Accelerator Glossary of Terms

Table of Contents

The Obligatory Disclaimer

This is a glossary of accelerator related terms that are important to the Beams Division, Operations Department, Fermilab National Accelerator Laboratory.

In the course of the day to day working with the accelerator there is a bewildering array of "Accelerator Technospeak" used in the Operations Group and other areas of the Beams Division. This glossary is meant to be an attempt at helping the uninitiated understand some of the jargon, slang, and buzz words that are commonly used in everyday communication within the Beams Division and the lab in general.

Since this glossary was created primarily for Operations Department personnel there are some terms included in this glossary that might be confusing or unfamiliar to those outside of the Operations Department. By the same token there are many commonly understood terms used by other divisions and groups in the lab that are not well known or non existent within the Operations Department. Many terms will not be found within this document.

If anybody has any contributions of terms, definitions or sources of other glossaries to be included please feel free to pass them on, even if they are not related to the Beams Division.

Sources of terms and definitions from other laboratory divisions will be greatly appreciated. Any comments, compliments or complaints are also welcome.

The original Glossary was written by John Crawford as a part of the Booster Rookie Book.

Later, Jack Standeven expanded the Glossary to include machines and modes of operation and turned it into a stand-alone Rookie Book.

Wally Kissel edited the next version of the Glossary.

Email comments to the present editor and keeper Bruce Worthel, worthel@fnal.gov.

-Numbers-

080 Module:
The interface module between a microprocessor and its associated CAMAC crate. The microprocessors, and HOGs, BPMs, use one parallel bus (Multibus) whereas the CAMAC Dataway is a different parallel bus.

170 Module:
A CIA crate vacuum controller.

175 Module:
This is an encoder for TCLK. This module generates an eight bit parallel signal, known as a "clock event". This is then shipped to the TCLK transmitter, (a 176 module) via a front panel ribbon connector, where it is converted to a serial format and superimposed onto a 10 MHz signal for transmission. Each 175 module contains 16 prioritized channels. The event is generated whenever a channel receives an external trigger.

177 Module:
A time delay module for many devices around the accelerator. Each module has 8 channels, that may be triggered independently, and each may be referenced to as many as 15 TCLK events. Each channel has a programmable delay ranging from 1 microsecond to 65.535 seconds. Upon receipt of a trigger each channel that is enabled outputs a TTL pulse that may be used to trigger any other device.

190 & 290 Module:
This is a module that interfaces the MADCs around the accelerator to the controls system. It can support up to 128 channels, and is capable of supporting up to 6 plots at a 2.1 kHz rate or a single channel at 70 kHz. It is able to determine that of the devices under its care are in an alarm state, and can decode events on the accelerator clock system.

200 Module:
This is a Tevatron abort system module capable of accepting up to 8 inputs from devices in a given service building. If the permit signal originating from a device disappears, an abort is generated.

279 Module:
This is a module that provides a programmable delay from a TCLK, MRBS, or TVBS event. The passage of time is measured directly in terms of the number of beam revolutions. A clock "tick" represents 7 RF cycles, so there are 159 ticks per revolution. The clock operates at approximately 7.5 MHz and is capable of delaying a signal up to 412 turns.

377 Module:
This module is a TCLK octal timer module, which is an improved 177.

460 Module:
A card that is capable of generating a ramp waveform that may be a function of time and/or a function of a front panel scale factor, I. This front panel scale factor is generally MDAT but may be any 12 bit digital word. The output of the card is of the form

$$(V\ out) = I * (V(I) + G(T))$$

where V(I) and G(T) are functions of current and time. The card was designed for the Tevatron dipole correction elements. In this usage the output tracks the Tevatron magnet current as represented by the MDAT signal and may contain a "time-bump" that changes the dipole current with respect to the time in the accelerator cycle. These cards are also used for Tevatron RF curves, flying wires, abort kicker waveforms, and some injection magnet waveforms.

465 Module:
This is a power supply controller for many devices. 465s are used almost exclusively for time dependant applications. The ramps are loaded from the MCR. The ramp is of the form: {V out = Scale factor * table value * ring energy} The scale factor is set by the D/A value entered by an operator on a parameter page. The table value is a time dependent multiplier set from a 465 control page. MDAT and defaults represent the beam energy to full scale if not specified.

4616:
Linac RF driver PA tube, with an output of 200 kW. Cathode driver for the 7835 PA tube. Manufactured by RCA.

7651:
Linac IPA2 tube, with an output of 2 kW. Drives 4616 driver tube. Manufactured by RCA.

7835:
Linac PA tube, with an output of 4 MW. Drives Linac RF cavity via 9" coaxial transmission line. Manufactured by RCA.

-A-

A/D, ADC:
This stands for an Analog to Digital converter (hardware) or the Analog readback of a device (software). The hardware is a device that converts an analog voltage presented at its input to a binary digital representation of that voltage for use by the control system. Most A/D's in the control system have a measurement resolution of less than 5 mv and accept input voltages in the range -10.23 to 10.24 volts. In some applications (Linac and MRPS regulation) special units are used that have a resolution of less than 1.25 mv.

AAL:
Activation Analysis Laboratory of the ES&H Section.

Abort:
Terminating the acceleration process prematurely, either by inhibiting the injection mechanism or by removing circulating beam to some sort of dump. This is generally done to prevent injury to some personnel or damage to accelerator components.

Abort Concentrator Module:
This is a CAMAC 200 module in the Main Injector, Tevatron, P1 and P2 line, and Pbar abort system capable of accepting up to 8 inputs from devices in a given service building. If the permit signal originating from a device disappears, an abort is generated.

Abort Link Generator Module:
This C201 card, which is located at the C0 Service Building, generates a Tevatron only 5 MHz permit signal broadcast around the abort loop.

Abort Logic/Pulse Shifter Interface:
Produces status of Main Injector and Tevatron abort loops. Inputs to Linac Keyswitch Module.

Abort Loop:
The abort loop is a system of electronics that decides to remove the beam from an accelerator in order to protect personnel and/or equipment.

Abort Reset Command (for all systems):
A command sent from the MCR in the form of a TCLK event that clears the latched abort status and restores a beam permit.

Abort System:
The Tevatron abort system at Fermilab is designed to dump the beam promptly on an abort. The Tevatron abort system, active whenever there are protons and antiprotons in the machine, uses the dump located in the A0 section. A proton only abort, during tune up, uses a dump at C0. The sequencer selects which dump to use, A0 or C0. Any one of several abnormal accelerator conditions or radiation alarms triggers the abort magnets. It is routinely fired at the end of an acceleration cycle to purge the accelerator of unextracted beam.

Absolute Pressure:
Units to measure gas pressure. Normally referred to as psia (pounds per square inch absolute) with zero being a perfect vacuum.

Accelerating Column:
This is located in the Preacc pit is a set of seven titanium electrodes (eight gaps) arranged in geometry to accelerate ions to 750 keV. They are situated between -750 kV dome and pit wall.

Accelerator:
Any machine used to impart large kinetic energies to charged particles such as electrons, protons, and atomic nuclei. These accelerated particles are then used to probe nuclear or subnuclear phenomena. There are also many accelerators in industrial and medical applications.

Accelerator Studies:
This is the mode of operation of the accelerator where accelerator performance and/or beam dynamics is studied and tested.

Acceptance:
The measure of the limiting aperture of a transport line, accelerator, or individual device; it defines how "large" a beam will fit without scraping. More technically acceptance is the phase-space volume within that the beam must lie in order to be transmitted through an optical system without losses. From an experimenters point of view acceptance is the phase-space volume intercepted by an experimenter's detector system. This is the complement of emittance.

Accidental Rate:
The rate of false coincidences in an electronic counter experiment that produced by products of the reactions of more than one beam particle within the time resolution of the apparatus.

Accumulator:
This is a storage ring. Successive pulses of antiprotons are collected here to create an antiproton beam of reasonable intensity for colliding beams physics. The Accumulator is designed to accept a pulse of antiprotons from the Debuncher every few seconds.

Achromatic:
This refers to the quality of a transport line or optical system where particle momentum has no effect on its trajectory through the system. An achromatic device or system is one in which the output beam displacement or divergence (or both) is independent of the input beam's momentum. If a system of lenses is achromatic, all particles of the same momentum will have equal path lengths through the system.

ACNET:
The Accelerator Control NETwork is a system of computers that monitors and controls the accelerator complex. Interfaced to users through consoles in the MCR and elsewhere.

ACNET CONSOLE USER'S GUIDE:
See Console User's Guide.

Adiabatic:
No heat transfer with the environment.

Adiabatic Cooling:
The classical description is a process that reduces a system's temperature without any heat being exchanged between the system and its surroundings. At Fermilab this term is used to describe the process in the Antiproton Source Accumulator storage ring where beam emittances are reduced without affecting beam energy. This process is used in accumulating antiprotons.

Adsorber:
Attracts and holds (by Van der Waal forces) molecular layers of dense gases (i.e. very near condensation temperatures) on porous high surface/volume ratio materials.

Adsorbent:
The material of an adsorber is Silica gel, Alumina, and Charcoal, characterized by high surface/volume ratio.

Aggregate ON/OFF:
A command used to control the digital status of a block of devices in the sequencer.

AGS:
Alternating Gradient Synchrotron accelerator at Brookhaven National Laboratory on Long Island, New York. It is a 30 GeV combined function proton synchrotron that started operation in 1959.

Air Ionization Chamber:
Devices used by NTF to monitor neutron flux during patient treatment.

ALARA:
As Low As Reasonably Achievable is a safety acronym used to describe the radiation safety philosophy of minimizing occupational radiation exposure.

Alarm:
A message usually generated by the Alarms Driver VAX process, indicating that the digital or analog status of a device is not within the tolerances set for it.

Alarm Display Monitor:
A color television display in the upper right-hand corner of each ACNET console that lists devices currently in a state of alarm.

Alarms_Driver
A process on the VAX that collects alarm information from the front-ends, combines that information with appropriate parameters in the database, and sends the package to the console CPUs.

Alarm screen:
Same as the Alarm Display Monitor (see above).

Alarm system:
Alarms reach the Alarm Display Screen from devices in the field through this integrated system. The front-ends each have their own way of generating alarm codes, which are then forwarded to the Alarms Driver process in the VAX. Alarms Driver in turn obtains information from the database before sending the combined package to the console CPU. Finally, the Alarm Display Task, a secondary applications program, puts the messages on the alarm screen.

Alpha Function:
(a_x, a_y) This is a measure of the change of the beta function dß/dz where a>0 implies converging, a<0 implies diverging, a=0 implies waist (see Dispersion). ($a = \alpha$)

Alpha Particle:
A Helium nucleus consisting of two protons and two neutrons, generally seen as a decay product from a heavy radioactive nucleus.

Amplifier:
This refers to any device that amplifies an electronic signal.

Amplitude Control Module:
Linac low-level RF system component that controls the amplitude of the RF gradient by varying the size of the modulator input pulse.

Analog:
Typically a device or circuit that expresses a signal in direct proportion to a physical measurement.

Analog-To-Digital-Converter:
See A/D, ADC.

Annihilation:
This is a process where a particle and its antiparticle meet and convert spontaneously into photons. It is the inverse of pair production.

Anode:
Positive electrode or plate of an amplifier tube or discharge tube. In terms of the accelerator it is also taken to mean the power supply cubicles for Booster, Main Injector, and Tevatron that contain the transformers for the RF PA anode supplies.

ANSI:
American National Standards Institute

Antiparticle:
Each particle has a partner called an antiparticle. Some properties of the antiparticle will be identical in magnitude but opposite in sign to the particle it is paired with. Examples of such properties are electric charge in the case of the electron and positron, and magnetic moment in the case of the neutron and antineutron. Strangeness and charm are two other properties among many that can vary in sign. When a particle or its antiparticle meet, these properties cancel out in a process called annihilation. The annihilation process between protons and antiprotons are the collisions that take place in the middle of the Tevatron particle detector experiments during colliding beams.

Antiprotons:
The antiparticle to the proton is a strongly interacting baryon carrying unit negative charge. It has mass of 938 MeV and carries spin 1/2.

Antiproton Jacking (PBJ)
When antiproton emittances are too small they have an adverse effect on proton lifetime and losses. To correct this, the antiprotons are injected into the Tevatron with an intentional offset that increases its emittance. To further increase the emittance, a noise is injected into the antiproton beam at flattop through a directional coupler; this process is called antiproton (pbar) jacking.

Antiquench:
The false appearance of a positive resistive voltage (negative resistance) is the result of the Quench Protection Monitor's calculation during an actual quench in another cell or due to an instrumentation failure. The antiquench applies only to positive resistive voltage readings that exceed the antiquench limit of +3 volts and fire the heaters. The small positive excursions seen when adjacent cells quench are not antiquenches.

AP:
This stands for anything associated with the Antiproton Source.

AP0:
Accelerator building situated above the pbar target vault enclosure. The power supplies, electronics and maintenance equipment for the pbar target station and lithium lens are located here.

AP1,2,3:
These are the beamlines that transport protons and antiprotons between the Main Ring remnant and the Antiproton Source.

Aperture:
A measure of the physical space available for beam to occupy in a device. Aperture limitations, however, are not always due to the physical size of the vacuum chamber; for instance, a magnetic field anomaly may deflect the beam so that the full available aperture cannot be used.

Aperture Scan:

Process of changing the beam position via 3- bumps in a localized area in order to determine the size of the aperture. The beam is moved until is scrapes the side of the beam pipe or encounters an obstruction.

APM:
The Applications Program Manager is a function on the console computer that coordinates application task scheduling by making sure the PA or SA executes at the proper periodic rate, recognizes the keyboard interrupt, etc. It also performs console data collection tasks, determines the visible cursor position, shaft encoder position, touch panel x, y position, and the status of the interrupt button.

Apparent Mean Thermal Conductivity:
The effective thermal conductivity of an assemblage of material (Pearlite, super insulation) between specified temperatures.

Application Programs:
Software designed for direct use by a console user. The programs reside on the ACNET consoles.

Archive:
Permanent storage of information regarding a given accelerator system. Magnetic tape is the primary medium. An archive should be distinguished from a "Save", where information is written onto a disk and is likely to be written over at some future date.

ARF1, 4 (2, 3):
There are two different radio frequency systems used in the Accumulator and are known as ARF1 and 4. Briefly, ARF1 is a 53 MHz system (h=84) and is used to capture the unbunched beam injected from the Debuncher, decelerate it across the aperture through that the shutter moves, and adiabatically unbunch the beam at the edge of the stack-tail.

ASME:
American Society of Mechanical Engineers

Atmosphere:
A convenient measure of pressure where 1 STD ATM = 14.696 psia.

Atom:
This is a particle of matter indivisible by chemical means. It is the fundamental building block of the chemical elements. The elements, such as iron, lead, and sulfur, differ from each other because they contain different amounts of protons. There are about six sextillion atoms in an ordinary drop of water. According to present day theory, an atom contains a dense inner core (the nucleus) and a much less dense outer domain consisting of electrons in motion around the nucleus. Atoms are electrically neutral.

Atomic %:
A way of describing mixtures, especially of NeH_2 (nearly equal to the volume percent).

$$Atomic\ \%\ Ne = \frac{Mole\ \%\ Ne}{2 - Mole\ \%\ Ne}$$

For NeH_2, only Mole % Ne is higher than Atomic % Ne.

Auto-Gradient:
Feature where the Linac RF gradients are controlled by computer through the Amplitude Control Module. Normally enabled.

Auto Quench Recovery (AQR, FSM):
A computer program residing in the refrigerator micro-p that automatically performs cooldown after a quench.

AUXNETPROCESS:
A process on the VAX that handles routine functions such as the time of day and boot capability for the ACNET network.

Notes:

-B-

B0:
This is a reference point on the Tevatron Ring. The Collider Detector Facility at Fermilab is located at B0 (pronounced "B zero"). Other significant reference points include the D0 collision region, and C0, E0, and F0 regions used for specialized purposes.

B0 Collision Hall:
Also referred to as the Collision Hall. CDF detector at BO resides in this hall during collider operation.

BAO:
Batavia Area Office of the DOE.

Back Porch:
This refers to the portion of Tevatron ramp after flattop where a bend field is held constant for a period of time.

Back Racks:
Electronics racks behind the primary working region of the Main Control Room; consists of patch panels, link modules, highpotters, and much more.

Background:
Whatever devices are used to make a measurement in an experiment, the measurement is a superposition of events from the target and events from all other sources (background). The background therefore sets a lower limit on the detection of small signals. More generally, background is any unwanted signal.

Bakeout:
Raising a device to extreme temperature to outgas contaminates such as water vapor, and oils. Vacuum pumps will take care of the effluent. A bakeout is done at temperatures of $\geq 100^{\circ}$ C.

Barn:
A unit for measuring cross sections where 1 barn = 10^{-24} square centimeters. The units appropriate in high-energy physics are usually the millibarn (10^{-3} barn), the microbarn (10^{-6}), or the nanobarn (10^{-9} barn).

Baryon:
A collective term for all strongly interacting particles with masses greater than or equal to the mass of the proton. Examples are the proton, neutron, and hyperons. A baryon contains three quarks.

Basic control:
The ability to change the digital status of a device by interrupting on a parameter page. This function is supported by the database. See basic status.

Basic status:
Digital status of a device as displayed on a parameter page. There are three characters displayed in a standard format (...). The first indicates ON/OFF status; the second indicates the trip/reset status; and the third indicates if the supply is in local or if the breaker has tripped. If all of the digital status for a device is good, three green dots will be present. Some devices have a fourth bit of +/- to show polarity.

Batch:
This refers to a unit of beam that corresponds to the output of one Booster cycle. The Booster can hold 84 bunches of beam in one acceleration cycle. The Main Injector can hold six batches. Tevatron can contain up to twelve batches, but only holds eleven due to timing problems.

Baud:
A unit of signaling speed; defined as the number of code elements (i.e. bits) per second.

Bayonet:
A low heat conduction, longitudinally extended connector for cryogenic piping. See Transfer Line.

BCS Theory:
This is the successful theory of superconductivity developed in the 1950s and eventually resulting in the Nobel Prize for the authors, J. Bardeen, L.N. Cooper, and J.R. Schrieffer, Phys. Rev. 108, 1175 (1957). This is the classic exposition of the BCS theory.

Beam:
This is a slender unidirectional stream of particles or radiation.

Beam-Beam Tune Shift:
This is an electromagnetic effect caused by interactions from the proton bunch upon the antiprotons and visa-versa, which causes a shift in the tune.

Beam Cooling:
The process where a particle beam's phase space volume is reduced, while conserving Liouville's theorem (there are empty spaces between particles). Beam cooling is manifest by a reduction in the transverse beam size (betatron cooling) or by a smaller momentum spread (momentum cooling). Beam cooling is primarily used these days to accumulate beams of antiprotons for colliding beams physics. There exists two ways of cooling a Hadron beam: Stochastic (employed at Fermilab and CERN), and Electron (first demonstrated at Novosibirsk).

Beam Damper:
A device for applying a force on the circulating beam in an accelerator to reduce either the excursions from the equilibrium orbit (betatron oscillations) or from equilibrium phase (synchrotron oscillations)

Beam Dump:
A massive object used to absorb unwanted beam and dissipate the resulting heat. Dumps for high intensity beams are often composed of large water-cooled metal blocks. The Tevatron and Main Injector dumps are made of graphite blocks kept in an inert atmosphere. They must be shielded from the surrounding environment due to the extreme radioactivity induced by the absorbed beam.

Beam Half Width:
(a_h, a_v) The direct measure of the beam size usually in mm given by:

$$a_v = \sqrt{\frac{E_v \beta_v \prod_0}{\pi P}}$$

For 8 GeV line $P_0 = P$.

Beam Intensity:
The average number of particles in a beam passing a given point during a certain time interval, given, for example, as the number of protons per pulse or protons per second.

Beam Line:
Beam line is a collective term referring to all the devices used to control, monitor, and produce a beam having particular characteristics. The common elements of a beam line are magnets, intensity monitors, beam position monitors, and collimators.

Beam Loading:
A phenomenon where beam being accelerated by a RF cavity changes the gradient and phase of the RF in the cavity.

Beam Loss:
A beam loss is any loss of particles due to any reason.

Beam Permit:
An electronic beam permit is enabled only after many interlocked systems have been checked and found to be operating within specified parameters.

Beam Roll:
This is a periodic change in horizontal and/or vertical positions during a spill. This doesn't include intentional changes.

Beam Stacking:
A form of accumulation where a single turn of beam is injected and then moved by acceleration or deceleration to make room for additional turns. This process, also called momentum space stacking, often appears in storage ring applications.

Beam Stop:
This is a thick metal shield that moves into the beam's path in order to prevent beam from entering a specific area. Beam stops are generally considered critical devices.

Beam Switch:
A device used to manually permit/inhibit beam from entering a particular accelerator. Because of the variety of modes in which we run, this seemingly simple action actually requires a high degree of logic — such is the purpose of the Beam Switch Sum Box.

Beam Switch Sum Box:
The hardware logic circuit that determines the response of any beam switch request, based on machine modes and current operating conditions.

Beam Sync Clock:
The clocks MRBS, RRBS, and TVBS have their basic frequency directly related to the revolution frequency of the beam. They are derived from their respective LLRF systems. They operate at frequencies of about 7.5 MHz and produce a clock "tick" every 7 bunches. Beam sync clocks are used for all critical timing of beam transfers between accelerators.

Beam Toroid:
A device used to determine beam intensities by measuring the magnetic field fluctuations produced by the passing beam. The magnetic field fluctuations produce a current in a coil that is wound around a closed circular ring (torus) through the beam passes. The calibrated current provides an intensity readback.

Beam Turns:
The length of the beam pulse going to Booster divided by the revolution period of the Booster at injection.

Beam Valve:
A pneumatically or manually operated gate valve that closes across the beam pipe to physically isolate one section of beam line from another. Beam valves are commonly used to isolate vacuum allowing the beamline in one sector or house to be brought up to atmosphere for maintenance while keeping adjacent sections under vacuum. In the event of a vacuum burst beam valves are closed automatically to isolate sectors in order to localize the vacuum problem.

Beamline (transport line):
A series of magnets and vacuum pipe that carry a particle beam from one portion of the accelerator to another.

Beamline microcomputer:
An NTF computer that monitors beamline devices, dose rates, and communicates with the NTF medical microcomputer as well as the local Linac secondary.

Bellows:
This is a flexible joint that allows for mechanical expansion and contraction between two vessels without compromising vacuum. Especially useful in the superconducting Tevatron where thermal expansion and contraction happen regularly.

Belly Pan:
A design feature of the Linac tanks that allows leaks in the tank welds to be put under vacuum.

Benelex:
A substance similar to G-10 used to hold NTF neutron collimators in position.

Berm:
A mound of earth shielding over the top of an enclosure used to absorb excess radiation

Beta function:
This is a measure of beam width. The beta function details how the beam changes around the accelerator. There are separate Beta functions for the x and y planes. The square root of $ß_x$ is proportional to the beam's x-axis extent in phase space.

Beta Matching:
Matching of the beam size to the ß of the receiving beam pipe.

Beta (ß) Particle:
An electron or positron emitted from a radioactive source.

Betatron Oscillation:
Betatron oscillations are the transverse oscillation of particles in a circular accelerator about the equilibrium orbit. Focusing components in the magnetic field provides the restoring force for the oscillation that act to bend a particle off the equilibrium orbit back toward it. In synchrotron accelerators of modern (strong focusing) design there are several cycles of betatron oscillation per revolution of beam particles. The name came from this type of oscillation in the first betatron accelerators.

Bias Pulser:
A Linac module that drives the grid of the 7651 tube in the Buncher RF system.

Bias Supply:
Programmable power supply used to power the ferrite tuners of RF cavities in the Main Injector and Booster.

Biddle:
The James Biddle Company makes various types of measuring devices. Fermilab uses a high current ohm meter made by Biddle to measure across joints and connections.

Bipolar Supply:
This is a power supply that has an operating voltage range of positive to minus. A unipolar supply has an operating range from zero to some positive value.

Bit:
This stands for Binary digIT. It may have a value of zero or one and is the smallest unit of measure. See byte and word.

Bleeder resistors:
In the Linac, the resistors between the High-Voltage Dome and ground that bleeds down the charge on the Dome when the power supply is turned off, 4250 MΩ resistors.

Blind Scaler:
A scaler made without a display for computer readout only.

BLM:
A device used to measure beam loss from the accelerator. The detectors are sealed ionization chambers. BLM stands for Beam Loss Monitor.

Block Transfer (BTR):
An option for data transfer in the CAMAC links. Although data is transmitted serially, it arrives at the front-end in a continuous stream rather than in discrete units. The BTR link is on a separate cable from the CAMAC serial link. It is able to transfer information at a 10 Mbit/sec rate in blocks 196 Kbytes in length.

Blow up:
A relatively sudden and usually catastrophic increase in beam size often caused by some magnetic field error driving the beam to resonance.

Boiling Point:
A phase equilibrium is the one temperature where a material coexists in either its solid and liquid form (melting point) or its liquid and vapor form (boiling point) with no phase exchange.

Booster:
The rapid cycling proton synchrotron at Fermilab that receives 400 MeV protons from the Linac, accelerates them to 8 GeV, and injects them into the Main Injector for further acceleration.

Booster Pulse:
A Booster pulse is that portion of the beam in the Main Injector resulting from the injection of one booster batch or partial batch.

Booster Serial Link:
This is the CAMAC link that connects all Booster CAMAC crates and allows the control cards to communicate with the Booster CAMAC front-end.

Boot:
Restarting a computer by means of loading a fresh copy of the managing program(s). In practice a short program is loaded into memory by hand or with special hardware that then reads in more sophisticated (and longer) programs from mass storage to actually reload the system. A reboot is an abbreviation for "remote boot."

Boson:
An integral spin particle of which Bose-Einstein statistics apply. Such particles do not follow the Pauli exclusion principle. Photons, pions, alpha particles, and nuclei of even mass numbers are examples of bosons. Bosons are capable of resembling each other with several in the same physical state. An ensemble of photons in the same state constitutes what we call a laser beam. Bosons are named after the Indian physicist Satyendranath Bose.

Bouncer circuit:
Haefely-designed system used to boost Dome voltage to compensate for charge leaving the Dome during the beam pulse. Not installed at FNAL.
BPM:
A diagnostic device that uses two plates around a beam tube to measure beam positions. BPM stands for Beam Position Monitor.

Breakover:
When a Main Injector or Tevatron power supply SCR shorts and conducts continuously (i.e., while in bypass, etc.).

Bremsstrahlung Radiation:
Electromagnetic radiation, usually in the X-ray region of the spectrum produced by electrons in a collision with the nucleus of an atom. Bremsstrahlung is German for braking. Bremsstrahlung radiation is produced in regions of high electric potential such as areas surrounding electrostatic septa and RF cavities.

BSS:
Business Services Section.

Bubble Chamber:
An instrument for rendering visible the tracks of ionizing particles. Essentially it is a vessel filled with a superheated transparent liquid, commonly hydrogen or deuterium. The passage of an ionizing particle through this liquid is marked by the appearance of a series of bubbles along the particle trajectory. If the liquid is subjected to a magnetic field, as is usually the case, the charged particle trajectories will be curved, the curvature providing information about the particles' charge and momentum. One or more photographs of the tracks are taken with each accelerator cycle for subsequent study. There were two bubble chambers at FERMILAB, both in the Neutrino Area. A 30-inch chamber with a conventional magnet was located in the N3 Hadron

beam, and a 15-foot chamber with a superconducting magnet was situated at the intersection of the N_5 Hadron and N_o neutrino beams. Both of these chambers are no longer used. The 15 ft. chamber was discontinued in 1988.

Bucket (R.F.):
A bucket is the stable region in longitudinal phase space. The bucket width gives the maximum phase error or timing error at the R.F. cavity that a particle may have and still complete the whole acceleration cycle. The bucket height is the corresponding limit on momentum error.

Bulk Tuner:
A long copper bar, D-shaped in cross section, that runs the length of a Linac RF cavity and trimmed to the correct cavity volume.

Bump:
A localized orbit displacement created by vertical or horizontal correction element dipoles used to steer beam through available aperture or around obstacles.

Bunch:
A group of particles captured in a phase space bucket.

Bunch Rotation:
Prior to extraction from the Main Injector at 120 GeV, the proton bunches destined to be used for antiproton production are rotated in momentum phase space by 90˚ so that a large momentum spread and smaller time spread (a given bunch is narrower in time) comes about. The antiprotons produced retain this structure. Upon injection into the Debuncher, the bunches are rotated 90˚ thereby reducing the momentum spread and broadening the time structure. This permits the $\Delta p/p$ of the antiprotons injected into the accumulator to be greatly reduced, permitting smaller magnet apertures and more effective stochastic cooling.

Bunch Satellites:
When a bunch is coalesced it is more than likely that the bunch is not ideally coalesced. There are often secondary bunches in buckets to either side of the coalesced bunch. These are known as satellites and are undesirable.

Burst Diaphragm:
A vacuum device that functions as a relief point for unexpected positive pressure in the beam tube. Pressure pushes the thin diaphragm against three blades, letting the vacuum up to atmosphere in an emergency, thus preserving bellows and other delicate equipment. Also known as Rupture Disk.

Buss:
1. An electrical configuration for transmitting signals within a computer system.
2. A rigid electrical conductor used for carrying high currents and for power distribution to several devices.

Bypass:
A condition that results in power supplies being on but not producing current. In this condition the three rectifying SCRs are disabled and the bypass SCRs are enabled, effectively shorting the output. In the turning on process accelerators are brought up in bypass before engaging the magnet ramps.
Bypass:
A device used to transport cryogens, Nitrogen and Helium, around a non-cryogenic device, while preserving continuous vacuum.

Byte:
A byte consists of 8 bits. It may have a signed value of -128 to + 127.

Notes:

-C-

C0 Collision Hall;
Located at the C0 interaction region.

C-SEAL:
A metal vacuum seal, usually coated with lead or indium, with a c-shaped cross-section. It is used in high radiation environments where O-ring seals would deteriorate.

Cache:
A small, high-speed memory that "borrows" information that has been recently used from the main memory in anticipation that the information is the next to be used. For example, an algorithm on the console computer determines that 300 applications programs have been used most. They are the ones privileged to exist on disk DL1 for easy access. A program not cached has to be loaded from the VAX.

Calorimeter:
A device used to determine particle energies by measuring the ionization of a particle shower in a heavy metal, usually iron and lead.

Calorimeter (Special Usage):
A calorimeter is a device used to measure a particle's energy. A typical calorimeter is made of a series of scintillators sandwiched between pieces of iron. The incoming particle interacts in the iron creating a Hadron shower; scintillators pick up the shower and the particle's energy is measured by the amount of light collected from the scintillators.

CAMAC:
Computer Automated Measurement And Control is a modular data handling system used at almost every nuclear physics research laboratory and many industrial sites all over the world. It represents the joint specifications of the U.S. NIM and the European ESONE Committees. There is an internationally accepted set of standards for electronic instrumentation that specifies mechanical, electrical, and functional characteristics of the instrument modules. CAMAC hardware is commercially available. Individual modules (cards) fit into a standard 25 slot receptacle (CAMAC crate) that provides common power, control, and data lines.

CAMAC Crate:
A commercially available 25-slot crate used to house CAMAC cards and to interface to the accelerator computer system. The crate has a back plane with connections to all cards in the crate. It has +/- 6 volt and +/- 24 volt DC crate voltages for use by the cards. At Fermilab the crate controller uses the last four slots, which have been adapted to accept a two slot wide card. All cards are electrically connected to the crate controller by two sets of busses: each card has its own address line, but they all share the same 24 parallel data lines. Also see Crate.

CAMAC Module:
A "control" card plugged into a CAMAC system for a specific input or output function.

Canned Magnet:
Magnets that are completed encased in their own vacuum jackets.

Capacitance Manometer:
A pressure gauge used in the rough and high vacuum range. A tensioned metal diaphragm contracts or expands, as the system pressure varies. The deflections causes a capacitance change that is sensed and converted to a frequency change proportional to the diaphragm deflection.

Capacitor Tree:
This refers to a group of capacitors once located in the "capacitor tree" outside the Master Substation. Since the capacitor tree is no longer used and has been converted into a High Rise apartment complex for migratory birds. (For bird occupancy information please contact the Fermilab Housing Authority.)

Capture:
The process of putting the beam into RF buckets.

Carbon Resistor Thermometer:
This is a carbon resistor whose temperature sensitivity provides good temperature resolution, especially below $\leq$ 10K.

Card:
This is a modular piece of electronics housed in a crate. Cards are typically used to interface a hardware device with a computer system.

Card (Printed Circuits):
This is an insulating substrate that electronic circuits are bonded to and discrete components are attached. Often used as a synonym for a CAMAC module.

CARESS:
This is an old acronym for the outdated Central Accelerator Radiation and Electrical Safety System.

Caution:
This is a software term used to warn console users that they are about to change the analog value or digital state of a device. It is generally used in the interrupt sequence during the control of any device that can cause beam loss, machine downtime, or an unsafe condition.

Cavity (R.F.):
An RF cavity is a volume enclosed by a conducting surface that resonates at some radio frequency. The usual application of the term at Fermilab is to the accelerating cavities in the Tevatron, Booster, and Main Injector that resonate at a harmonic frequency corresponding to the circulation frequency of the beam and thereby applies a synchronized accelerating voltage.

Cavity Short:
A grounded metal rod that goes in and out of the body of an RF cavity. When a station is off it is still a resonant cavity and can remove energy from the beam. By grounding the cavity it is kept from resonating.

CD:
Computing Division

CDF:
The Collider Detector Facility is a huge colliding beam detector located at B0 experimental facility.

CEA Quads:
Six large aperture quadrupole magnets in the N1 line used for focusing the muon beam. These quads were originally used at the Cambridge Electron Accelerator (CEA).

Cell:
This refers to the smallest repeatable configuration of magnets (a lattice—FODO or FOFDOOD).

Centroid:
Technically, the center of mass, which is used here to describe the center of a beam profile.

Cerenkov Counter:
A detector for charged particles that consists essentially of a transparent medium such as a gas that emits Cerenkov radiation when a charged particle passes through at a velocity greater than the velocity of light in the medium. The mass of a particle in a beam of known momentum can be determined with such a counter by measuring the characteristic angle at that the Cerenkov radiation is emitted.

Cerenkov Radiation:
Light emitted when a charged particle traverses a medium with a velocity greater than the velocity of light in the medium. The Cerenkov light is emitted in a cone centered on the particle trajectory. The opening angle of this cone depends on the velocity of the particle and on the velocity of light in the medium. The phenomenon involved is that of an electromagnetic shock wave that is the optical equivalence of sonic boom. Cerenkov radiation provides an important tool for particle detection.

Cesium Boiler:
This is an electrically heated crucible in the Preacc dome used to vaporize Cesium used to coat the source cathode.

CH:
DOE Field Office, Chicago

Chamber:
This is a working volume, not necessarily cryogenic, i.e., Bubble Chamber, EMI Chamber.

Channel 13:
This is a lab-wide closed circuit TV channel used for displaying accelerator data. The data displayed may consist of machine intensities, experimental area intensity requests, measured experimental area intensities, Main Injector and Tevatron ramp waveforms. It also displays colliding beams info such as the bunch intensities, store number, Pbar stacking rate, and stack size.

Charm:
A physical property (quantum number, degree of freedom) carried by the fourth quark. In the original quark model, three quarks ("up," "down," and "strange") are variously combined to produce the known Hadrons. The addition of a fourth quark, the "charmed" quark, gives rise to several new Hadron states called charmed particles. Proposed to account for an apparent lack of symmetry in the behavior of Hadrons relative to that of Leptons, to explain why certain reactions of elementary particles do not occur, and to account for the longevity of the Q1 and Q2 particles.

CHL:
The refrigeration plant that supplies liquid helium and liquid nitrogen to the accelerator complex. CHL stands for Central Helium Liquefier.

Chop Time Selector:
Module in the Preacc control room that selects times and sends them on to the 750 keV choppers.

Chopper:
Electrostatic device that selectively deflects a portion of the beam pulse to control intensity in the Linac or beam turns in booster. Two are found in the 750 keV lines, and one in the 400 MeV area.

Chopper:
A fast electrostatic beam deflector used to select a particular part of the beam during the time that beam is available. The 400 MeV Chopper is a fast electrostatic kicker at the end of Linac that deflects beam to either of two sides of a magnetic septum. One side of the septum bends the beam into the Booster for acceleration while the other side (straight ahead) sends the beam to a dump. There is one "chop" for every booster pulse or booster batch.

Chromatic aberration:
Beam spreading out due to different momentum particles being bent by the quadrupole fields at different angles.

Chromaticity:
The ratio of tune spread to momentum spread of the beam.

$$\Delta v_x = C_x\left(\Delta \mathrm{P}/\mathrm{P}\right)$$

where v is the tune, C_x is the horizontal chromaticity, and P is the momentum. Chromaticity affects the focussing and bending properties of magnets by making them sensitive to particle momentum. This results in focusing and bending dispersion of the beam in a manner analogous to an optical system.

Chute:
Passageway leading from the 400 MeV area to the booster radiation enclosure. The 400 MeV transport line to the booster travels through this.

CLIB:
Acronym for Console LIBrary. It is a collection of commonly used or convenient routines kept on the Development VAX that can be called upon by applications programmers.

Clock:
A series of digital pulses generated at regular intervals used to mark time. Clocks at Fermilab generally operate at either 15 Hz or in the MHz range, and can be encoded with timing information to be sent around the accelerator.

Clock, (Tevatron):
Also known as TCLK. Although the name implies it is only used for the Tevatron, it is essentially the master clock for the accelerator. It operates at a 10 MHz rate and is able to transmit encoded events at about a 1 MHz rate. There are 256 possible events (displayed in 2-digit hexadecimal numbers) that the clock can send out.

Clock, (Beam Sync.):
See Beam sync. clock.

Clock decoder:
Any card, such as a 177, 279, and 377 that recognizes a clock event and acts on it. Most of the decoder modules in the accelerator are based on a custom made Fermilab chip built specifically for decoding TCLK. The 177 and 377 modules decode TCLK only; the 279 modules can decode MRBS and TVBS as well.

Clock encoder:
A card, such as a 175 module, that stamps a bit pattern (clock event) onto a clock signal for recognition by a device.

Clock event:
A bit pattern superimposed on the clock frequency at a certain time in the accelerator cycle that is broadcast through the accelerator for decoding and action by a set of devices. Since they are eight bits long there can be a total of 256 unique events.

Clock Generator:
Modules in the Preacc control room (one for H- , one for I-) that take the 1 MHz clock and convert it to light pulses to send to the domes via fiber optic cables.

Clock Peek:
This is a process on the VAX that decodes TCLK events and generates timing information for internal consumption (for such things as the frequency of data acquisition.).

Clockscope:
A console applications program that monitors the clock events actually sent out on the link. It currently resides on D33.

Closed orbit:
This refers to the ideal orbit of particles in the accelerator. Betatron oscillations are superimposed on this orbit.

CNSCOM:
CoNSole COMmon. An area in console memory used by information that flows between APM, PLD, DPM, and the applications programs (See APM, PLD, and DPM.)

Coalescing:
Coalescing is the production of one high intensity bunch from several lower intensity bunches. Coalescing RF cavities run at 2.5 MHz and 5.0 MHz, which is lower than the 53 MHz of the Main Injector RF. The superposition of these two frequencies produces an RF wave that is linear through the region of the bunches to be coalesced. The bunches get pushed into the central bucket and then injected into the Tevatron.

Coasting Beam Safety System:
Part of the radiation safety system that protects personnel from circulating beam in Main Injector, Tevatron, and the Accelerator/Debuncher. This system controls beam valves that are inserted into the beam tube to dissipate circulating beam when an unsafe situation is detected.

Coasting Beam Valve:
Special beam line valves that close in order to stop circulating beam in the Main Injector, Tevatron, and Accumulator/Debuncher. These devices are part of the Coasting Beam Radiation Safety Systems.

Cockcroft-Walton Accelerator:
1. A high-voltage DC accelerator used for the acceleration of H- ions. A circuit of rectifiers and capacitors that takes low AC voltage and produces high voltage DC. The Preacc accelerator at Fermilab is a Cockcroft-Walton design.
2. Often referred to as a Preaccelerator (Preacc) at Fermilab. It is a large electrostatic accelerator that provides the first accelerating step to the H- ions produced by the ion source. The Preacc increases the energy of the H- ions to 750 KeV and injects them into the Linac. The apparatus is based on a development of the Greinacher voltage doubling circuit.

Cogging:
Collision point cogging is the process of spacing bunches of protons or antiprotons in the Tevatron so that they will collide at the proper points in the ring. It is used only in colliding beams mode.

Cold Box:
A cold box is a low-pressure vessel providing vacuum insulation for cryogenic heat exchangers. Often, loosely, synonymous with refrigerator box.

Cold Cathode Gauge:
This is an ionization vacuum gauge with no hot filament that uses electrons spiraling in a magnetic field to ionize any gas present. The ions produced are drawn to electrostatic plates. The current produced in this way is interpreted as a pressure. This type of gauge operates down to about 1 E^{-5} torr.

Cold Valve:
A valve with an approximately zero heat leak. Usually pneumatically activated by a noncondensable gas through long connecting tubes.

Cold Trap:
A cold trap is vacuum device that removes gases or vapors by freezing or condensing them onto chilled surfaces.

Collider Detector at Fermilab (CDF):
The apparatus used for experiments designed to measure the results of colliding beams of protons and antiprotons. CDF experiments study the highest energy collisions ever produced in a laboratory. This allows physicists to probe much deeper into the structure of matter than heretofore possible.

Colliding Beams:
This type of collision requires oppositely directed particle beams brought together at a small or zero angle to produce high-energy reactions. Because even the most intense beams are dilute compared to ordinary solid matter used as targets, the beams must be recirculated many times through the interaction point to obtain a useful number of interactions. The apparatus for recirculating beams for long periods of time are called storage rings. The motivation for this arrangement is to make available the entire kinetic energy of the beams in the center of mass of the interacting particles. At Fermilab the two counter circulating beams used are protons and antiprotons. The reason that antiprotons are used is that they only differ in charge from a proton but have the same mass. They can be injected into the same accelerator with the same bend field in the opposite direction and circulate along the same orbit. A proton on proton collider, such as the LHC, requires two separate beamlines to circulate the particles.

Collimator:
A collimator is generally a large block of steel or iron, but sometimes having an adjustable aperture, that enables one to choose the beam cross-section or angular divergence. It is also used to absorb the beam halo, and if closed further it can be used to control the intensity.

Collision:
A close approach of two or more particles, (photons, atoms, or nuclei) so that quantities such as energy, momentum, and charge may be exchanged.

COM:
COMputable. A process scheduling state on the VAX meaning that a given process is ready to use the CPU.

Common request list:
When an applications program displays data from accelerator devices it has to generate a list of what information is wanted. This list is assembled on the console computer and consists of DI/PI [device index/property index] pairs. The list is put together in the console computer by the console DPM task from information in the database. It is then organized and sent to the front end for further processing before requests for data are made to devices in the field.

Compiler:
A program that converts programs from problem oriented language (Fortran, BASIC, COBOL, etc.) into machine language.

Compressor Building:
A building located at each zero location of the TeV Ring that contains several Mycom Helium compressors. The compressors draw low pressure Helium from the suction header in the TeV Ring tunnel and send high pressure Helium along the discharge line atop the TeV Ring berm to each of the satellite refrigerator buildings.

Computer Room:
This room is located in the Cross Gallery across the hall from the Main Control Room (South).

Computing Counter:
A device that measures pulse frequencies with great accuracy. Used for the display of the Linac master oscillator frequency.

Condenser:
An extended surface heat exchanger for the purpose of extracting the heat of vaporization of fluid.

Conditioning:
Vacuum term. The process of running voltage in a septum or separator at a high level over a period of time to clean up the vacuum. After a high voltage beamline device such as a Septum or Separator is baked out it is then run at a high voltage to burn off any oils, dust, or sharp edges that the bakeout didn't get. The voltage is turned on at a low level and slowly raised over time to avoid sparking in the device that can spoil vacuum. By burning off these things the ability of the device to pump down to operating vacuum is greatly improved.

Conduction, Thermal:
Solid heat flow, similar to electrical conduction.

Configuration Control Lockout:
This is administrative control to ensure that no powered elements in designated enclosures exceed more than 50V or 50 Amps to its load or has more than 1 Joule of stored energy. Note that Configuration control does NOT meet LOTO requirements.

Convection, Natural:
A transfer of heat by a stream driven by density differences that results from distinct heating and cooling regions.

Convection, Forced:
This refers to a transfer of heat by a stream driven by external means between a region and itself, or between regions, of different temperature.

Console:
A standard set of screens and other devices used by an operator or systems specialist to control and monitor devices in the accelerator complex.
Controlled access:
Method used to enter an accelerator enclosure when three conditions have not been met: 1) A radiation survey has been performed in the enclosure. 2) The proper power supplies to the devices in the enclosure have been padlocked off. 3) The safety system has been broken requiring a search and secure.

Controls Hardware Release (HDWREL):
A type of document published by the Beams Division Controls group and distributed within the Division (including the Operations group) that details the operation of new control cards and other hardware built by the Controls group.

Controls Software Release (SFTREL):
A document also published by the Controls Group that includes detailed information on new applications programs and other software paraphernalia.

Controls Software Update (SFTUPD):
New versions of Software Releases that update information on applications programs, etc. This type of document is currently being phased out in favor of multiple versions (xx.1, xx.2, etc.) of the Software Release.

Converter:
A thin piece of material used to generate electron- positron pairs from incident photons via the process of pair production.

Core:

This is the densest region of the $\bar{p}$ beam in the Accumulator. The beam cooling systems act to 'push' the $\bar{p}$s into the core and keep them there. The design parameters include:

Intensity	5×10^{11}
$\Delta p/p$	0.05% (~4 MeV)
Emittance	2π mm-mrad (both planes)
Peak density	1×10^{5} eV^{-1}

Core:
The core is the active memory section of a computer system in which the CPU may most readily access stored data. Generally when program execution is complete, data stored in core is lost.

Corona Rings:
Curved metal surfaces shielding the outside of high-voltage devices to forestall the ionization of air by electric discharges. Used in the HV sources for the preaccelerators.

Correction element:
Additional magnet inserted in an accelerator's lattice to correct for manufacturing defects, variations in power supplies and magnets, obstacles in the beam path, etc.

Coupling:
A generally undesirable situation that occurs when particle motions in the transverse plane (or transverse-longitudinal) planes are not independent, but are related in some way.

Coupling Capacitor:
A capacitor used to couple AC voltages to parts of an electrical circuit while blocking DC voltages.

CPLD:
The Central Program LoaDer is a program on the VAX that loads applications programs onto the console disk. When a console computer calls a program it works in conjunction with PLD to assure that the console has the newest version of the program.

CPU:
The Central Processing Unit is that part of a computer or microprocessor that performs calculations and makes decisions, as opposed to memory functions, clocks, etc.

CPU (Central Processor Unit):
The main "thinking" component of a computer system. The CPU of a system performs all arithmetic and logical functions. In addition, the CPU is in control of all data acquisition and storage.

Crash Cord:
A crash cord was a rope strung along a wall in the Transfer Hall and in some of the experimental target halls. Its purpose is to protect individuals from radiation caused from the beam. If an individual is inside one of these areas and realizes beam is about to be turned on, he pulls the crash cord that immediately turns off the accelerator. This has been replaced with push buttons.

Crate:
A repository for control cards. Each type of crate has a different protocol for accessing and distributing information that must be recognized by the respective front-end. There are CAMAC, NIM, Multibus, and several less important types of crates. The cards for each of these crates are not interchangeable.

Crate (CAMAC Crate):
A standardized receptacle for electronic circuit modules providing a common set of data, control, and power lines.

Crate controller:
A card in a given crate that decodes address information arriving on the link and distributes messages to the appropriate cards in that crate. These cards also arbitrate the data and messages to and from each card in the crate, as they all share the same data lines.

Crate save/restore:
Using the D1 save/restore program to save/restore parameter values of all devices controlled by a particular crate.
Crates and slots page:
An applications program that allows the user to examine the types of microprocessors residing in a given building and its status. There is an individual applications program for each of the serial front-ends (B59, T96, P66, and S54).

Critical Device:
A device that can prevent beam from entering a specific accelerator area. Generally critical devices are designed for fail safe operation. The Radiation Safety System provides permits for critical devices.

Critical Device Failure:
A safety system condition where the Radiation Safety System (RSS) for an area drops before the critical device for that area has been turned off to remove beam from the area. Results in a pulse shifter inhibit and must be reset for each CDC.

Critical Magnetic Field:
This is the maximum magnetic field that a superconductor can tolerate before abruptly returning to the normal resistive state.

Critical Point:
The critical point is the point on the vapor pressure curve that shows where liquid and gas (or vapor) phases can exist together. This can only happen when the temperature and pressure are

less than those at the critical point. Gas at a temperature above the critical temperature does not separate into two phases when compressed isothermally, but its properties change gradually and continuously from those we ordinarily associate with a gas (low density, large compressibility) to those of liquid (high density, small compressibility).

Cross Section:
A measure of the probability of the occurrence of a specified interaction between a particular incident particle and a specified target particle or system of particles. Unless otherwise specified, the cross section is given by the reaction rate per target particle for a specified process (e.g. capture), divided by the flux of the incident.

Critical Temperature, Pressure:
This refers to the temperature and pressure at the critical point.

Crowbar:
When a device turns itself off, typically due to overcurrent.

Crowbar:
A crowbar refers to an electronic safety circuit that intentionally short circuits the output of a power supply, and forces it to zero, when its current and/or voltage goes to a dangerous level.

Crowbar Compare Circuit:
The Modulator and PA protection circuit that shuts down the RF system if the current from the modulator to the PA anode exceeds certain limits.

Cryogen:
1. By convention, a cryogen is one of the gases condensing below 150K.
2. A refrigerant to be used in a refrigerator for producing low temperatures. To reach superconducting temperatures, liquid gases such as Nitrogen are used in succession with liquid helium to reach the lowest temperatures.

Cryogenic:
A system or equipment that operates at a temperature set by convention at 150K or lower.

Cryogenic Valve:
see Extended Stem

Cryogenics:
1. This refers to the production and maintenance of very low temperatures, and the study of phenomena at these temperatures.
2. Cryogenics is the technology of the production and effects of very low temperatures. The adjective "cryogenic" is frequently used when describing liquid hydrogen targets and the phenomena of superconductivity. The niobium-titanium alloy used for superconducting magnets becomes superconducting at a temperature of 11K.

Cryostat:
1. A vacuum insulated vessel for cryogenic fluids. See Dewar.
2. A vessel for maintaining a constant low temperature.

Cryostat Vacuum:
Insulating vacuum specific to the cryogenic transfer line system.

CUB:
The Central Utility Building is the facility that provides LCW for accelerator cooling as well as chilled water for air conditioning systems. It is located directly behind the Booster pond.

CUR:
CURrent, a process scheduling state on the VAX indicating that a given process is currently operating.

Current-to-Pressure Transducer (I-P):
This TeV LCW temperature control device converts the 4-20 mA signal sent by the Love Controller into a 3-15 psi signal that the pneumatic actuator uses to position the heat exchanger valve.

Cursor:
A visible marker on the screen that indicates where on the screen a user may be interacting with the program.

CVT:
Stands for Constant Voltage Transformer. It provides proper voltage for Tevatron power supply SCR firing circuits.

Cycle Period:
This refers to the length of time between successive repetitions of a periodic phenomenon. The colliding beam cycle is 220 seconds.

Cyclotron:
A particle accelerator where the particles move in a constant magnetic field in a spiral orbit, the energy of the particles being increased by the application of an alternating electric field at constant frequency.

Cyclotron Magnet, Chicago:
The large magnet from the synchrocyclotron used by Fermi and his colleagues at the University of Chicago now used not as an accelerator, but as a particle-momentum analyzing device (spectrometer) in the N1 muon beam of the Neutrino Area. It is located in the Muon Lab Enclosure. The magnet is so massive that it was moved in several pieces, assembled and the building then built around it.

Notes:

-D-

D/A:
Digital to Analog converter (hardware) or a setting value for a device (software). The hardware is a unit that accepts a number from the control system (binary encoded) and converts it to a corresponding output voltage. Such a device is the complement of an A/D converter. In many instances the output is used to program the output of a power supply. In such a situation the transfer function of the power supply is assumed to be a constant. Most D/As in the accelerator control system output voltages in the range of a minus 10.24 to a positive 10.24 volts and have a resolution of 12 bits (including the sign bit).

D0 Collision Hall;
Collider Detector at D0 interaction region.

D to A Line:
This refers to the transport line joining the Debuncher and Accumulator. Extraction/injection is realized by means of sets of pulsed magnetic septa and kicker magnets all oriented to displace the beam horizontally. The Accumulator injection kicker is unique in that a physical shutter moves into the aperture when the kicker is fired to shield the already circulating stack from the magnetic field of the kicker (only the injected beam is perturbed).

DABBEL:
The acronym stands for DataBase Batch Editing Language. This is an interactive program on the Operational VAX that implements changes in the system database.

DAC:
Digital-to-Analog converter, is an electronic circuit that takes a digital message, usually transmitted on a link, and converts it to an analog voltage for use by a device. This usually means that the circuit has many input lines (generally 8, 12, or 14) corresponding to the number of bits in the digital word and a single output line whose voltage represents the sign and magnitude of the digital word.

Damper:
Device used to damp out coherent transverse and longitudinal beam oscillations.

Dark Current:
Current that flows from a photomultiplier tube in the absence of light. The main sources of dark current are ohmic leakage due to imperfect insulation and thermionic emission.

Data Selector:
Part of the monitor/control module for the Haefely power supply that selects either the voltage readback or the command voltage for display on the front of the module.

Database:
A list of properties for each device on the ACNET system. These properties include mnemonics, alarm limits, descriptor texts, and scaling information.

DBM:
This acronym stands for Data Base Manager. This is a process on the VAX that maintains the database. All accesses to the information in the database must be through routines that interface with this database manager.

Debuncher:
A radio frequency cavity phased so particles at the leading edge of a bunch of beam particles (higher momentum particles) are decelerated while the trailing particles are accelerated, thereby reducing the range of momenta in the beam. Such a device may be placed between two stages of acceleration to increase the efficiency of capturing the beam in the second stage as, for example, with the 200 MHz debuncher cavity installed between the Linac and Booster at Fermilab.

Debuncher, Booster:
The Booster debuncher is used to reduce the momentum spread of the Linac beam by decelerating particles with higher than nominal energy and accelerating those with lower energy.

Debuncher, Antiproton:
The first of the two rings (as seen by the pbars) that comprise the Antiproton source. The Debuncher is designed to accept a pulse of newly produced antiprotons, bunch rotate and adiabatically debunch the beam, then betatron cool the beam in preparation for injection into the Accumulator. Design parameters include:

Kinetic energy	8.0 GeV
Average radius	80.42 meters
Number of bunches injected	80
Momentum aperture $\Delta p/p$	4%
ßtron acceptance	20π mm-mrad
ßtron tunes (H & V)	9.75
Periodicity	3
Phase advance/cell	60˚

DEC:
Digital Equipment Corporation.

Decay:
A transformation in that an atom, nucleus, or subatomic particle changes into two or more objects whose total rest energy is less than the rest energy of the original object.

Decay Length:
The average distance a species of a particle at a given energy travels before decaying.

Decay Muon:
A muon produced via pion or kaon decay.

Decay Pipe:
NUMI contains a 677.1 meter decay pipe. The π and K particles produced at the target decay in flight through the decay pipe into the muons and neutrinos used by the experiment. The length of the decay pipe is determined by the decay half-life of the p and K particles and their velocity.

Deceleration:
Deceleration is the process of decelerating the antiproton stack to a set momentum. (The Tevatron will, some day, be able to decelerate.)

DECnet:
A system developed by the Digital Equipment Corporation, used before the advent of the Internet, that linked DEC computers together.

Defocusing Quadrupole Magnet:
This is a quadrupole magnet that focuses beam in the vertical plane and defocuses in the horizontal plane.

Density:
The mass per unit volume of anything, (g/cm3).

Deuteron:
The nucleus of the deuterium atom (an isotope of the hydrogen) consists of a proton and a neutron.

Device Index (DI):
This is a number assigned by DBM to all devices entered into the database. This number is then used by software routines to access information about a device from the database.

Dewar:
A vacuum insulated, cryogenic radiation insulated, low conduction heat loss vessel for cryogenic fluids. A Dewar is a vacuum insulated container for keeping material, chiefly liquids, cold or hot. The common thermos bottle is an example of a Dewar. At Fermilab Dewars store large quantities of cryogenic liquids.

Dewar, Antiprotons Source:
In Pbar the nitrogen Dewars are used to submerge the stochastic cooling electronics in order to reduce the amount of thermally induced electronic noise.

DFG:
Acronym for Dipole Function Generator. It is the card that controls and provides the output waveform for the Tevatron correction dipole regulators. These are also known as 460 modules.

D. I. Bottles:
De-ionization bottles. Used to lower the conductivity of the LCW cooling systems.

Diffracted Beam:
Particles exhibit wave like characteristics in their passage through matter. In striking a target the incident beam scatters off nucleons. The scattered waves then combine according to the superposition principle and the peak of this scattered wave is called the diffracted beam. Diffraction takes place when the wavelength of the incident beam is short compared to the interaction distance.

Diffusion pump:
After a mechanical (roughing) pump is used to remove about 99.99% of the air in the beam tube, a diffusion pump removes the remaining air down to about 1E-5 torr by capturing gas molecules in heated oil.

Digital Status:
Indicates whether a given device is on or off, and whether or not it has been reset. Usually there are also digital bits that signify interlock status, etc.

Digital Voltmeter (DVM):
A DVM is a modern solid state device capable of measuring voltage and displaying the value in digitized form. The term is also used loosely for the digital multimeter that can measure current and resistance as well.

DIO:
Direct Input/Output. It is generally used in the context of processor I/O.

Dipole:
A magnet with two pole faces, used to bend the beam either horizontally or vertically.

Direct Muon:
A muon produced by the direct interaction of a proton with a target rather than produced as a decay product.

DISC Cerenkov Counter:
A DISC (Differential Isochronous Self- Collimating) Cerenkov counter is used to identify particles over a wide range of masses and can also be used to give an independent calibration of the average momentum of a beam line. The DISC Cerenkov counter at Fermilab is located in the M6 beam in the Meson Lab.

Discriminator:
A discriminator is a circuit that accepts signals of various shapes and amplitudes, and for each input signal that is above threshold, it outputs a standardized logic pulse. The outputs are of standard amplitude and duration, completely independent of all characteristics of the input except time of occurrence.

Disk:
A device carrying magnetically encoded information that can be read by a computer system. The information load is usually in the few to hundreds of megabyte range.
Dispersion:
Quality of a beam transport system at a given point that defines the variation of the transverse position of the beam with variations in beam momentum. Usually expressed in meters.

Dispersion:
Spread in beam positions due to a spread in particle momenta. ($\Delta x = D_x(z)(\Delta p/p)$ where D_x is the horizontal dispersion as a function of z, the longitudinal coordinate).

Dispersion (high and zero):
Dispersion of the momentum variety can be looked at as the size of a beam as a function of the momentum spread. Dipoles can create dispersion or take it away (particles of different momenta will be bent at different angles by a dipole with uniform field), as can quadrupoles. In the case of the Antiproton source, high dispersion regions are good places for beam pickups to sense improper momenta- a good place to install momentum cooling pickups. Low (or zero) dispersion regions are suitable for sensing beam displacements primarily due to ßtron oscillations- similarly a good region in that to install pickups and kickers for ßtron cooling systems. As an aside, momentum cooling kicker electrodes are also placed in low dispersion areas, because placing them in high dispersion areas could induce unwanted heating of the beam.

Divergence:
This refers to the angle that the trajectory of each particle makes with the beam axis. Accelerator systems always try to reduce beam divergence.

DOE:
U.S. Department Of Energy.

Dogleg:
A two (or more) dipole system that first bends the beam away from a given path and then straightens it so that it parallels the original path. A shifting of the beam axis by a pair of dipole magnets, such that the initial and final beam axes are parallel.

Dome (Pre-Accelerator):
The -750 kilovolt direct current terminal of the Cockcroft Walton Preaccelerator, which is hosed in a large rounded box, contains the ion source and supporting equipment for the accelerator.

Dosimeter:
An instrument used for measuring or evaluating the absorbed dose of radiation. It may depend on the measurement of ionization for its operation or may simply involve the darkening of a piece of photographic film ("film badge").

DOSYL:
DOcument SYstem Locator. A documentation system residing on the Development VAX that is used to reference Operations Bulletins, Technical Memos, Software Releases, etc. It contains

information that can be accessed by keyword, date, author, or subject concerning major documents released by the Accelerator Division or the Publications Office.

Doublet:
A system of two quadrupoles in close proximity and with opposite polarity, used to simultaneously constrain the beam size in two dimensions at some point downstream. It also refers to a waveform consisting of a closely spaced pair of peaks with opposite polarity. (A typical example of this waveform would be the output of a BPM electrode)

Doughnut club:
The group of Physicist, Specialist, and Techs that gathers each morning to talk in the MCR while eating doughnuts and spilling coffee.

Download:
To write an operating program from one machine to another. Often the programs are stored in one machine and written onto the second if problems develop during operation.

Downstream:
This is a relative term that corresponds to the direction that the protons travel in that portion of the accelerator.

DPM:
The Data Pool Manager is a task on the console computer that accesses the database in the VAX in order to organize request lists for setting and reading data.

DRF1, 2, 3:
The Debuncher employs 3 unique radio frequency systems:

1. DRF1 is an h=90 (53 MHz) system used to capture the p□- bunches as they are injected, rotate the bunches 90˚ in phase space to reduce their momentum spread, then to adiabatically debunch the beam. It may not be obvious, but the $\bar{p}$s coming off of the production target will retain the same RF structure as the incident protons had, hence DRF1 can be locked to MRRF. There are 2 unique types of cavities comprising DRF1. Cavities 1 and 8 are referred to as adiabatic cavities. They operate at a lower voltage than the other 6 cavities in order to adiabatically debunch the beam. Cavities 2-7 are called 'Rotators' and primarily serve the function of capturing and bunch rotating the injected pbars.
2. DRF2 is a barrier bucket system operating at h=4. The Debuncher is physically longer than the Accumulator, by 200 nsec, so a gap is put into the circulating Debuncher beam to make the beam fit into the Accumulator. This also permits time for kicker magnets to reach full field without perturbing the beam. DRF2 creates one bucket (the other 3 are suppressed) that prevents particles from entering, hence a gap in the beam is created. The bucket height of DRF2 is greater than the beam energy spread, so a barrier is created.
3. DRF3 is also a h=4 system and is used only during studies as an aid in exploring the aperture, chromaticities, and other properties where moving the beam around the aperture radially is useful. Varying its frequency permits one to move the beam to the inside or outside of the central orbit.

Drift Chamber:
A series of drift chambers are used to detect particle trajectories. They are similar to multi-wire proportional chambers, except the wire spacing is increased. The correlation between the position of an ionized track produced by a charged particle and the time of appearance of an electric pulse at the wire is used to measure the distance of the trajectory from the wires.

Drift Tube:
This is a copper tube positioned inside a Linac RF cavity that protects the particle beam from the sinusoidally varying accelerating field. When the beam travels out of the drift tube and into the accelerating gap the beam sees a positive gradient and is accelerated.

Drive Loop:
The drive loop is the termination of the Linac coaxial transmission line leading from the PA to the RF cavity that couples the energy in the transmission line to the fields in the cavity.

Driver:
The 4616 power amplifier tube (200 kW output) used in Linac, Boost, Main Injector, and the Tevatron to drive the 5 MW PA.

Dry Engine:
This is a cryogenic device that cools the helium by allowing it to do work against a piston. It is used to cool the shell side of the heat exchangers.

Dugan:
This seldom-used term was unofficially used to describe the rate of stacking pbars. 1 Dugan = 1 mA/Hr. Named in honor of Dr. G. Dugan who used to be head of pbar.

Dumb module:
A relative term designating any card or module that does no on-board data processing or error checking. For dumb modules the front- end usually performs these functions.

Dump:
A dump is an area made of steel and dense concrete used to capture unwanted beam and safely dissipate its energy. This term also refers to a Tevatron ramp trip during that the stored energy of the ring is dissipated through high power resistors.

Dump resistor:
This is a 1/4Ω resistor that is switched into the Tevatron magnet circuit in order to dissipate the stored energy in the magnets in the event of a ramp trip.

Duoplasmatron:

A type of ion-producing source that develops protons by extracting positive ions from an arc struck in hydrogen gas. The I- source in the Preacc used to be a Duoplasmatron. Both sources are now magnetrons.

Duplex:
This refers to simultaneous two-way independent transmission in both directions. This may also be referred to as full duplex.

Dynamics:
This is the study of the motion of particles under the influence of forces. Dynamics deals with the causes of motion, as opposed to kinematics that deals with its geometric description.

-E-

E-Z Writer:
Applications programs that store commonly used plot information for convenient display on the Console or storage scope. Currently residing on D77, B67, M77, M78, T102, T107, S67, and P77.

Early Bird Report:
At the end of owl shift the Main Control Room crew chief writes a one page summary of the past 24 hrs and the proposed schedule of accelerator operations for the next 24 hrs. This summary is then delivered via email to all interested people.

East (West) Anode Supply:
The high voltage D.C. power supply for the anodes of the power amplifiers located under the east (west) gallery of the booster.

Echoing:
Refers to the returning of information from a computer or some part of the control system to insure that the information was received correctly.

Eddy Current:
Localized current flowing in a conductor in response to a changing magnetic field.

Electron:
A stable, elementary, negatively charged particle. Electrons have the smallest amount of mass of all the subatomic particles. Electrons may be in bound states around nuclei where they determine chemical properties of elements, may radiate through space as electron beams, or through conductors to form an electrical current. Electrons are spin 1/2 fermions and interact via the electromagnetic and weak forces.

Electron Shower:
These are usually called electron-photon showers and are made by high energy electrons or photons passing through a medium. A parent electron radiates photons in traversing a medium, and the photons convert to electron-positron pairs, that again radiate. The number of electrons and photons therefore increase exponentially until ionization loss becomes important and no further radiation is possible.

Electron Volt (eV):
The amount of kinetic energy gained by an electron when it is accelerated through an electric potential difference of 1 volt. It is a unit of energy or work, not voltage. Particle energies at FERMILAB are typically measured in billions of electron volts (GeV).

Electrostatic Septum:
The septum is the principal component of a beam splitting system. It contains an charged wire plane, either horizontal or vertical, that produces a different field on opposite sides of the wire

plane. Segments of beam on opposite sides of the plane will be deflected in opposite directions, thus cutting the beam into two parts, or "splitting the beam".

EMC:
Event Message Code. A list of alarms assembled by the appropriate front-end. This list is eventually given to ALARMS_DRIVER, which organizes the data for display on the alarm screens.

Emergency loop:
System of microswitches that when opened (by pulling on a crash cord on the tunnel wall) will disable the radiation and electrical safety systems for that particular enclosure.

Emittance:
This refers to the area in phase space occupied by a particle beam. The units are mm-milliradians for transverse emittance and eV-sec for longitudinal emittance. (πE, defined as the effective area of the beam in phase space and given by $\int x'\,dx$ where x' is the divergence.)

Emittance Probe:
Linac device used to measure the size of the phase space ellipse occupied by the beam, done by measuring the divergence of the beam at a number of points across the beam axis.

Emulsion (Nuclear):
A photographic substance designed for the detection of ionizing particles. When high speed charged particles traverse the emulsion, they cause ionization tracks that show up when the emulsion is developed. The charge, energy, and momenta of the particles may be deduced from their range in the emulsion, from the grain density of their tracks, and from their curvature in a magnetic field.

Enclosure:
A portion of the accelerator tunnel.

Energy Doubler/Saver:
This is the name originally given to the Tevatron because it permitted acceleration of protons to about 1000 GeV, which was twice the energy attainable by the old Main Ring. It is an "energy saver" because the superconducting magnets permit the acceleration of beam using less electrical energy than the Main Ring used to reach the same energy level.

Enthalpy:
The sum H of the internal energy U and the work energy PV of a fluid at a given temperature and pressure (H = U + PV) (J/g).

Entropy:
The measure of system disorder. The function of state of a thermodynamic system.
$\left(\delta Q / \delta m \delta \mathrm{T}\right) \leq \delta S$ where Q is heat, T is absolute temperature and S is entropy (J/g˚K).

EPA:
Environmental Protection Agency.

EPB:
Extracted Proton Beam. This term refers to 5 and 10 foot dipoles and quadrupoles originally designed for use in the Switchyard.

EPO:
Environmental Protection Officer.

ERM:
Event Request Modules. These are the CAMAC 175 Modules that encode events onto the Tevatron clock. They are located in the MAC room.

Error Codes:
Messages that appear in red on the consoles carry information about the controls system pertinent to the fact that you, have no data. These messages can be deciphered from D11 or using the error help facility under the utility window on the consoles.

ES&H:
Environment, Safety and Health.

ESEP:
Vertical splitting septa in the proton line. It is called ESEP because it is located in enclosure E in Switchyard.

ESHPAC:
ES&H Policy Advisory Committee.

ETHERNET:
This was once the link and communication protocol generally used between computer systems. It was a half-duplex link that transmitted data serially, in both directions, at a 100 Mbit rate.

Ethernet Controller Board:
Board found in the Linac primary microcomputer that handles communication with the Ethernet link.

Eurobus Crate:
One of two small crates in the Preacc control room containing cards used to interface the local microcomputer to the Haefely power supply controls.

Expansion:
Expansion makes the volume of a given mass, or mass flow, suddenly larger, as in Joule-Thomson and engine expansion. This generally cools the mass.

Expansion Efficiency:
The ratio of the actual change in enthalpy to the ideal (isentropic) change.

$$eff = \frac{\Delta H^{Real}}{\Delta H^{Ideal}}$$

Expansion Engine, Turbine:
Devices that are driven by gases, extract work, and lower the temperature of the gas.

Extended Stem:
Modifier for valves with long stems for cryogenic service.

Extraction:
The controlled removal of beam from one portion of the accelerator in order to send it to the next one.

Extractor:
An electrostatic device used to extract ions from the magnetron ion source in Preacc. It consists of a pair of plates mounted beneath the source connected to a pulsed power supply.

-F-

Factory (antiproton):
Refers to the installation where Antiprotons are produced and accumulated. Fermilab's Antiproton source, consisting of the Target station, Debuncher and Accumulator rings, and the associated transport lines, is a good example of an Antiproton factory.

Fail Safe Mode:
A situation where the failure of a component results in a safe condition. The critical devices of the safety system are designed to be fail safe, i.e.. they will not allow the transmission of beam pass the critical device.

Fan-in:
A board or other device that gathers signals from a variety of devices and consolidates them for processing (as with an MADC).

Fan-out:
A board or other device that receives a signal, replicates it, and sends it out to a number of devices.

Fast Time Plot:
The standard plot generated on the SA, SB, or SC window of a console.

Fast trip:
1. Automatic turn off of the Main Injector ramp in the event of a fault.
2. The switching off of a power supply or supplies (e.g. Main Injector or Tevatron power supplies) in response to a signal from an overcurrent, overvoltage, or ground fault detection circuit.

Feed Can:
Device that connects the satellite refrigerators to the magnet strings. At every '1' and '4' building there is a normal feed can, and at every '2' and '3' building there is a power feed can. The power feed cans are the points where the power supply bus enters the cryogenic system.

Feeder:
Underground cable(s) that delivers power from the Master Substation and Kautz Road to various accelerator sites.

Feeder:
A 13.8 kV electrical power distribution cable(s) running between the Master Substation or Kautz Road and a unit substation located near where the power is used.

Fermilab Clock Decoder:
A custom-made integrated circuit that decodes TCLK for internal use on a board.

Fermion:
A generic term for half integral spin particles to that Fermi-Dirac statistics apply (total wave function antisymmetric under identical Fermion exchange). The Pauli Exclusion Principle applies for such particles (two fermions cannot simultaneously occupy the same quantum state). Examples are electrons, protons, neutrons, muons and hyperons.

FESS:
Facilities Engineering Services Section.

Fiducials:
In general, reference marks that particle trajectories are compared to; may apply to wire spark chambers, optical spark chambers, bubble chambers, etc. In particular, permanent reference markings in SWIC displays to facilitate the referencing of beam trajectories in beam lines.

Fiducial Volume:
The volume of a detector or spectrometer system within that events are accepted as measurable.

FILEMASTER:
This is a user account on the Operational VAX that coordinates the creation, deletion and modification of all filesharing files on the AD OPER VAX. This also keeps track of all files on a master list.

Filesharing:
This refers to a type of file access system established on the OPER VAX. This system allows shared access to files from any connected node. This means that any console, front-end, OPER VAX process, or DEV VAX process may read from or write to a filesharing file.

Film Badge:
A device worn by those who work in radiation areas to record the amount of exposure the individual has received over a one month period.

Filter:
A device to separate particulate matter. In cryogenics includes frozen matter.

Finite State Machine (FSM):
An applications program currently residing on F13 that controls the refrigerators during automatic quench recovery or automatic cooldown.

FIRUS:
Acronym for FIRe and Utility System. A site-wide alarm system that reports alleged fires, power failures, pump alarms, etc. The FIRUS screen in the MCR is edited to report only those problems relevant to the Beams Division.

Fixed target:
Fixed target refers to a mode of operation that experiments use to produce secondary particles by striking a stationary object (target) with a particle beam. A fixed target could be a piece of metal, liquid hydrogen (bubble chamber), or some other detector.

Flattop:
The portion of a magnet current excitation cycle where a constant current maintains a constant maximum value.

Flow Orifice:
A carefully constructed hole used to measure flow by the small pressure difference across it, temperature and pressure dependent.

Fluid:
Refers to the gas, liquid, or mixed phase of a cryogen.

Flying Wire:
This is a single wire that is rapidly passed through the beam. The wire in the beam causes losses that can be plotted downstream as BLM signal vs. wire position, which gives a profile of the beam. Flying wires are passed through the beam horizontally or vertically for horizontal or vertical beam profiles. Flying wires are used in the Main Injector, Tevatron, Booster, and Pbar.

FNAL:
Fermi National Accelerator Laboratory.

Focal Length:
The distance from the center plane of the lens where an input-beam that is parallel to the axis and displaced from the axis, crosses the axis after passing through the lens. The point where the beam crosses the axis is known as the principal point of the lens.

Focussing Quadrupole Magnet:
This is a quadrupole magnet that focuses beam in the horizontal plane and defocuses beam in the vertical plane.

Foreline:
A vacuum line leading from a vacuum pump to the device or devices to be pumped.

Forward Power:
The power transmitted from one stage of an RF system to the next, that may not represent the full power of the first stage due to power reflected from the second (reverse power).

Four-Momentum:
Refers to the relativistic generalization of momentum that describes the energy and momentum. It is a Lorentz 4-vector whose time like component is the energy and whose space like components are the momentum components. The four-momentum is easily transformed from one

coordinate system to another (Lorentz transformation) and its product (Lorentz product) with any other 4-vector is independent of the particular coordinate system used (Lorentz invariance).

Frequency Control and Phase Lock Module:
Linac module in the low-level RF system that provides RF input to the amplifier chain at the correct phase.

Frequency Control Module:
Linac module in the low-level RF system that commands the tuning slug controller in response to error signals that represent the difference between the transmission line RF phase and the cavity RF phase.

Front End:
A front end is an intelligent interface between a standardized communications system (like ACNET) and the myriad of hardware components making up our accelerator. The front end recognizes the programmer's standardized dialect on one hand and a cacophony of other standardized dialects on the other. There may well be a sub level of front ends within a given system to facilitate comprehensive local control. Most often, however, Operators think in terms of one of the computers in the CAMAC crates located in the west-most racks of the computer room, which handles the communication of data requests for a given accelerator system (Booster, Pbar, TeV, etc.). These front ends are interfaced to the various hardware crates on one hand, and to the consoles and central computers on the other.

Front porch:
Portion of Tevatron ramp before flattop where a bend field is held constant for a period of time.

FSEP:
Splitting septa in the meson line. It is called FSEP because it is located in the F1 manhole in switchyard.

FSHARE:
File SHARE. This is a process on the OPER VAX that coordinates and manages access to the Filesharing files for console and front-end programs.

-G-

G-10:
A green glass-epoxy electrical insulator material used throughout the laboratory.

GAS:
This is an acronym for GHASP Advanced Software. GAS performs much of the work that would otherwise be done by the front end. (180 module.)

Gas:
This is a fluid with zero heat of vaporization (devoid of liquid), denoted GHe, GH_2, GN_2, etc.

Gamma Function:
A gamma function is a mathematical construct - $\Gamma(x)$

Gamma Ray:
This is high energy electromagnetic radiation (photon, gamma ray) emitted in the processes of nuclear transition, particle annihilation, or charged particle acceleration.

Gannon box:
Another name for the NTF interlock module, built by Jeff Gannon.

Gas Barrier:
This is a ceramic insulator in the Linac 9-3/16" transmission line that isolates RF cavity vacuum from the nitrogen that pressurizes the transmission line.

Gate:
An electronic circuit capable of turning a device (usually a counter) on at a particular time and for a specified interval. It is usually used with fast logic devices to insure that certain conditions are met before counting can begin.

Gate Valve Controller:
A module in the Preacc control room that shows the status of the 750 keV line vacuum valves and permits local control of those valves. Also the module at each cavity that monitors the ion pump power supply status and controls the vacuum valves at each end of the cavity.

Gauss:
This is a unit of measure for magnetic fields. At 980 GeV, the Tevatron magnets produce a field of 39,600 gauss or 39 kilogauss.

Getter:
Material used to absorb residual molecules in vacuum spaces. Sometimes used in transfer lines.

GeV/c or GEV/C:
This is a unit of momentum appropriate to high energy particle physics. At kinetic energies much larger than the rest energy, the momentum of a particle in GeV/c is slightly less than the total energy in GeV.

GHASP:
General Host And Subsystem Protocol. A software protocol used for communication between a CAMAC front-end processor and intelligent subsystems, such as the microprocessors distributed around the accelerator.

Glitch:
A sharp increase/decrease and then immediate restoration of electrical power, often times causing devices to trip off.

Global Mode:
One of three modes of Linac control system operation where data requests and commands from secondary microcomputers are serviced by other secondaries.

Gluon:
A gluon is vector gauge bosons that mediate strong color charge interactions of quarks in quantum chromodynamics (QCD). Unlike the neutral photon of quantum electrodynamics (QED), gluons themselves participate in strong interactions. The gluon has the ability to do this as it itself carries the color charge and so interacts with itself.

GPIB interface:
The General Purpose Interface Board is an interface between a hardware device and ACNET. The interface is available commercially from Hewlett-Packard. Examples include spectrum analyzers and the DCCT current monitors for the antiproton source.

Gradient:
A measure of the electric field amplitude in an RF cavity. Usually expressed in percent of nominal.

Gradient Magnet Power Supply (GMPS):
This is the power supply for the main Booster magnets.

Gradient Regulator:
This is a module in the modulator pulse-forming circuitry that acts to keep RF cavity gradient at the desired level.

Ground Fault:
A ground fault is the shorting of an electrical device or circuit to ground.

-H-

Hadron:
A particle that interacts via the strong force, either a meson or a baryon.

Haefely:
Trade name for a Swiss company that manufactures high- voltage equipment used in the high-voltage power supply that maintains the Preaccelerator dome at -750 kV.

Half-duplex:
This is a data transmission scheme that is characterized by transmission in both directions in an alternate one-way-at-a-time fashion.

Half-high NIM:
A small NIM crate at each of the console stations in the MCR that contains, beam switches, console abort buttons, etc. Half-high NIMs are also used in other places.

Half-life:
The average time required for the amount of a particular radionuclide (radioactive substance) to be reduced to half its value as a consequence of radioactive decay. Like wise, the average time to decay for an unstable particle.

Hall Probe:
A hall probe is used to measure the strength of magnetic fields. When a magnetic field is perpendicular to a conductor carrying current, a potential difference is observed between points on opposite sides of the bar. A measurement of this potential difference gives the value of the magnetic field.

Halon:
A gas ($CBrf_3$) used principally in computer fire protection systems. It can extinguish a fire by chemical decomposition at the combustion site without damaging the computer or injuring personnel.

Hard Ground Stick:
This stick has a direct connection to ground and is used to discharge a device that might be at high potential, but with relatively low stored energy. See hot and soft ground sticks.

Hard line:
A term that generally refers to a physical cable connecting two devices such as computers, control modules, repeaters, etc.

Hardware:
Computer terminology referring to the physical components of a computer as opposed to the programs (software) used by the computer. Also used more generally to refer to the physical components of any system.

Hardwire loop:
Monitors the status of all interlocked doors and gates in an accelerator enclosure. If one is opened, the loop drops.

Harmonic:
An integer multiple of some fundamental frequency. Also, something expressible as a combination of sine and cosine terms.

Harmonic number:
The number of times the RF voltage oscillates during the time the beam makes one revolution around a circular accelerator. It also equals the number of RF buckets in the machine. In the Accumulator, for example, the revolution time is 1.6 μs, hence the frequency is 1/1.6μs or about 625 kHz. The ARF1 frequency is about 52.8 MHz. The quotient of 52.8 MHz/625kHz is 84. This means that ARF1 operates at the 84th harmonic of the revolution frequency.

Head:
The pressure in length units (pressure/density) exerted by a fluid column or developed by a pump.

Heat Capacity:
The ability to absorb heat. Measured in units of Joules/g˚K.

Heater Firing Unit:
When an HFU discharges it heats up a cryogenic magnet evenly so that thermal forces of expanding helium can't cause damage.

Heat Exchanger:
This is a device driven by temperature difference that moves heat from a warmer fluid to the colder fluid through a common wall.

Heat Exchanger:
A device for passing heat from a working fluid (e.g. Main Injector magnet cooling water) to a reservoir or heat sink (e.g. Main Injector cooling ponds). Heat exchangers are also found in the satellite refrigerator buildings. These devices have an enormous range of forms and sizes depending on the application.

Heat Leak:
A heat leak is the enemy of things cryogenic and is the inability to thermally isolate a given cryogenic system due to conduction, convection or radiation.

Heat of Conversion:
The heat required (or released) to change an equilibrium state.

Heat of Fusion:
This refers to the heat that must be removed per unit mass to solidify a liquid at constant temperature.

Heat of Vaporization:
The energy required to cause a change of phase, liquid to gas, at constant temperature per unit mass.

Heavy Water:
Heavy water is where the Hydrogen of H_20 has been replaced by Deuterium, D_20—the source that yields gaseous Deuterium (GD_2) under electrolysis.

HELP facility:
Information that is readily available at a console on how to use a given applications program. The VAX cluster computers also have a help facility on many topics.

Hemorrhoid:
The Beam Switch Sum Box (BSSB) chassis is located in the MCR. So called because when it breaks down it can be a real pain.

HEP:
High Energy Physics. Means particle physics research where the particles involved have extremely high energy. It's the real reason we're all here.

HERMES:
This is the process on the VAX that displays messages on Channel 13.

Hertz (Hz):
A unit of frequency equal to one cycle (repetition) per second (cps).

HFU:
Heater Firing Unit. Device that dumps current into the Tevatron magnet heater elements in the event of a quench. This action serves to spread the quench quickly that also spreads out the energy deposition.

Hi-Pot:
Hi-Potting is the subjection of a system to a high potential, low current power supply in order to detect a current leakage or ground fault. This is usually done to the TeV and MI Ring bus after an access to make sure the bus is not grounded by a tool, cable, or something else that might have been left touching the bus during the access. Hipotting can also be used to find the location of a ground fault if one is indicated. For example, in the Main Injector, about 1 kV is connected to the bus, and a current probe is used to sample the output to determine that direction the current is flowing, and thus the direction of the ground fault. An interaction of this process pinpoints the location of the short.

HIB:
HIBernate. A process scheduling state on the VAX. It signifies that a particular process is inactive. The process is present on the system and just waiting for a "wake up" call to start doing its thing. This is a very similar state to LEF.

Higgs Boson:
This is a hypothetical massive scalar elementary particle predicted to exist by the Standard Model of particle physics. It is the only Standard Model particle not yet observed, but plays a key role in explaining the origins of the mass of other elementary particles, in particular the difference between the mass-less photon and the very heavy W and Z bosons. As of 2006, no experiment has directly detected the existence of the Higgs boson. The tau lepton (often called the tau or occasionally the tauon) is a negatively charged elementary particle with a lifetime of $3\times10-13$ seconds and a high mass of 1777 MeV (compared to 939 MeV for protons and 0.511 MeV for electrons). It has an associated antiparticle (the anti-tau) and neutrinos (the tau neutrino and tau antineutrino).

High Beta:
see Beta.

High Rise:
Alternative name for Wilson Hall used among accelerator personnel
Hodoscope:
A group of particle detectors (usually scintillation counters) arranged to give accurate positional or directional information.

HOPS:
Higher Order Power Supply. Power supply for Tevatron quadrupole, sextupole, and octupole correction elements.

Horn:
A magnetic focusing device used to produce a more intense beam of neutrinos. Charged mesons from the target are focused by these horn shaped pulsed current sheets before they decay into neutrinos and muons, resulting in a more intense neutrino beam. Unlike a standard magnet focusing system, the horns can efficiently focus the meson beam over a wide momentum range.

Hot Stick
This is a stick that has no connection to ground and is used to manipulate devices that potentially could be at high potentials (like knife switches). See soft and hard ground sticks.

Hydrogen:
The element that protons are extracted from for acceleration.

Hydrogen pump:
A centrifugal pump used to circulate liquid hydrogen (LH_2).

Hyperon:
Heavy unstable (short-lived) particles, Hyperons all have half-integral spin (hyperons are fermions), are more massive than either a proton or neutron, include protons or neutrons as final decay products (hyperons are baryons), interact via the strong and electromagnetic interactions (hyperons are Hadron). Examples are the lambda, sigma, xi, and omega particles.

Hysteresis:
The phenomenon where the magnetization induced in iron or steel that is made to vary over time lags behind the magnetic field. This term is also used in general to indicate that changes in a system are dependent upon its past history.

Hysteresis:

- Dielectric - Loss of energy caused by conversion to heat when the dielectric of, for example, a capacitor is stressed.
- Magnetic - Lagging of magnetization of iron behind the magnetic field intensity.

Notes:

-I-

IAG:
Internal Assessment Group.

Ignitron:
Device found in modulators used to dump the capacitor bank voltage in the event of a PA crowbar. An Ignitron passes electrical current to a pool of liquid mercury at ground potential.

Impedance:
This refers to the opposition of a circuit to an alternating current, equal to the complex ratio of the voltage to the current in complex notation. The equivalent of resistance in a DC circuit.

Inclusive Reaction:
A reaction where measurements are conducted on a specific subspace of the final state of particles and information on the remaining complementary components of the final state is disregarded (e.g. p+p → p+ "anything").

Index page:
A list of applications programs available at a console. Each major accelerator system has a representative console program that displays this list. If no specific applications program is requested, the index page is displayed by default. Any program displayed on the list may be executed by interrupting under the program name or number.

Inductrol:
This is a voltage regulator for the Linac PA filament supply that compensates for variations in line voltage due to other large loads at the laboratory.

Inflector:
A magnetic or electrostatic device to apply a transverse force to a beam. Most often the term is applied to the pulsed septa that bend the injected beam onto the equilibrium orbit of a circular accelerator.

Injection:
The process of putting a beam of particles into an accelerator.

Injector:
Usually depends on context of system being discussed. When talking about Booster, it is the 400 MeV line. When talking about Main Injector it is the 8 GeV line or collectively Preacc, Linac, and Booster.

Insulating Vacuum:
A vacuum provided for the express purpose of reducing gaseous conduction, usually <10-4mm Hg.

Insulation:
A means to reduce heat transfer. Conductive, radiated, or convected.

Integrated Luminosity:
This is the total number of collisions (collisions per second times the number of seconds).

Intensity:
Number of particles in the beam.

Interaction Length:
The interaction length is the mean distance a particle travels through a medium before it interacts with one of the target particles. Interaction as taken here is any effect of interest to the observer.

Interlock:
An interlock is something that constrains or inhibits a device, generally for the purpose of safety; There are temperature interlocks, electrical interlocks, radiation interlocks, etc.

Interlocked Radiation Detector:
This Rad detector is installed around the accelerators and beamlines to prevent radiation levels in specified areas from exceeding the limits of the Fermilab Radiological Control Manual. This prevents personnel who may be occupying those areas from exceeding exposure limits.

Intermediate cylinder:
This refers to a cylinder inside of a Main Injector RF cavity between the drift tube and outer wall. It is biased with a dedicated power supply.

Internal Energy:
Isolated system energy. DU = Q-W. See Enthalpy.

Interrupt:
In an operational context it is usually the point that a change is made or verified in the operation of a device or program. It is required for changes in the D/A of a device, to change pages on a console, etc. In a computer context it is a temporary break in the sequencing of a program initiated by events in the outside world.

Interrupt button:
A button next to the keyboard at each ACNET console that provides interrupt capability in conjunction with the selected applications program. The function is duplicated with the RETURN key on the keyboard.

Intertank Phase:
A signal that represents the difference in phase of two adjacent RF cavities in the Linac.

Invert:
To invert a power supply is to reverse its polarity at the end of a ramp to reduce the current at a rate exceeding the natural fall rate of the circuit.

Ion:
An atom or molecule that is not electrically neutral but instead carries a positive or negative charge.

Ion Gauge:
A vacuum-measuring gauge that works by ionizing gas molecules with electrons and measuring the amount of ion current drawn to an anode.

Ion Pump:
An ion pump is a type of vacuum pump that works by ionizing gas molecules with electrons and catching the ions on a titanium anode. Permanent magnets around the pump increase the electron's path length into a spiral that produces more ionization. Molecules of both active and inert gases are removed by this action. This pump usually cannot be used at pressures much above 10^{-4} torr.

Ion Source:
The ion source, located in the high voltage electrode (dome) of the Cockcroft-Walton Preaccelerator, uses an electrical arc in hydrogen gas to produce H- ions.

Ionization Chamber:
A particle passing through the gas in a small chamber forms ions. A voltage will cause the ions to be attracted to the collection plate, depending on their charge. As a result a pulse of current will flow for each particle that forms ions. Each pulse is proportional to the ionization energy delivered by the particle.

Ionization Gauge Controller:
One of two ion gauges in the Preacc control room that monitor column vacuum and control the vacuum valves leading to the columns, as well as being interlocked inputs to the 750 keV chopper supply controllers.

IPA:
Intermediate Power Amplifier. An intermediate level of amplification in the Linac high-level RF system. The 400 W solid- state amplifier is the first IPA, and the 7651 tube is the second IPA. This also refers to India Pale Ale, a hoppy ale originally brewed in England for their soldiers stationed in India. The hops acted as a preservative so that the ale could survive the long trip by sail ship from England to India.

IPE:
Index Page Editor. A program for enabling the programmer to make an applications program available from a console index page. Included is the capability of assigning a page number and title to the program.

IPPS:
Ion Pump Power Supply.

Isocenter:
One of two points in space defined by alignment fixtures in the NTF set-up and treatment rooms. Patient set-up is usually done on the premise that the area to be treated will lie at the isocenter.

Isoplane:
An imaginary plane perpendicular to the neutron beam axis and containing the isocenter. Used in NTF patient setup.

-J-

Jacketed:
Cryogenic devices that contain an outer covering to hold an insulating vacuum.

Jets:
Narrow clusters of subatomic particles resulting from collisions of quarks and antiquarks. The particles in jets are the objects actually observed in experiments such as those in the Collider Detector at Fermilab.

Johnson Controller:
At one time this device was exclusively used to control the LCW flow through heat exchanger and magnets. It regulated the water temperature and pressure. LUV Controllers have replaced most of them. Although you can still find them in CUB. Johnson controllers operate air conditioning and air handling fans and vents.

Joule:
A unit of energy J (1J = 1 watt-second) such that the heat capacity of water at 15˚C is 4.18 J/g˚C.

Joule Thomson Coefficient:
The Joule Thomson coefficient, μ, is defined as $\mu = -C_p^{-1}\left(\partial \mathrm{H} / \partial \mathrm{P}\right)_{\mathrm{T}} = \left(\partial \mathrm{H} / \partial \mathrm{P}\right)_{\mathrm{H}}$. The sign of μ indicates whether a gas expansion will cause an increase or decrease in the temperature. If μ is positive, the expanding gas will be cooled. The locus of points where μ = 0 is called the Joule Thomson inversion curve.

JT valve:
A cryogenic valve that cools the helium and nitrogen by allowing it to expand. They also serve to control helium flow. JT stands for Joule-Thompson (or Jay Theilacker).

Notes:

-K-

Kaon:
The K-Meson is a subgroup of unstable mesons that consist of an electrically charged form (mass 966 times an electron) and a neutral form (mass 974 times an electron), produced as a result of a high-energy particle collision.

Kautzky valve:
Cryogenic relief valve for Tevatron style magnets and spool pieces. They are kept closed under normal conditions by a constant pressure of helium gas.

Kelvin:
The Celsius unit with the constraint that absolute zero = zero Kelvin.

Kelvin Temperature Scale:
This scale uses the same degree interval as the centigrade (Celsius) scale but has an absolute zero. That is to say 0˚ Kelvin is -273˚C. K=˚C+273.

Keyer:
This is a solid-state device providing the first stage of amplification in a Linac modulator. The light-pipe input to the modulator is amplified to about 1 kV by the keyer.

Keylock Valves:
This refers to beam line vacuum valves that are manually opened and closed to isolate beam pipe for maintenance.

Kicker magnet:
A Kicker magnet has a very fast rise time and is used to divert the entire beam at once. Booster extraction, Main Injector extraction, Main Injector, and Tevatron abort are all typical uses of a kicker magnet.

Kinematics:
The description of the motion of particles and bodies without reference to the forces associated with that motion.

Kirk Keys:
Any keys that are captured by the lock they reside in. They are used in situations where a degree of safety is desired. Some are used to prevent a mechanical linkage from being manipulated unless the key is present in the lock. An example of this use is the Booster Brentford breaker switch arms. Others require another key's presence before they can be removed and used for access in another part of the system. An example of this use is accessing the TeV power supply DC breaker cabinet. The name Kirk comes from the company that makes the captured locksets.

Klixon:
A Klixon is the trade name of a temperature-sensitive electrical switch used in interlock circuits of power supplies and magnets that opens when a certain temperature is exceeded.

Klystron:
A Klystron is a power amplifier that supplies power for the high-energy end of Linac.

Knife Switches:
Single pole switches that connect individual Main Injector and Tevatron power supplies to their respective power buses. These knife switches are located in a cabinet on top of each Main Injector power supply. The TeV knife switches are located in the TeV dump filter cabinet. The knife switches have to be manipulated locally. The knife switches can be put in any of three states. They can be placed so that the power supply is racked in to the bus. They can also be placed so that the bus is shorted in the power supply effectively bypassing the supply from the bus. In the last state the knife switches are manipulated so that the bus is broke open at the power supply. This is done to facilitate highpotting a section of the bus in order to track down a ground fault.

Knob:
A wheel connected to a shaft encoder in the MCR capable of making a continuous change in the D/A of a device. This is generally located in the half-high NIM bin on the right-hand side of the console.

-L-

LAM:
Look At Me. It is a flag used by many accelerator control cards to indicate a state. In other words, the device has information to be passed to the front-end and uses the flag to indicate to the front-end that it should read its information.

Lambda Particle:
A neutral elementary particle just slightly more massive than the proton, a hyperon member of the baryon family.

Lambda Supply:
This is a power supply that provides +5, -5, +15,and -15 volts. They are used to power Main Injector electronics in the service buildings.

Lambertson Magnet:
A special magnet used to separate two adjacent beams by providing a bending field for one beam and a field-free region for the other beam. A beam is usually separated into two adjacent beams upstream of a Lambertson magnet by a septum. They are usually found downstream of electrostatic septa and kickers. The Lambertson magnet was designed at Fermilab and is named for its designer.

Latent Heat:
Heat of Vaporization. Units of J/g.

Latent Heat of Fusion:
The latent heat of fusion is the amount of heat required to melt a unit mass of a substance at constant temperature and pressure at temperatures above the triple point.

Latent Heat of Sublimation:
The amount of heat per unit mass required to vaporize the solid phase.

Latent Heat of Vaporization:
The amount of heat required to convert a unit mass of a substance from the liquid to the vapor state at a constant pressure.

Lattice:
The periodic relative arrangement of quadrupoles and drift spaces in an accelerator.

LCW:
Low Conductivity Water has had its free ions removed in order to increase the resistivity of the water to 9Ω or greater. It is deionized water that is used to cool magnets, power supplies, RF systems, etc.

Lead Flows:
Cryogenic cooling at the point where the warm Tevatron bus enters the cryostat. Liquid helium is allowed to flow from the single-phase system out the feed can or power spool and through the power lead to cool it down. When the TeV is at 90 GeV or 150 GeV the low energy lead flows are on leaking out a low rate of flow of single phase helium. When the TeV is ramped up to 980 GeV for collider operation the high-energy lead flows are leaking out at a higher rate of flow. When the TeV is not powered there is a lower need for cooling. A standby flow of helium removes the heat conducted down the lead from the room temperature bus.

Lead Glass Counter:
A Cerenkov Counter using dense lead glass as the Cerenkov radiator. It is sensitive down to very low velocities and therefore may be used as a total absorption shower counter for identifying electrons.

Leads:
see Power Leads.

Leak Detector:
A device for finding leaks in a vacuum system. The standard type for use in high vacuum systems is a mass spectrometer that can detect minute quantities of helium that is released outside the system at a suspected leak. The sensitivity of the leak detectors used in leak checking Tevatron components is one part in 10 billion.

LED:
Light Emitting Diode. These are used extensively for digital information display on control card front panels and elsewhere.

LEF:
Local Event Flag. A process scheduling state of activity for a given process on the VAX. It means that the process is waiting for a flag to be set before resuming activity.

Left Bends:
At one time, this referred to a set of cryogenic bending magnets that initially directed the beam toward the Meson Area. The MT 200s are conventional magnets that send beam to Meson.

Lepton:
A collective term for those spin 1/2 particles (Fermions) that do not undergo strong interactions. The word Lepton was coined from the Greek root to indicate that these are light particles. The known leptons ($e\pm$, $\mu\pm$, ν, ν_μ) are lighter than the mesons and baryons.

Light Link:
A light link is a light modulator/receiver combination used to carry control signals along a path across that a large electrical potential difference exists. The encoded control information crosses this high voltage region on either an optical fiber bundle or an air path.

Limiting Orifice:
This type of orifice limits the helium flow through a tube or cavity. An example might be a limiter placed on lead flow.

LINAC:
The LINear ACcelerator is essentially the first step in the acceleration process, bringing the beam energy to 400 MeV. A linear accelerator has a number of electrodes arranged so that when a voltage is applied at the proper radio frequency the particles passing through the electrodes receive successive increments of energy, sometimes described as riding a surf. The LINAC at Fermilab accepts H- ions from the Cockcroft-Walton Preaccelerator at 750 kV, accelerates them to 400 MeV, and injects them into the Booster accelerator.

Linac Steering:
Downstream steering dipoles align the beam at the head of the 400 MeV transport line.

Linear Variable Differential Transformer:
An LVDT detects small position changes along an axis. They are used to detect position changes of Septa and Tevatron cryo valves among other places.

Link:
At Fermilab, links are the systems of cables and repeaters that carry information to and from distant points in the accelerator.

Link Driver:
This is a device that organizes and transmits digital information on a link. In the context of the link drivers for the console and front-end computers this device performs a parallel to serial conversion on data to be transmitted on the link. It also acts as a receiver of data from the link and performs the reverse conversion.

Liouville's theorem:
A theorem from classical mechanics that states that for a beam with constant total energy, the area occupying a spatial coordinate and its conjugate momentum (q and p phase space) for each particle in the beam is conserved over time, although the shape and position of this region may vary.

Liquid:
The fluid phase with finite heat of vaporization and density greater than the gas phase. Denoted by LH_2, LD_2, LHe, LN_2, etc.

Liquid Helium:
This is the coldest substance that is still a liquid and thus the only refrigerant at temperatures of a few degrees Kelvin and atmospheric pressure.

Lithium lens:
A device located directly downstream of the antiproton production target that acts to collect the secondary particles by reducing the solid angle of particles coming off of the target. The lithium

lens could be looked at as a high gradient biplanar quadrupole magnet. The lenses at Fermilab typically run at currents of hundreds of kiloamperes.

LLPA:
Low Level Power Amplifier. Linac 5-watt solid-state amplifier in the rear of the A5 racks that is the first step in the high-level RF system.

LLRF:
Low Level Radio Frequency. This refers to the electronics that provide the proper phase and frequency for the RF voltage. The LLRF controls the High Level RF Power Amplifiers that in turn produces the electric fields in the RF acceleration cavities.

Lock Out:
The process of placing locks on power supplies or power distribution panels so that the supplies can not be turned on or energized. This is a safety measure allowing maintenance to be performed on individual devices. It is also done to power supplies that feed electrical devices in the tunnel, such as magnets and correction elements, as part of the conditions for an access. The locking and removal of power supply locks is taken very seriously at Fermilab. Unauthorized removal of a lock from a locked off supply is considered a safety violation and is grounds for immediate dismissal from the lab.

Logic loop:
An electrical relay loop that protects an accelerator enclosure by ensuring that no one can enter the area and reset the loop once inside. Once the logic loop has been dropped the interlocks must be reset in a specified manner on a search and secure.

Logic Unit:
A logic unit is the most flexible and useful type of coincidence circuit. Unlike the simple AND or OR circuits, it permits any logical combination of inputs to be required as an output.

e.g. output = 1 AND 2 OR 3 AND 4□ (1,2,3,4, = inputs).

Longitudinal Transit Time Factor:
This is the ratio of the energy gain of particle traversing a cell with a constant electric field to the energy gain of a particle traversing a cell with a sinusoidally varying electric field. Simple, no?

Loss monitor:
This is a diagnostic device that measures the amount of beam lost from the vacuum chamber by measuring the secondary radiation produced when the beam interacts with the vacuum chamber.

LOVE Controller:
Pneumatically controlled regulation system located next to the LCW heat exchanger in Tevatron and Main Injector service buildings that controls valves affecting the flow of LCW through the heat exchanger. This controller replaced the Johnson Controllers.

Low Beta Magnets:
These magnets focus the beam to create collisions of high luminosity. Low beta magnets are installed at B0 and D0.

Low Beta Squeeze:
After injecting protons and pbars into the Tevatron for collider operation a special set of quadrupoles are turned on at B0 and D0 to reduce the size of the beam and increase luminosity. (The procedure of changing the currents in these magnets is called a “low beta squeeze.”)

LSS:
Laboratory Services Section.

Lumberjack:
This is a program that allows for the automatic and regular acquisition of data from a given set of devices, each with its own frequency.

Luminosity:
A measure of the potential number of particle interactions for colliding beams. The luminosity depends on the intensity and phase space density of the interacting beams. The higher the luminosity is, the better it is for quark and Higgs hunters. In colliding beams theory when 2 bunches of beam collide luminosity is defined as L=Nn/At; N=protons/bunch; n=antiprotons/bunch; A=cross-sectional area of intersection; t=time interval between bunch collisions. It can be considered to be the potential for particle interactions.

LUST:
Leaking Underground Storage Tank

Notes:

-M-

MAC Room:
A room under the MCR that once housed old MAC-16 and DEC-11/55 computers. The room now contains the clock generators and encoders, TeV vacuum, and the time line generator.

Machine Cycle Reset:
A signal, or clock event, to any specific accelerator to begin a programmed sequence of events. The major signals originate in the Time-Line Generator and are clock events encoded onto the Tevatron clock.

MADC:
Multiplexed Analog-to-Digital Converter. At Fermilab, these are usually local stations capable of accepting up to 64 analog inputs and converting each of them into a digital signal expressed in units of voltage. They consist of a single analog to digital converter with an analog input multiplexor to select one of the many possible input signals for conversion. Since only one channel may be digitized at a time, many commands are needed to digitize all possible input channels. This gives rise for the need of an MADC controller to coordinate its activities and issue the necessary commands. The Main Injector utility crates use a CC130 module while the newer CAMAC design is the 290 module. If each input to the analog mux is the output of a "sample and hold" circuit, then all the inputs may be sampled simultaneously even though the conversion must proceed sequentially.

MADC Volts:
The voltage output of an MADC, ranging from -10.24 V to +10.24 V. The least significant bit is 2.5 mV. The voltage represents a twelve-digit bit pattern generated from an analog signal. Conversion factors to engineering units are kept in the System Database.

Magnet cage:
A caged-in area in the Transfer Gallery used for various high power tests.

Magnetic Field:
This is a field of force that comes from a magnetic pole or surrounding a current flowing through a conductor.

Magnetron:
Ion source that produces negative ions by extracting them from a plasma formed by an electric arc formed in hydrogen gas. Used in the Preacc H- and I- sources at FNAL.

Main Collimator:
NTF collimator assembly following the primary collimator and containing inserts to shape the neutron beam to the desired size.

Main Control Room:
The area at Fermilab located in the Cross Gallery where acceleration of the beam of protons is monitored and controlled.

Main Ring:
At one time it was the accelerator that took the proton beam at 8 GeV and increased its energy to 150 GeV for injection into the Tevatron (fixed target operation mode). The Main Injector now accomplishes this.

Main Injector Power Supply:
Power supplies for the Main Injector magnets. They are turned on sequentially to form the Main Injector ramp.

Main Injector Sample Time:
The time, once a cycle, that sample and hold modules are loaded before information is sent back to the MCR.

Mainframe:
The cabinet or piece of equipment in a computer system that contains the CPU. The term also refers to the type of computer that requires a mainframe; i.e., a large computer.

Make Up Water:
The process of replacing lost LCW or coolant for a particular cooling system.

Manchester coding:
This is a coding scheme for digital information on a high frequency RF carrier. The Tevatron clock, the Linac serial link, and other systems use it. For example, TCLK operates at a 10 MHz rate, and byte-sized signals can be sent out at a 1 MHz rate. That allows for 10 100-nsec frames. The clock is structured so that if a phase transition takes place in the middle of a frame, it is interpreted as a "1"; otherwise, it is interpreted as a "0". Being a "self-clocking" mechanism, time errors do not accumulate as clock events are superimposed on the pattern. There is also a start bit (0) at the beginning of each clock event and a parity bit at the end. The 10 MHz pattern is transmitted around the accelerator on an RF carrier frequency of 50 MHz, and is demodulated and retransmitted at each house.

Manhole:
A physically isolated section of beam line tunnel.

Manometer:
A type of rough vacuum gauge. An evacuated and sealed tube contracts or expands, as the system pressure varies, and operates a spring mechanism which rotates a needle over a graduated scale.

Manual disconnect:
The large switch on a power supply cubicle that can be used to disconnect the power supply (actually the primary of its transformer) from the feeder.

Mass:
Refers to the quantitative measure of a body's resistance to being accelerated.

Master Oscillator:
Oscillator that provides the RF signal for all Linac RF systems. Typically runs at 805 MHz and goes through a divide-by-four module for low-level Linac.

Matching:
The process of tailoring the emittance of a beam to the acceptance of a device.

Matter:
This refers to the substance that makes up a physical object. All materials in the universe have the same inner nature, that is, they are composed of atoms, and arranged in different (and often complex) ways; the specific atoms and the specific arrangements identify the various materials.

Maximum Working Pressure:
MWP refers to the maximum pressure that a pressure container should be operated at or under.

MCR:
The Main Control Room receives and acts most of the information on the ACNET system. A number of hardwired signals are available as well. The MCR controls the beam to all experimental areas.

MDAT:
Machine DATa. Among other data, the MDAT serial link transmits programmed values for the Tevatron current and dI/dT, around the accelerator, the measured values for the Tevatron current and dI/dT. MDAT is carried on one of the 19-conductor cables at a 720-Hz rate. This information is then decoded and used by several devices such as the ramped correction elements.

MDV:
MoDulator View. RF abbreviation. This is the output voltage of the modulator that supplies anode voltage for the final tube of the power amplifier. There are two types of modulators. The originals that are calibrated for 1 V input equals 2,500 V output and some that have been modified for 1 V in equals 3,000 V out.

Mechanical Phase Shifter:
Device strung between Linac RF cavities with inputs from each cavity that produces the intertank phase signal used for phase regulation.

Medical Microcomputer:
NTF computer that drives the NTF console and interfaces with the beamline microcomputer.

Melting Point:
Any of the points along the solidus line in the P-T phase plot. Most often quoted at one atmosphere.

Meshall:
The large concrete pre-target enclosure in the Meson Area providing access to the target train for inspection and minor maintenance. Meshall also contains beam diagnostic equipment and beam line magnets. The primary Meson Area target is positioned in a heavily shielded tube just downstream of Meshall.

Meson:
A meson is any of a family of unstable subatomic particles that participate in strong interactions, composed of a quark and an antiquark, and have masses generally intermediate between leptons and baryons. It is an elementary particle responsible for the forces in the atomic nucleus; a hadron with a baryon number of 0.

Meson Detector Building:
The airplane hanger shaped building in the Meson Area providing weather protection, crane coverage, and utility connections for the "upstream" end of the experiments in that area. Beam line monitoring and tuning is also conducted from the operations area on the mezzanine floor of the Detector Building. Also called Meson Hall.

Metering Resistor:
Precision resistor-capacitor network used for measuring the voltage on the Preaccelerator dome, 2125 MΩ.

MIBS clock:
Main Injector Beam Sync clock. It operates at about a 7.5 MHz rate, so that there are exactly 159 clock ticks per turn. It is used wherever synchronization to the beam has to be especially accurate. See beam sync.

Mil:
Unit of measurement equal to .001". This is not to be confused with a millimeter. 1 millimeter equals 40 Mils.

MIL-STD-1553B:
Digital multiplex data bus standard used for interface between the ground station VME and Eurobus crate cards that control the Haefely power supplies. Originally developed by the U.S. military.

Milliamp:
A unit of current measurement. 1 thousandth of an amp. In the Antiproton Source it is used as a unit for quantifying beam intensity in the Accumulator. 10^{10} antiprotons equal 1mA of antiprotons.

Millirad:
1/1000 of a rad. The rad (an acronym for Radiation Absorbed Dose) is defined as that quantity of radiation that delivers 100 ergs of energy to 1 gram of substance.

Milliradian:
A unit of angular measurement. 1/1000 of a radian or about 0.057 degrees. Milliradians are often used when discussing the amount steering a magnet does to a particle beam for a given magnet current.

Millirem:
1/1000 of a rem. The rem (an acronym for Roentgen Equivalent Man) is a biological rather than a physical unit of radiation damage. It represents that quantity of radiation that produces the same biological damage as 1 rad of x-rays or gamma radiation.

Min/Max:
The limits of tolerance for a particular device. An alarm (and sometimes a beam inhibit or abort) is generated when the value of the device falls outside these limits.

Mini Straight:
see Mini Tube.

Mini Tube:
This refers to braces that come off of the downstream end of a quadrupole. These braces support correction elements, BPM detectors, and other beam diagnostics that encircle a section of beam pipe in the P2 and P3 transfer lines. The term mini-straight is sometimes used in place of mini-tube.

Minimum Ionizing:
A charged particle traveling through matter near the velocity of light loses less energy per unit path to the atomic electron than a slower particle and is hence minimum ionizing. Above the velocity of minimum ionization there is a gradual (logarithmic) rise in ionization loss for extremely relativistic particles. Minimum ionization for protons is in the range from about 2-10 GeV.

Mixer:
A mixer is the final component in the Linac low-level RF system that passes the RF signal to the amplifier chain when gate signal arrives from waveform generator/sequencer. In other words, it's a circuit that produces the algebraic product of two input signals.

Mod Block:
Premature termination of a Linac modulator pulse triggered by a modulator current of greater than 400 amps during the pulse.

Modem:
A modem is a device that translates computer signals into a format that can be transmitted over telephone lines.

Modulator:
High-voltage device connected to the anode of the PA that controls the RF output to the cavity.

Modulator Regulator:
This is the module that regulates modulator current to maintain constant RF cavity gradient.

Mole %:
Describes the mixture in molar percent. In the Tevatron cryogenics system it is used most often in reference to the NeH_2 mixture.

$$Mole\ \%\ Ne = \frac{2\ atomic\ \%\ Ne}{atomic\ \%\ Ne + 1}$$

Momentum Compaction:
A function that describes the deviations from the equilibrium orbit due to momentum error in the beam generally denoted by a_p.

Momentum Dispersion:
Spread in momentum due to the bending of particle of different momenta passing through a dipole.

Monitor/Control Module:
Module in the Preacc control room that monitors voltage on the Preaccelerator dome, digitizes it, and sends it along with the command voltage to the regulator/oscillator module to complete the voltage regulation feedback loop.

Monitor Unit:
Artificially-derived unit used by NTF to define neutron dose rates.

Monatomic:
Single atom molecules: He, A, Kr.

Monte Carlo Calculation:
Any method for obtaining a statistical estimate of a desired quantity by random sampling. The sampling is made from an artificial population that is in some sense a model of the physical system being investigated.

MOU:
Memorandum Of Understanding.

Mountain range display:
An oscilloscope plot, usually generated in the MI60 building, that displays bunch structure vs. time. The value of this type of display is that it can be triggered at some frequency to show information (such as bunch structure) for a set number of triggers, with each trigger having a different vertical offset. If the frequency is chosen to be the revolution frequency, one can watch the time evolution, within a window, of the same bunch as it circulates in the accelerator.

MSDS:
Material Safety Data Sheet.
MULT: n:
A collection of two or more devices for that their D/A values can be changed in specific ratios to each other; n represents the number of devices.

Multibus:
This is the IEEE standard format for microcomputer systems hardware.

Multibus II:
This is a newer version of the standard multibus. Cards are not interchangeable between the two systems.

Multibus crate:
A set of standard signal lines used to interconnect the modules of various microprocessors, such as the Z80 and Motorola 68000. Physically it is a backplane that the modules plug into. The Multibus crate is capable of supporting twenty address lines, sixteen bi-directional data lines, and eight parallel interrupt lines, as well as bus control signals, data control signals, and power distribution lines.

Multipactoring:
An electron multiplication phenomenon observed in RF cavities when the fields between nearby metal surfaces is such that an electron originating on one surface can cross to the other surface in exactly one-half period of the RF. These electron beams can destroy parts of the cavities if not suppressed. Fortunately, there is a relatively narrow voltage range where multipactoring can occur, so the voltage can be stepped through this region rapidly.

Multiplex:
A system where one output channel can be selected from among many input channels.

Multiplexing:
A means of transmitting several independent signals over the same transmission line by separating them in time or frequency.

Multiplicity (special usage):
The number of particles produced from a single collision.

Multiturn Injection:
A technique of introducing beam into a circular accelerator over a time greater than the circulation period of the beam by moving the equilibrium orbit at the injection point so that the injected beam just misses the injection septum at the end of its first turn.

Multiwire:
A device consisting of many (~24) thin wires stretched across an opening in a paddle. This paddle can be rotated into the beam and each wire will produce an output signal proportional to the number of particles it intercepts. These signals are plotted by a computer to create a beam profile.

Muon:
A charged elementary particle having a mass about 207 times that of the electron. It decays into an electron and two neutrinos.

MUX:
A Multiplexor is a device that receives inputs from a number of sources but outputs only the one selected by the user.

MV:
Manual Valve.

-N-

Narrowband Train:
One of the target train systems in the Neutrino Area. It provides a momentum selected dichromatic neutrino beam (neutrinos of mainly two energies) and is compatible with operation of the muon beam N-1. "Narrowband" refers to the peaking of the neutrino beam intensity at two energies as opposed to a neutrino beam composed of a wide range of energies ("broadband").

NBP:
This stand for Normal (atmospheric) Boiling Point, a fluid temperature.

NIST Clock:
National Bureau of Standards Clock. There are two of these clocks in the MCR. One of these arrives via a WWV signal broadcast from Boulder, Colorado. The other is transmitted via satellite.

NEC:
National Electric Code.

NEPA:
National Environmental Policy Act.

NETPROCESS:
NETwork Process. Another name for ACNET. It is a process on the VAX that manages communications between nodes.

Neutral Current:
The first evidence of neutral current interactions was the observation absence of a charged muon in the final state of the reaction $\nu_\mu + p \rightarrow \nu_\mu$ + Hadron in that no muon appears in the final state. The theoretical necessity of neutral currents emerged as a result of the attempts to renormalize the theory of weak interactions so as to cure its divergence at high energies.

Neutrino:
This is an electrically neutral particle of very small mass. Neutrinos and antineutrinos can penetrate the earth without appreciable attenuation. Three types of neutrinos exist, one associated with electrons, another associated with muons, and a third the tau neutrino. It is currently believed that neutrinos interact only by the weak force.

Neutron:
An elementary particle with no charge and a rest mass slightly greater than the proton rest mass. The neutron is a spin 1/2 Fermion. It is one of the basic constituents of the atomic nucleus. A free neutron decays with a half-life of 12 minutes into a proton, an electron, and a neutrino (beta-decay).

NFPA:
National Fire Protection Agency.

NIM:
Nuclear Instrumentation Module. It is standard crate equipment, with a defined protocol, for some devices in the accelerator. "Half-high" NIM crates are used in the MCR and Pre- Acc control room. Other NIM crates are used in the MIRF building. The "half-high" crates in the MCR do not communicate with each other.

NIMBIN:
A rack mounting receptacle for electronic instrumentation modules standardized according to the NIM (Nuclear Instrumentation Module) system. It uses standardized rear connectors and serves a similar function to a CAMAC crate., but provides only power, not communication.

NMR probe:
A Nuclear Magnetic Resonance probe used to accurately monitor magnetic fields.

NO Q:
An error code generated when a GAS-speaking module, such as an 080 or 170 card, fails to "return Q", that is part of the communications protocol. No Q indicated data is not yet available for reading.

NO X:
An error code generated when a CAMAC module fails to acknowledge its function codes. It can mean that the user is trying to address a nonexistent module or that an incorrect address is being used or the module is busted.

Node:
A processing point in a network of computers.

Nominal:
The desired A/D value of a device, as defined by the user. For alarm purposes there is also a defined tolerance, or min/max value that brackets the nominal value.

Notch Filter:
Notch filters as used in the Stack Tail Δp/p cooling system act to suppress signals at frequencies that correspond to harmonics of the revolution frequency of the $\bar{p}$s in the core. If the stack tail momentum system is allowed to act on the core, beam heating results (not good). Notch filters also assist in shaping the gain vs. momentum (frequency) in the stack tail. I think this means that the filters help to provide the correct gain to the stack tail cooling kicker electrodes as a function of where particles are in the stack radially, that corresponds to the momentum of the particles.

*Notcher:
A notcher creates an empty space, a “notch,” in the beam. Booster uses this notch to extract beam to other machines.

NTF:
Neutron Therapy Facility is a medical facility investigating the treatment of malignant tumors with neutrons. Neutrons for the facility are generated by steering 66 MeV H- ions from the Linac into a beryllium target. The facility consists basically of the neutron beam line, a treatment enclosure with patient positioning apparatus, a few offices, patient preparation rooms, etc.

NTF Beam Control Module:
The module in the NTF control room that actually initiates beam when two switches on the front panel are pressed simultaneously.

NTF Interface Module:
Modules located at RF systems 3 and 4 that sense the time of the RFON pulse. The module at system 4 will send an RF4 INHIBIT to the NTF interlock module if the RFON pulse at system 4 does not shift at the proper time.

NTF Interlock Module:
Also known as the Gannon box. This is the locus of all the NTF interlocks. The logic for producing an NTF enable is contained in this unit, which then sends the enable to the prom module. The interlock module also drives the status modules in the NTF control room and the MCR.

NTF Status Module:
Module that shows the status of the NTF interlocks, generated by the NTF interlock module. The module in the MCR has key switches and toggle switches that are themselves part of the interlock chain. The module in the NTF control room has status only.

NTP:
This refers to Normal Temperature and Pressure, 70˚F and 14.696 psia.

Notes:

-O-

O-ring:
A vacuum seal of circular cross-section, usually made of Neoprene, that provides a seal between two parallel surfaces. It usually rests in a machined "O-ring groove" in one of the surfaces.

Object:
Optical term referring to one focus of a dipole magnet.

Octupole:
A magnet with eight pole faces used for correcting dipole magnetic field errors.

OddMod:
This refers to accelerator statistics gathering hardware. Feeds the statistics data to the VAX. If handshaking is interrupted, i.e. VAX dies, then OddMod continues to collect data. The Datalogger on the other hand is a program resident in the VAX. When the VAX dies, it dies and no statistics are gathered. OddMod was designed as a way to avoid the interruption of data gathering. The module was designed by Todd Johnson and was originally called the Todd Module. A parameter involving TOD MOD was made called T:ODDMOD. Eventually the name permutated to OddMod.

ODH:
Oxygen Deficiency Hazard. In areas where the cryogenic system is used a cryogen leak can displace Oxygen creating a hazard to personnel. This necessitates the implementation of special safety procedures and Oxygen monitoring equipment for working in designated ODH areas.

Off Tube:
One of two Linac Thyratrons that control the operation of a 750 keV chopper. After the on tube fires, the off tube fires to ground one side of a series capacitor and draw one of the chopper plates from ground to a negative potential. Can be used with other pulsed power supplies.

Operational VAX:
The VAX 11/785 in the computer room designated for operational use. This computer acts as the central node for the ACNET system. It handles the database and alarm reporting, and retains the applications programs to be written onto the console disks when necessary. Either VAX1 or VAX2 may serve as the operational one if the proper connections are made. Currently, VAX3 may not be configured to be the OPER VAX.

OPERATOR (Account):
An account on the operational VAX that allows operators to perform certain rebooting tasks and other functions on the ACNET system.

Optical Isolator:
An element in an electrical circuit that converts a signal to a light pulse at one point in the circuit and then back again in another in order to isolate the grounds of each part of the circuit from each other.

OPTO22:
This is the brand name of a device that converts a binary signal to a light pulse.

Orbump:
This is a pulsed magnet system in the injection section of the Booster. It moves the injected H- beam from the 400 MeV line and the circulating proton beam in Booster so that they overlap and pass through the stripping foil. This allows the Booster to accept and stack up to thirteen complete turns.

Orifice:
This is the mouth or aperture of a tube or cavity. From a cryogenic system standpoint, there are flow orifices (see Flow Orifice) and limiting orifices.

Ortho Hydrogen:
The product of normal hydrogen liquefaction. Not in equilibrium at liquid temperatures. Characterized by "Ortho" (↑↑) electron spins. Often referred to as "noral" hydrogen.

Oscilloscope:
An electronic instrument for displaying on a fluorescent screen waveforms from electrical signals.

OSHA:
Occupational Safety and Health Administration.

Overcurrent Trip:
With this trip the power supply turns off in response to drawing too much current.

Outgassing:
When a beam line or device is under vacuum, any oils or moisture in the device has a lower vapor pressure and evaporates. This is known as outgassing and spoils vacuum making it difficult for the device in question to pump down to operating vacuum levels. For this reason it is necessary to ensure that vacuum devices are exceptionally clean on the inside before they are used.

-P-

$\bar{p}$ (Pbar):
The symbol for antiproton. p is physicists' shorthand for a proton. A bar atop a symbol denotes that particle's anti- counterpart. $\bar{p}$ therefore is representative of an antiproton.

PA:
1. Primary Application in the ACNET environment.
2. Power Amplifier.

PA Crowbar:
Linac RF system trip that occurs when the modulator current is greater than 600 amps during the RF pulse or 125 amps between pulses. A PA crowbar fires the permanent inhibit, shorts the capacitor bank to ground through the Ignitron, and resets automatically after 30 seconds.

Pagoda:
The Pagoda was once the main control room for the Proton Area. It was built in a shape inspired by an oriental pagoda. The Pagoda is no longer used. The basement area underneath still has a power supplies and control diagnostic racks, but the Proton experimental area no longer receives beam from Switchyard.

Pair Production:
The conversion of a photon into an electron and positron when the photon traverses a strong electric field such as that surrounding a nucleus or an electron. Pair production is one of three distinct processes that a photon can effect the emission of an electron from matter; the other two processes being the photoelectric effect and the Compton effect.

Para Hydrogen:
The equilibrium condition at liquid hydrogen temperatures. Not in equilibrium at ambient temperatures. Characterized by “Para” electron spins.

Parallel data:
In terms of data transmission it means that all bits of a character or byte are transmitted simultaneously. This requires a multiconductor cable or bus with each conductor carrying a single bit. A 16 bit word requires a 16 conductor cable for transmission.

Parameter page:
Any of a number of pages with a standard format listing devices on the ACNET system. The device mnemonics, descriptor texts, D/A settings, and A/D readbacks appear on the screen when the page is first called; MADC voltages, HEX values or MIN/MAX tolerances may be substituted for the A/D readbacks by using the touch panel.

Paraphasing:

The bunches coming out of Linac do not have the same RF frequency as the Booster RF cavities. When the 201 MHz Linac bunch enters the Booster, the RF cavities are on, but out of phase with each other by 180 degrees. Since they are out of phase, the particles see no effect. Eventually, the 201 MHz structure dissipates and the particles nearly become a DC line of charge. The Booster cavities slowly come into phase and form the 37.8MHz bunches.

Parasitic:
Any activity being carried out that is not the top priority at that time. Parasitic activities are supposed to be carried out with minimal interference to the top priority activity.

Parsing:
A squeeze is made up of 24 steps. During each step numerous things occur. When a squeeze is being parsed, each step is played out one step at a time. This allows a person to take measurement and analyze what is happening.

Particle:
A small piece of matter. An elementary particle is a fundamental constituent of matter. Quarks and leptons now appear to be the only elementary particles but the term is often used in referring to any of the subnuclear particles.

Parton:
Obsolete term for hypothetical point like constituents of nucleons (protons and neutrons). Partons have since proved to be quark particles.

Pbar:
Fermilab slang for antiproton. Used most often in conjunction with the Antiproton Source.

Pbar Target:
see Target.

Pbar Shot:
The injection of antiprotons from the Accumulator into the Main Injector and on into the Tevatron in preparation for colliding beams operation.

Pbar Stack:
see Stack.

PDP 11:
A computer once manufactured by Digital Equipment Corporation with 20K of memory. PDP stood for Programmable Data Processor.

Peaking Strip:
An instrument used for magnetic field measurements. It measures the voltage pulse induced in a coil surrounding a sample of magnetic material when the direction of the magnetization is reversed.

Pearlite:
A finely divided powder used to insulate when vacuum failure is a serious consideration or the super insulation costs cannot be justified.

Penetrations Key:
This is a key that opens the lock on penetrations that lead into tunnel where beam travels. Most often implies the Key to the LINAC penetrations.

Periodic Interrupt:
This is a software term used to describe an aspect of program execution timing. For example, all of the console computer processors have a 15 Hz interrupt that signals the APM, and hence the applications program, to execute some section of code at this rate.

Permanent Inhibit:
Linac RF system trip caused by four successive mod blocks in a row. A permanent inhibit shuts off the modulator pulse and shuts down the high-voltage power supply for the capacitor bank.

Phase Advance:
A measure of the stage of the betatron oscillation at some point around the accelerator, usually denoted by the Greek letter psi (ϕ).

Phase Comparator Mixer:
An element of the low-level RF systems that looks at the relative phases of two RF signals and produces a signal proportional to the difference in phase.

Phase Diagram:
Phase diagrams indicate the boundaries between the solid liquid and or gas phases of a material for a given pressure or temperature.

Phase Lock Input:
Output of a Linac phase comparator mixer that looks at the desired RF phase and the cavity RF phase. This signal is raised by 5 volts to produce phase lock output.

Phase Lock Output:
Signal proportional to the difference between the desired RF phase and the cavity RF phase, used to drive a phase shifter that compensates for shifts in cavity RF phase due to beam loading.

Phase Reversal:
This is a method of encoding data on a clock where the shifting from one level to the other is shifted in phase for a number of cycles.

Phase Space:
A six-dimensional space consisting of a particle's position (x, y, and z) and divergence (x-prime, y-prime, and z-prime). Phase space is generally represented in two dimensions by plotting position on the horizontal axis and the corresponding divergence on the vertical axis.

Phase Space:
Phase space is an abstract space having a dimensionality equal to six times the number of particles in a system. A system point whose components are vectors of the particles represents the state of a system. The acceptance of an accelerator is simply the volume in phase space comprising the coordinates and momenta of all particles that will not be lost in the course of subsequent acceleration.

Phase Stability:
Phase stability enables particles to be accelerated to their final energy. The voltage waveform for the accelerating electric field is sinusoidal. Particles in an accelerator do not advance side by side but are spread along a line. Therefore if the front end of the line reaches the accelerating gap when the voltage is at its maximum all later particles experience less voltage and thus less acceleration. Consequently the line lengthens and ultimately many of the particles are decelerated because they arrive at the gap when the electric field is directed in the opposite way. If the phase ϕ of a synchronous particle (frequency of RF = frequency of revolution) is within certain limits then the accelerating voltage can accelerate particles that enter the gap with ϕ $\Delta\phi$ thus giving stability. However, if ϕ is outside these limits the RF gets "out of step" with the particles preventing acceleration to the desired full energy.

Photomultiplier:
An electronic tube that generates an electrical current roughly proportional to the light intensity impinging on the tube. Photomultiplier tubes typically measure the small light signals generated by a charged particle passing through a scintillator or Cerenkov counter.

Photon:
A quantum (bundle) of electromagnetic radiation. Its energy is proportional to its frequency, and it has a spin of 1 (is a boson).

Pickup Loop:
In Linac a small (1/8" square) loop at the end of a coaxial cable that is driven by the RF cavity magnetic field to produce a signal proportional to the electric field in the cavity.

Piezoelectric Crystal:
A symmetric crystal that bends when an electric potential is applied to it (or vice versa). Used in the Preacc ion sources to regulate the gas flow into the source. A piezoelectric crystal is also the heart of a crystal oscillator, such as the master oscillator.

Pig Gauge:
This term refers to a Penning gauge, Phillips gauge, or cold cathode gauge, all of which work on the same principle. Electrons are produced by a cold cathode and accelerated toward a high voltage anode, ionizing gas molecules. The ionization current is measured and converted to a pressure readout. A type of ion gauge used to measure vacuum and control valves in the 400 MeV area.

Pion:

A Pi-Meson is a strongly interacting elementary particle of spin 0 having a rest mass roughly 270 times that of the electron. It exists in neutral, positive, and negative charged states.

PIOR:
Programmed Input/Output Retrieval. PIOR is standard hardware for receiving data from links around the accelerator, including console communication, Tevatron links, and QXR.

PIOX:
Programmed Input/Output Transmission. PIOX is standard hardware for transmitting data over CAMAC links in the accelerator.

Pirani Gauge:
This gauge operates on the principle of thermal conductivity. Gas molecules conduct heat away from a hot filament. The temperature change causes a resistance change that translates to a pressure change. Pirani gauges work in a range from 2 torr to 10^{-3} torr.

Pit:
A large temperature and humidity controlled room containing the Haefely high-voltage transformers, voltage multiplier, Preaccelerator dome, column, and motor-generator for the Preaccelerator.

Pixel:
This is a picture element. A point on a TV or monitor screen; the smallest unit used to construct characters or images.

Plasma:
This is a high-temperature mixture of ionized atoms and electrons.

Plateau (to Plateau Counters):
The process of optimizing the efficiency of particle counters versus acceptable levels of noise, multiple counts, or voltage. Generally the efficiency of a counter is plotted versus applied voltage and the rapidly rising curve flattens out (plateaus) at some value where noise, etc. is still acceptable. Generally one will try to run counters well into the plateau region if other considerations permit because their efficiency is less subject to change from small changes in the applied voltage.

PLC:
Programmable Logic Controller. This is a device used to automate monitoring and control of cryo systems and other industrial equipment.

PLD:
Program LoaDer. A managing program on the console computers that works in conjunction with CPLD (Central Program Loader) to download applications programs from the VAX. It also

monitors the cache of the 300 most used applications programs on that console and verifies that the most recent version of each program is being used.

Polarity Check:
Procedure used to insure a magnet will have the desired polarity when powered. Checking the polarity of magnets by measuring the magnetic field with a Hall Probe is one way to accomplish this.

Polarization:
The preferential alignment of the spin of a particle along a particular axis in space defined e.g. by the electric or magnetic field direction, or the momentum vector of the particle itself.

Positron:
Refers to the antiparticle of the electron. It has the same mass as the electron but opposite (positive) electrical charge.

Post Coupler:
A copper stem with a tab on the end that is used to control the relative field levels in two adjacent cells in a Linac RF cavity.
Power Glitch:
A power glitch is an interruption of electrical power lasting only a fraction of a second.

Power On Access:
Entry into an enclosure in which devices are energized. Because of the lack of electrical insulation in some of these areas electrical hazards exist that require special safety procedures.

Power Supply Program:
A series of computerized commands that tell a power supply what waveform to produce throughout a given cycle.

PPE:
Personal Protective Equipment.

Preacc:
See Preaccelerator.

Preaccelerator:
Generally refers to all the hardware associated with the production of 750 keV H- ions, including the source itself and the Haefely power supply. The general layout is of the Cockcroft-Walton type.

Predet Timer Board:
A hardware box that delays a timing event by a predetermined amount. Predets are set manually by switches on the front of the box. They can be thought of as hardwired alternatives to the CAMAC 177 modules. They are used in the Preacc for triggering devices in the domes and in the Linac, as well as in the MCR as delays for scope triggers.

Prepulse:
Event on the booster clock that commands the 400 MeV, booster, and 8 GeV pulsed devices to fire in preparation for a beam pulse. Linac beam is not allowed on prepulses.
Pressure:
The force exerted per unit area. The units are pounds per square inch absolute (psia), pounds per square inch differential (psid), or pounds per sq. inch gage (psig). see Atmosphere.
Primary Applications (PA):
Applications programs that allow interaction with a console user.

Primary Collimator:
The first collimator after the beryllium target used to produce neutrons for NTF. The primary collimator is made of steel and is of fixed geometry.

Primary Critical Device:
The principle device that determines whether or not beam will enter a certain enclosure. Critical devices are controlled by the safety system, as well as through the control system. The primary critical device for the Linac is the beam stop in the 750 keV line. The secondary critical device for the Linac is the gate valve.

Printed Circuit Board:
An insulating surface containing a circuit made by depositing conductive materials in continuous paths from terminal to terminal. Soldering components to these terminals makes complex electronic circuits.

Production Angle:
The angle between a targeted primary beam and a secondary beam is called the production angle.

Prom Module:
Logic module in the Preacc control room that looks at the various beam enable inputs and decides that, if any, will produce a beam pulse. The prom module also selects the chop width to be sent to the choppers.

Prompt Muon:
(see Direct Muon)

Property Index (PI):
A secondary address pointer in the VAX database that associates the device index of a parameter with a property. Properties include such things as names, text, alarm limits, basic control, etc.

Proportional Wire Chamber (PWC):
A PWC is made up of fine parallel wires. The wires serving as anodes are located parallel to a cathode of foil or wires. The voltage and pressure of the gas in the chamber can be adjusted so that ions, liberated by passage of a charged particle, are accelerated to sufficient velocity to produce fresh ionization by collision, a phenomena known as gas multiplication. The output

voltage pulse generated when the electron avalanche reaches the anode is then proportional to the initial ionization.

Proton:
An elementary particle that is the positive unit charged constituent of ordinary matter. Its mass is 938 MeV and has a spin of 1/2. Protons are one of the particles constituting all nuclei. It is currently believed that protons do not decay although experiments are going on to prove that they do have a half life of approximately 10^{30} years. It is believed that most of the matter in the universe is in the form of protons.

Pull down menu:
A boxed set of options available upon interrupting. Used especially for copy options on a parameter page.

Pulse Interlock Module:
A Linac component in the modulator pulse-forming circuitry that will inhibit the modulator pulse if conditions warrant.

Pulse Shifter:
Module in the Preacc control room that will delay the reset pulse to the sources by 1 msec if no beam is desired in the Linac. Controlled by the prom module, safety system status, and vacuum valve status.

Pulse Shifter Status Module:
Module in the MCR that shows the Linac pulse shifter status and can reset a pulse over count if one occurs.

Pulse Train:
A sequence of electronic pulses generated by a device. The number of pulses is interpreted as a numerical value. In the Laboratory it usually represents analog information from a device such as a SEM or loss monitor that is converted into a stream of pulses that are counted by scalers.

Pulsed Devices:
A pulsed device as it relates to accelerator beam line components is one that is triggered to come on at a preset time or event. The pulsed device is powered from a large power reservoir such as a capacitor bank. When the trigger is received the power reservoir dumps its energy into the device. The energy in the device then decays off naturally. The advantage of a pulsed device is that a high level of power can be put through a small device in a short period of time. Some typical pulsed devices are kickers, magnetic septa, and electrostatic deflectors. The pulsed trims in Switchyard for steering fast beam around the electrostatic splitting septa are also pulsed devices.

Purge:
A purge consists of using a gas (usually Nitrogen) to flow through and protect a system while it is in open air to prevent either air or particles from entering it until it is re-sealed. Argonne is used while welding to prevent contamination (aka: sugar coating).

PV:
Pneumatically operated Valve.

PVT:
PVT stands for Pressure, Volume, and Temperature, the fundamental variables of the state of a pure fluid at equilibrium. Any two of the three variables may be specified. The third is then a unique value for a given fluid except where two or more phases coexist in that case the pressure is a unique function of the temperature but the volumes of the phases differ.

Notes:

-Q-

QA:
Quality Assurance.

QBS:
Quench Bypass Switch. System that bypasses the ring current around a quenched magnet cell. It is controlled by the QPM.

QPM:
The Quench Protection Monitor microprocessor system monitors superconducting magnets for a quench condition. In the event of a quench it takes action to protect the magnet system by firing the HFUs, pulling the Dump and Bypass loops, dropping the TECAR ramp, etc. It is sometimes called Quench Protection Mess.

Quad Enclosures:
Three underground enclosures in the Proton- West beam line containing a system of magnets and collimators designed to reduce the halo that accompanies the primary proton beam.

Quadrupole:
A magnet having four poles that serves to focus the proton beam in one plane. A focusing quadrupole serves to focus in the horizontal plane while a defocusing one focuses in the vertical plane.

Quadrupole Steering:
The bending of a particle beam by a quadrupole caused by the beam passing through it off-axis.

Quadrupole Triplet:
A series of three quadrupoles of alternating polarity that produces a net focusing of the beam in both planes. Typically the two outer elements of a triplet are wired in series.

Quark:
Any of a group of six elementary particles having electric charges of a magnitude one-third or two-thirds that of the electron, regarded as constituents of all hadrons. (A fractionally charged particle hypothesized by Gell-Mann and Zweig to explain Hadron structure. The quark theory has proved to be a very successful mathematical model. Physicists at Fermilab discovered the top quark on March 2, 1995.)

Quench:
When the superconductor magnet quenches the material passes from the superconducting state to a normal resistive state. In the Tevatron this process is potentially damaging to the magnets. The Niobium alloy superconductor in the Tevatron that is now a normal resistive conductor heats up very quickly due to the extremely high currents passing through the magnets (4400 amps). Typically only one small piece of the superconductor is the first to quench and the heating of this one spot causes it to expand in volume quickly in relation to the surrounding colder material.

Thermal stress induced by this sudden expansion can cause the magnet to break. For this reason very elaborate Quench Protection Monitor (QPM) systems electronically monitor the superconducting state of the TeV magnets. If a quench is detected beam is aborted and Heater Firing Units (HFU) are discharged to evenly heat the entire magnet. The magnet must then be cooled down to superconducting temperatures again before current can be passed through.

QXR:
A Quadrupole eXtraction Regulator is the system that controls the rate of extraction from the MI. It is composed of a microprocessor system that controls special air core quadrupoles in the MI.

QXR Link:
The link that transmits the programmed waveform to the Quad Extraction Regulator crates. It originates at the QXR microprocessor in the MAC room.

-R-

Rack In/Out:
Connecting/Disconnecting power to a power supply (or its transformer) via its manual disconnect switch. For the operations group the term also means to go to the Master Substation to connect/disconnect the Main Injector and Tevatron feeders.

RAD:
This acronym stands for Radiation Absorbed Dose. It is a measurement of radiation dosage and is the amount of radiation required to deposit 100 ergs of energy per gram of any substance.

Radial position:
Position of a particle or particles in the horizontal plane relative to the center of the beam pipe.

Radian:
This refers to a measure of angle. 360 degrees = 2π radians. The radian measure of an angle is given geometrically by the ratio arc length/radius of the arc of a circle with the angle defined at its center and subtending the arc.

Radiation:
Heat transfer by emission. It is unaffected by insulating vacuum. It varies as DT^4.

Radiation:
Emitted energy in the form of electromagnetic waves (photons) or ionizing particles (electrons, alpha particles or nuclei).

Radiation Baffles:
An inactive set of shields designed to reduce the effects of cryogenic radiation.

Radiation Length:
The average energy loss due to Bremsstrahlung for an electron of energy E is related to the radiation length:

$$-(dE/dx)_{\text{brems}} \doteq E/X_0 ,$$

and the probability for an electron pair to be created by a high-energy photon is 7/9 X_0. A radiation length is defined as the thickness required to reduce the mean energy of an electron beam by a factor of $e^{2.178}$.

Radiation Shield:
An active (cooled) shield designed to intercept cryogenic radiation. Often cooled by LN_2.

Radio Frequency:
In comparison with other electromagnetic waves or oscillations, radio frequencies are low frequencies (10^3 - 10^{10} Hz). The frequency of the accelerating electric field falls in the range of radio frequencies and RF in an accelerator refers to this accelerating field.

Ramp:
This means to excite a magnet with a time dependent excitation current. A time varying excitation current for a magnet used either to track changing beam energy or to reduce average power dissipation by reducing the excitation when the magnetic field is not required. At Fermilab, the Main Injector and Tevatron bending magnetic field varies with the energy of the accelerating protons in order to confine them within the beam pipe.

Ramp Enable:
A permit sent to the NTF 58 degree magnet power supply telling it that it may ramp. The ramp enable comes from the NTF interlock module.

Range:
A charged particle traversing a medium loses energy in collisions with atomic electrons. The range is the distance the charged particle travels before coming to rest in the medium. A measurement of the range may be used to give the energy of the incident particle.

Reboot:
To restart a computer by using the "bootstrap loader" to retrieve the correct program from a peripheral device, e.g., disk. See Boot.

Reference Source:
Part of the monitor/control module in the Preacc Haefely control system that produces a command voltage for the power supply in response to computer commands or local input.

Refrigeration:
The extraction of heat at lower than ambient temperature.

Regeneration:
A neutral kaon beam consists of two states, K_L ("K-long") and K_S ("K-short") particles. The K_S component decays rapidly, but can be "regenerated" when the remaining K_L component is retargeted.

Regulator/Oscillator Module:
Module in the Preacc Haefely control system that receives the digitized command and monitor voltages from the monitor/control module and uses them to generate a drive signal for the power amplifier. The regulator/oscillator also receives an input that represents the high-voltage transformer output and uses it for regulation.

Relief Valve:
Relief valves have two uses: pressure relief and thermal relief. The first is for pressure relief. The valve is set to open at the Maximum Working Pressure (MWP) + 10% of the system. The second is for thermal relief. The valve is set to open at a pressure conveniently above the system working pressure but below MWP to provide for cryogen expansion. The Frig building relief valves on the rooftops are an example of the first usage. The Kautzky valves in the tunnels are an example of the second.

REM:
This means Roentgen Equivalent for Man, which is a measurement of radiation dosage. It is the amount of radiation required to deposit 1 Joule of energy per kilogram (i.e., 100 ergs/gm) of body tissue. REM = (Quality Factor)x(RAD) Q.F. depends upon substance.

Remnant field:
The field remaining in the magnet after its excitation current has been removed. It is particularly important in ring magnets at injection, where the remnant field contributes a larger percentage of the field at injection; this causes field errors that must be compensated for during the injection process.

Repeater:
A module that receives information from a link and retransmits it to points further downstream.

Resistive wall effect:
As beam intensity is increased in a synchrotron, image currents flowing in the walls are increased, attracting the beam at high betatron oscillation points thus enhancing the betatron oscillations toward an unstable state.

Resolution:
The optical definition of resolution is the minimum separation of two objects so that they appear distinct and separate.

Resonance:
The term resonance is usually used to mean "betatron resonance" when talking about an accelerator. It occurs when some perturbing force in the accelerator distorts the orbit in a periodic way, causing the betatron oscillations to grow larger and larger, until beam is lost or perhaps extracted.

Resonance:
A phenomenon of AC circuits where they exhibit relatively large currents at certain frequencies.

Resonant Circuit:
see Tuned Circuit.

RETDAT:
RETurns DATa. A program present on all front-ends that receives request lists for data from consoles and organizes those lists to be sent out to the appropriate CAMAC crates in the field.

Retraction spring:
A small piece of spring-wire used to retract broken septum wires and keep them from shorting the cathode to ground.

Reverse Power:
The RF power from an amplifier that is reflected back by the load. The power not reflected back is the forward power. The sum of the two represents the total power of the amplifier. In RF station tuning, the reverse power between stages is always tuned for a minimum.

RF:
Radio Frequency. It is the type of electromagnetic energy used in acceleration systems. See Radio frequency.
RF Bucket:
That area in RF phase where particles oscillate about the synchronous phase angle. Particles in an RF bucket will normally remain in the bucket. Particles outside the bucket will not be accelerated.

RF Cavity:
An electrically resonant standing-wave cavity designed to impart energy to particles as they pass through a gap or number of gaps in the cavity by virtue of the electric field gradient across the gap(s).

RF Defocusing:
Phenomenon caused by the curved fields in the gap between drift tubes and the changing electric field strength that results in radial defocusing of the beam as it is accelerated between drift tubes.

RF EAST VME:
This is a controller that handles the digital control of Booster stations 1-8 in the East Gallery. Digital control means such things as turning stations or anode supplies on and off, etc.

RF Phase Adjust Module:
This is a Linac module in the low-level RF system that adjusts the phase of the input RF from the master oscillator under the direction of the local secondary microcomputer. This adjustment controls the intertank phase.

RF WEST VME:
This is a controller that handles the digital control of Booster stations 9-18 in the West Gallery. Digital control means such things as turning stations or anode supplies on and off, etc.

RF Gap Envelope:
RF Gap Envelope. RF abbreviation. This is the RF voltage that is present on the gaps of the cavity beam tube that accelerate the beam. There are two gap monitors on each cavity and are referred to as upstream and downstream. They both read the same gap voltage and should present readings that are within 2% accuracy.

Rigging:
The heavy material or instrumentation of an accelerator experiment must be moved into or rigged into a certain location. This usually requires a crane and a special crew referred to as riggers.

Ripple:
This is the oscillation about the desired output value of a power supply. It's an AC component or a periodic fluctuation of a direct current or voltage and is generally the result of inadequate filtering of the voltage produced by an AC source. May sometimes be loosely used to indicate any type of noisy output.

Roentgen, "R":
Measurement of radiation dosage caused by X-rays and gamma radiation. It is the amount of radiation required to deposit 97 ergs of energy per gram of air.

Roughing:
The first stage of vacuum pumping. It generally ranges from atmospheric pressure down to a few microns (one micron is 0.001 mm of mercury).

Roughing Pump:
A rotating-vane pump used in the initial stage of vacuum pumpdown, good down to about 10^{-3} torr.

RSO:
Radiation Safety Officer.

RSS:
This stands for the Radiation Safety System and is the Logic system for a particular enclosure that controls the primary and secondary critical devices for that area. Inputs to the RSS include the status of the gates leading to the enclosure, the emergency switches in the enclosure, and whether or not the enclosure has been secured.

Rupture Disc:
A vacuum device that functions as a relief point for unexpected positive pressure in the beam tube. Pressure pushes the thin diaphragm against three blades, letting the vacuum up to atmosphere in an emergency, thus preserving bellows and other delicate equipment. Also known as Burst Diaphragm.

Notes:

-S-

Safety lead:
Connection from the Tevatron main magnet bus to the QBSs. They are found at each spool piece downstream of a defocusing quadrupole.

Sample and hold:
This is a circuit, used throughout the accelerator, that upon command records the value (analog or digital) of a device in a buffer and holds this value until it receives a command to reset its buffer.

Sample time:
The time, unique to each accelerator subsystem, when data is loaded into buffers for use by the MCR or sampled by the front-end computers.

Saturation (loss monitor):
A loss monitor readback that has exceeded its maximum of 10.23 volts. At this point further losses do not result in a larger readback.

Saturation (of a magnet or of iron):
A magnet is said to be showing saturation when its field no longer rises linearly with the excitation current. The term properly applies to the steel of the magnetic core in that the permeability falls from a large value at low excitation to a value approaching that of vacuum at high excitation when all the magnetic domains are aligned with the field.

Save file:
This term generally refers to a filesharing file containing some type of data or information related to accelerator operation. These files are generally temporary. The purpose of these files is to record current operating conditions so that they may be hopefully duplicated at a later date.

SBD:
Sample Bunch Display – This is a scope that is used to measure the bunch and then send information to a computer.

Scaler:
An instrument used for counting electrical pulses and displaying the result in digitized form. Scalers may be used to display beam intensities. In NTF a Scaler is a hardwired device in the NTF control room that acts to terminate patient exposure in case the beamline μP fails to do so at the proper point. The scaler contains counters and timers not associated with the control system and inputs directly to the NTF interlock module. Scalers are also used by the Tevatron QPMs to measure VFC frequencies.

Scaling:
The conversion of MADC voltages into engineering units that humans can understand. Scaling factors for the devices in the ACNET system are kept in the database.

Schottky (pickup, signal, bands):
Schottky pickups are beam detectors, like BPMs, that are tuned to be sensitive to the revolution frequency of the circulating beam as well as the revolution frequency harmonics. If the signal from a Schottky pickup is looked at via a spectrum analyzer, the momentum spread and tunes can be measured by looking at the width of the Schottky bands and by looking at the amplitude of the revolution harmonic sidebands.

SCR:
This stands for Silicon Controlled Rectifier, which is also called a thyristor. A semiconductor rectifier whose forward anode-cathode current is controlled by a signal applied to a third electrode. The SCR will latch when forward biased. Widely used in power supplies throughout the laboratory.

SCR (Save/Compare/Restore):
A program that reads the current value of D/A settings, A/D readbacks, nominal values and alarm states and loads this information into a semipermanent buffer residing in the VAX. The program, currently found on page D1, can also read the saved values and display them on the console TV, load them back into the devices, or compare differences between two save files.

SDA:
Sequenced Data Acquisition. Used to gather data about a shot from start of shot set up to end of low beta squeeze.

Search and secure:
The method of searching an accelerator enclosure in a logical fashion and resetting safety system interlocks to ensure that no personnel are in the enclosure before turning on power supplies and sending beam through that enclosure.

Secondary Applications (SA):
An operating program where console control has been relinquished.

Secondary Particles:
Those particles that are produced by hitting a target with the primary proton beam from the accelerator.

Segmented Wire Ion Chamber (SWIC):
A SWIC resembles a wire spark chamber consisting of three parallel wire planes. A plane of horizontal signal wires, a high voltage plane, and a plane of vertical signal wires. The wires are connected to an integrating and scanning circuit capable of holding, scanning, and dumping the ionization current collected by the wire when the proton beam passes through the device. Its purpose is to give a profile of the beam.

SEM (grid):
This is an acronym for Secondary Emission Monitor. SEMs are diagnostic devices used to measure beam position in the Antiproton source transport lines. They are close relatives of

multiwires as found in the 750 keV, 400 MeV, and 8 GeV lines as well as Switchyard SWICs. The grids crossed x,y 10 micron titanium strips with either 1.5 or 3.0 mm grid spacing. The electronics includes modified up-based SWIC scanners as used in the fixed target experimental areas.

Separator
These Tevatron devices have positively and negatively charged plates that attract the antiprotons and protons, keeping them out of each other's way. At the interaction points, the experiments, there are special separators that reverse the attraction and causes the two particle beams to collide.

Separatrix:
In a phase space diagram, the boundary that divides the stable beam region from the unstable beam region.

Septum:
There are several types of septa (plural of septum). One deflects beam from its normal path. A magnetic or electrostatic septum deflects charged particles along one of two paths. Typically, a solid metal sheet or plane of wires separates a region with and electric or magnetic field from a region of no field. Beam entering the first region is deflected while beam entering the second region is not. There are other septa that split the proton beam into two beams. It consists of a chamber bisected by a row of fine wires. On one or both sides of the wires there exists an electrostatic field(s) that serves to separate the two beams.

Serial:
Data transmitted one bit at a time. Many of the links at Fermilab are serial links. Normally this data must be reconstructed into a parallel format before a computer can use it.

Series SCR:
The SCR that bypasses Tevatron current around the dump resistor except under ramp dump conditions.

Set Point:
In the context of feedback systems it is the nominal value toward that the system strives. In a controls context it is the D/A value of any parameter when an applications program is entered.

SETDAT:
A program present on all of the front-ends that organizes lists of D/A setting values before they are sent to the hardware.

Sextupole:
This is a magnet with six pole faces. Sextupoles compensate for the dipole magnet edge effect and control beam chromaticity.

Shift Plot:
This refers to the plot done at the end of each shift and posted in the elog. The plot is an indication of overall productivity of the accelerator. For fixed target mode TeV accelerated

intensity is plotted over the duration of the shift. For collider mode luminosity and the pbar stack are plotted. Any downtime is also indicated on the shift plot.

Shift Save:
A methodical saving of pertinent accelerator parameters, RF curves and ramped devices. The save is done according to a checklist once every 24 hours during accelerator operation. In the event of a failure of the accelerator, the last running conditions can be recalled from the shift save to restore the accelerator to running condition.

Short Sample Limit:
This is the figure of merit for a superconducting magnet. It is the highest field possible just before the critical magnetic field of the superconducting wire is exceeded. 1.

Shot:
see Pbar Shot.

Shunt Impedance:
Technically, it is an impedance in parallel with an electrical circuit. In this application, the ratio of the square of the electric field strength on the axis of an RF cavity to the power dissipated per meter of length.

Shunt SCR:
The SCR that bypasses a Tevatron power supply from the circuit in the event of a ramp dump or fast bypass.

Shuttered Kicker:
Kicker magnets are used to put the injected antiprotons from the Debuncher onto the Accumulator injection orbit and to kick out bunches of $\bar{p}$s from the Accumulator towards the Main Injector. Since there is almost always circulating beam in the Accumulator during stacking or unstacking operations, a magnetic shield, or shutter, is placed between the circulating beam and the beam to be kicked, thereby shielding the circulating particles from the effects of the kickers. These shutters are physically moved out of the beam once the kicker pulse is completed. The use of these kickers would be impossible were it not for the use of high dispersion regions that permit radial separation of the circulating beam as a function of momentum. Both the injection and extraction kickers are located in straight section 20.

Sibling:
This refers to a device that is logically or sequentially related to other devices: for example, two parameters that relate to different tables in the same ramp card.

SIDO:
This was an old term for a SIlicon DOrk that is no longer used. Generally used as a friendly derision for any person that is extremely knowledgeable about computers and computer systems. SIDOs consider it a point of honor to be known by such a title. Such knowledge extends way beyond that gained from everyday work usage or study. There are many computer professionals

that work with computers every day that do not qualify for SIDO status. The level of computer edification needed to qualify someone as a SIDO can only be had by those who posses a passionate interest that borders on the fanatical in anything to do with computers. SIDOs appear as true wizards able to do things that others thought difficult or impossible to accomplish. SIDOs willingly and often spend all hours of the night exploring new systems and devices, communicating among themselves in a language totally foreign to anyone who is not a SIDO.

Silicon Controlled Rectifier:
A rectifier having the ability to begin conducting at an arbitrary phase of an AC current cycle. A normal rectifier conducts for 180˚ of phase (Zener diodes excepted). An SCR conducts only after it has received a firing pulse, then continues to conduct until the polarity changes, so one can selectively chose to conduct on any phase ϕ, such that $0 < \phi < 180^{\circ}$.

Skew correction element:
This is an n-pole correction element that is rotated by an angle of 180/n degrees. Note that in this scheme, a vertical dipole is actually a skew horizontal dipole.

Skew dipole:
Dipole magnet rotated from the horizontal plane by some fraction of 90 degrees so that it bends the beam both horizontally and vertically.

Slow spill:
This refers to the resonant extraction of beam from an accelerator over a period of at least several seconds.

Smart module:
A relative term used to designate a module that can do some amount of internal data processing or error checking. All of the microprocessors, such as the, BPMs, QPMs, and Refrigerators, can do this, as well as many smaller units such as 080, 160, and 165 cards, etc.

Smeds Module:
Module in the MCR built by Jim Smedinghoff (Smeds) that allows computer enabling of 15 Hz beam for use by the Linac steering program (L36).

Snapshot:
In general terms, this refers to data taken at some specific time over a small time interval. The data obtained may or may not be representative of events over a longer time interval. A specific use is the Beam Position Monitor (BPM) data averaged over a number of turns and stored in a circular buffer. Another important use is for diagnosis of problems; for example, when the ramp trips a snapshot of the voltage-to-ground is taken and may be placed in a circular buffer to be analyzed at a later time.

Soft Ground Stick:
This stick is connected to ground through a bleeder resistor and is used to discharge a device that might be at high potential and might contain stored energy.

Software:
The programs, routines, etc. for use in a digital computer, as distinguished from the physical components (hardware) of the computer.

Space Charge:
A radially defocusing force caused by mutual electrostatic repulsion between protons within an accelerator.

Spark Chamber:
An instrument for recording the position of ionizing particles. A visible electrical discharge (spark) occurs at a point where a charged particle traverses a small gap between oppositely charged plates or wires. Spark chamber data may be collected photographically (optical spark chamber) or electrically (wire spark chamber). Many charged gaps are sometimes used. The charged particle trajectory may be traced by the sequence of sparks created through such a multi-gap system.

Spark Gap:
Electrodes found on the Haefely voltage multiplier and the accelerating column that will arc in the event of a voltage imbalance and thus prevent an arc from occurring in expensive/inaccessible components.

Specific Heat:
Heat capacity per unit mass per unit temperature change (J/g˚K):

$$C_p=\Delta H/\Delta T,\ C_v=\Delta U/\Delta T$$

Spectrometer:
This is a system for determining the momentum of a particle, usually by measuring its curvature in a magnetic field. The 40˚ bending magnet in the Linac momentum analysis line comprises a magnetic spectrometer. Particles with different momenta will follow different paths through the magnet and will appear in different positions at the scanning wire.

Spike:
An undesired intense portion of the spill.

Spill:
This refers to beam extracted from the Main Injector. Using resonant extraction, the beam "spills" out of the machine a little at a time. Spill also refers to the time structure of the extraction beam. This is of particular interest to those experiments that are often limited by problems of "accidental coincidences" and equipment dead time.

Spill Duty Factor:
The spill duty factor is a quantitative measure of the quality of the beam being extracted from the accelerator. The spill duty factor is given the range 0% - 100% and measures 1) The amount of time extracted beam is on divided by the maximum time it could be on and 2) The uniformity of the instantaneous intensities over the length of the flattop.

Spill structure:
This refers to the regularity or lack thereof of spill intensity over time.

Split:
The split of split ratio is the amount of beam going to a particular external experimental area divided by the amount of extracted beam, usually given as a percentage. It also refers to the septa, and bump magnets that control this ratio, i.e., a splitting station.
Splitting station:
Place where a single incoming proton beam is split into two or more beams. The primary elements of a splitting station are septa and lambertsons.

Spool piece:
The device that contains the Tevatron correction element coils.

Spot size:
The transverse size of the proton beam at a given point. It is usually referred to at a target.

SSDN:
Sub-System Device Number. Each database entry in a given subsystem (e.g. Linac, Tevatron, etc.) has a unique number assigned to it. This number is used by the front-ends and describes characteristics such as module type, location, etc. The format of these numbers is different between front-ends and different for each property of a device.

SSO:
Senior Safety Officer.

Stack:
The antiprotons are stored in the pbar Accumulator storage ring. Fermilab produces antiprotons by bombarding the antiproton target with protons, sweeping the antiprotons into the circulating accumulator antiproton beam, and then stochastically cooling them. This process is called stacking. The antiprotons collected in this manner are collectively called the stack. The amount of antiprotons stored in the stack are measured in milliamps.

Stack tail:
The least dense region of the $\bar{p}$ beam in the Accumulator. ARF1 and the stochastic cooling systems deposit beam onto the stack tail, specifically the Stack tail Δp system, which moves the $\bar{p}$s from the tail towards the core. The particle density of the stack increases in an approximately exponential fashion from the stack tail to the core.

Stacking (RF & momentum):
Stacking refers to successive pulses of antiprotons being combined into one beam in the Accumulator. This is accomplished by first moving an injected pulse of $\bar{p}$s from the injection orbit to the edge of the stack tail by means of RF deceleration (ARF1). The beam is then pushed towards the core by the stack tail momentum cooling system.

Stage:
To write (or cache) an applications program onto the console disk from the VAX, where it may be easily retrieved.
Stainless Steel:
18% NiCr steel with low conductivity, nonmagnetic, and good cryogenic material properties. Typical cryogenic types are 304, 304L, and 316, all low carbon.

Stem-Box Cover:
A cover over the tops of the Linac drift tube stems that protrude from the top of a Linac RF cavity. The Stem box cover may be evacuated to prevent vacuum leaks around the stems.

Stepping motor:
This is a motor that rotates a small specific amount in response to an encoded bit of information. It allows beam-line elements to be moved precise distances.

Stochastic
A designed process in which a sequence of values is drawn from a corresponding sequence of jointly distributed random variables—a random process.

Stochastic Cooling:
Stochastic cooling is a technique used in the antiproton source to reduce the beam size to make room in the Accumulator for the number of antiprotons required for collisions with high luminosities. Several hours are required to collect the needed antiprotons and increase the density of the beam in order to achieve the desired luminosity. Stochastic cooling works through a series of beam pickups, electronics, trunk lines and kicker electrodes. Consider the case of an individual $\bar{p}$. The particle passes through a pickup and some position is detected. Depending on the location of the pickup in the lattice, the position can be translated into a transverse or momentum error. The signal from the pickup is massaged electronically and transported across the ring to more electronics that serve to insure that the error signal derived at the pickup arrives at the kicker just as the p□- arrives at the kicker (at the correct amplitude and phase to correct the error). Real time feedback. The actual process is slightly more complicated, both in practice and due to the fact that more than one particle comprises the beam.

Stopband:
This refers to the vertical and horizontal tune values where field errors can cause beam blow up in an accelerator. These stop bands have a definite width, so that the beam reaches resonance as the offending tune value is approached. Widening the half-integer stop band produces resonant slow extraction.

Storage Ring:
A storage ring is a ring of magnets capable of storing particles for periods of up to many hours. The Accumulator and Recycle are storage rings. The Tevatron is also considered a storage ring during colliding physics.

Store:

A colliding set of protons and antiprotons in the Tevatron. To inject circulating beam into an accelerator and keep it there for long periods of time while the collider detector experiments take data. In the antiproton source, it means that an antiproton stack is established.

STP:
Standard Temperature and Pressure (STP) is defined as 0 degrees Celsius and 1 atmosphere of pressure. STP is used in many thermodynamic calculations and tabulations. Certain properties of matter such as density, viscosity, boiling point etc. will vary with changes in temperature or pressure. Having one common set of conditions ("state") for tabulating these values makes comparisons possible and eases calculations.

Straggling:
Because of the statistical nature of the collisions of charged particles with atomic electrons, the range of the charged particles is not unique, but is actually a mean value R. Fluctuations about R is called straggling.

Strangeness:
A property (quantum number) of elementary particles found useful to classify hyperons into families. Strangeness is conserved in reactions involving the strong interaction. The selection rules resulting from strangeness conservation are very important in explaining why some reactions take place much more slowly than others. In quark models, the strangeness quantum member is carried exclusively by the "strange quark", and Hadron exhibiting nonzero strangeness contains this quark as a constituent.

Streamer Chamber:
A streamer chamber is a wide-gap chamber that records a three-dimensional image of a particle trajectory. An electron avalanche develops along the trail of ions, as in a narrow gap chamber, but because of a short pulse duration, this is arrested at an early stage, so the "track" appears as a row of short streamers extending typically a few millimeters. If the plate electrodes are transparent, the streamers may be viewed along the field and then appear as a series of dots similar to a track in a bubble chamber.

Strong Focusing:
A system for focusing charged particles in that the particles pass alternately through non-uniform electric or magnetic fields having gradients of opposite sign. Strong focusing is employed in the Fermilab Tevatron , Main Injector, and Booster where quadrupole magnets of alternating signs provide the focusing for the circulating protons.

Subcooled:
The temperature difference between a liquid temperature and the (greater) equilibrium vapor pressure temperature.

Subcooler:
A device to subcool liquid. Accomplished by providing heat exchange to a bath of significantly reduced pressure, equilibrium liquid. Often from the same source.

Sublimation (pump):
Sputter ion pumps as found in the Main Injector and Recycler are not sufficient to achieve the ultra high vacuum needed in the Accumulator ring ($3X10^{-10}$ T), so titanium sublimation pumps are also employed. Sublimation pumps are a form of retainment pump. Retainment pumps operate by capturing gas molecules and retaining them on a surface. The $\bar{p}$ source uses Titanium sublimation pumps: a titanium filament is heated so as to cause the titanium to sublime and deposit on the nearby walls as a thin film. This fresh layer of titanium acts as a getter, passing gas molecules react with the Ti and are captured on the surface. Periodically a fresh film must be deposited. This is known as 'sublimating'.

Super Critical:
Pressures, Temperatures, or both above the critical point parameters.

Super Heat:
The difference between a gas temperature and the lower equilibrium vapor pressure temperature.

Super Heater:
A device specifically designed to provide some degree of super heat. see Vaporizer.

Super Insulation:
Multiple reflective layers of aluminized Mylar to reduce cryogenic radiation heat transfer.

Superbucket:
A superbucket is an R.F. bunch in the extracted beam containing a substantially larger number of particles than the average R.F. bunch. A superbucket arises when the accelerated beam undergoes oscillations that do not affect all bunches equally; typically there is a periodicity of every 3^{rd} or every 7^{th} bunch over a train of thousands or millions of bunches. The term is to some extent a misnomer because "bucket" applies only within the accelerator whereas the effect is most talked about as observed in the experimental area.

Superconducting:
Having no resistive component to electrical impedance.

Superconducting Magnet:
This is a magnet whose coils are made from superconducting material. Superconducting magnets reach much higher magnetic fields than conventional iron/copper magnets at a much lower electrical power cost. They must be cooled to 4K, which is achieved by a continual flow of liquid helium through the magnets.

Superconducting Transition Temperature:
This is the critical temperature below which a substance loses its electrical resistance and thus becomes a superconductor.

Superconducting Wire:

Wire made from materials that become superconducting at low temperatures and are thus able to carry very high currents without losses. Niobium-Titanium is a popular superconducting material that is used in the magnets for the Tevatron at Fermilab.

Superconductivity:
This is a state of matter that many metals and alloys reach at sufficiently low temperatures (i.e. a few K). This state is characterized by the total absence of electrical resistance thus making possible the conduction of electrical currents without any measurable loss. Kammerlingh Onnes in the Netherlands discovered superconductivity in 1911. He was the first person to liquefy helium and was thus able to reach the extreme cold necessary to observe superconducting effects in mercury.

Superconductor:
A superconductor is a substance that loses all electrical resistance when cooled to or below a critical temperature (typically 5-10 Kelvin).

Supercycle:
The supercycle time is the amount of time required to complete all the different machine cycles that have been defined to operate periodically as a unit. This implies that the supercycle time is periodic and that its length is dependent on the number and duration of different machine cycles defined to occur within its period. It is currently defined from page D69.

Supercycle reset:
This is the starting point for all of the sequences in a supercycle. It is initiated by TCLK event 00 and takes place automatically when the previous supercycle is complete.

Superperiod:
The large scale repetitive lattice of the Main injector and Tevatron accelerators that is made up of 14 normal cells, 1 long straight section cell, 1 medium straight, and 1 short straight section cell.

Superposition:
The principle of superposition states that the various wave trains that, in their totality, make up a wave may be considered as mutually independent. The properties of the combined waves can be computed as the sum (phase and amplitude) of the effects of elementary waves, treating the latter as if each were present alone.

SWIC:
Segmented Wire Ionization Chamber. It is a device used to determine beam profiles in the Switchyard and beam lines.

Switchyard:
An area that links the Main Injector to the External beamlines.

Switchyard Front End:

The computer that interfaces with the electronics that control and monitor Switchyard devices.

SWIX:
Signal SWitching MatrIX. A software controlled switch for signals to be put on an oscilloscope.

SY:
A common acronym meaning 'Switchyard'.

Synchrocyclotron:
The synchrocyclotron is a frequency modulated cyclotron that is capable of reaching higher energies by compensating for relativistic effects with a variable frequency accelerating voltage.
Synchronous Particle:
A particle that is at the synchronous phase angle with respect to the accelerating RF.

Synchronous Phase Angle:
That RF phase angle at which a particle will receive just enough energy in each cell to reach the next cell just as the RF goes through 360˚. The phase of the RF field needed to provide the proper accelerating voltage. The synchronous phase angle must be nonzero for acceleration to take place. The synchronous phase angle is zero at injection (provided there is not a phase error) and varied as the bend field in the magnets is increased to provide a positive accelerating voltage.

Synchrotron:
A circular machine that accelerates subatomic particles to high energy by radio frequency (RF) fields and constrained in a circular path of constant radius by a ring of electromagnets. The particles are made to move in constant circular orbits by magnetic forces that continually increase in magnitude. Fermilab's Booster accelerator, Main injector, and Tevatron are synchrotrons.

Synchrotron Frequency:
Frequency of longitudinal oscillations of the bunches.

Synchrotron Oscillation:
Synchrotron oscillation is the longitudinal oscillation of particles in an accelerator about an equilibrium of the phase of accelerating voltage at the time the particles are crossing the accelerating gap. The restoring force for the oscillation is provided by a property (phase focusing) of synchronous acceleration that out of time particles receive greater or less acceleration than the in time particles with the correct sense to reduce the time error on the next crossing of the accelerating gap. In synchrotrons like the Fermilab Booster and Main Injector, a particle makes many revolutions around the accelerator in a single synchrotron oscillation period.

Synchronous Particle:
The hypothetical particle circulating in phase with the RF voltage that other particles in the phase-space bucket would oscillate around.

Synchrotron Radiation:
Electromagnetic radiation generated by the acceleration of relativistic charged particles in a magnetic field. Synchrotron radiation is the major mechanism of energy loss in electron synchrotron accelerators.

SyncLite
This is an optical instrument used to measure the transverse profiles and positions of the proton and antiproton beams in the Tevatron by the synchrotron light emitted at the edge of a magnet.

System Ready:
Sum of the second-level interlocks in the NTF interlock module. Two such sums ("A" and "B") are required to be present in order to make up the next level of interlocks.

Notes:

-T-

Tachyon:
A hypothetical particle of imaginary mass whose velocity always exceeds the speed of light. Tachyons have never been observed.

Tagged Photon Lab:
This referred to an old experiment in the Proton-East beamline. Photons from the primary target make electron-positron pairs in a converter. The electrons are transported several hundred feet and then impinge on a thin sheet of lead in the Tagged Photon Lab. In passing through the lead, some of the electrons will be deflected, emitting a high-energy photon in approximately the forward direction. The energy of these photons is determined by measuring the energy of the deflected electrons, i.e., the photons are "tagged". The tagged photons are then used in experiments.

Tagging:
Tagging is a process that establishes the states of particles before they interact with a target. Information about these initial states combined with data on the final state enable the experimenter to study the details of a reaction.

Target:
Object intentionally struck by the proton beam in order to produce secondary particles that are then studied by experimenters.

Target, Pbar:
The pbar target is used to produce pbars for the Antiproton Source. Main Injector beam is accelerated to 120 GeV and strikes the target producing pbars. The pbar target is a stack of 1/2" high, 3" diameter disks encased in a titanium sheath to hold it together. The materials vary. Fermilab uses a nickel target. Heavy metals yield more pbars but tend to break up from thermal stress.

Target Tuning, Pbar:
The process of moving the position where Main Injector beam strikes the pbar target to maximize pbar production. Beam is steered by means of trim magnets in the AP1 line upstream from the target.

Target (station):
The real source in the Antiproton source. The major components of the target station include a system of collimators to minimize the beam halo followed by the target SEM and BPM's, then the production target itself, composed of stacked disks of target material such as Nickel and 'Heavymet', interspersed with cooling disks. The Lithium lens follows the target, then a pulsed 3˚ dipole magnet that bends negatively charged 8 GeV particles into the AP2 line, and finally a beam dump that absorbs any non-interacting 120 GeV protons and non 8 GeV, non negatively charged secondaries. The beam dump is similar in design to the MR/Tevatron abort beam dump. When 120 GeV protons strike the production target, that is designed to be of fairly high density

and able to withstand the repeated shock of a batch of 120 GeV protons striking it every 2-3 seconds, the protons interact with the atoms within the target material. A whole slew of particles are produced ranging in energy from 0 to 120 GeV. This shower of secondaries is contained within some solid angle that is a function of the incident beam spot size and the length of the target. Based on calculations, this shower contains some $\bar{p}$s (roughly $7X10^{-7}$/incident proton). These are the dreaded particles that ultimately wend their way into the Tevatron.

Target Box:
The targeting systems in Proton-East and Proton- Center are placed inside a steel box. Each box contains five sets of parallel rails. Components, that may be as simple as a block of steel or as complicated as a set of magnets, are mounted on steel plates (drawers) that slide along the rails on bearings.

Target Train:
A series of magnets, targets, collimators, and diagnostic equipment placed on small railroad flatcars. Temporary setups for one experiment can be built on one set of flatcars (train load) while beam is being delivered on another. There are target trains in the Meson and Neutrino Areas.

TBT (Turn-By-Turn):
A turn-by-turn display uses takes the data from one BPM and plots a point for each time the beam passes as it circles the TeV. It is used to find beam anomalies.

TCLK:
See clock, (Tevatron).

TCPort:
This is an application that runs in the background collecting ACNET device data and sending it to systems that are not ACNET based.

TECAR:
Tevatron Excitation Control And Regulation. The microprocessor system that sends phasing information to the Tevatron main power supplies and coordinates responses when a quench occurs.

Tesla:
The SI unit of magnetic flux density defined as one Weber per square meter. 10,000 Gauss equals one Tesla.

Terminal:
The point at that the operator interacts with the computer system. It usually consists of a keyboard and either a typewriter or TV screen.

Tetrode:
A thermionic emission tube with four electrodes: cathode, anode, grid, and screen.

TeV:
This refers to a Tera electron volt or 10^{12} electron volts. "T" is also conveniently the initial letter of trillion that in American terminology is 10^{12}.

Tevatron:
This is Fermilab's accelerator that increases the energy of the proton beam from 150 GeV to its final energy (~980 GeV).

Tevatron clock:
Is a 10 MHz encoded pulse train that carries the clock events for triggering the operation of accelerator electronics.

Tevatron Front End:
The computer that interfaces with the electronics that control and monitor Tevatron devices.

Thermal Conductivity:
K, The heat flow per unit length per unit temperature difference of a given material and temperature. Varies with the temperature range under consideration. (Wcm K)

Thermal Conductivity Integral:
The heat flow per unit length of a given material between two particular temperature end points.

Thermal Contraction:
The shrinkage for reductions in temperature, usually expressed as a dimensionless number x Δ Length/Length over a stated temperature range.
The coefficient of thermal contraction (a,Δl/l˚K) is a function of temperature.

Thermocouple gauge:
Used to measure vacuum pressure. This type of gauge utilizes a thermocouple to measure the temperature of a heated element exposed to the vacuum. It is typically used down to about $1E^{-3}$ torr.

Thyratron:
A Thyratron is a gas-filled triode where voltage on the grid can trigger ionization of the gas in the tube. Once the gas is ionized, current flows from cathode to anode until the potential across the two falls below a certain level. In Linac the Thyratrons are used as high-voltage relays in the chopper power supplies and in the RF modulators to trigger the Ignitrons. But their most common use is as a high current switch in kicker power supplies.

Tiger Team:
A U.S. Navy term for a highly specialized group with a special mission.

Time line generator:
The module that encodes accelerator reset events on the Tevatron clock.

TLG:

A Time Line Generator is a VME based system controlled from page D69. It's located in the MAC room.

Titanium Sublimation Pump (TSP):
A TSP consists of a titanium filament that periodically has a high current passed through it. This current causes the filament to reach the sublimation temperature of titanium and coats the surrounding chamber walls with a thin film of clean titanium. Since clean titanium is very reactive, the residual gas in the chamber that collides with the chamber wall form a stable, solid product attached to the wall and the gas pressure in the chamber is reduced.

TLM:
Total Loss Monitor. Any loss monitor that extends throughout an entire tunnel enclosure. TLMs give a good overall picture of losses in an area.

TM (010):
The transverse magnetic field configuration used in linear accelerators. This configuration has an axial electric field that is used to accelerate the particles.

TOF Measurement:
A time of flight (TOF) measurement takes advantage of the RF bunching in a beam to measure the time interval between a reference signal related to the production of particles in the target and the signal from detectors placed a known distance from the target. This method is frequently used to search for new particles.

Tolerance:
The amount that the readback of a device can deviate from the nominal value before going into an alarm state.

TOP:
This is an application program that "smoothes" the Tevatron beam orbit by making adjustments to the correction dipoles. The program has many other functions associated with controlling the beam position.

Toroid:
A device used to measure beam current in an accelerator; so named because it uses a toroidal winding on a core as a pickup.

Torr:
1. A practical unit of pressure equal to the amount of pressure required to support a column of mercury one millimeter high.
2. A unit of pressure: 1 torr = $1E^{3}$ microns = 1.3 E^{-3} atmospheres.

Trackball:
An encoder at the ACNET consoles that allows the user to change the (x,y) position of the cursor on the console's four monitors.

Training:
This is the process of successive excitations and quenches necessary to establish mechanical equilibrium within a superconducting magnet enabling it to approach the maximum field permitted for the superconductor employed. A magnet will train in 10 to 20 quenches to this limit (called the "short sample limit" because it depends on the intrinsic properties of the superconductor and can therefore be determined from a short sample of it). A poor magnet can take 100 quenches and bad magnets will never reach this limit. Good superconducting magnets, once trained, will remember their training even after long storage.

Transfer Hall:
This is a section of the TeV Ring that transfers 120 GeV beam from the Main Injector to the Switchyard.

Transfer Line:
A vacuum insulated, cryogenic radiation shielded, or concentric cryogenic pipe.

Transformer:
An electrical component consisting of two or more coils of wire placed in close proximity to each other such that the magnetic fields of each transformer overlap. Used to transfer electric energy from one alternating current circuit to one or more others. Often used to increase or decrease the voltage in the second circuit. A transformer is also used to physically isolate one circuit from another but still allow the transfer of AC power.

Transition:
Transition is the point in a synchrotron machine's cycle where all particles, regardless of their slight differences in momentum, take exactly the same amount of time to circle the machine. At this point the phase of the RF voltage with respect to the synchronous particle must be changed for the beam to remain stable. The machine's lattice determines where this energy occurs.

Transition Energy (Synchrotron):
This refers to the energy below the point where the particle rotation period decreases with increasing energy and above the point where the period increases with increasing energy. At this critical energy, a change in proton energy has no effect on the period. The RF electrical fields must be modified as the protons pass through the transition energy in order to assure stable acceleration to higher energies. The transition energy in the Fermilab Main Injector is about 19.5 GeV.

Transmission Line:
An electric line uniform in series resistance, series inductance, shunt inductance, and shunt capacitance. The transmission line from a PA to an RF cavity is coaxial in construction.

Transport Line:
A system of bending and focusing magnets used to transport beam from one area to another.

Trigger:

An experimenter sets up 'a priori criteria' for accepting data. Once these criteria are met, an electronic signal allows events to be recorded. Not all triggers are legitimate events, however, but are the raw data recorded for computer analysis.

Trim:
Small dipole magnet used for fine control of beam positions.

Triode:
A thermionic emission tube with three electrodes: cathode, anode, and grid.

Triple Point:
The triple-point temperature of a pure substance is a unique temperature at which the solid, liquid, and vapor phases coexist in thermal equilibrium.

Triplet:
A system of three quadrupoles of alternating polarity; it is used much like a doublet, but allows for coincidental focusing in the horizontal and vertical planes.

Triplet Train:
One of the target train systems in the Neutrino Area. It provides a broadband neutrino beam (a neutrino beam composed of a wide range of energies) using quadrupole focusing elements. The triplet train is compatible with operation of the muon beam N-1. "Triplet" refers to the three quadrupole magnet pairs used to focus the π and K particles produced at the target before they decay into the neutrinos and muons.

Trombone:
The trombone is another name for a variable delay line. It is a U-shaped device for adjusting the length of coaxial cables or transmission lines. Trombones are used in the stochastic cooling systems to provide the proper delay between the pickups and the kickers. Trombones can also be found in the Linac gallery basement in series with every RF system PA to cavity transmission line.

TSCC:
Tevatron Serial Crate Controller. It handles the serial to parallel conversion, and vice-versa, when information is being passed between the parallel CAMAC Dataway and a serial link.

TSS:
Technical Support Section.

Tune (v):
The number of betatron oscillations per revolution of the beam. There is a horizontal tune vx and a vertical tune vy. Its magnitude is primarily a function of quadrupole strengths. In operator parlance, tune is also used to mean the process of adjusting machine parameters to increase intensity or efficiency, or both.

Tune diagram:

A plot of vertical tune values versus horizontal tune values with stop bands shown as solid or dashed lines.

Tune of the Accelerator:
This is the number of betatron oscillations per Main Injector or Tevatron revolution.

Tuned Circuit:
A circuit that has its resistance, capacitance, and inductance adjusted so that it resonates at a certain frequency. (See Resonance.)

Tuner (R.F.):
An R.F. tuner is a variable reactance for changing the resonant frequency of an LC circuit or resonant cavity. As applied to the Fermilab Booster and Main Injector accelerating cavities, the tuner consists of ferrite rings coupled to the accelerating cavity and biased by a programmed D.C. current that flows in a toroidal winding around the rings to vary their magnetic permeability and hence their inductive loading of the cavity.

Tuning:
The activity of adjusting magnets and other equipment that interact with a beam of particles in order to obtain a beam of desired characteristics, e.g., a beam focused onto a target with a small spot size.

Tuning Slug:
Copper cylinders mounted in the wall of the Linac RF cavities that may be moved in and out to adjust cavity tune. Specifically, one motorized slug in each tank under the control of the low-level RF system.

Turbo molecular pump:
A vacuum pump. It uses rapidly rotating vanes (turbines) to impart a momentum component to gas molecules, compressing them and making them easier to pump with a roughing pump. Used in the second stage of vacuum pumpdown, and good down to about 10^{-9} torr. Ion pumps are used at operational pressures for the sake of economy and practicality.

Turnkey Account:
Also called captive account. An account that is open to any user. The password is publicly available information.

Turn-on order:
The order in which the Main Injector power supplies are phased on to ensure a minimal voltage to ground on the Main Injector bus.

TVBS:
Tevatron Beam Sync Clock. It is derived from a sub harmonic of the Tevatron RF frequency.

TWT:

Traveling Wave Tube. TWT's are the final amplifiers for the stochastic cooling kickers. The Debuncher tubes can be found in the tunnel above the Debuncher kicker tanks. Accumulator TWT's are enclosed either in racks in AP30 adjacent to the TWT power supplies or in the tunnel.

Notes:

-U-

Upstream:
This is a relative term indicating the direction opposite to the proton's normal direction.

URA:
University Research Association, Inc.

User:
High energy physics experimenter.

Notes:

-V-

Vacuum:
A vacuum refers to pressures below 1 atmosphere. The units are: inches of mercury ("Hg), millimeters (mm Hg), microns (μHg), and generally 10^{-N} (millimeters of mercury). See Insulating Vacuum.

Vacuum Window:
A vacuum window is a thin piece of metal in the path of a linear beam that separates one portion of the beam tube vacuum from another.

Vapor Pressure:
The pressure as a function of temperature of a liquid in equilibrium with its own vapor.

Vaporizer:
A device to cause a heat input for the sole purpose of delivering the heat of vaporization and changing liquid to the gas phase.

VAX:
VAX is an acronym for Virtual Address eXtension.

VAXAPM:
The VAX APplications Manager. A process on the Operational VAX that is somewhat analogous to the console APM.

VAXDPM:
The VAX Data Pool Manager. A process internal to the OPER and DEVL VAX that accesses the Datapool for applications programs on the VAX. It is identical in function to DPM on the consoles.

VCB:
Vacuum Circuit Breaker. It connects 13.8 kV to a Main Injector or Tevatron power supply. A loss of the Power Supply Permit loop will open the VCBs thus disconnecting the power supplies.

VCO:
Voltage Controlled Oscillator. It is used to produce the operating frequency for an RF system.

Vector:
A quantity possessing both magnitude and direction as distinguished from a scaler that has magnitude only. Common examples of vector quantities are velocity, force, displacement and electric field.

Velocity Meter, Linac (Griffon Detector)
This is a scope (a phase detector) in the MCR used to determine the energy level of the Linac. It is a diagnostic tool that shows a trace representing the energy level of the beam in the Linac and of the beam delivered to Booster.

Vernier Magnet:
Small dipole magnets in the external beam lines used for small corrections in beam positioning.

VFC:
Voltage to Frequency Converter. Device used to return cell voltages, power lead voltages, and voltage to ground to the QPM.

VME:
(VersaModule Eurocard bus) A 32-bit bus developed by Motorola, Signetics, Mostek and Thompson CSF. It is widely used in industrial, commercial and military applications with over 300 manufacturers of VMEbus products worldwide. VME64 is an expanded version that provides 64-bit data transfer and addressing.

Viscosity:
This is a measure of resistance to flow; some cryogenic fluids have amazingly low viscosity (g/cm sec).

VMS:
Virtual Memory System. The operating system for the VAXs used at Fermilab. Virtual systems allow programs requiring more physical memory than is actually available to be run (with degraded efficiency) by writing the surplus onto a disk.

VP Curve:
The plot of the gas liquid equilibrium in the PT plane. VP is an abbreviation for Vapor Pressure.

VPT:
Vapor Pressure Thermometer. Measures temperature below the critical point by the VP curve relationship. Note that it does not, in general, measure temperature to the critical point.

VSA
This is a Vector Signal Analyzer. It measures the longitudinal emittances. The longitudinal emittances must be below a certain size or it won't get captured in the RF bucket.

-W-

Watchdog:
A module that gives a permit for DC and RF gates in an RF high level system. Watchdogs monitor LCW temperatures, pressures, and conductivity, intermediate cylinder bias, etc. If faulted, the RF cavities are not allowed to be energized.

Water Heater:
Device that is used to tune the Tevatron RF cavities by varying the water temperature in them.

Water Resistor:
The water resistor is the plastic tubes, running from the Preaccelerator pit wall along the column and to the dome, which are used to control the potential drop among the column electrodes. The resistance of the tubes is controlled by LCW flowing through them. This resistance also has an effect on the current drawn by the Haefely power supply.

Waveform:
A current or voltage (electrical signal) considered as a function of time.

Waveform Generator/Sequencer:
A Linac module in the modulator pulse forming circuitry that generates RF system times in response to the RFON timing pulse. This module also forms the basic modulator waveform that is then passed to the amplitude control module.

Weak Focusing:
A system of focussing particles in a circular accelerator in which all of the focussing fields are the same sign. The system is weakly focussing because only very weak focussing fields can be used without making the beam oscillations (betatron oscillations) become unstable.

Wet Engine:
Cryogenic device that cools the helium by allowing it to do work against a piston. It is used to cool the primary helium flow to the magnets.

Wire scanner:
A single wire (in contrast to a multi-wire) that is stepped through a circulating beam; the signal it develops is read once per step by a computer and the readings are plotted to produce a beam profile.

Word:
A unit for storing integer data in the computer. In many computers, such as the PDPs and VAX's, it has a length of two bytes (sixteen bits) and is stored in two's complement representation. It may have a value in the range -32768 to +32767.

Work Function:
The difference in energy of the Fermi level of a solid and the energy of free space outside the solid. In this application, the amount of energy required to liberate an electron from a metal surface.

Working point:
The point or region on a tune diagram (vertical vs. horizontal tune) where an accelerator normally operates.

-X-

XBAR:
Crossbar. A kind of multiplexor for a number of channels that are hardware-selected. Crossbars are used extensively in the CATV system, and have applications in the Switchyard as well.

-Y-

Yield:
The yield is the number of secondary particles of the same type that are produced for a given number of primary particle, i.e., the yield for a certain target is 106 pions/1012 protons.

-Z-

ZOV:
A Zinc-Oxide Varistor is used for detecting voltage to ground spurts in Main Injector and Tevatron power supplies.

Notes: