

$$I(J^P) = 1(\frac{1}{2}^+) \text{ Status: } ****$$

We have omitted some results that have been superseded by later experiments. See our earlier editions.

## $\Sigma^-$ MASS

The fit uses  $\Sigma^+$ ,  $\Sigma^0$ ,  $\Sigma^-$ , and  $\Lambda$  mass and mass-difference measurements.

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1197.449±0.030 OUR FIT</b>				Error includes scale factor of 1.2.
<b>1197.45 ±0.04 OUR AVERAGE</b>				Error includes scale factor of 1.2.
1197.417±0.040		GUREV	93	SPEC $\Sigma^-$ C atom, crystal diff.
1197.532±0.057		GALL	88	CNTR $\Sigma^-$ Pb, $\Sigma^-$ W atoms
1197.43 ±0.08	3000	SCHMIDT	65	HBC See note with $\Lambda$ mass
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
1197.24 ±0.15		<sup>1</sup> DUGAN	75	CNTR Exotic atoms
<sup>1</sup> GALL 88 concludes that the DUGAN 75 mass needs to be reevaluated.				

## $m_{\Sigma^-} - m_{\Sigma^+}$

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>8.08±0.08 OUR FIT</b>				Error includes scale factor of 1.9.
<b>8.09±0.16 OUR AVERAGE</b>				
7.91±0.23	86	BOHM	72	EMUL
8.25±0.25	2500	DOSCH	65	HBC
8.25±0.40	87	BARKAS	63	EMUL

## $m_{\Sigma^-} - m_{\Lambda}$

VALUE (MeV)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>81.766±0.030 OUR FIT</b>				Error includes scale factor of 1.2.
<b>81.69 ±0.07 OUR AVERAGE</b>				
81.64 ±0.09	2279	HEPP	68	HBC
81.80 ±0.13	85	SCHMIDT	65	HBC See note with $\Lambda$ mass
81.70 ±0.19		BURNSTEIN	64	HBC

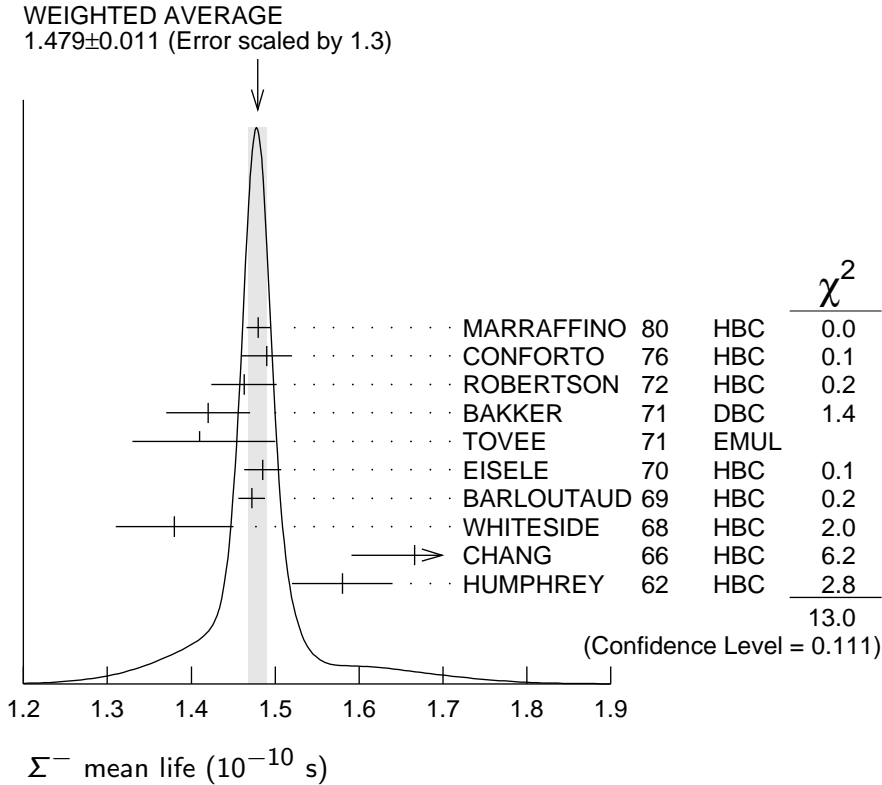
## $\Sigma^-$ MEAN LIFE

Measurements with an error  $\geq 0.2 \times 10^{-10}$  s have been omitted.

VALUE ( $10^{-10}$ s)	EVTS	DOCUMENT ID	TECN	COMMENT
<b>1.479±0.011 OUR AVERAGE</b>				Error includes scale factor of 1.3. See the ideogram below.
1.480±0.014	16k	MARRAFFINO	80	HBC $K^- p$ 0.42–0.5 GeV/c
1.49 ±0.03	8437	CONFORTO	76	HBC $K^- p$ 1–1.4 GeV/c
1.463±0.039	2400	ROBERTSON	72	HBC $K^- p$ 0.25 GeV/c
1.42 ±0.05	1383	BAKKER	71	DBC $K^- N \rightarrow \Sigma^- \pi \pi$
1.41 <sup>+0.09</sup> <sub>-0.08</sub>		TOVEE	71	EMUL

$1.485 \pm 0.022$	100k	EISELE	70	HBC	$K^- p$ at rest
$1.472 \pm 0.016$	10k	BARLOUTAUD	69	HBC	$K^- p$ 0.4–1.2 GeV/c
$1.38 \pm 0.07$	506	WHITESIDE	68	HBC	$K^- p$ at rest
$1.666 \pm 0.075$	3267	<sup>2</sup> CHANG	66	HBC	$K^- p$ at rest
$1.58 \pm 0.06$	1208	HUMPHREY	62	HBC	$K^- p$ at rest

<sup>2</sup>We have increased the CHANG 66 error of 0.026; see our 1970 edition, Reviews of Modern Physics **42** 87 (1970).

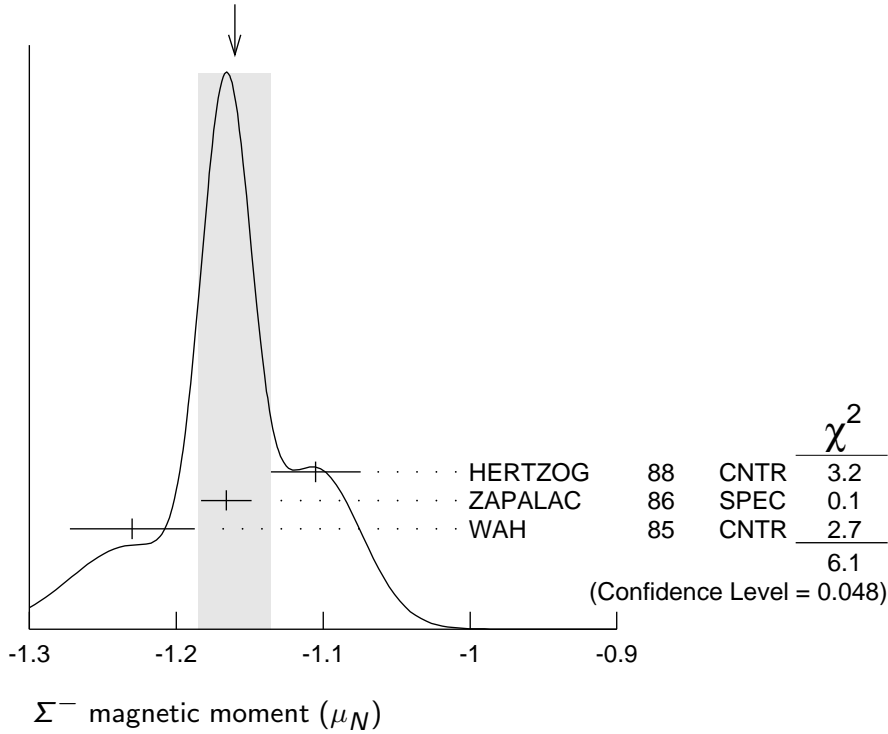


### $\Sigma^-$ MAGNETIC MOMENT

See the "Note on Baryon Magnetic Moments" in the  $\Lambda$  Listings. Measurements with an error  $\geq 0.3 \mu_N$  have been omitted.

VALUE ( $\mu_N$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>-1.160 \pm 0.025</math> OUR AVERAGE</b>				Error includes scale factor of 1.7. See the ideogram below.
$-1.105 \pm 0.029 \pm 0.010$		HERTZOG	88	CNTR $\Sigma^-$ Pb, $\Sigma^-$ W atoms
$-1.166 \pm 0.014 \pm 0.010$	671k	ZAPALAC	86	SPEC $ne^- \nu, n\pi^-$ decays
$-1.23 \pm 0.03 \pm 0.03$		WAH	85	CNTR $p\text{Cu} \rightarrow \Sigma^- X$
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$-0.89 \pm 0.14$	516k	DECK	83	SPEC $p\text{Be} \rightarrow \Sigma^- X$

WEIGHTED AVERAGE  
 $-1.160 \pm 0.025$  (Error scaled by 1.7)



### $\Sigma^-$ CHARGE RADIUS

VALUE (fm)	DOCUMENT ID	TECN	COMMENT
<b><math>0.780 \pm 0.080 \pm 0.060</math></b>	<sup>3</sup> ESCHRICH	01	$\Sigma^- e \rightarrow \Sigma^- e$

<sup>3</sup>ESCHRICH 01 actually gives  $\langle r^2 \rangle = (0.61 \pm 0.12 \pm 0.09) \text{ fm}^2$ .

### $\Sigma^-$ DECAY MODES

Mode	Fraction ( $\Gamma_i/\Gamma$ )
$\Gamma_1$ $n\pi^-$	$(99.848 \pm 0.005) \%$
$\Gamma_2$ $n\pi^- \gamma$	[a] $(4.6 \pm 0.6) \times 10^{-4}$
$\Gamma_3$ $ne^- \bar{\nu}_e$	$(1.017 \pm 0.034) \times 10^{-3}$
$\Gamma_4$ $n\mu^- \bar{\nu}_\mu$	$(4.5 \pm 0.4) \times 10^{-4}$
$\Gamma_5$ $\Lambda e^- \bar{\nu}_e$	$(5.73 \pm 0.27) \times 10^{-5}$

[a] See the Listings below for the pion momentum range used in this measurement.

## CONSTRAINED FIT INFORMATION

An overall fit to 3 branching ratios uses 16 measurements and one constraint to determine 4 parameters. The overall fit has a  $\chi^2 = 8.7$  for 13 degrees of freedom.

The following *off-diagonal* array elements are the correlation coefficients  $\langle \delta x_i \delta x_j \rangle / (\delta x_i \delta x_j)$ , in percent, from the fit to the branching fractions,  $x_i \equiv \Gamma_i / \Gamma_{\text{total}}$ . The fit constrains the  $x_i$  whose labels appear in this array to sum to one.

$x_3$	-64		
$x_4$	-77	0	
$x_5$	-5	0	0
	$x_1$	$x_3$	$x_4$

## $\Sigma^-$ BRANCHING RATIOS

### $\Gamma(n\pi^- \gamma) / \Gamma(n\pi^-)$

$\Gamma_2 / \Gamma_1$

The  $\pi^+$  momentum cuts differ, so we do not average the results but simply use the latest value for the Summary Table.

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>0.46 \pm 0.06</math></b>	292	EBENHOH	73 HBC	$\pi^+ < 150$ MeV/c
● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ●				
$0.10 \pm 0.02$	23	ANG	69B HBC	$\pi^- < 110$ MeV/c
$\sim 1.1$		BAZIN	65B HBC	$\pi^- < 166$ MeV/c

### $\Gamma(ne^- \bar{\nu}_e) / \Gamma(n\pi^-)$

$\Gamma_3 / \Gamma_1$

Measurements with an error  $\geq 0.2 \times 10^{-3}$  have been omitted.

VALUE (units $10^{-3}$ )	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>1.019 \pm 0.035</math> OUR FIT</b>				
<b><math>1.019^{+0.031}_{-0.040}</math> OUR AVERAGE</b>				
$0.96 \pm 0.05$	2847	BOURQUIN	83C SPEC	SPS hyperon beam
$1.09^{+0.06}_{-0.08}$	601	<sup>4</sup> EBENHOH	74 HBC	$K^- p$ at rest
$1.05^{+0.07}_{-0.13}$	455	<sup>4</sup> SECHI-ZORN	73 HBC	$K^- p$ at rest
$0.97 \pm 0.15$	57	COLE	71 HBC	$K^- p$ at rest
$1.11 \pm 0.09$	180	BIERMAN	68 HBC	

<sup>4</sup> An additional negative systematic error is included for internal radiative corrections and latest form factors; see BOURQUIN 83C.

$\Gamma(n\mu^-\bar{\nu}_\mu)/\Gamma(n\pi^-)$					$\Gamma_4/\Gamma_1$
<u>VALUE (units <math>10^{-3}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>0.45±0.04 OUR FIT</b>					
<b>0.45±0.04 OUR AVERAGE</b>					
0.38±0.11	13	COLE	71	HBC	$K^- p$ at rest
0.43±0.06	72	ANG	69	HBC	$K^- p$ at rest
0.43±0.09	56	BAGGETT	69	HBC	$K^- p$ at rest
0.56±0.20	11	BAZIN	65B	HBC	$K^- p$ at rest
0.66±0.15	22	COURANT	64	HBC	

$\Gamma(\Lambda e^-\bar{\nu}_e)/\Gamma(n\pi^-)$					$\Gamma_5/\Gamma_1$
<u>VALUE (units <math>10^{-4}</math>)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>	
<b>0.574±0.027 OUR FIT</b>					
<b>0.574±0.027 OUR AVERAGE</b>					
0.561±0.031	1620	<sup>5</sup> BOURQUIN	82	SPEC	SPS hyperon beam
0.63 ±0.11	114	THOMPSON	80	ASPK	Hyperon beam
0.52 ±0.09	31	BALTAY	69	HBC	$K^- p$ at rest
0.69 ±0.12	31	EISELE	69	HBC	$K^- p$ at rest
0.64 ±0.12	35	BARASH	67	HBC	$K^- p$ at rest
0.75 ±0.28	11	COURANT	64	HBC	$K^- p$ at rest

<sup>5</sup>The value is from BOURQUIN 83B, and includes radiation corrections and new acceptance.

### $\Sigma^-$ DECAY PARAMETERS

See the "Note on Baryon Decay Parameters" in the neutron Listings.  
Older, outdated results have been omitted.

#### $\alpha_-$ FOR $\Sigma^- \rightarrow n\pi^-$

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>-0.068±0.008 OUR AVERAGE</b>				
-0.062±0.024	28k	HANSL	78	HBC $K^- p \rightarrow \Sigma^- \pi^+$
-0.067±0.011	60k	BOGERT	70	HBC $K^- p$ 0.4 GeV/c
-0.071±0.012	51k	BANGERTER	69	HBC $K^- p$ 0.4 GeV/c

#### $\phi$ ANGLE FOR $\Sigma^- \rightarrow n\pi^-$

$$(\tan\phi = \beta / \gamma)$$

<u>VALUE (°)</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>10±15 OUR AVERAGE</b>				
+ 5±23	1092	<sup>6</sup> BERLEY	70B	HBC $n$ rescattering
14±19	1385	BANGERTER	69B	HBC $K^- p$ 0.4 GeV/c

<sup>6</sup>BERLEY 70B changed from -5 to +5° to agree with our sign convention.

**$g_A/g_V$  FOR  $\Sigma^- \rightarrow ne^-\bar{\nu}_e$** 

Measurements with fewer than 500 events have been omitted. Where necessary, signs have been changed to agree with our conventions, which are given in the “Note on Baryon Decay Parameters” in the neutron Listings. What is actually listed is  $|g_1/f_1 - 0.237g_2/f_1|$ . This reduces to  $g_A/g_V \equiv g_1(0)/f_1(0)$  on making the usual assumption that  $g_2 = 0$ . See also the note on HSUEH 88.

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.340±0.017 OUR AVERAGE</b>				
+0.327±0.007±0.019	50k	<sup>7</sup> HSUEH	88	SPEC $\Sigma^-$ 250 GeV
+0.34 ±0.05	4456	<sup>8</sup> BOURQUIN	83C	SPEC SPS hyperon beam
0.385±0.037	3507	<sup>9</sup> TANENBAUM	74	ASPK
• • • We do not use the following data for averages, fits, limits, etc. • • •				
0.29 ±0.07	25k	HSUEH	85	SPEC See HSUEH 88
0.17 <sup>+0.07</sup> <sub>-0.09</sub>	519	DECAMP	77	ELEC Hyperon beam

<sup>7</sup> The sign is, *with our conventions*, unambiguously positive. The value assumes, as usual, that  $g_2 = 0$ . If  $g_2$  is included in the fit, then (with our sign convention)  $g_2 = -0.56 \pm 0.37$ , with a corresponding reduction of  $g_A/g_V$  to  $+0.20 \pm 0.08$ .

<sup>8</sup> BOURQUIN 83C favors the positive sign by at least 2.6 standard deviations.

<sup>9</sup> TANENBAUM 74 gives  $0.435 \pm 0.035$ , assuming no  $q^2$  dependence in  $g_A$  and  $g_V$ . The listed result allows  $q^2$  dependence, and is taken from HSUEH 88.

 **$f_2(0)/f_1(0)$  FOR  $\Sigma^- \rightarrow ne^-\bar{\nu}_e$** 

The signs have been changed to be in accord with our conventions, given in the “Note on Baryon Decay Parameters” in the neutron Listings.

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.97±0.14 OUR AVERAGE</b>				
+0.96±0.07±0.13	50k	HSUEH	88	SPEC $\Sigma^-$ 250 GeV
+1.02±0.34	4456	BOURQUIN	83C	SPEC SPS hyperon beam

**TRIPLE CORRELATION COEFFICIENT  $D$  for  $\Sigma^- \rightarrow ne^-\bar{\nu}_e$** 

The coefficient  $D$  of the term  $D \mathbf{P} \cdot (\hat{\mathbf{p}}_e \times \hat{\mathbf{p}}_\nu)$  in the  $\Sigma^- \rightarrow ne^-\bar{\nu}$  decay angular distribution. A nonzero value would indicate a violation of time-reversal invariance.

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.11±0.10</b>	50k	HSUEH	88	SPEC $\Sigma^-$ 250 GeV

 **$g_V/g_A$  FOR  $\Sigma^- \rightarrow \Lambda e^-\bar{\nu}_e$** 

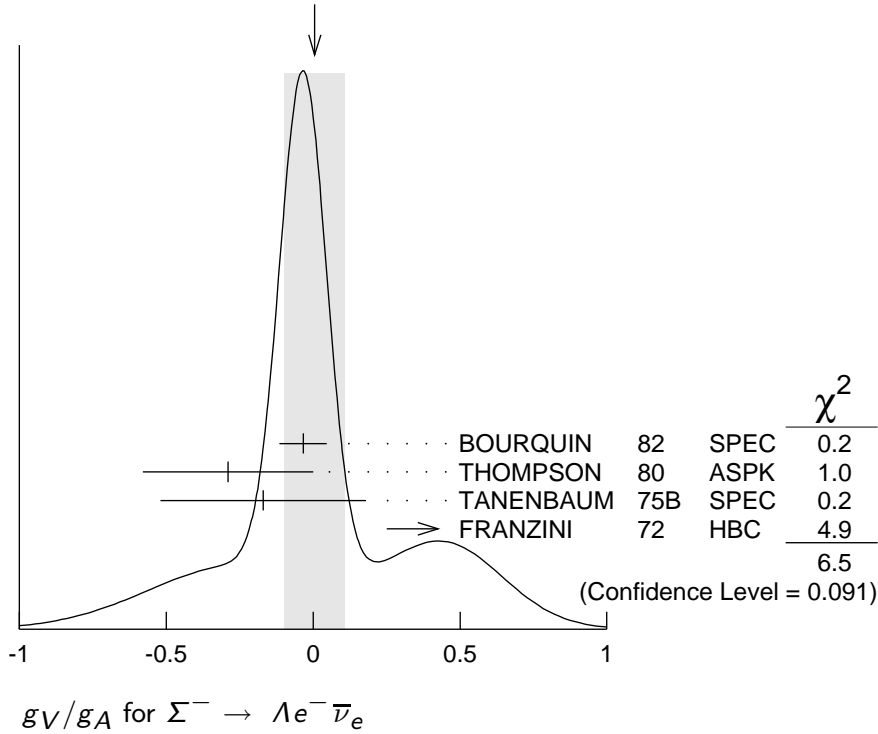
For the sign convention, see the “Note on Baryon Decay Parameters” in the neutron Listings. The value is predicted to be zero by conserved vector current theory. The values averaged assume CVC-SU(3) weak magnetism term.

<u>VALUE</u>	<u>EVTS</u>	<u>DOCUMENT ID</u>	<u>TECN</u>	<u>COMMENT</u>
<b>0.01 ±0.10 OUR AVERAGE</b> Error includes scale factor of 1.5. See the ideogram below.				
-0.034±0.080	1620	<sup>10</sup> BOURQUIN	82	SPEC SPS hyperon beam
-0.29 ±0.29	114	THOMPSON	80	ASPK BNL hyperon beam
-0.17 ±0.35	55	TANENBAUM	75B	SPEC BNL hyperon beam
+0.45 ±0.20	186	<sup>10,11</sup> FRANZINI	72	HBC

<sup>10</sup> The sign has been changed to agree with our convention.

<sup>11</sup> The FRANZINI 72 value includes the events of earlier papers.

WEIGHTED AVERAGE  
 $0.01 \pm 0.10$  (Error scaled by 1.5)



**$g_{WM}/g_A$  FOR  $\Sigma^- \rightarrow \Lambda e^- \bar{\nu}_e$**

The values quoted assume the CVC prediction  $g_V = 0$ .

VALUE	EVTS	DOCUMENT ID	TECN	COMMENT
<b><math>2.4 \pm 1.7</math> OUR AVERAGE</b>				
$1.75 \pm 3.5$	114	THOMPSON 80	ASPK	BNL hyperon beam
$3.5 \pm 4.5$	55	TANENBAUM 75B	SPEC	BNL hyperon beam
$2.4 \pm 2.1$	186	FRANZINI 72	HBC	

**$\Sigma^-$  REFERENCES**

We have omitted some papers that have been superseded by later experiments. See our earlier editions.

ESCHRICH 01	PL B522 233	I. Eschrich <i>et al.</i>	(FNAL SELEX Collab.)
GUREV 93	JETPL 57 400	M.P. Gurev <i>et al.</i>	(PNPI)
	Translated from ZETFP 57 389.		
GALL 88	PRL 60 186	K.P. Gall <i>et al.</i>	(BOST, MIT, WILL, CIT+)
HERTZOG 88	PR D37 1142	D.W. Hertzog <i>et al.</i>	(WILL, BOST, MIT+)
HSUEH 88	PR D38 2056	S.Y. Hsueh <i>et al.</i>	(CHIC, ELMT, FNAL+)
ZAPALAC 86	PRL 57 1526	G. Zapalac <i>et al.</i>	(EFI, ELMT, FNAL+)
HSUEH 85	PRL 54 2399	S.Y. Hsueh <i>et al.</i>	(CHIC, ELMT, FNAL+)
WAH 85	PRL 55 2551	Y.W. Wah <i>et al.</i>	(FNAL, IOWA, ISU)
BOURQUIN 83B	ZPHY C21 27	M.H. Bourquin <i>et al.</i>	(BRIS, GEVA, HEIDP+)
BOURQUIN 83C	ZPHY C21 17	M.H. Bourquin <i>et al.</i>	(BRIS, GEVA, HEIDP+)
DECK 83	PR D28 1	L. Deck <i>et al.</i>	(RUTG, WISC, MICH, MINN)
BOURQUIN 82	ZPHY C12 307	M.H. Bourquin <i>et al.</i>	(BRIS, GEVA, HEIDP+)
MARRAFFINO 80	PR D21 2501	J. Marraffino <i>et al.</i>	(VAND, MPIM)
THOMPSON 80	PR D21 25	J.A. Thompson <i>et al.</i>	(PITT, BNL)
HANSL 78	NP B132 45	T. Hansl <i>et al.</i>	(MPIM, VAND)
DECAMP 77	PL 66B 295	D. Decamp <i>et al.</i>	(LALO, EPOL)
CONFORTO 76	NP B105 189	B. Conforto <i>et al.</i>	(RHEL, LOIC)
DUGAN 75	NP A254 396	G. Dugan <i>et al.</i>	(COLU, YALE)
TANENBAUM 75B	PR D12 1871	W. Tanenbaum <i>et al.</i>	(YALE, FNAL, BNL)

EBENHOH	74	ZPHY 266 367	H. Ebenhoh <i>et al.</i>	(HEIDT)
TANENBAUM	74	PRL 33 175	W. Tanenbaum <i>et al.</i>	(YALE, FNAL, BNL)
EBENHOH	73	ZPHY 264 413	W. Ebenhoh <i>et al.</i>	(HEIDT)
SECHI-ZORN	73	PR D8 12	B. Sechi-Zorn, G.A. Snow	(UMD)
BOHM	72	NP B48 1	G. Bohm <i>et al.</i>	(BERL, KIDR, BRUX, IASD+)
FRANZINI	72	PR D6 2417	P. Franzini <i>et al.</i>	(COLU, HEID, UMD+)
ROBERTSON	72	Thesis UMI 78-00877	R.M. Robertson	(IIT)
BAKKER	71	LNC 1 37	A.M. Bakker <i>et al.</i>	(SABRE Collab.)
COLE	71	PR D4 631	J. Cole <i>et al.</i>	(STON, COLU)
Also		Thesis Nevis 175	H. Norton	(COLU)
TOVEE	71	NP B33 493	D.N. Tovee <i>et al.</i>	(LOUC, KIDR, BERL+)
BERLEY	70B	PR D1 2015	D. Berley <i>et al.</i>	(BNL, MASA, YALE)
BOGERT	70	PR D2 6	D.V. Bogert <i>et al.</i>	(BNL, MASA, YALE)
EISELE	70	ZPHY 238 372	F. Eisele <i>et al.</i>	(HEID)
PDG	70	RMP 42 87	A. Barbaro-Galtieri <i>et al.</i>	(LRL, BRAN+)
ANG	69	ZPHY 223 103	G. Ang <i>et al.</i>	(HEID)
ANG	69B	ZPHY 228 151	G. Ang <i>et al.</i>	(HEID)
BAGGETT	69	PRL 23 249	N.V. Baggett, B. Kehoe, G.A. Snow	(UMD)
BALTAY	69	PRL 22 615	C. Baltay <i>et al.</i>	(COLU, STON)
BANGERTER	69	Thesis UCRL 19244	R.O. Bangerter	(LRL)
BANGERTER	69B	PR 187 1821	R.O. Bangerter <i>et al.</i>	(LRL)
BARLOUTAUD	69	NP B14 153	R. Barloutaud <i>et al.</i>	(SACL, CERN, HEID)
EISELE	69	ZPHY 221 1	F. Eisele <i>et al.</i>	(HEID)
BIERMAN	68	PRL 20 1459	E. Bierman <i>et al.</i>	(PRIN)
HEPP	68	ZPHY 214 71	V. Hepp, H. Schleich	(HEID)
WHITESIDE	68	NC 54A 537	H. Whiteside, J. Gollub	(OBER)
BARASH	67	PRL 19 181	N. Barash <i>et al.</i>	(UMD)
CHANG	66	PR 151 1081	C.Y. Chang	(COLU)
BAZIN	65B	PR 140 B1358	M. Bazin <i>et al.</i>	(PRIN, RUTG, COLU)
DOSCH	65	PL 14 239	H.C. Dosch <i>et al.</i>	(HEID)
Also		PR 151 1081	C.Y. Chang	(COLU)
SCHMIDT	65	PR 140 B1328	P. Schmidt	(COLU)
BURNSTEIN	64	PRL 13 66	R.A. Burnstein <i>et al.</i>	(UMD)
COURANT	64	PR 136 B1791	H. Courant <i>et al.</i>	(CERN, HEID, UMD+)
BARKAS	63	PRL 11 26	W.H. Barkas, J.N. Dyer, H.H. Heckman	(LRL)
HUMPHREY	62	PR 127 1305	W.E. Humphrey, R.R. Ross	(LRL)