Z

$J = 1$

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Z MASS

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. We believe that this set is the most free of correlations. Common systematic errors are taken into account. For more details, see the 'Note on the Z Boson.'

The Z-boson mass listed here corresponds to a Breit-Wigner resonance parameter. 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 97K and ACKERSTAFF 97C for a detailed investigation of both these issues.

A new source of LEP energy variation was discovered in mid 1995: an energy change of a few MeV is correlated with the passage of a train on nearby railway tracks. The LEP energy working group is studying the implications of this effect for the high statistics data recorded since 1993. The main consequence of this is expected to be a shift in the overall LEP energy values leading to a corresponding shift in the value of m_Z. The LEP collaborations have consequently deferred publication of their results on Z lineshape and lepton forward-backward asymmetries based on 1993 and later data.

Because of the high current interest, we mention here the following preliminary results, but do not average them or include them in the Listings or Tables.

Combining published and unpublished preliminary LEP results (as of end of February 1999) yields an average Z-boson mass of 91.1867 ± 0.0021 GeV, with a total width of 2.4939 ± 0.0024 GeV.

VALUE (GeV)	EVTS	DOCUMENT ID		TECN	COMMENT
91.187±0.007 OUR FIT					
91.188±0.007 OUR AVERAGE					
91.187±0.007±0.006	1.16M	[1] ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
91.195±0.006±0.007	1.19M	[1] ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
91.182±0.007±0.006	1.33M	[1] AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
91.187±0.007±0.006	1.27M	[1] BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

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

91.193±0.010	1.2M	[2] ACCIARRI	97K	L3	E^{ee}_{cm}= LEP1 + 130–136 GeV + 161–172 GeV
91.185±0.010		[3] ACKERSTAFF	97C	OPAL	E^{ee}_{cm}= LEP1 + 130–136 GeV + 161 GeV
91.162±0.011	1.2M	[4] ACCIARRI	96B	L3	Repl. by ACCIARRI 97K
91.192±0.011	1.33M	[5] ALEXANDER	96X	OPAL	Repl. by ACKERSTAFF 97C
91.151±0.008		[6] MIYABAYASHI	95	TOPZ	E^{ee}_{cm}= 57.8 GeV
91.181±0.007±0.006	512k	[7] ACTON	93D	OPAL	Repl. by AKERS 94
91.195±0.009	460k	[8] ADRIANI	93F	L3	Repl. by ACCIARRI 94
91.187±0.009	520k	[9] BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
91.74 ±0.28 ±0.93	156	[10] ALITTI	92B	UA2	$E^{p\overline{p}}_{cm}$= 630 GeV
89.2 $^{+2.1}_{-1.8}$		[11] ADACHI	90F	RVUE	
90.9 ±0.3 ±0.2	188	[12] ABE	89C	CDF	$E^{p\overline{p}}_{cm}$= 1.8 TeV
91.14 ±0.12	480	[13] ABRAMS	89B	MRK2	E^{ee}_{cm}= 89–93 GeV
93.1 ±1.0 ±3.0	24	[14,15] ALBAJAR	89	UA1	$E^{p\overline{p}}_{cm}$= 546,630 GeV

[1] The second error of 6.3 MeV is due to a common LEP energy uncertainty.

[2] ACCIARRI 97K interpret the s-dependence of the cross sections and lepton forward-backward asymmetries in the framework of the S-matrix formalism with a combined fit to their cross section and asymmetry data at the Z peak (ACCIARRI 94) and their data at 130, 136, 161, and 172 GeV. 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 ±3 MeV due to the uncertainty on the γZ interference.

[3] ACKERSTAFF 97C obtain this using the S-matrix formalism for a combined fit to their cross-section and asymmetry data at the Z peak (AKERS 94) and their data at 130, 136, and 161 GeV. The authors have corrected the measurement for the 34 MeV shift with respect to the Breit-Wigner fits.

[4] ACCIARRI 96B interpret the s-dependence of the cross sections and lepton forward-backward asymmetries in the framework of the S-matrix ansatz. The 130–136 GeV data constrains the γZ interference terms. As expected, this result is below the mass values obtained with a standard Breit-Wigner parametrization.

[5] ALEXANDER 96X obtain this using the S-matrix formalism for a combined fit to their cross-section and asymmetry data at the Z peak (AKERS 94) and their data at 130 and 136 GeV. The authors have corrected the measurement for the 34 MeV shift with respect to the Breit-Wigner fits.

[6] 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.

[7] The systematic error in ACTON 93D is from the uncertainty in the LEP energy calibration.

[8] The error in ADRIANI 93F includes 6 MeV due to the uncertainty in LEP energy calibration.

[9] BUSKULIC 93J supersedes DECAMP 92B. The error includes 6 MeV due to the uncertainty in LEP energy calibration.

[10] 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.

[11] ADACHI 90F use a Breit-Wigner resonance shape fit and combine their results with published data of PEP and PETRA.

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

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

[14] Enters fit through Z-W mass difference given in the W Particle Listings.
[15] ALBAJAR 89 result is from a total sample of 33 $Z \to e^+ e^-$ events.

Z WIDTH

VALUE (GeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.490±0.007 OUR FIT					
2.491±0.007 OUR AVERAGE					
2.50 ±0.21 ±0.06		[16] ABREU	96R	DLPH	E^{ee}_{cm}= 91.2 GeV
2.483±0.011±0.0045	1.16M	[17] ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
2.494±0.009±0.0045	1.19M	[17] ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
2.483±0.011±0.0045	1.33M	[17] AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
2.501±0.011±0.0045	1.27M	[17] BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.494±0.010	1.2M	[18] ACCIARRI	97K	L3	E^{ee}_{cm}= LEP1 + 130–136 GeV + 161–172 GeV
2.492±0.010	1.2M	[19] ACCIARRI	96B	L3	Repl. by ACCIARRI 97K
2.483±0.011±0.004	512k	[20] ACTON	93D	OPAL	Repl. by AKERS 94
2.490±0.011	460k	[21] ADRIANI	93F	L3	Repl. by ACCIARRI 94
2.501±0.012	520k	[22] BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
3.8 ±0.8 ±1.0	188	ABE	89C	CDF	$E^{p\overline{p}}_{cm}$= 1.8 TeV
2.42 $^{+0.45}_{-0.35}$	480	[23] ABRAMS	89B	MRK2	E^{ee}_{cm}= 89–93 GeV
2.7 $^{+1.2}_{-1.0}$ ±1.3	24	[24] ALBAJAR	89	UA1	$E^{p\overline{p}}_{cm}$= 546,630 GeV
2.7 ±2.0 ±1.0	25	[25] ANSARI	87	UA2	$E^{p\overline{p}}_{cm}$= 546,630 GeV

[16] ABREU 96R obtain this value from a study of the interference between initial and final state radiation in the process $e^+ e^- \to Z \to \mu^+ \mu^-$.
[17] The second error of 4.5 MeV is due to a common LEP energy uncertainty.
[18] ACCIARRI 97K interpret the s-dependence of the cross sections and lepton forward-backward asymmetries in the framework of the S-matrix formalism with a combined fit to their cross section and asymmetry data at the Z peak (ACCIARRI 94) and their data at 130, 136, 161, and 172 GeV. The authors have corrected the measurement for the 0.9 MeV shift with respect to the Breit-Wigner fits.
[19] ACCIARRI 96B interpret the s-dependence of the cross sections and lepton forward-backward asymmetries in the framework of the S-matrix ansatz. The 130–136 GeV data constrains the γZ interference terms. The fitted width is expected to be 0.9 MeV less than that obtained using the standard Breit-Wigner parametrization (see 'Note on the Z Boson').
[20] The systematic error is from the uncertainty in the LEP energy calibration.
[21] The error in ADRIANI 93F includes 4 MeV due to the uncertainty in LEP energy calibration.
[22] The error in BUSKULIC 93J includes 4 MeV due to the uncertainty in LEP energy calibration.
[23] ABRAMS 89B uncertainty includes 50 MeV due to the miniSAM background subtraction error.
[24] ALBAJAR 89 result is from a total sample of 33 $Z \to e^+ e^-$ events.
[25] Quoted values of ANSARI 87 are from direct fit. Ratio of Z and W production gives either $\Gamma(Z) < (1.09\pm0.07) \times \Gamma(W)$, CL = 90% or $\Gamma(Z) = (0.82^{+0.19}_{-0.14}\pm0.06) \times \Gamma(W)$. Assuming Standard-Model value $\Gamma(W)$ = 2.65 GeV then gives $\Gamma(Z) <$ 2.89 ± 0.19 or $= 2.17^{+0.50}_{-0.37} \pm 0.16$.

Z DECAY MODES

	Mode		Fraction (Γ_i/Γ)	Confidence level
Γ_1	$e^+ e^-$		(3.366 ± 0.008) %	
Γ_2	$\mu^+ \mu^-$		(3.367 ± 0.013) %	
Γ_3	$\tau^+ \tau^-$		(3.360 ± 0.015) %	
Γ_4	$\ell^+ \ell^-$	[a]	(3.366 ± 0.006) %	
Γ_5	invisible		(20.01 ± 0.16) %	
Γ_6	hadrons		(69.90 ± 0.15) %	
Γ_7	$(u\overline{u}+c\overline{c})/2$		(10.1 ± 1.1) %	
Γ_8	$(d\overline{d}+s\overline{s}+b\overline{b})/3$		(16.6 ± 0.6) %	
Γ_9	$c\overline{c}$		(11.9 ± 0.4) %	
Γ_{10}	$b\overline{b}$		(15.13 ± 0.06) %	
Γ_{11}	ggg		< 1.1 %	95%
Γ_{12}	$\pi^0 \gamma$		$< 5.2 \times 10^{-5}$	95%
Γ_{13}	$\eta \gamma$		$< 5.1 \times 10^{-5}$	95%
Γ_{14}	$\omega \gamma$		$< 6.5 \times 10^{-4}$	95%
Γ_{15}	$\eta'(958) \gamma$		$< 4.2 \times 10^{-5}$	95%
Γ_{16}	$\gamma \gamma$		$< 5.2 \times 10^{-5}$	95%
Γ_{17}	$\gamma \gamma \gamma$		$< 1.0 \times 10^{-5}$	95%
Γ_{18}	$\pi^\pm W^\mp$	[b]	$< 7 \times 10^{-5}$	95%
Γ_{19}	$\rho^\pm W^\mp$	[b]	$< 8.3 \times 10^{-5}$	95%
Γ_{20}	$J/\psi(1S)$X		$(3.66 \pm 0.23) \times 10^{-3}$	
Γ_{21}	$\psi(2S)$X		$(1.60 \pm 0.29) \times 10^{-3}$	
Γ_{22}	$\chi_{c1}(1P)$X		$(2.9 \pm 0.7) \times 10^{-3}$	
Γ_{23}	$\chi_{c2}(1P)$X		$< 3.2 \times 10^{-3}$	90%
Γ_{24}	$\Upsilon(1S)$ X $+ \Upsilon(2S)$ X $+ \Upsilon(3S)$ X		$(1.0 \pm 0.5) \times 10^{-4}$	
Γ_{25}	$\Upsilon(1S)$X		$< 5.5 \times 10^{-5}$	95%
Γ_{26}	$\Upsilon(2S)$X		$< 1.39 \times 10^{-4}$	95%
Γ_{27}	$\Upsilon(3S)$X		$< 9.4 \times 10^{-5}$	95%
Γ_{28}	$(D^0/\overline{D}^0)$ X		(20.7 ± 2.0) %	
Γ_{29}	$D^\pm$X		(12.2 ± 1.7) %	
Γ_{30}	$D^*(2010)^\pm$X	[b]	(11.4 ± 1.3) %	
Γ_{31}	BX			
Γ_{32}	B^*X			
Γ_{33}	B^0_sX		seen	
Γ_{34}	B^+_cX		searched for	
Γ_{35}	anomalous $\gamma+$ hadrons	[c]	$< 3.2 \times 10^{-3}$	95%
Γ_{36}	$e^+ e^- \gamma$	[c]	$< 5.2 \times 10^{-4}$	95%
Γ_{37}	$\mu^+ \mu^- \gamma$	[c]	$< 5.6 \times 10^{-4}$	95%
Γ_{38}	$\tau^+ \tau^- \gamma$	[c]	$< 7.3 \times 10^{-4}$	95%

Γ_{39}	$\ell^+\ell^-\gamma\gamma$		[d] <	6.8	$\times 10^{-6}$	95%
Γ_{40}	$q\overline{q}\gamma\gamma$		[d] <	5.5	$\times 10^{-6}$	95%
Γ_{41}	$\nu\overline{\nu}\gamma\gamma$		[d] <	3.1	$\times 10^{-6}$	95%
Γ_{42}	$e^\pm\mu^\mp$	*LF*	[b] <	1.7	$\times 10^{-6}$	95%
Γ_{43}	$e^\pm\tau^\mp$	*LF*	[b] <	9.8	$\times 10^{-6}$	95%
Γ_{44}	$\mu^\pm\tau^\mp$	*LF*	[b] <	1.2	$\times 10^{-5}$	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] See the Particle Listings below for the γ energy range used in this measurement.

[d] For $m_{\gamma\gamma}$ = (60 ± 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 on the *Z* Boson.'

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
83.82±0.30 OUR FIT					
82.89±1.20±0.89		[26] ABE	95J	SLD	E^{ee}_{cm}= 91.31 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
83.31±0.54	31.4k	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
83.43±0.52	38k	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
83.63±0.53	42k	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
84.61±0.49	45.8k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

[26] 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 on the *Z* Boson.'

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
83.83±0.39 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
84.15±0.77	45.6k	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
83.20±0.79	34k	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
83.83±0.65	57k	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
83.62±0.75	46.4k	BUSKULIC	94	ALEP	E^{ee}_{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 on the Z Boson.'

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
83.67±0.44 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
83.55±0.91	25k	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
84.04±0.94	25k	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
82.90±0.77	47k	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
84.18±0.79	45.1k	BUSKULIC	94	ALEP	E^{ee}_{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 on the Z Boson.'

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
83.83±0.27 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
83.56±0.45	102k	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
83.49±0.46	97k	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
83.55±0.44	146k	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
84.40±0.43	137.3k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

$\Gamma(\text{invisible})$ Γ_5

We use only direct measurements of the invisible partial width to obtain the average value quoted below. The 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
498.3± 4.2 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. • • •					
509.4± 7.0		[27] ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
496.5± 7.9		[27] ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
490.3± 7.3		[27] AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
501 ± 6		[27] BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV
524 ±40 ±20	172	[28] ADRIANI	92E	L3	Repl. by ACCIARRI 98G

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

[28] ADRIANI 92E improves but does not supersede ADEVA 92, obtained with 1990 data only.

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 on the Z Boson.'

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
1740.7± 5.9 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1723 ±10	1.05M	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
1748 ±10	1.09M	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
1741 ±10	1.19M	[29] AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
1746 ±10	1.27M	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

[29] AKERS 94 assumes lepton universality. Without this assumption, it becomes 1742 ± 11 MeV.

Z BRANCHING RATIOS

Γ(hadrons)/Γ(e^+e^-) Γ_6/Γ_1

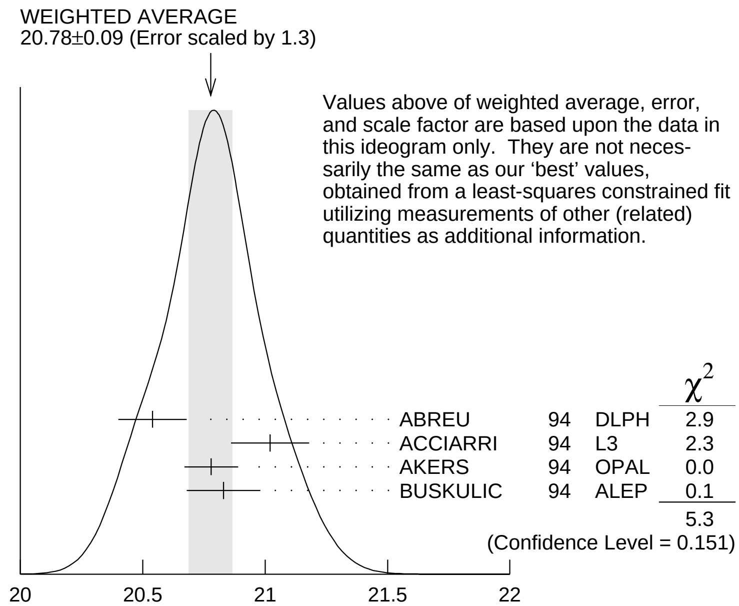
VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
20.77± 0.08 OUR FIT					
20.74± 0.18	31.4k	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
20.96± 0.15	38k	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
20.83± 0.16	42k	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
20.59± 0.15	45.8k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
20.99± 0.25	17k	ACTON	93D	OPAL	Repl. by AKERS 94
20.69± 0.21		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
27.0 $^{+11.7}_{-8.8}$	12	[30] ABRAMS	89D	MRK2	E^{ee}_{cm}= 89–93 GeV

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

Γ(hadrons)/Γ($\mu^+\mu^-$) Γ_6/Γ_2

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
20.76±0.07 OUR FIT					
20.78±0.09 OUR AVERAGE Error includes scale factor of 1.3. See the ideogram below.					
20.54±0.14	45.6k	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
21.02±0.16	34k	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
20.78±0.11	57k	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
20.83±0.15	46.4k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
20.65±0.17	23k	ACTON	93D	OPAL	Repl. by AKERS 94
20.88±0.20		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
18.9 $^{+7.1}_{-5.3}$	13	[31] ABRAMS	89D	MRK2	E^{ee}_{cm}= 89–93 GeV

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



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

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

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
20.80±0.08 OUR FIT					
20.81±0.08 OUR AVERAGE					
20.68±0.18	25k	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
20.80±0.20	25k	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
21.01±0.15	47k	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
20.70±0.16	45.1k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
21.22±0.25	18k	ACTON	93D	OPAL	Repl. by AKERS 94
20.77±0.23		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
$15.2\ ^{+4.8}_{-3.9}$	21	[32] ABRAMS	89D	MRK2	E^{ee}_{cm}= 89–93 GeV

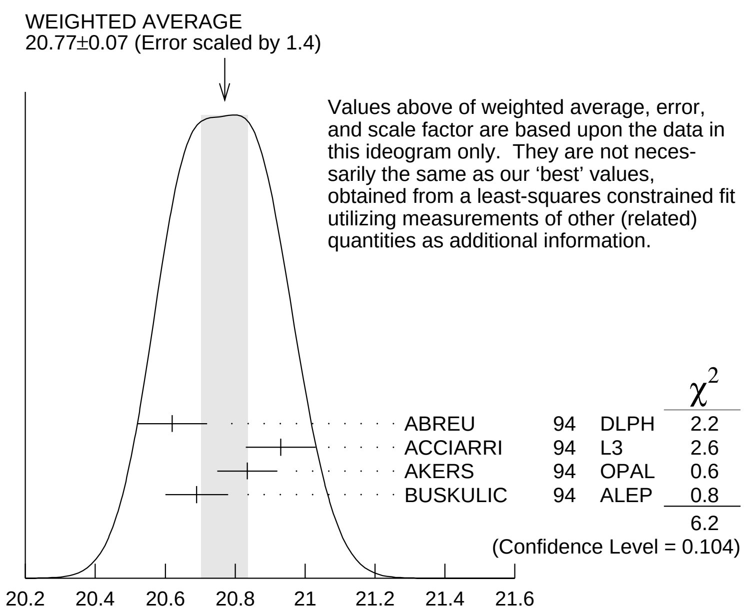
[32] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.

$\Gamma(\text{hadrons})/\Gamma(\ell^+\ell^-)$ 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
20.76 ±0.05 OUR FIT					
20.77 ±0.07 OUR AVERAGE		Error includes scale factor of 1.4. See the ideogram below.			
20.62 ±0.10	102k	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
20.93 ±0.10	97k	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
20.835±0.086	146k	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
20.69 ±0.09	137.3k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
20.88 ±0.13	58k	ACTON	93D	OPAL	Repl. by AKERS 94
21.00 ±0.15	40k	ADRIANI	93M	L3	Repl. by ACCIARRI 94
20.78 ±0.13		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
18.9 $^{+3.6}_{-3.2}$	46	ABRAMS	89B	MRK2	E^{ee}_{cm}= 89–93 GeV



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

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

This parameter is not directly used in the overall fit but is derived using the fit results; see the 'Note on the Z Boson.'

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.6990±0.0015 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.6983±0.0023	1.14M	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

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

This parameter is not directly used in the overall fit but is derived using the fit results; see the 'Note on the Z Boson.'

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.03366±0.00008 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.03383±0.00013	45.8k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

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

This parameter is not directly used in the overall fit but is derived using the fit results; see the 'Note on the Z Boson.'

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.03367±0.00013 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.03344±0.00026	46.4k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

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

This parameter is not directly used in the overall fit but is derived using the fit results; see the 'Note on the Z Boson.'

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.03360±0.00015 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.03366±0.00028	45.1k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

$\Gamma(\ell^+\ell^-)/\Gamma_{total}$ — 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 on the Z Boson.'

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.03366±0.00006 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.03375±0.00009	137.3k	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

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

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

VALUE	DOCUMENT ID
0.2001±0.0016 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 on the Z Boson.'

VALUE	DOCUMENT ID
1.000±0.005 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 on the Z Boson.'

VALUE	DOCUMENT ID
0.998±0.005 OUR FIT	

$\Gamma\big((u\overline{u}+c\overline{c})/2\big)/\Gamma\big(\text{hadrons}\big)$ 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 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
0.145±0.015 OUR AVERAGE				
$0.160\pm0.019\pm0.019$	[33] ACKERSTAFF	97T	OPAL	E^{ee}_{cm}= 88–94 GeV
$0.137^{+0.038}_{-0.054}$	[34] ABREU	95X	DLPH	E^{ee}_{cm}= 88–94 GeV
0.139 ± 0.026	[35] ACTON	93F	OPAL	E^{ee}_{cm}= 88–94 GeV
0.137 ± 0.033	[36] ADRIANI	93	L3	E^{ee}_{cm}= 91.2 GeV

[33] ACKERSTAFF 97T measure $\Gamma_{u\overline{u}}/(\Gamma_{d\overline{d}}+\Gamma_{u\overline{u}}+\Gamma_{s\overline{s}}) = 0.258\pm0.031\pm0.032$. 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.

[34] ABREU 95X use $M_Z = 91.187 \pm 0.009$ GeV, Γ(hadrons) = 1725 ± 12 MeV and $\alpha_s = 0.123\pm0.005$. To obtain this branching ratio we divide their value of $C_{2/3} = 0.91^{+0.25}_{-0.36}$ by their value of $(3C_{1/3} + 2C_{2/3}) = 6.66 \pm 0.05$.

[35] ACTON 93F use the LEP 92 value of Γ(hadrons) = 1740 ± 12 MeV and $\alpha_s = 0.122^{+0.006}_{-0.005}$.

[36] ADRIANI 93 use $M_Z = 91.181 \pm 0.022$ GeV, Γ(hadrons) = 1742 ± 19 MeV and $\alpha_s = 0.125\pm0.009$. To obtain this branching ratio we divide their value of $C_{2/3} = 0.92\pm0.22$ by their value of $(3C_{1/3} + 2C_{2/3}) = 6.720 \pm 0.076$.

$\Gamma\big((d\overline{d}+s\overline{s}+b\overline{b})/3\big)/\Gamma\big(\text{hadrons}\big)$ Γ_8/Γ_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 $\Gamma(Z \rightarrow \gamma +$ jets) where γ is a high-energy (>5 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
0.237±0.009 OUR AVERAGE				
$0.230\pm0.010\pm0.010$	[37] ACKERSTAFF	97T	OPAL	E^{ee}_{cm}= 88–94 GeV
$0.243^{+0.036}_{-0.026}$	[38] ABREU	95X	DLPH	E^{ee}_{cm}= 88–94 GeV
0.241 ± 0.017	[39] ACTON	93F	OPAL	E^{ee}_{cm}= 88–94 GeV
0.243 ± 0.022	[40] ADRIANI	93	L3	E^{ee}_{cm}= 91.2 GeV

[37] 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.

[38] ABREU 95X use $M_Z = 91.187 \pm 0.009$ GeV, Γ(hadrons) = 1725 ± 12 MeV and $\alpha_s = 0.123\pm0.005$. To obtain this branching ratio we divide their value of $C_{1/3} = 1.62^{+0.24}_{-0.17}$ by their value of $(3C_{1/3} + 2C_{2/3}) = 6.66 \pm 0.05$.

[39] ACTON 93F use the LEP 92 value of Γ(hadrons) = 1740 ± 12 MeV and $\alpha_s = 0.122^{+0.006}_{-0.005}$.

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

$R_c = \Gamma(c\overline{c})/\Gamma(\text{hadrons})$ Γ_9/Γ_6

OUR FIT is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the "Note on the Z boson." As a cross check we have also performed a weighted average of the R_c measurements taking into account the various common systematic errors. Assuming that the smallest common systematic error is fully correlated, we obtain R_c = 0.1693 ± 0.0055.

Because of the high current interest, we mention the following preliminary results here, but do not average them or include them in the Listings or Tables. Combining published and unpublished preliminary LEP and SLD electroweak results (as of end of February 1999) yields R_c = 0.1735 ± 0.0044. The Standard Model predicts R_c = 0.1723 for m_t = 175 GeV and M_H = 300 GeV.

VALUE	DOCUMENT ID		TECN	COMMENT
0.1705±0.0061 OUR FIT				
0.180 ±0.011 ±0.013	[41] ACKERSTAFF	98E	OPAL	E^{ee}_{cm}= 88–94 GeV
0.1675±0.0062±0.0103	[42] BARATE	98T	ALEP	E^{ee}_{cm}= 88–94 GeV
0.1689±0.0095±0.0068	[43] BARATE	98T	ALEP	E^{ee}_{cm}= 88–94 GeV
0.167 ±0.011 ±0.012	[44] ALEXANDER	96R	OPAL	E^{ee}_{cm}= 88–94 GeV
0.1623±0.0085±0.0209	[45] ABREU	95D	DLPH	E^{ee}_{cm}= 88–94 GeV
0.165 ±0.005 ±0.020	[46] BUSKULIC	94G	ALEP	E^{ee}_{cm}= 88–94 GeV
0.187 ±0.031 ±0.023	[47] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.142 ±0.008 ±0.014	[48] AKERS	95O	OPAL	Repl. by ACKERSTAFF 98E
0.151 ±0.008 ±0.041	[49] ABREU	92O	DLPH	E^{ee}_{cm}= 88–94 GeV

[41] ACKERSTAFF 98E use an inclusive/exclusive double tag. In one jet $D^{*\pm}$ mesons are exclusively reconstruced 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.

[42] BARATE 98T perform a simultaneous fit to the p and p_T spectra of electrons from hadronic Z decays. The semileptonic branching ratio B($c \to e$) is taken as 0.098 ± 0.005 and the systematic error includes an uncertainty of ±0.0084 due to this.

[43] BARATE 98T obtain this result combining two double-tagging techniques. Searching for a D meson in each hemisphere by full reconstruction in an exclusive decay mode gives R_c= 0.173 ± 0.014 ± 0.0009. The same tag in combination with inclusive identification using the slow pion from the $D^{*+} \to D^0\pi^+$ decay in the opposite hemisphere yields R_c= 0.166 ± 0.012 ± 0.009. The R_b dependence is given by R_c= 0.1689–0.023×(R_b–0.2159). The three measurements of BARATE 98T are combined with BUSKULIC 94G to give the average R_c= 0.1681 ± 0.0054 ± 0.0062.

[44] 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.

[45] 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.

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

[47] ABREU 93I assume that the D_s and charmed baryons are equally produced at LEP and CLEO (10 GeV) energies.

[48] AKERS 95O use the presence of a $D^{*\pm}$ to tag $Z \rightarrow c\overline{c}$ with $D^* \rightarrow D^0\pi$ and $D^0 \rightarrow K\pi$. They measure $P_c * \Gamma(c\overline{c})/\Gamma(\text{hadrons})$ to be $(1.006 \pm 0.055 \pm 0.061) \times 10^{-3}$, where P_c is the product branching ratio $B(c \rightarrow D^*)B(D^* \rightarrow D^0\pi)B(D^0 \rightarrow K\pi)$. Assuming that P_c remains unchanged with energy, they use its value $(7.1 \pm 0.5) \times 10^{-3}$ determined at CESR/PETRA to obtain $\Gamma(c\overline{c})/\Gamma(\text{hadrons})$. The second error of AKERS 95O includes an uncertainty of ± 0.011 from the uncertainty on P_c.

[49] ABREU 92O use the neural network techinque to tag heavy flavour events among a sample of 123k selected hadronic events. The systematic error consists of three parts: due to Monte Carlo (MC) parametrization (0.023), choice of MC model (0.033) and detector effects (0.009) added in quadrature.

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

OUR FIT is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the "Note on the Z boson." As a cross check we have also performed a weighted average of the R_b measurements taking into account the various common systematic errors. We have assumed that the smallest common systematic error is fully correlated. For R_c = 0.1705 (as given by OUR FIT above), we obtain R_b = 0.2166 ± 0.0008. For an expected Standard Model value of R_c = 0.1723, our weighted average gives R_b = 0.2165 ± 0.0008.

Because of the high current interest, we mention the following preliminary results here, but do not average them or include them in the Listings or Tables. Combining published and unpublished preliminary LEP and SLD electroweak results (as of end of February 1999 yields R_b = 0.21656 ± 0.00074. The Standard Model predicts R_b = 0.2158 for m_t = 175 GeV and M_H = 300 GeV.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.21640±0.00079 OUR FIT					
0.2178 ±0.0011 ±0.0013		[50] ABBIENDI	99B	OPAL	E^{ee}_{cm}= 88–94 GeV
0.21634±0.00067±0.00060		[51] ABREU	99B	DLPH	E^{ee}_{cm}= 88–94 GeV
0.2142 ±0.0034 ±0.0015		[52] ABE	98D	SLD	E^{ee}_{cm}= 91.2 GeV
0.2159 ±0.0009 ±0.0011		[53] BARATE	97F	ALEP	E^{ee}_{cm}= 88–94 GeV
0.2145 ±0.0089 ±0.0067		[54] ABREU	95D	DLPH	E^{ee}_{cm}= 88–94 GeV
0.219 ±0.006 ±0.005		[55] BUSKULIC	94G	ALEP	E^{ee}_{cm}= 88–94 GeV
0.222 ±0.003 ±0.007		[56] ADRIANI	93E	L3	E^{ee}_{cm}= 88–94 GeV
0.222 ±0.011 ±0.007		[57] AKERS	93B	OPAL	E^{ee}_{cm}= 88–94 GeV
0.251 ±0.049 ±0.030	32	[58] JACOBSEN	91	MRK2	E^{ee}_{cm}= 91 GeV

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

0.2175	±0.0014	±0.0017		[59] ACKERSTAFF	97K	OPAL	Repl. by ABBIENDI 99B
0.2167	±0.0011	±0.0013		[60] BARATE	97E	ALEP	E^{ee}_{cm}= 88–94 GeV
0.229	±0.011			[61] ABE	96E	SLD	Repl. by ABE 98D
0.2216	±0.0016	±0.0021		[62] ABREU	96	DLPH	Repl. by ABREU 99B
0.228	±0.005	±0.005		[63] BUSKULIC	93N	ALEP	E^{ee}_{cm}= 88–94 GeV
0.222	$^{+0.033}_{-0.031}$	±0.017		[64] ABREU	92	DLPH	E^{ee}_{cm}= 88–94 GeV
0.219	±0.014	±0.019		[65] ABREU	92K	DLPH	E^{ee}_{cm}= 88–94 GeV
0.232	±0.005	±0.017		[66] ABREU	92O	DLPH	E^{ee}_{cm}= 88–94 GeV
0.23	$^{+0.10}_{-0.08}$	$^{+0.05}_{-0.04}$	15	[67] KRAL	90	MRK2	E^{ee}_{cm}= 89–93 GeV

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

[51] 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 $-0.024\times(R_c–0.172)$.

[52] ABE 98D use a double tag based on 3D impact parameter with reconstruction of secondary vertices. The charm background is reduced by requiring the invariant mass at the secondary vertex to be above 2 GeV. The systematic error includes an uncertainty of ±0.0002 due to the uncertainty on R_c.

[53] BARATE 97F combine the lifetime-mass hemisphere tag (BARATE 97E) with event shape information and lepton tag to identify $Z \to b\overline{b}$ 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 $-0.019\times(R_c - 0.172)$.

[54] 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.

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

[56] ADRIANI 93E use a multidimensional analysis based on a neural network approach.

[57] AKERS 93B use a simultaneous fit to single and dilepton events (electrons and muons) to tag $Z \to b\overline{b}$.

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

[59] ACKERSTAFF 97K use lepton and/or separated decay vertex to tag independently each hemisphere. Comparing the numbers of single- and double-tagged events, they determine the b-tagging efficiency directly from the data.

[60] BARATE 97E combine a lifetime tag with a mass cut based on the mass difference between c hadrons and b hadrons. Included in BARATE 97F.

[61] ABE 96E obtain this value by combining results from three different b-tagging methods (2D impact parameter, 3D impact parameter, and 3D displaced vertex).

[62] ABREU 96 obtain this result combining several analyses (double lifetime tag, mixed tag and multivariate analysis). This value is obtained assuming $R_c=\Gamma(c\overline{c})/\Gamma(\text{hadrons}) = 0.172$. For a value of R_c different from this by an amount ΔR_c the change in the value is given by $-0.087 \cdot \Delta R_c$.

[63] BUSKULIC 93N use event shape and high p_T lepton discriminators applied to both hemispheres.

[64] ABREU 92 result is from an indirect technique. They measure the lifetime τ_B, but use a world average of τ_B independent of $\Gamma(b\overline{b})$ and compare to their $\Gamma(b\overline{b})$ dependent lifetime from a hadron sample.

[65] ABREU 92K use boosted−sphericity technique to tag and enrich the b-$\overline{b}$ content with a sample of 50k hadronic events. Most of the systematic error is from hadronization uncertainty.

[66] ABREU 92O use the neural network technique to tag heavy flavour events among a sample of 123k selected hadronic events. The systematic error consists of three parts: due to Monte Carlo (MC) parametrization (0.010), choice of MC model (0.008), and detector effects (0.011) added in quadrature.

[67] KRAL 90 used isolated leptons and found $\Gamma(b\overline{b})/\Gamma(\text{total}) = 0.17^{+0.07}_{-0.06}{}^{+0.04}_{-0.03}$.

$\Gamma(ggg)/\Gamma(\text{hadrons})$ — Γ_{11}/Γ_6

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<1.6 \times 10^{-2}$	95	[68] ABREU	96S	DLPH	E^{ee}_{cm}= 88–94 GeV

[68] 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_{12}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<5.2 \times 10^{-5}$	95	[69] 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
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<1.2 \times 10^{-4}$	95	[70] ADRIANI	92B	L3	Repl. by ACCIARRI 95G

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

[70] This limit is for both decay modes $Z \to \pi^0\gamma/\gamma\gamma$ which are indistinguishable in ADRIANI 92B.

$\Gamma(\eta\gamma)/\Gamma_{\text{total}}$ — Γ_{13}/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
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<1.8 \times 10^{-4}$	95	ADRIANI	92B	L3	Repl. by ACCIARRI 95G

$\Gamma(\omega\gamma)/\Gamma_{\text{total}}$ — Γ_{14}/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_{15}/Γ

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

$\Gamma(\gamma\gamma)/\Gamma_{total}$ Γ_{16}/Γ

This decay would violate the Landau-Yang theorem.

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<5.2 \times 10^{-5}$	95	[71] 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
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<1.2 \times 10^{-4}$	95	[72] ADRIANI 92B	L3	Repl. by ACCIARRI 95G

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

[72] This limit is for both decay modes $Z \rightarrow \pi^0\gamma/\gamma\gamma$ which are indistinguishable in ADRIANI 92B.

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<1.0 \times 10^{-5}$	95	[73] ACCIARRI 95C	L3	E^{ee}_{cm}= 88–94 GeV
$<1.7 \times 10^{-5}$	95	[73] ABREU 94B	DLPH	E^{ee}_{cm}= 88–94 GeV
$<6.6 \times 10^{-5}$	95	AKRAWY 91F	OPAL	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$<3.3 \times 10^{-5}$	95	ADRIANI 92B	L3	Repl. by ACCIARRI 95C

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

$\Gamma(\pi^{\pm}W^{\mp})/\Gamma_{total}$ Γ_{18}/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}_{cm}= 88–94 GeV

$\Gamma(\rho^{\pm}W^{\mp})/\Gamma_{total}$ Γ_{19}/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}_{cm}= 88–94 GeV

$\Gamma(J/\psi(1S)X)/\Gamma_{total}$ Γ_{20}/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID	TECN	COMMENT
3.66±0.23 OUR AVERAGE				
3.40±0.23±0.27	441	[74] ACCIARRI 97J	L3	E^{ee}_{cm}= 88–94 GeV
3.9 ±0.2 ±0.3	511	[75] ALEXANDER 96B	OPAL	E^{ee}_{cm}= 88–94 GeV
3.73±0.39±0.36	153	[76] ABREU 94P	DLPH	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
3.6 ±0.5 ±0.4	121	[76] ADRIANI 93J	L3	Repl. by ACCIARRI 97J

[74] ACCIARRI 97J combine $\mu^+\mu^-$ and e^+e^- $J/\psi(1S)$ decay channels and take into account the common systematic error.

[75] 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).

[76] 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.

$\Gamma(\psi(2S)X)/\Gamma_{total}$ — Γ_{21}/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
1.60±0.29 OUR AVERAGE					
1.6 ±0.5 ±0.3	39	[77] ACCIARRI	97J	L3	E^{ee}_{cm}= 88–94 GeV
1.6 ±0.3 ±0.2	46.9	[78] ALEXANDER	96B	OPAL	E^{ee}_{cm}= 88–94 GeV
1.60±0.73±0.33	5.4	[79] ABREU	94P	DLPH	E^{ee}_{cm}= 88–94 GeV

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

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

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

$\Gamma(\chi_{c1}(1P)X)/\Gamma_{total}$ — Γ_{22}/Γ

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
2.9±0.7 OUR AVERAGE					
2.7±0.6±0.5	33	[80] ACCIARRI	97J	L3	E^{ee}_{cm}= 88–94 GeV
$5.0\pm2.1^{+1.5}_{-0.9}$	6.4	[81] ABREU	94P	DLPH	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
7.5±2.9±0.6	19	[81] ADRIANI	93J	L3	Repl. by ACCIARRI 97J

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

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

$\Gamma(\chi_{c2}(1P)X)/\Gamma_{total}$ — Γ_{23}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<3.2 \times 10^{-3}$	90	[82] ACCIARRI	97J	L3	E^{ee}_{cm}= 88–94 GeV

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

$\Gamma(\Upsilon(1S)X+\Upsilon(2S)X+\Upsilon(3S)X)/\Gamma_{total}$ — $\Gamma_{24}/\Gamma=(\Gamma_{25}+\Gamma_{26}+\Gamma_{27})/\Gamma$

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
1.0±0.4±0.22	6.4	[83] ALEXANDER	96F	OPAL	E^{ee}_{cm}= 88–94 GeV

[83] 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.

$\Gamma(\Upsilon(1S)X)/\Gamma_{total}$ — Γ_{25}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<5.5 \times 10^{-5}$	95	[84] ACCIARRI	97R	L3	E^{ee}_{cm}= 88–94 GeV

[84] ACCIARRI 97R search for $\Upsilon(1S)$ through its decay into $\ell^+\ell^-$ ($\ell = e$ or μ).

$\Gamma(\Upsilon(2S)X)/\Gamma_{total}$ Γ_{26}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<13.9 \times 10^{-5}$	95	[85] ACCIARRI	97R	L3	E^{ee}_{cm}= 88–94 GeV

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

$\Gamma(\Upsilon(3S)X)/\Gamma_{total}$ Γ_{27}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<9.4 \times 10^{-5}$	95	[86] ACCIARRI	97R	L3	E^{ee}_{cm}= 88–94 GeV

[86] 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_{28}/Γ_6

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.296±0.019±0.021	369	[87] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV

[87] 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_{29}/Γ_6

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

[88] 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_{30}/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	[89] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV
0.21 ±0.04	362	[90] DECAMP	91J	ALEP	E^{ee}_{cm}= 88–94 GeV

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

[90] DECAMP 91J report B($D^*(2010)^+ \to D^0\pi^+$) B($D^0 \to K^-\pi^+$) $\Gamma(D^*(2010)^{\pm}X)$ / Γ(hadrons) = (5.11 ± 0.34) × 10^{-3}. They obtained the above number assuming B($D^0 \to K^-\pi^+$) = (3.62±0.34±0.44)% and B($D^*(2010)^+ \to D^0\pi^+$) = (55±4)%. We have rescaled their original result of 0.26 ± 0.05 taking into account the new CLEO II branching ratio B($D^*(2010)^+ \to D^0\pi^+$) = (68.1 ± 1.6)%.

$\Gamma(B^0_sX)/\Gamma(\text{hadrons})$ Γ_{33}/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[91] ABREU	92M	DLPH	E^{ee}_{cm}= 88–94 GeV
seen	[92] ACTON	92N	OPAL	E^{ee}_{cm}= 88–94 GeV
seen	[93] BUSKULIC	92E	ALEP	E^{ee}_{cm}= 88–94 GeV

[91] ABREU 92M reported value is $\Gamma(B^0_sX)$∗B($B^0_s \to D_s\mu\nu_\mu X$) ∗B($D_s \to \phi\pi$)/Γ(hadrons) = (18 ± 8) × 10^{-5}.

[92] ACTON 92N find evidence for B^0_s production using D_s-ℓ correlations, with $D^+_s \to \phi\pi^+$ 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 $f(\overline{b} \to B_s^0)\times B(B_s^0 \to D_s^- \ell^+ \nu_\ell X)\times B(D_s^- \to \phi\pi^-) = (3.9 \pm 1.1 \pm 0.8) \times 10^{-4}$.

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

$\Gamma(B_c^+ X)/\Gamma(\text{hadrons})$ Γ_{34}/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
searched for	[94] ACKERSTAFF	98O	OPAL	$E_{\rm cm}^{ee}$= 88–94 GeV
searched for	[95] ABREU	97E	DLPH	$E_{\rm cm}^{ee}$= 88–94 GeV
searched for	[96] BARATE	97H	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV

[94] 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 $\Gamma(B_c^+ X)*B(B_c \to J/\psi\pi^+)/\Gamma(\text{hadrons}) < 1.06\times 10^{-4}$, $\Gamma(B_c^+ X)*B(B_c \to J/\psi a_1^+)/\Gamma(\text{hadrons}) < 5.29 \times 10^{-4}$, $\Gamma(B_c^+ X)*B(B_c \to J/\psi \ell^+ \nu_\ell)/\Gamma(\text{hadrons}) < 6.96 \times 10^{-5}$.

[95] 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.

[96] 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 $\Gamma(B_c^+ X)*B(B_c \to J/\psi \ell^+ \nu_\ell)/\Gamma(\text{hadrons}) < 5.2 \times 10^{-5}$.

$\Gamma(B^* X)/[\Gamma(BX)+\Gamma(B^* X)]$ $\Gamma_{32}/(\Gamma_{31}+\Gamma_{32})$

As the experiments assume different values of the b-baryon contribution, our average should be taken with caution. If we assume a common baryon production fraction f_{Λ_b} = (13.2 ± 4.1)% as given in the 1996 edition of this *Review* OUR AVERAGE becomes 0.77 ± 0.04.

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.75 ±0.04 OUR AVERAGE					
0.760±0.036±0.083		[97] ACKERSTAFF	97M	OPAL	$E_{\rm cm}^{ee}$= 88–94 GeV
0.771±0.026±0.070		[98] BUSKULIC	96D	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV
0.72 ±0.03 ±0.06		[99] ABREU	95R	DLPH	$E_{\rm cm}^{ee}$= 88–94 GeV
0.76 ±0.08 ±0.06	1378	[100] ACCIARRI	95B	L3	$E_{\rm cm}^{ee}$= 88–94 GeV

[97] 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.

[98] 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.

[99] 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.

[100] 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.

$\Gamma(\text{anomalous } \gamma + \text{hadrons})/\Gamma_{\text{total}}$ — Γ_{35}/Γ

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<3.2 × 10⁻³	95	[101] AKRAWY	90J	OPAL	E^{ee}_{cm}= 88–94 GeV

[101] 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_{36}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<5.2 \times 10^{-4}$	95	[102] ACTON	91B	OPAL	E^{ee}_{cm}= 91.2 GeV

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

$\Gamma(\mu^+ \mu^- \gamma)/\Gamma_{\text{total}}$ — Γ_{37}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<5.6 \times 10^{-4}$	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).

$\Gamma(\tau^+ \tau^- \gamma)/\Gamma_{\text{total}}$ — Γ_{38}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<7.3 \times 10^{-4}$	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).

$\Gamma(\ell^+ \ell^- \gamma\gamma)/\Gamma_{\text{total}}$ — Γ_{39}/Γ

The value is the sum over $\ell = e$, μ, τ.

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<6.8 \times 10^{-6}$	95	[105] ACTON	93E	OPAL	E^{ee}_{cm}= 88–94 GeV

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

$\Gamma(q\overline{q}\gamma\gamma)/\Gamma_{\text{total}}$ — Γ_{40}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<5.5 \times 10^{-6}$	95	[106] ACTON	93E	OPAL	E^{ee}_{cm}= 88–94 GeV

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

$\Gamma(\nu\overline{\nu}\gamma\gamma)/\Gamma_{\text{total}}$ — Γ_{41}/Γ

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<3.1 \times 10^{-6}$	95	[107] ACTON	93E	OPAL	E^{ee}_{cm}= 88–94 GeV

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

$\Gamma(e^{\pm}\mu^{\mp})/\Gamma(e^+e^-)$ — Γ_{42}/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	$E_{\rm cm}^{p\overline{p}}$= 546,630 GeV

$\Gamma(e^{\pm}\mu^{\mp})/\Gamma_{\rm total}$ — Γ_{42}/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	$E_{\rm cm}^{ee}$= 88–94 GeV
$\mathbf{<1.7 \times 10^{-6}}$	95	AKERS	95W	OPAL	$E_{\rm cm}^{ee}$= 88–94 GeV
$<0.6 \times 10^{-5}$	95	ADRIANI	93I	L3	$E_{\rm cm}^{ee}$= 88–94 GeV
$<2.6 \times 10^{-5}$	95	DECAMP	92	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV

$\Gamma(e^{\pm}\tau^{\mp})/\Gamma_{\rm total}$ — Γ_{43}/Γ

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<2.2 \times 10^{-5}$	95	ABREU	97C	DLPH	$E_{\rm cm}^{ee}$= 88–94 GeV
$\mathbf{<9.8 \times 10^{-6}}$	95	AKERS	95W	OPAL	$E_{\rm cm}^{ee}$= 88–94 GeV
$<1.3 \times 10^{-5}$	95	ADRIANI	93I	L3	$E_{\rm cm}^{ee}$= 88–94 GeV
$<1.2 \times 10^{-4}$	95	DECAMP	92	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV

$\Gamma(\mu^{\pm}\tau^{\mp})/\Gamma_{\rm total}$ — Γ_{44}/Γ

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

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$\mathbf{<1.2 \times 10^{-5}}$	95	ABREU	97C	DLPH	$E_{\rm cm}^{ee}$= 88–94 GeV
$<1.7 \times 10^{-5}$	95	AKERS	95W	OPAL	$E_{\rm cm}^{ee}$= 88–94 GeV
$<1.9 \times 10^{-5}$	95	ADRIANI	93I	L3	$E_{\rm cm}^{ee}$= 88–94 GeV
$<1.0 \times 10^{-4}$	95	DECAMP	92	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV

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	$E_{\rm cm}^{ee}$= 91.2 GeV

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

VALUE	DOCUMENT ID		TECN	COMMENT
17.06±0.24 OUR AVERAGE				
17.26±0.10±0.88	ABREU	98L	DLPH	$E_{\rm cm}^{ee}$= 91.2 GeV
17.04±0.31	BARATE	98V	ALEP	$E_{\rm cm}^{ee}$= 91.2 GeV
17.05±0.43	AKERS	94P	OPAL	$E_{\rm cm}^{ee}$= 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}_{cm}= 91.2 GeV
9.63±0.13±0.63		BARATE	97J	ALEP	E^{ee}_{cm}= 91.2 GeV
9.90±0.02±0.33		ACCIARRI	96	L3	E^{ee}_{cm}= 91.2 GeV
9.2 ±0.2 ±1.0		ADAM	96	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
9.18±0.03±0.73		ACCIARRI	94B	L3	Repl. by ACCIARRI 96

$\langle N_{\eta} \rangle$

VALUE		DOCUMENT ID		TECN	COMMENT
0.95 ±0.07 OUR AVERAGE					
0.97 ±0.03 ±0.11		ACKERSTAFF	98A	OPAL	E^{ee}_{cm}= 91.2 GeV
0.93 ±0.01 ±0.09		ACCIARRI	96	L3	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.91 ±0.02 ±0.11		ACCIARRI	94B	L3	Repl. by ACCIARRI 96
0.298±0.023±0.021	[108]	BUSKULIC	92D	ALEP	E^{ee}_{cm}= 91.2 GeV

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

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

VALUE		DOCUMENT ID		TECN	COMMENT
2.40±0.06±0.43		ACKERSTAFF	98A	OPAL	E^{ee}_{cm}= 91.2 GeV

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

VALUE		DOCUMENT ID		TECN	COMMENT
1.30±0.12 OUR AVERAGE					
1.45±0.06±0.20		BUSKULIC	96H	ALEP	E^{ee}_{cm}= 91.2 GeV
1.21±0.04±0.15		ABREU	95L	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
1.43±0.12±0.22		ABREU	93	DLPH	Repl. by ABREU 95L

$\langle N_{\omega} \rangle$

VALUE		DOCUMENT ID		TECN	COMMENT
1.08±0.09 OUR AVERAGE					
1.04±0.04±0.14		ACKERSTAFF	98A	OPAL	E^{ee}_{cm}= 91.2 GeV
1.17±0.09±0.15		ACCIARRI	97D	L3	E^{ee}_{cm}= 91.2 GeV
1.07±0.06±0.13		BUSKULIC	96H	ALEP	E^{ee}_{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}_{cm}= 91.2 GeV
0.25 ±0.04	[109]	ACCIARRI	97D	L3	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.068±0.018±0.016	[110]	BUSKULIC	92D	ALEP	E^{ee}_{cm}= 91.2 GeV

[109] ACCIARRI 97D obtain this value averaging over the two decay channels $\eta' \rightarrow \pi^+\pi^-\eta$ and $\eta' \rightarrow \rho^0\gamma$.
[110] BUSKULIC 92D obtain this value for x> 0.1.

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.141±0.007±0.011	ACKERSTAFF	98Q	OPAL	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.098±0.016	[111] ABREU	95L	DLPH	E^{ee}_{cm}= 91.2 GeV
0.10 ±0.03 ±0.019	[112] ABREU	93	DLPH	Repl. by ABREU 95L

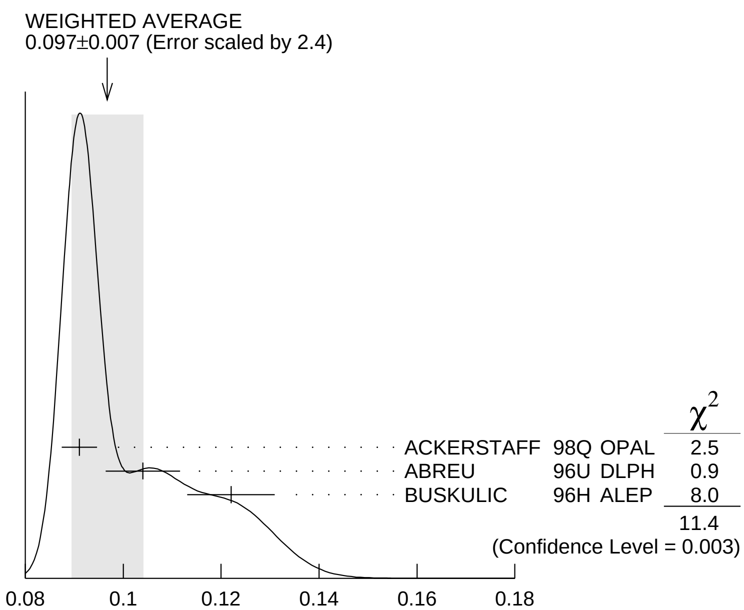
[111] ABREU 95L obtain this value for $0.05 < x < 0.6$.
[112] ABREU 93 obtain this value for $x > 0.05$.

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

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

$\langle N_\phi \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.097±0.007 OUR AVERAGE	Error includes scale factor of 2.4. See the ideogram below.			
0.091±0.002±0.003	ACKERSTAFF	98Q	OPAL	E^{ee}_{cm}= 91.2 GeV
0.104±0.003±0.007	ABREU	96U	DLPH	E^{ee}_{cm}= 91.2 GeV
0.122±0.004±0.008	BUSKULIC	96H	ALEP	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.100±0.004±0.007	AKERS	95X	OPAL	Repl. by ACKERSTAFF 98Q



$\langle N_\phi \rangle$

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

VALUE	DOCUMENT ID	TECN	COMMENT
0.155±0.011±0.018	ACKERSTAFF 98Q	OPAL	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.170±0.043	[113] ABREU 95L	DLPH	E^{ee}_{cm}= 91.2 GeV
0.11 ±0.04 ±0.03	[114] ABREU 93	DLPH	Repl. by ABREU 95L

[113] ABREU 95L obtain this value for $x>$ 0.05.
[114] ABREU 93 obtain this value for $x>$ 0.1.

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

VALUE	DOCUMENT ID	TECN	COMMENT
0.020±0.005±0.006	ABREU 96C	DLPH	E^{ee}_{cm}= 91.2 GeV

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

VALUE	DOCUMENT ID	TECN	COMMENT
2.26±0.06 OUR AVERAGE			
2.21±0.05±0.05	ABREU 98L	DLPH	E^{ee}_{cm}= 91.2 GeV
2.26±0.12	BARATE 98V	ALEP	E^{ee}_{cm}= 91.2 GeV
2.42±0.13	AKERS 94P	OPAL	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2.26±0.01±0.18	ABREU 95F	DLPH	Repl. by ABREU 98L

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

VALUE	DOCUMENT ID	TECN	COMMENT
2.013±0.023 OUR AVERAGE			
2.024±0.006±0.042	ACCIARRI 97L	L3	E^{ee}_{cm}= 91.2 GeV
1.962±0.022±0.056	ABREU 95L	DLPH	E^{ee}_{cm}= 91.2 GeV
1.99 ±0.01 ±0.04	AKERS 95U	OPAL	E^{ee}_{cm}= 91.2 GeV
2.061±0.047	BUSKULIC 94K	ALEP	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •			
2.04 ±0.02 ±0.14	ACCIARRI 94B	L3	Repl. by ACCIARRI 97L
2.12 ±0.05 ±0.04	ABREU 92G	DLPH	Repl. by ABREU 95L

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

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
• • • We do not use the following data for averages, fits, limits, etc. • • •			
1.33 ±0.11 ±0.24	ABREU 92G	DLPH	Repl. by ABREU 95L

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.752±0.025 OUR AVERAGE				
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
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.74 ±0.03 ±0.03	AKERS	95X	OPAL	Repl. by ACKERSTAFF 97S

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

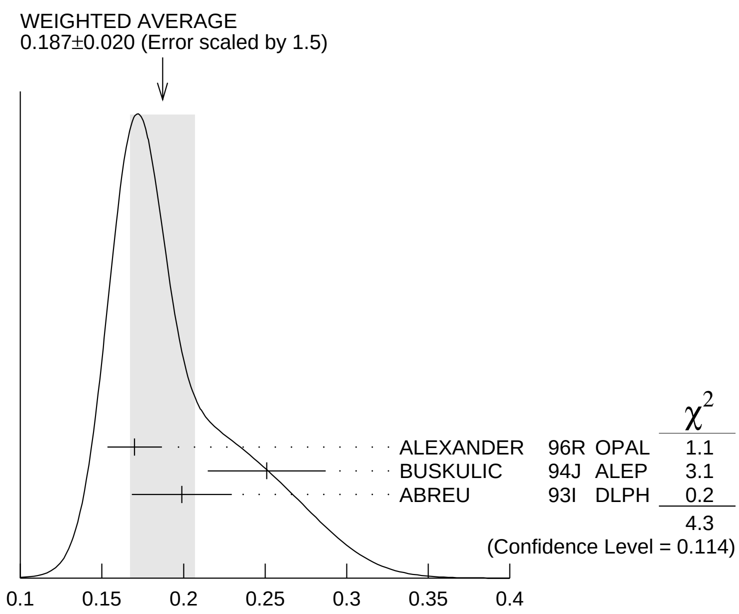
VALUE	DOCUMENT ID		TECN	COMMENT
0.079±0.026±0.031	ABREU	96U	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.19 ±0.04 ±0.06	[115] AKERS	95X	OPAL	E^{ee}_{cm}= 91.2 GeV

[115] 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	[116] ABREU	93I	DLPH	E^{ee}_{cm}= 91.2 GeV

[116] See ABREU 95 (erratum).



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

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

VALUE		DOCUMENT ID		TECN	COMMENT
0.462±0.026 OUR AVERAGE					
0.465±0.017±0.027		ALEXANDER	96R	OPAL	E^{ee}_{cm}= 91.2 GeV
0.518±0.052±0.035		BUSKULIC	94J	ALEP	E^{ee}_{cm}= 91.2 GeV
0.403±0.038±0.044	117	ABREU	93I	DLPH	E^{ee}_{cm}= 91.2 GeV

[117] 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^{ee}_{cm}= 91.2 GeV

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

VALUE		DOCUMENT ID		TECN	COMMENT
0.183 ±0.008 OUR AVERAGE					
0.1854±0.0041±0.0091	118	ACKERSTAFF	98E	OPAL	E^{ee}_{cm}= 91.2 GeV
0.187 ±0.015 ±0.013		BUSKULIC	94J	ALEP	E^{ee}_{cm}= 91.2 GeV
0.171 ±0.012 ±0.016	119	ABREU	93I	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.183 ±0.009 ±0.011	120	AKERS	95O	OPAL	Repl. by ACKERSTAFF 98E

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

[119] See ABREU 95 (erratum).

[120] AKERS 95O systematic error includes an uncertainty of ±0.008 due to the $D^{*\pm}$ and D^0 branching ratios [they use B($D^* \rightarrow D^0 \pi$) = 0.681 ± 0.016 and B($D^0 \rightarrow K\pi$) = 0.0401 ± 0.0014 to obtain this measurement].

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

VALUE (units 10^{-3})		DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$2.9^{+0.7}_{-0.6}$±0.2	121	ACKERSTAFF	97W	OPAL	E^{ee}_{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}_{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}_{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}_{cm}= 91.2 GeV

$\langle N_p \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
1.04±0.04 OUR AVERAGE				
1.08±0.04±0.03	ABREU	98L	DLPH	E^{ee}_{cm}= 91.2 GeV
1.00±0.07	BARATE	98V	ALEP	E^{ee}_{cm}= 91.2 GeV
0.92±0.11	AKERS	94P	OPAL	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
1.07±0.01±0.14	ABREU	95F	DLPH	Repl. by ABREU 98L

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

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}_{cm}= 91.2 GeV
0.22 ±0.04 ±0.04	ALEXANDER	95D	OPAL	E^{ee}_{cm}= 91.2 GeV

$\langle N_{\Lambda} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
0.372±0.007 OUR AVERAGE				
0.364±0.004±0.017	ACCIARRI	97L	L3	E^{ee}_{cm}= 91.2 GeV
0.374±0.002±0.010	ALEXANDER	97D	OPAL	E^{ee}_{cm}= 91.2 GeV
0.386±0.016	BUSKULIC	94K	ALEP	E^{ee}_{cm}= 91.2 GeV
0.357±0.003±0.017	ABREU	93L	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.37 ±0.01 ±0.04	ACCIARRI	94B	L3	Repl. by ACCIARRI 97L
0.351±0.019	ACTON	92J	OPAL	Repl. by ALEXANDER 97D

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.0213±0.0021±0.0019	ALEXANDER	97D	OPAL	E^{ee}_{cm}= 91.2 GeV

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.099±0.008±0.013	ALEXANDER	97E	OPAL	E^{ee}_{cm}= 91.2 GeV

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.083±0.006±0.009	ALEXANDER	97E	OPAL	E^{ee}_{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}_{cm}= 91.2 GeV
0.170±0.014±0.061	ABREU	95O	DLPH	E^{ee}_{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
0.070±0.011 OUR AVERAGE				
0.071±0.012±0.013	ALEXANDER	97E	OPAL	E^{ee}_{cm}= 91.2 GeV
0.070±0.010±0.010	ADAM	96B	DLPH	E^{ee}_{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}_{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}_{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}_{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}_{cm}= 91.2 GeV
0.0382±0.0028±0.0045	ABREU	95O	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.0380±0.0062	ACTON	92J	OPAL	Repl. by ALEXANDER 97D

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.0258±0.0009 OUR AVERAGE				
0.0259±0.0004±0.0009	ALEXANDER	97D	OPAL	E^{ee}_{cm}= 91.2 GeV
0.0250±0.0009±0.0021	ABREU	95O	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.020 ±0.004 ±0.003	ABREU	92G	DLPH	Repl. by ABREU 95O
0.0206±0.0021	ACTON	92J	OPAL	Repl. by ALEXANDER 97D

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.0053±0.0013 OUR AVERAGE	Error includes scale factor of 3.2.			
0.0068±0.0005±0.0004	ALEXANDER	97D	OPAL	E^{ee}_{cm}= 91.2 GeV
0.0041±0.0004±0.0004	ABREU	95O	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.0063±0.0014	ACTON	92J	OPAL	Repl. by ALEXANDER 97D

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

VALUE	DOCUMENT ID		TECN	COMMENT
0.00164±0.00028 OUR AVERAGE				
0.0018 ±0.0003 ±0.0002	ALEXANDER	97D	OPAL	E^{ee}_{cm}= 91.2 GeV
0.0014 ±0.0002 ±0.0004	ADAM	96B	DLPH	E^{ee}_{cm}= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.0050 ±0.0015	ACTON	92J	OPAL	Repl. by ALEXANDER 97D

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

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

$\langle N_{charged} \rangle$

VALUE	DOCUMENT ID		TECN	COMMENT
21.07±0.11 OUR AVERAGE				
21.21±0.01±0.20	ABREU	99	DLPH	E^{ee}_{cm}= 91.2 GeV
21.05±0.20	AKERS	95Z	OPAL	E^{ee}_{cm}= 91.2 GeV
20.91±0.03±0.22	BUSKULIC	95R	ALEP	E^{ee}_{cm}= 91.2 GeV
21.40±0.43	ACTON	92B	OPAL	E^{ee}_{cm}= 91.2 GeV
20.71±0.04±0.77	ABREU	91H	DLPH	E^{ee}_{cm}= 91.2 GeV
20.7 ±0.7	ADEVA	91I	L3	E^{ee}_{cm}= 91.2 GeV
20.1 ±1.0 ±0.9	ABRAMS	90	MRK2	E^{ee}_{cm}= 91.1 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
20.85±0.02±0.24	DECAMP	91K	ALEP	Repl. by BUSKULIC 95R

Z HADRONIC POLE CROSS SECTION

This quantity is defined as

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

It is one of the parameters used in the Z lineshape fit. (See the 'Note on the Z Boson.')

VALUE (nb)	EVTS	DOCUMENT ID		TECN	COMMENT
41.54±0.14 OUR FIT					
41.49±0.10 OUR AVERAGE					
41.23±0.20	1.05M	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
41.39±0.26	1.09M	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
41.70±0.23	1.19M	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
41.60±0.16	1.27M	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV

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

41.45±0.31	512k	ACTON	93D	OPAL	Repl. by AKERS 94
41.34±0.28	460k	ADRIANI	93M	L3	Repl. by ACCIARRI 94
41.60±0.27	520k	BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
42 ±4	450	ABRAMS	89B	MRK2	E^{ee}_{cm}= 89.2–93.0 GeV

Z VECTOR COUPLINGS TO CHARGED LEPTONS

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 and A_τ, or ν_e scattering. The fit values quoted below correspond to global nine- or five-parameter fits to lineshape, lepton forward-backward asymmetry, and A_e and A_τ measurements. See "Note on the Z boson" for details.

Within the current data set, the reason for the smallness of g^{μ}_V compared to g^{e}_V and g^{τ}_V is due to the large value of A_e which is heavily weighted by the SLD result. This large value of A_e leads to a large value of g^{e}_V. Since g^{μ}_V is obtained using the relation $A^{\mu}_{FB} = 0.75 \times A_e \times A_\mu$, a large value of g^{e}_V leads to a SMALL value of g^{μ}_V. Concerning the τ, its g_V gets mainly determined directly from A_τ which is obtained from a measurement of the τ polarization (see "Note on the Z boson").

g^{e}_V

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.0383±0.0008 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.0414±0.0020		[125] ABE	95J	SLD	E^{ee}_{cm}= 91.31 GeV
$-0.0364^{+0.0096}_{-0.0082}$	38k	[126] ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
−0.036 ±0.005	45.8k	[127] BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV
$-0.040^{+0.013}_{-0.011}$		[128] ADRIANI	93M	L3	Repl. by ACCIARRI 94
$-0.034^{+0.006}_{-0.005}$		[126] BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94

[125] ABE 95J obtain this result combining polarized Bhabha results with the A_{LR} measurement of ABE 94C. The Bhabha results alone give −0.0507 ± 0.0096 ± 0.0020.
[126] The τ polarization result has been included.
[127] BUSKULIC 94 use the added constraint of τ polarization.
[128] ADRIANI 93M use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

g_V^{μ}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
−0.0274±0.0047 OUR FIT				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$-0.0402^{+0.0153}_{-0.0211}$	34k	[129] ACCIARRI 94	L3	E^{ee}_{cm}= 88–94 GeV
−0.034 ±0.013	46.4k	[130] BUSKULIC 94	ALEP	E^{ee}_{cm}= 88–94 GeV
$-0.048\ ^{+0.021}_{-0.033}$		[131] ADRIANI 93M	L3	Repl. by ACCIARRI 94
$-0.019\ ^{+0.018}_{-0.019}$		[129] BUSKULIC 93J	ALEP	Repl. by BUSKULIC 94

[129] The τ polarization result has been included.
[130] BUSKULIC 94 use the added constraint of τ polarization.
[131] ADRIANI 93M use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

g_V^{τ}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
−0.0378±0.0020 OUR FIT				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.0384±0.0078	25k	[132] ACCIARRI 94	L3	E^{ee}_{cm}= 88–94 GeV
−0.038 ±0.005	45.1k	[133] BUSKULIC 94	ALEP	E^{ee}_{cm}= 88–94 GeV
−0.037 ±0.008	7441	[134] ADRIANI 93M	L3	Repl. by ACCIARRI 94
−0.039 ±0.006		[132] BUSKULIC 93J	ALEP	Repl. by BUSKULIC 94

[132] The τ polarization result has been included.
[133] BUSKULIC 94 use the added constraint of τ polarization.
[134] ADRIANI 93M use their measurement of the τ polarization in addition to forward-backward lepton asymmetries.

g_V^{ℓ}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
−0.0377±0.0007 OUR FIT				
• • • We do not use the following data for averages, fits, limits, etc. • • •				
−0.039 ±0.004	50.3k	[135] ABREU 94	DLPH	E^{ee}_{cm}= 88–94 GeV
$-0.0378^{+0.0045}_{-0.0042}$	97k	[136] ACCIARRI 94	L3	E^{ee}_{cm}= 88–94 GeV
−0.034 ±0.004	146k	[135] AKERS 94	OPAL	E^{ee}_{cm}= 88–94 GeV
−0.038 ±0.004	137.3k	[135] BUSKULIC 94	ALEP	E^{ee}_{cm}= 88–94 GeV
−0.027 ±0.008	58k	[135] ACTON 93D	OPAL	Repl. by AKERS 94
$-0.040\ ^{+0.006}_{-0.005}$		[136] ADRIANI 93M	L3	Repl. by ACCIARRI 94
$-0.034\ ^{+0.004}_{-0.003}$		[136] BUSKULIC 93J	ALEP	Repl. by BUSKULIC 94

[135] Using forward-backward lepton asymmetries.
[136] The τ polarization result has been included.

Z AXIAL-VECTOR COUPLINGS TO CHARGED LEPTONS

These quantities are the effective axial-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 and A_τ, or ν_e scattering. The fit values quoted below correspond to global nine- or five-parameter fits to lineshape, lepton forward-backward asymmetry, and A_e and A_τ measurements. See "Note on the Z boson" for details.

g_A^e

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.5007±0.0009 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.4977±0.0045		[137] ABE	95J	SLD	$E_{\rm cm}^{ee}$= 91.31 GeV
−0.4998±0.0016	38k	[138] ACCIARRI	94	L3	$E_{\rm cm}^{ee}$= 88–94 GeV
−0.503 ±0.002	45.8k	BUSKULIC	94	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV
−0.4980±0.0021		[138] ADRIANI	93M	L3	Repl. by ACCIARRI 94
−0.5029±0.0018		[138] BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94

[137] 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.

[138] The τ-polarization constraint has been included.

g_A^μ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.5015±0.0012 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.4987^{+0.0030}_{-0.0026}$	34k	[139] ACCIARRI	94	L3	$E_{\rm cm}^{ee}$= 88–94 GeV
−0.501 ±0.002	46.4k	BUSKULIC	94	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV
$-0.4968^{+0.0050}_{-0.0037}$		[139] ADRIANI	93M	L3	Repl. by ACCIARRI 94
−0.5014±0.0029		[139] BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94

[139] The τ-polarization constraint has been included.

g_A^τ

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.5009±0.0013 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.5014±0.0029	25k	[140] ACCIARRI	94	L3	$E_{\rm cm}^{ee}$= 88–94 GeV
−0.502 ±0.003	45.1k	BUSKULIC	94	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV
−0.5032±0.0038	7441	[140] ADRIANI	93M	L3	Repl. by ACCIARRI 94
−0.5016±0.0033		[140] BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94

[140] The τ-polarization constraint has been included.

g_A^{ℓ}

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.5008±0.0008 OUR FIT					
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.4999±0.0014	71k	ABREU	94	DLPH	E_{cm}^{ee}= 88–94 GeV
−0.4998±0.0014	97k	[141] ACCIARRI	94	L3	E_{cm}^{ee}= 88–94 GeV
−0.500 ±0.001	146k	AKERS	94	OPAL	E_{cm}^{ee}= 88–94 GeV
−0.502 ±0.001	137k	BUSKULIC	94	ALEP	E_{cm}^{ee}= 88–94 GeV
−0.4998±0.0016	58k	ACTON	93D	OPAL	Repl. by AKERS 94
−0.4986±0.0015		[141] ADRIANI	93M	L3	Repl. by ACCIARRI 94
−0.5022±0.0015		[141] BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94

[141] The τ-polarization constraint has been included.

Z COUPLINGS TO NEUTRAL LEPTONS

These quantities are the effective couplings of the Z to neutral leptons. $\nu_e e$ and $\nu_\mu e$ scattering results are combined with g_A^e and g_V^e measurements at the Z mass to obtain g^{ν_e} and g^{ν_μ} following NOVIKOV 93C.

g^{ν_e}

VALUE	DOCUMENT ID		TECN	COMMENT
0.528±0.085	[142] VILAIN	94	CHM2	From $\nu_\mu e$ and $\nu_e e$ scattering

[142] 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	[143] VILAIN	94	CHM2	From $\nu_\mu e$ scattering

[143] 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 $\nu_\mu e$ scattering. We have re-evaluated this value using the current PDG values for g_A^e and g_V^e.

Z ASYMMETRY PARAMETERS

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

$$A_f = \frac{2g_V^f g_A^f}{(g_V^f)^2 + (g_A^f)^2}$$

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 on the Z Boson.'

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
0.153 ±0.004 OUR AVERAGE	Error includes scale factor of 1.1.				
0.1678±0.0127±0.0030	137092	[144] ACCIARRI	98H	L3	$E_{\rm cm}^{ee}$= 88–94 GeV
0.162 ±0.041 ±0.014	89838	[145] ABE	97	SLD	$E_{\rm cm}^{ee}$= 91.27 GeV
0.1543±0.0039	93644	[146] ABE	97E	SLD	$E_{\rm cm}^{ee}$= 91.27 GeV
0.152 ±0.012		[147] ABE	97N	SLD	$E_{\rm cm}^{ee}$= 91.27 GeV
0.129 ±0.014 ±0.005	89075	[148] ALEXANDER	96U	OPAL	$E_{\rm cm}^{ee}$= 88–94 GeV
0.202 ±0.038 ±0.008		[149] ABE	95J	SLD	$E_{\rm cm}^{ee}$= 91.31 GeV
0.136 ±0.027 ±0.003		[144] ABREU	95I	DLPH	$E_{\rm cm}^{ee}$= 88–94 GeV
0.129 ±0.016 ±0.005	33000	[150] BUSKULIC	95Q	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.122 ±0.030 ±0.012	30663	[144] AKERS	95	OPAL	Repl. by ALEXANDER 96U
0.1656±0.0071±0.0028	49392	[151] ABE	94C	SLD	Repl. by ABE 97E
0.157 ±0.020 ±0.005	86000	[144] ACCIARRI	94E	L3	Repl. by ACCIARRI 98H
0.097 ±0.044 ±0.004	10224	[152] ABE	93	SLD	Repl. by ABE 97E
0.120 ±0.026		[144] BUSKULIC	93P	ALEP	Repl. by BUSKULIC 95Q

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

[145] ABE 97 obtain this result from a measurement of the observed left-right charge asymmetry, $A_Q^{\rm obs}$ = 0.225 ± 0.056 ± 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.

[146] ABE 97E measure the left-right asymmetry in hadronic Z production. This value (statistical and systematic errors added in quadrature) leads to $\sin^2\theta_W^{\rm eff}$ = 0.23060 ± 0.00050.

[147] ABE 97N obtain this direct measurement using the lef-right cross section asymmetry and the left-right forward-backward asymmetry in leptonic decays of the Z boson obtained with a polarized electron beam.

[148] ALEXANDER 96U measure the τ-lepton polarization and the forward-backward polarization asymmetry.

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

[150] BUSKULIC 95Q obtain this result fitting the τ polarization as a function of the polar τ production angle.

[151] ABE 94C measured the left-right asymmetry in Z production. This value leads to $\sin^2\theta_W$ = 0.2292 ± 0.0009 ± 0.0004.

[152] ABE 93 measured the left-right asymmetry in Z production.

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
0.102±0.034	3788	[153] ABE 97N	SLD	E^{ee}_{cm}= 91.27 GeV

[153] ABE 97N obtain this direct measurement using the lef-right cross section asymmetry and the left-right forward-backward asymmetry 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 average τ polarization in $Z \rightarrow \tau^+\tau^-$. The SLD Collaboration directly extracts this quantity from its measured left-right forward-backward asymmetry in $Z \rightarrow \tau^+\tau^-$ 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
0.144 ±0.007 OUR AVERAGE				
0.1476±0.0088±0.0062	137092	ACCIARRI 98H	L3	E^{ee}_{cm}= 88–94 GeV
0.195 ±0.034		[154] ABE 97N	SLD	E^{ee}_{cm}= 91.27 GeV
0.134 ±0.009 ±0.010	89075	[155] ALEXANDER 96U	OPAL	E^{ee}_{cm}= 88–94 GeV
0.148 ±0.017 ±0.014		ABREU 95I	DLPH	E^{ee}_{cm}= 88–94 GeV
0.136 ±0.012 ±0.009	33000	[156] BUSKULIC 95Q	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.153 ±0.019 ±0.013	30663	AKERS 95	OPAL	Repl. by ALEXANDER 96U
0.150 ±0.013 ±0.009	86000	ACCIARRI 94E	L3	Repl. by ACCIARRI 98H
0.132 ±0.033	10732	ADRIANI 93M	L3	Repl. by ACCIARRI 94E
0.143 ±0.023		BUSKULIC 93P	ALEP	Repl. by BUSKULIC 95Q
0.24 ±0.07	2021	ABREU 92N	DLPH	Repl. by ABREU 95I

[154] ABE 97N obtain this direct measurement using the left-right cross section asymmetry and the left-right forward-backward asymmetry in $\tau^+\tau^-$ decays of the Z boson obtained with a polarized electron beam.

[155] ALEXANDER 96U measure the τ-lepton polarization and the forward-backward polarization asymmetry.

[156] BUSKULIC 95Q obtain this result fitting the τ polarization as a function of the polar τ production angle.

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.

VALUE	DOCUMENT ID	TECN	COMMENT
0.59±0.19 OUR AVERAGE			
0.37±0.23±0.21	[157] ABE 95L	SLD	E^{ee}_{cm}= 91.26 GeV
0.73±0.22±0.10	[158] ABE,K 95	SLD	E^{ee}_{cm}= 91.26 GeV

[157] ABE 95L tag b and c quarks through their semileptonic decays into electrons and muons. A maximum likelihood fit is performed to extract A_b and A_c.

[158] ABE,K 95 tag $Z \to c\overline{c}$ events using D^{*+} and D^{+} meson production. To take care of the $b\overline{b}$ contamination in their analysis they use $A_b^D = 0.64 \pm 0.11$ (which is A_b from D^*/D tagging). This is obtained by starting with a Standard Model value of 0.935, assigning it an estimated error of ± 0.105 to cover LEP and SLD measurements, and finally taking into account B-$\overline{B}$ mixing ($1-2\chi_{\mathrm{mix}} = 0.72 \pm 0.09$). Combining with ABE 95L they quote 0.59 ± 0.19.

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.

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.91 ±0.06 OUR AVERAGE				
0.911±0.045±0.045	11092	[159] ABE 98I	SLD	$E^{ee}_{\mathrm{cm}} = 91.28$ GeV
0.91 ±0.14 ±0.07		[160] ABE 95L	SLD	$E^{ee}_{\mathrm{cm}} = 91.26$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.87 ±0.11 ±0.09	4032	[161] ABE 95K	SLD	Repl. by ABE 98I

[159] ABE 98I obtain an enriched sample of $b\overline{b}$ events tagging with an inclusive vertex mass cut. A momentum-weighted track charge is used to identify the sign of the charge of the underlying b quark.

[160] ABE 95L tag b and c quarks through their semileptonic decays into electrons and muons. A maximum likelihood fit is performed to extract A_b and A_c. Combining with ABE 95K, they quote $0.89 \pm 0.09 \pm 0.06$.

[161] ABE 95K obtain an enriched sample of $b\overline{b}$ events tagging with the impact parameter. A momentum-weighted charge sum is used to identify the charge of the underlying b quark.

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

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:

$$C_{TT} = \frac{|g_A^\tau|^2 - |g_V^\tau|^2}{|g_A^\tau|^2 + |g_V^\tau|^2}$$

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

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				
$0.87\pm0.20^{+0.10}_{-0.12}$	9.1k	ABREU 97G	DLPH	$E^{ee}_{\mathrm{cm}} = 91.2$ GeV
1.06±0.13±0.05	120k	BARATE 97D	ALEP	$E^{ee}_{\mathrm{cm}} = 91.2$ GeV

C_{TN}

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
0.08±0.13±0.04	120k	[162] BARATE 97D	ALEP	E^{ee}_{cm}= 91.2 GeV

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

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

For the Z peak, we report the pole asymmetry defined by $(3/4)A^2_e$ as determined by the nine-parameter fit to cross-section and lepton forward-backward asymmetry data. For details see the "Note on the Z boson."

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID	TECN
1.51±0.40 OUR FIT				
1.5 ±0.4 OUR AVERAGE				
2.5 ±0.9		91.2	ABREU 94	DLPH
1.04±0.92		91.2	ACCIARRI 94	L3
0.62±0.80		91.2	AKERS 94	OPAL
1.85±0.66		91.2	BUSKULIC 94	ALEP

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

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. For details see the "Note on the Z boson."

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID	TECN
1.33± 0.26 OUR FIT				
1.34± 0.24 OUR AVERAGE				
1.4 ± 0.5		91.2	ABREU 94	DLPH
1.79± 0.61		91.2	ACCIARRI 94	L3
0.99± 0.42		91.2	AKERS 94	OPAL
1.46± 0.48		91.2	BUSKULIC 94	ALEP
• • • We do not use the following data for averages, fits, limits, etc. • • •				
9 ±30	−2	20	[163] ABREU 95M	DLPH
7 ±26	−10	40	[163] ABREU 95M	DLPH
−11 ±33	−25	57	[163] ABREU 95M	DLPH
−62 ±17	−45	69	[163] ABREU 95M	DLPH
−56 ±10	−58	79	[163] ABREU 95M	DLPH
−13 ± 5	−23	87.5	[163] ABREU 95M	DLPH
$-29.0 ^{+5.0}_{-4.8} \pm 0.5$	−32.1	56.9	[164] ABE 90I	VNS
− 9.9 ± 1.5 ±0.5	−9.2	35	HEGNER 90	JADE
0.05± 0.22	0.026	91.14	[165] ABRAMS 89D	MRK2
−43.4 ±17.0	−24.9	52.0	[166] BACALA 89	AMY
−11.0 ±16.5	−29.4	55.0	[166] BACALA 89	AMY
−30.0 ±12.4	−31.2	56.0	[166] BACALA 89	AMY
−46.2 ±14.9	−33.0	57.0	[166] BACALA 89	AMY
−29 ±13	−25.9	53.3	ADACHI 88C	TOPZ

$+\ 5.3 \pm 5.0 \pm 0.5$	-1.2	14.0	ADEVA	88	MRKJ
$-10.4 \pm 1.3 \pm 0.5$	-8.6	34.8	ADEVA	88	MRKJ
$-12.3 \pm 5.3 \pm 0.5$	-10.7	38.3	ADEVA	88	MRKJ
$-15.6 \pm 3.0 \pm 0.5$	-14.9	43.8	ADEVA	88	MRKJ
$-\ 1.0 \pm 6.0$	-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
$-\ 7.1 \pm 1.7$	-5.7	29	LEVI	83	MRK2
-16.1 ± 3.2	-9.2	34.2	BRANDELIK	82C	TASS

[163] ABREU 95M perform this measurement using radiative muon-pair events associated with high-energy isolated photons.
[164] ABE 90I measurements in the range $50 \leq \sqrt{s} \leq 60.8$ GeV.
[165] ABRAMS 89D asymmetry includes both 9 $\mu^+\mu^-$ and 15 $\tau^+\tau^-$ events.
[166] BACALA 89 systematic error is about 5%.

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

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. For details see the "Note on the Z boson."

ASYMMETRY (%)	*STD. MODEL*	$\sqrt{s}$ *(GeV)*	*DOCUMENT ID*		*TECN*
2.12± 0.32 OUR FIT					
2.13± 0.31 OUR AVERAGE					
2.2 ± 0.7		91.2	ABREU	94	DLPH
2.65 ± 0.88		91.2	ACCIARRI	94	L3
2.05 ± 0.52		91.2	AKERS	94	OPAL
1.97 ± 0.56		91.2	BUSKULIC	94	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	[167] 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	[168] BACALA	89	AMY
-17.7 ± 26.1	-29.4	55.0	[168] BACALA	89	AMY
-45.9 ± 16.6	-31.2	56.0	[168] BACALA	89	AMY
-49.5 ± 18.0	-33.0	57.0	[168] 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 ± 6.6 ±1.5	−15.4	43.8	ADEVA	88	MRKJ
− 6.0 ± 2.5 ±1.0	8.8	34.6	BARTEL	85F	JADE
−11.8 ± 4.6 ±1.0	14.8	43.0	BARTEL	85F	JADE
− 5.5 ± 1.2 ±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

[167] ABE 90I measurements in the range 50 $\leq \sqrt{s} \leq$ 60.8 GeV.
[168] BACALA 89 systematic error is about 5%.

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

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 on the Z boson."

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
1.59±0.18 OUR FIT					
1.60±0.18 OUR AVERAGE					
1.77±0.37		91.2	ABREU	94	DLPH
1.84±0.45		91.2	ACCIARRI	94	L3
1.28±0.30		91.2	AKERS	94	OPAL
1.71±0.33		91.2	BUSKULIC	94	ALEP

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

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
4.0±7.3 OUR EVALUATION					
4.0 ± 6.7 ± 2.8	6	91.2	[169] ACKERSTAFF	97T	OPAL

[169] 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 $e^+e^- \rightarrow s\overline{s}$

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
9.9±3.1 OUR AVERAGE	Error includes scale factor of 1.2.				
6.8±3.5±1.1	10	91.2	[170] ACKERSTAFF	97T	OPAL
13.1±3.5±1.3		91.2	[171] ABREU	95G	DLPH

[170] 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.

171 ABREU 95G require the presence of a high-momentum charged kaon or Λ^0 to tag the s quark. An unresolved s- and d-quark asymmetry of $(11.2 \pm 3.1 \pm 5.4)\%$ is obtained by tagging the presence of a high-energy neutron or neutral kaon in the hadron calorimeter.

$A_{FB}^{(0,c)}$ 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 on the Z boson," refers to the Z pole asymmetry. As a cross check we have also performed a weighted average of the "near peak" measurements taking into account the various common systematic errors. We have assumed that the smallest common systematic error is fully correlated. Applying to this combined "peak" measurement QED and energy-dependence corrections, our weighted average gives a pole asymmetry of $(7.13 \pm 0.55)\%$.

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
7.15± 0.50 OUR FIT					
6.3 ± 0.9 ±0.3		91.22	172 BARATE	98O	ALEP
6.3 ± 1.2 ±0.6		91.22	173 ALEXANDER	97C	OPAL
6.00± 0.67±0.52		91.24	174 ALEXANDER	96	OPAL
7.7 ± 2.9 ±1.2		91.27	175 ABREU	95E	DLPH
8.3 ± 2.2 ±1.6		91.27	176 ABREU	95K	DLPH
9.9 ± 2.0 ±1.7		91.24	177 BUSKULIC	94G	ALEP
8.3 ± 3.8 ±2.7	5.6	91.24	178 ADRIANI	92D	L3
• • • We do not use the following data for averages, fits, limits, etc. • • •					
− 1.0 ± 4.3 ±1.0		89.37	172 BARATE	98O	ALEP
11.0 ± 3.3 ±0.8		92.96	172 BARATE	98O	ALEP
3.9 ± 5.1 ±0.9		89.45	173 ALEXANDER	97C	OPAL
15.8 ± 4.1 ±1.1		93.00	173 ALEXANDER	97C	OPAL
− 7.5 ± 3.4 ±0.6	−3.5	89.52	174 ALEXANDER	96	OPAL
14.1 ± 2.8 ±0.9	12.0	92.94	174 ALEXANDER	96	OPAL
6.99± 2.05±1.02		91.24	179 BUSKULIC	95I	ALEP
1.4 ± 3.0 ±2.0	5.6	91.24	180 ACTON	93K	OPAL
3.8 ± 4.4 ±1.0	5.4	91.28	181 AKERS	93D	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

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

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

174 ALEXANDER 96 tag heavy flavors using 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.

175 ABREU 95E require the presence of a $D^{*\pm}$ to identify c and b quarks.

176 ABREU 95K identify c and b quarks using both electron and muon semileptonic decays.

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

178 ADRIANI 92D use both electron and muon semileptonic decays.

[179] BUSKULIC 95I require the presence of a high momentum $D^{*\pm}$ to have an enriched sample of $Z \rightarrow c\overline{c}$ events. Replaced by BARATE 98O.
[180] ACTON 93K use the lepton tagging technique. Replaced by ALEXANDER 96.
[181] AKERS 93D identify the b and c decays using D^{*}. Replaced by ALEXANDER 97C.

$A_{FB}^{(0,b)}$ 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 on the Z boson," refers to the Z pole asymmetry. As a cross check we have also performed a weighted average of the "near peak" measurements taking into account the various common systematic errors. We have assumed that the smallest common systematic error is fully correlated. Applying to this combined "peak" measurement QED and energy-dependence corrections, our weighted average gives a pole asymmetry of (10.13 ± 0.29)%. For the jet-charge measurements (where the QCD effects are included since they represent an inherent part of the analysis), we use the corrections given by the authors.

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
10.02± 0.25 OUR FIT					
9.31± 1.01± 0.55		91.24	[182] ACCIARRI	98U	L3
10.40± 0.40± 0.32		91.25	[183] BARATE	98M	ALEP
9.94± 0.52± 0.44		91.21	[184] ACKERSTAFF	97P	OPAL
9.4 ± 2.7 ± 2.2		91.22	[185] ALEXANDER	97C	OPAL
9.06± 0.51± 0.23		91.24	[186] ALEXANDER	96	OPAL
9.65± 0.44± 0.26		91.21	[187] BUSKULIC	96Q	ALEP
5.9 ± 6.2 ± 2.4		91.27	[188] ABREU	95E	DLPH
10.4 ± 1.3 ± 0.5		91.27	[189] ABREU	95K	DLPH
11.5 ± 1.7 ± 1.0		91.27	[190] ABREU	95K	DLPH
8.7 ± 1.1 ± 0.4		91.3	[191] ACCIARRI	94D	L3
• • • We do not use the following data for averages, fits, limits, etc. • • •					
4.95± 5.23± 0.40		89.45	[182] ACCIARRI	98U	L3
11.37± 3.99± 0.65		92.99	[182] ACCIARRI	98U	L3
7.46± 1.78± 0.24		89.43	[183] BARATE	98M	ALEP
9.24± 1.79± 0.52		92.97	[183] BARATE	98M	ALEP
4.1 ± 2.1 ± 0.2		89.44	[184] ACKERSTAFF	97P	OPAL
14.5 ± 1.7 ± 0.7		92.91	[184] ACKERSTAFF	97P	OPAL
− 8.6 ±10.8 ± 2.9		89.45	[185] ALEXANDER	97C	OPAL
− 2.1 ± 9.0 ± 2.6		93.00	[185] ALEXANDER	97C	OPAL
5.5 ± 2.4 ± 0.3	5.5	89.52	[186] ALEXANDER	96	OPAL
11.7 ± 2.0 ± 0.3	11.4	92.94	[186] ALEXANDER	96	OPAL
− 3.4 ±11.2 ± 0.7		88.38	[187] BUSKULIC	96Q	ALEP
5.3 ± 2.0 ± 0.2		89.38	[187] BUSKULIC	96Q	ALEP
8.9 ± 5.9 ± 0.4		90.21	[187] BUSKULIC	96Q	ALEP
3.8 ± 5.1 ± 0.2		92.05	[187] BUSKULIC	96Q	ALEP
10.3 ± 1.6 ± 0.4		92.94	[187] BUSKULIC	96Q	ALEP
8.8 ± 7.5 ± 0.5		93.90	[187] BUSKULIC	96Q	ALEP
6.2 ± 3.4 ± 0.2		89.52	[192] AKERS	95S	OPAL
9.63± 0.67± 0.38		91.25	[192] AKERS	95S	OPAL
17.2 ± 2.8 ± 0.7		92.94	[192] AKERS	95S	OPAL

8.7 ± 1.4 ± 0.2		91.24	[193] BUSKULIC	94G	ALEP
9.92 ± 0.84 ± 0.46		91.19	[194] BUSKULIC	94I	ALEP
7.1 ± 5.4 ± 0.7	5.2	89.66	[195] ACTON	93K	OPAL
9.2 ± 1.8 ± 0.8	8.5	91.24	[195] ACTON	93K	OPAL
13.1 ± 4.7 ± 1.3	10.8	92.75	[195] ACTON	93K	OPAL
13.9 ± 9.7 ± 4.9	9.4	91.28	[196] AKERS	93D	OPAL
16.1 ± 6.0 ± 2.1		91.2	[197] ABREU	92H	DLPH
8.6 ± 1.5 ± 0.7	8.2	91.24	[198] ADRIANI	92D	L3
2.5 ± 5.1 ± 0.7	5.3	89.67	[199] ADRIANI	92D	L3
9.7 ± 1.7 ± 0.7	8.2	91.24	[199] ADRIANI	92D	L3
6.2 ± 4.2 ± 0.7	10.8	92.81	[199] ADRIANI	92D	L3
$-71 \pm 34 ^{+7}_{-8}$	−58	58.3	SHIMONAKA	91	TOPZ
−22.2 ± 7.7 ± 3.5	−26.0	35	BEHREND	90D	CELL
−49.1 ± 16.0 ± 5.0	−39.7	43	BEHREND	90D	CELL
−28 ± 11	−23	35	BRAUNSCH...	90	TASS
−16.6 ± 7.7 ± 4.8	−24.3	35	ELSEN	90	JADE
−33.6 ± 22.2 ± 5.2	−39.9	44	ELSEN	90	JADE
3.4 ± 7.0 ± 3.5	−16.0	29.0	BAND	89	MAC
−72 ± 28 ± 13	−56	55.2	SAGAWA	89	AMY

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

[183] BARATE 98M tag $Z \rightarrow b\overline{b}$ events using lifetime and measure the jet charge using the hemisphere charge. The analysis is performed as a function of the b quark purity and b polar angle.

[184] ACKERSTAFF 97P tag b quarks using lifetime. The quark charge is measured using both jet charge and vertex charge, a weighted sum of the charges of tracks in a jet which contains a tagged secondary vertex.

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

[186] ALEXANDER 96 tag heavy flavors using 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.

[187] BUSKULIC 96Q tag b-quark flavor and charge using high transverse momentum leptons. The asymmetry value at the Z peak is obtained using a charm charge asymmetry of 6.17%.

[188] ABREU 95E require the presence of a $D^{*\pm}$ to identify c and b quarks.

[189] ABREU 95K identify c and b quarks using both electron and muon semileptonic decays. The systematic error includes an uncertainty of ±0.3 due to the mixing correction ($\chi = 0.115 \pm 0.011$).

[190] ABREU 95K tag b quarks using lifetime; the quark charge is identified using jet charge. The systematic error includes an uncertainty of ±0.3 due to the mixing correction ($\chi = 0.115 \pm 0.011$).

[191] ACCIARRI 94D use both electron and muon semileptonic decays.

[192] AKERS 95S tag b quarks using lifetime; the quark charge is measured using jet charge. These asymmetry values are obtained using $R_b = \Gamma(b\overline{b})/\Gamma(\text{hadrons}) = 0.216$. For a value of R_b different from this by an amount ΔR_b, the change in the asymmetry values is given by $-K\Delta R_b$, where $K = 0.082$, 0.471, and 0.855 for $\sqrt{s}$ values of 89.52, 91.25, and 92.94 GeV respectively. Replaced by ACKERSTAFF 97P.

[193] BUSKULIC 94G perform a simultaneous fit to the p and p_T spectra of both single and dilepton events. Replaced by BUSKULIC 96Q.

[194] BUSKULIC 94I use the lifetime tag method to obtain a high purity sample of $Z \rightarrow b\overline{b}$ events and the hemisphere charge technique to obtain the jet charge. Replaced by BARATE 98M.

[195] ACTON 93K use the lepton tagging technique. The systematic error includes the uncertainty on the mixing parameter. Replaced by ALEXANDER 96.
[196] AKERS 93D identify the b and c decays using D^*. Replaced by ALEXANDER 97C.
[197] B tagging via its semimuonic decay. Experimental value corrected using average LEP B^0-$\overline{B}^0$ mixing parameter $\chi = 0.143 \pm 0.023$.
[198] ADRIANI 92D use both electron and muon semileptonic decays. For this measurement ADRIANI 92D average over all $\sqrt{s}$ values to obtain a single result.
[199] ADRIANI 92D use both electron and muon semileptonic decays. The quoted systematic error is common to all measurements. The peak value is superseded by ACCIARRI 94D.

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.

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-$ 0.76±0.12±0.15		91.2	[200] ABREU	92I	DLPH
4.0 ±0.4 ±0.63	4.0	91.3	[201] 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

[200] ABREU 92I has 0.14 systematic error due to uncertainty of quark fragmentation.
[201] 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 $0.2321 \pm 0.0017 \pm 0.0028$.

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

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •					
5.2±5.9±0.4		91	ABE	91E	CDF

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

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h_i^V

VALUE	DOCUMENT ID		TECN
• • • We do not use the following data for averages, fits, limits, etc. • • •			
	[202] ABBOTT	98M	D0
	[203] ABREU	98K	DLPH

[204] ACCIARRI 98L L3

[202] 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: $\left|h^Z_{30}\right| < 0.36$, $\left|h^Z_{40}\right| < 0.05$ (keeping h^{γ}_i=0) and $\left|h^{\gamma}_{30}\right| < 0.37$, $\left|h^{\gamma}_{40}\right| < 0.05$ (keeping h^Z_i=0). Limits on the *CP*-violating couplings are $\left|h^Z_{10}\right| < 0.36$, $\left|h^Z_{20}\right| < 0.05$ (keeping h^{γ}_i=0), and $\left|h^{\gamma}_{10}\right| < 0.37$, $\left|h^{\gamma}_{20}\right| < 0.05$ (keeping h^Z_i=0).

[203] 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 $\left|h^{\gamma}_{30}\right| < 0.8$ and $\left|h^Z_{30}\right| < 1.3$, derived at a scale Λ=1 TeV and with n=3 in the form factor representation.

[204] ACCIARRI 98L study 161, 172, and 183 GeV $e^+e^- \rightarrow q\overline{q}\gamma$ and $e^+e^- \rightarrow \nu\overline{\nu}\gamma$ events to derive 95% CL limits on h^V_i. For deriving each limit the others are fixed at zero. For $\Lambda = \infty$ they report: $-0.54 < h^Z_1 < 0.17$, $-0.11 < h^Z_2 < 0.37$, $-0.50 < h^Z_3 < 0.36$, $-0.12 < h^Z_4 < 0.39$, $-0.25 < h^{\gamma}_1 < 0.23$, $-0.18 < h^{\gamma}_2 < 0.18$, $-0.33 < h^{\gamma}_3 < 0.01$, $-0.02 < h^{\gamma}_4 < 0.24$.

Z REFERENCES

ABBIENDI	99B	EPJ C8 217	G. Abbiendi+	(OPAL Collab.)
ABREU	99	EPJ C6 19	P. Abreu+	(DELPHI Collab.)
ABREU	99B	CERN-EP/98-180	P. Abreu+	(DELPHI Collab.)
EPJ C (to be publ.)				
ABBOTT	98M	PR D57 R3817	B. Abbott+	(D0 Collab.)
ABE	98D	PRL 80 660	K. Abe+	(SLD Collab.)
ABE	98I	PRL 81 942	K. Abe+	(SLD Collab.)
ABREU	98K	PL B423 194	P. Abreu+	(DELPHI Collab.)
ABREU	98L	EPJ C5 585	P. Abreu+	(DELPHI Collab.)
ACCIARRI	98G	PL B431 199	M. Acciarri+	(L3 Collab.)
ACCIARRI	98H	PL B429 387	M. Acciarri+	(L3 Collab.)
ACCIARRI	98L	PL B436 187	M. Acciarri+	(L3 Collab.)
ACCIARRI	98U	PL B439 225	M. Acciarri+	(L3 Collab.)
ACKERSTAFF	98A	EPJ C5 411	K. Ackerstaff+	(OPAL Collab.)
ACKERSTAFF	98E	EPJ C1 439	K. Ackerstaff+	(OPAL Collab.)
ACKERSTAFF	98O	PL B420 157	K. Ackerstaff+	(OPAL Collab.)
ACKERSTAFF	98Q	EPJ C4 19	K. Ackerstaff+	(OPAL Collab.)
BARATE	98M	PL B426 217	R. Barate+	(ALEPH Collab.)
BARATE	98O	PL B434 415	R. Barate+	(ALEPH Collab.)
BARATE	98T	EPJ C4 557	R. Barate+	(ALEPH Collab.)
BARATE	98V	EPJ C5 205	R. Barate+	(ALEPH Collab.)
ABE	97	PRL 78 17	+Abe, Abt, Akagi, Allen+	(SLD Collab.)
ABE	97E	PRL 78 2075	+Abe, Abt, Akagi, Allen+	(SLD Collab.)
ABE	97N	PRL 79 804	K. Abe+	(SLD Collab.)
ABREU	97C	ZPHY C73 243	+Adam, Adye, Ajinenko+	(DELPHI Collab.)
ABREU	97E	PL B398 207	P. Abreu+	(DELPHI Collab.)
ABREU	97G	PL B404 194	P. Abreu+	(DELPHI Collab.)
ACCIARRI	97D	PL B393 465	+Adriani, Aguilar-Benitez, Ahlen+	(L3 Collab.)
ACCIARRI	97J	PL B407 351	M. Acciarri+	(L3 Collab.)
ACCIARRI	97K	PL B407 361	M. Acciarri+	(L3 Collab.)
ACCIARRI	97L	PL B407 389	M. Acciarri+	(L3 Collab.)
ACCIARRI	97R	PL B413 167	M. Acciarri+	(L3 Collab.)
ACKERSTAFF	97C	PL B391 221	+Alexander, Allison, Altekamp, Ametewee+	(OPAL Collab.)
ACKERSTAFF	97K	ZPHY C74 1	K. Ackerstaff+	(OPAL Collab.)
ACKERSTAFF	97M	ZPHY C74 413	K. Ackerstaff+	(OPAL Collab.)
ACKERSTAFF	97P	ZPHY C75 385	K. Ackerstaff+	(OPAL Collab.)
ACKERSTAFF	97S	PL B412 210	K. Ackerstaff+	(OPAL Collab.)
ACKERSTAFF	97T	ZPHY C76 387	K. Ackerstaff+	(OPAL Collab.)
ACKERSTAFF	97W	ZPHY C76 425	K. Ackerstaff+	(OPAL Collab.)
ALEXANDER	97C	ZPHY C73 379	+Allison, Altekamp, Ametewee+	(OPAL Collab.)
ALEXANDER	97D	ZPHY C73 569	+Allison, Altekamp, Ametewee+	(OPAL Collab.)

ALEXANDER	97E	ZPHY C73 587	+Allison, Altekamp, Ametewee+	(OPAL Collab.)
BARATE	97D	PL B405 191	R. Barate+	(ALEPH Collab.)
BARATE	97E	PL B401 150	R. Barate+	(ALEPH Collab.)
BARATE	97F	PL B401 163	R. Barate+	(ALEPH Collab.)
BARATE	97H	PL B402 213	R. Barate+	(ALEPH Collab.)
BARATE	97J	ZPHY C74 451	R. Barate+	(ALEPH Collab.)
ABE	96E	PR D53 1023	+Abt, Ahn, Akagi, Allen+	(SLD Collab.)
ABREU	96	ZPHY C70 531	+Adam, Adye+	(DELPHI Collab.)
ABREU	96C	PL B379 309	+Adam, Adye+	(DELPHI Collab.)
ABREU	96R	ZPHY C72 31	+Adam, Adye+	(DELPHI Collab.)
ABREU	96S	PL B389 405	+Adam, Adye, Ajinenko+	(DELPHI Collab.)
ABREU	96U	ZPHY C73 61	+Adam, Adye, Agasi, Ajinenko+	(DELPHI Collab.)
ACCIARRI	96	PL B371 126	+Adam, Adriani+	(L3 Collab.)
ACCIARRI	96B	PL B370 195	+Adam, Adriani+	(L3 Collab.)
ADAM	96	ZPHY C69 561	+Adye, Agasi, Ajinenko+	(DELPHI Collab.)
ADAM	96B	ZPHY C70 371	+Adye, Agasi+	(DELPHI Collab.)
ALEXANDER	96	ZPHY C70 357	+Allison, Altekamp+	(OPAL Collab.)
ALEXANDER	96B	ZPHY C70 197	+Allison, Altekamp+	(OPAL Collab.)
ALEXANDER	96F	PL B370 185	+Allison, Altekamp+	(OPAL Collab.)
ALEXANDER	96N	PL B384 343	+Allison, Altekamp, Ametewee+	(OPAL Collab.)
ALEXANDER	96R	ZPHY C72 1	+Allison, Altekamp+	(OPAL Collab.)
ALEXANDER	96U	ZPHY C72 365	+Allison, Altekamp, Ametewee+	(OPAL Collab.)
ALEXANDER	96X	PL B376 232	G. Alexander+	(OPAL Collab.)
BUSKULIC	96D	ZPHY C69 393	+Casper, De Bonis, Decamp+	(ALEPH Collab.)
BUSKULIC	96H	ZPHY C69 379	+Casper, De Bonis+	(ALEPH Collab.)
BUSKULIC	96Q	PL B384 414	+De Bonis, Decamp, Ghez+	(ALEPH Collab.)
ABE	95J	PRL 74 2880	+Abt, Ahn, Akagi+	(SLD Collab.)
ABE	95K	PRL 74 2890	+Abt, Ahn, Akagi+	(SLD Collab.)
ABE	95L	PRL 74 2895	+Abt, Ahn, Akagi+	(SLD Collab.)
ABE,K	95	PRL 75 3609	K. Abe, Abt, Ahn, Akagi+	(SLD Collab.)
ABREU	95	ZPHY C65 709 erratum	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95D	ZPHY C66 323	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95E	ZPHY C66 341	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95F	NP B444 3	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95G	ZPHY C67 1	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95I	ZPHY C67 183	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95K	ZPHY C65 569	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95L	ZPHY C65 587	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95M	ZPHY C65 603	+Adam, Adye, Agasi, Ajinenko+	(DELPHI Collab.)
ABREU	95O	ZPHY C67 543	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95R	ZPHY C68 353	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95W	PL B361 207	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	95X	ZPHY C69 1	+Adam, Adye, Agasi+	(DELPHI Collab.)
ACCIARRI	95B	PL B345 589	+Adam, Adriani, Aguilar-Benitez+	(L3 Collab.)
ACCIARRI	95C	PL B345 609	+Adam, Adriani, Aguilar-Benitez+	(L3 Collab.)
ACCIARRI	95G	PL B353 136	+Adam, Adriani, Aguilar-Benitez, Ahlen+	(L3 Collab.)
AKERS	95	ZPHY C65 1	+Alexander, Allison+	(OPAL Collab.)
AKERS	95C	ZPHY C65 47	+Alexander, Allison+	(OPAL Collab.)
AKERS	95O	ZPHY C67 27	+Alexander, Allison+	(OPAL Collab.)
AKERS	95S	ZPHY C67 365	+Alexander, Allison+	(OPAL Collab.)
AKERS	95U	ZPHY C67 389	+Alexander, Allison+	(OPAL Collab.)
AKERS	95W	ZPHY C67 555	+Alexander, Allison+	(OPAL Collab.)
AKERS	95X	ZPHY C68 1	+Alexander, Allison+	(OPAL Collab.)
AKERS	95Z	ZPHY C68 203	+Alexander, Allison+	(OPAL Collab.)
ALEXANDER	95D	PL B358 162	+Allison, Altekamp+	(OPAL Collab.)
BUSKULIC	95I	PL B352 479	+Casper, De Bonis+	(ALEPH Collab.)
BUSKULIC	95Q	ZPHY C69 183	+Casper, De Bonis+	(ALEPH Collab.)
BUSKULIC	95R	ZPHY C69 15	+Casper, De Bonis, Decamp+	(ALEPH Collab.)
MIYABAYASHI	95	PL B347 171	+Adachi, Fujii+	(TOPAZ Collab.)
ABE	94C	PRL 73 25	+Abt, Ash, Aston, Bacchetta, Baird+	(SLD Collab.)
ABREU	94	NP B418 403	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	94B	PL B327 386	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	94P	PL B341 109	+Adam, Adye, Agasi, Ajinenko+	(DELPHI Collab.)
ACCIARRI	94	ZPHY C62 551	+Adam, Adriani, Aguilar-Benitez+	(L3 Collab.)
ACCIARRI	94B	PL B328 223	+Adam, Adriani, Aguilar-Benitez+	(L3 Collab.)
ACCIARRI	94D	PL B335 542	+Adam, Adriani, Aguilar-Benitez, Ahlen+	(L3 Collab.)
ACCIARRI	94E	PL B341 245	+Adam, Adriani+	(L3 Collab.)
AKERS	94	ZPHY C61 19	+Alexander, Allison+	(OPAL Collab.)
AKERS	94P	ZPHY C63 181	+Alexander, Allison+	(OPAL Collab.)

BUSKULIC	94	ZPHY C62 539	+Casper, De Bonis, Decamp, Ghez, Goy+	(ALEPH Collab.)
BUSKULIC	94G	ZPHY C62 179	+Casper, De Bonis, Decamp, Ghez+	(ALEPH Collab.)
BUSKULIC	94I	PL B335 99	+Casper, De Bonis+	(ALEPH Collab.)
BUSKULIC	94J	ZPHY C62 1	+De Bonis, Decamp+	(ALEPH Collab.)
BUSKULIC	94K	ZPHY C64 361	+De Bonis, Decamp+	(ALEPH Collab.)
VILAIN	94	PL B320 203	+Wilquet, Beyer+	(CHARM II Collab.)
ABE	93	PRL 70 2515	+Abt, Acton+	(SLD Collab.)
ABREU	93	PL B298 236	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	93I	ZPHY C59 533	+Adam, Adye, Agasi+	(DELPHI Collab.)
Also	95	ZPHY C65 709 erratum	Abreu, Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	93L	PL B318 249	+Adam, Adami, Adye+	(DELPHI Collab.)
ACTON	93	PL B305 407	+Alexander, Allison+	(OPAL Collab.)
ACTON	93D	ZPHY C58 219	+Alexander, Allison+	(OPAL Collab.)
ACTON	93E	PL B311 391	+Akers, Alexander+	(OPAL Collab.)
ACTON	93F	ZPHY C58 405	+Alexander, Allison+	(OPAL Collab.)
ACTON	93K	ZPHY C60 19	+Akers, Alexander+	(OPAL Collab.)
ADRIANI	93	PL B301 136	+Aguilar-Benitez, Ahlen+	(L3 Collab.)
ADRIANI	93E	PL B307 237	+Aguilar-Benitez, Ahlen+	(L3 Collab.)
ADRIANI	93F	PL B309 451	+Aguilar-Benitez, Ahlen+	(L3 Collab.)
ADRIANI	93I	PL B316 427	+Aguilar-Benitez, Ahlen+	(L3 Collab.)
ADRIANI	93J	PL B317 467	+Aguilar-Benitez, Ahlen, Alcaraz+	(L3 Collab.)
ADRIANI	93M	PRPL 236 1	+Aguilar-Benitez, Ahlen, Alcaraz, Aloisio+	(L3 Collab.)
AKERS	93B	ZPHY C60 199	+Alexander, Allison, Anderson, Arcelli+	(OPAL Collab.)
AKERS	93D	ZPHY C60 601	+Alexander, Allison+	(OPAL Collab.)
BUSKULIC	93J	ZPHY C60 71	+Decamp, Goy, Lees, Minard+	(ALEPH Collab.)
BUSKULIC	93L	PL B313 520	+De Bonis, Decamp+	(ALEPH Collab.)
BUSKULIC	93N	PL B313 549	+De Bonis, Decamp+	(ALEPH Collab.)
BUSKULIC	93P	ZPHY C59 369	+Decamp, Goy+	(ALEPH Collab.)
NOVIKOV	93C	PL B298 453	+Okun, Vysotsky	(ITEP)
ABREU	92	ZPHY C53 567	+Adam, Adami, Adye+	(DELPHI Collab.)
ABREU	92G	PL B275 231	+Adam, Adami, Adye+	(DELPHI Collab.)
ABREU	92H	PL B276 536	+Adam, Adami, Adye+	(DELPHI Collab.)
ABREU	92I	PL B277 371	+Adam, Adami, Adye+	(DELPHI Collab.)
ABREU	92K	PL B281 383	+Adam, Adami, Adye+	(DELPHI Collab.)
ABREU	92M	PL B289 199	+Adam, Adye, Agasi, Alekseev+	(DELPHI Collab.)
ABREU	92N	ZPHY C55 555	+Adam, Adye, Agasi+	(DELPHI Collab.)
ABREU	92O	PL B295 383	+Adam, Adami, Adye+	(DELPHI Collab.)
ACTON	92B	ZPHY C53 539	+Alexander, Allisson, Allport+	(OPAL Collab.)
ACTON	92J	PL B291 503	+Alexander, Allison, Allport+	(OPAL Collab.)
ACTON	92L	PL B294 436	+Alexander, Allison, Allport+	(OPAL Collab.)
ACTON	92N	PL B295 357	+Alexander, Allison, Allport, Anderson+	(OPAL Collab.)
ADEVA	92	PL B275 209	+Adriani, Aguilar-Benitez+	(L3 Collab.)
ADRIANI	92B	PL B288 404	+Aguilar-Benitez, Ahlen, Akbari, Alcaraz+	(L3 Collab.)
ADRIANI	92D	PL B292 454	+Aguilar-Benitez, Ahlen, Akbari+	(L3 Collab.)
ADRIANI	92E	PL B292 463	+Aguilar-Benitez, Ahlen, Akbari, Alcaraz+	(L3 Collab.)
ALITTI	92B	PL B276 354	+Ambrosini, Ansari, Autiero, Bareyre+	(UA2 Collab.)
BUSKULIC	92D	PL B292 210	+Decamp, Goy, Lees+	(ALEPH Collab.)
BUSKULIC	92E	PL B294 145	+Decamp, Goy, Lees, Minard+	(ALEPH Collab.)
DECAMP	92	PRPL 216 253	+Deschizeaux, Goy, Lees, Minard+	(ALEPH Collab.)
DECAMP	92B	ZPHY C53 1	+Deschizeaux, Goy, Lees, Minard+	(ALEPH Collab.)
LEP	92	PL B276 247	+ALEPH, DELPHI, L3, OPAL	(LEP Collabs.)
ABE	91E	PRL 67 1502	+Amidei, Apollinari+	(CDF Collab.)
ABREU	91H	ZPHY C50 185	+Adam, Adami, Adye+	(DELPHI Collab.)
ACTON	91B	PL B273 338	+Alexander, Allison, Allport, Anderson+	(OPAL Collab.)
ADACHI	91	PL B255 613	+Anazawa, Doser, Enomoto+	(TOPAZ Collab.)
ADEVA	91I	PL B259 199	+Adriani, Aguilar-Benitez, Akbari+	(L3 Collab.)
AKRAWY	91F	PL B257 531	+Alexander, Allison, Allport, Anderson+	(OPAL Collab.)
DECAMP	91B	PL B259 377	+Deschizeaux, Goy+	(ALEPH Collab.)
DECAMP	91J	PL B266 218	+Deschizeaux, Goy, Lees+	(ALEPH Collab.)
DECAMP	91K	PL B273 181	+Deschizeaux, Goy, Lees, Minard+	(ALEPH Collab.)
JACOBSEN	91	PRL 67 3347	+Koetke, Adolphsen, Fujino+	(Mark II Collab.)
SHIMONAKA	91	PL B268 457	+Fujii, Miyamoto+	(TOPAZ Collab.)
ABE	90I	ZPHY C48 13	+Amako, Arai, Asano, Chiba+	(VENUS Collab.)
ABRAMS	90	PRL 64 1334	+Adolphsen, Averill, Ballam+	(Mark II Collab.)
ADACHI	90F	PL B234 525	+Doser, Enomoto, Fujii+	(TOPAZ Collab.)
AKRAWY	90J	PL B246 285	+Alexander, Allison, Allport, Anderson+	(OPAL Collab.)
BEHREND	90D	ZPHY C47 333	+Criegee, Field, Franke, Jung+	(CELLO Collab.)
BRAUNSCH...	90	ZPHY C48 433	Braunschweig, Gerhards, Kirschfink+	(TASSO Collab.)
ELSEN	90	ZPHY C46 349	+Allison, Ambrus, Barlow, Bartel+	(JADE Collab.)

HEGNER	90	ZPHY C46 547	+Naroska, Schroth, Allison+	(JADE Collab.)
KRAL	90	PRL 64 1211	+Abrams, Adolphsen, Averill, Ballam+	(Mark II Collab.)
STUART	90	PRL 64 983	+Breedon, Kim, Ko, Lander, Maeshima+	(AMY Collab.)
ABE	89	PRL 62 613	+Amidei, Apollinari, Ascori, Atac+	(CDF Collab.)
ABE	89C	PRL 63 720	+Amidei, Apollinari, Atac, Auchincloss+	(CDF Collab.)
ABE	89L	PL B232 425	+Amako, Arai, Asano, Chiba+	(VENUS Collab.)
ABRAMS	89B	PRL 63 2173	+Adolphsen, Averill, Ballam, Barish+	(Mark II Collab.)
ABRAMS	89D	PRL 63 2780	+Adolphsen, Averill, Ballam, Barish+	(Mark II Collab.)
ALBAJAR	89	ZPHY C44 15	+Albrow, Allkofer, Arnison, Astbury+	(UA1 Collab.)
BACALA	89	PL B218 112	+Malchow, Sparks, Imlay, Kirk+	(AMY Collab.)
BAND	89	PL B218 369	+Camporesi, Chadwick, Delfino, Desangro+	(MAC Collab.)
GREENSHAW	89	ZPHY C42 1	+Warming, Allison, Ambrus, Barlow+	(JADE Collab.)
OULD-SAADA	89	ZPHY C44 567	+Allison, Ambrus, Barlow, Bartel+	(JADE Collab.)
SAGAWA	89	PRL 63 2341	+Lim, Abe, Fujii, Higashi+	(AMY Collab.)
ADACHI	88C	PL B208 319	+Aihara, Dijkstra, Enomoto, Fujii+	(TOPAZ Collab.)
ADEVA	88	PR D38 2665	+Anderhub, Ansari, Becker+	(Mark-J Collab.)
BRAUNSCH...	88D	ZPHY C40 163	Braunschweig, Gerhards, Kirschfink+	(TASSO Collab.)
ANSARI	87	PL B186 440	+Bagnaia, Banner, Battiston+	(UA2 Collab.)
BEHREND	87C	PL B191 209	+Buerger, Criegee, Dainton+	(CELLO Collab.)
BARTEL	86C	ZPHY C30 371	+Becker, Cords, Felst, Haidt+	(JADE Collab.)
Also	85B	ZPHY C26 507	Bartel, Becker, Bowdery, Cords+	(JADE Collab.)
Also	82	PL 108B 140	Bartel, Cords, Dittmann, Eichler+	(JADE Collab.)
ASH	85	PRL 55 1831	+Band, Blume, Camporesi+	(MAC Collab.)
BARTEL	85F	PL 161B 188	+Becker, Cords, Felst+	(JADE Collab.)
DERRICK	85	PR D31 2352	+Fernandez, Fries, Hyman+	(HRS Collab.)
FERNANDEZ	85	PRL 54 1624	+Ford, Qi, Read+	(MAC Collab.)
LEVI	83	PRL 51 1941	+Blocker, Strait+	(Mark II Collab.)
BEHREND	82	PL 114B 282	+Chen, Fenner, Field+	(CELLO Collab.)
BRANDELIK	82C	PL 110B 173	+Braunschweig, Gather	(TASSO Collab.)