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FIRST OPERATIONAL EXPERIENCE WITH DORIS II

H. Nesemann, K. Wille
Deutsches Elektronen-Synchrotron, DESY
Hamburg, West Germany

Abstract

DORIS II is a completely new designed e^+-e^- storage ring with a mini-beta scheme. After first runs with a 8 cm optic, the vertical amplitude functions in the interaction points were reduced to 4 cm. This yielded luminosities of $L = 1.5 \cdot 10^{31}\ \mathrm{cm^{-2} sec^{-1}}$ with 2 x 27 mA at E = 5 GeV. Because of the short injection time, an integrated luminosity of more than 600 $\mathrm{nb^{-1}}$ per day has been obtained.

Introduction

DORIS II is an electron-positron storage ring with two interaction regions for high energy experiments[1,2]. In addition, synchrotron radiation is used by three laboratories (HASYLAB, EMBL, IFT)[3] . This machine was completely new designed, but it was built in the existing tunnel using, as far as possible, elements of the old storage ring DORIS I. Because of this "machine recycling" the construction time was not longer than half a year. Since June 1982 DORIS II has been ready for experiments.

Mini-Beta Scheme

The desired high luminosity of $L > 1 \cdot 10^{31}\ \mathrm{cm^{-2} sec^{-1}}$ in the energy region around 5 GeV is obtained by a mini-beta scheme. A special strong focussing quadrupole is mounted at a distance of only 1.23 m from the interaction point. With this mini-beta arrangement it is possible to reduce the vertical beta-function in the interaction points to minimal values of $\beta^*_z \approx 3$ cm. The limit is mainly given by the resulting chromaticity. Because of the small distance to the interaction point the mini-beta quadrupoles penetrate the particle detectors. At the northern interaction point the Crystal Ball fits within the mini-beta scheme; the diameter of the ball is less than the free space between the quads. The southern interaction region is occupied by the large magnetic detector ARGUS. The quadrupoles are inserted into the iron yoke and nearly 1/3 of the magnets reach into the inner space of the detector (Fig. 1).

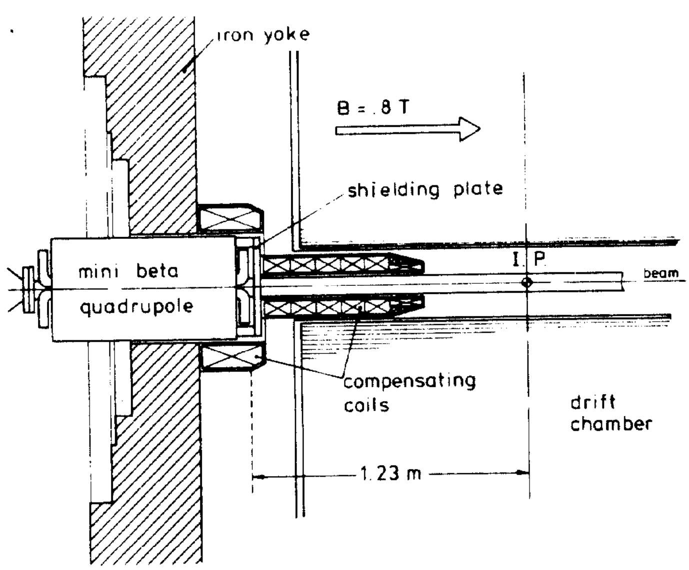

Fig. 1: Mini-Beta quadrupole inserted into the magnetic detector ARGUS

In order to keep the quadrupoles free from the longitudinal field of .8 T they are surrounded by compensating coils and shielded by 3 cm iron plates at the front plane. Another set of coils mounted at these plates compensates the influence of the detector field on the beam. The residual detector field in the quadrupole yoke, however, decreases the magnet strength due to iron saturation. This causes an untolerably strong vertical tune shift and unsymmetric optics. Therefore by use of a small power supply an additional current of some amperes is added to the two mini-beta quadrupoles on the ARGUS side, which increases the magnet strength and consequently the vertical tune to the original value. This simple method avoids the optical asymmetry and the resulting luminosity at both interaction points is equal within the accuracy of measurement.

Synchrotron Radiation Background

The strong synchrotron radiation from the last horizontal bending magnets cannot reach the interaction point because of the vertical bending inserted on both sides of the experimental regions. Here the beam axis is 20 cm below the rest of the ring (Fig. 2).

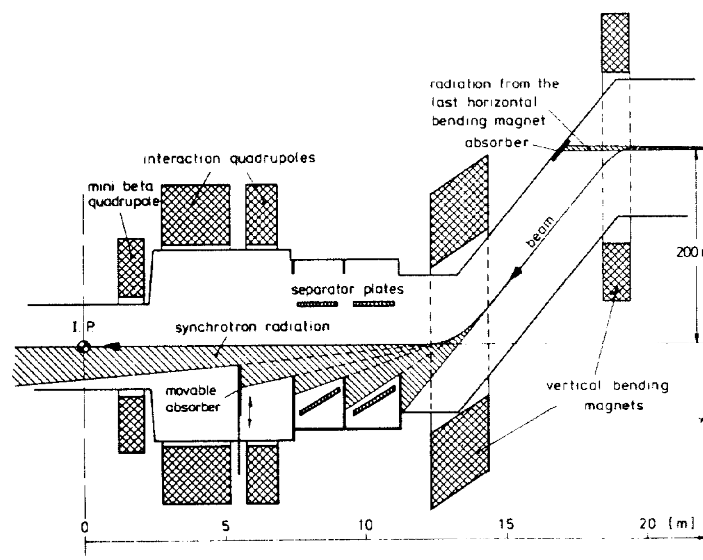

Fig. 2: Sketch of the vertical bending with synchrotron radiation

The only synchrotron radiation in the experimental area is produced by the weak vertical bending magnet. Some fixed and movable absorbers keep this radiation away from the detector region and during all runs at 5 GeV there were no problems with synchrotron radiation background. Background in DORIS II is only produced by scattered high energy particles.

Injection

A high integrated luminosity requires a fast and efficient injection. Therefore the whole injection system including the transport channels between the synchrotron and DORIS II have been significantly improved.The new system allows particle injection at every running energy of the machine up to E = 5.6 GeV. The control of all injection elements (magnets, kickers, tuning etc.) operates reliable and relatively stable. If the injection energy is not changed, the system re-

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quires no corrections over several days. The following data have been reached during colliding beam runs:

injection rep.rate	:	$f_o = 8.33$ Hz (e^+ and e^-)
max. injection rate:		$\frac{dI}{dt} = 1\text{-}2.5$ mA/sec (e^+ and e^-)
efficiency	:	$\eta > 90$ %
filling time	:	$t < 1$ min (2 x 25 mA)

There are electrostatic plates installed in DORIS II in order to seperate the beam in the interaction points, but until now the beam beam limit has not been reached at 5 GeV and therefore these plates have not been used.

Vacuum System

DORIS II is equiped with a new vacuum system which consists of stainless steel chambers with copper absorbers and water cooling brazed on these chambers (Fig. 3). All the vacuum chambers are made as smooth as possible to avoid instabilities and higher order mode losses. In the beginning, valves with sealing of synthetic material have been used. During longer runs with currents of $I > 2 \times 20$ mA a strong increase of the gas desorption was observed due to heating by higher order mode losses, reducing the beam lifetime to approximately one hour. In the meantime, these valves have been replaced by standard PETRA types with better r.f. properties. The vacuum limitation is now eliminated. At present, the average vacuum pressure is about $2 \cdot 10^{-9}$ mbar without beam and $8 \cdot 10^{-9}$ mbar with currents of 2 x 25 mA at an energy of 5 GeV. This yields a beam lifetime of about 3 hours. At lower currents or during multibunch runs for synchrotron radiation users the lifetime is larger than 5 hours.

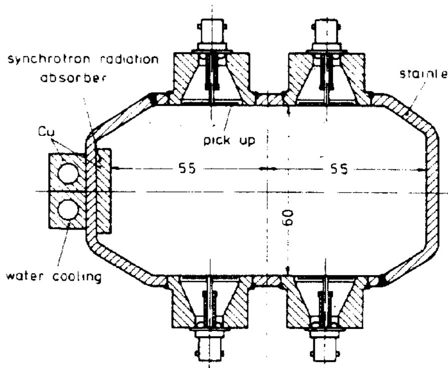

Fig. 3: Cross section of the standard vacuum chamber with position monitor

Orbit Correction

An important beam diagnostic is the beam position monitoring system. It consists of 35 sets of 4 discs (Fig. 3) very similar to the types used in PETRA. Four different computer programms are available for an automatic orbit correction. The correction is performed by use of 32 horizontal and 28 vertical correction coils. After correction the orbit distortions are typically $(x)_{RMS} \approx 1.2$ mm in the horizontal and $(z)_{RMS} \approx 0.6$ mm in the vertical plane respectively. These values are obtained for all DORIS II optics.

Maximum Currents and Instabilities

The single bunch current was limited to about 15 mA at 5 GeV by a coherent transverse instability excited by the accelerating cavities which had already observed in DORIS I[4]. Therefore a narrowband feedback system has been installed in the machine. By means of this system the maximum single bunch currents have increased to values of $I_{max} > 50$ mA limited by vacuum. During dedicated runs for synchrotron radiation experiments the machine normally is filled with an electron beam with 480 bunches. Under these conditions a maximum current of 120 mA was obtained. It is limited by transverse multibunch instabilities due to cavity resonances. This problem needs further investigations. A current limitation due to strong longitudinal instabilities has not been observed.

Optics

For the first experimental runs in 1982 two different optics have been prepared: The first one was developed for dedicated synchrotron radiation runs and the second one for colliding beam experiments. An acceptable luminosity and relatively low chromaticity was obtained with a vertical amplitude function of $\beta_z^* = 8$ cm in the interaction point. These optics have been used until the end of the last year. In February 1983 a more ambitious optic with a beta-function of $\beta_z^* = 4$ cm was successfully tested and is now being used for luminosity runs since that time (Fig. 4).

The chromaticity of the new optic amounts to $\xi_x = -19.6$ and $\xi_z = -21.6$ and is compensated by 4 sextupole families. The optimum strength of each family was investigated by tracking calculations. The resulting optic is sufficient for colliding beam operation as well as for injection. Special injection optics are therefore not necessary.

Luminosity

The luminosity achieved with DORIS II around 2x5 GeV is shown in fig. 5 for both optics. Most of the values are measured during normal experimental runs. The new 4 cm optic has increased the luminosity by a factor of 1.7 as expected. At present, a typical run is started with currents of approximately 2x27 mA and luminosities of $L = 1.5 \times 10^{31} \mathrm{cm}^{-2}\mathrm{sec}^{-1}$ at the beginning and $L = 0.8 \cdot 10^{31} \mathrm{cm}^{-2}\mathrm{sec}^{-1}$ at the end of the run. Under these conditions an integrated luminosity of more than 600 nb^{-1} per day has been obtained. The specific luminosity during the runs remains constant around values of $L_S = 2.0 \cdot 10^{28} \mathrm{cm}^{-2}\mathrm{sec}^{-1}\mathrm{mA}^{-2}$. The corresponding tune shift is $\Delta Q = 0.023$ for 2 x 27 mA, but that is obviously not the limit. It was found that a fine control of the vertical bending magnets is useful for reducing the vertical emittance ε_z and improving the specific luminosity. After a careful control including asymmetric beam bumps in the interaction regions maximum values of $L_S = 2.5 \cdot 10^{28} \mathrm{cm}^{-2}\mathrm{sec}^{-1}\mathrm{mA}^{-2}$ have been reached.

During normal colliding beam runs a spin polarisation of $P > 80$ % was found. This preliminary value was measured with 87 % compensation of the longitudinal ARGUS field. The operating energy was only 60 MeV different from that energy at which a main spin resonance occurs.

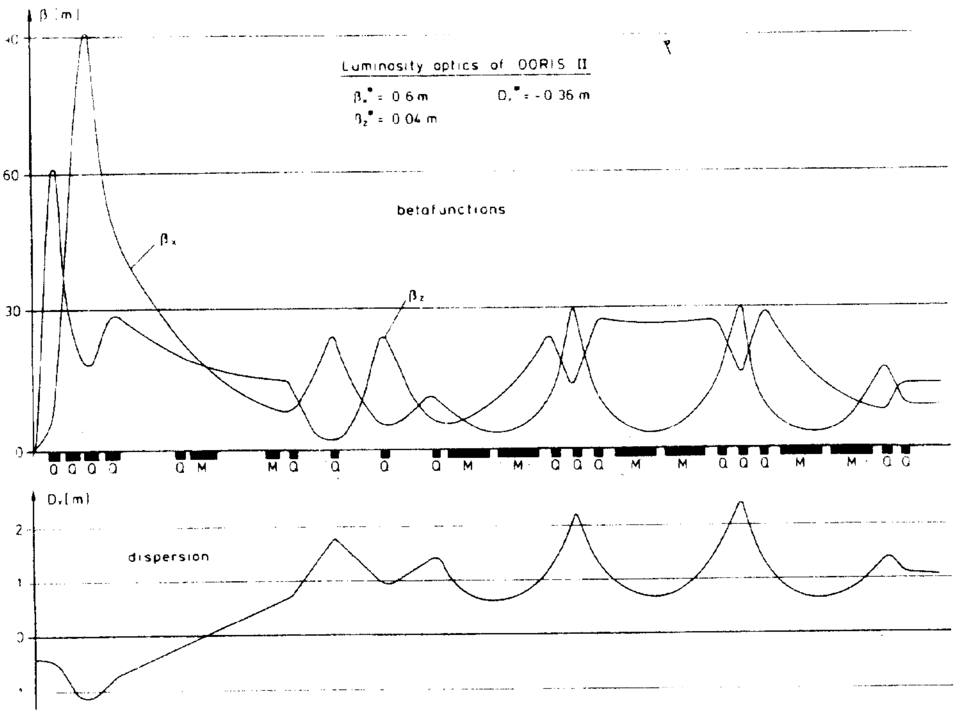

Fig. 4: Luminosity optic with very small amplitude functions in the interaction point. ($\beta_x^* = 0.6$ m, $\beta_z^* = 0.04$ m)

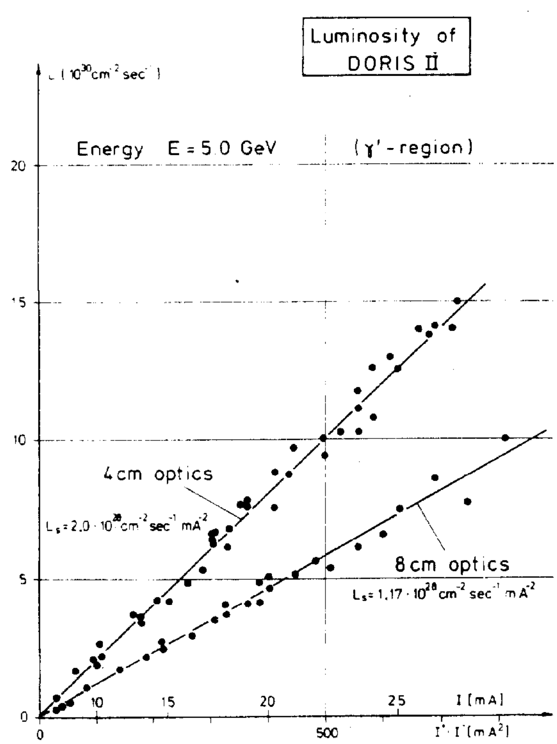

Fig. 5: Measured luminosity of DORIS II for the two different mini-beta optics

Acknowledgement

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