

# $\Lambda(1520) D_{03}$

$$I(J^P) = 0(\frac{3}{2}^-) \text{ Status: } ****$$

Discovered by FERRO-LUZZI 62; the elaboration in WATSON 63 is the classic paper on the Breit-Wigner analysis of a multichannel resonance.

The measurements of the mass, width, and elasticity published before 1975 are now obsolete and have been omitted. They were last listed in our 1982 edition Physics Letters **111B** (1982).

Production and formation experiments agree quite well, so they are listed together here.

## $\Lambda(1520)$ MASS

| <u>VALUE (MeV)</u>                | <u>EVTS</u> | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u>                           |
|-----------------------------------|-------------|--------------------|-------------|--|
| <b>1519.5 ± 1.0 OUR ESTIMATE</b>  |             |                    |             |  |
| <b>1519.50 ± 0.18 OUR AVERAGE</b> |             |                    |             |  |
| 1517.3 ± 1.5                      | 300         | BARBER             | 80D SPEC    | $\gamma p \rightarrow \Lambda(1520) K^+$ |
| 1519 ± 1                          |             | GOPAL              | 80 DPWA     | $\bar{K} N \rightarrow \bar{K} N$        |
| 1517.8 ± 1.2                      | 5k          | BARLAG             | 79 HBC      | $K^- p$ 4.2 GeV/c                        |
| 1520.0 ± 0.5                      |             | ALSTON-...         | 78 DPWA     | $\bar{K} N \rightarrow \bar{K} N$        |
| 1519.7 ± 0.3                      | 4k          | CAMERON            | 77 HBC      | $K^- p$ 0.96–1.36 GeV/c                  |
| 1519 ± 1                          |             | GOPAL              | 77 DPWA     | $\bar{K} N$ multichannel                 |
| 1519.4 ± 0.3                      | 2000        | CORDEN             | 75 DBC      | $K^- d$ 1.4–1.8 GeV/c                    |

## $\Lambda(1520)$ WIDTH

| <u>VALUE (MeV)</u>              | <u>EVTS</u> | <u>DOCUMENT ID</u>  | <u>TECN</u> | <u>COMMENT</u>                           |
|---------------------------------|-------------|---------------------|-------------|--|
| <b>15.6 ± 1.0 OUR ESTIMATE</b>  |             |                     |             |  |
| <b>15.59 ± 0.27 OUR AVERAGE</b> |             |                     |             |  |
| 16.3 ± 3.3                      | 300         | BARBER              | 80D SPEC    | $\gamma p \rightarrow \Lambda(1520) K^+$ |
| 16 ± 1                          |             | GOPAL               | 80 DPWA     | $\bar{K} N \rightarrow \bar{K} N$        |
| 14 ± 3                          | 677         | <sup>1</sup> BARLAG | 79 HBC      | $K^- p$ 4.2 GeV/c                        |
| 15.4 ± 0.5                      |             | ALSTON-...          | 78 DPWA     | $\bar{K} N \rightarrow \bar{K} N$        |
| 16.3 ± 0.5                      | 4k          | CAMERON             | 77 HBC      | $K^- p$ 0.96–1.36 GeV/c                  |
| 15.0 ± 0.5                      |             | GOPAL               | 77 DPWA     | $\bar{K} N$ multichannel                 |
| 15.5 ± 1.6                      | 2000        | CORDEN              | 75 DBC      | $K^- d$ 1.4–1.8 GeV/c                    |

## $\Lambda(1520)$ DECAY MODES

| Mode                         | Fraction ( $\Gamma_i/\Gamma$ ) |
|------------------------------|--------------------------------|
| $\Gamma_1$ $N\bar{K}$        | 45 ± 1%                        |
| $\Gamma_2$ $\Sigma\pi$       | 42 ± 1%                        |
| $\Gamma_3$ $\Lambda\pi\pi$   | 10 ± 1%                        |
| $\Gamma_4$ $\Sigma(1385)\pi$ |                                |

|            |   |                 |
|------------|---|-----------------|
| $\Gamma_5$ | $\Sigma(1385)\pi (\rightarrow \Lambda\pi\pi)$ |                 |
| $\Gamma_6$ | $\Lambda(\pi\pi)_{S\text{-wave}}$             |                 |
| $\Gamma_7$ | $\Sigma\pi\pi$                                | $0.9 \pm 0.1\%$ |
| $\Gamma_8$ | $\Lambda\gamma$                               | $0.8 \pm 0.2\%$ |
| $\Gamma_9$ | $\Sigma^0\gamma$                              |                 |

### CONSTRAINED FIT INFORMATION

An overall fit to 9 branching ratios uses 24 measurements and one constraint to determine 6 parameters. The overall fit has a  $\chi^2 = 16.5$  for 19 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.

|       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|
| $x_2$ | -63   |       |       |       |       |
| $x_3$ | -32   | -33   |       |       |       |
| $x_7$ | -4    | -3    | -1    |       |       |
| $x_8$ | -9    | -8    | -4    | 0     |       |
| $x_9$ | -24   | -21   | -10   | -1    | -2    |
|       | $x_1$ | $x_2$ | $x_3$ | $x_7$ | $x_8$ |

### $\Lambda(1520)$ BRANCHING RATIOS

See "Sign conventions for resonance couplings" in the Note on  $\Lambda$  and  $\Sigma$  Resonances.

#### $\Gamma(N\bar{K})/\Gamma_{\text{total}}$ $\Gamma_1/\Gamma$

| VALUE   | DOCUMENT ID | TECN | COMMENT                              |
|---|-------------|------|--------------------------------------|
| <b>0.45 ± 0.01 OUR ESTIMATE</b>   |             |      |                                      |
| <b>0.448 ± 0.007 OUR FIT</b>  |             |      | Error includes scale factor of 1.2.  |
| <b>0.455 ± 0.011 OUR AVERAGE</b>  |             |      |                                      |
| 0.47 ± 0.02   | GOPAL       | 80   | DPWA $\bar{K}N \rightarrow \bar{K}N$ |
| 0.45 ± 0.03   | ALSTON-...  | 78   | DPWA $\bar{K}N \rightarrow \bar{K}N$ |
| 0.448 ± 0.014   | CORDEN      | 75   | DBC $K^- d$ 1.4–1.8 GeV/c            |
| • • • We do not use the following data for averages, fits, limits, etc. • • • |             |      |                                      |
| 0.47 ± 0.01   | GOPAL       | 77   | DPWA See GOPAL 80                    |
| 0.42  | MAST        | 76   | HBC $K^- p \rightarrow \bar{K}^0 n$  |

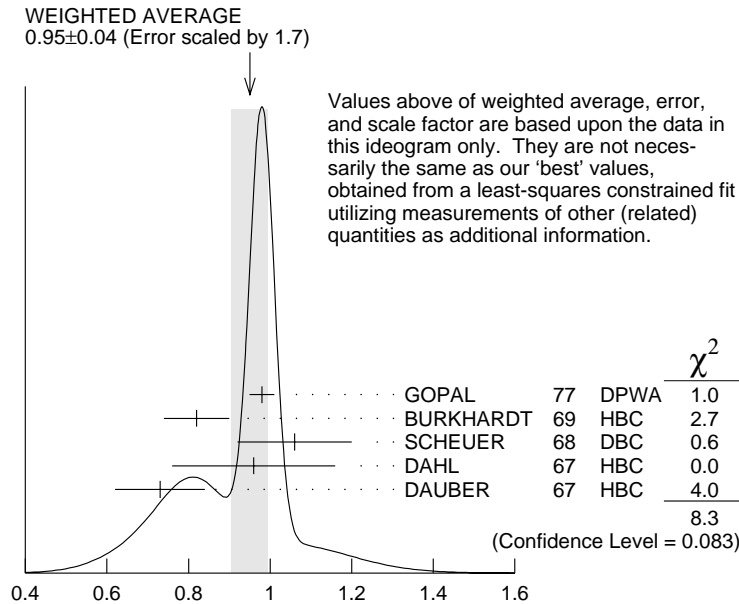
#### $\Gamma(\Sigma\pi)/\Gamma_{\text{total}}$ $\Gamma_2/\Gamma$

| VALUE   | DOCUMENT ID | TECN | COMMENT                             |
|---|-------------|------|-------------------------------------|
| <b>0.42 ± 0.01 OUR ESTIMATE</b>   |             |      |                                     |
| <b>0.421 ± 0.007 OUR FIT</b>  |             |      | Error includes scale factor of 1.2. |
| <b>0.423 ± 0.011 OUR AVERAGE</b>  |             |      |                                     |
| 0.426 ± 0.014   | CORDEN      | 75   | DBC $K^- d$ 1.4–1.8 GeV/c           |
| 0.418 ± 0.017   | BARBARO-... | 69B  | HBC $K^- p$ 0.28–0.45 GeV/c         |
| • • • We do not use the following data for averages, fits, limits, etc. • • • |             |      |                                     |
| 0.46  | KIM         | 71   | DPWA K-matrix analysis              |

$\Gamma(\Sigma\pi)/\Gamma(N\bar{K})$

$\Gamma_2/\Gamma_1$

| <u>VALUE</u>  | <u>DOCUMENT ID</u>  | <u>TECN</u> | <u>COMMENT</u>          |
|---|---|-------------|-------------------------|
| <b>0.940±0.026 OUR FIT</b>  | Error includes scale factor of 1.3.                         |             |                         |
| <b>0.95 ±0.04 OUR AVERAGE</b>   | Error includes scale factor of 1.7. See the ideogram below. |             |                         |
| 0.98 ±0.03  | <sup>2</sup> GOPAL  | 77 DPWA     | $\bar{K}N$ multichannel |
| 0.82 ±0.08  | BURKHARDT   | 69 HBC      | $K^- p$ 0.8–1.2 GeV/c   |
| 1.06 ±0.14  | SCHEUER   | 68 DBC      | $K^- N$ 3 GeV/c         |
| 0.96 ±0.20  | DAHL  | 67 HBC      | $\pi^- p$ 1.6–4 GeV/c   |
| 0.73 ±0.11  | DAUBER  | 67 HBC      | $K^- p$ 2 GeV/c         |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● |   |             |                         |
| 1.06 ±0.12  | BERTHON   | 74 HBC      | Quasi-2-body $\sigma$   |
| 1.72 ±0.78  | MUSGRAVE  | 65 HBC      |                         |



$\Gamma(\Sigma\pi)/\Gamma(N\bar{K})$

$\Gamma(\Lambda\pi\pi)/\Gamma_{total}$

$\Gamma_3/\Gamma$

| <u>VALUE</u>                   | <u>DOCUMENT ID</u>                  | <u>TECN</u> | <u>COMMENT</u>                    |
|--------------------------------|-------------------------------------|-------------|-----------------------------------|
| <b>0.10 ±0.01 OUR ESTIMATE</b> |                                     |             |                                   |
| <b>0.095±0.005 OUR FIT</b>     | Error includes scale factor of 1.2. |             |                                   |
| <b>0.096±0.008 OUR AVERAGE</b> | Error includes scale factor of 1.6. |             |                                   |
| 0.091±0.006                    | CORDEN                              | 75 DBC      | $K^- d$ 1.4–1.8 GeV/c             |
| 0.11 ±0.01                     | <sup>3</sup> MAST                   | 73B IPWA    | $K^- p \rightarrow \Lambda\pi\pi$ |

### $\Gamma(\Lambda\pi\pi)/\Gamma(N\bar{K})$

$\Gamma_3/\Gamma_1$

| <u>VALUE</u>  | <u>DOCUMENT ID</u>                  | <u>TECN</u> | <u>COMMENT</u>        |
|---|-------------------------------------|-------------|-----------------------|
| <b>0.213±0.012 OUR FIT</b>  | Error includes scale factor of 1.2. |             |                       |
| <b>0.202±0.021 OUR AVERAGE</b>  |                                     |             |                       |
| 0.22 ±0.03  | BURKHARDT 69                        | HBC         | $K^- p$ 0.8–1.2 GeV/c |
| 0.19 ±0.04  | SCHEUER 68                          | DBC         | $K^- N$ 3 GeV/c       |
| 0.17 ±0.05  | DAHL 67                             | HBC         | $\pi^- p$ 1.6–4 GeV/c |
| 0.21 ±0.18  | DAUBER 67                           | HBC         | $K^- p$ 2 GeV/c       |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● |                                     |             |                       |
| 0.27 ±0.13  | BERTHON 74                          | HBC         | Quasi-2-body $\sigma$ |
| 0.2   | KIM 71                              | DPWA        | K-matrix analysis     |

### $\Gamma(\Sigma\pi)/\Gamma(\Lambda\pi\pi)$

$\Gamma_2/\Gamma_3$

| <u>VALUE</u>                | <u>DOCUMENT ID</u>                  | <u>TECN</u> | <u>COMMENT</u>        |
|-----------------------------|-------------------------------------|-------------|-----------------------|
| <b>4.42±0.25 OUR FIT</b>    | Error includes scale factor of 1.2. |             |                       |
| <b>3.9 ±0.6 OUR AVERAGE</b> |                                     |             |                       |
| 3.9 ±1.0                    | UHLIG 67                            | HBC         | $K^- p$ 0.9–1.0 GeV/c |
| 3.3 ±1.1                    | BIRMINGHAM 66                       | HBC         | $K^- p$ 3.5 GeV/c     |
| 4.5 ±1.0                    | ARMENTEROS65C                       | HBC         |                       |

### $\Gamma(\Sigma(1385)\pi)/\Gamma_{\text{total}}$

$\Gamma_4/\Gamma$

| <u>VALUE</u>       | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u>                    |
|--------------------|--------------------|-------------|-----------------------------------|
| <b>0.041±0.005</b> | CHAN 72            | HBC         | $K^- p \rightarrow \Lambda\pi\pi$ |

### $\Gamma(\Sigma(1385)\pi(\rightarrow\Lambda\pi\pi))/\Gamma(\Lambda\pi\pi)$

$\Gamma_5/\Gamma_3$

The  $\Lambda\pi\pi$  mode is largely due to  $\Sigma(1385)\pi$ . Only the values of  $(\Sigma(1385)\pi) / (\Lambda\pi\pi)$  given by MAST 73B and CORDEN 75 are based on real 3-body partial-wave analyses. The discrepancy between the two results is essentially due to the different hypotheses made concerning the shape of the  $(\pi\pi)_S$ -wave state.

| <u>VALUE</u>  | <u>DOCUMENT ID</u>        | <u>TECN</u> | <u>COMMENT</u>                         |
|---|---------------------------|-------------|--|
| 0.58±0.22   | CORDEN 75                 | DBC         | $K^- d$ 1.4–1.8 GeV/c                  |
| 0.82±0.10   | <sup>4</sup> MAST 73B     | IPWA        | $K^- p \rightarrow \Lambda\pi\pi$      |
| ● ● ● We do not use the following data for averages, fits, limits, etc. ● ● ● |                           |             |  |
| 0.39±0.10   | <sup>5</sup> BURKHARDT 71 | HBC         | $K^- p \rightarrow (\Lambda\pi\pi)\pi$ |

### $\Gamma(\Lambda(\pi\pi)_S\text{-wave})/\Gamma(\Lambda\pi\pi)$

$\Gamma_6/\Gamma_3$

| <u>VALUE</u>     | <u>DOCUMENT ID</u> | <u>TECN</u> | <u>COMMENT</u>        |
|------------------|--------------------|-------------|-----------------------|
| <b>0.20±0.08</b> | CORDEN 75          | DBC         | $K^- d$ 1.4–1.8 GeV/c |

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

$\Gamma_7/\Gamma$

| <u>VALUE</u>                     | <u>DOCUMENT ID</u>     | <u>TECN</u> | <u>COMMENT</u>                   |
|----------------------------------|------------------------|-------------|----------------------------------|
| <b>0.009 ±0.001 OUR ESTIMATE</b> |                        |             |                                  |
| <b>0.0086±0.0005 OUR FIT</b>     |                        |             |                                  |
| <b>0.0086±0.0005 OUR AVERAGE</b> |                        |             |                                  |
| 0.007 ±0.002                     | <sup>6</sup> CORDEN 75 | DBC         | $K^- d$ 1.4–1.8 GeV/c            |
| 0.0085±0.0006                    | <sup>7</sup> MAST 73   | MPWA        | $K^- p \rightarrow \Sigma\pi\pi$ |
| 0.010 ±0.0015                    | BARBARO-... 69B        | HBC         | $K^- p$ 0.28–0.45 GeV/c          |

| $\Gamma(\Lambda\gamma)/\Gamma_{\text{total}}$ |      |             |         |   | $\Gamma_8/\Gamma$ |
|---|------|-------------|---------|---|-------------------|
| VALUE   | EVTs | DOCUMENT ID | TECN    | COMMENT   |                   |
| <b>0.008 ± 0.002 OUR ESTIMATE</b>             |      |             |         |   |                   |
| <b>0.0079 ± 0.0014 OUR FIT</b>                |      |             |         |   |                   |
| <b>0.0080 ± 0.0014</b>                        | 238  | MAST        | 68B HBC | Using $\Gamma(N\bar{K})/\Gamma_{\text{total}} = 0.45$ |                   |

| $\Gamma(\Sigma^0\gamma)/\Gamma_{\text{total}}$ |  |                   |         |                        | $\Gamma_9/\Gamma$ |
|--|--|-------------------|---------|------------------------|-------------------|
| VALUE  |  | DOCUMENT ID       | TECN    | COMMENT                |                   |
| <b>0.0195 ± 0.0034 OUR FIT</b>                 |  |                   |         |                        |                   |
| <b>0.02 ± 0.0035</b>                           |  | <sup>8</sup> MAST | 68B HBC | Not measured; see note |                   |

### $\Lambda(1520)$ FOOTNOTES

- <sup>1</sup> From the best-resolution sample of  $\Lambda\pi\pi$  events only.
- <sup>2</sup> The  $\bar{K}N \rightarrow \Sigma\pi$  amplitude at resonance is  $+0.46 \pm 0.01$ .
- <sup>3</sup> Assumes  $\Gamma(N\bar{K})/\Gamma_{\text{total}} = 0.46 \pm 0.02$ .
- <sup>4</sup> Both  $\Sigma(1385)\pi DS_{03}$  and  $\Sigma(\pi\pi) DP_{03}$  contribute.
- <sup>5</sup> The central bin (1514–1524 MeV) gives  $0.74 \pm 0.10$ ; other bins are lower by 2-to-5 standard deviations.
- <sup>6</sup> Much of the  $\Sigma\pi\pi$  decay proceeds via  $\Sigma(1385)\pi$ .
- <sup>7</sup> Assumes  $\Gamma(N\bar{K})/\Gamma_{\text{total}} = 0.46$ .
- <sup>8</sup> Calculated from  $\Gamma(\Lambda\gamma)/\Gamma_{\text{total}}$ , assuming SU(3). Needed to constrain the sum of all the branching ratios to be unity.

### $\Lambda(1520)$ REFERENCES

|             |     |                   |  |                                |
|-------------|-----|-------------------|--|--------------------------------|
| PDG         | 82  | PL 111B           | Roos, Porter, Aguilar-Benitez+           | (HELs, CIT, CERN)              |
| BARBER      | 80D | ZPHY C7 17        | +Dainton, Lee, Marshall+                 | (DARE, LANC, SHEF)             |
| GOPAL       | 80  | Toronto Conf. 159 |  | (RHEL) IJP                     |
| BARLAG      | 79  | NP B149 220       | +Blokzijl, Jongejans+                    | (AMST, CERN, NIJM, OXF)        |
| ALSTON-...  | 78  | PR D18 182        | Alston-Garnjost, Kenney+                 | (LBL, MTHO, CERN) IJP          |
| Also        | 77  | PRL 38 1007       | Alston-Garnjost, Kenney+                 | (LBL, MTHO, CERN) IJP          |
| CAMERON     | 77  | NP B131 399       | +Franek, Gopal, Kalmus, McPherson+       | (RHEL, LOIC) IJP               |
| GOPAL       | 77  | NP B119 362       | +Ross, VanHorn, McPherson+               | (LOIC, RHEL) IJP               |
| MAST        | 76  | PR D14 13         | +Alston-Garnjost, Bangerter+             | (LBL)                          |
| CORDEN      | 75  | NP B84 306        | +Cox, Dartnell, Kenyon, O'Neale+         | (BIRM)                         |
| BERTHON     | 74  | NC 21A 146        | +Tristram+                               | (CDEF, RHEL, SACL, STRB)       |
| MAST        | 73  | PR D7 3212        | +Bangerter, Alston-Garnjost+             | (LBL) IJP                      |
| MAST        | 73B | PR D7 5           | +Bangerter, Alston-Garnjost+             | (LBL) IJP                      |
| CHAN        | 72  | PRL 28 256        | +Button-Shafer, Hertzbach, Kofler+       | (MASA, YALE)                   |
| BURKHARDT   | 71  | NP B27 64         | +Filthuth, Kluge+                        | (HEID, CERN, SACL)             |
| KIM         | 71  | PRL 27 356        |  | (HARV) IJP                     |
| Also        | 70  | Duke Conf. 161    | Kim                                      | (HARV) IJP                     |
| BARBARO-... | 69B | Lund Conf. 352    | Barbaro-Galtieri, Bangerter, Mast, Tripp | (LRL)                          |
| Also        | 70  | Duke Conf. 95     | Tripp                                    | (LRL)                          |
| BURKHARDT   | 69  | NP B14 106        | +Filthuth, Kluge+                        | (HEID, EFI, CERN, SACL)        |
| MAST        | 68B | PRL 21 1715       | +Alston-Garnjost, Bangerter, Galtieri+   | (LRL)                          |
| SCHEUER     | 68  | NP B8 503         | +Merrill, Verglas, DeWitt+               | (SABRE Collab.)                |
| DAHL        | 67  | PR 163 1377       | +Hardy, Hess, Kirz, Miller               | (LRL)                          |
| DAUBER      | 67  | PL 24B 525        | +Malamud, Schlein, Slater, Stork         | (UCLA)                         |
| UHLIG       | 67  | PR 155 1448       | +Charlton, Condon, Glasser, Yodh+        | (UMD, NRL)                     |
| BIRMINGHAM  | 66  | PR 152 1148       |  | (BIRM, GLAS, LOIC, OXF, RHEL)  |
| ARMENTEROS  | 65C | PL 19 338         | +Ferro-Luzzi+                            | (CERN, HEID, SACL)             |
| MUSGRAVE    | 65  | NC 35 735         | +Petmezas+                               | (BIRM, CERN, EPOL, LOIC, SACL) |
| WATSON      | 63  | PR 131 2248       | +Ferro-Luzzi, Tripp                      | (LRL) IJP                      |
| FERRO-LUZZI | 62  | PRL 8 28          | +Tripp, Watson                           | (LRL) IJP                      |