3 Bunch Compression And Longitudinal Beam Dynamics 3 1

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3 Bunch Compression And Longitudinal Beam Dynamics 3 1 ***2022-02-24***

KELLEY ERIN

Measurement of the Longitudinal Wakefield in the SLAC Linac for Extremely Short Bunches IOS Press Since its invention in the 1920s, particle accelerators have made tremendous progress in accelerator science, technology and applications. However, the fundamental acceleration principle, namely, to apply an external radiofrequency (RF) electric field to accelerate charged particles, remains unchanged. As this method (either room temperature RF or superconducting RF) is approaching its intrinsic limitation in acceleration gradient (measured in MeV/m), it becomes apparent that new methods with much higher acceleration gradient (measured in GeV/m) must be found for future very high energy accelerators as well as future compact (table-top or room-size) accelerators. This volume introduces a number of advanced accelerator concepts (AAC) — their principles, technologies and potential applications. For the time being, none of them stands out as a definitive direction in which to go. But these novel ideas are in hot pursuit and look promising. Furthermore, some AAC requires a high power laser system. This has the implication of bringing two different communities — accelerator and laser — to join forces and work together. It will have profound impact on the future of our field. Also included are two special articles, one on "Particle Accelerators in China' which gives a comprehensive overview of the rapidly growing accelerator community in China. The other features the person-of-the-issue who was well-known nuclear physicist Jerome Lewis Duggan, a pioneer and founder of a huge community of industrial and medical accelerators in the US.

Beam Diagnostics in Superconducting Accelerating Cavities IOS Press

This book contains the Proceedings of the 24th International Free Electron Laser Conference and the 9th Free Electron Laser Users Workshop, which were held on September 9-13, 2002 at Argonne National Laboratory. Part I has been reprinted from Nucl. Instr. and Meth. A 507 (2003), Nos. 1-2.

Fermilab, Chicago, 19-21 October 2009

Springer Nature

In this paper, two possible bunch compression configurations are proposed and evaluated by numerical simulation in the Next Linear Collider Test Accelerator (NLCTA) at SLAC. A bunch compression ratio up to 20 could be achieved under a perfect condition, without consideration for the timing jitter and other error sources. The NLCTA is a test accelerator built at SLAC, which is approximately 42 meters long and composed of X-band acceleration structures. The main aim of building NLCTA is to develop and demonstrate the X-band rf acceleration technologies for the next generation linear collider, with a relatively high acceleration gradient between 50 MV/m and 100 MV/m. The current operation configuration of NLCTA features a thermionic-cathode electron gun at its starting point which generates an electron beam with an energy of 5 MeV. This is followed by a roughly 1.5 meter long X-band acceleration structure which boosts the electron beam energy to 60 MeV. Then there is a four-dipole magnetic chicane which is 6 meters long and provides a first order longitudinal dispersion of R56 = -73mm. Next the electron beam passes by several matching quadrupoles and can be accelerated further to 120 MeV through another one-meter-long X-band acceleration structure. After that, there are three small chicanes downstream, with a total first order longitudinal dispersion of R56 = -10mm. A sketch of the main components of NLCTA is shown in Figure 1, where the total length of this accelerator is 45 meters. Free Electron Lasers (FELs), proposed by J. Madey and demonstrated for the first time at Stanford University in 1970s [2] [3], use the lasing of relativistic electron beam traveling through a magnetic undulator, which can reach high power and can be widely tunable in wavelength. Linac based FEL source can provide sufficient brightness, and a short X-ray wavelength down to angstrom scale, which promises in supporting wide range of research experiments. In order to have an electron beam lasing coherently in an undulator, one needs a very bright beam in all three dimensions. In other words, one needs an electron beam with very short bunch length (high intensity), very small transverse emittance and very small energy spread. Most FELs currently being operated, commissioned, constructed or proposed are based on RF acceleration in a frequency range from L-band (1 GHz) to C-band (6 GHz). As RF frequency goes higher, wake fields effects tend to be much stronger and jitter tolerances are tighter. To demonstrate that X-band acceleration structures can be applied in constructing an FEL, one could perform bunch compression experiments at NLCTA as a first step, and investigate tolerances on timing jitter, misalignments etc. Another important point is to evaluate the transverse emittance growth in this bunch compression process. In the following sections, two possible bunch compression schemes are proposed to be tested at NLCTA. Elegant [4] 3-D simulation is performed to evaluate these two schemes, with wake fields, space charge and coherent synchrotron radiation (CSR) effects included. One million macro particles are adopted in the numerical simulations. The simulation starts with an electron beam of 20 pC at a beam energy of 5 MeV. The initial RMS bunch length is taken as 0.5 ps at such a low bunch charge, and the RMS energy spread is 5 x 10^{-3}. The normalized transverse emittance is 1 mm.mrad.

Studies of Proton Driven Plasma Wakefield Acceleration Newnes

The Linac Coherent Light Source (LCLS) [1] is an x-ray FEL project with a 1-nC electron bunch compressed to an rms length of 20 microns at 4.5 GeV, accelerated in 500 meters of SLAC linac to 15 GeV, and then injected into an undulator to generate SASE radiation. The longitudinal wakefield generated by the short bunch in the (S-band) linac is very strong, and is relied upon to cancel the energy chirp left in the beam after bunch compression. Up to now, both the average [2] and the shape [3] of the longitudinal wake of the SLAC linac have been measured and confirmed using bunches ranging down to an rms 500-microns in length. The recent installation of a chicane in the SLAC linac for the Sub-Picosecond Photon Source (SPPS) [4, 5, 6], however, allows compression of a 3.4-nC bunch down to 50 [mu]m rms length. We present measurements of the average wakefield, for bunch lengths down to this, LCLS-type scale, and compare with theory.

2nd European Particle Accelerator Conference : Nice, June 12-16, 1990 World Scientific Publishing

Virtually all existing high energy (>few MeV) linac-driven FELs compress the electron bunch length though the use of off-crest acceleration on the rising side of the RF waveform followed by transport through a magnetic chicane. This approach has at least three flaws: 1) it is difficult to correct aberrations- particularly RF curvature, 2) rising side acceleration exacerbates space charge-induced distortion of the longitudinal phase space, and 3) all achromatic "negative compaction" compressors create parasitic compression during the final compression process, increasing the CSR-induced emittance growth. One can avoid these deficiencies by using acceleration on the falling side of the RF waveform and a compressor with M56>0. This approach offers multiple advantages: 1) It is readily achieved in beam lines supporting simple schemes for aberration compensation, 2) Longitudinal space charge (LSC)-induced phase space distortion tends, on the falling side of the RF waveform, to enhance the chirp, and 3) Compressors with M56>0 can be configured to avoid spurious over-compression. We will discuss this bunch compression scheme in detail and give results of a successful beam test in April 2012 using the JLab UV Demo FEL.

Peak Current Optimization for LCLS Bunch Compressor 2 World Scientific

Research and development of high energy accelerators began in 1911. Since then, progresses achieved are:The impacts of the accelerator development are evidenced by the many ground-breaking discoveries in particle and nuclear physics, atomic and molecular physics, condensed matter physics, biology, biomedical physics, nuclear medicine, medical therapy, and industrial processing. This book is intended to be used as a graduate or senior undergraduate textbook in accelerator physics and science. It can be used as preparatory course material in graduate accelerator physics thesis research. The text covers historical accelerator development, transverse betatron motion, synchrotron motion, an introduction to linear accelerators, and synchrotron radiation phenomena in low emittance electron storage rings, introduction to special topics such as the free electron laser and the beam-beam interaction. Hamiltonian dynamics is used to understand beam manipulation, instability and nonlinearity. Each section is followed by exercises, which are designed to reinforce the concept discussed and to solve a realistic accelerator design problem.

A Fast Longitudinal Phase Space Tracking Code with Graphical User Interface World Scientific

This is the second book to RF Superconducting, written by one of the leading experts. The book provides fast and up-to-date access to the latest advances in the key technology for future accelerators. Experts as well as newcomers to the field will benefit from the discussion of progress in the basic science, technology as well as recent and forthcoming applications. Researchers in accelerator physics will also find much that is relevant to their discipline.

Electron-Photon Interaction in Dense Media Springer Science & Business Media

The Conference timetable had to be so arranged as to spread the main topics over several separate sessions. It was therefore decided to publish the material in these Proceedings under nine subject headings, irrespective of session. Within each chapter, which is preceded by a list of the sessions featuring the subject, all papers, invited and contributed, whether presented at the Conference or accepted for publication only, have been arranged in some lo gical order. The reports of the four Panel Discussions were edited or summarized by the respective Moderator in consultation with Panel Members. In one instance, shortened versions of the Introductory Papers precede the discussion. Where possible, verbatim accounts of the often lively exchanges have been retained. The customary catalogue of high-energy acceler ators has been published separately. The continuing world-wide activities in accelerator research, witl1 its ever larger pro jects, are reflected by the numerous contributions accepted for inclusion in these Proceedings, which have reached the limit of what a single volume can manageably contain, while making rapid publication even harder to achieve. All the more reason to extend the gratitude of all con cerned to those involved in the chain of production: - To the authors, for their prompt handing-in or timely posting of their papers. Thanks also to their secretaries who followed the guidelines for the presentation of camera-ready copy.

The Extraction of

Transverse Beam Position from Beam-Excited Higher Order Modes World Scientific Publishing Company

X-Ray Lasers 1996 provides not only an overview and progress report on this fast moving field, but also important reference material on which future work can be built. Topics covered include collisional x-ray lasers, table-top x-ray lasers, beam optics, x-ray optics, OFI and photo-pumped schemes, capillary schemes, international laser facilities, XUV nonlinear mixing, alternative soft x-ray sources, diagnostics, and applications. The volume is an essential addition to the libraries of researchers in the field.

Handbook Of Accelerator Physics And Engineering (2nd Edition) World Scientific

Edited by internationally recognized authorities in the field, this handbook focuses on Linacs, Synchrotrons and Storage Rings and is intended as a vade mecum for professional engineers and physicists engaged in these subjects. Here one will find, in addition to the common formulae of previous compilations, hard to find specialized formulae, recipes and material data pooled from the lifetime experiences of many of the world's most able practitioners of the art and science of accelerator building and operation.

Measurement and Control of Charged Particle Beams World Scientific

Hard x-ray Free electron lasers (FEL) are being built or proposed at many accelerator laboratories as it supports wide range of applications in many aspects. Most of the hard x-ray FEL design is similar with the SLAC Linac Coherent Light Source (LCLS), which features a two (or multiple) stage bunch compression. For the first stage of the bunch compression, usually the beam is accelerated in a lower-frequency RF section (such as S-band for LCLS), and then the longitudinal phase space is linearized by a higher-frequency RF section (harmonic RF, such as X-band for LCLS). In this paper, a compact hard x-ray FEL design is proposed, which is based on X-band RF acceleration and eliminating the need of a harmonic RF. The parameter selection and relation is discussed, and the longitudinal phase space simulation is presented. The FEL coherence condition of the electron beam in the undulators requires a large charge density, a small emittance and small energy spread. The RMS electron bunch length from the injector is in the ps scale, with a bunch charge in the range of hundreds pC to several nC, which means that the current is roughly 0.1 kA. According to the requirement from soft x-ray lasing and hard x-ray lasing, a peak current of 1 kA and 3 kA is needed respectively. Thus the bunch has to be compressed. Usually a two stage bunch compression or multipole stage bunch compression is adopted. The z-correlated energy chirp is normally established by letting the beam pass through a section of RF cavities, with a RF phase off crest. As stated above, S-band RF (3 GHz) acceleration could be applied in this section. Due to the nature of RF acceleration wave, the chirp on the bunch is not linear, but has the RF curvature on it. In order to linearize the energy chirp, a harmonic RF section with higher frequency is needed. For LCLS a short X-band RF section (12 GHz) is used which is a fourth order harmonic. The linearized bunch is then passing by a dispersive region, in which the particles with different energy have different path length. A four dipole chicane is the natural choice for the dispersive region. As the example illustrated in Figure 1, the head of the bunch has smaller energy, and gets a stronger bending kick from the dipole magnet, then has a longer path length in the dispersive region. Similarly, the tail of the bunch has larger energy and shorter path length in the dispersive region. At the exit of the dispersive region, the relative longitudinal position of the head and tail of the bunch both move to the center of the bunch, so the bunch length will be shorter.

Coherent and Collective Interactions of Particles and Radiation Beams

World Scientific

Research and development of high energy accelerators began in 1911. Since then, milestones achieved are: (1) development of high gradient dc and rf accelerators,(2) achievement of high field magnets with excellent field quality,(3) discovery of transverse and longitudinal beam focusing principles,(4) invention of high power rf sources,(5) improvement of ultra-high vacuum technology,(6) attainment of high brightness (polarized/unpolarized) electron/ionsources,(7) advancement of beam dynamics and beam manipulation schemes, such as beam injection, accumulation, slow and fast extraction, beam damping and beam cooling, instability feedback, laser-beam interaction and harvesting instability for high brilliance coherent photon source. The impacts of the accelerator development are evidenced by the many ground-breaking discoveries in particle and nuclear physics, atomic and molecular physics, condensed matter physics, biology, biomedical physics, nuclear medicine, medical therapy, and industrial processing. This book is intended to be used as a graduate or senior undergraduate textbook in accelerator physics and science. It can be used as preparatory course material in graduate accelerator physics thesis research. The text covers historical accelerator development, transverse betatron motion, synchrotron motion, an introduction to linear accelerators, and synchrotron radiation phenomena in low emittance electron storage rings, introduction to special topics such as the free electron laser and the beam-beam interaction. Attention is paid to derivation of the action-angle variables of the phase space, because the transformation is important for understanding advanced topics such as the collective instability and nonlinear beam dynamics. Each section is followed by exercises, which are designed to reinforce concepts and to solve realistic accelerator design problems. Contents:Introduction:Historical DevelopmentsLayout and Components of AcceleratorsAccelerator ApplicationsTransverse Motion:Hamiltonian for Particle Motion in AcceleratorsLinear Betatron MotionEffect of Linear Magnet ImperfectionsOff-Momentum OrbitChromatic AberrationLinear CouplingNonlinear ResonancesCollective Instability and Landau DampingSynchro-Betatron HamiltonianSynchrotron Motion:Longitudinal Equation of

MotionAdiabatic Synchrotron MotionRF Phase and Voltage ModulationsNonadiabatic and Nonlinear Synchrotron MotionBeam Manipulation in Synchrotron Phase SpaceFundamentals of RF SystemsLongitudinal Collective InstabilitiesIntroduction to Linear AcceleratorsPhysics of Electron Storage Rings:Fields of a Moving Charged ParticleRadiation Damping and ExcitationEmittance in Electron Storage RingsSpecial Topics in Beam Physics:Free Electron Laser (FEL)Beam-Beam InteractionClassical Mechanics and Analysis:Hamiltonian DynamicsStochastic Beam DynamicsModel Independent AnalysisNumerical Methods and Physical Constants:Fourier TransformCauchy Theorem and the Dispersion RelationUseful Handy FormulasMaxwell's EquationsPhysical Properties and Constants Readership: Accelerator, high-energy, nuclear, plasma and applied physicists.

Proceedings of the 24th International Free Electron Laser Conference and the 9th FEL Users Workshop, Argonne, Illinois, U.S.A., September 9-13, 2002 Springer Science & Business Media

An energetic charged particle beam introduced to an rf cavity excites a wakefield therein. This wakefield can be decomposed into a series of higher order modes and multipoles, which for sufficiently small beam offsets are dominated by the dipole component. This work focuses on using these dipole modes to detect the beam position in third harmonic superconducting S-band cavities for light source applications. A rigorous examination of several means of analysing the beam position based on signals radiated to higher order modes ports is presented. Experimental results indicate a position resolution, based on this technique, of 20 microns over a complete module of 4 cavities. Methods are also indicated for improving the resolution and for applying this method to other cavity configurations. This work is distinguished by its clarity and potential for application to several other international facilities. The material is presented in a didactic style and is recommended both for students new to the field, and for scientists well-versed in the field of rf diagnostics.

Free Electron Lasers 2000 Springer Science & Business Media

This volume, consisting of articles written by experts with international repute and long experience, reviews the state of the art of accelerator physics and technologies and the use of accelerators in research, industry and medicine. It covers a wide range of topics, from basic problems concerning the performance of circular and linear accelerators to technical issues and related fields. Also discussed are recent achievements that are of particular interest (such as RF quadrupole acceleration, ion sources and storage rings) and new technologies (such as superconductivity for magnets and RF cavities). The book will interest not only researchers and engineers in the field of accelerator development but also users of accelerators in research and industry. Moreover, teachers giving courses on accelerators and their applications will profit by learning about the most recent achievements and future possibilities.

Contents:Introduction:What Can We Learn from Experiments with Accelerators and Storage Rings (C Jarlskog)Circular Accelerators and Storage Rings:Beam Optics and Lattice Design (P J Bryant)Collective Phenomena and Instabilities (J Gareyte)The Relativistic Heavy Ion Collider, RHIC (H Foelsche et al.)Beauty- and Tau-Charm Factories (Y Baconnier)Linear Accelerators:General Aspects of Linear Accelerators (P Lapostolle)RF Quadrupoles as Accelerators (A Schempp)Accelerator Physics of the Stanford Linear Collider and SLC Accelerator Experiments Towards the Next Linear Collider (J T Seeman)The Road to TeV Electron-Positron Colliders (Y Kimura)New Methods and Technologies:Superconducting Magnets for Accelerators (G Brianti & T Tortschanoff)Superconducting Cavities for High Energy Accelerators and Storage Rings (H Lengeler)Cooling of Particle Beams (D Möhl)Acceleration of Polarized Particles (J Buon)Ion Sources (H Haseroth & H Hora)A Good Idea at the Time (B W Montague)Geodesy for Particle Acceleratos (J Gervais & M Mayoud)Applications:Synchrotron Radiation Sources (S Tazzari)The Impact of Pulsed Spallation Neutron Sources on Condensed Matter Research (J L Finney)Inertial Fusion with Heavy Ions (I Hofmann)High Energy Accelerators in Medicine (P Mandrillon)Industrial Applications of Accelerators (K H W Bethge) Readership: High energy physicists, nuclear physicists and engineers. Reviews: "… essential reading for the accelerator specialist … Bravo to the editor, Herwig Schopper, for making a success out of a timely compilation." CERN Courier

Microbunching Instability Due to Bunch Compression

World Scientific

This volume presents the non-linear theory of electrostatic focusing of an electron beam split into bunches under conditions when the plasma permittivity at the modulation frequency is negative and the effective Coulomb force acting on the electron bunches is reversed. Conditions for the spatial equilibrium between the bunch and plasma emission, as well as the dynamics of the formation of focussed bunches, are confirmed by solving (both analytically and numerically) the self-consistent set of equations.

Applications of High Intensity Proton Accelerators John Wiley & Sons

The 22nd International Free Electron Laser Conference and 7th FEL User Workshop were held August 13-18, 2000 at Washington Duke Inn and Golf Club in Durham, North Carolina, USA. The conference and the workshop were hosted by Duke University's Free Electron laser (FEL) Laboratory. Following tradition, the FEL prize award was announced at the banquet. The year 2000 FEL prize was awarded to three scientists propelling the limits of high power FELs: Steven Benson, Eisuke Minehara and George Neill. The conference program was comprised of traditional oral sessions on First Lasing, FEL theory, storage ring FELs, linac and high power FELs, long wavelength FELs, SASE FELs, accelerator and FEL physics and technology, and new developments and proposals. Two

sessions on accelerator and FEL physics and technology reflected the emphasis on the high quality of accelerators and components for modern FELs. The breadth of the applications was presented in the workshop oral sessions on materials processing, biomedical and surgical applications, physics and chemistry as well as on instrumentation and methods for FEL applications. A special oral session was dedicated to FEL center status reports for users to learn more about the opportunities with FELs. As usual, the oral sessions were supplemented by poster sessions with in-depth discussions and communications. The FEL physicists and FEL users had excellent opportunities to interact throughout the duration of the event, culminating a Joint Sessions. The year 2000 was very successful being marked by lasing with two SASE and one storage ring short-wavelength FELs, and by the first human surgery with the use of FEL, to mention but a few. The International Program Committee and chairs of the sessions had the challenging and exciting problem of selecting invived and contributed talks for the conferences and the workshop from the influx of abstracts mentioning new results and ideas. The success of the conference was determined by these contributions. Scientists from 15 countries gave 70 talks, presented 176 posters and submitted 146 papers, which are published in the present volume of proceedings.
Free Electron Lasers 2002
World Scientific
Edited by internationally recognized authorities in the field, this expanded edition of the bestselling Handbook first published in 1999 is aimed at the design and operation of modern accelerators including Linacs, Synchrotrons and Storage Rings. It is intended as a vade mecum for professional engineers and physicists engaged in these subjects. With a collection of 2200 equations, 345 illustrations and 185 tables, here one will find, in addition to the common formulae of previous compilations, hard to find, specialized formulae, recipes and material data pooled from the lifetime experience of many of the world's most able practitioners of the art and science of accelerators.The eight chapters include both theoretical and practical matters as well as an extensive glossary of accelerator types. Chapters on beam dynamics and electromagnetic and nuclear interactions deals with linear and nonlinear single particle and collective effects including spin motion, beam-environment, beam-beam and intrabeam interactions. The impedance concept and calculations are dealt with at length as are the instabilities associated with the various interactions mentioned. A chapter on operational considerations deals with orbit error assessment and correction. Chapters on mechanical and electrical considerations present material data and important aspects of component design including heat transfer and refrigeration. Hardware systems for particle sources, feedback systems, confinement and acceleration (both normal conducting and superconducting) receive detailed treatment in a subsystems chapter, beam measurement techniques and apparatus being treated therein as well. The closing chapter

gives data and methods for radiation protection computations as well as much data on radiation damage to various materials and devices.A detailed index is provided together with reliable references to the literature where the most detailed information available on all subjects treated can be found.
European Particle Accelerator Conference (Epac 94) (In 3 Volumes)
World Scientific
Single-pass free electron lasers require high peak currents from ultra-short electron bunches to reach saturation and an accurate measurement of bunch length and longitudinal bunch profile is necessary to control the bunch compression process from low to high beam energy. The various state-of-the-art diagnostics methods from ps to fs time scales using coherent radiation detection, RF deflection, and other techniques are presented. The use of linear accelerators as drivers for free electron lasers (FEL) and the advent of single-pass (SASE) FELs has driven the development of a wide range of diagnostic techniques for measuring the length and longitudinal distribution of short and ultra-short electron bunches. For SASE FELs the radiation power and the length of the undulator needed to achieve saturation depend strongly on the charge density of the electron beam. In the case of X-ray FELs, this requires the accelerator to produce ultra-high brightness beams with micron size transverse normalized emittances and peak currents of several kA through several stages of magnetic bunch compression. Different longitudinal diagnostics are employed to measure the peak current and bunch profile along these stages. The measurement techniques can be distinguished into different classes. Coherent methods detect the light emitted from the beam by some coherent radiation process (spectroscopic measurement), or directly measure the Coulomb field traveling with the beam (electro-optic). Phase space manipulation techniques map the time coordinate onto a transverse dimension and then use conventional transverse beam diagnostics (transverse deflector, rf zero-phasing). Further methods measure the profile or duration of an incoherent light pulse emitted by the bunch at wavelengths much shorted than the bunch length (streak camera, fluctuation technique) or modulate the electron beam at an optical wavelength and then generate a narrow bandwidth radiation pulse with the longitudinal profile of the beam mapped onto (optical replicator). The operational needs for bunch length measurements to have fast acquisitions, to be used in feedback systems, to distinguish pulse to pulse changes and to be nondestructive or parasitically have resulted into developing many of the diagnostics into single-shot techniques and in the following the main discussion will emphasize them.
Accelerator Physics
Microbunching Instability Due to Bunch CompressionMagnetic bunch compressors are designed to increase the peak current while maintaining the transverse and longitudinal emittances in order to drive a short-wavelength free electron laser (FEL). Recently, several linac-based FEL experiments observe self-

developing micro-structures in the longitudinal phase space of electron bunches undergoing strong compression [1-3]. In the mean time, computer simulations of coherent synchrotron radiation (CSR) effects in bunch compressors illustrate that a CSR-driven microbunching instability may significantly amplify small longitudinal density and energy modulations and hence degrade the beam quality [4]. Various theoretical models have since been developed to describe this instability [5-8]. It is also pointed out that the microbunching instability may be driven strongly by the longitudinal space charge (LSC) field [9,10] and by the linac wakefield [11] in the accelerator, leading to a very large overall gain of a two-stage compression system such as found in the Linac Coherent Light Source (LCLS) [12]. This paper reviews theory and simulations of microbunching instability due to bunch compression, the proposed method to suppress its effects for short-wavelength FELs, and experimental characterizations of beam modulations in linear accelerators. A related topic of interests is microbunching instability in storage rings, which has been reported in the previous ICFA beam dynamics newsletter No. 35 (http://wwwbd. fnal.gov/icfabd/Newsletter 35.pdf).Coherent and Collective Interactions of Particles and Radiation Beams

The main goal of the book is to provide a systematic and didactic approach to the physics and technology of free-electron lasers. Numerous figures are used for illustrating the underlying ideas and concepts and links to other fields of physics are provided. After an introduction to undulator radiation and the low-gain FEL, the one-dimensional theory of the high-gain FEL is developed in a systematic way. Particular emphasis is put on explaining and justifying the various assumptions and approximations that are needed to obtain the differential and integral equations governing the FEL dynamics. Analytical and numerical solutions are presented and important FEL parameters are defined, such as gain length, FEL bandwidth and saturation power. One of the most important features of a high-gain FEL, the formation of microbunches, is studied at length. The increase of gain length due to beam energy spread, space charge forces, and three-dimensional effects such as betatron oscillations and optical diffraction is analyzed. The mechanism of Self-Amplified Spontaneous Emission is described theoretically and illustrated with numerous experimental results. Various methods of FEL seeding by coherent external radiation are introduced, together with experimental results. The world’s first soft X-ray FEL, the user facility FLASH at DESY, is described in some detail to give an impression of the complexity of such an accelerator-based light source. The last chapter is devoted to the new hard X-ray FELs which generate extremely intense radiation in the Angstrøm regime. The appendices contain supplementary material and more involved calculations.

A Bunch Compression Method for Free Electron Lasers that Avoids Parasitic Compressions Springer The development of high energy accelerators began in 1911, when

Rutherford discovered the atomic nuclei inside the atom. Since then, progress has been made in the following: (1) development of high voltage dc and rf accelerators, (2) achievement of high field magnets with excellent field quality, (3) discovery of transverse and longitudinal beam focusing principles, (4) invention of high power rf sources, (5) improvement of high vacuum technology, (6) attainment of high brightness (polarized/unpolarized) electron/ion sources, (7) advancement of beam dynamics and beam manipulation schemes, such as beam injection, accumulation, slow and fast extraction, beam damping and beam cooling, instability feedback, etc.The impacts of the accelerator development are evidenced by the many ground-breaking discoveries in particle and nuclear physics, atomic and molecular physics, condensed matter physics, biomedical physics, medicine, biology, and industrial processing.This book is intended to be used as a graduate or senior undergraduate textbook in accelerator physics and science. It can be used as preparatory course material for graduate accelerator physics students doing thesis research. The text covers historical accelerator development, transverse betatron motion, synchrotron motion, an introduction to linear accelerators, and synchrotron radiation phenomena in low emittance electron storage rings, introduction to special topics such as the free electron laser and the beam-beam interaction. Attention is paid to derivation of the action-angle variables of the phase space, because the transformation is important for understanding advanced topics such as the collective instability and nonlinear beam dynamics. Each section is followed by exercises, which are designed to reinforce the concept discussed and to solve a realistic accelerator design problem.