

S T A N D P O I N T

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**on the dissertation for awarding the educational and scientific title of
"Doctor of Philosophy":**

**"INNOVATIVE BREAST PHANTOMS FOR STUDYING IMAGE
QUALITY IN MODERN MAMMOGRAPHIC TECHNIQUES"**

Thesis by

Yanka Ivanova Baneva

Doctoral student in the Scientific Specialty "Medical Physics",
Professional Heading "Physics Sciences" (4.1), area of higher education "Natural
Sciences, Mathematics, and Informatics"

By written order of the Rector № P-109-338/05.08.2022 I have been appointed as an Internal Member of the Scientific Jury judging on the aforementioned thesis. In accordance with protocol № 1 / 16.08.2022 of the conducted first session of the Scientific Jury I have been appointed to formulate a standpoint.

I. BRIEF BIOGRAPHIC DATA

Yanka Baneva graduates the Shumen University "Konstantin Preslavski" in 2002 as a bachelor in "Physics". IN 2021 she attains a Mastery degree in "Medical Radiation Physics and Technologies" at the Plovdiv University "Paisius of Hilendar". In 2021 she attains the specialty "Medical Sanitary Physics". She has been working as a university teaching assistant at the

“Department of Physics and Biophysics” of Medical University “Prof. Dr. Paraskev Stoyanov” Varna.

The doctoral student has participated in many training sessions and seminars, organized in Bulgarian and international institutions in the span between 2010 and 2022. She is a member of the Varna branch of the Union of Physicists, the Varna branch of the Union of Scientists, and the Bulgarian Society of Biomedical Physics and Engineering.

II. RELEVANCE OF THE DISSERTATION’S TOPIC

Breast cancer is the most common oncological cause of death in women. The cases are observed in a wide age range, beginning from about 20 years, while the risk of disease development increases with age. Timely diagnosis is paramount. The screening and diagnostic methods needed for said timely diagnosis are undergoing constant improvement, while also being the object of strict quality control. The work of the doctoral student is focused on this pursuit, using mathematical software modelling of breast phantoms. With this in mind the dissertation is especially topical and with high practical applicability.

III. STRUCTURE OF THE DISSERTATION

Yanka Baneva’s work encompasses 105 pages, from which: *Introduction and Literature Review* – 27 pages, *Aim and Tasks* – 2 pages, *Breast Models for X-Ray Imaging Research* – 6 pages, *Methods of Research* – 7 pages, *Development and Utilization of Computer Models for Breast Tomosynthesis* – 12 pages, *Influence of Incident Mammography Spectra and Phantom Breast Characteristics on Mammography Image Features* – 10 pages, *Computational Breast Models for Contrast-Enhanced Spectral Mammography* – 11 pages, *Conclusion* – 3 pages, *Contributions* – 2 pages, *Publications Associated with the Dissertation* – 1 pages, *Bibliography* – 10 pages

The dissertation is richly illustrated with 50 figures and 19 tables.

The writing style is accessible, the structure – avant-garde.

IV. CHAPTER BY CHAPTER ANALYSIS OF THE DISSERTATION

Literature review: The literature review is succinct (27 pages), excellently structured and illustrated. The separate chapter “Breast Models for X-Ray Imaging Research” (6 pages) – altogether 33 pages. The reader is introduced to the topic with statistical data about the frequency and social significance of breast cancer. The methods for diagnostic imaging are assiduously described with special attention given to the imaging findings in each modality. The sensitivity and accuracy of each method are presented. A careful and thorough review is made of the development of physical and computer-based breast modelling.

The review cites 133 sources, 11 of which in Bulgarian and 122 in English. Of the international sources 20 are from the last 5 years, comprising 15%. With this in mind I determine the presented assembly of sources as sufficiently up to date. Additionally, the large number of sources quoted demonstrates substantial knowledge of the topic.

Aim of the Study: The doctoral student aims to “*create, validate, and use innovative computational phantoms to study the image quality of modern mammographic techniques, such as tomosynthesis and contrast-enhanced mammography, which have the potential to be used for early screening and diagnosis of breast tumours*”. The aim is ambitious and complex.

Tasks: To achieve this Yanka Baneva sets out to complete 6 tasks with varying degrees of difficulty and clinical relevance. The tasks most relevant to the clinician are “d”, “e”, and “f”.

Methods of Research: A comprehensive description is given for each of the utilized software products (*LUCMRFGGen, BreastSimulator, XRAYImagingSimulator, FDKR, Quality platform*), as well as for their utility in the context of the study. The terms *histogram, kurtosis, skewness fractal analysis and power spectrum* are explained, as well as their importance for the quality of the mammogram.

Development and Utilization of Computer Models for Breast Tomosynthesis: The process of creating virtual breast models and their simulated contents are detailed. The doctoral student comprehensively describes the generation of X-ray images from the thus developed phantoms, after which she compares the planar mammograms derived from actual physical

phantoms and the mammograms from computer-simulated phantoms. The author notes good compliance between the two types of images.

Influence of Incident Mammography Spectra and Phantom Breast Characteristics on Mammography Image Features: The doctoral student describes the creation of innovative virtual phantoms and the principle of their implementation in the modelling of different mammographic energy spectra depending on the X-ray tube.

Computational Breast Models for Contrast-Enhanced Spectral Mammography: The doctoral student details the development of three virtual phantoms of a compressed breast with contrast material incorporated therein. The contrast reservoirs are shaped like cylinders. Radiographs at different energies are simulated, demonstrating the differences between contrast and non-contrast low-dose images. Additionally, the difference between computer phantoms with homogeneous and inhomogeneous structure is demonstrated.

Conclusion: Yanka Baneva presents a succinct conclusion that notes the excellent correlation between results, acquired via physical and virtual phantoms. The author discusses the implications of computer-based phantoms as tools in medical research and quality control of mammographic equipment. She also notes the necessity of additional studies with a greater focus on the precision of the computer modelling of the radiological scattering in the virtual phantom. The optimal materials for the construction of a physical phantom simulating a denser breast are delineated. The doctoral student expresses plans to produce one of the aforementioned phantoms in order to further validate the simulated results and for future implementation in diagnostic imaging. e

Contributions: The author presents a method for the development of multiple complex virtual computer-based breast phantoms, which bear substantial significance to mammographic quality control, which can also be utilized in future studies. The doctoral student points out 17 contributions, which have a scientific, applied, and practical character. I concur with the author's defined contributions.

V. PUBLICATIONS, ASSOCIATED WITH THE DISSERTATION

Yanka Baneva presents 6 scientific publications, associated with the dissertation, part of Bulgarian and international journals. The author notes participation in 5 scientific conferences in relation to the dissertation.

The doctoral student presents a Thesis Summary in Bulgarian comprising 78 pages, which sufficiently well presents the results of the dissertation. The Thesis Summary is also available in English.

The aforementioned materials completely satisfy and exceed the scientific metric criteria for the acquisition of the title of “Doctor of Philosophy” in Medicine.

Yanka Baneva has active scientific profiles in *Google Scholar and ORCID*.

The candidate holds several awards for her work in the scientific field of physics.

Yanka Baneva is a participant in several projects on a national and international level: Division/Group-experiment: APOTEMA, Legnaro National Laboratories, Italy; MaXIMA project from frame program “Horizon” 2020 of the European Union for scientific research and innovation (H2020-TWINN-2015); “Science” Fund project № 21021 “An Innovative Method for Quality Control of Radiological Apparatuses” led by associate professor engineer Kristina Bliznakova.

The works of Yanka Baneva possess scientific, theoretical, and practical significance in radiological quality control via the creation of phantoms. The publications are varied and demonstrate the broad scope of the doctoral student’s interests and competences.

VI. CONCLUSION

The dissertation “Innovative Breast Phantoms for Studying Image Quality in Modern Mammographic Techniques” is an exhaustive study with substantial clinical value and practical applications. The topic is current and of great significance, pertaining to the creation of virtual models of mammographic phantoms and comparing their effectiveness with actual physical phantoms, as well as proposing new models for fabrication of physical phantoms.

The conducted study is thorough and excellently structured, while the inferences are logical and substantiated by the results. I deem that the doctoral student demonstrates the ability for assiduous and competent work in the field of medical physics and computer modelling. The work satisfies the requirements of the Law for the Development of Academic Staff in the

Republic of Bulgaria, as well as those of the Rules for the Development of Academic Staff of MU "Prof. Dr. Paraskev Stoyanov" Varna, legitimizing the author as a reliable researcher.

I confidently express my **positive** assessment of the doctoral student Yanka Ivanova Baneva. I propose to the honorable members of the Scientific Jury that they also **vote in favor** of Yanka Baneva being awarded the educational and scientific title of "Doctor of Philosophy" in the higher education field of "Medical Physics", Professional Heading "Physics Sciences" (4.1), area of higher education "Natural Sciences, Mathematics, and Informatics".

14.09.2022

Varna

Regards,

Assoc. Prof. Georgi Nikolaev Valchev, MD, PhD

A handwritten signature in blue ink, consisting of a long horizontal stroke followed by several vertical and diagonal strokes, characteristic of the signature of Georgi Nikolaev Valchev.