Prof. dr. Mustafa Busuladžić
Prof. dr. Gordana Žauhar
Prof. dr. Senad Odžak

VIJEĆU UNIVERZITETA U SARAJEVU - PRIRODNO-MATEMATIČKI FAKULTET

Predmet: Izbor nastavnika u zvanje redovnog profesora za oblast "Medicinska fizika" na Odsjeku za fiziku

Odlukom Vijeća Univerziteta u Sarajevu – Prirodno-matematički fakultet (br. 01/06-1824/2-2024), donesenoj na elektronskoj 77. sjednici koja je održana 05.09.2024. godine, imenovana je komisija za pripremanje prijedloga za izbor nastavnika u zvanje redovnog profesora za oblast: "Medicinska fizika", jedan izvršilac sa nepunim radnim vremenom, u sastavu:

Dr. Mustafa Busuladžić, redovni profesor Univerziteta u Sarajevu – Medicinski fakultet, uža naučna oblast "Medicinska fizika i biofizika", predsjednik;

Dr.Gordana Žauhar, redovnaprofesoricaFakulteta za fiziku Sveučilišta u Rijeci, uža naučna oblast"Prirodne znanosti" – polje "Fizika", član;

Dr.Senad Odžak, redovni profesor Univerziteta u Sarajevu – Prirodno-matematički fakultet, uža naučna oblast "Teorijska fizika", član.

Na konkurs objavljen 26.07.2024. godine na web stranici Univerziteta u Sarajevu – Prirodno-matematičkog fakulteta, kao jedini kandidat prijavio se dr.Adnan Beganović, vanredni profesor na Univerzitetu u Sarajevu– Prirodno-matematičkom fakultetu, Odsjek za fiziku. Nakon uvida u priloženu dokumentaciju Komisija podnosi sljedeći

I Z V J E Š T A J

BIOGRAFSKI PODACI KANDIDATA

Adnan Beganović rođen je 25. marta 1978. godine u Zenici, gdje je završio osnovnu i nižu muzičku školu. Srednje obrazovanje stekao je 1997. godine u srednjoj školi Nantucket, Massachusetts, SAD. Iste godine upisao je Prirodno-matematički fakultet Univerziteta u Sarajevu, Odsjek za fiziku, na kojem je diplomirao 2002. godine. Njegovo obrazovanje uključuje i magistarski studij iz oblasti jonizirajućeg zračenja na Prirodno-matematičkom fakultetu Univerziteta u Tuzli, gdje je 2009. godine stekao titulu magistra fizičkih nauka. Doktorsku disertaciju odbranio je 2013. godine na Prirodno-matematičkom fakultetu Univerziteta u Sarajevu.

Svoju profesionalnu karijeru započeo je kao medicinski fizičar u dijagnostičkoj radiologiji na Kliničkom centru Univerziteta u Sarajevu, gdje je bio odgovoran za kontrolu kvaliteta, dozimetriju pacijenata i zaštitu od zračenja u dijagnostičkoj i interventnoj radiologiji. U periodu od 2008. do 2016. godine obavljao je funkciju šefa Odsjeka za radiodijagnostičku i nuklearnomedicinsku fiziku, proširivši svoje odgovornosti i na područje nuklearne medicine. Od 2015. godine obnaša dužnost šefa Službe za zaštitu od zračenja i medicinsku fiziku. Paralelno s radom na Kliničkom centru, aktivno je uključen u nastavu na Prirodno-matematičkom fakultetu Univerziteta u Sarajevu, gdje je najprijebio docent (2014–2018), a zatim vanredni profesor (2018–2024), predajući predmete iz oblasti medicinske radijacijske fizike i zaštite od zračenja.

Tokom karijere, usavršavao se u evropskim i američkim centrima u oblasti medicinske fizike i zaštite od zračenja, posebno se ističući kroz boravke u bolnicama u Maidstoneu (UK) i Malmöu (Švedska), kao i kroz obuku iz zaštite od zračenja u Atini (Grčka). Od 2020. godine priznat je kao ekspert za zaštitu od zračenja u medicinskim i nemedicinskim djelatnostima, te u visokom

obrazovanju i naučnoistraživačkom radu, pri Državnoj regulatornoj agenciji za radijacijsku i nuklearnu sigurnost. Od 2022. godine priznati je specijalista medicinske fizike od strane Federalnog ministarstva zdravstva.

Objavio je niz naučnih radova i autor je knjiga "Fizika jonizirajućih zračenja II: Radiometrija i dozimetrija" (2018) i "Vodič za optimizaciju doza i kvalitet snimaka kod kompjuterizirane tomografije" (2020), te je preveo knjigu na bosanski jezik "IAEA. QA Programme for Film Screen Mammography" (2010).

Pored naučnih i obrazovnih aktivnosti, učestvovao je u brojnim nacionalnim i regionalnim projektima u saradnji s Međunarodnom agencijom za atomsku energiju (IAEA), te je redovan učesnik međunarodnih konferencija i seminara iz oblasti medicinske fizike i zaštite od zračenja. Aktivno govori engleski jezik.

NAUČNI RADOVI I NAUČNOISTRAŽIVAČKA AKTIVNOST PRIJE IZBORA U ZVANJE VANREDNOG PROFESORA

Magistarski rad

Adnan Beganović, "Analiza stanja i mogućnosti smanjenja pacijentnih doza u CT radio-dijagnostici", Magistarski rad, Prirodno-matematički fakultet, Univerzitet u Tuzli, 2008.

Doktorska disertacija

Adnan Beganović, "Kožne doze kod perfuzije kompjuterizovanom tomografijom", Doktorska disertacija, Prirodno-matematički fakultet, Univerzitet u Sarajevu, 2013.

Radovi registrirani u Web of Science Core Collection ili Scopus bazama podataka

1. Muhogora WE, Ahmed NA, Almosabihi A, Alsuwaidi JS, **Beganović A**, Ciraj-Bjelac O, et al. Patient doses in radiographic examinations in 12 countries in Asia, Africa, and Eastern Europe: Initial results from IAEA projects. Am J Roentgenol. 2008;190(6):1453–61.
2. Bašić B, **Beganović A**, Samek D, Skopljak-Beganović A, Gazdić-Šantić M. Ten years of monitoring the occupational radiation exposure in Bosnia and Herzegovina. RadiatProt Dosimetry. 2010;139(1-3):400–2.
3. **Beganović A**, Kulić M, Spužić M, Gazdić-Šantić M, Skopljak-Beganović A, Drljević A, et al. Patient doses in interventional cardiology in Bosnia and Herzegovina: First results. RadiatProt Dosimetry. 2010;139(1-3):254–7.
4. Muhogora W, Ahmed N, Alsuwaidi J, **Beganović A**, Ciraj-Bjelac O, Gershan V, et al. Paediatric CT examinations in 19 developing countries: Frequency and radiation dose. RadiatProt Dosimetry. 2010;140(1):49–58.
5. Ciraj-Bjelac O, **Beganović A**, Faj D, Ivanović S, Videnović I, Rehani M. Status of radiation protection in interventional cardiology in four East European countries. RadiatProt Dosimetry. 2011;147(1-2):62–7.
6. **Beganović A**, Bašić B, Gazdić-Šantić M, Kulić M, Spužić M, Skopljak-Beganović A, et al. Occupational and patient exposure in interventional cardiology in Bosnia and Herzegovina. RadiatProt Dosimetry. 2011;147(1-2):102–5.
7. Bašić B, **Beganović A**, Skopljak-Beganović A, Samek D. Occupational exposure doses in interventional procedures in Bosnia and Herzegovina. RadiatProt Dosimetry. 2011;144(1-4):501–4.
8. Ciraj-Bjelac O, **Beganović A**, Faj D, Gershan V, Ivanović S, Videnović IR, Rehani MM. Radiation protection of patients in diagnostic radiology: Status of practice in five Eastern-European countries, based on IAEA project. Eur J Radiol. 2011; 79(2):e70–e73.
9. Vassileva J, Rehani MM, Al-Dhuhli H, Al-Naemi HM, Al-Suwaidi JS, Appelgate K, et al. IAEA survey of pediatric CT practice in 40 countries in Asia, Europe, Latin America, and Africa: Part 1, frequency and appropriateness. Am J Roentgenol. 2012;198(5):1021–31.
10. Ciraj-Bjelac O, Avramova-Čolakova S, **Beganović A**, Economides S, Faj D, Gershan V, et al. Image quality and dose in mammography in 17 countries in Africa, Asia, and Eastern Europe: Results from IAEA projects. Eur J Radiol. 2012;81(9):2161–8.
11. **Beganović A**, Sefić-Pašić I, Skopljak-Beganović A, Kristić S, Šunjić S, Mekić A, et al. Doses to skin during dynamic perfusion computed tomography of the liver. RadiatProt Dosimetry. 2013;153(1):106–11.
12. Pašić IS, Pašić A, Kristić S, **Beganović A**, Čarovac A, Džananović A, et al. Possibilities of differentiation of solitary focal liver lesions by computed tomography perfusion. Med Glas (Zenica). 2015;12(2).
13. Đedović E, Gazibegović-Busuladžić A, **Beganović A**. Fractal analysis of digital mammograms. Folia Med Fac Med Univ Saraeviensis. 2015;50(1).
14. Ćerić Š, Ćerić T, Šadija A, Hadžiahmetović M, Agić S, **Beganović A**, et al. Risk assessment of patients with differentiated thyroid cancer comparing AMES and EORTC prognostic scoring systems with evaluation of tumour size significance. Med J. 2015;21(3).
15. Beslić N, Šadija A, Milardović R, Ćerić T, Ćerić S, **Beganović A**, et al. Advantages of combined PET-CT in mediastinal staging in patients with non-small cell lung carcinoma. Acta Inform Med. 2016;24(2):99.
16. Redžić M, **Beganović A**, Čiva L, Jašić R, Skopljak-Beganović A, Vegar-Zubović S. Quality control of angular tube current modulation. In: CMBEBIH 2017. Singapore: Springer; 2017. p. 563–7.

Naučnoistraživački projekti

Kandidat je bio učesnik u sljedećim naučnoistraživačkim projektima:

1. IAEA projekat tehničke saradnje BOH6013: Strengthening Radiotherapy Physics Units to Meet the Requirements of International Standards (2012–2013);
2. IAEA projekat tehničke saradnje BOH9005: Strengthening Radiation Protection in Medicine (2014–2015);
3. IAEA projekat tehničke saradnje BOH6015: Establishing National Diagnostic Reference Levels in Diagnostic Radiology (2016–2018).

UDŽBENICI I MONOGRAFIJE PRIJE IZBORA U ZVANJE VANREDNOG PROFESORA

Beganović A, Samek D. Fizika jonizirajućih zračenja II: radiometrija i dozimetrija. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; 2018.

PEDAGOŠKE AKTIVNOSTI PRIJE IZBORA U ZVANJE VANREDNOG PROFESORA

Kandidat je od 2007. godineangažiran na Univerzitetu u Sarajevu– Prirodno-matematičkom fakultetu kao asistent na predmetu "Medicinska radijacijska fizika I i II"na I ciklusu, te predmetima "Fizika u radiodijagnostici I i II", "Fizika u nuklearnoj medicini I i II" i "Fizika u radioterapiji I i II" na II ciklusu studija. Od 2013. godine je docent na Odsjeku za fiziku.Odgovorni je nastavnik na predmetima "Medicinska radijacijska fizika I i II"i "Uređaji za dobivanje slike u medicinskoj fizici"na I ciklusu, te"Fizika u radiodijagnostici I i II" na II ciklusu studija.
Radioje kao vanjski saradnik na Univerzitetu u Sarajevu – Fakultetu zdravstvenih studija na predmetu"Radiološka zaštita".
Bioje mentor završnih radova naII ciklusu studija.

NAUČNI RADOVI I NAUČNOISTRAŽIVAČKA AKTIVNOST <u>NAKON IZBORA</u> U ZVANJE VANREDNOG PROFESORA

Radovi registrirani u Web of Science Core Collection (WoS) ili Scopus bazama podataka

Radovi kandidata su iz oblasti medicinske fizike i biofizike. Ovdje navodimo naslove i apstrakte radova koji su objavljeni nakon izbora kandidata u zvanje vanrednog profesora.

1. Kurić H, Kristić S, Bukvić M, Strika-Kurić J, Vegar-Zubović S, Beganović A, et al. Benefits of low-dose carotid CT angiography in stroke patients. J Health Sci. 2023;13(3):187-192.

   Abstract: Computed tomography angiography (CTA) represents the gold standard as a method for the diagnosis of carotid artery diseases. The current topic is the use of CTA for the evaluation of carotid arteries with a reduction in the dose of contrast agent and dose of ionizing radiation, which, with adequate preparation, would enable the use of this method in some risk groups. The aim of this study was to evaluate the feasibility and image quality of a new low-dose CTA protocol in comparison with a standard protocol. Forty patients with recumbent ischemic stroke were included in the study, twenty of whom underwent lowdose CTA, and the remaining twenty underwent a standard CTA protocol of the carotid arteries. No significant difference was found between the mean values of CT number (Hounsfield unit), signal-to-noise ratio, contrast-to-noise ratio, and subjective assessment of image quality in the comparison of the control and experimental groups. CT dose index, volume, and dose length product were significantly lower in patients who underwent lowdose carotid CTA. There was no significant difference in the degree of carotid stenosis between color Doppler and CTA. The use of the low-dose protocol for carotid CTA allows the application of this method in risk groups, in which it was previously not possible to perform, with the same image quality in comparison with the standard protocol.

2. Fajić H, **Beganović A**, Odžak S, Odžak A. Radiation protection and estimate of commercial aircrew effective doses in Bosnia and Herzegovina. RadiatProt Dosimetry. 2023;199(19):2303-2310.

    Abstract: Cosmic rays are the primary source of the daily exposure of aircrew and passengers to ionising radiation. This study aims to estimate the effective doses of ionising radiation for aircraft crews in Bosnia and Herzegovina by taking into consideration factors such as flight duration and altitude, as well as the geographical position of airports. The CARI-7 algorithm and neural network method were used in the analysis of data obtained from the Sarajevo International Airport. The results show that the estimated annual effective doses in 2021 range from 0.06 to 10 mSv for flights to and from Belgrade and Dubai, respectively. Both linear regression and neural network models were developed to predict the effective dose based on flight duration, average altitude, latitude and maximum altitude. The findings reveal that flight duration is the most statistically significant factor, followed by average altitude, latitude and maximum altitude.

3. Vučković SH, Vegar-Zubović S, Milišić L, Kristić S, **Beganović A**, et al. Correlation of MRI Findings with ODI and VAS Score in Patients with Lower Back Pain. Open Neuroimaging J. 2023;16(1).

    Abstract: In clinical practice, there is a very common discrepancy between the clinical findings of patients with lumboischialgia and the radiological findings. This research aimed to determine the degree of correlation between the ODI index and the VAS scale with degenerative changes in the lumbar spine found using MRI. The study included 100 patients, who were referred for an MRI of the lumbar spine and who had a clear clinical picture of lumboischialgia. Patients underwent MRI. Degenerative changes in the lumbar spine and discs were analysed. Patients were asked to answer the questions in the questionnaire about the subjective feeling of pain and functional status, and ODI and VAS scores were calculated. There has been a statistically significant correlation found between the answers to the survey questions and the VAS score ($p < 0.001$). There was a significant correlation obtained between the level of degeneration and the disability index ($p = 0.022$), while the correlation with the VAS score has not been found to be significant ($p = 0.325$). This study has demonstrated a significant correlation between the VAS pain score and the ODI, as well as a significant correlation between the level of degeneration on MRI scans and the disability index; however, the correlation of MRI scan results with VAS score has not been found to be significant.

4. Hanić B, Čiva LM, Busuladžić M, Gazibegović-Busuladžić A,Skopljak-Beganović A, **Beganović A**. Importance of Patient Dose Evaluation and Optimization in Thorax Computed Tomography. In: Mediterranean Conference on Medical and Biological Engineering and Computing. 2023.

    Abstract: Computed tomography (CT) is one of the most important imaging modalities in modern medicine. Using CT, one can obtain useful information about a patient's health status, or condition. As this modality delivers some amount of radiation to the patient's body that can be harmful, special attention must be paid to choosing appropriate parameters that can reduce the dose but maintain helpful diagnostic information from the CT image. Radiation doses for CT examinations vary considerably among patients, institutions, and countries. This variation is mostly attributable to the technical parameters of the CT scanning protocols. An optimization process is a team effort of the CT radiologist, the lead CT technologist, and the clinically qualified medical physicist. The purpose of this study is to analyze patient doses in thorax CT in two public hospitals in Sarajevo, the capital of Bosnia and Herzegovina. Data were collected from five different CT devices from these hospitals, using the OpenREM system. The optimization process in both hospitals was surveyed as well, investigating their benefits and shortcomings. Finally, we propose possible ways for future optimization and harmonization of existing protocols in two hospitals, by adjusting different technical parameters such as the tube voltage, tube current, and pitch.

5. Huseljić E, Odžak S, **Beganović A**, Odžak A, Pandžić A, Jusufbegović M. Design, Manufacturing and Quality Assessment of 3D-Printed Anthropomorphic Breast Phantom for Mammography. In: Mediterranean Conference on Medical and Biological Engineering and Computing. 2023.

Abstract: Radiological anthropomorphic phantoms are objects that mimic patient's anatomy when imaged by x-rays. These objects play a major role in optimizing radiation dose and image quality, allowing repeated exposure without exposing patients to harmful ionizing radiation. The goal of this study was to create a three-dimensionally-printed (3D-printed) phantom that would allow production of images that closely match those of human breast produced in digital mammography. We determined the attenuation properties of the Gray V4 resin using an imaged step-wedge. Gray values in image were associated with corresponding material thickness and a real mammogram was converted to two-dimensional (2D) matrix with elements whose values correspond to material thickness. Geometrical corrections for perspective and projection were taken into account. A standard triangle language (STL) file was used as input for the 3D printer. The quality of the printed phantom was evaluated by comparing its images to those of the real patient mammogram using different quantifying measures in spatial and frequency domain. The calculated similarity index (SSIM) was approximately 0.99, which indicates that SLA 3D printing technology can be successfully utilized to produce mammography phantoms.

6. Čorbić H, **Beganović A**, Redžić M, Šehić A, Salkica N, Bajrović J. Results of Daily Quality Control in Computed Tomography. In: Mediterranean Conference on Medical and Biological Engineering and Computing. 2023.

Abstract: Regular quality control in computed tomography (CT) in Bosnia and Herzegovina is made mandatory by national regulations. Conducting daily quality control (QC) tests is the responsibility of radiographers, also known as radiological technologists. Basic tests prescribed by the Ordinance are: Image noise, and CT number uniformity and accuracy. The purpose of this paper is to perform analysis of daily image QC tests and to compare the results of different imaging methods and reconstruction on CT devices, as well as to evaluate more complex image quality parameters, such as noise power spectrum (NPS). This research was conducted as a retrospective-prospective study done within 4-month period at the Clinical center of the University of Sarajevo. A 100 scans with 3 different CT devices were included in the study. Image noise analysis with standard deviation and NPS, as well as CT number uniformity and accuracy was performed using different scanning parameters and reconstructions utilizing the standard water phantom. All results conformed the criteria from regulations. Overall, the results of this study showed stability over time for all image quality tests that indicates the regularity of CT imaging systems. Image quality tests are very important in accepting operation of any CT device after installation and during maintenance to confirm that the image parameters are acceptable by using the phantom. This research can serve as a guideline for advanced daily image quality control tests for computerized tomography devices, using modern image quality metrics.

7. **Beganović A**, Petrović B, SurićMihić M. Extremity dosimetry for exposed workers in positron emission tomography in Bosnia and Herzegovina. RadiatProt Dosimetry. 2023;199(8-9):859-864.

Abstract: Occupational exposure in Bosnia and Herzegovina is regulated by the national regulation on radiation protection for occupational and public exposure. All radiation workers are required to be monitored using whole body passive thermoluminescent dosemeters and, in case of non-uniform external exposures, by dosemeters that would indicate dose to the most affected body parts. Exposed workers are almost exclusively employed in the medical field, and some of them work in nuclear medicine departments where they handle unsealed radioactive sources. Introduction of the positron emission tomography–computed tomography (PET–CT) in two largest clinical centers in the country was expected to cause the increase of equivalent doses to hands received by staff handling the positron emitting radionuclides. Hence, routine monitoring of finger doses became a necessity. The purpose of this study was to evaluate the available data on monitoring with ring dosemeters during PET–CT procedure in two hospitals in Bosnia and Herzegovina and compare them with other practices in the nuclear medicine department, as well as with the results of monitoring in other countries. In general, results confirm that effective doses, as well as equivalent doses to hands, are well below annual dose limits. Finger dosemeters have been proven to be an invaluable asset in the incidental situations that sometimes occur in nuclear medicine departments. Different number of patients and differences in

injection methodologies are identified as a possible source of differences between doses in two hospitals. Overall, routine evaluation of doses to hands provides a sound basis for possible optimization processes, as well as confirmation of good practices.

8. Salkica N, Begić A, **Beganović A**, Julardžija F, Šehić A, Ćorović H, et al. Optimisation of the bone single photon emission computed tomography in oncology patients. J Health Sci. 2023;13(3 Suppl 1):209-212.

Abstract: The introduction of hybrid imaging systems such as Single Photon Emission Computed Tomography/Computed Tomography (SPECT/CT) has completely changed the scanning procedure of conventional diagnostic nuclear medicine protocols. Modern bone scintigraphy protocols include SUV quanitification and Whole Body (WB) SPECT/CT scanning modality. The major limitation of these new technologies is relatively long scanning time. New detector systems with modern reconstruction softwares have been developed for fast scanning SPECT protocolos. These new technologies can produce images of reduced acquisition with same quality as full scanning acquisition. As a result new studies suggest that planar WB scintigraphy should be replaced with WB SPECT/CT. One hundred oncology patients performed SPECT/CT as a part as their clinical follow-up. Three different scanning and three reconstruction protocols have been evaluated. Two nuclear medicine physicians evaluated with Likert scale image sharpness, lesion visibility, and lesion background detectability. The overall image quality was determined as the sum of these three parameters. In terms of scan duration reduction on image quality, Volumetrix Evolution for Bone performed during ultra-fast SPECT acquisition achieved the highest score, which is superior compared to the standard SPECT acquisition protocol. The overall image quality was the best with the Volumetrix MI Evolution for Bone protocol for ultra-fast acquisition The Evolution for Bone protocol for ultra-fast acquisition showed best results compared to other protocols. The adoption of new acquisition SPECT protocol may offer more comfortable exams, resulting in higher patient satisfaction. The implementation of this new protocol can lead to an improvement in SPECT sensitivity, primarily due to the reduction of SPECT motion artifacts.

9. Jusufbegović M, Pandžić A, Busuladžić M, Čiva LM, Gazibegović-Busuladžić A, Šehić A, Vegar-Zubović S, Jašić R, **Beganović A**. Utilisation of 3D Printing in the Manufacturing of an Anthropomorphic Paediatric Head Phantom for the Optimisation of Scanning Parameters in CT. Diagnostics (Basel). 2023;13:328.

Abstract: Computed tomography (CT) is a diagnostic imaging process that uses ionising radiation to obtain information about the interior anatomic structure of the human body. Considering that the medical use of ionising radiation implies exposing patients to radiation that may lead to unwanted stochastic effects and that those effects are less probable at lower doses, optimising imaging protocols is of great importance. In this paper, we used an assembled 3D-printed infant head phantom and matched its image quality parameters with those obtained for a commercially available adult head phantom using the imaging protocol dedicated for adult patients. In accordance with the results, an optimised scanning protocol was designed which resulted in dose reductions for paediatric patients while keeping image quality at an adequate level.

10. Topčagić M, Julardžija F, Pašalić A, Šehić A, **Beganović A**, Osmić H, et al. Electronic On-line Incident Reporting System (IRS) as a Tool for Risk Assessment in Radiation Therapy. Acta Inform Med. 2023;31(3):222.

Abstract: Radiotherapy is one of the primary treatment options in cancer management, together with surgery and chemotherapy. Radiation therapy is technologically complex discipline involving professionals with various specialties, and using high energy radiation in treatment of wide range of different cancer types. Technical complexity, increasing number of patients, large workload, and delivery of radiation therapy treatment with lack of human, technical and financial resources in low and middle income countries creates environment with great potential to develop incidents. Emerging need of modern radiation therapy is to develop preventive approach to risk management i to improve the patient safety. The objective of this research is to identify and assess risk associated with radiation therapy practice in Bosnia and Herzegovina. An anonymous, voluntary electronic on-line radiation therapy incident reporting system (IRS) was created. IRS consists of four sections containing questions about working environment, incident occurrence, root causes and contributing factors, and incident severity assessment. Data collected using IRS were used to create taxonomy of incidents in radiation

therapy. Risk assessment was made using Risk Matrix method. Research was made using the data collected from first 60 incidents reported to IRS.

Based on probability and frequency of incident occurrence and severity of consequences, it was assessed that 41.7% of incidents had low risk level (L), 50% of incidents had moderate risk level (M), and 8.3% of incidents had high risk level (H). Radiation therapy risk profile based on risk assessment results clearly shows that incidents with low frequency, low occurrence probability, but high consequences severity level have highest level of risk. The results of this research confirm that the electronic on-line radiation therapy IRS allows the identification and classification of the most significant risk factors in radiotherapy and prevention of serious incidents occurrence.

11. Haverić A, Gajski G, **Beganović A**, Rahmanović A, Omanović MH, et al. Medical personnel occupationally exposed to low-dose ionising radiation in Federation of Bosnia and Herzegovina: A cytogenetic study. Mutat Res Genet Toxicol Environ Mutagen. 2022;882:503546.

Abstract: Medical radiation exposures have been reduced significantly with modern equipment and protection measures. Biomonitoring of medical personnel can provide information concerning possible effects of radiation exposure. However, chromosome aberration (CA) analysis is now recommended only when the estimated effective dose is 200 mSv or higher. In this retrospective study in Bosnia and Herzegovina, we have measured the cytogenetic status of medical workers and healthy volunteers (controls). Peripheral blood samples from 66 medical workers exposed to low-dose ionising radiation and 89 non-exposed volunteers were collected for chromosome aberrations (CA) analysis and the cytokinesis-block micronucleus (CBMN) assay. Higher rates of chromatid and chromosome breaks, acentric fragments, double minutes, micronuclei, and micronucleated binuclear cells were observed in the control group, while the rate of nucleoplasmic bridges was higher in the medical workers group.

12. Jusufbegović M, Pandžić A, Šehić A, Jašić R, Julardžija F, Vegar-Zubović S, **Beganović A**. Computed tomography tissue equivalence of 3D printing materials. Radiography. 2022;28(3):788-792.

Abstract: Additive production refers to the process of prototyping, which allows the production of highly complex medical devices and products. Interpretation of additive manufacturing (AM) material in Computed Tomography (CT) has not been widely investigated. The aim of this study was to determine the CT number values of commercially available fused deposition modelling (FDM) and stereolithography (SLA) AM materials. Total of 15 AM materials, 7 FMD and 8 SLA, were selected and scanned on CT to determine the HU value and appearance on the images. All test object were designed as rectangular blocks and after their production physical description were calculated. AM materials were scanned on CT operating at 80, 100, 120 and 135 kV. All materials correspond to a certain human tissue and they have uniformity when printed with 100% infill. CT number ranged from a minimum of -188.0 HU to a maximum of 189.1 HU, for FDM materials, and from -15.8 HU to 167.3 HU, for SLA materials. Knowing the CT number of an AM materials can allow the design of medical or rehabilitation products with a specific appearance on CT images. Analysed and collected data can find application in the design and manufacture of immobilization devices that can be easily distinguished from other materials or human tissue. This study provides information that can be used in the design and fabrication of anthropomorphic diagnostic and therapeutic phantoms. There is significant potential for the use of AM material for sophisticated test objects when used in medical image modality testing. Knowing actual CT numbers of frequently used AM materials allows manufacturing anthropomorphic phantoms to investigate radiation doses in diagnostic radiology and radiotherapy.

13. Čiva LM, **Beganović A**, Busuladžić M, Jusufbegović M, Awad-Dedić T, et al. Dose Descriptors and Assessment of Risk of Exposure Induced-Death in Patients Undergoing COVID-19 Related Chest Computed Tomography. Diagnostics (Basel). 2022;12:2012.

Abstract: For more than two years, coronavirus disease 19 (COVID-19) has represented a threat to global health and lifestyles. Computed tomography (CT) imaging provides useful information in patients with COVID-19 pneumonia. However, this diagnostic modality is based on exposure to ionizing radiation, which is associated with an increased risk of radiation-induced cancer. In this study, we evaluated the common dose descriptors, CTDIvol and DLP, for 1180 adult patients. This data was used to estimate the effective dose, and risk of exposure-induced death (REID). Awareness of the

extensive use of CT as a diagnostic tool in the management of COVID-19 during the pandemic is vital for the evaluation of radiation exposure parameters, dose reduction methods development and radiation protection.

14. Bulja D, Strika J, Jusufbegović M, Bečirčić M, Šehić A, Julardžija F, **Beganović A**, et al. Effects of axial loaded magnetic resonance imaging of lumbar spine on dural sac and lateral recesses. J Health Sci. 2021;11(3):181-185.

Abstract: Axial-loaded magnetic resonance imaging (MRI), which can simulate an upright position of the patient may cause a significant reduction of the dural sac cross-sectional area (DCSA) compared with standard MRI, thus providing valuable information in the assessment of the lumbar spinal canal. The purpose of this study was to investigate excessiveness of the change in DCSA and depth of lateral recesses (DLRs) before and after axial-loaded imaging in relation to body mass index (BMI) of the subjects. Twenty patients were scanned to evaluate DCSA and DLR at three consecutive lumbar spine intervertebral disc levels (L3/4, L4/5, and L5/S1) on conventional-recumbent MRI, and after axial loading were applied. Axial-loaded MRI demonstrates a significant difference of DSCA in comparison to conventional MRI. Furthermore, results show a significant correlation between the DCSA and BMI on level L3/L4, both before and after axial loading MRI. With axial loading, there is a reduction of DSCA of 12.2%, 12.1%, and 2.1% at the levels L3/L4, L4/L5, and L5/S1, respectively. After axial loading has been applied, the depth of the neural foramen has been reduced by an average of 10.1%. Axial-loaded MRI reduces DCSA and DLRs in comparison to standard MRI. Information obtained in this way may be useful to explain the patient's symptomatology and may provide an additional insight that can influence the treatment decision plan accordingly.

15. Awad-Dedić T, Čiva LM, **Beganović A**, Busuladžić M, Đedović E, et al. Local Diagnostic Reference Levels in Emergency Computed Tomography of the Head. In: International Conference on Medical and Biological Engineering. 2021;768-776.

Abstract: Computed tomography (CT) is a widely used modality in diagnostic radiology. It has found its way into emergency medicine where it represents an indispensable diagnostic tool. The main disadvantage of CT is the high radiation dose delivered to patients, which is why a lot of emphases is given to the development of optimised scanning protocols. Aim of this study was to assess the patient doses in the form of air kerma length product ($P_{KL,CT}$ or DLP) and volume computed tomography air kerma dose index (C_{VOL} or CTDIvol), for the most common head CT procedures, and to compare them to different diagnostic reference levels (DRLs). The results have shown that patient doses for non-contrast CT of the head are in line with the DRLs in many countries. The results from this paper will provide a basis for the optimisation of surveyed radiological procedures.

16. **Beganović A**, Stabančić-Dragunić S, Odžak S, Skopljak-Beganović A, et al. Estimation of effective doses to patients in whole body computed tomography with automatic tube current modulation systems. In: International Conference on Medical and Biological Engineering. 2021;760-767.

Abstract: Computed tomography (CT) is a digital radiological modality which has been classified as the largest source of medical radiation exposure. In this study, we estimated the effective dose to patients undergoing CT examinations using information obtained from DICOM images, including tube current, patient size and positioning, collimation etc. The custom code was used to calculate the conversion factors between an effective dose and air kerma length product. Their values are 0.0232 mSv/(mGy cm) and 0.0263 mSv/(mGy cm), for male and female patients, respectively. The effective dose for the whole-body CT is estimated to be 8.7 mSv.

17. Skopljak-Beganović A, Čiva LM, Đedović E, ZulićHrelja S, Gazibegović-Busuladžić A, **Beganović A**. Evaluation of the Effectiveness of Protective Aprons in the Primary and Scattered Radiation X-ray Beam. In: International Conference on Medical and Biological Engineering. 2021;817-825.

Abstract: Occupational radiation protection is important for the safe use of radiation in medicine. In some situations, medical professionals are required to use personal protective equipment, such as lead aprons, thyroid shield collars and glasses. Weight of lead aprons is an issue interventionalists face when performing long procedures. A lot of vendors market "lightweight" aprons that are made of alternative materials which supposedly provide the same attenuation power as the lead. In this paper, we propose a method to test protective garments, in both direct and scattered radiation beam,

simultaneously, in a consistent and repeatable manner. The obtained results were compared to measurements in other studies, including those done in the clinical environment.

18. Hasanović-Vučković S, Jusufbegović M, Vegar-Zubović S, Milišić L, Šehić A, Hasanbegović I, **Beganović A**. Assessment of lumbar spine disc degeneration in coherence to Pfirrman Grades and Oswestry Disability Index. J Health Sci. 2020;10(3):191-195.

Abstract: Intervertebral disc (IVD) degeneration (IDD) is one of the main causes of low back pain (LBP). Standardized diagnostic algorithms for adequate estimation and classification of changes of lumbar discs are mandatory before starting with therapy. One hundred patients who were indicated for lumbar magnetic resonance imaging (MRI) were included in the study. Pfirrmann grading system was used for the determination of IDD, while the visual analog scale (VAS) is used for evaluation of the intensity of LBP. To quantification of disability for LBP, we used the Oswestry Disability Index (ODI). Results showed higher Pfirrmann grades II and III for L2/L3 and L3/L4 lumbar levels and lower scores at L4/L5 and L5/S1. The analysis also showed low scores at the L2/3 and L3/4 lumbar level for Pfirrmann grades IV and V, and there was an increased at more inferior lumbosacral levels L4/5 and L5/S1. There was a significant correlation between Pfirrmann grades and ODI ($p = 0.24$) as well as VAS ($p = 0.16$). Higher Pfirrmann grades correlated with increased ODI and VAS. Therefore, MRI can be used as a strong indicator of clinical appearance, but it is important to take into consideration that LBP should be correlated with clinical features. By summing Pfirrmann grades of all lumbar intervertebral levels in each patient, we can get more accurate insight for the status of the lumbar spine.

19. Praskalo J, **Beganović A**, Milanović J, Stanković K. Intraoral dental x-ray radiography in Bosnia and Herzegovina: Study for revising diagnostic reference level value. RadiatProt Dosimetry. 2020;190(1):90-99.

Abstract: This paper presents the study that would allow a revision of the currently valid diagnostic reference level in intraoral dental X-ray radiography in Bosnia and Herzegovina. The study was conducted for six procedures that are used to capture incisor, premolar and molar teeth, of both maxilla and mandible, in adults. Measurements were performed on 41 intraoral X-ray devices, 20 of which were systems with digital image receptor and 21 film-based X-ray systems. In this study, incident air kerma (K_i) and air kerma-area product (P_{KA}) were used as patient dose descriptors. The third quartile (Q_3) of the measured incident air-kerma values was used to compare with the current national diagnostic reference level (DRL) for intraoral dental procedures. The obtained results of Q_3 for both types of devices, with film-based and digital image receptors, have shown that the third quartile values are lower (3.5 and 1.2 mGy, respectively) than the current national DRL (7.0 mGy). Hence, new data can be used to re-establish the diagnostic reference levels in intraoral dental X-ray examinations in Bosnia and Herzegovina.

20. **Beganović A**, Ciraj-Bjelac O, Dyakov I, Gershan V, Kralik I, Milatović A, et al. IAEA survey of dental cone beam computed tomography practice and related patient exposure in nine Central and Eastern European countries. DentomaxillofacRadiol. 2020;49(1):20190157.

Abstract: Cone beam CT (CBCT) in dentistry and maxillofacial surgery is a widely used imaging method for the assessment of various maxillofacial and dental pathological conditions. The objective of this study was to summarize the results of a multinational retrospective–prospective study that focused on patient exposure in this modality. The study included 27 CBCT units and 325 adult and paediatric patients, in total. Data on patients, clinical indications, technical parameters of exposure, patient dose indicator, or, alternatively, dose to phantom were collected. The dose indicator used was air kerma–area product, P_{KA}. In most scanners operators are offered with a variety of options regarding technical parameters, especially the field of view size. The median and the third quartile value of P_{KA} for adult patients in 14 different facilities were 820 mGy cm² and 1000 mGy cm² (interquartile range = 1058 mGy cm²), and 653 mGy cm² and 740 mGy cm² (interquartile range = 1179 mGy cm²) for children, as reported by four different institutions. Phantom dose data were reported from 15 institutions, and median P_{KA} ranged from 125 mGy cm² to 1951 mGy cm². Median P_{KA} values varied by more than a 10-fold between institutions, mainly due to differences in imaging protocol used, in particular field of view and tube current-exposure time product. The results emphasize the need for a cautious approach to using dental CBCT. Imaging only when the clinical indications are clear, accompanied with the appropriate radiographic techniques and the optimum imaging protocol, will help reduce radiation dose to patients.

21. Đedović E, Gazibegović-Busuladžić A, Busuladžić M, **Beganović A**. Comparison of specific fractal and multifractal parameters for certain regions of interest from digital mammograms. In: CMBEBIH 2019: Proceedings of the International Conference on Medical and Biological Engineering. 2020.

Abstract: Fractal analysis of grey-scale digital image is a recognized tool for detection of irregularities in the image and as measure of complexity of the image. Basic idea of this paper is to explore relation of fractal dimensions and some other related parameters in the chosen regions of interest (ROI) of grey-scale digital medical image with corresponding specific tissue characteristics. If difference of the values for calculated parameters is proven to be statistically significant for ROI of mammograms with different specific characteristics, this kind of analysis can be helpful for computer aided diagnostics. Especially, possibility of automatic detection of microcalcifications is considered. Analysis of mammograms in this manner is not a simple task, as there are four different types of parenchym tissue, there are five grades for microcalcifications according to their malignity (BI-RADS), and there are several different types of microcalcifications. Results of fractal and multifractal analysis of 131 ROIs (150×150 pixels) from 60 different mammograms are presented in this paper. Out of total 131, 60 ROIs encloses normal tissue (without dense masses or microcalcifications), and remaining 71 ROIs encloses tissue with microcalcifications. Out of total 60 mammograms concerning parenchym tissue type, 17 mammograms is for ACR 1 structure, 21 ACR 2, i 22 ACR 3 structure. Fractal parameter that is considered is Hurst coefficient, and it is considered how it changes with size of ROI. Hölder exponent and multifractal spectra for each ROI is calculated, and corresponding histograms are analyzed. Values of suitable parameters from these histograms are tabulated to check their statistical dependance on ACR and BI-RADS grades. Zero hypothesis that there is no difference between normal ROI and ROI with microcalcifications is tested.

22. Čiva LM, **Beganović A**, Redžić M, Lasić I, Gazdić-Šantić M, et al. Evaluation of Computed Tomography X-Ray Beam Dose Profiles. In: CMBEBIH 2019: Proceedings of the International Conference on Medical and Biological Engineering. 2020.

Abstract: Computed tomography (CT) is an imaging procedure that uses X-rays to create detailed pictures, or cross-section scans, of areas inside the body. Benefits of the CT have been proven over the past decades, but they come with a price high radiation dose to patients. Understanding how doses depend on technical parameters is a necessary step towards an optimized imaging procedure. Aim of this study was to assess the air kerma distribution and size of the X-ray beam of a conventional computed tomography scanner.

23. Praskalo JŽ, Petrović BV, **Beganović A**. Portable X-ray devices: loosing border between controlled and supervised areas. In: CMBEBIH 2019: Proceedings of the International Conference on Medical and Biological Engineering. 2020.

Abstract: The introduction of portable hand-held X-ray devices opened a new chapter in dental radiology. The strict border between the controlled and supervised areas ceases to exist. The aim of this paper is to measure the dose rate around a portable dental X-ray device, as well as to provide spatial distribution of the ambient dose equivalent of scattered radiation. Results also include measurements of X-ray tube voltage, incidence air kerma, exposure time, half-value layer and total filtration according to the international standard IEC 61223-3-2:2015 Evaluation and routine testing in medical imaging departments for the quality control of dental X-ray devices. Measured values of incidence air kerma indicate the values of the patient doses which are much lower than existing national diagnostic reference values.

24. **Beganović A**, Jašić R, Gazdić-Šantić M, Skopljak-Beganović A, Bešlić N, et al. Use of Uptake Values to Estimate the Effective Dose to Patients in Positron Emission Tomography. In: CMBEBIH 2019: Proceedings of the International Conference on Medical and Biological Engineering. 2020.

Abstract: Positron emission tomography (PET) is a diagnostic imaging modality in nuclear medicine. The most common radionuclide in PET is ^{18}F fluorodeoxyglucose (FDG). In this study we used the information on radionuclide uptake from PET images and software to make an estimation of effective

dose received by patients during ^{18}F-FDG PET examination. We analysed data from 50 patients who performed positron emission tomography—computed tomography (PET-CT) examination. Uptake values were collected in bladder, bones, heart wall, kidneys, liver, brain and remainder. Using a simplified biokinetic model, residence time was calculated and used as an input parameter in OLINDA/EXM® software package. The conversion factor from administered activity to effective dose was found to be 0.016 mSv/MBq, which is only 15% less then value found in literature. The method described in the paper might be suitable in situations when standard calculation models are not adequate.

25. Lasić I, Galić K, **Beganović A**, Lasić V, Čiva L, Krasić-Arapović A. Dose Optimization of CT Thorax Exam in University Clinical Hospital Mostar. In: CMBEBIH 2019: Proceedings of the International Conference on Medical and Biological Engineering. 2020.

Abstract: Aim was to determine the impact of decreasing patient dose on image quality or diagnostic information during diagnostic thorax examination using computed tomography/CT/at University Clinical Hospital Mostar/UCH/. Methods Images were acquired using a CT General Electric LightSpeed 16 slice scanner. There were 62 adult patients with different input diagnoses involved in this research, which lasted from March 1st 2018 to June 1st 2018. After determination of patient dose, the objective was optimization of protocol parameters for the purpose of lowering the dose received by patients, in a manner that does not jeopardize image quality or diagnostic information. A thoracic radiologist using a double-stimulation method assessed image quality according to the European Guidelines on image quality criteria for CT 16262/EUR16262 EN/, followed by calculation of dose efficiency factor figure of merit/FOM/. Results Changing the protocol parameters enabled a significantly decreased patient dose. Visualization of pulmonary anatomical structures was not significantly changed by decreasing the dose. The mean FOM before optimization was 1.28 mSv^{-1} and 2.46 mSv^{-1} after optimization ($p< 0.001$). Conclusion By changing the parameters of the protocol a significant dose reduction was achieved without affecting the diagnostic information.

26. **Beganović A**, Sefić-Pašić I, Gazdić-Šantić M, Jašić R, et al. Radiation Exposure of Patients in Neonatal Intensive Care Unit. In: CMBEBIH 2019: Proceedings of the International Conference on Medical and Biological Engineering. 2020.

Abstract: The chest radiography is the most valuable imaging modality in the assessment of respiratory problems in neonates. However, use of X-rays is associated with exposure to ionising radiation. Scattered and leakage radiation increases over-all dose received by each patient in the ward. In this study we explore medical and public exposure of patients in neonatal intensive care unit (NICU) in the Clinical Centre of Sarajevo University (CCSU). Study included 120 randomly selected patients. The effective dose arising from medical and public exposure was estimated using direct measurements and appropriate software tools. The entrance surface air kerma for a single chest radiography exposure is 86 μGy, which corresponds to 0.60 mSv effective dose. On average, patients are exposed 2.1 times, so the average cumulative effective dose is 0.13 mSv. The estimated effective dose from public exposure was 1.25×10^{-4} mSv, which could be considered negligible. For patients undergoing more examinations, one could consider introducing ultrasound (LUS) as a method of choice.

27. Avdić S, **Beganović A**, Lagumdžija A, Pehlivanović B, Demirović D, Kadić I. Assessment of the indoor-to-outdoor ratio of dose rates in and around the historic objects in Bosnia and Herzegovina. J RadioanalNucl Chem. 2019;320:535-542.

Abstract: This paper deals with the first study of the indoor to outdoor ambient dose equivalent rates ratio measured in and around the historic objects at various locations in Bosnia and Herzegovina. The IndentiFINDER-N spectrometer results showed a positive correlation between the dose rates inside and outside the studied objects while the Radiagem™2000 survey meter indicated larger fluctuations. It was found that the average indoor to outdoor dose rate ratio of 1.2 for the historic objects was close to the ratio for the dwellings made of materials having nearly the same radioactivity content as the surrounding soil.

28. Avdić S, **Beganović A**, Lagumdžija A, Sadiković S, Pehlivanović B, et al. Comparative analysis of gamma dose rates measured by ion chamber in and around the historical sacral objects in Bosnia and Herzegovina. Nucl Technol Radiat Prot. 2019;34(2):157-164.

Abstract: The main objective of this study was to investigate the correlation between the indoor and outdoor ambient dose equivalent rates measured by the ion chamber inside and around the historical sacral objects at a few locations in Bosnia and Herzegovina. The investigated objects made of the traditional building materials were built in the Late Medieval, Post Medieval, and Ottoman Period of Bosnia and Herzegovina history. The LUDLUM Model 9DP instrument based on a pressurized ion chamber was selected for natural low level radiation measurements since the ionisation chambers have higher sensitivities than the other types of detectors. The detection capability of the LUDLUM Model 9DP pressurized ion chamber was examined in the laboratory conditions with a source of low activity and under natural environmental radiation conditions by measuring the indoor and outdoor dose rates. A weak positive correlation was found between the ambient dose equivalent rates inside the historical sacral objects and the dose rates outside the objects. The average evaluated value of the indoor to outdoor dose rate ratio of 1.07 for the studied historic objects is less than that obtained for the contemporary building materials such as concrete. No study on the indoor to outdoor dose rate ratio in Bosnia and Herzegovina measured by the LUDLUM 9DP dose rate meter based on an ion chamber has been conducted yet. In addition to direct measurements, the first gamma spectrometric analysis of a few samples of building materials from the Late Medieval period in Bosna and Herzegovina was performed. The results of the gamma analysis revealed almost uniform distribution of primordial radionuclides in the investigated samples. It was demonstrated that such materials had the reduced content of radioactive isotopes compared to the contemporary building materials and therefore they could have potential advantages in specific applications related to the environmentally sustainable architecture.

29. Bašić B, **Beganović A**, Gazdić-Šantić M, Skopljak-Beganović A, Samek D. Fifteen years of occupational exposure monitoring in the Federation of Bosnia and Herzegovina. Nucl Technol Radiat Prot. 2018;33(4):395-405.

Abstract: The personal dosimetry in Bosnia and Herzegovina started in 1960. After a brief interruption in 1990s, the dosimetry service resumed in 1999. Until 2013, the Radiation Protection Centre of the Institute of Public Health of Federation of Bosnia and Herzegovina has been the only institution in the country that could provide this service. In 2013, this Center covered more than 70 % (1,485) of all radiation workers in the country. They mostly worked in medical institutions (1,417 or 95.4 %), while others are exposed to radiation sources in industry and veterinary radiology. From 1999 to 2013, the majority of annual doses were less than 1 mSv (96.2 %). There are no registered cases of exceeding the annual dose limit (20 mSv). The results analysis shows the reduction of individual doses in last five years. Newly adopted practices in medicine, such as the positron emission tomography, could cause the increase of doses in the years to come.

Radovi registrirani u drugim relevantnim bazama

1. Tinjak E, **Beganović A**, Smajlbegović V, Julardžija F, Šehić A, Prevljak S, et al. Influence of computed tomography parameters on the radiotherapy plan calculation. Knowledge. 2022;54(4):603-610.

Abstract: Contouring, planning and dose calculation in treatment planning systems (TPS) are based on computed tomography (CT) images. Therefore, it is important to have developed, optimized and adapted scanning protocols for specific anatomic regions and special radiotherapy modalities such as stereotactic radiosurgery (SRS). The aim of this study was to determine influence of tube voltage, field of view size (FOV) and reconstruction kernels on CT numbers and the resulting radiotherapy (RT) dose calculation. This study was performed at Clinic of Oncology, Clinical Center University of Sarajevo. Verification electron density and CT number values was performed using CIRS Thorax 002LFC phantom, while anthropomorphic CIRS 038 phantom for stereotactic end-to-end verification was used for the purpose of dose plan calculation analysis with large bore CT simulator Canon Aquillion LB. The significant correlation between the tube voltage and the measured values of CT numbers is significant for all materials ($p < 0.05$), except for water ($p = 0.310$). No significant correlation between FOV and obtained values of CT numbers was found in any of the evaluated tissue

equivalent materials. Evaluating the impact of reconstruction kernels on Hounsfield units (HU), significant deviations were found for the FC62, FC68 and FC07 reconstruction kernels. Also, analyzing the influence of reconstruction kernels on the RT dose calculation, the extreme values are associated with D_{min}/D in PTV for kernels FC41 and FC68, where deviations from the values obtained using the baseline scanning parameters were -1.3% and -1.9%. For deviation of 1 HU in muscle tissue of CIRS 002LFC, the calculated D_{min}/D in PTV of CIRS STEEV phantom will reduce by 0.79%. Similarly, the reduction of D_{98} and D_2 would be 6.8 cGy and 3.03 cGy for 1 HU, respectively. Change of the reconstruction kernels caused differences of 0.4% in D_{min}/D calculation in clinical target volume (CTV). CT scanning and reconstruction parameters may affect Hounsfield units, which could have an impact on dose calculations in RT plan. Hence, it is recommended to standardize the scanning protocol used in calibration curve generation for TPS. One should avoid use of different tube voltages and kernels, while according to this study, the change of FOV will have no impact on dose calculations.

2. Sadiković E, **Beganović A**, Julardžija F, Šehić A, Tatarovac S, Pezo A. The analysis of the subjective image quality of a dental radiogram obtained with a digital and film detector: Analizasubjektivnogkvalitetaslikedentalnogradiograma. Radiološketehnologije. 2020;11(1):30-34.

Abstract: Today film-based technologies are largely abandoned in dental radiology. New technologies based on digital detectors are being adopted. This change is part of the global digitalization of radiological procedures. A person operating the radiological device needs to be educated and well informed about radiological procedures and technologies, as well as to know how the system operates and to be sure about the dose required for the adequate image quality. The awareness of radiation doses received by patients is necessary for the estimation of risk from ionizing radiation. The aim of this study was to evaluate whether patient doses in intraoral dental radiology affect image quality. The study included subjective analysis of radiological image quality for an intraoral x-ray device with possibility to use both digital and film detector. Subjective assessment of image quality is performed according to criteria taken from the literature and is expressed using the Likert scale, grade 1–5. In order to improve the quality of inferential statistics related ratings to detector quality and image quality were collected, thus introducing two variables: the detector quality index and the technique quality index. Z-test proportions column shows that the number of grades four given as a contrast score is significantly higher in the RVG detector (65%) compared to the film (40%). There is also a significant difference in the number of given grades five as a rating of the apex preview. The share of grades five in film is 19%, while in RVG it is 42%. It is similar in the evaluation of the preview of the dental canal, where there is also a significant difference in the number of given grades five, so that the share in the film is 11% and in RVG 35%. Analysis of the subjective quality of the radiological image in devices for intraoral radiography with the possibility of recording using digital and film detectors indicates that the digital detector is superior to film in low contrast resolution, apex and dental canal preview.

3. Tinjak E, Smajlbegović V, **Beganović A**, Ristanić M, Ćorović H, et al. Adaptive radiotherapy for head and neck cancer: Adaptivnaradioterapijakarcinomaglaveivrata. Radiološketehnologije. 2020;11(1):9-16.

Abstract: Radiation therapy has long played an integral role in the manage¬ment of locally advanced head and neck cancer (HNC), both for organ preservation and to improve tumor control in the postoperative setting. The aim of this research is to investigate the effects of adaptive radiotherapy on dosimetric, clinical, and toxicity outcomes for patients with head and neck cancer undergoing radiation therapy treatment. Many sources have reported volume reductions in the primary target, nodal volumes, and parotid glands over treatment, which may result in unintended dosimetric changes affecting the side effect profile and even efficacy of the treatment. Adaptive radiotherapy (ART) is an interesting treatment paradigm that has been developed to directly adjust to these changes. This research contains the results of 15 studies, including clinical trials, randomized prospective and retrospective studies. The researches analyze the impact of radiation therapy on changes in tumor volume and the relationship with planned radiation dose delivery, as well as the possibility of using adaptive radiotherapy in response to identified changes. Also, medical articles and abstracts that are closely related to the title of adaptive radiotherapy were researched. The application of ART significantly improved the quality of life of patients with head and neck cancer, as well as two-year locoregional control of the disease. The average time to apply ART is the middle of the treatment course approximately 17 to 20 fractions of the treatment. Based on systematic review of the literature, evidence based changes in target volumes and dose reduction at OAR, adaptive radiotherapy is

recommended treatment for most of the patients with head and neck cancer with the support of image-guided radiotherapy.

Naučnoistraživački projekti

1. "Primjena 3D štampanja u izradi pedijatrijskih fantoma za optimizaciju doza zračenja i kvaliteta slike u kompjuteriziranoj tomografiji", projekat odobren od strane Ministarstva za obrazovanje, nauku i mlade Kantona Sarajevo 2022. godine (u toku).
2. "Mjerenje koncetracije radona u predškolskim ustanovama Kantona Sarajevo", projekat odobren od strane Ministarstva za obrazovanje, nauku i mlade Kantona Sarajevo 2023. godine (u toku).
3. "Razvoj modela vještačke inteligencije u predviđanju bolesti dojke i njegova evaluacija pomoću 3D-printanog antropomorfnog fantoma",projekat odobren od strane Ministarstva za obrazovanje, nauku i mlade Kantona Sarajevo 2023. godine (u toku)

UDŽBENICI I MONOGRAFIJE NAKON IZBORA U ZVANJE VANREDNOG PROFESORA

Izetbegović S, Vegar-Zubović S, Zukić F, **Beganović A**, Sefić-Pašić I, Begić N, Jusufbegović M. Vodič za optimizaciju doza i kvalitet snimaka kod kompjuterizirane tomografije. Sarajevo: Klinički centar Univerziteta u Sarajevu; 2020. 66 p. ISBN: 978-9958-00-028-7.

PEDAGOŠKE AKTIVNOSTI NAKON IZBORA U ZVANJE VANREDNOG PROFESORA

Kandidat je od 2017. godine angažiran na Univerzitetu u Sarajevu – Prirodno-matematičkom fakultetu kao vanredni profesor iz oblasti "Medicinska fizika". Odgovorni je nastavnik na predmetima "Medicinska radijacijska fizika I i II" i "Radiološka zaštita" na I ciklusu, te predmetima "Fizika u radiodijagnostici" i "Slikovne metode u radiologiji" na II ciklusu studija.
Radi kao vanjski saradnik na Univerzitetu u Sarajevu – Fakultetu zdravstvenih studija na predmetima "Biofizika", "Dozimetrija u radioterapiji i radioizotopskim tehnologijama", "Kontrola kvaliteta rada u radioterapiji", a ranije i na predmetima "Kontrola kvaliteta rada u nuklearnoj medicini" i "Zaštita od zračenja u radiološkim tehnologijama".
Bio je mentor na 3 završna rada III ciklusu studija, te na 30 završnih radova II ciklusa studija.

Predmeti koje je kandidat vodio na Odsjeku za fiziku u periodu od 2018-2024. godine:

Prvi ciklus studija:

- – Medicinska radijacijska fizika I
- – Medicinska radijacijska fizika II
- – Radiološka zaštita

Drugi ciklus studija:

- – Fizika u radiodijagnostici
- – Slikovne metode u radiologiji

Mentorstva završnih radova II ciklusa studija na Univerzitetu u Sarajevu – Prirodno-matematički fakultet i Fakultet zdravstvenih studija

1. Selma Zulić Hrelja, *Evaluacija utjecaja parametara akvizicije na kontrast slike u jednofotonskoj emisijskoj tomografiji* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 17.07.2019.

2. Belma Pandžo, *Procjena rizika od jonizirajućeg zračenja kod radiografije* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 24.06.2019.

3. Medina Hamzić, *Doze zračenja za pacijente kod slikovnih metoda u radioterapiji* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 27.09.2019.

4. Amra Ibrahimović, *Testing of stripping foils for a light ion therapy facility* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 31.03.2020.

5. Amila Avdić, *Multi-turn injection of carbon ions in a medical synchrotron* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 10.06.2020.

6. Mirsad Tunja, *Projektovanje strukturalne zaštite od jonizirajućeg zračenja* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 23.07.2020.

7. Ermina Sadiković, *Kvalitet slike i doza zračenja u intraoralnoj dentalnoj radiologiji* [završni rad II ciklusa studija]. Sarajevo: Fakultet zdravstvenih studija Univerziteta u Sarajevu; odbranjen 16.10.2020.

8. Hanka Bečirović, *Primjena umjetnih neuralnih mreža u procjeni efektivne doze* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 21.06.2021.

9. Hatidža Terzić, *Procjena izloženosti jonizirajućem zračenju članova posade aviona* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 08.07.2021.

10. Benjamin Dedić, *Simulation of low energy beam transport* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 28.10.2021.

11. Stipe Pavić, *Pareto search approximation and multi-criteria optimization for intensity-modulated radiotherapy* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 15.11.2021.

12. Fatima Alić, *Doze zračenja i tehnike snimanja kompjuteriziranom tomografijom kod pedijatrijskih pacijenata oboljelih od COVID 19* [završni rad II ciklusa studija]. Sarajevo: Fakultet zdravstvenih studija Univerziteta u Sarajevu; odbranjen 20.04.2022.

13. Nina Hajdin, *Metrika kvaliteta radiološke slike u mamografiji* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 16.05.2022.

14. Melika Damadžić, *Metrika kvaliteta radiološke slike u kompjuteriziranoj tomografiji* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 17.06.2022.

15. Adisa Opardija Helja, *Metrika kvaliteta radiološke slike u radiografiji* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 17.06.2022.

16. Damir Škrijelj, *Dose calculation for ultra-high dose rate radiotherapy* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 13.09.2022.

17. Esma Mešić, *Slabljenje uzrokovano masom uzorka pri mjerenjima na alfa-beta brojaču* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 15.09.2022.

18. Ivana Čuturić Lončarević, *Rekonstrukcija i filtracija slike u jednofotonskoj emisijskoj kompjuteriziranoj tomografiji* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 29.09.2022.
19. Samra Hasanhodžić, *Izazovi u poučavanju o zaštiti od jonizirajućeg zračenja* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 29.09.2022.
20. Amar Nuhan, *Komparacija palijativnog radioterapijskog tretmana koštanih struktura na konvencionalnom i CT simulatoru* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 30.09.2022.
21. Biljana Petrović, *Mjerna nesigurnost u termoluminiscentnoj dozimetriji pri procjeni ličnog doznog ekvivalenta $H_p(0,07)$ i $H_p(10)$ za cijelo tijelo* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 12.01.2023.
22. Dželila Maljić Ćordalija, *Doze zračenja kod urografije kompjuteriziranom tomografijom* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 16.01.2023.
23. Hatina Čorbić, *Kontrola kvaliteta slike na uređajima za kompjuteriziranu tomografiju* [završni rad II ciklusa studija]. Sarajevo: Fakultet zdravstvenih studija Univerziteta u Sarajevu; odbranjen 16.02.2023.
24. Sanja Ćosić, *Evaluacija polja apsolutnih efikasnosti u gamaspektrometriji sa koaksijalnim germanijevim detektorom visoke čistoće* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 17.02.2023.
25. Belma Grebović, *Kontrola kvaliteta slike u stomatološkoj radiologiji* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 17.04.2023.
26. Elma Huseljić, *Dizajn i proizvodnja mamografskog antropomorfnog fantoma dojke* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 15.05.2023.
27. Fuada Salkić, *Upotreba Monte Carlo simulacija kod optimizacije dizajna strukturne zaštite od zračenja za medicinski linearni akcelerator* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 12.07.2023.
28. Irhad Šišić, *Prodornost primarnog i raspršenog snopa jonizirajućeg zračenja kroz različite materijale* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 21.07.2023.
29. Milica Drašković, *Analiza dozimetrijskih sistema za mjerenje indeksa zračne kerme u kompjuteriziranoj tomografiji* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 28.09.2023.
30. Ajdin Burnić, *Primjena vještačke inteligencije u analizi medicinskih slika* [završni rad II ciklusa studija]. Sarajevo: Prirodno-matematički fakultet Univerziteta u Sarajevu; odbranjen 28.09.2023.

Mentorstva završnih radova III ciklusa studija na Univerzitetu u Sarajevu – Fakultet zdravstvenih studija

1. Enis Tinjak, *Analiza uticaja tehničkih parametara simulacije kompjuteriziranom tomografijom na proračun terapijskog plana* [doktorska disertacija]. Sarajevo: Fakultet zdravstvenih studija Univerziteta u Sarajevu; odbranjena 26.12.2022.
2. Halil Ćorović, *Optimizacija protokola perfuzione scintigrafije miokarda korištenjem antropomorfnog fantoma* [doktorska disertacija]. Sarajevo: Fakultet zdravstvenih studija Univerziteta u Sarajevu; odbranjena 31.10.2022.
3. Merim Jusufbegović, *Primjena stereolitografske tehnike trodimenzionalnog štampanja u izradi antropomorfnog dijagnostičkog fantoma za kompjuteriziranu tomografiju* [doktorska disertacija]. Sarajevo: Fakultet zdravstvenih studija Univerziteta u Sarajevu; odbranjena 01.07.2024.

PRIJEDLOG SA OBRAZLOŽENJEM

Na osnovu Zakona o visokom obrazovanju Kantona Sarajevo ("Službene novine Kantona Sarajevo", broj 33/17), člana 96. stav f), član 176. stav (1) i člana 194. Statuta Univerziteta u Sarajevu iz 2018. godine, jediniprijavljeni kandidat, dr. Adnan Beganović, vanredni profesor Univerziteta u Sarajevu – Prirodno-matematičkog fakulteta, ispunjava sve zakonske uslove za izbor u zvanje redovnog profesora za oblast "Medicinska fizika", jer:

- je proveo jedan izborni period u zvanju vanrednog profesora,
- je nakonposljednjeg izbora, iz oblasti za koju se bira, objavio29 radova u citatnim bazama podataka i 3 rada u drugim, relevantnim bazama podataka,
- je nakon posljednjeg izbora objavio jednu knjigu. Kao supstituciju za objavu drugeknjigekandidat koristitri objavljena rada, što je u skladu sa članom 199. stav (1) Statuta Univerziteta iz 2018. godine,
- je nakon posljednjeg izbora učestvovao na tri naučnoistraživačka projekta,
- nakon posljednjeg izbora ima uspješno mentorstvo trideset (30) kandidata na drugom ciklusu studija i tri (3)uspješna mentorstvana trećem ciklusustudija.

Vanredni profesor dr. Adnan Beganović je do sada postigao veoma značajne naučne rezultate. Do sada je objavio48 radova koji su citirani 735 puta (izvor: Google Scholar). Odgovarajući *h* indekstih radova je 10. Bio je učesnikukupno šest domaćih naučnoistraživačkih projekata.Kandidat posjeduje bogato pedagoško iskustvo. Mentor je više magistarskihi doktorskih radova. Autor je dva univerzitetska udžbenika.

S obzirom na navedene činjenice, članovi Komisije smatraju da kandidat ispunjava sve Zakonom predviđene uslove za izbor u zvanje redovnog profesora. Sa zadovoljstvom predlažemo Vijeću Univerziteta u Sarajevu – Prirodno-matematičkog fakulteta da **izabere** dr. **Adnana Beganovića**, **u zvanje redovnog profesora za oblast "Medicinska fizika"** na Univerzitetu u Sarajevu – Prirodno-matematički fakultet.

U Sarajevu, 23. 09. 2024. godine

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dr. Mustafa Busuladžić, redovni profesor

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dr. Gordana Žauhar, redovnaprofesorica

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dr. Senad Odžak,redovniprofesor