Hounsfield Unit (HU) Comparison of Different Materials Produced by Plastic Injection Molding Method with Commercial Bolus

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Abstract:
In radiation therapy, a bolus is a kind of tissue-equivalent material used to deliver an adequate radiation dose to the level of the skin and improve dose homogeneity in superficial tumours. With the development of technology, bolus material is produced with a 3 Dimension (3D) printer in radiotherapy. Polylactic Acid (PLA) and Acrylonitrile Butadiene Styrene (ABS) are generally used as bolus material produced in a 3D printer. In addition to 3D printers, one of the cheapest and the most common methods used to produce plastic parts is plastic injection moulding. In a radiotherapy treatment planning system (TPS), essential input is the data from computed tomography (CT) simulator scan, which takes into account the effect of inhomogeneities in dose calculations. Since HU values affect dose distribution in treatment planning, the values in TPS and CT should be compatible with each other. In this study, we performed an HU comparison of different materials (ABS, PLA) produced by the plastic injection molding method with commercial bolus material routinely used in radiotherapy. ABS, used in natural color and the granule form, was obtained from the company Sabic under the trade name cycolac resin. PLA, the alternative second material used in this study, was obtained from the company Ingeo in the granular form under the trade name Biopolymer 3052D. The test specimens were produced by direct injection molding in an ISO D2 type mold made of S235JR steel (material number 1.0038) according to ISO 294-3. Both of the materials are 10x10x1 cm^3 (L x W x H) dimension. Their densities are 1.040, 1.240, and 2.56 g/cm^3 for ABS, PLA, and bolus, respectively. ABS, PLA, and commercial bolus materials were placed on RW-3 solid water phantom and scanned by General Electric (GE) Discovery RT CT simulator (Figure 1).

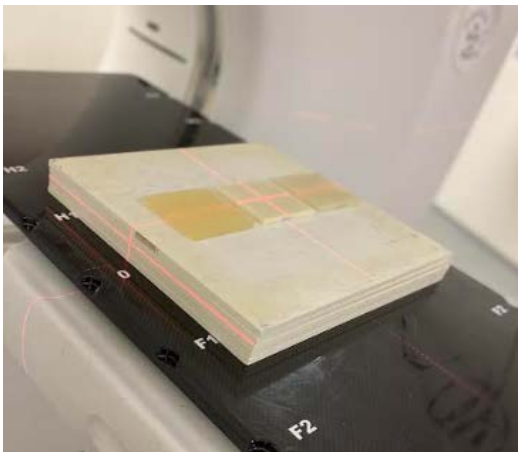

Figure 1. CT scanning setup with RW-3 solid water phantom and different materials.

CT images were obtained with 120 kV and 300 mA scanning parameters. HU values were determined from the center, left and right edges for all three materials with circular regions of interest (ROIs) in GE CT software programme. In the same way, the HU values were also obtained from Varian Eclipse Treatment Planning System (TPS) for each material. The reported HU variations may be explained due to using different density materials. In literature for various CT scanners, the difference between the measured HU numbers and nominal HU number values has been reported especially for different materials. Maximum HU number difference was observed within the range of 1-19 HU for bolus, ABS, and PLA when the measured values were compared with nominal values quoted in the manual CT simulator and TPS systems. HU values in materials with different densities are given in Table 1.

Table 1. HU values of different materials

Material	**HU (-4 cm)**		**HU (center)**		**HU (+ 4cm)**		**Density**
	CT	**TPS**	**CT**	**TPS**	**CT**	**TPS**	**(g/cm^3)**
ABS	-78.02	-80	-77.92	-80	-94.65	-90	1.04
PLA	101.45	90	108.49	90	136.00	131	1.24
Bolus	52.26	60	27.40	25	42.51	49	2.56

In terms of HU values, ABS material was found to be compatible with polystyrene, and PLA was found to be compatible with acrylic material. Although it has been found that the materials do not have significantly different HU values than the bolus, detailed dosimetric studies on these materials are going to be studied.

Keywords*:* Plastic Injection Molding, Hounsfield Unit, Bolus.

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XV. International Conference on Nuclear Structure Properties

28-30 June 2022 Kırıkkale University, Science and Arts Faculty, Kırıkkale, TÜRKİYE

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Certificate of Attendance

We hereby confirm that

Duygu TUNÇMAN

actively participate in the XV. International Conference on Nuclear Structure Properties with two oral presentations titled

"Hounsfield unit (HU) comparison of different materials produced by plastic injection molding method with commercial bolus"

&

"Investigation of the effect of the patient cover materials on surface and build-up region doses".

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BOOK OF ABSTRACTS

XV. INTERNATIONAL CONFERENCE ON NUCLEAR STRUCTURE PROPERTIES

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9. Inspiring Technologies and Innovations (INOTECH)

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INVITED SPEAKERS

Andrea VITTURI (National Institute for Nuclear Physics – INFN, Padova, Italy)
"The algebraic molecular model in ^{12}C and its application to the alpha + ^{12}C scattering: From densities and transition densities to optical potentials, nuclear form factors and cross sections"

Andrew BOSTON (Liverpool University, Liverpool, England)
"The AGATA spectrometer"

Dennis BONATSOS (Institute of Nuclear and Particle Physics, NCSR Demokritos, Greece)
"Islands of shape coexistence"

Francesco CAPPUZZELLO (Catania University, Catania, Italy)
"Heavy-ion induced direct reactions in view of the NUMEN project: a multichannel approach"

Hasan GUMUS (Ondokuz Mayıs University, Samsun, Türkiye)
"The concept of effective charge and electronic energy loss calculations for intermediate energy electrons and positrons"

Hatice DURAN YILDIZ (Institute of Technology Accelerator, Ankara University, Ankara, Türkiye)
"Beam dynamic studies at SRF accelerator system for free-electron laser and ATLAS experiment ADCoS duties at CERN"

Jameel-Un NABI (Wah University, Punjab, Pakistan)
"Updated status of key nuclei for presupernova evolution"

José M. ARIAS (Sevilla University, Sevilla, Spain)
"Quantum simulation of the Agassi Model in trapped ions"

Muhsin N. HARAKEH (Groningen University, Groningen, Netherlands)
"Nuclear compression modes from stable to exotic nuclei"

Sabin STOICA (International Centre for Advanced Training and Research in Physics (CIFRA), Romania, Bucharest, Romania)
"Challenges in the study of double-beta decay"

Sefa ERTURK (Niğde Ömer Halisdemir University, Niğde, Türkiye)
"Recent developments in SPECT and PET medical imaging systems"

Serdar UNLU (Burdur Mehmet Akif Ersoy University, Burdur, Türkiye)
"Allowed and forbidden contributions to two-neutrino double beta decay process"

Takehiko R. SAITO (High Energy Nuclear Physics Laboratory, RIKEN, Saitama, Japan)
"Solving puzzles of light hypernuclei by using heavy-ion beams, nuclear emulsions, and machine learning"

Valentin Olegovich NESTERENKO (Joint Institute for Nuclear Research, Dubna, Russia)
"Low-energy M1 states in deformed nuclei: spin scissors or spin-flip?"

Yu ZHANG (Liaoning Normal University, Dalian, China)
"Effects of single-particle on shape phase transitions in odd-even systems"

TOPICS

Nuclear Structure
Nuclear Reactions
Nuclear Astrophysics
Nuclear Models
Nuclear Scattering
Nuclear Energy
Nuclear Reactors
Accelerator Physics
Nuclear Analytical Methods
Medical and Health Physics
High Energy and Particle Physics
Nuclear Application in Life Science
Radiation Measurements and Dosimeters
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SCIENTIFIC PROGRAMME

28 June 2022 Tuesday

Registration 09:00 – 17:25 (During day)

Morning Section-I 10:00 – 11:00 (Hall-1: Yahya KEMAL Hall)

Chair: Mahmut BÖYÜKATA (Kırıkkale University, Türkiye)

10:00-11:00 Opening Ceremony

11:00-11:30 Conference Photo + Coffee Break

Morning Section-II 11:30 – 12:50 (Hall-1: Yahya KEMAL Hall)

Chair: Neçla CAKMAK (Karabük University, Türkiye)

11:30-11:55 **Sefa ERTURK** (Niğde Ömer Halisdemir University, Türkiye)
Recent developments in SPECT and PET medical imaging systems

11:55-12:20 **Hatice DURAN YILDIZ** (Institute of Technology Accelerator, Ankara Univ., Türkiye)
Beam dynamic studies at SRF accelerator system for free electron laser and ATLAS experiment ADCoS duties at CERN

12:20-12:35 **Haris DAPO** (Turkish Accelerator and Radiation Laboratory, Ankara University, Türkiye)
Design and initial results of the experiment for proton cross-section measurement with stacked-foil technique

12:35-12:50 **Özgür ETİŞKEN** (Kırıkkale University, Türkiye)
Designing a particle accelerator for the future: FCC-e+e-injector complex design

12:50-14:15 LUNCH

Afternoon Section-I 14:15 – 15:30 (Hall-1: Yahya KEMAL Hall)

Chair: İsmail BOZTOSUN (NUKEN-TENMAK, Ankara & Akdeniz University, Antalya, Türkiye)

14:15-14:40 **José M. ARIAS** (Sevilla University, Sevilla, Spain)
Quantum simulation of the Agassi model in trapped ions

14:40-15:05 **Sabin STOICA** (International Centre for Advanced Training and Research in Physics (CIFRA), Romania)
Challenges in the study of double-beta decay

15:05-15:30 **Jameel-Un NABI [ON-LINE]** (Wah University, Punjab, Pakistan)
Updated status of key nuclei for presupernova evolution

15:30-15:55 Coffee Break + (Opening Ceremony of Prof. Dr. İhsan ULUER Hall)

Afternoon Section-II 15:55–17:10

	Hall-1: Yahya KEMAL Hall **Chair: Kaan MANISA** (Kütahya Dumlupınar Un., Türkiye)	**Hall-2: İhsan ULUER Hall** **Chair: Bayram DEMİR** (İstanbul Univ., Türkiye)
15:55-16:10	**Samira BAID** (Cadi Ayyad Un., Marrakech, Morocco) **Collective motion in γ-unstable nuclei within energy-dependent Davidson potential and deformation dependent mass formalisms**	**Duygu TUNÇMAN** (Istanbul Univ.-Cerrahpaşa, Türkiye) **Hounsfield unit (HU) comparison of different materials produced by plastic injection molding method with commercial bolus**
16:10-16:25	**Robert POENARU** (Horia Hulubei Nat. Ins., IFIN-HH, Romania) **Evaluation of the wobbling motion in even-even nuclei within a Simple Rotor Model**	**Duygu TUNÇMAN** (Istanbul Univ.-Cerrahpaşa, Türkiye) **Investigation of the effect of the patient cover materials on surface and build-up region doses**
16:25-16:40	**Hasan BİRCAN** (Kütahya Dumlupınar Univ., Türkiye) **Seyler-blanchard effective interaction calculations for nuclear matter**	**Menekşe ŞENYİĞİT** (Ankara Univ., Türkiye) **Developing a novel dosimeter system used in radiotherapy**
16:40-16:55	**Aysel ÖZFİDAN** (Tarsus Univ., Türkiye) **Lightest pseudo-mirror nuclei in the nuclear chart**	**Özgür ETİŞKEN** (Kırıkkale Univ., Türkiye) **A Proposal for Kırıkkale-2053 Vision: Hadron Therapy Center**
16:55-17:10	**Serkan AKKOYUN** (Sivas Cumhuriyet Univ., Türkiye) **Determination of the shell model single particle energies by using machine learning methods**	**Adem PEHLİVANLI** (Kırıkkale Univ., Türkiye) **Calculation of secondary neutron spectrum and additive dose in a water phantom of 135 MeV/u carbon ion beam by Monte Carlo method**

17:10-17:25 Break