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TECHNOLOGY TRANSFER MECHANISM IN NUCLEAR PHYSICS, APPLIED TO ACHIEVE AN EXPERIMENT TO STUDY COSMIC RAYS

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Abstract. Technology transfer is defined as the transformation of the research and development results into marketable products or services. The starting point is the finalization of the technology in the research unit and the exit point is the prototype product. In this paper, the technology is designed to study the cosmic rays and their effects and the prototype product is the calorimeter WILLI. Technology transfer mechanism is drawn for the mechanical construction of the calorimeter.

Key words: technology transfer, nuclear physics.

1. INTRODUCTION

This paper aims to describe the technology transfer mechanism applied to carry-out an experiment in nuclear physics. In the beginning the paper presents the procedure to understand the physical phenomenon and follows the steps to reach to the practical application.

The topic approaches the concept and implementation of the Rotatable Support for Calorimeter WILLI (Weakly Ionizing Lepton Lead Interactions). The Rotatable WILLI detector, build in IFIN-HH Bucharest, is a compact detector offering the possibility to measure the muon charge ratio by a method, based on the observation of the muons capture and subsequent decay in the detector layers. Such a rotatable system allows measurements of the charge ratio of muons with different angles of incidence, making possible the determination of the East-West effect of the Earth magnetic field, which deflects the trajectories of the charged particles in the atmosphere [1].

The muon belongs to the family of elementary particles known as leptons. Like the electron it may be positively or negatively charged and has a spin 1/2. It is produced mainly by the decay of pions and kaons generated by high-energy collisions of cosmic rays with the atoms of the Earth atmosphere [2].

In order to facilitate the study of these particles it was necessary to build a special device to position the calorimeter.

The term “technology transfer” (TT) refers to all activities leading to a new product or new procedure by any user group. Technology transfer is an active term: it involves the interaction between the bidder and users of the new technology and the genuine innovation that results [3]. The description of the technological transfer steps that led to the achievement of the device mentioned above, are intended to underline the role of technological transfer in nuclear physics.

A physicist or a group of physicists are willing to put into practice one or several of their theoretical ideas and to check if their detection instruments are recording the same data as their mathematical model. In order to get such compatibility, it is necessary to co-work with the engineers for the practical experiment. Physicists describe the principle and the aim of the experiment and after having understood the phenomenon and the working conditions, the engineers will make a sketch of the prototype. Such drawing is then analyzed and if both parties agree, they start the project development: calculating, sizing and choosing the materials, elaborating the documentation and, finally, putting it all into practice. In this stage, the job of the second group of engineers specialized in manufacturing, starts. It is worth mentioning that because it is not a serial product but a prototype and, most importantly, because the various device and installations are supposed to operate in special conditions (radiation fields, chemical environments, pools), it is very important that the manufacturing company be extremely carefully selected. After having completed the experiment and tests, the final step is to get a patent. In this stage, the technological transfer has already been accomplished, but not finalized because there is still the need to find a broad range of its usage, the target reason why the experiment was mainly designed.

2. CALORIMETER WILLI – GENERAL DESCRIPTION

Muons are the EAS penetrating component and they carry information about the mass and energy of the primary cosmic particle. Measurements of the low energy (< 1 GeV) muon flux and muon charge ratio were performed using the WILLI detector [4, 5] which is a compact, modular rotatable system. The merit of the WILLI detector is that it approaches the very low muon energy range with excellent accuracy. The detector determines the charge ratio of atmospheric muons by measuring the life time of stopped muons in the detector layers: the stopped positive muons decay with a lifetime of 2.2 μs, while negative muons are captured in the atomic orbits, leading to an effectively smaller lifetime function of the stopping material. The muon charge ratio is determined from the measured decay curve of all muons stopped in the detector, by matching the measured decay spectrum with the theoretical curve [6].

In the initial configuration, the electromagnetic calorimeter WILLI – 97 was built from 20 modules of 90×90 cm^2, each module containing a Pb layer (1 cm thickness) and a scintillator layer NE174 (3 cm thickness) fastened in Al support (1 cm thickness) (Fig. 1) [7].

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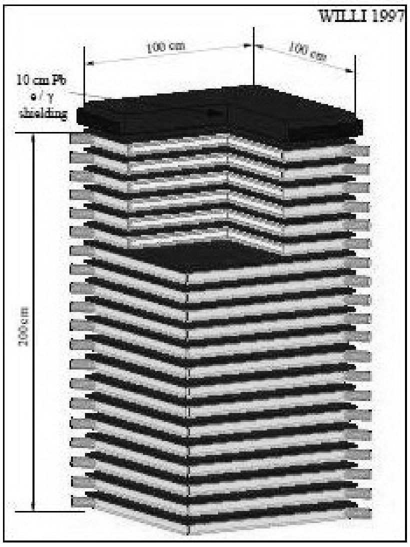

Fig.1 – Initial configuration WILLI – 97 [7].

With the next configuration, the detector was modified and optimized for muon charge ratio investigation, by eliminating the Pb layers and improving the detection efficiency by rejecting the background noise with an anticoincidence system (Fig. 2) [7].

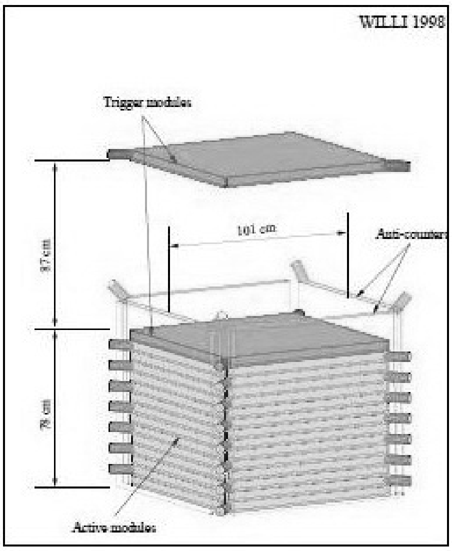

Fig. 2 – Next configuration WILLI – 98 [7].

With the last modification the detector became in a compact rigid detector with rotating facilities in zenith azimuth direction (Fig. 3) [7].

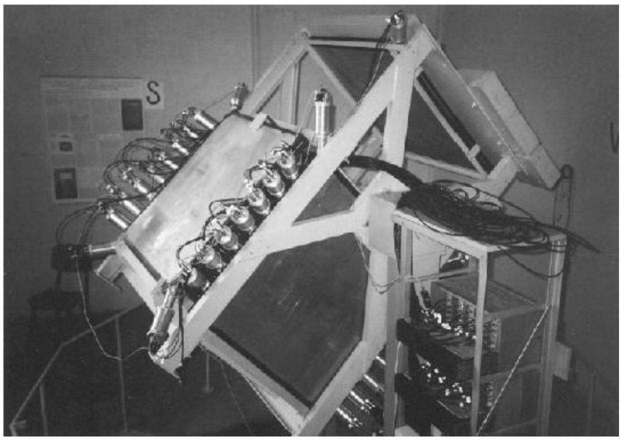

Fig. 3 – Rotatable WILLI detector [7].

3. ISSUE OF TECHNOLOGICAL TRANSFER, THE ROTATABLE SUPPORT FOR CALORIMETER WILLI ACHIEVEMENT

To make possible such an arrangement of layers for all configurations, it was necessary to build a complex system called "Rotatable Support".

The Support was made to hold and spatially direct the detectors so to cover a solid angle of 2π sr. For the system to have the possibility to rotate in two planes and be asymmetric towards the rotation axes, it was provided with a rail gauge stopper. The rotation angle in a horizontal plane is 360^0 and in a vertical plane is 90^0. An engine provides the movement in a vertical plane. In a horizontal plane the rotation is manually carried-out. Technical characteristics are presented in Table 1.

Table 1

Technical characteristics of rotatable support for WILLI

Total weight of the cardanic system (equipped with detectors and Pb screens)	6 000 kg
Load on base	1 500 kg/m^2
The maximum diameter bounded by railing around detector	3.475 m
The rotation angle in a horizontal plan	360^0
The rotation angle in a vertical plan	90^0
The maximum height (for a 40^0 tilting angle)	2.95 m

The entire device was designed by a group of engineers from IFIN-HH, Bucharest, and the mechanical construction has been made in collaboration with Nuclear and Vacuum Co., Bucharest. Initially, the job was started with discussions for a better understanding of the physical phenomenon and the purpose of the research was defined. The physicists presented to the designer engineers facilities which would be necessary for studying the muons. The engineers followed the usual stages of a project, the sketches, 3D design (using AutoCAD program), dimensions and calculations, checks and final documentation for the general assembly. The final stage was, of course, the installation *in situ* of the device, the verification and testing. After the Rotatable WILLI successfully passed all the tests, the scientific and technical novelties of the experiment have been patented (Romanian Patent – OSIM, no. 121056).

Presently, this detector is used in IFIN-HH for the study of the cosmic rays, as shown in the beginning of this paper. The results of measurements are presented in technical papers by the disciplines [6].

As showed above, in the broadest sense, the technology transfer is a communication process that leads to the introduction of the research results into practice. It is the transfer of know-how from the basic research to applied technology. Technology transfer is essentially a problem of knowledge flow from some people to others, with the aim of application into practice [8].

This experiment shows that the technology (know-how) transfer was made from the theoretical to the applied physics and subsequently to the practical realization of the calorimeter. The ultimate result and satisfaction was that the data obtained by the theorists could be verified.

On the other hand, it envisages the continuation of cooperation for the development of new detection systems in parallel with the calorimeter WILLI [9,10,11].

The author of this paper was involved in the mechanical design of the project and also in the collaboration with Nuclear and Vacuum Co.

4. CONCLUSIONS

The Rotatable Support for calorimeter WILLI was a success in terms of design and construction. This particular device can be used for any structure, which has to be positioned on a precise direction, covering the possibility of rotation a solid angle of 2π sr, being useful also in industry. Such a structure can make possible the accurate positioning of various components, also ensuring a high machining accuracy even for large-sized pieces.

The success could not have been possible without an excellent cooperation between the working teams of engineers and physicists.

This paper wants to draw to attention on the very important role played by the technological transfer in applied physics, even though its importance has not been sufficiently highlighted so far.

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