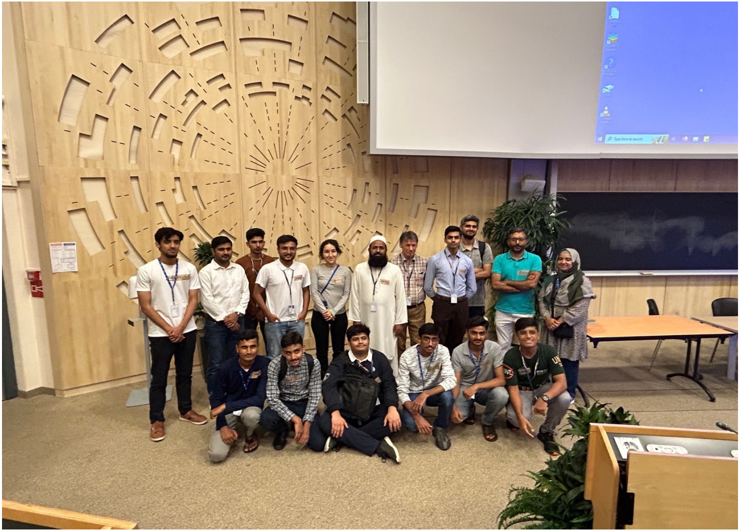
Measuring The Beam Composition Of The T10 Beamline

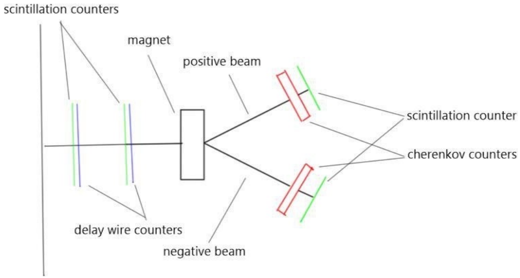
Team Particular Perspective
Pakistan

Our Team



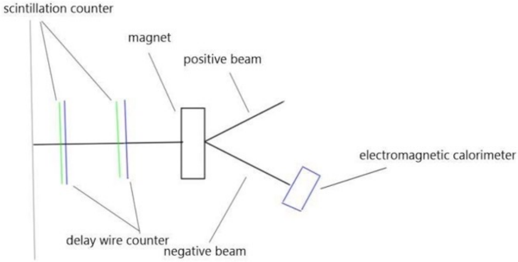
Our Proposal

- Measuring the particle composition of the beamline
- Potential lack of data due to recent upgrade
- Multiple setups and counting methods
- Cherenkov detectors
- Electromagnetic calorimeter (Lead Glass calorimeter)



Our Proposal

- Counting electrons using a thin lead filter
- A thin lead filter would only affect the electrons in the beam



- Counting muons by blocking everything else
- Using a heavy iron block (beam stopper)

Problems Encountered

Inevitable Scattering:

- In our initial proposal, we run an accelerated beam from the proton synchrotron that would strike the primary target.
- The interaction of the proton beam with the target produces a stream of particles that include protons, pions, electrons, kaons, and muons.
- We characterize this as our secondary beam.
- Moreover, we may find anti-particles such as positrons and antiprotons in trace amounts.
- The secondary beam would direct towards the lead filter and this filter would slow down the electrons while other particles would retain the momentum.
- We would use a magnetic field and a delay wire chamber to distinguish between particles
- However, after some GEANT4 simulations, we realized that other particles were scattered as well.
- Although they'd retained their momentum, the scattering would lead to the divergence of particles from the path of the particle detectors so that proper detection and counting would not be possible.

Problems

The Block Problem:

- In our initial experiment, we attempted to measure the number of muons in the beam.
- When we place the iron block to act as a filter for the muons, the other remaining particles in the negative beam can undergo interactions with the iron-block.
- Similar to how the proton beam interacted with the primary target.
- This may lead to the production of another stream of particles.
- We did not predict this phenomenon initially.
- This leads to intricacies where we need more detector equipment to account for those new particles which may be not possible due to the finite size of the beam-area.
- Moreover, the production of these new particles may also lead to muons again and thus, the muon count may not be accurately recorded as it leads to the same problem.
- Due to the size and location of the beam stopper, we were not able place extra detector before and immediately after to get around these problems

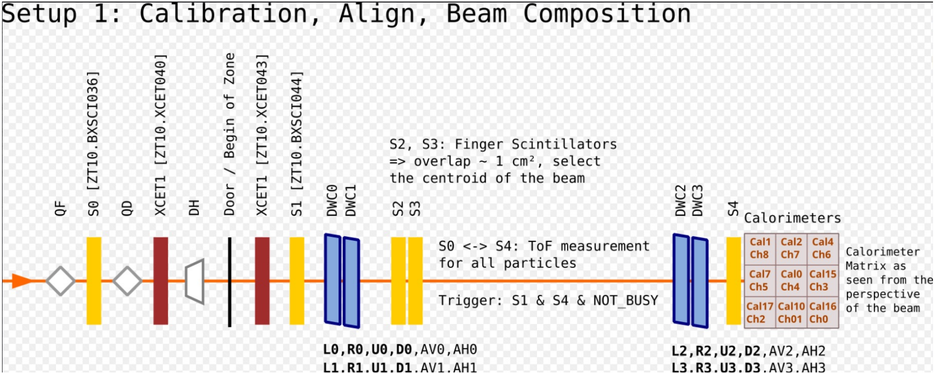
Problems

Cherenkov counter limitations:

- Cherenkov counters gas chambers could not be pressurized high enough to detect heavier particles at lower momenta.
- One of the Cherenkov counters had problems with gas leakage into the PMT.
- Thus the efficiency of the PMT had decreased
- It was fixed by changing the gas being used in the chamber and increasing the voltage supplied to the PMT
- This subsequently increased noise levels in one of our two Cherenkov counters.

Progression At CERN

Updated Schematic



Progression At CERN

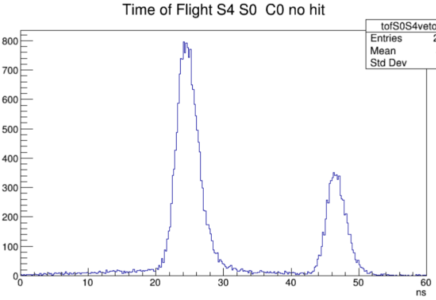
Finger Scintillators:

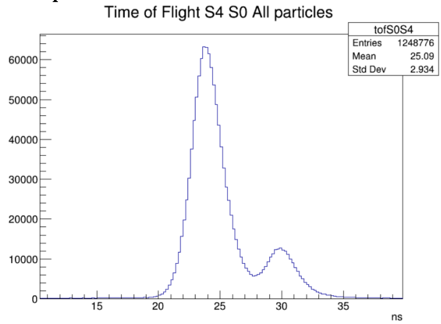
- As mentioned earlier, the scattering of particles causes difficulty in obtaining the counts of the particles.
- We changed our setup by using two finger scintillation detectors in a trigger system.
- This selects a small part of the beam and counts the particles only in coincidence which is set by 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.
- However we did not end up using this method in the end as we had planned redundancies for counting electrons
- Although, this proved useful in monitoring the beam profile for the Myriad Magnets experiment.

Progression at CERN

Time of flight measurement:

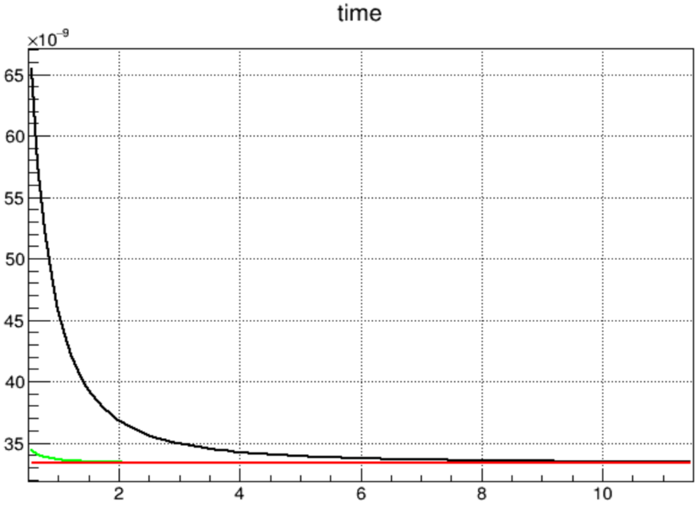
- The Cherenkov counters could not count heavy particles at low momenta
- The main issue was obtaining counts of protons at these low momenta
- A work around was found by using time of flight measurements
- we measured time of flight of particles between the farthest possible scintillators
- Most particles were at relativistic speeds and could not be distinguished using this method
- However protons could be distinguished at up to 2 GeV.





Progression At CERN

Time of Flight



Progression At CERN

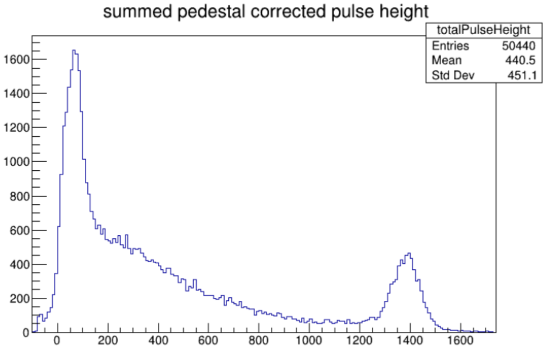
Use of Cherenkov counters:

- We had two Cherenkov counters available, one of which had a lot of noise in the signal.
- Our method of measurement was to first measure all for example electrons, muons and pions and then on a second run, with the same detector, measure only electrons and muons.
- Normalize each count and subtract both.
- This helps eliminate the noise involved in the counts
- We could not subtract counts from different detectors in a single run because of the different noise levels involved
- The Cherenkov counters however could not count some particles at lower momenta and despite the time of flight measurements, some gaps in measurements were left
- We were also not able to obtain data for electrons and muons at higher momenta due to time constraints.

Progression at CERN

Use of Calorimeters:

- We used a lead glass calorimeter in the end of the beam zone
- This helped us get a count for the electrons at the higher momenta
- Electrons deposit all of their energy in the calorimeters while other particles drop some or none of their energy
- We measured charge deposition form the QDCs to attached to the calorimeter to obtain the energy depositions of particles
- Electrons had a characteristic and relatively defined energy peak because they deposit all their energy
- We used this peak to differentiate and count these electrons.



Progression At CERN

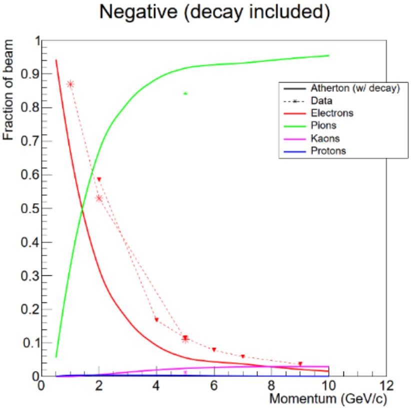
TDC and Delay Wire Chamber(DWC) Issues:

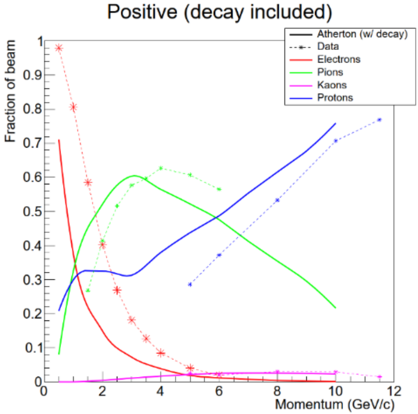
- During the early stages of the experiment, there were problems concerning the delay wire chambers and time to digital converter(TDC).
- The delay wire chambers, specifically DWC0 was unable to record any data, including noise.
- We initially thought that this may be due to a hardware issue for the 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 cables in the data acquisition system were not connected to the correct channels for the DWC0.
- We were able to continue after correcting the connections.

Results

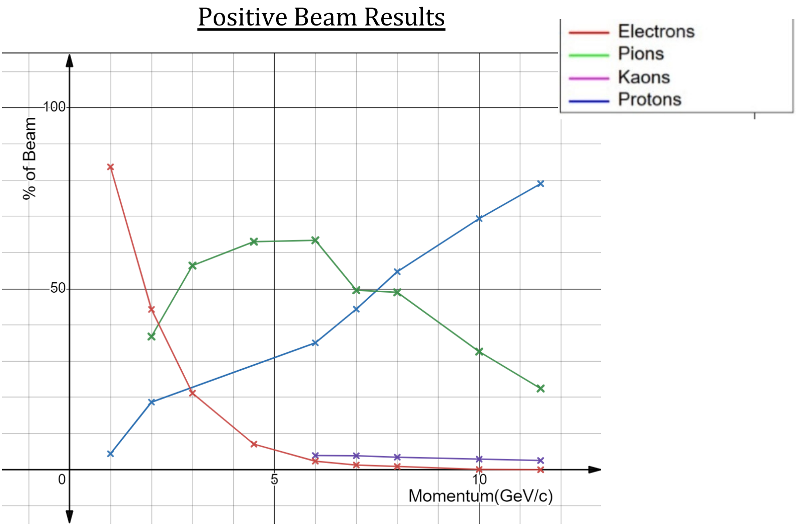
Simulation and Experimental Data:

- This simulation and the da was conducted by the beam department.



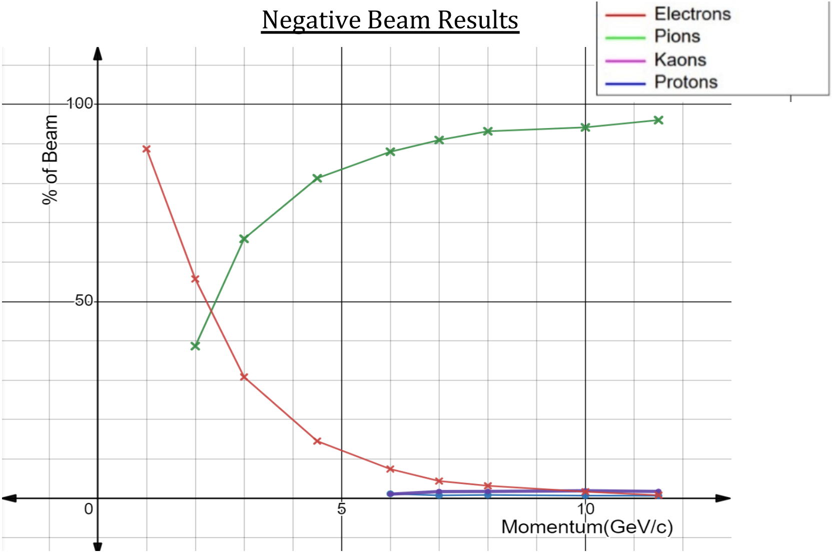


Results



Positive Beam Results
Electrons
Pions
Kaons
Protons
% of Beam
100
50
0
5
10
Momentum(GeV/c)

Results


Negative Beam Results
Electrons
Pions
Kaons
Protons
100
50
0
5
10
% of Beam
Momentum(GeV/c)

Conclusions and acknowledgments

Conclusion:

- We were very lucky to have such an opportunity
- This was a great learning experience
- We had a lot of stories to tell back home
- Gathered meaningful data

Acknowledgments:

- We are thankful to the BL4S management for giving us this opportunity
- The CERN society foundation for sponsoring this venture
- Markus Joos, Sascha Schmeling, Sarah Maria Zoechling, Martin Schwinzerl, Berare Gokturk, Şeyma Esen, Ahmetcan Sansar, Maarten van Dijk, Jorgen Petersen, Louis Tremblet for their amazing help throughout before and after our trip to CERN.

Thank you for listening
Q/A