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Z – THIS IS PART 1 OF 2

To reduce the size of this section's PostScript file, we have divided it into two PostScript files. We present the following index:

PART 1

PART 2

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 96B and ADRIANI 93H 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.

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. • • •					
91.185±0.010		[2] ACKERSTAFF	97C	OPAL	E^{ee}_{cm}= LEP1 + 130–136 GeV + 161 GeV
91.162±0.011	1.2M	[3] ACCIARRI	96B	L3	E^{ee}_{cm}= 88–94, 130–140 GeV
91.151±0.008		[4] MIYABAYASHI	95	TOPZ	E^{ee}_{cm}= 57.8 GeV
91.181±0.007±0.006	512k	[5] ACTON	93D	OPAL	Repl. by AKERS 94
91.195±0.009	460k	[6] ADRIANI	93F	L3	Repl. by ACCIARRI 94
91.160±0.010	463k	[7] ADRIANI	93H	L3	Repl. by ACCIARRI 96B
91.187±0.009	520k	[8] BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
91.187±0.007	2.2M	[9] LEP	93	RVUE	E^{ee}_{cm}= 88–94 GeV

91.187±0.007	1.9M	[10] QUAST	93	RVUE	E_{cm}^{ee}= 88–94 GeV
91.74 ±0.28 ±0.93	156	[11] ALITTI	92B	UA2	$E_{\mathrm{cm}}^{p\overline{p}}$= 630 GeV
89.2 $^{+2.1}_{-1.8}$		[12] ADACHI	90F	RVUE	
90.9 ±0.3 ±0.2	188	[13] ABE	89C	CDF	$E_{\mathrm{cm}}^{p\overline{p}}$= 1.8 TeV
91.14 ±0.12	480	[14] ABRAMS	89B	MRK2	E_{cm}^{ee}= 89–93 GeV
93.1 ±1.0 ±3.0	24	[15,16] ALBAJAR	89	UA1	$E_{\mathrm{cm}}^{p\overline{p}}$= 546,630 GeV
88.6 $^{+2.0}_{-1.8}$		[12] MORI	89	RVUE	

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

[2] 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.

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

[4] 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.

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

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

[7] ADRIANI 93H use the S-matrix approach to determine the pole position for the Z boson. Note the shift of this result with respect to the standard Breit-Wigner parametrization.

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

[9] The LEP 93 error due to the experiments is 4 MeV and the uncertainty due to the absolute LEP energy scale is 6 MeV.

[10] QUAST 93 is a combined analysis of LEP results as of Feb. 1993. A common systematic error of 6 MeV is taken into account.

[11] 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.

[12] MORI 89, ADACHI 90F use a Breit-Wigner resonance shape fit and combine their results with published data of PEP and PETRA.

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

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

[15] Enters fit through Z-W mass difference given in the W Particle Listings.

[16] 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		[17] ABREU	96R	DLPH	E_{cm}^{ee}= 91.2 GeV
2.483±0.011±0.0045	1.16M	[18] ABREU	94	DLPH	E_{cm}^{ee}= 88–94 GeV
2.494±0.009±0.0045	1.19M	[18] ACCIARRI	94	L3	E_{cm}^{ee}= 88–94 GeV
2.483±0.011±0.0045	1.33M	[18] AKERS	94	OPAL	E_{cm}^{ee}= 88–94 GeV
2.501±0.011±0.0045	1.27M	[18] BUSKULIC	94	ALEP	E_{cm}^{ee}= 88–94 GeV

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

2.492±0.010	1.2M	[19] ACCIARRI	96B	L3	$E^{ee}_{\rm cm}$= 88–94, 130–140 GeV
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
2.492±0.012	463k	[22] ADRIANI	93H	L3	Repl. by ACCIARRI 96B
2.501±0.012	520k	[23] BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
2.490±0.007	1.9M	[24] QUAST	93	RVUE	$E^{ee}_{\rm cm}$= 88–94 GeV
3.8 ±0.8 ±1.0	188	ABE	89C	CDF	$E^{p\overline{p}}_{\rm cm}$= 1.8 TeV
2.42 $^{+0.45}_{-0.35}$	480	[25] ABRAMS	89B	MRK2	$E^{ee}_{\rm cm}$= 89–93 GeV
2.7 $^{+1.2}_{-1.0}$ ±1.3	24	[26] ALBAJAR	89	UA1	$E^{p\overline{p}}_{\rm cm}$= 546,630 GeV
2.7 ±2.0 ±1.0	25	[27] ANSARI	87	UA2	$E^{p\overline{p}}_{\rm cm}$= 546,630 GeV

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

[18] The second error of 4.5 MeV is due to a common LEP energy uncertainty.

[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 high-energy 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] ADRIANI 93H use the S-matrix approach to determine the pole position for the Z boson. 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').

[23] The error in BUSKULIC 93J includes 4 MeV due to the uncertainty in LEP energy calibration.

[24] QUAST 93 is a combined analysis of LEP results as of Feb. 1993. A common systematic error of 4 MeV is taken into account.

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

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

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

Z DECAY MODES

	Mode			Fraction (Γ_i/Γ)	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	$(u\overline{u}+c\overline{c})/2$			(9.6 ±1.3) %	
Γ_8	$(d\overline{d}+s\overline{s}+b\overline{b})/3$			(16.9 ±0.9) %	
Γ_9	$c\overline{c}$			(11.0 ±0.7) %	
Γ_{10}	$b\overline{b}$			(15.46 ±0.14) %	
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			(3.80 ±0.27) $\times 10^{-3}$	
Γ_{21}	$\psi(2S)$X			(1.60 ±0.33) $\times 10^{-3}$	
Γ_{22}	$\chi_{c1}(1P)$X			(6.0 ±1.9) $\times 10^{-3}$	
Γ_{23}	ΥX			(1.0 ±0.5) $\times 10^{-4}$	
Γ_{24}	$(D^0/\overline{D}^0)$ X			(20.7 ±2.0) %	
Γ_{25}	$D^{\pm}$X			(12.2 ±1.7) %	
Γ_{26}	$D^*(2010)^{\pm}$X		[b]	(11.4 ±1.3) %	
Γ_{27}	BX				
Γ_{28}	B^*X				
Γ_{29}	B_s^0X			seen	
Γ_{30}	anomalous $\gamma+$ hadrons		[c]	< 3.2 $\times 10^{-3}$	95%
Γ_{31}	$e^+ e^- \gamma$		[c]	< 5.2 $\times 10^{-4}$	95%
Γ_{32}	$\mu^+ \mu^- \gamma$		[c]	< 5.6 $\times 10^{-4}$	95%
Γ_{33}	$\tau^+ \tau^- \gamma$		[c]	< 7.3 $\times 10^{-4}$	95%
Γ_{34}	$\ell^+ \ell^- \gamma \gamma$		[d]	< 6.8 $\times 10^{-6}$	95%
Γ_{35}	$q\overline{q}\gamma\gamma$		[d]	< 5.5 $\times 10^{-6}$	95%
Γ_{36}	$\nu\overline{\nu}\gamma\gamma$		[d]	< 3.1 $\times 10^{-6}$	95%
Γ_{37}	$e^{\pm} \mu^{\mp}$	*LF*	[b]	< 1.7 $\times 10^{-6}$	95%
Γ_{38}	$e^{\pm} \tau^{\mp}$	*LF*	[b]	< 9.8 $\times 10^{-6}$	95%
Γ_{39}	$\mu^{\pm} \tau^{\mp}$	*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 of particle/antiparticle states indicated.

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

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

Z PARTIAL WIDTHS

$\Gamma(e^+e^-)$ — Γ_1

For the LEP experiments, this parameter is not directly used in the overall fit but is derived using the fit results; see the 'Note on the *Z* Boson.'

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
83.82±0.30 OUR FIT					
82.89±1.20±0.89		[28] 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
83.03±0.66	17k	ACTON	93D	OPAL	Repl. by AKERS 94
83.0 ±0.6	16k	ADRIANI	93M	L3	Repl. by ACCIARRI 94
84.43±0.60		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
83.30±0.35	70k	[29] QUAST	93	RVUE	E^{ee}_{cm} = 88–94 GeV

[28] 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.

[29] QUAST 93 is a combined analysis of LEP results as of Feb. 1993.

$\Gamma(\mu^+\mu^-)$ — 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
84.43±0.92	23k	ACTON	93D	OPAL	Repl. by AKERS 94
82.8 ±1.0	14k	ADRIANI	93M	L3	Repl. by ACCIARRI 94
83.66±0.95		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
83.82±0.52	70k	[30] QUAST	93	RVUE	E^{ee}_{cm} = 88–94 GeV

[30] QUAST 93 is a combined analysis of LEP results as of Feb. 1993.

$\Gamma(\tau^+\tau^-)$ 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
82.2 ±1.1	18k	ACTON	93D	OPAL	Repl. by AKERS 94
84.6 ±1.2	10k	ADRIANI	93M	L3	Repl. by ACCIARRI 94
84.09±1.10		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
83.54±0.62	50k	[31] QUAST	93	RVUE	E^{ee}_{cm}= 88–94 GeV

[31] QUAST 93 is a combined analysis of LEP results as of Feb. 1993.

$\Gamma(\ell^+\ell^-)$ 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
83.27±0.50	58k	ACTON	93D	OPAL	Repl. by AKERS 94
83.1 ±0.5	40k	ADRIANI	93F	L3	Repl. by ACCIARRI 94
84.22±0.48		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
83.40±0.29	190k	[32] QUAST	93	RVUE	E^{ee}_{cm}= 88–94 GeV

[32] QUAST 93 is a combined analysis of LEP results as of Feb. 1993.

Γ(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					
517 ±22 OUR AVERAGE					
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
524 ±40 ±20	172	[33] ADRIANI	92E	L3	E^{ee}_{cm}= 88–94 GeV

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

509.4± 7.0	ABREU	94	DLPH	E^{ee}_{cm}= 88–94 GeV
496.5± 7.9	ACCIARRI	94	L3	E^{ee}_{cm}= 88–94 GeV
490.3± 7.3	AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
501 ± 6	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV
495 ±10	ACTON	93D	OPAL	Repl. by AKERS 94
494 ±10	ADRIANI	93M	L3	Repl. by ACCIARRI 94
498 ± 9	BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
499 ± 6	[34] QUAST	93	RVUE	E^{ee}_{cm}= 88–94 GeV

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

[34] QUAST 93 is a combined analysis of LEP results as of Feb. 1993. Assumes lepton universality.

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	[35] AKERS	94	OPAL	E^{ee}_{cm}= 88–94 GeV
1746 ±10	1.27M	BUSKULIC	94	ALEP	E^{ee}_{cm}= 88–94 GeV
1738 ±12	454k	[36] ACTON	93D	OPAL	Repl. by AKERS 94
1747 ±11	420k	ADRIANI	93F	L3	Repl. by ACCIARRI 94
1751 ±11		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
1741 ± 7	1.7M	[37] QUAST	93	RVUE	E^{ee}_{cm}= 88–94 GeV

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

[36] ACTON 93D assumes lepton universality. Without this assumption it becomes 1743 ± 15 MeV.

[37] QUAST 93 is a combined analysis of LEP results as of Feb. 1993. Assumes lepton universality.

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. • • •

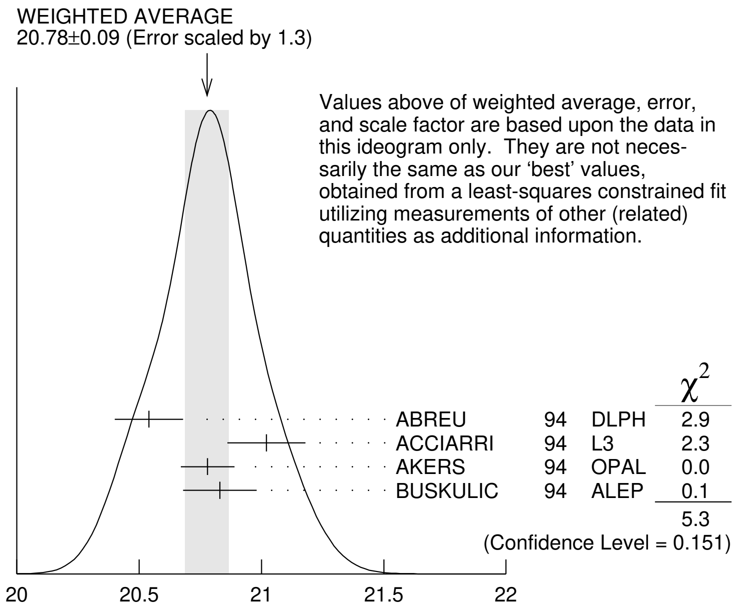
20.99± 0.25	17k	ACTON	93D	OPAL	Repl. by AKERS 94
20.69± 0.21		BUSKULIC	93J	ALEP	Repl. by BUSKULIC 94
20.92± 0.12	70k	[38] QUAST	93	RVUE	E^{ee}_{cm}= 88–94 GeV
27.0 $^{+11.7}_{-\ 8.8}$	12	[39] ABRAMS	89D	MRK2	E^{ee}_{cm}= 89–93 GeV

[38] QUAST 93 is a combined analysis of LEP results as of Feb. 1993.
[39] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.

Γ(hadrons)/$\Gamma(\mu^+\mu^-)$ — 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
20.79±0.10	70k	[40] QUAST	93	RVUE	E^{ee}_{cm}= 88–94 GeV
18.9 $^{+7.1}_{-5.3}$	13	[41] ABRAMS	89D	MRK2	E^{ee}_{cm}= 89–93 GeV

[40] QUAST 93 is a combined analysis of LEP results as of Feb. 1993.
[41] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.



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

$\Gamma(\text{hadrons})/\Gamma(\tau^+\tau^-)$ 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
20.86±0.13	50k	[42] QUAST	93	RVUE	E^{ee}_{cm}= 88–94 GeV
$15.2\ ^{+4.8}_{-3.9}$	21	[43] ABRAMS	89D	MRK2	E^{ee}_{cm}= 89–93 GeV

[42] QUAST 93 is a combined analysis of LEP results as of Feb. 1993.
[43] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.

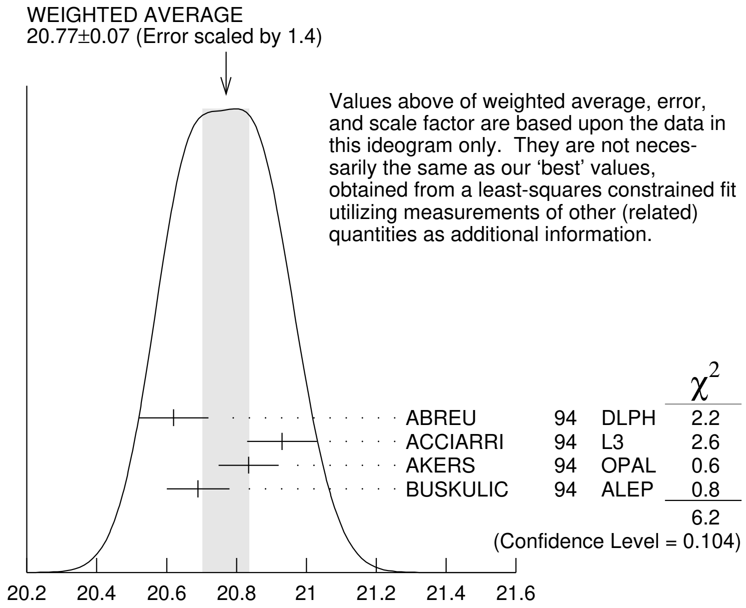
$\Gamma(\text{hadrons})/\Gamma(\ell^+\ell^-)$ Γ_6/Γ_4

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
20.87 ±0.07	190k	[44] QUAST	93	RVUE	E^{ee}_{cm}= 88–94 GeV
18.9 $^{+3.6}_{-3.2}$	46	ABRAMS	89B	MRK2	E^{ee}_{cm}= 89–93 GeV

[44] QUAST 93 is a combined analysis of LEP results as of Feb. 1993. Assumes lepton universality.



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

$\Gamma(\text{hadrons})/\Gamma_{\text{total}}$ $\qquad\Gamma_6/\Gamma$

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
0.6993±0.0031	570k	[45] LEP	92	RVUE	E^{ee}_{cm}= 88–94 GeV

[45] LEP 92 is combined analysis by the four LEP experiments as of December 1991. Systematic errors are included. Assumes lepton universality.

$\Gamma(e^+e^-)/\Gamma_{total}$ — 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
0.03345±0.00020	19k	[46] LEP	92	RVUE	E^{ee}_{cm}= 88–94 GeV

[46] LEP 92 is combined analysis by the four LEP experiments as of December 1991. Systematic errors are included.

$\Gamma(\mu^+\mu^-)/\Gamma_{total}$ — 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
0.03351±0.00034	21k	[47] LEP	92	RVUE	E^{ee}_{cm}= 88–94 GeV

[47] LEP 92 is combined analysis by the four LEP experiments as of December 1991. Systematic errors are included.

$\Gamma(\tau^+\tau^-)/\Gamma_{total}$ — 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
0.03328±0.00040	17k	[48] LEP	92	RVUE	E^{ee}_{cm}= 88–94 GeV

[48] LEP 92 is combined analysis by the four LEP experiments as of December 1991. Systematic errors are included.

$\Gamma(\ell^+\ell^-)/\Gamma_{total}$ — 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
0.03347±0.00013	57k	[49] LEP	92	RVUE	E^{ee}_{cm}= 88–94 GeV

[49] LEP 92 is combined analysis by the four LEP experiments as of December 1991. Systematic errors are included.

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

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

VALUE	DOCUMENT ID
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	

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

This quantity is the branching ratio of $Z \to$ "up-type" quarks to $Z \to$ hadrons. The values of $Z \to$ "up-type" and $Z \to$ "down-type" branchings are extracted from measurements of Γ(hadrons), and $\Gamma(Z \to \gamma+\text{jets})$ where γ is a high-energy (>5 GeV) isolated photon. As the experiments use 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
0.138±0.019 OUR AVERAGE				
$0.137^{+0.038}_{-0.054}$	[50] ABREU	95X	DLPH	E^{ee}_{cm}= 88–94 GeV
0.139 ± 0.026	[51] ACTON	93F	OPAL	E^{ee}_{cm}= 88–94 GeV
0.137 ± 0.033	[52] ADRIANI	93	L3	E^{ee}_{cm}= 91.2 GeV

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

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

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

$\Gamma((d\overline{d}+s\overline{s}+b\overline{b})/3)/\Gamma(\text{hadrons})$ — Γ_8/Γ_6

This quantity is the branching ratio of $Z \to$ "down-type" quarks to $Z \to$ hadrons. The values of $Z \to$ "up-type" and $Z \to$ "down-type" branchings are extracted from measurements of Γ(hadrons), and $\Gamma(Z \to \gamma+\text{jets})$ where γ is a high-energy (>5 GeV) isolated photon. As the experiments use 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
0.242±0.012 OUR AVERAGE				
$0.243^{+0.036}_{-0.026}$	[53] ABREU	95X	DLPH	E^{ee}_{cm}= 88–94 GeV
0.241 ± 0.017	[54] ACTON	93F	OPAL	E^{ee}_{cm}= 88–94 GeV
0.243 ± 0.022	[55] ADRIANI	93	L3	E^{ee}_{cm}= 91.2 GeV

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

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

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

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

OUR FIT is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the "Note 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 $R_c = 0.160 \pm 0.009$.

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 March 1997) yields $R_c = 0.1722 \pm 0.0053$. The Standard Model predicts $R_c = 0.1723$ for $m_t = 175$ GeV and $M_H = 300$ GeV.

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.158 ±0.010 OUR FIT				
0.167 ±0.011 ±0.012	[56] ALEXANDER	96R	OPAL	E^{ee}_{cm}= 88–94 GeV
0.1623±0.0085±0.0209	[57] ABREU	95D	DLPH	E^{ee}_{cm}= 88–94 GeV
0.142 ±0.008 ±0.014	[58] AKERS	95O	OPAL	E^{ee}_{cm}= 88–94 GeV
0.165 ±0.005 ±0.020	[59] BUSKULIC	94G	ALEP	E^{ee}_{cm}= 88–94 GeV
0.187 ±0.031 ±0.023	[60] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.151 ±0.008 ±0.041	[61] ABREU	92O	DLPH	E^{ee}_{cm}= 88–94 GeV

[56] 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.

[57] 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.

[58] AKERS 95O use the presence of a $D^{*\pm}$ to tag $Z \to c\overline{c}$ with $D^* \to D^0\pi$ and $D^0 \to K\pi$. 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 $B(c \to D^*)B(D^* \to D^0\pi)B(D^0 \to K\pi)$. 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 $\Gamma(c\overline{c})/\Gamma$(hadrons). The second error of AKERS 95O includes an uncertainty of ± 0.011 from the uncertainty on P_c.

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

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

[61] 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 = 0.158 (as given by OUR FIT above), we obtain R_b = 0.2213 ± 0.0019. For an expected Standard Model value of R_c = 0.172, our weighted average gives R_b = 0.2200 ± 0.0019 while OUR FIT value becomes R_b = 0.2202 ± 0.0018.

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 March 1997) yields R_b = 0.2177 ± 0.0011 (for R_c = 0.1723). The Standard Model predicts R_b = 0.2158 for m_t = 175 GeV and M_H = 300 GeV.

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
0.2212±0.0019 OUR FIT					
0.229 ±0.011		[62] ABE	96E	SLD	E^{ee}_{cm}= 91.2 GeV
0.2216±0.0016±0.0021		[63] ABREU	96	DLPH	E^{ee}_{cm}= 88–94 GeV
0.2145±0.0089±0.0067		[64] ABREU	95D	DLPH	E^{ee}_{cm}= 88–94 GeV
0.2171±0.0021±0.0021		[65] AKERS	95B	OPAL	E^{ee}_{cm}= 88–94 GeV
0.219 ±0.006 ±0.005		[66] BUSKULIC	94G	ALEP	E^{ee}_{cm}= 88–94 GeV
0.222 ±0.003 ±0.007		[67] ADRIANI	93E	L3	E^{ee}_{cm}= 88–94 GeV
0.222 ±0.011 ±0.007		[68] AKERS	93B	OPAL	E^{ee}_{cm}= 88–94 GeV
0.2192±0.0022±0.0031		[69] BUSKULIC	93M	ALEP	E^{ee}_{cm}= 91.3 GeV
0.228 ±0.005 ±0.005		[70] BUSKULIC	93N	ALEP	E^{ee}_{cm}= 88–94 GeV
0.251 ±0.049 ±0.030	32	[71] JACOBSEN	91	MRK2	E^{ee}_{cm}= 91 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.2217±0.0020±0.0033		[72] ABREU	95D	DLPH	Repl. by ABREU 96
0.2241±0.0063±0.0046		[73] ABREU	95J	DLPH	Repl. by ABREU 96
0.218 ±0.006 ±0.010		[74] AKERS	94D	OPAL	Repl. by AKERS 95B
0.220 ±0.002 ±0.013	11893	[75] ACTON	93I	OPAL	Repl. by AKERS 95B
0.222 ±0.007 ±0.008		[76] ACTON	93M	OPAL	Repl. by AKERS 95B
0.222 $^{+0.033}_{-0.031}$ ±0.017		[77] ABREU	92	DLPH	E^{ee}_{cm}= 88–94 GeV
0.219 ±0.014 ±0.019		[78] ABREU	92K	DLPH	E^{ee}_{cm}= 88–94 GeV
0.232 ±0.005 ±0.017		[79] ABREU	92O	DLPH	E^{ee}_{cm}= 88–94 GeV
0.23 $^{+0.10}_{-0.08}$ $^{+0.05}_{-0.04}$	15	[80] KRAL	90	MRK2	E^{ee}_{cm}= 89–93 GeV

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

[63] 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 $-0.087 \cdot \Delta R_c$.

[64] 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.

[65] AKERS 95B select events based on the lepton and/or vertex tag independently in each hemisphere. Comparing the numbers of single- and double-tagged events, they determine the b-tagging efficiency directly from data.

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

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

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

[69] BUSKULIC 93M use a method which tags the $Z \rightarrow b\overline{b}$ decays through the lifetime of the produced heavy hadrons. The systematic error includes a contribution of ± 0.0016 due to the uncertainty of the charm partial width.

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

[71] 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).

[72] ABREU 95D obtain this result combining several analyses (double-lifetime tag and mixed tags). The second error contains an uncertainty of ± 0.0029 due to the total systematics and an uncertainty of ± 0.0016 due to an 8% variation of $\Gamma(c\overline{c})/\Gamma(\text{hadrons})$ around its Standard Model value (0.171 ± 0.014). Combining with their own lepton analysis, ABREU 95D obtain $0.2210 \pm 0.0033 \pm 0.0003$ (models) ± 0.0014 $[\Gamma(c\overline{c})/\Gamma(\text{hadrons})]$.

[73] ABREU 95J obtain this value with a multivariate analysis based on event shape and particle trajectories near the interaction point. The second error contains an uncertainty of ± 0.0012 due to an 8% variation of $\Gamma(c\overline{c})/\Gamma(\text{hadrons})$ around its Standard Model value (0.171 ± 0.014).

[74] AKERS 94D perform an analysis based on a "mixed tag" method (impact parameter and lepton tagging). The systematic error includes a contribution (± 0.007) due to the $\Gamma(c\overline{c})/\Gamma(\text{hadrons})$ uncertainty.

[75] ACTON 93I use both electrons and muons to tag B semileptonic decays. The systematic error includes components due to b and c quark fragmentation uncertainties, decay branching ratios, and $\Gamma(c\overline{c})/\Gamma(\text{hadrons})$.

[76] ACTON 93M tagged $Z \rightarrow b\overline{b}$ events using the impact parameter technique.

[77] 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.

[78] 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.

[79] 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.

[80] 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	[81] ABREU	96S	DLPH	E^{ee}_{cm} = 88–94 GeV

[81] 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}.

$\Gamma(\pi^0\gamma)/\Gamma_{total}$ — Γ_{12}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<5.2 × 10^−5	95	[82] 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	[83] ADRIANI	92B	L3	Repl. by ACCIARRI 95G

[82] This limit is for both decay modes $Z \to \pi^0\gamma/\gamma\gamma$ which are indistinguishable in ACCIARRI 95G.
[83] This limit is for both decay modes $Z \to \pi^0\gamma/\gamma\gamma$ which are indistinguishable in ADRIANI 92B.

$\Gamma(\eta\gamma)/\Gamma_{total}$ — 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 × 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

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

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

$\Gamma(\eta'(958)\gamma)/\Gamma_{total}$ — Γ_{15}/Γ

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
<4.2 × 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 × 10^−5	95	[84] 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	[85] ADRIANI	92B	L3	Repl. by ACCIARRI 95G

[84] This limit is for both decay modes $Z \to \pi^0\gamma/\gamma\gamma$ which are indistinguishable in ACCIARRI 95G.
[85] This limit is for both decay modes $Z \to \pi^0\gamma/\gamma\gamma$ 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	[86] ACCIARRI	95C	L3	E^{ee}_{cm}= 88–94 GeV
$<1.7 \times 10^{-5}$	95	[86] 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

[86] 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
3.80±0.27 OUR AVERAGE					
3.9 ±0.2 ±0.3	511	[87] ALEXANDER	96B	OPAL	E^{ee}_{cm}= 88–94 GeV
3.73±0.39±0.36	153	[88] ABREU	94P	DLPH	E^{ee}_{cm}= 88–94 GeV
3.6 ±0.5 ±0.4	121	[88] ADRIANI	93J	L3	E^{ee}_{cm}= 88–94 GeV

[87] 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).

[88] 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±0.33 OUR AVERAGE					
1.6 ±0.3 ±0.2	46.9	[89] ALEXANDER	96B	OPAL	E^{ee}_{cm}= 88–94 GeV
1.60±0.73±0.33	5.4	[90] ABREU	94P	DLPH	E^{ee}_{cm}= 88–94 GeV

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

[90] 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
6.0±1.9 OUR AVERAGE					
$5.0\pm2.1^{+1.5}_{-0.9}$	6.4	[91] ABREU	94P	DLPH	E^{ee}_{cm}= 88–94 GeV
7.5±2.9±0.6	19	[91] ADRIANI	93J	L3	E^{ee}_{cm}= 88–94 GeV

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

$\Gamma(\Upsilon X)/\Gamma_{total}$ — Γ_{23}/Γ

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
1.0±0.4±0.22	6.4	[92] ALEXANDER	96F	OPAL	E^{ee}_{cm}= 88–94 GeV

[92] 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.

$\Gamma((D^0/\overline{D}^0)X)/\Gamma(\text{hadrons})$ — Γ_{24}/Γ_6

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

[93] 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_{25}/Γ_6

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

[94] 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_{26}/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	[95] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV
0.21 ±0.04	362	[96] DECAMP	91J	ALEP	E^{ee}_{cm}= 88–94 GeV

[95] $D^*(2010)^{\pm}$ 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).

[96] 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_{29}/Γ_6

VALUE	DOCUMENT ID		TECN	COMMENT
seen	[97] ABREU	92M	DLPH	E^{ee}_{cm}= 88–94 GeV

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

$\Gamma(B^*X)/[\Gamma(BX)+\Gamma(B^*X)]$ — $\Gamma_{28}/(\Gamma_{27}+\Gamma_{28})$

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.75 ±0.04 OUR AVERAGE					
0.771±0.026±0.070		[98] BUSKULIC	96D	ALEP	E^{ee}_{cm}= 88–94 GeV
0.72 ±0.03 ±0.06		[99] ABREU	95R	DLPH	E^{ee}_{cm}= 88–94 GeV
0.76 ±0.08 ±0.06	1378	[100] ACCIARRI	95B	L3	E^{ee}_{cm}= 88–94 GeV

[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_{30}/Γ

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

VALUE	*CL%*	*DOCUMENT ID*		*TECN*	*COMMENT*
$<3.2 \times 10^{-3}$	95	[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_{31}/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_{32}/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_{33}/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_{34}/Γ

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

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_{35}/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_{36}/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_{37}/Γ_{1}

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

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

$\Gamma(e^{\pm}\mu^{\mp})/\Gamma_{\text{total}}$ Γ_{37}/Γ

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

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

$\Gamma(e^{\pm}\tau^{\mp})/\Gamma_{\text{total}}$ Γ_{38}/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^{ee}_{cm}= 88–94 GeV
$\mathbf{<9.8 \times 10^{-6}}$	95	AKERS	95W	OPAL	E^{ee}_{cm}= 88–94 GeV
$<1.3 \times 10^{-5}$	95	ADRIANI	93I	L3	E^{ee}_{cm}= 88–94 GeV
$<1.2 \times 10^{-4}$	95	DECAMP	92	ALEP	E^{ee}_{cm}= 88–94 GeV

$\Gamma(\mu^{\pm}\tau^{\mp})/\Gamma_{\text{total}}$ Γ_{39}/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^{ee}_{cm}= 88–94 GeV
$<1.7 \times 10^{-5}$	95	AKERS	95W	OPAL	E^{ee}_{cm}= 88–94 GeV
$<1.9 \times 10^{-5}$	95	ADRIANI	93I	L3	E^{ee}_{cm}= 88–94 GeV
$<1.0 \times 10^{-4}$	95	DECAMP	92	ALEP	E^{ee}_{cm}= 88–94 GeV