FUTURE DEVELOPMENTS AT DESY

G.-A. Voss

Deutsches Elektronen Synchrotron DESY

2000 Hamburg 52, W.Germany

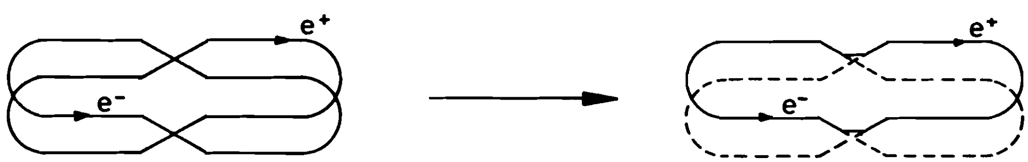
Abstract

During the time from November 81 until April 82 the electron-positron storage ring DORIS will be completely rebuilt with the aim of increasing its maximum energy from 2x5.1 GeV to 2x5.6 GeV, increasing its maximum luminosity by at least a factor of 20 and reducing at the same time its electrical power consumption by 50 %.

The electron-positron storage ring PETRA is in the midst of an energy upgrading program which by 1982/83 will result in maximum energies of 2x23 GeV. The recent installation of mini-β-regions has resulted in a luminosity increase by a factor of 3 (at present $L_{max} = 1.7 \times 10^{31} cm^{-2} s^{-1}$, with integrated values of 870 nb^{-1} per day). A further increase through superconducting quadrupoles is under study. The test of a higher harmonic rf-system for combating bunch instabilities and satellite resonances is imminent. A superconducting rf-cavity development program may, if successful, eventually boost PETRA energies to 2x30 GeV.

HERA is a new proposal for a 30/80 GeV electron/protron storage ring. Authorization of this 650 million Deutschmark project is hoped for the years of 1982 to 1984. The ensuing construction period is expected to be 6 years.

The electron-positron storage ring DORIS was originally built as a low energy, high luminosity facility, in which 2 separate rings stored a large number (each up to 480) of particle bunches and brought them to a collision with a crossing beam geometry at 2 points. When the rings worked at the highest energies in the rf limited region (2x3.5 GeV) they no longer had a luminosity advantage over a single ring with two single counterrotating electron and positron bunches. In 1975 DORIS was therefore converted to a single ring structure to boost the energy to 5.1 GeV in order to investigate the Y-resonances which had been discovered at Fermilab shortly before. In that reconstruction the vertical bending near the interaction regions had been preserved (Fig.1).



as originaly designed   after first conversion

Fig.1 DORIS

This prevented the hard synchrotron radiation from the horizontal bends from reaching the detectors and made good colliding beam physics up to 2x5.1 GeV possible. The energy limit of 2x5.1 GeV was given by magnet saturation and lack of rf-voltage.

The strong interest in the investigation of the higher excited states of the Y-resonance and the bottom mesons made the rebuilding of DORIS necessary. Such rebuilding not only allows higher collision energies but would also correct some luminosity and power consumption deficiencies due to the original 2-ring low energy design.

Starting in November 2, 1981 the DORIS rings will be completely dismantled and removed from the tunnel. The bending magnets will be rebuilt by adding back leg spacers, pole-pieces and the coils from the original second ring (Fig.2).

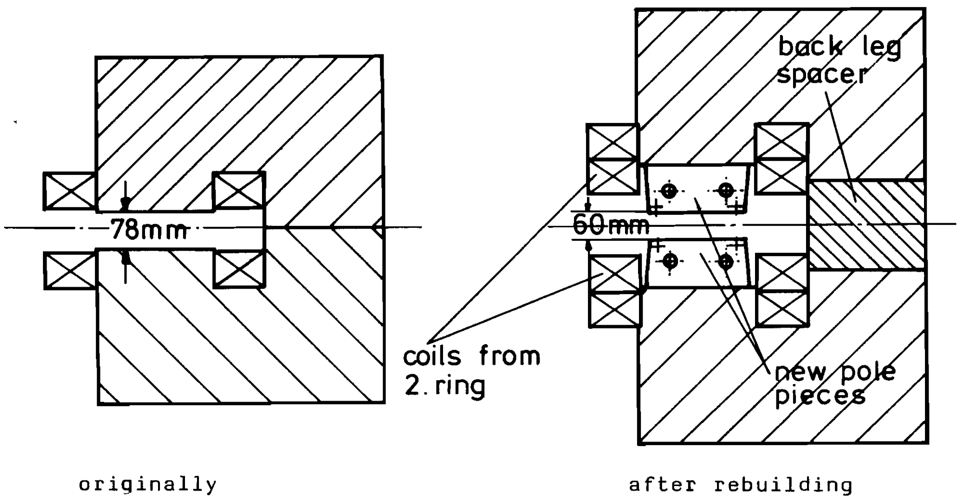


Fig.2 DORIS bending magnet cross section

This will allow energies up to 2x5.6 GeV and reduce the electrical power consumption to 40 % of the original value. Quadrupole apertures will also be reduced by adding pole pieces in order to prevent steel saturation and save electrical power. The new vacuum chamber system will maintain the old beam aperture by doing away with the original bake-out mantles. The system is built with emphasis on a low impedance as seen by the beam, i.e. the vacuum structure is very smooth.

The injection transport systems will be upgraded to make storage ring ramping unnecessary after injection even at the highest beam energies. This should significantly improve the average luminosity.

The rebuilding of DORIS does not affect number and lay-out of the many synchrotron radiation beam lines to the 3 attached synchrotron radiation laboratories IFT, EMBL and HASYLAB.

Fig.3 gives a summary of the main parameters of the DORIS machine before and after this reconstruction.

	DORIS I	DORIS II
Max.rf-voltage [MV]	16	≥20
Max.energy [GeV]	2x5.1	2x5.6
Max.currents in single bunches [mA]	2x20	>2x30
Beta values at I.Rs. [m] (β_x/β_z)	1.2/0.3	0.4/0.03
Max.luminosity [$cm^{-2}s^{-1}$]	10^{30}	$>2\times10^{31}$ ($\Delta Q_{Max} \leq 0.025$, $i_{Max} = 2\times30$ mA)
No of HASYLAB beams	15	15
No of HASYLAB stations	36	36
Rebuilding costs	-	4.5 MDM
Rebuilding time schedule	-	Nov.2.81 → April 82

Fig. 3 DORIS - parameters before and after rebuilding

The rebuilding is scheduled to take 6 months, and first operation is expected in May 1982.

The PETRA-performance was greatly improved after the installation of the "mini-beta" interaction regions at the beginning of 1981.
Fig. 4 gives numbers for the present performance.

E_{Max}	19 GeV
E_{Max} for colliding beam physics	2x18.4 GeV
L_{Max}(at 17 GeV)(current limited)	$1.7\times10^{31}cm^{-2}s^{-1}$
$\int_{day} Ldt$	870 nb^{-1}
	($\bar{L}=9.1\times10^{30}cm^{-2}s^{-1}$ i.e.54 %)
L_{Max}(at 11 GeV,ΔQ limited to .025)	$8\times10^{30}cm^{-2}s^{-1}$
$\int_{day} Ldt$	306 nb^{-1}
	($\bar{L}=3.5\times10^{30}cm^{-2}s^{-1}$ i.e.44 %)
L_{Max}(at 7 GeV,ΔQ limited to .02)	$2.1\times10^{30}cm^{-2}s^{-1}$
$\int_{day} Ldt$	128 nb^{-1}
	($\bar{L}=1.48\times10^{30}cm^{-2}s^{-1}$ i.e.70.5 %)

Fig.4 present PETRA-performance
(after installation of "mini-beta" (β_x/β_z=1.3/.08 m)

Peak energies of 19 GeV have been reached with single beams, and colliding beam experiments have been carried out up to energies of 2x18.4 GeV. Since the long predicted toponium has not been seen up to that energy, there is much interest in extending PETRA's energy range. A program is under way to double the present rf-installation by adding eight 600 kW klystrons and another 60 accelerating structures in the east and west straight sections (see Fig. 5).

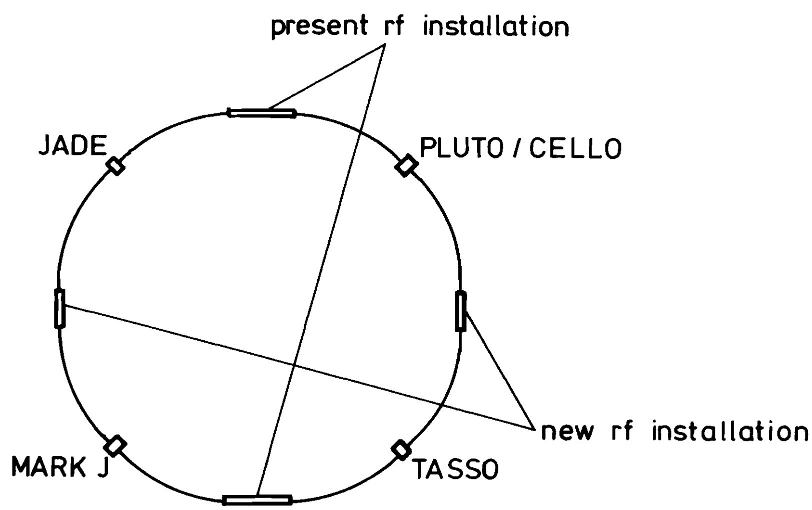


Fig. 5 Location of rf installations and detectors in PETRA

The new 500 MHz accelerating structures will have 7 individual cells each as compared with the present 5 cell structures. In this way the available accelerating voltage in PETRA will be more than doubled and should allow operation up to 2x23 GeV after the completion of the upgrading program. The first stage, namely the doubling of the total rf-power, will be finished by the summer of 1982 and will allow operation at 2x20.5 GeV. The completion of the new cavity installation is scheduled for the spring of 1983.

In order to boost the PETRA energy even higher and in view of the fact that most of the PETRA magnets are sufficient for an operation at considerably higher energies, a superconducting rf-cavity development program was started at DESY in collaboration with the University of Wuppertal and with close contacts to groups at CERN and the Kernforschungszentrum Karlsruhe. The aim of the DESY-development is a 10-cell-structure of 1000 MHz-niobium cavities operating at the liquid helium temperature of 4.2^0 K and providing an effective accelerating field of 3 MV/m over the active cavity length of 1.5 m. If successful, a system of such cavities in PETRA might reach a total accelerating voltage of 600 MV/turn and make operation possible at energies of 2x30 GeV. The test of the first prototype cavity in PETRA is anticipated for thebeginning of 1983. Depending on the outcome and future development, a large system could be envisioned for 1985/86.

A system of eight warm 7-cell cavities operating at 1000 MHz has been installed in PETRA and will be tested in the very soon future. The purpose of this higher harmonic rf-system is to lengthen bunches at low energies and thereby reduce the peak current. This is expected to have a positive effect on satellite resonances and single bunch instabilities, which presently limit the PETRA-performance in the energy region of 2x(15-17) GeV. With a successfully working higher harmonic rf-system larger maximum luminosity might be expected.

Another luminosity increase seems to be possible by a further reduction of the beam size at the interaction regions. This is only possible by moving the focusing quadrupoles even closer to the interaction points, so that they are within the experimental detectors. Since the required focus strength also increases at the same time, such quadrupoles will have to be ironless superconducting structures. Electron optical solutions have been worked out for such "micro-beta"-interaction regions with vertical beta-values down to values of 1.5 cm and horizontal values of 30 cm. This should lead to a further luminosity increase by a factor up to 3 as compared to the present mini-beta solution. The problems of how to power eight isolated superconducting high current quadrupoles, how to mount such structures in the detector solenoids and to shield them against synchrotron radiation are presently under study. Such a system might be installed in 2 to 3 years.

The main project for DESY's future is the 30/820 GeV electron/proton storage ring HERA (Hadron-Electron-Ring-Accelerator). This project aims at the investigation of neutral and charged currents and their interactions with the quarks in the proton, making use of the unique tool of the point-like electron. This machine woulk allow reactions with momentum transfers up to Q^2 of 100 000 GeV^2, far into the range, where weak interaction effects would dominate. It would be unrivaled by any other e-p-project proposed so far in the world. The storage rings will be housed in a 6.3 km long ringtunnel of 3.2 m diameter which is tunnelled without disturbing the surface in an area adjoining the laboratory site (see Fig.6)

Fig.6 The site of the proposed HERA ring. Indicated is also the PETRA ring which surrounds the site of the DESY laboratory.

90 % of the land under which HERA will be built is public property. In particular the four places where the underground experimental halls are to be built in an open cut-and-fill construction method are on public land. After the construction of the halls the only visible structures will be the small entrance houses. All services for the ring such as power, cooling and compressor plants are located on DESY property and distributed underground.

The ring proper will consist of a storage ring for protons using superconducting magnets and will be quite similar to the FERMI-lab doubler ring. The vacuum pipe in the magnets will be at liquid helium temperature, while the magnet steel is at room temperature (see Fig.7)

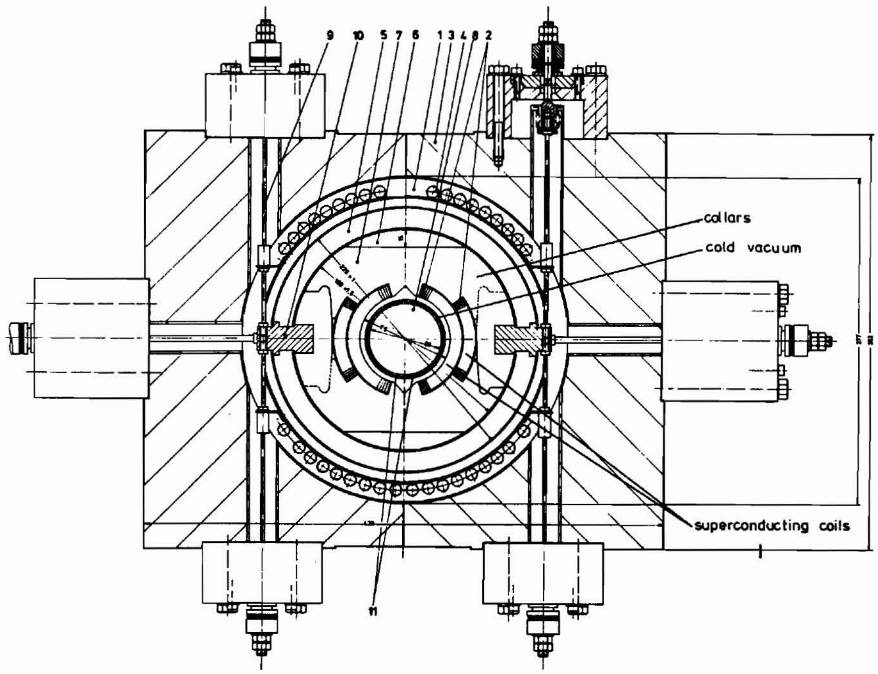


Fig. 7 Cross section of HERA-bending magnets for the proton ring

The second ring for the storage of electrons or, with reversed polarity of positrons, is quite similar to the PETRA-machine, only that the 2.7 times larger circumference makes somewhat higher energies possible and, because of the weaker fields in its magnets, allows for a somewhat simpler magnet design (see Fig.8).

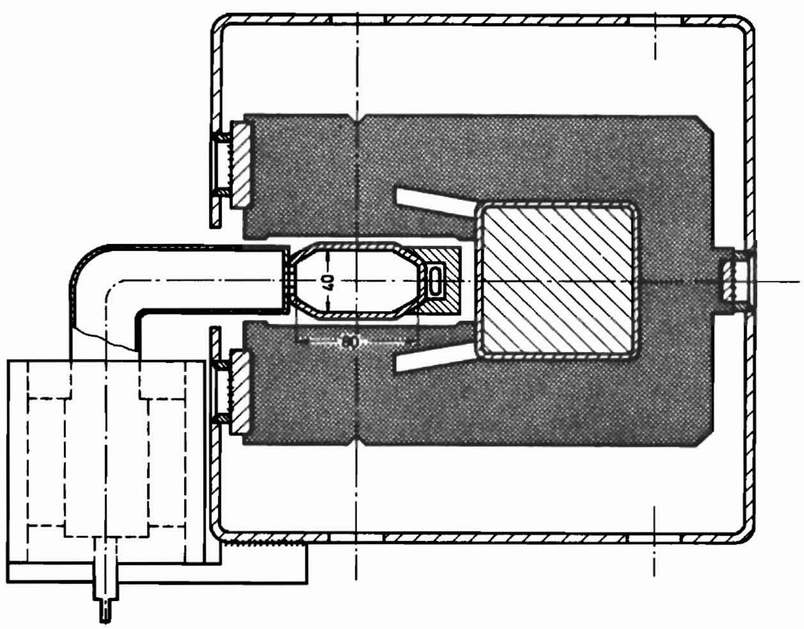


Fig. 8 Cross section of the HERA-bending magnets with vacuum chamber (electronring)

Electron (positron) beams intersect at the four interaction points with angles of 20 mrad. Since there is the expectation that with proper care electron beams will be transversely polarized in HERA as they are now in PETRA, there is the exciting possibility of turning the spin at the interaction points such that reactions with longitudinally polarized and unpolarized beams can be observed. This would give an important handle on the interpretation of weak interaction effects. The spin manipulation will be done in special spin rotators designed to preserve the absolute degree of polarization.

Injection of protons into HERA will be at 40 GeV from the PETRA ring. Using PETRA as a proton accelerator will require the addition of a proton rf-accelerating system and by-passes at the electron acceleration rf-structures in order to avoid proton beam instabilities produced by the interaction of the high intensity proton beam with the high shunt impedance cavity system. Protons would originate in a new 50 MeV-linac and be preaccelerated in the DESY synchrotron. For that DESY would also require a proton accelerating rf-system. Accumulation of the 220 proton bunches in HERA is expected to take some 30 minutes.

Fig. 9 shows a list of the most important HERA parameters(Fig.9)

	Proton Ring		Electron Ring	Units
Energy	820		30	GeV
Momentum transfer (Q^2)		98400		GeV^2
Luminosity		$0.5x10^{32}$		$cm^{-2}s^{-1}$
Polarization time			19.5	min
Total number of particles	$6.3x10^{13}$		$7.4x10^{12}$	
Number of bunches		210		
Number of interaction points			4	
Free space for experiment		15		m
Circumference		6336		m
Lattice		FODO		m
Injection energy	40		14	GeV
Filling time	8.5		5	min
Peak bending field	4.53		0.1832	T
Magnet aperture	60		80x40	mm
RF frequency	208.189		499.667	MHz
Energy loss per turn	$0.14x10^{-9}$		140.2	MeV
Critical energy	$1\ 0^{-6}$		111.0	KeV
Straight section		4x360		m
Geometric radius of arcs		779.2		m
Diameter of the tunnel		3.2		m
Depth of the tunnel below surface		10...20		m
Floorspace for experiment per interaction region		875		m^2
Height of the beam in the halls above floor		5.5		m

Fig. 9 HERA Parameter List

The cost of the HERA-project is estimated at 650 MDM and will require the addition of some 3000 man-years of physicist's, engineer's and technician's work. The larger part of this work force will have to be found at the DESY-laboratory, making it necessary during the 6 year HERA-construction period to reduce the staff for the PETRA and DORIS operation to a very low level.
But it is also expected that other European institutes will contribute very significantly with money and/or labor to the HERA-project. Encouraging discussions in this direction with other non-german agencies and institutes are presently under way.
The HERA-project was studied first in great detail by a project group formed by ECFA (European Committee for Future Accelerators). ECFA subsequently gave the HERA-project a strong endorsement. The project was then together with 9 other research facilities presented to a special review committee appointed by the German minister of science and technology. This group recommended strongly the construction of HERA. But in view of the large costs and some worries about the performance of large superconducting magnet systems the committee accepted a perhaps necessary delay of the authorization until 1984, during which time significant pledges for contributions from other European collaborators should be sought. Meanwhile a formal HERA-proposal has been prepared by the DESY-staff together with collaborators from 25 other European institutes. Many of the necessary steps for starting the civil engineering work have been prepared such that after authorization on site work can start within a few months. Prototypes of superconducting magnets are under construction and preliminary design work on many other components is under way.