FERMILAB WIDEBAND PHOTON BEAM

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"I just love it when a great plan comes together."

H. Smith

On June 23, the world's highest-energy electron/photon beam was commissioned successfully at Fermilab. This beam, constructed in the Proton East area, is capable of producing electrons of energies in excess of 650 GeV. The beam is named "Wideline" because it gathers up electrons over a very large momentum range and this results in a very high intensity. The first experiments to be performed with this beam use the high-energy electrons to create the highest-energy photon beam available anywhere in the world. Because of its unique design, the beam can also operate in several other modes--as a high-intensity pion beam, a primary proton beam, or a neutron beam.

The major systems of this beam are:

1) A beam-splitting station to create a second primary proton beam in Proton East.

2) A system of Energy Doubler/Saver (E/D/S) dipoles and quadrupoles which direct the primary beam to the production target and focus it to a small spot.

3) An 800-ton steel target pile which contains the production target, and the shielding and magnets required to remove unwanted radiation and charged particles emerging from the target. A hole at the downstream end admits photons and neutrons to the remainder of the beam.

4) A thin piece of lead (about 3/8 in.) which converts the high-energy photons to electrons and positrons. The neutrons essentially don't react in the converter.

5) A 1200-ft-long secondary beam transport which collects the electrons over a very large range of momentum and bends them away from the neutrons and positrons. The electrons are refocussed to a reasonably small spot near the Experimental Hall. After the electrons are separated from the neutrons and positrons, these unwanted particles are absorbed in a dump--called the "neutral dump"--located about halfway down the beam.

6) Just before the Experimental Hall, the electron beam is passed through a "radiator"--which is another thin piece of lead. As the electrons pass through the lead, they are jiggled and this causes them to radiate photons. The electrons, whose energy is now somewhat depleted by the emission of the energetic photons, are no longer needed and
are swept by an elaborate system of magnets into a dump called the "electron dump."

7) The photons interact at one of two experimental target stations located in the new Wideband Photon Laboratory.

This scheme, shown below, of going from photons to electrons to photons, is a classic approach to the production of photon

![Bremstrahlung Photon Beam Diagram]

**Bremstrahlung Photon Beam**

**Step 1: Get a Neutral beam**

![Diagram showing the transformation from photons to neutrons and K-long particles]

**Step 2: Convert photons**

![Diagram showing the conversion of photons to positrons and electrons, with a lead converter and capture of charged beam transport]

**Step 3: Capture electrons in regular charged beam transport**

**Step 4: Convert electrons back into photons by bremstrahlung**

![Diagram showing the conversion of electrons to photons with a lead radiator and electron dump]

Strategy for making photon beam.

beams. It is necessary in order to be able to separate the photons from the unwanted neutrons. If this separation did not take place, the interactions of the neutrons in the experimental
target would totally dominate and obscure the interactions by the photons. Of course, each stage costs energy and intensity. It is, therefore, necessary to collect the electrons over the widest possible range of angles and momenta; this is the approach taken in designing the Wideband beam. The figure below is a schematic showing the beam optics.

Wideband beam optics schematic.
This project took over four years to complete. The civil construction and the technical components of the primary beam were funded under the Tevatron II project, directed by Tom Kirk. The civil design was done by the Tevatron Construction Group under Wayne Nestander's supervision. The secondary beam components and the installation were provided by the Research Division. Ken Stanfield, Research Division Head, was involved in the original design of the beam and contributed to its construction in many ways, as did Roger Dixon.

The upstream beam enclosures were constructed in 1983 and the downstream enclosures in 1984 and 1985. Each enclosure was operated as soon as all components were installed. No enclosure required more than one half hour to commission. The final components were installed on Wednesday, June 19, 1985 and the beam was sent to the Experimental Hall on Sunday, June 23, 1985. The beam was confirmed to be a highly pure electron beam by observing its interaction in a lead-lucite shower counter built by Peter Garbincius. Typical pulse height spectra derived from this counter are shown in Figs. (a), (b), and (c) on the opposite page. The contamination of charged pions in the electron beam is revealed by inserting a lead block into the beam. This brick removes essentially the entire electron component of the beam, but hardly affects the charged pion component at all. Figure (d) shows the shower counter response with the lead brick inserted. In the course of the recently completed run, the beam was operated at central energy settings as low as 15 GeV and as high as 650 GeV. At the 650-GeV central setting, the beam accepts charged particles at energies up to 780 GeV. The beam is capable of running at a central setting of greater than 800 GeV and is therefore capable of using the higher proton energies expected to become available in the future.

Some of the most difficult technical components associated with this project are shown in the photos on page 6. The top photo shows the 800-ton target pile. The design and construction of this huge object were the responsibility of the Research Division Mechanical Department. The pile is serviced by an overhead crane which can be operated from a distance so as to avoid personnel exposure to radiation. The basic concepts were worked out by Dave Eartly and were employed first in the target pile for Meson Center. The detailed design of this station was worked out by Ron Currier and Bill Strickland. Bill Strickland supervised installation. The bottom photo shows part of the cryogenic system for the string of ED/S dipoles and quadrupoles that convey the beam to the target station. The driving forces behind this effort were Rich Stanek, Jim Bywater, and Bob Pighetti. The top photo on page 7 shows the electron sweeper magnets. The magnets were made in the Fermilab Magnet Facility and use laminations and copper conductor from the Antiproton Accumulator large- and small-aperture dipoles. The bottom photo on page 7 and the photo on page 8 show the Wideband Experimental Hall with some of the detectors from Experiment 687 already in place. The installation
(a) Shower counter spectrum at 250 GeV/c.

(b) Shower counter spectrum at 500 GeV/c (horizontal scale changed by a factor of 2).

(c) Spectrum at 250 GeV/c (log scale).

(d) Shower counter spectrum at 250 GeV/c (log scale) with lead brick in beam to remove electrons.
Upstream end of the Wideband Target pile. On the right is the last magnet of the primary beam. Visible at the upstream end of the target pile are the stand of the target (vertical) drive and the coils of the first sweeping magnet. The pile is about 60-ft long. Additional shielding components are (left to right) Dave Early, Ross Doyle, and Bill Strickland.
(Fermilab photograph 85-645-20)

Cryogenic system for string of ED/S dipoles and quads in primary proton beam. On the right, the ED/S dipoles are barely visible. Shown in the picture are Jim Buatier (RD/Cryofl), Terry O’Brian (RD/Electrical), Tom Neustadt (RD/Cryofl), Don Walek (RD/Electrical), and Al Legan (RD/Electrical). Rich Stanek and Bob Pighetti were supposed to be in the picture but couldn’t find their Oxygen Deficiency Hazard qualification cards.
(Fermilab photograph 85-645-5)
Upstream end of the electron sweeping magnet system. Shown in the picture are Debbi Cobb, Dick Nelson, Lee Bradstreet, Julius Lentz, Junus Santoso, Ron Davis, and Don Byrd. (Fermilab photograph 85-645-31)

View of Wideband Experimental Hall with components of E-687 partially installed. (Fermilab photograph 85-646-21)
The new, large analysis magnet for E-887 in Wideband Lab. Shown in the picture are: John Bookman, John Gran, Jack Jagger, Ron Currier, Tom Gutierrez, Jim Humbert, Jim Goblet, Andy Heussner, Dave Smiley, and Tom Bennett. Missing is Ed Black, who ran out of the Hall screaming after hearing an experimenter say, "Well, maybe we should see what happens at 3000 amps." (Fermilab photograph 85-846-2)

Effort was coordinated by Al Guthke and Ron Currier. The electrical design and installation was coordinated by Age Visser, Stan Orr, Leon Beverly, Paul Czarapata, Gianni Tassotto, Fred Rittgarn, and Dwight Featherston. Julius Lentz was responsible for the power supplies; Gary Ross lead the effort to install the radiation interlocks. Ross Doyle installed the water system.
The radiation shielding was designed by Mike Gerardi. The Accelerator Division contributed the electrostatic septa and controls for the beam split and, of course, deliver to us the 800-GeV/c protons which make this the world's highest-energy photon/electron beam.

In any project of this size, a large number of people work in design, construction, fabrication, and installation. We can't list them all for fear of leaving someone out. Thanks to one and all for a splendid job.
"A New Map of America" by John Senex.
Published in 1720.
Size of original: 19-1/8 x 22-1/4 in.
(From Antique Maps for the Collector
by Richard Van De Ghent; The Macmillan Co.)