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The CDF Remote Control Room

Getting in on the Action, from Afar

Photo by REIDAR HAHN

G.P. Yeh, seated at a demonstration unit of the CDF remote control room in the lobby of Wilson Hall. The monitors on the upper right display cross-sections of the detector. Monitors on the left show the "head-on" view of the colliding region in the detector, and a "lego plot" of the secondary particle energy. Yeh is filmed by a small video camera mounted at about eye-level; he's looking into the display from those cameras on the monitors below. Two graduate students are seated behind Yeh.

by Leila Belkora, Office of Public Affairs

An invisible hand draws a white circle against a black background, almost filling the screen of a computer monitor. The circle represents the outer edge of the CDF detector at Fermilab. A spray of green, blue, and red lines blooms rapidly from the center of the circle, revealing the trajectories of particles stemming from the latest collision of a proton and an antiproton in the Tevatron accelerator. One green line arcs toward the upper right of the screen, two more curl around to the lower left. Faster than you can say data visualization, the invisible hand draws a yellow box around the green line on the right, the path of the particle with the highest calculated momentum. The screen goes black again. The image of another proton-antiproton collision at CDF—an ordinary event, as these collisions go, or a rare one that will send up a flag to physicists on the experiment—is due on the screen in less than ten seconds.

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CDF Remote Control Room

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The screen showing the paths of particles after a collision event is part of the CDF control room at Fermilab, alongside displays of cross-sectional views of the detector, diagnostic signals, and other information relating to the stream of data. At all times when the accelerator is running, a researcher on shift monitors the detector operation from the control room at Fermilab, and takes care of any problems that arise. Now, thanks to duplicate displays and Internet communication lines, a researcher in Japan or Italy may participate in operating the detector. The fleeting signature of a top quark born in Batavia may catch the eye of a physicist in Pisa.

CDF collaborators thought of a remote control room several years ago, but the plan was too costly to implement until recently. The first test of the CDF remote control room, about one year ago, came about thanks to Internet-based video links and the strong support of Alvin Tollestrup and Joel Butler at Fermilab, Kuni Kondo of the University of Tsukuba, and leaders at KEK, a national high-energy physics laboratory in Japan. Earlier video links required Fermilab to lease dedicated phone lines or a dial-up line from the telephone company, at a cost of a few hundred dollars an hour. The new system is less expensive for Fermilab to use, because it makes use of the Energy Sciences Network (ESnet), a communication network within the Internet serving the DOE Energy Research community and supported by the Department of Energy. Three institutions besides Fermilab have experimented with a CDF control room on a trial basis: the University of Tsukuba and KEK in Japan, and the University of Pisa in Italy.

The fleeting signature of a top quark born in Batavia may catch the eye of a physicist in Pisa.

Not only can collaborators in the CDF team monitor the progress of their experiment from faraway institutions using the CDF remote control room, they can also interact with the shift operator on duty at Fermilab and issue commands to control the data acquisition. If, for example, a researcher at the University of Tsukuba noticed that a section of the detector display was blank, indicating a "dead" component of the instrument, he or she could call a shift operator at CDF using a microphone installed over the computer monitor. Within minutes, these experts separated by about 6,000 miles could start solving the problem they both see on the screen.

G.P. Yeh, a CDF physicist who designed some of the on-screen event displays and worked to implement the remote control room in its trial run in Japan, says the innovation was necessary because of the increasing scope of the collaborations. "Experiments are getting bigger and bigger, more international, and everyone wants to have access from their own lab," he says. He adds that many high-energy physicists believe that only international collaborations can sustain the big experiments they are hoping to build in the future.

The CDF remote control room has other advantages, besides fostering international collaboration. Although physicists will still travel to Fermilab, the remote control room would allow graduate students who otherwise would not have funds to make the trip to participate in running the detector. Yeh says the remote control room may also make shift work easier. Collaborators take turns at the control room, each monitoring the displays eight hours a day over a nine-day period that comes around two or three times a year.

Photo by FRED ULLRICH

When You're a Jet, You're a Jet All the Way: They may look poised to dance, but this team's fancy footwork was in setting up the CDF remote control room (at left, behind). Front row, left to right: G.P. Yeh, Dick Adamo, Mark Leininger, Chuck Andrews. Back row: Dave Bundy, Al Thomas, Ken Stox, Mark Schmitz (Research Division), Marc Haibeck, and Nick Karonis. All but Yeh and Schmitz work for the Computing Division.

素粒子実験を遠隔操作

米国立加速器研WSにアクセス　筑波大が公開

インターネットを用いて日本から米国フェルミ国立加速器研究所の大型加速器を制御しているワークステーションにアクセスし、データ収集を行う実験が七日、筑波大学で公開された。筑波大の素粒子実験チームはワークステーションの画像と音声で、フェルミ研の実験室に居る技術者と打ち合わせ、加速器による衝突実験が順調に進んでいるかなどのデータをチェックした。素粒子実験を遠隔操作する試みは世界で初めてという。

筑波大と高エネルギー物理学研究所を中心とする日本の素粒子実験チーム（代表近藤都登筑波大教授）は米国、イタリアなど四カ国とCDFという国際研究グループを結成。フェルミ研のテバトロン加速器で素粒子実験を行っており、今年三月には基本粒子であるクオークのうち、ただ一つ発見されていなかったトップクオークを確認する成果を上げている。

テバトロンは九九年一月からビーム強度を約十倍に上げるが、これを機に日本、イタリアから遠隔実験を行う計画。遠隔実験ができるようになると、研究者は自分の大学や研究所に居ながら、実験の現場にいるのと同じような操作ができ、データ収集のためにわざわざ米国に出張する必要がなくなる。

CDFグループでは開発中の遠隔実験システムを、二日から八日まで米国サンディエゴで開かれているスーパー・コンピューティング・ワークショップでデモをしており、今回はそのシステムを公開した。

The CDF remote control room made an impression in Japan. The headline to the article reads (loose translation): Particle Physics Experiment Remote Control.

With the remote control room, it would be possible for a "Consumer Operator" at the helm in a different time zone to take the shift that occurs during the wee hours of the morning at Fermilab. However, members of the CDF team are still discussing to what extent they might safely relinquish control to remote users.

The displays of the remote control room do not keep up with the rate of collisions in the detector: a million proton-antiproton collisions occur every second. A few of these are interesting enough to record on tape every second, and the display screens sample only one event every 10 seconds. Nevertheless, this rate is sufficient for monitoring purposes, and keeps the transmission rate over intercontinental networks to a level that does not interfere with other users of the available bandwidth. Users usually set the tunable video link to a transmission rate of 128 kilobits per second. Information animating the event monitors requires a baud rate of about 200 kilobits per second.

What does the CDF remote control room cost? Yeh, who was demonstrating the setup in the lobby of Wilson Hall a few weeks ago, says with a smile, "This year, we just borrowed the equipment–it didn't cost anything!" He estimates that the monitors and other elements together would cost about $150,000. Fermilab constructed a remote control room at a supercomputing conference in San Diego in December 1995, as well as the demonstration unit in Wilson Hall. Graduate students Shin Aota, Paul Chang, and Hiroyuki Minato volunteered their time and effort to help set up the demonstration.

Assembling the remote control room also required the assistance of computing and network professionals. Bill Lidinsky in the Computing Division is in charge of the High-Energy Physics Network Resource Center, located at Fermilab and funded by DOE to help the high-energy physics community utilize network resources. His group implemented the Multi-Session Bridge, software that allows audio and video signals to be "packet-switched" and sent over the Internet. (See sidebar for an explanation of packet-switching.) The HEP-NRC group worked with Mark Kaletka's team on data communications and networking. The distributed hardware group, led by Marc Haibeck, put together the equipment for the CDF remote control room.

Yeh reckons that tests of the remote control room he helped set up in Japan were very successful, in part because of the fascination of collider detector data appearing in real time on the screen. "Even the director of KEK and various dignitaries came by to see the control room," Yeh says. Each time those colored lines bloom on the screen, there's a chance the underlying collision event will turn out to be *the* event: the conclusive imprint of a rare particle, or the unmistakable record that adds statistical weight to a long-sought sum of evidence. Stay tuned to the CDF control room nearest you! ❑

PACKET-SWITCHING: OF 'LUCID INTERVALS AND HAPPY PAUSES'

There are two common practices in sending a signal over a communication line: to reserve the line for the users on either end, whether or not information flows continuously, or to "packet-switch" the information. In packet-switching, the signal or data takes the form of packets of information, which merge with other packets on the transmission line much as cars merge with traffic on a highway.

Circuit-switching, as reserving the line is called, is more of a luxury in the world of communication: "Even if we make no noise at all," explains Al Thomas, head of distributed computing in the Computing Division, "the resources are still reserved." In the case of packet-switching, a user occupies the line only to the extent that he or she has information to send. To put it in Francis Bacon's terms, in packet-switching we pay only for the lucid intervals, not for the happy pauses. The disadvantage of packet-switching, according to Thomas, is that the flow of information to the recipient may not be continuous. A stream of heavy traffic on the line may delay one user's packet.