



NUCLEAR PHYSICS INSTITUTE

The Czech Academy of Sciences

Dissertation supervisor's report

Title of the Thesis: *Influence of Cosmic Rays on Ionization in the Atmosphere during Thunderstorms*

Author: Ing. Jakub Šlegl

Supervisor: Ing. Ondřej Ploc, Ph.D.

Field of Study: Nuclear Engineering

The dissertation of Jakub Šlegl focuses on the influence of cosmic rays on atmospheric ionization during thunderstorms, including its interaction with the Cloud Electrification Model (CEM). This is a highly topical and technically demanding subject that intersects multiple disciplines—from atmospheric physics and meteorology to the dosimetry of ionizing radiation. The phenomena studied, involving high-energy processes in the upper atmosphere during thunderstorms and their connection to cosmic rays, remain insufficiently understood, and new findings in this area are therefore of great scientific value.

In his work, the author has employed a combination of advanced modeling and experimental methods. For the calculation of ionization induced by galactic cosmic rays, he used the CRAC:CRII model. Furthermore, he performed Monte Carlo simulations using the PHITS code. A major contribution of the dissertation is the development of a new model called CRIT (Cosmic Ray Ionization of Thunderstorms). This model connects the influence of cosmic rays with cloud electrification processes and enables detailed analysis of ionization within thunderstorm clouds. The model was subsequently validated using data from SEVAN detectors and the RT-56 gamma-ray spectrometer, with measurements performed at various observatories, including Milešovka and Lomnický Štít. The results were also correlated with meteorological data.

The dissertation set ambitious goals, which were successfully achieved. The author developed the new CRIT model, which expands the existing CEM model by incorporating the effect of cosmic-ray-induced ionization, compared simulation results with experimental data, and thus contributed to a deeper understanding of thunderstorm activity.

The results of the dissertation have high scientific value. They have been partially published in peer-reviewed journals, including *Atmospheric Research* and, more recently,

Atmospheric Chemistry and Physics, and were presented at international conferences (e.g., AGU Fall Meeting, San Francisco, USA, 2023). The research is significant both for fundamental science and for applications in dosimetric and meteorological modeling. Moreover, the author has been actively involved in international projects such as CRREAT and BIOSPHERE.

This is the second submission of the dissertation—the author has thoroughly addressed all comments from the previous review, expanded the methodology sections, improved the presentation of results, and corrected formal deficiencies. The dissertation now fully meets all requirements for a high-quality doctoral thesis.

The dissertation fulfills the demanding criteria for a doctoral degree. Jakub Šlegl has demonstrated independent scientific thinking, professional competence, and research skills. I recommend this thesis for defense.

Prague, May 22, 2025

Ing. Ondřej Ploc, Ph.D.
Nuclear Physics Institute, Czech Academy of Sciences