Review of doctoral thesis

Title: Radiation hardness and performance of the hadron calorimeter designed for Projectile Spectator Detection in the framework of international collaboration CBM@FAIR

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The content of the submitted 333 pages dissertation is based on the original projects of experimental work in which Vasily Mikhaylov participated to a significant or decisive extent as a member of the international CBM@FAIR experiment.

Experimental work in the field of nuclear and subnuclear physics in a number of large European facilities requires sophisticated detection systems. These detection systems must be radiation-resistant at the same time. The development and testing of the systems are important for the development of knowledge in above named fields of science.

Presented work deals mainly with the radiation resistance of components for energetic particles detection, namely SiPM detectors and scintillators in Projectile Spectator Detector (PSD).

The thesis is divided together with the introduction and conclusion into ten Chapters which include an overview and analysis of the current state of the issue. The text also contains an extensive research section on the current state of the problem. Together with large experimental work it finally contains conclusions and suggestions for further research and development. Lists of used references and own publications are natural part of the thesis.

a) The topicality of the topic of the work

The Compressed Baryonic Matter (CBM) experiment at the Facility for Antiproton and Ion Research (FAIR) can serve as a good example. Within this experiment the phase diagram of strongly interacting matter at neutron star core densities under laboratory conditions is investigated. It is a fixed target heavy-ion collision experiment operating in the medium energy range, i.e. 2 – 11 AGeV for gold ions. Projectile Spectator Detector (PSD) reconstructs the collision centrality and reaction plane orientation from the energy distribution of non-interacting nucleons and fragments emitted at very low polar angles in the forward direction. It is a compensating lead/scintillator hadron calorimeter with a light readout via wavelength shifting (WLS) fibers coupled to Silicon Photomultipliers (SiPM). The expected high radiation load becomes one of the challenges in the design of the detector. The thesis focuses on the evaluation of the PSD radiation hardness. Results are of high importance for PSD functioning and further developments.

b) The methods of processing for the work

The dissertant demonstrated appropriate knowledge in the field, selected appropriate methods of solution which he successfully used in the work on the project set goals. The work contains a sufficient amount of original results related to current issues.

c) Fulfilling of dissertation goals

The goals are set in the introduction part. The author has participated in a number of experiments in several top foreign and Czech laboratories. The author performed a detailed investigation of the radiation hardness for the Projectile Spectator Detector. Presented experiments produced several unique observations. One of them is e.g. the improvement of radiation hardness with the reduction of SiPM pixel size. Another unique observation is the evaluation of the dependence of the calorimeter energy resolution on fluence achieved by SiPMs.

d) The results and the scientific contribution of the work

Scientific level is documented by the author's publications and international cooperation. The author presented the data discussed in his work on 9 international conferences, and 15 internal meetings organized by CBM and HADES collaborations, and by FAIR-CZ project. He is the main author of 8 articles and proceedings in peer-reviewed journals, including two articles in journals with impact factor > 1. He is co-author of 11 other articles and proceedings in peer reviewed journals published by members of PSD team, CBM and HADES collaborations.

The thesis is written in English language and is at good level. Very low number of small typing errors do not affect the overall quality of the work. The division of the work is logical and contains the necessary research, theoretical and experimental parts, evaluation of the results, used literature and other required formalities.

On the formal side I have no comments that would be of a serious nature.

To author I have only a few questions that can be answered in the defence:

1. Could you describe in more detail how the impact of multiple photons on one SiPM pixel will affect linearity?
2. What do you think about the applicability of SiPM detectors for direct detection of X-rays?
3. Could you specify your contribution to the preparation and execution of experiments in CERN?

The results presented in this thesis are scientifically sound, and the thesis is well written. Scope of content and form meet the requirements for the dissertation. In conclusion, I believe that this work fulfills the requirements for a Ph.D degree in Nuclear Engineering. I propose to accept the thesis for defense and I recommend the award of an academic degree.

Prague 19.05.2021

Ladislav Pina