

Service to Physics Community

Review of Particle Physics

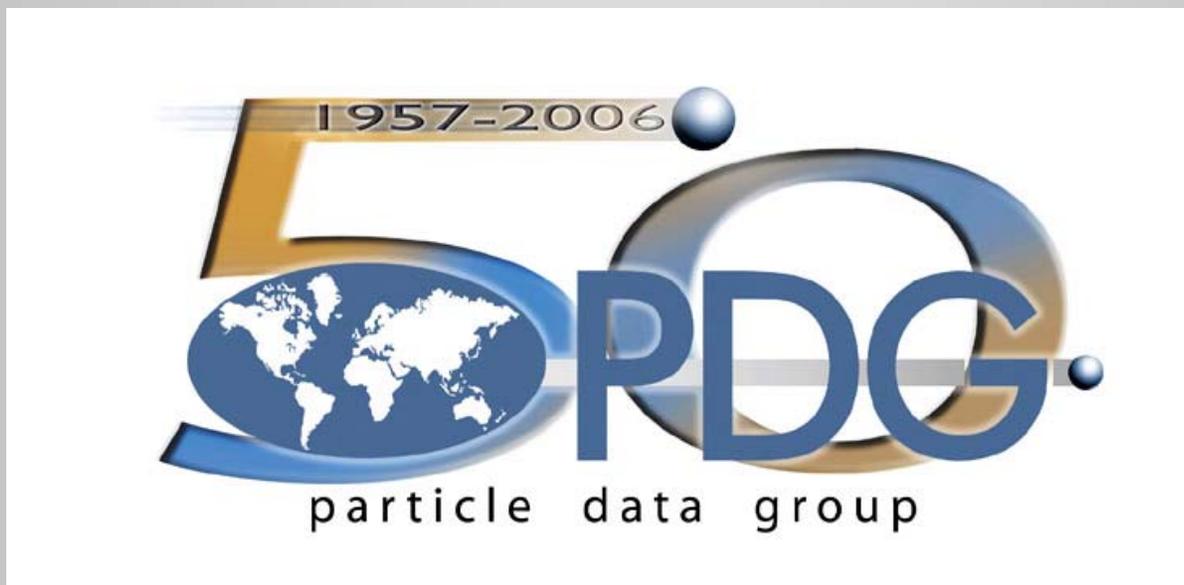
Education/Outreach Programs

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 ± 0.06 (a)		$(2.22 \pm 0.02) \times 10^{-6}$	0.45×10^6
Mesons	π^+	0	139.63 ± 0.06 (a)	4.6 (a)	$(2.56 \pm 0.05) \times 10^{-8}$ (a)	0.39×10^8
	π^0	0	135.04 ± 0.16 (a)		$< 4 \times 10^{-16}$ (d)	$> 2.5 \times 10^{15}$
	K^+	0	494.0 ± 0.2 (g)	0.4 ± 1.8	$(1.224 \pm 0.013) \times 10^{-8}$ (h)	0.815×10^8
	K^0	0	494.4 ± 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 ± 0.01 (a)		stable	0.0
	n	$\frac{1}{2}$	939.506 ± 0.01 (a)		$(1.04 \pm 0.13) \times 10^{+3}$ (a)	0.96×10^{-3}
	Λ	$\frac{1}{2}$	1115.2 ± 0.14 (j)		$(2.77 \pm 0.15) \times 10^{-10}$ (k)	0.36×10^{10}
	Σ^+	$\frac{1}{2}$	1189.4 ± 0.25 (l)	7.1 ± 0.4	$(0.83^{+0.06}_{-0.05}) \times 10^{-10}$ (m)	1.21×10^{10}
	Σ^-	$\frac{1}{2}$	1196.5 ± 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 $\sim 10^{-19}$	theoretically $\sim 10^{19}$
Ξ	?	1320.4 ± 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

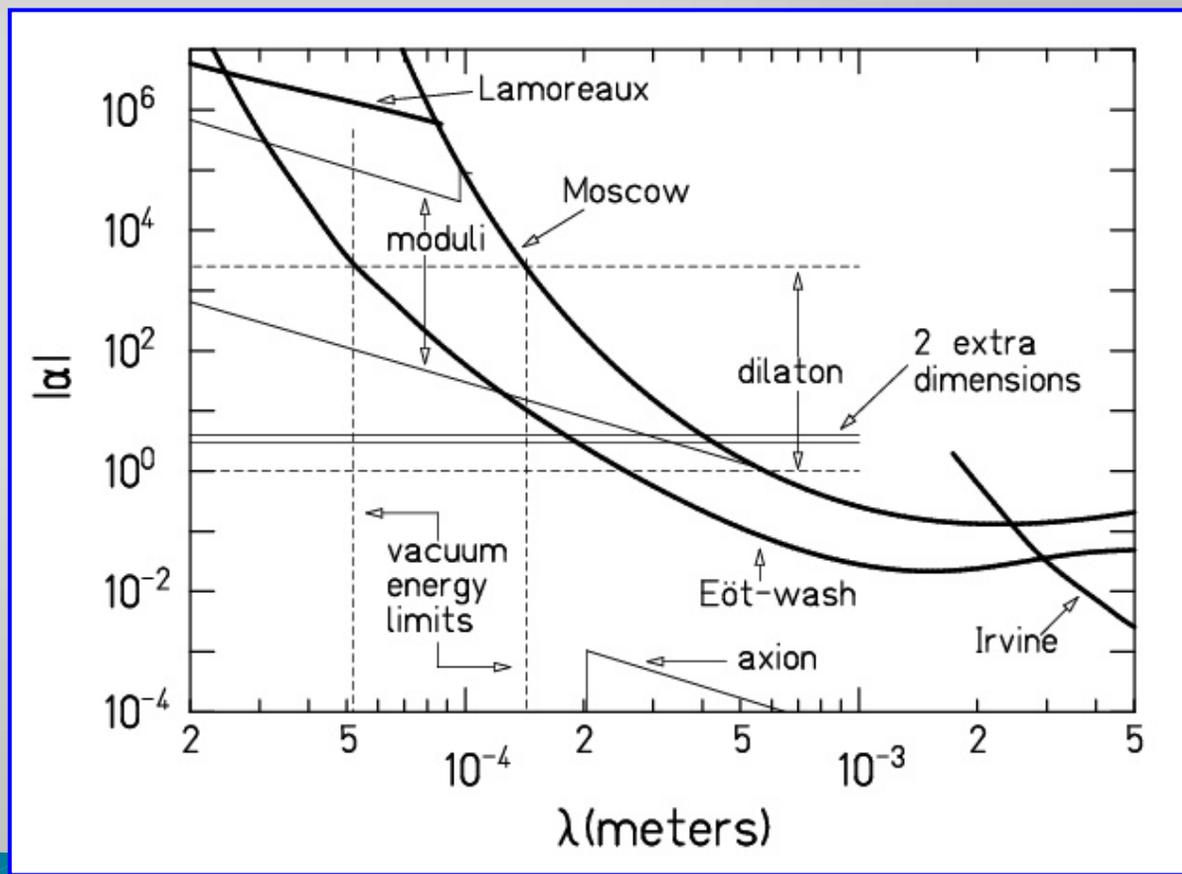
LBLN Leads
the Particle Data Group collaboration
of 156 authors
from 17 countries and 90 institutions
+ 700 consultants in the HEP community



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.

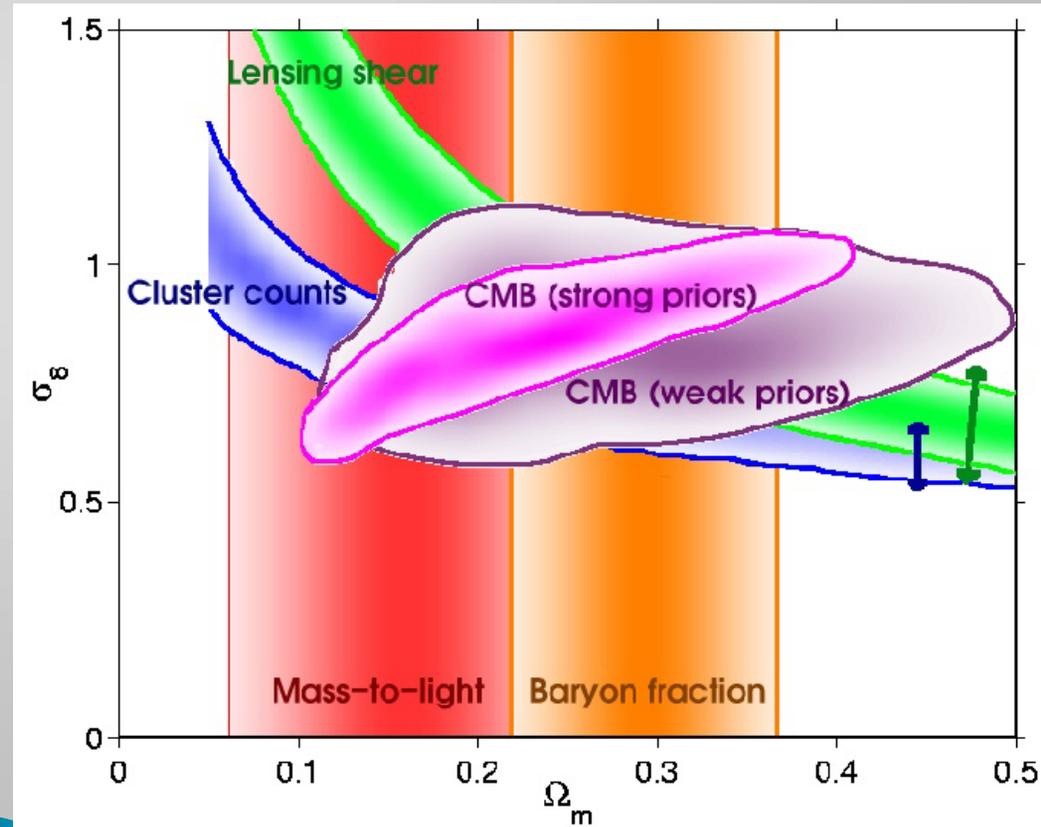
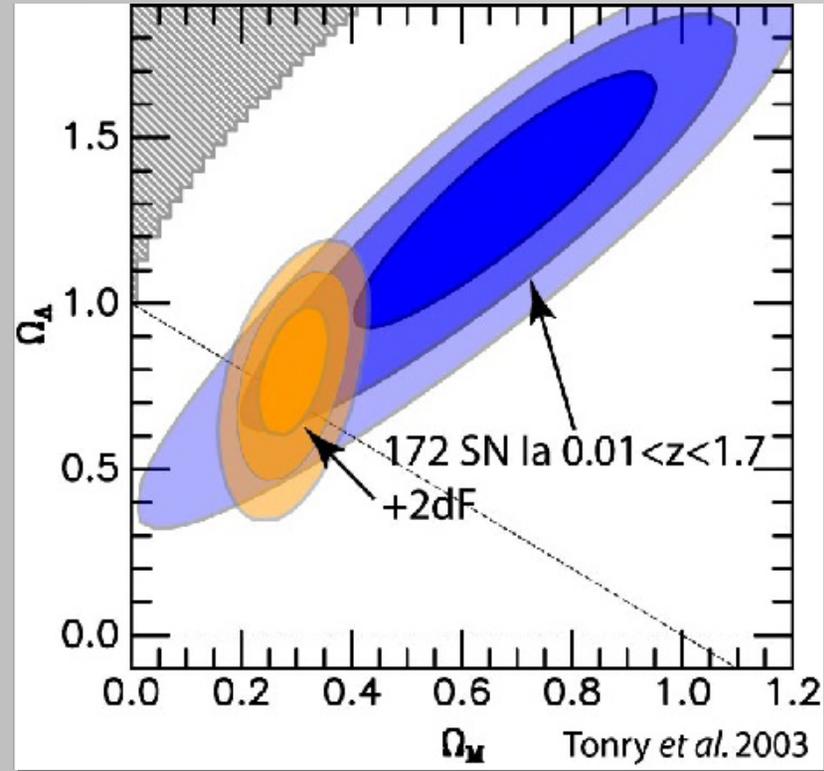
Experimental Tests of Gravitational Theory

Dark Matter

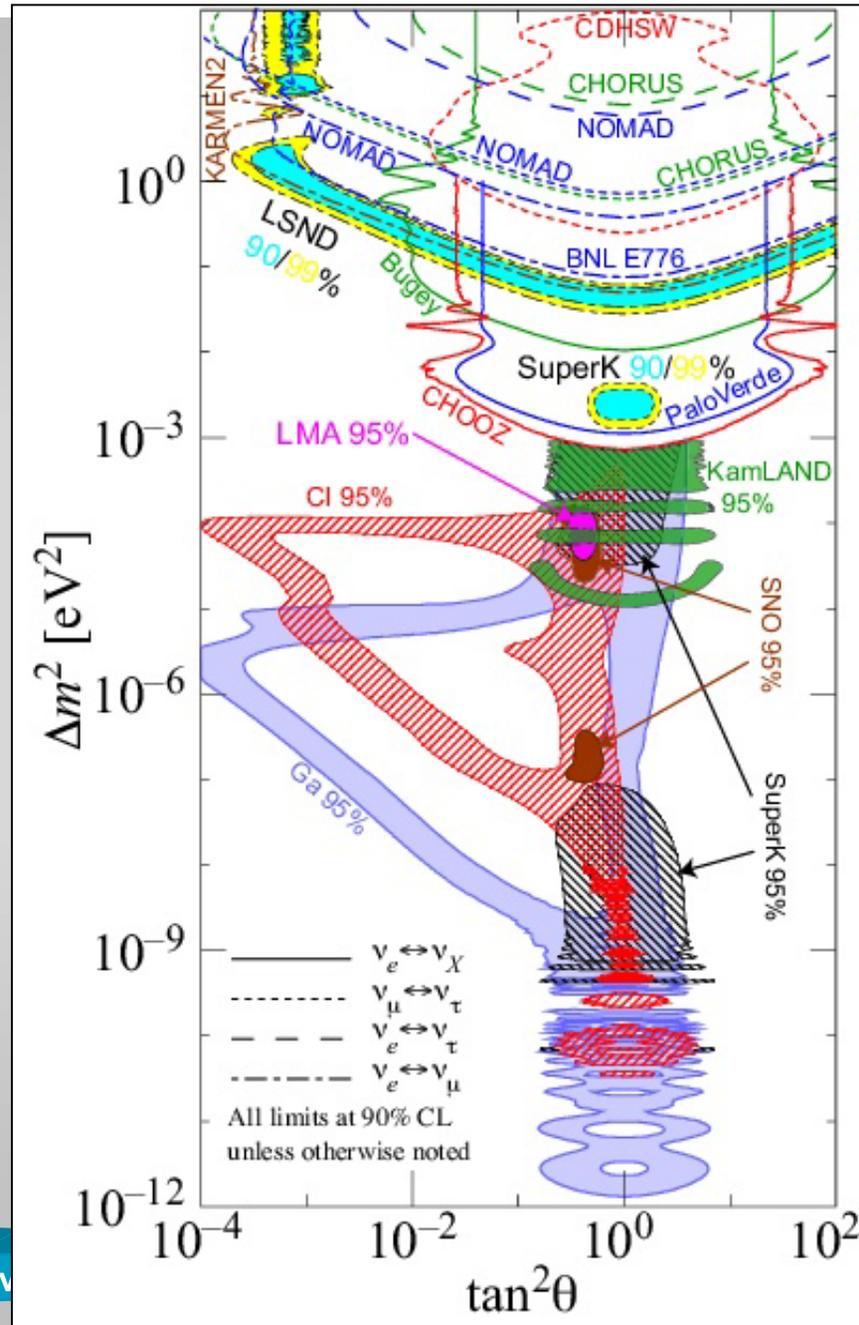
Cosmic Background Radiation

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

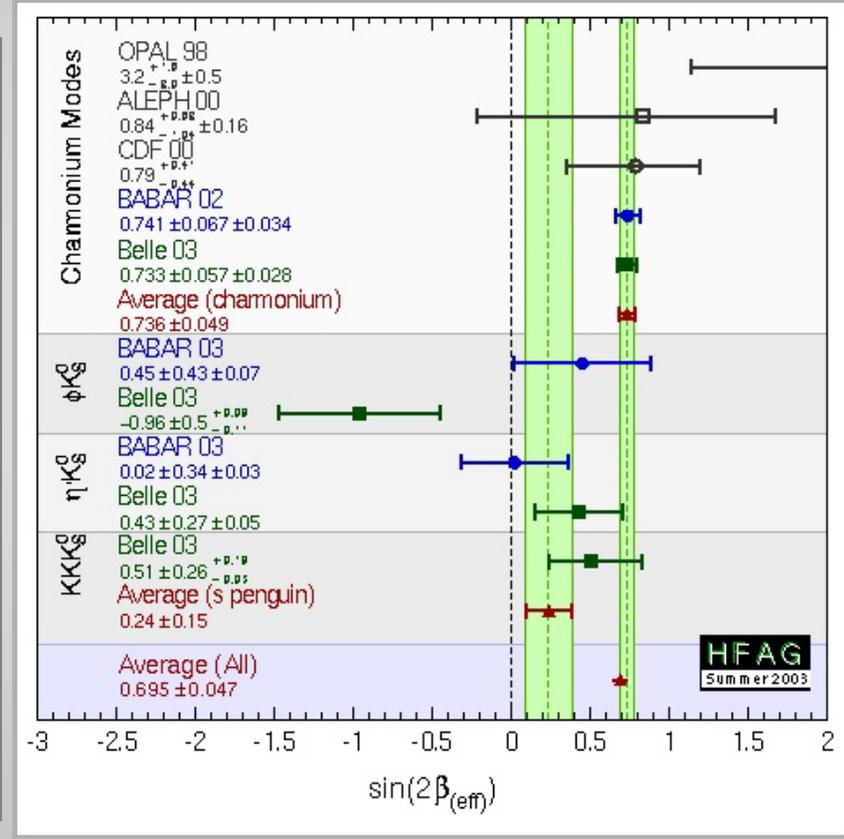
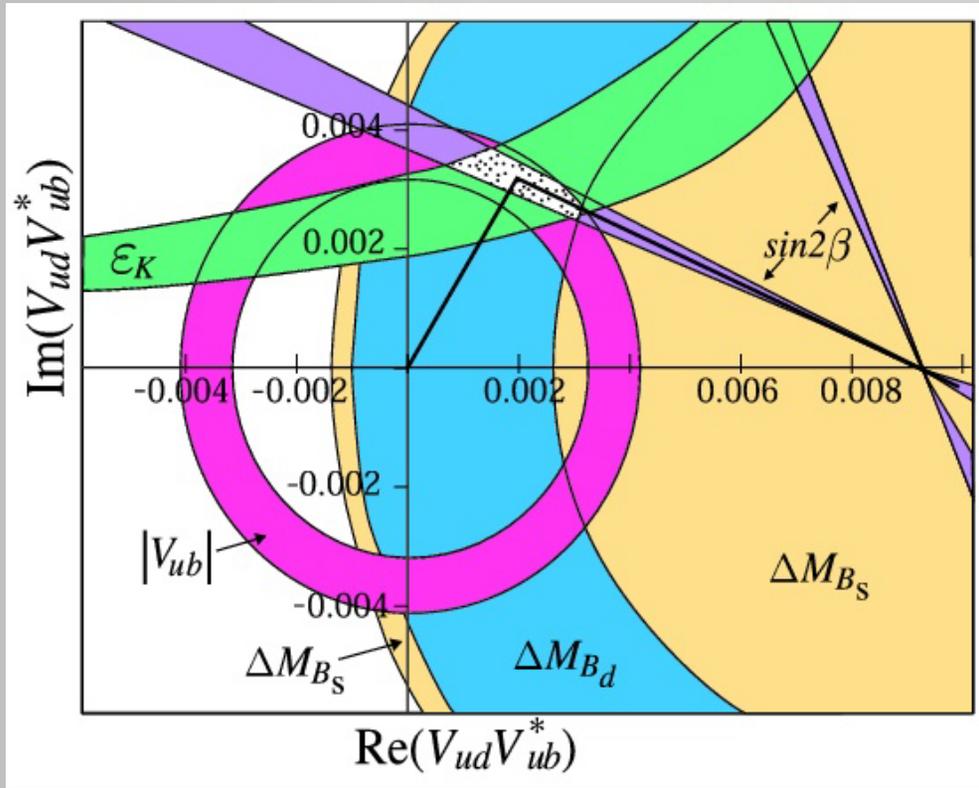
The well-established baryon states can be understood as combinations of three valence quarks. In this discussion, we confine ourselves to baryon states constructed from combinations of u , d , and s quarks. The three-quark combinations are members of SU(3) singlets, octets, and decuplets. Baryon states 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

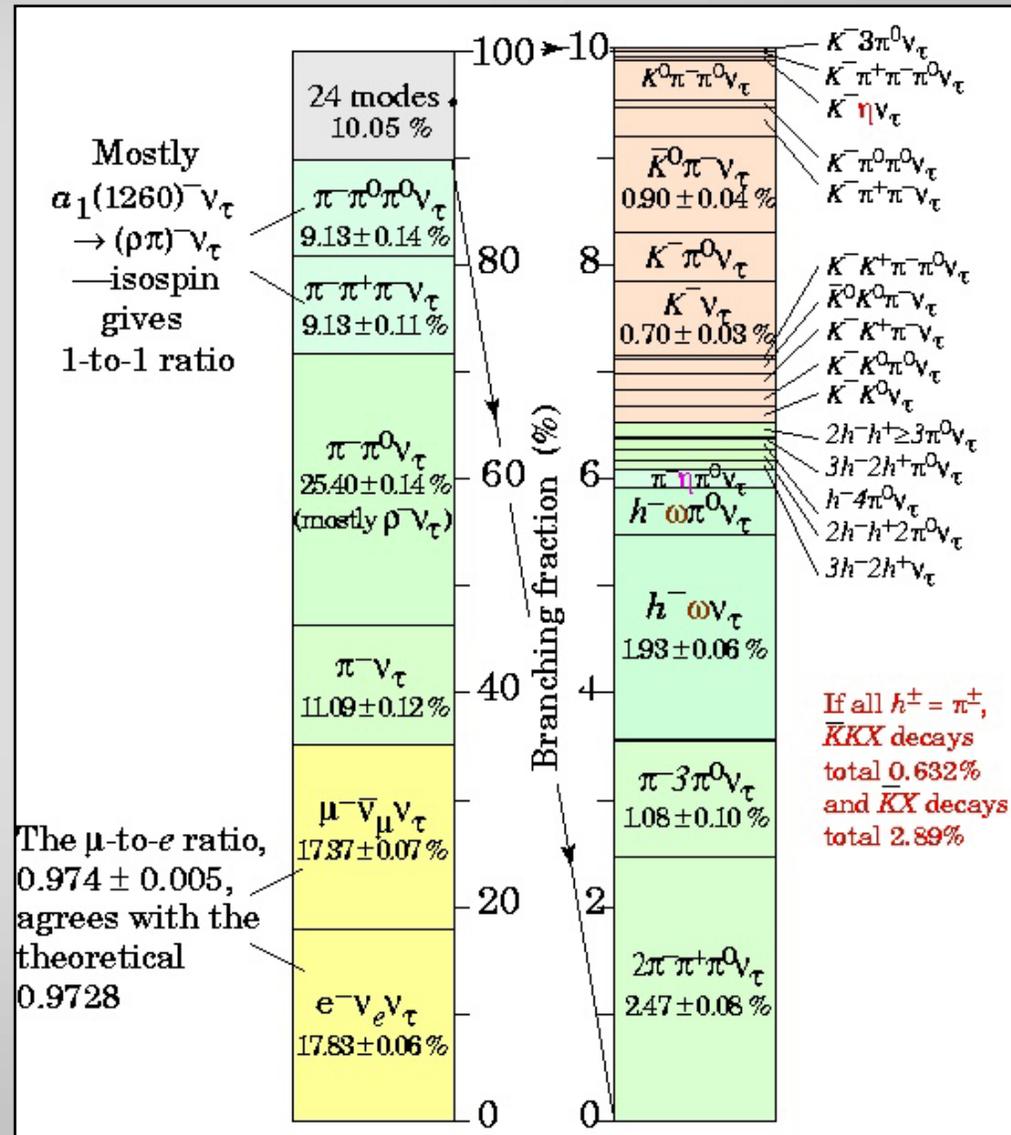
Unifies CP Violation in K, D and B Mesons



Complex Fits with Correlations

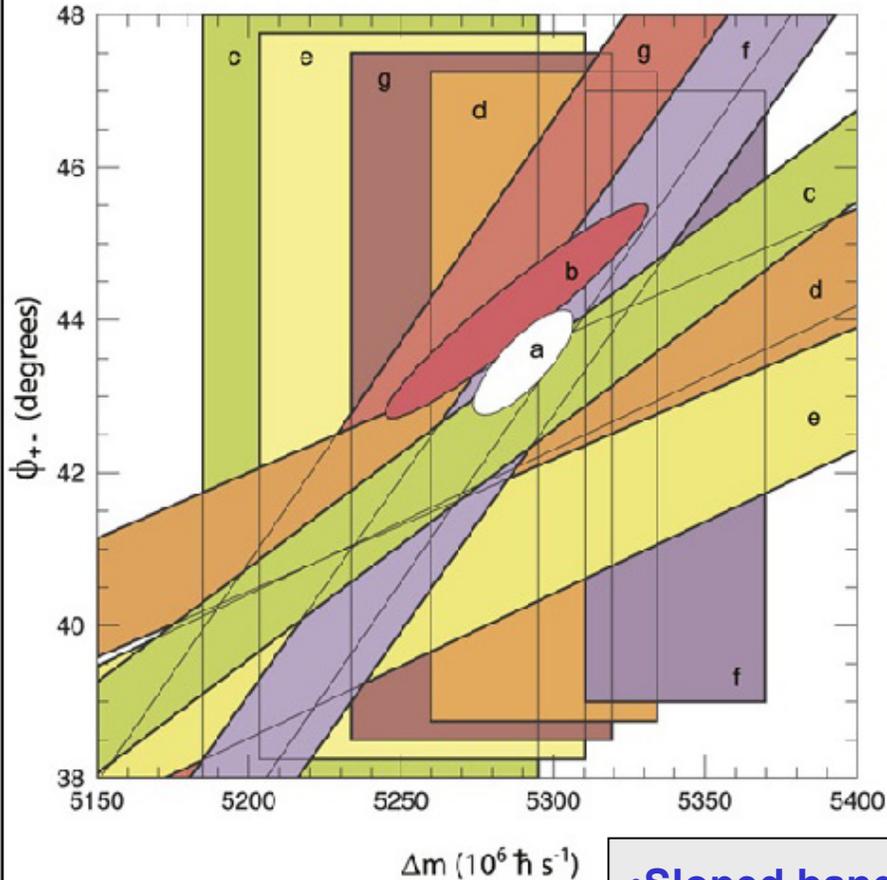
e.g.:

τ Branching Fractions



K_L CP Violation Fit

($\chi^2=17.4$ 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_{+-}

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

Δm is $K_L - K_S$ mass diff.

- Sloped bands show dependence of ϕ meas.'s on $\Delta(m)$
- 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
<ul style="list-style-type: none"> ▼ Reviews on Bosons ▼ γ ▼ gluon ▼ graviton ▼ W ▼ Z ▼ Higgs Bosons ▼ Heavy Bosons ▼ Axions 	<ul style="list-style-type: none"> ▼ Reviews on the Leptons ▼ e, μ, τ ▼ Heavy Charged Lepton Searches ▼ ν_e, ν_μ, ν_τ ▼ Number of Neutrino Types ▼ Double-β Decay ▼ Neutrino Mixing ▼ Heavy Neutral Leptons, Searches for 	<ul style="list-style-type: none"> ▼ Reviews on Quarks ▼ Light quarks (u, d, s) ▼ c ▼ b ▼ t ▼ b' quark, searches for ▼ Free quark searches
MESONS	BARYONS	Other Searches
<ul style="list-style-type: none"> ▼ Reviews on Mesons ▼ Light Unflavoured Mesons ▼ Other Light Unflavoured Mesons ▼ Strange Mesons ▼ Charmed Mesons ▼ Charmed, Strange Mesons ▼ Bottom Mesons ← ▼ Bottom, Strange Mesons ▼ Bottom, Charmed Mesons ▼ $c\bar{c}$ Mesons ▼ $b\bar{b}$ Mesons ▼ Non $q\bar{q}$ Candidates 	<ul style="list-style-type: none"> ▼ Reviews on Baryons ▼ N Baryons ▼ Δ Baryons ▼ Exotic Baryons ▼ Λ Baryons ▼ Σ Baryons ▼ Ξ Baryons ▼ Ω Baryons ▼ Charmed Baryons ▼ Doubly-Charmed Baryons ▼ Bottom Baryons 	<ul style="list-style-type: none"> ▼ Reviews on Other Searches ▼ Magnetic Monopole Searches ▼ Supersymmetric Particles ▼ Technicolor ▼ Searches for Quark and Lepton Compositeness ▼ Extra Dimensions ▼ WIMPs and Other Particle Searches

Future of RPP on the Web

GAUGE AND HIGGS BOSONS	LEPTONS	QUARKS
<ul style="list-style-type: none"> ▼ <i>Reviews on Bosons</i> ▼ γ ▼ gluon ▼ graviton ▼ W ▼ Z ▼ Higgs Bosons ▼ Heavy Bosons ▼ Axions 	<ul style="list-style-type: none"> ▼ <i>Reviews on the Leptons</i> ▼ e, μ, τ ▼ Heavy Charged Lepton Searches ▼ ν_e, ν_μ, ν_τ ▼ Number of Neutrino Types ▼ Double-β Decay ▼ Neutrino Mixing ▼ Heavy Neutral Leptons, Searches for 	<ul style="list-style-type: none"> ▼ <i>Reviews on Quarks</i> ▼ Light quarks (u, d, s) ▼ c ▼ b ▼ t ▼ b' quark, searches for ▼ Free quark searches
MESONS	BARYONS	Other Searches
<ul style="list-style-type: none"> ▼ <i>Reviews on Mesons</i> ▼ F^{\pm} ▼ B^0 ← ▼ B^{\pm}/B^0 Admixture ▼ $B^{\pm}/B^0/B_s^0/lb$-baryon Admixture ▼ V_{cb} and V^{ub} CKM Matrix Elements ▼ B^* ▼ $B_s^{*+}(5732)$ 	<ul style="list-style-type: none"> ▼ <i>Reviews on Baryons</i> 	<ul style="list-style-type: none"> ▼ <i>Reviews on Other Searches</i> ▼ Magnetic Monopole Searches ▼ Supersymmetric Particles ▼ Technicolor ▼ Searches for Quark and Lepton Compos ▼ Extra Dimensions ▼ WIMPs and Other Particle Searches

Future of RPP on the Web

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

$$\Gamma(\mathcal{J}\psi(1S) K^0) / \Gamma_{\text{total}}$$

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	$e^+ e^- \rightarrow \Upsilon(4S)$
8.3 ± 0.4 ± 0.5	1	AUBERT	02	BABR	$e^+ e^- \rightarrow \Upsilon(4S)$
9.5 ± 0.8 ± 0.6	1	AVERY	00	CLE2	$e^+ e^- \rightarrow \Upsilon(4S)$
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	$e^+ e^- \rightarrow \Upsilon(4S)$
9.3086 ± 7.3586 ± 0.1570	2 4	ALBRECHT	90J	ARG	$e^+ e^- \rightarrow \Upsilon(4S)$
*** We do not use the following data for averages, fits, limits, etc. ***					
8.5 ^{+1.4} _{-1.2} ± 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	$e^+ e^- \rightarrow \Upsilon(4S)$

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

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

³ BORTOLETTO 1992 reports $6 \pm 3 \pm 2$ for $B(\mathcal{J}\psi(1S) \rightarrow e^+ e^-) = 0.069 \pm 0.009$. We rescale to our best value $B(\mathcal{J}\psi(1S) \rightarrow e^+ e^-) = (5.93 \pm 0.10) \times 10^{-2}$. 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 $8 \pm 6 \pm 2$ for $B(\mathcal{J}\psi(1S) \rightarrow e^+ e^-) = 0.069 \pm 0.009$. We rescale to our best value $B(\mathcal{J}\psi(1S) \rightarrow e^+ e^-) =$

SPIRES

HEP :: HEPNAMES :: INSTITUTIONS :: CONFERENCES :: EXPERIMENTS :: JOINT

Modify your search below.

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-PJB-89C9, 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

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FULL LIST OF MEASUREMENTS

Physical Review D65 (2002)032001
AUBERT 2002
BaBar Collab.
Measurement of Branching Fractions for Exclusive B Decays to Charmonium Final States

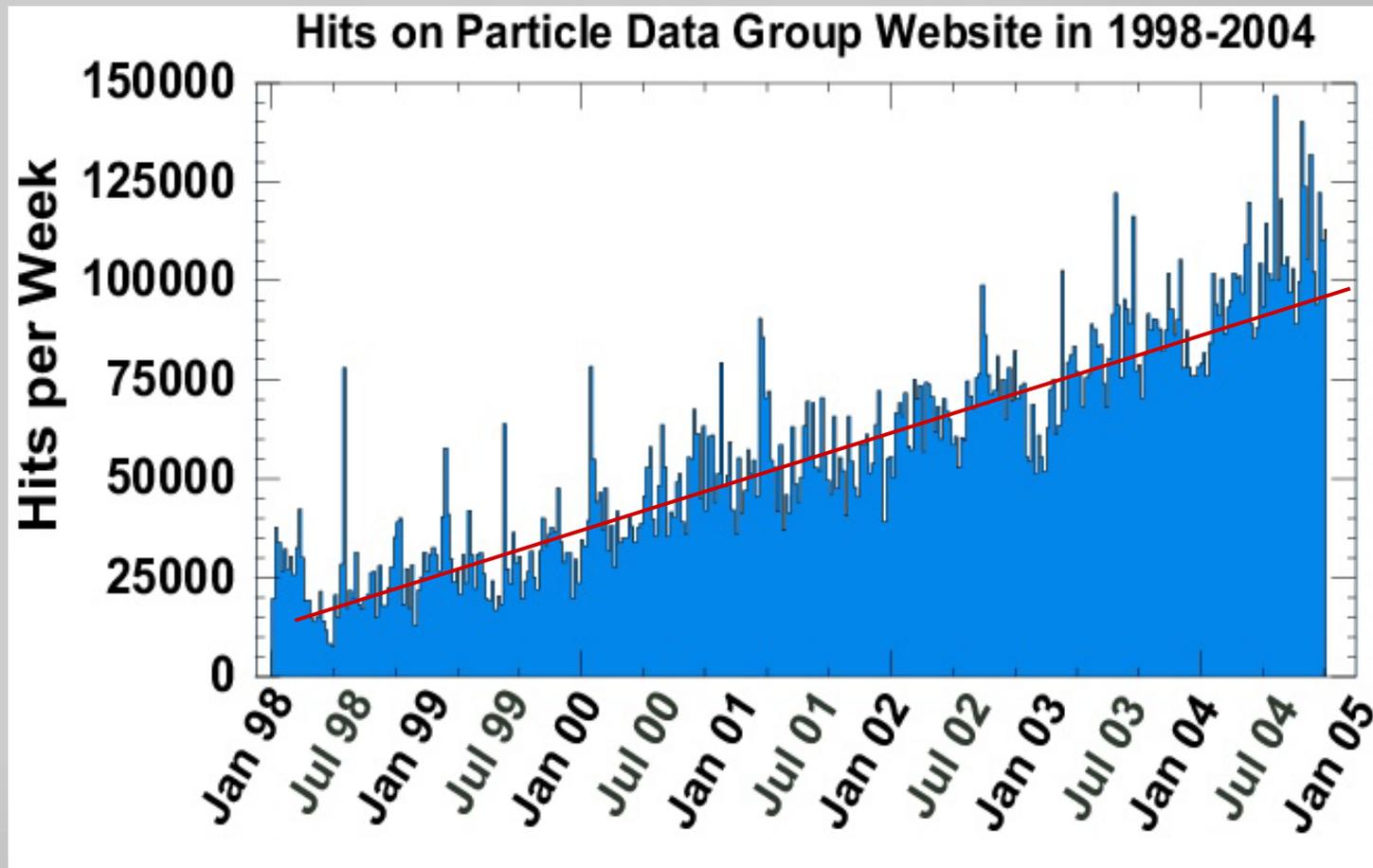
	Measurement			(Unit)	Particle (Section)	Observable
used	0.1	± 0.3	± 0.5	(10 ⁻⁴)	B [±]	Γ(B _s → S)K [±] / Γ _{total}
used	0.37	± 0.09	± 0.11	(10 ⁻³)	B [±]	Γ(B _s → S)K [±] (892 [±]) / Γ _{total}
used	0.57	-0.10	+0.08		B [±]	Γ(B _s → S)K [±] (892 [±])/Γ(B _s → S)K [±] (15)
used	6.4	± 0.5	± 0.8	(10 ⁻⁴)	B [±]	Γ(ψ(2S)K [±]) / Γ _{total}
used	0.64	± 0.06	± 0.07		B [±]	Γ(ψ(2S)K [±])/Γ(B _s → S)K [±]
used	6.4794	± 1.0351	± 0.6766	(10 ⁻⁴)	B [±]	Γ(X _{c1} (1P)K [±]) / Γ _{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

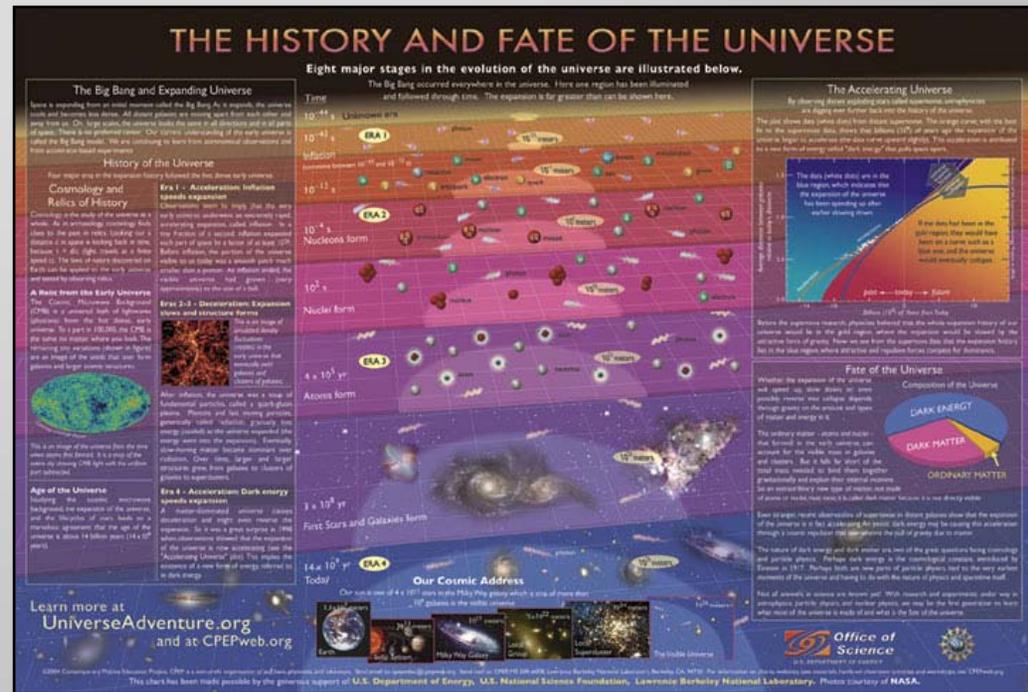
**PDG, ATLAS, QuarkNet,
Contemporary Physics Education Project,
European Outreach Group,
NOVA, Nobel Foundation, etc.**

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

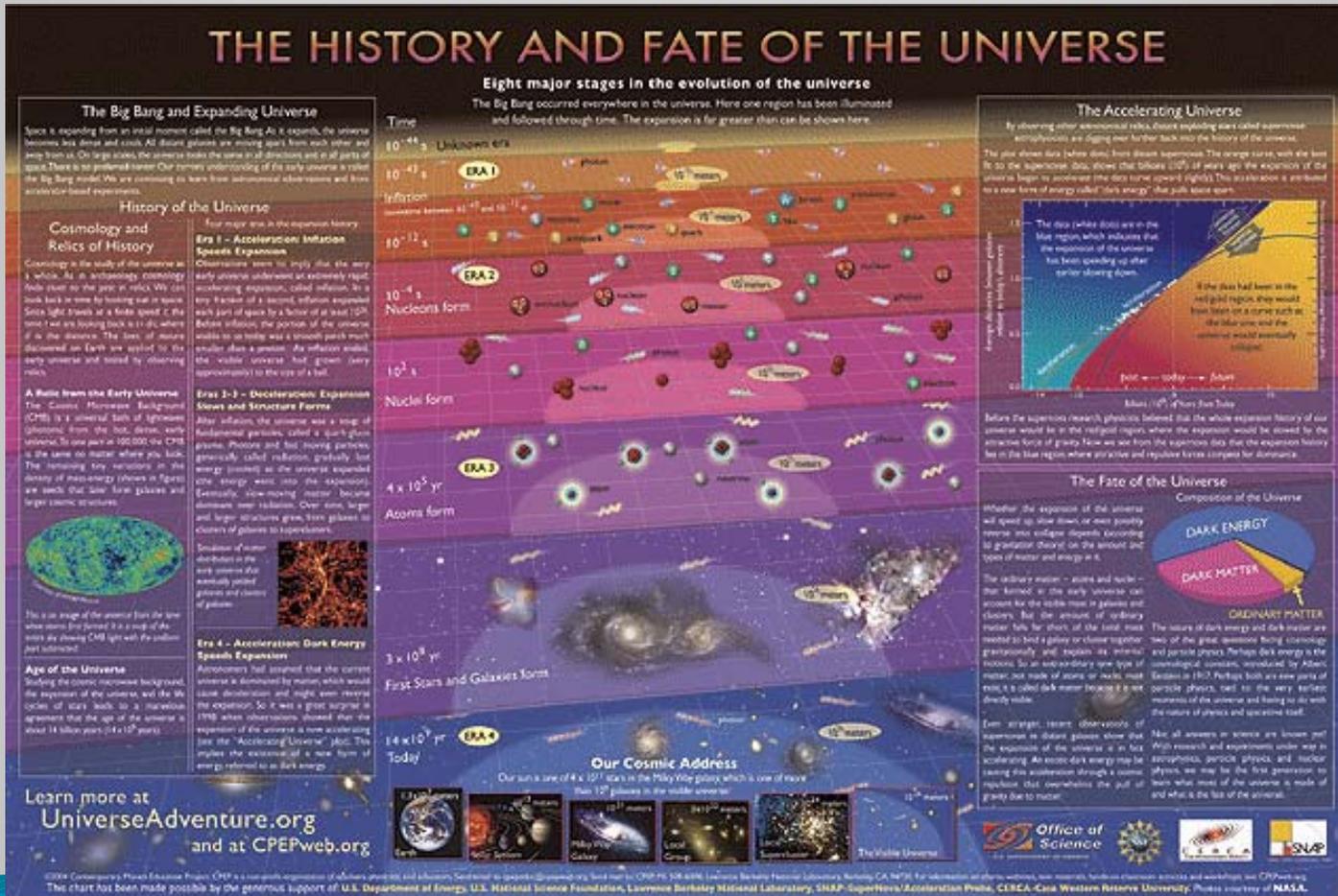
Several years of work by physicists and teachers, and a field test in classrooms.



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



[SITE MAP](#) [GLOSSARY](#) **The Universe Adventure**

The Physics Division of Lawrence Berkeley National Laboratory presents
an interactive tour of the History and Fate of the Universe

[Start](#)

The Universe Adventure

 **Office of Science**
U.S. DEPARTMENT OF ENERGY



[Poster: History and Fate of the Universe](#)
[Other Interesting Sites](#)
[credits](#)

Photos courtesy of NASA

Copyright 2003 by the Particle Data Group. Notice to Users.

[◀ previous](#) | [next ▶](#)

UniverseAdventure.org

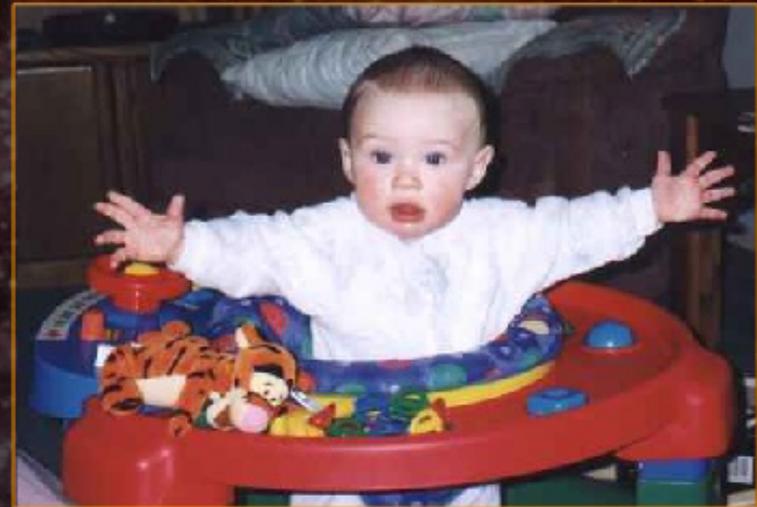
SITE MAP GLOSSARY

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

SITE MAP **GLOSSARY**

- Introduction
- Homepage
- Think Big
 - You Are Here
 - Cosmic Address
- Is The Universe Expanding?
- Are We At The Center?
- The Expanding Universe
- Everywhere Expansion
- Redshifts
- More Redshifts
- Do Galaxies Expand?
- Measuring Cosmic Distances
- Standard Candles
- How Do We Measure?
 - How Are Apparent Brightness
 - And actual Luminosity Related
- Supernova as Standard Candles
- The BigBang
- Looking Back In Time
- How Far Back?
- What Is The Big Bang?
- How Old Is The Universe?
- Age Of The Universe: Refined
- How Big Is The Universe?
- The Cosmological Principle
- How big Is The Entire Universe?
- What Is The History?
- The Universe Today
- The Accelerating Universe
- What Causes Acceleration
- The future Of The Universe
- What is Dark Matter
- Where Are We Going?

The Universe Adventure

Where are we now in space?

Are We At The Center?

... still believed the model of Earth in the center of our universe as developed because of the sun revolving around Earth. ... assume we are special or ...

Copernican Principle. ... as the sun at the center of ...

... of the solar system, ... : the center of the universe?

You may think it is obvious that we are not in the center of the universe but ...



Nicolaus Copernicus:
(1473-1543)

Glossary -- UniverseAdventure.org

SITE MAP **GLOSSARY**

The Universe Adventure

Big Bang
 A broadly accepted theory for the origin and evolution of our universe. The theory says that the universe started expanding roughly 14 billion years ago from an extremely dense and incredibly hot initial state.

acceleration
 accelerating universe
 angular size
 annihilated/annihilation
 antiparticle
 antimatter
 apparent luminosities
 atoms
 background radiation
 baryon
 baryonic matter
 Big Bang

REDSHIFTS

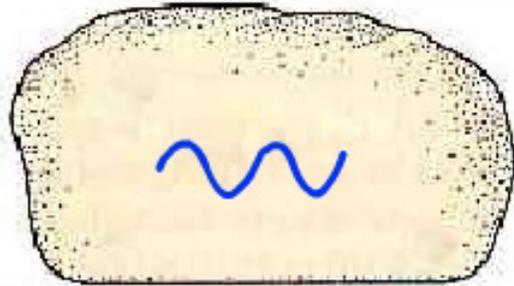
As galaxies get stretched and their wavelengths stretched, the longer the wavelengths, the more the wave gets shifted in the red direction. Light from a galaxy is shifted in the red direction because...



→

the red direction of the color spectrum

light wave
...
...?



"Play" to expand our raisin bread universe

Play

... Doppler effect?

How can we observe redshifts?

Posters star in movies



Standard Model of FUNDAMENTAL PARTICLES AND INTERACTIONS

The Standard Model comprises the current knowledge in Particle Physics. It is the quantum theory that includes the theory of strong interactions (Quantum Chromodynamics or QCD) and the unified theory of weak and electromagnetic interactions (electroweak). Gravity is included on this chart because it is one of the fundamental interactions even though not part of the "Standard Model".

FERMIONS

Leptons spin = 1/2

Flavor	Mass GeV/c ²	Electric charge
e^- electron	0.511×10^{-6}	0
μ^- muon	0.105658	-1
τ^- tau	1.777	-1

Quarks spin = 1/2

Flavor	Approx. Mass GeV/c ²	Electric charge
u up	0.003	2/3
d down	0.006	-1/3
c charm	1.3	2/3
s strange	0.1	-1/3
t top	175	2/3
b bottom	4.3	-1/3

Structure within the Atom

BOSONS

Unified Electroweak spin = 1

Name	Mass GeV/c ²	Electric charge
γ photon	0	0
W^\pm	80.4	-1
Z^0	91.1876	0

Strong (color) spin = 1

Name	Mass GeV/c ²	Electric charge
g gluon	0	0

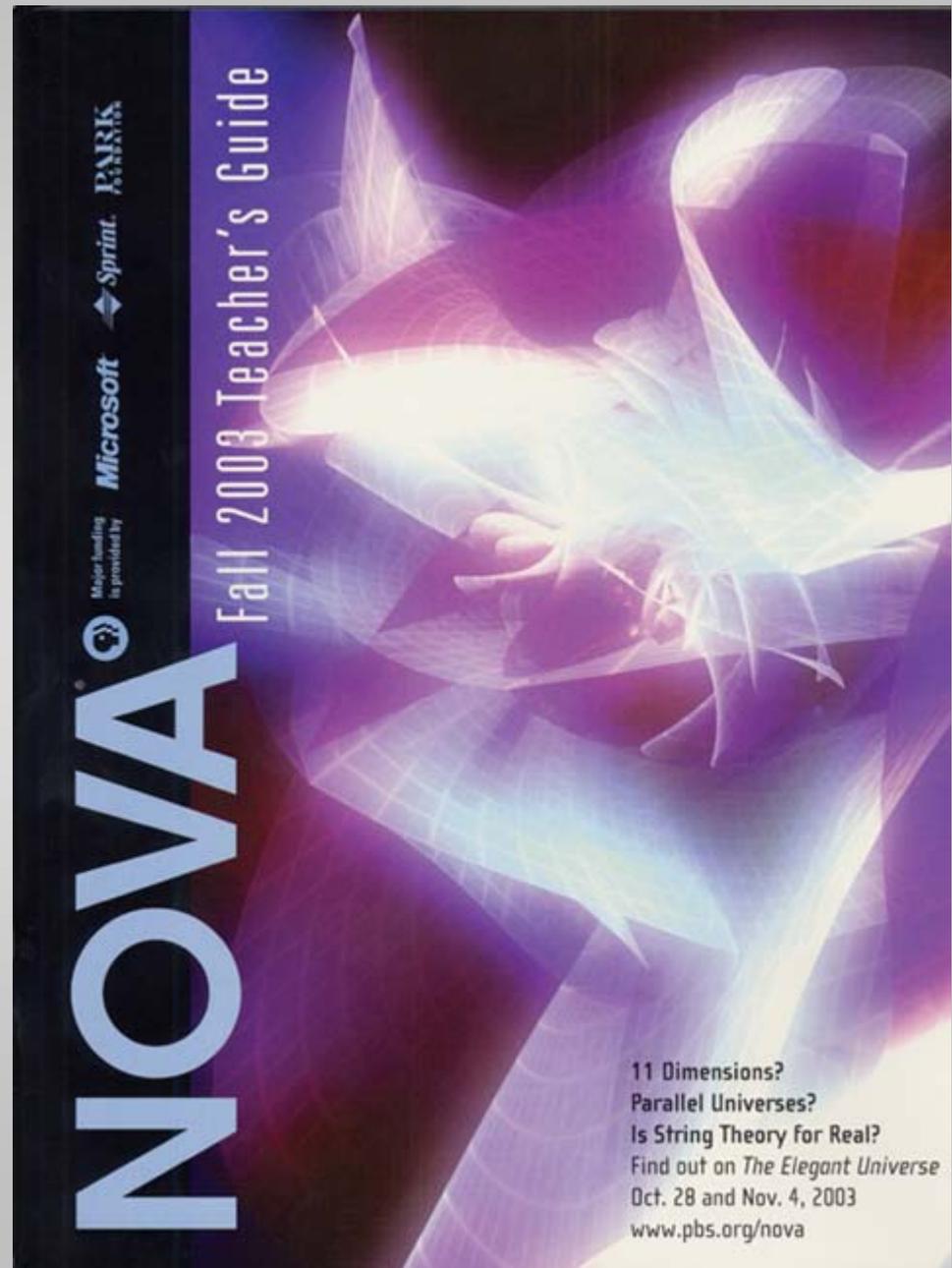
PROPERTIES OF THE INTERACTIONS

Property	Gravitational	Weak	Electromagnetic	Strong
Acts on:	Mass + Energy	Flavor	Electric Charge	Color Charge
Particles experiencing:	All	Quarks, Leptons	Electrically charged	Quarks, Gluons
Particles mediating:	Graviton (not observed)	W^\pm, Z^0	γ	Gluons
Strength (compared to electromagnetism)	10^{-42}	10^{-6}	1	25
Range (compared to electromagnetism)	10^{26}	10^{-16}	10^8	Not applicable to quarks
Not applicable to:				20

NOVA
ONLINE

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

M. Barnett – Directors Review Nov 2004



Languages :

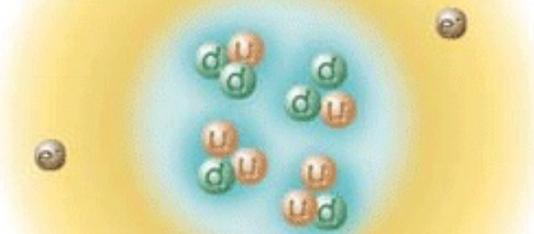
- [Chinese](#)
- [\(in USA / Taiwan\)](#)
- [Deutsch](#)
- [Dutch](#)
- [Español](#)
- [\(in USA / Spain\)](#)
- [Française](#)
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- [Polski](#)
- [Português](#)
- [Slovenska](#)
- [Suomea \(Finnish\)](#)

Languages →

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

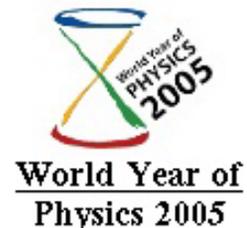
the fundamentals of matter and force



Start Here

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](#)



Supported by
US
DOE and NSF



[Funding Credits](#)

[Project Credits](#)

We appreciate your comments.

Send email to pdgeduc@lbl.gov

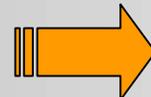
Teachers may use this [form](#)

Example of Recognition



Physics

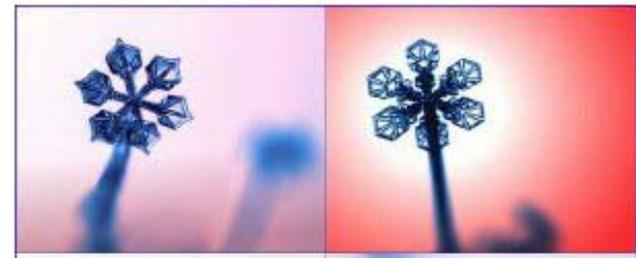
[The Particle Adventure](#)



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)

語言:
[Español \(USA\)](#)
[Español \(Spain\)](#)
[Française](#)
[Greek](#)
[Italiano](#)
[Polski](#)
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Supported by
US DOE and NSF



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

The [Particle Data Group of Lawrence Berkeley National Laboratory](#) presents
以下網頁由師大物理系朱玉棉與鄭伊嵐同學翻譯完成
更感謝原始網站同意我們將其內容翻譯成中文!

粒子冒險奇境

力與物質的基本



由此進入 

關於夸克、微中子、反物質、另一個次元、黑暗物質、加速器及粒子偵測器的奇妙旅行。

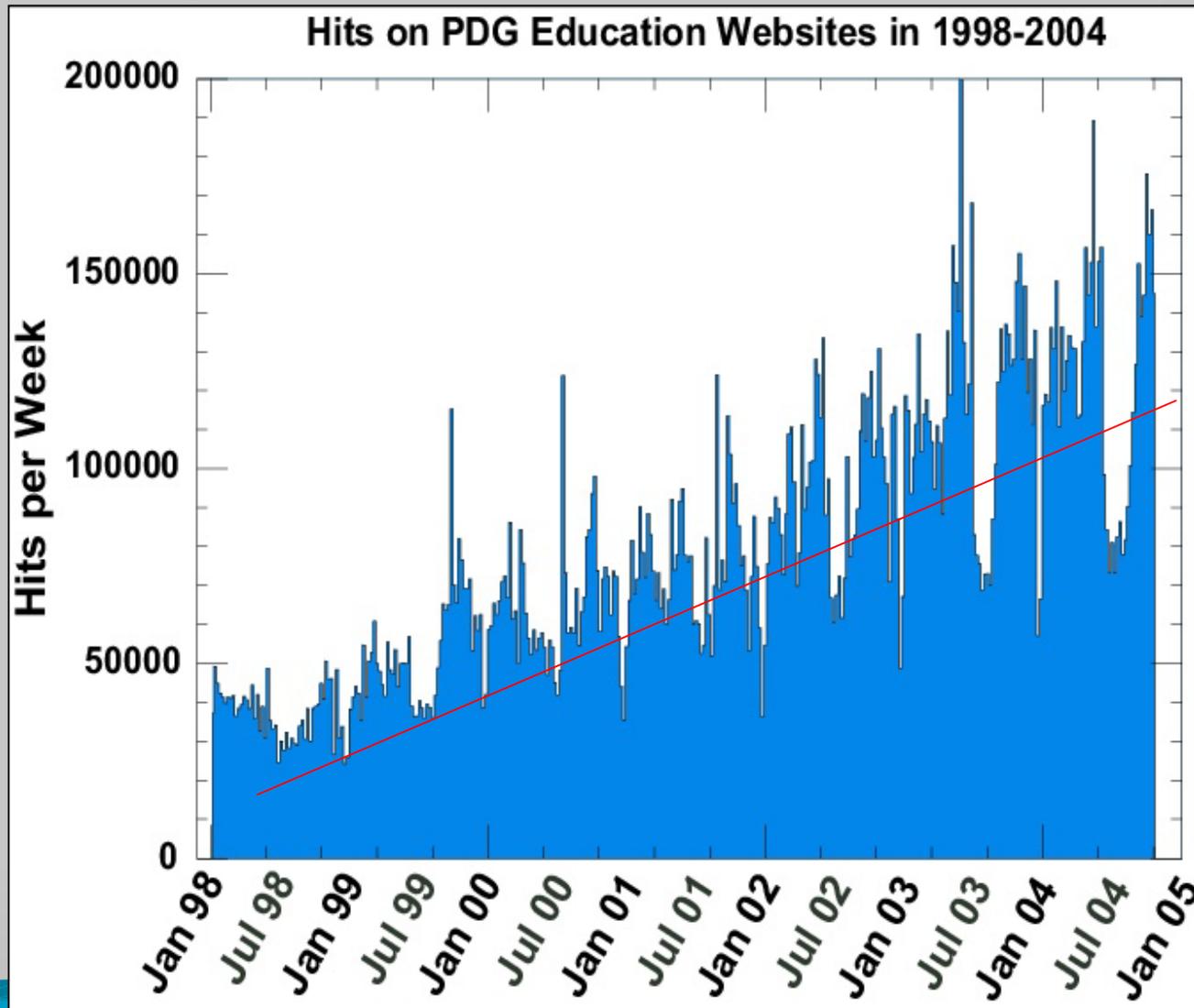
The Particle Adventure

粒子物理新聞

- [物質與反物質的本質差異](#)
- [LHC 粒子數據挑戰標準模型](#)
- [重粒子的暗示：希格斯玻色子](#)
- [發現微中子](#)
- [初期的宇宙](#)
- [Intriguing Indications of CP Violation in B Mesons](#)
- [另一維空間？](#)
- [微中子振盪知識的進展](#)
- [The Arrow of Time](#)
- [宇宙中的壓力](#)
- [諾貝爾物理獎](#)

2000 版權 by the Particle Data Group. [使用者注意事項](#)

Web Usage (Excluding mirror / language sites)



ATLAS Outreach Coordinator

Public
Webpages
With 45-second
Flash animation

<http://ATLAS.ch>



The ATLAS Experiment

TAKE an eTOUR!

Introduction Physics Experiment Accelerator

ATLAS is a particle physics experiment that will explore the fundamental nature of matter and the basic forces that shape our universe. The ATLAS detector will search for new discoveries in the head-on collisions of protons of extraordinarily high energy. ATLAS is the largest collaborative effort ever attempted in the physical sciences. There are 1800 physicists participating from more than 150 universities and laboratories in 34 countries.
[More...](#)

The ATLAS Detector
Large Hadron Collider at CERN

Start again

Watch the award winning ATLAS Movie

ATLAS Multimedia Detector Description!

ATLAS Collaboration ATLAS eNews Education Committee Glossary

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

<http://atlas.ch/movie>

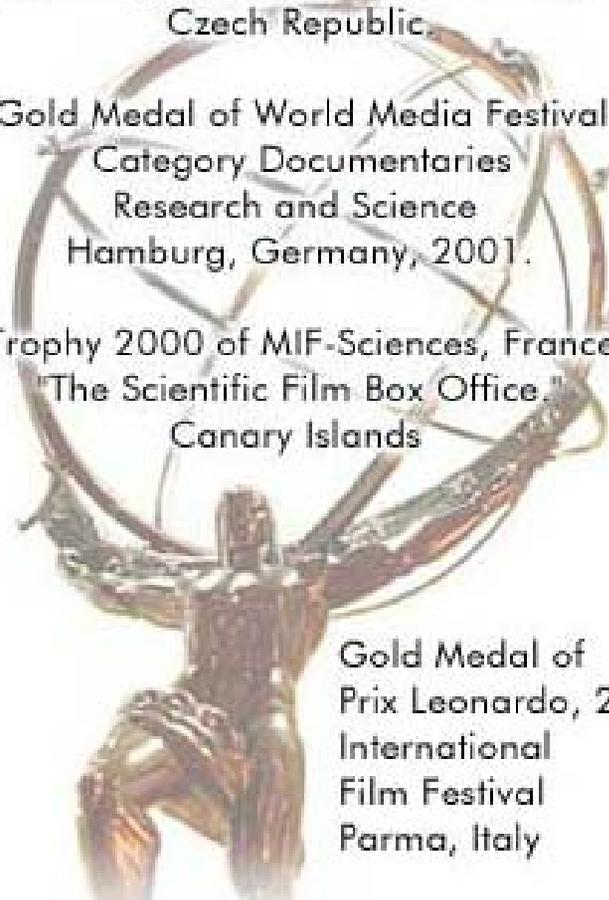
**Czech, Dutch, English, French,
German, Italian, Japanese,
Spanish, Swedish, Chinese**

FILM AWARDS

The prize for scientific films and
the prize for popular scientific films
39th International Festival
"Technology and Art TECHFILM 2001"
Czech Republic.

Gold Medal of World Media Festival
Category Documentaries
Research and Science
Hamburg, Germany, 2001.

Trophy 2000 of MIF-Sciences, France
"The Scientific Film Box Office."
Canary Islands

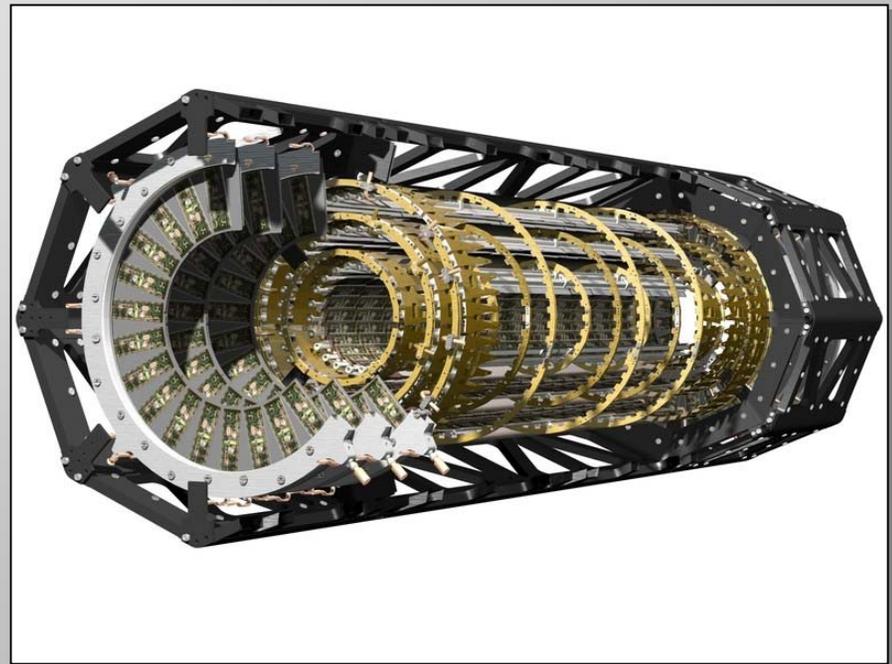
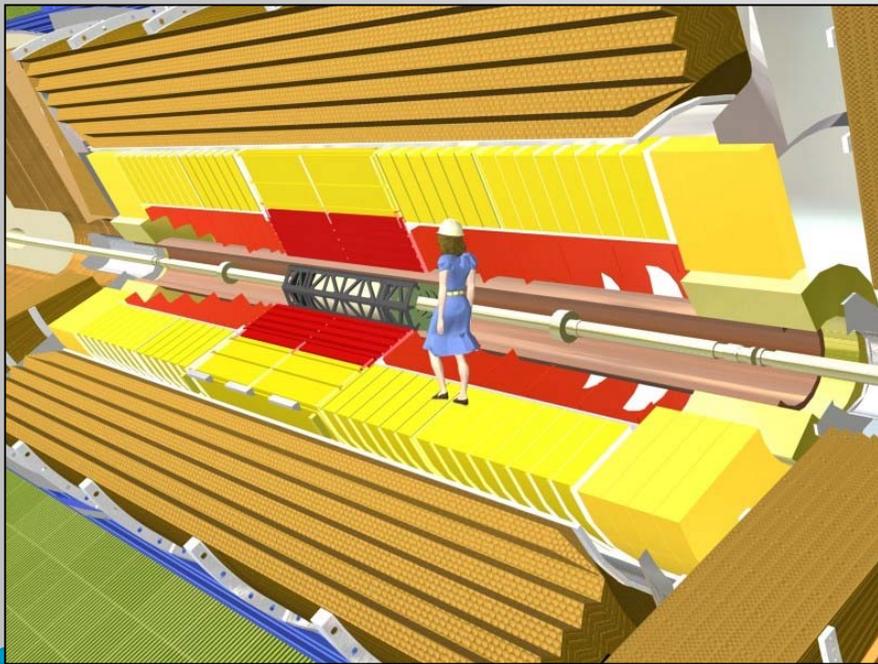


Gold Medal of
Prix Leonardo, 2001
International
Film Festival
Parma, Italy

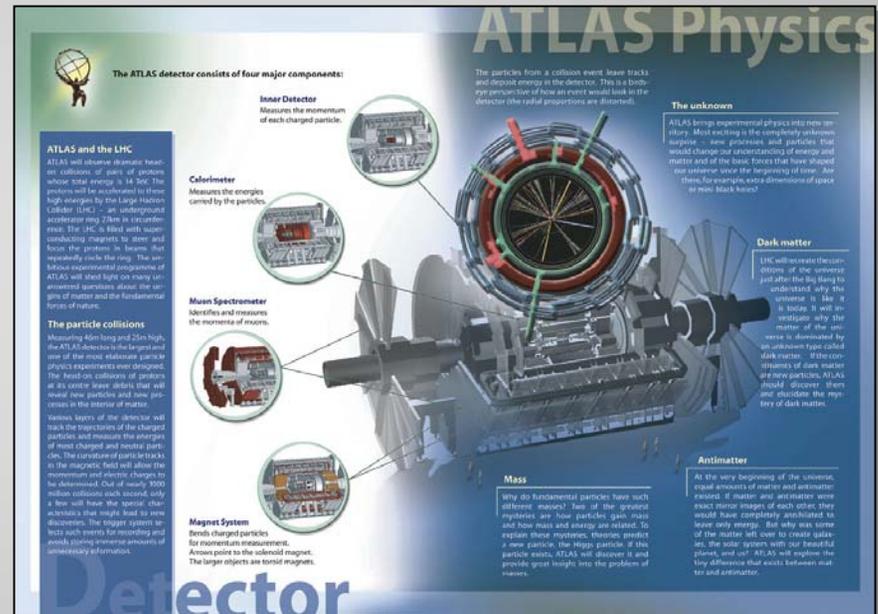
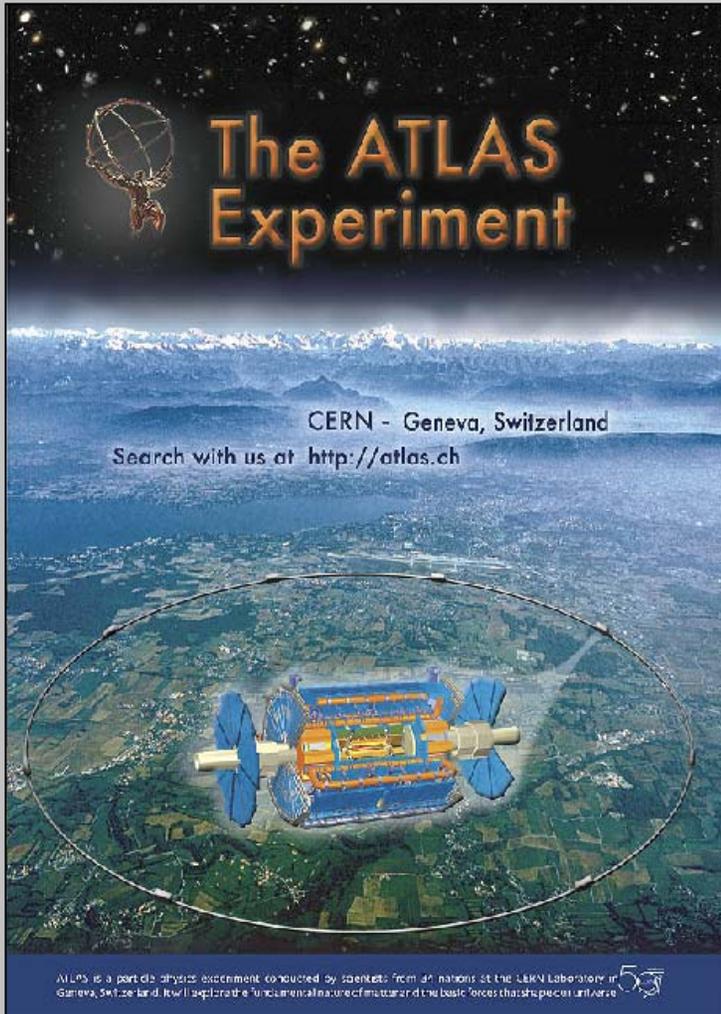
3D Animation of ATLAS

- 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 together.

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

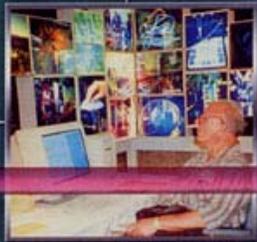
12 Associate Teachers.

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