

# REVIEW

by Prof. Dr. Vanio Tcholakov

Scientific specialty: 4. Natural Sciences, Mathematics, and Informatics, professional field  
4.1. Physical Sciences (High energies and elementary particles physics), Retired

on the materials submitted for participation in the competition for the academic position of  
"Associate Professor" at Plovdiv University "Paisii Hilendarski"

in the field of higher education: 4.1. Natural sciences, Mathematics and Informatics  
professional field: Physical Sciences (Physics of microcosm, high energies and elementary  
particles)

## 1. Information about the competition

In the competition, announced for the needs of the Faculty of Physics and Technology at Plovdiv University "Paisii Hilendarski" in the State Gazette, issue 98/19th of November 2024 and on the internet page of Plovdiv University "Paisii Hilendarski", only one candidate has submitted documents for participation: **Mariana Filipova Shopova, PhD.**, holding the academic position of "Chief Assistant Professor" in the "Educational technologies" Department of the Faculty of Physics and Technology (FPT) at Plovdiv University "Paisii Hilendarski". I am appointed as a member of the scientific jury for this competition according to Order № RD-22-96/17th of January 2025 by the Rector of Plovdiv University "Paisii Hilendarski".

## 2. General presentation of the materials submitted for the procedure

The set of materials submitted by Ch. Ass. Prof. Mariana Filipova Shopova is **in accordance with the requirements** of the Regulations for the Development of the Academic Staff of PU "P. Hilendarski" and includes the following documents: 1) application form to the Rector of PU "P. Hilendarski" for admission of participation in the competition; 2) curriculum vitae in the European format; 3) a higher education diploma with an acquired educational and qualification degree "master"; 4) a diploma for an acquired PhD degree; 5) a list of the scientific works; 6) the scientific works; 7) a list of the citations; 8) certificate of compliance with the minimum national requirements; 9) annotations of the materials under Art. 65 from the Regulations for the Development of the Academic Staff of PU (in Bulgarian and English) with extended habilitation certificate; 10) self-evaluation of the contributions (in Bulgarian and English); 11) statement of originality and authenticity of the attached documents; 12) work experience certificate; 13) documents for educational work; 14) documents for scientific research; 15) documents in accordance with the additional requirements of the FPT; 16) other documents.

The candidate, Mariana Filipova Shopova, PhD, participates in the competition with **18 scientific publications**, which do not repeat the scientific publications submitted for the academic position of Chief Assistant Professor, nor those submitted for the acquisition of the PhD degree. All of these scientific works are published in referenced and indexed in the scientific information databases Web of Science and Scopus journals, with **a total IF of 42.17** and a total number of **80 independent citations**. As an equivalent of a **habilitation thesis**, i.e.

according to the indicators of group V, **7 scientific articles** are identified (2 are published in first quartile journals (Q1) and 5 are published in second quartile journals). According to the **indicators of group G, 11 scientific articles** are presented – 6 are published in first quartile journals and 5 are in second quartile journals. The applicant's points for indicator **groups V and G**, related to the publication activity, are **150 and 250**, respectively. For comparison, the minimum national requirements for indicator groups V and G correspond to 100 and 200 points. Mariana Shopova's **points for indicator D**, related to the citations of her scientific works, are **160**, while the minimum national requirements for this indicator are 50 points. According to Scopus, Mariana Shopova, PhD., had an **h-index of 117**.

**The publication activity** of Dr. Mariana Shopova **fully satisfies** the minimum requirements for occupying the academic position “Associate Professor” in the Faculty of Physics and Technology of the PU, and **the number of citations** of her scientific works **exceeds the required ones many times over**.

The main research topics of the candidate's materials submitted for the competition are focused in the field of high energy and elementary particles physics, particle detectors, gaseous detectors, trigger detectors, performance (operation) of high-energy physics detectors, complex detector systems and physical studies with muons in final states.

Documents testifying to the candidate's active and multifaceted educational activity, as well as those certifying Mariana Shopova's contributions to affirming and raising the prestige of the department, the faculty and the university are also submitted.

The submitted materials are very well arranged and carefully described, which gives a clear idea of the overall scientific research and teaching activity of the candidate.

### **3. Brief biographical data about the candidate**

Dr. Maraina Shopova was born in 1987. She is a graduate of PU "P. Hilendarski", from which she graduated with a Bachelor's Degree in Engineering Physics (2010) and two Master's Degrees – in Applied Nuclear Physics (2012) and Photonics and Modern Optical Technologies (2013). In 2018, Mariana Shopova defended her dissertation entitled “PERFORMANCE OF THE CMS RPC SYSTEM – FROM LS1 UPGRADE TO RUN2 AT LHC” at the Institute of Nuclear Research and Nuclear Energy – BAS for the award of the PhD degree in professional direction 4.1. Physical Sciences (High energy and elementary particles physics). In 2016 Mariana Shopova was employed as an assistant professor, and since 2019 till now, she holds the position of “Chief Assistant Professor” at FPT at PU "P. Hilendarski”.

After the defense of her dissertation (2018), Mariana Shopova, PhD has continued her research on high energy and elementary particles physics and in particular in detector physics and gaseous detectors in the Institute for Nuclear Research and Nuclear Energy – BAS, where she works as a physicist (since 2019). For her scientific work in the field of high energy and elementary particle physics, in 2020, Dr. Mariana Shopova was nominated by ELSEVIER for the prestigious PITAGOR awards for science (category “Women in Science”).

Mariana Shopova, PhD has been a member of the organizational committees of 2 international and 1 national scientific forums, as well as all international CERN masterclasses (using CMS data) held in Bulgaria from 2018 till now (28 events). She is a member of the team of CERN Bulgarian teachers program. Currently, she is a member of the attestation committee in the FPT at PU, a representative of the university in different working groups in Bulgarian Ministry of Education, as well as the non-political organization of Bulgarian Atomic Forum (BULATOM). Since 2019, Mariana Shopova is the Head of the “Isotope Laboratory, Biophysics Laboratory and RAS Storage“ facility at PU “Paisii Hilendarski”.

Dr. Mariana Shopova is a member of the international scientific organization “European Organization for Nuclear Research – CERN” and the national scientific organization “Union of the Physicists in Bulgaria (UPB)”. From 2019 to 2024, she was the representative of Bulgaria in the Early Career Researchers Panel (ECR Panel) of the European Committee for Future Accelerators.

Within the international CMS collaboration, Mariana Shopova, PhD., is coordinator of the RPC Conference and Publications Group, as well as deputy of the RPC Detector Performance Group. She is also the contact person of the RPC system within the CMS Muon Conference and Publications Group.

#### **4. General characteristics of the candidate’s activity**

##### **4.1 Characteristics and assessment of the candidate’s teaching activity**

The teaching activity of Mariana Shopova, PhD covers training in Bachelor’s and Master’s Degrees.

For the last six years, the candidate is the author of the study programs of **8 study disciplines** (3 – for the Bachelor’s Degree and 5– for the Master’s degree), related to the subject of the competition “Physics of microcosm, high energies and elementary particles” and intended for students studying at the Faculty of Physics and Technology and Faculty of Chemistry (FCh) at PU “P. Hilendarski”:

- for the Bachelor's Degree: 1) Physics of Microcosm (*mandatory*); 2) Atom Physics (*mandatory*); 3) Nuclear physics (*mandatory*); 4) Ionizing radiation technologies (*mandatory*).
- for the Master's Degree: 1) Physics of Microcosm (*mandatory*); 2) Atom and Nuclear Physics (*mandatory*); 3) Radioecology (*mandatory*); 4) Dosimetry and Radiation protection (*mandatory*).

In addition to the academic disciplines listed above (both seminar and laboratory classes), Ch. Ass. Prof. Mariana Shopova has been conducting seminar classes in Mathematics 1, as well as laboratory classes in Radiation physics, Dosimetry and Radiation protection, Mechanics and Physics 1 studied in the FPT at the PU.

The candidate is **the author of 6 e-learning courses** intended for the students studying in undergraduate specialties of the FPT and FCh at PU “Paisii Hilendarski” **and co-author of the e-learning courses “Radiation Physics” and “Dosimetry and Radiation Physics”**, conducted jointly with university professors from the Faculty of Physics at SU “St. Kliment Ohridski” and intended for the Master's specialty in English “Medical Physics”.

Mariana Shopova, PhD, has been **the supervisor of 6 successfully defended diploma theses** (for Bachelor's degree) and **the reviewer of 7 diploma theses** (both for Bachelor’s as well as Master’s degree).

Dr. Mariana Shopova is actively participating in various physics outreach events.

The teaching activity of Ch. Ass. Prof. Mariana Shopova reflects her quest on thorough preparation and following the modern trends in training. She is well-respected professor, both by her students and her colleagues.

##### **4.2 Characteristics of the candidate’s scientific research activity and scientific achievements**

The research interests and works of the candidate are in the field of experimental High Energy and Particle Physics - particle detectors, gaseous detectors, trigger detectors, complex detector systems, performance (operation) of high energy physics detectors and physical studies with muons in final states. Dr. Mariana Shopova’s scientific work is related to the CMS Collaboration at LHC in CERN, as she is a member of the collaboration since 2012.

The **18 scientific articles**, submitted for participation in the competition, published in the period 2019 – 2024, are in the field of High energy and Elementary particles Physics and fully correspond to the scientific specialty for which the competition is announced.

The presented publications for participation in the competition for the academic position of “Associate professor” are grouped according to the following criteria – V4 and G7:

- Following the **V4 criteria: Habilitation thesis** – scientific works, published in journals referenced and indexed in the scientific information databases Web of Science and Scopus – **7 papers**;
- Following the **G7 criteria**: scientific works, published in journals referenced and indexed in the scientific information databases Web of Science and Scopus, outside the Habilitation thesis – **11 papers**.

Each of the scientific papers is presented with a short annotation, indexes and an assessment of the candidate’s personal contribution.

The main scientific contributions in the scientific publications submitted for participation in the competition can be summarized as follows:

➤ **Performance and stability of the CMS muon system and RPC system**

Publications [V4-1], [V4-2], [V4-7], [G7-2], [G7-3], [G7-4], [G7-5] and [G7-6] report the results of the detector analysis and monitoring of the RPC system, while its contribution to the CMS L1 trigger is reported in [V4-6], and the details of muon reconstruction and triggering are reported in [V4-7].

The overall contribution of the muon system in recording a sufficiently large volume of good quality data for different physics analysis and obtaining correct results is reflected in [G7-8], [G7-9], [G7-10] and [G7-11], as well as in other CMS analyses involving muons in the final states.

One of the main methods to obtain and evaluate the performance and stability of the RPC system is the segment-extrapolation method, where the segments of reconstructed hits in several detector layers from adjacent muon detectors, DT in the central and CSC in the closing parts of the system, are extrapolated to the plane of the corresponding RPC chamber and matches are searched for locally reconstructed clusters of simultaneously triggered signal electrodes (strips) of the RPC.

The software package allows not only to determine the performance of the chambers, but also to estimate the timing synchronization with the LHC collisions, the populations of the chambers with hits, to estimate the size of the formed clusters and other essential information. Results based on this method are shown in [V4-1], [V4-2], [V4-7], [G7-2] and [G7-4].

The segment-extrapolation method and the associated software are the main tools for the analysis of data collected in so-called calibration datasets - special datasets where the aim is to determine the optimal operating points of the detectors. For the RPC system, the most important and basic ones are the High Voltage Scan, which are conducted once or twice every year in search of the optimal operating voltage of the detectors. The results of such a survey are reported in [G7-5]. Another calibration study is the discriminating voltage threshold scan applied to the detector electronics, the so-called Threshold Scan, presented in paper [G7-3].

There are other methods for analyzing the performance and stability of the RPC system, such as the Tag-and-Probe method described in [G7-6]. This analysis requires a much larger volume of data compared to the segment-extrapolation one and is therefore conducted less frequently, usually at the end of several years of data set. The comparison between different detector analysis methods provides a good basis for confirmation of the good detector performance based on the obtained results.

*Dr. Mariana Shopova's personal contribution in these papers is mainly in the data analysis; timely reporting of problems encountered in the course of work with the software for RPC system performance analysis, as well as other software packages within CMSSW, responsible for processing of the RPC data; coordinating individual detector analysis tasks; in processing data and bringing it to a final result, and also in training and mentoring new colleagues.*

➤ **CMS Muon Trigger and RPC system Trigger**

Details on the trigger operation of the RPC system during different periods are shown in [V4-1] and [V4-6]. The trigger system of the CMS experiment consists of two levels, a hardware level, L1, and a complex set of software algorithms and computational resources, HLT. The first phase of the upgrade of the muon L1 trigger at the beginning of the LHC Run-2 period (2015-2018), i.e., Phase 1, was a necessary step to handle the increased event flux following the increase in collision energy from 8 TeV to 13 TeV and the increased intensity of interactions. To accomplish this, the entire event selection logic was fundamentally changed. The local hardware triggers, associated with each of the muon sub-systems were replaced by a new type of logic that combines the information from all the muon detectors in a specific region by pseudo-speed and based on this, generic trigger primitives are formed and sent for further processing to the muon search algorithms, the so-called Muon Track Finders, whose logic is programmed on special field-programmable gate array (FPGA) integrated circuits in the trigger electronics. Depending on the area, the muon system uses three different algorithms, and the RPC system provides information to each of them. Some of the results in publications [V4-1] and [V4-6] were obtained using the segment-extrapolation method.

*Dr. Mariana Shopova's personal contribution is in the analysis of the source data used for reconstruction and also in ensuring good quality of the recorded data and robust performance of the RPC system, in addition, she is the main editor of the text for the RPC system of [V4-1].*

➤ **Longevity studies on the present CMS RPC system**

The latest results from a comprehensive and long-running study (which is ongoing) on the reliability and longevity of the current RPC system over the next data taking period, are shown in [V4-1] and [V4-5]. Two test chambers were subjected to prolonged irradiation with a caesium source of 13.5 Tbq activity, the aim being to accumulate as much charge in the chambers as they would have received after HL-LHC was completed, in other words, after a volume of collected data of 3000 fb<sup>-1</sup>. During particular periods, the main characteristics of the detectors are analyzed and compared to the results obtained from reference chambers that are not irradiated. Using appropriate filters, the magnitude of the gamma flux can be adjusted to match the expected during the HL-LHC.

*The candidate's personal contribution to this analysis has been in participating in the assembly of some of the detectors, the analysis of their operating parameters and the estimation of their lifetimes, as well as providing the good quality of collected data during the different test periods at the GIF++ laboratory at CERN.*

➤ **CMS Muon system Upgrades**

One of the main tasks for the groups, maintaining the detector systems, is the development of new and/or upgraded detectors for the next phase of the LHC (HL-LHC), where the collision energy is expected to reach 14 TeV and the instantaneous luminosity  $5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$  in the base scenario or  $7.5 \times 10^{34} \text{ cm}^{-2}\text{s}^{-1}$  in the so-called ultimate scenario. With these estimates, the recorded CMS data are expected to reach an integrated luminosity of 3000 fb<sup>-1</sup> or 4000 fb<sup>-1</sup>, respectively. This will lead to an increase in the particle flux that will have to be recorded by

the detectors as well as an increase in the radiation background at the locations where they are installed.

In view of the upcoming high-luminosity LHC (HL-LHC) period, the CMS muon system will be upgraded to maintain its high efficiency in muon triggering and reconstruction. The RPC system will be extended up to 2.4 in pseudorapidity. Before the LHC Long Shutdown 3, new RE3/1 and RE4/1 stations of the forward Muon system will be equipped with improved Resistive Plate Chambers (iRPC) having, compared to the present RPC system, a different design and geometry and 2D strip readout. This advanced iRPC geometry configuration allows the rate capability to improve and hence survive the harsh background conditions during the HL-LHC phase. A summary of the design of the new improved RPC detectors (iRPC) is given in publications [V4-3] and [G7-1].

*Dr. Mariana Shopova's personal contribution to this project consists in participating in the assembly and testing of the new detectors, as well as in the analysis of their performance and criteria for passing the different quality control stages. In addition, she has also been involved in the testing of these new detectors at the Gamma Irradiation Laboratory at GIF++ CERN, where an RPC based tracking system was implemented to clean the fake hits, taking profit of the high muon efficiency of these chambers, as described in publication [V4-4].*

In addition to the RPC system upgrades, additional muon detectors are being installed in the CMS endcaps, based on Gas Electron Multiplier technology. For this purpose, 161 large triple-Gas Electron Multiplier detectors have been constructed and tested. Installation of these devices began in 2019 with the GE1/1 station and will be followed by two additional stations, GE2/1 and ME0. The assembly and quality control of the GE1/1 detectors, such as various visual inspections, gas tightness tests, intrinsic noise rate characterizations, and effective gas gain and response uniformity tests, are described in [G7-7].

*The candidate's personal contribution to this project is in participating in the assembly and testing of the GEM detectors for the GE1/1 station of the CMS muon system at CERN, as well as in the analysis of their operating parameters and criteria for passing of the different quality control stages.*

In the period 2019–2024 scientific results from the papers presented for participation in this competition for “Associate Professor” were shown at a number of international scientific conferences and dedicated workshops, as 2 talks on the overall readiness and performance of the CMS RPC system were given by Dr. Mariana Shopova.

The researches leading to the published scientific results were financed by national and international organizations. Since 2018 Mariana Shopova, PhD, has participated in **six national research projects** (two of which are ongoing) – five projects with base organization Institute for Nuclear Research and Nuclear Energy – BAS (two projects for “**Conducting physics research with the CMS detector at the LHC accelerator**” and three projects for “**National Roadmap for Scientific Infrastructure (NRSI) 2020-2027**) and one project with base organization PU “Paisii Hilendarski” (Project BG05M2OP001-2.016-0018 “**MODERN-A: Modernization in partnership through digitalization of the Academic Ecosystem**”).

## **5. Assessment of the candidate's personal contribution**

I have assessed Dr. Mariana Shopova's personal contributions based on her contribution statement and the recommendation letter, received from Salvatore Buontempo, CMS RPC Project Manager in CERN. He confirms the candidate's personal contributions in the presented scientific publications and adds additional information on her active participation in the commissioning and maintenance of the RPC system. In her work, she demonstrates excellent understanding of the work of the RPC detector system and its part within the entire complex chain of the CMS data proceeding, including triggering and reconstruction. All this lead to her

election as an RPC DPG (Detector Performance Group) co-coordinator in 2023, a position she is serving until now, as well as her election as the RPC CPB (Conferences & Publications Board) coordinator and representative in the MCPB (Muon Conferences & Publications Board) (2020).

The candidate's scientific research activity is well-known to the world academic community. In all of the presented scientific publications Mariana Shopova, PhD is either the corresponding author or a co-author in an international team of authors. Part of her job is monitoring the approval/review process of all scientific papers written within the CMS RPC group (since 2020), and in addition she is often invited to review scientific papers from the other three gaseous detector systems of the CMS muon system.

Based on the above, I have no doubts about the originality of the candidate's personal contribution.

## 6. Critical remarks and recommendation

I have no critical remarks on the content and the layout of the submitted documents. All of them are well written and outlined, following the requirements and recommendations on how they should be done, which gives a clear idea on the candidate's overall teaching and research activities.

I recommend Dr. Mariana Shopova to continue with the same passion and dedication her scientific work related to the studies done at the CMS experiment at LHC in CERN, where she is established as a responsible and dedicated member of the CMS Collaboration, as well as her academic work in PU "Paisii Hilendarski".

## 7. Personal impressions

I know personally Ch. Assist. Prof. Mariana Shopova. I have been her professor in all disciplines related to Nuclear and High energy and elementary particles Physics both during her Bachelor's and her Master's degrees. Even as a student, she has shown remarkable interest and theoretical skills in the high energy and elementary particles physics. Currently, Mariana Shopova, PhD is an university lecturer who is very responsible and values the efforts of her students. Her scientific development is linked with her work in the CMS experiment at LHC in CERN, where she has demonstrated very good skills and experience in teamwork..

## CONCLUSION

The documents and materials submitted by Ch. Assist. Prof. Mariana Shopova, PhD **meet fully** all the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria, the Regulations for its Implementation and the relevant Regulations of PU "Paisii Hilendarski".

The candidate in the competition has presented a **significant number** of scientific works published after those used in the defense of the PhD degree and the acquisition of the academic position of "Chief Assistant Professor". The scientific works of Ch. Assist. Prof. Mariana Shopova, PhD contain **original scientific contributions** that have received international recognition. The candidate also has significant achievements in teaching practice. The scientific and teaching qualifications of Ch. Assist. Prof. Mariana Shopova, PhD, are **indisputable**.

The achievements of Ch. Ass. Prof. Mariana Shopova, PhD, in the teaching and research activities **fully correspond to the minimum national requirements** for occupying the academic position "Associate Professor", which coincide with those of the Faculty of Physics and Technology at PU "Paisii Hilendarski", adopted in relation to the Regulations of PU for the application of the Law on the Development of the Academic Staff in the Republic of Bulgaria.

After a detailed look at the administrative and scientific materials, presented for the competition, taking into account the analysis on their significance and based on the above, I confidently give my positive assessment and recommend to the Scientific Jury to prepare a report-proposal to the Faculty Council of the Faculty of Physics and Technology at PU "Paisii Hilendarski" for the election of Ch. Assistant Prof. Mariana Filipova Shopova, PhD to the academic position of "Associate Professor" at PU "Paisii Hilendarski" in the field of higher education 4. Natural Sciences, Mathematics and Informatics; professional direction 4.1. Physical Sciences (Physics of microcosm, high energies and elementary particles).

March 4th 2025  
Plovdiv

Reviewer: .....  
/ Prof. Vanio Tcholakov, PhD./