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dr hab. Aleksandra Wrońska, prof. UJ
Wydział Fizyki, Astronomii i Informatyki Stosowanej
Uniwersytet Jagielloński
ul. Stanislawa Łojasiewicza 11
30-348 Kraków
aleksandra.wronska@uj.edu.pl

JAGIELLONIAN
UNIVERSITY
IN KRAKOW

Faculty
of Physics,
Astronomy
and Applied
Computer Science

Review and assessment of the doctoral dissertation of Mr. Krystian Rosłon "Particle Detection in High-Radiation Environment: A Case Study of the ALICE – Fast Interaction Trigger at the LHC"

This review has been prepared upon the request of dr hab. inż. Jerzy Antonowicz, chairman of the Scientific Council in Physical Sciences of the Warsaw University of Technology, expressed in the letter dated January 23, 2026. By accordance with the requirements of the Higher Education and Science Act, the aim of this assessment is to determine whether the submitted dissertation fulfills the prerequisites for the conferment of a doctoral degree, which are the following:

1. the doctoral dissertation constitutes an original solution to a scientific problem,
2. the dissertation demonstrates the candidate's general theoretical knowledge in a given scientific discipline,
3. the dissertation demonstrates the candidate's ability to independently conduct scientific work.

In my report, I will refer to those points.

The thesis presented by Mr. Krystian Rosłon is focused on investigation of the ageing effects of radiation detectors operated in a high-load environment, and their quantitative description and modelling enabling prediction of their future performance. Overall, it comprises 229 pages, the main content being organized in ten chapters (126 pages), complemented by seven appendices (71 pages), a bibliography, lists of figures, tables, and acronyms. The main part is preceded by an abstract presented both in English and Polish, complying to the legal requirements in this respect. The content of the thesis is presented in very good and easily readable English language, and incorporates 71 figures and 26 tables. The figures are carefully thought through and prepared, and significantly facilitate assimilation of the dissertation content by the reader, although in some cases a too small size makes it impossible to read some of the labels. Notably, the dissertation has been prepared as part of the ALICE experiment (A Large Ion Collider Experiment) at the LHC (Large Hadron Collider), CERN.

The subject matter - the ageing effects in the subdetectors of FIT (Fast Interaction Trigger) - and objectives of Mr. Rosłon's doctoral project are very clearly stated in the **first, introductory chapter**, along with the five working hypotheses. This chapter contains also a very clear statement about the Author's contributions to the ALICE experiment and the FIT project, that are elaborated in more detail in Appendix A. **Chapter 2** offers a glance at the ALICE physics program, giving context to the Author's

ul. prof. Stanisława
Łojasiewicza 11
PL 30-348 Kraków
tel. +48(12) 664-48-90
fax +48(12) 664-49-05
e-mail:
wydzial.fais@uj.edu.pl

research. It discusses also particle detection techniques, in particular scintillation and Cherenkov detectors forming the FIT detector, including the photosensors. Detector ageing and its impact on detector performance are discussed in that chapter. The **third chapter** describes briefly CERN and ALICE, while the **following chapter** proceeds with a detailed description of the main subject of study: the FIT detector. The individual subsystems, their readout, calibration, services, and the resulting performance are presented. **Chapter 5** is the heart of the thesis from a physics point of view. It contains the analysis of the FT0 ageing effects based on the ALICE experimental and laser-calibration data, modelling of those effects, and the proposed mitigation strategy for the upcoming Run4. **Chapters 6 and 7** form the engineering part of the thesis – they present the data analysis frameworks (O^2, AGRANA, FIT Detector Toolkit) and the Detector Control System for FIT. They are essential components for operating this detector system. The functions and measurements performed with the FIT detector are described in **Chapter 8**, while the **following chapter** focuses on the performance of the FT0 detector. The thesis is concluded with the **Summary and Outlook** chapter. The main body of the thesis is complemented by appendices, containing (besides Appendix A) numerical values and technical details. While the latter are not critical for following the thesis content, they are certainly useful for the Author's successors, forming a solid documentation basis. The bibliography, containing 176 items, is exhaustive and up to date.

The presented thesis layout and content are logical. I was hesitating, if a more natural chapter order would not be to present the FT0 ageing study in the final (or last but one) chapter, since chapters 6-8 contain the description of tools (both hardware and software) used in that study. However, I accept the Author's choice to separate the physics and the engineering parts and order them accordingly. The thesis has been very carefully edited and was a pleasure to read.

Mr. Rosłon set the following goals for his doctoral project:

1. Quantitative description of the key performance parameters as a function of radiation dose and accumulated anode charge for the FT0 detector, which is a Cherenkov detector read out by microchannel plate photomultipliers (MCP-PMT). These parameters are time resolution and gain.
2. Identification of the dominant physics mechanisms leading to the observed detector ageing.
3. Development of a model, benchmarked against ALICE experimental data, offering predictive power for detector performance.
4. Elaboration of compensation and calibration procedures.
5. Prediction for detector performance in Run4, lifetime of individual modules, maintenance planning.

In my opinion, these objectives have been achieved in Mr. Rosłon's doctoral thesis. The only exception is goal 2. There, the evidence is indirect. However, a direct study would require access to the MCP-PMTs of FT0, which was not possible within the time frame of the doctoral project. Chapter 5 addresses directly the goals 1, 3 and 5, while Chapter 6 presents the methods developed for goal 4. The applied methods were correctly chosen (on the physics side), and expertly implemented and validated (on the software engineering side). They have already found their place in the standard tools and procedures used by the ALICE experiment. On a broader context, ageing model developed by the Author may be useful for other experiments dealing with similar challenges, showing how to account for different effects, like e.g. different collision systems or the presence of background.

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The content of the thesis shows that the Author has broad knowledge of the high-energy physics experimental techniques. His expertise comprises not only a deep understanding of the detector operation principles, but also complex data acquisition and control systems. Given that his engagement in the ALICE experiment started in 2022, the Author's expertise presents a surprisingly high level. I infer it from the number of roles the Author was trusted in the collaboration: ALICE Run Coordinator, FIT Detector Control System Technical Coordinator, FIT (Deputy) System Run Coordinator, and several others. He served also as a FIT on-call expert and FIT DCS expert. He actively participated in hardware interventions in the ALICE cavern, which complements his expertise with hands-on experience.

Although the thesis is to some extent a result of a collaborative effort, Mr. Rosłon very clearly identifies his individual contributions. They are related to the realization of the goals of the doctoral project. Even if he was supported by others, as was the case in the FIT Detector Control System implementation, Mr. Rosłon was the initiator and the coordinator of the implementation.

Having listed the merits of Mr. Rosłon's dissertation, I would pose several questions that occurred to me when reading the thesis and indicate some shortcomings/mistakes/errors. I divided them into two categories based on their importance.

Major issues and questions:

1. Repetitive statements. Although it is common to repeat the key conclusions in research papers, the number of repetitions in the thesis exceeds my personal threshold and, I believe, the standard. Example: second paragraph on p. 101 and second paragraph on p. 103.
2. P. 32: when discussing inorganic scintillators, the Author writes that they provide "faster decay components". Faster than what? Plastic scintillators are unbeatable here, I believe.
3. P. 50-51: For FT0-A, time resolution is stated as sigma (standard deviation), for FV0 it is termed "time resolution" without any symbol, while in section 2.2 the Author uses FWHM. This is somewhat confusing and misleading for the reader.
4. Sections 4.2 and 4.3 are not supported with references.
5. Figure 5.2: x-axis title is ambiguous. Bin value of what? Time, presumably?
6. Eqs. 5.15, 5.16 - if I understand the description above Figure 5.2 correctly, those equations should have different integration ranges. The use of the same symbols is thus confusing.
7. P. 77 The Author states that "both approaches yield comparable orders of magnitude for the accumulated radiation load". Earlier in the thesis, the Author considers corrections on the per-cent level.
8. Figure 5.6: The figure presents the charge distribution (though the axis is not meaningfully labelled again), but the caption reads "The bin width along the horizontal axis corresponds to a single TDC channel, equivalent to 13 ps." Is charge measured using the time-over-threshold method? This is the only way I can understand the content, but it is not stated explicitly anywhere.
9. The statement "Values $\Lambda(k)_{ch}=1$ correspond to stable operation, while $\Lambda(k)_{ch}<1$ indicate a reduction in gain proportional to the accumulated operational exposure." This statement here is premature; it remains to be shown.
10. Figure 5.8: How does the Author explain the increase of Λ in time for selected channels? Is it likely to be a purely statistical effect?

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wydzial.fais@uj.edu.pl

11. Figure 5.9: The data representation has been changed from lin-lin (Figure 5.8) to log-log. What was the motivation for this change?
12. Figure 5.10 shows the evolution of Λ_{ch} for a selected, representative channel. What was the motivation to select a channel that is missing the information for small integrated charge densities? Other channels do have data points in there.
13. P. 90: Two formulae are provided to describe the $\Lambda_{ch}(Q^*_{ch})$ dependence, without any references. Both are applied to the data, and the results from the purely exponential fit are taken as valid due to their smaller spread. A few remarks to the results:
    13.1. How to interpret results with the negative alpha coefficient?
    13.2. Why are the fit errors for the alpha coefficients not provided?
    13.3. What is the reason for a huge spread of the alpha values, even for the exponential fit?
    13.4. A graphical representation of the obtained fit results (histograms of the alpha values) for both models would be desired.
14. P.92, last paragraph of section 5.4. The strong statement that "the observed gain evolution on FT0C is dominated by annealing effects, which partially compensate the charge–driven degradation of the MCP structure." seems a bit speculative without microscopic examination of MCPs. Question: given the higher luminosity in Run4, will the annealing effects still compensate for the ageing effects?
15. Better description of Figure 8.3 is required or a non-insider reader.

Minor issues:

1. Occasional typographic issues ("Chapters 7" on p. 18, "procdure" on p. 96, "charge charge" in Table 8.2, to give a few examples).
2. Footnote 2 at p. 45 is misleading – it can be mistaken for an extra exponent!
3. P. 49, second bullet: the last sentence is almost identical to the first one. Repetition.
4. Units in the table headings should be typed in regular font (e.g. Table 5.1).
5. Tables on p. 71 could be merged for better readability.
6. P. 75 "Each channel is then expressed by..." is a slang expression. Rather "Normalized rate for each channel is then expressed by..."
7. P. 89: The stated precision of uncertainties in Table 5.6 is excessive.
8. Figure 5.13: on the x-axis probably the offset of HV with respect to the nominal value is shown.
9. P. 96, middle: reference to Figure 5.13, although probably meant 5.14.
10. P. 99: "AO2D" neither resolved nor reference given.

While I would be happy to discuss the major issues listed above during the public defense, they do not change my positive assessment of the dissertation and the overall outcome of Mr. Rosłon's doctoral project.

In my opinion, the thesis clearly demonstrated that Mr. Rosłon has become an expert in the physics of radiation detectors and challenges of experimental high-energy physics. This means that **criterion 2** from the initial list has been met. The thesis defines a problem of the FIT detector ageing in ALICE, gives a quantitative model thereof with a predictive power, and proposes scenarios for effect compensation or problem mitigation by the exchange of detection modules most prone to ageing effects due to their location. With this, I consider **criterion 1** to be fulfilled. Mr. Rosłon was also a coordinator and a driving force in the development of the FIT Detector Control System

and its integration with the existing environment. This shows that he is a mature researcher, able to work independently, thus **criterion 3** is met as well.

The Author's developments presented in this thesis resulted in four journal papers, where he is the first author. Two of them, however, are still under review (see Publication list on p. 19, items 1 and 2), and of the other two only one was published in a journal included in the Journal Citation Report (item 3). As the Author does not list his conference presentations, I am not able to assess his visibility. Thus, although my overall assessment of the thesis and the Author's achievements is very positive, I must state that, regretfully, the Author is not eligible to obtain distinctions for his thesis, according to the criteria I was informed about by the Chairman of the Scientific Council in his letter.

Summing up, I consider the doctoral thesis of Mr. Krystian Rosłon to be a valuable contribution to the field of radiation detectors physics and to meet both the substantive and the formal criteria prescribed by the law for a doctoral dissertation. Therefore, I request that this dissertation be admitted to a public defense.

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