

Education and Outreach

An extensive and diverse program

PDG books and booklets are primary educational tools (textbooks for the next generation of physicists).

Booklet:

<u>year</u>	<u>student</u>	<u>grad. fract.</u>
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2000	27%	74%
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2002	33%	72%
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2004	39%	70%
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2006	40%	73%
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2008*	33%	78%
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(% LBNL distribution to students and % of those who are grad students)

* Initial distribution only

RPP Book:

<u>year</u>	<u>student</u>	<u>grad. fract.</u>
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2000	24%	78%
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2002	31%	76%
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2004	38%	75%
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2006	37%	77%
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2008*	31%	80%
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Barnett with PDG staff

LHC Awareness Proposal – Initiator and Co-Principal Investigator

US LHC Communications Task Force – Member

ATLAS Education & Outreach Committee – Coordinator

QuarkNet – Co-Principal Investigator

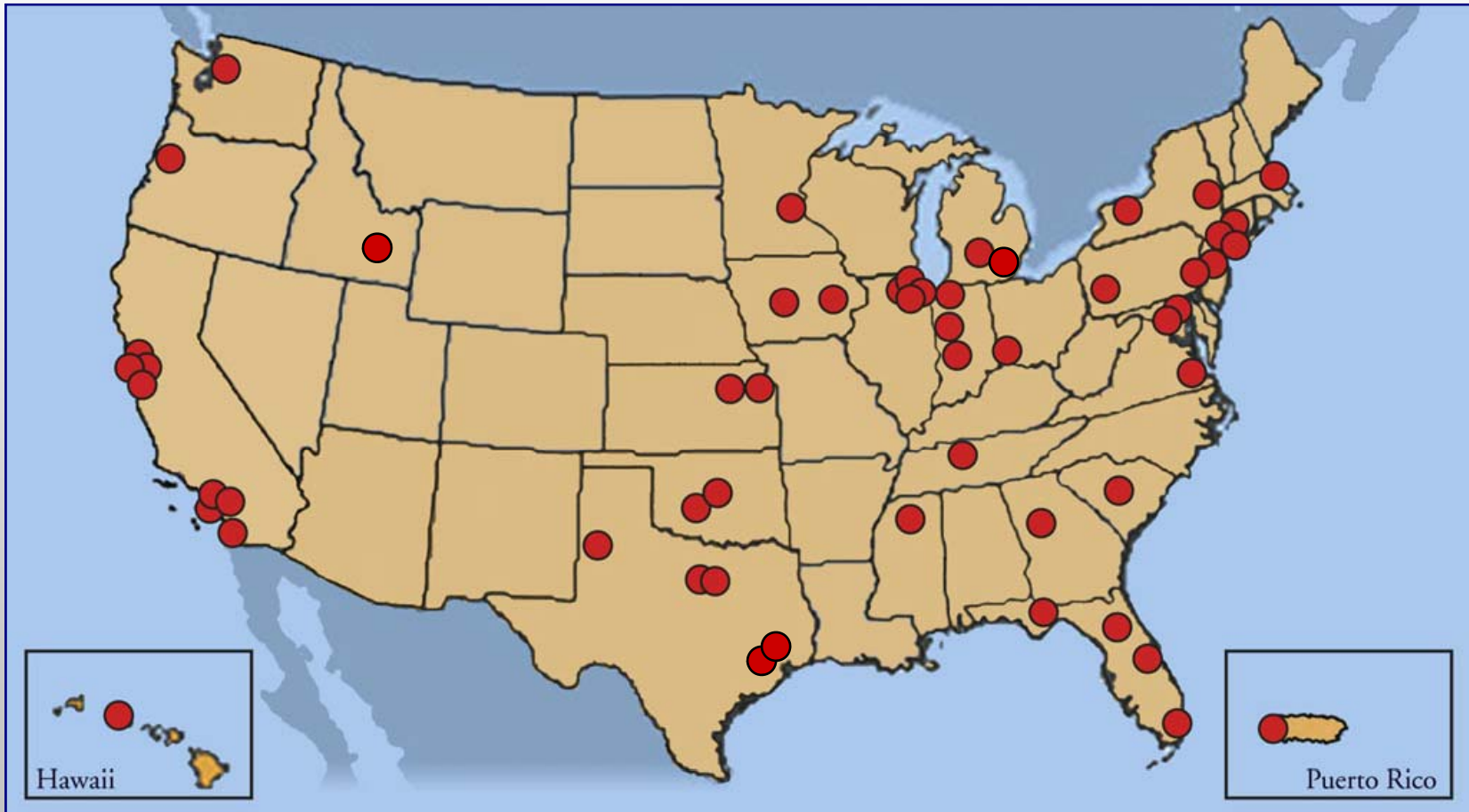
Contemporary Physics Education Project – Founder, Vice Pres.

APS-Calif Section – Chair, then Past Chair

American Assoc of Physics Teachers N. Cal. Sec. – Vice Pres.

Homestake DUSEL – Education Advisor

Helping Develop America's Technological Workforce



**Centers at 52 universities/labs.
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570 high schools in 26 states.
Impacts on 60,000 students/yr.**



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

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

Standard Model of FUNDAMENTAL PARTICLES AND INTERACTIONS

The Standard Model is a quantum theory that summarizes our current knowledge of the physics of fundamental particles and fundamental interactions (interactions are manifested by forces and by decay rates of unstable particles).

FERMIONS matter constituents
spin = 1/2, 3/2, 5/2, ...

Leptons spin = 1/2			Quarks spin = 1/2		
Flavor	Mass GeV/c ²	Electric charge	Flavor	Approx. Mass GeV/c ²	Electric charge
ν_e lightest neutrino*	(0-0.13) $\times 10^{-9}$	0	u up	0.002	2/3
e electron	0.000511	-1	d down	0.005	-1/3
ν_μ middle neutrino*	(0.009-0.13) $\times 10^{-9}$	0	c charm	1.3	2/3
μ muon	0.106	-1	s strange	0.1	-1/3
ν_τ heaviest neutrino*	(0.04-0.14) $\times 10^{-9}$	0	t top	173	2/3
τ tau	1.777	-1	b bottom	4.2	-1/3

*See the neutrino paragraph below.

Spin is the intrinsic angular momentum of particles. Spin is given in units of \hbar , which is the quantum unit of angular momentum where $\hbar = h/2\pi = 6.58 \times 10^{-25} \text{ GeV s} = 1.05 \times 10^{-34} \text{ J s}$.

Electric charges are given in units of the proton's charge. In SI units the electric charge of the proton is 1.60×10^{-19} coulombs.

The **energy** unit of particle physics is the electronvolt (eV), the energy gained by one electron in crossing a potential difference of one volt. **Masses** are given in GeV/c² (remember $E = mc^2$) where $1 \text{ GeV} = 10^9 \text{ eV} = 1.60 \times 10^{-10} \text{ joule}$. The mass of the proton is $0.938 \text{ GeV}/c^2 = 1.67 \times 10^{-27} \text{ kg}$.

Neutrinos

Neutrinos are produced in the sun, supernovae, reactors, accelerator collisions, and many other processes. Any produced neutrino can be described as one of three neutrino flavor states ν_e , ν_μ , or ν_τ , labelled by the type of charged lepton associated with its production. Each is a defined quantum mixture of the three definite mass neutrinos ν_1 , ν_2 , and ν_3 for which currently allowed mass ranges are shown in the table. Further exploration of the properties of neutrinos may yield powerful clues to puzzles about matter and antimatter and the evolution of stars and galaxy structures.

Matter and Antimatter

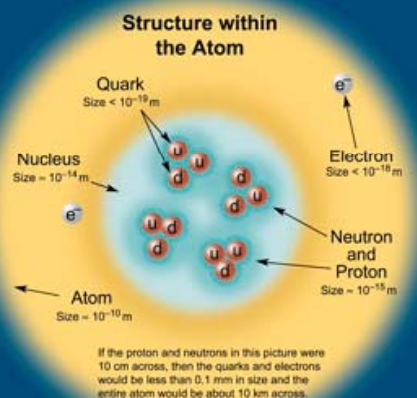
For every particle type there is a corresponding antiparticle type, denoted by a bar over the particle symbol (unless + or - charge is shown). Particle and antiparticle have identical mass and spin but opposite charges. Some electrically neutral bosons (e.g., Z^0 , γ , and $h_0 = \omega$ but not $K^0 = \bar{d}s$) are their own antiparticles.

Particle Processes

These diagrams are an artist's conception. Blue-green shaded areas represent the cloud of gluons.

A free neutron (udd) decays to a proton (uud), an electron, and an antineutrino via a virtual (mediating) W boson. This is neutron β (beta) decay.

An electron and positron (antilepton) colliding at high energy can annihilate to produce B^0 and \bar{B}^0 mesons via a virtual Z boson or a virtual photon.



If the proton and neutrons in this picture were 10 cm across, then the quarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across.

BOSONS force carriers
spin = 0, 1, 2, ...

Unified Electroweak spin = 1			Strong (color) spin = 1		
Name	Mass GeV/c ²	Electric charge	Name	Mass GeV/c ²	Electric charge
γ photon	0	0	g gluon	0	0
W^-	80.39	-1			
W^+	80.39	+1			
Z^0	91.188	0			

Color Charge
Only quarks and gluons carry "strong charge" (also called "color charge") and can have strong interactions. Each quark carries three types of color charge. These charges have nothing to do with the colors of visible light. Just as electrically-charged particles interact by exchanging photons, in strong interactions, color-charged particles interact by exchanging gluons.

Quarks Confined in Mesons and Baryons

Quarks and gluons cannot be isolated - they are confined in color-neutral particles called hadrons. This confinement (binding) results from multiple exchanges of gluons among the color-charged constituents. As color-charged particles (quarks and gluons) move apart, the energy in the color-force field between them increases. This energy eventually is converted into additional quark-antiquark pairs. The quarks and antiquarks then combine into hadrons, these are the particles seen to emerge.

Two types of hadrons have been observed in nature **mesons** (qq) and **baryons** (qqq). Among the many types of baryons observed are the proton (uud), antiproton ($\bar{u}\bar{u}\bar{d}$), neutron (udd), lambda Λ (uds), and omega Ω^- (sss). Quark charges add in such a way as to make the proton have charge +1 and the neutron charge 0. Among the many types of mesons are the pion π^+ (ud), kaon K^+ (su), B^+ (db), and η_c (cc). Their charges are +1, -1, 0, 0 respectively.

Visit the award-winning web feature [The Particle Adventure at ParticleAdventure.org](http://TheParticleAdventure.org)

This chart has been made possible by the generous support of
U.S. Department of Energy
U.S. National Science Foundation
Lawrence Berkeley National Laboratory
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Properties of the Interactions

The strengths of the interactions (forces) are shown relative to the strength of the electromagnetic force for two u quarks separated by the specified distances.

Property	Gravitational Interaction	Weak Interaction (Electroweak)	Electromagnetic Interaction	Strong Interaction
Acts on:	Mass - Energy	Flavor	Electric Charge	Color Charge
Particles experiencing:	All	Quarks, Leptons	Electrically Charged	Quarks, Gluons
Particles mediating:	Graviton (not yet observed)	W^+ W^- Z^0	γ	Gluons
Strength at $\left\{ \begin{array}{l} 10^{-16} \text{ m} \\ 3 \times 10^{-17} \text{ m} \end{array} \right.$	10^{-41} 10^{-41}	0.8 10^{-4}	1 1	25 60

Unsolved Mysteries

Driven by new puzzles in our understanding of the physical world, particle physicists are following paths to new wonders and startling discoveries. Experiments may even find extra dimensions of space, mini-black holes, and/or evidence of string theory.

Universe Accelerating?

The expansion of the universe appears to be accelerating. Is this due to Einstein's Cosmological Constant? If not, will experiments reveal a new force of nature or even extra (hidden) dimensions of space?

Why No Antimatter?

Matter and antimatter were created in the Big Bang. Why do we now see only matter except for the tiny amounts of antimatter that we make in the lab and observe in cosmic rays?

Dark Matter?

Invisible forms of matter make up much of the mass observed in galaxies and clusters of galaxies. Does this dark matter consist of new types of particles that interact very weakly with ordinary matter?

Origin of Mass?

In the Standard Model, for fundamental particles to have masses, there must exist a particle called the Higgs boson. Will it be discovered soon? Is supersymmetry theory correct in predicting more than one type of Higgs?



PDC

particle data group

Particles Chart on prime time TV



Big Bang Theory



The Big Bang Theory - The Bat Jar Conjecture

Since Sheldon's only focus is to prove his mental superiority while preparing for the Physics Bowl, the guys kick him off the team and enlist his nemesis Leslie Winkle.

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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



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Send email to pdgeduc@lbl.gov

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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


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- Intriguing Indications of CP Violation in B Mesons
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THE ATLAS EXPERIMENT



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Incident in LHC will cause delay
 ATLAS is not affected and continues to take cosmic-ray data to commission and tune the detector, awaiting further developments.


First Beam and First Events in ATLAS (Sept. 10)
 ATLAS experimenters celebrated today as the first beams circulated the Large Hadron Collider in both directions. While everyone was cheering in the LHC control room... [More](#)

What is ATLAS

ATLAS is a particle physics experiment at the Large Hadron Collider at CERN. Starting later in 2008, the ATLAS detector will search for new discoveries in the head-on collisions of protons of extraordinarily high energy. ATLAS will learn about the basic forces that have shaped our universe since the beginning of time and that will determine its fate. Among the possible unknowns are the origin of mass, extra dimensions of space, microscopic black holes, and evidence for dark matter candidates in the universe.


- What is the schedule of ATLAS?
- Who are the 2500 physicists in ATLAS?
- What is the LHC?
- How big is ATLAS?
- How much data will be recorded?
- Why is there so much excitement?
- Are students involved?


First Splash of Particles in ATLAS





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Have concerns?

YouTube.com/TheATLASExperiment

20 videos.

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Total is over 370,000 viewings.

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DIRECTOR

ATLAS is a particle physics experiment that will explore the fundamental nature of matter and the basic forces that shape our universe. Starting in late-2008, the ATLAS detector will search for new discoveries in the head-on collisions of protons of extraordinarily high energy. ATLAS is one of the largest collaborative efforts ever attempted in the physical sciences. There are 2500 physicists (including 700 students) participating from more than 169 universities and laboratories in 37 countries.

Visit <http://atlas.ch>

Name: **ATLAS**

City: **Geneva**



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Large Hadron Rap



will rock you in the head.

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Animated film about the
“Discovery Physics of the LHC”

Pixar has an advisory role.



The End