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### Z MASS

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

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

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

<sup>1</sup> ABBIENDI 01A error includes approximately 2.3 MeV due to statistics and 1.8 MeV due to LEP energy uncertainty.

<sup>2</sup> The error includes 1.6 MeV due to LEP energy uncertainty.

<sup>3</sup> The error includes 1.8 MeV due to LEP energy uncertainty.

<sup>4</sup> 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.

<sup>5</sup> 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.

- <sup>6</sup> ACHARD 04C select  $e^+e^- \rightarrow Z\gamma$  events with hard initial–state radiation.  $Z$  decays to  $q\bar{q}$  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.
- <sup>7</sup> 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  $\gamma/Z$  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  $\pm 2.3$  MeV due to the uncertainty on the  $\gamma Z$  interference.
- <sup>8</sup> 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.
- <sup>9</sup> Enters fit through  $W/Z$  mass ratio given in the  $W$  Particle Listings. The ALITTI 92B systematic error ( $\pm 0.93$ ) has two contributions: one ( $\pm 0.92$ ) cancels in  $m_W/m_Z$  and one ( $\pm 0.12$ ) is noncancelling. These were added in quadrature.
- <sup>10</sup> First error of ABE 89 is combination of statistical and systematic contributions; second is mass scale uncertainty.
- <sup>11</sup> ABRAMS 89B uncertainty includes 35 MeV due to the absolute energy measurement.
- <sup>12</sup> ALBAJAR 89 result is from a total sample of 33  $Z \rightarrow e^+e^-$  events.

## Z WIDTH

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the “Note on the  $Z$  boson”).

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

- <sup>13</sup> 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.
- <sup>14</sup> The error includes 1.2 MeV due to LEP energy uncertainty.
- <sup>15</sup> The error includes 1.3 MeV due to LEP energy uncertainty.
- <sup>16</sup> 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.
- <sup>17</sup> 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.
- <sup>18</sup> 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  $\gamma/Z$  interference term. The authors have corrected the measurement for the 0.9 MeV shift with respect to the Breit-Wigner fits.
- <sup>19</sup> ABREU 96R obtain this value from a study of the interference between initial and final state radiation in the process  $e^+e^- \rightarrow Z \rightarrow \mu^+\mu^-$ .
- <sup>20</sup> ABRAMS 89B uncertainty includes 50 MeV due to the miniSAM background subtraction error.
- <sup>21</sup> ALBAJAR 89 result is from a total sample of 33  $Z \rightarrow e^+e^-$  events.
- <sup>22</sup> Quoted values of ANSARI 87 are from direct fit. Ratio of Z and W production gives either  $\Gamma(Z) < (1.09 \pm 0.07) \times \Gamma(W)$ , CL = 90% or  $\Gamma(Z) = (0.82^{+0.19}_{-0.14} \pm 0.06) \times \Gamma(W)$ . Assuming Standard-Model value  $\Gamma(W) = 2.65$  GeV then gives  $\Gamma(Z) < 2.89 \pm 0.19$  or  $= 2.17^{+0.50}_{-0.37} \pm 0.16$ .

## Z DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )	Scale factor/ Confidence level
$\Gamma_1$ $e^+e^-$	( 3.363 $\pm$ 0.004 ) %	
$\Gamma_2$ $\mu^+\mu^-$	( 3.366 $\pm$ 0.007 ) %	
$\Gamma_3$ $\tau^+\tau^-$	( 3.370 $\pm$ 0.008 ) %	
$\Gamma_4$ $\ell^+\ell^-$	[a] ( 3.3658 $\pm$ 0.0023) %	
$\Gamma_5$ invisible	(20.00 $\pm$ 0.06 ) %	
$\Gamma_6$ hadrons	(69.91 $\pm$ 0.06 ) %	
$\Gamma_7$ $(u\bar{u} + c\bar{c})/2$	(11.6 $\pm$ 0.6 ) %	
$\Gamma_8$ $(d\bar{d} + s\bar{s} + b\bar{b})/3$	(15.6 $\pm$ 0.4 ) %	
$\Gamma_9$ $c\bar{c}$	(11.79 $\pm$ 0.33 ) %	
$\Gamma_{10}$ $b\bar{b}$	(15.13 $\pm$ 0.05 ) %	
$\Gamma_{11}$ $b\bar{b}b\bar{b}$	( 3.6 $\pm$ 1.3 ) $\times 10^{-4}$	
$\Gamma_{12}$ $ggg$	< 1.1	% CL=95%
$\Gamma_{13}$ $\pi^0\gamma$	< 5.2	$\times 10^{-5}$ CL=95%
$\Gamma_{14}$ $\eta\gamma$	< 5.1	$\times 10^{-5}$ CL=95%
$\Gamma_{15}$ $\omega\gamma$	< 6.5	$\times 10^{-4}$ CL=95%
$\Gamma_{16}$ $\eta'(958)\gamma$	< 4.2	$\times 10^{-5}$ CL=95%
$\Gamma_{17}$ $\gamma\gamma$	< 5.2	$\times 10^{-5}$ CL=95%
$\Gamma_{18}$ $\gamma\gamma\gamma$	< 1.0	$\times 10^{-5}$ CL=95%
$\Gamma_{19}$ $\pi^\pm W^\mp$	[b] < 7	$\times 10^{-5}$ CL=95%

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

[a]  $\ell$  indicates each type of lepton ( $e$ ,  $\mu$ , and  $\tau$ ), not sum over them.

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

[c] See the Particle Listings below for the  $\gamma$  energy range used in this measurement.

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

## Z PARTIAL WIDTHS

### $\Gamma(e^+e^-)$

$\Gamma_1$

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

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>83.91±0.12 OUR FIT</b>				
83.66±0.20	137.0K	ABBIENDI	01A OPAL	$E_{cm}^{ee} = 88-94$ GeV
83.54±0.27	117.8k	ABREU	00F DLPH	$E_{cm}^{ee} = 88-94$ GeV
84.16±0.22	124.4k	ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
83.88±0.19		BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV
82.89±1.20±0.89		<sup>23</sup> ABE	95J SLD	$E_{cm}^{ee} = 91.31$ GeV

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

### $\Gamma(\mu^+\mu^-)$

$\Gamma_2$

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

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

### $\Gamma(\tau^+\tau^-)$

$\Gamma_3$

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

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

### $\Gamma(\ell^+\ell^-)$

$\Gamma_4$

In our fit  $\Gamma(\ell^+\ell^-)$  is defined as the partial Z width for the decay into a pair of massless charged leptons. This parameter is not directly used in the 5-parameter fit assuming lepton universality but is derived using the fit results. See the 'Note on the Z Boson.'

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

## $\Gamma(\text{invisible})$

$\Gamma_5$

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

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

<sup>24</sup> This is an indirect determination of  $\Gamma(\text{invisible})$  from a fit to the visible  $Z$  decay modes.

## $\Gamma(\text{hadrons})$

$\Gamma_6$

This parameter is not directly used in the 5-parameter fit assuming lepton universality, but is derived using the fit results. See the 'Note on the  $Z$  Boson.'

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

## Z BRANCHING RATIOS

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the "Note on the  $Z$  boson").

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

$\Gamma_6/\Gamma_1$

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

- <sup>25</sup> 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.
- <sup>26</sup> 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.
- <sup>27</sup> ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.

### $\Gamma(\text{hadrons})/\Gamma(\mu^+\mu^-)$ $\Gamma_6/\Gamma_2$

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the "Note on the Z boson").

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>20.785 ± 0.033 OUR FIT</b>				
20.811 ± 0.058	182.8K	<sup>28</sup> ABBIENDI	01A OPAL	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
20.65 ± 0.08	157.6k	ABREU	00F DLPH	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
20.861 ± 0.097	113.4k	ACCIARRI	00C L3	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
20.799 ± 0.056		<sup>29</sup> BARATE	00C ALEP	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

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

18.9 $\begin{smallmatrix} +7.1 \\ -5.3 \end{smallmatrix}$	13	<sup>30</sup> ABRAMS	89D MRK2	$E_{\text{cm}}^{ee} = 89\text{--}93$ GeV
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- <sup>28</sup> ABBIENDI 01A error includes approximately 0.050 due to statistics and 0.027 due to event selection systematics.
- <sup>29</sup> BARATE 00C error includes approximately 0.053 due to statistics and 0.021 due to experimental systematics.
- <sup>30</sup> ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.

### $\Gamma(\text{hadrons})/\Gamma(\tau^+\tau^-)$ $\Gamma_6/\Gamma_3$

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the "Note on the Z boson").

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>20.764 ± 0.045 OUR FIT</b>				
20.832 ± 0.091	151.5K	<sup>31</sup> ABBIENDI	01A OPAL	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
20.84 ± 0.13	104.0k	ABREU	00F DLPH	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
20.792 ± 0.133	103.0k	ACCIARRI	00C L3	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
20.707 ± 0.062		<sup>32</sup> BARATE	00C ALEP	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

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

15.2 $\begin{smallmatrix} +4.8 \\ -3.9 \end{smallmatrix}$	21	<sup>33</sup> ABRAMS	89D MRK2	$E_{\text{cm}}^{ee} = 89\text{--}93$ GeV
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- <sup>31</sup> ABBIENDI 01A error includes approximately 0.055 due to statistics and 0.071 due to event selection systematics.
- <sup>32</sup> BARATE 00C error includes approximately 0.054 due to statistics and 0.033 due to experimental systematics.
- <sup>33</sup> ABRAMS 89D have included both statistical and systematic uncertainties in their quoted errors.

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

$\Gamma_6/\Gamma_4$

$\ell$  indicates each type of lepton ( $e$ ,  $\mu$ , and  $\tau$ ), not sum over them.

Our fit result is obtained requiring lepton universality.

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

<sup>34</sup> ABBIENDI 01A error includes approximately 0.034 due to statistics and 0.027 due to event selection systematics.

<sup>35</sup> BARATE 00C error includes approximately 0.033 due to statistics, 0.020 due to experimental systematics, and 0.005 due to the theoretical uncertainty in  $t$ -channel prediction.

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

$\Gamma_6/\Gamma$

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>
<b>69.911 ± 0.056 OUR FIT</b>	

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

$\Gamma_1/\Gamma$

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>
<b>3.3632 ± 0.0042 OUR FIT</b>	

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

$\Gamma_2/\Gamma$

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>
<b>3.3662 ± 0.0066 OUR FIT</b>	

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

$\Gamma_3/\Gamma$

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>
<b>3.3696 ± 0.0083 OUR FIT</b>	

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

$\Gamma_4/\Gamma$

$\ell$  indicates each type of lepton ( $e$ ,  $\mu$ , and  $\tau$ ), not sum over them.

Our fit result assumes lepton universality.

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

<u>VALUE (%)</u>	<u>DOCUMENT ID</u>
<b>3.3658 ± 0.0023 OUR FIT</b>	



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

$\Gamma_5/\Gamma$

See the data, the note, and the fit result for the partial width,  $\Gamma_5$ , above.

VALUE (%)

DOCUMENT ID

**20.000 ± 0.055 OUR FIT**

### $\Gamma(\mu^+ \mu^-)/\Gamma(e^+ e^-)$

$\Gamma_2/\Gamma_1$

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

VALUE

DOCUMENT ID

**1.0009 ± 0.0028 OUR FIT**

### $\Gamma(\tau^+ \tau^-)/\Gamma(e^+ e^-)$

$\Gamma_3/\Gamma_1$

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

VALUE

DOCUMENT ID

**1.0019 ± 0.0032 OUR FIT**

### $\Gamma((u\bar{u} + c\bar{c})/2)/\Gamma(\text{hadrons})$

$\Gamma_7/\Gamma_6$

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

VALUE

DOCUMENT ID

TECN

COMMENT

**0.166 ± 0.009 OUR AVERAGE**

0.172<sup>+0.011</sup><sub>-0.010</sub>

36 ABBIENDI 04E OPAL  $E_{\text{cm}}^{ee} = 91.2$  GeV

0.160 ± 0.019 ± 0.019

37 ACKERSTAFF 97T OPAL  $E_{\text{cm}}^{ee} = 88-94$  GeV

0.137<sup>+0.038</sup><sub>-0.054</sub>

38 ABREU 95X DLPH  $E_{\text{cm}}^{ee} = 88-94$  GeV

0.137 ± 0.033

39 ADRIANI 93 L3  $E_{\text{cm}}^{ee} = 91.2$  GeV

<sup>36</sup> 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.

<sup>37</sup> ACKERSTAFF 97T measure  $\Gamma_{u\bar{u}}/(\Gamma_{d\bar{d}} + \Gamma_{u\bar{u}} + \Gamma_{s\bar{s}}) = 0.258 \pm 0.031 \pm 0.032$ . 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  $\Gamma_{d\bar{d},s\bar{s}}/(\Gamma_{d\bar{d}} + \Gamma_{u\bar{u}} + \Gamma_{s\bar{s}})$  given in the next data block.

<sup>38</sup> 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  $(3C_{1/3} + 2C_{2/3}) = 6.66 \pm 0.05$ .

<sup>39</sup> 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  $(3C_{1/3} + 2C_{2/3}) = 6.720 \pm 0.076$ .

## $\Gamma((d\bar{d}+s\bar{s}+b\bar{b})/3)/\Gamma(\text{hadrons})$ $\Gamma_8/\Gamma_6$

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

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

<sup>40</sup> 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  $\Gamma_d = 381 \pm 12$  MeV.

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

<sup>42</sup> 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  $C_{1/3} = 1.62^{+0.24}_{-0.17}$  by their value of  $(3C_{1/3} + 2C_{2/3}) = 6.66 \pm 0.05$ .

<sup>43</sup> 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  $C_{1/3} = 1.63 \pm 0.15$  by their value of  $(3C_{1/3} + 2C_{2/3}) = 6.720 \pm 0.076$ .

## $R_c = \Gamma(c\bar{c})/\Gamma(\text{hadrons})$ $\Gamma_9/\Gamma_6$

OUR FIT is obtained by a simultaneous fit to several  $c$ - and  $b$ -quark measurements as explained in the “Note on the  $Z$  boson.” As a cross check we have also performed a weighted average of the  $R_c$  measurements. Taking into account the various common systematic errors, we obtain  $R_c = 0.1686 \pm 0.0069$ .

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.1686±0.0047 OUR FIT</b>			
0.1665±0.0051±0.0081	44	ABREU 00	DLPH $E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
0.1698±0.0069	45	BARATE 00B	ALEP $E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
0.180 ±0.011 ±0.013	46	ACKERSTAFF 98E	OPAL $E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
0.167 ±0.011 ±0.012	47	ALEXANDER 96R	OPAL $E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.1675±0.0062±0.0103	48	BARATE 98T	ALEP Repl. by BARATE 00B
0.1689±0.0095±0.0068	49	BARATE 98T	ALEP Repl. by BARATE 00B
0.1623±0.0085±0.0209	50	ABREU 95D	DLPH $E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
0.142 ±0.008 ±0.014	51	AKERS 95O	OPAL Repl. by ACKERSTAFF 98E
0.165 ±0.005 ±0.020	52	BUSKULIC 94G	ALEP Repl. by BARATE 00B

- 44 ABREU 00 obtain this result properly combining the measurement from the  $D^{*+}$  production rate ( $R_C = 0.1610 \pm 0.0104 \pm 0.0077 \pm 0.0043$  (BR)) with that from the overall charm counting ( $R_C = 0.1692 \pm 0.0047 \pm 0.0063 \pm 0.0074$  (BR)) in  $c\bar{c}$  events. The systematic error includes an uncertainty of  $\pm 0.0054$  due to the uncertainty on the charmed hadron branching fractions.
- 45 BARATE 00B use exclusive decay modes to independently determine the quantities  $R_C \times f(c \rightarrow X)$ ,  $X = D^0, D^+, D_s^+$ , and  $\Lambda_c$ . Estimating  $R_C \times f(c \rightarrow \Xi_c / \Omega_c) = 0.0034$ , they simply sum over all the charm decays to obtain  $R_C = 0.1738 \pm 0.0047 \pm 0.0088 \pm 0.0075$  (BR). This is combined with all previous ALEPH measurements (BARATE 98T and BUSKULIC 94G,  $R_C = 0.1681 \pm 0.0054 \pm 0.0062$ ) to obtain the quoted value.
- 46 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  $\pm 0.006$  due to the external branching ratios.
- 47 ALEXANDER 96R obtain this value via direct charm counting, summing the partial contributions from  $D^0, D^+, D_s^+$ , and  $\Lambda_c^+$ , and assuming that strange-charmed baryons account for the 15% of the  $\Lambda_c^+$  production. An uncertainty of  $\pm 0.005$  due to the uncertainties in the charm hadron branching ratios is included in the overall systematics.
- 48 BARATE 98T perform a simultaneous fit to the  $p$  and  $p_T$  spectra of electrons from hadronic  $Z$  decays. The semileptonic branching ratio  $B(c \rightarrow e)$  is taken as  $0.098 \pm 0.005$  and the systematic error includes an uncertainty of  $\pm 0.0084$  due to this.
- 49 BARATE 98T obtain this result combining two double-tagging techniques. Searching for a  $D$  meson in each hemisphere by full reconstruction in an exclusive decay mode gives  $R_C = 0.173 \pm 0.014 \pm 0.0009$ . The same tag in combination with inclusive identification using the slow pion from the  $D^{*+} \rightarrow D^0 \pi^+$  decay in the opposite hemisphere yields  $R_C = 0.166 \pm 0.012 \pm 0.009$ . The  $R_b$  dependence is given by  $R_C = 0.1689 - 0.023 \times (R_b - 0.2159)$ . The three measurements of BARATE 98T are combined with BUSKULIC 94G to give the average  $R_C = 0.1681 \pm 0.0054 \pm 0.0062$ .
- 50 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  $\pm 0.0124$  due to models and branching ratios.
- 51 AKERS 95O use the presence of a  $D^{*\pm}$  to tag  $Z \rightarrow c\bar{c}$  with  $D^* \rightarrow D^0 \pi$  and  $D^0 \rightarrow K\pi$ . They measure  $P_C * \Gamma(c\bar{c}) / \Gamma(\text{hadrons})$  to be  $(1.006 \pm 0.055 \pm 0.061) \times 10^{-3}$ , where  $P_C$  is the product branching ratio  $B(c \rightarrow D^*)B(D^* \rightarrow D^0 \pi)B(D^0 \rightarrow K\pi)$ . Assuming that  $P_C$  remains unchanged with energy, they use its value  $(7.1 \pm 0.5) \times 10^{-3}$  determined at CESR/PETRA to obtain  $\Gamma(c\bar{c}) / \Gamma(\text{hadrons})$ . The second error of AKERS 95O includes an uncertainty of  $\pm 0.011$  from the uncertainty on  $P_C$ .
- 52 BUSKULIC 94G perform a simultaneous fit to the  $p$  and  $p_T$  spectra of both single and dilepton events.

### $R_b = \Gamma(b\bar{b}) / \Gamma(\text{hadrons})$

$\Gamma_{10} / \Gamma_6$

OUR FIT is obtained by a simultaneous fit to several  $c$ - and  $b$ -quark measurements as explained in the "Note on the  $Z$  boson." As a cross check we have also performed a weighted average of the  $R_b$  measurements taking into account the various common systematic errors. For  $R_C = 0.1686$  (as given by OUR FIT above), we obtain  $R_b = 0.21635 \pm 0.00075$ . For an expected Standard Model value of  $R_C = 0.1723$ , our weighted average gives  $R_b = 0.21627 \pm 0.00075$ .

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.21643±0.00072 OUR FIT</b>			
0.2174 ±0.0015 ±0.0028	<sup>53</sup> ACCIARRI	00 L3	$E_{cm}^{ee} = 89-93$ GeV
0.2178 ±0.0011 ±0.0013	<sup>54</sup> ABBIENDI	99B OPAL	$E_{cm}^{ee} = 88-94$ GeV
0.21634±0.00067±0.00060	<sup>55</sup> ABREU	99B DLPH	$E_{cm}^{ee} = 88-94$ GeV
0.2142 ±0.0034 ±0.0015	<sup>56</sup> ABE	98D SLD	$E_{cm}^{ee} = 91.2$ GeV
0.2159 ±0.0009 ±0.0011	<sup>57</sup> BARATE	97F ALEP	$E_{cm}^{ee} = 88-94$ GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.2175 ±0.0014 ±0.0017	<sup>58</sup> ACKERSTAFF	97K OPAL	Repl. by ABBIENDI 99B
0.2167 ±0.0011 ±0.0013	<sup>59</sup> BARATE	97E ALEP	$E_{cm}^{ee} = 88-94$ GeV
0.229 ±0.011	<sup>60</sup> ABE	96E SLD	Repl. by ABE 98D
0.2216 ±0.0016 ±0.0021	<sup>61</sup> ABREU	96 DLPH	Repl. by ABREU 99B
0.2145 ±0.0089 ±0.0067	<sup>62</sup> ABREU	95D DLPH	$E_{cm}^{ee} = 88-94$ GeV
0.219 ±0.006 ±0.005	<sup>63</sup> BUSKULIC	94G ALEP	$E_{cm}^{ee} = 88-94$ GeV
0.251 ±0.049 ±0.030	<sup>64</sup> JACOBSEN	91 MRK2	$E_{cm}^{ee} = 91$ GeV

<sup>53</sup> 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.

<sup>54</sup> ABBIENDI 99B tag  $Z \rightarrow b\bar{b}$  decays using leptons and/or separated decay vertices. The  $b$ -tagging efficiency is measured directly from the data using a double-tagging technique.

<sup>55</sup> 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  $-0.024 \times (R_c - 0.172)$ .

<sup>56</sup> ABE 98D use a double tag based on 3D impact parameter with reconstruction of secondary vertices. The charm background is reduced by requiring the invariant mass at the secondary vertex to be above 2 GeV. The systematic error includes an uncertainty of  $\pm 0.0002$  due to the uncertainty on  $R_c$ .

<sup>57</sup> BARATE 97F combine the lifetime-mass hemisphere tag (BARATE 97E) with event shape information and lepton tag to identify  $Z \rightarrow b\bar{b}$  candidates. They further use  $c$ - and  $uds$ -selection tags to identify the background. For  $R_c$  different from its Standard Model value of 0.172,  $R_b$  varies as  $-0.019 \times (R_c - 0.172)$ .

<sup>58</sup> ACKERSTAFF 97K use lepton and/or separated decay vertex to tag independently each hemisphere. Comparing the numbers of single- and double-tagged events, they determine the  $b$ -tagging efficiency directly from the data.

<sup>59</sup> BARATE 97E combine a lifetime tag with a mass cut based on the mass difference between  $c$  hadrons and  $b$  hadrons. Included in BARATE 97F.

<sup>60</sup> ABE 96E obtain this value by combining results from three different  $b$ -tagging methods (2D impact parameter, 3D impact parameter, and 3D displaced vertex).

<sup>61</sup> ABREU 96 obtain this result combining several analyses (double lifetime tag, mixed tag and multivariate analysis). This value is obtained assuming  $R_c = \Gamma(c\bar{c})/\Gamma(\text{hadrons}) = 0.172$ . For a value of  $R_c$  different from this by an amount  $\Delta R_c$  the change in the value is given by  $-0.087 \cdot \Delta R_c$ .

<sup>62</sup> 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  $\pm 0.0023$  due to models and branching ratios.

<sup>63</sup> BUSKULIC 94G perform a simultaneous fit to the  $p$  and  $p_T$  spectra of both single and dilepton events.

<sup>64</sup> JACOBSEN 91 tagged  $b\bar{b}$  events by requiring coincidence of  $\geq 3$  tracks with significant impact parameters using vertex detector. Systematic error includes lifetime and decay uncertainties ( $\pm 0.014$ ).

### $\Gamma(b\bar{b}b\bar{b})/\Gamma(\text{hadrons})$

$\Gamma_{11}/\Gamma_6$

VALUE (units $10^{-4}$ )	DOCUMENT ID	TECN	COMMENT
<b><math>5.2 \pm 1.9</math> OUR AVERAGE</b>			
$3.6 \pm 1.7 \pm 2.7$	<sup>65</sup> ABBIENDI	01G OPAL	$E_{\text{cm}}^{ee} = 88-94$ GeV
$6.0 \pm 1.9 \pm 1.4$	<sup>66</sup> ABREU	99U DLPH	$E_{\text{cm}}^{ee} = 88-94$ GeV

<sup>65</sup> ABBIENDI 01G use a sample of four-jet events from hadronic  $Z$  decays. To enhance the  $b\bar{b}b\bar{b}$  signal, at least three of the four jets are required to have a significantly detached secondary vertex.

<sup>66</sup> ABREU 99U force hadronic  $Z$  decays into 3jets to use all the available phase space and require a  $b$  tag for every jet. This decay mode includes primary and secondary  $4b$  production, e.g. from gluon splitting to  $b\bar{b}$ .

### $\Gamma(ggg)/\Gamma(\text{hadrons})$

$\Gamma_{12}/\Gamma_6$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b><math>&lt; 1.6 \times 10^{-2}</math></b>	95	<sup>67</sup> ABREU	96S DLPH	$E_{\text{cm}}^{ee} = 88-94$ GeV

<sup>67</sup> 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  $1.5 \times 10^{-2}$ .

### $\Gamma(\pi^0\gamma)/\Gamma_{\text{total}}$

$\Gamma_{13}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b><math>&lt; 5.2 \times 10^{-5}</math></b>	95	<sup>68</sup> ACCIARRI	95G L3	$E_{\text{cm}}^{ee} = 88-94$ GeV
$< 5.5 \times 10^{-5}$	95	ABREU	94B DLPH	$E_{\text{cm}}^{ee} = 88-94$ GeV
$< 2.1 \times 10^{-4}$	95	DECAMP	92 ALEP	$E_{\text{cm}}^{ee} = 88-94$ GeV
$< 1.4 \times 10^{-4}$	95	AKRAWY	91F OPAL	$E_{\text{cm}}^{ee} = 88-94$ GeV

<sup>68</sup> This limit is for both decay modes  $Z \rightarrow \pi^0\gamma/\gamma\gamma$  which are indistinguishable in ACCIARRI 95G.

### $\Gamma(\eta\gamma)/\Gamma_{\text{total}}$

$\Gamma_{14}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$< 7.6 \times 10^{-5}$	95	ACCIARRI	95G L3	$E_{\text{cm}}^{ee} = 88-94$ GeV
$< 8.0 \times 10^{-5}$	95	ABREU	94B DLPH	$E_{\text{cm}}^{ee} = 88-94$ GeV
<b><math>&lt; 5.1 \times 10^{-5}</math></b>	95	DECAMP	92 ALEP	$E_{\text{cm}}^{ee} = 88-94$ GeV
$< 2.0 \times 10^{-4}$	95	AKRAWY	91F OPAL	$E_{\text{cm}}^{ee} = 88-94$ GeV

### $\Gamma(\omega\gamma)/\Gamma_{\text{total}}$

$\Gamma_{15}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b><math>&lt; 6.5 \times 10^{-4}</math></b>	95	ABREU	94B DLPH	$E_{\text{cm}}^{ee} = 88-94$ GeV

### $\Gamma(\eta'(958)\gamma)/\Gamma_{\text{total}}$

$\Gamma_{16}/\Gamma$

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
<b><math>&lt; 4.2 \times 10^{-5}</math></b>	95	DECAMP	92 ALEP	$E_{\text{cm}}^{ee} = 88-94$ GeV

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

This decay would violate the Landau-Yang theorem.

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;5.2 \times 10^{-5}</math></b>	95	<sup>69</sup> ACCIARRI	95G L3	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
$<5.5 \times 10^{-5}$	95	ABREU	94B DLPH	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
$<1.4 \times 10^{-4}$	95	AKRAWY	91F OPAL	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

<sup>69</sup> This limit is for both decay modes  $Z \rightarrow \pi^0 \gamma/\gamma\gamma$  which are indistinguishable in ACCIARRI 95G.

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;1.0 \times 10^{-5}</math></b>	95	<sup>70</sup> ACCIARRI	95C L3	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
$<1.7 \times 10^{-5}$	95	<sup>70</sup> ABREU	94B DLPH	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
$<6.6 \times 10^{-5}$	95	AKRAWY	91F OPAL	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

<sup>70</sup> Limit derived in the context of composite  $Z$  model.

**$\Gamma(\pi^\pm W^\mp)/\Gamma_{\text{total}}$**   **$\Gamma_{19}/\Gamma$**

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;7 \times 10^{-5}</math></b>	95	DECAMP	92 ALEP	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

**$\Gamma(\rho^\pm W^\mp)/\Gamma_{\text{total}}$**   **$\Gamma_{20}/\Gamma$**

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt;8.3 \times 10^{-5}</math></b>	95	DECAMP	92 ALEP	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

**$\Gamma(J/\psi(1S)X)/\Gamma_{\text{total}}$**   **$\Gamma_{21}/\Gamma$**

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
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**$3.51^{+0.23}_{-0.25}$  OUR AVERAGE** Error includes scale factor of 1.1.

$3.21 \pm 0.21^{+0.19}_{-0.28}$	553	<sup>71</sup> ACCIARRI	99F L3	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
$3.9 \pm 0.2 \pm 0.3$	511	<sup>72</sup> ALEXANDER	96B OPAL	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
$3.73 \pm 0.39 \pm 0.36$	153	<sup>73</sup> ABREU	94P DLPH	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

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

$3.40 \pm 0.23 \pm 0.27$	441	<sup>74</sup> ACCIARRI	97J L3	Repl. by ACCIARRI 99F
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<sup>71</sup> ACCIARRI 99F combine  $\mu^+ \mu^-$  and  $e^+ e^- J/\psi(1S)$  decay channels. The branching ratio for prompt  $J/\psi(1S)$  production is measured to be  $(2.1 \pm 0.6 \pm 0.4^{+0.4}_{-0.2}(\text{theor.})) \times 10^{-4}$ .

<sup>72</sup> ALEXANDER 96B identify  $J/\psi(1S)$  from the decays into lepton pairs.  $(4.8 \pm 2.4)\%$  of this branching ratio is due to prompt  $J/\psi(1S)$  production (ALEXANDER 96N).

<sup>73</sup> 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.

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

**$\Gamma(\psi(2S)X)/\Gamma_{\text{total}}$**   **$\Gamma_{22}/\Gamma$**

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.60±0.29 OUR AVERAGE</b>				
1.6 ±0.5 ±0.3	39	<sup>75</sup> ACCIARRI	97J L3	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
1.6 ±0.3 ±0.2	46.9	<sup>76</sup> ALEXANDER	96B OPAL	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
1.60±0.73±0.33	5.4	<sup>77</sup> ABREU	94P DLPH	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

<sup>75</sup> ACCIARRI 97J measure this branching ratio via the decay channel  $\psi(2S) \rightarrow \ell^+ \ell^-$  ( $\ell = \mu, e$ ).

<sup>76</sup> ALEXANDER 96B measure this branching ratio via the decay channel  $\psi(2S) \rightarrow J/\psi \pi^+ \pi^-$ , with  $J/\psi \rightarrow \ell^+ \ell^-$ .

<sup>77</sup> ABREU 94P measure this branching ratio via decay channel  $\psi(2S) \rightarrow J/\psi \pi^+ \pi^-$ , with  $J/\psi \rightarrow \mu^+ \mu^-$ .

**$\Gamma(\chi_{c1}(1P)X)/\Gamma_{\text{total}}$**   **$\Gamma_{23}/\Gamma$**

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>2.9±0.7 OUR AVERAGE</b>				
2.7±0.6±0.5	33	<sup>78</sup> ACCIARRI	97J L3	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
5.0±2.1 <sup>+1.5</sup> <sub>-0.9</sub>	6.4	<sup>79</sup> ABREU	94P DLPH	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

<sup>78</sup> ACCIARRI 97J measure this branching ratio via the decay channel  $\chi_{c1} \rightarrow J/\psi + \gamma$ , with  $J/\psi \rightarrow \ell^+ \ell^-$  ( $\ell = \mu, e$ ). The  $M(\ell^+ \ell^- \gamma) - M(\ell^+ \ell^-)$  mass difference spectrum is fitted with two gaussian shapes for  $\chi_{c1}$  and  $\chi_{c2}$ .

<sup>79</sup> This branching ratio is measured via the decay channel  $\chi_{c1} \rightarrow J/\psi + \gamma$ , with  $J/\psi \rightarrow \mu^+ \mu^-$ .

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;3.2 × 10<sup>-3</sup></b>	90	<sup>80</sup> ACCIARRI	97J L3	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

<sup>80</sup> 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  $\chi_{c1}$  and  $\chi_{c2}$ .

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

<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.0±0.4±0.22</b>	6.4	<sup>81</sup> ALEXANDER	96F OPAL	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

<sup>81</sup> ALEXANDER 96F identify the  $\Upsilon$  (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  $\pm 0.2$  due to the production mechanism.

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;4.4 × 10<sup>-5</sup></b>	95	<sup>82</sup> ACCIARRI	99F L3	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

<sup>82</sup> ACCIARRI 99F search for  $\Upsilon(1S)$  through its decay into  $\ell^+ \ell^-$  ( $\ell = e$  or  $\mu$ ).

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;13.9 × 10<sup>-5</sup></b>	95	<sup>83</sup> ACCIARRI	97R L3	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

<sup>83</sup> ACCIARRI 97R search for  $\Upsilon(2S)$  through its decay into  $\ell^+ \ell^-$  ( $\ell = e$  or  $\mu$ ).

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

VALUE	CL%	DOCUMENT ID	TECN	COMMENT
$<9.4 \times 10^{-5}$	95	<sup>84</sup> ACCIARRI	97R L3	$E_{\text{cm}}^{ee} = 88-94$ GeV

<sup>84</sup> ACCIARRI 97R search for  $\Upsilon(3S)$  through its decay into  $\ell^+ \ell^-$  ( $\ell = e$  or  $\mu$ ).

$\Gamma((D^0/\bar{D}^0)X)/\Gamma(\text{hadrons})$   $\Gamma_{29}/\Gamma_6$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$0.296 \pm 0.019 \pm 0.021$	369	<sup>85</sup> ABREU	93i DLPH	$E_{\text{cm}}^{ee} = 88-94$ GeV

<sup>85</sup> The  $(D^0/\bar{D}^0)$  states in ABREU 93i are detected by the  $K\pi$  decay mode. This is a corrected result (see the erratum of ABREU 93i).

$\Gamma(D^\pm X)/\Gamma(\text{hadrons})$   $\Gamma_{30}/\Gamma_6$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
$0.174 \pm 0.016 \pm 0.018$	539	<sup>86</sup> ABREU	93i DLPH	$E_{\text{cm}}^{ee} = 88-94$ GeV

<sup>86</sup> The  $D^\pm$  states in ABREU 93i are detected by the  $K\pi\pi$  decay mode. This is a corrected result (see the erratum of ABREU 93i).

$\Gamma(D^*(2010)^\pm X)/\Gamma(\text{hadrons})$   $\Gamma_{31}/\Gamma_6$

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>0.163 \pm 0.019</math> OUR AVERAGE</b>				Error includes scale factor of 1.3.

0.155 ± 0.010 ± 0.013      358      <sup>87</sup> ABREU      93i DLPH       $E_{\text{cm}}^{ee} = 88-94$  GeV

0.21 ± 0.04      362      <sup>88</sup> DECAMP      91J ALEP       $E_{\text{cm}}^{ee} = 88-94$  GeV

<sup>87</sup>  $D^*(2010)^\pm$  in ABREU 93i are reconstructed from  $D^0\pi^\pm$ , with  $D^0 \rightarrow K^-\pi^+$ . The new CLEO II measurement of  $B(D^{*\pm} \rightarrow D^0\pi^\pm) = (68.1 \pm 1.6)\%$  is used. This is a corrected result (see the erratum of ABREU 93i).

<sup>88</sup> DECAMP 91J report  $B(D^*(2010)^+ \rightarrow D^0\pi^+) B(D^0 \rightarrow K^-\pi^+) \Gamma(D^*(2010)^\pm X) / \Gamma(\text{hadrons}) = (5.11 \pm 0.34) \times 10^{-3}$ . They obtained the above number assuming  $B(D^0 \rightarrow K^-\pi^+) = (3.62 \pm 0.34 \pm 0.44)\%$  and  $B(D^*(2010)^+ \rightarrow D^0\pi^+) = (55 \pm 4)\%$ . We have rescaled their original result of  $0.26 \pm 0.05$  taking into account the new CLEO II branching ratio  $B(D^*(2010)^+ \rightarrow D^0\pi^+) = (68.1 \pm 1.6)\%$ .

$\Gamma(D_{s1}(2536)^\pm X)/\Gamma(\text{hadrons})$   $\Gamma_{32}/\Gamma_6$

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

VALUE (%)	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>0.52 \pm 0.09 \pm 0.06</math></b>	92	<sup>89</sup> HEISTER	02B ALEP	$E_{\text{cm}}^{ee} = 88-94$ GeV

<sup>89</sup> HEISTER 02B reconstruct this meson in the decay modes  $D_{s1}(2536)^\pm \rightarrow D^{*\pm} K^0$  and  $D_{s1}(2536)^\pm \rightarrow D^{*0} K^\pm$ . The quoted branching ratio assumes that the decay width of the  $D_{s1}(2536)$  is saturated by the two measured decay modes.

$\Gamma(D_{sJ}(2573)^\pm X)/\Gamma(\text{hadrons})$   $\Gamma_{33}/\Gamma_6$

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

VALUE (%)	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>0.83 \pm 0.29^{+0.07}_{-0.13}</math></b>	64	<sup>90</sup> HEISTER	02B ALEP	$E_{\text{cm}}^{ee} = 88-94$ GeV

<sup>90</sup> HEISTER 02B reconstruct this meson in the decay mode  $D_{s2}(2573)^\pm \rightarrow D^0 K^\pm$ . The quoted branching ratio assumes that the detected decay mode represents 45% of the full decay width.



### $\Gamma(D^{*'}(2629)^{\pm}X)/\Gamma(\text{hadrons})$

$\Gamma_{34}/\Gamma_6$

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

VALUE	DOCUMENT ID	TECN	COMMENT
searched for	91 ABBIENDI	01N OPAL	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

<sup>91</sup> ABBIENDI 01N searched for the decay mode  $D^{*'}(2629)^{\pm} \rightarrow D^{*\pm}\pi^+\pi^-$  with  $D^{*+} \rightarrow D^0\pi^+$ , and  $D^0 \rightarrow K^-\pi^+$ . They quote a 95% CL limit for  $Z \rightarrow D^{*'}(2629)^{\pm} \times B(D^{*'}(2629)^{\pm} \rightarrow D^{*+}\pi^+\pi^-) < 3.1 \times 10^{-3}$ .

### $\Gamma(B_s^0X)/\Gamma(\text{hadrons})$

$\Gamma_{37}/\Gamma_6$

VALUE	DOCUMENT ID	TECN	COMMENT
seen	92 ABREU	92M DLPH	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
seen	93 ACTON	92N OPAL	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV
seen	94 BUSKULIC	92E ALEP	$E_{\text{cm}}^{ee} = 88\text{--}94$ GeV

<sup>92</sup> ABREU 92M reported value is  $\Gamma(B_s^0X) \times B(B_s^0 \rightarrow D_s\mu\nu_\mu X) \times B(D_s \rightarrow \phi\pi)/\Gamma(\text{hadrons}) = (18 \pm 8) \times 10^{-5}$ .

<sup>93</sup> ACTON 92N find evidence for  $B_s^0$  production using  $D_s$ - $\ell$  correlations, with  $D_s^+ \rightarrow \phi\pi^+$  and  $K^*(892)K^+$ . Assuming  $R_b$  from the Standard Model and averaging over the  $e$  and  $\mu$  channels, authors measure the product branching fraction to be  $f(\bar{b} \rightarrow B_s^0) \times B(B_s^0 \rightarrow D_s^-\ell^+\nu_\ell X) \times B(D_s^- \rightarrow \phi\pi^-) = (3.9 \pm 1.1 \pm 0.8) \times 10^{-4}$ .

<sup>94</sup> BUSKULIC 92E find evidence for  $B_s^0$  production using  $D_s$ - $\ell$  correlations, with  $D_s^+ \rightarrow \phi\pi^+$  and  $K^*(892)K^+$ . Using  $B(D_s^+ \rightarrow \phi\pi^+) = (2.7 \pm 0.7)\%$  and summing up the  $e$  and  $\mu$  channels, the weighted average product branching fraction is measured to be  $B(\bar{b} \rightarrow B_s^0) \times B(B_s^0 \rightarrow D_s^-\ell^+\nu_\ell X) = 0.040 \pm 0.011^{+0.010}_{-0.012}$ .

### $\Gamma(B_c^+X)/\Gamma(\text{hadrons})$

$\Gamma_{38}/\Gamma_6$

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

<sup>95</sup> ACKERSTAFF 98O searched for the decay modes  $B_c \rightarrow J/\psi\pi^+$ ,  $J/\psi a_1^+$ , and  $J/\psi\ell^+\nu_\ell$ , with  $J/\psi \rightarrow \ell^+\ell^-$ ,  $\ell = e, \mu$ . The number of candidates (background) for the three decay modes is 2 ( $0.63 \pm 0.2$ ), 0 ( $1.10 \pm 0.22$ ), and 1 ( $0.82 \pm 0.19$ ) respectively. Interpreting the 2  $B_c \rightarrow J/\psi\pi^+$  candidates as signal, they report  $\Gamma(B_c^+X) \times B(B_c \rightarrow J/\psi\pi^+)/\Gamma(\text{hadrons}) = (3.8^{+5.0}_{-2.4} \pm 0.5) \times 10^{-5}$ . Interpreted as background, the 90% CL bounds are  $\Gamma(B_c^+X) \times B(B_c \rightarrow J/\psi\pi^+)/\Gamma(\text{hadrons}) < 1.06 \times 10^{-4}$ ,  $\Gamma(B_c^+X) \times B(B_c \rightarrow J/\psi a_1^+)/\Gamma(\text{hadrons}) < 5.29 \times 10^{-4}$ ,  $\Gamma(B_c^+X) \times B(B_c \rightarrow J/\psi\ell^+\nu_\ell)/\Gamma(\text{hadrons}) < 6.96 \times 10^{-5}$ .

<sup>96</sup> ABREU 97E searched for the decay modes  $B_c \rightarrow J/\psi\pi^+$ ,  $J/\psi\ell^+\nu_\ell$ , and  $J/\psi(3\pi)^+$ , with  $J/\psi \rightarrow \ell^+\ell^-$ ,  $\ell = e, \mu$ . 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:  $\Gamma(B_c^+X) \times B(B_c \rightarrow J/\psi\pi^+)/\Gamma(\text{hadrons}) < (1.05\text{--}0.84) \times 10^{-4}$ ,  $\Gamma(B_c^+X) \times B(B_c \rightarrow J/\psi\ell^+\nu_\ell)/\Gamma(\text{hadrons}) < (5.8\text{--}5.0) \times 10^{-5}$ ,  $\Gamma(B_c^+X) \times B(B_c \rightarrow J/\psi(3\pi)^+)/\Gamma(\text{hadrons}) < 1.75 \times 10^{-4}$ , where the ranges are due to the predicted  $B_c$  lifetime (0.4–1.4) ps.

<sup>97</sup> BARATE 97H searched for the decay modes  $B_c \rightarrow J/\psi \pi^+$  and  $J/\psi \ell^+ \nu_\ell$  with  $J/\psi \rightarrow \ell^+ \ell^-$ ,  $\ell = e, \mu$ . 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:  $\Gamma(B_c^+ X) * B(B_c \rightarrow J/\psi \pi^+) / \Gamma(\text{hadrons}) < 3.6 \times 10^{-5}$  and  $\Gamma(B_c^+ X) * B(B_c \rightarrow J/\psi \ell^+ \nu_\ell) / \Gamma(\text{hadrons}) < 5.2 \times 10^{-5}$ .

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

As the experiments assume different values of the  $b$ -baryon contribution, our average should be taken with caution. If we assume a common baryon production fraction of  $(11.8 \pm 2.0)\%$  as given in the 2002 edition of this Review OUR AVERAGE becomes  $0.75 \pm 0.04$ .

<u>VALUE</u>	<u>EVT</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>0.75 \pm 0.04</math></b>	<b>OUR AVERAGE</b>			
$0.760 \pm 0.036 \pm 0.083$		98 ACKERSTAFF 97M OPAL		$E_{\text{cm}}^{ee} = 88-94$ GeV
$0.771 \pm 0.026 \pm 0.070$		99 BUSKULIC 96D ALEP		$E_{\text{cm}}^{ee} = 88-94$ GeV
$0.72 \pm 0.03 \pm 0.06$		100 ABREU 95R DLPH		$E_{\text{cm}}^{ee} = 88-94$ GeV
$0.76 \pm 0.08 \pm 0.06$	1378	101 ACCIARRI 95B L3		$E_{\text{cm}}^{ee} = 88-94$ GeV

<sup>98</sup> ACKERSTAFF 97M use an inclusive  $B$  reconstruction method and assume a  $(13.2 \pm 4.1)\%$   $b$ -baryon contribution. The value refers to a  $b$ -flavored meson mixture of  $B_u$ ,  $B_d$ , and  $B_s$ .

<sup>99</sup> BUSKULIC 96D use an inclusive reconstruction of  $B$  hadrons and assume a  $(12.2 \pm 4.3)\%$   $b$ -baryon contribution. The value refers to a  $b$ -flavored mixture of  $B_u$ ,  $B_d$ , and  $B_s$ .

<sup>100</sup> ABREU 95R use an inclusive  $B$ -reconstruction method and assume a  $(10 \pm 4)\%$   $b$ -baryon contribution. The value refers to a  $b$ -flavored meson mixture of  $B_u$ ,  $B_d$ , and  $B_s$ .

<sup>101</sup> ACCIARRI 95B assume a  $9.4\%$   $b$ -baryon contribution. The value refers to a  $b$ -flavored mixture of  $B_u$ ,  $B_d$ , and  $B_s$ .

**$\Gamma(\text{anomalous } \gamma + \text{hadrons}) / \Gamma_{\text{total}}$   $\Gamma_{39} / \Gamma$**

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt; 3.2 \times 10^{-3}</math></b>	95	102 AKRAWY 90J OPAL		$E_{\text{cm}}^{ee} = 88-94$ GeV

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

**$\Gamma(e^+ e^- \gamma) / \Gamma_{\text{total}}$   $\Gamma_{40} / \Gamma$**

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt; 5.2 \times 10^{-4}</math></b>	95	103 ACTON 91B OPAL		$E_{\text{cm}}^{ee} = 91.2$ GeV

<sup>103</sup> ACTON 91B looked for isolated photons with  $E > 2\%$  of beam energy ( $> 0.9$  GeV).

**$\Gamma(\mu^+ \mu^- \gamma) / \Gamma_{\text{total}}$   $\Gamma_{41} / \Gamma$**

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>&lt; 5.6 \times 10^{-4}</math></b>	95	104 ACTON 91B OPAL		$E_{\text{cm}}^{ee} = 91.2$ GeV

<sup>104</sup> ACTON 91B looked for isolated photons with  $E > 2\%$  of beam energy ( $> 0.9$  GeV).

$\Gamma(\tau^+ \tau^- \gamma)/\Gamma_{\text{total}}$   $\Gamma_{42}/\Gamma$

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;7.3 × 10<sup>-4</sup></b>	95	105 ACTON	91B OPAL	$E_{\text{cm}}^{ee} = 91.2 \text{ GeV}$

<sup>105</sup> ACTON 91B looked for isolated photons with  $E > 2\%$  of beam energy ( $> 0.9 \text{ GeV}$ ).

$\Gamma(\ell^+ \ell^- \gamma \gamma)/\Gamma_{\text{total}}$   $\Gamma_{43}/\Gamma$

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;6.8 × 10<sup>-6</sup></b>	95	106 ACTON	93E OPAL	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

<sup>106</sup> For  $m_{\gamma\gamma} = 60 \pm 5 \text{ GeV}$ .

$\Gamma(q\bar{q}\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_{44}/\Gamma$

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;5.5 × 10<sup>-6</sup></b>	95	107 ACTON	93E OPAL	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

<sup>107</sup> For  $m_{\gamma\gamma} = 60 \pm 5 \text{ GeV}$ .

$\Gamma(\nu\bar{\nu}\gamma\gamma)/\Gamma_{\text{total}}$   $\Gamma_{45}/\Gamma$

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;3.1 × 10<sup>-6</sup></b>	95	108 ACTON	93E OPAL	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

<sup>108</sup> For  $m_{\gamma\gamma} = 60 \pm 5 \text{ GeV}$ .

$\Gamma(e^\pm \mu^\mp)/\Gamma(e^+ e^-)$   $\Gamma_{46}/\Gamma_1$

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>&lt;0.07</b>	90	ALBAJAR	89 UA1	$E_{\text{cm}}^{p\bar{p}} = 546,630 \text{ GeV}$

$\Gamma(e^\pm \mu^\mp)/\Gamma_{\text{total}}$   $\Gamma_{46}/\Gamma$

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<2.5 × 10 <sup>-6</sup>	95	ABREU	97C DLPH	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
<b>&lt;1.7 × 10<sup>-6</sup></b>	95	AKERS	95W OPAL	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
<0.6 × 10 <sup>-5</sup>	95	ADRIANI	93i L3	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
<2.6 × 10 <sup>-5</sup>	95	DECAMP	92 ALEP	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

$\Gamma(e^\pm \tau^\mp)/\Gamma_{\text{total}}$   $\Gamma_{47}/\Gamma$

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<2.2 × 10 <sup>-5</sup>	95	ABREU	97C DLPH	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
<b>&lt;9.8 × 10<sup>-6</sup></b>	95	AKERS	95W OPAL	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
<1.3 × 10 <sup>-5</sup>	95	ADRIANI	93i L3	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$
<1.2 × 10 <sup>-4</sup>	95	DECAMP	92 ALEP	$E_{\text{cm}}^{ee} = 88-94 \text{ GeV}$

**$\Gamma(\mu^\pm \tau^\mp)/\Gamma_{\text{total}}$**   **$\Gamma_{48}/\Gamma$**

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

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

**$\Gamma(pe)/\Gamma_{\text{total}}$**   **$\Gamma_{49}/\Gamma$**

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<1.8 \times 10^{-6}$	95	<sup>109</sup> ABBIENDI	99I OPAL	$E_{\text{cm}}^{ee} = 88-94$ GeV

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

**$\Gamma(p\mu)/\Gamma_{\text{total}}$**   **$\Gamma_{50}/\Gamma$**

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

<u>VALUE</u>	<u>CL%</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
$<1.8 \times 10^{-6}$	95	<sup>110</sup> ABBIENDI	99I OPAL	$E_{\text{cm}}^{ee} = 88-94$ GeV

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

**AVERAGE PARTICLE MULTIPLICITIES IN HADRONIC Z DECAY**

Summed over particle and antiparticle, when appropriate.

For topical interest the 95% CL limits on production rates, N, of pentaquarks per Z decay from a search by the ALEPH collaboration (SCHAEEL 04) are given below. (See also the baryons section).

$$N_{\Theta(1540)^+} \times B(\Theta(1540)^+ \rightarrow pK_S^0) < 6.2 \times 10^{-4}$$

$$N_{\Phi(1860)^{--}} \times B(\Phi(1860)^{--} \rightarrow \Xi^- \pi^-) < 4.5 \times 10^{-4}$$

$$N_{\Phi(1860)^0} \times B(\Phi(1860)^0 \rightarrow \Xi^- \pi^+) < 8.9 \times 10^{-4}$$

$$N_{\Theta_c(3100)} \times B(\Theta_c(3100) \rightarrow D^{*-} p) < 6.3 \times 10^{-4}$$

$$N_{\Theta_c(3100)} \times B(\Theta_c(3100) \rightarrow D^- p) < 31 \times 10^{-4}$$

**$\langle N_\gamma \rangle$**

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>20.97 \pm 0.02 \pm 1.15</math></b>	ACKERSTAFF 98A	OPAL	$E_{\text{cm}}^{ee} = 91.2$ GeV

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

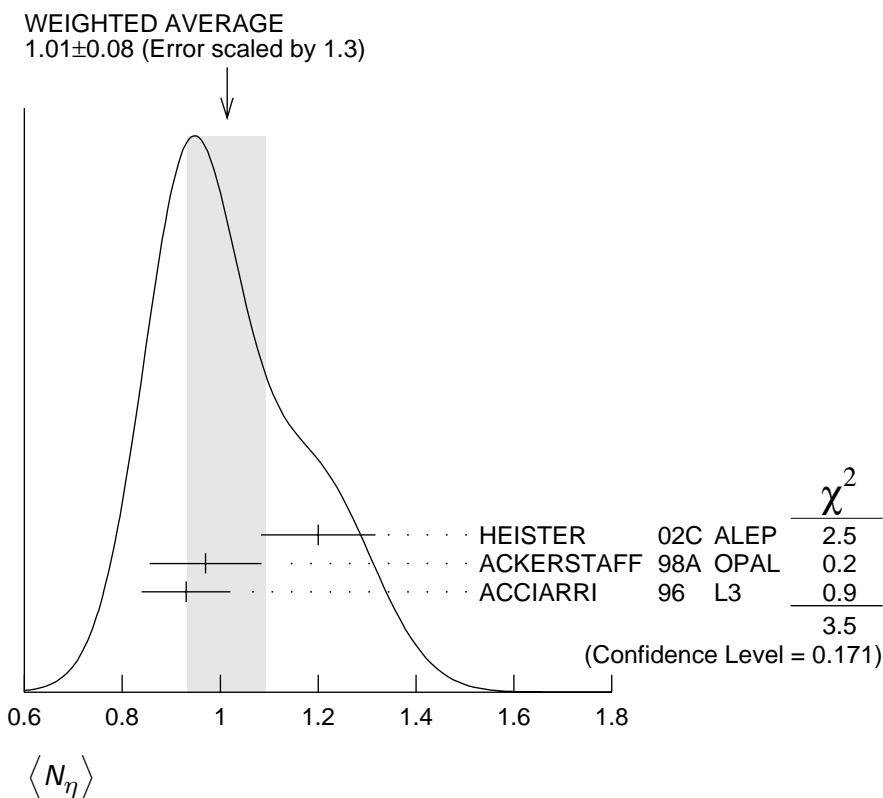
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b><math>17.03 \pm 0.16</math> OUR AVERAGE</b>			
$17.007 \pm 0.209$	ABE	04C SLD	$E_{\text{cm}}^{ee} = 91.2$ GeV
$17.26 \pm 0.10 \pm 0.88$	ABREU	98L DLPH	$E_{\text{cm}}^{ee} = 91.2$ GeV
$17.04 \pm 0.31$	BARATE	98V ALEP	$E_{\text{cm}}^{ee} = 91.2$ GeV
$17.05 \pm 0.43$	AKERS	94P OPAL	$E_{\text{cm}}^{ee} = 91.2$ GeV

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

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

$\langle N_{\eta} \rangle$

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



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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>2.40±0.06±0.43</b>	ACKERSTAFF 98A	OPAL	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.24±0.10 OUR AVERAGE</b>	Error includes scale factor of 1.1.		
1.19±0.10	ABREU 99J	DLPH	$E_{cm}^{ee} = 91.2$ GeV
1.45±0.06±0.20	BUSKULIC 96H	ALEP	$E_{cm}^{ee} = 91.2$ GeV

$\langle N_\omega \rangle$

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.02 ± 0.06 OUR AVERAGE</b>			
1.00 ± 0.03 ± 0.06	HEISTER	02C ALEP	$E_{cm}^{ee} = 91.2$ GeV
1.04 ± 0.04 ± 0.14	ACKERSTAFF	98A OPAL	$E_{cm}^{ee} = 91.2$ GeV
1.17 ± 0.09 ± 0.15	ACCIARRI	97D L3	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.17 ± 0.05 OUR AVERAGE</b>	Error includes scale factor of 2.4.		
0.14 ± 0.01 ± 0.02	ACKERSTAFF	98A OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.25 ± 0.04	<sup>111</sup> ACCIARRI	97D L3	$E_{cm}^{ee} = 91.2$ GeV
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●			
0.068 ± 0.018 ± 0.016	<sup>112</sup> BUSKULIC	92D ALEP	$E_{cm}^{ee} = 91.2$ GeV
<sup>111</sup> ACCIARRI 97D obtain this value averaging over the two decay channels $\eta' \rightarrow \pi^+ \pi^- \eta$ and $\eta' \rightarrow \rho^0 \gamma$ .			
<sup>112</sup> BUSKULIC 92D obtain this value for $x > 0.1$ .			

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

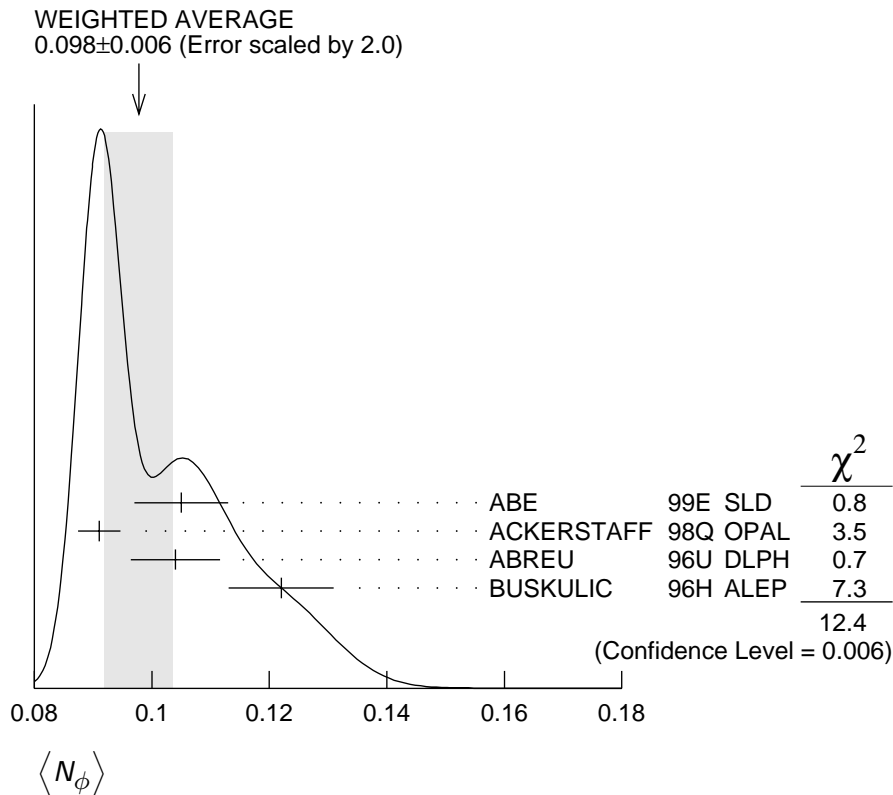
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.147 ± 0.011 OUR AVERAGE</b>			
0.164 ± 0.021	ABREU	99J DLPH	$E_{cm}^{ee} = 91.2$ GeV
0.141 ± 0.007 ± 0.011	ACKERSTAFF	98Q OPAL	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.27 ± 0.04 ± 0.10</b>	ACKERSTAFF	98A OPAL	$E_{cm}^{ee} = 91.2$ GeV

$\langle N_\phi \rangle$

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



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

VALUE	DOCUMENT ID	TECN	COMMENT
<b><math>0.169 \pm 0.025</math> OUR AVERAGE</b>			Error includes scale factor of 1.4.
$0.214 \pm 0.038$	ABREU	99J DLPH	$E_{cm}^{ee} = 91.2$ GeV
$0.155 \pm 0.011 \pm 0.018$	ACKERSTAFF	98Q OPAL	$E_{cm}^{ee} = 91.2$ GeV

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b><math>0.165 \pm 0.051</math></b>	<sup>113</sup> ABDALLAH	03H DLPH	$E_{cm}^{ee} = 91.2$ GeV
	<sup>113</sup> ABDALLAH	03H	assume a $K\bar{K}\pi$ branching ratio of $(9.0 \pm 0.4)\%$ .

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

VALUE	DOCUMENT ID	TECN	COMMENT
<b><math>0.056 \pm 0.012</math></b>	<sup>114</sup> ABDALLAH	03H DLPH	$E_{cm}^{ee} = 91.2$ GeV
	<sup>114</sup> ABDALLAH	03H	assume a $K\bar{K}\pi$ branching ratio of 100%.

**$\langle N_{f_2'(1525)} \rangle$**

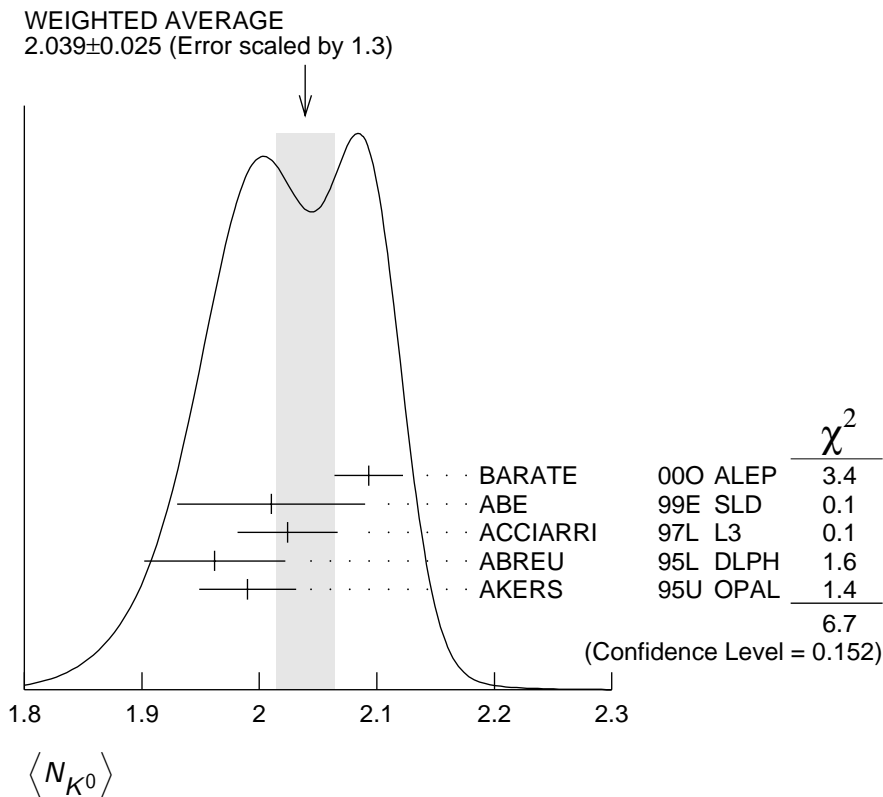
VALUE	DOCUMENT ID	TECN	COMMENT
<b><math>0.012 \pm 0.006</math></b>	ABREU	99J DLPH	$E_{cm}^{ee} = 91.2$ GeV

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

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

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

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



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

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.72 ± 0.05 OUR AVERAGE</b>			
0.712 ± 0.031 ± 0.059	ABREU	95L DLPH	$E_{cm}^{ee} = 91.2$ GeV
0.72 ± 0.02 ± 0.08	ACTON	93 OPAL	$E_{cm}^{ee} = 91.2$ GeV



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

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

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

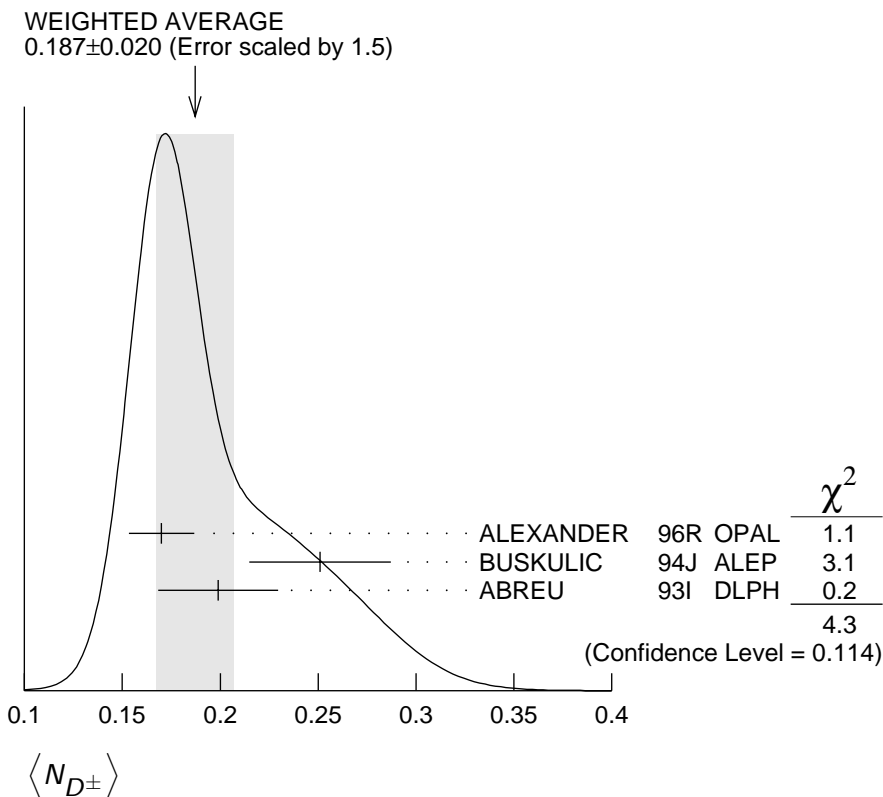
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.073±0.023</b>	ABREU	99J DLPH	$E_{cm}^{ee} = 91.2$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.19 ±0.04 ±0.06	<sup>115</sup> AKERS	95X OPAL	$E_{cm}^{ee} = 91.2$ GeV

<sup>115</sup> AKERS 95X obtain this value for  $x < 0.3$ .

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.187±0.020 OUR AVERAGE</b>	Error includes scale factor of 1.5. See the ideogram below.		
0.170±0.009±0.014	ALEXANDER	96R OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.251±0.026±0.025	BUSKULIC	94J ALEP	$E_{cm}^{ee} = 91.2$ GeV
0.199±0.019±0.024	<sup>116</sup> ABREU	93I DLPH	$E_{cm}^{ee} = 91.2$ GeV

<sup>116</sup> See ABREU 95 (erratum).



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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.462 ± 0.026 OUR AVERAGE</b>			
0.465 ± 0.017 ± 0.027	ALEXANDER	96R OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.518 ± 0.052 ± 0.035	BUSKULIC	94J ALEP	$E_{cm}^{ee} = 91.2$ GeV
0.403 ± 0.038 ± 0.044	<sup>117</sup> ABREU	93i DLPH	$E_{cm}^{ee} = 91.2$ GeV

<sup>117</sup> See ABREU 95 (erratum).

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.131 ± 0.010 ± 0.018</b>	ALEXANDER	96R OPAL	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.183 ± 0.008 OUR AVERAGE</b>			
0.1854 ± 0.0041 ± 0.0091	<sup>118</sup> ACKERSTAFF	98E OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.187 ± 0.015 ± 0.013	BUSKULIC	94J ALEP	$E_{cm}^{ee} = 91.2$ GeV
0.171 ± 0.012 ± 0.016	<sup>119</sup> ABREU	93i DLPH	$E_{cm}^{ee} = 91.2$ GeV

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

<sup>119</sup> See ABREU 95 (erratum).

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

<u>VALUE (units <math>10^{-3}</math>)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>• • • We do not use the following data for averages, fits, limits, etc. • • •</b>			
$2.9^{+0.7}_{-0.6} \pm 0.2$	<sup>120</sup> ACKERSTAFF	97W OPAL	$E_{cm}^{ee} = 91.2$ GeV

<sup>120</sup> ACKERSTAFF 97W obtain this value for  $x > 0.6$  and with the assumption that its decay width is saturated by the  $D^* K$  final states.

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.28 ± 0.01 ± 0.03</b>	<sup>121</sup> ABREU	95R DLPH	$E_{cm}^{ee} = 91.2$ GeV

<sup>121</sup> ABREU 95R quote this value for a flavor-averaged excited state.

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0056 ± 0.0003 ± 0.0004</b>	<sup>122</sup> ALEXANDER	96B OPAL	$E_{cm}^{ee} = 91.2$ GeV

<sup>122</sup> ALEXANDER 96B identify  $J/\psi(1S)$  from the decays into lepton pairs.

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0023 ± 0.0004 ± 0.0003</b>	ALEXANDER	96B OPAL	$E_{cm}^{ee} = 91.2$ GeV

$\langle N_p \rangle$

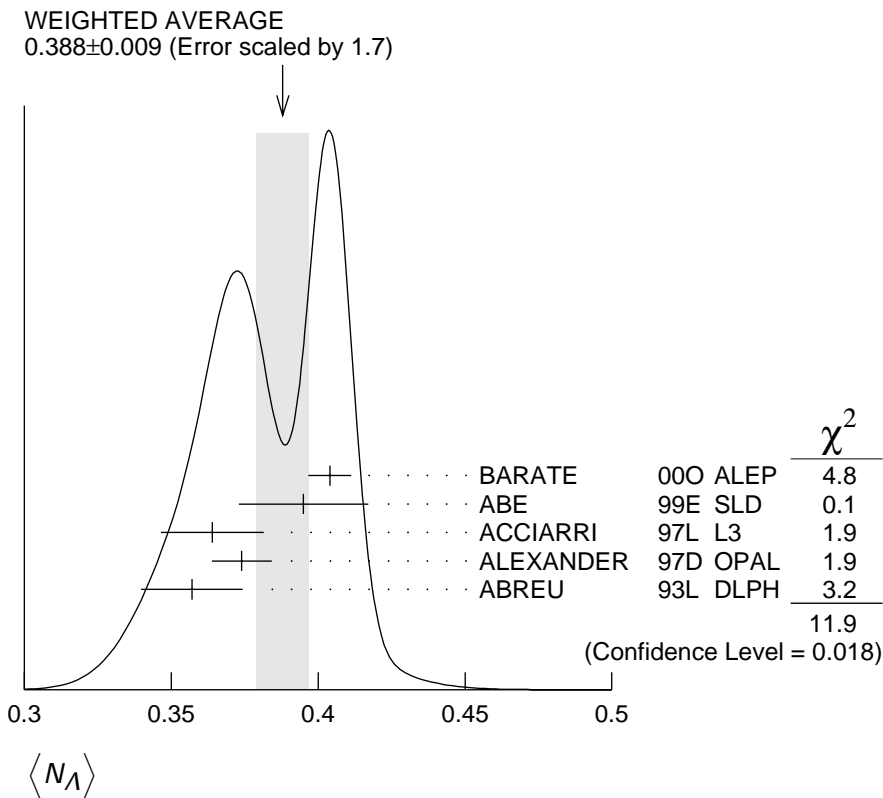
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>1.046 ± 0.026 OUR AVERAGE</b>			
1.054 ± 0.035	ABE	04C SLD	$E_{cm}^{ee} = 91.2$ GeV
1.08 ± 0.04 ± 0.03	ABREU	98L DLPH	$E_{cm}^{ee} = 91.2$ GeV
1.00 ± 0.07	BARATE	98V ALEP	$E_{cm}^{ee} = 91.2$ GeV
0.92 ± 0.11	AKERS	94P OPAL	$E_{cm}^{ee} = 91.2$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

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.087 ± 0.033 OUR AVERAGE</b>	Error includes scale factor of 2.4.		
0.079 ± 0.009 ± 0.011	ABREU	95W DLPH	$E_{cm}^{ee} = 91.2$ GeV
0.22 ± 0.04 ± 0.04	ALEXANDER	95D OPAL	$E_{cm}^{ee} = 91.2$ GeV

$\langle N_{\Lambda} \rangle$

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



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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0224 ± 0.0027 OUR AVERAGE</b>			
0.029 ± 0.005 ± 0.005	ABREU	00P DLPH	$E_{cm}^{ee} = 91.2$ GeV
0.0213 ± 0.0021 ± 0.0019	ALEXANDER	97D OPAL	$E_{cm}^{ee} = 91.2$ GeV

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

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

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

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

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.181 ± 0.018 OUR AVERAGE</b>			
0.182 ± 0.010 ± 0.016	<sup>123</sup> ALEXANDER	97E OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.170 ± 0.014 ± 0.061	ABREU	95O DLPH	$E_{cm}^{ee} = 91.2$ GeV

<sup>123</sup> 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  $0.174 \pm 0.010 \pm 0.015$ .

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.076 ± 0.010 OUR AVERAGE</b>			
0.095 ± 0.015 ± 0.013	ACCIARRI	00J L3	$E_{cm}^{ee} = 91.2$ GeV
0.071 ± 0.012 ± 0.013	ALEXANDER	97E OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.070 ± 0.010 ± 0.010	ADAM	96B DLPH	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.084 ± 0.005 ± 0.008</b>	ALEXANDER	97E OPAL	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0239 ± 0.0009 ± 0.0012</b>	ALEXANDER	97D OPAL	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0240 ± 0.0010 ± 0.0014</b>	ALEXANDER	97D OPAL	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.046 ± 0.004 OUR AVERAGE</b>	Error includes scale factor of 1.6.		
0.0479 ± 0.0013 ± 0.0026	ALEXANDER	97D OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.0382 ± 0.0028 ± 0.0045	ABREU	95O DLPH	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0258 ± 0.0009 OUR AVERAGE</b>			
0.0259 ± 0.0004 ± 0.0009	ALEXANDER	97D OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.0250 ± 0.0009 ± 0.0021	ABREU	95O DLPH	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.0053 ± 0.0013 OUR AVERAGE</b>	Error includes scale factor of 3.2.		
0.0068 ± 0.0005 ± 0.0004	ALEXANDER	97D OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.0041 ± 0.0004 ± 0.0004	ABREU	95O DLPH	$E_{cm}^{ee} = 91.2$ GeV

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

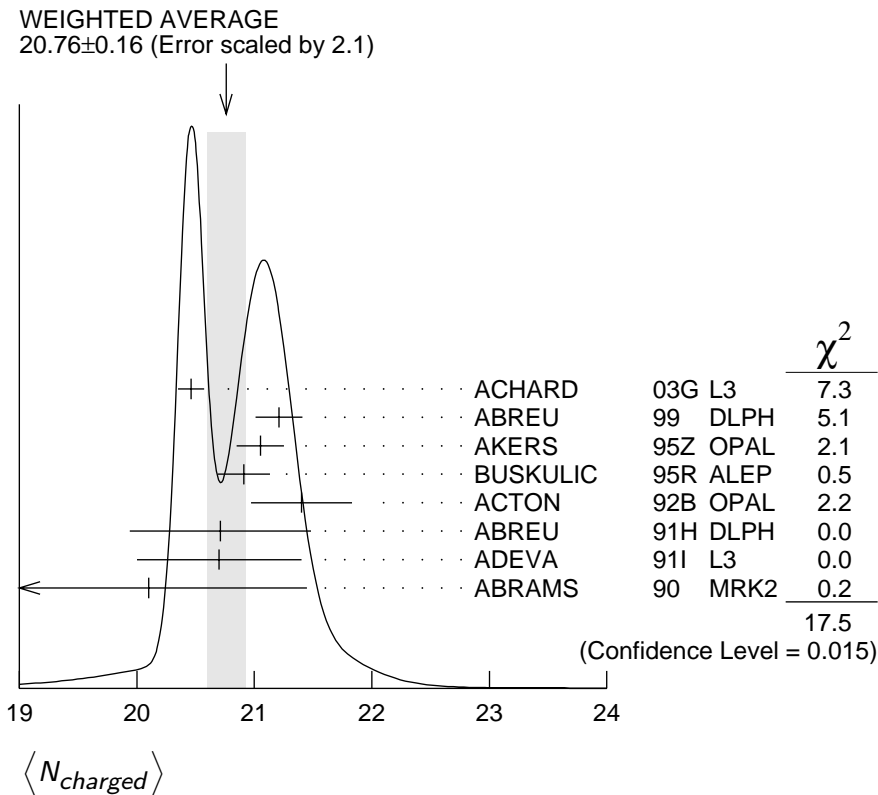
<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.00164 ± 0.00028 OUR AVERAGE</b>			
0.0018 ± 0.0003 ± 0.0002	ALEXANDER	97D OPAL	$E_{cm}^{ee} = 91.2$ GeV
0.0014 ± 0.0002 ± 0.0004	ADAM	96B DLPH	$E_{cm}^{ee} = 91.2$ GeV

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.078 ± 0.012 ± 0.012</b>	ALEXANDER	96R OPAL	$E_{cm}^{ee} = 91.2$ GeV

$\langle N_{charged} \rangle$

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



## Z HADRONIC POLE CROSS SECTION

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the "Note on the Z boson"). This quantity is defined as

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

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

VALUE (nb)	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>41.541 \pm 0.037</math> OUR FIT</b>				
$41.501 \pm 0.055$	4.10M	<sup>124</sup> ABBIENDI	01A OPAL	$E_{cm}^{ee} = 88-94$ GeV
$41.578 \pm 0.069$	3.70M	ABREU	00F DLPH	$E_{cm}^{ee} = 88-94$ GeV
$41.535 \pm 0.055$	3.54M	ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
$41.559 \pm 0.058$	4.07M	<sup>125</sup> BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV

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

42 ± 4      450      ABRAMS      89B MRK2       $E_{cm}^{ee} = 89.2-93.0$  GeV

<sup>124</sup> 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.

<sup>125</sup> BARATE 00C error includes approximately 0.030 due to statistics, 0.026 due to experimental systematics, and 0.025 due to uncertainty in luminosity measurement.

## Z VECTOR COUPLINGS TO CHARGED LEPTONS

These quantities are the effective vector couplings of the  $Z$  to charged leptons. Their magnitude is derived from a measurement of the  $Z$  lineshape and the forward-backward lepton asymmetries as a function of energy around the  $Z$  mass. The relative sign among the vector to axial-vector couplings is obtained from a measurement of the  $Z$  asymmetry parameters,  $A_e$ ,  $A_\mu$ , and  $A_\tau$ . By convention the sign of  $g_A^e$  is fixed to be negative (and opposite to that of  $g_V^e$  obtained using  $\nu_e$  scattering measurements). The fit values quoted below correspond to global nine- or five-parameter fits to lineshape, lepton forward-backward asymmetry, and  $A_e$ ,  $A_\mu$ , and  $A_\tau$  measurements. See "Note on the  $Z$  boson" for details.

### $g_V^e$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>-0.03816 \pm 0.00047</math> OUR FIT</b>				
$-0.0346 \pm 0.0023$	137.0K	<sup>126</sup> ABBIENDI	01O OPAL	$E_{cm}^{ee} = 88-94$ GeV
$-0.0412 \pm 0.0027$	124.4k	<sup>127</sup> ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
$-0.0400 \pm 0.0037$		BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV
$-0.0414 \pm 0.0020$		<sup>128</sup> ABE	95J SLD	$E_{cm}^{ee} = 91.31$ GeV

<sup>126</sup> ABBIENDI 01O use their measurement of the  $\tau$  polarization in addition to the lineshape and forward-backward lepton asymmetries.

<sup>127</sup> ACCIARRI 00C use their measurement of the  $\tau$  polarization in addition to forward-backward lepton asymmetries.

<sup>128</sup> ABE 95J obtain this result combining polarized Bhabha results with the  $A_{LR}$  measurement of ABE 94C. The Bhabha results alone give  $-0.0507 \pm 0.0096 \pm 0.0020$ .

### $g_V^\mu$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>-0.0367 \pm 0.0023</math> OUR FIT</b>				
$-0.0388^{+0.0060}_{-0.0064}$	182.8K	<sup>129</sup> ABBIENDI	01O OPAL	$E_{cm}^{ee} = 88-94$ GeV
$-0.0386 \pm 0.0073$	113.4k	<sup>130</sup> ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
$-0.0362 \pm 0.0061$		BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV

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

$-0.0413 \pm 0.0060$  66143 <sup>131</sup> ABBIENDI 01K OPAL  $E_{cm}^{ee} = 89-93$  GeV

<sup>129</sup> ABBIENDI 01O use their measurement of the  $\tau$  polarization in addition to the lineshape and forward-backward lepton asymmetries.

<sup>130</sup> ACCIARRI 00C use their measurement of the  $\tau$  polarization in addition to forward-backward lepton asymmetries.

<sup>131</sup> ABBIENDI 01K obtain this from an angular analysis of the muon pair asymmetry which takes into account effects of initial state radiation on an event by event basis and of initial-final state interference.

### $g_V^\tau$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>-0.0366 \pm 0.0010</math> OUR FIT</b>				
$-0.0365 \pm 0.0023$	151.5K	<sup>132</sup> ABBIENDI	01O OPAL	$E_{cm}^{ee} = 88-94$ GeV
$-0.0384 \pm 0.0026$	103.0k	<sup>133</sup> ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
$-0.0361 \pm 0.0068$		BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV

<sup>132</sup> ABBIENDI 010 use their measurement of the  $\tau$  polarization in addition to the lineshape and forward-backward lepton asymmetries.

<sup>133</sup> ACCIARRI 00C use their measurement of the  $\tau$  polarization in addition to forward-backward lepton asymmetries.

$g_V^l$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>-0.03783 \pm 0.00041</math> OUR FIT</b>				
$-0.0358 \pm 0.0014$	471.3K	<sup>134</sup> ABBIENDI	010 OPAL	$E_{cm}^{ee} = 88-94$ GeV
$-0.0397 \pm 0.0020$	379.4k	<sup>135</sup> ABREU	00F DLPH	$E_{cm}^{ee} = 88-94$ GeV
$-0.0397 \pm 0.0017$	340.8k	<sup>136</sup> ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
$-0.0383 \pm 0.0018$	500k	BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV

<sup>134</sup> ABBIENDI 010 use their measurement of the  $\tau$  polarization in addition to the lineshape and forward-backward lepton asymmetries.

<sup>135</sup> Using forward-backward lepton asymmetries.

<sup>136</sup> ACCIARRI 00C use their measurement of the  $\tau$  polarization in addition to forward-backward lepton asymmetries.

## Z AXIAL-VECTOR COUPLINGS TO CHARGED LEPTONS

These quantities are the effective axial-vector couplings of the Z to charged leptons. Their magnitude is derived from a measurement of the Z lineshape and the forward-backward lepton asymmetries as a function of energy around the Z mass. The relative sign among the vector to axial-vector couplings is obtained from a measurement of the Z asymmetry parameters,  $A_e$ ,  $A_\mu$ , and  $A_\tau$ . By convention the sign of  $g_A^e$  is fixed to be negative (and opposite to that of  $g_V^e$  obtained using  $\nu_e$  scattering measurements). The fit values quoted below correspond to global nine- or five-parameter fits to lineshape, lepton forward-backward asymmetry, and  $A_e$ ,  $A_\mu$ , and  $A_\tau$  measurements. See "Note on the Z boson" for details.

$g_A^e$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>-0.50111 \pm 0.00035</math> OUR FIT</b>				
$-0.50062 \pm 0.00062$	137.0K	<sup>137</sup> ABBIENDI	010 OPAL	$E_{cm}^{ee} = 88-94$ GeV
$-0.5015 \pm 0.0007$	124.4k	<sup>138</sup> ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
$-0.50166 \pm 0.00057$		BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV
$-0.4977 \pm 0.0045$		<sup>139</sup> ABE	95J SLD	$E_{cm}^{ee} = 91.31$ GeV

<sup>137</sup> ABBIENDI 010 use their measurement of the  $\tau$  polarization in addition to the lineshape and forward-backward lepton asymmetries.

<sup>138</sup> ACCIARRI 00C use their measurement of the  $\tau$  polarization in addition to forward-backward lepton asymmetries.

<sup>139</sup> ABE 95J obtain this result combining polarized Bhabha results with the  $A_{LR}$  measurement of ABE 94C. The Bhabha results alone give  $-0.4968 \pm 0.0039 \pm 0.0027$ .



### $g_A^\mu$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>-0.50120 \pm 0.00054</math></b>				<b>OUR FIT</b>
$-0.50117 \pm 0.00099$	182.8K	<sup>140</sup> ABBIENDI	010 OPAL	$E_{cm}^{ee} = 88-94$ GeV
$-0.5009 \pm 0.0014$	113.4k	<sup>141</sup> ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
$-0.50046 \pm 0.00093$		BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
$-0.520 \pm 0.015$	66143	<sup>142</sup> ABBIENDI	01K OPAL	$E_{cm}^{ee} = 89-93$ GeV

<sup>140</sup> ABBIENDI 010 use their measurement of the  $\tau$  polarization in addition to the lineshape and forward-backward lepton asymmetries.  
<sup>141</sup> ACCIARRI 00C use their measurement of the  $\tau$  polarization in addition to forward-backward lepton asymmetries.  
<sup>142</sup> ABBIENDI 01K obtain this from an angular analysis of the muon pair asymmetry which takes into account effects of initial state radiation on an event by event basis and of initial-final state interference.

### $g_A^\tau$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>-0.50204 \pm 0.00064</math></b>				<b>OUR FIT</b>
$-0.50165 \pm 0.00124$	151.5K	<sup>143</sup> ABBIENDI	010 OPAL	$E_{cm}^{ee} = 88-94$ GeV
$-0.5023 \pm 0.0017$	103.0k	<sup>144</sup> ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
$-0.50216 \pm 0.00100$		BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV

<sup>143</sup> ABBIENDI 010 use their measurement of the  $\tau$  polarization in addition to the lineshape and forward-backward lepton asymmetries.  
<sup>144</sup> ACCIARRI 00C use their measurement of the  $\tau$  polarization in addition to forward-backward lepton asymmetries.

### $g_A^l$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>-0.50123 \pm 0.00026</math></b>				<b>OUR FIT</b>
$-0.50089 \pm 0.00045$	471.3K	<sup>145</sup> ABBIENDI	010 OPAL	$E_{cm}^{ee} = 88-94$ GeV
$-0.5007 \pm 0.0005$	379.4k	ABREU	00F DLPH	$E_{cm}^{ee} = 88-94$ GeV
$-0.50153 \pm 0.00053$	340.8k	<sup>146</sup> ACCIARRI	00C L3	$E_{cm}^{ee} = 88-94$ GeV
$-0.50150 \pm 0.00046$	500k	BARATE	00C ALEP	$E_{cm}^{ee} = 88-94$ GeV

<sup>145</sup> ABBIENDI 010 use their measurement of the  $\tau$  polarization in addition to the lineshape and forward-backward lepton asymmetries.  
<sup>146</sup> ACCIARRI 00C use their measurement of the  $\tau$  polarization in addition to forward-backward lepton asymmetries.

## Z COUPLINGS TO NEUTRAL LEPTONS

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

### $g^{\nu e}$

VALUE	DOCUMENT ID	TECN	COMMENT
<b><math>0.528 \pm 0.085</math></b>	<sup>147</sup> VILAIN	94 CHM2	From $\nu_\mu e$ and $\nu_e e$ scattering

<sup>147</sup> VILAIN 94 derive this value from their value of  $g^{\nu\mu}$  and their ratio  $g^{\nu e}/g^{\nu\mu} = 1.05^{+0.15}_{-0.18}$ .

### $g^{\nu\mu}$

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.502±0.017</b>	148 VILAIN	94 CHM2	From $\nu_\mu e$ scattering

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

## Z ASYMMETRY PARAMETERS

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

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

where  $g_V^f$  and  $g_A^f$  are the effective vector and axial-vector couplings. For their relation to the various lepton asymmetries see the 'Note on the  $Z$  Boson.'

### $A_e$

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

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.1515±0.0019 OUR AVERAGE</b>				
0.1454±0.0108±0.0036	144810	149 ABBIENDI	01O OPAL	$E_{cm}^{ee} = 88-94$ GeV
0.1516±0.0021	559000	150 ABE	01B SLD	$E_{cm}^{ee} = 91.24$ GeV
0.1504±0.0068±0.0008		151 HEISTER	01 ALEP	$E_{cm}^{ee} = 88-94$ GeV
0.1382±0.0116±0.0005	105000	152 ABREU	00E DLPH	$E_{cm}^{ee} = 88-94$ GeV
0.1678±0.0127±0.0030	137092	153 ACCIARRI	98H L3	$E_{cm}^{ee} = 88-94$ GeV
0.162 ±0.041 ±0.014	89838	154 ABE	97 SLD	$E_{cm}^{ee} = 91.27$ GeV
0.202 ±0.038 ±0.008		155 ABE	95J SLD	$E_{cm}^{ee} = 91.31$ GeV

149 ABBIENDI 01O fit for  $A_e$  and  $A_\tau$  from measurements of the  $\tau$  polarization at varying  $\tau$  production angles. The correlation between  $A_e$  and  $A_\tau$  is less than 0.03.

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

151 HEISTER 01 obtain this result fitting the  $\tau$  polarization as a function of the polar production angle of the  $\tau$ .

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

153 Derived from the measurement of forward-backward  $\tau$  polarization asymmetry.

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

155 ABE 95J obtain this result from polarized Bhabha scattering.

### $A_\mu$

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  $A_e$ .

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.142±0.015</b>	16844	<sup>156</sup> ABE	01B SLD	$E_{cm}^{ee} = 91.24$ GeV

<sup>156</sup> ABE 01B obtain this direct measurement using the left-right production and left-right forward-backward polar angle asymmetries in  $\mu^+\mu^-$  decays of the  $Z$  boson obtained with a polarized electron beam.

### $A_\tau$

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

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.143 ±0.004 OUR AVERAGE</b>				
0.1456±0.0076±0.0057	144810	<sup>157</sup> ABBIENDI	01O OPAL	$E_{cm}^{ee} = 88-94$ GeV
0.136 ±0.015	16083	<sup>158</sup> ABE	01B SLD	$E_{cm}^{ee} = 91.24$ GeV
0.1451±0.0052±0.0029		<sup>159</sup> HEISTER	01 ALEP	$E_{cm}^{ee} = 88-94$ GeV
0.1359±0.0079±0.0055	105000	<sup>160</sup> ABREU	00E DLPH	$E_{cm}^{ee} = 88-94$ GeV
0.1476±0.0088±0.0062	137092	ACCIARRI	98H L3	$E_{cm}^{ee} = 88-94$ GeV

<sup>157</sup> ABBIENDI 01O fit for  $A_e$  and  $A_\tau$  from measurements of the  $\tau$  polarization at varying  $\tau$  production angles. The correlation between  $A_e$  and  $A_\tau$  is less than 0.03.

<sup>158</sup> 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.

<sup>159</sup> HEISTER 01 obtain this result fitting the  $\tau$  polarization as a function of the polar production angle of the  $\tau$ .

<sup>160</sup> ABREU 00E obtain this result fitting the  $\tau$  polarization as a function of the polar  $\tau$  production angle. This measurement is a combination of different analyses (exclusive  $\tau$  decay modes, inclusive hadronic 1-prong reconstruction, and a neural network analysis).

### $A_s$

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

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.895±0.066±0.062</b>	2870	<sup>161</sup> ABE	00D SLD	$E_{cm}^{ee} = 91.2$ GeV

<sup>161</sup> ABE 00D tag  $Z \rightarrow s\bar{s}$  events by an absence of  $B$  or  $D$  hadrons and the presence in each hemisphere of a high momentum  $K^\pm$  or  $K_S^0$ .

## $A_c$

This quantity is directly extracted from a measurement of the left-right forward-backward asymmetry in  $c\bar{c}$  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."

VALUE	DOCUMENT ID	TECN	COMMENT
<b>0.671 ± 0.027 OUR FIT</b>			
0.6712 ± 0.0224 ± 0.0157	162 ABE	05 SLD	$E_{\text{cm}}^{ee} = 91.24$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •			
0.583 ± 0.055 ± 0.055	163 ABE	02G SLD	$E_{\text{cm}}^{ee} = 91.24$ GeV
0.688 ± 0.041	164 ABE	01C SLD	$E_{\text{cm}}^{ee} = 91.25$ GeV

<sup>162</sup> ABE 05 use hadronic  $Z$  decays collected during 1996–98 to obtain an enriched sample of  $c\bar{c}$  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.

<sup>163</sup> 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  $A_c$ .

<sup>164</sup> ABE 01C tag  $Z \rightarrow c\bar{c}$  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  $b\bar{b}$  events is separated efficiently from the signal using precision vertex information. When combining the  $A_c$  values from these two samples, care is taken to avoid double counting of events common to the two samples, and common systematic errors are properly taken into account.

## $A_b$

This quantity is directly extracted from a measurement of the left-right forward-backward asymmetry in  $b\bar{b}$  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."

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.923 ± 0.020 OUR FIT</b>				
0.9170 ± 0.0147 ± 0.0145		165 ABE	05 SLD	$E_{\text{cm}}^{ee} = 91.24$ GeV
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.907 ± 0.020 ± 0.024	48028	166 ABE	03F SLD	$E_{\text{cm}}^{ee} = 91.24$ GeV
0.919 ± 0.030 ± 0.024		167 ABE	02G SLD	$E_{\text{cm}}^{ee} = 91.24$ GeV
0.855 ± 0.088 ± 0.102	7473	168 ABE	99L SLD	$E_{\text{cm}}^{ee} = 91.27$ GeV

<sup>165</sup> ABE 05 use hadronic  $Z$  decays collected during 1996–98 to obtain an enriched sample of  $b\bar{b}$  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.

<sup>166</sup> ABE 03F obtain an enriched sample of  $b\bar{b}$  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 981 (1993–1995 data sample).

- 167 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  $A_c$ .
- 168 ABE 99L obtain an enriched sample of  $b\bar{b}$  events tagging with an inclusive vertex mass cut. For distinguishing  $b$  and  $\bar{b}$  quarks they use the charge of identified  $K^\pm$ .

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

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

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

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

$C_{TT}$  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  $\tau$  polarization  $P_\tau$  ( $= -A_\tau$ ) 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  $\Phi$  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  $P_\tau$ .

### $C_{TT}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.01 ± 0.12 OUR AVERAGE</b>				
0.87 ± 0.20 <sup>+0.10</sup> <sub>-0.12</sub>	9.1k	ABREU	97G DLPH	$E_{\text{cm}}^{ee} = 91.2$ GeV
1.06 ± 0.13 ± 0.05	120k	BARATE	97D ALEP	$E_{\text{cm}}^{ee} = 91.2$ GeV

### $C_{TN}$

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b>0.08 ± 0.13 ± 0.04</b>	120k	169 BARATE	97D ALEP	$E_{\text{cm}}^{ee} = 91.2$ GeV

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

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

These asymmetries are experimentally determined by tagging the respective lepton or quark flavor in  $e^+ e^-$  interactions. Details of heavy flavor ( $c$ - or  $b$ -quark) tagging at LEP are described in the note on "The Z Boson." 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,  $M_{\text{top}} = 174.3$  GeV,  $M_{\text{Higgs}} = 150$  GeV,  $\alpha_s = 0.119$ ,  $\alpha^{(5)}(M_Z) = 1/128.877$  and the Fermi constant  $G_F = 1.16637 \times 10^{-5} \text{ GeV}^{-2}$  (see the note on "The Z Boson" for references).

For non-LEP data the Standard Model predictions are as given by the authors of the respective publications.

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

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

<u>ASYMMETRY (%)</u>	<u>STD. MODEL</u>	<u><math>\sqrt{s}</math> (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b>1.45 ± 0.25 OUR FIT</b>				
0.89 ± 0.44	1.57	91.2	170 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	171 BARATE	00C ALEP

<sup>170</sup> 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.

<sup>171</sup> BARATE 00C error includes approximately 0.31 due to statistics, 0.06 due to experimental systematics, and 0.13 due to the theoretical uncertainty in *t*-channel prediction.

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

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

<u>ASYMMETRY (%)</u>	<u>STD. MODEL</u>	<u><math>\sqrt{s}</math> (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b>1.69 ± 0.13 OUR FIT</b>				
1.59 ± 0.23	1.57	91.2	172 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	173 BARATE	00C ALEP

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

9 ± 30	-1.3	20	174 ABREU	95M DLPH
7 ± 26	-8.3	40	174 ABREU	95M DLPH
-11 ± 33	-24.1	57	174 ABREU	95M DLPH
-62 ± 17	-44.6	69	174 ABREU	95M DLPH
-56 ± 10	-63.5	79	174 ABREU	95M DLPH
-13 ± 5	-34.4	87.5	174 ABREU	95M DLPH
-29.0 <sup>+</sup> 5.0 <sub>-</sub> 4.8 ± 0.5	-32.1	56.9	175 ABE	90I VNS
- 9.9 ± 1.5 ± 0.5	-9.2	35	HEGNER	90 JADE
0.05 ± 0.22	0.026	91.14	176 ABRAMS	89D MRK2
-43.4 ± 17.0	-24.9	52.0	177 BACALA	89 AMY
-11.0 ± 16.5	-29.4	55.0	177 BACALA	89 AMY
-30.0 ± 12.4	-31.2	56.0	177 BACALA	89 AMY

-46.2 ± 14.9	-33.0	57.0	<sup>177</sup> BACALA	89 AMY
-29 ± 13	-25.9	53.3	ADACHI	88C TOPZ
+ 5.3 ± 5.0 ± 0.5	-1.2	14.0	ADEVA	88 MRKJ
-10.4 ± 1.3 ± 0.5	-8.6	34.8	ADEVA	88 MRKJ
-12.3 ± 5.3 ± 0.5	-10.7	38.3	ADEVA	88 MRKJ
-15.6 ± 3.0 ± 0.5	-14.9	43.8	ADEVA	88 MRKJ
- 1.0 ± 6.0	-1.2	13.9	BRAUNSCH...	88D TASS
- 9.1 ± 2.3 ± 0.5	-8.6	34.5	BRAUNSCH...	88D TASS
-10.6 + <sup>2.2</sup> / <sub>-2.3</sub> ± 0.5	-8.9	35.0	BRAUNSCH...	88D TASS
-17.6 + <sup>4.4</sup> / <sub>-4.3</sub> ± 0.5	-15.2	43.6	BRAUNSCH...	88D TASS
- 4.8 ± 6.5 ± 1.0	-11.5	39	BEHREND	87C CELL
-18.8 ± 4.5 ± 1.0	-15.5	44	BEHREND	87C CELL
+ 2.7 ± 4.9	-1.2	13.9	BARTEL	86C JADE
-11.1 ± 1.8 ± 1.0	-8.6	34.4	BARTEL	86C JADE
-17.3 ± 4.8 ± 1.0	-13.7	41.5	BARTEL	86C JADE
-22.8 ± 5.1 ± 1.0	-16.6	44.8	BARTEL	86C JADE
- 6.3 ± 0.8 ± 0.2	-6.3	29	ASH	85 MAC
- 4.9 ± 1.5 ± 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

<sup>172</sup> ABBIENDI 01A error is almost entirely on account of statistics.

<sup>173</sup> BARATE 00C error is almost entirely on account of statistics.

<sup>174</sup> ABREU 95M perform this measurement using radiative muon-pair events associated with high-energy isolated photons.

<sup>175</sup> ABE 90I measurements in the range  $50 \leq \sqrt{s} \leq 60.8$  GeV.

<sup>176</sup> ABRAMS 89D asymmetry includes both 9  $\mu^+\mu^-$  and 15  $\tau^+\tau^-$  events.

<sup>177</sup> BACALA 89 systematic error is about 5%.

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

OUR FIT is obtained using the fit procedure and correlations as determined by the LEP Electroweak Working Group (see the "Note on the Z boson"). 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.

<u>ASYMMETRY (%)</u>	<u>STD. MODEL</u>	<u><math>\sqrt{s}</math> (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b>1.88 ± 0.17 OUR FIT</b>				
1.45 ± 0.30	1.57	91.2	<sup>178</sup> 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	<sup>179</sup> BARATE	00C ALEP
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
-32.8 + <sup>6.4</sup> / <sub>-6.2</sub> ± 1.5	-32.1	56.9	<sup>180</sup> ABE	90I VNS
- 8.1 ± 2.0 ± 0.6	-9.2	35	HEGNER	90 JADE
-18.4 ± 19.2	-24.9	52.0	<sup>181</sup> BACALA	89 AMY
-17.7 ± 26.1	-29.4	55.0	<sup>181</sup> BACALA	89 AMY
-45.9 ± 16.6	-31.2	56.0	<sup>181</sup> BACALA	89 AMY
-49.5 ± 18.0	-33.0	57.0	<sup>181</sup> BACALA	89 AMY

-20 ±14	-25.9	53.3	ADACHI	88C TOPZ
-10.6 ± 3.1 ±1.5	-8.5	34.7	ADEVA	88 MRKJ
- 8.5 ± 6.6 ±1.5	-15.4	43.8	ADEVA	88 MRKJ
- 6.0 ± 2.5 ±1.0	8.8	34.6	BARTEL	85F JADE
-11.8 ± 4.6 ±1.0	14.8	43.0	BARTEL	85F JADE
- 5.5 ± 1.2 ±0.5	-0.063	29.0	FERNANDEZ	85 MAC
- 4.2 ± 2.0	0.057	29	LEVI	83 MRK2
-10.3 ± 5.2	-9.2	34.2	BEHREND	82 CELL
- 0.4 ± 6.6	-9.1	34.2	BRANDELIK	82C TASS

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

179 BARATE 00C error includes approximately 0.26 due to statistics and 0.11 due to experimental systematics.

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

181 BACALA 89 systematic error is about 5%.

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

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

<u>ASYMMETRY (%)</u>	<u>STD. MODEL</u>	<u><math>\sqrt{s}</math> (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b>1.71±0.10 OUR FIT</b>				
1.45±0.17	1.57	91.2	182 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	183 BARATE	00C ALEP

182 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.

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

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

<u>ASYMMETRY (%)</u>	<u>STD. MODEL</u>	<u><math>\sqrt{s}</math> (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b>4.0±6.7±2.8</b>	<b>7.2</b>	<b>91.2</b>	184 ACKERSTAFF	97T OPAL

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



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

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

<u>ASYMMETRY (%)</u>	<u>STD. MODEL</u>	<u><math>\sqrt{s}</math> (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b>9.8 ± 1.1 OUR AVERAGE</b>				
10.08 ± 1.13 ± 0.40	10.1	91.2	185 ABREU	00B DLPH
6.8 ± 3.5 ± 1.1	10.1	91.2	186 ACKERSTAFF	97T OPAL
13.1 ± 3.5 ± 1.3	10.1	91.2	187 ABREU	95G DLPH

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

185 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.

186 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.

187 ABREU 95G require the presence of a high-momentum charged kaon or  $\Lambda^0$  to tag the  $s$  quark. An unresolved  $s$ - and  $d$ -quark asymmetry of  $(11.2 \pm 3.1 \pm 5.4)\%$  is obtained by tagging the presence of a high-energy neutron or neutral kaon in the hadron calorimeter. Superseded by ABREU 00B.

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

OUR FIT, which is obtained by a simultaneous fit to several  $c$ - and  $b$ -quark measurements as explained in the “Note on the  $Z$  boson,” refers to the **Z pole** asymmetry. The experimental values, on the other hand, correspond to the measurements carried out at the respective energies. As a cross check we have also performed a weighted average of the “near peak” measurements taking into account the various common systematic errors. Applying to this combined “peak” measurement QED and energy-dependence corrections, our weighted average gives a pole asymmetry of  $(6.89 \pm 0.39)\%$ , the Standard Model prediction being 7.25%.

<u>ASYMMETRY (%)</u>	<u>STD. MODEL</u>	<u><math>\sqrt{s}</math> (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b>7.08 ± 0.35 OUR FIT</b>				
6.31 ± 0.93 ± 0.65	6.35	91.26	188 ABDALLAH	04F DLPH
5.68 ± 0.54 ± 0.39	6.3	91.25	189 ABBIENDI	03P OPAL
6.45 ± 0.57 ± 0.37	6.10	91.21	190 HEISTER	02H ALEP
6.59 ± 0.94 ± 0.35	6.2	91.235	191 ABREU	99Y DLPH
6.3 ± 0.9 ± 0.3	6.1	91.22	192 BARATE	98O ALEP
6.3 ± 1.2 ± 0.6	6.1	91.22	193 ALEXANDER	97C OPAL
8.3 ± 3.8 ± 2.7	6.2	91.24	194 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	188	ABDALLAH	04F	DLPH
11.0 ± 2.8 ± 0.7	12.3	92.99	188	ABDALLAH	04F	DLPH
− 6.8 ± 2.5 ± 0.9	−3.0	89.51	189	ABBIENDI	03P	OPAL
14.6 ± 2.0 ± 0.8	12.2	92.95	189	ABBIENDI	03P	OPAL
−12.4 ± 15.9 ± 2.0	−9.6	88.38	190	HEISTER	02H	ALEP
− 2.3 ± 2.6 ± 0.2	−3.8	89.38	190	HEISTER	02H	ALEP
− 0.3 ± 8.3 ± 0.6	0.9	90.21	190	HEISTER	02H	ALEP
10.6 ± 7.7 ± 0.7	9.6	92.05	190	HEISTER	02H	ALEP
11.9 ± 2.1 ± 0.6	12.2	92.94	190	HEISTER	02H	ALEP
12.1 ± 11.0 ± 1.0	14.2	93.90	190	HEISTER	02H	ALEP
− 4.96 ± 3.68 ± 0.53	−3.5	89.434	191	ABREU	99Y	DLPH
11.80 ± 3.18 ± 0.62	12.3	92.990	191	ABREU	99Y	DLPH
− 1.0 ± 4.3 ± 1.0	−3.9	89.37	192	BARATE	98O	ALEP
11.0 ± 3.3 ± 0.8	12.3	92.96	192	BARATE	98O	ALEP
3.9 ± 5.1 ± 0.9	−3.4	89.45	193	ALEXANDER	97C	OPAL
15.8 ± 4.1 ± 1.1	12.4	93.00	193	ALEXANDER	97C	OPAL
−12.9 ± 7.8 ± 5.5	−13.6	35		BEHREND	90D	CELL
7.7 ± 13.4 ± 5.0	−22.1	43		BEHREND	90D	CELL
−12.8 ± 4.4 ± 4.1	−13.6	35		ELSEN	90	JADE
−10.9 ± 12.9 ± 4.6	−23.2	44		ELSEN	90	JADE
−14.9 ± 6.7	−13.3	35		OULD-SAADA	89	JADE

188 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  $c\bar{c}$  and  $b\bar{b}$  events are obtained using lifetime information.

189 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  $B^0$ - $\bar{B}^0$  mixing.

190 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.

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

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

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

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

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

OUR FIT, which is obtained by a simultaneous fit to several  $c$ - and  $b$ -quark measurements as explained in the “Note on the  $Z$  boson,” refers to the  **$Z$  pole** asymmetry. The experimental values, on the other hand, correspond to the measurements carried out at the respective energies. As a cross check we have also performed a weighted average of the “near peak” measurements taking into account the various common systematic errors. Applying to this combined “peak” measurement QED and energy-dependence corrections, our weighted average gives a pole asymmetry of  $(10.05 \pm 0.17)\%$ , the Standard Model prediction being 10.15%. For the jet-charge measurements (where the QCD effects are included since they

represent an inherent part of the analysis), we use the corrections given by the authors.

<u>ASYMMETRY (%)</u>	<u>STD. MODEL</u>	<u><math>\sqrt{s}</math> (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
<b>9.91 ± 0.16 OUR FIT</b>				
9.58 ± 0.32 ± 0.14	9.68	91.231	195 ABDALLAH	05 DLPH
10.04 ± 0.56 ± 0.25	9.69	91.26	196 ABDALLAH	04F DLPH
9.72 ± 0.42 ± 0.15	9.67	91.25	197 ABBIENDI	03P OPAL
9.77 ± 0.36 ± 0.18	9.69	91.26	198 ABBIENDI	02I OPAL
9.52 ± 0.41 ± 0.17	9.59	91.21	199 HEISTER	02H ALEP
10.00 ± 0.27 ± 0.11	9.63	91.232	200 HEISTER	01D ALEP
7.62 ± 1.94 ± 0.85	9.64	91.235	201 ABREU	99Y DLPH
9.60 ± 0.66 ± 0.33	9.69	91.26	202 ACCIARRI	99D L3
9.31 ± 1.01 ± 0.55	9.65	91.24	203 ACCIARRI	98U L3
9.4 ± 2.7 ± 2.2	9.61	91.22	204 ALEXANDER	97C OPAL
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
6.37 ± 1.43 ± 0.17	5.8	89.449	195 ABDALLAH	05 DLPH
10.41 ± 1.15 ± 0.24	12.1	92.990	195 ABDALLAH	05 DLPH
6.7 ± 2.2 ± 0.2	5.7	89.43	196 ABDALLAH	04F DLPH
11.2 ± 1.8 ± 0.2	12.1	92.99	196 ABDALLAH	04F DLPH
4.7 ± 1.8 ± 0.1	5.9	89.51	197 ABBIENDI	03P OPAL
10.3 ± 1.5 ± 0.2	12.0	92.95	197 ABBIENDI	03P OPAL
5.82 ± 1.53 ± 0.12	5.9	89.50	198 ABBIENDI	02I OPAL
12.21 ± 1.23 ± 0.25	12.0	92.91	198 ABBIENDI	02I OPAL
-13.1 ± 13.5 ± 1.0	3.2	88.38	199 HEISTER	02H ALEP
5.5 ± 1.9 ± 0.1	5.6	89.38	199 HEISTER	02H ALEP
-0.4 ± 6.7 ± 0.8	7.5	90.21	199 HEISTER	02H ALEP
11.1 ± 6.4 ± 0.5	11.0	92.05	199 HEISTER	02H ALEP
10.4 ± 1.5 ± 0.3	12.0	92.94	199 HEISTER	02H ALEP
13.8 ± 9.3 ± 1.1	12.9	93.90	199 HEISTER	02H ALEP
4.36 ± 1.19 ± 0.11	5.8	89.472	200 HEISTER	01D ALEP
11.72 ± 0.97 ± 0.11	12.0	92.950	200 HEISTER	01D ALEP
5.67 ± 7.56 ± 1.17	5.7	89.434	201 ABREU	99Y DLPH
8.82 ± 6.33 ± 1.22	12.1	92.990	201 ABREU	99Y DLPH
6.11 ± 2.93 ± 0.43	5.9	89.50	202 ACCIARRI	99D L3
13.71 ± 2.40 ± 0.44	12.2	93.10	202 ACCIARRI	99D L3
4.95 ± 5.23 ± 0.40	5.8	89.45	203 ACCIARRI	98U L3
11.37 ± 3.99 ± 0.65	12.1	92.99	203 ACCIARRI	98U L3
-8.6 ± 10.8 ± 2.9	5.8	89.45	204 ALEXANDER	97C OPAL
-2.1 ± 9.0 ± 2.6	12.1	93.00	204 ALEXANDER	97C OPAL
-71 ± 34 + - 8	-58	58.3	SHIMONAKA	91 TOPZ
-22.2 ± 7.7 ± 3.5	-26.0	35	BEHREND	90D CELL
-49.1 ± 16.0 ± 5.0	-39.7	43	BEHREND	90D CELL
-28 ± 11	-23	35	BRAUNSCH...	90 TASS
-16.6 ± 7.7 ± 4.8	-24.3	35	ELSEN	90 JADE
-33.6 ± 22.2 ± 5.2	-39.9	44	ELSEN	90 JADE
3.4 ± 7.0 ± 3.5	-16.0	29.0	BAND	89 MAC
-72 ± 28 ± 13	-56	55.2	SAGAWA	89 AMY

- 195 ABDALLAH 05 obtain an enriched samples of  $b\bar{b}$  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.
- 196 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  $c\bar{c}$  and  $b\bar{b}$  events are obtained using lifetime information.
- 197 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  $B^0-\bar{B}^0$  mixing.
- 198 ABBIENDI 02I tag  $Z^0 \rightarrow b\bar{b}$  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.
- 199 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.
- 200 HEISTER 01D tag  $Z \rightarrow b\bar{b}$  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  $A_{FB}^C$  and  $R_b$  is given as  $+0.103 (A_{FB}^C - 0.0651) - 0.440 (R_b - 0.21585)$ .
- 201 ABREU 99Y tag  $Z \rightarrow b\bar{b}$  and  $Z \rightarrow c\bar{c}$  events by an exclusive reconstruction of several  $D$  meson decay modes ( $D^{*+}$ ,  $D^0$ , and  $D^+$  with their charge-conjugate states).
- 202 ACCIARRI 99D tag  $Z \rightarrow b\bar{b}$  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.
- 203 ACCIARRI 98U tag  $Z \rightarrow b\bar{b}$  events using lifetime and measure the jet charge using the hemisphere charge.
- 204 ALEXANDER 97C identify the  $b$  and  $c$  events using a  $D/D^*$  tag.

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

Summed over five lighter flavors.

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

<u>ASYMMETRY (%)</u>	<u>STD. MODEL</u>	<u><math>\sqrt{s}</math> (GeV)</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
– 0.76 ± 0.12 ± 0.15		91.2	205 ABREU	92I DLPH
4.0 ± 0.4 ± 0.63	4.0	91.3	206 ACTON	92L OPAL
9.1 ± 1.4 ± 1.6	9.0	57.9	ADACHI	91 TOPZ
– 0.84 ± 0.15 ± 0.04		91	DECAMP	91B ALEP
8.3 ± 2.9 ± 1.9	8.7	56.6	STUART	90 AMY
11.4 ± 2.2 ± 2.1	8.7	57.6	ABE	89L VNS
6.0 ± 1.3	5.0	34.8	GREENSHAW	89 JADE
8.2 ± 2.9	8.5	43.6	GREENSHAW	89 JADE

- 205 ABREU 92I has 0.14 systematic error due to uncertainty of quark fragmentation.  
 206 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  $B^0-\bar{B}^0$  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  $0.2321 \pm 0.0017 \pm 0.0028$ .

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

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

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

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$h_i^V$

Combining the LEP results properly taking into account the correlations the following 95% CL limits are derived:

(See EP Preprint Summer 2004: CERN-PH-EP/2004-069 and hep-ex/0412015, 6 December 2004, on <http://lepewwg.web.cern.ch/LEPEWWG/stanmod/>)

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

<u>VALUE</u>	<u>DOCUMENT ID</u>	<u>TECN</u>
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• • • We do not use the following data for averages, fits, limits, etc. • • •

207 ACHARD	04H L3
208 ABBIENDI,G	00C OPAL
209 ABBOTT	98M D0
210 ABREU	98K DLPH

- 207 ACHARD 04H select 3515  $e^+e^- \rightarrow Z\gamma$  events with  $Z \rightarrow q\bar{q}$  or  $\nu\bar{\nu}$  at  $\sqrt{s} = 189\text{--}209$  GeV to derive 95% CL limits on  $h_i^V$ . For deriving each limit the other parameters are fixed at zero. They report:  $-0.153 < h_1^Z < 0.141$ ,  $-0.087 < h_2^Z < 0.079$ ,  $-0.220 < h_3^Z < 0.112$ ,  $-0.068 < h_4^Z < 0.148$ ,  $-0.057 < h_1^\gamma < 0.057$ ,  $-0.050 < h_2^\gamma < 0.023$ ,  $-0.059 < h_3^\gamma < 0.004$ ,  $-0.004 < h_4^\gamma < 0.042$ .

- 208 ABBIENDI,G 00C study  $e^+e^- \rightarrow Z\gamma$  events (with  $Z \rightarrow q\bar{q}$  and  $Z \rightarrow \nu\bar{\nu}$ ) 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.

- 209 ABBOTT 98M study  $p\bar{p} \rightarrow Z\gamma + X$ , with  $Z \rightarrow e^+e^-, \mu^+\mu^-, \bar{\nu}\nu$  at 1.8 TeV, to obtain 95% CL limits at  $\Lambda = 750$  GeV:  $|h_{30}^Z| < 0.36$ ,  $|h_{40}^Z| < 0.05$  (keeping  $|h_{30}^\gamma| < 0.37$ ,  $|h_{40}^\gamma| < 0.05$  (keeping  $h_i^Z=0$ )). Limits on the  $CP$ -violating couplings are  $|h_{10}^Z| < 0.36$ ,  $|h_{20}^Z| < 0.05$  (keeping  $h_i^\gamma=0$ ), and  $|h_{10}^\gamma| < 0.37$ ,  $|h_{20}^\gamma| < 0.05$  (keeping  $h_i^Z=0$ ).
- 210 ABREU 98K determine a 95% CL upper limit on  $\sigma(e^+e^- \rightarrow \gamma + \text{invisible particles}) < 2.5$  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  $\Lambda=1$  TeV and with  $n=3$  in the form factor representation.

**$f_i^V$**

Combining the LEP results properly taking into account the correlations the following 95% CL limits are derived:

(See EP Preprint Summer 2004: CERN-PH-EP/2004-069 and hep-ex/0412015, 6 December 2004, on <http://lepewwg.web.cern.ch/LEPEWWG/stanmod/>)

$$\begin{aligned} -0.30 < f_4^Z < +0.30, & \quad -0.34 < f_5^Z < +0.38, \\ -0.17 < f_4^\gamma < +0.19, & \quad -0.32 < f_5^\gamma < +0.36. \end{aligned}$$

VALUE \_\_\_\_\_ DOCUMENT ID \_\_\_\_\_ TECN \_\_\_\_\_

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

211 ABBIENDI 04C OPAL  
212 ACHARD 03D L3

- 211 ABBIENDI 04C study  $ZZ$  production in  $e^+e^-$  collisions in the C.M. energy range 190–209 GeV. They select 340 events with an expected background of 180 events. Including the ABBIENDI 00N data at 183 and 189 GeV (118 events with an expected background of 65 events) they report the following 95% CL limits:  $-0.45 < f_4^Z < 0.58$ ,  $-0.94 < f_5^Z < 0.25$ ,  $-0.32 < f_4^\gamma < 0.33$ , and  $-0.71 < f_5^\gamma < 0.59$ .
- 212 ACHARD 03D study  $Z$ -boson pair production in  $e^+e^-$  collisions in the C.M. energy range 200–209 GeV. They select 549 events with an expected background of 432 events. Including the ACCIARRI 99G and ACCIARRI 99O data (183 and 189 GeV respectively, 286 events with an expected background of 241 events) and the 192–202 GeV ACCIARRI 01I results (656 events, expected background of 512 events), they report the following 95% CL limits:  $-0.48 \leq f_4^Z \leq 0.46$ ,  $-0.36 \leq f_5^Z \leq 1.03$ ,  $-0.28 \leq f_4^\gamma \leq 0.28$ , and  $-0.40 \leq f_5^\gamma \leq 0.47$ .

## ANOMALOUS $W/Z$ QUARTIC COUPLINGS

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**$a_0/\Lambda^2, a_c/\Lambda^2$**

Combining published and unpublished preliminary LEP results the following 95% CL intervals for the QGCs associated with the  $ZZ\gamma\gamma$  vertex are derived:

(See EP Preprint Summer 2004: CERN-PH-EP/2004-069 and hep-ex/0412015, 6 December 2004, on <http://lepewwg.web.cern.ch/LEPEWWG/stanmod/>)

$$\begin{aligned} -0.008 < a_0^Z/\Lambda^2 < +0.021 \\ -0.029 < a_c^Z/\Lambda^2 < +0.039 \end{aligned}$$

VALUE \_\_\_\_\_ DOCUMENT ID \_\_\_\_\_ TECN \_\_\_\_\_

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

213 ABBIENDI 04L OPAL  
 214 HEISTER 04A ALEP  
 215 ACHARD 02G L3

213 ABBIENDI 04L select 20  $e^+e^- \rightarrow \nu\bar{\nu}\gamma\gamma$  acoplanar events in the energy range 180–209 GeV and 176  $e^+e^- \rightarrow q\bar{q}\gamma\gamma$  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:  $-0.007 < a_0^Z/\Lambda^2 < 0.023 \text{ GeV}^{-2}$ ,  $-0.029 < a_c^Z/\Lambda^2 < 0.029 \text{ GeV}^{-2}$ ,  $-0.020 < a_0^W/\Lambda^2 < 0.020 \text{ GeV}^{-2}$ ,  $-0.052 < a_c^W/\Lambda^2 < 0.037 \text{ GeV}^{-2}$ .

214 In the CM energy range 183 to 209 GeV HEISTER 04A select 30  $e^+e^- \rightarrow \nu\bar{\nu}\gamma\gamma$  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:  $-0.012 < a_0^Z/\Lambda^2 < 0.019 \text{ GeV}^{-2}$ ,  $-0.041 < a_c^Z/\Lambda^2 < 0.044 \text{ GeV}^{-2}$ ,  $-0.060 < a_0^W/\Lambda^2 < 0.055 \text{ GeV}^{-2}$ ,  $-0.099 < a_c^W/\Lambda^2 < 0.093 \text{ GeV}^{-2}$ .

215 ACHARD 02G study  $e^+e^- \rightarrow Z\gamma\gamma \rightarrow q\bar{q}\gamma\gamma$  events using data at center-of-mass energies from 200 to 209 GeV. The photons are required to be isolated, each with energy  $> 5 \text{ GeV}$  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  $q\bar{q}\gamma\gamma$  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  $a_0/\Lambda^2 = 0.00^{+0.02}_{-0.01} \text{ GeV}^{-2}$  and  $a_c/\Lambda^2 = 0.03^{+0.01}_{-0.02} \text{ GeV}^{-2}$ , where the other parameter is kept fixed to its Standard Model value (0). A simultaneous fit to both parameters yields the 95% CL limits  $-0.02 \text{ GeV}^{-2} < a_0/\Lambda^2 < 0.03 \text{ GeV}^{-2}$  and  $-0.07 \text{ GeV}^{-2} < a_c/\Lambda^2 < 0.05 \text{ GeV}^{-2}$ .

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ABE	05	PRL 94 091801	K. Abe <i>et al.</i>	(SLD Collab.)
ABBIENDI	04B	PL B580 17	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	04C	EPJ C32 303	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	04E	PL B586 167	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	04G	EPJ C33 173	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	04L	PR D70 032005	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABDALLAH	04F	EPJ C34 109	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
ABE	04C	PR D69 072003	K. Abe <i>et al.</i>	(SLD Collab.)
ACHARD	04C	PL B585 42	P. Achard <i>et al.</i>	(L3 Collab.)
ACHARD	04H	PL B597 119	P. Achard <i>et al.</i>	(L3 Collab.)
HEISTER	04A	PL B602 31	A. Heister <i>et al.</i>	(ALEPH Collab.)
SCHAEEL	04	PL B599 1	S. Schaeel <i>et al.</i>	(ALEPH Collab.)
ABBIENDI	03P	PL B577 18	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABDALLAH	03H	PL B569 129	J. Abdallah <i>et al.</i>	(DELPHI Collab.)
ABE	03F	PRL 90 141804	K. Abe <i>et al.</i>	(SLD Collab.)
ACHARD	03D	PL B572 133	P. Achard <i>et al.</i>	(L3 Collab.)
ACHARD	03G	PL B577 109	P. Achard <i>et al.</i>	(L3 Collab.)
ABBIENDI	02I	PL B546 29	G. Abbiendi <i>et al.</i>	(OPAL Collab.)

ABE	02G	PRL 88 151801	K. Abe <i>et al.</i>	(SLD Collab.)
ACHARD	02G	PL B540 43	P. Achard <i>et al.</i>	(L3 Collab.)
HEISTER	02B	PL B526 34	A. Heister <i>et al.</i>	(ALEPH Collab.)
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ABBIENDI	01A	EPJ C19 587	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
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ABBIENDI	01N	EPJ C20 445	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI	01O	EPJ C21 1	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABE	01B	PRL 86 1162	K. Abe <i>et al.</i>	(SLD Collab.)
ABE	01C	PR D63 032005	K. Abe <i>et al.</i>	(SLD Collab.)
ACCIARRI	01E	PL B505 47	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	01I	PL B497 23	M. Acciarri <i>et al.</i>	(L3 Collab.)
HEISTER	01	EPJ C20 401	A. Heister <i>et al.</i>	(ALEPH Collab.)
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ABBIENDI	00N	PL B476 256	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABBIENDI,G	00C	EPJ C17 553	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
ABE	00B	PRL 84 5945	K. Abe <i>et al.</i>	(SLD Collab.)
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ABREU	00E	EPJ C14 585	P. Abreu <i>et al.</i>	(DELPHI Collab.)
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ABREU	00P	PL B475 429	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	00	EPJ C13 47	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	00C	EPJ C16 1	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	00J	PL B479 79	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	00Q	PL B489 93	M. Acciarri <i>et al.</i>	(L3 Collab.)
BARATE	00B	EPJ C16 597	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	00C	EPJ C14 1	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	00O	EPJ C16 613	R. Barate <i>et al.</i>	(ALEPH Collab.)
ABBIENDI	99B	EPJ C8 217	G. Abbiendi <i>et al.</i>	(OPAL Collab.)
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ABREU	99	EPJ C6 19	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	99B	EPJ C10 415	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	99J	PL B449 364	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	99U	PL B462 425	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	99Y	EPJ C10 219	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	99D	PL B448 152	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	99F	PL B453 94	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	99G	PL B450 281	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	99O	PL B465 363	M. Acciarri <i>et al.</i>	(L3 Collab.)
ABBOTT	98M	PR D57 R3817	B. Abbott <i>et al.</i>	(D0 Collab.)
ABE	98D	PRL 80 660	K. Abe <i>et al.</i>	(SLD Collab.)
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ABREU	98K	PL B423 194	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	98L	EPJ C5 585	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	98G	PL B431 199	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	98H	PL B429 387	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	98U	PL B439 225	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACKERSTAFF	98A	EPJ C5 411	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
ACKERSTAFF	98E	EPJ C1 439	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
ACKERSTAFF	98O	PL B420 157	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
ACKERSTAFF	98Q	EPJ C4 19	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
BARATE	98O	PL B434 415	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	98T	EPJ C4 557	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	98V	EPJ C5 205	R. Barate <i>et al.</i>	(ALEPH Collab.)
ABE	97	PRL 78 17	K. Abe <i>et al.</i>	(SLD Collab.)
ABREU	97C	ZPHY C73 243	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	97E	PL B398 207	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	97G	PL B404 194	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	97D	PL B393 465	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	97J	PL B407 351	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	97L	PL B407 389	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	97R	PL B413 167	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACKERSTAFF	97K	ZPHY C74 1	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
ACKERSTAFF	97M	ZPHY C74 413	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)
ACKERSTAFF	97S	PL B412 210	K. Ackerstaff <i>et al.</i>	(OPAL Collab.)



ACKERSTAFF	97T	ZPHY C76 387	K. Akerstaff <i>et al.</i>	(OPAL Collab.)
ACKERSTAFF	97W	ZPHY C76 425	K. Akerstaff <i>et al.</i>	(OPAL Collab.)
ALEXANDER	97C	ZPHY C73 379	G. Alexander <i>et al.</i>	(OPAL Collab.)
ALEXANDER	97D	ZPHY C73 569	G. Alexander <i>et al.</i>	(OPAL Collab.)
ALEXANDER	97E	ZPHY C73 587	G. Alexander <i>et al.</i>	(OPAL Collab.)
BARATE	97D	PL B405 191	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	97E	PL B401 150	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	97F	PL B401 163	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	97H	PL B402 213	R. Barate <i>et al.</i>	(ALEPH Collab.)
BARATE	97J	ZPHY C74 451	R. Barate <i>et al.</i>	(ALEPH Collab.)
ABE	96E	PR D53 1023	K. Abe <i>et al.</i>	(SLD Collab.)
ABREU	96	ZPHY C70 531	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	96R	ZPHY C72 31	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	96S	PL B389 405	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	96U	ZPHY C73 61	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	96	PL B371 126	M. Acciarri <i>et al.</i>	(L3 Collab.)
ADAM	96	ZPHY C69 561	W. Adam <i>et al.</i>	(DELPHI Collab.)
ADAM	96B	ZPHY C70 371	W. Adam <i>et al.</i>	(DELPHI Collab.)
ALEXANDER	96B	ZPHY C70 197	G. Alexander <i>et al.</i>	(OPAL Collab.)
ALEXANDER	96F	PL B370 185	G. Alexander <i>et al.</i>	(OPAL Collab.)
ALEXANDER	96N	PL B384 343	G. Alexander <i>et al.</i>	(OPAL Collab.)
ALEXANDER	96R	ZPHY C72 1	G. Alexander <i>et al.</i>	(OPAL Collab.)
BUSKULIC	96D	ZPHY C69 393	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
BUSKULIC	96H	ZPHY C69 379	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
ABE	95J	PRL 74 2880	K. Abe <i>et al.</i>	(SLD Collab.)
ABREU	95	ZPHY C65 709 erratum	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95D	ZPHY C66 323	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95G	ZPHY C67 1	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95L	ZPHY C65 587	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95M	ZPHY C65 603	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95O	ZPHY C67 543	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95R	ZPHY C68 353	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95W	PL B361 207	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	95X	ZPHY C69 1	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACCIARRI	95B	PL B345 589	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	95C	PL B345 609	M. Acciarri <i>et al.</i>	(L3 Collab.)
ACCIARRI	95G	PL B353 136	M. Acciarri <i>et al.</i>	(L3 Collab.)
AKERS	95C	ZPHY C65 47	R. Akers <i>et al.</i>	(OPAL Collab.)
AKERS	95O	ZPHY C67 27	R. Akers <i>et al.</i>	(OPAL Collab.)
AKERS	95U	ZPHY C67 389	R. Akers <i>et al.</i>	(OPAL Collab.)
AKERS	95W	ZPHY C67 555	R. Akers <i>et al.</i>	(OPAL Collab.)
AKERS	95X	ZPHY C68 1	R. Akers <i>et al.</i>	(OPAL Collab.)
AKERS	95Z	ZPHY C68 203	R. Akers <i>et al.</i>	(OPAL Collab.)
ALEXANDER	95D	PL B358 162	G. Alexander <i>et al.</i>	(OPAL Collab.)
BUSKULIC	95R	ZPHY C69 15	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
MIYABAYASHI	95	PL B347 171	K. Miyabayashi <i>et al.</i>	(TOPAZ Collab.)
ABE	94C	PRL 73 25	K. Abe <i>et al.</i>	(SLD Collab.)
ABREU	94B	PL B327 386	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	94P	PL B341 109	P. Abreu <i>et al.</i>	(DELPHI Collab.)
AKERS	94P	ZPHY C63 181	R. Akers <i>et al.</i>	(OPAL Collab.)
BUSKULIC	94G	ZPHY C62 179	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
BUSKULIC	94J	ZPHY C62 1	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
VILAIN	94	PL B320 203	P. Vilain <i>et al.</i>	(CHARM II Collab.)
ABREU	93	PL B298 236	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	93I	ZPHY C59 533	P. Abreu <i>et al.</i>	(DELPHI Collab.)
Also	95	ZPHY C65 709 erratum	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	93L	PL B318 249	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACTON	93	PL B305 407	P.D. Acton <i>et al.</i>	(OPAL Collab.)
ACTON	93D	ZPHY C58 219	P.D. Acton <i>et al.</i>	(OPAL Collab.)
ACTON	93E	PL B311 391	P.D. Acton <i>et al.</i>	(OPAL Collab.)
ADRIANI	93	PL B301 136	O. Adriani <i>et al.</i>	(L3 Collab.)
ADRIANI	93I	PL B316 427	O. Adriani <i>et al.</i>	(L3 Collab.)
BUSKULIC	93L	PL B313 520	D. Buskulic <i>et al.</i>	(ALEPH Collab.)
NOVIKOV	93C	PL B298 453	V.A. Novikov, L.B. Okun, M.I. Vysotsky	(ITEP)
ABREU	92I	PL B277 371	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ABREU	92M	PL B289 199	P. Abreu <i>et al.</i>	(DELPHI Collab.)
ACTON	92B	ZPHY C53 539	D.P. Acton <i>et al.</i>	(OPAL Collab.)
ACTON	92L	PL B294 436	P.D. Acton <i>et al.</i>	(OPAL Collab.)
ACTON	92N	PL B295 357	P.D. Acton <i>et al.</i>	(OPAL Collab.)
ADEVA	92	PL B275 209	B. Adeva <i>et al.</i>	(L3 Collab.)
ADRIANI	92D	PL B292 454	O. Adriani <i>et al.</i>	(L3 Collab.)

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