PHASE SPACE MANIPULATION (Tuesday, 7/29, 11:10 – 12:00)

1. Phase Space Transform and Exchange Techniques (11:10 – 11:40)

Kwang-Je Kim (ANL)—Emittance exchange and flat beam transform are two phase-space converting techniques being developed recently to enhance the performance of electron beams for various applications, in particular, to improve the performance of high-gain free electron lasers and to obviate the electron damping ring in a linear collider. We review these applications, the basic principles of the converters, and the progress of the proof-of-the ?principle experiments of these techniques at Femilab A0 facility and Argonne Wakefield accelerator Laboratory.

2. Transverse to Longitudinal Emittance Exchange at the FNAL A0 Photoinjector (11:40- 12:00)

Raymond Fliller (FNAL) Timothy Koeth (Rutgers University, Piscataway, New Jersey), Donald Edwards (FNAL), Helen Edwards (FNAL), Leo Bellantoni (FNAL), Jinhao Ruan (FNAL), Grigory Kazakevich (BINP SB RAS, Novosibirsk), Randy Thurman-Keup (FNAL)—The A0 Photoinjector is a 16MeV electron linac at Fermilab which is used for Accelerator R&D. Most experiments to date have involved interesting and unique beam manipulations and development of the relevant diagnostics to measure these beams. Most recently a transverse to longitudinal emittance exchange beamline has been installed. This beamline uses a copper 3.9 GHz deflecting mode or crab cavity between two doglegs to affect the exchange. Data taking for this experiment is underway. Various mechanisms may dilute this exchange or effect the emittance measurements, such as Coherent Synchrotron Radiation. In this talk we will discuss the progress of the transverse to longitudinal emittance exchange experiment at Fermilab. We will also discuss measurements of Coherent Synchrotron Radiation, its effect on the electron beam and consequences for the emittance exchange.

ELECTRON INJECTORS I (Tuesday, 7/29, 1:30 – 3:00)

3. Review of Electron PhotoInjectors (1:30 – 2:00)

Pat O'Shea (UMD)—Photoinjectors generate high-brightness beams by emission of electrons from a photocathode illuminated with a short laser pulse. The electrons are quickly accelerated by intense electric fields in a DC gun, or a superconducting or normal-conducting resonant cavity gun. I will discuss some important recent physics and technology developments.

4. Progress in Diamond Amplified Photocathode R&D (2:00 – 2:15)

Ilan Ben-Zvi (BNL), Andrew Burrill (Brookhaven National Laboratory), Xiangyun Chang (Brookhaven National Laboratory), Triveni Rao (Brookhaven National Laboratory), John Smedley (Brookhaven National Laboratory), Qiong Wu (Brookhaven National Laboratory), Richard Busby (Tech-X Corporation), Dimitre Dimitrov (Tech-X Corporation)—Laser photocathodes that are robust, possess high quantum efficiency and have negative electron affinity have long been the dream of designers of injectors. Significant progress has been made towards the realization of the Diamond Amplified Photocathode (DAP), which promise to combine these properties. This paper will report on the progress made on various aspects of DAP R&D, including measurements of basic properties, detailed simulations of the basic DAP mechanisms and measurements of electron transmission through diamonds and emission of electrons through the negative electron affinity face of the DAP.

5. Upgrade of X-band thermionic RF gun for monochromatic X-ray source (2:15 – 2:30)

Mitsuru UESAKA (U. Tokyo) Fumito SAKAMOTO (2-22, Shirakata-Shirane, Tokai, Naka, Ibaraki, JAPAN), Yoshihiro TANIGUCHI (2-22, Shirakata-Shirane, Tokai, Naka, Ibaraki, JAPAN), Tomohiko YAMAMOTO (2-22, Shirakata-Shirane, Tokai, Naka, Ibaraki, JAPAN), Takuya NATSUI (2-22, Shirakata- Shirane, Tokai, Naka, Ibaraki, JAPAN), Eiko HASHIMOTO (2-22, Shirakata-Shirane, Tokai, Naka, Ibaraki, JAPAN), Mitsuhiro YOSHIDA (1-1, Oho, Tsukuba, Ibaraki, JAPAN)—We are currently developing a compact monochromatic X-ray source based on laser-electron Compton scattering. To realize remarkably compact-high-intensity- and highly stable system, we adopt an X-band multi-bunch liner accelerator (linac) and reliable Q-switch laser. The injector of the system consists of a 3.5-cell X-band thermionic cathode RF gun and an alpha magnet. So far, we have continued high-power experiment on X-band thermionic cathode RF gun. However, breakdown was frequently occurred at coaxial structure around the thermionic cathode. In order to resolve the breakdown, we adopt a choke structure around the thermionic cathode. Here, we report the design and experimental results of the thermionic cathode RF gun with choke structure.

6. Advanced photoinjector research at the UCLA Pegasus Laboratory (2:30 – 2:45)

Pietro Musumeci, J. T. Moody (moodyj@ucla.edu), C. M. Scoby (scoby@physics.ucla.edu), T. Tran (ttran80@ucla.edu), M. S. Gutierrez (msgutierrez@ucla.edu)—Recently, a scheme for producing ideal uniformly filled ellipsoidal beam distributions, which depends on the strong longitudinal expansion of an initially very short beam under its own space charge forces, has been demonstrated at the UCLA Pegasus Laboratory. Here we present the initial results, and the following work on the characterization of this novel regime of operation of a photoinjector. The ultra-high brightness of the beam created operating in this `blow-out? regime is verified obtaining high quality relativistic electron diffraction patterns from thin Al foils.

7. Temporal Laser Pulse Shaping For RF Photoinjectors: The Cheap and Easy way using UV Birefringent Crystals (2:45 – 3:00)

John G. Power and Chunguang Jing (Argonne National Laboratory)— The quality of the electron bunch generated by an RF photoinjector is directly linked to the quality of the laser pulse striking the photocathode. RF photinjector simulations have shown that when the laser pulse density is a uniform cylinder (so called "beer can" or tri-flat-top distribution) the transverse emittance is significantly improved over the Gaussian distribution. However, the natural laser pulse shape is tri-Gaussian so pulse shaping is needed. While it is relatively easy to generate a transverse flat-top laser distribution (e.g. with an overfilled iris) the temporal structure is more difficult to manipulate. Over the last several years, various schemes have achieved excellent results, but also tend to be expensive and complex. At the AWA, we are developing a new scheme using inexpensive UV birefringent crystals capable of generating a variety of pulse shapes including: (i) extremely fast risetime flat-top pulses with variable pulse duration and high efficiency. (ii) microbunch trains, and (iii) some limited ramped pulse generation. Streak camera measurements of the temporal profiles generated with a 2-crystal set and a 4-crystal set are presented. We will consider several applications for beam generation at the AWA including a flat-top laser pulse for low emittance production and matched bunch length for enhanced transformer ratio production.

PULSE TRAIN GENERATION (Tuesday, 7/29, 3:30 – 5:00)

8. Femtosecond microbunching of electron beam in a 7th harmonic coupled IFEL (3:30 – 4:00)

Sergei Tochitsky (UCLA), O.B. Williams (Department of Physics, UCLA), P. Musumeci (Department of Physics, UCLA), C. Sung (Department of Electrical Engineering, UCLA), D.J. Haberberger (Department of Electrical Engineering,UCLA), A.M. Cook (Department of Physics, UCLA), J.B. Rosenzweig (Department of Physics, UCLA)—Seeded IFEL /FELs have proved to be very useful techniques for the modulation of a relativistic electron beam on the scale of the optical radiation wavelength. An electron beam tightly microbunched on the optical (femtosecond) time scale can be used either for matched injection in a laser/plasma accelerator or for driving of a plasma wakefield accelerator. For a planar undulator, the electron beam is strongly coupled to both the fundamental and odd harmonics, if the normalized undulator parameter K is greater than 1. In some cases, when the laser frequency is constrained by the source availability and the energy of the beam is so low that in order to design an FEL buncher at the resonant condition the undulator parameters are difficult to achieve, coupling on high-order harmonics may become the only viable approach to microbunch the beam. Here we report the results of studying the electron beam microbunching in a 7th order IFEL interaction using coherent transition radiation. The resonant wavelength for the undulator with a period of 3.3. cm and K=1.8 was 74.2um, but it was seeded by a CO_2 laser with a seven times shorter wavelength of 10.6 um. The optimal bunching for 12 MeV electrons was achieved at a seed CO_2 laser power of ~25 MW. The microbunching was observed in fundamental, second and third harmonics, an indication that the beam was bunched at a shorter then ~3 ?m scale. CTR energy on harmonics was carefully measured and analyzed as a function of the drive leaser power, providing an insight into the evolution of the beam at the high-order IFEL interaction. The measurements were compared to the predictions of IFEL simulations. These experimental results demonstrate for the first time the feasibility of using very high order harmonic coupling for efficient IFEL/FEL interactions.

9. A mask technique for the generation of trains or microbunches with subpicosecond spacing and length (4:00 – 4:20)

Patrick Muggli (USC), V. Yakimenko (BNL), J. Park (BNL), E. Kallos (USC), K. Kusche (BNL), M. Babzien (BNL)—We present experimental results obtained with a method for producing trains of microbunches with time separation and length of less than a picosecond. The method uses a solid mask placed in a region of the beam line where the bunch transverse size is dominated by its correlated energy spread. The mask spoils the emittance of selected bunch slices. The particles scattered by the solid parts of the mask are lost along the beam line. The modulation in energy of the beam charge therefore also corresponds to a modulation of the beam current in time. The mask and beam parameters can be chosen to design the bunch current profile for particular applications, such as plasma wakefield accelerators (PWFAs) or free electron lasers (FELs). Work supported by US Department of Energy

10. Beat-wave Photoinjector for Generating Periodic Electron Bunches at THz Frequencies (4:20 – 4:40)

Yen-Chieh Huang (Tsinghua U.)—A laser beat wave is used to induce a density modulated electron current from a photoinjector. The modulation frequency of the electron current is in the THz frequency range. This laser-beat-wave driven photoinjector is useful for driving and loading a plasma-wave accelerator. Our study also shows that the density modulated electron beam is extremely efficient for generating electron superradiance in the THz frequencies. We will present the experimental progress of the beat-wave laser system and the photocathode gun for an electron bunch frequency over a 10-THz bandwidth.

11. Production of Relativistic Electron Bunch with Tunable Current Distribution (4:40 – 5:00)

Philippe Piot (Northern Illinois University and Fermi National Accelerator Laboratory)—We proposed a novel method for tailoring the current distribution of relativistic electron bunches. The technique relies on a recently proposed transverse-to-longitudinal phase space exchange. The bunch is transversely shaped and the phase space exchange mechanism converts this transverse profile into a current profile. The technique provides a tool for generating arbitrary current profiles in a tunable fashion. We demonstrate, via computer simulations, the method and its application to tailor specific current profiles such as, e.g., linearly ramped profiles and train of femtosecond micro-bunches that have application in plasma and dielectric wakefield accelerators.

INTENSE BEAMS I (Wednesday, 7/30, 10:30 – 12:00)

12. Use of ionization electron columns for space-charge compensation in high intensity proton accelerators (10:30 – 10:50)

Vladimir Shiltsev (FNAL), V.Kamerdzhiev (vsevolod@Fnal.gov), G.Kuznetsov (gkuznetsov@fnal.gov), Yu.Alexahin (alexahin@fnal.gov), V.Kapin (kapin@fnal.gov)—We discuss a recent proposal to use strongly magnetized electron columns created by beam ionization of the residual gas for compensation of space charge forces of high intensity proton beams in synchrotrons and linacs. Possible technical solutions for the electron columns are presented. We also discuss the first numerical simulation results for space charge compensation in the FNAL Booster and results of relevant beam studies in the Tevatron.

13. Ultracold ion bunches: studying space charge effects in slow motion (10:50 – 11:10)

Jom Luiten (Eindoven U.), Merijn Reijnders (Eindhoven University of Technology), Gabriel Taban (Eindhoven University of Technology), Peter van Kruisbergen (Eindhoven University of Technology), Bas van der Geer (Eindhoven University of Technology), Edgar Vredenbregt (Eindhoven University of Technology)—At Eindhoven University of Technology a new type of charged particle source is being developed, which is based on extraction of electrons and ions from a laser-cooled and trapped atomic gas. By pulsed near-threshold photoionization, ultracold ion bunches (T~100 microkelvin, i.e. kT~ 10 neV) can be created, enabling well-defined, small divergence ion beams with energies as low as 1 eV and ~1% energy spread. The corresponding extremely low bunch velocities (~1 km/s) allow us to investigate longitudinal space charge effects in great detail by straightforward time-of-flight measurements with a scope. By varying the bunch charge and the acceleration voltage we have studied the transition from the space-charge-dominated regime to the regime of fully ballistic flight, in which the Coulomb interactions between the ions can be neglected. In the intermediate regime we have observed a reduction of the longitudinal kinetic energy spread with increasing bunch charge. This surprising and subtle effect is probably due to cancellation of the space charge expansion by ballistic self-compression of the bunch. The measurements can be reproduced in great detail by GPT particle tracking simulations. In addition, the behavior in both the space-charge-dominated regime and the ballistic regime can be understood in terms of analytical models.

14. Adiabatic Thermal Beam Equilibrium in an Alternating-Gradient Focusing Field (11:10 – 11:30)

Chiping Chen (MIT), Ksenia R. Samokhvalova (Plasma Science and Fusion Center, MIT, Cambridge, MA 02139)—An adiabatic warm-fluid equilibrium theory for a thermal charged-particle beam in an alternating gradient (AG) focusing field is presented. Warm-fluid equilibrium equations are solved in the paraxial approximation. The theory predicts that the 4D rms thermal emittance of the beam is conserved, but the 2D rms thermal emittances are not constant. The rms beam envelope equations and the self-consistent Poisson equation, governing the beam density and potential distributions, are derived. Although the presented rms beam envelope equations have the same form as the previously known rms beam envelope equations, the evolution of the rms emittances in the present theory is given by analytical expressions. The density does not have the simplest elliptical symmetry, but the constant density contours are ellipses, and the aspect ratio of the elliptical constant-density contours decreases as the density decreases along the transverse displacement from the beam axis. For high-intensity beams, the beam density profile is flat in the center of the beam and falls off rapidly within a few Debye lengths, and the rate at which the density falls is approximately isotropic in the transverse directions. *Research supported by Department of Energy, Office of High-Energy Physics, Grant No. DE-FG02-95ER40919, and Air Force Office of Scientific Research, Grant No. FA9550-06-1-0269.

15. Recent Developments in Off-Axis Space-Charge Limit Theory (11:30 – 11:50)

Mark Hess (Indiana U.)—Recent Developments in Off-Axis Space-Charge Limit Theory When modeling the physics of high average current bunched electron beams (100 A?s ? 10?s kA) in high-power microwave sources, it is important to consider the effects of image charges and image currents on the dynamics of the beam. In particular, electron beams which are slightly off-center from the axis of a circular conducting structure will experience a center-of-mass force that further drives the beam off-axis. The center-of-mass force gives rise to a space-charge limit, i.e. a minimum magnetic field required to stabilize the off-axis force. Previously, these limits were first computed for a single circular conducting pipe [1], but recently, space-charge limits were computed for annular electron beams in a circular coaxial conducting structure [2]. We show how the space-charge limit is modified with the presence of an inner conductor and its? implications for coaxial HPM design. [1] M. Hess and C. Chen, Phys. Rev. STAB 7, 092002 (2004). [2] M. Hess, IEEE Trans. Plasma Sci. 36, 729-734 (2008).

ELECTRON INJECTORS II (Wednesday, 7/30, 1:30 – 3:00)

16. Generation and Measurement of Ramped Electron Bunches with Applications to the Plasma Wakefield Accelerator (1:30 – 2:00)

R. J. England (SLAC), J. B. Rosenzweig (UCLA Dept. Physics & Astronomy, 405 Hilgard Ave, Los Angeles, CA 90095), G. Travish (UCLA Dept. Physics & Astronomy, 405 Hilgard Ave, Los Angeles, CA 90095)—We discuss a recent experiment at the UCLA Neptune linear accelerator laboratory to generate 12 MeV electron bunches characterized by a triangularly ramped current profile that rises linearly from head to tail. Bunches with this type of longitudinal distribution have been predicted to be optimal for driving large-amplitude wakefields in a plasma wakefield accelerator. The technique employed utilizes a sextupolecorrected dogleg section as a bunch compressor. The ramped shape of the resultant bunches was verified by using an X-band deflecting mode cavity to measure the longitudinal profile of the beam, including a pseudo-reconstruction of the z phase space by introducing a residual horizontal dispersion in the dogleg.

17. Quasicrystalline Beam Formation in RF Photoinjectors (2:00 – 2:20)
James Rosenzweig (UCLA), Massimo Ferrario (INFN LNF), Pietro Musumeci (UCLA), Sven Reiche (UCLA), Michael Dunning (UCLA), Gerard Andonian (UCLA), Gabe Marcus (UCLA), Erik Hemsing (UCLA)—The recent observation of coherent optical transition radiation from the beam after the injector line at the LCLS has raised serious questions concerning the present model of beam dynamics in RF photoinjectors. We present here an analysis of what we term quasicrystalline beam formation. In this scenario, the relatively low longitudinal temperature, in combination with strong acceleration and, finally, temporal rearrangement due to bending, allows the longitudinal beam dimension to become more regular, on the microscopic scale of optical wavelengths, than expected from equilibrium statistical properties. This beam distribution then may then display a strong degree of coherence in its optical transition radiation output. We discuss further experimental investigations of this phenomenon.

18. Cold electron beams from trapped atoms (2:20 – 2:40)
G. Taban (Eindoven University of Technology), B. Fleskens (Eindhoven University of Technology), M.P. Reijnders (Eindhoven University of Technology), E.J.D. Vredenbregt (Eindhoven University of Technology), O.J. Luiten (Eindhoven University of Technology)—Presently, state-of-the-art pulsed electron sources, based on photo-emission, operate close to the fundamental limit set by the initial ?thermal? emittance. There are at least two distinct pathways that are being pursued to lower the thermal emittace further, and thus open new ways to increase the brightness. One is the reduction of the source size, leading to the development of needle sources [1]. The other, pursued by us [2, 3], is the reduction of the beam divergence by decreasing the random thermal motion of the electrons, i.e. extracting bunches from an ultracold source. To achieve this, we start from a cloud of laser-cooled and trapped rubidium atoms, located inside a coaxial accelerating structure [4]. The atoms are then either photo-ionized in a DC electric field by a pulsed laser, or field-ionized by a pulsed electric field after excitation to a high Rydberg state. We have measured electron source temperatures as low as 15 K, i.e. 3 orders of magnitude lower than conventional photo- or field-emission electron sources. As expected, we can tune the electron source temperature by adjusting the ionization laser wavelength with respect to the ionization threshold. In the DC experiments, typically electron bunches of 10 fC are produced, with a 5 ns length given by the ionization laser pulse width. By field ionizing high Rydberg states, sub-picosecond bunch lengths can be reached. Further development of this technique may lead to 100 pC electron bunches with ultralow emittance. [1] C.H. Garcia et al, Nucl. Intrum. Methods Phys. Res., Sec. A 483, 273 (2002). [2] B.J. Claessens et al, Phys. Rev. Lett. 95, 164801 (2005). [3] B.J. Claessens et al, Phys. Plasmas 14, 093101 (2007). [4] G. Taban et al, Phys. Rev. STAB 11, 050102-1, (2008).

19. RF photogun operating in the bunch blow out regime (2:40 – 3:00)
W. Op't Root (Eindoven U.), M.J. de Loos (), S.B. van Geer (), M.J. van der Wiel (), O.J. Luiten ()—We are using an RF photogun, in which the electrons are created by femtosecond photoemission and typically have a charge of 100 pC. We are aiming for electron bunches with a normalized transverse emittance of ~ 0.5 mm mrad, which means we are operating in a space charge dominated regime. The challenge is to tailor the space-charge forces such that the emittance is only limited by the thermal emittance of the photoemission process in copper. This is achieved by creating uniformly filled ellipsoidal electron bunches. Since they have linear self-field the emittance is conserved even in a space-charge dominated electron bunch. In order to create ellipsoidal electron bunches the intensity of the ionization laser should be shaped into a halfsphere. The resulting sheet of electrons will then evolve into an ellipsoidal electron bunch due to its own space-charge forces. In practice the half-sphere intensity profile is actually a Gaussian laser beam cut-off at 1 sigma. To show that we indeed have created uniformly filled ellipsoidal electron bunches we are planning to measure the transverse emittance using a magnetic quadrupole lens. In the future we want to measure the longitudinal bunch profile using coherent transition radiation in combination with electro-optic detection. The gun has full cylindrical symmetry with axial input coupling, allowing a focusing solenoid around the cavity, which should lead to better bunch qualities. An important technological innovation is clamping instead of braising of the different parts of the cavity, allowing easy replacement of, e.g., the cathode. Electron bunches with charges up to 100 pC and energies up to 3 MeV have been produced by photoemission with femtosecond laser pulses from the copper cathode surface.

DIAGNOSTICS AND CONTROL (Thursday, 7/31, 10:30 – 12:00)

20. LCLS RF Control System (10:30 – 10:55)

Ronald Akre (SLAC)—The Linac Coherent Light Source (LCLS) at SLAC will be the brightest X-ray laser in the world when it comes on line. In order to achieve the brightness a 3kA electron bunch, 200fS in length, is passed through an undulator. To create the 200fS, 3kA bunch, a 10pS electron bunch, created from a photo cathode in an RF gun, is run off crest on the RF to set up a position to energy correlation. The bunch is then compressed by chicanes. The stability of the RF system is critical in setting up the position to energy correlation. Specifications derived from simulations require several of the RF sub-systems to be stable to below 100fS rms jitter. To achieve this stability an RF control system was designed to run on top ofthe existing SLC control system. Initial design choises were made, the system was built, and specifictions met.

21. Longitudinal high-resolution bunch diagnostics (10:55 – 11:15)

Shaukat Khan (U. Hamburg)—Novel acceleration concepts such as laser- or beam-driven plasma acceleration require advanced diagnostics techniques to characterize and monitor the beam. A particular challenge is to measure bunch lengths of the order of 10 femtoseconds. Several methods are currently explored at the free-electron laser FLASH at DESY/Hamburg and will be discussed it this paper, such as electro-optical sampling with different decoding techniques, streaking bunches with a transversely deflecting cavity, and - most recently implemented at FLASH - the optical-replica synthesizer, a laserbased technique promising a time resolution of a few femtoseconds.

22. Electro-optic sampling for time-stamping of ultrashort time-resolved electron diffraction images (11:15 – 11:30)

Cheyne Scoby (UCLA), Pietro Musumeci (Particle Beam Physics Lab, Department of Physics and Astronomy, UC Los Angeles), Josh Moody (Particle Beam Physics Lab, Department of Physics and Astronomy, UC Los Angeles), Tan Tran (Particle Beam Physics Lab, Department of Physics and Astronomy, UC Los Angeles), Michael Gutierrez (Particle Beam Physics Lab, Department of Physics and Astronomy, UC Los Angeles)—The UCLA Pegasus photocathode rf gun was recently commissioned at UCLA to demonstrate the experimental feasibility of generating uniformly filled ellipsoidal electron bunches in the intense space charge driven blowout regime. The success of these initial experiments has resulted in 4-MeV sub-picosecond bunches whose brightness is limited only by thermal emittance. Relativistic electron diffraction experiments on thin metal foils have produced good results. The lab is now poised to utilize the shortness of these bunches in a pump-probe time-resolved electron diffraction experiment. In the simplest proposed setup, the pump is split off the laser pulse used to drive the photocathode. Due to timing jitter in the accelerator-laser complex, it is difficult to control the time-of arrival of the probe electron bunch with respect to the pump laser beam to better than a few hundred femtoseconds. Rather than try to control the timing of the pump-probe interaction, a non-destructive electro optic sampling (EOS) setup has been proposed to obtain timestamp information for diffraction images. The EOS setup employs a 0.5-mm thick zinc telluride crystal to spatially encode the electron bunch?s time information onto the polarization of a 35-fs 800-nm laser pulse in a single shot. The phase modulation is read out with a polarization analyzer and CCD. Strong EOS signals in the linear regime have been observed and two-dimensional EOS images of bunch-induced wakefields in the crystal have been obtained and analyzed. Over the past few months, simple EOS experiments at Pegasus have shown that time-of-arrival between electron probe and laser pump can be measured with better than 200-fs resolution. An rf deflecting cavity has been used in lieu of the pumped diffraction target as a proof-of-principle to show timing correlation between the bunch injection phase and the time-of-arrival at both the deflector and the EOS site. In conclusion, initial EOS time-stamping has cleared the way for pump-probe time-resolved diffraction studies on simple materials at the Pegasus lab. The correlation of EOS with known phase delays show promise for successful time-resolved relativistic electron diffraction.

23. Development of metamaterials for Cherenkov radiation based particle detectors (11:30 – 11:45)

Paul Schoessow (Euclid Techlabs), J.G.Power (ANL), A.V. Tyukhtin (Physical Dep. of St.-Petersburg State University, St.-Petersburg, Russia), A. Kanareykin (Euclid Techlabs), S. Antipov (ANL), C. Jing (Euclid Techlabs), E. Semouchkina (Pennsylvania State University), G. Semouchkin (Pennsylvania State University), W. Gai (ANL)—Measurement of Cherenkov radiation (CR) has long been a useful technique for charged particle detection and beam diagnostics. We are investigating metamaterials engineered to have refractive indices tailored to enhance properties of CR that are useful for particle detectors and that cannot be obtained using conventional media. Cherenkov radiation in dispersive media with a large refractive index differs significantly from the same effect in conventional detector media, like gases or aerogel. The radiation pattern of CR in dispersive metamaterials presents lobes at very large angles with respect to particle motion. Moreover, the frequency and particle velocity dependence of the radiated energy can differ significantly from CR in a conventional dielectric medium. Analytical and numerical analyses of Cherenkov radiation in presence of a dispersive, anisotropic metamaterial are presented. A convenient method to determine the Lorenz factor of charged particles, gamma, is based on measuring the frequencies of the harmonics generated in a waveguide. In this work, it is shown that this method for determining gamma can be performed using certain metamaterials, such as an anisotropic medium with plasma-type dispersion. In particular, it is shown that the medium?s parameters can be selected in such a way as to obtain a strong gamma-dependence of the mode frequencies in some predetermined narrow range of gammas. It may also be possible to obtain a gamma-dependence for a wide range including very large values of the particle energy. We are exploring the design, development and demonstration of metamaterials (MTM) with unique properties under Cherenkov radiation for particle detector applications, beginning with CR with novel properties in dispersive and anisotropic media in the 5-15 GHz frequency range. The frequency range is chosen for simplicity of MTM production and test equipment and fixtures available for cold tests. The MTMs are being designed to have anisotropy and dispersion characteristics that match the results of theoretical studies mentioned above. GHz range MTMs will be produced using conventional printed circuit board methods or Low- Temperature Cofired Ceramics (LTCC) technology. The results of the work do not apply only to 10 GHz-range metamaterials. We also consider a metamaterial design based on dielectric resonators. This design is scalable with some modifications to THz and even far Infrared (FIR) wavelengths. A scaled design can be produced by conventional microfabrication techniques.

24. New Coupler for Traveling Wave RF Deflector (11:45 – 12:00)

V.A. Dolgashev (SLAC)—Traveling wave rf deflectors are used as a beam diagnostic tool in linear accelerators. They allow measurements of bunch longitudinal charge distribution and slice emittance. Resolution of an rf deflector is determined by its operating frequency and peak maximum deflection. The peak maximum deflection is limited by available rf power and high gradient performance of the structure. One of critical elements determining this high gradient performance is structure?s coupler. In this report a design of a coupler for X-band (11.4 GHz) traveling wave deflector is presented. The design is based on the ?waveguide coupler? used in NLC accelerating structures. This work was supported by the U.S. Department of Energy contract DE-AC02-76SF00515.

RADIATION (Joint with WG1) (Thursday, 7/31, 1:30 – 3:00)

25. Compact Radiation source based on laser-plasma wakefield accelerator (1:30 – 1:55)

Dino Jaroszynski (University of Strathclyde)—Radiation sources are ubiquitous tools for studying the structure and dynamics of matter. Current light sources can produce both brilliant and picosecond duration x-ray pulses which are useful for time resolved studies. There is a drive to reduce their pulse durations to a few femtoseconds or less, and increase their brilliance to enable single-shot measurements for unravelling structural or chemical changes on unprecedented time scales. Synchrotron source provide high average power and tuneable x-ray radiation, whereas the next generation x-ray free-electron lasers (FELs), which are currently being developed, will provide intense coherent radiation with several tens of femtosecond pulse durations. However, these sources are some of the largest instruments that exist. Their huge size and cost is a result of the microwave accelerator technology on which they are based. The acceleration gradients are restricted to gradients of 10?100 MV/m. The recent development of table-top multi-terawatt femtosecond lasers has provided the opportunity to significantly miniaturise accelerator technology by harnessing plasma waves as a medium for generating electrostatic fields with gradients approaching 1 TV/m. Recent pioneering developments in laser-driven plasma wakefield accelerators has resulted in controllable high quality electron bunches that are providing a realistic prospect of realising a table-top synchrotron source and possibly an X-ray FEL. This could transform the way science is done by making available compact femtosecond duration sources of infrared, UV and X-ray sources to University sized establishments. We will present the significant challenges facing the realisation of a compact plasma based source and review the first major advance where synchrotron radiation from an undulator driven by wakefield accelerator was demonstrated. Recent progress towards an FEL based on a plasma wakefield accelerator and results from the ALPHA-X project will be presented. We will also show how compact undulator radiation can be used to measure the energy spread of a high energy electron beam.

26. Free-electron laser driven by the LBNL laser-plasma accelerator (1:55 – 2:10)
Carl B. Schroeder (LBNL), W. M. Fawley (LBNL), K. E. Robinson (LBNL), M. Bakeman (Univ. of Nevada - Reno), K. Nakamura (Univ. of Nevada - Reno), Cs. Toth (LBNL), E. Esarey (LBNL), W. P. Leemans (LBNL)—In this talk I will present a design for a compact free-electron laser (FEL) source of ultra-fast, high-peak flux, EUV pulses employing a high-current, GeV electron beam from the existing LBNL laserplasma accelerator. The proposed ultra-fast source would be intrinsically temporally synchronized to the drive laser pulse, enabling pump-probe studies in ultra-fast science with pulse lengths of tens of fs. Owing to the high current (>10 kA) of the laser-plasma-accelerated electron beams, saturated output fluxes are potentially greater than 1E13 photons/pulse. I will discuss devices based both on SASE and high harmonic generated input seeds to reduce undulator length and fluctuations. Numerical results for the expected FEL performance using current laser-plasma-accelerator beam parameters are presented. The impact of longitudinal wakefields from the high-current beam in the undulator vacuum chamber and electron beam energy chirps from space-charge forces during transport to the undulator are examined. Initial experiments will focus on generation of spontaneous undulator radiation, and beam diagnostics based on spontaneous undulator radiation will also be discussed.

27. Polarized gamma source based on Compton backscattering in a laser cavity (2:10 – 2:25)
Vitaly Yakimenko (BNL)—We propose a novel gamma source suitable for generating a polarized positron beam for the next generation of electron-positron colliders, such as the International Linear Collider (ILC), the Compact Linear Collider (CLIC), and SuperB. This 30-MeV polarized gamma source is based on Compton scattering inside a picosecond CO2 laser cavity generated from electron bunches produced by a 4-GeV linac. We identified and experimentally verified the optimum conditions for obtaining at least one gamma photon per electron. After multiplication at several consecutive interaction points, the circularly polarized gamma rays are stopped on a target, thereby creating copious numbers of polarized positrons. We address the practicality of having an intracavity Compton-polarized positron source as the injector for these new colliders.

28. EUV X-ray and electron generation by colliding laser pulses (2:25 – 2:40)
Masaki Kando (Japan Atomic Energy Agency)—Using counter-crossing laser pulses we have investigated light reflection from moving electron density modulation (flying mirror) driven by ultra-intense laser pulses. When the appropriate colliding of two laser pulses was achieved we observed reflected photons frequency of which was 50-110 times higher than initial one. Using the same setup, we made optical injection of electrons into wakefield. The stability of electron generation and quality were improved. Recently, we have conducted flying mirror and optical injection using the complete counter propagating setup. The results will be presented at the workshop

29. Space-charge effects in electron bunches generated by laser-plasma accelerators and their impact on table-top FELs (2:40 – 2:50)
Florian Gruener (Max-Planck-Institute of Quantum Optics)—Recent advances in laser-plasma accelerators, including the generation of GeV-scale electron bunches, enable applications such as driving a compact free-electron-laser (FEL). Significant reduction in size of the FEL is facilitated by the expected ultra-high peak beam currents (10--100~kA) generated in laser-plasma accelerators. At low electron energies such peak currents are expected to cause large space-charge effects such as bunch expansion and induced energy variations along the bunch, hindering the FEL process. In this paper we discuss a self-consistent approach to modeling space-charge effects for the regime of laser-plasma-accelerated ultra-compact electron bunches at low or moderate energies. Analytical treatments are considered as well as point-to-point particle simulations, including the beam transport from the laser-plasma accelerator through focusing devices and the undulator. In contradiction to non-self-consistent analyses (i.e., neglecting bunch evolution), which predict a linearly growing energy chirp, we have found the energy chirp reaches a maximum and decreases thereafter. The impact of the space-charge induced chirp on FEL performance is discussed and possible solutions are also presented.

30. Status of Coherent Cherenkov Wakefield Experiment at UCLA (2:50 – 3:00)
Alan Cook (UCLA). O.B. Williams (UCLA Department of Physics), R. Tikhoplav (UCLA Department of Physics), G. Travish (UCLA Department of Physics), J. B. Rosenzweig (UCLA Department of Physics), A. Knyazik (UCLA Department of Physics)—Coherent Cherenkov radiation wakefields are produced when a compressed electron beam travels along the axis of a hollow cylindrical dielectric tube. In a dielectric wakefield accelerator (DWA) these wakefields accelerate either a trailing electron bunch or the tail of the driving bunch, depending on the modal structure of the radiation. For an appropriate choice of dielectric structure geometry and beam parameters the device operates in a single-mode regime, producing sinusoidal wakefields with wavelengths in the THz range. We report on preliminary results of an experiment at UCLA studying the potential of a DWA structure to produce high-power, narrow-band THz radiation.

INTENSE BEAMS II (Friday, 8/1, 10:30 – 12:00)

31. Operational Studies of the 10 keV Electron Storage Ring UMER (10:30 – 10:50)
Santiago Bernal (UMD), B. Beaudoin (), M. Cornacchia (), D. Feldman (), R. Fiorito (), T. F. Godlove (), I. Haber (), R. A. Kishek (), C. Papadopoulos (), M. Reiser (), D. Sutter (), J.C.T. Thangaraj (), C. Wu (), P.G. O'Shea ()—The University of Maryland Electron Ring (UMER) is now operational. UMER can operate with currents from 0.6 mA to 100 mA, ranging from the emittance dominated to the heavily space charge dominated regimes. Multiple turns have been achieved at all operating currents, from 250 turns at 0.6 mA to about 12 turns at 100 mA, but not optimized for operation above 25 mA. Machine development in the past year has been on understanding the single particle behavior of the machine in order to establish a strong basis for studying the effects of space charge. Basic machine parameters such as the tune and the equilibrium orbit have been measured over a range of currents and used to refine the tuning of the machine. The effect of the earth?s field has also been studied (22% of the bending in the horizontal) and compensation implemented. Further, longitudinal beam dynamics studies have shown the need for bunch containment, while experiments have demonstrated its feasibility. The areas where machine improvement is clearly needed have been identified. This work is funded by US Dept. of Energy Programs of High Energy Physics and High Energy Density Physics, and by the US Dept. of Defense Office of Naval Research and Joint Technology Office.

32. Error and Resonance Analysis of Beams with Intense Space Charge in the University of Maryland Electron Ring (UMER) (10:50 – 11:10)
Chao Wu (UMD), Eyad Abed (Institute for Systesm Research, University of Maryland, College Park, MD, 20742), Patrick O'Shea (Institute for Research in Electronics&Applied Physics, University of Maryland, College Park, MD, 20742), Rami Kishek (Institute for Research in Electronics&Applied Physics, University of Maryland, College Park, MD, 20742), David Sutter (Institute for Research in Electronics&Applied Physics, University of Maryland, College Park, MD, 20742), Santiago Bernal (Institute for Research in Electronics&Applied Physics, University of Maryland, College Park, MD, 20742), Brain Beaudoin (Institute for Research in Electronics&Applied Physics, University of Maryland, College Park, MD, 20742), Irving Haber (Institute for Research in Electronics&Applied Physics, University of Maryland, College Park, MD, 20742), Chris Papadopoulos (Institute for Research in Electronics&Applied Physics, University of Maryland, College Park, MD, 20742)—Space charge can significantly affect the resonant properties of rings. The University of Maryland Electron Ring is a scaled experiment in which we have circulated beams with unprecedented intensities. Here we discuss the resonance analysis performed using the electrostatic particle-in-cell code WARP, to understand the effect of space charge on the ring resonances. Beams with varying degrees of space charge in both the emittanceand space-charge-dominated regimes are attempted. The operating point is scanned to map the tune diagram under various lattice and injection errors. The results of the simulation study are compared to experimental measurements. This work is funded by US Dept. of Energy Offices of High Energy Physics and High Energy Density Physics, and by the US Dept. of Defense Office of Naval Research and Joint Technology Office.

33. Generation and transport of space charge waves in the University of Maryland Electron Ring (11:10 – 11:30)
Jayakar Thangaraj (UMD), B.Beaudoin (beaudoin@umd.edu), D.Feldman (dfeldman@umd.edu), R.Kishek (ramiak@umd.edu), S.Bernal (sabern@umd.edu), P.O'Shea (poshea@umd.edu), M.Reiser

(mreiser@umd.edu), D.Sutter (accelphy@aol.com)—An experimental study of longitudinal dynamics of space charge dominated beams is presented. By launching waves on intense beams, using laser, properties of the waves (speed of the waves) as well as the beam (transverse beam size) are inferred. Collective effects like propagation of space charge waves, superposition of waves and crossing of waves are presented and verified with 1-D cold fluid model theory. Multiturn transport of parabolic beam and other collective effects in UMER are discussed. This work is funded by US Dept. of Energy Offices of High Energy Physics and High Energy Density Physics, and by the US Dept. of Defense Office of Naval Research and Joint Technology Office.

34. Observation of transverse space charge effect in multi-beamlet electron bunch (11:30 – 11:50)

Marwan Rihaoui (NIU)—A "multiple beamlet" experiment aimed at investigating the transverse space charge effect was recently conducted at the Argonne Wakefield Accelerator. The experiment generated a symmetric pattern of 5 beamlets on the photocathode of the RF gun with the drive laser. We explored the evolution of the thereby produced ~5 MeV, space-charge dominated electron beamlets in the ~2m drift following the RF photocathode gun for various external focusing. Two important effects were observed and benchmarked using the particle-in-cell beam dynamics code IMPACT-T. In this paper, we present our experimental observation and their benchmarking with Impact-T.