W. A. R. P.

(Wonderful Antimatter Research Project)

AUTHORS

ConCreate is a team of five sixteen-years-old students of a Technical School named after "Enrico Fermi", involved in the courses of Electronics and Automation.

While our primary goal would have been the development of high-performance electronic instrumentation to detect particles, we realized that our skills and knowledge are not adequate, yet. Therefore, we thought of a scientific event that fascinates us.

INTRODUCTION

At the beginning, the Big Bang created matter and antimatter. Afterwards, matter didn't distribute in space in an uniform way, but randomly thickened. But what happened to antimatter? One of the most interesting questions of the last years is if the Universe is indeed made of matter and antimatter in equal amounts or if, for some strange reasons, it is not.

With our experiment we want to produce matter and antimatter transforming high-energy protons hitting a target in particles and antiparticles, according to the known law of Einstein's $E=mc^2$ and in respect to the charge symmetry.

MOTIVATION

The Universe appears to be populated exclusively with matter rather than antimatter.

There are some theories about this asymmetry. The most known is the baryogenesis: this situation took place few picoseconds after the Big Bang. In this particular event, an asymmetry between baryons and antibaryons was generated. This asymmetry can just be measured with instruments that only particular accelerators beam lines possess.

An important aspect in any experimental study of matter-antimatter asymmetries in a laboratory is to consider that of the equipment (accelerator, target and detectors) is made of matter, and not of an equal amount of matter and antimatter. Our intent consists in the measurement of this asymmetry by analyzing the quantity of matter and antimatter produced by a collision of protons with a target.

We know that CERN is a place of maximum scientific growth, because there are people coming from all over the word, with just benefic scientific search intents. We would love to go there, implement our experiment and learn useful information for our studies and, in the next future, for our careers.

REQUIRED EQUIPMENT

Fig. 1 shows the layout of the experimental set-up.

The experiment will be split in two sessions: in the first the positive particles will be analyzed, in the second the negative ones. Neutral particles will be discarded.

The incoming proton beam from the Proton-Synchrotron accelerator will impinge on a beryllium target. This has been preferred to aluminum and tungsten, since the intent is to analyze the type of particles generated in the collision, their mass and charge. In this respect aluminum, despite of its high cross-section, doesn't produce a large variety of particles. Tungsten produces an high quantity of electrons, we are not interested in.

In our experiment the secondary beam is deflected by a bending magnet and later it passes through an horizontal collimator that selects the particles' momentum. After that, the beam passes through two Cherenkov counters that allow a first particle identification, as they only give a light signal when the particle velocity is above a certain adjustable threshold (i.e.: if the particle mass is below a set value). Particles with a specific momentum are counted by two scintillators, which can discriminate between lighter and heavier elementary particles thanks to their different time of flight (TOF). The first scintillator activates a clock upon being hit while the other stops the clock. If the two masses are m_1 and m_2 and their velocities v_1 and v_2 then the TOF difference is given by

$$\Delta t = L(1/v_1 - 1/v_2) \sim Lc(m_1^2 - m_2^2)/2p^2$$

where L is the distance between the two scintillators, p is the relativistic momentum $p=mv(1-v^2/c^2)^{-1/2}$ and c is the speed of light in vacuum. As an example, if we consider $L{\sim}5m$, $p{\sim}3GeV/c$ (to have a good enough relativistic approximation even for heavier particles, such as protons) we estimate $\Delta t{\sim}200ps$ for K+/π+ particles.

Linking the two Cherenkov detectors with the two scintillators, we will be able to obtain information on the type of particles (see table below). We will take the signal from both scintillators to exclude that a cosmic ray passing through one of them could be misinterpreted as a proton.

CHERENKOV 1 SIGNAL	**CHERENKOV 2 SIGNAL**	**SCINTILLATORS 1-2 SIGNAL**	**TYPE OF PARTICLE**
NO	NO	YES	PROTON
NO	YES	YES	K+ MESON
YES	YES	YES	π+ MESON

The scintillator signal reveals the presence of particles, as long as the Cherenkov signals at different thresholds discriminate K+ mesons (m_0(K+)= 494MeV/c^2) from π+ mesons (m_0(π+)= 140MeV/c^2) or protons (m_0(p)= 938MeV/c^2).

We will place a six-plane-telescope between the two scintillators, as close as possible to the second one for better precision measurements, to record the path of the beam particles. To improve the knowledge of the particle momentum we will put a second magnet and a Delay Wire Chamber (DWC): the magnet will deflect particles at angles depending on the momentum and the DWC will be used to measure these angles, thus determining the momentum.

A calorimeter will measure the energy of the impinging particles: we know that electrons and positrons deposit a larger amount of energy than the heavier particles, a property that will be used to identify positrons.

Finally, to detect also muons that pass the calorimeter, a *muon filter* and a final scintillator will be installed.

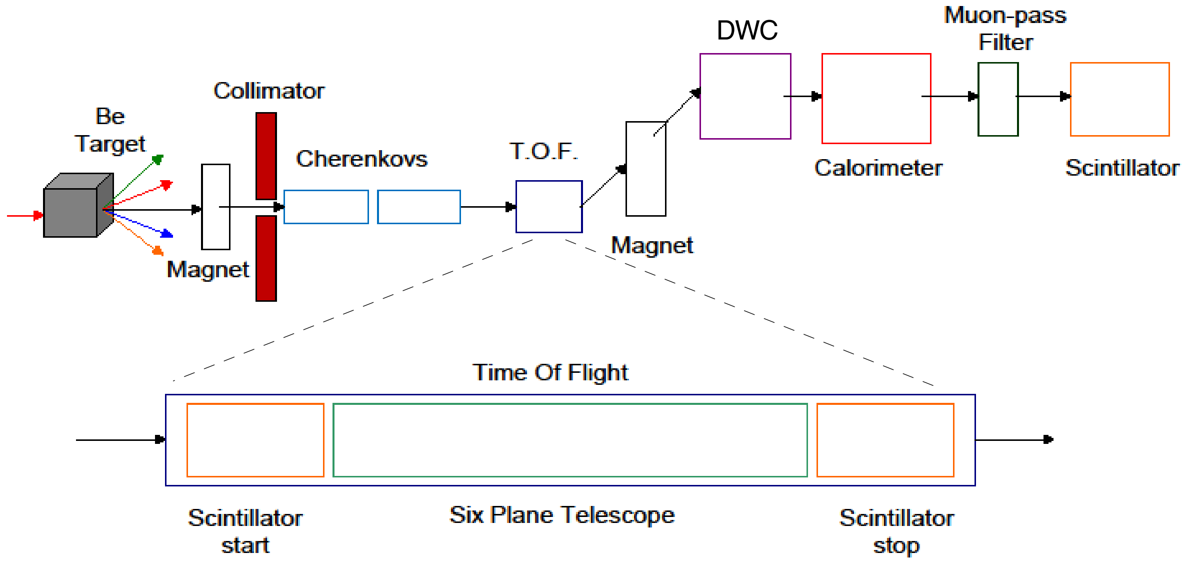

Fig. 1 – Schematic layout of the experiment.

EXPECTED RESULTS

At the end of the measurement we'll make the balance of all particles of matter and antimatter. We expect a majority of matter particles compared to antimatter for several reasons. The first is related to the nature of the primary beam: protons are made of matter and many of them pass through the target and are collected. The target is also made of matter and the impinging beam produces other baryons. Furthermore, there is a high probability of annihilation between particles and antiparticles after they have been produced. In spite of this, we hope to detect a sizeable amount of antimatter.