Research Project

Continuous progress in the development of monolithic pixel detectors for high energy and nuclear physics is producing sensors with improved performances that can be used in the existing FOOT project. The physics program of the FOOT experiment aims at filling the gaps in the cross-section data of heavy fragments produced in the beam-target interaction by means of both direct and inverse kinematics measurement methods. The opportunity to exploit the developments in microelectronics is particularly important for the proposed detector in view of the high costs associated with the required microelectronic technologies. Moreover, the use of developments carried out in much larger scale scientific experiments has been a reference since the design of the detector itself. We propose to improve the detection characteristics of the FOOT experiment's Vertex Detector by using the MIMOSIS sensor, recently developed for the Compressed Barionic Matter (CBM) experiment by the In2p3 research group in Strasbourg. We propose this project with the aim of significantly improving the capabilities of the pixel tracker, particularly in terms of the amount of data that can be collected for the same amount of time and spatial resolution, which for obvious statistical reasons allows for greater accuracy on the measurements. The starting characteristics have already been demonstrated by the performances of the currently existing Vertex Detector. Replacing the sensors with those of the next 'generation' (the MIMOSIS sensor), with integration times approximately 40 times shorter, will improve the overall capabilities of the experiment. The sensor is currently available, and the techniques for using it are already fully in the hands of the involved teams. Finally, the new Vertex Detector should also be able to cope with measurements for much heavier nuclei such as Fe56, which is of considerable importance for the studies of radio protection in space, fundamental for the planning of future deep space missions.

The activity foreseen in the project is subdivided into various items:
WP1 - design and production of the PCB (Printed Circuit Board) to house the sensors (same for new Vertex and monitor station before the target). We estimate the time needed for the design and implementation of the PCB, including the needed time to learn all the sensor functionalities.
WP2 - Assembling of the sensor on the PCB and its testing.
The testing of the 'naked' chips, the assembly of the sensors on the PCBs and the first test will be carried out by the Strasbourg team using, in part, the detector readout system developed as part of the project. The planned part of the in2p3 work is accounted for in the purchase cost of the sensors.
WP3 - Development of the the proximity readout board to the SoC-SOM board.
A second board to interface the commercial SoC-SOM board housing the high performance FPGA will be needed. This board is needed to house all the interface electronics to both the sensor and the experiment trigger system that cannot be installed on the sensor board itself. It will be implemented in parallel with WP1 and WP2, and will be delayed by two months to wait for the definition of the board to be implemented in WP1.
WP4 - Design of the decoding and trigger signal processing firmware.
Firmware development is an essential part of the project and is basically divided into two parts: WP4 and WP5. The first one takes care of the following tasks:
- sensor initialization
- decoding of the sensor serial lines and collection of data in a buffer memory
- interface with the trigger system
WP5 - Design of the firmware to interface the central DAQ system.
This part of the firmware to be developed interfaces that provided in WP4 in collecting

data and then sending it with the appropriate protocols to the central DAQ. A similar implementation time is estimated and it runs in parallel with the previous one with obvious interactions of the two developments.
WP6 - Development of the new read-out software on the Soc-SOM board.
WP7 - Development of the new read-out software on the central DAQ system.
WP8 - Testing of the new FOOT vertex system in laboratory and on special purpose test beams.
WP9 - Integration of the new system in the general FOOT experiment.
WP4, WP5, WP6 and WP7 are linked to the purchase of the new SOC-SOM boards in the first 4 months of the project.

Activity Plan

The researcher that will obtain the present grant should actively follow the activities of the FOOT project and interact with the other participants to the projects. The researcher will attend to regular meetings among the project members and to other collaboration meetings that can be of importance for the development and integration of the project in FOOT.
The main activities required to be fulfilled by the researcher will be:

- understanding the physics of nuclear processes of fragmentation and in particular with the neutron detection;
- developing a DAQ system to fulfill the requirement of the proposed new tracking system for the FOOT experiment;
- test the systems during dedicated beam tests;
- being independent and proactive in carrying on the assigned tasks;
- to share and discuss regularly the status of the assigned tasks with the other members of FOOT and
- collaborate together to reach the project goal and obtain the best possible outcome of it.