STATUS OF THE DESY II PROJECT

The DESY II Collaboration*
presented by G. Hemmie
Deutsches Elektronen-Synchrotron DESY
Notkestr. 85, 2000 Hamburg 52, W.-Germany

Abstract

DESY II has been extensively tested at low magnet current excitations corresponding to 1 GeV maximum energy. After the old DESY I synchrotron was turned off in Nov. 86 the provisional power supplies were replaced by magnet- and rf-power supplies of full 8 GeV rating. All external beam lines have now been connected to the new machine. Some modifications on components are described. A report on the results from the initial tests of the machine under full power conditions is given.

Introduction

The major components of DESY II were installed during a shutdown period from Nov. 84 to Febr. 85. The first injection tests were carried out soon after all other DESY machines began operation again. The tests were made during the gaps when the old DESY I electron synchrotron was not in use for filling PETRA and DORIS. Although these tests were made with low priority it was found that the new machine worked quite well and that the behaviour was as expected. Because only provisional supplies allowing electron injection and acceleration up to 1 GeV were available, many questions relating to full energy operation with positron injection and all external beam lines connected to the machine remained open. Thus, it seemed unwise to take DESY I out of service until the end of the important physics research program on PETRA which was scheduled to the end of October 1986.

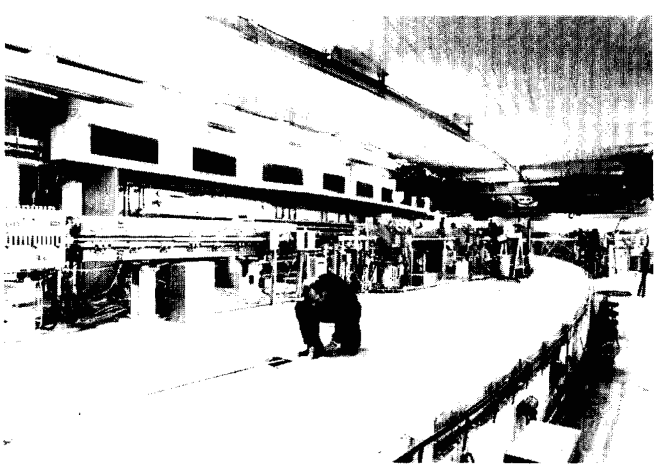

Fig. 1 Synchrotron ring tunnel with DESY II on the left hand side and the ring carrier cleared of the old DESY I synchrotron and ready for the installation of the proton machine DESY III.

A tightly scheduled shutdown program then followed in which full magnet and rf-power was installed and all external beam lines were connected to the new synchrotron. In parallel with this task, the old DESY I synchrotron was completely dismantled and all components of the old machine were taken out of the ring tunnel (see Fig. 1). The combined function magnets of this machine will be refurdished for use in a new proton synchrotron, DESY III [1].

Geometric Arrangement

Fig. 2 shows the layout of the DESY II ring and its external beam lines for injection and ejection. Together with DESY III the machine fits quite well into the spacious synchrotron ring tunnel. The median planes of both machines are at the same height. Since the positron and electron injection beam lines cross DESY III at its long straight sections no interference will occur when DESY III is operating. This is also true for the electron ejection channel for DORIS. The ejection beam lines for PETRA however, cross bending magnets of DESY III and thus cause interference with DESY III if it is running during positron or electron injection into PETRA. This will not be harmful because there is no strong requirement to run both machines simultaneously. In fact, PETRA can only accept either protons, electrons or positrons and it takes some time to change over from one mode of particle acceleration to the other.

Components

The parameters of DESY II described in [2], [3] have not changed in the meantime. Only slight modifications to some components have been made. These are described in the following sections.

Magnet Power Supplies

In a two month shutdown period from Nov. to Dez. 86 the whole 50 Hz White circuit, connected to the DESY I magnets until that date, was rearranged to form a 12.5 Hz resonant circuit together with the DESY II dipoles. In total there are five magnet circuits, one dipole-, two quadrupole- and two sextupole magnet circuits, that have to be supplied with ac and dc currents in a very accuracy parallel tracking mode [4].
For the quadrupoles and sextupoles, common sources for the ac and dc components are installed. They act as "modulated 12-phase rectifiers" with fast transfer response. For the dipole circuit, a separate 12.5 Hz ac-power supply has been chosen because the existing White-circuit has separated dc and ac power feed points and the existing dc source can be kept. The substantially higher active power of the dipole supplies compared with the quadrupole supplies makes it necessary to protect the mains network from strong 12.5 Hz loading. Therefore the ac supply is a cycloconverter with compensation for single phase active load. For a variation in betatron frequency of $\Delta Q = \pm 0.05$ the relative stability of the dipoles and quadrupoles currents must be of the order ± 1E-4, which is very difficult to achieve. So far we have nearly reached this goal and the overall stability is sufficient for the ongoing tests of PETRA and HERA during this spring.

* D. Barber, W. Bothe, W. Ebeling, A. Febel, R. Fischer, U. Gloer, D. Heins, H.R. Heller, G. Hemmie, K. Holm, G. Jacobs, J. Kouptsidis, W. Kriens, H. Musfeldt, F. Neubau, R. Neumann, S. Paetzold, P. Pillat, W. Radloff, D. Ramert, J. Rümmler, J. Sajons, B. Sarau, H.P. Scholz, M. Schwartz

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PAC 1987

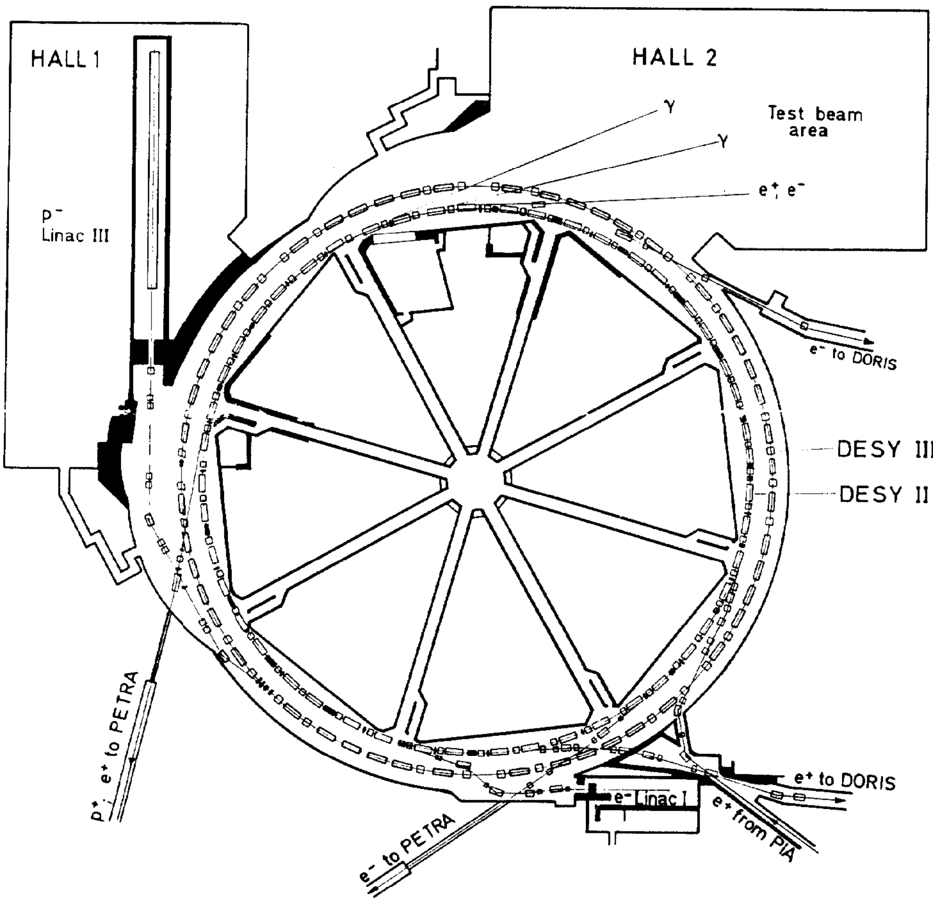
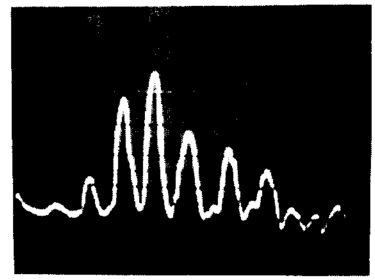
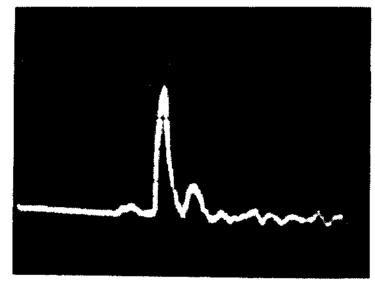


Fig. 2 The DESY synchrotrons:
DESY II e^+ and e^-
DESY III p^+



a)



b)

Fig. 3 Linac 1 beam current signal
(300 ps p. div)
a) with chopper off
b) with chopper on

Injection

The electron Linac 1 which formerly produced 50 MeV electrons for injection into DESY I has been equipped with two additional post acceleration sections which boost the final energy up to 200 MeV. Some modifications to the transport channel to DESY II have been made. Since there was no space to put a pre chopping device between the gun and the first accelerating section a post accelerator chopper was developed which deflects the beam vertically over a 3 mm slit. Fig. 3 shows the performance of this chopper. We are able to cut one single S-band bunch out of a 4 ns train of linac bunches. Under normal conditions we use 2 to 3 S-bunches and these fit right into one 500 MHz bucket of DESY II.

The positrons are produced in the powerful Linac 2, accumulated in PIA at 450 MeV and transferred to DESY II in a 160 ms sequence. More than 1E10 positrons are injected into the synchrotron.

Vacuum

In the all metal vacuum system the ellyptical chambers (cross section 80 * 40 mm) are made from .3 mm thick stainless steel tubes reinforced by thin ribs [5]. For injection and ejection, special widened chambers (110 * 40 mm) are installed which are connected to the external beam lines via small beam pipes of 20 mm diameter. The average pressure along the beam line chamber was found to be of the order 1E-8 Torr which is well below the required vacuum level. The eddy current heating of the chambers causes a 20 ... 30 degree temperature increase in the standard dipole vacuum chambers and widened outlet chambers respectively. These values agree quite well with those predicted.

Correction Elements

The horizontal orbit correction system has been rearranged in such a way that one can easily produce single kicks. Fig. 4 shows the circuit layout. Since there are ac induced voltages on the backleg windings we need some compensation voltage in series to protect the dc-power supplies from backward loading. The return windings on each magnet act as a compensation source. They are all connected in parallel and so carry the sum of all 24 power supply currents. If only one power supply is turned on one can easily see that the return current is split into 24 equal parts thus producing one positive kick in one magnet and 23 negative ones of 1:23 rd size in the other 23 magnets. The sum of all kicks is always zero so that the energy of the machine is not shifted. All 24 steering currents add up linearly. If the sum of all currents is kept close to zero, the currents in the return windings are also nearly zero.

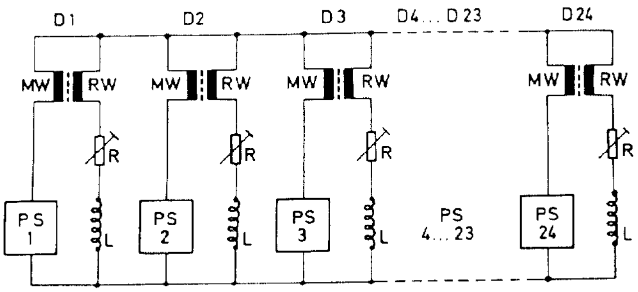


Fig. 4 Horizontal orbit correction network
D1 ... D24 Dipoles
MB Main backleg windings
RB Return " "
R,L Balancing impedance
PS1 ... PS24 DC-correction supplies

Present Performance

After setting up the magnet current supplies and after having reached reasonable tracking stability the beam-tests began on Febr. 10th. Within 4 hours the electrons from Linac 1 were accepted and fully accelerated to 7 GeV. The amount of rf peak power needed is 650 kW. (A maximum of 1 MW is available).

In order to obtain the correct working point (Q_x = 6.70, Q_z = 5.70) the current ratio between the quadrupoles and the dipoles had to be shifted + 1 % off from the theoretical number. Fluctuations in the working point of about ± 0.1 at 200 MeV injection level are mainly caused by insufficient phase stability of the ac current supply for the dipoles. This must be improved in order to get a more stable working point and to increase acceptance. However, at present, about 80 % of the Linac 1 beam containing 5E9 electrons can be captured and accelerated, this is three times the number we obtained with DESY I.

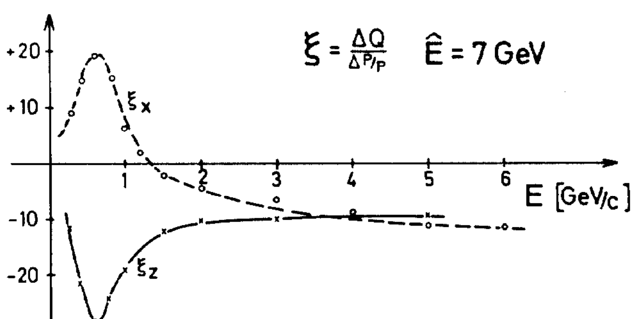


Fig. 5 Chromaticity vs. energy without sextupoles

The single bunch instability (vertical head tail mode) without chromaticity correction was found to occur above 5E8 particles per bunch. This can easily be observed on the beam profile monitor that uses the synchrotron light. The change of the chromaticity due to eddy currents in the vacuum chambers has been studied. Fig. 5 shows the plot of the measured values vs. time without sextupole excitation.

The emittances at 7 GeV were found to be e_x = 1.0 mrad * mm and e_z = .5 mrad * mm in agreement with the calculated numbers. Fig. 6 shows the result of a scan of the horizontal and vertical beam emittances.

The orbit monitor system uses 24 beam position pickup monitors placed near the defocussing quadrupoles. Each one is equipped with 4 buttons. The system is quite sufficient. We can do first turn steering as well as closed orbit measurements. Fig. 7 shows the vertical orbit at injection energy before and after orbit corrections.

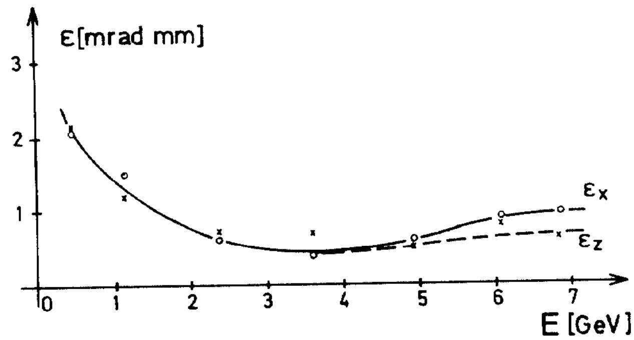


Fig. 6 Beam emittance vs. time

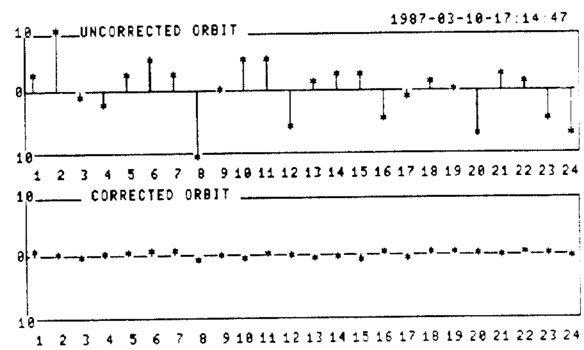


Fig. 7 Vertical orbit before and after correction at 200 MeV

Outlook

The initial performance of the new electron synchrotron DESY II is very encouraging. The machine is ready and from March 26, 1987 it will serve as a 3.7 GeV e^- injector for a synchrotron radiation run of the DORIS storage ring and from about April 1, 1987 as a 7 GeV e^+ injector into PETRA for first tests of the transfer channel between PETRA and the new storage ring HERA.

Acknowledgement

The authors wish to thank their colleagues for their efforts and encouragement in bringing DESY II into operation.

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