The “Bible” of Particle Physics

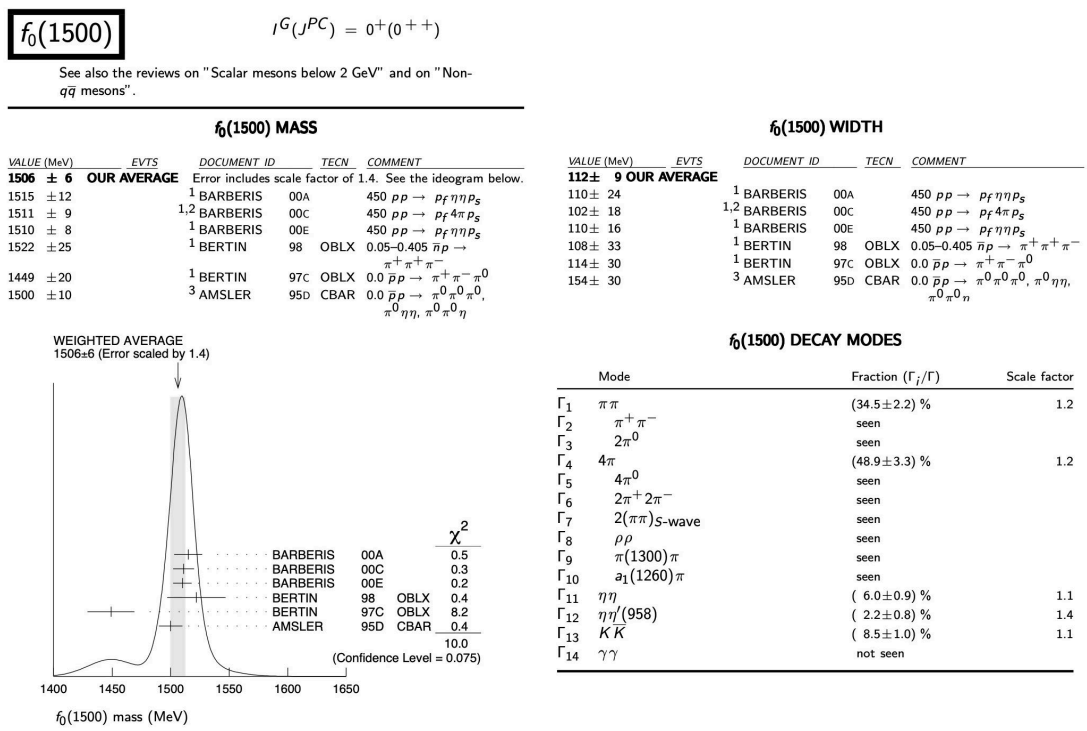
(December 2021)

The Review of Particle Physics is published by the Particle Data Group (PDG), an international collaboration which compiles and summarizes data from particle physics experiments, and provides reviews on Particle Physics and on related areas of Cosmology. The Review of Particle Physics (henceforth abbreviated the Review) is updated every year online and is published biennially in a peer-reviewed physics journal (figure 1, left).

Figure 1: Left: The 2016 Review leaning against all previous editions (image credit: Lawrence Berkeley National Laboratory). Right: some of the booklets published between 1988 and 2018.

The 2021 version of the review, available online only, updates the 2020 version which appeared in print in “Progress of Theoretical and Experimental Physics” (PTEP) the journal of the Physical Society of Japan. The 2020 edition has been prepared by a collaboration of 242 authors from 174 institutions in 26 countries. It is based on some 3324 new measurements from 878 publications which add to the 41371 measurements published in previous editions. There are 120 reviews on topics such as the quark model, quantum chromodynamics, CP-violation, neutrino oscillations, the Higgs boson, supersymmetry or big-bang cosmology. The Review also includes write-ups on probability, statistics, accelerators and detectors, as well as updated tables of the fundamental physical constants. Since 2018 the Review consists of two volumes, volume 1 appearing online and in print, while volume 2 (the “Listings” containing full details on data and bibliographic references) is available only online.

With its updated database and bibliographic references the Review has become an invaluable tool for researchers and is the most cited publication in Particle Physics, with recent issues being cited more than 6000 times. Figure 2 shows, as an example of the Listings, an excerpt on the f0(1500) (spin 0 scalar) meson discovered at CERN in the nineties by an experiment to which the author contributed. PDG also publishes an abridged version of the Review, a pocket booklet of about 300 pages (a simple wallet card in the early days) which is appreciated in particular by undergraduate and graduate university students (figure 1, right). About 10000 copies of the book were produced in 2018, together with 25000 booklets. The Review and the booklets are available to anyone in print and online for free. An interactive site is also available.



$f_0(1500)$ $I^G(J^{PC}) = 0^+(0^{++})$

See also the reviews on "Scalar mesons below 2 GeV" and on "Non-$q\bar{q}$ mesons".

$f_0(1500)$ MASS

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
1506 ± 6 OUR AVERAGE		Error includes scale factor of 1.4. See the ideogram below.			
1515 ±12		[1] BARBERIS	00A		450 $pp \to p_f \eta\eta p_s$
1511 ± 9		[1,2] BARBERIS	00C		450 $pp \to p_f 4\pi p_s$
1510 ± 8		[1] BARBERIS	00E		450 $pp \to p_f \eta\eta p_s$
1522 ±25		[1] BERTIN	98	OBLX	0.05–0.405 $\bar{n}p \to \pi^+\pi^+\pi^-$
1449 ±20		[1] BERTIN	97C	OBLX	0.0 $\bar{p}p \to \pi^+\pi^-\pi^0$
1500 ±10		[3] AMSLER	95D	CBAR	0.0 $\bar{p}p \to \pi^0\pi^0\pi^0$, $\pi^0\eta\eta$, $\pi^0\pi^0\eta$

$f_0(1500)$ WIDTH

VALUE (MeV)	EVTS	DOCUMENT ID		TECN	COMMENT
112± 9 OUR AVERAGE					
110± 24		[1] BARBERIS	00A		450 $pp \to p_f \eta\eta p_s$
102± 18		[1,2] BARBERIS	00C		450 $pp \to p_f 4\pi p_s$
110± 16		[1] BARBERIS	00E		450 $pp \to p_f \eta\eta p_s$
108± 33		[1] BERTIN	98	OBLX	0.05–0.405 $\bar{n}p \to \pi^+\pi^+\pi^-$
114± 30		[1] BERTIN	97C	OBLX	0.0 $\bar{p}p \to \pi^+\pi^-\pi^0$
154± 30		[3] AMSLER	95D	CBAR	0.0 $\bar{p}p \to \pi^0\pi^0\pi^0$, $\pi^0\eta\eta$, $\pi^0\pi^0\eta$

$f_0(1500)$ DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Scale factor
Γ_1	$\pi\pi$	(34.5±2.2) %	1.2
Γ_2	$\pi^+\pi^-$	seen	
Γ_3	$2\pi^0$	seen	
Γ_4	4π	(48.9±3.3) %	1.2
Γ_5	$4\pi^0$	seen	
Γ_6	$2\pi^+2\pi^-$	seen	
Γ_7	$2(\pi\pi)_{S\text{-wave}}$	seen	
Γ_8	$\rho\rho$	seen	
Γ_9	$\pi(1300)\pi$	seen	
Γ_{10}	$a_1(1260)\pi$	seen	
Γ_{11}	$\eta\eta$	(6.0±0.9) %	1.1
Γ_{12}	$\eta\eta'(958)$	(2.2±0.8) %	1.4
Γ_{13}	$K\bar{K}$	(8.5±1.0) %	1.1
Γ_{14}	$\gamma\gamma$	not seen	

Figure 2: Excerpt from the Review, showing a compilation of data on the mass and width of the f0(1500) meson, together with an ideogram and information on its decay modes.

The Particle Data Group was founded in 1957 by W. H. Barkas and A. H. Rosenfeld [1]. The author of this note, who joined the Stefan Meyer Institute in 2016, has been with PDG since 1995. He is coordinating a team reviewing the current knowledge of mesons, which in the quark model are believed to be composed of quark-antiquark pairs. A photograph of the meson team on the CERN premises, together with other members of the PDG, is shown in figure 3.

Several specialized articles have also been submitted to the Review by the author, together with fewer colleagues: Fundamental concepts are explained in a report on the quark model [2]. In the last decade evidence is mounting for the existence of more complex mesons composed of several quarks and antiquarks, which are reviewed in an article on “non quark-antiquark” states [3,4]. Furthermore, two publications discuss light spin 0 mesons [5,6] a sector which needs clarification.

The Particle Data Group is coordinated by a team at the Lawrence Berkeley National Laboratory (LBNL). A detailed account can be found in the November 2017 issue of the CERN Courier. The publication of the Review is funded by the Office of High Energy Physics of the U.S. Department of Energy (DOE), by the European Laboratory for Particle Physics (CERN), by an arrangement between Japan (Ministry of Education, Culture, Sports, Science and Technology) and (DOE) on cooperative research and development, and by the Italian National Institute of Nuclear Physics (INFN).

[1] A.H. Rosenfeld, Annu. Rev. Nucl. Sci. 25 (1975) 555
[2] **Quark Model**, C. Amsler (Stefan Meyer Institute), T. DeGrand (Colorado U., Boulder) and B. Krusche (Basel U.)
[3] **Non-qqbar Mesons**, C. Amsler (Stefan Meyer Institute) and C. Hanhart (Jülich)
[4] **Spectroscopy of Light Meson Resonances**, C. Amsler (Stefan Meyer Institute), S. Eidelman (Budker Institute, Novosibirsk), A. Masoni (INFN, Cagliary), G. Venanzoni (INFN, Pisa)
[5] **Pseudoscalar and Pseudovector Mesons in the 1400 MeV Region**, C. Amsler (Stefan Meyer Institute) and A. Masoni (INFN, Cagliary)
[6] **Scalar Mesons below 2 GeV**, C. Amsler (Stefan Meyer Institute), S. Eidelman (Budker Institute, Novosibirsk), T. Gutsche (Tübingen U.), C. Hanhart (Jülich) and S. Spanier (Tennessee U.)

Figure 3: Members of the Particle Data Group in February 1996 during a meeting at CERN. From left to right are F. James (CERN), N. Törnqvist (Helsinki), A. Gurtu (Tata Inst., India), M. Roos (Helsinki), B. Armstrong (LBNL), K. Mönig (CERN), S. Eidelman (Budker Institute, Novosibirsk), J. Hernandez (Valencia), M. Aguilar-Benitez (CIEMAT, Madrid), A. Hicks (CERN), C. Caso (Genova), P. Gee (LBNL), and C. Amsler (Zürich) (Image credit Lawrence Berkeley National Laboratory).