Particle Data Group

From Wallet Cards to Smartphone Apps

58 years of evaluating data

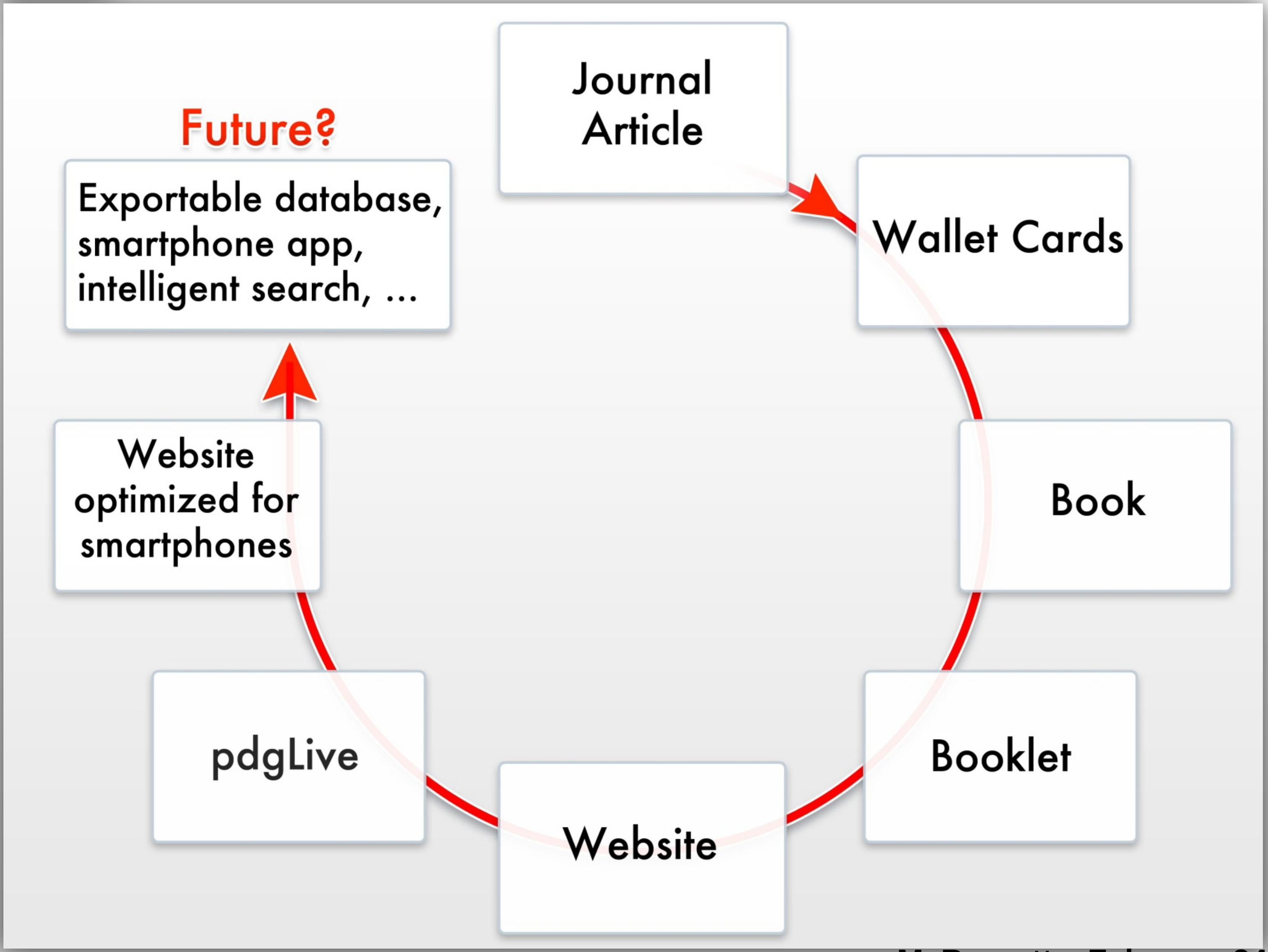
M. Barnett – February 24, 2016

Introduction

Three goals of PDG:

- Highest Quality
- Innovation
- Timeliness

PDG Innovations



Timely Additions

LIGO announcement Feb. 11, 2016 : already in PDG Review on: "Experimental Tests of Gravitational Theory"

> **… The existence of transverse-traceless quadrupolar gravitational waves (in the wave zone), and a direct observational proof of the existence of coalescing black holes, …**

Similarly the July 4, 2012 announcement of the Higgs boson discovery appeared in the PDG book soon thereafter as a July 12 Addendum to the review on Higgs Bosons:

> **On July 4, 2012, the ATLAS and CMS collaborations simultaneously announced observation of a new particle produced in pp collision data at high energies …**

Art Rosenfeld
1975 review article

THE PARTICLE DATA GROUP: GROWTH AND OPERATIONS

Excerpts:

A single international group, the Particle Data Group (PDG), compiles all the data on particle properties.

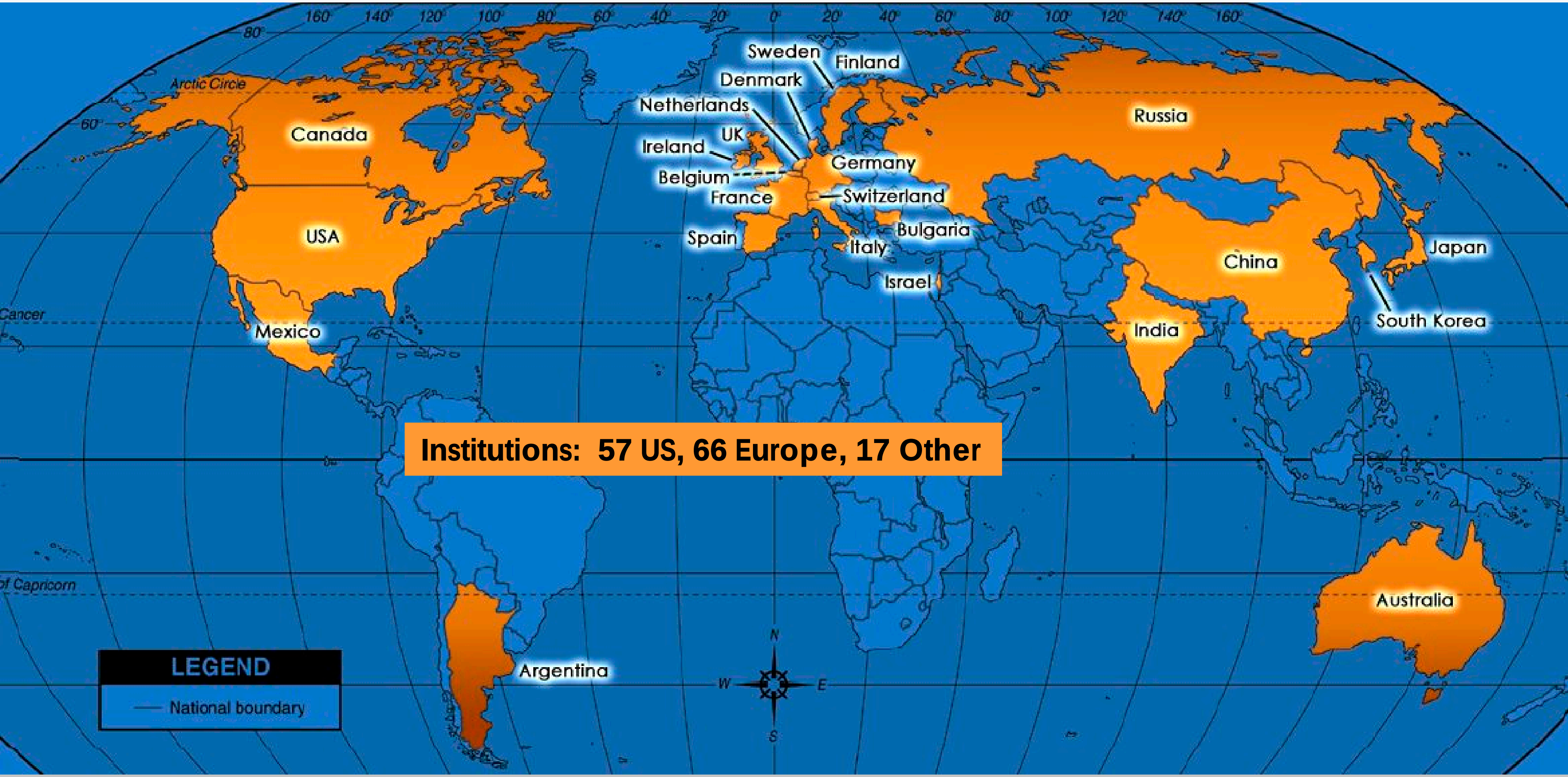
We briefly discuss how the data rate grew from a trickle to a fairly steady flood.... We outline how PDG has learned to collect, evaluate, correct, verify, analyze, and distribute the data,…
PDG has taken on the responsibility of critically reviewing the results of experiments.

Of over 154 pages of "Listings," 50 pages are actually not listings, but figures, or …reviews.

In our experience, transatlantic collaboration works surprisingly well, but only after people have worked together and grown to know one another well.

PDG Collaboration

206 authors from 140 institutions
plus 700 consultants



Institutions: 57 US, 66 Europe, 17 Other

Fermilab Collaborators in PDG

Authors

(2014 edition)

- Marcela Carena
- Bogdan Dobrescu
- Lynn Garren
- Tom Junk
- Michael Syphers
- Ruth Van de Water
- Geralyn (Sam) Zeller

Chair of the PDG Advisory Committee (2014)

- Deborah Harris

And many consultants

including Dmitri Denisov

Fermilab Discoveries in PDG

b Quark Discovery (1977)

$\Upsilon_1(9410)$

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49  UPSILON1(9410,JPG=1- ) I=
------ --------- --------- --------- --------- --------- --------- --------

              49  UPSILON1 MASS (MEV)
M  I        9410.      13.                INNES      77 SPEC  0 400 P+A,MU+MU-     12/77*
M  I     FROM 2-PEAK FIT                                                          12/77*

------ --------- --------- --------- --------- --------- --------- --------

              49  UPSILON1 WIDTH (GEV)

W  A        (100.)     OR LESS            INNES      77 SPEC  0 400 P+A,MU+MU-     12/77*
W  A     FROM QUOTED RESOLUTION

------ --------- --------- --------- --------- --------- --------- --------
              49  UPSILON1 PARTIAL DECAY MODES

                                                               DECAY MASSES
P1       UPSILON1 INTO MU+ MU-                               105+ 105
P2       UPSILON1 INTO E+ E-                                  .5+  .5

------ --------- --------- --------- --------- --------- --------- --------

              49  UPSILON1 BRANCHING RATIOS

R1       UPSILON1 INTO MU+ MU-                                (P1)
R1          SEEN                          HERB       77                               12/77*

R2       UPSILON1 INTO E+ E-                                  (P2)
R2          SEEN                          COBB       77                               12/77*

****** ********* ********* ********* ********* ********* ********* ********

                          REFERENCES FOR UPSILON1(9410)

COBB      77 PL                    +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB      77 PRL 39 252            +HOM,LEDERMAN,APPEL,ITO,+  (COLU+FNAL+STON)
INNES     77 PRL 39 1240           +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

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PDG Database 1980

Fermilab Discoveries in PDG

t Quark Discovery (1995)

And more discoveries

t-Quark Mass in $p\overline{p}$ Collisions

The t quark has now been observed. Its mass is sufficiently high that decay is expected to occur before hadronization.

Preliminary results for the top mass based on the full (Run Ia+Ib) data set have been presented by CDF and DØ at conferences in early 1996:

$m_t = 175.6 \pm 5.7 \pm 7.1$ GeV	CDF	lepton + jets
$m_t = 159^{+24}_{-22} \pm 17$ GeV	CDF	dilepton
$m_t = 187 \pm 8 \pm 12$ GeV	CDF	hadronic
$m_t = 170 \pm 15 \pm 10$ GeV	DØ	lepton + jets
$m_t = 158 \pm 24 \pm 10$ GeV	DØ	$e\mu$

Because of the high current interest, we mention these preliminary results here but do not average them or include them in the Listings or Tables. See the note on the top quark for references.

Search limits, which are now primarily of historical interest, are based on the assumption that no nonstandard decay modes such as $t \rightarrow bH^+$ are available, except as noted in the comments.

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
180±12 OUR AVERAGE					
$199^{+19}_{-21} \pm 22$		[1] ABACHI	95	D0	ℓ + jet
$176 \pm 8 \pm 10$		[2] ABE	95F	CDF	ℓ + b-jet

Full Summary Table 1957

(from Wallet Cards)

Barkas and Rosenfeld UCRL-8030 Table I

Masses and mean lives of elementary particles; November, 1957
(The antiparticles are assumed to have the same spins, masses, and mean lives as the particles listed)

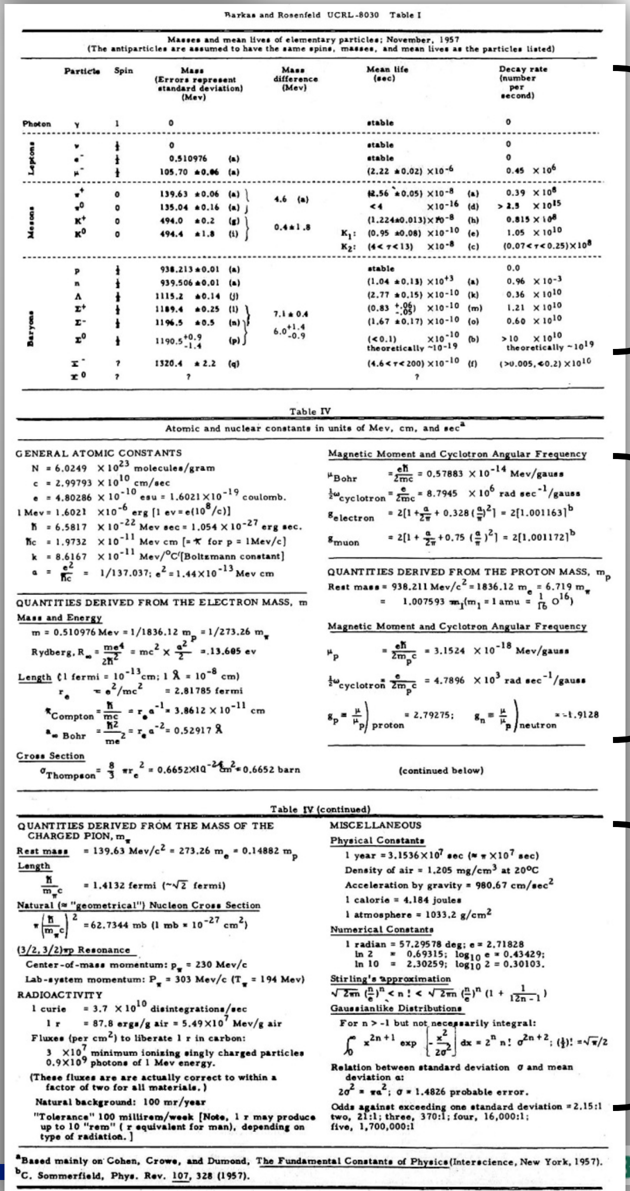
	Particle	Spin	Mass (Errors represent standard deviation) (Mev)		Mass difference (Mev)	Mean life (sec)		Decay rate (number per second)
Photon	γ	1	0			stable		0
Leptons	ν	$\frac{1}{2}$	0			stable		0
	e^-	$\frac{1}{2}$	0.510976	(a)		stable		0
	μ^-	$\frac{1}{2}$	105.70 $\pm$0.06	(a)		$(2.22 \pm 0.02) \times 10^{-6}$		0.45×10^{6}
Mesons	π^+	0	139.63 $\pm$0.06	(a)	4.6 (a)	$(2.56 \pm 0.05) \times 10^{-8}$	(a)	0.39×10^{8}
	π^0	0	135.04 $\pm$0.16	(a)		$< 4 \times 10^{-16}$	(d)	$> 2.5 \times 10^{15}$
	K^+	0	494.0 $\pm$0.2	(g)	0.4 $\pm$ 1.8	$(1.224 \pm 0.013) \times 10^{-8}$	(h)	0.815×10^{8}
	K^0	0	494.4 $\pm$1.8	(i)		K_1: $(0.95 \pm 0.08) \times 10^{-10}$	(e)	1.05×10^{10}
						K_2: $(4 < \tau < 13) \times 10^{-8}$	(c)	$(0.07 < \tau < 0.25) \times 10^{8}$
Baryons	p	$\frac{1}{2}$	938.213 $\pm$0.01	(a)		stable		0.0
	n	$\frac{1}{2}$	939.506 $\pm$0.01	(a)		$(1.04 \pm 0.13) \times 10^{+3}$	(a)	0.96×10^{-3}
	Λ	$\frac{1}{2}$	1115.2 $\pm$0.14	(j)		$(2.77 \pm 0.15) \times 10^{-10}$	(k)	0.36×10^{10}
	Σ^+	$\frac{1}{2}$	1189.4 $\pm$0.25	(l)	7.1 $\pm$ 0.4	$(0.83\, ^{+.06}_{-.05}) \times 10^{-10}$	(m)	1.21×10^{10}
	Σ^-	$\frac{1}{2}$	1196.5 $\pm$0.5	(n)	$6.0^{+1.4}_{-0.9}$	$(1.67 \pm 0.17) \times 10^{-10}$	(o)	0.60×10^{10}
	Σ^0	$\frac{1}{2}$	$1190.5^{+0.9}_{-1.4}$	(p)		$(< 0.1) \times 10^{-10}$ theoretically $\sim 10^{-19}$	(b)	$> 10 \times 10^{10}$ theoretically $\sim 10^{19}$
	Ξ^-	?	1320.4 $\pm$ 2.2	(q)		$(4.6 < \tau < 200) \times 10^{-10}$	(f)	$(> 0.005, < 0.2) \times 10^{10}$
	Ξ^0	?	?			?		

Wallet Cards 1957

PDG particle data group

BERKELEY LAB

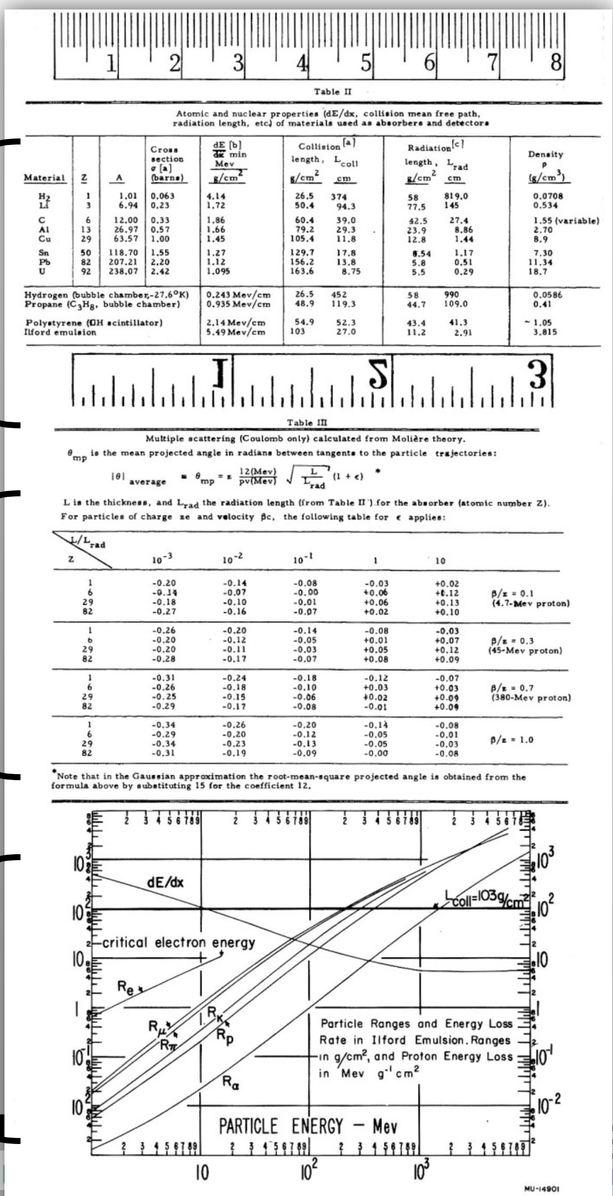
Front ⟷ Back



Summary Table

Atomic & Nuclear Constants

Physical Constants, Num'l Constants, Gaussian Dist's, etc.



dE/dx, Radiation lengths, etc.

Multiple Scattering

Particle Ranges, Energy Loss Rates

The Essence of PDG

- **Listings of Data**
  (with Summary Tables)
- **Reviews of Essential Topics**
- **pdgLive**
  (an interactive combination of Listings and Reviews)

Listings and Reviews

The Web allows us to see what most interest our readers.

The hits (page views) on

Data Listings = Reviews

almost exactly equal.

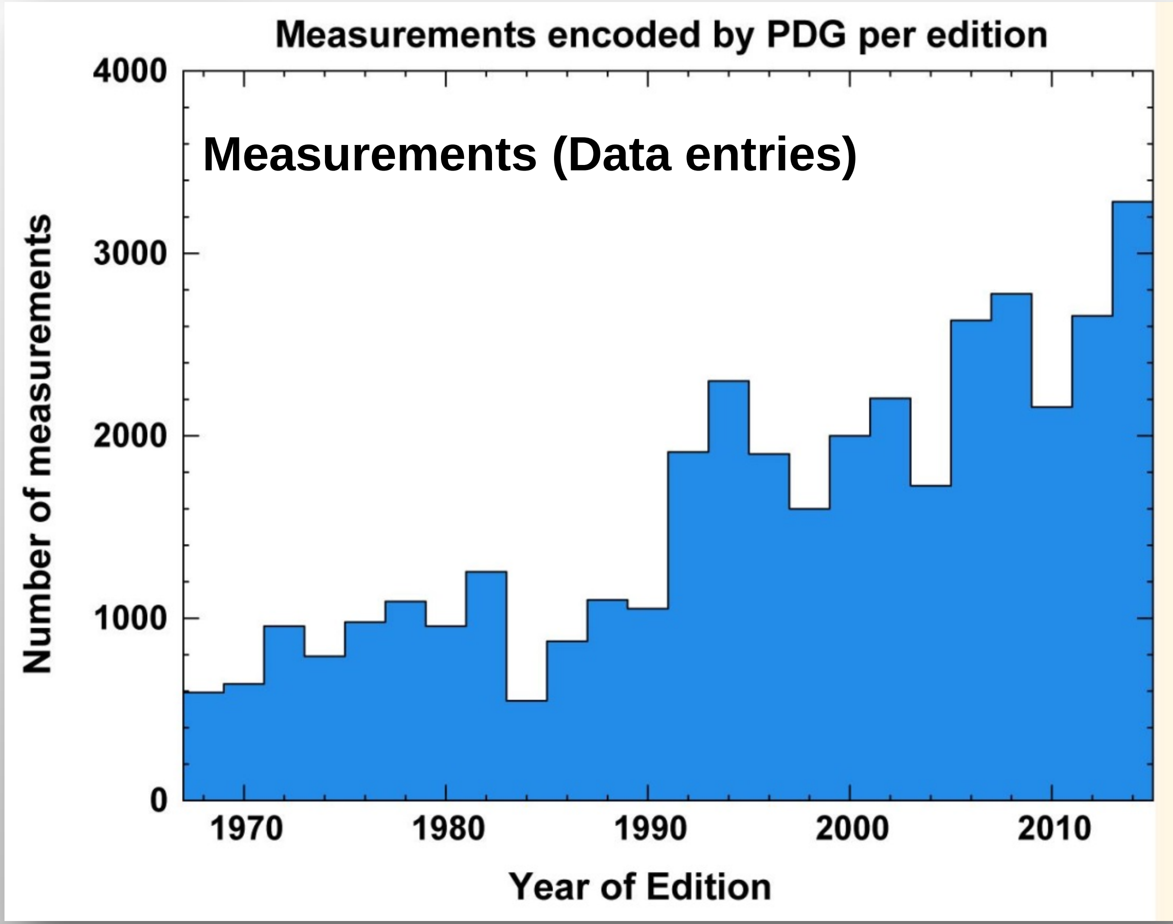
Clearly people care about both.

About Data Listings

Huge Increase in Search Papers

Year of Book	Number of Search Papers
2010	136
2014	509

Workload Trends



Some editions are more or less than 24 months, yielding fluctuations in graphs.

LHC bump

So there is an increasing workload on the LBNL group.

Highlights in 2014 Listings

899 new papers with 3283 new measurements.

330 LHC papers: ATLAS, CMS, and LHCb

Extensive Higgs boson coverage from 138 papers with 258 measurements.

Supersymmetry: 123 papers, many from LHC experiments.

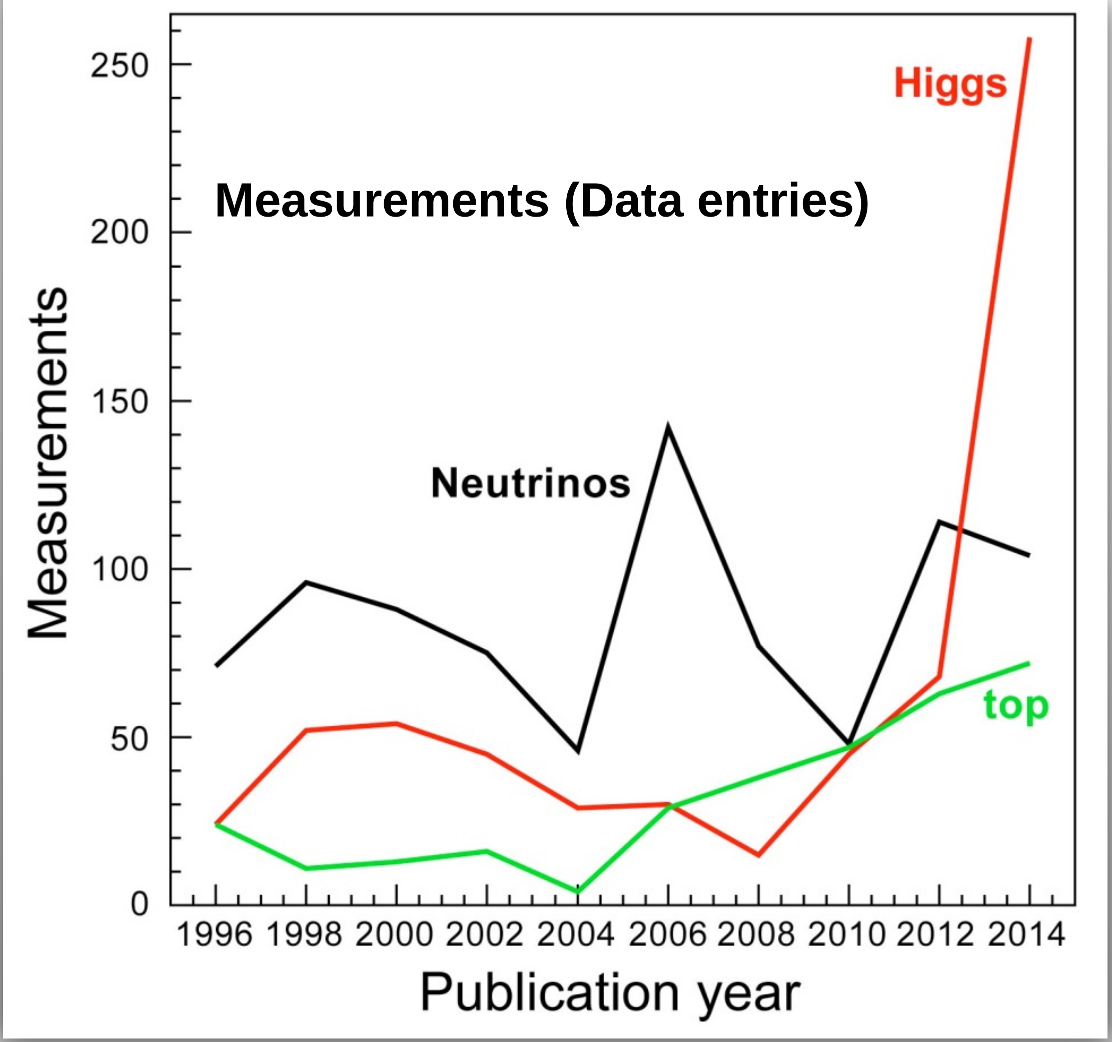
Cosmology reviews updated to include 2013 Planck.

Updated and new results in neutrino mixing on Δm^2 and mixing angle measurements.

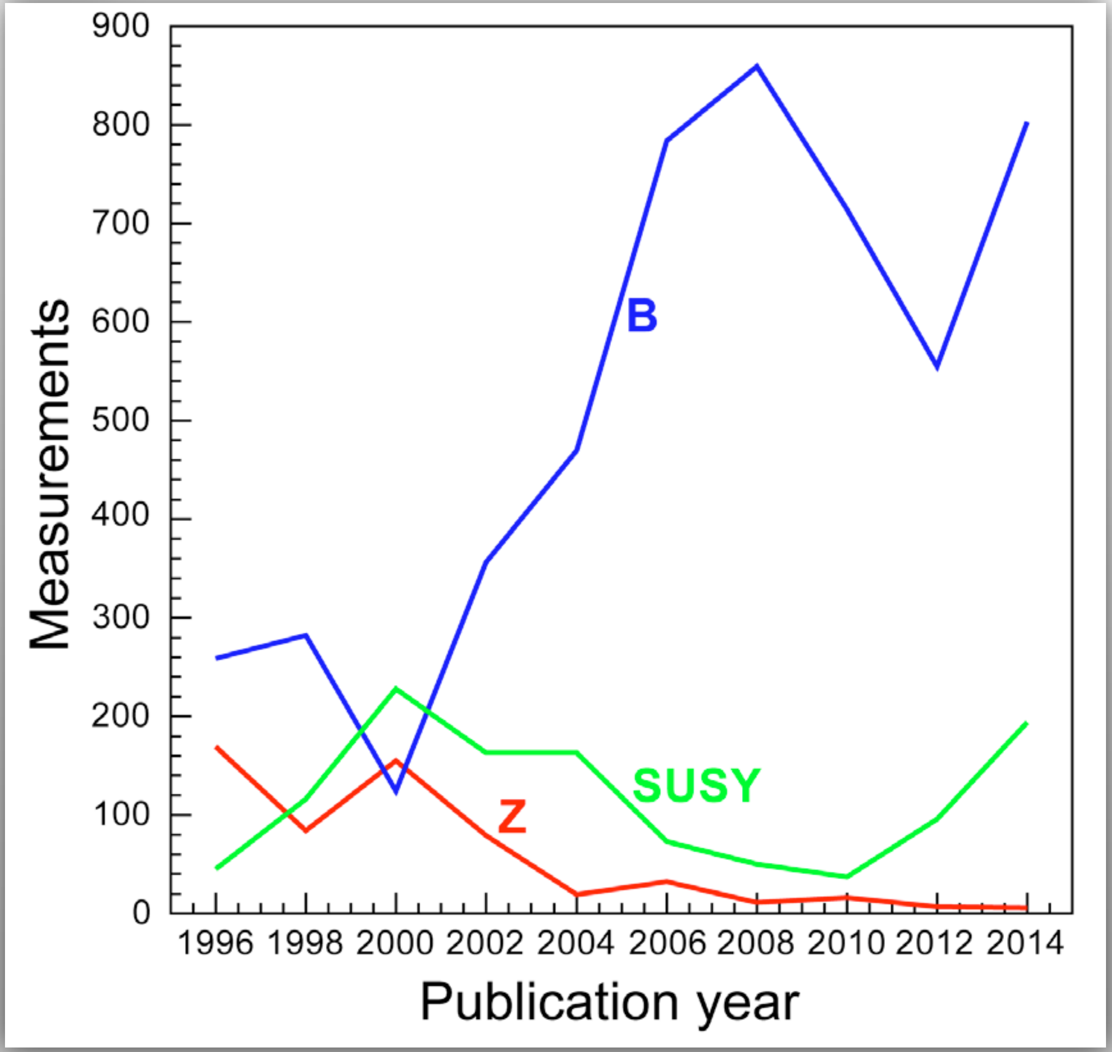
Latest from B meson physics: 183 papers with 803 measurements, including first observation of $B_s \to \mu^+\mu^-$ from LHCb and CMS.

And much more…

Data versus time

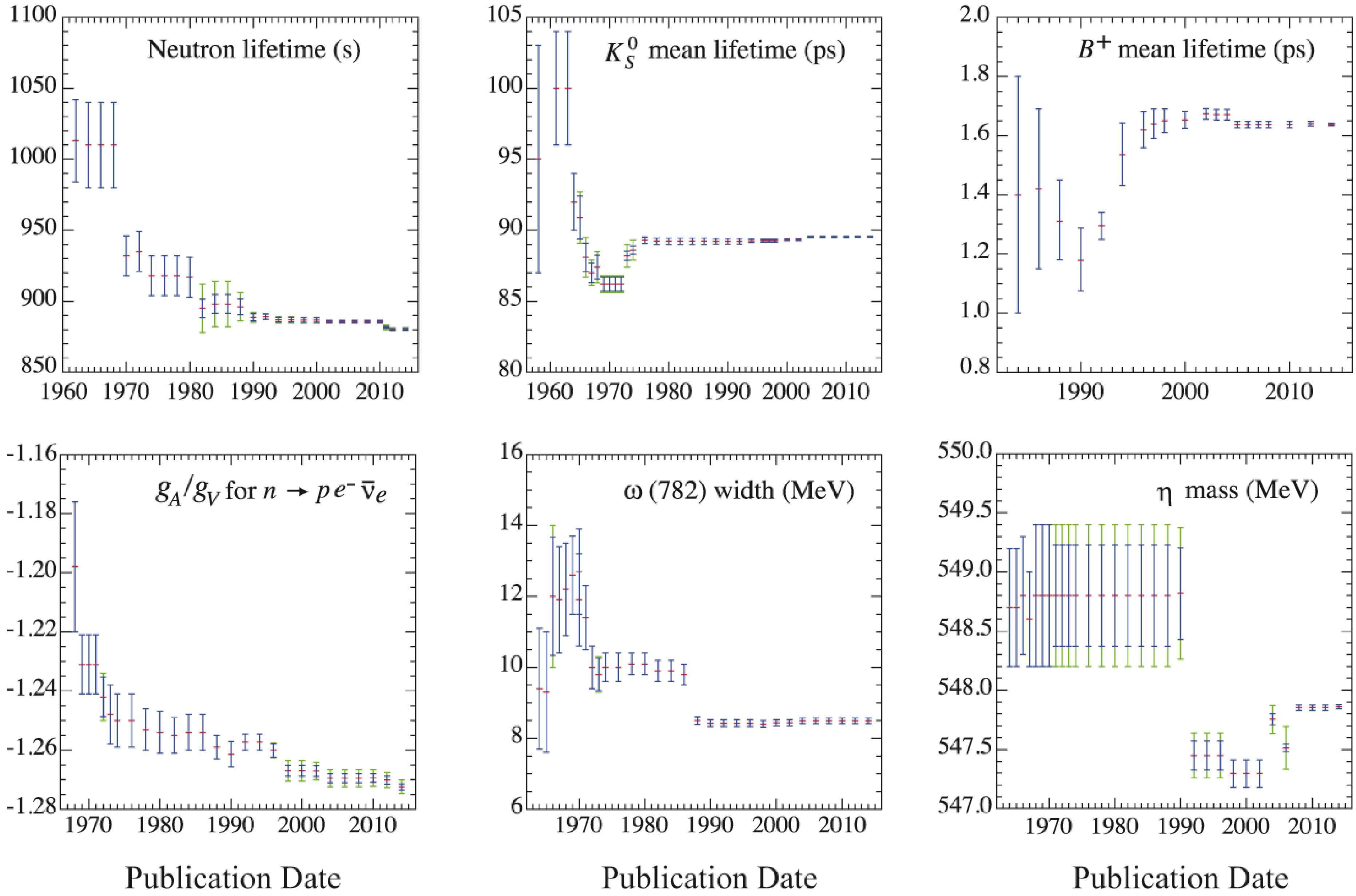


Data versus time



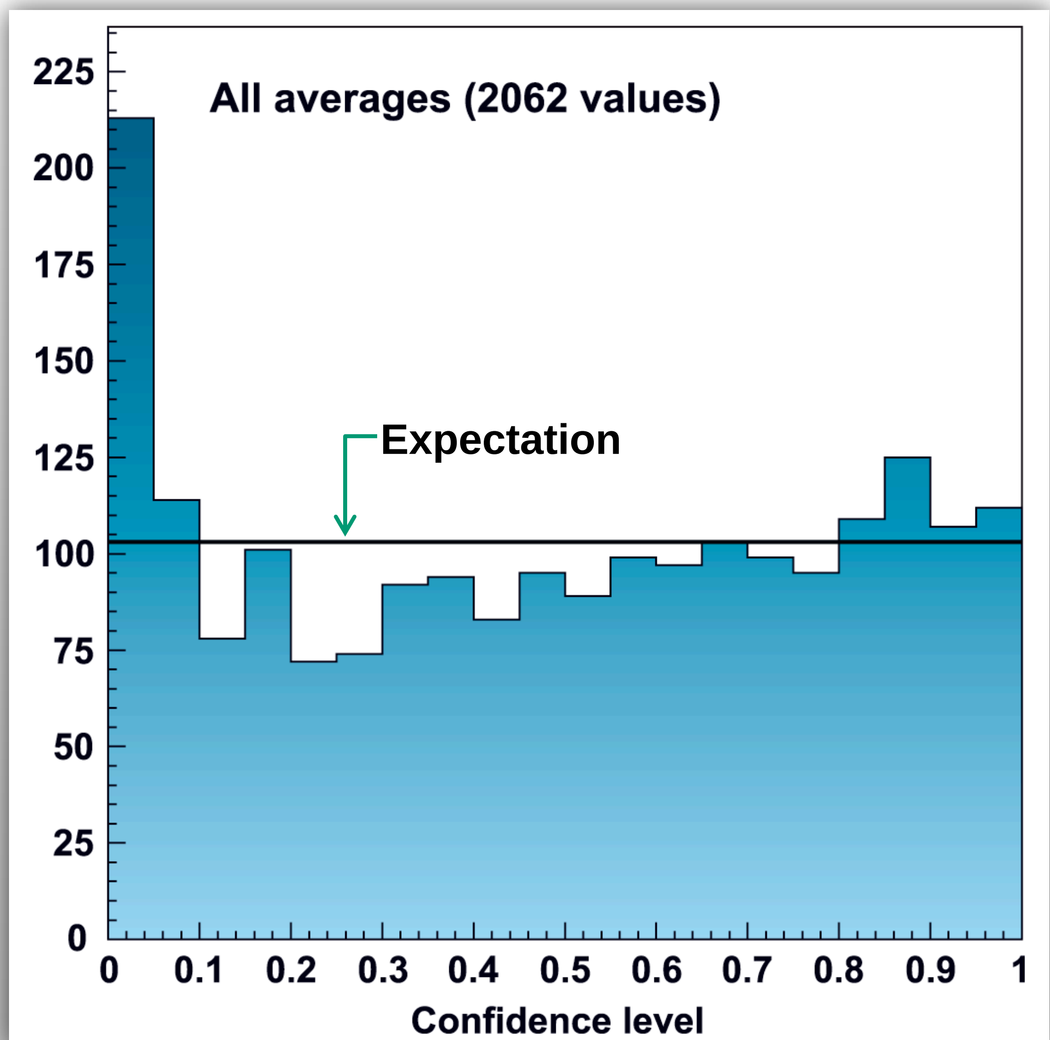
Measurements (Data entries)

History Plots

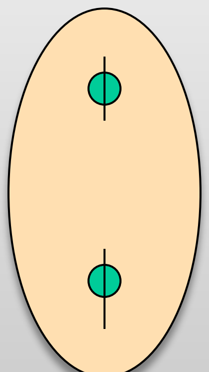


Confidence Levels in PDG Averages

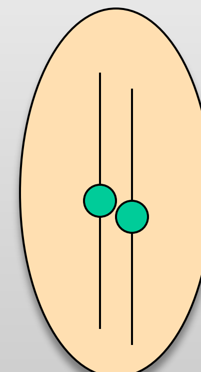
Each point is one average.



Peak at left due to conflicting measurements.

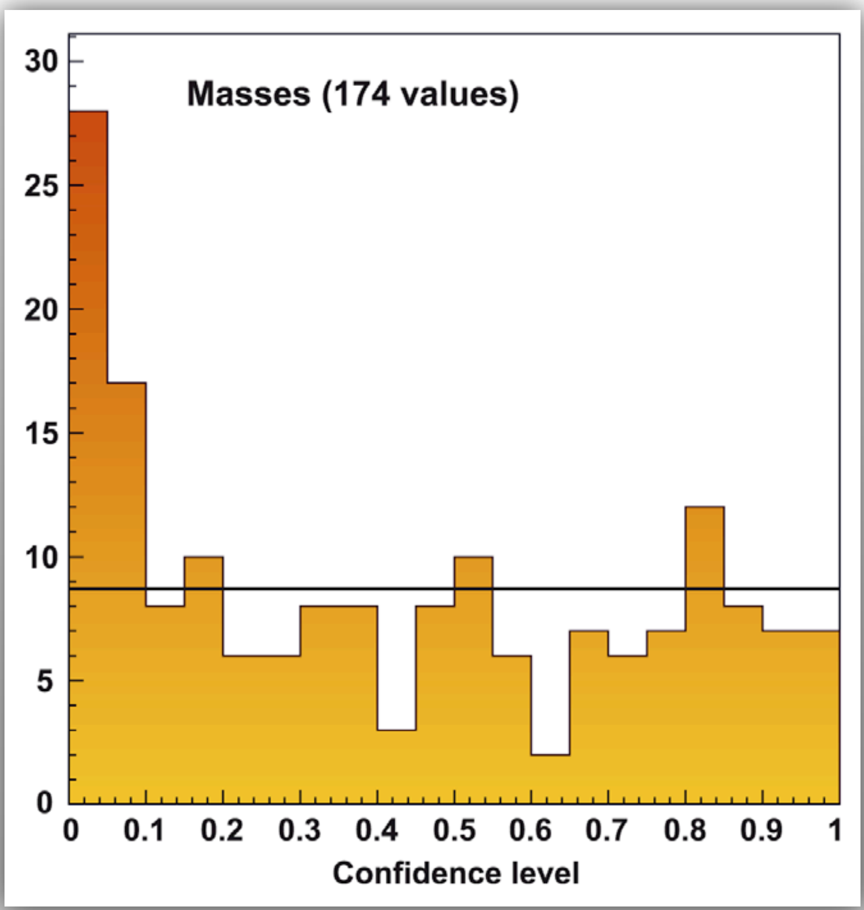


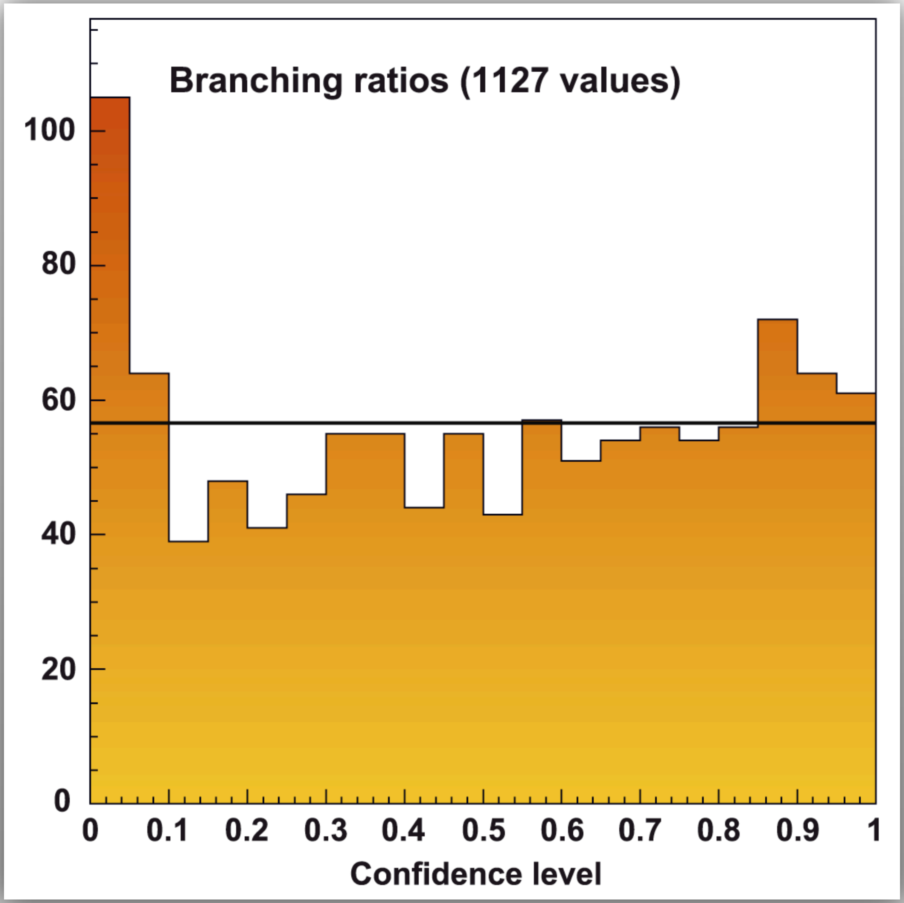
Broad peak at right due to conservative error bars.



Confidence Levels in PDG Listings

Masses | **Branching Ratios**



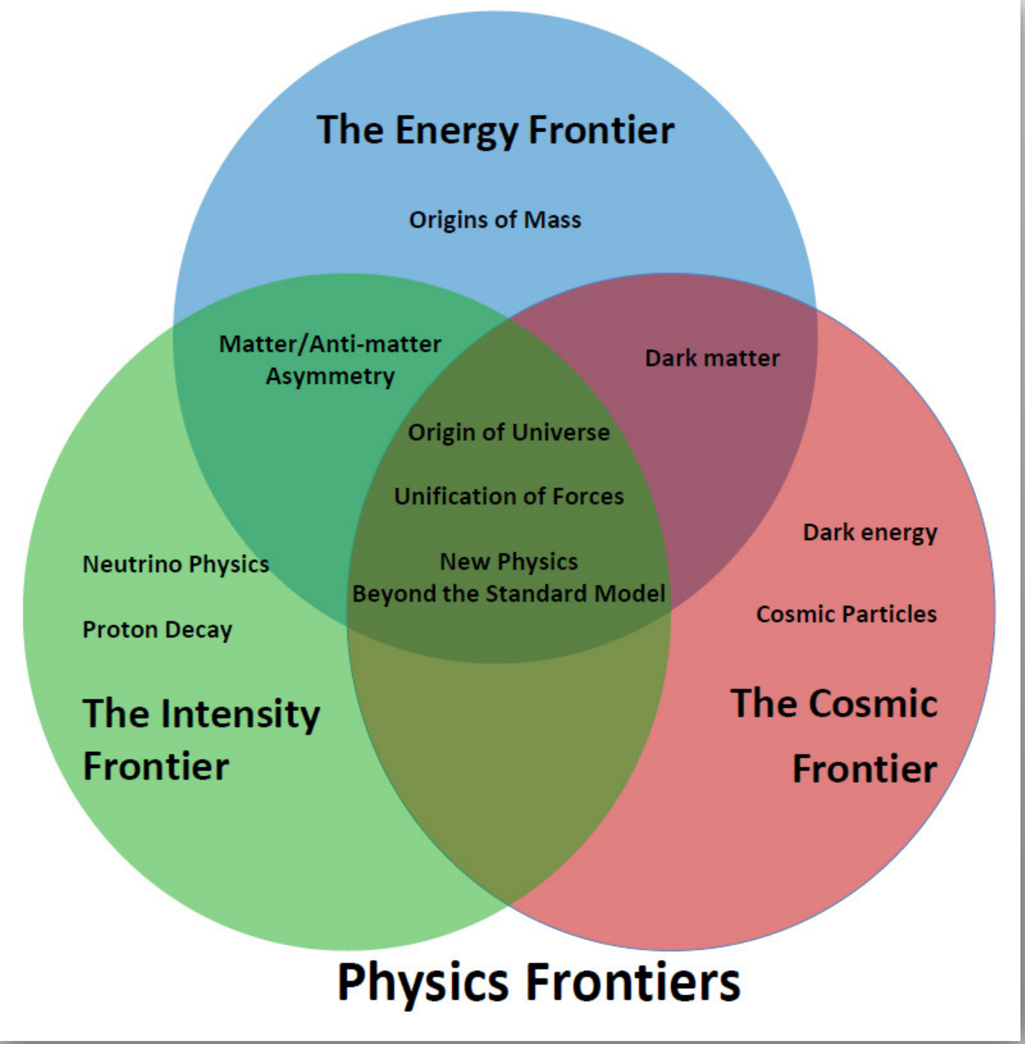


About Reviews

Covered by PDG

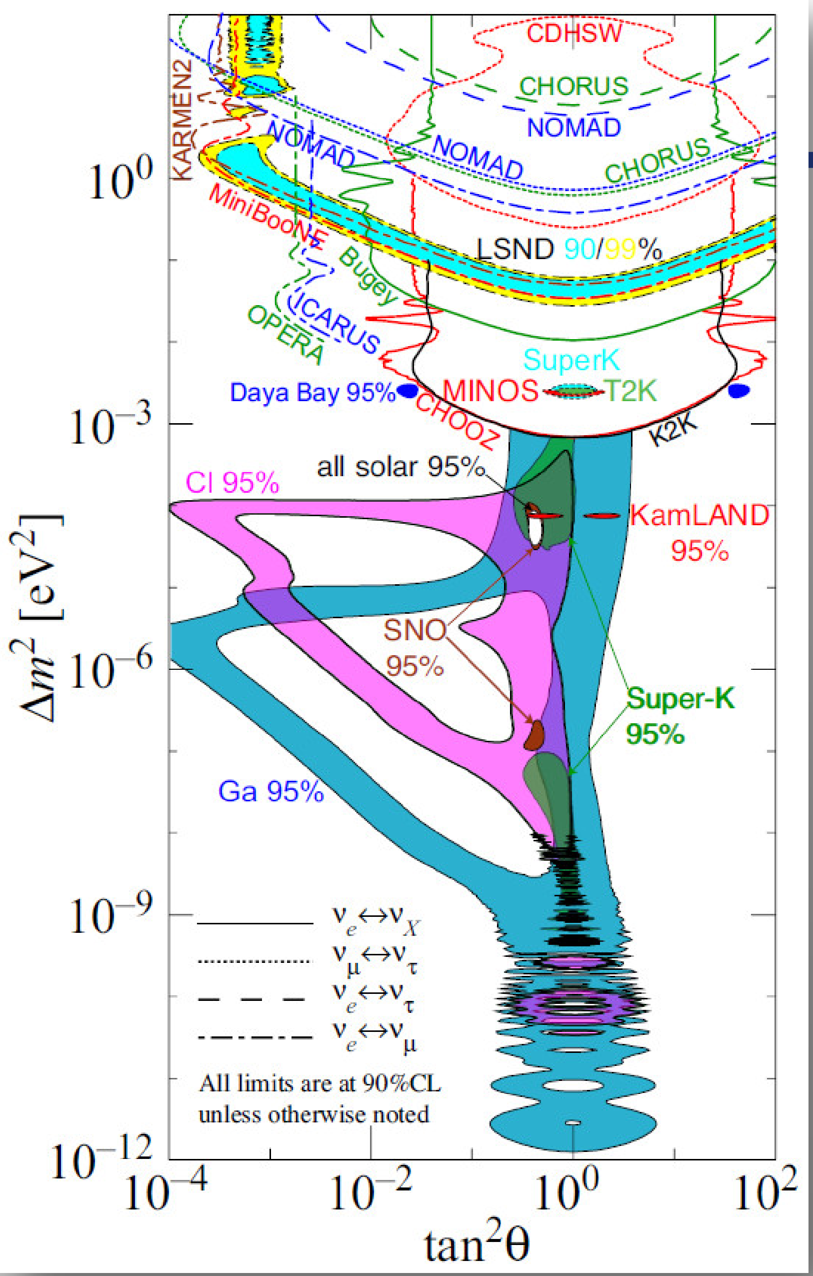
PDG leverages all frontier areas:

- **Energy,**
- **Intensity,**
- **Cosmic.**



Neutrinos

Latest plot shows large mixing of neutrinos



Hitoshi Murayama

Astrophysics & Cosmology

Downloads of Reviews:

Astrophysical Constants 6091

Big Bang Cosmology 7799

Cosmological Parameters:
H_0, Λ, Ω, etc. 13769

Experimental Tests of Gravitational Theory 4234

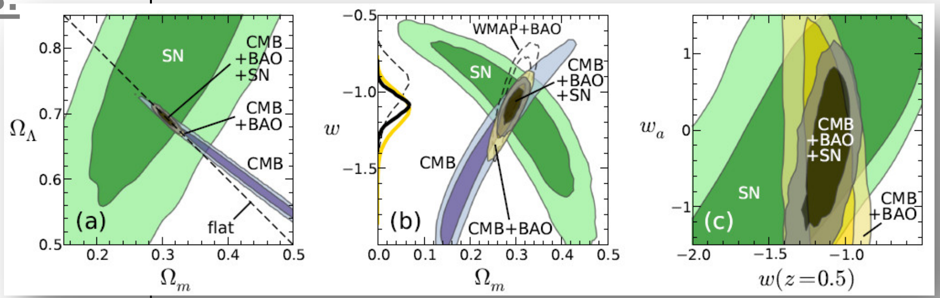
Dark Matter 8591

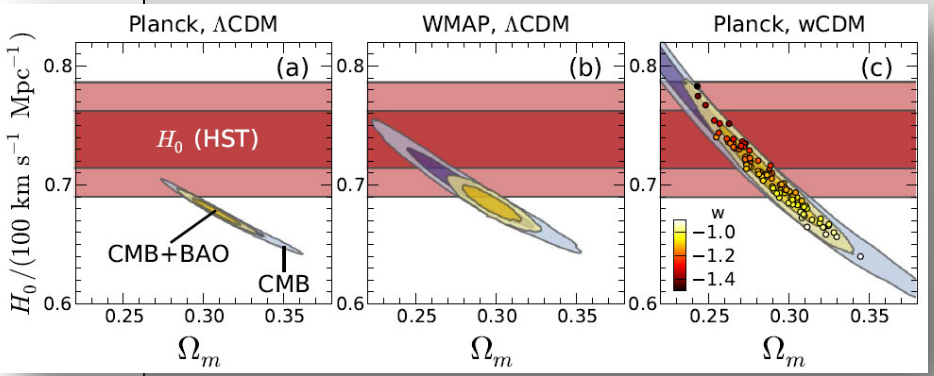
Dark Energy 7627

Cosmic Background Rad. 5587

Big Bang Nucleosynthesis 4343

Total Cosmology Downloads 58,041 (9.4%)





(from Dark Energy review)

Reviews: Linked or Not to Listings

616,000 downloads of Reviews per year.

Linked Reviews:

2/3 of reviews are linked to the Listings

(Higgs, neutrinos, top quarks, K mesons, B mesons, SUSY, etc.).

Vital to understanding content of Listings.

Non-linked Reviews:

The 1/3 non-linked reviews are both vital and among the most downloaded.

(Electroweak Model, Statistics, Particle Detectors, Cosmological Parameters, etc.)

112 reviews in 2014 Edition
(most are revised or new)

New reviews on:

Higgs Boson Physics

Dark Energy

Monte Carlo Neutrino Generators

Resonances

Significant update/revision to reviews on:

Top Quark

Dynamical Electroweak Symmetry Breaking

Astrophysical Constants

Dark Matter

Big Bang Nucleosynthesis

Neutrino Cross Section Measurements

Accelerator Physics of Colliders

High Energy Collider Parameters

New in 2016 Edition:

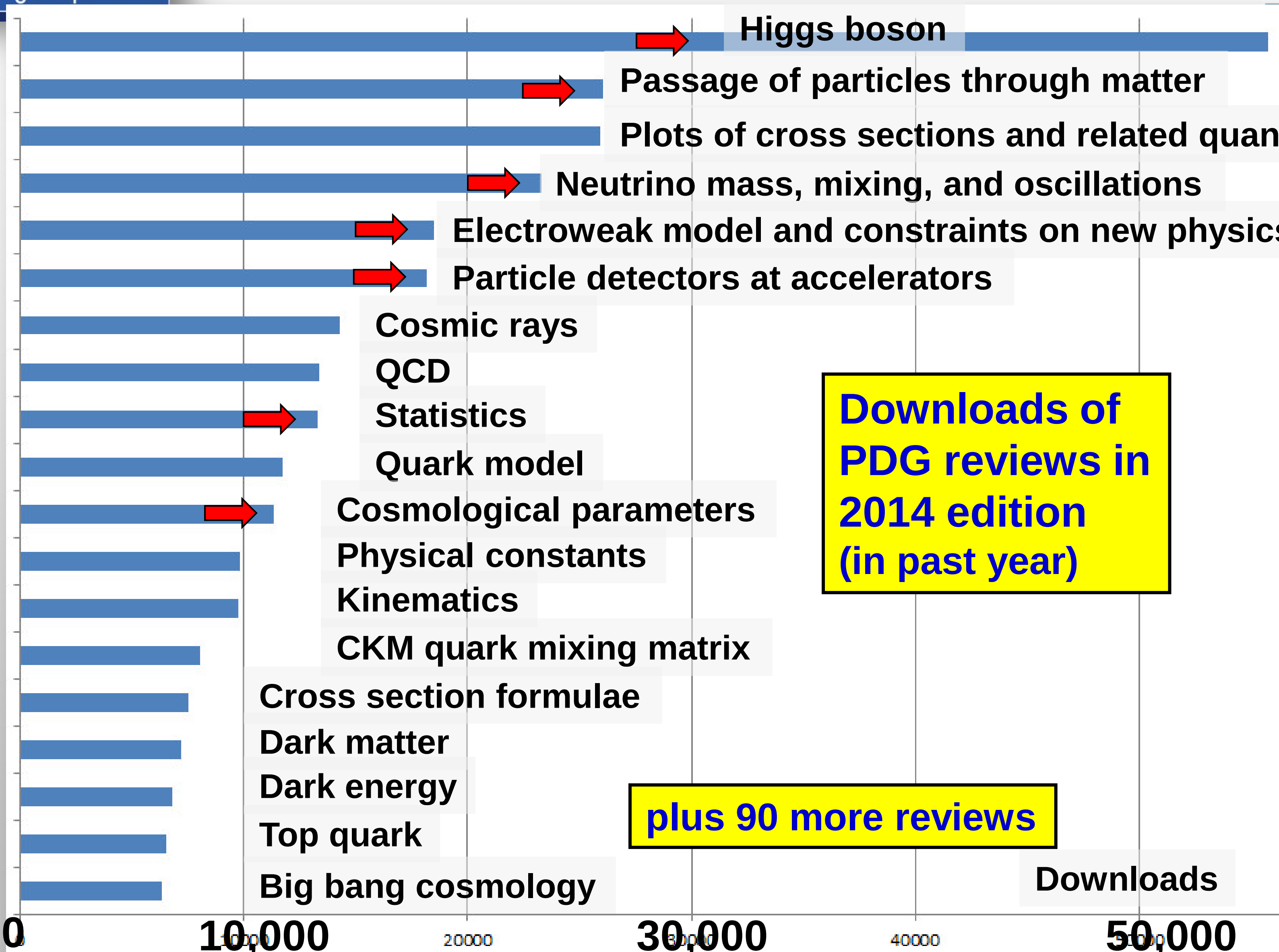
Inflation

Grand Unified Theories

Pentaquarks

etc.

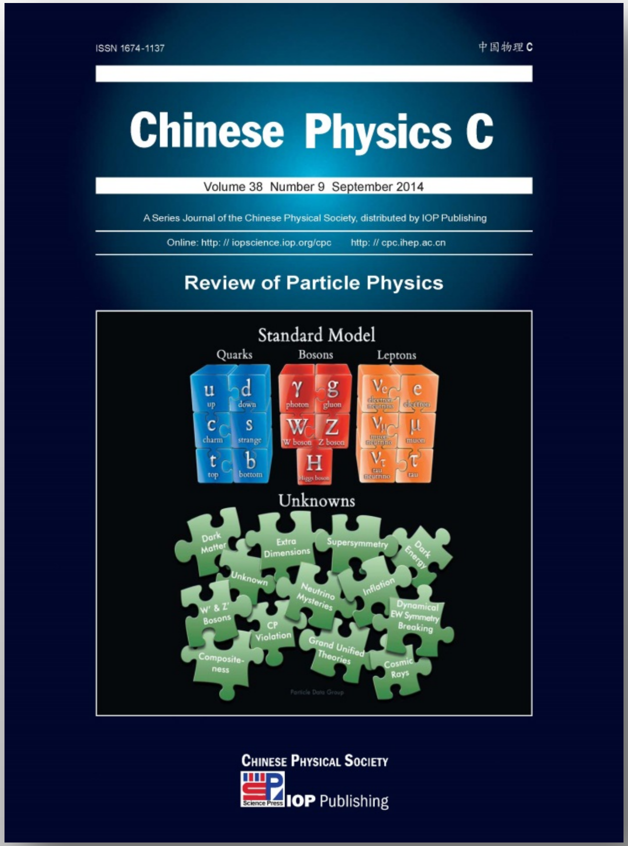
Amazing Diversity of Topics Interest Our Community

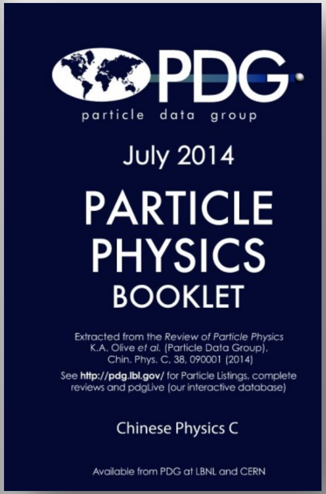


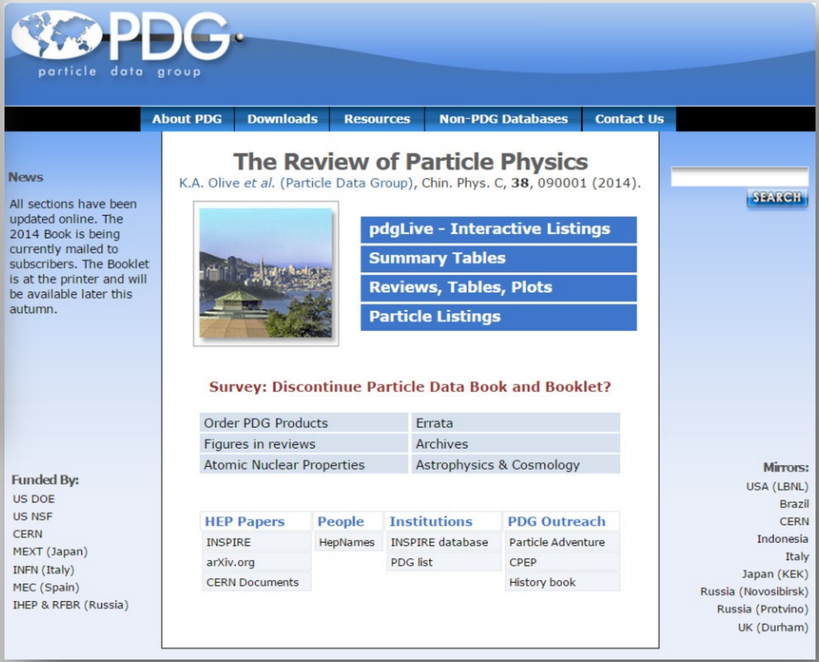
PDG Products

Review of Particle Physics

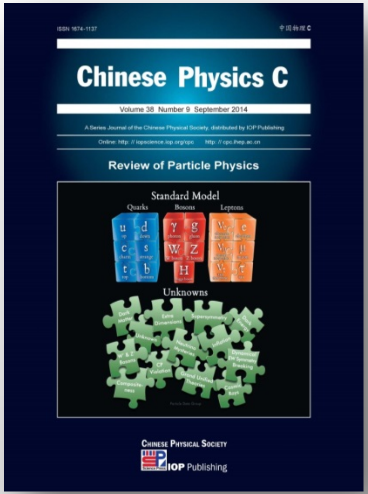
2014 Edition (book, booklet, web, pdgLive)







Review of Particle Physics



<u>Formats</u>:

Printed – updated in even years

- **Book – 14,000 copies**
- **Booklet – 32,000 copies**

Online – updated once a year.

More than 100 million hits total.

- **Full content of the book (PDF)**
- **pdgLive – Interactive web app**

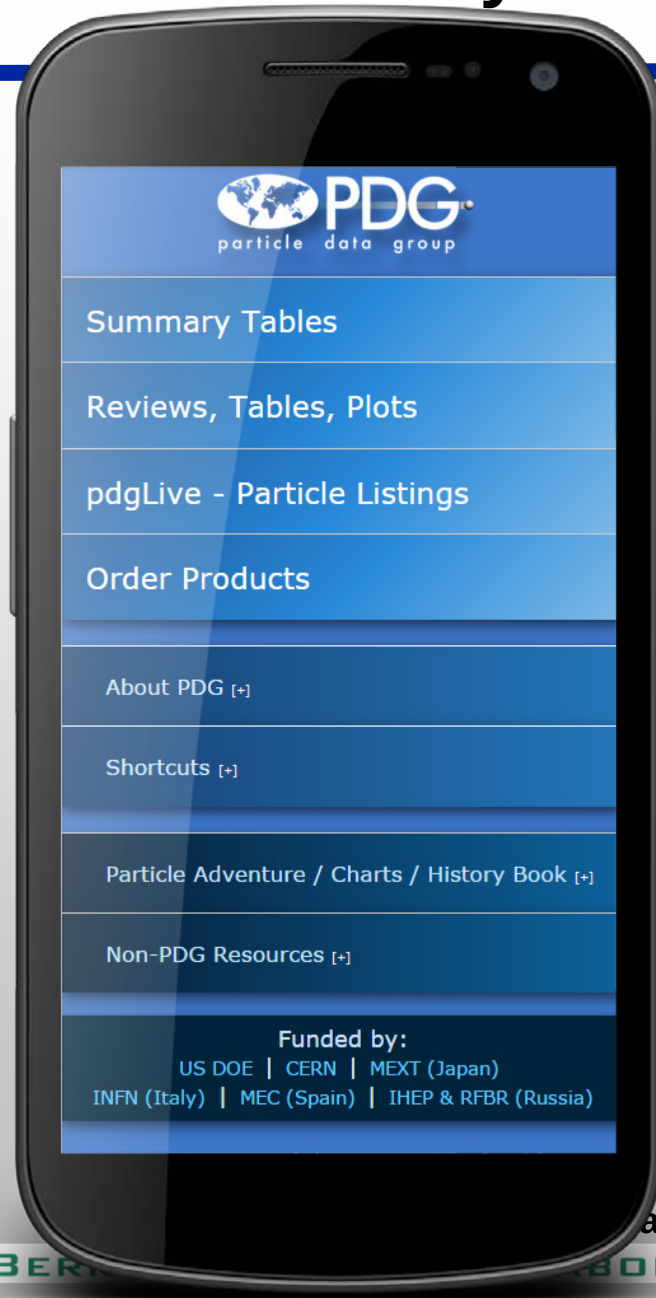
All the content as the PDF files. Cross-linked with INSPIRE, which is cross-linked with others.

8 Mirror sites

Mobile Version

New: Mobile-Friendly Version

All the content of the regular site including pdgLive: The entire book in your pocket.



pdg.lbl.gov

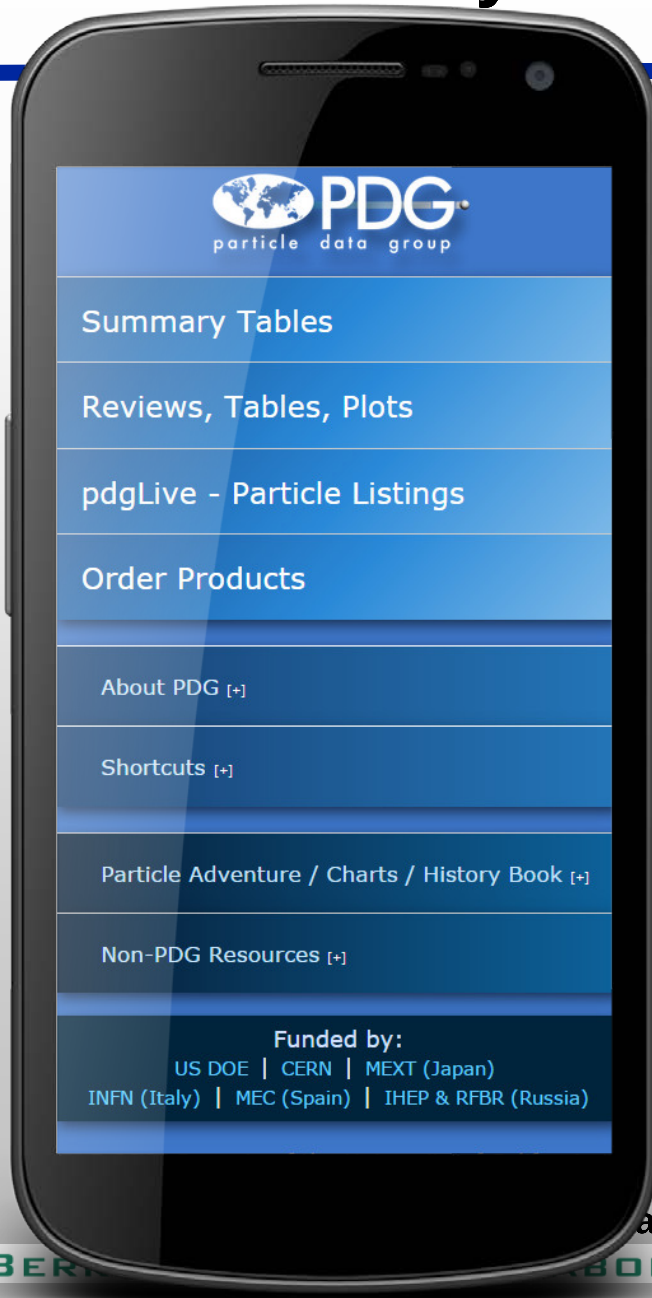
Google now gives priority to mobile-friendly websites for searches from smartphones.

New: Mobile-Friendly Version

pdg.lbl.gov

All the content of the regular site including pdgLive

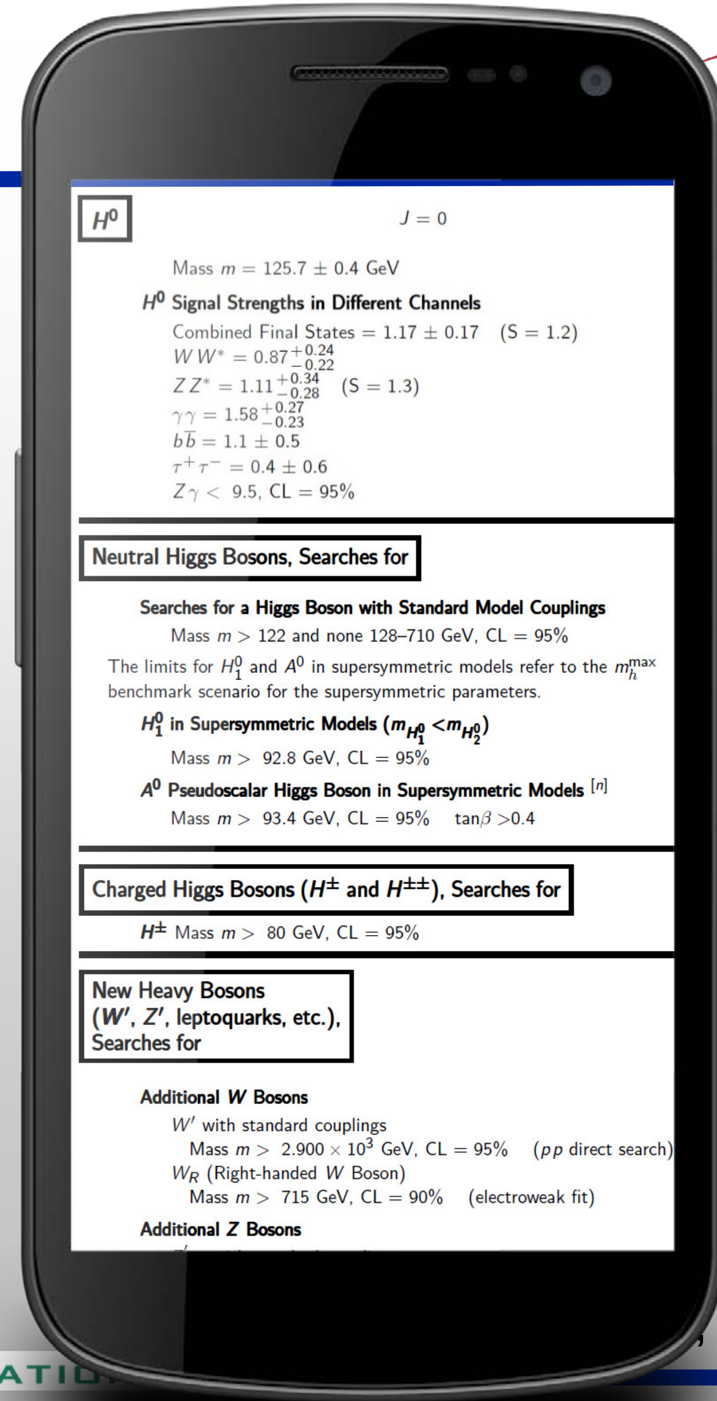
The entire book in your pocket.



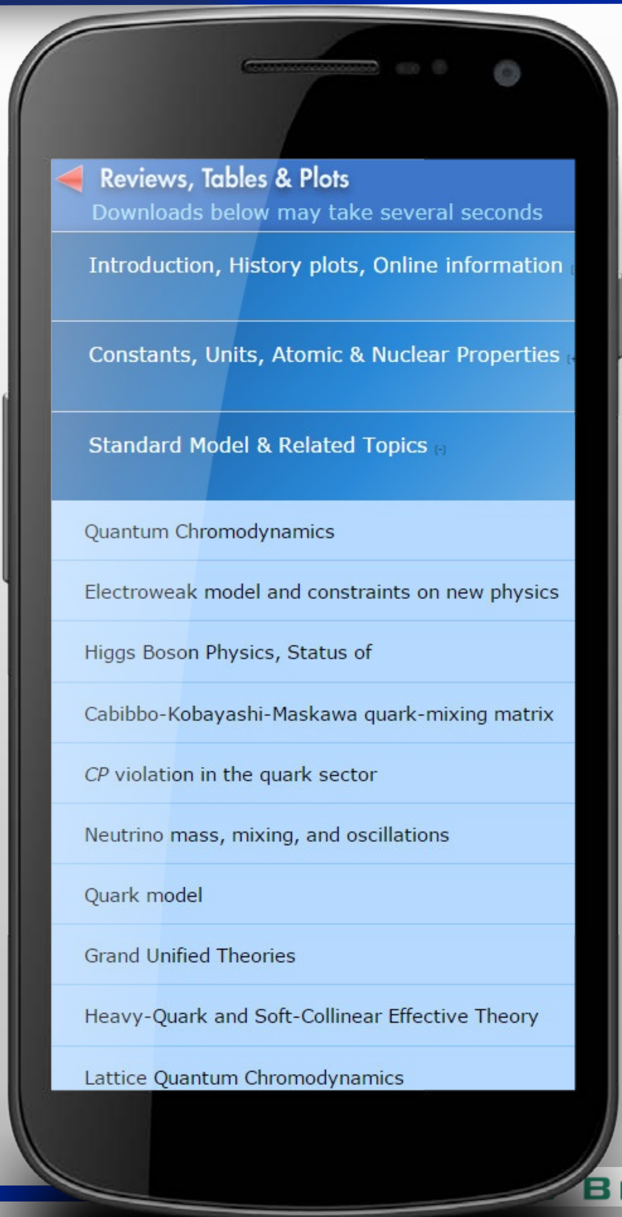
Click

Mobile Summary Tables

Click



Mobile Reviews



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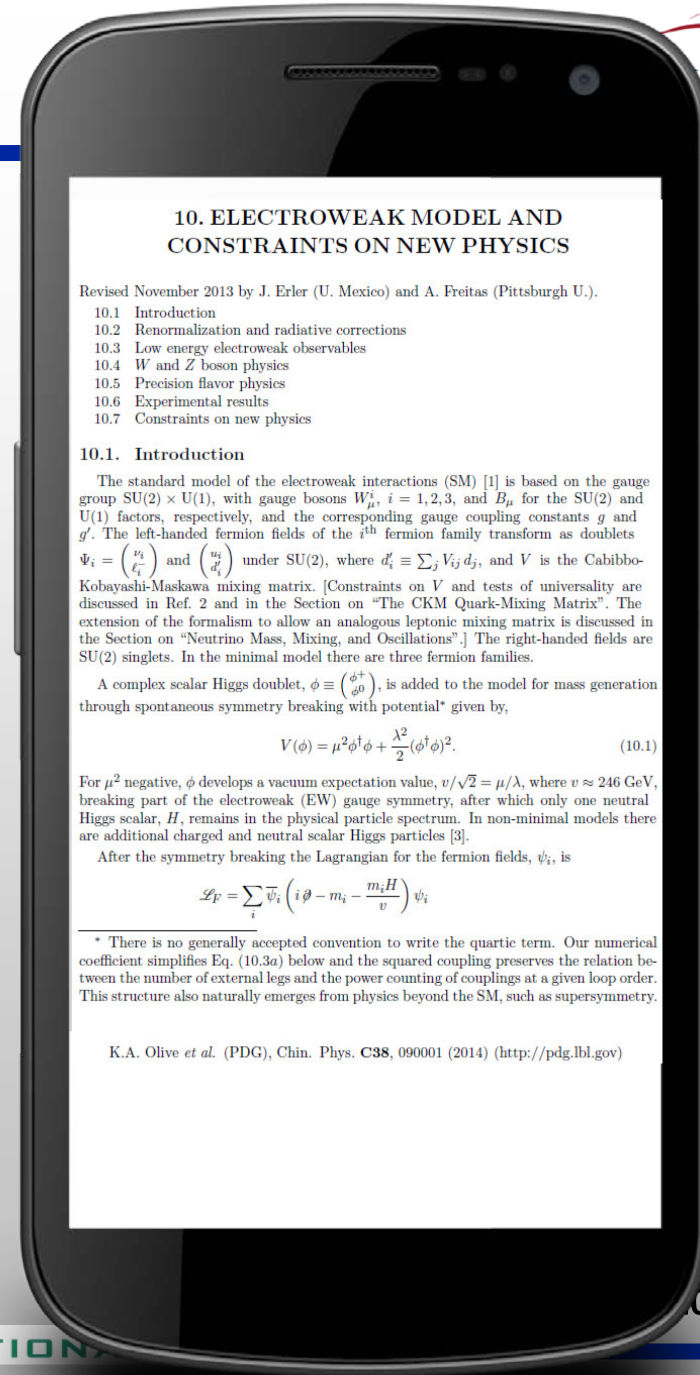


10. ELECTROWEAK MODEL AND CONSTRAINTS ON NEW PHYSICS

Revised November 2013 by J. Erler (U. Mexico) and A. Freitas (Pittsburgh U.).

10.1. Introduction

The standard model of the electroweak interactions (SM) [1] is based on the gauge group $SU(2) \times U(1)$, with gauge bosons W^i_μ, $i = 1,2,3$, and B_μ for the SU(2) and U(1) factors, respectively, and the corresponding gauge coupling constants g and g'. The left-handed fermion fields of the $i^{\rm th}$ fermion family transform as doublets $\Psi_i = \binom{\nu_i}{\ell^-_i}$ and $\binom{u_i}{d'_i}$ under SU(2), where $d'_i \equiv \sum_j V_{ij} d_j$, and V is the Cabibbo-Kobayashi-Maskawa mixing matrix. [Constraints on V and tests of universality are discussed in Ref. 2 and in the Section on "The CKM Quark-Mixing Matrix". The extension of the formalism to allow an analogous leptonic mixing matrix is discussed in the Section on "Neutrino Mass, Mixing, and Oscillations".] The right-handed fields are SU(2) singlets. In the minimal model there are three fermion families.

A complex scalar Higgs doublet, $\phi \equiv \binom{\phi^+}{\phi^0}$, is added to the model for mass generation through spontaneous symmetry breaking with potential* given by,

$$V(\phi) = \mu^2 \phi^\dagger \phi + \frac{\lambda^2}{2}(\phi^\dagger\phi)^2. \qquad (10.1)$$

For μ^2 negative, ϕ develops a vacuum expectation value, $v/\sqrt{2} = \mu/\lambda$, where $v \approx 246$ GeV, breaking part of the electroweak (EW) gauge symmetry, after which only one neutral Higgs scalar, H, remains in the physical particle spectrum. In non-minimal models there are additional charged and neutral scalar Higgs particles [3].

After the symmetry breaking the Lagrangian for the fermion fields, ψ_i, is

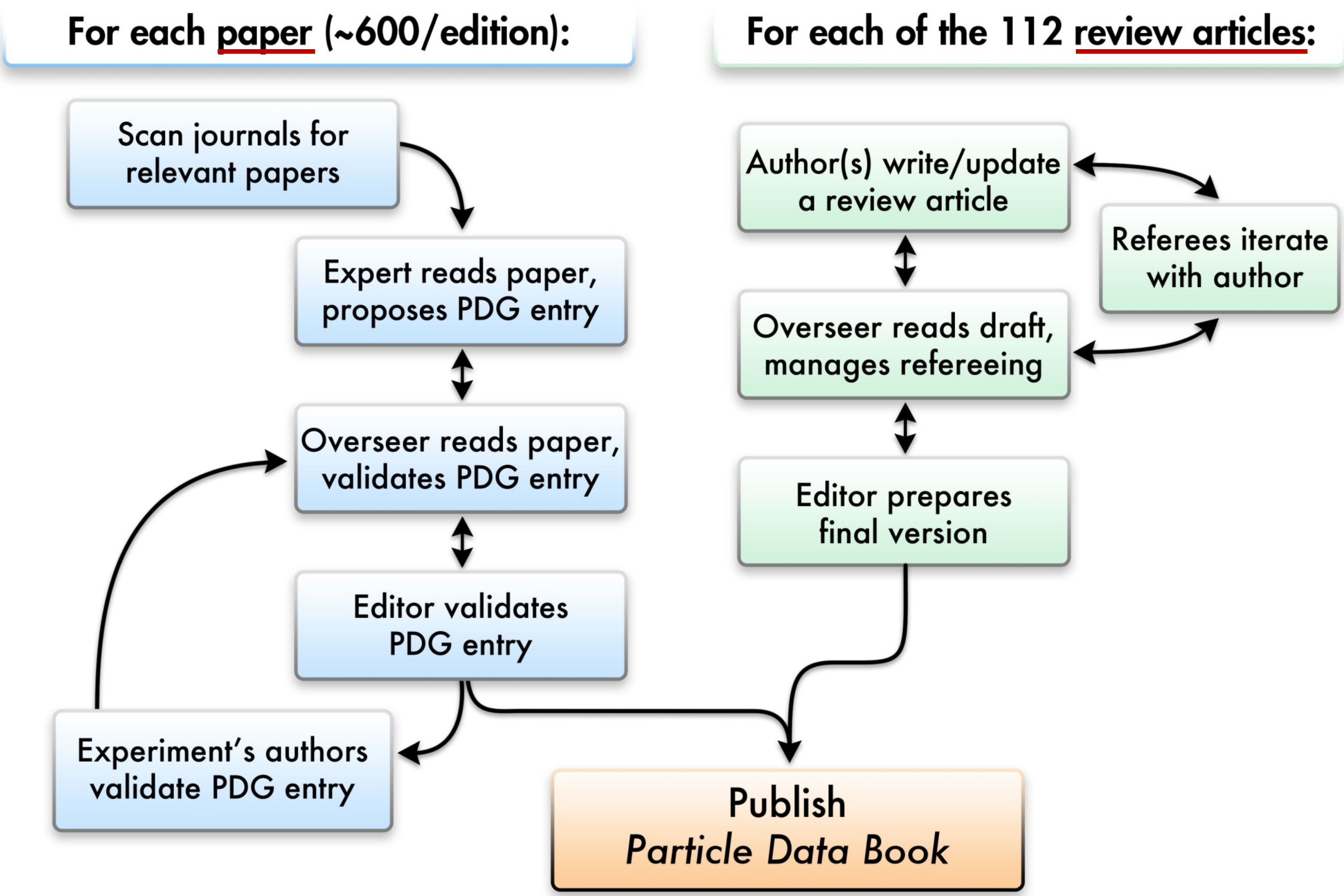
$$\mathscr{L}_F = \sum_i \overline{\psi}_i \left(i\partial\!\!\!/ - m_i - \frac{m_i H}{v} \right) \psi_i$$

* There is no generally accepted convention to write the quartic term. Our numerical coefficient simplifies Eq. (10.3a) below and the squared coupling preserves the relation between the number of external legs and the power counting of couplings at a given loop order. This structure also naturally emerges from physics beyond the SM, such as supersymmetry.

K.A. Olive *et al.* (PDG), Chin. Phys. **C38**, 090001 (2014) (http://pdg.lbl.gov)

The Process of Producing the Particle Data Book

PDG Workflow



Community Connections

PDG Advisory Committee

Collaboration with Working Groups

PDG Workshops

Periodic Surveys

Input from users

Via membership in research collaborations

Collaboration with Working Groups

Working groups:

LHC, Tevatron, B-factories,…

- **Higgs**
- **Electroweak fits,**
- **B lifetimes, B mixing,**
- **V_{cb} and V_{ub}**
- **top quark mass, etc.**

Provide fits to our data using PDG guidelines.

Vital PDG Workshops

With experts lead to improved coverage:

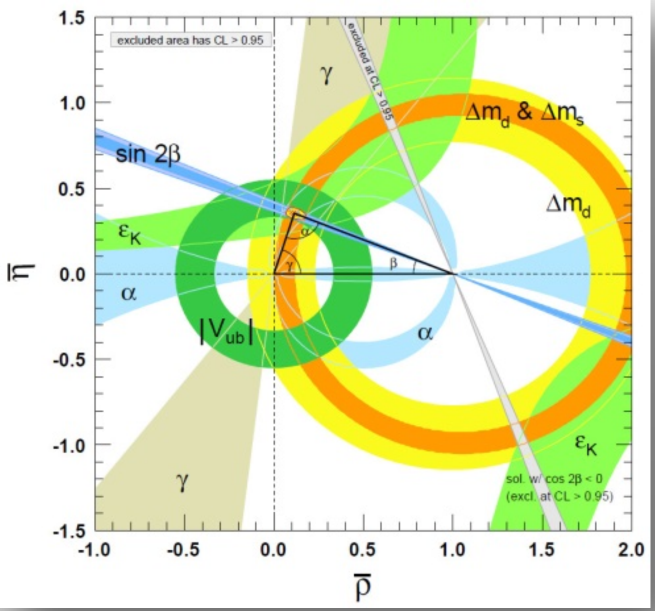
Searches

Higgs

Neutrino

D meson

CKM →



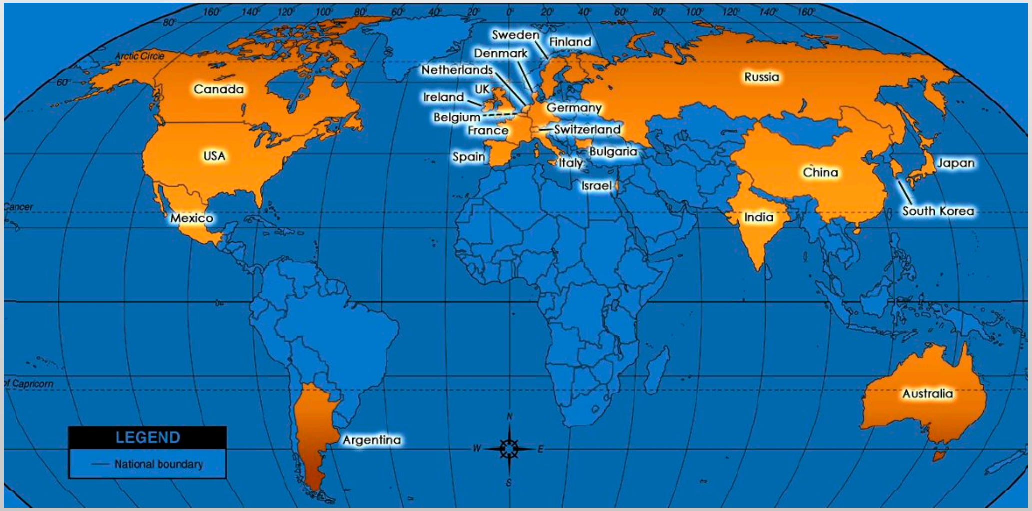
τ lepton

Extra-dimensions

Statistics

M. Barnett – February 24, 2016

Nature of PDG Collaboration



What is the PDG Collaboration?

PDG at LBNL (Central coordination, data evaluation, quality assurance, schedule control, and production)

3.5 FTE's (6 physicists: half research) + editor, programmer, etc.

PDG Collaborators outside of LBNL PDG

200 Physicists from 24 countries (volunteers at <5% level).

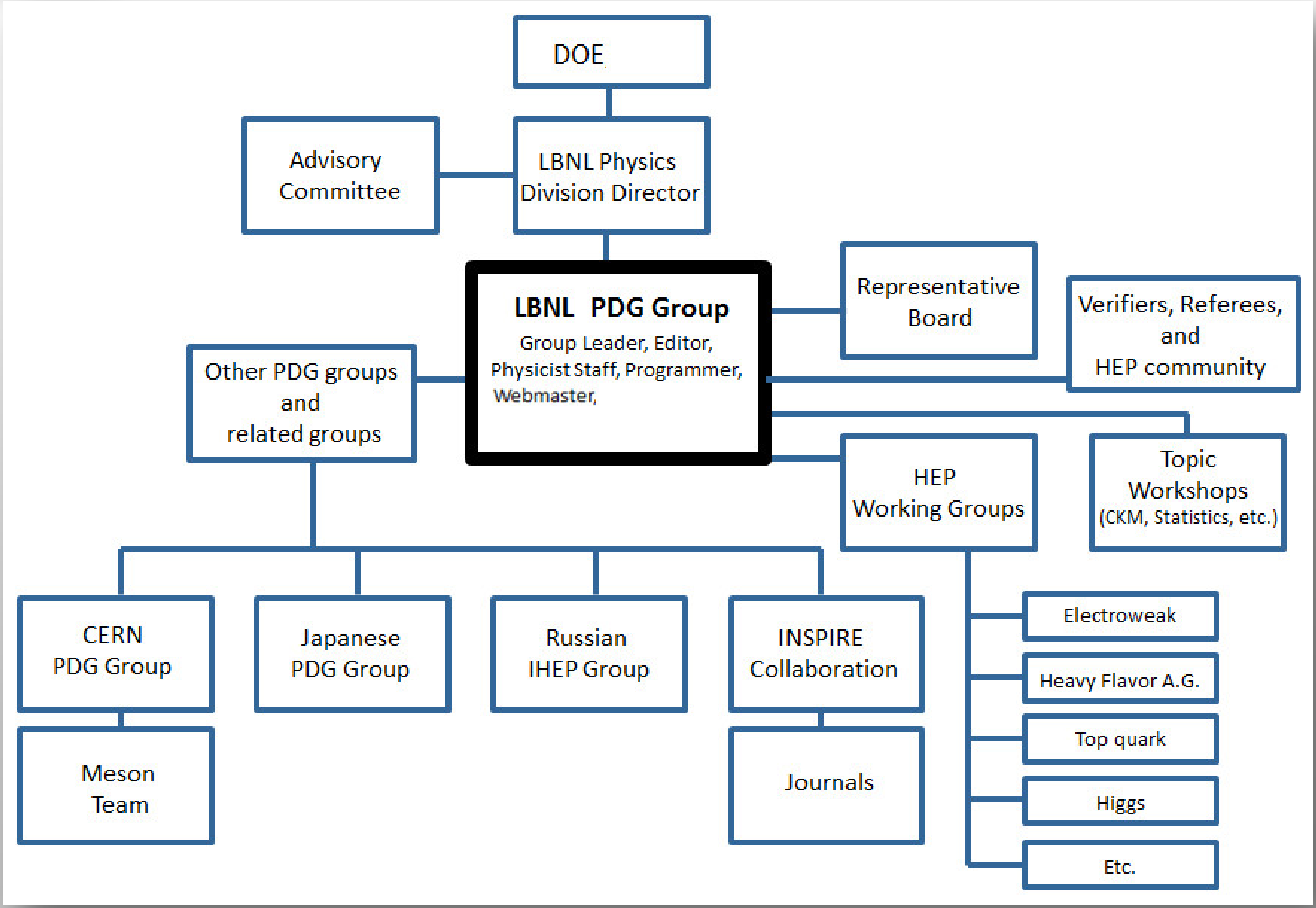
PDG Consultants – 700 physicists

- **Experiments' Physics Coordinators (etc.) – verifying data listings**
- **Referees of reviews (3-5 for each review)**
- **General consultants on content**

PDG Users: tens of thousands

Clearly this cannot work without vital central coordination.

PDG Chart
(much to coordinate)



Central Leadership

PDG leadership group at LBNL coordinates the entire effort

- **Produce and publish the Review (book, booklet, web, pdgLive)**
- **Data evaluation, all the final checking & editing**
- **Major contributor to the content**
- **Choose the authors and the content**
- **Maintain & drive the schedule**
- **Coordinate the input of 700 consultants from HEP community**

Essential for

- **High quality**
- **Timely publication**

Survey and the Future

PDG Survey in 2014

Is having a copy of the full-sized book essential to your work or study?

Is a Book without Data Listings OK? (45% as big)
(keeping online Data Listings)

How important is an app?

Similar questions were asked about the Booklet.

PDG Survey in 2014

An amazing 6172 readers responded, demonstrating the very high value our community places on PDG products (and 1495 comments).

The comments occupy 110 pages.

The book has been great (seriously, thanks!), but the age of ink marks on dead tree carcasses is over. Nevertheless, keep some hard copies around for after the next big solar flare....

I think the smartphone app is a great idea but I would hate to see it supplant the printed form.

PDG Survey on Book

- **68%** **want the book,**
  with or without the Data Listings

2/3 **said app was important or very important.**

82% **want the booklet**

Future of Book

Issues:

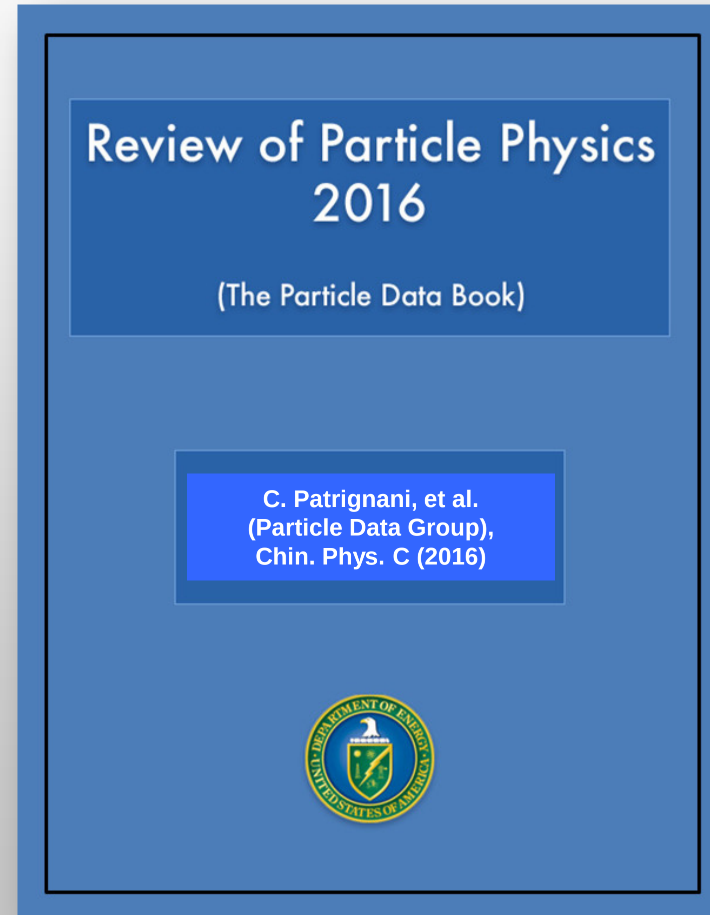
- **Declining budget makes full-size book too expensive.**
- **The book is too big and growing.**

Next book will have only:

Summary Tables and Reviews, but <u>no</u> Data Listings.

(Data Listings <u>remain</u> in journal article and online as PDF files and pdgLive.)

Reduces size to about 45%



Future Developments
(budget allowing)

Future Possibilities

- Downloadable PDG data
- pdgLive version for offline use (as an app)
- Emphasis on searching and indexing, rather than navigation
- Interactive plotting, data selection and evaluation
- User tagging or display of contributed content
- Cross-linking with other services (pdgLive ↔ INSPIRE available)

Implementing these new features is a long-term effort given our declining resources

PDG App (no Internet)

- ***Summary Tables***

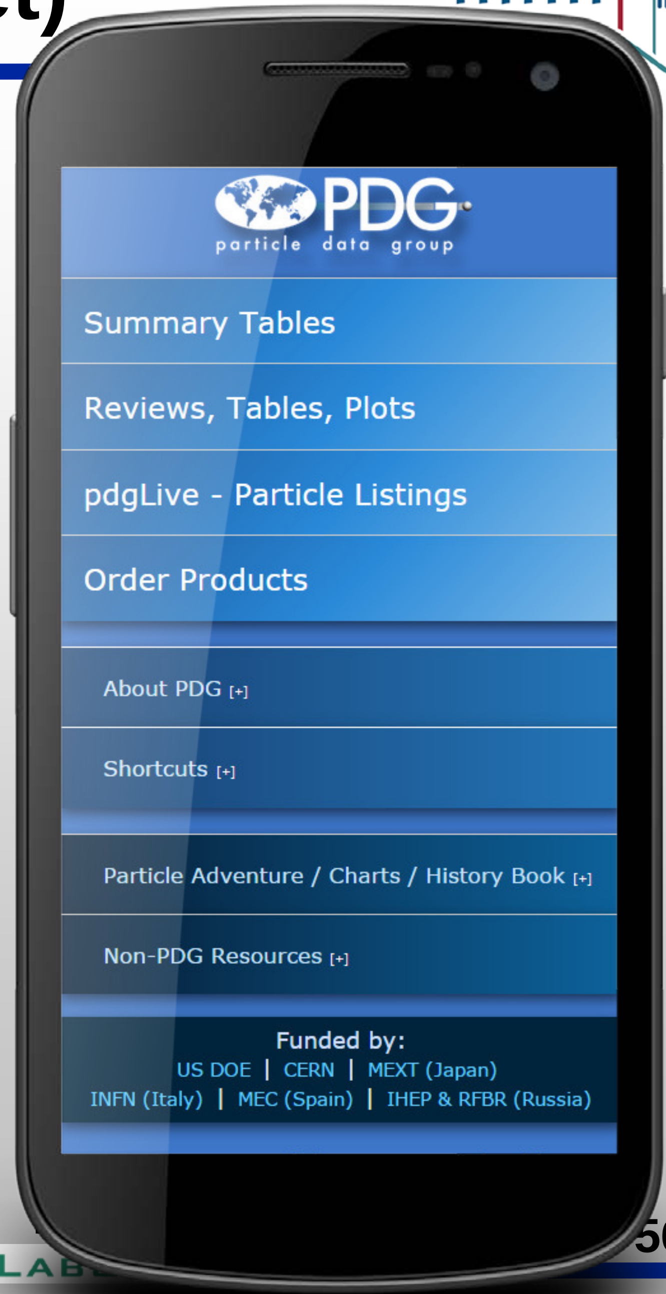
  Basically easy;
  just formatting for readability

- ***Review articles***

  Even easier

- ***pdgLive***

  Not easy. Major programming to develop exportable database and to present on-the-fly.



Downloadable PDG Data

- **Make complete PDG data available in machine-readable format**
  (including especially branching fractions)
  - PDG production database not suitable for distribution

- Particle masses, widths and MC ID numbers have been available for many years
  - http://pdg.lbl.gov/2015/mcdata/mass_width_2015.mcd

Future Developments

Require substantial efforts and therefore budget, and are not possible in current declining funding.

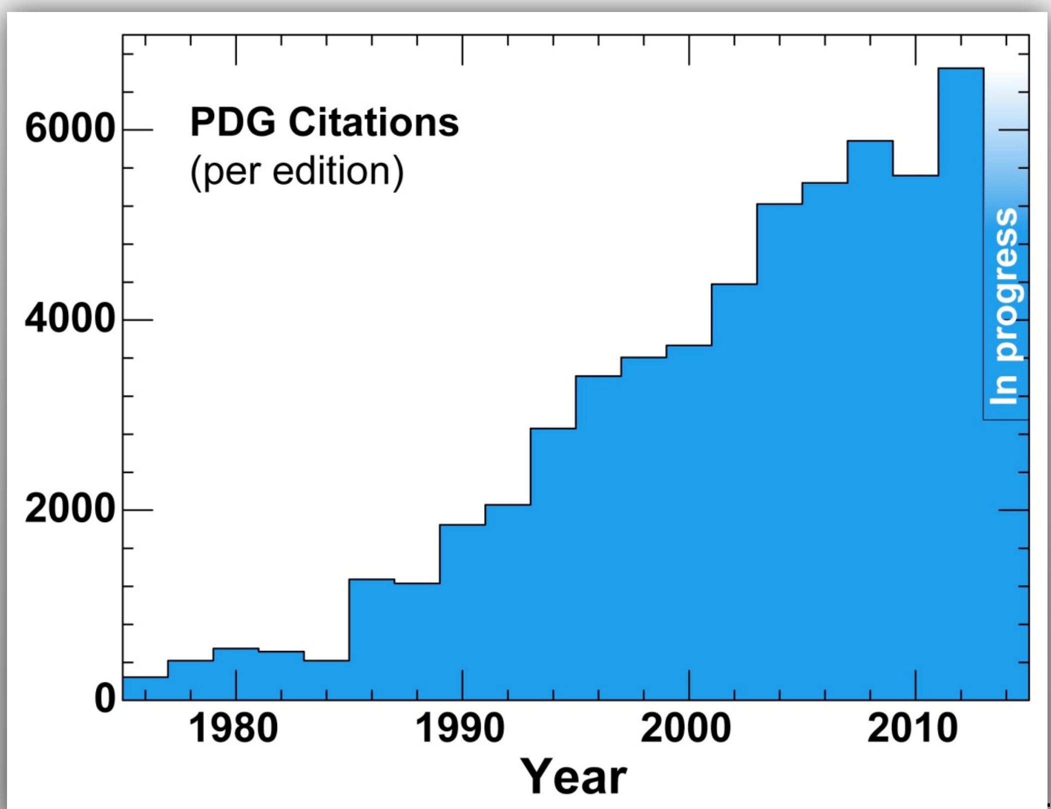
PDG Impact

PDG Impact

- 32,000 Booklets requested
- 14,000 RPP books requested
- 9 million hits/year on website (>180 countries)
- 108 million hits on website in total
- 56,000 combined citations of RPP
- Most cited publication in HEP

Top Cited

The Review is the all-time top cited article in High Energy Physics with more than 56,000 citations (INSPIRE)



Citations increase for years after an edition is published

PDG Summary

PDG provides a vital, dynamic, innovative service.
It leverages the work of all the HEP community.

The HEP community depends on PDG to provide standards and to assure integrity and quality in summarizing particle physics.

Your support has been vital to PDG success for the past 58 years. Thank you.

FROM THE PARTICLE DATA GROUP TO FERMILAB FOR THE DISCOVERY OF THE b QUARK AND t QUARK

1978 PDG Book
First edition with b quark discovery

$\Upsilon_1(9410)$

```
49   UPSILON1(9410,JPG=1- ) I=
------ --------- --------- --------- --------- --------- --------- --------

                 49  UPSILON1 MASS (MEV)
M  I      9410.      13.        INNES      77 SPEC   0 400 P+A,MU+MU-
M  I    FROM 2-PEAK FIT
------ --------- --------- --------- --------- --------- --------- --------

                 49  UPSILON1 WIDTH (GEV)

W  A      (100.)    OR LESS     INNES      77 SPEC   0 400 P+A,MU+MU-
W  A    FROM QUOTED RESOLUTION
------ --------- --------- --------- --------- --------- --------- --------
                 49  UPSILON1 PARTIAL DECAY MODES

                                                        DECAY MASSES
P1      UPSILON1  INTO MU+ MU-                       105+ 105
P2      UPSILON1  INTO E+ E-                          .5+  .5
------ --------- --------- --------- --------- --------- --------- --------

                 49  UPSILON1 BRANCHING RATIOS

R1      UPSILON1  INTO MU+ MU-                    (P1)
R1          SEEN                HERB       77

R2      UPSILON1  INTO E+ E-                      (P2)
R2          SEEN                COBB       77

****** ********* ********* ********* ********* ********* ********* ********

                     REFERENCES FOR UPSILON1(9410)

COBB      77 PL                 +IWATA,FABJAN,GOLDBERG+(BNL+CERN+SYRA+YALE)
HERB      77 PRL  39 252        +HOM,LEDERMAN,APPEL,ITO,+   (COLU+FNAL+STON)
INNES     77 PRL  39 1240       +APPEL,BROWN,HERB,HOM,FISK+(COLU+FNAL+STON)

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1996 PDG Book
First edition with t quark discovery

t-Quark Mass in $p\overline{p}$ Collisions

The t quark has now been observed. Its mass is sufficiently high that decay is expected to occur before hadronization.

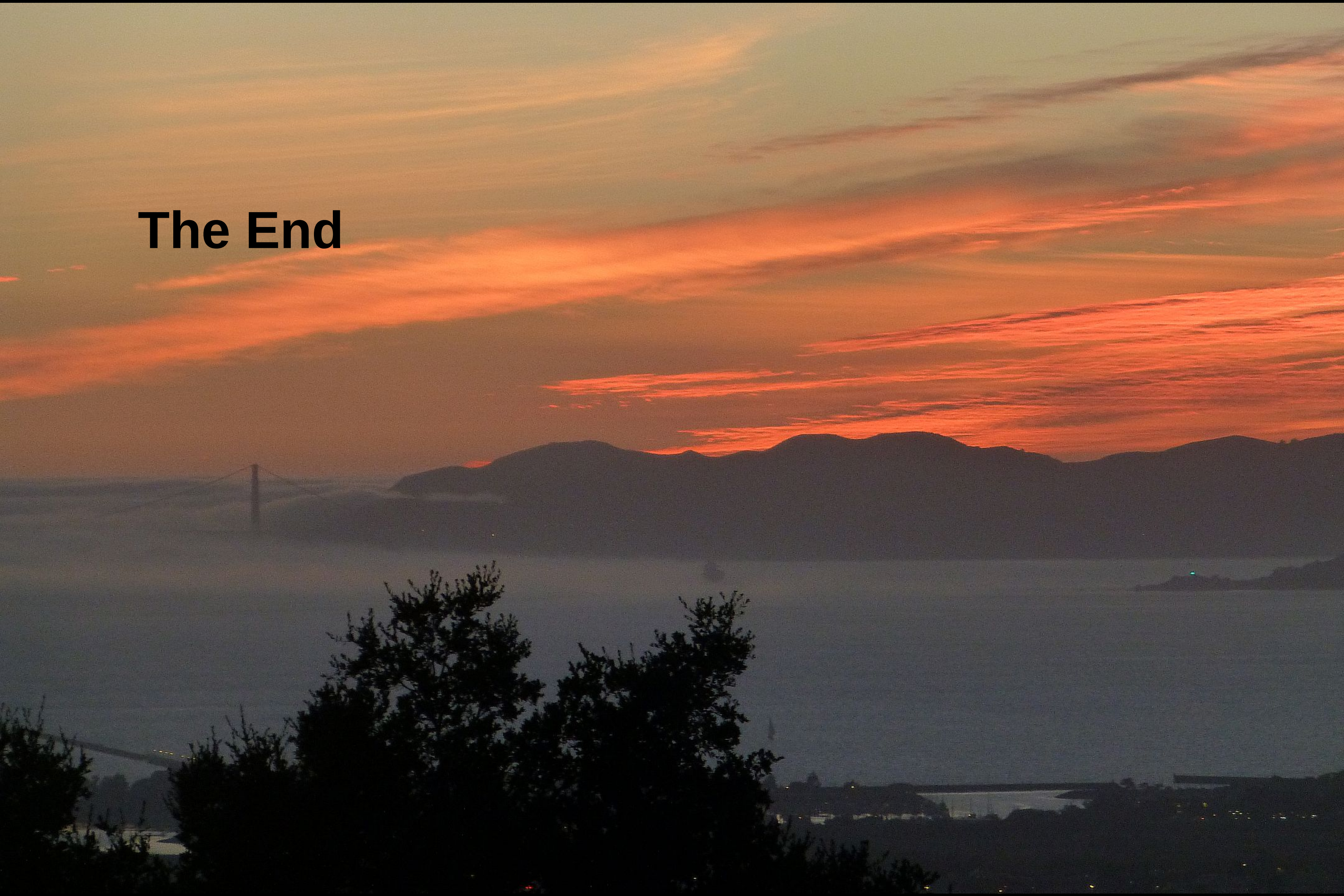
Preliminary results for the top mass based on the full (Run Ia+Ib) data set have been presented by CDF and DØ at conferences in early 1996:

$m_t = 175.6 \pm 5.7 \pm 7.1$ GeV	CDF	lepton + jets
$m_t = 159^{+24}_{-22} \pm 17$ GeV	CDF	dilepton
$m_t = 187 \pm 8 \pm 12$ GeV	CDF	hadronic
$m_t = 170 \pm 15 \pm 10$ GeV	DØ	lepton + jets
$m_t = 158 \pm 24 \pm 10$ GeV	DØ	$e\mu$

Because of the high current interest, we mention these preliminary results here but do not average them or include them in the Listings or Tables. See the note on the top quark for references.

Search limits, which are now primarily of historical interest, are based on the assumption that no nonstandard decay modes such as $t \to bH^+$ are available, except as noted in the comments.

VALUE (GeV)	CL%	DOCUMENT ID		TECN	COMMENT
180±12 OUR AVERAGE					
$199^{+19}_{-21} \pm 22$		[1] ABACHI	95	D0	ℓ + jet
$176 \pm 8 \pm 10$		[2] ABE	95F	CDF	ℓ + b-jet
• • • We do not use the following data for averages, fits, limits, etc. • • •					
		[3] ABACHI	95B	D0	$\ell\ell$ + jets, ℓ + jets
>128	95	[4] ABACHI	95F	D0	$\ell\ell$ + jets, ℓ + jets
		[5] ABE	95O	CDF	
		[6] ABE	95V	CDF	


The End

Downloadable PDG Data

- **Machine-readable table** of particle masses, widths and MC ID numbers has been available for many years
  - http://pdg.lbl.gov/2015/mcdata/mass_width_2015.mcd
- **Would like to make complete PDG data available** in machine-readable format (including especially branching fractions)
  - PDG production database not suitable for distribution
  - Trying to find resources to develop a downloadable database that provides easy access to the evaluated PDG data
    - Also the first step towards allowing us to build the PDG app
  - A Python-based API that can be used to extract all PDG data from a database hosted by PDG will likely be an intermediate step
    - Same API can later be used with downloadable database

Towards a PDG App

- **Goals for the PDG App (no Internet)**
  - Interactive access to Listings (“pdgLive”) plus all review articles
  - Optimal presentation on device (screen size and resolution)
  - Fully functioning without Internet access (on a plane, train, …)
- **To function without Internet access one needs**
  - All relevant PDG data stored in database **on the device**
  - Database optimized for fast retrieval of the data to be presented
    - Rather than optimized for PDG data evaluation, as is the case for the master PDG database
    - Limited resources (CPU, RAM) on device do not allow full processing done by pdgLive (i.e. cannot simply copy PDG database onto device)
    - To minimize processing in app, database should contain preprocessed “snippets” of information (e.g. HTML for a full line in the summary table)
  - Review articles in HTML (allows dynamic rendering by the device's web browser), or in a format tailored to screen size and resolution

Implementing a PDG App

- **Two main approaches for app implementation**
  - Native app
    - Most flexible, but also most development effort
    - Need to develop separate app for Android, iOS, …
      - Tools such as cross-compilers exist to help with this
    - How to display symbols and equations?
  - Web-based app
    - App runs essentially in the device's browser
    - Leverages work done for mobile PDG site
    - Need to develop backend web application server that will run on the device and generate or retrieve relevant pages using a local database
    - Need to have MathJax libraries installed on the device for displaying symbols and equations
- Some approaches and app development tools combine elements from both of the above
- **Substantial development effort for PDG app in all approaches**

PDG Advisory Committee

“The PDG is already operating at a very efficient level, which is how they have managed to expand the coverage into the field of cosmology and particle astrophysics while still maintaining the high standards in the rest of particle physics.

“This efficiency comes from several advances:

- **the new software infrastructure that allows for more authors to enter data themselves,**
- **the fact that the PDG works in concert with experimental working groups when appropriate, and**
- **the fact that the PDG has been able to coax some 200 authors to contribute and a total of 700 physicists worldwide to provide input through the peer review process.**

“The quality of the work that the PDG represents is part of what makes people want to provide input to the PDG process.”

Quotes

- "Several reviewers remarked that HEP would be a qualitatively weaker field if the PDG were not there as a current, growing resource."

  DOE S&T review of LBNL

- "This review is used by people at all levels in the both theory and experiment, and the committee frankly cannot imagine the field without the compilation that is embodied in the RPP.

  "The importance of this work can not be overstated."

  PDG Advisory Committee