MUNI

Příloha č. 11 směrnice MU Habilitační řízení a řízení ke jmenování profesorem

POSUDEK OPONENTA HABILITAČNÍ PRÁCE

Masarykova univerzita	
Uchazeč	RNDr. Zdeněk Matěj, Ph.D.
Habilitační práce	*Spectrometric systems for mixed field of gamma radiation and neutrons*
Oponent	doc. Mgr. Milan Krtička, Ph.D.
Pracoviště oponenta, instituce	ÚČJF MFF UK v Praze

Viz příloha

Závěr

Habilitační práce Zdeňka Matěje „*Spectrometric systems for mixed field of gamma radiation and neutrons*“ ***splňuje*** požadavky standardně kladené na habilitační práce v oboru Informatika.

Praha dne 9.6.2020

Report on habilitation of Zdeněk Matěj

The applicant is a member of a group which specializes in the determination and/or verification of the spectrum of gamma rays (γ) and neutrons in the so-called mixed fields, i.e. in places where both these particle types are present. These particles can be found in the vicinity of many nuclear facilities and it is important to know their intensity and energy spectra. Measurement of these quantities is challenging especially for neutrons. The applicant is in the group evidently responsible for the development of the spectrometric system, used for measurements of these particles, that consists of a detector, electronics that transports and transforms the signal coming from the detector, and the software used for on-line or off-line signal analysis.

As it is difficult to find a material sensitive only to neutrons but not γs, both particles are typically measured simultaneously with one (scintillation) detector and neutrons and γs are identified using the so-called pulse-shape-discrimination method. This method (traditionally used for decades) allows – usually with the exception of low energies deposited in the detector – identification of particle type from the "shape" of the signal which results from different physical interaction of neutrons and γs in the detector. Further, the knowledge of energy spectrum of individual particles, especially neutrons, is usually of a great interest. Due to the nature of interaction of the particles with matter (detector), obtaining their (especially neutron) energy spectrum is a non-trivial task as the energy deposited in the detector is only a fraction of the initial particle energy and the efficiency of the detector for different energies also plays a role. The papers enclosed to the habilitation indicate that the original neutron spectrum is typically determined using previously proposed method based on the Maximum-Likelihood estimator.

The applicant has developed (or at least significantly contributed to the development of) a detection system, which is based on Stilbene organic scintillator detector (highly sensitive to fast neutrons), in conjunction with a "classic" photomultiplier, digitizer and analysis software. A special interest during the system development was paid to its performance in "harsh" conditions of a high count-rate (with hundreds of thousands detected particles per second). Operation of the detection system in such a high count rate allows short measurements, however, precise information on energy distribution of particles is difficult to obtain.

The applicant discusses various aspects of the spectrometric system. He is clearly not only an author of the analysis software but participated also in some adjustment of the hardware. He specifically mentions that he developed a new voltage divider for the photomultiplier, which allowed better energy resolution of the system. However, he mainly contributed to the development of the analysis software. Although it is difficult to compare the performance of the system to other available ones as well as the quality of algorithms implemented, the habilitation shows that the system has been successfully used in several high-quality physical measurements, which is demonstrated by a number of papers (enclosed to the habilitation). The spectrometric system thus must show a very decent performance which is undoubtedly the merit/credit of the author. The author showed ability to participate in development of the spectroscopic systems. However, the software uses "standard" algorithms and I, as a nuclear physicist, am not really able to assess the complexity of the work needed for preparation of the software.

I have read the habilitation carefully but I have not found answers to the following questions, which seem interesting to me:

- Is the applicant the only author of the software that comes with the hardware? Can the system be used in different experiments without a special tuning that requires assistance of the applicant, or, in other words - could the tuning be easily performed by a "relatively-unexperienced" user?
- Is the software written by the applicant restricted for use with the Stilbene detector adjacent to one specific photomultiplier (and ADC)? How universal is the developed active high-voltage divider and does the software allow a user to apply different voltage to different dynodes of the photomultiplier?
- The system has so far been used on facilities in the Czech Republic. Is there any plan for its use outside the country?
- Finally, in the last section of the introductory/accompanying text the applicant mentions further development of a spectrometric system that would allow determination of spectrum of neutrons with lower energies. He says: "Thanks to the knowledge we gained from our research we continue to develop our own liquid and plastic scintillation materials. This material provides us with new research opportunities in the radiation mixed fields." I am not sure what the "development" means here – testing or preparation of such a material? This should be specified precisely. The text seems to indicate that the author really participates in the "development" of a new (scintillation) material. However, it is difficult for me to believe in this as this is a task for material science physicists and/or chemists.

In addition to questions posed above – that are related to the main subject of the habilitation - I have a number of reservations about the formal part of the text. Specifically

- The English used in the introductory/accompanying text to the articles is really far from being perfect.
- The introductory/accompanying text is divided into three different sections and a few subsections but I had problems to understand this division. It seemed to me that the author lists the subjects of individual published papers, together with a specification of his contribution, but I have not found any reasonable pattern in this list/division.
- There are several typos in the text and some sentence are very difficult to understand (probably due to missing words). For instance, in the beginning of Sec. 3, the sentence says: "Enhancement of the spectrometric systems shows an important step in improving the functionality of the spectrometric system Figure 3.1 and of its parts."
- It is sometimes very difficult to understand the exact meaning of presented figures. I would expect a bit more precise description of what is shown in the figures. For instance,
    - Fig. 2.3, with the figure caption "The output after filtration and separation algorithms" shows two signals with a few "time stamps". However, meaning of these time stamps is not clear at all. I would say that they are not explained even in the main text.
    - Fig. 3.2, with the caption "Spectrum - demonstration (red line) of problematic areas in the separation of individual areas of the spectrum (two separate „trousers"). At this point it is not possible to separate the other parts of the spectrum.", shows a screenshot of the analysis software (similar to Fig. 2.4) with a few lines and a point in the 2D spectrum. The caption seems to indicate that problematic separation appears either "on the horizontal line" or "below" it (where the two trousers are observed). However, the separation is surely problematic in the region "above the red line".

- Fig. 3.1, the caption "NGA-01 spectrometric system", shows a digitizer, which is likely only a part of the whole spectrometric system. Or does the "box" in the figure contain not only the digitizer but also other components (high-voltage source for the photomultiplier,...)?
- The caption of Fig. 2.1 says "The output signal form the spectrometric detector.". First, there is a typo "form"->"from". Second, it is a signal either from the photomultiplier or from the (pre)amplifier and not from the "detector"...

- The applicant talks about "the system", at least in the introductory/accompanying text. He never mentions its name. However, some of the papers refer to the NGA-01 spectrometric system which seems to be commercially available via "VF Nuclear" company. Does it mean that the applicant participated in the development of this system? I am a bit confused as In Sec. 3 the author also talks about FD-11 spectrometric system.
- Many sentences seem to be not sufficiently "accurate/precise" to me. For instance, on page 14, the text says: `"Based on these measurements the analog parts of signal wires were adjusted"`. I am not sure what the exact meaning of `"analog parts of signal wires"` is. The author probably refers to the part of the spectrometric system before the ADC. However, the sentence might mean that the high voltage was adjusted on the dynodes of the photomultiplier, some adjustment was performed at the level of the amplifier, or something else. In the next sentence the author says `"My contribution was in the research of the analog technologies and ..."`. The meaning of this text is likely similar to the previous sentence but I am lost even more here.

To conclude, although the applicant's professional level seems to be sufficient for achieving the associate professor degree, I really think that the habilitation should have definitely been prepared more carefully.

Prague, June 9, 2020