

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

The numbers here were received from representatives of the colliders in early 2002 (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	2003	1994	1989	1999
Physics end date	2000	—	—	—	—
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	20	10 at 1.843 GeV/beam 5 at 1.55 GeV/beam	50(→500)
Time between collisions (μ s)	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	≈ 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)	± 1	± 1	± 2	± 2.15	± 0.46 (± 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 \times 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	≈ 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

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

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	CESR (Cornell)	KEKB (KEK)	PEP-II (SLAC)	SLC (SLAC)	LEP (CERN)
Physics start date	1979	1999	1999	1989	1989
Physics end date	—	—	—	1998	2000
Maximum beam energy (GeV)	6	$e^- \times e^+ : 8 \times 3.5$	$e^- : 7-12$ (9.0 nominal) $e^+ : 2.5-4$ (3.1 ") (nominal $E_{cm} = 10.5$ GeV)	50	101 in 1999 (105=max. foreseen)
Luminosity ($10^{30} \text{ cm}^{-2}\text{s}^{-1}$)	1280 at 5.3 GeV/beam	7249	4600	2.5	24 at Z^0 100 at > 90 GeV
Time between collisions (μs)	0.014 to 0.22	0.008	0.0042	8300	22
Crossing angle (μ rad)	± 2000	$\pm 11,000$	0	0	0
Energy spread (units 10^{-3})	0.6 at 5.3 GeV/beam	0.7	$e^-/e^+ : 0.61/0.77$	1.2	0.7→1.5
Bunch length (cm)	1.8	0.65	$e^-/e^+ : 1.1/1.0$	0.1	1.0
Beam radius (μm)	$H : 460$ $V : 4$	$H : 110$ $V : 2.7$	$H : 157$ $V : 4.7$	$H : 1.5$ $V : 0.5$	$H : 200 \rightarrow 300$ $V : 2.5 \rightarrow 8$
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	3.4	2.5	—	20 at Z^0 10 at > 90 GeV
Filling time (min)	5 (topping up)	10 (topping up)	3 (topping up)	—	20 to setup 20 to accumulate
Acceleration period (s)	—	—	—	—	600
Injection energy (GeV)	1.8-6	$e^-/e^+ : 8/3.5$	2.5-12	45.64	22
Transverse emittance (π rad-nm)	$H : 210$ $V : 1$	$e^- : 24$ (H), 1.1 (V) $e^+ : 18$ (H), 1.2 (V)	$e^- : 48$ (H), 1.5 (V) $e^+ : 24$ (H), 1.5 (V)	$H : 0.5$ $V : 0.05$	$H : 20-45$ $V : 0.25 \rightarrow 1$
β^* , amplitude function at interaction point (m)	$H : 1.0$ $V : 0.018$	$e^- : 0.63$ (H), 0.0070 (V) $e^+ : 0.59$ (H), 0.0062 (V)	$e^- : 0.50$ (H), 0.012 (V) $e^+ : 0.50$ (H), 0.012 (V)	$H : 0.0025$ $V : 0.0015$	$H : 1.5$ $V : 0.05$
Beam-beam tune shift per crossing (units 10^{-4})	$H : 250$ $V : 620$	$e^- : 730$ (H), 430 (V) $e^+ : 780$ (H), 460 (V)	$H : 650$ $V : 350$	—	830
RF frequency (MHz)	500	508.887	476	—	352.2
Particles per bunch (units 10^{10})	1.15	$e^-/e^+ : 4.5/7.2$	$e^-/e^+ : 2.1/5.9$	4.0	45 in collision 60 in single beam
Bunches per ring per species	9 trains of 5 bunches	1224	800	1	4 trains of 1 or 2
Average beam current per species (mA)	340	$e^-/e^+ : 800/1100$	$e^-/e^+ : 1050/1800$	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	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	$e^-/e^+ : 0.25/0.72$	$e^-/e^+ : 0.18/0.75$	0.597	0.135

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

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	HERA (DESY)	$Spp\bar{S}$ (CERN)	TEVATRON (Fermilab)	RHIC (Brookhaven)		LHC (CERN)	
Physics start date	1992	1981	1987	2000		2007	2008
Physics end date	—	1990	—	—		—	
Particles collided	ep	$p\bar{p}$	$p\bar{p}$	pp (pol.)	Au Au	pp	Pb Pb
Maximum beam energy (TeV)	e : 0.030 p : 0.92	0.315 (0.45 in pulsed mode)	1.0	0.25	0.1 TeV/u	7.0	2.76 TeV/u
Luminosity (10^{30} cm $^{-2}$ s $^{-1}$)	75	6	210	10	0.0002	1.0×10^4	0.001
Time between collisions (μ s)	0.096	3.8	0.396	0.213		0.025	0.100
Crossing angle (μ rad)	0	0	0	0		300	≤ 100
Energy spread (units 10^{-3})	e : 0.91 p : 0.2	0.35	0.09	0.7		0.1	0.1
Bunch length (cm)	e : 0.83 p : 8.5	20	38	20		7.5	7.5
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	125 ($\beta^*=1$ m)		16	16
Free space at interaction point (m)	± 5.8	16	± 6.5	16		38	38
Luminosity lifetime (hr)	10	15	7–30	10	3	10	6.7
Filling time (min)	e : 60 p : 120	0.5	30	15		7.5 (both beams)	20 (both beams)
Acceleration period (s)	e : 200 p : 1500	10	86	100		1200	
Injection energy (TeV)	e : 0.012 p : 0.040	0.026	0.15	0.023	0.011 TeV/u	0.450	0.1774 TeV/u
Transverse emittance ($10^{-9}\pi$ rad-m)	e : 20(H), 6(V) p : 5(H), 5(V)	p : 9 \bar{p} : 5	p : 3.5 \bar{p} : 2.5	13	16	0.5	0.5
β^* , amplitude function at interaction point (m)	e : 0.6 (H), 0.26(V) p : 2.45(H), 0.18(V)	0.6 (H) 0.15 (V)	0.35	1–10		0.5	0.5
Beam-beam tune shift per crossing (units 10^{-4})	e : 190(H), 450(V) p : 12(H), 9(V)	50	p : 38 \bar{p} : 97	37	23	34	—
RF frequency (MHz)	e : 499.7 p : 208.2/52.05	100+200	53	accel: 28 store: 197		400.8	400.8
Particles per bunch (units 10^{10})	e : 3 p : 7	p : 15 \bar{p} : 8	p : 27 \bar{p} : 7.5	10	0.1	11	0.007
Bunches per ring per species	e : 189 p : 180	6	36	56		2808	592
Average beam current per species (mA)	e : 40 p : 90	p : 6 \bar{p} : 3	p : 81 \bar{p} : 22	70	55	536	7.8
Circumference (km)	6.336	6.911	6.28	3.834		26.659	
Interaction regions	ep : 2; e, p : 1 each, internal fixed target	2	2 high \mathcal{L}	6		2 high \mathcal{L} +1	1
Utility insertions	4	—	4	13/ring		4	
Magnetic length of dipole (m)	e : 9.185 p : 8.82	6.26	6.12	9.45		14.3	
Length of standard cell (m)	e : 23.5 p : 47	64	59.5	29.7		106.90	
Phase advance per cell (deg)	e : 60 p : 90	90	67.8	84		90	
Dipoles in ring	e : 396 p : 416	744	774	192 per ring + 12 common		1232 main dipoles	
Quadrupoles in ring	e : 580 p : 280	232	216	246 per ring		482 2-in-1 24 1-in-1	
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. $\cos\theta$ cold iron		s.c. 2 in 1 cold iron	
Peak magnetic field (T)	e : 0.274 p : 4.65	1.4 (2 in pulsed mode)	4.4	3.5		8.3	
\bar{p} source accum. rate (hr $^{-1}$)	—	6×10^{10}	20×10^{10}	—		—	
Max. no. \bar{p} in accum. ring	—	1.2×10^{12}	2.6×10^{12}	—		—	