The Young Particle Physicists Organization
DPF Conference, Riverside California
August 30, 2004

Neil Calder, Director of Communications

$$\mathcal{L}_0 = \int \left(-i b^{ij} D_i c_j - B^{ij} D_i \phi_j\right),$$

$$\langle P\rangle = \frac{\epsilon^{1+(1/k)}}{1+(1/k)}$$
$$\langle P\,P\rangle = \epsilon^{1/k}$$
$$\langle P\,P\,P\rangle = \frac{1}{k}\epsilon^{(1/k)-1}$$

$$\langle \sigma_n\ P\rangle = \frac{\partial}{\partial\epsilon}\langle\sigma_n\rangle = a_n b_n \epsilon^{b_n-1}$$
$$\langle \sigma_n\ P\ P\rangle = \frac{\partial^2}{\partial\epsilon^2}\langle\sigma_n\rangle = a_n b_n (b_n-1)\epsilon^{b_n-2},$$

$$\langle \sigma_n\ P\rangle = \frac{\partial}{\partial\epsilon}\langle\sigma_n\rangle = a_n b_n \epsilon^{b_n-1}$$
$$\langle \sigma_n\ P\ P\rangle = \frac{\partial^2}{\partial\epsilon^2}\langle\sigma_n\rangle = a_n b_n (b_n-1)\epsilon^{b_n-2},$$

$$V^{\alpha}_{-1/2}(z) = e^{-\phi/2} S_\alpha\, e^{i\frac{\sqrt{3}}{2}H}(z),$$

$$G^{+}_{-1/2}|h=\tfrac{1}{2}q\rangle = 0 = G^{-}_{-1/2}|h=-\tfrac{1}{2}q\rangle.$$

$$\langle \sigma_n\ P\rangle = \frac{\partial}{\partial\epsilon}\langle\sigma_n\rangle = a_n b_n \epsilon^{b_n-1}$$
$$\langle \sigma_n\ P\ P\rangle = \frac{\partial^2}{\partial\epsilon^2}\langle\sigma_n\rangle = a_n b_n (b_n-1)\epsilon^{b_n-2},$$

$$\langle \mathcal{O}_{d_1,\alpha_1}\mathcal{O}_{d-2,\alpha_2}\dots\mathcal{O}_{d_s,\alpha_s}\rangle_0 = d_1\cdot\sum_{S=X\cup Y}\langle\mathcal{O}_{d_1-1,\alpha_1}\cdot\prod_{j\in X}\mathcal{O}_{d_j,\alpha_j}\cdot\mathcal{O}_e\rangle_0\,\eta^{e\tau}\langle\mathcal{O}^{\tau}\cdot\prod_{i\in Y}\mathcal{O}_{d_i,\alpha_i}\cdot\mathcal{O}_{d_{s-1},\alpha_{s-1}}\mathcal{O}_{d_s,\alpha_s}\rangle_0.$$

$$J(z)J(w) \sim \frac{\frac{1}{3}c}{(z-w)^2}+\cdots,$$
$$J(z)T_F^{\pm}(w) \sim \pm\frac{T_F^{\pm}(w)}{z-w}+\cdots,$$
$$T_F^{+}(z)T_F^{+}(w) \sim T_F^{-}(z)T_F^{-}(w) \sim O(1),$$
$$T_F^{+}(z)T_F^{-}(w) \sim \frac{\frac{1}{4}c}{(z-w)^3}+\frac{\frac{1}{2}J(w)}{(z-w)^2}+\frac{\frac{1}{2}T(w)+\frac{1}{4}\partial_w J(w)}{z-w}+$$

$$V^{\dot\alpha}_{-1/2}(z) = e^{-\phi/2} S_{\dot\alpha}\, e^{-i\frac{\sqrt{3}}{2}H}(z),$$

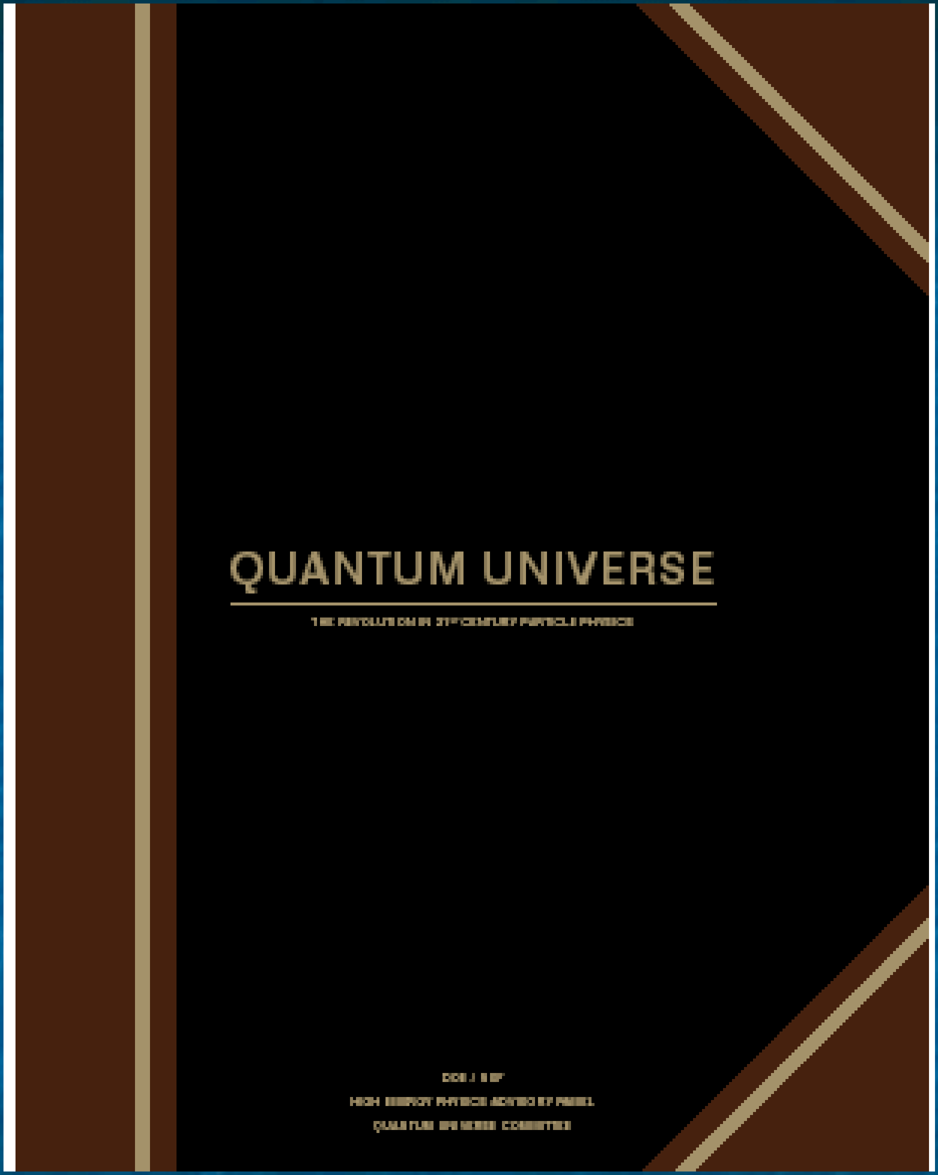
$$T_F(z)\Phi_0(w) \sim \frac{\frac{1}{2}\Phi_1(w)}{z-w}+\cdots,$$
$$T_F(z)\Phi_1(w) \sim \frac{h\Phi_0(w)}{(z-w)^2}+\frac{\frac{1}{2}\partial_w\Phi_0(w)}{z-w}+\cdots,$$
$$T(z)\Phi_0(w) \sim \frac{h\Phi_0(w)}{(z-w)^2}+\frac{\partial_w\Phi_0(w)}{z-w}+\cdots,$$
$$T(z)\Phi_1(w) \sim \frac{(h+\frac{1}{2})\Phi_1(w)}{(z-w)^2}+\frac{\partial_w\Phi_1(w)}{z-w}+\cdots$$

$$\langle\mathcal{O}_1\dots\mathcal{O}_n\rangle = \int_M \alpha_1\wedge\alpha_2\wedge\dots\wedge\alpha_n.$$

$$\langle\sigma_{d_1}\sigma_{d_2}\dots\sigma_{d_n}\rangle = \#(H_{(1)}\cap H_{(2)}\cap\dots\cap H_{(n)})\cdot\prod_i d_i!$$

$$\delta g_{\mu\nu} = \epsilon\psi_{\mu\nu}$$
$$\delta\psi_{\mu\nu} = -\epsilon(D_\mu C_\nu + D_\nu C_\mu)$$
$$\delta C^\mu = 0.$$

$$\langle\sigma_n\rangle = \frac{\epsilon^{1+(n+1)/k}}{(n+1)(1+(n+1)/k)}.$$



QUANTUM UNIVERSE

Think about the audience

- Executive Summary
- Chapter 1

  No previous knowledge
- Chapter 2

  Some
- Chapter 3

  Loads

Design

- Had to be different
- Engaging but not glitzy
- Correct balance between experiments, funding agencies etc.
- Innovative web site to come
- 3 print runs so far

Reactions so Far: Very Positive

- On the hill, at DOE, OSTP, NSF:
  - They like it
  - "This will help us"
  - "This is good"
- Mike Holland: "I can sell this"
- What do they like?
  - The sense of excitement
  - The accessibility
  - The cover!
  - The 'look' inside
  - The tables
  - The sense that the field has a vision for its future that they can be excited about and can communicate effectively.

QUANTUM UNIVERSE

THE REVOLUTION IN 21ST CENTURY PARTICLE PHYSICS

Most of the matter in the universe is dark. Without dark matter, galaxies and stars would not have formed and life would not exist. It holds the universe together. What is it?

Although the existence of dark matter was suggested in the 1930s, only in the last 10 to 15 years have scientists made substantial progress in understanding its properties, mostly by establishing what it is not. Recent observations of the effect of dark matter on the structure of the universe have shown that it is unlike any form of matter that we have discovered or measured in the laboratory. At the same time, new theories have emerged that may tell us what dark matter actually is. The theory of supersymmetry predicts new families of particles interacting very weakly with ordinary matter. The lightest supersymmetric particle could well be the elusive dark matter particle. We need to study dark matter directly by detecting relic dark matter particles in an underground detector and by creating dark matter particles at accelerators, where we can measure their properties and understand how they fit into the cosmic picture.

Andreas Albrecht, of University of California at Davis, talks about one of the current great mysteries of the universe - dark matter.
View the Video

TOOLS FOR A SCIENTIFIC REVOLUTION

Most of the matter in the universe is dark. Early evidence for dark matter came from the rotation curves of galaxies, which showed that galaxies contain more mass than is contained in the stars. More recently, direct evidence for dark matter has come from the discovery and characterization of gravitational lenses, regions of space where mass bends light. These astronomical constraints do not directly distinguish between nonbaryonic models for dark matter (WIMPs) and other possible ideas involving more massive objects (MACHOs) such as Jupiter-sized planets and mini-black holes. However experiments in the 1990s established that MACHOs do not make an appreciable contribution to the dark matter content of our galaxy.

The tightest constraints on the amount of dark matter in the universe come from cosmological measurements. The frequency and amplitude dependence of the fluctuations in the cosmic microwave background (CMB) measured by WMAP (and in the future by Planck) are sensitive to both the total matter density and the baryon density. The baryon density is also constrained by the nucleosynthesis models of the early universe. All of these methods suggest that normal baryonic matter can only account for a small fraction, about five percent, of the total matter density.

DARK MATTER SEARCH GOES UNDERGROUND

From a vantage point a half-mile below ground, physicists of the Cryogenic Dark Matter Search have launched a quest to detect the dark matter that pervades the universe...
read more

Scientists are measuring the distribution of dark matter in the universe in a variety of ways: (a) by studying the large-scale distribution of galaxies, as with the Sloan Digital Sky Survey (SDSS); (b) by constraining the dark matter mass power spectrum through weak lensing studies, as by a future Large Synoptic Survey Telescope (LSST) and the Joint Dark Energy Mission (JDEM); and (c) by cataloguing massive clusters of galaxies as a function of redshift, using the Sunyaev-Zeldovitch effect, by the South Polar Telescope and the Atacama Cosmology Telescope.

What is dark matter? Particle physics models suggest that dark matter is either axions (hypothetical new

PHYSICS | New sense of excitement

Continued from Page 1E

is accessible to our customers, as we refer to them — the funding agencies, the policy-makers.

Q What are those surprises?

A Five years ago, I would talk about the standard model of particle physics, which is this enormous intellectual achievement of the second half of the 20th century. It has allowed us to understand in enormous depth and detail all the matter we see around us on Earth, all the matter we see coming in on cosmic rays, all the matter we have been able to create in our particle accelerators.

And there were still open issues in the standard model — it wasn't a complete package — but it was a very powerful predictive model. My one-liner was always that every experiment in my career lifetime — which is getting to be not that short! — either agreed with the theorists' predictions, or the experiment was wrong. For an experimentalist, that's very frustrating.

Now, as the result of the experimental discoveries of the last five years, what we are realizing is this normal matter that we had been studying for 40 years and that we can describe so well actually is only 5 percent of the universe, and 95 percent of the universe is made of forms of matter and energy that we don't have a clue about.

DAI SUGANO — MERCURY NEWS

Physicist Persis Drell says her team at the Stanford Linear Accelerator Center is focused on the most exciting questions in the field.

is, how does it evolve with cosmic time.

And then from accelerator-based experiments, we would hope to discover new symmetries like supersymmetry that will help us try to understand and explain it.

Five years from now, we'll know a lot more about dark matter. I think five years from now, we'll know a lot more about what we *don't* know about dark energy.

We had a conference here this week, and Joe Lykken of Fermilab gave a beautiful talk, and he pointed out something that I think is quite interesting: When we talk about the 5 percent of the universe — the bright universe, if you will, that's the matter we know and understand and describe with the Standard Model — it's very complex. There are 57 particles, lots of forces. We're now sitting here talking about the rest of universe, the 95 percent, as if it's got two components: dark matter and dark energy. And it's pretty arrogant to think that the dark universe would be so simple when the bright universe is so complex.

Q How can we be sure the 57 known particles aren't made up of even smaller particles?

A We keep trying to probe the quarks. We do experiments that try to break the quarks up and see if there's something underneath them.

At the moment, there is no

PERSIS DRELL

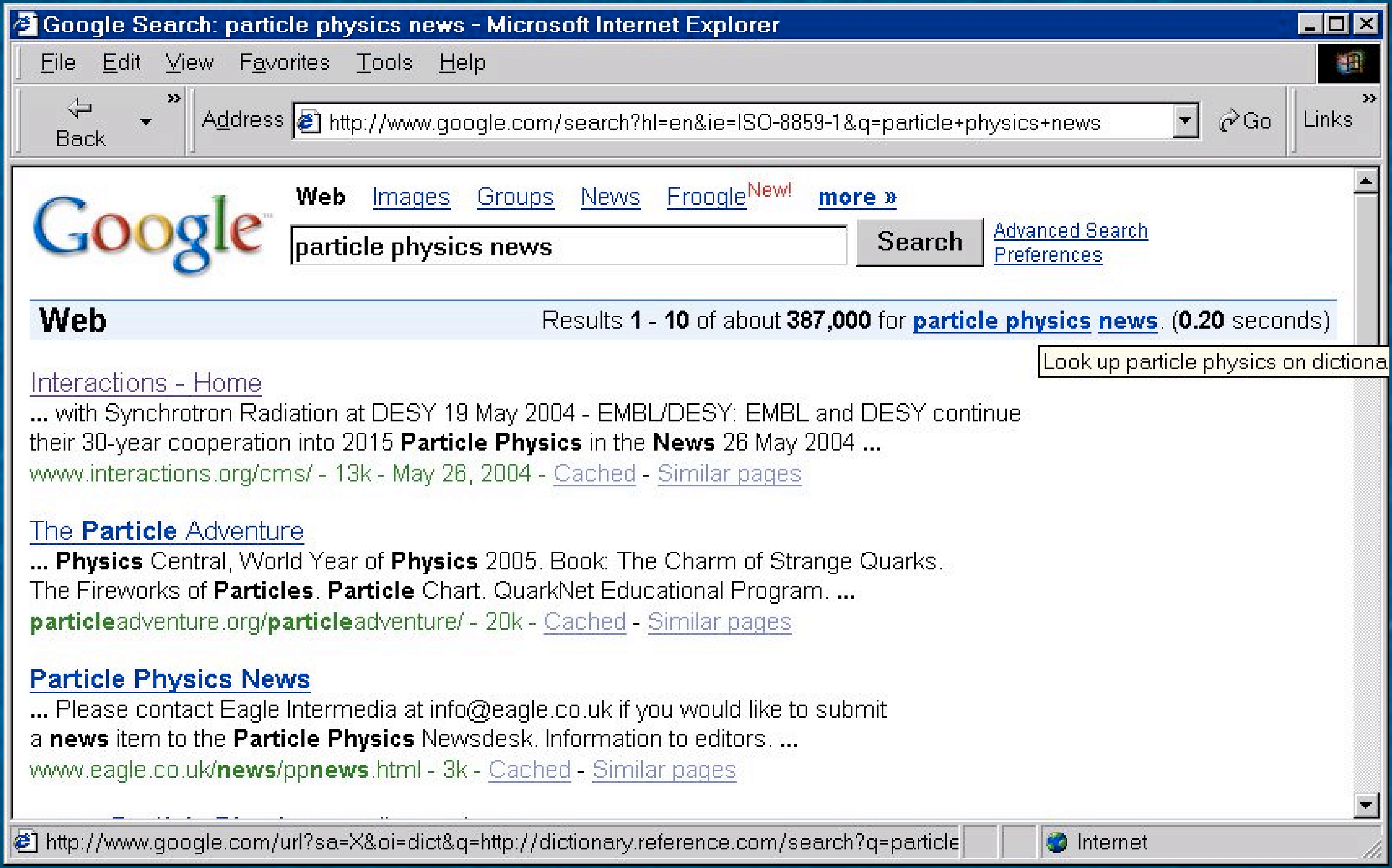
Her role: Drell, 48, is a professor and director of research at the Stanford Linear Accelerator Center, where she has worked for two years. She studies

The evidence for dark matter

The mystery of dark matter came to scientists' attention while they were observing the speed at which galaxies rotate. By adding up the mass of all of

But they found that galaxies are spinning faster than they should be able to — more than twice as fast. This raises the possibility that the galaxies

No 1 on Google



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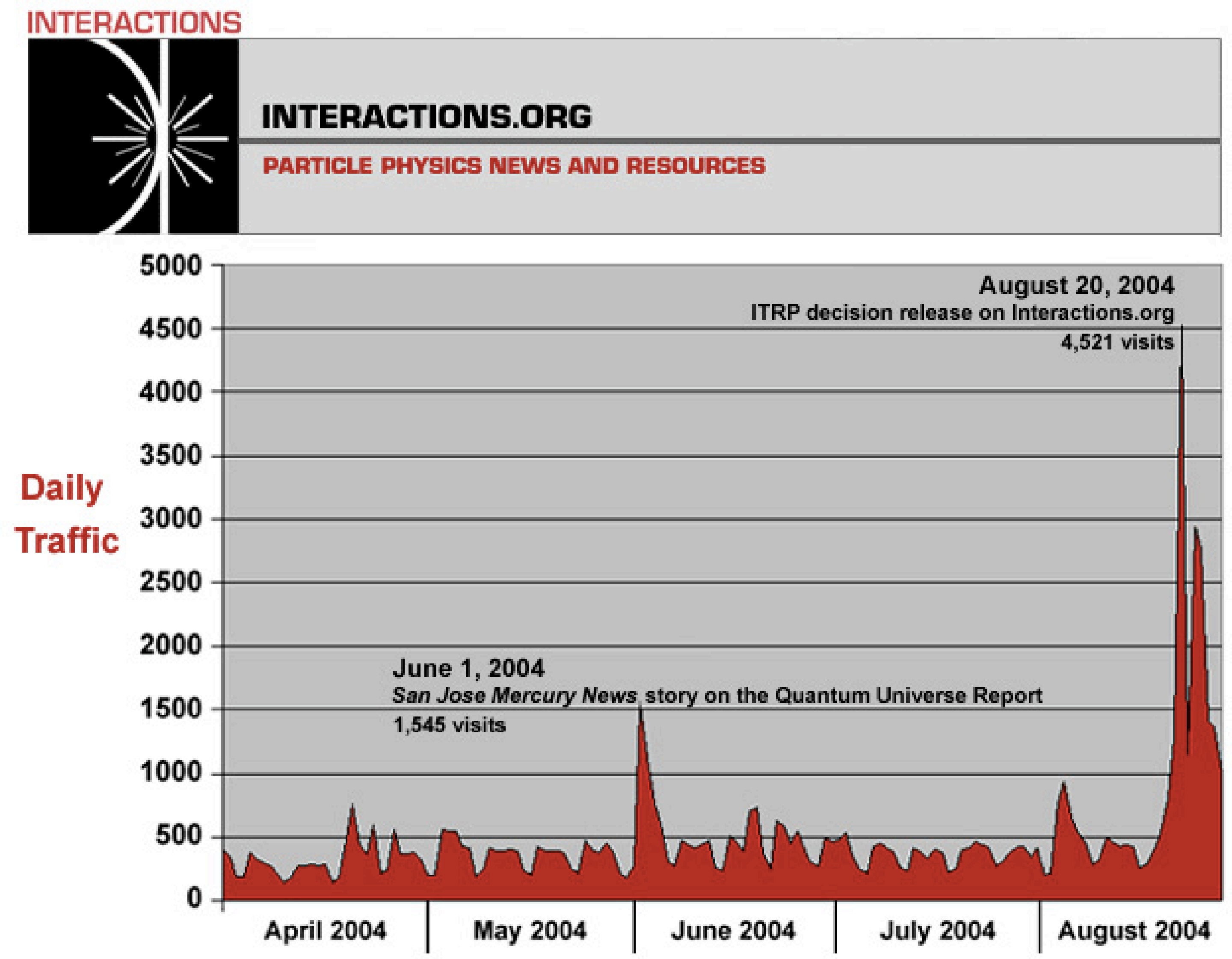

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June 1, 2004
San Jose Mercury News story on the Quantum Universe Report
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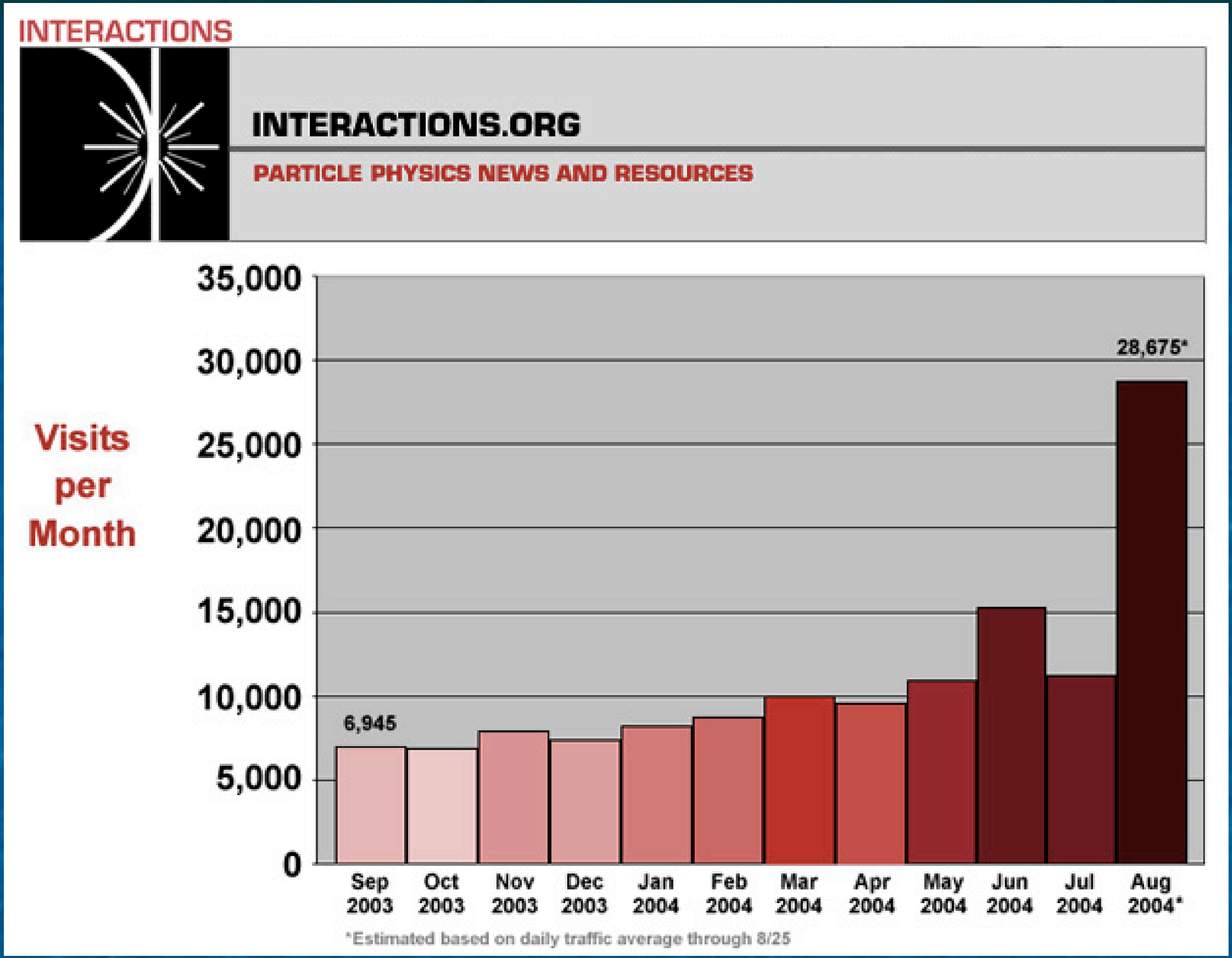

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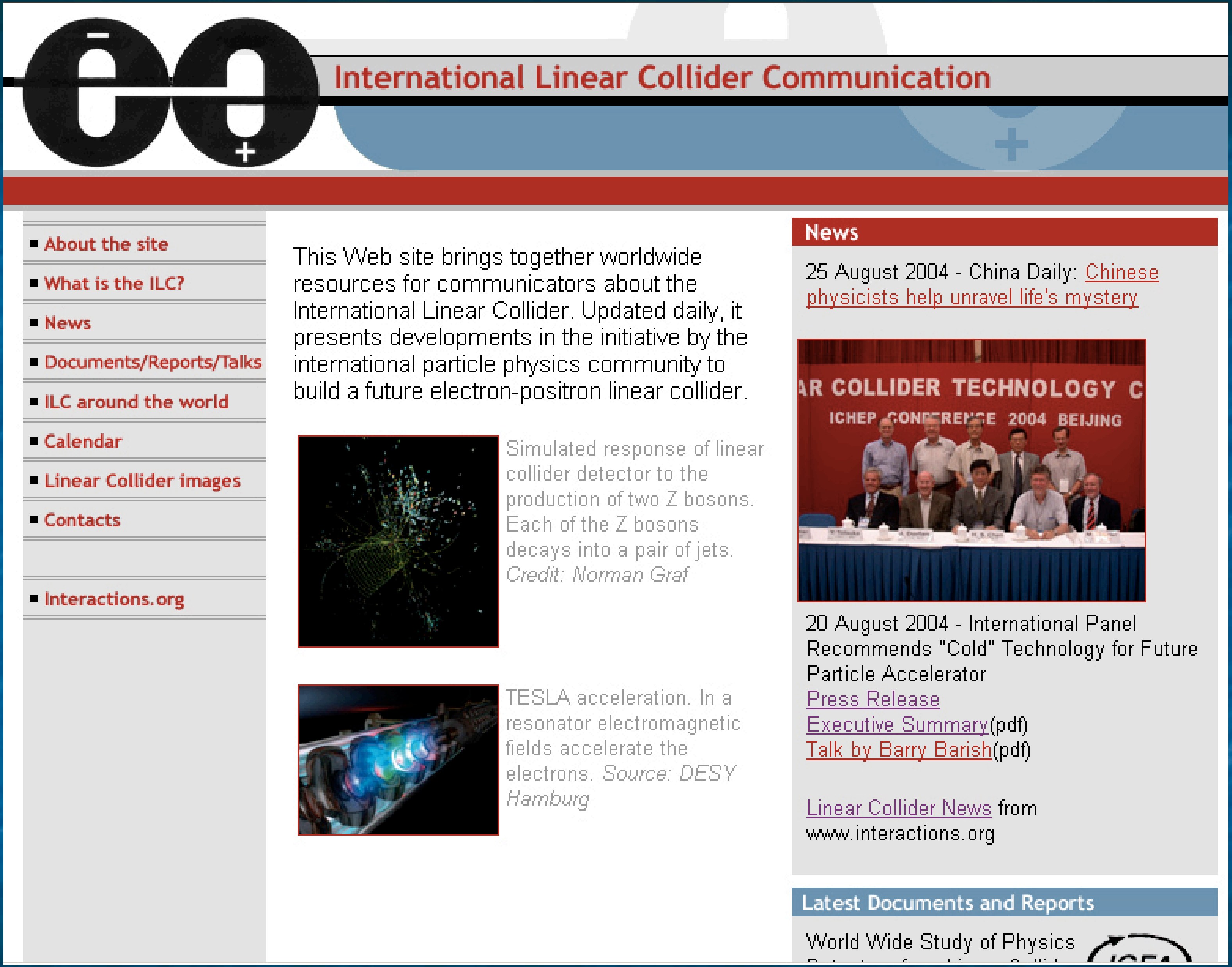

International Linear Collider Communication

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This Web site brings together worldwide resources for communicators about the International Linear Collider. Updated daily, it presents developments in the initiative by the international particle physics community to build a future electron-positron linear collider.

Simulated response of linear collider detector to the production of two Z bosons. Each of the Z bosons decays into a pair of jets. *Credit: Norman Graf*

TESLA acceleration. In a resonator electromagnetic fields accelerate the electrons. *Source: DESY Hamburg*

News

25 August 2004 - China Daily: Chinese physicists help unravel life's mystery

20 August 2004 - International Panel Recommends "Cold" Technology for Future Particle Accelerator

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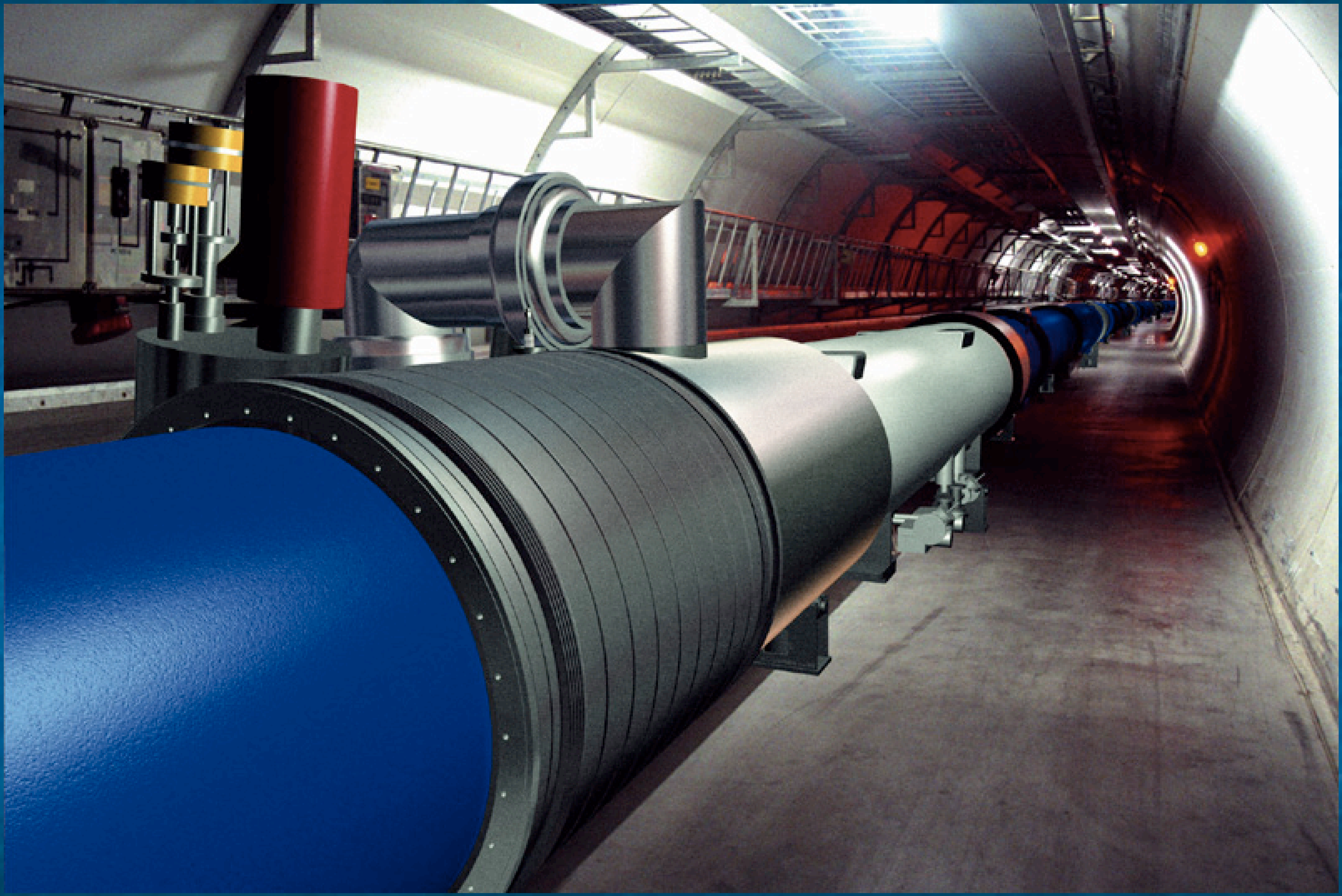

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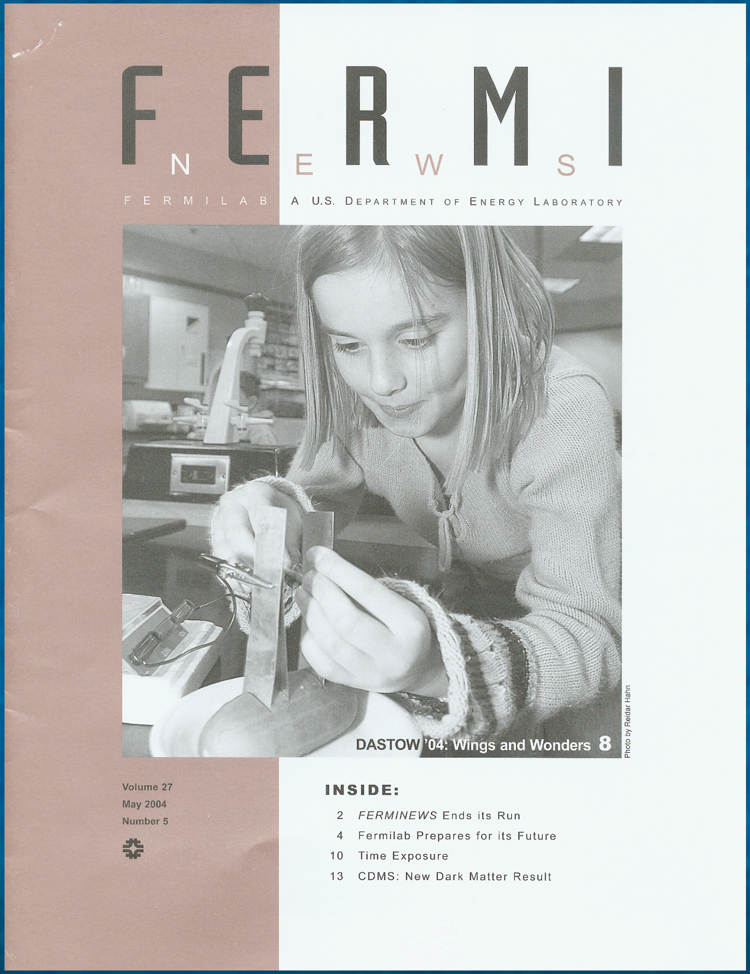

FERMI NEWS

FERMILAB A U.S. Department of Energy Laboratory

DASTOW '04: Wings and Wonders 8

Photo by Reidar Hahn

Volume 27
May 2004
Number 5

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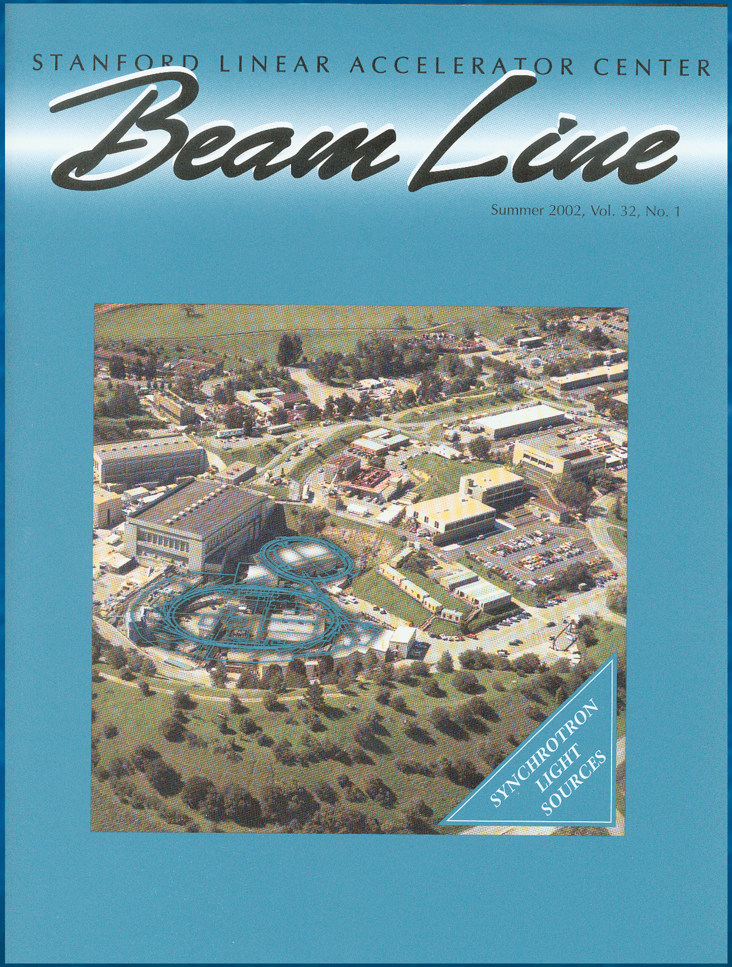
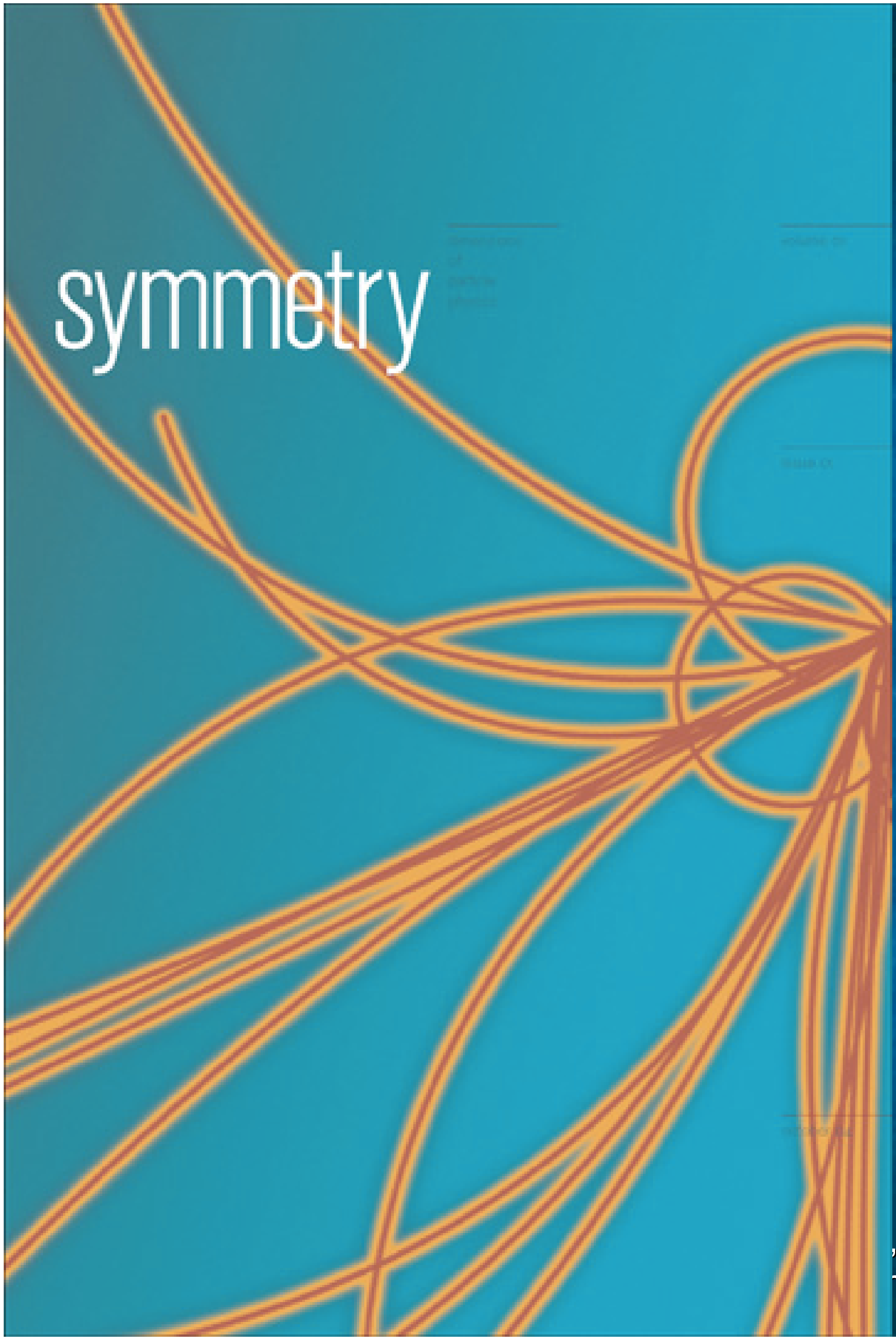


STANFORD LINEAR ACCELERATOR CENTER

Beam Line

Summer 2002, Vol. 32, No. 1

SYNCHROTRON LIGHT SOURCES



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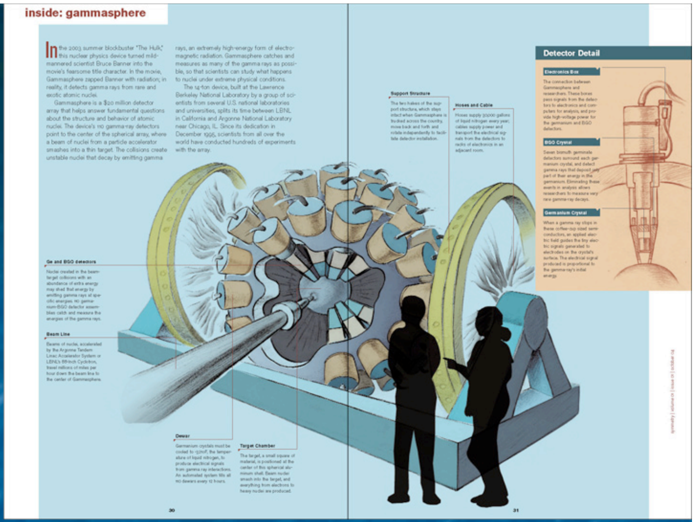


inside: gammasphere

In the 2003 summer blockbuster "The Hulk," this nuclear physics device turned mild-mannered scientist Bruce Banner into the movie's fearsome title character. In the movie, Gammasphere zapped Banner with radiation; in reality, it detects gamma rays from rare and exotic atomic nuclei.

Gammasphere is a $20 million detector array that helps answer fundamental questions about the structure and behavior of atomic nuclei. The device's 110 gamma-ray detectors point to the center of the spherical array, where a beam of nuclei from a particle accelerator smashes into a thin target. The collisions create unstable nuclei that decay by emitting gamma rays, an extremely high-energy form of electromagnetic radiation. Gammasphere catches and measures as many of the gamma rays as possible, so that scientists can study what happens to nuclei under extreme physical conditions.

The 14-ton device, built at the Lawrence Berkeley National Laboratory by a group of scientists from several U.S. national laboratories and universities, splits its time between LBNL in California and Argonne National Laboratory near Chicago, IL. Since its dedication in December 1995, scientists from all over the world have conducted hundreds of experiments with the array.

Ge and BGO detectors

Nuclei created in the beam-target collisions with an abundance of extra energy may shed that energy by emitting gamma rays at specific energies. 110 germanium-BGO detector assemblies catch and measure the energies of the gamma rays.

Beam Line

Beams of nuclei, accelerated by the Argonne Tandem Linac Accelerator System or LBNL's 88-inch Cyclotron, travel millions of miles per hour down the beam line to the center of Gammasphere.

Support Structure

The two halves of the support structure, which stays intact when Gammasphere is trucked across the country, move back and forth and rotate independently to facilitate detector installation.

Hoses and Cable

Hoses supply 30,000 gallons of liquid nitrogen every year; cables supply power and transport the electrical signals from the detectors to racks of electronics in an adjacent room.

Dewar

Germanium crystals must be cooled to -320°F, the temperature of liquid nitrogen, to produce electrical signals from gamma ray interactions. An automated system fills all 110 dewars every 12 hours.

Target Chamber

The target, a small square of material, is positioned at the center of this spherical aluminum shell. Beam nuclei smash into the target, and everything from electrons to heavy nuclei are produced.

Detector Detail

Electronics Box

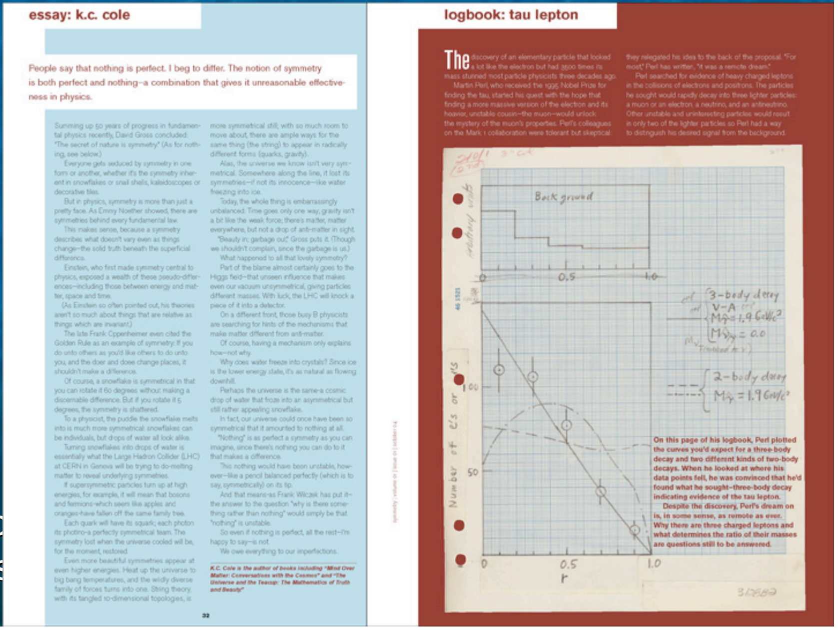
The connection between Gammasphere and researchers. These boxes pass signals from the detectors to electronics and computers for analysis, and provide high-voltage power for the germanium and BGO detectors.

BGO Crystal

Seven bismuth germinate detectors surround each germanium crystal, and detect gamma rays that deposit only part of their energy in the germanium. Eliminating these events in analysis allows researchers to measure very rare gamma-ray decays.

Germanium Crystal

When a gamma ray stops in these coffee-cup sized semiconductors, an applied electric field guides the tiny electric signals generated to electrodes on the crystal's surface. The electrical signal produced is proportional to the gamma-ray's initial energy.



essay: k.c. cole

People say that nothing is perfect. I beg to differ. The notion of symmetry is both perfect and nothing–a combination that gives it unreasonable effectiveness in physics.

Summing up 50 years of progress in fundamental physics recently, David Gross concluded: "The secret of nature is symmetry." (As for nothing, see below.)

Everyone gets seduced by symmetry in one form or another, whether it's the symmetry inherent in snowflakes or snail shells, kaleidoscopes or decorative tiles.

But in physics, symmetry is more than just a pretty face. As Emmy Noether showed, there are symmetries behind every fundamental law.

This makes sense, because a symmetry describes what doesn't vary even as things change–the solid truth beneath the superficial difference.

Einstein, who first made symmetry central to physics, exposed a wealth of these pseudo-differences–including those between energy and matter, space and time.

(As Einstein so often pointed out, his theories aren't so much about things that are relative as things which are invariant.)

The late Frank Oppenheimer even cited the Golden Rule as an example of symmetry: If you do unto others as you'd like others to do unto you, and the doer and doee change places, it shouldn't make a difference.

Of course, a snowflake is symmetrical in that you can rotate it 60 degrees without making a discernable difference. But if you rotate it 5 degrees, the symmetry is shattered.

To a physicist, the puddle the snowflake melts into is much more symmetrical: snowflakes can be individuals, but drops of water all look alike.

Turning snowflakes into drops of water is essentially what the Large Hadron Collider (LHC) at CERN in Geneva will be trying to do–melting matter to reveal underlying symmetries.

If supersymmetric particles turn up at high energies, for example, it will mean that bosons and fermions–which seem like apples and oranges–have fallen off the same family tree.

Each quark will have its squark; each photon its photino–a perfectly symmetrical team. The symmetry lost when the universe cooled will be, for the moment, restored.

Even more beautiful symmetries appear at even higher energies. Heat up the universe to big bang temperatures, and the wildly diverse family of forces turns into one. String theory, with its tangled 10-dimensional topologies, is more symmetrical still; with so much room to move about, there are ample ways for the same thing (the string) to appear in radically different forms (quarks, gravity).

Alas, the universe we know isn't very symmetrical. Somewhere along the line, it lost its symmetries–if not its innocence–like water freezing into ice.

Today, the whole thing is embarrassingly unbalanced. Time goes only one way; gravity isn't a bit like the weak force; there's matter, matter everywhere, but not a drop of anti-matter in sight.

"Beauty in; garbage out," Gross puts it. (Though we shouldn't complain, since the garbage is us.)

What happened to all that lovely symmetry?

Part of the blame almost certainly goes to the Higgs field–that unseen influence that makes even our vacuum unsymmetrical, giving particles different masses. With luck, the LHC will knock a piece of it into a detector.

On a different front, those busy B physicists are searching for hints of the mechanisms that make matter different from anti-matter.

Of course, having a mechanism only explains how–not why.

Why does water freeze into crystals? Since ice is the lower energy state, it's as natural as flowing downhill.

Perhaps the universe is the same–a cosmic drop of water that froze into an asymmetrical but still rather appealing snowflake.

In fact, our universe could once have been so symmetrical that it amounted to nothing at all.

"Nothing" is as perfect a symmetry as you can imagine, since there's nothing you can do to it that makes a difference.

This nothing would have been unstable, however–like a pencil balanced perfectly (which is to say, symmetrically) on its tip.

And that means–as Frank Wilczek has put it–the answer to the question "why is there something rather than nothing" would simply be that "nothing" is unstable.

So even if nothing is perfect, all the rest–I'm happy to say–is not.

We owe everything to our imperfections.

K.C. Cole is the author of books including "Mind Over Matter: Conversations with the Cosmos" and "The Universe and the Teacup: The Mathematics of Truth and Beauty."

logbook: tau lepton

The discovery of an elementary particle that looked a lot like the electron but had 3500 times its mass stunned most particle physicists three decades ago.

Martin Perl, who received the 1995 Nobel Prize for finding the tau, started his quest with the hope that finding a more massive version of the electron and its heavier, unstable cousin–the muon–would unlock the mystery of the muon's properties. Perl's colleagues on the Mark I collaboration were tolerant but skeptical: they relegated his idea to the back of the proposal. "For most," Perl has written, "it was a remote dream."

Perl searched for evidence of heavy charged leptons in the collisions of electrons and positrons. The particles he sought would rapidly decay into three lighter particles: a muon or an electron, a neutrino, and an antineutrino. Other unstable and uninteresting particles would result in only two of the lighter particles so Perl had a way to distinguish his desired signal from the background.

On this page of his logbook, Perl plotted the curves you'd expect for a three-body decay and two different kinds of two-body decays. When he looked at where his data points fell, he was convinced that he'd found what he sought–three-body decay indicating evidence of the tau lepton.

Despite the discovery, Perl's dream on is, in some sense, as remote as ever. Why there are three charged leptons and what determines the ratio of their masses are questions still to be answered.

WHO?

Only lightly hierachized

- Policy makers and opinion leaders who will determine the course of HEP in the coming years
- International HEP community and other branches of science
- Resource for educators and a source of insight and information for interested public

EXTREME NEUTRINOS

SEARCHING FOR THE SECRETS OF THE UNIVERSE IN THE DEPTHS OF THE EARTH.

BY KATIE YURKEWICZ

Kurt Woschnagg has been waiting nine days to catch a plane to the South Pole. He flew for 15 hours from San Francisco to New Zealand, waited several days to spend another eight hours in a cargo plane to McMurdo Station in Antarctica, only to wait again for the weather to clear. Finally, wearing layers of cold-weather gear topped off with a bright-red parka, he is stuffed into a C-130 cargo plane for the last leg of his trip. He emerges three hours later at the South Pole—an ice sheet at 9,500 feet elevation, with a temperature of−200F and air drier than the driest deserts.

Nine thousand miles away, Vincent Bertin is on a ship in the Mediterranean Sea. He will spend the next seven hours lying on his stomach, in a titanium sphere two meters in diameter, with two other men-the pilot and co-pilot of the submarine Nautile. Bertin squeezes into the small craft, recalling the instructions to turn off the oxygen immediately in case of fire. He hopes nothing goes wrong. A huge rope lifts the Nautile out of the ship and deposits it in the sea. An hour later, the three men reach the sea floor, 2,500 meters below the surface.

Woschnagg and Bertin, both particle physicists, are going to extreme environments to study some of the most exotic phenomena in the universe.

In search of colliding galaxies, exploding stars, gamma-ray bursts and dark matter, they are building the largest particle detectors in the world. These are a new type of telescope using high-energy neutrinos, instead of light, to view the sky. Neutrinos make ideal astronomical messengers. They have no electric charge, almost no mass, and are extremely difficult to catch-trillions of neutrinos stream through your body every second without a trace. Unlike light, they travel unhindered from the distant reaches of the universe and from the very centers of violent astrophysical phenomena.

> **"IT'S THE DIFFERENCE BETWEEN A PHOTOGRAPH OF A PERSON AND AN X-RAY."**

"Neutrinos reveal different information about the same objects," explained theoretical astrophysicist John Beacom from The Ohio State University. "It's the difference between a photograph of a person and an x-ray."

Neutrinos can "x-ray" gamma-ray bursts-extremely high-energy explosions whose origins are a mystery; they can penetrate the cosmos, displaying the farthest and oldest parts of the universe; they can offer clues to the sources of high-energy cosmic rays that constantly shower the earth with energies up to 100 million times that of the most powerful particle accelerators. Neutrinos produced in the centers of stars and galaxies could hold clues to the invisible dark matter comprising some 25 percent of the universe.

First, physicists must catch them. Because neutrinos interact with matter so rarely, giant detectors are needed to measure their energies and directions. Detectors big enough to see neutrinos from a distant galaxy would be prohibitively expensive to build. Physicists are calling on nature to measure what nature has made so elusive, using large quantities of water and ice to turn the earth itself into a great neutrino target.

Deep freeze-in summer

Woschnagg, a physicist from the University of California, Berkeley, has ventured to the Antarctic seven times to build a neutrino telescope-the Antarctic Muon and Neutrino Detector Array, frozen 2,000 meters deep in the South Pole ice.

With hundreds of detectors, called photomultiplier tubes, frozen in the ice, AMANDA researchers measure the properties of neutrinos coming through the earth from the northern sky. A neutrino traveling through the earth from the north will occasionally crash into a proton or neutron, creating another subatomic particle called a muon. The muon enters the South Pole ice from below, traveling extremely fast-so fast that it gives off a shock wave of faint blue and ultraviolet light. The PMTs embedded in the ice can track the muon as it travels through the telescope, allowing researchers to reconstruct the original neutrino's energy and direction and determine its point of origin in the cosmos.

Tracking the muon can be difficult due to dust from the Sahara desert that drifted to the South Pole between 40,000 and 70,000 years ago. The Sahara dust embedded in the deep ice causes the blue and UV light to scatter, masking the muon's true speed and direction.

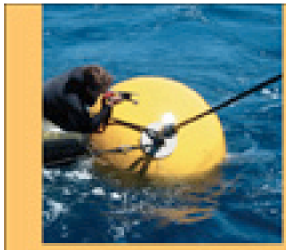
PMTs act like light bulbs in reverse-when a photon of light enters a PMT, an electrical signal is generated. The PMTs are enclosed in pressure-resistant glass spheres bigger than bowling balls. In AMANDA, 700 of these glass optical modules are arranged on 19 electrical cables, like beads on a string 2,000 meters long. The optical modules are positioned between 1,500 and 2,000 meters deep in the ice. The electrical cables rise to the surface, where the PMT signals are digitized and sent to computers for analysis. The AMANDA array encloses a volume of ice 500 meters tall and 200 meters wide-bigger than the Eiffel Tower.

The Antarctic summer allows about 3 months of working time per year, and storms are common, especially early in the season. All the AMANDA components-along with equipment for assembly and installation; electronics and computers to make sense of the detector signals; food, clothing, and fuel for researchers-must be flown to the South Pole in dozens of huge C-130 cargo planes, at the whim of weather and wind.

"Pilots don't have any ETAs; they're happy to get you down there in a day or two," said Steve Barwick, a professor at the University of California, Irvine, and co-spokesperson of the AMANDA experiment. "Once you've flown down there, you never complain about commercial aviation again."

After arriving and waiting a few days to adjust to the polar climate, Woschnagg, Barwick, and their fellow AMANDA researchers wait again. A dozen professional ice drillers create a two-kilometer deep, half-meter wide hole, using a hot-water drill that works at one centimeter a second. Running in shifts around the clock, the drilling takes 70 hours. The minute the drillers have finished, the researchers suit up in huge red parkas, giant boots, gloves, sunglasses and sunscreen, grab hand- and

AMANDA
Cables: 19
Detectors: 700
Depth: 2000m



foot-warmers and tools, and head onto the ice. They work in shifts for the next 20 hours, sometimes without gloves in temperatures of -100 F to -400 F, to install one string of the AMANDA detector.

"If there's a little bit of wind, you get frostbitten," said Barwick. "The water in your skin freezes and causes your skin to puff up, and since your nose sticks out, you end up with a little white Bozo nose."

The scientists lower the two-kilometer electrical cable into the hole, attaching one optical module every 17 meters. After the last optical module is attached, the rest of the string is lowered and held in place. The deployment must be completed within 30 hours, before re-freezing halts the work. The AMANDA array, and everything else ever buried at the South Pole-a cargo plane that broke down years ago, the old South Pole station-are entombed in the Antarctic ice.

"IT'S ALL GOING TO BE THERE FOR 100,000 YEARS UNTIL IT'S SWEPT INTO THE OCEAN," SAID WOSCHNAGG.

AMANDA's installation was completed in 2000, but five years of data have produced no extraordinary results yet.

"We're seeing about 800 high-energy neutrinos a year," said Barwick, "but all are consistent with neutrinos being produced in the earth's atmosphere."

"Atmospheric" neutrinos, produced by interactions of cosmic ray particles with the earth's atmosphere, might be useful for studying the properties of neutrinos. But if you're hunting sources of neutrinos in the universe, atmospheric neutrinos are nothing but noise.

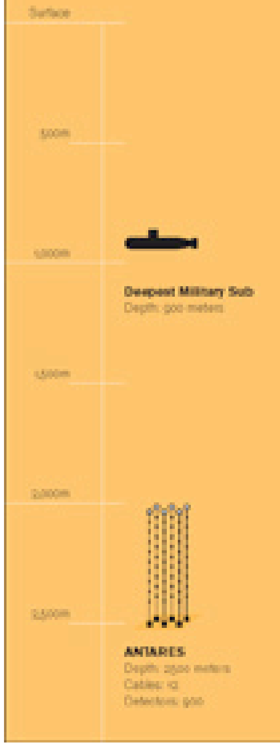
The Baikal Neutrino Telescope, the first underwater neutrino detector array, has reported similar results. The telescope, located in Siberia's Lake Baikal at a depth of 1.1 kilometers, covers a 43-meter diameter, 72-meter high area of the lake. Baikal looks through the earth for neutrinos from the southern hemisphere. One-tenth the size of AMANDA, Baikal was completed in 1993 and has been collecting data for over 10 years. Baikal has seen hundreds of atmospheric neutrinos, but no exotic astrophysical sources or dark matter annihilations.

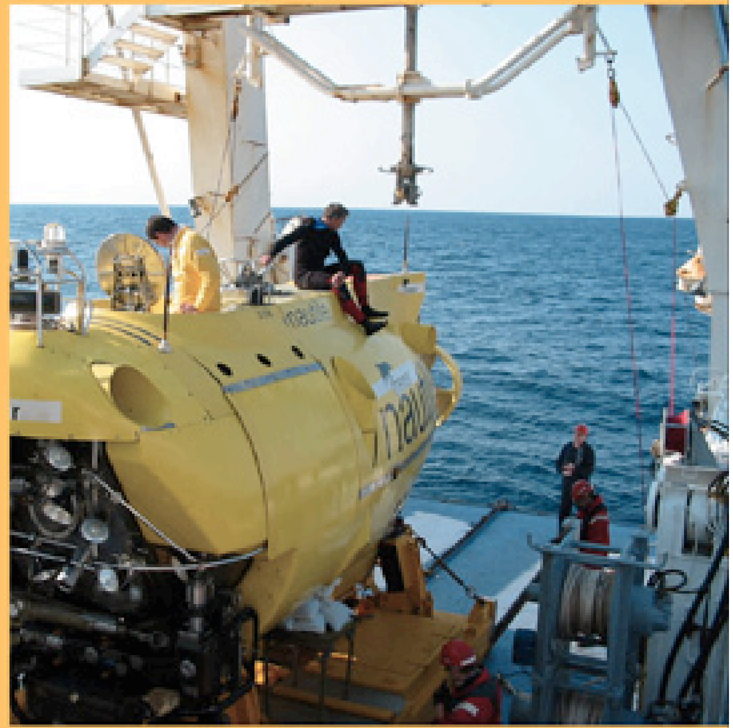
A pitch-black undersea beach

Bertin's voyage to the bottom of the sea took place in 1999. A physicist at the Centre de Physique des Particules de Marseille, he was scouting a location 2,500 meters deep and 40 kilometers off the coast of Toulon, France, for an underwater neutrino telescope, the Astronomy with a Neutrino Telescope and Abyss Environmental Research. The 150-meter-wide, 300-meter-high ANTARES array needed a deep, flat and featureless section of sea floor.

"It was like a huge beach," Bertin recalls of his view from the small submarine. "At that depth there is no sunshine at all, so there are no plants or algae and very few fish. It was also amazing to see many bottles of beer, cans, plastic bags-there is nothing to hide them."

While beer cans and bottles are no obstacle to underwater telescopes, ANTARES faces other environmental and technological challenges. The telescope will have 900 optical modules strung along 12 electrical cables, all of which must be kept leak-free-even a tiny leak would destroy the PMT inside. A small mechanical weakness in the glass optical module could cause it to implode at the depth of ANTARES, where the pressure is 200 to 240 times that at the surface.



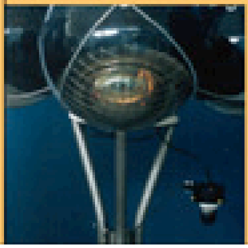


Salt water contains a radioactive isotope of potassium, whose decay produces a speeding electron; that electron can emit blue and UV light, simulating a muon and fooling the closest PMT. Ocean currents as strong as 18 centimeters per second can move the tops of the ANTARES detector strings by as much as five or ten meters. Strong ocean currents also stimulate another source of light in the deep sea-fish and other organisms that have learned to overcome the lack of natural light by producing their own bioluminescence. Bertin experienced this light "noise" from the submarine.

"Sometimes the pilot would turn off the sub lights and we could see shining everywhere-very small flashes from shrimp-like beasts," he said. "It was quite beautiful."

The problems of leaky optical modules, light from glowing fish, and moving detectors have been solved after years of research. The 40-kilometer power cable, laid on the sea floor from the French coast to the site of the telescope, seems to have avoided another anticipated problem.

"We send an electric current through the cable, and when we told other people who had done this kind of power distribution before, they



said that sharks are attracted to it," explained ANTARES collaborator Greg Hallewell. "People say that sharks are attracted by the electric fields of dying prey, but it's been more than two years and we haven't had any damage."

The 12 strings of ANTARES will be deployed over a span of three years. Each deployment requires a combination of good weather and permission from the French navy, which has a submarine base in nearby Toulon. The submarines pose no threat to the telescope, which is much deeper in the sea than the they dive, but the navy often denies access to the surrounding waters in the interests of secrecy. Depending on sea and storm conditions, ANTARES deployment can take as little as 14 hours, or as long as many months.

"The most delicate operation is putting the detector in the surface of the water," explained Luciano Moscoso, deputy spokesman for ANTARES. "To avoid a shock in your detectors, you need less than one meter between the wave minimum and maximum. The quality of the sea is a big problem."

The strings are deployed slowly, using two winches attached to the boat. First the anchor is deployed, then the electrical cable is paid out, while three optical modules are attached every 14.5 meters. Once the anchor is 200 meters from the sea floor, the position is measured using acoustic beacons, and the ship is moved as necessary to adjust the position.

A small submarine is needed to connect each string of detectors to the 40-kilometer electrical cable, so the signals can be brought from the detectors to the shore. Manned craft like the Nautile are often unavailable-the connection of one prototype string of detectors was delayed for three months while the Nautile worked on the wreck of an oil tanker off the Spanish coast-so researchers are negotiating for the use of unmanned, remotely-operated submarines.

NESTOR *(When Completed)*
Tiers: 12
Detectors: 144
Depth: 4000m

Cosmic fishing expedition

Nine hundred miles away, another group of researchers prepares to install the Neutrino Extended Submarine Telescope with Oceanographic Research 4,000 meters deep in the Mediterranean Sea, 14 kilometers off the coast of Pylos, Greece.

NESTOR's optical modules sit in groups of two at the ends of giant six-armed titanium stars. The 410-meter high NESTOR detector is a tower made up of a stack of twelve of these 32-meter diameter stars. The tower's depth considerably reduces the background from bioluminescence, and all electrical connections are made above the surface, eliminating the need for a submarine.

"We follow the standard Mediterranean fishing technique," said physicist Leonidas Resvanis, director of the NESTOR institute. "You put your fishing nets on the sea floor, and you have a rope that goes up to a buoy, and you grab the buoy and bring everything up."

One floor of NESTOR has been installed. To install subsequent floors, the entire array will be removed from the sea, the next floor attached, and the whole telescope replaced.

When completed, ANTARES and NESTOR will be the largest neutrino telescopes in the northern hemisphere, and the largest underwater telescopes. Following hard on their heels, however, is IceCube, a $270 million neutrino telescope being built under the South Pole. IceCube, AMANDA's successor, will be about 100 times bigger than ANTARES and NESTOR. Similar to AMANDA in design, IceCube will cover an area one kilometer wide, one kilometer deep and one kilometer high, with 80 strings of 60 optical modules each, for a total of 4800 PMTs. The first few strings of IceCube will be installed this winter, with work continuing on detector deployment every year through 2010.

So when will the first neutrinos from a black hole at the center of a far-off galaxy be spotted in these new telescopes? Scientists aren't sure, but they're hoping that the next ten years will bring big advances.

"In astronomy, every time a new type of instrument was made, completely new sources were discovered," said Beacom. "Your stockbroker will say that past performance is no guarantee of future results, but we have every expectation that the neutrino will be extremely important to the future of astronomy and astrophysics."

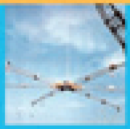
AMANDA and Baikal continue their searches. NESTOR and ANTARES will be completed by 2007 and IceCube a few years later. Two kilometer-cubed detector arrays for the Mediterranean have been proposed-the Neutrino Mediterranean Observatory near Sicily, and a joint [illegible] ANTARES and NESTOR [illegible]

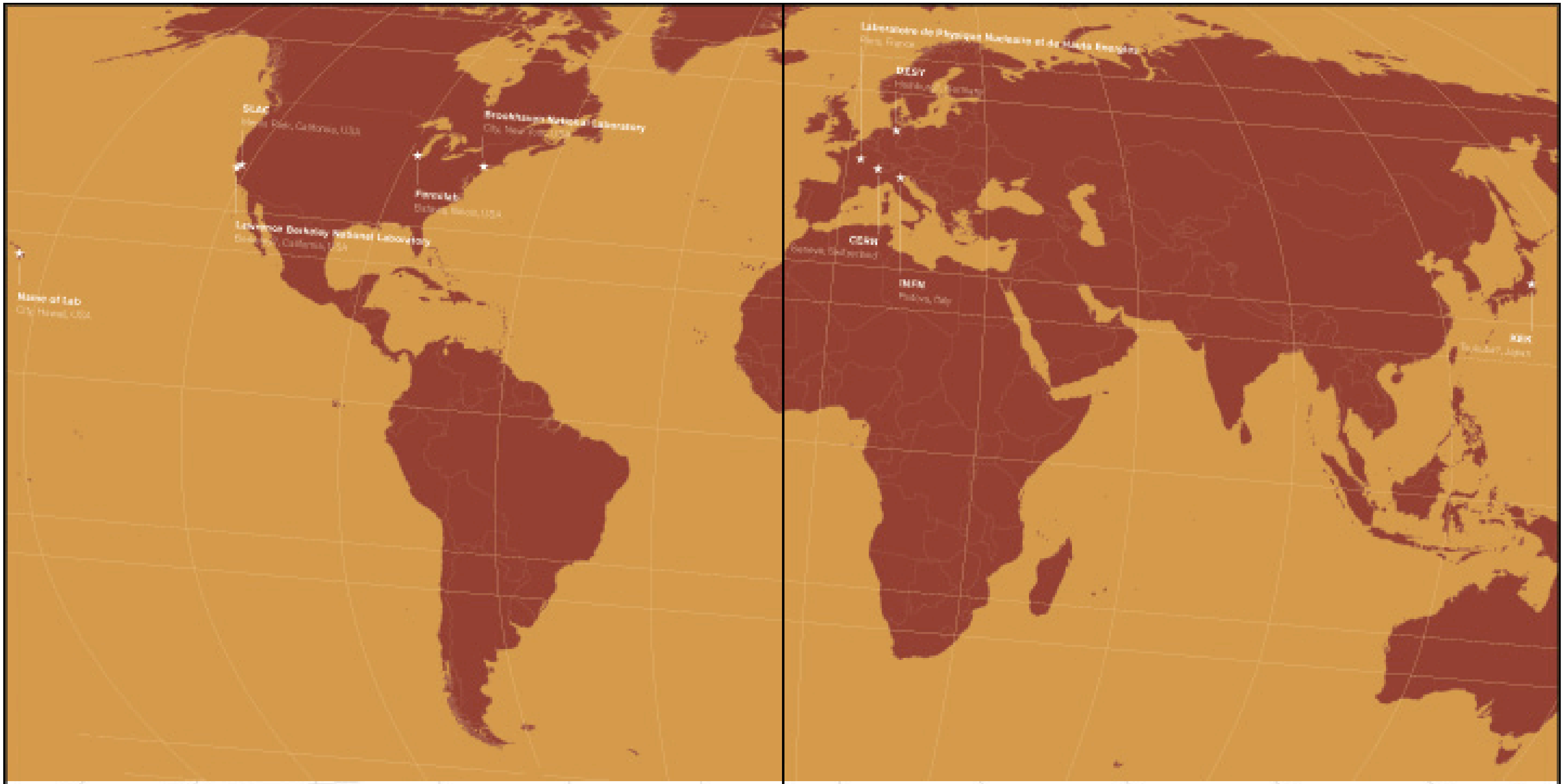
"THIS IS A FISHING EXPEDITION FOR COSMIC NEUTRINOS," SAID RESVANIS. "NOBODY REALLY KNOWS HOW BIG A NET YOU NEED TO CATCH THEM."

Funding for Physics Experiments

The U.S. National Science Foundation is the primary source of funding for IceCube. Construction of IceCube, which NSF lists as a Major Research Equipment project, will cost about $270 million. The NSF requested $33.4 million in MRE and Facilities Construction funding for IceCube for fiscal year 2005. The administration requested the same amount, and in July the House Appropriations Committee recommended to Congress $51.2 million in funding for IceCube for FY05. This increase of $17.8 million over the request was recommended in the hopes of reducing the overall total project cost. The next step in the FY05 funding process is for the Senate to take action on the VA/HUD spending bill that includes funding for the National Science Foundation. IceCube receives additional funding from the Department of Energy's Office of Science, the University of Wisconsin, and government and private funding agencies in Belgium, Germany, Sweden and Japan.

The ANTARES neutrino telescope will cost about $25 million to build. Several French governmental agencies and local governments; the European Union; and agencies and institutions in Germany, Italy, Netherlands, Russia, Spain and the United Kingdom are providing funding for the telescope. NESTOR, which will cost around $20 million, receives major funding from governmental agencies and institutions in Greece, and additional funding from collaborating institutions in Germany, Russia, Switzerland, and the United States.





Families of the world

Physicists in the global era

by Heather Rock Woods

The increasingly international nature of particle physics is compelling scientists and their families to adapt. The effects on family life go way beyond jet lag and it's up to individuals to navigate the foreign terrain.

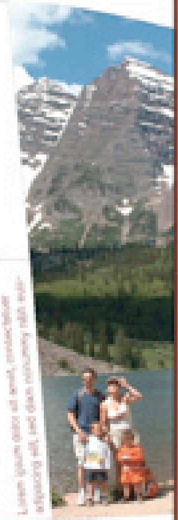
Paris-based particle physicist Pierre Antilogus spends more than a month a year at his experimental site, lately Hawaii. He missed his youngest daughter's first birthday and his oldest daughter's sixth birthday this past year, with travel to Hawaii and Lawrence Berkeley National Laboratory (LBNL) to prepare and install a supernova-detecting spectrograph in a Hawaiian telescope. He is a researcher at Laboratoire de Physique Nucleaire et de Haute Energies.

"For the small kids, it's really difficult to handle when one of the parents is not around," he says. For example, "Five weeks away for a one-year-old baby: When she saw me again for the first time, she opened her big eyes and started a terrible cry – five minutes later she wanted to come in my arms and stayed glued to me for half an hour like a small animal. Five weeks away for a six-year-old kid, you got a letter two weeks after you leave: 'Dad, you should come back NOW. I'm too sad when you are not here.'"

"So on the kid side, when you leave you should try to set up a minimum of support for the mother," says Antilogus. "But anyway, it will be hell. We try to have a 50 percent share among us for what should be done for the family. My wife is working a lot too and she has then a full double agenda when I'm not here. It's clear that this generates tension between us."

He does try to make it up to his wife. "Indeed when I'm back I'll try to work a bit less and pick up more often the kids or get up more often the first one in the morning."

"Also, when I travel, this can make real to my kids a few facts. My 6-year-old daughter realized this year, when I was in Hawaii, that the sun is always somewhere on Earth," he grins by email.



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Thirty years ago the American particle physics landscape looked different from today. Nobel Prize winning experiments had nine people on their teams. Foreign scientists were part of the mix, but collaborations involved few, mostly domestic, institutions. Even at CERN, an international organization from its inception in 1952, the lab acted more as a regional facility for a small continent, says James Gillies, its head of education and communication.

Now collaborations routinely involve 300 to 800 hundred physicists and engineers. Two of the detector collaborations for the Large Hadron Collider (LHC) being built at CERN in Geneva each have about 2000 people from 36 countries. Another big change is that even accelerators, once the province of the labs who operated them, are beginning to be designed and built by international collaborations.

Working internationally is now a necessary ingredient of many particle physics projects. New revolutionary questions about our universe require telescopes looking farther into space and higher-energy accelerators that take many nations to plan, build, fund, and operate.

"This is the only way I can do research. All interesting research projects today use many people and funding difficult to find in a single country," Antilogus says. "The ones who can't travel at all are in trouble–they will not be able to contribute to experimental research today."

Frequent emails, hours-long conference calls, and videoconferences are part of the package. But travel, including relocation, is still necessary to test and install equipment, oversee an experiment, take data, work out issues face-to-face and present results. To save money and not interfere with teaching duties, trips often go through weekends.

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Yoji Yamazaki , a researcher for KEK in Japan, essentially relocated to DESY in Germany nine years ago to oversee a hardware system for the ZEUS experiment. His wife, a pianist, cannot work in Germany.

"My wife is learning German but still do not have many friends. I am sure she feels herself quite isolated and this is indeed a possible problem," he says.

Yamazaki relies on technology to spend more time with his wife. "I think the best thing to make it easier is to stay home as much with her by bringing back some work to home. In this sense, the recent development on the broadband connection has been the best technology to make the foreign life easier."

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For better and for worse, physicists and their families continue to join the global village in growing numbers to do the work they love. Families can gain much: foreign friends, overseas vacations and vibrant cultural exchanges, and an introduction at a young age to the world. But sometimes it comes at the expense of a baby who doesn't immediately recognize you after a long trip, a spouse with a sidelined career, or feeling linguistically and culturally illiterate in a foreign environment.

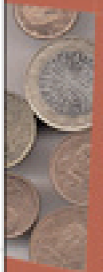
"Not much is done in our profession to take care of family life," says Steve Goldfarb, an American researcher for the University of Michigan, based at CERN for the last 16 years. He married a local Frenchwoman and has two kids, ages 1 and 4. [DJH]

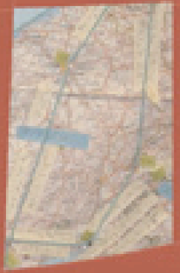
"This has nothing to do with being abroad or not. Just a problem that will take many generations to solve, if we are so motivated. In my situation, I have had to trade in the pursuit of tenure in order to remain here at CERN with my wife and family," he says.

As a software coordinator on the giant ATLAS collaboration, he sees lots of families coming and going.

"Sometimes families are split up for up to a year at a time," he says. "Sometimes spouses have to give up jobs to follow the other's career path. Sometimes children have to spend a year attending school in a different language. I have seen people come here and like it and want to stay. I have also seen couples split up or families have to move back before they had planned."

"The cultural change itself is rarely a factor," Goldfarb says. "Taking a spouse away from a job and putting them some place where they cannot work and are somewhat isolated is probably the biggest problem for couples."





Families aren't entirely on their own. CERN and other labs do have users' offices that provide assistance with foreign paperwork and local information and customs. And some technologies and situations called for by the science can prove beneficial to families, but only by coincidence. For example, the proposed international linear collider project is exploring the possibility of using a remote control room that would allow people to take shifts at their home institutions.

"Everyone seems to have found some way of coming to terms with it," says Archana Sharma, an applied physicist at CERN who travels frequently. In her experience, she and her collaborators generally do not plan around families, and she sees the benefits of international work as solely professional. Still, given their work demands, many scientists try to compensate for the difficulties and provide some advantage for their families. After a trip, Sharma spends extra time with her family and cooks them a special meal with food from the place she's just visited.

Physicists, whose bread-and-butter is solving challenges, are applying their inventiveness to life outside the lab. Some limit their travel time when their children are young; some rotate travel obligations with co-

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The shape of things to come

International Panel Recommends "Cold" Technology for Future Particle Accelerator

Beijing, China—The International Committee for Future Accelerators(ICFA), meeting during an international physics conference here, today (August 20) endorsed the recommendation of a panel of physicists charged to recommend the technology choice for a proposed future international particle accelerator.

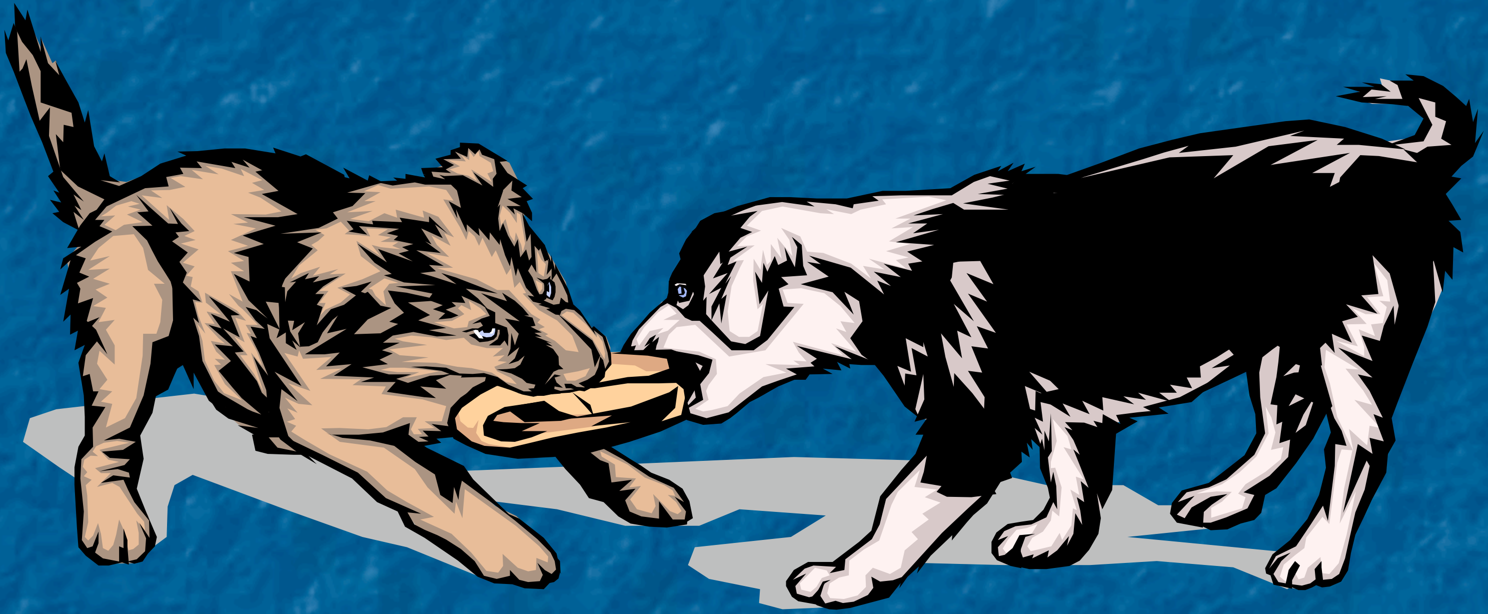
The 12-member International Technology Recommendation Panel, chaired by Barry Barish of the California Institute of Technology, recommended that the world particle physics community adopt superconducting accelerating structures that operate at 2 Kelvin, rather than "X-band" accelerating structures operating at room temperature, as the technology choice for the internationally-federated design of a new electron-positron linear collider to operate at an energy between 0.5 and 1 TeV.

"Both the 'warm' X-band technology and the 'cold' superconducting technology would work for a linear collider," the ITRP’s Barish said.

Neil Calder, Director of
Communications

United in Beijing

No Squabbling



The shape of things to come