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Author

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Publication Date

1995-05-01

10/9-28-95 YS (1)

LBL-37231
UC-411

CENTER FOR BEAM PHYSICS

1994-95



Accelerator and Fusion Research Division
Lawrence Berkeley Laboratory
University of California
Berkeley, California 94720

May 1995

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Cover Illustration

More than ten billion electrons in a 60-cm-long bunch (2 ns) are produced from the thermionic cathode of the Advanced Light Source injector gun and are transported into a linear accelerator structure. Light emitted by the accelerated electrons (via transition radiation) when they traverse an ultrathin foil is captured on a streak camera with picosecond time resolution. Without prebunching, these electrons are trapped and accelerated into many radiofrequency buckets (top). To increase the peak current, powerful prebunchers are used to shorten the electron bunch length one hundred times (20 ps) before entering the accelerating structures (middle). One electron bunch is then made to collide (bottom) with a focused terawatt near-infrared pulse (small spot at the bottom) in an attempt, at the Center's Beam Test Facility, to produce femtosecond x-ray pulses—the shortest ever aimed toward time-resolved studies of nuclear motion in ultrafast dynamic processes.

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This work was supported principally by the U.S. Department of Energy under Contract No. DE-AC03-76SF00098. Support came from the Director, Office of Energy Research, through the Office of Basic Energy Sciences (Materials Sciences Division) and the Office of High Energy and Nuclear Physics (High Energy Physics Division).

MASTER

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Contents

Welcome to CBP	2
Facilities	4
Organizational Chart	6
Roster	8
Profiles	
Scientific and Technical Staff	9
UCB Faculty Associates	23
International Visitors	25
Post Docs	27
Center Affiliates	29
Administrative Support	39
Students	41
Participating Guests (Emeriti)	47
Principal Collaborators	51
Summary of Activities	53
Publications and Presentations	77

Welcome to CBP

"Nothing happens unless first a dream" — Carl Sandburg

The Center for Beam Physics is a multidisciplinary research and development unit in the Accelerator and Fusion Research Division at the Lawrence Berkeley Laboratory of the University of California. At the heart of the Center's mission is the fundamental quest for mechanisms of acceleration, radiation, transport, and focusing of energy and information. Dedicated to exploring the frontiers of particle and photon beam physics, its primary mission is to promote the science and technology of the production, manipulation, storage, and control of systems of charged particles and photons—often in the form of "beams" with directed energy and embedded information—as applied to studies of the fundamental structure and processes of the natural world. The Center serves this mission via conceptual

studies, theoretical and experimental research, design and development, institutional project involvement, external collaborations, association with industry, and technology transfer. These activities support exploring the next steps in the development of particle accelerators, further continuing the tradition of pioneering accelerator research at the Laboratory since its inception in 1932. The program of the Center is not limited to specific programmatic categories of the Department of Energy, but rather serves wide areas of research. The research program of the Center is directly linked to advances in high-energy and nuclear physics, condensed-matter research, the material and chemical sciences, physics at high-energy density, the life sciences, and various industrial applications.



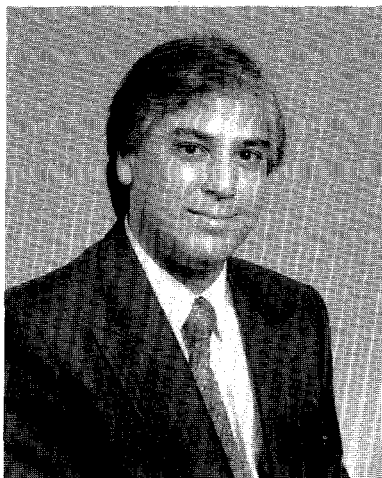
Yet another important mission of the Center is education of students, the scientific community, and the society at large via graduate instruction, research supervision, pedagogical expositions, and public service.

Special features of the Center's program include addressing R&D issues needing long development time and providing a platform for conception, initiation, and support of institutional projects based on beams. The Center brings to bear a significant amount of diverse, complementary, and self-sufficient expertise in accelerator physics, synchrotron radiation, advanced microwave techniques, plasma physics, optics, and lasers on the forefront R&D issues in particle and photon beam research. In addition to functioning as a clearinghouse for novel ideas and concepts and related R&D (e.g., various theoretical and experimental studies in beam physics such as nonlinear dynamics, phase-space control, laser-beam-plasma interaction, free-electron lasers, optics, and instrumentation), the Center provides significant support to Laboratory facilities and initiatives (e.g., the Advanced Light Source (ALS), the PEP-II asymmetric B-factory).

The multidisciplinary programs of the Center are funded by various divisions within the DOE (largely by High Energy and Nuclear Physics and Basic Energy Sciences), as well as by Laboratory-directed R&D funds. The Center also manages three in-house research facilities: the Lambertson Beam

Electrodynamics Laboratory, the CBP Laser-Optics Laboratory, and the Beam Test Facility at the ALS. Formal external collaborations include SLAC-LBL-LLNL PEP-II and NLC studies, Stanford-LBL-BNL-TRW on FEL SCRF technology, LBL-Stanford on FEL diagnostics, CEBAF-LBL on IRFEL studies, LBL-Peking University on Photocathode/SCRF technology, and LBL-BNL on heavy-ion cooling for RHIC.

This roster and annual report provides a glimpse of the scientists, engineers, technical support, students, and administrative staff that make up the CBP's outstanding team and gives a flavor of our multifaceted activities during 1994 and 1995. We welcome students, academia, industry, and the public at large to participate in our programs to help us contribute to mutual flourishing.



Swapan Chattopadhyay

Swapan Chattopadhyay
Head, Center for Beam Physics

Facilities

Lambertson Beam Electrodynamics Laboratory

Nurtured, promoted, and continually updated over the years by Glen Lambertson of LBL, this laboratory houses, in an environment of controlled temperature, various instruments, equipment, and apparatus for low-power, high-precision RF measurements of beam-handling structures. Inventory includes a sophisticated bead-pulling apparatus, a time-domain reflectometry setup, high-frequency network and spectrum analyzers, microwave parts and absorbing materials, etc. The lab also includes a small shop and facilities for performing sophisticated electrodynamic computations of properties of dynamic RF devices.



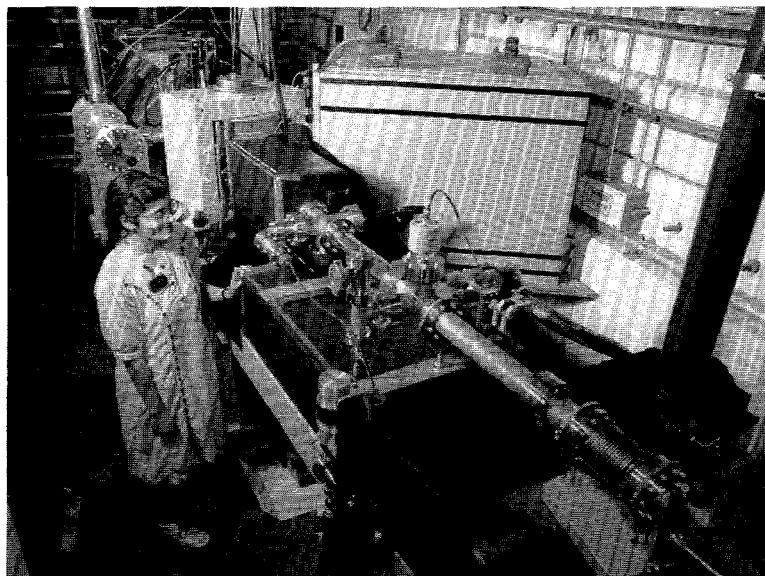
CBP Laser-Optics Laboratory

This laboratory houses lasers, optical components, plasma devices, and computers for data acquisition and control for the experimental study of optical cavities, optical spectrometers, scaled FEL optics configurations, plasmas, etc.



Beam Test Facility

This facility provides access to a 50-MeV electron beam from the ALS injector linac as well as a terawatt CPA laser system. The electron beam is transferred via a magnetic transport line to a specially shielded experimental vault for various beam-plasma, laser-electron-beam scattering and beam-RF-structure interaction studies.



CBP Dedicated Workstations

Solbourne 502
Hewlett-Packard 375
IBM RS/6000 (two)
VAXstation II
SPARC-20

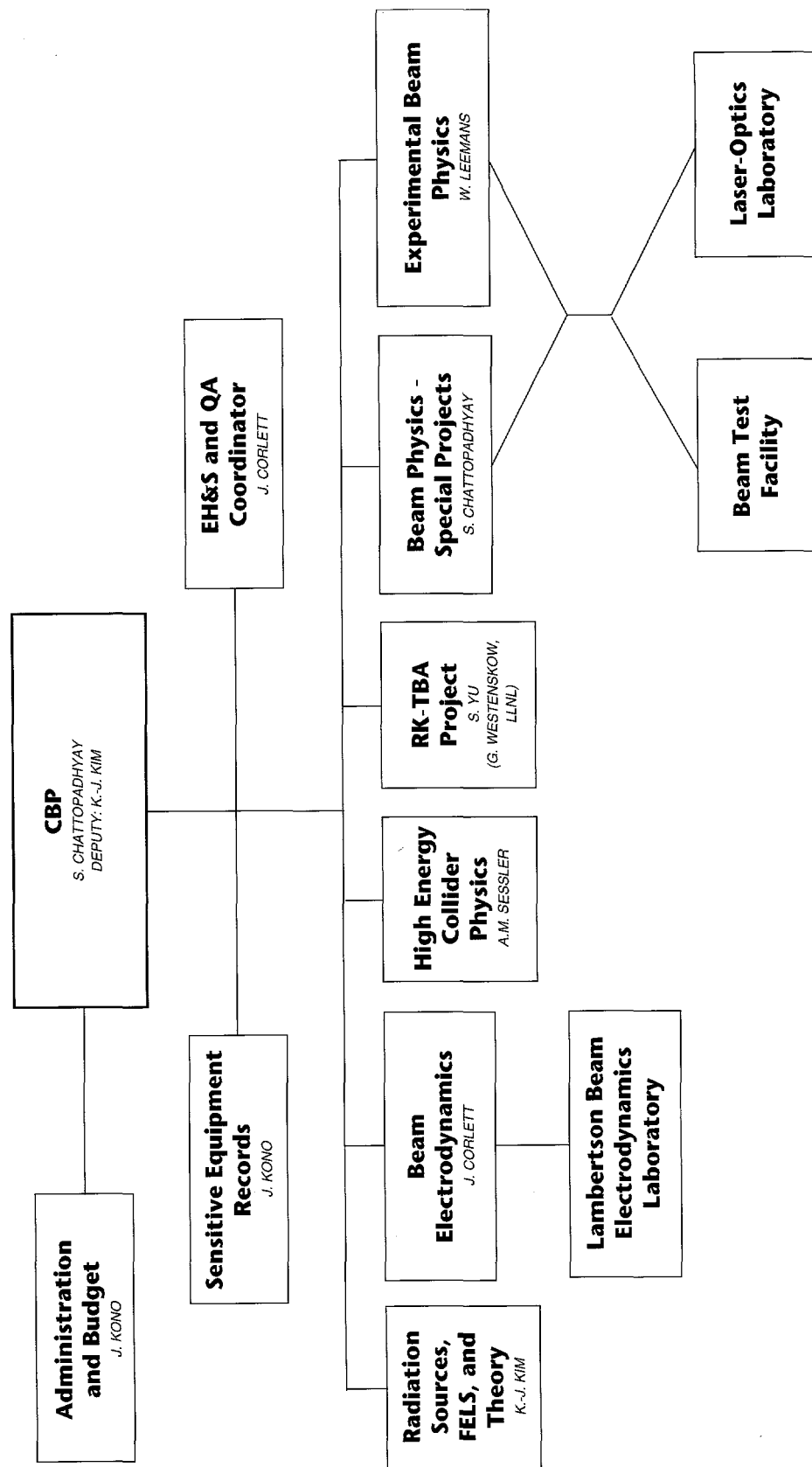
CBP Mini-Library

This library contains selected reference and textbooks on beams, plasmas, lasers, accelerator physics, dynamics, etc., as well as a few technical journals, recent preprints, and conference proceedings. It is also used as a mini-conference room.

APIARY Conference Room and Microwave Link

This is a large conference room for seminars and meetings. It is equipped with the special feature of a microwave link to SLAC, allowing joint conferences and meetings with the scientists and engineers from SLAC and Stanford University. At present, the room is routinely used for joint LBL-SLAC-LLNL meetings on the PEP-II asymmetric B-factory (elegantly acronymed APIARY by LBL physicist A. A. Garren before the present project title was adopted). It is also used regularly for the biweekly Center for Beam Physics seminars.

CENTER FOR BEAM PHYSICS Organization





Roster

Scientific and Technical Staff

ARCHAMBAULT, Leon
BARRY, Walter
BENGTSSON, Johan
BYRD, John
CHATTOPADHYAY, Swapan
CHIN, Yong Ho
CONDE, Manoel
CORLETT, John
EDIGHOFFER, John
FAWLEY, William
FOREST, Etienne
FURMAN, Miguel
GOLDBERG, David
JOHNSON, Jimmie
KIM, Kwang-Je
LEEMANS, Wim
LOZANO, David
RIMMER, Robert
SESSLER, Andrew
XIE, Ming
YU, Simon
ZHOLENTS, Alexander
ZISMAN, Michael

UCB Faculty Associates

FALCONE, Roger
WURTELE, Jonathan

International Visitors

GARDENT, Dominique
GIORDANO, Guido
HAHN, Sang June

Post Docs

GARDENT, Dominique
LI, Hai

Center Affiliates

BARLETTA, William
GOUGH, Richard
GLOVER, T. Ernest
HOUCK, Tim
JACKSON, Alan

KELLER, Roderich
KIM, Charles
KRUPNICK, James
LUHMANN, Neville
NISHIMURA, Hiroshi
ROBIN, David
SCHACHINGER, Lindsay
SCHOENLEIN, Robert
SHANK, Charles
TAJIMA, Toshiki
TAUSCHWITZ, Andreas
WESTENSKOW, Glen
ZOLOTOREV, Max

Administrative Support

CONDON, Martha
KONO, Joy
VANECEK, Sam
WONG, Olivia

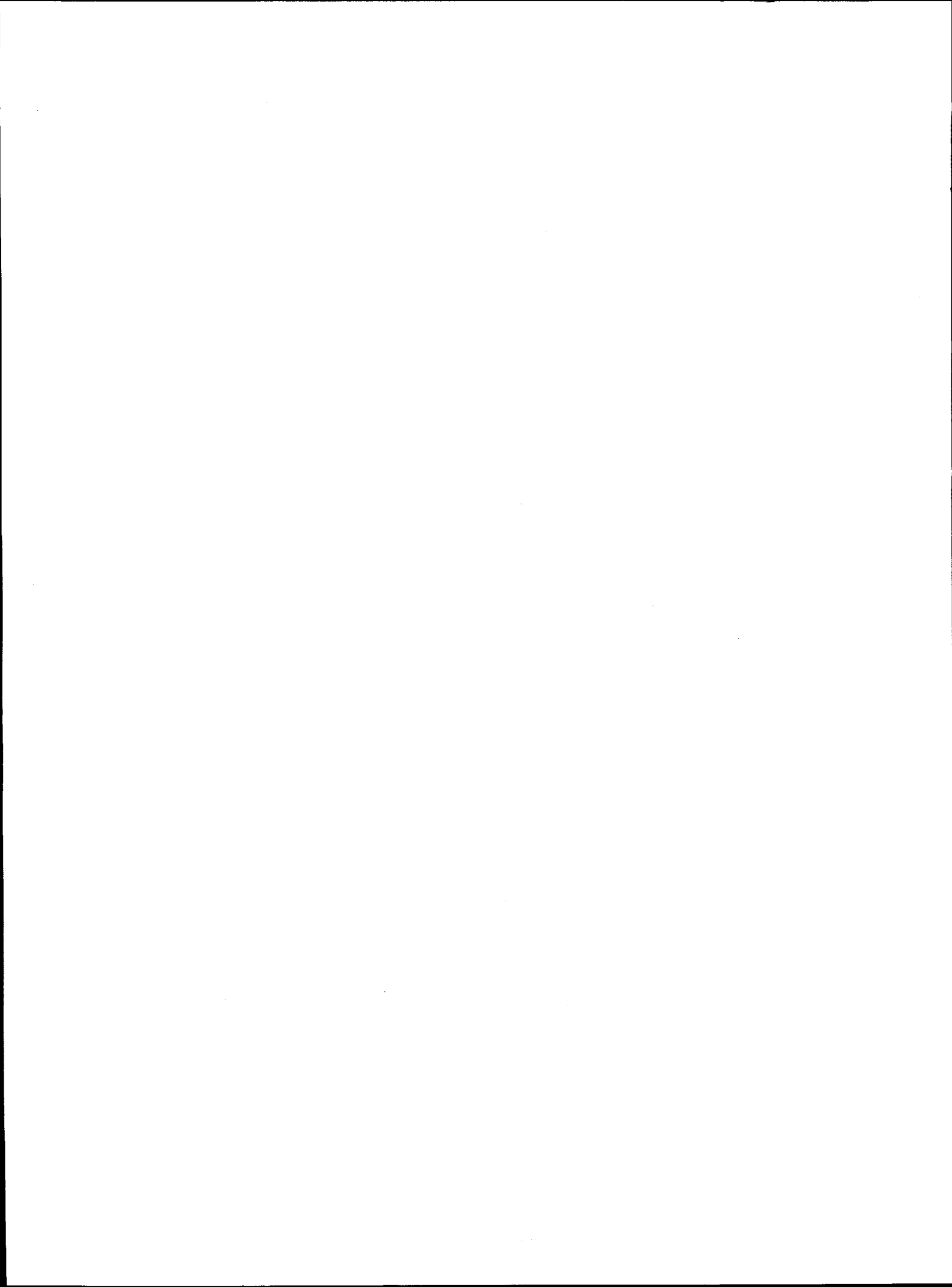
Students

CHIN, Alan
DE LOOS, Marieke
DIERON, Roel
DRAESEKE, Andrew
GIORDANO, Guido
GOFFENEY, Nicholas
GOVIL, Richa
IRWIN, Michael
LA MON, Ken
VAKARCHUK, Victoria
VAN DER GEER, Bas
VOLFBEYN, Pavel
YEH, Chih-Hung
YU, Johnathan
ZEGE, Andrew

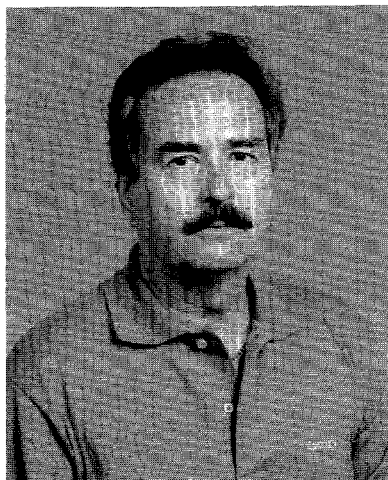
Participating Guests (Emeriti)

GARREN, Alper
GHIORSO, Albert
LAMBERTSON, Glen
PETERSON, Jack
SELPH, Frank
VOELKER, Ferdinand

Scientific and Technical Staff



Leon Archambault



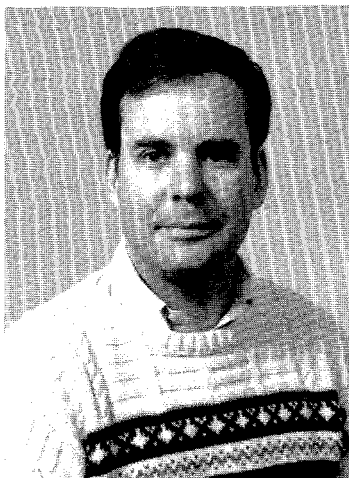
Senior Mechanical Engineering Associate
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Joined LBL in 1959

Research interests: Particle beam, vacuum, mechanical system design, engineering drawing, nuclear physics facilities, new acceleration methods.

Technical accomplishments: Nuclear physics research at LBL's OASIS, IsoSpin Laboratory systems studies, target physics and engineering.

Walter C. Barry

Staff Scientist
MS 71-259
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Joined LBL in 1992



M.S., Electrical Engineering, Georgia Institute of Technology, 1982.

Research interests: Accelerator instrumentation, theory and applications of electromagnetic and microwave devices in accelerators, coherent transition and diffraction radiation, superconducting RF cavity studies, feedback systems for controlling coupled bunch instabilities in electron storage rings.

Selected publications: "An Autocorrelation Technique for Measuring Sub-Picosecond Bunch Length Using Coherent Transition Radiation," *Proc. 1991 Advanced Beam Instrumentation Workshop*, KEK National Laboratory for High Energy Physics, Tsukuba, Japan (April 1991).

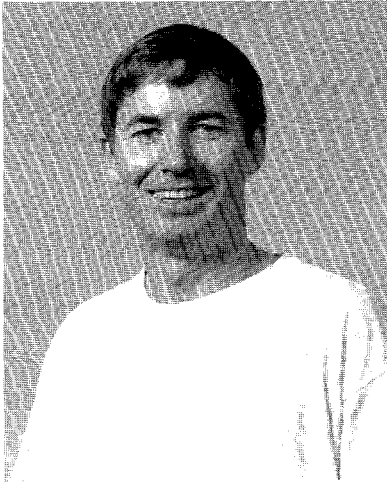
"A General Analysis of Thin Wire Pickups for High Frequency Beam Position Monitors," *Nucl. Instrum. Methods in Phys. Res.* **A301** (3) (1991).

"Characteristic Impedance and Loss Data for a Common Stripline Pickup Geometry" (with S. Y. R. Liu), *Nucl. Instrum. Methods in Phys. Res.* **A288** (2, 3) (1990).

"Perturbation Method for the Measurement of Longitudinal and Transverse Beam Impedance" (with G. Lambertson), *Proc. 1987 IEEE Particle Accelerator Conference* (March 1987).

"A Broadband Automated, Stripline Technique for the Simultaneous Measurement of Complex Permittivity and Permeability," *IEEE Trans. on Microwave Theory and Techniques* **MTT-34** (1) (1986).

Johan A. Bengtsson



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MS 71-259
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Joined LBL in 1989

Ph.D., Physics, MAX-lab, University of Lund, Sweden, 1988.

Research interests: Computer modeling, nonlinear dynamics, control theory, circular accelerators, beam measurements, signal processing, computer science.

Selected publications: "A Closed-Loop Photon Beam Control Study for the Advanced Light Source" (with G. Portmann), IEEE 1993 Particle Accelerator Conference, Washington, D.C. (May 1993).

"Study of Possible Energy Upgrade for the ALS and Modeling of the 'Real Lattice' for the Diagnosis of Lattice Problems" (with M. Meddahi), IEEE 1993 Particle Accelerator Conference, Washington, D.C. (May 1993).

"Study of Transverse Coupled Bunch Instabilities by Using Non-Linear Taylor Maps for the Advanced Light Source (ALS)" (with M. Meddahi), IEEE 1993 Particle Accelerator Conference, Washington, D.C. (May 1993).

"Achromatic and Isochronous Electron Beam Transport for Tunable Free Electron Lasers" (with K.-J. Kim), *Nucl. Instrum. Methods in Phys. Res.* **A318** (1992).

"Application of the Yoshida-Ruth Techniques to Implicit Integration and Multi-Map Explicit Integration" (with E. Forest and M. F. Reusch), *Phys. Lett. A* **158** (1991).

"Global Matching of the Normalized Ring" (with E. Forest), Advanced Beam Dynamics Workshop on Effects of Errors in Accelerators, Their Diagnosis and Corrections, Corpus Christi, Texas (October 1991).

John M. Byrd

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Ph.D., Physics, Cornell University, 1992.

Research interests: RF aspects of accelerators, single and coupled-bunch instabilities and feedback systems.

Selected publications: "Beam Instabilities," in *Synchrotron Radiation Sources—A Primer* (H. Winick, ed.), World Scientific Publishing Company (July 1994), Chapter 12, p. 306.

"Spectral Characterization of Longitudinal Coupled-Bunch Instabilities at the Advanced Light Source" (with J. N. Corlett), to be published in *Particle Accelerators*.

"Measurements of Collective Effects at the Advanced Light Source," Proceedings of the European Particle Accelerator Conference (June 1994).

"Coupled-Bunch Stability at the ALS" (with J. N. Corlett), *Proc. 1993 IEEE Particle Accelerator Conference* (May 1993).

"Simulation of the ALS Longitudinal Feedback System," *Proc. 1993 IEEE Particle Accelerator Conference* (May 1993).

"ALS Transverse Multibunch Feedback System" (with W. Barry, J. N. Corlett, J. Hinkson, and G. R. Lambertson), *Proc. 1993 IEEE Particle Accelerator Conference* (May 1993).

"Coupled-Bunch Stability at the PEP-II B-Factor," *Proc. 1993 IEEE Particle Accelerator Conference* (May 1993).

"A Collection of Complex Permittivity and Permeability Measurements" (with W. Barry, J. Johnson, and J. Smithwick), *Proc. Workshop on Microwave-Absorbing Materials for Accelerators* (February 1993).

Swapan Chattopadhyay



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Ph.D., Physics, University of California, Berkeley, 1982. Attaché Scientific, CERN, Geneva, Switzerland, 1982-84. Guest lecturer, UC Berkeley, 1987. Visiting Professor, University of Illinois at Urbana-Champaign, 1991.

Affiliations: Editor-in-chief, *Particle Accelerators* (Western Hemisphere); Member: American Physical Society (APS), American Association for the Advancement of Science (AAAS), Optical Society of America (OSA), International Committee on Future Accelerators (ICFA), Advisory Board to International Linac and Particle Accelerator Conferences, Advisory Committee to PEP-II Project. National Scholar (1967) and National Science Talent Scholar (1967-72), Govt. of India.

Research interests: Particle and photon beam physics, synchrotron radiation, free electron lasers, beam-plasma physics, nonlinear dynamics, collider physics, novel accelerators.

Selected publications: "Generation of Femtosecond X-rays by 90° Thomson Scattering" (with K.-J. Kim and C. Shank), *Nucl. Instrum. Methods in Phys. Res.* **A341**, 351-354 (1994).

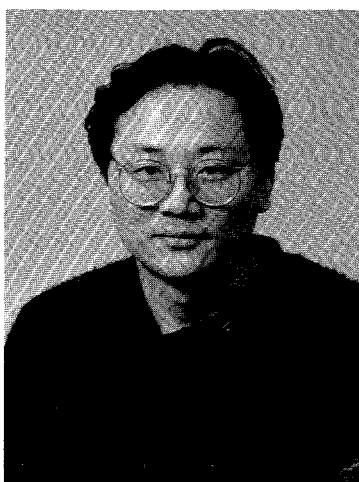
"Physics and Design Issues of Asymmetric Storage Ring Colliders as B-Factories," *Particle Accelerators* **30** (1990).

"Feasibility Study of a Storage Ring for a High-Power XUV Free Electron Laser" (with J. J. Bisognano et al.), *Particle Accelerators* **18**, 223 (1986).

"Some Fundamental Aspects of Fluctuation and Coherence in Charged Particle Beams in Storage Rings," *AIP Conf. Proc. Series* **127**, 467, (1985).

Yong Ho Chin

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Ph.D., University of Tokyo, 1984.

Major awards: Japan Accelerators Society Annual Award.

Research interests: Free electron laser, calculation of wake fields.

Selected publications: "User's Guide for ABCI, Version 8.7 (Azimuthal Beam Cavity Interaction)," CERN Report SL/94-02 (AP) (1994).

"Three-Dimensional Theory of Small-Signal, High-Gain Free Electron Laser Including Betatron Oscillations" (with K.-J. Kim and M. Xie), *Phys. Rev. A* **46**, 6662 (1992).

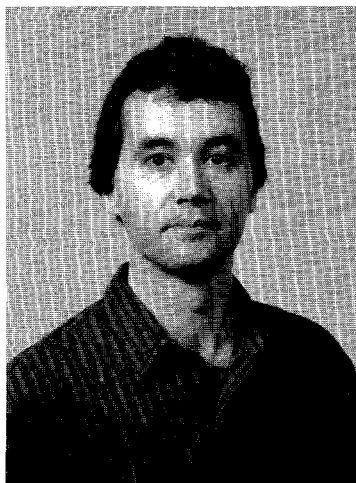
"Renormalized Theory of Beam-Beam Interaction in Electron-Positron Colliders," in *Proc. 3rd Advanced ICFA Beam Dynamics Workshop on Beam-Beam Effects in Circular Colliders* (I. Koop and G. Tumaikin, eds.), Akademgorodok, Novosibirsk, USSR (May 1989), pp. 69-75.

"User's Guide for New MOSES Version 2.0 (Mode-Coupling Single Bunch Instability in an Electron Storage Ring)," CERN Report, CERN/LEP-TH/88-05 (1988).

"Nonlinear Perturbation Approach to Bunch Lengthening and Blow-up of Energy Spread" (with K. Yokoya), *Nucl. Instrum. Methods* **226**, 223 (1984).

"Analytical Approach to the Overshoot Phenomenon for a Coasting Beam in Particle Accelerators" (with K. Yokoya), *Phys. Rev. D* **28**, 2141 (1983).

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Joined LBL in 1992

Ph.D., Physics, Massachusetts Institute of Technology, 1992.

Research interests: Free electron lasers, particle accelerators and plasma physics, photocathode RF guns and plasma lenses.

Selected publications: "Observations of Frequency Upshift in a Pulsed Free-Electron Laser Amplifier" (with C. J. Taylor and G. Bekefi), *Phys. Fluids B* **5**, 1934 (1993).

"Electron Quantum Yields from a Barium Photocathode Illuminated with Polarized Light" (with S. Chattopadhyay et al.), LBL-33303 (May 1993).

"Amplification and Superradiant Emission from a 33.3-GHz Free Electron Laser with a Reversed Axial Guide Magnetic Field" (with G. Bekefi), *IEEE Trans. Plasma Sci.* **20**, 240 (1992).

"Experimental Study of a 33.3-GHz Free Electron Laser Amplifier with a Reversed Axial Guide Magnetic Field" (with G. Bekefi), *Phys. Rev. Lett.* **67**, 3082 (1991).

"Shape of the Plasma Boundary in TBR" (with R. M. O. Galvao et al.), *Rev. Bras. Fis.* **17**, 109 (1987).

John N. Corlett

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Joined LBL in 1991



B.S., Liverpool University, 1983. Microwave engineer, EEV Co., Ltd, 1983-86. Accelerator physicist, Daresbury Laboratory, U.K., 1986-91. Joined CBP in 1991.

Research interests: Monochromatic RF structures, beam-coupling impedance, feedback systems, bunched beam instabilities.

Selected publications: "Longitudinal and Transverse Feedback Kickers for the ALS" (with J. Johnson, G. Lambertson, and F. Voelker), to be published in *Proc. Fourth European Particle Accelerator Conference*, London, England (June-July 1994).

"Measurements of Collective Effects in the ALS," (with J. Byrd), to be published in *Proc. Fourth European Particle Accelerator Conference*, London, England (June-July 1994).

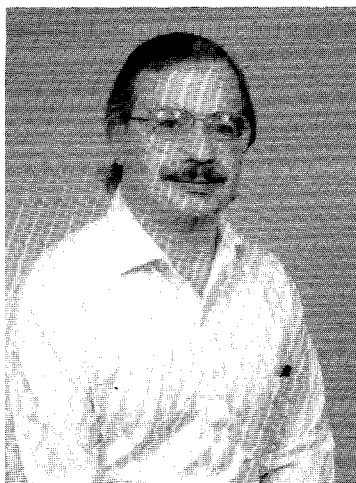
"Transverse Coupled-Bunch Feedback in the Advanced Light Source" (with W. Barry, J. Byrd, G. R. Lambertson, and C. C. Lo), to be published in *Proc. Fourth European Particle Accelerator Conference*, London, England (June-July 1994).

"Impedance Measurements of Components for the ALS," (with R. Rimmer), *Proc. IEEE Particle Accelerator Conference*, Washington, D.C. (May 1993).

"Measurement and Computation of the Higher Order Modes of the ALS 500 MHz Accelerating Cavities" (with J. Byrd), *Proc. IEEE 1993 Particle Accelerator Conference*, Washington, D.C. (May 1993).

"Experience with Cavity Design Programs," *Proc. CERN Accelerator School RF Engineering for Particle Accelerators*, CERN 92-03, Geneva (June 1992).

John A. Edighoffer



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Joined LBL in 1991

Ph.D., Applied Physics, Stanford University, 1981. Ten years at TRW doing FEL research.

Research interests: Free electron lasers, optical diagnostics, photocathodes, superconducting RF, accelerator physics and modeling, accelerator diagnostics; CDRL FEL conceptual design, Stanford/LBL/BNL superconducting RF collaboration; Stanford/LBL FEL diagnostics collaboration; LBL/CEBAF FEL/RF photocathode collaboration; hole out-coupling scaled FEL benchtop experiments.

Selected publications: "Energy Measurement of the Electron Beam Beyond the PALADIN Wiggler" (with T. J. Orzechowski et al.), Proc. 11th FEL Conf. (September 1989).

"Visible Free-Electron Laser Oscillator (Constant and Tapered Wiggler)" (with G. R. Neil et al.), *J. Appl. Phys.* (June 1987).

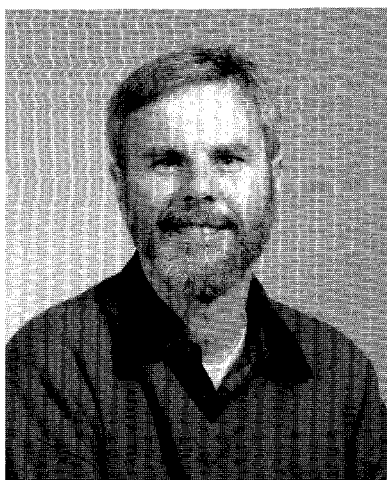
"First Operation of a Tapered Wiggler Free Electron Laser Oscillator" (with S. W. Fornaca et al.), *J. Appl. Phys.* (1983).

"Free Electron Laser Small Signal Gain Measurement at 10.6 mm," *Appl. Phys. Lett.* (1982).

"Observation of Inverse Cerenkov Interaction Between Free Electrons and Laser Light" (with W. D. Kimura, R. H. Pantell, M. A. Piestrup, and D. Y. Wang), *Phys. Rev. A* **23** (4) (April 1981).

William M. Fawley

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Joined LBL in 1990



A.B., Astrophysical Sciences, Princeton University; Ph.D., Astronomy, University of California, Berkeley, 1978. Assistant Professor, University of Pennsylvania, 1978–79. Physicist, Lawrence Livermore National Laboratory, 1979–89.

Research interests: Intense charged-particle beam physics, free electron lasers, heavy-ion fusion, novel accelerators, numerical simulation techniques.

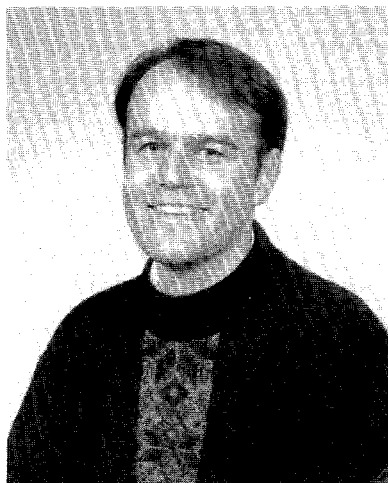
Selected publications: "Coherence and Line-width Studies of a 4-nm High Power FEL" (with A. M. Sessler and E. T. Scharlemann), *1993 Particle Accelerator Conference*, 93CH3279-7, 1530–32 (1993).

"Simulation Studies of Space-Charge Dominated Beam Transport in Large Aperture Ratio Quadrupoles" (with L. J. Laslett et al.), *Nuovo Cimento* (in press) (1993).

"Multidimensional Simulation Studies of the SELENE FEL Oscillator/Buncher Followed by a Radiator/Amplifier Output Scheme" (with S. J. Hahn), LBL-36749, to appear in *Laser Power Beaming II*, SPIE Tech. Conf. 2376, San Jose, California (February 1995).

"Sideband Control in a Millimeter-Wave Free Electron Laser" (with J. Masud et al.), *Phys. Rev. Lett.*, **58**, 763–766 (1987).

Etienne Forest



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Joined LBL in 1985

Ph.D., University of Maryland, 1984.

Research interests: Nonlinear dynamics in accelerators, perturbation theory and other approximate methods for accelerator maps.

Selected publications: "The Absolute Bare Minimum for Tracking in Small Rings" (with M. Reusch, D. Bruhwiler, and A. Amiry), *Part. Accel.* (1994).

"Freedom in Minimal Normal Forms" (with D. Murray), accepted in *Physica D* (1994).

"Construction of Symplectic Maps for Non-linear Motion of Particles in Accelerators" (with J. S. Berg, R. L. Warnock, and R. D. Ruth), *Phys. Rev.* (1993).

"Symplectic Methods in Circular Accelerators," Workshop on Integration Algorithms for Classical Mechanics, The Fields Institute, Waterloo, Ontario, Canada (October 1993).

"The Modern Approach to Single-Particle Dynamics for Circular Rings" (with L. Michelotti, A. J. Dragt, and J. S. Berg), with a foreword by J. Bengtsson, *Proc. Workshop on Stability in Storage Rings*, Upton, New York (1992). Series 54, AIP Conf. Proc. No. 292.

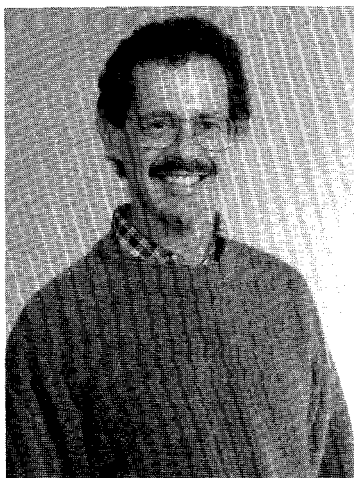
"Sixth Order Lie Group Integrator," *J. Comp. Phys.* (1992).

"A Contemporary Guide to Beam Dynamics" (with K. Hirata), KEK Report 92-12 (1992).

"Dynamic Aperture Study for the Duke FEL Storage Ring" (with Y. Wu, V. N. Litvinenko and J. Madey), *Nucl. Instrum. and Methods, Sect. A*, Elsevier North Holland Science Publishers B.V. (1992).

Miguel A. Furman

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Joined LBL in 1984



Ph. D., Theoretical Particle Physics, University of California, Santa Cruz, 1977. Joined LBL in August 1984. Worked "on loan" for the SSC Central Design Group (1984-89), and then for the SSC Laboratory (1989-90). Since 1990, working full-time at the CBP on the PEP-II project.

Research interests: Beam-beam interaction, impedances and beam instabilities, longitudinal phase space management and matching in chains of proton accelerators, space-charge effects.

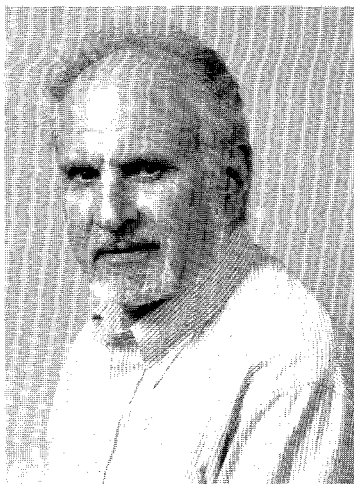
Selected publications: "Compact Complex Expressions for the Electric Field of 2-D Elliptical Charge Distributions," *Am. J. Phys.* **62** (12), 1134-40 (December 1994).

"Beam-Beam Tune Shift and Dynamical Beta Function in PEP-II," *Proc. European Particle Accelerator Conference*, London, England (June-July 1994), p. 1145.

"Closed Orbit Distortion from Parasitic Collisions in PEP-II," *Proc. European Particle Accelerator Conference*, London, England (June-July 1994), p. 1147.

"Beam Instabilities" (with J. Byrd and S. Chattopadhyay), in *Synchrotron Radiation Sources—A Primer* (H. Winick, ed.), World Scientific Publishing Company (July 1994), Chapter 12, p. 306. Senior Scientist

David A. Goldberg



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Joined LBL in 1980

Ph.D., Nuclear Physics, Johns Hopkins University, 1967.

Research interests: Beam instrumentation and feedback, beam impedance measurements, stochastic cooling.

Selected publications: "Automated Bead-Positioning System for Measuring Impedances of RF Cavity Modes" (with R. A. Rimmer), contribution to Particle Accelerator Conference (1993).

"Measurements of Higher-Order Mode Damping in the PEP-II Low-Power Test Cavity" (with R. A. Rimmer), contribution to the Particle Accelerator Conference (1993).

"Dynamic Devices: A Primer on Pickups and Kickers" (with G. R. Lambertson), in *Physics of Particle Accelerators* (M. Month and M. Dienes, eds.) (1992).

"Modes of Elliptical Waveguides: A Correction" (with L. J. Laslett and R. A. Rimmer), *IEEE Trans. on Microwave Theory and Techniques* **38** (1990).

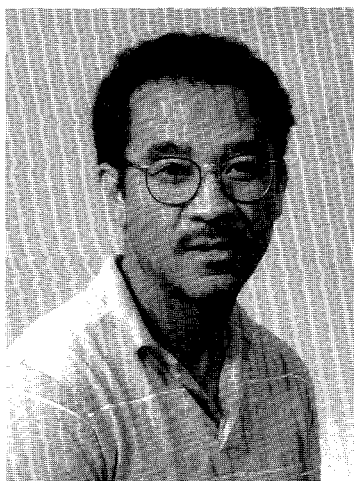
"Successful Observation of Schottky Signals at the Tevatron Collider" (with G. R. Lambertson), *Particle Accelerators* **30** (1990).

"Improving the Performance of Power-Limited Stochastic Cooling Systems" (with G. R. Lambertson), *Particle Accelerators* **30** (1990).

"Beam Impedance Measurements on the ALS Curved Sector Tank" (with R. A. Rimmer et al.), contribution to 1990 European Particle Accelerator Conference.

Jimmie K. Johnson

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Joined LBL in 1981



B.S., Electronics Engineering, University of California, Davis, 1981.

Research interests: Accelerator technology, microwave devices, computer-aided modeling, multibunch feedback systems.

Selected publications: "Novel Electrode Design for a 4-8 GHz Stochastic Cooling System" (with D. Goldberg, G. Lambertson, F. Voelker), *Bull. Am. Phys. Soc.* **33**, 1025 (1988).

"Power Combiners/Dividers for Loop Pickup and Kicker Arrays for FNAL Stochastic Cooling Rings" (with R. Nemetz), 1985 Particle Accelerator Conference, Vancouver, B.C., Canada (May 1985), *IEEE Trans. Nucl. Sci.*, NS-32 (October 1985), p. 2171.

"An Array of 1 to 2 GHz Electrodes for Stochastic Cooling" (with F. Voelker and T. Henderson), 1983 Particle Accelerator Conference, Santa Fe, New Mexico (March 1983).

Kwang-Je Kim



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Joined LBL in 1978

Ph.D., Elementary Particle Physics, University of Maryland, 1970. Visiting Scientist, SLAC 1970-73; Max Planck Inst. für Phys. and Astrophys., 1973-75; University of Mainz, 1975-78.

Affiliations: Fellow of American Physical Society, International FEL Program Committee (1993), International Advisory Committee for Pohang Light Source.

Research interests: Novel x-ray generation, free electron lasers, synchrotron radiation optics, high-brightness electron beams.

Selected publications: "Generation of Sub-Picosecond X-rays by 90° Thomson Scattering" (with S. Chattopadhyay and C.V. Shank), to be published in *Nucl. Instrum. Methods*.

"Spectral Bandwidth in FEL Oscillators," *Phys. Rev. Lett.* **66**, 2746 (1991).

"Free Electron Lasers: Present Status and Future Prospect" (with A. M. Sessler), *Sciences* **250**, 88 (October 1990).

"RF and Space Charge Effects in Laser-Driven RF Electron Guns," *Nucl. Instrum. Methods* **A275**, 201 (1989).

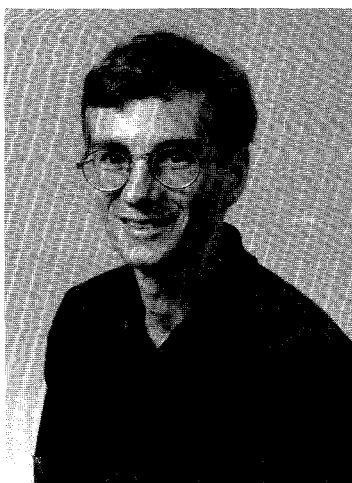
"Three-Dimensional Analysis of Coherent Amplification and Self-Amplified Spontaneous Emission in Free Electron Lasers," *Phys. Rev. Lett.* **57**, 1871 (1986).

"Brightness, Coherence, and Propagation Characteristics of Synchrotron Radiation," *Nucl. Instrum. Methods* **A246**, 71 (1986).

"A Synchrotron Radiation Source With Arbitrarily Adjustable Elliptical Polarization," *Nucl. Instrum. Methods* **222**, (1984).

Wim Leemans

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Joined LBL in 1991



Ph.D., Electrical Engineering, University of California, Los Angeles, 1991.

Major awards: Simon Ramo Award 1992, American Physical Society.

Research interests: Photon and particle beam-plasma interaction, novel x-ray generation, free electron lasers, advanced accelerator concepts, ultra-high intensity pulse lasers.

Selected publications: "Ultra-High Gradient Acceleration of Injected Electrons by Laser Excited Relativistic Electron Plasma Wave" (with C.E. Clayton et al.), *Phys. Rev. Lett.* **70**, 37 (1993).

"Non-linear Dynamics of Driven Relativistic Electron Plasma Waves" (with C. Joshi, W. B. Mori, C. E. Clayton, and T. W. Johnston), *Phys. Rev. A* **46**, 15 (1992).

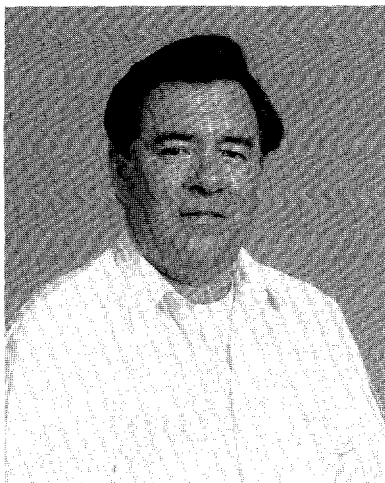
"Experiments and Simulations of Tunnel-Ionized Plasmas" (with C.E. Clayton et al.), *Phys. Rev. A* **46**, 1091-1105 (1992).

"Plasma Physics Aspects of Tunnel-Ionized Gases" (with E. Clayton et al.), *Phys. Rev. Lett.* **68**, 321-324 (1992).

"Stimulated Compton Scattering from Pre-formed Underdense Plasmas" (with C.E. Clayton, K. A. Marsh, and C. Joshi), *Phys. Rev. Lett.* **67**, 1434-1437 (1991).

"Detection of Trapped Magnetic Fields in a q-Pinch Plasma Using a Relativistic Electron Beam" (with C. Joshi and C.E. Clayton), *Rev. Sci. Instrum.* **59**, 1641 (1988).

David Lozano



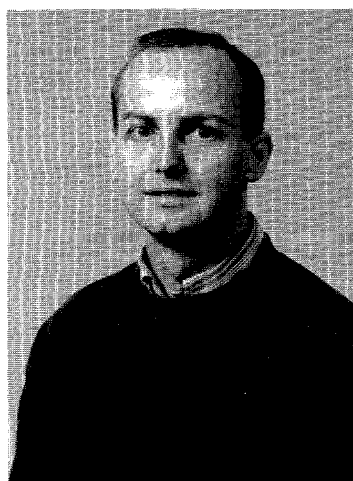
Senior Assistant Tech Coordinator
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Joined LBL in 1970

Research interests: Technical and mechanical design, fabrication, installation and testing. Microwave systems mechanical and electrical design and fabrication.

Technical accomplishments: More than 25 years of service to the LBL Bevatron/Bevalac program; presently at the Center in the Beam Electrodynamics Group.

Robert A. Rimmer

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Joined LBL in 1988



Ph.D., Lancaster University, U.K., Engineering Department, 1988; subject: High Power Microwave Window Failures.

Research interests: Computer simulation of high-frequency electromagnetic problems, Higher-Order-Mode suppression in RF cavities and structures, microwave windows, beam impedance of accelerator components.

Selected publications: "Extraction and Absorption of Higher Order Modes in Room Temperature Accelerators," invited paper, *Proc. Workshop on Microwave Absorbing Materials for Accelerators*, MAMA (February 1993), CEBAF, Newport News, Virginia.

"RF Cavity Development for the PEP-II B Factory," *Proc. International Workshop on B-Factories*, BFWS92, KEK, Japan (November 1992).

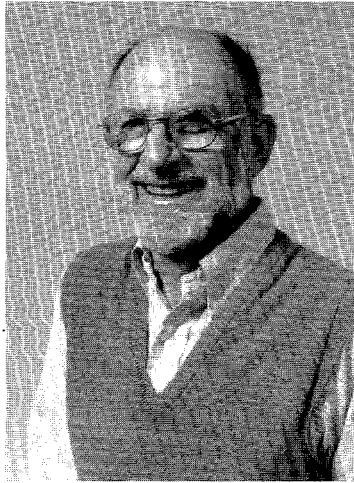
"An RF Cavity for the B-Factory" (R. Rimmer et al.), *Proc. 1991 U.S. Particle Accelerator Conference*, San Francisco, California (May 1991).

"Modes of Elliptical Waveguides; a Correction" (with D. A. Goldberg and L. J. Laslett), *IEEE Trans. MTT* **38** (11), 1603-1608 (November 1990).

"Beam Impedance Measurements on the ALS Curved Sector Tank" (R. A. Rimmer et al.), *Proc. 1990 European Particle Accelerator Conference*, Nice, France (June 1990); LBL-28192.

"Determination of Failure Mechanisms of RF Cavity Aperture Windows," *Proc. 1989 IEEE Particle Accelerator Conference*, Chicago, Illinois (March 1989).

Andrew M. Sessler



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Joined LBL 1961
Director 1973-1980

Ph.D., Theoretical Physics, Columbia University, 1953.

Major awards and affiliations: E. O. Lawrence Award by U.S. Atomic Energy Commission; U.S. Particle Accelerator School Prize; Leland J. Haworth Distinguished Scientist, Brookhaven National Laboratory, Dwight R. Nicholson Humanitarian Award. Member, National Academy of Sciences.

Research interests: Beams in plasmas, conventional and novel high-energy accelerators, free electron lasers.

Selected publications: "Radio-Frequency Beam Conditioner for Fast-Wave Free-Electron Generators of Coherent Radiation" (with D. H. Whittum and L.-H. Yu), *Phys. Rev. Lett.* **64** (1992).

"Photon Storage Cavities" (with K.-J. Kim), *Nucl. Instrum. Methods in Phys. Res.* **A318** (1992).

"Free Electron Laser Generation of VUV and X-ray Radiation Using a Conditioned Beam and Ion-Channel Focusing" (with L.-H. Yu and D. H. Whittum), *Nucl. Instrum. Methods in Phys. Res.* **A318** (1992).

"Transverse Resistive Wall Instability in the Two-Beam Accelerator" (with D. H. Whittum and V. K. Neil), *Phys. Rev. A* **43** (1991).

"Relativistic Klystrons for High-Gradient Accelerators" (with G. W. Westenskow et al.), *Proc. 1990 Linear Accelerator Conference* (1991).

"Standing-Wave Free-Electron Laser Two-Beam Accelerator" (with D. H. Whittum, et al.), *Nucl. Instrum. Methods in Phys. Res.* **A306** (1991).

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Joined LBL in 1988

Ph.D., Physics, Stanford University, 1988.

Research interests: Generation of intense short wavelength radiation, free electron laser, laser optics.

Selected publications: "Self-Amplified Spontaneous Emission for Short Wavelength Coherent Radiation" (with K.-J. Kim), *Nucl. Instrum. Methods in Phys. Res.* **A331**, 359 (1993).

"Three-Dimensional Theory of the Small-Signal High-Gain Free Electron Laser Including Betatron Oscillations" (with Y. Chin and K.-J. Kim), *Phys. Rev. A* **46** (10) 6662, (1992).

"Performance of Hole Coupling Resonator in the Presence of Asymmetric Modes and FEL Gain" (with K.-J. Kim), *Nucl. Instrum. Methods in Phys. Res.* **A318**, 877 (1992).

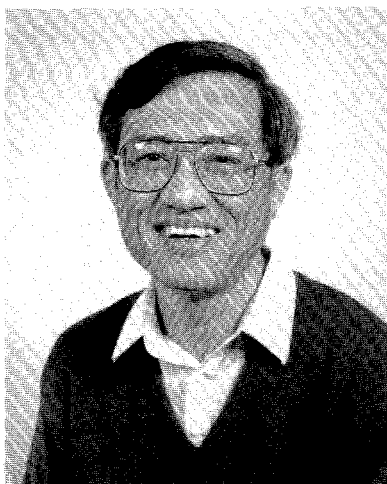
"Hole Coupling Resonator for Free Electron Lasers" (with K.-J. Kim), *Nucl. Instrum. Methods in Phys. Res.* **A304**, 792 (1991).

"Stability and Performance of CDRL-FEL" (with K.-J. Kim), *Nucl. Instrum. Methods in Phys. Res.* **A304**, 146 (1991).

"Eigenmode Analysis of Optical Guiding in Free Electron Lasers" (with D. A. G. Deacon and J. M. J. Madey), *Phys. Rev. A* **41** (3), 1662 (1990).

"Theoretical Study of FEL Active Guiding in the Small Signal Regime" (with D. A. G. Deacon), *Nucl. Instrum. Methods in Phys. Res.* **A250**, 426 (1986).

Simon Yu



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Joined LBL in 1992

Ph.D., University of Washington, 1970.

Research interests: Induction accelerators, accelerator physics, linear colliders, heavy ion fusion, beams in plasmas, conventional and novel high-energy accelerators.

Affiliations and honors: Fellow of American Physical Society.

Selected publications: "High Current Injector for Heavy Ion Fusion" (with S. Yu et al.), *Proc. International Symposium on Heavy Ion Inertial Fusion*, Frascati, Italy (1993).

"Study of Recirculating Induction Accelerator as Drivers for Heavy Ion Fusion," *Research Trends in Physics*, La Jolla International School of Physics, New York, New York (1992), p. 205.

"A Plasma-Based Adiabatic Focuser" (with P. Chen, K. Oide, and A. M. Sessler), *Phys. Rev. Lett.* **64**, 1231 (1990).

"Relativistic Klystron Version of the Two-Beam Accelerator" (with A. M. Sessler), *Phys. Rev. Lett.* **58**, 2439 (1987).

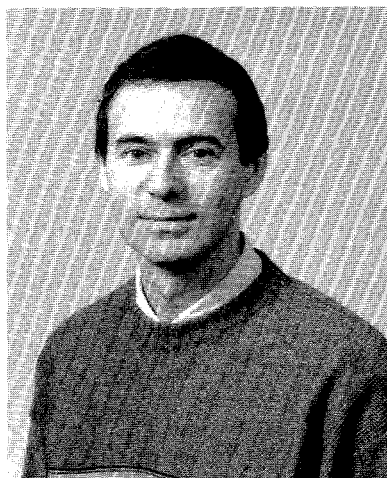
"Waveguide Suppression of the Free Electron Laser Sideband Instability" (with S. Yu et al.), *Nucl. Instrum. Methods* **A259**, 219-225 (1987).

"Intense Electron Beams," *Lecture Notes in Physics*, Proceedings of Frontiers of Particle Beams, South Padre Island, Texas (1986), p. 238.

"Phase Space Distortions of a Heavy Ion Beam Propagating Through a Vacuum Reactor Vessel" (with E. P. Lee and W. A. Barletta), *Nucl. Fusion* **21**, 961 (1981).

Alexander Zholents

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Joined LBL in 1992



Ph.D., Institute of Nuclear Physics, Novosibirsk, Russia, 1983. Scientist at Institute of Nuclear Physics, Novosibirsk, 1983-1992.

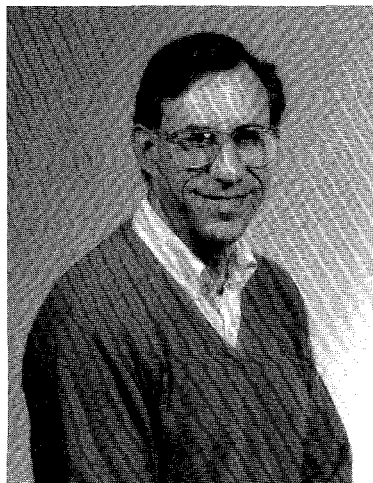
Research interest: Dynamics of charged particle beams, high-luminosity electron-positron colliders, optical stochastic cooling.

Selected publications: "Transit-Time Method of Optical Stochastic Cooling" (with M. Zolotarev), *Phys. Rev. E* **50**, 3087 (1994).

"The Tau-Charm Factory" (with J. M. Jowett, M. Munoz, J.-M. Quesada, and C. Willmott), *Proc. 16th International Conference on Charged Particle Accelerators* (1993), p. 439.

"Beam-Beam Effects in Electron Storage Rings," *Lect. Notes in Phys.* **400**, 321 (1992).

Michael S. Zisman



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Joined LBL in 1966

Ph.D., University of California, Berkeley, 1972.

Research interests: Design of electron storage rings and high-luminosity electron-positron colliders, beam instabilities, collective effects, design of PEP-II asymmetric B factory, study of high-luminosity collider design.

Selected publications: "General B Factory Design Considerations," *Lect. Notes in Phys.* **425**, 57 (H. Dienes, M. Month, B. Strasser, S. Turner, eds.) Springer-Verlag, Berlin, Germany (1994).

"Physics and Technology Challenges of $B\bar{B}$ Factories," *Proc. 1991 Particle Accelerator Conference*, San Francisco, California, (May 1991), p. 1. Also in *Lect. Notes in Phys.* **400** (M. Dienes, M. Month, S. Turner, eds.), Springer-Verlag, Berlin (1992), p. 600.

"PEP-II Asymmetric B Factory: R&D Results" (with J. Dorfan, A. Hutton, and W. Barletta for the PEP-II Design Group), *Proc. European Particle Accelerator Conference*, Berlin, Germany (March 1992).

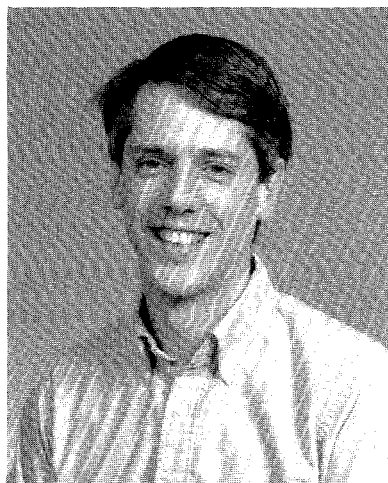
"B Factory RF System Design Issues," *Proc. International Conference on B Factories: The State of the Art in Accelerators, Detectors and Physics*, Stanford, California (April 1992).

"PEP-II: An Asymmetric B Factory Based on PEP" (with A. Hutton, for the SLAC/LBL/LLNL B Factory Design Group), *Proc. 1991 Particle Accelerator Conference*, San Francisco, California (May 1991), p. 84.

"ZAP and Its Application to the Optimization of Synchrotron Light Source Parameters," *Part. Accel.* **23**, 289 (1988).

UCB Faculty Associates

Roger W. Falcone



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Joined LBL/UCB in 1983

Ph. D., Electrical Engineering, Stanford University, 1979. Marvin Chodorow Fellow, Applied Physics Department, Stanford University, 1980-83.

Major awards: Fellow of the American Physical Society; Fellow of the Optical Society of America; Distinguished Traveling Lecturer, APS Laser Science Topical Group (1992-93); Presidential Young Investigator Award of the NSF (1984-89).

Research interests: Interactions of intense light with matter; applications of lasers in plasma, atomic, and condensed-matter physics; ultrashort pulse lasers.

Selected publications: "High Density Plasmas Produced by Ultrafast Laser Pulses" (with M. M. Murnane and H. C. Kapteyn), *Phys. Rev. Lett.* **62**, 155 (1989).

"X-Rays from Microstructured Targets Heated by Femtosecond Lasers" (with S. P. Gordon, T. Donnelly, A. Sullivan, and H. Hamster), *Opt. Lett.* **19**, 484 (1994).

"Short-Pulse Terahertz Radiation from High-Intensity Laser-Produced Plasmas" (with H. Hamster, A. Sullivan, and S. Gordon), *Phys. Rev. E* **49**, 671 (1994).

"Propagation of Intense, Ultrashort Laser Pulses in Plasmas" (A. Sullivan, H. Hamster, S. P. Gordon, and H. Nathel), *Opt. Lett.* **19**, 154.

Jonathan S. Wurtele

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Joined LBL in 1995



Ph.D., Physics, University of California, Berkeley, 1985.

Research interests: Generation of coherent radiation from charged particle beams, advanced accelerator concepts, intense laser-plasma interactions, nonneutral plasma physics.

Selected publications: "Nonlinear Theory and Experiment of Collective Free Electron Lasers" (with R. Chu and J. Fajans), *Phys. Fluids* **B2**, 1626 (1990).

"Free Electron Laser Simulation Techniques" (with T. M. Tran), *Phys. Reports* **195**, 1 (1990).

"Asymmetric Stable Equilibria in Nonlinear Plasmas" (with J. Notte, A. J. Peurring, J. Fajans, and R. Chu), *Phys. Rev. Lett.* **69**, 3065 (1992).

"Calculation of the Bunch Lengthening Threshold" (with X. T. Yu), *Proc. 1993 IEEE Particle Accelerator Conference* (1993), p. 3327.

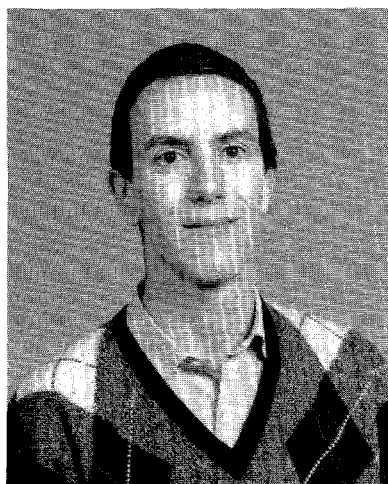
"The Role of Plasma in Future Accelerators," *Phys. Fluids* **B5**, 2363 (1993).

"Advanced Accelerator Concepts," *Phys. Today* (July 1994).

"Stability of Channel Guided Laser Pulses" (with G. Shvets), *Phys. Rev. Lett.*, in press (1994).

International Visitors

Guido F. Giordano



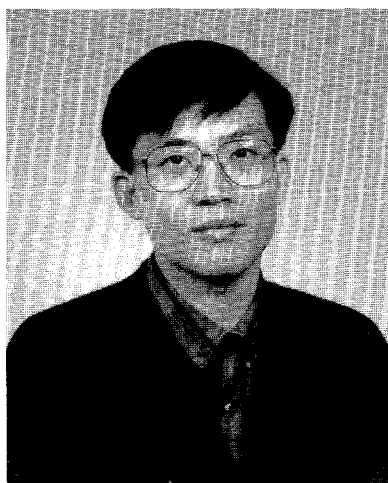
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Degree at Università degli Studi di Milano, Italy, 1994.

Research interests: Beam physics in detuned TW extraction cavities (Relativistic-Klystron Two-Beam Accelerator project).

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Ph.D., Physics, Pohang Institute of Science and Technology (POSTECH), Pohang, Korea, 1993. Research Scientist, Pohang Light Source (PLS), Pohang, Korea, 1988-89; Research Associate, POSTECH, Pohang, Korea, 1993.

Research interests: Coherent radiation sources, free-electron lasers, nonlinear dynamics and chaos, beam-plasma physics.

Selected publications: "Chaotic Transitions in a Short-Pulse FEL Oscillator," submitted to *Nucl. Instrum. Methods A* (1993).

"Nonlinear Short-Pulse Propagation in a Free-Electron Laser," *Phys. Rev. E* **48**, 2162 (1993).

"Optical Spikes and Superradiant Pulse Propagation in a Free-Electron Laser," *Nucl. Instrum. Methods A* **331**, 390 (1993).

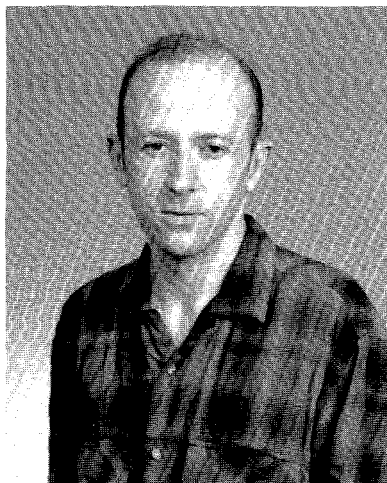
"Bifurcations in a Short-Pulse Free-Electron Laser Oscillator," *Phys. Lett. A* **176**, 339 (1993).

"Kinetic Simulation for the Transient Sheath in the Plasma Ion Implantation," *Jpn. J. Appl. Phys.* **31**, 2570 (1992).

"Off-Peak Saturation Effects of Beam-Plasma Instability," *IEEE Trans. Plasma Sci.* **19**, 52 (1991).

Post Docs

Dominique Gardent



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Joined LBL in 1995

Ph.D., Physics, University of Paris (Orsay), 1994. Visiting Scientist at MIT, 1994–95.

Research interests: Dynamics of charged particle beams, beams in plasmas, free electron lasers, two-beam accelerators, gamma-gamma colliders.

Selected publications: "Electron Trajectories in a Free Electron Laser with a Reversed Axial Guide Field" (with A. Bourdier et al.), *Nucl. Instrum. Methods* **A341**, 250 (1994).

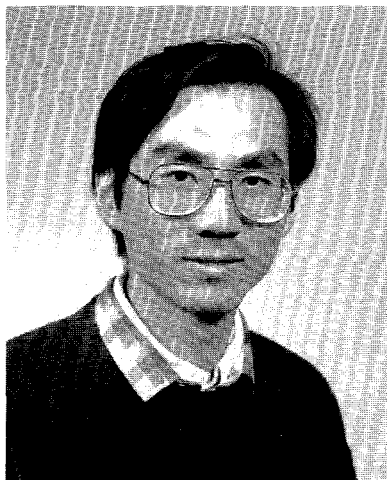
"Sources Micro-Ondes" (with J. M. Buzzi et al.), *Conférence invitée. Journée thématique "gaz ionisés,"* DRET-ETCA, Arcueil, France (1993).

"Microwave FEL Experiment at CESTA" (with J. Launsbach et al.), *Nucl. Instrum. Methods* **A331**, 149 (1993).

"Progress in Free Electron Maser Experiment at CESTA" (with H. Bottellier-Curtet et al.), *SPIE, Intense Microwave and Particle Beams III* **1629**, 159 (1992); also in *Nucl. Instrum. Methods* **A318**, 131 (1992).

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Joined LBL in 1993



Ph.D., Physics, University of Maryland at College Park, 1993.

Research interests: Analytical and numerical studies of beam dynamics and RF properties that are related to the conceptual designs of RF linear colliders, especially the two-beam accelerators, both the relativistic klystron version and the standing-wave free electron laser version.

Selected publications: "Design Study of Beam Dynamics Issues for 1 TeV Next Linear Collider Based Upon the Relativistic-Klystron Two-Beam Accelerator" (with T. Houck et al.), presented at the 1994 Advanced Accelerator Concept Workshop; to be published in the Proceedings.

"Theory for Inductively Detuned Traveling Wave Structures" (with S. Yu), accepted for publication in *Nucl. Instrum. Methods in Phys. Res. A* (1995).

"Suppression of Beam Break-Up in a Standing Wave Free Electron Laser Two-Beam Accelerator" (with J. S. Kim), presented at the 1994 SPIE International Symposium, Los Angeles, California (January 1994); published in *Proc. Intense Microwave Pulses II* (H. E. Brandt, ed.), pp. 91–98.

"Space Charge Instabilities in Gyrotron Beams" (with T. M. Antonsen, Jr.), in *Phys. Plasmas* **1** (3), 714 (1994).

"Theory of Gyro-Traveling-Wave Tubes at Cyclotron Harmonics" (with G. S. Nusinovich), *Int. J. Electron.* **72** (5–6), 895 (1992).

Center Affiliates

"I still say to myself when I am depressed and find myself forced to listen to pompous and tiresome people, 'Well, I have done one thing you could never have done, and that is to have collaborated with Littlewood and Ramanujan on something like equal terms.'"

— G.H. Hardy in
A Mathematician's Apology

William A. Barletta



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Joined LBL in March 1993

Ph.D., Experimental High-Energy Physics, University of Chicago, 1972. 1989-92: Visiting Professor, Department of Physics, UCLA. 1990-93: Assistant Laboratory Associate Director for Programs at Lawrence Livermore National Laboratory.

Affiliations and honors: Sigma Xi (Yale); Woodrow Wilson Fellow (University of Chicago); Member, American Physical Society.

Selected publications: "Luminosity Limitations in Hadron Supercolliders," to be published in *Supercolliders and Superdetectors* (W. Barletta and H. Leutz, eds.), World Scientific (1993).

"Characteristics of a High Energy $\mu^+\mu^-$ Collider Based on Electro-production of Muons" (with A. M. Sessler), LBL-33613, for submission to *Nucl. Instrum. Methods* (January 1993).

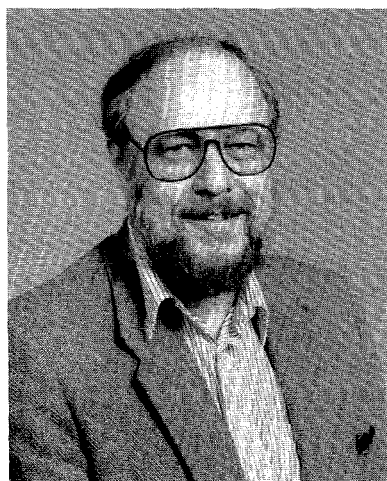
"Physically Transparent Formulation of the Free Electron Laser in the Linear Gain Regime" (with A. M. Sessler and L. H. Yu), published in *Nucl. Instrum. Methods* and in *Proc. 14th International Free Electron Laser Conference*, Kobe, Japan (August 1992).

"Measurements of Photo-desorption from Copper Alloys" (W. A. Barletta et al.), *Proc. 15th International High Energy Accelerator Conference*, Hamburg, Germany (July 1992).

"Critical Vacuum Issues for B-factories," *Proc. International Symposium on B-factories: State of the Art*, Stanford, California (April 1992).

Richard A. Gough

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Joined LBL in 1970



Ph.D., Nuclear Physics, McMaster University, 1970.

Research interests: Design, construction, and management of accelerator facilities, conceptualization and development of accelerator facilities with applications to the scientific community.

Selected publications: "Design of a Super-conducting Linear Accelerator for an Infrared Free Electron Laser of the Proposed Chemical Dynamics Research Laboratory at LBL" (with S. Chattopadhyay et al.), 16th International Linac Conference, Ottawa, Ontario, Canada (August 1992).

"Design Overview of Highly Stable Infrared Free Electron Laser at LBL" (with K.-J. Kim et al.), *Proc. Twelfth International Free Electron Laser Conference*, Paris, France (September 1990).

"Performance of the Oxygen Injector for the CERN Linac I" (with B. Wolf et al.), *Nucl. Instrum. Methods A258* (1987).

"Medical Heavy Ion Accelerator Proposals," *Proc. 1985 Particle Accelerator Conference*, Vancouver, B.C., Canada (May 1985), p. 3282.

T. Ernest Glover

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Joined LBL in 1994

Ph.D., Physics, University of California, Berkeley, 1994. AT&T Bell Laboratories, Photonics Dept., Holmdel, New Jersey, 1986-87. DOE Distinguished Postdoctoral Research Fellow, 1995. University of California President's Postdoctoral Research Fellow, 1994.

Research interests: Short-pulse x-ray generation, measurement, and applications; high-intensity laser-matter interactions; ultrafast phenomena.

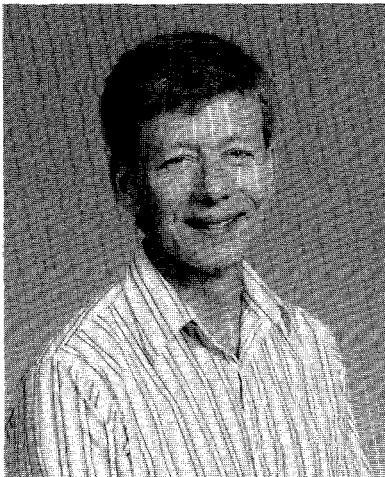
Selected publications: "Subpicosecond Thomson Scattering Measurements of Optically Ionized Helium Plasmas" (with T. D. Donnelly, E. A. Lipman, A. Sullivan, and R. W. Falcone), *Phys. Rev. Lett.* **73**, 78 (1994).

"Measurement of Velocity Distributions and Recombination Kinetics in Tunnel Ionized Helium Plasmas" (J. K. Crane, M. D. Perry, R. W. Lee, and R. W. Falcone), submitted to *Phys. Rev. Lett.* (1995).

"Electron Energies in Field-Ionized Laser Plasmas" (with T. D. Donnelly et al.), oral presentation and publication in *Proc. OSA Conference on Ultrafast Phenomena*, Dana Point, California (May 1994).

"Electron Energy Distributions in Optically Ionized Helium Plasmas" (with R. W. Falcone), invited lecture at OSA conference on High Field Interactions and Short Wavelength Generation, St.-Malo, France (August 1994).

Timothy L. Houck



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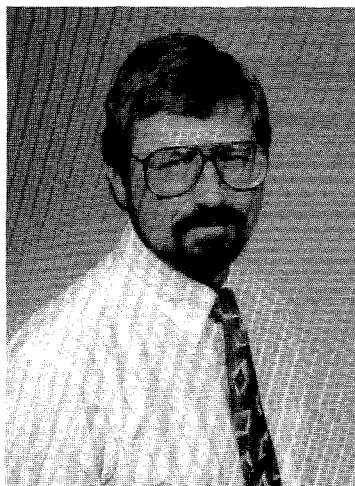
Research interests: Induction accelerators, beam dynamics, high-power microwave generation, novel accelerators.

Selected publications: "Relativistic Klystron Two-Beam Accelerator" (with G. Westenskow), *IEEE Trans. Plasma Sci.* **22** (1994).

"Design Study of a Microwave Driver for a Relativistic Klystron Two-Beam Accelerator," *Proc. 1993 IEEE Particle Accelerator Conference* (1993).

"BBU Code Development for High-Power Microwave Generators" (with G. Westenskow and S. Yu), *Proc. 16th International LINAC Conference* (1992).

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B.A. (Hons), Physics, Lancaster University, 1968. 1968–84: Scientific Officer at Daresbury Nuclear Physics Laboratory, U.K. 1984–present: At LBL, member of the team that designed and commissioned the third-generation Advanced Light Source.

Affiliations: Member, APS and AAAS

Research interests: Design, construction, and operation of synchrotron radiation sources; fourth-generation synchrotron radiation source.

Selected publications: "Ideas for Future Synchrotron Light Sources," presented at the Third European Accelerator Conference, Berlin, Germany (March 1992); to be published in the Proceedings.

"The Challenges of Third Generation Synchrotron Light Sources," *Synchrotron Radiation News* 3 (3), 13–20 (May–June 1990).

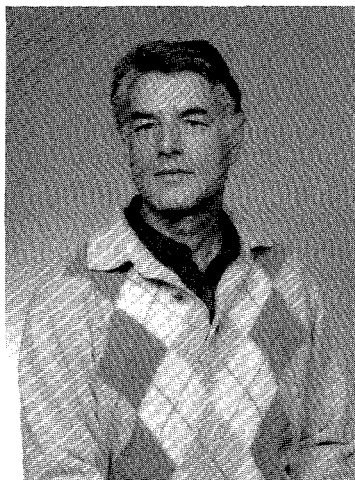
"The Effect of Insertion Devices on the Behavior of the ALS" (A. Jackson et al.), *IEEE Trans. Nucl. Sci.*, IEEE 89CH2669-0 (1989).

"A Comparison of the Chasman-Green and Triple Bend Achromat Lattices," *Particle Accelerators* 22 (2) (1987).

"Feasibility Study of a Storage Ring for a High Power XUV Free Electron Laser" (with J. Bisognano et al.), *Particle Accelerators* 18 (1986).

"The NINA Polarized Photon Beam," *Nucl. Instrum. Methods* 129 (1975).

Roderich Keller



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Joined LBL in 1988

Dr. rer. nat., Experimental Physics, University of Kiel, Germany, 1973.

Awards: Three patents on ion sources and components.

Research interests: Particle accelerators, ion sources for accelerators and industrial applications.

Current activities: Characterization of the Advanced Light Source electron storage ring and its development for operation with multiple insertion devices.

Selected publications: "Final Analysis of the ALS Lattice Magnet Data," *IEEE* #93 CH32977 (1993), p. 2811.

"Survey and Alignment of the Advanced Light Source in Berkeley," *Nucl. Instrum. Methods in Phys. Res.* B56/57, 422 (1991).

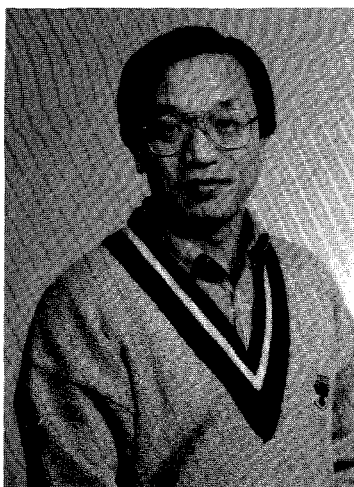
"Study of a 'Relaxed' ALS Storage Ring Lattice," Second European Particle Accelerator Conference, Nice, France (1990).

"Ion Extraction Systems: Optics and Design," *Nucl. Instrum. Methods in Phys. Res.* A298, 247–254 (1990).

"High Current Gaseous Ion Sources" in *The Physics and Technology of Ion Sources* (I. G. Brown, ed.) (John Wiley, New York, 1989), p. 151.

"Spectroscopic Measurements on an H⁻ Ion Source Discharge," *IEEE Trans. Nucl. Sci.* NS-32, 1736 (1985)

Charles H. Kim



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Ph.D., Plasma Physics, University of California, Los Angeles, 1974.

Awards: Fannie and John Hertz Foundation Fellow.

Research interests: Accelerators, RF linac, synchrotron, storage ring, accelerator diagnostics instrumentation, linac simulations.

Selected publications: "Performance of the ALS Injector," *Proc. IEEE Particle Accelerator Conference* (1993), p. 2036.

"Advanced Light Source Instrumentation Overview," *Proc. 1992 Accelerator Instrumentation Workshop* (1992).

"Commissioning Experiences of the ALS Booster Synchrotron," *Proc. IEEE Particle Accelerator Conference* (1991), p. 2691.

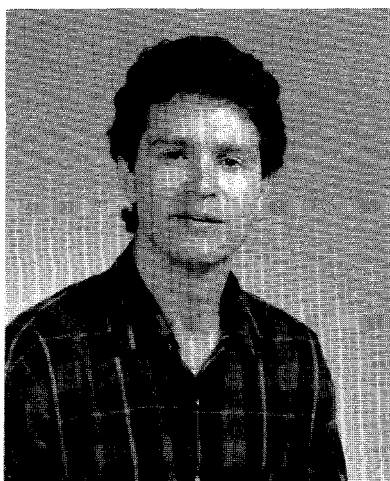
"Dynamic Aperture of the ALS Booster Synchrotron," *Proc. IEEE Particle Accelerator Conference* (1989), p. 1328.

"Simulation of Emittance Growth in the ALS Pre-Injector," *Linear Accelerator Conference Proceedings* (1988), p. 427.

"Design of a Bunching System for a High-Intensity Electron Linac," *Proc. European Particle Conference* (1988), p. 863.

"Development of Heavy Ion Induction Linear Accelerators as Drivers for Inertial Confinement Fusion," *Proc. European Particle Conference* (1988), p. 1521.

Jim Krupnick



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Joined LBL in 1976

B.A., Sociology, University of California, Berkeley, 1972; A.A., Electronics, Merritt College, 1973; M.B.A., Strategic Planning, University of California, Berkeley, 1988. Bevatron Electronics Maintenance Technician, 1976-80; Bevatron Electronics Coordinator, 1980-87; ALS Assistant Project Manager, 1987-93; BTF Engineering Manager, 1992-94; ALS Manager for Planning and Development, 1993-present.

Affiliations: Member: DOE Review Committee, Advanced Photon Source Construction Project; Independent Accelerator Readiness Review 3 Committee, CEBAF.

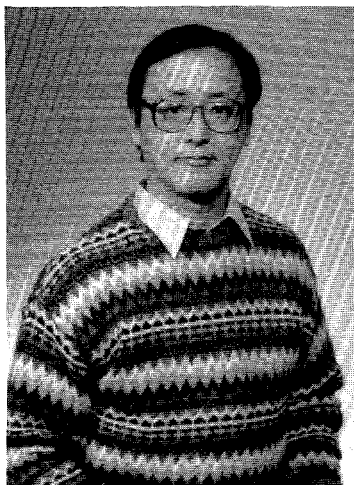
Selected publications: "The 50 MeV Beam Test Facility at LBL" (with W. Leemans et al.), presented at the IEEE Particle Accelerator Conference, Washington, D.C. (May 1993).

"Magnet Costs for the Advanced Light Source" (with J. Tanabe et al.), presented at the IEEE Particle Accelerator Conference, Washington, D.C. (May 1993).

"White Paper on Development of a Protein Crystallography Facility at the ALS," co-author (December 1993).

"A Facility for Macromolecular Crystallography at the Advanced Light Source," co-author (May 1994).

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Joined LBL in 1985

Ph.D., Physics, University of Tokyo, 1982.

Research interests: Accelerator physics for ALS; modeling and simulation code construction for real accelerator control using the novel programming methodologies like OOP.

Selected publications: "Dynamic Accelerator Modeling Uses Objects in Eiffel," *Comput. Phys.* 6, 456 (1992).

"Framework for Control System Development" (with C. W. Cork), to appear in *Proc. International Conference on Accelerator and Large Physics Control Systems*, Tsukuba, Japan (1991).

"Vertically Integrated Simulation Tools for Self-Consistent Tracking and Analysis" (with E. Forest), *Proc. Particle Accelerator Conference*, CH2669 (1989), p. 1304.

"Dynamic Aperture of the ALS Booster Synchrotron" (with C. Kim), *Proc. Particle Accelerator Conference*, CH2669 (1989), p. 132.

"The Effects of Insertion Devices on the Behavior in the ALS" (with A. Jackson, E. Forest, and M. S. Zisman), *Proc. Particle Accelerator Conference*, CH2669 (1989), p. 1752.

"TRACY, A Tool for Accelerator Design and Analysis," *Proc. European Particle Accelerator Conference* (1988), p. 803.

"Particle Simulation Code for Non-Relativistic Electron Bunch in LASERTRON," *Proc. Linear Accelerator Conference*, GSI-84-11 (1984), p. 165.

"LASERTRON: Laser-Triggered RF Source for Linacs in the TeV Region" (with M. Yoshioka et al.), *Proc. Linear Accelerator Conference*, GSI-84-11 (1984), p. 469.

David S. Robin



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Joined LBL in 1991

Ph.D., Physics, University of California, Los Angeles, 1991.

Research interests: Studies of the linear and nonlinear dynamics of lepton storage ring colliders.

Selected publications: "Quasi-Isochronous Storage Rings" (D. Robin et al.), *Phys. Rev. E* 48 (3), 2149-2156 (1993).

"Study of a Magnetic Lattice for a Quasi-Isochronous Ring" (with A. Amiry et al.), *Particle Accelerators* 44, 65-76 (1994).

"Status of the Variable Momentum Compaction Storage Ring Experiment in Spear" (with P. Tran et al.), to be published in *Proc. 1993 IEEE Particle Accelerator Conference* (1993).

"Localized Chromaticity Correction of Low-Beta Insertions in Storage Rings" (with M. Donald et al.), to be published in *Proc. 1993 IEEE Particle Accelerator Conference* (1993).

"Local Chromatic Correction Scheme for LER of PEP-II" (with E. Forest et al.), *Proc. International Workshop on B Factories: Accelerators and Experiments*, KEK, Tsukuba, Japan (November 1992).

"Quasi-Isochronous Ring Flavor Factories" (with C. Pellegrini), *Rare and Exclusive B and K Decays and Novel Flavor Factories* (1992).

"Sources of Amplitude Dependent Tune Shift in the PEP-II Design and Their Compensation with Octupoles," (with E. Forest et al.), to be published in *Proc. 1994 European Accelerator Conference*.

Lindsay C. Schachinger



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Joined LBL in 1990

Ph.D., Physics, Rutgers University, 1978.

Research interests: Accelerator simulation and modeling both for design and controls, nonlinear dynamics, controls and modeling for accelerator physics studies in circular accelerators.

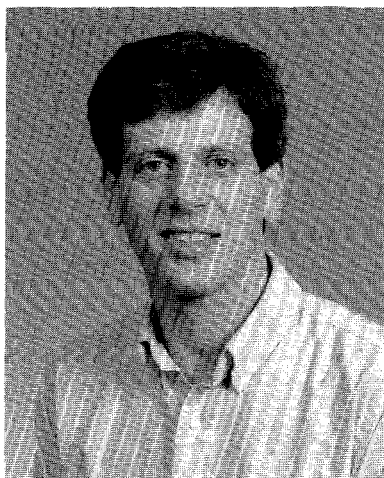
Selected publications: "Summary of the Working Group on Modeling and Simulation," *Proc. Advanced Beam Dynamics Workshop on Effects of Errors in Accelerators, Their Diagnosis and Corrections*, AIP Conference Proceedings No. 255, Particles and Fields Series, 48, Corpus Christi, Texas (1991).

"Experimental Investigation of Nonlinear Dynamics in the Fermilab Tevatron" (with A. Chao et al.), *Phys. Rev. Lett.* **61**, 2752 (1988).

"Teapot: A Thin-Element Accelerator Program for Optics and Tracking" (with R. Talman), *Part. Accel.*, **22**, 35 (1987).

Robert W. Schoenlein

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Joined LBL in 1989



Ph.D., Massachusetts Institute of Technology, 1989. Postdoctoral Fellow Lawrence Berkeley Laboratory, 1989-91.

Affiliations and awards: Sigma Xi, Eta Kappa Nu, Optical Society of America, Institute of Electrical and Electronics Engineers, American Physical Society. American Association for the Advancement of Science, Optical Society of America Adolph Lomb Medal (1994); Newport Research Award (1988).

Research interests: Generation of femtosecond x-ray pulses via Thomson scattering, femtosecond structural dynamics of materials using x-ray pulses, studies of electron-hole dephasing and coherent vibrational dynamics in semiconductor nanocrystals, ultrafast carrier scattering and dephasing dynamics in metal films, femtosecond photochemical isomerization, and nonstationary states in rhodopsin pigments.

Selected publications: "Generation of Blue-Green 10 fs Pulses Using an Excimer-Pumped Dye Amplifier" (with R. W. Schoenlein, J.-Y. Bigot, M. T. Portella, and C. V. Shank), *Appl. Phys. Lett.* **58**, 801 (1991).

"Femtosecond Relaxation Dynamics of Image-Potential States" (with R. W. Schoenlein, J. G. Fujimoto, G. L. Eesley, and T. W. Capehart), *Phys. Rev. B* **43**, 4688 (1991).

"The First Step in Vision: Femtosecond Isomerization of Rhodopsin," (with R. W. Schoenlein, L. A. Peteanu, R. A. Mathies, and C. V. Shank), *Science* **254**, 412 (October 1991).

"Investigation of Femtosecond Electronic Dephasing in CdSe Nanocrystals Using Quantum-Beat-Suppressed Photon Echoes," (with R. W. Schoenlein et al.), *Phys. Rev. Lett.* **70**, 1014 (1993).

Charles V. Shank



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Joined LBL in 1989

Ph.D., Electrical Engineering, University of California, Berkeley, 1969. AT&T Bell Laboratories: Member of Technical Staff (1969–76), Head, Quantum Physics and Electronics Research Department (1976–83), Director, Electronics Research Laboratory (1983–89). Professor, University of California, Berkeley (1989–present).

Major awards and affiliations: The John Scott Award (1991); SPIE—The International Society for Optical Engineering 1990 Edgerton Award; Distinguished Engineering Alumnus Award (1990); IEEE David Sarnoff Award (1989); IEEE Morris E. Leeds Award (1983); Edward P. Longstreth Medal of the Franklin Society (1982); R. W. Wood Prize of the Optical Society of America (1981). Member: National Academy of Sciences (NAS), 1984; National Academy of Engineering (NAE), 1983; American Academy of Arts and Sciences; Fellow of the American Association for the Advancement of Science (AAAS); Fellow of the American Physical Society; Fellow of

the Institute of Electrical and Electronics Engineers, Inc. (IEEE); Fellow of the Optical Society of America (OSA).

Research interests: Studies of ultrafast phenomena in condensed matter systems. Generation of femtosecond x-ray pulses for probing structural dynamics of materials.

Selected publications: "Investigation of Ultrafast Phenomena in the Femtosecond Time Domain," *Science* **233**, 1276–1280 (September 1986).

"Generation of Femtosecond X-rays by 90° Thomson Scattering" (with K.-J. Kim and S. Chattopadhyay), *Nucl. Instrum. Methods in Phys. Res.* **A341**, 351–354 (1994).

"Vibrationally Coherent Photochemistry in the Femtosecond Primary Event in Vision" (with Q. Wang, R. W. Schoenlein, L. A. Peteanu, and R. A. Mathies), *Science* **226**, 244–24 (October 1994).

Toshiki Tajima



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Sabbatical at LBL; first in 1989

Ph.D., Physics, University of California, Irvine, 1975. Staff Scientist at UCLA, 1976–80; Assistant, Associate, and Full Professor at University of Texas, Austin, 1980–present. Visiting Professor at Nagoya, 1972; Visiting Scientist at Los Alamos National Laboratory, 1983–85; University of California, Berkeley, 1989; Institute of Nuclear Physics (Novosibirsk), 1990. Member of SSC Lab, 1989–93.

Major awards and affiliations: Fellow, Japan Society for Promotion of Science; Fellow, American Physical Society. Member: National Research Council of National Academy of Science; Leadership, Japan Atomic Energy Research Institute.

Research interests: Laser acceleration, beam-beam interaction, beam (and laser) cooling, solid-state acceleration, x-ray and laser physics, plasma physics, computational techniques.

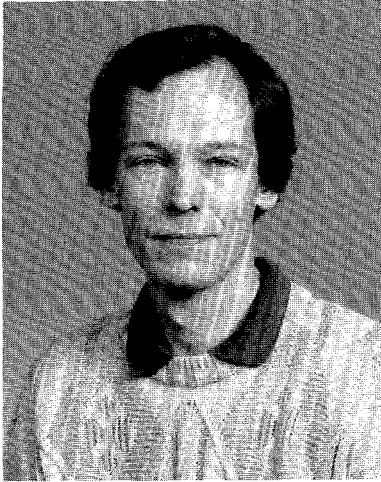
Selected publications: *Computational Plasma Physics* (Addison-Wesley, 1989).

"Laser Electron Accelerator" (with J. M. Dawson), *Phys. Rev. Lett.* **43**, 267 (1979).

"Crystal X-ray Accelerator" (with M. Cavenago), *Phys. Rev. Lett.* **59**, 1440 (1987).

"Particle Diffusion from the Beam-Beam Interaction in Synchrotron Colliders" (with J. K. Koga), *Phys. Rev. Lett.* **72**, 2025 (1994).

Andreas Tauschwitz



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Joined LBL in 1994

Dr. rer. nat. in Physics from the Technical University (TH) of Darmstadt, Germany, 1993. Visit at LBL supported by the German Alexander-von-Humboldt Stiftung with a Feodor-Lynen-Fellowship.

Research interests: Inertial confinement fusion, interaction of ion beams with ionized matter, plasma diagnostics, beam physics, pulsed power applications in accelerator technology.

Selected publications: "Improvement of the Active Cylindrical Plasma Lens Concept by a Tapered Discharge Geometry" (with M. de Magistris et al.), accepted for publication in *IEEE Trans. on Plasma Sci.*

"Heavy-Ion Beam Focusing with a Wall-Stabilized Plasma Lens" (with E. Boggasch et al.), *Laser and Particle Beams* **13**, 2 (1995).

"The Plasma Lens Solution for Heavy-Ion Beam Focusing" (with E. Boggasch et al.), *Il Nuovo Cimento* **106A**, 1733 (1993).

"Plasma Lens Fine Focusing of Heavy-Ion Beams" (with E. Boggasch et al.), *Appl. Phys. Lett.* **60**, 2475 (1992).

"Schlieren Diagnostics of the Plasma Focus Using a Mode Locked Dye Laser" (with L. Michel and W. Seelig), *Appl. Phys. B* **53**, 92 (1991).

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Joined LLNL in 1986; worked on collaborative experiments with LBL since 1986.



Ph.D., Physics, Stanford University, 1981.

Research interest: High-power RF sources, induction accelerators, electron sources, accelerator physics, conventional and novel high-energy accelerators.

Selected publications: "Relativistic Klystron Two-Beam Accelerator," *IEEE Trans. on Plasma Sci.* (Special Issue on High Power Microwave Generation) **22** (5), 750-755 (1994).

"Reacceleration Experiment to Demonstrate the Concept of Efficiency Enhancement in a Relativistic Klystron Two-Beam Accelerator," *Proc. 1993 IEEE Particle Accelerator Conference* (1993), p. 2611.

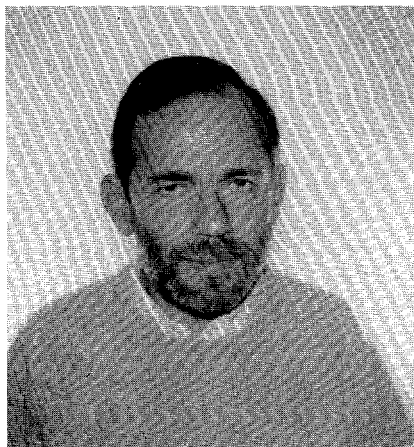
"Transverse Instabilities in a Relativistic Klystron Two-Beam Klystron," *Proc. 1992 Linear Accelerator Conference* (1992), pp. 263-267.

"High Gradient Electron Accelerator Powered by a Relativistic Klystron," *Phys. Rev. Lett.* **63** (22), 2472 (1989).

"The Stanford Mark III Infrared Free-Electron Laser" (7th Int. FEL Conf.), *Nucl. Instrum. Methods* **A250**, 39-43 (1986).

"Microwave Electron Gun," *Laser and Particle Beams* **2**, 223-225 (1984).

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Joined SLAC in 1990

Ph.D., Experimental High-Energy Physics, Institute of Nuclear Physics, Novosibirsk (Russia), 1974. Doctor of Science, Institute of Nuclear Physics, Novosibirsk (Russia), 1979; Leading Physicist, Novosibirsk, Russia, 1979–85; Professor of Novosibirsk State University, Russia, 1985–89; Staff Scientist, Lawrence Berkeley Laboratory, 1989–90.

Affiliations and honors: Special Award of the Academy of Sciences of the USSR for the best experimental work of the year (1979). Member: American Physical Society (APS).

Research interests: Particle and photon beam physics, sources of polarized electrons, collider physics, nonlinear optics, P- and T-violation in atomic physics.

Selected publications: "Transit-Time Method of Optical Stochastic Cooling" (with A. Zholents), *Phys. Rev. E* **50** (4), 3087 (1994).

"An Inverted-Geometry High-Voltage Polarized Gun with UHV Load Lock" (with M. Breidenbach et al.), *Nucl. Instrum. Methods* **A350**, 1–7 (1994).

"Optical Stochastic Cooling," (with A. Mikhailichenko) *Phys. Rev. Lett.* **71** (25), 4146 (1993).

"Investigation of Nearly Degenerate Opposite Parity States in Atomic Dysprosium" (with D. Budker, E. Commins, and D. DeMille), *Phys. Rev. Lett.* **70** (20), 3019 (1993).

"Observation of Parity Nonconservation in Atomic Transition" (with L. Barkov), *Sov. JETP Pis'ma* **28**, 379 (1978).

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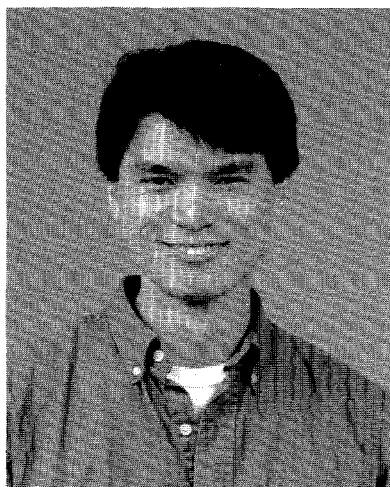


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Joined LBL in 1993

B.S., Physics, Electrical Engineering, Oregon State University, 1990.

Research interests: Ultrafast dynamics in semiconductors, phase transitions, femtosecond mode-locked lasers, generation of ultrashort x-ray pulses.

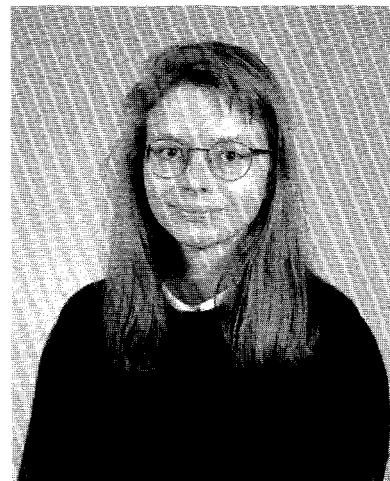
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Joined LBL in 1993

Student at Rijksuniversiteit te Utrecht, now at Lawrence Berkeley Laboratory as a Visiting Scholar for one year.

Research interests: Optical transition radiation, beam-plasma interaction, and accelerator physics.

Selected publication: "Status of the 50 MeV Plasma Lens Experiment at LBL" (with W. P. Leemans, B. van der Geer, A. M. Sessler, and S. Chattopadhyay), presented at APS (November 1993).

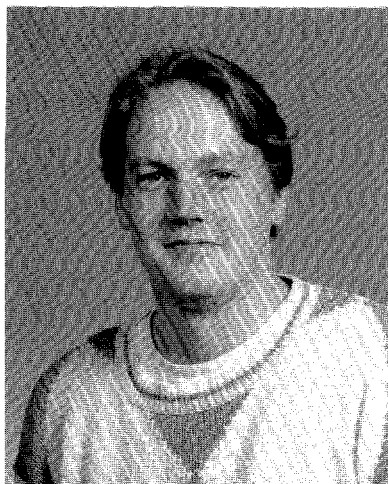


Roel Dieron

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B.S., Mechanical Engineering, University of California, San Diego, 1990. Manufacturing Automation Engineer at Applied Magnetics Corp., 1990-94; Graduate Student Researcher with Berkeley Sensor & Actuator Center since 1994.

Research interests: High-precision manufacturing, micro-electromechanical systems (MEMS), integrated micro-disk drive arm. M.S. project title: Integrated Micro-Disk Drive Arm.



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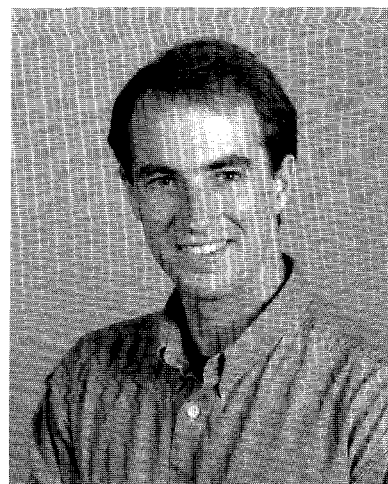
Research interests: Quantum electrodynamics, quantum cosmology, plasma physics.

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B.S. and B.A., Physics and Applied Mathematics, University of California, San Diego, 1993.

Research interests: Relativistic klystron two-beam accelerators, beam-breakup instabilities, astrophysical plasmas, parametric plasma instabilities, numerical simulations.

Selected publications: "Design of Output Structures for a Traveling Wave Relativistic Klystron Two-Beam Accelerator: Suppression of Multi-Bunch Beam-Break-Up" (with H. Li, T. Houck, and S. Yu), *Proc. 1994 SPIE Symposium on Intense Microwave Pulses OE/LASE-94*, Vol. 2154-10.



Richa Govil

Graduate Student
University of California, Berkeley
MS 71-259
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Joined LBL in 1991
A.B., Physics, University of California, Berkeley.

Major awards: Certificate of Distinction, University Medal, UC Berkeley, 1991.

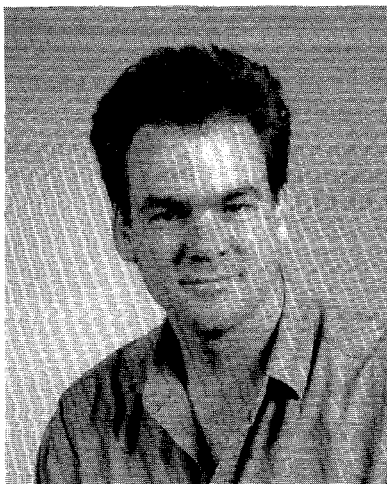
Research interests: Plasma-electron beam interactions, advanced accelerator concepts, free-electron lasers.

Selected publications: "Plasma Production for the 50 MeV Plasma Lens Experiment at LBL" (with W. P. Leemans et al.), *Proc. 1994 European Particle Accelerator Conference*, London, U.K. (June-July 1994).

"Time-resolved Study of Sideband Generation and Transition to Chaos on an Infrared FEL" (with W. P. Leemans et al.), *Proc. 16th International FEL Conference*, Stanford, California (August 1994).

"Design of RF Conditioner Cavities" (with R. A. Rimmer, A. M. Sessler, and H. G. Kirk), *Proc. 14th International FEL Conference*, Kobe, Japan (August 1992).

"Macroparticle Theory of a Standing-Wave Free-Electron Laser Two-Beam Accelerator" (with K. Takayama and A. M. Sessler), *Nucl. Instrum. Methods in Phys. Res. A320*, 587 (1992).



Michael Irwin

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Joined LBL in 1994

Research interests: Engineering physics.

Kenneth LaMon

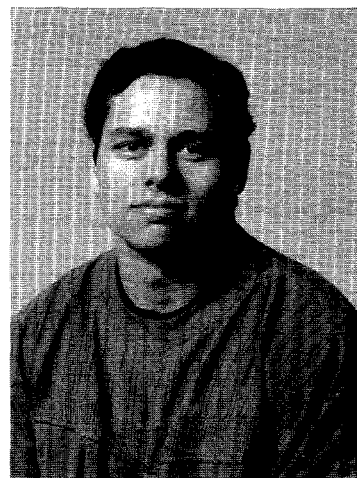
Graduate Student
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Joined LBL in 1988

A.B., University of California, Berkeley, 1989; Ph.D., University of California, Berkeley, 1993. Student researcher HIFAR group 1988-89, CBP 1989. Graduate Student Research Assistant with CBP since 1991.

Research interests: Theoretical beam physics. Ph.D. thesis title: *The Isochronous Storage Ring Free Electron Laser*.

Selected publications: "Removal of Singularities from Taylor Series," LBL-27689; ESG Note-77 (August 1989).

"Lie Series in an Extended Region of Phase Space," *J. Phys. A* **23**, 3875 (1990).



Victoria Vakarchuk

Undergraduate Student
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Joined LBL 1995

Research interests: Life, the universe, and everything.



Bas van der Geer

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Joined LBL in 1993

Student at Rijksuniversiteit te Utrecht, now at Lawrence Berkeley Laboratory as a Visiting Scholar for one year.

Research interests: Computational physics, optical transition radiation, and beam-plasma interaction.

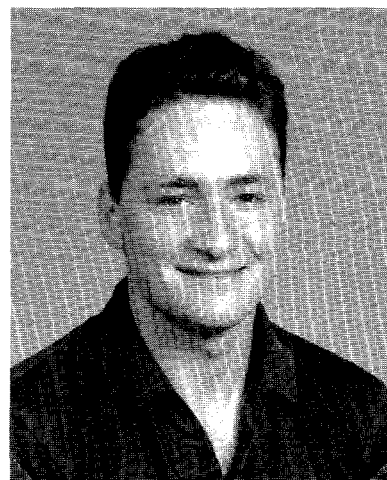
Selected publication: "Status of the 50 MeV Plasma Lens Experiment at LBL" (with W. P. Leemans, M. de Loos, A. M. Sessler, and S. Chattopadhyay), presented at APS (November 1993).

Pavel Volfbeyn

Graduate Student
Massachusetts Institute of Technology
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Joined LBL in 1995

B.S., Moscow Institute of Physics and Technology, 1991. 1991-94 Research Assistant in the Beam Physics Group at RLE-MIT; M.S. received from MIT 1995.

Research interests: Plasma acceleration, FELs, ultrashort laser sources and applications.



Chih-Hung Yeh

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Research interests: Biology, computer science, artificial intelligence.

Jonathan Yu



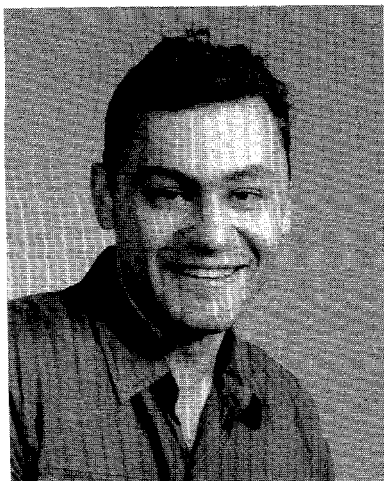
Student Assistant
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Joined LBL in 1994

Senior, University of California, Berkeley.

Research interests: Spatial and temporal plasma lens diagnostics, laser optics, beam-plasma interaction.

Andrew Zege

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Joined LBL in 1992



Candidate of Sciences, Theoretical and Mathematical Physics, Byelorussian State University, Minsk, Byelorussia, 1992.

Research interests: X-ray lasers on channeling radiation, free electron lasers, channeling, parametric and synchrotron radiation, multibeam x-ray diffraction.

Selected publications: "Advantages of the 'Kinetic' Amplification Regime in a Free Electron Laser with Optical Undulator," *Nucl. Instrum. Methods in Phys. Res. A* **304**, 520 (1991).

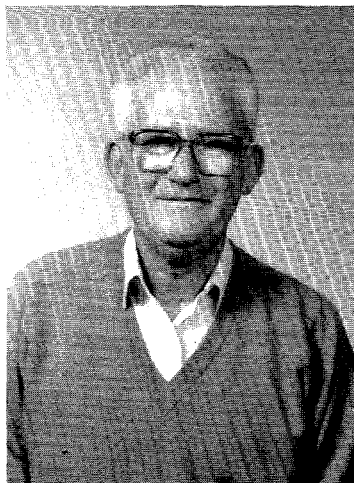
"X-ray Free Electron Laser in a Crystal as Distributed Feedback Resonator" (with V. G. Barushevsky and I. Ya. Dubovskaya), *Nucl. Instrum. Methods in Phys. Res. A* **304**, 421 (1991).

"The Influence of Absorption on the Generation Threshold in an X-ray Laser by Channeling Radiation in the Presence of Distributed Feedback," *Phys. Lett. A* **149**, 30 (1990).

"X-ray Laser by Channeling Radiation in the Presence of a Distributed Feedback" (with V. G. Barushevsky and I. Ya. Dubovskaya), *Nucl. Instrum. Methods in Phys. Res. B* **51**, 368 (1990).

Participating Guests (Emeriti)

Alper Garren



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Joined LBL in 1955

Ph.D., Carnegie Institute of Technology, 1955.

Accelerator theorist with contributions to design of many accelerators and their lattices—e.g., Bevatron, FNAL, PEP, BNL/CBA, ALS, PEP-II, SSC. Author of the lattice program SYNCH. Also contributed to heavy-ion fusion, magnetic fusion with mirror machines, spiral-ridge cyclotrons (e.g., 88-Inch Cyclotron at LBL), and to the Electron Ring Accelerator Study.

Selected publications: "SYNCH Users Guide" (with A. S. Kenney, E. D. Courant, A. D. Russell, and M. Syphers), SSCL-MAN-0002 (1993).

"APIARY B-Factory Separation Scheme" (with M. Sullivan), LBL PUB-30730 (May 1991).

"APIARY B-Factory Lattice Design" (with M. H. R. Donald), LBL PUB-30665 (May 1991).

"Low-Momentum Compaction Lattice Study for the SSC Low Energy Booster" (with E. D. Courant and U. Wienands), *Proc. 1991 Particle Accelerator Conference* (May 1991).

"Site-Specific Conceptual Design of the Superconducting Supercollider," SSCL-SR-1056 (July 1990).

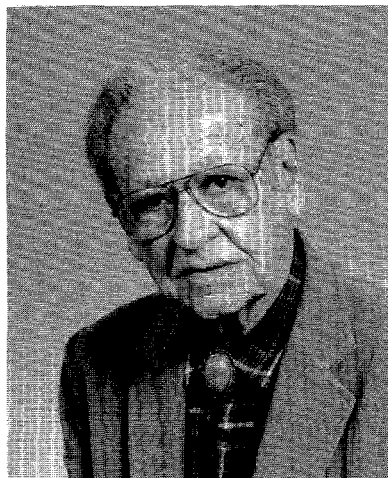
"An Asymmetric B-Meson Factory at PEP" (A. A. Garren et al.), *Proc. 1989 Particle Accelerator Conference*, Chicago, Illinois (1989).

"Thin Lens Optics with Space Charge," *Proc. 7th International Conference on High Energy Accelerators*, Yerevan, USSR, UCRL-19313 (1969).

"Lattice of the NAL Proton Synchrotron," *Proc. 1969 Particle Accelerator Conference* (1969).

"Orbit Dynamics in the Spiral-Ridged Cyclotron" (with Lloyd Smith), UCRL-8598 (1959).

Albert Ghiorso



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Joined LBL in 1946

B.S., Electrical Engineering, University of California, Berkeley, 1937; honorary Doctor of Science degree, Gustavus Adolphus College, 1966. Staff Member, University of Chicago Metallurgical Laboratory, 1942–46. Senior Scientist, Lawrence Berkeley Laboratory, 1946–82. Director of the HILAC and then the SuperHILAC, 1957–71. Co-inventor of the Omnitron. Inventor of the Bevalac. Senior Scientist Emeritus, Lawrence Berkeley Laboratory, 1982–present. Presently a member of the LBL Nuclear Science Division. Co-discoverer of 13 elements, 95–106 and 110 (to be confirmed).

Major awards and affiliations: American Chemical Society Award: Nuclear Applications in Chemistry, 1973. Member: American Physical Society; American Association for the Advancement of Science (AAAS).

Selected publications: "Systematics of Alpha-Radioactivity" (with I. Perlman and G. T. Seaborg), *Phys. Rev.* **77**, 26 (1950).

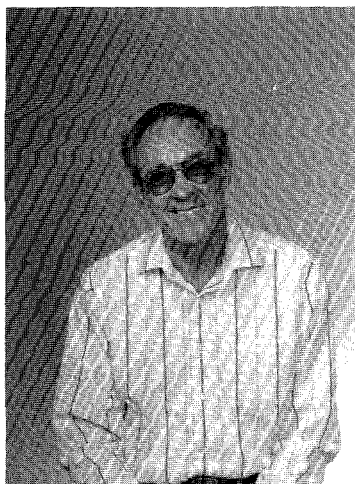
"Evidence for Subshell at $N = 152$ " (with S. G. Thompson, G. H. Higgins, B. G. Harvey, and G. T. Seaborg), *Phys. Rev.* **95**, 293 (1954).

"New Elements Einsteinium and Fermium, Atomic Numbers 99 and 100," Ghiorso et al., *Phys. Rev.* **99**, 1048 (1955).

"The Omnitron: A Versatile Medium-Energy Synchrotron for the Acceleration of Light and Heavy Ions" (with R. M. Main and B. H. Smith), *IEEE Trans. Nucl. Sci.* **NS-13**, 280 (1966).

"A History of the Discovery of the Transplutonium Elements," in *Actinides in Perspective*, N. M. Edelstein, ed. (Pergamon Press, Oxford and New York, 1982), p. 23.

"Evidence for the Synthesis of Element $^{267}110$ Produced by the $^{59}\text{Co} + ^{209}\text{Bi}$ Reaction," A. Ghiorso et al., *Proc. Fifth International Conference on Nucleus-Nucleus Collisions*, Taormina, Italy (May–June 1994); *Nucl. Phys. A* **583**, 861c (1995).



Glen R. Lambertson

Senior Scientist
MS 71-259
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Joined LBL in 1951

M.S., Physics, University of California, Berkeley, 1951.

Award: U.S. Particle Accelerator School Prize for Achievement in Accelerator Physics and Technology, 1991.

Current research: Particle beam electrodes, stochastic beam cooling, feedback stabilization of beam instabilities.

Selected publications: "Dynamic Devices, A Primer on Pickups and Kickers" (with D. Goldberg), *Proc. ALP Conference* **249**, 537 (1992).

"Higher Order Mode Damping Studies on the PEP-II B-Factor RF Cavity" (with R. A. Rimmer et al.), *3rd European Particle Accelerator Conference* (1992).

"Transverse Feedback in a 100 TeV Storage Ring," *Proc. 19th Workshop on Maximizing Luminosity of Hadron Colliders at 180 TeV*, Erice, Italy (1991).

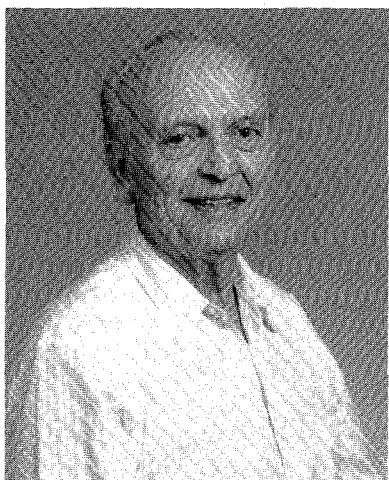
"Control of Coupled-Bunch Instabilities in High-Current Storage Rings," invited paper, 1991 IEEE Particle Accelerator Conference **4**, 2537 (1991).

"Higher Order Mode Damping in a Pill Box Cavity" (with R. A. Rimmer and F. Voelker), 1991 IEEE Particle Accelerator Conference **2**, 687 (1991).

"Techniques for Beam Impedance Measurements Above Cutoff" (with A. F. Jacob, R. A. Rimmer, and F. Voelker), 2nd European Particle Accelerator Conference, Nice, France (June 1990), p. 1049; LBL-28190.

Jack M. Peterson

Senior Scientist
MS 71-259
(510) 486-6570
Joined LBL in 1946, LLNL in 1952, and LBL again in 1964.



A.B., Harvard, 1942; Ph.D., University of California, Berkeley, 1950. Fulbright Fellow, Bohr Institute, Copenhagen, 1960; Visiting Scientist, Max Planck Institute for Plasma Physics, Munich, 1973.

Research interests: Methods of beam injection and extraction, beam emittance degradation due to various effects, storage-ring design, magnet design, effects of magnetic errors and their correction, collective beam effects, feedback systems, neutron cross-sections, neutron giant resonances.

Selected publications: "Photo-production of Mesons by X-rays" (with E. M. McMillan and R. S. White), *Science* **110**, 579 (1949).

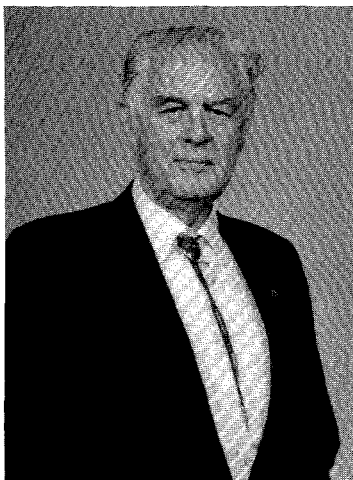
"Neutron Giant Resonances—A Nuclear Ramsauer Effect," *Phys. Rev.* **125**, 955 (1962).

"Use of Collective Fields in the Acceleration of Particles," APS Meeting, San Francisco, California (1972).

"PEP Injection System" (with K. Brown), Particle Accelerator Conference, Washington, D.C.; *IEEE Trans. Nucl. Sci.* **NS-22** (3), 1423 (1975).

"Effects from Measured Ground Motions at the SSC" (with K.-Y. Ng), SSCL-277-Rev; Fermilab Pub-9119 (1990).

"Correction of Random Multipole Errors with Lumped Correctors" (with E. Forest), SSCL-N-383.



Frank Selph

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Joined LBL in 1962

M.S., Physics, University of California, Berkeley, 1963. Joined LBL in 1962, retired 1991. Continues to work on accelerator projects.

Current research: ALS linac improvement, design of a storage ring for improved ion stripping.

Selected publications: "A Ring to Test Stripping Enforcement," LBL-35289 (1993).

"Magnetic Ring for Stripping Enhancement," LBL 82940 (1992).

"Operating Experience with the ALS Linac" (with D. Massoletti), *Proc. 1991 Particle Accelerator Conference*, IEEE 91CH3038-7, Z (1991), pp. 2978-80.

"Compensation of Beam Loading in the ALS Injector Linac," *Proc. 1988 Linear Accelerator Conference*, CEBAF Report 89-001 (1988), pp. 580-82.

"Wakefield Effects in the Two-Beam Accelerator" (with A. Sessler), *Nucl. Instrum. Methods* **A244**, 323-29 (1986).

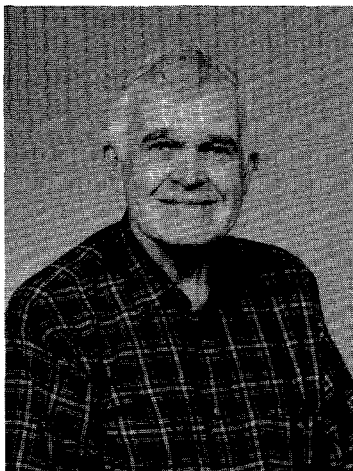
"Acceleration of Uranium at the Bevalac" (with J. Alonso et al.), *Science* **217**, 1135-37 (1982).

"The Next Generation of Relativistic Heavy Ion Accelerators" (with H. Grunder and C. Leeman), *Proc. Symposium on Heavy Ion Research*, G.S.I. Darmstadt, Germany (1978).

"A Method for Obtaining Linac Beams of Continuously Variable Energy," *Proc. 1970 Proton Linac Accelerator Conference*, National Accelerator Laboratory, Batavia, New York (1970), pp. 868-79.

Ferdinand Voelker

Senior Scientist
MS 71-259
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Joined LBL in 1952



M.S., University of California, Berkeley.

Research interests: Damping of HOM in RF cavities, study of multi-electrode kickers for particle beam, beam impedance measurements.

Selected publications: "ALS Longitudinal Kickers," presented at the 1992 Accelerator Instrumentation Workshop, LBL, Berkeley, California (1992); LBL-33088.

"Higher Order Model Damping Studies on the PEP-II B-Factor RF Cavity" (with R. Rimmer, D. Goldberg, G. Lambertson, et al.), presented at the 3rd European Particle Accelerator Conference, Technical University of Berlin, Germany (1992); LBL-32549.

"Calculations on RF Cavity Feedback Using Simple Analytic Model" (with G. Lambertson) (1991).

"Technique for Beam Impedance Measurements Above Cutoff" (with G. R. Lambertson, A. F. Jacob, and R. A. Rimmer), presented at the European Particle Accelerator Conference, Nice, France (1990); LBL-28190.

"A High-Frequency Schottky Detector for Use in the Tevatron" (with D. A. Goldberg, W. Barry, and G. R. Lambertson), presented at the Particle Accelerator Conference, Washington, D.C. (1987); LBL-22273.

"An Array of 1 to 2 GHz Electrodes for Stochastic Cooling" (with T. Henderson and J. Johnson), presented at the 1983 Particle Accelerator Conference, Santa Fe, New Mexico (1983).

Principal Collaborators

"I still say to myself when I am depressed and find myself forced to listen to pompous and tiresome people, 'Well, I have done one thing you could never have done, and that is to have collaborated with Littlewood and Ramanujan on something like equal terms.'"

— G.H. Hardy in
A Mathematician's Apology

CENTER FOR BEAM PHYSICS — Principal Collaborators

Femtosecond X-ray Source Collaboration:	R. Schoenlein, LBL C. V. Shank, LBL
PEP-II B-Factory Collaboration:	J. Dorfan, SLAC D. Hitlin, Caltech P. Oddone, LBL
FEL Diagnostics Collaboration:	A. Schwettman, Stanford T. Smith, Stanford
SCRF/FEL Collaboration:	F. Dylla, CEBAF G. Neil, CEBAF
FEL for Chemical Processing Collaboration:	J. Madey, Duke University
Photocathode/SCRF Collaboration:	Chia-Erh Chen, Peking University
Two-Beam Accelerator Collaboration:	J. P. Delahaye, CERN J. Haimson, Haimson Research G. Westenskow, LLNL
Heavy-Ion Beam Cooling in RHIC:	M. Harrison, BNL S. Ozaki, BNL
Advanced Accelerator Concepts:	S. Amatuni (FSU) A. Dzergach (FSU) B. Ivanov (FSU) Y. Kishimoto (JAERI, Japan) E. Laziev (FSU) A. Michailichenko (Cornell U.) G. Mourou (UM, Ann Arbor) A. Ostrovsky (FSU) A. Sergeev (Nizni Novogorod, Russia) T. Tajima (UT, Austin)

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Summary of Activities

S. Chattopadhyay (Center Head) **K.-J. Kim (Deputy)**

Scientific and Technical Staff

L. Archambault
W. Barry*
J. Bengtsson
J. Byrd
Y. H. Chin
M. Conde
J. Corlett
J. Edighoffer
W. Fawley
E. Forest
M. Furman
D. Goldberg
J. Johnson*
W. Leemans

D. Lozano
R. Rimmer
A. Sessler
M. Xie
S. Yu
A. Zholents
M. Zisman

UCB Faculty Associates

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G. Giordano
S. J. Hahn

Postdoctoral Fellows

D. Gardent
H. Li

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R. Gough
T.E. Glover
T. Houck
A. Jackson
R. Keller
C. Kim
J. Krupnick
N. Luhmann
H. Nishimura
D. Robin
L. Schachinger
R. Schoenlein

C. V. Shank
T. Tajima
A. Tauschwitz
G. Westenskow
M. Zolotorev

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J. Kono
S. Vanecek
O. Wong

Students

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R. Dieron
A. Draeseke
G. Giordano

N. Goffeney
R. Govil
M. Irwin
K. La Mon
V. Vakarchuk
B. Van Der Geer
P. Volfbeyn
C.-H. Yeh
J. Yu
A. Zege

Participating Guests (Emeriti)

A. Garren
A. Ghiorso
G. Lambertson
J. Peterson
F. Selph
F. Voelker

*Engineering Division

Nineteen ninety-four and ninety-five witnessed significant expansion—in breadth, depth, and scope—of the Center's research and development activities. Originally chartered as the Exploratory Studies Group in 1985, we were soon recognized and organized as a center, in accordance with our mission: to help meet the technical challenges of major facilities and initiatives and to generally enhance LBL's capabilities in particle- and photon-beam research.

Our staff played a pivotal role in the design, construction, and commissioning of the Advanced Light Source. We were also one of the primary factors in the genesis of PEP-II, the energy-asymmetric B-meson factory at the Stanford Linear Accelerator Center that has since evolved into a major collaborative construction project. The project, when completed, will greatly facilitate the study of CP violation. Our scientists and engineers remain involved with the ALS and PEP-II, especially in beam dynamics studies and in rf and feedback systems. (The technical problems are similar; PEP-II benefits from ALS experience and, with care to avoid disrupting user operations, we can use the ALS as a testbed.) Meanwhile, with an eye toward the future of accelerators, we have spearheaded a collaboration on the preliminary design of the Next Linear Collider (NLC), a possible successor to the Stanford Linear Collider in high-energy physics with lepton collisions.

The NLC that we are envisioning would have a 500-GeV center-of-mass collision energy. The Center's responsibilities in this collaboration with the Stanford Linear Accelerator Center include damping rings, an interaction point for gamma-gamma collision physics to leverage the investment, and scenarios and technologies for an eventual upgrade to 1 TeV. The energy-upgrade studies are intimately tied to the Two-Beam Accelerator (TBA) concept that we have been exploring for some years in collaboration with Lawrence Livermore National Laboratory. The collaboration is now planning to propose an LBL testbed for a relativistic-klystron TBA where we would prototype technology that could serve as the source of rf power for the NLC upgrade.

We continued expanding our experimental capabilities over the past year. The Beam Test Facility, which will increase the benefits of the ALS injector linac by using the beam during several hours of otherwise idle time between ALS injection cycles, was fully commissioned. Besides the two experiments on the immediate horizon—plasma focusing of beams and generation, detection, and use of femtosecond x-ray pulses—preparations are under way for research into laser acceleration, laser guiding, optical stochastic cooling, and the entropy of particle and photon beams. And short-pulse tabletop terawatt lasers are being added to our Laser Optics Laboratory, which has embarked on collaborations with the University of California, Berkeley, physics department.

Aside from the growth in these activities, we have also continued making progress in our traditional focus areas: accelerator theory, linear and nonlinear beam dynamics, the fundamental physics of free-electron lasers, and high-energy collider physics (including diagnostics and beam cooling for large facilities such as the Large Hadron Collider at CERN and the Relativistic Heavy Ion Collider at Brookhaven). And our diverse research and educational activities have enjoyed enhanced participation by students and international visitors.

Experimental Beam Physics

To put theory to the test of experiment (and hopefully to develop new accelerating mechanisms, high-performance beam-control techniques, radiation sources with novel and useful characteristics), the Experimental Beam Physics group has become an integral part of the Center's activities. The group's 1994 and 1995 achievements have centered on the Beam Test Facility at the Advanced Light Source, the plasma lens and femtosecond x-ray experiments being set up and performed there, and experiments related to the Center's long-standing interest in free-electron lasers.

Beam Test Facility

The Beam Test Facility is based on the 50-MeV Advanced Light Source injector linac, multiplying the scientific productivity of the ALS by using the linac beam for physics experiments during the several hours of otherwise idle time between ALS injection cycles (Figure 5-1). The BTF also has a terawatt, femtosecond laser system (Figure 5-2). The two systems work together in one of the most interesting experiments: generation and detection of x-ray pulses as short as tens of femtoseconds (Figure 5-3). Another interesting initial experiment, with implications for inertial-confinement fusion, involves focusing of a beam by using a plasma lens. In collaboration with the Fusion Energy Research Program, we are studying UV-laser-initiated discharges for heavy-ion-beam focusing and transport. Experiments are under way to investigate the stability of such discharge channels.

By mid-1994, the beamline was complete up to TV5 and was being commissioned, but the laser system had not been installed. Since then, the beamline has been finished and commissioned, including two additional optical transition radiation (OTR) beam diagnostic systems; the terawatt Ti:Al₂O₃ CPA laser system and associated beam transport system have been commissioned; and a transport line between the B5 and Q9 magnets for the plasma lens experiment has been installed.

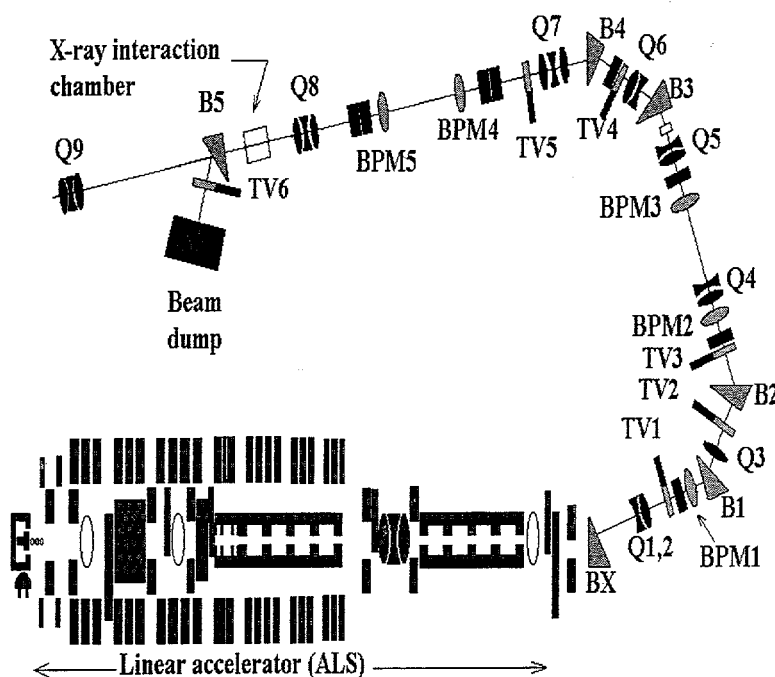
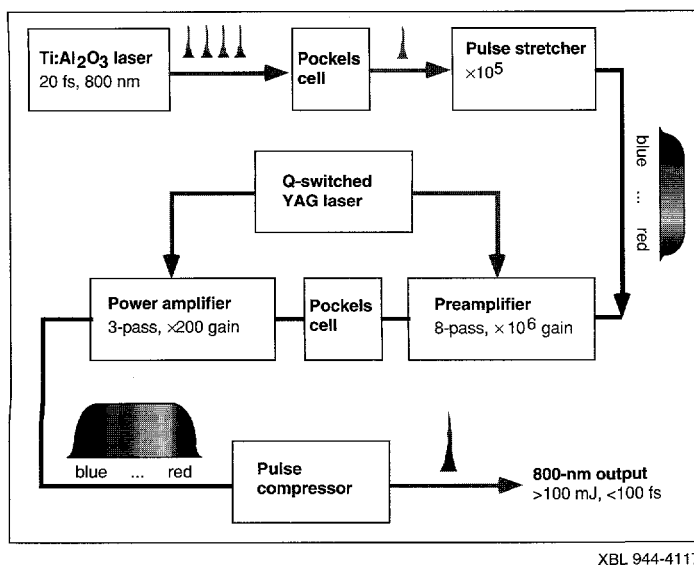


Figure 5-1. A diagram of the Beam Test Facility beamline shows bend magnets (B), quadrupole magnets (Q), beam position monitors (BPM), and fluorescent screens (TV). Optical Transition Radiation diagnostics are currently installed between Q5 and B3 and between Q8 and B5.



XBL 944-4117

Figure 5-2. The femtosecond terawatt laser system that will be used in this experiment was developed by LBL's Materials Sciences Division (Femtosecond Laser Spectroscopy Group).

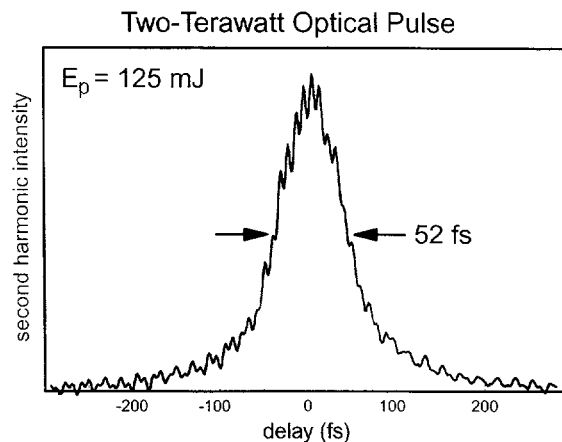
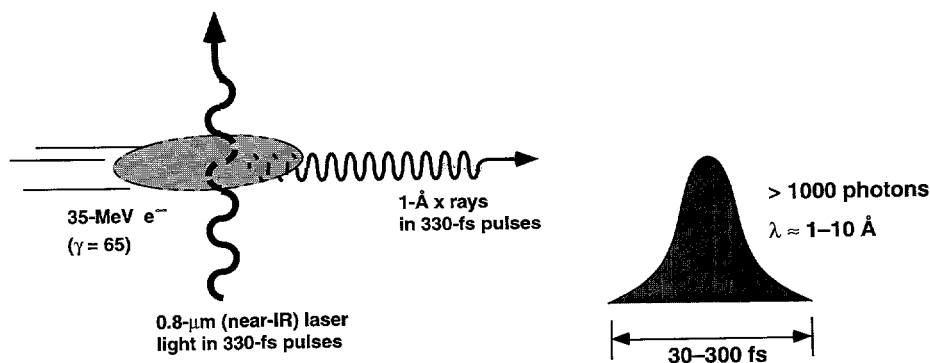


Figure 5-3. One of the most intriguing experiments for the Beam Test Facility is production of subpicosecond x-ray pulses through 90° Thomson scattering of a near-infrared laser beam against a relativistic (<50-MeV) electron beam.

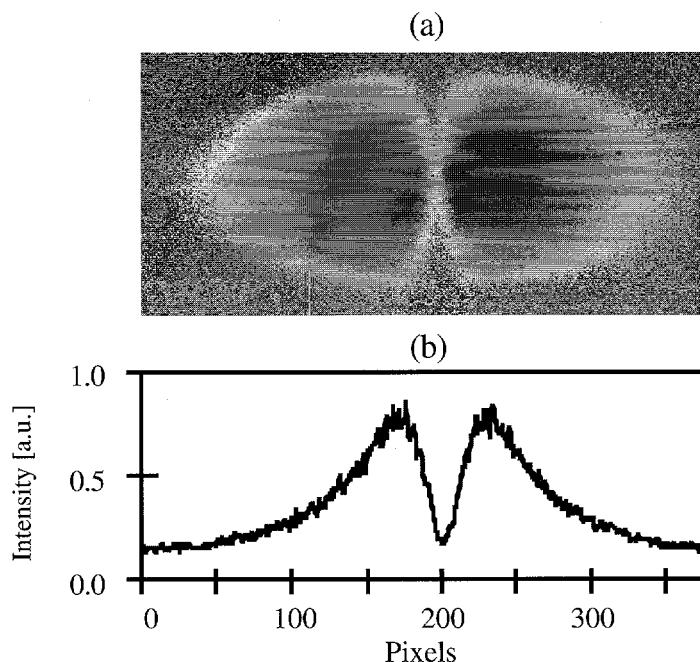


XBL 931-4708

BTF Commissioning

The commissioning phase of the BTF has progressed well. The main goal has been to deliver an optimized and fully characterized electron beam to the various experiments. Three OTR-based electron beam diagnostic systems have been implemented. OTR has allowed us to simultaneously measure beam energy, size and divergence (i.e., emittance), and bunch length; see Figure 5-4. Two of the systems use time-integrating charge-coupled-device (CCD) cameras, giving time-averaged measurements within a macropulse. The third system is equipped with a streak camera with picosecond time resolution for time-resolved information. (The streak camera was obtained from the former Soviet Union with funding from the ILAB program in the State Department.) In addition to their usefulness in beamline and linac tuning, these systems have enabled specialized measurements that are useful to the plasma lens focusing and the femtosecond x-ray generation experiments.

Figure 5-4. A typical optical transition radiation image of the radiation cone, along with a horizontal line-out. A polarizer was used to minimize the contribution of the vertical divergence of the electron beam.



Plasma Lens Experiment

The plasma lens experiment will examine the way electromagnetic interactions focus the beam when a relativistic electron beam passes through a plasma. To date, most work with the plasma-focus concept has involved thin "lenses." Continuous plasma focusing with thick lenses holds the promise of overcoming the so-called Oide limit—a fundamental limit of focusability arising from statistical emission of high-energy photons in a sharp focusing bend. A proof-of-principle test and a systematic exploration of plasma-focus ideas generated at our Center will be conducted.

One of the ideas is a long, continuous plasma focus in which the plasma density is tapered by either diaphragms and differential pumping or a focused laser beam. The density will be tapered from about 1×10^{10} to $5 \times 10^{12} \text{ cm}^{-3}$ over a length of 0.5 m. We hypothesize that, at 50 MeV, such a device could focus a beam with a 3-mm cross section into a 400- μm spot. Our scaled proof-of-principle work will involve plasma lengths ranging from 10 to 50 cm, with density tapering from about 1×10^{11} to $5 \times 10^{13} \text{ cm}^{-3}$ over that distance.

Two requirements must be satisfied for an effective plasma focus: the plasma response time must be short compared to the pulse length, and the plasma return currents within the beam must be small. We have calculated parameters for a number of experiments that can be performed using the 50-MeV injector; they will allow careful study of these requirements in both underdense and overdense plasmas.* Furthermore, a study of how plasma return currents change the effectiveness of the focusing can provide insight into the usefulness of plasmas in reducing beam-beam interaction.

* The terms "overdense" and "underdense" indicate whether the plasma is denser than the particle beam or vice versa.

A detailed parameter study of relevant plasma lens experiments, in both the overdense and underdense plasma regimes, has been carried out using actual measured electron beam parameters. Also studied was the effect of thin foils (used for separating the plasma chamber from the ultrahigh vacuum section and as substrates for mirrors) on the beam properties.

For the overdense case, typical plasma lengths range from 3 to 10 cm and plasma densities range from 4×10^{12} to $5 \times 10^{13} \text{ cm}^{-3}$. For the underdense (adiabatic and tapered) lens, the plasma lengths range from 3 to 5 cm with density profiles spatially varying longitudinally from 1×10^{12} to $5 \times 10^{14} \text{ cm}^{-3}$. We have chosen to produce the plasmas through quasi-resonant two-photon ionization of tripropylamine, or TPA. The advantages of this technique are the ease of plasma profiling through the quadratic dependence on laser intensity, as well as the low laser power requirements. Longitudinally tapered plasmas will be produced using a UV laser beam, incident at 90° to the electron beam, brought to a line focus with a spatially tapered intensity profile.

Using 94.3-GHz interferometry we have shown that uniform plasma densities (1 cm^2 cross-section) for the overdense case can easily be produced in TPA with a 15-MW peak power KrF laser ($\lambda = 248 \text{ nm}$). For safety reasons, we are now switching to a frequency-quadrupled Nd:YAG laser ($\lambda = 266 \text{ nm}$) for plasma production. We do not expect the slight change in wavelength to significantly reduce the ionization efficiency or increase the laser power requirements.

To improve the spatial resolution of the density measurement and increase the maximum density we can measure, a plasma diagnostic based on optical HeNe Fabry-Perot interferometry has been designed and built, and is currently being tested. This system should allow us to measure plasma densities in the range of 5×10^{13} to $1 \times 10^{16} \text{ cm}^{-3}$ with $35 \text{ }\mu\text{m}$ spatial resolution.

A vacuum chamber has been designed which meets the requirements for both experiments and can accommodate both microwave and optical interferometry. It allows for a complete scan of the electron beam profile using OTR before and after the plasma lens.

The CBP Laser-Optics Laboratory has been expanded into the adjacent room, doubling its floor space. We have obtained a Nd:YAG laser system from LLNL for plasma production tests and are currently installing it.

In the next few months, we expect to finish the following tasks:

- Construction of the vacuum chamber.
- Production of uniform and tapered plasmas using 266 nm in TPA
- Testing and calibration of the HeNe interferometer
- Installation of the vacuum chamber at the BTF

By the end of the summer 1995 we expect to have results on plasma focusing.

Femtosecond X-ray Experiment

Another experiment at the BTF will produce ultrashort x-ray pulses. Today, the shortness of photon pulses that are produced by either interaction with a magnetic field (synchrotron radiation) or interaction with visible photons (Thomson scattering) is limited by, and comparable with, the length of the electron beam bunch. For the ALS linac beam, the shortest photon pulses obtainable from a direct collinear interaction would be a few tens of picoseconds long. We have recently hypothesized that a third approach could break through this limit, producing subpicosecond x-ray pulses.

The new approach, being supported with Laboratory-Directed Research and Development funds, is based upon 90° Thomson scattering with a visible laser. In this configuration, the shortness of the x-ray pulse is limited not by the length of the electron pulse, but rather by the length of the laser pulse or the transit time of the laser pulse across the waist of the focused electron pulse. Therefore it is crucial to focus the electron beam to a narrow waist matching the laser pulse length. The output pulse is much higher in energy than the laser pulse: the upshift is given by $4\gamma^2$, where γ is the Lorentz factor of the electron beam.

A short-pulse, solid-state laser ($\tau_L = 200$ fs, $E = 100$ – 200 mJ) is nearing completion in the femtosecond laser laboratory of LBL's Materials Sciences Division. In cooperation with that division's Center for X-ray Optics, we are examining ways to direct the beam onto detectors and experimental apparatus. To detect the x-ray beam with femtosecond resolution, itself a challenging problem, this collaboration is developing an x-ray detector that uses part of the laser beam to melt a silicon wafer and then measures the change in diffraction pattern as a function of the known delay time before the arrival of the x-ray beam. (We are also exploring autocorrelation of the laser pulse with the visible pulse given off by a gas column that was photoionized by the x-ray pulse.) We are also designing the beamline components required to focus the electron beam to a 70–100 μm spot and then separate it from the x-rays after the interaction point. With the current design parameters, we should be able to produce a 100–300 fs x-ray pulse, containing about 10^5 – 10^6 photons, with a wavelength that can be varied in the range of 1–10 Å by changing the electron-beam energy.

A variety of other experiments will also be made possible by the facility, including beam-structure interaction studies, investigations of beam-conditioning cavities for free-electron lasers, and the "chirping"* of conveniently long (10-ps) electron-beam bunches to produce photon pulses much shorter than that.

Preparations for this experiment are well under way. The electron beam has been focused down in the x-ray interaction chamber to a spot size of less than 100 μm with a pointing accuracy of better than 50 μm . The electron bunch length has been measured, using the OTR diagnostics, to be 15 ps. Synchronization jitter between the electron and the laser pulses has been measured using OTR to be about 2 ps. Using a phosphor screen and a slow-scan CCD camera, the background x-ray flux has been estimated at 100 to 1000 photons per pulse.

During the next three months, we expect to have finished the following tasks:

- Retuning of the electron beamline after a scheduled ALS shutdown during which the linac cathode will be changed.
- Transport of the high-power laser beam into the x-ray interaction chamber.
- Measurement of the x-ray background spectrum using germanium, scintillator, and bismuth germanium oxide detectors.
- Time-integrated, spatially and spectrally resolved measurement of the x-ray beam profile.

By the end of summer 1995 we expect to have preliminary results on x-ray generation.

* A term for a small, rapid change in energy during a pulse, historically based in radio transmission of Morse code.

Free-Electron Lasers and Radiation Sources

Although the effort of past years to build a large infrared free-electron laser for chemical sciences here at LBL is on hold, the Free-Electron Laser and Radiation Source Group carries on the Center's long-standing interest in FELs. This largely theoretical group studies such topics as characterizing the qualities of particle and photon beams via entropy; optical stochastic cooling; cooling of relativistic heavy ions beams with broadband lasers; and coherence and power characteristics of high-gain FELs. An underlying theme is supplementing and/or moving beyond today's "third-generation" synchrotron-light sources by finding advantageous ways of generating radiation that has similar but improved qualities. Such advantages might include size, cost, access to a difficult spectral region, and taking advantage of otherwise idle beamtime at an accelerator facility.

A prime example has been the leadership in theoretical and numerical-analysis that our group has provided to the SLAC Linear Collider Light Source (LCLS) project, which seeks to use the Stanford Linear Accelerator Center's "two-mile linac" for an x-ray FEL. As a recognized international center in short-wavelength FEL research, we were asked to organize a special session devoted to discuss the physics and technology of short wavelength FELs during the 16th International FEL Conference at Stanford University.

A major new activity that has emerged recently is the incorporation of gamma-gamma collision in the design of the Next Linear Collider. We are participating in the recently formed SLAC-LBL-LLNL collaboration that is preparing a preliminary NLC design.

Free Electron Laser R&D

We have been steadily expanding our theoretical/numerical capabilities for reliable predictions of high-gain FEL operation in the short wavelength (UV and beyond) region. We have developed a more-comprehensive theoretical framework for handling the startup and exponential gain behavior, taking into account the slippage between the electron and the photon pulses and the finite pulse duration. An interpolation formula for accurate prediction of the behavior in the exponential gain regime, including the growth rate, the transverse mode structure, coherence and degeneracy, etc., has been worked out.

In the process, we have created various simulation codes to study different aspects of FEL behavior. In particular, the simulation code GINGER has been refined and upgraded to permit calculation of the harmonic generation, startup from noise, undulator interruptions, oscillator-type FELs, etc. These capabilities have enabled us to be a leading partner in the Linear Collider Light Source (LCLS) collaboration, as discussed below.

Linear Collider Light Source

Over the past year we have done extensive numerical modeling for several different FELs proposed conceptually at LBL and at other institutions. The most extensive effort has been in support of the LCLS, which is being studied by a consortium of institutions including SLAC, LBL, the University of California at Los Angeles, and Livermore. The LCLS would pass the electron beam from the SLAC linac through a long (25- to 50-m) wiggler to produce very bright, coherent x-rays in the 1-5 Angstrom range. This beam is high in both energy (15 GeV) and peak current (5 kA) and has a low transverse emittance (1-2 π mm-mrad normalized).

We have carried out the comprehensive multidimensional parameter optimization that is necessary to develop a strategy for a phased approach, starting with longer wavelength operation and progressing toward the ultimate goal of an x-ray FEL. We used the time-dependent, two-dimensional

(r-z) FEL simulation code GINGER to examine the startup of the LCLS FEL from shot noise (i.e., random bunching) naturally present on the input electron beam and the development of longitudinal coherence as the radiation grows exponentially with distance down the wiggler.

We have also investigated the usefulness of various modifications, such as making the first part of the wiggler resonant with the third subharmonic (4.5 Å, compared with the ultimately desired 1.5 Å) because its exponential gain length is shorter. The second half of the wiggler, which would remain resonant at 1.5 Å, would use the third-harmonic bunching produced by the first wiggler as an enhanced "seed" for continued exponential growth. And we investigated the advantages, if any, of inserting various drift spaces in the LCLS to make an optical klystron configuration and enhance the bunching. We found that the inclusion of time-dependent effects significantly reduces the gain from what would be found with a monochromatic signal.

Infrared FELs

Over the past several years, we had been working actively on designs for an infrared FEL whose characteristics were tailored to the needs of a user community in chemical dynamics. Construction of such a facility was strongly endorsed by the Committee on Free Electron Lasers and Other Advanced Coherent Radiation Sources, sponsored by the National Academy of Sciences. Encouraged by the report, we attempted one more time to propose an IRFEL producing hundred-microjoule, one-picosecond pulses in the wavelength region from 10 to 100 microns, to be constructed near the Advanced Light Source so that the two kinds of beams could be brought to bear on the same experiment. This is a wavelength region where tunable, high-power sources are not available with the conventional laser techniques, but which is important for fundamental studies in chemical dynamics, material sciences, biology, and physics via excitation of vibrational levels and nonlinear optical phenomena. Some hardware has been generously transferred to us, e.g., rf power equipment from Boeing and a gap-tunable undulator from the University of Wisconsin Synchrotron Radiation Center. We have, regrettably, had to put this aspect of our program on hold because the current funding climate would not support a construction program or even continuation of research at a significant level of effort.

Meanwhile, we are continuing the collaboration with CEBAF in their IRFEL design effort by providing detailed studies of the optical mode and the output coupling performance of a confocal FEL cavity.

Study of a High-Power FEL

We have studied an idea for a very high average power FEL based on a multi-turn, recirculating microtron. Such an FEL could be important in certain industrial applications such as material processing, or in beaming power down to Earth from orbiting solar-energy satellites. A numerical simulation code was developed to study the energy loss instability of the accelerator system, which is crucial for these multiturn, recirculating accelerators. Following extensive modifications to GINGER to model oscillator FELs, we have used it and a one-dimensional time-dependent code to model the "electron output scheme" that has been proposed as a path to a high average power FEL at short infrared wavelengths.

The electron output scheme involves a relatively standard oscillator FEL whose major purpose is to bunch the electron micropulses, followed by a single-pass amplifier wiggler (the "radiator") in which the bunched beam would radiate copious amounts of coherent power without the limitations that

are set by mirror damage in ordinary FELs. In a series of papers, we put forth the requirements for operating the oscillator in a stable mode, especially in an optical klystron configuration, as well as the expected extraction efficiency of the output radiator with and without tapering of the wiggler. Depending upon the exact beam parameters chosen, we found that relatively high cavity losses and careful detuning will probably be necessary to produce output bunching at a level of 0.3 to 0.5. Furthermore, extraction efficiencies much above a few percent will require relatively long (> 5 m) radiator wigglers.

Studies at the Stanford IRFEL

In 1995 we continued our experimental collaboration with the Stanford group that has built a 3–12 μm FEL. An image dissector system was used to measure sideband generation and transition to chaos in an infrared FEL operating at a wavelength λ_r of 4 mm with a low-loss optical cavity. The temporal evolution of the radiation spectrum through the complete macropulse has been measured on a micropulse-to-micropulse basis. Stable sidebands were observed for small cavity detuning with frequency offsets in good agreement with calculations. For even smaller cavity detuning, self-oscillations occur with the main laser wavelength varying by up to 2%. Using a wavelength stabilization system based on rf feedback, we have suppressed these wavelength fluctuations without loss of peak power.

The wavelength and power stability of the Stanford FEL, operating with the TRW wiggler, have also been measured using a high-resolution spectrometer and an image dissector system. The image dissector is capable of reading the spectrum of every micropulse at 12 MHz throughout a macropulse of up to 2-ms duration. The intrinsic wavelength and power stability of the FEL are found to be $d\lambda/\lambda = 0.035\%$ and $\delta P/P = 18\%$. The use of a feedback control system to stabilize the wavelength, and an acoustic-optic modulator for output power smoothing, improves the performance to $\delta\lambda/\lambda = 0.012\%$ and $\delta P/P = 7\%$.

Study of a Gamma-Gamma Collider

An e^+e^- collider can be made into an $e-\gamma$ or $\gamma-\gamma$ collider by converting the electrons into gamma rays via Compton backscattering with terawatt optical beams, as shown schematically in Figure 5-5. This is desirable because gamma rays are energetic enough for the "particle" aspect of wave/particle duality to be significant. Gamma-gamma collisions provide unique access to

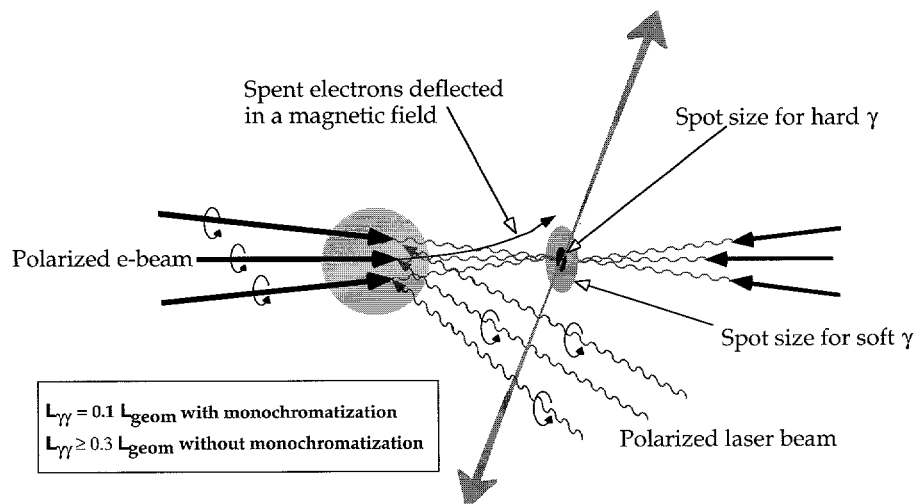


Figure 5-5. Our concept for a gamma-gamma collider is based on Compton scattering between TeV electron beams and TW optical beams. Its physical context is a TeV upgrade of the Next Linear Collider based on non-superconducting rf systems (which we are also studying).

some areas of fundamental physics, and the data also supply desirable redundancy to the data from e^+e^- collisions. In March 1994, the Center organized a Workshop on Gamma-Gamma Colliders to examine these issues. The workshop confirmed community interest in these benefits and also showed that adding a $\gamma\gamma$ facility to an e^+e^- collider would involve a relatively small incremental cost, and that the technology is sufficiently advanced today to seriously consider a $\gamma\gamma$ collider.

The probable physical context of this work is the Next Linear Collider (NLC). A SLAC-LBL-LLNL collaboration has recently been formed to complete a preliminary design of this facility. The NLC's goal is a luminosity of $5 \times 10^{33} \text{ s}^{-1} \text{ cm}^{-2}$ with 0.5 TeV center-of-mass energy in the first phase, upgradable to 1 TeV and beyond as well as higher luminosity (Figure 5-6). There are many challenging technical issues involved in a $\gamma\gamma$ collider; they include detectors and masks in the interaction region; special focusing components; high-power optical beam sources, including FELs; bright sources of polarized electrons; and high-power, low-loss optical components.

Many of these challenges overlap with the Center's expertise. The three-laboratory collaboration agreed that parameter specification and project coordination for the $\gamma\gamma$ collider should be our responsibility. In addition, the Center will contribute in its areas of special competence: FELs, bright sources of polarized electron beams, and photon- and particle- beam transport in the interaction region. (A related damping-ring design study is described in the Beam Electrodynamics Group section of this report.)

The optical beams converting the electron beams to gamma rays need to satisfy very stringent requirements. To achieve 1:1 conversion, each micropulse must contain about a joule of 1- μm radiation and deliver it in about 1 ps. A sequence of 90 micropulses separated by 1.4 ns long makes up a macropulse. The macropulses are repeated at a rate of 120–180 Hz. Thus the peak power of the beam in the micropulse is 1 TW, while the time-averaged power is about 20 kW.

Research at the e^+e^- Energy Frontier

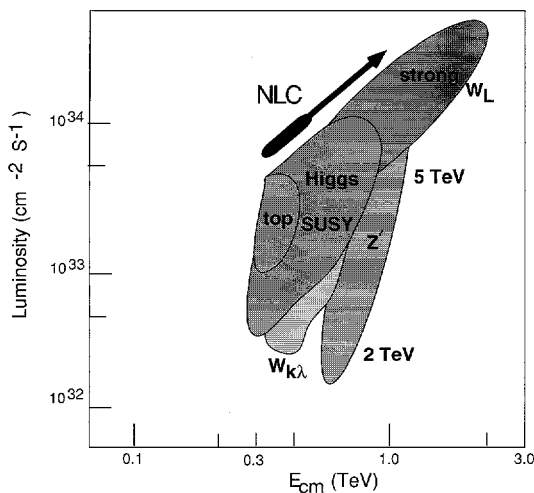
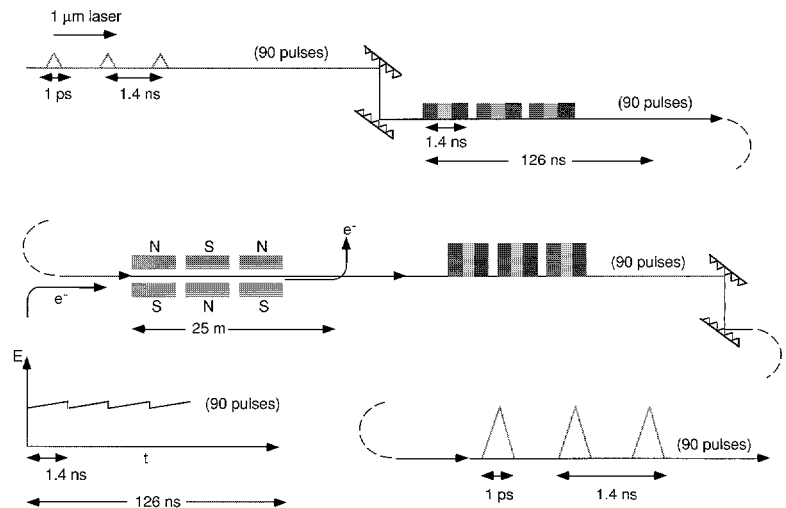


Figure 5-6. Several phenomena at the "energy frontier" of high-energy physics will be accessible to a machine with the energy and luminosity of the Next Linear Collider collaboration's preliminary design. Also shown here is a specific example of technical progress toward gamma-gamma collisions at the NLC: a pulse-stretching, FEL-amplifying, and pulse-compressing system to produce an optical beam with the necessary characteristics.



Terawatt, picosecond lasers with the chirped-pulse amplification and compression technique have been built. However, the maximum average power of these lasers is at present about 10 W. Solid-state cw lasers pumped by diode arrays are currently being developed, with 1-kW systems demonstrated and a 10–20-kW system apparently feasible. The challenge is in combining the high peak power capability with the high average power via advances in dielectric gratings and phase-conjugation materials that can handle the power.

We have initiated a promising scheme for producing an optical beam of the required characteristics using pulse-stretching, FEL-amplifying, and pulse-compressing techniques. In this scheme, a low-power beam with the same time structure required for the final beam is passed through a grating pair to stretch and chirp the picosecond micropulses to 1.4 ns, so that each macropulse will be almost continuous through its 126-ns length. The optical beam is then amplified in an FEL, which is driven by an intense electron beam from an induction linac. The electron beam may need to be chirped to match the input optical beam. The amplified beam—now up to about 1 J per micropulse—is then passed through another grating pair to compress the micropulses and to recover the original time structure.

The requirements for the electron beam (current about 1 kA, energy about 100 MeV, energy spread about 10⁻³, and normalized rms emittance about 50 mm-mrad) are consistent with known induction linac performance. Preliminary study shows that possible degradation of pulse compression performance due to the phase/frequency fluctuation of the optical beam, which in turn is caused by electron-beam fluctuation from the induction linac, is small. The issue is whether gratings with the necessary high thermal damage threshold can be designed. This problem will be explored in close collaboration with the LLNL partners in the collaboration.

Additional Theoretical Topics

Entropy of Particle and Photon Beams. We have investigated the entropy of a particle beam, relating it to the more familiar concept of emittance as a measure of its disorder. Both concepts can be generalized to the case of photon beams, the entropy in this case being related to the density operator. In this work we are studying in detail the case where the photon beam is a stochastic superposition of coherent Gaussian beams. The goal of the study is to understand the qualities of particle and photon beams from a fundamental point of view.

Broadband Laser Cooling of Relativistic Ion Beams. In collaboration with a visiting scientist from the former Soviet Union, we are investigating the possibility of cooling relativistic ion beams in a storage ring by introducing a broadband laser beam into the straight sections. The process is similar to radiative cooling, except that the radiation is enhanced via resonance with the atomic energy level. Compared to the usual laser cooling schemes based on narrowband lasers, the proposed scheme has the advantage of operating in all three dimensions. The disadvantages are that the cooling rate is slower and the minimum achievable temperature is higher.

Optical Stochastic Cooling. During this past year, several of the Center's staff have been involved in a study of Optical Stochastic Cooling (OSC) — a new technique that has the potential to make the cooling of relativistic protons and heavy ions in storage rings quicker by several orders of magnitude, compared to what has been achieved in microwave stochastic cooling.

A detailed theoretical analysis of OSC is being developed. The field of a particle as a function of the kinematic variable at the pickup is determined by

solving Maxwell's equations, and is approximated by a simple Gaussian function. At the kicker, the particle sees an amplified superposition of fields from all particles of the beam. The change of the rms energy spread of the beam is evaluated using a distribution function of kinematic variables. We find that a sample in OSC is delineated not only by its length, as it is in microwave stochastic cooling, but also by its transverse size. The signal is picked up only from, and applied only to, particles belonging to a transverse sample in an area whose size is on the order of the product of the radiation wavelength and the length of the pickup. We are analyzing the dependence of cooling rate on the number of transverse samples and on the precision of the optical and particle beam transport between pickup and kicker.

We have also identified two problems that have to be resolved experimentally to verify the feasibility of OSC. The first is isochronicity of the lattice in the presence of a cooling insertion, along with preservation of fluctuations in the beam when it passes the insertion. The second is transportation and amplification of the pulse of undulator light while preserving fluctuations in the initial signal. Looking for an opportunity to do the experimental work at LBL, we settled on the electron beam from the ALS booster synchrotron at 150 MeV (which is far lower than the normal injection energy for the ALS storage ring, but is attainable). After extraction, the electrons would be directed to a special beamline that will include two undulators connected by a highly isochronous lattice, a setup that resembles a cooling insertion for a storage ring. Several variants of this beamline that would fit in the available space in the extraction area of the booster have been designed, as shown in Figure 5-7. The first experiment would consist of observation of the interference pattern of the radiation extracted from the undulator.

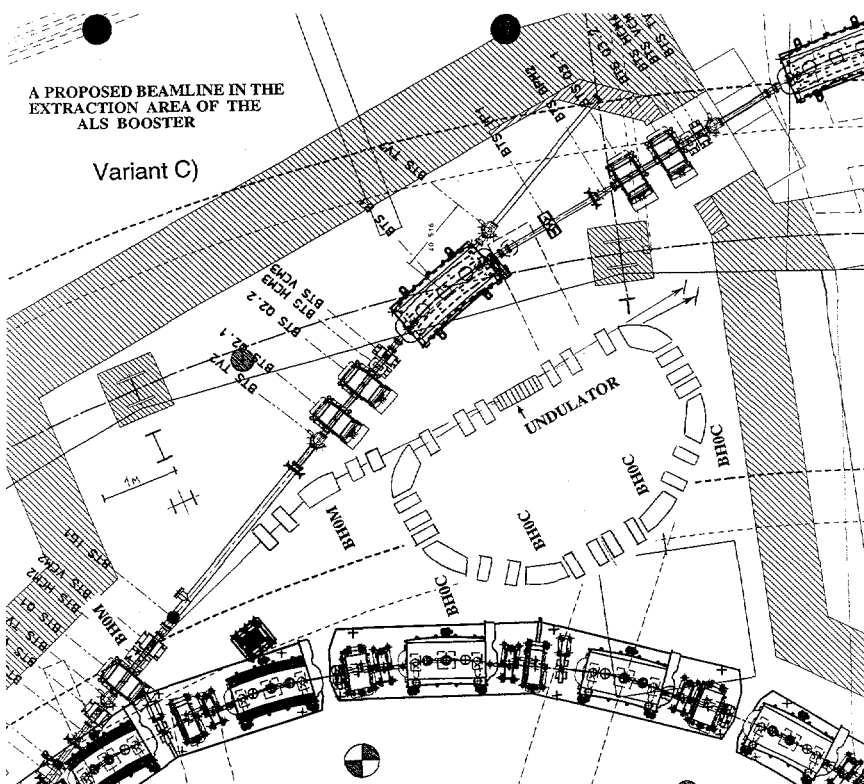


Figure 5-7. A schematic of the Optical Stochastic Cooling testbed that could make use of the beam from the Advanced Light Source booster synchrotron.

Electrodynamics

The increasing variety and difficulty of the rf manipulations needed by today's accelerators has opened new opportunities for what began as our beam-cooling group. Now called the Beam Electrodynamics Group, its activities during the year involved crucial work for the PEP-II B-factory, the ALS, the Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory, and the design of the Next Linear Collider (NLC) damping rings. Particular attention has been focused on rf and microwave components and systems for PEP-II.

PEP-II

Control of the longitudinal and transverse coupled-bunch oscillations of the electron and positron beams in PEP-II is crucial to the success of the project. Feedback systems like the transverse system shown in Figure 5-8, together with impedance minimization, are required to achieve this goal. Beam Electrodynamics Group members are responsible for the design and fabrication of the transverse coupled-bunch feedback systems, and, in collaboration with SLAC, the longitudinal feedback system. Previous work on beam impedance calculations and measurements of a test cavity in the Lambertson Beam Electrodynamics Laboratory have determined the dominant driving impedances for the coupled-bunch instabilities.

The coupled-bunch instabilities encountered at the ALS have characteristics similar to those expected for the PEP-II rings; in particular, the growth rates of the coupled-bunch modes are of the order of milliseconds or less in both cases. Commissioning of the feedback systems at ALS has progressed well. We have demonstrated control of the transverse coupled-bunch motion of multibunch beams of up to 175 mA. Commissioning of the systems is in progress. Our experience in building and commissioning the ALS feedback systems has been of great value for PEP-II feedback systems design.

A design review held in October 1994 led to system specifications, and several components of the system are now in the detailed design stage. The receivers, which use signals from pickups in the accelerator vacuum chamber

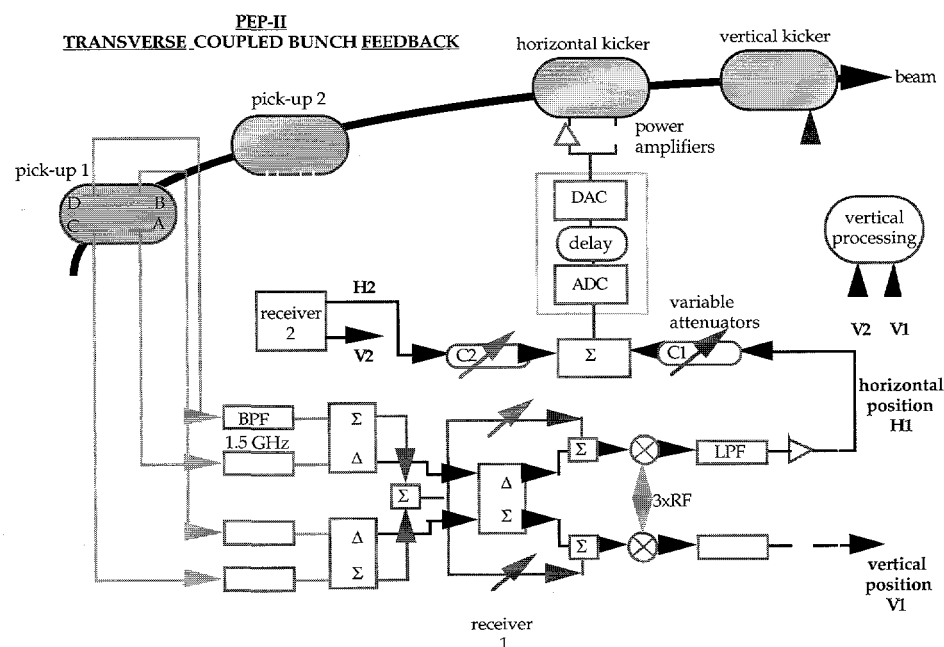


Figure 5-8. Theoretical studies indicate that this transverse feedback system will control coupled-bunch motion in PEP-II; experimental confirmation is beginning, as is design work on a longitudinal feedback system.

to determine the beam position, have been designed and components are on order. Pickups for the system have been specified and are on order, as are the high-power radio-frequency amplifiers that generate the deflecting kick to correct the beam oscillations. Digital electronics to provide a suitable delay between pickup signal and corrective kick, and also to allow particular bunches in the beam to be driven to large amplitude to scrape off some of the charge, are in the design stage. The stripline kickers, which create electromagnetic fields and provide the transverse kick to the beam, are being prototyped and will soon be measured in the laboratory.

Cataloging the impedance of components in the vacuum chamber is another ongoing task of the Beam Electrodynamics Group. These impedances cause beam instabilities as the wall currents induced by the beam excite electromagnetic fields that influence the trajectory of following particles. Impedance computations of components have been made with state-of-the-art three-dimensional electromagnetic design codes, and careful laboratory measurements of prototype components assure a low impedance. Figure 5-9 shows the measured beam impedance of a Beam Position Monitor (BPM) button in the LER arc vacuum chamber, which has an elliptical cross section. A sharp resonance at 7.16 GHz is observed, due to a TE-type mode generated in the gap around the circumference of the button. The button size has been adjusted to move the frequency of this mode further out of the beam power envelope. Any coupled-bunch motion driven by this impedance will be controlled by the longitudinal feedback system.

Figure 5-10 shows the measured transfer impedance for an LER BPM, which relates the signal voltage at the pickup to the beam current. At the BPM operating frequency of 952 MHz, a quite acceptable 0.7Ω is obtained.

Computations of instability thresholds and collective effects—including simulations of the operation of the feedback systems with realistic machine impedances and under realistic conditions of injection transients—have been made for PEP-II. For rigid-bunch motion the feedback systems are shown to control the beam motion. The feedback systems act on center-of-charge of each bunch, and are not designed to control modes involving motion within a bunch. Measurements of the low-power test cavity are being made to determine whether additional damping of some transverse cavity modes is required to avoid this kind of coupled-bunch motion.

Figure 5-9. The measured beam impedance of a beam position monitor pickup button in the LER arc vacuum chamber. A resonance at 7.16 GHz is observed. The longitudinal feedback system will control any coupled-bunch motion excited by this impedance.

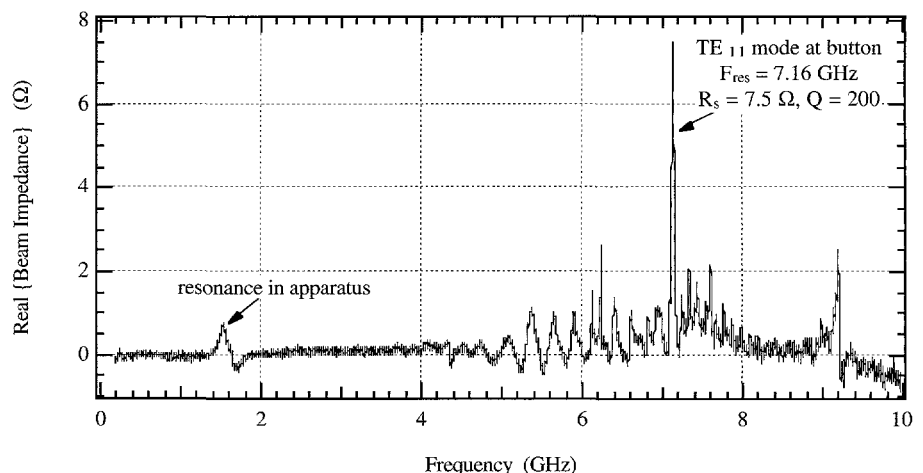
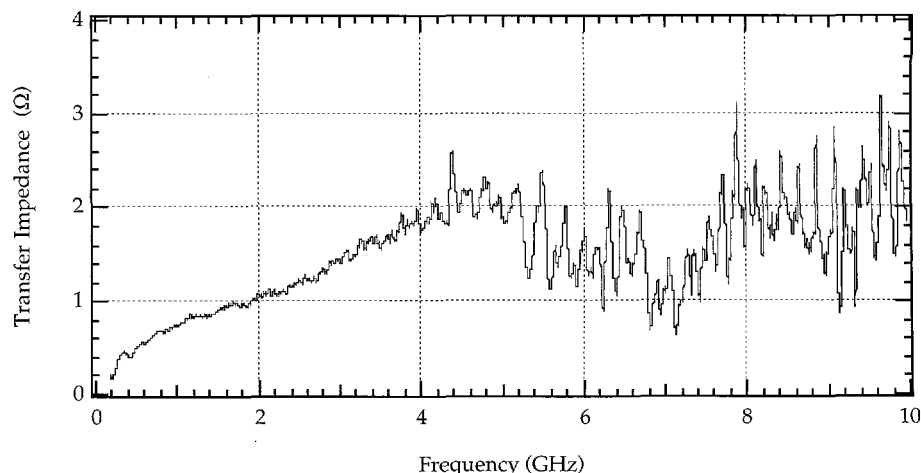


Figure 5-10. The measured transfer impedance of a beam position monitor pickup button in the LER arc vacuum chamber. The impedance at the BPM operating frequency of 952 MHz is $0.7\ \Omega$.



The kickout of a single bunch in PEP-II (without causing too much disruption of the other bunches in the ring) has been studied using a particle tracking code that we developed. In this technique, bunches are removed that have been injected into the gap in the bunch train during injection set-up procedures; the technique also deals with a bunch inadvertently overfilled during the injection process. Because of the nonlinear behavior of the beam as it moves off-axis in the machine, we find that the particles in a bunch smear into a large conglomeration before the feedback system can move the bunch over to strike a limiting aperture in the horizontal direction. However, in the vertical direction we find that the system can indeed kick out a single bunch rather rapidly—within about 300 turns. Figure 5-11 shows the evolution of a beam in transverse phase space as it is kicked to a large amplitude by the feedback system.

In addition to the transverse feedback systems, a multi-element longitudinal kicker is being designed for the longitudinal feedback system. This traveling-wave device consists of three coaxial electrodes connected by delay lines that provide voltages of opposite sign at the ends of the electrodes, increasing the efficiency of the structure. Such high-impedance kickers are necessary to provide the voltage kick of several kilovolts needed in the PEP-II rings, at a reasonable cost in high-power rf amplifiers.

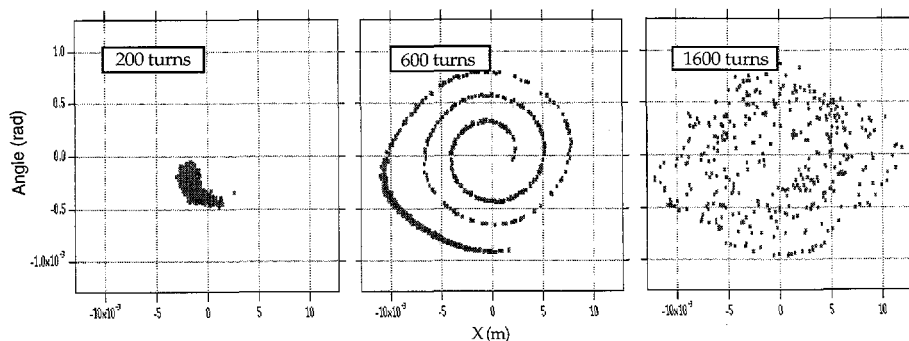


Figure 5-11. Simulations show the evolution of a beam in transverse phase space as it receives large-amplitude kicks from the feedback system.

High-Power RF Systems for PEP-II

The design of the rf systems for PEP-II has continued under our physics direction, initially as an offshoot of LER development and now directly as a top-level project subsystem. We have helped to determine the operating requirements of the system and have been involved in the ongoing R&D of the major components, particularly the high-power cavity, vacuum window, and higher-order-mode (HOM) absorbers.

The distinctive arrangement of three HOM damping waveguides opening into the body of the cavity was developed at LBL. This scheme was proved to be very effective by a series of measurements on a cold-test model in the Lambertson Beam Electrodynamics Laboratory. With the success of this model, the rf group, drawing upon resources from SLAC and LLNL as well as LBL, has gone on to design a full-power version with only minor changes to the geometry. The major challenges in the design of the high-power cavity were in the area of thermal management; i.e., to efficiently dispose of the power from wall losses and to minimize stresses in the cavity body. The cooling scheme was optimized with sophisticated three-dimensional finite-element, rf, thermal, and stress analyses.

Calculations of the power deposited in the cavity HOMs have been made in order to determine the absorber power rating. Figure 5-12 shows the power spectrum for the LER nominal fill pattern (alternate buckets filled), at 3 A with a 5% ion clearing gap. A total of 3.6 kW is deposited in the form of these HOMs in each cavity. Additional power is deposited in cavity modes above the cut-off frequency of the beam pipe. For different fill patterns the spectrum changes, and more or less power is deposited in particular HOMs.

The design of the HOM loads has been optimized to make best use of the absorbing material and to fit into the limited space available in the tunnel. The damping waveguides are now folded so that the loads are "tucked in" parallel to the beam pipe. The cavity, coupler, and load assembly will be prealigned and tested on a raft before installation in the tunnel (Figure 5-13).

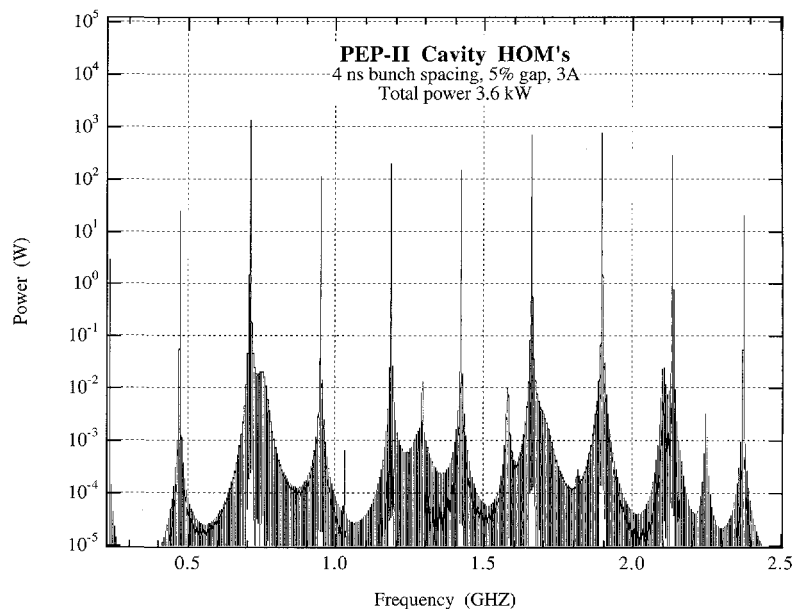
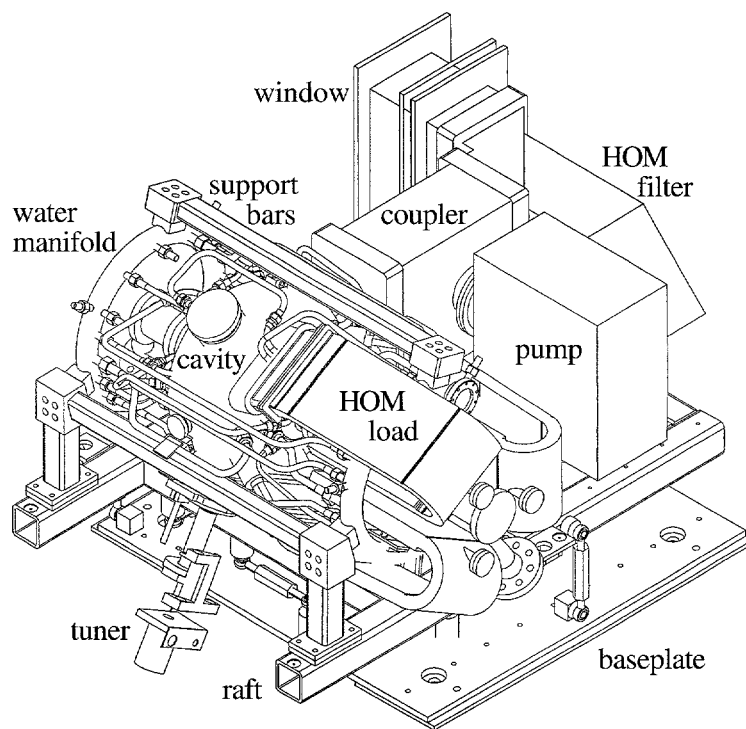


Figure 5-12. The power spectrum for cavity HOMs excited by the LER beam.

Figure 5-13. The PEP-II rf cavity and physically associated components will be preassembled on a "raft" for installation.



The design of the cavity itself is mature, and a mechanically robust high-power test cavity is almost finished. In making the high-power cavity, fabrication technologies from the collaborating laboratories and high-technology industry, including multi-axis CNC machining, high-purity copper electroforming, hydrogen furnace brazing, and electron-beam welding, were used. Tuning of the high-power test cavity, which involves machining the inside surfaces to achieve the required resonant frequency, began in March.

Once the machining is complete, tests and measurements will evaluate the power-handling capabilities of the 476-MHz cavity. High-power testing of the first cavity will begin in late spring or early summer 1995, using the new 1.2-MW klystron built at SLAC. The power level in the cavity will be gradually increased to avoid rf-induced breakdown, which may be expected during conditioning. The cavity has been designed to dissipate up to 150 kW in its copper walls.

The project is planning to build eight cells in-house while issuing a request for proposals for fabricating the remaining cells by December 1995. By carrying out production of the initial set of rf cavities in-house, the project will be able to respond with maximum flexibility to any schedule issues involving this component.

Other high-power components in the rf system have been designed, and high-power tests are due to begin this spring. The rf vacuum window is a critical piece of the system that must allow propagation of 500 kW of rf power without being damaged or compromising the vacuum. We have designed a window that uses a single disk of high-purity alumina ceramic

brazed into a water-cooled flange. The design is unusual in that the flange is made of stainless steel and is joined to the ceramic at high temperature using a substantial molybdenum keeper ring to ensure the correct braze gap. On cooldown, the stainless steel ring tries to contract more than the ceramic, leaving a residual compressive stress in the alumina. This prestressed assembly should be able to withstand higher dielectric losses and should be generally more rugged in the face of arcing or multipactoring than an unconstrained ceramic (which is susceptible to failure due to tensile stresses from differential heating). The brazing process has been optimized using small-scale models and the first full-size windows have been built. High-power testing is under way and initial results are encouraging. Vacuum seals on certain ports are also undergoing tests.

Measurements of the low-power test cavity are continuing to accurately determine the impedance presented by the cavity HOMs. This information is necessary in determining the minimum power and gain requirements for the coupled-bunch feedback systems.

Stochastic Cooling and Beam Diagnostics

We have maintained our history of involvement in stochastic cooling by studying the beam cooling and diagnostics requirements for the Relativistic Heavy Ion Collider being built at Brookhaven National Laboratory. Stochastic cooling is the process by which the deviations from nominal energy or position of particles in a beam are measured and corrected. The control of gold ions in this machine is a particular problem, and microwave frequency stochastic cooling systems are likely to be required to provide sufficient integrated luminosity to effectively study the collisions of these heavy ions. Cooling in both transverse directions and the longitudinal dimension is under consideration. Diagnostics are necessary to determine the behavior of the beam and make necessary corrections. We are developing cavity-based detectors for measuring the noise signals of the beam—an important quantity in hadron and heavy-ion colliders.

Feedback Systems and Collective Effects Measurements for the ALS

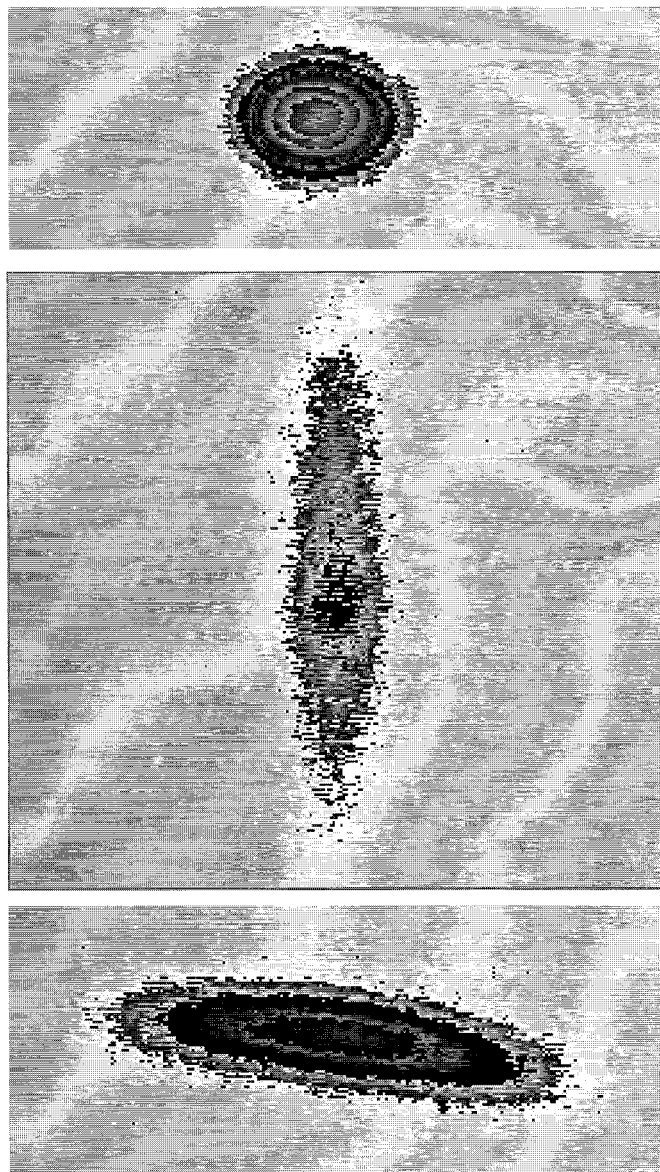
We are continuing to apply our group's capabilities to the improvement of the Advanced Light Source here at LBL. Besides the obvious benefit of enhancing this important user facility, the opportunity to use a state-of-the-art storage ring like the ALS in developing systems for PEP-II is not to be missed.

Installation of the hardware and cables for the transverse feedback systems at the ALS is now complete, and the longitudinal feedback kickers have been installed. Commissioning of these systems continues during the regular accelerator-physics shifts that are interspersed with user shifts. Figure 5-14 illustrates their performance. Spontaneous betatron oscillations have been successfully damped at the nominal ALS user conditions—400 mA in 328 bunches. The large-amplitude synchrotron oscillations provide some damping of the transverse beam motion.

A dedicated longitudinal feedback system is also being commissioned. At present a prototype capable of controlling up to 82 bunches is being used; the full complement of electronics will soon be available to control all 328 bunches. Power requirements are currently being evaluated for the system.

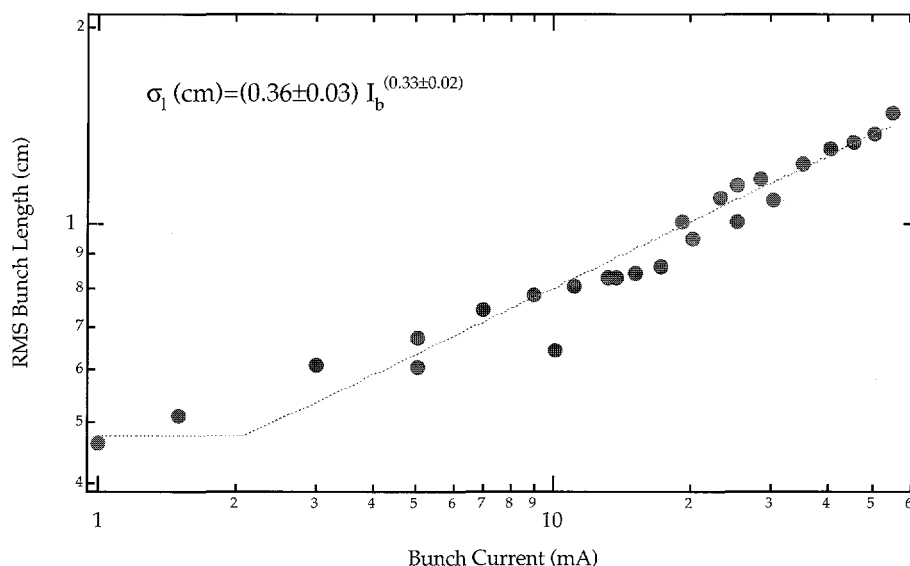
Measurements of the beam characteristics at the ALS have led to a greater understanding of the storage-ring beam impedance. Bunch length estimates and transverse beam dimension measurements have been made, and instability thresholds measured. Figure 5-15 shows the measured bunch

Figure 5-14. This ALS beam (175 mA in 40 bunches) is shown in three states of stabilization, as imaged on diagnostic beamline 3.1. At top it is stabilized by feedback systems in all three directions (horizontal, vertical, and longitudinal). In the center image, vertical feedback has been turned off. Large-amplitude coupled-bunch motion is evident (and is also indicated by coherent signals observed on a spectrum analyzer). The horizontal feedback system was controlling a significantly smaller amplitude of betatron motion. Finally, at bottom, longitudinal feedback is removed while horizontal and vertical feedback remain on. The bunch-to-bunch energy differences result in a horizontal beam size increase through the dispersion at the image point of the beamline. The large amplitude longitudinal motion results in an effective damping mechanism for the transverse motion. For resonant driving impedances, such as the cavity HOMs, the longitudinal oscillations cause dephasing of the transverse kicks due to differing arrival times of a bunch from turn to turn. Also, with nonzero chromaticity, the energy oscillations result in a bunch-to-bunch betatron tune variation, which weakens the coupled-bunch motion in the transverse directions.



lengthening data as a function of single bunch current, together with a fit to the $I^{1/3}$ scaling law expected due to a microwave instability. Measurements of energy spread as a function of beam current support the interpretation of a microwave instability causing this bunch lengthening. The broadband impedance derived from these measurements is estimated to be $0.2 \, \Omega$. This supports earlier estimates, and is consistent with the small impedances found in components measured in the laboratory.

Figure 5-15. Measured single-bunch length as a function of beam current, and $I^{1/3}$ scaling fit.



NLC Damping Rings

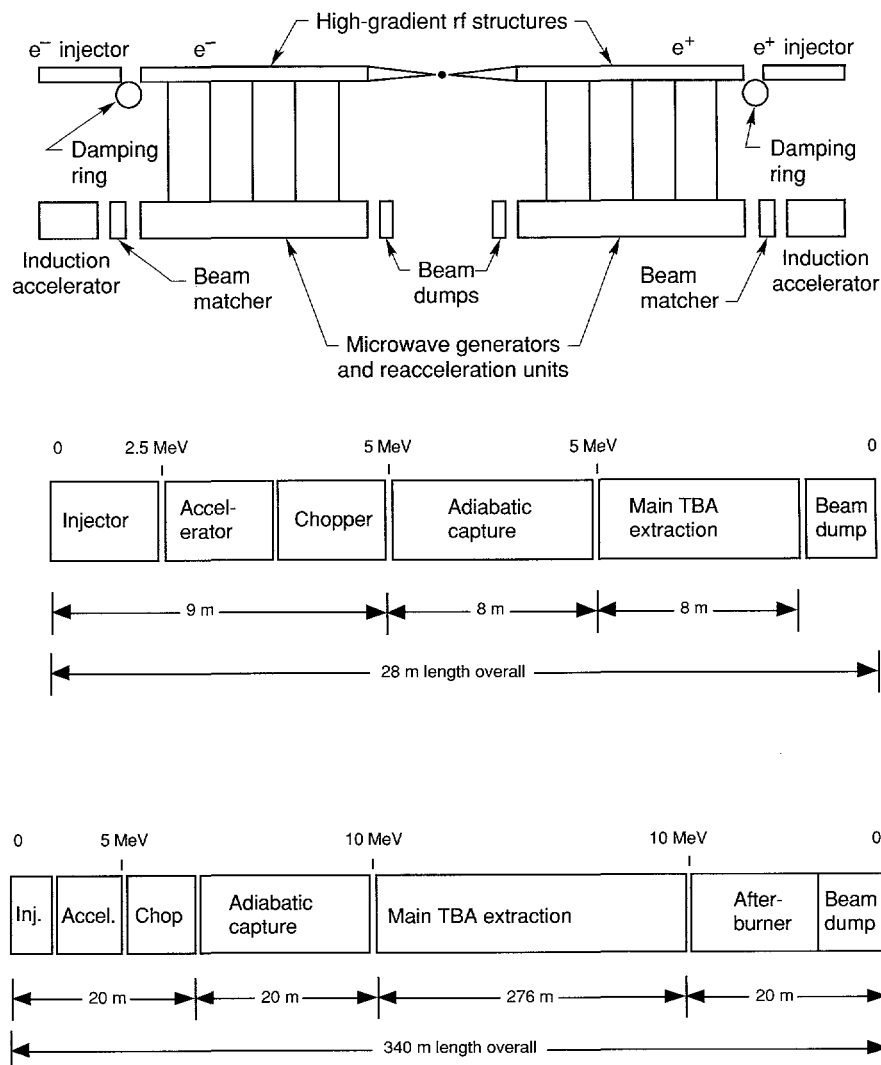
A new venture for us this year has been the collaboration with SLAC on the Next Linear Collider, which involves several groups within the Center for Beam Physics. In particular, our group is involved in the rf systems design and studies of collective effects and feedback systems for the damping rings. The large beam current (1 A), divided into four trains of bunches, results in transient loading of the rf system, which must be compensated to maintain beam quality. Beam instabilities must be avoided by impedance minimization and feedback systems. We contributed an analysis of the damping rings' coupled-bunch instabilities and an outline of the rf system design to the preliminary design.

The RK-TBA as a Power Source for NLC

As a power source for linear colliders, the two-beam accelerator or TBA (see Figure 5-16), a concept developed by Andrew Sessler of the Center for Beam Physics, has the inherent advantage of very high efficiency for power conversion from the drive beam to rf power. In addition, TBAs based on induction linacs would scale quite favorably to high frequencies (≥ 11.4 GHz) and high accelerating gradients (≥ 100 MV/m). Recent reacceleration experiments have successfully demonstrated bunched beam transport through two reacceleration induction cells and three traveling-wave extraction cavities for a total rf output of over 200 MW. The phase and amplitude were shown to be stable over a significant portion of the beam pulse.

The technical challenges for making TBAs into real-world power sources lie in the dynamics of the drive beam, which is quite high in current (hundreds of amperes) and must propagate over long distances. In particular, the beam breakup instability through the long multicavity relativistic klystron version of the TBA is known to be severe. While BBU suppression techniques have been successfully demonstrated for a few cavities, a scenario with acceptable BBU control over many traveling-wave cavities must be constructed. Similarly, the longitudinal stability of the rf bunches over a multicavity TBA must be demonstrated. In addition to technical feasibility, a case for economic attractiveness is no less essential for the viability of the TBA as a power source.

Figure 5-16. In the Two-Beam Accelerator, a high-current, low-energy drive beam is used for generating rf power that is applied to a high-gradient acceleration structure, where a low-current load beam is accelerated to high energy. Relativistic klystrons would generate the rf power in the example we are studying for possible NLC applications, although we have also done research on wiggler-based TBAs. The point design for the RK-TBA of the NLC is also shown, as is the far shorter RK-TBA proof-of-concept prototype that we would like to build and operate at LBL.



XBL 901-5730

With these general considerations in mind, we performed a conceptual study, including physics and engineering designs and "bottom-up" cost analysis, for a new version of the RK-TBA that has acceptable longitudinal and transverse beam stability, as well as low cost and high efficiency. This particular RK-TBA is designed as a power source for a linear collider with 1 TeV of center-of-mass collision energy, representing the upgrade phase of the NLC.

To generate an unloaded gradient of 100 MV/m in the high-gradient structures, the TBA must supply 360 MW of rf power at 11.4 GHz every 2 meters. The output rf field is specified to have a 100-ns linear risetime followed by a 200-ns flat top. The repetition rate is 120 Hz. To power a 15-km-long collider (two 7.5-km arms), we propose 50 RK-TBA units, each 300 m long, operating at an average drive beam energy of 10 MeV, with an average current of 600 A over the duration of the pulse, and a reacceleration gradient of 300 kV/m.

The front end of each RK-TBA unit consists of a 1.5-kA injector, followed by an rf chopper at 2.5 MeV, and an "adiabatic capture" unit in which the chopped beam (average current 600 A) is accelerated to 10 MeV and further bunched with idler cavities in preparation for injection into the main TBA. To enhance the efficiency of the TBA system, an "afterburner" at the end of the main TBA continues to extract rf power through 12 successive output cavities before depositing the spent beam (average beam energy < 3 MeV) at the beam dump. The overall efficiency (drive-beam to rf) of each RK-TBA unit is 90%.

The new RK-TBA design is based on the technology of the long-pulse (few microseconds) induction machines that have been studied over the last 18 years for heavy ion fusion applications. The magnetic material used in this design is Metglas, a metallic glass product that can accommodate a large flux swing—nearly 3 T—before saturation. The induction cores can therefore be made quite compact.

Nonaccelerator applications of this material over the last few years have led to dramatic reductions in the cost of Metglas. The small Metglas cores, when combined with low-field (800 gauss) permanent magnets for quadrupole focusing, and small beam pipes (5-cm diameter), have led to a compact induction cell design whose transverse diameter is about 34 cm — much smaller than any of the previously known induction cell designs.

The pulse power for the induction cells comes from a low-voltage system. The induction cores consist of small 20-kV units, powered by pulse forming networks (PFNs) switched by ceramic thyratrons. Power is fed into the PFNs via dc power supplies and command-resonant-charging systems. The low-voltage design avoids the use of step-up transformers, which have high losses. The main losses in this system are associated with core currents in the induction cells. The overall efficiency of the pulse power system (from wall plug to drive-beam) is estimated to be 40%.

The rf extraction cavities are located every 2 m. Present designs center on traveling-wave structures with three inductively detuned rf cells, with an inner radius of 8 mm. Two iris waveguide structures in the last cell are matched for power extraction.

Longitudinally, beams will debunch because of space-charge and rf-induced energy spread. To counter these debunching effects, the rf output cavities are inductively detuned. This is accomplished by making the phase velocity of the three-cell traveling-wave structure faster than the velocity of the particles. The particle bunch lags behind the decelerating crest of the wave, and the energy loss becomes phase dependent, with the particles at the bunch tail losing the least energy. Kinematics cause the tail to catch up with head of the bunch, which is followed by synchrotron oscillation in stable rf buckets. One-dimensional PIC simulations with a coupled cavity circuit model show stable propagation through 150 cavities. For comparison, cavities with no inductive detuning are shown to result in particle debunching after a few cavities.

A key design feature of this particular TBA is that the betatron period is exactly equal to the spacing between adjacent output cavities. This "betatron-node" scheme leads to minimal beam offset at the rf cavities. Excitation of the HEM_{11} mode at 14 GHz is drastically reduced as a result. Transverse dynamics have been modeled with a beam-breakup code that includes both cumulative and regenerative effects; it shows BBU growth is acceptable. The cavity parameters for these simulations were obtained from the codes URMEL

and MAFIA. For an 8-mm radius cell, a natural de-Qing of the dipole mode occurs because of the coupling to the TE_{11} mode in the beam pipe. The betatron-node scheme imposes constraints on the accuracy of the focusing fields and beam energy. Sensitivity studies to this point indicate that without feedback, the field errors must be less than $\pm 1\%$ and energy variation from head to tail must have comparable accuracy.

There is another low-frequency BBU mode, associated with the induction gaps, that must be controlled. The relatively low current of 600 A, combined with the Landau damping that occurs naturally because of the energy spread in the rf buckets, have led again to simulated BBU growth of about 4 e-folds. To achieve this low growth, the induction gaps were designed for maximal dipole de-Qing, using the induction-cavity design code Amos.

A first engineering and costing exercise for the full TBA system has been performed. The electrical design includes all components starting from the ac power distribution system, through the dc power supplies, the command resonant charging system, the pulse forming networks, and the induction cores. Racks and installation, as well as instrumentation and control, were included in this exercise. Costs were estimated with a "bottom-up" approach (that is, starting from individual components and adding them up to arrive at the entire system), assuming mass production procedures for fabrication and assembly. Our preliminary cost estimate for the TBA-based power source for a 1 TeV cm linear collider is less than \$1 billion. This estimate does not include conventional facilities, or any institutional overhead. The overall efficiency of the system (wall plug to rf) is estimated to be 36%.

The preliminary design report for our systems study has also been completed. On the basis of this design, a joint proposal between LBL and LLNL has been submitted to DOE for a five-year RK-TBA project that would build and test a 30-m prototype. The project would use existing injector hardware from LLNL and would be sited at LBL. This facility could test many of the critical issues of cost, efficiency, and beam dynamics. Should the power extraction tests prove successful, the RTA could be mated to the NLC Test Accelerator at SLAC to power the high gradient structures to 100 MV/m. The proposed RTA work is a component of the collaborative effort by SLAC, LBL, and LLNL.

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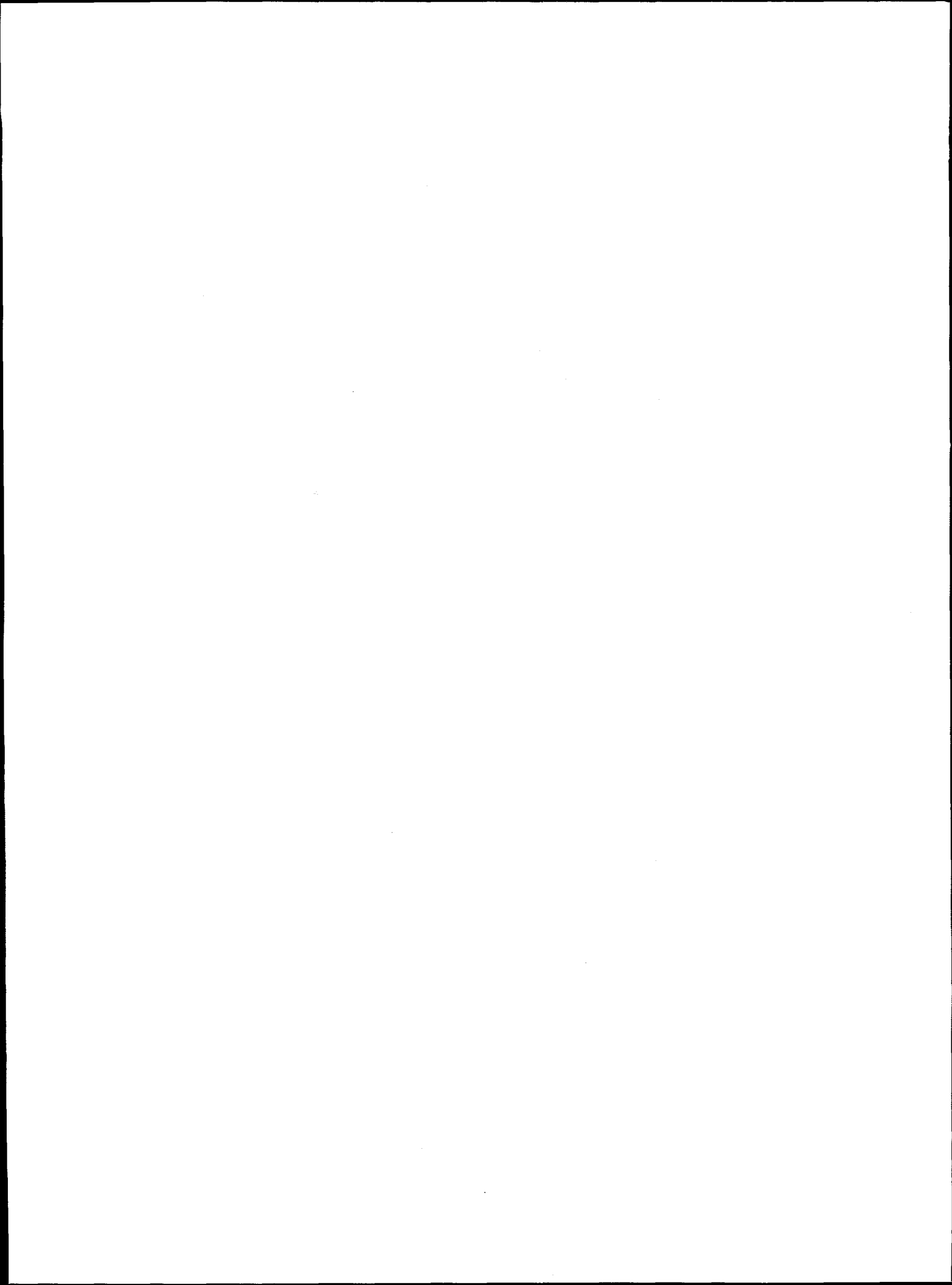
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