

Report of the evaluation of the thesis entitled "Detection of Cosmic Radiation in the Atmosphere and Radiation Induced in Thunderclouds" by Marek Sommer

Evaluator: François TROMPIER (Researcher at IRSN, France)

Topic of the thesis

Two different subjects are studied in the framework of this thesis (measurement of cosmic rays on the one hand and TGFs on the other) but with in common the proposal to use a measurement approach based on the use of scintillators alone or in addition to silicon detectors. This last approach is an original approach to address the difficulty of measuring at altitude, especially in monitoring campaigns. The thesis is not limited to the development of the instrumentation alone, but includes a very important work of characterisation and calibration, requiring an in-depth reflection on the phenomena involved. The aim was to propose two measurement approaches to respond to two problems identified for the study of solar phenomena on the one hand and terrestrial gamma-ray flashes on the other. The subject of the thesis is perfectly relevant and justified.

General comments on the thesis

This thesis is very comprehensive because, although it is mainly concerned with the development of measurement instruments and the exploitation of the data produced, it nevertheless requires a wide range of skills, from the mastery of spectrometry techniques to signal analysis and numerical simulation. Moreover, the thesis does not only cover the development of the instruments but also their implementation with examples of applications and measurements obtained in the field, which is very remarkable in the time available for this thesis. The structure of this thesis is not classical compared to science theses written in France, generally based on a classical article structure. In the absence of knowledge of the requirements of the doctoral school, I cannot therefore comment on the form. However, the format remains pleasant to read and the organisation is logical and does not hinder comprehension. Appendices could have been provided to elaborate on certain paragraphs. The work described is well justified by a thorough study of the literature and a perspective on the issues and difficulties related to this theme.

Evaluation of the methods used/proposed in the thesis

The measurement methods proposed in this thesis are not in themselves original, but the originality lies in the coupling of complementary methods and in the methods proposed to calibrate the devices and analyse the data produced.

Scientific values of the obtained results

This thesis allowed the development of two measurement approaches for two different applications with particular attention paid to characterisation, calibration and data analysis. Measurements in situation could thus be produced. For the "GLE" part, the validation

consisted in successfully measuring the galactic component on several flights. This is a first validation step. The next step would be to collect more data by continuously installing the device on an airliner to obtain data in different altitude and latitude conditions. It is obvious that if measurements are made during a GLE, additional work will be required to analyse the data. It is very appreciable that the sensor has been put into the situation of the intended use, which is already very remarkable in the time of the thesis.

For the second approach, instruments were installed on site, but due to the low occurrence of the studied phenomena, only the results related to the characterization are presented, which is already remarkable. These results give a good understanding of the capabilities of the instrument which seem to be in line with the physical parameters of the phenomena to be measured.

Specific comments and remarks

Many technical details and results from scientific publications are not given directly in the text, but simply referred to a reference. This sometimes hinders the understanding of the document and requires access to the cited articles. The text is sometimes not self-supporting enough. This is certainly a choice to make the document concise. But in the end, considering the amount of work done, one can only welcome this fine work of synthesis.

For the first part, in paragraph 4.5, it would have been desirable to clearly show the gain of this approach compared to the sole use of Si and compared to the performance of TEPCs, which remain the ideal detector but difficult to use for monitoring campaigns. Indeed, the approach still requires a certain number of assumptions on the quality factor or the neutron spectrum. As the neutron component can be different in the case of a GLE from that of the galactic component and from one GLE to another, a more in-depth discussion on the limits and contributions of the technique would have been appreciated.

For the second part, the choice of the type of scintillator would have required a little more justification in relation to what is done in the literature and to the specific needs of the topic.

The possibility of tracing the incident neutron spectrum by deconvolution methods, which is a priori possible for at least one segment of the energy spectrum (fast component), would have deserved to be discussed and presented in perspectives. Knowledge of the energy spectrum is essential for neutron dosimetry and for understanding the mechanisms involved in neutron production.

The second part focuses on the measurement of TGFs at ground level. These are so-called inverted TGFs, which are a priori quite rare, whereas TGEs are much more frequent. It seems that the proposed detector is able to measure both. So why limit the application to TGFs? The acronym TGE is still controversial, why not just mention the "Gamma-rays glows" which are widely mentioned in the literature. Is there a difference between these phenomena?

Mistyping to be corrected Page 72: Gaiger-Müller

Overall evaluation of the thesis and recommendations

A very large amount of work has been done in the framework of this thesis, which required Marek Sommer to acquire skills in various fields (numerical simulation, electronics and instrumentation, fundamental physics), which makes it a very complete and remarkable work. The manuscript as it stands gives a synthesis of all the work done, which in view of the amount of work done is also very remarkable. In this thesis two instrumentations have been developed, characterized with the proposal of data analysis methods and a setting of the detectors, which again is remarkable especially for the duration of a thesis. This very complete and successful thesis work is well worth supporting for the doctoral degree.