Activities in Italy and at European Synchrotron Radiation Sources

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INFN-LNF Frascati, Italy

1. Beam dynamics activities in Italy

Based on information received from: G.Acerbi/INFN and Universita' di Milano, M.Conte/Universita' di Genova, M.Cornacchia/Sincrotrone Trieste, M.Preger/LNF, A.Renieri/ENEA, L.Palumbo/INFN and Universita' di Roma , M.Puglisi /INFN and Universita' di Pavia , M.Pusterla /INFN and Universita' di Padova, V.Vaccaro/INFN and Universita' di Napoli.

1.1 INFN/Milano University

A superconducting cyclotron with K = 500 is in the final phases of construction. The main beam dynamics activities are connected with the computation of proper field configurations and in general with the study of the stability of trajectories, and of injection and extraction . Since the machine is to become a post-accelerator for a Tandem . phase space matching at injection and extraction for all different possible ions and in the presence of strong fringe fields is a particularly delicate problem. An experiment on a two-beam device consisting of a SC FEL and a normal conducting Linac structure is in progress.

1.2 LNF / Laboratori Nazionali di Frascati dell'INF.

The Laboratory operates two accelerators : Adone a 1.5 GeV electron/positron storage ring and its 350 MeV electron- positron injector Linac, the latter also used to produce very high flux positron beams for nuclear physics. The storage ring is used for nuclear physics and synchrotron radiation experiments. A jet-target and an improved Compton backscattering photon beam are being installed and will be commissioned early in 1988. The ring is also being re-fitted for two beam operation and a new gun and buncher section have been installed on the LINAC to improve the positron injection efficiency. Electron peak currents of 10 A in 10 ns pulses have been obtained from the gun. The dynamics of low energy , space charge dominated beams is also being studied in connection with this upgrade program .

The ring vacuum chamber and orbit position diagnostics have been changed in 1987; experiments are in progress to assess the effect on the effective impedance seen by the beam.

A first design study for the third generation, low emittance Trieste SR source has been completed. In connection with this work the code RACETRACK has been installed, to compare its results with those from other codes.

In the framework of R&D on electron/positron colliders. the costruction of a SC, 30 MeV, low emittance LINAC with recirculation (for energy doubling or recovery) has been funded and is in progress. The beam dynamics in the room temperature injector and in the four five-cell 500 MHz SC cavities is being studied (including space charge) mainly with the Los Alamos code PARMELA. The design of the recirculation channel, under study, is constrained by beam quality requirements: it should be achromatic. isochronous and imaging. It is planned to use the LINAC for a high efficiency (through energy recovery), high power f.e.l. in the infrared. The interaction of the beam with the radiation field and the problems of the energy recovery system are being studied.

1.3. ENEA/TIB Frascati

ENEA operates in the field of microtrons . small Linacs for industrial applications . race track microtrons and and single pass FEL's. Dynamics of high current microtrons is being studied : 150 mA in 6 ms long pulses have been obtained on a 20 MeV machine and 200 mA in 4 ms pulses on a 5 MeV one. An 80 MeV racetrack is in the final stage of design and should be operational in '88.

Significant activity is in progress on single pass FEL's : a 10 mm device has lased and is being upgraded in view of achieving higher efficiency, a microwave Cerenkov FEL has also lased.

1.4 INFN/ Rome University La Sapienza (Dip.Energetica)

Electromagnetic radiation from relativistic particles passing by discontinuities in the vacuum chamber or traversing cavity like structures are being studied. Coupling impedances, radiation losses and wake potentials are derived. Problems and codes connected with the collective behavior of particle beams in low emittance lattices for SR sources are also being studied (in collaboration with LNF). A design study for a conventional magnet synchrotron x-ray source Lithografy has been developed.

1.5. INFN/Universities of Trieste, Pavia, Pisa, Lecce

A collaboration has been set up to study , design and build a 140 KeV proton RFQ. An approximate analytical solution of the differential non linear equation describing the motion of a particle in a RFQ accelerator has been worked out. The problem of transverse stability in RFQ devices has also been treated.

1.6. INFN/Universities of Padua and Bologna

Beam-beam stability in proton synchrotrons (such as EHF) and proton storage rings (such as L.H.C.) is being studied (in collaboration with CERN, SPS Accelerator Group). In particular the typical non-linear effects (Tuneshift. Dynamical Aperture, etc...) are under computation with the intention of extending the already obtained bidimensional case (in phase space) for the transfer-map, to four and six dimensions. The normal form method for simplectic dynamics reveals very promising in comparison with LIR algebra approach (MARYLIE) as far as approximations are concerned. Beam-beam effects can be easily added to the transfer-map. Polarization calculations and transverse and longitudinal 'Painting' are investigated at the injection LINAC-BOOSTER in the

EHF Project. Tracking studies including the spin-motion are also under investigation.

1.7. INFN/ Naples University

Plasma wave acceleration is being studied . An experiment at microwave frequencies is in progress. By working in the microwave region lower plasma density is needed and larger physical dimensions can be used to ease the study of basic principles. Stochastic cooling using the microwave Cerenkov effect is also being studied in connection with ACOL and the SPS collider.

Diffractive energy losses suffered by ultrarelativistic particles interacting with variously shaped surrounding conductors are being studied. Conclusive results are being obtained for cylindrical pipes or circular holes in a conducting plane.

1.8 Trieste Synchrotron Light Source (Sincrotrone Trieste)

A third generation synchrotron radiation facility is currently under construction in Trieste. The facility consists of a 2 GeV storage ring optimized for low emittance electron (or positron) beams. The design incorporates 12 long straight sections in which wigglers and undulators produce intense SR beams. Various options for the injection system, currently under investigation. include a linac plus a full energy booster, as well as a full energy LInac.

The beam dynamics studies associated with the design cover a wide rannge of subjects. The requirements for a small emittance has led to the study of various lattices that offer the best compromise between small emittance and large dynamic aperture. The linear and nonlinear effects of wigglers and undulators are also important topics of study. The strong focussing required to achieve a small emittance and the great orbit stability asked for by the users. make these lattices particularly sensitive to the effect of orbit errors. Simulations and theoretical studies are under way.

The experimental requirements for short bunches and high circulating currents demand a very careful study of collective instabilities and of the impedance of the ring. These effects are being evaluated with special emphasis on ways of damping the accelerating cavities parasitic modes.

The possibility of using the injector Linac for FEL experiments in the infrared (oscillator mode) and the XUV (amplified spontaneous emission mode) regions is being studied.

1.9. INFN/ Genoa University

Role of the multiple Coulomb scattering as chaos generator in the beam-beam interaction. Compensation, through low-energy electron beams, of the space-charge borne nonlinear forces in the beam-beam interaction in hadron colliders.

Design of a small (proton) ring to investigate beam behaviours during multicrossing of nonlinear elements. In collaboration with CERN and with the Universities of Padua and Trieste the separation of the two spin states of antiprotons in LEAR is being worked on .

2. Beam dynamics activities at Synchrotron radiation dedicated sources in Europe.

Based on information received from: W.Brefeld/HASYLAB/DESY, J.L.Laclare/ESRF, M.Sommer/LURE/Orsay, V.Suller/SRS/Daresbury, E.Weihreter/BESSY.

2.1 European Synchrotron Radiation Facility (Grenoble)

The work being pursued includes :

The optimization of various low emittance lattices by the choice of the best working points, the compensation of resonance driving terms and the minimization of tune shifts on momentum and on amplitude. The problem of aperture , with all its technical complement of tracking codes.analytical approaches etc., is a central one and is being attacked from various angles.

The study of the sensitivity of lattices to errors. of alignment and magnetic field tolerances , of the effects and the correction of orbit errors. of the effects on aperture of nonlinear field components in the lattice magnets and in insertion devices. and of matching of insertion devices into the lattice.In addition the flexibility of the lattice and its abilityu to accomodate a variable number of wigglers and undulators has been investigated.

New developments in the in-house tracking codes : the non linear effect of insertion devices on beam dynamics and treatment of synchrotron motion have been implemented in the BETA code.

The effect of ground vibrations on the beam emittance and on the beam stability .

The study of single beam and collective effects and of instability thresholds . including the investigation of the electromagnetic properties of the beam surroundings . The contribution of various elements of the vacuum chamber to the coupling impedance has been estimated by computing wake potentials and the loss parameters with the TBCI code.

2.2 SRS, Daresbury, U.K.

An upgrade of the SRG was carried out from October 86 to March 87. The upgrade is designed to increase the spectral brilliance of the source through reduction of the beam emittance by more than a factor of 10. The 8-fold FODO structure of the storage ring lattice was changed to a 16-fold FODO structure by installing additional quadrupoles in each straight section together with new vacuum chambers and pumps. The upgrade was completed on schedule and within the capital budget of approximately one million pounds. The installation phase was completed in March 87 and recommissioning followed. The source came back into scheduled operation for experimental science in mid June.

Measurements with a pinhole X-ray camera and also using the visible component of the synchrotron radiation show that the beam emittance at 28 eV is as predicted 0.1 mm-mrad. The vertical coupling has not yet been measured precisely but is less than 3%. The typical beam size is 1.0 mm horizontal and 0.1 mm vertical (sigma values). The normal beam current at the start of a run is between 150 and 200 mA with a beam

lifetime at 100 mA. (The RF is 500 MHz with a harmonic number of 160). In multibunch, currents of over 500 mA have been stored at the injection energy 600 MeV.

Great attention is being paid to the stability of the corrected closed orbit and the alignment of the synchrotron radiation beams. The accuracy of the new button beam position detectors is also being measured carefully. One of the first topics for accelerator physics studies will be the measurement of single bunch length as function of energy and current in order to characterize the impedance of the new vacuum chambers.

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2.3 Super ACO (LURE.Orsay)

The facility is being commissioned using positrons and with the low emittance optics.

Emittance. transverse dimensions confirm the computations. Bunch length and lengthening are somewhat better than expected, Touschek life-time is by 25 % shorter than computed value. but the simple bunch transverse threshold is 40 mA to be compared to the nominal value of 20 mA.

The main problem to solve is the longitudinal multibunch oscillation for more than three bunches.The application programs developed for machine operation were of great help during all this phase.Three insertions will be installed on the machine during the next months, compensation schemes and beam steering programs are ready.

2.4 BESSY (Berlin)

A 1.5 GeV third generation low emittance storage ring (BESSY II) is being designed.

To obtain more physical insight in the low emittance conditions and to optimize a TBA-type lattice, analytical calculations using symbolic algebra are being performed.

Work is also in progress on an experiment to investigate bunch lengthening effects at BESSY I, with the aim of obtaining experimental data on the frequency dependence of the machine effective impedance . The experiment will take advantage from the fact that at BESSY I the bunchlength can be varied over a large range using different optics and the existing double RF system.

The COSY machine, a compact storage ring for x-ray lithography is in the commisioning stage. Experiments are in progress to learn more on lifetime limitations and emittance broadening effects at low injection energies.

FORTHCOMING BEAM DYNAMICS EVENTS

International Workshop on "Constracting VUV soft X-ray Synchrotron Radiation Facilities", Taipeh, Taiwan. Republic of China. 22-27 February 1988. Contact: E.Yen, Synchrotron Radiation Research Center, Roosevelt Road, Sec.1, 10757 Taipeh, Taiwan.

Workshop on "RHIC Performance", Brookhaven, March 21-26, 1988. Contact: A.G.Ruggiero. Brookhaven National Laborary, Upton. Long Island, New York 11973, USA.

Advanced Beam Dynamics Workshop on "Aperture-Related Limitations of the Performance and Beam Lifetime in Storage Rings". Lugano. Switzerland, April 11-16. 1988. Contact: E.Keil, CERN. Geneva. Switzerland.

Spring Meeting of the American Physical Society. Baltimore.MD. April 18-21,1988. Contact: M.Month, Brookhaven National Laboratory, Upton N.Y. 11793, USA.

Seminar on "Beam Dynamics and Luminosity". Erice, Sicily, May 21-28, 1988. Contact: G.Torelli. Istituto Nationale di Fisica Nucleare, Pisa, Italy

Specialised CAS course on "Superconductivity in Particle Accelerators", DESY, Hamburg. Germany. 30 May - 3 June 1988. Contact: Mrs. S.von Wartburg, CERN, Geneva, Switzerland.

European Particle Accelerator Conference, Rome, Italy, June 7-11, 1988. Contact: S.Tazzari, INFN-LNF Frascati(Rome), Italy

Joint ICFA-INFN Workshop on "Physics of Linear Colliders", Capri, Italy, 14-18 June 1988. Contact: R.B.Palmer, SLAC, Stanford, CA 94305, USA.

7th International Conference on "High-Power Particle Beams", Karlsruhe, Germany, 4-7 July, 1988. Contact: G.Kessler, Kernforschungszentrum Karlsruhe, Karlsruhe, Germany.

1988 US Particle Accelerator School. Cornell University, Ithaca N.Y., 1-12 August, 1988. Contact: US Particle Accelerator School, Fermilab, Batavia, Il 60510, USA.

8th International Symposium on "High Energy Spin Physics", University of Minnesota, Minneapolis, 12-17 September 1988. Contact: Sandy Smith, School of Physics and Astronomy, University of Minnesota, Minneapolis, Minnesota 55455, USA.

Main CAS course on "General Accelerator Physics", Salamanca, Spain, 19-30 September 1988. Contact: Mrs. S.von Wartburg, CERN, Geneva, Switzerland.

1988 Linear Accelerator Conference (Linac 88), Williamsburg, VA, USA, 3-7 October. Contact: C.W.Leeman, CEBAF, Newport News, VA 23606, USA.

Joint US-CERN course on "Beam Observation, Measurement. Diagnosis and Correction". Capri, Italy, 20-26 October 1988. Contact: Mrs. S.von Wartburg, CERN, Geneva, Switzerland.

National Accelerator Conference, Dubna, October 25-27, 1988. Contact: N.S.Dikansky, Institute of Nuclear Physics, Novosibirsk 90, U.S.S.R.

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