HIGH-ENERGY COLLIDER PARAMETERS: e^+e^- Colliders (I)

The numbers here were received from representatives of the colliders in late 1999 (contact C.G. Wohl, LBNL). Many of the numbers of course change with time, and only the latest values (or estimates) are given here; those in brackets are for coming upgrades. Quantities are, where appropriate, r.m.s. H and V indicate horizontal and vertical directions. Parameters for the defunct SPEAR, DORIS, PETRA, PEP, and TRISTAN colliders may be found in our 1996 edition (Phys. Rev. **D54**, 1 July 1996, Part I).

	VEPP-2M (Novosibirsk)	VEPP-2000* (Novosibirsk)	VEPP-4M (Novosibirsk)	BEPC (China)	DAΦNE (Frascati)
Physics start date	1974	2001	1994	1989	1999
Maximum beam energy (GeV)	0.7	1.0	6	2.2	0.510 (0.75 max.)
Luminosity (10^{30} cm^{-2}s^{-1})	5	100	50	10 at 2 GeV 5 at 1.55 GeV	50(→500)
Time between collisions (μs)	0.03	0.04	0.6	0.8	0.0027–0.0054
Crossing angle (μ rad)	0	0	0	0	$\pm$(1.0 to 1.5)$\times 10^4$
Energy spread (units 10^{-3})	0.36	0.64	1	0.58 at 2.2 GeV	0.40
Bunch length (cm)	3	4	5	$\approx$ 5	2(→3)
Beam radius (10^{-6} m)	H: 300 V: 10	125 (round)	H: 1000 V: 30	H: 890 V: 37	H: 2100 V: 21
Free space at interaction point (m)	$\pm$1	$\pm$1	$\pm$2	$\pm$2.15	$\pm$0.46 ($\pm$157 mrad cone)
Luminosity lifetime (hr)	continuous	continuous	2	7–12	2
Filling time (min)	continuous	continuous	15	30	2 (topping up)
Acceleration period (s)	—	—	150	120	—
Injection energy (GeV)	0.2–0.6	0.2–1.0	1.8	1.55	0.510
Transverse emittance ($10^{-9}\pi$ rad-m)	H: 110 V: 1.3	H: 250 V: 250	H: 400 V: 20	H: 660 V: 28	H: 1000 V: 10
β^*, amplitude function at interaction point (m)	H: 0.45 V: 0.045	H: 0.06 V: 0.06	H: 0.75 V: 0.05	H: 1.2 V: 0.05	H: 4.5 V: 0.045
Beam-beam tune shift per crossing (units 10^{-4})	H: 200 V: 500	H: 750 V: 750	500	350	400
RF frequency (MHz)	200	172	180	199.53	368.25
Particles per bunch (units 10^{10})	2	16	15	20 at 2 GeV 11 at 1.55 GeV	3(→ 9)
Bunches per ring per species	1	1	2	1	50–120
Average beam current per species (mA)	50	300	80	40 at 2 GeV 22 at 1.55 GeV	800(→5000)
Circumference or length (km)	0.018	0.024	0.366	0.2404	0.0977
Interaction regions	2	2	1	2	1(→2)
Utility insertions	1	2	1	4	2×2
Magnetic length of dipole (m)	1	1.2	2	1.6	e^+: 1.21/0.99 e^-: 1.21/0.99
Length of standard cell (m)	4.5	12	7.2	6.6	—
Phase advance per cell (deg)	280	H: 738 V: 378	65	$\approx$ 60	—
Dipoles in ring	8	8	78	40 + 4 weak	e^+: 8(+4 wigglers) e^-: 8(+4 wigglers)
Quadrupoles in ring	20	20	150	68	e^+/e^-: 53/53
Peak magnetic field (T)	1.8	2.4	0.6	0.9028 at 2.8 GeV	1.2(→1.76) dipoles 1.8 wigglers

*VEPP-2000 is a major upgrade of VEPP-2M.

HIGH-ENERGY COLLIDER PARAMETERS: e^+e^- Colliders (II)

The numbers here were received from representatives of the colliders in late 1999. Many of the numbers of course change with time, and only the latest values (or estimates) are given here. Quantities are, where appropriate, r.m.s. H and V indicate horizontal and vertical directions; s.c. indicates superconducting.

	CESR (Cornell)	KEKB (KEK)	PEP-II (SLAC)	SLC (SLAC)	LEP (CERN)
Physics start date	1979	1999	1999	1989	1989
Maximum beam energy (GeV)	6	$e^- \times e^+$: 8 × 3.5	e^-: 7–12 (9.0 nominal) e^+: 2.5–4 (3.1 ") (nominal $E_{\rm cm}$ = 10.5 GeV)	50	101 in 1999 (105=max. foreseen)
Luminosity (10^{30} cm^{-2}s^{-1})	830 at 5.3 GeV	10000	3000	2.5	24 at Z^0 100 at > 90 GeV
Time between collisions (μs)	0.014 to 0.22	0.002	0.0042	8300	22
Crossing angle (μ rad)	±2000	±11,000	0	0	0
Energy spread (units 10^{-3})	0.6 at 5.3 GeV	0.7	e^-/e^+: 0.61/0.77	1.2	0.7→1.5
Bunch length (cm)	1.8	0.4	e^-/e^+: 1.1/1.0	0.1	1.0
Beam radius (μm)	H: 500 V: 10	H: 77 V: 1.9	H: 157 V: 4.7	H: 1.5 V: 0.5	H: 200 → 300 V: 2.5 → 8
Free space at interaction point (m)	±2.2 (±0.6 to REC quads)	+0.75/−0.58 (+300/−500) mrad cone	±0.2, ±300 mrad cone	±2.8	±3.5
Luminosity lifetime (hr)	2–3	2	2.5	—	20 at Z^0 10 at > 90 GeV
Filling time (min)	10 (topping up)	8 (topping up)	3 (topping up)	—	20 to setup 20 to accumulate
Acceleration period (s)	—	—	—	—	600
Injection energy (GeV)	6	e^-/e^+ : 8/3.5	2.5–12	45.64	22
Transverse emittance (π rad-nm)	H: 240 V: 6	H: 18 V: 0.36	e^-: 48 (H), 1.5 (V) e^+: 48 (H), 1.5 (V)	H: 0.5 V: 0.05	H: 20–45 V: 0.25 → 1
β^*, amplitude function at interaction point (m)	H: 1.0 V: 0.018	H: 0.33 V: 0.01	e^-: 0.50 (H), 0.015 (V) e^+: 0.50 (H), 0.015 (V)	H: 0.0025 V: 0.0015	H: 1.5 V: 0.05
Beam-beam tune shift per crossing (units 10^{-4})	480	H: 390 V: 520	300	—	830
RF frequency (MHz)	500	508.887	476	—	352.2
Particles per bunch (units 10^{10})	1.15	e^-/e^+: 1.3/3.2	e^-/e^+: 2.1/5.9	4.0	45 in collision 60 in single beam
Bunches per ring per species	9 trains of 4 bunches	5120 (5–10% gap is necessary)	1658	1	4 trains of 1 or 2
Average beam current per species (mA)	260	e^-/e^+: 1100/2600	e^-/e^+: 750/2161	0.0008	4 at Z^0 4→6 at > 90 GeV
Beam polarization (%)	—	—	—	e^-: 80	55 at 45 GeV 5 at 61 GeV
Circumference or length (km)	0.768	3.016	2.2	1.45 +1.47	26.66
Interaction regions	1	1	1 (2 possible)	1	4
Utility insertions	3	3 per ring	5	—	4
Magnetic length of dipole (m)	1.6–6.6	e^-/e^+ : 5.86/0.915	e^-/e^+: 5.4/0.45	2.5	11.66/pair
Length of standard cell (m)	16	e^-/e^+ : 75.7/76.1	15.2	5.2	79
Phase advance per cell (deg)	45–90 (no standard cell)	450	e^-/e^+: 60/90	108	102/90
Dipoles in ring	86	e^-/e^+ : 116/112	e^-/e^+: 192/192	460+440	3280+24 inj. + 64 weak
Quadrupoles in ring	104	e^-/e^+ : 452/452	e^-/e^+: 290/326	—	520+288 + 8 s.c.
Peak magnetic field (T)	0.3 normal 0.8 high field } at 8 GeV	e^-/e^+ : 0.25/0.72	e^-/e^+: 0.18/0.75	0.597	0.135

HIGH-ENERGY COLLIDER PARAMETERS: ep, $\overline{p}p$, and pp Colliders

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	HERA (DESY)	S$p\overline{p}$S (CERN)	TEVATRON (Fermilab)	LHC (CERN)		SSC (USA)
Physics start date	1992	1981	1987	2005		Terminated
Physics end date	—	1990	—	—		—
Particles collided	ep	$p\overline{p}$	$p\overline{p}$	pp	Pb Pb	pp
Maximum beam energy (TeV)	e: 0.030 p: 0.92	0.315 (0.45 in pulsed mode)	1.0	7.0	2.76 TeV/u	20
Luminosity (10^{30} cm^{-2}s^{-1})	14	6	210	1.0×10^4	0.002	1000
Time between collisions (μs)	0.096	3.8	0.396	0.025	0.125	0.016678
Crossing angle (μ rad)	0	0	0	≥ 200	≤ 200	100 to 200 (135 nominal)
Energy spread (units 10^{-3})	e: 0.91 p: 0.2	0.35	0.09	0.1	0.1	0.055
Bunch length (cm)	e: 0.83 p: 8.5	20	38	7.5	7.5	6.0
Beam radius (10^{-6} m)	e: 280(H), 50(V) p: 265(H), 50(V)	p: 73(H), 36(V) $\bar{p}$: 55(H), 27(V)	p: 34 $\bar{p}$: 29	16	15	4.8
Free space at interaction point (m)	±5.8	16	±6.5	38	38	±20
Luminosity lifetime (hr)	10	15	7–30	10	6.7	∼24
Filling time (min)	e: 60 p: 120	0.5	30	6	20	72
Acceleration period (s)	e: 200 p: 1500	10	86	1200		1500
Injection energy (TeV)	e: 0.012 p: 0.040	0.026	0.15	0.450	177.4 GeV/u	2
Transverse emittance ($10^{-9}\pi$ rad-m)	e: 42(H), 6(V) p: 5(H), 5(V)	p: 9 $\bar{p}$: 5	p: 3.5 $\bar{p}$: 2.5	0.5	0.5	0.047
β^*, amplitude function at interaction point (m)	e: 1(H), 0.7(V) p: 7(H), 0.5(V)	0.6 (H) 0.15 (V)	0.35	0.5	0.5	0.5
Beam-beam tune shift per crossing (units 10^{-4})	e: 190(H), 360(V) p: 12(H), 9(V)	50	p: 38 $\bar{p}$: 97	34	—	8 head on 13 long range
RF frequency (MHz)	e: 499.7 p: 208.2/52.05	100+200	53	400.8	400.8	359.75
Particles per bunch (units 10^{10})	e: 3 p: 7	p: 15 $\bar{p}$: 8	p: 27 $\bar{p}$: 7.5	10.5	0.0094	0.8
Bunches per ring per species	e: 189 p: 180	6	36	2835	608	17,424
Average beam current per species (mA)	e: 40 p: 90	p: 6 $\bar{p}$: 3	p: 81 $\bar{p}$: 22	536	7.8	71
Circumference (km)	6.336	6.911	6.28	26.659		87.12
Interaction regions	ep: 2; e, p: 1 each, internal fixed target	2	2 high $\mathscr{L}$	2 high $\mathscr{L}$ +1	1	4
Utility insertions	4	—	4	4		2
Magnetic length of dipole (m)	e: 9.185 p: 8.82	6.26	6.12	14.3		Mostly 14.928
Length of standard cell (m)	e: 23.5 p: 47	64	59.5	106.90		180
Phase advance per cell (deg)	e: 60 p: 90	90	67.8	90		90
Dipoles in ring	e: 396 p: 416	744	774	1232 main dipoles		H: 8336 V: 88 } in 2 rings
Quadrupoles in ring	e: 580 p: 280	232	216	692 focussing +96 skew		2084 } 2 rings
Magnet type	e: C-shaped p: s.c., collared, cold iron	H type with bent-up coil ends	s.c. cos θ warm iron	s.c. 2 in 1 cold iron		s.c. cos θ cold iron
Peak magnetic field (T)	e: 0.274 p: 4.65	1.4 (2 in pulsed mode)	4.4	8.3		6.790
$\overline{p}$ source accum. rate (hr^{-1})	—	6×10^{10}	20×10^{10}	—		—
Max. no. $\overline{p}$ in accum. ring	—	1.2×10^{12}	2.6×10^{12}	—		—