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

The numbers here were received from representatives of the colliders in early 2004 (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, SLC, TRISTAN, and VEPP-2M colliders may be found in our 1996 edition (Phys. Rev. **D54**, 1 July 1996, Part I).

	VEPP-2000 (Novosibirsk)	VEPP-4M (Novosibirsk)	BEPC (China)	BEPC-II (China)	DAΦNE (Frascati)
Physics start date	2005	1994	1989	2007	1999
Physics end date	—	—	—	—	~2007
Maximum beam energy (GeV)	1.0	6	2.2	1.89 (2.1 max)	0.700
Luminosity (10^{30} cm^{-2}s^{-1})	100	20	10 at 1.843 GeV/beam 5 at 1.55 GeV/beam	1000	80 present 200 achievable
Time between collisions (μs)	0.04	0.6	0.8	0.008	0.0027
Crossing angle (μ rad)	0	0	0	1.1×10^4	$(2.5 \text{ to } 3.2)\times10^4$
Energy spread (units 10^{-3})	0.64	1	0.58 at 2.2 GeV	0.52	0.40
Bunch length (cm)	4	5	≈ 5	1.3	1 low current 2 high current
Beam radius (10^{-6} m)	125 (round)	H: 1000 V: 30	H: 890 V: 37	H: 380 V: 5.7	H: 800 V: 4.8
Free space at interaction point (m)	±1	±2	±2.15	±1.009	±0.40
Luminosity lifetime (hr)	continuous	2	7–12	1.5	0.7
Filling time (min)	continuous	15	30	26	0.8 (topping up)
Acceleration period (s)	—	150	120	—	on energy
Injection energy (GeV)	0.2–1.0	1.8	1.55	1.89	on energy
Transverse emittance ($10^{-9}\pi$ rad-m)	H: 250 V: 250	H: 200 V: 20	H: 660 V: 28	H: 144 V: 3.1	H: 300 V: 1
β^*, amplitude function at interaction point (m)	H: 0.06 V: 0.06	H: 0.75 V: 0.05	H: 1.2 V: 0.05	H: 1.0 V: 0.015	H: 1.7 V: 0.025
Beam-beam tune shift per crossing (units 10^{-4})	H: 750 V: 750	500	350	400	250
RF frequency (MHz)	172	180	199.53	499.8	356
Particles per bunch (units 10^{10})	16	15	20 at 2 GeV 11 at 1.55 GeV	4.8	
Bunches per ring per species	1	2	1	93	110/120
Average beam current per species (mA)	300	80	40 at 2 GeV 22 at 1.55 GeV	910	1000 (goal 2000)
Circumference or length (km)	0.024	0.366	0.2404	0.23753	0.098
Interaction regions	2	1	2	1	2
Utility insertions	2	1	4	4	2
Magnetic length of dipole (m)	1.2	2	1.6	Outer ring 1.6 Inner ring 1.41	1
Length of standard cell (m)	12	7.2	6.6	Outer ring 6.6 Inner ring 6.2	12
Phase advance per cell (deg)	H: 738 V: 378	65	≈ 60	60–90 no standard cell	360
Dipoles in ring	8	78	40 + 4 weak	84 + 8 weak	8
Quadrupoles in ring	20	150	68	134+2 s.c.	48
Peak magnetic field (T)	2.4	0.6	0.9028 at 2.8 GeV	Outer ring 0.67712 Inner ring 0.76636	1.7

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

The numbers here were received from representatives of the colliders in early 2004. 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)	CESR-C (Cornell)	KEKB (KEK)	PEP-II (SLAC)	LEP (CERN)
Physics start date	1979	2002	1999	1999	1989
Physics end date	2002	—	—	—	2000
Maximum beam energy (GeV)	6	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)	101 in 1999 (105=max. foreseen
Luminosity (10^{30} cm^{-2}s^{-1})	1280 at 5.3 GeV/beam	35 at 1.9 GeV/beam	11305	6777	24 at Z^0 100 at > 90 GeV
Time between collisions (μs)	0.014 to 0.22	0.014 to 0.22	0.008	0.0042	22
Crossing angle (μ rad)	±2000	±4000	±11,000	0	0
Energy spread (units 10^{-3})	0.6 at 5.3 GeV/beam	0.8 at 1.9 GeV/beam	0.7	e^-/e^+: 0.61/0.77	0.7→1.5
Bunch length (cm)	1.8	1.2	0.65	e^-/e^+: 1.1/1.0	1.0
Beam radius (μm)	H: 460 V: 4	H: 300 V: 5.7	H: 110 V: 2.4	H: 157 V: 4.7	H: 200 → 300 V: 2.5 → 8
Free space at interaction point (m)	±2.2 (±0.6 to REC quads)	±2.2 (±0.3 to PM quads)	+0.75/−0.58 (+300/−500) mrad cone	±0.2, ±300 mrad cone	±3.5
Luminosity lifetime (hr)	2–3	2–3	continuous	3.5	20 at Z^0 10 at > 90 GeV
Filling time (min)	5 (topping up)	5 (topping up)	continuous	3 (topping up)	20 to setup 20 to accumulate
Acceleration period (s)	—	—	—	—	600
Injection energy (GeV)	1.8–6	1.5–6	e^-/e^+ : 8/3.5	2.5–12	22
Transverse emittance (π rad-nm)	H: 210 V: 1	H: 150 V: 2.5	e^-: 24 (H), 0.82 (V) e^+: 18 (H), 1.0 (V)	e^-: 48 (H), 1.5 (V) e^+: 24 (H), 1.5 (V)	H: 20–45 V: 0.25 → 1
β^*, amplitude function at interaction point (m)	H: 1.0 V: 0.018	H: 0.60 V: 0.013	e^-: 0.63 (H), 0.0070 (V) e^+: 0.59 (H), 0.0058 (V)	e^-: 0.50 (H), 0.012 (V) e^+: 0.50 (H), 0.012 (V)	H: 1.5 V: 0.05
Beam-beam tune shift per crossing (units 10^{-4})	H: 250 V: 620	H: 175 V: 200	e^-: 710 (H), 510 (V) e^+: 1040 (H), 680 (V)	e^-: 400 (H), 400 (V) e^+: 990 (H), 800 (V)	830
RF frequency (MHz)	500	500	508.887	476	352.2
Particles per bunch (units 10^{10})	1.15	1.15	e^-/e^+: 5.5/7.3	e^-/e^+: 4.6/6.7	45 in collision 60 in single beam
Bunches per ring per species	9 trains of 5 bunches	8 trains of 5 bunches	1281	1230	4 trains of 1 or 2
Average beam current per species (mA)	340	55	e^-/e^+: 1130/1500	e^-/e^+: 1200/1800	4 at Z^0 4→6 at > 90 GeV
Beam polarization (%)	—	—	—	—	55 at 45 GeV 5 at 61 GeV
Circumference or length (km)	0.768	0.768	3.016	2.2	26.66
Interaction regions	1	1	1	1 (2 possible)	4
Utility insertions	3	3	3 per ring	5	4
Magnetic length of dipole (m)	1.6–6.6	1.6–6.6	e^-/e^+ : 5.86/0.915	e^-/e^+: 5.4/0.45	11.66/pair
Length of standard cell (m)	16	16	e^-/e^+ : 75.7/76.1	15.2	79
Phase advance per cell (deg)	45–90 (no standard cell)	45–90 (no standard cell)	450	e^-/e^+: 60/90	102/90
Dipoles in ring	86	84	e^-/e^+ : 116/112	e^-/e^+: 192/192	3280+24 inj. + 64 weak
Quadrupoles in ring	101 + 4 s.c.	101 + 4 s.c.	e^-/e^+ : 452/452	e^-/e^+: 290/326	520+288 + 8 s.c.
Peak magnetic field (T)	$\left.\begin{matrix}\text{0.3 normal}\\ \text{0.8 high field}\end{matrix}\right\}$ at 8 GeV	$\left.\begin{matrix}\text{0.3 normal}\\ \text{0.8 high field}\end{matrix}\right\}$ at 8 GeV 2.1 wigglers at 1.9 GeV	e^-/e^+ : 0.25/0.72	e^-/e^+: 0.18/0.75	0.135

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

The numbers here were received from representatives of the colliders in early 2004. 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. For existing colliders, the table shows achieved parameters.

	HERA (DESY)	TEVATRON (Fermilab)	RHIC (Brookhaven)			LHC (CERN)	
Physics start date	1992	1987	2000			2007	2008
Physics end date	—	—	—			—	
Particles collided	ep	$p\overline{p}$	pp (pol.)	Au Au	d Au	pp	Pb Pb
Maximum beam energy (TeV)	e: 0.030 p: 0.92	0.980	0.1 40% pol	0.1 TeV/u	0.1 TeV/u	7.0	2.76 TeV/u
Luminosity (10^{30} cm^{-2}s^{-1})	75	50	6	0.0004	0.07	1.0×10^4	0.001
Time between collisions (μs)	0.096	0.396	0.213			0.025	0.100
Crossing angle (μ rad)	0	0	0			300	≤ 100
Energy spread (units 10^{-3})	e: 0.91 p: 0.2	0.14	0.2	0.5	0.5	0.11	0.11
Bunch length (cm)	e: 0.83 p: 8.5	57	40	20	20	7.7	7.94
Beam radius (10^{-6} m)	e: $280(H), 50(V)$ p: $265(H), 50(V)$	p: 39 $\bar{p}$: 31	175 (β^*=1 m)	150 (215 β^*=1 m)	(β^*=2 m)	16.7	15.9
Free space at interaction point (m)	±2	±6.5	16			38	38
Luminosity lifetime (hr)	10	11–13	10	3	6	14.9	7.3
Filling time (min)	e: 60 p: 120	30	15			7.5 (both beams)	20 (both beams)
Acceleration period (s)	e: 200 p: 1500	86	140	230	230	1200	
Injection energy (TeV)	e: 0.012 p: 0.040	0.15	0.023	0.011 TeV/u	0.012 TeV/u	0.450	0.1774 TeV/u
Transverse emittance ($10^{-9}\pi$ rad-m)	e: $20(H), 3.5(V)$ p: $5(H), 5(V)$	p: 4.3 $\bar{p}$: 2.7	31	23	23	0.5	0.5
β^*, ampl. function at interaction point (m)	e: $0.6\ (H), 0.26(V)$ p: $2.45(H), 0.18(V)$	0.35	1–10	1–5	2–5	0.55	0.5
Beam-beam tune shift per crossing (units 10^{-4})	e: $190(H), 450(V)$ p: $12(H),\ 9(V)$	p: 14 $\bar{p}$: 70	26	9	11	34	—
RF frequency (MHz)	e: 499.7 p: 208.2/52.05	53	accel: 28 store: 28	accel: 28 store: 197	accel: 28 store: 197	400.8	400.8
Particles per bunch (units 10^{10})	e: 3 p: 7	p: 24 $\bar{p}$: 3	7	0.06	d: 1.1 Au: 0.07	11.5	0.007
Bunches per ring per species	e: 189 p: 180	36	55			2808	592
Average beam current per species (mA)	e: 40 p: 90	p: 66 $\bar{p}$: 8.2	48	33	d: 7.7 Au: 38	584	6.12
Circumference (km)	6.336	6.28	3.834			26.659	
Interaction regions	2 colliding beams 1 fixed target (e beam)	2 high $\mathscr{L}$	6			2 high $\mathscr{L}$ +1	1
Utility insertions	4	4	13/ring			4	
Magnetic length of dipole (m)	e: 9.185 p: 8.82	6.12	9.45			14.3	
Length of standard cell (m)	e: 23.5 p: 47	59.5	29.7			106.90	
Phase advance per cell (deg)	e: 60 p: 90	67.8	84			90	
Dipoles in ring	e: 396 p: 416	774	192 per ring + 12 common			1232 main dipoles	
Quadrupoles in ring	e: 580 p: 280	216	246 per ring			482 2-in-1 24 1-in-1	
Magnet type	e: C-shaped p: s.c., collared, cold iron	s.c. $\cos\theta$ warm iron	s.c. $\cos\theta$ cold iron			s.c. 2 in 1 cold iron	
Peak magnetic field (T)	e: 0.274 p: 5	4.4	3.5			8.3	
$\overline{p}$ source accum. rate (hr^{-1})	—	13.5×10^{10}	—			—	
Max. no. $\overline{p}$ in accum. ring	—	2.4×10^{12}	—			—	