MOLECULAR IMAGE GROUP, LIFE SCIENCE RESEARCH CENTER, XIDIAN UNIVERSITY, XIAN, P.R.C. MEDIAL IMAGE PROCESSING GROUP, INSTITUTE OF AUTOMATION, CAS, BEIJING, P.R.C. VT-WFU SCHOOL OF BIOMEDICAL ENGINEERING & SCIENCES, VIRGINIA, U.S.A.

# MOSE

## Molecular Optical Simulation Environment

User's Manual Release 2.0

[Service e-mail: mose@life.xidian.edu.cn]

Appendix A		2
What is MO	SE?	2
How do I inj	put the parameters?	2
How does M	IOSE simulate?	2
Can I run M	OSE on my computer?	2
Appendix B		3
Getting star	ted with MOSE	3
Step 1	Run MOSE	3
Step 2	Parameter Input	6
Step 3	Simulation and Output of MOSE	20
Appendix C		23
Output Res	ults	23
Appendix D		25
FAQ		25

# Appendix A.

#### What is MOSE?

MOSE is a photon tracing program for optical analysis of biological tissue models. MOSE traces photons using "Monte Carlo Technique".

The best way to describe how MOSE works might be to briefly outline the steps that are typically taken if you were to start a new MOSE project. These steps will be discussed in greater depth in the following sections.

1. 'Input the Parameters' - The first step is to build a geometrical model representing the system you wish to analyze. During this operation, you need to input both the geometric and optical properties of the tissue.

2. 'Simulation' - This second step is to run the system you defined above.

3. 'Output the MOSE' - Once the simulation finished, you can find the output of MOSE including 'absorption map', 'flee map' and 'CCD map'. You can also save the simulation parameters, absorption results and transmittance results.

In MOSE, for consistency we use millimetre (mm) as the basic unit of length throughout the whole software.

#### How do I input the parameters?

MOSE has a very friendly user interface. And it offers two efficient approaches for us to input the parameters. One is loading the parameter files (.mse file), which has a specified form. We will offer some standard parameter files to the users to study how to construct the parameter file. The other is inputting the parameters in the parameter setting dialog box.

No matter which approach, you can simply modify parameters after inputting. You can add or delete tissues or light sources or detectors if you need. This is especially useful when the kinds of tissues or light sources or detectors are more than the default settings.

#### How does MOSE simulate?

The whole propagation of each photon packet includes three main parts: photon packet generation from bioluminescent sources, the propagation in biological tissues and detection by the CCD detectors, which was completed through the Monte Carlo (MC) method. The MC method has been proved to be exact and efficient. During the whole process, MOSE not only traces the travel paths of each photon packet but also records the absorption and transmittance information. Through these records, MOSE can give the absorption and flee map of the photons in phantom.

#### Can I run MOSE on my computer?

Until now, MOSE can run on Microsoft Windows 98/2000/NT/XP/Vista.

# Appendix B.

#### Getting started with MOSE

#### Step 1 Run MOSE

1. Double click the **MOSE.exe** file, and Monte Carlo simulation application software will start immediately (Figure 1).

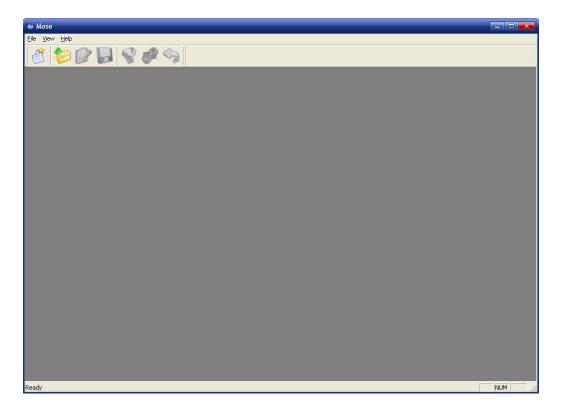


Figure 1. Main Window of MOSE

2. The first step to start the simulation is to build a new project. Select the menu named **New** under the **File** menu, or click the button in the toolbar, the *New Simulation Project* window appears (Figure 2).

New Simulation Proje	ct 🛛 💌
Project Name:	123
Path:	D:\
Selected Envi	ronment
C 2D Sim	ulation
3D Anal	ytic Simulation
C 3D Mes	h Simulation
	OK Cancel

Figure 2. Build a New Project

Input your project name, select the save path through and the simulation environment. There are three environment in MOSE: 2D environment, 3D analytic environment and 3D mesh environment. The different simulation environment has different type of phantom. After this step MOSE will display different interface according to your choice. Figure 3-1, Figure 3-2 and Figure 3-3 shows the interface of 2D, 3D analytic and 3D mesh environment respectively.

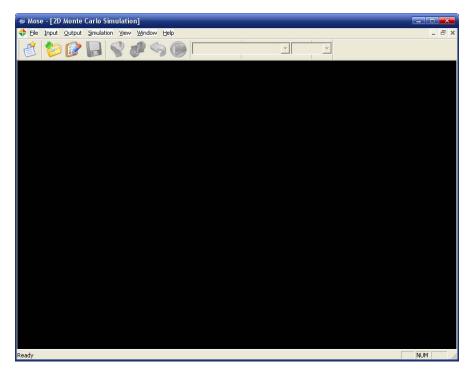


Figure 3-1. Default interface of 2D simulation environment

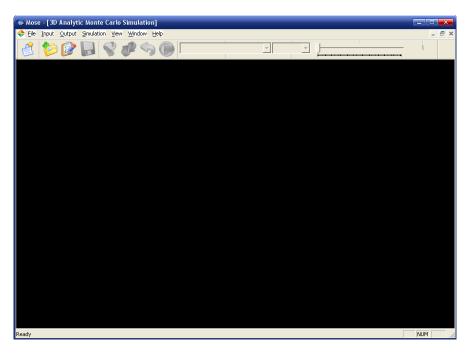


Figure 3-2. Default interface of 3D analytic simulation environment

🐃 Mose - [3D Mesh Monte Carlo Simulation]						- I <b>- X</b>
Eile Input Qutput Simulation Mesh Simplification	Segmentation View	Window Help				- 8 ×
1 2 2 2 3		i.	<b>Y Y</b>	]	1	
Ready						NUM

Figure 3-3. Default interface of 3D mesh simulation environment

3. Open a project: You can open the project you have simulated before. Select the

**Open** menu under the **File** menu or click the button on the toolbar, and find the parameter file (.mse file) you have saved last time, MOSE will automaticlly select the simulation environment and show the image of the phantom according to the parameter file(Figure 4).

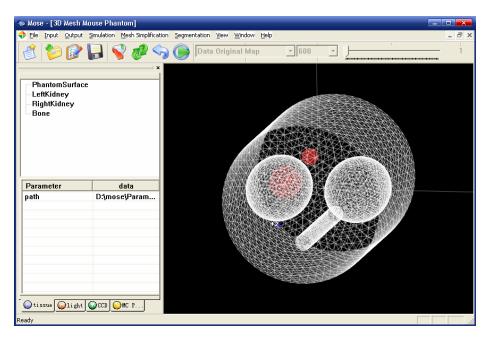


Figure 4. Open a project that is in 3D mesh environment

#### Step 2 Parameter Input

1. The steps of inputting the parameter in the three simulation environments are similar. Here, we just take the 3D analytic environment as the example.

See Figure 3-2, in the main window, under the input menu, click 3D Analytic

**Parameter** or click the button **I**. The *Input Parameters* window appears (See

Figure 5). There are four different input pages named '*Tissue*', '*Light Source*' '*CCD*' and '*MC simulation*', respectively.

D Analytic Simulation	
Tissue Parameter   Light Source Parameter   CCD Parameter   MC Simulation	Parameter
Tissue	Load Data
Parameter         X (mm)         Y (mm)         Z (mm)         Shape         Alpha (degree)         Belta (degree)	Gamma (degree)
	Add Spectrum
	Del Spectrum
Optical Parameter	
Wavelengh (nm) Absorption (1/mm) Scattering (1/mm) Anisotropy Refractive	
	Apply
	Cancel
Add Tissue Del	OK

Figure 5. Input dialog box for simulation parameters

a. Click the button **Load Data**, we can load 3D analytic parameter file (\*.mse/\*.txt) from outside. We provide some file examples for user to study how to use MOSE. If the form of the file is not correct, only the correct parameters will be read in and other parameters need to be input manually. After loading data, the parameter will be seen in the Input Parameters dialog box.

b. Click the button **Add Spectrum**, we can add new spectrum band as Figure 6-1 indicates. Also the optical parameter of all the tissues in the new spectrum band should be set in this dialog box. The information of the light sources in this spectrum band could be set in '*Light Source*' Parameter Page.

Notice: In MOSE, we take the center wavelength to represent the spectrum band.

Add Spectrum		_	_	_	X
Waveleng Tissue Oj	th :	nm			٦
tissue	Absorption (1/mm)	Scattering (1/mm)	Anisotropy	Refractive	
PhantomSu					
Heart					
LeftKidney					
RightKidne					
Bone					
		ОК		Cancel	

Figure 6-1. Dialog box for adding spectrum band

c. Click the button **Del Spectrum**, choose the spectrum band that we want to delete as Figure 6-2 indicates, and press Button **OK** to delete it. After this step the tissues parameters and the light sources parameters related to this spectrum would be deleted.

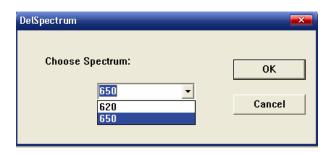


Figure 6-2. Dialog box for deleting a spectrum band

- d. Click button **Apply**, all the parameters in the pages will be saved.
- 2. Page of *Tissue* parameter

See Figure 7-1, The '*Tissue*' list of this page shows the parameters of all tissues, including the center coordinates, shape, rotation angle, half-axis length.

issue								Load Dat
Parameter	X (mm)	Y (mm)	Z (mm)	Shape	Alpha (degree)	Belta (degree)	Ga	
PhantomSurface	0.000000	0.000000	0.000000	Cylinder	0.000000	0.000000		
Heart	0.000000	4.000000	6.000000	Ellipsoid	0.000000	0.000000		
LeftKidney	-5.000000	0.000000	0.000000	Ellipsoid	0.000000	0.000000		
RightKidney	5.000000	0.000000	0.000000	Ellipsoid	0.000000	0.000000		Add Spect
Bone	0.000000	-5.000000	0.000000	Cylinder	0.000000	0.000000		
A state of the	er of Phant	mSurfac	e				>	Del Spect
ptical Paramete		omSurfac		(1/mm)	Anizatuanu	ofunctive	>	Del Spect
	r of Phant Absorption 0.008	tomSurfac n (1/mm)	e Scattering 20.973			efractive .350000	>	Del Spect

Figure 7-1. Input dialog box for tissue parameter

*X*: x coordinates of the center location of the tissue

*Y*: y coordinates of the center location of the tissue

*Z*: z coordinates of the center location of the tissue

Alpha: the rotation angle of the tissue shape with respect to x-axis

*Beta*: the rotation angle of the tissue shape with respect to y-axis

Gamma: the rotation angle of the tissue shape with respect to z-axis

- *a*: the length of half axis of x coordinate
- *b*: the length of half axis of y coordinate
- *c*: the length of half axis of z coordinate

*Shape*: the geometric shape of the tissue.

Where, MOSE provides two kinds of shape model: **Ellipse, Rectangle** in 2D environment and **Ellipsoid**, **Cylinder** in 3D environment.

Especially, in 3D mesh environment, tissue shape consist of triangle mesh structure, such as .ply/.off files (see Figure 7-2).

	eter	Light Sour	ce Para	meter	CCD Para	meter	AC Sim	ulation P	arameter		
lissue										-	
Parameter	Sha	pe File Path	Change	Path						Loa	ad Dat
PhantomS	c:\cyl	nder_surfa	Brows	;e							
Heart	c:\elli	soid_heart	Brows	se							
LeftKidney	c:\elli	osoid_leftki	Brows	se							
RightKidney	c:\elli	psoid_right	Brows	e							
Bone	c:\cy	inder_bone	Brows	e							Spect
Optical Para		1				1	1		_	Del	Spect
<u>.</u>		1			aving (1/mm)	Anisotro	Du D	fractivo		Del	Spect
Dptical Para Wavelengh 500		Absorption	(1/mm)	Scatte	ering (1/mm) ).973200	Anisotro		efractive		Del	Spect
Wavelengh		Absorption	(1/mm) 761	Scatte 20		Anisotro 0.94000 0.94000	00 1	efractive .350000 .350000		Del	Spect
Wavelengh		Absorption 0.0087	(1/mm) 761	Scatte 20	.973200	0.94000	00 1	.350000	Ī		Specti Apply
Wavelengh		Absorption 0.0087	(1/mm) 761	Scatte 20	.973200	0.94000	00 1	.350000			

Figure 7-2. Input dialog box for parameter of tissues in 3D mesh

The 'Optical Parameter' list shows the optical parameters of the tissue which is chosen in the 'Tissue' list in each spectrum band, including absorption coefficient, scattering coefficient, refractive index, and anisotropy coefficient.

**Notice:** Since the first tissue represents the phantom, it cannot be deleted. And other tissues must be in the range of the phantom. Otherwise, errors would happen during simulation.

	arameters –		Ce	enter	r Positia	on —	
Tiss	ue Name :			<:		0	mm
		,	3	:		0	тт
Tiss	ue Shape :		•	z :		0	mm
	Rotation A	ngle	SI	nape	Param	eter –	
	Alpha :	0	4	a :		0	mm
	Belta :	0	I	<b>)</b> :		0	mm
	Gamma :	0		::		0	mm
		,					
	al Paramete		5	1		Refrac	e a
	avelengh (nm) 620	Absorption (1/mm)	Scattering (1/mm)	AD	isotropy	Rerrac	tive
l							

Figure 7-3. Dialog box for adding a new tissue

a. Click the button Add Tissue, an input dialog box will be shown as Figure 7-3. We

can add tissue we need. Here we should input the tissue's name, shape, center coordinates, rotation angle, half axis length and optical parameters. Especially, in 3D mesh environment, we need to input the path of the .ply/.off files (see Figure 7-4). Click the '**OK**' button, the new tissue will be add at the bottom of the '*Tissue*' list.

Add Tis	ssue ue Name:	_	-		×
	pe File Path:				Browse <u>.</u>
	Optical Paramet	er			
	Wavelengh (nm)	Absorpt	Scattering (1/mm)	Anisotropy	Refractive
	620				
	650				
			0		Cancel

Figure 7-4. 'Add Tissue' dialog box in 3D mesh

- b. Click the button **Del Tissue**, delete selected tissue and its optical parameters.
- 3. Page of *Light Source* parameter

This page consists of the information of regular shape light sources (Figure 8-1). Similar to the tissue page, the upper list shows the information of the light sources, including the center coordinates, shape, rotation angle, half-axis length and the form of energy distribution.

		Light out	nee i didi		D Falai		ulation Parame		
Ľ	ight Source								Load Dat
	Parameter	X (mm)	Y (mm)	Z (mm)	Shape	Alpha (degree)	Belta (degree)	Gi	
	Light source 1	4.000000	-6.000000	7.000000	Ellipsoid	0.000000	0.000000		
	Light source 2	4.000000	6.000000	7.000000	Cylinder	0.000000	0.000000		
	<		ш			-	-	>	Del Spect
	Property of L	ight sour	ce 1 ——						
	Wavelenth (nm	i) Numb	erOfPhotons	Source	Energy (W			_	
	620		550	1.000	1000e+000		Add Light Sou	rce	
									Apply
							Del Light Sou	rce	
									Cance

Figure 8-1. Input dialog box for light source parameter

The lower list shows the information of the light source which is chose in the upper list, including the photon energy and photon number of the light source in different spectrum band. Here, if the light source doesn't include one of the spectrum bands, the corresponding photon number and energy should be set to zero.

Especially, in 3D mesh environment, there're two kinds of shape of the light source. One is analytic shape (ellipsoid, cylinder), the other is mesh shape (mctrian -glemesh). The upper list mentioned above is divided into two lists (Figure 8-2). The '*Analytic Light Source*' list shows the light sources which are of analytic shape, while the '*Mesh Light Source*' list shows the light sources which are of mesh shape.

sue Parameter	Light So	urce Para	meter	CD Para	meter   MC Sin	nulation Parameter	
-Analytic Light S	ource						
Parameter	X (mm)	Y (mm)	Z (mm)	Shape	Alpha (degree)	Belta (degree)	Load Data
Light source 1	-4.000000	6.000000	7.000000	Cylinder	0.000000	0.000000	
<		Ш				>	
-Mesh Light Sou	irce						Add Spectr
Parameter	Shape File	e Path 🛛 🔿	hange Path				
Light source 2	c:\2.p	dy 🛛	Browse				Del Spectr
Property of Lig	t course	1	_	_			Apply
Wavelengh (nm)		rOfPhotons	Sourcel	Energy (W)			
620		500	_	D00e+000		Add Light Source	Cancel
650		500		000e+000			
			110000			Del Light Source	ок

Figure 8-2. Input dialog box for parameter of light sources in 3D mesh environment

a. Click the button **Add Light Source**, regular shape light source will be added and the input dialog box is as follows (Figure 8-3):

Light Source Shape :		[
Light Source Distribut	ion :	[
Center Position	Rotation Angle	Shape Parameter
×: 0 mm	n Alpha:	0 a: 0 mm
y: 0 mm	Belta:	0 b: 0 mm
z: 0 mm	Gamma :	0 c: 0 mm
Property		
Wavele NumberOfPhoto	ns SourceEnergy	
620		

Figure 8-3. Dialog box for adding a light source

Where, we should set the shape, the form of energy distribution, center coordinates, rotation angle, half-axis length of the light source and photon number and energy in corresponding spectrum band.

Especially, in 3D mesh environment, we should select the shape type before we input the parameters of the light source (see Figure 8-4 and Figure 8-5).

Light Source Shape Type	<b>~</b>
Analytic Shape	
🔿 Mesh Shape	
ОК	Cancel

Figure 8-4. Dialog for selecting the shape type

	, File Path:	Parameter		 
Г	Property	1		 
	Wavele	NumberOfPhotons	SourceEnergy	
	620			
	650			

Figure 8-5. 'Add Light Source' dialog box if select the mesh shape

b. Click the button **Del Light Source**, the selected light source and its parameters would be deleted.

#### 4. Page of CCD detector parameter

See Figure 9, information, including the center coordinates, shape, rotation angle, half axis length, resolution and normal vector of CCD, the flag for detector matrix saving, the coordinate system of detector matrix and the flag for lens being, is shown in the '*CCD*' list of this page. Where,

Resolution(dx): the resolution of x coordinate

*Resolution(dy):* the resolution of y coordinate

Resolution(dz): the resolution of z coordinate

The '*Lens*' list shows the information about lens corresponding to each of the detectors, including the center coordinates, shape, rotation angle, half axis length, normal vector and focus of the lens.

Parameter	X (mm)	Y (mm)	Z (mm)	Shape	Alpha (degree)	Belta (degree)	Ga	Load D
Detector 1	11.000000	0.000000	0.000000	Cube	0.000000	0.000000		
Detector 2	-11.000000	0.000000	0.000000	Cube	0.000000	0.000000		
Detector 3	0.000000	11.000000	0.000000	Cube	0.000000	0.000000		
Detector 4	0.000000	-11.000000	0.000000	Cube	0.000000	0.000000		
<	Ш						>	Add Spe
Detector1				lipsoid lipsoid	0.000000	0.000000	0.0	
Detector2				lipsoid	0.000000	0.000000	0.0	
Detector3	0.000000	0.000000 -3	.000000 El	lipsoid	0.000000	0.000000	0.0	
Detector4	0.000000 0	0.000000 -3	.000000 El	lipsoid	0.000000	0.000000	0.0	Арр
<		Ш					>	
							_,	Can

Figure 9. Input dialog box for parameter of detectors and lens

If the last item 'Lens' item in the '*CCD*' list is set to be "nolens", all the lens parameters in the '*Lens*' list for the corresponding detector will be set to zero.

a. Click the button **Add CCD**, a new row for detector would be added into the '*CCD*' list. And the corresponding parameters information can be input by user.

b. Click the button **Del CCD**, the selected detector and its information would be deleted.

#### 5. Page of Monte Carlo (MC) parameter

The information about absorption matrix and transmittance matrix for Monte Carlo simulation is illustrated in this page (Figure 10), including the coordinate system and resolution of the absorption matrix and transmittance matrix. We can choose whether to save the two matrixes or not.

3D Analytic Simulation	<b>—</b> ×
Tissue Parameter   Light Source Parameter   CCD Parameter   MC Simulation Parameter   Absorption Matrix coordinate system   Cylindrical   V save	Load Data
Transmittance Matrix coordinate system Cylindrical v v save	Add Spectrum Del Spectrum
Resolution         x-axis       0.1       mm       y-axis       0.1       mm       z-axis       0.1       mm         polar radius       0.3       mm       polar angle       1       degree	Apply Cancel OK

Figure 10. Input dialog box for MC simulation parameter

6. Modification of the parameter in sidebar

When the parameters in four pages are all inputted, click the button **OK** then enter the simulation interface (shown in Figure 11).

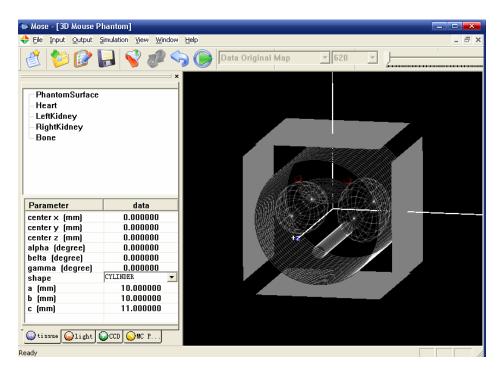


Figure 11. Interface of simulation in 3D analytic environment

In this image, white represents tissues, red represents light source and gray is CCD.

Unfolding the sidebar, we can find the parameters of tissue, light source, CCD and MC inputted. These parameters can be modified easily and flexibly here.

a. *Tissue* list: Tissue name is shown in the upper list, corresponding information including position and shape parameters which can be modified are shown in the second list (in 3D mesh environment, the second list shows the path of the .ply/.off file). We can add tissue, delete tissue, or set the optical parameter by right clicking the tissue name (see Figure 12-1, Figure 12-2, Figure 12-3).

	^
PhantomSurface Heart LeftKidney Bone Bone Del Tissue Optical Para	meters
Parameter	data
center × (mm) center y (mm) center z (mm) alpha (degree) belta (degree) gamma (degree) shape a (mm) b (mm) c (mm)	5.00000 0.00000 0.000000 0.000000 0.000000
🔘 tissue 😡 light 🕻	CCD OMC Parameter

Figure 12-1. Add a tissue

≫ Mose - [3D Mouse   ✦ Eile Input Qutput		ndow Help
2 60	🕞 😵 🥒	6/10 Data Original Map _ 620 6/10
Bone Del	Tissue Tissue cal Parameters	
Parameter center × (mm) center y (mm) center z (mm) alpha (degree) belta (degree) gamma (degree)	data 5.000000 0.000000 0.000000 0.000000 0.000000	
shape a (mm) b (mm) c (mm)	ELLIPSOID 4.000000 5.000000 7.000000 @CCD OMC Param	eter

Figure 12-2. Delete a tissue

PhantomSurface Heart LeftKidney RightKid Bone Optical P		Opti	ical Paramete	1				X
Parameter	data							
center × (mm)	5.000000		Wavelength	Absorption (	Scattering (	Anisotropy	Refractive	
center y (mm)	0.000000		620	0.154980	18.092400	0.860000	1.370000	-
center z (mm)	0.000000		620	0.134900	18.092400	0.00000	1.370000	
alpha (degree)	0.000000							
belta (degree)	0.000000							
gamma (degree)	0.000000							
shape	ELLIPSOID 💌							
a (mm)	4.000000							
b (mm)	5.000000		<				>	
c (mm)	7.000000							
tissue Olight (	CCD MC Parameter				ОК		Cancel	

Figure 12-3. Set the optical parameters of the light source

b. *Light* list: Light source is shown in the upper list, corresponding information including position and shape parameters which can be modified are shown in the second list. Right click a certain light source, we can add or delete a light source, or set the energy distributing and the number of photons in each spectrum band (see Figure 12-4, Figure 12-5, and Figure 12-6).

	Light Source light Source erty	A	Add Light Source Light Source Parameter Light Source Shape :						
			Center Position Rotation Angle Shape Parameter						
Parameter	data		X: 0 mm Alpha: 0 a: 0 mm						
center × (mm)	-4.000000		y: 0 mm Belta: 0 b: 0 mm						
center y (mm)	6.000000								
center z (mm)	7.000000		z: 0 mm Gamma: 0 c: 0 mm						
alpha (degree)	0.000000								
belta (degree)	0.000000		Property						
gamma (degree)	0.000000	_	Wavele NumberOfPhotons SourceEnergy						
shape	CYLINDER	-	620						
a (mm)	0.500000								
b (mm)	0.500000								
c (mm)	0.500000	_							
distribution	Uniform	•							
∫	▶CCD   ◯MC Paramet	e	OK Cancel						

Figure 12-4. Add a light source

File Input Qutput	Simulation View Wi	Indow Help _ 5
	nt Source t Source y	
Parameter	data	
	4.000000	
center× (mm) centery (mm)	4.000000 6.000000	
center× (mm) centery (mm) centerz (mm)	4.000000 6.000000 7.000000	
center× (mm) centery (mm) centerz (mm) alpha (degree)	4.000000 6.000000 7.000000 0.000000	
center× (mm) centery (mm) centerz (mm) alpha (degree)	4.000000 6.000000 7.000000	
center× (mm) centery (mm) centerz (mm) alpha (degree) belta (degree)	4.000000 6.000000 7.000000 0.000000 0.000000 0.000000	
center× (mm) centery (mm) centerz (mm) alpha (degree) belta (degree) gamma (degree)	4.000000 6.000000 7.000000 0.000000 0.000000	
center × (mm) center y (mm) center z (mm) alpha (degree) belta (degree) gamma (degree) shape	4.000000 6.000000 7.000000 0.000000 0.000000 0.000000	
center × (mm) center y (mm) center z (mm) alpha (degree) belta (degree) gamma (degree) shape a (mm)	4.000000 6.000000 7.000000 0.000000 0.000000 0.000000 CYLINDER	
Parameter center × (mm) center y (mm) alpha (degree) belta (degree) gamma (degree) shape a (mm) b (mm) c (mm)	4.000000 6.000000 7.000000 0.000000 0.000000 CYLINDER 0.500000	

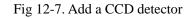
Figure 12-5. Delete a light source

Light source 1 Light s Add Ligh Del Light Property	Source		Lig	ht Source Prop	erty	
Parameter	data			Wavelength (	Number of Photons	Source Energy
center × (mm)	4.000000					
centery (mm)	6.000000			620	3500	1.000000e+000
center z (mm)	7.000000					
alpha (degree)	0.000000					
belta (degree)	0.000000					
gamma (degree)	0.000000					
shape	CYLINDER	<b>•</b>				
a (mm)	0.500000			<		>
b (mm)	0.500000					
c (mm)	0.500000					
distribution	Uniform	<b>•</b>		(m)	0K	01
		_			UK	Cancel
🕘 tissue 🥥 light 🕻	🖸 CCD 🚫 MC Param	eter				

Figure 12-6. Set the property of the light source

c. *CCD* List: All the detectors are shown on the upper list, corresponding information including position and shape parameters which can be modified are shown in the second list. Right click a certain detector, we could add or delete a detector or set the parameters of lens (see Figure 12-7, Figure 12-8, Figure 12-9).

	,			
DetectorLen 1				
DetectorLen 2				
DetectorLen 3				
DetectorLen_4 Add CCD				
Add CCD Del CCD				
Del CCD Lens				
Lens	;			
-				
Parameter	data			
center× (mm)	0.000000			
center y (mm)	entery (mm) -12.000000			
enter z (mm) 0.000000				
shape				
alpha (degree)	0.000000			
belta (degree)	0.000000			
gamma (degree)	0.000000			
a (mm)	10.000000			
b (mm)	0.000000			
c (mm)	11.000000			
Save Matrix	Yes			
Coordinate System	Cartesian 💽			
1 ( )	0.200000			
ax (mm) dy (mm)	0.200000			



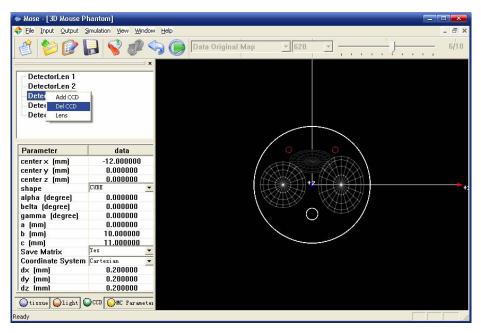


Fig 12-8. Delete a CCD detector

DetectorLen 1 DetectorLen 2 Detect Detect Detect Detect Lens		<u> </u>	s Flag: Shape :	YES Ellipsoid	•	Focus:	5	
Parameter	data	-	Center Posit	tion		Rotation An	gle	
center × (mm)	-12.000000	_	x:	0 mm		Alpha :	0	
center y (mm)	0.000000		~·	0		. aprila .		
center z (mm)	0.000000		y:	0 mm		Belta :	0	
shape	CUBE	-				Gamma :		
alpha (degree)	0.000000		z:	-3 mm		Gainnia .	0	
belta (degree)	0.000000							
gamma (degree)	0.000000		Shape Para	neter		Vector		
a (mm)	0.000000		зпаре гата	neter		VELIDI		
b (mm)	10.000000		a:	11 mm		x:	0 mm	
c (mm)	11.000000							
Save Matrix	Yes	•	b:	13 mm		y:	0 mm	
Coordinate System	Cartesian	-						
dx (mm)	0.200000		c:	0 mm		z:	1 mm	
dy (mm)	0.200000							
dz (mm)	0.200000							1
🕘 tissue 🥥 light 🌘	)CCD 🚫MC Paramet	ter				ОК	Cancel	

Fig 12-9. Set the parameters of lens

d. *MC parameter* page: see Figure 12-10, we can set the information of absorption and transmittance matrix in this page.

se Mose -[30 Mouse Phantom] ♣ Ele jrout Qutext Seudaton yew Window Belp	- 7
😤 😰 🔂 😵 🥔 🥱 🙆 Data Original Map	×  620 × }
-Absorption Matrix coordinate system	
Cylindrical 💌	
Transmittance Matrix coordinate system	
Cylindrical	
Resolution ×exis 0.100000 mm	
y-axis 0.100000 mm z-axis 0.100000 mm	
polar radius 1.000000 mm	
polar angle 1.000000 degree	74.04

Figure 12-10. Set the simulation parameter for MC

e. After modifying all the parameters, click the button **I** on the toolbar to save them all.

#### Step 3 Simulation and Output of MOSE

After we finished the parameters setting, click the menu Run under the menu **Simulation** or the button *(Intersection on the toolbar to start simulation.)* 

After the simulation is finished (see Figure 13), we can choose the output we need. Here, in the display window, Rotation and zoom in or zoom out operation of the image can be done by dragging the mouse left key and dragging the mouse right key, respectively. And dragging the mouse middle key could move the image. Other buttons are as follows:



: the button to fold/unfold the sidebar

: the button to switch the display form of the phantom: wireframe or flat shaded

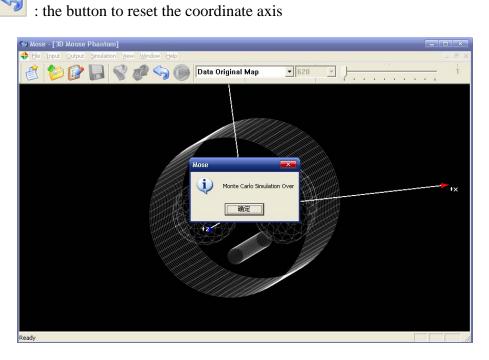


Figure 13. Simulation is over

#### a. Output of Simulation Parameter

Select menu Simulation parameter under Output menu, we can save the parameters, including the tissues, the light sources, the detectors and the simulation parameter for MC, in the form of the standard parameter file (.mse file), which will be saved into the current project folder for simulation in future.

b. Output of simulation results for Monte Carlo

Select menu **3D** Analytic Absorption Result under Output menu, we can save the absorption matrix of the Monte Carlo simulation to the current project folder.

Select menu **3D** Analytic Transmittance Result under Output menu, we can save the transmittance matrix of the Monte Carlo simulation to the current project folder.

c. Output of 3D CCD Result

Select menu **3D CCD Result** under **Output** menu, we can save the detection matrix of the Monte Carlo simulation to the current project folder.

**Notice**: The results of the different spectrum bands of absorption results are output into the same file, the transmittance and detection results are also too.

d. Output of 3D Flee Map

Select menu **3D** Flee Map under **Output** menu or *Flee Map* in the first drop down list box on the toolbar, we can see the Flee Map of this simulation. And we can select the spectrum band in the following drop down list box (See Figure 14-1).

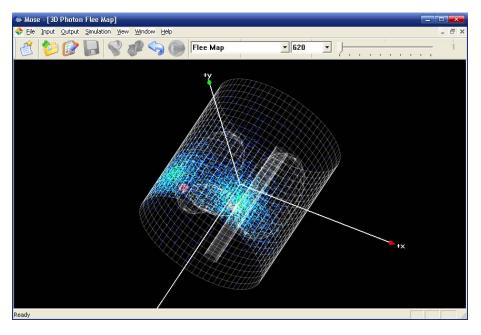


Figure 14-1. Flee map in 3D analytic environment

#### e. Output of 3D CCD Map

Select menu **CCD Map** under **Output** menu or *CCD Map* in the first drop down list box on the toolbar to show the map on CCD. In the following drop down list box we can choose the spectrum band. The serial number of CCD Map is consistent with the sequence of detectors, which can be changed through the glide bar (see Figure 14-2).

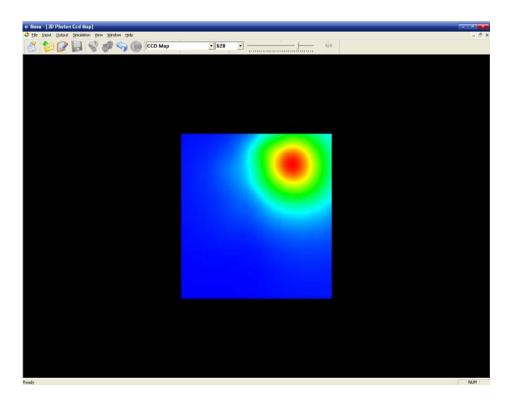


Figure 14-2. CCD map in 3D analytic environment

f. Output of 3D Absorption Map

Select menu **Absorption Map** under **Output** menu or *Absorption Map* in the first drop down list box on the toolbar to show the Absorption Map of the simulation. We can choose the spectrum band in the following drop down list box. The display of the absorption maps here is layered. Absorption Map of a certain layer can be shown by dragging the slider of the glide bar (see Figure 14-3).

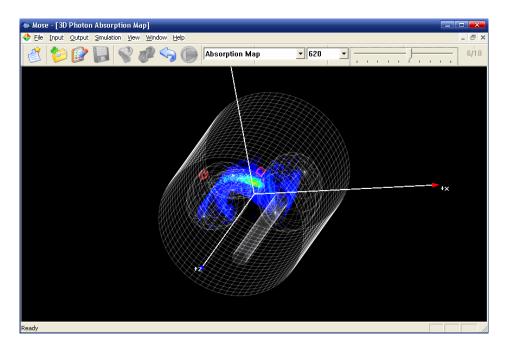


Figure 14-3. Absorption map in 3D analytic environment

## Appendix C.

#### **Output Results**

1. The file of the absorption result

```
spectrum 400
3DAbsorption
2.99970e-001
countR 11 countA 360 countZ 23
3DAbsorptionRAZ
0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000
0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000
0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000
0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000
0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000
0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000
0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000
0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000 0.0000e+000
```

*spectrum* **400** // the center wavelength of the spectrum band

3DAbosrption

2.99970e-001 // the total energy in corresponding spectrum band (Watt) countR 11 countA 360 countZ 23 // the size of the absorption matrix // The unit of the matrix is W/mm<sup>2</sup> in 2D, while is W/mm<sup>3</sup> in 3D environment. 3DAbsorptionRAZ 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000 0.00000e+000

•••••

// data of the matrix

2. The file of the transmittance result

```
Spectrum
.
620
3DTransmittanceSide
8.89940e-001
countA countZ
360 20
3DTransmittanceSideAZ
7.19233e-002 7.00232e-002 6.30366e-002 6.98502e-002 6.65337e-002 7.68149e-002 7.47553e-002
6.59276e-002 7.52075e-002 7.13249e-002 6.77375e-002 6.95952e-002 7.02507e-002 7.37581e-002
6.66025e-002 5.75769e-002 5.66038e-002 7.33157e-002 7.45284e-002 6.50071e-002 7.18405e-002
6.93954e-002 6.43372e-002 6.44187e-002 6.33097e-002 7.10104e-002 8.33816e-002 7.12816e-002
7.74180e-002 7.24055e-002 6.53469e-002 7.44774e-002 6.94068e-002 6.78089e-002 6.88087e-002
6.66815e-002 6.91224e-002 6.86219e-002 8.68799e-002 7.77902e-002 6.00808e-002 7.29118e-002
6.27886e-002 5.92126e-002 7.67275e-002 6.97743e-002 7.09935e-002 7.55155e-002 7.57063e-002
7.29741e-002 6.46770e-002 6.70363e-002 6.67993e-002 7.25535e-002 7.58401e-002 8.36254e-002
7.20905e-002 6.68235e-002 7.36440e-002 7.59133e-002 6.76546e-002 7.56179e-002 7.61395e-002
7.20941e-002 7.63066e-002 7.14933e-002 6.28390e-002 7.54890e-002 6.21581e-002 6.36163e-002
7.87945e-002 7.20770e-002 7.37344e-002 7.39146e-002 7.10967e-002 8.17438e-002 6.55976e-002
7.89946e-002 6.37282e-002 7.72315e-002 5.64365e-002 7.86734e-002 7.75934e-002 8.73230e-002
7.07722e-002 6.13928e-002 7.18169e-002 7.89247e-002 7.76880e-002 7.07065e-002 7.60212e-002
7.84467e-002 7.51462e-002 7.18119e-002 6.37517e-002 7.72371e-002 7.48367e-002 5.90184e-002
```

spectrum620// center wavelength of the spectrum3DTransmittanceSide8.89940e-00// the total energy (Watt) of corresponding spectrum bandcountA countZ360 20// the size of the matrix//The unit of the matrix is W/mm² in 2D, while is W/mm³ in 3D environment.

3DtransmittanceSideAZ

7.19233e-002 7.00232e-002 6.30366e-002 6.98502e-002 6.65337e-002 7.68149e-002 7.47553e-002 7.08378e-002 6.55314e-002 8.05368e-002 7.46624e-002 6.86954e-002 7.42054e-002 6.82968e-002 6.59465e-002 7.60552e-002 7.38552e-002 8.44916e-002

••••

// data of the matrix

3. The file of detector result

```
Spectrum 620

3DDetection 1

1.49110e-002

countY countZ

100 110

3DDetectionYZ

8.29847e-006 8.55013e-006 8.81174e-006 9.08377e-006 9.36672e-006 9.66114e-006 9.96756e-006

8.32638e-006 8.57958e-006 8.84282e-006 9.11660e-006 9.40143e-006 9.69783e-006 1.00064e-005

8.28357e-006 8.53645e-006 8.79942e-006 9.07299e-006 9.35765e-006 9.65396e-006 9.96249e-006

8.19424e-006 8.44561e-006 8.70708e-006 8.97914e-006 9.26232e-006 9.55717e-006 9.86426e-006

8.15282e-006 8.38635e-006 8.64716e-006 8.91859e-006 9.20117e-006 9.49546e-006 9.80206e-006

8.15282e-006 8.40450e-006 8.66637e-006 8.93894e-006 9.22274e-006 9.51835e-006 9.82635e-006

8.16722e-006 8.41975e-006 8.68253e-006 8.95608e-006 9.24093e-006 9.53767e-006 9.84687e-006
```

spectrum 620// center wavelength of the spectrum3DDetection 1// The Num 1 is the serial number of the CCD.1.49110e-002// the total energy (Watt) in corresponding spectrum bandabsorbed by CCD1// the total energy (Watt) in corresponding spectrum bandCountY CountZ// the size of the matrix100 110// the size of the matrix// The unit of the matrix is W/mm² in 3D environment.3DDetectionYZ8.29847e-006 8.55013e-006 8.81174e-006 9.08377e-006 9.36672e-006 9.66114e-006

9.96756e-006 1.02866e-005 1.06188e-005 1.09650e-005 1.13257e-005 1.17017e-005 1.20938e-005 1.25029e-005 1.29296e-005 1.33751e-005 1.38401e-005 1.43259e-005

•••••

// data of the matrix

# Appendix D.

### FAQ

1. Why the display of the phantom stay unchanged after the parameters have been modified in the sidebar?

**Answer**: After modify the parameters in the sidebar, clicking the "save" button on the toolbar will save the parameters meanwhile updating their display.

2. What is the meaning of different types of absorption matrix and transmission matrix in the '*MC Simulation Parameter*' page of the input parameter dialog box?

**Answer**: The absorption matrix has two forms of cartesian coordinate and cylindrical coordinate. The difference between them is to define the position of photon be absorbed in cartesian coordinate or cylindrical coordinate. The different choice of coordinate system will lead to different absorption matrix visual effect. The cartesian coordinate form absorption matrix will display in form of slice of absorption matrix parallel to X-Y plane. The cylindrical coordinate form absorption matrix parallel to Z axis. Slices need to be observed can be chosen by glide bar. The amount of absorb is represented by color. But corresponding color bar is not been displayed yet.

According to different simulation environment, absorption matrix has different type. It only has polar coordinate form in 2D simulation environment, but has cartesian coordinate form and cylindrical coordinate form in 3D analytic and mesh environment.

Transmission matrix has polar coordinate form in 2D simulation environment, cylindrical coordinate form in 3D analytic environment, cartesian coordinate form in 3D analytic and mesh environment.

3. When the program is running, why clicking the left key of mouse is ineffective to restore up a minimized program window?

Answer: You can restore up the window by clicking the restore menu on the taskbar.

4. In the 3-D mesh simulation environment, what are the meanings of the "3DTransmittanceMeshFace" and the "3DTransmittanceMeshVertsx" respectively?

**Answer**: "3DTransmittanceMeshFace" represents the emitted flux density (w/mm<sup>2</sup>) of each triangular mesh face. "3DTransmittanceMeshVertex" represents the emitted flux density (w/mm<sup>2</sup>) of each triangular mesh vertex. The former is the ratio between the total weight of photons that emitted from the triangular mesh face and the area of the triangular mesh, the later is the ratio between the total energy and total area of triangular mesh which exists in the intersectant parts of the point, and the order of the results of the "3DTransmittanceMeshVertex" conforms to that of the vertexes of the outer tissue of the phantom.

5. The progress bar would shade the image of the original simulation data and make the user couldn't observer the data, how to handle this problem?

Answer: When the MOSE running, the progress bar is in the center of the window of MOSE all the time and can't be moved to other places, but the user could move the image of the original simulation data by the left button, right button and middle button. Moving the mouse after depress the left button could rotate the image, or the right button could zoom in\out the image, or the middle button could move the image in the window.

6. Why the process of MOSE still exists in the task manager when the error appears in some situation when running and the MOSE is closed?

**Answer**: Because the MOSE is still in the development. There have some bugs that can't be avoided existing in the MOSE and that can make the execution abort unexpected, and this caused that the memory of the MOSE isn't released correctly. So the process of MOSE still exists in the task management. We would solve this problem gradually in the subsequent versions.

7. In the 3-D mesh simulation environment, why the error still happens in reading the simulation parameters file (.mse) when the path of the file representing the tissue shape is right?

**Answer**: Maybe the reason is that the path of file contains blank or some other illegal character that can't be identified by the computer. You need to set the path of the shape file in the *'Tissue Parameter'* page or *'Light Source Parameter'* page.