COHEN	73	JPCRD 2 663	+Taylor	(RISC, NBS)
DUCLOS	73	PL 47B 491	+Magnon, Picard	(SACL)
EICHTEN	73	PL 46B 281	+Deden, Hasert, Krenz+	(Gargamelle Collab.)
BRYMAN	72	PRL 28 1469	+Blecher, Gotow, Powers	(VPI)
CROWE	72	PR D5 2145	+Hague, Rothberg, Schenck+	(LBL, WASH)
CRANE	71	PRL 27 474	+Casperson, Crane, Egan, Hughes+	(YALE)
DERENZO	69	PR 181 1854		(EFI)
VOSSLER	69	NC 63A 423		(EFI)
AKHMANOV	68	SJNP 6 230	+Gurevich, Dobretsov, Makarina+	(KIAE)
		Translated from YAF 6 316.		
BAILEY	68	PL 28B 287	+Bartl, VonBochmann, Brown, Farley+	(CERN)
Also	72	NC 9A 369	Bailey, Bartl, VonBochmann, Brown+	(CERN)
FRYBERGER	68	PR 166 1379		(EFI)
BOGART	67	PR 156 1405	+Dicapua, Nemethy, Strelzoff	(COLU)
SCHWARTZ	67	PR 162 1306		(EFI)
SHERWOOD	67	PR 156 1475		(EFI)
PEOPLES	66	Nevis 147 unpub.		(COLU)
BLOOM	64	PL 8 87	+Dick, Feuvrais, Henry, Macq, Spighel	(CERN)
DUCLOS	64	PL 9 62	+Heintze, DeRujula, Soergel	(CERN)
GUREVICH	64	PL 11 185	+Makarina+	(KIAE)
BUHLER	63	PL 7 368	+Cabibbo, Fidecaro, Massam, Muller+	(CERN)
MEYER	63	PR 132 2693	+Anderson, Bleser, Lederman+	(COLU)
CHARPAK	62	PL 1 16	+Farley, Garwin+	(CERN)
CONFORTO	62	NC 26 261	+Conversi, Dilella+	(INFN, ROMA, CERN)
ALI-ZADE	61	JETP 13 313	+Gurevich, Nikolski	
		Translated from ZETF 40 452.		
CRITTENDEN	61	PR 121 1823	+Walker, Ballam	(WISC, MSU)
KRUGER	61	UCRL 9322 unpub.		(LRL)
GUREVICH	60	JETP 10 225	+Nikolski, Surkova	(ITEP)
		Translated from ZETF 37 318.		
PLANO	60	PR 119 1400		(COLU)
ASHKIN	59	NC 14 1266	+Fazzini, Fidecaro, Lipman, Merrison+	(CERN)
BARDON	59	PRL 2 56	+Berley, Lederman	(COLU)
LEE	59	PRL 3 55	+Samios	(COLU)

τ

$J = \frac{1}{2}$

τ discovery paper was PERL 75. $e^+e^- \rightarrow \tau^+\tau^-$ cross-section threshold behavior and magnitude are consistent with pointlike spin-1/2 Dirac particle. BRANDELIK 78 ruled out pointlike spin-0 or spin-1 particle. FELDMAN 78 ruled out $J = 3/2$. KIRKBY 79 also ruled out J=integer, $J = 3/2$.

NOTE ON PROBLEMS IN THE τ-DECAY DATA

(by K.G. Hayes, Hillsdale College)

Problems remain in the experimental data for τ branching ratios. The first evidence that something was wrong was noticed in 1984 in what became known as the "1-prong deficit" [1,2]: If world averages were considered and theoretical predictions were used to limit certain poorly measured modes, then the measured inclusive 1-prong topological branching ratio was significantly larger than the sum of branching ratios of exclusive 1-prong decay modes. Reviews of this problem have appeared in these Listings starting with the 1988 edition. At the time of the 1992 edition, significant discrepancies had appeared between some recent and older measurements of the branching ratios for several modes, most notably $\mathrm{B}(h^-2\pi^0\nu_\tau)$ and $\mathrm{B}(h^-h^-h^+\nu_\tau)$.

Since the 1992 edition, the situation has changed in two significant ways. The long-standing "tau decay puzzle" has been resolved. If one assumes unitarity, then the leptonic branching ratios ($\mathrm{B}_e \equiv \mathrm{B}(e^-\overline{\nu}_e\nu_\tau)$ or $\mathrm{B}_\mu \equiv \mathrm{B}(\mu^-\overline{\nu}_\mu\nu_\tau)$) can be predicted from masses and lifetimes of the muon and tau. Theory and prediction have differed at the 1.5 to 2 standard deviation level since 1986. Since the last edition, new precise measurements have lowered the world averages for the τ mass and lifetime by 1.9 and 1.7 standard deviations, respectively. Using our current world averages for these quantities, the predicted electron branching ratio [3] is $18.11 \pm 0.19\%$, while the world average for $\mathrm{B}_e = 17.90 \pm 0.17\%$. This agreement provides strong evidence that the measured leptonic branching ratios of the τ are accurate, and argues against the existence of widespread systematic problems in the various strategies used to derive branching ratios from the observed numbers of $\tau^- \rightarrow e^-\overline{\nu}_e\nu_\tau$ and $\tau^- \rightarrow \mu^-\overline{\nu}_\mu\nu_\tau$ decays.

The second significant change has resulted from the publication [4,5,6] of precise new branching ratio measurements of τ decay modes of the form $\tau^- \rightarrow h^- + (\geq)n\pi^0\nu_\tau$. The CLEO collaboration [5,6] has reported values for $n = 1$, 2, 3, and 4, based upon reconstructed $\pi^0 \rightarrow \gamma\gamma$ decays for all π^0's. These new measurements have increased the internal inconsistency of the world data for these modes. The $\mathrm{B}(h^-3\pi^0\nu_\tau)$ and $\mathrm{B}(h^-4\pi^0\nu_\tau)$ measurements have allowed the replacement of our fit mode $\tau^- \rightarrow h^- \geq 3\pi^0\nu_\tau$ by the two new modes $\tau^- \rightarrow h^-3\pi^0\nu_\tau$ and $\tau^- \rightarrow h^-4\pi^0\nu_\tau$ with the assumption, valid at the present level of precision, that $\mathrm{B}(h^- \geq 5\pi^0\nu_\tau)$ is small enough to ignore. A comparison between the current and the 1992 branching ratio fit values for fit modes containing one charged hadron and one or more π^0's is presented in Table 1. The error scale factors from the fit, which are also listed, are all just under two. It is clear that significant discrepancies exist between experimental measurements of these modes.

Table 1: Fit branching ratios (%) and scale factors for τ decay modes containing one charged hadron and one or more π^0's.

Mode	1992 Fit	Scale factor	1994 Fit	Scale factor
$h^-\pi^0\nu_\tau$	24.4 ± 0.6	1.1	25.7 ± 0.4	1.7
$h^-2\pi^0\nu_\tau$	10.3 ± 0.9	1.7	9.6 ± 0.4	1.5
$h^-3\pi^0\nu_\tau$			1.28 ± 0.24	1.7
$h^-4\pi^0\nu_\tau$			$0.19 {}^{+0.12}_{-0.10}$	1.7
$h^- \geq 3\pi^0\nu_\tau$	2.7 ± 0.9	1.9	1.48 ± 0.26	1.7

The new measurements have a significant impact on the constrained fit. The fit branching ratios cannot exhibit a problem such as the 1-prong deficit, since the fit 1-prong topological branching ratio is defined to be the sum of branching ratios of exclusive 1-prong modes. Since the set of fit modes sum exactly to one, the fact that the world averages exhibit a 1-prong deficit means that the fit values for some 1-prong modes must be larger than the corresponding average values; many examples are to be found in the present Listings. How much the constraint will increase the fit values above their corresponding averages depends on the errors. In the last two editions, $\mathrm{B}(h^-2\pi^0\nu_\tau)$ and $\mathrm{B}(h^- \geq 3\pi^0\nu_\tau)$ had relatively large errors, and the fit could account for much of the deficit by increasing these modes with only a small increase in the fit χ^2. For example, the 1992 fit had a χ^2 of 91.8 for 91 degrees of freedom, while the current fit has a χ^2 of 134.6 for 105 degrees of freedom. The large χ^2 is not caused by one or two outlying measurements; the largest single contribution to the χ^2 is 7.0. Table 2 gives the average χ^2 contribution per datum* grouped by decay mode in various ways: all modes used in the fit, modes containing one prong and no neutrals, modes containing one prong plus $\geq 1\pi^0$, and all modes except 1-prong exclusive modes. It is clear that the 1-prong plus $\geq 1\pi^0$ modes contribute the largest amount to the χ^2.