Contents

An Introduction to ICFA Beam Dynamics Panel

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A brief introduction to the panel was given in the previous issue. Here, I want to repeat something and add some more personal opinions.

Mission of the Panel Its mission is to encourage and promote the international collaboration on beam dynamics studies for the present and future accelerators.

ICFA is an organization for future accelerators. Also is this panel. But the future comes of the present. All the accelerators are quite the same from beam dynamics point of view. A beam dynamics study for MeV machines can help that for TeV machines, and vice versa. Thus, all the activities related to the "dynamics of the beam" are within the scope of the panel's activity. We need all the knowledge of past and existing accelerators in order to proceed to the future machines.

Newsletter This is one of the most important activities of the panel. The instruction for the contributor is put in the last page. We are trying to make the newsletter more and more informative and useful.

In particular, I want to call your contribution to the section **"Letters to the editors"** where you can express your opinions on

- this newsletter
- articles on the newsletter including "letters to the editors"
- panel activities
- even on general beam dynamics activities in the world.

The panel members will try to improve their activities according to your suggestions.

For the distribution of the Newsletter, for Europe, USA and Canada, contact panel members nearby. For the rest of the world, contact Prof. S. Kamada (kamada@kekvax.kek.jp), who is kindly taking care of its distribution.

We are going to have a home page of the Newsletter in WWW soon but the printed version will be kept. (Number of printing will be decreased). **This issue will also appear in the home page of DESY library;**

WWW file address is "HTCP://info.desy.de.library.bdnl0495.ps".

ICFA Advanced Beam Dynamics Workshops The ICFA Advanced Beam Dynamics Workshops have played important and unique role. First, let us summarize the past workshops.

No.	Year	Place	Subject
1	1987	Brookhaven	Production of Low-Emittance Electron and Positron Beams
2	1988	Lugano	Aperture-Related Limitations of the Performance and Beam Lifetime in Storage Rings
3	1989	Novosibirsk	Beam-Beam Effects in Circular Colliders
4	1990	Tsukuba	Collective Effects in Short Bunches

5	1991	Corpus Christi	Effects of Errors in Accelerators, their Diagonosis and Corrections
6	1993	Madeira	Synchro-Betatron Resonances

Our workshops have attracted not only specialists of the subject of each workshop but also other people who usually do not participate in such a workshop. It is of great importance. Exchange of knowledges and mutual criticism between different research area are quite important. I hope it will continue to be so in the future.

The planned workshops are listed as follows:

- **Seventh ICFA Advanced Beam Dynamics Workshop**, Beam-Beam Issues for Multibunch, High-Luminosity Colliders, 18 to 20 May 1995, at Joint Institute for Nuclear Research, Dubna. (See the announcement in the previous issue). Requests for more information should be directed to:
  E.Perelstein e-mail: perel@ljap12.jinr.dubna.su
  P.Beloshitsky e-mail: beloshitsky@ljap12.jinr.dubna.su
- **Eighth ICFA Advanced Beam Dynamics Workshop**, Space Charge Dominated Beams and High Brightness Beams for Advanced Applications, Oct. 11-13, 1995, at Bloomington Indiana. (See the announcement in the present issue).
- Beam Dynamics of $\mu^+\mu^-$ colliders.
- Next Generation Light Sources, January 1996.
  Contact person: J.L. Laclare (bouvet@esrf.fr).
- Nonlinear Dynamics in Particle Accelerators, 2 to 6 September 1996 at Arcidosso, Italy.
  Contact person: C. Pellegrini (claudio@vesta.physics.ucla.edu).
- Physics of Beam Cooling, autumn 1996 in Novosibirsk.

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Second Annual Workshop on Synchrotron Radiation Light Sources

ESRF, Grenoble, 15-16 November,1994

J. L. Laclare (bouvet@esrf.fr)

on behalf of all the participants

Following the success of a workshop on Synchrotron Radiation Light Sources organized at the ESRF in October 1993, it was decided to make it an annual event. The ESRF again hosted the second edition, for which presentations from the following projects were made:

Anka (Germany)
Barcelona Synchrotron Light Source (Catalonia)
Bessy II (Germany)
Delta (Germany)
Diamond and Sinbad (UK)
Doris III (Germany)
Elettra (Italy)
ESRF (France)
Max II (Sweden)
Soleil (France)
Swiss Light Source (Switzerland)

During this workshop, the major topics of design and operation of 3rd generation synchrotron light sources were addressed and views on the present state of art and possible future developments were exchanged in round-table-discussions. Below are accounts of two of the most important topics: Lattice performance, and "RF current limits and cavities."

1 Lattice Performances

At the design stage the criteria for the choice of a third generation light source lattice is oriented by constraints on:

- the achievable low emittance of the stored beam (number of dipoles)
- beta values at specific locations
- free length for insertion devices

and similarly by considerations of:

- flexibility

- production of a large dynamic acceptance
- sensitivity to errors

At a certain stage the maximum circumference has to be fixed and comparisons of lattice performance are made for this fixed circumference. Contributions demonstrated that the many types of structures (double bend, triple bend, double double-bend achromats) which can be envisaged are more or less equivalent in terms of achievable emittance. Attempts to go below twice the minimum theoretical value of the emittance inevitably lead to a reduction of the dynamic aperture and of the acceptance in $\Delta p/p$, as well as too high betas and chromaticity which imply certain compromises.

The simplest lattice, i.e. the Double-Bend Achromat, provides a satisfactory solution, as illustrated by the successful running-in of the ESRF, Elettra and the ALS showing that the lattice is not over-sensitive as feared in the past. In particular, it was pointed out that the perfection of the closed orbit is an essential pre-requisite for achieving good performance. In the case of Elettra, the dependence of lattice performance (coupling, amplitude of the spurious vertical dispersion, tunes, ...) on the residual closed orbit was reported. To a significantly lesser extent, the ESRF has experienced some dispersion distortion, however nothing comparable to the vertical spurious dispersion at Elettra. For both machines, the experimental lattice performances are in good agreement with results from modelling. The Double-Bend Achromat has been adopted by more and more projects: Bessy II, Soleil, ...

As far as emittance reduction is concerned, the possible merits of adding a field index in the bending magnets were discussed. No final conclusion was drawn. On the other hand, a factor of two on the emittance can easily be gained by allowing a finite dispersion all around the machine. Such a scenario has already been tested at the ESRF, leading to a 4 nm horizontal emittance compared to the 7 nm of the regular optics, and should be routinely operated in the forthcoming months. It was pointed out that the optimization of beta and alpha values at the insertion device source points could also provide a significant increase of the effective brilliance.

The flexibility and tunability of the lattice are of prime importance for machines in operation in order to satisfy future needs that may arise. Again the Double-Bend Achromat demonstrates its potential in this respect. At the ESRF, this lattice can run either in the normal mode alternating high beta and low beta straight sections, or in the low emittance mode (with the same alternation of betas) or with all straight sections tuned to high betas. On the same machine, in order to test ion trapping, a weak focusing tuning has been tested, resulting in a large emittance. Exciting perspectives on the ESRF lattice operating in a quasi isochronous mode with even negative momentum compaction were also reviewed. The likely advantages of such optics in terms of instabilities look very attractive since, among others, it is naturally stable for head tail effects, and strong sextupoles are no longer necessary.

But present lattice operation requires chromaticity over-compensation. It was highly recommended, as illustrated by experience at Super-Aco and the ESRF and contrary to LEP, that machine designers envisage large positive chromaticities from the outset (to increase single bunch intensity thresholds or overcome resistive wall related instabilities).This has of course some impact on the optimization of the dynamic aperture and the necessary sextupole strengths. On the other hand, the possibility of running these machines with natural chromaticity should also be questioned. Tests have been carried out on this at the ESRF with 20 mA stored with a slightly reduced (close to natural)m negative chromaticity (natural chromaticity would induce overly large tune shifts). Elettra also has some experience in this field, as well as the ALS. To support the same idea, it was reported that the ESRF booster, for instance, can be operated without chromaticity correction, although conditions are different from those of the storage ring.

The correction of resonances is not usually practised in electron storage rings (contrary to hadron machines). However, the benefits from correcting all lines in the vicinity of the working point were clearly demonstrated at the ESRF with the subsequent enlargement of the longitudinal acceptance which in turn contributes to the increase of lifetime. This feature is of prime importance for low energy machines for which the Touschek effects, linked to an insufficient acceptance in energy, play a major role.

Up to now, during lattice design the achievement of a large dynamic aperture and a low emittance has taken priority over longitudinal acceptance. Designers were fully satisfied with an energy acceptance of a few per cent and insufficiently concerned by its enlargement, despite this being the key solution to a long lifetime in the few bunch mode. Initial operation of third generation machines reminds us of the evident fact that obtaining good lifetime strongly depends on a large energy acceptance. In this respect, simulation programmes should be up-graded to provide adequate tools for optimizing this parameter.

2 RF Current Limits and Cavities

It was commonly agreed that current limits could be split into two categories: single bunch and multibunch and that third generation light source projects have rather low intensity targets when compared to second generation machines.

A clear distinction was made between pure beam instabilities (machine optics, HOMs and other impedances, ions,...) and hardware limitations (heat load, RF supply...) or even user requirements. According to the ESRF, a few years ago one could have feared that beamline optics would not be advanced enough to sustain the heat load. This fear no longer exists today however. Not only do the beamlines take full beam, but the beam is not allowed to significantly decay and new injection is requested more frequently than necessary.

Concerning multibunch longitudinal and transverse oscillations ELETTRA and the ESRF have very similar experience:

- low instability threshold prediction
- possibility to detune the responsible HOMs away from the beam eigen frequencies

ELETTRA presented the effect of a longitudinal beam instability (energy oscillations) on an undulator spectrum. The ESRF presented the Landau damping by RF voltage modulation produced by beam loading in their favourite 1/3 filling mode of the storage ring. This is their preferred solution to overcome longitudinal HOM driven instabilities. All benefits of the 1/3 filling cannot apply during operation with 16 regularly spaced bunches in which case temperature regulation of the cavity body is successful to avoid HOM excitation. The SLAC and ELETTRA approach to fighting HOMs is to add dampers to normal conducting cavities. The HOMs become so broadband that they can no longer be detuned from the beam resonances (higher current threshold but unavoidable coupling impedance): the probability of an interaction between beam and HOM therefore approaches 1. It is essential for the HOM damping to yield Q values smaller than 100 or even less, if high currents are to be stored. The problem of designing appropriate absorbing loads was pointed out, the difficulty is to find material that absorbs RF power that is vacuumcompatible and may be brazed to a metallic support. The priority for ELETTRA to have HOM-free cavities has been lowered as a consequence of the excellent results obtained on the standard cavities with the simple temperature tuning system.

Although simple tricks can be used to get rid of HOM excitations without reducing the shunt impedance of the fundamental accelerating mode, it is natural to "quest" for HOM-free cavities. This quest systematically leads to a smooth cavity wall contour and accordingly, reduced shunt impedance. Many cavities are then necessary to provide the accelerating voltage. This in turn suggests using superconductivity. It was reported that at Cornell 200 mA have been stored with a prototype superconducting HOM-free cavity. This design has the advantage of really being HOM-free and, due to the superconductivity, having an accelerating mode with nevertheless a very large shunt impedance. The Workshop agreed that this approach is certainly worth developing, but it still needs to be demonstrated that the addition of cryogenics to the RF system, which is at the root of most failures, would not be an additional severe handicap for operation.

With regards to single bunch current limitations, at the ESRF the thresholds for the transverse instability can be pushed from 3 mA to 15 mA with a chromaticity varying from $\xi = 0$ to $+1$. However, such large chromaticities lead to large tune excursions associated with Delta p/p deviations and accordingly strong Touschek lifetime limitations. With a Digital Signal Processing based transverse feedback, up to 20 mA were stored for what is still an intermediate chromaticity $\xi = 0.6$ (the current was then vacuum limited).

The full Proceedings from this workshop are available from the ESRF (e-mail: bouvet@esrf.fr).

Tamura Symposium on Accelerator Physics

November 14-16, 1994
Joe C. Thompson Conference Center
The University of Texas at Austin

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The Tamura Symposium has been held approximately every two years, either in Austin or in Japan, since the establishment of the Tamura Fund by family and friends in memory of Professor Taro Tamura of The University of Texas at Austin. For each Symposium, a topic is chosen which is closely related to Professor Tamura's past activities. This time, we have chosen the topic of accelerator physics.

This is a crucial juncture for accelerator physics. We are facing the emergence of several new and very exciting technical developments and at the same time still reeling from the demise of the SSC. It is important to glean the best information we can from this debacle and to preserve scientific vitality for the future. It is also critical to develop both near and far future visions and strategies for accelerator physics. The Symposium was organized by the Department of Physics of The University of Texas at Austin chaired by T. Tajima and the Japanese delegates were headed by Y. Miyahara.

During this Symposium on the market-place of ideas and visions the participants put forth many suggestions, among which I wrote down without any particular order:

- 30 TeV x 30 TeV collider, where much stronger synchrotron radiation may change the beam dynamics
- Mobius accelerator, a revolutionary thinking in beam lattice.
- tasks of next generation accelerators such as RHIC, NLC . . .
- emergence of new magnets
- emergence of table-top terawatt (T^3) lasers
- crystal utilizations for accelerators, as crystal being the nature's smallest periodic beam lattice
- free space acceleration
- muon-muon collider (the workshop held in the same week in California) and gamma-gamma collider.
- advanced cooling of beams, including optical cooling. The interest in quality, in addition to the quantity=energy, is on the rise. Entropy vs. energy?
- nonlinear dynamics and the issues of acceptance, emittance and luminosity.
- recirculation of radiation and the question of efficiency
- brilliant x-ray radiation sources, utilization of quasi-crystal lattice
- novel beam sources and optics (focus, etc.)
- new mathematical lattice calculation through symbolic computation

In particular, Japanese groups suggested utilization of accelerators and storage rings for radiation sources, medical uses, etc., in addition to high energy physics, itself. Perhaps the strongest impression I had was the emergence of T^3 lasers in recent years and the accompanying works by several groups on laser wakefield which point out specific scientific questions that need to be analyzed for T3 to become a realistic new tool for an accelerator component.

This presents both a tremendous opportunity as well as a multitude of challenges. Attached are the list of participants and the program.

Attendance List

Speakers	Affil	Tentative Title of Talk
	US	
Barty, C.	UCSD	Multiterawatt Femtosecond Lasers for High Field Physics
Channell, P.	LANL	Production of Intense Positron Beams
Chao, A.	SLAC	Attendance only
Chattopadhyay,S.	LBL	Advances in Beam Physics; Colliders of the Future
Chen, B.	SSC	Attendance only
Chen, P.	SLAC	Channelling Acceleration: A Path to Ultrahigh Energy Colliders
Colestock, P.	FermiLab	Nonlinear Wave Phenomena & Emittance Growth in Coasting Beams
Debenham, P.	DOE	Attendance only
Downer, M.	UT	Laser Wakefield Excitation
Esarey, E.	NRL	Self-Modulated Laser Wakefield Acceleration
Falcone, R.	UCB	Interactions of High-Power, Ultrashort Laser Pulses w/ Gaseous Plasmas
Fisher, D.	UT	Two Dimensional Dynamics of a Laser Pulse in a Gas Plasma Media
Hennelly, M.	AIP	Attendance only
Huang, Z.	SLAC	Attendance only
Kasper, R.	SloanFnd	Attendance only
Katsouleas, T.	USC	Advanced Accelerator Techniques
Leemans, W.	LBL	Femtosecond X-ray Generation Through 90 Thomson Scattering
Meinke, R.	SSC	Design Guidelines for Future High Energy Proton Proton Colliders
Milchberg, H.	U Md	High Intensity Optical Beam Propagation in Preformed Plasma Channels
Mourou, G.	U Mich	Chirped Pulse Amplification Systems for Future Laser Wake-Field Accelerator
Ohnuma, S.	U Houston	Attendance only
Ottinger, M.	UT	Poster
Ozaki, S.	RHIC/BNL	Relativistic Heavy Ion Collider (RHIC) at Brookhaven National Laboratory
Rau, B.	UT	Atomic and Plasma Physics Issues in the UT Austin Laser Wakefield Project
Riley, P.	UT	Welcome
Rose-Petruck, C.	UCSD	Attendance only
Ruth, R.	SLAC	The Next Linear Collider
Schwitters, R.	UT	What a High-Energy Experimentalist Wants fm. Accelerator Physicists

Sessler, A.	LBL	Laser Cooling of Stored Ion Beams
Shchagin, A.	Kharkov	Spectral-Angular Distr. & Absol. Differ. Yield of Parametric X-Ray Rad.
Siders, C.	UT	UT Laser Wakefield Experiment
Sudan, R.	Cornell	A New Accel. Tech. for Charged Neutralized Med-Heavy Ion Beams for ICF
Syphers, M.	BNL	A Report on the Indiana Workshop on Future U.S. Hadron Facilities
Tajima, T.	UT	Possibility of 1 TeV/m Accelerating Fields
Talman, R.	Cornell	The Mobius Accelerator
Tsyganov, E.	SSC	High Efficiency Beam Halo Crystal Extraction from Proton-Proton Colliders
Umstadter, D.	U Mich	Electron Accel by NP Waves Reson Driven w/ Optim High-Inten Pulse Trains
Wood, M.	LANL	Preformed Trans Gas Channels for Laser Wake. Particle Acceleration
Woodworth, J.	LLNL	Petawatt Ultra-High Irradiance Laser; and Free Wave Accelerator
Yan, Y.	SLAC	The Differential Lie Algebraic Methods for Accelerator Lattice Studies
	JAPAN	
Ando, A.	SPring-8	Correlation of Emittance Modulation by Linear Coupling
Date, S.	JSRRI	RF Noise and Longitudinal Emittance in an Electron Storage Ring
Hara, M.	SPring-8	Coupling Bunch Instability & Cavity Structure of the SPring-8 Storage Ring
Hashimoto, S.	JSRRI	Quasi-Periodic Undulator
Kishimoto, Y.	JAERI	Beam Cooling by Using Laser-Undulator Beat Wave
Kitagawa, Y.	Osaka U.	Beat-Wave Experiment at ILE, Osaka University
Koga, J.	JAERI	Coherent Synchrotron Radiation Cooling of Charged Particle Beams
Miyahara, Y.	SPring-8	Radiation Power Available in Storage Ring Free Electron Laser
Nakajima, K.	KEK	Development of Ultra-High Gradient Particle Accelerators
Sato, K.	Osaka U.	Advanced Concept in Power-Supply & Rf Technols of HIMAC Synchrotron
Takayama, K.	KEK	Exp Demo of 100 MW Ion-Channel Guided X-Band Free Elec Laser Amp
Tanaka, H.	SPring-8	Emittance Reduction in Electron Storage Ring
Tani, K.	JAERI	Attendance only
Yamakawa, K.	JAERI	1 Hz, 1 ps, Table-Top Terawatt Nd:Glass Laser
Yano, Y.	RIKEN	RIKEN RI Beam Factory Project
Yokoya, K.	KEK	Bunch Lengthening in Electron Storage Rings
Yugami, N.	Utsun.U	Large Amp. Wakefield in Ion Wave Regime Excited by Short Micro Pulse

REPORT on the International Workshop on Particle Dynamics in Accelerators – Emittance in Circular Accelerators –

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This workshop was held at KEK from 21 to 26 November, 1994, which was attended by around 90 participants. The purpose was to review our current understanding of beam emittance in both proton and electron synchrotrons and storage rings, identify sources of emittance growth, examine emittance measurement from both fundamental physics process and instrumentation points of view, discuss emittance manipulation, and suggest future experimental and theoretical studies. The stress was to establish a forum for theorists, machine physicists, and instrumentation specialists to criticize and stimulate each other so as to integrate their knowledge of beam emittance, which occasionally lacks clear mutual understanding. Discussions between "electron physicists" and "proton physicists" were also pursued.

The proceedings will be published soon as a KEK Report. Here, we will highlight some discussions given in the workshop.

Plenary talks are:

S.Y.Lee	Sources of Emittance Growth
I. Yamane & Y. Mori	Emittance Manipulation in Proton Machines
S. Myers	Emittance Manipulation in Electron Machines
R. Cappi	Emittance Issues in CERN PS
K. Oide	Anomalous Emittance Growth
E. Perelstein	The Emittance Problems in Tau-Charm Factory
C.S.Hsue	The Emittance performance and its Measurement of SRRC
M. Halling	Operation Experience and Instrumentation Development at Fermilab
A. Ogata	Emittance Measurement in Electron Machinmes
K. Wittenburg	Emittance Measurement in the Proton Accelerators at DESY
N. Toge	Emittance Measurement in SLC

There were three working groups:

Number	Working Group	chair	vice-chair
1	Sources of emittance growth	S.Y. Lee	K. Hirata
2	Electron machines	S. Myers	A. Ogata
3	Proton machines	R. Cappi	Y. Mori

Groups No.1 and No.2 had a joint session on nonlinear resonances. Groups No.1 and 3 had joint sessions on space charge and on γ_t transition.

Working Group "Sources of emittance growth"

List of talks in working group

1. Y. Senichev, *Space charge and emittance growth in some applications of accelerators.*
2. R. Baartman, *Betatron resonances with space charge.*
3. C. Ohmori, *Space charge effects in KEK booster.*
4. J. Struckmeier, *Description of emittance effects due to stochastic processes.*
5. Y. Batygin, *Conservation of high beam current emittance in nonlinear field.*
6. S. Myers, *Measurements of synchro-betatron effects in LEP.*
7. D. Pestrikov, *Effects of nonlinear fields on betatron emittance.*
8. K. Ohmi, *Beam envelope formalism for emittance calculation.*
9. S. Myers, *Transverse mode coupling.*
10. A. Gerasimov, *Coherent chaos.*
11. T. Ieiri, *Hysteresis phenomena in bunch lengthening at TRISTAN AR.*
12. K. Bane, *Longitudinal instabilities at the SLC damping ring.*
13. R. Baartman, *Longitudinal instability for short range wakes.*
14. K. Oide, *A mechanism of longitudinal single bunch instability in storage rings.*
15. K. Yokoya, *Self-consistent solution to Vlasov equation in longitudinal beam instability.*
16. S.X. Fang, *Effects of negative momentum compaction on instability threshold.*

The major subjects were (1) space charge effects, (2) emittance growth due to nonlinear resonances, (3) transition energy crossing, and (4) coherent instabilities. Among them, (1), (2) and (3) were in joint sessions with other groups.

The (incoherent) effects due to nonlinear lattice (emittance growth, tail formation etc) do not seem to be the problem in operating machines. They, however, should be (and can be) understood more. Because such effects may provide us more information on the lattice and may be used for diagnostic purpose.

The current dependent phenomena are more difficult. Several effects can occur at the same time.

The space charge is still a difficult, challenging and thus interesting subject. The simulation codes are not reliable enough: the symplecticity is unclear (might be serious for circular machines) and there is no clear criterion to judge how the simulation is reliable. It seems quite desirable that we have a simple model including intrabeam scattering on which simulation and theoretical calculation can be done in a reliable manner.

One hot issue was the recent progress in the theory of bunch lengthening in electron rings. Supported by new algorithms to calculate the bunch lengthening threshold in a self-consistent way, some observed phenomena were almost explained and we can try exotic ideas (such as negative momentum compaction) in more reliable way.

Working Group "Measurement and Manipulation of emittance in electron machines"

List of talks in working group

1. R. Jung, *Precision emittance measurement in LEP.*
2. T. Miyahara, *Emittance measurement using interference of synchrotron light.*
3. L. Palumbo, *DAΦNE project.*

4. O. Chubar, *Edge radiation based method for complex beam diagnostics in electron storage rings.*
5. M. Kato, *Emittance upgrade of KEK Photon Factory.*
6. H. Sugiyama, *Emittance measurement by means in synchrotron radiation on TRISTAN Main Ring.*
7. H. Fukuma, *Low emittance operation in TRISTAN AR.*
8. K. Nakajima, *Beam tomography in the storage ring.*
9. T. Ieiri, *Measurement and simulation of bunch length at TRISTAN MR.*
10. A. Anderson, *Measurement of emittance at the MAX-I ring.*
11. K. Takayama, *Ion-channel guided emittance selector.*
12. S. X. Fang, *Bunch length phenomena at BEPC.*
13. A. Hofmann (presented by R. Jung), *Diagnostics with undulator radiation having a Gaussian angular distribution.*

Utilization of synchrotron radiation to measure beam emittance was the major subject of the working group. Visible lights from bending magnets are in daily use for the emittance measurement in many light sources and colliders. Edge radiation and synchrotron light through a double slit were introduced to measure emittance around the diffraction limit of visible light. X-rays from multipole wigglers and undulators were used and/or in preparation for the measurement of emittance far beyond the diffraction limit of visible light. Modified undulator was proposed to make Gaussian angular distribution of light for the sake of easy deconvolution. Techniques of tomography was proposed to measure phase space distribution of beams in transverse and longitudinal planes.

From the view point of emittance manipulation, plans and experiences in lowering emittance were reported on light source machines. A new idea to make bunch length shorter with negative α lattice was presented.

Working Group "Measurement and Manipulation of emittance in proton machines"

List of talks in working group

1. E. Bleser, *Emittance at the Brookhaven AGS.*
2. H. Sato, *Emittance issues in KEK-PS.*
3. Y. Yamazaki, *Secondary electron emission in ion-foil, solid interactions.*
4. Ch. Steinbach, *The CERN PS wire scanner.*
5. T. Kawakubo, *Introduction on the methods and measured results of non-destructive beam profile monitors in KEK-PS.*
6. T. Toyama, *Transverse aspect -injection period of PS MR -.*
7. S.Y. Lee, *Transition energy crossing.*
8. M. Yoshii, *Longitudinal dynamics at Injection and Transition.*
9. S. Ninomiya, *Longitudinal emittance manipulation.*
10. Y. Shoji, *The emittance of slowly extracted beam from the KEK-PS.*
11. K. Hiramoto, *Low emittance beam extraction scheme using a transverse rf noise.*

The primary goal of this working group was to identify various problems which would increase beam emittance and therefore limit proton beam intensity or decrease luminosity. Space charge effects were one item for which we spent quite large fraction of time. Longitudinal (and transverse also) emittance growth at transition was another big item. We thought that prescriptions to cure those problems could be made once they are examined carefully, even though some technical difficulties are involved to apply the prescriptions in an individual machine.

The KEK PS was taken as the target machine. In fact, the increase of intensity on the KEK PS is urgent necessity for the future physics experiment using neutrino as secondary particles. Because of the lack of preparation, the results of beam study conducted in the KEK PS sometimes contradict to each other, which caused unnecessary confusion during the session. Except that, the working group was full of interesting discussions and practical suggestions based on each participant's unique, still universal, experiences. At last, we got a list of action items which are well satisfactory not only for the KEK PS, but also for general proton synchrotrons.

Considerable time were also devoted to the discussion on emittance measurement technique such as non destructive profile monitor and wire scanner, and its fundamental physics behind, secondary electron emission for example. For some people, measurement technique of proton beam emittance seem to be well established. However, it does not mean that they are producing satisfactory data for the machine physicists who really concerns emittance. The importance of understanding fundamental physics of measurement and careful examination of signal they obtain from a measurement system were shared with all participants.

Beam Dynamics Activity at TRIUMF

Rick Baartman (KRAB@TRIUMF.CA)

Racetrack Lattices for the KAON Accumulator and Booster Rings
–(D. Kaltchev, R.V. Servranckx and M.K. Craddock)

Lattice studies for the KAON Factory were completed by the design of compatible racetrack lattices for the 450 MeV Accumulator and 3 GeV Booster rings – a longstanding challenge because of the long list of important design requirements. These included simplicity, high γ_t, dispersion-free long straights for rf and beam transfer, dispersive straights for H^- injection and momentum collimators, compatibility of shape, good dynamic aperture, insensitivity to space charge, and polarization friendliness. A large number of designs were examined. Those chosen use FODO lattices with missing dipoles, the Booster arcs consisting of four identical 3-cell achromats, and the Accumulator arcs of two identical 4-cell achromats with split central D quadrupoles giving the required space, momentum resolution and tunability for H^- injection. The Booster lattice has $\gamma_t = 10.5$ and a dynamic aperture of $120\,\pi$ mm-mrad.

Synchrotron Light Source Lattices
–(D. Kaltchev, R.V. Servranckx and M.K. Craddock)

With the collaboration of PSI some modified versions of the Swiss Light Source (SLS) lattice have been investigated for use in a low-emittance Canadian Light Source. The SLS proposal uses a hexagonal lattice, with each arc consisting of a seven-bend achromat. To increase the number of straights available for insertion devices we have looked at eight- and ten-sided lattices using fewer bends (and focusing cells) per arc.

To achieve the necessary dynamic aperture in ultra-low-emittance lattices it is crucial to correct the resonances excited by the chromaticity-correcting sextupoles. The DIMAD-COSY family of codes was therefore used to calculate the strengths of the resonance-correcting sextupoles for a range of betatron tunes, to identify those giving the best dynamic aperture. Runs performed on the original hexagon lattice gave solutions very similar to those found at PSI. For the new lattices studied so far we have been able to preserve the very low emittance (1.6 nm-rad at 1.5 GeV), large dynamic aperture and good tunability achieved in the hexagon, with only minor increases in circumference and number of magnets. One of the most attractive lattices uses eight five-bend achromats with four long and four short straight sections.

Single Bunch Stability
–(R. Baartman and M. D'yachkov)

(a) *Stability Threshold*

Conventionally, one investigates stability by adding a vanishingly small perturbation to the stationary distribution and looking for exponential solutions to the Vlasov equation. In the case of a bunched beam in a purely harmonic potential well, the solutions can be written as a complete set of eigenmodes; such solutions have been found for many practically important bunch distributions. However, if the potential well is non-harmonic, such modes may not even exist. This is because Landau-damped excitations do not damp exponentially. If the potential well distortion arises from the wake field, it can occur that the only possible mode is the (trivial) rigid dipole mode. In the naïve analysis where synchrotron frequency 'spread' is compared with the 'shift' of modes found in the no-distortion case, this can be thought of as due to the fact that when potential well distortion arises from the collective effect itself, the 'spread' grows with intensity to keep pace with the 'shift', and always stays at the same location relative to threshold.

If the wake field is much shorter than the bunch length (as is the case for space charge), one can approximate the force as the derivative of the line density. We have developed methods to deal with this case, as reported earlier. Our conclusion was that as long as a stationary distribution exists, there is no instability. Another case is when the wake field length is comparable with the bunch length, as is the typical situation for high luminosity electron machines. In this case, the bunch size is determined by two competing processes: radiation damping and quantum excitation.

It is not obvious whether there are other stable modes besides the rigid dipole mode. Moreover, if they exist, how do they look? Using the traditional threshold diagram method in the case of narrow band impedance, one can see that unstable modes just above threshold may have very sharp edges and are not likely to be seen in electron synchrotrons where the distribution is governed by the Fokker-Plank equation and should be quite smooth.

Solving the linearized Vlasov equation can be very difficult when the wakefield length is comparable with the bunch length. There are several methods currently used for this purpose; we have used a method suggested by Oide and Yokoya. In this method the action variable is subdivided into small intervals, thereby converting the integral equation into a matrix equation, which is then solved numerically.

This method seems to be in agreement with particle tracking simulations, however no mathematical proof has yet been given of its convergence and stability. One important feature of this method is that for the solutions to be valid, they must be smooth. Therefore they may become erroneous as threshold is approached. Another problem is that increasing the dimension of the matrix also increases the number of eigenmodes and there is no easy way to determine which modes are 'physical' and which are not. That some modes are nonphysical we know from the fact that they are discontinuous, and remain discontinuous no matter how finely the action is subdivided. Since these modes are mainly confined to one or two action subdivisions, and since their eigenfrequencies are found to be simply integer multiples of the incoherent synchrotron frequency at that value of action, we call these 'incoherent' modes.

By sifting through the many eigenmodes, we have found one other type of 'real' mode besides the rigid dipole. It corresponds to the usual series (dipole, quadrupole, sextupole, etc.) of azimuthal modes confined to a region of action localized near the point where the derivative of the synchrotron frequency is zero. Such a location can usually be found at sufficiently high intensity when the wake field is oscillatory. The width in action of these modes does not diminish along with the action interval width as the matrix size is increased. The physical interpretation is that in this region, the particles can stay 'in step' longer and so this area constitutes a 'coherent band' of action.

For the wakefields we have so far considered, the instability threshold occurs when one of these modes couples to the rigid dipole mode. This is handy since such thresholds can be found from the features of the stationary distribution and do not require solving the linearized Vlasov equation.

(b) *Behaviour of the beam at threshold*

A very interesting effect was observed in the numerical simulation of a bunch whose natural length was smaller than the typical wake-field length. In this case at some intensity the self-consistent distribution becomes two-peaked and even may form a system of two subbunches: most of the particles form a narrow single bunch, which is shifted forward (relative to the synchronous phase) and the rest of the particles concentrate around another stable point which forms behind the head bunch due to the wake field generated by the particles in the head bunch. The bunches are separated by a potential well barrier and their motion is confined within one of the subbunches (head or tail), however, some particles can *diffuse* from the head bunch to the tail, so that the number of particles in the tail bunch will increase and the number of particles in the head bunch will decrease. As the number of particles in the tail bunch increases, it begins to move forward. At the same time, the head bunch, losing intensity, moves backward.

The distance between the two bunches gradually decreases until they collapse into each other. Then the compound bunch moves forward to its new 'equilibrium' position. Since the collapse itself is a turbulent process, some of the particles are thrown backward and form a new two-peak system with the distance between the peaks bigger than it was at the moment just before the collapse. Then the process repeats.

If we look at the time dependence of some of the bunch parameters (such as rms size, energy spread, synchronous phase etc.) this diagram will resemble a 'sawtooth' wave. The time scale of the instability is determined mainly by the diffusion process rather than the radiation damping time. Another interesting property of this effect is that the threshold current increases with increasing RF voltage instead of decreasing, as expected from conventional theory of microwave instability. This latter property agrees with observations at KEK (TRISTAN AR) and SLAC (SLC damping ring).

Revisions to Longitudinal Single Bunch Coherent Instability Theory
–(S. Koscielniak)

Robinson gave two conditions for the stability of a bunched beam interacting with a resonator impedance. Violating them gives: (i) an instability with growth rate proportional to the resistive impedance, and (ii) a coherent tune shift proportional to the reactive impedance. For the case of a bunched beam confined to a quadratic potential well, the instability (i) has no current threshold; while the effect (ii) gives a d.c. instability, with a definite threshold beam current, when the coherent bucket to zero. We find it is essential to consider $+/-$ mode-coupling to correctly obtain the threshold current for the d.c. instability; ignoring mode-coupling under-estimates the threshold by exactly a factor of two.

When finding growth rates and tune-shifts, it is usual practise to evaluate the impedance at the nominal value of the synchrotron frequency (or its multiples). However, one must strictly evaluate the impedance at the coherent frequency one is trying to find, and so recursion is required. Moreover, the response of an impedance to a growing beam-perturbation signal is not the same as the response to a sinusoid of constant amplitude and infinite duration. Consequently, when finding growth rate and coherent tune shift, one should evaluate the impedance at a complex frequency. This can be done by using the Cauchy-Riemann relations to extend measurements of impedance at real frequencies into the complex plane. One finds, in fact, that there is no change in the growth rate, but the coherent tune-shift is altered away from the value obtained in a naive calculation.

The effect of a spread of incoherent frequencies is to introduce Landau damping and create a beam current threshold for the Robinson type-(i) instability. In low current beams, the major source of frequency spread is the non-linearity of the externally applied radio-frequency sinusoidal restoring force. Calculation of the stability diagram for this system is a 'classic' problem which forms a bridge to more modern problems which start by finding a self-consistent distribution and confining potential. In fact, when the impedance is the fundamental resonance of the r.f. cavities, the problem of a bunched beam confined to a cosine potential well is a self-consistent one, because the generator current can always be adjusted to compensate the steady-state wakefield of the beam. Despite is 'classic' status, an exact analytic expression for the dispersion integral in terms of standard special-functions has never been reported in the literature. We have found the dispersion integral for the case of $-1, +1$ azimuthal mode-coupling (but no radial mode coupling) in terms of the complete elliptic integral of the first kind and an algebraic combination of power of the 'nome' (used for Taylor expansion of the Jacobean elliptic functions). We have calculated (with no approximations) the stability diagram (for the Robinson instability) for a variety of steady state distributions.

Advances in RFQ beam dynamics design at TRIUMF

–(S. Koscielniak)

TRIUMF is engaged in designing a radioactive heavy ion facility to accelerate ions of mass-to-charge ratio 30 from 2 keV/u to 150 keV/u in an RFQ and thence, after stripping, to 1.5 MeV/u in a DT linac. The RFQ design considerations for a few nA ion beam are very different from those of a multi-mA proton beam: the duty factor is 100%, the inter-vane voltage well below the sparking-limit, the emittances are very small (0.25 $\pi\mu$m normalized transverse, and 1 πns-keV/u longitudinal for 95% of particles), and the transmission is desired greater than 90%. There is the usual objective to keep the overall length of the structure small. A conventional adiabatic bunching is not used because (i) there is no space-charge, (ii) the structure gets quite long, and (iii) to achieve a sufficiently small emittance would require to deterministically shape vane modulations below the limit that can be comfortably machined on a standard NC mill. A novel design has been adopted at TRIUMF to meet these constraints. The beam is bunched non-adiabatically in a discrete buncher consisting of a few modulated cells, followed by unmodulated cells. At the moment the beam has completed a quarter synchrotron oscillation, the synchronous phase is non-adiabatically jumped from -90° to -85° by inserting a special long cell and then the beam is accelerated by smooth variations of the modulation parameter and synchronous phase toward final values of $m = 2.5$ and $\phi_s = -20^\circ$, respectively. The use of only a few accelerating cells keeps the effective r.f. bucket very small and likewise the longitudinal emittance, while allowing vane modulation $m \geq 1.01$. The use of a sudden phase jump gets acceleration started rapidly and reduces the overall structure length, without having to use high values of the modulation parameter which tends to increase the multipole content of the transverse focusing fields. In the present design, the RFQ structure is 8 m long, the inter-vane voltage is 85 kV, the operating frequency is 35 MHz and the transmission is 92%.

High Intensity Cyclotrons
–(T. Kuo, R. Baartman, B. Milton)

Experiments and calculations are being performed to determine the ultimate intensity limit of our small H^- cyclotrons (25 keV injection energy). We have demonstrated 1.6 mA in our centre region model (1 MeV), and indications are that this is still far from the space charge limit. Because of its economy, this type of machine is a candidate for a first stage of a 10 MW beam for the 'energy amplifier' proposed by C. Rubbia.

Accelerator for Detection of Explosives
–(P. Schmor, R. Baartman)

A novel accelerator application is being pursued. A 1.76 MeV proton beam is to be used to generate γ-rays which in turn are to be used to scan closed containers (e.g. airport luggage) for concealed plastic explosives. The initial design consists of a tandem H^- electrostatic accelerator with a gaseous stripper in the 0.86 MV terminal. The challenging aspects of the design arise mainly from the need to go to as high intensity as possible. The envisaged intensity of 10 mA leads to large space charge effects both at the injection end of the tandem and at the stripper.

Beam Dynamics Activities in SPring-8 Project

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1 SPring-8 Project

The aim of the SPring-8 project is to provide high-brilliance X-ray beams by utilizing synchrotron radiation from high-energy electrons. The facility consists of a 1GeV electron linac, an 8GeV booster synchrotron, and a storage ring about 1.5km in circumference. The project is now in a construction phase, and commissioning will start early in 1997 [?].

Lattice structure of the SPring-8 storage ring is of DBA (Chasman-Green) type designed suitably for using insertion devices. In the ring there are 38 straight sections (6.65m long) in which an undulator or a wiggler is installed. X-ray beams are obtained from insertion devices as well as from bending magnets. Note that stability and brilliance are important features of the X-ray beam. If we require stable X-ray beams of high brilliance, we need a stable electron beam with small emittance. Our target value of emittance is 5.5nm·rad and we are planning to reduce it further in the future (see below).

2 Beam Dynamics Activities

In SPring-8 the beam dynamics group has been in charge of lattice design and beam stability analysis. Improvement of a lattice and refinement of stability analysis are now going on in addition to design work of graphical interface of a control system. In the following, we pick up some topics of interest and give an outline. Further details can be found in refs. [?]-[?].

2.1 Coupling of betatron oscillations and skew compensation

Since brilliance of X-ray beams is inversely proportional to the product of horizontal and vertical emittances of the electron beam, one can obtain high-brilliance X-ray beams by reducing the vertical emittance. This can be done by controlling the horizontal-vertical (H-V) coupling ratio.

In low-emittance electron storage rings, like SPring-8, a major part of the vertical emittance comes from H-V coupling of betatron oscillations. This coupling is induced by skew-quadrupole components of error fields associated with quadrupole and sextupole misalignment. In ref. [?] the authors derived analytical formulas for describing modulation of horizontal and vertical betatron oscillations by assuming that a single linear coupling resonance is excited. The most important result is that the area of phase space in the laboratory frame is not constant and varies point by point along a ring. The formulas are generally applicable to the rings with any nonlinear fields. They applied the formulas to the SPring-8 storage ring and calculated vertical emittance modulation along the ring.

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Based on these formulas, they also proposed two kinds of correction scheme for H-V coupling. It was found that the formulas are useful for both global and local correction of the coupling.

2.2 Reduction of natural emittance

As explained above, the brilliance of X-ray beams can be increased by reducing the vertical emittance of the stored electron beam. Another way of increasing brilliance is to reduce the natural emittance of the beam.

In general, the Chasman-Green lattice includes dispersion-free straight sections for insertion devices. In order to reduce the emittance under the constraint of dispersion-free (achromatic) condition, one needs strong sextupole magnets for chromaticity correction and the strong sextupole fields give rise to a small dynamic aperture. The minimum emittance is thus limited in the achromatic lattice.

In ref. [?] it was pointed out that the natural emittance can be reduced by breaking the achromatic condition, keeping the dynamic aperture large enough. The minimum emittance under the non-achromatic condition was found to be three times smaller than that under the achromatic condition. Efficiency of this scheme in the SPring-8 storage ring is under investigation.

2.3 Transverse instability

In discussing stability of a stored electron beam it is essential to estimate broad-band impedance of the vacuum chamber. The impedance can be estimated by using the two-dimensional (three-dimensional) simulation code MAFIA T2 (MAFIA T3). In ref. [?] the author evaluated longitudinal impedance $Z^{\parallel}$ and transverse impedance $Z^{\perp}$ for the SPring-8 storage ring. The analysis includes the effects of a detailed three-dimensional structure of the chamber, e.g. a structure of slots to antechamber, and the difference between a round chamber and an elliptical chamber. The following relation was then tested: $Z_1^{\perp}(\omega) \cong (2c/d^2\omega)Z_0^{\parallel}(\omega)$, where d is a constant with dimension of length. From this one can derive $W_1'(z) \cong (2/d^2)W_0'(z)$ by using the Panofsky-Wenzel theorem. These useful relations were found to be valid even in the three-dimensional treatment. Details of the calculations are shown in ref. [?] together with numerical results.

Based on these studies, we are now improving calculations on beam instability, aiming at higher performance of the ring.

2.4 Equilibrium bunch length with RF noises

In proton storage rings it is important to solve problems caused by noises in RF system in order to keep long term stability against diffusion. This is because phase feedback between beam and RF is essential. In electron storage rings such problems can be neglected in view of stability because the stochastic process of quantum radiation smears out any history of motion. However, in order to obtain an equilibrium longitudinal emittance (or density distribution), RF noises must be included in the same way as quantum excitation. In ref. [?] the authors derived formulas which give the equilibrium r.m.s. value of a longitudinal density distribution when RF phase noises are significant in an electron storage ring. These noises are caused by a ripple of the acceleration voltage in klystrons. An interesting result is that the effect of a systematic noise (deviation), which is a source of forced oscillation, is not symmetric in energy and phase. Numerical estimates are also given in the reference for the SPring-8 storage ring.

2.5 Slow positron source

An intense positron beam with very low energies is a useful tool in solid state physics, materials science, etc. If we can install a superconducting (S/C) wiggler with field strength of 8-10T in the SPring-8 storage ring, such an intense positron beam ($10^8 - 10^9$ slow-e^+/s/mrad/100mA) will become available since high-energy gamma rays create positrons in a target slab through electron-positron pair production process [**?**].

In ref. [**?**] the authors have checked its effect on tune, amplitude function, dynamic aperture, and emittance by using a simple model of a S/C wiggler. It was found that it is necessary to keep residual dispersion in the vertical plane as small as possible in order to maintain a given horizontal-vertical coupling ratio. For example, if one aims at 1% coupling, residual dispersion must be smaller than 0.5cm in the vertical plane.

Another problem of importance is the heat load. A S/C wiggler with strength 8T, for example, generates the power of ~60kW for 100mA beam current, and the divergence angle of gamma rays is about 15mrad. Such gamma rays can not be absorbed easily. A key to solve this problem would be to rearrange the lattice so that a magnet-free section becomes ~30m long (see also section **??**).

Further analysis will be made on this topics.

2.6 Super-long straight section

A feature of SPring-8 is that after rearranging the lattice with minimal modifications a super-long (~30m) straight section can be realized in the storage ring [**?**]. This section can accommodate, for example, a long undulator or a series of undulators, and with these undulators X-ray beams with higher brilliance or broader bandwidth will be available.

The super-long straight section is realized step by step. In the first phase of commissioning, the ring is operated with a symmetric lattice configuration to reduce the sensitivity against errors. In this operation mode the lattice is composed of 4 straight cells and 44 normal cells and has (approximate) 24-fold symmetry. In the second phase, straight cells and neighboring normal cells are modified without changing others. The design of lattice structure has been improved [**?**]. Our present understanding is that the lattice has an enough dynamic aperture if the closed orbit distortion (c.o.d.) is less than 0.1mm in r.m.s. We are now planning to rearrange the lattice after the first phase of commissioning. The task force is to develop an algorithm to realign magnets in arc sections using the c.o.d. data in beam commissioning.

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The Conference and Symposium of Particle Accelerator in China

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The development of particle accelerators in the recent decade in China turns out to be active and fruitful. The large projects for basic research as the Beijing Electron-Positron Collider, the Lanzhou Heavy Ion Research Facility, and the Hefei Synchrotron Radiation Facility, were completed and put into operation successfully in succession between 1989 to 1992.Many interesting results were obtained on these machine. Meanwhile, a great number of small accelerators aiming at applications in the fields such as radiotherapy, micro electronics,radiation processing, ion beam analysis and others have emerged to meet the urgent needs from medical treatments and various industries. According to the recent incomplete statistic, the number of accelerators totals up to 300 in China, and nearly 2000 scientists and engineers are engaged in these fields.

In order to promote the development of the accelerators in China as well as the academic communication and cooperation, the Particle Accelerators Society of China (PASC) was established in 1980. Up to now the total numbers of the PASC are about 1400, most of them from research institutes, universities and industries.

Due to the limited resource of the PASC, most academic activities, under the sponsorship of PASC, concentrate on the more general and widely concerned topics. As for the issues related to some individual accelerators,the workshops or symposium are used to be organized by the institute itself, sometimes by the institutes and PASC jointly.

The academic activities independently or jointly organized by PASC in 1993 and 1994 are briefly reported as below:

1. The School of Particle Accelerator Physics was jointly organized by IHEP and CERN, as well as PASC at Beijing in February 1993. About 100 students coming from 10 universities and institutes joined the school.

2. Technical Symposium on Ion Implantation was held by Shanghai Institute of Nuclear Research, Chinese Academy of Sciences and PASC at Shanghai in March 1993. About 50 participants attended the symposium, on which 40-50 papers were presented.

3. The First Asian Free-Electron Lasers Symposium was held by IHEP and PASC at Beijing in May 1993. About 150 participants coming from several Asian countries took part in the symposium.

4. The First Hope Cup Competition for the excellent papers on accelerator physics and technology presented by young people was held by PASC at Weihai city, Shandong Province in August 1993. 10 excellent papers were awarded the Hope Cup Prize.

5. The Fifth International Ion Source Symposium was held by Beijing University and PASC at Beijing in September 1993. About 180 participants coming from 21 countries joined the symposium, 150-160 papers were presented.

6. The Fifth High Power Particle Beam Symposium was held by PASC and Hefei Optical Machine Institute at Hefei in September 1993.

7. The Symposium on Computer Application for Accelerator was held by PASC at Hunan province in June 1994. About 50 participants attended the symposium.

8. The Third Symposium on Particle Accelerator Physics was held by PASC at Yellow Mountain in August 1994. About 50 accelerator physicists and graduate students took part in the symposium. 46 papers submitted to the symposium.

9. The Third Symposium on Medical Accelerator and Their Application was held by PASC at Wuxi city, Jiangsu Province in October 1994. About 150 participants working at the accelerator design, manufacture and their clinical application got together in the symposium coming from dozens of institutes, universities and hospitals throughout the country.

Reports on Beam Dynamic Activities from Russian Laboratories

Beam Dynamics Activities at BINP

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Traditionally, the beam dynamics activity in Budker Institute for Nuclear Physics (Novosibirsk) is a manifold one and is mainly focused on supporting the projects, where the Institute is involved. These are local existing colliders and storage rings (like VEPP-4, VEPP-3 and VEPP-2), synchrotron light sources and (e^+, e^-)-factories. Definite efforts are also spent to study the beam cooling techniques and their application, as well as to continue studying of the ground motion impact on beam dynamics. Below we give a collection of progress reports, about current beam dynamics activities obtained from several groups of the Institute.

1. VEPP-4{ *D. Shatilov, E. Simonov, V. Kiselev, G. Tumaikin, D. Parkhomchuk* }
Presently the VEPP-4 team is mainly engaged in setting up the collider to reach the designed parameters. The following beam dynamics problems are studying:

Ground vibrations, which result in beam vertical vibration. Strong effect was discovered and analyzed in order to determine the sources. Next, the efforts to reduce vibrations were applied. Although the situation was improved, the problem is still under consideration.

Transverse mode coupling instability. The current threshold was raised by increasing the bunch length. The next step is to put into operation the narrow-bandwidth feedback system. Now we go over a threshold by a factor of 1.3 and we hope to get more current.

Since we still have not enough current to get the designed luminosity, only the computer simulations are available now to study beam-beam interaction. We develop three trends in beam-beam simulations:

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"Strong-strong" case. A completely symplectic transformation through IP is used for each macroparticle. This code allows us to study coherent beam oscillations. It was obtained a threshold for the space charge parameter ξ; the further increase in beams current results in the transverse blowup of bunches. In the last case ξ is constant or even falls down.

Lifetime determination and building the equilibrium distribution on large amplitudes. The developed tracking technique allow us to reduce the required CPU time by several orders of magnitude. The occurrences with almost unperturbed core region and short lifetime were detected and analyzed.

Simulation with account of transverse beam coupling. This code determines the equilibrium beam sizes (both horizontal and vertical) without beam-beam interaction and with the presence of it. The significant vertical beam size dependence on the initial coupling locations was found. We hope to optimize the coupling to increase the beam-beam threshold.

2. Nonlinear dynamics in low emittance storage rings {*E. Levichev, V. Sajaev*} The goal of the present work is to comprehend the nonlinear dynamics of low emittance synchrotron radiation sources for which the major features of a dynamical system (phase space structure, amplitude dependence of tunes, the size of a finite motion area, etc.) are formed by strong chromatic sextupoles. This work is expected to be a basis for i) the development of the concept of a SRS whose parameters (betatron tunes, sextupoles location, etc.) are optimal for large dynamic aperture obtaining, ii) to devise the technique for dynamic aperture increase in low emittance rings, iii) to perform the nonlinear dynamics experiments on a 2.5 GeV synchrotron radiation source SIBERIA-2 being commissioned at the present stage in Russia.

The numerical simulation of the SIBERIA-2 dynamics using both common codes (MAD, PATRICIA, RACETRACK) and our own codes developed for some special cases is complete. To explain the tracking results a perturbation theory based on the Lie transformation technique was elaborated. It enables us to draw invariant curves and surfaces for 1D and 2D dynamical systems both in resonant and nonresonant cases using realistic accelerator lattice. The results obtained have offered a possibility to estimate dynamic aperture and other characteristics of storage rings analytically. The effect of the sextupole azimuthal harmonics on the nonlinear behaviour of SIBERIA-2 has been investigated taking into account higher order approximations. The schemes to eliminate undesirable harmonics are designed.

3. Beam Dynamics Issues for e^+, e^--Factories {D. Pestrikov} In this field the studies are focused on the inspecting of more, or less traditional subjects like lattice design, dynamics aperture calculations, the calculations of the impedance budgets of rings, beam-beam instability with an impact on those specific features of phenomena, which at least in principle enable significant increase in the luminosity of a collider.

Experimental study of the beam-beam instability for colliding bunches with a round cross sections (equal β-functions and equal transverse emittances) is now preparing at VEPP-2M.

Computer simulations of the beam-beam interaction are carried out, or in preparation in order to supply the team by both traditional tools (like the calculation of the beam footprints, weak-strong beam nonlinear and stochastic analysis) and the tools enabling analysis of specific features of the beam-beam instability of long bunches. Some efforts are spent for analytic study of the dependence of strengths of coherent synchrobetatron beam-beam resonances on the bunch lengths, and to study effects due to interference of coherent and incoherent beam-beam instability.

As is known, the most adequate, selfconsitent description of colliding bunches still demands very long CPU-times. Presently, a collaboration with Laboratories of LPC-Collége de France (Paris), DESY (Hamburg), Frascati, IPN (Orsay) and University of Amsterdam is prepared in order to develop a set of codes to study beam-beam instability, using parallel computer set-ups.

Ion trapping in straight sections due to their reflections from edges of raising magnetic fields of the ring dipoles was studied (by Dr. *V.G. Shamovsky*) using the modified drift approximation. The used modification enables now the calculations of ion trajectories for all magnetic fields, including regions of very low field.

These reflection coefficients were calculated and studied for both the fringe field of the storage ring dipoles and for alternating an undulator-type magnets.

4. Experimental Investigations of Ground Motion Impact on Beam Dynamics {*V. Shiltsev* } Experimental study of the ground motion and of its effect on the beam dynamics was continued by recent measurements of the uncorrelated ground motion in the frequency range $10^{-3} - 100$ Hz at the HERA tunnel (Hamburg, August-October 1994, collaboration BINP with the DESY MPY group). These investigations had two novel features: first, special low frequency seismometers allowed us to detect the ground motion in the range from some milliherz to 0.1 Hz – the field that had lacked experimental information; and, second, simultaneously with the tunnel motion we recorded the proton beam position at some point of the $p - e$ collider HERA, the proton loss rate and the angle of the HERA electron beam at the interaction point.

The results of this work call to reject the plausible assumption on the ground motion as weakly damped waves in elastic media. It was shown that vibrations of two points of the tunnel distanced up to hundred meters are well correlated only at frequencies of 0.1–0.5 Hz due to the contribution of the so called *microseismic waves* which were found in Hamburg having amplitude 0.2–2 μm and coming from the North-West coast of Denmark. In contrast, below 0.1 Hz and above 1 Hz the ground motion signals became significantly uncorrelated at some-dozen-meters distance; moreover, the spectra of ground motion at these frequencies are continuous like for noise processes.

Some other useful results include an observation of the ground surface sagging beneath low flying airplanes (as big as several microns), a comparison of vertical and horizontal ground motions (they were found to be the same within factor of 3), a statistical analysis of the incidence of the waves from remote earthquakes (during the two months there were detected a few dozen earthquake events which produced a ground motion in Hamburg area as big as 0.01–0.5 mm).

As for beam observations, we have found that proton losses in HERA are well correlated with the orbit motion at the frequency range of 0.01–50 Hz. There was also directly observed an essential correlation between the HERA proton orbit drifts and the ground motion with periods over 100 s. We also found that drifts of the proton orbit grow with time $\propto \sqrt{T}$ up to $T \approx 5$ hours. This is in a good agreement with the previous analysis of the 3-months orbit drifts at the HERA electron ring, and, as these drifts are due to the tunnel displacements, it's a repetitive evidence in support of the ATL rule for the diffusive wandering of ground:

$$dX = \sqrt{A \cdot T \cdot L}.$$

Here, T is the time of observation, L is the distance between the points, dX is the rms value of the displacement. The HERA-p orbit drift data give the value of the constant

$A \approx 10^{-5} \mu m^2/(s \cdot m)$ which is within the limits of the values extracted from the ground motion measurements at some other sites.

Beam Dynamics Activities at JINR and FIAN

A. Lebedev[2]

P.N. Lebedev Physical Institute, Russian Academy of Sciences

The XIV National Conference on Charged Particles Accelerators, a continuation of the series of All-Union Conferences, took place in October 1994 at the Institute of High Energy Physics (Protvino). While it was mainly devoted to engineering problems and technological applications of accelerators, a number of panel sessions dealt with work on beam dynamics in Russia during the last year. [**?**].

To be sure, these investigations were directed, in the main, towards operation of specific facilities. Thus, for example, A. Lukyanova and D. Ovsyannikov (St.Petersburg University) set out to optimize a beam having large space-charge density in systems with uniform RFQ focusing starting from envelope equations and using various optimization criteria. On the basis of the developed algorithm, one can also determine the system of tolerances on the structure parameter

An analogous work was performed by V. Petrov in Efremov Institute (St.Petersburg) on matching the beam with the RFQ channel at large values of the accelerating field (at the order of 1–1.5 MeV/m) typical for small-dimension facilities. Matching is achieved by varying the mean radius of the channel not only in the first section but in the bunching and accelerating sections as well.

A. Balabin *et al* (ITEP, Moscow) proposed a new method of particle focusing by means of two-electrodes RF lenses with decelerating fields.The system is effective within a large energy range (from 60 keV up to 100 MeV) and is compatible with high acceleration rates (up to 6–8 MeV/m).

A number of investigations were performed in IHEP (Protvino) on the stability of an intense proton beam applicable to the UNK project. S. Ivanov and M. Pozdeyev calculated the thresholds of transverse head-tail instability due to narrow-band resonators, taking into account systems of correction for chromaticity and cubic nonlinearity of magnetic field. The corresponding limiting coupling impedances of parasitic oscillations in the accelerating resonators were established

From the standpoint of the general theory of betatron resonances, the case of joint analytic consideration of arbitrary sum and difference coupling resonances is of interest. I. Petrenko and P. Chirkov assert that their joint action noticeably reduces the region of possible choice of operating point.

P. Pashkov and A. Smirnov investigated the dependence of effective transverse beam emittance on the initial position of the operating point for multiple passage through unidimensional resonance of betatron oscillations due to Coulomb displacement of betatron frequency and the appearance of chromaticity in the system in the process of synchrotron oscillations. It was shown that this dependence has several sharp maxima due to coupling of longitudinal and transverse motion. The proposed procedure can be generalized to the case of two-dimensional resonance.

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A new approach to the problem of pre-bunching of particles in linear accelerators was proposed by M. Avilov and A. Novokhatski (Novosibirsk). It is asserted that for exponentially increasing accelerating field in space, bunching is more effective due to the compensating action of space-charge forces. This assertion is verified analytically for small longitudinal oscillations as well as numerically for arbitrary large amplitudes.

A paper of a group from the Institute of Nuclear Physics (Novosibirsk) reports on experimental investigation of the longitudinal dynamic of a single electron in a storage ring, undertaken to directly verify the quasi-classical theory of stochastic motion due to quantum fluctuations of radiation.

Works were also reported on the investigations related to the possibility of reducing the phase space occupied by a beam of heavy particles. O. Borisov and L. Onishchenko (Dubna) examined numerically phase motion in a synchrocyclotron, taking into account ionization losses in a diagnostic foil leading to a reduction in the amplitude of phase oscillations. E. Bessonov (LPI) considered the possibility of cooling a circulating beam of ions by their resonance backscattering of laser photons. In his example the author gives a value of 80 s as the possible attainable cooling time.

Besides of the Conference, works by V. Papadichev (LPI) should be mentioned, who performed analytic calculations of the dynamics of particles in FEL undulators, taking into account space-charge forces of the beam and longitudinal magnetic field transport [**?**]. The effect of fringe fields on the trajectory of particles was also examied.n

In the Laboratory of Nuclear Problems (JINR,Dubna) beam dynamics of a high intensity beam in an electron ring relativistic cyclotron was studied and a new effective beam extraction method exploiting the closed orbit expansion effect is now under investigation [**?**]. Other activity in the JINR LNP is connected with beam dynamics calculations for a FFAG phasotron as a pulsed neutron spallation source.

Several variants of tau-charm factory designs have been studied at JINR since 1991. The conception of versatile design allowing to work with conventional scheme as well as with monochromatization one was adopted.

The proposal for JINR tau-charm factory was worked on including electromagnetic systems, injection systems, power supply, vacuum system. The variants of the RF power supply have been proposed and studied[**?**].

References

[1] *Proceedings of the XIV National Conference on Charged Particles Accelerators.* October, 1994. IHEP, Protvino. (To be published.)

[2] *Proceedings of the XVI Internat. FEL Conference.* Stanford, USA, August, 1994. (To be published.)

[3] *Proceedings of the EPAC-94 Conference.* (To be published)

inside UNK Project at IHEP

K.P. Myznikov[3]

At present, most of the beam dynamics work at IHEP is concentrated on the UNK Project which is now under realization. Parameters of this ring (e.g., large orbit circumference, high beam current, quite large magnetic field errors, etc.) determine the range problems to be solved.

RF Noise Diffusion. A formal procedure to derive diffusion equation of a bunch subjected to an external RF noise has been developed. It proceeds from Vlasov rather than Fokker-Planck equation. The diffusion coefficient is thus expressed through a sum over cross-correlations in time of complex amplitudes of random E-field waves propagating along the orbit. The standard results pioneered at CERN by G. Dome are re-derived as the ultimate case of a low-pass narrow-band stationary noise introduced a co-moving frame directly. The approach is readily applied to a few practically important problems: (a) dynamical impact of wide-band noises with their spectrum stretching over many revolution frequency harmonics, which may be the case for large rings (UNK, LHC); (b) effect of periodically non-stationary AM noises and stationary band-pass noises both imposed from the lab frame as they done in practice; (c) effect on noise-induced diffusion of coupled-bunch feedbacks via dedicated circuits and parasitic impedances, etc (S. Ivanov).

Longitudinal Feedbacks. Considerable effort has been spent to outline the feasible technical contours of the system to stabilize accelerating field in the UNK proton synchrotron. To this effect, a now standard (D. Boussard) RF feedback system is proposed with one-turn time delay and two loops of automatic voltage control (the in-phase and quadrature ones) having unequal gains. The system would handle a pair of crucial dynamical effects caused by the fundamental mode of accelerating cavities: heavy transient beam loading, and strong longitudinal instabilities of the beam at dipole and quadrupole within-bunch modes. It had been found that beam-cavity coupling impedance near RF is split up by the feedback loops into a 2×2 matrix which accounts for the cross-talk between E-field and current waves with positive and negative wave numbers. by twice the main RF harmonic number. This matrix is used to estimate the residual departure of the voltage across accelerating gap from its nominal and the instability driving impedances to be plotted on a standard longitudinal threshold map under various scenarios of the feedback operation.

The similar, impedance treatment is now actively applied to study the dynamical impact of the band-pass beam feedback near RF intended to damp the longitudinal injection errors and provide better stability against coupled-bunch lower-order odd multipole instabilities. To this end, employment of a pair of standard over-coupled RF cavities driven in quadrature to the net accelerating voltage is foreseen. Of the utmost importance is the problem of a proper tailoring of the band-pass feedback gain, its bandwidth exceeding revolution frequency, so as to introduce appreciable damping into the lower azimuthal coupled-bunch modes without expulsion the higher ones beyond the Landau-damping threshold (S. Ivanov, A. Malovitsky).

Transverse Instabilities. The theory of transverse coupled-bunch coherent instabil-

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ities at the "head-tail" modes has been carefully reviewed. Special attention was paid to threshold calculations of the instability caused by narrow-band HOM resonators, effect of chromaticity and cubic non-linearity of the lattice being taken into account. The former factor is of prior importance as one of the UNK Project's options is to employ a slow beam extraction scheme at large negative values of horizontal chromaticity. While accounting for the latter factor, various ways to build-up the effective betatron tune spread with octupole correctors by tailoring partial spreads in 2-D function $Q_y(\mathcal{J}_x, \mathcal{J}_z)$, $y = x, z$ of transverse action variables in x, z-directions were looked through. The tolerable values of transverse coupling impedances at parasitic higher-order E_{1np}-modes of the UNK accelerating cavities were estimated, forwarded to RF-engineers and the required HOM damping is now confirmed by bench measurements.

Now, much attention is paid to detailed studies of the dynamical impact of the low-pass beam transverse feedback intended to counteract the strong resistive-wall instability and damp transverse injection errors. The final goal is to provide a set of operational tuning characteristics to enable a rational trade between various scenarios of tailoring the feedback gain and setting octupole non-linearity and chromaticity of the ring (S. Ivanov, M. Pozdeev, S. Merker).

Optics and Magnet Errors. The joint effect of an arbitrary sum betatron resonance and linear coupling resonance $Q_z - Q_x = 0$ on the stability of transverse motion was studied. The common vision that the loss of stability occurs only on the condition $\vec{n}\vec{Q} = k$ being satisfied was found to be not quite the case. It does hold true for the isolated sum resonance, given there exists only one such a resonant straight line in the (Q_x, Q_z)-plane of the unperturbed betatron tunes near the working point. The presence of strong linear coupling is shown to result in splitting the cluster of sum resonance straight lines into a family of hyperbolic curves. In (Q_x, Q_z)-plane, such a splitting decreases domain free of a noticeable effect of the sum resonances and, thus, can decrease the dynamic aperture of the ring (P. Chirkov, I. Petrenko).

Impedance Calculations. Technique to calculate longitudinal coupling impedance of a vacuum chamber with many small heterogeneities (insertions) has been developed. It employs the boundary-value problem statement similar to the one by Leontovitch. The effective surface impedances inside the insertions are expressed through their inherent impedances which are readily parametrized in terms of an inductance, a capacitance and an active resistance. These are easily estimated for plain insertions like "pill-box".

Major attention has been paid to calculation of impedance of a complex chamber, its insertion's inherent impedances being assumed given a priory. The problem is reduced to a system of equations in terms of differences in potentials across the gaps. The analytical solution is obtained for a symmetrical chamber. In a general case, the problem is reduced to a form amenable to computer treatment, and the relevant codes are now available.

The most important results are as follows: (a) Below cut-off, insertions enter the net impedance additively, provided insertion-to-insertion distances exceed the chamber diameter. Their contributions do not coincide with the insertion's inherent impedances as the chamber imposes its inherent shunting capacitance. As a result, a resonance of chamber capacitance against insertion inductance shows itself up just below cut-off. In such a case, peak values of coupling impedance are bounded by the chamber and insertion resistances. (b) Above the cut-off, a single insertion is unable to introduce impedance exceeding 60 Ohm. It is due to energy escaping out of insertion via propagating waves with dissipating ultimately inside the walls. (c) In a general case, the insertions no longer sum additively in the impedance. This effect is the most noticeable in symmetrical chambers where, due to interference of the scattered waves, the net impedance is a fast-oscillating function of frequency. Usually, its peak values exceed sizably the mere sum of insertion impedances. The lower energy dissipation inside the walls, the more appreciable the effect. (d) The additiveness is partially restored with the chamber symmetry violation, the most essential factor being the spread in insertion-to-insertion distances. Given a sufficiently large spread, the impedance beyond cut-off would not exceed $60N$ Ohm, N being the number of insertions (V. Balbekov).

Beam Dynamics Activities in RAL

G. H. Rees[1]
Rutherford Appleton Laboratory

1 Design Study for a European Spallation Source, ESS.

RAL is collaborating with the Aarhus University, Denmark, Hahn-Meitner-Institute, Berlin, University of Naples and the Sveberg Laboratory , Uppsala, Sweden on the design of rings required for a pulsed spallation source , ESS. Design of the high power neutron target stations is also proceeding in collaboration with KFA, Jülich and PSI, Switzerland. An initial outline design for the rings is described in an ESS report, ESS-94-14-R; and associated reports on the injector linac and the targets are to be issued shortly.

The specification for the ESS includes 5 MW of proton beam power at 50 Hz, in pulses of time duration 1 μs or less, with 1 MW to be provided on one target station at 10 Hz, and up to 5 MW on a second at 50 Hz. Two ring schemes are under study:

- A 1.334 GeV H- linac and two, 50 Hz accumulator (compressor) rings.
- A 0.8 GeV H- linac and two, 3 GeV, 25 Hz proton synchrotrons (RCS).

The two, 50 Hz accumulator rings are filled and emptied successively, once every cycle, whereas the two, 25 Hz synchrotrons, operate out of phase, providing output beams in alternate cycles. Numbers of particles per ring are 2.34 10^{14} for each accumulator and 2.08 10^{14} for each synchrotron.

Two areas are of major importance for the rings. The linacs, though modest in comparison with the 200 MW linacs envisioned for transmutation and tritium production, are at the state of the art for pulsed, high brightness linacs, and beyond the state of the art for the required H- ion sources. Secondly, the beam loss percentage levels in the rings have to be much lower than has previously been achieved in circular accelerators. Improved H- ion sources and H- stripping foils must therefore be developed, and methods sought to contain and reduce the ring beam losses. Special halo collimators are proposed for the injection

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beam line and the rings, and a special injection region for the ring magnet lattices; these features influence strongly the ring designs.

Particular attention is being payed to the injection beam line collimation and the H- charge exchange injection system. Detailed longitudinal tracking studies have been made for the 1000 turn injection process (C.R. Prior, ESS-94-7R Nov 94) and detailed transverse tracking studies have now commenced. An attempt is being made to reduce the injection to less than 2 parts in 10^4 (500 watts per ring) to allow hands-on maintenance for most areas.

2 ISIS Proton Synchrotron, 50 Hz, 70 - 800 MeV, 160 kW

The ISIS synchrotron has reached its design intensity at transverse tune shifts of approximately 0.4 in both transverse phase planes. Interesting aspects of its performance include:

- Increased sensitivity to closed orbit errors when operating at maximum intensity. This has been traced to image effects for particles crossing a horizontal integer resonance.(G.H. Rees, C.R. Prior, to be published in Particle Accelerators).
- Absence of an electron-proton instability, in contrast to the performance of the 800 MeV PSR ring at LANL.
- Operation more than an order of magnitude above the Keil-Schnell Longitudinal Stability Threschold. This has been traced to incorrect interpretations of the traditional U-V Stability Diagram.
- Presence of an unusual coherent vertical head-tail instability. The m=1 mode is observed, though the head-tail phase shift is much larger than is predicted for this mode. (G.H. Rees, Particle Accelerators, 1992)

Detailed tracking studies have been made for the possibility of dual harmonic acceleration in ISIS (C.R. Prior, RAL 94-025). A 50% intensity increase is predicted, with lower trapping losses.

Letters to the Editors

[from P. Chen (CHEN@SLAC.Stanford.EDU)]

Dear Kohji:

Congratulations on the nice job that you, Dr. S. Y. Lee, and Dr. F. Willeke did on the new issue of Beam Dynamics Newsletter. The Newsletter now serves as a very effective forum among beam dynamicists, and I wish to take this advantage to express a few of my suggestions.

As we come close to the end of this century, which observes tremendous progress of particle accelerator technologies which we are proud to have helped to contribute, we are also now facing a severe challenge to continue such a pace in pushing up the energy frontier of high energy particle accelerators. The demise of the SSC maybe symbolic to what I am pointing at. Although we the scientists believe that there is no fundamental technical obstacle to build such a machine, with the Cold War ending and various other reasons the price tag of the SSC was eventually considered so high that the politicians decided to cancel it. The real cause of its demise is certainly more complex than this simple-minded description, but there is indeed a partial truth that straightforward extrapolations of the conventional approach of accelerators is facing a difficult future if we intend to push the energy frontier way beyond the level of the LHC and the next generation of linear colliders. It is time that we think seriously about our future directions.

There have been wide spread research activities over the last decade in advanced accelerator concepts that depart from the conventional approach, such as plasma and laser accelerators. Many so-called "proof-of-principle" experiments have verified the underlying acceleration mechanisms, and observed the acceleration of particles. The major research efforts so far, however, have been mostly from the plasma physics and laser science communities. Accelerator physicists and beam dynamicists, who mostly centered at large accelerator laboratories and are normally deeply involved in making the in-house machine to function, have not been active in this pursuit, except for a few exceptions. Knowing how stringent the constraints are in making a collider to work, most beam experts would agree that it is indeed premature to predict any of these new concepts will eventually turn into practicality. But instead of taking a passive wait-and-see attitude, I believe that it is time now that beam dynamicists come out and join our colleagues across the disciplines to expedite the progress. We may help, through our expertise, to study various beam dynamics issues involved in any of the new concepts.

These will necessarily mean that we need to pick up new knowledge on plasmas or lasers, and to look into beam-plasma or beam-laser interactions, beyond our traditional practice of beam-cavity interaction, for example. But as many of us will agree, the opportunities in science very often lie in the newly emerged inter-disciplinary fields.

In this regard, the ICFA Beam Dynamics Panel can play a very crucial role to advance such a cause. The BD Panel should certainly continue, or even strengthen, its current activities. After all, there is no lack of applications of the so-called conventional accelerators (which still demand clever innovations and theoretical advances), such as low energy particle factories and advanced light sources, to name just a few, far into the foreseeable future. But at the mean time, the BD Panel may also want to consider expanding its scope to include the study of beam dynamics issues in novel accelerator concepts. This can include sponsoring workshops on these topics, inviting activity reports (in these directions) on the newsletter, holding joint conferences with other scientific organizations, etc.

Over the decades, the accelerators that we help to develop have been serving as very useful instruments to the scientific community (which we should all be proud of), yet the theoretical (e.g., the beam dynamics) knowledge that we have accumulated, so far has been rather limited in its utility. To raise our discipline to the same level of prestige as other fields in physics, we need to demonstrate that our knowledge has a more universal value, that it can help to better understand a general class of phenomena relating to particle acceleration or beam transportation in physical systems not limited to the conventional accelerators, but also to novel accelerator schemes, to laser science, to fusion studies, or even to astrophysical settings where a convincing theory is still lacking regarding the acceleration mechanism for the observed very high energy cosmic rays. By expanding our activities, and by reaching out to other fields in physics, we are only helping others to help ourselves in building a stronger and healthier scientific discipline called Beam Dynamics.

Very truly yours,
Pisin Chen

International Workshop on 2nd Generation Plasma Accelerators

(Preliminary Announcement)
A forum for reviewing recent experiments around the world and addressing accelerator issues for experiments beyond proof-of-principle
25-29 June 1995
Kardamyli, Greece

Attendance: limited to approximately 40 participants (by invitation only).

Organizing Committee:	T.Katsouleas (USC,USA)	R. Bingham (RAL,UK)
	C. Joshi (UCLA,USA)	A.Ogata (KEK)
	C. Pellegrini (UCLA,USA)	P.Sprangle (NRL,USA)

Requests for further information on the Workshop should be directed to:
Ms. Shirin Mistry, Univ. of Southern California,
Dept. of Elec. Engineering-Electrophysics
Tel: (213) 740-7759; Fax: (213) 740-7581; e-mail: smistry@mizar.usc.edu

International Workshop on Collective Effects and Impedance for B-Factories

Tsukuba, Japan
12 - 17 June, 1995

The International Workshop on Collective Effects and Impedance for B-Factories will be held from 12 - 17 June 1995 in Tsukuba, Japan, hosted by KEK. The aim of the workshop is to review and discuss the current understanding of collective effects and impedance in B-factories (KEKB and PEP-II). Short reviews on related subjects from other types of existing and future machines such as LEP, ALS, a Tau-Charm and DAFNE will be also presented.

Topics to be discussed will include: coupled-bunch instabilities due to various effects (cavity HOMs, photo-electrons, DIPs), ion trapping, bunch lengthening, feedback system, damped RF cavities, impedance of various beamline elements (pumping slots, BPM, bellows, IR chamber, etc.) and feedback kickers.

For more information, contact
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Workshop on Beam Dynamics and Technology Issues for $\mu^+\mu^-$ Colliders

October 15–20, 1995 – Montauk, New York, U.S.A.

Interest in high energy muon colliders has grown considerably in the accelerator community since the *2nd Workshop on Physics Potential and Development of $\mu^+\mu^-$ Colliders* last November in Sausalito. This workshop will continue to examine the main issues affecting the design, realization and physics potential of a $\mu^+\mu^-$ collider. We plan to have the following working groups:

1) Muon Production: Proton source, targeting, π capture and decay. Phase rotation linacs.

2) Muon Cooling: Various cooling schemes (ionization, optical stochastic, electron cooling) including demonstration experiments.

3) Machine Design: Pre-acceleration, recirculating accelerators, collider ring, low beta insertion. Background and heating problems.

4) Detector/Physics: Design of detectors. Physics at 250 + 250 GeV and 2 + 2 TeV. Trade-off between luminosity and polarization and luminosity and energy spread.

For additional information contact Kathleen Tuohy at tuohy@bnlcl1.bnl.gov or on the World Wide Web open URL, http://www.cap.bnl.gov/~cap/mumu/workshop.html

MICRO BUNCHES WORKSHOP

E.B. Blum and J.B. Murphy[1], Co-Chairs
NSLS, Brookhaven National Laboratory

A Workshop on the Production, Measurement & Applications of Short Bunches of Electrons and Positrons in Linacs & Storage Rings

Topics of interest for the workshop include:

- Production of Short Bunches
- Impedance, Collective Effects and Feedback
- Diagnostics & Measurements
- Uses in Factories, FELs, Colliders and Coherent Emission

Sponsored by the National Synchrotron Light Source and to be held at Brookhaven National Laboratory on September 28-30, 1995

Invited and contributed talks and working groups will examine the production, measurement and applications of short bunches of electrons and positrons in linacs and storage rings.

Registration and information are available on the World Wide Web at
URL = http://www.nsls.bnl.gov/Intro/News/News.html
or by contacting the workshop secretary, Kathy Loverro:
Fax: (516) 282-3029, Phone: (516) 282-7188, E-Mail: bunches@bnl.gov

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Seventh Advanced ICFA Beam Dynamics Workshop

Beam-Beam Issues for Multibunch, High-Luminosity Colliders

18-20 May 1995

Joint Institute for Nuclear Research, Dubna, Russia

Erratum The workshop was announced in the previous issue (page 35). The second paragraph should be as follows:
To increase the luminosity in colliders new ideas are under discussion presently. Finite crossing angle scheme now is considered as an option of several projects of new colliders (Phi, Tau-Charm and B Factories). There is a big interest to the experimental studies of the crossing angle collisions at CESR. This Workshop is planned to discuss specially physical and technical aspects of crossing angle schemes, present experimental experience, details of realization. Finite crossing angle with and without crab cavities, technical and theoretical aspects of crab-crossing, effects of parasitic collisions, control systems to make collision head-on, observations and calculations of beam-beam tail, new ideas for high luminosity performance (monochromatic collision etc.) will be the subjects for discussion. Current limitations are also of a strong interest.

Some of Planned Talks

1. A. Piwinski, DESY, Beam-beam observation and its analysis with DORIS
2. A.Temnykh and J. Welch, Cornell University, Crossing Angle Experiment and its Analysis at CESR.
3. K. HIRATA, KEK, Crossing angle issues in KEKB
4. N. Dikanski, BINP (Novosibirsk), Beam-beam issues in BINP electron-positron factories
5. K. Ohmi, KEK, A weak strong beam simulation with crossing angle
6. A.Zholents, LBL, Lifetime and Tail Simulations for Beam-Beam Effects in PEP-II B Factory.
7. H. Burkhardt, CERN, Beam Lifetime and Beam- Beam Tails in LEP.
8. J. JOWETT, CERN, Beam-beam effects in the LEP Pretzel Scheme
9. Y. Alexahin, JINR (or/and A.Zholents, LBL), (Monochromatization)
10. N. Dikanski, BINP (Novosibirsk), Beam-beam issues in BINP electron-positron factories
11. Y. Funakoshi, KEK Simulations on Crab Cavity System
12. D. Pestrikov, BINP (Novosibirsk) Effect of the Bunch Length on Strength of Synchro-Betatron Resonances Due to Crossing Angle
13. D. Shatilov, BINP (Novosibirsk) Simulation of Beam-beam at large Amplitudes and of the Life Time of Colliding Bunches
14. E. Simonov, BINP (Novosibirsk) Beam-beam Simulation in the Strong-strong Approximation
15. D. Parkhomchuk, BINP (Novosibirsk) Coupling Correction for the Beam-Beam Optimization
16. V. Shiltsev, BINP (Novosibirsk) Decoherence of a Gaussian Beam due to Beam-Beam Interaction
17. V. Parkhomchuk, BINP (Novosibirsk) C-Tau Factory at Novosibirsk
18. V. Yakimenko, BINP (Novosibirsk) Lattice of C-Tau at Novosibirsk
19. A. Rodionov, BINP (Novosibirsk) Footprints of Colliding Bunches
20. Y. Eidelman, BINP (Novosibirsk) Studying of Dynamic aperture of VEPP-4
21. P. Beloshitsky, JINR Optics in Finite Crossing Angle Scheme for Tau-Charm Factory
22. S. Ivanov, IHEP (Protvino) Recent and Ongoing Beam Dynamics Activity inside UNK Project
23. P. Chirkov, IHEP (Protvino) Interference of Sum Betatron and Linear Coupling Resonances
24. S. Arutunian, Yerevan Physics Institute Next Linear Colliders Beams Disturbances due to Granularity of Beamstrahlung
25. J. Cary, University of Colorado Object Oriented Methods for Accelerator Analysis

The 8th ICFA beam dynamics workshop on Space Charge Dominated Beams and applications of High Brightness Beams

October 11-13, 1995
Indidna University, Bloomington, IN 47405

The International Committee for Future Accelerators (ICFA) Beam Dynamics Panel and the Accelerator Physics Group at IU/IUCF are organizing an advanced beam dynamics workshop on the space charge dominated beams and applications of high brightness beams. The time of the workshop is Oct. 11 through Oct. 13, 1995 and the place is a lake-side resort Hotel, the Fourwinds, at Bloomington Indiana ($52/per night with limited occupancy).

Topics of interest for the workshop include beam dynamics issues associated with large space charge effects, e.g. halo formation, emittance dilution, chaos, beam instabilities, and space charge effects of bunching and maintaining ultrashort pulse electron beams. Working groups will be divided into (1) Experiments, (2) Theory, and (3) Beam dynamics of ultrashort-pulse bunches. In particular, applications of high brightness beams in heavy ion fusion, free electron laser, meson factory, neutron spallation source, and high-luminosity colliders will be discussed in the workshop. The proceedings of the workshop will be published in the AIP conference proceedings.

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ICFA Beam Dynamics Newsletter

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Instructions to the authors

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ICFA Beam Dynamics Panel

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 the international collaboration in beam dynamics. The categories of articles in the newsletter are the following:

1. Announcements from the panel
2. Reports of Beam Dynamics Activity of a group
3. Reports of Beam Dynamics related workshops and meetings
4. Announcements of future Beam Dynamics related international workshops and meetings.
5. Letters to the editors (It is a forum open to everyone.)
6. Editorial

All articles except for 5) are invitation only. Those who want to submit articles are encouraged to contact with a panel member nearby. Our preference for the submission of articles to the editors is as follows:

1. in the form of LaTeX file through e-mail: To avoid wrapping problem, please do not put comments (%).
2. computer readable file through e-mail.
3. in a camera-ready form via normal mail: everything should be within a rectangle of 23.5cm (vertically) times 16.5 cm (horizontally), excluding page number.

Figures can be sent as postscript files. For safety, it is better that the originals are sent via usual mail.
Each article should have the title, author's name(s) and his/her/their e-mail address(es).

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