SLAC.

B. The two Laboratory Directors will be advised in relation to the project by a single PEP Program Committee (PPC) having a majority of non-SLAC, non-LBL members. This Committee will be appointed jointly by the Directors of the Laboratories. This Committee shall advise the Directors on all major phases of the PEP Project such as experimental facilities construction, and storage ring modification projects. Such projects shall go forward only after authorization by both Laboratory Directors, irrespective of the source of funding. The Committee shall meet as often as required but not less frequently than twice each year.

C. It is intended that the PEP Project will be operated as a National Physics Facility. Steps are in progress to involve the national high-energy-physics community in planning for the physics utilization as well as in setting up appropriate advisory mechanisms. In particular, it is agreed that an Experimental Program Committee (EPC) will be constituted to review experimental proposals under procedures designed to assure equitable access to the entire high-energy physics community. Detailed scheduling decisions and coordination of PEP Project experiments with SLAC operations shall be made under SLAC procedures.

D. The Presidents of Stanford and UC will be advised of the status of the PEP Project through, respectively, the Directors of SLAC and LBL. In addition, the Scientific Policy Committee (SPC) of SLAC, advisory to the President of Stanford University, and the Scientific Educational Advisory Committee (SEAC), advisory to the President of the University of California, will schedule joint meetings when deemed advisable if it is believed that further advice on scientific policy governing the conduct of the PEP Project should be made available to the Presidents of the collaborating universities and, through them, as appropriate, to the Atomic Energy Commission.

E. Stanford and UC may enter into modifications of this agreement or into agreements implementing this agreement as may be necessary to carry out the PEP Project.

IV. MANPOWER AND FISCAL ARRANGEMENTS

A. Preconstruction research and development work is now under way at both Laboratories, supported by the operating funds of each institution under the financial plans of their contracts with AEC.

B. The construction proposal described in Article II. A. will set forth the scope and estimated costs of major elements and components of the design and construction phase of the first stage of the PEP Project.

C. It is agreed that Stanford and UC shall seek to have the construction of the first stage of the PEP Project performed by Stanford under a contract between Stanford and the Atomic Energy Commission. Requests to the Atomic Energy Commission for construction directives to proceed with stages of the construction of the PEP Project shall be approved by both Laboratory Directors. It is agreed that the health and strength of the technical high-energy support efforts as well as of the research programs of the two Laboratories must be maintained, and this goal will be used as a guide in determining how the personnel and facilities of each Laboratory are to support the design, preparation of specifications, and construction of the PEP Project.

D. After completion of construction to the satisfaction of both Laboratory Directors, SLAC and LBL will participate in the operation of the PEP Facility as follows:

1. SLAC will be responsible under the terms of Article III. for managing and coordinating accelerator operations. Funding support for accelerator operations will be through the SLAC operating contract with AEC.

2. The operation of each experimental facility built with SLAC and/or LBL funds shall be the responsibility of SLAC or LBL and shall be supported with their operating funds in the manner most advantageous to the conduct of the national high-energy physics program.

3. During the operational phase of PEP, accelerator research and development and facilities research and development pertaining to PEP, as well as preconstruction work for the full PEP, will be supported by the two Laboratories, using their operation funds.

4. Experimental facilities construction and PEP storage ring modification projects may be supported separately or jointly in accordance with funding provided to LBL and SLAC.

5. The Laboratories will participate in the physics research program of the PEP Project using operating funds from their separate contracts in a manner similar to that of other laboratories or universities performing research at the PEP National Physics Facility.

V. SETTLEMENT OF DISAGREEMENTS

Should the two Laboratory Directors be unable to agree on a substantive issue relating to this Agreement, it shall be referred to the Presidents of Stanford and UC for resolution.

VI. TERM AND TERMINATION

This Agreement shall continue in force from year to year from date of execution; provided, however:

A. Should Federal or other funding not be obligated for the construction of the PEP Project by June 30, 1980, this Agreement shall terminate.

B. This Agreement shall continue so long as Federal or other funding is provided for the operation of SLAC and LBL and for the construction and operation of the PEP Project.

IN WITNESS WHEREOF, the parties hereto have executed this Agreement as of the date first above written.

THE REGENTS OF THE
UNIVERSITY OF CALIFORNIA

By: C. Hitch
Charles J. Hitch
President, University of
California

By: Marjorie J. Woolman
Marjorie J. Woolman
Secretary

By: Dean Watkins
Dean A. Watkins
Chairman

THE BOARD OF TRUSTEES
OF THE LELAND STANFORD
JUNIOR UNIVERSITY

By: R. W. Lyman
Richard W. Lyman
President, Stanford University

APPROVED AS TO FORM:
Aletha R. Titmus
ALETHA R. TITMUS 2-22-74
ASSISTANT COUNSEL OF THE REGENTS
OF THE UNIVERSITY OF CALIFORNIA

APPENDIX D

PEP Reports

PEP Note #	Title	Author(s)
1	A High-Energy Proton-Electron-Positron Colliding Beam System	C. Pellegrini, J. Rees, B. Richter, M. Schwartz, D. Möhl and A. Sessler
2	A Model for a High Energy Proton-Electron-Positron Colliding Beam System: SPEAR plus a Proton Ring	D. Möhl and A. Sessler
3	Inelastic Electron-Proton Scattering with SPEAR plus a Proton Ring	M. L. Stevenson
4	(PEP Note #4 was a piece of the Isabelle report)	
5	Feasibility Study for a 15-GeV Electron-Positron Storage Ring	S. Berman, S. Drell, J. Rees, B. Richter
6	Electromagnetic Backgrounds and Photon Tagging	M. Davier and A. Odian
7	How Much Free Space Can We Provide for Experimental Apparatus?	P. Morton and J. Rees
8	On the Use of Isabelle in a PEP System and Other Related Topics	D. Möhl and A. Sessler
9	Proposed NAL Photoproduction Experiments and Some Comparisons with PEP Capabilities	S. M. Flatté
10	A Question of Duty Cycle	S. M. Flatté
11	Angular Distributions for Hadrons Produced in PEP Electroproduction Experiments	F. J. Gilman
12	PEP Kinematics - Deep Inelastic Scattering -- Two Exclusive Reactions as Examples	G. Goldhaber
13	Brookhaven HEDG Meeting of December 10, 1971	J. Rees
14	Check on the Equivalent Radiator for PEP	A. Odian
15	Radiative Processes in Electron-Proton Collisions at PEP	S. J. Brodsky

PEP Note #	Title	Author(s)
16	The Kinematics and Possible Dynamics of Inelastic Lepton Scattering in PEP (15 GeV electrons on 70 GeV protons)	M. L. Stevenson
17	PEP Kinematics -- Additional Remarks on the Reaction of the Type $ep \to e'\rho N$	G. Goldhaber
18	PEP Parameters	D. Möhl
19	Limitation of the Transition Energy in Large e-p Colliding Beam Facilities	H. Wiedemann
20	On the Calculation of Luminosity for Electron-Proton Colliding Beam	L. Smith
21	High Voltage Rf Systems for the PEP Rings	M. Allen and J. Rees
22	The Self-Destructive Behavior of Stored Electron Beams: The Disease Patterns, Symptoms and Cures	A. Sessler
23	PEP Model One -- A Machine Design Example	A. Garren
24	Conceptual Design of a Hybrid Detector for Electron Physics at Isabelle and PEP: Solenoid + Quantameter + Hadrometer (Calorimeter)	M. L. Stevenson
25	Further Consideration of the Rf System for PEP	M. A. Allen
26	Multiple Coulomb Scattering and Multiple Gas Bremsstrahlung at SPEAR	J. E. Augustin
27	A Correction to Formulas Computing the Touschek Lifetime in Storage Rings	H. Wiedemann
28	Strongly Turbulent Collective Motion and the Anomalous Size of Stored Particle Beams	A. Sessler
29	Variable Proton Momentum at PEP	R. O. Bangerter
30	Noise in Proton Accelerators	E. Hartwig, V. K. Neil, R. K. Cooper
31	PEP Lattice Design	R. Bangerter, A. Garren, P. Morton and J. Rees

PEP Note #	Title	Author(s)
32	Use of the Electron Ring for Protons in the PEP System	A. Garren and T. Elioff
33	Proton-Electron-Positron Design Study	The LBL/SLAC Storage Ring Study Group
34	PEP Model Five: An Update of PEP Parameters	A. Garren
35		
36	Notes on PEP "Bull Session" of March 1-2, 1973	
37	Beam Loading in High-Energy Storage Rings	P. B. Wilson
38	PEP Model Six	A. Garren
39	Scaling of FODO-CELL Parameters	H. Wiedemann
40	Closed Orbit Beam-Beam Effect for Crossing Beams	M. Month and A. G. Ruggiero
41	Space-Charge Effects at Transition Energy: An Attempt to Scale from the CPS to PEP-6 and Other Machines	D. Möhl
42	The Excitation of Non-linear Resonances by a Displaced Elliptical Beam	E. Keil
43	Bunch Lengthening and Widening Effects Due to the Combination of Rf Noise and the Presence of Inductive Wall Elements	G. H. Rees
44	The Beam-Beam Limit in SPEAR as a Single Resonance Effect	A. G. Ruggiero
45	Bunch Lengthening	F. J. Sacherer
46	Proton Beam Enlargement by Gas Scattering	H. Wiedemann
47	Synchrotron Radiation Integrals for PEP-6	R. H. Helm
48	Enlargement of the Electron Beam Cross-Section in a Storage Ring Due to an Oscillating Synchrotron Radiation Damping Time Constant	H. Wiedemann

PEP Note #	Title	Author(s)
49	Transverse Bunch-Bunch Instability in PEP (Resistive Wall)	A. G. Ruggiero
50		
51	Aspects of PEP as Compared to EPIC	G. H. Rees
52	Calculation of Resonance Effects Due to a Localized Gaussian Charge Distribution	A. G. Ruggiero and L. Smith
53	Equilibrium Energy Distribution in a Non-linear Potential Well in the Presence of Quantum Fluctuations	H. G. Hereward
54	The Head-Tail Effect in PEP	A. G. Ruggiero
55	Interaction of a Coasting Beam and a Bunched Beam with Frequency Slip	M. Month and A. G. Ruggiero
56	Some Possible Causes of Bunch Shape Distortion in SPEAR	H. G. Hereward
57	Possibility of Observing Turbulence in SPEAR	H. G. Hereward
58	e-p Luminosity for Different Energies in PEP	H. Wiedemann
59	Diffusion-like Blow-up in Asynchronous Bunched Beam Collisions	E. Keil
60	A Negative Momentum-Compaction Lattice	R. H. Helm
61	Magnet Insertion Code (MAGIC)	W. W. Lee, L. C. Teng, M. J. Lee
62	PEP with Crossing Angle	R. Chasman, A. Garren, and M. Month
63	Longitudinal Beam-Beam Effect in Head-on Collisions	J. E. Augustin
64	Behaviour of a Stochastic Non-linear System Excited by an External Harmonic Force	J. R. LeDuff
65	Diffusion on a Single Non-linear Resonance in the Case of e-p Collisions	J. R. LeDuff

PEP Note #	Title	Author(s)
66	Storage Ring Experiments	T. Elioff, H. Hereward, J. M. Paterson, H. Wiedemann
67	Influence of the Touschek Effect on Life-time Measurements in SPEAR	H. G. Hereward
68	The Use of Rf-knockout to Measure Synchrotron Oscillation Frequencies and Energy Spread	D. Möhl, P. L. Morton
69	Preliminary Design of a 15-GeV Electron-Positron Variable-Tune Storage Ring	J. Rees, B. Richter
70	Superconducting Dipoles and Quadrupoles for the PEP Accelerating-Storage Ring	M. A. Green
71	Properties of Bunch Lengthening Effect Observed on Existing e^+-e^- Storage Rings	J. LeDuff
72	Incoherent Beam-Beam Effect: A Computer Simulation	A. Renieri
73		
74		
75	Comments on Obtaining Longitudinally Polarized Beams in e^+-e^- Storage Rings	R. F. Schwitters
76	Neutron Shielding for PEP	J. B. McCaslin and R. H. Thomas
77	Detection of Proton Beam Jet in 15 x 200 GeV PEP	A. Garren,,J. Kadyk
78	Double Thin-lens Approximation for Preliminary PEPSI8 Lattice Design	R. Helm and M. J. Lee
79	PEP Parameters	B. Richter
80	Typical PEP Condigurations and the Resulting Beam-Stay-Clear Requirements	R. Helm, M. Lee, A. Lisin, P. Morton

PEP Note #	Title	Author(s)
81	Transverse Diffusion of Proton Beams Due to Noise	P. Channell
82	Proton Losses from PEP	R. H. Thomas
83	Muon Shielding for PEP	T. M. Jenkins, R. H. Thomas
84	PEP Inflection	G. E. Fischer
85	A Few Thoughts Regarding Beam Cavity Mode Excitation in PEP	G. Loew *et al.*
86	Proton-Electron-Positron: PEP	Lloyd Smith
87	A Method for Producing Long Beam Polarization at PEP	R. Schwitters, B. Richter
88	Synchrotron Radiation Absorbing Surfaces	J. Jurow and N. Dean
89	Higher-Order Modes in SPEAR II Cavities	M. Allen
90	Energy Loss to Parasitic Modes of the Accelerating Cavities	M. Sands
91	Concerning the Density Distribution and Associated Fields	J. Laslett
92	Parasitic Cavity Losses in SPEAR-2	M. Sands
93	Examples of Weak-Beam/Strong-Beam Computation Formed by Use of the Program "WEAK 8" with Graphic Output	J. Laslett
94	An Example of the Use of Program "WEAK 9"	J. Laslett
95	A Bench Measurement of the Energy Loss of a Stored Beam to a Cavity	M. Sands and J. Rees
96	The PEP Electron-Positron Ring -- PEP Stage I	J. Rees
97	Rf Systems for High-Energy e^-e^+ Storage Rings	M. A. Allen and P. B. Wilson
98	Preliminary Design Considerations for the Stage I PEP Lattice	R. H. Helm and M. J. Lee
99	Beam Enlargement by Mismatching the Energy-Dispersion Function	R. H. Helm, M. J. Lee and J. M. Paterson

PEP Note #	Title	Author(s)
100	Beam Loading in High-Energy Storage Rings	P. B. Wilson
101	Stored Current Capability of the PEP Rf System	P. B. Wilson
102	Comparison of Two Configurations for Intersection Regions	W. A. Wenzel
103	Measurement of Higher-Order Mode Losses in SPEAR II by Shift in Synchrotron Phase and Increase in Net Cavity Power	M. A. Allen, J. M. Paterson, P. B. Wilson
104	Alternative Theories of the Non-Linear Negative Mass Instability	Paul J. Channell
105	Physical Picture of the Electromagnetic Fields between Two Infinite Conducting Plates Produced by a Point Charge Moving at the Speed of Light	A. W. Chao, P. L. Morton
106	Shielding Requirements for Radiation Produced by 15-GeV Stored Electrons	T. M. Jenkins, J. B. McCaslin, R. H. Thomas
107	PEP Experimental Areas -- Winter 1975	W. A. Wenzel
108	The PEP Electron-Positron Ring -- an Update	LBL-SLAC Joint Study Group
109	The Radiation Dose to the Tunnel Linings and the Production of Nitric Acid and Ozone from PEP Synchrotron Radiation	W. R. Nelson
110	Higher Order Multipole Magnet Tolerances	A. W. Chao, P. L. Morton, M. J. Lee
111	Control of Closed Orbit Deviation Due to Synchrotron Radiation	M. J. Lee, P. L. Morton, J. R. Rees and B. Richter
112		K. Bane and P. Wilson
113	The PEP Injection System	K. L. Brown, R. T. Avery J. M. Peterson
114	Vacuum System for the Stanford-LBL Storage Ring (PEP)	D. Bostic, U. Cummings, N. Dean, D. Jeong, J. Jurow
115	Beam Energy Loss to Parasitic Modes in SPEAR II	M. A. Allen, J. M. Paterson J. R. Rees, P. B. Wilson

PEP Note #	Title	Author(s)
116	Background Estimates for PEP	F. Martin
117	Implications of Shorter Cells in PEP	H. Wiedemann
118	Parasitic Loss of a Gaussian Bunch in a Closed Cavity	A. W. Chao
119	Differential Energy Loss for a Particle in a Square Pulse of Charge Traveling between Infinite Conducting Plates	A. W. Chao, P. L. Morton
120	Design of an Electrode System for Beam Tranverse Excitation	J.-L. Pellegrin
121	The Behavior of Betatron Oscillation in the Vicinity of Half Integral Structure Resonances	E. Keil
122	Beam Induced Transit Time Signals at SPEAR	R. McConnell
123	Stored Current in PEP at 125, 200 and 358 MHz	P. B. Wilson
124	High Performance Magnet Power Supply Optimization	T. Jackson
125	Control of Beam-Size and Polarization Time in PEP	J. M. Paterson, J. R. Rees, H. Wiedemann
126	Bunch Lengthening and Bucket Distortion Due to Cavities	E. Keil
127	PEP Initial Design -- Injection Transfer Line Coordinates	R. T. Avery
128	PEP Ring Coordinates -- Configuration E	R. Avery, T. Chan
129	On the Horizontal Shape of an Electron Bunch	A. Chao
130	Stationary Solution of the Fokker-Planck Equation for Linearly Coupled Motion in an Electron Storage Ring	A.W. Chao, M.J. Lee
131	Transient Particle Distribution for Linearly Coupled Motion in an Electron Storage Ring	A.W. Chao, M.J. Lee

PEP NOTE #	Title	Author(s)
132	Evaluation of the Field Quality of the Prototype PEP Cell Quadrupole Magnet	A.W. Chao, M.J. Lee, P.L. Morton
133	PEP Cooling Water Systems and Underground Piped Utilities Design Criteria Report	F. Hall, D. Robbins
134	Some Up-to-date Additions to MAGIC for PEP Deisgn Studies	M. Lee, A. King
135	Closed Orbit Distortions due to Survey and Alignment Errors in PEP I	Dick Sah
136	Particle Distribution and Beam Lifetime with Vacuum Chamber Walls	A. W. Chao
137	1974 Summer Study	
138	Introductory Remarks	K. Strauch
139	The PEP Electron-Positron Ring	J. Rees
140	Event Rates to be Expected at PEP	B. Richter
141	Report of the Study Group for the Measurement of the Total Cross Section for e^+e^- Hadrons	G. Abrams, G. Feldman, D. Hitlin, H. Lynch, D. Nygren, R. Schwitters, B. Shen
142	Non-magnetic Detector for Measuring σ_T and Charged Multiplicities in e^+e^- Annihilation	H. Lynch, R. Schwitters
143	Precise Measurement of the Total Cross Section	G. Feldman, D. Hitlin
144	The Time-projection Chamber -- A New 4π Detector for Charged Particles	D. Nygren
145	Contribution of the Two-photon Annihilation Process in the Measurement of σ_T at PEP	B. Shen
146	Detection of High-momentum Hadrons	G. Buschhorn, D. Coyne, J. Cronin, J. Klems, C. Morehouse, M. Strovink
147	Heavy Hadrons -- Group Report	G. Barbiellini, C. Buchanan, B. Cork, J. Dakin, H. Lynch, J. Marx, J. Perez-y-Jorba, P. Yamin

PEP NOTE #	Title	Author(s)
148	Large-solid-angle Detector for Charged and Neutral Particles -- Group Report	A. Barbaro-Galtieri, J. Kadyk, T. Mast, J. Nelson, A. Odian, D. Yount
149	The Detection of Low-energy Charged Particles with Particle Identification Up to 3.5 GeV/c	J. Perez-y-Jorba
150	Study of a Multi-hadron Facility for PEP Based on Toroidal Field Magnets	P. Spillantini
151	A Streamer Chamber Detector for PEP	G. Buschhorn, H. Meyer, A. Odian, D. Yount
152	Comments on the Simultaneous Measurement of Charged and Neutral Components of Multihadron Events	P. Yamin
153	Some Design Considerations for a Large Solid Angle Charged Plus Neutrals Detector for e^+e^- Storage Ring	T. Mast, J. Nelson
154	Report on Neutral Particle Detectors and Q.E.D. -- Group Report	E. Bloom, F. Bulos, G. Buschhorn, J. Dakin, E. B. Hughes, T. Mast, J. Nelson, A. Odian, C. Prescott, S. Yellin, D. Yount
155	Properties of Some Photon Detectors	E. Bloom, F. Bulos, G. Buschhorn, D. Cheng, J. Dakin, E. B. Hughes, T. Mast, J. Nelson, A. Odian, C. Prescott, S. Yellin, D. Yount
156	Liquid Argon Gamma Ray Detector -- Variations of the Willis Chamber	A. Odian
157	Report of the Weak Interactions/EM Final States Group	D. Buchholtz, D. Cline, P. Limon, A. Litke, C. Prescott, L. Resvanis, L. Stevenson, K. Strauch, L. Sulak, P. Wanderer, W. Wenzel, S. Yellin
158	Tests of μ-e Universality for Weak Neutral Currents at PEP	D. Cline, L. Resvanis

PEP NOTE #	Title	Author(s)
159	A Compact Magnetic Detector for μ^+-μ^- Asymmetry Measurements and Longitudinal Polarization Utilization at PEP	U. Camerini, D. Cline J. Learned, P. Wanderer, L. Resvanis
160	A Suggested Detector	S. Yellin
161	Study of the Reaction $e^+e^- \to \mu^+\mu^-$ with an Iron Solenoid Spectrometer	K. Strauch
162	Solenoid Spectrometers for $e^+e^- \to \mu^+\mu^-$ and Other Final States	W. Wenzel
163	Direct Measurement of Muon Polarization in $e^+e^- \to \mu^+\mu^-$	P. Limon, M. L. Stevenson, W. Wenzel
164	Strange Particle Experiments at PEP	D. Hitlin, J. Marx, P. Yamin
165	Parity Violating Momentum Correlations as a Means of Observing Weak Interactions in $e^+e^- \to$ Hadrons	J. Klems
166	Polarization Group Coordinators' Summary	D. Buchholz, G. Manning, F. Martin, C. Morehouse, C. Prescott, L. Resvanis, G. Shapiro, H. Steiner, R. Schwitters, K. Strauch, W. Taner, P. Wanderer, W. Wenzel
167	Control of Direction of Beam Polarization	R. Schwitters
168	Note on Longitudinal Beam Polarization	W. Wenzel
169	Resonance Method to Produce a Polarization Asymmetry in Electron-Positron Storage Rings	W. Toner
170	Two Methods to Measure the $e^{\pm}$ Polarization at PEP	U. Camarini, D. Cline, J. Learned, A. Mann, L. Resvanis, P. Wanderer
171	A Pulsed Polarization Monitor for PEP	C. Prescott
172	A First Look at a Polarimeter for EPIC or PEP	W. Toner
173	An Alternate Way of Measuring Beam Polarization at an e^+e^- Colliding Beam Facility	D. Buchholz, G. Manning, C. Prescott
174	New Particle Searches at PEP	D. Berley, F. Bulos, D. Cheng, B. Cork, P. Limon, A. Litke, U. Nauenberg, J. Rosen, B. Shen, L. Sulak, J. Trefil, F. Winkelmann

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176	Background Sources at PEP	H. Lynch, R. Schwitters, W. Toner
177	Report of the Experimental Areas Group	D. Berley, D. Coyne, J. Cronin, G. Feldman, D. Hitlin, P. Innocenti, J. Kadyk, G. Manning, F. Martin, U. Nauenberg, B. Richter, R. Schwitters, M. Stevenson, K. Strauch, M. Strovink, R. Taylor, P. Wanderer, W. Wenzel
178	1975 PEP Summer Study	
179	An Experimenter's View of PEP	J. M. Paterson
180	Comparison of Jet and Phase Space Models at $E_{cm} = 30$ GeV	G. Hanson, P. Oddone
181	Report of the Polarization Group	W. Ford, K. Kondo, F. Martin, G. Manning, D. Miller, C. Prescott
182	Measurement of Weak Interaction Contributions to $e^+e^- \rightarrow \mu^+\mu^-$ Using Longitudinal Polarization of the e^+ and e^- Beams	G. Manning
183	A Beam Pipe for Polarization Experiments	F. Martin
184	A System for Obtaining Longitudinal Beam Polarization at PEP with Vertical Dipoles Located Outside of the Interaction Region	A. Garren, J. Kadyk
185	Summary of the Weak Interactions Group	A. Benvenuti, W. Ford, D. Hitlin, K. Kondo, G. Manning, R. Morse, T. Rhoades, A. Sessoms, L. Stevenson, K. Strauch, A. Zallo
186	Iron Ball Mark II	W. T. Ford
187	EM-Weak Interference in $e^+e^- \rightarrow \mu^+\mu^-$ Scattering	R. Morse

PEP NOTE #	Title	Author(s)
188	Weak-Electromagnetic Interference Effects in $e^+e^- \to \mu^+\mu^-$ Hadrons	D. Hitlin, A. Sessoms
189	A General Users Magnet Design	F. Lobkowicz, U. Becker, K. Berkelman, M. A. Green, E. Groves, K. Halbach, J. Kadyk, N. Mistry, A. Sessoms, M. Strovink
190	Use of Discrete Coils in Axial Field Spectrometers	J.D. Taylor, W.A. Wenzel
191	The Study of Neutral Particles	W. Bartel, F. Bulos, A. Eisner, G. Hanson, D. Hitlin, U. Koetz, R. Kotthaus, D. Luke, M. Marshak, T. Mast, J. Matthews, C. Peck, K. Strauch, D. Yount
192	The Crystal Ball at PEP	W. Bartel, F. Bulos, D. Luke, C. Peck, K. Strauch
193	A Liquid Argon Neutrals Detector (LAND) for PEP	A. Eisner, G. Hanson, D. Hitlin, U. Koetz, M. Marshak, T. Mast, J. Matthews, C. Peck, D. Yount
194	Resolving Overlapping Gammas in a Modular Neutrals Detector	F. Bulos
195	Report of the General Purpose Detector Group	A. Barbaro-Galtieri, W. Bartel, F. Bulos, R. Cool, G. Hanson, U. Koetz, R. Kotthaus, S. Loken, D. Luke, A. Rothenberg
196	Considerations for a General Flexible Detector	F. Bulos
197	The Streamer Chamber as a General Detector	G. Barbiellini, R. Kotthaus S. Poucher, A. Seidl, F. Villa, D. Yount
198	A Time Projection Chamber	D. Nygren
199	Comparison of Time Projection and Drift Chamber Detectors	J.A.J. Matthews, A. Rothenberg

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200	Mark II Magnetic Detector for SPEAR	R. R. Larsen
201	Detection of High Momentum Particles with Identification of the Final State	U. Becker, R. Cashmore, E. Groves, L. Keller, S. Loken, C. Morehouse, S. Poucher, M. Strovink
202	Use of Microchannel Electron Multipliers in High Energy Physics	P. Lecomte, V. Perez-Mendez
203	Photon-photon Physics	G. Barbiellini, A. Benvenuti, K. Berkelman, A. Courau, F. Foster, K.-W. Lai, F. Lobkowicz, J. Matthews, N. Mistry, T. Rhoades
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APPENDIX E

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APPENDIX F

STORAGE RING PARAMETERS

Main Storage Ring Parameters

Nominal maximum energy	18	GeV
Minimum energy	4	GeV
Maximum current per beam (at 15 GeV)	92	ma
Design luminosity per interaction region		
Maximum luminosity at 15 GeV	1×10^{32}	$\text{cm}^{-2}\text{sec}^{-1}$
Below 15 GeV	$10^{32}(E/15)^2$	$\text{cm}^{-2}\text{sec}^{-1}$
At 18 GeV	1.5×10^{31}	$\text{cm}^{-2}\text{sec}^{-1}$
Beam lifetime	2.5 to 5.7	h
Number of interaction regions	6	
Available free length for experimental setup	19.0	m

Circumference	2200.0002	m
Symmetry	sixfold	
Average radius	350.1409	m
Largest diameter	710.8429	m
Smallest diameter	677.7638	m
Average radius with normal periodic cells	219.9240	m
Magnetic radius	165.5177	m
Bending magnet filling factor in cells	75	%
Length of interaction straight section (IP to center of Q3)	58.54335	m
Length of bend section (center of Q3 to center of 9QF)	121.96000	m
Length of symmetry straight section (center of 9QF to center of sextant)	2.83000	m
Orbital frequency	136.2693	kHz

Lattice Parameters for Standard Configurations Used for Operation with Wiggler Magnets from below 5 GeV to up to 15 GeV

Focusing structure in bend section	F-0-D-0	
Total number of cells	96	
Number of normal cells		
Mechanically identical	72	
Electrically identical	48	
Number of matching cells	24	
Length of normal cell	14.35	m
Length of matching cell at symmetry point	14.90	m
Length of matching cell at interaction straight section	20.96	m

	Beam dynamics function values in		
	Normal cell	Matching cell	Interaction straight section
Maximum betatron function:			
β_x(m)	26.5	33.5	190
β_y(m)	33.1	32.3	530
Maximum eta function:			
η_x(m)	1.81	1.98	1.15
η_y(m)	0	0	0

Phase advance per normal cell $\psi_x = 47^0$

$\psi_y = 36^0$

Betatron oscillation tunes $\nu_x = 18.77$

$\nu_y = 19.26$

Synchrotron oscillation tune $\nu_s = 0.064$

Momentum compaction factor $\alpha_c = 0.00415$

Transverse acceptance of the storage ring for ideal orbit and on-momentum particles

$A_x = 30\ \pi$ mrad mm

$A_y = 14\ \pi$ mrad mm

Maximum energy spread acceptance relative to beam energy	≥ 1.4	%
Horizontal beam emittance	$\sigma_x^2/\beta_x = 0.231\,\pi$	mrad mm
Natural energy spread	$\sigma_\varepsilon/E_0 = \pm 0.100$	%
Transverse damping time	$\tau_x = \tau_y = 8.2$	msec
Uncorrected chromaticity ($\delta = \Delta p/p_0$)		
	$\xi_x = \Delta\nu_x/\delta = -34.0$	
	$\xi_y = \Delta\nu_y/\delta = -100.3$	
Variation of damping partition number with energy	$\Delta J/\delta = 462$	

Beam dynamics parameters at interaction point:

Betatron function	$\beta_x^* = 3.707$	m
	$\beta_y^* = 0.184$	m
Eta function	$\eta_x^* = -0.653$	m
	$\eta_y^* = 0$	m
Crossing angle	$\chi = 0$	
Maximum beam-beam tune shift	$\Delta\nu_x = \Delta\nu_y = 0.06$	
Optimum coupling	$\kappa = 0.27$	

PEP Main Ring Bend Parameters

Magnet Designation	70C5400	
Number of Magnets	192	
Field @ 18 GeV	0.3625	T
$\int B d\ell$ @ 18 GeV	1.957	T-m
Pole Width	0.21	m
Gap Height	70	mm
Core Length	5.33	m
Magnetic Length	5.40	m
Width of Useful Field (0.1%)	100	mm
Lamination Height	0.496	m
Lamination Width	0.53	m
Packing Factor (min)	96	%
Core Weight	8580	kg
Amp Turns per Pole @ 18 GeV	10409	A-turns
Turns per Pole	16	
Pancakes per Pole	1	
Conductor Cross Section	65 x 9	mm^2
Cooling Hole Diameter	2 @ 5	mm
Conductor Cross-Sectional Area	546	mm^2
Current @ 18 GeV	650.6	A
Inductance	19.6	mH
Resistance @ 40^oC	17.9	mΩ
Power @ 18 GeV	7.58	kW
Voltage Drop @ 18 GeV	11.6	V
Stored Energy @ 18 GeV	4.15	kJ
Coil Weight	242	kg
Number of Water Circuits	2	
Water Flow Rate	9.45×10^{-5}	m^3/sec
Water Pressure Drop	1.38	MPa
Temperature Rise	19	^oC

PEP Standard Quadrupole Parameters (18 GeV)

(Low Impedance Design)

Magnet Designation	120Q640
Nominal Peak Gradient	20 T/m
Gradient	12.61 T/m
Pole Tip Field	0.757 T
Gradient Length Product	8.07 T
Inscribed Radius	60 mm
Minimum Gap	34.4 mm
Core Length	0.580 m
Magnetic Length	0.64 m
Width of Useful Field	120 mm
Laminate Height	365 mm
Laminate Width	402 mm
Packing Factor (min)	96%
Core Weight	1700 kg
Amp Turns per Pole	18062 A-turns
Turns per Pole	12
Pancakes per Pole	1
Conductor Cross Section	9×72 mm^2
Cooling Hole(s) Diameter	2 @ 5 mm
Conductor Cross-sectional Area	609 mm^2
Current	1505 A
Current Density	2.47 A/mm^2
Inductance	5.14 mH
Resistance @ 40°C	4.47 mΩ
Power	10.1 kW
Voltage Drop	6.73 V
Stored Energy	5.82 kJ
Aluminum Weight	150 kg
Number of Water Circuits	1
Temperature Rise	35.4 °C
Water Flow Rate	6.85×10^{-5} m^3/sec
Water Pressure Drop	1.034 MPa

PEP Standard Quadrupole Parameters (18 GeV)
(High-impedance Design)

Magnet Designation		120Q750	120Q1000	120Q380
Used for		QF, QD, 2QF, 3QF, 8QF, 8QD, 1QD	Q3, 1QF	9QF
Number of Magnets		180	24	12
Nominal Peak Gradient	T/m	20	20	20
Operating Gradient	T/m	10.76	10.76	10.76
Pole Tip Field @ Operating Gradient	T	0.646	0.646	0.646
Gradient Length Product	T	8.07	10.76	4.09
Inscribed Radius	mm	60	60	60
Minimum Gap	mm	34.4	34.4	34.4
Core Length	m	0.690	0.940	0.32
Magnetic Length	m	0.750	1.00	0.38
Width of Useful Field	mm	120	120	120
Lamination Height	mm	340	340	340
Lamination Width	mm	378	378	378
Packing Factor (min)	%	96	96	96
Core Weight	kg	1700	2316	788
Amp Turns per Pole	A-turns	15412	15412	15412
Turns per Pole		57	57	57
Pancakes per Pole		1	1	1
Conductor Cross Section	mm^2	12.7 sq.	12.7 sq.	12.7 sq.
Cooling Hole Diameter	mm	6.3	6.3	6.3
Conductor Cross-Sectional Area	mm^2	121.3	121.3	121.3
Current	A	270.4	270.4	270.4
Current Density	A/mm^2	2.23	2.23	2.23
Inductance	mH	56.4	75.2	28.6
Resistance @ 40^{0}C	mΩ	112	140	68.4
Power @ 18 GeV	kW	8.17	10.2	5.0
Voltage Drop @ 18 GeV	V	30.2	37.9	18.5
Stored Energy	kJ	2.06	2.74	1.04
Aluminum Weight	kg	150	187.5	91.6
Number of Water Circuits		2	4	2
Temperature Rise	^{o}C	24.6	10.2	11.4
Water Flow Rate	10^{-5}m^3/sec	7.95	18.4	10.5
Water Pressure Drop	MPa	1.034	1.034	1.034

PEP Insertion Region Quadrupole Parameters

Magnet Designation		160Q2000 (Q1)	160Q1500 (Q2)
Number of Quadrupoles		12	12
Rated Gradient	T/m	6.6 (±0.4)	6.6 (±0.4)
Rated Pole-tip Field @ 18 GeV	T	0.53 (±0.03)	0.53 (±0.03)
Inscribed Aperture Radius	mm	80	80
Minimum Gap Between Poles	mm	53	53
Core Length	m	1.95	1.45
Magnetic Length	m	2.0	1.5
Useful Field Width ($\Delta B/B \leq 10^{-4}$)	mm	168	168
Turns per Pole		26 (16)	26 (16)
Rated Current	A	660 (±65)	660 (±65)
Current @ 15 GeV	A	542 (-16)	542 (+9)
Current @ 18 GeV	A	651 (-5)	651 (+22)
Coil Sections per Pole		2 (1)	2 (1)
Conductor Cross Section	mm^2	23 x 20 (6.5 x 6.5)	23 x 20 (6.5 x 6.5)
Cooling Hole Diameter	mm	6.5 (3.5)	6.5 (3.5)
Conductor Area	mm^2	426 (32)	426 (32)
Rated Current Density @ 18 GeV	A/mm^2	1.54 (2.0)	1.54 (2.0)
Resistance @ 40^oC	mΩ	36.5 (260)	29.1 (200)
Rated Voltage (max.)	V	24.1 (16.9)	19.2 (13.0)
Rated Power (max.)	kW	15.9 (1.1)	12.7 (0.9)
Stored Energy @ 18 GeV	kJ	9 (∿0)	7 (∿0)
Inductance @ 18 GeV	mH	42 (16)	32 (12)
Core Weight	kg	9000	6700
Aluminum Coil Weight	kg	594	474
Number of Water Circuits		4 (2)	4 (2)
Water Temperature Rise	^oC	20	20
Water Flow Rate	m^3/sec	1.90×10^{-4} (1.3×10^{-5})	1.52×10^{-4} (1.0×10^{-5})
Water Pressure Drop	MPa	0.82 (0.60)	0.46 (0.30)

Values in parentheses are for auxiliary windings.

PEP Standard Sextupole Parameters

Magnet Designation	140S250	
Number of Sextupoles	162	
Peak Design Gradient	15.0	T/m
Design Gradient at Pole Tip	7.91	T/m
Pole Tip Field @ Design Gradient	0.277	T
Inscribed Radius	70	mm
Core Length	0.20	m
Magnetic Length	0.25	m
Weight of Iron	205	kg
Amp Turns per Pole	5655	A-turns
Turns per Pole	49	
Design Current	115	A
Conductor Size (square copper)	5.8 x 5.8	mm^2
Conductor Area	24.7	mm^2
Current Density	4.7	A/mm^2
Resistance @ $40^{o}C$	91.6	mΩ
Power	1.22	kW
Number of Water Circuits	2	
Temperature Rise	9	°C
Water Flow Rate	1.6×10^{-5}	m^3/sec
Water Pressure Drop	1.03	MPa

PEP Wiggler Magnet

Magnet Designation	50H1200	
Number of Magnets	9	
Peak Field	2	T
$\int B d\ell$ @ 2T	2.40	T-m
Gap Height	50	mm
Pole Width	240	mm
Core Length	1.15	m
Magnetic Length	1.20	m
Width of Useful Field ($\Delta B/B < 0.1\%$)	130	mm
Magnet Height	500	mm
Magnet Width	960	mm
Core Weight	3360	kg
Amp Turns per Pole @ 2T	44210	A-turns
Turns per Pole	96	
Pancakes per Pole	3	
Conductor Cross Section (sq. aluminum)	12.7 x 12.7	mm^2
Cooling Hole Diameter	6.3	mm
Conductor Cross-Sectional Area	121.3	mm^2
Current @ 2T	460.5	A
Inductance	968	mH
Resistance @ 40°C	184	mΩ
Power @ 2T	39.1	kW
Voltage Drop	84.7	V
Stored Energy	102.7	kJ
Coil Weight	123.4	kg
Number of Water Circuits	6	
Water Flow Rate	3.26 x 10^{-4}	m^3/sec
Water Pressure Drop	1.38	mPa
Temperature Rise	28.8	°C

Low Field Bend Magnet

Magnet designation	70C2000	
Number of magnets	24	
Field @ 18 GeV	240	G
$\int B d\ell$ @ 18 GeV	480	G-m
Pole width	0.19	m
Gap height	0.07	m
Core length	1.93	m
Magnetic length	2.0	m
Width of the useful field	.080	m
Amp-turns/pole @ 18 GeV	690	A-turns
Turns/pole	23	
Conductor cross section	26.7	mm^2
Cooling	Air	
Current @ 18 GeV	30	A
Resistance	0.172	Ω
Power @ 18 GeV	154	W
Voltage drop	5.13	V

PEP Magnet Power Supplies

Ring and Injection Choppers

Magnet Circuits	Total Power Required (kW)	No. of 600V dc Choppers	Current Rating (A)	Locations	No. of Magnets per Circuit
B+Q1+Q2	1850	6	700	4, 8, 12	192+12+12
Q3	134	1	300	8	12
1QF	185	1	300	8	12
1QD	114	1	300	8	12
2QF	252	1	300	8	12
3QF	196	1	300	8	12
QF	430	3	300	4, 8, 12	48
QD	420	3	300	4, 8, 12	72
8QF	130	1	300	8	12
8QD	116	1	300	8	12
9QF	99	1	300	8	12
Wigglers	180	1	700	8	9
SD	53	1	300	8	48
SF	26	1	300	8	48
H1	160	1	200	Sector 30	15
H9S	80	1	200	Sector 30	8
H9N	80	1	200	Sector 30	8
Q1S	36	1	100	Sector 30	9
Q1N	36	1	100	Sector 30	9
Q18S	28	1	100	Sector 30	7
Q18N	28	1	100	Sector 30	7

Magnet	Total Power	No. of Circuits	Rating (V/A)	Location
Ring Corrective Elements (not choppers)				
Special Sextupoles	60	5		8
Q1, Q2 Trims	48	24	± 30/100	2, 4, 6, 8, 10, 12
Steering Coils (transitions)	160	48	± 30/100	2, 4, 6, 8, 10, 12
Steering Coils (arcs)	30	96	± 30/10	2, 4, 6, 8, 10, 12
Low Field Bends	7	24	± 30/10	2, 4, 6, 8, 10, 12
Rotated Quad	20	2	± 120/100	8
Remaining Injection Supply Requirements (not choppers)				
Q6N, S thru Q17N, S	64	16	+ 50/100	Sector 30
Bumps	40	8	+ 50/100	Sector 30
Trim T1	3	1	± 50/100	Sector 30
Vertical Bends	36	3	+ 120/100	Sector 30
Trims T2S, N thru T18S, N	12	10	± 120/10	Sector 30
V and H Steering	29	24	± 120/10	Sector 30

Rf Parameters (15 GeV)

Orbital frequency	136.2693	kHz
Radiofrequency	353.21016	MHz
Harmonic number ($2^5 \times 3^4$)	2592	
Momentum compaction factor	0.00417	
Synchrotron radiation loss per turn	27.056	MeV
Energy loss into parasitic modes per turn[1]	3.7	MeV
Peak rf voltage	48.8	MV
Quantum lifetime	50	h
Circulating current per beam	92	mA
Particles per beam	4.22×10^{12}	
Synchrotron radiation power per beam	2.5	MW
Total active length of accelerating structure	38.2	m
Total shunt impedance	715	MΩ
Number of accelerator sections	18	
Number of cavities per accelerator section	5	
Fundamental mode dissipation per cavity	36.7	kW
Power loss to parasitic modes[1]	0.7	MW
Total available rf power	9.0	MW
Number of vacuum pumps (500 ℓ/sec) per accelerator section	3	
Number of klystrons	18	
Klystron beam voltage	62	kV
Klystron beam current	11.5	A
Klystron beam power	713	kW
Klystron drive power	15W	
Klystron output power	500	kW
Klystron efficiency	70	%
Maximum energy, limited by rf system		
9 MW, 38.2-m accelerating structure	18.4	GeV
9 MW, 76.4-m accelerating structure	20.5	GeV
9 MW, 152.8-m accelerating structure	22.8	GeV
Bunch length (theoretical, without bunch lengthening)	$\sigma_e = 2.3$	cm
Total rf bucket height relative to beam energy	≥ 1.4	%

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[1] Estimated for a bunch length of 4.5 cm and a parasitic-mode-loss impedance of 40 MΩ.

Vacuum System

1. Vacuum Components in One Bend Arc

Average pressure	2.2×10^{-8}	Torr
Desorption due to synchrotron radiation at 15 GeV	10^{-5}	Torr ℓ/sec/ma
Total pumping speed	27,400	ℓ/sec
Number of distribution pumps	32	
Pumping speed of distribution pumps	800	ℓ/sec
Number of holding pumps	18	
Pumping speed of holding pumps	100	ℓ/sec
Material for bend chamber	Al 6061-T4	
Length of bend chamber	13.92	m
Number of bend chambers	32	
Material for instrument module	304 Stainless Steel/Copper	
Length of instrument module	0.43	m
Number of instrument modules	18	
Number of isolation valves	4	
Number of ion gauges	4	
In situ bake-out temperature (hot water, 18 atm)	185	°C

2. Vacuum Components in One Interaction Straight Section

Average pressure	5×10^{-9}	Torr
Total pumping speed per straight section	4400	ℓ/sec
Number of pumps (pumps at rf cavities not included)	20	
Pumping speed per pump	220	ℓ/sec
Number of fast valves	2	
Number of isolation valves	2	
Material for vacuum chamber	304 Stainless Steel	
Number of ion gauges	8	
In situ bake-out temperature	200	°C max.

3. General Vacuum Components

Number of roughing pumps (portable units)	6
Quadrupole residual gas analyzer	3
Temperature-monitoring system with 100 thermocouples (movable unit)	1

Injection System

Injector accelerator	SLAC	
SLAC beam parameters for injection into PEP		
Energy	4 to 15	GeV
Momentum width	±0.5	%
Emittance		
Positrons	$0.2\pi \times (15\ \mathrm{GeV}/E)$	mm-mrad
Electrons	$0.02\pi \times (15\ \mathrm{GeV}/E)$	mm-mrad
Pulse length	1	nsec
Particles per pulse		
Positrons	1.3×10^8	
Electrons	1.3×10^9	
Repetition rate	up to 360	pps
Injection time	4 to 10	min.

Injection System Magnet Parameters

1. Pulsed Switching Magnet (29PM1)

Maximum field	3.3	kG
Effective length	0.96	m
Bend angle (15 GeV)	6.3	mr
Clear aperture	± 12.5	mm
Wave form	Single 600-Hz sinusoid	
Repetition rate	360	Hz
Peak voltage	3.8	kV
Peak current	420	A
Average power	3	kW
Weight	725	kg
Number required	1	

2. Splitter Iron-Septum Magnet (29B1)

Maximum field	10.9	kG
Effective length	3.0	m
Bend angle (15 GeV)	65	mr (3.75^{o})
Gap height	30	mm
Clear aperture		
Vertical	± 12.5	mm
Horizontal	±115	mm
Ampere-turns	34,000	A-t, d.c.
Power	22	kW
Weight	9,000	kg
Number required	1	

3. Horizontal Bend Magnets (28B2 to 28B16; 30B2 to 30B16)

Maximum field	12.6	kG
Effective length	2.6	m
Bend angle (15 GeV)	65	mr (3.75^{o})
Gap height	30	mm
Clear aperture		
Vertical	± 12.5	mm
Horizontal	± 25	mm
Ampere-turns	32,000	A-t, d.c.
Power	12	kW
Weight	2,700	kg
Number required	30	

4. Quadrupoles (28Q1 to 28Q23; 30Q1 to 30Q23)

Maximum gradient	3.0	kG/cm
Effective length	0.4	m
Inscribed radius	30	mm
Clear aperture	25.0	mm radius
Ampere-turns per pole	12,000	A-t, d.c.
Power	7.9	kW, max.
Weight	225	kg
Number required	46	

5. Vertical Bend Magnets (28B17, 30B17)

Maximum field	7.3	kG
Effective length	3.0	m
Bend angle	44	mr (2.5°)
Gap height	45	mm
Clear aperture		
Horizontal	± 20	mm
Vertical	± 35	mm
Ampere-turns	28,000	A-t, d.c.
Power	10	kW
Weight	2,250	kg
Number required	2	

6. Injection Iron-Septum Magnets (28B18, 30B18)

Maximum field	7.3	kG
Effective length	3.0	m
Bend angle (15 GeV)	44	mr (2.5°)
Gap height	35	mm
Clear Aperture		
Horizontal	± 12.5	mm
Vertical	± 25	mm
Ampere-turns	21,500	A-t,d.c.
Power	8.2	kW
Weight	2,250	kg
Number required	2	

7. Pulsed Kicker Magnets (28PM1 to 28PM3; 30PM1 to 30PM3)

Maximum field	∿ 0.6	kG
Effective length	1.0 2.0	m (28PM1 & 28PM3) m (30PM1 & 30PM3)
Clear aperture		
Vertical	∿ ± 40	mm
Horizontal	∿ ± 40 - ± 80	mm
Wave form	Half-sinusoid, damped, 3 μs long	
Peak Voltage	12 - 19	kV
Peak current	10 - 15	kA
Repetition rate	360	Hz
Number required	6	

8. d.c. Bump Magnets (28A1 to 28A4; 30A1 to 30A4)

Maximum field	4.7	kG
Effective length	0.5	m
Gap height	140	mm
Clear aperture		
Vertical	± 25 - ± 40	mm
Horizontal	± 50 - ± 80	mm
Ampere-turns	23 - 50	kA-t
Power	2 - 5	kW (max.)
Weight	∿ 225	kg
Number required	8	

PEP Power Requirements at 18 GeV (kW)

Region Location	12	2	4	6	8	10	Sector 30	Total Demand by Components	Total[a] Demand to Power Supply
SYSTEM									
1. Magnets and Buses									
Main Dipoles [b]	500		500		500			1890	2224
Q1 and Q2	130		130		130				
Q1-Q2 Trim [c]	10	10	10	10	10	10		60	70
QF's and QD's	280		280		280			840	988
All other Quads					1250			1250	1470
Sextupoles					300			300	353
Wiggler					(180)			0	0
Correction Elements	30	30	30	30	30	30		180	212
Injection Magnets[d]							760	760	895
(Magnet Subtotal)	(950)	(40)	(950)	(40)	(2500)	(40)	(760)	(5280)	(6210)
2. Rf System	3000		3000		3000			9000	15000
3. Experimental Equipment[e]	850	850	850	850	850	~100[f]		4350	5120
4. House Power[g]									
Tunnels	40	40	40	40	40	20[f]	50	270	
Interaction Halls	35	35	35	35	45	10		195	
Surface Buildings	100	60	100	70	110	50[f]	20	520	
MCR					50[f]			50	
(HP Subtotal)	(175)	(135)	(175)	(145)	(245)	(80)	(70)	(1035)	1035
5. Mechanical Utilities									
LCW Systems	400	60	400	60	420	0	150	1490	1490
Cooling Towers					1200			1200	1200
TOTAL	5375	1085	5375	1095	8215	220	980	22345	30055

NOTES:

[a] Projects overall magnet power supply efficiency of 85% and overall rf system's efficiency of 60%.

[b] Dipoles and insertion Quads, Q1Q2, are in series.

[c] Based on 120 mm design for normal cell quads. (The potential 100 mm bore design being studied can provide ~700 kW power reduction.)

[d] For operation at 15 GeV.

[e] Actual demand per area can be 3 × 850 kW with the total power for all areas constrained to 4350 kW.

[f] Assumes power from existing substations.

[g] Power for lights, electronics, cranes, convenience outlets, etc.

PEP Power Requirements (18 GeV) by Area

Region Location	System	Maximum[1] Power Demand (kW)	Approx.[2] Line Requirement KVA	Area Sub-Station Transfers
12 and 4	Magnets	1120	1315	- One 1500 kVA (12.5 kV - 480 V)
	R.F.	5000	5880	- 12.5 kV Step Regulators
	Exp. Equip.	1000	1175	- One 1500 kVA (12.5 kV - 480 V)
	House Power	175	205	One 300 kVA (480-208/120
	Mech. Utilities	400	470	Two 75 kVA (480 - 120)
2 and 6	Magnets	47	55	- One 1500 kVA (12.5 kV - 480 V)
	Exp. Equip	1000	1175	One 300 kVA (480 - 208/120)
	House Power	140	165	Two 75 kVA (480-120)
	Mech. Utilities	60	70	
8	Magnets	2940	3450	- Two 2000 kVA (12.5 kV - 480 V)
	R.F.	5000	5880	- 12.5 kV Step Regulators
	Exp. Equip.	1000	1175	- Two 1500 kVA (12.5 - 480 V)
	House Power	245	290	One 300 kVA (480 - 208/120)
	Mech. Utilities	1620	1900	Two 75 kVA (480 - 120)
10	Magnets	47	55	From Existing Sub-station
	Exp. Equipment	120	140	
	House Power	70	80	
Sector 30	Magnets	895	1050	- One 1500 kVA (12.5 - 480 V)
	House Power	70	80	Two 100 kVA (480-208/120)
	Mech. Utilities	150	175	

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(1) Includes power supplies where applicable

(2) Assumes average power factor of .85.