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

The numbers here were received from representatives of the colliders in 1998 (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 [round beams] (Novosibirsk)	DAΦNE (Frascati)	ϕ FACTORY (Novosibirsk)	τ-CHARM FACTORY (Novosibirsk)	BEPC (China)	VEPP-4M (Novosibirsk)
Physics start date	1974 [1998]	1998	2001	?	1989	1994
Maximum beam energy (GeV)	0.7 [0.55]	0.510 (0.75 max.)	0.55	2.1	2.2	6
Luminosity (10^{30} cm^{-2}s^{-1})	5 [100]	135(→540)	2500	10000	10 at 2 GeV	50
Time between collisions (μs)	0.03	0.0108(→0.0027)	0.007	0.027	0.8	0.6
Crossing angle (μ rad)	0	$\pm$(1.0 to 1.5)$\times 10^4$	0	0	0	0
Energy spread (units 10^{-3})	0.36	0.40	0.43	0.002–0.7	0.58 at 2.2 GeV	1
Bunch length (cm)	3	3.0	1	1	≈ 5	5
Beam radius (10^{-6} m)	H/V: 300/10 [90 (round)]	H: 2100 V: 21	35 (beams are round)	33	H: 890 V: 37	H: 1000 V: 30
Free space at interaction point (m)	$\pm$1	$\pm$0.46 ($\pm$157 mrad cone)	$\pm$2	$\pm$1.5	$\pm$2.15	$\pm$2
Luminosity lifetime (hr)	continuous	2	continuous	continuous	7–12	2
Filling time (min)	continuous	3 (topping up)	continuous	continuous	30	15
Acceleration period (s)	—	—	—	—	120	150
Injection energy (GeV)	0.2–0.6 [0.2–0.55]	0.510	—	2.1	1.55	1.8
Transverse emittance ($10^{-9}\pi$ rad-m)	H/V: 110/1.3 [170]	H: 1000 V: 10	125	H: 100–10000 V: 1–10000	H: 660 V: 28	H: 400 V: 20
β^*, amplitude function at interaction point (m)	H/V: 0.45/0.045 [0.05]	H: 4.5 V: 0.045	0.01	0.01	H: 1.2 V: 0.05	H: 0.75 V: 0.05
Beam-beam tune shift per crossing (units 10^{-4})	H/V: 200/500 [1000]	400	1000	500	350	500
RF frequency (MHz)	200	368.25	700	700	199.53	180
Particles per bunch (units 10^{10})	2 [6.7]	8.9	5	20	20 at 2 GeV	15
Bunches per ring per species	1	30(→120)	11	95	1	2
Average beam current per species (mA)	50 [160]	1313(→5250)	550	1120	40 at 2 GeV	80
Circumference or length (km)	0.018	0.0977	0.047	0.773	0.2404	0.366
Interaction regions	2	2	1	1	2	1
Utility insertions	1	2×2	1	1	4	1
Magnetic length of dipole (m)	1	e^+: 1.21/0.99 e^-: 1.21/0.99	0.8	1.47	1.6	2
Length of standard cell (m)	4.5 [9.0]	—	—	5	6.6	7.2
Phase advance per cell (deg)	280 [560]	—	—	60	≈ 60	65
Dipoles in ring	8	e^+: 8(+4 wigglers) e^-: 8(+4 wigglers)	22	112	40 + 4 weak	78
Quadrupoles in ring	20 [12]	e^+/e^-: 53/53	22	112	68	150
Peak magnetic field (T)	1.8 [1.5]	1.2(→1.76) dipoles 1.8 wigglers	1.8	0.13	0.9028 at 2.8 GeV	0.6

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

The numbers here were received from representatives of the colliders in 1998. 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	92 in 1997 (100=max. foreseen)
Luminosity (10^{30} cm^{-2}s^{-1})	470 at 5.3 GeV	10000	3000	2.5	24 at Z^0 50 at > 90 GeV
Time between collisions (μs)	0.028 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	1.0
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: 181 V: 5.4	H: 1.5 V: 0.5	H: 200 V: 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)	3–4	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)	—	—	—	—	550
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^+: 64 (H), 2.0 (V)	H: 0.5 V: 0.05	H: 35 V: 0.25 → 1
β^*, amplitude function at interaction point (m)	H: 1.0 V: 0.018	H: 0.33 V: 0.01	e^-: 0.67 (H), 0.02 (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})	420	H: 390 V: 520	300	—	500
RF frequency (MHz)	500	508.887	476	—	352.2
Particles per bunch (units 10^{10})	15	e^-/e^+: 1.3/3.2	e^-/e^+: 2.7/5.9	4.0	30 in collision 60 in single beam
Bunches per ring per species	9 trains of 2 bunches	5120	1658	1	4 trains of 1 or 2
Average beam current per species (mA)	180	e^-/e^+: 1100/2600	e^-/e^+: 995/2161	0.0008	4 at Z^0 2.5 at > 90 GeV
Beam polarization (%)	—	—	—	e^-: 80	55
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	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	90/60
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

The numbers here were received from representatives of the colliders in 1998. 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, V, and, s.c. indicate horizontal and vertical directions, and superconducting. The SSC is kept for purposes of comparison.

	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: 0.82	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. $\cos\theta$ warm iron	s.c. 2 in 1 cold iron		s.c. $\cos\theta$ 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}	—		—

†TEVATRON numbers are for the year 2000, when it again runs in collider mode.