PARTICLE PHYSICS

## First Glimpse of the Last Neutrino?

Of the 12 elementary particles thought to make up all of the matter of the universe, physicists have spotted 11. Now the last holdout, the tau neutrino, may finally be in the bag. At least three of the exotic particles appear to have left their tracks in a detector at the Fermi National Accelerator Laboratory (Fermilab), in Batavia, Illinois. But researchers on the experiment, called DONUT, want to find another seven or so before popping the champagne.

Neutrinos are notoriously difficult to detect—make one in the lab, and it is likely to slip insouciantly through the table, the planet, and much of the universe. These runaways come in three flavors: the electron neutrino, the muon neutrino, and the tau neutrino, each named for the particle it creates when it does happen to interact with matter. Over the years, physicists have become adept at spotting electron and muon neutrinos, but no one has ever seen a tau neutrino.

Physicists, however, are pretty sure that the tau neutrino exists. Experiments at the European accelerator laboratory CERN near Geneva have shown that a heavy particle called the Z decays into exactly three types of neutrinos, for instance. The unseen tau neutrino also made headlines recently when an experiment in Japan suggested that muon neutrinos raining down from the upper atmosphere might be changing into tau neutrinos and eluding detection—a transformation that would imply that neutrinos have mass, contrary to a long-standing assumption (*Science*, 12 June, p. 1689). To confirm the identity shift, future experiments will try to detect the tau neutrinos directly. For that reason "it's very important to confirm that one can actually see a tau neutrino first," says Carl Albright of Fermilab and Northern Illinois University in De Kalb.

That's a challenge because, unlike the relatively pedestrian electron and muon neutrinos, tau neutrinos are very difficult to make in the laboratory. At DONUT, a dense stream of protons from Fermilab's Tevatron accelerator is smashed into a tungsten target, but fewer than one collision in 10,000 produces a tau neutrino, says Byron Lundberg, a spokesperson for the group.

To detect these rare particles, the team built a stack of sheets coated with silver bromide emulsion next to the collision area. When a tau neutrino plows through these sheets, it has a slight chance of bumping into an atom and creating a tau particle. The tau would leave a millimeter-long track in the emulsion—which operates like a photographic plate—before decaying to other particles, which would also leave tracks.

After 4 months of taking data, the team found what looked like the tracks of three tau neutrinos. The group expects to find more tau tracks when they analyze the rest of the emulsion. Until then they're not making any definite claims. "I think it is very likely that [their observations] are correct," says Hywel White, a neutrino expert from Los Alamos National Laboratory in New Mexico. "Everybody believes that there is a tau neutrino, but you have to have experimental proof of it."

–MEHER ANTIA

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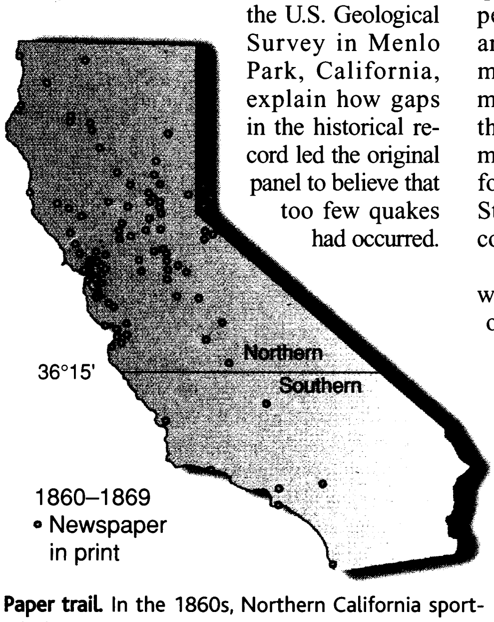
SEISMOLOGY

## A Quieter Forecast for Southern California

Four years ago, Southern Californians—already resigned to the risk of quakes, fires, and floods—got a bad jolt. An official group of seismologists had concluded that despite the powerful earthquakes of 1992 and 1994, destructive temblors were likely to strike the region even more frequently in coming decades. The reason: the strain built up in the crust by an "earthquake deficit" over the past 150 years (*Science*, 28 January 1994, p. 460). Earthquake insurance rates quadrupled after the announcement. But now an independent analysis and a review by seismologists, including one of the original panel members, both conclude that the deficit was due to accounting errors—and that the region is right on schedule for quakes.

In the current issue of the *Bulletin of the Seismological Society of America*, seismologists Ross Stein and Thomas Hanks of the U.S. Geological Survey in Menlo Park, California, explain how gaps in the historical record led the original panel to believe that too few quakes had occurred.

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**Paper trail.** In the 1860s, Northern California sported plenty of newspapers to record earthquakes, but there were few in the southern part of the state.

"Based on this analysis, I'm sold on there being no indication of a major earthquake deficit," says seismologist Duncan Agnew of the University of California (UC), San Diego.

The Working Group on Southern California Earthquake Probabilities reached its original, ominous conclusion by combining, for the first time, every type of observation that could indicate how often big quakes should strike. The group compiled geological data on active faults, the historical record of past quakes, and geophysical measurements of accumulating crustal strain. In the end, the combined geological and geophysical constraints seemed to call for twice as many quakes of magnitude 6 and above as had occurred. The strain would be released in an increased rate of moderate-to-large quakes, or, as working group member David Jackson of UC Los Angeles suggested on his own, in a single huge quake many times more powerful than the Big One—estimated to be of magnitude 7.9—that rocked Southern California in 1857.

But Stein and Hanks came to a different conclusion after scrutinizing the historical record more closely. They compiled their own record of Southern California seismicity since 1903 and found the number of quakes to be in line with that expected from the geological and geophysical data. The quake numbers dropped off before 1903—but that's just when quake records would be expected to get spotty in Southern California, they say.

In the 19th century, the primary seismic recording device was the newspaper. Seismologists today map the location and size of old quakes from newspaper accounts of how hard the ground shook in a given quake. The 1849 gold rush drew enough people—and newspapers—into northern and central California to ensure that no magnitude 6 or larger quakes would be missed there, Stein and Hanks found, but in the south the population was sparse (see map). "It's a rotten record in southern California until the turn of the century," says Stein. "It would be impossible to have a complete catalog until about 1900."

In response to this work, seismologists Edward Field and James Dolan of the University of Southern California in Los Angeles, together with Jackson, completely redid the working group's analysis. They found numerous small mistakes, from the missed 19th century quakes to a rounding error, and they agree that the quake deficit is no more. That means a lowered risk from future quakes—and perhaps lower earthquake insurance rates. But Southern Californians can't relax: Even without a deficit to make up, they are still due for four or five magnitude 6 and larger quakes per decade.

–RICHARD A. KERR