Tevatron sets world record; the most productive age for research; numbers: Pierre Auger Observatory; bicycle networks; keeping computers cool; opera review: *Doctor Atomic.*

Photo: Reidar Hahn, Fermilab

A bright machine

The Fermilab Tevatron achieved a world-record peak luminosity, or brightness, in colliding protons and antiprotons on October 4, 2005. The luminosity of $141x10^{30}$ $cm^{-2}sec^{-1}$ is about four times the luminosity achieved three years ago, and more is expected to come.

To maximize the potential for scientific discovery, accelerator experts improve and tune their machines to produce the largest number of collisions per second, a rate known as the peak luminosity of a particle-collider machine.

The Tevatron record surpasses that set in December 1982 by the ISR collider at CERN, which collided protons on protons. The ISR achieved a peak luminosity of $140x10^{30}$ $cm^{-2}sec^{-1}$ at a collision energy of 62 GeV.

Why did it take 23 years to break the ISR record? Beams of antiprotons are much harder to produce than protons, and the Tevatron operates at a much higher collision energy of 1960 GeV. The Tevatron record is tied to the startup of a new technique to cool antiproton beams, which makes the beams more concentrated.

Kurt Riesselmann

Don't cite anybody over 30?

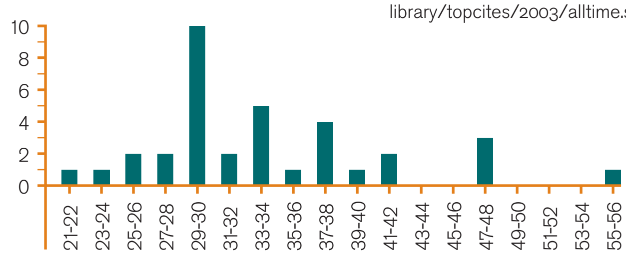
A common assertion is that the best work in physics is done by people who are under 30. Is it true? This chart shows the ages of authors at the date of publication of the top 25 theoretical papers from the SPIRES all-time top-cited list. Included are the 29 authors whose ages are in the database. Some appear more than once as authors on multiple papers.

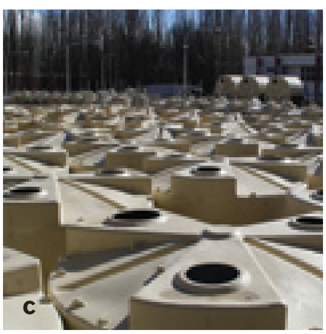
Half the authors were 32 or younger when they published their famous papers. The chart shows that the most frequent ages are 29 and 30. In fact, almost half the ages are concentrated around the window of 29-30.

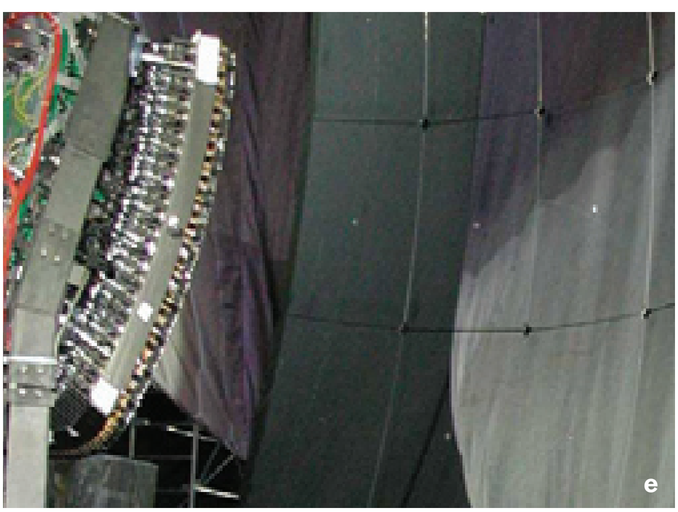
Heath O'Connell, Fermilab

Ages at publication of top-cited papers

Source: SPIRES (http://www.slac.stanford.edu/library/topcites/2003/alltime.shtml)







Photos: Pierre Auger Observatory

Numbers: Pierre Auger Observatory

In November, the Pierre Auger Observatory outside Malargüe, Argentina, celebrates its scientific launch. The observatory will record high-energy cosmic-ray showers with ground-based water tank detectors and air-shower cameras.

David Harris

3000	Detector area in square kilometers	a
30	Number of times Paris would fit within detector area	
1400	Meters above sea level	b
739	Current number of water tanks	
1600	Eventual number of tanks	c
11,000	Liters of water per tank	
1500	Meters between water tanks	
20	Years of expected lifetime for tanks	
3	Current air observation cameras	d
440	Photomultiplier tubes per camera	e
1500	Events per day recorded	
140	Highest energy of a recorded event in EeV (exa-electronvolts=10^{18} eV)	
100	Speed in miles/hour of tennis ball with equivalent energy	
15	Countries participating	
1938	Year Pierre Auger discovered cosmic ray showers	
20,000	Population of Malargüe	
927	Argentina's average human population per detector area	
81	Argentina's average llama population per detector area	

Photo: Fermilab

Networks of the past

In today's particle physics experiments, it takes a fraction of a second for data recorded by detectors to be transferred to a data storage facility. Soon thereafter, collaboration members from around the world have access to the data via the Internet.

Not so thirty years ago. In the 1970s, experimentalists at Fermilab and other labs had no networks to transfer their experimental data from the data acquisition system to the places where they would store and analyze their data. Their mode of data transfer was rather low-tech: the bicycle. At the end of a shift, a scientist would take the tapes with data, hop on a bike, and ride over to the computer center or wherever the data analysis took place. This process even received its own acronym: BOL, for "Bicycle Online."

Today, the Bicycle Online transfer is history. But like thirty years ago, Fermilab again has a pool of bicycles that is available for experimenters to ride around the site. But today's bike trips are usually to meetings and seminars, or just out to lunch.

Kurt Riesselmann

Hot computers

Computing centers are hot–literally. At least, they are in the absence of extensive cooling systems. With an increasing number of computers installed at scientific labs nationwide, the efficiency of those cooling systems is becoming much more important. Just ask John Weisskopf, technical operations manager at the Stanford Linear Accelerator Center. He is responsible for keeping the more than 3500 computers in the laboratory's main computer center from overheating.

The cooling process starts at SLAC's water cooling plant, where nearly 300 tons of chilled water is circulated to the computer center. The water is distributed to the building's cooling coils, which work like giant radiators in reverse, to extract heat from the air. The cooled air is blown into the 12-inch raised floors of the computer rooms. The current system can cool at a rate of 125 watts per square foot, Weisskopf said, but with a yearly increase in the number of computers installed, an ideal system needs to handle 500-600 watts per square foot.

"We are at the breaking point for old-fashioned under-floor cooling systems," Weisskopf says. "We're stuffing thousands more little hot computers in here, and it's more and more difficult to power and cool them." Four air handlers, which resemble 14-foot-long giant refrigerators, have been installed to cool areas of the center that produce excessive amounts of heat. Six more are scheduled for installation before winter. But even those won't be sufficient for long, Weisskopf says. By spring 2006, Weisskopf hopes to install a water-cooling system that will deliver cold water to each individual computer rack in the center.

The ultimate solution is to direct chilled water as close to the computers as possible. Some manufacturers are working on cooling systems that would channel chilled water directly to computer chips. But until the plumbing intricacies are solved, water-cooled racks are the best option for SLAC, Weisskopf says. "If you get a leak [near a computer chip], you're in trouble," he says.

Kendra Snyder

Photo: Diana Rogers, SLAC

Doctor Atomic: A Manhattan Project opera

Reviewed by Mary K. Miller, Exploratorium

Photo: Terrence McCarthy

Particle physics has been getting its due in the theater world with the recent plays *Copenhagen* and *QED*, which celebrate the lives and work of famous physicists. Now the field is being paid the highest musical and artistic compliment, inspiring the new opera *Doctor Atomic*, which had its première in early October by San Francisco Opera. It tells the story of the Manhattan Project, boiling the action down to a few weeks and hours before the test of the first atomic bomb in April 1945. The opera centers on science director and physicist J. Robert Oppenheimer, his wife Kitty, Edward Teller, General Leslie Groves, and the young idealistic scientist, Robert Wilson. Pulitzer-prize winning composer John Adams wrote the music and his long-time collaborator Peter Sellars directed the opera and cobbled together the libretto from declassified government documents, personal letters, interviews with project participants, and Oppenheimer's favorite poetry.

As a science writer at the Exploratorium, I became involved in this production when the museum was asked by San Francisco Opera to create a companion Web site for the opera, focusing on the scientific, cultural, and historical impact of the atomic bomb. My museum has a stake in the story: physicist Frank Oppenheimer, who founded the Exploratorium in 1969, was the younger brother of J. Robert, and worked alongside him on the Manhattan Project.

So it was with great anticipation that I attended the opera's première, wondering how the celebrated creators of *Doctor Atomic* would handle such a complex, momentous event in our nation's history. For the most part, I wasn't disappointed. It was a musically thrilling, intellectually challenging, and deeply affecting three hours with only a few fizzles. John Adams uses a full palate of musical devices, from electronic compositions that evoke industrial mayhem, to tender passionate duets between Robert and Kitty, to clashing chords and tympani that pulled me to the edge of my seat. The orchestral music was at times full of tension and menace, foreshadowing the bomb detonation and its consequences. At other times, it provided quiet interludes, where the audience could contemplate the legacy of this ultimate weapon of mass destruction. In one of the most gorgeous passages at the end of Act 1, Oppenheimer is alone with his creation, known by scientists as "the gadget," singing the words of the John Donne sonnet, "Trinity" (for which the bomb test was named): "Batter my heart, three-person'd God." After fending off his fellow scientists' moral objections to the bomb's use against Japan, he surrenders a moment to his own Faustian misgivings.

The libretto was both intriguing and risky. Since Peter Sellars pieced it together from disparate sources and compressed the story into a very short time period, people not familiar with the science or history of the Manhattan Project may feel dropped into the middle of the action with precious little character or plot development. The dialog between physicists was often dense, as when Teller reports that Enrico Fermi was taking bets on whether the bomb test would ignite Earth's atmosphere in a vast "chain reaction." (This was an erroneous bit of physics since the question was whether heat from the blast would ignite a thermonuclear fusion reaction, not a fission chain reaction.) For background, it helped to attend the pre-opera lecture and I appreciated that Adams and Sellars never talked down to the audience but assumed we would come to the material with our own knowledge, background, and thoughts about atomic weapons and their use.

Of course, the opera's dramatic and anticipated high point comes at the end: the bomb goes off. In this age of special effects, Adams and Sellars were subtle. The countdown to the Trinity test stretched out with the orchestra driving relentlessly forward and the chorus shriek-singing words from the *Bhagavad Gita*: "I am become Death, the destroyer of worlds." Then all goes quiet, we see the greenish glow of a distant explosion on the faces of the chorus, and then hear the soft voice of a Japanese woman asking for a drink of water—taped testimony from a Hiroshima survivor. Thus, the opera ushers in a new age.

Explore more of *Doctor Atomic* at www.exploratorium.edu/doctoratomic