

Spring 2011 State of the ID Lab and Party





Why are we here??

Standard Model of FUNDAMENTAL PARTICLES AND INTERACTIONS

matter constituents FERMIONS 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
₩ lightest neutrino*	(0-0.13)×10 ⁻⁹	0	up up	0.002	2/3
e electron	0.000511	-1	d down	0.005	-1/3
M middle neutrino*	(0.009-0.13)×10 ⁻⁹	0	C charm	1.3	2/3
μ) muon	0.106	-1	S strange	0.1	-1/3
\mathcal{V}_{H} heaviest neutrino*	(0.04-0.14)×10 ⁻⁹	0	top	173	2/3
T tau	1.777	-1	bottom	4.2	-1/3

See the neutrino paragraph below

Spin is the intrinsic angular momentum of particles. Spin is given in units of h, which is the quantum unit of angular momentum where $h = h/2\pi = 6.58 \times 10^{-25}$ GeV s =1.05×10⁻³⁴ 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 = mc²) where 1 GeV = 10⁹ eV =1.60×10⁻¹⁰ joule. The mass of the proton is 0.938 GeV/c² = 1.67×10⁻²⁷ kg

Neutrinos

Neutrinos are produced in the sun, supernovae, reactors, accelerator 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 $Y_0, Y_{11}, or Y_{7}$ labelled by the type of charged lepton associated with its production. Each is a defined quantum mixture of the three definite mass neutrinos Y_{12}, Y_{13} , and Y_{14} for h 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

n→ pe⁻ v_e

W-

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 own antiparticles.

Particle Processes





10 cm across, then the guarks and electrons would be less than 0.1 mm in size and the entire atom would be about 10 km across.

Properties of the Interactions

Property	Gravitational Interaction	Weak Interaction (Electr	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 f 10 ⁻¹⁸ m	10-41	0.8	1	25
Suengur at { 3×10 ⁻¹⁷ m	10-41	10-4	1	60

BOSONS force carriers spin = 0, 1, 2,

Name

g

aluon



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 ing interactions, color-charged particles interact by exchanging gluons.

Strong (color) spin =1

Mass

GeV/c²

0

Electric

charge

0

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 onal 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 (uud), neutron (udd), lambda A

(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), B⁰ (db), and n_C (cc). Their charges are +1, -1, 0, 0 respectively.

Visit the award-winning web feature The Particle Adventure at ParticleAdventure.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 of teachers, physicists, and educators. For more infor CPEPweb.org

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.



SSC ~ 20 years ago today... • Very ambitious... SUPERCONDUCTING SUPER COLLIDER LABORATORY Gary S. Varner NAME Boston Univ. AFFILIATION ED SI 1/95 SERIAL NUMBER EXPIRES **VIS00795** 40TeV vs 14 TeV (LHC)

Crash and Burn

• \$2B, 14.6 mi tunnel, Space Station instead



Central Facility







• Perhaps AMS will do science ...

Sadly, in last 2 decades...



We need you! (for new measurements)





Follow the physics...

LAPPD



From South to north -- a very big year

- Hopeless to cover everything
- Just a brief overview of each project
- For further detailed information, 2 new websites:



Trying to keep track...

- idlab.phys.hawaii.edu
- >>50 active circuit board designs
- ~15 active ASICs (chips)
- Huge number of design details, components, firmware, software





ANITA3





Physics Goals

- Discovery experiment for "BZ" neutrinos, created by the so-called GZK process
- Uses the entire Antarctic continent as a detector!
- Best near-term chance to observe neutrinos from earliest universe
- 3rd (final) flight in December 2013



ANITA3 – ID Lab



Askaryan Radio Array (ARA)



ARA – ID Lab

IRS ASIC



Our Developments

- Translate ANITA trigger/digitizer electronics and experience to ARA
- "array crossing" waveform sampler (IRS)
- Built "testbed" almost 4 years ago....
- Finally deployed in January, taking data









Atmospheric Bremsstrahlung (AMBER)



AMBER – ID Lab



Bremsstrahlung x-rays: UH FEL

First x-rays: September 2010

50MeV max. (40MeV typ.)



TEDA – ID Lab

cPCI crate (control room)



Master module

Large Area Photodetector



Project goals

- Photomultipliers still built on vacuum tube technology
- CRT \rightarrow flat panel screen transition
- Integrated readout electronics
- Necessary for next generation (large) detectors





CHAMP







Final beam abort of KEKB on June 30, 2010 marked the start of SuperKEKB/BelleII



Earthquake





As is now well known, Japan suffered a terrible earthquake and tsunami on March 11, which has caused tremendous damage, especially in the Tohoku area. Fortunately, all KEK personnel and users are safe and accounted for. The injection linac did suffer significant but manageable damage, and repairs are underway. The damage to the KEKB main rings appears to be less serious, though non-negligible. No serious damage has been reported so far at Belle. Further investigation is necessary. We would like to convey our deep appreciation to everyone for your generous expressions of concern and encouragement.

Belle II



Physics Goals

- Belle extremely successful at confirming the Kobayashi-Maskawa mechanism of CP violation in the quark sector
- Data ~ 50x = beyond Standard Model

Very broad program in beauty, charm and tau physics

329 individuals, ~13 nations, ~53 institutes





Belle II – ID Lab



Got fiber?





Our activities KLM – ID Lab



SuperKEKB – ID Lab

STURM2 ASIC Our Developments x-ray monitoring • High speed sampler, compact RF amplifiers • Test at the ATF2 facility Survived shaking IDL フラナガン GSV STURM2 **Belle**ØVarner CHIP ATF2 State of the Instrumentation Dev. Lab Meeting/Party – May 2011

PoGO-lite



Physics Goals

- Direct observation of polarized gammas from back-scatter at pulsar/black-hole energetic region
- Unique ability to measure polarization of photons
- Pioneering flight in a couple weeks
- If neutron backgrounds OK much larger payload



Personnel changes...

- Continuing in new role: Dr. Kurtis Nishimura
- From this summer
 - New graduate student: Eric Anderson
 - New undergraduates
 - Xiaowen Shi
 - Grace Jung, Casey, Honniball, Christina Yee
 - Next Finnish (Savonia) visitors
 - Jussi Malin from May 25th
 - 4x(!) more in January
 - Yet more:
 - Prof. Roberto Mussa (INFN Torino)
 - Zhe Cao (USTC postdoc)
 - Joachim Cohen (Paris)



They are all needed...

- 1. Endcap KLM 150 channel system (full quadrant test of muon system) →
- iTOP beam test --> boards and board test plan
 [512 channel system = 4x 128ch]
- 3. ATF2 (Fermionics-based) DAQ [128 channels]
- 4. xFEL Fermionics readout [128 channels]
- 5. mini-Time Cube [12x 64-channel tube readout minimum?]
- 6. fDIRC2 readout [14x 64-channel tubes]



State of the Instrumentation Dev. Lab Meeting/Party - May 2011

120 X-Stri

1855

3255

What is the Future?

- Belle II iTOP/KLM by 2014, pixel upgrade thereafter
- Disruptive technology: LAPPD (Detector dev center ANL)
- ANITA 3rd Flight approved \rightarrow active R&D (ASICs, trigger...)
- Deploy AMBER station this next <u>week</u> \rightarrow large array?
- New initiatives: ARA Test bed installed, year 2 & 3
- Great opportunities life cycle of a university
 - Jr./Sr. research projects (EE 399/499, PHYS 499)
 - Directed study/NASA Space Grant/REU/PUF (Japan/Antarctica/Paris)
 - Publications (NIM/IEEE/JINST ...)
 - Board/firmware/chip design (PHYS476)
 - Many designs in queue; LAB4, BLAB3B, STURM3, GRAPH..
 - Design, layout, simulation and test opportunities



