# $\Xi^-$

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

The parity has not actually been measured, but + is of course expected.

We have omitted some results that have been superseded by later experiments.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

## $\Xi^-$ MASS

The fit uses the $\Xi^-$, $\overline{\Xi}^+$, and $\Xi^0$ mass and mass difference measurements. It assumes the $\Xi^-$ and $\overline{\Xi}^+$ masses are the same.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **1321.31±0.13 OUR FIT** | | | | | |
| **1321.34±0.14 OUR AVERAGE** | | | | | |
| 1321.46±0.34 | 632 | DIBIANCA | 75 | DBC | 4.9 GeV/$c$ $K^- d$ |
| 1321.12±0.41 | 268 | WILQUET | 72 | HLBC | |
| 1321.87±0.51 | 195 | [1] GOLDWASSER | 70 | HBC | 5.5 GeV/$c$ $K^- p$ |
| 1321.67±0.52 | 6 | CHIEN | 66 | HBC | 6.9 GeV/$c$ $\overline{p}p$ |
| 1321.4 ±1.1 | 299 | LONDON | 66 | HBC | |
| 1321.3 ±0.4 | 149 | PJERROU | 65B | HBC | |
| 1321.1 ±0.3 | 241 | [2] BADIER | 64 | HBC | |
| 1321.4 ±0.4 | 517 | [2] JAUNEAU | 63D | FBC | |
| 1321.1 ±0.65 | 62 | [2] SCHNEIDER | 63 | HBC | |

[1] GOLDWASSER 70 uses $m_\Lambda = 1115.58$ MeV.

[2] These masses have been increased 0.09 MeV because the $\Lambda$ mass increased.

## $\overline{\Xi}^+$ MASS

The fit uses the $\Xi^-$, $\overline{\Xi}^+$, and $\Xi^0$ mass and mass difference measurements. It assumes the $\Xi^-$ and $\overline{\Xi}^+$ masses are the same.

| *VALUE* (MeV) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **1321.31±0.13 OUR FIT** | | | | | |
| **1321.20±0.33 OUR AVERAGE** | | | | | |
| 1321.6 ±0.8 | 35 | VOTRUBA | 72 | HBC | 10 GeV/$c$ $K^+ p$ |
| 1321.2 ±0.4 | 34 | STONE | 70 | HBC | |
| 1320.69±0.93 | 5 | CHIEN | 66 | HBC | 6.9 GeV/$c$ $\overline{p}p$ |

## $(m_{\Xi^-} - m_{\overline{\Xi}^+}) / m_{\Xi^-}$

A test of *CPT* invariance. We calculate this from the *average* $\Xi^-$ and $\overline{\Xi}^+$ masses above.

| *VALUE* | *DOCUMENT ID* |
|---|---|
| **$(1.1\pm2.7)\times10^{-4}$ OUR EVALUATION** | |

## $\Xi^-$ MEAN LIFE

Measurements with an error $> 0.2 \times 10^{-10}$ s or with systematic errors not included have been omitted.

| VALUE ($10^{-10}$ s) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1.639±0.015 OUR AVERAGE** | | | | | |
| 1.652±0.051 | 32k | BOURQUIN | 84 | SPEC | Hyperon beam |
| 1.665±0.065 | 41k | BOURQUIN | 79 | SPEC | Hyperon beam |
| 1.609±0.028 | 4286 | HEMINGWAY | 78 | HBC | 4.2 GeV/$c$ $K^- p$ |
| 1.67 ±0.08 | | DIBIANCA | 75 | DBC | 4.9 GeV/$c$ $K^- d$ |
| 1.63 ±0.03 | 4303 | BALTAY | 74 | HBC | 1.75 GeV/$c$ $K^- p$ |
| $1.73\ ^{+0.08}_{-0.07}$ | 680 | MAYEUR | 72 | HLBC | 2.1 GeV/$c$ $K^-$ |
| 1.61 ±0.04 | 2610 | DAUBER | 69 | HBC | |
| 1.80 ±0.16 | 299 | LONDON | 66 | HBC | |
| 1.70 ±0.12 | 246 | PJERROU | 65B | HBC | |
| 1.69 ±0.07 | 794 | HUBBARD | 64 | HBC | |
| $1.86\ ^{+0.15}_{-0.14}$ | 517 | JAUNEAU | 63D | FBC | |

## $\overline{\Xi}^+$ MEAN LIFE

| VALUE ($10^{-10}$ s) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1.6 ±0.3** | 34 | STONE | 70 | HBC | |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| $1.55\ ^{+0.35}_{-0.20}$ | 35 | [3] VOTRUBA | 72 | HBC | 10 GeV/$c$ $K^+ p$ |
| $1.9\ ^{+0.7}_{-0.5}$ | 12 | [3] SHEN | 67 | HBC | |
| 1.51±0.55 | 5 | [3] CHIEN | 66 | HBC | 6.9 GeV/$c$ $\overline{p} p$ |

[3] The error is statistical only.

## $(\tau_{\Xi^-} - \tau_{\overline{\Xi}^+}) / \tau_{\Xi^-}$

A test of $CPT$ invariance. Calculated from the $\Xi^-$ and $\overline{\Xi}^+$ mean lives, above.

| VALUE | DOCUMENT ID |
|---|---|
| **0.02±0.18 OUR EVALUATION** | |

## $\Xi^-$ MAGNETIC MOMENT

See the "Note on Baryon Magnetic Moments" in the $\Lambda$ Listings.

| VALUE ($\mu_N$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **−0.6507±0.0025 OUR AVERAGE** | | | | | |
| −0.6505±0.0025 | 4.36M | DURYEA | 92 | SPEC | 800 GeV $p$ Be |
| −0.661 ±0.036 ±0.036 | 44k | TROST | 89 | SPEC | $\Xi^-$ ~ 250 GeV |
| −0.69 ±0.04 | 218k | RAMEIKA | 84 | SPEC | 400 GeV $p$ Be |

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

| | | | | | | |
|---|---|---|---|---|---|---|
| $-0.674$ | $\pm 0.021$ $\pm 0.020$ | 122k | HO | 90 | SPEC | See DURYEA 92 |
| $-2.1$ | $\pm 0.8$ | 2436 | COOL | 74 | OSPK | 1.8 GeV/$c$ $K^- p$ |
| $-0.1$ | $\pm 2.1$ | 2724 | BINGHAM | 70B | OSPK | 1.8 GeV/$c$ $K^- p$ |

## $\overline{\Xi}^+$ MAGNETIC MOMENT

See the "Note on Baryon Magnetic Moments" in the $\Lambda$ Listings.

| VALUE ($\mu_N$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **$+0.657 \pm 0.028 \pm 0.020$** | 70k | HO | 90 | SPEC | 800 GeV $p$Be |

## $(\mu_{\Xi^-} + \mu_{\overline{\Xi}^+}) / |\mu_{\Xi^-}|$

A test of $CPT$ invariance. We calculate this from the $\Xi^-$ and $\overline{\Xi}^+$ magnetic moments above.

| VALUE | DOCUMENT ID |
|---|---|
| **$+0.01 \pm 0.05$ OUR EVALUATION** | |

## $\Xi^-$ DECAY MODES

| | Mode | | Fraction ($\Gamma_i/\Gamma$) | Confidence level |
|---|---|---|---|---|
| $\Gamma_1$ | $\Lambda \pi^-$ | | $(99.887 \pm 0.035)$ % | |
| $\Gamma_2$ | $\Sigma^- \gamma$ | | $(1.27 \pm 0.23) \times 10^{-4}$ | |
| $\Gamma_3$ | $\Lambda e^- \overline{\nu}_e$ | | $(5.63 \pm 0.31) \times 10^{-4}$ | |
| $\Gamma_4$ | $\Lambda \mu^- \overline{\nu}_\mu$ | | $(3.5 {}^{+3.5}_{-2.2}) \times 10^{-4}$ | |
| $\Gamma_5$ | $\Sigma^0 e^- \overline{\nu}_e$ | | $(8.7 \pm 1.7) \times 10^{-5}$ | |
| $\Gamma_6$ | $\Sigma^0 \mu^- \overline{\nu}_\mu$ | | $< 8 \times 10^{-4}$ | 90% |
| $\Gamma_7$ | $\Xi^0 e^- \overline{\nu}_e$ | | $< 2.3 \times 10^{-3}$ | 90% |
| | **$\Delta S = 2$ forbidden ($S2$) modes** | | | |
| $\Gamma_8$ | $n \pi^-$ | $S2$ | $< 1.9 \times 10^{-5}$ | 90% |
| $\Gamma_9$ | $n e^- \overline{\nu}_e$ | $S2$ | $< 3.2 \times 10^{-3}$ | 90% |
| $\Gamma_{10}$ | $n \mu^- \overline{\nu}_\mu$ | $S2$ | $< 1.5$ % | 90% |
| $\Gamma_{11}$ | $p \pi^- \pi^-$ | $S2$ | $< 4 \times 10^{-4}$ | 90% |
| $\Gamma_{12}$ | $p \pi^- e^- \overline{\nu}_e$ | $S2$ | $< 4 \times 10^{-4}$ | 90% |
| $\Gamma_{13}$ | $p \pi^- \mu^- \overline{\nu}_\mu$ | $S2$ | $< 4 \times 10^{-4}$ | 90% |
| $\Gamma_{14}$ | $p \mu^- \mu^-$ | $L$ | $< 4 \times 10^{-4}$ | 90% |

## CONSTRAINED FIT INFORMATION

An overall fit to 4 branching ratios uses 5 measurements and one constraint to determine 5 parameters. The overall fit has a $\chi^2$ = 1.0 for 1 degrees of freedom.

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

| | $x_1$ | $x_2$ | $x_3$ | $x_4$ |
|---|---|---|---|---|
| $x_2$ | −6 | | | |
| $x_3$ | −8 | 0 | | |
| $x_4$ | −99 | 0 | −1 | |
| $x_5$ | −5 | 0 | 0 | 0 |

## $\Xi^-$ BRANCHING RATIOS

A number of early results have been omitted.

### $\Gamma(\Sigma^-\gamma)/\Gamma(\Lambda\pi^-)$ — $\Gamma_2/\Gamma_1$

| VALUE (units $10^{-4}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **1.27±0.24 OUR FIT** | | | | | |
| **1.27±0.23 OUR AVERAGE** | | | | | |
| 1.22±0.23±0.06 | 211 | [4] DUBBS | 94 | E761 | $\Xi^-$ 375 GeV |
| 2.27±1.02 | 9 | BIAGI | 87B | SPEC | SPS hyperon beam |

[4] DUBBS 94 also finds weak evidence that the asymmetry parameter $\alpha_\gamma$ is positive ($\alpha_\gamma$ = 1.0 ± 1.3).

### $\Gamma(\Lambda e^-\overline{\nu}_e)/\Gamma(\Lambda\pi^-)$ — $\Gamma_3/\Gamma_1$

| VALUE (units $10^{-3}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.564±0.031 OUR FIT** | | | | | |
| **0.564±0.031** | 2857 | BOURQUIN | 83 | SPEC | SPS hyperon beam |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.30 ±0.13 | 11 | THOMPSON | 80 | ASPK | Hyperon beam |

### $\Gamma(\Lambda\mu^-\overline{\nu}_\mu)/\Gamma(\Lambda\pi^-)$ — $\Gamma_4/\Gamma_1$

| VALUE (units $10^{-3}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **$0.35^{+0.35}_{-0.22}$ OUR FIT** | | | | | | |
| **0.35±0.35** | | 1 | YEH | 74 | HBC | Effective denom.=2859 |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| < 2.3 | 90 | 0 | THOMPSON | 80 | ASPK | Effective denom.=1017 |
| < 1.3 | | | DAUBER | 69 | HBC | |
| <12 | | | BERGE | 66 | HBC | |

## $\Gamma(\Sigma^0 e^- \overline{\nu}_e)/\Gamma(\Lambda\pi^-)$ — $\Gamma_5/\Gamma_1$

| VALUE (units $10^{-3}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **0.087±0.017 OUR FIT** | | | | | |
| **0.087±0.017** | 154 | BOURQUIN | 83 | SPEC | SPS hyperon beam |

## $\Gamma(\Sigma^0 \mu^- \overline{\nu}_\mu)/\Gamma(\Lambda\pi^-)$ — $\Gamma_6/\Gamma_1$

| VALUE (units $10^{-3}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **<0.76** | 90 | 0 | YEH | 74 | HBC | Effective denom.=3026 |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| <5 | | | BERGE | 66 | HBC | |

## $[\Gamma(\Lambda e^- \overline{\nu}_e) + \Gamma(\Sigma^0 e^- \overline{\nu}_e)]/\Gamma(\Lambda\pi^-)$ — $(\Gamma_3+\Gamma_5)/\Gamma_1$

| VALUE (units $10^{-3}$) | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | |
| 0.651±0.031 | 3011 | [5] BOURQUIN | 83 | SPEC | SPS hyperon beam |
| 0.68 ±0.22 | 17 | [6] DUCLOS | 71 | OSPK | |

[5] See the separate BOURQUIN 83 values for $\Gamma(\Lambda e^- \overline{\nu}_e)/\Gamma(\Lambda\pi^-)$ and $\Gamma(\Sigma^0 e^- \overline{\nu}_e)/\Gamma(\Lambda\pi^-)$ above.

[6] DUCLOS 71 cannot distinguish $\Sigma^0$'s from $\Lambda$'s. The Cabibbo theory predicts the $\Sigma^0$ rate is about a factor 6 smaller than the $\Lambda$ rate.

## $\Gamma(\Xi^0 e^- \overline{\nu}_e)/\Gamma(\Lambda\pi^-)$ — $\Gamma_7/\Gamma_1$

| VALUE (units $10^{-3}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **<2.3** | 90 | 0 | YEH | 74 | HBC | Effective denom.=1000 |

## $\Gamma(n\pi^-)/\Gamma(\Lambda\pi^-)$ — $\Gamma_8/\Gamma_1$

$\Delta S$=2. Forbidden in first-order weak interaction.

| VALUE (units $10^{-3}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **<0.019** | 90 | | BIAGI | 82B | SPEC | SPS hyperon beam |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| <3.0 | 90 | 0 | YEH | 74 | HBC | Effective denom.=760 |
| <1.1 | | | DAUBER | 69 | HBC | |
| <5.0 | | | FERRO-LUZZI | 63 | HBC | |

## $\Gamma(n e^- \overline{\nu}_e)/\Gamma(\Lambda\pi^-)$ — $\Gamma_9/\Gamma_1$

$\Delta S$=2. Forbidden in first-order weak interaction.

| VALUE (units $10^{-3}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **< 3.2** | 90 | 0 | YEH | 74 | HBC | Effective denom.=715 |
| • • • We do not use the following data for averages, fits, limits, etc. • • • | | | | | | |
| <10 | 90 | | BINGHAM | 65 | RVUE | |

## $\Gamma(n\mu^- \overline{\nu}_\mu)/\Gamma(\Lambda\pi^-)$ — $\Gamma_{10}/\Gamma_1$

$\Delta S$=2. Forbidden in first-order weak interaction.

| VALUE (units $10^{-3}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **<15.3** | 90 | 0 | YEH | 74 | HBC | Effective denom.=150 |

### $\Gamma(p\pi^-\pi^-)/\Gamma(\Lambda\pi^-)$ — $\Gamma_{11}/\Gamma_1$

$\Delta S$=2. Forbidden in first-order weak interaction.

| VALUE (units $10^{-4}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **<3.7** | 90 | 0 | YEH | 74 | HBC | Effective denom.=6200 |

### $\Gamma(p\pi^-e^-\overline{\nu}_e)/\Gamma(\Lambda\pi^-)$ — $\Gamma_{12}/\Gamma_1$

$\Delta S$=2. Forbidden in first-order weak interaction.

| VALUE (units $10^{-4}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **<3.7** | 90 | 0 | YEH | 74 | HBC | Effective denom.=6200 |

### $\Gamma(p\pi^-\mu^-\overline{\nu}_\mu)/\Gamma(\Lambda\pi^-)$ — $\Gamma_{13}/\Gamma_1$

$\Delta S$=2. Forbidden in first-order weak interaction.

| VALUE (units $10^{-4}$) | CL% | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|---|
| **<3.7** | 90 | 0 | YEH | 74 | HBC | Effective denom.=6200 |

### $\Gamma(p\mu^-\mu^-)/\Gamma(\Lambda\pi^-)$ — $\Gamma_{14}/\Gamma_1$

A $\Delta L$=2 decay, forbidden by total lepton number conservation.

| VALUE (units $10^{-4}$) | CL% | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **<3.7** | 90 | [7] LITTENBERG | 92B | HBC | Uses YEH 74 data |

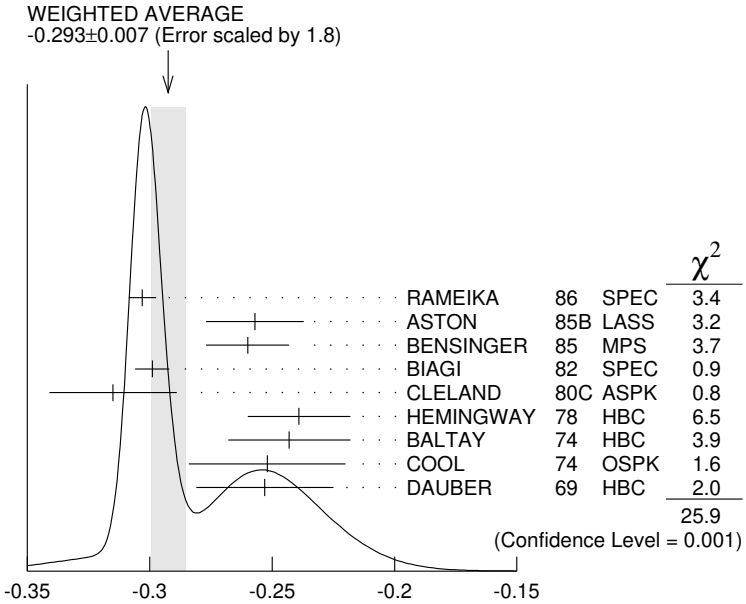
[7] This LITTENBERG 92B limit and the identical YEH 74 limits for the preceding three modes all result from nonobservance of any 3-prong decays of the $\Xi^-$. One could as well apply the limit to the *sum* of the four modes.

## $\Xi^-$ DECAY PARAMETERS

See the "Note on Baryon Decay Parameters" in the neutron Listings.

### $\alpha(\Xi^-)\alpha_-(\Lambda)$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| **−0.293±0.007 OUR AVERAGE** | Error includes scale factor of 1.8. See the ideogram below. | | | | |
| −0.303±0.004±0.004 | 192k | RAMEIKA | 86 | SPEC | 400 GeV $p$Be |
| −0.257±0.020 | 11k | ASTON | 85B | LASS | 11 GeV/$c$ $K^-p$ |
| −0.260±0.017 | 21k | BENSINGER | 85 | MPS | 5 GeV/$c$ $K^-p$ |
| −0.299±0.007 | 150k | BIAGI | 82 | SPEC | SPS hyperon beam |
| −0.315±0.026 | 9046 | CLELAND | 80C | ASPK | BNL hyperon beam |
| −0.239±0.021 | 6599 | HEMINGWAY | 78 | HBC | 4.2 GeV/$c$ $K^-p$ |
| −0.243±0.025 | 4303 | BALTAY | 74 | HBC | 1.75 GeV/$c$ $K^-p$ |
| −0.252±0.032 | 2436 | COOL | 74 | OSPK | 1.8 GeV/$c$ $K^-p$ |
| −0.253±0.028 | 2781 | DAUBER | 69 | HBC | |




$\alpha(\Xi^-)\alpha_(\Lambda)$

## $\alpha$ FOR $\Xi^- \rightarrow \Lambda\pi^-$

The above average, $\alpha(\Xi^-)\ \alpha_(\Lambda) = -0.293 \pm 0.007$, where the error includes a scale factor of 1.8, divided by our current average $\alpha_(\Lambda) = 0.642 \pm 0.013$, gives the following value for $\alpha(\Xi^-)$.

| *VALUE* | *DOCUMENT ID* |
|---|---|
| **−0.456±0.014 OUR EVALUATION** | Error includes scale factor of 1.8. |

## $\phi$ ANGLE FOR $\Xi^- \rightarrow \Lambda\pi^-$ ($\tan\phi = \beta/\gamma$)

| *VALUE* (°) | *EVTS* | *DOCUMENT ID* | | *TECN* | *COMMENT* |
|---|---|---|---|---|---|
| **4 ± 4 OUR AVERAGE** | | | | | |
| 5 ±10 | 11k | ASTON | 85B | LASS | $K^- p$ |
| 14.7±16.0 | 21k | [8] BENSINGER | 85 | MPS | 5 GeV/$c$ $K^- p$ |
| 11 ± 9 | 4303 | BALTAY | 74 | HBC | 1.75 GeV/$c$ $K^- p$ |
| 5 ±16 | 2436 | COOL | 74 | OSPK | 1.8 GeV/$c$ $K^- p$ |
| −26 ±30 | 2724 | BINGHAM | 70B | OSPK | |
| −14 ±11 | 2781 | DAUBER | 69 | HBC | Uses $\alpha_\Lambda = 0.647 \pm 0.020$ |
| 0 ±12 | 1004 | [9] BERGE | 66 | HBC | |
| 0 ±20.4 | 364 | [9] LONDON | 66 | HBC | Using $\alpha_\Lambda = 0.62$ |
| 54 ±30 | 356 | [9] CARMONY | 64B | HBC | |

[8] BENSINGER 85 used $\alpha_\Lambda = 0.642 \pm 0.013$.

[9] The errors have been multiplied by 1.2 due to approximations used for the $\Xi$ polarization; see DAUBER 69 for a discussion.

## $g_A$ / $g_V$ FOR $\Xi^- \to \Lambda e^- \overline{\nu}_e$

| VALUE | EVTS | DOCUMENT ID | | TECN | COMMENT |
|---|---|---|---|---|---|
| $=$**0.25±0.05** | 1992 | [10] BOURQUIN | 83 | SPEC | SPS hyperon beam |

[10] BOURQUIN 83 assumes that $g_2 = 0$. Also, the sign has been changed to agree with our conventions, given in the "Note on Baryon Decay Parameters" in the neutron Listings.

## $\Xi^-$ REFERENCES

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


| | | | | |
|---|---|---|---|---|
| DUBBS | 94 | PRL 72 808 | T. Dubbs *et al.* | (FNAL E761 Collab.) |
| DURYEA | 92 | PRL 68 768 | J. Duryea *et al.* | (MINN, FNAL, MICH, RUTG) |
| LITTENBERG | 92B | PR D46 R892 | L.S. Littenberg, R.E. Shrock | (BNL, STON) |
| HO | 90 | PRL 65 1713 | P.M. Ho *et al.* | (MICH, FNAL, MINN, RUTG) |
| Also | 91 | PR D44 3402 | P.M. Ho *et al.* | (MICH, FNAL, MINN, RUTG) |
| TROST | 89 | PR D40 1703 | L.H. Trost *et al.* | (FNAL-715 Collab.) |
| BIAGI | 87B | ZPHY C35 143 | S.F. Biagi *et al.* | (BRIS, CERN, GEVA+) |
| RAMEIKA | 86 | PR D33 3172 | R. Rameika *et al.* | (RUTG, MICH, WISC+) |
| ASTON | 85B | PR D32 2270 | D. Aston *et al.* | (SLAC, CARL, CNRC, CINC) |
| BENSINGER | 85 | NP B252 561 | J.R. Bensinger *et al.* | (CHIC, ELMT, FNAL+) |
| BOURQUIN | 84 | NP B241 1 | M.H. Bourquin *et al.* | (BRIS, GEVA, HEIDP+) |
| RAMEIKA | 84 | PRL 52 581 | R. Rameika *et al.* | (RUTG, MICH, WISC+) |
| BOURQUIN | 83 | ZPHY C21 1 | M.H. Bourquin *et al.* | (BRIS, GEVA, HEIDP+) |
| BIAGI | 82 | PL 112B 265 | S.F. Biagi *et al.* | (BRIS, CAVE, GEVA+) |
| BIAGI | 82B | PL 112B 277 | S.F. Biagi *et al.* | (LOQM, GEVA, RL+) |
| CLELAND | 80C | PR D21 12 | W.E. Cleland *et al.* | (PITT, BNL) |
| THOMPSON | 80 | PR D21 25 | J.A. Thompson *et al.* | (PITT, BNL) |
| BOURQUIN | 79 | PL 87B 297 | M.H. Bourquin *et al.* | (BRIS, GEVA, HEIDP+) |
| HEMINGWAY | 78 | NP B142 205 | R.J. Hemingway *et al.* | (CERN, ZEEM, NIJM+) |
| DIBIANCA | 75 | NP B98 137 | F.A. Dibianca, R.J. Endorf | (CMU) |
| BALTAY | 74 | PR D9 49 | C. Baltay *et al.* | (COLU, BING) J |
| COOL | 74 | PR D10 792 | R.L. Cool *et al.* | (BNL) |
| Also | 72 | PRL 29 1630 | R.L. Cool *et al.* | (BNL) |
| YEH | 74 | PR D10 3545 | N. Yeh *et al.* | (BING, COLU) |
| MAYEUR | 72 | NP B47 333 | C. Mayeur *et al.* | (BRUX, CERN, TUFTS, LOUC) |
| VOTRUBA | 72 | NP B45 77 | M.F. Votruba, A. Safder, T.M. Ratcliffe | (BIRM+) |
| WILQUET | 72 | PL 42B 372 | G. Wilquet *et al.* | (BRUX, CERN, TUFTS+) |
| DUCLOS | 71 | NP B32 493 | J. Duclos *et al.* | (CERN) |
| BINGHAM | 70B | PR D1 3010 | G.M. Bingham *et al.* | (UCSD, WASH) |
| GOLDWASSER | 70 | PR D1 1960 | E.L. Goldwasser, P.F. Schultz | (ILL) |
| STONE | 70 | PL 32B 515 | S.L. Stone *et al.* | (ROCH) |
| DAUBER | 69 | PR 179 1262 | P.M. Dauber *et al.* | (LRL) J |
| SHEN | 67 | PL 25B 443 | B.C. Shen, A. Firestone, G. Goldhaber | (UCB+) |
| BERGE | 66 | PR 147 945 | J.P. Berge *et al.* | (LRL) |
| CHIEN | 66 | PR 152 1171 | C.Y. Chien *et al.* | (YALE, BNL) |
| LONDON | 66 | PR 143 1034 | G.W. London *et al.* | (BNL, SYRA) |
| BINGHAM | 65 | PRSL 285 202 | H.H. Bingham | (CERN) |
| PJERROU | 65B | PRL 14 275 | G.M. Pjerrou *et al.* | (UCLA) |
| Also | 65 | Thesis | G.M. Pjerrou | (UCLA) |
| BADIER | 64 | Dubna Conf. 1 593 | J. Badier *et al.* | (EPOL, SACL, ZEEM) |
| CARMONY | 64B | PRL 12 482 | D.D. Carmony *et al.* | (UCLA) J |
| HUBBARD | 64 | PR 135B 183 | J.R. Hubbard *et al.* | (LRL) |
| FERRO-LUZZI | 63 | PR 130 1568 | M. Ferro-Luzzi *et al.* | (LRL) |
| JAUNEAU | 63D | Siena Conf. 4 | L. Jauneau *et al.* | (EPOL, CERN, LOUC+) |
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