

GEANT4

^{99m}Tc

가

2007 11 16 / 2008 2 19

.....

^{99m}Tc 가 , GEANT4 370 MBq
 가 0.4 mL ^{99m}Tc 가 가 , (0.29 μSv
 sec⁻¹), (1.19 μSv sec⁻¹), (1.07 μSv sec⁻¹), (4.36 μSv sec⁻¹), (3.37 μSv sec⁻¹) 가
 .
 .
 : GEANT4 , 가 , 가

1.

2.1

가

가

^{99m}Tc ¹³¹I

[5].

가

[1].

^{99m}Tc

[6]. 가

, Gauri

가 [2].
50 mSv year⁻¹,
500 mSv year⁻¹

가 (ICRP)

[7] ^{99m}Tc(34.6 GBq) ¹³¹I(21.6 GBq)
10.2 mSv

가 1

가 10 가 [3].
가

가 , ^{99m}Tc
1.9 mSv

500 mSv

1995

0.2 mSv

가 가 가 ,
가 가 가

가 75% , 가
가 30% [8]. , 가

0.5 mSv

가 [4].

가 (1992) “
GEANT4

가 가 [9], 2003

^{99m}Tc

가 가

“ [10]

가

가

가

2003-6

2.

116 1

: , rth@hanmail.net,
1가 664-14

가

[4]. 가 , 가 가 가 .
 가 . GEANT
 GEANT4 , , 가 ,
^{99m}Tc 가 ,
 가 . GEANT4 9.0
 , Linux, SUN, Windows 가
 2.2 GEANT4 가 , GEANT4
 1970 CERN [12].
 (LHC : Large Hadron Collider) 가 GEANT4 , GEANT4 1
 가 17
 . Fortran , 1
 GEANT3 [13]. GEANT4
 , 1994 C (NIST : National Institute of Standards and Technology)
 (OOT: Object Oriented Technology)
 [11]. 1998 GEANT4 가 .

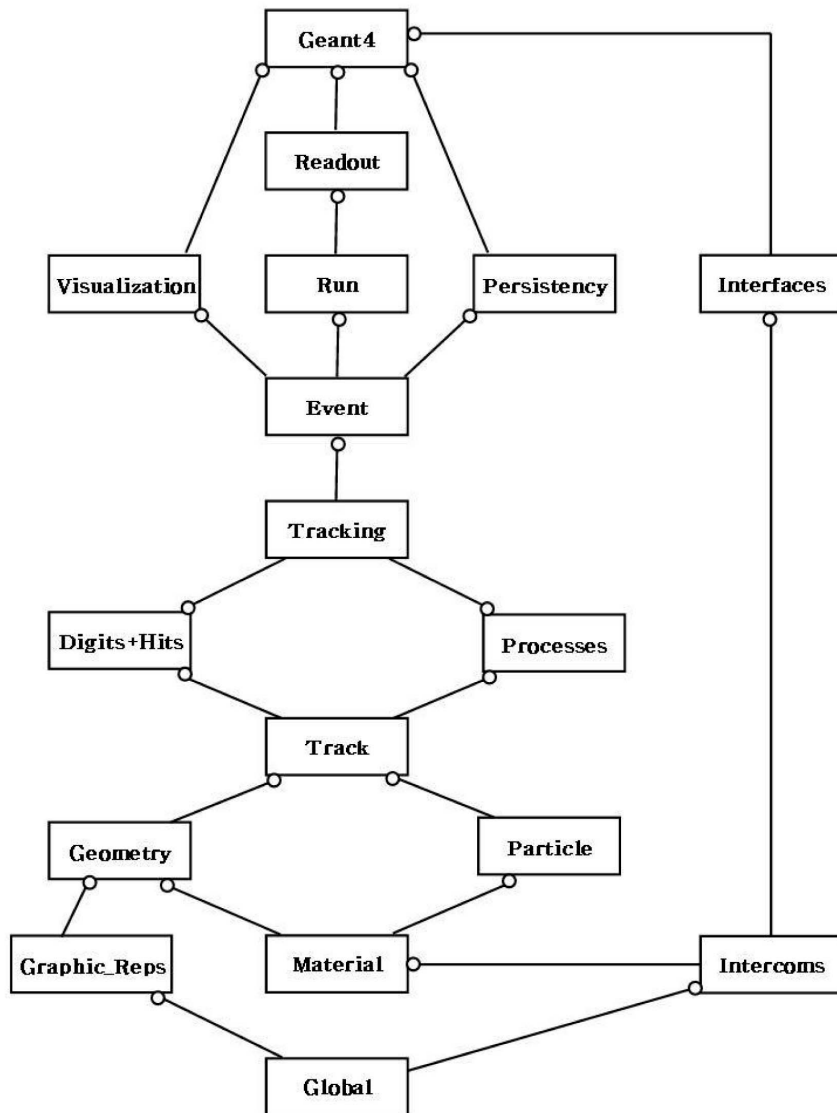


Fig. 1. The top level class category diagram of GEANT4.

CGS(Constructed Solid Geometry) X- (175 cm, 75 kg) 가
 , OpenGL 3D , 가
 GEANT4 가 2
 [12 14]. G4Tubs 가 가 가 가 3
 Tissue_Soft_ICRP, Bone_ICRP 가
 3. 2) 1 mL 1 mL
 3.1 , 3
 1) 가 PVC ,

Table 1. Function of the Categories of GEANT4.

Category	Function
Run, Event	Event , event generator interface,
Tracking	step 가 , Processes 가 track, step
Material, Particle	
Processes	lepton, photon, hadron, ion
Hit, Digits	, G4Step object 가
Visualization	Graphical library solid, trajectory, hit, interaction
Interfaces	GUI interface

Table 2. Geometry of Fingers. [cm]

Finger	Thumb	Index Finger	Middle Finger
Tissue	2.40 × 5.56	2.12 × 7.64	2.08 × 8.60
Bone	1.10 × 5.56	1.00 × 7.64	1.00 × 8.60

Table 3. Element weight percent, Density and component of Syringe and Finger.

Geometry	Material	Element weight(%)	Density (gcm ⁻³)
Syringe needle	Fe	Fe(100)	7.874
Syringe body	PVC	H(2.0793), C(24.7793), Cl(73.1413)	0.92
Finger Tissue	Tissue_Soft (ICRP)	H(10.447), C(23.219), N(2.488), O(63.024), Na(0.113) Mg(0.013), S(0.199), P(0.133), Cl(0.134), K(0.199) Ca(0.023), Fe(0.005), Zn(0.003)	1.0
Finger Bone	Bone (ICRP)	H(4.72), C(14.43), N(4.20), O(44.61), Mg(0.22) P(10.50), S(0.31), Ca(21.00), Zn(0.01)	1.850

2 ^{99m}Tc 가
 , 3 가



Fig. 2. Finger position for intravenous administration to patient.

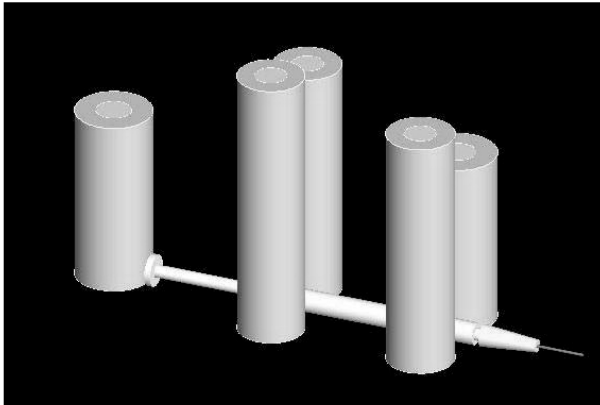


Fig. 3. Geometry Modeling.

3.2

^{99m}Tc 0.4 mL ^{99m}Tc
 141 keV 가

G4EmStandardPhysics 4 ^{99m}Tc
 300 OpenGL

(1) 370 MBq ^{99m}Tc

$$N = Y \cdot A \quad (1)$$

N (#/sec) , Y
 (^{99m}Tc : 0.89 photons/decay) , A
 (Bq)

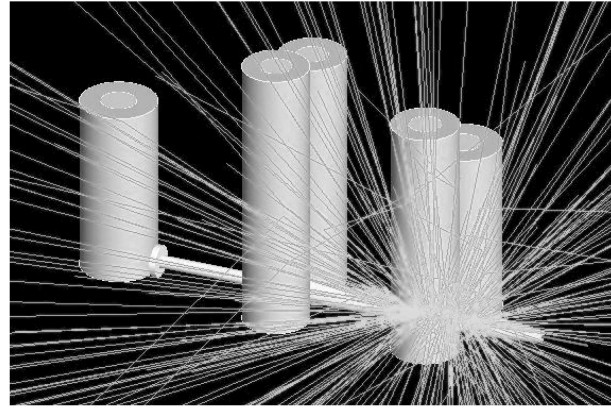


Fig. 4. Visualization of accumulated tracking.

370 MBq 3.293×10^8 #/sec
 10^9

3.3 가

가 가 가 가
 Joule (J) 가
 가 가

GEANT4.9.0 version, CLHEP2.0.3.1
 version Microsoft Windows Server 2003
 Enterprise Edition sp2, Intel(R) Xeon(R) CPU 5150 @ 2.66GHz,
 6.00GB RAM Workstation

4.

370 MBq 가 가 가
 가 가 가 가

가 가 가 가

가 가 가

가 가 가

가 ^{99m}Tc 가

가 가 가

가 가 가

5 가 가

가 가 가

Table 4. Finger dose rate received during ^{99m}Tc injection. [$\mu\text{Sv} \cdot \text{sec}^{-1}$]

Activity	Right Thumb	Right Index Finger	Right Middle Finger	Left Thumb	Left Index Finger
370 MBq	0.29	1.19	1.07	4.36	3.37

Table 5. Comparison of dose equivalent per 370 MBq. [$\mu\text{Sv} \cdot \text{sec}^{-1}$]

	Right Thumb	Right Index Finger	Right Middle Finger	Left Thumb	Left Index Finger
Finger tissue	0.126	0.516	0.464	2.081	1.585
Finger bone	0.164	0.670	0.603	2.275	1.789

가
 , 가
 ,
 ICRP가
 70 μm
 GEANT4 가 가 가
 가
 5.
^{99m}Tc 가 GEANT4 가
 가 가 , 가
 가 가
 0.4 mL 가 ^{99m}Tc
 370 MBq 가 가
 : (0.29 $\mu\text{Sv sec}^{-1}$), (1.19 $\mu\text{Sv sec}^{-1}$), (1.07 $\mu\text{Sv sec}^{-1}$), (4.36 $\mu\text{Sv sec}^{-1}$), (3.37 $\mu\text{Sv sec}^{-1}$).
^{99m}Tc 가
 (No. M2060-852001-07B0852-00110).

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2. , 1999:139-148 ;
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 2003-6. “ 가
 ” . 2003 가
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Finger Doses Received during ^{99m}Tc Injections Calculated with GEANT4

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Abstract - To estimate the finger dose absorbed by ^{99m}Tc injection, simulations are carried out to calculate the dose equivalent of each finger per second with radioactivity of 370 MBq, based on the GEANT4 simulator. For the ^{99m}Tc source of the volume of 0.4mL and the radioactivity of 370 MBq, we obtained the dose equivalent of the right thumb ($0.29 \mu\text{Sv} \cdot \text{sec}^{-1}$), the right index finger ($1.19 \mu\text{Sv} \cdot \text{sec}^{-1}$), the right middle finger ($1.07 \mu\text{Sv} \cdot \text{sec}^{-1}$), the left thumb ($4.36 \mu\text{Sv} \cdot \text{sec}^{-1}$), and the left index finger ($3.37 \mu\text{Sv} \cdot \text{sec}^{-1}$), respectively. This simulation results may serve as a useful data in the prediction of finger dose absorbed by ^{99m}Tc injection.

Keywords : GEANT4 simulator, finger dose, dose equivalent