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

Updated in early 2006 with numbers received from representatives of the colliders (contact J. Beringer, LBNL). For existing (future) colliders the latest achieved (design) values are given. Quantities are, where appropriate, r.m.s.; H and V indicate horizontal and vertical directions; s.c. stands for superconducting. 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	2006	1994	1989	2007	1999
Physics end date	—	—	2005	—	2008
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	12.6 at 1.843 GeV/beam 5 at 1.55 GeV/beam	1000	150 (300 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	$(2.5 \text{ to } 3.2)\times 10^4$
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	low current: 1 high current: 3
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	± 0.63	± 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: 2.2	H: 300 V: 1
β^*, amplitude function at interaction point (m)	H: 0.06 – 0.11 V: 0.06 – 0.10	H: 0.75 V: 0.05	H: 1.2 V: 0.05	H: 1.0 V: 0.015	H: 1.7 V: 0.0017
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	e^-: 3.3 e^+: 2.4
Bunches per ring per species	1	2	1	93	120 (incl. 10 bunch gap)
Average beam current per species (mA)	150	80	40 at 2 GeV 22 at 1.55 GeV	910	e^-: 1800 e^+: 1300
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	5	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)

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	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) (nominal $E_{\rm cm}$ = 10.5 GeV)	100 - 104.6
Luminosity (10^{30} cm^{-2}s^{-1})	1280 at 5.3 GeV/beam	60 at 1.9 GeV/beam	16270	10025	24 at Z^0 100 at > 90 GeV
Time between collisions (μs)	0.014 to 0.22	0.014 to 0.22	0.00590 or 0.00786	0.0042	22
Crossing angle (μ rad)	±2000	±3500	±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: 340 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	continuous	20 at Z^0 10 at > 90 GeV
Filling time (min)	5 (topping up)	4 (topping up)	continuous	continuous	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: 130 V: 1.0	e^-: 24 (H), 0.71 (V) e^+: 18 (H), 0.68 (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: 0.90 V: 0.013	e^-: 0.56 (H), 0.0062 (V) e^+: 0.59 (H), 0.0065 (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	e^-: 270 (H), 380 (V) e^+: 180 (H), 260 (V)	e^-: 730 (H), 550 (V) e^+: 1170 (H), 960 (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^+: 6.0/8.0	e^-/e^+: 4.6/7.8	45 in collision 60 in single beam
Bunches per ring per species	9 trains of 5 bunches	8 trains of 5 bunches	1388	1732	4 trains of 1 or 2
Average beam current per species (mA)	340	62	e^-/e^+: 1350/1720	e^-/e^+: 1750/2950	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)	0.3 normal } at 8 0.8 high field } GeV	0.3 normal } at 8 0.8 high field } 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, $\overline{p}p$, pp, and Heavy Ion Colliders

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	HERA (DESY)	TEVATRON (Fermilab)	RHIC (Brookhaven)				LHC (CERN)	
Physics start date	1992	1987	2001	2000	2004	2002	2007	2008
Physics end date	—	—	—				—	
Particles collided	ep	$p\overline{p}$	pp (pol.)	Au Au	Cu Cu	d Au	pp	Pb Pb
Maximum beam energy (TeV)	e: 0.030 p: 0.92	0.980	0.1 46% pol	0.1 TeV/n	0.1 TeV/n	0.1 TeV/n	7.0	2.76 TeV/n
Luminosity (10^{30} cm^{-2}s^{-1})	75	171	10	0.0015	0.020	0.07	1.0×10^4	0.001
Time between collisions (ns)	96	396	107	213	213	213	24.95	99.8
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	0.5	0.113	0.11
Bunch length (cm)	e: 0.83 p: 8.5	p: 50 $\bar{p}$: 45	40	20	20	20	7.55	7.94
Beam radius (10^{-6} m)	e: $280(H), 50(V)$ p: $265(H), 50(V)$	p: 29 $\bar{p}$: 21	175 (β^*=1 m)	150 (β^*=1m)	145 (β^*=0.9m)	215 (β^*=2m)	16.6	15.9
Free space at interaction point (m)	±2	±6.5	16				38	38
Luminosity lifetime (hr)	10	7 (average, start of store)	10	3	5	6	14.9	10.9 - 3.6 (initial, 1 - 3 exp.)
Filling time (min)	e: 60, p: 120 (includes magnet cycling, accel.)	30	30	15	15	15	8.6 (both beams)	
Acceleration period (s)	e: 200 p: 1500	86	220	280	290	230	1200	
Injection energy (TeV)	e: 0.012 p: 0.040	0.15	0.023	0.011 TeV/n	0.011 TeV/n	0.012 TeV/n	0.450	0.1774 TeV/n
Transverse emittance ($10^{-9}\pi$ rad-m)	e: $20(H), 3.5(V)$ p: $5(H), 5(V)$	p: 3 $\bar{p}$: 1.5	31	23	23	23	0.5	0.5
β^*, ampl. function at interaction point (m)	e: $0.6(H), 0.26(V)$ p: $2.45(H), 0.18(V)$	0.28	1–10	1–5	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: 50 $\bar{p}$: 100	45	17	29	d: 27 Au: 21	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	accel: 28 store: 197	400.8	400.8
Particles per bunch (units 10^{10})	e: 3 p: 7	p: 24 $\bar{p}$: 6	9	0.11	0.38	d: 11 Au: 0.07	11.5	0.007
Bunches per ring per species	e: 189 p: 180	36	106	45	37	55	2808	592
Average beam current per species (mA)	e: 40 p: 90	p: 66 $\bar{p}$: 16	119	49	60	d: 77 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 total, 2 high $\mathscr{L}$				2 high $\mathscr{L}$ +1	1 dedicated +2
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})	—	16×10^{10}	—				—	
Max. no. $\overline{p}$ in accum. ring	—	2.4×10^{12}	—				—	