International Committee for Future Accelerators

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BEAM DYNAMICS NEWSLETTER

No. 25

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1: From the Chairman of the ICFA Beam Dynamics Panel

John M. Jowett John.Jowett@cern.ch The Chairman

1.1 About our workshops

A look at the ICFA Beam Dynamics Panel's Web page

http://wwwslap.cern.ch/icfa/

shows that we are now organising ICFA Advanced Beam Dynamics Workshops (ABDWs) at a rate of 3 or 4 each year. The Beam Dynamics Panel (BDP) and, I believe, the entire beam dynamics community is grateful to our colleagues who take on the very considerable effort of planning and organising these workshops.

We are often asked what exactly is the role of the BDP in organising these workshops? After all, we have no budget to support them and, while there is always at least one BDP member in the Programme and Organising Committees, much of the work is done by colleagues outside the Panel. Yet there are an increasing number of requests for ICFA approval of workshops so what is the attraction?

The answer, I think, is analogous to branding in the commercial world. The approval of a workshop as an ICFA ABDW is a guarantee of quality and this is valuable in attracting the best participants and gaining the support of funding bodies and hosting institutions. As with a commercial brand we must take care to preserve the integrity and high reputation of our label. That is why any proposal for a workshop must be submitted to the BDP in the first instance and why a Panel member must take responsibility for a workshop with respect to the Panel. If the BDP approves it, then the proposal is submitted to ICFA itself for final approval. Since ICFA is the highest level body devoted to international collaboration in the construction and use of accelerators for high energy physics, this final endorsement clearly indicates that the workshop is important for the future of high energy physics.

The value of the ICFA ABDW series is often that they treat advanced subjects where the number of active workers world-wide is small and where it might be difficult to organise a workshop in any other framework. In some cases they have led to the opening up of new fields of research in beam dynamics.

Not every interesting or worthwhile workshop on Beam Dynamics can be an ICFA ABDW. But of course there is nothing to stop interested parties organising workshops within any other framework.

On the other hand, it should be clear that the BDP does not have the resources to guarantee that all subjects important enough to merit a workshop actually get one devoted to them! If no group of organisers comes forward and the necessary support and funding cannot be found then it is not possible to hold a workshop. However ICFA's endorsement of a good proposal from motivated individuals can be pivotal in gathering the necessary support.

Another point to be borne in mind is that neither the schedules of individuals nor our funding agencies can support an indefinite number of workshops. Typically, an ABDW works well with a few tens of participants.

I feel that we owe it to the international Beam Dynamics community to make the criteria and procedures as open and transparent as possible.

Therefor I would like to recall the clear guidelines concerning the ICFA ABDWs. They were last set out over 5 years ago in the August 1996 newsletter

`http://wwwslap.cern.ch/icfa/nlaug96/nlaug96/nlaug96.html`

I hope that repeating them will help proposals to be correctly formulated and help to avoid situations where proposals cannot be accepted. With some rephrasing and amplification of points that were understood implicitly, they are:

- Sponsorship is an official declaration by the BDP, and by ICFA, of the importance and urgency of the subject. The subject and the aim should first be approved by the BDP and then by ICFA. Only then may the workshop be publicised as an ICFA ABDW.
- The subject of the workshop should be a topic of current advanced research in beam dynamics. It should be timely and of importance to the future development of particle accelerators, especially those for high energy physics.
- The workshop should be publicised in the Beam Dynamics Newsletter, the ICFA BDP Web page and elsewhere. It should be open to suitably qualified participants world-wide.
- The workshop should not be focused on the advancement of any particular accelerator project. If, for example, the subject is some beam dynamics problem related to linear colliders, then the workshop should treat it in general without emphasis on any particular project. There may, of course, be contributions from individual projects.
- The workshop should be proposed to the Panel by one or more Panel member. At least one Panel member should be involved as a real organizer and be responsible for the workshop to the Panel.
- The workshop should be reviewed quickly in the next issue of the Beam Dynamics Newsletter by the organisers. The responsible Panel member is also responsible for ensuring that this report is produced. It is highly desirable that parts of the proceedings, or other material such as transparencies, should be made available on the World-Wide Web as quickly as possible.
- The Programme Committe must be representative of experts in the subject world-wide.
- The BDP members are automatically nominated as International Advisory Committee members (but their individual names need not be listed in Web pages or posters). They can also be members of the programme and/or the local organising committees.
- When the discussion on the workshop is done by email, there should be at least two iterations between members and the chairman in order that each member knows the opinions of the others.
- Workshop proceedings must be published promptly and be available world-wide. Publication can be in any convenient form from CD-ROM to bound book or a special volume of a journal.

In practice, the proposal to the Panel needs to take place at least a year before the workshop in order to allow time for the approval process (ICFA meetings are normally held only twice per year) and the subsequent period of planning and publicising the event.

I am concerned that there may be important fields of beam dynamics activity that are not well represented among the present Panel membership. Indeed this is quite rightly pointed out in a letter from Andrew Sessler in this issue. Since our Panel is intended to serve the whole field, rapidly evolving though it is, we will do our best to remedy this situation as quickly as possible.

In the meantime, anyone who wishes to organise a workshop meeting the above criteria should not be deterred simply because there appears to be no obvious Panel member to contact. They can always contact their nearest Panel member or the chairman directly and we will try to find an appropriate solution.

In his letter, Dr Sessler also points out that the research interests of Panel members may also influence the selection of articles for the newsletter. This, I truly hope, is a much weaker effect: to the best of my knowledge we have never turned down an article for that kind of reason. If some topic is not covered in the newsletter it is usually because no-one has volunteered to write about it. Readers who feel that their favourite topic is inadequately covered are strongly encouraged to contribute! Good articles are always very welcome.

1.2 Minutes of the 14th Panel Meeting

The 14th meeting of the ICFA Beam Dynamics Panel was held at the Hyatt Regency Hotel,Chicago on 21 June 2001, during the Particle Accelerator Cconference. The following Panel members, or their representatives, took part:

> Weiren Chou, Zhiyuan Guo (for Chuang Zhang), John M. Jowett (Chairman), Kwang-Je Kim, Jeffrey Kraft (for Swapan Chattopadhyay), Jean-Louis Laclare, Helmut Mais, Luigi Palumbo, Evgeni Troyanov (for Sergei Ivanov), Jie Wei.

Apologies for their absence were received from Yoshihiro Funakoshi, Kohji Hirata, Ingo Hofmann, Pisin Chen, Claudio Pellegrini, Elcuno A. Perelstein and Dmitri Pestrikov.

1.2.1 General

The Chairman started the meeting by acknowledging the contributions of Kohji Hirata who had been Chairman from 1994–2000 and summarising the Panel's activities during that time. The term of office of the new Chairman is 3 years from 1 January 2001.

He welcomed Swapan Chattopadhyay of Jefferson Lab, who has joined the Panel, replacing David Whittum of SLAC.

He went on to recall the role of the Beam Dynamics Panel within ICFA, see Newsletter No. 24,

`http://wwwslap.cern.ch/icfa/nlapr2001/`

ICFA expects the Panel to actively further its work by pursuing various activities (newsletter, working groups, workshops, etc.) designed to encourage and promote international collaboration on beam dynamics studies for present and future accelerators. The Chairman reports on these activities at the meetings of ICFA itself, every 6 months or so. The Panel has 17 members, appointed for nominal 3-year terms, although terms of office are generally longer.

The members were asked to reflect on ways in which the Panel could better further ICFA's aims.

1.2.2 Beam Dynamics Newsletter

The Chairman reviewed the organization of the Beam Dynamics Newsletter. This is available mainly from the Beam Dynamics Panel Home Page.

`http://wwwslap.cern.ch/icfa/`

but 1300 paper copies are still distributed.

There are three issues per year with rotating editors (Chattopadhyay, Chou, Ivanov, Mais, Wei, Zhang) guided by the chief editors (Hirata, Jowett). The editors may choose to give individual newsletters a special theme.

All Panel members contribute regularly and encourage contributions from colleagues and contacts.

Articles are welcomed from everyone in the beam dynamics community. The types of article can include: letters, opinions, workshop and conference reports, activity reports, announcements of forthcoming beam dynamics events, announcements of Ph.D. theses in beam dynamics. Articles in the newsletter are NOT scientific papers.

The editorial rota for the next few issues is:

August 2001	J.M. Jowett
December 2001	S. Chattopadhyay
April 2002	W. Chou

1.2.3 Web Site

The practice of mirroring the Beam Dynamics Panel Home Page at three locations has been dropped. In any case, the pages behind the Home Page were not mirrored. The Home Page will have links to regional pages maintained by Chattopadhyay (Americas), Jowett (Europe/Africa) and Hirata (Asia/Pacific).

As time allows, a number of upgrades to the Web site software are envisaged, e.g., in order to create a subscription list for the newsletter. Unfortunately, for technical reasons, this may require a change of address of the Home page. However the old address will continue to forward Web browsers to the new one.

1.2.4 Reports from Working Groups

1.2.4.1 Working Group on Future Light Sources

The Working Group leader, K.-J. Kim, reported on the activities of this group. They are centred mainly on the planning of the 24th and 25th Advanced ICFA Beam Dynamics Workshops to be held in September 2001 and May 2002.

1.2.4.2 Working Group on High Luminosity e^+e^- Colliders

In the absence of the working group leader, Y. Funakoshi, the Chairman recalled that this working group was set up in late 2000 to encourage world-wide effort to achieve a luminosity at least 10 times larger than present limit in e^+e^- factories. At present the main activity is the 23rd Advanced ICFA Beam Dynamics Workshops to be held in September 2001.

1.2.4.3 *Working Group on High Intensity High Brightness Hadron Beams*

The Working Group leader, W. Chou, reported on this very active group which has organised several informal Mini-Workshops and is hosting the Snowmass 2001 Working Group on High-Intensity Proton Sources. All these activities are well-documented on the working group's Web pages.

The 20th Advanced ICFA Beam Dynamics Workshop on High Intensity and High Brightness Hadron Beams has had to be delayed but it is hoped to hold it in late 2001 or early 2002 at Fermilab.

1.2.5 Recent Workshops

Since the last Panel meeting in 1999, four Advanced ICFA Beam Dynamics Workshops have taken place. Reports of these have appeared in the Beam Dynamics Newsletter and publication of proceedings is under way.

1.2.6 Future Workshops

On behalf of of P. Chen, J.M. Jowett presented a proposal from F. Zimmermann and R. Assmann of CERN for an Advanced ICFA Beam Dynamics Workshop on "Nanometre-Size Colliding Beams". This would be held at CERN in September 2002.

On behalf of C. Pellegrini, L. Palumbo presented a proposal for an Advanced ICFA Beam Dynamics Workshop on "Physics and Applications of High Brightness Electron Beams". This would be held in Sardinia, Italy in 2002. A date in September was favoured over one in July because of a clash with the IFEL conference in Argonne.

The Panel Members present approved both of these proposals unanimously.

J.-L. Laclare asked whether it might be possible for ICFA to delegate the process of workshop approval entirely to the Panel in order to speed up the procedure.

1.2.7 Next Panel Meeting

J.-L. Laclare asked where the next Panel meeting would be held, given that the last two had taken place during the US Particle Accelerator Conference. The Chairman said that the next meeting could be held either at the APAC (Asian Particle Accelerator Conference) in September 2001 or at the EPAC (European Particle Accelerator Conference) in June 2002.

1.2.8 Follow-up of Panel Meeting

In the period between the Panel meeting and publication of this newsletter, there have been further developments of points raised in the meeting.

- At its meeting in Rome on 27 July 2001, ICFA approved the proposal of a workshop on "Nanometre-Size Colliding Beams" as the 26th Advanced ICFA Beam Dynamics Workshop. It will be held on 2–6 September 2002, at or near CERN, Geneva, Switzerland.

- Following an initial presentation in Rome, ICFA deferred approval of the proposal of a workshop on "The Physics and Applications of High Brightness Electron Beams" as the 27th Advanced ICFA Beam Dynamics Workshop until further information was made available. Subsequently, the workshop was approved, and will be held on 20-25 September 2002, near Cagliari, Sardinia, Italy.

- Having consulted the Panel members and the conference organisers, it appears that there are not enough Panel members attending the APAC in Beijing in September 2001 to justify having a Panel meeting so soon after the last one. Therefore we plan to hold the next Panel meeting at the EPAC in 2002.

1.3 Next Meeting

The next meeting of the ICFA Beam Dynamics Panel will be held during the European Particle Accelerator Conference (EPAC2002)

`http://epac.web.cern.ch/EPAC/Welcome.html`

that will be held from 3 to 7 June 2002 at the Congress Centre of the *Cité des Sciences et de l'Industrie* at La Villette, Paris, France.

2: Letters to the Editors

From Andrew M. Sessler

To the Editor, ICFA Beam Dynamics Newsletter

I believe that the ICFA Panel would gain by adding members active in areas that are in the "front line" for consideration for future construction. Just what areas should be included will be seen when the HEPAP Sub-Panel reports in, but we know it certainly will include linear colliders, super LHCs, neutrino factories/muon colliders, and proton drivers. Some of these areas are already well covered by the Panel, but some are not. Having representation from these areas ensures that the Panel is involved with "real things"; not only with far-off possibilities. Clearly, a proper balance, not only of activities, but of geography, age, and sex, is needed.

All of these machines have important—usually vital—beam dynamic issues and having a representative on the Panel will assure that these issues will be brought up when consideration is given to the choice of articles and workshops. Most particularly, an active member of the Panel can—should–stimulate activity in areas of importance. Speaking for the Muon Collaboration, I know that we face many beam dynamics issues; I suspect the same can be said for each of the other machines under consideration.

Andrew M. Sessler
Spokesperson for the Neutrino Factory and Muon Collider Collaboration

3: Activity Reports

3.1 Electron-Cloud Studies at CERN

F. Zimmermann frank.zimmermann@cern.ch CERN

An electron amplification via beam-induced multipacting was first observed in the CERN ISR around 1976 [1]. Based on the experience of the ISR, the resulting beam induced pressure rise has been a concern for the LHC since the early design phase [2]. Further motivated by the more recent observations of the electron-cloud driven instabilities at the KEK Photon Factory [3, 4] and in view of the heat load to the cryogenic system, in 1997 a crash program was lanched at CERN [5, 6, 7, 8, 9, 10, 11].

Since 1999 electron cloud effects are indeed seen with the LHC test beam (72 bunches, about 10^{11} protons per bunch, 25 ns spacing) [12, 13] in the CERN SPS and since 2000 also in the PS [14]. At the SPS multipacting threshold, an increase of the vacuum pressure by a factor 10-100 is observed as well as a charge deposition on both electro-static pick ups [12] and dedicated electron-cloud monitors, and a transverse instability. The instability results in significant emittance growth and even beam loss. So far the best and only method of avoiding beam loss is to operate the machine with a very high chromaticity, up to $\xi = +0.8$ [13]. In the PS and the PS-to-SPS transfer line, similar electron-cloud effects are observed [14]. It is expected that scrubbing (surface modifications due to electron bombardment) will improve the situation [15]. Preliminary evidence in 2000 appears to indicate that scrubbing takes place in the real SPS machine as foreseen [17, 18].

Recent laboratory measurement have extended the range of secondary emission yields measured on LHC candidate vacuum chambers to primary energies of only a few eV. These studies provide a precise knowledge of the number of elastically reflected electrons at small primary electron energies [19], which is an important input parameter to the simulations.

In the real machine, some primary electrons are generated by gas ionization, or, at the LHC, by photoemission. The electrons are then amplified by a beam-induced multipacting process. This amplification process has been simulated in the laboratory using a travelling wave system to represent the proton bunches [20]. The measured evolution of the cloud in the SPS, and in particular its saturation near the center of the bunch train, are well reproduced by simulation programs [21, 22], if the measured elastic reflection of low-energy electrons from the chamber wall is taken into account. The main concern for the LHC is the heat load deposited by electrons on the beam screen inside the superconducting magnets. According to recent simulations [21, 23] the computed heat load sensitively depends on the energy spectrum of the secondary electrons, and, in particular, on the fraction of primary electrons which is elastically reflected on the wall. At the LHC the problem is compounded by a large number of primary photoelectrons.

Presently contemplated countermeasures for the LHC include (1) the impression of a sawtooth pattern on the vacuum chamber to reduce the photon reflectivity [24], (2) the coating of all bakeable warm sections with a getter material to lower the secondary emission yield [16], (3) and surface conditioning using special fill patterns during commissioning, also to reduce the secondary emission yield. As a back-up option the installation of weak solenoid fields in the field-free regions is considered. Such solenoids have recently improved the performances of the two B factories, SLAC and KEKB [25, 26, 27], which are partially limited by an electron cloud.

The electron cloud can drive multi- [4, 28] and single-bunch instabilities [29, 30, 31, 33], and it can also induce coherent and incoherent tune shifts [34, 35, 21]. Electrons near the beam are thought to be responsible for the single bunch instability. A broadband pick up at the CERN SPS

has allowed the detection of motion inside the bunch, and to fit for the period of the effective wakefield [36]. The result is consistent with the estimated electron oscillation wave length, and with the proposed instability model based on a head-tail interaction [30, 31, 33].

The CERN electron-cloud studies are conducted by a concerted action of many CERN groups (SL/AP: F. Ruggiero, G. Rumolo, F. Zimmermann; SL/OP: G. Arduini, K. Cornelis; SL/RF: W. Höfle, T. Linnecar, J. Tückmantel; EST/SM: C. Benvenuti; LHC/VAC: V. Baglin, I. Collins, O. Gröbner, B. Henrist, N. Hilleret, M. Jimenez, J.-M. Laurent, A. Rossi; CERN PS: R. Cappi, F. Caspers, M. Giovannozzi, E. Metral, G. Metral) together with outside collaborators and partners such as LBNL (M. Furman, M. Pivi), TRIUMF (D. Kaltchev), KEK (H. Fukuma, T. Ieiri, K. Ohmi, K. Oide, E. Perevedentsev), University of Southern California (S. Lee, T. Katsouleas), Argonne National Laboratory (K. Harkay, R. Rosenberg), INFN Trieste (R. Cimino), BINP Novosibirsk (O.B. Malyshev, V.V. Anashin et al.), and SLAC (G. Stupakov).

After the amount of synchrotron radiation absorbed by the electron cloud was shown to be small [37], and the effects of ions and sputtering were both demonstrated to be insignificant [38], recent electron-cloud related beam dynamics activities at CERN have concentrated on the single-bunch instability. Different analytical and simulation models were developed to better understand this effect [29, 30, 31, 32, 33, 39]. Good agreement between the various approaches and experiments was achieved [40]. It is believed that there is a threshold similar to that for the transverse mode coupling instability (TMCI), which governs the onset of beam blow up. K. Ohmi has shown that the effective wake field of the cloud can be parametrized by a broadband resonator [31]. Employing this parametrization, thresholds are computed from approximative solutions of the linearized Vlasov equation [41, 42]. A recently written PIC code [33]. is used to study not only the isolated effect of the electron cloud, but also the combined action of electron cloud, regular broadband impedance and space charge. First results of these simulations are intriguing, indicating the potential of a large synergy between the various phenomena [33]. Another continuing activity are heat-load estimates for the LHC. Steadily updated measurements of secondary emission yields including the low-energy elastically reflected electrons, which are performed by the LHC vacuum group [43], serve as an indispensable input to these simulations. The results are used to estimate vacuum pressure and gas desorption for various operational conditions [44].

The SPS experimental program this year will address the beam stability and transverse emittance preservation with the LHC beam in the presence of the electron cloud, and the confirmation of beam scrubbing. Various new electron-cloud monitors have been installed prior to the 2001 SPS run [45]. One apparatus will provide the first in-situ measurement of the secondary emission yield and its evolution during the run. A biased pick up will measure the electron energy spectrum. A calorimeter inside the vacuum chamber can directly detect the heat load deposited by electrons. A special 'stripe' detector can observe the horizontal regions inside a dipole where enhanced multipacting occurs, as a function of beam current and dipole field strength. All these measurements will be useful for verifying or calibrating the computer simulation.

Detailed informations on the ongoing electron-cloud studies at CERN and elsewhere, as well as a list of publications can be found at the web page (*http://wwwslap.cern.ch/collective/electron-cloud/electron-cloud.html*) and a selected set of recent papers and related links are listed below. There is also an electron-cloud web page at Argonne (*http://www.aps.anl.gov/asd/physics/ecloud/papers_top.html*). In September 2001 a dedicated workshop on 'Two-Stream Instabilities' will be held at KEK (*http://conference.kek.jp/two-stream/*).

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3.2 Studies of Multi-turn Rxtraction at CERN-PS via Particle Trapping in Islands of Phase Space

R. Cappi and M. Giovannozzi

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A new approach is under study to improve the performance of the high-intensity proton beam for the approved CERN Neutrino to Gran Sasso (CNGS) project. The need for a multi-turn extraction towards the SPS is twofold: firstly, the difference in length of the PS and SPS circumference ($C_{\rm SPS} = 11\, C_{\rm PS}$) together with the need of uniformly fill the SPS to avoid beam loading. Secondly, the transverse beam emittance delivered by the PS machine has to be reduced to remove acceptance limitations in the SPS. In the nominal scheme, the PS machine extracts the proton beam over five turns, in two consecutive cycles, so that $10/11$ of the SPS circumference are filled.

In the standard scheme, just before extracting the beam, the horizontal tune of the PS machine

is set to the value 6.25, then the beam is cut in five parts by means of the blade of an electrostatic septum (see Fig. 3.1 for a sketch of the principle).

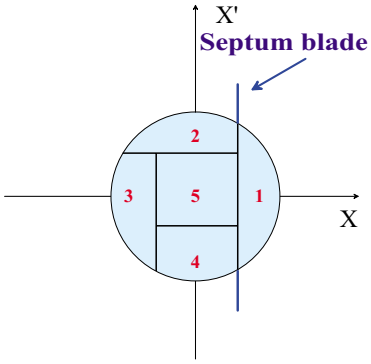

Figure 3.1: Principle of the standard multi-turn extraction from the PS machine.

The main drawbacks of such a method are

- Beam losses are unavoidable. They are at the level of $10 - 15$ % of the circulating beam intensity.
- The five slices do not have the same emittance.
- The five slices do not match the natural phase space topology based on ellipses (or circles in normalised phase space).

The proton intensity for the CNGS beam is $\approx 3 \times 10^{13}$ ppp: already in this situation the electrostatic septum receives such a high dose that serious problems for hands-on maintenance and radiation damage are expected. The situation will become even worse in case of intensity upgrade (by a factor of two) that is presently under study!

In view of improving the multi-turn extraction mechanism, a new approach has been proposed: nonlinear elements (sextupoles and octupoles, for instance) are used to excite the 4^{th} order resonance, thus generating four stable islands. The islands parameters, position and size, can be controlled by varying the tune and the strength of the nonlinear elements respectively. By chang-

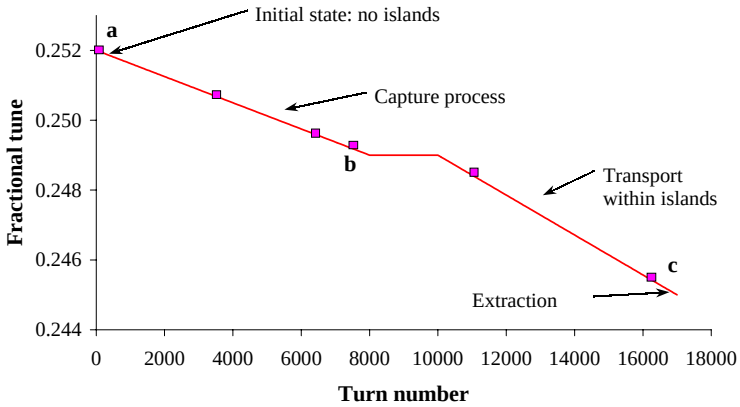

Figure 3.2: Tune as a function of the turn number used in the numerical simulations of the trapping process based on nonlinear resonances.

ing the tune according to the curve shown in Fig. 3.2 it is possible to create islands inside the phase space region where the beam is, to capture adiabatically the particles inside the islands, and then to move the four structures towards higher-amplitudes without losing particles. Once the separation between the four filled islands and the beam left in the central region is big enough for accommodating a septum blade, the beam is ready for extraction. The advantage of this novel scheme is that the beam is cut in different parts without any *mechanical* action.

This process has been simulated using a simplified model made of a linear part plus a sextupole and an octupole in the kick-approximation, namely

$$\begin{pmatrix} x_{n+1} \\ {x'}_{n+1} \end{pmatrix} = R(2\,\pi\,\nu_n) \begin{pmatrix} x_n \\ {x'}_n + {x^2}_n + \alpha\ {x^3}_n \end{pmatrix}, \tag{3.1}$$

where (x, x') are co-ordinates in the normalised phase space scaled using the sextupolar gradient (see Ref. [1] for more details), $R(2\,\pi\,\nu_n)$ is a 2×2 rotation matrix of angle ν_n. In this model ν_n depends on the time-like variable n according to the function shown in Fig. 3.2, and the coefficient α is proportional to the ratio of the sextupolar and octupolar gradients.

The results of the numerical simulations are shown in Fig. 3.3, where the evolution of the beam distribution in normalised phase space is depicted. The initial conditions are Gaussian-distributed, and they are tracked by using the map (3.1). Trapping in the four islands is clearly shown, as well as the migration of the particles towards higher-amplitudes following the tune variation. No particle loss occurs during the whole process.

Although the preliminary results are rather encouraging, a long way is still to go before having an operation version of the proposed scheme. Presently, the activities are concentrated on the following topics

- Theoretical
  - Better understanding of the trapping process (adiabatic condition, emittance of the extracted beam vs strength of nonlinear elements, speed of variation of the tune, etc.)
  - Robustness of the approach against perturbing effects (uncontrolled nonlinearities, tune ripple etc.)
  - Detailed numerical simulations of a realistic model of the PS.
  - The complex system of slow and fast bumps to be used in order to extract the beam is under study to assess whether existing hardware is suitable for the new extraction or new elements have to be designed.
- Experimental
  - The closed orbit measurement system presently installed in the PS, does not allow a turn-by-turn measurement of the horizontal and vertical phase space at a given section of the machine. Hardware modifications are under study to improve and adapt the system to the new needs.
  - Test of an "anti-dumper" system to excite the beam in view of scanning the phase space to detect its topology (islands position and size) is in progress.
  - Machine development sessions will start to determine whether the phase space has the right topology for this new extraction, and to test the capture mechanism.

References

[1] A. Bazzani, G. Servizi, E. Todesco, G. Turchetti, *CERN* **94-02** (1994).

[2] Cappi and M. Giovannozzi, "Novel Method for Multi-Turn Extraction: Trapping Charged Particles in Islands of Phase Space", *CERN PS (AE)* **2001-015** (2001).

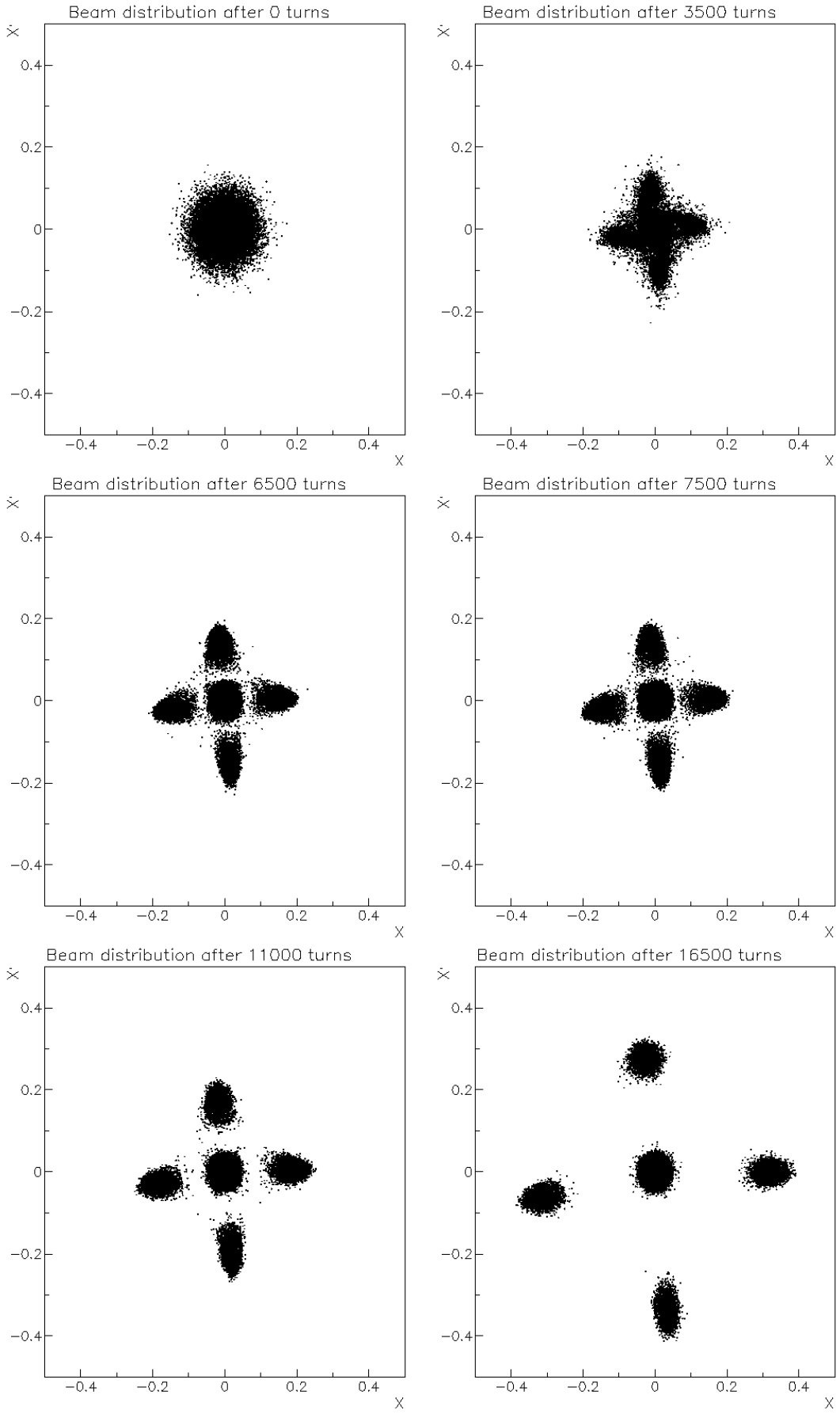

Figure 3.3: Evolution of the beam distribution during the trapping process. The different plots correspond to tune values values represented by solid squares in Fig. 3.2. Each plot represents 2.25×10^4 points. The initial Gaussian distribution has $\mu = 0$ and $\sigma = 0.04$.

4: Recent Doctoral Theses

4.1 Symplectic Approximation of Hamiltonian Flows and Accurate Simulation of Fringe Field Effects

Bela Erdelyi erdelyib@msu.edu Michigan State University

Institution: Michigan State University]

Title: Symplectic Approximation of Hamiltonian Flows and Accurate Simulation of Fringe Field Effects

Name: Bela Erdelyi

Graduation date: August 2001

Advisor: Prof. Martin Berz

Reference: http://bt.nscl.msu.edu/cgi-bin/display.pl?name=erdelyiphd

Abstract: In the field of accelerator physics, the motion of particles in the electromagnetic fields of periodic accelerators is usually approximated by the iteration of a symplectic map, which represents the system over short time, such as one turn around the accelerator. Unfortunately, due to the complexity of the systems, in practice only some approximation of the one-turn map can be computed, as, for example, the truncated Taylor series. To this end, simulation of the nonlinear dynamics consists, in general, of the following three steps: 1) Computation of the truncated Taylor approximation of the one-turn map, 2) Symplectification of the Taylor map, and 3) Iteration of the resulting exactly symplectic map. This dissertation addresses all three components of the process, with the emphasis being on developing new methods that allow long-term tracking as accurately and efficiently as possible.

Specifically, the contributions to the first step concern the fringe field effects. The truncated Taylor map should include every relevant effect, so that it is an accurate representation of the system over one turn. While it is straightforward to compute the truncated maps over the regions where the fields are independent of the longitudinal variable, it is not so anymore at the ends of the magnets, the so-called fringe field regions. We study fringe fields generically, to show their importance, and develop a method that allows ”exact” fringe field map computation of superconducting magnets, for which the coils and the iron parts are represented by current wires. The theory is illustrated by a detailed study of fringe field effects on the nonlinear dynamics of the Large Hadron Collider at collision energy.

Many contributions are established to the second step. It is well known that the theory of generating functions of canonical transformations provides a possible symplectification method. It is shown that, by transforming the dynamical problem into a problem in symplectic geometry, a general theory can be developed, which leads to a set of infinitely many new types of generating functions. It follows that it is possible to use this extended set to produce symplectic maps, and to reduce the whole set of generators to classes that give the same symplectified map. Moreover, the effects of factorization of the linear parts on the outcome of symplectification were studied. A variety of examples show the performance of various generator types, from which it can be concluded that it is not only important to symplectify, but also to symplectify “the right way”. The precise meaning of the last statement is the subject of the optimal symplectification theory, which can be formulated using methods of symplectic topology. In particular, Hofer’s metric allows the formulation of the optimality condition in a very general setting, and the solution leads to a generating function type (EXPO) that, in general, gives

optimal results. In the proof, an interesting one-to-one correspondence between fixed points of symplectic maps and critical points of generating functions is developed, and a generalized Hamilton-Jacobi equation is derived.
Finally, as contribution to the third step, it is pointed out that the numerical method used to solve the implicit equations arising in the iteration of the symplectic maps makes a difference in the final results, and, in general, a fixed point iteration is more robust than the widely used Newton method.

5: Workshop Reports

5.1 The 21st Advanced ICFA Beam Dynamics Workshop on Laser-Beam Interactions

Igor Pogorelsky Program Chair

Ilan Ben-Zvi Co-Chair
Tachishige Hirose Co-Chair

Tje 21st ICFA Beam Dynamics Workshop on Laser-Beam Interactions was held from June 11-15, 2001 at the State University of New York at Stony Brook, NY (SUNYSB). The workshop was co- sponsored by Brookhaven National Laboratory (BNL), Argonne National Laboratory (ANL), the Office of Naval Research (ONR) and SUNYSB. I. Ben-Zvi (BNL) and T. Hirose (Tokyo Metropolitan Univ) chaired the workshop. The Program Chair was I. Pogorelsky (BNL) and M. Babzien (BNL) chaired the Local Organizing Committee.

The workshop brought together researchers working on fundamental problems and applications that stem from the interaction of high-power, short-pulse lasers and high-brightness electron beams. Attendees came from 38 different user facilities, multidisciplinary laboratories, universities, and private companies in Asia, Europe, and North America.

The workshop opened with a tour of BNL research facilities and lectures of leading BNL scientists working in the field of synchrotron radiation and laser-electron interaction. The meeting continued for the next 5 days at the Student Activity Center of SUNYSB. More than 100 attendees presented 70 invited and contributed talks. These numbers increased by 50% as compared to the first Laser-Beam Interactions Workshop that took place at Tokyo Metropolitan University in October 1999, underscoring the dynamic state of this exciting field.

The presented talks illustrate that the subject of the interaction of laser and electron beams is very rich with interesting science, applications and opportunities for new discoveries. Review talks presented by leading researchers in the field were balanced with original reports on new results and developments from facilities all over the world.

Invited talks of A. Ting (NRL), K. Nakajima (KEK), P. Norreys (RAL) displayed a panorama of increasing experimental activity in the field of laser-beam interactions in US, Japan and Europe.

J. Hastings (BNL), V. Litvinenko (Duke Univ.), C. Jacobsen (SUNY at Stony Brook), R. Falcone (UC Berkeley), P. Krejcik (SLAC), and R. Schoenlein (LBL) provided a comprehensive insight into emerging technology and applications of ultra-bright femtosecond x-ray sources.

E. Esarey (LBL), Kwang-Je Kim (ANL), T. Tajima (Univ. of Texas at Austin), and Pisin Chen (SLAC) discussed ultra-relativistic effects in electron-laser interactions and their significance for fundamental science and such advanced applications as future electron-positron and gamma-gamma colliders.

X.J. Wang (BNL) and W. Kimura (STI Optronics) talks on production of high-luminosity femtosecond electron bunches complemented reports on new developments in femtosecond laser technology presented by K. Kobayashi (Sumitomo), Z. Chang (Michigan Univ.), I.N. Ross (RAL) and J.I. Rudati (BNL).

Fresh record-high results with Thomson x-ray beams at the BNL/ATF and proton beams at GSI have been reported by T. Kumita (TMU) and M. Roth (GSI).

A new idea of enhancing laser coupling on solid targets by resonance laser-electron-ion energy transfer has been proposed by V. I. Vysotskii (Kiev Univ.)

A special session on FELs has been rich with breakthrough results achieved in several experiments including: VISA, LEUTL, HGHG reported correspondingly by A. Tremaine (UCLA), S.V. Milton (ANL), and M. Babzien (BNL).

Other workshop sessions highlighted progress in various other areas of laser-beam interaction. Sessions on laser acceleration included reports by Y.K. Ho (Fudan Univ.), L. Schachter (Technion), J.R. Peano (NRL), R.N. Agarwal (New-Delhi Univ.), G.J.H. Brussaard (Eindhoven Univ. Tech.), M. Uesaka (Univ. of Tokyo), F. Zhou (UCLA), T. Marshall (Columbia Univ.), B. Hafizi (NRL), S.Ya. Tochitsky (UCLA), C. V. Filip (UCLA), R. Narang (UCLA);

Sessions on low-emittance electron beam generation and diagnostic had reports from P. Karataev (TMU), T. Kamps (Univ. of London), J.W. Lewellen (APS), S. Kashiwagi (Waseda Univ), K. Kinoshita (Univ. of Tokyo), T. Muto (TMU), N. Yugami (Utsunomiya Univ.), K. Batchelor (Brookhaven Technology Group, Co.), A.M. Tron (MEPhI), K. Chouffani (Idaho Accelerator Center), G. Geloni (Eindhoven Univ. Tech.), F.B. Kiewiet (Eindhoven Univ. Tech.), K. Takasago (FESTA), T. Srinivasan-Rao (BNL), T. Watanabe (Univ. of Tokyo);

On laser-induced electron cooling, focusing and production of polarized positron beams, we heard from K. Sasahara (TMU), K.Wada (TMU), S. Heifets (SLAC), T. Ohgaki (Hiroshima Univ.), E.G. Bessonov (Lebedev Inst.), P.R. Bolton (SLAC);

The subject of x-ray and gamma sources was covered by G. Ingold (Inst. Villigen), K. Nakajima (KEK), Yuelin Li (ANL), F. Sakai (Sumitomo), I. Sakai (TMU), J. Urakawa (KEK), Y. Miyahara (SPring-8).

By shedding light on the new developments in the technology and applications of ultra-fast lasers and high-brightness electron beams and their various interactions, the workshop promoted progress in this fast evolving field, promising new avenues for multi-disciplinary exploration on the molecular and atomic time scale.

More information on 21st ICFA beam Dynamics workshop is available from the web site

http://nslserver.physics.sunysb.edu/icfa/Home.htm.

A collection of workshop presentations will be posted soon on the KEK Web page and distributed among the participants and other interested individuals on CD ROM.

Watch also for an upcoming Special Conference Edition of Physical Review Special Topics - Accelerators and Beams.

6: Announcements of Forthcoming Beam Dynamics Events

The latest information on all future ICFA Advanced Beam Dynamics Workshops (some announced in earlier newsletters) is available at the Beam Dynamics Panel's home page

`http://wwwslap.cern.ch/icfa/`

6.1 25th ICFA Advanced Beam Dynamics Workshop on Intermediate Energy Light Sources

From 24 to 26 September 2001, the Shanghai Synchrotron Radiation Center (SSRC) will host the 25th ICFA Advanced Beam Dynamics Workshop, the Shanghai Symposium on Intermediate Energy Light Sources (SSILS).

The workshop will address important issues relating to beam dynamics and both accelerator and photon beam line technology for storage ring light sources in the intermediate energy range. SSILS has received proposals for over 75 presentations from 25 laboratories in 15 countries. About 50 oral presentations and 25 poster presentations are scheduled. The SSILS symposium will provide a forum for intensive communication among groups involved in the design and construction of such facilities as well as with groups representing storage rings operating at other energies.

Focus sessions include light source cost and performance, new light sources, insertion devices, high power beamlines, vacuum technology, RF and future directions. Poster sessions have been arranged to cover facility reports, technological innovations and special projects. The poster sessions are considered an integral part of the program as they facilitate direct communication between participants. All contributors are encouraged to submit up to 5-page camera-ready manuscripts for publication.

With the large number of new and proposed sources underway, there are many novel and innovative approaches to discuss. The 25th ICFA Advanced Beam Dynamics Workshop (SSILS) will focus on exchange of these ideas and application of these technologies to new storage rings.

For further information, please contact SSILS Secretary Tongzhou Xu (xutz@ssrc.ac.cn ()), visit the SSILS web site (`http://ssils.ssrc.ac.cn`) or the ICFA Beam Dynamics Panel home page (`http://wwwslap.cern.ch/icfa`).

6.2 The 20th ICFA Advanced Beam Dynamics Workshop on High Intensity High Brightness Hadron Beams

The 20th ICFA Advanced Beam Dynamics Workshop will take place from April 8 to 12, 2002 at Fermilab. The theme of this workshop is "High Intensity and High Brightness Hadron Beams." It will discuss a broad range of topics associated with such type of beams, including review of the performance of existing high intensity hadron machines, overview of planned high intensity hadron sources and projects, accelerator physics issues, technical systems design, applications of this type of beams in high energy physics, nuclear physics, heavy ion fusion, industry and other fields. Advanced planning is taking place for this workshop pending DOE approval.

This workshop is co-sponsored by Fermilab and the KEK. For more information, please contact:
Weiren Chou, workshop co-chairman, Fermilab, +1-630-840-5489, choufnal.gov
Yoshiharu Mori, workshop co-chairman, KEK, +81-298-64-5209, yoshiharu.morikek.jp

For administrative information, please contact:
Cynthia Sazama, Fermilab, P.O. Box 500, Batavia, IL 60510, USA, fax: +1-630-840-8589, e-mail: sazamafnal.gov

6.3 The 26th ICFA Advanced Beam Dynamics Workshop on Nanometre-Size Colliding Beams

Ralph Assmann Ralph.Assmann@cern.ch CERN

Frank Zimmermann Frank.Zimmermann@cern.ch CERN

The spot size at the interaction points of future linear colliders can approach nanometre values, because the beam-beam limit from circular colliders does not apply for single-passage collisions. The design values for the vertical spot size range from 5 nm for the 500 GeV TESLA design to 1 nm for the 3 TeV CLIC study. Those small spot sizes are a factor 100-1000 beyond the smallest IP spot sizes achieved in previous colliders. Many issues are involved in demonstrating the feasibility of establishing and maintaining collisions of nanometer size beams.

The ICFA workshop on Nanometre-Size Colliding Beams in Future Linear Colliders will review and study the different aspects of the problems involved in demonstrating the feasibility of those small spot sizes. In particular the following issues will be discussed:

- Design of appropriate Final Focus Systems and comparison of different design approaches.
- Impact of ground motion, magnet vibration, and field fluctuations on the luminosity performance.
- Design and optimization of required Final-Focus magnets.
- Possible benefits of beam-based feedbacks and modern stabilization technology.
- Design and verification of conventional or advanced collimation sections.
- Estimation of expected background levels and the interface to the physics detector.
- Challenges connected to the handling of the spent beam and beam dump.
- Required beam instrumentation and component alignment.
- Unconventional focusing techniques.

The following goals should guide the workshop:

- Describe a path towards proving feasibility of colliding nanometre-size beams.
- Document existing solutions and identify open questions.
- Develop a coherent program for future research and development.
- Strengthen and expand international collaborations for this work.

The workshop will take place from 2–6 September 2002 at, or in the nearby region of, the European Organization for Nuclear Research, CERN, Geneva, Switzerland.

The latest information about the workshop is available from

http://icfa-nanobeam.web.cern.ch/icfa-nanobeam/

7: Announcements of the Beam Dynamics Panel

7.1 ICFA Beam Dynamics Newsletter

Instructions to authors

7.1.1 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
   This is a forum open to everyone. Anybody can give his/her opinion on beam dynamics and related topics, by sending it to one of the editors. The editors reserve the right to reject a contribution.
7. Editorial

All articles except for 6) 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 their e-mail address(es).

7.1.1.1 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@soken.ac.jp}{Sokendai/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://wwwslap.cern.ch/icfa/}.

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}
```

7.1.2 World-Wide Web

Recent issues of this newsletter are available through the World-Wide-Web via the address 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://wwwslap.cern.ch/icfa/`

This Web page provides access to the Newsletters, information about Future and Past Workshops, and other information useful to accelerator physicists. There are links to pages of information of local interest for each area.

7.1.3 Distribution

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

W. Chou	chou@adcon.fnal.gov	North and South Americas
Helmut Mais	mais@mail.desy.de	Europe* and Africa
Susumu Kamada	Susumu.Kamada@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 wish to receive it regularly can request this from one of the distributors. In order to reduce the distribution cost, however, please use the Web as much as possible. In particular, if you no longer need a paper copy, please inform the appropriate distributor.

7.2 World-Wide Web

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

`http://wwwslap.cern.ch/icfa/`

Formerly there were three mirror sites around the world but these are no longer used. However the main page contains links to information of local interest for each area.

7.3 ICFA Beam Dynamics Panel Organization

The mission of ICFA Beam Dynamics Panel is *to encourage and promote international collaboration on beam dynamics studies for present and future accelerators*. For this purpose, we publish *ICFA Beam Dynamics Newsletters* three times a year, we sponsor *Advanced ICFA Beam Dynamics Workshops* and *ICFA Beam Dynamics Mini-Workshops*, and we organize *Working Groups* within the Panel to promote several important issues.

Chairman J.M. Jowett

Chief Editors of ICFA Beam Dynamics Newsletter K. Hirata and J.M. Jowett

Editors of ICFA Beam Dynamics Newsletter S. Chattopadhyay, W. Chou, S. Ivanov, H. Mais, J. Wei, and C. Zhang

Distributors of ICFA Beam Dynamics Newsletter W. Chou, H. Mais, S. Kamada

Leader and Deputy Leader of Future Light Source Working Group K.J. Kim and J.L. Laclare

Leader of High Luminosity e+e- Colliders Working Group Y. Funakoshi

Leader of High-Brightness Hadron Beams Working Group W. Chou

Web site S. Chattopadhyay, K. Hirata, J.M. Jowett

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The most up-to-date version of this list is kept at the ICFA Beam Dynamics Panel Home Page

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