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PETRA, Model 1

Orbit and Beam Parameters

for the

15 GeV/c Electron Storage Ring ESR

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The Model 1 layout of a 120/15 GeV/c proton-electron colliding beam facility PETRA, as described in ref.(1), incorporates a 15 GeV/c electron storage ring ESR.

For the ESR, the relevant orbit parameters have been determined using a modified version of an existing optics program (ref.(2)). Hereby, the exact amplitude and dispersion functions have been used for the normal cell structure (ref.(3)), and the approximate functions of ref.(1) for the straight sections and matching cells.

Based on the optical mean values thus obtained, the electron beam parameters as determined by synchrotron radiation effects have been computed and are given below for momenta of 4 GeV/c (injection) and 15 GeV/c, respectively, assuming an rf power of 3 MW and a shunt impedance of 1600 MΩ.

Orbit Parameter

orbit length			2462 m
frequency of revolution			122 kHz
number of superperiods			4
number of cells per superperiod			17 1/2
length of cell			23.98 m
deflecting field in normal cell	B_o(4GeV/c)	=	0.56 kG
	B_o(15GeV/c)	=	2.09 kG
average amplitude functions in normal cell	$\overline{\beta}_x$	=	19.4 m
	$\overline{\beta}_z$	=	26.8 m
average dispersion in normal cell	$\overline{D}_x$	=	0.72 m
amplitude function at I.P.	$\beta_{xo} = \beta_{zo}$	=	0.5 m
vertical dispersion at I.P.	D_{zo}	=	-0.28 m
ν-values	ν_x	$\approx$	24
	ν_z	$\approx$	20
chromaticities	$\frac{d\nu_x}{d(\Delta p/p_o)}$	=	- 97
	$\frac{d\nu_z}{d(\Delta p/p_o)}$	=	- 52

momentum compaction factor	$\alpha = \langle D_x/\rho_x \rangle + \langle D_z/\rho_z \rangle$ =	$1.97 \cdot 10^{-3}$
transition energy	$\gamma_{tr} = \frac{1}{\sqrt{\alpha}}$ =	22.5

Orbital Beam Parameters

		4 GeV/c	15 GeV/c
energy loss per revolution		0.10 MeV	19.8 MeV
damping times	τ_x:	646 msec	12.2 msec
	τ_z:	655 "	12.4 "
	τ_s:	330 "	6.2 "
natural energy spread	$\sigma_{E/E}$:	$2.3 \cdot 10^{-4}$	$8.5 \cdot 10^{-4}$
natural emittances of beam core (one standard deviation)	ε_x, core:	$4.2 \cdot 10^{-3}$ mradmm	$5.3 \cdot 10^{-2}$ mradmm
	ε_z, core:	$1.0 \cdot 10^{-3}$ "	$1.1 \cdot 10^{-2}$ "
natural beam emittances including 10h-tails	ε_x:	0.12 mrad mm	2.0 mrad mm
	ε_z:	0.029 "	0.4 "
average beam dimensions in normal cell	$2\sigma_x$:	0.6 mm	2.0 mm
	$2\sigma_z$:	0.3 "	1.1 "
assumed gas pressure		$3 \cdot 10^{-9}$ torr	$8 \cdot 10^{-9}$ torr
beam lifetime due to gas bremsstrahlung		25 h	9 h

Rf-dependent Beam Parameters

rf frequency	500 MHz
harmonic number	$\sim$ 4100
total shunt impedance of accelerating structure	1600 MΩ
rf power	3 MW

	4 GeV/c	15 GeV/c
assumed quantum lifetime	>> 10 h	10 h
equilibrium rf phase angle	0.65^{o}	42.4^{o}
beam current	115mA (65mA for 2 MW)	
number of particles	$5.9 \cdot 10^{12}$	
rf peak voltage per revolution	13.9 MV	46.2 MV
rf frequency shift due to beam loading	110 kHz (limit)	26.7 kHz
synchrotron frequency	6.8 kHz	5.26 kHz
bunch length $2\sigma_s$:	0.65 mm	30 mm

References:

(1) K. Steffen, E. Daßkowski;
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(2) G. Mülhaupt, H. Wiedemann; priv. comm.

(3) H. Gerke, R.D. Kohaupt, H. Wiedemann;
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