NODE=S044

Z

$J = 1$

See the related review(s):

Z Boson

Z MASS

NODE=S044M

NODE=S044M

OUR AVERAGE is given by the weighted average of the combined CDF result and the combined LEP result, assuming no correlations between CDF and LEP. The combined LEP result, 91.1876 $\pm$ 0.0021 GeV, is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06). The LEP fit is performed using the Z mass and width, the Z hadronic pole cross section, the ratios of hadronic to leptonic partial widths, and the Z pole forward-backward lepton asymmetries. This set is believed to be most free of correlations.

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

NODE=S044M

NEW

VALUE (GeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
91.1879±0.0020 OUR AVERAGE					
[91.1880 $\pm$ 0.0020 GeV OUR 2025 AVERAGE]					
91.1857$\pm$0.0083$\pm$0.0039	174K	[1] AAIJ	25AH	LHCB	$E^{pp}_{\rm cm}$ = 13 TeV
91.1923$\pm$0.0071		[2] AALTONEN	22	CDF	$E^{p\overline{p}}_{\rm cm}$= 1.8 TeV
91.1876$\pm$0.0021		[3] LEP-SLC	06	LEP	$E^{ee}_{\rm cm}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
91.084 $\pm$0.107		[4] ANDREEV	18A	H1	$e^{\pm}p$
91.1872$\pm$0.0033		[5] ABBIENDI	04G	OPAL	$E^{ee}_{\rm cm}$= LEP1 + 130–209 GeV
91.272 $\pm$0.032 $\pm$0.033		[6] ACHARD	04C	L3	$E^{ee}_{\rm cm}$= 183–209 GeV
91.1852$\pm$0.0030	4.57M	[7] ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
91.1863$\pm$0.0028	4.08M	[8] ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
91.1898$\pm$0.0031	3.96M	[9] ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
91.1875$\pm$0.0039	3.97M	[10] ACCIARRI	00Q	L3	$E^{ee}_{\rm cm}$= LEP1 + 130–189 GeV
91.1885$\pm$0.0031	4.57M	[11] BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
91.151 $\pm$0.008		[12] MIYABAYASHI	95	TOPZ	$E^{ee}_{\rm cm}$= 57.8 GeV
91.74 $\pm$0.28 $\pm$0.93	156	[13] ALITTI	92B	UA2	$E^{p\overline{p}}_{\rm cm}$= 630 GeV
90.9 $\pm$0.3 $\pm$0.2	188	[14] ABE	89C	CDF	$E^{p\overline{p}}_{\rm cm}$= 1.8 TeV
91.14 $\pm$0.12	480	[15] ABRAMS	89B	MRK2	$E^{ee}_{\rm cm}$= 89–93 GeV
93.1 $\pm$1.0 $\pm$3.0	24	[16] ALBAJAR	89	UA1	$E^{p\overline{p}}_{\rm cm}$= 546,630 GeV

[1] AAIJ 25AH analyse Z production in the muon decay channel in their 2016 data, with the transverse momentum of the muon required to be above 20 GeV and the pseudorapidity of muons $2.2 < \eta < 4.4$. They obtain a Z mass measurement based on a template fit. The systematic error is dominated by 0.0036 GeV from momentum calibration. NODE=S044M;LINKAGE=R

[2] AALTONEN 22 analyse Z decays in the di-muon and di-electron channels using their full Run-II data set. They obtain Z mass values of 91192.0 $\pm$ 6.4(stat.)$\pm$4.0(syst.) MeV and 91194.3 $\pm$ 13.8(stat.)$\pm$7.6(syst.) MeV, respectively. Combining these results using the systematic uncertainty contributions and their correlations as given in AALTONEN 22, we obtain an average of 91192.3 $\pm$ 5.8(stat.)$\pm$4.1(syst.) MeV. NODE=S044M;LINKAGE=O

[3] This result combines ABBIENDI 01A, ABREU 00F, ACCIARRI 00C, BARATE 00C, taking correlated uncertainties into account. NODE=S044M;LINKAGE=Q

[4] ANDREEV 18A obtain this result in a combined electroweak and QCD analysis using all deep-inelastic $e^+ p$ and $e^- p$ neutral current and charged current scattering cross sections published by the H1 Collaboration, including data with longitudinally polarized lepton beams. NODE=S044M;LINKAGE=N

[5] ABBIENDI 04G obtain this result using the S–matrix formalism for a combined fit to their cross section and asymmetry data at the Z peak and their data at 130–209 GeV. The authors have corrected the measurement for the 34 MeV shift with respect to the Breit–Wigner fits. NODE=S044M;LINKAGE=AI

[6] ACHARD 04C select $e^+ e^- \rightarrow Z\gamma$ events with hard initial–state radiation. Z decays to $q\overline{q}$ and muon pairs are considered. The fit results obtained in the two samples are found consistent to each other and combined considering the uncertainty due to ISR modelling as fully correlated. NODE=S044M;LINKAGE=AH

[7] ABBIENDI 01A error includes approximately 2.3 MeV due to statistics and 1.8 MeV due to LEP energy uncertainty. This result is included in the LEP average LEP-SLC 06. NODE=S044M;LINKAGE=DB

[8] The error includes 1.6 MeV due to LEP energy uncertainty. This result is included in the LEP average LEP-SLC 06. NODE=S044M;LINKAGE=AC

[9] The error includes 1.8 MeV due to LEP energy uncertainty. This result is included in the LEP average LEP-SLC 06. NODE=S044M;LINKAGE=AB

[10] ACCIARRI 00Q interpret the s-dependence of the cross sections and lepton forward-backward asymmetries in the framework of the S-matrix formalism. They fit to their cross section and asymmetry data at high energies, using the results of S-matrix fits to Z-peak data (ACCIARRI 00C) as constraints. The 130–189 GeV data constrains the γ/Z interference term. The authors have corrected the measurement for the 34.1 MeV shift with respect to the Breit-Wigner fits. The error contains a contribution of ± 2.3 MeV due to the uncertainty on the γZ interference. NODE=S044M;LINKAGE=NN

[11] BARATE 00C error includes approximately 2.4 MeV due to statistics, 0.2 MeV due to experimental systematics, and 1.7 MeV due to LEP energy uncertainty. This result is included in the LEP average LEP-SLC 06. NODE=S044M;LINKAGE=KA

[12] 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. NODE=S044M;LINKAGE=M

[13] 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. NODE=S044M;LINKAGE=AG

[14] First error of ABE 89 is combination of statistical and systematic contributions; second is mass scale uncertainty. NODE=S044M;LINKAGE=E

[15] ABRAMS 89B uncertainty includes 35 MeV due to the absolute energy measurement. NODE=S044M;LINKAGE=I

[16] ALBAJAR 89 result is from a total sample of 33 $Z \rightarrow e^+ e^-$ events. NODE=S044M;LINKAGE=F

Z WIDTH

NODE=S044W

OUR EVALUATION is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06). Corrections as discussed in VOUTSINAS 20 and JANOT 20 are also included. NODE=S044W

NODE=S044W

VALUE (GeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
2.4955±0.0023 OUR EVALUATION					
2.4955±0.0023		[1] JANOT	20		
• • • We do not use the following data for averages, fits, limits, etc. • • •					
2.4955±0.0023		[2] VOUTSINAS	20		
2.4952±0.0023		[3] LEP-SLC	06		$E^{ee}_{\rm cm}$ = 88–94 GeV
2.4943±0.0041		[4] ABBIENDI	04G	OPAL	$E^{ee}_{\rm cm}$= LEP1 + 130–209 GeV
2.4948±0.0041	4.57M	[5] ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
2.4876±0.0041	4.08M	[6] ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
2.5024±0.0042	3.96M	[7] ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
2.5025±0.0041	3.97M	[8] ACCIARRI	00Q	L3	$E^{ee}_{\rm cm}$= LEP1 + 130–189 GeV
2.4951±0.0043	4.57M	[9] BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
2.50 ±0.21 ±0.06		[10] ABREU	96R	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
3.8 ±0.8 ±1.0	188	ABE	89C	CDF	$E^{p\overline{p}}_{\rm cm}$= 1.8 TeV
2.42 $^{+0.45}_{-0.35}$	480	[11] ABRAMS	89B	MRK2	$E^{ee}_{\rm cm}$= 89–93 GeV
2.7 $^{+1.2}_{-1.0}$ ±1.3	24	[12] ALBAJAR	89	UA1	$E^{p\overline{p}}_{\rm cm}$= 546,630 GeV
2.7 ±2.0 ±1.0	25	[13] ANSARI	87	UA2	$E^{p\overline{p}}_{\rm cm}$= 546,630 GeV

→ UNCHECKED ←

OCCUR=2

[1] JANOT 20 applies a correction to LEP-SLC 06 using an updated Bhabha cross section calculation. This result also includes a correction to account for correlated luminosity bias as presented in VOUTSINAS 20. NODE=S044W;LINKAGE=G

[2] VOUTSINAS 20 applies a correction to LEP-SLC 06 to account for correlated luminosity bias. NODE=S044W;LINKAGE=A

[3] This result combines ABBIENDI 01A, ABREU 00F, ACCIARRI 00C, BARATE 00C, taking correlated uncertainties into account. NODE=S044W;LINKAGE=K

[4] ABBIENDI 04G obtain this result using the S–matrix formalism for a combined fit to their cross section and asymmetry data at the Z peak and their data at 130–209 GeV. The authors have corrected the measurement for the 1 MeV shift with respect to the Breit–Wigner fits. NODE=S044W;LINKAGE=AI

[5] ABBIENDI 01A error includes approximately 3.6 MeV due to statistics, 1 MeV due to event selection systematics, and 1.3 MeV due to LEP energy uncertainty. NODE=S044W;LINKAGE=DB

[6] The error includes 1.2 MeV due to LEP energy uncertainty. NODE=S044W;LINKAGE=AC

[7] The error includes 1.3 MeV due to LEP energy uncertainty. NODE=S044W;LINKAGE=AB

[8] ACCIARRI 00Q interpret the s-dependence of the cross sections and lepton forward-backward asymmetries in the framework of the S-matrix formalism. They fit to their cross section and asymmetry data at high energies, using the results of S-matrix fits to Z-peak data (ACCIARRI 00C) as constraints. The 130–189 GeV data constrains the γ/Z interference term. The authors have corrected the measurement for the 0.9 MeV shift with respect to the Breit-Wigner fits. NODE=S044W;LINKAGE=NN

[9] BARATE 00C error includes approximately 3.8 MeV due to statistics, 0.9 MeV due to experimental systematics, and 1.3 MeV due to LEP energy uncertainty. NODE=S044W;LINKAGE=KA

[10] ABREU 96R obtain this value from a study of the interference between initial and final state radiation in the process $e^+e^- \to Z \to \mu^+\mu^-$. NODE=S044W;LINKAGE=M

[11] ABRAMS 89B uncertainty includes 50 MeV due to the miniSAM background subtraction error. NODE=S044W;LINKAGE=I

[12] ALBAJAR 89 result is from a total sample of 33 $Z \to e^+e^-$ events. NODE=S044W;LINKAGE=F

[13] 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 $= 2.17^{+0.50}_{-0.37} \pm 0.16$. NODE=S044W;LINKAGE=E

Z DECAY MODES

NODE=S044215;NODE=S044

	Mode		Fraction (Γ_i/Γ)	Scale factor/ Confidence level	
Γ_1	e^+e^-		(3.3632 ± 0.0042) %		DESIG=1
Γ_2	$\mu^+\mu^-$		(3.3662 ± 0.0066) %		DESIG=2
Γ_3	$\tau^+\tau^-$		(3.3696 ± 0.0083) %		DESIG=8
Γ_4	$\ell^+\ell^-$	[a]	(3.3658 ± 0.0023) %		DESIG=16
Γ_5	$\mu^+\mu^-\mu^+\mu^-$				DESIG=92
Γ_6	$\ell^+\ell^-\ell^+\ell^-$	[b]	$(4.55 \pm 0.17) \times 10^{-6}$		DESIG=82
Γ_7	invisible		(20.000 ± 0.055) %		DESIG=9
Γ_8	hadrons		(69.911 ± 0.056) %		DESIG=7
Γ_9	$(u\overline{u}+c\overline{c})/2$		(11.6 ± 0.6) %		DESIG=21
Γ_{10}	$(d\overline{d}+s\overline{s}+b\overline{b})/3$		(15.6 ± 0.4) %		DESIG=22
Γ_{11}	$c\overline{c}$		(12.03 ± 0.21) %		DESIG=17
Γ_{12}	$b\overline{b}$		(15.12 ± 0.05) %		DESIG=6
Γ_{13}	$b\overline{b}b\overline{b}$		$(3.6 \pm 1.3) \times 10^{-4}$		DESIG=73
Γ_{14}	ggg		< 1.1 %	CL=95%	DESIG=64
Γ_{15}	$\pi^0\gamma$		$< 2.01 \times 10^{-5}$	CL=95%	DESIG=10
Γ_{16}	$\eta\gamma$		$< 5.1 \times 10^{-5}$	CL=95%	DESIG=11
Γ_{17}	$\rho^0\gamma$		$< 4.0 \times 10^{-6}$	CL=95%	DESIG=86
Γ_{18}	$\omega\gamma$		$< 3.9 \times 10^{-6}$	CL=95%	DESIG=48
Γ_{19}	$\eta'(958)\gamma$		$< 4.2 \times 10^{-5}$	CL=95%	DESIG=12
Γ_{20}	$\phi\gamma$		$< 7 \times 10^{-7}$	CL=95%	DESIG=85
Γ_{21}	$\gamma\gamma$		$< 1.46 \times 10^{-5}$	CL=95%	DESIG=13
Γ_{22}	$\pi^0\pi^0$		$< 1.52 \times 10^{-5}$	CL=95%	DESIG=83
Γ_{23}	$\gamma\gamma\gamma$		$< 2.2 \times 10^{-6}$	CL=95%	DESIG=14
Γ_{24}	$\pi^\pm W^\mp$	[c]	$< 7 \times 10^{-5}$	CL=95%	DESIG=18
Γ_{25}	$\rho^\pm W^\mp$	[c]	$< 8.3 \times 10^{-5}$	CL=95%	DESIG=19
Γ_{26}	$J/\psi(1S)X$		$(3.51 {}^{+0.23}_{-0.25}) \times 10^{-3}$	S=1.1	DESIG=23
Γ_{27}	$J/\psi(1S)\gamma$		$< 6 \times 10^{-7}$	CL=95%	DESIG=84
Γ_{28}	$\psi(2S)X$		$(1.60 \pm 0.29) \times 10^{-3}$		DESIG=60
Γ_{29}	$\psi(2S)\gamma$		$< 1.3 \times 10^{-6}$	CL=95%	DESIG=87
Γ_{30}	$J/\psi(1S)\ell^+\ell^-$				DESIG=91
Γ_{31}	$J/\psi(1S)J/\psi(1S)$		$< 2.2 \times 10^{-6}$	CL=95%	DESIG=93
Γ_{32}	$\chi_{c1}(1P)X$		$(2.9 \pm 0.7) \times 10^{-3}$		DESIG=42
Γ_{33}	$\chi_{c2}(1P)X$		$< 3.2 \times 10^{-3}$	CL=90%	DESIG=65
Γ_{34}	$\Upsilon(1S)X + \Upsilon(2S)X + \Upsilon(3S)X$		$(1.0 \pm 0.5) \times 10^{-4}$		DESIG=69
Γ_{35}	$\Upsilon(1S)X$		$< 4.4 \times 10^{-5}$	CL=95%	DESIG=66

Γ_{36}	$\Upsilon(1S)\gamma$			< 1.1	$\times 10^{-6}$ CL=95%	DESIG=88
Γ_{37}	$\Upsilon(2S)$X			< 1.39	$\times 10^{-4}$ CL=95%	DESIG=67
Γ_{38}	$\Upsilon(2S)\gamma$			< 1.3	$\times 10^{-6}$ CL=95%	DESIG=89
Γ_{39}	$\Upsilon(3S)$X			< 9.4	$\times 10^{-5}$ CL=95%	DESIG=68
Γ_{40}	$\Upsilon(3S)\gamma$			< 2.4	$\times 10^{-6}$ CL=95%	DESIG=90
Γ_{41}	$\Upsilon(1,2,3S)\,\Upsilon(1,2,3S)$			< 1.5	$\times 10^{-6}$ CL=95%	DESIG=94
Γ_{42}	$K^0_S\gamma$			< 3.1	$\times 10^{-6}$ CL=95%	DESIG=96
Γ_{43}	$D^0\gamma$			< 4.0	$\times 10^{-6}$ CL=95%	DESIG=95
Γ_{44}	$(D^0/\overline{D}^0)$ X			(20.7 ± 2.0) %		DESIG=43
Γ_{45}	$D^{\pm}$X			(12.2 ± 1.7) %		DESIG=44
Γ_{46}	$D^*(2010)^{\pm}$X		[c]	(11.4 ± 1.3) %		DESIG=24
Γ_{47}	$D_{s1}(2536)^{\pm}$X			$(3.6 \pm 0.8) \times 10^{-3}$		DESIG=75
Γ_{48}	$D_{sJ}(2573)^{\pm}$X			$(5.8 \pm 2.2) \times 10^{-3}$		DESIG=76
Γ_{49}	$D^{*\prime}(2629)^{\pm}$X			searched for		DESIG=74;OUR EVAL;→ UNCHECKED ←
Γ_{50}	BX					DESIG=61
Γ_{51}	B^*X					DESIG=62
Γ_{52}	B^+X		[d]	(6.08 ± 0.13) %		DESIG=77
Γ_{53}	B^0_sX		[d]	(1.59 ± 0.13) %		DESIG=49
Γ_{54}	B^+_cX			searched for		DESIG=70;OUR EVAL;→ UNCHECKED ←
Γ_{55}	Λ^+_cX			(1.54 ± 0.33) %		DESIG=78
Γ_{56}	Ξ^0_cX			seen		DESIG=80;OUR EST;→ UNCHECKED ←
Γ_{57}	Ξ_bX			seen		DESIG=81;OUR EST;→ UNCHECKED ←
Γ_{58}	b-baryon X		[d]	(1.38 ± 0.22) %		DESIG=79
Γ_{59}	anomalous $\gamma+$ hadrons		[e]	< 3.2	$\times 10^{-3}$ CL=95%	DESIG=31
Γ_{60}	$e^+e^-\gamma$		[e]	< 5.2	$\times 10^{-4}$ CL=95%	DESIG=3
Γ_{61}	$\mu^+\mu^-\gamma$		[e]	< 5.6	$\times 10^{-4}$ CL=95%	DESIG=4
Γ_{62}	$\tau^+\tau^-\gamma$		[e]	< 7.3	$\times 10^{-4}$ CL=95%	DESIG=29
Γ_{63}	$\ell^+\ell^-\gamma\gamma$		[f]	< 6.8	$\times 10^{-6}$ CL=95%	DESIG=45
Γ_{64}	$q\overline{q}\gamma\gamma$		[f]	< 5.5	$\times 10^{-6}$ CL=95%	DESIG=46
Γ_{65}	$\nu\overline{\nu}\gamma\gamma$		[f]	< 3.1	$\times 10^{-6}$ CL=95%	DESIG=47
Γ_{66}	$e^{\pm}\mu^{\mp}$	LF	[c]	< 1.9	$\times 10^{-7}$ CL=95%	DESIG=5
Γ_{67}	$e^{\pm}\tau^{\mp}$	LF	[c]	< 5.0	$\times 10^{-6}$ CL=95%	DESIG=25
Γ_{68}	$\mu^{\pm}\tau^{\mp}$	LF	[c]	< 6.5	$\times 10^{-6}$ CL=95%	DESIG=26
Γ_{69}	pe	L,B		< 1.8	$\times 10^{-6}$ CL=95%	DESIG=71
Γ_{70}	$p\mu$	L,B		< 1.8	$\times 10^{-6}$ CL=95%	DESIG=72

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

[b] Here ℓ indicates e or μ. LINKAGE=LEM

[c] The value is for the sum of the charge states or particle/antiparticle states indicated. LINKAGE=SG

[d] This value is updated using the product of (i) the $Z \to b\overline{b}$ fraction from this listing and (ii) the b-hadron fraction in an unbiased sample of weakly decaying b-hadrons produced in Z-decays provided by the Heavy Flavor Averaging Group (HFLAV, http://www.slac.stanford.edu/xorg/hflav/osc/PDG_2009/#FRACZ). LINKAGE=HFF

[e] See the Particle Listings below for the γ energy range used in this measurement. LINKAGE=GDZ

[f] For $m_{\gamma\gamma} = (60 \pm 5)$ GeV. LINKAGE=DYY

Z PARTIAL WIDTHS

NODE=S044218

$\Gamma(e^+e^-)$ Γ_1

NODE=S044W1

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

NODE=S044W1

NODE=S044W1

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
83.91±0.12 OUR FIT					
83.66±0.20	137.0k	ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
83.54±0.27	117.8k	ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
84.16±0.22	124.4k	ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
83.88±0.19		BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
82.89±1.20±0.89		[1] ABE	95J	SLD	E^{ee}_{cm}= 91.31 GeV

[1] 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. NODE=S044W1;LINKAGE=KG

$\Gamma(\mu^+\mu^-)$ Γ_2

NODE=S044W2

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06. NODE=S044W2

NODE=S044W2

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

$\Gamma(\tau^+\tau^-)$ Γ_3

NODE=S044W3

This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06. NODE=S044W3

NODE=S044W3

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

$\Gamma(\ell^+\ell^-)$ Γ_4

NODE=S044W4

ℓ indicates each type of lepton (e, μ, and τ), not sum over them. NODE=S044W4

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

NODE=S044W4

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

Γ(invisible) Γ_7

NODE=S044W6

The Z boson also decays to final states invisible in any detector, for example, the decay to a neutrino pair as predicted in the Standard Model. Measurements of Γ(invisible) fall into two categories: direct or indirect. Direct measurements look for final states with missing energy, missing momentum, or missing mass, corresponding to the invisible decay of a produced Z boson, including single-photon final states which arise from initial-state radiation. The indirect determination is based on Z lineshape analyses performed at the LEP collider, where the invisible decay width is calculated by subtracting all visible partial decay widths from the total decay width of the Z boson. Within the framework of the Standard Model these two determinations should be identical, but not in non-SM scenarios. NODE=S044W6

NODE=S044W6

VALUE (MeV)	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
499.3± 1.5 OUR AVERAGE					
506 ± 2 ±12		[1] AAD	24L	ATLS	$E^{pp}_{\rm cm}$ = 13 TeV
523 ± 3 ±16		[2] TUMASYAN	23E	CMS	$E^{pp}_{\rm cm}$ = 13 TeV
499.0± 1.5		[3] LEP-SLC	06	LEP	$E^{ee}_{\rm cm}$= 88–94 GeV
498 ±12 ±12	1791	[4] ACCIARRI	98G	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
539 ±26 ±17	410	[4] AKERS	95C	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
450 ±34 ±34	258	[4] BUSKULIC	93L	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
540 ±80 ±40	52	[4] ADEVA	92	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
498.1± 2.6		[5] ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
498.1± 3.2		[5] ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
499.1± 2.9		[5] ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
499.1± 2.5		[5] BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

[1] AAD 24L use the measured ratio of invisible Z decays and leptonic Z decays to derive the width of the Z decaying to invisible particles. Events with transverse momentum of the Z larger than 130 GeV and at least one central jet with transverse momentum larger than 110 GeV are selected. NODE=S044W6;LINKAGE=F

[2] TUMASYAN 23E analyses leptonic Z decay modes, with the invisible Z decay identified by missing momentum. NODE=S044W6;LINKAGE=D

[3] The LEP Collaborations perform a combined fit to their line-shape results and determine this quantity as a difference between the total width and the sum of all the visible widths, assuming lepton universality. This result combines ABBIENDI 01A, ABREU 00F, ACCIARRI 00C, BARATE 00C, taking correlated uncertainties into account. NODE=S044W6;LINKAGE=C

[4] This analysis selects single-photon events arising from inital state radiation. NODE=S044W6;LINKAGE=E

[5] This is an indirect determination of Γ(invisible) from a fit to the visible Z decay modes. It is included in the determination of the LEP average LEP-SLC 06 reported above. NODE=S044W6;LINKAGE=B1

Γ(hadrons) Γ_8

NODE=S044W5

This parameter is not directly used in the 5-parameter fit assuming lepton universality, but is derived using the fit results. See the note "The Z boson" and ref. LEP-SLC 06. NODE=S044W5

NODE=S044W5

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

Z BRANCHING RATIOS

NODE=S044220

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06). NODE=S044220

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

NODE=S044R3
NODE=S044R3

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
1.0001±0.0024 OUR AVERAGE				
0.9974±0.0050	[1] AABOUD	17Q	ATLS	E^{pp}_{cm} = 7 TeV
1.0009±0.0028	[2] LEP-SLC	06		E^{ee}_{cm} = 88–94 GeV

[1] AABOUD 17Q make a precise determination of $Z \to ee$ and $Z \to \mu\mu$ production in the lepton pseudo-rapidity range $|\eta| < 2.5$ and determine the ratio of the Z branching fractions B($Z \to ee$)/B($Z \to \mu\mu$) = 1.0026 ± 0.0013 ± 0.0048 = 1.0026 ± 0.0050. NODE=S044R3;LINKAGE=A

[2] This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06. NODE=S044R3;LINKAGE=B

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

NODE=S044R19
NODE=S044R19

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
1.0020±0.0032 OUR AVERAGE				
1.02 ±0.06	[1] AAIJ	18AR	LHCB	E^{pp}_{cm} = 8 TeV
1.0019±0.0032	[2] LEP-SLC	06		E^{ee}_{cm} = 88–94 GeV

[1] AAIJ 18AR obtain the result from the ratio of the measured $pp \to Z + X$ cross sections in the corresponding Z decay channels. NODE=S044R19;LINKAGE=B

[2] This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06. NODE=S044R19;LINKAGE=D

$\Gamma(\tau^+\tau^-)/\Gamma(\mu^+\mu^-)$ Γ_3/Γ_2

NODE=S044R37
NODE=S044R37

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
1.0010±0.0026 OUR AVERAGE				
1.01 ±0.05	[1] AAIJ	18AR	LHCB	E^{pp}_{cm} = 8 TeV
1.0010±0.0026	[2] LEP-SLC	06		E^{ee}_{cm} = 88–94 GeV

[1] AAIJ 18AR obtain the result from the ratio of the measured $pp \to Z + X$ cross sections in the corresponding Z decay channels. NODE=S044R37;LINKAGE=A

[2] This parameter is not directly used in the overall fit but is derived using the fit results; see the note "The Z boson" and ref. LEP-SLC 06. NODE=S044R37;LINKAGE=B

$\Gamma(\ell^+\ell^-\ell^+\ell^-)/\Gamma_{total}$ Γ_6/Γ

NODE=S044R01

Here ℓ indicates either e or μ. The branching fractions in this node are given within the phase-space defined by the requirements that (i) the 4-lepton invariant mass is between 80 GeV and 100 GeV, and (ii) any opposite-sign same-flavor lepton pair has a di-lepton invariant mass larger than 4 GeV.

NODE=S044R01

NODE=S044R01

VALUE (units 10^{-6})	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
4.55±0.17 OUR AVERAGE					
$4.41\pm0.13\pm0.27$		[1] AAD	21AQ	ATLS	$E^{pp}_{\rm cm}$ = 13 TeV
$4.70\pm0.32\pm0.25$		[2] AABOUD	19N	ATLS	$E^{pp}_{\rm cm}$ = 13 TeV
$4.83^{+0.23}_{-0.22}{}^{+0.35}_{-0.32}$	509	[3] SIRUNYAN	18BT	CMS	$E^{pp}_{\rm cm}$ = 13 TeV
$4.9\ ^{+0.8}_{-0.7}\ ^{+0.4}_{-0.2}$	39	[4] KHACHATRY...	16CC	CMS	$E^{pp}_{\rm cm}$ = 13 TeV
$4.31\pm0.34\pm0.17$	172	AAD	14N	ATLS	$E^{pp}_{\rm cm}$ = 7, 8 TeV
$4.6\ ^{+1.0}_{-0.9}\ \pm0.2$	28	[5] CHATRCHYAN	12BN	CMS	$E^{pp}_{\rm cm}$ = 7 TeV

[1] AAD 21AQ analyze differential cross-sections in four-lepton events. Based on the measured cross section in the $Z \to 4\ell$ channel, a branching fraction of B($Z \to 4\ell$) = $(4.41 \pm 0.13 \pm 0.23 \pm 0.09 \pm 0.12) \times 10^{-6}$ is obtained, where the uncertainties are statistical, systematic, theory and luminosity, respectively. NODE=S044R01;LINKAGE=F

[2] AABOUD 19N reports $(4.70 \pm 0.32 \pm 0.21 \pm 0.14) \times 10^{-6}$, where the uncertainties are statistical, systematic, and luminosity. We have combined the latter two in quadrature. NODE=S044R01;LINKAGE=E

[3] SIRUNYAN 18BT report the $Z \to 4\ell$ branching fraction = $(4.83^{+0.23}_{-0.22}{}^{+0.32}_{-0.29} \pm 0.08 \pm 0.12) \times 10^{-6}$, where the uncertainties are statistical, systematic, due to theory, and luminosity. The last three have been added in quadrature to obtain the total systematic error. NODE=S044R01;LINKAGE=D

[4] KHACHATRYAN 16CC reports $(4.9^{+0.8}_{-0.7}{}^{+0.3}_{-0.2}{}^{+0.2}_{-0.1}{}^{+0.1}_{-0.1}) \times 10^{-6}$ value, where the uncertainties are statistical, systematic, theory, and due to luminosity. We have combined uncertainties in quadrature. NODE=S044R01;LINKAGE=B

[5] CHATRCHYAN 12BN reports $(4.2^{+0.9}_{-0.8} \pm 0.2) \times 10^{-6}$ value. Their result (both central value and uncertainties) is scaled up by 10% to account for the different phase-space definition used here (see RAINBOLT 19). NODE=S044R01;LINKAGE=CH

$\Gamma(\text{hadrons})/\Gamma(e^+e^-)$ Γ_8/Γ_1

NODE=S044R11
NODE=S044R11

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
20.804± 0.050 OUR FIT					
$20.902\pm\ 0.084$	137.0k	[1] ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
$20.88\ \pm\ 0.12$	117.8k	ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
$20.816\pm\ 0.089$	124.4k	ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
$20.677\pm\ 0.075$		[2] BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$27.0\ ^{+11.7}_{-\ 8.8}$	12	[3] ABRAMS	89D	MRK2	$E^{ee}_{\rm cm}$= 89–93 GeV

[1] ABBIENDI 01A error includes approximately 0.067 due to statistics, 0.040 due to event selection systematics, 0.027 due to the theoretical uncertainty in t-channel prediction, and 0.014 due to LEP energy uncertainty. NODE=S044R11;LINKAGE=DB

[2] BARATE 00C error includes approximately 0.062 due to statistics, 0.033 due to experimental systematics, and 0.026 due to the theoretical uncertainty in t-channel prediction. NODE=S044R11;LINKAGE=AC

[3] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors. NODE=S044R11;LINKAGE=AB

$\Gamma(\text{hadrons})/\Gamma(\mu^+\mu^-)$ Γ_8/Γ_2

NODE=S044R9

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

NODE=S044R9

NODE=S044R9

VALUE	*EVTS*	*DOCUMENT ID*		*TECN*	*COMMENT*
20.785±0.033 OUR FIT					
20.811 ± 0.058	182.8k	[1] ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
$20.65\ \pm0.08$	157.6k	ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
20.861 ± 0.097	113.4k	ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
20.799 ± 0.056		[2] BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$18.9\ ^{+7.1}_{-5.3}$	13	[3] ABRAMS	89D	MRK2	$E^{ee}_{\rm cm}$= 89–93 GeV

[1] ABBIENDI 01A error includes approximately 0.050 due to statistics and 0.027 due to event selection systematics. NODE=S044R9;LINKAGE=DB

[2] BARATE 00C error includes approximately 0.053 due to statistics and 0.021 due to experimental systematics. NODE=S044R9;LINKAGE=AC

[3] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors. NODE=S044R9;LINKAGE=AB

$\Gamma(\text{hadrons})/\Gamma(\tau^+\tau^-)$ Γ_8/Γ_3

NODE=S044R12

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06). NODE=S044R12

NODE=S044R12

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
20.764±0.045 OUR FIT					
20.832±0.091	151.5k	[1] ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
20.84 ±0.13	104.0k	ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
20.792±0.133	103.0k	ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
20.707±0.062		[2] BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
15.2 $^{+4.8}_{-3.9}$	21	[3] ABRAMS	89D	MRK2	$E^{ee}_{\rm cm}$= 89–93 GeV

[1] ABBIENDI 01A error includes approximately 0.055 due to statistics and 0.071 due to event selection systematics. NODE=S044R12;LINKAGE=DB

[2] BARATE 00C error includes approximately 0.054 due to statistics and 0.033 due to experimental systematics. NODE=S044R12;LINKAGE=AC

[3] ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors. NODE=S044R12;LINKAGE=AB

$\Gamma(\text{hadrons})/\Gamma(\ell^+\ell^-)$ Γ_8/Γ_4

NODE=S044R20

ℓ indicates each type of lepton (e, μ, and τ), not sum over them. NODE=S044R20

Our fit result is obtained requiring lepton universality.

NODE=S044R20

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
20.767±0.025 OUR FIT					
20.823±0.044	471.3k	[1] ABBIENDI	01A	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
20.730±0.060	379.4k	ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
20.810±0.060	340.8k	ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
20.725±0.039	500k	[2] BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
18.9 $^{+3.6}_{-3.2}$	46	ABRAMS	89B	MRK2	$E^{ee}_{\rm cm}$= 89–93 GeV

[1] ABBIENDI 01A error includes approximately 0.034 due to statistics and 0.027 due to event selection systematics. NODE=S044R20;LINKAGE=DB

[2] BARATE 00C error includes approximately 0.033 due to statistics, 0.020 due to experimental systematics, and 0.005 due to the theoretical uncertainty in t-channel prediction. NODE=S044R20;LINKAGE=AC

$\Gamma((u\overline{u}+c\overline{c})/2)/\Gamma(\text{hadrons})$ Γ_9/Γ_8

NODE=S044R21

This quantity is the branching ratio of $Z \rightarrow$ "up-type" quarks to $Z \rightarrow$ hadrons. Except ACKERSTAFF 97T the values of $Z \rightarrow$ "up-type" and $Z \rightarrow$ "down-type" branchings are extracted from measurements of Γ(hadrons), and $\Gamma(Z \rightarrow \gamma+$ jets) where γ is a high-energy (>5 or 7 GeV) isolated photon. As the experiments use different procedures and slightly different values of M_Z, Γ(hadrons) and α_s in their extraction procedures, our average has to be taken with caution. NODE=S044R21

NODE=S044R21

VALUE	DOCUMENT ID		TECN	COMMENT
0.166±0.009 OUR AVERAGE				
0.172 $^{+0.011}_{-0.010}$	[1] ABBIENDI	04E	OPAL	$E^{ee}_{\rm cm}$ = 91.2 GeV
0.160±0.019±0.019	[2] ACKERSTAFF	97T	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
0.137 $^{+0.038}_{-0.054}$	[3] ABREU	95X	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
0.137±0.033	[4] ADRIANI	93	L3	$E^{ee}_{\rm cm}$= 91.2 GeV

[1] ABBIENDI 04E select photons with energy > 7 GeV and use $\Gamma(\text{hadrons}) = 1744.4 \pm 2.0$ MeV and $\alpha_s = 0.1172 \pm 0.002$ to obtain $\Gamma_u = 300^{+19}_{-18}$ MeV. NODE=S044R21;LINKAGE=AB

[2] ACKERSTAFF 97T measure $\Gamma_{u\overline{u}}/(\Gamma_{d\overline{d}}+\Gamma_{u\overline{u}}+\Gamma_{s\overline{s}}) = 0.258 \pm 0.031 \pm 0.032$. To obtain this branching ratio authors use $R_c+R_b = 0.380 \pm 0.010$. This measurement is fully negatively correlated with the measurement of $\Gamma_{d\overline{d},s\overline{s}}/(\Gamma_{d\overline{d}}+\Gamma_{u\overline{u}}+\Gamma_{s\overline{s}})$ given in the next data block. NODE=S044R21;LINKAGE=D

[3] ABREU 95X use $M_Z = 91.187 \pm 0.009$ GeV, $\Gamma(\text{hadrons}) = 1725 \pm 12$ 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 $(3C_{1/3} + 2C_{2/3}) = 6.66 \pm 0.05$. NODE=S044R21;LINKAGE=C

[4] ADRIANI 93 use $M_Z = 91.181 \pm 0.022$ GeV, $\Gamma(\text{hadrons}) = 1742 \pm 19$ 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 $(3C_{1/3} + 2C_{2/3}) = 6.720 \pm 0.076$. NODE=S044R21;LINKAGE=B

$\Gamma\big((d\overline{d}+s\overline{s}+b\overline{b})/3\big)/\Gamma(\text{hadrons})$ Γ_{10}/Γ_8

NODE=S044R22

NODE=S044R22

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 or 7 GeV) isolated photon. As the experiments use different procedures and slightly different values of M_Z, Γ(hadrons) and α_s in their extraction procedures, our average has to be taken with caution.

NODE=S044R22

VALUE	DOCUMENT ID		TECN	COMMENT
0.223±0.006 OUR AVERAGE				
0.218±0.007	[1] ABBIENDI	04E	OPAL	E^{ee}_{cm} = 91.2 GeV
0.230±0.010±0.010	[2] ACKERSTAFF	97T	OPAL	E^{ee}_{cm}= 88–94 GeV
$0.243^{+0.036}_{-0.026}$	[3] ABREU	95X	DLPH	E^{ee}_{cm}= 88–94 GeV
0.243±0.022	[4] ADRIANI	93	L3	E^{ee}_{cm}= 91.2 GeV

NODE=S044R22;LINKAGE=AB

[1] ABBIENDI 04E select photons with energy > 7 GeV and use Γ(hadrons) = 1744.4 ± 2.0 MeV and α_s = 0.1172 ± 0.002 to obtain Γ_d = 381 ± 12 MeV.

NODE=S044R22;LINKAGE=D

[2] ACKERSTAFF 97T measure $\Gamma_{d\overline{d},s\overline{s}}/(\Gamma_{d\overline{d}}+\Gamma_{u\overline{u}}+\Gamma_{s\overline{s}})$ = 0.371 ± 0.016 ± 0.016. To obtain this branching ratio authors use R_c+R_b = 0.380 ± 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.

NODE=S044R22;LINKAGE=C

[3] ABREU 95X use M_Z = 91.187 ± 0.009 GeV, Γ(hadrons) = 1725 ± 12 MeV and α_s = 0.123 ± 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 ± 0.05.

NODE=S044R22;LINKAGE=B

[4] 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_{11}/Γ_8

NODE=S044R29

NODE=S044R29

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

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

NODE=S044R29

VALUE	DOCUMENT ID		TECN	COMMENT
0.1721±0.0030 OUR FIT				
0.1744±0.0031±0.0021	[1] ABE	05F	SLD	E^{ee}_{cm}=91.28 GeV
0.1665±0.0051±0.0081	[2] ABREU	00	DLPH	E^{ee}_{cm}= 88–94 GeV
0.1698±0.0069	[3] BARATE	00B	ALEP	E^{ee}_{cm}= 88–94 GeV
0.180 ±0.011 ±0.013	[4] ACKERSTAFF	98E	OPAL	E^{ee}_{cm}= 88–94 GeV
0.167 ±0.011 ±0.012	[5] ALEXANDER	96R	OPAL	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.1623±0.0085±0.0209	[6] ABREU	95D	DLPH	E^{ee}_{cm}= 88–94 GeV

NODE=S044R29;LINKAGE=AB

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

NODE=S044R29;LINKAGE=Z

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

NODE=S044R29;LINKAGE=T

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

NODE=S044R29;LINKAGE=H

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

NODE=S044R29;LINKAGE=G

[5] 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.

[6] 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. NODE=S044R29;LINKAGE=AR

$R_b = \Gamma(b\overline{b})/\Gamma(\text{hadrons})$ Γ_{12}/Γ_8

NODE=S044R18

OUR FIT is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the note "The Z boson" and ref. LEP-SLC 06. NODE=S044R18

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

NODE=S044R18

VALUE	DOCUMENT ID		TECN	COMMENT
0.21629±0.00066 OUR FIT				
0.21594±0.00094±0.00075	[1] ABE	05F	SLD	E^{ee}_{cm}=91.28 GeV
0.2174 ±0.0015 ±0.0028	[2] ACCIARRI	00	L3	E^{ee}_{cm}= 89–93 GeV
0.2178 ±0.0011 ±0.0013	[3] ABBIENDI	99B	OPAL	E^{ee}_{cm}= 88–94 GeV
0.21634±0.00067±0.00060	[4] ABREU	99B	DLPH	E^{ee}_{cm}= 88–94 GeV
0.2159 ±0.0009 ±0.0011	[5] BARATE	97F	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.2145 ±0.0089 ±0.0067	[6] ABREU	95D	DLPH	E^{ee}_{cm}= 88–94 GeV
0.219 ±0.006 ±0.005	[7] BUSKULIC	94G	ALEP	E^{ee}_{cm}= 88–94 GeV
0.251 ±0.049 ±0.030	[8] JACOBSEN	91	MRK2	E^{ee}_{cm}= 91 GeV

OCCUR=2

[1] ABE 05F use hadronic Z decays collected during 1996–98 to obtain an enriched sample of $b\overline{b}$ events using a double tag method. The single b–tag is obtained with a neural network trained to perform flavor discrimination using as input several signatures (corrected secondary vertex mass, vertex decay length, multiplicity and total momentum of the hemisphere; the key tag is obtained requiring the secondary vertex corrected mass to be above the D–meson mass). ABE 05F obtain R_b =0.21604 $\pm$ 0.00098 $\pm$ 0.00074 where the systematic error includes an uncertainty of $\pm$0.00012 due to the uncertainty on R_c. The value reported here is obtained properly combining with ABE 98D. The quoted systematic error includes an uncertainty of $\pm$0.00012 due to the uncertainty on R_c. NODE=S044R18;LINKAGE=AB

[2] ACCIARRI 00 obtain this result using a double-tagging technique, with a high p_T lepton tag and an impact parameter tag in opposite hemispheres. NODE=S044R18;LINKAGE=Z

[3] ABBIENDI 99B tag $Z \rightarrow b\overline{b}$ decays using leptons and/or separated decay vertices. The b-tagging efficiency is measured directly from the data using a double-tagging technique. NODE=S044R18;LINKAGE=IB

[4] 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). NODE=S044R18;LINKAGE=I

[5] BARATE 97F combine the lifetime-mass hemisphere tag (BARATE 97E) with event shape information and lepton tag to identify $Z \rightarrow b\overline{b}$ 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 $-0.019\times(R_c - 0.172)$. NODE=S044R18;LINKAGE=W

[6] 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. NODE=S044R18;LINKAGE=AR

[7] BUSKULIC 94G perform a simultaneous fit to the p and p_T spectra of both single and dilepton events. NODE=S044R18;LINKAGE=BB

[8] JACOBSEN 91 tagged $b\overline{b}$ events by requiring coincidence of $\geq$ 3 tracks with significant impact parameters using vertex detector. Systematic error includes lifetime and decay uncertainties ($\pm$0.014). NODE=S044R18;LINKAGE=B

$\Gamma(b\overline{b}b\overline{b})/\Gamma(\text{hadrons})$ Γ_{13}/Γ_8

NODE=S044B4
NODE=S044B4

VALUE (units 10^{-4})	DOCUMENT ID		TECN	COMMENT
5.2±1.9 OUR AVERAGE				
3.6±1.7±2.7	[1] ABBIENDI	01G	OPAL	E^{ee}_{cm}= 88–94 GeV
6.0±1.9±1.4	[2] ABREU	99U	DLPH	E^{ee}_{cm}= 88–94 GeV

[1] ABBIENDI 01G use a sample of four-jet events from hadronic Z decays. To enhance the $b\overline{b}b\overline{b}$ signal, at least three of the four jets are required to have a significantly detached secondary vertex. NODE=S044B4;LINKAGE=B

[2] ABREU 99U force hadronic Z decays into 3 jets to use all the available phase space and require a b tag for every jet. This decay mode includes primary and secondary 4b production, *e.g*, from gluon splitting to $b\overline{b}$. NODE=S044B4;LINKAGE=A

$\Gamma(ggg)/\Gamma(\text{hadrons})$ Γ_{14}/Γ_8

NODE=S044R63
NODE=S044R63

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<1.6 × 10^{-2}	95	[1] ABREU	96S	DLPH	E^{ee}_{cm}= 88–94 GeV

[1] 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}. NODE=S044R63;LINKAGE=A

$\Gamma(\pi^0\gamma)/\Gamma_{total}$ — Γ_{15}/Γ

NODE=S044R13
NODE=S044R13

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<2.01 × 10^{-5}	95	AALTONEN	14E	CDF	$E^{p\overline{p}}_{cm}$ = 1.96 TeV
<5.2 × 10^{-5}	95	[1] ACCIARRI	95G	L3	E^{ee}_{cm} = 88–94 GeV
<5.5 × 10^{-5}	95	ABREU	94B	DLPH	E^{ee}_{cm} = 88–94 GeV
<2.1 × 10^{-4}	95	DECAMP	92	ALEP	E^{ee}_{cm} = 88–94 GeV
<1.4 × 10^{-4}	95	AKRAWY	91F	OPAL	E^{ee}_{cm} = 88–94 GeV

[1] This limit is for both decay modes $Z \to \pi^0\gamma/\gamma\gamma$ which are indistinguishable in ACCIARRI 95G. NODE=S044R13;LINKAGE=C

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

NODE=S044R14
NODE=S044R14

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<7.6 × 10^{-5}	95	ACCIARRI	95G	L3	E^{ee}_{cm} = 88–94 GeV
<8.0 × 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 × 10^{-4}	95	AKRAWY	91F	OPAL	E^{ee}_{cm} = 88–94 GeV

$\Gamma(\rho^0\gamma)/\Gamma_{total}$ — Γ_{17}/Γ

NODE=S044R00
NODE=S044R00

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<4.0 × 10^{-6}	95	12.5k	[1] AABOUD	18AU	ATLS	E^{pp}_{cm} = 13 TeV

[1] AABOUD 18AU search for the $Z \to \rho\gamma$ decay mode where the ρ is identified through its decay $\rho \to \pi^+\pi^-$. In the data corresponding to 32.3 fb^{-1}, 12,583 events are selected for 635 < m($\pi^+\pi^-$) < 915 MeV. See erratum AABOUD 23A. NODE=S044R00;LINKAGE=A

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

NODE=S044R48
NODE=S044R48

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<3.9 × 10^{-6}	95	AAD	23BS	ATLS	E^{pp}_{cm} = 13 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<6.5 × 10^{-4}	95	ABREU	94B	DLPH	E^{ee}_{cm} = 88–94 GeV

$\Gamma(\eta'(958)\gamma)/\Gamma_{total}$ — Γ_{19}/Γ

NODE=S044R15
NODE=S044R15

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

$\Gamma(\phi\gamma)/\Gamma_{total}$ — Γ_{20}/Γ

NODE=S044R04
NODE=S044R04

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<7 × 10^{-7}	95	3.3k	[1] AABOUD	18AU	ATLS	E^{pp}_{cm} = 13 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •						
<8.3 × 10^{-6}	95	1.0k	[2] AABOUD	16K	ATLS	E^{pp}_{cm} = 13 TeV

[1] AABOUD 18AU search for the $Z \to \phi\gamma$ decay mode where the ϕ is identified through its decay $\phi \to K^+K^-$. In the data corresponding to 32.3 fb^{-1}, 3,364 events are selected for 1012 < m(K^+K^-) < 1028 MeV. See erratum AABOUD 23A. NODE=S044R04;LINKAGE=B

[2] AABOUD 16K search for the $Z \to \phi\gamma$ decay mode where the ϕ is identified through its decay into K^+K^-. In the data corresponding to a total luminosity of 2.7 fb^{-1}, 1065 events are selected and their $K^+K^-\gamma$ invariant mass spectrum is analyzed. NODE=S044R04;LINKAGE=A

$\Gamma(\gamma\gamma)/\Gamma_{total}$ — Γ_{21}/Γ

NODE=S044R16

This decay would violate the Landau-Yang theorem.

NODE=S044R16
NODE=S044R16

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<1.46 × 10^{-5}	95	AALTONEN	14E	CDF	$E^{p\overline{p}}_{cm}$ = 1.96 TeV
<5.2 × 10^{-5}	95	[1] ACCIARRI	95G	L3	E^{ee}_{cm} = 88–94 GeV
<5.5 × 10^{-5}	95	ABREU	94B	DLPH	E^{ee}_{cm} = 88–94 GeV
<1.4 × 10^{-4}	95	AKRAWY	91F	OPAL	E^{ee}_{cm} = 88–94 GeV

[1] This limit is for both decay modes $Z \to \pi^0\gamma/\gamma\gamma$ which are indistinguishable in ACCIARRI 95G. NODE=S044R16;LINKAGE=C

$\Gamma(\pi^0\pi^0)/\Gamma_{total}$ — Γ_{22}/Γ

NODE=S044R02
NODE=S044R02

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<1.52 × 10^{-5}	95	AALTONEN	14E	CDF	$E^{p\overline{p}}_{cm}$ = 1.96 TeV

$\Gamma(\gamma\gamma\gamma)/\Gamma_{\text{total}}$ Γ_{23}/Γ

NODE=S044R17
NODE=S044R17

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<2.2\times10^{-6}$	95	AAD	16L	ATLS	$E^{pp}_{\rm cm}$ = 8 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<1.0\times10^{-5}$	95	[1] ACCIARRI	95C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
$<1.7\times10^{-5}$	95	[1] ABREU	94B	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
$<6.6\times10^{-5}$	95	AKRAWY	91F	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV

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

NODE=S044R17;LINKAGE=AB

$\Gamma(\pi^{\pm}W^{\mp})/\Gamma_{\text{total}}$ Γ_{24}/Γ

NODE=S044R32

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

NODE=S044R32
NODE=S044R32

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<7\times10^{-5}$	95	DECAMP	92	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

$\Gamma(\rho^{\pm}W^{\mp})/\Gamma_{\text{total}}$ Γ_{25}/Γ

NODE=S044R33

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

NODE=S044R33
NODE=S044R33

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<8.3\times10^{-5}$	95	DECAMP	92	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

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

NODE=S044R23
NODE=S044R23

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
$3.51^{+0.23}_{-0.25}$ OUR AVERAGE Error includes scale factor of 1.1.					
$3.21\pm0.21^{+0.19}_{-0.28}$	553	[1] ACCIARRI	99F	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
$3.9\ \pm0.2\ \pm0.3$	511	[2] ALEXANDER	96B	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
$3.73\pm0.39\pm0.36$	153	[3] ABREU	94P	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV

[1] ACCIARRI 99F combine $\mu^+\mu^-$ and e^+e^- $J/\psi(1S)$ decay channels. The branching ratio for prompt $J/\psi(1S)$ production is measured to be $(2.1\pm0.6\pm0.4^{+0.4}_{-0.2}(\text{theor.}))\times10^{-4}$.

NODE=S044R23;LINKAGE=F

[2] 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).

NODE=S044R23;LINKAGE=D

[3] 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.

NODE=S044R23;LINKAGE=C

$\Gamma(J/\psi(1S)\gamma)/\Gamma_{\text{total}}$ Γ_{27}/Γ

NODE=S044R03
NODE=S044R03

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<6\ \times10^{-7}$ (CL = 95%) [$<1.2\times10^{-6}$ (CL = 95%) OUR 2025 BEST LIMIT]					
$<0.6\times10^{-6}$	95	HAYRAPETY...	25H	CMS	$E^{pp}_{\rm cm}$ = 13 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<1.2\times10^{-6}$	95	AAD	23CD	ATLS	$E^{pp}_{\rm cm}$ = 13 TeV
$<1.4\times10^{-6}$	95	[1] SIRUNYAN	19AJ	CMS	$E^{pp}_{\rm cm}$ = 13 TeV
$<2.3\times10^{-6}$	95	[2] AABOUD	18BL	ATLS	$E^{pp}_{\rm cm}$ = 13 TeV
$<2.6\times10^{-6}$	95	[3] AAD	15I	ATLS	$E^{pp}_{\rm cm}$ = 8 TeV

[1] SIRUNYAN 19AJ study $Z\rightarrow\ J/\psi\gamma$ with $J/\psi\rightarrow\ \mu^+\mu^-$. Candidate events are selected by requiring a pair of oppositely charged muons and a well isolated photon. The leading (subleading) muon is require to have a transverse momentum larger than 20 GeV (4 GeV), while the photon must have a transverse energy larger than 33 GeV. Requiring the invariant mass of the $\mu\mu$ ($\mu\mu\gamma$) system in the range 3.0 to 3.2 (81 to 101) GeV, selects 183 data events which is consistent with the expected background. The 95% C.L. limit on the Z branching fraction is obtained assuming the J/ψ to be unpolarized.

NODE=S044R03;LINKAGE=D

[2] AABOUD 18BL study $Z\rightarrow\ J/\psi\gamma$ in 13 TeV pp interactions. Two triggers were used: isolated photon of $p_T\ >35(25)$ GeV and a muon with $p_T\ >18(24)$ GeV. The J/ψ is detected via its dimuon decay and it is required that the azimuthal angle between the photon and the J/ψ in the plane transverse to the beam direction is $>\ \pi/2$. The number of observed/expected background events is $92/89\pm6$ in the dimuon mass range 2.9–3.3 GeV leading to the quoted 95% C.L. limit.

NODE=S044R03;LINKAGE=C

[3] AAD 15I use events with the highest p_T muon in the pair required to have $p_T\ >20$ GeV, the dimuon mass required to be within 0.2 GeV of the $J/\psi(1S)$ mass and it's transverse momentum required to be >36 GeV. The photon is also required to have it's $p_T\ >36$ GeV.

NODE=S044R03;LINKAGE=A

$\Gamma(\psi(2S)X)/\Gamma_{total}$ Γ_{28}/Γ

NODE=S044R60

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
1.60±0.29 OUR AVERAGE					
1.6 ±0.5 ±0.3	39	[1] ACCIARRI	97J	L3	E^{ee}_{cm}= 88–94 GeV
1.6 ±0.3 ±0.2	46.9	[2] ALEXANDER	96B	OPAL	E^{ee}_{cm}= 88–94 GeV
1.60±0.73±0.33	5.4	[3] ABREU	94P	DLPH	E^{ee}_{cm}= 88–94 GeV

[1] ACCIARRI 97J measure this branching ratio via the decay channel $\psi(2S) \to \ell^+\ell^-$ ($\ell = \mu$, e). NODE=S044R60;LINKAGE=C

[2] ALEXANDER 96B measure this branching ratio via the decay channel $\psi(2S) \to J/\psi\pi^+\pi^-$, with $J/\psi \to \ell^+\ell^-$. NODE=S044R60;LINKAGE=BB

[3] ABREU 94P measure this branching ratio via decay channel $\psi(2S) \to J/\psi\pi^+\pi^-$, with $J/\psi \to \mu^+\mu^-$. NODE=S044R60;LINKAGE=A

$\Gamma(\psi(2S)\gamma)/\Gamma_{total}$ Γ_{29}/Γ

NODE=S044R05

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<1.3 × 10⁻⁶ (CL = 95%) [<2.4 × 10⁻⁶ (CL = 95%) OUR 2025 BEST LIMIT]					
$<1.3 \times 10^{-6}$	95	HAYRAPETY...25H		CMS	E^{pp}_{cm} = 13 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<2.4 \times 10^{-6}$	95	AAD	23CD	ATLS	E^{pp}_{cm} = 13 TeV
$<4.5 \times 10^{-6}$	95	[1] AABOUD	18BL	ATLS	E^{pp}_{cm} = 13 TeV

[1] AABOUD 18BL study $Z \to \psi(2S)\gamma$ in 13 TeV pp interactions. Two triggers were used: isolated photon of $p_T > 35(25)$ GeV and a muon with $p_T > 18(24)$ GeV. The $\psi(2S)$ is detected via its dimuon decay and it is required that the azimuthal angle between the photon and the $\psi(2S)$ in the plane transverse to the beam direction is $> \pi/2$. The number of observed/expected background events is $43/42 \pm 5$ in the dimuon mass range 3.5–3.9 GeV leading to the quoted 95% C.L. limit. NODE=S044R05;LINKAGE=B

$\Gamma(J/\psi(1S)\ell^+\ell^-)/\Gamma(\mu^+\mu^-\mu^+\mu^-)$ Γ_{30}/Γ_5

NODE=S044R09

VALUE	DOCUMENT ID		TECN	COMMENT
0.67±0.18±0.05	[1] SIRUNYAN	18DZ	CMS	pp at 13 TeV

[1] SIRUNYAN 18DZ observe the decay $Z \to \Psi\ell^+\ell^-$ in pp collisions at $\sqrt{s}$ = 13 TeV, where Ψ includes J/ψ as well as $\psi(2S) \to J/\psi X$, and $\ell^+\ell^-$ represents an electron or muon pair while the J/ψ is detected via its $\mu^+\mu^-$ decay channel. To reduce systematic errors they determine the ratio of the branching fraction of this decay to that of $Z \to \mu^+\mu^-\mu^+\mu^-$ within phase-space cuts imposed on lepton transverse momentum and pseudo rapidity, dilepton invariant mass, and J/ψ transverse momentum. The number of selected $\Psi\mu^+\mu^-$ (Ψe^+e^-) candidate events is 29 (18). Analyzing the $\mu^+\mu^-$ and $\mu^+\mu^-\ell^+\ell^-$ invariant mass distributions, a yield of 13.0 ± 3.9 (11.2 ± 3.4) events for the $\Psi\mu^+\mu^-$ (Ψe^+e^-) mode is obtained. The ratio of the branching fractions is determined as 0.67 ± 0.18 ± 0.05 within the selected phase-space cuts. Assuming extrapolation to full phase space cancels in the ratio, and using their measured value of B($Z \to \mu^+\mu^-\mu^+\mu^-$) = (1.20 ± 0.08) × 10^{-6}, they estimate B($Z \to J/\psi\ell^+\ell^-$) = 8 × 10^{-7}. NODE=S044R09;LINKAGE=A

$\Gamma(J/\psi(1S)J/\psi(1S))/\Gamma_{total}$ Γ_{31}/Γ

NODE=S044R38

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
$<2.2 \times 10^{-6}$	95	189	[1] SIRUNYAN	19BR	CMS	E^{pp}_{cm} = 13 TeV

[1] SIRUNYAN 19BR search for Z decays to a pair of J/ψ mesons in the channel $J/\psi \to \mu^+\mu^-$. The invariant masses of the higher/lower-p_T J/ψ candidates have to be within 0.1/0.15 GeV of the nominal J/ψ mass. A total of 189 events are selected in the 40–140 GeV 4-muon invariant mass range. An un-binned extended maximum likelihood fit leads to the 95% C.L. upper limit, obtained assuming the J/ψ mesons to be unpolarised. NODE=S044R38;LINKAGE=A

$\Gamma(\chi_{c1}(1P)X)/\Gamma_{total}$ Γ_{32}/Γ

NODE=S044R42

VALUE (units 10^{-3})	EVTS	DOCUMENT ID		TECN	COMMENT
2.9±0.7 OUR AVERAGE					
2.7±0.6±0.5	33	[1] ACCIARRI	97J	L3	E^{ee}_{cm}= 88–94 GeV
$5.0\pm2.1^{+1.5}_{-0.9}$	6.4	[2] ABREU	94P	DLPH	E^{ee}_{cm}= 88–94 GeV

[1] 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}. NODE=S044R42;LINKAGE=C

[2] This branching ratio is measured via the decay channel $\chi_{c1} \to J/\psi + \gamma$, with $J/\psi \to \mu^+\mu^-$. NODE=S044R42;LINKAGE=A

$\Gamma(\chi_{c2}(1P)X)/\Gamma_{total}$ Γ_{33}/Γ

NODE=S044R65

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<3.2 × 10^{-3}	90	[1] ACCIARRI	97J	L3	E^{ee}_{cm} = 88–94 GeV

[1] ACCIARRI 97J derive this limit via the decay channel $\chi_{c2} \rightarrow J/\psi + \gamma$, with $J/\psi \rightarrow \ell^+\ell^-$ ($\ell = \mu$, e). The $M(\ell^+\ell^-\gamma)$–$M(\ell^+\ell^-)$ mass difference spectrum is fitted with two gaussian shapes for χ_{c1} and χ_{c2}. NODE=S044R65;LINKAGE=A

$\Gamma(\Upsilon(1S)X+\Upsilon(2S)X+\Upsilon(3S)X)/\Gamma_{total}$ $\Gamma_{34}/\Gamma=(\Gamma_{35}+\Gamma_{37}+\Gamma_{39})/\Gamma$

NODE=S044R62

VALUE (units 10^{-4})	EVTS	DOCUMENT ID		TECN	COMMENT
1.0±0.4±0.22	6.4	[1] ALEXANDER	96F	OPAL	E^{ee}_{cm} = 88–94 GeV

[1] 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. NODE=S044R62;LINKAGE=A

$\Gamma(\Upsilon(1S)X)/\Gamma_{total}$ Γ_{35}/Γ

NODE=S044R66

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<4.4 × 10^{-5}	95	[1] ACCIARRI	99F	L3	E^{ee}_{cm} = 88–94 GeV

[1] ACCIARRI 99F search for $\Upsilon(1S)$ through its decay into $\ell^+\ell^-$ ($\ell = e$ or μ). NODE=S044R66;LINKAGE=B

$\Gamma(\Upsilon(1S)\gamma)/\Gamma_{total}$ Γ_{36}/Γ

NODE=S044R06

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<1.1 × 10^{-6}	95	AAD	23CD	ATLS	E^{pp}_{cm} = 13 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<2.8 × 10^{-6}	95	[1] AABOUD	18BL	ATLS	E^{pp}_{cm} = 13 TeV
<3.4 × 10^{-6}	95	[2] AAD	15I	ATLS	E^{pp}_{cm} = 8 TeV

[1] AABOUD 18BL study $Z \rightarrow \Upsilon(1S)\gamma$ in 13 TeV pp interactions. Two triggers were used: isolated photon of $p_T > 35(25)$ GeV and a muon with $p_T > 18(24)$ GeV. The $\Upsilon(1S)$ is detected via its dimuon decay and it is required that the azimuthal angle between the photon and the $\Upsilon(1S)$ in the plane transverse to the beam direction is $> \pi/2$. The number of observed/expected background events is 115/126 ± 8 in the dimuon mass range 9.0–10.0 GeV leading to the quoted 95% C.L. limit. NODE=S044R06;LINKAGE=A

[2] AAD 15I use events with the highest p_T muon in the pair required to have $p_T > 20$ GeV, the dimuon mass required to be in the range 8–12 GeV and it's transverse momentum required to be > 36 GeV. The photon is also required to have it's $p_T > 36$ GeV. NODE=S044R06;LINKAGE=B

$\Gamma(\Upsilon(2S)X)/\Gamma_{total}$ Γ_{37}/Γ

NODE=S044R67

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<13.9 × 10^{-5}	95	[1] ACCIARRI	97R	L3	E^{ee}_{cm} = 88–94 GeV

[1] ACCIARRI 97R search for $\Upsilon(2S)$ through its decay into $\ell^+\ell^-$ ($\ell = e$ or μ). NODE=S044R67;LINKAGE=A

$\Gamma(\Upsilon(2S)\gamma)/\Gamma_{total}$ Γ_{38}/Γ

NODE=S044R07

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<1.3 × 10^{-6}	95	AAD	23CD	ATLS	E^{pp}_{cm} = 13 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
<1.7 × 10^{-6}	95	[1] AABOUD	18BL	ATLS	E^{pp}_{cm} = 13 TeV
<6.5 × 10^{-6}	95	[2] AAD	15I	ATLS	E^{pp}_{cm} = 8 TeV

[1] AABOUD 18BL study $Z \rightarrow \Upsilon(2S)\gamma$ in 13 TeV pp interactions. Two triggers were used: isolated photon of $p_T > 35(25)$ GeV and a muon with $p_T > 18(24)$ GeV. The $\Upsilon(2S)$ is detected via its dimuon decay and it is required that the azimuthal angle between the photon and the $\Upsilon(2S)$ in the plane transverse to the beam direction is $> \pi/2$. The number of observed/expected background events is 106/121 ± 8 in the dimuon mass range 9.5–10.5 GeV leading to the quoted 95% C.L. limit. NODE=S044R07;LINKAGE=A

[2] AAD 15I use events with the highest p_T muon in the pair required to have $p_T > 20$ GeV, the dimuon mass required to be in the range 8–12 GeV and it's transverse momentum required to be > 36 GeV. The photon is also required to have it's $p_T > 36$ GeV. NODE=S044R07;LINKAGE=B

$\Gamma(\Upsilon(3S)X)/\Gamma_{total}$ Γ_{39}/Γ

NODE=S044R68

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<9.4 × 10^{-5}	95	[1] ACCIARRI	97R	L3	E^{ee}_{cm} = 88–94 GeV

[1] ACCIARRI 97R search for $\Upsilon(3S)$ through its decay into $\ell^+\ell^-$ ($\ell = e$ or μ). NODE=S044R68;LINKAGE=A

$\Gamma(\Upsilon(3S)\gamma)/\Gamma_{total}$ Γ_{40}/Γ

NODE=S044R08
NODE=S044R08

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<2.4 × 10^−6	95	AAD	23CD	ATLS	E^{pp}_{cm} = 13 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$<4.8 \times 10^{-6}$	95	[1] AABOUD	18BL	ATLS	E^{pp}_{cm} = 13 TeV
$<5.4 \times 10^{-6}$	95	[2] AAD	15I	ATLS	E^{pp}_{cm} = 8 TeV

[1] AABOUD 18BL study $Z \to \Upsilon(3S)\gamma$ in 13 TeV pp interactions. Two triggers were used: isolated photon of $p_T > 35(25)$ GeV and a muon with $p_T > 18(24)$ GeV. The $\Upsilon(3S)$ is detected via its dimuon decay and it is required that the azimuthal angle between the photon and the $\Upsilon(3S)$ in the plane transverse to the beam direction is $> \pi/2$. The number of observed/expected background events is 112/113 ± 8 in the dimuon mass range 10.0–11.0 GeV leading to the quoted 95% C.L. limit. NODE=S044R08;LINKAGE=A

[2] AAD 15I use events with the highest p_T muon in the pair required to have $p_T > 20$ GeV, the dimuon mass required to be in the range 8–12 GeV and it's transverse momentum required to be > 36 GeV. The photon is also required to have it's $p_T > 36$ GeV. NODE=S044R08;LINKAGE=B

$\Gamma(\Upsilon(1,2,3S)\,\Upsilon(1,2,3S))/\Gamma_{total}$ Γ_{41}/Γ

NODE=S044R39
NODE=S044R39

VALUE	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
<1.5 × 10^−6	95	106	[1] SIRUNYAN	19BR	CMS	E^{pp}_{cm} = 13 TeV

[1] SIRUNYAN 19BR search for Z decays to a pair of Υ mesons in the channel $\Upsilon \to \mu^+\mu^-$. The invariant mass of the Υ candidates has to be in the range of 8.5 to 11 GeV. A total of 106 events are selected in the 20–140 GeV 4-muon invariant mass range. An un-binned extended maximum likelihood fit leads to the 95% C.L. upper limit, obtained assuming the Υ mesons to be unpolarised. NODE=S044R39;LINKAGE=A

$\Gamma(K^0_S\gamma)/\Gamma_{total}$ Γ_{42}/Γ

NODE=S044R73
NODE=S044R73

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<3.1 × 10^−6	95	[1] AAD	24R	ATLS	E^{pp}_{cm} = 13 TeV

[1] AAD 24R identify the K^0_S via its decay to $\pi^+\pi^-$. The transverse momentum of the photon is required to be larger than 25 GeV or 35 GeV for different periods of data taking. NODE=S044R73;LINKAGE=A

$\Gamma(D^0\gamma)/\Gamma_{total}$ Γ_{43}/Γ

NODE=S044R72
NODE=S044R72

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<4.0 × 10^−6	95	[1] AAD	24R	ATLS	E^{pp}_{cm} = 13 TeV

[1] AAD 24R identify the D^0 via its decay to $K^-\pi^+$. The transverse momentum of the photon is required to be larger than 25 GeV or 35 GeV for different periods of data taking. NODE=S044R72;LINKAGE=A

$\Gamma(D^0\gamma)/\Gamma(\mu^+\mu^-)$ Γ_{43}/Γ_2

NODE=S044R64
NODE=S044R64

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<6.4 × 10^−2	95	[1] AAIJ	23AM	LHCB	E^{pp}_{cm} = 13 TeV

[1] AAIJ 23AM also quotes the branching fraction limit $B(Z \to D^0\gamma) < 2.1 \times 10^{-3}$, using the known $Z \to \mu\mu$ branching fraction. NODE=S044R64;LINKAGE=A

$\Gamma((D^0/\overline{D}^0)\,X)/\Gamma(\text{hadrons})$ Γ_{44}/Γ_8

NODE=S044R43
NODE=S044R43

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.296±0.019±0.021	369	[1] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV

[1] 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). NODE=S044R43;LINKAGE=A

$\Gamma(D^\pm X)/\Gamma(\text{hadrons})$ Γ_{45}/Γ_8

NODE=S044R44
NODE=S044R44

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.174±0.016±0.018	539	[1] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV

[1] 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). NODE=S044R44;LINKAGE=A

$\Gamma(D^*(2010)^\pm X)/\Gamma(\text{hadrons})$ Γ_{46}/Γ_8

NODE=S044R24

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

NODE=S044R24
NODE=S044R24

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	[1] ABREU	93I	DLPH	E^{ee}_{cm}= 88–94 GeV
0.21 ±0.04	362	[2] DECAMP	91J	ALEP	E^{ee}_{cm}= 88–94 GeV

[1] $D^*(2010)^{\pm}$ 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). NODE=S044R24;LINKAGE=B

[2] 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)%. NODE=S044R24;LINKAGE=A

$\Gamma(D_{s1}(2536)^{\pm}X)/\Gamma(\text{hadrons})$ Γ_{47}/Γ_8

NODE=S044R70

$D_{s1}(2536)^{\pm}$ is an expected orbitally-excited state of the D_s meson. NODE=S044R70

NODE=S044R70

VALUE (%)	EVTS	DOCUMENT ID		TECN	COMMENT
0.52±0.09±0.06	92	[1] HEISTER	02B	ALEP	E^{ee}_{cm} = 88–94 GeV

[1] HEISTER 02B reconstruct this meson in the decay modes $D_{s1}(2536)^{\pm} \to D^{*\pm}K^0$ and $D_{s1}(2536)^{\pm} \to D^{*0}K^{\pm}$. The quoted branching ratio assumes that the decay width of the $D_{s1}(2536)$ is saturated by the two measured decay modes. NODE=S044R70;LINKAGE=A

$\Gamma(D_{sJ}(2573)^{\pm}X)/\Gamma(\text{hadrons})$ Γ_{48}/Γ_8

NODE=S044R71

$D_{sJ}(2573)^{\pm}$ is an expected orbitally-excited state of the D_s meson. NODE=S044R71

NODE=S044R71

VALUE (%)	EVTS	DOCUMENT ID		TECN	COMMENT
$0.83\pm0.29^{+0.07}_{-0.13}$	64	[1] HEISTER	02B	ALEP	E^{ee}_{cm} = 88–94 GeV

[1] HEISTER 02B reconstruct this meson in the decay mode $D^*_{s2}(2573)^{\pm} \to D^0K^{\pm}$. The quoted branching ratio assumes that the detected decay mode represents 45% of the full decay width. NODE=S044R71;LINKAGE=A

$\Gamma(D^{*\prime}(2629)^{\pm}X)/\Gamma(\text{hadrons})$ Γ_{49}/Γ_8

NODE=S044R69

$D^{*\prime}(2629)^{\pm}$ is a predicted radial excitation of the $D^*(2010)^{\pm}$ meson. NODE=S044R69

NODE=S044R69

VALUE	DOCUMENT ID		TECN	COMMENT
searched for	[1] ABBIENDI	01N	OPAL	E^{ee}_{cm} = 88–94 GeV

[1] ABBIENDI 01N searched for the decay mode $D^{*\prime}(2629)^{\pm} \to D^{*\pm}\pi^+\pi^-$ with $D^{*+} \to D^0\pi^+$, and $D^0 \to K^-\pi^+$. They quote a 95% CL limit for $Z \to D^{*\prime}(2629)^{\pm} \times$ B($D^{*\prime}(2629)^+ \to D^{*+}\pi^+\pi^-$) < 3.1 × 10^{-3}. NODE=S044R69;LINKAGE=A

$\Gamma(B^*X)/[\Gamma(BX)+\Gamma(B^*X)]$ $\Gamma_{51}/(\Gamma_{50}+\Gamma_{51})$

NODE=S044R61

As the experiments assume different values of the b-baryon contribution, our average should be taken with caution. NODE=S044R61

NODE=S044R61

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.75 ±0.04 OUR AVERAGE					
0.760±0.036±0.083		[1] ACKERSTAFF	97M	OPAL	E^{ee}_{cm} = 88–94 GeV
0.771±0.026±0.070		[2] BUSKULIC	96D	ALEP	E^{ee}_{cm} = 88–94 GeV
0.72 ±0.03 ±0.06		[3] ABREU	95R	DLPH	E^{ee}_{cm} = 88–94 GeV
0.76 ±0.08 ±0.06	1378	[4] ACCIARRI	95B	L3	E^{ee}_{cm} = 88–94 GeV

[1] 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. NODE=S044R61;LINKAGE=D

[2] 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. NODE=S044R61;LINKAGE=C

[3] 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. NODE=S044R61;LINKAGE=B

[4] 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. NODE=S044R61;LINKAGE=A

$\Gamma(B^+X)/\Gamma(\text{hadrons})$ Γ_{52}/Γ_8

NODE=S044B+X

"OUR EVALUATION" is obtained using our current values for f($\overline{b} \to B^+$) and R_b = $\Gamma(b\overline{b})/\Gamma(\text{hadrons})$. We calculate $\Gamma(B^+X)/\Gamma(\text{hadrons})$ = R_b × f($\overline{b} \to B^+$). NODE=S044B+X

NODE=S044B+X

VALUE	DOCUMENT ID		TECN	COMMENT
0.0869±0.0019 OUR EVALUATION	(Produced by HFLAV)			
0.0887±0.0030	[1] ABDALLAH	03K	DLPH	E^{ee}_{cm} = 88–94 GeV

→ UNCHECKED ←

[1] ABDALLAH 03K measure the production fraction of B^+ mesons in hadronic Z decays f(B^+) = (40.99 ± 0.82 ± 1.11)%. The value quoted here is obtained multiplying this production fraction by our value of $R_b = \Gamma(\overline{b}b)/\Gamma(\text{hadrons})$. NODE=S044B+X;LINKAGE=AB

$\Gamma(B_s^0 X)/\Gamma(\text{hadrons})$ Γ_{53}/Γ_8

NODE=S044R49

"OUR EVALUATION" is obtained using our current values for $f(\overline{b} \to B_s^0)$ and $R_b = \Gamma(b\overline{b})/\Gamma(\text{hadrons})$. We calculate $\Gamma(B_s^0)/\Gamma(\text{hadrons}) = R_b \times f(\overline{b} \to B_s^0)$.

NODE=S044R49

VALUE	DOCUMENT ID		TECN	COMMENT
0.0227±0.0019 OUR EVALUATION	(Produced by HFLAV)			
seen	[1] ABREU	92M	DLPH	$E_{\rm cm}^{ee}$= 88–94 GeV
seen	[2] ACTON	92N	OPAL	$E_{\rm cm}^{ee}$= 88–94 GeV
seen	[3] BUSKULIC	92E	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV

NODE=S044R49
→ UNCHECKED ←

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

NODE=S044R49;LINKAGE=A

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

NODE=S044R49;LINKAGE=C

[3] 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 $B(\overline{b} \to B_s^0) \times B(B_s^0 \to D_s^- \ell^+ \nu_\ell X) = 0.040 \pm 0.011 {}^{+0.010}_{-0.012}$.

NODE=S044R49;LINKAGE=B

$\Gamma(B_c^+ X)/\Gamma(\text{hadrons})$ Γ_{54}/Γ_8

NODE=S044BCC
NODE=S044BCC

VALUE	DOCUMENT ID		TECN	COMMENT
searched for	[1] ACKERSTAFF	98O	OPAL	$E_{\rm cm}^{ee}$= 88–94 GeV
searched for	[2] ABREU	97E	DLPH	$E_{\rm cm}^{ee}$= 88–94 GeV
searched for	[3] BARATE	97H	ALEP	$E_{\rm cm}^{ee}$= 88–94 GeV

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

NODE=S044BCC;LINKAGE=A

[2] 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.

NODE=S044BCC;LINKAGE=B

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

NODE=S044BCC;LINKAGE=C

$\Gamma(\Lambda_c^+ X)/\Gamma(\text{hadrons})$ Γ_{55}/Γ_8

NODE=S044LCX
NODE=S044LCX

VALUE	DOCUMENT ID		TECN	COMMENT
0.022±0.005 OUR AVERAGE				
0.024±0.005±0.006	[1] ALEXANDER	96R	OPAL	$E_{\rm cm}^{ee}$ = 88–94 GeV
0.021±0.003±0.005	[2] BUSKULIC	96Y	ALEP	$E_{\rm cm}^{ee}$ = 88–94 GeV

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

NODE=S044LCX;LINKAGE=AL

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

NODE=S044LCX;LINKAGE=BU

$\Gamma(\Xi_c^0 X)/\Gamma(\text{hadrons})$ Γ_{56}/Γ_8

NODE=S044XIC
NODE=S044XIC

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	[1] ABDALLAH	05C	DLPH	E_{cm}^{ee} = 88–94 GeV

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

NODE=S044XIC;LINKAGE=AB

$\Gamma(\Xi_b X)/\Gamma(\text{hadrons})$ Γ_{57}/Γ_8

NODE=S044XIB

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

NODE=S044XIB
NODE=S044XIB

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
seen	[1] ABDALLAH	05C	DLPH	E_{cm}^{ee} = 88–94 GeV
seen	[2] BUSKULIC	96T	ALEP	E_{cm}^{ee} = 88–94 GeV
seen	[3] ABREU	95V	DLPH	E_{cm}^{ee} = 88–94 GeV

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

NODE=S044XIB;LINKAGE=AB

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

NODE=S044XIB;LINKAGE=BU

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

NODE=S044XIB;LINKAGE=AR

$\Gamma(b\text{-baryon } X)/\Gamma(\text{hadrons})$ Γ_{58}/Γ_8

NODE=S044BBR

"OUR EVALUATION" is obtained using our current values for f($b \to b$-baryon) and R_b = $\Gamma(b\overline{b})/\Gamma$(hadrons). We calculate Γ(b-baryon X)/Γ(hadrons) = R_b × f($b \to b$-baryon).

NODE=S044BBR

VALUE	DOCUMENT ID		TECN	COMMENT
0.0197±0.0032 OUR EVALUATION	(Produced by HFLAV)			
0.0221±0.0015±0.0058	[1] BARATE	98V	ALEP	E_{cm}^{ee}= 88–94 GeV

NODE=S044BBR
→ UNCHECKED ←

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

NODE=S044BBR;LINKAGE=BA

$\Gamma(\text{anomalous } \gamma + \text{hadrons})/\Gamma_{\text{total}}$ Γ_{59}/Γ

NODE=S044R31

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

NODE=S044R31

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<3.2 × 10^{-3}	95	[1] AKRAWY	90J	OPAL	E_{cm}^{ee}= 88–94 GeV

NODE=S044R31

[1] 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(γ) > 10 GeV.

NODE=S044R31;LINKAGE=A

$\Gamma(e^+ e^- \gamma)/\Gamma_{\text{total}}$ Γ_{60}/Γ

NODE=S044R34
NODE=S044R34

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<5.2 × 10^{-4}	95	[1] ACTON	91B	OPAL	E_{cm}^{ee}= 91.2 GeV

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

NODE=S044R34;LINKAGE=A

$\Gamma(\mu^+ \mu^- \gamma)/\Gamma_{\text{total}}$ Γ_{61}/Γ

NODE=S044R35
NODE=S044R35

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
<5.6 × 10^{-4}	95	[1] ACTON	91B	OPAL	E_{cm}^{ee}= 91.2 GeV

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

NODE=S044R35;LINKAGE=A

$\Gamma(\tau^+\tau^-\gamma)/\Gamma_{total}$ Γ_{62}/Γ

NODE=S044R36
NODE=S044R36

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<7.3 × 10^{-4}	95	[1] ACTON 91B	OPAL	E^{ee}_{cm}= 91.2 GeV

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

NODE=S044R36;LINKAGE=A

$\Gamma(\ell^+\ell^-\gamma\gamma)/\Gamma_{total}$ Γ_{63}/Γ

NODE=S044R45

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

NODE=S044R45
NODE=S044R45

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<6.8 × 10^{-6}	95	[1] ACTON 93E	OPAL	E^{ee}_{cm}= 88–94 GeV

[1] For $m_{\gamma\gamma}$ = 60 ± 5 GeV.

NODE=S044R45;LINKAGE=A

$\Gamma(q\overline{q}\gamma\gamma)/\Gamma_{total}$ Γ_{64}/Γ

NODE=S044R46
NODE=S044R46

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<5.5 × 10^{-6}	95	[1] ACTON 93E	OPAL	E^{ee}_{cm}= 88–94 GeV

[1] For $m_{\gamma\gamma}$ = 60 ± 5 GeV.

NODE=S044R46;LINKAGE=A

$\Gamma(\nu\overline{\nu}\gamma\gamma)/\Gamma_{total}$ Γ_{65}/Γ

NODE=S044R47
NODE=S044R47

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<3.1 × 10^{-6}	95	[1] ACTON 93E	OPAL	E^{ee}_{cm}= 88–94 GeV

[1] For $m_{\gamma\gamma}$ = 60 ± 5 GeV.

NODE=S044R47;LINKAGE=A

$\Gamma(e^\pm\mu^\mp)/\Gamma_{total}$ Γ_{66}/Γ

NODE=S044R27

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

NODE=S044R27
NODE=S044R27

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<1.9 × 10^{-7} (CL = 95%) [<2.62 × 10^{-7} (CL = 95%) OUR 2025 BEST LIMIT]				
<1.9 × 10^{-7}	95	HAYRAPETY...25AK	CMS	E^{pp}_{cm} = 13 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<2.62 × 10^{-7}	95	AAD 23AQ	ATLS	E^{pp}_{cm} = 13 TeV
<7.5 × 10^{-7}	95	AAD 14AU	ATLS	E^{pp}_{cm} = 8 TeV
<2.5 × 10^{-6}	95	ABREU 97C	DLPH	E^{ee}_{cm}= 88–94 GeV
<1.7 × 10^{-6}	95	AKERS 95W	OPAL	E^{ee}_{cm}= 88–94 GeV
<0.6 × 10^{-5}	95	ADRIANI 93I	L3	E^{ee}_{cm}= 88–94 GeV
<2.6 × 10^{-5}	95	DECAMP 92	ALEP	E^{ee}_{cm}= 88–94 GeV

$\Gamma(e^\pm\mu^\mp)/\Gamma(e^+e^-)$ Γ_{66}/Γ_1

NODE=S044R6

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

NODE=S044R6
NODE=S044R6

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

$\Gamma(e^\pm\tau^\mp)/\Gamma_{total}$ Γ_{67}/Γ

NODE=S044R25

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

NODE=S044R25
NODE=S044R25

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
< 5.0 × 10^{-6}	95	AAD 21AV	ATLS	E^{pp}_{cm} = 13 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
<13.8 × 10^{-6}	95	HAYRAPETY...25AK	CMS	E^{pp}_{cm} = 13 TeV
< 8.1 × 10^{-6}	95	AAD 21AO	ATLS	E^{pp}_{cm} = 13 TeV
< 5.8 × 10^{-5}	95	AABOUD 18CN	ATLS	E^{pp}_{cm} = 13 TeV
< 2.2 × 10^{-5}	95	ABREU 97C	DLPH	E^{ee}_{cm}= 88–94 GeV
< 9.8 × 10^{-6}	95	AKERS 95W	OPAL	E^{ee}_{cm}= 88–94 GeV
< 1.3 × 10^{-5}	95	ADRIANI 93I	L3	E^{ee}_{cm}= 88–94 GeV
< 1.2 × 10^{-4}	95	DECAMP 92	ALEP	E^{ee}_{cm}= 88–94 GeV

$\Gamma(\mu^\pm\tau^\mp)/\Gamma_{total}$ Γ_{68}/Γ

NODE=S044R26

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

NODE=S044R26
NODE=S044R26

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
< 6.5 × 10^{-6}	95	AAD 21AV	ATLS	E^{pp}_{cm} = 13 TeV

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

$<12.0 \times 10^{-6}$	95	HAYRAPETY...	25AK	CMS	E^{pp}_{cm} = 13 TeV
$< 9.5 \times 10^{-6}$	95	AAD	21AO	ATLS	E^{pp}_{cm} = 13 TeV
$< 1.3 \times 10^{-5}$	95	AABOUD	18CN	ATLS	E^{pp}_{cm} = 8, 13 TeV
$< 1.2 \times 10^{-5}$	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

$\Gamma(p e)/\Gamma_{total}$ Γ_{69}/Γ NODE=S044PE

Test of baryon number and lepton number conservations. Charge conjugate states are implied. NODE=S044PE

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<1.8 \times 10^{-6}$	95	[1] ABBIENDI	99I	OPAL	E^{ee}_{cm}= 88–94 GeV

NODE=S044PE

[1] ABBIENDI 99I give the 95%CL limit on the partial width $\Gamma(Z^0 \rightarrow p e) <$ 4.6 KeV and we have transformed it into a branching ratio. NODE=S044PE;LINKAGE=A

$\Gamma(p \mu)/\Gamma_{total}$ Γ_{70}/Γ NODE=S044PMU

Test of baryon number and lepton number conservations. Charge conjugate states are implied. NODE=S044PMU

VALUE	CL%	DOCUMENT ID		TECN	COMMENT
$<1.8 \times 10^{-6}$	95	[1] ABBIENDI	99I	OPAL	E^{ee}_{cm}= 88–94 GeV

NODE=S044PMU

[1] ABBIENDI 99I give the 95%CL limit on the partial width $\Gamma(Z^0 \rightarrow p\mu) <$ 4.4 KeV and we have transformed it into a branching ratio. NODE=S044PMU;LINKAGE=A

AVERAGE PARTICLE MULTIPLICITIES IN HADRONIC Z DECAY NODE=S044260

Summed over particle and antiparticle, when appropriate. NODE=S044260

$\langle N_\gamma \rangle$ NODE=S044GAM

NODE=S044GAM

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

$\langle N_{\pi^\pm} \rangle$ NODE=S044PIC

NODE=S044PIC

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

$\langle N_{\pi^0} \rangle$ NODE=S044PIZ

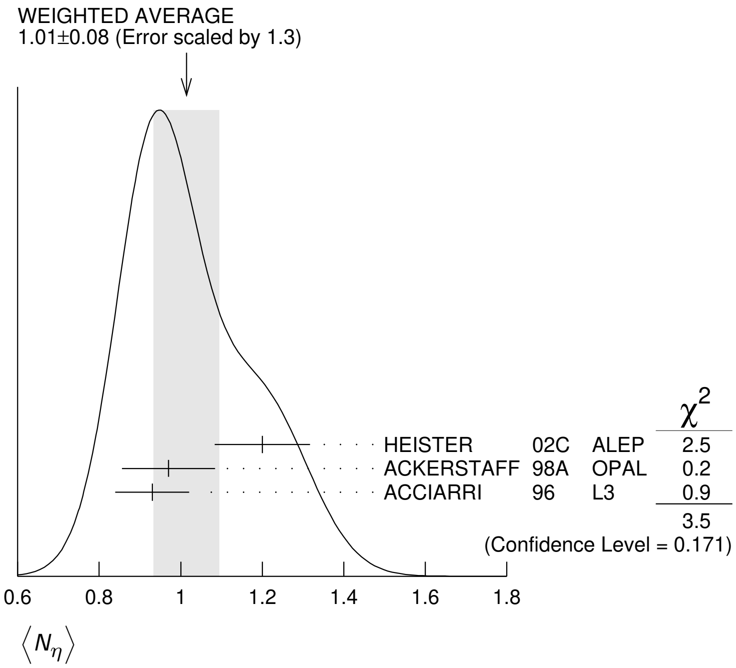
NODE=S044PIZ

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

$\langle N_\eta \rangle$ NODE=S044ETA

NODE=S044ETA

VALUE	DOCUMENT ID		TECN	COMMENT
1.01±0.08 OUR AVERAGE Error includes scale factor of 1.3. See the ideogram below.				
1.20±0.04±0.11	HEISTER	02C	ALEP	E^{ee}_{cm}= 91.2 GeV
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



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

NODE=S044RHC
NODE=S044RHC

VALUE	DOCUMENT ID		TECN	COMMENT
2.57±0.15 OUR AVERAGE				
2.59±0.03±0.16	[1] BEDDALL	09		ALEPH archive, $E^{ee}_{\rm cm}$= 91.2 GeV
2.40±0.06±0.43	ACKERSTAFF	98A	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

[1] BEDDALL 09 analyse 3.2 million hadronic Z decays as archived by ALEPH collaboration and report a value of 2.59 ± 0.03 ± 0.15 ± 0.04. The first error is statistical, the second systematic, and the third arises from extrapolation to full phase space. We combine the systematic errors in quadrature. NODE=S044RHC;LINKAGE=BE

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

NODE=S044RHZ
NODE=S044RHZ

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

$\langle N_{\omega} \rangle$

NODE=S044OME
NODE=S044OME

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

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

NODE=S044ETP
NODE=S044ETP

VALUE	DOCUMENT ID		TECN	COMMENT
0.17 ±0.05 OUR AVERAGE Error includes scale factor of 2.4.				
0.14 ±0.01 ±0.02	ACKERSTAFF	98A	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV
0.25 ±0.04	[1] ACCIARRI	97D	L3	$E^{ee}_{\rm cm}$= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.068±0.018±0.016	[2] BUSKULIC	92D	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV

[1] ACCIARRI 97D obtain this value averaging over the two decay channels $\eta' \rightarrow \pi^+\pi^-\eta$ and $\eta' \rightarrow \rho^0\gamma$. NODE=S044ETP;LINKAGE=B

[2] BUSKULIC 92D obtain this value for $x>$ 0.1. NODE=S044ETP;LINKAGE=A

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

NODE=S044FZ
NODE=S044FZ

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

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

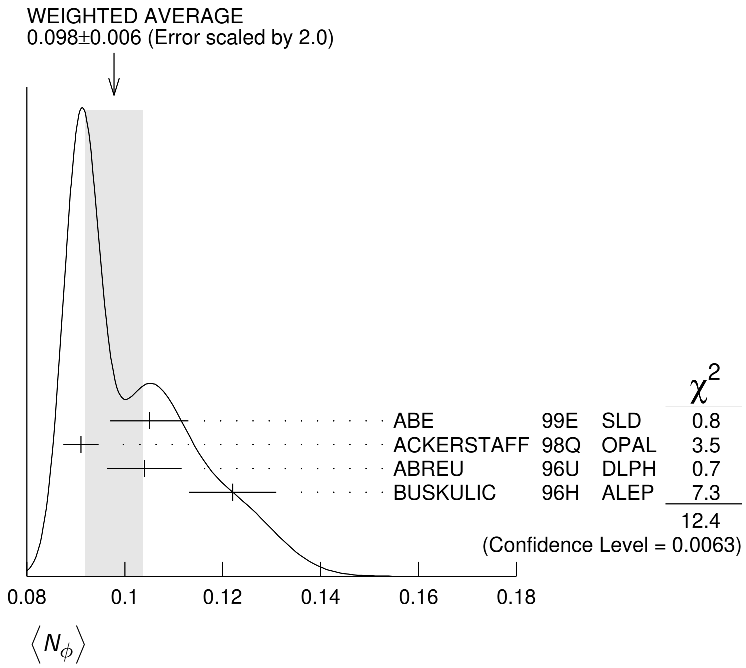
NODE=S044AZC
NODE=S044AZC

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

$\langle N_\phi \rangle$

NODE=S044PHI
NODE=S044PHI

VALUE	DOCUMENT ID		TECN	COMMENT
0.098±0.006 OUR AVERAGE	Error includes scale factor of 2.0. See the ideogram below.			
0.105±0.008	ABE	99E	SLD	E^{ee}_{cm}= 91.2 GeV
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



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

NODE=S044F2
NODE=S044F2

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

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

NODE=S044F85
NODE=S044F85

VALUE	DOCUMENT ID		TECN	COMMENT
0.165±0.051	[1] ABDALLAH	03H	DLPH	E^{ee}_{cm}= 91.2 GeV

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

NODE=S044F85;LINKAGE=A

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

NODE=S044F20
NODE=S044F20

VALUE	DOCUMENT ID		TECN	COMMENT
0.056±0.012	[1] ABDALLAH	03H	DLPH	E^{ee}_{cm}= 91.2 GeV

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

NODE=S044F20;LINKAGE=A

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

NODE=S044F2P
NODE=S044F2P

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

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

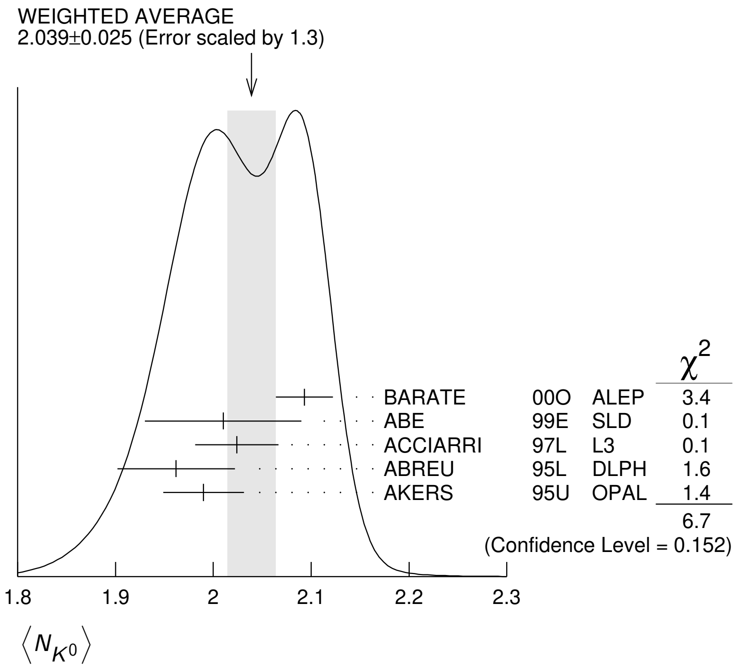
NODE=S044KC
NODE=S044KC

VALUE	DOCUMENT ID		TECN	COMMENT
2.24 ±0.04 OUR AVERAGE				
2.203±0.071	ABE	04C	SLD	E^{ee}_{cm}= 91.2 GeV
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

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

NODE=S044KZ

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



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

NODE=S044KSC

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

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

NODE=S044KSZ

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

$\langle N_{K_2^*(1430)} \rangle$

NODE=S044KS2

VALUE	DOCUMENT ID		TECN	COMMENT
0.073±0.023	ABREU	99J	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.19 ±0.04 ±0.06	[1] AKERS	95X	OPAL	$E^{ee}_{\rm cm}$= 91.2 GeV

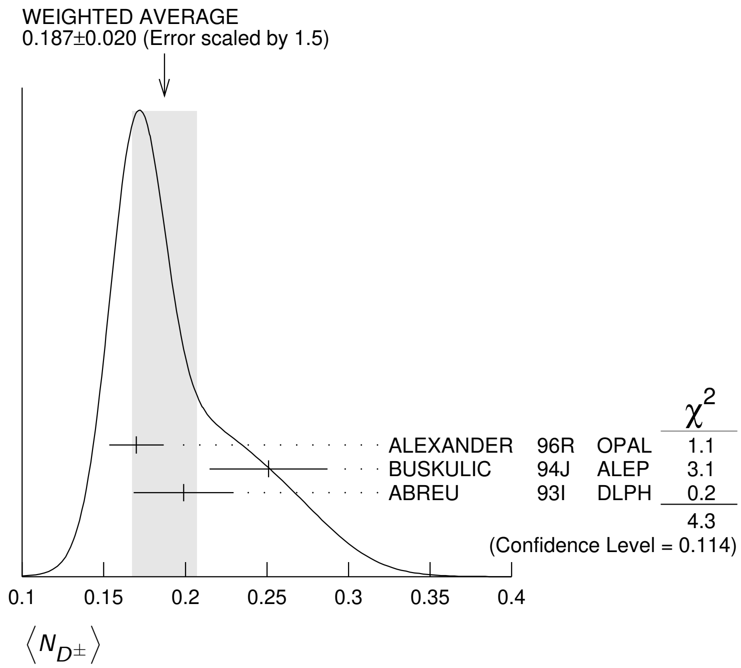
[1] AKERS 95X obtain this value for $x <$ 0.3. NODE=S044KS2;LINKAGE=A

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

NODE=S044DC

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	$E^{ee}_{\rm cm}$= 91.2 GeV
0.251±0.026±0.025	BUSKULIC	94J	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV
0.199±0.019±0.024	[1] ABREU	93I	DLPH	$E^{ee}_{\rm cm}$= 91.2 GeV

[1] See ABREU 95 (erratum). NODE=S044DC;LINKAGE=A



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

NODE=S044DZ
NODE=S044DZ

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

[1] See ABREU 95 (erratum). NODE=S044DZ;LINKAGE=A

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

NODE=S044DSP
NODE=S044DSP

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.131±0.010±0.018	ALEXANDER	96R	OPAL	E^{ee}_{cm}= 91.2 GeV

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

NODE=S044DSC
NODE=S044DSC

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.183 ±0.008 OUR AVERAGE				
0.1854±0.0041±0.0091	[1] 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	[2] ABREU	93I	DLPH	E^{ee}_{cm}= 91.2 GeV

[1] ACKERSTAFF 98E systematic error includes an uncertainty of ±0.0069 due to the branching ratios B($D^{*+} \to D^0 \pi^+$) = 0.683±0.014 and B($D^0 \to K^- \pi^+$) = 0.0383±0.0012. NODE=S044DSC;LINKAGE=B

[2] See ABREU 95 (erratum). NODE=S044DSC;LINKAGE=A

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

NODE=S044DS1
NODE=S044DS1

VALUE (units 10^{-3})	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$2.9^{+0.7}_{-0.6}\pm0.2$	[1] ACKERSTAFF	97W	OPAL	E^{ee}_{cm}= 91.2 GeV

[1] 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. NODE=S044DS1;LINKAGE=A

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

NODE=S044BS
NODE=S044BS

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
0.28±0.01±0.03	[1] ABREU	95R	DLPH	E^{ee}_{cm}= 91.2 GeV

[1] ABREU 95R quote this value for a flavor-averaged excited state. NODE=S044BS;LINKAGE=A

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

NODE=S044JPS

VALUE	DOCUMENT ID		TECN	COMMENT
0.0056±0.0003±0.0004	[1] ALEXANDER	96B	OPAL	E^{ee}_{cm}= 91.2 GeV

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

NODE=S044JPS;LINKAGE=B

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

NODE=S044P2S

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

$\langle N_p \rangle$

NODE=S044PRO

VALUE	DOCUMENT ID		TECN	COMMENT
1.046±0.026 OUR AVERAGE				
1.054±0.035	ABE	04C	SLD	E^{ee}_{cm}= 91.2 GeV
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

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

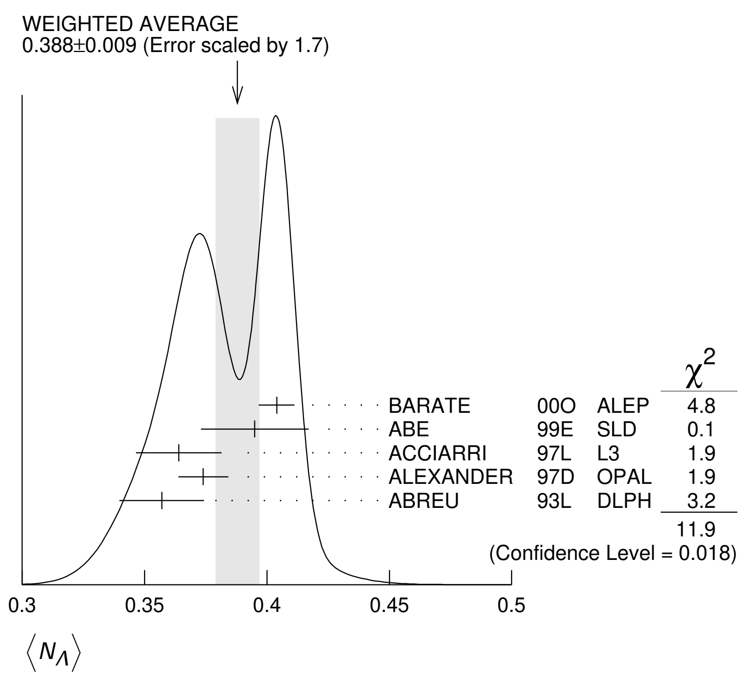
NODE=S044D12

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

$\langle N_{\Lambda} \rangle$

NODE=S044LAM

VALUE	DOCUMENT ID		TECN	COMMENT
0.388±0.009 OUR AVERAGE	Error includes scale factor of 1.7. See the ideogram below.			
0.404±0.002±0.007	BARATE	00O	ALEP	E^{ee}_{cm}= 91.2 GeV
0.395±0.022	ABE	99E	SLD	E^{ee}_{cm}= 91.2 GeV
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
0.357±0.003±0.017	ABREU	93L	DLPH	E^{ee}_{cm}= 91.2 GeV



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

NODE=S044L15

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

$\langle N_{\Sigma^+} \rangle$ NODE=S044SI+

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

$\langle N_{\Sigma^-} \rangle$ NODE=S044SI-

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

$\langle N_{\Sigma^+ + \Sigma^-} \rangle$ NODE=S044SIC

VALUE	DOCUMENT ID		TECN	COMMENT
0.181±0.018 OUR AVERAGE				
0.182±0.010±0.016	[1] ALEXANDER	97E	OPAL	E^{ee}_{cm}= 91.2 GeV
0.170±0.014±0.061	ABREU	95O	DLPH	E^{ee}_{cm}= 91.2 GeV

[1] 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. NODE=S044SIC;LINKAGE=A

$\langle N_{\Sigma^0} \rangle$ NODE=S044SIZ

VALUE	DOCUMENT ID		TECN	COMMENT
0.076±0.010 OUR AVERAGE				
0.095±0.015±0.013	ACCIARRI	00J	L3	E^{ee}_{cm}= 91.2 GeV
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

$\langle N_{(\Sigma^+ + \Sigma^- + \Sigma^0)/3} \rangle$ NODE=S044SIG

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

$\langle N_{\Sigma(1385)^+} \rangle$ NODE=S04413+

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

$\langle N_{\Sigma(1385)^-} \rangle$ NODE=S04413-

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

$\langle N_{\Sigma(1385)^+ + \Sigma(1385)^-} \rangle$ NODE=S044S13

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

$\langle N_{\Xi^-} \rangle$ NODE=S044XI-

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

$\langle N_{\Xi(1530)^0} \rangle$ NODE=S044X15

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

$\langle N_{\Omega^-} \rangle$ NODE=S044OM-

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

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

NODE=S044L+C
NODE=S044L+C

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

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

NODE=S044DBR
NODE=S044DBR

VALUE (units 10^{-6})	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
5.9±1.8±0.5	[1] SCHAEL	06A	ALEP	E^{ee}_{cm} = 91.2 GeV

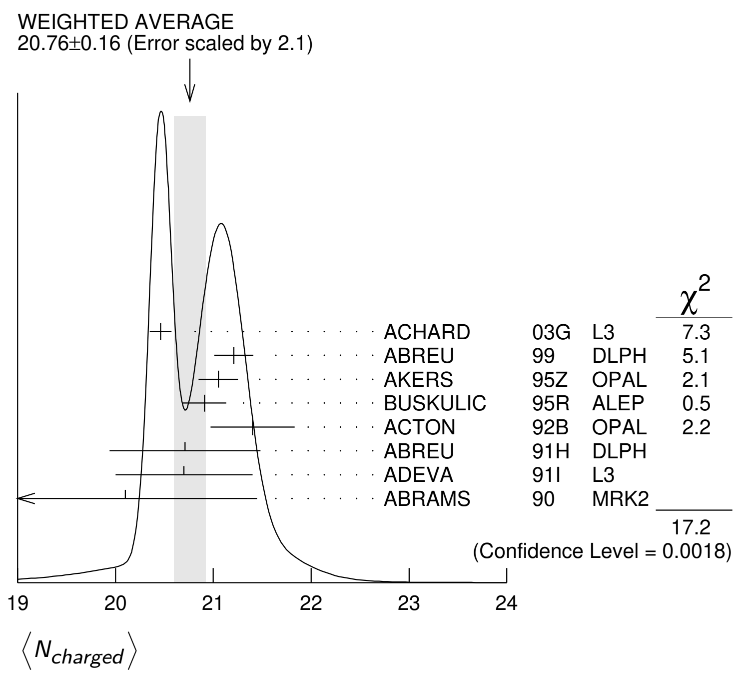
[1] SCHAEL 06A obtain this anti-deuteron production rate per hadronic Z decay in the anti-deuteron momentum range from 0.62 to 1.03 GeV/c.

NODE=S044DBR;LINKAGE=SC

$\langle N_{charged} \rangle$

NODE=S044CHG
NODE=S044CHG

VALUE	DOCUMENT ID		TECN	COMMENT
20.76±0.16 OUR AVERAGE	Error includes scale factor of 2.1. See the ideogram below.			
20.46±0.01±0.11	ACHARD	03G	L3	E^{ee}_{cm}= 91.2 GeV
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



Z HADRONIC POLE CROSS SECTION

NODE=S044SH

OUR EVALUATION is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the note "The Z boson" and ref. LEP-SLC 06). Corrections as discussed in VOUTSINAS 20 and JANOT 20 are also included. This quantity is defined as

NODE=S044SH

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

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

NODE=S044SH

→ UNCHECKED ←

VALUE (nb)	EVTS	DOCUMENT ID		TECN	COMMENT
41.4802±0.0325 OUR EVALUATION					
41.4802±0.0325		[1] JANOT	20		

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

41.500 ±0.037		[2] VOUTSINAS	20		
41.541 ±0.037		[3] LEP-SLC	06		E^{ee}_{cm} = 88–94 GeV
41.501 ±0.055	4.10M	[4] ABBIENDI	01A	OPAL	E^{ee}_{cm}= 88–94 GeV
41.578 ±0.069	3.70M	ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
41.535 ±0.055	3.54M	ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
41.559 ±0.058	4.07M	[5] BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
42 ±4	450	ABRAMS	89B	MRK2	E^{ee}_{cm}= 89.2–93.0 GeV

[1] JANOT 20 applies a correction to LEP-SLC 06 using an updated Bhabha cross section calculation. This result also includes a correction to account for correlated luminosity bias as presented in VOUTSINAS 20. NODE=S044SH;LINKAGE=C

[2] VOUTSINAS 20 applies a correction to LEP-SLC 06 to account for correlated luminosity bias. NODE=S044SH;LINKAGE=B

[3] This result combines ABBIENDI 01A, ABREU 00F, ACCIARRI 00C, BARATE 00C, taking correlated uncertainties into account. NODE=S044SH;LINKAGE=D

[4] ABBIENDI 01A error includes approximately 0.031 due to statistics, 0.033 due to event selection systematics, 0.029 due to uncertainty in luminosity measurement, and 0.011 due to LEP energy uncertainty. NODE=S044SH;LINKAGE=DB

[5] BARATE 00C error includes approximately 0.030 due to statistics, 0.026 due to experimental systematics, and 0.025 due to uncertainty in luminosity measurement. NODE=S044SH;LINKAGE=AC

Z VECTOR COUPLINGS

NODE=S044223

These quantities are the effective vector couplings of the Z to charged leptons and quarks. Their magnitude is derived from a measurement of the Z lineshape and the forward-backward lepton asymmetries as a function of energy around the Z mass. The relative sign among the vector to axial-vector couplings is obtained from a measurement of the Z asymmetry parameters, A_e, A_μ, and A_τ. By convention the sign of g^e_A is fixed to be negative (and opposite to that of g^{ν_e} obtained using ν_e scattering measurements). For the light quarks, the sign of the couplings is assigned consistently with this assumption. The LEP/SLD-based fit values quoted below correspond to global nine- or five-parameter fits to lineshape, lepton forward-backward asymmetry, and A_e, A_μ, and A_τ measurements. See the note "The Z boson" and ref. LEP-SLC 06 for details. Where $p\overline{p}$ and $e p$ data is quoted, OUR FIT value corresponds to a weighted average of this with the LEP/SLD fit result. NODE=S044223

g^e_V

NODE=S044GEV
NODE=S044GEV

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.03817±0.00047 OUR FIT					
−0.058 ±0.016 ±0.007	5026	[1] ACOSTA	05M	CDF	$E^{p\overline{p}}_{cm}$= 1.96 TeV
−0.0346 ±0.0023	137.0k	[2] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
−0.0412 ±0.0027	124.4k	[3] ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
−0.0400 ±0.0037		BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
−0.0414 ±0.0020		[4] ABE	95J	SLD	E^{ee}_{cm}= 91.31 GeV

[1] ACOSTA 05M determine the forward–backward asymmetry of $e^+ e^-$ pairs produced via $q\overline{q} \to Z/\gamma^* \to e^+ e^-$ in 15 M($e^+ e^-$) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial–vector couplings of the Z to $e^+ e^-$, assuming the quark couplings are as predicted by the standard model. Higher order radiative corrections have not been taken into account. NODE=S044GEV;LINKAGE=AC

[2] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries. NODE=S044GEV;LINKAGE=OA

[3] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries. NODE=S044GEV;LINKAGE=Z

[4] 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. NODE=S044GEV;LINKAGE=KG

g^μ_V

NODE=S044GMV
NODE=S044GMV

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.0367±0.0023 OUR FIT					
$-0.0388^{+0.0060}_{-0.0064}$	182.8k	[1] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
−0.0386±0.0073	113.4k	[2] ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
−0.0362±0.0061		BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.0413±0.0060	66143	[3] ABBIENDI	01K	OPAL	E^{ee}_{cm}= 89–93 GeV

[1] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries. NODE=S044GMV;LINKAGE=OA
[2] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries. NODE=S044GMV;LINKAGE=Z
[3] ABBIENDI 01K obtain this from an angular analysis of the muon pair asymmetry which takes into account effects of initial state radiation on an event by event basis and of initial-final state interference. NODE=S044GMV;LINKAGE=GM

g_V^{τ}

NODE=S044GTV
NODE=S044GTV

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.0366±0.0010 OUR FIT					
−0.0365±0.0023	151.5k	[1] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
−0.0384±0.0026	103.0k	[2] ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
−0.0361±0.0068		BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV

[1] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries. NODE=S044GTV;LINKAGE=OA
[2] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries. NODE=S044GTV;LINKAGE=Z

g_V^{ℓ}

NODE=S044GLV
NODE=S044GLV

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.03783±0.00041 OUR FIT					
−0.0358 ±0.0014	471.3k	[1] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
−0.0397 ±0.0020	379.4k	[2] ABREU	00F	DLPH	E^{ee}_{cm}= 88–94 GeV
−0.0397 ±0.0017	340.8k	[3] ACCIARRI	00C	L3	E^{ee}_{cm}= 88–94 GeV
−0.0383 ±0.0018	500k	BARATE	00C	ALEP	E^{ee}_{cm}= 88–94 GeV

[1] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries. NODE=S044GLV;LINKAGE=OA
[2] Using forward-backward lepton asymmetries. NODE=S044GLV;LINKAGE=B
[3] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries. NODE=S044GLV;LINKAGE=Z

g_V^{u}

NODE=S044GUV
NODE=S044GUV

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.266±0.034 OUR AVERAGE					
0.270±0.037		[1] ANDREEV	18A	H1	$e^{\pm}p$
0.201±0.112	156k	[2] ABAZOV	11D	D0	$E^{p\overline{p}}_{cm}$ = 1.97 TeV
0.24 $^{+0.28}_{-0.11}$		[3] LEP-SLC	06		E^{ee}_{cm} = 88–94 GeV
0.399$^{+0.152}_{-0.188}$±0.066	5026	[4] ACOSTA	05M	CDF	$E^{p\overline{p}}_{cm}$= 1.96 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.14 $^{+0.09}_{-0.09}$		[5] ABRAMOWICZ	16A	ZEUS	
0.144$^{+0.066}_{-0.058}$		[6] ABT	16		
0.27 ±0.13	1500	[7] AKTAS	06	H1	$e^{\pm}p \rightarrow \overline{\nu}_e(\nu_e)X$, $\sqrt{s}\approx$ 300 GeV

[1] ANDREEV 18A obtain this result in a combined electroweak and QCD analysis using all deep-inelastic $e^+ p$ and $e^- p$ neutral current and charged current scattering cross sections published by the H1 Collaboration, including data with longitudinally polarized lepton beams. NODE=S044GUV;LINKAGE=C
[2] ABAZOV 11D study $p\overline{p} \rightarrow Z/\gamma^* e^+ e^-$ events using 5 fb^{-1} data at $\sqrt{s}$ = 1.96 TeV. The candidate events are selected by requiring two isolated electromagnetic showers with $E_T >$ 25 GeV, at least one electron in the central region and the di-electron mass in the range 50–1000 GeV. From the forward-backward asymmetry, determined as a function of the di-electron mass, they derive the axial and vector couplings of the u- and d- quarks and the value of $\sin^2\theta^{\ell}_{eff}$ = 0.2309 ± 0.0008(stat)±0.0006(syst). NODE=S044GUV;LINKAGE=AB
[3] LEP-SLC 06 is a combination of the results from LEP and SLC experiments using light quark tagging. s- and d-quark couplings are assumed to be identical. NODE=S044GUV;LINKAGE=LS
[4] ACOSTA 05M determine the forward-backward asymmetry of $e^+ e^-$ pairs produced via $q\overline{q} \rightarrow Z/\gamma^* \rightarrow e^+ e^-$ in 15 M($e^+ e^-$) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial-vector couplings of the Z to the light quarks, assuming the electron couplings are as predicted by the Standard Model. Higher order radiative corrections have not been taken into account. NODE=S044GUV;LINKAGE=AC
[5] ABRAMOWICZ 16A determine the Z^0 couplings to u- and d-quarks using the ZEUS polarised data from Run II together with the unpolarised data from both ZEUS and H1 Collaborations for Run I and unpolarised H1 data from Run II. NODE=S044GUV;LINKAGE=B
[6] ABT 16 determine the Z^0 couplings to u- and d-quarks using the same techniques and data as ABRAMOWICZ 16A but additionally use the published H1 polarised data. NODE=S044GUV;LINKAGE=A
[7] AKTAS 06 fit the neutral current (1.5 ≤ Q^2 ≤ 30,000 GeV^2) and charged current (1.5 ≤ Q^2 ≤ 15,000 GeV^2) differential cross sections. In the determination of the u-quark couplings the electron and d-quark couplings are fixed to their standard model values. NODE=S044GUV;LINKAGE=AK

g_V^d

NODE=S044GDV
NODE=S044GDV

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$-0.38\ ^{+0.04}_{-0.05}$ OUR AVERAGE					
-0.488 ± 0.092		[1] ANDREEV	18A	H1	$e^{\pm}p$
-0.351 ± 0.251	156k	[2] ABAZOV	11D	D0	$E^{p\overline{p}}_{\rm cm} = 1.97$ TeV
$-0.33\ ^{+0.05}_{-0.07}$		[3] LEP-SLC	06		$E^{ee}_{\rm cm} = 88–94$ GeV
$-0.226^{+0.635}_{-0.290}\pm0.090$	5026	[4] ACOSTA	05M	CDF	$E^{p\overline{p}}_{\rm cm} = 1.96$ TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.41\ ^{+0.25}_{-0.20}$		[5] ABRAMOWICZ	16A	ZEUS	
$-0.503^{+0.171}_{-0.103}$		[6] ABT	16		
$-0.33\ \pm0.33$	1500	[7] AKTAS	06	H1	$e^{\pm}p \rightarrow \overline{\nu}_e(\nu_e)X$, $\sqrt{s} \approx 300$ GeV

[1] ANDREEV 18A obtain this result in a combined electroweak and QCD analysis using all deep-inelastic e^+p and e^-p neutral current and charged current scattering cross sections published by the H1 Collaboration, including data with longitudinally polarized lepton beams. NODE=S044GDV;LINKAGE=C

[2] ABAZOV 11D study $p\overline{p} \rightarrow Z/\gamma^* e^+e^-$ events using 5 fb^{-1} data at $\sqrt{s} = 1.96$ TeV. The candidate events are selected by requiring two isolated electromagnetic showers with $E_T > 25$ GeV, at least one electron in the central region and the di-electron mass in the range 50–1000 GeV. From the forward-backward asymmetry, determined as a function of the di-electron mass, they derive the axial and vector couplings of the u- and d- quarks and the value of $\sin^2\theta^{\ell}_{eff} = 0.2309 \pm 0.0008(\text{stat})\pm0.0006(\text{syst})$. NODE=S044GDV;LINKAGE=AB

[3] LEP-SLC 06 is a combination of the results from LEP and SLC experiments using light quark tagging. s- and d-quark couplings are assumed to be identical. NODE=S044GDV;LINKAGE=LS

[4] ACOSTA 05M determine the forward-backward asymmetry of e^+e^- pairs produced via $q\overline{q} \rightarrow Z/\gamma^* \rightarrow e^+e^-$ in 15 M(e^+e^-) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial-vector couplings of the Z to the light quarks, assuming the electron couplings are as predicted by the Standard Model. Higher order radiative corrections have not been taken into account. NODE=S044GDV;LINKAGE=AC

[5] ABRAMOWICZ 16A determine the Z^0 couplings to u- and d-quarks using the ZEUS polarised data from Run II together with the unpolarised data from both ZEUS and H1 Collaborations for Run I and unpolarised H1 data from Run II. NODE=S044GDV;LINKAGE=B

[6] ABT 16 determine the Z^0 couplings to u- and d-quarks using the same techniques and data as ABRAMOWICZ 16A but additionally use the published H1 polarised data. NODE=S044GDV;LINKAGE=A

[7] AKTAS 06 fit the neutral current ($1.5 \leq Q^2 \leq 30{,}000$ GeV^2) and charged current ($1.5 \leq Q^2 \leq 15{,}000$ GeV^2) differential cross sections. In the determination of the d-quark couplings the electron and u-quark couplings are fixed to their standard model values. NODE=S044GDV;LINKAGE=AK

Z AXIAL-VECTOR COUPLINGS

NODE=S044219

These quantities are the effective axial-vector couplings of the Z to charged leptons and quarks. Their magnitude is derived from a measurement of the Z lineshape and the forward-backward lepton asymmetries as a function of energy around the Z mass. The relative sign among the vector to axial-vector couplings is obtained from a measurement of the Z asymmetry parameters, A_e, A_μ, and A_τ. By convention the sign of g_A^e is fixed to be negative (and opposite to that of g^{ν_e} obtained using ν_e scattering measurements). For the light quarks, the sign of the couplings is assigned consistently with this assumption. The LEP/SLD-based fit values quoted below correspond to global nine- or five-parameter fits to lineshape, lepton forward-backward asymmetry, and A_e, A_μ, and A_τ measurements. See the note "The Z boson" and ref. LEP-SLC 06 for details. Where $p\overline{p}$ and ep data is quoted, OUR FIT value corresponds to a weighted average of this with the LEP/SLD fit result. NODE=S044219

g_A^e

NODE=S044GEA
NODE=S044GEA

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
-0.50111 ± 0.00035 OUR FIT					
$-0.528\ \ \pm0.123\ \ \pm0.059$	5026	[1] ACOSTA	05M	CDF	$E^{p\overline{p}}_{\rm cm} = 1.96$ TeV
-0.50062 ± 0.00062	137.0k	[2] ABBIENDI	01O	OPAL	$E^{ee}_{\rm cm} = 88–94$ GeV
$-0.5015\ \pm0.0007$	124.4k	[3] ACCIARRI	00C	L3	$E^{ee}_{\rm cm} = 88–94$ GeV
-0.50166 ± 0.00057		BARATE	00C	ALEP	$E^{ee}_{\rm cm} = 88–94$ GeV
$-0.4977\ \pm0.0045$		[4] ABE	95J	SLD	$E^{ee}_{\rm cm} = 91.31$ GeV

[1] ACOSTA 05M determine the forward–backward asymmetry of e^+e^- pairs produced via $q\overline{q} \rightarrow Z/\gamma^* \rightarrow e^+e^-$ in 15 M(e^+e^-) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial–vector couplings of the Z to e^+e^-, assuming the quark couplings are as predicted by the standard model. Higher order radiative corrections have not been taken into account. NODE=S044GEA;LINKAGE=AC

[2] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries. NODE=S044GEA;LINKAGE=OA

[3] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries. NODE=S044GEA;LINKAGE=Z

[4] ABE 95J obtain this result combining polarized Bhabha results with the A_{LR} measurement of ABE 94C. The Bhabha results alone give $-0.4968 \pm 0.0039 \pm 0.0027$. NODE=S044GEA;LINKAGE=KG

g^{μ}_{A}

NODE=S044GMA
NODE=S044GMA

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.50120±0.00054 OUR FIT					
−0.50117±0.00099	182.8k	[1] ABBIENDI	01O	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
−0.5009 ±0.0014	113.4k	[2] ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
−0.50046±0.00093		BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
−0.520 ±0.015	66143	[3] ABBIENDI	01K	OPAL	$E^{ee}_{\rm cm}$= 89–93 GeV

[1] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries. NODE=S044GMA;LINKAGE=OA

[2] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries. NODE=S044GMA;LINKAGE=Z

[3] ABBIENDI 01K obtain this from an angular analysis of the muon pair asymmetry which takes into account effects of initial state radiation on an event by event basis and of initial-final state interference. NODE=S044GMA;LINKAGE=GM

g^{τ}_{A}

NODE=S044GTA
NODE=S044GTA

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.50204±0.00064 OUR FIT					
−0.50165±0.00124	151.5k	[1] ABBIENDI	01O	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
−0.5023 ±0.0017	103.0k	[2] ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
−0.50216±0.00100		BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

[1] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries. NODE=S044GTA;LINKAGE=OA

[2] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries. NODE=S044GTA;LINKAGE=Z

g^{ℓ}_{A}

NODE=S044GLA
NODE=S044GLA

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
−0.50123±0.00026 OUR FIT					
−0.50089±0.00045	471.3k	[1] ABBIENDI	01O	OPAL	$E^{ee}_{\rm cm}$= 88–94 GeV
−0.5007 ±0.0005	379.4k	ABREU	00F	DLPH	$E^{ee}_{\rm cm}$= 88–94 GeV
−0.50153±0.00053	340.8k	[2] ACCIARRI	00C	L3	$E^{ee}_{\rm cm}$= 88–94 GeV
−0.50150±0.00046	500k	BARATE	00C	ALEP	$E^{ee}_{\rm cm}$= 88–94 GeV

[1] ABBIENDI 01O use their measurement of the τ polarization in addition to the lineshape and forward-backward lepton asymmetries. NODE=S044GLA;LINKAGE=OA

[2] ACCIARRI 00C use their measurement of the τ polarization in addition to forward-backward lepton asymmetries. NODE=S044GLA;LINKAGE=Z

g^{u}_{A}

NODE=S044GUA
NODE=S044GUA

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$0.519^{+0.028}_{-0.033}$ OUR AVERAGE					
0.548±0.036		[1] ANDREEV	18A	H1	$e^{\pm}p$
0.501±0.110	156k	[2] ABAZOV	11D	D0	$E^{p\overline{p}}_{\rm cm}$ = 1.97 TeV
$0.47\ ^{+0.05}_{-0.33}$		[3] LEP-SLC	06		$E^{ee}_{\rm cm}$ = 88–94 GeV
$0.441^{+0.207}_{-0.173}\pm0.067$	5026	[4] ACOSTA	05M	CDF	$E^{p\overline{p}}_{\rm cm}$= 1.96 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$0.50\ ^{+0.12}_{-0.05}$		[5] ABRAMOWICZ	16A	ZEUS	
$0.532^{+0.107}_{-0.063}$		[6] ABT	16		
0.57 ±0.08	1500	[7] AKTAS	06	H1	$e^{\pm}p \rightarrow \overline{\nu}_e(\nu_e)X$, $\sqrt{s} \approx 300$ GeV

[1] ANDREEV 18A obtain this result in a combined electroweak and QCD analysis using all deep-inelastic $e^+ p$ and $e^- p$ neutral current and charged current scattering cross sections published by the H1 Collaboration, including data with longitudinally polarized lepton beams. NODE=S044GUA;LINKAGE=C

[2] ABAZOV 11D study $p\overline{p} \rightarrow Z/\gamma^* e^+ e^-$ events using 5 fb^{-1} data at $\sqrt{s}$ = 1.96 TeV. The candidate events are selected by requiring two isolated electromagnetic showers with $E_T >$ 25 GeV, at least one electron in the central region and the di-electron mass in the range 50–1000 GeV. From the forward-backward asymmetry, determined as a function of the di-electron mass, they derive the axial and vector couplings of the *u*- and *d*- quarks and the value of $\sin^2\theta^{\ell}_{eff}$ = 0.2309 ± 0.0008(stat) ± 0.0006(syst). NODE=S044GUA;LINKAGE=AB

[3] LEP-SLC 06 is a combination of the results from LEP and SLC experiments using light quark tagging. *s*- and *d*-quark couplings are assumed to be identical. NODE=S044GUA;LINKAGE=LS

[4] ACOSTA 05M determine the forward-backward asymmetry of $e^+ e^-$ pairs produced via $q\overline{q} \rightarrow Z/\gamma^* \rightarrow e^+ e^-$ in 15 M($e^+ e^-$) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial-vector couplings of the *Z* to the light quarks, assuming the electron couplings are as predicted by the Standard Model. Higher order radiative corrections have not been taken into account. NODE=S044GUA;LINKAGE=AC

[5] ABRAMOWICZ 16A determine the Z^0 couplings to *u*- and *d*-quarks using the ZEUS polarised data from Run II together with the unpolarised data from both ZEUS and H1 Collaborations for Run I and unpolarised H1 data from Run II. NODE=S044GUA;LINKAGE=B

[6] ABT 16 determine the Z^0 couplings to *u*- and *d*-quarks using the same techniques and data as ABRAMOWICZ 16A but additionally use the published H1 polarised data. NODE=S044GUA;LINKAGE=A

[7] AKTAS 06 fit the neutral current ($1.5 \leq Q^2 \leq 30{,}000$ GeV^2) and charged current ($1.5 \leq Q^2 \leq 15{,}000$ GeV^2) differential cross sections. In the determination of the *u*-quark couplings the electron and *d*-quark couplings are fixed to their standard model values. NODE=S044GUA;LINKAGE=AK

g^d_A

NODE=S044GDA

NODE=S044GDA

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
$-0.527^{+0.040}_{-0.028}$ OUR AVERAGE					
-0.619 ± 0.108		[1] ANDREEV	18A	H1	$e^{\pm} p$
-0.497 ± 0.165	156k	[2] ABAZOV	11D	D0	$E^{p\overline{p}}_{\rm cm}$ = 1.97 TeV
$-0.52\ ^{+0.05}_{-0.03}$		[3] LEP-SLC	06		$E^{ee}_{\rm cm}$ = 88–94 GeV
$-0.016^{+0.346}_{-0.536} \pm 0.091$	5026	[4] ACOSTA	05M	CDF	$E^{p\overline{p}}_{\rm cm}$ = 1.96 TeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
$-0.56\ ^{+0.41}_{-0.15}$		[5] ABRAMOWICZ	16A	ZEUS	
$-0.409^{+0.373}_{-0.213}$		[6] ABT	16		
-0.80 ± 0.24	1500	[7] AKTAS	06	H1	$e^{\pm} p \rightarrow \overline{\nu}_e(\nu_e) X$, $\sqrt{s} \approx$ 300 GeV

[1] ANDREEV 18A obtain this result in a combined electroweak and QCD analysis using all deep-inelastic $e^+ p$ and $e^- p$ neutral current and charged current scattering cross sections published by the H1 Collaboration, including data with longitudinally polarized lepton beams. NODE=S044GDA;LINKAGE=C

[2] ABAZOV 11D study $p\overline{p} \rightarrow Z/\gamma^* e^+ e^-$ events using 5 fb^{-1} data at $\sqrt{s}$ = 1.96 TeV. The candidate events are selected by requiring two isolated electromagnetic showers with $E_T >$ 25 GeV, at least one electron in the central region and the di-electron mass in the range 50–1000 GeV. From the forward-backward asymmetry, determined as a function of the di-electron mass, they derive the axial and vector couplings of the *u*- and *d*- quarks and the value of $\sin^2\theta^{\ell}_{eff}$ = 0.2309 ± 0.0008(stat) ± 0.0006(syst). NODE=S044GDA;LINKAGE=AB

[3] LEP-SLC 06 is a combination of the results from LEP and SLC experiments using light quark tagging. *s*- and *d*-quark couplings are assumed to be identical. NODE=S044GDA;LINKAGE=LS

[4] ACOSTA 05M determine the forward-backward asymmetry of $e^+ e^-$ pairs produced via $q\overline{q} \rightarrow Z/\gamma^* \rightarrow e^+ e^-$ in 15 M($e^+ e^-$) effective mass bins ranging from 40 GeV to 600 GeV. These results are used to obtain the vector and axial-vector couplings of the *Z* to the light quarks, assuming the electron couplings are as predicted by the Standard Model. Higher order radiative corrections have not been taken into account. NODE=S044GDA;LINKAGE=AC

[5] ABRAMOWICZ 16A determine the Z^0 couplings to *u*- and *d*-quarks using the ZEUS polarised data from Run II together with the unpolarised data from both ZEUS and H1 Collaborations for Run I and unpolarised H1 data from Run II. NODE=S044GDA;LINKAGE=B

[6] ABT 16 determine the Z^0 couplings to *u*- and *d*-quarks using the same techniques and data as ABRAMOWICZ 16A but additionally use the published H1 polarised data. NODE=S044GDA;LINKAGE=A

[7] AKTAS 06 fit the neutral current ($1.5 \leq Q^2 \leq 30{,}000$ GeV^2) and charged current ($1.5 \leq Q^2 \leq 15{,}000$ GeV^2) differential cross sections. In the determination of the *d*-quark couplings the electron and *u*-quark couplings are fixed to their standard model values. NODE=S044GDA;LINKAGE=AK

Z COUPLINGS TO NEUTRAL LEPTONS

NODE=S044228

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

NODE=S044228

g^{ν_ℓ}

NODE=S044GNL
NODE=S044GNL

VALUE	DOCUMENT ID		COMMENT
0.50076±0.00076	[1] LEP-SLC	06	E^{ee}_{cm} = 88–94 GeV

[1] From invisible Z-decay width.

NODE=S044GNL;LINKAGE=LE

g^{ν_e}

NODE=S044GNE
NODE=S044GNE

VALUE	DOCUMENT ID		TECN	COMMENT
0.528±0.085	[1] VILAIN	94	CHM2	From $\nu_\mu e$ and $\nu_e e$ scattering

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

NODE=S044GNE;LINKAGE=A

g^{ν_μ}

NODE=S044GNM
NODE=S044GNM

VALUE	DOCUMENT ID		TECN	COMMENT
0.502±0.017	[1] VILAIN	94	CHM2	From $\nu_\mu e$ scattering

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

NODE=S044GNM;LINKAGE=A

Z ASYMMETRY PARAMETERS

NODE=S044224

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

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

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

NODE=S044224

A_e

NODE=S044AE

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.

NODE=S044AE

NODE=S044AE

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.1515±0.0019 OUR AVERAGE					
0.1454±0.0108±0.0036	144810	[1] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
0.1516±0.0021	559000	[2] ABE	01B	SLD	E^{ee}_{cm}= 91.24 GeV
0.1504±0.0068±0.0008		[3] HEISTER	01	ALEP	E^{ee}_{cm}= 88–94 GeV
0.1382±0.0116±0.0005	105000	[4] ABREU	00E	DLPH	E^{ee}_{cm}= 88–94 GeV
0.1678±0.0127±0.0030	137092	[5] ACCIARRI	98H	L3	E^{ee}_{cm}= 88–94 GeV
0.162 ±0.041 ±0.014	89838	[6] ABE	97	SLD	E^{ee}_{cm}= 91.27 GeV
0.202 ±0.038 ±0.008		[7] ABE	95J	SLD	E^{ee}_{cm}= 91.31 GeV

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

NODE=S044AE;LINKAGE=OA

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

NODE=S044AE;LINKAGE=BB

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

NODE=S044AE;LINKAGE=HE

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

NODE=S044AE;LINKAGE=L

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

NODE=S044AE;LINKAGE=A

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

NODE=S044AE;LINKAGE=E

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

NODE=S044AE;LINKAGE=KG

A_μ

NODE=S044AM

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.

NODE=S044AM

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.142±0.015	16844	[1] ABE	01B	SLD	E^{ee}_{cm}= 91.24 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.153±0.012	1.7M	[2] AAD	15BT	ATLS	E^{pp}_{cm} = 7 TeV

NODE=S044AM

[1] ABE 01B obtain this direct measurement using the left-right production and left-right forward-backward polar angle asymmetries in $\mu^+\mu^-$ decays of the Z boson obtained with a polarized electron beam. NODE=S044AM;LINKAGE=BB

[2] AAD 15BT study $pp \to Z \to \ell^+\ell^-$ events where ℓ is an electron or a muon in the dilepton mass region 70–1000 GeV. The background in the Z peak region is estimated to be $< 1\%$ for the muon channel. The muon asymmetry parameter is derived from the measured forward-backward asymmetry assuming the value of the quark asymmetry parameter from the SM. For this reason it is not used in the average. NODE=S044AM;LINKAGE=A

A_τ

NODE=S044AT

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

NODE=S044AT

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.143 ±0.004 OUR AVERAGE					
0.144 ±0.015		[1] HAYRAPETY...	24T	CMS	E^{pp}_{cm} = 13 TeV
0.1456±0.0076±0.0057	144810	[2] ABBIENDI	01O	OPAL	E^{ee}_{cm}= 88–94 GeV
0.136 ±0.015	16083	[3] ABE	01B	SLD	E^{ee}_{cm}= 91.24 GeV
0.1451±0.0052±0.0029		[4] HEISTER	01	ALEP	E^{ee}_{cm}= 88–94 GeV
0.1359±0.0079±0.0055	105000	[5] ABREU	00E	DLPH	E^{ee}_{cm}= 88–94 GeV
0.1476±0.0088±0.0062	137092	ACCIARRI	98H	L3	E^{ee}_{cm}= 88–94 GeV

NODE=S044AT

[1] HAYRAPETYAN 24T analyse the polarisation of tau leptons in Z bosons decaying to tau pairs. NODE=S044AT;LINKAGE=B

[2] ABBIENDI 01O fit for A_e and A_τ from measurements of the τ polarization at varying τ production angles. The correlation between A_e and A_τ is less than 0.03. NODE=S044AT;LINKAGE=OA

[3] ABE 01B obtain this direct measurement using the left-right production and left-right forward-backward polar angle asymmetries in $\tau^+\tau^-$ decays of the Z boson obtained with a polarized electron beam. NODE=S044AT;LINKAGE=BB

[4] HEISTER 01 obtain this result fitting the τ polarization as a function of the polar production angle of the τ. NODE=S044AT;LINKAGE=HE

[5] ABREU 00E obtain this result fitting the τ polarization as a function of the polar τ production angle. This measurement is a combination of different analyses (exclusive τ decay modes, inclusive hadronic 1-prong reconstruction, and a neural network analysis). NODE=S044AT;LINKAGE=L

A_s

NODE=S044AS

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

NODE=S044AS

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.895±0.066±0.062	2870	[1] ABE	00D	SLD	E^{ee}_{cm}= 91.2 GeV

NODE=S044AS

[1] ABE 00D tag $Z \to s\overline{s}$ events by an absence of B or D hadrons and the presence in each hemisphere of a high momentum $K^\pm$ or K^0_S. NODE=S044AS;LINKAGE=A

A_c

NODE=S044AC

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

NODE=S044AC

VALUE	DOCUMENT ID		TECN	COMMENT
0.670 ±0.027 OUR FIT				
0.6712±0.0224±0.0157	[1] ABE	05	SLD	E^{ee}_{cm}= 91.24 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.583 ±0.055 ±0.055	[2] ABE	02G	SLD	E^{ee}_{cm}= 91.24 GeV
0.688 ±0.041	[3] ABE	01C	SLD	E^{ee}_{cm}= 91.25 GeV

NODE=S044AC

[1] ABE 05 use hadronic Z decays collected during 1996–98 to obtain an enriched sample of $c\overline{c}$ events tagging on the invariant mass of reconstructed secondary decay vertices. The charge of the underlying c–quark is obtained with an algorithm that takes into account the net charge of the vertex as well as the charge of tracks emanating from the vertex and identified as kaons. This yields (9970 events) $A_c = 0.6747 \pm 0.0290 \pm 0.0233$. Taking into account all correlations with earlier results reported in ABE 02G and ABE 01C, they obtain the quoted overall SLD result. NODE=S044AC;LINKAGE=AB

[2] ABE 02G tag b and c quarks through their semileptonic decays into electrons and muons. A maximum likelihood fit is performed to extract simultaneously A_b and A_c. NODE=S044AC;LINKAGE=G2

[3] ABE 01C tag $Z \rightarrow c\overline{c}$ events using two techniques: exclusive reconstruction of D^{*+}, D^+ and D^0 mesons and the soft pion tag for $D^{*+} \rightarrow D^0\pi^+$. The large background from D mesons produced in $b\overline{b}$ events is separated efficiently from the signal using precision vertex information. When combining the A_c values from these two samples, care is taken to avoid double counting of events common to the two samples, and common systematic errors are properly taken into account. NODE=S044AC;LINKAGE=A

A_b

NODE=S044AB

This quantity is directly extracted from a measurement of the left-right forward-backward asymmetry in $b\overline{b}$ production at SLC using polarized electron beam. This double asymmetry eliminates the dependence on the Z-e-e coupling parameter A_e. OUR FIT is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the note "The Z boson" and ref. LEP-SLC 06. NODE=S044AB

NODE=S044AB

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.923 ±0.020 OUR FIT					
0.9170±0.0147±0.0145		[1] ABE	05	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.907 ±0.020 ±0.024	48028	[2] ABE	03F	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
0.919 ±0.030 ±0.024		[3] ABE	02G	SLD	$E^{ee}_{\rm cm}$= 91.24 GeV
0.855 ±0.088 ±0.102	7473	[4] ABE	99L	SLD	$E^{ee}_{\rm cm}$= 91.27 GeV

[1] ABE 05 use hadronic Z decays collected during 1996–98 to obtain an enriched sample of $b\overline{b}$ events tagging on the invariant mass of reconstructed secondary decay vertices. The charge of the underlying b–quark is obtained with an algorithm that takes into account the net charge of the vertex as well as the charge of tracks emanating from the vertex and identified as kaons. This yields (25917 events) $A_b = 0.9173 \pm 0.0184 \pm 0.0173$. Taking into account all correlations with earlier results reported in ABE 03F, ABE 02G and ABE 99L, they obtain the quoted overall SLD result. NODE=S044AB;LINKAGE=AB

[2] ABE 03F obtain an enriched sample of $b\overline{b}$ events tagging on the invariant mass of a 3-dimensional topologically reconstructed secondary decay. The charge of the underlying b quark is obtained using a self-calibrating track-charge method. For the 1996–1998 data sample they measure $A_b = 0.906 \pm 0.022 \pm 0.023$. The value quoted here is obtained combining the above with the result of ABE 98I (1993–1995 data sample). NODE=S044AB;LINKAGE=F

[3] ABE 02G tag b and c quarks through their semileptonic decays into electrons and muons. A maximum likelihood fit is performed to extract simultaneously A_b and A_c. NODE=S044AB;LINKAGE=G2

[4] ABE 99L obtain an enriched sample of $b\overline{b}$ events tagging with an inclusive vertex mass cut. For distinguishing b and $\overline{b}$ quarks they use the charge of identified $K^\pm$. NODE=S044AB;LINKAGE=D

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

NODE=S044248

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: NODE=S044248

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

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

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}

NODE=S044CTT

NODE=S044CTT

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	$E^{ee}_{\rm cm}$= 91.2 GeV
1.06±0.13±0.05	120k	BARATE	97D	ALEP	$E^{ee}_{\rm cm}$= 91.2 GeV

C_{TN}

NODE=S044CTN

VALUE	EVTS	DOCUMENT ID		TECN	COMMENT
0.08±0.13±0.04	120k	[1] BARATE	97D	ALEP	E^{ee}_{cm}= 91.2 GeV

[1] BARATE 97D combine their value of C_{TN} with the world average $P_\tau = -0.140 \pm 0.007$ to obtain $\tan(\Phi_{g^\tau_V} - \Phi_{g^\tau_A}) = -0.57 \pm 0.97$. NODE=S044CTN;LINKAGE=A

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

NODE=S044280

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

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

NODE=S044Z01

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

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
1.45±0.25 OUR FIT					
0.89±0.44	1.57	91.2	[1] ABBIENDI	01A	OPAL
1.71±0.49	1.57	91.2	ABREU	00F	DLPH
1.06±0.58	1.57	91.2	ACCIARRI	00C	L3
1.88±0.34	1.57	91.2	[2] BARATE	00C	ALEP

[1] ABBIENDI 01A error includes approximately 0.38 due to statistics, 0.16 due to event selection systematics, and 0.18 due to the theoretical uncertainty in t-channel prediction. NODE=S044Z01;LINKAGE=DB

[2] BARATE 00C error includes approximately 0.31 due to statistics, 0.06 due to experimental systematics, and 0.13 due to the theoretical uncertainty in t-channel prediction. NODE=S044Z01;LINKAGE=A

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

NODE=S044Z0A

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

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN	
1.69± 0.13 OUR FIT						
1.59± 0.23	1.57	91.2	[1] ABBIENDI	01A	OPAL	
1.65± 0.25	1.57	91.2	ABREU	00F	DLPH	
1.88± 0.33	1.57	91.2	ACCIARRI	00C	L3	
1.71± 0.24	1.57	91.2	[2] BARATE	00C	ALEP	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
9 ±30	−1.3	20	[3] ABREU	95M	DLPH	
7 ±26	−8.3	40	[3] ABREU	95M	DLPH	OCCUR=2
−11 ±33	−24.1	57	[3] ABREU	95M	DLPH	OCCUR=3
−62 ±17	−44.6	69	[3] ABREU	95M	DLPH	OCCUR=4
−56 ±10	−63.5	79	[3] ABREU	95M	DLPH	OCCUR=5
−13 ± 5	−34.4	87.5	[3] ABREU	95M	DLPH	OCCUR=6
$-29.0\ ^{+5.0}_{-4.8} \pm 0.5$	−32.1	56.9	[4] ABE	90I	VNS	
− 9.9 ± 1.5 ±0.5	−9.2	35	HEGNER	90	JADE	
0.05± 0.22	0.026	91.14	[5] ABRAMS	89D	MRK2	
−43.4 ±17.0	−24.9	52.0	[6] BACALA	89	AMY	
−11.0 ±16.5	−29.4	55.0	[6] BACALA	89	AMY	OCCUR=2
−30.0 ±12.4	−31.2	56.0	[6] BACALA	89	AMY	OCCUR=3

-46.2 ± 14.9	-33.0	57.0	[6] BACALA	89	AMY	OCCUR=4
-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	OCCUR=2
$-12.3 \pm 5.3 \pm 0.5$	-10.7	38.3	ADEVA	88	MRKJ	OCCUR=3
$-15.6 \pm 3.0 \pm 0.5$	-14.9	43.8	ADEVA	88	MRKJ	OCCUR=4
-1.0 ± 6.0	-1.2	13.9	BRAUNSCH...	88D	TASS	
$-9.1 \pm 2.3 \pm 0.5$	-8.6	34.5	BRAUNSCH...	88D	TASS	OCCUR=2
$-10.6\ {}^{+2.2}_{-2.3} \pm 0.5$	-8.9	35.0	BRAUNSCH...	88D	TASS	OCCUR=3
$-17.6\ {}^{+4.4}_{-4.3} \pm 0.5$	-15.2	43.6	BRAUNSCH...	88D	TASS	OCCUR=4
$-4.8 \pm 6.5 \pm 1.0$	-11.5	39	BEHREND	87C	CELL	
$-18.8 \pm 4.5 \pm 1.0$	-15.5	44	BEHREND	87C	CELL	OCCUR=2
$+2.7 \pm 4.9$	-1.2	13.9	BARTEL	86C	JADE	
$-11.1 \pm 1.8 \pm 1.0$	-8.6	34.4	BARTEL	86C	JADE	OCCUR=2
$-17.3 \pm 4.8 \pm 1.0$	-13.7	41.5	BARTEL	86C	JADE	OCCUR=3
$-22.8 \pm 5.1 \pm 1.0$	-16.6	44.8	BARTEL	86C	JADE	OCCUR=4
$-6.3 \pm 0.8 \pm 0.2$	-6.3	29	ASH	85	MAC	
$-4.9 \pm 1.5 \pm 0.5$	-5.9	29	DERRICK	85	HRS	
-7.1 ± 1.7	-5.7	29	LEVI	83	MRK2	
-16.1 ± 3.2	-9.2	34.2	BRANDELIK	82C	TASS	

[1] ABBIENDI 01A error is almost entirely on account of statistics. NODE=S044Z0A;LINKAGE=DB
[2] BARATE 00C error is almost entirely on account of statistics. NODE=S044Z0A;LINKAGE=LB
[3] ABREU 95M perform this measurement using radiative muon-pair events associated with high-energy isolated photons. NODE=S044Z0A;LINKAGE=H
[4] ABE 90I measurements in the range $50 \leq \sqrt{s} \leq 60.8$ GeV. NODE=S044Z0A;LINKAGE=AT
[5] ABRAMS 89D asymmetry includes both 9 $\mu^+\mu^-$ and 15 $\tau^+\tau^-$ events. NODE=S044Z0A;LINKAGE=AB
[6] BACALA 89 systematic error is about 5%. NODE=S044Z0A;LINKAGE=F

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

NODE=S044Z0T

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

NODE=S044Z0T

NODE=S044Z0T

ASYMMETRY (%)	*STD. MODEL*	$\sqrt{s}$ (GeV)	*DOCUMENT ID*		*TECN*	
1.88± 0.17 OUR FIT						
1.45 ± 0.30	1.57	91.2	[1] ABBIENDI	01A	OPAL	
2.41 ± 0.37	1.57	91.2	ABREU	00F	DLPH	
2.60 ± 0.47	1.57	91.2	ACCIARRI	00C	L3	
1.70 ± 0.28	1.57	91.2	[2] BARATE	00C	ALEP	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$-32.8\ {}^{+6.4}_{-6.2} \pm 1.5$	-32.1	56.9	[3] 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	[4] BACALA	89	AMY	
-17.7 ± 26.1	-29.4	55.0	[4] BACALA	89	AMY	OCCUR=2
-45.9 ± 16.6	-31.2	56.0	[4] BACALA	89	AMY	OCCUR=3
-49.5 ± 18.0	-33.0	57.0	[4] BACALA	89	AMY	OCCUR=4
-20 ± 14	-25.9	53.3	ADACHI	88C	TOPZ	
$-10.6 \pm 3.1 \pm 1.5$	-8.5	34.7	ADEVA	88	MRKJ	
$-8.5 \pm 6.6 \pm 1.5$	-15.4	43.8	ADEVA	88	MRKJ	OCCUR=2
$-6.0 \pm 2.5 \pm 1.0$	8.8	34.6	BARTEL	85F	JADE	
$-11.8 \pm 4.6 \pm 1.0$	14.8	43.0	BARTEL	85F	JADE	OCCUR=2
$-5.5 \pm 1.2 \pm 0.5$	-0.063	29.0	FERNANDEZ	85A	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	

[1] ABBIENDI 01A error includes approximately 0.26 due to statistics and 0.14 due to event selection systematics.
[2] BARATE 00C error includes approximately 0.26 due to statistics and 0.11 due to experimental systematics.
[3] ABE 90I measurements in the range 50 $\leq \sqrt{s} \leq$ 60.8 GeV.
[4] BACALA 89 systematic error is about 5%.

NODE=S044Z0T;LINKAGE=DB
NODE=S044Z0T;LINKAGE=LB
NODE=S044Z0T;LINKAGE=AT
NODE=S044Z0T;LINKAGE=F

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

NODE=S044Z0L

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

NODE=S044Z0L

NODE=S044Z0L

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
1.71±0.10 OUR FIT					
1.45±0.17	1.57	91.2	[1] ABBIENDI	01A	OPAL
1.87±0.19	1.57	91.2	ABREU	00F	DLPH
1.92±0.24	1.57	91.2	ACCIARRI	00C	L3
1.73±0.16	1.57	91.2	[2] BARATE	00C	ALEP

[1] ABBIENDI 01A error includes approximately 0.15 due to statistics, 0.06 due to event selection systematics, and 0.03 due to the theoretical uncertainty in t-channel prediction.
[2] BARATE 00C error includes approximately 0.15 due to statistics, 0.04 due to experimental systematics, and 0.02 due to the theoretical uncertainty in t-channel prediction.

NODE=S044Z0L;LINKAGE=DB
NODE=S044Z0L;LINKAGE=AC

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

NODE=S044Z0U

NODE=S044Z0U

NODE=S044Z0U

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
4.0±6.7±2.8	**7.2**	**91.2**	[1] ACKERSTAFF	97T	OPAL

[1] 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.

NODE=S044Z0U;LINKAGE=A

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

NODE=S044Z0S

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

NODE=S044Z0S

NODE=S044Z0S

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN
9.8 ±1.1 OUR AVERAGE					
10.08±1.13±0.40	10.1	91.2	[1] ABREU	00B	DLPH
6.8 ±3.5 ±1.1	10.1	91.2	[2] ACKERSTAFF	97T	OPAL

[1] ABREU 00B tag the presence of an s quark requiring a high-momentum-identified charged kaon. The s-quark pole asymmetry is extracted from the charged-kaon asymmetry taking the expected d- and u-quark asymmetries from the Standard Model and using the measured values for the c- and b-quark asymmetries.
[2] 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.

NODE=S044Z0S;LINKAGE=C
NODE=S044Z0S;LINKAGE=B

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

NODE=S044Z0C

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

NODE=S044Z0C

NODE=S044Z0C

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN	
7.07± 0.35 OUR FIT						
6.31± 0.93±0.65	6.35	91.26	[1] ABDALLAH	04F	DLPH	OCCUR=2
5.68± 0.54±0.39	6.3	91.25	[2] ABBIENDI	03P	OPAL	
6.45± 0.57±0.37	6.10	91.21	[3] HEISTER	02H	ALEP	
6.59± 0.94±0.35	6.2	91.235	[4] ABREU	99Y	DLPH	
6.3 ± 0.9 ±0.3	6.1	91.22	[5] BARATE	98O	ALEP	
6.3 ± 1.2 ±0.6	6.1	91.22	[6] ALEXANDER	97C	OPAL	OCCUR=2
8.3 ± 3.8 ±2.7	6.2	91.24	[7] ADRIANI	92D	L3	

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

3.1 ± 3.5 ±0.5	−3.5	89.43	[1] ABDALLAH	04F	DLPH	
11.0 ± 2.8 ±0.7	12.3	92.99	[1] ABDALLAH	04F	DLPH	OCCUR=3
− 6.8 ± 2.5 ±0.9	−3.0	89.51	[2] ABBIENDI	03P	OPAL	OCCUR=2
14.6 ± 2.0 ±0.8	12.2	92.95	[2] ABBIENDI	03P	OPAL	OCCUR=3
−12.4 ±15.9 ±2.0	−9.6	88.38	[3] HEISTER	02H	ALEP	OCCUR=2
− 2.3 ± 2.6 ±0.2	−3.8	89.38	[3] HEISTER	02H	ALEP	OCCUR=3
− 0.3 ± 8.3 ±0.6	0.9	90.21	[3] HEISTER	02H	ALEP	OCCUR=4
10.6 ± 7.7 ±0.7	9.6	92.05	[3] HEISTER	02H	ALEP	OCCUR=5
11.9 ± 2.1 ±0.6	12.2	92.94	[3] HEISTER	02H	ALEP	OCCUR=6
12.1 ±11.0 ±1.0	14.2	93.90	[3] HEISTER	02H	ALEP	OCCUR=7
− 4.96± 3.68±0.53	−3.5	89.434	[4] ABREU	99Y	DLPH	OCCUR=2
11.80± 3.18±0.62	12.3	92.990	[4] ABREU	99Y	DLPH	OCCUR=3
− 1.0 ± 4.3 ±1.0	−3.9	89.37	[5] BARATE	98O	ALEP	OCCUR=2
11.0 ± 3.3 ±0.8	12.3	92.96	[5] BARATE	98O	ALEP	OCCUR=3
3.9 ± 5.1 ±0.9	−3.4	89.45	[6] ALEXANDER	97C	OPAL	
15.8 ± 4.1 ±1.1	12.4	93.00	[6] ALEXANDER	97C	OPAL	OCCUR=3
−12.9 ± 7.8 ±5.5	−13.6	35	BEHREND	90D	CELL	
7.7 ±13.4 ±5.0	−22.1	43	BEHREND	90D	CELL	OCCUR=2
−12.8 ± 4.4 ±4.1	−13.6	35	ELSEN	90	JADE	
−10.9 ±12.9 ±4.6	−23.2	44	ELSEN	90	JADE	OCCUR=2
−14.9 ± 6.7	−13.3	35	OULD-SAADA	89	JADE	

[1] ABDALLAH 04F tag b– and c–quarks using semileptonic decays combined with charge flow information from the hemisphere opposite to the lepton. Enriched samples of $c\overline{c}$ and $b\overline{b}$ events are obtained using lifetime information. NODE=S044Z0C;LINKAGE=AD

[2] ABBIENDI 03P tag heavy flavors using events with one or two identified leptons. This allows the simultaneous fitting of the b and c quark forward-backward asymmetries as well as the average B^0-$\overline{B}^0$ mixing. NODE=S044Z0C;LINKAGE=AB

[3] HEISTER 02H measure simultaneously b and c quark forward-backward asymmetries using their semileptonic decays to tag the quark charge. The flavor separation is obtained with a discriminating multivariate analysis. NODE=S044Z0C;LINKAGE=HH

[4] ABREU 99Y tag $Z \rightarrow b\overline{b}$ and $Z \rightarrow c\overline{c}$ events by an exclusive reconstruction of several D meson decay modes (D^{*+}, D^0, and D^+ with their charge-conjugate states). NODE=S044Z0C;LINKAGE=G

[5] BARATE 98O tag $Z \rightarrow c\overline{c}$ events requiring the presence of high-momentum reconstructed D^{*+}, D^+, or D^0 mesons. NODE=S044Z0C;LINKAGE=AA

[6] ALEXANDER 97C identify the b and c events using a D/D^* tag. NODE=S044Z0C;LINKAGE=DD

[7] ADRIANI 92D use both electron and muon semileptonic decays. NODE=S044Z0C;LINKAGE=A

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

NODE=S044Z0B

OUR FIT, which is obtained by a simultaneous fit to several c- and b-quark measurements as explained in the note "The Z boson" and ref. LEP-SLC 06, refers to the ***Z* pole** asymmetry. The experimental values, on the other hand, correspond to the measurements carried out at the respective energies. NODE=S044Z0B

NODE=S044Z0B

ASYMMETRY (%)	*STD. MODEL*	*$\sqrt{s}$ (GeV)*	*DOCUMENT ID*		*TECN*	
9.92± 0.16 OUR FIT						
9.58± 0.32± 0.14	9.68	91.231	[1] ABDALLAH	05	DLPH	OCCUR=2
10.04± 0.56± 0.25	9.69	91.26	[2] ABDALLAH	04F	DLPH	OCCUR=2
9.72± 0.42± 0.15	9.67	91.25	[3] ABBIENDI	03P	OPAL	
9.77± 0.36± 0.18	9.69	91.26	[4] ABBIENDI	02I	OPAL	OCCUR=2
9.52± 0.41± 0.17	9.59	91.21	[5] HEISTER	02H	ALEP	
10.00± 0.27± 0.11	9.63	91.232	[6] HEISTER	01D	ALEP	
7.62± 1.94± 0.85	9.64	91.235	[7] ABREU	99Y	DLPH	
9.60± 0.66± 0.33	9.69	91.26	[8] ACCIARRI	99D	L3	
9.31± 1.01± 0.55	9.65	91.24	[9] ACCIARRI	98U	L3	
9.4 ± 2.7 ± 2.2	9.61	91.22	[10] ALEXANDER	97C	OPAL	OCCUR=2
• • • We do not use the following data for averages, fits, limits, etc. • • •						
6.37± 1.43± 0.17	5.8	89.449	[1] ABDALLAH	05	DLPH	
10.41± 1.15± 0.24	12.1	92.990	[1] ABDALLAH	05	DLPH	OCCUR=3
6.7 ± 2.2 ± 0.2	5.7	89.43	[2] ABDALLAH	04F	DLPH	
11.2 ± 1.8 ± 0.2	12.1	92.99	[2] ABDALLAH	04F	DLPH	OCCUR=3
4.7 ± 1.8 ± 0.1	5.9	89.51	[3] ABBIENDI	03P	OPAL	OCCUR=2
10.3 ± 1.5 ± 0.2	12.0	92.95	[3] ABBIENDI	03P	OPAL	OCCUR=3
5.82± 1.53± 0.12	5.9	89.50	[4] ABBIENDI	02I	OPAL	
12.21± 1.23± 0.25	12.0	92.91	[4] ABBIENDI	02I	OPAL	OCCUR=3
−13.1 ±13.5 ± 1.0	3.2	88.38	[5] HEISTER	02H	ALEP	OCCUR=2
5.5 ± 1.9 ± 0.1	5.6	89.38	[5] HEISTER	02H	ALEP	OCCUR=3

$-$ 0.4 $\pm$ 6.7 $\pm$ 0.8	7.5	90.21	[5] HEISTER	02H	ALEP		OCCUR=4
11.1 $\pm$ 6.4 $\pm$ 0.5	11.0	92.05	[5] HEISTER	02H	ALEP		OCCUR=5
10.4 $\pm$ 1.5 $\pm$ 0.3	12.0	92.94	[5] HEISTER	02H	ALEP		OCCUR=6
13.8 $\pm$ 9.3 $\pm$ 1.1	12.9	93.90	[5] HEISTER	02H	ALEP		OCCUR=7
4.36 $\pm$ 1.19 $\pm$ 0.11	5.8	89.472	[6] HEISTER	01D	ALEP		OCCUR=2
11.72 $\pm$ 0.97 $\pm$ 0.11	12.0	92.950	[6] HEISTER	01D	ALEP		OCCUR=3
5.67 $\pm$ 7.56 $\pm$ 1.17	5.7	89.434	[7] ABREU	99Y	DLPH		OCCUR=2
8.82 $\pm$ 6.33 $\pm$ 1.22	12.1	92.990	[7] ABREU	99Y	DLPH		OCCUR=3
6.11 $\pm$ 2.93 $\pm$ 0.43	5.9	89.50	[8] ACCIARRI	99D	L3		OCCUR=2
13.71 $\pm$ 2.40 $\pm$ 0.44	12.2	93.10	[8] ACCIARRI	99D	L3		OCCUR=3
4.95 $\pm$ 5.23 $\pm$ 0.40	5.8	89.45	[9] ACCIARRI	98U	L3		OCCUR=2
11.37 $\pm$ 3.99 $\pm$ 0.65	12.1	92.99	[9] ACCIARRI	98U	L3		OCCUR=3
$-$ 8.6 $\pm$10.8 $\pm$ 2.9	5.8	89.45	[10] ALEXANDER	97C	OPAL		
$-$ 2.1 $\pm$ 9.0 $\pm$ 2.6	12.1	93.00	[10] ALEXANDER	97C	OPAL		OCCUR=3
$-71 \pm 34 {}^{+7}_{-8}$	-58	58.3	SHIMONAKA	91	TOPZ		
$-22.2 \pm 7.7 \pm 3.5$	-26.0	35	BEHREND	90D	CELL		
$-49.1 \pm 16.0 \pm 5.0$	-39.7	43	BEHREND	90D	CELL		OCCUR=2
-28 ± 11	-23	35	BRAUNSCH...	90	TASS		
$-16.6 \pm 7.7 \pm 4.8$	-24.3	35	ELSEN	90	JADE		
$-33.6 \pm 22.2 \pm 5.2$	-39.9	44	ELSEN	90	JADE		OCCUR=2
$3.4 \pm 7.0 \pm 3.5$	-16.0	29.0	BAND	89	MAC		
$-72 \pm 28 \pm 13$	-56	55.2	SAGAWA	89	AMY		

[1] ABDALLAH 05 obtain an enriched samples of $b\overline{b}$ events using lifetime information. The quark (or antiquark) charge is determined with a neural network using the secondary vertex charge, the jet charge and particle identification. NODE=S044Z0B;LINKAGE=AL

[2] ABDALLAH 04F tag b– and c–quarks using semileptonic decays combined with charge flow information from the hemisphere opposite to the lepton. Enriched samples of $c\overline{c}$ and $b\overline{b}$ events are obtained using lifetime information. NODE=S044Z0B;LINKAGE=AD

[3] ABBIENDI 03P tag heavy flavors using events with one or two identified leptons. This allows the simultaneous fitting of the b and c quark forward-backward asymmetries as well as the average B^0-$\overline{B}^0$ mixing. NODE=S044Z0B;LINKAGE=AB

[4] ABBIENDI 02I tag $Z^0 \rightarrow b\overline{b}$ decays using a combination of secondary vertex and lepton tags. The sign of the b-quark charge is determined using an inclusive tag based on jet, vertex, and kaon charges. NODE=S044Z0B;LINKAGE=ZQ

[5] HEISTER 02H measure simultaneously b and c quark forward-backward asymmetries using their semileptonic decays to tag the quark charge. The flavor separation is obtained with a discriminating multivariate analysis. NODE=S044Z0B;LINKAGE=HH

[6] HEISTER 01D tag $Z \rightarrow b\overline{b}$ events using the impact parameters of charged tracks complemented with information from displaced vertices, event shape variables, and lepton identification. The b-quark direction and charge is determined using the hemisphere charge method along with information from fast kaon tagging and charge estimators of primary and secondary vertices. The change in the quoted value due to variation of A^c_{FB} and R_b is given as $+0.103$ (A^c_{FB} – 0.0651) -0.440 (R_b – 0.21585). NODE=S044Z0B;LINKAGE=WW

[7] ABREU 99Y tag $Z \rightarrow b\overline{b}$ and $Z \rightarrow c\overline{c}$ events by an exclusive reconstruction of several D meson decay modes (D^{*+}, D^0, and D^+ with their charge-conjugate states). NODE=S044Z0B;LINKAGE=XY

[8] ACCIARRI 99D tag $Z \rightarrow b\overline{b}$ events using high p and p$_T$ leptons. The analysis determines simultaneously a mixing parameter $\chi_b = 0.1192 \pm 0.0068 \pm 0.0051$ which is used to correct the observed asymmetry. NODE=S044Z0B;LINKAGE=XX

[9] ACCIARRI 98U tag $Z \rightarrow b\overline{b}$ events using lifetime and measure the jet charge using the hemisphere charge. NODE=S044Z0B;LINKAGE=Y

[10] ALEXANDER 97C identify the b and c events using a D/D^* tag. NODE=S044Z0B;LINKAGE=FF

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

NODE=S044Z0Q

Summed over five lighter flavors.

NODE=S044Z0Q

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.

NODE=S044Z0Q

ASYMMETRY (%)	STD. MODEL	$\sqrt{s}$ (GeV)	DOCUMENT ID		TECN	
• • • We do not use the following data for averages, fits, limits, etc. • • •						
$-$ 0.76 $\pm$ 0.12 $\pm$ 0.15		91.2	[1] ABREU	92I	DLPH	
4.0 $\pm$ 0.4 $\pm$ 0.63	4.0	91.3	[2] ACTON	92L	OPAL	
9.1 $\pm$ 1.4 $\pm$ 1.6	9.0	57.9	ADACHI	91	TOPZ	
$-$ 0.84 $\pm$ 0.15 $\pm$ 0.04		91	DECAMP	91B	ALEP	
8.3 $\pm$ 2.9 $\pm$ 1.9	8.7	56.6	STUART	90	AMY	
11.4 $\pm$ 2.2 $\pm$ 2.1	8.7	57.6	ABE	89L	VNS	
6.0 $\pm$ 1.3	5.0	34.8	GREENSHAW	89	JADE	
8.2 $\pm$ 2.9	8.5	43.6	GREENSHAW	89	JADE	OCCUR=2

[1] ABREU 92I has 0.14 systematic error due to uncertainty of quark fragmentation. NODE=S044Z0Q;LINKAGE=B

[2] 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 $\sin^2\theta_W^{\text{eff}}$ to be 0.2321 $\pm$ 0.0017 $\pm$ 0.0028. NODE=S044Z0Q;LINKAGE=C

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

NODE=S044Z0E

NODE=S044Z0E

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

$\sin^2(\theta_{\text{eff}})$

NODE=S044SEF

The leptonic effective electroweak mixing angle, $\sin^2\theta_{\text{eff}}^{\text{lept}}$, is given in terms of the ratio of leptonic vector and axial-vector coupling constants, $r = g_\ell^V/g_\ell^A$ for $\ell = e,\ \mu,\ \tau$, with $\sin^2\theta_{\text{eff}}^{\text{lept}} = (1-r)/4$. It can be extracted directly from the leptonic asymmetry parameter, $A_\ell = 2r/(1+r^2)$. See note "The Z boson" and ref. LEP-SLC 06.

NODE=S044SEF

NODE=S044SEF

VALUE	DOCUMENT ID		TECN	COMMENT	
0.23148±0.00012 OUR AVERAGE					NEW
[0.23148 ± 0.00013 OUR 2025 AVERAGE]					
0.23152±0.00031	[1] HAYRAPETY...	25AF	CMS	E_{cm}^{pp} = 13 TeV	
0.23147±0.00050	[2] AAIJ	24AL	LHCB	E_{cm}^{pp} = 13 TeV	
0.2319 ±0.0019	[3] HAYRAPETY...	24T	CMS	E_{cm}^{pp} = 13 TeV	
0.23148±0.00033	[4] AALTONEN	18B	TEVA	$E_{\text{cm}}^{p\overline{p}}$ = 1.96 TeV	
0.23101±0.00053	[5] SIRUNYAN	18CY	CMS	E_{cm}^{pp} = 8 TeV	
0.2308 ±0.0012	[6] AAD	15BT	ATLS	E_{cm}^{pp} = 7 TeV	
0.2314 ±0.0011	[7] AAIJ	15BF	LHCB	E_{cm}^{pp} = 7+8 TeV	
0.23153±0.00016	[8] LEP-SLC	06		E_{cm}^{ee} = 88–94 GeV	OCCUR=7
• • • We do not use the following data for averages, fits, limits, etc. • • •					
0.23016±0.00064	[9] ABAZOV	18	D0	$E_{\text{cm}}^{p\overline{p}}$ = 1.96 TeV	
0.23248±0.00053	[10] AALTONEN	16D	CDF2	$E_{\text{cm}}^{p\overline{p}}$ = 1.96 TeV	
0.23147±0.00047	[11] ABAZOV	15C	D0	$E_{\text{cm}}^{p\overline{p}}$ = 1.96 TeV	
0.2315 ±0.0010	[12] AALTONEN	14C	CDF2	$E_{\text{cm}}^{p\overline{p}}$ = 1.96 TeV	
0.23099±0.00053	[13] LEP-SLC	06	LEP	E_{cm}^{ee} = 88–94 GeV	
0.23159±0.00041	[14] LEP-SLC	06	LEP	E_{cm}^{ee} = 88–94 GeV	OCCUR=2
0.23098±0.00026	[15] LEP-SLC	06	SLD	E_{cm}^{ee} = 88–94 GeV	OCCUR=3
0.23221±0.00029	[16] LEP-SLC	06		E_{cm}^{ee} = 88–94 GeV	OCCUR=4
0.23220±0.00081	[17] LEP-SLC	06		E_{cm}^{ee} = 88–94 GeV	OCCUR=5
0.2324 ±0.0012	[18] LEP-SLC	06	LEP	E_{cm}^{ee} = 88–94 GeV	OCCUR=6

[1] HAYRAPETYAN 25AF analyse the forward-backward asymmetry in Drell-Yan production of Z bosons decaying to electron and muon pairs. NODE=S044SEF;LINKAGE=R

[2] AAIJ 24AL analyse the forward-backward asymmetry in Drell-Yan production of Z bosons decaying to muon pairs. NODE=S044SEF;LINKAGE=Q

[3] HAYRAPETYAN 24T analyse the polarisation of tau leptons in Z bosons decaying to tau pairs. NODE=S044SEF;LINKAGE=O

[4] AALTONEN 18B is a combination of the the results from the Tevatron experiments CDF and D0 in the electron and muon channels, AALTONEN 14C, AALTONEN 16D, ABAZOV 15C, ABAZOV 18, averaging the combined value from CDF and from D0 as also provided by the experiments in AALTONEN 16D and ABAZOV 18, respectively. The average of the two results takes correlations into account and has a χ^2 probability of 2.6%. NODE=S044SEF;LINKAGE=L

[5] SIRUNYAN 18CY analyse the forward-backward asymmetry in Drell-Yan production of Z bosons decaying to muon or electron pairs. NODE=S044SEF;LINKAGE=P

[6] AAD 15BT analyse the forward-backward asymmetry in Drell-Yan production of Z bosons decaying to muon or electron pairs. NODE=S044SEF;LINKAGE=M

[7] AAIJ 15BF analyse the forward-backward asymmetry in Drell-Yan production of Z bosons decaying to muon pairs. NODE=S044SEF;LINKAGE=N

[8] This result combines the six individual results from LEP and SLC. The average, described in LEP-SLC 06, has a χ^2 probability of 3.7%. NODE=S044SEF;LINKAGE=G

[9] ABAZOV 18 analyse the forward-backward asymmetry in Drell-Yan production of Z bosons decaying to muon pairs. Combining this result with the one from ABAZOV 15C, a value of 0.23095 ± 0.00040 is obtained. NODE=S044SEF;LINKAGE=K

[10] AALTONEN 16D analyse the forward-backward asymmetry in Drell-Yan production of Z bosons decaying to electron pairs. Combining this result with the one from AALTONEN 14C, a value of 0.23221 ± 0.00046 is obtained. NODE=S044SEF;LINKAGE=I

[11] ABAZOV 15C analyse the forward-backward asymmetry in Drell-Yan production of Z bosons decaying to electron pairs. NODE=S044SEF;LINKAGE=J

[12] AALTONEN 14C analyse the forward-backward asymmetry in Drell-Yan production of Z bosons decaying to muon pairs. NODE=S044SEF;LINKAGE=H

[13] The result is based on the forward-backward asymmetry measured in leptonic Z decays (electrons, muons, taus). It combines the results of the LEP experiments, ALEPH, DELPHI, L3 and OPAL, taking correlations into account, see LEP-SLC 06. NODE=S044SEF;LINKAGE=A

[14] The result is based on the polarisation of tau leptons measured in Z decays to tau-lepton pairs. It combines the results of the LEP experiments, ALEPH, DELPHI, L3 and OPAL, taking correlations into account, see LEP-SLC 06. NODE=S044SEF;LINKAGE=B

[15] The result is based on the left-right and forward-backward left-right asymmetry measured in leptonic Z decays (electrons, muons, taus). It combines the results of the SLC experiment, SLD, taking correlations into account, see LEP-SLC 06. NODE=S044SEF;LINKAGE=C

[16] The result is based on the forward-backward asymmetry measured at LEP and the forward-backward left-right asymmetry measured at SLC, in both cases using Z decays to b-quarks. It combines the results of the LEP and SLC experiments, ALEPH, DELPHI, L3, OPAL and SLD, taking correlations into account, see LEP-SLC 06. NODE=S044SEF;LINKAGE=D

[17] The result is based on the forward-backward asymmetry measured at LEP and the forward-backward left-right asymmetry measured at SLC, in both cases using Z decays to c-quarks. It combines the results of the LEP and SLC experiments ALEPH, DELPHI, L3, OPAL and SLD, taking correlations into account, see LEP-SLC 06. NODE=S044SEF;LINKAGE=E

[18] The result is based on the inclusive hadronic charge asymmetry measured in hadronic Z decays. It combines the results of the LEP experiments, ALEPH, DELPHI, L3 and OPAL, taking correlations into account, see LEP-SLC 06. NODE=S044SEF;LINKAGE=F

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

NODE=S044270

NODE=S044270

Revised September 2013 by M.W. Grünewald (U. College Dublin) and A. Gurtu (Formerly Tata Inst.).

In on-shell $Z\gamma$ production, deviations from the Standard Model for the $Z\gamma\gamma^*$ and $Z\gamma Z^*$ couplings may be described in terms of eight parameters, h_i^V $(i = 1, 4;\ V = \gamma, Z)$ [1]. The parameters h_i^γ describe the $Z\gamma\gamma^*$ couplings and the parameters h_i^Z the $Z\gamma Z^*$ couplings. In this formalism h_1^V and h_2^V lead to CP-violating and h_3^V and h_4^V to CP-conserving effects. All these anomalous contributions to the cross section increase rapidly with center-of-mass energy. In order to ensure unitarity, these parameters are usually described by a form-factor representation, $h_i^V(s) = h_{i\circ}^V/(1 + s/\Lambda^2)^n$, where Λ is the energy scale for the manifestation of a new phenomenon and n is a sufficiently large power. By convention one uses $n = 3$ for $h_{1,3}^V$ and $n = 4$ for $h_{2,4}^V$. Usually limits on h_i^V's are put assuming some value of Λ, sometimes ∞.

In on-shell ZZ production, deviations from the Standard Model for the $ZZ\gamma^*$ and ZZZ^* couplings may be described by means of four anomalous couplings f_i^V $(i = 4, 5; V = \gamma, Z)$ [2]. As above, the parameters f_i^γ describe the $ZZ\gamma^*$ couplings and the parameters f_i^Z the ZZZ^* couplings. The anomalous couplings f_5^V lead to violation of C and P symmetries while f_4^V introduces CP violation. Also here, formfactors depending on a scale Λ are used.

All these couplings h_i^V and f_i^V are zero at tree level in the Standard Model; they are measured in e^+e^-, $p\bar{p}$ and pp collisions at LEP, Tevatron and LHC.

References

1. U. Baur and E.L. Berger, Phys. Rev. **D47**, 4889 (1993).
2. K. Hagiwara *et al.*, Nucl. Phys. **B282**, 253 (1987).

h_i^V

NODE=S044ZVG

Combining the LEP-2 results taking into account the correlations, the following 95% CL limits are derived [SCHAEL 13A]: NODE=S044ZVG

$$-0.12 < h_1^Z < +0.11, \qquad -0.07 < h_2^Z < +0.07,$$
$$-0.19 < h_3^Z < +0.06, \qquad -0.04 < h_4^Z < +0.13,$$
$$-0.05 < h_1^\gamma < +0.05, \qquad -0.04 < h_2^\gamma < +0.02,$$
$$-0.05 < h_3^\gamma < +0.00, \qquad +0.01 < h_4^\gamma < +0.05.$$

Some of the recent results from the Tevatron and LHC experiments individually surpass the combined LEP-2 results in precision (see below).

NODE=S044ZVG

VALUE	DOCUMENT ID		TECN	COMMENT
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] AAD	16Q	ATLS	$E_{\rm cm}^{pp}$ = 8 TeV
	[2] KHACHATRY...	16AE	CMS	$E_{\rm cm}^{pp}$ = 8 TeV
	[3] KHACHATRY...	15AC	CMS	$E_{\rm cm}^{pp}$ = 8 TeV
	[4] CHATRCHYAN	14AB	CMS	$E_{\rm cm}^{pp}$ = 7 TeV
	[5] AAD	13AN	ATLS	$E_{\rm cm}^{pp}$ = 7 TeV
	[6] CHATRCHYAN	13BI	CMS	$E_{\rm cm}^{pp}$ = 7 TeV
	[7] ABAZOV	12S	D0	$E_{\rm cm}^{p\bar{p}}$ = 1.96 TeV
	[8] AALTONEN	11S	CDF	$E_{\rm cm}^{p\bar{p}}$ = 1.96 TeV
	[9] CHATRCHYAN	11M	CMS	$E_{\rm cm}^{pp}$ = 7 TeV
	[10] ABAZOV	09L	D0	$E_{\rm cm}^{p\bar{p}}$ = 1.96 TeV
	[11] ABAZOV	07M	D0	$E_{\rm cm}^{p\bar{p}}$ = 1.96 TeV
	[12] ABDALLAH	07C	DLPH	$E_{\rm cm}^{ee}$ = 183–208 GeV
	[13] ACHARD	04H	L3	$E_{\rm cm}^{ee}$ = 183–208 GeV
	[14] ABBIENDI,G	00C	OPAL	$E_{\rm cm}^{ee}$ = 189 GeV
	[15] ABBOTT	98M	D0	$E_{\rm cm}^{p\bar{p}}$ = 1.8 TeV
	[16] ABREU	98K	DLPH	$E_{\rm cm}^{ee}$ = 161, 172 GeV

[1] AAD 16Q study $Z\gamma$ production in pp collisions. In events with no additional jets, 10268 (12738) Z decays to electron (muon) pairs are selected, with an expected background of 1291 $\pm$ 340 (1537 $\pm$ 408) events, as well as 1039 Z decays to neutrino pairs with an expected background of 450 $\pm$ 96 events. Analyzing the photon transverse momentum distribution above 250 GeV (400 GeV) for lepton (neutrino) events, yields the 95% C.L. limits: $-7.8 \times 10^{-4} < h_3^Z < 8.6 \times 10^{-4}$, $-3.0 \times 10^{-6} < h_4^Z < 2.9 \times 10^{-6}$, $-9.5 \times 10^{-4} < h_3^\gamma < 9.9 \times 10^{-4}$, $-3.2 \times 10^{-6} < h_4^\gamma < 3.2 \times 10^{-6}$. NODE=S044ZVG;LINKAGE=I

[2] KHACHATRYAN 16AE determine the $Z\gamma \to \nu\bar{\nu}\gamma$ cross section by selecting events with a photon of E_T > 145 GeV and $\not{E}_T$ > 140 GeV. 630 candidate events are observed with an expected SM background of 269 $\pm$ 26. The E_T spectrum of the photon is used to set 95% C.L. limits as follows: $-1.5 \times 10^{-3} < h_3^Z < 1.6 \times 10^{-3}$, $-3.9 \times 10^{-6} < h_4^Z < 4.5 \times 10^{-6}$, $-1.1 \times 10^{-3} < h_3^\gamma < 0.9 \times 10^{-3}$, $-3.8 \times 10^{-6} < h_4^\gamma < 4.3 \times 10^{-6}$. NODE=S044ZVG;LINKAGE=J

[3] KHACHATRYAN 15AC study $Z\gamma$ events in 8 TeV pp interactions, where the Z decays into 2 same-flavor, opposite sign leptons (e or μ) and a photon with p_T > 15 GeV. The p_T of a lepton is required to be > 20 GeV/c, their effective mass > 50 GeV, and the photon should have a separation ΔR > 0.7 with each lepton. The observed p_T distribution of the photons is used to extract the 95% C.L. limits: $-3.8 \times 10^{-3} < h_3^Z < 3.7 \times 10^{-3}$, $-3.1 \times 10^{-5} < h_4^Z < 3.0 \times 10^{-5}$, $-4.6 \times 10^{-3} < h_3^\gamma < 4.6 \times 10^{-3}$, $-3.6 \times 10^{-5} < h_4^\gamma < 3.5 \times 10^{-5}$. NODE=S044ZVG;LINKAGE=H

[4] CHATRCHYAN 14AB measure $Z\gamma$ production cross section for p_T^γ > 15 GeV and R($\ell\gamma$) > 0.7, which is the separation between the γ and the final state charged lepton (e or NODE=S044ZVG;LINKAGE=CA

μ) in the azimuthal angle-pseudorapidity ($\phi - \eta$) plane. The di-lepton mass is required to be > 50 GeV. After background subtraction the number of $ee\gamma$ and $\mu\mu\gamma$ events is determined to be 3160 ± 120 and 5030 ± 233 respectively, compatible with expectations from the SM. This leads to a 95% CL limits of $-1 \times 10^{-2} < h_3^\gamma < 1 \times 10^{-2}$, $-9 \times 10^{-5} < h_4^\gamma < 9 \times 10^{-5}$, $-9 \times 10^{-3} < h_3^Z < 9 \times 10^{-3}$, $-8 \times 10^{-5} < h_4^Z < 8 \times 10^{-5}$, assuming h_1^V and h_2^V have SM values, $V = \gamma$ or Z.

[5] AAD 13AN study $Z\gamma$ production in pp collisions. In events with no additional jet, 1417 (2031) Z decays to electron (muon) pairs are selected, with an expected background of 156 ± 54 (244 ± 64) events, as well as 662 Z decays to neutrino pairs with an expected background of 302 ± 42 events. Analysing the photon p_T spectrum above 100 GeV yields the 95% C.L. limts: $-0.013 < h_3^Z < 0.014$, $-8.7 \times 10^{-5} < h_4^Z < 8.7 \times 10^{-5}$, $-0.015 < h_3^\gamma < 0.016$, $-9.4 \times 10^{-5} < h_4^\gamma < 9.2 \times 10^{-5}$. Supersedes AAD 12BX. NODE=S044ZVG;LINKAGE=G

[6] CHATRCHYAN 13BI determine the $Z\gamma \to \nu\overline{\nu}\gamma$ cross section by selecting events with a photon of $E_T > 145$ GeV and a $\not{E}_T > 130$ GeV. 73 candidate events are observed with an expected SM background of 30.2 ± 6.5. The E_T spectrum of the photon is used to set 95% C.L. limits as follows: $|h_3^Z| < 2.7 \times 10^{-3}$, $|h_4^Z| < 1.3 \times 10^{-5}$, $|h_3^\gamma| < 2.9 \times 10^{-3}$, $|h_4^\gamma| < 1.5 \times 10^{-5}$. NODE=S044ZVG;LINKAGE=F

[7] ABAZOV 12S study $Z\gamma$ production in $p\overline{p}$ collisions at $\sqrt{s} = 1.96$ TeV using 6.2 fb^{-1} of data where the Z decays to electron (muon) pairs and the photon has at least 10 GeV of transverse momentum. In data, 304 (308) di-electron (di-muon) events are observed with an expected background of 255 ± 16 (285 ± 24) events. Based on the photon p_T spectrum, and including also earlier data and the $Z \to \nu\overline{\nu}$ decay mode (from ABAZOV 09L), the following 95% C.L. limits are reported: $|h_{03}^Z| < 0.026$, $|h_{04}^Z| < 0.0013$, $|h_{03}^\gamma| < 0.027$, $|h_{04}^\gamma| < 0.0014$ for a form factor scale of $\Lambda = 1.5$ TeV. NODE=S044ZVG;LINKAGE=BA

[8] AALTONEN 11S study $Z\gamma$ events in $p\overline{p}$ interactions at $\sqrt{s} = 1.96$ TeV with integrated luminosity 5.1 fb^{-1} for $Z \to e^+e^-/\mu^+\mu^-$ and 4.9 fb^{-1} for $Z \to \nu\overline{\nu}$. For the charged lepton case, the two leptons must be of the same flavor with the transverse momentum/energy of one > 20 GeV and the other > 10 GeV. The isolated photon must have $E_T > 50$ GeV. They observe 91 events with 87.2 ± 7.8 events expected from standard model processes. For the $\nu\overline{\nu}$ case they require solitary photons with $E_T > 25$ GeV and missing $E_T > 25$ GeV and observe 85 events with standard model expectation of 85.9 ± 5.6 events. Taking the form factor $\Lambda = 1.5$ TeV they derive 95% C.L. limits as $|h_3^{\gamma,Z}| < 0.022$ and $|h_4^{\gamma,Z}| < 0.0009$. NODE=S044ZVG;LINKAGE=AL

[9] CHATRCHYAN 11M study $Z\gamma$ production in pp collisions at $\sqrt{s} = 7$ TeV using 36 pb^{-1} pp data, where the Z decays to e^+e^- or $\mu^+\mu^-$. The total cross sections are measured for photon transverse energy $E_T^\gamma > 10$ GeV and spatial separation from charged leptons in the plane of pseudo rapidity and azimuthal angle $\Delta R(\ell,\gamma) > 0.7$ with the dilepton invariant mass requirement of $M_{\ell\ell} > 50$ GeV. The number of $e^+e^-\gamma$ and $\mu^+\mu^-\gamma$ candidates is 81 and 90 with estimated backgrounds of 20.5 ± 2.5 and 27.3 ± 3.2 events respectively. The 95% CL limits for $ZZ\gamma$ couplings are $-0.05 < h_3^Z < 0.06$ and $-0.0005 < h_4^Z < 0.0005$, and for $Z\gamma\gamma$ couplings are $-0.07 < h_3^\gamma < 0.07$ and $-0.0005 < h_4^\gamma < 0.0006$. NODE=S044ZVG;LINKAGE=CH

[10] ABAZOV 09L study $Z\gamma$, $Z \to \nu\overline{\nu}$ production in $p\overline{p}$ collisions at 1.96 TeV C.M. energy. They select 51 events with a photon of transverse energy E_T larger than 90 GeV, with an expected background of 17 events. Based on the photon E_T spectrum and including also Z decays to charged leptons (from ABAZOV 07M), the following 95% CL limits are reported: $|h_{30}^\gamma| < 0.033$, $|h_{40}^\gamma| < 0.0017$, $|h_{30}^Z| < 0.033$, $|h_{40}^Z| < 0.0017$. NODE=S044ZVG;LINKAGE=AZ

[11] ABAZOV 07M use 968 $p\overline{p} \to e^+e^-/\mu^+\mu^-\gamma X$ candidates, at 1.96 TeV center of mass energy, to tag $p\overline{p} \to Z\gamma$ events by requiring $E_T(\gamma) > 7$ GeV, lepton-gamma separation $\Delta R_{\ell\gamma} > 0.7$, and di-lepton invariant mass > 30 GeV. The cross section is in agreement with the SM prediction. Using these $Z\gamma$ events they obtain 95% C.L. limits on each h_i^V, keeping all others fixed at their SM values. They report: $-0.083 < h_{30}^Z < 0.082$, $-0.0053 < h_{40}^Z < 0.0054$, $-0.085 < h_{30}^\gamma < 0.084$, $-0.0053 < h_{40}^\gamma < 0.0054$, for the form factor scale $\Lambda = 1.2$ TeV. NODE=S044ZVG;LINKAGE=AA

[12] Using data collected at $\sqrt{s} = 183$–208, ABDALLAH 07C select 1,877 $e^+e^- \to Z\gamma$ events with $Z \to q\overline{q}$ or $\nu\overline{\nu}$, 171 $e^+e^- \to ZZ$ events with $Z \to q\overline{q}$ or lepton pair (except an explicit τ pair), and 74 $e^+e^- \to Z\gamma^*$ events with a $q\overline{q}\mu^+\mu^-$ or $q\overline{q}e^+e^-$ signature, to derive 95% CL limits on h_i^V. Each limit is derived with other parameters set to zero. They report: $-0.23 < h_1^Z < 0.23$, $-0.30 < h_3^Z < 0.16$, $-0.14 < h_1^\gamma < 0.14$, $-0.049 < h_3^\gamma < 0.044$. NODE=S044ZVG;LINKAGE=AD

[13] ACHARD 04H select 3515 $e^+e^- \to Z\gamma$ events with $Z \to q\overline{q}$ or $\nu\overline{\nu}$ at $\sqrt{s} = 189$–209 GeV to derive 95% CL limits on h_i^V. For deriving each limit the other parameters are fixed at zero. They report: $-0.153 < h_1^Z < 0.141$, $-0.087 < h_2^Z < 0.079$, $-0.220 <$ NODE=S044ZVG;LINKAGE=AC

$h_3^Z < 0.112$, $-0.068 < h_4^Z < 0.148$, $-0.057 < h_1^\gamma < 0.057$, $-0.050 < h_2^\gamma < 0.023$, $-0.059 < h_3^\gamma < 0.004$, $-0.004 < h_4^\gamma < 0.042$.

[14] ABBIENDI,G 00C study $e^+e^- \to Z\gamma$ events (with $Z \to q\overline{q}$ and $Z \to \nu\overline{\nu}$) at 189 GeV to obtain the central values (and 95% CL limits) of these couplings: $h_1^Z = 0.000 \pm 0.100$ $(-0.190, 0.190)$, $h_2^Z = 0.000 \pm 0.068$ $(-0.128, 0.128)$, $h_3^Z = -0.074^{+0.102}_{-0.103}$ $(-0.269, 0.119)$, $h_4^Z = 0.046 \pm 0.068$ $(-0.084, 0.175)$, $h_1^\gamma = 0.000 \pm 0.061$ $(-0.115, 0.115)$, $h_2^\gamma = 0.000 \pm 0.041$ $(-0.077, 0.077)$, $h_3^\gamma = -0.080^{+0.039}_{-0.041}$ $(-0.164, -0.006)$, $h_4^\gamma = 0.064^{+0.033}_{-0.030}$ $(+0.007, +0.134)$. The results are derived assuming that only one coupling at a time is different from zero. NODE=S044ZVG;LINKAGE=D

[15] ABBOTT 98M study $p\overline{p} \to Z\gamma + X$, with $Z \to e^+e^-$, $\mu^+\mu^-$, $\overline{\nu}\nu$ at 1.8 TeV, to obtain 95% CL limits at Λ= 750 GeV: $|h_{30}^Z| < 0.36$, $|h_{40}^Z| < 0.05$ (keeping h_i^γ=0), and $|h_{30}^\gamma| < 0.37$, $|h_{40}^\gamma| < 0.05$ (keeping h_i^Z=0). Limits on the *CP*-violating couplings are $|h_{10}^Z| < 0.36$, $|h_{20}^Z| < 0.05$ (keeping h_i^γ=0), and $|h_{10}^\gamma| < 0.37$, $|h_{20}^\gamma| < 0.05$ (keeping h_i^Z=0). NODE=S044ZVG;LINKAGE=C

[16] ABREU 98K determine a 95% CL upper limit on $\sigma(e^+e^- \to \gamma +$ invisible particles$)$ < 2.5 pb using 161 and 172 GeV data. This is used to set 95% CL limits on $|h_{30}^\gamma| < 0.8$ and $|h_{30}^Z| < 1.3$, derived at a scale Λ=1 TeV and with n=3 in the form factor representation. NODE=S044ZVG;LINKAGE=A

f_i^V

NODE=S044ZZZ

Combining the LEP-2 results taking into account the correlations, the following 95% CL limits are derived [SCHAEL 13A]: NODE=S044ZZZ

$$-0.28 < f_4^Z < +0.32, \qquad -0.34 < f_5^Z < +0.35,$$
$$-0.17 < f_4^\gamma < +0.19, \qquad -0.35 < f_5^\gamma < +0.32.$$

Some of the recent results from the Tevatron and LHC experiments individually surpass the combined LEP-2 results in precision (see below).

NODE=S044ZZZ

VALUE	*DOCUMENT ID*		*TECN*	*COMMENT*
• • • We do not use the following data for averages, fits, limits, etc. • • •				
	[1] AAD	23CH		$E_{cm}^{pp} = 13$ TeV
	[2] SIRUNYAN	21Q	CMS	$E_{cm}^{pp} = 13$ TeV
	[3] AABOUD	19AY	ATLS	$E_{cm}^{pp} = 13$ TeV
	[4] AABOUD	18Q	ATLS	$E_{cm}^{pp} = 13$ TeV
	[5] SIRUNYAN	18BT	CMS	$E_{cm}^{pp} = 13$ TeV
	[6] KHACHATRY...	15B	CMS	$E_{cm}^{pp} = 8$ TeV
	[7] KHACHATRY...	15BC	CMS	$E_{cm}^{pp} = 7, 8$ TeV
	[8] AAD	13Z	ATLS	$E_{cm}^{pp} = 7$ TeV
	[9] CHATRCHYAN	13B	CMS	$E_{cm}^{pp} = 7$ TeV
	[10] SCHAEL	09	ALEP	$E_{cm}^{ee} = 192$–209 GeV
	[11] ABAZOV	08K	D0	$E_{cm}^{p\overline{p}} = 1.96$ TeV
	[12] ABDALLAH	07C	DLPH	$E_{cm}^{ee} = 183$–208 GeV
	[13] ABBIENDI	04C	OPAL	
	[14] ACHARD	03D	L3	

[1] AAD 23CH measure ZZ production with the Z bosons decaying to electrons or muons. Analysing the angular information of the final-state four-lepton system, the following limits are derived at 95% C.L.: -0.012 < f_4^Z < 0.012, -0.015 < f_4^γ < 0.015. NODE=S044ZZZ;LINKAGE=J

[2] SIRUNYAN 21Q measure ZZ production where both Z bosons decay in the electron or muon channel. Analyzing the four-lepton invariant mass distribution, the following limits are derived at 95% C.L. in units of 10^{-4}: $-6.6 < f_4^Z < 6.0$, $-5.5 < f_5^Z < 7.5$, $-7.8 < f_4^\gamma < 7.1$, $-6.8 < f_5^\gamma < 7.5$. This set of parameters is linearly related to a set of EFT parameters, resulting in the following limits at 95% C.L. in units of TeV^{-4}: $-2.3 < c_{\widetilde{B}W}/\Lambda^4 < 2.5$, $-1.4 < c_{WW}/\Lambda^4 < 1.2$, $-1.4 < c_{BW}/\Lambda^4 < 1.3$, $-1.2 < c_{BB}/\Lambda^4 < 1.2$. NODE=S044ZZZ;LINKAGE=I

[3] AABOUD 19AY study ZZ production in the $\ell\ell\nu\nu$ decay channel. Events with a pair of isolated high-transverse momentum charged leptons (electron pairs or muon pairs), and with large missing energy, are selected. In the data, 371 (416) di-electron (di-muon) events are found, with a total expected background of 128 ± 8 (143 ± 8) events. Analysing the transverse momentum distribution of the charged dilepton system above NODE=S044ZZZ;LINKAGE=H

150 GeV, the following 95% C.L. limits are derived in units of 10^{-3}: $-1.2 < f_4^\gamma < 1.2$, $-1.0 < f_4^Z < 1.0$, $-1.2 < f_5^\gamma < 1.2$, $-1.0 < f_5^Z < 1.0$.

[4] AABOUD 18Q study $pp \to ZZ$ events at $\sqrt{s} = 13$ TeV with $Z \to e^+e^-$ or $Z \to \mu^+\mu^-$. The number of events observed in the $4e$, $2e\,2\mu$, and 4μ channels is 249, 465, and 303 respectively. Analysing the p_T spectrum of the leading Z boson, the following the following 95% C.L. limits are derived in units of 10^{-4}: $-1.8 < f_4^\gamma < 1.8$, $-1.5 < f_4^Z < 1.5$, $-1.8 < f_5^\gamma < 1.8$, $-1.5 < f_5^Z < 1.5$. NODE=S044ZZZ;LINKAGE=F

[5] SIRUNYAN 18BT study $ppZZ$ events at $\sqrt{s} = 13$ TeV with $Z \to e^+e^-$ or $Z \to \mu^+\mu^-$. The number of events observed in the $4e$, $2e2\mu$, and 4μ channels is 220, 543 and 335 respectively. Analysing the 4-lepton invariant mass spectrum, the following 95% C.L. limits are derived in units of 10^{-3}: $-1.2 < f_4^\gamma < 1.3$, $-1.2 < f_4^Z < 1.0$, $-1.2 < f_5^\gamma < 1.3$, $-1.0 < f_5^Z < 1.3$. NODE=S044ZZZ;LINKAGE=G

[6] KHACHATRYAN 15B study ZZ production in 8 TeV pp collisions. In the decay modes $ZZ \to 4e$, 4μ, $2e2\mu$, 54, 75, 148 events are observed, with an expected background of 2.2 ± 0.9, 1.2 ± 0.6, and 2.4 ± 1.0 events, respectively. Analysing the 4-lepton invariant mass spectrum in the range from 110 GeV to 1200 GeV, the following 95% C.L. limits are obtained: $|f_4^Z| < 0.004$, $|f_5^Z| < 0.004$, $|f_4^\gamma| < 0.005$, $|f_5^\gamma| < 0.005$. NODE=S044ZZZ;LINKAGE=D

[7] KHACHATRYAN 15BC use the cross section measurement of the final state $pp \to ZZ \to 2\ell 2\nu$, (ℓ being an electron or a muon) at 7 and 8 TeV to put limits on these triple gauge couplings. Effective mass of the charged lepton pair is required to be in the range 83.5–98.5 GeV and the dilepton $p_T > 45$ GeV. The reduced missing E_T is required to be > 65 GeV, which takes into account the fake missing E_T due to detector effects. The numbers of e^+e^- and $\mu^+\mu^-$ events selected are 35 and 40 at 7 TeV and 176 and 271 at 8 TeV respectively. The production cross sections so obtained are in agreement with SM predictions. The following 95% C.L. limits are set: $-0.0028 < f_4^Z < 0.0032$, $-0.0037 < f_4^\gamma < 0.0033$, $-0.0029 < f_5^Z < 0.0031$, $-0.0033 < f_5^\gamma < 0.0037$. Combining with previous results (KHACHATRYAN 15B and CHATRCHYAN 13B) which include 7 TeV and 8 TeV data on the final states $pp \to ZZ \to 2\ell 2\ell'$ where ℓ and ℓ' are an electron or a muon, the best limits are $-0.0022 < f_4^Z < 0.0026$, $-0.0029 < f_4^\gamma < 0.0026$, $-0.0023 < f_5^Z < 0.0023$, $-0.0026 < f_5^\gamma < 0.0027$. NODE=S044ZZZ;LINKAGE=E

[8] AAD 13Z study ZZ production in pp collisions at $\sqrt{s} = 7$ TeV. In the $ZZ \to \ell^+\ell^-\ell'^+\ell'^-$ final state they observe a total of 66 events with an expected background of 0.9 ± 1.3. In the $ZZ \to \ell^+\ell^-\nu\nu$ final state they observe a total of 87 events with an expected background of 46.9 ± 5.2. The limits on anomalous TGCs are determined using the observed and expected numbers of these ZZ events binned in p_T^Z. The 95% C.L. are as follows: for form factor scale $\Lambda = \infty$, $-0.015 < f_4^\gamma < 0.015$, $-0.013 < f_4^Z < 0.013$, $-0.016 < f_5^\gamma < 0.015$, $-0.013 < f_5^Z < 0.013$; for form factor scale $\Lambda = 3$ TeV, $-0.022 < f_4^\gamma < 0.023$, $-0.019 < f_4^Z < 0.019$, $-0.023 < f_5^\gamma < 0.023$, $-0.020 < f_5^Z < 0.019$. NODE=S044ZZZ;LINKAGE=AA

[9] CHATRCHYAN 13B study ZZ production in pp collisions and select 54 ZZ candidates in the Z decay channel with electrons or muons with an expected background of 1.4 ± 0.5 events. The resulting 95% C.L. ranges are: $-0.013 < f_4^\gamma < 0.015$, $-0.011 < f_4^Z < 0.012$, $-0.014 < f_5^\gamma < 0.014$, $-0.012 < f_5^Z < 0.012$. NODE=S044ZZZ;LINKAGE=CH

[10] Using data collected in the center of mass energy range 192–209 GeV, SCHAEL 09 select 318 $e^+e^- \to ZZ$ events with 319.4 expected from the standard model. Using this data they derive the following 95% CL limits: $-0.321 < f_4^\gamma < 0.318$, $-0.534 < f_4^Z < 0.534$, $-0.724 < f_5^\gamma < 0.733$, $-1.194 < f_5^Z < 1.190$. NODE=S044ZZZ;LINKAGE=SC

[11] ABAZOV 08K search for ZZ and $Z\gamma^*$ events with 1 fb^{-1} $p\overline{p}$ data at $\sqrt{s} = 1.96$ TeV in $(ee)(ee)$, $(\mu\mu)(\mu\mu)$, $(ee)(\mu\mu)$ final states requiring the lepton pair masses to be > 30 GeV. They observe 1 event, which is consistent with an expected signal of 1.71 ± 0.15 events and a background of 0.13 ± 0.03 events. From this they derive the following limits, for a form factor (Λ) value of 1.2 TeV: $-0.28 < f_{40}^Z < 0.28$, $-0.31 < f_{50}^Z < 0.29$, $-0.26 < f_{40}^\gamma < 0.26$, $-0.30 < f_{50}^\gamma < 0.28$. NODE=S044ZZZ;LINKAGE=AB

[12] Using data collected at $\sqrt{s} = 183$–208 GeV, ABDALLAH 07C select 171 $e^+e^- \to ZZ$ events with $Z \to q\overline{q}$ or lepton pair (except an explicit τ pair), and 74 $e^+e^- \to Z\gamma^*$ events with a $q\overline{q}\mu^+\mu^-$ or $q\overline{q}e^+e^-$ signature, to derive 95% CL limits on f_i^V. Each limit is derived with other parameters set to zero. They report: $-0.40 < f_4^Z < 0.42$, $-0.38 < f_5^Z < 0.62$, $-0.23 < f_4^\gamma < 0.25$, $-0.52 < f_5^\gamma < 0.48$. NODE=S044ZZZ;LINKAGE=AD

[13] ABBIENDI 04C study ZZ production in e^+e^- collisions in the C.M. energy range 190–209 GeV. They select 340 events with an expected background of 180 events. Including the ABBIENDI 00N data at 183 and 189 GeV (118 events with an expected NODE=S044ZZZ;LINKAGE=BI

background of 65 events) they report the following 95% CL limits: $-0.45 < f_4^Z < 0.58$, $-0.94 < f_5^Z < 0.25$, $-0.32 < f_4^\gamma < 0.33$, and $-0.71 < f_5^\gamma < 0.59$.

[14] ACHARD 03D study Z-boson pair production in e^+e^- collisions in the C.M. energy range 200–209 GeV. They select 549 events with an expected background of 432 events. Including the ACCIARRI 99G and ACCIARRI 99O data (183 and 189 GeV respectively, 286 events with an expected background of 241 events) and the 192–202 GeV ACCIARRI 01I results (656 events, expected background of 512 events), they report the following 95% CL limits: $-0.48 \le f_4^Z \le 0.46$, $-0.36 \le f_5^Z \le 1.03$, $-0.28 \le f_4^\gamma \le 0.28$, and $-0.40 \le f_5^\gamma \le 0.47$. NODE=S044ZZZ;LINKAGE=D3

ANOMALOUS W/Z QUARTIC COUPLINGS

NODE=S044275
NODE=S044275

Revised March 2024 by M.W. Grünewald (U. College Dublin) and A. Gurtu (CERN; TIFR Mumbay).

Quartic couplings, $WWZZ$, $WWZ\gamma$, $WW\gamma\gamma$, and $ZZ\gamma\gamma$, were studied at LEP and Tevatron at energies at which the Standard Model predicts negligible contributions to multiboson production. Thus, to parametrize limits on these couplings, an effective theory approach is adopted which supplements the Standard Model Lagrangian with higher dimensional operators which include quartic couplings. The LEP collaborations chose the lowest dimensional representation of operators (dimension 6) which presumes the SU(2)×U(1) gauge symmetry is broken by means other than the conventional Higgs scalar doublet [1–3]. In this representation possible quartic couplings, a_0, a_c, a_n, are expressed in terms of the following dimension-6 operators [1,2];

$$L_6^0 = -\frac{e^2}{16\Lambda^2}\, a_0\, F^{\mu\nu}\, F_{\mu\nu}\vec{W}^{\alpha} \cdot \vec{W}_{\alpha}$$
$$L_6^c = -\frac{e^2}{16\Lambda^2}\, a_c\, F^{\mu\alpha}\, F_{\mu\beta}\vec{W}^{\beta} \cdot \vec{W}_{\alpha}$$
$$L_6^n = -i\frac{e^2}{16\Lambda^2}\, a_n\epsilon_{ijk}\, W_{\mu\alpha}^{(i)}\, W_{\nu}^{(j)}\, W^{(k)\alpha}F^{\mu\nu}$$
$$\widetilde{L}_6^0 = -\frac{e^2}{16\Lambda^2}\, \widetilde{a}_0\, F^{\mu\nu}\, \widetilde{F}_{\mu\nu}\vec{W}^{\alpha} \cdot \vec{W}_{\alpha}$$
$$\widetilde{L}_6^n = -i\frac{e^2}{16\Lambda^2}\, \widetilde{a}_n\epsilon_{ijk}\, W_{\mu\alpha}^{(i)}\, W_{\nu}^{(j)}\, W^{(k)\alpha}\widetilde{F}^{\mu\nu}$$

where F, W are photon and W fields, L_6^0 and L_6^c conserve C, P separately ($\widetilde{L}_6^0$ conserves only C) and generate anomalous $W^+W^-\gamma\gamma$ and $ZZ\gamma\gamma$ couplings, L_6^n violates CP ($\widetilde{L}_6^n$ violates both C and P) and generates an anomalous $W^+W^-Z\gamma$ coupling, and Λ is an energy scale for new physics. For the $ZZ\gamma\gamma$ coupling the CP-violating term represented by L_6^n does not contribute. These couplings are assumed to be real and to vanish at tree level in the Standard Model.

Within the same framework as above, a more recent description of the quartic couplings [3] treats the anomalous parts of the $WW\gamma\gamma$ and $ZZ\gamma\gamma$ couplings separately, leading to two sets parametrized as a_0^V/Λ^2 and a_c^V/Λ^2, where $V = W$ or Z.

With the discovery of a Higgs at the LHC in 2012, it is then useful to go to the next higher dimensional representation (dimension 8 operators) in which the gauge symmetry is broken by the conventional Higgs scalar doublet [3,4]. There are 14 operators which can contribute to the anomalous quartic coupling signal. Some of the operators have analogues in the dimension 6 scheme. The CMS collaboration, [5], have used this parametrization, in which the connections between the two schemes are also summarized:

$$\begin{aligned}
\mathcal{L}_{AQGC} = & -\frac{e^2}{8}\frac{a_0^W}{\Lambda^2}F_{\mu\nu}F^{\mu\nu}W^{+a}W_a^- \\
& -\frac{e^2}{16}\frac{a_c^W}{\Lambda^2}F_{\mu\nu}F^{\mu a}(W^{+\nu}W_a^- + W^{-\nu}W_a^+) \\
& -e^2g^2\frac{\kappa_0^W}{\Lambda^2}F_{\mu\nu}Z^{\mu\nu}W^{+a}W_a^- \\
& -\frac{e^2g^2}{2}\frac{\kappa_c^W}{\Lambda^2}F_{\mu\nu}Z^{\mu a}(W^{+\nu}W_a^- + W^{-\nu}W_a^+) \\
& +\frac{f_{T,0}}{\Lambda^4}Tr[\widehat{W}_{\mu\nu}\widehat{W}^{\mu\nu}] \times Tr[\widehat{W}_{\alpha\beta}\widehat{W}^{\alpha\beta}]
\end{aligned}$$

The energy scale of possible new physics is Λ, and $g = e/sin(\theta_W)$, e being the unit electric charge and θ_W the Weinberg angle. The field tensors are described in [3,4].

The two dimension 6 operators a_0^W/Λ^2 and a_c^W/Λ^2 are associated with the $WW\gamma\gamma$ vertex. Among dimension 8 operators, κ_0^W/Λ^2 and κ_c^W/Λ^2 are associated with the $WWZ\gamma$ vertex, whereas the parameter $f_{T,0}/\Lambda^4$ contributes to both vertices. There is a relationship between these two dimension 6 parameters and the dimension 8 parameters $f_{M,i}/\Lambda^4$ as follows [3]:

$$\frac{a_0^W}{\Lambda^2} = -\frac{4M_W^2}{g^2}\frac{f_{M,0}}{\Lambda^4} - \frac{8M_W^2}{g'^2}\frac{f_{M,2}}{\Lambda^4}$$

$$\frac{a_c^W}{\Lambda^2} = -\frac{4M_W^2}{g^2}\frac{f_{M,1}}{\Lambda^4} - \frac{8M_W^2}{g'^2}\frac{f_{M,3}}{\Lambda^4}$$

where $g' = e/cos(\theta_W)$ and M_W is the invariant mass of the W boson. This relation provides a translation between limits on dimension 6 operators $a_{0,c}^W$ and $f_{M,j}/\Lambda^4$. It is further required [4] that $f_{M,0} = 2f_{M,2}$ and $f_{M,1} = 2f_{M,3}$ which suppresses contributions to the $WWZ\gamma$ vertex. The complete set of Lagrangian contributions as presented in [4] corresponds to 19 anomalous couplings in total – $f_{S,i}$, $i = 1, 2$, $f_{M,i}$, $i = 0, \ldots, 8$ and $f_{T,i}, i = 0, \ldots, 9$ – each scaled by $1/\Lambda^4$.

Another approach to couplings is the so called K-matrix framework [7], in which the anomalous couplings can be expressed in terms of two parameters α_4 and α_5, which account for all BSM effects.

The LHC collaborations have published couplings results based on various theoretical frameworks. It is hoped that the collaborations will agree to use at least one common set of parameters to express these limits to enable the reader to make a comparison, and to allow for a possible LHC combination.

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a_0/Λ^2, a_c/Λ^2

NODE=S044AQC

NODE=S044AQC

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

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

Anomalous Z quartic couplings have also been measured by the Tevatron and LHC experiments. As discussed in the review on "Anomalous W/Z quartic couplings," the coupling parameters in the Anomalous QGC Lagrangian may relate to processes involving only the W or only to the Z or to both. Thus, results on all other AQGCs are reported together in the W listings.

NODE=S044AQC

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

[1] ABBIENDI 04L select 20 $e^+ e^- \rightarrow \nu\overline{\nu}\gamma\gamma$ acoplanar events in the energy range 180–209 GeV and 176 $e^+ e^- \rightarrow q\overline{q}\gamma\gamma$ events in the energy range 130–209 GeV. These samples are used to constrain possible anomalous $W^+W^-\gamma\gamma$ and $ZZ\gamma\gamma$ quartic couplings. Further combining with the $W^+W^-\gamma$ sample of ABBIENDI 04B the following one–parameter 95% CL limits are obtained: $-0.007 < a_0^Z/\Lambda^2 < 0.023$ GeV^{-2}, $-0.029 < a_c^Z/\Lambda^2 < 0.029$ GeV^{-2}, $-0.020 < a_0^W/\Lambda^2 < 0.020$ GeV^{-2}, $-0.052 < a_c^W/\Lambda^2 < 0.037$ GeV^{-2}. NODE=S044AQC;LINKAGE=AB

[2] In the CM energy range 183 to 209 GeV HEISTER 04A select 30 $e^+ e^- \rightarrow \nu\overline{\nu}\gamma\gamma$ events with two acoplanar, high energy and high transverse momentum photons. The photon–photon acoplanarity is required to be $> 5^\circ$, $E_\gamma/\sqrt{s} > 0.025$ (the more energetic photon having energy $> 0.2\sqrt{s}$), $p_{T_\gamma}/E_{beam} > 0.05$ and $|\cos\theta_\gamma| < 0.94$. A likelihood fit to the photon energy and recoil missing mass yields the following one–parameter 95% CL limits: $-0.012 < a_0^Z/\Lambda^2 < 0.019$ GeV^{-2}, $-0.041 < a_c^Z/\Lambda^2 < 0.044$ GeV^{-2}, $-0.060 < a_0^W/\Lambda^2 < 0.055$ GeV^{-2}, $-0.099 < a_c^W/\Lambda^2 < 0.093$ GeV^{-2}. NODE=S044AQC;LINKAGE=HE

[3] ACHARD 02G study $e^+ e^- \rightarrow Z\gamma\gamma \rightarrow q\overline{q}\gamma\gamma$ events using data at center-of-mass energies from 200 to 209 GeV. The photons are required to be isolated, each with energy >5 GeV and $|\cos\theta| < 0.97$, and the di-jet invariant mass to be compatible with that of the Z boson (74–111 GeV). Cuts on Z velocity ($\beta < 0.73$) and on the energy of the most energetic photon reduce the backgrounds due to non-resonant production of the $q\overline{q}\gamma\gamma$ state and due to ISR respectively, yielding a total of 40 candidate events of which 8.6 are expected to be due to background. The energy spectra of the least energetic photon are fitted for all ten center-of-mass energy values from 130 GeV to 209 GeV (as obtained adding to the present analysis 130–202 GeV data of ACCIARRI 01E, for a total of 137 events with an expected background of 34.1 events) to obtain the fitted values $a_0/\Lambda^2 = 0.00^{+0.02}_{-0.01}$ GeV^{-2} and $a_c/\Lambda^2 = 0.03^{+0.01}_{-0.02}$ GeV^{-2}, where the other parameter is kept fixed to its Standard Model value (0). A simultaneous fit to both parameters yields the 95% CL limits -0.02 GeV^{-2} $< a_0/\Lambda^2 < 0.03$ GeV^{-2} and -0.07 GeV^{-2} $< a_c/\Lambda^2 < 0.05$ GeV^{-2}. NODE=S044AQC;LINKAGE=C

Z REFERENCES

NODE=S044

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AAD	24L	PL B854 138705	G. Aad *et al.*	(ATLAS Collab.)	REFID=62753
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AAD	23AQ	PR D108 032015	G. Aad *et al.*	(ATLAS Collab.)	REFID=62353
AAD	23BS	PL B847 138292	G. Aad *et al.*	(ATLAS Collab.)	REFID=62479
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SIRUNYAN	19BR	PL B797 134811	A.M. Sirunyan *et al.*	(CMS Collab.)	REFID=59934
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CHATRCHYAN	13B	JHEP 1301 063	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54820
CHATRCHYAN	13BI	JHEP 1310 164	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=55426
SCHAEL	13A	PRPL 532 119	S. Schael *et al.*	(ALEPH, DELPHI, L3, OPAL+)	REFID=55475
AAD	12BX	PL B717 49	G. Aad *et al.*	(ATLAS Collab.)	REFID=54585
ABAZOV	12S	PR D85 052001	V.M. Abazov *et al.*	(D0 Collab.)	REFID=54348
CHATRCHYAN	12BN	JHEP 1212 034	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=54777
AALTONEN	11S	PRL 107 051802	T. Aaltonen *et al.*	(CDF Collab.)	REFID=16457
ABAZOV	11D	PR D84 012007	V.M. Abazov *et al.*	(D0 Collab.)	REFID=16465
CHATRCHYAN	11M	PL B701 535	S. Chatrchyan *et al.*	(CMS Collab.)	REFID=16645
ABAZOV	09L	PRL 102 201802	V.M. Abazov *et al.*	(D0 Collab.)	REFID=52865
BEDDALL	09	PL B670 300	A. Beddall, A. Beddall, A. Bingul	(UGAZ)	REFID=52611
SCHAEL	09	JHEP 0904 124	S. Schael *et al.*	(ALEPH Collab.)	REFID=52779
ABAZOV	08K	PRL 100 131801	V.M. Abazov *et al.*	(D0 Collab.)	REFID=52389
ABAZOV	07M	PL B653 378	V.M. Abazov *et al.*	(D0 Collab.)	REFID=51928
ABDALLAH	07C	EPJ C51 525	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=51839
ABDALLAH	06E	PL B639 179	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=51265
AKTAS	06	PL B632 35	A. Aktas *et al.*	(H1 Collab.)	REFID=51010
LEP-SLC	06	PRPL 427 257	ALEPH, DELPHI, L3, OPAL, SLD and working groups		REFID=51219;ERROR=1;ERROR=2
SCHAEL	06A	PL B639 192	S. Schael *et al.*	(ALEPH Collab.)	REFID=51266
ABDALLAH	05	EPJ C40 1	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=50321
ABDALLAH	05C	EPJ C44 299	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=51221
ABE	05	PRL 94 091801	K. Abe *et al.*	(SLD Collab.)	REFID=50449
ABE	05F	PR D71 112004	K. Abe *et al.*	(SLD Collab.)	REFID=50666
ACOSTA	05M	PR D71 052002	D. Acosta *et al.*	(CDF Collab.)	REFID=50721
ABBIENDI	04B	PL B580 17	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=49616
ABBIENDI	04C	EPJ C32 303	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=49627
ABBIENDI	04E	PL B586 167	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=49886
ABBIENDI	04G	EPJ C33 173	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=49915
ABBIENDI	04L	PR D70 032005	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=50050
ABDALLAH	04F	EPJ C34 109	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=49918
ABE	04C	PR D69 072003	K. Abe *et al.*	(SLD Collab.)	REFID=49963
ACHARD	04C	PL B585 42	P. Achard *et al.*	(L3 Collab.)	REFID=49832
ACHARD	04H	PL B597 119	P. Achard *et al.*	(L3 Collab.)	REFID=50107
HEISTER	04A	PL B602 31	A. Heister *et al.*	(ALEPH Collab.)	REFID=50282
ABBIENDI	03P	PL B577 18	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=49606
ABDALLAH	03H	PL B569 129	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=49548
ABDALLAH	03K	PL B576 29	J. Abdallah *et al.*	(DELPHI Collab.)	REFID=49645
ABE	03F	PRL 90 141804	K. Abe *et al.*	(SLD Collab.)	REFID=49393
ACHARD	03D	PL B572 133	P. Achard *et al.*	(L3 Collab.)	REFID=49556
ACHARD	03G	PL B577 109	P. Achard *et al.*	(L3 Collab.)	REFID=49808
ABBIENDI	02I	PL B546 29	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=48991
ABE	02G	PRL 88 151801	K. Abe *et al.*	(SLD Collab.)	REFID=48627
ACHARD	02G	PL B540 43	P. Achard *et al.*	(L3 Collab.)	REFID=48778
HEISTER	02B	PL B526 34	A. Heister *et al.*	(ALEPH Collab.)	REFID=48562
HEISTER	02C	PL B528 19	A. Heister *et al.*	(ALEPH Collab.)	REFID=48564
HEISTER	02H	EPJ C24 177	A. Heister *et al.*	(ALEPH Collab.)	REFID=48626
ABBIENDI	01A	EPJ C19 587	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=48022
ABBIENDI	01G	EPJ C18 447	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=48078
ABBIENDI	01K	PL B516 1	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=48283
ABBIENDI	01N	EPJ C20 445	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=48296
ABBIENDI	01O	EPJ C21 1	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=48364
ABE	01B	PRL 86 1162	K. Abe *et al.*	(SLD Collab.)	REFID=48042
ABE	01C	PR D63 032005	K. Abe *et al.*	(SLD Collab.)	REFID=48051
ACCIARRI	01E	PL B505 47	M. Acciarri *et al.*	(L3 Collab.)	REFID=48127
ACCIARRI	01I	PL B497 23	M. Acciarri *et al.*	(L3 Collab.)	REFID=47915
HEISTER	01	EPJ C20 401	A. Heister *et al.*	(ALEPH Collab.)	REFID=48196
HEISTER	01D	EPJ C22 201	A. Heister *et al.*	(ALEPH Collab.)	REFID=48508
ABBIENDI	00N	PL B476 256	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=47602
ABBIENDI,G	00C	EPJ C17 553	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=47850
ABE	00B	PRL 84 5945	K. Abe *et al.*	(SLD Collab.)	REFID=47651
ABE	00D	PRL 85 5059	K. Abe *et al.*	(SLD Collab.)	REFID=47880
ABREU	00	EPJ C12 225	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47374
ABREU	00B	EPJ C14 613	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47375
ABREU	00E	EPJ C14 585	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47481
ABREU	00F	EPJ C16 371	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47482
ABREU	00P	PL B475 429	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47585
ACCIARRI	00	EPJ C13 47	M. Acciarri *et al.*	(L3 Collab.)	REFID=47433
ACCIARRI	00C	EPJ C16 1	M. Acciarri *et al.*	(L3 Collab.)	REFID=47483
ACCIARRI	00J	PL B479 79	M. Acciarri *et al.*	(L3 Collab.)	REFID=47620
ACCIARRI	00Q	PL B489 93	M. Acciarri *et al.*	(L3 Collab.)	REFID=47758
BARATE	00B	EPJ C16 597	R. Barate *et al.*	(ALEPH Collab.)	REFID=47376
BARATE	00C	EPJ C14 1	R. Barate *et al.*	(ALEPH Collab.)	REFID=47377
BARATE	00O	EPJ C16 613	R. Barate *et al.*	(ALEPH Collab.)	REFID=47786
ABBIENDI	99B	EPJ C8 217	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=46595
ABBIENDI	99I	PL B447 157	G. Abbiendi *et al.*	(OPAL Collab.)	REFID=46717
ABE	99E	PR D59 052001	K. Abe *et al.*	(SLD Collab.)	REFID=46722
ABE	99L	PRL 83 1902	K. Abe *et al.*	(SLD Collab.)	REFID=47146
ABREU	99	EPJ C6 19	P. Abreu *et al.*	(DELPHI Collab.)	REFID=46534
ABREU	99B	EPJ C10 415	P. Abreu *et al.*	(DELPHI Collab.)	REFID=46594
ABREU	99J	PL B449 364	P. Abreu *et al.*	(DELPHI Collab.)	REFID=46917
ABREU	99U	PL B462 425	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47225
ABREU	99Y	EPJ C10 219	P. Abreu *et al.*	(DELPHI Collab.)	REFID=47303
ACCIARRI	99D	PL B448 152	M. Acciarri *et al.*	(L3 Collab.)	REFID=46733
ACCIARRI	99F	PL B453 94	M. Acciarri *et al.*	(L3 Collab.)	REFID=46968
ACCIARRI	99G	PL B450 281	M. Acciarri *et al.*	(L3 Collab.)	REFID=46991
ACCIARRI	99O	PL B465 363	M. Acciarri *et al.*	(L3 Collab.)	REFID=47248

ABBOTT	98M	PR D57 3817	B. Abbott *et al.*	(D0 Collab.)	REFID=46188
ABE	98D	PRL 80 660	K. Abe *et al.*	(SLD Collab.)	REFID=45885
ABE	98I	PRL 81 942	K. Abe *et al.*	(SLD Collab.)	REFID=46094
ABREU	98K	PL B423 194	P. Abreu *et al.*	(DELPHI Collab.)	REFID=46224
ABREU	98L	EPJ C5 585	P. Abreu *et al.*	(DELPHI Collab.)	REFID=46265
ACCIARRI	98G	PL B431 199	M. Acciarri *et al.*	(L3 Collab.)	REFID=45974
ACCIARRI	98H	PL B429 387	M. Acciarri *et al.*	(L3 Collab.)	REFID=46064
ACCIARRI	98U	PL B439 225	M. Acciarri *et al.*	(L3 Collab.)	REFID=46509
ACKERSTAFF	98A	EPJ C5 411	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=46263
ACKERSTAFF	98E	EPJ C1 439	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=45837
ACKERSTAFF	98O	PL B420 157	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=46029
ACKERSTAFF	98Q	EPJ C4 19	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=46145
BARATE	98O	PL B434 415	R. Barate *et al.*	(ALEPH Collab.)	REFID=46133
BARATE	98T	EPJ C4 557	R. Barate *et al.*	(ALEPH Collab.)	REFID=46149
BARATE	98V	EPJ C5 205	R. Barate *et al.*	(ALEPH Collab.)	REFID=46151
ABE	97	PRL 78 17	K. Abe *et al.*	(SLD Collab.)	REFID=45226
ABREU	97C	ZPHY C73 243	P. Abreu *et al.*	(DELPHI Collab.)	REFID=45288
ABREU	97E	PL B398 207	P. Abreu *et al.*	(DELPHI Collab.)	REFID=45322
ABREU	97G	PL B404 194	P. Abreu *et al.*	(DELPHI Collab.)	REFID=45454
ACCIARRI	97D	PL B393 465	M. Acciarri *et al.*	(L3 Collab.)	REFID=45253
ACCIARRI	97J	PL B407 351	M. Acciarri *et al.*	(L3 Collab.)	REFID=45632
ACCIARRI	97L	PL B407 389	M. Acciarri *et al.*	(L3 Collab.)	REFID=45655
ACCIARRI	97R	PL B413 167	M. Acciarri *et al.*	(L3 Collab.)	REFID=45748
ACKERSTAFF	97M	ZPHY C74 413	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=45487
ACKERSTAFF	97S	PL B412 210	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=45739
ACKERSTAFF	97T	ZPHY C76 387	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=45785
ACKERSTAFF	97W	ZPHY C76 425	K. Ackerstaff *et al.*	(OPAL Collab.)	REFID=45788
ALEXANDER	97C	ZPHY C73 379	G. Alexander *et al.*	(OPAL Collab.)	REFID=45289
ALEXANDER	97D	ZPHY C73 569	G. Alexander *et al.*	(OPAL Collab.)	REFID=45292
ALEXANDER	97E	ZPHY C73 587	G. Alexander *et al.*	(OPAL Collab.)	REFID=45293
BARATE	97D	PL B405 191	R. Barate *et al.*	(ALEPH Collab.)	REFID=45457
BARATE	97E	PL B401 150	R. Barate *et al.*	(ALEPH Collab.)	REFID=45473
BARATE	97F	PL B401 163	R. Barate *et al.*	(ALEPH Collab.)	REFID=45474
BARATE	97H	PL B402 213	R. Barate *et al.*	(ALEPH Collab.)	REFID=45480
BARATE	97J	ZPHY C74 451	R. Barate *et al.*	(ALEPH Collab.)	REFID=45490
ABREU	96R	ZPHY C72 31	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44935
ABREU	96S	PL B389 405	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44969
ABREU	96U	ZPHY C73 61	P. Abreu *et al.*	(DELPHI Collab.)	REFID=45285
ACCIARRI	96	PL B371 126	M. Acciarri *et al.*	(L3 Collab.)	REFID=44637
ADAM	96	ZPHY C69 561	W. Adam *et al.*	(DELPHI Collab.)	REFID=44627
ADAM	96B	ZPHY C70 371	W. Adam *et al.*	(DELPHI Collab.)	REFID=44629
ALEXANDER	96B	ZPHY C70 197	G. Alexander *et al.*	(OPAL Collab.)	REFID=44638
ALEXANDER	96F	PL B370 185	G. Alexander *et al.*	(OPAL Collab.)	REFID=44670
ALEXANDER	96N	PL B384 343	G. Alexander *et al.*	(OPAL Collab.)	REFID=44901
ALEXANDER	96R	ZPHY C72 1	G. Alexander *et al.*	(OPAL Collab.)	REFID=44933
BUSKULIC	96D	ZPHY C69 393	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=44677
BUSKULIC	96H	ZPHY C69 379	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=44703
BUSKULIC	96T	PL B384 449	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=44907
BUSKULIC	96Y	PL B388 648	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=44963
ABE	95J	PRL 74 2880	K. Abe *et al.*	(SLD Collab.)	REFID=44191
ABREU	95	ZPHY C65 709 (errat.)	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44104
ABREU	95D	ZPHY C66 323	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44261
ABREU	95L	ZPHY C65 587	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44390
ABREU	95M	ZPHY C65 603	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44398
ABREU	95O	ZPHY C67 543	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44457
ABREU	95R	ZPHY C68 353	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44464
ABREU	95V	ZPHY C68 541	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44538
ABREU	95W	PL B361 207	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44542
ABREU	95X	ZPHY C69 1	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44685
ACCIARRI	95B	PL B345 589	M. Acciarri *et al.*	(L3 Collab.)	REFID=44130
ACCIARRI	95C	PL B345 609	M. Acciarri *et al.*	(L3 Collab.)	REFID=44132
ACCIARRI	95G	PL B353 136	M. Acciarri *et al.*	(L3 Collab.)	REFID=44281
AKERS	95C	ZPHY C65 47	R. Akers *et al.*	(OPAL Collab.)	REFID=44157
AKERS	95U	ZPHY C67 389	R. Akers *et al.*	(OPAL Collab.)	REFID=44380
AKERS	95W	ZPHY C67 555	R. Akers *et al.*	(OPAL Collab.)	REFID=44458
AKERS	95X	ZPHY C68 1	R. Akers *et al.*	(OPAL Collab.)	REFID=44459
AKERS	95Z	ZPHY C68 203	R. Akers *et al.*	(OPAL Collab.)	REFID=44669
ALEXANDER	95D	PL B358 162	G. Alexander *et al.*	(OPAL Collab.)	REFID=44472
BUSKULIC	95R	ZPHY C69 15	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=44813
MIYABAYASHI	95	PL B347 171	K. Miyabayashi *et al.*	(TOPAZ Collab.)	REFID=44209
ABE	94C	PRL 73 25	K. Abe *et al.*	(SLD Collab.)	REFID=43754
ABREU	94B	PL B327 386	P. Abreu *et al.*	(DELPHI Collab.)	REFID=43720
ABREU	94P	PL B341 109	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44067
AKERS	94P	ZPHY C63 181	R. Akers *et al.*	(OPAL Collab.)	REFID=44059
BUSKULIC	94G	ZPHY C62 179	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=43911
BUSKULIC	94J	ZPHY C62 1	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=44011
VILAIN	94	PL B320 203	P. Vilain *et al.*	(CHARM II Collab.)	REFID=43882
ABREU	93	PL B298 236	P. Abreu *et al.*	(DELPHI Collab.)	REFID=43224
ABREU	93I	ZPHY C59 533	P. Abreu *et al.*	(DELPHI Collab.)	REFID=43506
Also		ZPHY C65 709 (errat.)	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44104
ABREU	93L	PL B318 249	P. Abreu *et al.*	(DELPHI Collab.)	REFID=43632
ACTON	93	PL B305 407	P.D. Acton *et al.*	(OPAL Collab.)	REFID=43341
ACTON	93D	ZPHY C58 219	P.D. Acton *et al.*	(OPAL Collab.)	REFID=43378
ACTON	93E	PL B311 391	P.D. Acton *et al.*	(OPAL Collab.)	REFID=43438
ADRIANI	93	PL B301 136	O. Adriani *et al.*	(L3 Collab.)	REFID=43235
ADRIANI	93I	PL B316 427	O. Adriani *et al.*	(L3 Collab.)	REFID=43540
BUSKULIC	93L	PL B313 520	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=43524
NOVIKOV	93C	PL B298 453	V.A. Novikov, L.B. Okun, M.I. Vysotsky	(ITEP)	REFID=44105
ABREU	92I	PL B277 371	P. Abreu *et al.*	(DELPHI Collab.)	REFID=41986
ABREU	92M	PL B289 199	P. Abreu *et al.*	(DELPHI Collab.)	REFID=42151
ACTON	92B	ZPHY C53 539	D.P. Acton *et al.*	(OPAL Collab.)	REFID=41956
ACTON	92L	PL B294 436	P.D. Acton *et al.*	(OPAL Collab.)	REFID=43129
ACTON	92N	PL B295 357	P.D. Acton *et al.*	(OPAL Collab.)	REFID=43139

ADEVA	92	PL B275 209	B. Adeva *et al.*	(L3 Collab.)	REFID=41885
ADRIANI	92D	PL B292 454	O. Adriani *et al.*	(L3 Collab.)	REFID=42220
ALITTI	92B	PL B276 354	J. Alitti *et al.*	(UA2 Collab.)	REFID=41821
BUSKULIC	92D	PL B292 210	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=42210
BUSKULIC	92E	PL B294 145	D. Buskulic *et al.*	(ALEPH Collab.)	REFID=42241
DECAMP	92	PRPL 216 253	D. Decamp *et al.*	(ALEPH Collab.)	REFID=41877
ABE	91E	PRL 67 1502	F. Abe *et al.*	(CDF Collab.)	REFID=41709
ABREU	91H	ZPHY C50 185	P. Abreu *et al.*	(DELPHI Collab.)	REFID=44682
ACTON	91B	PL B273 338	D.P. Acton *et al.*	(OPAL Collab.)	REFID=41878
ADACHI	91	PL B255 613	I. Adachi *et al.*	(TOPAZ Collab.)	REFID=41667
ADEVA	91I	PL B259 199	B. Adeva *et al.*	(L3 Collab.)	REFID=44683
AKRAWY	91F	PL B257 531	M.Z. Akrawy *et al.*	(OPAL Collab.)	REFID=41638
DECAMP	91B	PL B259 377	D. Decamp *et al.*	(ALEPH Collab.)	REFID=41488
DECAMP	91J	PL B266 218	D. Decamp *et al.*	(ALEPH Collab.)	REFID=41614
JACOBSEN	91	PRL 67 3347	R.G. Jacobsen *et al.*	(Mark II Collab.)	REFID=41841
SHIMONAKA	91	PL B268 457	A. Shimonaka *et al.*	(TOPAZ Collab.)	REFID=41791
ABE	90I	ZPHY C48 13	K. Abe *et al.*	(VENUS Collab.)	REFID=41507
ABRAMS	90	PRL 64 1334	G.S. Abrams *et al.*	(Mark II Collab.)	REFID=44684
AKRAWY	90J	PL B246 285	M.Z. Akrawy *et al.*	(OPAL Collab.)	REFID=41336
BEHREND	90D	ZPHY C47 333	H.J. Behrend *et al.*	(CELLO Collab.)	REFID=41735
BRAUNSCH...	90	ZPHY C48 433	W. Braunschweig *et al.*	(TASSO Collab.)	REFID=41736
ELSEN	90	ZPHY C46 349	E. Elsen *et al.*	(JADE Collab.)	REFID=41049
HEGNER	90	ZPHY C46 547	S. Hegner *et al.*	(JADE Collab.)	REFID=41734
STUART	90	PRL 64 983	D. Stuart *et al.*	(AMY Collab.)	REFID=41898
ABE	89	PRL 62 613	F. Abe *et al.*	(CDF Collab.)	REFID=40629
ABE	89C	PRL 63 720	F. Abe *et al.*	(CDF Collab.)	REFID=40793
ABE	89L	PL B232 425	K. Abe *et al.*	(VENUS Collab.)	REFID=41058
ABRAMS	89B	PRL 63 2173	G.S. Abrams *et al.*	(Mark II Collab.)	REFID=40962
ABRAMS	89D	PRL 63 2780	G.S. Abrams *et al.*	(Mark II Collab.)	REFID=40989
ALBAJAR	89	ZPHY C44 15	C. Albajar *et al.*	(UA1 Collab.)	REFID=40860
BACALA	89	PL B218 112	A. Bacala *et al.*	(AMY Collab.)	REFID=40805
BAND	89	PL B218 369	H.R. Band *et al.*	(MAC Collab.)	REFID=40807
GREENSHAW	89	ZPHY C42 1	T. Greenshaw *et al.*	(JADE Collab.)	REFID=40853
OULD-SAADA	89	ZPHY C44 567	F. Ould-Saada *et al.*	(JADE Collab.)	REFID=40965
SAGAWA	89	PRL 63 2341	H. Sagawa *et al.*	(AMY Collab.)	REFID=40979
ADACHI	88C	PL B208 319	I. Adachi *et al.*	(TOPAZ Collab.)	REFID=40766
ADEVA	88	PR D38 2665	B. Adeva *et al.*	(Mark-J Collab.)	REFID=40686
BRAUNSCH...	88D	ZPHY C40 163	W. Braunschweig *et al.*	(TASSO Collab.)	REFID=40697
ANSARI	87	PL B186 440	R. Ansari *et al.*	(UA2 Collab.)	REFID=40199
BEHREND	87C	PL B191 209	H.J. Behrend *et al.*	(CELLO Collab.)	REFID=40203
BARTEL	86C	ZPHY C30 371	W. Bartel *et al.*	(JADE Collab.)	REFID=40179
Also		ZPHY C26 507	W. Bartel *et al.*	(JADE Collab.)	REFID=10047
Also		PL 108B 140	W. Bartel *et al.*	(JADE Collab.)	REFID=10033
ASH	85	PRL 55 1831	W.W. Ash *et al.*	(MAC Collab.)	REFID=10046
BARTEL	85F	PL 161B 188	W. Bartel *et al.*	(JADE Collab.)	REFID=10342
DERRICK	85	PR D31 2352	M. Derrick *et al.*	(HRS Collab.)	REFID=10049
FERNANDEZ	85A	PRL 54 1620	E. Fernandez *et al.*	(MAC Collab.)	REFID=62037
LEVI	83	PRL 51 1941	M.E. Levi *et al.*	(Mark II Collab.)	REFID=41536
BEHREND	82	PL 114B 282	H.J. Behrend *et al.*	(CELLO Collab.)	REFID=10324
BRANDELIK	82C	PL 110B 173	R. Brandelik *et al.*	(TASSO Collab.)	REFID=41537