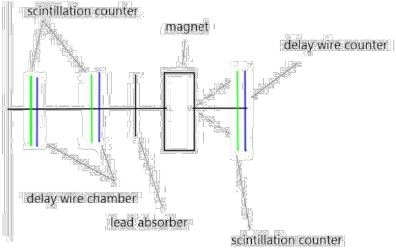
Measuring The Proton Beam Composition Of The T10 Beamline

Team Particular Perspective
Pakistan

Our Team

Initial Experimental Setup

- In the first setup, we used the scintillation counters, delay wire chambers, lead absorber, and magnet
- This scintillation counters and delay wire chamber(DWC) will count the total number of particles



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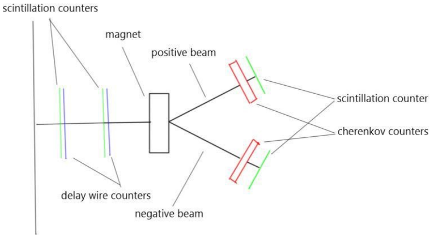
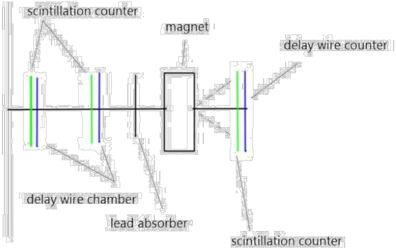


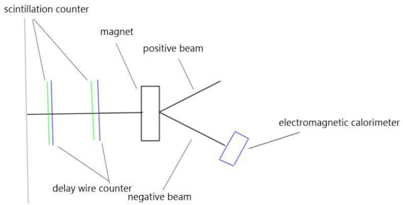
Initial Experimental Setup

- In this setup, we select the positive charged beam that emerges.
- We use the cherenkov and scintillation counters to then count the positive charged particles which we expect to be proton, pions, and kaons.
- We do the same for the other secondary beam to count for the negatively charged particles.



Initial Experimental Setup

- In the third setup, we use an electromagnetic calorimeter for the negative beam
- We calculate the energy of the electrons
- We use the momentum of the electrons and total energy of the electrons to find the redundant count of electrons.



Problems

1. Scattering Catastrophe

- In our initial proposal, the accelerated beam from the proton synchotron would strike the primary
- target and produce a secondary beam of particles,
- The particles in the secondary beam include: protons, pions, kaons, muons, electrons, and some
- anti-particlessuch as positrons and anti-protons in small amounts.
- The secondary beam would direct towards the lead filter and slow down the electrons.
- The other particles would retain their momentum
- However, the other particles would still undergo scattering
- This contradicted our initial assumption that there wouldn't be significant scattering

2. The Block Problem

- In setup 4, we attempted to measure the composition of the beam by isolating the positive and the negative beam.
- While the positive beam composition can be measured, difficulties occur in measuring the negative
- beam.
- Specificially, when we place the iron block to act as a muon filter, the interactions of the particles
- with the block produce new particles,
- We did not predict this phenomenon initially.

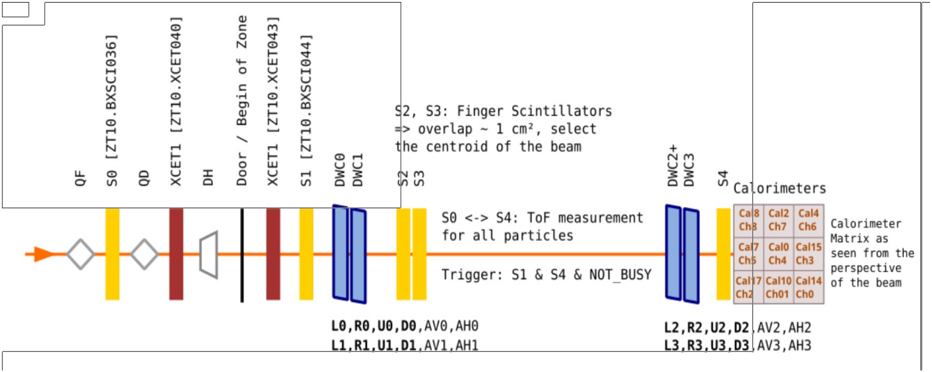
Problems

2. The Block Problem

- We faced difficulty in resolving the problem because the size of the filter is large.
- Thus, we can not place it where it was intended in setup 4
- The other issue is that if we place a scintillator before and after the filter,we could not measure the counts of the particles.
- This is because the filtering the actual setup would have to be placed very far back and early before the setups.

Progression At CERN

Updated Schematic



Progression At CERN

With the problems we discussed, we proceed to devise solutions appropriately to improve our experimental setups and results.

1. Finger Scintillation

- As we mentioned that the scattering of particles cause difficulty in obtaining the counts of the particles,.
- we change our setup by using two finger scintillation detectors in trigger
- it selects a small part of the beam and counts the particles only in coincidence which is set by the use of an AND gate.
- This allows us to take the count of the particles more accurately and becomes a suitable representative of the entire beam.

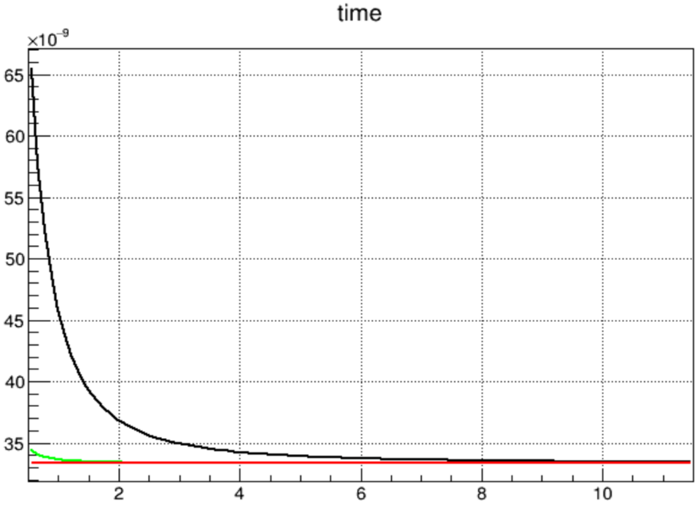
Progression At CERN

2. Time of Flight Measurements

- In our experiment, we change our setups by placing a scintillator at the start and a scintillator at the end, specifically S0 and S4.
- This allows us to calculate the time of flight of the particles
- This can be used to differentiate between the heavier particles like the proton and light particles like the electron at certain momentum, usually at a lower beam momentum like 0.5Gev to 3Gev.
- We developed a statistical relationship between the time of flight and momentum of different particles.

Progression At CERN

Time of Flight



3. Other Developments

Use of Cherenkov Detector

- We will use the Cherenkov detectors to identify particles using pressure thresholds
- We have two Cherenkov detectors in our setups (CO and C1)
- C0 is the Cherenkov with the higher pressure relative to C1
- C1 is the Cherenkov with the lower pressure relative to C0
- C0 uses carbon dioxide as the gas and helium for C1 initially.
- However, we had to change it from helium to CO2 in C1 as the helium was leaking into the photomultiplier tube(PMT).
- This caused difficulty in taking readings.
- Another issue is that the lower pressure Cerenkov faces too much noise which disrupts our readings as well.
- What we have done is that we take two readings from the same Cherenkov but at different thresholds which are set appropriately for specific particles we can obtain
- The different threshold allows for recording the counts for an alternative particle.
- We subtract the two counts and obtain the count for a specific particle.
- This is useful as it also mitigates the noise as the noise count cancels out from this procedure
- So far, this methodology has met our experimental and theoretical expectations

Progression At CERN

TDC and Delay Wire Chamber(DWC) Issues

- During the early stages of the experiment, there were problems concerning the delay wire chambers and time to digital converter(TDC).
- The delay wire chambers, specifically DWC0 was unable to record any data, including noise.
- We initially thought that this may be due to a hardware issue for the chamber or the TDC.
- While we initially felt that the TDC was working after taking runs, we later realized that it was in fact a TDC issue.
- The power cables were not connected to the correct channels for the DWC0.
- Once we did correct the cabling, we were able to record the data in the hit map for all the chambers and are now functional.

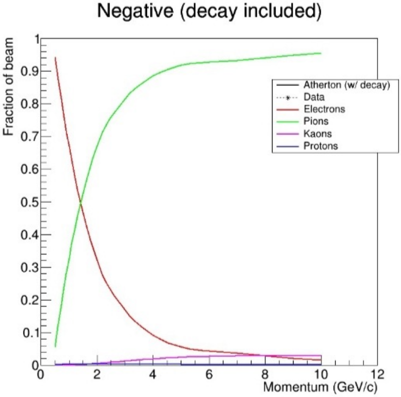
Calorimeter Accuracy

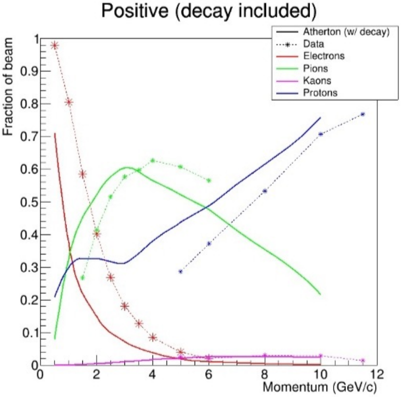
- We use the calorimeter to count the electron by measuring the charge deposited.
- We use the data from the Charge to digital converter(QDC) to do this.
- One limitation of the calorimeter is that it has a low accuracy at low beam momenta, in the range of 1-3, where the accuracy is very low at 2Gev and becomes reasonably better at Gev.
- Beyond 4Gev, we will be relying on the calorimeter as we expect it to be more accurate at higher beam momenta.

Data Analysis

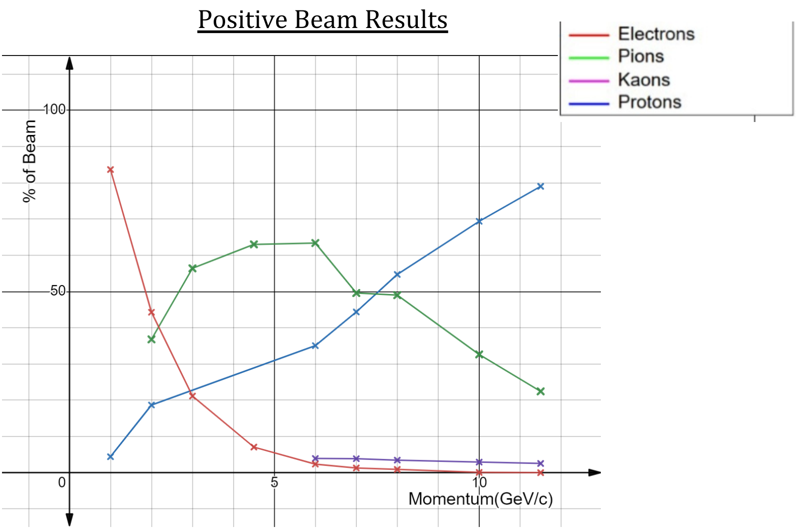
Pre-Simulation and Experimental Data

- This simulation was conducted by our support scientists.





Data Analysis



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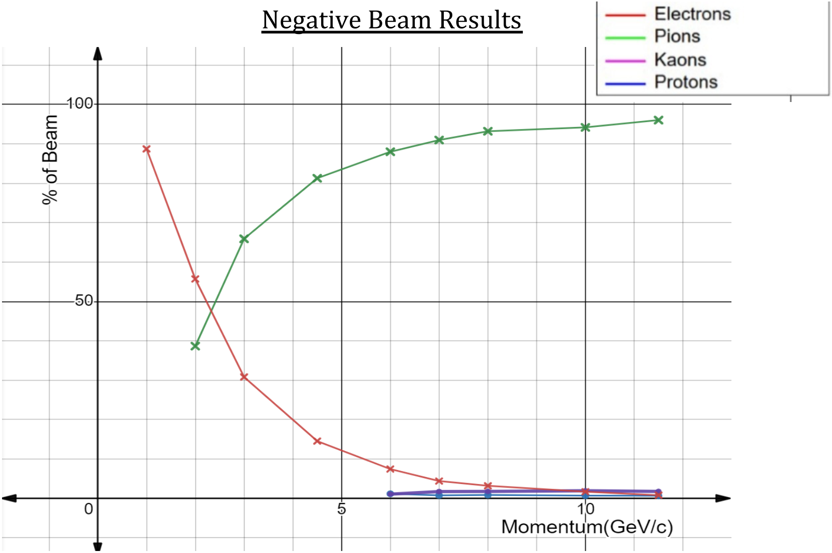

Q/A