Itinerary for HST 2003 [6th Draft]
CERN High Energy Accelerator Laboratory
Geneva, Switzerland
Linear and Centripetal Electromagnetic Accelerator Workshop

Notes:

- All participants will receive CD with associated files, schematics, diagrams, images, video clips and instructions for labs and measuring. In addition, they will receive hard copies in a notebook of selected presented materials and other associated electronic files on CD.
- At end of week participant's documentation of their work (spreadsheets, powerpoint, word documents, images and video clips) will be saved to original CD such that participants and others have records of what they've accomplished.
- All participants will be expected to complete each of the three labs over five days and produce individual projects they will take back to their schools. In other words, they may work in groups for facilitation, direction and guidance, but must produce, individually, each of the three accelerator experiments.
- Participants will use materials supplied for lab.

Monday, June 30-Friday, July 4, 2003 (1 hour on one of these days)

Short brief overview of next week's particle accelerator experiments. Phil and I will each spend 15-30 minutes explaining PPA's (portable particle accelerators) labs for next week.

Monday, July 7, 2003 (13:00-18:00)
Introduction to tabletop accelerators(15 min)
Introduction and overview of electronic measurements (30 min)
Introduction to computer probe ware for data analysis. (force, photogate, current, differential voltage, magnetic field sensors) (30 min)(will be longer on first day)

Objective: Design, Build and Test CO2 Linear Accelerator for particle collisions.

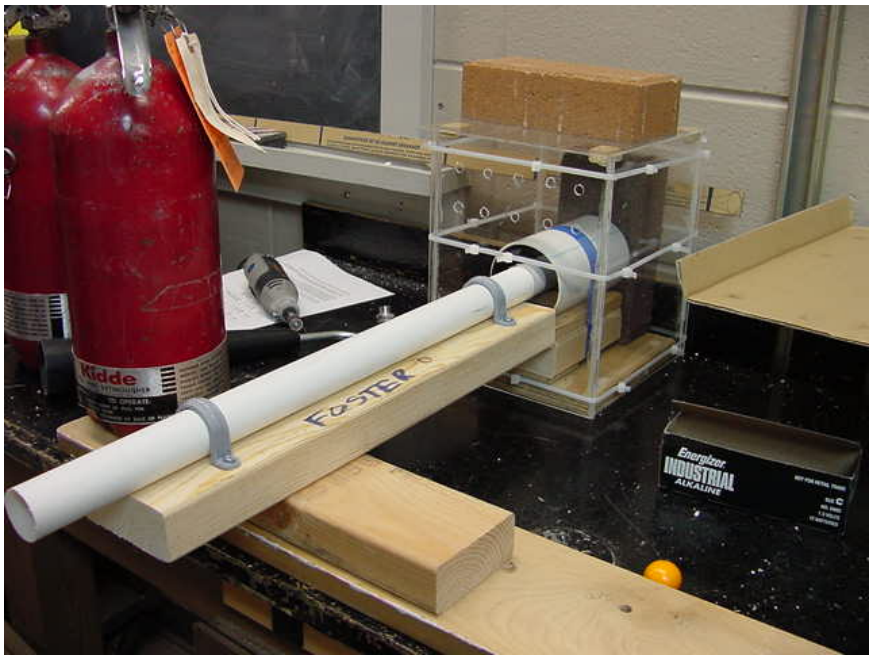
Duration: **1 Day or 6 hours**

Key words and components measured: linear accelerator, fixed target collision, proton and anti-proton collisions, velocity, force, acceleration, momentum, trajectory, acceleration, mass, tube length, compressed gas, clamps, PVC, Plexiglas, wood blocks, acrylic cement.

Description of Discussions: First day pre-lab discussions will include introduction to particle acceleration experiments and theory. We will discuss in detail an overview of electronic measurement using both digital/analog professional equipment ( )and sensors (force and photogates) and a very short description of labs they will be doing during this week and what our expectations are of them by Friday 7/11. More concentrated discussions and graphical displays on today's lab with the CO2 Linear Accelerator initial set up and its modifications.

Description of Lab: The objective of this one day laboratory is to provide secondary level teachers with a simple, low cost laboratory to emulate proton and anti-proton particle collisions on a much larger, visual context. Prior to commencement of lab, Discussions with group on how to integrate and correctly analyze professional electronic measurement devices and digital sensors from Vernier Software and Technology interfaced with PC's to obtain various types of measurements such as velocity, force, momentum, trajectory, acceleration, mass of particles, etc... It is important for them to interpret measurement data such that experiment can be modified to achieve more efficient results and so that participants are able to expose themselves to the process of information gathering with advanced digital and electronic equipment, analyzing this data and modifying experiment to achieve more desired results.

Participants will see schematics and explained theory of how this particular experiment relates to what is happening at CERN. Table top Compressed Carbon Dioxide (CO_2) Linear accelerators will be designed and manufactured during this 5.5 hour lab. Using Plexiglas or acrylic sheeting, a square will be constructed with several holes drilled into side to relieve pressure and a main hole for inserting a one inch inside diameter PVC pipe secured to a wood block. Spherical particles are injected through PVC opening and accelerated at a high rate of velocity, upwards in the range of 500 mph, into a fixed target and into another spherical particle (for proton/anti-proton collision) . Inside the Plexiglas box are sensors that collect various components of data mentioned above. Experiment is recorded, outside Plexiglas box, digitally in .avi or .mpeg and analyzed with sensors with the objective of recording initial results and modifying experimental design to achieve not only more efficient outcomes, but also change in variables examined and examination of particles "created" from resulting collision. Spreadsheets, created from each participant, will be used to collect results from experiment and changes to velocity, force, acceleration, momentum and trajectory as a function of changes in the experiment. Changes to the experiment include such variables as tube diameter and length, mass and size of ball, propulsion component, etc...



Tuesday, July 8, 2003 (13:00-18:00)
Electronics Computer probe-ware demo (radiation, surface temperature, rotary motion sensors.) (15 min)
Brief discussion on yesterdays lab and possible modifications that allow proton to be accelerated at greater speeds and with maximum force. Discussion on today's lab and objectives surrounding maximizing results of data collected.(15 min)

Objective: Design, Build and Test Centripetal Electromagnetic Accelerator using switch mechanisms.

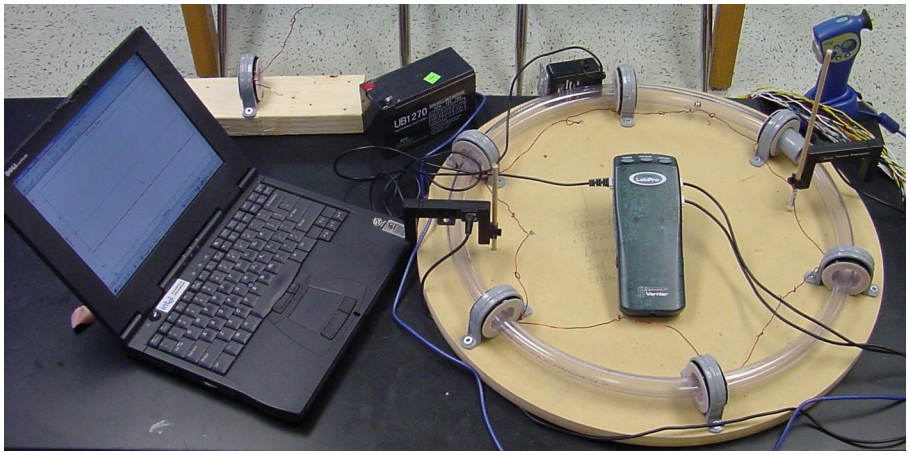
Duration: 1 day or 6 hours

Description of Discussions: Today's discussions include electronics for accelerators and demonstration of how these work to obtain precise measurement. Concentrated discussions on today's lab with theory, diagrams and graphics that include how to build a centripetal accelerator and possible modifications that will allow this device to reach maximum velocities.

Key words and components measured: solenoids, volts, ampere, current, magnetic field, radiation, electricity, differential voltage, force, acceleration, momentum, frictional coefficient, velocity, motion sensor, sound meter, photogates, switches, vinyl tubing, lexar tubing, plastic/metal clamps, 3 axis acceleration, temperature, steal bearings, battery, 12/24/36 Volt power sources, wire, alligator clamps, electrical tape, graphite, inner and outer tubes, diameter, flux, copper sheeting, wood screws.

Description of Lab: Participants will design, manufacture and test a centripetal electromagnetic accelerator used to accelerate particles around a clear, vinyl tube at varying rates of speed inter dispersed between tightly coiled solenoid magnets. This one day lab provides a visual description of that which occurs within the beam pipe that surrounds CERN and allows one to visualize particles accelerating around a circle. Multiple components of electricity, magnetism and acceleration are examined here. Participants will be shown schematic examples of models during pre-lab discussions. While the overall objective of this lab remains to accelerate the proton as fast as possible using a switch mechanism, it is also suggested that modifications to experimental velocity can be manipulated by adjustments to the following variables: tube diameter, proton diameter and mass, degree of voltage and ampere in power source, location of solenoids, #turns on solenoids, length and width of wire, manipulations to switch, temperature change to solenoid, etc...It is an objective of this lab to find which variables can be adjusted to allow for maximum speed of particle and to document data and changes to variables in spreadsheet to graphically represent how changes to variable affected outcome of particle velocity. Beginning with a round, medium density fiberboard (MDF), Participants will clamp six solenoid magnets at equal lengths around the board and feed vinyl tubing through each magnets core balancing the tubes with added additional inverted clamps between each magnet so as to allow for the proton to roll directly through the center of coil. A 12 volt power source connected to a switch and assortment of wires will be used to pulse each of the magnets with an aim of accelerating protons through

the coil. Other objectives of this lab will be, once accelerator is built, is to test and record on spreadsheets changes in velocity, acceleration, momentum, magnetic field, force as function of the above modifications. In addition, as a trigger switch is used to accelerate these protons, participants may find it beneficial to design and create another type of mechanical switch device that allows proton to move through the magnet automatically without human intervention



Wednesday, July 9, 2003 (8:30 -13:00)
Thursday, July 10, 2003 (13:00-18:00)
Friday, July 11, 2003 (8:30-13:00)
Introduction to Electronic Measurements :(1 hour)

Objective 1:
Help workshop participants become confidant in making electronic measurements using oscilloscopes, digital Multimeters, and frequency/counter meters.

Objective 2:
Build and Test a Linear Electromagnetic Accelerator from scratch. Following construction, there will be an electronic measurement lab to allow students to verify what they learned from objective 1.

Duration: 3 days or 16.5 hours

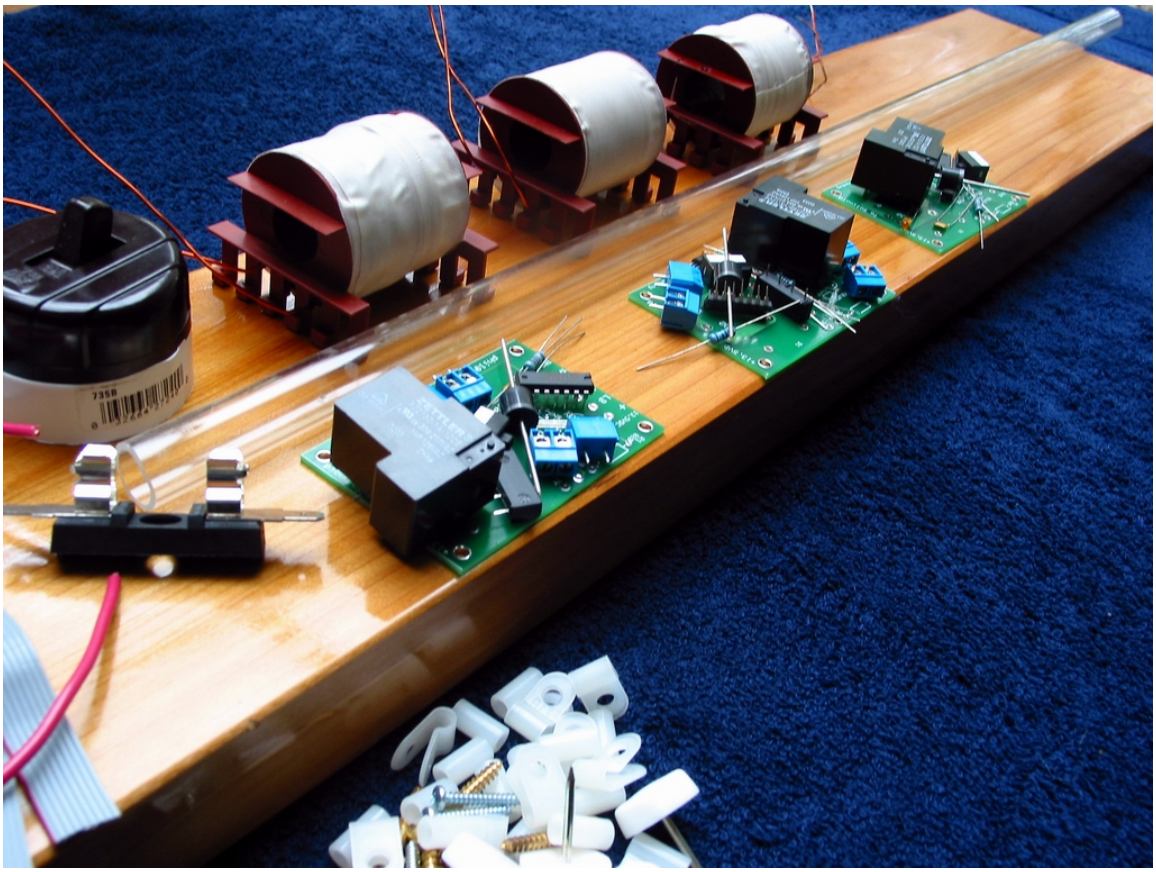
Description of Discussions:
The next three days will focus on hands-on activities. These activities include: Learning how to operate standard laboratory electronic measurement equipment i.e. Oscilloscope; Analog/Digital Multimeter; 2 channel Counter/Frequency Meter etc. which will address Objective 1. Objective 2 will be addressed by having students build a 2 or 3 stage linear accelerator from scratch. When completed, students will make electronic measurements using oscilloscopes, digital Multimeters, and frequency counters. Workshop participants will learn how to interpret data gathered from two test points designed into the pc boards.

Key words and components measured:
Discussions on electronic measurements will include: Bandwidth, Impedance matching, Time interval, Pulse width, Sampling rate, Rise time, Timebase, Gain, Peak, Average, RMS, Frequency, Period, and any other terms used to describe a particular measurement. There will also be detailed discussion on how to know what instrument to choose for a given need. Students will demonstrate understanding of discussions by making electronic measurements on an accelerator that they have constructed. The accelerator was designed to have electronic test points to help facilitate data collection and give meaning to the test conditions.

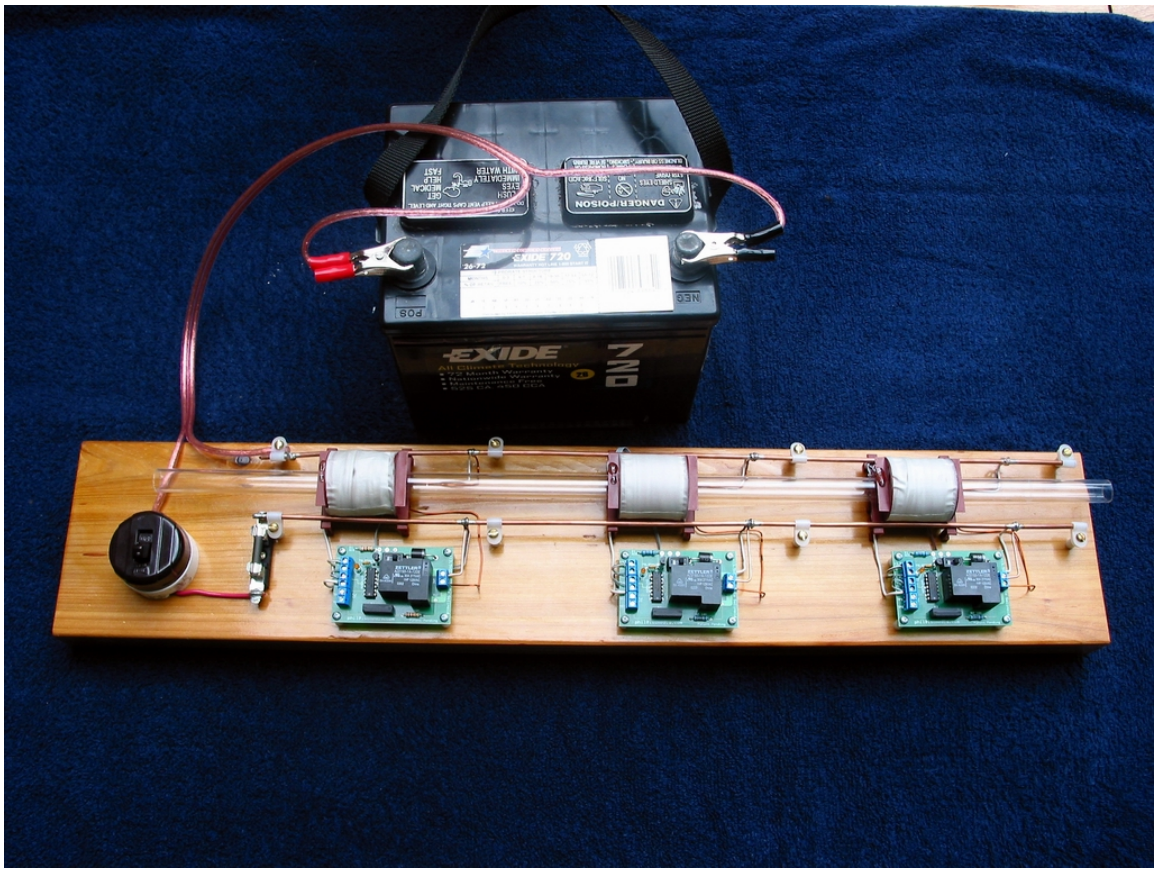
Discussions on construction details for the Linear Accelerator will include all information to make this a successful activity.

Description of Labs:
Labs will be preceded each day by a warming up discussion of the day's activities. There may be need for a break in lab time to explain or demonstrate new topics for continued lab activity. This is true for both Electronic Measurement & Accelerator construction labs.

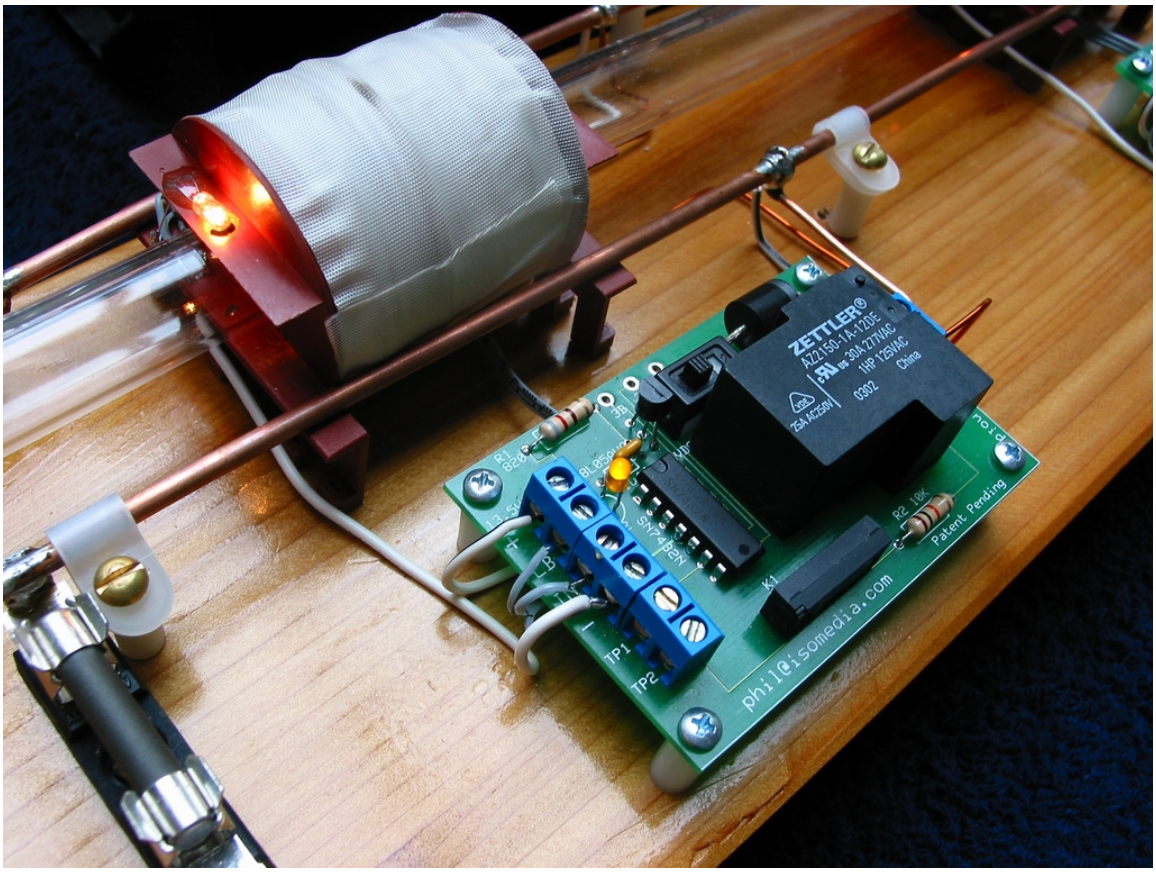
Below there are three pictures that best describes where and how the three days will be spent. Below each is a caption that describes the picture.



This is a picture of a pile of parts along with a 70cm long board that will, when constructed, turn into the next picture. It's estimated that construction can be completed in 8 to 10 man hours. Students will be required to solder components onto pc boards, wind a solenoid, and mount light sensors, drill holes and test electronic logic boards.



This is a picture of the finished product. The linear accelerator you see here is a three stage device, solenoid + logic control board, that when activated will sense the presents of a metallic steel ball and respond by applying approximately 15 amps of current to the solenoid. The ball gets pulled into the solenoid and is accelerated to the next station. Current is supplied by a car battery. Each logic board consist of: Logic chip (SN7432 Nor gate), and support components, 30 amp switching relay, ON/OFF control switch, 2 test points, 1 unused Nor gate access, and screw-down connectors. On the solenoids are mounted both the light source and an infrared sensing transistor. In this picture you will also see the main power switch, fuse, power cords and car battery.



Here is a close-up of the solenoid and its control board. The light source for the light gate and the LED, located on the pc board, is on showing that the system is actuated. The picture also shows the location of the two test points located on the pc board. This solenoid/logic board combination can be used for other physics experiment applications as well. Students will make time interval. Pulse width, voltage, rise time, time delay and frequency using the two test points. If measurement equipment allows, print outs of captured waveforms will be used to interpret data and add to students log book.

Monday, July 14, 2003 (13:00-18:00)
Tuesday, July 15, 2003 (13:00-18:00)
Project presentations: Participants can select a minimum of one of the three projects to present to group. Each person will have 45 minutes each to present and can present all three if they feel they can get this all into 30-45 min time frame.

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