Service to Physics Community

Review of Particle Physics

Education/Outreach Programs

Census/Demographics for DOE/NSF

Only two years away

50th Anniversary

of the Particle Data Group

The original table - 1957

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)		$(1.67 \pm 0.17) \times 10^{-10}$ (o)	0.60×10^{10}
	Σ^0	$\frac{1}{2}$	$1190.5\ ^{+0.9}_{-1.4}$ (p)	$6.0\ ^{+1.4}_{-0.9}$	$(< 0.1) \times 10^{-10}$ (b) theoretically $\sim 10^{-19}$	$> 10 \times 10^{10}$ 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	?	?		?	

The 2004 Review of Particle Physics

500 new papers with **1700** measurements

119 Reviews many written by external experts

Distribute (on request only)

29,500 Booklets

14,200 RPP books

Website: **5-10 million** hits/year

According to SLAC Library, the Review is the all-time top cited article in High Energy Physics with 19,775 citations.

2nd is Weinberg's Standard Model paper with 5424

LBNL Leads

the Particle Data Group collaboration

of 156 authors

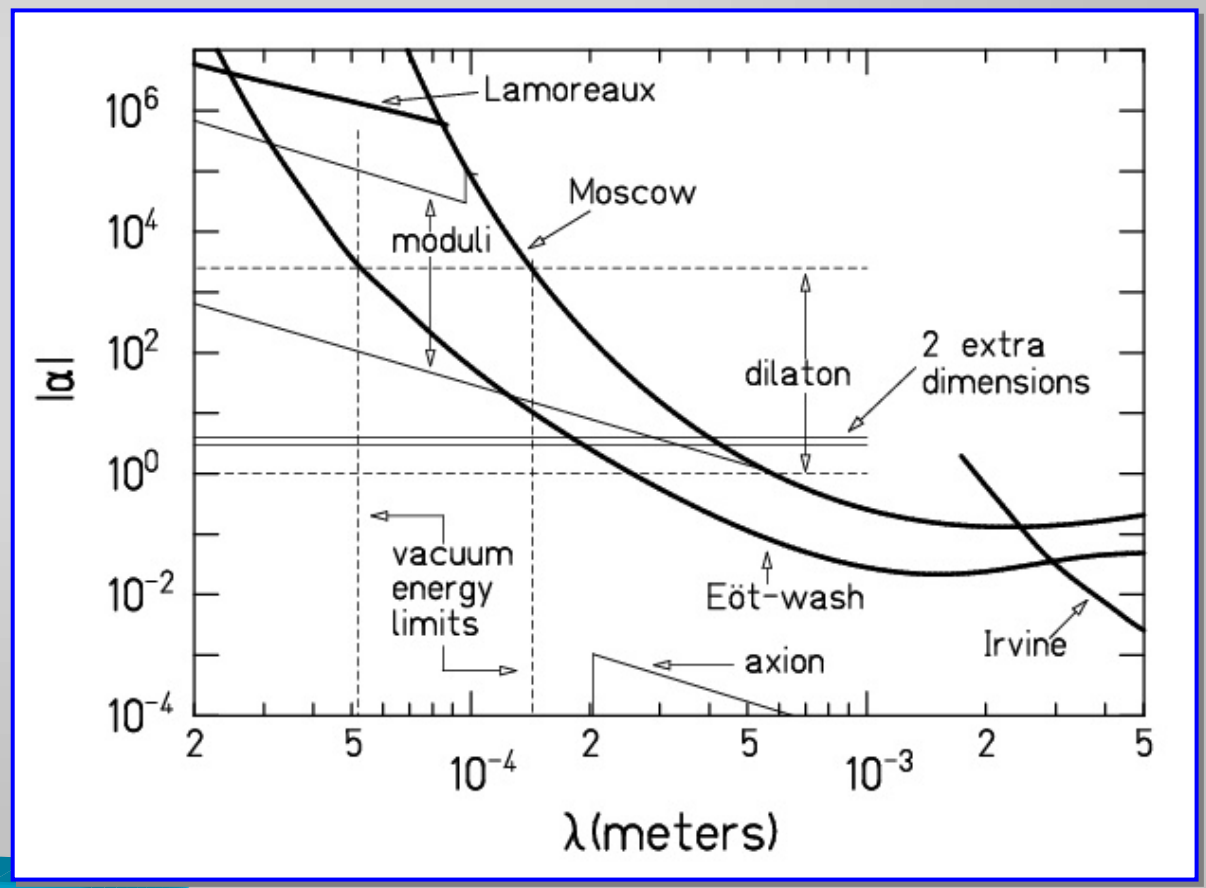
from 17 countries and 90 institutions

+ 700 consultants in the HEP community

Vital PDG workshops lead to improved coverage

- Neutrino
- CKM
- D Meson
- τ lepton
- Extra-dimensions

Constraints on deviations from Newton's gravitational force law



Collaboration with Working Groups

Coordination with LEP, Tevatron and B-factory working groups on:

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

PDG role in

CKM workshops (CERN 2002, Durham 2003, San Diego 2005)

Statistics workshops, etc.

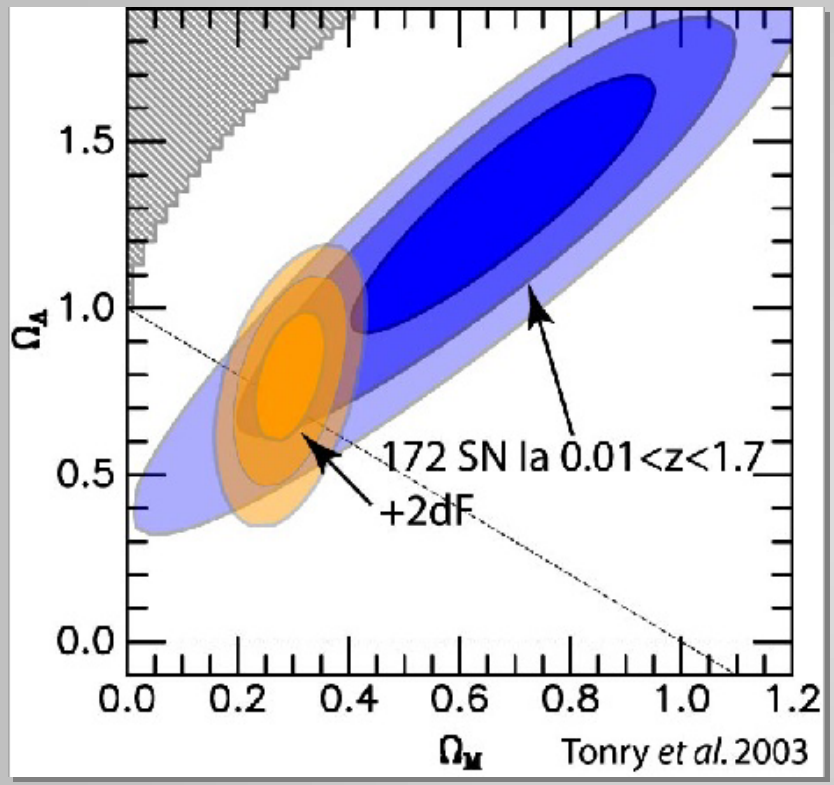
Astrophysics & Cosmology

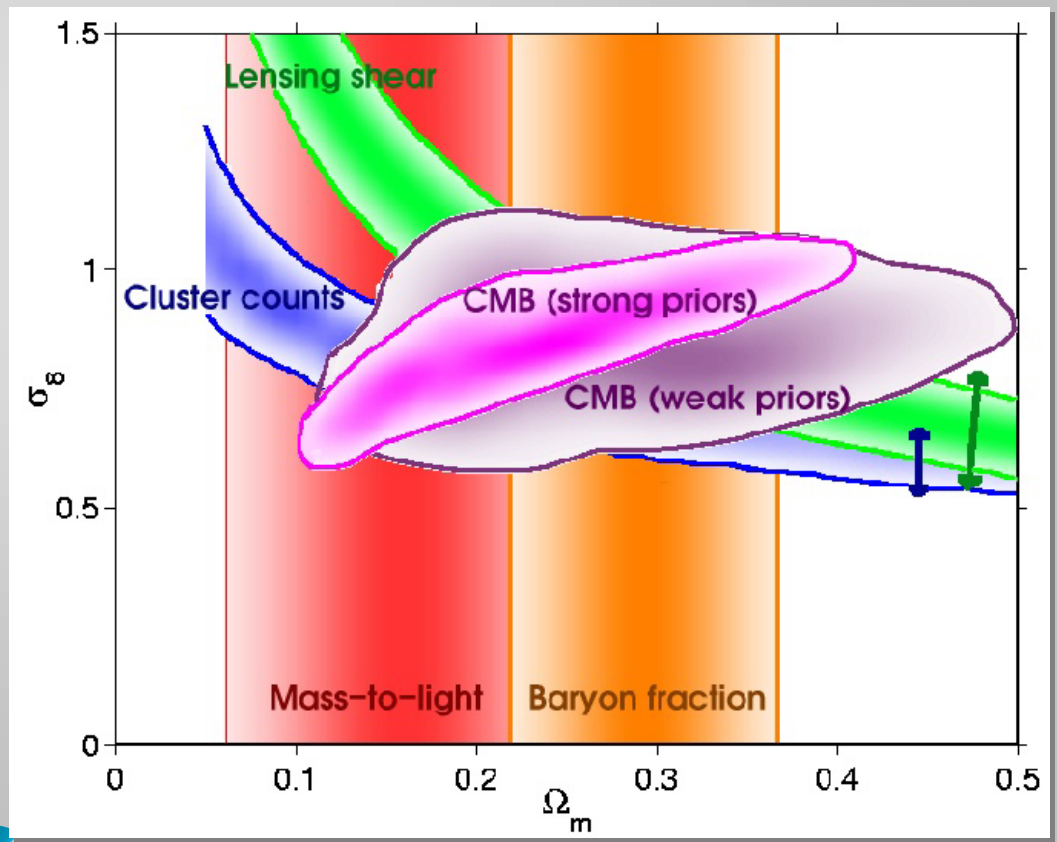
10 years ago: Very little

Now:

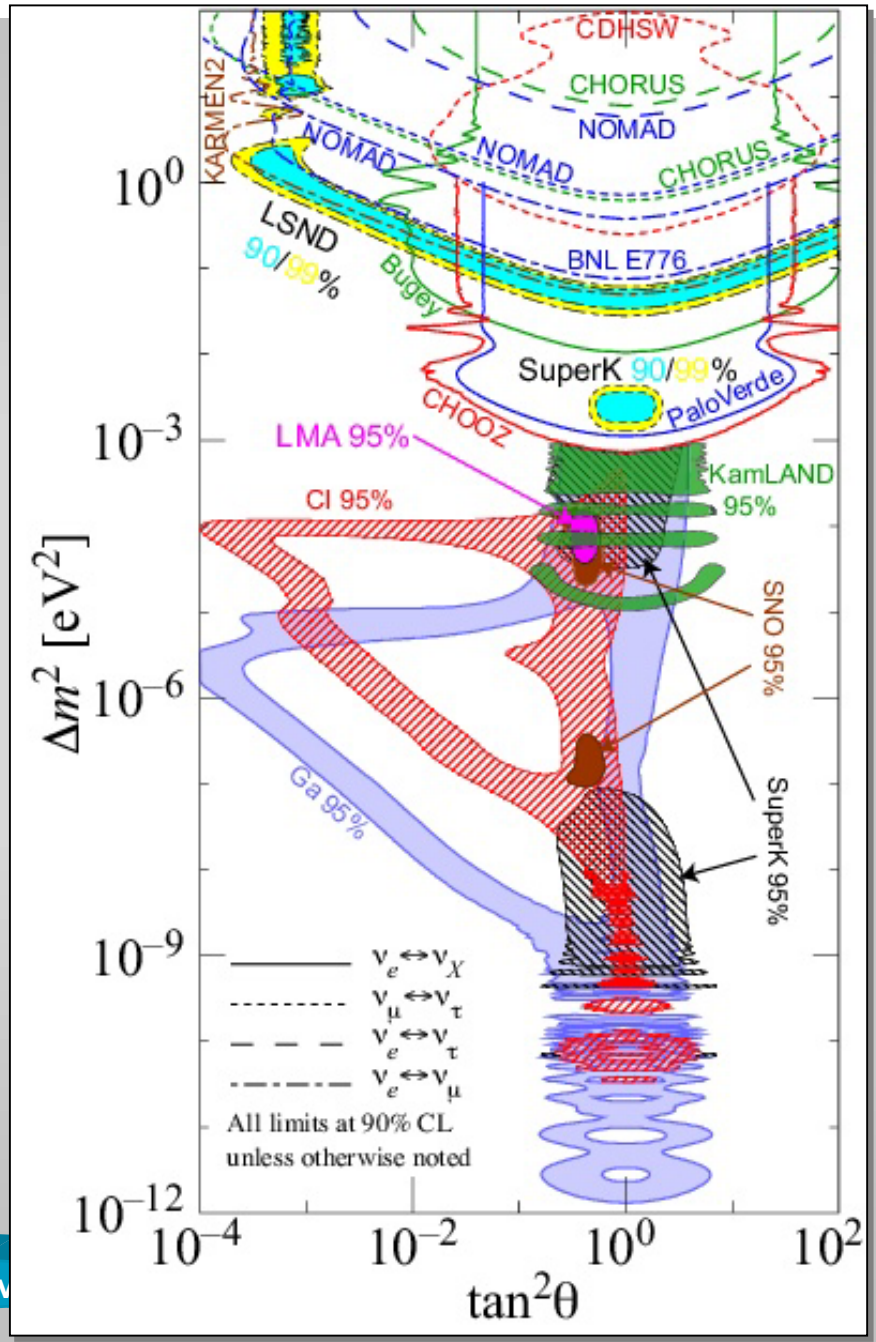
Astrophysical Constants
Big Bang Cosmology
Cosmological Parameters:
H_0, Λ, Ω, etc.
Experimental Tests of Gravitational Theory
Dark Matter
Cosmic Background Radiation
Cosmic Rays

Cosmological Parameters





New plot shows large mixing of neutrinos



Hitoshi Murayama

New Review:

Are there Pentaquarks?

A POSSIBLE EXOTIC BARYON RESONANCE

Written November 2003 by G. Trilling (LBNL).

I. Introduction

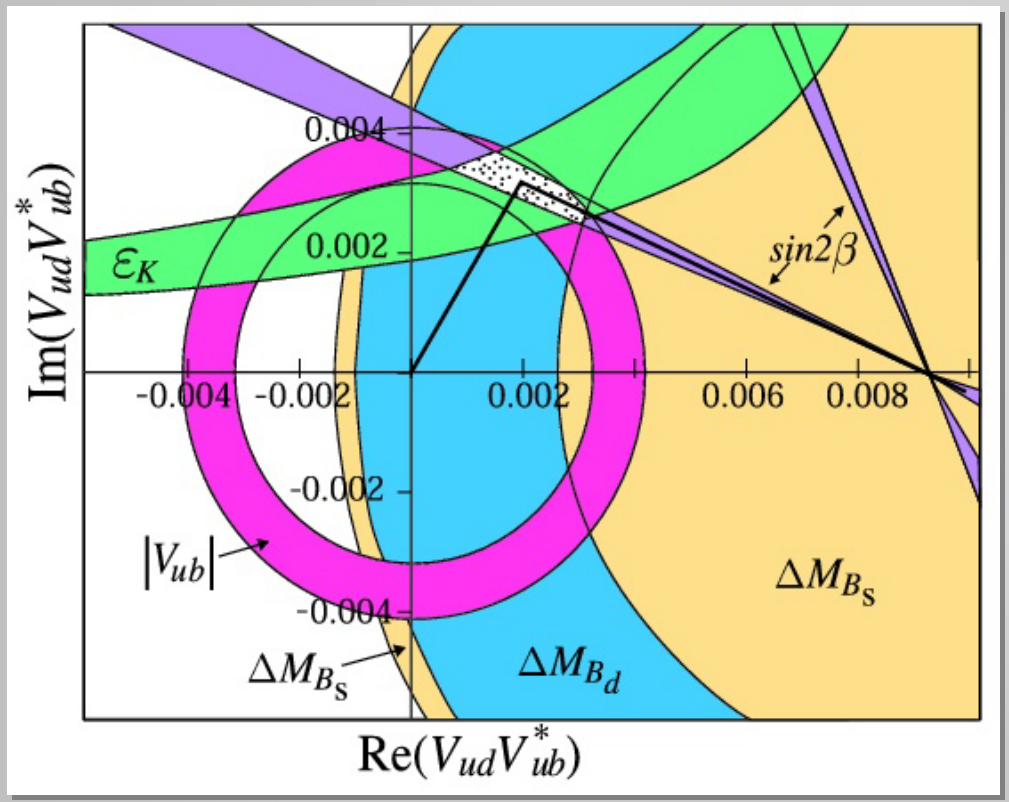
The well-established baryon states can be understood as combinations of three valence quarks. In this discussion, we confine ourselves to baryon states constructed from combinations of u, d, and s quarks. The three-quark combinations are members of SU(3) singlets, octets, and decuplets. Baryon states that cannot be constructed with triplets of u, d, and s quarks are called exotic.

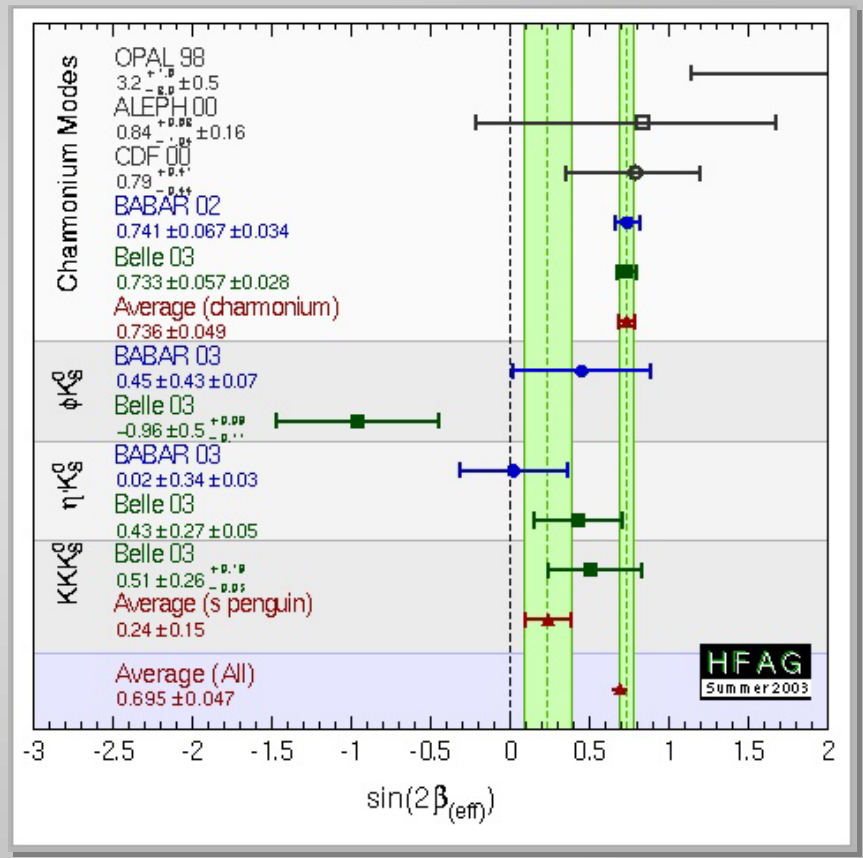
Do there exist in nature baryon states constructed from more complicated quark configurations? The simplest might consist of four quarks plus an antiquark. In a 1997 paper [1],

New CP Review

by Yossi Nir and David Kirkby

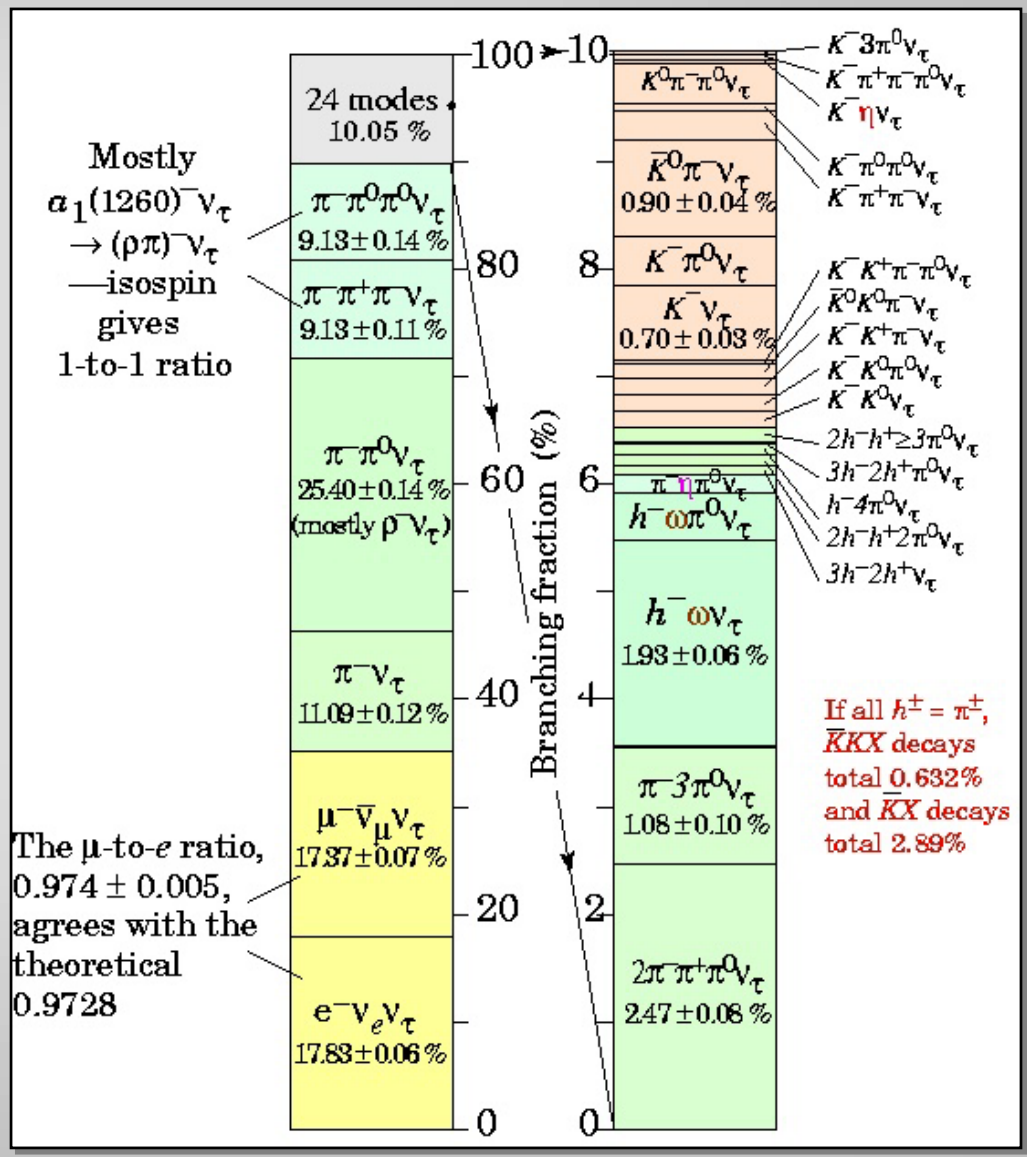
Unifies CP Violation in K, D and B Mesons





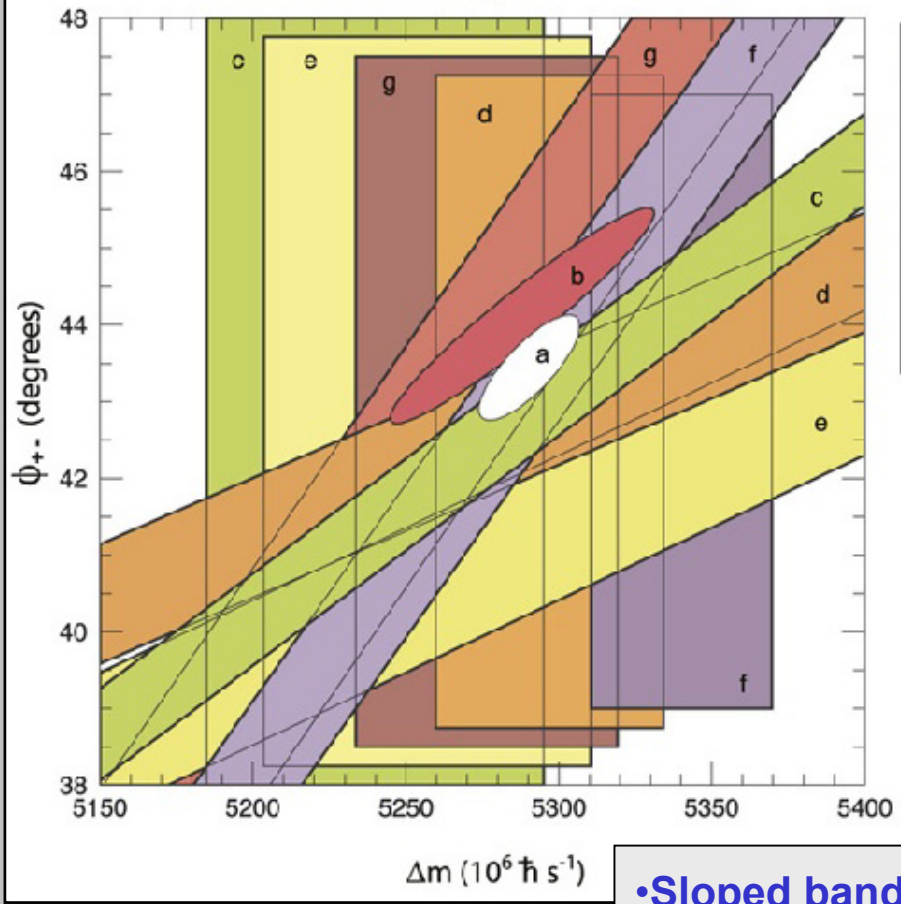
Complex Fits with Correlations e.g.:

τ Branching Fractions



K_L CP Violation Fit

(χ^2=17.4 for 13 degrees of freedom)



Label	Source	Year
a	Combined fit	2004
b	FNAL KTeV	2003
c	CERN CPLEAR	1999
d	FNAL E773	1995
e	FNAL E731	1993
f	CERN	1974
g	CERN NA31	1990

ϕ_{+-} is phase of η_{+-}

$$\eta_{+-} = \frac{\text{ampl}(K_L \to \pi^+\pi^-)}{\text{ampl}(K_S \to \pi^+\pi^-)}$$

Δm is $K_L - K_S$ mass diff.

- Sloped bands show dependence of ϕ meas.'s on Δ(m)
- Red ellipse is meas. with correlation between ϕ and Δ.
- Vertical bands are meas.'s of Δ independent of ϕ.

Future of RPP on the Web

Finding the information you want will become much easier:

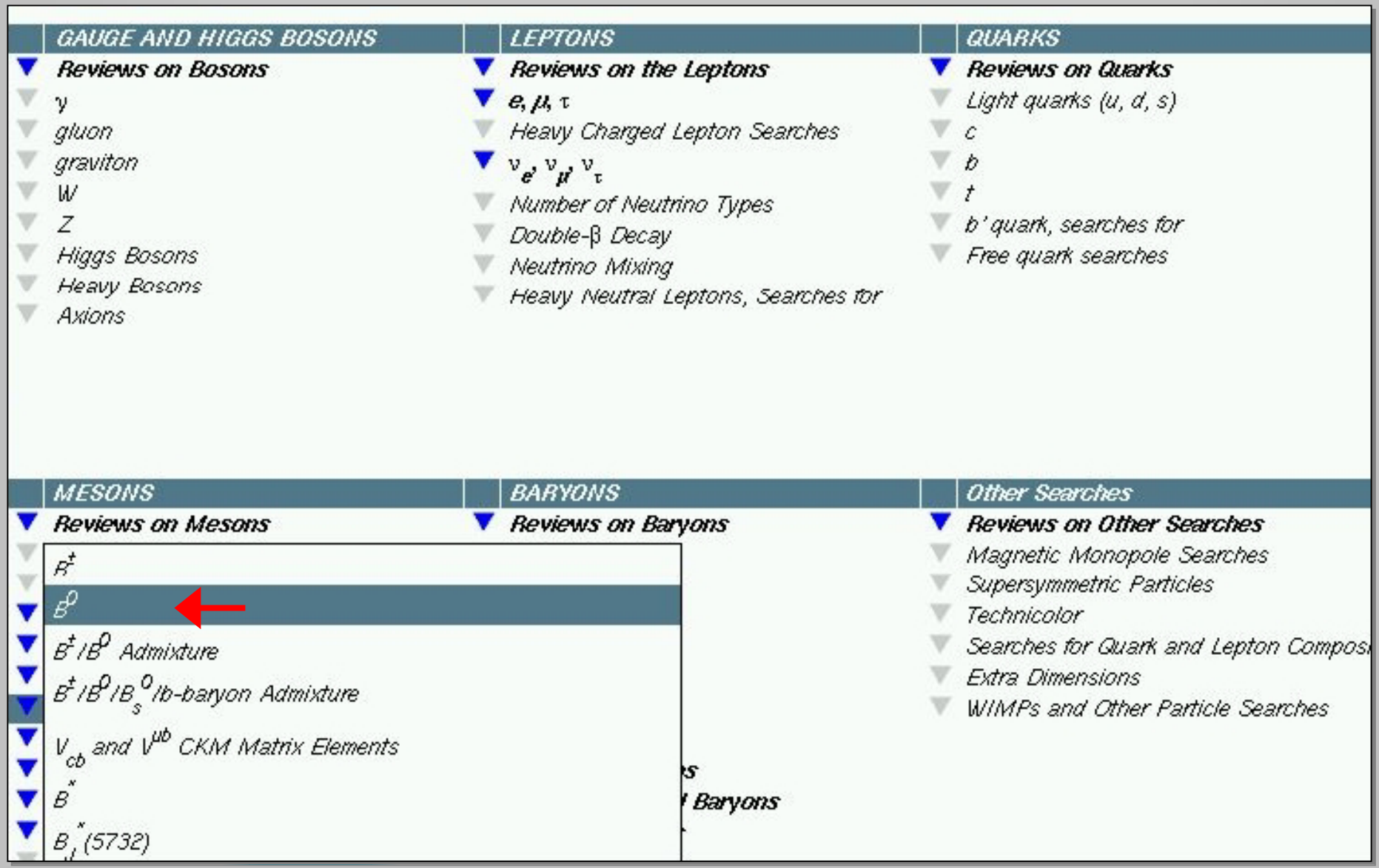
- **Enable powerful searches of RPP database**
- **Produce search results with Greek and math**
  - Request particle
  - Request particle property
  - Request collaboration
  - Request journal article
  - Request review
- **Link References to actual papers**
- **Maintain PDF versions**

Future of RPP on the Web

GAUGE AND HIGGS BOSONS	LEPTONS	QUARKS
Reviews on Bosons	**Reviews on the Leptons**	**Reviews on Quarks**
γ	**e, μ, τ**	*Light quarks (u, d, s)*
gluon	*Heavy Charged Lepton Searches*	*c*
graviton	ν_e, ν_μ, ν_τ	*b*
W	*Number of Neutrino Types*	*t*
Z	*Double-β Decay*	*b' quark, searches for*
Higgs Bosons	*Neutrino Mixing*	*Free quark searches*
Heavy Bosons	*Heavy Neutral Leptons, Searches for*	
Axions		

MESONS	BARYONS	Other Searches
Reviews on Mesons	**Reviews on Baryons**	**Reviews on Other Searches**
Light Unflavoured Mesons	**N Baryons**	*Magnetic Monopole Searches*
Other Light Unflavoured Mesons	**Δ Baryons**	*Supersymmetric Particles*
Strange Mesons	**Exotic Baryons**	*Technicolor*
Charmed Mesons	**Λ Baryons**	*Searches for Quark and Lepton Compositene*
Charmed, Strange Mesons	**Σ Baryons**	*Extra Dimensions*
Bottom Mesons	**Ξ Baryons**	*WIMPs and Other Particle Searches*
Bottom, Strange Mesons	**Ω Baryons**	
Bottom, Charmed Mesons	**Charmed Baryons**	
$c\bar{c}$ Mesons	**Doubly-Charmed Baryons**	
$b\bar{b}$ Mesons	**Bottom Baryons**	
Non $q\bar{q}$ Candidates		

Future of RPP on the Web



Future of RPP on the Web

B^0 DECAY MODES		Fraction (Γ_i/Γ)	Scale factor/ Confidence level
		Inclusive modes	
		D, D^*, or D_s modes	
		Charmonium modes	
Γ_{98}	$\eta_c K^0$	$(1.2 \pm 0.4) \times 10^{-3}$	
Γ_{99}	$\eta_c K^*(892)^0$	$(1.6 \pm 0.7) \times 10^{-3}$	
Γ_{100}	$J/\psi(1S) K^0$	$(8.5 \pm 0.5) \times 10^{-4}$	
Γ_{101}	$J/\psi(1S) K^+ \pi^-$	$(1.2 \pm 0.6) \times 10^{-3}$	
Γ_{102}	$J/\psi(1S) K^*(892)^0$	$(1.31 \pm 0.07) \times 10^{-3}$	
Γ_{103}	$J/\psi(1S) \phi K^0$	$(9.4 \pm 2.6) \times 10^{-5}$	
Γ_{104}	$J/\psi(1S) K(1270)^0$	$(1.3 \pm 0.5) \times 10^{-3}$	
Γ_{105}	$J/\psi(1S) \pi^0$	$(2.2 \pm 0.4) \times 10^{-5}$	
Γ_{106}	$J/\psi(1S) \eta$	$< 2.7 \times 10^{-5}$	CL=90%
Γ_{107}	$J/\psi(1S) \pi^+ \pi^-$	$(4.6 \pm 0.9) \times 10^{-5}$	
Γ_{108}	$J/\psi(1S) \rho^0$	$(1.6 \pm 0.7) \times 10^{-5}$	
Γ_{109}	$J/\psi(1S) \omega$	$< 2.7 \times 10^{-4}$	CL=90%
Γ_{110}	$J/\psi(1S) \phi$	$< 9.2 \times 10^{-6}$	CL=90%
Γ_{111}	$J/\psi(1S) \eta'(958)$	$< 6.3 \times 10^{-5}$	CL=90%
Γ_{112}	$J/\psi(1S) K^0 \pi^+ \pi^-$	$(1.0 \pm 0.4) \times 10^{-3}$	
Γ_{113}	$J/\psi(1S) K^0 \rho^0$	$(5.4 \pm 3.0) \times 10^{-4}$	

$\Gamma(J/\psi(1S) K^0) / \Gamma_{total}$ Section References Γ_{100} / Γ

back to B^0

For branching ratios in which the charge of the decaying B is not determined, see the $B^{\pm}$ section.

Γ_{100} / Γ

VALUE (10^{-4})	CL%	EVTS	DOCUMENT ID		TECN	COMMENT
8.5 ± 0.5	**OUR AVERAGE**					
7.9 ± 0.4 ± 0.9			1 ABE	03B	BELL	$e^+e^- \to \Upsilon(4S)$
8.3 ± 0.4 ± 0.5			1 AUBERT	02	BABR	$e^+e^- \to \Upsilon(4S)$
9.5 ± 0.8 ± 0.6			1 AVERY	00	CLE2	$e^+e^- \to \Upsilon(4S)$
11.5 ± 2.3 ± 1.7			2 ABE	96H	CDF	$p\bar{p}$ at 1.8 TeV
6.9815 ± 4.1949 ± 0.1177			3 BORTOLETTO	92	CLEO	$e^+e^- \to \Upsilon(4S)$
9.3086 ± 7.3586 ± 0.1570		2	4 ALBRECHT	90J	ARG	$e^+e^- \to \Upsilon(4S)$
* * * We do not use the following data for averages, fits, limits, *etc.* * * *						
$8.5^{+1.4}_{-1.2} \pm 0.6$			1 JESSOP	97	CLE2	Repl. by AVERY 2000
7.5 ± 2.4 ± 0.8		10	3 ALAM	94	CLE2	Sup. by JESSOP 1997
<50	90		ALAM	86	CLEO	$e^+e^- \to \Upsilon(4S)$

1 Assumes equal production of B^+ and B^0 at the $\Upsilon(4S)$.

2 ABE 1996H assumes that $B(B^+ \to J/\psi K^+) = (1.02 \pm 0.14) \times 10^{-3}$.

3 BORTOLETTO 1992 reports 6 ± 3 ± 2 for $B(J/\psi(1S) \to e^+e^-) = 0.069 \pm 0.009$. We rescale to our best value $B(J/\psi(1S) \to e^+e^-) = (5.93 \pm 0.10) \times 10^{-2}$. Our first error is their experiment's error and our second error is the systematic error from using our best value. Assumes equal production of B^+ and B^0 at the $\Upsilon(4S)$.

4 ALBRECHT 1990J reports 8 ± 6 ± 2 for $B(J/\psi(1S) \to e^+e^-) = 0.069 \pm 0.009$. We rescale to our best value $B(J/\psi(1S) \to e^+e^-) =$

SPIRES

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FIND KEY 4676572

Browse Author | Format: **Standard** Cites Citesummary LaTeX

MEASUREMENT OF BRANCHING FRACTIONS FOR EXCLUSIVE B DECAYS TO CHARMONIUM FINAL STATES

By BABAR Collaboration (B. Aubert *et al.*). SLAC-PUB-8909, BABAR-PUB-01-07, Jul 2001. 25pp.

Published in **Phys.Rev.D65:032001,2002**

e-Print Archive: **hep-ex/0107025**

List of Authors TOPCITE = 50+

References | LaTeX(US) | LaTeX(EU) | Harvmac | BibTeX | Keywords | Cited 54 times

Abstract and Postscript and PDF from arXiv.org (mirrors: au br cn de es fr il n it jp kr ru tw uk za eps anl)

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CERN Library Record

Phys. Rev. D Server

SLAC Document Server

EXP SLAC-PEP2-BABAR

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FULL LIST OF MEASUREMENTS

AUBERT 2002 BaBar Collab.

Physical Review **D65** (2002) 032001

Measurement of Branching Fractions for Exclusive *B* Decays to Charmonium Final States

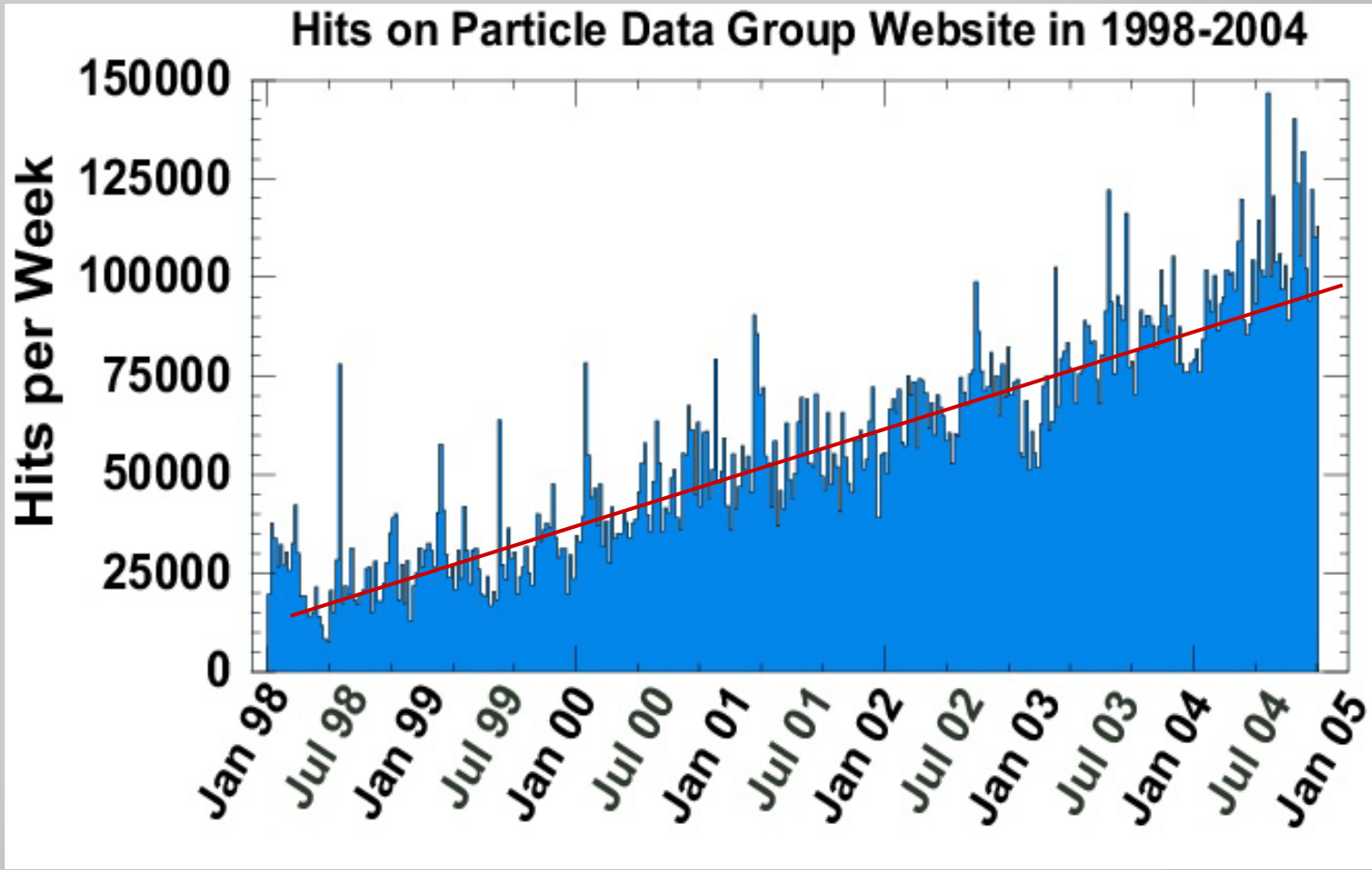
	Measurement			(Unit)	Particle (Section)	Observable
used	0.1	± 0.3	± 0.5	(10^{-4})	$B^{\pm}$	$\Gamma(J/\psi(1S)K^{+}) / \Gamma_{total}$
used	1.37	± 0.09	± 0.11	(10^{-3})	$B^{\pm}$	$\Gamma(J/\psi(1S)K^{*}(892)^{+}) / \Gamma_{total}$
used	1.37	+ 0.10	+ 0.08		$B^{\pm}$	$\Gamma(J/\psi(1S)K^{*}(892)^{+}) / \Gamma(J/\psi(1S)K^{*})$
used	6.4	± 0.5	± 0.8	(10^{-4})	$B^{\pm}$	$\Gamma(\psi(2S)K^{+}) / \Gamma_{total}$
used	0.64	± 0.06	± 0.07		$B^{\pm}$	$\Gamma(\psi(2S)K^{+}) / \Gamma(J/\psi(1S)K^{+})$
used	6.4794	± 1.0351	± 0.6766	(10^{-4})	$B^{\pm}$	$\Gamma(\chi_{c1}(1P)K^{+}) / \Gamma_{total}$

Consequence of PDG Dynamic Improvements

- 29,500 Booklets
- 14,200 RPP books
- 5-10 million hits/year on website (>140 countries)
- 20,000 citations of RPP
- Most cited publication in HEP

Consequence of PDG Dynamic Improvements

Excluding mirror sites and excluding Education webpages



Outreach

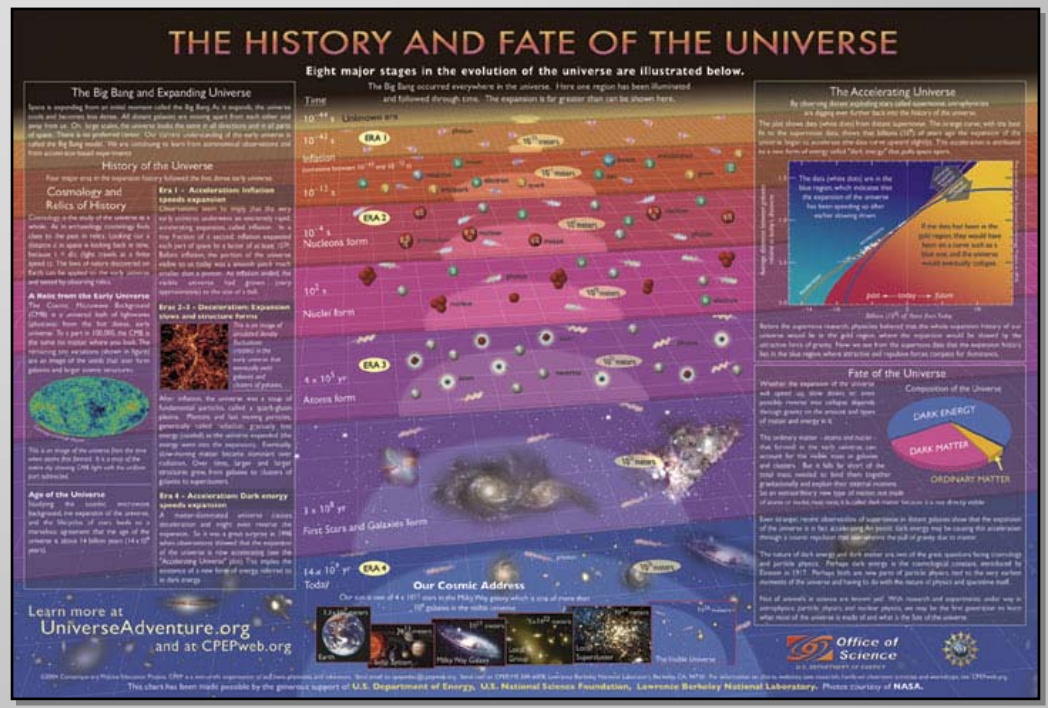
PDG, ATLAS, QuarkNet,
Contemporary Physics Education Project,
European Outreach Group,
NOVA, Nobel Foundation, etc.

Cosmology and Particle Physics

- Programs/Research for
  High School Teachers and Students
- Websites for Public and Students
- Special Events and Webcasts
- Educational Materials
  - Books and booklets
  - Charts, Placemats, Transparencies
  - CDROMs, Films

Cosmology Chart

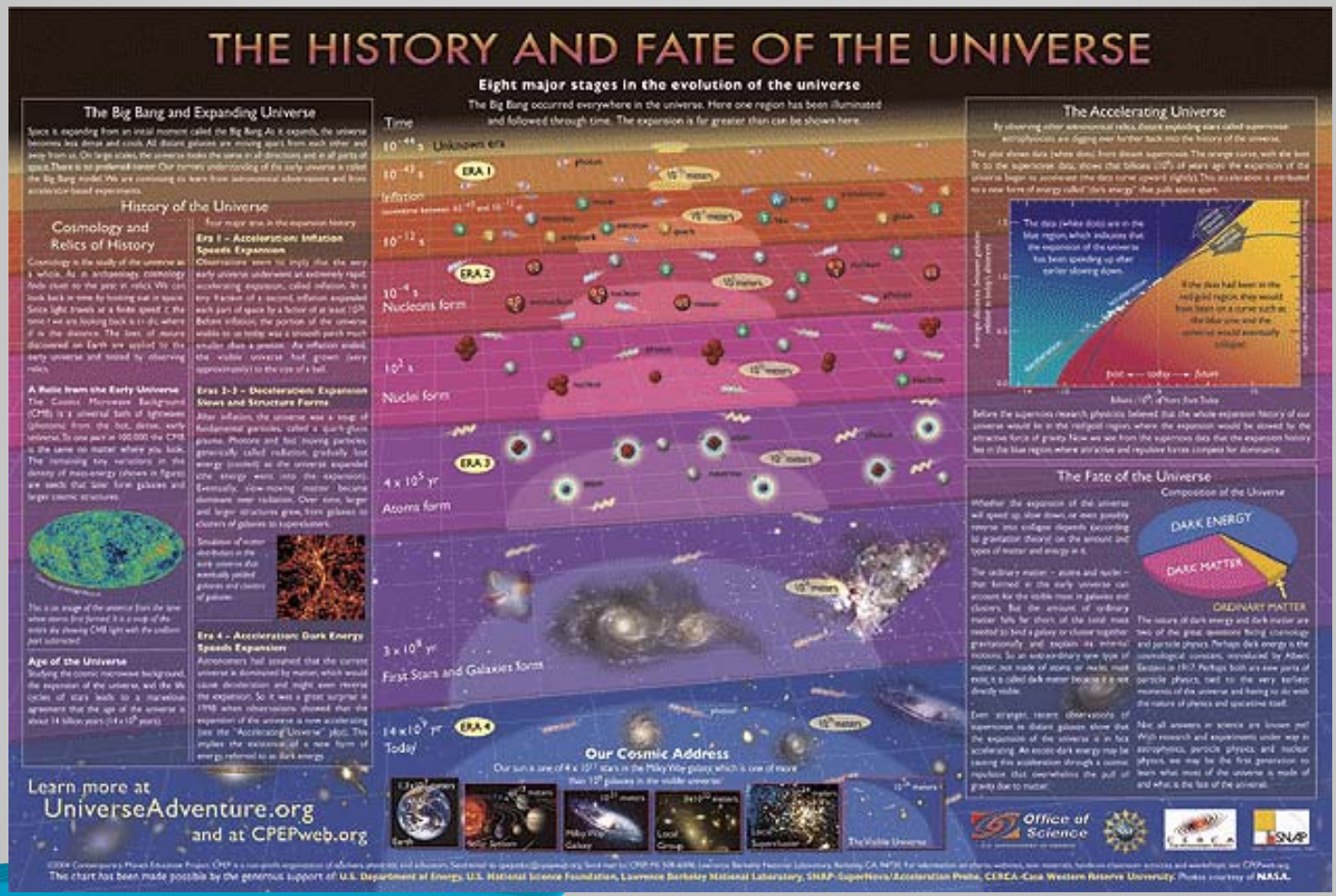
Several years of work by physicists and teachers, and a field test in classrooms.



The History and Fate of the Universe

Chart was enclosed in the February issue of *The Physics Teacher* magazine. The AAPT magazine went to 11,000 teachers. Extensively used by DOE Office of Science Director Ray Orbach.

Final Chart



UniverseAdventure.org

Under construction

UniverseAdventure.org

SITE MAP GLOSSARY

The Universe Adventure

How Big is the Universe?

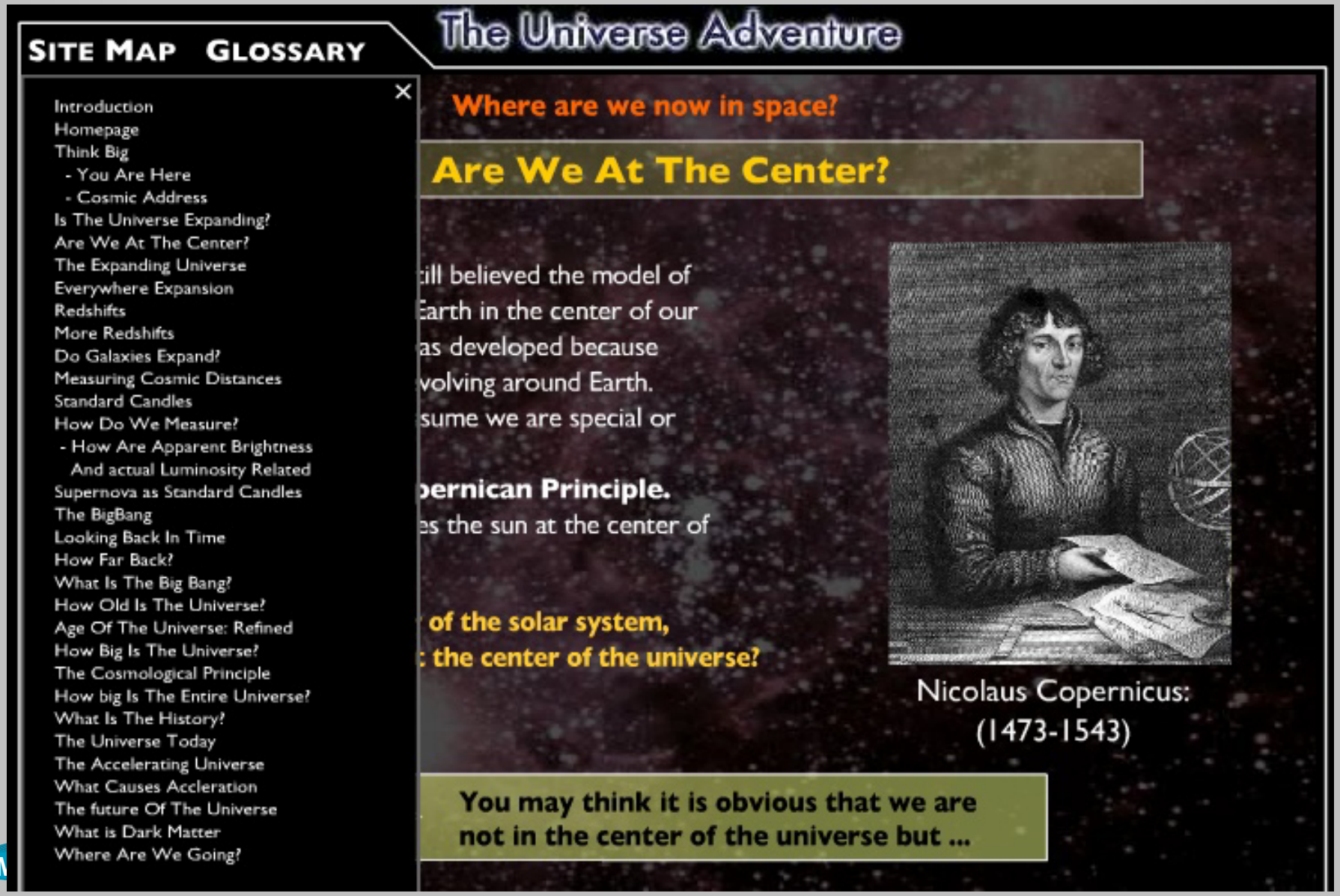
The Visible Universe

Even with the best imaginable telescopes, we can only see a small fraction of the universe. Why? Because it takes time for light to travel. So if the universe is now 14 billion years old, light can only have travelled...14 billion light years since the beginning. Thus, the part of the universe we can observe (the visible universe) lies within a sphere of radius 14 billion light years, and our earth at the center.

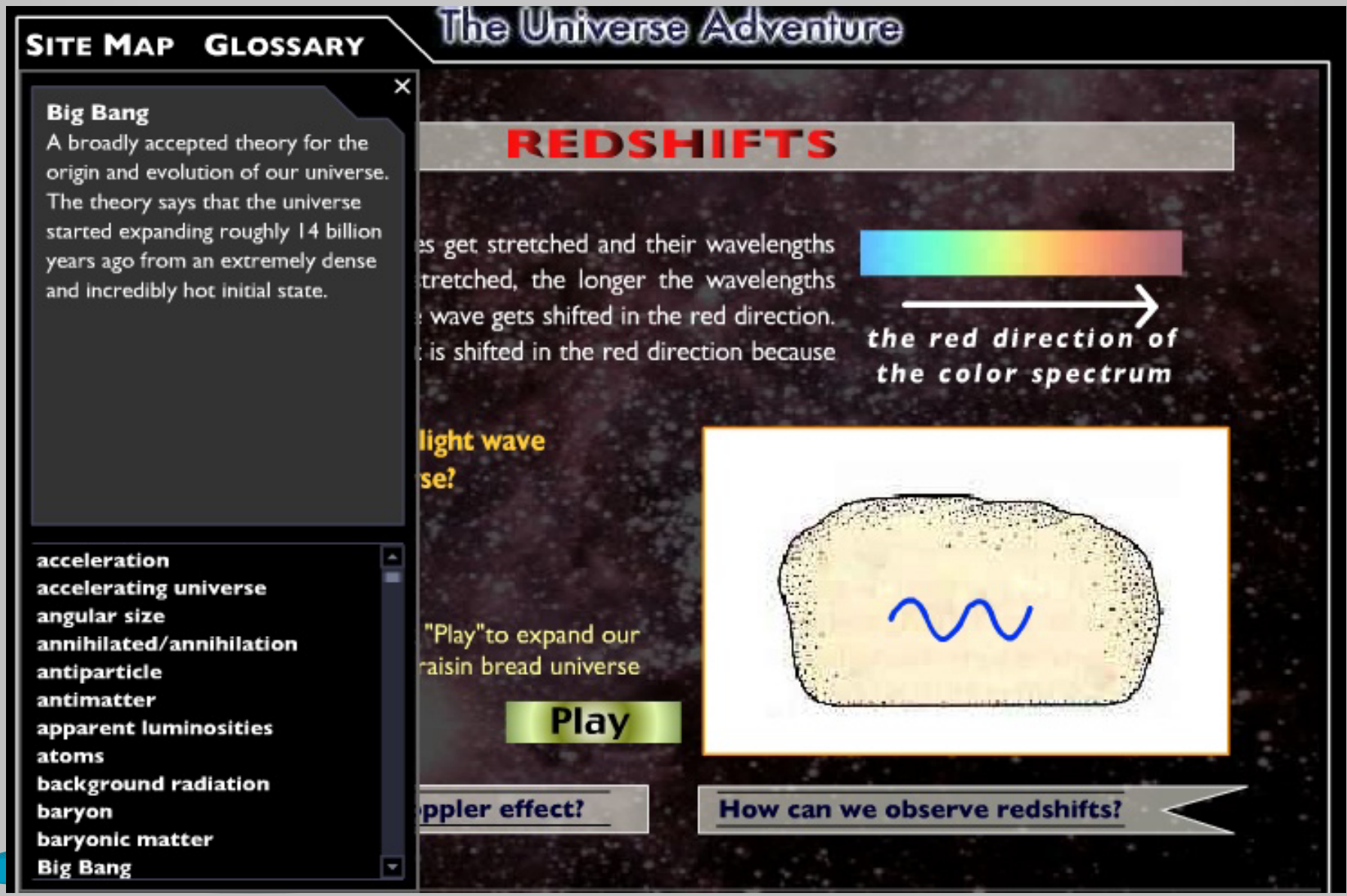
"The universe is THIS big."

But is the universe infinite or just big?

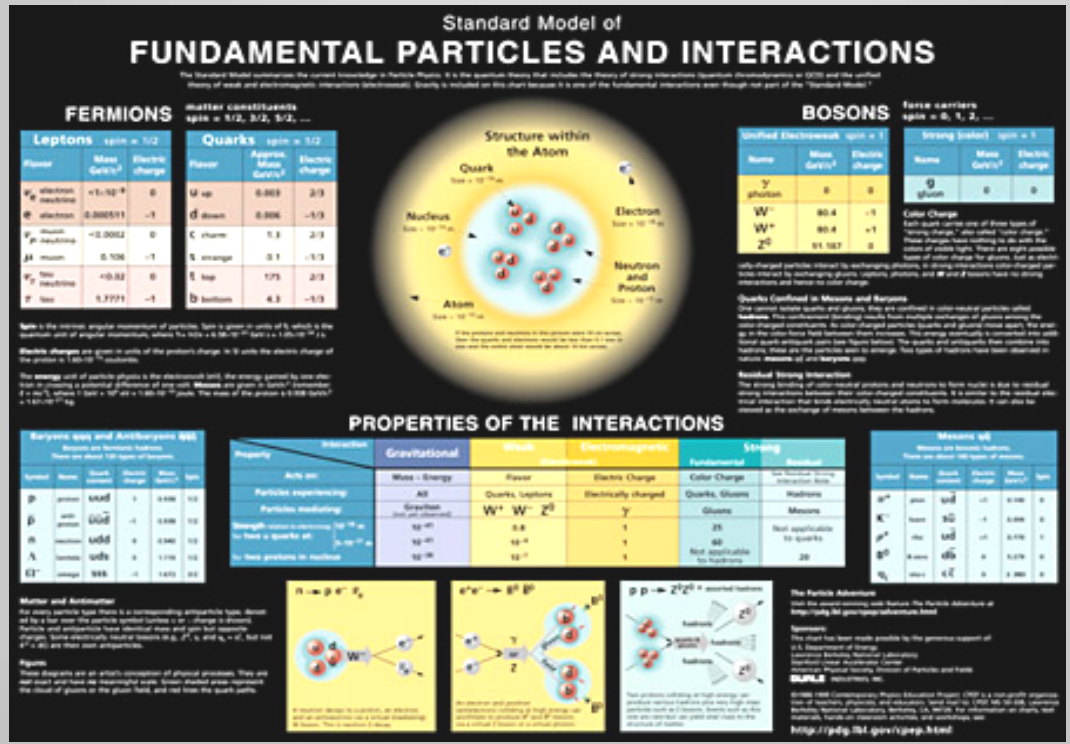
Site Map -- UniverseAdventure.org



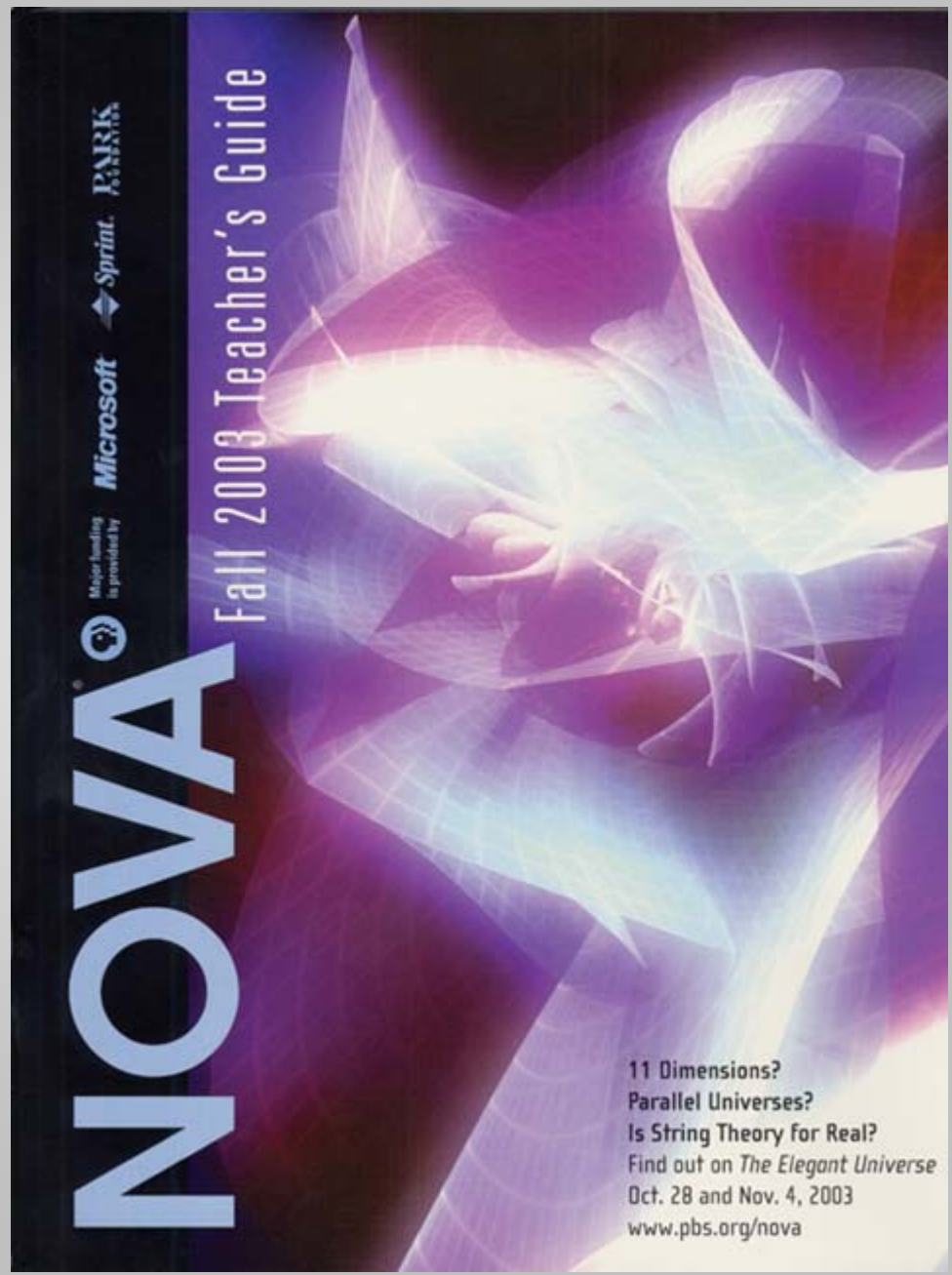
Glossary -- UniverseAdventure.org



Posters star in movies



Consultants for the NOVA program on string theory:
Brian Greene's Elegant Universe



see all the excitement at QuarkDance.org!

Mirror sites: USA (LBNL) | Switzerland (CERN) | UK (Durham) | Japan (KEK) | Russia (Novosibirsk) | Russia (Protvino) | Brazil | Italy (Genova)

Languages

Languages:
Chinese (in USA / Taiwan)
Deutsch
Dutch
Español (in USA / Spain)
Française
Greek
Italiano
Norsk
Polski
Português
Slovenska
Suomea (Finnish)

The Particle Data Group of Lawrence Berkeley National Laboratory presents an award-winning interactive tour of quarks, neutrinos, antimatter, extra dimensions, dark matter, accelerators and particle detectors.

The Particle Adventure

the fundamentals of matter and force

Supported by US DOE and NSF

Funding Credits

Project Credits

ADDITIONAL FEATURES

- Posters, CD-ROMs, and Educational Material
- Book: The Charm of Strange Quarks
- Particle Chart
- Particle History & Summary
- Glossary
- Site Map, How to Use this Site
- Physics Central
- The Fireworks of Particles
- QuarkNet Educational Program
- Hands on CERN
- Interesting Physics Sites

World Year of Physics 2005

We appreciate your comments.

Send email to pdgeduc@lbl.gov

Teachers may use this form

Example of Recognition

SCIENTIFIC AMERICAN

Main Menu | Interview | Bookmarks | Feedback
Current Issue | Explore! | Ask the Experts | Marketplace | Search the Site

EXPLORE!

Physics

The Particle Adventure

If you?ve ever wondered what the heck quarks and neutrinos are, or why anyone cares, this is the site for you. Lawrence Berkeley National Laboratory?s particle physicists have created an accessible, entertaining primer on, as they describe it, what the world is made of and what holds it together. Nine sections address these fundamental questions and explore related topics, such as how researchers collect and interpret particle data, and how particles decay into other particles. One not–to–be–missed chapter covers unsolved mysteries, delving into supersymmetry, string theory, dark matter and the possible existence of extra dimensions. Other features include particle physics news and a page of links to other particle physics education sites.

Snow Crystals

A visit to this site might help you appreciate the season's flakes next time you're out shoveling them away. The author, California Institute of Technology professor Ken Libbrecht, explains everything you ever wanted to know–and then some–about natural snow, lab–made designer crystals and the physics behind them in a clear,

This site takes your students into the future. Check out this totally awesome interactive site for students of chemistry and physics.

A great site to introduce your students to the multimedia nature of the internet.

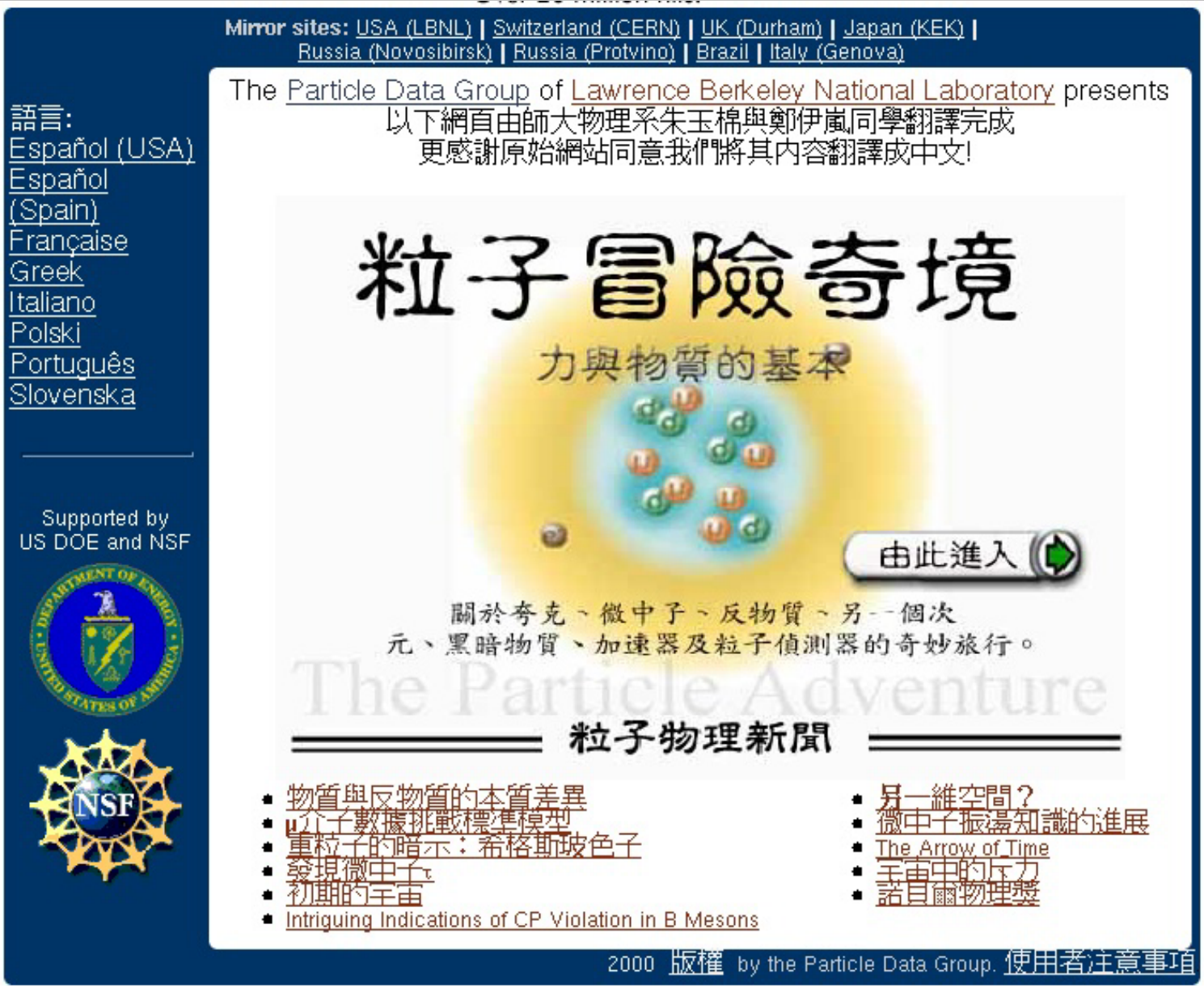
Science magazine

Wild ride. The present best theory of what all matter boils down to, known as the Standard Model, is explained in the remarkably clear and simple pages of The Particle Adventure, a widely praised site aimed at high school students.

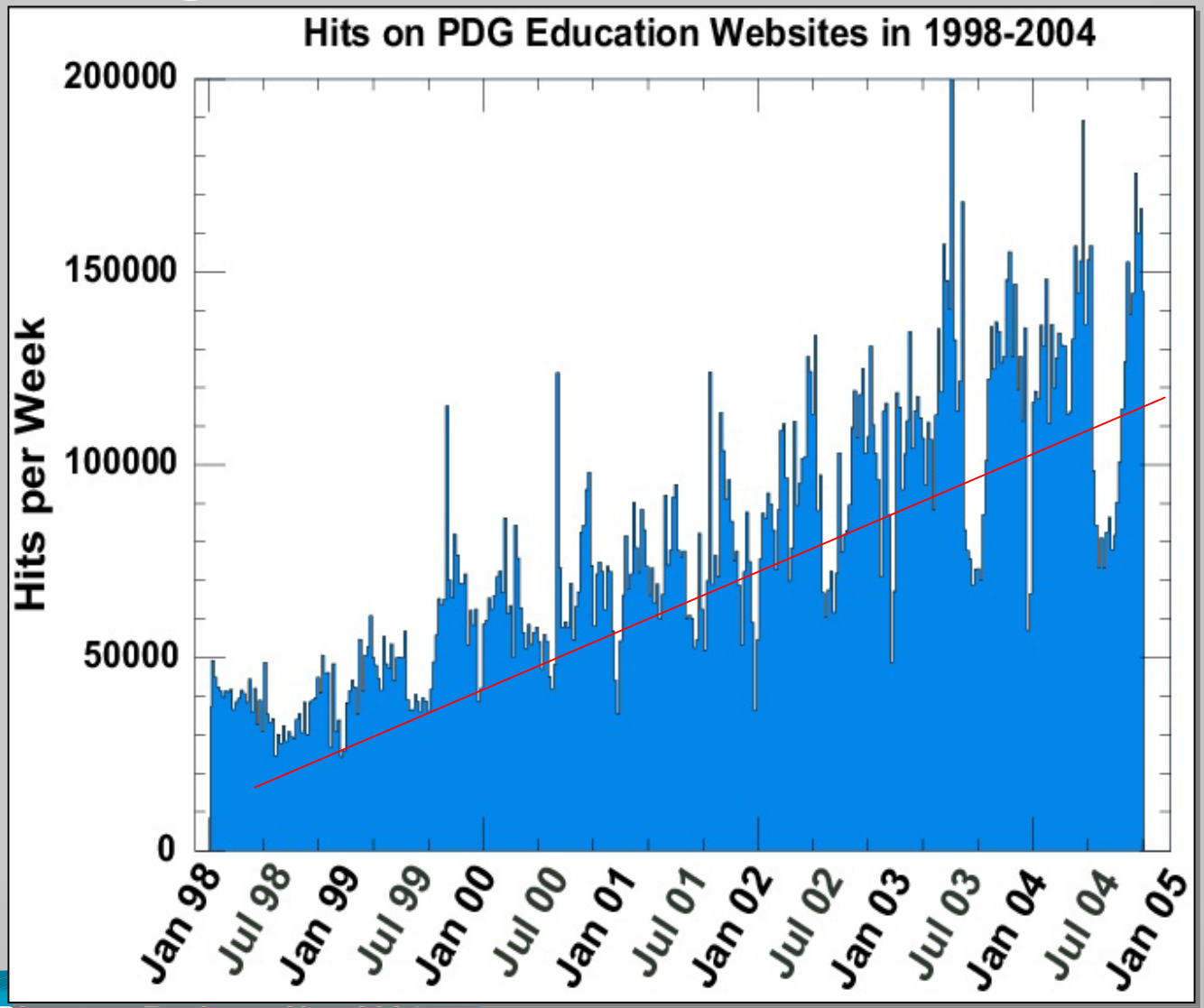
Replete with animations of decays, quizzes, and a pop-up glossary, the site starts out by discussing quarks, leptons, and other particles, lays out the experimental evidence for them, then explains the workings of giant accelerators and detectors."
(June 9, 2000)

Chinese

Translate Text, Images, Flash & Site map (~200 pages)



Web Usage (Excluding mirror / language sites)



ATLAS Outreach Coordinator

Public Webpages With 45-second Flash animation

http://ATLAS.ch

Movie made by ATLAS Experiment's Outreach Committee has won four gold medals at int'l film festivals!

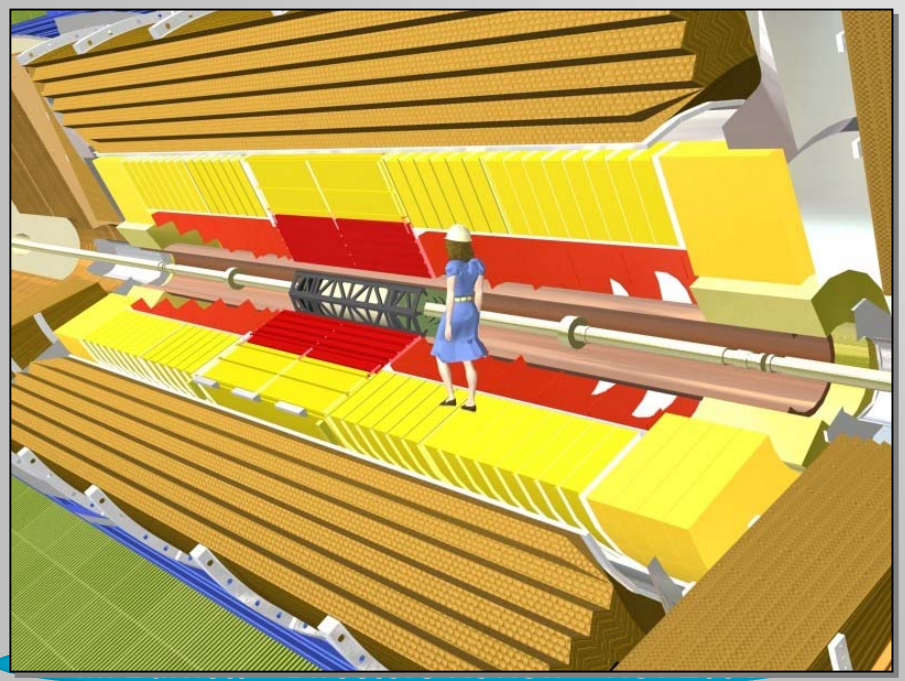
http://atlas.ch/movie

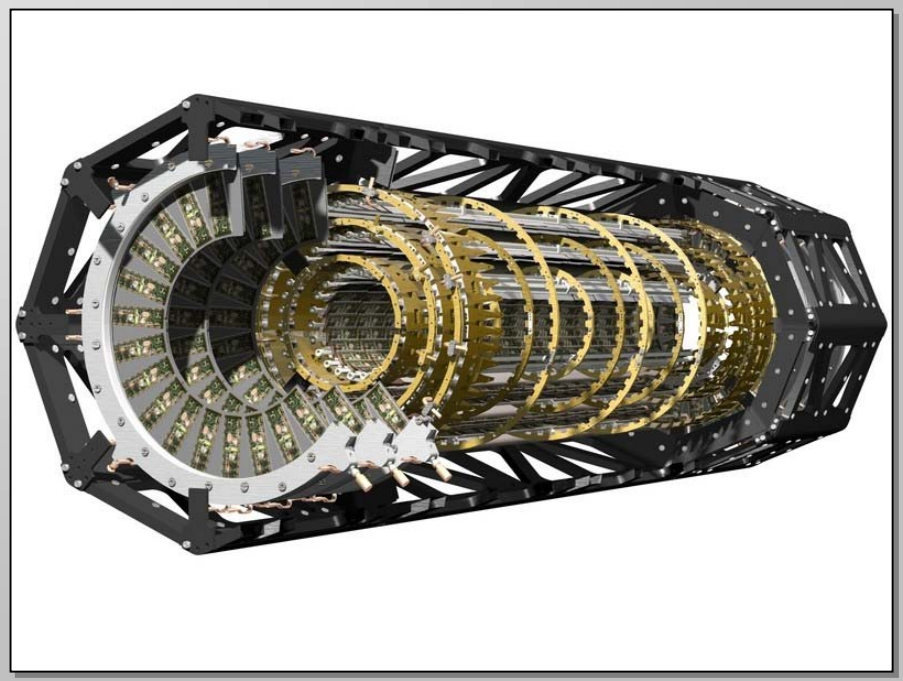
Czech, Dutch, English, French, German, Italian, Japanese, Spanish, Swedish, Chinese

3D Animation of ATLAS

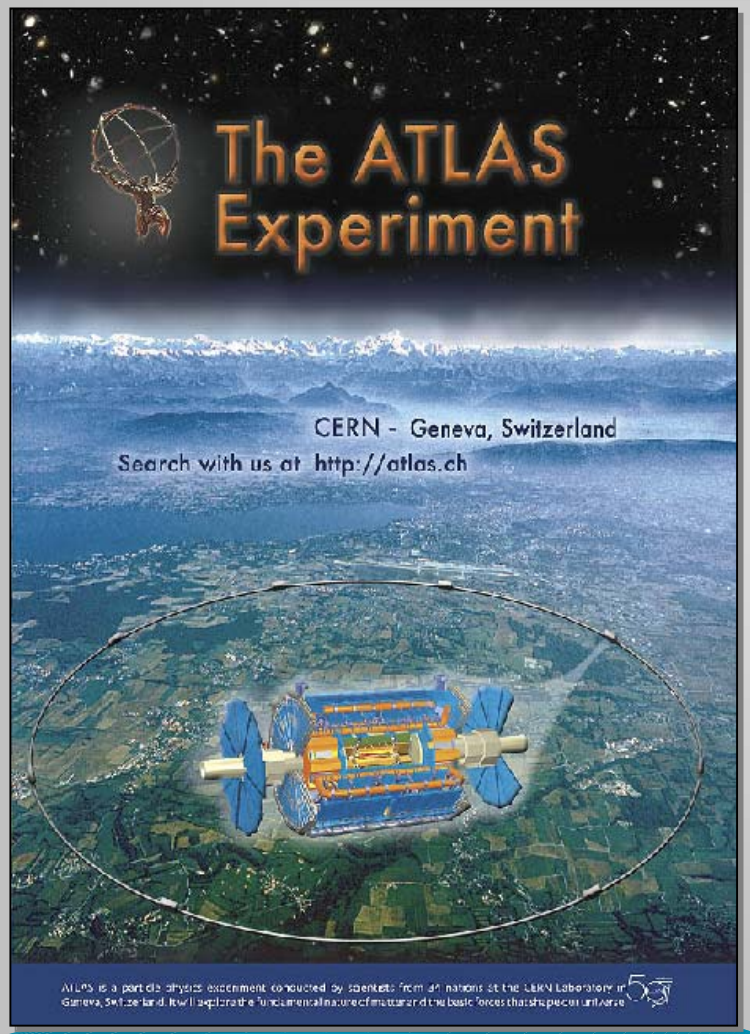
- Installation of ATLAS
- Particles passing through six components of ATLAS
- Physics events in ATLAS

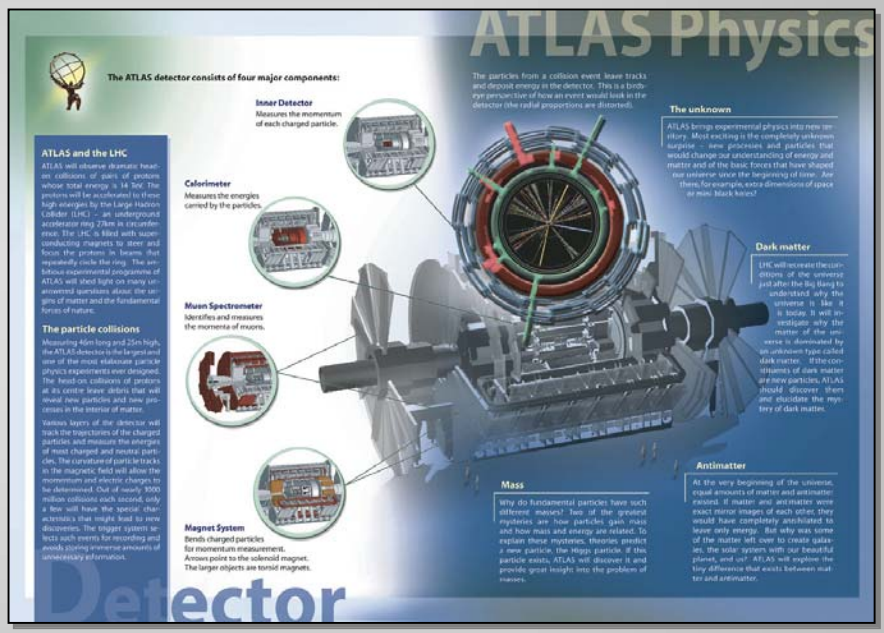
Using red-cyan glasses





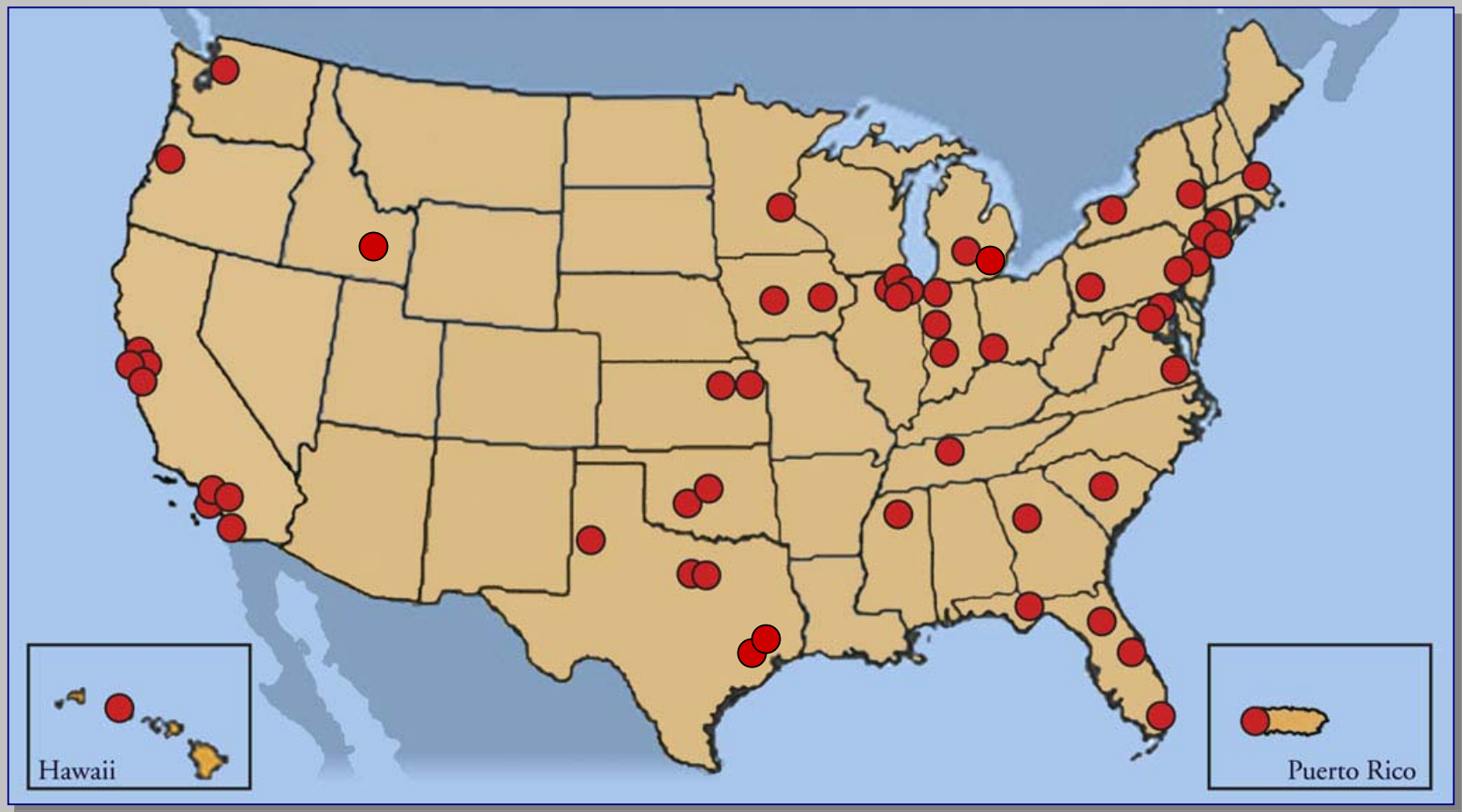
New Brochure





QuarkNet

Helping Develop America's Technological Workforce



QuarkNet - CoFounder and Co-PI

Centers at 54 universities,

11 different HEP experiments,

500 high schools in 37 states.

Impacts on 60,000 students/yr.

Changing teachers and teaching by making them part of of research collaborations.

The focus of QuarkNet is to involve teachers and students in our experiments:

Teachers: do research with us and bring that excitement and experience to their classrooms;

Students: analyze web-data in their classrooms.

QuarkNet is getting students excited about science and involved in inquiry-based learning.

by getting scientists and teachers working <u>together</u>.

QuarkNet is in 54 communities across America helping produce the 21st century workforce we need.

Our work with teachers is giving them the ability to attract and train American students.

Teacher in the "most racially diverse school system in Indiana"

"This program has enriched my teaching. I have many resources to tap into now. I have a broader knowledge base as a result of lectures and research.

"I have a warm web of friends across the United States who have the same goals as I do and who are eager to help with encouragement and advice. I feel a part of something larger and I don't feel like I am alone in the classroom any more.

"I have had several students express an interest in becoming a high school science teacher like me because what we do is so interesting."

Another QuarkNet teacher:

"I feel very strongly about the positive impact QuarkNet has made on my students, particularly since they are mostly minority, low-income kids.

"Contact with the QuarkNet program has been a terrific boost for them and started a number of students seriously thinking about going to a 4-year college and maybe pursuing careers in science."

QuarkNet program at LBNL

began Summer 2001.

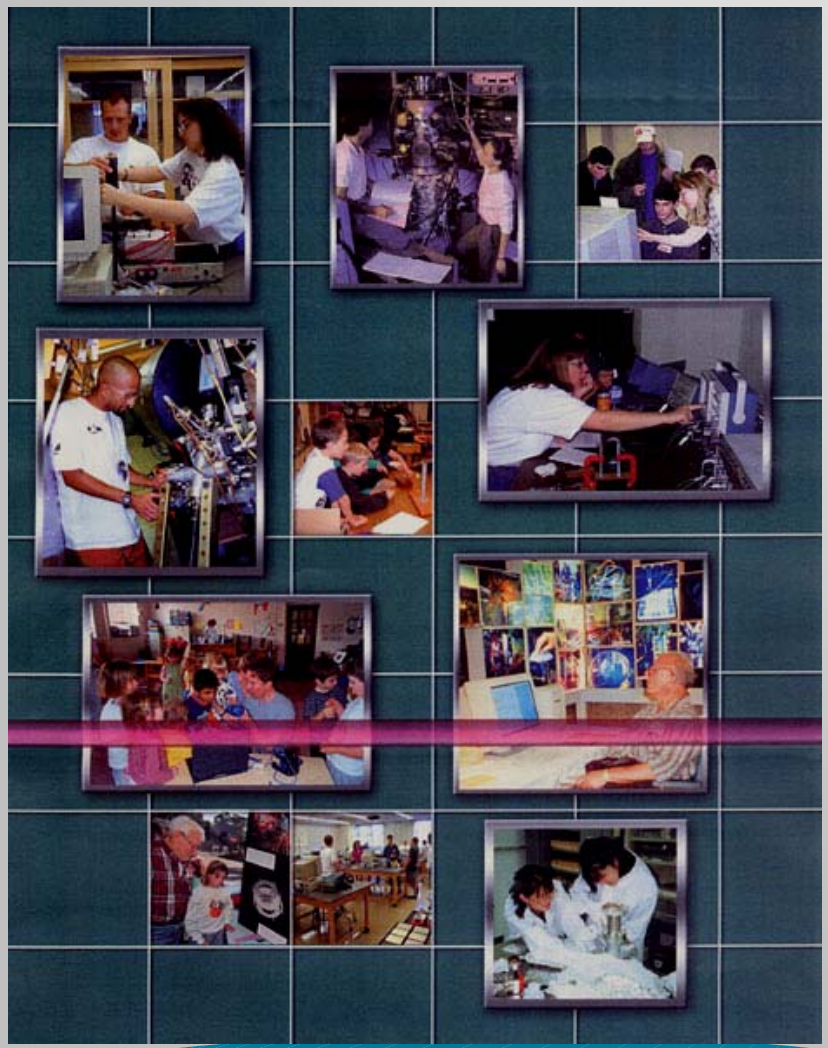
3 Lead Teachers

12 Associate Teachers.

Led by Stu Loken
and Helmuth Spieler

These teachers (as well as their students and their parents) are a corps of goodwill ambassadors for particle physics.

Education Summary



- QuarkNet
- Contemporary Physics Educ Project
- Charts
- Particle Adventure
- ATLAS (movie, website, event, etc.)
- Nobel e-Museum
- Collaboration with NOVA, APS, Europeans,…
- Outreach Book