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STATUS REPORT ON THE DESY II SYNCHROTRON

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Abstract

After approval of the construction of the new separated function electron synchrotron, DESY II, in May 1983, the design and fabrication of all components was completed and the new machine fully installed during a four month winter shutdown from Nov. 84 until Feb. 85. The new machine will be tested in parallel with normal operation of the old 7 GeV synchrotron, DESY I, by using 200 MeV electrons injected from the upgraded Linac I. Provisional power supplies run the magnets up to 1 GeV. During a second shutdown in winter 85/86 it is planned to install full magnet- and rf-power and to connect all beam transfer lines to PETRA and DORIS. DESY I will then be turned off and most of the components will be used to form a new proton synchrotron (DESY III) for the HERA e-p project.

An updated parameter list and first results from the initial tests of DESY II will be presented.

Introduction

On March 22, 1985 the first electron beam was injected from Linac I into the new electron synchrotron DESY II. The captured beam revolved several thousands of turns in the machine. A construction period of less than two years had elapsed since May 1983 when the project was authorized. Further beam-tests have been carried out up to the present time (April 85). Since the old synchrotron DESY I is still serving the two storage rings DORIS and PETRA and test beam users, these DESY II tests have to be carried out between the filling procedures and do not interfere with the high energy physics program at DESY. The upgraded Linac I is switched back and forth from DESY I 55 MeV injection to DESY II 200 MeV injection.

Parameters

The parameters of the machine described in /1/, /2/ have change only slightly. Due to eddy current effects in the metallic vacuum chamber additional sextupole fields proportional to the rate of rise of the magnetic field appear and drastically reduce the acceptance /3/. With additional defocussing sextupole magnets the undisturbed acceptance can be restored to = 10 mradmm at $\Delta p/p = \pm 1\%$ momentum spread. Although the magnets and the power supplies are capable of running up to 10 GeV/c the rf-system will be equipped only with eight 7-cell cavities. This completion step is sufficient to accelererate the beam to more than 8 GeV/c. But only 7 GeV/c are necessary because the physics program at PETRA will come to an end in 1986/87 and after that PETRA will act as an intermediate accelerator for electrons and positrons between 7 and 14 GeV/c for the HERA project.

Magnets

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All magnets were built, shipped and tested in 1984. Details on design, construction and performance are given in /4/. Two prototype dipoles and one prototype quadrupole were built in order to aet experience with A.C. field quality and to achieve the optimum shape for the endfield region. A new method for precise ac-magnetic field measurements has been developed /5/. The dipoles which are of a completely new "in house" design, fabrication and assembly were made in close cooperation between various engineering firms and the DESY workshops.

Parameter list:	
repetition frequency max. energy (for magnet design) 1 St completion stage	12.5 Hz 10 GeV 8 GeV
e single bunch 5×10^{9} particles e " " 8×10^{7} " circumference lattice sep. function 8 superperiods (PM + 3.05 + 3.00 + 2.50 + 1.55	200 MeV 450 MeV 292.8 m
<pre>6 BM + 5 WF + 5 WD + 2 SD + 1 Sr acceptance (Δp/p) = ± 1 %) A_{x,z} = max. horiz. beta " vert. " momentum compaction rf harmonic number frequency no. of cavities (7-cell type) total shunt impedance peak power</pre>	10 mradmm 21.8 m 21.8 m .243 488 499.65 MHz 8 168 MOhm 900 kW
<pre>magnets (rating refer to 10 GeV/c exc dipoles length</pre>	160:45 mm ² ± 40 mm 27.12 m 1.23 T 1147 A 33.2 mH 30 kW .58 m 14.7 T/m 1350 A 6 kW .18 m 77.8 T/m ² ~ 1.1 kW

Fig. 1 shows details of the dipole and fig. 2 the results of measurements of the field homogenity.

The design and construction of the quadrupoles and sextupoles partly based on the PETRA magnet design. But they are different in length, coils and endfield shape. The length of the quadrupoles is chosen so that the saturation behaviour of the magnetic field is similar to that in the dipoles. Fig. 3 and 4 show the cross-sections of a quadrupole and a sextupole.

In the four month shutdown from Nov. 1984 to Feb. 1985 all magnets were installed in the ring tunnel. All other machine components were also added and the whole machine became ready for first injection tests. Fig. 5 illustrates the periodic machine structure of DESY II within the ring tunnel side by side with the old synchrotron DESY I. For injection orbit correction the evenly numbered dipoles are equipped with two backleg coils. Two individual coils separated by about 2π in horizontal phase advance and connected in series with one 10 A D.C. power supply form a "S" shape beam bump. The induced A.C. voltage is compensated and thus the power supply is not loaded. For the vertical orbit correction at injection energy all 16 defocussing sextupoles are equipped with four coils on the return. voke.

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completes the

whole vertical

Fig. 1: Dipole cross-section



Fig. 2: Dipole field: Deviation from homogenity



Fig. 3: Quadrupole cross-section



Fig. 4: Sextupole cross-section

Power Supplies

The separated function lattice requires five independent magnet circuits. For test purposes provisional power supplies have been built which allow the synchrotron to run at 1 GeV/c. These power supplies are similar to those originally used for the Fermilab. Booster synchrotron. Each power supply is controlled by four parameters: the D.C. and A.C. amplitudes, the frequency and the phase. All power supplies are being extensively tested and special care is being taken to reduce the higher harmonics generated in the mains supply circuit. The results of these measurements are encouraging, details are presented in /6/.

Injection

Electrons and positrons for the injection into DESY II will be generated by two different sources. The positrons come from the Linac II - PIA system /7/ and will be injected at 450 MeV/c. We expect about 10 particles within one single bunch with FWHM \simeq l ns. Since the accelerating sequence in DESY II will alternate between electrons and positrons we wish the Linac I electron beam to be just as powerfull as the positron source. Therefore the Linac I-energy has been raised to more than 200 MeV by adding two post accelerating sections to the old 55 MeV accelerator. The installation was made during the shutdown period Nov.1984 to Feb.1985. These two sections were obtained from the Linac II after an improvement program had been carried out where all klystrons were equipped with storage cavities. This modification, as with the SLED program at SLAC, causes the input power to the accelerating section to be raised from 20 MW to about 90 MW and thus the acceleration energy from 57 MeV to 88 MeV. Since then there are only seven accelerating sections for the 450 MeV PIA injection necessary instead of nine in the past.

The guide field of DESY II is suitable for the injection of 55 MeV electrons. However experience with the old DESY I machine suggests that it is worthwhile to operate DESY II at higher injection energy since the magnet field quality is better and thus the injection efficiency is higher.

At present we can easily switch the Linac I and the associated transport channels from 55 MeV injection into DESY I to 200 MeV injection into DESY II within a few minutes.

steering magnets

correction system.



Fig. 5: Ring tunnel with DESY I and DESY II

Vacuum

A novel fabrication technique for the metallic vacuum chamber has been developed that allows the vertical beam profile to use nearly the complete dipole gap height /8/. These vacuum chambers consist of an $80x40 \text{ mm}^2$ elliptical stainless steel tube of .3 mm wall thickness. For reinforcement thin ribs are brazed on the tubes. The eddy current losses /3/ are 60 W/m at full A.C. excitation of the dipoles. Fig. 6 shows the cross section of the dipole chamber and a typical outlet chamber. After complete fiq.7 installation of the vacuum system in the last shutdown (Nov.84-Feb.85) and after the start of pumping the measured average pressure was better than 10^{-7} Torr. This is about one order of magnitude better than necessary for normal operation.





Fig. 7: Typical outlet chamber

Controls

Various monitors for beam observation and -control have been installed. For initial turn steering and injection matching measurements there are ten screen monitors built in. Furthermore inductive ring core monitors for beam current measurements, resistive wall monitors with fast response for single bunch coherent signals and knob monitors for beam position measurements similar to those developed for PETRA are pro-



Fig. 8: Vacuum chamber with pick up buttons

vided (Fig. 8). A synchrotron light monitor for beam profile measurements is installed. Coherent radial oscillations of the beam will be controlled by a transverse feedback system.

All functions of the synchrotron are computer controlled. SEDAC and PADAC provides the interface between the components and the NORD computer. This control system is based on the experience gained from the machine control of PETRA and DORIS.

Initial Tests

In March 1985 all DESY machines were brought back into operation. In the gaps between the filling operations for the storage rings initial component test were undertaken. The post accelerator for Linac I was turned on and after some attempts a 200 MeV beam was accelerated and injected into DESY II. After the remanent fields in the dipoles had been equalized by individual powering of the magnets the beam was accepted and revolved for about 40 ms in the machine. In the second attempt the rf was turned on and the particles were captured longitudinally. The magnets were provisionally powered with D.C. currents. In parallel, the A.C. power supplies were undergoing extensive tests, and especial efforts were made to reduce the harmonics in the magnet currents.

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