CERN SUMMER STUDENT 2018

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1. INTRODUCTION

A) AEgIS (Antihydrogen Experiment: Gravity, Interferometer, Spectroscopy)

AEgIS primary scientific goal is the Earth's local gravitational acceleration g direct measurement on antihydrogen. The purposes of AEgIS are to measure directly the free-fall of an uncharged probe, antihydrogen and to determine the aforementioned ratio to less than a part in 10^2. In order to measure the gravitational pull directly, letting an uncollimated cold antihydrogen beam through a moiré deflectometer. The particles were subject will need to be measured when both flight time through the full deflectometer and vertical displacement. The charge exchange production was using by AEgIS to meet its demand cold antihydrogen pulsed. This production is having an antiproton react with a Rydberg excited positronium and then yields an antihydrogen and free electron. To allow for the production of colder antihydrogen, the charge reaction transfers less recoil to the emerging antihydrogen as opposed to the mixing production.

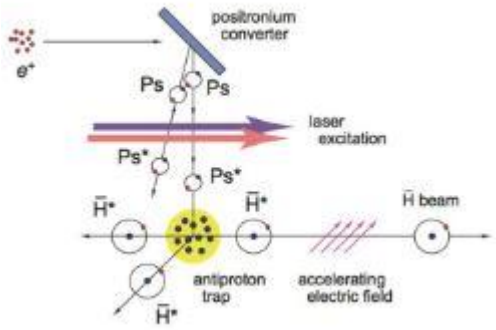

Figure 1 represents forseen method for the production of a pulsed beam of cold antihydrogen atoms.

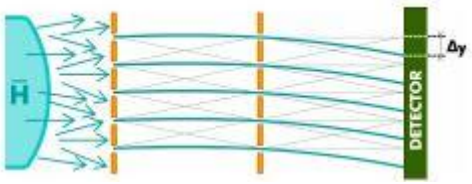

Figure 2 represents moiré deflectometer working principle.

B) FACT (Fast Annihilation Cryogenic Tracking)

FACT detector is a primary tool for detecting antihydrogen produced in the antiproton trap of the AEgIS experiment. This detector is developed based on scintillating plastic fiber and silicon photomultiplier. It consists two layers of scintillating fibers which every constructed of two superimposed rows at radial distances of 70, 70.86, 98, 98.86 mm from its center. There are 800 scintillating fibers and each layer made up of 400 scintillating fibers separated by 0.6 mm with the displaced of the alternate fibers radially by 0.8 mm which to eliminated any gaps in the solid angle of the detector. The transports scintillation light to a Hammamatsu Muti-Pixel-Photon-Counters (MPPC) by coupling mechanically of each scintillating fiber to clear fiber where located at room temperature approximately 2 m downstream of the detector. The MPPCs analog signal is then amplified and discriminated at a rate of 200 MHz. FACT has 17 FPGAs that read these signals in groups of 48 fibers. The signals are sent from FPGAs to the DAQ-system via Ethernet.

C) gAn

A gAn is an online analysis of several detectors and sensors all across the AEgIS experiment tool which is being used and developed. At the first stage, the FACT part of gAn was developed by Germano Bonomi, David Pagano and Francesco Guatieri. *Hit* is atomic unit of a FACT detector acquisition. A *Hit* is a bundle of the three different pieces of information: a) fiber number from 0 to 799 (containing the information of the spatial position in (r,z) of the fiber), the fiber starting to fire time, and pulse length (time over threshold).

2. OBJECTIVES

The CERN Summer Student Program is to expose students to forefront research, aid in their development as scientists, teach them knowledge and skills for future work. For my first project I need to understand FACT digital response by studying the time over threshold (ToT) distribution which shown two peaks distribution. First of all, the data in form of root file are vector contained of these hits which sorted by starting times (Clock). The differences time in the form of vector which contains events for every fiber number. For example, we have our fiber number is 700 and every value last time for clock is same. When push back last time in differences vector, it will give different value time differences for hits for fiber 700. When looped differences for fiber 700, there are many events contained for every different *Hit* in the same fiber. Next, *Hit* will continue loop it will give new start time for the same fiber.

The second task is to determine the non-biased efficiency for fiber. From the previous studied that have been proposed by Francesco Guatieri is only consider 3 and 4 layer tracks. Assume that have a reasonable sample of all detected tracks and an efficiency for the fiber. The distributed this sample they expect to see the tracks except for the one or more fibers are missing. Hence, this method produced biased estimator which is the inverse of efficiency. The efficiency given by a rational function with an asymptote around 0.66, however this technique will fail worthless for fiber efficiencies below 2/3. By choosing to observe only events in which all three fibers are present in order to overcome this, regardless of the presence or not of the studied one. Currently, idea by Philip Hackstock is the reconstructing tracks and counting hits and misses for each fiber. This way is successful that produced an unbiased estimator with a low uncertainty. Only consider two cases 4/4 and 3/4 are possible fibers firing. Generally, this approach is not limited to FACT, however can be implement to any pixel-like tracking detector in order to measure its efficiency on the level of its smallest unit.

3. Result & Analysis/ Expected result

A) Determination of time differences between two consecutive hits in the same fiber

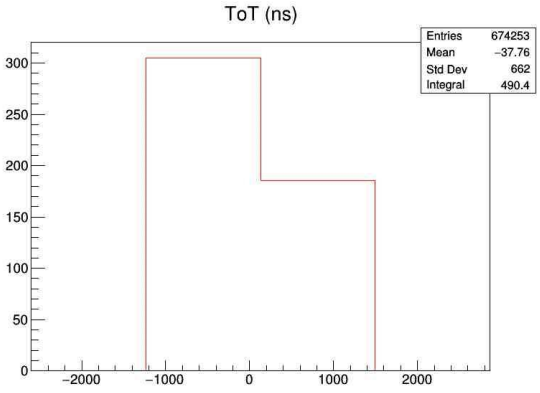

Figure 4 represents the number of ToT versus time

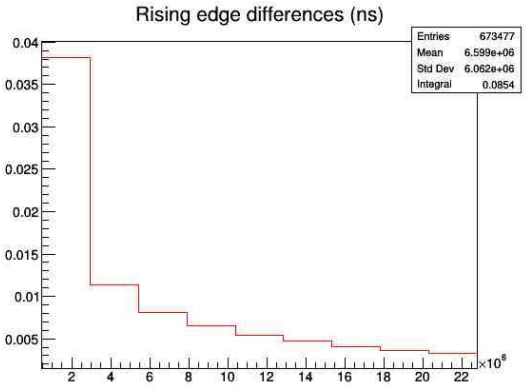

Figure 5 represents the rising edge differences versus time

From the analysis, there are 673477 events occurred in ToT on pbar killing spree. Each time difference in 800 fibers composed of many time differences. When the ToT increases, the number of antiprotons recovered back which due to they are re-caught in flight. However, the efficiency of itself is higher could cause some losses due to the heating inherent. When we observed the rising edge differences, when the compression of antiproton cloud which the rotating wall with apply the magnetic and electric fields is rotating to reduce antiprotons from colliding to the wall. As we can see that there are some antiprotons are annihilate due to antiprotons collided with the wall which produced pions. Since pions produced, it will passed through the fibers. This event is called hits. Since rotating wall is rotated, the probabilities to meet the two consecutive events is high. The two consecutive events decreases as the time of events getting longer.

B) Determination biased or non-biased efficiency for fiber

I used method proposed by Philip Hackstock to find another combinations. Unfortunately, it does not work. However, I tried my method without considering studied fiber to get every efficiency of fiber for each layer. My idea is let try to consider that there are two cases, a) possible hits can formed track (4,3 and 2 fibers are fired) and b) impossible hit/hits which impossible to form track (1 and 2 are fired). When I did mathematical derivations, I matched the combinations of 4 and 3 layers track, 3 and 2 layer tracks, and 2 and 1 layer tracks in order to get efficiency of each fiber layer. Overall, what I realized is I repeating the same combinations to get every efficiency fiber and tried to figure out the more combinations too. Unfortunately, I could not get the estimator of fiber efficiency either biased or non-biased.

4. Conclusion

From my previous experiences, I used ROOT 5 to analysis small data and implemented my basic knowledge in C++ to develop the code for my final year project that I had learnt my university. I worked my analysis on Windows OS. Here, I changed from Windows to Linux. I learnt from the beginning to install ROOT 6 and several tools to identify the errors during compiling the code. It was valuable for me. I gained the knowledge more advanced during my analysis such as pointer and

references, range-based for loop, ROOT interactive and many more. In analysis time differences between two consecutive hits in the same fiber, I learnt how to analysis and deal with huge data which all data in root file contained vectors. In gAn, there are contained C++ file which composed of method of the functions while header file contained functions that developed in the method from header file. In order to time differences between two consecutive hits in the same fiber, I used the functions are provided in gAn to make analysis.