Z

$J = 1$

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Z MASS

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The *Z* boson" and ref. LEP-SLC 06). The fit is performed using the *Z* mass and width, the *Z* hadronic pole cross section, the ratios of hadronic to leptonic partial widths, and the *Z* pole forward-backward lepton asymmetries. This set is believed to be most free of correlations.

The *Z*-boson mass listed here corresponds to the mass parameter in a Breit-Wigner distribution with mass dependent width. The value is 34 MeV greater than the real part of the position of the pole (in the energy-squared plane) in the *Z*-boson propagator. Also the LEP experiments have generally assumed a fixed value of the $\gamma - Z$ interferences term based on the standard model. Keeping this term as free parameter leads to a somewhat larger error on the fitted *Z* mass. See ACCIARRI 00Q and ABBIENDI 04G for a detailed investigation of both these issues.

VALUE (GeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
91.1876±0.0021 OUR FIT					
91.1852±0.0030	4.57M	[1] ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
91.1863±0.0028	4.08M	[2] ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
91.1898±0.0031	3.96M	[3] ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
91.1885±0.0031	4.57M	[4] BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
91.1872±0.0033		[5] ABBIENDI	04G	OPAL	$E^{ee}_{\rm cm}$= LEP1 + 130–209 GeV
91.272 ±0.032 ±0.033		[6] ACHARD	04C	L3	$E^{ee}_{\rm cm}$= 183–209 GeV
91.1875±0.0039	3.97M	[7] ACCIARRI	00Q	L3	$E^{ee}_{\rm cm}$= LEP1 + 130–189 GeV
91.151 ±0.008		[8] MIYABAYASHI	95	TOPZ	$E^{ee}_{\rm cm}$= 57.8 GeV
91.74 ±0.28 ±0.93	156	[9] ALITTI	92B	UA2	$E^{p\overline{p}}_{\rm cm}$= 630 GeV
90.9 ±0.3 ±0.2	188	[10] ABE	89C	CDF	$E^{p\overline{p}}_{\rm cm}$= 1.8 TeV
91.14 ±0.12	480	[11] ABRAMS	89B	MRK2	$E^{ee}_{\rm cm}$= 89–93 GeV
93.1 ±1.0 ±3.0	24	[12] ALBAJAR	89	UA1	$E^{p\overline{p}}_{\rm cm}$= 546,630 GeV

[1] ABBIENDI 01A error includes approximately 2.3 MeV due to statistics and 1.8 MeV due to LEP energy uncertainty.

[2] The error includes 1.6 MeV due to LEP energy uncertainty.

[3] The error includes 1.8 MeV due to LEP energy uncertainty.

[4] BARATE 00C error includes approximately 2.4 MeV due to statistics, 0.2 MeV due to experimental systematics, and 1.7 MeV due to LEP energy uncertainty.

[5] ABBIENDI 04G obtain this result using the S–matrix formalism for a combined fit to their cross section and asymmetry data at the *Z* peak and their data at 130–209 GeV. The authors have corrected the measurement for the 34 MeV shift with respect to the Breit–Wigner fits.

[6] ACHARD 04C select $e^+e^- \rightarrow Z\gamma$ events with hard initial–state radiation. Z decays to $q\overline{q}$ and muon pairs are considered. The fit results obtained in the two samples are found consistent to each other and combined considering the uncertainty due to ISR modelling as fully correlated.

[7] ACCIARRI 00Q interpret the s-dependence of the cross sections and lepton forward-backward asymmetries in the framework of the S-matrix formalism. They fit to their cross section and asymmetry data at high energies, using the results of S-matrix fits to Z-peak data (ACCIARRI 00C) as constraints. The 130–189 GeV data constrains the γ/Z interference term. The authors have corrected the measurement for the 34.1 MeV shift with respect to the Breit-Wigner fits. The error contains a contribution of ±2.3 MeV due to the uncertainty on the γZ interference.

[8] MIYABAYASHI 95 combine their low energy total hadronic cross-section measurement with the ACTON 93D data and perform a fit using an S-matrix formalism. As expected, this result is below the mass values obtained with the standard Breit-Wigner parametrization.

[9] Enters fit through W/Z mass ratio given in the W Particle Listings. The ALITTI 92B systematic error (±0.93) has two contributions: one (±0.92) cancels in m_W/m_Z and one (±0.12) is noncancelling. These were added in quadrature.

[10] First error of ABE 89 is combination of statistical and systematic contributions; second is mass scale uncertainty.

[11] ABRAMS 89B uncertainty includes 35 MeV due to the absolute energy measurement.

[12] ALBAJAR 89 result is from a total sample of 33 $Z \rightarrow e^+e^-$ events.

Z WIDTH

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06).

VALUE (GeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.4952±0.0023 OUR FIT					
2.4948±0.0041	4.57M	[13] ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
2.4876±0.0041	4.08M	[14] ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
2.5024±0.0042	3.96M	[15] ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
2.4951±0.0043	4.57M	[16] BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.4943±0.0041		[17] ABBIENDI	04G	OPAL	$E^{ee}_{\rm cm}$= LEP1 + 130–209 GeV
2.5025±0.0041	3.97M	[18] ACCIARRI	00Q	L3	$E^{ee}_{\rm cm}$= LEP1 + 130–189 GeV
2.50 ±0.21 ±0.06		[19] ABREU	96R	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
3.8 ±0.8 ±1.0	188	ABE	89C	CDF	$E^{p\overline{p}}_{\rm cm}$= 1.8 TeV
$2.42^{+0.45}_{-0.35}$	480	[20] ABRAMS	89B	MRK2	$E^{ee}_{\rm cm}$= 89–93 GeV
$2.7^{+1.2}_{-1.0}$ ±1.3	24	[21] ALBAJAR	89	UA1	$E^{p\overline{p}}_{\rm cm}$= 546,630 GeV
2.7 ±2.0 ±1.0	25	[22] ANSARI	87	UA2	$E^{p\overline{p}}_{\rm cm}$= 546,630 GeV

[13] ABBIENDI 01A error includes approximately 3.6 MeV due to statistics, 1 MeV due to event selection systematics, and 1.3 MeV due to LEP energy uncertainty.

[14] The error includes 1.2 MeV due to LEP energy uncertainty.

[15] The error includes 1.3 MeV due to LEP energy uncertainty.

[16] BARATE 00C error includes approximately 3.8 MeV due to statistics, 0.9 MeV due to experimental systematics, and 1.3 MeV due to LEP energy uncertainty.

[17] ABBIENDI 04G obtain this result using the S–matrix formalism for a combined fit to their cross section and asymmetry data at the Z peak and their data at 130–209 GeV. The authors have corrected the measurement for the 1 MeV shift with respect to the Breit–Wigner fits.

[18] ACCIARRI 00Q interpret the s-dependence of the cross sections and lepton forward-backward asymmetries in the framework of the S-matrix formalism. They fit to their cross section and asymmetry data at high energies, using the results of S-matrix fits to Z-peak data (ACCIARRI 00C) as constraints. The 130–189 GeV data constrains the γ/Z interference term. The authors have corrected the measurement for the 0.9 MeV shift with respect to the Breit-Wigner fits.

[19] ABREU 96R obtain this value from a study of the interference between initial and final state radiation in the process $e^+e^- \rightarrow Z \rightarrow \mu^+\mu^-$.

[20] ABRAMS 89B uncertainty includes 50 MeV due to the miniSAM background subtraction error.

[21] ALBAJAR 89 result is from a total sample of 33 $Z \rightarrow e^+e^-$ events.

[22] Quoted values of ANSARI 87 are from direct fit. Ratio of Z and W production gives either $\Gamma(Z) < (1.09 \pm 0.07) \times \Gamma(W)$, CL = 90% or $\Gamma(Z) = (0.82^{+0.19}_{-0.14} \pm 0.06) \times \Gamma(W)$. Assuming Standard-Model value $\Gamma(W) = 2.65$ GeV then gives $\Gamma(Z) < 2.89 \pm 0.19$ or $= 2.17^{+0.50}_{-0.37} \pm 0.16$.

Z DECAY MODES

	Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level
Γ_1	e^+e^-		(3.363 ± 0.004) %	
Γ_2	$\mu^+\mu^-$		(3.366 ± 0.007) %	
Γ_3	$\tau^+\tau^-$		(3.370 ± 0.008) %	
Γ_4	$\ell^+\ell^-$	[a]	(3.3658 ± 0.0023) %	
Γ_5	invisible		(20.00 ± 0.06) %	
Γ_6	hadrons		(69.91 ± 0.06) %	
Γ_7	$(u\overline{u}+c\overline{c})/2$		(11.6 ± 0.6) %	
Γ_8	$(d\overline{d}+s\overline{s}+b\overline{b})/3$		(15.6 ± 0.4) %	
Γ_9	$c\overline{c}$		(12.03 ± 0.21) %	
Γ_{10}	$b\overline{b}$		(15.12 ± 0.05) %	
Γ_{11}	$b\overline{b}b\overline{b}$		$(3.6 \pm 1.3) \times 10^{-4}$	
Γ_{12}	ggg		< 1.1 %	CL=95%
Γ_{13}	$\pi^0\gamma$		$< 5.2 \times 10^{-5}$	CL=95%
Γ_{14}	$\eta\gamma$		$< 5.1 \times 10^{-5}$	CL=95%
Γ_{15}	$\omega\gamma$		$< 6.5 \times 10^{-4}$	CL=95%
Γ_{16}	$\eta'(958)\gamma$		$< 4.2 \times 10^{-5}$	CL=95%
Γ_{17}	$\gamma\gamma$		$< 5.2 \times 10^{-5}$	CL=95%
Γ_{18}	$\gamma\gamma\gamma$		$< 1.0 \times 10^{-5}$	CL=95%
Γ_{19}	$\pi^\pm W^\mp$	[b]	$< 7 \times 10^{-5}$	CL=95%

Γ_{20}	$\rho^{\pm} W^{\mp}$		[b]	$< 8.3 \times 10^{-5}$	CL=95%
Γ_{21}	$J/\psi(1S)$X			$(3.51 {}^{+0.23}_{-0.25}) \times 10^{-3}$	S=1.1
Γ_{22}	$\psi(2S)$X			$(1.60 \pm 0.29) \times 10^{-3}$	
Γ_{23}	$\chi_{c1}(1P)$X			$(2.9 \pm 0.7) \times 10^{-3}$	
Γ_{24}	$\chi_{c2}(1P)$X			$< 3.2 \times 10^{-3}$	CL=90%
Γ_{25}	$\Upsilon(1S)$ X $+ \Upsilon(2S)$ X $+ \Upsilon(3S)$ X			$(1.0 \pm 0.5) \times 10^{-4}$	
Γ_{26}	$\Upsilon(1S)$X			$< 4.4 \times 10^{-5}$	CL=95%
Γ_{27}	$\Upsilon(2S)$X			$< 1.39 \times 10^{-4}$	CL=95%
Γ_{28}	$\Upsilon(3S)$X			$< 9.4 \times 10^{-5}$	CL=95%
Γ_{29}	$(D^0/\overline{D}^0)$ X			(20.7 ± 2.0) %	
Γ_{30}	$D^{\pm}$X			(12.2 ± 1.7) %	
Γ_{31}	$D^*(2010)^{\pm}$X		[b]	(11.4 ± 1.3) %	
Γ_{32}	$D_{s1}(2536)^{\pm}$X			$(3.6 \pm 0.8) \times 10^{-3}$	
Γ_{33}	$D_{sJ}(2573)^{\pm}$X			$(5.8 \pm 2.2) \times 10^{-3}$	
Γ_{34}	$D^{*\prime}(2629)^{\pm}$X			searched for	
Γ_{35}	BX				
Γ_{36}	B^*X				
Γ_{37}	B^+X		[c]	(6.08 ± 0.13) %	
Γ_{38}	B^0_sX		[c]	(1.59 ± 0.13) %	
Γ_{39}	B^+_cX			searched for	
Γ_{40}	Λ^+_cX			(1.54 ± 0.33) %	
Γ_{41}	Ξ^0_cX			seen	
Γ_{42}	Ξ_bX			seen	
Γ_{43}	b-baryon X		[c]	(1.38 ± 0.22) %	
Γ_{44}	anomalous $\gamma +$ hadrons		[d]	$< 3.2 \times 10^{-3}$	CL=95%
Γ_{45}	$e^+ e^- \gamma$		[d]	$< 5.2 \times 10^{-4}$	CL=95%
Γ_{46}	$\mu^+ \mu^- \gamma$		[d]	$< 5.6 \times 10^{-4}$	CL=95%
Γ_{47}	$\tau^+ \tau^- \gamma$		[d]	$< 7.3 \times 10^{-4}$	CL=95%
Γ_{48}	$\ell^+ \ell^- \gamma\gamma$		[e]	$< 6.8 \times 10^{-6}$	CL=95%
Γ_{49}	$q\overline{q}\gamma\gamma$		[e]	$< 5.5 \times 10^{-6}$	CL=95%
Γ_{50}	$\nu\overline{\nu}\gamma\gamma$		[e]	$< 3.1 \times 10^{-6}$	CL=95%
Γ_{51}	$e^{\pm} \mu^{\mp}$	*LF*	[b]	$< 1.7 \times 10^{-6}$	CL=95%
Γ_{52}	$e^{\pm} \tau^{\mp}$	*LF*	[b]	$< 9.8 \times 10^{-6}$	CL=95%
Γ_{53}	$\mu^{\pm} \tau^{\mp}$	*LF*	[b]	$< 1.2 \times 10^{-5}$	CL=95%
Γ_{54}	pe	*L,B*		$< 1.8 \times 10^{-6}$	CL=95%
Γ_{55}	$p\mu$	*L,B*		$< 1.8 \times 10^{-6}$	CL=95%

[a] ℓ indicates each type of lepton (e, μ, and τ), not sum over them.

[b] The value is for the sum of the charge states or particle/antiparticle states indicated.

[c] This value is updated using the product of (i) the $Z \to b\overline{b}$ fraction from this listing and (ii) the b-hadron fraction in an

unbiased sample of weakly decaying *b*-hadrons produced in *Z*-decays provided by the Heavy Flavor Averaging Group (HFAG, http://www.slac.stanford.edu/xorg/hfag/osc/PDG_2009/#FRACZ).

[*d*] See the Particle Listings below for the γ energy range used in this measurement.

[*e*] For $m_{\gamma\gamma} = (60 \pm 5)$ GeV.

Z PARTIAL WIDTHS

$\Gamma(e^+ e^-)$ Γ_1

For the LEP experiments, this parameter is not directly used in the overall fit but is derived using the fit results; see the note "The *Z* boson" and ref. LEP-SLC 06.

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
83.91±0.12 OUR FIT					
83.66±0.20	137.0K	ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
83.54±0.27	117.8k	ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
84.16±0.22	124.4k	ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
83.88±0.19		BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
82.89±1.20±0.89		[23] ABE	95J	SLD	$E^{ee}_{\rm cm}$= 91.31 GeV

[23] ABE 95J obtain this measurement from Bhabha events in a restricted fiducial region to improve systematics. They use the values 91.187 and 2.489 GeV for the *Z* mass and total decay width to extract this partial width.

$\Gamma(\mu^+ \mu^-)$ Γ_2

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The *Z* boson" and ref. LEP-SLC 06.

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
83.99±0.18 OUR FIT					
84.03±0.30	182.8K	ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
84.48±0.40	157.6k	ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
83.95±0.44	113.4k	ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
84.02±0.28		BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

$\Gamma(\tau^+ \tau^-)$ Γ_3

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The *Z* boson" and ref. LEP-SLC 06.

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
84.08±0.22 OUR FIT					
83.94±0.41	151.5K	ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
83.71±0.58	104.0k	ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
84.23±0.58	103.0k	ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
84.38±0.31		BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

$\Gamma(\ell^+\ell^-)$ Γ_4

In our fit $\Gamma(\ell^+\ell^-)$ is defined as the partial Z width for the decay into a pair of massless charged leptons. This parameter is not directly used in the 5-parameter fit assuming lepton universality but is derived using the fit results. See the note "The Z boson" and ref. LEP-SLC 06.

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
83.984±0.086 OUR FIT					
83.82 ±0.15	471.3K	ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
83.85 ±0.17	379.4k	ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
84.14 ±0.17	340.8k	ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
84.02 ±0.15	500k	BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV

Γ(invisible) Γ_5

We use only direct measurements of the invisible partial width using the single photon channel to obtain the average value quoted below. OUR FIT value is obtained as a difference between the total and the observed partial widths assuming lepton universality.

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
499.0± 1.5 OUR FIT					
503 ±16 OUR AVERAGE	Error includes scale factor of 1.2.				
498 ±12 ±12	1791	ACCIARRI	98G	L3	E^{ee}_{cm}= 88–94 GeV
539 ±26 ±17	410	AKERS	95C	OPAL	E^{ee}_{cm}= 88–94 GeV
450 ±34 ±34	258	BUSKULIC	93L	ALEP	E^{ee}_{cm}= 88–94 GeV
540 ±80 ±40	52	ADEVA	92	L3	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
498.1± 2.6		[24] ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
498.1± 3.2		[24] ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
499.1± 2.9		[24] ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
499.1± 2.5		[24] BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV

[24] This is an indirect determination of Γ(invisible) from a fit to the visible Z decay modes.

Γ(hadrons) Γ_6

This parameter is not directly used in the 5-parameter fit assuming lepton universality, but is derived using the fit results. See the note "The Z boson" and ref. LEP-SLC 06.

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1744.4±2.0 OUR FIT					
1745.4±3.5	4.10M	ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
1738.1±4.0	3.70M	ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
1751.1±3.8	3.54M	ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
1744.0±3.4	4.07M	BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV

Z BRANCHING RATIOS

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The *Z* boson" and ref. LEP-SLC 06).

$\Gamma(\text{hadrons})/\Gamma(e^+e^-)$ Γ_6/Γ_1

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
20.804± 0.050 OUR FIT					
20.902± 0.084	137.0K	[25] ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
20.88 ± 0.12	117.8k	ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
20.816± 0.089	124.4k	ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
20.677± 0.075		[26] BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$27.0\ ^{+11.7}_{-\ 8.8}$	12	[27] ABRAMS	89D	MRK2	E^{ee}_{cm}= 89–93 GeV

[25] ABBIENDI 01A error includes approximately 0.067 due to statistics, 0.040 due to event selection systematics, 0.027 due to the theoretical uncertainty in *t*-channel prediction, and 0.014 due to LEP energy uncertainty.

[26] BARATE 00C error includes approximately 0.062 due to statistics, 0.033 due to experimental systematics, and 0.026 due to the theoretical uncertainty in *t*-channel prediction.

[27] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.

$\Gamma(\text{hadrons})/\Gamma(\mu^+\mu^-)$ Γ_6/Γ_2

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The *Z* boson" and ref. LEP-SLC 06).

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
20.785±0.033 OUR FIT					
20.811±0.058	182.8K	[28] ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
20.65 ±0.08	157.6k	ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
20.861±0.097	113.4k	ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
20.799±0.056		[29] BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$18.9\ ^{+7.1}_{-5.3}$	13	[30] ABRAMS	89D	MRK2	E^{ee}_{cm}= 89–93 GeV

[28] ABBIENDI 01A error includes approximately 0.050 due to statistics and 0.027 due to event selection systematics.

[29] BARATE 00C error includes approximately 0.053 due to statistics and 0.021 due to experimental systematics.

[30] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.

$\Gamma(\text{hadrons})/\Gamma(\tau^+\tau^-)$ Γ_6/Γ_3

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06).

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
20.764±0.045 OUR FIT					
20.832±0.091	151.5K	[31] ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
20.84 ±0.13	104.0k	ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
20.792±0.133	103.0k	ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
20.707±0.062		[32] BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$15.2\ ^{+4.8}_{-3.9}$	21	[33] ABRAMS	89D	MRK2	E^{ee}_{cm}= 89–93 GeV

[31] ABBIENDI 01A error includes approximately 0.055 due to statistics and 0.071 due to event selection systematics.

[32] BARATE 00C error includes approximately 0.054 due to statistics and 0.033 due to experimental systematics.

[33] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.

$\Gamma(\text{hadrons})/\Gamma(\ell^+\ell^-)$ Γ_6/Γ_4

ℓ indicates each type of lepton (e, μ, and τ), not sum over them.

Our fit result is obtained requiring lepton universality.

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
20.767±0.025 OUR FIT					
20.823±0.044	471.3K	[34] ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
20.730±0.060	379.4k	ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
20.810±0.060	340.8k	ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
20.725±0.039	500k	[35] BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$18.9\ ^{+3.6}_{-3.2}$	46	ABRAMS	89B	MRK2	E^{ee}_{cm}= 89–93 GeV

[34] ABBIENDI 01A error includes approximately 0.034 due to statistics and 0.027 due to event selection systematics.

[35] BARATE 00C error includes approximately 0.033 due to statistics, 0.020 due to experimental systematics, and 0.005 due to the theoretical uncertainty in t-channel prediction.

$\Gamma(\text{hadrons})/\Gamma_{\text{total}}$ Γ_6/Γ

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06.

VALUE (%)	*DOCUMENT ID*
69.911±0.056 OUR FIT	

$\Gamma(e^+e^-)/\Gamma_{\text{total}}$ Γ_1/Γ

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06.

VALUE (%)	*DOCUMENT ID*
3.3632±0.0042 OUR FIT	

$\Gamma(\mu^+\mu^-)/\Gamma_{\text{total}}$ Γ_2/Γ

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06.

VALUE (%)	*DOCUMENT ID*
3.3662±0.0066 OUR FIT	

$\Gamma(\mu^+\mu^-)/\Gamma(e^+e^-)$ Γ_2/Γ_1

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06.

VALUE	*DOCUMENT ID*
1.0009±0.0028 OUR FIT	

$\Gamma(\tau^+\tau^-)/\Gamma_{\text{total}}$ Γ_3/Γ

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06.

VALUE (%)	*DOCUMENT ID*
3.3696±0.0083 OUR FIT	

$\Gamma(\tau^+\tau^-)/\Gamma(e^+e^-)$ Γ_3/Γ_1

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06.

VALUE	*DOCUMENT ID*
1.0019±0.0032 OUR FIT	

$\Gamma(\ell^+\ell^-)/\Gamma_{\text{total}}$ Γ_4/Γ

ℓ indicates each type of lepton (e, μ, and τ), not sum over them.

Our fit result assumes lepton universality.

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06.

VALUE (%)	*DOCUMENT ID*
3.3658±0.0023 OUR FIT	

$\Gamma(\text{invisible})/\Gamma_{\text{total}}$ Γ_5/Γ

See the data, the note, and the fit result for the partial width, Γ_5, above.

VALUE (%)	*DOCUMENT ID*
20.000±0.055 OUR FIT	

$\Gamma((u\overline{u}+c\overline{c})/2)/\Gamma(\text{hadrons})$ Γ_7/Γ_6

This quantity is the branching ratio of $Z \rightarrow$ "up-type" quarks to $Z \rightarrow$ hadrons. Except ACKERSTAFF 97T the values of $Z \rightarrow$ "up-type" and $Z \rightarrow$ "down-type" branchings are extracted from measurements of Γ(hadrons), and $\Gamma(Z \rightarrow \gamma +$ jets) where γ is a high-energy (>5 or 7 GeV) isolated photon. As the experiments use different procedures and slightly different values of M_Z, Γ(hadrons) and α_s in their extraction procedures, our average has to be taken with caution.

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.166±0.009 OUR AVERAGE				
$0.172^{+0.011}_{-0.010}$	[36] ABBIENDI	04E	OPAL	$E^{ee}_{\text{cm}} = 91.2$ GeV
0.160±0.019±0.019	[37] ACKERSTAFF	97T	OPAL	E^{ee}_{cm}= 88–94 GeV
$0.137^{+0.038}_{-0.054}$	[38] ABREU	95X	DLPH	E^{ee}_{cm}= 88–94 GeV
0.137±0.033	[39] ADRIANI	93	L3	E^{ee}_{cm}= 91.2 GeV

[36] ABBIENDI 04E select photons with energy > 7 GeV and use Γ(hadrons) = 1744.4 ± 2.0 MeV and $\alpha_s = 0.1172 \pm 0.002$ to obtain $\Gamma_u = 300^{+19}_{-18}$ MeV.

[37] ACKERSTAFF 97T measure $\Gamma_{u\overline{u}}/(\Gamma_{d\overline{d}}+\Gamma_{u\overline{u}}+\Gamma_{s\overline{s}}) = 0.258 \pm 0.031 \pm 0.032$. To obtain this branching ratio authors use $R_c+R_b = 0.380 \pm 0.010$. This measurement is fully negatively correlated with the measurement of $\Gamma_{d\overline{d},s\overline{s}}/(\Gamma_{d\overline{d}}+\Gamma_{u\overline{u}}+\Gamma_{s\overline{s}})$ given in the next data block.

[38] ABREU 95X use $M_Z = 91.187 \pm 0.009$ GeV, Γ(hadrons) = 1725 ± 12 MeV and $\alpha_s = 0.123 \pm 0.005$. To obtain this branching ratio we divide their value of $C_{2/3} = 0.91^{+0.25}_{-0.36}$ by their value of $(3C_{1/3} + 2C_{2/3}) = 6.66 \pm 0.05$.

[39] ADRIANI 93 use $M_Z = 91.181 \pm 0.022$ GeV, Γ(hadrons) = 1742 ± 19 MeV and $\alpha_s = 0.125 \pm 0.009$. To obtain this branching ratio we divide their value of $C_{2/3} = 0.92 \pm 0.22$ by their value of $(3C_{1/3} + 2C_{2/3}) = 6.720 \pm 0.076$.

$\Gamma\big((d\overline{d}+s\overline{s}+b\overline{b})/3\big)/\Gamma(\text{hadrons})$ $\qquad\Gamma_8/\Gamma_6$

This quantity is the branching ratio of $Z \rightarrow$ "down-type" quarks to $Z \rightarrow$ hadrons. Except ACKERSTAFF 97T the values of $Z \rightarrow$ "up-type" and $Z \rightarrow$ "down-type" branchings are extracted from measurements of Γ(hadrons), and Γ($Z \rightarrow \gamma+$ jets) where γ is a high-energy (>5 or 7 GeV) isolated photon. As the experiments use different procedures and slightly different values of M_Z, Γ(hadrons) and α_s in their extraction procedures, our average has to be taken with caution.

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.223±0.006 OUR AVERAGE				
0.218±0.007	[40] ABBIENDI	04E	OPAL	$E^{ee}_{\text{cm}} = 91.2$ GeV
0.230±0.010±0.010	[41] ACKERSTAFF	97T	OPAL	E^{ee}_{cm}= 88–94 GeV
$0.243^{+0.036}_{-0.026}$	[42] ABREU	95X	DLPH	E^{ee}_{cm}= 88–94 GeV
0.243±0.022	[43] ADRIANI	93	L3	E^{ee}_{cm}= 91.2 GeV

[40] ABBIENDI 04E select photons with energy > 7 GeV and use Γ(hadrons) = 1744.4 ± 2.0 MeV and $\alpha_s = 0.1172 \pm 0.002$ to obtain $\Gamma_d = 381 \pm 12$ MeV.

[41] ACKERSTAFF 97T measure $\Gamma_{d\overline{d},s\overline{s}}/(\Gamma_{d\overline{d}}+\Gamma_{u\overline{u}}+\Gamma_{s\overline{s}}) = 0.371 \pm 0.016 \pm 0.016$. To obtain this branching ratio authors use $R_c+R_b = 0.380 \pm 0.010$. This measurement is fully negatively correlated with the measurement of $\Gamma_{u\overline{u}}/(\Gamma_{d\overline{d}}+\Gamma_{u\overline{u}}+\Gamma_{s\overline{s}})$ presented in the previous data block.

[42] ABREU 95X use $M_Z = 91.187 \pm 0.009$ GeV, Γ(hadrons) = 1725 ± 12 MeV and $\alpha_s = 0.123 \pm 0.005$. To obtain this branching ratio we divide their value of $C_{1/3} = 1.62^{+0.24}_{-0.17}$ by their value of $(3C_{1/3} + 2C_{2/3}) = 6.66 \pm 0.05$.

[43] ADRIANI 93 use $M_Z = 91.181 \pm 0.022$ GeV, Γ(hadrons) = 1742 ± 19 MeV and $\alpha_s = 0.125 \pm 0.009$. To obtain this branching ratio we divide their value of $C_{1/3} = 1.63 \pm 0.15$ by their value of $(3C_{1/3} + 2C_{2/3}) = 6.720 \pm 0.076$.

$R_c = \Gamma(c\overline{c})/\Gamma(\text{hadrons})$ $\qquad\Gamma_9/\Gamma_6$

OUR FIT is obtained by a simultaneous fit to several *c*- and *b*-quark measurements as explained in the note "The *Z* boson" and ref. LEP-SLC 06.

The Standard Model predicts $R_c = 0.1723$ for $m_t = 174.3$ GeV and $M_H = 150$ GeV.

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.1721±0.0030 OUR FIT				
0.1744±0.0031±0.0021	[44] ABE	05F	SLD	E^{ee}_{cm}=91.28 GeV
0.1665±0.0051±0.0081	[45] ABREU	00	DLPH	E^{ee}_{cm}= 88–94 GeV
0.1698±0.0069	[46] BARATE	00B	ALEP	E^{ee}_{cm}= 88–94 GeV
0.180 ±0.011 ±0.013	[47] ACKERSTAFF	98E	OPAL	E^{ee}_{cm}= 88–94 GeV
0.167 ±0.011 ±0.012	[48] ALEXANDER	96R	OPAL	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.1623±0.0085±0.0209	[49] ABREU	95D	DLPH	E^{ee}_{cm}= 88–94 GeV

[44] ABE 05F use hadronic Z decays collected during 1996–98 to obtain an enriched sample of $c\overline{c}$ events using a double tag method. The single c–tag is obtained with a neural network trained to perform flavor discrimination using as input several signatures (corrected secondary vertex mass, vertex decay length, multiplicity and total momentum of the hemisphere). A multitag approach is used, defining 4 regions of the output value of the neural network and R_c is extracted from a simultaneous fit to the count rates of the 4 different tags. The quoted systematic error includes an uncertainty of ±0.0006 due to the uncertainty on R_b.

[45] ABREU 00 obtain this result properly combining the measurement from the D^{*+} production rate (R_c= 0.1610 ± 0.0104 ± 0.0077 ± 0.0043 (BR)) with that from the overall charm counting (R_c= 0.1692 ± 0.0047 ± 0.0063 ± 0.0074 (BR)) in $c\overline{c}$ events. The systematic error includes an uncertainty of ±0.0054 due to the uncertainty on the charmed hadron branching fractions.

[46] BARATE 00B use exclusive decay modes to independently determine the quantities $R_c\times$f($c \rightarrow$ X), X=D^0, D^+, D^+_s, and Λ_c. Estimating $R_c\times$f($c \rightarrow$ Ξ_c/Ω_c)= 0.0034, they simply sum over all the charm decays to obtain R_c= 0.1738 ± 0.0047 ± 0.0088 ± 0.0075(BR). This is combined with all previous ALEPH measurements (BARATE 98T and BUSKULIC 94G, R_c= 0.1681 ± 0.0054 ± 0.0062) to obtain the quoted value.

[47] ACKERSTAFF 98E use an inclusive/exclusive double tag. In one jet $D^{*\pm}$ mesons are exclusively reconstructed in several decay channels and in the opposite jet a slow pion (opposite charge inclusive $D^{*\pm}$) tag is used. The b content of this sample is measured by the simultaneous detection of a lepton in one jet and an inclusively reconstructed $D^{*\pm}$ meson in the opposite jet. The systematic error includes an uncertainty of ±0.006 due to the external branching ratios.

[48] ALEXANDER 96R obtain this value via direct charm counting, summing the partial contributions from D^0, D^+, D^+_s, and Λ^+_c, and assuming that strange-charmed baryons account for the 15% of the Λ^+_c production. An uncertainty of ±0.005 due to the uncertainties in the charm hadron branching ratios is included in the overall systematics.

[49] ABREU 95D perform a maximum likelihood fit to the combined p and p_T distributions of single and dilepton samples. The second error includes an uncertainty of ±0.0124 due to models and branching ratios.

$R_b = \Gamma(b\overline{b})/\Gamma(\text{hadrons})$ Γ_{10}/Γ_6

OUR FIT is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the note "The Z boson" and ref. LEP-SLC 06.

The Standard Model predicts R_b=0.21581 for m_t=174.3 GeV and M_H=150 GeV.

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.21629±0.00066 OUR FIT				
0.21594±0.00094±0.00075	[50] ABE	05F	SLD	E^{ee}_{cm}=91.28 GeV
0.2174 ±0.0015 ±0.0028	[51] ACCIARRI	00	L3	E^{ee}_{cm}= 89–93 GeV
0.2178 ±0.0011 ±0.0013	[52] ABBIENDI	99B	OPAL	E^{ee}_{cm}= 88–94 GeV
0.21634±0.00067±0.00060	[53] ABREU	99B	DLPH	E^{ee}_{cm}= 88–94 GeV
0.2159 ±0.0009 ±0.0011	[54] BARATE	97F	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.2145 ±0.0089 ±0.0067	[55] ABREU	95D	DLPH	E^{ee}_{cm}= 88–94 GeV
0.219 ±0.006 ±0.005	[56] BUSKULIC	94G	ALEP	E^{ee}_{cm}= 88–94 GeV
0.251 ±0.049 ±0.030	[57] JACOBSEN	91	MRK2	E^{ee}_{cm}= 91 GeV

[50] ABE 05F use hadronic Z decays collected during 1996–98 to obtain an enriched sample of $b\bar{b}$ events using a double tag method. The single b–tag is obtained with a neural network trained to perform flavor discrimination using as input several signatures (corrected secondary vertex mass, vertex decay length, multiplicity and total momentum of the hemisphere; the key tag is obtained requiring the secondary vertex corrected mass to be above the D–meson mass). ABE 05F obtain R_b =0.21604 ± 0.00098 ± 0.00074 where the systematic error includes an uncertainty of ±0.00012 due to the uncertainty on R_c. The value reported here is obtained properly combining with ABE 98D. The quoted systematic error includes an uncertainty of ±0.00012 due to the uncertainty on R_c.

[51] ACCIARRI 00 obtain this result using a double-tagging technique, with a high p_T lepton tag and an impact parameter tag in opposite hemispheres.

[52] ABBIENDI 99B tag $Z \rightarrow b\bar{b}$ decays using leptons and/or separated decay vertices. The b-tagging efficiency is measured directly from the data using a double-tagging technique.

[53] ABREU 99B obtain this result combining in a multivariate analysis several tagging methods (impact parameter and secondary vertex reconstruction, complemented by event shape variables). For R_c different from its Standard Model value of 0.172, R_b varies as $-0.024\times(R_c–0.172)$.

[54] BARATE 97F combine the lifetime-mass hemisphere tag (BARATE 97E) with event shape information and lepton tag to identify $Z \rightarrow b\bar{b}$ candidates. They further use c- and uds-selection tags to identify the background. For R_c different from its Standard Model value of 0.172, R_b varies as $-0.019\times(R_c - 0.172)$.

[55] ABREU 95D perform a maximum likelihood fit to the combined p and p_T distributions of single and dilepton samples. The second error includes an uncertainty of ±0.0023 due to models and branching ratios.

[56] BUSKULIC 94G perform a simultaneous fit to the p and p_T spectra of both single and dilepton events.

[57] JACOBSEN 91 tagged $b\bar{b}$ events by requiring coincidence of $\geq$ 3 tracks with significant impact parameters using vertex detector. Systematic error includes lifetime and decay uncertainties (±0.014).

$\Gamma(b\bar{b}b\bar{b})/\Gamma(\text{hadrons})$ Γ_{11}/Γ_6

VALUE (units 10^{-4})	*DOCUMENT ID*		*TECN*	*COMMENT*
5.2±1.9 OUR AVERAGE				
3.6±1.7±2.7	[58] ABBIENDI	01G	OPAL	E^{ee}_{cm}= 88–94 GeV
6.0±1.9±1.4	[59] ABREU	99U	DLPH	E^{ee}_{cm}= 88–94 GeV

[58] ABBIENDI 01G use a sample of four-jet events from hadronic Z decays. To enhance the $b\bar{b}b\bar{b}$ signal, at least three of the four jets are required to have a significantly detached secondary vertex.

[59] ABREU 99U force hadronic Z decays into 3 jets to use all the available phase space and require a b tag for every jet. This decay mode includes primary and secondary 4b production, *e.g*, from gluon splitting to $b\bar{b}$.

$\Gamma(ggg)/\Gamma(\text{hadrons})$ Γ_{12}/Γ_6

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<1.6 \times 10^{-2}$	95	[60] ABREU	96S	DLPH	E^{ee}_{cm}= 88–94 GeV

[60] This branching ratio is slightly dependent on the jet-finder algorithm. The value we quote is obtained using the JADE algorithm, while using the DURHAM algorithm ABREU 96S obtain an upper limit of 1.5×10^{-2}.

$\Gamma(\pi^0\gamma)/\Gamma_{\text{total}}$ Γ_{13}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<5.2 \times 10^{-5}$	95	[61] ACCIARRI	95G	L3	E^{ee}_{cm}= 88–94 GeV
$<5.5 \times 10^{-5}$	95	ABREU	94B	DLPH	E^{ee}_{cm}= 88–94 GeV
$<2.1 \times 10^{-4}$	95	DECAMP	92	ALEP	E^{ee}_{cm}= 88–94 GeV
$<1.4 \times 10^{-4}$	95	AKRAWY	91F	OPAL	E^{ee}_{cm}= 88–94 GeV

[61] This limit is for both decay modes $Z \rightarrow \pi^0\gamma/\gamma\gamma$ which are indistinguishable in ACCIARRI 95G.

$\Gamma(\eta\gamma)/\Gamma_{\text{total}}$ Γ_{14}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<7.6 \times 10^{-5}$	95	ACCIARRI	95G	L3	E^{ee}_{cm}= 88–94 GeV
$<8.0 \times 10^{-5}$	95	ABREU	94B	DLPH	E^{ee}_{cm}= 88–94 GeV
$<5.1 \times 10^{-5}$	95	DECAMP	92	ALEP	E^{ee}_{cm}= 88–94 GeV
$<2.0 \times 10^{-4}$	95	AKRAWY	91F	OPAL	E^{ee}_{cm}= 88–94 GeV

$\Gamma(\omega\gamma)/\Gamma_{\text{total}}$ Γ_{15}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<6.5 \times 10^{-4}$	95	ABREU	94B	DLPH	E^{ee}_{cm}= 88–94 GeV

$\Gamma(\eta'(958)\gamma)/\Gamma_{\text{total}}$ Γ_{16}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<4.2 \times 10^{-5}$	95	DECAMP	92	ALEP	E^{ee}_{cm}= 88–94 GeV

$\Gamma(\gamma\gamma)/\Gamma_{\text{total}}$ Γ_{17}/Γ

This decay would violate the Landau-Yang theorem.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<5.2 \times 10^{-5}$	95	[62] ACCIARRI	95G	L3	E^{ee}_{cm}= 88–94 GeV
$<5.5 \times 10^{-5}$	95	ABREU	94B	DLPH	E^{ee}_{cm}= 88–94 GeV
$<1.4 \times 10^{-4}$	95	AKRAWY	91F	OPAL	E^{ee}_{cm}= 88–94 GeV

[62] This limit is for both decay modes $Z \rightarrow \pi^0\gamma/\gamma\gamma$ which are indistinguishable in ACCIARRI 95G.

$\Gamma(\gamma\gamma\gamma)/\Gamma_{\text{total}}$ Γ_{18}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<1.0 \times 10^{-5}$	95	[63] ACCIARRI	95C	L3	E^{ee}_{cm}= 88–94 GeV
$<1.7 \times 10^{-5}$	95	[63] ABREU	94B	DLPH	E^{ee}_{cm}= 88–94 GeV
$<6.6 \times 10^{-5}$	95	AKRAWY	91F	OPAL	E^{ee}_{cm}= 88–94 GeV

[63] Limit derived in the context of composite Z model.

$\Gamma(\pi^{\pm} W^{\mp})/\Gamma_{\rm total}$ Γ_{19}/Γ

The value is for the sum of the charge states indicated.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<7 \times 10^{-5}$	95	DECAMP	92	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

$\Gamma(\rho^{\pm} W^{\mp})/\Gamma_{\rm total}$ Γ_{20}/Γ

The value is for the sum of the charge states indicated.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<8.3 \times 10^{-5}$	95	DECAMP	92	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

$\Gamma(J/\psi(1S)X)/\Gamma_{\rm total}$ Γ_{21}/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
$3.51^{+0.23}_{-0.25}$ OUR AVERAGE Error includes scale factor of 1.1.					
$3.21 \pm 0.21^{+0.19}_{-0.28}$	553	[64] ACCIARRI	99F	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
$3.9 \pm 0.2 \pm 0.3$	511	[65] ALEXANDER	96B	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
$3.73 \pm 0.39 \pm 0.36$	153	[66] ABREU	94P	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV

[64] ACCIARRI 99F combine $\mu^+\mu^-$ and e^+e^- $J/\psi(1S)$ decay channels. The branching ratio for prompt $J/\psi(1S)$ production is measured to be $(2.1 \pm 0.6 \pm 0.4^{+0.4}_{-0.2}(\text{theor.})) \times 10^{-4}$.

[65] ALEXANDER 96B identify $J/\psi(1S)$ from the decays into lepton pairs. (4.8 ± 2.4)% of this branching ratio is due to prompt $J/\psi(1S)$ production (ALEXANDER 96N).

[66] Combining $\mu^+\mu^-$ and e^+e^- channels and taking into account the common systematic errors. $(7.7^{+6.3}_{-5.4})$% of this branching ratio is due to prompt $J/\psi(1S)$ production.

$\Gamma(\psi(2S)X)/\Gamma_{\rm total}$ Γ_{22}/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
1.60 ± 0.29 OUR AVERAGE					
$1.6 \pm 0.5 \pm 0.3$	39	[67] ACCIARRI	97J	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
$1.6 \pm 0.3 \pm 0.2$	46.9	[68] ALEXANDER	96B	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
$1.60 \pm 0.73 \pm 0.33$	5.4	[69] ABREU	94P	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV

[67] ACCIARRI 97J measure this branching ratio via the decay channel $\psi(2S) \rightarrow \ell^+\ell^-$ ($\ell = \mu$, e).

[68] ALEXANDER 96B measure this branching ratio via the decay channel $\psi(2S) \rightarrow J/\psi \pi^+\pi^-$, with $J/\psi \rightarrow \ell^+\ell^-$.

[69] ABREU 94P measure this branching ratio via decay channel $\psi(2S) \rightarrow J/\psi \pi^+\pi^-$, with $J/\psi \rightarrow \mu^+\mu^-$.

$\Gamma(\chi_{c1}(1P)X)/\Gamma_{\rm total}$ Γ_{23}/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
2.9 ± 0.7 OUR AVERAGE					
$2.7 \pm 0.6 \pm 0.5$	33	[70] ACCIARRI	97J	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
$5.0 \pm 2.1^{+1.5}_{-0.9}$	6.4	[71] ABREU	94P	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV

[70] ACCIARRI 97J measure this branching ratio via the decay channel $\chi_{c1} \rightarrow J/\psi + \gamma$, with $J/\psi \rightarrow \ell^+\ell^-$ ($\ell = \mu$, e). The $M(\ell^+\ell^-\gamma)$–$M(\ell^+\ell^-)$ mass difference spectrum is fitted with two gaussian shapes for χ_{c1} and χ_{c2}.

[71] This branching ratio is measured via the decay channel $\chi_{c1} \rightarrow J/\psi + \gamma$, with $J/\psi \rightarrow \mu^+\mu^-$.

$\Gamma(\chi_{c2}(1P)X)/\Gamma_{\text{total}}$ Γ_{24}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<3.2 \times 10^{-3}$	90	[72] ACCIARRI	97J	L3	E^{ee}_{cm}= 88–94 GeV

[72] ACCIARRI 97J derive this limit via the decay channel $\chi_{c2} \rightarrow J/\psi + \gamma$, with $J/\psi \rightarrow \ell^+ \ell^-$ ($\ell = \mu$, e). The $M(\ell^+ \ell^- \gamma)$–$M(\ell^+ \ell^-)$ mass difference spectrum is fitted with two gaussian shapes for χ_{c1} and χ_{c2}.

$\Gamma(\Upsilon(1S)X + \Upsilon(2S)X + \Upsilon(3S)X)/\Gamma_{\text{total}}$ $\Gamma_{25}/\Gamma = (\Gamma_{26}+\Gamma_{27}+\Gamma_{28})/\Gamma$

VALUE (units 10^{-4})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.0±0.4±0.22	6.4	[73] ALEXANDER	96F	OPAL	E^{ee}_{cm}= 88–94 GeV

[73] ALEXANDER 96F identify the Υ (which refers to any of the three lowest bound states) through its decay into $e^+ e^-$ and $\mu^+ \mu^-$. The systematic error includes an uncertainty of ±0.2 due to the production mechanism.

$\Gamma(\Upsilon(1S)X)/\Gamma_{\text{total}}$ Γ_{26}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<4.4 \times 10^{-5}$	95	[74] ACCIARRI	99F	L3	E^{ee}_{cm}= 88–94 GeV

[74] ACCIARRI 99F search for $\Upsilon(1S)$ through its decay into $\ell^+ \ell^-$ ($\ell = e$ or μ).

$\Gamma(\Upsilon(2S)X)/\Gamma_{\text{total}}$ Γ_{27}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<13.9 \times 10^{-5}$	95	[75] ACCIARRI	97R	L3	E^{ee}_{cm}= 88–94 GeV

[75] ACCIARRI 97R search for $\Upsilon(2S)$ through its decay into $\ell^+ \ell^-$ ($\ell = e$ or μ).

$\Gamma(\Upsilon(3S)X)/\Gamma_{\text{total}}$ Γ_{28}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<9.4 \times 10^{-5}$	95	[76] ACCIARRI	97R	L3	E^{ee}_{cm}= 88–94 GeV

[76] ACCIARRI 97R search for $\Upsilon(3S)$ through its decay into $\ell^+ \ell^-$ ($\ell = e$ or μ).

$\Gamma((D^0/\overline{D}^0)X)/\Gamma(\text{hadrons})$ Γ_{29}/Γ_6

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.296±0.019±0.021	369	[77] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV

[77] The $(D^0/\overline{D}^0)$ states in ABREU 93I are detected by the $K\pi$ decay mode. This is a corrected result (see the erratum of ABREU 93I).

$\Gamma(D^{\pm}X)/\Gamma(\text{hadrons})$ Γ_{30}/Γ_6

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.174±0.016±0.018	539	[78] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV

[78] The $D^{\pm}$ states in ABREU 93I are detected by the $K\pi\pi$ decay mode. This is a corrected result (see the erratum of ABREU 93I).

$\Gamma(D^*(2010)^{\pm}X)/\Gamma(\text{hadrons})$ Γ_{31}/Γ_6

The value is for the sum of the charge states indicated.

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.163±0.019 OUR AVERAGE	Error includes scale factor of 1.3.				
0.155±0.010±0.013	358	[79] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV
0.21 ±0.04	362	[80] DECAMP	91J	ALEP	E^{ee}_{cm}= 88–94 GeV

[79] $D^*(2010)^\pm$ in ABREU 93I are reconstructed from $D^0\pi^\pm$, with $D^0 \rightarrow K^-\pi^+$. The new CLEO II measurement of $B(D^{*\pm} \rightarrow D^0\pi^\pm) = (68.1 \pm 1.6)$ % is used. This is a corrected result (see the erratum of ABREU 93I).

[80] DECAMP 91J report $B(D^*(2010)^+ \rightarrow D^0\pi^+)$ $B(D^0 \rightarrow K^-\pi^+)$ $\Gamma(D^*(2010)^\pm X)$ / Γ(hadrons) $= (5.11 \pm 0.34) \times 10^{-3}$. They obtained the above number assuming $B(D^0 \rightarrow K^-\pi^+) = (3.62\pm0.34\pm0.44)\%$ and $B(D^*(2010)^+ \rightarrow D^0\pi^+) = (55\pm4)\%$. We have rescaled their original result of 0.26 ± 0.05 taking into account the new CLEO II branching ratio $B(D^*(2010)^+ \rightarrow D^0\pi^+) = (68.1 \pm 1.6)\%$.

$\Gamma(D_{s1}(2536)^\pm X)/\Gamma(\text{hadrons})$ Γ_{32}/Γ_6

$D_{s1}(2536)^\pm$ is an expected orbitally-excited state of the D_s meson.

VALUE (%)	EVTS	DOCUMENT ID		TECN	COMMENT
0.52±0.09±0.06	92	[81] HEISTER	02B	ALEP	E^{ee}_{cm}= 88–94 GeV

[81] HEISTER 02B reconstruct this meson in the decay modes $D_{s1}(2536)^\pm \rightarrow D^{*\pm}K^0$ and $D_{s1}(2536)^\pm \rightarrow D^{*0}K^\pm$. The quoted branching ratio assumes that the decay width of the $D_{s1}(2536)$ is saturated by the two measured decay modes.

$\Gamma(D_{sJ}(2573)^\pm X)/\Gamma(\text{hadrons})$ Γ_{33}/Γ_6

$D_{sJ}(2573)^\pm$ is an expected orbitally-excited state of the D_s meson.

VALUE (%)	EVTS	DOCUMENT ID		TECN	COMMENT
$\mathbf{0.83\pm0.29^{+0.07}_{-0.13}}$	64	[82] HEISTER	02B	ALEP	E^{ee}_{cm}= 88–94 GeV

[82] HEISTER 02B reconstruct this meson in the decay mode $D_{s2}(2573)^\pm \rightarrow D^0K^\pm$. The quoted branching ratio assumes that the detected decay mode represents 45% of the full decay width.

$\Gamma(D^{*\prime}(2629)^\pm X)/\Gamma(\text{hadrons})$ Γ_{34}/Γ_6

$D^{*\prime}(2629)^\pm$ is a predicted radial excitation of the $D^*(2010)^\pm$ meson.

VALUE	DOCUMENT ID		TECN	COMMENT
searched for	[83] ABBIENDI	01N	OPAL	E^{ee}_{cm}= 88–94 GeV

[83] ABBIENDI 01N searched for the decay mode $D^{*\prime}(2629)^\pm \rightarrow D^{*\pm}\pi^+\pi^-$ with $D^{*+} \rightarrow D^0\pi^+$, and $D^0 \rightarrow K^-\pi^+$. They quote a 95% CL limit for $Z \rightarrow D^{*\prime}(2629)^\pm \times B(D^{*\prime}(2629)^+ \rightarrow D^{*+}\pi^+\pi^-) < 3.1 \times 10^{-3}$.

$\Gamma(B^*X)/[\Gamma(BX)+\Gamma(B^*X)]$ $\Gamma_{36}/(\Gamma_{35}+\Gamma_{36})$

As the experiments assume different values of the b-baryon contribution, our average should be taken with caution.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.75 ±0.04 OUR AVERAGE					
0.760±0.036±0.083		[84] ACKERSTAFF	97M	OPAL	E^{ee}_{cm}= 88–94 GeV
0.771±0.026±0.070		[85] BUSKULIC	96D	ALEP	E^{ee}_{cm}= 88–94 GeV
0.72 ±0.03 ±0.06		[86] ABREU	95R	DLPH	E^{ee}_{cm}= 88–94 GeV
0.76 ±0.08 ±0.06	1378	[87] ACCIARRI	95B	L3	E^{ee}_{cm}= 88–94 GeV

[84] ACKERSTAFF 97M use an inclusive B reconstruction method and assume a (13.2 ± 4.1)% b-baryon contribution. The value refers to a b-flavored meson mixture of B_u, B_d, and B_s.

[85] BUSKULIC 96D use an inclusive reconstruction of B hadrons and assume a (12.2 ± 4.3)% b-baryon contribution. The value refers to a b-flavored mixture of B_u, B_d, and B_s.

[86] ABREU 95R use an inclusive B-reconstruction method and assume a (10 ± 4)% b-baryon contribution. The value refers to a b-flavored meson mixture of B_u, B_d, and B_s.

[87] ACCIARRI 95B assume a 9.4% b-baryon contribution. The value refers to a b-flavored mixture of B_u, B_d, and B_s.

$\Gamma(B^+ X)/\Gamma(\text{hadrons})$ Γ_{37}/Γ_6

"OUR EVALUATION" is obtained using our current values for $f(\overline{b} \rightarrow B^+)$ and $R_b = \Gamma(b\overline{b})/\Gamma(\text{hadrons})$. We calculate $\Gamma(B^+ X)/\Gamma(\text{hadrons}) = R_b \times f(\overline{b} \rightarrow B^+)$. The decay fraction $f(\overline{b} \rightarrow B^+)$ was provided by the Heavy Flavor Averaging Group (HFAG, http://www.slac.stanford.edu/xorg/hfag/osc/PDG_2009/#FRACZ).

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.0869±0.0019 OUR EVALUATION			
0.0887±0.0030	[88] ABDALLAH 03K	DLPH	$E^{ee}_{\text{cm}} = 88$–94 GeV

[88] ABDALLAH 03K measure the production fraction of B^+ mesons in hadronic Z decays $f(B^+) = (40.99 \pm 0.82 \pm 1.11)$%. The value quoted here is obtained multiplying this production fraction by our value of $R_b = \Gamma(\overline{b}b)/\Gamma(\text{hadrons})$.

$\Gamma(B^0_s X)/\Gamma(\text{hadrons})$ Γ_{38}/Γ_6

"OUR EVALUATION" is obtained using our current values for $f(\overline{b} \rightarrow B^0_s)$ and $R_b = \Gamma(b\overline{b})/\Gamma(\text{hadrons})$. We calculate $\Gamma(B^0_s)/\Gamma(\text{hadrons}) = R_b \times f(\overline{b} \rightarrow B^0_s)$. The decay fraction $f(\overline{b} \rightarrow B^0_s)$ was provided by the Heavy Flavor Averaging Group (HFAG, http://www.slac.stanford.edu/xorg/hfag/osc/PDG_2009/#FRACZ).

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.0227±0.0019 OUR EVALUATION			
seen	[89] ABREU 92M	DLPH	$E^{ee}_{\text{cm}} = 88$–94 GeV
seen	[90] ACTON 92N	OPAL	$E^{ee}_{\text{cm}} = 88$–94 GeV
seen	[91] BUSKULIC 92E	ALEP	$E^{ee}_{\text{cm}} = 88$–94 GeV

[89] ABREU 92M reported value is $\Gamma(B^0_s X) * B(B^0_s \rightarrow D_s \mu \nu_\mu X) * B(D_s \rightarrow \phi\pi)/\Gamma(\text{hadrons}) = (18 \pm 8) \times 10^{-5}$.

[90] ACTON 92N find evidence for B^0_s production using D_s-ℓ correlations, with $D^+_s \rightarrow \phi\pi^+$ and $K^*(892) K^+$. Assuming R_b from the Standard Model and averaging over the e and μ channels, authors measure the product branching fraction to be $f(\overline{b} \rightarrow B^0_s) \times B(B^0_s \rightarrow D^-_s \ell^+ \nu_\ell X) \times B(D^-_s \rightarrow \phi\pi^-) = (3.9 \pm 1.1 \pm 0.8) \times 10^{-4}$.

[91] BUSKULIC 92E find evidence for B^0_s production using D_s-ℓ correlations, with $D^+_s \rightarrow \phi\pi^+$ and $K^*(892) K^+$. Using $B(D^+_s \rightarrow \phi\pi^+) = (2.7 \pm 0.7)$% and summing up the e and μ channels, the weighted average product branching fraction is measured to be $B(\overline{b} \rightarrow B^0_s) \times B(B^0_s \rightarrow D^-_s \ell^+ \nu_\ell X) = 0.040 \pm 0.011^{+0.010}_{-0.012}$.

$\Gamma(B_c^+ X)/\Gamma(\text{hadrons})$ Γ_{39}/Γ_6

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
searched for	[92] ACKERSTAFF	98O	OPAL	E^{ee}_{cm}= 88–94 GeV
searched for	[93] ABREU	97E	DLPH	E^{ee}_{cm}= 88–94 GeV
searched for	[94] BARATE	97H	ALEP	E^{ee}_{cm}= 88–94 GeV

[92] ACKERSTAFF 98O searched for the decay modes $B_c \to J/\psi\pi^+$, $J/\psi a_1^+$, and $J/\psi\ell^+\nu_\ell$, with $J/\psi \to \ell^+\ell^-$, $\ell = e,\mu$. The number of candidates (background) for the three decay modes is 2 (0.63 ± 0.2), 0 (1.10 ± 0.22), and 1 (0.82 ± 0.19) respectively. Interpreting the 2 $B_c \to J/\psi\pi^+$ candidates as signal, they report $\Gamma(B_c^+ X)\times B(B_c \to J/\psi\pi^+)/\Gamma(\text{hadrons}) = (3.8^{+5.0}_{-2.4} \pm 0.5)\times 10^{-5}$. Interpreted as background, the 90% CL bounds are $\Gamma(B_c^+ X)*B(B_c \to J/\psi\pi^+)/\Gamma(\text{hadrons}) < 1.06\times 10^{-4}$, $\Gamma(B_c^+ X)*B(B_c \to J/\psi a_1^+)/\Gamma(\text{hadrons}) < 5.29 \times 10^{-4}$, $\Gamma(B_c^+ X)*B(B_c \to J/\psi\ell^+\nu_\ell)/\Gamma(\text{hadrons}) < 6.96 \times 10^{-5}$.

[93] ABREU 97E searched for the decay modes $B_c \to J/\psi\pi^+$, $J/\psi\ell^+\nu_\ell$, and $J/\psi(3\pi)^+$, with $J/\psi \to \ell^+\ell^-$, $\ell = e,\mu$. The number of candidates (background) for the three decay modes is 1 (1.7), 0 (0.3), and 1 (2.3) respectively. They report the following 90% CL limits: $\Gamma(B_c^+ X)*B(B_c \to J/\psi\pi^+)/\Gamma(\text{hadrons}) <(1.05\text{–}0.84) \times 10^{-4}$, $\Gamma(B_c^+ X)*B(B_c \to J/\psi\ell\nu_\ell)/\Gamma(\text{hadrons}) <(5.8\text{–}5.0) \times 10^{-5}$, $\Gamma(B_c^+ X)*B(B_c \to J/\psi(3\pi)^+)/\Gamma(\text{hadrons}) < 1.75 \times 10^{-4}$, where the ranges are due to the predicted B_c lifetime (0.4–1.4) ps.

[94] BARATE 97H searched for the decay modes $B_c \to J/\psi\pi^+$ and $J/\psi\ell^+\nu_\ell$ with $J/\psi \to \ell^+\ell^-$, $\ell = e,\mu$. The number of candidates (background) for the two decay modes is 0 (0.44) and 2 (0.81) respectively. They report the following 90% CL limits: $\Gamma(B_c^+ X)*B(B_c \to J/\psi\pi^+)/\Gamma(\text{hadrons}) < 3.6 \times 10^{-5}$ and $\Gamma(B_c^+ X)*B(B_c \to J/\psi\ell^+\nu_\ell)/\Gamma(\text{hadrons}) < 5.2 \times 10^{-5}$.

$\Gamma(\Lambda_c^+ X)/\Gamma(\text{hadrons})$ Γ_{40}/Γ_6

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.022±0.005 OUR AVERAGE				
0.024±0.005±0.006	[95] ALEXANDER	96R	OPAL	E^{ee}_{cm} = 88–94 GeV
0.021±0.003±0.005	[96] BUSKULIC	96Y	ALEP	E^{ee}_{cm} = 88–94 GeV

[95] ALEXANDER 96R measure $R_b \times f(b \to \Lambda_c^+ X) \times B(\Lambda_c^+ \to pK^-\pi^+) = (0.122 \pm 0.023 \pm 0.010)\%$ in hadronic Z decays; the value quoted here is obtained using our best value $B(\Lambda_c^+ \to pK^-\pi^+) = (5.0 \pm 1.3)\%$. The first error is the total experiment's error and the second error is the systematic error due to the branching fraction uncertainty.

[96] BUSKULIC 96Y obtain the production fraction of Λ_c^+ baryons in hadronic Z decays $f(b \to \Lambda_c^+ X) = 0.110 \pm 0.014 \pm 0.006$ using $B(\Lambda_c^+ \to pK^-\pi^+) = (4.4 \pm 0.6)\%$; we have rescaled using our best value $B(\Lambda_c^+ \to pK^-\pi^+) = (5.0 \pm 1.3)\%$ obtaining $f(b \to \Lambda_c^+ X) = 0.097 \pm 0.013 \pm 0.025$ where the first error is their total experiment's error and the second error is the systematic error due to the branching fraction uncertainty. The value quoted here is obtained multiplying this production fraction by our value of $R_b = \Gamma(b\overline{b})/\Gamma(\text{hadrons})$.

$\Gamma(\Xi_c^0 X)/\Gamma(\text{hadrons})$ Γ_{41}/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	[97] ABDALLAH	05C	DLPH	$E_{\rm cm}^{ee}$ = 88–94 GeV

[97] ABDALLAH 05C searched for the charmed strange baryon Ξ_c^0 in the decay channel $\Xi_c^0 \to \Xi^- \pi^+$ ($\Xi^- \to \Lambda \pi^-$). The production rate is measured to be $f_{\Xi_c^0} \times$ B($\Xi_c^0 \to \Xi^- \pi^+$) = $(4.7 \pm 1.4 \pm 1.1) \times 10^{-4}$ per hadronic Z decay.

$\Gamma(\Xi_b X)/\Gamma(\text{hadrons})$ Γ_{42}/Γ_6

Here Ξ_b is used as a notation for the strange b-baryon states Ξ_b^- and Ξ_b^0.

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	[98] ABDALLAH	05C	DLPH	$E_{\rm cm}^{ee}$ = 88–94 GeV
seen	[99] BUSKULIC	96T	ALEP	$E_{\rm cm}^{ee}$ = 88–94 GeV
seen	[100] ABREU	95V	DLPH	$E_{\rm cm}^{ee}$ = 88–94 GeV

[98] ABDALLAH 05C searched for the beauty strange baryon Ξ_b in the inclusive semileptonic decay channel $\Xi_b \to \Xi^- \ell^- \overline{\nu}_\ell X$. Evidence for the Ξ_b production is seen from the observation of $\Xi^\mp$ production accompanied by a lepton of the same sign. From the excess of "right-sign" pairs $\Xi^\mp \ell^\mp$ compared to "wrong-sign" pairs $\Xi^\mp \ell^\pm$ the production rate is measured to be B($b \to \Xi_b$) × B($\Xi_b \to \Xi^- \ell^- X$) = $(3.0 \pm 1.0 \pm 0.3) \times 10^{-4}$ per lepton species, averaged over electrons and muons.

[99] BUSKULIC 96T investigate Ξ-lepton correlations and find a significant excess of "right–sign" pairs $\Xi^\mp \ell^\mp$ compared to "wrong–sign" pairs $\Xi^\mp \ell^\pm$. This excess is interpreted as evidence for Ξ_b semileptonic decay. The measured product branching ratio is B($b \to \Xi_b$) × B($\Xi_b \to X_c X \ell^- \overline{\nu}_\ell$) × B($X_c \to \Xi^- X'$) = $(5.4 \pm 1.1 \pm 0.8) \times 10^{-4}$ per lepton species, averaged over electrons and muons, with X_c a charmed baryon.

[100] ABREU 95V observe an excess of "right-sign" pairs $\Xi^\mp \ell^\mp$ compared to "wrong-sign" pairs $\Xi^\mp \ell^\pm$ in jets: this excess is interpreted as evidence for the beauty strange baryon Ξ_b production, with $\Xi_b \to \Xi^- \ell^- \overline{\nu}_\ell X$. They find that the probability for this signal to come from non b-baryon decays is less than 5×10^{-4} and that Λ_b decays can account for less than 10% of these events. The Ξ_b production rate is then measured to be B($b \to \Xi_b$) × B($\Xi_b \to \Xi^- \ell^- X$) = $(5.9 \pm 2.1 \pm 1.0) \times 10^{-4}$ per lepton species, averaged over electrons and muons.

$\Gamma(b\text{-baryon } X)/\Gamma(\text{hadrons})$ Γ_{43}/Γ_6

"OUR EVALUATION" is obtained using our current values for f($b \to$ b-baryon) and $R_b = \Gamma(b\overline{b})/\Gamma(\text{hadrons})$. We calculate Γ(b-baryon X)/Γ(hadrons) = R_b × f($b \to$ b-baryon). The decay fraction f($b \to$ b-baryon) was provided by the Heavy Flavor Averaging Group (HFAG, http://www.slac.stanford.edu/xorg/hfag/osc/PDG_2009).

VALUE	DOCUMENT ID		TECN	COMMENT
0.0197±0.0032 OUR EVALUATION				
0.0221±0.0015±0.0058	[101] BARATE	98V	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV

[101] BARATE 98V use the overall number of identified protons in b-hadron decays to measure f($b \to$ b-baryon) = $0.102 \pm 0.007 \pm 0.027$. They assume BR(b-baryon→ pX) = (58 ± 6)% and BR($B_s^0 \to pX$) = (8.0 ± 4.0)%. The value quoted here is obtained multiplying this production fraction by our value of $R_b = \Gamma(b\overline{b})/\Gamma(\text{hadrons})$.

$\Gamma(\text{anomalous }\gamma+\text{hadrons})/\Gamma_{\text{total}}$ Γ_{44}/Γ

Limits on additional sources of prompt photons beyond expectations for final-state bremsstrahlung.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<3.2 \times 10^{-3}$	95	[102] AKRAWY	90J	OPAL	E^{ee}_{cm}= 88–94 GeV

[102] AKRAWY 90J report $\Gamma(\gamma X) <$ 8.2 MeV at 95%CL. They assume a three-body $\gamma q \overline{q}$ distribution and use $E(\gamma) >$ 10 GeV.

$\Gamma(e^+ e^- \gamma)/\Gamma_{\text{total}}$ Γ_{45}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<5.2 \times 10^{-4}$	95	[103] ACTON	91B	OPAL	E^{ee}_{cm}= 91.2 GeV

[103] ACTON 91B looked for isolated photons with $E>$2% of beam energy ($>$ 0.9 GeV).

$\Gamma(\mu^+ \mu^- \gamma)/\Gamma_{\text{total}}$ Γ_{46}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<5.6 \times 10^{-4}$	95	[104] ACTON	91B	OPAL	E^{ee}_{cm}= 91.2 GeV

[104] ACTON 91B looked for isolated photons with $E>$2% of beam energy ($>$ 0.9 GeV).

$\Gamma(\tau^+ \tau^- \gamma)/\Gamma_{\text{total}}$ Γ_{47}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<7.3 \times 10^{-4}$	95	[105] ACTON	91B	OPAL	E^{ee}_{cm}= 91.2 GeV

[105] ACTON 91B looked for isolated photons with $E>$2% of beam energy ($>$ 0.9 GeV).

$\Gamma(\ell^+ \ell^- \gamma\gamma)/\Gamma_{\text{total}}$ Γ_{48}/Γ

The value is the sum over $\ell = e, \mu, \tau$.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<6.8 \times 10^{-6}$	95	[106] ACTON	93E	OPAL	E^{ee}_{cm}= 88–94 GeV

[106] For $m_{\gamma\gamma} = 60 \pm 5$ GeV.

$\Gamma(q\overline{q}\gamma\gamma)/\Gamma_{\text{total}}$ Γ_{49}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<5.5 \times 10^{-6}$	95	[107] ACTON	93E	OPAL	E^{ee}_{cm}= 88–94 GeV

[107] For $m_{\gamma\gamma} = 60 \pm 5$ GeV.

$\Gamma(\nu\overline{\nu}\gamma\gamma)/\Gamma_{\text{total}}$ Γ_{50}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<3.1 \times 10^{-6}$	95	[108] ACTON	93E	OPAL	E^{ee}_{cm}= 88–94 GeV

[108] For $m_{\gamma\gamma} = 60 \pm 5$ GeV.

$\Gamma(e^{\pm} \mu^{\mp})/\Gamma_{\text{total}}$ Γ_{51}/Γ

Test of lepton family number conservation. The value is for the sum of the charge states indicated.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<2.5 \times 10^{-6}$	95	ABREU	97C	DLPH	E^{ee}_{cm}= 88–94 GeV
$<1.7 \times 10^{-6}$	95	AKERS	95W	OPAL	E^{ee}_{cm}= 88–94 GeV
$<0.6 \times 10^{-5}$	95	ADRIANI	93I	L3	E^{ee}_{cm}= 88–94 GeV
$<2.6 \times 10^{-5}$	95	DECAMP	92	ALEP	E^{ee}_{cm}= 88–94 GeV

$\Gamma(e^{\pm}\mu^{\mp})/\Gamma(e^{+}e^{-})$ Γ_{51}/Γ_{1}

Test of lepton family number conservation. The value is for the sum of the charge states indicated.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<0.07	90	ALBAJAR	89	UA1	$E^{p\overline{p}}_{\text{cm}}$= 546,630 GeV

$\Gamma(e^{\pm}\tau^{\mp})/\Gamma_{\text{total}}$ Γ_{52}/Γ

Test of lepton family number conservation. The value is for the sum of the charge states indicated.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<2.2\times10^{-5}$	95	ABREU	97C	DLPH	E^{ee}_{cm}= 88–94 GeV
$\mathbf{<9.8\times10^{-6}}$	95	AKERS	95W	OPAL	E^{ee}_{cm}= 88–94 GeV
$<1.3\times10^{-5}$	95	ADRIANI	93I	L3	E^{ee}_{cm}= 88–94 GeV
$<1.2\times10^{-4}$	95	DECAMP	92	ALEP	E^{ee}_{cm}= 88–94 GeV

$\Gamma(\mu^{\pm}\tau^{\mp})/\Gamma_{\text{total}}$ Γ_{53}/Γ

Test of lepton family number conservation. The value is for the sum of the charge states indicated.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$\mathbf{<1.2\times10^{-5}}$	95	ABREU	97C	DLPH	E^{ee}_{cm}= 88–94 GeV
$<1.7\times10^{-5}$	95	AKERS	95W	OPAL	E^{ee}_{cm}= 88–94 GeV
$<1.9\times10^{-5}$	95	ADRIANI	93I	L3	E^{ee}_{cm}= 88–94 GeV
$<1.0\times10^{-4}$	95	DECAMP	92	ALEP	E^{ee}_{cm}= 88–94 GeV

$\Gamma(pe)/\Gamma_{\text{total}}$ Γ_{54}/Γ

Test of baryon number and lepton number conservations. Charge conjugate states are implied.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$\mathbf{<1.8\times10^{-6}}$	95	[109] ABBIENDI	99I	OPAL	E^{ee}_{cm}= 88–94 GeV

[109] ABBIENDI 99I give the 95%CL limit on the partial width $\Gamma(Z^0 \rightarrow pe) < 4.6$ KeV and we have transformed it into a branching ratio.

$\Gamma(p\mu)/\Gamma_{\text{total}}$ Γ_{55}/Γ

Test of baryon number and lepton number conservations. Charge conjugate states are implied.

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$\mathbf{<1.8\times10^{-6}}$	95	[110] ABBIENDI	99I	OPAL	E^{ee}_{cm}= 88–94 GeV

[110] ABBIENDI 99I give the 95%CL limit on the partial width $\Gamma(Z^0 \rightarrow p\mu) < 4.4$ KeV and we have transformed it into a branching ratio.

AVERAGE PARTICLE MULTIPLICITIES IN HADRONIC *Z* DECAY

Summed over particle and antiparticle, when appropriate.

$\langle N_{\gamma}\rangle$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
20.97±0.02±1.15	ACKERSTAFF	98A	OPAL	E^{ee}_{cm}= 91.2 GeV

$\langle N_{\pi^\pm} \rangle$

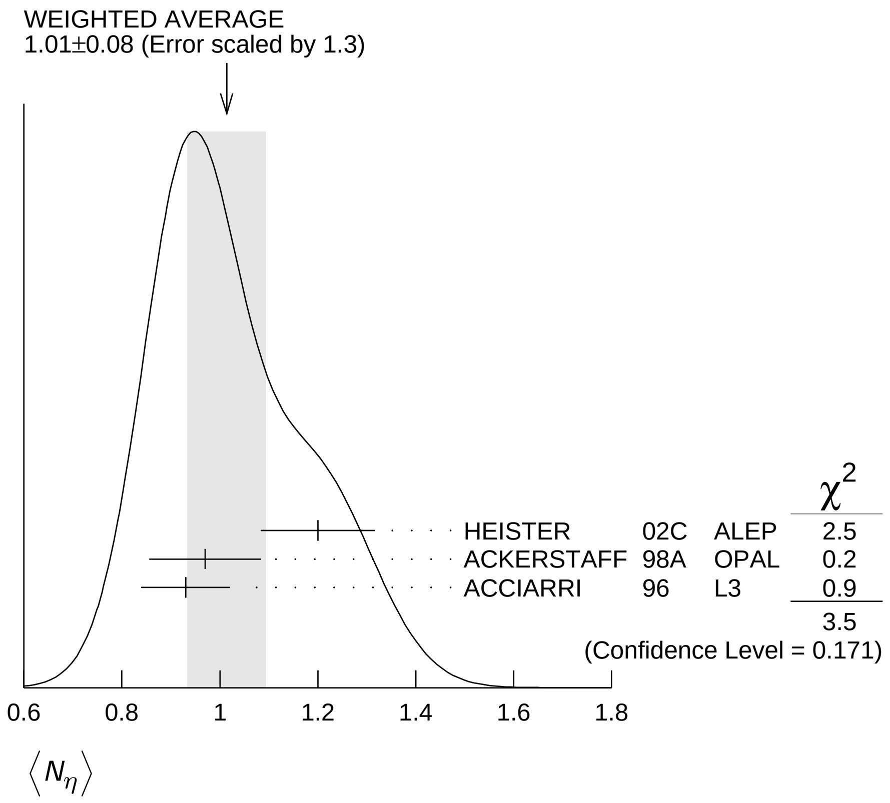
VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
17.03 ±0.16 OUR AVERAGE			
17.007±0.209	ABE 04C	SLD	$E^{ee}_{\rm cm}$= 91.2 GeV
17.26 ±0.10 ±0.88	ABREU 98L	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
17.04 ±0.31	BARATE 98V	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
17.05 ±0.43	AKERS 94P	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\pi^0} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
9.76±0.26 OUR AVERAGE			
9.55±0.06±0.75	ACKERSTAFF 98A	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
9.63±0.13±0.63	BARATE 97J	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
9.90±0.02±0.33	ACCIARRI 96	L3	$E^{ee}_{\rm cm}$= 91.2 GeV
9.2 ±0.2 ±1.0	ADAM 96	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\eta} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
1.01±0.08 OUR AVERAGE	Error includes scale factor of 1.3. See the ideogram below.		
1.20±0.04±0.11	HEISTER 02C	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
0.97±0.03±0.11	ACKERSTAFF 98A	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
0.93±0.01±0.09	ACCIARRI 96	L3	$E^{ee}_{\rm cm}$= 91.2 GeV



$\langle N_{\rho^\pm} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
2.57±0.15 OUR AVERAGE				
2.59±0.03±0.16	[111] BEDDALL	09		ALEPH archive, $E^{ee}_{\rm cm}$= 91.2 GeV
2.40±0.06±0.43	ACKERSTAFF	98A	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

[111] BEDDALL 09 analyse 3.2 million hadronic Z decays as archived by ALEPH collaboration and report a value of 2.59 ± 0.03 ± 0.15 ± 0.04. The first error is statistcal, the second systematic, and the third arises from extrapolation to full phase space. We combine the systematic errors in quadrature.

$\langle N_{\rho^0} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
1.24±0.10 OUR AVERAGE Error includes scale factor of 1.1.				
1.19±0.10	ABREU	99J	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
1.45±0.06±0.20	BUSKULIC	96H	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\omega} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
1.02±0.06 OUR AVERAGE				
1.00±0.03±0.06	HEISTER	02C	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
1.04±0.04±0.14	ACKERSTAFF	98A	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
1.17±0.09±0.15	ACCIARRI	97D	L3	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\eta'} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.17 ±0.05 OUR AVERAGE Error includes scale factor of 2.4.				
0.14 ±0.01 ±0.02	ACKERSTAFF	98A	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
0.25 ±0.04	[112] ACCIARRI	97D	L3	$E^{ee}_{\rm cm}$= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.068±0.018±0.016	[113] BUSKULIC	92D	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV

[112] ACCIARRI 97D obtain this value averaging over the two decay channels $\eta' \rightarrow \pi^+\pi^-\eta$ and $\eta' \rightarrow \rho^0\gamma$.

[113] BUSKULIC 92D obtain this value for $x>$ 0.1.

$\langle N_{f_0(980)} \rangle$

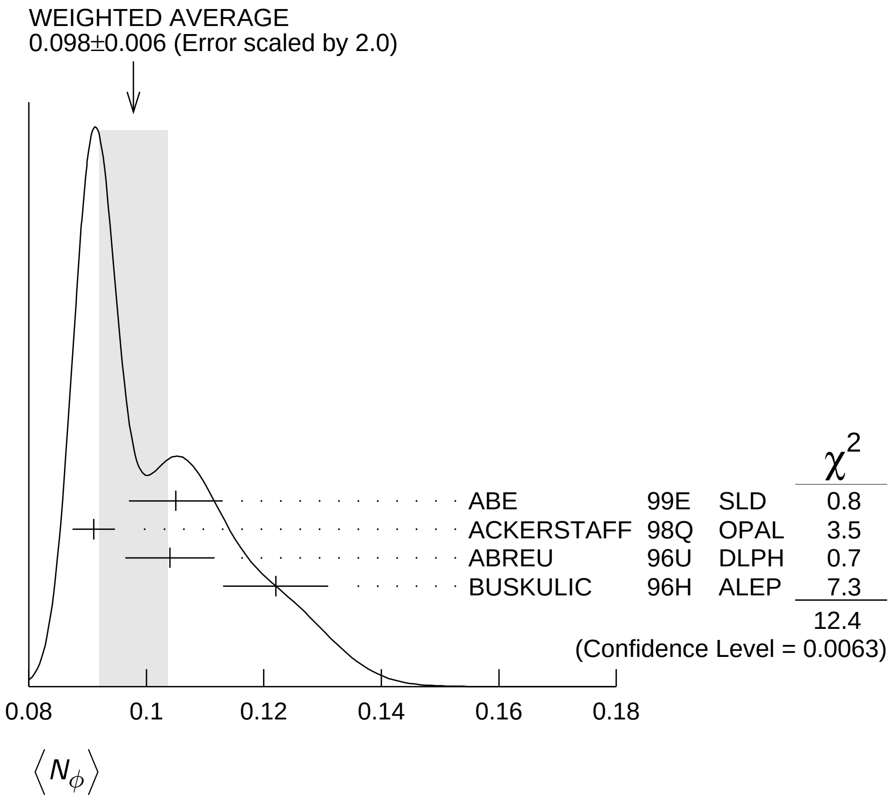
VALUE	DOCUMENT ID		TECN	COMMENT
0.147±0.011 OUR AVERAGE				
0.164±0.021	ABREU	99J	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
0.141±0.007±0.011	ACKERSTAFF	98Q	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{a_0(980)^\pm} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.27±0.04±0.10	ACKERSTAFF	98A	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\phi} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.098±0.006 OUR AVERAGE	Error includes scale factor of 2.0.		See the ideogram below.
0.105±0.008	ABE 99E	SLD	$E^{ee}_{\rm cm}$= 91.2 GeV
0.091±0.002±0.003	ACKERSTAFF 98Q	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
0.104±0.003±0.007	ABREU 96U	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
0.122±0.004±0.008	BUSKULIC 96H	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV



$\langle N_{f_2(1270)} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.169±0.025 OUR AVERAGE	Error includes scale factor of 1.4.		
0.214±0.038	ABREU 99J	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
0.155±0.011±0.018	ACKERSTAFF 98Q	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{f_1(1285)} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.165±0.051	[114] ABDALLAH 03H	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

[114] ABDALLAH 03H assume a $K \overline{K} \pi$ branching ratio of (9.0 ± 0.4)%.

$\langle N_{f_1(1420)} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.056±0.012	[115] ABDALLAH 03H	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

[115] ABDALLAH 03H assume a $K \overline{K} \pi$ branching ratio of 100%.

$\langle N_{f'_2(1525)} \rangle$

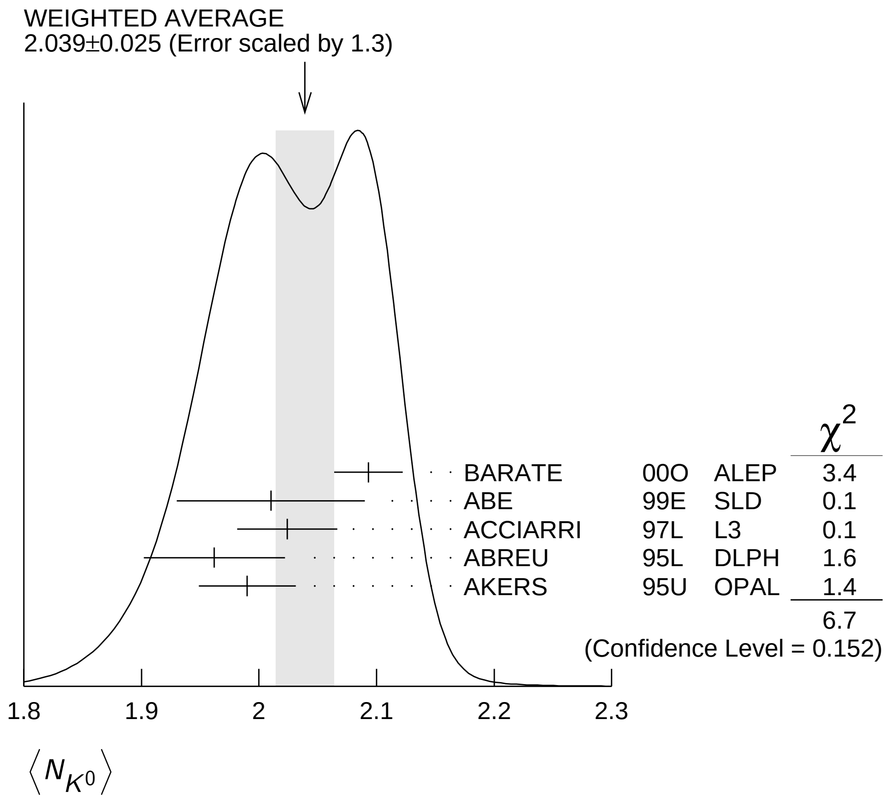
VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.012±0.006	ABREU 99J	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{K^\pm} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
2.24 ±0.04 OUR AVERAGE			
2.203±0.071	ABE 04C	SLD	$E^{ee}_{\rm cm}$= 91.2 GeV
2.21 ±0.05 ±0.05	ABREU 98L	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
2.26 ±0.12	BARATE 98V	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
2.42 ±0.13	AKERS 94P	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{K^0} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
2.039±0.025 OUR AVERAGE	Error includes scale factor of 1.3. See the ideogram below.		
2.093±0.004±0.029	BARATE 00O	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
2.01 ±0.08	ABE 99E	SLD	$E^{ee}_{\rm cm}$= 91.2 GeV
2.024±0.006±0.042	ACCIARRI 97L	L3	$E^{ee}_{\rm cm}$= 91.2 GeV
1.962±0.022±0.056	ABREU 95L	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
1.99 ±0.01 ±0.04	AKERS 95U	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV



$\langle N_{K^*(892)^\pm} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.72 ±0.05 OUR AVERAGE				
0.712±0.031±0.059	ABREU	95L	DLPH	E^{ee}_{cm}= 91.2 GeV
0.72 ±0.02 ±0.08	ACTON	93	OPAL	E^{ee}_{cm}= 91.2 GeV

$\langle N_{K^*(892)^0} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.739±0.022 OUR AVERAGE				
0.707±0.041	ABE	99E	SLD	E^{ee}_{cm}= 91.2 GeV
0.74 ±0.02 ±0.02	ACKERSTAFF	97S	OPAL	E^{ee}_{cm}= 91.2 GeV
0.77 ±0.02 ±0.07	ABREU	96U	DLPH	E^{ee}_{cm}= 91.2 GeV
0.83 ±0.01 ±0.09	BUSKULIC	96H	ALEP	E^{ee}_{cm}= 91.2 GeV
0.97 ±0.18 ±0.31	ABREU	93	DLPH	E^{ee}_{cm}= 91.2 GeV

$\langle N_{K^*_2(1430)} \rangle$

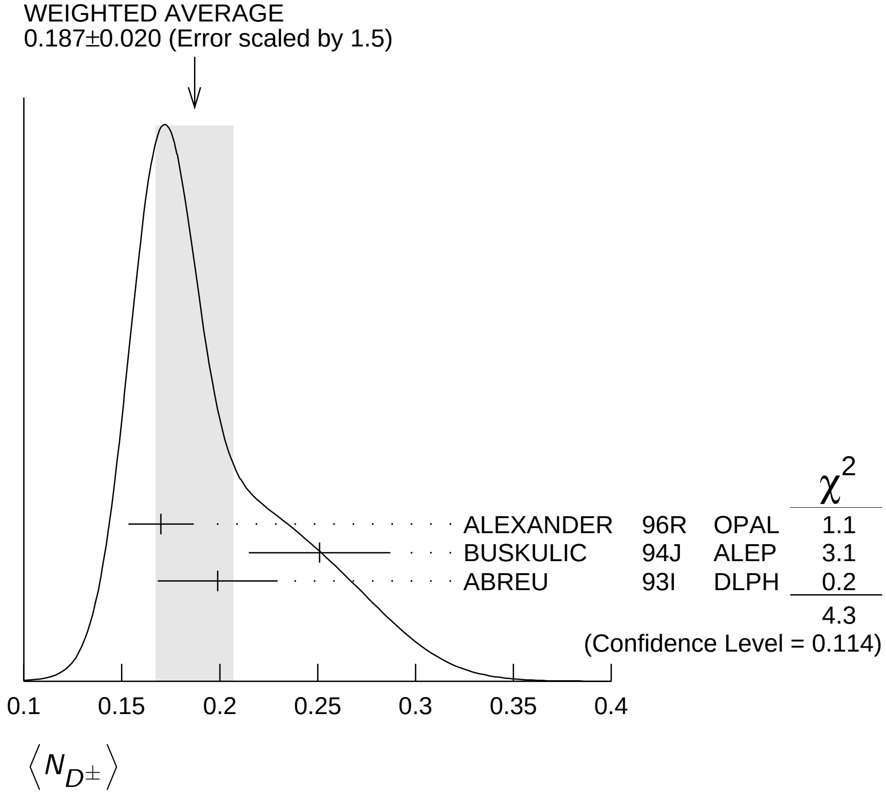
VALUE	DOCUMENT ID		TECN	COMMENT
0.073±0.023	ABREU	99J	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.19 ±0.04 ±0.06	[116] AKERS	95X	OPAL	E^{ee}_{cm}= 91.2 GeV

[116] AKERS 95X obtain this value for $x< 0.3$.

$\langle N_{D^\pm} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.187±0.020 OUR AVERAGE	Error includes scale factor of 1.5. See the ideogram below.			
0.170±0.009±0.014	ALEXANDER	96R	OPAL	E^{ee}_{cm}= 91.2 GeV
0.251±0.026±0.025	BUSKULIC	94J	ALEP	E^{ee}_{cm}= 91.2 GeV
0.199±0.019±0.024	[117] ABREU	93I	DLPH	E^{ee}_{cm}= 91.2 GeV

[117] See ABREU 95 (erratum).



$\langle N_{D^0} \rangle$

VALUE		DOCUMENT ID		TECN	COMMENT
0.462±0.026 OUR AVERAGE					
$0.465 \pm 0.017 \pm 0.027$		ALEXANDER	96R	OPAL	$E_{\rm cm}^{ee}$= 91.2 GeV
$0.518 \pm 0.052 \pm 0.035$		BUSKULIC	94J	ALEP	$E_{\rm cm}^{ee}$= 91.2 GeV
$0.403 \pm 0.038 \pm 0.044$	[118]	ABREU	93I	DLPH	$E_{\rm cm}^{ee}$= 91.2 GeV

[118] See ABREU 95 (erratum).

$\langle N_{D_s^\pm} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.131±0.010±0.018	ALEXANDER	96R	OPAL	$E_{\rm cm}^{ee}$= 91.2 GeV

$\langle N_{D^*(2010)^\pm} \rangle$

VALUE		DOCUMENT ID		TECN	COMMENT
0.183 ±0.008 OUR AVERAGE					
$0.1854 \pm 0.0041 \pm 0.0091$	[119]	ACKERSTAFF	98E	OPAL	$E_{\rm cm}^{ee}$= 91.2 GeV
$0.187 \pm 0.015 \pm 0.013$		BUSKULIC	94J	ALEP	$E_{\rm cm}^{ee}$= 91.2 GeV
$0.171 \pm 0.012 \pm 0.016$	[120]	ABREU	93I	DLPH	$E_{\rm cm}^{ee}$= 91.2 GeV

[119] ACKERSTAFF 98E systematic error includes an uncertainty of ±0.0069 due to the branching ratios B($D^{*+} \to D^0 \pi^+$) = 0.683 ± 0.014 and B($D^0 \to K^- \pi^+$) = 0.0383 ± 0.0012.

[120] See ABREU 95 (erratum).

$\langle N_{D_{s1}(2536)^+} \rangle$

VALUE (units 10^{-3})	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$2.9^{+0.7}_{-0.6}\pm0.2$	[121] ACKERSTAFF	97W	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

[121] ACKERSTAFF 97W obtain this value for $x>$ 0.6 and with the assumption that its decay width is saturated by the $D^* K$ final states.

$\langle N_{B^*} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.28±0.01 ±0.03	[122] ABREU	95R	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

[122] ABREU 95R quote this value for a flavor-averaged excited state.

$\langle N_{J/\psi(1S)} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.0056±0.0003±0.0004	[123] ALEXANDER	96B	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

[123] ALEXANDER 96B identify $J/\psi(1S)$ from the decays into lepton pairs.

$\langle N_{\psi(2S)} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.0023±0.0004±0.0003	ALEXANDER	96B	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_p \rangle$

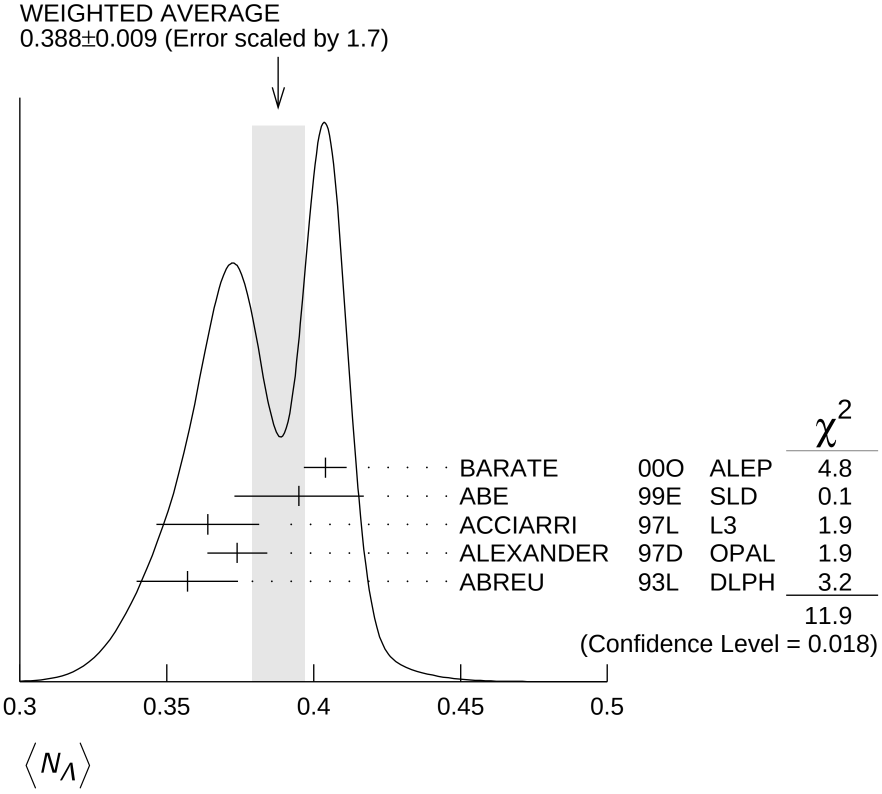
VALUE	DOCUMENT ID		TECN	COMMENT
1.046±0.026 OUR AVERAGE				
1.054±0.035	ABE	04C	SLD	$E^{ee}_{\rm cm}$= 91.2 GeV
1.08 ±0.04 ±0.03	ABREU	98L	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
1.00 ±0.07	BARATE	98V	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
0.92 ±0.11	AKERS	94P	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Delta(1232)^{++}} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.087±0.033 OUR AVERAGE	Error includes scale factor of 2.4.			
0.079±0.009±0.011	ABREU	95W	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
0.22 ±0.04 ±0.04	ALEXANDER	95D	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_\Lambda \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.388±0.009 OUR AVERAGE	Error includes scale factor of 1.7. See the ideogram below.			
0.404±0.002±0.007	BARATE	00O	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
0.395±0.022	ABE	99E	SLD	$E^{ee}_{\rm cm}$= 91.2 GeV
0.364±0.004±0.017	ACCIARRI	97L	L3	$E^{ee}_{\rm cm}$= 91.2 GeV
0.374±0.002±0.010	ALEXANDER	97D	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
0.357±0.003±0.017	ABREU	93L	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV



$\langle N_{\Lambda(1520)} \rangle$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.0224±0.0027 OUR AVERAGE				
0.029 ±0.005 ±0.005	ABREU	00P	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
0.0213±0.0021±0.0019	ALEXANDER	97D	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Sigma^+} \rangle$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.107±0.010 OUR AVERAGE				
0.114±0.011±0.009	ACCIARRI	00J	L3	$E^{ee}_{\rm cm}$= 91.2 GeV
0.099±0.008±0.013	ALEXANDER	97E	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Sigma^-} \rangle$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.082±0.007 OUR AVERAGE				
0.081±0.002±0.010	ABREU	00P	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
0.083±0.006±0.009	ALEXANDER	97E	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Sigma^+ + \Sigma^-} \rangle$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.181±0.018 OUR AVERAGE				
0.182±0.010±0.016	[124] ALEXANDER	97E	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
0.170±0.014±0.061	ABREU	95O	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

[124] We have combined the values of $\langle N_{\Sigma^+} \rangle$ and $\langle N_{\Sigma^-} \rangle$ from ALEXANDER 97E adding the statistical and systematic errors of the two final states separately in quadrature. If isospin symmetry is assumed this value becomes 0.174 ± 0.010 ± 0.015.

$\langle N_{\Sigma^0} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.076±0.010 OUR AVERAGE			
0.095±0.015±0.013	ACCIARRI 00J	L3	$E^{ee}_{\rm cm}$= 91.2 GeV
0.071±0.012±0.013	ALEXANDER 97E	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
0.070±0.010±0.010	ADAM 96B	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{(\Sigma^+ + \Sigma^- + \Sigma^0)/3} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.084±0.005±0.008	ALEXANDER 97E	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Sigma(1385)^+} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.0239±0.0009±0.0012	ALEXANDER 97D	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Sigma(1385)^-} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.0240±0.0010±0.0014	ALEXANDER 97D	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Sigma(1385)^+ + \Sigma(1385)^-} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.046 ±0.004 OUR AVERAGE	Error includes scale factor of 1.6.		
0.0479±0.0013±0.0026	ALEXANDER 97D	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
0.0382±0.0028±0.0045	ABREU 95O	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Xi^-} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.0258±0.0009 OUR AVERAGE			
0.0247±0.0009±0.0025	ABDALLAH 06E	DLPH	$E^{ee}_{\rm cm}$ = 91.2 GeV
0.0259±0.0004±0.0009	ALEXANDER 97D	OPAL	$E^{ee}_{\rm cm}$ = 91.2 GeV

$\langle N_{\Xi(1530)^0} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.0059±0.0011 OUR AVERAGE	Error includes scale factor of 2.3.		
0.0045±0.0005±0.0006	ABDALLAH 05C	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
0.0068±0.0005±0.0004	ALEXANDER 97D	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Omega^-} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.00164±0.00028 OUR AVERAGE			
0.0018 ±0.0003 ±0.0002	ALEXANDER 97D	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
0.0014 ±0.0002 ±0.0004	ADAM 96B	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

$\langle N_{\Lambda_c^+} \rangle$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*
0.078±0.012±0.012	ALEXANDER 96R	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

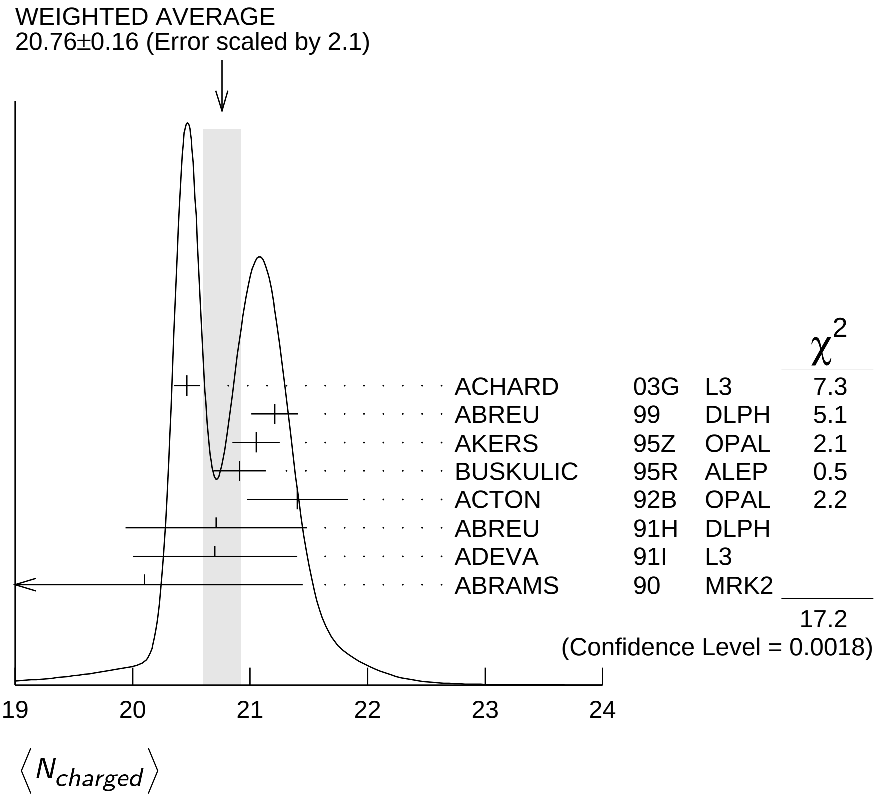
$\langle N_{\overline{D}} \rangle$

VALUE (units 10^{-6})	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
5.9±1.8±0.5	[125] SCHAEL	06A	ALEP	$E^{ee}_{\rm cm}$ = 91.2 GeV

[125] SCHAEL 06A obtain this anti-deuteron production rate per hadronic Z decay in the anti-deuteron momentum range from 0.62 to 1.03 GeV/c.

$\langle N_{charged} \rangle$

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
20.76±0.16 OUR AVERAGE	Error includes scale factor of 2.1. See the ideogram below.			
20.46±0.01±0.11	ACHARD	03G	L3	$E^{ee}_{\rm cm}$= 91.2 GeV
21.21±0.01±0.20	ABREU	99	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
21.05±0.20	AKERS	95Z	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
20.91±0.03±0.22	BUSKULIC	95R	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
21.40±0.43	ACTON	92B	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
20.71±0.04±0.77	ABREU	91H	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
20.7 ±0.7	ADEVA	91I	L3	$E^{ee}_{\rm cm}$= 91.2 GeV
20.1 ±1.0 ±0.9	ABRAMS	90	MRK2	$E^{ee}_{\rm cm}$= 91.1 GeV



Z HADRONIC POLE CROSS SECTION

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The *Z* boson" and ref. LEP-SLC 06). This quantity is defined as

$$\sigma_h^0 = \frac{12\pi}{M_Z^2} \frac{\Gamma(e^+ e^-)\,\Gamma(\text{hadrons})}{\Gamma_Z^2}$$

It is one of the parameters used in the *Z* lineshape fit.

VALUE (nb)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
41.541±0.037 OUR FIT					
41.501±0.055	4.10M	[126] ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
41.578±0.069	3.70M	ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
41.535±0.055	3.54M	ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
41.559±0.058	4.07M	[127] BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
42 ±4	450	ABRAMS	89B	MRK2	E^{ee}_{cm}= 89.2–93.0 GeV

[126] ABBIENDI 01A error includes approximately 0.031 due to statistics, 0.033 due to event selection systematics, 0.029 due to uncertainty in luminosity measurement, and 0.011 due to LEP energy uncertainty.

[127] BARATE 00C error includes approximately 0.030 due to statistics, 0.026 due to experimental systematics, and 0.025 due to uncertainty in luminosity measurement.

Z VECTOR COUPLINGS

These quantities are the effective vector couplings of the *Z* to charged leptons. Their magnitude is derived from a measurement of the *Z* lineshape and the forward-backward lepton asymmetries as a function of energy around the *Z* mass. The relative sign among the vector to axial-vector couplings is obtained from a measurement of the *Z* asymmetry parameters, A_e, A_μ, and A_τ. By convention the sign of g^e_A is fixed to be negative (and opposite to that of g^{ν_e} obtained using ν_e scattering measurements). For the light quarks, the sign of the couplings is assigned consistently with this assumption. The fit values quoted below correspond to global nine- or five-parameter fits to lineshape, lepton forward-backward asymmetry, and A_e, A_μ, and A_τ measurements. See the note "The *Z* boson" and ref. LEP-SLC 06 for details. Where $p\overline{p}$ and $e p$ data is quoted, OUR FIT value corresponds to a weighted average of this with the LEP/SLD fit result.

g^e_V

VALUE			*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
−0.03817±0.00047 OUR FIT							
−0.058	±0.016	±0.007	5026	[128] ACOSTA	05M	CDF	$E^{p\overline{p}}_{cm}$= 1.96 TeV
−0.0346	±0.0023		137.0K	[129] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
−0.0412	±0.0027		124.4k	[130] ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
−0.0400	±0.0037			BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
−0.0414	±0.0020			[131] ABE	95J	SLD	E^{ee}_{cm}= 91.31 GeV

[128] ACOSTA 05M determine the forward–backward asymmetry of $e^+ e^-$ pairs produced via $q\overline{q} \rightarrow Z/\gamma^* \rightarrow e^+ e^-$ in 15 M($e^+ e^-$) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial–vector couplings of the Z to $e^+ e^-$, assuming the quark couplings are as predicted by the standard model. Higher order radiative corrections have not been taken into account.

[129] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries.

[130] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

[131] ABE 95J obtain this result combining polarized Bhabha results with the A_{LR} measurement of ABE 94C. The Bhabha results alone give $-0.0507 \pm 0.0096 \pm 0.0020$.

g^{μ}_{V}

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
-0.0367 ± 0.0023 OUR FIT					
$-0.0388^{+0.0060}_{-0.0064}$	182.8K	[132] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
-0.0386 ± 0.0073	113.4k	[133] ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
-0.0362 ± 0.0061		BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
-0.0413 ± 0.0060	66143	[134] ABBIENDI	01K	OPAL	E^{ee}_{cm}= 89–93 GeV

[132] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries.

[133] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

[134] ABBIENDI 01K obtain this from an angular analysis of the muon pair asymmetry which takes into account effects of initial state radiation on an event by event basis and of initial-final state interference.

g^{τ}_{V}

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
-0.0366 ± 0.0010 OUR FIT					
-0.0365 ± 0.0023	151.5K	[135] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
-0.0384 ± 0.0026	103.0k	[136] ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
-0.0361 ± 0.0068		BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV

[135] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries.

[136] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

g^{ℓ}_{V}

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
-0.03783 ± 0.00041 OUR FIT					
-0.0358 ± 0.0014	471.3K	[137] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
-0.0397 ± 0.0020	379.4k	[138] ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
-0.0397 ± 0.0017	340.8k	[139] ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
-0.0383 ± 0.0018	500k	BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV

[137] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries.

[138] Using forward-backward lepton asymmetries.

[139] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

g_V^u

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$0.29^{+0.10}_{-0.08}$ OUR AVERAGE				
0.27 ± 0.13	1500	[140] AKTAS 06	H1	$e^{\pm} p \to \overline{\nu}_e(\nu_e) X$, $\sqrt{s} \approx 300$ GeV
$0.24^{+0.28}_{-0.11}$		[141] LEP-SLC 06		$E_{\rm cm}^{ee}$ = 88–94 GeV
$0.399^{+0.152}_{-0.188} \pm 0.066$	5026	[142] ACOSTA 05M	CDF	$E_{\rm cm}^{p\overline{p}}$= 1.96 TeV

[140] AKTAS 06 fit the neutral current ($1.5 \leq Q^2 \leq 30{,}000$ GeV^2) and charged current ($1.5 \leq Q^2 \leq 15{,}000$ GeV^2) differential cross sections. In the determination of the *u*-quark couplings the electron and *d*-quark couplings are fixed to their standard model values.

[141] LEP-SLC 06 is a combination of the results from LEP and SLC experiments using light quark tagging. s- and d-quark couplings are assumed to be identical.

[142] ACOSTA 05M determine the forward-backward asymmetry of $e^+ e^-$ pairs produced via $q\overline{q} \to Z/\gamma^* \to e^+ e^-$ in 15 $M(e^+ e^-)$ effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial-vector couplings of the *Z* to the light quarks, assuming the electron couplings are as predicted by the Standard Model. Higher order radiative corrections have not been taken into account.

g_V^d

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$-0.33^{+0.05}_{-0.07}$ OUR AVERAGE				
-0.33 ± 0.33	1500	[143] AKTAS 06	H1	$e^{\pm} p \to \overline{\nu}_e(\nu_e) X$, $\sqrt{s} \approx 300$ GeV
$-0.33^{+0.05}_{-0.07}$		[144] LEP-SLC 06		$E_{\rm cm}^{ee}$ = 88–94 GeV
$-0.226^{+0.635}_{-0.290} \pm 0.090$	5026	[145] ACOSTA 05M	CDF	$E_{\rm cm}^{p\overline{p}}$= 1.96 TeV

[143] AKTAS 06 fit the neutral current ($1.5 \leq Q^2 \leq 30{,}000$ GeV^2) and charged current ($1.5 \leq Q^2 \leq 15{,}000$ GeV^2) differential cross sections. In the determination of the *d*-quark couplings the electron and *u*-quark couplings are fixed to their standard model values.

[144] LEP-SLC 06 is a combination of the results from LEP and SLC experiments using light quark tagging. s- and d-quark couplings are assumed to be identical.

[145] ACOSTA 05M determine the forward-backward asymmetry of $e^+ e^-$ pairs produced via $q\overline{q} \to Z/\gamma^* \to e^+ e^-$ in 15 $M(e^+ e^-)$ effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial-vector couplings of the *Z* to the light quarks, assuming the electron couplings are as predicted by the Standard Model. Higher order radiative corrections have not been taken into account.

Z AXIAL-VECTOR COUPLINGS

These quantities are the effective axial-vector couplings of the *Z* to charged leptons. Their magnitude is derived from a measurement of the *Z* line-shape and the forward-backward lepton asymmetries as a function of energy around the *Z* mass. The relative sign among the vector to axial-vector couplings is obtained from a measurement of the *Z* asymmetry parameters, A_e, A_μ, and A_τ. By convention the sign of g_A^e is fixed to be negative (and opposite to that of g^{ν_e} obtained using ν_e scattering measurements).

For the light quarks, the sign of the couplings is assigned consistently with this assumption. The fit values quoted below correspond to global nine- or five-parameter fits to lineshape, lepton forward-backward asymmetry, and A_e, A_μ, and A_τ measurements. See the note "The Z boson" and ref. LEP-SLC 06 for details. Where $p\overline{p}$ and $e\,p$ data is quoted, OUR FIT value corresponds to a weighted average of this with the LEP/SLD fit result.

g_A^e

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
−0.50111±0.00035 OUR FIT				
−0.528 ±0.123 ±0.059	5026	[146] ACOSTA 05M	CDF	$E_{\mathrm{cm}}^{p\overline{p}}$= 1.96 TeV
−0.50062±0.00062	137.0K	[147] ABBIENDI 01O	OPAL	E_{cm}^{ee}= 88–94 GeV
−0.5015 ±0.0007	124.4k	[148] ACCIARRI 00C	L3	E_{cm}^{ee}= 88–94 GeV
−0.50166±0.00057		BARATE 00C	ALEP	E_{cm}^{ee}= 88–94 GeV
−0.4977 ±0.0045		[149] ABE 95J	SLD	E_{cm}^{ee}= 91.31 GeV

[146] ACOSTA 05M determine the forward–backward asymmetry of e^+e^- pairs produced via $q\overline{q} \rightarrow Z/\gamma^* \rightarrow e^+e^-$ in 15 M(e^+e^-) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial–vector couplings of the Z to e^+e^-, assuming the quark couplings are as predicted by the standard model. Higher order radiative corrections have not been taken into account.

[147] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries.

[148] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

[149] ABE 95J obtain this result combining polarized Bhabha results with the A_{LR} measurement of ABE 94C. The Bhabha results alone give −0.4968 ± 0.0039 ± 0.0027.

g_A^μ

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
−0.50120±0.00054 OUR FIT				
−0.50117±0.00099	182.8K	[150] ABBIENDI 01O	OPAL	E_{cm}^{ee}= 88–94 GeV
−0.5009 ±0.0014	113.4k	[151] ACCIARRI 00C	L3	E_{cm}^{ee}= 88–94 GeV
−0.50046±0.00093		BARATE 00C	ALEP	E_{cm}^{ee}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.520 ±0.015	66143	[152] ABBIENDI 01K	OPAL	E_{cm}^{ee}= 89–93 GeV

[150] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries.

[151] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

[152] ABBIENDI 01K obtain this from an angular analysis of the muon pair asymmetry which takes into account effects of initial state radiation on an event by event basis and of initial-final state interference.

g_A^τ

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
−0.50204±0.00064 OUR FIT				
−0.50165±0.00124	151.5K	[153] ABBIENDI 01O	OPAL	E_{cm}^{ee}= 88–94 GeV
−0.5023 ±0.0017	103.0k	[154] ACCIARRI 00C	L3	E_{cm}^{ee}= 88–94 GeV
−0.50216±0.00100		BARATE 00C	ALEP	E_{cm}^{ee}= 88–94 GeV

[153] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries.

[154] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

g^{ℓ}_{A}

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
$-$0.50123$\pm$0.00026 OUR FIT				
-0.50089 ± 0.00045	471.3K	[155] ABBIENDI 01O	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
$-0.5007\ \pm0.0005$	379.4k	ABREU 00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
-0.50153 ± 0.00053	340.8k	[156] ACCIARRI 00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
-0.50150 ± 0.00046	500k	BARATE 00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

[155] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries.

[156] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

g^{u}_{A}

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
0.50 $^{+0.04}_{-0.07}$ OUR AVERAGE				
$0.57\ \pm0.08$	1500	[157] AKTAS 06	H1	$e^{\pm} p \to \overline{\nu}_e(\nu_e) X$, $\sqrt{s} \approx$ 300 GeV
$0.47\ ^{+0.05}_{-0.33}$		[158] LEP-SLC 06		$E^{ee}_{\rm cm}$ = 88–94 GeV
$0.441^{+0.207}_{-0.173}\pm0.067$	5026	[159] ACOSTA 05M	CDF	$E^{p\overline{p}}_{\rm cm}$= 1.96 TeV

[157] AKTAS 06 fit the neutral current ($1.5 \leq Q^2 \leq$ 30,000 GeV^2) and charged current ($1.5 \leq Q^2 \leq$ 15,000 GeV^2) differential cross sections. In the determination of the *u*-quark couplings the electron and *d*-quark couplings are fixed to their standard model values.

[158] LEP-SLC 06 is a combination of the results from LEP and SLC experiments using light quark tagging. s- and d-quark couplings are assumed to be identical.

[159] ACOSTA 05M determine the forward-backward asymmetry of $e^+ e^-$ pairs produced via $q\overline{q} \to Z/\gamma^* \to e^+ e^-$ in 15 M($e^+ e^-$) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial-vector couplings of the *Z* to the light quarks, assuming the electron couplings are as predicted by the Standard Model. Higher order radiative corrections have not been taken into account.

g^{d}_{A}

VALUE	*EVTS*	*DOCUMENT ID*	*TECN*	*COMMENT*
$-$0.524$^{+0.050}_{-0.030}$ OUR AVERAGE				
$-0.80\ \pm0.24$	1500	[160] AKTAS 06	H1	$e^{\pm} p \to \overline{\nu}_e(\nu_e) X$, $\sqrt{s} \approx$ 300 GeV
$-0.52\ ^{+0.05}_{-0.03}$		[161] LEP-SLC 06		$E^{ee}_{\rm cm}$ = 88–94 GeV
$-0.016^{+0.346}_{-0.536}\pm0.091$	5026	[162] ACOSTA 05M	CDF	$E^{p\overline{p}}_{\rm cm}$= 1.96 TeV

[160] AKTAS 06 fit the neutral current ($1.5 \leq Q^2 \leq 30{,}000$ GeV^2) and charged current ($1.5 \leq Q^2 \leq 15{,}000$ GeV^2) differential cross sections. In the determination of the *d*-quark couplings the electron and *u*-quark couplings are fixed to their standard model values.

[161] LEP-SLC 06 is a combination of the results from LEP and SLC experiments using light quark tagging. s- and d-quark couplings are assumed to be identical.

[162] ACOSTA 05M determine the forward-backward asymmetry of e^+e^- pairs produced via $q\overline{q} \to Z/\gamma^* \to e^+e^-$ in 15 M(e^+e^-) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial-vector couplings of the Z to the light quarks, assuming the electron couplings are as predicted by the Standard Model. Higher order radiative corrections have not been taken into account.

Z COUPLINGS TO NEUTRAL LEPTONS

Averaging over neutrino species, the invisible Z decay width determines the effective neutrino coupling g^{ν_ℓ}. For g^{ν_e} and g^{ν_μ}, $\nu_e e$ and $\nu_\mu e$ scattering results are combined with g^e_A and g^e_V measurements at the Z mass to obtain g^{ν_e} and g^{ν_μ} following NOVIKOV 93C.

g^{ν_ℓ}

VALUE	*DOCUMENT ID*		*COMMENT*
0.50076±0.00076	[163] LEP-SLC	06	$E^{ee}_{\rm cm}$ = 88–94 GeV

[163] From invisible Z-decay width.

g^{ν_e}

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.528±0.085	[164] VILAIN	94	CHM2	From ν_μ e and ν_e e scattering

[164] VILAIN 94 derive this value from their value of g^{ν_μ} and their ratio $g^{\nu_e}/g^{\nu_\mu} = 1.05^{+0.15}_{-0.18}$.

g^{ν_μ}

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.502±0.017	[165] VILAIN	94	CHM2	From ν_μ e scattering

[165] VILAIN 94 derive this value from their measurement of the couplings $g_A^{e\nu_\mu} = -0.503 \pm 0.017$ and $g_V^{e\nu_\mu} = -0.035 \pm 0.017$ obtained from ν_μ e scattering. We have re-evaluated this value using the current PDG values for g^e_A and g^e_V.

Z ASYMMETRY PARAMETERS

For each fermion-antifermion pair coupling to the Z these quantities are defined as

$$A_f = \frac{2g^f_V g^f_A}{(g^f_V)^2 + (g^f_A)^2}$$

where g_V^f and g_A^f are the effective vector and axial-vector couplings. For their relation to the various lepton asymmetries see the note "The Z boson" and ref. LEP-SLC 06.

A_e

Using polarized beams, this quantity can also be measured as $(\sigma_L - \sigma_R)/\,(\sigma_L + \sigma_R)$, where σ_L and σ_R are the e^+e^- production cross sections for Z bosons produced with left-handed and right-handed electrons respectively.

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.1515±0.0019 OUR AVERAGE					
0.1454±0.0108±0.0036	144810	[166] ABBIENDI	01O	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
0.1516±0.0021	559000	[167] ABE	01B	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
0.1504±0.0068±0.0008		[168] HEISTER	01	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
0.1382±0.0116±0.0005	105000	[169] ABREU	00E	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
0.1678±0.0127±0.0030	137092	[170] ACCIARRI	98H	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
0.162 ±0.041 ±0.014	89838	[171] ABE	97	SLD	$E^{ee}_{\rm cm}$= 91.27 GeV
0.202 ±0.038 ±0.008		[172] ABE	95J	SLD	$E^{ee}_{\rm cm}$= 91.31 GeV

[166] ABBIENDI 01O fit for A_e and A_τ from measurements of the τ polarization at varying τ production angles. The correlation between A_e and A_τ is less than 0.03.

[167] ABE 01B use the left-right production and left-right forward-backward decay asymmetries in leptonic Z decays to obtain a value of 0.1544 ± 0.0060. This is combined with left-right production asymmetry measurement using hadronic Z decays (ABE 00B) to obtain the quoted value.

[168] HEISTER 01 obtain this result fitting the τ polarization as a function of the polar production angle of the τ.

[169] ABREU 00E obtain this result fitting the τ polarization as a function of the polar τ production angle. This measurement is a combination of different analyses (exclusive τ decay modes, inclusive hadronic 1-prong reconstruction, and a neural network analysis).

[170] Derived from the measurement of forward-backward τ polarization asymmetry.

[171] ABE 97 obtain this result from a measurement of the observed left-right charge asymmetry, $A_Q^{\rm obs} = 0.225 \pm 0.056 \pm 0.019$, in hadronic Z decays. If they combine this value of $A_Q^{\rm obs}$ with their earlier measurement of $A_{LR}^{\rm obs}$ they determine A_e to be 0.1574 ± 0.0197 ± 0.0067 independent of the beam polarization.

[172] ABE 95J obtain this result from polarized Bhabha scattering.

A_μ

This quantity is directly extracted from a measurement of the left-right forward-backward asymmetry in $\mu^+\mu^-$ production at SLC using a polarized electron beam. This double asymmetry eliminates the dependence on the Z-e-e coupling parameter A_e.

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.142±0.015	16844	[173] ABE	01B	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV

[173] ABE 01B obtain this direct measurement using the left-right production and left-right forward-backward polar angle asymmetries in $\mu^+\mu^-$ decays of the Z boson obtained with a polarized electron beam.

A_τ

The LEP Collaborations derive this quantity from the measurement of the τ polarization in $Z \to \tau^+\tau^-$. The SLD Collaboration directly extracts this quantity from its measured left-right forward-backward asymmetry in $Z \to \tau^+\tau^-$ produced using a polarized e^- beam. This double asymmetry eliminates the dependence on the Z-e-e coupling parameter A_e.

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.143 ±0.004 OUR AVERAGE					
0.1456±0.0076±0.0057	144810	[174] ABBIENDI	01O	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
0.136 ±0.015	16083	[175] ABE	01B	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
0.1451±0.0052±0.0029		[176] HEISTER	01	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
0.1359±0.0079±0.0055	105000	[177] ABREU	00E	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
0.1476±0.0088±0.0062	137092	ACCIARRI	98H	L3	$E^{ee}_{\rm cm}$= 88–94 GeV

[174] ABBIENDI 01O fit for A_e and A_τ from measurements of the τ polarization at varying τ production angles. The correlation between A_e and A_τ is less than 0.03.

[175] ABE 01B obtain this direct measurement using the left-right production and left-right forward-backward polar angle asymmetries in $\tau^+\tau^-$ decays of the Z boson obtained with a polarized electron beam.

[176] HEISTER 01 obtain this result fitting the τ polarization as a function of the polar production angle of the τ.

[177] ABREU 00E obtain this result fitting the τ polarization as a function of the polar τ production angle. This measurement is a combination of different analyses (exclusive τ decay modes, inclusive hadronic 1-prong reconstruction, and a neural network analysis).

A_s

The SLD Collaboration directly extracts this quantity by a simultaneous fit to four measured s-quark polar angle distributions corresponding to two states of e^- polarization (positive and negative) and to the K^+K^- and $K^\pm K^0_S$ strange particle tagging modes in the hadronic final states.

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.895±0.066±0.062	2870	[178] ABE	00D	SLD	$E^{ee}_{\rm cm}$= 91.2 GeV

[178] ABE 00D tag $Z \to s\overline{s}$ events by an absence of B or D hadrons and the presence in each hemisphere of a high momentum $K^\pm$ or K^0_S.

A_c

This quantity is directly extracted from a measurement of the left-right forward-backward asymmetry in $c\overline{c}$ production at SLC using polarized electron beam. This double asymmetry eliminates the dependence on the Z-e-e coupling parameter A_e. OUR FIT is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the note "The Z boson" and ref. LEP-SLC 06.

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.670 ±0.027 OUR FIT				
0.6712±0.0224±0.0157	[179] ABE	05	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.583 ±0.055 ±0.055	[180] ABE	02G	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
0.688 ±0.041	[181] ABE	01C	SLD	$E^{ee}_{\rm cm}$= 91.25 GeV

[179] ABE 05 use hadronic Z decays collected during 1996–98 to obtain an enriched sample of $c\overline{c}$ events tagging on the invariant mass of reconstructed secondary decay vertices. The charge of the underlying c–quark is obtained with an algorithm that takes into account the net charge of the vertex as well as the charge of tracks emanating from the vertex and identified as kaons. This yields (9970 events) $A_c = 0.6747 \pm 0.0290 \pm 0.0233$. Taking into account all correlations with earlier results reported in ABE 02G and ABE 01C, they obtain the quoted overall SLD result.

[180] ABE 02G tag b and c quarks through their semileptonic decays into electrons and muons. A maximum likelihood fit is performed to extract simultaneously A_b and A_c.

[181] ABE 01C tag $Z \rightarrow c\overline{c}$ events using two techniques: exclusive reconstruction of D^{*+}, D^+ and D^0 mesons and the soft pion tag for $D^{*+} \rightarrow D^0\pi^+$. The large background from D mesons produced in $b\overline{b}$ events is separated efficiently from the signal using precision vertex information. When combining the A_c values from these two samples, care is taken to avoid double counting of events common to the two samples, and common systematic errors are properly taken into account.

A_b

This quantity is directly extracted from a measurement of the left-right forward-backward asymmetry in $b\overline{b}$ production at SLC using polarized electron beam. This double asymmetry eliminates the dependence on the Z-e-e coupling parameter A_e. OUR FIT is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the note "The Z boson" and ref. LEP-SLC 06.

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.923 ±0.020 OUR FIT					
0.9170±0.0147±0.0145		[182] ABE	05	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.907 ±0.020 ±0.024	48028	[183] ABE	03F	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
0.919 ±0.030 ±0.024		[184] ABE	02G	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
0.855 ±0.088 ±0.102	7473	[185] ABE	99L	SLD	$E^{ee}_{\rm cm}$= 91.27 GeV

[182] ABE 05 use hadronic Z decays collected during 1996–98 to obtain an enriched sample of $b\overline{b}$ events tagging on the invariant mass of reconstructed secondary decay vertices. The charge of the underlying b–quark is obtained with an algorithm that takes into account the net charge of the vertex as well as the charge of tracks emanating from the vertex and identified as kaons. This yields (25917 events) $A_b = 0.9173 \pm 0.0184 \pm 0.0173$. Taking into account all correlations with earlier results reported in ABE 03F, ABE 02G and ABE 99L, they obtain the quoted overall SLD result.

[183] ABE 03F obtain an enriched sample of $b\overline{b}$ events tagging on the invariant mass of a 3-dimensional topologically reconstructed secondary decay. The charge of the underlying b quark is obtained using a self-calibrating track-charge method. For the 1996–1998 data sample they measure $A_b = 0.906 \pm 0.022 \pm 0.023$. The value quoted here is obtained combining the above with the result of ABE 98I (1993–1995 data sample).

[184] ABE 02G tag b and c quarks through their semileptonic decays into electrons and muons. A maximum likelihood fit is performed to extract simultaneously A_b and A_c.

[185] ABE 99L obtain an enriched sample of $b\overline{b}$ events tagging with an inclusive vertex mass cut. For distinguishing b and $\overline{b}$ quarks they use the charge of identified $K^{\pm}$.

TRANSVERSE SPIN CORRELATIONS IN $Z \rightarrow \tau^+\tau^-$

The correlations between the transverse spin components of $\tau^+\tau^-$ produced in Z decays may be expressed in terms of the vector and axial-vector couplings:

$$C_{TT} = \frac{|g^{\tau}_A|^2 - |g^{\tau}_V|^2}{|g^{\tau}_A|^2 + |g^{\tau}_V|^2}$$

$$C_{TN} = -2\frac{|g_A^\tau||g_V^\tau|}{|g_A^\tau|^2+|g_V^\tau|^2} \sin(\Phi_{g_V^\tau} - \Phi_{g_A^\tau})$$

C_{TT} refers to the transverse-transverse (within the collision plane) spin correlation and C_{TN} refers to the transverse-normal (to the collision plane) spin correlation.

The longitudinal τ polarization P_τ $(= -A_\tau)$ is given by:

$$P_\tau = -2\frac{|g_A^\tau||g_V^\tau|}{|g_A^\tau|^2+|g_V^\tau|^2} \cos(\Phi_{g_V^\tau} - \Phi_{g_A^\tau})$$

Here Φ is the phase and the phase difference $\Phi_{g_V^\tau} - \Phi_{g_A^\tau}$ can be obtained using both the measurements of C_{TN} and P_τ.

C_{TT}

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
1.01±0.12 OUR AVERAGE					
$0.87 \pm 0.20 {}^{+0.10}_{-0.12}$	9.1k	ABREU	97G	DLPH	E^{ee}_{cm}= 91.2 GeV
1.06±0.13±0.05	120k	BARATE	97D	ALEP	E^{ee}_{cm}= 91.2 GeV

C_{TN}

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.08±0.13±0.04	120k	[186] BARATE	97D	ALEP	E^{ee}_{cm}= 91.2 GeV

[186] BARATE 97D combine their value of C_{TN} with the world average $P_\tau = -0.140 \pm 0.007$ to obtain $\tan(\Phi_{g_V^\tau} - \Phi_{g_A^\tau}) = -0.57 \pm 0.97$.

FORWARD-BACKWARD $e^+e^- \rightarrow f\overline{f}$ CHARGE ASYMMETRIES

These asymmetries are experimentally determined by tagging the respective lepton or quark flavor in e^+e^- interactions. Details of heavy flavor (c- or b-quark) tagging at LEP are described in the note on "The Z boson" and ref. LEP-SLC 06. The Standard Model predictions for LEP data have been (re)computed using the ZFITTER package (version 6.36) with input parameters M_Z=91.187 GeV, M_{top}=174.3 GeV, M_{Higgs}=150 GeV, α_s=0.119, $\alpha^{(5)}$ (M_Z)= 1/128.877 and the Fermi constant G_F= 1.16637×10^{-5} GeV^{-2} (see the note on "The Z boson" for references). For non-LEP data the Standard Model predictions are as given by the authors of the respective publications.

$A_{FB}^{(0,e)}$ CHARGE ASYMMETRY IN $e^+e^- \rightarrow e^+e^-$

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06). For the Z peak, we report the pole asymmetry defined by $(3/4)A_e^2$ as determined by the nine-parameter fit to cross-section and lepton forward-backward asymmetry data.

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*		*TECN*
1.45±0.25 OUR FIT					
0.89±0.44	1.57	91.2	[187] ABBIENDI	01A	OPAL
1.71±0.49	1.57	91.2	ABREU	00F	DLPH
1.06±0.58	1.57	91.2	ACCIARRI	00C	L3
1.88±0.34	1.57	91.2	[188] BARATE	00C	ALEP

[187] ABBIENDI 01A error includes approximately 0.38 due to statistics, 0.16 due to event selection systematics, and 0.18 due to the theoretical uncertainty in t-channel prediction.

[188] BARATE 00C error includes approximately 0.31 due to statistics, 0.06 due to experimental systematics, and 0.13 due to the theoretical uncertainty in t-channel prediction.

$A_{FB}^{(0,\mu)}$ CHARGE ASYMMETRY IN $e^+e^- \to \mu^+\mu^-$

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06). For the Z peak, we report the pole asymmetry defined by $(3/4)A_e A_\mu$ as determined by the nine-parameter fit to cross-section and lepton forward-backward asymmetry data.

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*		*TECN*
1.69± 0.13 OUR FIT					
1.59± 0.23	1.57	91.2	[189] ABBIENDI	01A	OPAL
1.65± 0.25	1.57	91.2	ABREU	00F	DLPH
1.88± 0.33	1.57	91.2	ACCIARRI	00C	L3
1.71± 0.24	1.57	91.2	[190] BARATE	00C	ALEP
• • • We do not use the following data for averages, fits, limits, etc. • • •					
9 ±30	−1.3	20	[191] ABREU	95M	DLPH
7 ±26	−8.3	40	[191] ABREU	95M	DLPH
−11 ±33	−24.1	57	[191] ABREU	95M	DLPH
−62 ±17	−44.6	69	[191] ABREU	95M	DLPH
−56 ±10	−63.5	79	[191] ABREU	95M	DLPH
−13 ± 5	−34.4	87.5	[191] ABREU	95M	DLPH
$-29.0\,^{+5.0}_{-4.8} \pm 0.5$	−32.1	56.9	[192] ABE	90I	VNS
− 9.9 ± 1.5 ±0.5	−9.2	35	HEGNER	90	JADE
0.05± 0.22	0.026	91.14	[193] ABRAMS	89D	MRK2
−43.4 ±17.0	−24.9	52.0	[194] BACALA	89	AMY
−11.0 ±16.5	−29.4	55.0	[194] BACALA	89	AMY
−30.0 ±12.4	−31.2	56.0	[194] BACALA	89	AMY
−46.2 ±14.9	−33.0	57.0	[194] BACALA	89	AMY
−29 ±13	−25.9	53.3	ADACHI	88C	TOPZ
+ 5.3 ± 5.0 ±0.5	−1.2	14.0	ADEVA	88	MRKJ
−10.4 ± 1.3 ±0.5	−8.6	34.8	ADEVA	88	MRKJ
−12.3 ± 5.3 ±0.5	−10.7	38.3	ADEVA	88	MRKJ
−15.6 ± 3.0 ±0.5	−14.9	43.8	ADEVA	88	MRKJ

-1.0 ± 6.0	-1.2	13.9	BRAUNSCH...	88D	TASS
$-9.1 \pm 2.3 \pm 0.5$	-8.6	34.5	BRAUNSCH...	88D	TASS
$-10.6^{+2.2}_{-2.3} \pm 0.5$	-8.9	35.0	BRAUNSCH...	88D	TASS
$-17.6^{+4.4}_{-4.3} \pm 0.5$	-15.2	43.6	BRAUNSCH...	88D	TASS
$-4.8 \pm 6.5 \pm 1.0$	-11.5	39	BEHREND	87C	CELL
$-18.8 \pm 4.5 \pm 1.0$	-15.5	44	BEHREND	87C	CELL
$+2.7 \pm 4.9$	-1.2	13.9	BARTEL	86C	JADE
$-11.1 \pm 1.8 \pm 1.0$	-8.6	34.4	BARTEL	86C	JADE
$-17.3 \pm 4.8 \pm 1.0$	-13.7	41.5	BARTEL	86C	JADE
$-22.8 \pm 5.1 \pm 1.0$	-16.6	44.8	BARTEL	86C	JADE
$-6.3 \pm 0.8 \pm 0.2$	-6.3	29	ASH	85	MAC
$-4.9 \pm 1.5 \pm 0.5$	-5.9	29	DERRICK	85	HRS
-7.1 ± 1.7	-5.7	29	LEVI	83	MRK2
-16.1 ± 3.2	-9.2	34.2	BRANDELIK	82C	TASS

[189] ABBIENDI 01A error is almost entirely on account of statistics.

[190] BARATE 00C error is almost entirely on account of statistics.

[191] ABREU 95M perform this measurement using radiative muon-pair events associated with high-energy isolated photons.

[192] ABE 90I measurements in the range $50 \leq \sqrt{s} \leq 60.8$ GeV.

[193] ABRAMS 89D asymmetry includes both 9 $\mu^+\mu^-$ and 15 $\tau^+\tau^-$ events.

[194] BACALA 89 systematic error is about 5%.

$A_{FB}^{(0,\tau)}$ CHARGE ASYMMETRY IN $e^+e^- \rightarrow \tau^+\tau^-$

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06). For the Z peak, we report the pole asymmetry defined by $(3/4)A_e A_\tau$ as determined by the nine-parameter fit to cross-section and lepton forward-backward asymmetry data.

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*		*TECN*
1.88 ± 0.17 OUR FIT					
1.45 ± 0.30	1.57	91.2	[195] ABBIENDI	01A	OPAL
2.41 ± 0.37	1.57	91.2	ABREU	00F	DLPH
2.60 ± 0.47	1.57	91.2	ACCIARRI	00C	L3
1.70 ± 0.28	1.57	91.2	[196] BARATE	00C	ALEP
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-32.8^{+6.4}_{-6.2} \pm 1.5$	-32.1	56.9	[197] ABE	90I	VNS
$-8.1 \pm 2.0 \pm 0.6$	-9.2	35	HEGNER	90	JADE
-18.4 ± 19.2	-24.9	52.0	[198] BACALA	89	AMY
-17.7 ± 26.1	-29.4	55.0	[198] BACALA	89	AMY
-45.9 ± 16.6	-31.2	56.0	[198] BACALA	89	AMY
-49.5 ± 18.0	-33.0	57.0	[198] BACALA	89	AMY
-20 ± 14	-25.9	53.3	ADACHI	88C	TOPZ
$-10.6 \pm 3.1 \pm 1.5$	-8.5	34.7	ADEVA	88	MRKJ

$-8.5 \pm 6.6 \pm 1.5$	-15.4	43.8	ADEVA 88	MRKJ
$-6.0 \pm 2.5 \pm 1.0$	8.8	34.6	BARTEL 85F	JADE
$-11.8 \pm 4.6 \pm 1.0$	14.8	43.0	BARTEL 85F	JADE
$-5.5 \pm 1.2 \pm 0.5$	-0.063	29.0	FERNANDEZ 85	MAC
-4.2 ± 2.0	0.057	29	LEVI 83	MRK2
-10.3 ± 5.2	-9.2	34.2	BEHREND 82	CELL
-0.4 ± 6.6	-9.1	34.2	BRANDELIK 82C	TASS

[195] ABBIENDI 01A error includes approximately 0.26 due to statistics and 0.14 due to event selection systematics.

[196] BARATE 00C error includes approximately 0.26 due to statistics and 0.11 due to experimental systematics.

[197] ABE 90I measurements in the range $50 \leq \sqrt{s} \leq 60.8$ GeV.

[198] BACALA 89 systematic error is about 5%.

$A_{FB}^{(0,\ell)}$ CHARGE ASYMMETRY IN $e^+ e^- \to \ell^+ \ell^-$

For the Z peak, we report the pole asymmetry defined by $(3/4)A_\ell^2$ as determined by the five-parameter fit to cross-section and lepton forward-backward asymmetry data assuming lepton universality. For details see the note "The Z boson" and ref. LEP-SLC 06.

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*	*TECN*
1.71±0.10 OUR FIT				
1.45±0.17	1.57	91.2	[199] ABBIENDI 01A	OPAL
1.87±0.19	1.57	91.2	ABREU 00F	DLPH
1.92±0.24	1.57	91.2	ACCIARRI 00C	L3
1.73±0.16	1.57	91.2	[200] BARATE 00C	ALEP

[199] ABBIENDI 01A error includes approximately 0.15 due to statistics, 0.06 due to event selection systematics, and 0.03 due to the theoretical uncertainty in t-channel prediction.

[200] BARATE 00C error includes approximately 0.15 due to statistics, 0.04 due to experimental systematics, and 0.02 due to the theoretical uncertainty in t-channel prediction.

$A_{FB}^{(0,u)}$ CHARGE ASYMMETRY IN $e^+ e^- \to u\overline{u}$

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*	*TECN*
4.0±6.7±2.8	**7.2**	**91.2**	[201] ACKERSTAFF 97T	OPAL

[201] ACKERSTAFF 97T measure the forward-backward asymmetry of various fast hadrons made of light quarks. Then using SU(2) isospin symmetry and flavor independence for down and strange quarks authors solve for the different quark types.

$A_{FB}^{(0,s)}$ CHARGE ASYMMETRY IN $e^+ e^- \to s\overline{s}$

The s-quark asymmetry is derived from measurements of the forward-backward asymmetry of fast hadrons containing an s quark.

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*	*TECN*
9.8 ±1.1 OUR AVERAGE				
10.08±1.13±0.40	10.1	91.2	[202] ABREU 00B	DLPH
6.8 ±3.5 ±1.1	10.1	91.2	[203] ACKERSTAFF 97T	OPAL

[202] ABREU 00B tag the presence of an *s* quark requiring a high-momentum-identified charged kaon. The *s*-quark pole asymmetry is extracted from the charged-kaon asymmetry taking the expected *d*- and *u*-quark asymmetries from the Standard Model and using the measured values for the *c*- and *b*-quark asymmetries.

[203] ACKERSTAFF 97T measure the forward-backward asymmetry of various fast hadrons made of light quarks. Then using SU(2) isospin symmetry and flavor independence for down and strange quarks authors solve for the different quark types. The value reported here corresponds then to the forward-backward asymmetry for "down-type" quarks.

$A_{FB}^{(0,c)}$ CHARGE ASYMMETRY IN $e^+e^- \to c\overline{c}$

OUR FIT, which is obtained by a simultaneous fit to several *c*- and *b*-quark measurements as explained in the note "The *Z* boson" and ref. LEP-SLC 06, refers to the ***Z* pole** asymmetry. The experimental values, on the other hand, correspond to the measurements carried out at the respective energies.

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*		*TECN*
7.07± 0.35 OUR FIT					
6.31± 0.93±0.65	6.35	91.26	[204] ABDALLAH	04F	DLPH
5.68± 0.54±0.39	6.3	91.25	[205] ABBIENDI	03P	OPAL
6.45± 0.57±0.37	6.10	91.21	[206] HEISTER	02H	ALEP
6.59± 0.94±0.35	6.2	91.235	[207] ABREU	99Y	DLPH
6.3 ± 0.9 ±0.3	6.1	91.22	[208] BARATE	98O	ALEP
6.3 ± 1.2 ±0.6	6.1	91.22	[209] ALEXANDER	97C	OPAL
8.3 ± 3.8 ±2.7	6.2	91.24	[210] ADRIANI	92D	L3

• • • We do not use the following data for averages, fits, limits, etc. • • •

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*		*TECN*
3.1 ± 3.5 ±0.5	−3.5	89.43	[204] ABDALLAH	04F	DLPH
11.0 ± 2.8 ±0.7	12.3	92.99	[204] ABDALLAH	04F	DLPH
− 6.8 ± 2.5 ±0.9	−3.0	89.51	[205] ABBIENDI	03P	OPAL
14.6 ± 2.0 ±0.8	12.2	92.95	[205] ABBIENDI	03P	OPAL
−12.4 ±15.9 ±2.0	−9.6	88.38	[206] HEISTER	02H	ALEP
− 2.3 ± 2.6 ±0.2	−3.8	89.38	[206] HEISTER	02H	ALEP
− 0.3 ± 8.3 ±0.6	0.9	90.21	[206] HEISTER	02H	ALEP
10.6 ± 7.7 ±0.7	9.6	92.05	[206] HEISTER	02H	ALEP
11.9 ± 2.1 ±0.6	12.2	92.94	[206] HEISTER	02H	ALEP
12.1 ±11.0 ±1.0	14.2	93.90	[206] HEISTER	02H	ALEP
− 4.96± 3.68±0.53	−3.5	89.434	[207] ABREU	99Y	DLPH
11.80± 3.18±0.62	12.3	92.990	[207] ABREU	99Y	DLPH
− 1.0 ± 4.3 ±1.0	−3.9	89.37	[208] BARATE	98O	ALEP
11.0 ± 3.3 ±0.8	12.3	92.96	[208] BARATE	98O	ALEP
3.9 ± 5.1 ±0.9	−3.4	89.45	[209] ALEXANDER	97C	OPAL
15.8 ± 4.1 ±1.1	12.4	93.00	[209] ALEXANDER	97C	OPAL
−12.9 ± 7.8 ±5.5	−13.6	35	BEHREND	90D	CELL
7.7 ±13.4 ±5.0	−22.1	43	BEHREND	90D	CELL
−12.8 ± 4.4 ±4.1	−13.6	35	ELSEN	90	JADE
−10.9 ±12.9 ±4.6	−23.2	44	ELSEN	90	JADE
−14.9 ± 6.7	−13.3	35	OULD-SAADA	89	JADE

[204] ABDALLAH 04F tag b– and c–quarks using semileptonic decays combined with charge flow information from the hemisphere opposite to the lepton. Enriched samples of $c\overline{c}$ and $b\overline{b}$ events are obtained using lifetime information.

[205] ABBIENDI 03P tag heavy flavors using events with one or two identified leptons. This allows the simultaneous fitting of the b and c quark forward-backward asymmetries as well as the average B^0-$\overline{B}^0$ mixing.

[206] HEISTER 02H measure simultaneously b and c quark forward-backward asymmetries using their semileptonic decays to tag the quark charge. The flavor separation is obtained with a discriminating multivariate analysis.

[207] ABREU 99Y tag $Z \rightarrow b\overline{b}$ and $Z \rightarrow c\overline{c}$ events by an exclusive reconstruction of several D meson decay modes (D^{*+}, D^0, and D^+ with their charge-conjugate states).

[208] BARATE 98O tag $Z \rightarrow c\overline{c}$ events requiring the presence of high-momentum reconstructed D^{*+}, D^+, or D^0 mesons.

[209] ALEXANDER 97C identify the b and c events using a D/D^* tag.

[210] ADRIANI 92D use both electron and muon semileptonic decays.

$A_{FB}^{(0,b)}$ CHARGE ASYMMETRY IN $e^+e^- \rightarrow b\overline{b}$

OUR FIT, which is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the note "The Z boson" and ref. LEP-SLC 06, refers to the ***Z* pole** asymmetry. The experimental values, on the other hand, correspond to the measurements carried out at the respective energies.

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*	*TECN*
9.92 ± 0.16 OUR FIT				
9.58 ± 0.32 ± 0.14	9.68	91.231	[211] ABDALLAH 05	DLPH
10.04 ± 0.56 ± 0.25	9.69	91.26	[212] ABDALLAH 04F	DLPH
9.72 ± 0.42 ± 0.15	9.67	91.25	[213] ABBIENDI 03P	OPAL
9.77 ± 0.36 ± 0.18	9.69	91.26	[214] ABBIENDI 02I	OPAL
9.52 ± 0.41 ± 0.17	9.59	91.21	[215] HEISTER 02H	ALEP
10.00 ± 0.27 ± 0.11	9.63	91.232	[216] HEISTER 01D	ALEP
7.62 ± 1.94 ± 0.85	9.64	91.235	[217] ABREU 99Y	DLPH
9.60 ± 0.66 ± 0.33	9.69	91.26	[218] ACCIARRI 99D	L3
9.31 ± 1.01 ± 0.55	9.65	91.24	[219] ACCIARRI 98U	L3
9.4 ± 2.7 ± 2.2	9.61	91.22	[220] ALEXANDER 97C	OPAL
• • • We do not use the following data for averages, fits, limits, etc. • • •				
6.37 ± 1.43 ± 0.17	5.8	89.449	[211] ABDALLAH 05	DLPH
10.41 ± 1.15 ± 0.24	12.1	92.990	[211] ABDALLAH 05	DLPH
6.7 ± 2.2 ± 0.2	5.7	89.43	[212] ABDALLAH 04F	DLPH
11.2 ± 1.8 ± 0.2	12.1	92.99	[212] ABDALLAH 04F	DLPH
4.7 ± 1.8 ± 0.1	5.9	89.51	[213] ABBIENDI 03P	OPAL
10.3 ± 1.5 ± 0.2	12.0	92.95	[213] ABBIENDI 03P	OPAL
5.82 ± 1.53 ± 0.12	5.9	89.50	[214] ABBIENDI 02I	OPAL
12.21 ± 1.23 ± 0.25	12.0	92.91	[214] ABBIENDI 02I	OPAL
−13.1 ± 13.5 ± 1.0	3.2	88.38	[215] HEISTER 02H	ALEP
5.5 ± 1.9 ± 0.1	5.6	89.38	[215] HEISTER 02H	ALEP
− 0.4 ± 6.7 ± 0.8	7.5	90.21	[215] HEISTER 02H	ALEP
11.1 ± 6.4 ± 0.5	11.0	92.05	[215] HEISTER 02H	ALEP
10.4 ± 1.5 ± 0.3	12.0	92.94	[215] HEISTER 02H	ALEP
13.8 ± 9.3 ± 1.1	12.9	93.90	[215] HEISTER 02H	ALEP
4.36 ± 1.19 ± 0.11	5.8	89.472	[216] HEISTER 01D	ALEP

$11.72 \pm 0.97 \pm 0.11$	12.0	92.950	[216] HEISTER 01D	ALEP
$5.67 \pm 7.56 \pm 1.17$	5.7	89.434	[217] ABREU 99Y	DLPH
$8.82 \pm 6.33 \pm 1.22$	12.1	92.990	[217] ABREU 99Y	DLPH
$6.11 \pm 2.93 \pm 0.43$	5.9	89.50	[218] ACCIARRI 99D	L3
$13.71 \pm 2.40 \pm 0.44$	12.2	93.10	[218] ACCIARRI 99D	L3
$4.95 \pm 5.23 \pm 0.40$	5.8	89.45	[219] ACCIARRI 98U	L3
$11.37 \pm 3.99 \pm 0.65$	12.1	92.99	[219] ACCIARRI 98U	L3
$-8.6 \pm 10.8 \pm 2.9$	5.8	89.45	[220] ALEXANDER 97C	OPAL
$-2.1 \pm 9.0 \pm 2.6$	12.1	93.00	[220] ALEXANDER 97C	OPAL
$-71 \pm 34 \, ^{+7}_{-8}$	-58	58.3	SHIMONAKA 91	TOPZ
$-22.2 \pm 7.7 \pm 3.5$	-26.0	35	BEHREND 90D	CELL
$-49.1 \pm 16.0 \pm 5.0$	-39.7	43	BEHREND 90D	CELL
-28 ± 11	-23	35	BRAUNSCH... 90	TASS
$-16.6 \pm 7.7 \pm 4.8$	-24.3	35	ELSEN 90	JADE
$-33.6 \pm 22.2 \pm 5.2$	-39.9	44	ELSEN 90	JADE
$3.4 \pm 7.0 \pm 3.5$	-16.0	29.0	BAND 89	MAC
$-72 \pm 28 \pm 13$	-56	55.2	SAGAWA 89	AMY

[211] ABDALLAH 05 obtain an enriched samples of $b\overline{b}$ events using lifetime information. The quark (or antiquark) charge is determined with a neural network using the secondary vertex charge, the jet charge and particle identification.

[212] ABDALLAH 04F tag b– and c–quarks using semileptonic decays combined with charge flow information from the hemisphere opposite to the lepton. Enriched samples of $c\overline{c}$ and $b\overline{b}$ events are obtained using lifetime information.

[213] ABBIENDI 03P tag heavy flavors using events with one or two identified leptons. This allows the simultaneous fitting of the b and c quark forward-backward asymmetries as well as the average B^0-$\overline{B}^0$ mixing.

[214] ABBIENDI 02I tag $Z^0 \rightarrow b\overline{b}$ decays using a combination of secondary vertex and lepton tags. The sign of the b-quark charge is determined using an inclusive tag based on jet, vertex, and kaon charges.

[215] HEISTER 02H measure simultaneously b and c quark forward-backward asymmetries using their semileptonic decays to tag the quark charge. The flavor separation is obtained with a discriminating multivariate analysis.

[216] HEISTER 01D tag $Z \rightarrow b\overline{b}$ events using the impact parameters of charged tracks complemented with information from displaced vertices, event shape variables, and lepton identification. The b-quark direction and charge is determined using the hemisphere charge method along with information from fast kaon tagging and charge estimators of primary and secondary vertices. The change in the quoted value due to variation of A^c_{FB} and R_b is given as $+0.103\ (A^c_{FB} - 0.0651)\ -0.440\ (R_b - 0.21585)$.

[217] ABREU 99Y tag $Z \rightarrow b\overline{b}$ and $Z \rightarrow c\overline{c}$ events by an exclusive reconstruction of several D meson decay modes (D^{*+}, D^0, and D^+ with their charge-conjugate states).

[218] ACCIARRI 99D tag $Z \rightarrow b\overline{b}$ events using high p and p_T leptons. The analysis determines simultaneously a mixing parameter $\chi_b = 0.1192 \pm 0.0068 \pm 0.0051$ which is used to correct the observed asymmetry.

[219] ACCIARRI 98U tag $Z \rightarrow b\overline{b}$ events using lifetime and measure the jet charge using the hemisphere charge.

[220] ALEXANDER 97C identify the b and c events using a D/D^* tag.

CHARGE ASYMMETRY IN $e^+e^- \rightarrow q\overline{q}$

Summed over five lighter flavors.

Experimental and Standard Model values are somewhat event-selection dependent. Standard Model expectations contain some assumptions on B^0-$\overline{B}^0$ mixing and on other electroweak parameters.

• • • We do not use the following data for averages, fits, limits, etc. • • •

ASYMMETRY (%)	*STD. MODEL*	$\sqrt{s}$ *(GeV)*	*DOCUMENT ID*		*TECN*
$-$ 0.76±0.12±0.15		91.2	[221] ABREU	92I	DLPH
4.0 ±0.4 ±0.63	4.0	91.3	[222] ACTON	92L	OPAL
9.1 ±1.4 ±1.6	9.0	57.9	ADACHI	91	TOPZ
$-$ 0.84±0.15±0.04		91	DECAMP	91B	ALEP
8.3 ±2.9 ±1.9	8.7	56.6	STUART	90	AMY
11.4 ±2.2 ±2.1	8.7	57.6	ABE	89L	VNS
6.0 ±1.3	5.0	34.8	GREENSHAW	89	JADE
8.2 ±2.9	8.5	43.6	GREENSHAW	89	JADE

[221] ABREU 92I has 0.14 systematic error due to uncertainty of quark fragmentation.

[222] ACTON 92L use the weight function method on 259k selected $Z \rightarrow$ hadrons events. The systematic error includes a contribution of 0.2 due to B^0-$\overline{B}^0$ mixing effect, 0.4 due to Monte Carlo (MC) fragmentation uncertainties and 0.3 due to MC statistics. ACTON 92L derive a value of $\sin^2\theta_W^{\rm eff}$ to be 0.2321 ± 0.0017 ± 0.0028.

CHARGE ASYMMETRY IN $p\overline{p} \rightarrow Z \rightarrow e^+e^-$

• • • We do not use the following data for averages, fits, limits, etc. • • •

ASYMMETRY (%)	*STD. MODEL*	$\sqrt{s}$ *(GeV)*	*DOCUMENT ID*		*TECN*
5.2±5.9±0.4		91	ABE	91E	CDF

ANOMALOUS $ZZ\gamma$, $Z\gamma\gamma$, AND ZZV COUPLINGS

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h_i^V

Combining the LEP results properly taking into account the correlations the following 95% CL limits are derived (CERN-PH-EP/2005-051 or hep-ex/0511027):

$$-0.13 < h_1^Z < +0.13, \qquad -0.078 < h_2^Z < +0.071,$$
$$-0.20 < h_3^Z < +0.07, \qquad -0.05 < h_4^Z < +0.12,$$
$$-0.056 < h_1^\gamma < +0.055, \qquad -0.045 < h_2^\gamma < +0.025,$$
$$-0.049 < h_3^\gamma < -0.008, \qquad -0.002 < h_4^\gamma < +0.034.$$

VALUE	*DOCUMENT ID*	*TECN*	*COMMENT*

• • • We do not use the following data for averages, fits, limits, etc. • • •

[223] ABAZOV	07M	D0	
[224] ABDALLAH	07C	DLPH	$E^{ee}_{\rm cm}$ = 183–208 GeV
[225] ACHARD	04H	L3	
[226] ABBIENDI,G	00C	OPAL	
[227] ABBOTT	98M	D0	
[228] ABREU	98K	DLPH	

[223] ABAZOV 07M use 968 $p\overline{p} \rightarrow e^+e^-/\mu^+\mu^-\gamma X$ candidates, at 1.96 TeV center of mass energy, to tag $p\overline{p} \rightarrow Z\gamma$ events by requiring $E_T(\gamma) > 7$ GeV, lepton-gamma separation $\Delta R_{\ell\gamma} > 0.7$, and di-lepton invariant mass > 30 GeV. The cross section is in agreement with the SM prediction. Using these $Z\gamma$ events they obtain 95% C.L. limits on each h^V_i, keeping all others fixed at their SM values. They report: $-0.083 < h^Z_{30} < 0.082$, $-0.0053 < h^Z_{40} < 0.0054$, $-0.085 < h^\gamma_{30} < 0.084$, $-0.0053 < h^\gamma_{40} < 0.0054$, for the form factor scale $\Lambda = 1.2$ TeV.

[224] Using data collected at $\sqrt{s}$ = 183–208, ABDALLAH 07C select 1,877 $e^+e^- \rightarrow Z\gamma$ events with $Z \rightarrow q\overline{q}$ or $\nu\overline{\nu}$, 171 $e^+e^- \rightarrow ZZ$ events with $Z \rightarrow q\overline{q}$ or lepton pair (except an explicit τ pair), and 74 $e^+e^- \rightarrow Z\gamma^*$ events with a $q\overline{q}\mu^+\mu^-$ or $q\overline{q}e^+e^-$ signature, to derive 95% CL limits on h^V_i. Each limit is derived with other parameters set to zero. They report: $-0.23 < h^Z_1 < 0.23$, $-0.30 < h^Z_3 < 0.16$, $-0.14 < h^\gamma_1 < 0.14$, $-0.049 < h^\gamma_3 < 0.044$.

[225] ACHARD 04H select 3515 $e^+e^- \rightarrow Z\gamma$ events with $Z \rightarrow q\overline{q}$ or $\nu\overline{\nu}$ at $\sqrt{s}$ = 189–209 GeV to derive 95% CL limits on h^V_i. For deriving each limit the other parameters are fixed at zero. They report: $-0.153 < h^Z_1 < 0.141$, $-0.087 < h^Z_2 < 0.079$, $-0.220 < h^Z_3 < 0.112$, $-0.068 < h^Z_4 < 0.148$, $-0.057 < h^\gamma_1 < 0.057$, $-0.050 < h^\gamma_2 < 0.023$, $-0.059 < h^\gamma_3 < 0.004$, $-0.004 < h^\gamma_4 < 0.042$.

[226] ABBIENDI,G 00C study $e^+e^- \rightarrow Z\gamma$ events (with $Z \rightarrow q\overline{q}$ and $Z \rightarrow \nu\overline{\nu}$) at 189 GeV to obtain the central values (and 95% CL limits) of these couplings: $h^Z_1 = 0.000 \pm 0.100$ $(-0.190, 0.190)$, $h^Z_2 = 0.000 \pm 0.068$ $(-0.128, 0.128)$, $h^Z_3 = -0.074^{+0.102}_{-0.103}$ $(-0.269, 0.119)$, $h^Z_4 = 0.046 \pm 0.068$ $(-0.084, 0.175)$, $h^\gamma_1 = 0.000 \pm 0.061$ $(-0.115, 0.115)$, $h^\gamma_2 = 0.000 \pm 0.041$ $(-0.077, 0.077)$, $h^\gamma_3 = -0.080^{+0.039}_{-0.041}$ $(-0.164, -0.006)$, $h^\gamma_4 = 0.064^{+0.033}_{-0.030}$ $(+0.007, +0.134)$. The results are derived assuming that only one coupling at a time is different from zero.

[227] ABBOTT 98M study $p\overline{p} \rightarrow Z\gamma$ + X, with $Z \rightarrow e^+e^-$, $\mu^+\mu^-$, $\overline{\nu}\nu$ at 1.8 TeV, to obtain 95% CL limits at Λ= 750 GeV: $|h^Z_{30}| < 0.36$, $|h^Z_{40}| < 0.05$ (keeping h^γ_i=0), and $|h^\gamma_{30}| < 0.37$, $|h^\gamma_{40}| < 0.05$ (keeping h^Z_i=0). Limits on the *CP*-violating couplings are $|h^Z_{10}| < 0.36$, $|h^Z_{20}| < 0.05$ (keeping h^γ_i=0), and $|h^\gamma_{10}| < 0.37$, $|h^\gamma_{20}| < 0.05$ (keeping h^Z_i=0).

[228] ABREU 98K determine a 95% CL upper limit on $\sigma(e^+e^- \rightarrow \gamma +$ invisible particles$) <$ 2.5 pb using 161 and 172 GeV data. This is used to set 95% CL limits on $|h^\gamma_{30}| < 0.8$ and $|h^Z_{30}| < 1.3$, derived at a scale Λ=1 TeV and with n=3 in the form factor representation.

f_i^V

Combining the LEP results properly taking into account the correlations the following 95% CL limits are derived (CERN-PH-EP/2005-051 or hep-ex/0511027):

$$-0.30 < f_4^Z < +0.30, \qquad -0.34 < f_5^Z < +0.38,$$
$$-0.17 < f_4^\gamma < +0.19, \qquad -0.32 < f_5^\gamma < +0.36.$$

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[229] ABAZOV	08K	D0	$E_{\rm cm}^{p\overline{p}}$ = 1.96 TeV
	[230] ABDALLAH	07C	DLPH	$E_{\rm cm}^{ee}$ = 183–208 GeV
	[231] ABBIENDI	04C	OPAL	
	[232] ACHARD	03D	L3	

[229] ABAZOV 08K search for ZZ and $Z\gamma^*$ events with 1 fb^{-1} $p\overline{p}$ data at 1.96 TeV in $(ee)(ee)$, $(\mu\mu)(\mu\mu)$, $(ee)(\mu\mu)$ final states requiring the lepton pair masses to be $>$ 30 GeV. They observe 1 event, which is consistent with an expected signal of 1.71 ± 0.15 events and a background of 0.13 ± 0.03 events. From this they derive the following limits, for a form factor (Λ) value of 1.2 TeV: $-0.28 < f_{40}^Z < 0.28$, $-0.31 < f_{50}^Z < 0.29$, $-0.26 < f_{40}^\gamma < 0.26$, $-0.30 < f_{50}^\gamma < 0.28$.

[230] Using data collected at $\sqrt{s}$ = 183–208, ABDALLAH 07C select 171 $e^+e^- \rightarrow ZZ$ events with $Z \rightarrow q\overline{q}$ or lepton pair (except an explicit τ pair), and 74 $e^+e^- \rightarrow Z\gamma^*$ events with a $q\overline{q}\mu^+\mu^-$ or $q\overline{q}e^+e^-$ signature, to derive 95% CL limits on f_i^V. Each limit is derived with other parameters set to zero. They report: $-0.40 < f_4^Z < 0.42$, $-0.38 < f_5^Z < 0.62$, $-0.23 < f_4^\gamma < 0.25$, $-0.52 < f_5^\gamma < 0.48$.

[231] ABBIENDI 04C study ZZ production in e^+e^- collisions in the C.M. energy range 190–209 GeV. They select 340 events with an expected background of 180 events. Including the ABBIENDI 00N data at 183 and 189 GeV (118 events with an expected background of 65 events) they report the following 95% CL limits: $-0.45 < f_4^Z < 0.58$, $-0.94 < f_5^Z < 0.25$, $-0.32 < f_4^\gamma < 0.33$, and $-0.71 < f_5^\gamma < 0.59$.

[232] ACHARD 03D study Z-boson pair production in e^+e^- collisions in the C.M. energy range 200–209 GeV. They select 549 events with an expected background of 432 events. Including the ACCIARRI 99G and ACCIARRI 99O data (183 and 189 GeV respectively, 286 events with an expected background of 241 events) and the 192–202 GeV ACCIARRI 01I results (656 events, expected background of 512 events), they report the following 95% CL limits: $-0.48 \leq f_4^Z \leq 0.46$, $-0.36 \leq f_5^Z \leq 1.03$, $-0.28 \leq f_4^\gamma \leq 0.28$, and $-0.40 \leq f_5^\gamma \leq 0.47$.

ANOMALOUS *W*/*Z* QUARTIC COUPLINGS

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a_0/Λ^2, a_c/Λ^2

Combining published and unpublished preliminary LEP results the following 95% CL intervals for the QGCs associated with the $ZZ\gamma\gamma$ vertex are derived (CERN-PH-EP/2005-051 or hep-ex/0511027):

$$-0.008 < a_0^Z/\Lambda^2 < +0.021$$
$$-0.029 < a_c^Z/\Lambda^2 < +0.039$$

VALUE	*DOCUMENT ID*		*TECN*
• • • We do not use the following data for averages, fits, limits, etc. • • •			
	[233] ABBIENDI	04L	OPAL
	[234] HEISTER	04A	ALEP
	[235] ACHARD	02G	L3

[233] ABBIENDI 04L select 20 $e^+e^- \to \nu\overline{\nu}\gamma\gamma$ acoplanar events in the energy range 180–209 GeV and 176 $e^+e^- \to q\overline{q}\gamma\gamma$ events in the energy range 130–209 GeV. These samples are used to constrain possible anomalous $W^+W^-\gamma\gamma$ and $ZZ\gamma\gamma$ quartic couplings. Further combining with the $W^+W^-\gamma$ sample of ABBIENDI 04B the following one–parameter 95% CL limits are obtained: $-0.007 < a_0^Z/\Lambda^2 < 0.023$ GeV^{-2}, $-0.029 < a_c^Z/\Lambda^2 < 0.029$ GeV^{-2}, $-0.020 < a_0^W/\Lambda^2 < 0.020$ GeV^{-2}, $-0.052 < a_c^W/\Lambda^2 < 0.037$ GeV^{-2}.

[234] In the CM energy range 183 to 209 GeV HEISTER 04A select 30 $e^+e^- \to \nu\overline{\nu}\gamma\gamma$ events with two acoplanar, high energy and high transverse momentum photons. The photon–photon acoplanarity is required to be $> 5^\circ$, $E_\gamma/\sqrt{s} > 0.025$ (the more energetic photon having energy $> 0.2\sqrt{s}$), $p_{T_\gamma}/E_{\text{beam}} > 0.05$ and $|\cos\theta_\gamma| < 0.94$. A likelihood fit to the photon energy and recoil missing mass yields the following one–parameter 95% CL limits: $-0.012 < a_0^Z/\Lambda^2 < 0.019$ GeV^{-2}, $-0.041 < a_c^Z/\Lambda^2 < 0.044$ GeV^{-2}, $-0.060 < a_0^W/\Lambda^2 < 0.055$ GeV^{-2}, $-0.099 < a_c^W/\Lambda^2 < 0.093$ GeV^{-2}.

[235] ACHARD 02G study $e^+e^- \to Z\gamma\gamma \to q\overline{q}\gamma\gamma$ events using data at center-of-mass energies from 200 to 209 GeV. The photons are required to be isolated, each with energy >5 GeV and $|\cos\theta| < 0.97$, and the di-jet invariant mass to be compatible with that of the Z boson (74–111 GeV). Cuts on Z velocity ($\beta < 0.73$) and on the energy of the most energetic photon reduce the backgrounds due to non-resonant production of the $q\overline{q}\gamma\gamma$ state and due to ISR respectively, yielding a total of 40 candidate events of which 8.6 are expected to be due to background. The energy spectra of the least energetic photon are fitted for all ten center-of-mass energy values from 130 GeV to 209 GeV (as obtained adding to the present analysis 130–202 GeV data of ACCIARRI 01E, for a total of 137 events with an expected background of 34.1 events) to obtain the fitted values $a_0/\Lambda^2 = 0.00^{+0.02}_{-0.01}$ GeV^{-2} and $a_c/\Lambda^2 = 0.03^{+0.01}_{-0.02}$ GeV^{-2}, where the other parameter is kept fixed to its Standard Model value (0). A simultaneous fit to both parameters yields the 95% CL limits -0.02 GeV^{-2} $< a_0/\Lambda^2 < 0.03$ GeV^{-2} and -0.07 GeV^{-2} $< a_c/\Lambda^2 < 0.05$ GeV^{-2}.

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ABE 01B	PRL 86 1162	K. Abe *et al.*	(SLD Collab.)
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ACCIARRI 01E	PL B505 47	M. Acciarri *et al.*	(L3 Collab.)
ACCIARRI 01I	PL B497 23	M. Acciarri *et al.*	(L3 Collab.)
HEISTER 01	EPJ C20 401	A. Heister *et al.*	(ALEPH Collab.)
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ABREU 00E	EPJ C14 585	P. Abreu *et al.*	(DELPHI Collab.)
ABREU 00F	EPJ C16 371	P. Abreu *et al.*	(DELPHI Collab.)
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ACCIARRI 00	EPJ C13 47	M. Acciarri *et al.*	(L3 Collab.)
ACCIARRI 00C	EPJ C16 1	M. Acciarri *et al.*	(L3 Collab.)
ACCIARRI 00J	PL B479 79	M. Acciarri *et al.*	(L3 Collab.)
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BARATE 00B	EPJ C16 597	R. Barate *et al.*	(ALEPH Collab.)
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ACCIARRI 99D	PL B448 152	M. Acciarri *et al.*	(L3 Collab.)
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ABREU	96S	PL B389 405	P. Abreu *et al.*	(DELPHI Collab.)
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ADAM	96	ZPHY C69 561	W. Adam *et al.*	(DELPHI Collab.)
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ABREU	95M	ZPHY C65 603	P. Abreu *et al.*	(DELPHI Collab.)
ABREU	95O	ZPHY C67 543	P. Abreu *et al.*	(DELPHI Collab.)
ABREU	95R	ZPHY C68 353	P. Abreu *et al.*	(DELPHI Collab.)
ABREU	95V	ZPHY C68 541	P. Abreu *et al.*	(DELPHI Collab.)
ABREU	95W	PL B361 207	P. Abreu *et al.*	(DELPHI Collab.)
ABREU	95X	ZPHY C69 1	P. Abreu *et al.*	(DELPHI Collab.)
ACCIARRI	95B	PL B345 589	M. Acciarri *et al.*	(L3 Collab.)
ACCIARRI	95C	PL B345 609	M. Acciarri *et al.*	(L3 Collab.)
ACCIARRI	95G	PL B353 136	M. Acciarri *et al.*	(L3 Collab.)
AKERS	95C	ZPHY C65 47	R. Akers *et al.*	(OPAL Collab.)
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ABREU	94B	PL B327 386	P. Abreu *et al.*	(DELPHI Collab.)
ABREU	94P	PL B341 109	P. Abreu *et al.*	(DELPHI Collab.)
AKERS	94P	ZPHY C63 181	R. Akers *et al.*	(OPAL Collab.)
BUSKULIC	94G	ZPHY C62 179	D. Buskulic *et al.*	(ALEPH Collab.)
BUSKULIC	94J	ZPHY C62 1	D. Buskulic *et al.*	(ALEPH Collab.)
VILAIN	94	PL B320 203	P. Vilain *et al.*	(CHARM II Collab.)
ABREU	93	PL B298 236	P. Abreu *et al.*	(DELPHI Collab.)
ABREU	93I	ZPHY C59 533	P. Abreu *et al.*	(DELPHI Collab.)
Also		ZPHY C65 709 (erratum)	P. Abreu *et al.*	(DELPHI Collab.)
ABREU	93L	PL B318 249	P. Abreu *et al.*	(DELPHI Collab.)
ACTON	93	PL B305 407	P.D. Acton *et al.*	(OPAL Collab.)
ACTON	93D	ZPHY C58 219	P.D. Acton *et al.*	(OPAL Collab.)
ACTON	93E	PL B311 391	P.D. Acton *et al.*	(OPAL Collab.)
ADRIANI	93	PL B301 136	O. Adriani *et al.*	(L3 Collab.)

ADRIANI	93I	PL B316 427	O. Adriani *et al.*	(L3 Collab.)
BUSKULIC	93L	PL B313 520	D. Buskulic *et al.*	(ALEPH Collab.)
NOVIKOV	93C	PL B298 453	V.A. Novikov, L.B. Okun, M.I. Vysotsky	(ITEP)
ABREU	92I	PL B277 371	P. Abreu *et al.*	(DELPHI Collab.)
ABREU	92M	PL B289 199	P. Abreu *et al.*	(DELPHI Collab.)
ACTON	92B	ZPHY C53 539	D.P. Acton *et al.*	(OPAL Collab.)
ACTON	92L	PL B294 436	P.D. Acton *et al.*	(OPAL Collab.)
ACTON	92N	PL B295 357	P.D. Acton *et al.*	(OPAL Collab.)
ADEVA	92	PL B275 209	B. Adeva *et al.*	(L3 Collab.)
ADRIANI	92D	PL B292 454	O. Adriani *et al.*	(L3 Collab.)
ALITTI	92B	PL B276 354	J. Alitti *et al.*	(UA2 Collab.)
BUSKULIC	92D	PL B292 210	D. Buskulic *et al.*	(ALEPH Collab.)
BUSKULIC	92E	PL B294 145	D. Buskulic *et al.*	(ALEPH Collab.)
DECAMP	92	PRPL 216 253	D. Decamp *et al.*	(ALEPH Collab.)
ABE	91E	PRL 67 1502	F. Abe *et al.*	(CDF Collab.)
ABREU	91H	ZPHY C50 185	P. Abreu *et al.*	(DELPHI Collab.)
ACTON	91B	PL B273 338	D.P. Acton *et al.*	(OPAL Collab.)
ADACHI	91	PL B255 613	I. Adachi *et al.*	(TOPAZ Collab.)
ADEVA	91I	PL B259 199	B. Adeva *et al.*	(L3 Collab.)
AKRAWY	91F	PL B257 531	M.Z. Akrawy *et al.*	(OPAL Collab.)
DECAMP	91B	PL B259 377	D. Decamp *et al.*	(ALEPH Collab.)
DECAMP	91J	PL B266 218	D. Decamp *et al.*	(ALEPH Collab.)
JACOBSEN	91	PRL 67 3347	R.G. Jacobsen *et al.*	(Mark II Collab.)
SHIMONAKA	91	PL B268 457	A. Shimonaka *et al.*	(TOPAZ Collab.)
ABE	90I	ZPHY C48 13	K. Abe *et al.*	(VENUS Collab.)
ABRAMS	90	PRL 64 1334	G.S. Abrams *et al.*	(Mark II Collab.)
AKRAWY	90J	PL B246 285	M.Z. Akrawy *et al.*	(OPAL Collab.)
BEHREND	90D	ZPHY C47 333	H.J. Behrend *et al.*	(CELLO Collab.)
BRAUNSCH...	90	ZPHY C48 433	W. Braunschweig *et al.*	(TASSO Collab.)
ELSEN	90	ZPHY C46 349	E. Elsen *et al.*	(JADE Collab.)
HEGNER	90	ZPHY C46 547	S. Hegner *et al.*	(JADE Collab.)
STUART	90	PRL 64 983	D. Stuart *et al.*	(AMY Collab.)
ABE	89	PRL 62 613	F. Abe *et al.*	(CDF Collab.)
ABE	89C	PRL 63 720	F. Abe *et al.*	(CDF Collab.)
ABE	89L	PL B232 425	K. Abe *et al.*	(VENUS Collab.)
ABRAMS	89B	PRL 63 2173	G.S. Abrams *et al.*	(Mark II Collab.)
ABRAMS	89D	PRL 63 2780	G.S. Abrams *et al.*	(Mark II Collab.)
ALBAJAR	89	ZPHY C44 15	C. Albajar *et al.*	(UA1 Collab.)
BACALA	89	PL B218 112	A. Bacala *et al.*	(AMY Collab.)
BAND	89	PL B218 369	H.R. Band *et al.*	(MAC Collab.)
GREENSHAW	89	ZPHY C42 1	T. Greenshaw *et al.*	(JADE Collab.)
OULD-SAADA	89	ZPHY C44 567	F. Ould-Saada *et al.*	(JADE Collab.)
SAGAWA	89	PRL 63 2341	H. Sagawa *et al.*	(AMY Collab.)
ADACHI	88C	PL B208 319	I. Adachi *et al.*	(TOPAZ Collab.)
ADEVA	88	PR D38 2665	B. Adeva *et al.*	(Mark-J Collab.)
BRAUNSCH...	88D	ZPHY C40 163	W. Braunschweig *et al.*	(TASSO Collab.)
ANSARI	87	PL B186 440	R. Ansari *et al.*	(UA2 Collab.)
BEHREND	87C	PL B191 209	H.J. Behrend *et al.*	(CELLO Collab.)
BARTEL	86C	ZPHY C30 371	W. Bartel *et al.*	(JADE Collab.)
Also		ZPHY C26 507	W. Bartel *et al.*	(JADE Collab.)
Also		PL 108B 140	W. Bartel *et al.*	(JADE Collab.)
ASH	85	PRL 55 1831	W.W. Ash *et al.*	(MAC Collab.)
BARTEL	85F	PL 161B 188	W. Bartel *et al.*	(JADE Collab.)
DERRICK	85	PR D31 2352	M. Derrick *et al.*	(HRS Collab.)
FERNANDEZ	85	PRL 54 1624	E. Fernandez *et al.*	(MAC Collab.)
LEVI	83	PRL 51 1941	M.E. Levi *et al.*	(Mark II Collab.)
BEHREND	82	PL 114B 282	H.J. Behrend *et al.*	(CELLO Collab.)
BRANDELIK	82C	PL 110B 173	R. Brandelik *et al.*	(TASSO Collab.)