

SUPERVISOR'S REPORT ON PH.D. THESIS

Author: Ing. Marek Sommer

Title: Detection of Cosmic Radiation in the Atmosphere and Radiation Induced in Thunderclouds

Actuality and novelty of the research topic

Cosmic radiation at flight altitudes of commercial aircraft forms a mixed radiation field which is sometimes further affected by high-energy gamma and neutron radiation from thunderstorms, so called terrestrial gamma-ray flashes (TGFs). Composition and intensity of the radiation field change in space and time. The Directive 96/29/ Euratom in 1996 and its implementation in the Czech national legislation in 1998 mandated the obligation of air travel providers to make estimates of personal doses of aircraft crews if such doses could exceed 1 mSv per year. The methods were evaluated using calculation codes and have been implemented in the routine dosimetry of aircraft crew in the Czech Republic by our group at the Nuclear Physics Institute of the CAS, Department of Radiation Dosimetry. We have monitored the annual effective doses of aircrews since 1998 using CARI-7 code. However, it is known that the calculated doses need to be validated by measurements because they may be subject to major uncertainties caused by the complexity of the radiation field. This problem is recently reflected by the ISO standard 20785-4:2019 Dosimetry for exposures to cosmic radiation in civilian aircraft — Part 4: Validation of codes. This norm supports the relevance and actuality of the first topic of the dissertation, i.e. the need to validate codes used for aircrew radiation monitoring by measurement. The novelty of this research topic is in the selection of a dosimetry method. Our group has been performing long-term measurements with the Liulin (PIN diode) detector onboard aircraft since 2001 and with the Airdos (also PIN diode) detector onboard several aircraft since 2017. However, from time to time we also perform special flights focused on intercomparison of dosimetry methods used by several groups over the globe and these measurements show high uncertainties of the frequently used silicon detectors. Marek Sommer therefore chose and developed the detector based on a plastic scintillator, which has not yet been used for onboard aircraft radiation measurements. It contributes to more accurate measurements of personal aircrew doses since the plastic scintillator is closer to tissue and better evaluates doses from neutrons.

The dissertation thesis is also involved in the topical theme of TGF detection via accompanying neutrons from thunderstorms which undoubtedly belongs to one of the contemporary key subjects of high-energy atmospheric physics. Author proposed, designed, participated in development, and tested a new neutron detector for registration of terrestrial gamma ray flashes. Actuality and novelty of the research topic was completely fulfilled.

Research methods and procedure

The author's approach to achieving the set goals was methodical, where an analysis of the current state of the problem is carried out, followed by the problem formulation, proposing its own solution and formulation of conclusions, in several logically connected areas. The author's ability to directly connect theory (use of literature review and Monte-Carlo simulations) with practical solutions (design and development of new detectors, and performing experiments with them) should be highlighted.

Quality of literature review

There are two literature reviews in the dissertation thesis: the first is about cosmic radiation and dosimetry onboard aircraft and the second is about high-energy atmospheric phenomena. Both are well done, documented and cited.

Formal layout of the doctoral thesis and the level of language used

The thesis has a high formal standard. The structure in a sufficient way follows recommendation for doctoral thesis. All used sources are cited correctly according to the citation norm.

A few words about the work attitude of the author

Marek Sommer represents a very strong support to our team at the Nuclear Physics Institute of the CAS, e.g. in the current year, he is our most active author of publications (first author of 4 articles, co-author of another 2, see the list of publications). In addition, he received a prestigious award - the Henri Becquerel prize. According to his design, a stationary neutron detector enabling the detection of TGF was assembled and placed on Lomnický štít observatory in High Tatras - Slovakia. Two other Airwatch hybrid detectors including his plastic scintillator, which he also designed and built, have been collecting data aboard ABS Jets aircraft for several months. He also participated in other experiments at accelerators HIMAC, CERF, Microtron etc. He is currently involved in two projects: CRREAT funded by EU funds (Research Center for Cosmic Rays and Radiation Events in the Atmosphere) and LVICE2 funded by ESA (preparatory phase of the first Czech space satellite into cislunar space). The BICZEPS project, in which he participated for two years, was successfully completed in June 2022.

Marek is a team worker but, as well, he evaluated his Ph.D. thesis individually. He also communicated well with me as his supervisor. He is a capable young researcher, developer, and electronics engineer.

I am very satisfied with the results of his work. After the completion of his PhD studies, his 6-month postdoctoral internship in France at IRSN is arranged.

Applicability of the results in practice

Most of the author's results were raised and also were used in the basic research in the CRREAT project mentioned above (continuous radiation measurements onboard aircraft using the plastic scintillator detector and TGF detection at Lomnický štít observatory in summer and in Japan, Kanazawa, in winter). His work on plastic scintillators was used also in the Czech utility model 36353 "Linear energy transfer spectrometer" of which he is a co-author. Continuous Radiation measurements using his neutron detector is an important part of the new international project BIOSPHERE.

Overall Assessment

According to my opinion and professional experience, the presented work as a whole perfectly satisfies basic requirements for dissertations in the particular area. The author has demonstrated his abilities to focus on an important research topic and to correctly address scientific problems (improve radiation dosimetry onboard aircraft and detect neutrons from thunderstorm radiation), proposed possible methods of its solution by selecting the methodological approaches (plastic scintillator for aircraft measurements and liquid scintillator for neutrons from thunderstorm radiation), performed the solution by designing and developing new detectors, and tested them in relevant conditions.

Summing up, I certify that Marek Sommer's thesis represents an original, valuable contribution to knowledge and that it clearly and accurately describes the work performed. I am convinced that the student is able to communicate his scientific efforts to others with a high degree of skills. All five goals defined for this work were achieved. For these reasons, I recommend that after the defense of the thesis he will be awarded a Ph.D. degree.

In Prague, December 8th, 2022

Ing. Ondrej Ploc, Ph.D.
Nuclear Physics Institute of the CAS
Department of Radiation Dosimetry
Na Truhlářce 39/64, 180 00 Praha, Czechia