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Book of Abstracts

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Emittance Growth and Tune Spectra at PETRA III

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At DESY the PETRA ring has been converted into a synchrotron radiation facility, called PETRA III. 20 damping wigglers have been installed to achieve an emittance of 1 nm. The commissioning with beam started in April 2009 and user runs have been started in 2010. The design current is 100 mA and the bunch to bunch distance is 8 ns for one particular filling pattern with 960 bunches.

At a current of about 50 mA a strong vertical emittance increase has been observed. During machine studies it was found that the emittance increase depends strongly on the bunch filling pattern. For the user operation a filling scheme has been found which mitigates the increase of the vertical emittance. In Aug. 2010 PETRA III has been operated without damping wigglers for one week. The vertical emittance growth was not significantly smaller without wigglers. Furthermore tune spectra at PETRA III show characteristic lines which have been observed at other storage rings in the connection with electron clouds. The measurements at PETRA III are presented for different bunch filling patterns and with and without wiggler magnets.

Updates from Operating Machines / 6

Can electron multipacting explain the pressure rise in a cold bore superconducting undulator?

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Preliminary studies performed with the cold bore superconducting undulator installed in the ANKA (Angstrom source Karlsruhe) storage ring suggest that the beam heat load is mainly due to the electron wall bombardment. Electron bombardment can both heat the cold vacuum chamber and induce an increase in the pressure because of gas desorption. In this contribution we compare the measurements of the pressure in a cold bore performed in the electron storage ring ANKA with the predictions obtained using the equations of gas dynamic balance in a cold vacuum chamber exposed to synchrotron radiation and electron bombardment. The balance results from two competing effects: the photon and electron stimulated desorption of the gas contained in the surface layer of the chamber wall and of the gas cryosorbed, and the cryopumping by the cold surface. We show that photodesorption alone cannot explain the experimental results and that electron multipacting is needed to reproduce the observed pressure rise. Electron bombardment can at the same time explain the observed beam heat load.
http://prst-ab.aps.org/abstract/PRSTAB/v13/i7/e073201

Electron Cloud Diagnostics and Measurements / 7

COLDDIAG: a cold vacuum chamber for diagnostics

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One of the still open issues for the development of superconducting insertion devices is the understanding of the heat load induced by the beam passage. With the aim of measuring the beam heat load to a cold bore and in order to gain a deeper understanding in the beam heat load mechanisms, a cold vacuum chamber for diagnostics is under construction. We plan to have access with the same set-up to a number of different diagnostics, so we are implementing: i) retarding field analyzers to measure the electron flux, ii) temperature sensors to measure the total heat load, iii) pressure gauges, iv) and mass spectrometers to measure the gas content. The inner vacuum chamber will be removable in order to test different geometries and materials. COLDDIAG is built to fit in a short straight section at ANKA, but we are proposing its installation in different synchrotron light sources with different energies and beam characteristics. A first installation in DIAMOND is planned in June 2011. Here we describe the technical design report of this device and the planned measurements with beam.

Updates from Operating Machines / 8

Recent studies of the electron cloud induced beam instability at the Los Alamos PSR

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Recent beam studies have focused on two aspects of the observed e-p instability at the Los Alamos Proton Storage Ring (PSR). 1) Most recently it has been observed that a stable beam with the standard production bunch width (290 ns injected beam bunch width) will become e-p unstable when the bunch width is shortened to 200 ns or less. This was not the case years earlier. Experimental characteristics and possible explanations of this recent "short pulse instability phenomenon"will be presented. 2) Other beam studies have focused on understanding the main sources and locations of electron clouds (EC), which drive the observed e-p instability. Significant EC signals are observed in drift spaces and quadrupole magnets at PSR which together cover ˜65% of the ring circumference. Results making use of two longitudinal barriers to isolate the drift space electron diagnostic have provided definitive evidence that most of the drift space EC signal is "seeded"by electrons ejected longitudinally by ExB drifts from adjacent quadrupole magnets. This result can explain why weak solenoids and TiN coatings in several drifts spaces had no effect on the e-p instability threshold. Modeling of EC generation in 3D quadrupoles using a modified version of the POSINST code shows that a sizeable fraction of the electrons generated in the quadrupoles are ejected longitudinally into the adjacent drifts. The experimental findings and simulation results of this focus will be summarized.

Beam Dynamics Issues / 9

xBSM bunch-by-bunch measurements in EC conditions at CesrTA

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Measurements have been made of the bunch size and position along the train in electron cloud conditions at CesrTA. Preliminary results show a bunch size blow-up starting partway down the train, with the threshold bunch position moving forward at higher bunch currents, as would be expected for electron-cloud blow-up. The bunch-by-bunch beam profile and position data, and their Fourier power spectra, are further analyzed and presented.

Electron Cloud Build-Up Modeling / 10

Simulation of the electron cloud in the Fermilab Main Injector using VORPAL

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We present results from a precision simulation of the electron cloud (EC) problem in the Fermilab Main Injector using the code VORPAL. Fully3d and self consistent that include both distributions of electrons in6D phase-space and E.M. field maps. Various configurations of themagnetic fields found around the machine have been studied. Plasma waves associated to the fluctuation density of the cloud have been analyzed. Our results are compaired with those obtained with the POSINST code. It is shown that the 3D effects are important. Theresponse of a Retarding Field Analyzer (RFA) to the EC has been simulated, as well as the more challenging microwave absorptionexperiment. Definite predictions of their exact response aredifficult to compute, mostly because of the uncertainties in thesecondary emission yield and, in the case of the RFA, because of thesensitivity of the electron collection efficiency to unknown straymagnetic fields. Nonetheless, our simulations do ! provide guidance to the experimental program.

Updates from Operating Machines / 11

RECENT EXPERIMENTAL RESULTS ON AMORPHOUS CARBON COATINGS FOR ELECTRON CLOUD MITIGATION IN CERN SPS

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Amorphous carbon (a-C) thin films, produced in different coating configurations by using d.c magnetron sputtering, have been investigated in laboratory for low secondary electron yield (SEY) applications. After the coatings had shown a reliable low initial SEY, the a-C thin films have been applied in the SPS and tested with LHC type beams. Currently, we have used a-C thin film coated in so-called liner configuration for the electron cloud monitors as well as for a removable sample. In addition the vacuum chambers of three dipole magnets have been coated and inserted in the machine.

After describing the different configurations used for the coatings, results of the tests in the machine and a summary of the analyses after extraction will be presented. Based on comparison between different coating configurations, a new series of coatings has been applied on three further dipole magnet vacuum chambers. They have been installed and will be tested in coming machine development runs.

Electron Cloud Diagnostics and Measurements / 12

Analysis of the electron cloud density measurement with RFA in a positron ring

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In a positron ring such as KEKB LER, clouding electrons receive an almost instantaneous kick from circulating bunches. Therefore, high energy electrons in the cloud are produced just after the interaction with the bunch locally around the beam. The authors gave an estimation of their density using a high energy electron current measured with RFA and a calculated volume neglecting their initial velocity before the interaction with the bunch. To evaluate the accuracy of this estimation, the process of the measurement is analyzed using the phase space density for the motion of electrons in the transverse plane of the beam. The expressions that can evaluate the accuracy of the estimation with the help of simulation are obtained. One of the authors has shown that the accuracy for a drift space is within ±5% error. For other cases such as in a solenoid field, in a quadruple field, the evaluation is not yet given. In addition to this discussion, some examples of the estimation with RFA are shown.

Updates from Operating Machines (cont'd) & Mitigation Studies / 13

e-Cloud Activity of DLC and TiN Coated Chambers at KEKB Positron Ring

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A copper chamber without coating and TiN and diamond like carbon (DLC) coated aluminum chambers were installed to an arc section of the KEKB positron ring to make comparisons of electron cloud activity as well as total pressure and residual gas components during the beam operation under the same condition. Recently a DLC coated aluminum chamber with high surface roughness that was obtained with cost-effective simple abrasive of the large grain before the coating was installed in the same arc section and exposed to the electron cloud until the KEKB shutdown.
The measured electron cloud activity in the DLC coated chamber with smooth surface showed half and one-sixth of those in the TiN coated chamber and the copper chamber, respectively at the operation of around 1000 Ah. Much more reduction of the e-cloud activity owing to the DLC on the roughed chamber surface was found, that is ,a reduction of one-fifth and one-tenth, respectively, in comparison with the DLC on non-roughed chamber and the TiN coating on non-roughed chamber at around 1000 Ah.
Preparation of the DLC coated chamber, characteristics of the DLC and measurements including the residual gas observation will be also reported in detail.

Electron Cloud Diagnostics and Measurements / 14

The Ecloud Measurement Setup in the Main Injector

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An ecloud measurement setup was installed in a straight section of the Main Injector in 2009. The goal of the setup was to compare the characteristics of different beam pipe coatings when subjected to proton beam. The setup consists of one coated and one uncoated beam pipe with the same physical dimensions installed at the same location. Four RFAs (retarding field analysers) and two BPMs (used for RF measurements) have been used to measure the ecloud densities. The RFAs have performed very well and have collected both the time evolution and energy distribution of the ecloud for bare and two types of beam pipe coatings.

Electron Cloud Diagnostics and Measurements / 15

Electron Cloud Studies in the Fermilab Main Injector using Microwave Transmission

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In this paper, we present recent results from our measurement at the Fermilab Main Injector through microwave transmission in a beam pipe. We present three types of measurement techniques. In the first technique, we use time-resolved direct phase shift measurement to measure the e-cloud density. In the second and third techniques, we look for side bands in the frequency spectrum with or without frequency span by collecting turns of data. Finally, we also discuss the resonant BPM method, where a signal below the waveguide cutoff is sent through a one side of the BPM and is collected on the other side of the BPM to look for phase shift due to electron cloud. We present experimental results taken from MI40 and MI52 section of the main injector.

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Electron Cloud Measurements at Fermilab

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Using the new measurement station in the Main Injector, we have made a series of ECloud measurements in 2009 and 2010. The installation included Titanium-Nitride (TiN) and amorphous carbon coated beam pipes; these materials were directly compared to an adjacent stainless chamber through measurement with Retarding Field Analyzers (RFAs). Over the long period of running we were able to observe the conditioning of the beam pipe caused by the beam, and correlate it with electron fluence, establishing a conditioning history for each material. Additionally, the installation has been used to measure of the electron energy spectrum, compare detector results, and the detailed behavior of the Electron Cloud during the acceleration cycle. Finally, a new installation, developed in conjunction with Cornell and SLAC, will allow direct measurement of the SEY as conditioned in the accelerator; this conditioning will be compared to that found at Cornell, allowing comparison between electron/positron and proton machines.

Beam Dynamics Issues / 17

Numerical Modeling of E-Cloud Driven Instability and its Mitigation using a Simulated Feedback System in the CERN SPS

Author: Jean-Luc Vay[1]

Co-authors: C. H. Rivetta [2]; J. D. Fox [2]; J. M. Byrd [1]; M. A. Furman [1]; Marco Venturini [1]; R. Secondo [1]; W. Hofle [3]

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Electron clouds impose limitations on current accelerators that may be more severe for future machines, unless adequate measures of mitigation are taken. Recently, it has been proposed to use feedback systems operating at high frequency (in the GHz range) to damp single-bunch transverse coherent oscillations that may otherwise be amplified during the interaction of the beam with ambient electron clouds. We have used the simulation package WARP-POSINST to study the growth rate and frequency patterns in space-time of the electron cloud driven transverse instability in the CERN SPS accelerator with, or without, feedback models (with various levels of idealization) for damping the instability. We will present our latest simulation results, contrast them with actual measurements and discuss the implications for the design of the actual feedback system. More simulations results are presented by Raffaello Secondo using a Finite Impulse Response (FIR) as processing channel in a more realistic, albeit yet highly simplified, model of feedback control system.

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Poster Session - Board: 1 / **18**

E-cloud effects in the proposed CERN PS2 synchrotron

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One of the options considered for a future aupgrade of the LHC injection complex entails the replacement of PS with PS2, a larger circumference and higher-energy synchrotron. Electron cloud has been identified as a potential limitation to the machine performance. We review studies of e-cloud build-up and present recent results of simulations of short-term e-cloud effects on the single-bunch dynamics in the smooth-lattice, quasi-static approximation, as implemented in the code Warp.

Beam Dynamics Issues / **19**

Simulated Performance of an FIR-Based Feedback System to Control the Electron Cloud Single-Bunch Transverse Instabilities in the CERN SPS

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Co-authors: Claudio Rivetta [2]; Jean-Luc Vay [1]; John Byrd [1]; John Fox [2]; Marco Venturini [1]; Miguel Furman [1]; Wolfgang Hofle [3]

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The performance of High Energy proton machines like the SPS at CERN is affected by transverse single-bunch instabilities due to the Electron Cloud effect. In a first step to model a Feedback control system to stabilize the bunch dynamics, we use a Finite Impulse Response filter to represent the processing channel. The effect of this simplified processing channel in the bunch dynamics is analyzed using the simulation package WARP-POSINST (see talk by J. L. Vay et al.). We report on simulation results, discuss the basic features of the feedback model and present our plans for further development of the numerical models used in the simulations.

Electron Cloud Build-Up Modeling / **20**

Modeling Electron Cloud Buildup and Microwave Diagnostics using VORPAL

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We present an overview of recent electron cloud modeling results using the multi-dimensional, parallel, plasma simulation code VORPAL. We have used VORPAL to model cloud buildup in dipole, quadrupole, and field-free magnetic field configurations, in both circular and elliptical cross section pipes relevant to microwave diagnostics at the PEP-II experiment at SLAC, and ongoing experiments in the Main Injector at Fermilab. In addition, we present preliminary results for modeling electron orbits in the CesrTA wiggler, which is the beginning of a more detailed modeling effort to understand electron cloud effects in electron/positron accelerators, as well as connecting microwave side-band measurements to cloud densities. We also report on recent 3-Dimensional microwave transmission simulations through uniform and non-uniform clouds, and with higher order TE and TM waves using VORPAL.

Planning for Future Machines / 21

Mitigation strategy of electron cloud effects in the Super KEKB positron ring

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The upgrade of KEKB to Super KEKB has just started. Now the design work of the positron ring is underway. The present mitigation plan of the electron cloud effect will be reported.

Electron Cloud Build-Up Modeling / 22

Electron cloud issues for the APS superconducting undulator

Author: Katherine Harkay[1]

Co-authors: Art Garfinkel [2]; Elizabeth Moog [1]; Emil Trakhtenberg [1]; Laura Boon [2]; Richard Rosenberg [1]; Robert Kustom [1]; Sara Casalbuoni [3]; Yury Ivanyushenkov [1]

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The APS Upgrade calls for the development and commissioning of a superconducting undulator (SCU) at the Advanced Photon Source (APS), a 7-GeV electron synchrotron. Operation of an SCU at ANKA, also an electron ring, suggests that electron multipacting may in part be responsible for the observed heat load and pressure rise, but this effect is not predicted by an electron cloud generation code. It was found at APS that while the cloud code POSINST agreed fairly well with Retarding Field Analyzer (RFA) data for a positron beam (operated 1996-98), the agreement was less satisfactory for the electron beam. The APS data suggest that the photoelectron model is not complete. Given that the heat load is a critical parameter in designing the cryosystem for the SCU and given the experience at ANKA, a study is underway to minimize the possible contribution to the heat load by the electron cloud at APS, the photoelectrons in particular. In this talk, the results from POSINST are presented.

Preliminary tracking of the photon flux using SYNRAD3D for the APS SCU chamber is presented, and possible ways to mitigate the photoelectrons are discussed.

Poster Session - Board: 3 / **23**

Implementation and Operation of Electron Cloud Diagnostics for CesrTA

Author: Yulin Li[1]

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The vacuum system of Cornell Electron Storage Ring (CESR) was successfully reconfigured to support CesrTA physics programs, including electron cloud (EC) build-up and suppression studies. One of key features of the reconfigured CESR vacuum system is the flexibility for exchange of various vacuum chambers with minimized impact to the accelerator operations. This is achieved by creation of three short gate-valve isolated vacuum sections. Over the last three years, many vacuum chambers with various EC diagnostics (such as RFAs, shielded pickups, etc) were rotated through these short experimental sections. With these instrumented test chambers, EC build-up was studied in many magnetic field types, including dipoles, quadrupoles, wigglers and field-free drifts. EC suppression techniques by coating (TiN, NEG and a-C), surface textures (grooves) and clearing electrode are incorporated in these test chambers to evaluate their effectiveness. We present the implementation and operations of EC diagnostics.

Electron Cloud Build-Up Modeling / **24**

Analysis of Synchrotron Radiation using SYNRAD3D and Plans to Create a Photoemission Model

Author: Laura Boon[1]

Co-authors: Art Garfinkel [1]; David Sagan [2]; Gerry Dugan [2]; Jim Crittendon [2]; Joseph Calvey [2]; Kathy Harkay [3]; Kiran Sonnad [2]

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Electron cloud data from electron rings suggest that the photoelectron model in electron cloud generation codes is incomplete. The photoelectron model will be important in modeling the cloud generation on components downstream of wigglers, which can produce a very high photon flux on the wall in a local region. The code SYNRAD3D has been developed in the context of the Bmad accelerator physics software library. SYNRAD3D includes computation of synchrotron radiation and propagation in 3D through a vacuum chamber. The probability of reflection vs. absorption of the photons on the chamber wall is included, using data from the literature. We used SYNRAD3D to model the photon flux for the ILC damping ring. For simplicity in modeling, we started with a round chamber and varied parameters such as the number of simulation-generated photons, bin size, photon energy cutoff, and whether photons reflect off the wall. With a realistic photon flux and distribution, we can study models for the photoemission. Preliminary work has begun to develop a photoelectron model using Retarding Field Analyzer (RFA) data. The work to date and future plans are described.

Planning for Future Machines / 25

CesrTA Preliminary Recommendations for the ILC Positron Damping Ring

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The first phase of the CesrTA experimental program is now complete. Electron cloud research over the course of the last 2.5 years has focused on two principle topics. The first is the characterization of methods to mitigate the electron cloud build-up in each of the magnetic field regions of concern for damping ring design. The second is the characterization of the cloud's impact on ultra-low emittance beams. Our intent is now to incorporate these results into the technical design of the positron damping ring for the International Linear Collider. Implications for the ILC DR design will be discussed.

Electron Cloud Build-Up Modeling / 26

Electron Dynamics in the Wigglers of CESR-TA

Author: Christine Celata[1]

[1] *LBNL / Cornell University*

Simulations of electron cloud buildup in the CESR-TA wigglers have been performed using the 3D code WARP-POSINST. The beam field is modeled using the Bassetti-Erskine electric field and does not evolve in time. The electron cloud distribution during the passage of a 45-bunch train has been examined with particular attention to the difference in dynamics at the z locations of the maximum and minimum vertical magnetic field, By. Near the z locations of the zeroes of By electrons near the chamber midplane cross field lines, driven by the gradient and curvature of the magnetic field, eventually reaching the vicinity of the beam. Near the maxima of By the cloud buildup is like that in a dipole, and this cloud spatial distribution occurs through much of the length of the wiggler period. This report will discuss these findings, delineate the areas of the wiggler in which each of these different behaviors occurs, and give results for the tune shift caused by the cloud in each area and for the whole wiggler period.

- This work was supported by the National Science Foundation under contract PHY-0734867 and the Office of Science, U. S. Department of Energy, under Contract No. DE-FC02-08ER41538. Visitor; California Institute of Technology; Physics, Mathematics, and Astronomy, and guest, Lawrence Berkeley National Laboratory, Berkeley, CA

Beam Dynamics Issues / 27

Electron instability in low emittance rings, Cesr-TA and SuperKEKB

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We discuss single bunch instability in low emittance rings, especially focus side band appearance.
Multi-bunch instability due to electron cloud in bending field is discussed.

Updates from Operating Machines / **28**

ELECTRON CLOUD BUILD UP AND INSTABILITY IN DAFNE

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A strong horizontal instability limiting the positron current has been observed at DAFNE since the installation of the FINUDA detector in 2003. Experiments and simulations seem to provide an evidence that the electron cloud build-up in the wigglers and bending magnets of the DAFNE positron ring induces a coupled bunch instability with features compatible with observations . To better understand the electron cloud effects and possibly to find a remedy, a detailed simulation study is undergoing. In this communication we present recent simulation results relative to the build up of the electron cloud, also taking into account the effect of clearing electrodes in the dipoles and wigglers of the DAFNE positron ring. The resulting electron cloud distribution is used to study both coupled and single bunch induced instabilities.

Poster Session - Board: 2 / **29**

Bunch By Bunch Instrumentation Upgrades For CESR Based On Requirements For The CESR Test Accelerator Research Program

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The research focus of the CESR Test Accelerator program requires new instrumentation hardware, software and techniques in order to accurately investigate beam dynamics in the presence of electron cloud effects. These new instruments are also required to develop low emittance beam conditions which are key to the success of the damping ring design for the International Linear Collider. This poster will detail some of the architecture and tools which have been developed to support these efforts. Emphasis will be placed on the 4 nS bunch by bunch Beam Position Monitoring system as well as the 4 nS capable X-ray Beam Size Monitor.

Electron Cloud Diagnostics and Measurements / **30**

TE Wave Measurements at Cesr-TA

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Co-authors: Gregory Penn [1]; John Byrd [1]; John Sikora [2]; Kenneth Hammond [3]

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TE wave transmission is currently used as a diagnostic tool for measurements of the electron cloud density in several regions of the Cesr-TA ring.
While the method is conceptually well established, a number of effects contribute to making a quantitative estimate of the density not straightforward.
We report on the measurements currently performed during Cesr-TA experimental runs, describe experimental challenges, and the methods devised to analyze and solve them.

Updates from Operating Machines (cont'd) & Mitigation Studies / **31**

Electron Cloud Mitigation Investigations at CesrTA

Author: Joseph Calvey[1]

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Over the course of the CesrTA program at Cornell, over 30 Retarding Field Analyzers (RFAs) have been installed in the CESR storage ring. These devices, which measure the local electron cloud density and energy distribution, have been deployed in drift, dipole, quadrupole, and wiggler field regions. They can be used to evaluate the efficacy of cloud mitigation techniques in each magnetic field element. Techniques investigated so far include different beam pipe coatings, grooves, and clearing electrodes. This talk will provide an overview of the electron cloud mitigation program at CESR, give a preliminary evaluation of the effectiveness of various mitigation techniques, and discuss methods used to obtain quantitative information about vacuum chamber properties via simulation.

Poster Session - Board: 5 / **32**

Methods for Quantitative Interpretation of Retarding Field Analyzer Data

Author: Joseph Calvey[1]

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A great deal of Retarding Field Analyzer (RFA) data has been taken as part of the CesrTA program at Cornell. Obtaining a quantitative understanding of this data requires use of cloud simulation programs, as well as a detailed model of the RFA itself. In some cases the RFA can be modeled by postprocessing the output of a simulation codes, and one can obtain "best fit"values for important simulation parameters using a systematic method to improve agreement between data and simulation. In other cases, in particular in high magnetic field regions, the presence of the RFA can have an effect on the cloud, and one needs to include a model of the RFA in the simulation program itself.

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Electron Cloud Build-Up: Theory and Data(*)

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We will provide an introductory overview of the ingredients that make up the physical model used for the simulation of the electron-cloud build-up and decay in the presence of a given, prescribed, beam. The three primary electron generation mechanisms (photoemission, ionization of residual gas, and electron generation from beam stray particles striking the chamber walls) will be presented, with emphasis on photoemission. The secondary electron emission (SEE) model will then be presented in more detail, as SEE typically, dominates the build-up of the electron cloud. A very simplified analytic model will also be presented, which embodies the essential ingredients. Effects of the electron cloud back on the beam will not be covered, except possibly for coherent tune shifts (effects on the beam will be covered in the following two talks).

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ILC Damping Ring Electron Cloud R&D effort and Single-Bunch instability simulations using CMAD

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Co-authors: Catherine Harkay [2]; Christine Celata [3]; Dugan Gerry [4]; Ioannis Papaphilippou [5]; Jim Crittenden [4]; Kazuhito Ohmi [6]; Kiran Sonnad [4]; Lanfa Wang [1]; Marco Venturini [3]; Mark Palmer [4]; Miguel Furman [3]; Oleg Malyshev [7]; Susanna Guiducci [8]; Theo Demma [8]; Yusuke Suetsugu [6]

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As part of the international Linear Collider (ILC) collaboration, we have compared the electron cloud (EC) effect for different Damping Ring (DR) designs respectively with 6.4 km and 3.2 km circumference and investigated the feasibility of the shorter damping ring with respect to the electron cloud build-up and related beam instabilities. The studies for a 3.2 km ring were carried out with beam parameters of the ILC Low Power option. A reduced damping ring circumference has been proposed for the new ILC baseline design and would allow considerable reduction of the number of components, wiggler magnets and costs. We also present the results for the luminosity upgrade option with shorter 3ns bunch spacing. In particular we will go through the evaluation of mitigation techniques for the ILC DR and discuss the integration of the CesrTA results into the Damping Ring design.

Furthermore (with Kiran Sonnad, Cornell) we have performed detailed simulations using the CMAD code for CesrTA single-bunch instability and linear emittance growth below threshold and preliminary comparisons with experimental data are discussed here in view of the validation of the simulation codes prediction for the ILC DR.

Beam Dynamics Issues / 35

CesrTA EC-Induced Beam Dynamics

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This talk will review recent data and simulation results related to electron-cloud induced beam dynamics studies at Cesr-TA.

Poster Session - Board: 6 / **36**

TE Wave Measurements at CesrTA

Author: John Sikora Sikora[1]

Co-authors: Kenneth Hammond [2]; Stefano De Santis [3]

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TE Wave measurement systems have been installed in the L0 and L3 regions of CesrTA. L0 is the location of 6 superconducting wiggler magnets; L3 has round beampipe through a chicane magnet (PEPII) and a NEG coated chamber. At both locations, rf relays are used to multiplex signals from a signal generator output, through the beampipe, and to the input of a spectrum analyzer. Software monitors can be triggered to take data on demand, or on changes in accelerator conditions such as beam current or wiggler fields. The poster will describe the TE Wave measurement technique, the installation of hardware at CesrTA and some measurement examples. It will also outline some of the problems in the interpretation of data, specifically the results of reflections and standing waves.

This work is supported by the US National Science Foundation PHY-0734867, and the US Department of Energy DE-FC02-08ER41538.

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VERSATILE DEVICE FOR IN-SITU MULTIPLE COATINGS OF LONG, SMALL DIAMETER TUBES

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TBD

Author: Claudio Rivetta[None]

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Electron cloud generation, trapping and ejection from quadrupoles at the Los Alamos PSR

Author: Robert Macek[1]

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Since the ECLOUD'07 workshop, our electron cloud studies have focused on understanding the main sources and locations of electron clouds (EC), which drive the observed e-p instability. Significant EC signals are observed in drift spaces and quadrupole magnets at PSR which together cover ˜65% of the ring circumference. Measurements using the EC diagnostic in a quadrupole have also shown significant trapping of electrons in the quadrupole well after the beam is extracted. Results making use of two longitudinal barriers to isolate the drift space electron diagnostic have provided definitive evidence that most of the drift space EC signal is "seeded"by electrons ejected longitudinally by ExB drifts from adjacent quadrupole magnets. Modeling of EC generation in 3D quadrupoles using a modified version of the POSINST code shows that a sizeable fraction of the electrons generated in the quadrupoles are ejected longitudinally into the adjacent drifts. The experimental findings and simulation results of this focus will be presented.

Poster Session - Board: 7 / **52**

Simulation of electron cloud induced instabilities and emittance growth.

Author: Kiran Sonnad[1]

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In this presentation, we will report the progress made in the past few years on simulations to study the electron cloud effects on the dynamics of beams in cicular accelerators. Results associated with various acclerators such as the Fermilab Main Injector, SPS, LHC, ILC damping rings will be shown. Comparisions between the results obtained from three codes, namely Warp, HeadTail and CMad will be discussed. More recent studies done on CesrTA will be discussed in greater detail.

co authors :
M. T. F. Pivi, J-L Vay, F. Zimmermann, G. Rumolo, G. Franchetti, R Thomas,
M. Billing, G. Dugan, M. Palmer, J. Crittenden, J. Calvey, D. Kreinick, R Holtzapple, D. Sagan, D. Rubin

Poster Session - Board: 8 / **53**

Simulations using VORPAL on the effect of imperfections and nonuniformities in TE wave propagation through electron clouds.

Author: Kiran Sonnad[1]

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The simulation code VORPAL has been used as a tool to study charecteristics of TE wave transmission in the presence of electron clouds for CesrTA. We look at how the electron cloud induced phase shift is influenced by (1) reflections of the wave, caused by possible protrusions in the beam pipe and (2)effect of nonuniformities of the cloud density distribution in the transverse plane.

Authors: K Hammond, J Sikora, S Veitzer, K G Sonnad

Updates from Operating Machines (cont'd) & Mitigation Studies / **54**

Experimental efforts at LNF to reduce Secondary Electron Yield in particle accelerators

Author: Roberto Cimino[1]

Co-authors: D. Grosso [1]; M. Commisso [1]; R. Larciprete [1]; T. Demma [1]; V. Nistor [1]

[1] *LNF-INFN*

A common effort in most of the accelerator centers is to develop new technologies to produce and test beam pipe inner walls of particle accelerators with an as low as possible Secondary Electron Yield (SEY). This item, in fact, is crucial in controlling Electron Cloud formation and in reducing its effects, that are well known to be a potential bottle-neck to the performances obtainable from present and future accelerators. Frascati has a longstanding experience in qualifying materials in terms of surface parameters of interest to e-cloud issues. We are routinely measuring SEY, its dependence from electron energy, temperature and scrubbing and we are about to be ready to study not only Photo Electron Yield (PEY) by using synchrotron radiation beamlines in construction at DAFNE, but more importantly, to characterize in situ the surface chemical composition and eventual modifications occurring during electron or photon irradiation. Such characterization effort is also suggesting ways to produce Low SEY materials. Some preliminary results will be here discussed.

Electron Cloud Build-Up Modeling / **55**

Electron Cloud Trapping in Quadrupole and Sextupole Magnets

Author: Lanfa Wang[1]

[1] *SLAC*

This talk will discuss the electron trapping mechanism in quadrupole and sextupole magnets. We will present the results in CESRTA and ILC quadrupole and sextupole magnets.

Poster Session - Board: 9 / **56**

Beam Dynamics Techniques

Author: Michael Billing[1]

Co-authors: Gabriel Ramirez [1]; Gerry Dugan [1]; John Sikora [1]; Kiran Sonnad [1]; Mark Palmer [1]; Robert Holtzapple [2]; Robert Meller [1]

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[2] *California Polytechnic State University, San Luis Obispo, CA*

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During the last several years CESR has been studying the effects of electron clouds on stored beams in order to understand their impact on future linear-collider damping ring designs. One of the important issues is the way that the electron cloud alters the dynamics of bunches within the train. Techniques for observing the dynamical effects of beams interacting with the electron clouds have been developed. These methods and examples of measurements are presented here.

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Electron Cloud Build-Up Simulations for the ILCDR's: Antechamber Benefit

Author: Miguel Furman[1]

[1] *LBNL and Cornell Univ.*

Corresponding Author: mafurman@lbl.gov

We review the simulation results for the electron cloud build-up for the ILC Damping Rings, for both lattice options considered (6 km and 3 km), in a field-free region and in a bending dipole magnet. While the 6 km lattice is slightly more forgiving than the 3-km lattice vis-a-vis the electron cloud effects, we conclude that, in general, the existence of an antechamber helps to dramatically reduce the electron-cloud density (factor ˜50) only if the peak secondary yield of the chamber surface is below a certain critical value. This critical value is in the range ˜1.1˜1.3, depending on various details.

Poster Session - Board: 11 / **58**

Synrad3D photon propagation and scattering simulation

Author: Gerry Dugan[1]

Co-authors: David Sagan [1]; Saroja Milashuk [1]

[1] *Cornell University*

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As part of the Bmad software library, a program called Synrad3d has been written to track synchrotron radiation photons generated in storage rings. The purpose of the program is primarily to estimate the intensity and distribution of photon absorption sites, which are critical inputs to codes which model the growth of electron clouds. Synrad3d includes scattering from the vacuum chamber walls using X-ray data from an LBNL database. Synrad3d can handle any planar lattice and a wide variety of vacuum chamber profiles. A description of the program will be given, together with some examples of results.

Poster Session - Board: 12 / **59**

Electron Cloud Modeling Results for Time-Resolved Shielded Pickup Measurements at CesrTA

Author: Jim Crittenden[1]

Co-authors: Giovanni Rumolo [2]; John Sikora [1]; Mark Palmer [1]; Sergio Calatroni [2]; Xianghong Liu [1]; Yulin Li [1]

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The Cornell Electron Storage Ring Test Accelerator (CesrTA) program includes investigations into electron cloud buildup, applying various mitigation techniques in custom vacuum chambers.
Among these are two 1.1-m-long sections located symmetrically in the east and west arc regions. These chambers are equipped with pickup detectors shielded against the direct beam-induced signal. They detect cloud electrons migrating through an 18-mm-diameter pattern of holes in the top of the chamber.
A digitizing oscilloscope is used to record the signals, providing time-resolved information on cloud development.
Carbon-coated, TiN-coated and uncoated aluminum chambers have been tested.
Electron and positron beams of 2.1, 4.0 and 5.3 GeV with a variety of bunch populations and spacings in steps of 4 and 14 ns have been used. Here we report on results from the ECLOUD modeling code which highlight the sensitivity of these measurements to model parameters such as the photoelectron azimuthal and energy distributions at production,

and the secondary yield parameters including
the true secondary, rediffused, and elastic yield values. In particular,
witness bunch studies exhibit high sensitivity to the elastic yield
by providing information on cloud decay times.

Poster Session - Board: 13 / **60**

Using Coherent Tune Shifts to Evaluate Electron Cloud Effects on Beam Dynamics at CesrTA

Author: David Kreinick[1]

Co-authors: Gerald Dugan [1]; James Crittenden [1]; Marco Venturini [2]; Mark Palmer [1]; Matt Randazzo [3]; Miguel Furman [2]; Robert Holtzapple [3]; Zhidong Leong [1]

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One technique used at CesrTA for studying the effects of electron clouds
on beam dynamics is to measure electron and positron bunch tunes under
a wide variety of beam energies, bunch charge, and bunch train
configurations. Comparing the observed tunes with the predictions of
various simulation programs allows the evaluation of important
parameters in the cloud formation models. These simulations will be
used to predict the behavior of the electron cloud in damping rings
for future linear colliders.

Poster Session - Board: 14 / **61**

CesrTA Low Emittance Tuning

Authors: David Rubin[1]; David Sagan[1]; Jim Shanks[1]; Yariv Yanay[1]

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Low emittance tuning and characterization of electron cloud phenomena are central to the CesrTA R&D program. A small vertical emittance is required in order to be sensitive to the emittance diluting effects of the electron cloud. We have developed techniques to systematically and efficiently eliminate optical and alignment errors that are the sources of vertical emittance. Beam based measurements are used to center the beam position monitors with respect to the adjacent quadrupoles, determine the relative gains of the BPM button electrodes, and measure the BPM tilts, thus allowing precision measurement of transverse coupling and vertical dispersion. Low emittance also requires that the tune plane be relatively clear of nonlinear coupling resonances associated with sextupoles. We report on tests of a sextupole distribution designed to minimize resonance driving terms. We also report on efforts to measure sextupole strengths. Our standard low emittance tuning procedure typically yields sub 20pm emittance in one or two iterations. With tuning, we achieve a vertical emittance of εv ˜15 pm at 2.1 GeV.

Poster Session - Board: 15 / **62**

In Situ SEY Measurements in CesrTA

Author: Jin-Sung Kim[1]

Co-authors: David Asner [1]; Joe Conway [1]; Mark Palmer [1]; Shlomo Greenwald [1]; Tobey Moore [1]; Valeri Medjidzade [1]; Yulin Li [1]

[1] *Cornell University*

Measuring secondary electron yields (SEYs) on technical surfaces in accelerator vacuum systems provides essential information for many accelerator R&D projects, such as the ILC Damping Rings, regarding to electron cloud growth and suppression. As a part of CesrTA research program, we developed and deployed SEY in-situ measurement systems. Two such SEY systems were installed to expose samples with direct and scattered synchrotron radiation (SR), and the SEYs of the samples were measured as a function of SR dosages. In this poster, we describe the in-situ SEY measurement systems and the initial results on bare aluminum and TiN-coated aluminum samples.

Updates from Operating Machines (cont'd) & Mitigation Studies / 63

Overview of the CesrTA R&D Program

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The Cornell Electron Storage Ring (CESR) is configured as a test accelerator (CesrTA) for investigation of electron cloud phenomena in the regime of low emittance damping rings. The storage ring is equipped with superconducting damping wigglers and focusing optics to reduce horizontal emittance to 2.5 nm at 2.1GeV. The machine is instrumented with detectors (retarding field analyzers) to measure the growth of the electron cloud in wiggler magnets, dipoles, quadrupoles and field free drifts. Shielded button pickups are used to measure the time development of the cloud. A gated tune receiver is used to measure the cloud induced tune shift along a train of bunches and to identify sidebands associated with a head tail instability. An xray camera with high speed readout provides a single pass measurement of the vertical size of each bunch in a long train of bunches, so that emittance growth due to the electron cloud can be observed. Various mitigations are tested by installation of prepared vacuum chambers in association with retarding field analyzers. The phase shift in the transmission of a TE wave propagated between adjacent beam position monitors provides a measure of the local electron density, obviating the need for specialized detectors. We measure the energy dependence of the secondary emission yield of a variety of sample materials, including the effect of beam processing. We utilize high bandwidth precision beam position monitors to measure and correct transverse coupling and vertical dispersion in order to minimize vertical emittance. Our low emittance tuning procedure typically yields vertical emittance less than 20pm in one or two iterations, so that measurements of electron cloud effects peculiar to ultra-low emittance can be readily accomodated. Modeling and simulation of RFA detector response, electron cloud growth, electron cloud - beam interaction, cloud as plasma, and nonlinear beam dynamics provide context for interpretation of the experimental data, and motivation to pursue additional measurements and develop new experimental techniques.

Beam Dynamics Issues / 64

Control of Transverse Intra-Bunch Instabilities using GHz Bandwidth Feedback Techniques.

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Electron cloud driven instability can impose limitations on the maximum stored beam current in present and future accelerators. It drives inter-bunch and intra-bunch instabilities. Feedback control techniques have been proposed to mitigate transverse instabilities within a bunch as an extension of techniques used to control inter-bunch (coupled-bunch) instabilities.

The US LHC Accelerator Research Program (LARP) has supported a collaboration between US labs and CERN to explore systems to mitigate E-cloud instabilities and transverse mode coupled instability (TMCI) for the SPS and LHC machines. For intra-bunch (within a bunch) control of nanosecond scale bunch lengths the feedback channel has to be wide-band (GHz range) to be able to measure and control the vertical position of individual sections of a bunch.

The design and implementation of the feedback control system involves the modeling and identification of the bunch dynamics, the design of a feedback control algorithm, and the selection of digital and analog hardware that operates in the GHz range. We present the goals of this collaboration and analyze the different research lines to implement and evaluate a full-function prototype feedback system for the SPS. We include details of the feedback system topology and technical limitations, modeling and identification of the bunch dynamics via simulators and machine measurements. We estimate the necessary control bandwidths, and complexity of the processing channel via design considerations for the control algorithm. Very initial efforts at modeling feedback control via reduced bunch models and semi-realistic feedback system specifications are presented.

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Electron Cloud Build Up and Instability in DAFNE (Rescheduled Talk)

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Updates from Operating Machines (Hartill/Suetsugu)

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