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The Voxel Mice Model of MCNPX for Simulation In Vivo Test BNCT

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Abstract-A study of voxel mice model of MCNPX has been done for in vivo test Boron Neutron Capture Therapy (BNCT). Mathematical and parameters were used to construct the stylized Mice model phantom. The geometry was modified into simulation software MCNPX (Monte Carlo N-Particle eXtended) simulation input. The result of mice stylized model phantom has been showed Figure 3.

Keywords: voxel mice model, MCNPX, in vivo, and BNCT

INTRODUCTION

Boron neutron capture therapy (BNCT) is the ideal technique to selectively kill cancer cells without damaging healthy cells around it. The concept base on the reaction of ^{10}B which captures neutrons to produce α-particles and ^{7}Li. The product of reaction between ^{10}B and neutron is α-particle and Li which can damage components of cancer cells (Walker, 1998) and (Huang, J, 2009). Monte Carlo N-Particle eXtended (MCNPX) is a computer code for general purposes that can be used to perform probabilistic simulation for neutrons, photons, electrons, or transport neutron/photon/electron coupled (RSICC, 2008).

Simulation used the MCNPX with the probabilistic approach include in vivo test BNCT. In order that the simulation results in accordance with the physical phenomena studied, the input parameter should be made as realistic as possible close to the real phenomenon. Input parameters of MCNPX are the definition of the object geometry, material, and other physical parameters such as the energy and number of particles (Redd. RA, 2003)

The main of this study is developing the basic research of simulation in vivo/in vitro test BNCT in Reactor Research Kartini by using MCNPX. The study focuses on creating voxel mice model geometry code of MCNPX. The model will be expected to have a realistic nature, approaching the original object, and having flexibility in terms of its size setting.

BACKGROUND AND METHODS

MCNPX Input Formats

MCNPX input file has 3 parts which namely are cell card, surface card, and data card. Part one and another are separated by a blank line. One line can be charged up to 80 characters.

Cell card

Model phantom geometry is written in the form of MCNPX input which forms of cells that represent elements of organs.

j m d geom params

j	=	Cell number (1<j<999999)
M	=	Material number, if void fills 0 (1<m<99999)

D	=	Material density, (+) in 10^{-24} atom/cm^3, (-) in g/cm^3
geom	=	Geometry specification
params	=	Another specification such as universe, fill, etc.

1 1 -1.03 -1 24 u=1 imp:p=1 imp:n=1

It represents an element which is cell number 1, material number 1 with density 1,03 g/cm^3 and also having importance value photon and neutron.

Surface card

Surface which limits voxel is the size of the beam according voxel size. The dimension is 2 mm × 2 mm × 2 mm. it also defines a large beam that will accommodate the many elements of the voxel.

j a list

j	=	Surface number (1<j<999999)
a	=	Mathematical definition and parameters for surface
list	=	The value of the mathematical equations

Data card

Material definition refers to the composition and fraction elements recommended by ICRP 89 (ICRP,2002) and ICRU 44 (ICRU, 1989).

mn zaid1 fraction1 zaid2 fraction2, etc.

mn	=	material number (1<n<999999)
zaidn	=	Atom number material n,
fraction	=	Nuclides fraction (+) atom fraction atom/b-cm, (-) weight fraction

Geometry specifications are *lattice*, *universe*, and *fill*. It is very useful in medical physics applications especially for making models phantom. In this case, geometry of the mice model form distributed in a voxel. There are two lattice. First lattice interprets shapes of cube and the second lattice interprets shapes of hexagonal. *Lattice* defines surface which only arranges once and repeats a number of array x, y, and z. *Universe* interprets unity for example cell 1, 2, and 3 are same shapes. If they are written u=1, then all three are into a single unit cell which is a new cell. *Fill* indicates array which is filled by elements of the lattice.

For example, the dimensional array as follows:

Fill = 0:2 1:3 0:2

It indicates lattice size of 3×3×3, with 8 elements. Figure 1.Describes a voxel into 3D lattice.

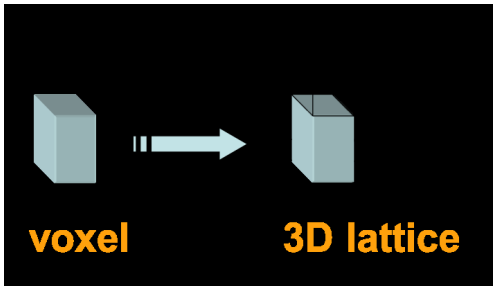

Figure 1. Lattice geometry (Taranenko et al, 2005)

Nearest Neighbor Method

Voxelization is a process to make continuous objects into discrete objects. Voxelization required in the manufacture phantom because the definition of the geometry of the radiation transport software used cannot accommodate a continuous object, but rather a discrete form of the blocks that make up a geometry.

The method used for vocalization is the nearest neighbor pixel operations. This method is based on the scaling or pixel size setting. Continuous object is an object with a large pixel size, while the discrete objects having a small pixel size. Therefore, voxelization base is changing the pixel size into smaller. The new pixel value obtained from the results of the

election in the pixel values between the pixels closest, by rounding operation (Achmad and Firdausy, 2011).

Stylized Phantom

Nowadays, there are three types of phantom. They are stylized phantom, voxel phantom, and hybrid phantom. Stylized phantom based on mathematical equations used to approach the volumetric geometry of the organs and outer body surfaces. The overall volume is composed of the combined volume of the organ that is approached with a cylindrical shape, ball, blocks, cubes, cones, and ellipsoidal. This phantom type has advantages in terms of setting the size of the geometry, shape, and placement of organs, but has the disadvantage of such a form that is not realistic anatomy (Pinasti S.G, 2014).

Study Scheme

In general, this study is divided into several main stages, i.e. literature, manufacture

Table 1. Mathematic Definition and Parameters Used for Stylized Mice Model (Konijnenberg M.et al, 2015)

Ellipsoids							angle with z-axis
Organ	a (cm)	b (cm)	c (cm)	x0 (cm)	y0 (cm)	z0 (cm)	0
Liver	1.8	2.35	1.15	0	0	0.5	0˚
Spleen	0.3	1.6	0.375	0.5	1.25	-1	-13
Kidney	0.5	0.7	1.1	±1	0	-1.5	0˚
Surface	0.4	0.6	1	±1	0	-1.5	0˚
Cortex	0.3	0.45	0.725	±1	0	-1.5	0˚
Lungs	0.475	1.6	1.9	±0.75	1	3.5	±10˚
Heart	0.6	0.7	1	0	0	4	0˚
Stomach	0.75	1.1	1.75	0	-2	-0.5	0˚
Small bowel	1.9	0.5	2.5	0	-1	-2	0˚
Large bowel	0.63	2.31	2.36	0	0	-5	0˚
Thyroid	0.29	0.074	0.66	0	2	5	0˚
Pancreas	1.8	0.5	0.26	0	0	-0.5	0˚
Bladder wall	0.2	0.5	0.625	0	-0.25	-10	0˚
Contents	0.15	0.45	0.575	0	-0.25	-10	0˚
Testis	0.47	0.94	0.94	±0.47	1	-10	0˚
Skull	0.85	1.6	4	0	0	10.5	0˚
Brain	0.75	1.5	1.5	0	0	10.5	0˚
Body contour	1.65	13.3	12.9	0	0	0	0˚

Cylinders						
Organ	r (cm)	A (cm)	x0 (cm)	y0 (cm)	z0 (cm)	
Femur	0.2	5.56	±0.79	-1	-9	±4.5˚
Marrow	0.1	2.3	±0.79	-1	-9	±4.5˚

Elliptical tori				
	a (cm)	b (cm)	c (cm)	y` (cm)
Spine	42.5	0.25	0.2	39.25
Spinal core	42.5	0.1	0.1	39.25

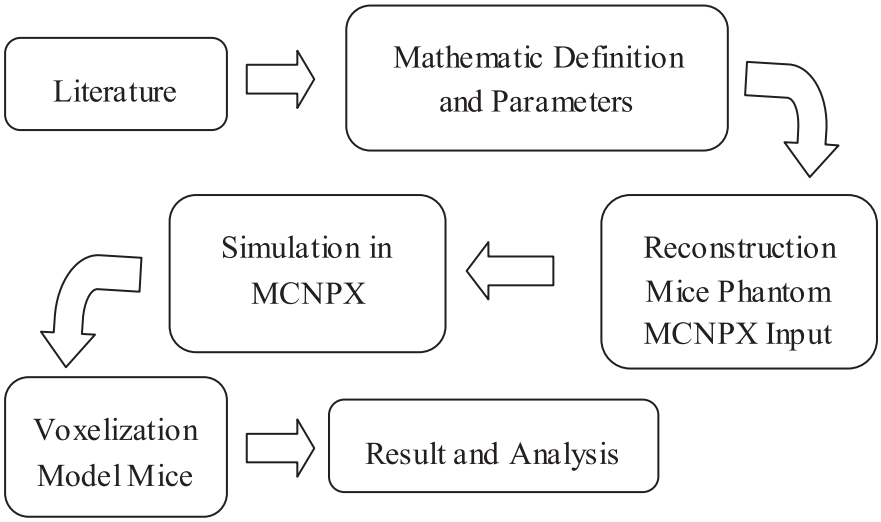

Figure 2. Scheme of Making Mice Model MCNPX

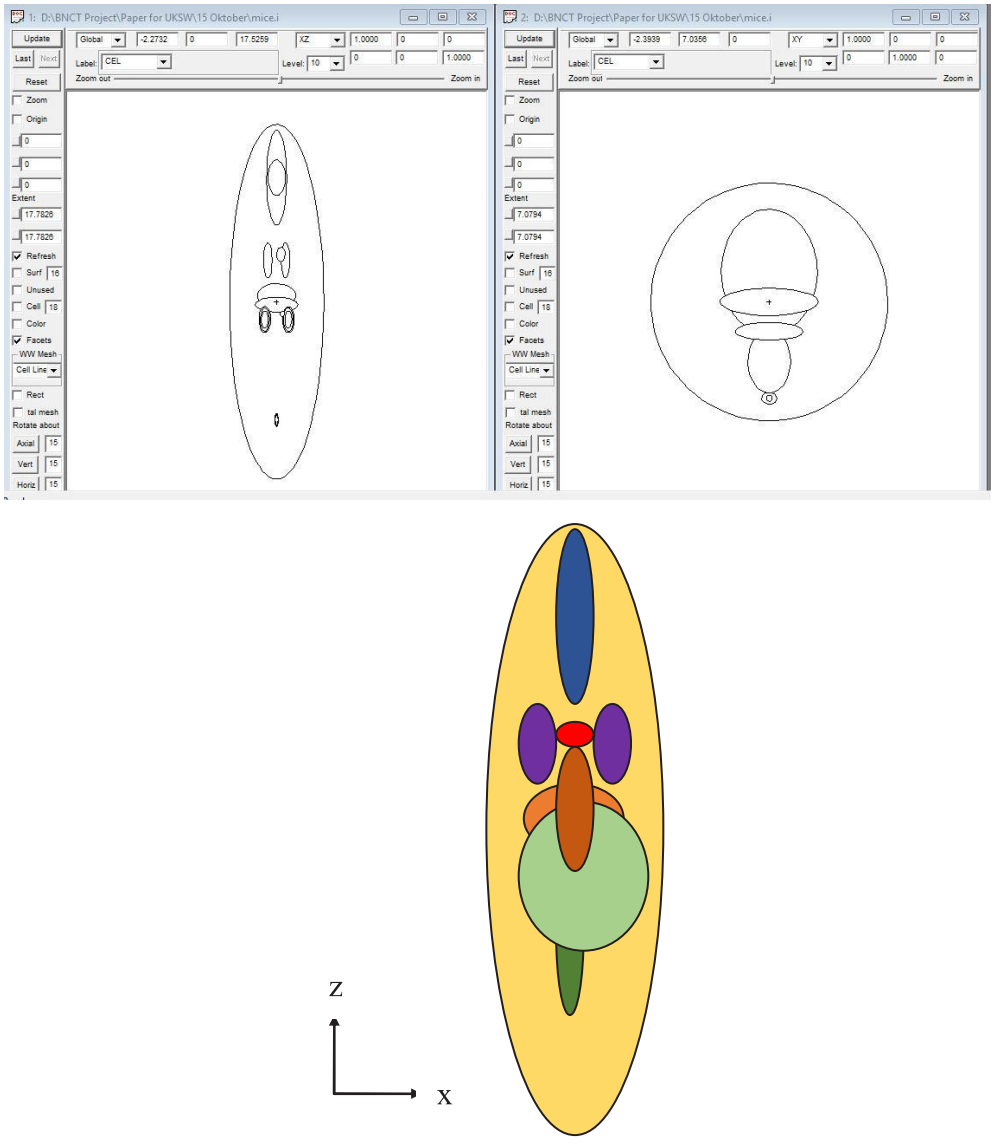

Figure 3. The Stylized Mice Model Phantom of MCNPX

phantom, simulation implementation, and data analysis. In detail, this study is divided into advanced stages as shown in Figure 2.

RESULTS AND DISCUSSION

Reconstruction Mice Model Phantom

Voxelization process is necessary to adjust the format of the input geometry permitted in MCNPX. The object will be shown continuously and increasingly close to the original, but the number of voxels generated more. A number of Voxel allowed in MCNPX number of 25,000,000 voxels (Burn, K.W, 2007). The result of reconstruction mice model can be viewed Figure 3.

CONCLUSION AND REMARKS

This study has been done to develop mice model phantom for simulation in vivo test BNCT in Reactor Research Kartini by using MCNPX. Figure 3 showed the stylized mice model phantom. It has been created by Mathematic definition and parameters refers to (Konijnenberg M. et al, 2015). To make voxel of the mice model has not been done yet.

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