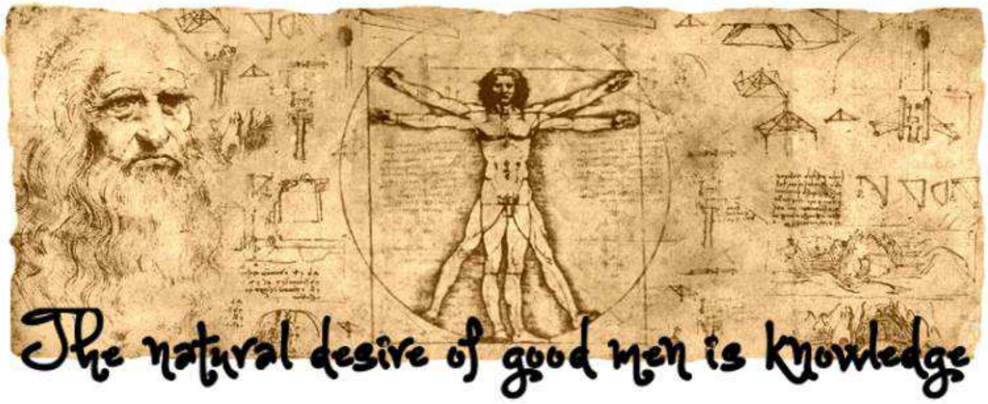

A beam line for schools

MORE THAN A WEBCAM: LOW-COST PARTICLE DETECTOR

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Dicono quella cognizione esser meccanica la quale è partorita dall' esperienza, e quella esser scientifica che nasce e finisce nella mente. Ma a me pare che quelle scienze sieno vane e piene di errori le quali non sono nate dall'esperienza, madre di ogni certezza, e che non terminano in nota esperienza.

That knowledge, which comes from experience, is said to be mechanical and the one, which starts and ends in the mind, is said to be scientific. But those sciences, which aren't born from experience,mother of all certainties, and don't end in experience, to me seem to be vain and erroneous.

Leonardo da Vinci, Trattato della Pittura.

Abstract

The project aim is to use and calibrate a particle detector that we have built with common and low-cost materials. The purpose is to verify the correct functionality of our product using a scientific and high technology setup as the Proton Sychrotron particle accelerator, made available for schools in the T9 beam line. We strongly believe that the chance to work closely with researchers at CERN is to be considered a unique opportunity to understand more about the scientific world in his operating reality.

Motivation

This project seemed a great opportunity to do something different from the usual school activities. Although the news of the existence of this contest arrived with short notice, we decided to try and to see what was like to invent an experiment and develop it. Each one of us has contributed to the project with his own different abilities, always trying to do his best. When we started to study physics we have always considered theories as something far away from reality, this year we got in contact with the physics research center of Florence and thanks to this we were able to appreciate aspects of physics closer to our everyday life. A visit at a linear particle accelerator, which is situated in the INFN section of the University of Florence, stimulated us to think about how high school students could contribute to easily "see" a particles beam. What we wanted to demonstrate is how a tool for particle beam diagnostic, that can be used in a real experiment, could be realized with common materials. So we though: will we be able to use a mid-market webcam to analyze the particles ? At the beginning all we got was just an idea: we read up on it the bases and have built a particle detector based on the CMOS detector, but we think that there are many different possible variation of the experiments. All we want is to realize them at CERN with the help of experts; we'd enjoy working in the most prestigious center for scientific research, trying to understand what means to be a researcher and then, of course, sharing our experience with all the other students. We wouldn't forget such a chance!

Project details

The detector was realized with a C270 Logitec webcam, provided with a CMOS sensor: the front case and the optics were removed (Fig.1). We then proceeded with the application of a sheet of aluminum foil on the CMOS sensor, in order to shield it from UV radiation, visible and infrared ones and to be sure it will detect only the high-energy particles. Aiming for a sharper and more accurate quantitative measure, the cooling surface of a Peltier cell has been placed adjacent to the webcam, to reduce the thermal noise present in the system. The hot surface of the cell is instead been placed in contact with a heat sink.

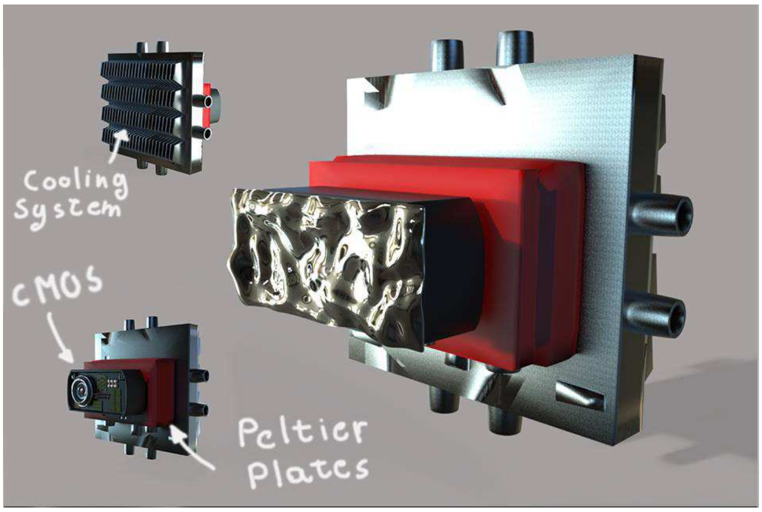

Figure 1: Schematic of the webcam detector.

The energy of the particles will be accumulated inside every single smitten photosite of the CMOS: taking advantage of the webcam electronics, the signal will be transmitted through an USB cable to an Arduino Yùn device, suitably programmed so that it acquires the image from the CMOS. Arduino Yùn features a Wi-Fi system: this allows consulting dates without any cables, so the detector will be versatile and easily integrated into the measurement setup. In Fig.2 (`http://youtu.be/L8adYBecwuM`) a picture of the complete device is reported.

Figure 2: Picture of our complete device.

The experimental setup, that follows the T9 beam line, has been chosen with the main purpose of filtering the beam particles that will reach the experimental area so that the excessive density of the beam won't saturate the detector (Fig.3).

To achieve this we believe that the experimental area should be provided with:

1. A collimator, which allows us to significantly reduce the density of the particle of the particle beam.

2. Two Cherenkov counters to identify the particles.

3. An absorber to decrease the density of the beam, allowing only some particles with a determined momentum.

4. The MNP17 Magnet to select the particles based on charge, energy and momentum: this will allow us to carry out a calibration on the intensity of the detected signal, depending on the momentum of the selected particles.

5. A scintillator and a DWC (Delay Wide Chamber) to receive the image of the beam.

6. Our detector, which captures the beam profile, will recreate the image on a html page, specifically created, that will update automatically. This is possible thanks to the Wi-Fi system included in the Arduino Yùn device. As a result, everyone who knows the link will be able to see the images, not also on PCs but on tablet and smartphone too.

7. A second scintillator, coupled to a DWC, for immediate comparison of data between the first scintillator relative to the particles that have passed the webcam.

The type of particles selected will be changed to analyse possible modifications in the characteristics of the signals from our detectors. In the case of acceleration of electrons, there is the possibility of adding a copper plate which decrease density and momentum for a more accurate and precise detection.

The energy transferred by accelerated particles to the CMOS photosites can be calculated using the Bethe-Bloch formula, considering silicon thick 300 μm detector. As it is described in Fig.4, referred to the impact of electrons, we could know the ceded energy of the particles as a function of their energy before the impact. We believe we'll be able to effectuate a quantitative calibration of thresholds of saturation of our detector, changing the type of particles and their momenta.

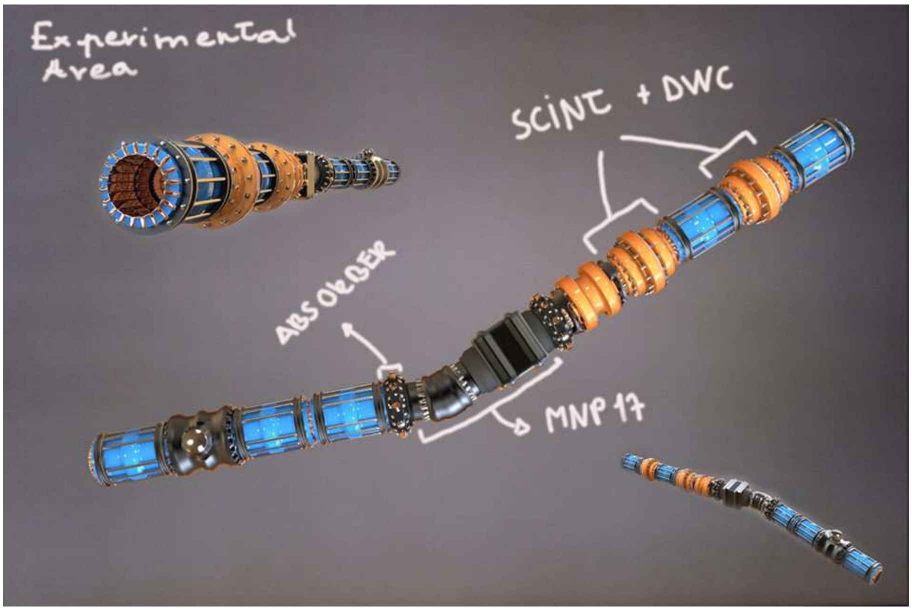

Figure 3: Schematic of the T9 experimental area setup.

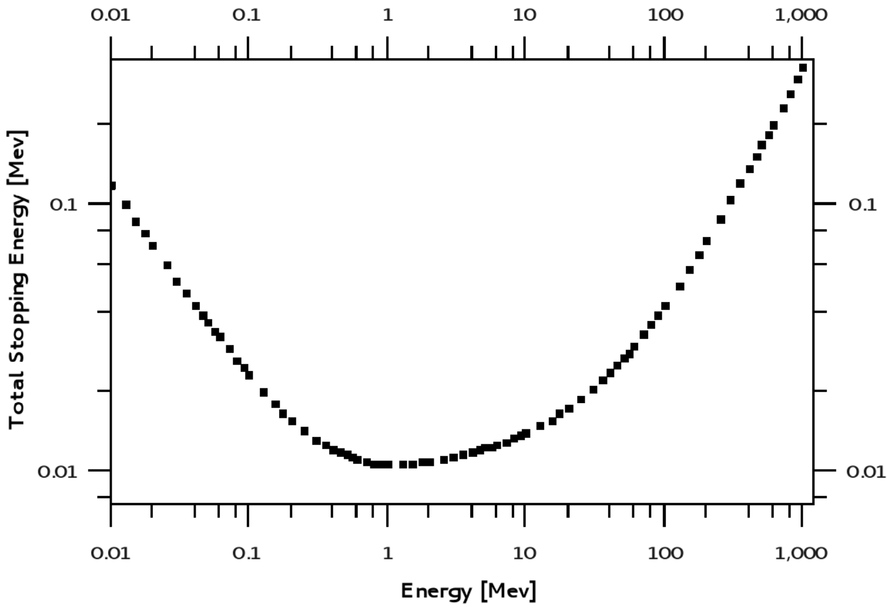

Figure 4: Total stopping energy calculated from NIST database. It refers to the energy lost by an electron in a silicon substrate of 300 μm thickness .

Future perspectives

The CMOS sensor has an area of $6mm^2$, so it will be necessary to reduce considerably the size of the accelerated beam in order to prevent it from missing the target. To overcome this problem, the project allows a possible extension of the experiment with the addiction of other webcams: we will thus create a matrix of detectors that, we believe, will let us create an extended receiving area and consequentially a more precise one.

Acknowledgement

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