ICFA Beam Dynamics Newsletter, No. 14

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Contents

1: Forewords

1.1 From the Chairman of ICFA Beam Dynamics Panel

K. Hirata `hirata@kekvax.kek.jp` The chairman

1.1.1 News from the Panel

On the occasion of the PAC97, we have held the 12th panel meeting in Hotel Vancouver. I will show the minutes below. One of the highlights were activity reports of the working groups. The working group for the High Intensity High Brightness Hadron Beams is the newest one and is going to encourage and promote the international and inter-laboratory collaborations. The chairman of the future light source working group was changed from Jean-Louis Laclare to Kwang-Je Kim, who had been a panel member from April 1997. Some Advanced ICFA Beam Dynamics Workshops are now scheduled. I believe that we should offer workshops which aim to extend the research front of the beam dynamics community.

In the panel meeting, D. Brandt (representing J. Jowett) raised the questions:

1. Does an article in the newsletters represent the opinion of the panel?
2. What one can do if (s)he does not agree with an article in it?

The answers are as follows:

1. No, the author is responsible for the article,
2. (S)he is encouraged to submit an article (or a letter to the editor).

Unless the submitted article is obviously and scientifically wrong, the editors prefer to show it to the beam dynamics society, sometimes expecting reasonable responses from the society.

The most recent information on the activities of the Beam Dynamics Panel can be found at the WWW site

`http://www-acc-theory.kek.jp/ICFA/icfa.html`

which also has European and Americal mirror sites. Now, ICFA itself has its own home page at

`http://www.fnal.gov/directorate/icfa/icfa_home.html`

where you can find its mission, history, past activities and so on.

1.1.2 Minutes of the 12th panel meeting

The 12th meeting of the ICFA Beam Dynamics panel was held at the Hotel Vancouver, Vancouver on 15 May 1997. The following panel members took part:

W.Chou, K.Hirata, D. Brandt (for J.M. Jowett), K.-J.Kim, J.-L. Laclare, S.Y.Lee, H. Mais, L. Palumbo, C. Pellegrini, E. A. Perelstein.

R.A. Baartman (TRIUMF) attended the meeting as an observer. Appologises were received from C. Zhang, D.Pestrikov, A. Ando, A. Hofmann, and P. Chen.

1.1.2.1 Reports of Working Groups (WG)

Tau-Charm WG The activity of the tau-charm WG was reported by Perelstein, the leader. A report "The challenge of Tau-Charm Factories" was completed by L. Teng based on the discussions within the WG through e-mail. This appeared in the recent ICFA Beam Dynamics Newsletter (no. 13). The next WG activity will be the workshop in Frascati this October, where one whole day will be devoted to the discussions on the tau-charm factories. See

`http://www.lnf.infn.it/conference/icfa97.html`

Light Source WG The activity of the future light source WG was described by Laclare, the leader. Because of the recent change of his position (moved from ESRF to SOLEIL), he was sorry that he could not continue to work as the leader of this WG. The panel concluded that Kim will become the new leader and Laclare will serve as the vice-leader. Laclare made some proposals for the activity of the WG, based on his thinking during his leadership:

1. He intended to include the beam dynamics, R & D and associated techniques into the activity of the group and extend its interest to FEL's (ring driven and linac driven) as well as the ring accelerators.

2. To establish links with all SR labs, he wanted to have one correspondent from each lab. To spread all relevant information, the publication of the newsletter and the preparation of the WWW site was intended with list of parameters of all SR sources with regular update.

3. He wanted to establish a regular links with the user communities.

4. There are several regular workshops on the light sources. In particular, he wanted to continue the series of the workshops on the "new generation" (the first was in ESRF and the second was in Argonne) under the ICFA sponsorship.

5. There are several schools related light sources. He wanted to review the program of specialized schools.

High Intensity Proton WG The activity of the recently created WG on High Intensity High Brightness Hadron Beams was reported by Chou, the leader. The WG had its first group meeting on May 13, 1997 at Hotel Vancouver during the PAC 97 conference. The highlights of the discussions include:

1. The mini-workshop series will continue. The last one held in May, 1997 at BNL on longitudinal dynamics and rf issues was successful. The organizing committee, of which a majority has joined this group, will retain its responsibility for organizing future mini-workshops.

2. There are now fourteen members in this group. It was approved that another four people (R. Cappi/CERN, B. Weng/BNL, A. Thiessen/LANL and P. Martin/FNAL) to be invited to join this group.

3. J.G. Wang introduced a small electron ring that will be built at the University of Maryland and can be used for the study of space charge effects in hadron machines. This group strongly endorsed this project and decided to put on its agenda the promotion of beam dynamics experiments on machines.

4. This group will maintain several important machine parameter tables, such as the table of proton synchrotron performance comparison, the particle loss table of existing proton machines, etc.

5. This group has set up a home page on the Web. The address is:

   `http://www-bd.fnal.gov/icfa/`.

   It includes a bulletin board for interactive communications.

6. J. Wurtele, who is an organizer of the muon collider workshops, expressed his wish to get high level ICFA support for muon collider studies.

7. This group will consider the feasibility to sponsor a symposium of high intensity high brightness hadron beams. It may include both the high energy physics community and the nuclear physics community for machines such as Main Injector (FNAL), PS/SPS (CERN), JHF (KEK), AGS (BNL), PSR (LANL), ISIS (RAL), DESY III/PETRA (DESY), proton driver of the muon collider, spallation neutron source, APT, etc.

8. The group meeting will be held about once a year. E-mail and webpage bulletin board will be the main tools for communications among group members.

1.1.2.2 Reports on Workshop Preparation

The 13th Advanced ICFA Beam Dynamics workshop: 2nd Generation Plasma Accelerators was reviewd by Hirata. It will be held together with JAERI-Kansai International Workshop. Two workshops will run together with the combined plenary talk sessions but the working group discussion will be done separately. It was approved by the panel that this 13th Advanced ICFA Beam Dynamics Workshop will also be sponsored by the Novel and Advanced Accelerator Panel.

The 14th Advanced ICFA Beam Dynamics workshop: Beam Dynamics Issues in e+e- Factories was reviewd by Palumbo. The organizing committee was held a few days before in Vancouver. The chairmens of the working groups and the tau-charm days will open WWW home pages to organize better working groups. The number of participants is already enough but the committee can accept people until the number considerably exceeds 80.

The 15th Advanced ICFA Beam Dynamics workshop: Quantum Aspects was reviewd by Hirata. It will be held on 4–9 January 1998 in Monterey, California. The topics included are

1. Quantum Fluctuations in Beam Dynamics;

2. Photon-Electron Interaction in Beam Handling;

3. Beam Phenomena under Strong EM Fields;

4. Production and Handling of Condensate Beams;

5. Fundamental Physics under Violent Acceleration;

6. Quantum Methodology in Beam Physics.

The list of the chairmen of the working groups and the list of Invited speakers were shown.

The next ICFA mini-workshop on high intensity high brightness hadron beams will be held November 5-7, 1997 at CERN. The title is “Transverse emittance preservation and measurements.” The organizer is Roberto Cappi (CERN/PS).

A proposal of a workshop was made by Pellegrini. It will be held in Arcidosso, 7–11 September 1998. The subject is “Nonlinear and Collective Phenomena in Beam Physics”. The Organizing Committee consists of: Swapan Chattopadhyay (LBNL), Max Cornacchia (SLAC), Kohji Hirata (KEK), Claudio Pellegrini (UCLA), Alberto Renieri (ENEA-Frascati), Gaetano Vignola (INFN-Frascati). It was supported by the panel and Hirata will propose its approval to ICFA.

1.1.2.3 WWW

It was requested by Hirata that everbody makes a link to the ICFA Beam Dynamics Panel home page.

1.1.2.4 Newsletters

Jowett has proposed that the WWW version of the newsletter should be prepared in PDF format. It was discussed that the ps format is still most popular and we should keep PS format. It was recommended that we try PDF format and observe how many people prefer PDF to PS.

It was argued and approved that the newsletter should have several regular correspondents from many regions where the membership of the panel does not cover.

It was propsed and approved that the newsletter shows a list of recently finished PhD-theses. The editors will discuss the appropriate format for it and try to start it soon.

To help the Advanced and Novel Accelerators (ANA) panel, it was approved that the beam dynamics newsletter offer several pages for this panel for around one year. It will be clearly stated that these pages are edited by the responsibility of the ANA panel.

1.1.2.5 Future Activities

It was reported that, based on the agreement between Hirata and Pellegrini, Pellegrini will remain in the Beam Dynamics panel and Hirata serves as a panel member of the ANA panel for a while to have a good and efficient collaboration between the two. This idea was supported by the panel.

It was reported that Siemann and Lebedev will retire from the Beam Dynamics panel and move to the new panel “Advanced and Novel Accelerators”.

1.1.2.6 Next Meeting

The next panel meeting will be held either in the occasion of EPAC98 or HEACC98. Hirata will decide based on the number of panel members who can attend the conferences.

The panel members should like to thank the organizing committee of PAC97 for providing the facilities for the meeting and for the hospitality extended to them.

1.2 The ICFA Beam Dynamics Newsletter No. 14

John M. Jowett `John.Jowett@cern.ch` CERN

Editing this newsletter for a couple of years has made me think again about the relationship that we, practitioners of beam dynamics, and, by extension, most of our colleagues in the physical sciences, have with the written word. It's actually quite hard to persuade many of us to sit down and write for the newsletter. The editors' task is less one of technical redaction than of cajolery by email.

This is curious: you would think that we would welcome the opportunity to set down thoughts and opinions about our field, relatively free of the dreary constraints of writing for lab reports and published papers. Yet, like long-term jailbirds, we have gotten used to these restrictions and seem loath to assume a little freedom when it comes our way.

Nevertheless, recent newsletters have provided outstanding exceptions to prove this rule. Personally, I am delighted with the new series of invited articles by senior figures in our field. In this newsletter, the contributions by Andrew Sessler and Bruno Zotter are full of insight, opinion and historical information that would be hard to come by otherwise. While the history of beam dynamics is interesting in itself, the experience and knowledge of authors like these imbue their ideas on present and future directions of the field with special value.

The Editors encourage other members of the Beam Dynamics Panel and other correspondents and readers of the Newsletter to consider who among their colleagues might contribute such articles and to propose their names to us. As always, anyone who wishes to volunteer a contribution can contact us directly or submit it as a letter to the editors.

Activity reports from laboratories or collaborations have always been a mainstay of the Newsletter. This issue shows the importance of the growing number of world-wide, inter-laboratory collaborations and working groups on specific topics, some of them created by the Beam Dynamics Panel itself. Besides these, we have reports of activities in several laboratories in Asia and Europe.

While an essential role of Beam Dynamics Panel members is to write some activity reports themselves, it is impossible to have a Panel member in, or even in contact with, every institution. The newsletter therefore relies on regular correspondents who provide information about activities in beam dynamics. The Editors encourage readers to become regular correspondents and contribute activity reports, especially for institutions that are not regularly represented in the newsletter.

Please remember, however, that articles in the newsletter are not a means of disseminating formal accounts of scientific results: that is for the usual journals, conferences and so on. The newsletter is a forum for *informal* communication within a global community of specialists.

Finally, I should like to draw attention to another new feature in this newsletter, the announcement of recent doctoral theses in beam dynamics. Please point this out to graduate students and their supervisors and encourage them to submit announcements following the guidelines in Sections 4.8 and 7.3.1.

2: Letters to the Editors

2.1 From Andrew M. Sessler

Andrew M. Sessler `Andrew_Sessler@macmail.lbl.gov` LBNL

> *This is a summary of the remarks made by A. Sessler at the presentation of the R.R. Wilson Prize during the PAC'97 in Vancouver. K. Hirata has asked him to present it in our newsletter.*

Thank you, thank you. Of course this Prize is the result of childhood training, great teachers, great co-workers and great students. All of them are honored; I'm only the spokesperson for the Group.

Normally, as you know, I would in public talks, make jokes and say things where I mean just the opposite. But here I feel constrained to act as a "statesman of science". That is a heavy responsibility. I could discharge that responsibility by talking about funding for research, the job situation for young scientists, or the state of education. All responsible, but heavy and depressing, subjects.

History Let me, rather, use this occasion to make some remarks upon the history, the present status and future of the field of accelerators. The field is only 70 years old; I have known essentially all the physicists who have made contributions to our science.

There are, in my opinion, five major components of modern accelerators. The first is the concept of RF acceleration. That started with Ising's suggestion, in 1924, and was achieved, by Wideroe, in 1928. The second component is the concept of bending particles in circles as conceived by E.O. Lawrence in 1929, and achieved by him and Stan Livingston for protons in 1930, and for electrons by Don Kerst in 1940. The third component is phase focusing, developed independently, by Ed McMillan and Veksler in 1944. The fourth is strong focusing conceived by Nick Christofilos and, independently, by Ernie Courant, Stan Livingston and Hartland Snyder in 1952. And the fifth is the understanding, and control, of collective (space charge) phenomena, developed by Don Kerst, Keith Symon, Ernie Courant, Jackson Laslett, Ken Robinson, and Claudio Pellegrini and many others, primarily in the 50's and 60's.

With major contributions in these five areas, augmented, of course, with numerous extensions of these basic ideas; the concept, and realization, of beam cooling; and advances in technology (vacuum, control circuits, power generators, super conducting magnets, better cathodes, ion-sources, and photo-cathodes, beam control by feedback, better materials for a variety of uses, and, of course, computers for display of accelerator parameters, control of beams, and the design of machines, etc.) the components were in place to build major accelerators and that, as we know, is exactly what was done.

Future Looking to the future, we can see many things that probably will happen. Certainly there will be lots of technological advances. It is clear that we will have an "adiabatic" continuation of hadron collider (super SSCs), electron-hadron colliders (super HERAs), electron linear colliders (super SLCs), ion colliders (super RHICs), radioactive species accelerators, low-energy and medium-energy accelerators, and synchrotron radiation facilities. And, of course, there will be the application of accelerators to medicine, industrial processing, isotope production, and environmental clean-up.

Less clearly so, for it is not quite so adiabatic, but probably in our future, are X-ray FELs, muon colliders, gamma ray colliders, and neutron spallation sources. Possible in our future, but even less sure, are the large and sophisticated machines for the accelerator production of tritium, heavy ion fusion, accelerator energy production, and the burning-up of radioactive waste, as well as laser accelerators and diverse collective accelerators such as wake-field accelerators.

But even the best of my crystal balls only work for 3 or 4 decades into the next century, and even in that time frame, the really interesting work no one can foresee, beyond that time-frame it is anybody's guess. That, after all, is what it is all about, which is why our field should be supported and, equally important, why we find it so exciting.

Beam Physics Accelerators have come a long way during my lifetime and, also, during my lifetime has come an ever-changing, and ever-improving, attitude of other scientists and engineers to our discipline. That hasn't happened by accident, but is the result of much effort, by very many individuals.

These very conferences, started in the 60s, and copied first by the Soviets, then by the Europeans, and, just now copied by the Japanese, have been very important. The development of programs in some of the engineering and some of the physics departments have been important in the teaching and training of young people. And the Accelerator Summer Schools have been important in extending the training of young workers already in the field. The establishment of a Topical Group, and then a Division, within the American Physical Society, has given us physicists a proper "home". This has allowed us, and our discipline, to receive appropriate recognition from other physicists. It has also allowed us to give proper recognition to our fellow workers through Fellowship and Prizes.

All, however, isn't perfect. Much more needs to be done. Many of us need to work on these problems, for they won't be solved in one grand announcement, but rather by the accumulated effect of many small actions.

Clearly we must get more departments to create professorships and give courses in accelerator physics; this is the source of young people and an increased university presence is essential for us. Recognition of our discipline, and consequent direct support of some of our activities, by the funding agencies is necessary. As you know, a high-level panel was formed by the DOE to do just that, after, I might say, about three years of lobbying by many of us. A report was submitted, and it was positive towards our field, but—so far—nothing has been done to implement its recommendations. I believe it is time to put more pressure on the DOE.

Sometimes we hurt ourselves by non-thinking actions; an example is the location and timing of the next PAC Meeting. As you know the APS is having, that year a great celebration of its Centenial. Many physicists will attend the celebration. (I will make great efforts to have as many attend as possible, I have already gotten more than 30 Nobelists to agree to attend.) The accelerator people will probably not attend, for the PAC Meeting is at a different time and in a different city. You can say, in political terms, that I haven't even delivered my own Division. At the Centennial we will not be missed by our absence, we will simply not be missed. And that just adds to the lack of recognition we so desperately want—and need—from our colleagues.

Conclusion Let me end on a cheerful note, by reminding you of the importance of accelerator physics. Not only are accelerators essential to high energy physics and nuclear physics, but they play an important role in fusion research, and an ever-increasing role in condensed matter physics, chemistry, biology, and medicine. A world without ion-implantation devices, synchrotron radiation facilities, medical isotope and therapy accelerators would be a very different, and a much poorer, world. We can confidently expect that beam physics will become even stronger in the future.

And, now, I want to thank you—once again—for this recognition, and the opportunity to make some remarks.

Thank you.

3: Reviews of Beam Dynamics Problems

3.1 From Analysis to Simulation—30 Years of Accelerator Physics

Bruno Zotter `Bruno.Zotter@cern.ch`

3.1.1 Microwave Tubes

Nearly 30 years ago, in April 1968, I came to CERN after working for over 5 years in the USA on low-noise travelling wave tubes (TWTs for short). Actually, I had already constructed Austria's first—and probably only—TWT for my diploma at the Technical University of Vienna in the mid 50-ies. It consisted of an electron beam of a few KeV energy, interacting with a surrounding helix, which slowed the circuit wave to just below the beam velocity—then energy was transferred to it, and the waves could be amplified over a wide frequency region. This property of high gain over a very wide bandwidth made TWTs a favourite choice for satellite transceivers up to recent times, in particular since they often had life expectancies of several years. My thesis tube did not have such a problem—after 2 weeks of hesitant operation, the getter started to become white and the tube was given to the museum collection.

During my studies I spent a summer at the Siemens Tube Factory in Munich, Germany, where I had already worked on TWTs. Another summer I spent at the Philips Laboratories in Eindhoven, where I was asked to work on magnetrons, another type of microwave tubes. European industry had fallen behind in their development, although they were originally invented in Britain during the war. By the way, also the TWT was invented there—by the emigrant Austrian architect Kompfner, then working for the British Admirality.

In the early 50-ies, jobs for physicists were almost as scarce as nowadays, and my supervisor at the Philips Laboratories had spent a year or two as truck driver for a chocolate company before finding a job in his field. After my diploma I found a job at the International Patent Office in The Hague, Netherlands, during which time I also prepared my PhD thesis. It was mainly on the computation of electro-magnetic fields in re-entrant cavities, using field-matching techniques. Actually I had to do the work twice, as I found practically the same problem being published in a journal article while I was still working on it—and I was honest (or careless?) enough to show it to my Professor. He then changed the task slightly, which meant that I had to start all over again. For this I needed to invert 20 by 20 matrices, in order to get reasonable accuracy for the expansion coefficients—a task which then occupied the "Rechenzentrum" of the Technical University in Vienna for weeks—nowadays it is done in seconds even on small, hand-held computers!

After a decade of fervent research and development (R&D), microwave tubes had started to suffer from a typical ill of engineering: since many tubes reached a very long life, they needed to be replaced only after several years of operation—and therefore their development did no longer interest industry. In addition, semiconductor devices started to become available for many of their tasks, and seemed to be more promising for the future.

With the end of microwave tube R&D in sight, I was looking for another field where I could use my previous experience: particle accelerators seemed to be the right answer. After all, a linac is just a travelling wave tube operated in reverse— instead of giving energy from the beam to the circuit wave, it is taken from the it and accelerates the beam. The main difference was the relativistic velocity of the beam—but this made the problem only more interesting.

3.1.2 The CERN Intersecting Storage Rings ISR

My first task at CERN was to calculate coherent beam stability in the ISR, the world's first high energy proton collider. In these days, a major concern was the "resistive wall instability". It had just been described in two seminal papers by Laslett and Sessler from the Lawrence Berkeley Laboratory. However, Skrinski and Dikanski from the Institute of Nuclear Physics in Novosibirsk also claimed priority—it sounded a bit like the old quarrel between Marconi and Popov of who invented the radio! However, the resistive wall effect had already been known for quite some time in the microwave tube community, and was actually made use of in the "resistive wall amplifier", built and described in the literature by a fellow from Bell Labs called Haeff (and hence also called "Haeff tube"). A few years later its detailed analysis was published by Prof. Birdsall, from the same University of California in Berkeley as its "discoverers" in the accelerator field!

The next years I continued to work on the ISR, which started to operate in 1971. These years were very fruitful and led to many new insights, mostly for myself. With my colleagues of the "Theory Group"—which then was not yet a bad word—we calculated the dangerous effects of the many vacuum chamber enlargements, which were forming "accidental cavities", whose resonances could make the beam unstable well below the desired current levels. A large program was started to install damping resistors in all 300 of these enlargements, an exercise which seems to be repeated again in our days, to suppress resonances in the vacuum chamber enlargements of the SPS, the large CERN "Super Proton Synchrotron", so it can reach the higher current levels desired for LHC injection.

In order to better verify the theoretical predictions, Pete Bramham and myself had installed an "experimental cavity" in the ISR. It had a variable resonant frequency, and also variable impedance by changing the coupling to an external load with a rotating loop. This should also have permitted to make the impedance small enough to avoid limiting the circulating beam during operation. Or so we thought— until Albert Hofmann, freshly imported from the defunct Cambridge Electron Accelerator near Boston, measured that our cavity was still the largest impedance in the machine, and we quickly installed a set of short-circuit claws to be able to close the cavity gap completely!

Another subject of interest was the "e-p instability" which occurred due to the accumulation of electrons in the potential well of the proton beam of the ISR. The effect appeared first as repetitive background spikes, every few seconds or so, which sent the experimenters up from their detectors to the ISR control room to ask what was going on. The original suggestion of a two-beam instability could soon be verified by experiment, and led to a campaign of improving electron clearing, and also further reducing the vacuum pressure which was already at a record low for such a large vessel as the ISR vacuum chamber.

The accumulation of current in the circulating beam in the ISR was limited originally by the "brick-wall effect"—an seemingly impenetrable maximum current where part of the beam was lost again and again. It was recognised as being caused by the change of tune across the beam due to the increasing charge in the impedance environment. The repeated compensation of the tunes and their slopes with the quadrupoles and the poleface windings of the dipole magnets permitted increasing the current almost indefinitely, until over 60 A had been stored. However, the compensation had to be applied every 3 A or so. Originally, it was based entirely on theoretical estimates of the detuning, later this was adjusted by actual measurements of the tune change in the machine.

We also did a series of experiments on the beam-beam effect for proton-proton collisions. Contrary to the quite hard limits for electron colliders, there appeared only a slow blow-up of the beam size, presumably due to the absence of radiation damping. At tune shifts of 0.01-0.02, the growth of the beams became fast enough to lead to beam loss and subsequent background near limiting apertures. In order to achieve such large tune shifts, the beta-function of the test beam had been increased by special “high beta optics”. These were designed on some early, rather primitive computers—using punched cards which most younger physicists know only from hearsay.

One of these attempts of “computer matching” the lattice to achieve high beta-functions inadvertently led to the inverse result— quite small beta-functions were obtained in all 8 interaction regions of the ISR, using just the existing “tuning quadrupoles”. Such a configuration would have been highly desirable for the experimenters on the ISR, giving increased luminosity to all of them. However, its development was stopped, since it did interfere with the construction of a (single), very-low beta insertion using super-conducting quadrupoles, which had been going on already for several years and was then near completion.

Rather than pursuing the development of a new option, the “troublemaker” was sent for 2 years to the SPS where the p-pbar operation was being developed and theoretical help was still welcome. After those 2 years the SC low-beta insertion had been completed successfully, but the ISR was already close to the end of its operation. It had been decided that man-power and money were needed in order to build LEP.

3.1.3 The Large Electron Positron Storage Ring LEP

Progressing from coasting proton beams in the ISR to bunched electrons in LEP, the work on instabilities—and also on beam optics—continued. Actually, we had imported the tracking program PETROS from DESY, and found that it was indeed possible to obtain stable orbits on a computer also in such very large, high-energy electron rings after correcting the chromaticity carefully—earlier work by the competition had claimed that 8 out of 10 machines tested with random seeds were unstable, and such machines could not be built with any guarantee of success!

The dominant role of TMCI for LEP was uncovered already during its design phase, and thus the limitations could be shifted to higher currents by a number of changes which are most easily seen from the simplified expression for the threshold current:

$$I_{\mathrm{thresh}} = \frac{C_{\mathrm{tmc}} \omega_s E}{e \sum_i \beta_i \kappa_{\perp,i}(\sigma)} \,, \tag{3.1}$$

where $C_{\mathrm{tmc}} \approx 8$ is a constant, ω_s the synchrotron frequency, E/e the beam energy (in Volt), β the value of the amplitude or “beta” function in the transverse plane of interest (usually the vertical one), and $\kappa_\perp$ the transverse loss (or kick) factor, which is a strong function of the rms bunch length σ, usually decreasing as $1/\sigma$ for longer bunches. The summation is over all elements which have significant values of the transverse impedance , and hence of the loss factor. It seems obvious that a high synchrotron frequency should increase the threshold current, but a high rf-voltage also decreases the bunch length which therefore needs to be adjusted independently, e.g., by wigglers which were installed in LEP partly for that reason. A higher injection energy also helps, but is limited by the strength of transfer line magnets and possible radiation damage in the injectors. Lowering the beta-functions, in particular at the rf-cavities which are the major contribution to the transverse impedance in LEP, was pursued by adjusting the phase advance to over 100 degrees which minimizes the average value. However, the main effort was spent on reducing the transverse impedance of the various components in the LEP vacuum chamber, in particular the large number of bellows. A careful design of shielding with sliding contacts brought their effect to less than half of that of the rf-cavities, in spite of the larger beta-functions at their positions. Many other components were carefully calculated or measured before their installation in LEP, such as separators, pick-ups, experimental chambers, collimators etc.,etc.

The theory of transverse mode coupling was slowly improved, after its original formulation by Rudolf Kohaupt. Together with Gilbert Besnier from the University of Rennes, France, we developed a consistent theoretical model, and YongHo Chin wrote the computer code MOSES which gave results in good agreement with observations. In his thesis written at CERN, Francesco Rugggiero extended the theory to localised impedances. We also derived a simple two-particle model which actually showed most of the important results of more complicated theories.

The calculation of impedances and wake fields, required for quantitative estimates of instability thresholds, was constantly improved, and verified by measurements on LEP during MD (machine development) studies. This effort finally led to the somewhat presumptuous task of writing a book, together with Sam Kheifets from SLAC, with whom I had collaborated several times in the past, with the lengthy title “Impedances and Wakes in High-Energy Particle Accelerators”. It is finally finished, and has already been announced by the publisher—so we learned that it will be a bargain at only 46 $!

3.1.4 Simulation of Single Bunch Stability

With more and more powerful computers available, the purely analytical work can now be supplemented—and sometimes even replaced—by simulation, using quite detailed “data bases” for the large number of elements which can interact with a beam. However, the physical insight offered by analysis remains important to correctly interpret the flood of output produced by computers. The final test remains the comparison of theoretical results with machine experiments, and the importance of such “academic MD studies” is now often underrated. The correct understanding of the physical phenomena occurring in the complex environment of a storage ring can often lead to easier operation and better performance.

A number of simulations codes for single bunch stability in circular accelerators or storage rings were developed, mostly by fellows and scientific associates in the LEP Theory group, which was later called Accelerator Physics group of the SL division. The first of these codes was based on wakes of single particles or “delta function distributions”, i.e. on wake functions which can be used as Green functions for an arbitrary distribution. The code, written by Daniel Brandt in the early 80-ies, was called SIMTRAC. It was limited to tracking the motion of a several hundred “super particles’ over a few thousand turns, corresponding to one or two damping times in LEP at injection energy - a few thousand “super particles” could be tracked if one was patient enough to submit the job over a weekend! To speed things up, all cavities (and other impedances) were usually concentrated at a single position of the machine circumference. This led to the interesting results of reduced thresholds for the TMC instability at particular tunes, corresponding to “coherent synchro-betatron resonances”. The effect was reduced when several cavities were distributed around the ring, and even disappeared completely for a particular distribution - but the simplification of a single cavity had led to the discovery of these resonances!

A disadvantage of this code was the necessity to compute wake functions, which can only be approximated rather poorly by wake potentials of very short bunches - and this is also very time consuming even with the fastest computers! Furthermore, the results of the simulation depended quite strongly on the number of super particles used, and an extrapolation procedure was used to get predictions for the number of particles actually present in a bunch. Hence another approach was to use the wake potentials of finite distributions, and the expansion into Hermite polynomials was the most natural one for nearly Gaussian electron bunches. A code based on this method, called HERSIM, was written by Vincent Nys and later improved by Tai-sen Wang. It used many large, two-dimensional, pre-calculated tables of wake potentials (for bunch length and distance from the bunch centre) to get simulation results faster. The tables for the wakes of Gaussian bunches could be obtained from a single computer run with the shortest bunch expected, and also the tables for the Hermite polynomials could be generated from them by numerical differentiation.

However, this process and the large oscillations of higher-order wakes limited the expansion to about 6 terms. Unfortunately, the series in Hermite polynomials do not converge very well for bunch distributions which are not very close to a Gaussian, and such a low number of terms then gives a rather poor approximation. Nevertheless, the results were much less dependent on the number of super particles used, and could be used to predict the performance of LEP for a variety of lattices and tunes.

This problem of representing arbitrary distribution functions correctly was finally solved by expanding then into shifted “basis functions”, of which the triangular basis was the simplest one without infinite slopes. The resulting simulation program, written by Gianluca Sabbi, was called TRISIM and was extremely fast compared to the older ones. By using triangles of a fixed width, it needs only one-dimensional tables, and computer simulations with tens of thousand super-particles over many damping times are nowadays possible in less than an hour. The program was used extensively to investigate reactive feedback in LEP, and also to prepare the machine experiments with high synchrotron tunes which led to record currents of nearly 1 mA/bunch. A variant of the program, called GAUSSIM, was recently developed by Olaf Meincke to ease the computation of wakes of very short basis functions. Finally, the code TRISIM-3D is being developed by Andreas Wagner to permit computation of instabilities in all three spatial directions, and to investigate the effect of current-dependent coupling of transverse oscillations due to wake fields of structures which are not axially symmetric.

Nevertheless, the results of all these simulation programs nowadays coming out of the computers at great speed, need understanding and correct interpretation in order to verify their credibility. It is very easy to discover effects which are purely due to some limiting assumptions in the input or the equations of motion, and one thus needs to be very careful in making predictions. This is where the insight from analytical work is still very valuable—together with verification by machine experiment if possible.

4: Activity Reports

4.1 Minutes of the 1st Meeting of the ICFA Working Group on High Intensity High Brightness Hadron Beams

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1. The first meeting of the ICFA Working Group on High Intensity High Brightness (HIHB) Hadron Beams was held May 13, 1997 at Hotel Vancouver, Vancouver, B.C., Canada, during the 1997 Particle Accelerator Conference. Seven members attended this meeting: R. Baartman, W. Chou, T. Linnecar, Y. Mori, T. Roser, J. Wurtele and Z.Y. Guo (for C. Zhang). Five members were excused (P. Colestock, S. Machida, D. Pestrikov, J. Galayda and G. Rees), and two were absent (R. Davidson and J. Maidment). The chairman of the ICFA Beam Dynamics Panel, K. Hirata, and four observers (E. Jensen/CERN, P. Martin/FNAL, L. Teng/ANL and J.G. Wang/U. Maryland) also attended this meeting.

2. The following briefings were presented to this meeting:

   - Hirata: The ICFA Beam Dynamics Panel and its mission;
   - Teng: The beginning of the ICFA;
   - Chou: The ICFA Working Group and its mission;
   - Martin: The 1st mini-workshop in May, 1996 at Fermilab;
   - Mori: The 2nd mini-workshop in December, 1996 at KEK;
   - Roser: The 3rd mini-workshop in May, 1997 at BNL;
   - Teng: Spallation neutron source activities at ANL;
   - Roser: Spallation neutron source activities at BNL;
   - Wang: The Electron Ring Project at University of Maryland;
   - Wurtele: The Muon Collider and its proton driver.

3. In order to make this group to be more representative and its work more effective, the meeting recommended to invite four more people to join this group: Roberto Cappi (CERN/PS Division), Phil Martin (FNAL/MI Department), Arch Thiessen (LANL/LANSCE) and Bill Weng (BNL/AGS Department).

   Note: After the meeting, these people were contacted and all have accepted our invitation. The ICFA Beam Dynamics Panel has approved their participation in this group.

4. The mini-workshop series on HIHB hadron beams will continue. This series features small size (20-25 participants), one selected topic each time, problem solving and no formal proceedings. The first two mini-workshops (May 1996 at FNAL and December 1996 at KEK, respectively) were held before the formation of this working group. Thus, the third one (May 1997 at BNL) was indeed the first time for it to be entitled an ICFA mini-workshop. The 18 next one will be November 5-7, 1997 at CERN (see Section 7.1.1). It has been approved by the ICFA. The topic is "*Transverse emittance preservation and measurements.*" The organizer is Roberto Cappi (CERN/PS).

The meeting decided that the present organizing committee will retain its responsibility for organizing future mini-workshops. In the meantime, proposals for new mini-workshops should be submitted to the ICFA for approval.

5. On behalf of Martin Reiser, J.G. Wang introduced a small project at University of Maryland. It is an electron ring with low energy (10 keV) and high beam intensity. The cost of this project is moderate (US$600K for hardware including contingency), while it has the potential to study some fundamental beam dynamics problems that are essential in the design and construction of large and expensive machines, e.g., the space charge effects in high intensity hadron beams. Therefore, this group strongly endorses this project and has decided to put on its agenda the promotion of beam dynamics experiments on machines.

6. This group will take the responsibility of maintaining several important machine parameter tables. For example, the table of the comparison of proton synchrotron performance, and the table of particle losses in existing proton machines.

7. J. Wurtele, who is an organizer of muon collider workshops, expressed his wish to get support from the ICFA for muon collider studies.

8. This group has set up a home page on the web. The address is:

   `http://www-bd.fnal.gov/icfa/`

   The announcements and summary reports of mini- workshops can be found there. It also includes a bulletin board for interactive communications.

9. As an integral part of the efforts for accomplishing its mission, this group will consider the feasibility to sponsor a symposium on high intensity high brightness hadron beams. It would include the high energy physics community, nuclear physics community and some industry. The machines to be addressed may include the Main Injector (FNAL), PS/SPS (CERN), JHF (KEK), AGS (BNL), PSR (LANL), ISIS (RAL), DESY III/PETRA (DESY), proton driver of the Muon Collider, spallation neutron sources and APT, etc.

   Note: After the meeting when we began to seek sponsors of this symposium, we first contacted Dave Sutter from the US Department of Energy. His response was positive.

10. The group meeting will be held once a year. E-mail and bulletin board on the web will be the main tools for communications among group members. The date and place of the next meeting will be announced in early 1998. Proposals are welcome.

4.2 Report from Future Light Source Working Group

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4.2.1 Greetings from the New Leader

As some of you may already know, I have been assigned as the Leader of the Future Light Source Working Group at the meeting of ICFA Beam Dynamics Panel held during PAC 97 in Vancouver, succeeding Jean-Louis Laclare. I am taking this job anticipating significant contributions from each of member of the Future Light Source Working Group. I thank all members, as well as others who are interested in the light source development, in advance for their time and effort.

The working group should establish an active communication channel. I expect that, at least for the beginning, the e-mail would be the main channel.

There are several items to discuss, starting with the suggestions Laclare made during the last ICFA meeting:

1. Preparing a document spelling out the scope of the Working Group.(beam dynamics issues, different generation techniques, make-up and terms of the membership, etc.)

2. Establishing links with SR laboratories (via WG members, one correspondent in each laboratories, news letters, www site updating machine and source parameters, etc.)

3. Establishing links with the user community. Such a link already exists in Europe. How about elsewhere?

4. Promoting workshops and schools, either new ones or connection with already established meetings such as ESLS and the international FEL meetings. How often should the 4th Generation Workshops (the second one was at ESRF in January 1996) be held? Every 3 years? The location of the next one?

It would also be also desirable for us to meet from time to time. In case a majority of the members could attend, the first meeting could take place during the SRI conference in Himeji during the first week of August.

4.2.2 Some Ideas for the Future Capability

The third generation light sources are based on undulators in straight sections of high current, low emittance electron storage rings. They provide time averaged spectral brightness approaching 10^{21} in units of photons $\mathrm{s}^{-1}\mathrm{mm}^{-2}\mathrm{mrad}^{-2}$ per 0.1% spectral bandwidth, up to about 10 keV photon energy, the radiation consisting of 10–20 ps bursts.

Several promising extensions of the capabilities in higher brightness, shorter pulse length, and higher photon energy, are possible. Storage rings with larger circumference could be designed to provide diffraction limited emittance up to 1 keV, achieving a factor ten increase in the brightness. A quasi-isochronous storage ring may provide a subpicosecond pulses. Free electron laser oscillators and amplifiers will be an important direction for very high brightness. There are also several ideas taking advantage of the recent progress in high power lasers, which could significantly extend the light source capability in various directions.

The undulator radiation is an incoherent sum of radiation from individual electrons. In a free electron laser (FEL), the electron beam energy is modulated leading to a density modulation leading to a coherent superposition of the wave trains from individual electrons, with a large enhancement in the intensity. The FEL operation requires a tighter beam quality requirement because the beam quality affect both the modulation as well as the radiation processes. Up to the UV spectral range (tens of KeV), the storage ring based free electron laser (FEL) oscillators should provide a spectral brightness several orders of magnitudes higher than available in the third generation light sources. For a sufficiently good beam qualities and long undulators, the spontaneous undulator radiation generated at the beginning should be amplified through he FEL process to a very high power, fully coherent transversely, and quasi-coherent temporally. Such radiation is called the self amplified spontaneous radiation, and is the basis of the several proposals taking advantage of the recent high brightness, high energy electron linac development. The SASE does not require mirrors so that it could reach 10 keV photons.

For short pulse capabilities, it is possible to take use the recently developed femtosecond, high power lasers, making them scatter a low energy electron beams to obtain femtosecond x-ray pulses. The method is limited due to the limited repetition rate of both linac and the laser pulsed. A higher repetition rate can be achieved by the femto-slicing technique, in which a low power , femtosecond laser beam interact and modulate a femtosecond portion of the electron beam through the FEL interaction, which can then be separated from the main beam.

In all these techniques, the most important factor is the electron beam qualities, namely the emittance. There are various ways to damp the electron beam emittances, perhaps the best known example is the radiative damping in storage rings. A similar damping can be induced in electron linac via the laser e-beam scattering and reacceleration. A more drastic example is the radiative damping in relativistic heavy ion ring, which has the possibility of generating intense, diffraction limited gamma rays. Thus we have the possibility of high brightness gamma ray sources.

4.3 Linear Collider Beam Dynamics Study Group

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The beam dynamics of the TESLA and SBLC linear collider designs is regularly discussed in a group with members from several institutes of the international collaboration. The last meeting was held in June at the Technical University Darmstadt, Germany. Conveners of the working group are R. Wanzenberg and A. Mosnier.

The group has contributed to the beam dynamics chapters of the Conceptual Design Report (CDR). The chapter can be found on the www. For the TESLA design see:

`http://www-mpy.desy.de/lc-cdr/tesla/tesla.html`,

and for the SBLC design:

`http://www-mpy.desy.de/lc-cdr/s-band/s-band.html` .

The beam dynamics in the main linac of the TESLA and SBLC has been studied by computer simulations. Two computer codes, DILEM (Saclay) and L (Desy/TH-Darmstadt) have been developed which are being used to study the single and multi bunch dynamics in a linear accelerator including several beam based alignment techniques. Effects due to strong transient beam loading and excitation of higher order dipole modes are included. At the June meeting beam dynamics simulations have been presented which include the effect of the sixth passband of the 6 m long SBLC accelerating structure.

One goal of future studies is to evaluate the luminosity potential of the TESLA 500 GeV center of mass linear collider design. The conclusion from simple scaling arguments is that one can gain luminosity from a higher ac-power to beam power transfer efficiency and a reduced vertical emittance. A reduced vertical emittance has several consequences for the bunch length, bunch population, number of bunches and bunch spacing if the disruption parameter is not to exceed 20 and the beamstrahlung limit of about 3% should be maintained. The consequences for the linac beam dynamics have to be investigated.

The beam dynamics study group will continue work on the damping ring design since it could be a “bottleneck” of the TESLA design. First studies consider the longitudinal single bunch dynamics. Bunch lengthening or a sawtooth instability would harm the bunch compression after the damping ring.

The CDR contains also a design for a superbrilliant X-ray laser facility which uses a part of the main linac to accelerate very short bunches (say 50 - 250 μm rms) to energies between 10 and 50 GeV. Beam dynamics issues specific to the X-ray laser facility will be continued to be discussed in the beam dynamics group together with linear collider related topics, thus keeping up the spirit of working on a common project. Recent results of wakefield calculations for very short bunches in two cavity modules have been presented at the last meeting in Darmstadt.

Pulse-to-pulse and bunch-to-bunch orbit feedback systems are considered for the TESLA design. Several fast kickers, similar to those used for the HERA, are needed to apply a sufficient kick to a a 250 GeV beam. The effects on the feedback system due to errors and noise have been studied.

4.4 Beam Physics Activities in Taiwan

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In Taiwan, there are 65 accelerators for a population of 21 million. Among the 65 accelerators, 52 of them are for radiotherapeutic applications and all of these are electron linacs. Two cyclotrons are used for nuclear medicine applications. Five accelerators are for industrial applications. The rest of them are used for scientific research. Currently, two proton machines for radiotherapeutic applications at two medical centers are under planing. The major institutes involving the beam physics research in Taiwan are: National Tsing Hua University (NTHU), Synchrotron Radiation Research Center (SRRC), Institute of Nuclear Energy Research (INER). The major beam physics activities in NTHU are: Research on Gyrotron[1, 2], Free Electron Lasers, innovatory beam observations[3, 4], collider beam physics, and laser-driven electron accelerator[5, 6]. The beam dynamics research activities in SRRC has been reported in a previous issue[7]. Other beam physics activities in SRRC include: the development of x-band RF gun[8], beam physics related vacuum systems[9, 10], and development of insertion devices[11]. The major beam physics activities in INER are: Induction Linac driven FEL, and Cyclotron related beam physics. The upcoming one or two proton machines should also stimulate some beam physics activities in their host centers.

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4.5 Beam dynamics experiments using the electron cooled beam at COSY

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Beam dynamics experiments done at the cooler synchrotron COSY (accelerator presented in [1]) will be described. After the installation of the electron cooler in 1993 it has been shown that an electron beam could be successfully used to cool the beam to an emittance of approximately 0.3 πmmmrad in the horizontal and 0.4 πmmmrad in the vertical plane after a cooling period of 3 s. The momentum deviation ($\Delta p/p$) is about $2{\cdot}10^{-3}$ before the beam is cooled and $1{\cdot}10^{-4}$ afterwards. The electron cooled beam can be successfully accelerated to flat top energy. Recently, several experiments were carried out to increase the injection efficiency by stacking. In this paper, beam dynamics experiments will be presented.

The experimental procedure starts with an electron-cooled beam (approximately $5{\cdot}10^9$) circulating stored protons at injection energy (45 MeV). Then, a single bunch is kicked horizontally by a pulsed deflection magnet (kicker). The subsequent beam-centroid displacement (the betatron motion) is measured by beam position monitors (BPM's). The turn-by-turn beam positions are digitised and recorded in FIFO memories. In this way the data of 200 (with 4K FIFO-length) or 3200 (64K FIFO-length) successive turns are recorded respectively. After the beam is kicked the transverse motion is damped after about 40000 turns. Non-linear beam dynamics experiments will be shown that were done near resonances.

4.5.1 Difference resonance

The difference resonance $Q_x - Q_z = 0$ was investigated first. The tune (betatron oscillation) was shifted to a point where the horizontal and vertical tune are near each other but no coupling between the horizontal and vertical motion is present. The magnitude of the coupling constant is given by the minimum tune separation between the two betatron oscillations. For accelerators with a periodic focusing and defocusing cell structure, the linear coupling constant is dominantly real. In this case, the calculated minimal tune seperation is 0.010 due to skew quadrupoles and the solenoid field of the electron cooler (neglecting the imaginary part) [2], the measurements shows 0.008 ± 0.001.

In a resonant precessing frame, the action-angle variables are given by $\phi_1 = \phi_x + \phi_z$ and $J_1 = J_x$. Normalised coordinates $Q = \sqrt{2J_1} \cos \phi_1$ and $P = -\sqrt{2J_1} \sin \phi_1$ are used. In the first plot, see figure 4.1 (a), the tunes are far from each other and the plot showes an almost unperturbed circle. In the second plot (b), the particles are on the edge of the difference resonance (constraint to one side of the figure). In the following picture the width of the coupling is increased. In picture (d) the centre of the resonance is reached. Then, the coupling becomes less until the resonance is crossed completely (e - g). The resonant phase was determined to be $\mu = -0.79$ to rotate the plot so that the coupling arc is in upright position.

The Courant-Snyder invariant circle is visible in all figures. Because the kick amplitude has the same size during the measurements and only the working point is varied, the circles have the same size. When we are locked on the difference resonance, the particles in the resonant precessing frame move from the centre upwards to the top and then outwards on both directions to close the curve in the centre again.

4.5.2 Third integer resonance

The third integer resonance at $3Q_x = 11$ was experimentally investigated. The working point is shifted near the horizontal third-integer resonance ($Q_x = 3.656$, $Q_y = 3.538$). A sextupole is used to excite the third integer resonance. The effect of the non-linearity makes the tune increase with increasing kick amplitude. There is one amplitude for which the repetition is exactle 11/3, and the repetition is perfect. The sextupole group MXL is excited to -8$\%$ to excite the resonance. Furthermore, there is a frequency entrainment effect causing all nearby amplitudes to lock-on to exactly the same tune. This accounts for the existence of so called resonance islands. When the beam is kicked with a small amplitude the particles are not kicked upon the resonance. At a certain amplitude the “lock-on” is visible and islands are formed. The kick amplitude is varied and the measured beam positions are measured and digitised. First, the beam is kicked with a small amplitude so that the particles are not excited upon the resonance, see figure 4.2. Second, at a certain amplitude the “lock-on” is visible (fig 4.2).

Third, when the kick amplitude is increased to 3.2 mrad or higher the beam is kicked on the resonance islands. In figure 4.3 the resulting curves are converted to phase-space coordinates (x, p_x). The beam is damped in about 100 turns (kick deflection is 3.2 mrad) and then it stays in the stable region of the resonance. The width of the islands is about 5 mm. The same results were obtained by measuring the phase plot with an oscilloscope online using the analoque BPM signals [3]. When the kick amplitude is larger then 4.0 mrad the beam is lost.

In figure 4.4 measured data is presented in $J - \phi$ space. The first data-set was taken with a kick of 1.6 mrad. The signal is damped in a few thousend turns. The spikes indicate the position of the unstable fixed points. The motion is unstable and the amplitude increases quadratically. Between the unstable fixed point the island-structure is visible (kick excitation 4.0 mrad). The beam is kicked after which the signal is damped until the circular motion about the stable fixed point is reached.

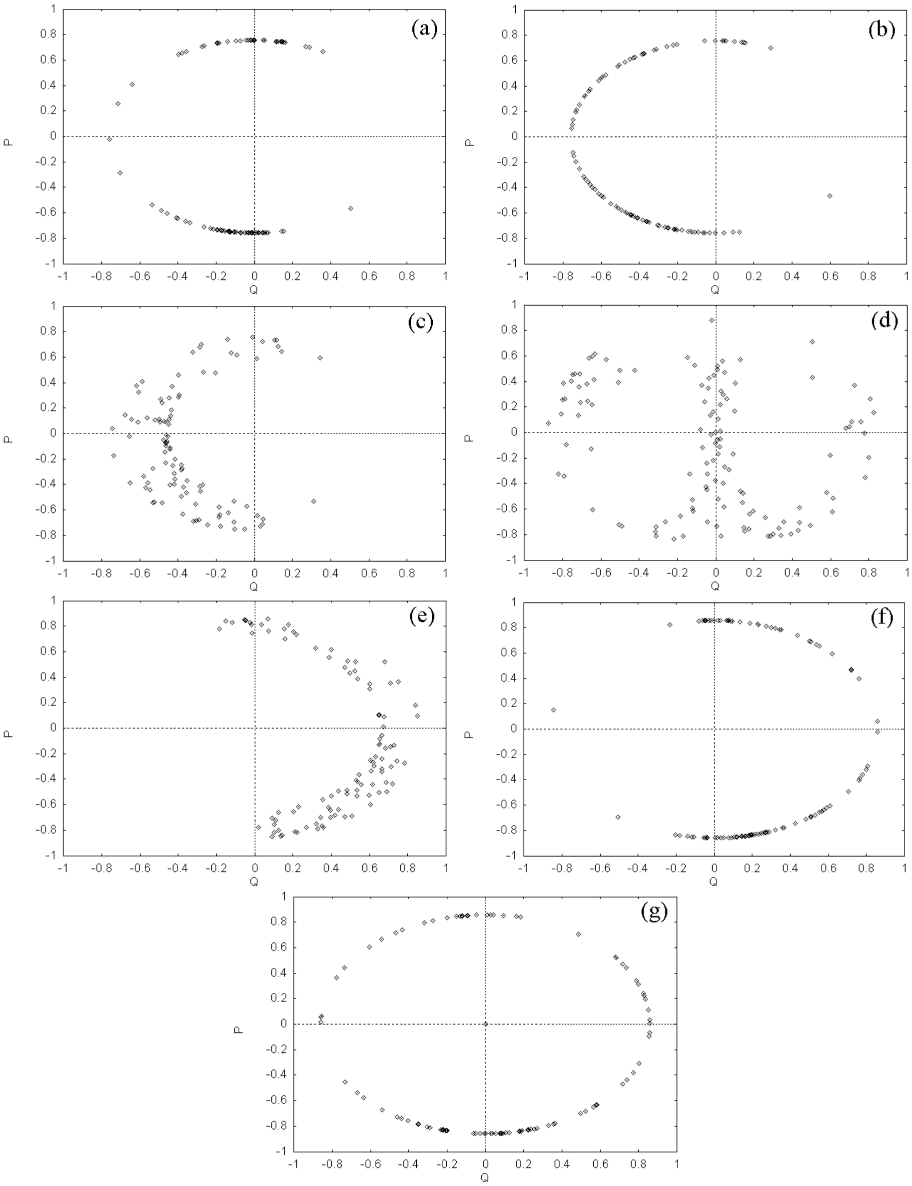

Figure 4.1: The Poincaré map in the resonant precessing frame as measured for several working points. The tunes are shifted to cross the resonance from plot (a) to plot (g), figure (d) shows the centre of the resonance.

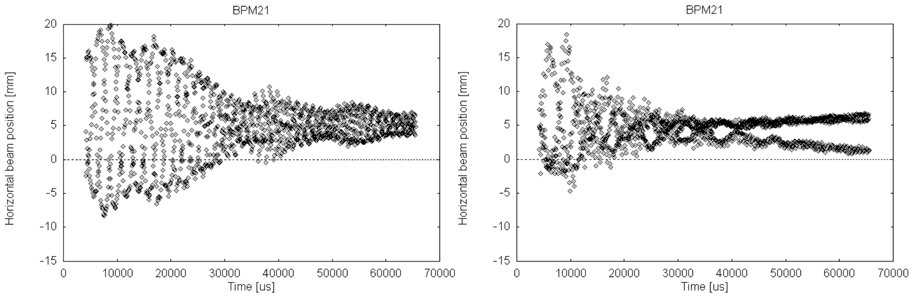

Figure 4.2: Turn-by-turn data from BPM21H with kick amplitude of 2.4 mrad and 2.8 mrad. In the first case damping is visible, in the second measurement lock on to the resonance is visible.

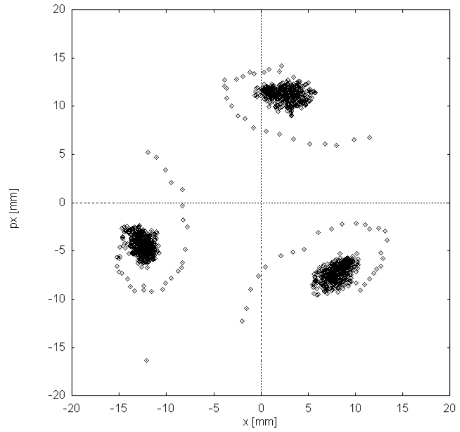

Figure 4.3: The Poincaré map where sextupole MXL=-8% and the horizontal tune is 3.666 with a kick amplitude of 3.2 mrad.

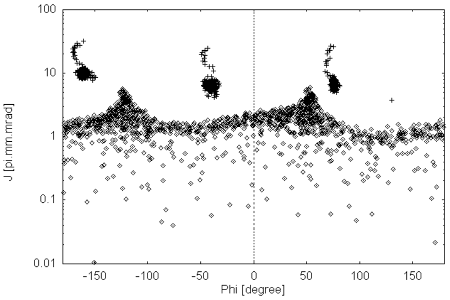

Figure 4.4: Measured data in J-ϕ space. Two data-sets, one with kick excitation 1.6 mrad (indicated with diamonds) and another with kick excitation of 4.0 mrad (indicated with crosses).

4.5.3 Summary

The particle motion in the COSY accelerator was studied near the betatron coupling resonance and near the third integer resonance. The properties of the third-order non-linear motion and of the resonance islands have been measured. The motion in phase-space of the difference resonance was investigated. For the investigation of resonances using a kicker an electron cooled beam is necessary.

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4.6 Commissioning of the SPring-8 Storage Ring

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4.6.1 Introduction

SPring-8 is one of the third-generation synchrotron radiation facilities, offering brilliant X-ray beams to various fields of science. The SPring-8 has an accelerator complex composed of a 1 GeV linac, an 8 GeV booster synchrotron, and an 8 GeV storage ring. The storage ring (SR), the heart of the facility, consists of 44 expanded Chasman-Green cells and 4 straight cells with two bending magnets removed, having a circumference of 1436 m. The natural emittance and beam current are designed to be 5.5 nm.rad and 100 mA, respectively. The SR could be incorporated with sixty one beamlines in total. In order to open the facility from October 1997, beam commissioning of the SPring-8 was started with the linac on August 1996. Successively, beam commissioning of the booster synchrotron was started on December.

4.6.2 Progress of SR beam commissioning

The SR beam commissioning was started from March 13th and its first phase was successfully completed by accumulating the electron beams of 20 mA one month later. This quick tuning was mainly due to the high level of completion of hardware. Especially, the precision of magnet alignment was so high that no steering magnet was used to store the first beam in the ring. The major milestones during the SR beam commissioning are listed below.

> So far, 20 mA is approved as a maximum current by the Science and Technology Agency (STA). Shortly, an application for the maximum current of 100 mA will be sent to the STA.

Date	Milestones
1997/03/13	Start of storage ring beam commissioning
1997/03/14	Completion of first turn
1997/03/25	Capture of electron beams in RF buckets
1997/03/26	First observation of photon beams
1997/04/23	Stored current of 20 mA (lifetime $\sim$ 4 hr with ID gap fully opened)
1997/05/14	Operation with ID gap of 8 mm
1997/07/03	Start of experiments at two beamlines

Following the first phase of the SR beam commissioning, tuning of the beamlines and insertion devices (IDs), conditioning of the vacuum system with electron beams and tuning of the SR machine parameters are being performed. At present, the COD correction reduces the residue down to $\sim$ 0.2 mm in terms of an rms value and the beam lifetime of $\sim$ 35 hours has been already achieved at the beam current of 20 mA with the ID gap fully opened. At the beam current of 20 mA, the ID gap has been also closed down to 8 mm, but the beam lifetime is slightly reduced due to the narrow ID gap. Various kinds of beam filling (single bunch, single + multi-bunches and so on) are being studied and $\sim$ 4 mA per bunch has been achieved.

A topic during the commissioning is observation of the orbit-drift by a tidal ground movement. The reasons why the ring is sensitive to the tidal movement could be: (1) the ring is sensitive to the change of path length due to a low momentum compaction factor, $\sim 10^{-4}$, (2) the ring is on a hard and stable rock bed, and (3) the machine tunnel is almost free from the changes of ambient temperature and sunshine. The COD data are periodically being taken and analyzed in detail.

4.6.3 Future Prospects

In parallel to preparing the service operation for SR users, the following things will be taken to upgrade performance of the SR.

(1) High current operation (from 20 mA to 100 mA)

(2) Effective emittance reduction

  (2-a) development of monitors to precisely measure electron beam emittance, energy-dispersion, and so on

(2-b) correction scheme for the COD, spurious energy-dispersion and so on

(2-c) reduction of sources causing the orbit-drift

(2-d) photon beam stabilization

(3) Investigation on peak and average current dependent phenomena and their cure

(4) Precise measurement of machine parameters with beams

4.7 CERN

Other beam dynamics activities at CERN were described in the previous newsletter.

4.7.1 LHC

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Version 5.0 of the LHC lattice is now completed. The horizontal and vertical cell phase advances are 91.4° and 87.3° in all arcs, contributing to the tune split by 2 units. The dispersion suppressors are extended into the arcs to include two focusing quadrupoles used to cancel dispersion and its derivative. The exact antisymmetry is broken to increase the parameter space and find more natural optical solutions, resulting in an overall reduction of the number of quadrupoles units required. A fourth quadrupole is added to the matching section linking the low-β triplet to the dispersion suppressor. With these provisions, the lattice is more robust against small changes and more flexible (tune split up to 8 units). As an example, the β-function can be reduced in the low-β triplet at injection by more than a factor of two, allowing a significantly larger beam separation ($> 10\sigma$). With the contribution of the insertions, the present tunes are $Q_x = 63.28$, $Q_y = 59.31$. In the absence of optics symmetry, they have yet to be optimized with respect to resonances.

Significant statistics (95% confidence level) were gathered on the dynamic aperture (D.A.) of the former version 4 of LHC to estimate better the relationship between the tracking results and the D.A. of the actual machine (longer times, more initial conditions, tune ripple,…). A factor of 2 seems necessary. The present D.A. of 9.5σ shall be increased to 12σ to ensure that the beam dynamics is weakly perturbed at the primary collimators positioned at 6σ. A new table of magnet imperfections was synthesized to fulfil this goal. Part of the required improvement are already met by the new dipole coil design and the others are under study. The first tracking results show the same D.A. for LHC version 5 with however a more significant reduction for a mostly horizontal motion. This point is under investigation.

Synchrotron radiation from proton bunches in the LHC creates photoelectrons at the beam screen wall. These photoelectrons are pulled toward the positively charged proton bunch. When they hit the opposite wall, they generate secondary electrons which can in turn be accelerated by the next bunch. Depending on several assumptions about surface reflectivity, photoelectron and secondary electron yield, this mechanism can lead to the fast build-up of an electron cloud with potential implications for beam stability and heat load on the beam screen. A crash program has been set up to measure the relevant physical quantities (by EPA irradiation tests and multipacting tests in a superconducting magnet), thus ‘calibrating’ analytic estimates and numeric simulations. The ongoing activity is documented in the World-wide web page

`http://wwwslap.cern.ch/collective/electron-cloud/electron-cloud.html`

Surface resistance measurements for the copper coated LHC beam screen at cryogenic temperatures indicate a beam-induced ohmic heating about a factor two larger than previously estimated. For frequencies up to 1.5 GHz, the additional effect of an 8.4 T magnetic field is only 10 to 15%: an absolute measurement precision of a few per cent is reached by comparing the quality factors of even and odd TEM modes in a cylindrical structure with two inner conductors.

Impedance estimates have been completed for several LHC components, such as bellows, monitors, and experimental chambers (whose design is being modified to reduce coherent losses). Stability studies based on Landau damping thresholds with two-dimensional betatron tune spread, for a detuning at 1 σ of 10^{-4} in both planes achieved by two octupole families, show that a pilot bunch with poorly controlled chromaticity is stable against the head-tail instability for currents as high as 10% of the nominal current. Multiple bunches in the same current range remain stable without feedback for negative chromaticities as large as -15.

4.8 New Doctoral Theses in Beam Dynamics

This is a new chapter of the newsletter that will announce the completion of *new* doctoral theses in *beam dynamics*.

Initially, a thesis will be considered new if the doctorate was awarded in the twelve months preceding the date of publication of the newsletter. This period may be reduced later once this listing becomes better known and regularly used.

Instructions for submitting an announcement can be found at

`http://www-acc-theory.kek.jp/ICFA/instruction.html`

or in Section 7.3.1.

Author: *Migliorati Mauro* `migliorati@lnf.infn.it` LNF-INFN

Title: *Effetti collettivi nella dinamica dei fasci in una macchina acceleratrice circolare con applicazioni al progetto DAFNE* (Collective effects in the dynamics of beams in circular accelerators with applications to the project DAFNE)[1]

Supervisor: *Luigi Palumbo* `lpalumbo@frascati.infn.it` Univ.Rome/LNF-INFN

Institution: University of Rome ”LA SAPIENZA”

Author: *Eun-San Kim* `eskim@kekvax.kek.jp`

Title: A Simulation Method on Tail Distributions due to Random Processes in Electron-Positron Storage Rings

Supervisor: *Prof. K. Hirata* `hirata@kekvax.kek.jp` KEK

Institution: Department of Accelerator Science, The Graduate University for Advanced Studies, KEK

Abstract: A new simulation method for the beam tail is proposed. This method provides a means to investigate the beam tails due to rare random processes in storage rings. Only core particles

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[1] Editor’s translation.

in a beam are tracked in random processes. Beam-beam bremsstrahlung, beam-residual gas scattering and bremsstrahlung in the ring are considered as examples. This simulation shows good agreements with the results of solvable models. It is shown that the variations in the longitudinal motion due to random processes have an effect on the vertical tail distribution in the presence of a beam-beam interaction. It is shown that particles with large energy amplitudes can expand beyond vertical aperture due to betatron and synchro-betatron resonances. Estimates of the beam tails and lifetimes for KEKB are presented.

5: Workshop Reports

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5.1 11th International Advanced ICFA Beam Dynamics Workshop on Beam Cooling and Instability Damping

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The proceedings of this workshop, held on board the “Alexander Suvorov” on the Volga river from 18–25 June 1996 have appeared in the July 1997 issue of Nuclear Instruments and Methods.

5.2 Report on the Free-electron Laser Challenges Symposium, San Jose

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The “Free-electron Laser Challenges Symposium” was held in San Jose, CA, USA, February 13-14 1997.

Free electron lasers show promise as bright, high-power sources at wavelengths where other light sources are weak. To date we have seen this promise fulfilled over a limited range of wavelengths at modest average power levels. In order for FELs to be of continued interest to users, they must deliver performance that far surpasses conventional sources, in brightness, power and wavelength range. The FEL Challenges Symposium focused on two areas of research and development where FELs have particularly strong potential: very short wavelength and very high average power. The FEL symposium, sponsored by SPIE as part of the LASE’97 meeting, had over 70 attendees, and 36 oral papers were presented over two days.

5.2.1 Short Wavelength

Linac driven FELs will be an important component in the next generation of light sources in which production of coherent, short-pulse radiation at x-ray wavelengths will be a key feature. The technical challenges are particularly great x-ray region where high-reflectivity optics are not available. Recent developments in accelerator technology and synchrotron radiation research, however, have made the new frontiers both alluring and reachable. Such FELs require high-peak current, high-brightness electron beams, as drivers for x-ray self-amplified spontaneous emission (SASE) FELs. SASE eliminates the need for optical cavities by achieving saturation in a single pass. A proposed prototype x-ray FEL is the Linac Coherent Light Source (LCLS) at SLAC. The LCLS group presented a paper on the proposed 1.5 Angstrom SASE FEL which will use 1/3 of the SLAC linac (15 GeV) as a driver. The requirements for the electron beam are challenging: normalized rms emittance $= 1.5\,\mathrm{mm} - \mathrm{mrad}$, peak current $= 3.4\,\mathrm{kA}$, energy spread $= 0.02\%$. The undulator of the LCLS is also challenging. It will be 100 m long, with a 3 cm period, a 6 mm aperture, and 1.32 T undulator magnetic field. A number of papers were presented on issues associated with the production of bright-electron beams of a quality required for the LCLS. It should be noted that the final emittance requirement of the beam at the LCLS undulator is not much greater that the emittance of the beam from the gun. At present most of the experimental attention is focused on electron gun development and low-energy beam transport, with experiments underway at BNL, Boeing, SLAC, LANL and UCLA. These experiments typically operate at currents in the 100–300 A range, and, with the exception of Boeing, do not yet include bunchers. Electron guns with emittances at the level required for LCLS have been demonstrated in the BNL and LANL experiments. Detailed measurements on a new gun were reported by the SLAC/BNL/UCLA collaboration. Beyond the gun, the critical issues of bunching and long-distance electron beam transport are just beginning to be addressed. The Boeing group reported preliminary studies of bunch compression on their 18 MeV linac, and they continue to investigate potential sources of bend-plane emittance growth. The ultra-short, sub-ps electron bunches required as FEL drivers present new diagnostic challenges for the experimenter. Much of the interesting physics will take place on a sub-micropulse timescale. Alex Lumpkin of ANL presented a comprehensive review of the latest developments. A number of papers were presented on SASE simulation techniques. While the various simulation codes such as MEDUSA, FELEX, TDA3D and GINGER are in general agreement in regard to the predicated performance of the x-ray SASE devices, there is concern that given the large extrapolations in wavelength from existing experimental data, there may be unknown unknowns lurking in the shadows. To help advance our understanding of the SAE process, SASE experiments are underway at BNL (1 micron), LANL (16 micron), and UCLA (22 micron). These experiments are designed to test SASE theory and simulations in systems where this single-pass gain is expected to be very large. In the LANL case a gain of 100,000 per pass is predicted, and the preliminary reports indicate that a single pass gain of at least 60 was achieved, and possibly much higher. None of the current experiments is expected to reach saturation in a single pass. New experiments are under construction or planned at ANL, BNL and Duke which should achieve single pass saturation at sub-micron wavelengths. The user perspective for an x-ray SASE device was given by K. David Straub of Duke. Applications such as x-ray microprobes, tomography of cells and crystallography were discussed. Papers outlining the latest developments in Storage ring FELs were present by the Duke and Tsukuba groups, were UV FELs and inverse Compton gamma-ray sources are in operation.

5.2.2 High Average Power

The second focus area is the generation of high average power at near optical UV and IR wavelengths. Such devices will require electron beams that are both bright and high average current. Electron beam halo formation and beam loss are particularly important issues in for the accelerator, while optical distortion and damage are challenges for the laser. The present record for average power from an FEL is 11 W at a wavelength 5 microns. The groups at Budker Institute, Boeing, LANL and TJNAF plan to beat this record, and they reported significant progress in the construction of their facilities. The common near-term goal is an average optical power of 1 kW in the near IR. TJNAF is constructing a superconducting accelerator using technology developed for the Continuous Electron Beam Accelerator. Both Boeing and the Budker Institute are constructing room-temperature copper structures. LANL is testing a compact system using a regenerative amplifier FEL. The Budker Institute, TJNAF and Boeing plan to use electron energy recovery to improve efficiency, and to reduce the level of hazardous radiation from the electron beam dump. The Rocketdyne group discussed the many areas of commonality between SASE and high average power IR FELs. Reports were presented on the applications of high average power devices, such as: industrial processing of materials (DuPont and TJNAF), clearing of near-earth space debris (Northeast Science and Technology), power beaming to space (Bennett Optical Research), and shipboard defense (US Navy, Grumman). The meeting was very successful. It was very exciting to hear of the significant recent progress made towards meeting our FEL challenges.

The proceedings of the symposium will be published by SPIE (Free-Electron Laser Challenges, P.G. O'Shea, H.E. Bennett, Editors, Proc. SPIE 2988)

5.3 New Ideas for Particle Accelerators, Symposia Report

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5.3.1 Introduction—Goals of the Program

The "New Ideas for Particle Accelerators" program was held July–December, 1996 at the Institute for Theoretical Physics (ITP), in Santa Barbara California. This was the "first" Accelerator research program that was sponsored by the Santa Barbara Institute for Theoretical Physics, National Science Foundation and in the United States. The program consisted of a 5 month workshop and 3 Symposia (in parallel with the workshop). The program, workshop and symposia were organized and coordinated by Dr. Zohreh Parsa, ITP/ Brookhaven National Laboratory (BNL). It began in July 1996, (with about 40 in residence participants from the USA and abroad, and had about 300 additional participants in the three symposia associated with it). It was successfully completed on December 20, 1996.

The 5 month program was structured such that the participants could work individually and /or in mini workshops on various topics. With one or two exceptions, the participants were active in individual research and very active during the mini-workshops, seminars and discussion sessions that were arranged and attended by the participants.

The primary objective of this 5 month workshop was an in - depth study of the underlying principles and problems in particle acceleration. Topics of discussion included: novel modes of particle acceleration using plasma, lasers, collective modes, etc.; new particle sources; limitations of existing accelerator technology; collider physics and new types of particle colliders such as muon - antimuon and photon - photon; and theoretical advances and formalism for studying nonlinear beam dynamics and stability.

The workshop covered various topics in the particle-accelerator field. Although, the majority of our applicants (later, in-residence participants) interest and time clustered on: New methods of particle Acceleration and Sources (July-August), Collider Physics (September - October) and Nonlinear Beam Dynamics and Stability (November - December). The reason for arranging for 3 symposia.

The "New Ideas for Particle Accelerators" ended very successfully with many new results and ideas, some already published and some that will be published soon. Some of the ideas developed in this program have been submitted as proposals and letters of intent at various universities and Laboratories in USA and abroad (including a new high Intensity Muon Source, New enhanced Inverse Free Electron Laser scheme, New Particle Driven Plasma Accelerator, Muon Cooling schemes, New Dynamic Aperture Scheme for LHC, New emittance reduction scheme for photon - photon colliders and electron - positron (NLC) accelerators, etc.) The comments received during and after the program, have been very positive. The participants included scientist with expertise in particle and/ or accelerator physics, mathematics and astrophysics.

In the following sections we provide brief summaries of some of the miniworkshops, followed by summary reports on the 3 symposia, held during the 5 month program.

5.3.1.1 High Intensity Muon workshop—Summary

The most compelling low energy physics case is the search for rare or “forbidden” processes such as muon-electron conversion in the field of a nucleus or muon decay to electron plus photon. A positive result would revolutionize physics. Many theoretical ideas suggest that a discovery may not be far off.

Using intense muon beams, it seems possible that one could push the searches for such rare reactions by 4 orders of magnitude. That is very impressive when one realizes that such searches are already probing one in a trillion rates.

The ITP workshop provided an ideal opportunity to bring together some of the major players in the intense muon source community. The efforts were focused on new physics ideas, frontier accelerator ideas, and future experimental initiatives. (Z. Parsa, W. Marciano, R. Djilkibaev, Y. Kuno, W. Molzon, Y. Ogada).

5.3.1.2 Muon Collider

New ideas for a muon-antimuon collider envision as their starting point very intense clean muon beams with a small momentum spread. Such beams would be accelerated to collider energies and be used to search for new short-distance phenomena.

There has been much interest and studies at Brookhaven, and elsewhere on possibilities and problems of building a muon collider in US.

A muon collider with center of mass energy less than about 10TeV can be circular. Relative to a NLC (Next Linear Collider) of the same energy, it would be far smaller. For the same luminosity, because the muons make $\sim$ 1000 crossings, a far larger spot-size can be employed. And, because there is little beamstrahlung, very small energy spread is possible. Although muon colliders remain a promising complement, or alternative, to e^+e^- colliders, much work is still needed. Including radiation, demonstrations of μ production and cooling.

At the ITP workshop we studied the various problems including electron cooling, Muon Ionization cooling as well as other methods of cooling for the electron and muon colliders (Z. Parsa, A. Skrinsky, P. Zenkowich, D. Cline). We had various seminars and discussion on this subject with other members of the group. Skrinsky presented his new results comparing it to the Muon Collider Study that were presented at the Snowmass workshop (June 1996). Including the “final” Ionization cooling, with some discussions on the multi-channel pion collection system, the high efficiency polarized muon beams production, the removing of beam-beam limit for muon collider luminosity, etc. Additional studies were made [3].

5.3.2 Symposia

In addition to seminars by resident physicists or short term visitors, 3 symposia were planned and held in parallel with the New Ideas for Particle Accelerator workshop:

1. August 19–23, 1996, New Modes of Particle Acceleration Techniques & Sources;
2. October 21–25, 1996, Future High Energy Colliders;
3. December 3–5, 1996, Particle Beam Stability and Nonlinear Dynamics.

Some of the new results developed during the 5 month Workshop were presented during our symposia, and in addition are being published in a special set of conference proceedings [1, 2, 3].

In the following, We first summarize the third symposium which dealt primarily with beam dynamics topics then we summarize the other two symposia.

5.3.2.1 Beam Stability and Nonlinear Dynamics

A Symposium on “Beam Stability and Nonlinear Dynamic” was held December 3 - 5, 1996 in Santa Barbara, This was the third symposia hosted by the ITP and supported by its sponsor the National Science Foundation, as part of the 1st US long term accelerator research program, on “New Ideas for Particle Accelerators”. The symposium was chaired by Dr. Zohreh Parsa of BNL/ITP.

The purpose of this symposium was to deal with some of the fundamental theoretical problems of accelerator physics by bringing together leaders from accelerator physics communities, mathematics, and other fields of physics. The focus was on nonlinear dynamics and beam stability. The symposium began with some defining talks on relevant mathematical topics such as single-particle Hamiltonian dynamics, chaos, and new ideas in symplectic integrators. The physics topics included single-particle and many-particle dynamics. These topics concern circular accelerators in which particles circulate for a very large number of turns as well as linear accelerators where space charge and wakefields induced in accelerating cavities play a strong role.

A major question is to determine the best model for numerical simulations in order to accurately reproduce behavior of beams in real accelerators and to predict long-term or long distance stability. Comparison with experiment is recognized as an important tool in improving models.

Straight-forward tracking using linear elements and thin-lens multipoles to preserve symplecticity is the basic tool for studying single-particle dynamics and stability in large circular accelerators such as the Large Hadron Collider (LHC), which was recently approved for construction at CERN. Ideas have been aimed at improving the computation time and/ or in improving analysis of the results. Symplectification of Taylor maps are used since truncation of expansion maps leads to maps that are not symplectic. The concept of jolt factorization makes it possible to obtain a symplectic truncated expansion. But if the nonlinearity is too large, as is usually the case near the onset of unstable motion, map predictions fail. This raises the difficult question of the applicability of a complete-turn map to a large accelerator. The expansion of such maps is laborious for phase-space dimensions larger than four. Another related development is the use of Taylor’s models with additional functions which bound the initial function from above and below. Application of this concept to maps led to the development of an arithmetic, which applies to both the polynomial and the remainders, termed Remainder Differential Algebra. This should provide information on the accuracy of the map description. Symplecticity is ensured if we use the Hamiltonian formalism and action-angle variables. In this approach, the map over one turn or a fraction of turn can be computed by solving algebraic equations related to canonical transformations which are in implicit form. This is done for the non-periodic solutions of the generating function equation by using Newton iterations and approximation in Fourier series and B-spline functions.

Interesting results of numerous trackings and analyses (including those developed during our ITP workshop) were presented for the LHC. Different methods for estimating the dynamic aperture were tested, first using the Henon map. Early indicators such as the Lyapunov criterion, frequency map analysis, and variation of tunes have been used with tracking over an increasing number of turns. A new conjecture combining the result of the KAM theorem with the Nkhoroshev estimate predicts that the dynamic aperture depends on the inverse logarithm of the number of turns. There seemed to be a good agreement between the predictions of the early indicators and the result of the conjecture extrapolated to a very large number of revolutions. This gives an increased confidence in the numerical predictions, to within 10 or 20% of the actual value as supported by measurements on existing accelerators.

Particular examples of stability analysis were presented, such as a Hamiltonian system with a quartic potential and the three-body problem in celestial mechanics. Linearization around a periodic solution in the first case and around a Lagrangian fixed point in the second, provides a monodromic matrix which give information on the stability. For the three-body problem, developments to second order allows us to solve the equation of motion near resonance. Also presented was the idea to apply to accelerator dynamics the wavelet analysis of Hamiltonian systems.

New Applications of moment method to study kinetics and dynamics of muon cooling systems (Z. Parsa, P. Zenkovich see Ref. [3]) and the use of moments and new variables for Beam matching and Halo control were also very interesting. New dynamical variables to describe phase-space distributions were investigated. The goal was to develop a scheme in which we solve directly for the evolution of the beam halo. Symbolic computations were used to generate beams matched to high order and to compute mode invariants (analogs of moment invariants, emittance-like quantities that are conserved) for several types of dynamical variables. A promising development is that of weighted moments. In this approach, we can study nonlinear beam dynamics using only second moments. Higher-order effects are accessed by considering a collection of second moments having different weight functions. The advantage of this approach is that a number of existing theoretical results and computational techniques, originally meant to study linear effects only, can now be applied to nonlinear beam-dynamics effects like halo generation (W. Lysenko, Z. Parsa, see e.g. Ref. [3]).

Among the other subjects treated were spin dynamics nonlinear aberration correction including space charge aberrations, collective effects in the LHC, sawtooth instability, and Landau damping in the presence of strong nonlinearity. There were other presentations concerning plasma physics effects relevant to accelerators. And the peculiar effect of beam echos that has recently been observed for the first time in an existing accelerator with echo times as long as one to two minutes. Numerical tools for studying multibunch instability in linear accelerators with strong wakefields were presented, together with a statistical method of analysis of wakefield effects on emittance growth, based on beamline response coefficients.

Some of the Presentations were given by Drs. J. Meiss (U Colorado, USA), J. Marsden (Cal Tech, USA), M. Berz (Michigan State, USA), A. Dragt (UM, USA), J. Irwin (SLAC, USA), E. Todesco (INFN, Italy), J. Laskar (BDL, France), R. Warnock (SLAC, USA), V. Balandin (DESY, Germany), F. Schmidt (CERN, Swiss), F. Ruggiero (CERN, Swiss), R. Siemann (SLAC, USA), S. Andrianov (St. Petersburg, Russia), G. Guignard (CERN, swiss), M. Zeitlin, (IPME, Russia), P. Zenkevitch (ITEP, Russia), J. Hagel (Univ Maderia, Portugal), H. Yoshida (NAO, Japan), A. Pankin (INR, Russia), S. Heifets (SLAC, USA), V. Zadorozhny (IC, Russia), W. Lysenko (LANL, USA), Z. Parsa (BNL, USA), etc.

The conference ended with a unique discussion session in which participants presented and clarified their views on outstanding problems and topics presented at the symposium. This international forum has provided new and valuable input for future developments in this field. For a complete list of the symposium presentations see [3].

5.3.2.2 New Modes of Particle Acceleration: Technique and Sources

The Symposium on “New Modes of Particle Acceleration Technique and Sources” which was held August 19 - 23, 1996 at the Institute for Theoretical Physics (ITP) in Santa Barbara, was the first of the three symposia hosted by the ITP and supported by the National Science Foundation. The symposium was chaired by Dr. Zohreh Parsa of BNL/ITP.

This Symposium provided a perspective on the future direction of the Advanced Accelerator Research.

The ITP conference on New Modes of Particle Acceleration featured several presentations reviewing current progress in developing revolutionary accelerators based on laser driven plasma waves. In 1979, Dawson, proposed three basic laser plasma acceleration concepts; however only with the recent development of compact terawatt laser systems could these concepts be fully investigated in the laboratory.

The three proposed schemes were laser wakefield acceleration (LWFA), the plasma beat-wave accelerator (PBWA) and the self-modulated laser-wakefield accelerator (SMLWFA). In the LWFA a single short laser pulse of length L excites a plasma wave of wavelength λ_p. In this scheme $L \simeq \lambda_p$. This method requires short, $\lesssim$1 pico-second, laser pulses of ultra high intensity $\gtrsim 10^{18}$ W/cm^2 and could not be tested until chirped-pulse amplification (CPA) was used to create Table-Top Terawatt (T^3) lasers. Two papers on progress in T^3 technology based on CPA in solid state lasers were presented at the ITP Symposium by University of Michigan (UMI) and University of California at San Diego (UCSD).

The PBWA was proposed earlier as an alternative to LWFA because short-pulse, high-power lasers were not available. This approach employs two long pulse laser beams of slightly different frequencies w_1 and w_2 such that $w_1 - w_2 \simeq w_p$ the frequency of the plasma wave which is to be resonantly excited. PBWA experiments have been performed in Japan (ILE), the USA (UCLA), Canada (CRL) and France (LULI). The UCLA experiment observed the highest electron energy gain, $\sim$28 MeV [Clayton (UCLA) et al.], with an effective accelerating gradient of 2.8 GV/m. They plan to continue with PBWA experiments.

The most impressive advances reported at the Conference came in the area of self-modulated laser wakefield acceleration (SMLWFA). In this method, a laser pulse of length $L > \lambda_p$ is subdivided into a series of shorter pulses of length $\sim \lambda_p/2$ by its interaction with the plasma wave (which it created). This interaction creates a large amplitude (resonantly driven) plasma wave. This process requires a laser power greater than the critical level required for relativistic guiding of the laser field. The phase velocity of the guiding plasma wake can become relativistic for high enough plasma electron densities, $n_p \sim 10^{19}\ cm^{-3}$, for example.

Experiments on SMLWFA have been performed in Japan (KEK), the US (LLNL, CUOS, NRL) and the UK (RAL). The latter experiment achieved impressive results: electron energy gains of $\gtrsim 44$ MeV and accelerating gradients $\gtrsim 100$ GV/m. Conventional accelerators are capable of accelerating gradients of ~ 100 MV/m. This experiment employed a 2.5 TW, 0.5 picosecond laser, producing an intensity of 10^{19} W/cm^2 and a plasma electron density of $10^{19} cm^{-3}$.

The accelerated electrons in this experiment cover a wide range of energies from a few MeV up to the maximum. The theoretical limit for this experiment was ~ 70 MeV. The spectrometer was capable of measuring only up to 44 MeV. The normalized transverse emittance of any particular energy group was about 5π mm-mrad, which is on the order of the emittance of photo injector based linacs. However the measured beam current was 10-100 times lower than that achieved with photoinjectors.

Although the reported accelerating gradients for SMLWFA are spectacular, they are achieved over short distances of the order of 100's of microns to millimeters. The size of the acceleration distance is determined by the diffraction limited Rayleigh length (of the region of minimum focal spot size). Various schemes for getting accelerating lengths greater than a few Rayleigh lengths were discussed at the Conference.

For example, optical guiding can be achieved with preformed lower density plasma channels produced by hydrodynamic expansion of ionized gas generated by another laser focused along the acceleration axis. Other approaches suggested were using laser blow out to create a low density hollow plasma channel or using acoustic wave channel formation. Relativistic focusing can provide optical guiding in the case of SMLWFA for laser power levels $P > P_c = 17(w/w_p)^2$ GW. Other limiting factors on accelerating lengths are electron detuning, (i.e., the length over which the accelerated relativistic electron outruns the plasma wave), and pump depletion,(i.e. is roughly the length over which the laser pulse gives up all its energy to the plasma wake).

All these SMLWFA experiments have accelerated background plasma electrons. Producing and injecting 20-100 femto-second electron bunches is a difficult challenge. Umstadter et al. propose to solve this problem by using two orthogonally propagating laser pulses, one along the acceleration direction as a plasma wave pump pulse, and an injection pulse at right angles. This scheme is called LILAC, laser injection and laser acceleration. The University of Michigan is building an all optical accelerator to produce femto-second electron pulses with GeV energies.

Another approach discussed at the conference, was that of Plasma wakefield accelerators, which are similar to LWFA, except that one or more relativistic electron beams are used to excite the accelerating plasma wave. The electron beam pulse must be shorter than the plasma wavelength in analogy with the situation for the LWFA. This concept was originally proposed by Fainberg in 1956. Enhancing the wakefield by using multiple electron drive bunches spaced at the plasma period was proposed in the original work on PWFA. The first PWFA experiment was performed by Berezin and co-workers in the early 1970's in Ukraine. More recently experiments were performed in the US (e.g. at Argonne Nat. Lab) and in Japan (at KEK).

At this conference Skrinsky and co-workers proposed a system design for a 1TeV PWFA using a pre-ionized hydrogen plasma, which is driven by trains of electron bunches, which are made of 10 micro-bunches of 0.2 mm length. This system would employ a 10 GeV drive beam at 10 kHz rep rate with 2×10^9 electrons/bunch. Challenges involve the energy requirements of maintaining the hydrogen plasma channel. A PWFA test experiment is being proposed at INP, Novosibirsk with a goal to reach more than 0.5 GeV/m over several tens of cm.

Another scheme (D. Umstadter, University of Michigan (UMI)) plans for all optical laser accelerators to produce femto-second electron pulses at the GeV level.

Among the other subjects treated were power sources such as RF Sources (R. Phillips, Stanford Linear Accelerator Center (SLAC)), Laser as a power source (G. Mourou, UMI), Pulsed Power Sources (M. Gunderson, USC); Advanced accelerator schemes such as Laser Acceleration (W. Mori, University of California, Los Angeles (UCLA)), Two Beam Accelerator (S. Yu, Lawrence Berkeley Lab (LBL)), Inverse Free Electron Laser & Free Electron Laseres (C. Pellegrini, UCLA), Inverse Cerenkov (W. Kimmura, STI), open waveguide structure for laser acceleration (R. Pantel, SLAC); beam cooling (A. Skrinsky, Institute of Nuclear Physics, Novosibirsk (BINP)); Laser cooling (A. Sessler, LBL);crystal Accelerator (P. Chen, SLAC).

There were other presentations by A. Shahigan, Kharkov IPT; M. Zholents, LBL; D. Cline, UCLA; M. Pato, Brazil; B. Breizman U. Texas; W. Molzon, UCI; Beam Sources such as High current short pulse Ion Sources by K. Leung, LBL; High Intensity Neutron Spallation Sources by R. Macek, Los Alamos National Lab (LANL); also presentations on High Intensity Muon Source; Beam Dynamics and emittance, etc.

Laser Plasma issues (Esarey, Naval Research Lab (NRL)), Self Modulation of Intense Laser Pulses in plasma Channels (N. Andreev, Russian Academy of Science (RAS)), Production of Ultra Short Laser Pulses (C. Barty, UCSD), Short Bunch Injection, Synchronization and Acceleration in Laser Wakefields (D. Umstadter, UMI), update on Laser Plasma experiments (C. Joshi, UCLA) also were discussed.

The symposium included two unique discussion sessions on “Laser plasma based Acceleration” and on “New Advances and basic issues” in which participants presented and clarified their views on outstanding problems and topics presented at this conference. This forum provided new and valuable input for future direction and developments in this field. There was a great interest and request by participants to write up a “white paper” on the future direction of the advanced accelerator research. And some have sent in contributions and suggestions on what to be included in the write up of the “white paper”.

In terms of a white paper, Umstadter suggests that the critical issues to be studied are (1) what are the means of injecting electrons with femtosecond precision, (2) what are the means of creating plasma channels many Rayleigh lengths long, and (3) can the electron beam properties preserved through multiple synchronized accelerating stages. Of course, it must also be demonstrated that electron beams can be accelerated in a single stage with suitable properties for high energy physics. There were many other very interesting comments from the participants, but due to time and space limitations are not included here.

The Symposium started with a defining perspective presentation by R. Siemann (SLAC) and ended with a summary and closing presentation by Z. Parsa (BNL). The symposium was a success, with a very interesting program and an overwhelming active group of expert participants. For a complete list of presentations see [1].

5.3.3 Future High Energy Colliders

A “Future High Energy Colliders” Symposium was held October 21-25, 1996 at the Institute for Theoretical Physics (ITP) in Santa Barbara. This was the 2nd of the 3 symposia hosted by the ITP and supported by the National Science Foundation. The symposium was chaired by Dr. Zohreh Parsa of BNL/ITP.

The purpose of the symposium was to discuss the future direction of high energy physics by bringing together leaders from the theoretical, experimental and accelerator physics communities. Their talks provided personal perspectives on the physics objectives and the technology demands of future high energy colliders. Collectively, they formed a vision for where the field should be heading and how it might best reach its objectives.

As the name of this conference suggests, the primary tools for performing high energy physics research are particle beam colliders. Collisions of high energy particles produce events in which much of the energy of the beams is converted into the masses of new heavy particles not normally found in nature. By studying the production and decay of these new particles, the underlying structure of the universe and the laws that govern it are unveiled.

The design and construction of particle accelerators used in high energy physics are motivated and constrained by 1) the forefront physics questions being asked, 2) the availability of technology needed to build and operate these machines as well as capabilities to detect and analyze the collisions, and 3) the cost of the machine and the availability of construction funds from home and foreign governments. High Energy Physics in the United States is now at a crossroads where its future will depend on: participation in foreign projects, upgrading and utilizing existing facilities, and new construction initiatives.

Some of the underlying physics motivations and technical issues had been addressed at earlier workshops such as Snowmass 1996. The Santa Barbara “Future High Energy Colliders” Symposium’s novel aim was to begin the process of reaching a consensus on how to attain the vision.

Currently, the operation of the Tevatron proton-antiproton collider at the Fermi National Accelerator Laboratory and the SLC electron-positron collider at the Stanford Linear Accelerator Center are at the energy frontier of the field. The use of both proton-antiproton and electron-positron collisions is important in order to provide complementary information. At the energy frontier new particles never before observed are discovered and studied, providing unique insight into the laws of nature. Recently, the LEP electron-positron collider at the CERN laboratory in Geneva began upgrading its energy, expanding the energy frontier in electron-positron collisions by about a factor of 2. Sometime near the year 2005 the LHC proton-proton collider in Geneva will operate with world record beam energy about 7 times that of the Fermilab Tevatron.

The Large Hadron Collider (LHC) at CERN is intended to address the question of the origin of mass. Because we know the energy scale associated with mass generation, we can be reasonably confident that the LHC will discover this new physics, whether it is a Higgs boson or something quite different.

Although the LHC should elucidate the origin of mass, it probably cannot answer all the outstanding questions. For that reason, a collaboration involving institutions from Germany, Japan, the United States and many other countries has been developing a design for a high energy e^+e^- collider, the Next Linear Collider (NLC). This would have a somewhat lower energy reach than the LHC, at least initially, but it would be able to make many interesting unique measurements that would complement those at the LHC. Together the LHC and the NLC should clarify the origin of mass and address many other open questions. They might also find the explanation for the dark matter in the universe and open new frontiers such as the much anticipated spectrum of heavy particles predicted by supersymmetry, an elegant extension of the underlying structure of space - time. If supersymmetry is found, it will become the focus of high energy physics. Studying its spectrum of particles and their properties will be a major experimental enterprise.

Also under discussion at Laboratories, and many Universities is a muon collider and the feasibility of building an accelerator in which muons collide with antimuons. Since muons (at rest) decay in about two millionth of a second, building such a collider would be a major technological achievement. A survey of the physics that could be studied at such a machine overlaps with e^+e^- collider capabilities but also includes novelties such as the possibility for fusion of the colliding beams to produce Higgs particles. This process would permit e.g. the precise direct measurement of the mass and lifetime of the Higgs particle as well as its decay properties. However, the main enthusiasm for the muon collider stems from its potential to reach very high energies and the possibility that it could be constructed at an existing national laboratory.

An explanation of the matter-antimatter asymmetry in our universe requires first an understanding of the origin of mass.

A unique feature of the symposium was the bringing together of many physicists who will have a major impact on the future direction of the field. Especially important was the set of presentations made by the Department of Energy Director of Energy Research Dr. M. Krebs, by Dr. B. Kayser of the National Science Foundation, and by the directors of the three U.S. High Energy Physics laboratories, Drs. J. Peoples (Fermilab), B. Richter (Stanford Linear Accelerator Center) and N. Samios (Brookhaven National Laboratory). Their perspectives combined with presentations by internationally distinguished high energy and accelerator physicists provided a comprehensive picture of the issues involved in formulating appropriate goals for the future.

Some of the Presentations were given by Drs. W. Marciano, BNL; D. Gross, Princeton Univ./ITP; S. Willenbrock, UIL; J. Gunion, UCD; T. Appelquist, Yale; L. Rolandi, CERN; D. Amidei, UMI; G. Jackson, FNAL; E. Keil, CERN; I. Hinchliffe, LBL; M. Harrison, BNL;H. Murayama, LBL; F. Paige, BNL; D. Burke, SLAC; N. Toge, KEK; R. Brinkman, DESY; P. Wilson, SLAC; R. Palmer, BNL; D. Cline, UCLA; V. Barger, UWI; C. Heusch, UCSC; V. Telnov, INP; S. Ritz, Columbia U.; R. Siemann, SLAC; J. Irwin, SLAC; T. Katsouleas, USC; S. Chattopadhyay, LBL; Z. Parsa, BNL, etc.

The difficult aspects and the far reaching consequences of the decisions that must be made were further clarified during a unique panel discussion designed to initiate the process of reaching accord in the high energy community as to what the future physics and accelerator priorities should be. Although there is not unanimity of opinion in all matters, there is a consensus that an NLC should be built somewhere in the world and vigorous R & D should be pursued in promising new areas such as the muon collider concept and new modes of particle acceleration.

Given the long lead times necessary for the design of new particle accelerators, it is important for the high energy physics community to decide soon what types and energy ranges of colliders are necessary to address the additional questions which the LEP and LHC may not be able to answer.

The perspectives that were presented at the symposium on the state and future of high energy physics are vital ingredients in the continuing discussion of how the U.S. High Energy Physics community should best marshal its national scientific resources while continuing a high level of international collaboration. They should provide valuable input for ongoing discussions and in making decisions regarding the future direction of the field [2, 4].

5.3.3.1 Acknowledgements

I would like to take this opportunity and thank my colleagues for their interest, participation and support prior and during the 5 month program I organized and coordinated. Their help is especially appreciated because the other coordinators that I selected to assist with the program did not participate due to various reasons. It was a lot of work, but I am very pleased with the outcome and success of the first Santa Barbara (ITP) and US, long term accelerator research program. I thank the advisors, speakers, conveners and participants for making the 5 month program and symposia a unique and stimulating experience. I also thank the ITP and the National Science Foundation for their support and for providing a nice place for our program.

This report was written at the invitation of Dr. K. Hirata. The author thanks him and Dr. J. Jowett for their interest.

References

[1] Z. Parsa, Editor “New Modes of PArticle Acceleration- Techniques and Sources”, AIP CP 396 (1997), AIP Press, Woodbury, NY ; and references therein.

[2] Z. Parsa, Editor “Future High Energy Colliders”, AIP CP 397 (1997), AIP Press, Woodbury, NY; and references therein;

[3] Z. Parsa, Editor “Beam Stability and Nonlinear Dynamics”, AIP CP 405 (1997), AIP Press, Woodbury, NY; and references therein.

[4] Z. Parsa, “Collision Crossroads”, CERN Courier, Vol. 37, No. 2, (March 1997).

5.4 The XVI RCNP OSAKA International Symposium on Multi-GeV High-Performance Accelerators and Related Technology

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An international symposium entitled Multi-GeV High-Performance Accelerators and Related Technology was held at Ichou Kaikan in Suita Campus of Osaka University from March 12 to 14, 1997 as announced in Beam Dynamics Newsletter No. 12. It was held just one day before the RCNP 25th anniversary ceremony and is the 16th symposium of series of RCNP International Symposia on subjects of nuclear physics including instruments and accelerators.

The symposium consisted of 27 invited/oral talks and 20 poster presentations. About 120 active accelerator physicists and engineers participated in the symposium from European countries, United States, China, and Japan. The development of collider was reviewed by Prof. A.M. Sessler (LBL) who recalled the main milestones. Extensive discussions were made on the present status and future perspectives on accelerators and related technology for sub-GeV and multi-GeV energy region from the viewpoint of realization of high-performance.

In his opening address, Director General of the RCNP, Prof. H. Ejiri expressed that the RCNP emphasizes high-quality beam in medium energy region and that the way of accelerator development of the RCNP is a quality frontier in a multi-GeV energy region for studies of nuclear-particle physics, mainly non-perturbed QCD region.

On the last day of the symposium, a round table discussion on a talk of an RCNP future accelerator project of a cooler-synchrotron-collider for protons/light ions/electrons/polarized ions presented by one of the reporters (K. S.) was added just before the summary talk by Prof. A.M. Sessler due to his kind arrangement. Four excellent accelerator physicists, D. Reistadt (TSL), S.Y. Lee (IUCF), P. Schwandt (IUCF), and J. Wei (BNL), Gave encouragements and comments on it.

The proceedings of the symposium will be published in 1997.

6: Announcements of Forthcoming Beam Dynamics Events

6.1 International Symposium on Near Beam Physics

Nikolai Mokhov `mokhov@fnal.gov` Fermilab

We are pleased to announce the first International Symposium on Near Beam Physics to be held at Fermilab on September 22-24, 1997. The purpose of the symposium is to assay the current understanding of beam halo phenomena, accelerator techniques, and experiments that operate near beams. The emphasis will be on the interplay of these subjects, not on experimental results. The symposium will also apprise future possibilities and determine where additional work is needed to exploit opportunities for near beam operation. There appear to have been no recent meetings that have emphasized the interplay between detectors operating near accelerator beams and accelerator physics. This meeting is intended to provide a forum for sharing experience.

The complete information can be found on the Symposium home page

`http://www-ap.fnal.gov/NEARBEAM/`.

You are encouraged to fill in the registration form there if you would like to participate in the Symposium. There will be a registration fee ($ 150 before August 15 or $ 200 after August 15) which will include the cost of refreshments, evening reception and pizza party and proceedings. If you have any questions contact the Symposium co-chairmen Dick Carrigan (carrigan@fnal.gov) or Nikolai Mokhov (mokhov@fnal.gov), or the Symposium secretaries Cynthia Sazama and Marion Richardson (mhr98@fnal.gov).

Organizing Committee

M. Albrow, Fermilab
A. Asseev, IHEP
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K. Ehret, DESY
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M. Sullivan, SLAC
K. Takayama, KEK
C. Taylor, Case Western Reserve
F. Willeke, DESY

6.2 Nonlinear and Stochastic Beam Dynamics in Accelerators—A Challenge to Theoretical and Computational Physics

H. Mais `mais@mail.desy.de` DESY
S. Martin `s.martin@kfa-juelich.de` Forschungszentrum Juelich

We are pleased to announce a workshop on “Nonlinear and Stochastic Beam Dynamics in Accelerators—A Challenge to Theoretical and Computational Physics” to be held in Lüneburg, Germany from 29 September–3 October, 1997.

Solving the rather intricate beam dynamics problems of existing and future accelerators (boosters, synchrotron light sources and colliders) requires a good knowledge and understanding of various mathematical tools and methods as for example from dynamical system theory, stochastic dynamics and partial differential equations - to name only a few. In order to discuss some of these topics and their applications to accelerator physics DESY will organize a workshop from September 29 to October 3 in Lüneburg. In a series of review and tutorial talks the following topics will be covered:

- beam dynamics issues for synchrotron light sources and FEL's
- old and new collective effects in circular accelerators: single- and multibunch phenomena
- formation and control of halos induced by space charge
- mathematical and computational aspects of nonlinear dynamics
- adiabatic invariants in classical mechanics
- mathematical concepts and tools for solving stochastic dynamical systems

Besides these survey talks there will be time for 20 minutes contributions from the participants. A special session of the workshop is reserved for the presentation of the results of the European network **"Nonlinear Problems in Beam Dynamics and Transport"**.

The aim of this workshop is to strengthen the collaboration between the big accelerator laboratories and universities and to facilitate the transfer of knowledge and expertise.

The workshop will be held in the **Hotel Seminaris in Lüneburg**.

Lüneburg, a more than thousand years old former Hanseatic City is located 50 km south of Hamburg. Because of its saline works it was one of the richest and most influential cities of the Hanseatic League in Germany. Today, because of its picturesque market square with the impressive Townhall, whose oldest parts date from the middle of the 13th century, and because of its historic center of the town (Altstadt) with many restored patrician houses and salt storehouses, Lüneburg has become an attractive tourist place.

The registration fee is DM 1150 . This fee includes accomodation in single bed rooms, breakfast, lunch and dinner from Sunday, September 28 (arrival) to Friday, October 3, 1997, a copy of the proceedings, a sightseeing tour of Lüneburg and a transportation opportunity from DESY to Lüneburg and back to Hamburg. The conference dinner will take place in an old brewery.

Deadline for applications is **August 15, 1997**. Further information can be obtained via WWW.

`http://www.desy.de/~beam97`

or by contacting

Dr. Helmut Mais	`mais@mail.desy.de`	DESY
Ms. Swaantje Sievers	`beam97@desy.de`	beam97@desy.de

6.3 BDO-97, Fourth International Workshop on Beam Dynamics & Optimization

First Announcement

The Fourth International Workshop on Beam Dynamics & Optimization will be held at Dubna, near Moscow, Russia, 13–17 October, 1997.

Organization

Joint Institute of Nuclear Research (Dubna),
St.Petersburg State University - Faculty of Applied Mathematics & Control Processes - Institute of Computational Mathematics & Control Processes,
D.V.Efremov Institute of Electrophysical Apparatus (St.Petersburg),
Institute of High Energy Physics (Protvino), Russia Research Center I.V. Kurchatov Institute (Moscow).

Scientific Topics

Nonlinear problems of beam dynamics: mathematical modelling, nonlinear aberrations, including space charge forces and the self-consistent distributions problem, long time beam evalution, dynamic aperture and halo problems. Methods of control theory in the problems for the beam and plasma dynamics optimization. Mathematical modelling of the electro- and magnetic fields. Computing problems for beam physics. Software for the beam dynamics and optimization.

Program Committee

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Official Languages

The workshop languages are English and Russian (with mutual translation).

Abstracts and Proceedings

The submitted ABSTRACTS are published in the Book of ABSTRACTS and are available for participants during the Workshop. The contributed papers will be included in the Workshop PROCEEDINGS after being refereed and accepted for publication. Instruction for authors will be mailed later to registered authors and will be available on the BDO-97 WWW-page.

6.4 HEACC'98, XVIIth International Conference on High Energy Accelerators

First Circular

The 17th International Conference on High Energy Accelerators (HEACC'98) will take place in Dubna, Moscow Region, Russia from 7 to 12 September 1998. The Conference is organized by the Joint Institute for Nuclear Research, the Russian Academy of Sciences, the International Committee for Future Accelerators and the Russian Foundation for Fundamental Research.

Scope and Topics

Review on High Energy Physics Which accelerators do we need today? Physics on Accelerators - Physics for Hadron Colliders; Hadron Accelerators; Positron-Electron Storage Rings and Factories; Small Accelerators.

Circular Colliders and Accelerators Hadron Colliders; Electron-Positron Colliders; B, j, Ct-Factories; Hadron Accelerators; Electron Accelerators.

Linear Colliders and Accelerators Conventional Linear Colliders; Superconducting Linear Colliders; Two-Beam Linear Colliders; Linear Accelerators.

Muon Colliders

Particle Beam and Accelerator Physics New Methods of Acceleration; Beam Dynamics; Beam Formation and Manipulation; Beam Cooling.

Accelerator Technology Injectors Particle Sources; Injectors; Damping Rings; Injection/ Ejection Technology; and others.

Beam Observation Instrumentation; Control. General Technology - Power Supply Technology; Vacuum Technology; Survey Technology; and others.

General Technology Power Supply Technology; Vacuum Technology; Survey Technology; and others.

Magnet Technology Magnetic Field Measurements; Field Calculations; Superconducting Magnets

RF Technology Superconducting Cavities; RF Technology; Impedance Calculation.

Scientists concerned with high energy accelerators are invited to participate. Those interested in the Conference are kindly requested to fill in the questionnaire which can be faxed or e-mailed. The questionnaire is available from the WWW page:

`http://nuweb.jinr.ru/~ebeam`

Programme Advisory Committee

A.Skrinsky, Chairman (Budker INP), Balakin V.E. (BINP), Baldin A.M. (JINR), Dikansky N.S. (BINP), Dzelepov V.P. (JINR), Dmitrievsky V.P. (JINR), Grunder H.A. (TJNAF), Hirata K. (KEK), Kimura Y. (KEK), Kravchuk L.V. (INR), Kulipanov G.N. (BINP), Lebedev A.N. (LPRAS), Llewellyn Smith C. (CERN), Meshkov I.N. (JINR), Moehl D. (CERN), Oganessian Y. (JINR), Peoples J. (FNAL), Richter B. (SLAC), Sessler A. (LBNL), Shukeilo I (RIEPA), Wiik B.H. (DESY), Yano Y. (RIKEN).

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HEACC'98 programme, registration c/o Grigori Shirkov, LPP JINR, Phone: (+7 09621) 65136 fax (+7 09621) 65767 Dubna Moscow Region, 141980 Dubna, e-mail HEACC98@sunse.jinr.ru

Accommodation, visas and etc. c/o Natalia Dokalenko, Intern. Depart., JINR Phone: : (+7 09621) 65011 fax (+7 09621) 65599; 65891 Dubna Moscow Region, 141980 Dubna, e-mail natasha@cv.jinr.ru

7: Announcements of the Beam Dynamics Panel

7.1 ICFA Beam Dynamics Mini-workshops on High Brightness Hadron Beams

Four institutions: the AGS Dept. at BNL, the Main Injector Dept. at FNAL, the PS Division at KEK and the PS Division at CERN have agreed on an informal collaboration to co-sponsor a mini-workshop series. The purpose of this series is to investigate the major technical issues associated with achieving high intensity high brightness hadron beams. This type of beam is expected in such accelerators as AGS in the RHIC era at BNL, the Main Injector at FNAL, the 50 GeV synchrotron under study at KEK and the CERN-PS in the LHC era. The term ”Mini-Workshop” defines a workshop with limited attendance (on invitation), no formal proceedings, problem-solving and discussion oriented rather than presentation-oriented.

Contact people at the various labs are:

T.Roser	`roser@bnldag.ags.bnl.gov`	BNL
P.Martin	`pmartin@fnal.gov`	FNAL
Y.Mori	`moriy@KEKVAX.KEK.JP`	KEK
R.Cappi	`roberto.cappi@cern.ch`	CERN chairman of the local organising committee

7.1.1 Preliminary Announcement: Mini-Workshop, CERN, September 1997

The ”4th ICFA Beam Dynamics Mini-Workshop on Transverse Emittance Preservation and Measurements” will be held at CERN on 5–7 November, 1997.

A detailed program will be available at beginning of September.

7.2 Advanced ICFA Beam Dynamics Workshop on Quantum Aspects of Beam Physics

The 15th Advanced ICFA Beam Dynamics Workshop on Quantum Aspects of Beam Physics will be held in Monterey, California, USA on January 4-9, 1998.

The latest information on this workshop can be found at
`http://www.slac.stanford.edu/grp/ara/qabp/qabp.html`

Introduction

The frontiers of beam research point to ever higher energy, higher brightness, lower emittance (or lower temperature) beams with ever increasing particle species. These demands in turn have triggered a rapidly increasing number of beam phenomena that involve quantum effects. Concurrently, the violent accelerations which are becoming available through novel accelerator research may, perhaps, help to investigate fundamental physics associated with general relativity. In a different apsect, certain mathematical formulations developed in quantum mechanics and quantum field theory have been applied to describe beam phenomena, although those phenomena do not necessarily involve the Planck constant. With these exciting developments in mind and the important role they may potentially play in the next century, it should be timely to organize such a workshop dedicated entirely to the quantum aspects of beam physics.

International Advisory Committee

Members of the ICFA Beam Dynamics Panel, see 52.

Program Committee

J.D. Bjorken (SLAC), P. Chen (SLAC, Chairman), A. Dragt (U. Maryland), K. Hirata (KEK), C. Pellegrini (UCLA), F. Ruggiero (CERN), R. Ruth (SLAC), V. Serbo (Novosibirsk State U.), A. Sessler (LBNL), K. Tajima (U. Texas), K. Yokoya (KEK).

Local Organizing Committee

T. Anderson (SLAC), A. Chao (SLAC), P. Chen (SLAC, Chairman), Z. Huang (SLAC), J. Irwin (SLAC), E. Mitchell (SLAC (Conference Administrator)), R. Ruth (SLAC).

Program and Working Groups

As the very first workshop on such a subject, the program will be blended with a reasonable amount of pedagogical lectures. The topics of lectures/working groups include

1. Quantum Fluctuations in Beam Dynamics: synchrotron radiation and spin polarization in storage rings, spontaneous/stimulated emmissions in FELs, radiation reaction in focusing systems, etc.

2. Photon-Electron Interaction in Beam Production, Cooling, Monitoring: laser cooling, Compton backscattering, Shintake monitor, laser wire, quantum efficiency in photocathodes, etc.

3. Beam Phenomena under Strong EM Fields: beamstrahlung, coherent pair creation, minijets, crystal channeling, nonlinear QED effects in heavy ion collisions, etc.

4. Production and Handling of Condensate Beams: production and handling of Bose-Einstein Condensate atomic beams, crystalization/Fermi liquidation of ion, proton, and electron beams, ultimate limit of low emittance photon beams, etc.

5. Fundamental Physics under Violent Acceleration: laboratory tests of general relativity, Unruh effect, and dynamic Casmir effect, etc; accelerator production of gravitational waves and gravitons.

6. Quantum Methodology in Beam Physics: uses of renormalization theory, supersymmetry, Wigner function, Schrodinger equation, Dirac equation, etc, in beam physics.

   Depending on the eventual response from our colleagues attending the meeting, certain topics listed above may be organized into joint working groups. A tentative plan of the working groups and their convenors are as follows:

   Group A (Topic 1): K. J. Kim* and K. Oide*,

   Group B (Topics 2&4): S. Chattopadhay and another name to be identified,

Group C (Topics3&5): K. Yokoya and A. Mellisinos,

Group D (Topic 6): A. Dragt.

Plenary Talks and Speakers

A tentative list of plenary talks are given below for your information.

The speaker names will be announced in the next circular.

1. ”Overview on Quantum Aspects of Beam Physics”,
2. ”Radiation Reaction and Fundamental Limits of Beam Emittance”,
3. ”Collective and Coherent States in Beam-Radiation Interaction”,
4. ”Electron-Photon Interaction in Beam Production and Cooling”,
5. ”Beamstrahlung and Coherent Pair Creation in Linear Colliders”,
6. ”Nonlinear QED Effects in Heavy Ion Collisions”,
7. ”Bose-Einstein Condensate Atomic Beams and Its Applications”,
8. ”Laser Cooling of Ion Beams”,
9. ”From Hawking Radiation to Unruh Radiation”,
10. ”Laboratory Production of Violent Acceleration and Tests of General Relativistic Effects”,
11. ”Quantum Methodology in Beam Dynamics”,
12. ”Quantum Computing”.

7.3 ICFA Beam Dynamics Newsletter

Editors in chief

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Instructions to the authors

7.3.1 Instructions to the authors

The ICFA Beam Dynamics Newsletter is intended as a channel for describing unsolved problems and highlighting important ongoing works, and not as substitute for journal articles and conference proceedings which usually describe completed work. It is published by the ICFA Beam Dynamics Panel, one of whose missions is to encourage international collaboration in beam dynamics.

It is published every April, August and December. The deadlines are 15 March, 15 July and 15 November, respectively.

The categories of articles in the newsletter are the following:

1. Anouncements from the panel

2. Reports of Beam Dynamics Activity of a group

3. Reports of Beam Dynamics related workshops and meetings

4. Anouncements of future Beam Dynamics related international workshops and meetings.

   Those who want to use newsletter to anounce their workshops etc can do so. Articles should typically fit within half a page and include descriptions of the subject, date, place and details of the contact person.

5. Review of Beam Dynamics Problems

   This is a place to put forward unsolved problems and not to be used as the achievement report. Clear and short highlights on the problem is encouraged.

6. Letters to the editor

   It is a forum open to everyone. Anybody can show his/her opinion on the beam dynamics and related activities, by sending it to one of the editors. The editors keep the right to reject a contribution.

7. New Doctoral Theses in Beam Dynamics

   Please send announcements to the editors including the following items (as a minimum):

   (a) Name, email address and affiliation of the author,

   (b) Name, email address and affiliation of the supervisor,

   (c) Name of the institution awarding the degree,

   (d) The title of the thesis or dissertation.

   (e) Date of award of degree.

   A *short* abstract of the thesis is also very desirable.

8. Editorial

All articles except for 6) and 7) are by invitation only. The editors request an article following a recommendation by panel members. Those who wish to submit an article are encouraged to contact a nearby panel member.

The manuscript should be sent to one of the editors as a LaTeX file or plain text. The former is encouraged and authors are asked to follow the example below.

Each article should have the title, author's name(s) and his/her/their e-mail address(es).

To avoid wrapping problem, please do not put comments (through e-mail.

7.3.1.1 An example of LaTeX format

The following can be used as a model for preparing contributions.

```
\documentclass{report}
\usepackage{graphics}

% PLEASE USE THESE DUMMY DEFINITIONS FOR DRAFTING AND
% DO NOT CHANGE THEM !!
% They will facilitate the conversion to hypertext for WWW.

% use this to give a link on WWW
\newcommand{\htmllink}[1]{\texttt{#1}}

% use this to give a person's name and email address
\newcommand{\email}[2]{#1 (\texttt{#2})}

% use this to give name, email and address at the top of a
% contribution
\newcommand{\contact}[3]{{\noindent%
                          \parbox[t]{0.6\columnwidth}%
                                    {\textit{#1}\hfill\texttt{#2}
                                    }%
                          \hfill%
                          \parbox[t]{0.35\columnwidth}
                                    {\small\raggedright#3}\\%
                         }%
                        }

% The following can be used for long comments
\newcommand{\comm}[1]{}

\begin{document}

\section{Beam Dynamics Activities at KEK}

\contact{K.~Hirata}{hirata@kekvax.kek.jp}{KEK\\
                     National Laboratory for High Energy Physics}

Recent developments at KEK include \ldots

\subsection{Further instructions}

You can refer to these instructions at
\htmllink{http://www-acc-theory.kek.jp/ICFA/instruction.html}.

Please prepare your contribution as plain text or straightforward
\LaTeX, following this example.  Remember that the final version
(fonts, layout, etc.) of the newsletter (whether on the World-Wide Web
or on paper) will look very different from your draft so it is
\emph{useless to include any visual formatting commands} (such as
vertical or horizontal spacing, centering, tabs, etc.).  Use only
structural markup as recommended in~\cite{Lamport}.

Above all, avoid \TeX\ commands that are not part of standard \LaTeX.
These include the likes of \verb|\def|, \verb|\centerline|,
\verb|\align|, \ldots.

These restrictions are necessary so that we can automate production
and conversion of the newsletter into HTML for the Web.

Please include the author's name, electronic mail and laboratory
```

```
addresses as above and keep the title of your section concise.

Please keep figures to a minimum.
The preferred graphics format is Encapsulated Postscript (EPS) files.

Remembering that this is a newsletter and not a journal or laboratory
report, please also avoid using too much mathematics and giving formal
statements of results.

\begin{figure}[htbp]
    \resizebox{\columnwidth}{!}
         {\includegraphics*[144bp,598bp][349bp,720bp]{dummy.eps}}
    \caption{Example of a figure.
             The optional arguments give the coordinates of the
             lower left and upper right corners of the part of the
             image which is to be included.
             The units bp are the same ‘‘points’’ used in Postscript.
             The image is resized to the width of the current column.
             See~\protect\cite{Lamport}, pp.129--131.
            }
    \label{fig:example}
\end{figure}

A short bibliography may be included.

\begin{thebibliography}{99}

\bibitem{Lamport}
      \LaTeX: A Document Preparation System, Second Edition
      Addison-Wesley, Reading, Massachussets, 1994.

\end{thebibliography}

\end{document}
```

7.3.2 World-Wide Web

Recent issues of this newsletter are available through the World-Wide-Web via the addresses given below. This is now intended as the *primary method of communication.*

The home page of the ICFA Beam Dynamics Panel is at the address

`http://www-acc-theory.kek.jp/ICFA/icfa.html`

(which happens to be in Japan). For reasons of access speed, there are mirror sites for Europe and the USA at

`http://wwwslap.cern.ch/icfa/`
`http://www.indiana.edu/~icfa/icfa.html`

All three sites are essentially identical and provide access to the Newsletters, Future Workshops, and other information useful to accelerator physicists. There are links to information of local interest for each area.

7.3.3 Distribution

The ICFA Beam Dynamics Newsletters are distributed through the following distributors:

W. Chou	chou@adcon.fnal.gov	North and South Americas
Helmut Mais	mail@mail.desy.de	Europe* and Africa
Susumu Kamada	kamada@kekvax.kek.jp	Asia** and Pacific

(*) including former Soviet Union.
(**) For mainland China, Chuang Zhang (`zhangc@bepc5.ihep.ac.cn`) takes care of the distribution with Ms. Su Ping, Secretariat of PASC, P.O.Box 918, Beijing 100039, China.

It can be distributed on a personal basis. Those who want to receive it regularly can ask the distributor to do so. In order to reduce the distribution cost, however, please use WWW as much as possible.

7.4 ICFA Beam Dynamics Panel Members

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The views expressed in this newsletter do not necessarily coincide with those of the editors. The individual authors are responsible for their text.