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PETRA, AN EXTENSION OF THE STORAGE RING FACILITIES AT DESY

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Summary

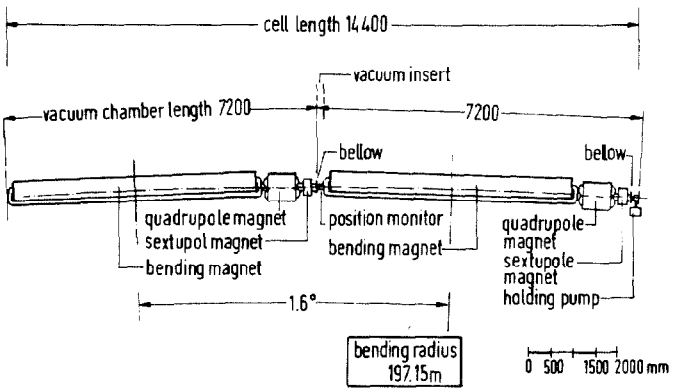
A proposal for the construction of a 19 GeV electron-positron storage ring at DESY has been submitted for approval.The circumference of the ring will be 2304m, the bending radius in the magnets 197m,the maximum luminosity $1.2 \times 10^{32} cm^{-2} s^{-1}$. PETRA will make use of the storage ring DORIS as an intermediate storage facility during injection and the 7 GeV-DESY synchrotron as the injector.

Plans for long range development at DESY have been discussed for many years:Among the many projects considered were a "Mesotron" (1) and an electron-positron-proton storage ring facility (2). Recent development in high energy physics finally led to the proposal of the electron-positron storage ring PETRA (Positron Electron Tandem Ring Accelerator) in 1974. This choice of an electron-positron storage ring was determined by the growing physics interest in such a machine and the fact that there is a long-standing expertise in electron physics and electron machines at DESY. The prerequisites for a fast and relatively inexpensive construction of a large electron storage ring are given: With DESY and its two linear accelerators as injectors and DORIS as an intermediate storage ring, a powerful injection system for a large ring is available, and many of the required components for a large machine are already on hand, if the DORIS energy is limited to less than 3.5 GeV once PETRA comes into operation (DORIS has now most of the components necessary for 5 GeV operation). These facts taken together should make it possible to construct at DESY an electron-positron storage ring for a peak energy of 19 GeV in each beam and a maximum luminosity of $10^{32} cm^{-2} s^{-1}$, that can be put into operation before the end of the decade.

The main design criteria for PETRA are:

1. To reach the highest energy possible with justifiable means,
2. to obtain large luminosities at intermediate energies and
3. to provide for a large number of interaction regions to make possible a good exploitation of this machine.

High energy is facilitated by an optics which provides for one quadrupole at each bending magnet. This large number of quadrupoles allows a strong focusing which in turn reduces the momentum compaction factor and subsequently the emittance (Fig.1).



normal cell in PETRA

Fig. 1.

A large cavity length -134 m- provides for the high shunt impedance necessary to compensate for high radiation losses at high energies. A large bending radius (197 m) keeps radiation losses small.

Large luminosities are ensured by a variable tune (3), which keeps the beam emittance almost independent of energy, and by relatively large bunch currents. As one approaches the highest energies the original number of bunches in each beam will be reduced from 4 to 1 (Fig.2 and Fig.3).

The large number of interaction regions is given by a ring arrangement with 8 straight sections. Four experimental halls will be built in the shorter of the two different types of straight sections. Four additional halls can later be put into the longer straight sections. Two of the latter also accomodate the radio frequency system. The ring with its length of 2304 m will be located on the present DESY site and on land owned by the Federal Government (Fig.4).

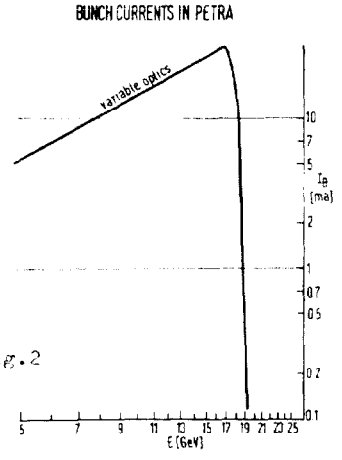


Fig.2

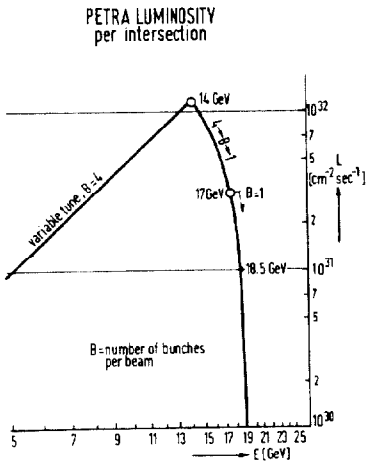


Fig.3

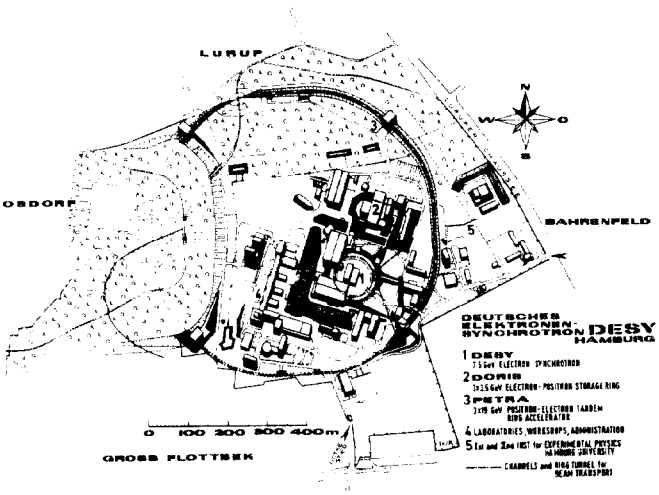


Fig.4

A list of PETRA-parameters is given in Fig.5.

PETRA
Parameter List

Energy	< 19 GeV
max.luminosity/interaction region	$1.2 \cdot 10^{32} cm^{-2} sec^{-1}$
Beam current in each beam	< 95 mA
rf-power	4 MW
No. of bunches	1 to 4
Free length for experiments	10 m
Circumference	2304 m
Bending radius	197.15 m
Focusing structure	FODO
Betatronfrequencies Qx/Qz	22.2/22.2
Natural chromaticity ξ_x/ξ_z	-32/-65
β-functions at interaction point	3.00 m / 0.15 m
Linear ΔQ-shift	.06/.06
Bending magnet gap, width/height	20 cm / 6 cm
Quadrupole bore, normal cell	10 cm
rf-system frequency	499.67 MHz
rf-power	4 MW
Length of accelerating structure	134.4 m
Energy loss/turn at 19 GeV	58.5 MeV
Peak accelerating voltage	101 MV
Injection energy	7 GeV
Positron filling time	< 7 min
Beam life time	4-11 hours

Fig. 5

Positron injection into a big ring is generally made difficult by the facts that the long damping times at injection energy usually do not allow the use of the high pulse repetition frequency of positron linacs, and that a linac with its many accelerated bunches does not lend itself easily to fill only 4 short buckets in a large ring. The result of these difficulties may be a long positron filling time, or the need for some rather new and untried techniques. The use of the DESY-DORIS installation overcomes these difficulties in a natural way:

The 400 MeV positron injector of DESY will inject 30 bunches/pulse into the synchrotron. In a magnet cycle which goes up to fields corresponding to 7.5 GeV these positrons will be accelerated to 2.2 GeV. At this energy they will be ejected from the synchrotron and accumulated in the storage ring DORIS. The short damping time in DORIS at this energy allows accumulation at the rate of 50 HZ. Fast kickers in DORIS will eject single bunches which then will be reinjected in DESY. After acceleration to 7 GeV these single bunches will be injected into PETRA. The use of DORIS as an intermediate storage ring results in an improvement factor of larger than 200 over direct injection into PETRA. Positron filling times will be shorter than 7 minutes.

If authorization is given in spring of 1975, construction should be completed in 1979. The cost of PETRA is estimated to be 97.000.000 DM, excluding salaries and wages. Options for possible extensions under consideration include the addition of a second ring for electron-electron collisions, an increase of the peak energy to 23 GeV through more rf-power and more rf-cavities and eventually the use of superconducting cavities for even higher particle energies.

References:

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2. Interne Berichte
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29. August 1973 29. August 1973 September 1973

3. PEP-Note 39 Scaling of FODO-Cell-Parameters
H.Wiedemann