



	Pages	per kg
← RPP08: 1339 pages 2.3 kg	580	
← RPP06: 1231 pages 2.5 kg	490	
← RPP04: 1109 pages 1.65 kg	670	
← RPP02: 974 pages 1.5 kg	650	
← RPP00: 878 pages 1.7 kg	520	
← RPP98: 794 pages 1.5 kg	530	

# Particle Data Group



October 2008

# US Department of Energy (DOE) Review of PDG on September 12 (all day) in Washington DC

Never done before, but a new administration in DOE-HEP, and they want to review all programs. It was triggered by our request for substantial funds for a major computing upgrade, but the review was of the entire PDG program. Many slides taken from that.

# Significance and Relevance of the PDG to HEP





**Particle Data Group collaboration  
of 170 authors  
from 20 countries and 108 institutions  
+ 700 consultants in the HEP community**



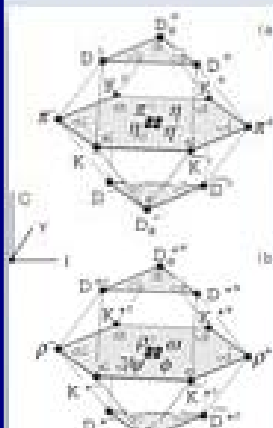
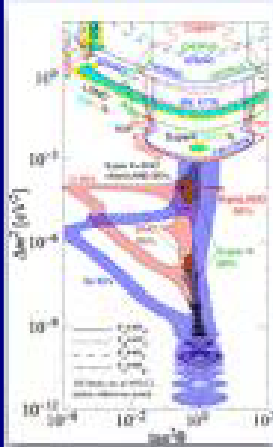
M. Barnett – October 2008

## PDG 50th ANNIVERSARY FESTIVITIES

Date: Saturday, September 23, 2006

Location: Lawrence Berkeley National Laboratory  
 Building 50 Auditorium

Also celebrating  
 75th birthday of Matts Roos  
 80th birthday of Art Rosenfeld



### PROGRAM

- Art Rosenfeld** - PDG History
- Matts Roos** - Meson Team History
- Chris Quigg** - Standard Model Theory
- Michael Riordan** - Toward the Standard Model
- Hiroaki Aihara** - B Physics
- Boris Kayser** - Neutrinos
- Lina Galtieri** - Top Quark
- Michael Turner** - Cosmology
- John Ellis** - Searches for New physics
- Michelangelo Mangano** - LHC and its Impact on PDG
- Michael Barnett** - Summary
- Banquet

**645** new papers with **2778** measurements

**108** Reviews written or edited by PDG

**RPP: 1344 pages** (in 2008)

**Booklet: 320 pages** (in 2006)



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

The hits on

Data Listings = Reviews

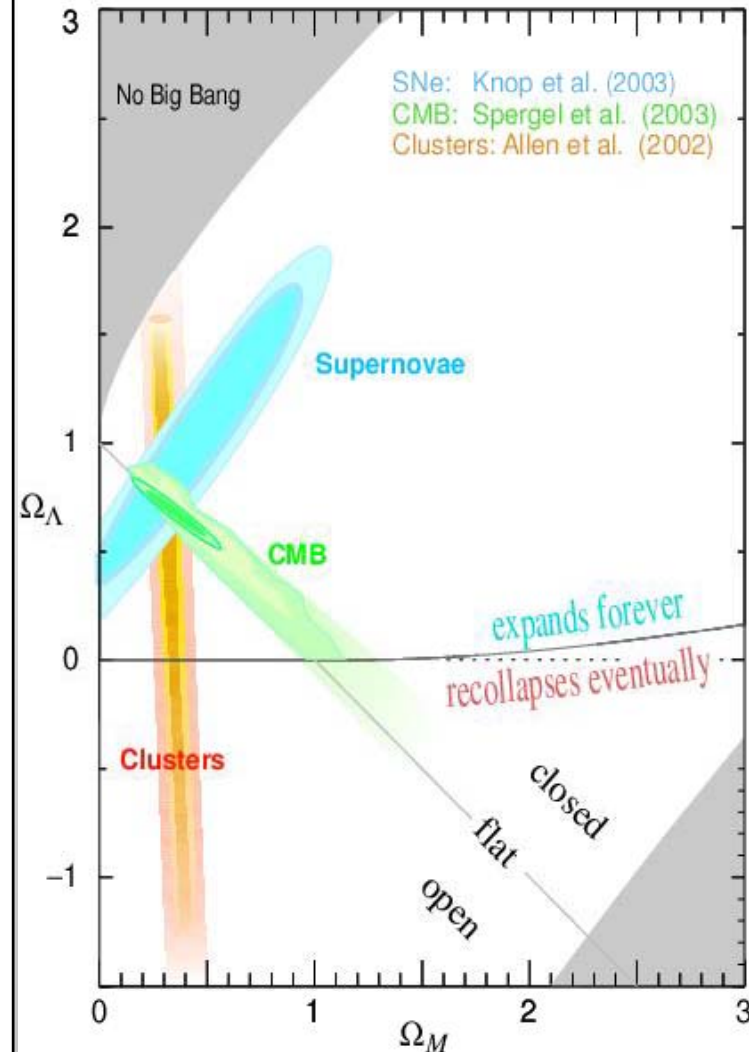
almost exactly equal.

Clearly people care about both.

**10 years ago:** Very little

**Now:**

**Astrophysical Constants**  
**Big Bang Cosmology**  
**Cosmological Parameters:**  
 $H_0$ ,  $\Lambda$ ,  $\Omega$ , etc.  
**Experimental Tests of**  
**Gravitational Theory**  
**Dark Matter**  
**Cosmic Background Radiation**  
**Cosmic Rays**



M. Barnett – October 2008

# B Meson Section 1984

Entire section was one page

**B<sup>±</sup>, B<sup>0</sup>, B**

**B<sup>±</sup>**

41 CHARGED B(5271, JP= ) I=

SEE ALSO THE LISTING FOR THE B (FOLLOWING THE ENTRY FOR THE NEUTRAL B) FOR MEASUREMENTS WHICH DO NOT IDENTIFY THE CHARGE STATE.

---

41 CHARGED B MASS (MEV)

M	A	6	5270.8	3.0	BEHREND	83	CLEO +- D*0- PI+ PI+ + CC	4/83*
M	A						STATISTICAL (2.3 MEV) AND SYSTEMATICAL (2.0 MEV) ERRORS COMBINED.	4/83*

---

41 CHARGED B PARTIAL DECAY MODES

P1	B+ INTO DOBAR PI+	DECAY MASSES
P2	B+ INTO D*(2010)- PI+ PI+	1865+ 140
		2007+ 140+ 140

B- MODES ARE CHARGE CONJUGATES OF THE ABOVE MODES.

---

41 CHARGED B BRANCHING RATIOS

R1	B+ INTO DOBAR PI+	(P1)	
R1	2	0.042	0.042
			BEHREND 83 CLEO +- E+ E-, UPSIL(4S) 4/83*
R2	B+ INTO D*(2010)- PI+ PI+	(P2)	
R2	6	0.048	0.030
			BEHREND 83 CLEO +- E+ E-, UPSIL(4S) 4/83*

\*\*\*\*\*

REFERENCES FOR CHARGED B

BEHREND 83 PRL 50 881 + (ROCH+RUTG+SYRA+VAND+CORN+ITHA+HARV+OSU)

\*\*\*\*\*

**B<sup>0</sup>**

42 NEUTRAL B(5274, JP= ) I=

SEE ALSO THE LISTING FOR THE B (FOLLOWING THIS ENTRY) FOR MEASUREMENTS WHICH DO NOT IDENTIFY THE CHARGE STATE.

---

42 NEUTRAL B MASS (MEV)

M	A	5	5274.2	2.8	BEHREND	83	CLEO 0 D*0- PI+ + CC	4/83*
M	A						STATISTICAL (1.9 MEV) AND SYSTEMATICAL (2.0 MEV) ERRORS COMBINED.	4/83*

---

42 (B0) - (B+) MASS DIFFERENCE (MEV)

DM	A	3.4	3.6	BEHREND	83	CLEO E+E-, UPSIL(4S)	3/84*	
DM	A						STATISTICAL (3.0) AND SYSTEMATICAL (2.0) ERRORS COMBINED.	3/84*

---

39 B PARTIAL DECAY M

P1	B INTO ELECTRON NEUTRINO HADRONS
P2	B INTO MUON NEUTRINO HADRONS
P3	B INTO E+ E- ANYTHING
P4	B INTO MU+ MU- ANYTHING
P5	B INTO KAON ANYTHING
P6	B INTO J/PSI ANYTHING
P7	B INTO D0 ANYTHING
P8	B INTO PROTON ANYTHING
P9	B INTO LAMBDA ANYTHING

---

39 B BRANCHING RATIO

R1	B INTO (ELECTRON NEUTRINO HADRONS)
R1	A (0.13) (0.042) BEB
R1	B (0.136) (0.039) SPE
R1	C 0.127 0.021 CHA
R1	D 0.132 0.016 KLO
R1	E (0.116) (0.027) NEL
R1	A THE STATISTICAL AND SYSTEMATIC ER
R1	B THE STATISTICAL AND SYSTEMATIC ER
R1	AB THE ELECTRON ENERGY SPECTRA IN BO
R1	AB B-TO-C OVER B-TO-U QUARK TRANSITI
R1	C THE STATISTICAL AND SYSTEMATIC ER
R1	D STATISTICAL AND SYSTEMATIC ERRORS
R1	E THE STATISTICAL AND SYSTEMATIC ER
R1	ONLY THE EXPERIMENTS AT THE UPSIL
R1	AVG 0.130 0.013 AVERAGE
R2	B INTO (MUON NEUTRINO HADRONS)/TOT
R2	A (0.094) (0.036) CHA
R2	B (0.105) (0.020) ADE
R2	C 0.124 0.035 CHA
R2	D (0.155) (0.054) (0.029) FER
R2	E (0.117) (0.028) ALT
R2	A THE STATISTICAL AND SYSTEMATIC ER
R2	B THE STATISTICAL AND SYSTEMATIC ER
R2	THE AVERAGE OF THE THREE HIGH-ENE
R2	THESE EXPERIMENTS PRODUCE OTHER B
R2	THE B MESON.
R3	B INTO (E+ E- ANYTHING)/TOTAL
R3	(0.05) OR LESS CL=.90 BEB
R4	B INTO (MU+ MU- ANYTHING)/TOTAL
R4	(0.017)OR LESS CL=.90 CHA
R4	0.007 OR LESS CL=.95 ADE
R4	0.007 OR LESS CL=.95 BAR
R4	(0.02) OR LESS CL=.95 ALT
R5	B INTO (DILEPTON ANYTHING)

Section  
is 144  
pages

## BOTTOM, CHARMED MESONS ( $B = C = \pm 1$ )

$$B_C^+ = c\bar{b}, B_C^- = \bar{c}b, \text{ similarly for } B_C^{*'}\text{'s}$$



$$I(J^P) = 0(0^-)$$

$I, J, P$  need confirmation.

Quantum numbers shown are quark-model predictions.

### $B_C^\pm$ MASS

VALUE (GeV)	DOCUMENT ID	TECN	COMMENT
<b>6.276 ± 0.004 OUR AVERAGE</b>			
6.2756 ± 0.0029 ± 0.0025	<sup>1</sup> AALTONEN 08M	CDF	$p\bar{p}$ at 1.96 TeV
6.4 ± 0.39 ± 0.13	<sup>2</sup> ABE 98M	CDF	$p\bar{p}$ at 1.8 TeV
6.2857 ± 0.0053 ± 0.0012	<sup>1</sup> ABULENCIA 06C	CDF	Repl. by AALTONEN 08M
6.32 ± 0.06	<sup>3</sup> ACKERSTAFF 980	OPAL	$e^+e^- \rightarrow Z$

<sup>1</sup>Measured using a fully reconstructed decay mode of  $B_C \rightarrow J/\psi \pi$ .

<sup>2</sup>ABE 98M observed  $20.4^{+6.2}_{-5.5}$  events in the  $B_C^+ \rightarrow J/\psi(1S) \ell \nu_\ell$  with a significance of  $> 4.8$  standard deviations. The mass value is estimated from  $m(J/\psi(1S) \ell)$ .

<sup>3</sup>ACKERSTAFF 980 observed 2 candidate events in the  $B_C \rightarrow J/\psi(1S) \pi^+$  channel with an estimated background of  $0.63 \pm 0.20$  events.

### $B_C^\pm$ MEAN LIFE

VALUE ( $10^{-12}$ s)	DOCUMENT ID	TECN	COMMENT
<b>0.46 ± 0.07 OUR AVERAGE</b>			
$0.463^{+0.073}_{-0.065} \pm 0.036$	<sup>4</sup> ABULENCIA 060	CDF	$p\bar{p}$ at 1.96 TeV
$0.46^{+0.18}_{-0.16} \pm 0.03$	<sup>4</sup> ABE 98M	CDF	$p\bar{p}$ 1.8 TeV

<sup>4</sup>The lifetime is measured from the  $J/\psi(1S) e$  decay vertices.

### $\Gamma(J/\psi(1S)\pi^+)/\Gamma_{\text{total}} \times B(\bar{b} \rightarrow B_C)$

VALUE	CL%	DOCUMENT ID	TECN	CL
<b>&lt; 8.2 × 10<sup>-5</sup></b>	90	<sup>9</sup> BARATE	97H	ALEP e
• • • We do not use the following data for averages, fits, limits, etc				
< 2.4 × 10 <sup>-4</sup>	90	<sup>10</sup> ACKERSTAFF	980	OPAL e
< 3.4 × 10 <sup>-4</sup>	90	<sup>11</sup> ABREU	97E	DLPH e
< 2.0 × 10 <sup>-5</sup>	95	<sup>12</sup> ABE	96R	CDF $\mu$

<sup>9</sup>BARATE 97H reports  $B(Z \rightarrow B_C X)/B(Z \rightarrow qq) \cdot B(B_C^+ \rightarrow J/\psi(1S) \pi^+) < 0.053$  at 90%CL. We rescale to our PDG 96 values of  $B(Z \rightarrow b\bar{b})$ .

<sup>10</sup>ACKERSTAFF 980 reports  $B(Z \rightarrow B_C X)/B(Z \rightarrow qq) \times B(B_C^+ \rightarrow J/\psi(1S) \pi^+) < 1.06 \times 10^{-4}$  at 90%CL. We rescale to our PDG 98 values of  $B(Z \rightarrow b\bar{b})$ .

<sup>11</sup>ABREU 97E value listed is for an assumed  $\tau_{B_C} = 0.4$  ps and  $\text{imp} \tau_{B_C} = 1.4$  ps.

<sup>12</sup>ABE 96R reports  $B(b \rightarrow B_C X)/B(b \rightarrow B^+ X) \cdot B(B_C^+ \rightarrow J/\psi(1S) \pi^+) < 0.053$  at 95%CL for  $\tau_{B_C} = 0.8$  ps. It changes to  $0.17 \text{ ps} < \tau_{B_C} < 1.6 \text{ ps}$ . We rescale to our PDG 96 values of  $B(b \rightarrow b\bar{b})$  and  $B(B^+ \rightarrow J/\psi(1S) \pi^+) = 0.00101 \pm 0.00014$ .

### $\Gamma(J/\psi(1S)\pi^+\pi^+\pi^-)/\Gamma_{\text{total}} \times B(\bar{b} \rightarrow B_C)$

VALUE	CL%	DOCUMENT ID	TECN	CL
<b>&lt; 5.7 × 10<sup>-4</sup></b>	90	<sup>13</sup> ABREU	97E	DLPH e

<sup>13</sup>ABREU 97E value listed is independent of  $0.4 \text{ ps} < \tau_{B_C} < 1.4 \text{ ps}$ .

### $\Gamma(J/\psi(1S)a_1(1260))/\Gamma_{\text{total}} \times B(\bar{b} \rightarrow B_C)$

VALUE	CL%	DOCUMENT ID	TECN	CL
<b>&lt; 1.2 × 10<sup>-3</sup></b>	90	<sup>14</sup> ACKERSTAFF	980	OPAL e

<sup>14</sup>ACKERSTAFF 980 reports  $B(Z \rightarrow B_C X)/B(Z \rightarrow qq) \times B(B_C^+ \rightarrow J/\psi(1S) a_1(1260)) < 5.29 \times 10^{-4}$  at 90%CL. We rescale to our PDG 98 values of  $B(Z \rightarrow b\bar{b})$ .

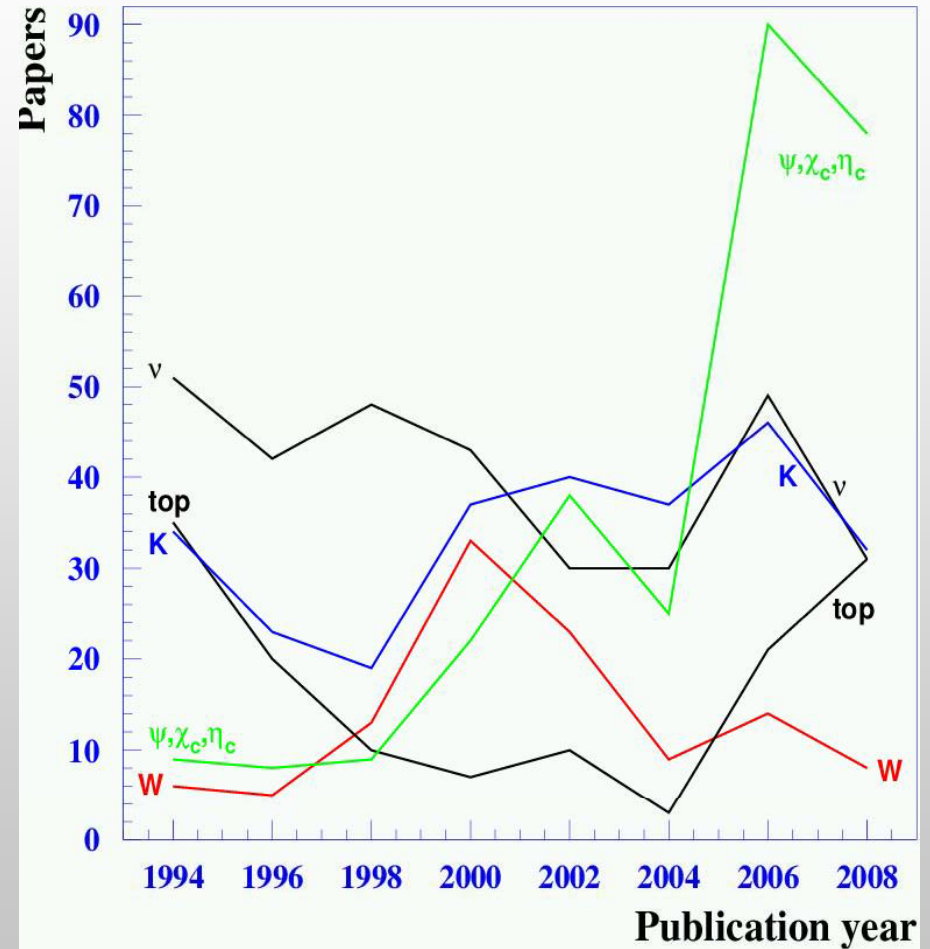
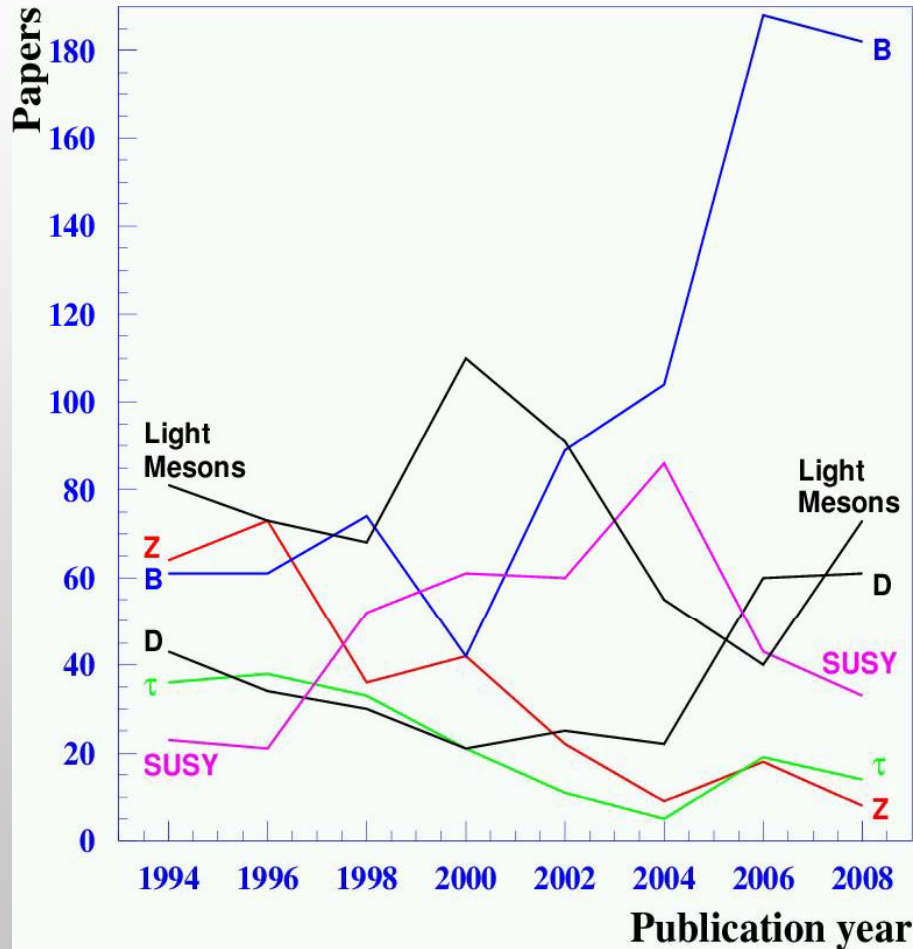
### $\Gamma(D^*(2010)^+\bar{D}^0)/\Gamma_{\text{total}} \times B(\bar{b} \rightarrow B_C)$

VALUE	CL%	DOCUMENT ID	TECN	CL
<b>&lt; 6.2 × 10<sup>-3</sup></b>	90	<sup>15</sup> BARATE	98Q	ALEP e

<sup>15</sup>BARATE 98Q reports  $B(Z \rightarrow B_C X) \times B(B_C^+ \rightarrow D^*(2010)^+\bar{D}^0) < 90\%$ CL. We rescale to our PDG 98 values of  $B(Z \rightarrow b\bar{b})$ .



## 186/182 B papers in 2006/2008 editions



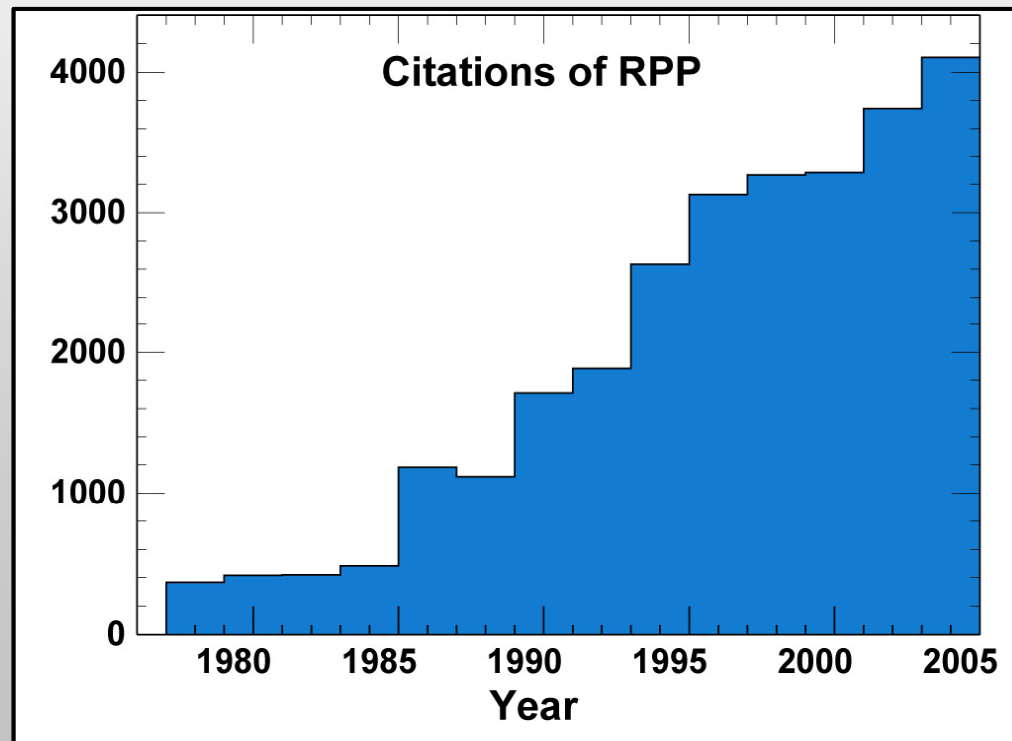
Notice different vertical scales

<u>Papers</u>	<u>2004</u>	<u>2006</u>	<u>2008</u>	<u>Measurements</u>	<u>2004</u>	<u>2006</u>	<u>2008</u>
W Boson	8	14	8	W Boson	12	39	18
Z Boson	9	18	8	Z Boson	19	32	11
$\tau$ Lepton	5	19	14	$\tau$ lepton	15	82	77
Neutrinos and mixing	30	49	31	Neutrinos and mixing	43	142	77
Charged hvy leptons	1	0	0	Charged hvy leptons	1	0	0
Quarks (u,d,c,s,b)	19	14	18	Quarks (u,d,c,s,b)	31	24	42
Top quark	3	21	31	Top quark	4	29	38
b', t' quarks	1	0	3	b', t' quarks	1	0	3
$\gamma, e, \mu, \pi, \eta$	□7	20	22	$\gamma, e, \mu, \pi, \eta$	12	32	44
K mesons	36	46	32	K mesons	87	134	70
D and D <sub>s</sub> mesons	29	60	61	D and D <sub>s</sub> mesons	123	251	241
B and B <sub>s</sub> mesons	106	188	179	B and B <sub>s</sub> mesons	466	784	862
Supersymmetry	83	43	33	Supersymmetry	157	73	50
Axions	12	11	18	Axions	15	13	18
Higgs	19	23	12	Higgs	25	30	15
W', Z'	9	13	18	W', Z'	13	24	32
Compositeness	7	6	6	Compositeness	21	12	15
Extra dimensions	16	11	11	Extra dimensions	28	15	12
Other searches	8	11	4	Other searches	15	23	10
Free q, monopoles	3	3	1	Free q, monopoles	3	10	1
Baryons	48	46	33	Baryons	197	206	362
$\Psi, \eta_c, \chi_c, \chi_b, \text{upsilon}$	30	90	78	$\Psi, \eta_c, \chi_c, \chi_b, \text{upsilon}$	90	454	422
Other unstable mesons	60	42	66	Other unstable mesons	335	221	355
<b>TOTAL</b>	<b>505</b>	<b>689</b>	<b>645</b>	<b>TOTAL</b>	<b>1708</b>	<b>2633</b>	<b>2778</b>

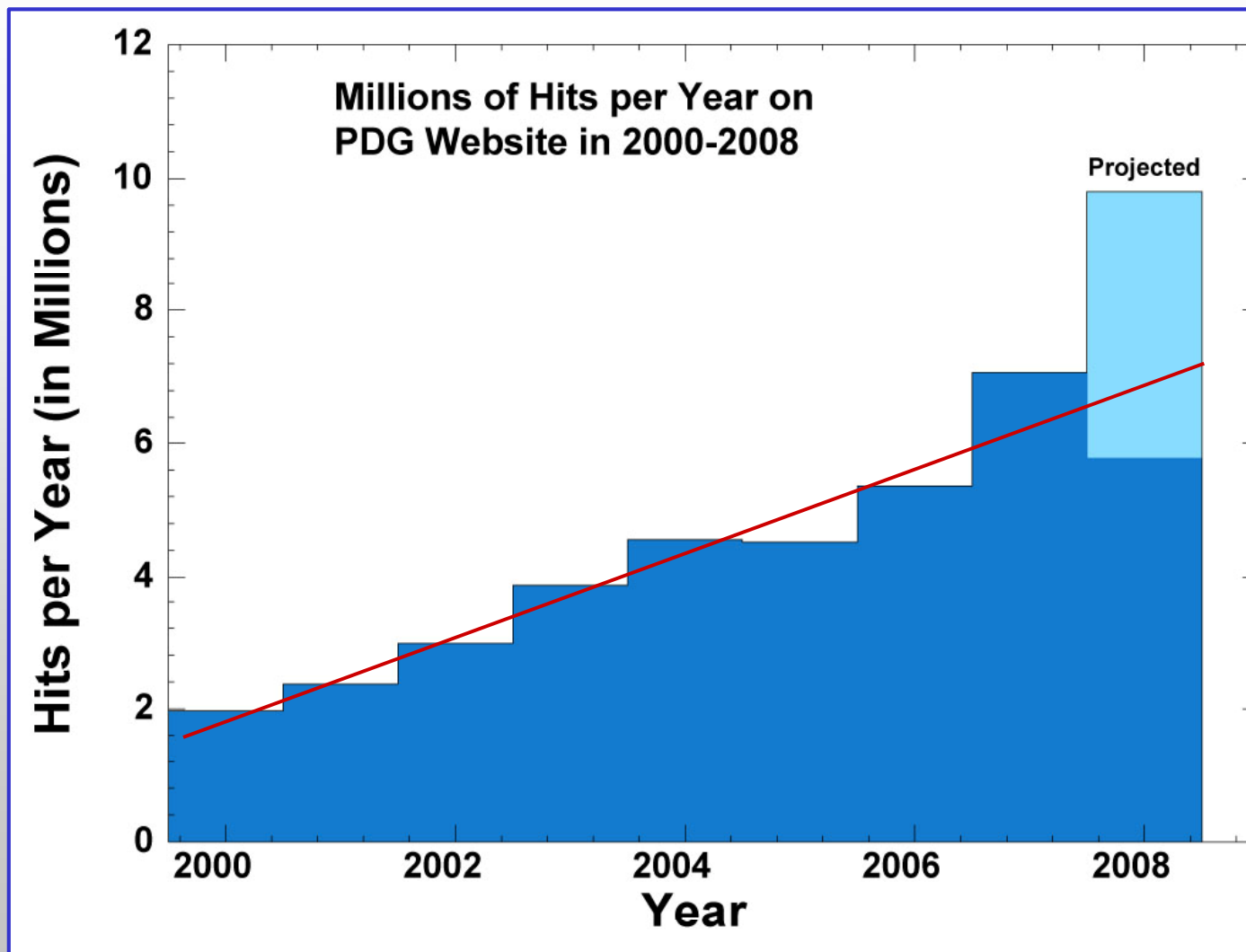


- ➔ 31,000 Booklets requested
- ➔ 16,000 RPP books requested
- ➔ 7 million hits/year on website (>180 countries)  
2008 is projected at 10 million.
- ➔ 30,000 citations of RPP
- ➔ Most cited publication in HEP

The Review is the all-time top cited article in High Energy Physics with 30,000 citations (SLAC-SPIRES)



Excluding  
mirror sites  
and  
excluding  
Education  
webpages



**Following the publication of the ISI Journal Citation Reports, ...**

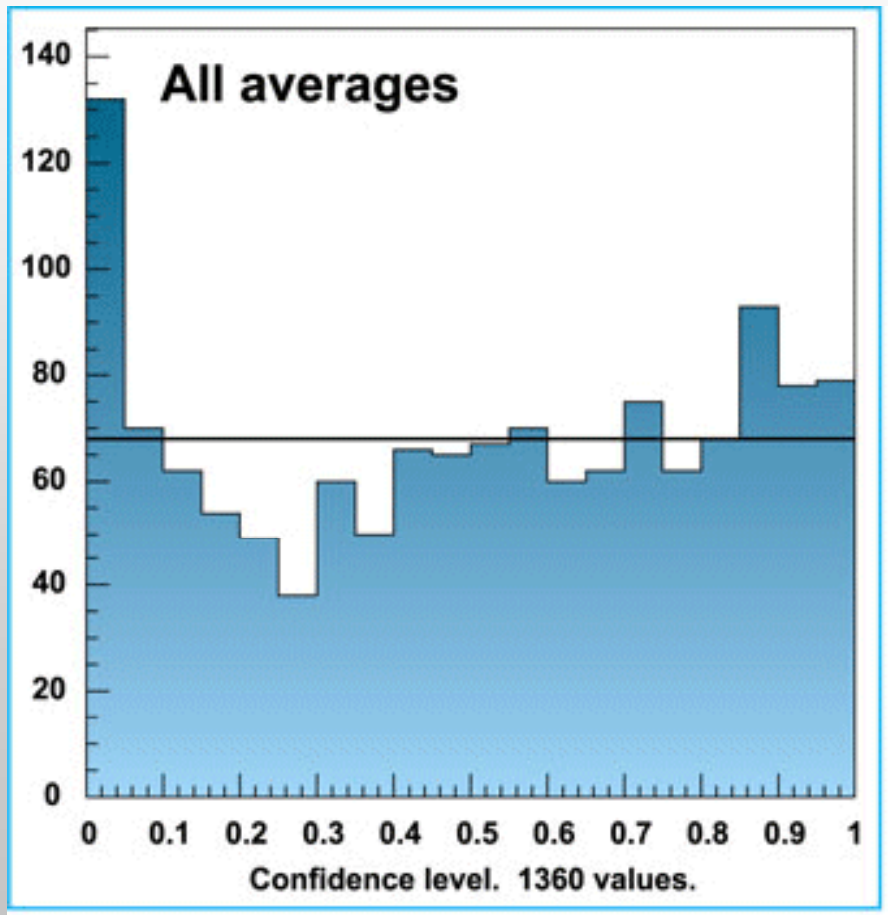
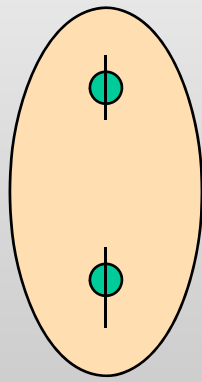
**Journal of Physics G has increased its Impact Factor to 3.485. This is a 96% increase on last year's result and shows that researchers who publish with us are in the right place to be cited by their peers. JPhysG is also the highest impact factor of any original research journal in ISI's category of Nuclear Physics!**

**With the increase in Impact Factor, there has never been a better time to publish with JPhysG to achieve worldwide visibility for your work. ...**

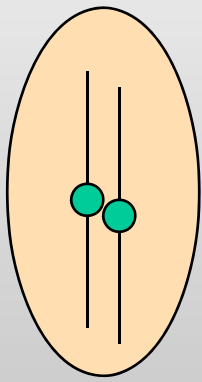
**Sarah Thompson  
Senior Marketing Executive, Journal of Physics G...  
IOP Publishing**

Each point is one average.

Peak at left due to conflicting measurements.



Broad peak at right due to conservative error bars.



# Vital roles of CERN, Japan, SLAC, Retirees

(written for DOE Review)



## 50-year collaboration

**Administration for CERN funding (Michael Doser, deputy chair of Physics Division).**

**Pays publisher directly for their copies.**

**Oversees support for the Meson Team (space, travel), which is mostly non-CERN people who meet at CERN.**

**Mirror website maintained.**

**In general, no direct support for the nine CERN members: Doser, Bloch, Ceccucci, Giudice, Gurtu, Hoecker, Mangano, Roesler and Sauli.**

## 22-year collaboration

**Administration for Japanese funding (Ken-ichi Hikasa)**

**Oversees support for Japanese members (travel).**

**Mirror website maintained.**

## Reviews and Data Sections

- Neutrinos
- CKM Quark Mixing
- Top quark
- Higgs bosons
- Supersymmetry
- Compositeness of quarks and leptons
- Axions
- Heavy bosons ( $W'$ ,  $Z'$ , etc.)
- Even more exotic particles.

## Leadership (past and present)

- Dr. Kasuke Takahashi
- Prof. Yoshio Oyanagi
- Prof. Ken-ichi Hikasa (current leader)

## Seven Japanese physicists

- Dr. Kaoru Hagiwara (KEK)
- Prof. Ken-ichi Hikasa (Tohoku University)
- Dr. Kenzo Nakamura (KEK)
- Dr. Yoshihide Sakai (KEK)
- Prof. Takayuki Sumiyoshi (Tokyo Metropolitan U.)
- Prof. Masaharu Tanabashi (Nagoya University)
- Dr. Akira Yamamoto (KEK)

## Many years collaboration (> 20)

Coordination with SLAC SPIRES database via the SLAC Library group.

Yields our ability to link to the papers from which the measurements come.

Many discussions of improved coverage for the HEP community.

No support needed for this collaboration.

## 100 years of experience

### Dependent on retirees for

- Computing
- Data Listings
- Reviews
- Coordination
- Management of non-Berkeley personnel
- Judgment and wisdom



**The End**