

“RAYWIZ Basic & Display Application”

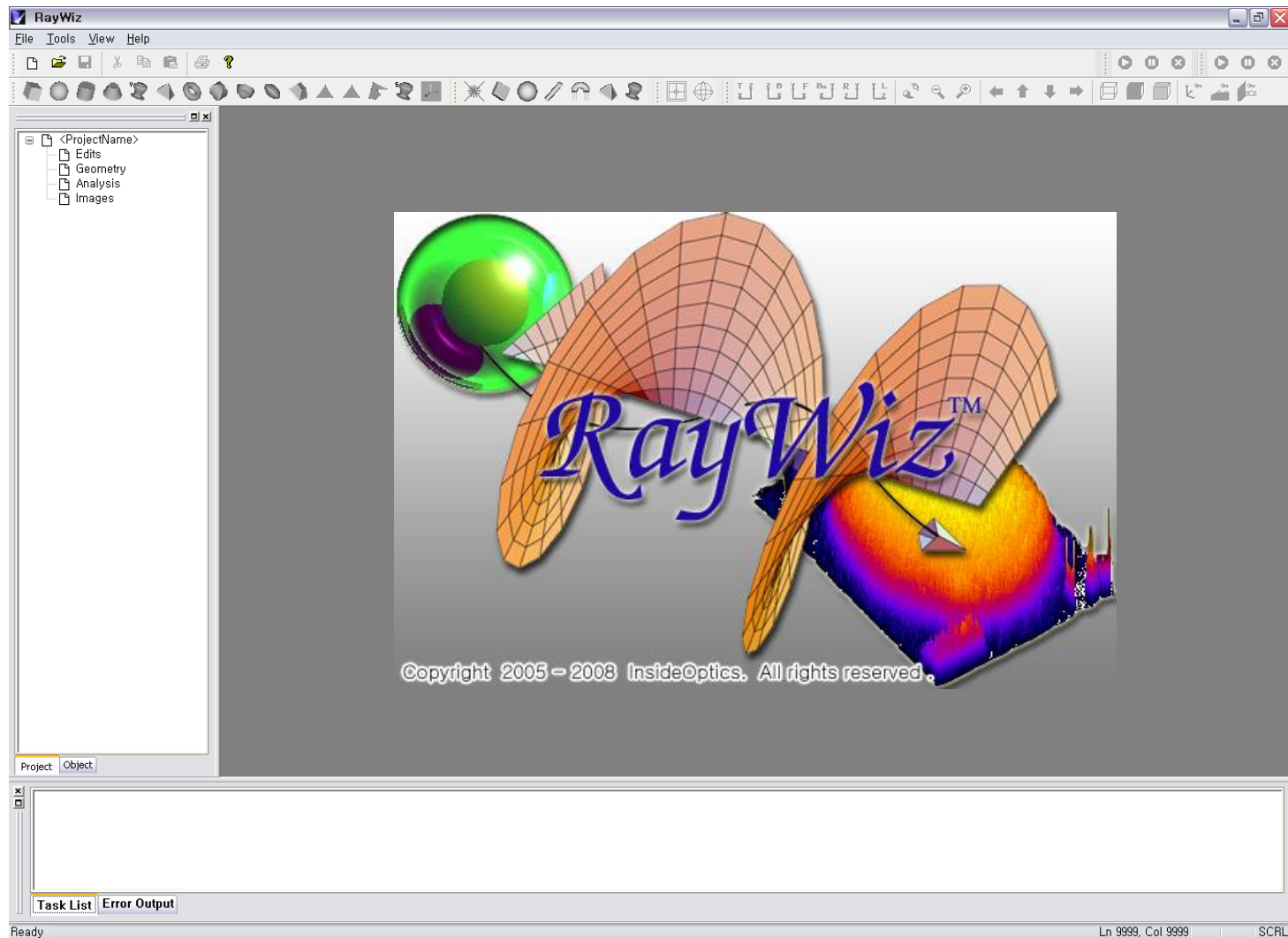
www.insideoptics.com

RAYWIZ BASIC

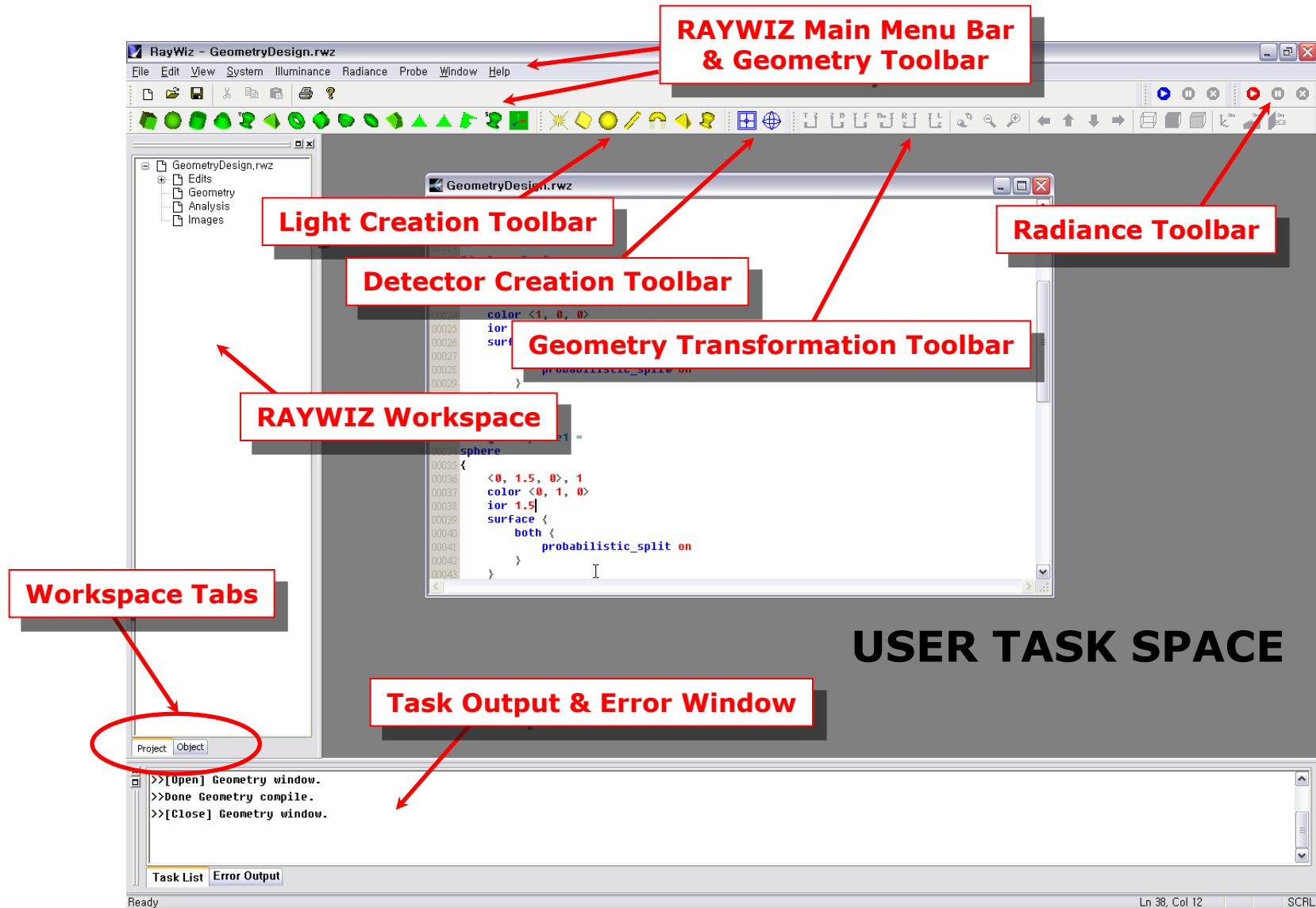
Basic: Starting RAYWIZ



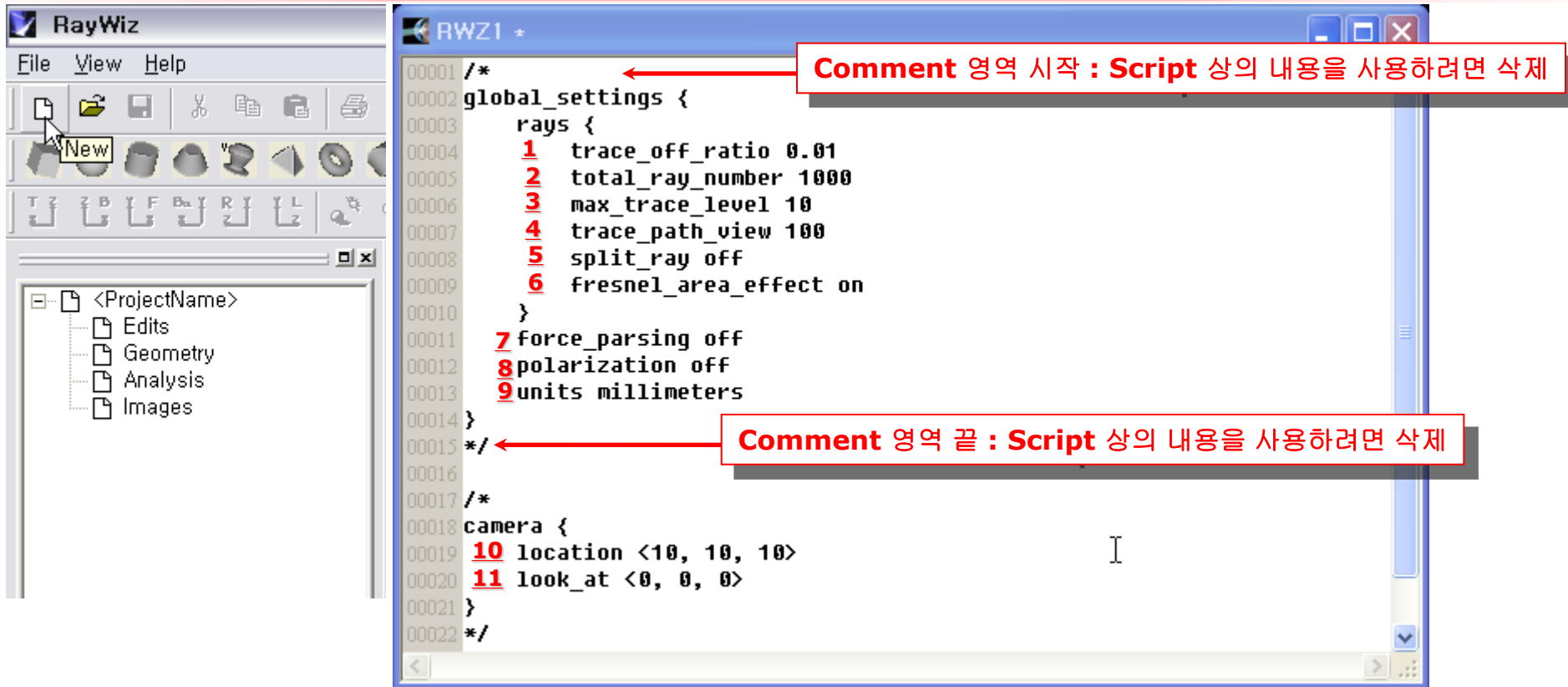
바탕화면의 **RAYWIZ** 아이콘을 **Double-Click** 하여 실행



Basic: The RAYWIZ Window



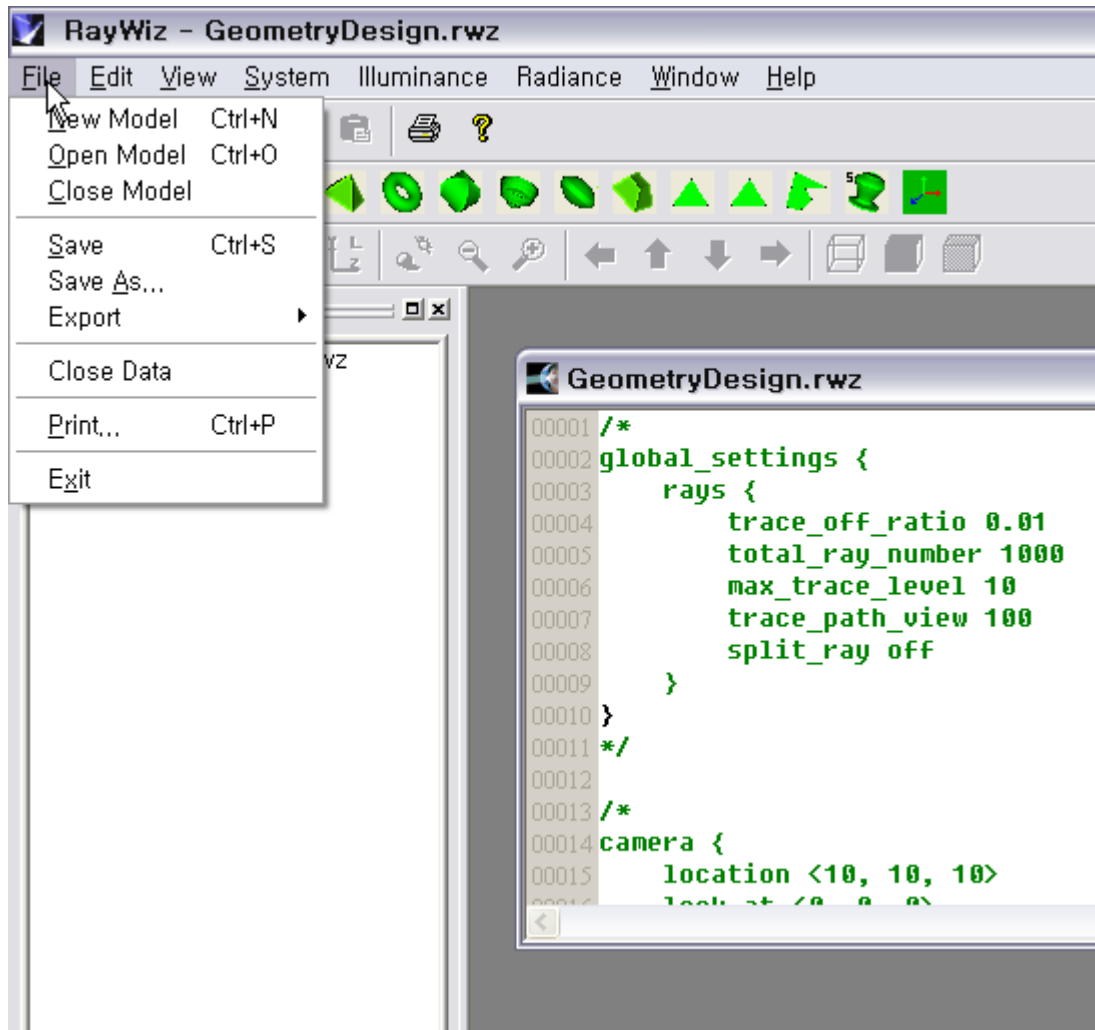
Basic: Project File



1. Light Source 에서 출발한 Ray가 처음에너지의 몇%에 도달할 때 까지 진행할지 설정
2. Simulation에 사용할 총 Ray 수 설정
3. Object의 각 Surface에 몇 회의 충돌을 허용 할지 설정
4. Simulation이 끝나면 Geometry View 창에 표시해줄 Ray 수 설정
5. Ray가 Object의 Surface와 만났을 때 매번 Split 시켜 두개의 Ray로 진행시킬지 설정
6. Ray 진행에 있어 Frsnel Equation의 면적효과를 적용 설정
7. Uniformity Optimization을 위한 강제 갱신 기능설정
8. Surface에 Jones Matrix를 부여한 경우 Polarization을 설정. 9. 시스템에 적용할 기본 단위
10. Radiance View의 위치를 설정
11. Radiance View의 관찰점을 설정

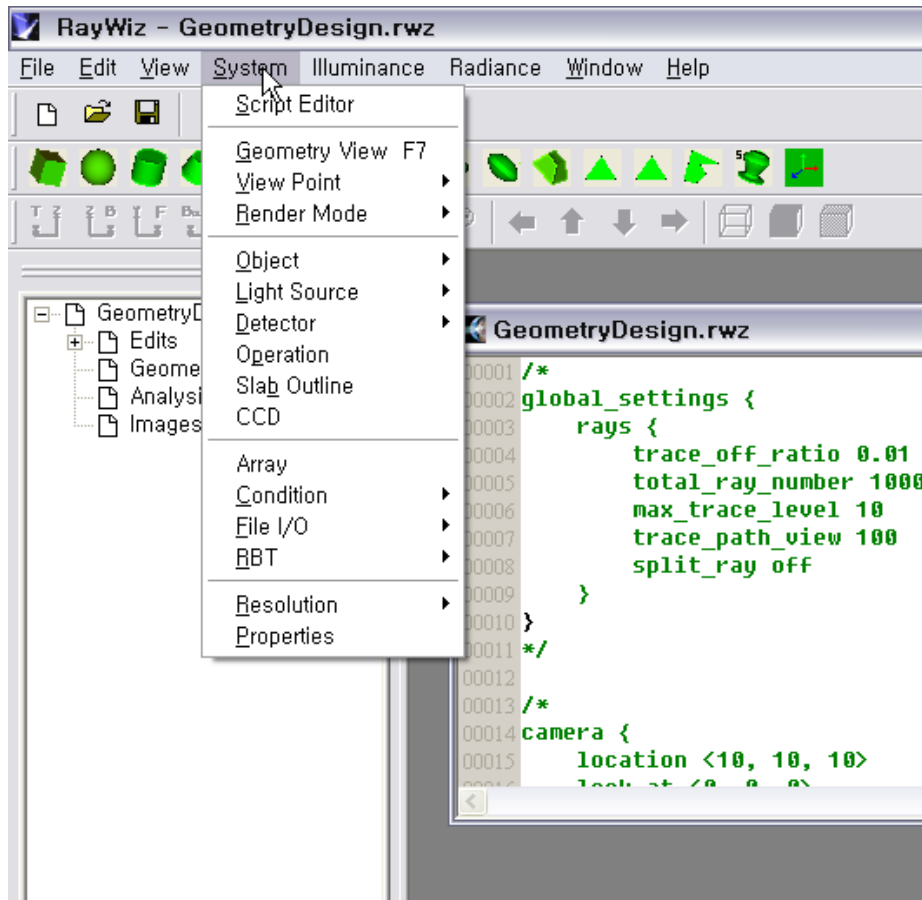
RAYWIZ BASIC - MENU -

Basic: File Menu



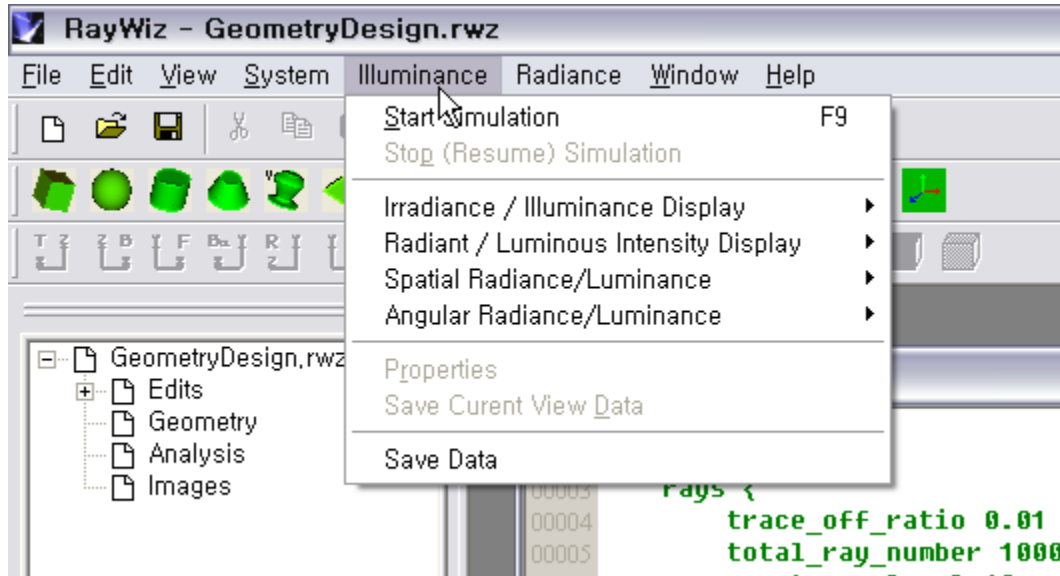
1. **File**
2. **Edit**
3. **View**
4. **System**
5. **Illuminance**
6. **Radiance**
7. **Window**
8. **Help**

Basic: System Menu



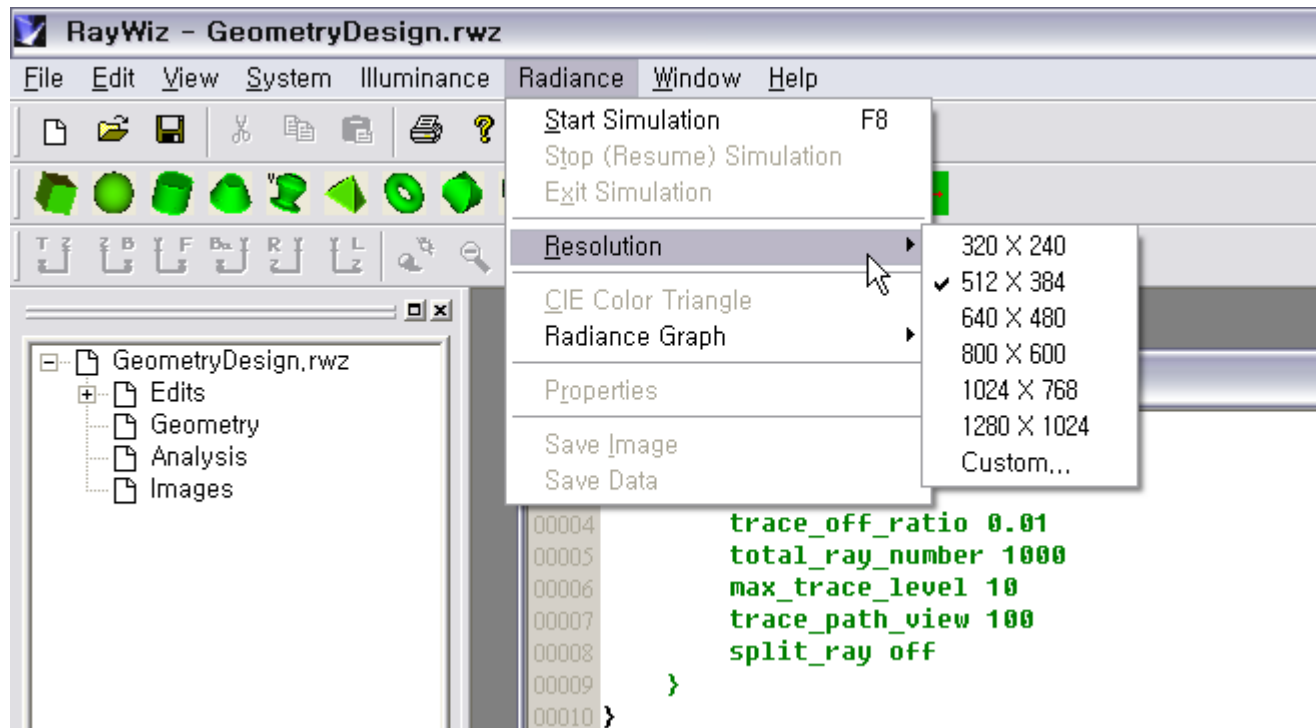
- **Script Editor** : 에디터 창으로 이동
- **Geometry View** : **Geometry** 화면 보기
- **View Point** : **Geometry** 화면에서 좌표계의 시점을 변경
- **Render Mode** : **Geometry** 화면을
/Wireframe
/ Solid
/ Translucent 보기 변경
- **Object** : 에디터 창에 **Geometry Object**를 생성
- **Light Source** : 에디터 창에 **Light Source**를 생성
- **Detector** : 에디터 창에 **Detector**를 생성
- **Operation** : 에디터 창에
/Union
/Intersect
/Subtract
/Immerse
/Group 실행
- **Slab Outline** : **Slab Object** 생성
- **CCD**: 시스템 스크립트 생성
- **Array**: 명령어 스크립트 생성
- **Condition**: 매크로 문법 스크립트 생성
- **File I/O**: **File Input/Output** 스크립트 생성
- **RBT**: *.rbt 파일을 위한 스크립트 생성
- **Resolution** : **Geometry** 해상도
- **Properties** : **Global Setting** 대화상자 실행

Basic: Illuminance Menu



- **Start Simulation** : 시뮬레이션 시작
- **Stop Simulation** : 시뮬레이션 중지
- **Irradiance/Illuminance Display** : **Illuminance** 계산
- **Radiant/Luminous Intensity Display** : **Radiance** 계산
- **Spatial Radiance/Luminance** : **Plane Detector** 가 있을 경우
Luminance(위치 별) 계산
- **Angular Radiance/Luminance** : **Plane Detector** 가 있을 경우
Luminance(각도 별) 계산
- **Properties** : 측정 **Bin** 의 크기 속성 변경 및 **Intensity Bar Range** 속성 변경
- **Save current View Data** : 개별의 결과분석 창의 **Data**를 저장
- **Save Data** : **Simulation**을 수행한 전체 **Ray Data**를 저장
← 다시 불러들여 모든 분석창을 재실행할 수 있음.

Basic: Radiance Menu

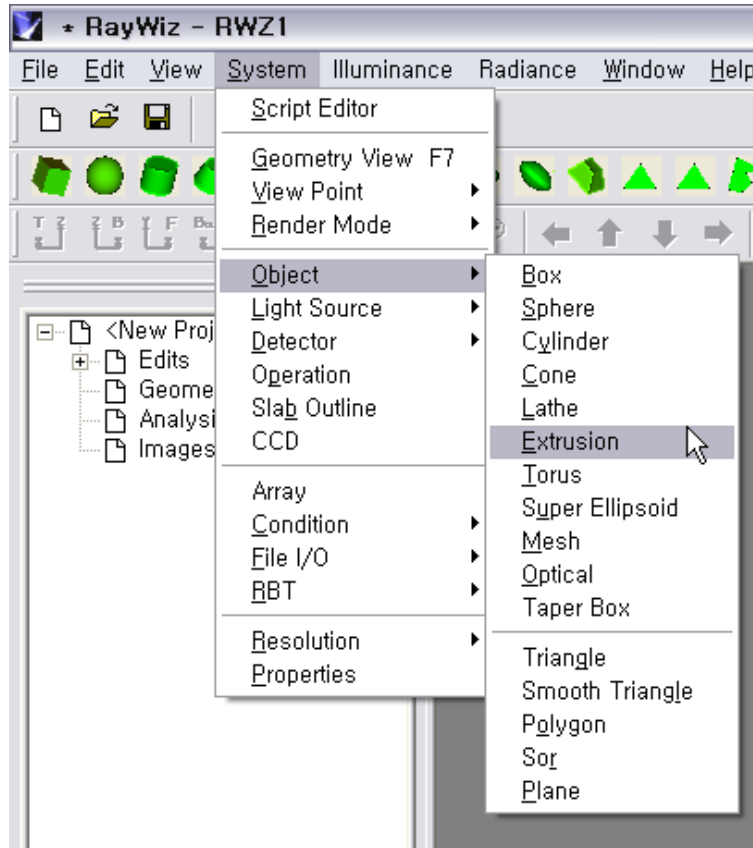


- **Start Simulation** : 시뮬레이션 시작
- **Stop Simulation** : 시뮬레이션 일시 정지
- **Exit Simulation** : 시뮬레이션 정지
- **Resolution** : 해상도 변경
- **CIE Color Triangle, Radiance Graph** : 정량 분석창
- **Save Image** : 결과이미지 및 변환 이미지 저장

RAYWIZ BASIC

- Object Geometry I -

Geometry I: Primitive Object



1. **Box**
2. **Sphere**
3. **Cylinder**
4. **Cone**
5. **Lathe**
6. **Extrusion**
7. **Torus**
8. **Super Ellipsoid**
9. **Mesh**
10. **Optical**
11. **Taper Box**
12. **Triangle**
13. **Smooth Triangle**
14. **Polygon**
15. **Sor**
16. **Plane**

Geometry I: Create Your First Object – Box(1)

The screenshot displays the RayWiz software interface with three main components: a script editor on the left, a menu system in the center, and a toolbar on the right.

Script Editor (Left): Contains a script for a global settings and a camera. The script is as follows:

```
00001 /*  
00002 global_settings {  
00003     rays {  
00004         trace_off_ratio 0.01  
00005         total_ray_number 1000  
00006         max_trace_level 10  
00007         trace_path_view 100  
00008         split_ray off  
00009         fresnel_area_effect on  
00010         random_spectrum on  
00011     }  
00012     force_parsing off  
00013     polarization off  
00014     units millimeters  
00015     summary on  
00016     geometry_intensity on  
00017 }  
00018 */  
00019  
00020 /*  
00021 camera {  
00022     location <10, 10, 10>  
00023     look_at <0, 0, 0>  
00024 }  
00025 */  
00026  
00027
```

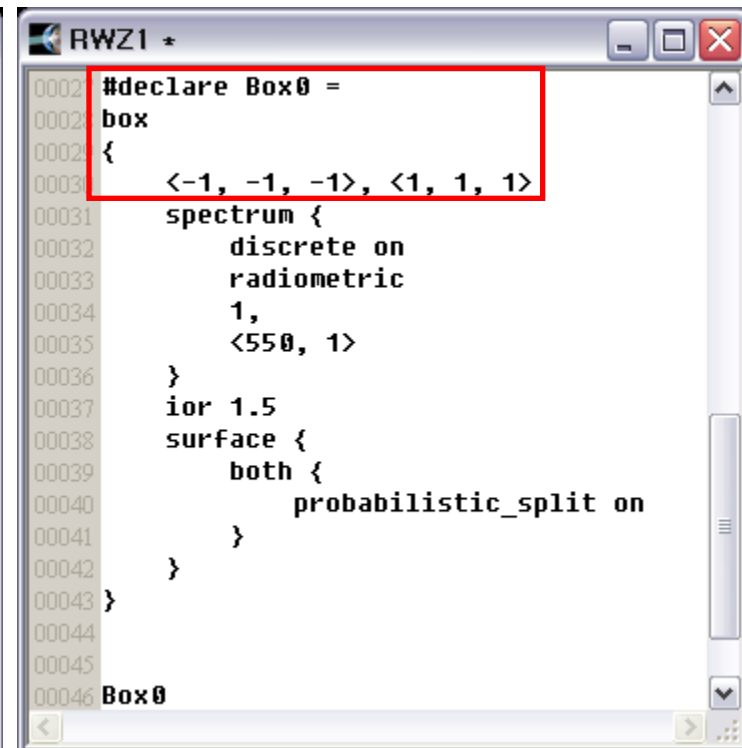
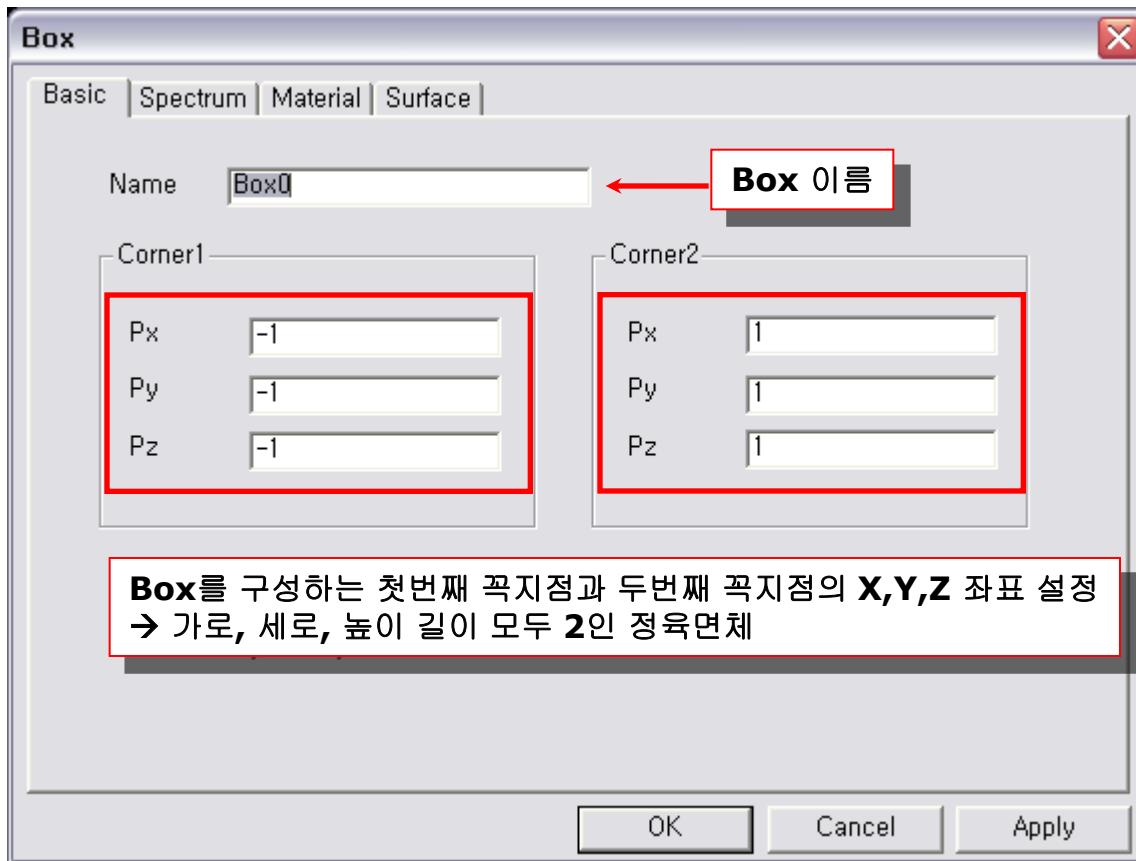
Menu System (Center): The 'System' menu is open, showing options like 'Script Editor', 'Geometry View F7', 'View Point', 'Render Mode', 'Object', 'Light Source', 'Detector', 'Operation', 'Slab Outline', 'CCD', 'Array', 'Condition', 'File I/O', 'RBT', 'Resolution', and 'Properties'. The 'Object' submenu is also open, listing various geometric shapes: 'Box', 'Sphere', 'Cylinder', 'Cone', 'Lathe', 'Extrusion', 'Torus', 'Super Ellipsoid', 'Mesh', 'Optical', 'Taper Box', 'Triangle', 'Smooth Triangle', 'Polygon', 'Sor', and 'Plane'. A red arrow points from the 'Box' option in the 'Object' submenu to the 'Box' button in the toolbar.

Toolbar (Right): The 'Box' button is highlighted. A red arrow points from the 'Box' button in the toolbar to the 'Box' option in the 'Object' submenu.

Annotations:

- A red arrow points from the text 'Object Script가 들어갈 위치에 마우스 클릭하여 Cursor를 활성화' to the script editor area.
- A red box contains the text: 'System > Object > Box 선택 또는 Object Toolbar에서 Box 선택'.

Geometry I: Create Your First Object – Box(2)



기본값 설정 그대로 확인을 누르면 **Script** 창에 **Box0**라는 **Object**가 선언된다.

Geometry I: Create Your First Object – Box(3)

The image shows two windows from the RayWiz software. The left window is the 'Box' configuration dialog, and the right window shows the scene script.

Box Configuration Dialog:

- Basic** | **Spectrum** | Material | Surface
- Color** (selected): R: 0, G: 1, B: 0
- Spectrum** (selected):
 - 1** (selected)
 - Wavelength: 550, Intensity: 1.0
 - Radiometric** (selected)
 - Photometric** (unselected)
 - User Defined** (selected)
 - From Folder** (unselected): BLUE.spc
 - Select File** (unselected)
 - Standard** (unselected): A
 - 0 K

Annotations:

- Red box around Color R, G, B inputs.
- Red box around the 'Spectrum' tab and the '1' selection, with text: **Spectrum 설정 갯수 지정 후 Enter**
- Red box around the 'From Folder' dropdown and 'Load...' button, with text: **반사 특성 Spectrum 파일 Load**

Scene Script (RWZ1):

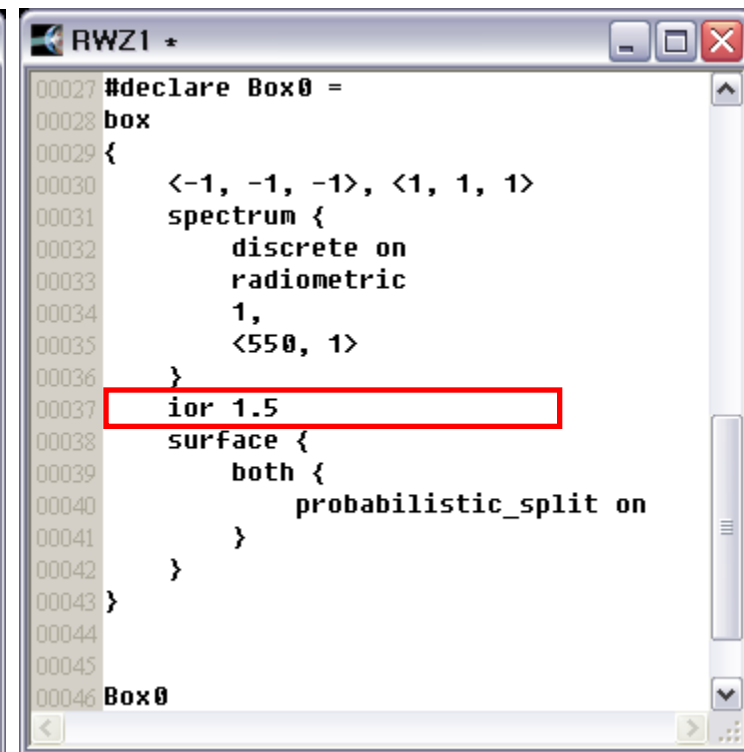
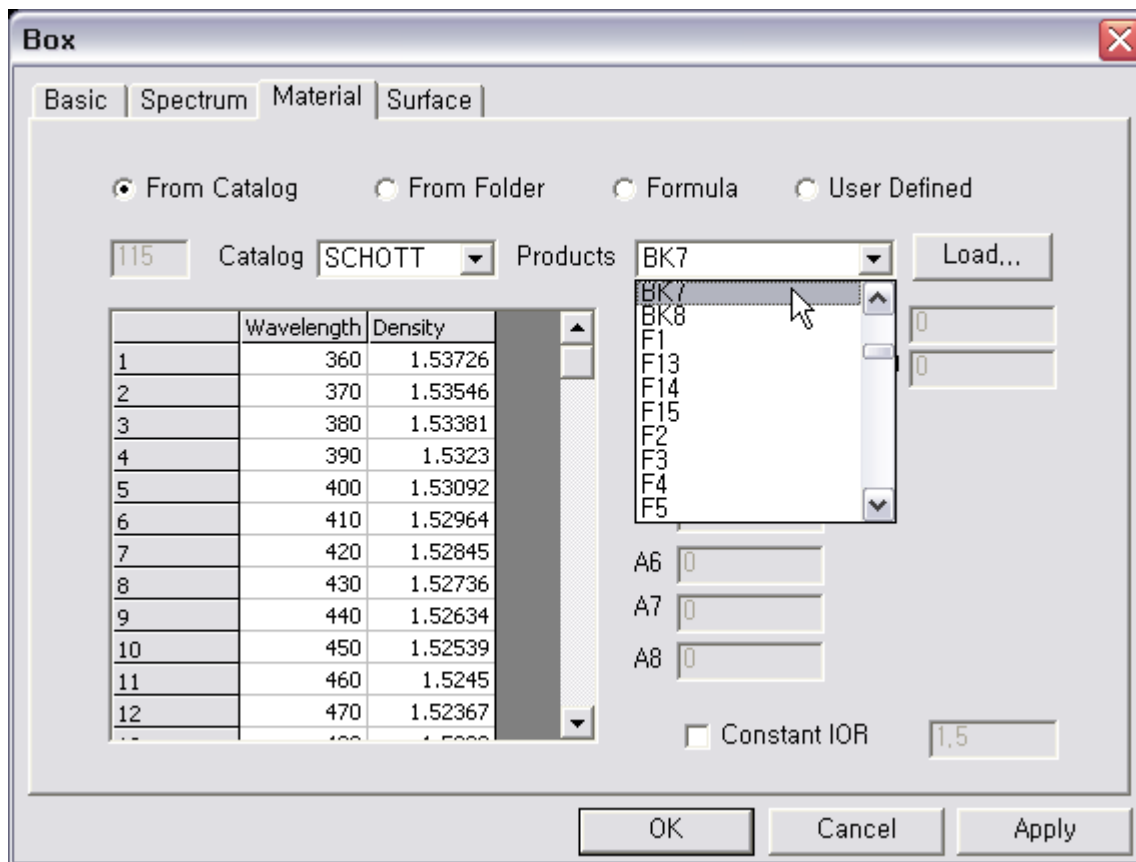
```
00027 #declare Box0 =
00028 box
00029 {
00030     <-1, -1, -1>, <1, 1, 1>
00031     spectrum {
00032         discrete on
00033         radiometric
00034         1,
00035         <550, 1>
00036     }
00037     ior 1.5
00038     surface {
00039         both {
00040             probabilistic_split on
00041         }
00042     }
00043 }
00044
00045
00046 Box0
```

Annotations:

- Red box around the spectrum definition lines (00031-00035).

Color R,G,B 값으로 반사 특성을 정의하거나 **Spectrum**을 직접 입력하여 정의할 수 있다.

Geometry I: Create Your First Object – Box(4-1)



IOR (Index of Refraction) 지정을 위한 **Tab**으로
기본값인 **Constant IOR**를 해제하여 **Glass**나 **Formula**에 의한 설정을 할 수 있다.

Geometry I: Create Your First Object – Box(4-2)

CONRADY

CONRADY1	$n(\lambda) = A + \frac{B}{\lambda} + \frac{C}{\lambda^{3.5}}$
----------	--

EXTENDED-SCHOTT

SCHOTT5X5	$n(\lambda)^2 = A + B\lambda^2 + C\lambda^4 + D\lambda^6 + E\lambda^8 + \frac{F}{\lambda^2} + \frac{G}{\lambda^4} + \frac{H}{\lambda^6} + \frac{J}{\lambda^8} + \frac{K}{\lambda^{10}}$
-----------	---

HERZBERG

HERZBRGR4X2	$n(\lambda) = A + B\lambda^2 + C\lambda^4 + D\lambda^6 + \frac{E}{(\lambda^2 - 0.028)} + \frac{F}{(\lambda^2 - 0.028)^2}$
-------------	---

OPTICS1

HoO1	$n(\lambda)^2 = A + B\lambda^2 + \frac{C}{\lambda^2 - D^2}$
------	---

OPTICS2

HoO2	$n(\lambda)^2 = A + B\lambda^2 + \frac{C\lambda^2}{\lambda^2 - D^2}$
------	--

SCHOTT

SCHOTT2X4	$n(\lambda)^2 = A + B\lambda^2 + \frac{C}{\lambda^2} + \frac{D}{\lambda^4} + \frac{E}{\lambda^6} + \frac{F}{\lambda^8}$
-----------	---

SELLMEIER1

SELL3T	$n(\lambda)^2 - 1 = \frac{A\lambda^2}{\lambda^2 - B^2} + \frac{C\lambda^2}{\lambda^2 - D^2} + \frac{E\lambda^2}{\lambda^2 - F^2}$
--------	---

SELLMEIER2

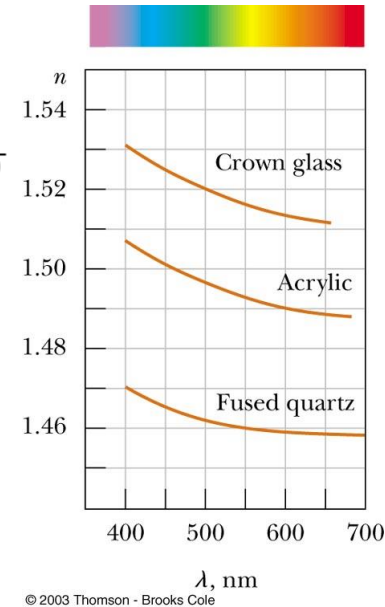
SELLMOD6	$n(\lambda)^2 = A + \frac{B\lambda^2}{\lambda^2 - C^2} + \frac{D}{\lambda^2 - E^2}$
----------	---

SELLMEIER3

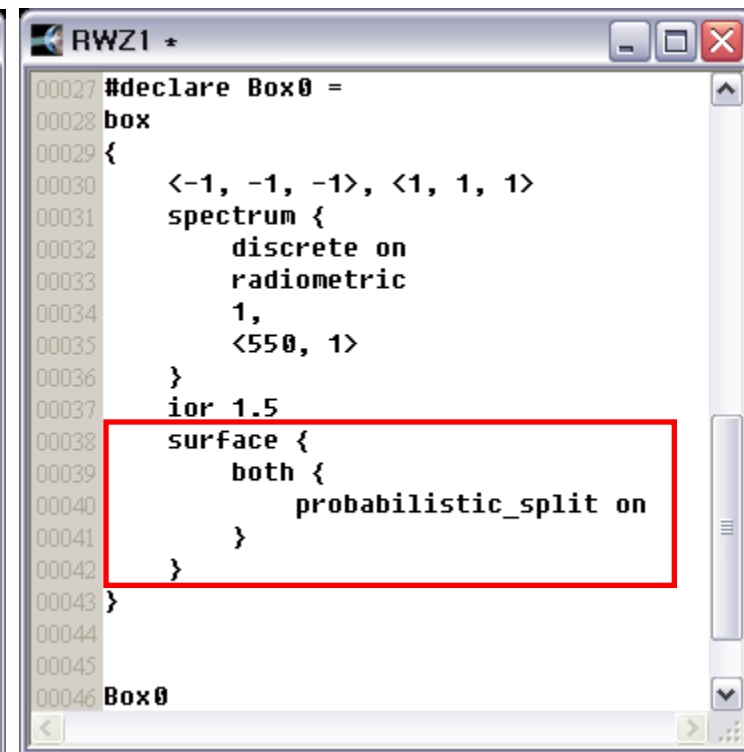
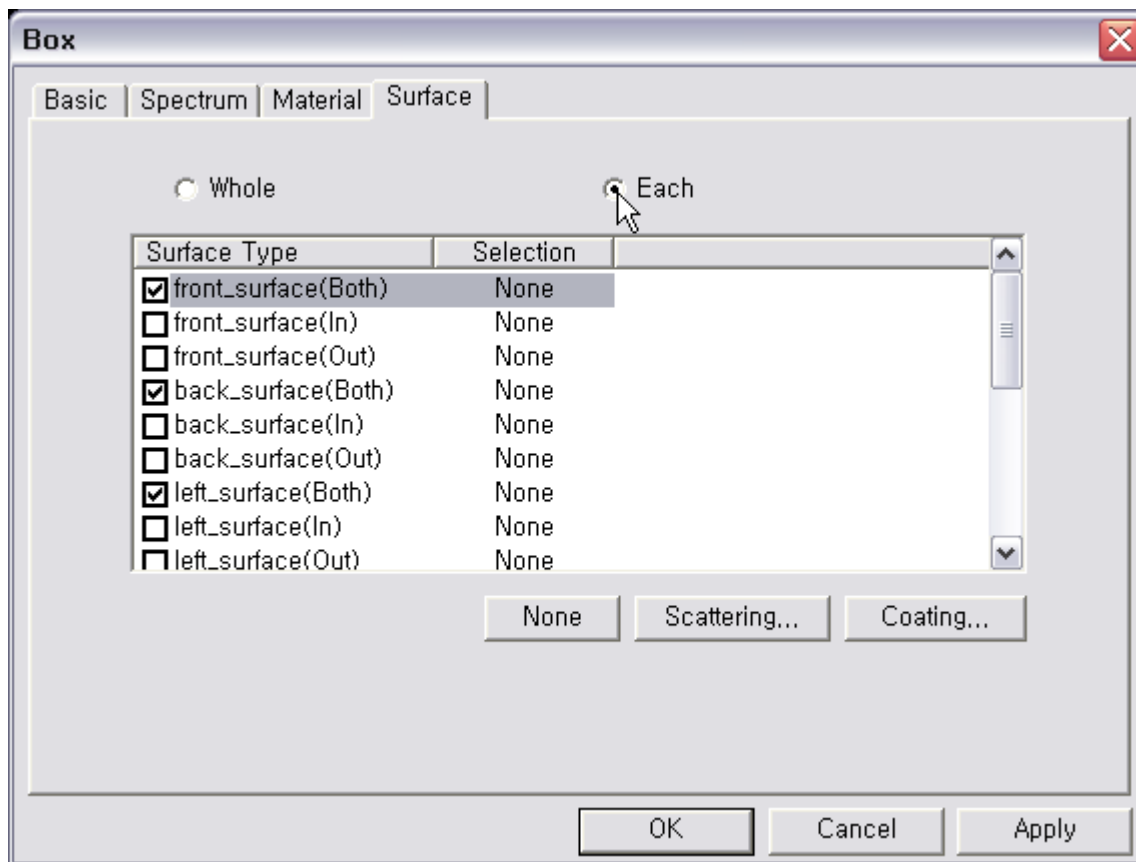
SELL4T	$n(\lambda)^2 - 1 = \frac{A\lambda^2}{\lambda^2 - B^2} + \frac{C\lambda^2}{\lambda^2 - D^2} + \frac{E\lambda^2}{\lambda^2 - F^2} + \frac{G\lambda^2}{\lambda^2 - H^2}$
--------	--

SELLMEIER4

SELL2TA	$n(\lambda)^2 = A + \frac{B\lambda^2}{\lambda^2 - C^2} + \frac{D\lambda^2}{\lambda^2 - E^2}$
---------	--



Geometry I: Create Your First Object – Box(5)

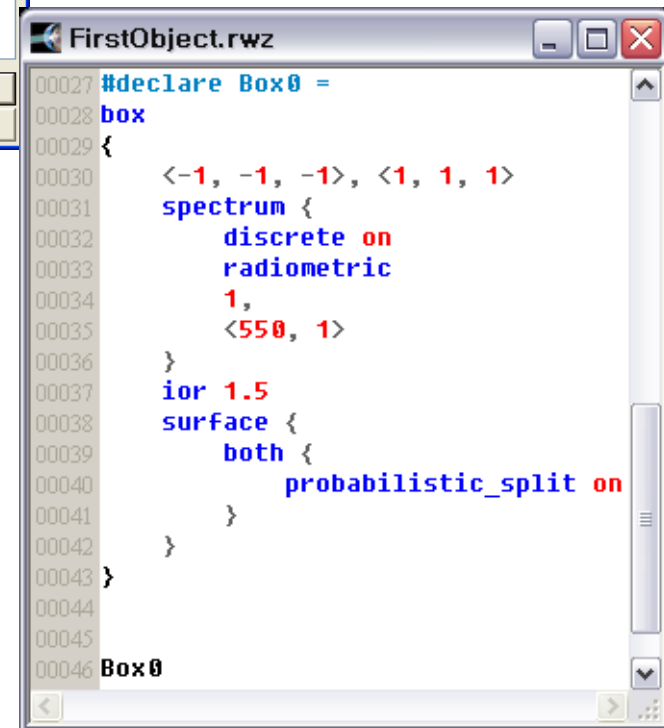


기본값은 **Object**의 모든 **Surface** 특성을 한번에 정의하는 **Whole**이 선택되어 있으나 **Object**의 각 **Surface**의 특성을 달리 설정하려면 **Each**를 선택하여 **Scattering**이나 **Coating** 설정을 한다.

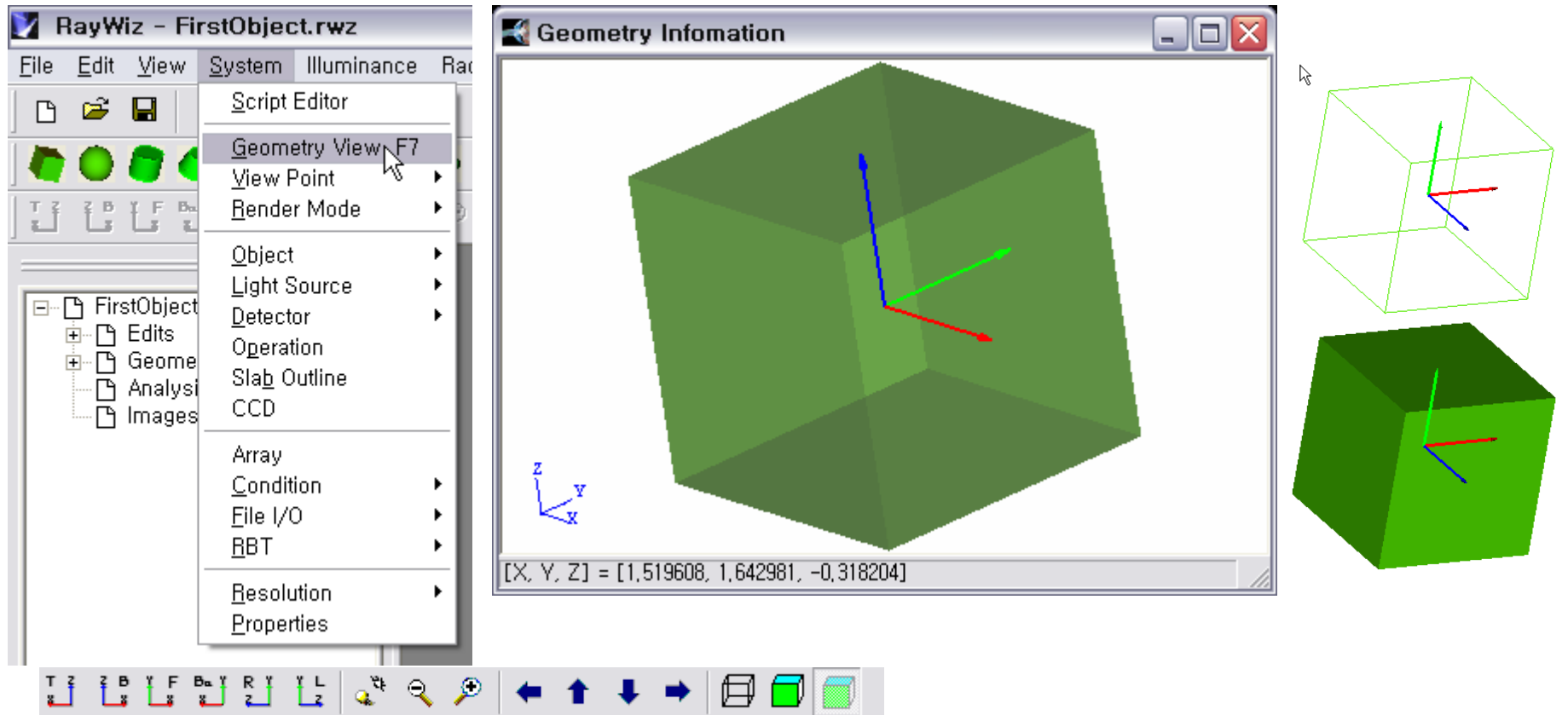
Geometry I: Create Your First Object – Box(6)



File>Save 를 선택하여 적절한 이름으로 **Project Script**를 저장한다.
그러면 **Script**창의 **Title**이 저장한 이름으로 변경되며 명령어들은 몇 가지 색깔로 변하게 된다.



Geometry I: Create Your First Object – Box(7)



기준축 정렬

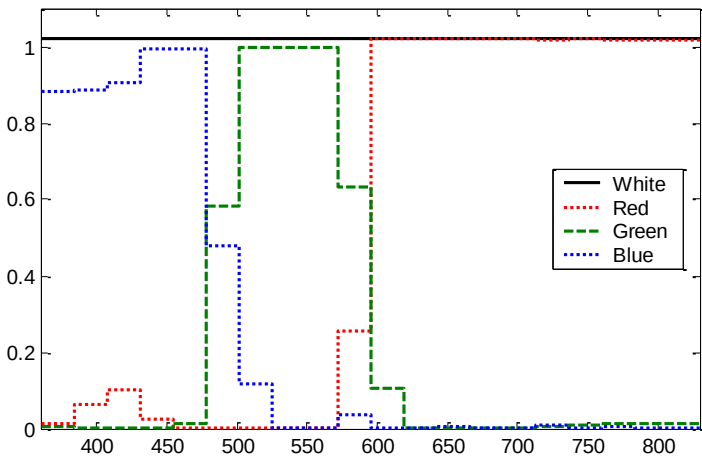
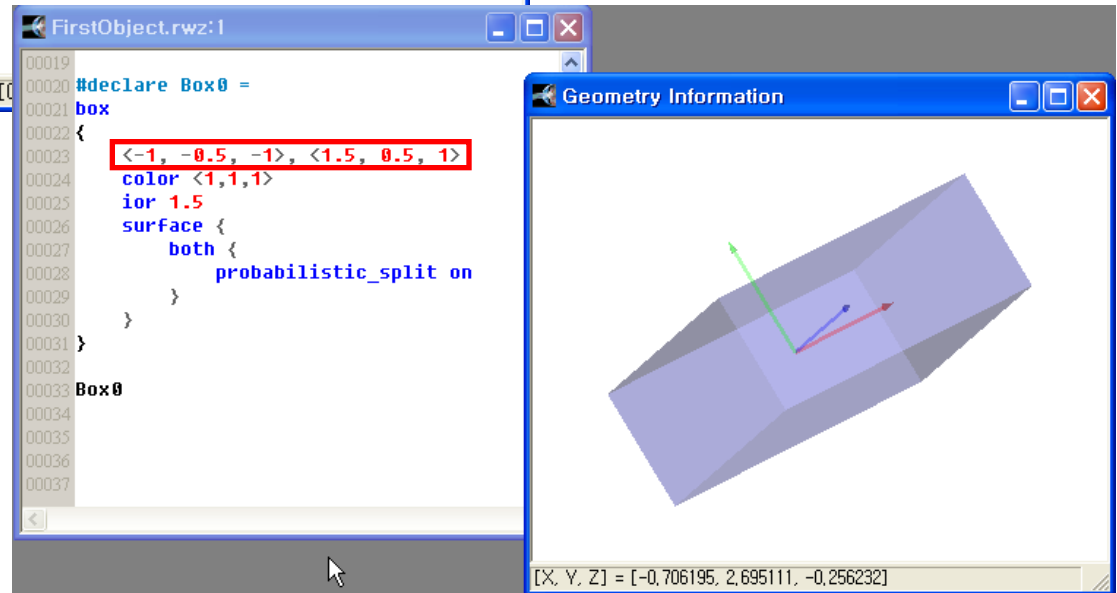
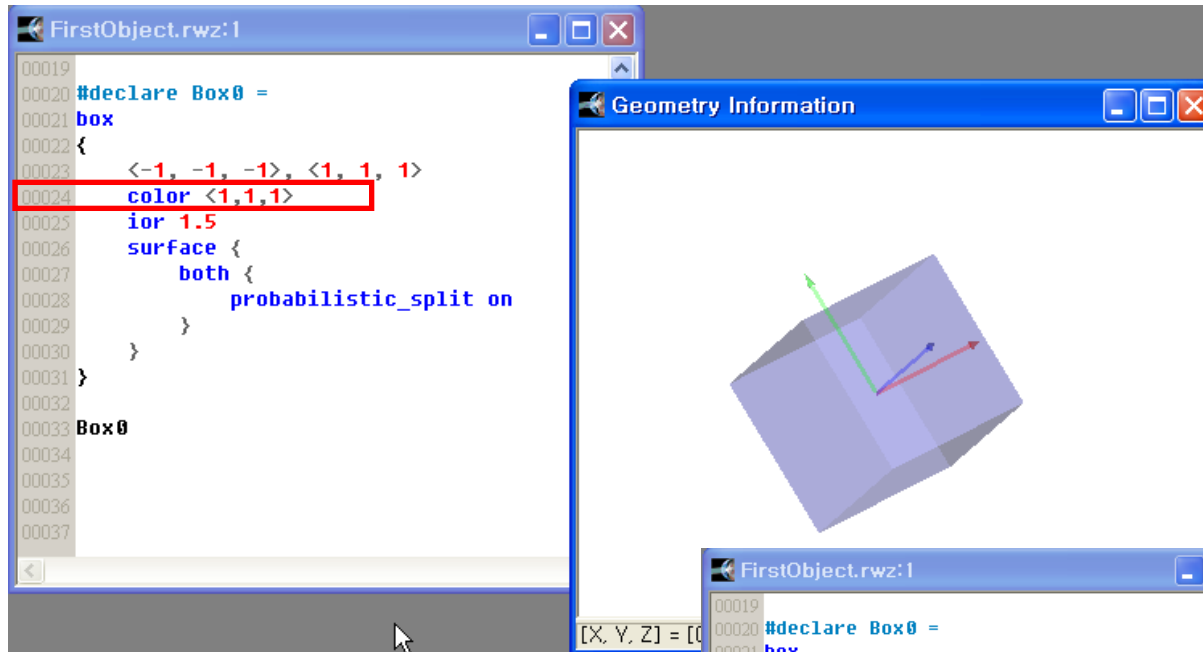
상하, 좌우 이동

Perspective View 및 확대 축소

Wireframe/ Solid/ Translucent

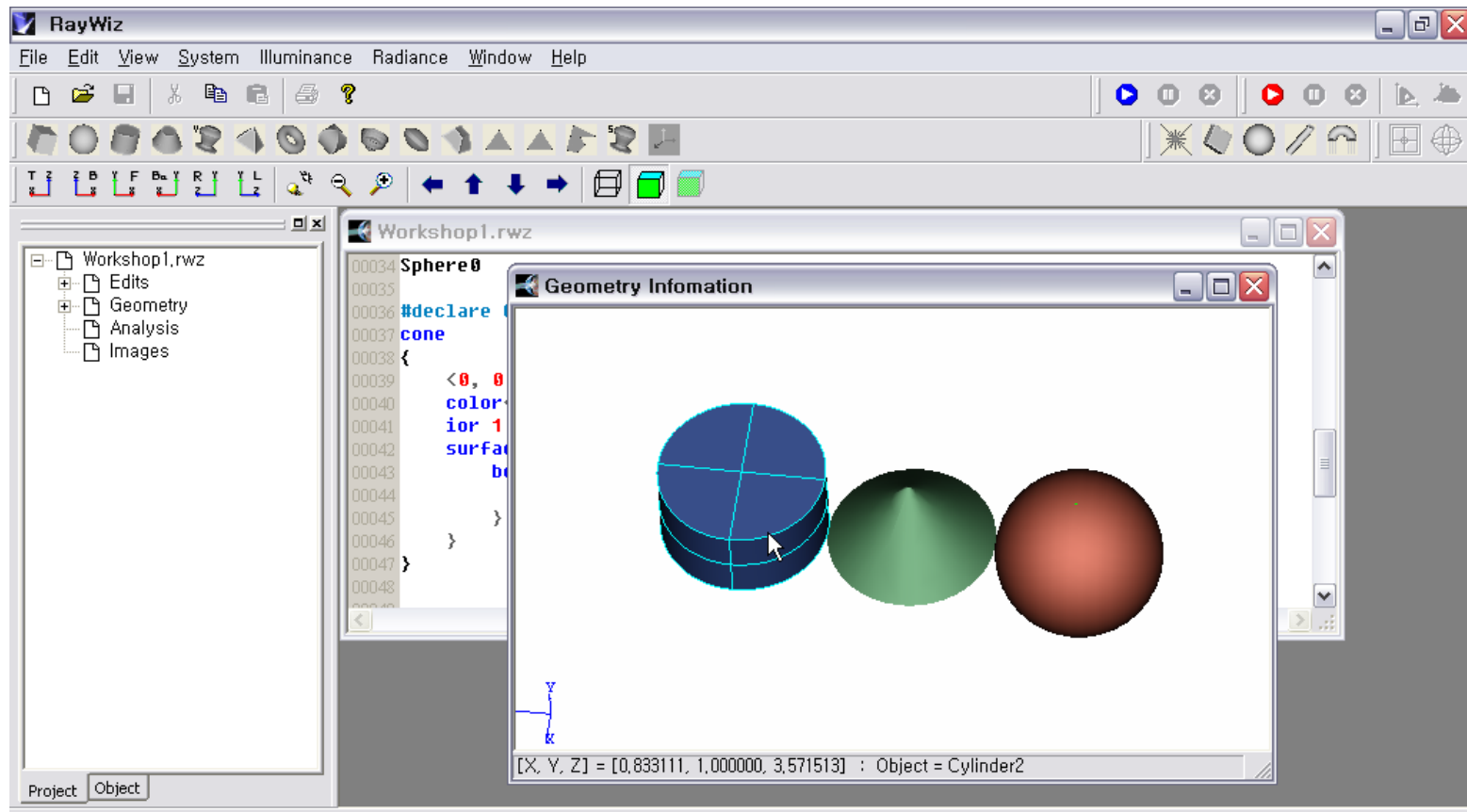
- 마우스 왼쪽 버튼을 누르고 드래그 → 자유회전
- 스크롤 또는 오른쪽 버튼을 누르고 드래그 → 확대, 축소
- **Shift** 키 누르고 드래그 → **2D** 자유이동
- 마우스 오른쪽 버튼이용 영역선택 → 부분확대

Geometry I: Modify Your First Object – Spectrum & Scale

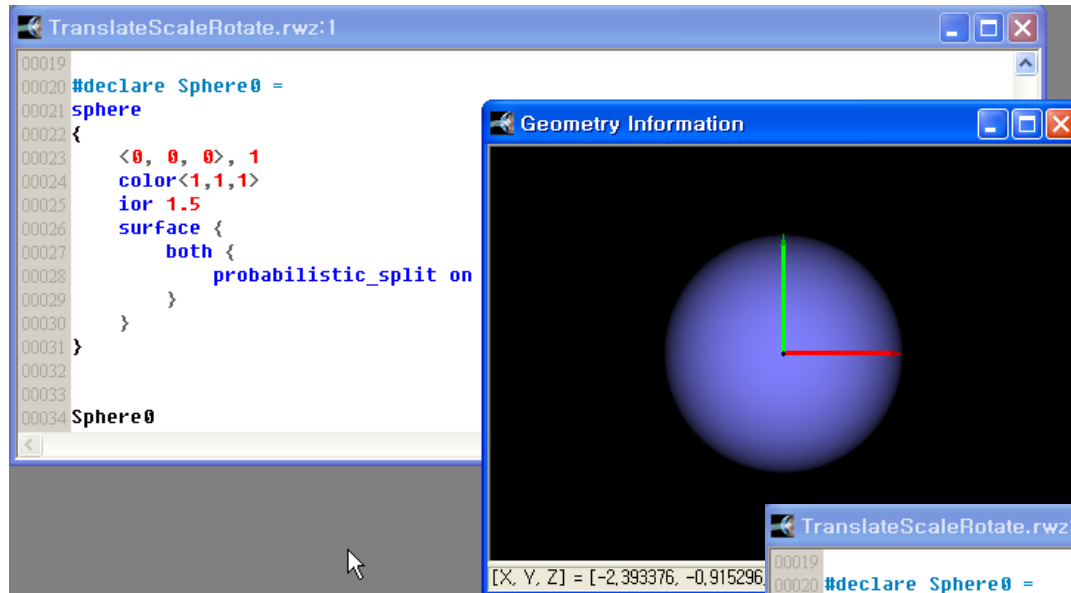


Workshop 1: Make Objects

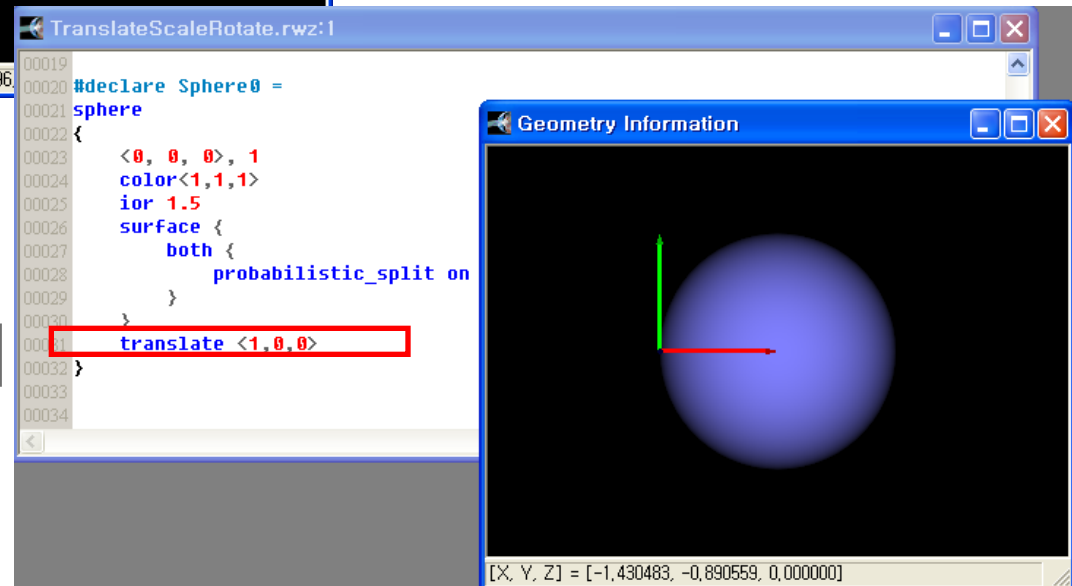
1. RayWiz를 실행하고 새 파일을 만들어 작업 **Directory**에 “**Workshop1.rwz**”로 저장하시오.
2. **Menu**나 **Toolbar**를 이용하여 **Sphere**와 **Cone** 그리고 **Cylinder**를 작성해 보시오.
3. **Geometry View**를 실행하여 만약 **object**들이 만나는 영역이 존재한다면 **Script**를 적절히 수정하여 만나지 않도록 만드시오.
4. **Script**를 수정하여 **Sphere**는 붉은색, **Cone**은 초록색, **Cylinder**는 파란색으로 수정하시오.



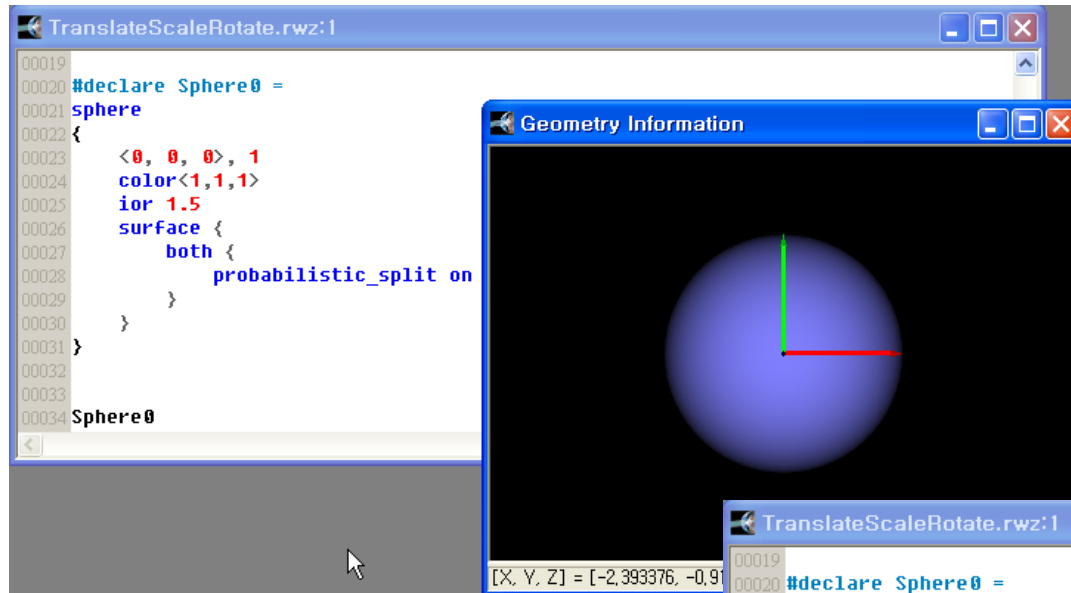
Geometry I: Translate



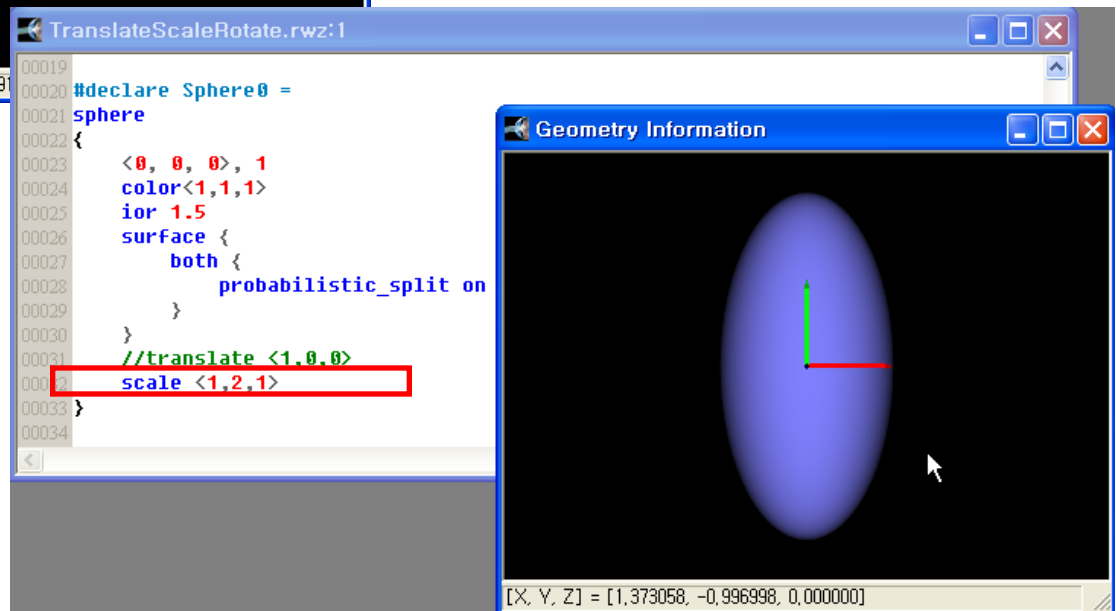
절대좌표상의 X,Y,Z 방향으로의 변량을 표시



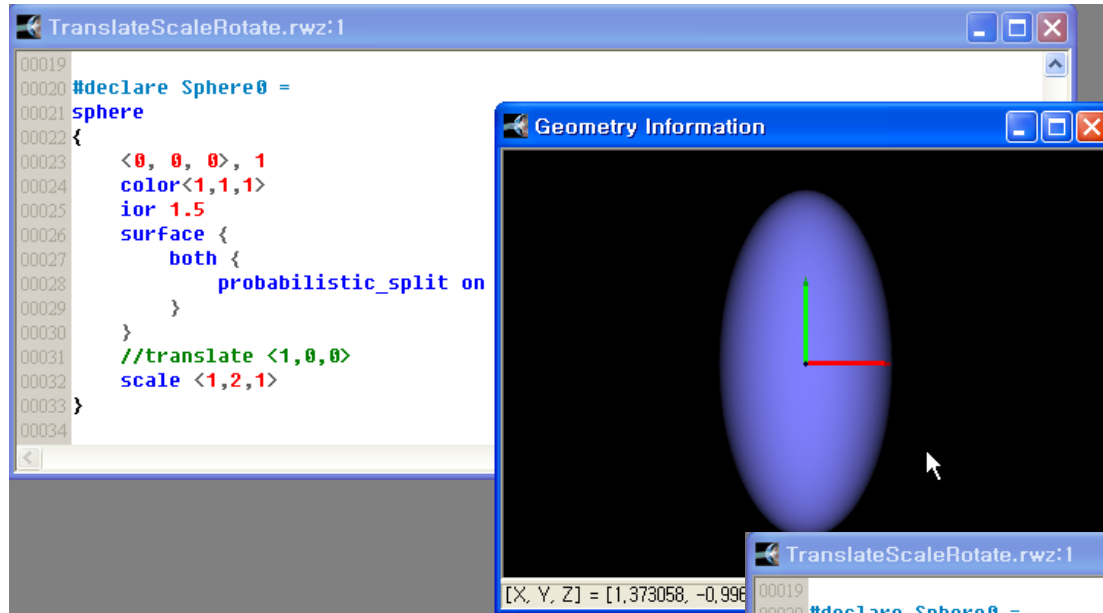
Geometry I: Scale



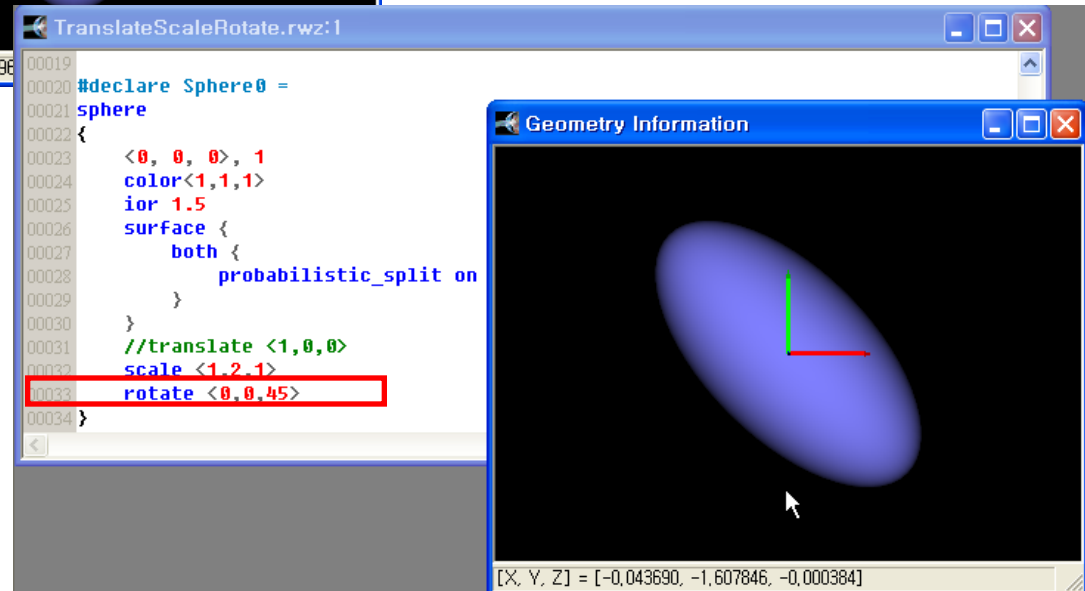
절대좌표상의 X,Y,Z 방향으로 X와 Z축
방향으로는 원래 크기대로 Y축 방향으론
2배로 변형하여 타원체 형성
← 원점기준



Geometry I: Rotate



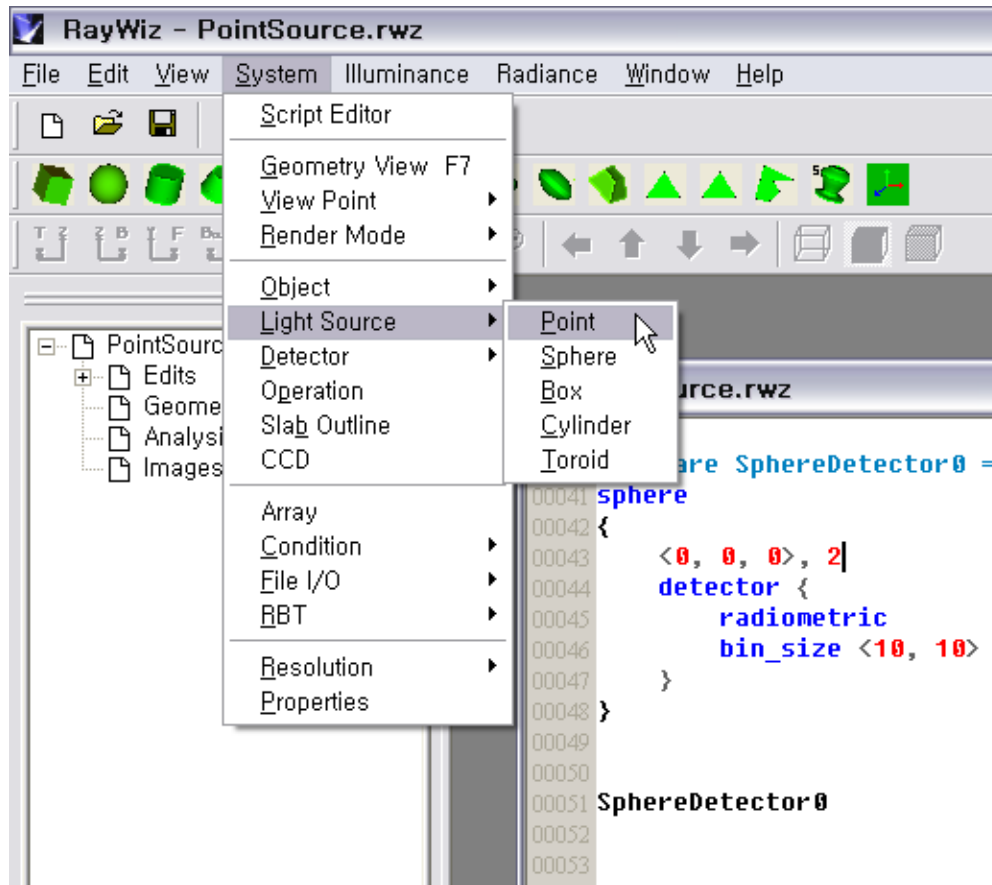
절대좌표상의 X,Y,Z 각 축을 잡고 원점을 기준으로 **object**를 회전 변환함.



RAYWIZ BASIC

- Light Source I -

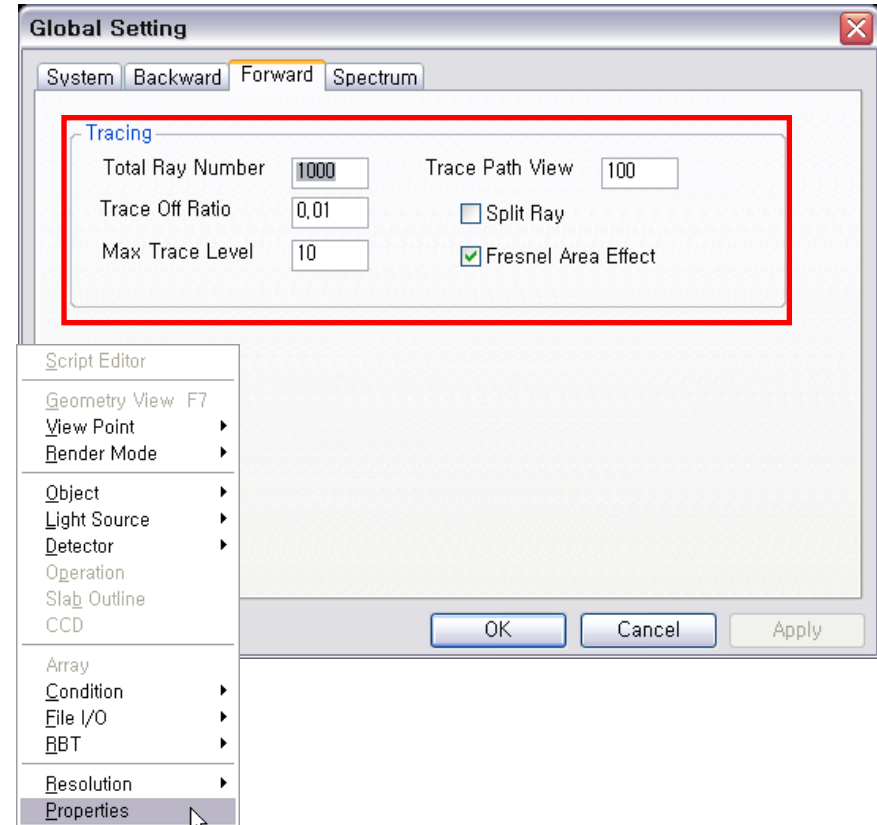
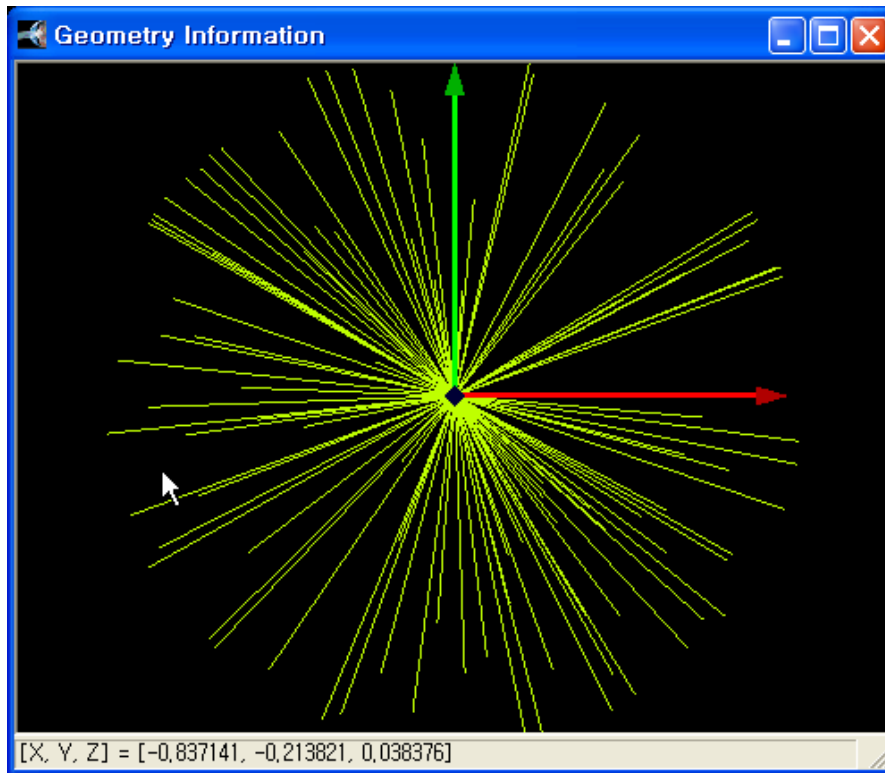
Light Source I: Light Sources



1. Point Source
2. Sphere Source
3. Box Source
4. Cylinder Source
5. Toroid Source
6. CSG Source

Light Source는 Ray 들의 집합체로 **Object**의 형태로 분포를 하는 것으로 **Light**의 실제 **Surface**란 존재하지 않는다.
또한 **System**의 어떠한 **Object**에도 위치 될 수 있으며 **LED Die**와 같이 **Material** 안에 위치 시킬 경우에도 **Light**에서 출발한 **Ray**는 특별한 설정 없이 물질 안에서 출발 했음을 전제로 **Simulation**을 수행한다.

Light Source I: Point Source(1)



- 크기도 없고 보이지도 않는 일반적인 광원(볼륨이 없는 광원)
- 모든 방향을 향해 빛을 보낼 수도 있고 각도를 지정하여 제한영역을 주어 빛을 보내는 것도 가능하다.
- 사용자가 직접 광선의 방향과 세기를 지정할 수 있다.

Light Source I: Point Source(2)

Point Source

Basic | Aim Region | Spectrum | Distribution

Name: PointSource1

☒ Radiometric ☐ Photometric Power: 1

☒ Measured Whole

Point

Px: 0
Py: 0
Pz: 0

OK Cancel Apply

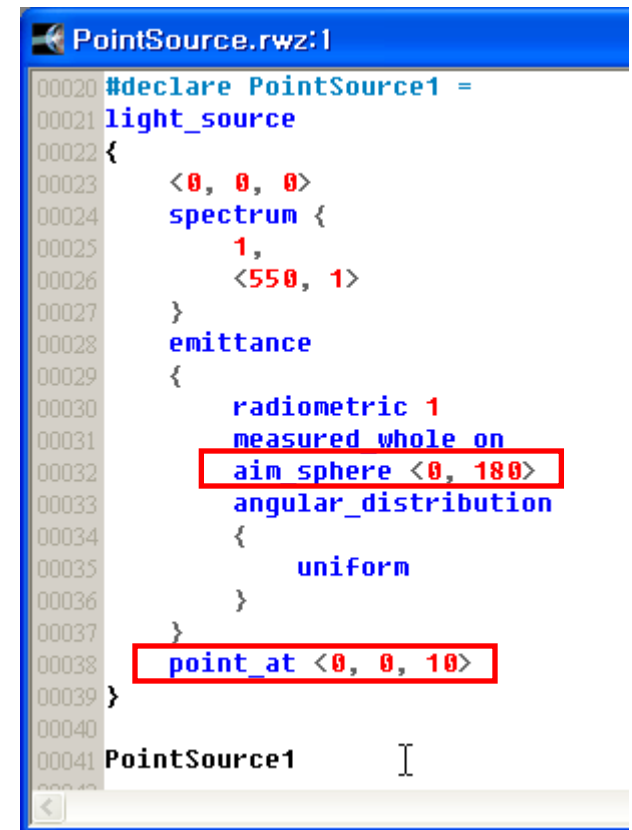
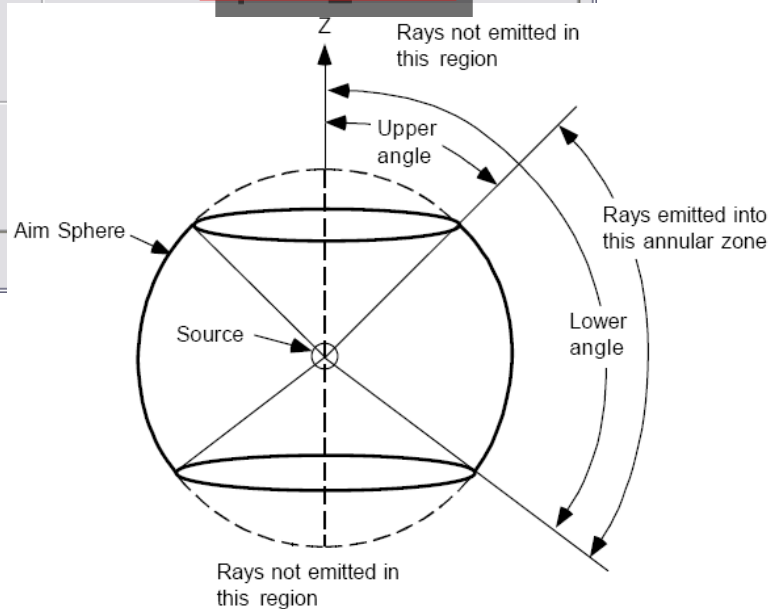
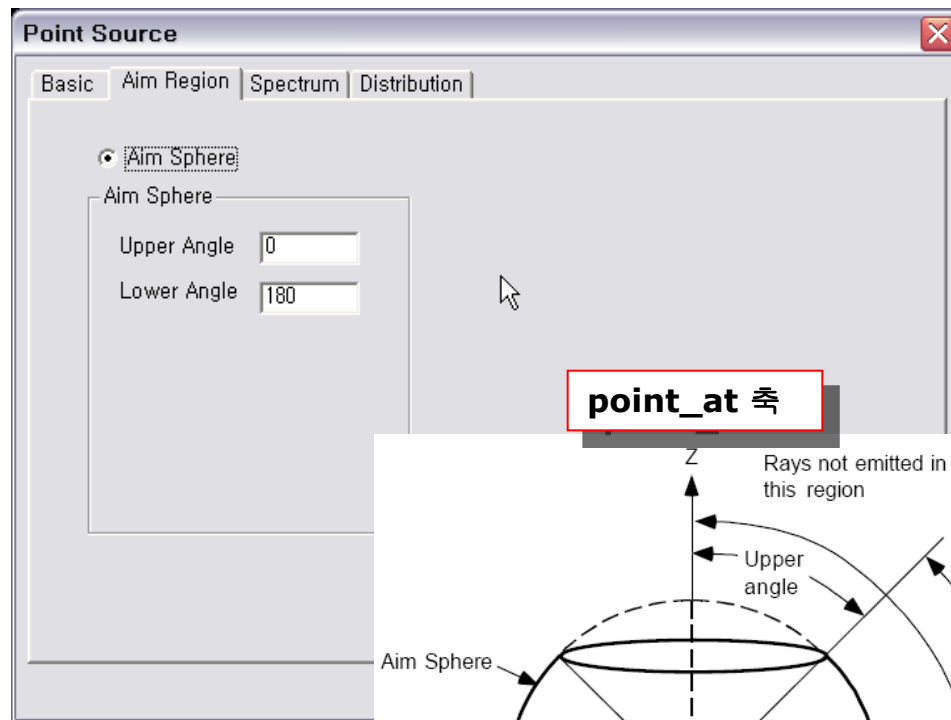
Total Flux의 설정기준

Radiometric(Watt) / Photometric(lm)

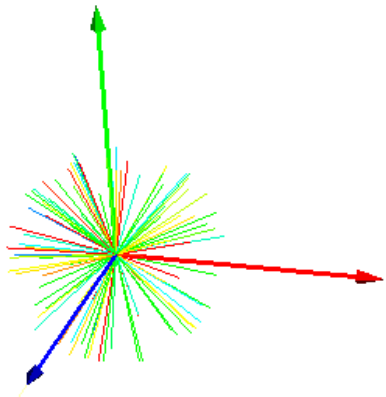
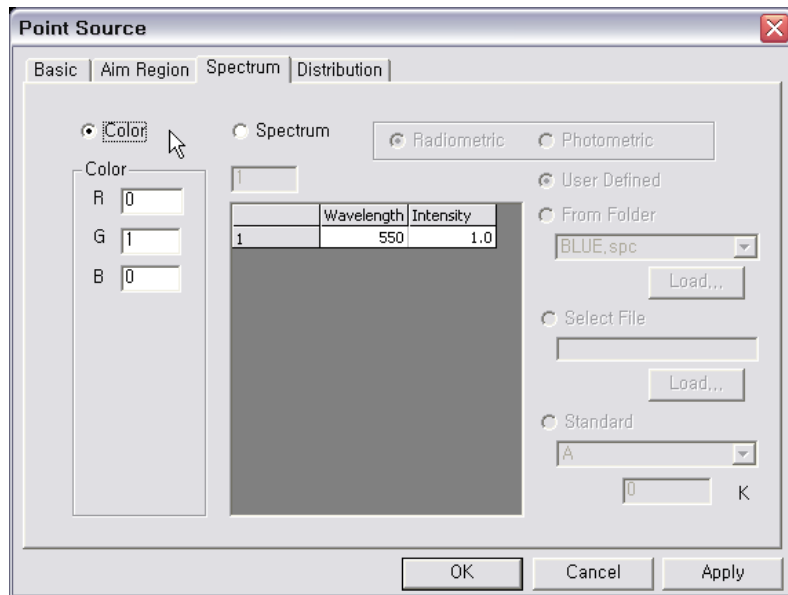
```
00020 #declare PointSource1 =
00021 light_source
00022 {
00023   <0, 0, 0>
00024   spectrum {
00025     1,
00026     <550, 1>
00027   }
00028   emittance
00029   {
00030     radiometric 1
00031     measured whole on
00032     aim_sphere <0, 180>
00033     angular_distribution
00034     {
00035       uniform
00036     }
00037   }
00038   point_at <0, 0, 10>
00039 }
00040
00041 PointSource1
```

Light의 위치

Light Source I: Point Source(3)

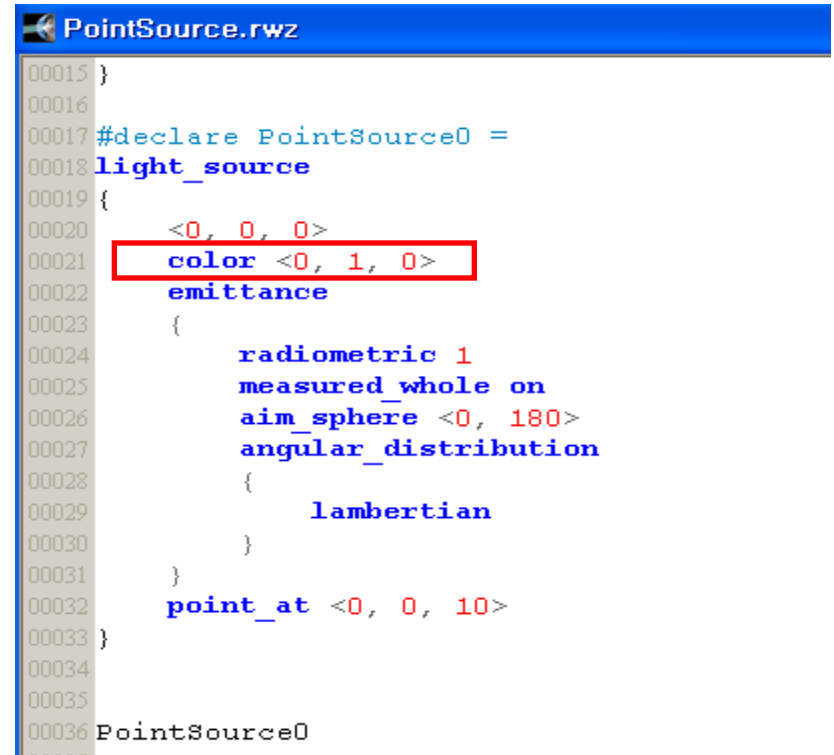


Light Source I: Point Source(4)

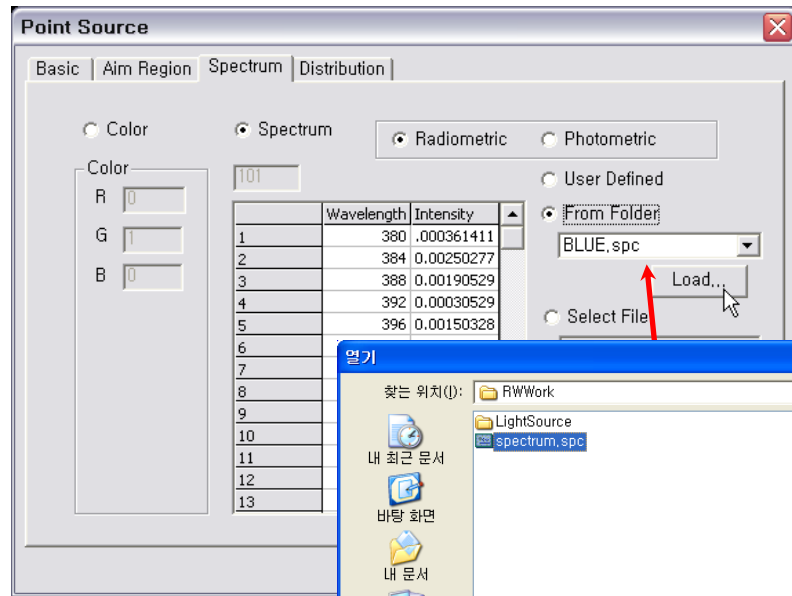


Color $\langle 0, 1, 0 \rangle$ 에 해당하는 **Spectrum**으로 변환

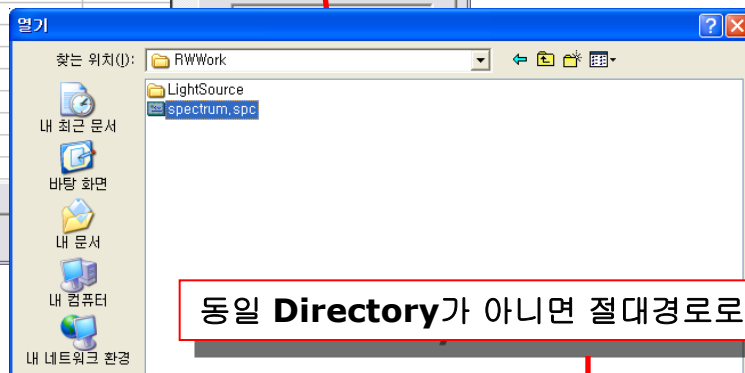
- Ray의 **Spectrum**을 RGB로 입력가능
- **Illuminance Ray Tracing** 시, RGB Color는 **Spectrum**으로 변환.



Light Source I: Point Source(5)



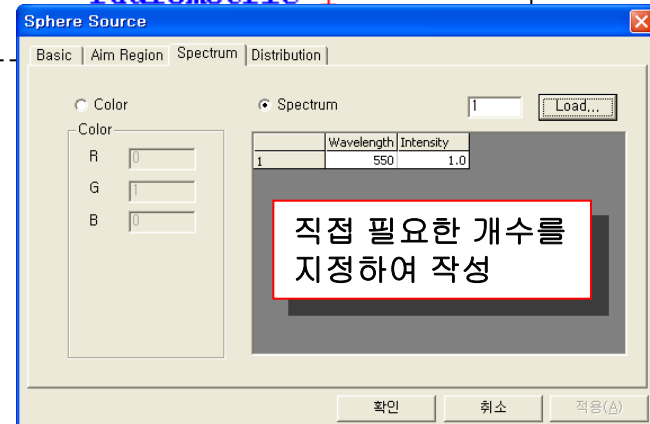
- **Spectrum**을 파일로 읽어서 광선의 파장 별 **Intensity**를 지정할 수 있다.
- **Spectrum**을 **Grid**에 직접 입력 할 수도 있다.



동일 **Directory**가 아니면 절대경로로 표시

```
#declare PointSource0 =
light_source
{
    <0, 0, 0>
    spectrum {
        "C:\RWWork\spectrum.spc"
    }
    emittance
    {
        radiometric 1
        measured whole on
        aim_sphere <0, 180>
        visible distribution
    }
}
```

```
#declare PointSource0 =
light_source
{
    <0, 0, 0>
    spectrum {
        1,
        <550, 1.5>
    }
    emittance
    {
        radiometric 1
    }
}
```



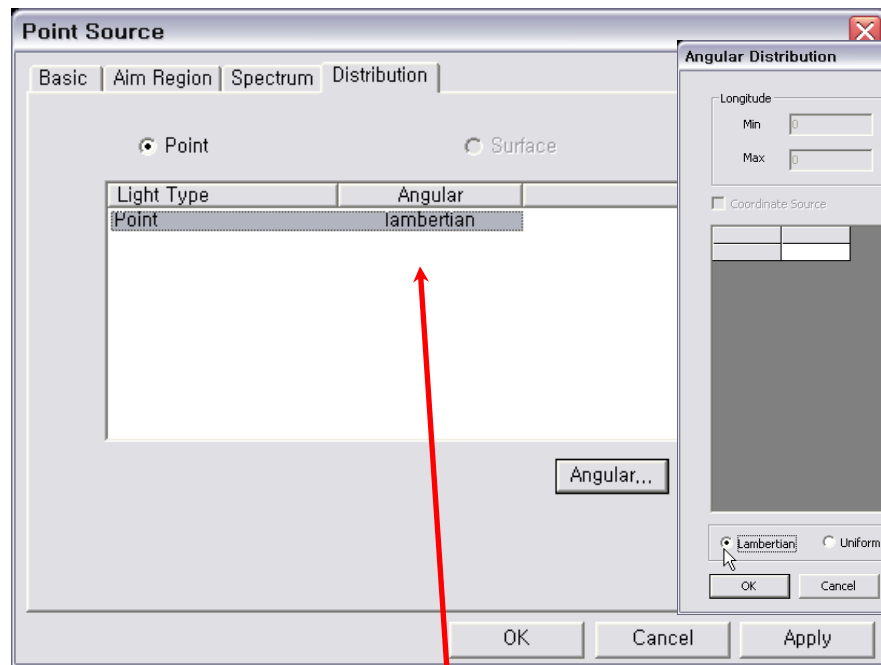
직접 필요한 개수를
지정하여 작성

spectrum.spc

1	191	데이터 수
2	380	9.80E+00
3	382	1.02E+01
4	384	1.07E+01
5	386	1.11E+01
6	388	1.16E+01

파장(nm) Intensity

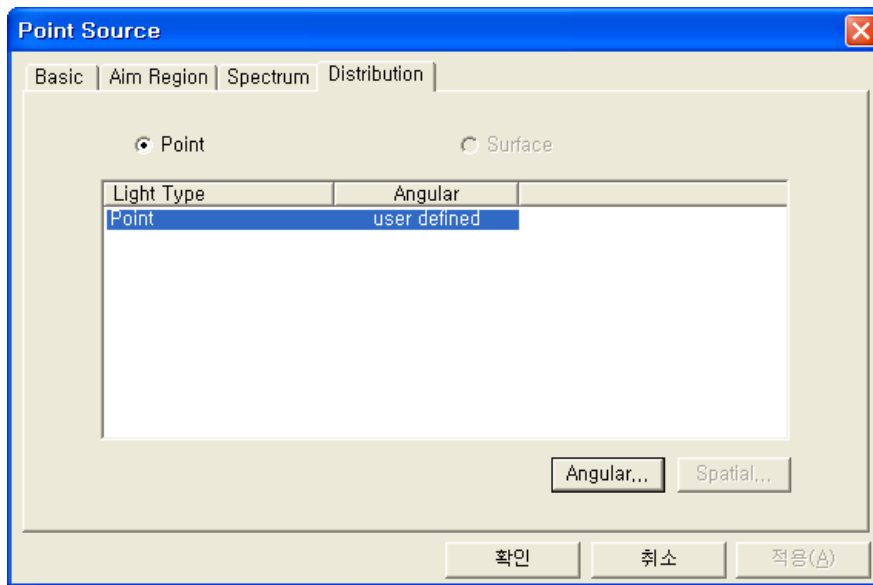
Light Source I: Point Source(6)



모든 방향으로의 **Intensity**가 동일한 **Uniform** 또는 **Cosine** 함수형태를 따르는 **Lambertian Type**으로 설정 가능하다.

```
PointSource.rwz
00015 }
00016
00017 #declare PointSource0 =
00018 light_source
00019 {
00020     <0, 0, 0>
00021     color <0, 1, 0>
00022     emittance
00023     {
00024         radiometric 1
00025         measured_whole on
00026         aim_sphere <0, 180>
00027         angular_distribution
00028         {
00029             lambertian
00030         }
00031     }
00032     point_at <0, 0, 10>
00033 }
00034
00035
00036 PointSource0
```

Light Source I: Point Source(7)

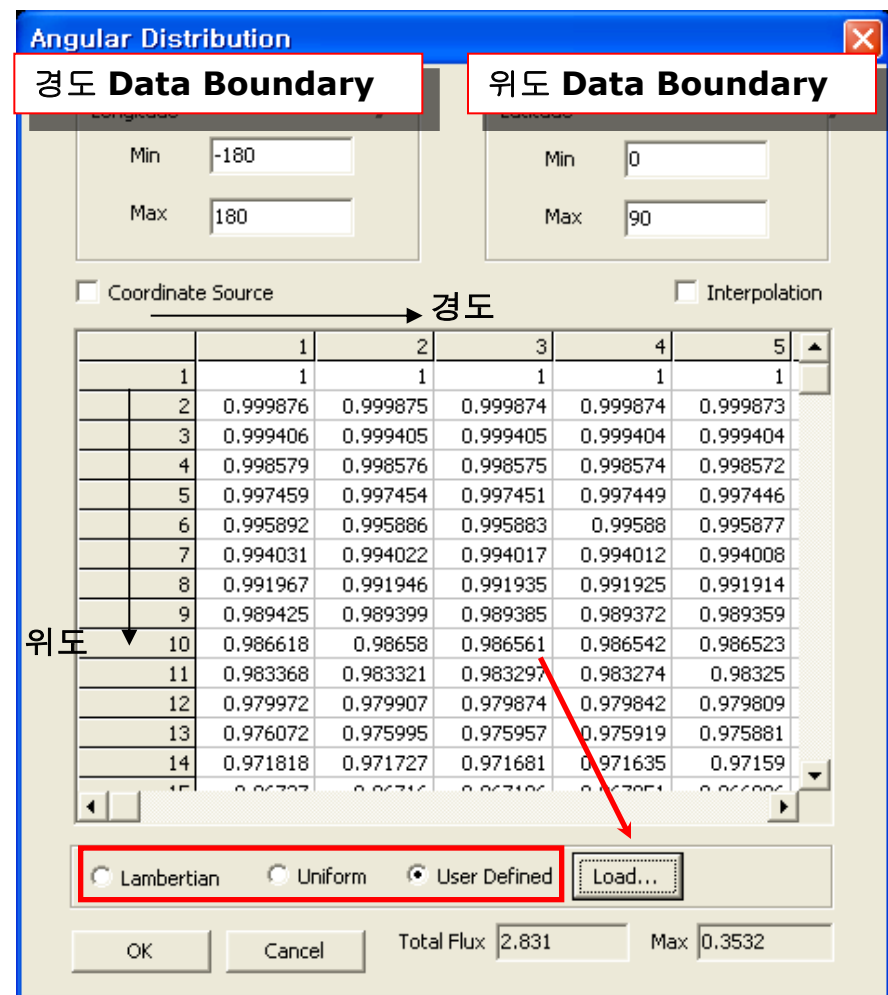


emittance

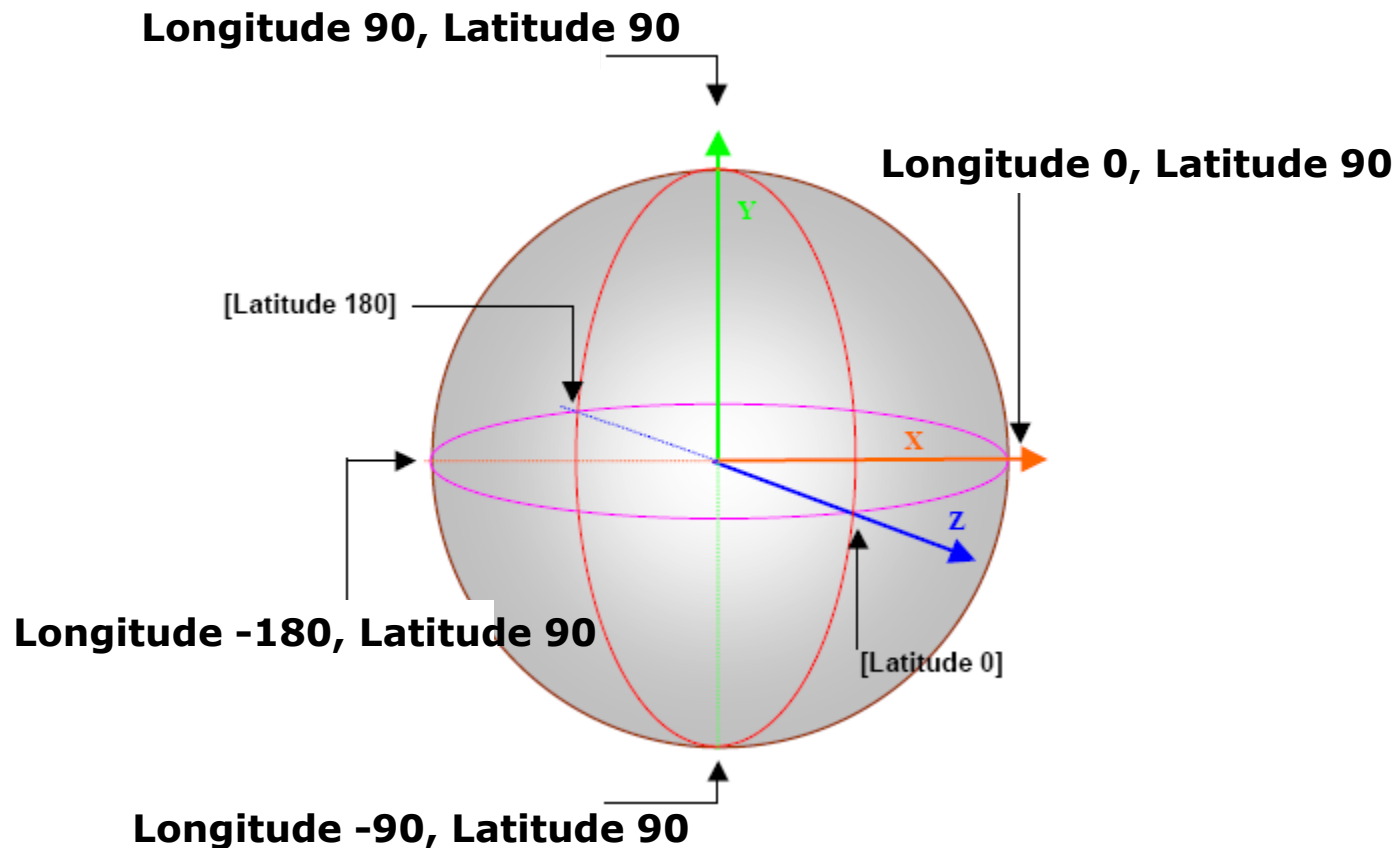
```
{
  radiometric 1
  measured_whole on
  aim_sphere <0, 180>
  angular_distribution
  {
    "C:\RWWork\angular_apodization.apo"
    interpolation off
    coordinate_source off
  }
}
```

point_at <0, 0, 10>

Apodize 파일 경로 표시

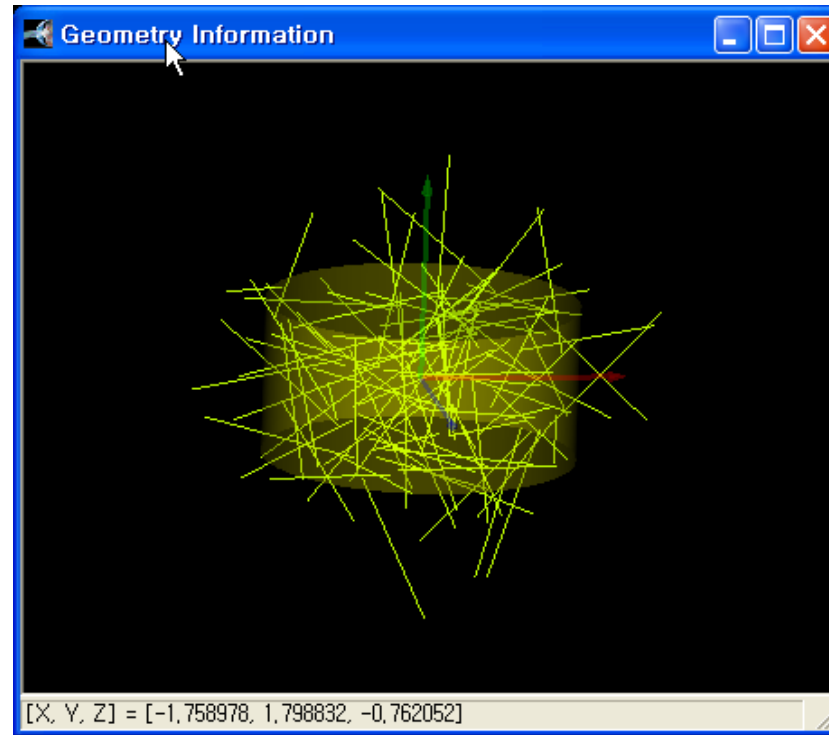


Light Source I: Point Source(8)



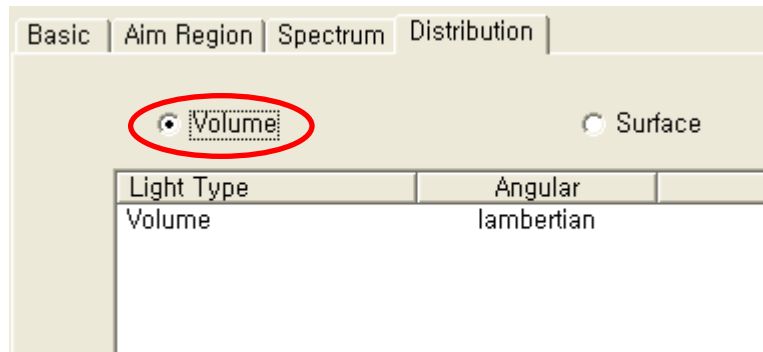
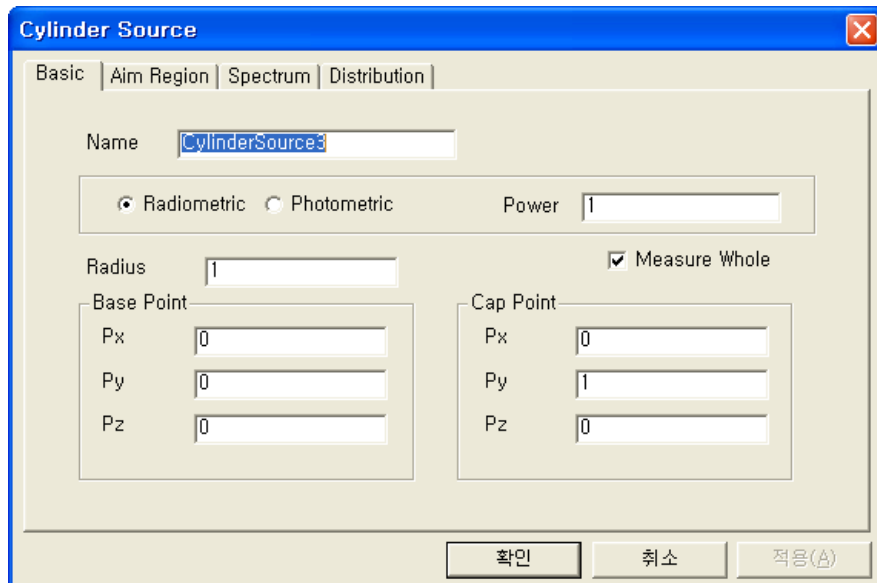
Point_at 축을 **Z** 기준으로 했을 때 경도는 **-X**에서 **-180**도로 시작하여 **180** 도로 설정되며, 위도는 **Z**축을 **0**도로 시작하여 **-Z**축을 **180** 도로 설정된다.

Light Source I: Cylinder Source - Volume(1)



- 원기둥의 크기를 가지는 볼륨 광원
- 원기둥의 내부영역에서부터 광선을 내보낸다.
- 모든 방향을 향해 빛을 보낼 수도 있고 각도를 지정하여 제한영역을 주어 빛을 보내는 것도 가능하다.
- 사용자가 직접 광선의 방향과 세기를 지정할 수 있다.

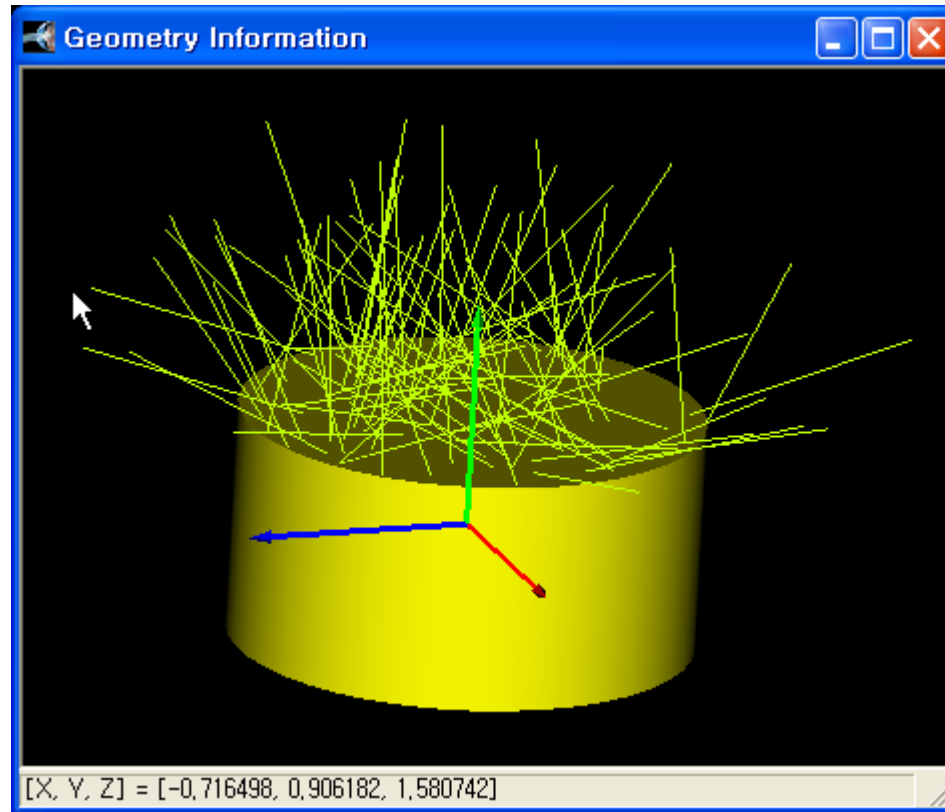
Light Source I: Cylinder Source - Volume(2)



```
00020 #declare CylinderSource0 =
00021 light_source
00022 {
00023     <0, 0, 0>
00024     spectrum {
00025         1,
00026         <550, 1>
00027     }
00028     object_light
00029     {
00030         volume
00031         cylinder
00032         {
00033             <0, 0, 0>, <0, 1, 0>, 1
00034         }
00035     }
00036     emittance
00037     {
00038         radiometric 1
00039         measured_whole on
00040         aim_sphere <0, 180>
00041         angular_distribution
00042         {
00043             uniform
00044         }
00045         volume_distribution
00046         {
00047             uniform
00048         }
00049     }
00050     point_at <0, 2, 0>
00051 }
00052
00053 CylinderSource0
00054
00055
```

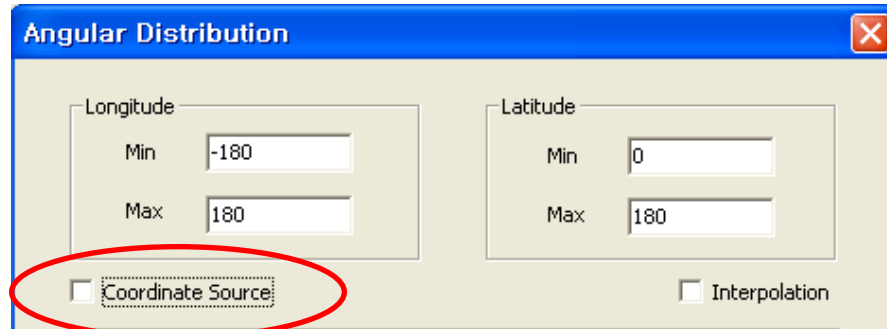
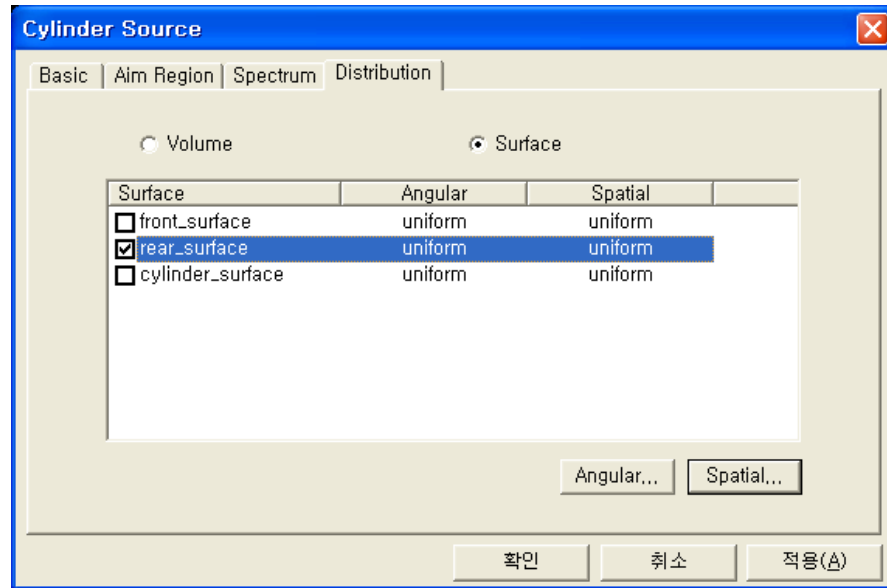
광원의 형태를 **Cylinder**로 정의한다
(아랫면/윗면의 꼭지점, 반지름)

Light Source I: Cylinder Source - Surface(3)

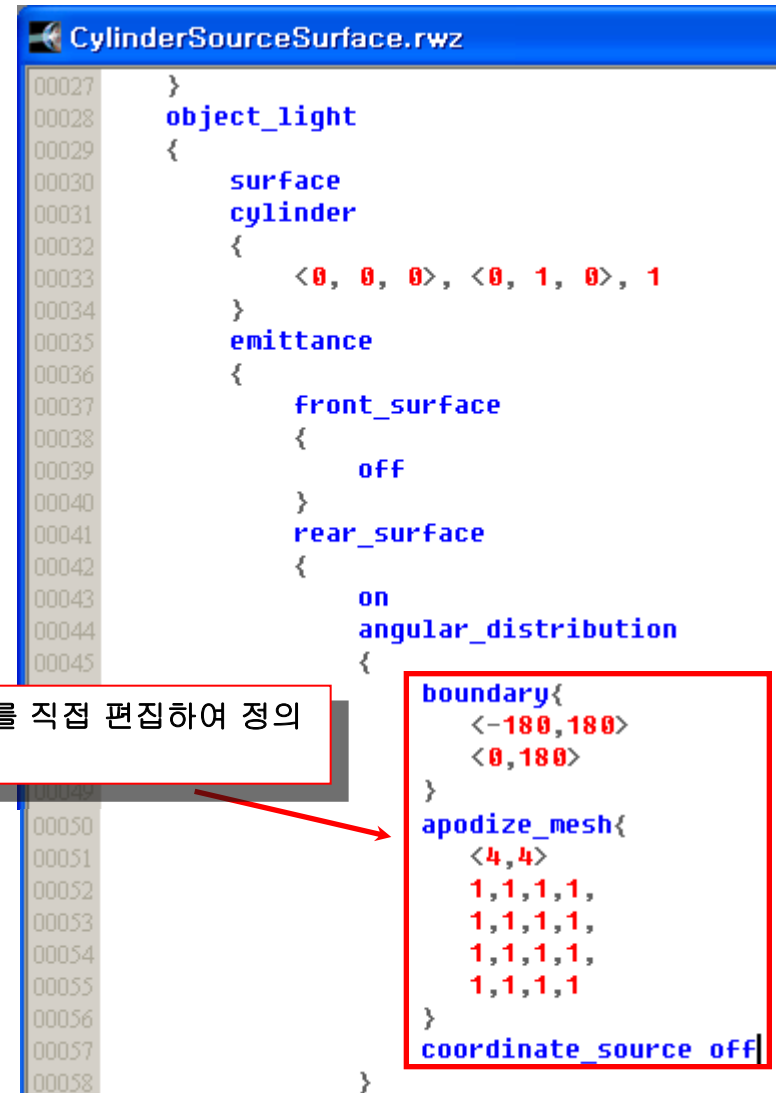


- 원기둥 면에서부터 빛이 나가는 광원
- **3**개의 면마다 빛이 나가거나 안 나가게 할 수 있다.
- **3**개의 면 각각에 광선의 방향과 세기를 지정할 수 있다.

Light Source I: Cylinder Source - Surface(4)



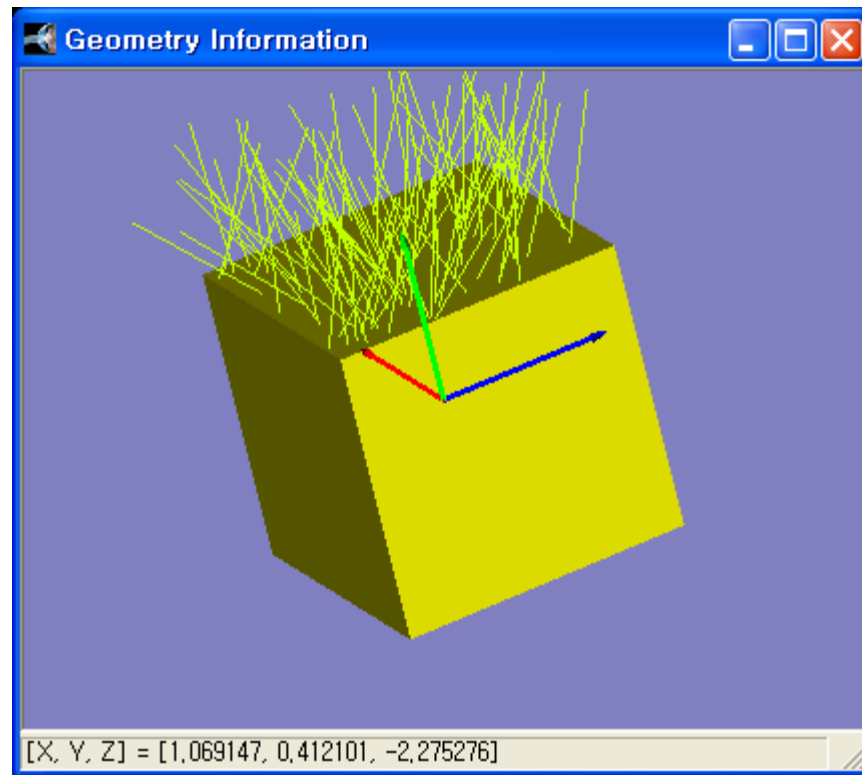
기본값은 선택되어 있지 않으면 각도 측정의 중심점을 **Surface**의 중심으로 하며 선택하게 되면 **Object**의 중심을 기준으로 한다.



Script를 직접 편집하여 정의 가능

Workshop 2: Make Light

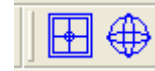
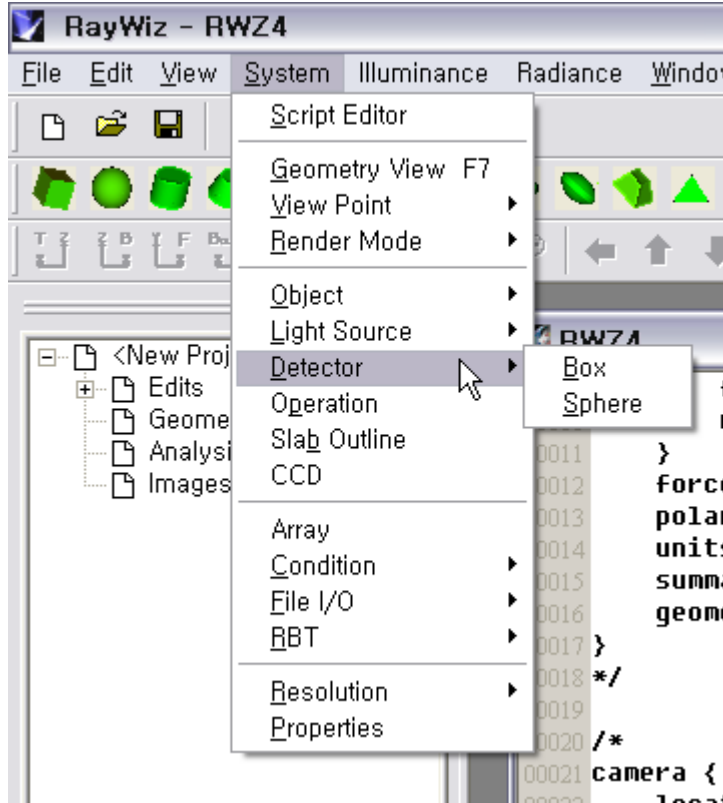
1. RayWiz를 실행하고 새 파일을 만들어 작업 **Directory**에 “**Workshop2.rwz**”로 저장하시오.
2. **Menu**나 **Toolbar**를 이용하여 **Surface Box Light**를 작성하되 **+Y(Top_Surface)**로만 나가도록 설정하며 **aim_angle**을 **0도 45도로** 제한을 주시오.
3. **Geometry View**를 실행하여 **Illuminance** 메뉴에 있는 **>Start Simulation**을 선택하여 **Ray**들의 진행 방향을 관찰하시오



RAYWIZ BASIC

- Detector I -

Detector: Detector Types



1. **Box Detector**
2. **Sphere Detector**

Total Flux를 기준으로 계산하려는 정량데이터의 종류에 단위면적이 기준이 되면 **Box Detector**를 입사각이 기준이면 **Sphere Detector**를 필요로 하게 된다.
RAYWIZ는 복수개의 **Detector**설정이 가능하다.

Detector: Box Detector(1)

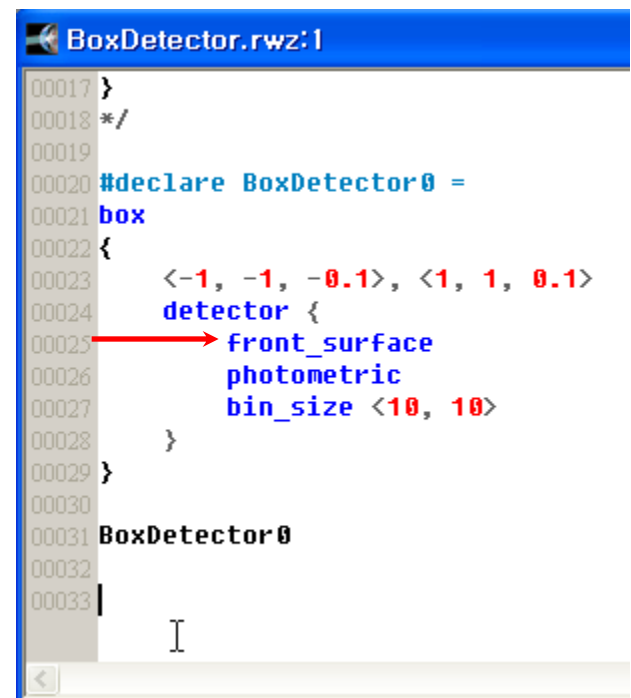
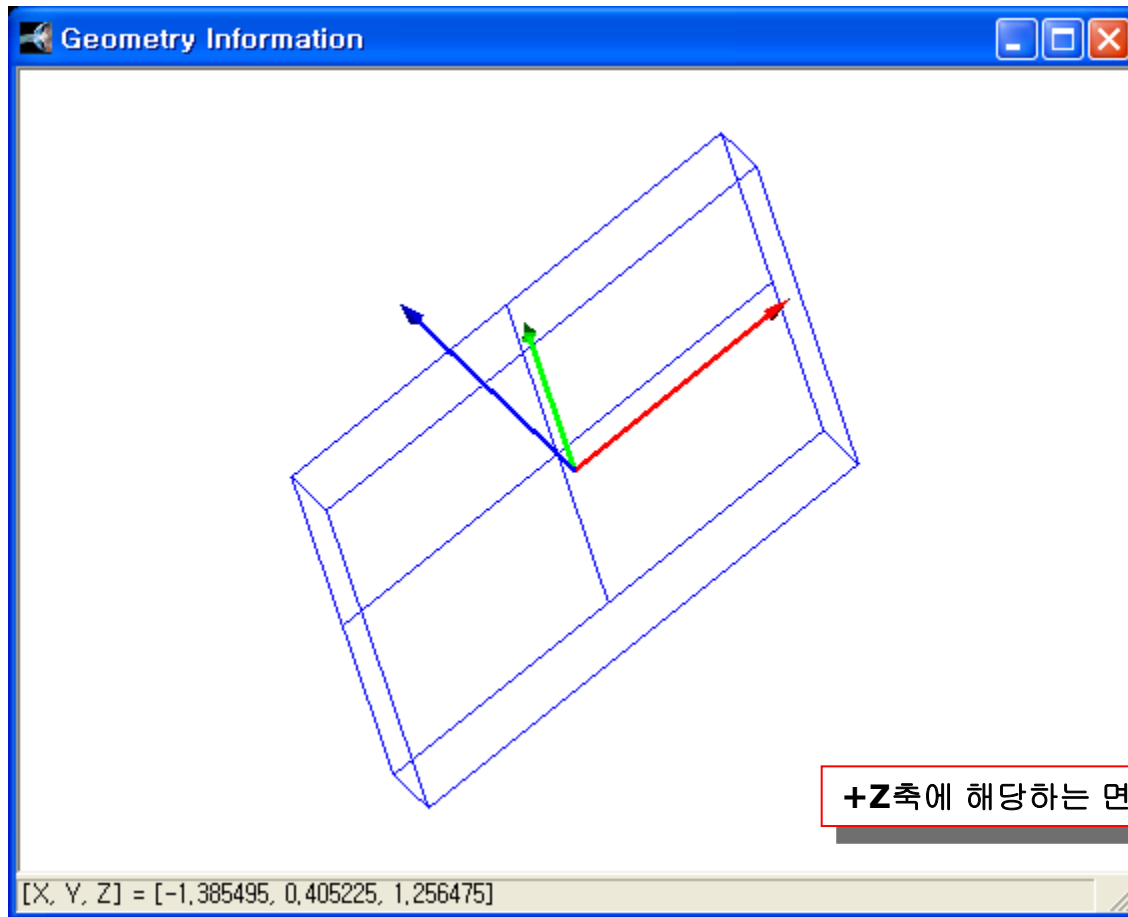
The image shows a 'Box Detector' dialog box with the following fields and controls:

- Name:** BoxDetector0
- Corner1:** Px: -1, Py: -1, Pz: -1
- Corner2:** Px: 1, Py: 1, Pz: 1
- Surface:** front_surface(Z+)
- Units:** Radiometric (unselected), Photometric (selected)
- Range:** Min: 0, Max: 0
- Bin Size:** X: 10, Y: 10
- Buttons:** 확인 (OK), 취소 (Cancel), 적용(A) (Apply)

Annotations in Korean:

- Detector 이름** (Detector Name) points to the Name field.
- Geometry 설정부분으로 Box를 이루는 대각의 두 점을 지정한다.** (Specify the two diagonal points forming the box in the Geometry setting section.) points to the Corner1 and Corner2 fields.
- Detector로 사용될 Surface** (Surface to be used by the Detector) points to the Surface dropdown menu.
- Photometry 단위선택** (Photometry Unit Selection) points to the Radiometric/Photometric radio buttons.
- 결과 값으로 표현할 Data 최대, 최소** (Maximum and minimum Data to be expressed as result values) points to the Range Min/Max fields.
- Detecting 2D Cell 수** (Number of 2D Cells to be detected) points to the Bin Size X/Y fields.

Detector: Box Detector(2)



+Z축에 해당하는 면에 십자 표시가 나타남.

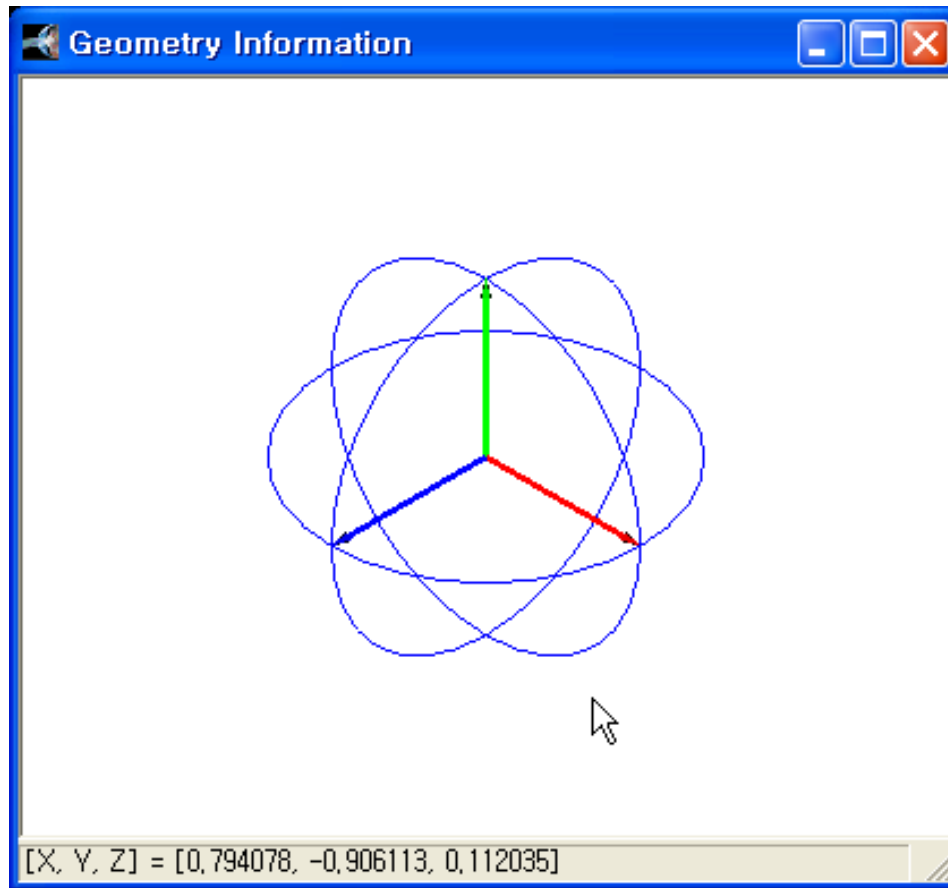
Detector: Sphere Detector(1)

The image shows a software window titled "Sphere Detector" with a "Basic" tab. The window contains several input fields and controls. Red boxes and arrows highlight specific areas with Korean annotations:

- Detector 이름**: Points to the "Name" field, which contains "SphereDetector1".
- Sphere Detector의 중심점과 반경을 지정.**: Points to a group of fields including "Center" (Px: 0, Py: 0, Pz: 0) and "Radius" (1).
- Photometry 단위선택**: Points to the "Radiometric" and "Photometric" radio buttons, with "Radiometric" selected.
- Detecting 2D Cell 수**: Points to the "Bin Size" fields, where X and Y are both set to 10.
- 결과 값으로 표현할 Data 최대, 최소**: Points to the "Range" checkbox and the "Min" and "Max" input fields, which are currently set to 0.

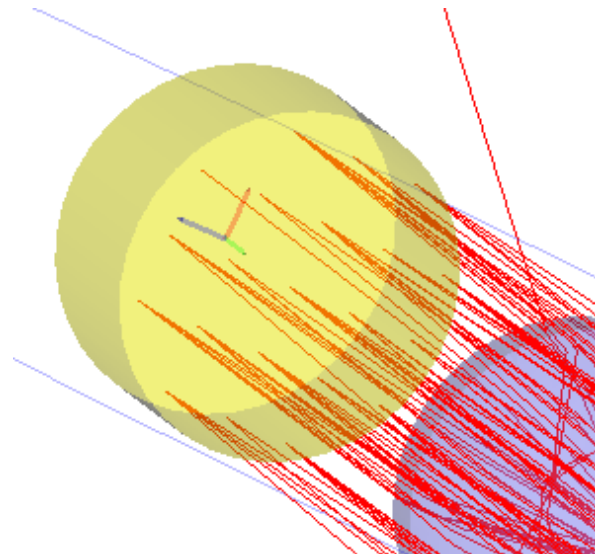
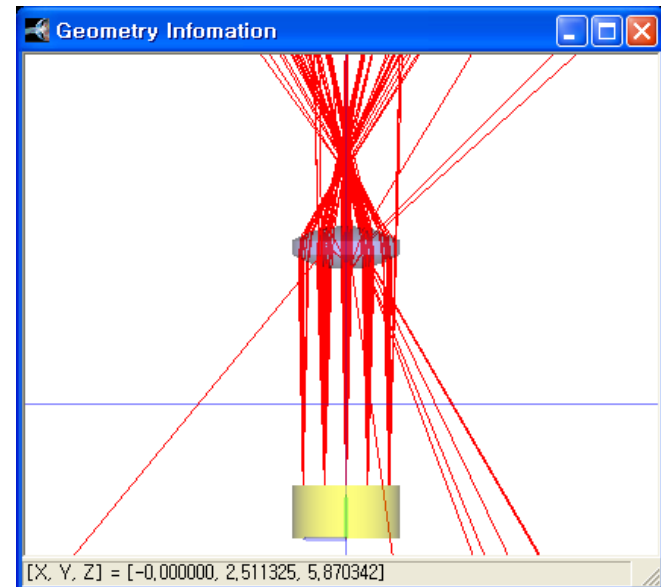
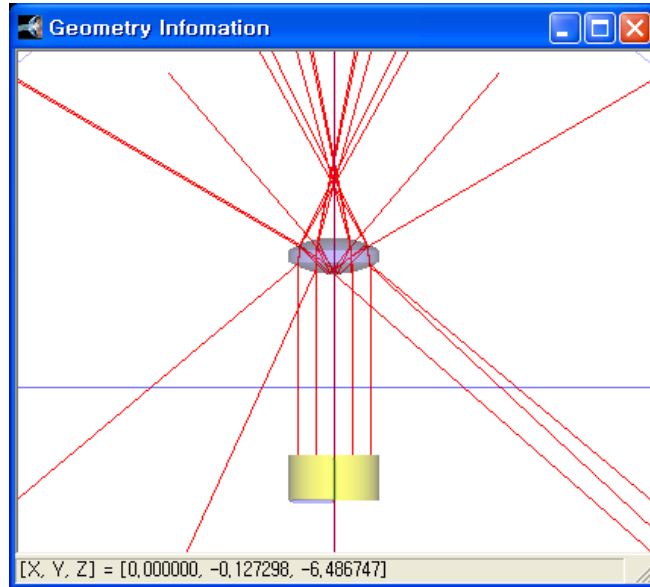
At the bottom of the window are three buttons: "확인" (OK), "취소" (Cancel), and "적용(A)" (Apply).

Detector: Sphere Detector(2)

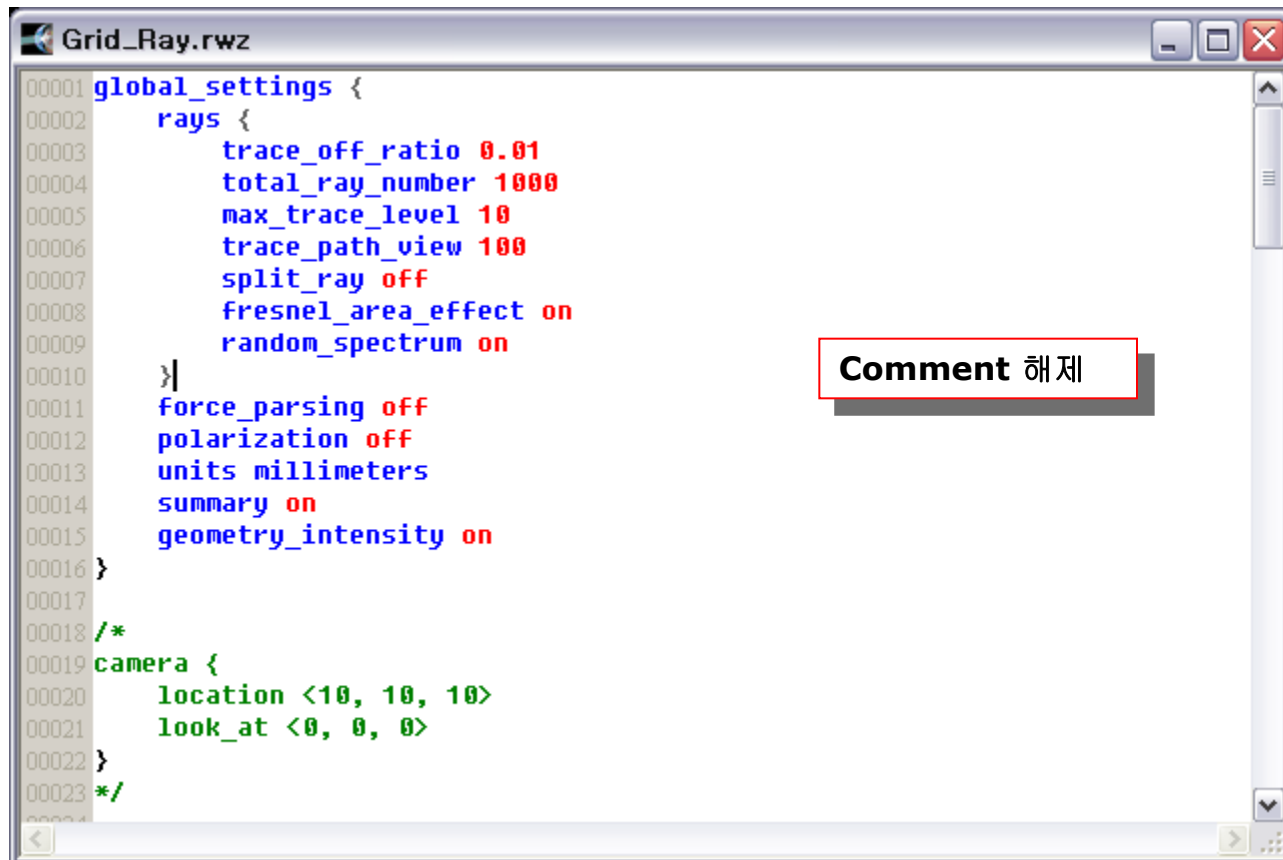


```
00020 #declare SphereDetector0 =
00021 sphere
00022 {
00023   <0, 0, 0>, 1
00024   detector {
00025     radiometric
00026     bin_size <10, 10>
00027   }
00028 }
00029
00030 SphereDetector0
```

Light Source II: Grid Light (1)



Light Source II: Grid Light (2)



```
00001 global_settings {
00002     rays {
00003         trace_off_ratio 0.01
00004         total_ray_number 1000
00005         max_trace_level 10
00006         trace_path_view 100
00007         split_ray off
00008         fresnel_area_effect on
00009         random_spectrum on
00010     }
00011     force_parsing off
00012     polarization off
00013     units millimeters
00014     summary on
00015     geometry_intensity on
00016 }
00017
00018 /*
00019 camera {
00020     location <10, 10, 10>
00021     look_at <0, 0, 0>
00022 }
00023 */
```

Comment 해제

Light Source II: Grid Light (3)

Cylinder Source

Basic | Aim Region | Spectrum | Distribution

Name:

☒ Radiometric ☐ Photometric Power:

Radius: ☒ Measured Whole

Base Point

Px	0
Py	0
Pz	0

Cap Point

Px	0
Py	1
Pz	0

OK Cancel Apply

Cylinder Source

Basic | Aim Region | Spectrum | Distribution

☒ Aim Sphere

Aim Sphere

Upper Angle:

Lower Angle:

OK Cancel Apply

Cylinder Source

Basic | Aim Region | Spectrum | Distribution

☐ Color ☒ Spectrum ☒ Radiometric ☐ Photometric

Color

R	0
G	1
B	0

☒ User Defined

	Wavelength	Intensity
1	650	1.0

☐ From Folder Load...

☐ Select File Load...

☐ Standard K

OK Cancel Apply

Cylinder Source

Basic | Aim Region | Spectrum | Distribution

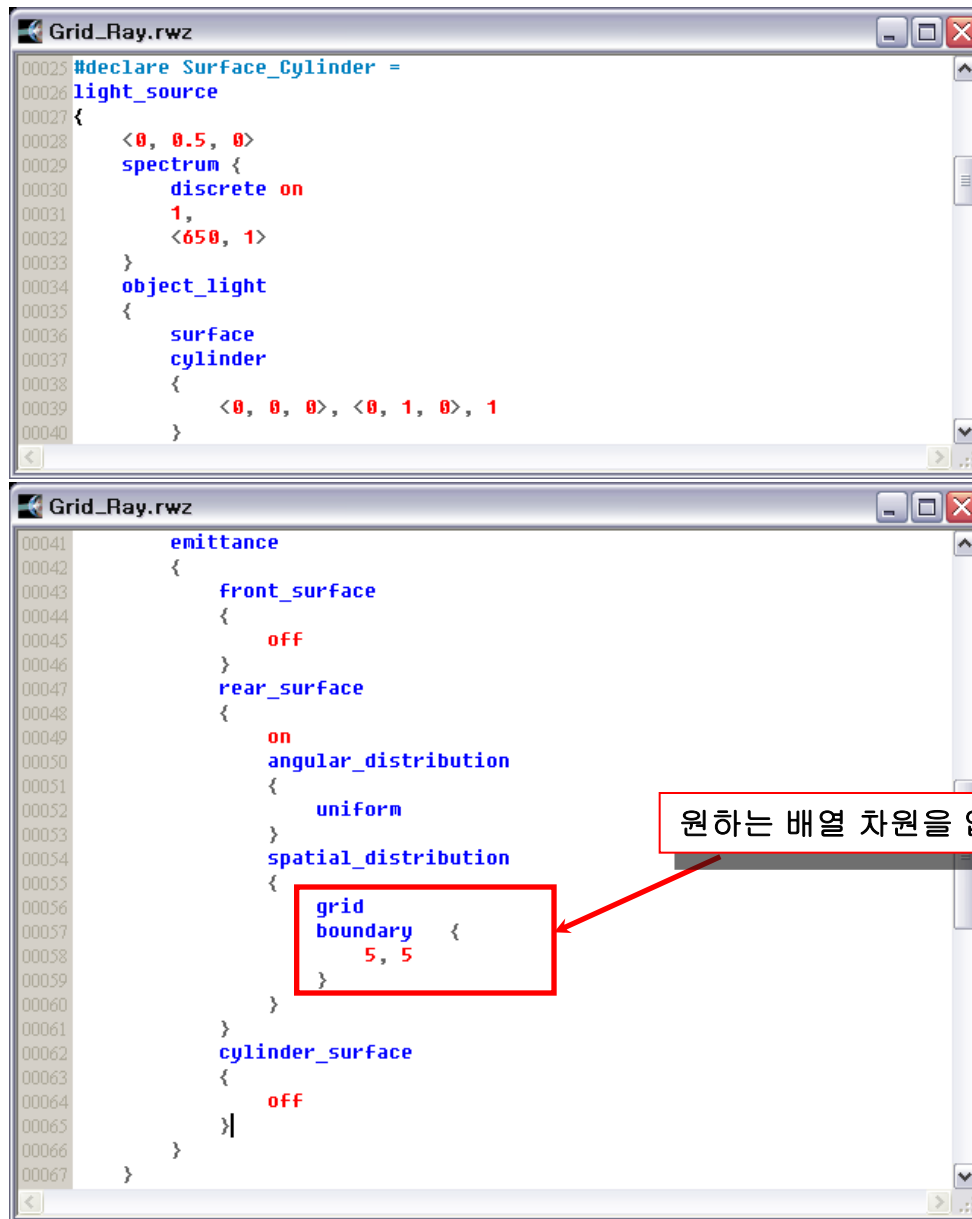
☐ Volume ☒ Surface

Surface	Angular	Spatial
☐ front_surface	uniform	uniform
☒ rear_surface	uniform	uniform
☐ cylinder_surface	uniform	uniform

Angular... Spatial...

OK Cancel Apply

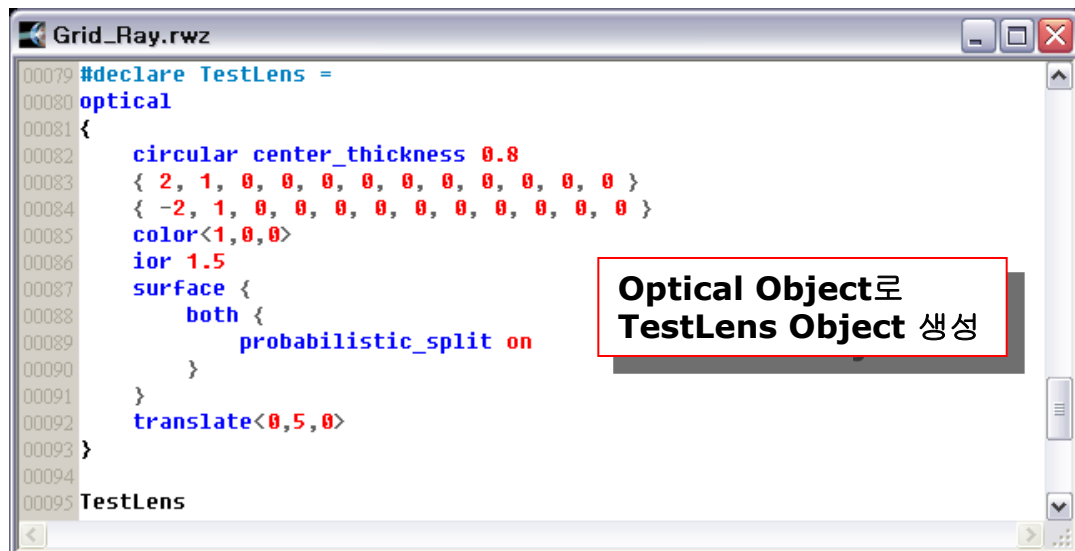
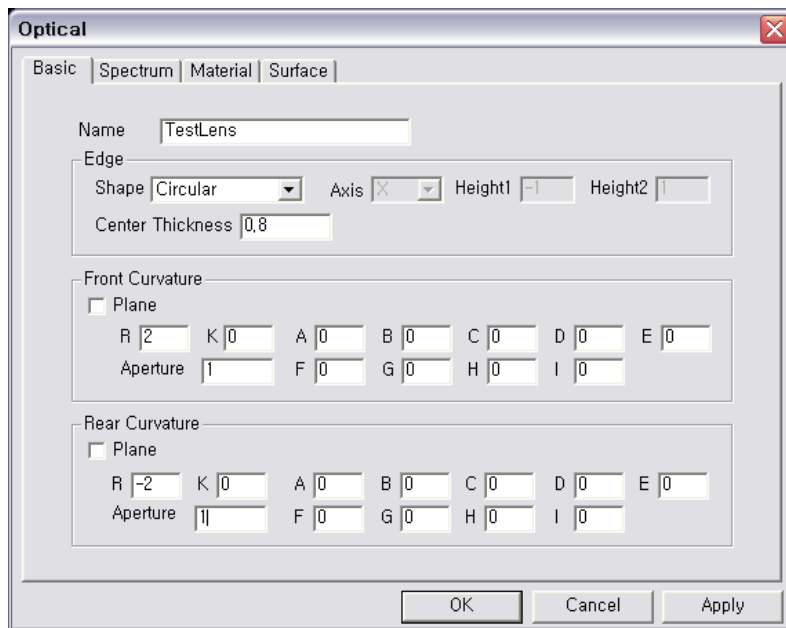
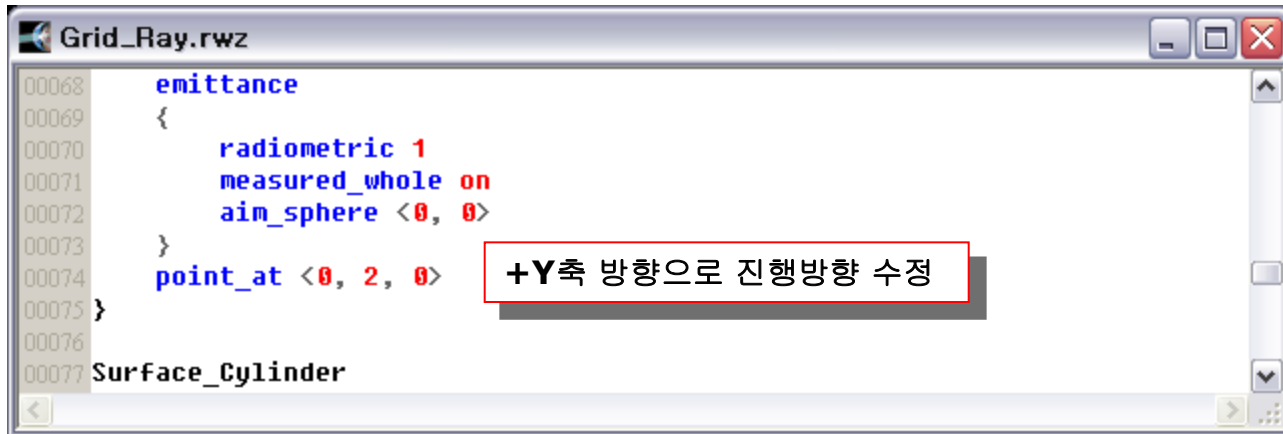
Light Source II: Grid Light (4)



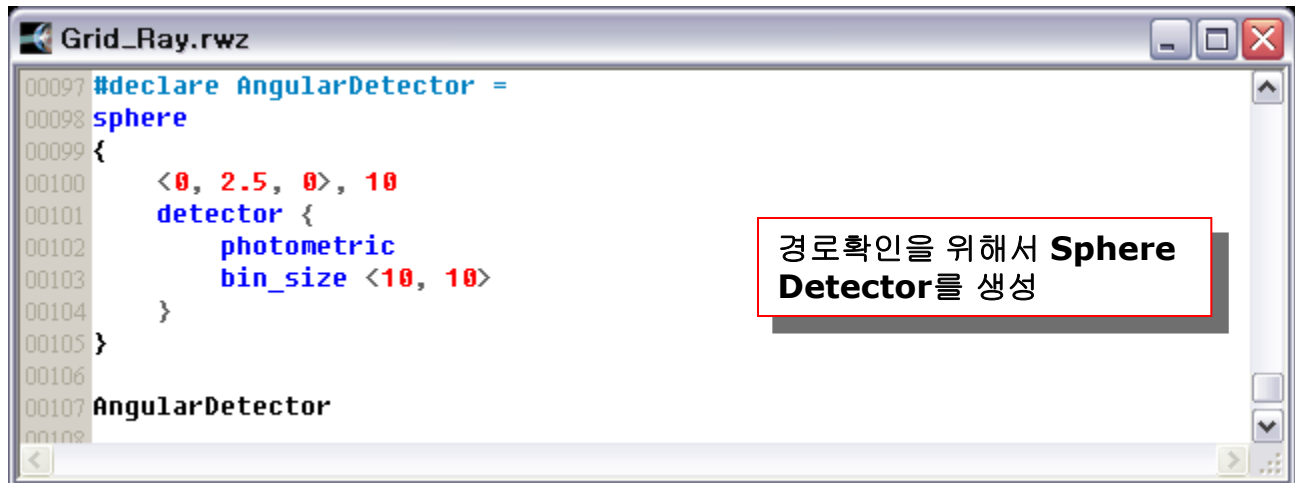
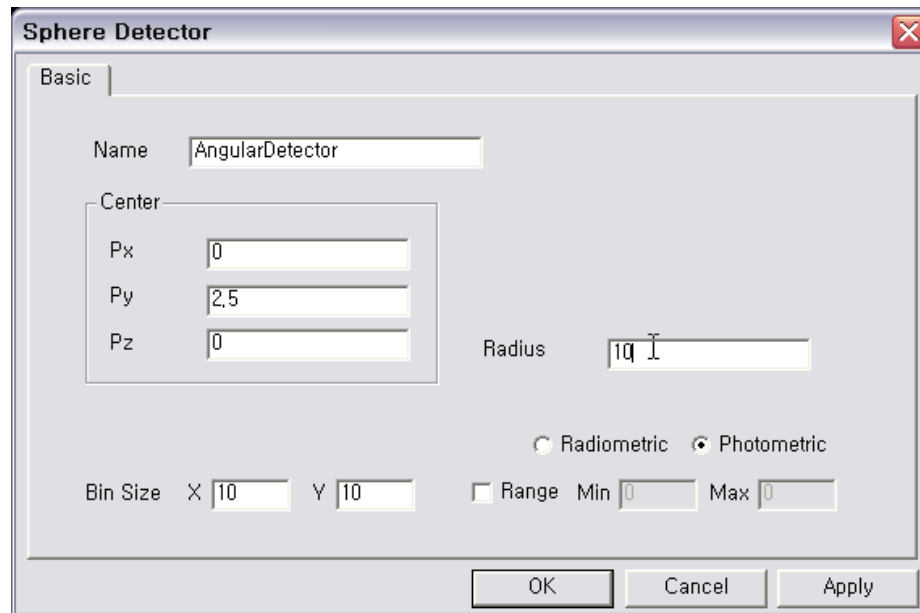
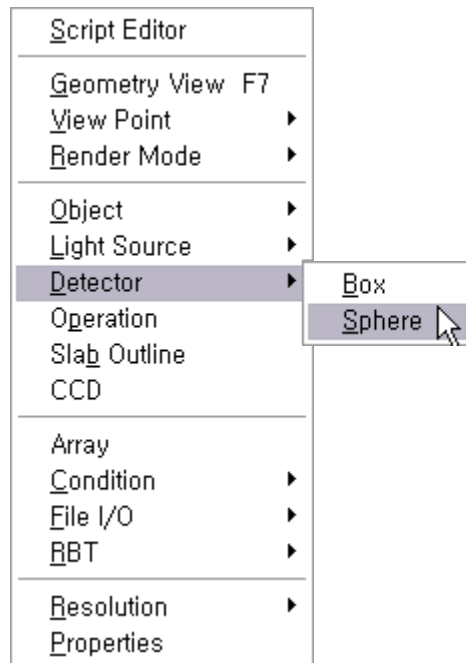
```
Grid_Ray.rwz
00025 #declare Surface_Cylinder =
00026 light_source
00027 {
00028     <0, 0.5, 0>
00029     spectrum {
00030         discrete on
00031         1,
00032         <650, 1>
00033     }
00034     object_light
00035     {
00036         surface
00037         cylinder
00038         {
00039             <0, 0, 0>, <0, 1, 0>, 1
00040         }
00041     }
00042 }
00043
00041 emittance
00042 {
00043     front_surface
00044     {
00045         off
00046     }
00047     rear_surface
00048     {
00049         on
00050         angular_distribution
00051         {
00052             uniform
00053         }
00054         spatial_distribution
00055         {
00056             grid
00057             boundary {
00058                 5, 5
00059             }
00060         }
00061     }
00062     cylinder_surface
00063     {
00064         off
00065     }
00066 }
00067 }
```

원하는 배열 차원을 입력

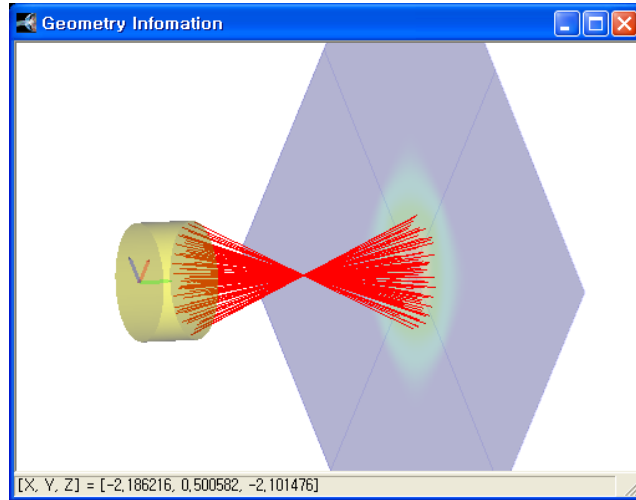
Light Source II: Grid Light (5)



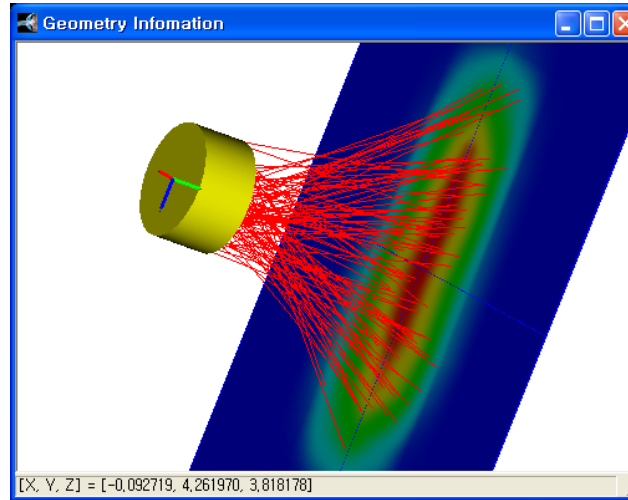
Light Source II: Grid Light (6)



Light Source II: Aim_Sphere, Aim_Point, Aim_Area (1)



<Aim_Point>

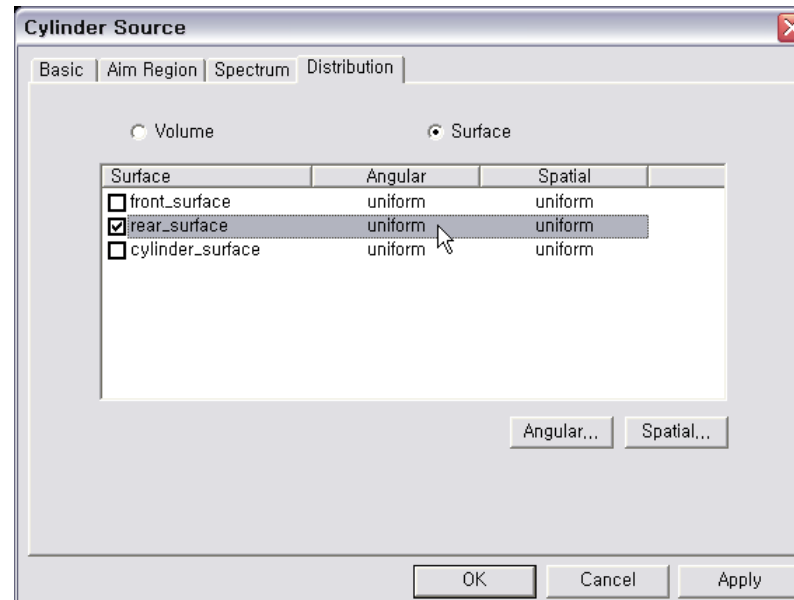
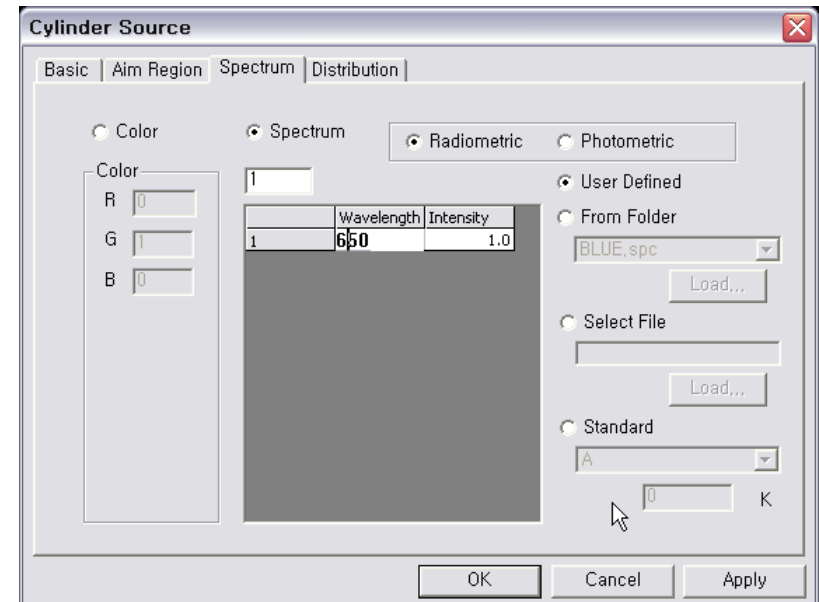
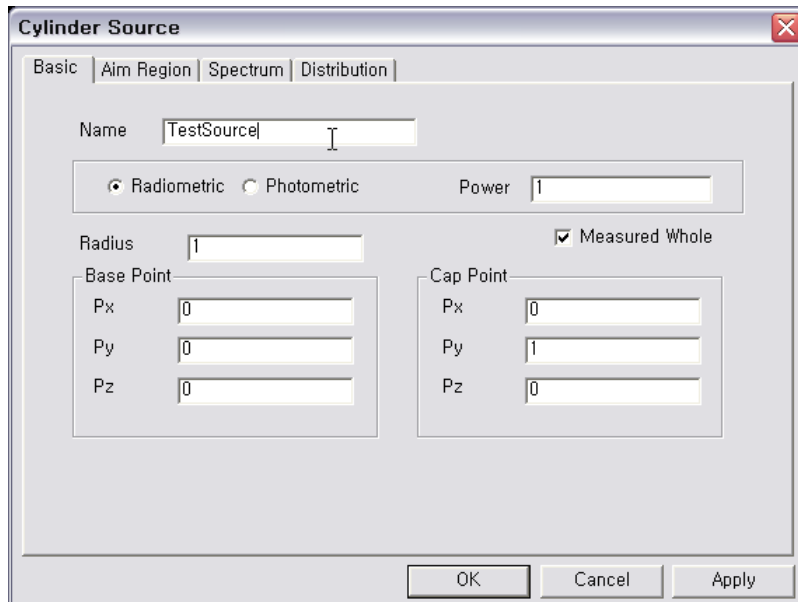


<Aim_Area>

Aim_Sphere,
Aim_Point,
Aim_Area 중
하나를 설정

```
AimPoint_AimArea.rwz
00061 }
00062 }
00063 emittance
00064 {
00065     radiometric 1
00066     measured whole on
00067     //aim_sphere <0, 180>
00068     //aim_point
00069     aim_area {
00070         <0,3,0> <0,6,0> //<center point> <direction point>
00071         //circular 0.1 // circular [radius]
00072         rectangular 1, 3 // rectangular [width],[height]
00073     }
00074 }
00075 point_at <0, 3, 0>
00076 }
00077
00078 TestSource
00079
00080 #declare TestDetector =
```

Light Source II: Aim_Sphere, Aim_Point, Aim_Area (2)



Light Source II: Aim_Sphere, Aim_Point, Aim_Area (3)

```
AimPoint_AimArea.rwz
00025 #declare TestSource =
00026 light_source
00027 {
00028   <0, 0.5, 0>
00029   spectrum {
00030     discrete on
00031     1,
00032     <650, 1>
00033   }
00034   object_light
00035   {
00036     surface
00037     cylinder
00038     {
00039       <0, 0, 0>, <0, 1, 0>, 1
00040     }
00041   }
00042 }
```

```
AimPoint_AimArea.rwz
00041   emittance
00042   {
00043     front_surface
00044     {
00045       off
00046     }
00047     rear_surface
00048     {
00049       on
00050       angular_distribution
00051       {
00052         uniform
00053       }
00054       spatial_distribution
00055       {
00056         uniform
00057       }
00058     }
00059     cylinder_surface
00060     {
00061       off
00062     }
00063   }
00064 }
```

Rear Surface 만
Emitting

Light Source II: Aim_Sphere, Aim_Point, Aim_Area (4)

```
AimPoint_AimArea.rwz
00065   emittance
00066   {
00067       radiometric 1
00068       measured_whole on
00069       //aim_sphere <0, 180>
00070       //aim_point
00071       aim_area {
00072           <0,3,0> <0,6,0> //<center point> <direction point>
00073           //circular 0.1 // circular [radius]
00074           rectangular 1, 3 // rectangular [width],[height]
00075       }
00076   }
00077   point_at <2, 3, 0>
00078 }
00079
00080 TestSource

AimPoint_AimArea.rwz
00081
00082 #declare TestDetector =
00083 box
00084 {
00085     <-5, 5, -5>, <5, 5.01, 5>
00086     detector {
00087         bottom_surface
00088         photometric
00089         bin_size <10, 10>
00090     }
00091 }
00092
00093 TestDetector
00094
```

Aim_sphere 부분을 **comment** 처리하고 **aim_point** 나 **aim_area**를 입력한다.
-**Aim_point**인 경우는 **point_at** 의 좌표를 마치 이상적인 렌즈 초점처럼 **Ray**들을 집중 시킨다.
-**Aim_area**인 경우는 가상의 목표 영역의 중심점과 방향벡터 그리고 가로세로의 길이나 반경을 입력하여 정의하고 **Ray**들은 이 지정된 영역으로만 **Emitting** 하게된다.

Box Detector를 정의하여 **Ray Path**를 관찰한다.

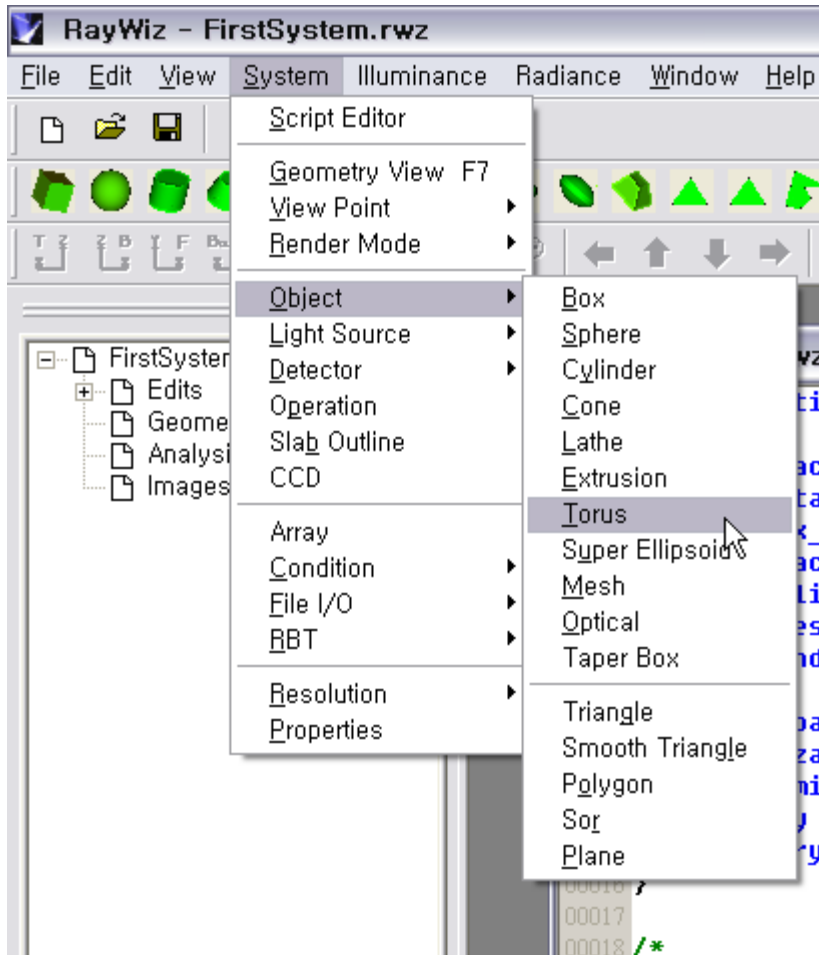
Detector: Create Your First System (1) – File Creation

The screenshot displays the RayWiz software interface. On the left is the RayWiz application window with a menu bar (File, Edit, View) and a toolbar. The main window is a file explorer titled '다른 이름으로 저장' (Save with another name), showing the 'RayWiz 실험파일' (RayWiz experiment files) folder. It lists several files: BoxDetector.rwz, CylinderSource.rwz, CylinderSourceSurface.rwz, FirstObject.rwz, PointSource.rwz, SphereDetector.rwz, TranslateScaleRotate.rwz, Workshop1.rwz, and Workshop2.rwz. The '파일 이름(N):' (File name) field is set to 'FirstSystem.rwz' and the '파일 형식(T):' (File type) is set to 'RayWiz Files (*.rwz; *.rbk; *.wrl)'. A red arrow points from a text box to the 'Uncomment' option in a context menu. The context menu is open over the 'FirstSystem.rwz' file, showing options like Undo, Redo, Copy, Cut, Paste, Delete, Comment, Uncomment, Increase Ident, Decrease Ident, Select All, Find, Replace, and Goto. The background shows the 'FirstSystem.rwz' script editor with a code window displaying the following script:

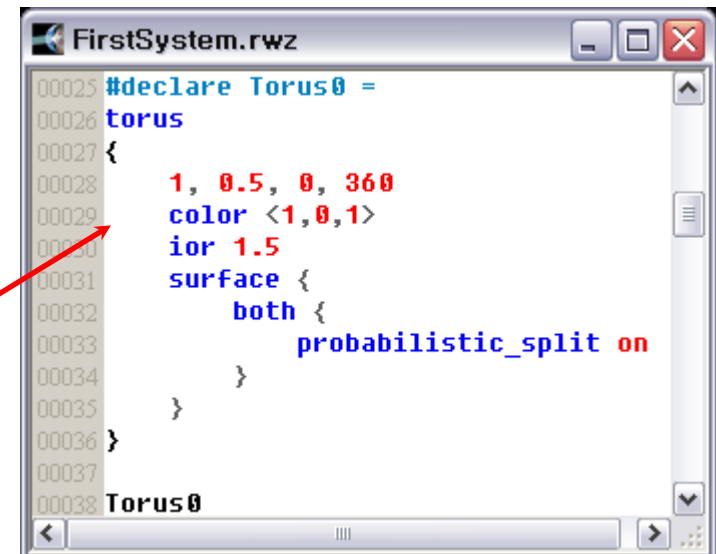
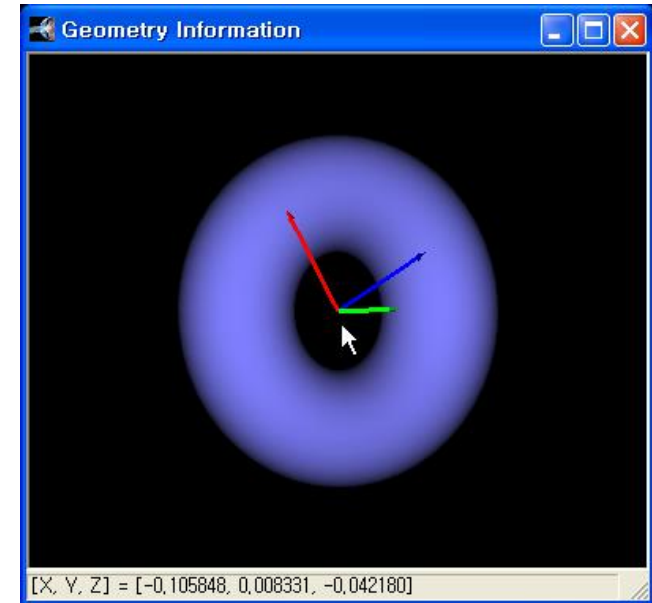
```
00001 /*
00002 global_settings {
00003   rays {
00004     trace_off_ratio 0.01
00005     total_ray_number 1000
00006     max_trace_level 10
00007   }
00008   spli
00009   fres
00010   rand
00011 }
00012 force_pa
00013 polariza
00014 units mi
00015 summary
00016 geometry
00017 }
00018 */
00019
```

Script 창에서 마우스 오른쪽 버튼을 눌러 >Uncomment를 선택하고 저장한다.

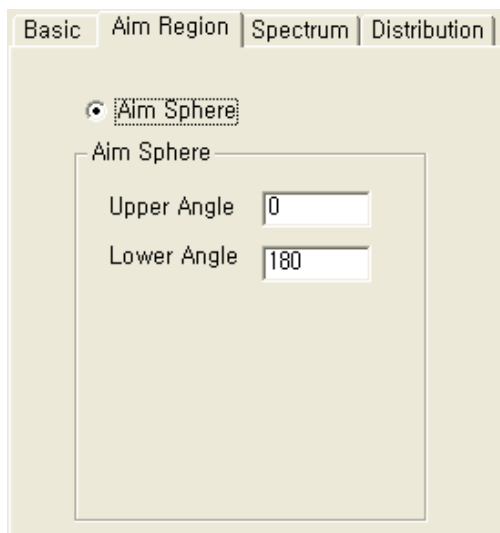
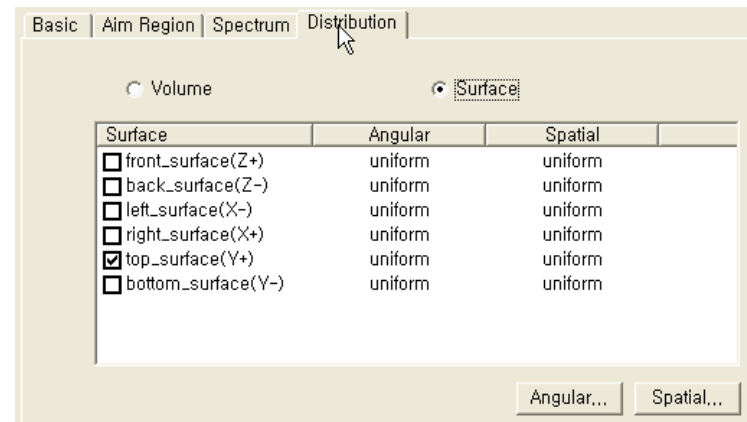
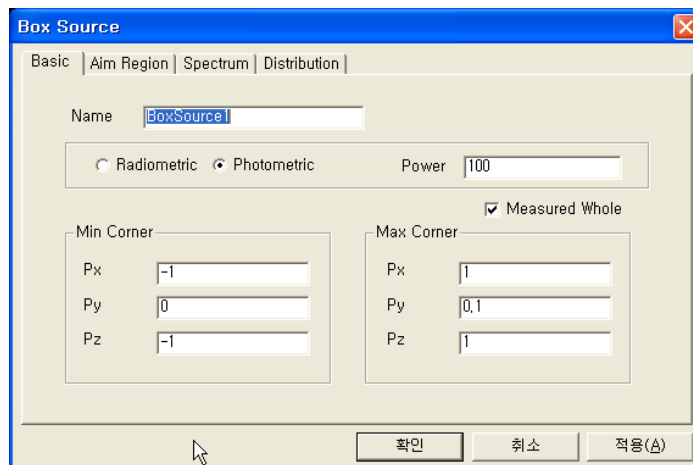
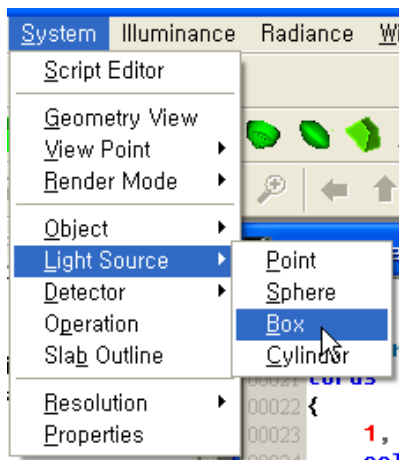
Detector: Create Your First System (2) – Object Creation



안쪽 반경이 **0.5**이고 바깥쪽 반경이 **1**인 **Torus**를 만들고 E광원 **Spectrum**에 해당하는 **RGB <1,0,1>**로 설정한다.



Detector: Create Your First System (3) – Source Creation

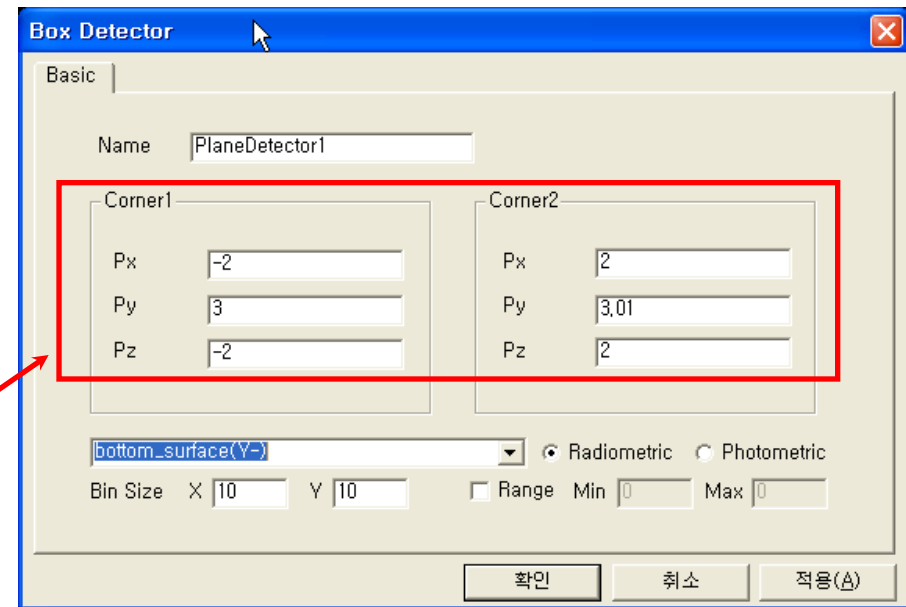
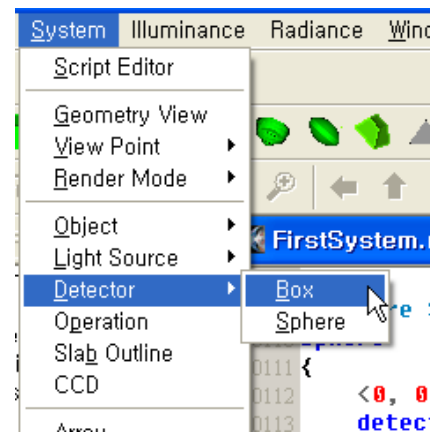
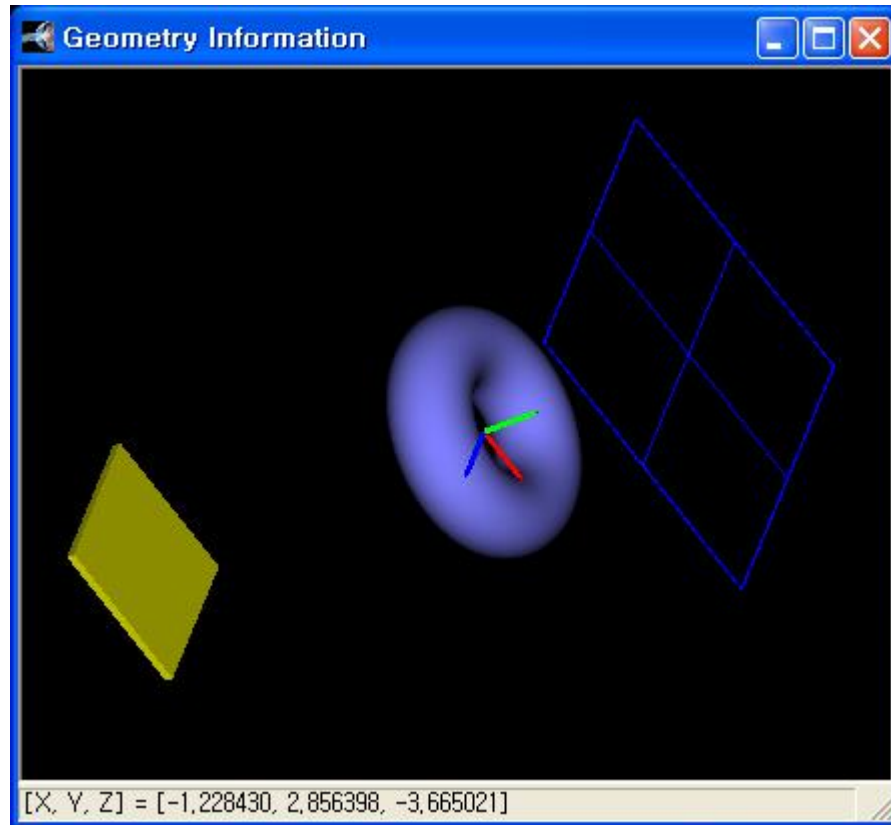


```
00035 #declare BoxSource1 =
00036 light_source
00037 {
00038   <0, -5, 0>
00039   color <1, 1, 1>
00040   object_light
00041   {
00042     surface
00043     box
00044     {
00045       <-1, 0, -1>, <1, 0.1, 1>
00046     }
00047     emittance
00048     {
00049       photometric 100
00050       measured_whole on
00051       aim_sphere <0, 0>
00052     }
00053     point_at <0, 3, 0>
00054   }
00055 }
```

Light Source의 중점을
-Y축 방향으로
이동하도록 Script 수정

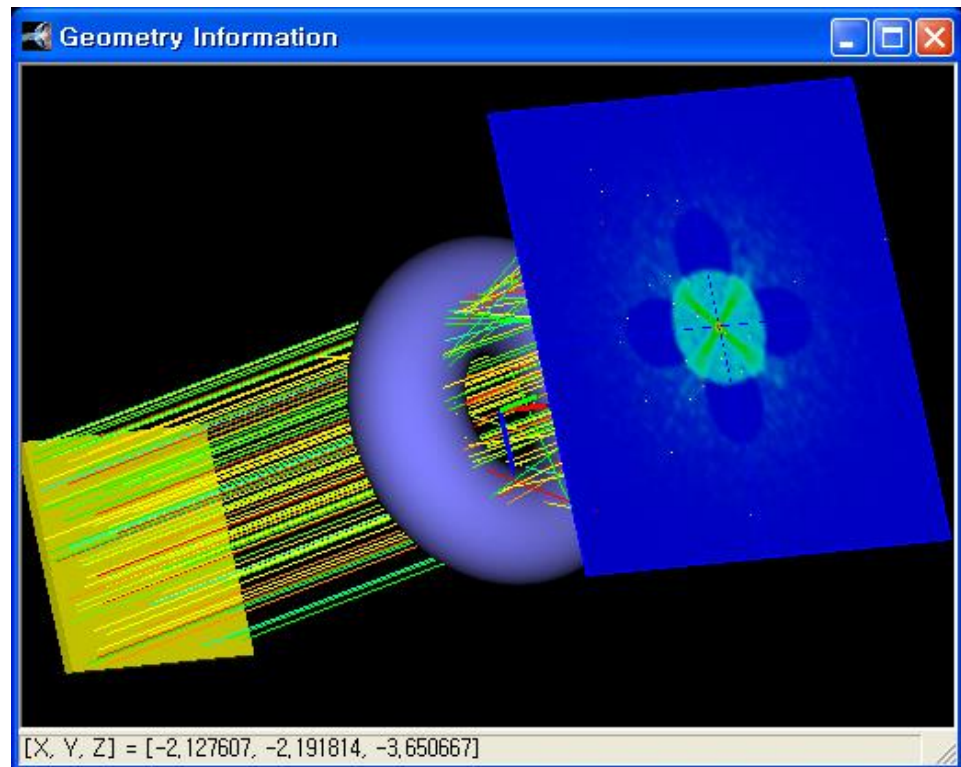
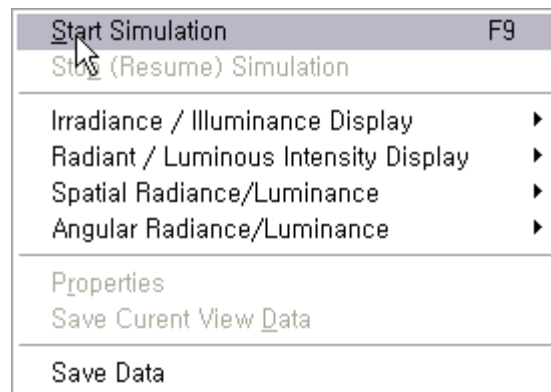
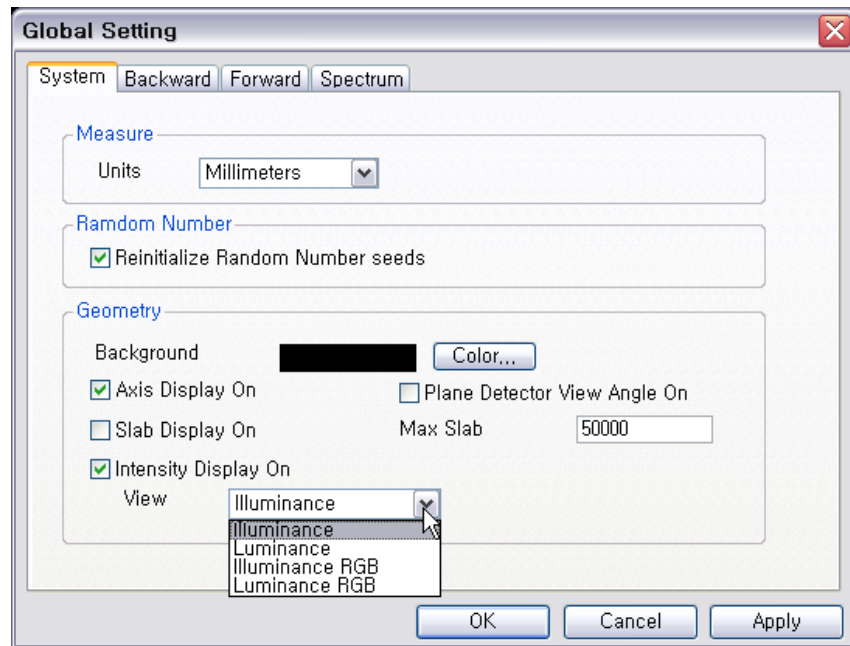
+Y방향을 향하도록 수정

Detector: Create Your First System (4)–Detector Creation



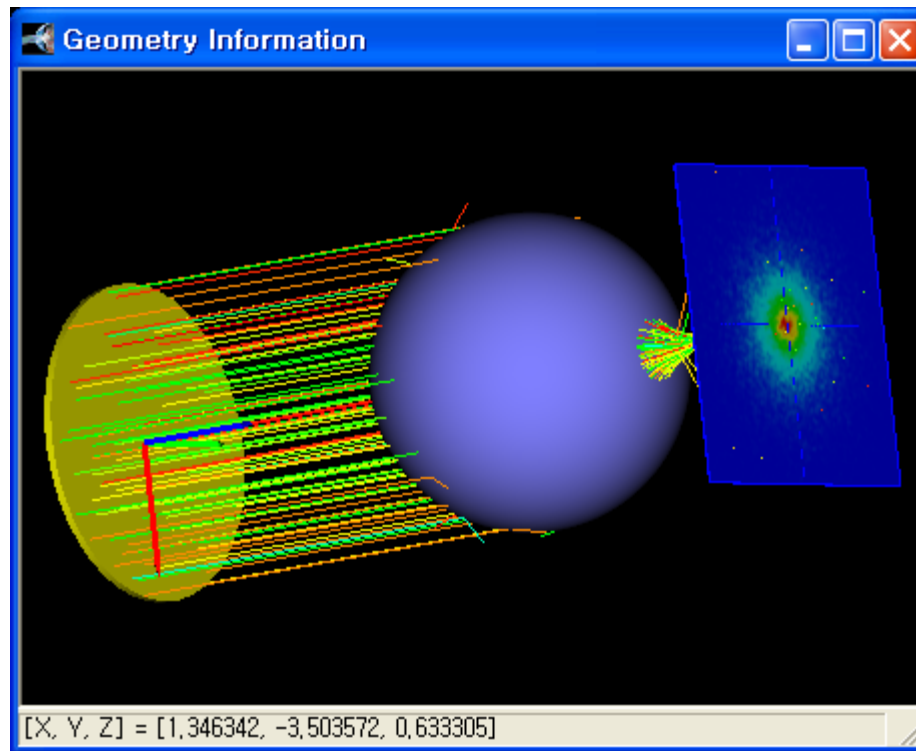
Y축 방향의 두께가 얇은 **box detector**를 정의하고
Bottom_surface (Y-)를 **detecting** 면으로 정의

Detector: Create Your First System (5) – Simulation



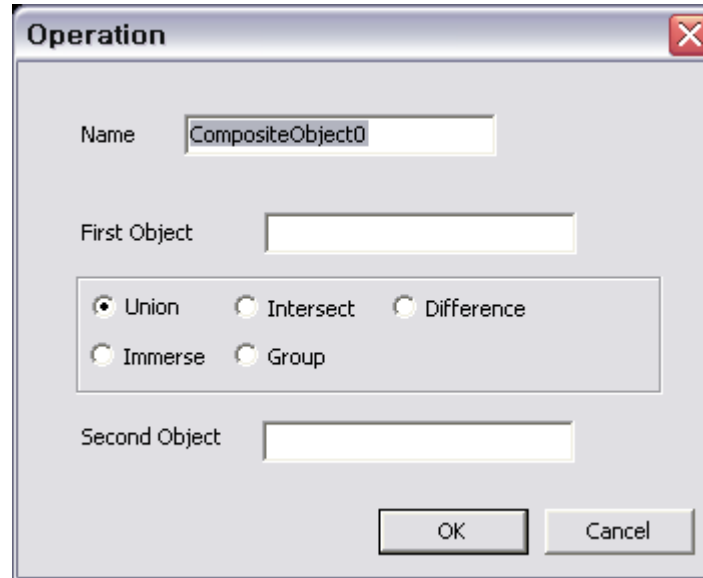
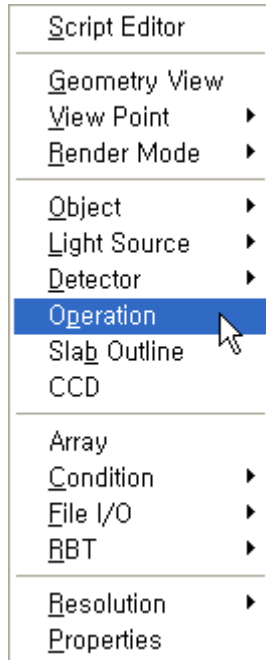
Workshop 3: Make System

1. RayWiz를 실행하고 새 파일을 만들어 작업 **Directory**에 “**Workshop3.rwz**”로 저장하시오.
2. 반경이 **2mm**인 **Sphere object**를 작성하고 그 중점의 위치를 **<0,0,6>** 으로 설정하시오.
3. 반경이 **2mm**이고 높이가 **0.1mm**인 **Surface Cylinder Light**를 작성하고 **Rear Surface**에서만 **Ray**가 직진하도록 하고 **Light**의 위치를 **<0,0,0>**으로 설정하시오.
4. **+Z**축 방향의 두께가 **0.01mm**이고 가로,세로 길이가 각각 **4mm** **Box Detector** 하나를 생성하고 **back_surface(Z-)**를 **detecting** 면으로 지정하고 그 위치를 **<0,0,10>**으로 설정하시오.
5. **Ray number**를 **100000**으로 설정하고 **simulation**을 수행하시오.



RAYWIZ BASIC Object Geometry II - [Operation] -

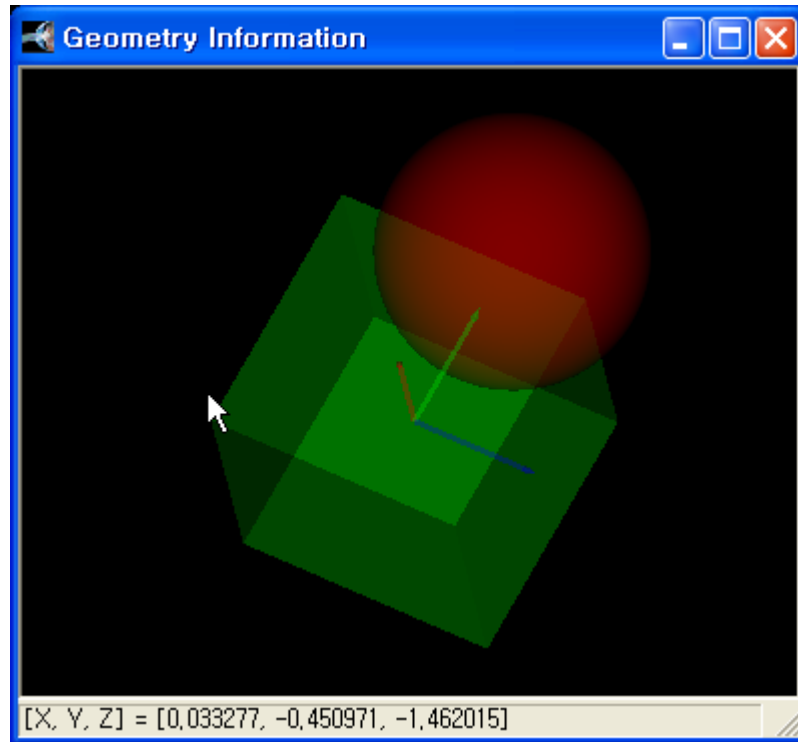
Geometry II: Operation



1. Union
2. Intersect
3. Subtract
4. Immerse
5. Group

물성이 다른 **Object**들의
묶음을 하나로 정의

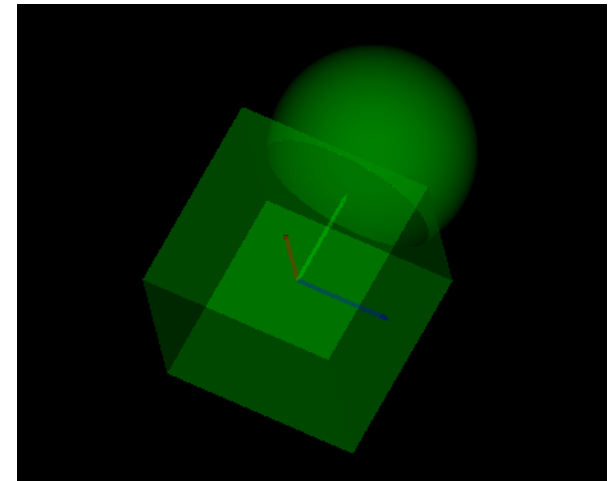
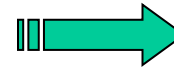
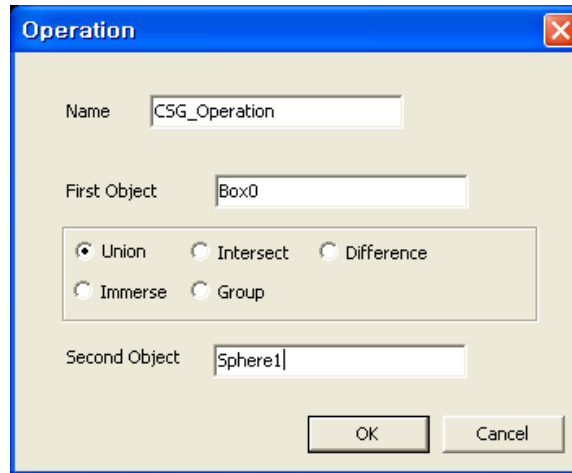
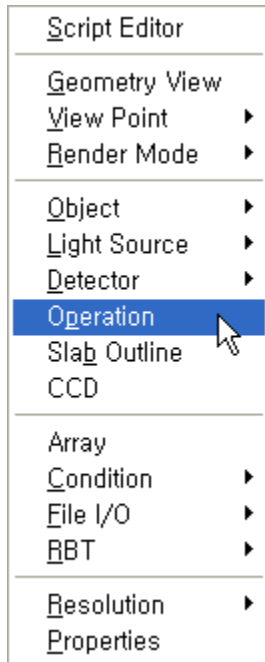
Geometry II: Declare



```
00020 #declare Box0 =
00021 box
00022 {
00023     <-1, -1, -1>, <1, 1, 1>
00024     color <0, 1, 0>
00025     ior 1.5
00026     surface {
00027         both {
00028             probabilistic_split on
00029         }
00030     }
00031 }
00032
00033 #declare Sphere1 =
00034 sphere
00035 {
00036     <0, 1.5, 0>, 1
00037     color <1, 0, 0>
00038     ior 1.5
00039     surface {
00040         both {
00041             probabilistic_split on
00042         }
00043     }
00044 }
```

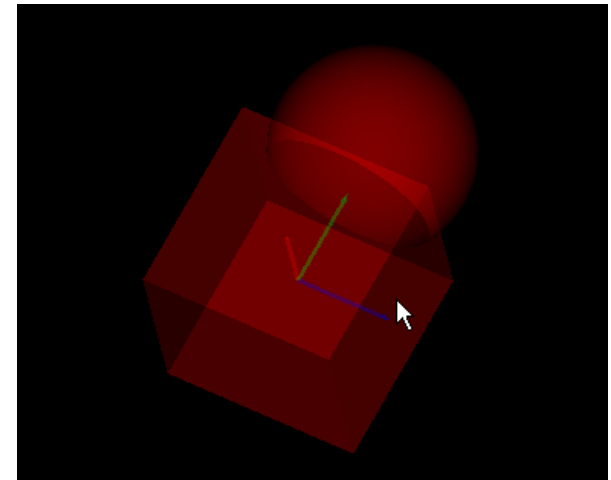
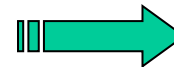
Operation에 사용될 **Object**들을 정의하고 부르는
않는다.
초록색의 **Box**와 빨간색의 **Sphere** !

Geometry II: Union

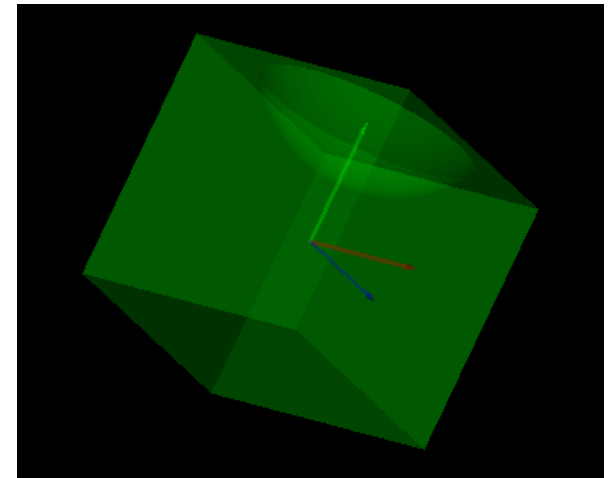
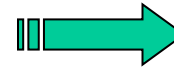
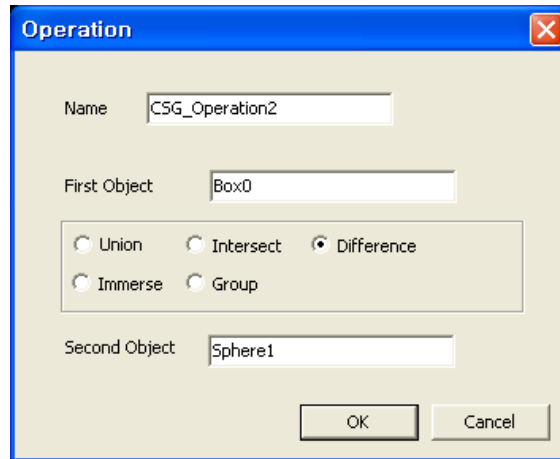
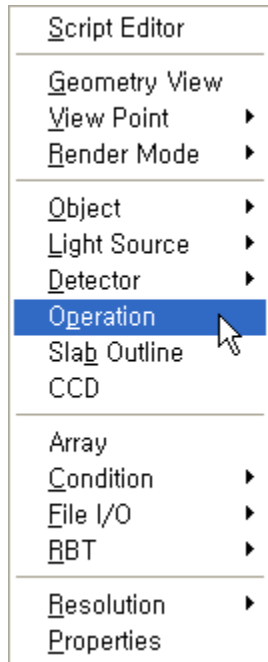


Union 된 Object는 First Object의 물성을 따른다.

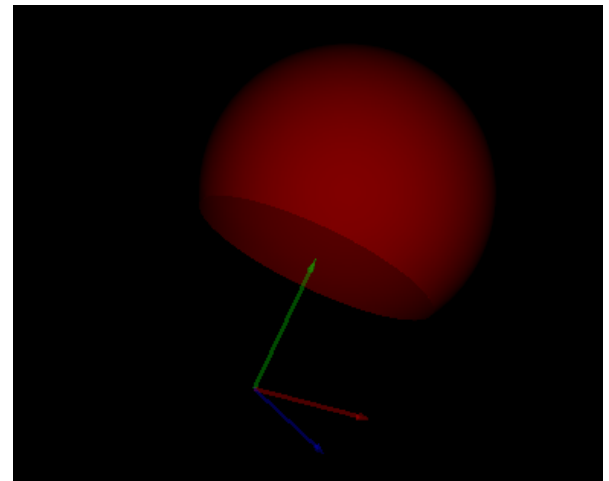
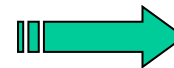
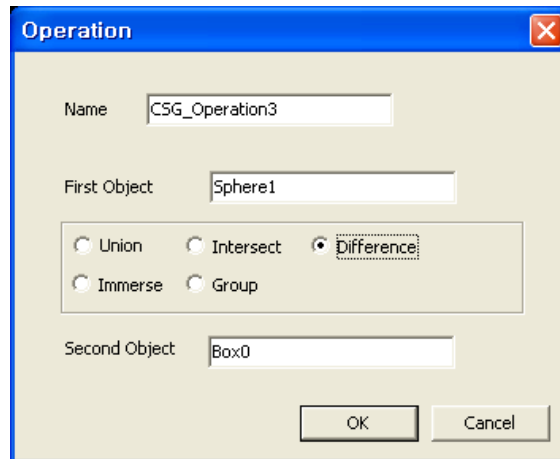
```
00046 #declare CSG_Operation =  
00047 union  
00048 {  
00049     object { Sphere1 }  
00050     object { Box0 }  
00051 }  
00052  
00053 CSG_Operation
```



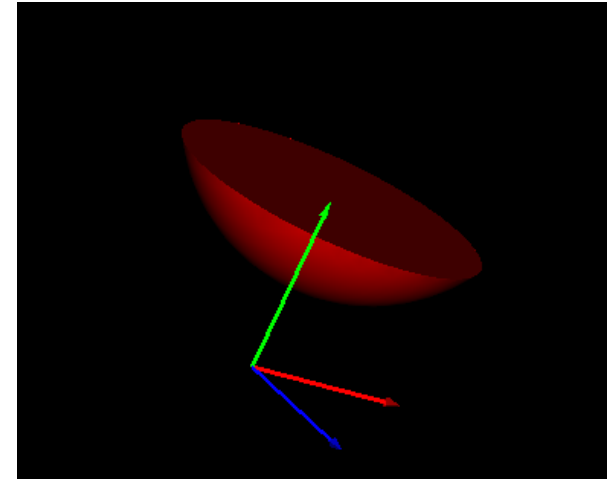
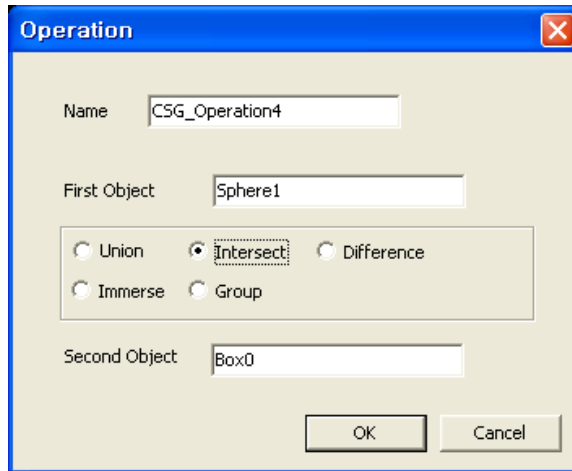
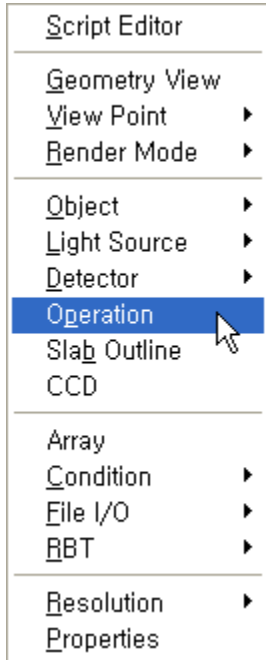
Geometry II: Difference



Difference 된 Object는 First Object의 물성을 따른다.

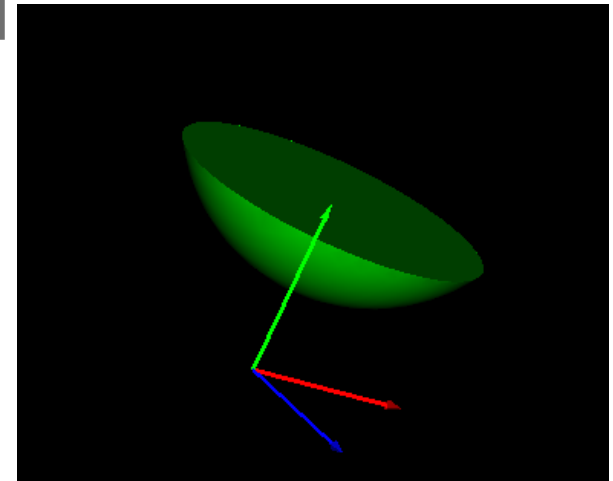
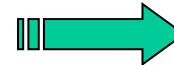


Geometry II: Intersection

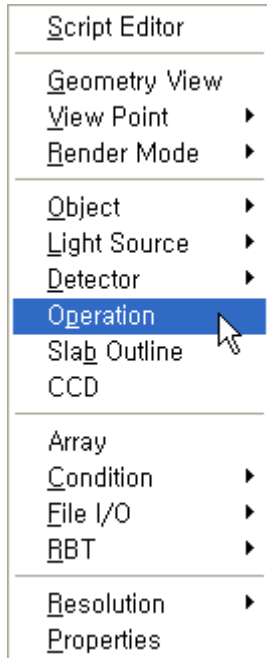


Intersection 된 Object는 First Object의 물성을 따른다.

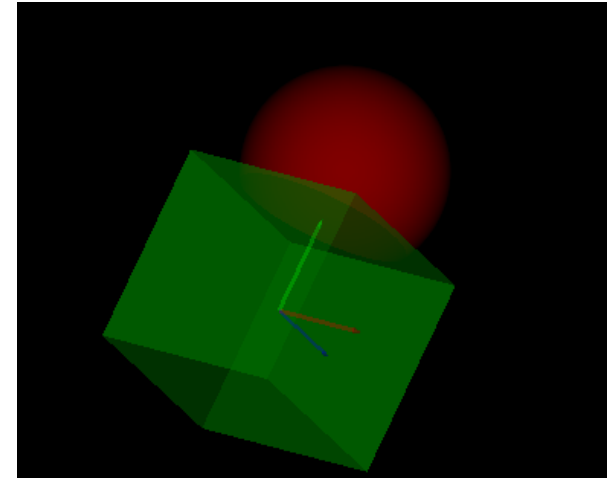
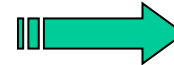
```
00085 #declare CSG_Operation5 =
00086 intersection
00087 {
00088     object { Box0 }
00089     object { Sphere1 }
00090 }
00091
00092 CSG_Operation5
```



Geometry II: Immerse

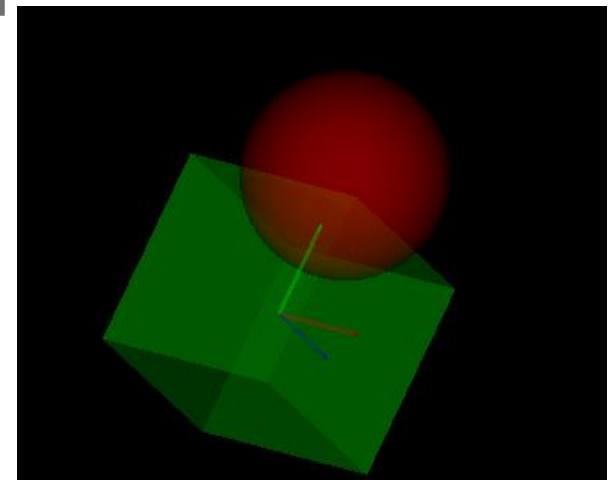


```
00094 #declare CSG_Operation6 =  
00095 immerse  
00096 {  
00097     object { Box0 }  
00098     object { Sphere1 }  
00099 }  
00100  
00101 CSG_Operation6
```



First Object는 물성을 유지하며 **Second Object**에 공유 영역 만큼 들어가게 된다.

```
00103 #declare CSG_Operation7 =  
00104 immerse  
00105 {  
00106     object { Sphere1 }  
00107     object { Box0 }  
00108 }  
00109  
00110 CSG_Operation7
```

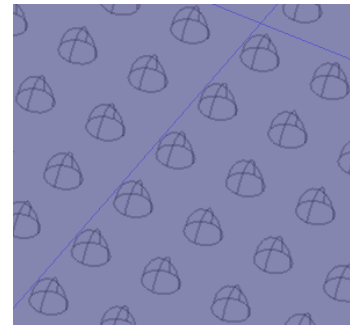
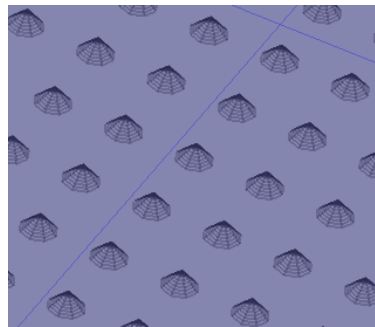


RAYWIZ BASIC Object Geometry II - [Slab Outline] -

Geometry II: What is Slab ?

BLU 의 **LGP**와 **BEF**와 같이 동일한 종류의 **Object** 가 반복적으로 그룹을 지어 단일 **Object** 표면에 돌출되어 있는 경우(**Bump**)나 **Object** 표면이 함몰되어있는 경우(**Hole**), 또는 **LCD Color Filter**나 **Panel**의 **Pixel** 와 같이 반복적인 형상을 가지며 그 물성이 다른 경우(**Immerse**) **Slab_Outline** 명령어를 사용합니다.

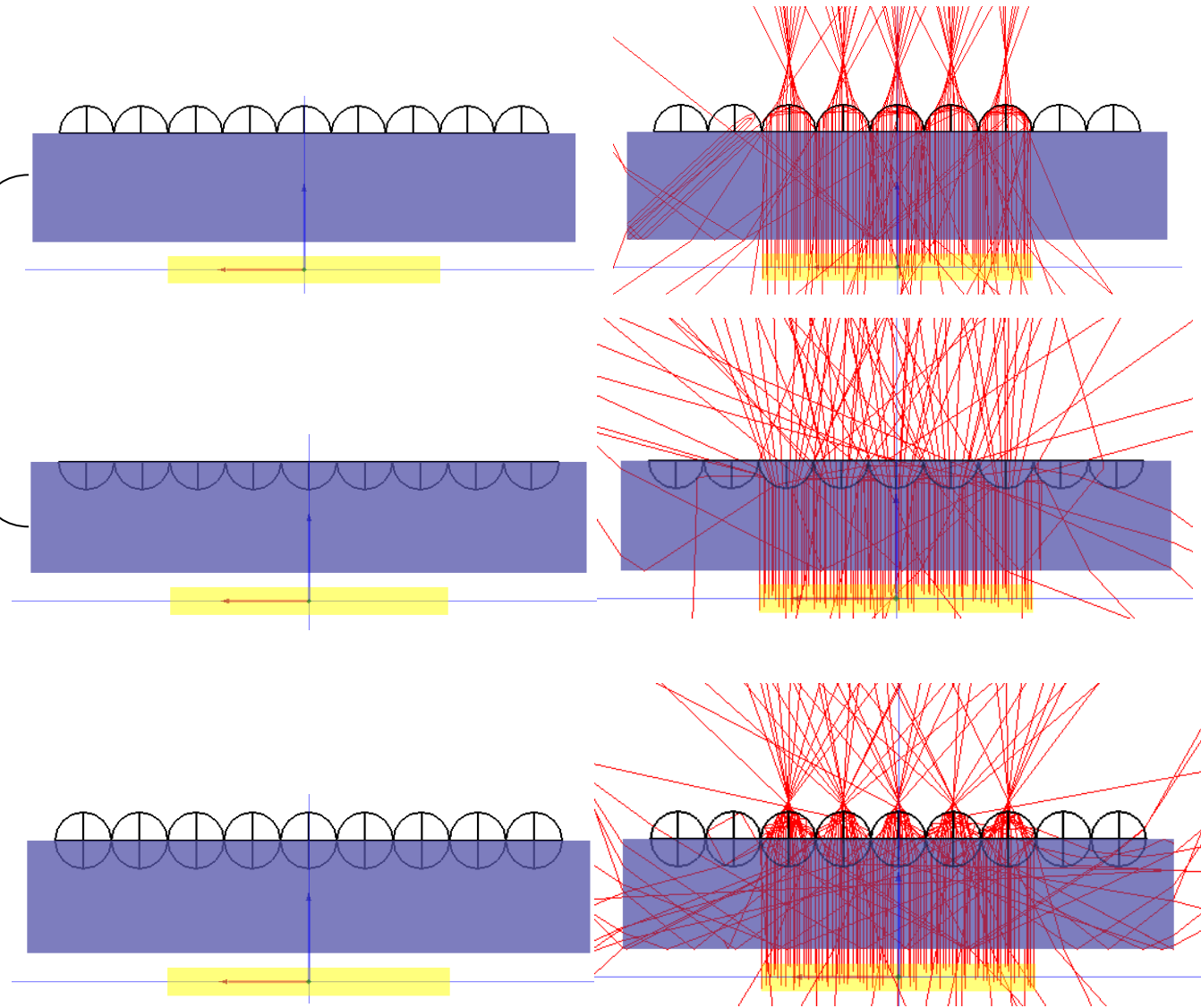
Geometry View 상에 **Slab Object**의 아웃라인만을 그리기 때문에 **Geometry** 표현시간을 줄일 수 있으며, 특수한 **Algorithm**이 적용되어 빠른 **Simulation** 이 가능하게 합니다.



Geometry II: Smart Slab

3D Texture

Slab



Geometry II: Slab_Outline Grammar (1)

모든 **Object**는 **Slab**으로 사용되어 질 수 있으며 모든 **Object Surface**에 적용 가능하다.
또한 간단한 **macro** 작업에 의해서 어떠한 형태의 분포라도 형성이 가능하다.
자주 사용되어지는 **Cube Surface**에 대해서는 자동으로 몇 가지 미리 정해진 규칙에 의한 배열을 형성시켜준다.

SLAB_OUTLINE:

slab_outline

{

SLAB_TYPE CUBE_SURFACE_TYPE

[normal]

[SLAB_DETAILS...]

base { BASE_OBJECT }

slab { SLAB_OBJECT }

}

SLAB_TYPE:

bump | hole | immerse

CUBE_SURFACE_TYPE:

left_surface | right_surface | front_surface | back_surface |

top_surface | bottom_surface

Geometry II: Slab_Outline Grammar (2)

SLAB_DETAILS:

SLAB_POSITION | SLAB_SIZE | SLAB_DEPTH | SLAB_SHIFT

SLAB_POSITION:

```
position_x|position_y {  
    Coefficient_N0(상수부), Coefficient_N1(1차),  
    Coefficient_N2(2차), Coefficient_N3(3차),  
    Coefficient_N4(4차), Coefficient_N5(5차)  
}  
|  
position { SLAB_POSITION_FILE_LOCATION }
```

Polynomial 5th 계수 입력

위치 값이 있는 파일지정

SLAB_SIZE:

```
size_x|size_y {  
    Coefficient_N0(상수부), Coefficient_N1(1차),  
    Coefficient_N2(2차), Coefficient_N3(3차)  
}  
|  
size { SLAB_SIZE_FILE_LOCATION }
```

Polynomial 3th 계수 입력

크기 값이 있는 파일지정

Geometry II: Slab_Outline Grammar (3)

SLAB_DEPTH:

depth {

Coefficient_N0(상수부), Coefficient_N1(1차),
Coefficient_N2(2차), Coefficient_N3(3차)

Polynomial 3th 계수 입력

}

|

depth { SLAB_DEPTH_FILE_LOCATION }

깊이 값이 있는 파일지정

SLAB_SHIFT:

shift <X_Shift, Y_Shift>

지정된 면의 시작점을 변경

Geometry II: FirstSlab - Base Object & Slab Object

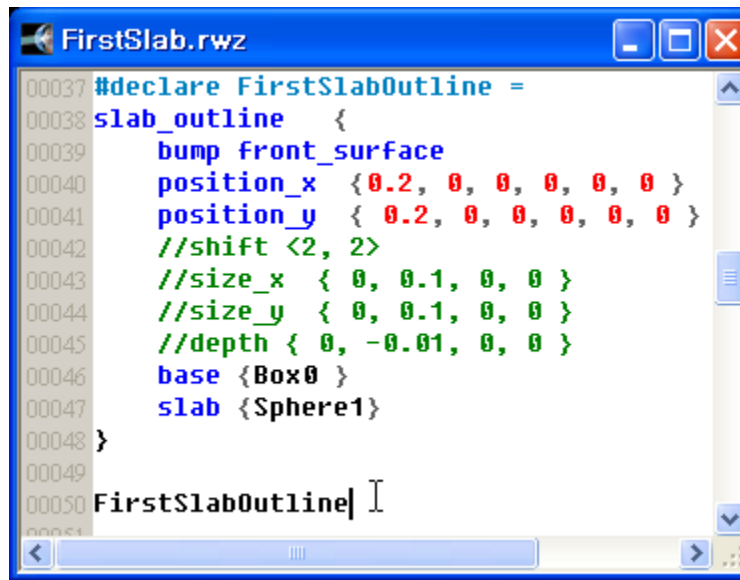
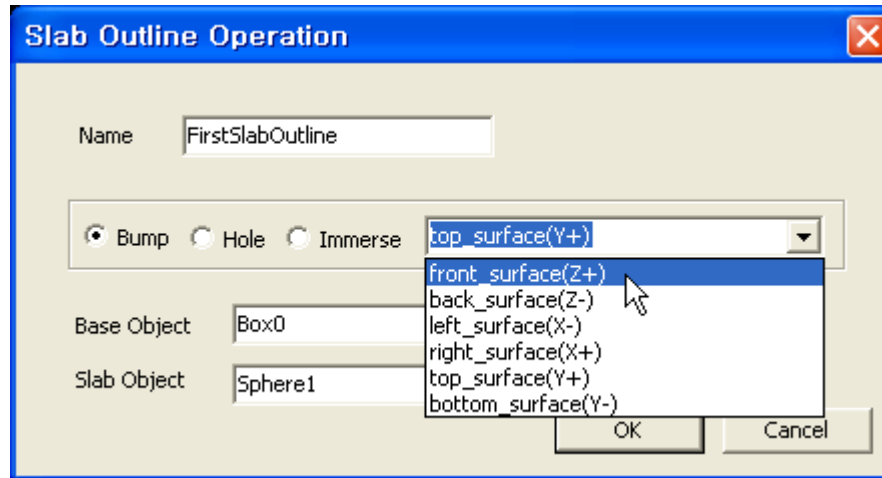
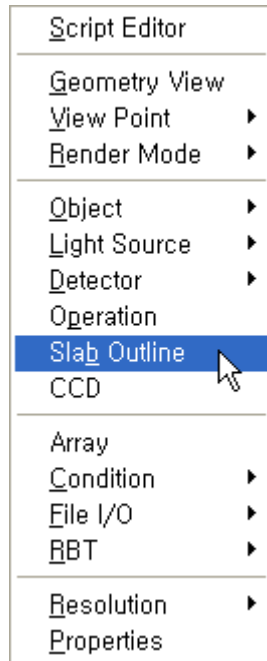
```
00011 #declare Box0 =
00012 box
00013 {
00014     <-1, -1, 0.1>, <1, 1, 0.5>
00015     color <1,1,1>
00016     ior 1.5
00017     surface {
00018         both {
00019             probabilistic_split on
00020         }
00021     }
00022 }
```

Base로 사용될 Box 선언

```
00024 #declare Sphere1 =
00025 sphere
00026 {
00027     <0, 0, 0>, 0.1
00028     color <1,1,1>
00029     ior 2.0
00030     surface {
00031         both {
00032             probabilistic_split on
00033         }
00034     }
00035 }
```

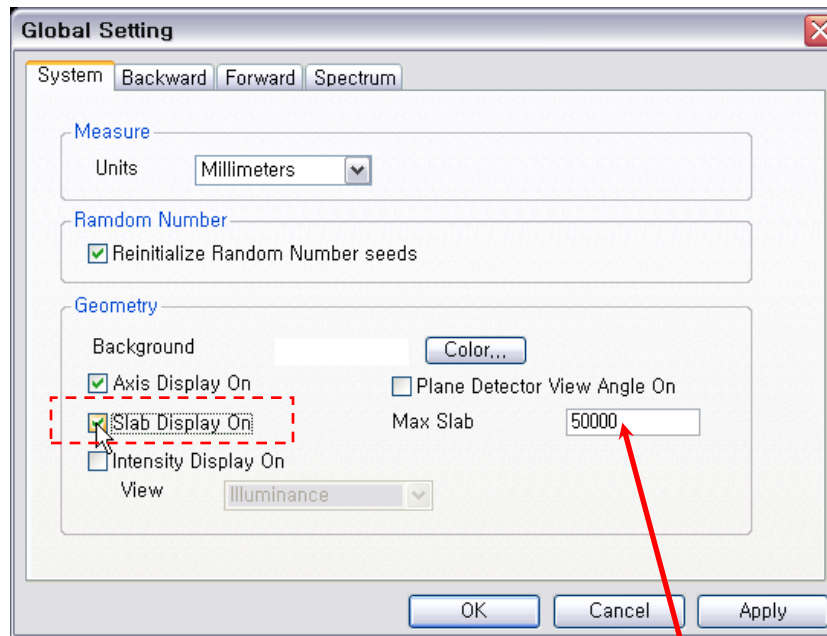
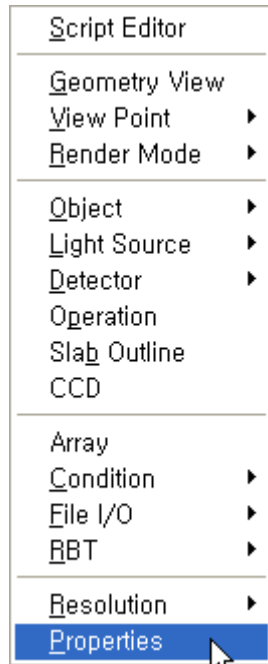
Slab으로 사용될 Sphere 선언

Geometry II: FirstSlab - Slab_Outline Operation

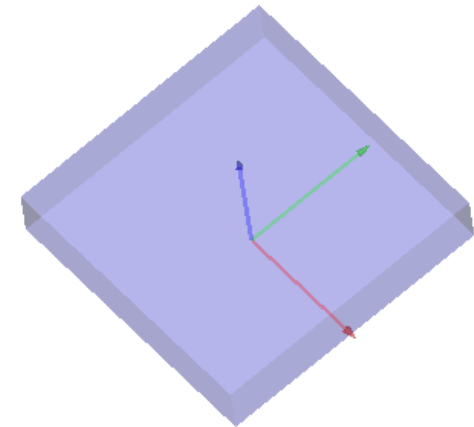
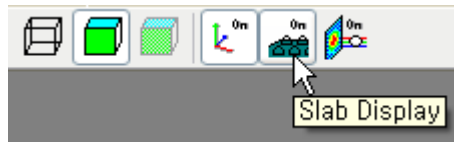


X-Y Pitch를 **Slab**으로 사용된
Sphere의 지름으로 설정하여
정방 배열로 만든다.

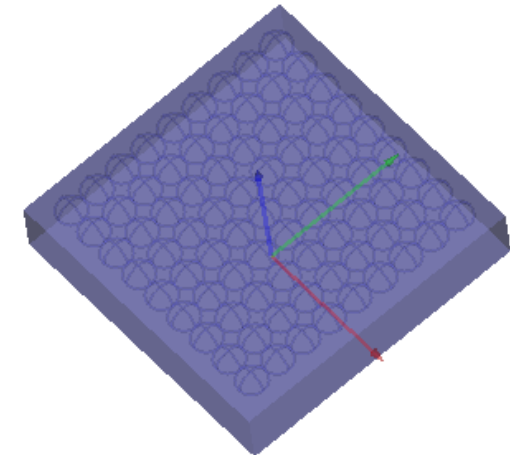
Geometry II: FirstSlab - Geometry View



Slab이 보여지도록 설정되어 있을 경우 최대 몇 개 까지를 그릴 것인지에 대한 제한
→ 그래픽카드나 메모리의 양에 따라 적절히 조절한다.

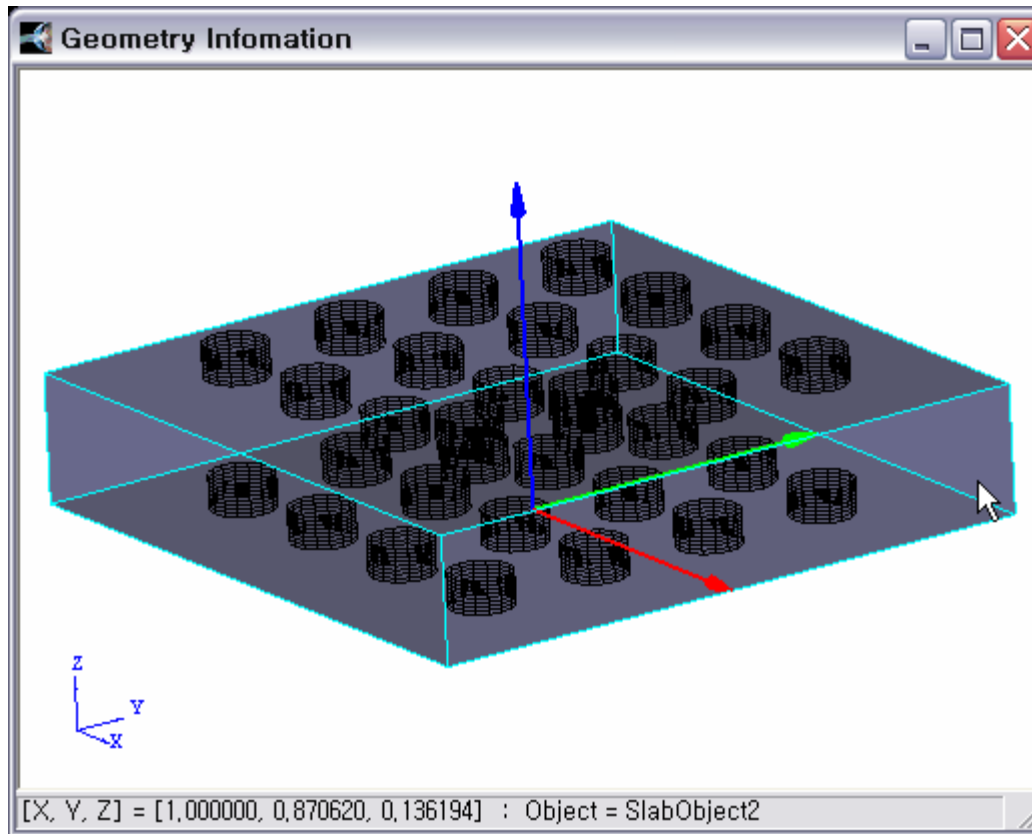


Global Option의 기본값은 **Slab**이 나타나지 표현되지 않도록 되어있다.



Workshop 4: Make Slab Object

1. RayWiz를 실행하고 새 파일을 만들어 작업 **Directory**에 “**Workshop4.rwz**”로 저장하시오.
2. **Menu**나 **Toolbar**를 이용하여 **Base**로 사용될 **2mm x 2mm x 0.4mm** 인 **Box Object**를 선언하고 **Slab**으로 사용될 반지름이 **0.1mm** 이고 높이가 **0.1mm**인 **Cylinder** 선언하시오.
3. **Slab Operation** 메뉴를 2번 사용하여 피치가 **0.4mm**가 되도록 **Base Box**의 한쪽 면에는 정방 배열의 **Bump**를 반대쪽 면에는 정방배열의 **Hole**을 작성하시오.

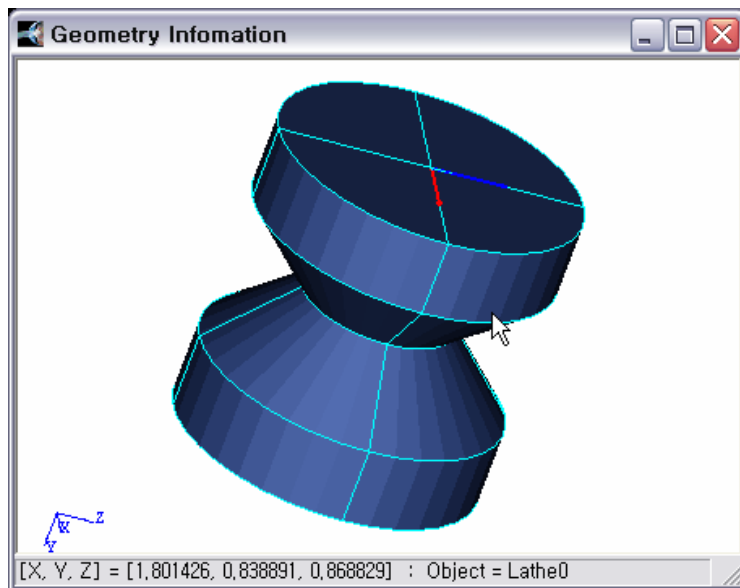
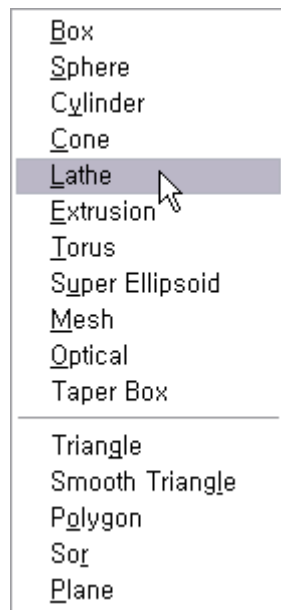


RAYWIZ BASIC

Object Geometry II

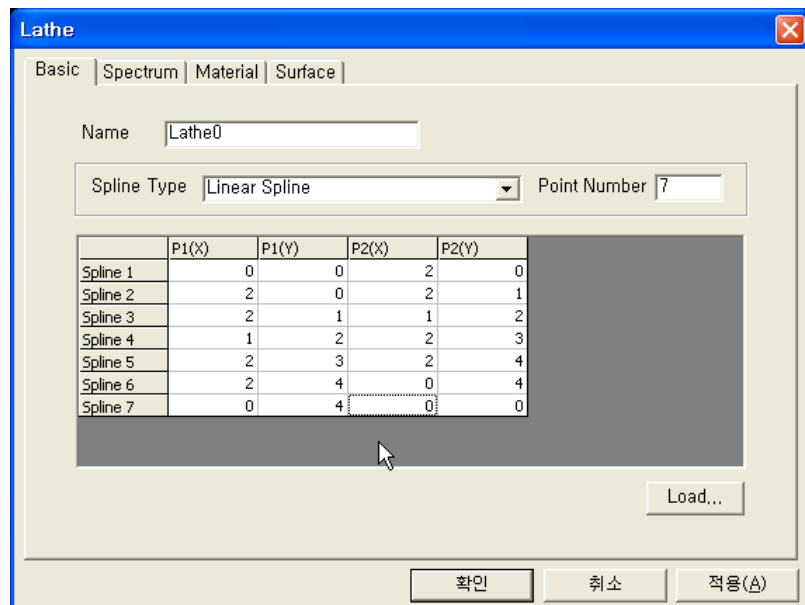
- [Complex Geometry] -

Geometry II: Lathe



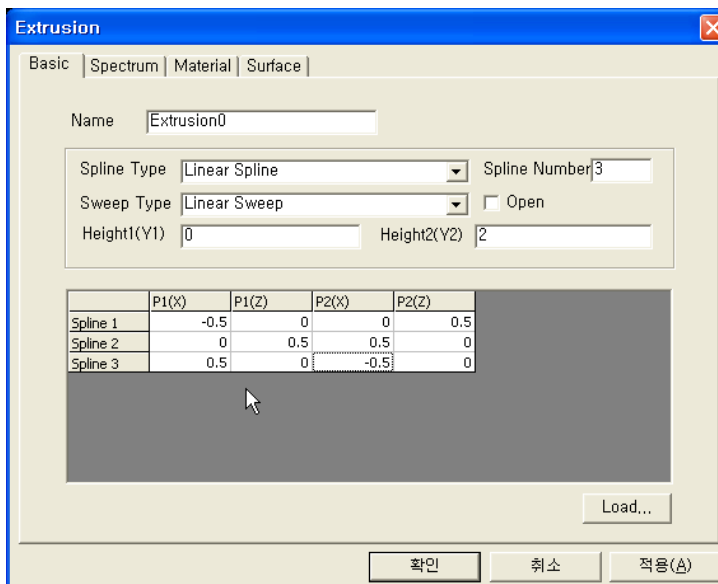
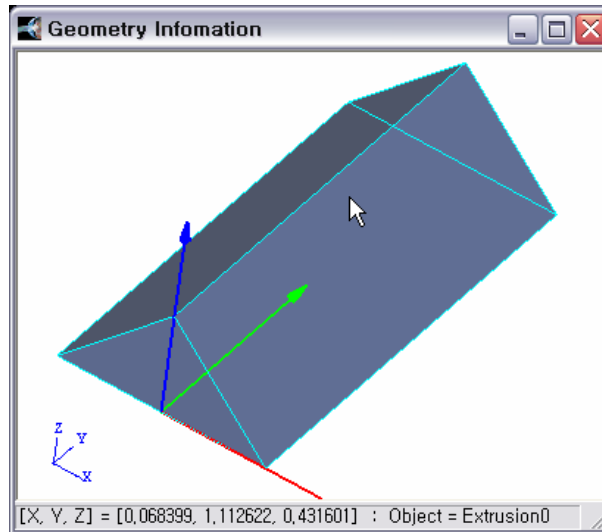
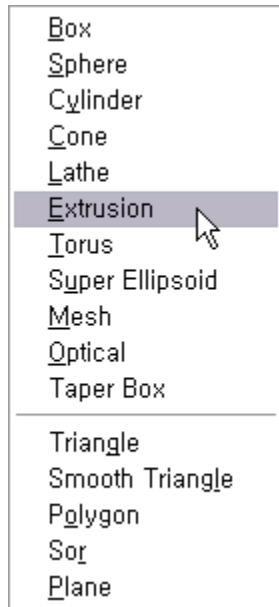
```

00020 #declare Lathe0 =
00021 lathe
00022 {
00023     linear_spline 7,
00024     <0, 0>,
00025     <2, 0>,
00026     <2, 1>,
00027     <1, 2>,
00028     <2, 3>,
00029     <2, 4>,
00030     <0, 4>
00031     color <1, 1, 1>
00032     ior 1.5
00033     surface {
00034         both {
00035             probabilistic_split on
00036         }
00037     }
00038 }
00039
00040 Lathe0
    
```



- 회전체
- Y축으로 회전시킬 면을 이루는 꼭지점의 좌표를 입력한다.
- 회전체를 생성하는 경우는 첫 번째 점과 마지막 점의 좌표를 동일하게 입력해준다.

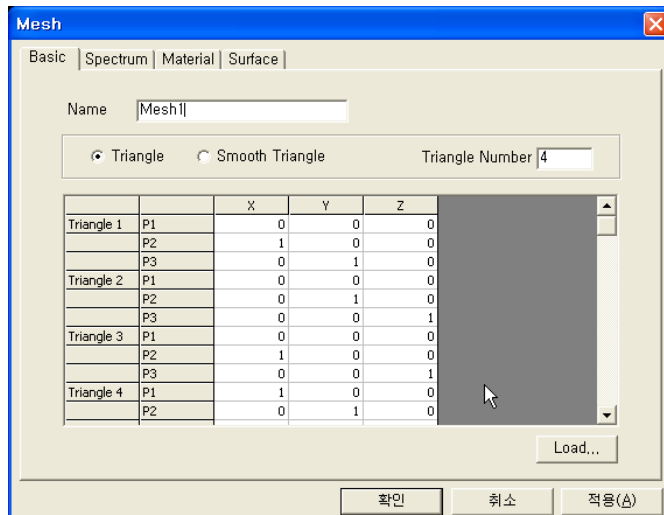
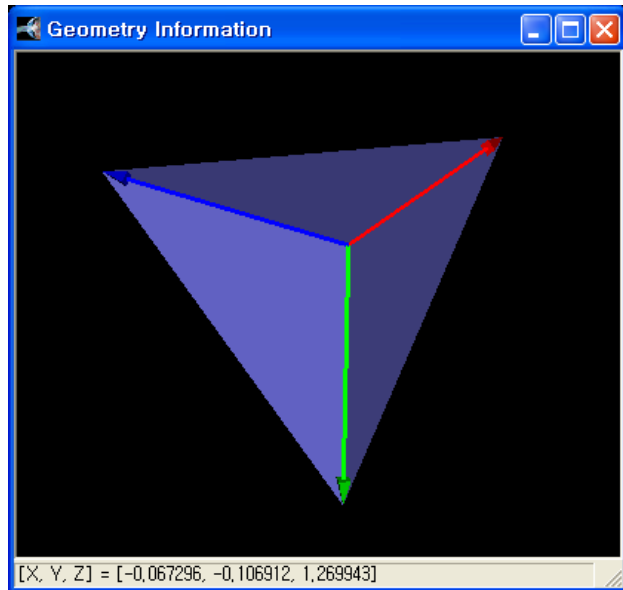
Geometry II: Extrusion



```
00020 #declare Extrusion0 =
00021 extrusion
00022 {
00023     linear_spline linear_sweep
00024     0, 2,
00025     4,
00026     <-0.5, 0>,
00027     <0, 0.5>,
00028     <0.5, 0>,
00029     <-0.5, 0>
00030     color <1,1,1>
00031     ior 1.5
00032     surface {
00033         both {
00034             probabilistic_split on
00035         }
00036     }
00037 }
00038
00039 Extrusion0
```

- XZ평면도형을 Y축으로 돌출시킨 입체
- 선의 종류와 높이, XZ 평면 도형의 꼭지점의 좌표를 입력한다.

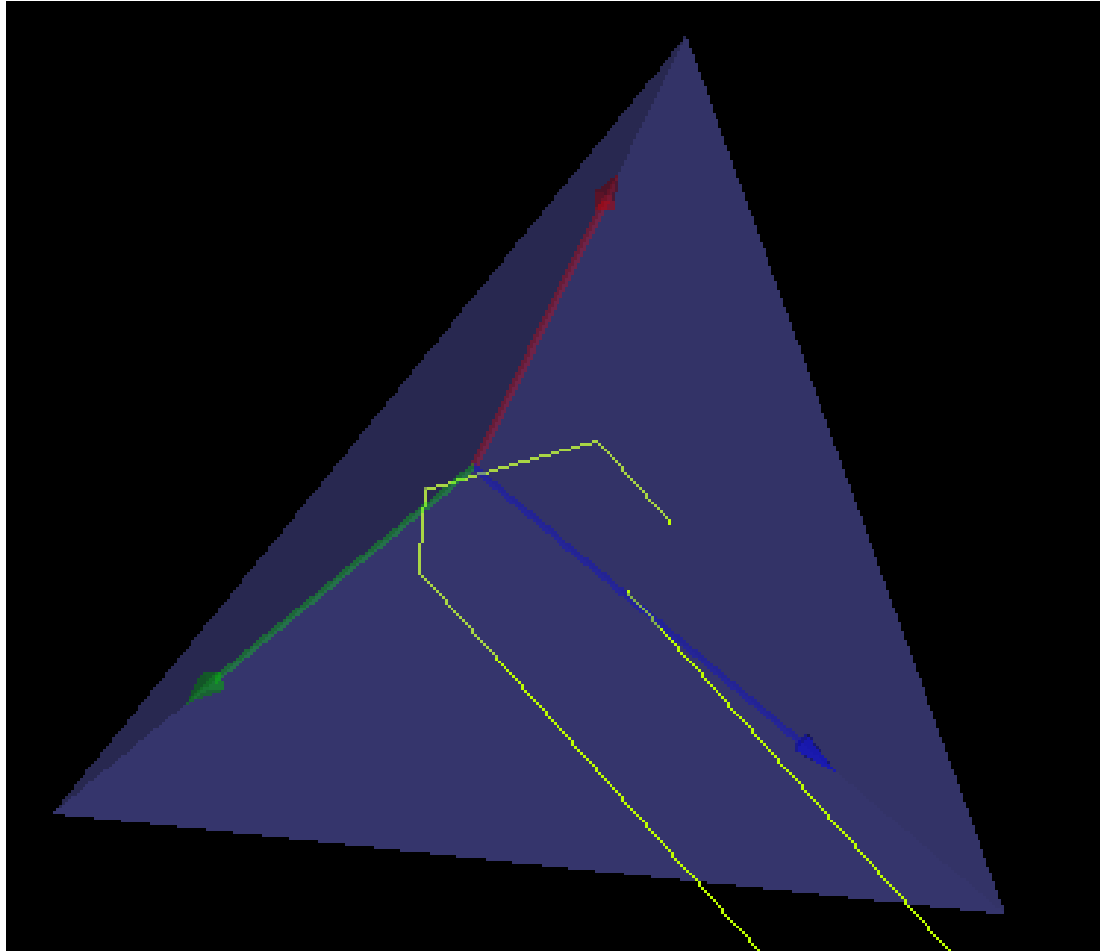
Geometry II: Mesh Object – Corner Cube (1)



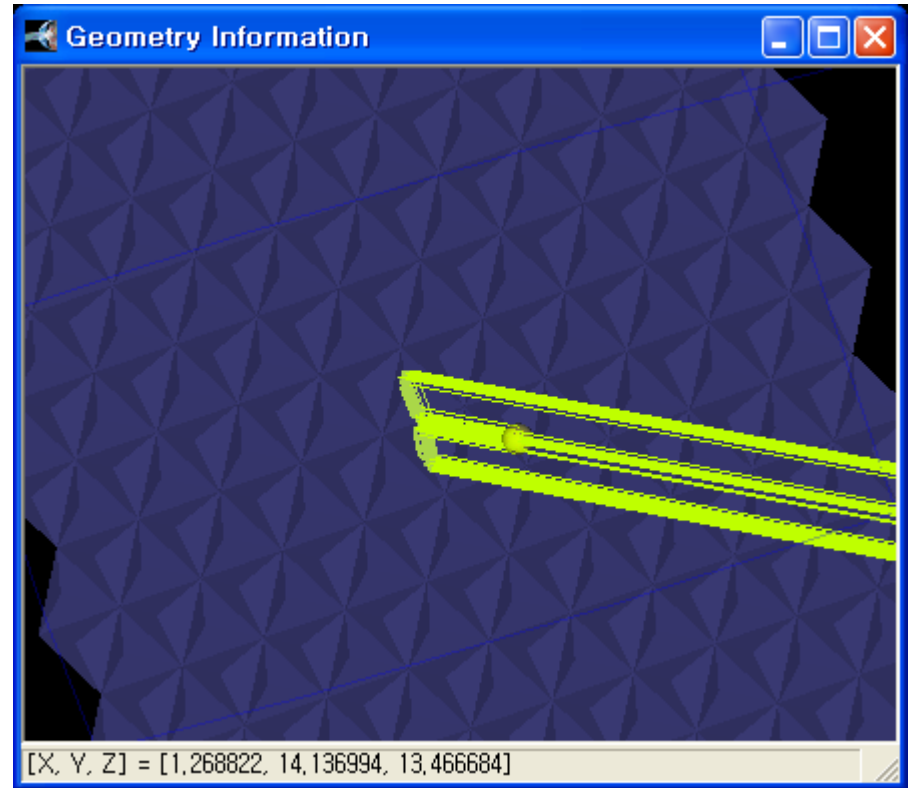
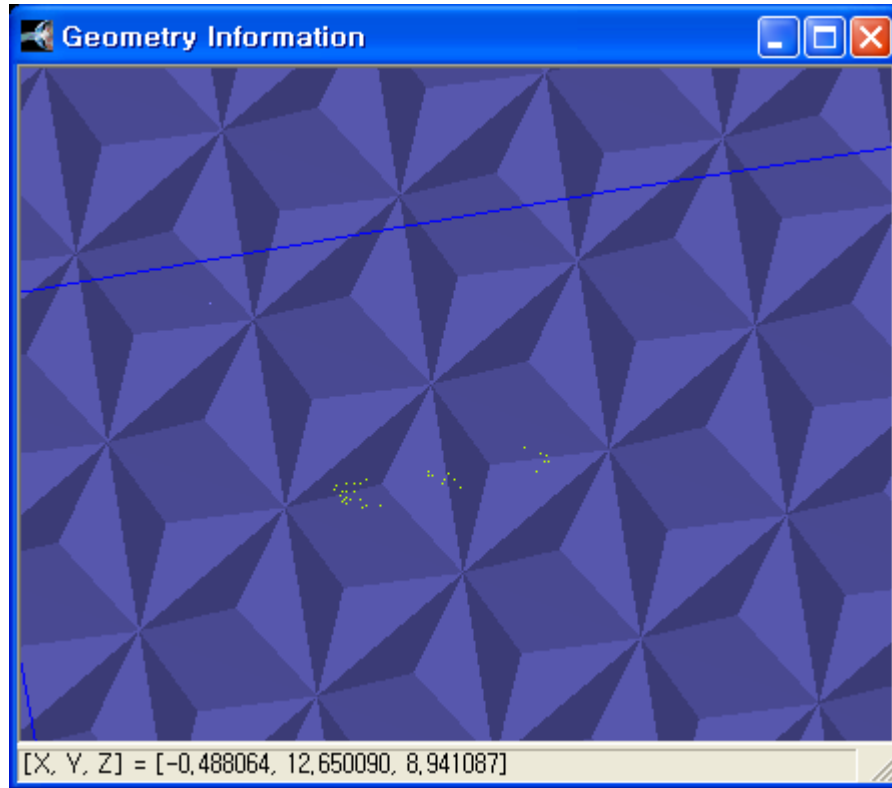
```
00020 #declare Mesh1 =
00021 mesh
00022 {
00023   triangle
00024   {
00025     <0, 0, 0>, <1, 0, 0>, <0, 1, 0>
00026   }
00027   triangle
00028   {
00029     <0, 0, 0>, <1, 0, 0>, <0, 0, 1>
00030   }
00031   triangle
00032   {
00033     <0, 0, 0>, <0, 1, 0>, <0, 0, 1>
00034   }
00035   triangle
00036   {
00037     <1, 0, 0>, <0, 1, 0>, <0, 0, 1>
00038   }
00039   color <1, 1, 1>
00040   ior 1.5
00041   surface {
00042     both {
00043       probabilistic_split on
00044     }
00045   }
00046 }
00047 Mesh1
00048
```

- 삼각형으로 이루어진 그물 모양의 면
- 다수의 삼각형의 좌표를 입력한다.
- 모서리를 부드럽게 표현하기 위해서는 **Smooth Triangle**을 선택하여 법선 벡터를 지정한다.

Geometry II: Mesh Object – Corner Cube (2)



Geometry II: Mesh Object – Corner Cube (3)

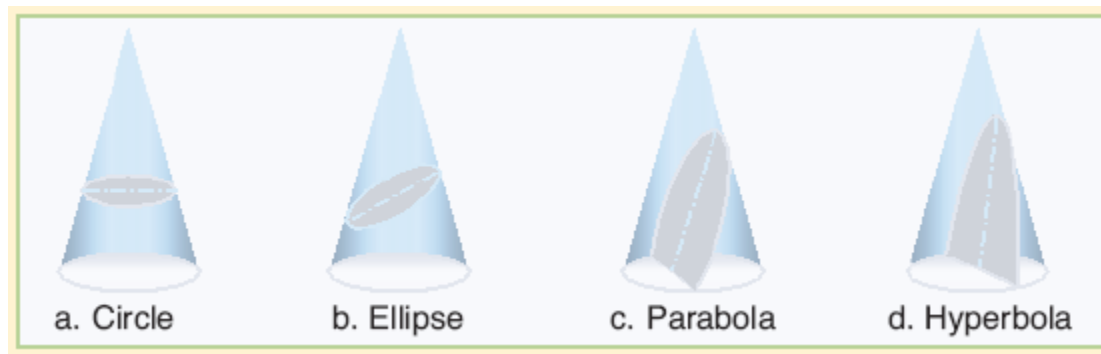


Geometry II: Lens Surface Type

Conic

$$z = \frac{cr^2}{1 + \sqrt{1 - (1+k)c^2r^2}} \quad \text{where} \quad r^2 = x^2 + y^2$$

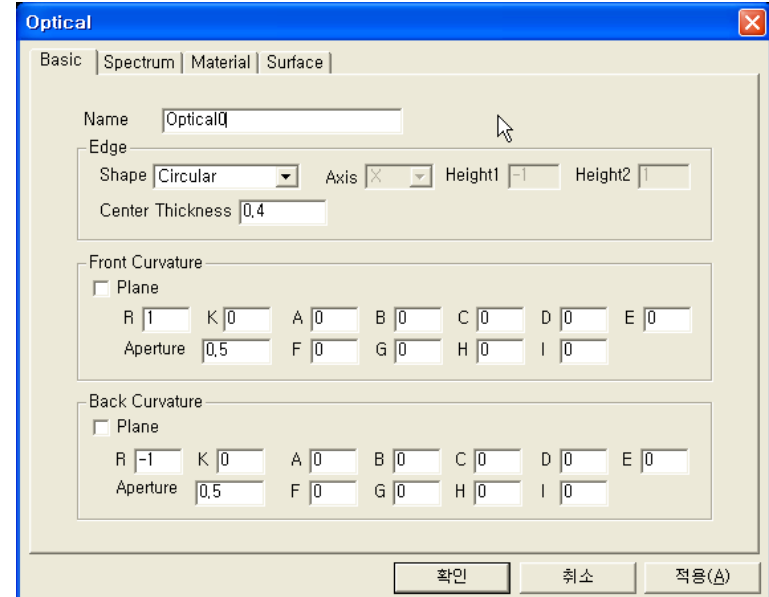
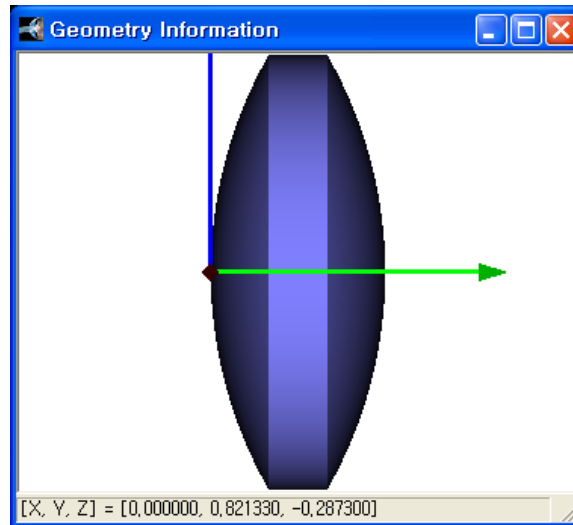
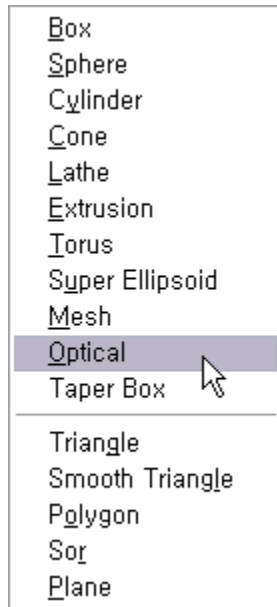
$k = 0$	sphere
$-1 < k < 0$	ellipse with major axis on the z axis
$k = -1$	parabola
$k < -1$	hyperbola
$k > 0$	oblate sphere (not a true conic section)



Polynomial Aspheric

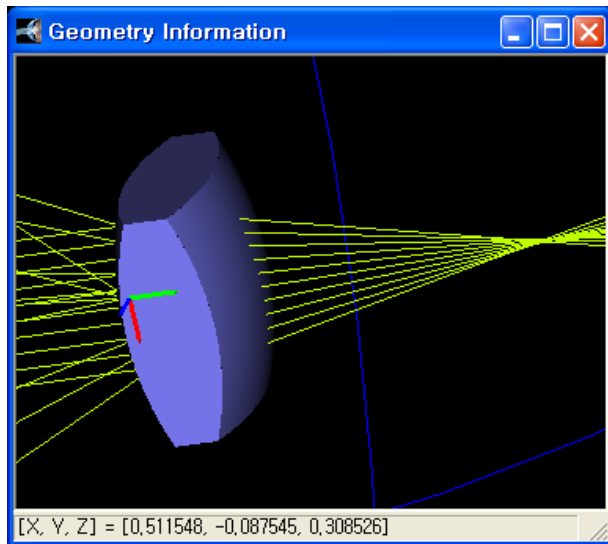
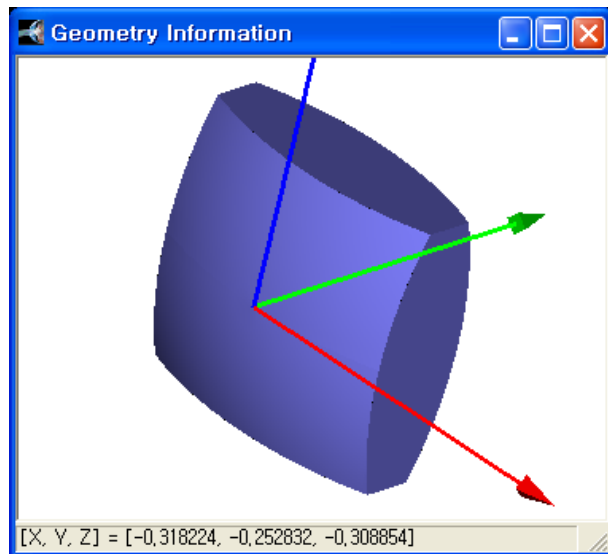
$$z = \frac{cr^2}{1 + \sqrt{1 - (1+k)c^2r^2}} + \sum_{n=2}^{10} C_{2n} r^{2n} \quad \text{where} \quad r^2 = x^2 + y^2$$

Geometry II: Lens & Reflector (1)



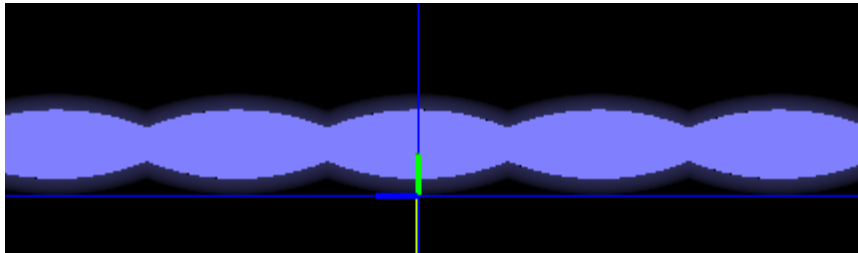
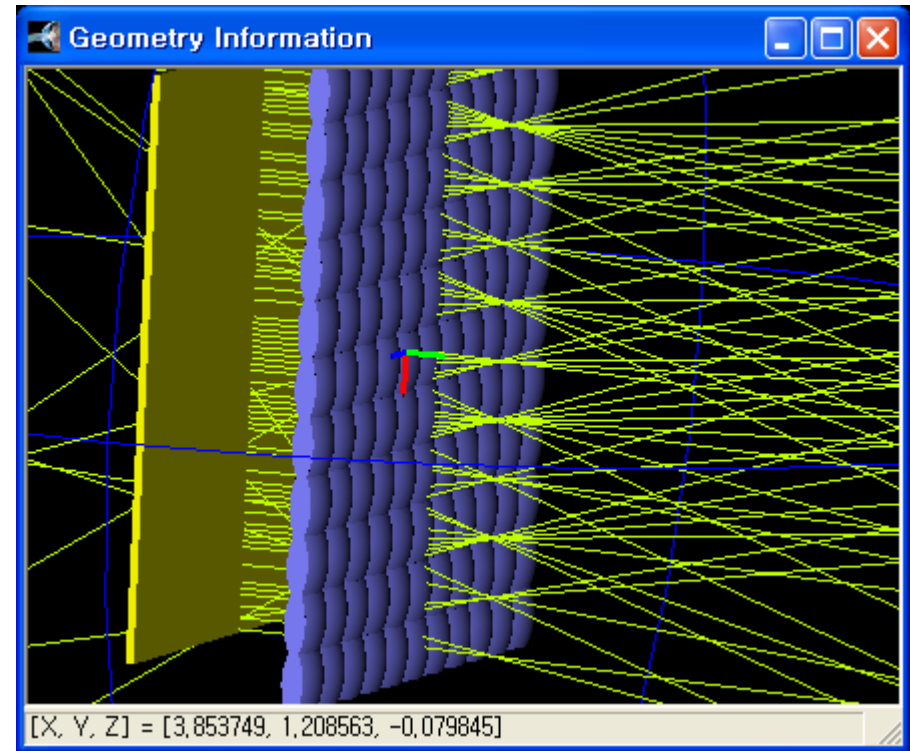
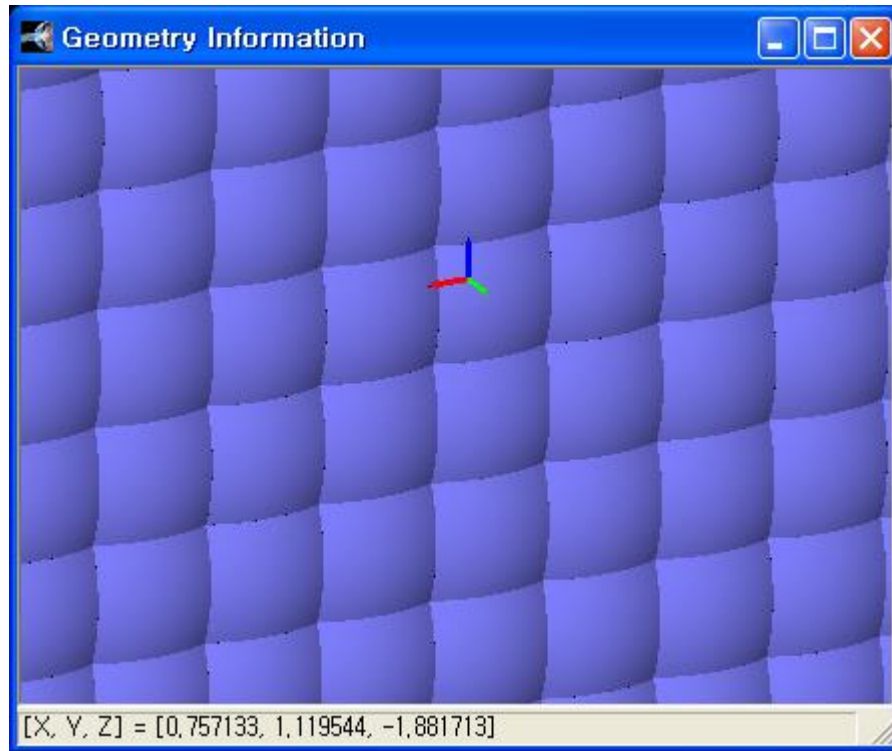
```
00020 #declare Optical0 =
00021 optical
00022 {
00023     circular center_thickness 0.4
00024     { 1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00025     { -1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00026     color <1, 1, 1>
00027     ior 1.5
00028     surface {
00029         both {
00030             probabilistic_split on
00031         }
00032     }
00033 }
00034
00035
00036 Optical0
```

Geometry II: Lens & Reflector (2-1)



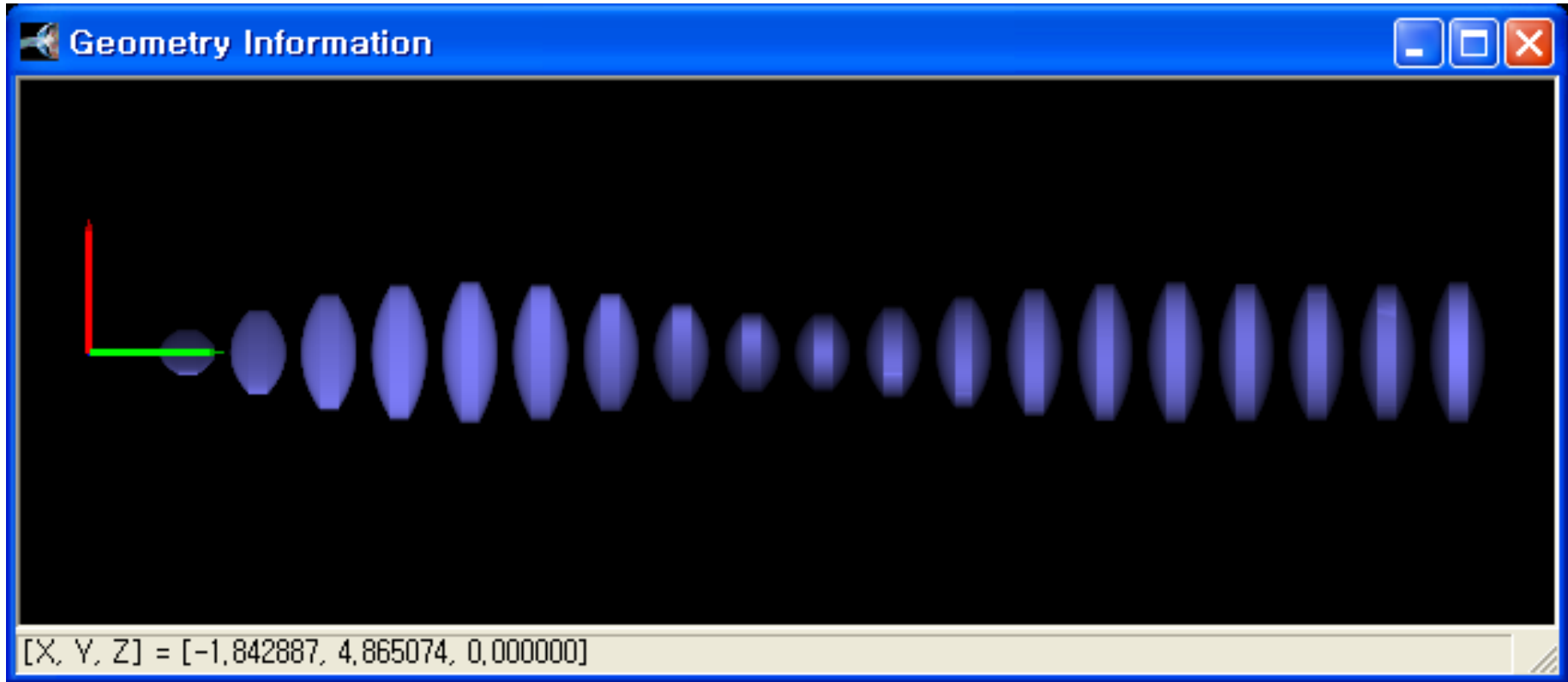
```
00037 #declare Optical1 =
00038 optical
00039 {
00040     rectangular center_thickness 0.4
00041     { 1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00042     { -1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00043     color <1, 1, 1>
00044     ior 1.5
00045     surface {
00046         both {
00047             probabilistic_split on
00048         }
00049     }
00050 }
00051
00052 Optical1
```

Geometry II: Lens & Reflector (2-2)



```
#macro FlyEyeLens()
#declare ii=0;
#while(ii<11)
#declare jj=0;
#while(jj<11)
object{
    Optical1
    translate<((ii-5)*sqrt(2)/2,0,(jj-5)*sqrt(2)/2>
}
#declare jj=jj+1;
#end
#declare ii=ii+1;
#end
#end
```

Workshop 5: #declare, #macro, #while (1)



그림과 같이 **20**개의 렌즈가 점진적으로 회전하고 크기가 바뀌는 배열을
#macro와 **#while**문을 사용하여 작성해 보시오.
[곡률반경: **1, -1, Aperture Size : 0.5**]

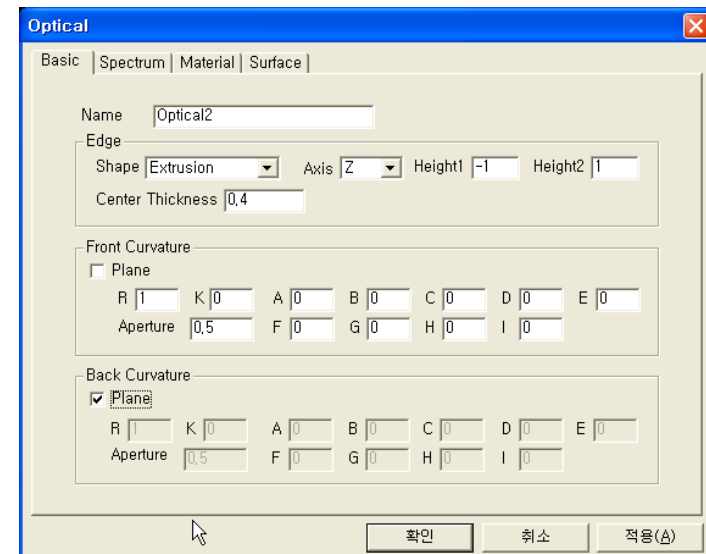
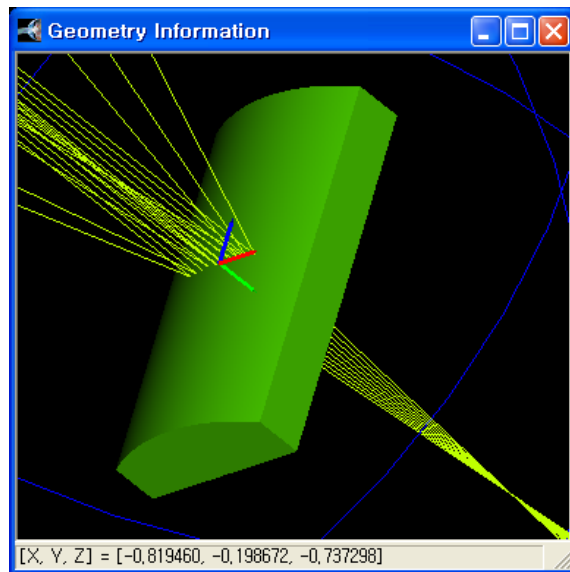
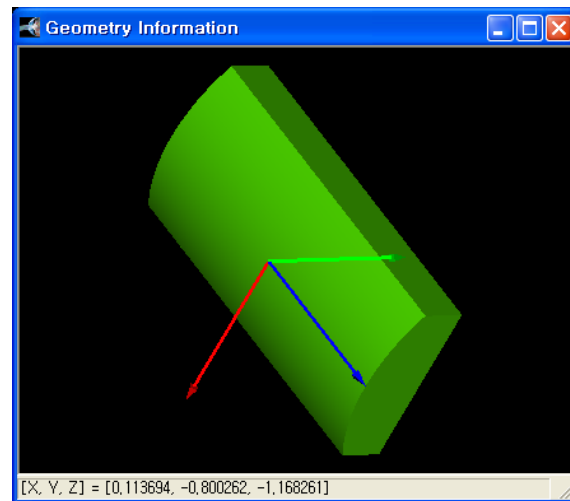
Workshop 5: #declare, #macro, #while (2)

```
00019 #declare NumUnit=20;  
00020 #declare NumScaleStep=NumUnit;  
00021 #declare Lens2Lens=0.5;
```

```
00023 #declare LensUnit =  
00024 optical  
00025 {  
00026     circular center_thickness 0.4  
00027     { 1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }  
00028     { -1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }  
00029     color<1,1,1>  
00030     ior 1.5  
00031     surface {  
00032         both {  
00033             probabilistic_split on  
00034         }  
00035     }  
00036 }
```

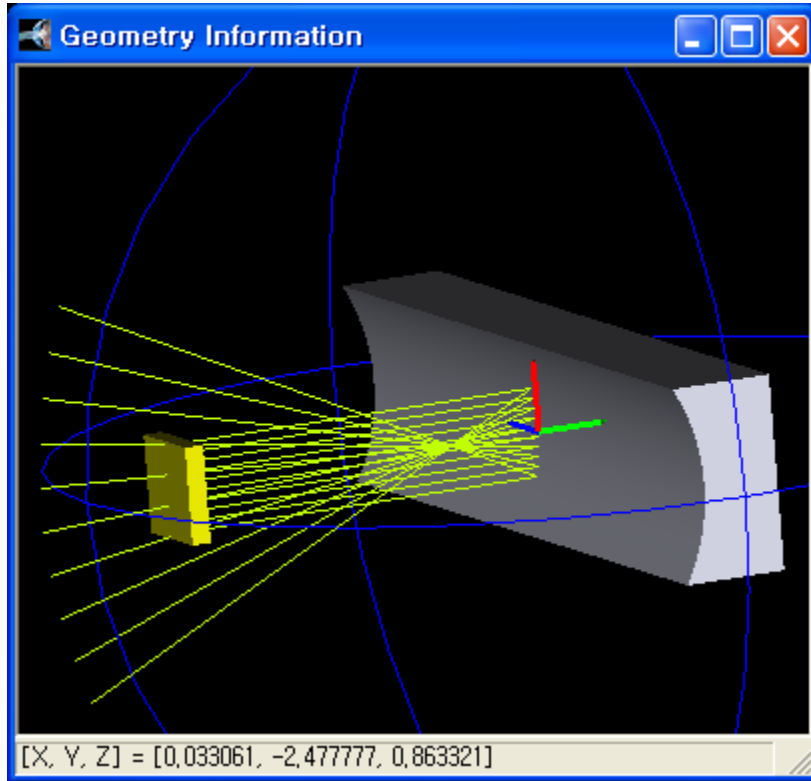
```
00038 #macro LensArray()  
00039 #declare ii=0;  
00040     #while(ii < NumUnit)  
00041     object{  
00042         LensUnit  
00043         translate<0,Lens2Lens*ii,0>  
00044         scale<1/NumUnit*(ii+1),1,1>  
00045         rotate<0,360/NumUnit*ii,0>  
00046     }  
00047     #declare ii=ii+1;  
00048 #end  
00049 #end  
00050  
00051 LensArray()
```


Geometry II: Lens & Reflector (3)



```
00054 #declare Optical2 =
00055 optical
00056 {
00057     extrusion { z_axis, -1, 1 } center_thickness 0.4
00058     { 1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00059     { 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00060     spectrum {
00061         1,
00062         <550, 1>
00063     }
00064     ior 1.5
00065     surface {
00066         both {
00067             probabilistic_split on
00068         }
00069     }
00070 }
00071
00072 Optical2
```

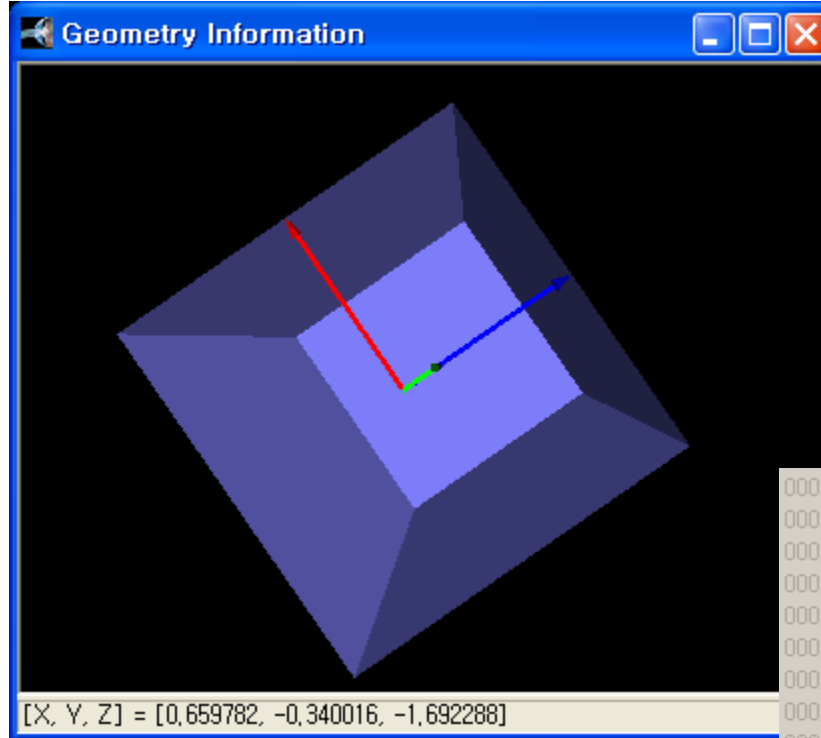
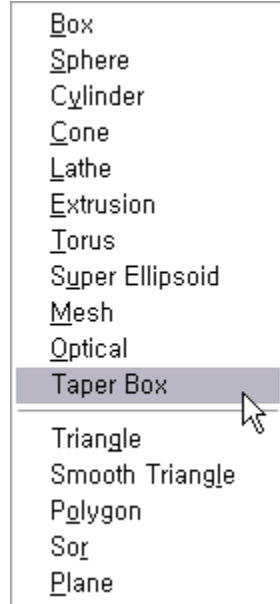
Geometry II: Lens & Reflector (4)



```
00074 #declare Optical3 =  
00075 optical  
00076 {  
00077     extrusion { z_axis, -2, 2 } center_thickness 0.4  
00078     { -1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0 }  
00079     { 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }  
00080     color silver  
00081     surface {  
00082         both {  
00083             reflectance{0.92}  
00084             transmittance{0}  
00085         }  
00086     }  
00087 }  
00088  
00089 Optical3
```

- 불투명체로 **IOR**을 삭제하고 반사 투과율을 지정한다.

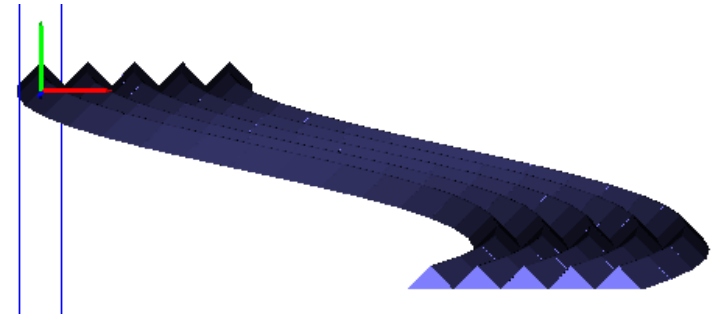
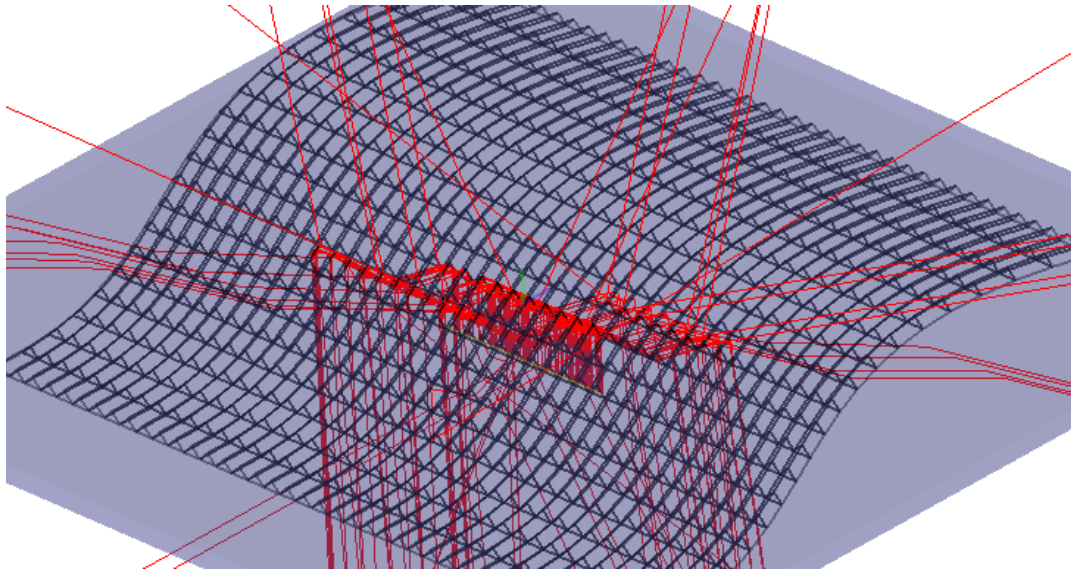
Geometry II: Taper Box



front_surface(Z+)
back_surface(Z-)
left_surface(X-)
right_surface(X+)
top_surface(Y+)
bottom_surface(Y-)

```
00020 #declare TaperBox0 =  
00021 taper_box  
00022 {  
00023     bottom { <-1, 0, -1>, <1, 0, 1> }  
00024     top { <-0.5, 1, -0.5>, <0.5, 1, 0.5> }  
00025     color <1, 1, 1>  
00026     ior 1.5  
00027     surface {  
00028         both {  
00029             probabilistic_split on  
00030         }  
00031     }  
00032 }  
00033  
00034 TaperBox0
```

Geometry II: Skew Object – BEF3

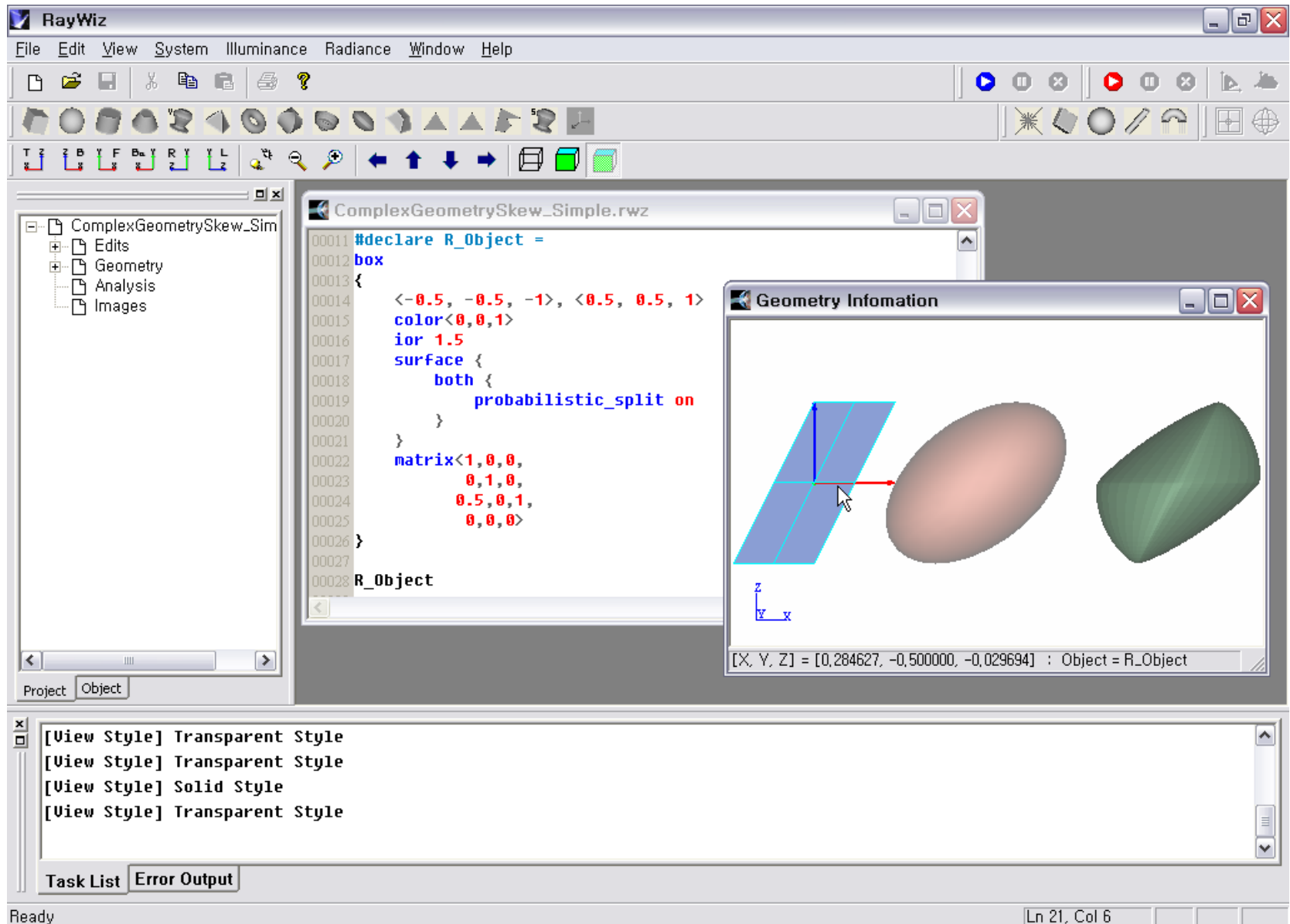


```
#declare SkewXX=Skew_val*sin(0.2*ii);  
#declare XX=SkewXX;  
matrix<1,0,0,  
       0,1,0,  
       SkewXX,0,1,  
       XX,0,2*ii>
```

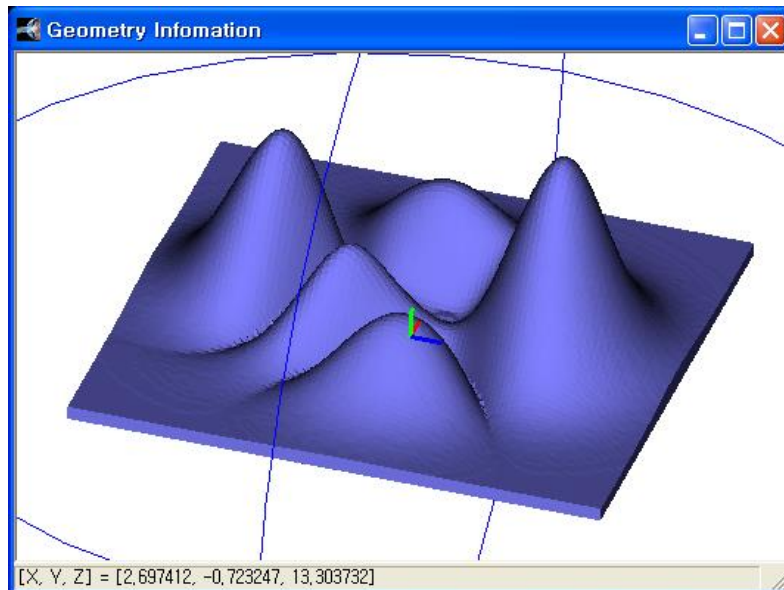
translate

X-Axis Skew

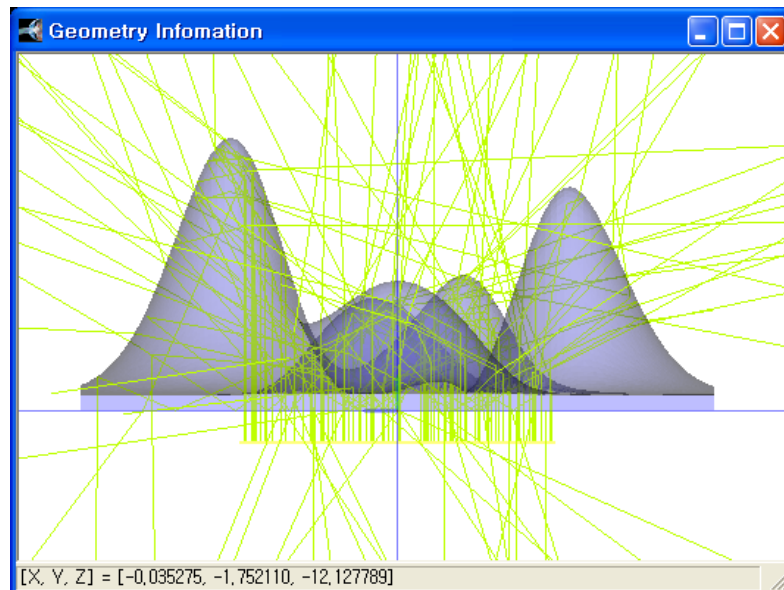
Geometry II: Skew Object



Geometry II: Matrix_Mesh (1)



```
MatrixMesh.rwz
00017 //File을 읽어 배열에 할당
00018 #fopen DataFile "exp.txt" read
00019 #read(DataFile, NumR1, NumC1)
00020 #declare NumR=NumR1;
00021 #declare NumC=NumC1;
00022 #declare DataArray = array[NumR][NumC]
00023 #declare I = 0;
00024 #while ( I < NumR )
00025     #declare J = 0;
00026     #while (J < NumC)
00027         #read (DataFile, MyData)
00028         #declare DataArray[I][J] = abs(MyData);
00029         #declare J = J+1;
00030     #end
00031 #declare I = I+1;
00032 #end
00033 #fclose DataFile
```

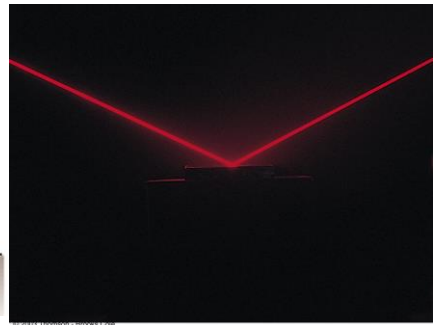
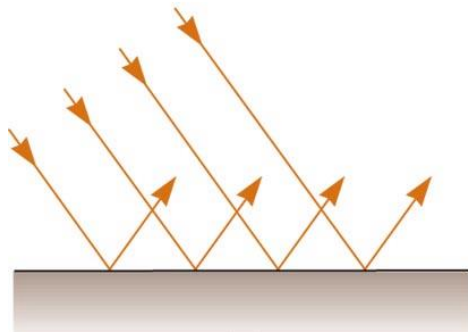


```
MatrixMesh.rwz
00035 mesh_array {
00036     boundary {
00037         <-10, 10>
00038         <-10, 10>
00039     }
00040     thickness 0.5
00041     DataArray
00042     color<1,1,1>
00043     ior 1.5
00044     surface {
00045         both {
00046             probabilistic_split on
00047         }
00048     }
00049     //scale<1,1,1>|
00050 }
```

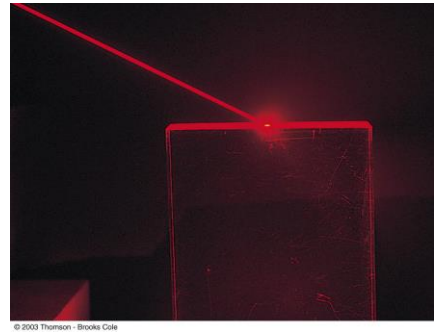
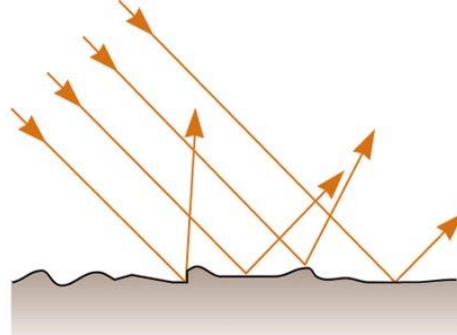
RAYWIZ BASIC Optical Properties I

Optical Property I: Specular & Diffuse (Scatter)

Specular



Diffuse



Optical Property I: Specular & Diffuse (Scatter)

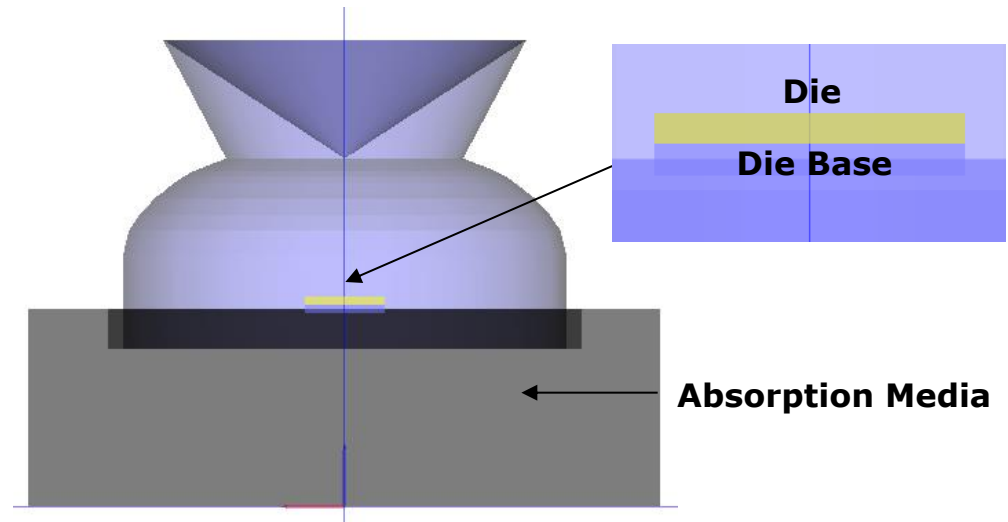
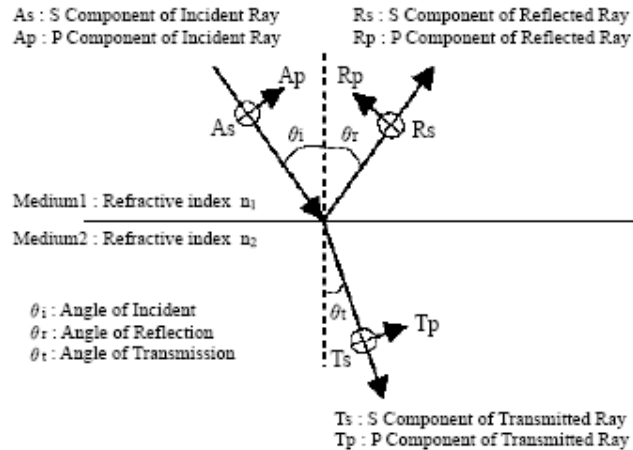
Specular



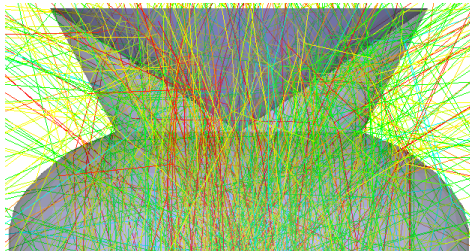
Diffuse



Optical Property I: Specular [Ray & Surface]



**Input Energy =
Reflected Energy + Transmitted Energy**

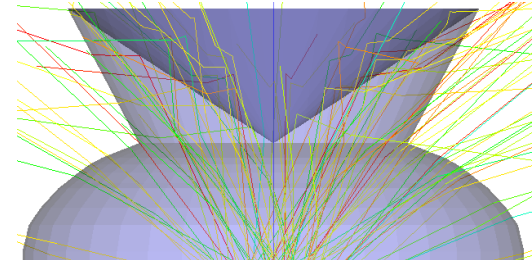


<Split_Ray On>

```

surface {
  both
  {
    Probabilistic_split on
  }
}
    
```

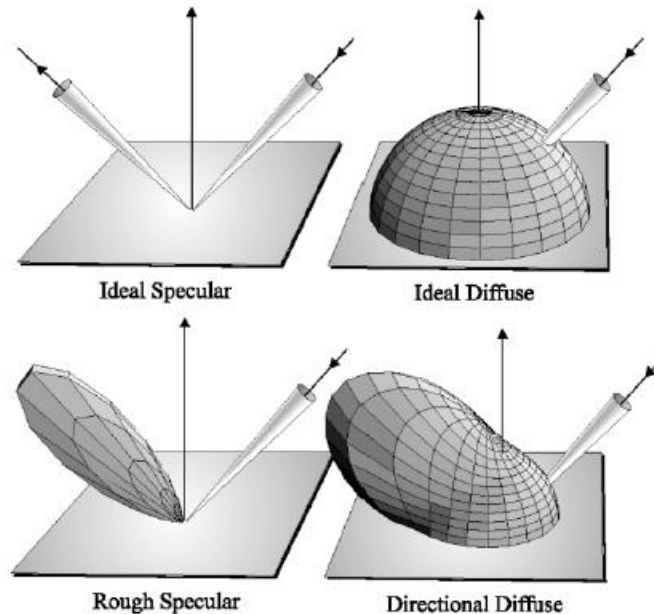
**Input Energy =
Reflected Energy or Transmitted Energy**



<Split_Ray Off>

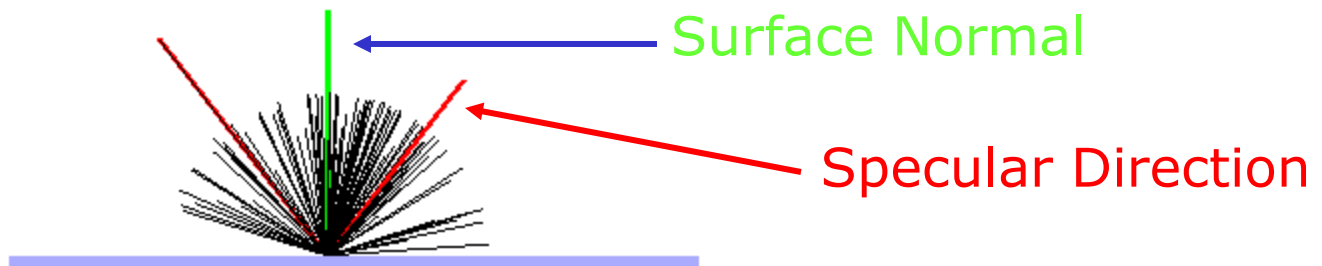
Optical Property I: Scatter Models

- Rays spread after reflection/transmission
- Ray Propagation Direction can be Transmitted (forward scatter), Reflected (back scatter) or both
- Specify scattering distribution
 - Most distributions centered about the specular (specular: direction of the ray that obeys Snell's law)



Optical Property I: Lambertian Scattering

- Random scattering surface (white paint)
- Each incident ray can scatter in any direction with the same probability
- Scattering occurs about the surface normal and *not* the incident angle
- Each scattered ray has the same energy



Optical Property I: Gaussian Scattering

- Each incident ray can scatter with the Gaussian distribution given by

$$P(\theta) = P_o \exp\left[-\frac{1}{2}\left(\frac{\theta}{\sigma}\right)^2\right]$$

where

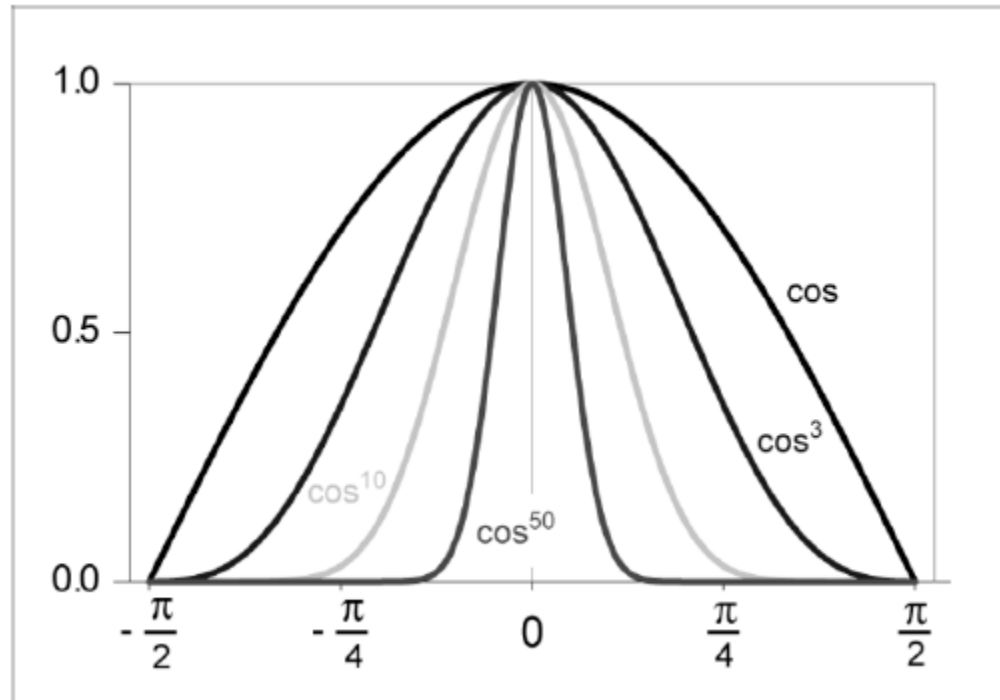
$P(\theta)$ = intensity or radiance in the θ direction

P_o = intensity or radiance in the specular direction

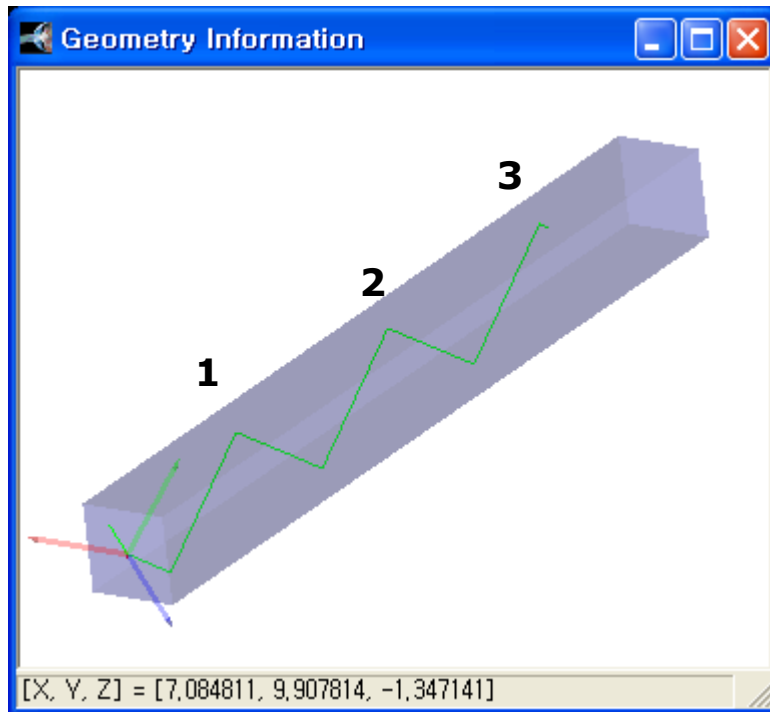
σ = standard deviation of the Gaussian distribution, in degrees

- Useful for near-specular or narrow distribution scatter

Optical Property I: Cosine Nth



Optical Property I: max_trace_level & trace_off_ratio

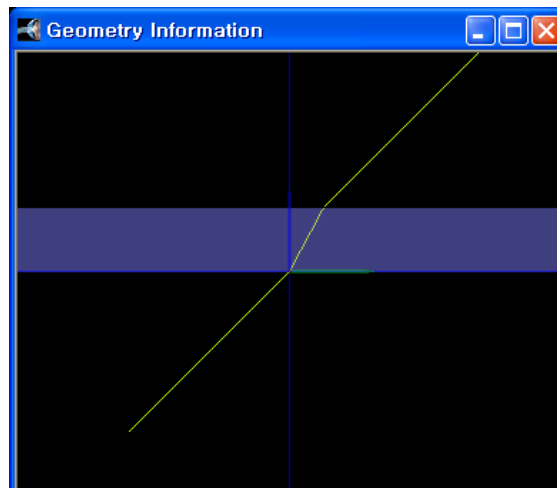


```
MaxTraceLevel.rwz:1
00001
00002 global_settings {
00003   rays {
00004     trace_off_ratio 0.01
00005     total_ray_number 1000
00006     max_trace_level 3
00007     trace_path_view 100
00008     split_ray off
00009   }
00010 }
00011
```

- **max_trace_level**: Object를 구성하는 각 Surface에 Ray가 몇 번 맞을 때 까지 **tracing**을 진행할 것인지를 결정.
- **trace_off_ratio**: Ray가 처음 출발할 시점의 에너지 대비 얼마만큼의 비율로 감소될 시점까지 **tracing**을 진행할 것인지를 결정.
- 두 가지 설정 부분의 내용 중 먼저 만족되는 조건을 따름.

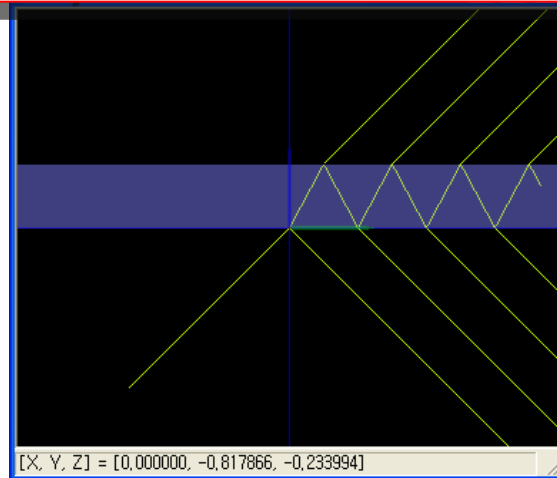
Optical Property I: split_ray [on, off]

split_ray off



- **Surface**를 만나게 되는 **Ray**를 투과, 반사 성분으로 두개의 **Ray**로 파생 시킬 것인지 여부를 결정

split_ray on

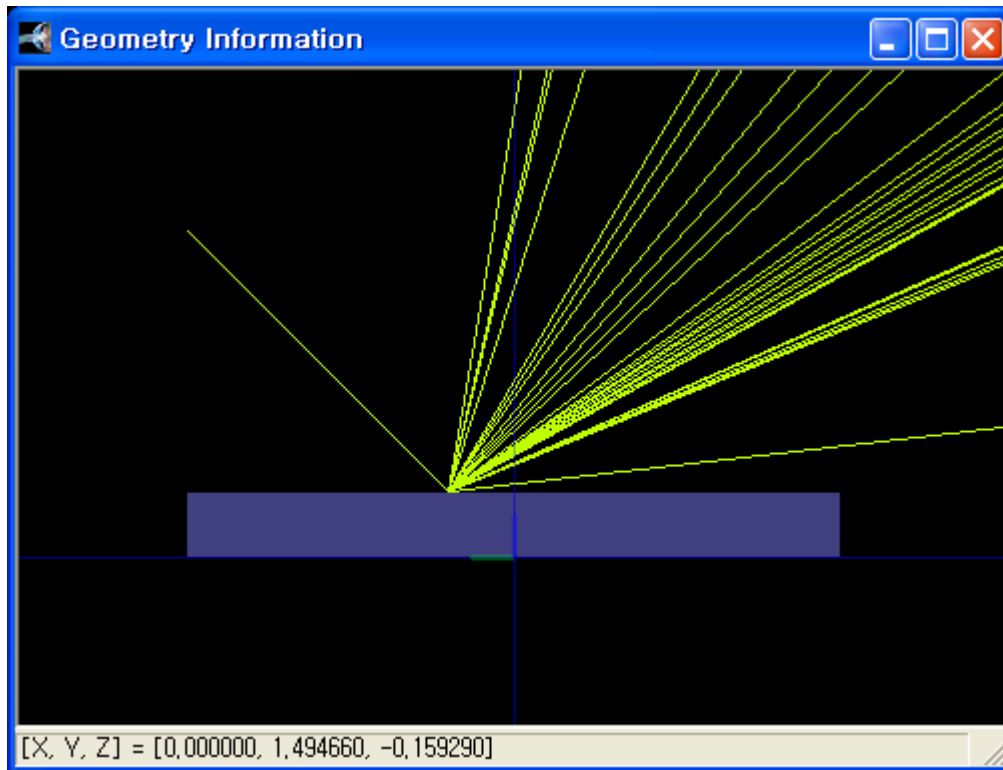


```
00018 #declare Box0 =
00019 box
00020 {
00021     <-1, -1, 0>, <1, 1, 0.2>
00022     color <1, 1, 1>
00023     ior 1.5
00024     surface {
00025         both {
00026             transmittance{0.6}
00027             reflectance{0.4}
00028         }
00029     }
00030 }
```

```
00001 global_settings {
00002     rays {
00003         trace_off_ratio 0.001
00004         total_ray_number 1
00005         max_trace_level 10
00006         trace_path view 1
00007         split_ray off
00008     }
00009 }
```

```
00001 global_settings {
00002     rays {
00003         trace_off_ratio 0.001
00004         total_ray_number 1
00005         max_trace_level 10
00006         trace_path view 1
00007         split_ray on
00008     }
00009 }
```

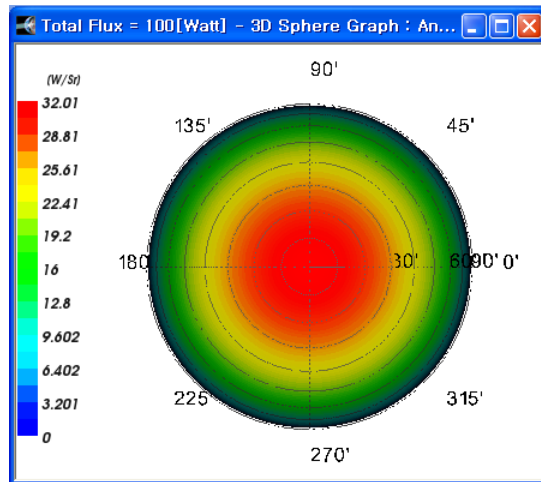

Optical Property I: Scattering(1)



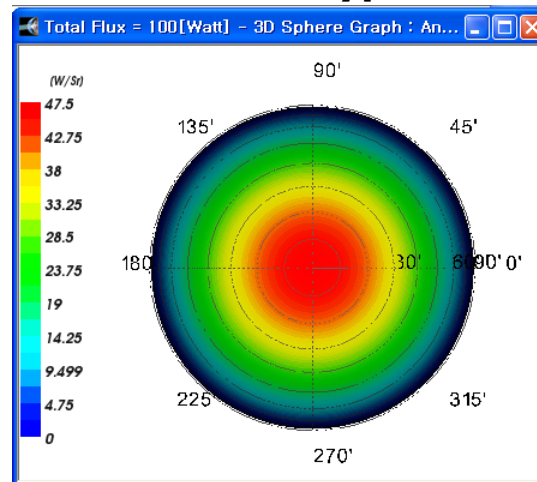
```
00018 #declare Box0 =  
00019 box  
00020 {  
00021     <-1, -1, 0>, <1, 1, 0.2>  
00022     color <1, 1, 1>  
00023     surface {  
00024         both {  
00025             reflectance {1.0}  
00026         }  
00027         front_surface {  
00028             both {  
00029                 reflectance {  
00030                     cosnth 10  
00031                 }  
00032                 scattering_num 30  
00033             }  
00034         }  
00035     }  
00036 }
```

Optical Property I: Scattering(2) – Basic Function

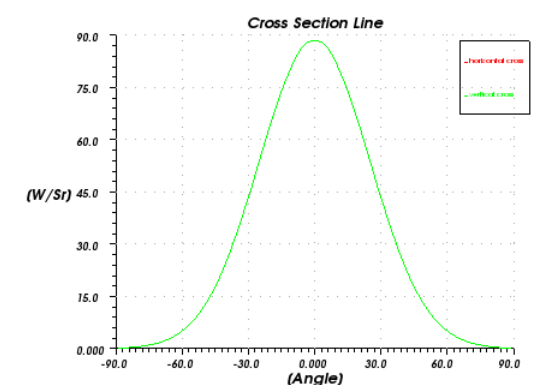
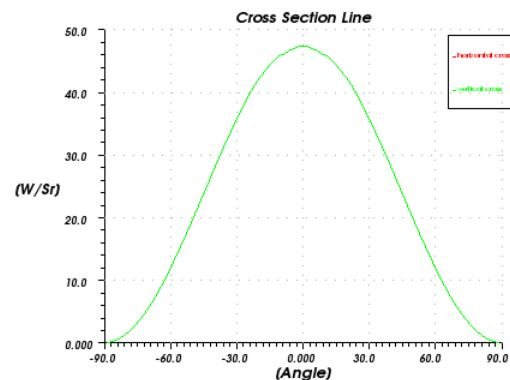
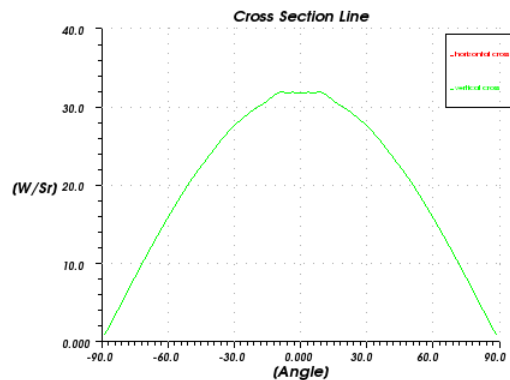
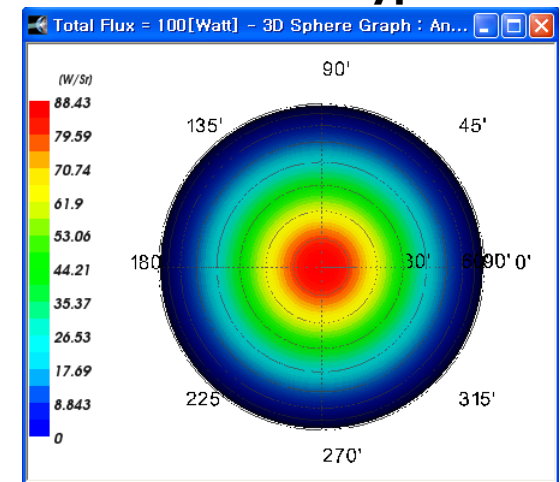
<Lambertian Type>



<CosNth Type>

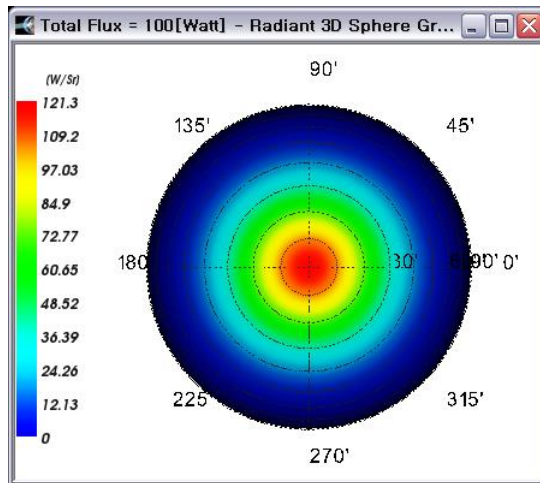


<Gaussian Type>

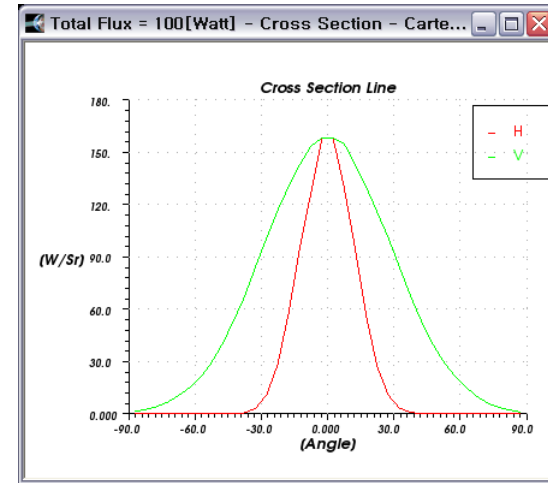
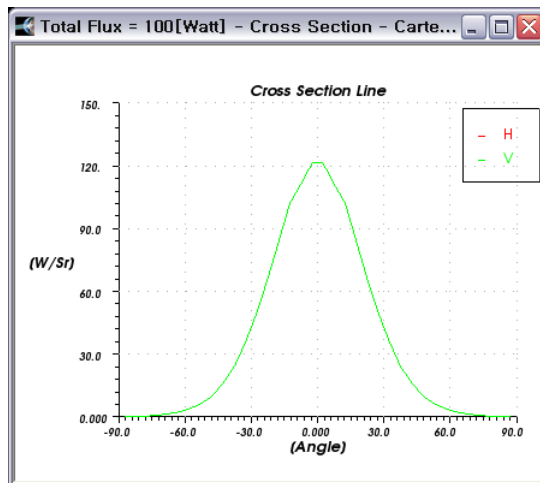
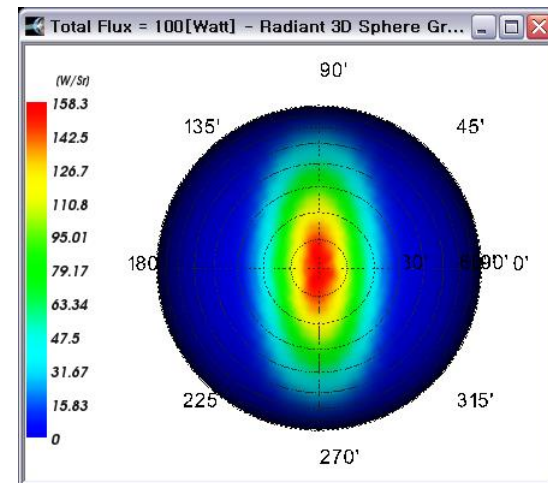


Optical Property I: Scattering(3) – Basic Function

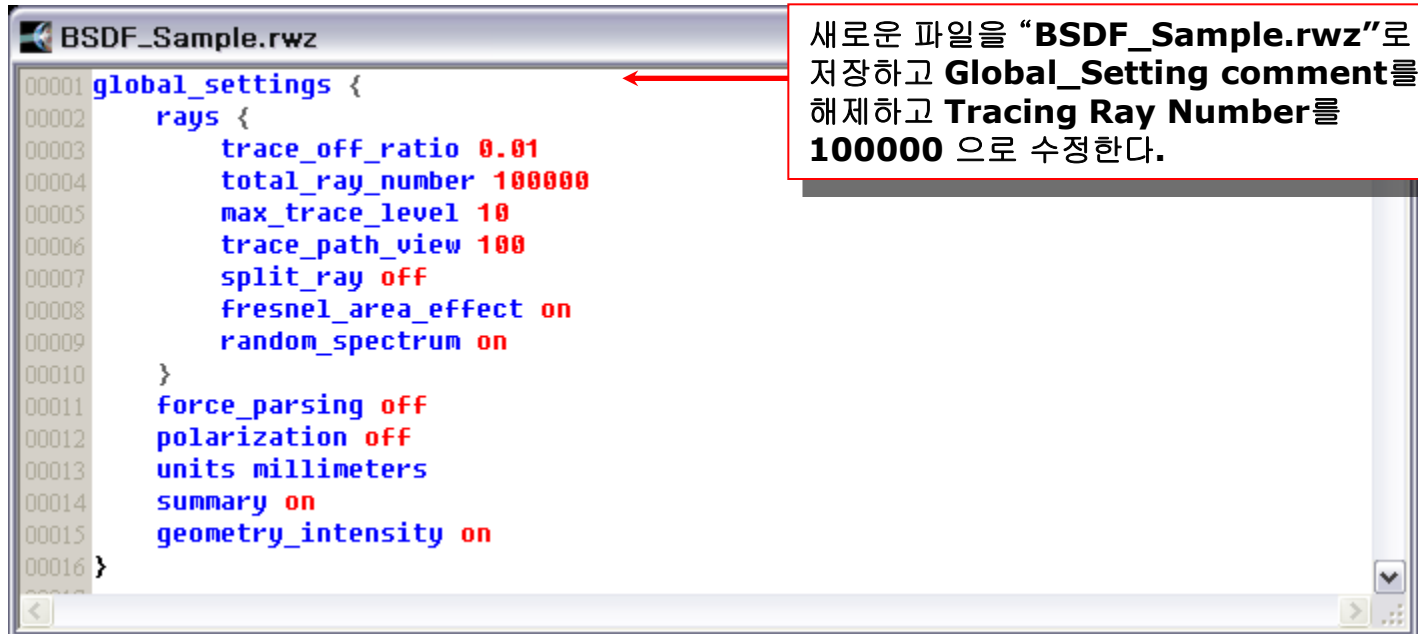
<Composite Type>



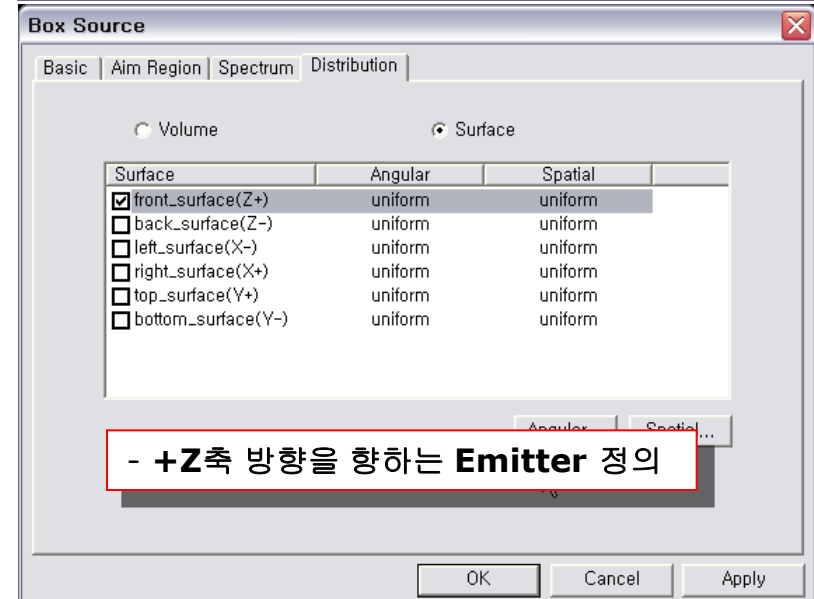
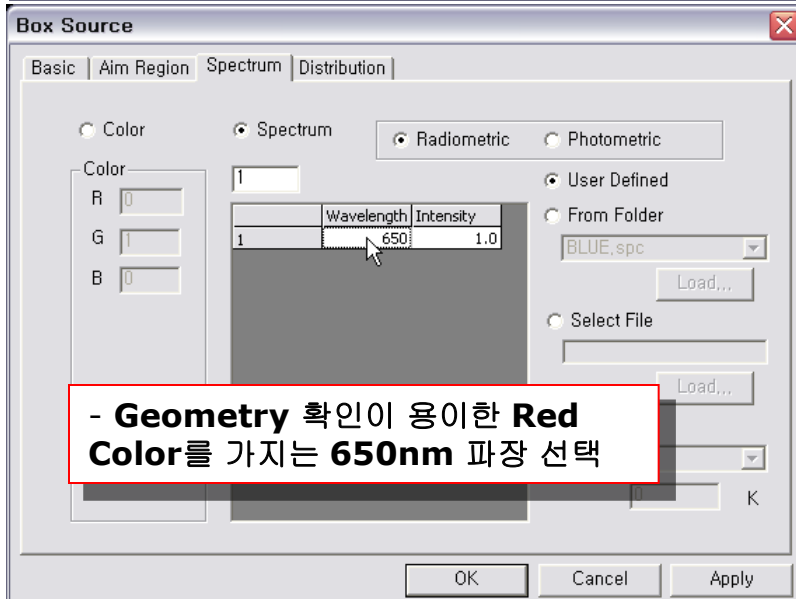
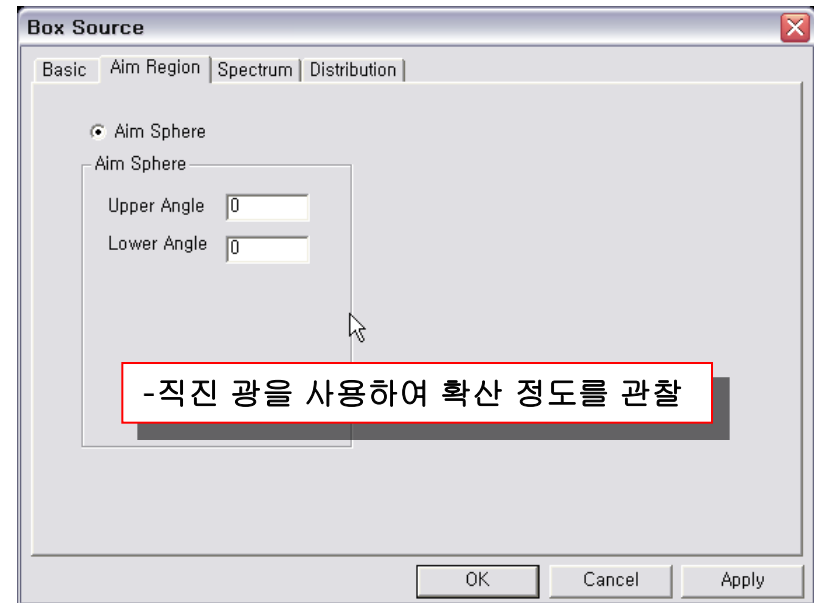
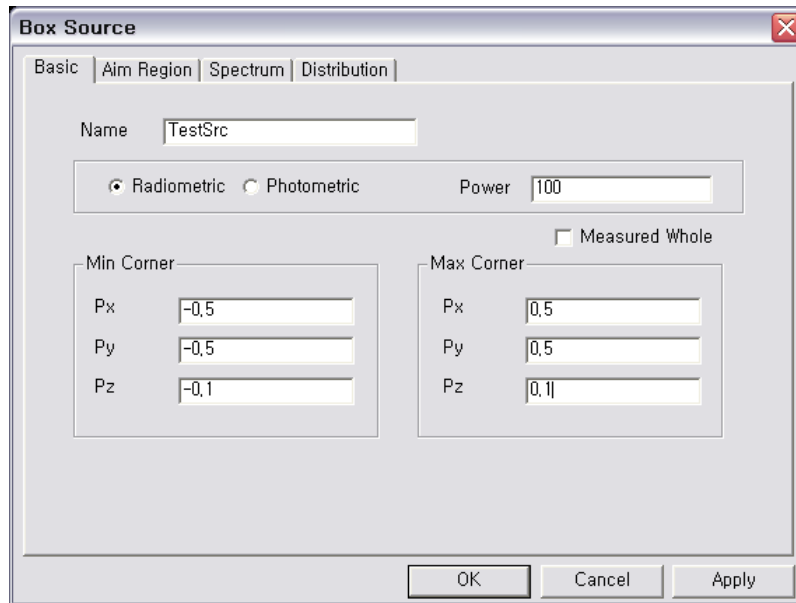
<Elliptical_Gaussian>



Optical Property I: Scattering(4) – Basic Function



Optical Property I: Scattering(5) – Basic Function



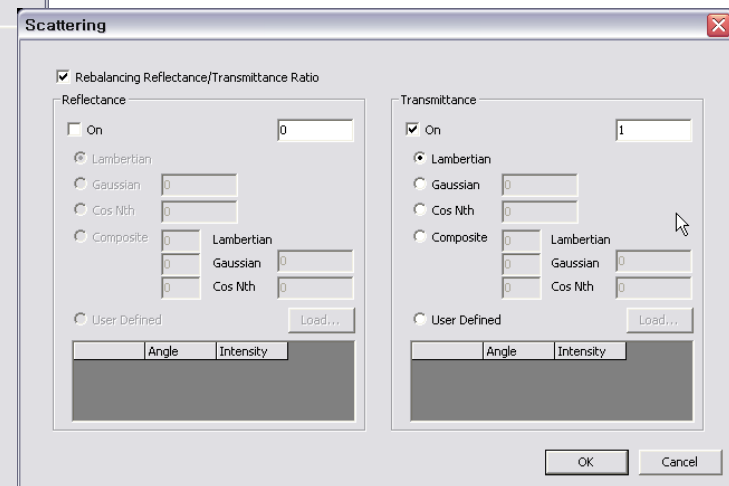
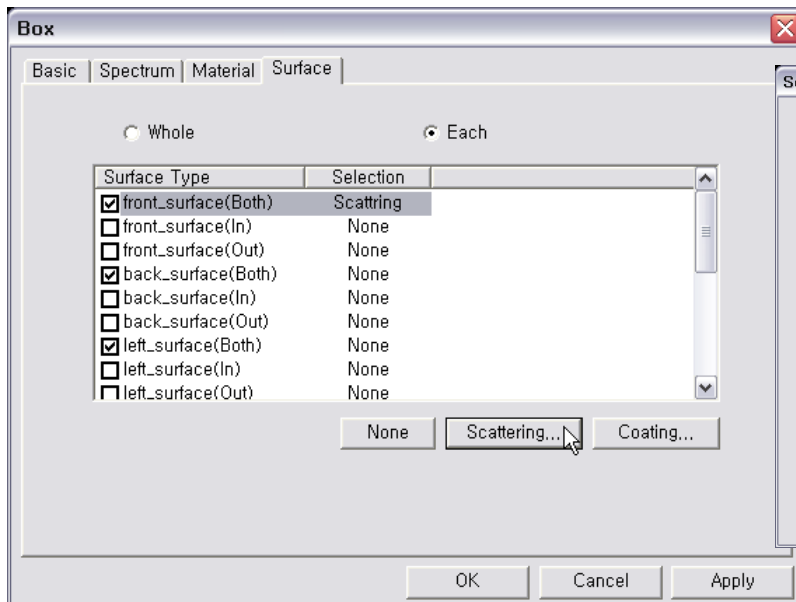
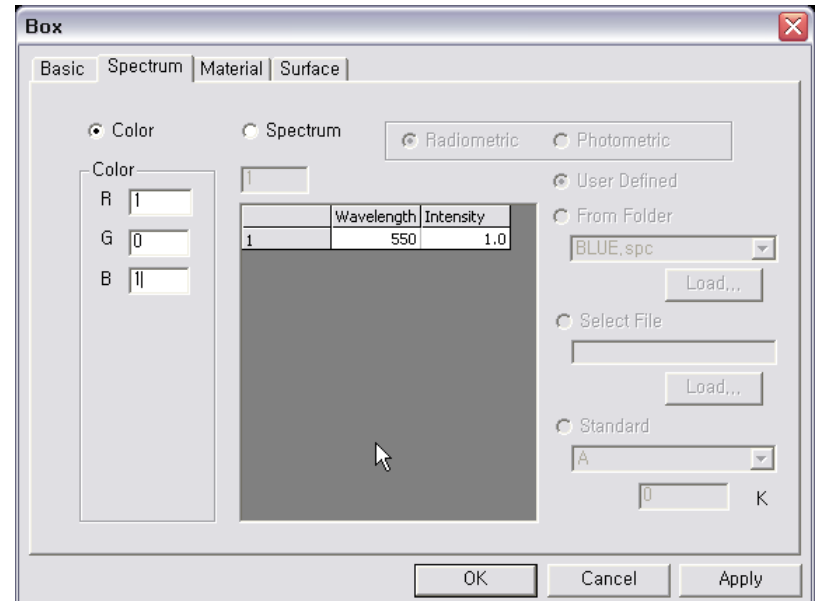
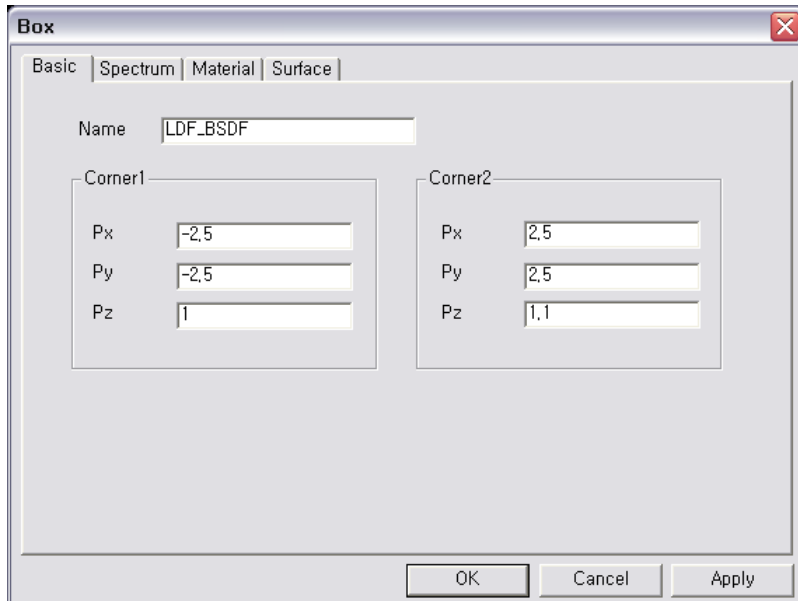
Optical Property I: Scattering(6) – Basic Function

```
BSDF_Sample.rwz
00018 #declare TestSrc =
00019 light_source
00020 {
00021   <0, 0, 0>
00022   spectrum {
00023     1,
00024     <650, 1>
00025   }
00026   object_light
00027   {
00028     surface
00029     box
00030     {
00031       <-0.5, -0.5, -0.1>, <0.5, 0.5, 0.1>
00032     }
00033   }
00034 }
```

```
BSDF_Sample.rwz
00033   emittance
00034   {
00035     front_surface
00036     {
00037       on
00038       angular_distribution
00039       {
00040         uniform
00041       }
00042       spatial_distribution
00043       {
00044         uniform
00045       }
00046     }
00047   }
00048   emittance
00049   {
00050     radiometric 100
00051     measured_whole on
00052     aim_sphere <0, 0>
00053   }
00054   point_at <0, 0, 3>
00055 }
00056 TestSrc
00057
00058
```

+Z 방향을 향하도록 **point_at** 좌표 지정

Optical Property I: Scattering(7) – Basic Function

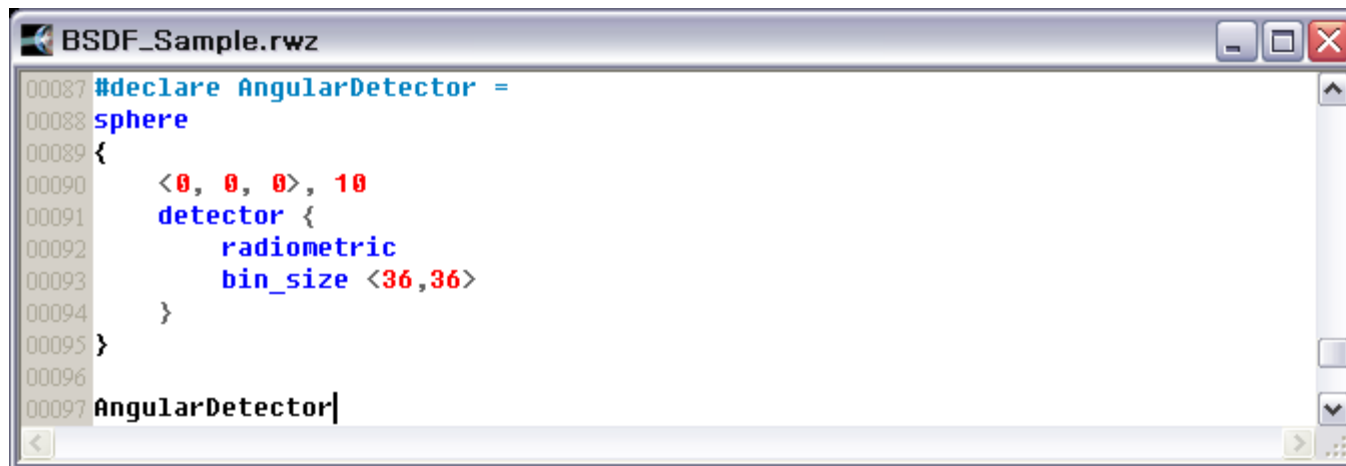
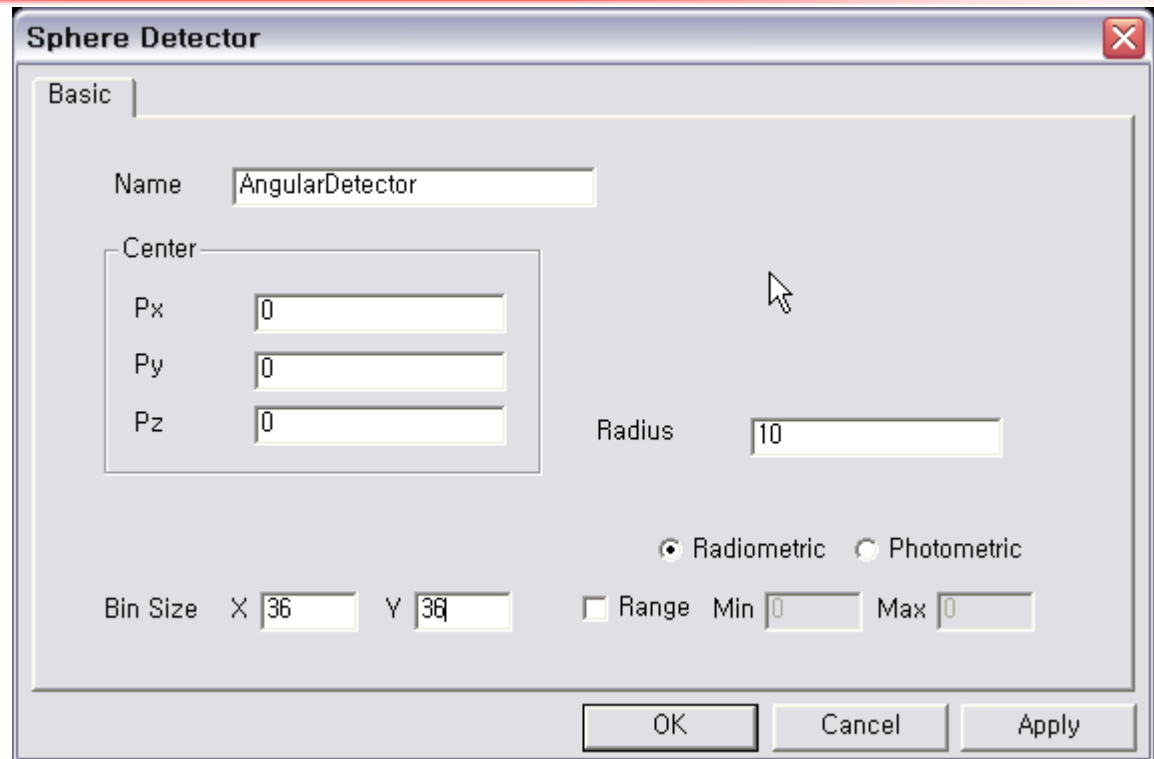
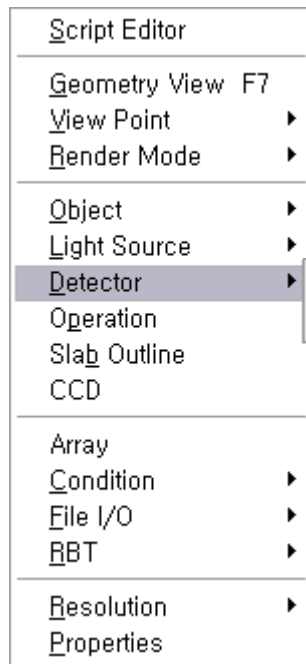


Optical Property I: Scattering(7) – Basic Function

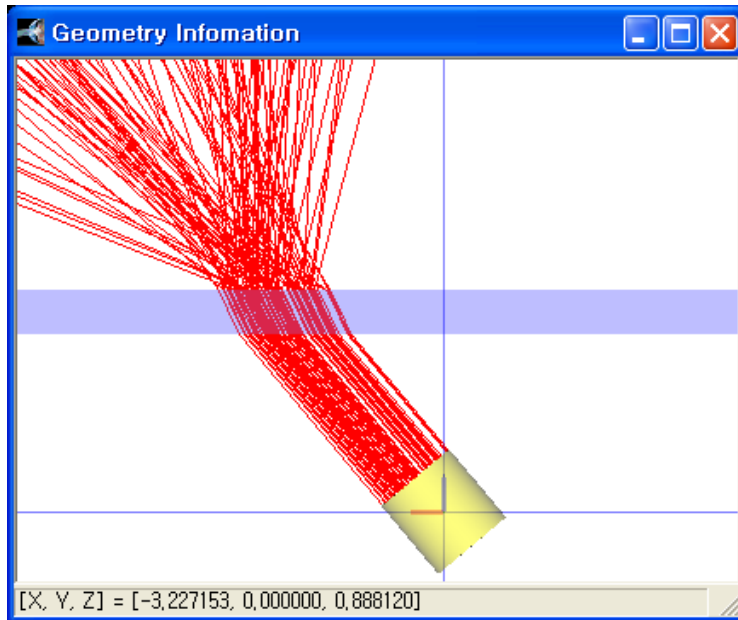
```
BSDF_Sample.rwz
00060 #declare LDF_BSDF =
00061 box
00062 {
00063     <-2.5, -2.5, 1>, <2.5, 2.5, 1.1>
00064     color<1,0,1>
00065     ior 1.5
00066     surface {
00067         both{
00068             probabilistic_split off
00069         }
00070         front_surface{
00071             both{
00072                 transmittance{1
00073                     lambertian
00074                         //cosnth 4
00075                         //gaussian 25
00076                         //composite{0.2, 0.5, 0.3, 25, 10} //Le:Ge:Ce Sigma Nth*/
00077                         //elliptical_gaussian 10 30
00078                 }
00079                 reflectance{0}
00080             }
00081         }
00082     }
00083 }
00084
00085 LDF_BSDF
```

확산특성은 투과 반사 비율 다음에 기록하거나 투과 반사 비율에 대한 항이 없으면 **Fresnel Equation**을 기준으로 **Simulation** 한다.

Optical Property I: Scattering(8) – Basic Function



Optical Property I: Scattering(9) – Angle_Intensity



```

00015 #declare TestBox1 =
00016 box
00017 {
00018   <-5, -5, 2>, <5, 5, 2.5>
00019   color<1,1,1>
00020   ior 1.5
00021   surface {
00022     both {
00023       probabilistic_split off
00024     }
00025     front_surface {
00026       both {
00027         transmittance {
00028           angle_intensity {
00029             // "angle_intensity.ain"
00030             5, <0, 1>, <10, 0.8>, <20, 0.6>, <30, 0.4>, <40, 0.2>
00031           }
00032         }
00033       }
00034     }
00035   }
00036 }
00037

```

```

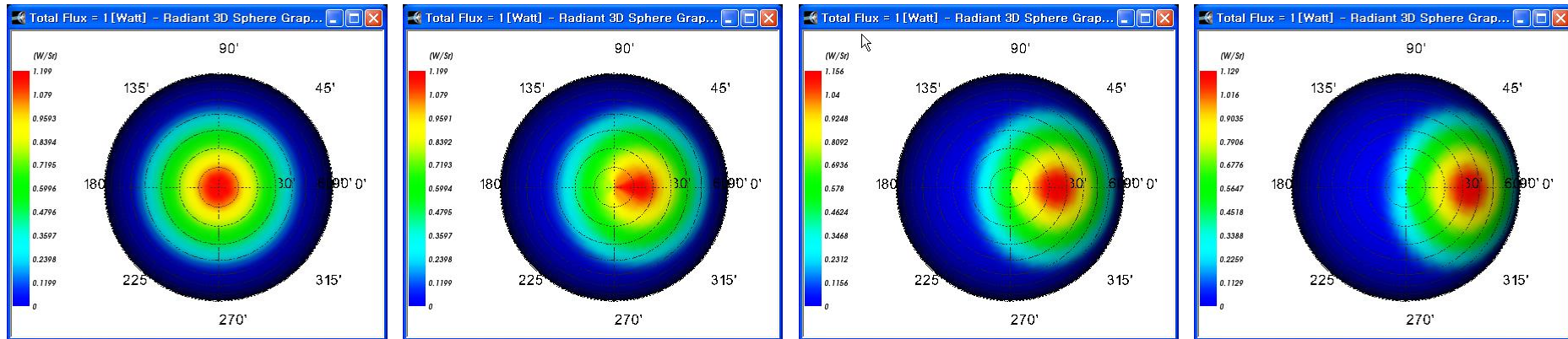
front_surface {
  both {
    transmittance {
      angle2_intensity {
        // "angle2_intensity_data.ain"
        3, 5,
        { 0, <0, 1>, <10, 0.8>, <20, 0.6>, <30, 0.4>, <40, 0.2> }
        { 15, <0, 0.8>, <10, 1>, <20, 0.8>, <30, 0.6>, <40, 0.4> }
        { 30, <0, 0.4>, <10, 0.6>, <20, 0.8>, <30, 1>, <40, 0.8> }
      }
    }
  }
}

```

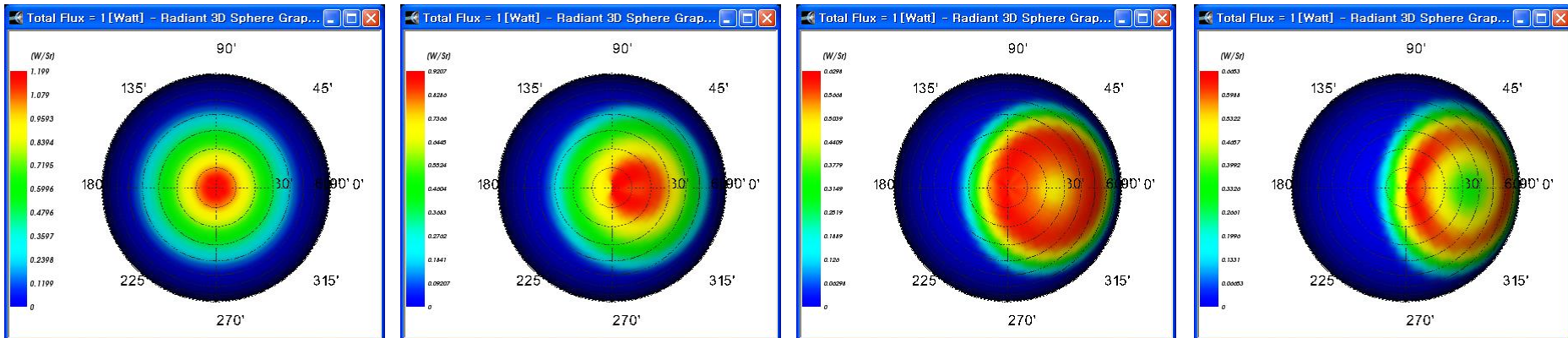
angle2_intensity_data.ain	
0	5
0	0
0	1.0
10	0.8
20	0.6
30	0.4
40	0.2
15	0
0	0.8
10	1.0
20	0.8
30	0.6
40	0.4
30	0
0	0.4
10	0.6
20	0.8
30	1.0
40	0.8

Optical Property I: Scattering(10) – Angle_Intensity

Angle_Intensity



Angle2_Intensity



<0도 입사>

<20도 입사>

<40도 입사>

<60도 입사>

Optical Property I: Coating(1)

```
<9, 3>
0,
<450, 0.0, 0.9>
<550, 0.1, 0.8>
<650, 0.2, 0.7>
10,
<450, 0.0, 0.9>
<550, 0.1, 0.8>
<650, 0.2, 0.7>
20,
<450, 0.0, 0.9>
<550, 0.1, 0.8>
<650, 0.2, 0.7>
30,
<450, 0.0, 0.9>
<550, 0.1, 0.8>
<650, 0.2, 0.7>
40,
<450, 0.0, 0.9>
<550, 0.1, 0.8>
<650, 0.2, 0.7>
50,
```

COATING:

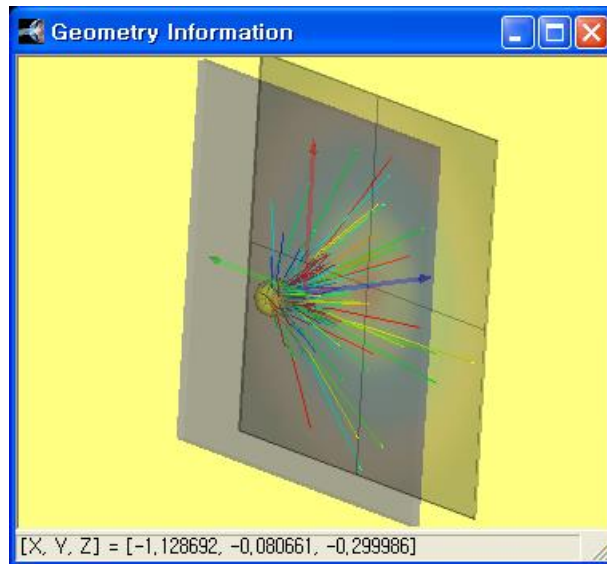
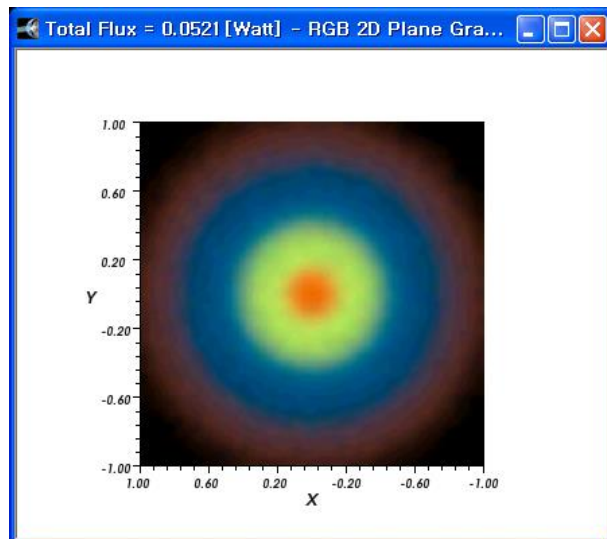
```
coating {
  <Angle_Of_Incidence_Num, Wavelength_Num>
  Angle_Of_Incidence_1,
  <Wavelength_1, Reflectance, Transmittance>
  <Wavelength_2, Reflectance, Transmittance>
  ...
  Angle_Of_Incidence_N,
  <Wavelength_1, Reflectance, Transmittance>
  <Wavelength_2, Reflectance, Transmittance>
  ...
  <Wavelength_N, Reflectance, Transmittance>
} |
coating {
  COATING_FILE_LOCATION
}
```

```
9 3
0
450 0.0 0.9
550 0.1 0.8
650 0.2 0.7
10
450 0.0 0.9
550 0.1 0.8
650 0.2 0.7
20
450 0.0 0.9
550 0.1 0.8
650 0.2 0.7
30
450 0.0 0.9
550 0.1 0.8
650 0.2 0.7
40
450 0.0 0.9
550 0.1 0.8
650 0.2 0.7
50
```

Script Expression

File Expression

Optical Property I: Coating(2)



coating_data.txt

	0	10
9	3	
0		
450	0.0	0
550	0.0	0
650	0.0	1
10		
450	0.0	0
550	0.0	0
650	0.0	1
20		
450	0.0	0
550	0.0	1
650	0.0	0
30		
450	0.0	0
550	0.0	1
650	0.0	0
40		
450	0.0	1
550	0.0	0
650	0.0	0
50		
450	0.0	1
550	0.0	0
650	0.0	0
60		

```

00019 #declare Box1 =
00020 box
00021 {
00022     <-1, -1, 0>, <1, 1, 0.05>
00023     color <1, 1, 1>
00024     ior 1.5
00025     surface {
00026         both {
00027             probabilistic_split on
00028         }
00029         back_surface{
00030             out{
00031                 coating{ "coating_data.txt" }
00032             }
00033         }
00034     }
00035 }
00036
00037 Box1
emittance
{
    radiometric 1
    measured_whole on
    aim_sphere <0, 60>
    angular_distribution
    {
        uniform
    }
    volume_distribution
    {
        uniform
    }
}
point_at <0, 0, 1>
    
```

Optical Property II: Bitmap Surface(1)

```
surface {  
    both {  
        reflectance {  
            1  
            lambertian  
        }  
        transmittance {  
            0  
        }  
        zone {  
            "1bit.bmp"  
        }  
        //probabilistic_split off  
        //scattering_num N  
    }  
}
```

Zone 에 따로 **Transmittance** 와 **Reflectance** 조건이 설정되어 있으면 전체 면 특성 무시

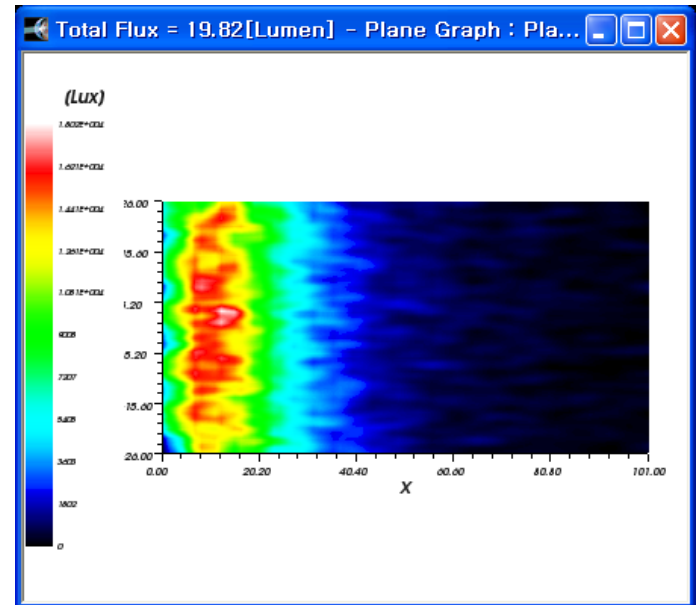
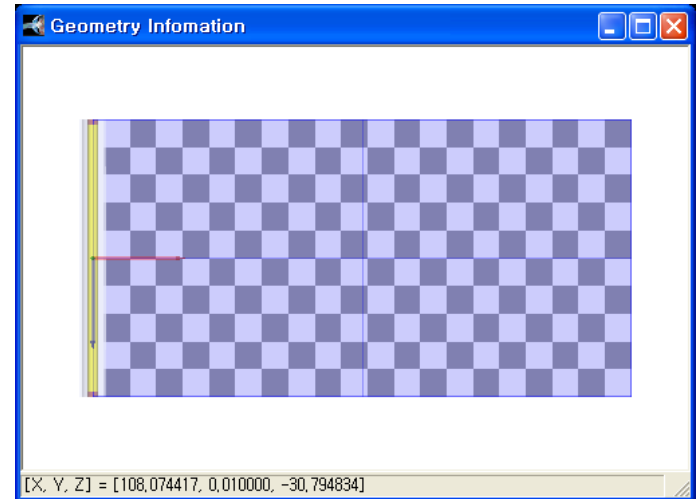
```
zone { <10,10>, //비트맵 사이즈  
    1, //비트맵 칼라 비트 수  
    0,1,0,1,0, ....  
    1,0,0,1, .... //비트맵 데이터  
}
```

Optical Property II: Bitmap Surface(2-1)

```

00133 #declare LGP =
00134 box
00135 {
00136     <2, -2.25, -26>, <101, 2.25, 26>|
00137     color<1,1,1>
00138     ior {"PMMA.mat"}
00139     surface {
00140         both {
00141             probabilistic_split on
00142         }
00143         bottom_surface{
00144             both{
00145                 reflectance {0.92 lambertian}
00146                 transmittance {0}
00147             }
00148             zone{
00149                 <10,20>, //행,열
00150                 1,
00151                 1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,
00152                 0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,
00153                 1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,
00154                 0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,
00155                 1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,
00156                 0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,
00157                 1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,
00158                 0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,
00159                 1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,
00160                 0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1,0,1
00161                 invert on
00162             }
00163         }
00164     }
00165 }

```



Optical Property II: Bitmap Surface(2-2)

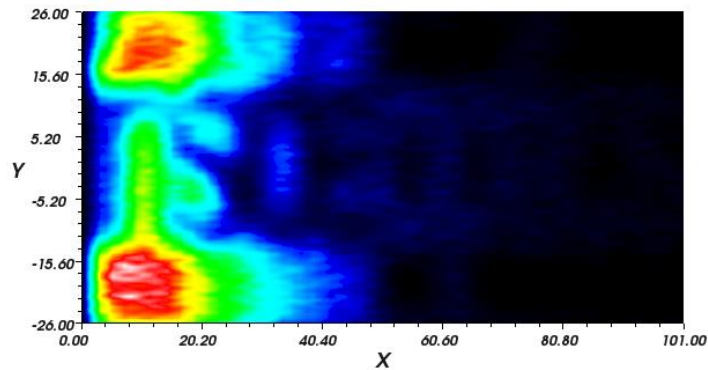
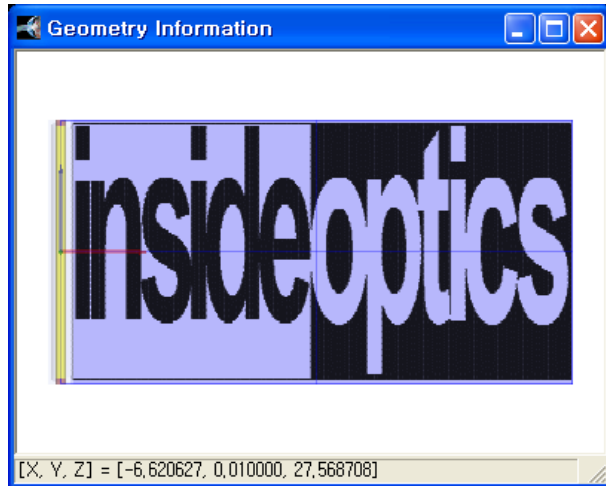
```
00095 #declare Check_Array = array[10][20]
00096 #local ii=0;
00097 #while (ii<10)
00098     #local jj=0;
00099     #while(jj<20)
00100         #declare Check_Array[ii][jj]=mod((ii+jj),2);
00101     #local jj=jj+1;
00102     #end
00103     #local ii=ii+1;
00104 #end

00106 #declare LGP =
00107 box
00108 {
00109     <2, -2.25, -26>, <101, 2.25, 26>
00110     color<1,0,0>
00111     ior {"PMMA.mat"}
00112     surface {
00113         both {
00114             probabilistic_split on
00115         }
00116         bottom_surface{
00117             both{
00118                 reflectance {0.92 lambertian}
00119                 transmittance {0}
00120                 zone{
00121                     Check_Array
00122                     //transpose
00123                     invert on
00124                 }
00125             }
00126         }
00127     }
00128 }
```

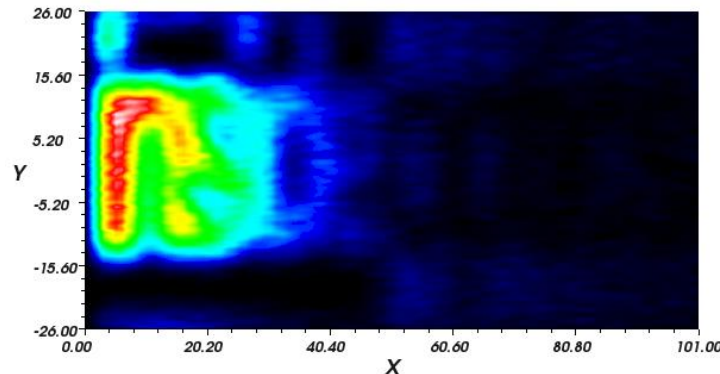
Bitmap Type으로 사용할 Array 변수 정의

Array 변수 Call

LGP: Bitmap Surface(3)

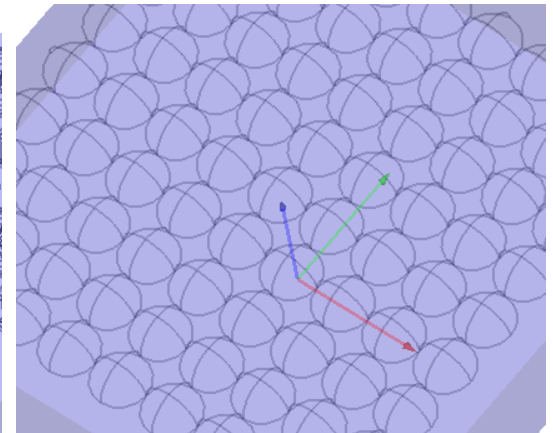
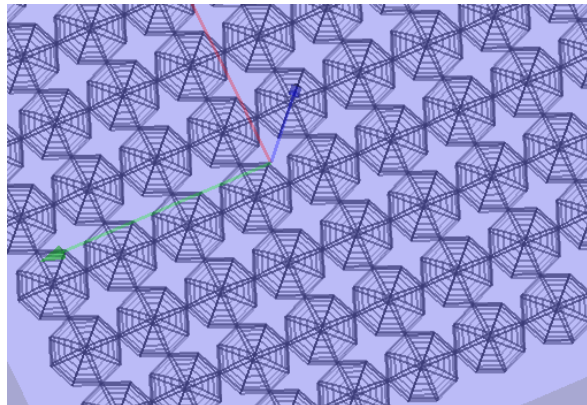
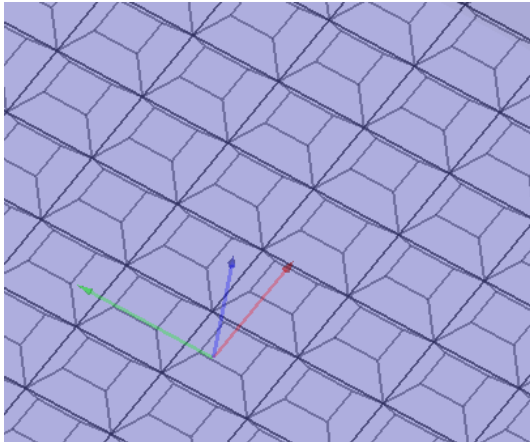
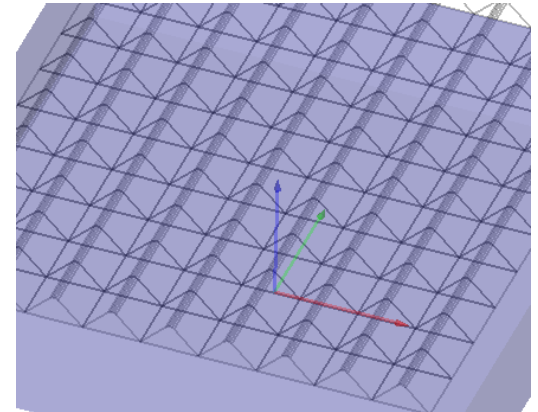
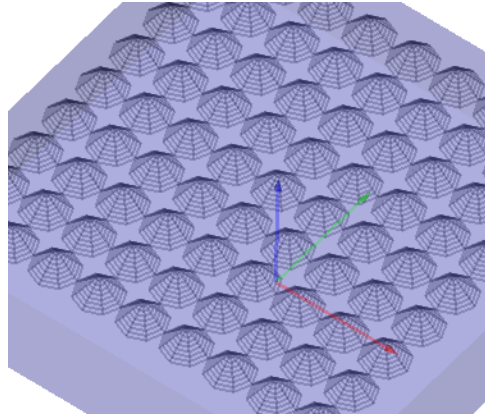
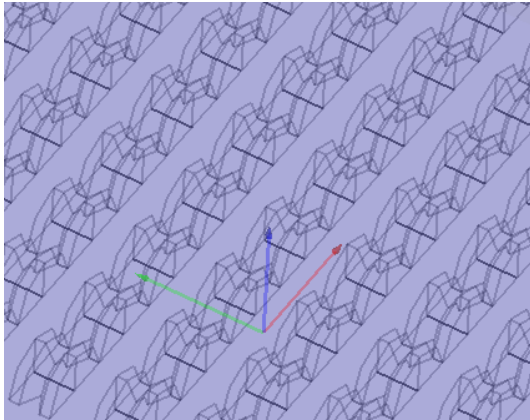


```
surface {  
  both {  
    probabilistic_split on  
  }  
  bottom_surface {  
    both {  
      reflectance {0.92 lambertian}  
      transmittance {0}  
      zone {  
        "InsideOptics.bmp"  
        invert on  
      }  
    }  
  }  
}
```



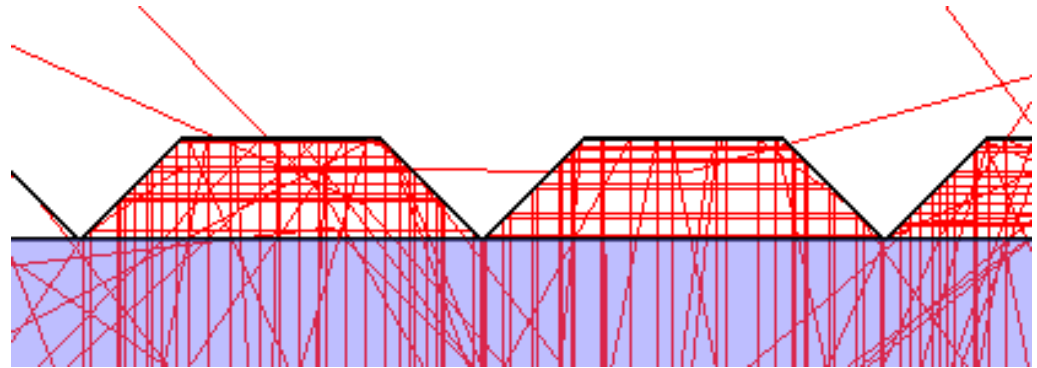
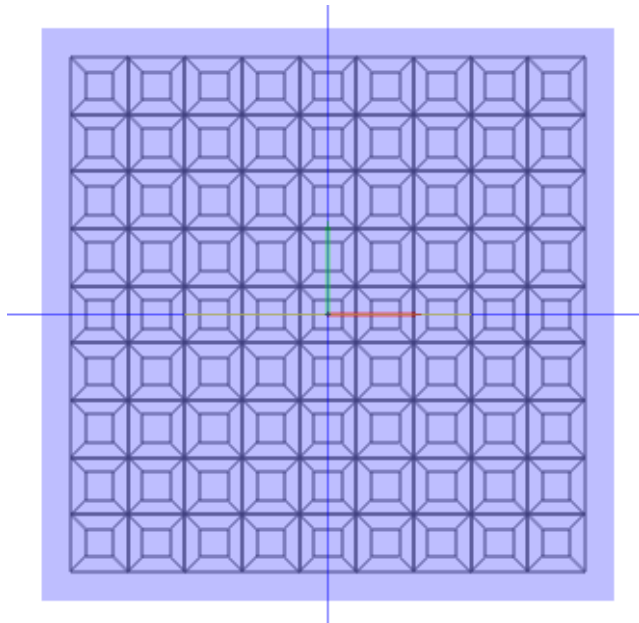
```
surface {  
  both {  
    probabilistic_split on  
  }  
  bottom_surface {  
    both {  
      reflectance {0.92 lambertian}  
      transmittance {0}  
      zone {  
        "InsideOptics.bmp"  
        invert off  
      }  
    }  
  }  
}
```

LGP: Slab Object - Geometry



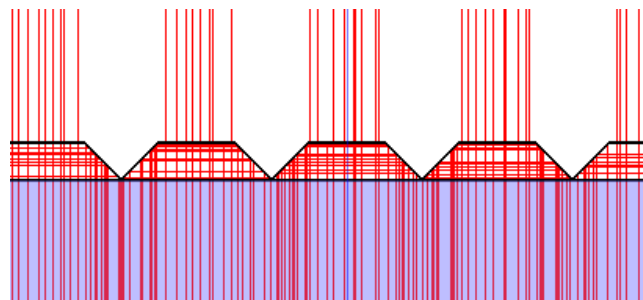
모든 **Geometry** 지원: 기본 **Object**,
CSG (Constructive Solid Geometry),
CAD Imported Geometry

LGP: Slab Object - Property



```
#declare TaperBox1 =  
taper_box  
{  
  back { <-0.1, -0.1, 0>, <0.1, 0.1, 0> }  
  front { <-0.05, -0.05, 0.05>, <0.05, 0.05, 0.05> }  
  color<1,1,1>  
  ior 1.5  
  surface {  
    both {  
      probabilistic_split on  
    }  
    front_surface{  
      in{  
        reflectance{0.92 lambertian}  
        transmittance{0}  
      }  
    }  
  }  
}
```

**Different IOR & Different BSDF
← Immerse Slab**



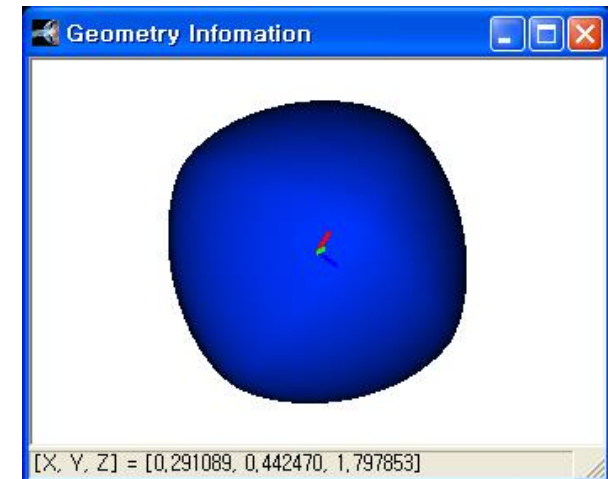
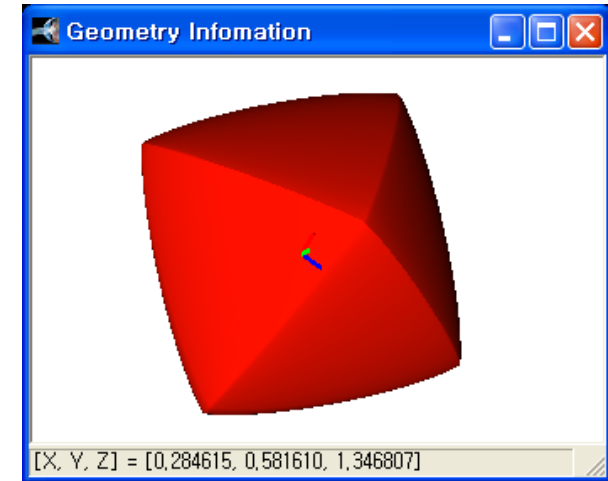
Macro Grammar I

- Basic -

Macro Basic: #declare & #local

DECLARATION: #declare IDENTIFIER = VALUE
#local IDENTIFIER = VALUE

```
declare_local.rwz
00024 #declare A=1.2;
00025 #declare B=<650,1>;
00026 #declare C=<450,1>;
00027
00028 #declare SuperEllipsoid0 =
00029 superellipsoid
00030 {
00031     <A, A>
00032     spectrum {
00033         discrete on
00034         1,
00035         B//<550, 1>
00036     }
00037     ior 1.5
00038     surface {
00039         both {
00040             probabilistic_split on
00041         }
00042     }
00043 }
00044
00045 SuperEllipsoid0
```



$$f(x, y, z) = \left(|x|^{\left(\frac{2}{e}\right)} + |y|^{\left(\frac{2}{e}\right)} \right)^{\left(\frac{e}{n}\right)} + |z|^{\left(\frac{2}{n}\right)} - 1 = 0$$

Macro Basic: Math Functions & Pre-defined Math Values

Pi
True| False
degrees(FLOAT) | radians(FLOAT) |
val(STRING) |
abs(FLOAT) | int(FLOAT) |
pow(FLOAT , FLOAT) | sqrt(FLOAT) |
ceil(FLOAT) | floor(FLOAT) |
sin(FLOAT) | sinh(FLOAT) |
asin(FLOAT) | asinh(FLOAT) |
cos(FLOAT) | cosh(FLOAT) |
acos(FLOAT) | acosh(FLOAT) |
tan(FLOAT) | tanh(FLOAT) |
atan(FLOAT) | atanh(FLOAT) | atan2(FLOAT , FLOAT) |
exp(FLOAT) | log(FLOAT) | ln(FLOAT) |
max(FLOAT , FLOAT, ...) | min(FLOAT , FLOAT, ...) | mod(FLOAT , FLOAT) |
seed(FLOAT) | rand(FLOAT) |
strcmp(STRING , STRING) | strlen(STRING)

Expression: -2.0 -4 34 3.4e6 2e-5 .3 0.6

Macro Basic: String Functions

STRING:

**STRING_FUNCTION | STRING_IDENTIFIER |
STRING_LITERAL STRING_LITERAL:**

"up to 256 ASCII characters"

STRING_FUNCTION:

str(FLOAT , INT , INT) |

chr(INT) |

concat(STRING , STRING , [STRING ,...]) |

```
str(123.456, 0, 2) "123.46"
```

```
str(123.456, 0, 0) "123"
```

```
str(123.456, 5, 0) " 123"
```

```
str(123.000, 7, 2) " 123.00"
```

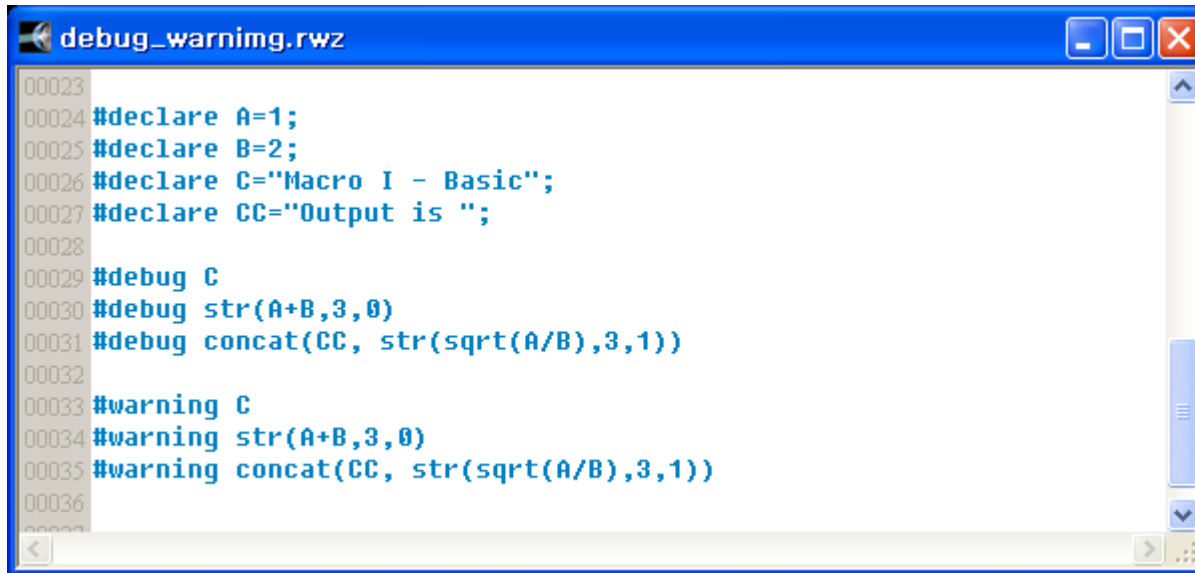
```
#declare A=34.567;
```

```
concat("Result is ", str(A,3,1), " lm")
```

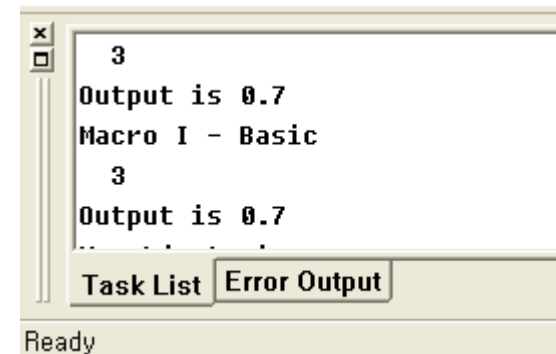
```
→ "Result is 34.5 lm"
```

Macro Basic: #debug, #warning

#debug STRING | #error STRING | #warning STRING

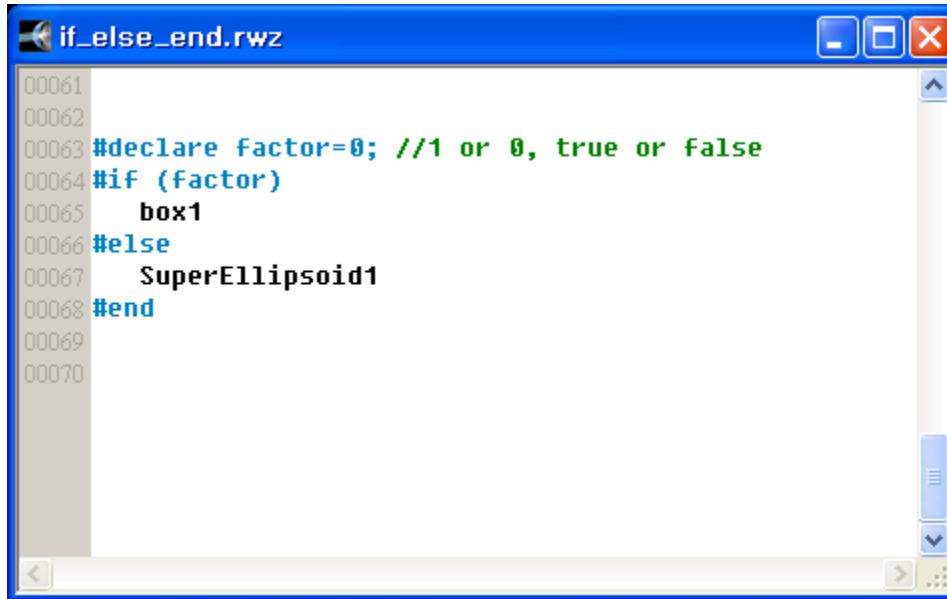


```
00023
00024 #declare A=1;
00025 #declare B=2;
00026 #declare C="Macro I - Basic";
00027 #declare CC="Output is ";
00028
00029 #debug C
00030 #debug str(A+B,3,0)
00031 #debug concat(CC, str(sqrt(A/B),3,1))
00032
00033 #warning C
00034 #warning str(A+B,3,0)
00035 #warning concat(CC, str(sqrt(A/B),3,1))
00036
```

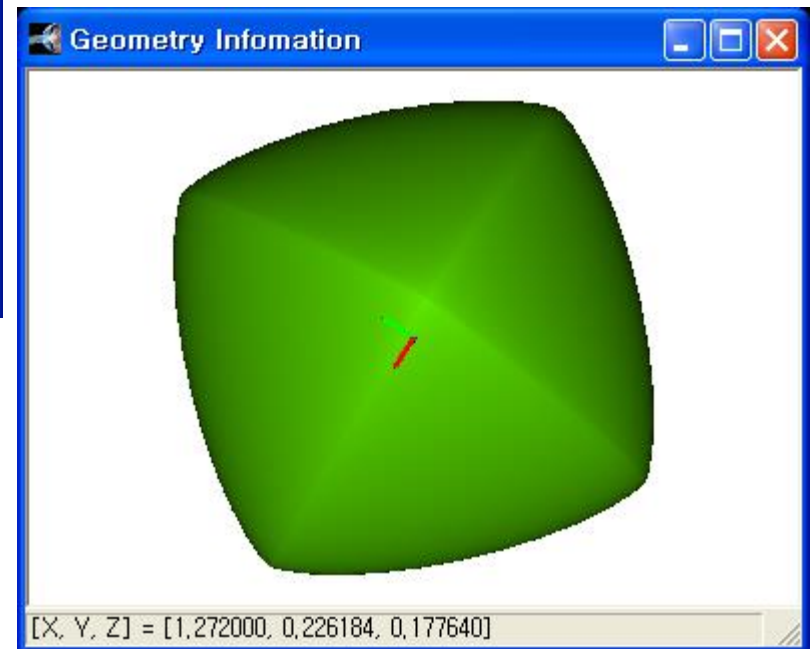


Macro Basic: #if, #else, #end

#if (Cond) TOKENS... [#else TOKENS...] #end



```
00061
00062
00063 #declare factor=0; //1 or 0, true or false
00064 #if (factor)
00065     box1
00066 #else
00067     SuperEllipsoid1
00068 #end
00069
00070
```



Macro Basic: #switch, #case, #range, #break

SWITCH_DIRECTIVE:

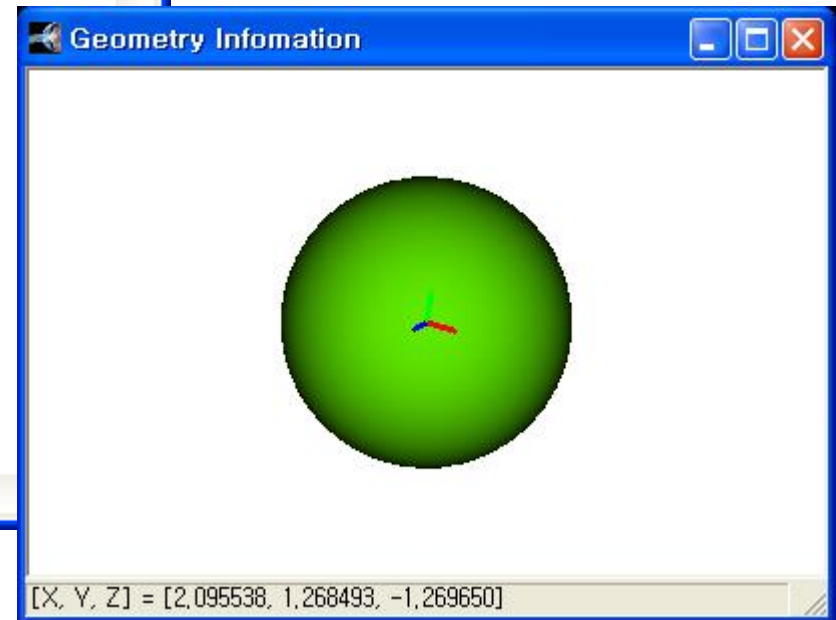
#switch (Switch_Value) SWITCH_CLAUSE... [#else TOKENS...] #end

SWITCH_CLAUSE:

#case(Case_Value) TOKENS... [#break] |

#range(Low_Value , High_Value) TOKENS... [#break]

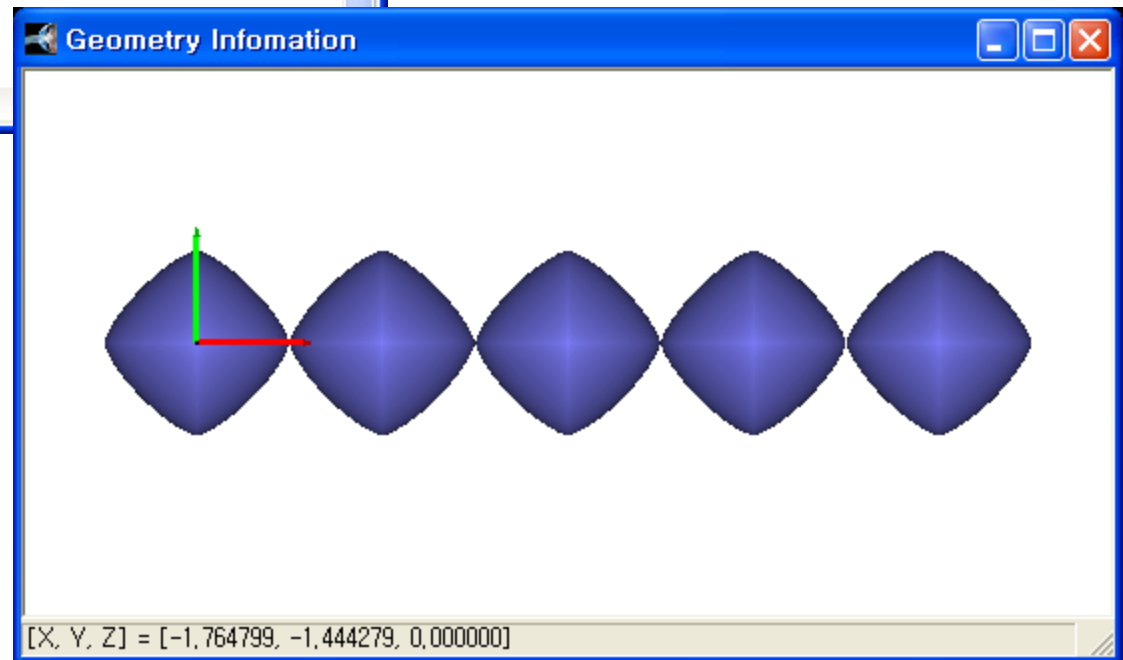
```
switch_case_range_break.rwz
00074
00075 #declare TestValue=1;
00076 #switch(TestValue)
00077     #case(1)
00078         Sphere1
00079     #break
00080     #case(5)
00081         Box1
00082     #break
00083     #range(2,4)
00084         Cylinder1
00085     #break
00086 #else
00087 #end
```



Macro Basic: #while, #end (1)

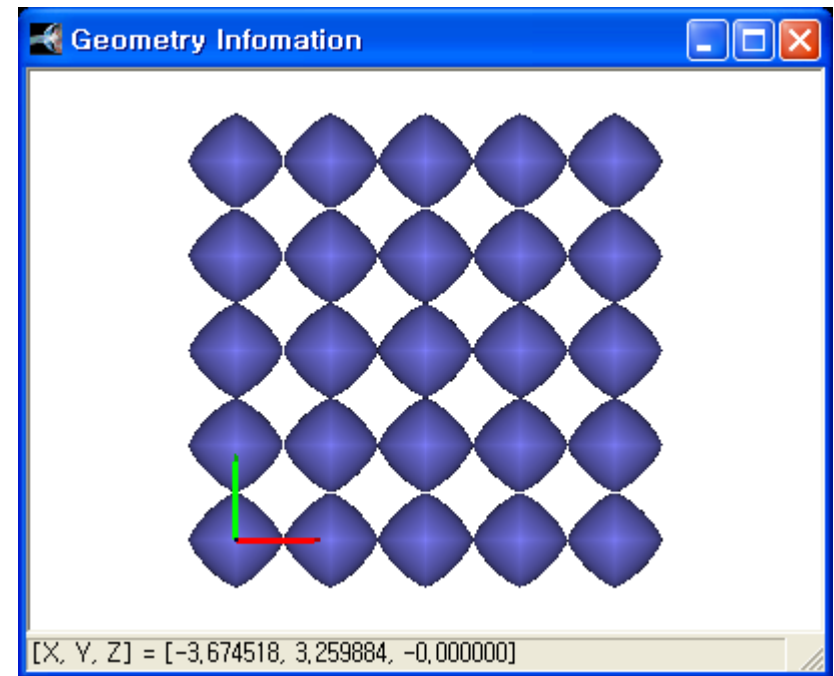
#while (Cond) TOKENS... #end

```
while_end.rwz
00036
00037 #declare ii=0;
00038 #while (ii < 5)
00039     object{
00040         MyObject
00041         translate <2*ii,0,0>
00042     }
00043 #declare ii=ii+1;
00044 #end
00045
```



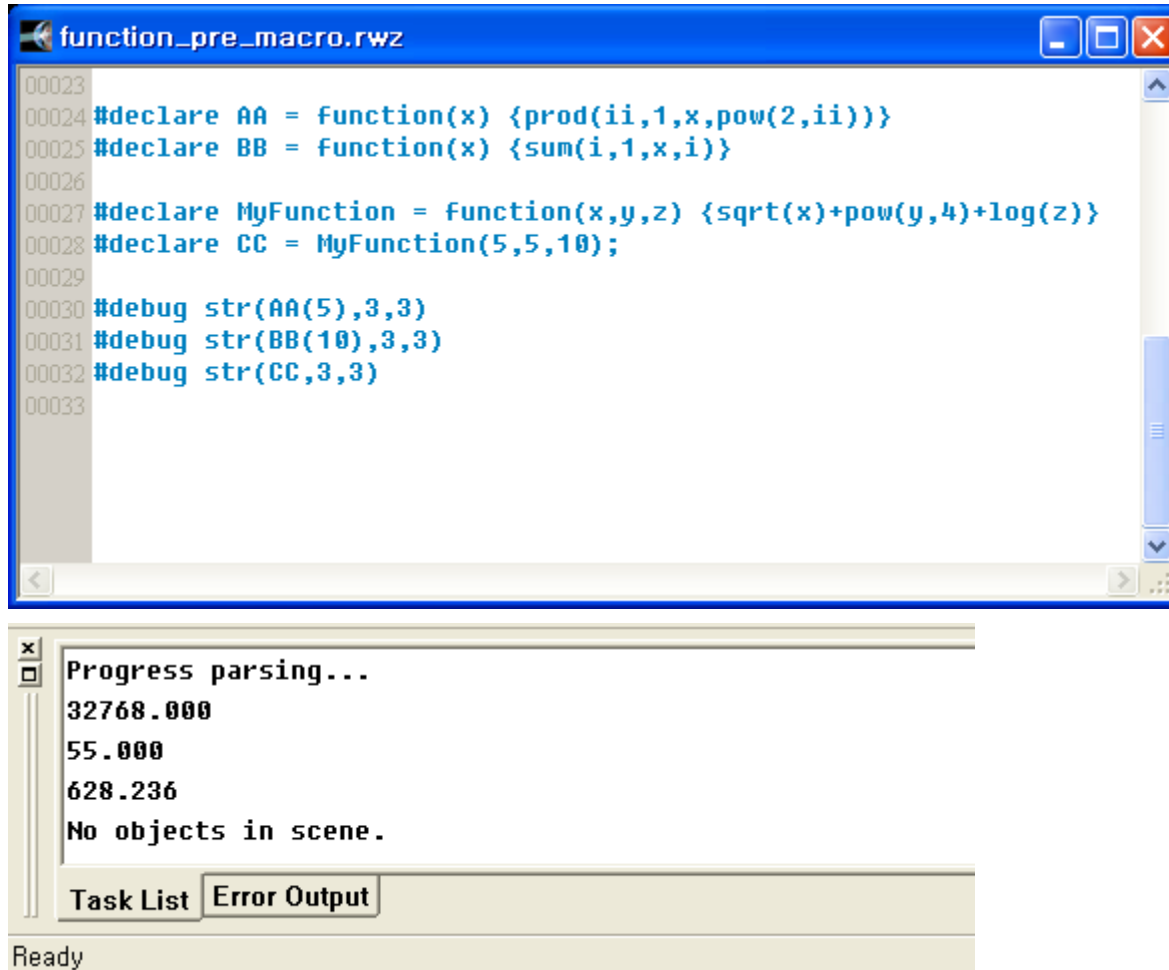
Macro Basic: #while, #end (2)

```
while_end_2.rwz
00036
00037 #declare ii=0;
00038 #while (ii < 5)
00039     #declare jj=0;
00040     #while (jj < 5)
00041         object{
00042             MyObject
00043             translate <2*ii,2*jj,0>
00044         }
00045     #declare jj=jj+1;
00046     #end
00047 #declare ii=ii+1;
00048 #end
00049
```



Macro Basic: function command & Pre-defined Macro

```
#local FUNCTION_IDENTIFIER = function(IDENT_LIST) { FLOAT }  
#declare FUNCTION_IDENTIFIER = function(IDENT_LIST) { FLOAT }
```



The screenshot shows a window titled "function_pre_macro.rwz" containing the following code:

```
00023  
00024 #declare AA = function(x) {prod(ii,1,x,pow(2,ii))}  
00025 #declare BB = function(x) {sum(i,1,x,i)}  
00026  
00027 #declare MyFunction = function(x,y,z) {sqrt(x)+pow(y,4)+log(z)}  
00028 #declare CC = MyFunction(5,5,10);  
00029  
00030 #debug str(AA(5),3,3)  
00031 #debug str(BB(10),3,3)  
00032 #debug str(CC,3,3)  
00033
```

Below the code editor is a console window showing the output of the debug commands:

```
Progress parsing...  
32768.000  
55.000  
628.236  
No objects in scene.
```

At the bottom, there are tabs for "Task List" and "Error Output", and a status bar that says "Ready".

$$\prod_{i=a}^n F$$

Prod (i, a, n, F)

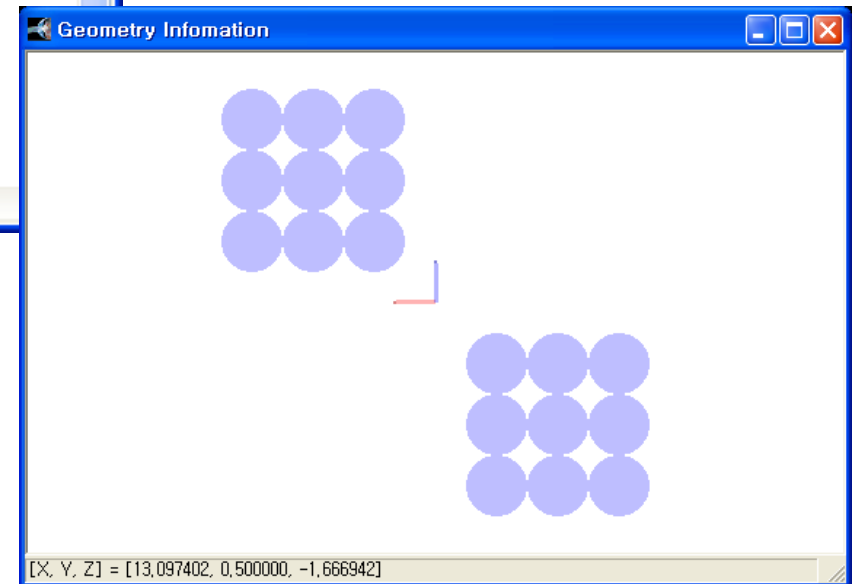
$$\sum_{i=a}^n F$$

Sum (i, a, n, F)

Macro Basic: #macro, #end (1)

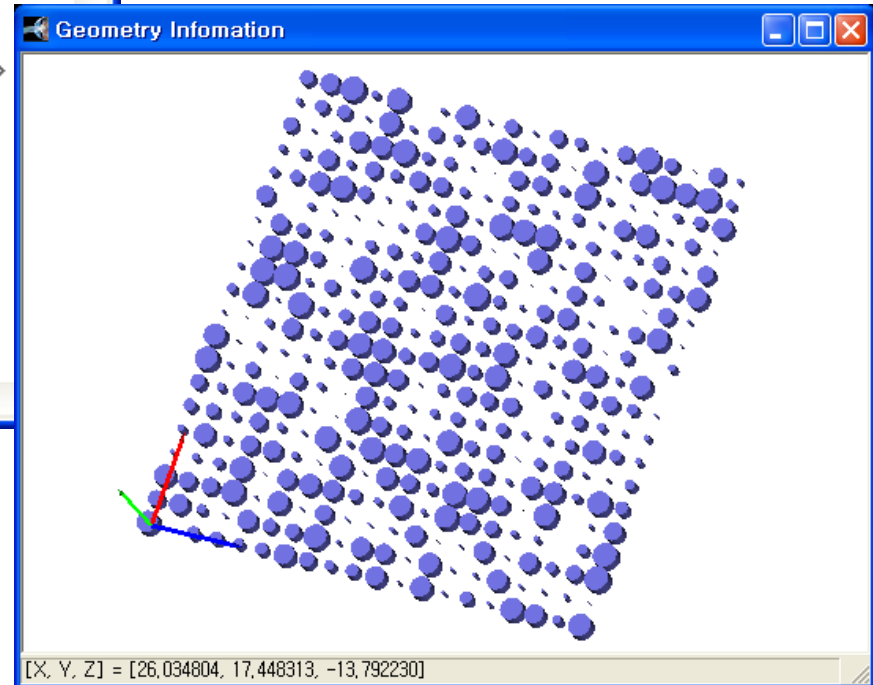
#macro IDENTIFIER ([PARAM_IDENT] [, PARAM_IDENT]...) TOKENS... #end

```
macro_end.rwz
00035
00036 #macro MyMacro(PosX,PosZ,NumX,NumY)
00037     #local ii=0;
00038     #while(ii<NumX)
00039         #local jj=0;
00040         #while(jj<NumY)
00041             object{
00042                 UnitObject
00043                 translate <PosX+2*ii,0,PosZ+2*jj>
00044             }
00045             #local jj=jj+1;
00046         #end
00047         #local ii=ii+1;
00048     #end
00049 #end
00050
00051 MyMacro(2,2,3,3)
00052 MyMacro(-6,-6,3,3)
```



Macro Basic: #macro, #end (2)

```
macro_end_2.rwz
00036 #declare R1 = seed(10000);
00037 #macro MyMacro(PosX,PosZ,NumX,NumY)
00038     #local ii=0;
00039     #while(ii<NumX)
00040         #local jj=0;
00041         #while(jj<NumY)
00042             object{
00043                 UnitObject
00044                 #local RVal=rand(R1);
00045                 #if(0.5<=RVal<=1)
00046                 #else
00047                     #local RVal=1;
00048                 #end
00049                 scale<RVal,1,RVal>
00050                 translate <PosX+2*ii,0,PosZ+2*jj>
00051             }
00052             #local jj=jj+1;
00053         #end
00054         #local ii=ii+1;
00055     #end
00056 #end
00057
00058 MyMacro(0,0,20,20)
00059
```



Macro Basic: #declare, #local array

ARRAY_DECLARATION:

#declare IDENTIFIER = array[INT][[INT]]..[ARRAY_INITIALIZER] |

#local IDENTIFIER = array[INT][[INT]].[ARRAY_INITIALIZER]

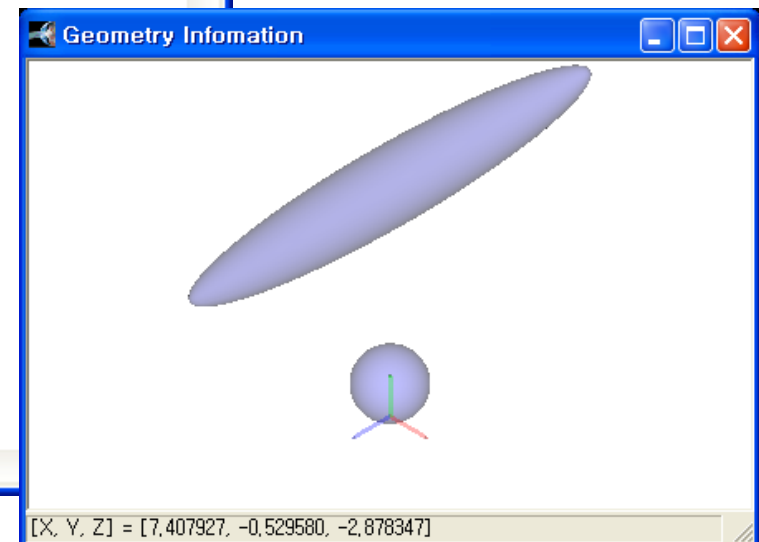
ARRAY_INITIALIZER:

{ARRAY_ITEM, [ARRAY_ITEM,]... }

ARRAY_ITEM:

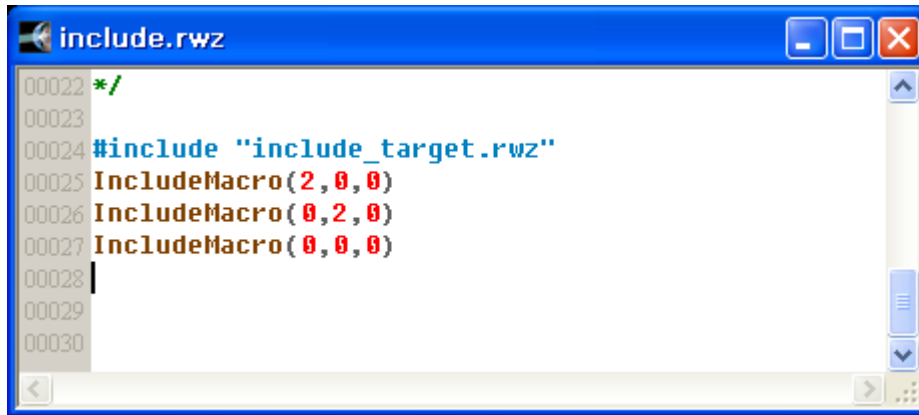
RVALUE | ARRAY_INITIALIZER

```
array.rwz
00037 #declare LocationArray = array[4][10] //4행(0 ~ 3) 10열(0 ~ 9)
00038 {
00039   {7,6,7,0,2,1,6,5,5,0},
00040   {1,2,3,4,5,6,7,8,9,0},
00041   {0,9,8,7,6,5,4,3,2,1},
00042   {1,1,2,2,3,3,4,4,5,5}
00043 }
00044
00045 #macro SphereArray(A,B)
00046 object{
00047   Sphere0
00048   translate<0,LocationArray[A][B],0>
00049   scale<1,1,LocationArray[A][B]>
00050 }
00051 #end
00052
00053 SphereArray(2,3)
00054 SphereArray(3,1)|
```

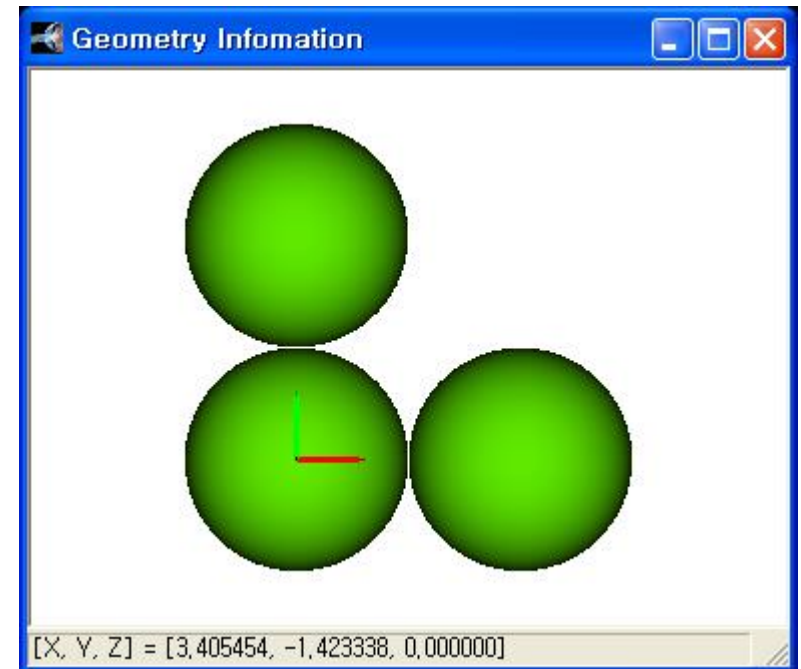


Macro Basic: #include

#include "filename"



```
00022 */
00023
00024 #include "include_target.rwz"
00025 IncludeMacro(2,0,0)
00026 IncludeMacro(0,2,0)
00027 IncludeMacro(0,0,0)
00028
00029
00030
```



Macro Basic: #fopen, #fclose

FOPEN_DIRECTIVE:

#fopen IDENTIFIER "filename" OPEN_TYPE

OPEN_TYPE:

read | write | append

FCLOSE_DIRECTIVE:

#fclose FILE_HANDLE_IDENTIFIER

READ_DIRECTIVE:

#read (FILE_HANDLE_IDENTIFIER, DATA_IDENTIFIER[,DATA_IDENTIFIER]..)

DATA_IDENTIFIER:

**UNDECLARED_IDENTIFIER | FLOAT_IDENTIFIER | VECTOR_IDENTIFIER |
STRING_IDENTIFIER**

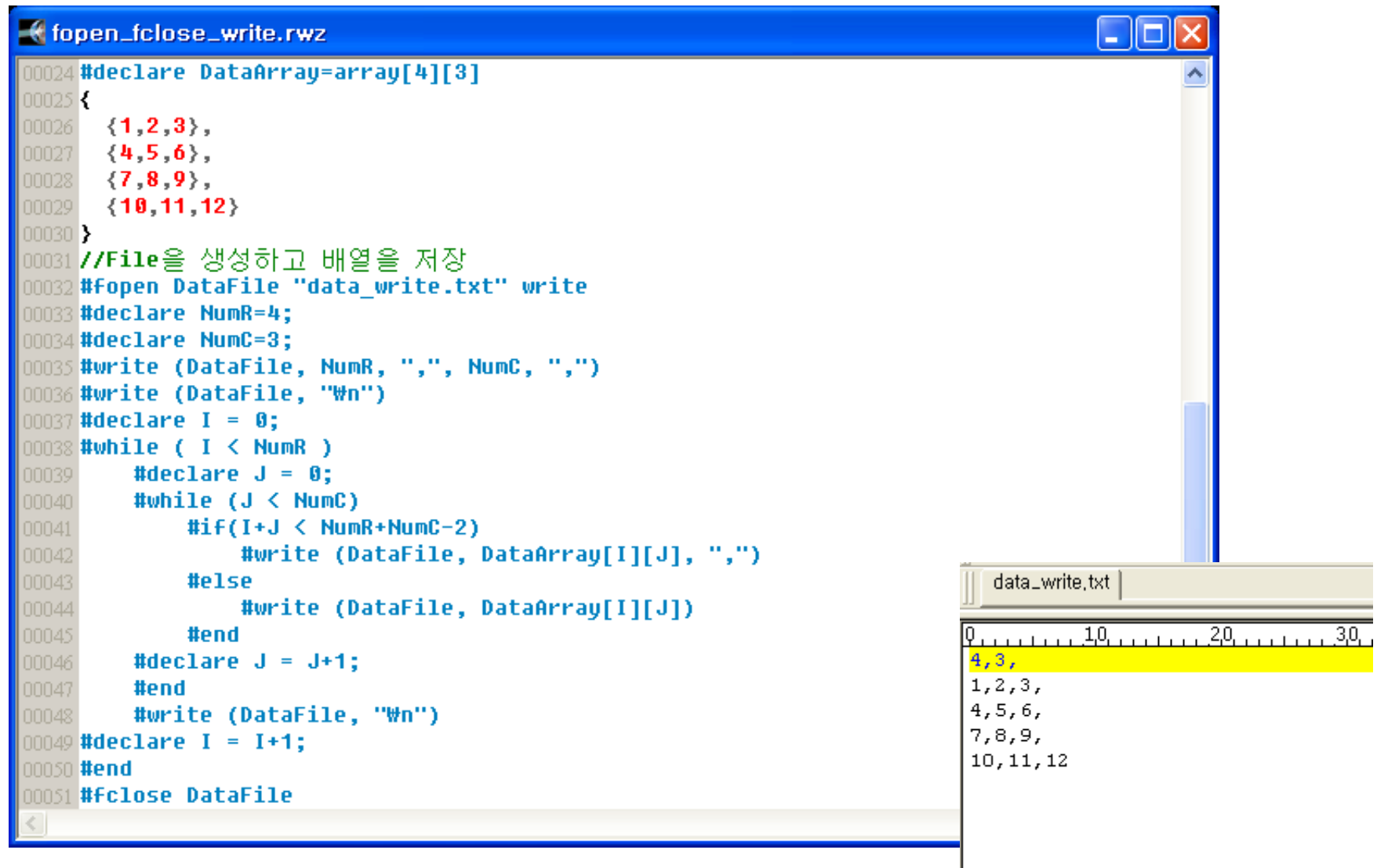
WRITE_DIRECTIVE:

#write(FILE_HANDLE_IDENTIFIER, DATA_ITEM[,DATA_ITEM]...)

DATA_ITEM:

FLOAT | VECTOR | STRING

Macro Basic: #fopen, #fclose - #write



```
00024 #declare dataArray=array[4][3]
00025 {
00026     {1,2,3},
00027     {4,5,6},
00028     {7,8,9},
00029     {10,11,12}
00030 }
00031 //File을 생성하고 배열을 저장
00032 #fopen DataFile "data_write.txt" write
00033 #declare NumR=4;
00034 #declare NumC=3;
00035 #write (DataFile, NumR, ",", NumC, ",")
00036 #write (DataFile, "\n")
00037 #declare I = 0;
00038 #while ( I < NumR )
00039     #declare J = 0;
00040     #while (J < NumC)
00041         #if(I+J < NumR+NumC-2)
00042             #write (DataFile, dataArray[I][J], ",")
00043         #else
00044             #write (DataFile, dataArray[I][J])
00045         #end
00046         #declare J = J+1;
00047     #end
00048     #write (DataFile, "\n")
00049     #declare I = I+1;
00050 #end
00051 #fclose DataFile
```

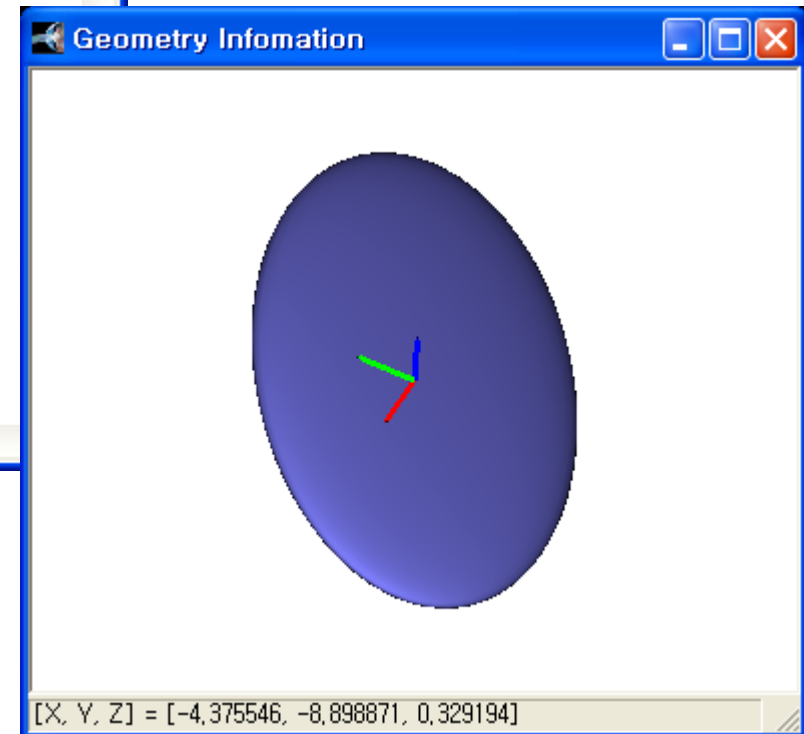
data_write.txt

0 10 20 30

4,3,
1,2,3,
4,5,6,
7,8,9,
10,11,12

Macro Basic: #fopen, #fclose - #read

```
fopen_fclose_read.rwz
00036
00037 //File을 읽어 배열에 할당
00038 #fopen DataFile "data_write.txt" read
00039 #read(DataFile, NumR1, NumC1)
00040 #declare NumR=NumR1;
00041 #declare NumC=NumC1;
00042 #declare DataArray = array[NumR][NumC]
00043 #declare I = 0;
00044 #while ( I < NumR )
00045     #declare J = 0;
00046     #while (J < NumC)
00047         #read (DataFile, MyData)
00048         #declare DataArray[I][J] = MyData;
00049         #declare J = J+1;
00050     #end
00051 #declare I = I+1;
00052 #end
00053 #fclose DataFile
00054
00055 object{
00056     SphereUnit
00057     scale<DataArray[0][0],DataArray[1][1],DataArray[2][2]>
00058 }
00059
```



Macro Grammar II

- RBT: [Sequence, Loop] -

RBT: Syntax (1)

```
RBT :  
    [RBT_TYPE] ,  
    [RBT_STATEMENT]
```

```
RBT_TYPE:  
    [ SEQUENCE | LOOP | OPTIMIZE ]
```

RBT_STATEMENT :

SEQUENCE :

```
    Number of files,  
    { "FileName" , [OUTPUT TYPE]}  
    { "FileName" , [OUTPUT TYPE]}  
    ...
```

LOOP :

```
    Number of Loop Variable1, Number of Loop Variable2,..., Number of Loop VariableN,  
    FILE    { "FileName" , [OUTPUT TYPE] }  
    SCRIPT  string
```

RBT: Syntax (2)

OPTIMIZE :

LIMIT	<i>number</i>
SCRIPT_FILE	<i>"FileName"</i>
OBJECTIVE_FUNCTION	{ [OBJECTIVE FUNCTION]}

TARGET_VALUE	{ [INTENSITY_VALUE <i>number</i> CIE_VALUE < <i>val</i> , <i>va</i> >] }
--------------	---

DELTA	<i>number</i>
-------	---------------

VARIABLES

{

Number of variables,
<Lower bound, Upper bound> ,
<Lower bound, Upper bound> ,
...

}

RBT: Syntax (3)

OUTPUT TYPE :

RAW_DATA | DETECTOR_DATA | RASTER_DATA | SPECTRUM_DATA | IMAGE_DATA [*null* | ALL]

OBJECTIVE FUNCTION :

DETECTOR_NUM

{

"Detector Name 1 ",

[**VALUE TYPE**] [**CONDITION**] [COMPARE] [VALUE]

}

..

{

"Detector Name N ",

[**VALUE TYPE**] [**CONDITION**] [COMPARE] [VALUE]

}

RBT: Syntax (4)

VALUE TYPE :

[Illuminance | Spatial_Luminance | Angular_Luminance | Illuminance_CIExy |
Luminance_CIExy | Intensity | Intensity_CIExy | Total_Flux]

CONDITION :

[**TOTAL** | **FUNCTION**]

TOTAL : Total

FUNCTION :

Function_Express “ [**OPERATOR**] [**Bin Index**] + [*Number*] “

COMPARE :

= | < | > | <= | >=

VALUE : Number

OPERATOR :

[(|) | + | - | * | / | sqrt | sqr | exp | pow | sin | cos | tan]

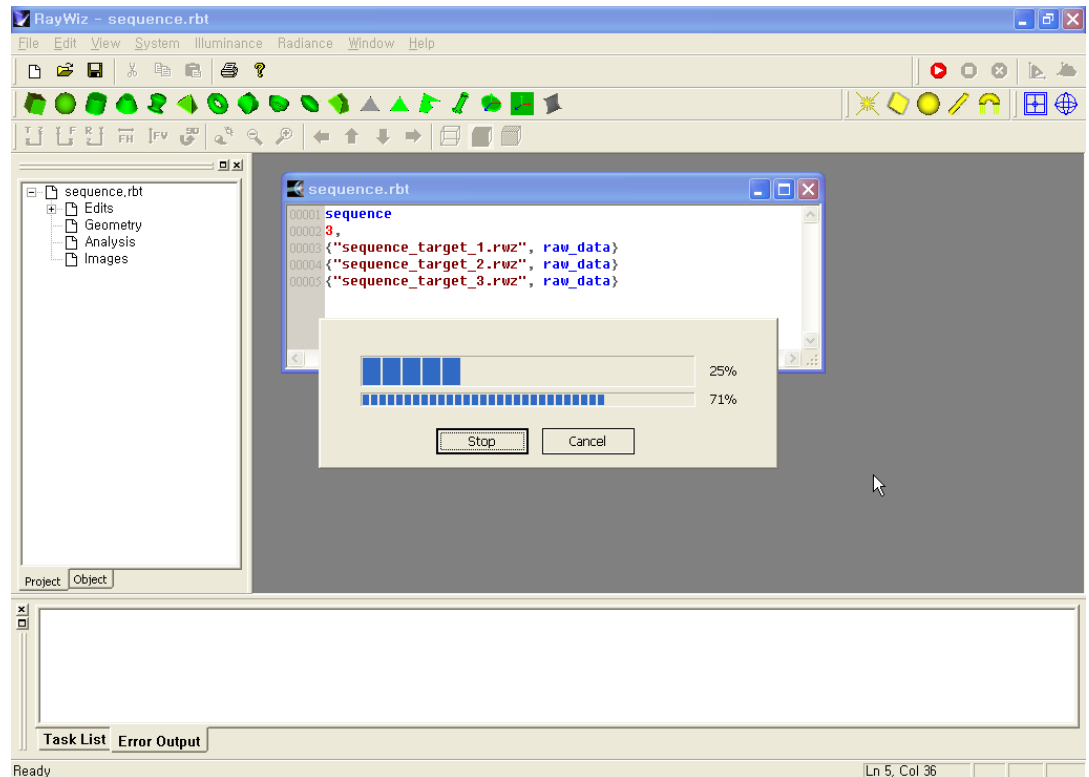
Bin Index : bin[i, j] | bin[i1 ~ i2, j1 ~ j2] | maxbin[i1 ~ i2, j1 ~ j2] | minbin[i1 ~ i2, j1 ~
j2] | meanbin[i1 ~ i2, j1 ~ j2] | totalMax | totalMin | totalMean

i, j : 0 .. N

RBT: Sequence

```
sequence.rbt
00001 sequence
00002 3,
00003 {"sequence_target_1.rwz", raw_data}
00004 {"sequence_target_2.rwz", raw_data}
00005 {"sequence_target_3.rwz", raw_data}
```

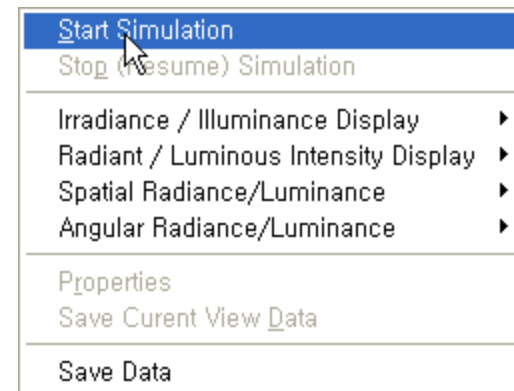
- Start Simulation
- Stop (Resume) Simulation
- Irradiance / Illuminance Display ▶
- Radiant / Luminous Intensity Display ▶
- Spatial Radiance/Luminance ▶
- Angular Radiance/Luminance ▶
- Properties
- Save Current View Data
- Save Data



RBT: Loop (1)

```
loop_target.rwz
00038 }
00039 emittance
00040 {
00041     radiometric 1
00042     measured_whole on
00043     aim_sphere <0, 0+(nextstep-1)*5>
00044     angular_distribution
00045     {
00046         uniform
00047     }
00048     volume_distribution
00049     {
00050         uniform
00051     }
00052 }
00053 point_at <0, 5, 0>
00054 }
```

```
loop.rbt
00001 loop
00002 5,
00003 file {"loop_target.rwz", raw_data}
00004
```



RBT: Loop (2)

```
loop_multi_target.rwz
00057
00058 #declare SuperEllipsoid1 =
00059 superellipsoid
00060 {
00061     <1.0+$x0*0.1, 1.0+$x1*0.1>
00062     color<1,1,1>
00063     ior 1.5
00064     surface {
00065         both {
00066             probabilistic_split on
00067         }
00068     }
00069     translate<0,2,0>
00070 }
00071
```

```
loop_multi.rbt
00001 loop
00002 3,3,
00003 file {"loop_multi_target.rwz", raw_data}
00004
```

Microsoft Excel - loop_multi.csv

	A	B	C	D
1	Index	\$x0	\$x1	
2	1	1	1	
3	2	2	1	
4	3	3	1	
5	4	1	2	
6	5	2	2	
7	6	3	2	
8	7	1	3	
9	8	2	3	
10	9	3	3	
11				

Macro Grammar III

- RBT: [Optimization] -

Optimization in RAYWIZ

Optimization: Center Intensity Maximization

The screenshot displays the RayWiz software interface for optimization. The main window, titled "RayWiz - Optimize_BEf.rbt", shows a project tree on the left with folders for Edits, Geometry, Analysis, and Images. The central area displays a configuration window for "Optimize_BEf.rbt" with a code editor showing the following configuration:

```
00006 1
00007 {
00008     "FarFieldDetector",
00009     Intensity function_express "meanbin[0~0,0~36]" >= 80
00010 }
00011 }
00012
00013
00014
00015
00016
00017
00018
00019
00020
```

Below the code editor, there are two progress bars: one for "65%" and another for "3%". Buttons for "Stop" and "Cancel" are visible.

The bottom panel shows the "Task List" and "Error Output" tabs. The "Task List" tab displays the following information:

1	BOX	50000	100(WATT)	100(LUMEN)
Simulation input : [91.829972587297689] [1.575]				
Simulation result : [54.8382091]				
409 objects parsed.				

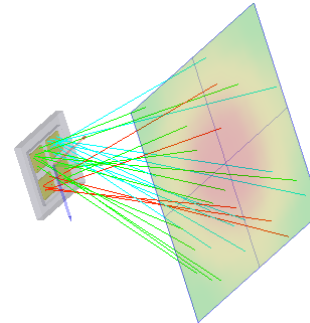
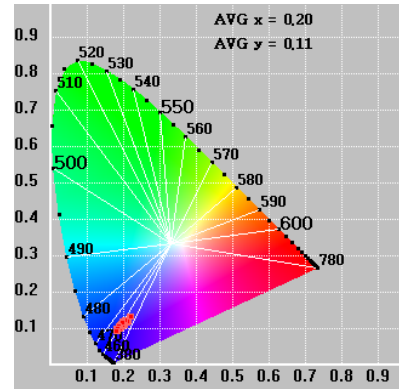
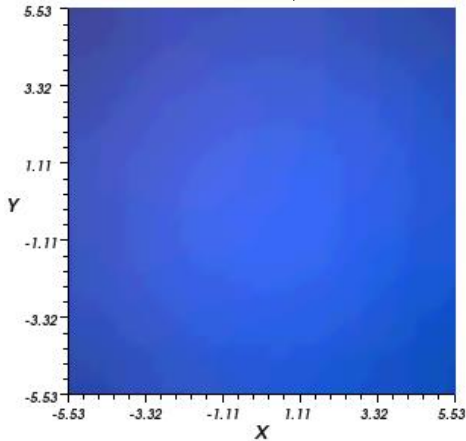
The "Error Output" tab is currently empty.

A separate window titled "BEF.rwz" is open, showing the following configuration:

```
00001 #declare Apex_Angle=$x0; //프리즘 꼭지각
00002 #declare Pitch=0.050; //prism pitch (mm)
00003 #declare BEF_IOR=$x1; //프리즘 수지 굴절률
00004 #declare PET_IOR=1.64; //기재필름 굴절률
00005
00006 global_settings {
00007     rays {
00008         trace_off_ratio 0.01
00009         total_ray_number 50000
00010         max_trace_level 10
00011         trace_path_view 100
00012         split_ray off
00013         fresnel_area_effect on
00014         random_spectrum on
00015     }
00016     force_parsing off
00017 }
```

Optimization: Color Balance

Initial



```

00000 #declare CupBaseIn_Y = 2*Pixel_Y;
00001 #declare CupBaseOut_X = CupBaseIn_X+1;
00002 #declare CupBaseOut_Y = CupBaseIn_Y+1;
00003 #declare CupDepth = 0.2;
00004 #declare Power = 100;
00005 #declare Ratio_R = $x0+1;//ex)lumen 28:25:5
00006 #declare Ratio_G = $x1+1;
00007 #declare Ratio_B = $x2+1;
00008 #declare Power_R = Power*Ratio_R;
00009 #declare Power_G = Power*Ratio_G;
00010 #declare Power_B = Power*Ratio_B;
00011 #declare LED_Space_X = 10; //10mm
00012 #declare LED_Space_Y = 10; //65mm
00013 #declare Display_X = 2*25.4*4/18.3576; //NumLED_X*LED_Space_X;
00014 #declare Display_Y = 2*25.4*4/18.3576; //NumLED_Y*LED_Space_Y;
    
```

Optimize_RGGB4in1.rbt

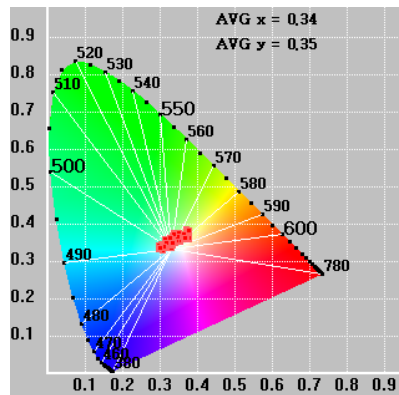
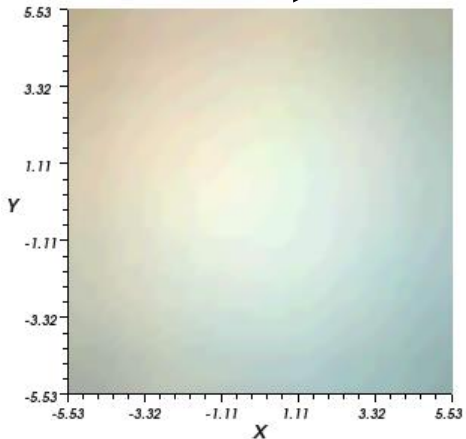
```

00001 optimize
00002 limit 100
00003 script_file "RGGB4in1.rwz"
00004 objective_function
00005 {
00006     "PlaneDetector",
00007     Illuminance_CIExy function_express
00008     "(Bin[4,4]+Bin[5,5]+Bin[4,5]+Bin[5,4])/4"
00009 }
00010 target_value { CIE_Value <0.31,0.31> }
00011 delta 0.01
00012 variable
00013 {
    
```

Microsoft Excel - Optimize_RGGB4in1_opt20070324123018.csv

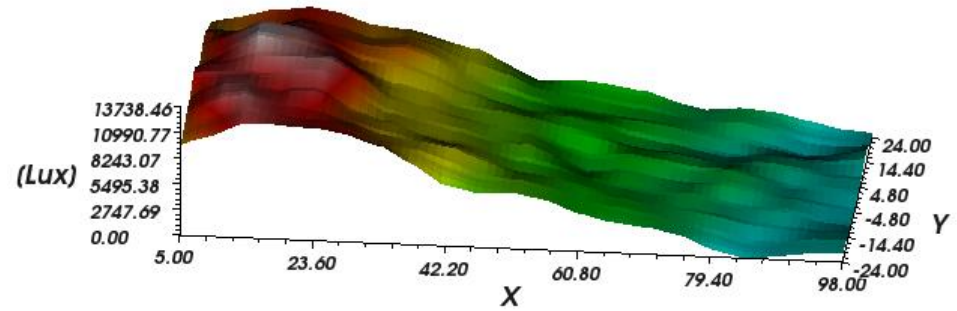
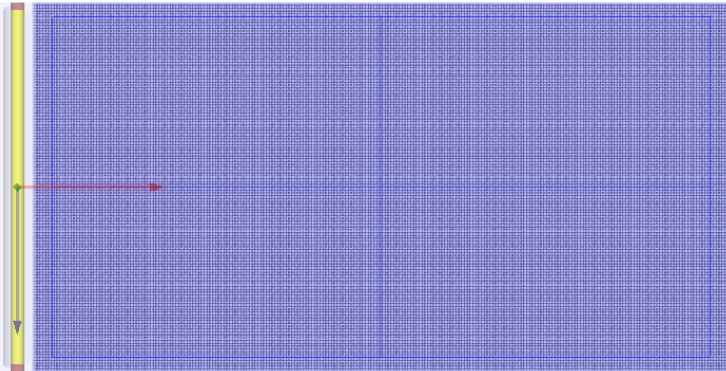
	A	B	C	D	E	F
	Calculation	Variable0	Variable1	Variable2	Objective Value1	Objective Value2
1	Temporal	17	17	17	0.198596253	0.109218354
2	Temporal	17,17	17	17	0.199062179	0.109393266
3	Temporal	17	17,17	17	0.198561995	0.10967629
4	Temporal	17	17	17,17	0.198173283	0.108593443
5	Temporal	17	17	17	0.198596253	0.109218354
6	Temporal	17,17	17	17	0.199062179	0.109393266
7	Temporal	17	17,17	17	0.198561995	0.10967629
8	Temporal	17	17	17,17	0.198173283	0.108593443
9	Temporal	25,54718441	26,79011467	1	0.377244996	0.384158987
10	Step	25,54718441	26,79011467	1	0.198596253	0.109218354
11	Temporal	25,54718441	26,79011467	1	0.377244996	0.384158987
12	Temporal	25,80265625	26,79011467	1	0.378562708	0.383809361
13	Temporal	25,54718441	27,05801582	1	0.376524715	0.385432241
14	Temporal	25,54718441	26,79011467	1.01	0.376931381	0.383680425
15	Temporal	24,12463981	28,02872676	2,73590881	0.323967017	0.322682265
16	Step	24,12463981	28,02872676	2,73590881	0.377244996	0.384158987
17	Final	24,12463981	28,02872676	2,73590881	0.377244996	0.384158987

Final

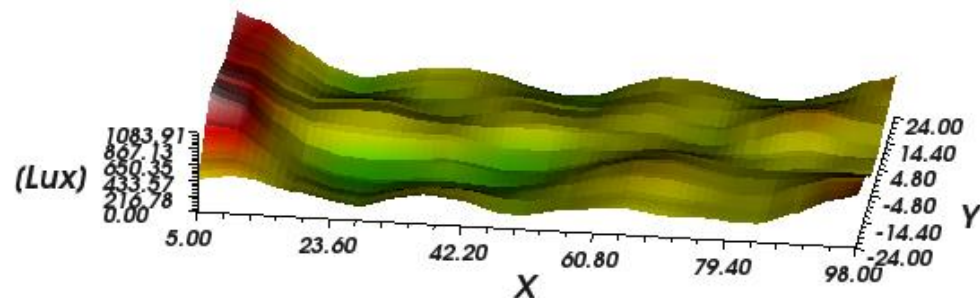
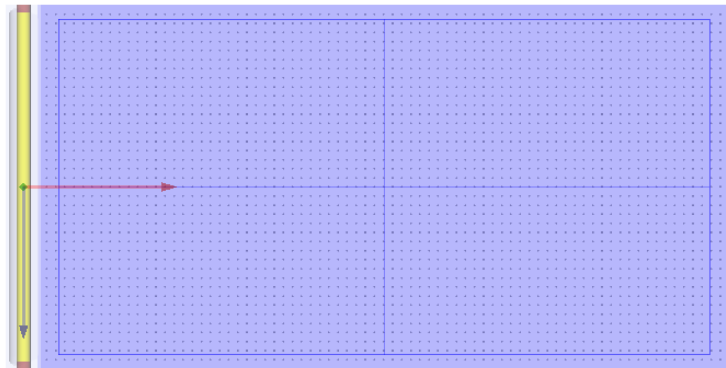


Optimization: Uniformity

Initial

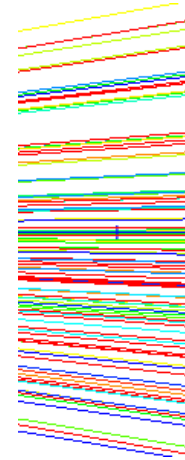
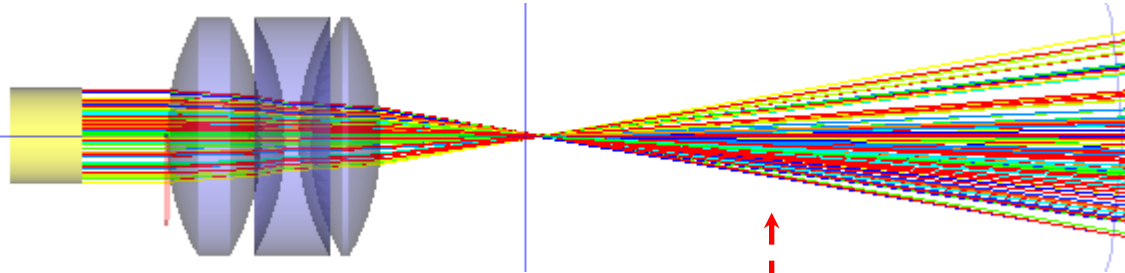


Final



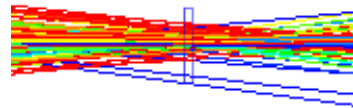
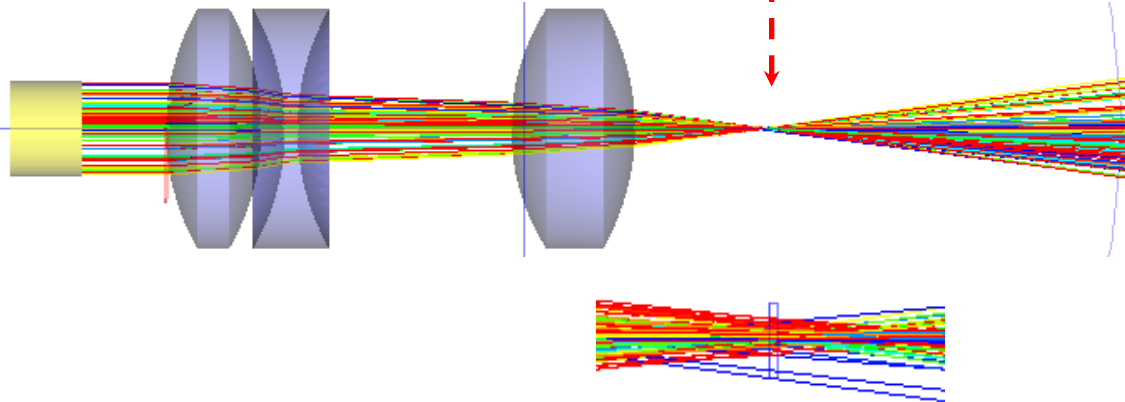
Optimization: Lens System

Initial



Target Focal Point

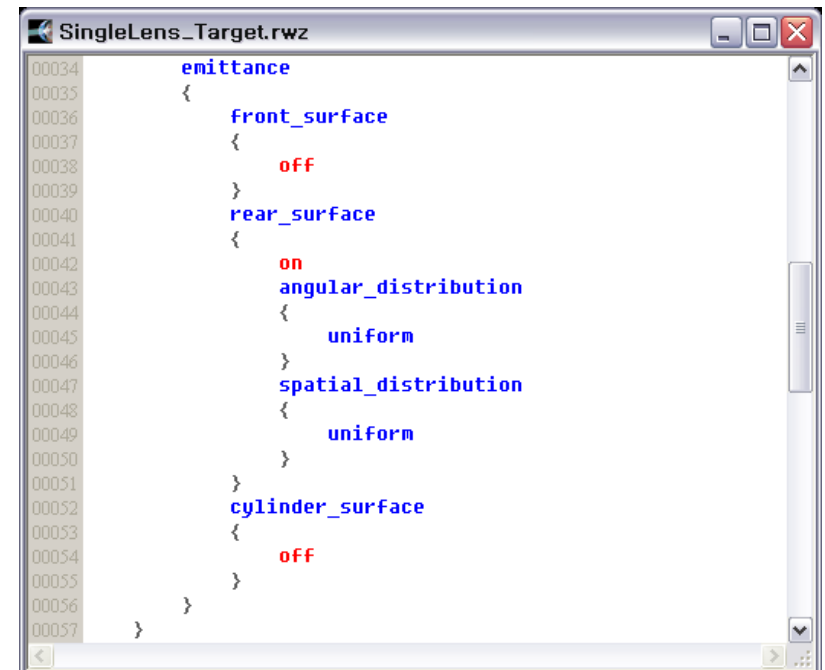
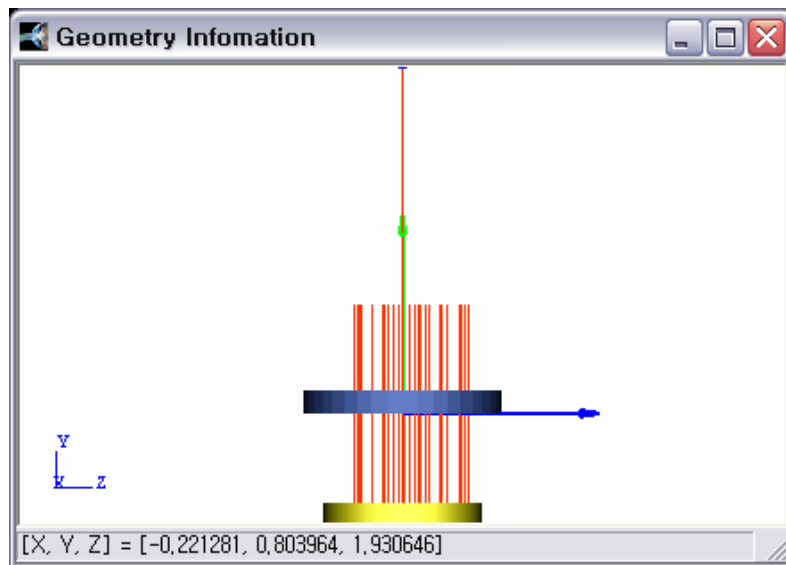
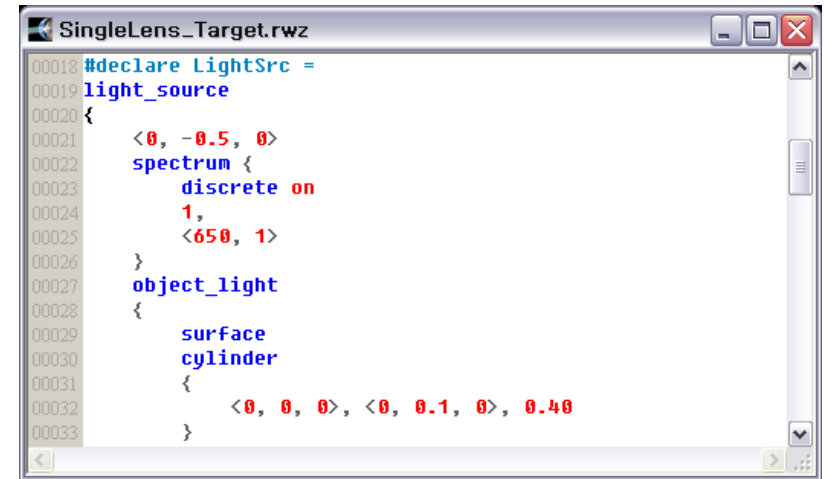
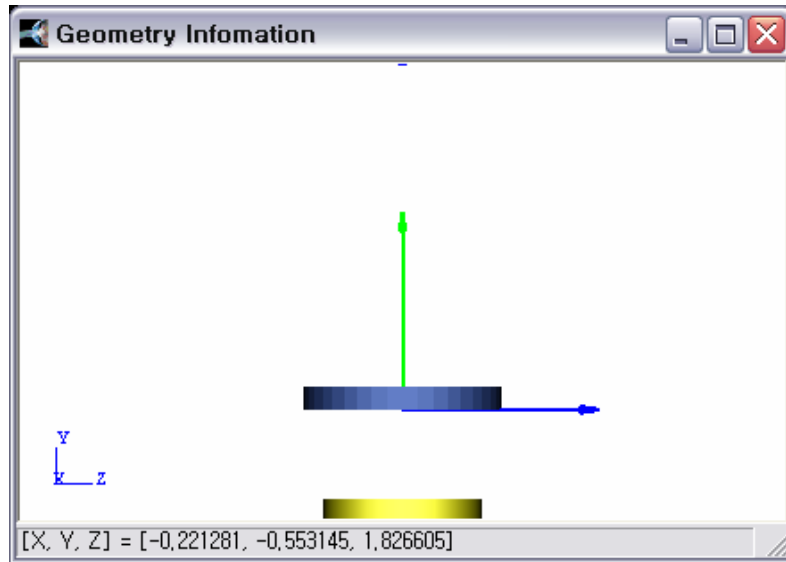
Final



Microsoft Excel - Optimize_TripleLens_opt20070324153649.csv

	A	B	C	D	E	F
	Calculation Type	Variable0	Variable1	Variable2	Variable3	Objective Value1
1	Temporal	0	0	1	0.25	0.034699999
2	Temporal	0.001	0	1	0.25	0.034599999
3	Temporal	0	0.001	1	0.25	0.034699999
4	Temporal	0	0	1.01	0.25	0.031699999
5	Temporal	0	0	1	0.2525	0.033999999
6	Temporal	0	0	1	0.25	0.034699999
7	Temporal	0.001	0	1	0.25	0.034599999
8	Temporal	0	0.001	1	0.25	0.034699999
9	Temporal	0	0	1.01	0.25	0.031699999
10	Temporal	0	0	1	0.2525	0.033999999
11	Temporal	-0.5	0	0	0	0.0004
12	Temporal	-0.5	0	0	0	0.0004
13	Temporal	-0.230815196	0	0.538369609	0.134592402	0.0077
14	Temporal	-0.082698031	0	0.834603939	0.208650985	0.953399976
15	Temporal	-0.082698031	0	0.834603939	0.208650985	0.953399976
16	Step	-0.082698031	0	0.834603939	0.208650985	0.953399976
17	Temporal	-0.082698031	0	0.834603939	0.208650985	0.953399976
18	Temporal	-0.081698031	0	0.834603939	0.208650985	0.954399976
19	Temporal	-0.082698031	0.001	0.834603939	0.208650985	0.952899976
20	Temporal	-0.082698031	0	0.842949978	0.208650985	0.972699976
21	Temporal	-0.082698031	0	0.834603939	0.210737495	0.958399976
22	Temporal	-0.078921838	-0.001888096	0.843336287	0.21770005	0.985599976
23	Step	-0.078921838	-0.001888096	0.843336287	0.21770005	0.953399976
24	Final	-0.078921838	-0.001888096	0.843336287	0.21770005	0.953399976

RBT Optimization: Focusing (1)



RBT Optimization: Focusing (2)

```
SingleLens_Target.rwz
00058   emittance
00059   {
00060       photometric 100
00061       measured_whole on
00062       aim_sphere <0, 0>
00063   }
00064   point_at <0, 2, 0>
00065 }
00066 LightSrc
```

```
SingleLens_Target.rwz
00086 #declare FocalPlane =
00087 box
00088 {
00089     <-0.025, 1.75, -0.025>, <0.025, 1.751, 0.025>
00090     detector {
00091         bottom_surface
00092         photometric
00093         bin_size <21, 21>
00094     }
00095 }
00096 FocalPlane
```

```
SingleLens_Target.rwz
00069 #declare SingleLens =
00070 optical
00071 {
00072     circular center_thickness 0.12+$x0
00073     { $x1, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00074     { $x2, 0.5, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00075     color<0,0,1>
00076     ior 1.5
00077     surface {
00078         both {
00079             probabilistic_split on
00080         }
00081     }
00082 }
00083 SingleLens
```

Optimization 대상 변수[\$x0~\$xn]
처음 초기값은 0

RBT Optimization: Focusing (3)

```
00001 optimize
00002 limit 100
00003 script_file "SingleLens_Target.rwz"
00004 objective_function
00005 {
00006     1
00007     {
00008         "FocalPlane",
00009         total_flux total >= 100
00010     }
00011 }
00012 target_value { INTENSITY_VALUE 0 }
00013 delta 0.01
00014 variables
00015 {
00016     3,
00017     <-0.1,0.2>
00018     <1,2>,
00019     <-3,-1>
00020 }
```

해를 찾기 위한 최대 허용 횟수

Optimization 대상 파일이름

목적 값을 정의할 **Detector** 수

Detector 이름

목적식

목적값

정밀도 지수

변수 개수와 변수 값
제한조건

Start Simulation	F9
Stop (Resume) Simulation	
Irradiance / Illuminance Display	▶
Radiant / Luminous Intensity Display	▶
Spatial Radiance/Luminance	▶
Angular Radiance/Luminance	▶
Properties	
Save Current View Data	
Save Data	

RBT Optimization: Focusing (4)

X0 = [0.1375383]

X1 = [1.124533]

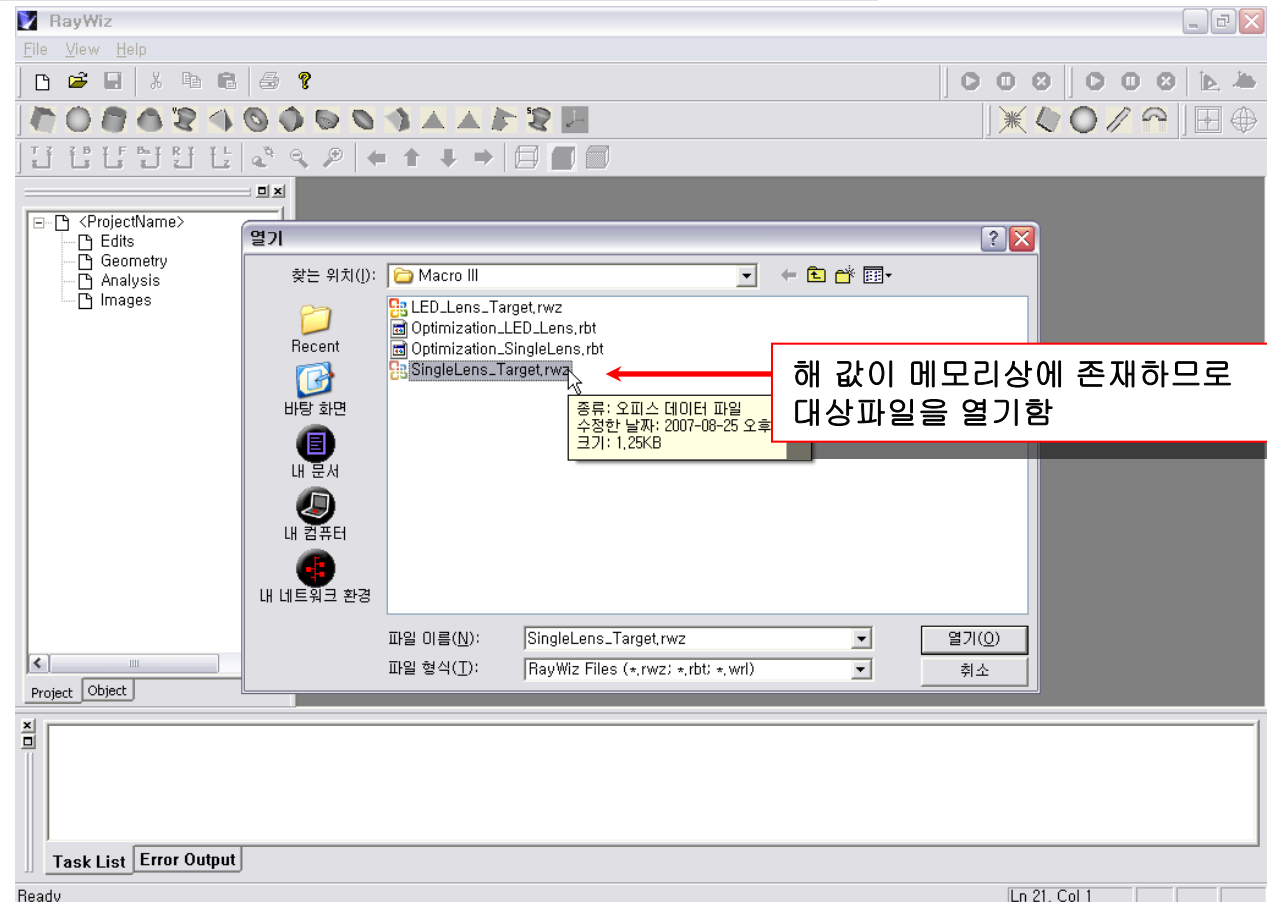
X2 = [-3]

Optimize result data saved at 'Optimization_SingleLens_opt20070826212419.csv'

Done Simulation.

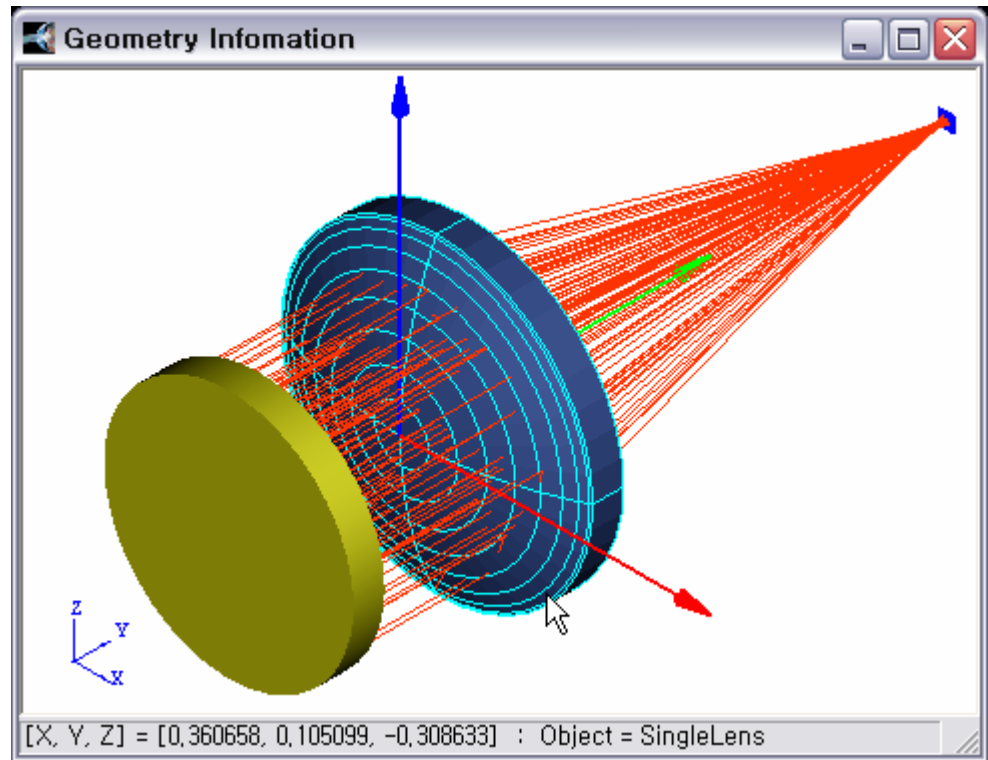
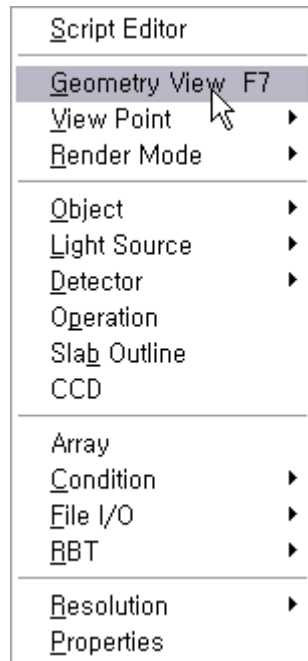
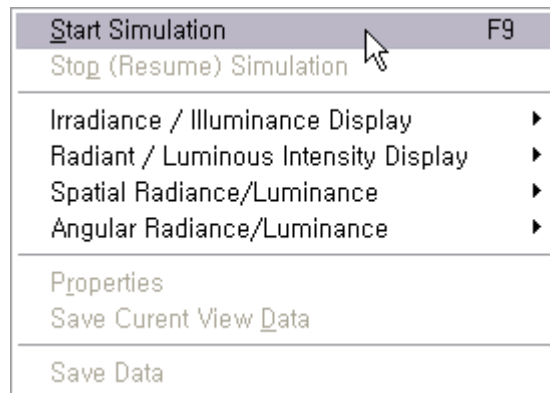
Task List Error Output

결과값 및 저장파일명



해 값이 메모리상에 존재하므로
대상파일을 열기함

RBT Optimization: Focusing (5)



RBT Optimization: Focusing (6)

Microsoft Excel - Optimization_SingleLens_opt20070825211219.csv

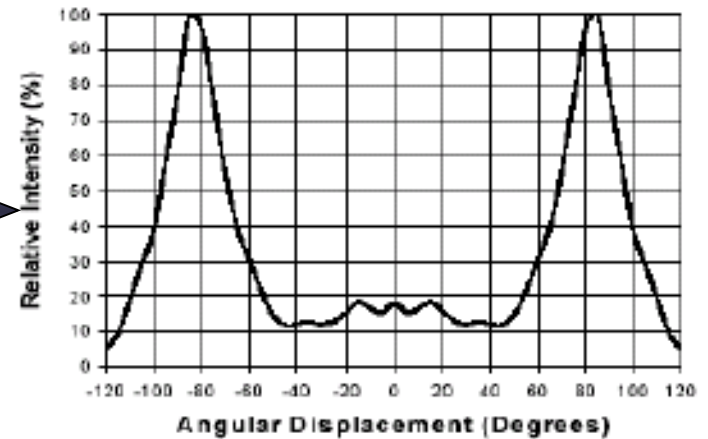
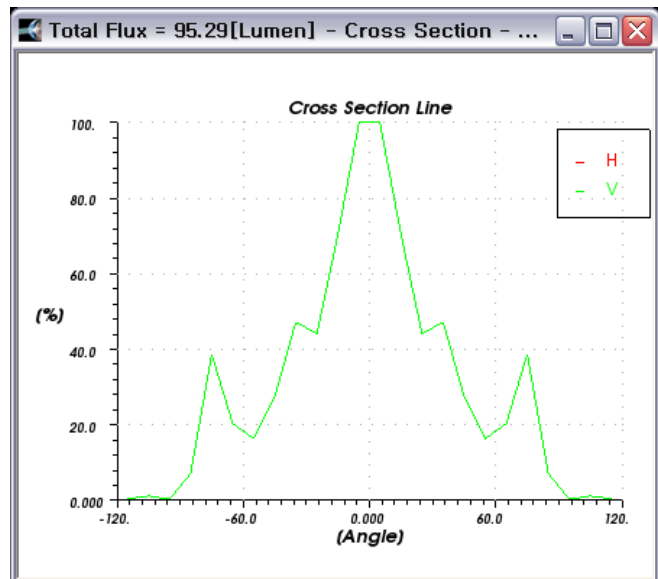
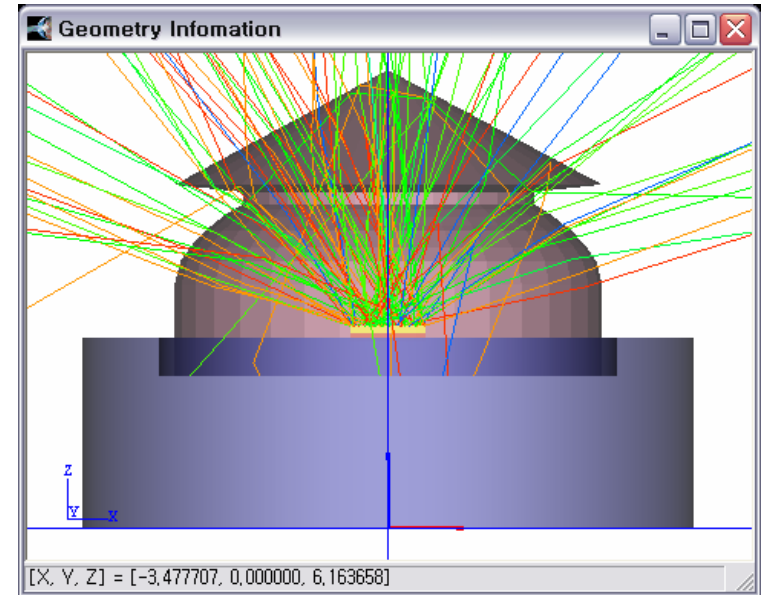
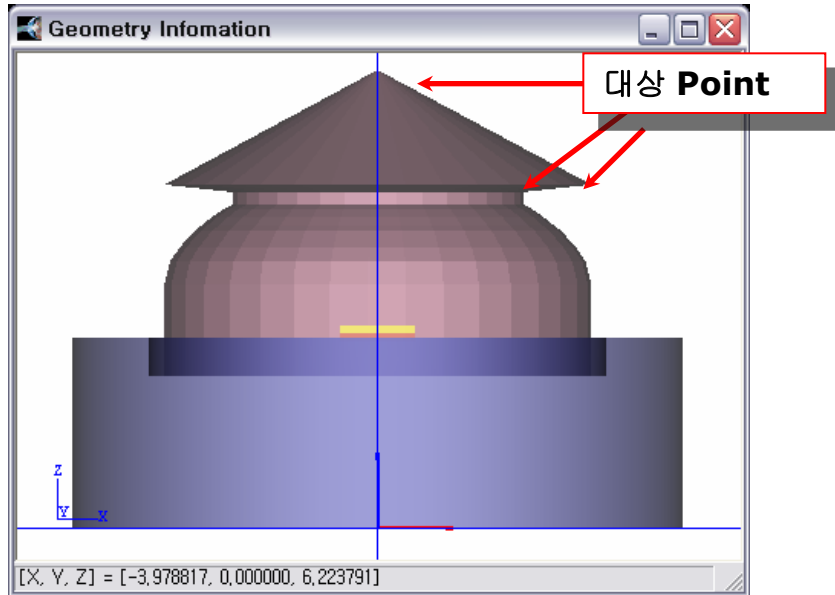
파일(F) 편집(E) 보기(V) 삽입(I) 서식(O) 도구(T) 데이터(D) 창(W) 도움말(H) Adobe

지정 목적식 값의 변화

	A32		Final				
	A	B	C	D	E	F	
19	Temporal	0.063076	1.035877	-3	0	45.1000007	
20	Temporal	0.064076	1.035877	-3	0	45.4000007	
21	Temporal	0.063076	1.046235	-3	0	48.8000007	
22	Temporal	0.063076	1.035877	-2.97	0	43.3000006	
23	Temporal	0.063076	1.035877	-3	0.001	45.1000007	
24	Temporal	0.137538	1.124533	-3	0	91.5000014	
25	Step	0.137538	1.124533	-3	0	91.5000014	
26	Temporal	0.137538	1.124533	-3	0	91.5000014	
27	Temporal	0.138914	1.124533	-3	0	91.5000014	
28	Temporal	0.137538	1.135778	-3	0	91.5000014	
29	Temporal	0.137538	1.124533	-2.97	0	91.5000014	
30	Temporal	0.137538	1.124533	-3	0.001	91.5000014	
31	Step	0.137538	1.124533	-3	0	91.5000014	
32	Final	0.137538	1.124533	-3	0	91.5000014	
33							

대상 변수 해의 값의 변화

RBT Optimization: Angular Profile (1)



RBT Optimization: Angular Profile (2)

```
LED_Lens_Target.rwz
00001 global_settings {
00002     rays {
00003         trace_off_ratio 0.000001
00004         total_ray_number 50000
00005         max_trace_level 10
00006         trace_path_view 100
00007         split_ray off
00008         fresnel_area_effect on
00009         random_spectrum on
00010     }
00011     force_parsing off
00012     polarization off
00013     units millimeters
00014     summary on
00015     geometry_intensity on
00016 }
```

```
LED_Lens_Target.rwz
00018 #declare DieBase =
00019 box
00020 {
00021     <-0.5, -0.5, 0>, <0.5, 0.5, 0.1>
00022     color <1,0,0>
00023     surface {
00024         both {
00025             reflectance {1 gaussian 5}
00026             transmittance{0}
00027         }
00028     }
00029     translate<0,0,2.4499>
00030 }
```

반사체 이므로 **IOR** 항목 삭제

RBT Optimization: Angular Profile (3)

```
LED_Lens_Target.rwz
00032 //**** BaseCup ***
00033 #declare Cup=
00034 difference{
00035     cylinder{<0,0,0>, <0,0,2.5>, 4}
00036     cylinder{<0,0,2.0>, <0,0,3>, 3}
00037     color <0,0,0>
00038     surface{
00039         both
00040         {
00041             transmittance{0}
00042             reflectance {0}
00043         }
00044     }
00045 }
```

Cylinder 를 이용한 CSG Object

초기 형상정보 정의 및 변수 설정

```
LED_Lens_Target.rwz
00047 //*** Lens ***
00048 #declare Lens=
00049 lathe{
00050     linear_spline
00051     14,
00052     <0,0>,<2.8,0>,<2.8,1.2>, //base vertical
00053     <2.73,1.49>,<2.6,1.68>,<2.4,1.9>,<2.32,1.96>,
00054     <2.17,2.08>,<2.04,2.17>,<1.91,2.24>,
00055     <1.91+$x0,2.4>, //<1.5,2.4>, //1st variable
00056     <2.8+$x1,2.5+$x2>, //<2.3,3.9>, //2nd variable
00057     <0,4+$x3> //<0,2.4>, //3rd variable
00058     <0,0>
00059     ior 1.49
00060     color <1,0,1>
00061     surface {
00062         both
00063         {
00064             Probabilistic_split on
00065         }
00066     }
00067     rotate <90,0,0>
00068     translate <0,0,2.001>
00069 }
```

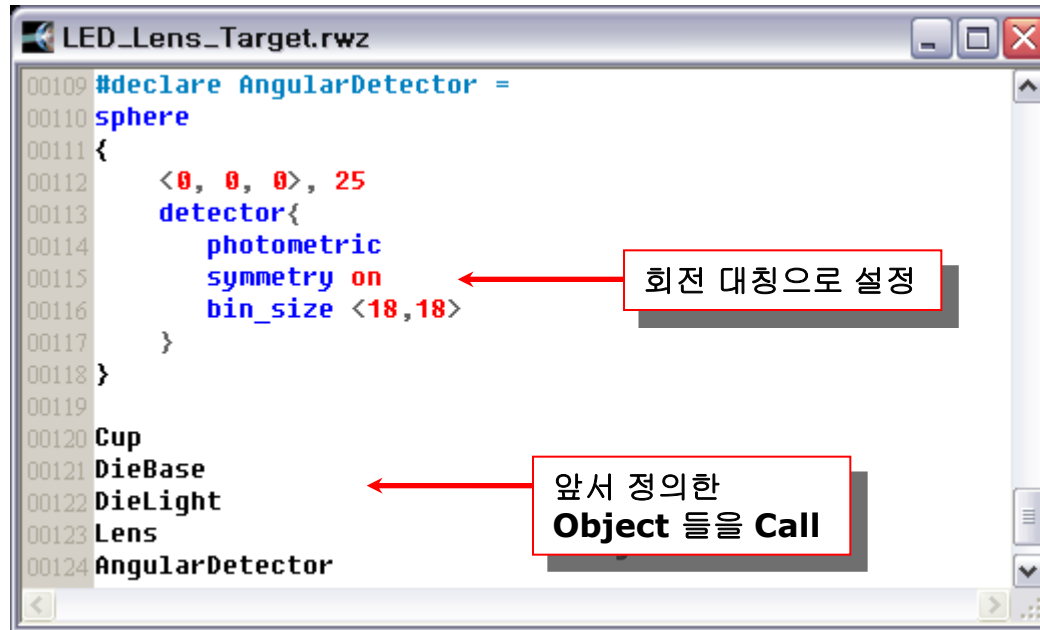
RBT Optimization: Angular Profile (4)

```
LED_Lens_Target.rwz
00071 #declare DieLight =
00072 light_source
00073 {
00074     <0,0,0>
00075     color <1,1,1>
00076     object_light
00077     {
00078         surface
00079         box
00080         {
00081             <-0.5, -0.5, 0>, <0.5, 0.5, 0.1>
00082         }
00083     }
00084 }
```

Box Surface Light를 정의하고
Spectrum은 E광원으로 설정

```
LED_Lens_Target.rwz
00083     emittance
00084     {
00085         front_surface
00086         {
00087             on
00088             angular_distribution
00089             {
00090                 lambertian
00091             }
00092             spatial_distribution
00093             {
00094                 uniform
00095             }
00096         }
00097     }
00098 }
00099 emittance
00100 {
00101     photometric 100
00102     measured_whole off
00103     aim_sphere <0, 90>
00104 }
00105 point_at <0, 0, 1>
00106 translate <0,0,2.6>
00107 }
```

RBT Optimization: Angular Profile (5)

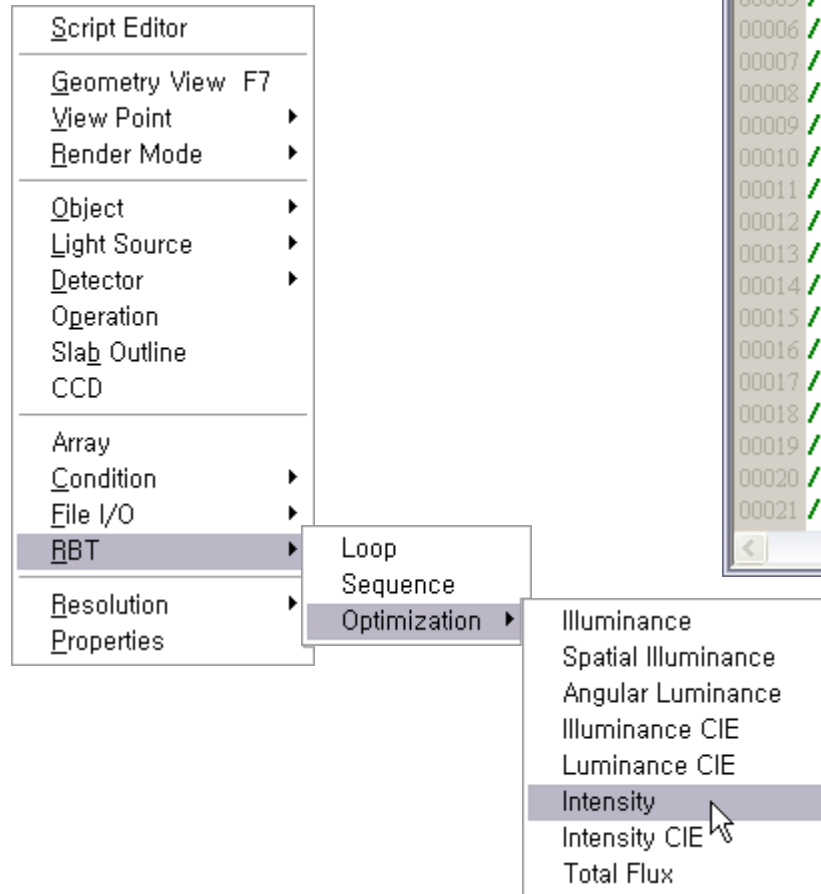


```
00109 #declare AngularDetector =
00110 sphere
00111 {
00112     <0, 0, 0>, 25
00113     detector{
00114         photometric
00115         symmetry on
00116         bin_size <18,18>
00117     }
00118 }
00119
00120 Cup
00121 DieBase
00122 DieLight
00123 Lens
00124 AngularDetector
```

회전 대칭으로 설정

앞서 정의한 Object 들을 Call

RBT Optimization: Angular Profile (6)



The screenshot shows the 'Optimization_LED_Lens.rbt' script editor. The script contains a list of optimization targets, each with a line number and a comment. A red arrow points from a text box labeled '목표 값 분포' (Target Value Distribution) to the line number '00011'.

```
00001 optimize
00002 limit 100
00003 script_file "LED_Lens_Target.rwz"
00004 //8.3 <-- 5
00005 //20.0 <-- 15
00006 //13.0
00007 //13.6
00008 //26.7
00009 //52.4
00010 //78.5
00011 //100.0
00012 //41.4
00013 //14.6
00014 //0.7
00015 //0.0
00016 //0.0
00017 //0.1
00018 //0.2
00019 //0.0
00020 //0.0
00021 //0.0 <-- 175
```

RBT Optimization: Angular Profile (7)

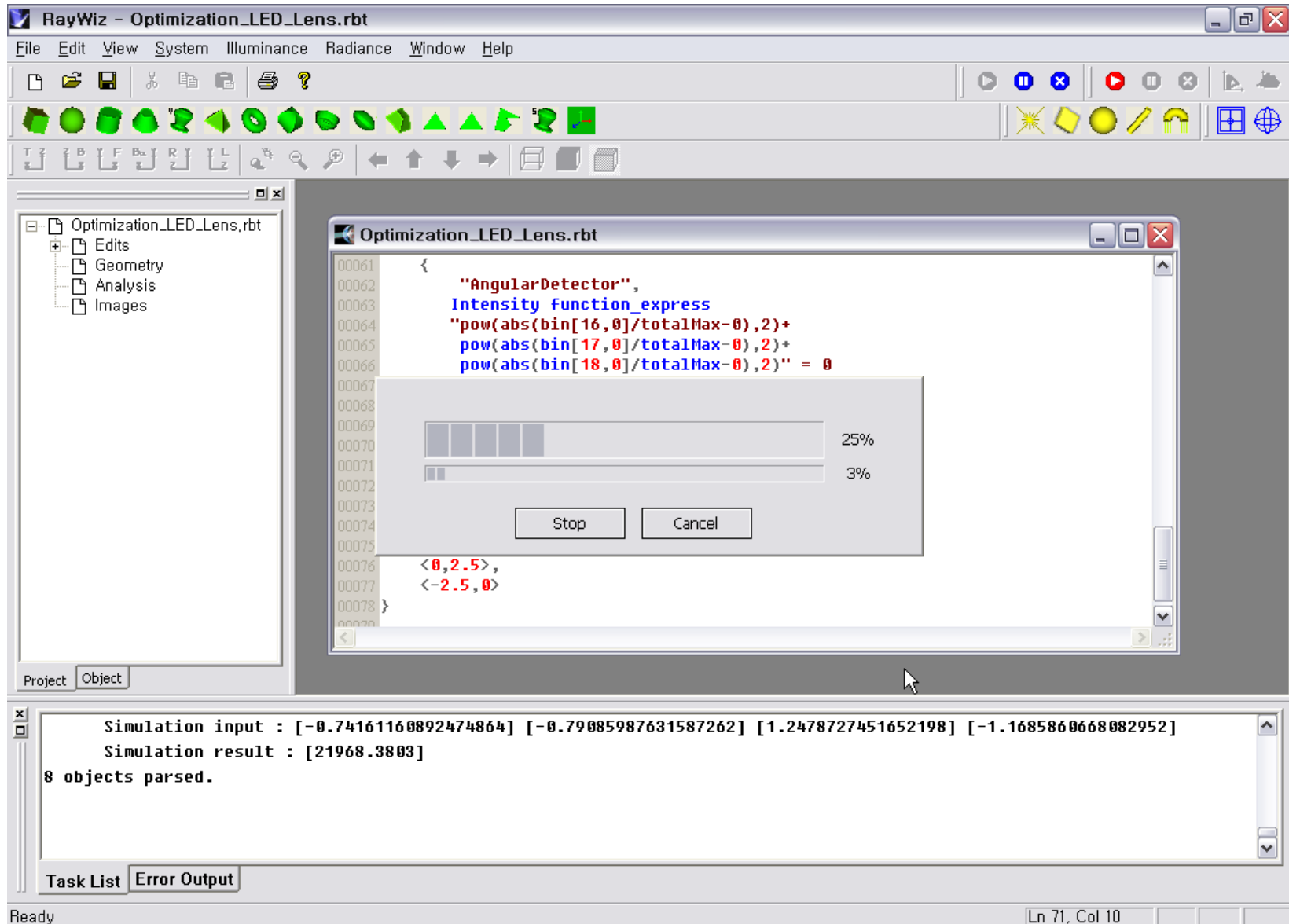
```
Optimization_LED_Lens.rbt
00023 objective_function
00024 {
00025     6
00026     {
00027         "AngularDetector",
00028         Intensity function_express
00029         "pow(abs(bin[1,0]/totalMax-8.3),2)+
00030         pow(abs(bin[2,0]/totalMax-20.0),2)+
00031         pow(abs(bin[3,0]/totalMax-13.0),2)" = 0
00032     }
00033     {
00034         "AngularDetector",
00035         Intensity function_express
00036         "pow(abs(bin[4,0]/totalMax-13.6),2)+
00037         pow(abs(bin[5,0]/totalMax-26.7),2)+
00038         pow(abs(bin[6,0]/totalMax-52.4),2)" = 0
00039     }
00040     {
00041         "AngularDetector",
00042         Intensity function_express
00043         "pow(abs(bin[7,0]/totalMax-78.5),2)+
00044         pow(abs(bin[8,0]/totalMax-100),2)+
00045         pow(abs(bin[9,0]/totalMax-41.4),2)" = 0
00046     }
}
```

```
Optimization_LED_Lens.rbt
00047 {
00048     "AngularDetector",
00049     Intensity function_express
00050     "pow(abs(bin[10,0]/totalMax-14.6),2)+
00051     pow(abs(bin[11,0]/totalMax-0.7),2)+
00052     pow(abs(bin[12,0]/totalMax-0),2)" = 0
00053 }
00054 {
00055     "AngularDetector",
00056     Intensity function_express
00057     "pow(abs(bin[13,0]/totalMax-0),2)+
00058     pow(abs(bin[14,0]/totalMax-0.1),2)+
00059     pow(abs(bin[15,0]/totalMax-0.2),2)" = 0
00060 }
00061 {
00062     "AngularDetector",
00063     Intensity function_express
00064     "pow(abs(bin[16,0]/totalMax-0),2)+
00065     pow(abs(bin[17,0]/totalMax-0),2)+
00066     pow(abs(bin[18,0]/totalMax-0),2)" = 0
00067 }
00068 }
```

```
Optimization_LED_Lens.rbt
00069 target_value { INTENSITY_VALUE 0 }
00070 delta 0.01
00071 variables
00072 {
00073     4,
00074     <-1.5,0>,
00075     <-1.5,0>,
00076     <0,2.5>,
00077     <-2.5,0>
00078 }
```

변수 값 범위

RBT Optimization: Angular Profile (8)



RBT Optimization: Angular Profile (9)

X0 = [-0.7025561]

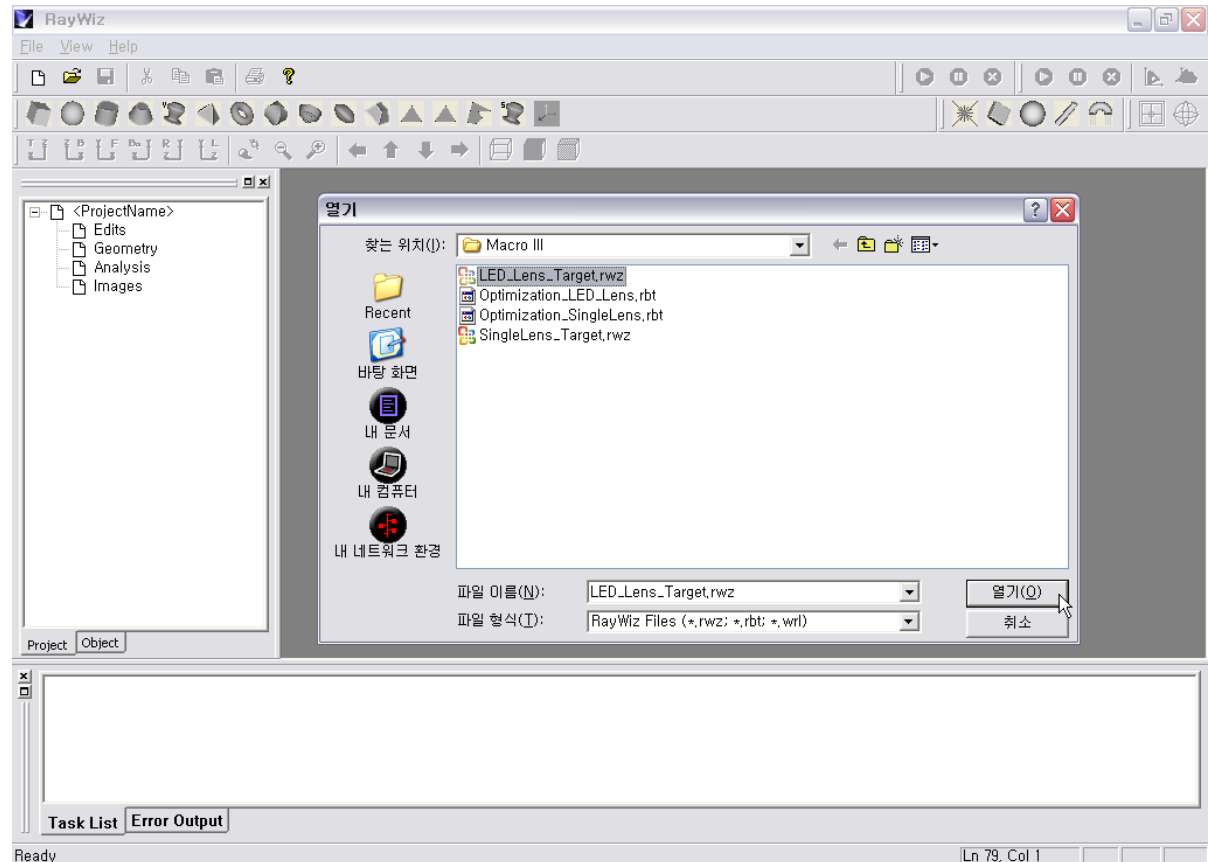
X1 = [-0.7567785]

X2 = [1.182156]

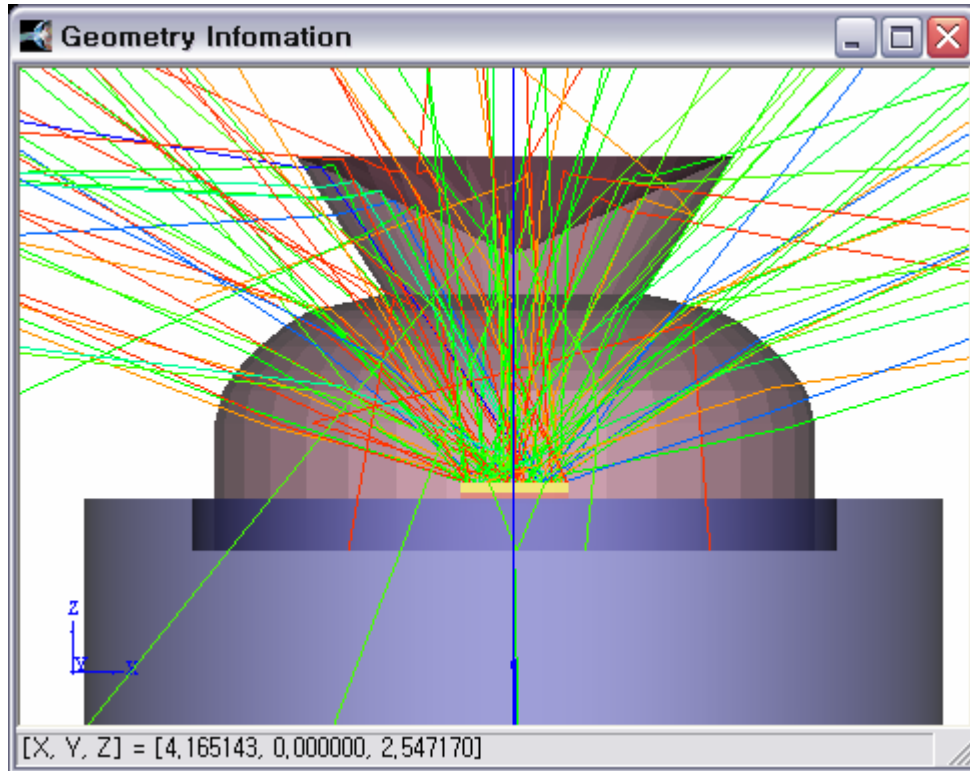
X3 = [-1.238702]

Optimize result data saved at 'Optimization_LED_Lens_opt20070825214755.csv'

Task List Error Output



RBT Optimization: Angular Profile (10)



Illuminance

CIE Color | Cross Line | Data

Illuminance Config | Spatial Radiance / Luminance | Contour

Detector Mesh Dimensions

Detector: AngularDetector

☐ User Defined MeshSize

X(Azimuth): 18 bins Base: Z

Y(Polar): 18 bins ☒ Symmetry

☐ Average Over

X(Azimuth): bins

Y(Polar): bins

☒ Far-Field Radius: 25 Limit Angle $\pm$: 15

☐ Cos Correction

Display

☒ Auto Adjust detail: 4

Scalar Bar Color: Blue -> Red 256

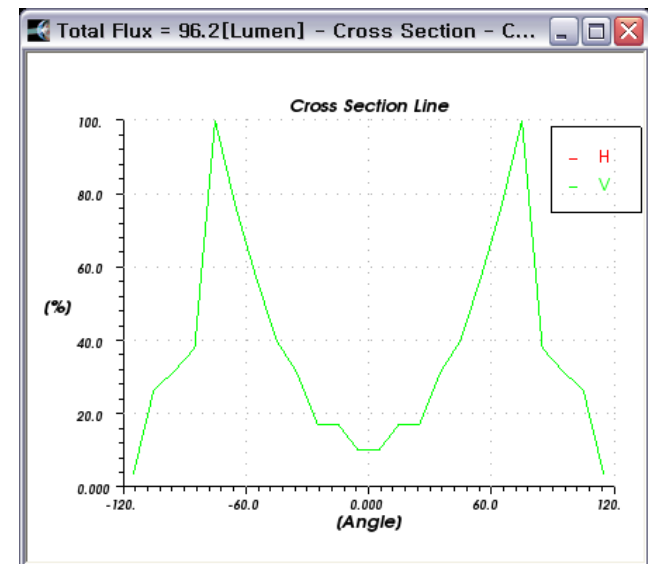
Axis Ranges

☐ Auto Range ☒ Percent(%)

Max: 0 Min: 0

Max: 120 Min: -120

OK Cancel Apply



RBT Optimization: Angular Profile (11)

Microsoft Excel - Optimization_LED_Lens_opt20070822185117.csv

파일(F) 편집(E) 보기(V) 삽입(I) 서식(O) 도구(T) 데이터(D) 창(W) 도움말(H) Adobe PDF(B) 질문을 입력하십시오.

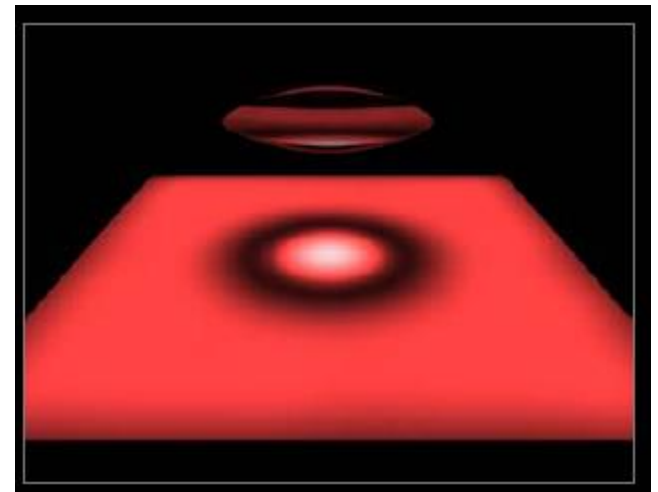
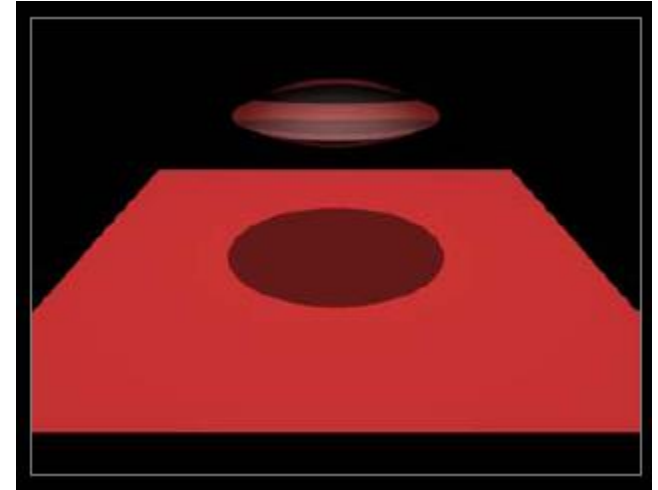
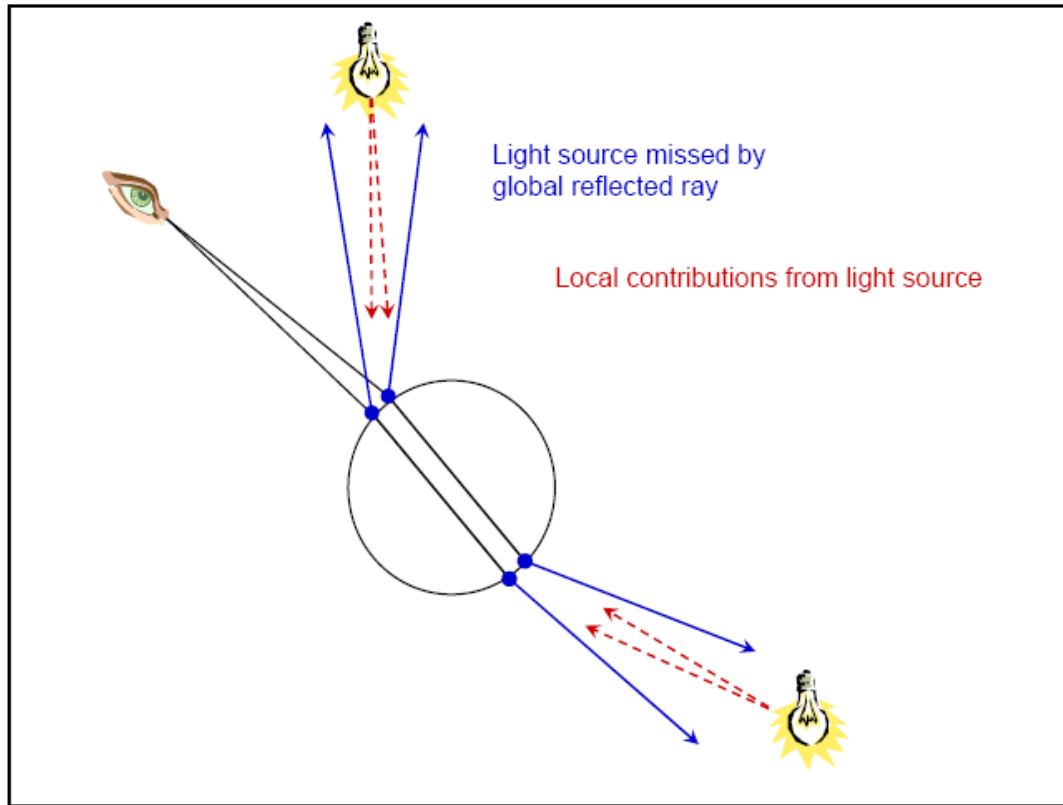
11 가 가 가 목록 목록 목록

A1 Calculation Type

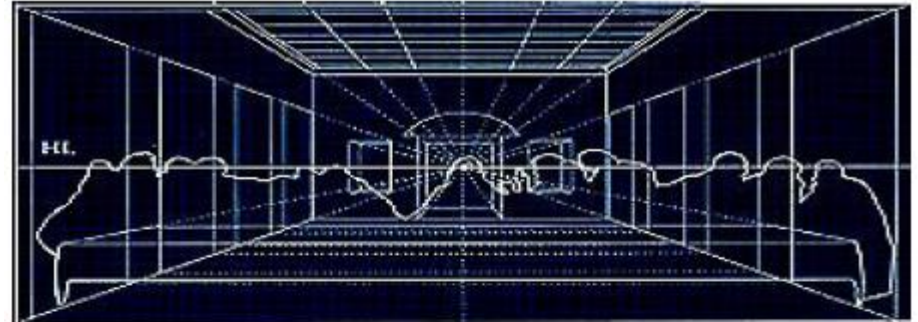
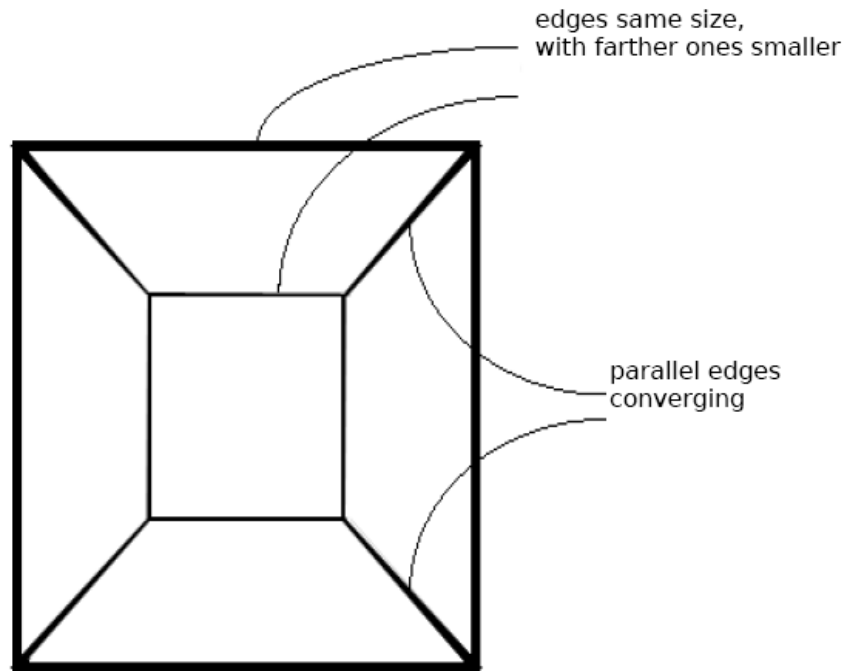
	A	B	C	D	E	F	G	H	I	J	K	L
79	Temporal	-0.4733	-0.50983	0.796406	-1.65028	0	0	0	0	0	0	21986.15
80	Temporal	-0.64158	-0.69109	1.079549	-1.34818	0	0	0	0	0	0	21973.35
81	Temporal	-0.70256	-0.75678	1.182156	-1.2387	0	0	0	0	0	0	21967.81
82	Step	-0.70256	-0.75678	1.182156	-1.2387	0	0	0	0	0	0	21967.81
83	Temporal	-0.70256	-0.75678	1.182156	-1.2387	0	0	0	0	0	0	21967.81
84	Temporal	-0.69553	-0.75678	1.182156	-1.2387	0	0	0	0	0	0	21968.22
85	Temporal	-0.70256	-0.74921	1.182156	-1.2387	0	0	0	0	0	0	21969.71
86	Temporal	-0.70256	-0.75678	1.193977	-1.2387	0	0	0	0	0	0	21970.98
87	Temporal	-0.70256	-0.75678	1.182156	-1.22632	0	0	0	0	0	0	21969.47
88	Temporal	-0.70256	-0.75678	1.182156	-1.2387	0.001	0	0	0	0	0	21967.81
89	Temporal	-0.70256	-0.75678	1.182156	-1.2387	0	0.001	0	0	0	0	21967.81
90	Temporal	-0.70256	-0.75678	1.182156	-1.2387	0	0	0.001	0	0	0	21967.81
91	Temporal	-0.70256	-0.75678	1.182156	-1.2387	0	0	0	0.001	0	0	21967.81
92	Temporal	-0.70256	-0.75678	1.182156	-1.2387	0	0	0	0	0.001	0	21967.81
93	Temporal	-0.70256	-0.75678	1.182156	-1.2387	0	0	0	0	0	0.001	21967.81
94	Temporal	-1.5	-1.5	0	-2.5	0	0	0	0	0	0	22048.96
95	Temporal	-1.5	-1.5	0	-2.5	0	0	0	0	0	0	22048.96
96	Temporal	-1.0607	-1.09057	0.651231	-1.80517	0	0	0	0	0	0	22001.84
97	Temporal	-0.83836	-0.88335	0.980834	-1.4535	0	0	0	0	0	0	21989.88
98	Temporal	-0.7512	-0.80211	1.110045	-1.31564	0	0	0	0	0	0	21978.44
99	Temporal	-0.71914	-0.77224	1.157566	-1.26494	0	0	0	0	0	0	21971.67
100	Temporal	-0.7082	-0.76204	1.173792	-1.24763	0	0	0	0	0	0	21971.13
101	Temporal	-0.70393	-0.75806	1.180119	-1.24088	0	0	0	0	0	0	21969.4
102	Temporal	-0.70281	-0.75701	1.181782	-1.2391	0	0	0	0	0	0	21967.95
103	Temporal	-0.70263	-0.75685	1.182049	-1.23882	0	0	0	0	0	0	21967.77
104	Step	-0.70256	-0.75678	1.182156	-1.2387	0	0	0	0	0	0	21967.77
105	Final	-0.70256	-0.75678	1.182156	-1.2387	0	0	0	0	0	0	21967.77

Radiance

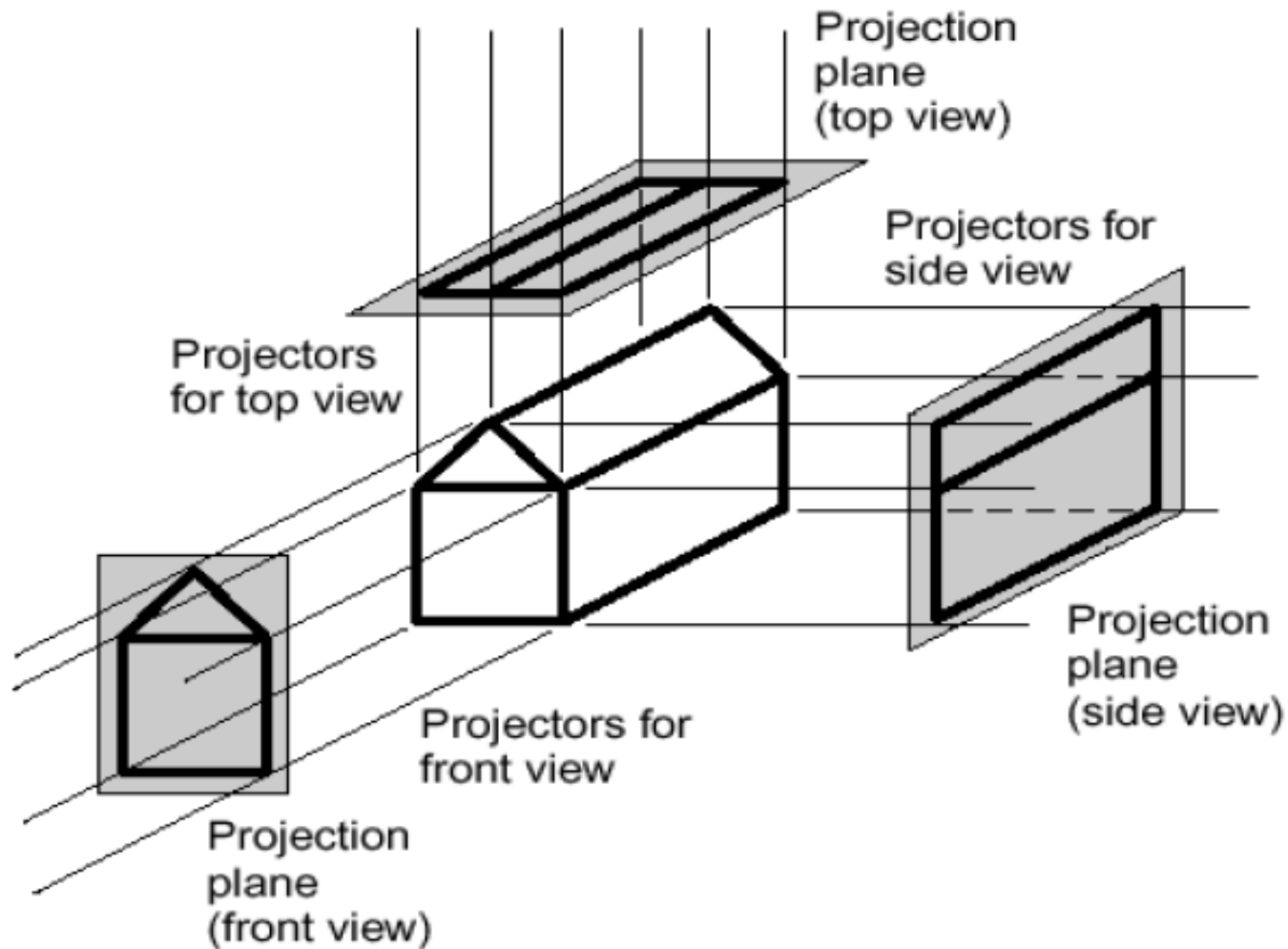
Radiance: Basic Concept (1)



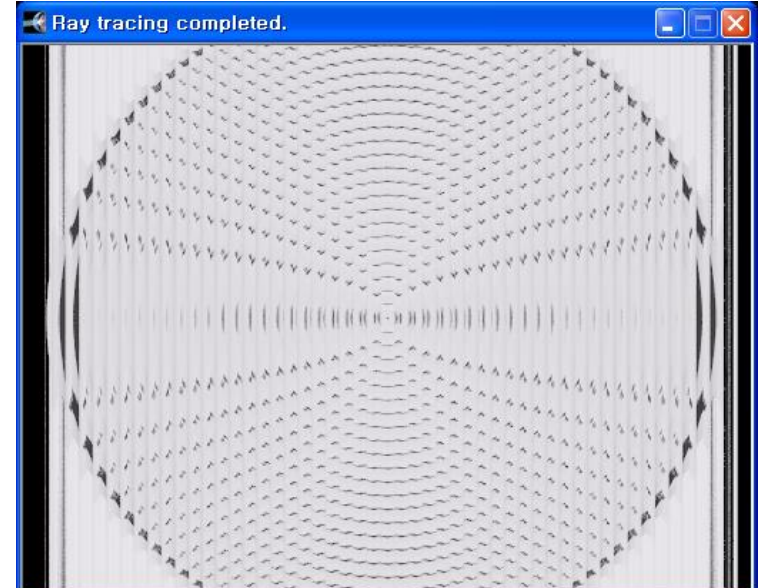
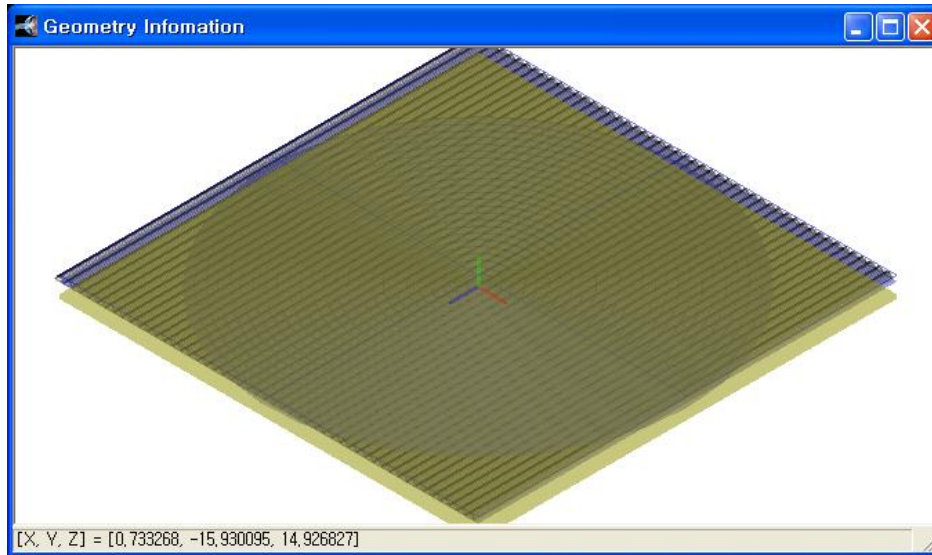
Radiance: Basic Concept (2) – Perspective View



Radiance: Basic Concept (3) – Orthographic View

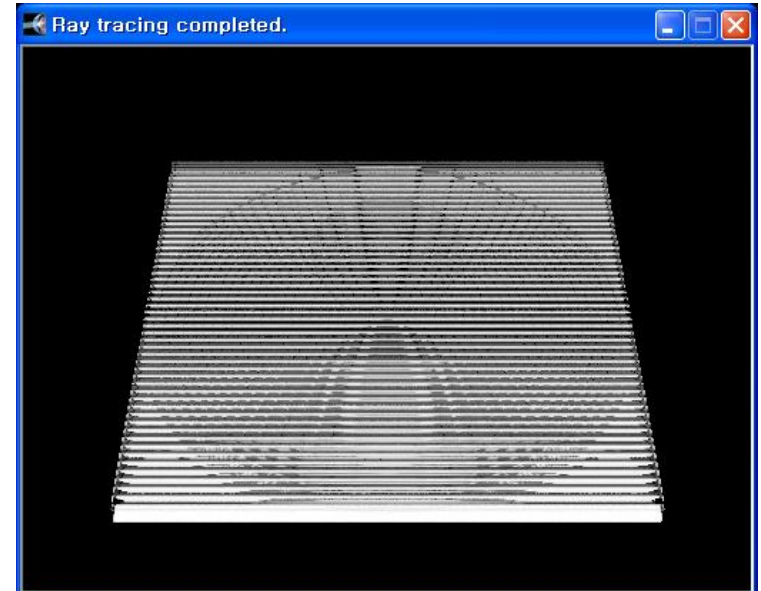


Radiance: Camera (1)



Camera

```
{  
    Perspective | orthographic  
    Location < X,Y,Z >  
    Direction < X,Y,Z >  
    Look_at < X,Y,Z >  
    Up < X,Y,Z >  
    Right < X,Y,Z >  
    Angle degree(각도)  
}
```



Radiance: Camera (2)

Moire.rwz

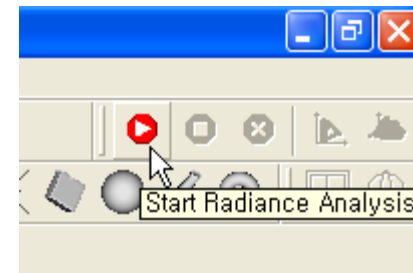
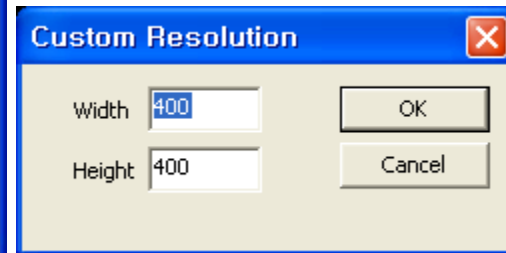
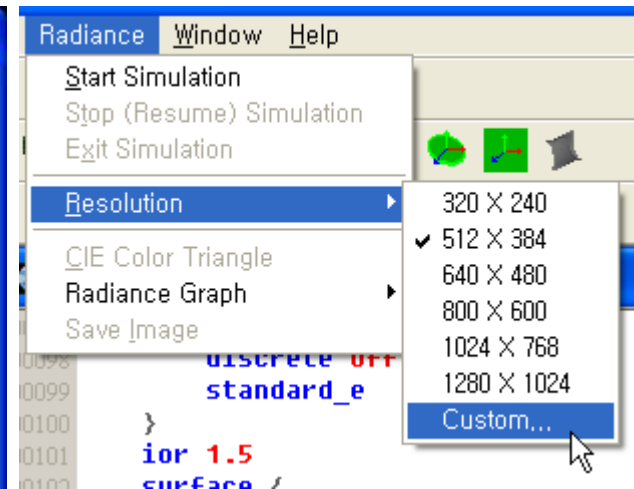
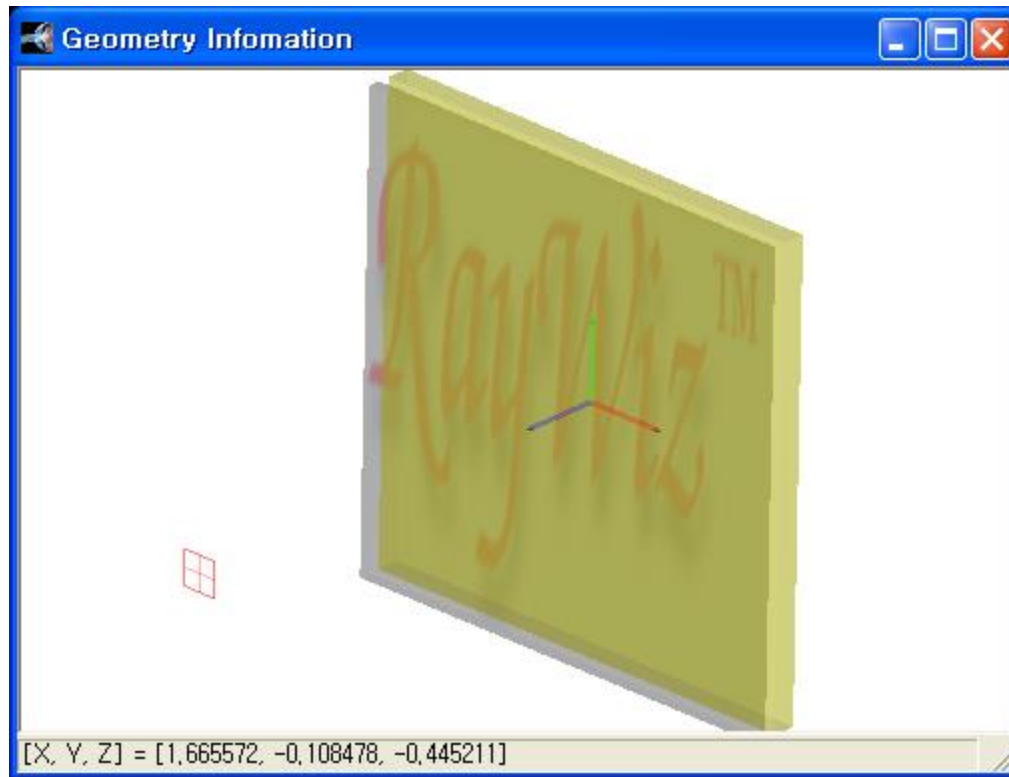
```
00001 #declare SampleSize=50;
00002 #declare FresnelPitch=1;
00003 #declare LentiPitch=1;
00004
00005 global_settings {
00006     rays {
00007         trace_off_ratio 0.0001
00008         total_ray_number 100000
00009         max_trace_level 100
00010         trace_path_view 100
00011         split_ray off
00012     }
00013 }
00014
00015 camera {
00016     location <0, 100, 0>
00017     look_at <0, 0, 0>
00018     angle 30
00019 }
```

```
00051 #declare FresnelMaxHeight=FresnelPitch/2;
00052 #declare Fresnel_Lens =
00053 lathe
00054 {
00055     linear_spline 3*int(SampleSize/FresnelPitch/2)+1,
00056     #declare i=0;
00057     #while (i < int(SampleSize/FresnelPitch/2))
00058         <i*FresnelPitch, 0>,
00059         <i*FresnelPitch+FresnelPitch*0.05, FresnelMaxHeight>,
00060         <i*FresnelPitch+FresnelPitch, 0>,
00061     #declare i=i+1;
00062     #end
00063     <0,0>
00064     color <1, 1, 1>
00065     ior 1.5
00066     surface{
00067         both{
00068             probabilistic_split on
00069         }
00070     }
00071 }
00072
00073 #declare NumLentiPitch= int(SampleSize/LentiPitch);
00074 #declare LentiUnit =
00075 extrusion
00076 {
00077     linear_spline linear_sweep
00078     0, SampleSize,
00079     12,
00080     <-LentiPitch/2, 0>,
00081     <-LentiPitch/2+LentiPitch/10, 1.5*LentiPitch/10>,
00082     <-LentiPitch/2+2*LentiPitch/10, 2.7*LentiPitch/10>,
00083     <-LentiPitch/2+3*LentiPitch/10, 3.7*LentiPitch/10>,
00084     <-LentiPitch/2+4*LentiPitch/10, 4.5*LentiPitch/10>,
00085     <-LentiPitch/2+5*LentiPitch/10, 4.7*LentiPitch/10>,
00086     <-LentiPitch/2+6*LentiPitch/10, 4.5*LentiPitch/10>,
00087     <-LentiPitch/2+7*LentiPitch/10, 3.7*LentiPitch/10>,
00088     <-LentiPitch/2+8*LentiPitch/10, 2.7*LentiPitch/10>,
00089     <-LentiPitch/2+9*LentiPitch/10, 1.5*LentiPitch/10>,
00090     <-LentiPitch/2+LentiPitch, 0>,
00091     <-LentiPitch/2,0>
00092     rotate <-90,0,0>
00093     color <1, 1, 1>
00094     ior 1.5
00095     slab
00096 }
```

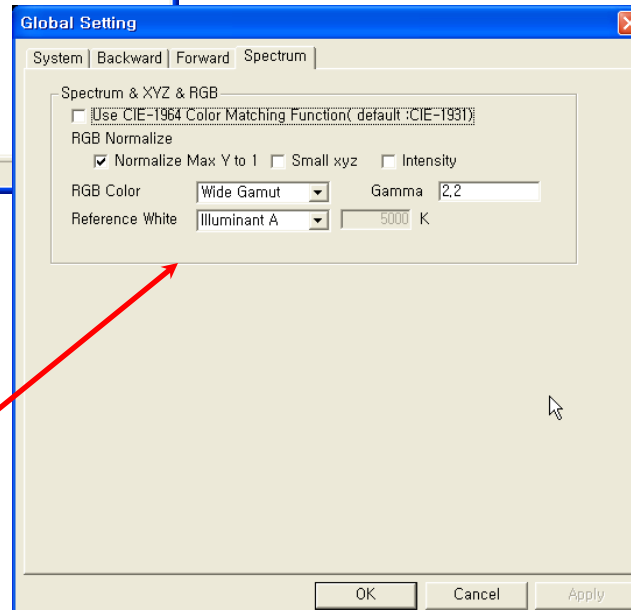
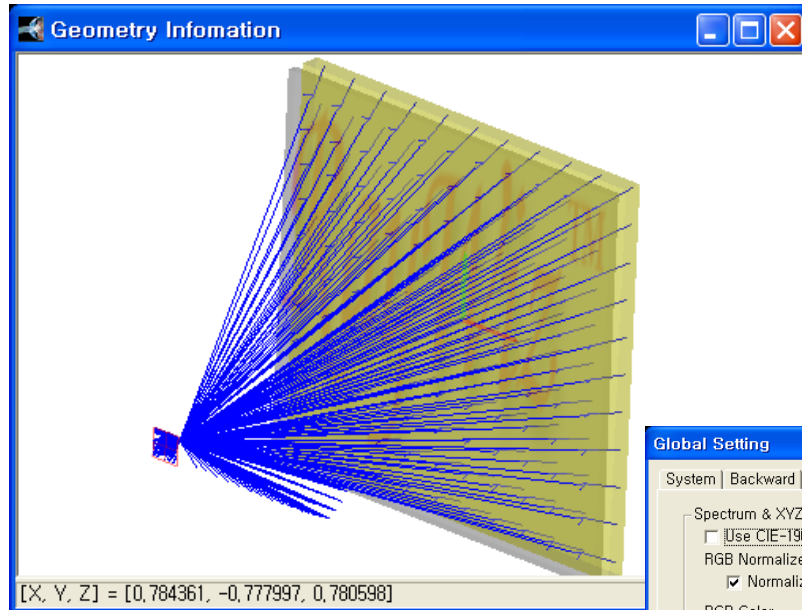
Radiance: Camera (3)

```
00108 #macro LentiArray()
00109     #declare Count_i=0;
00110     #while (Count_i < NumLentiPitch)
00111         object{
00112             LentiUnit
00113             translate <-SampleSize/2+Count_i*LentiPitch,FresnelMaxHeight+LentiPitch/10+0.01,SampleSize/2>
00114         }
00115         #declare Count_i=Count_i+1;
00116     #end
00117 #end
00118
00119 #declare LentiScreen=
00120 union
00121 {
00122     slab_outline on
00123     object{LentiBase}
00124     union{
00125         slab_outline on
00126         LentiArray()
00127     }
00128 }
```

Radiance: CCD (1)



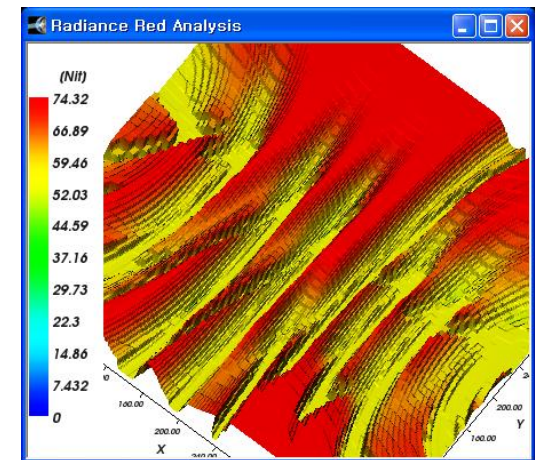
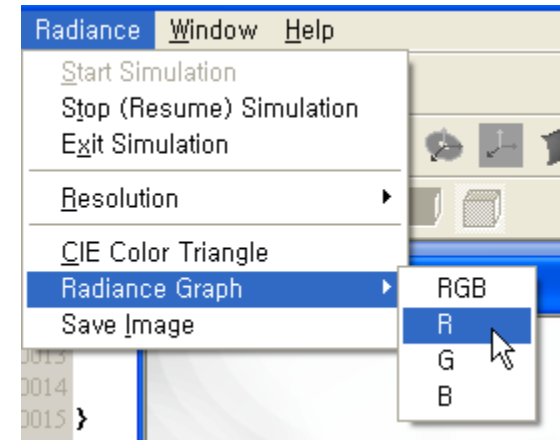
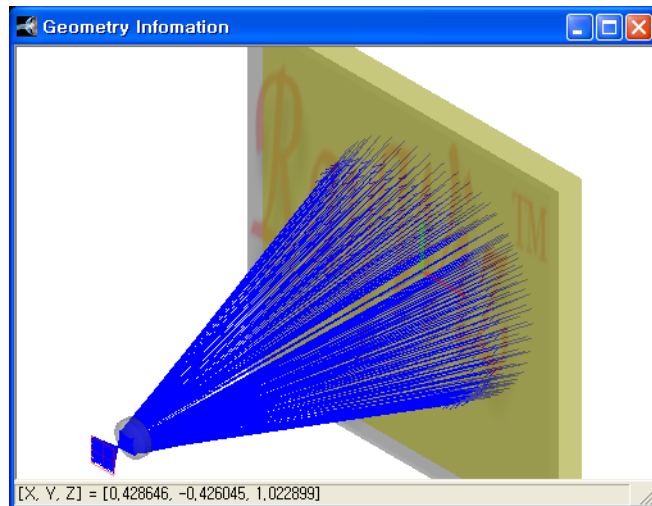
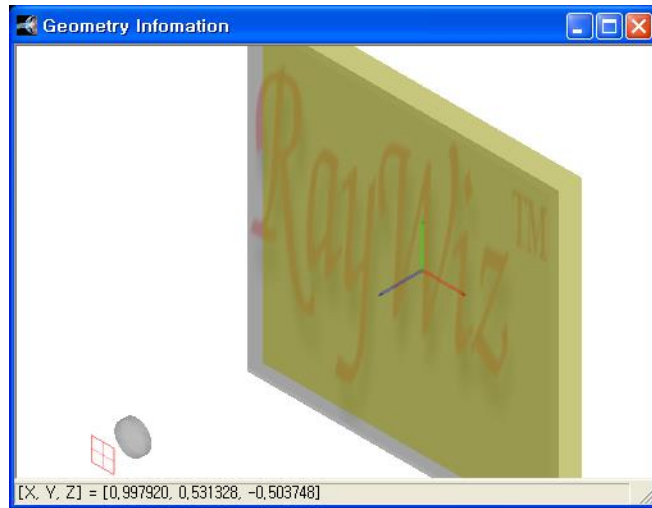
Radiance: CCD (2)



**Color Matrix,
Gamma,
Reference White에
따른 변환 조건 선택**



Radiance: CCD (3)



Radiance: CCD (4)

```
CCD-Image.rwz
00001 #declare Lens_Flag=1;
00002
00003 global_settings {
00004     rays {
00005         trace_off_ratio 0.01
00006         total_ray_number 100000
00007         max_trace_level 10
00008         trace_path_view 100
00009         split_ray off
00010         fresnel_area_effect on
00011     }
00012     force_parsing off
00013     polarization off
00014     units millimeters
00015 }
```

```
00017 camera {
00018     ccd
00019     width 0.15
00020     height 0.15
00021     aim_area {
00022         <0, 0, 2> // Center Point
00023         <0, 0, -1> // Direction Point
00024         circular 0.0001 // Radius
00025         //rectangular Width_Value, Height_Value
00026     }
00027     location <0, 0, 2.1>
00028     look_at <0, 0, 0>
00029     up <0, 0, 1>
00030     right <1, 0, 0>
00031 }
```

```
00093 #declare ImgBox =
00094 box
00095 {
00096     <-1, -1, 0.1>, <1, 1, 0.15>
00097     spectrum {
00098         discrete off
00099         standard_e
00100     }
00101     ior 1.5
00102     surface {
00103         both {
00104             probabilistic_split on
00105         }
00106         front_surface{
00107             both{
00108                 zone{
00109                     transmittance{1.0}
00110                     reflectance{0}
00111                     "RayWiz.bmp"
00112                 }
00113             }
00114         }
00115     }
00116 }
```

Radiance: CCD (5)

```
00033 #declare BL =
00034 light_source
00035 {
00036     <0, 0, 0>
00037     spectrum {
00038         discrete off
00039         standard_e
00040     }
00041     object_light
00042     {
00043         surface
00044         box
00045         {
00046             <-1, -1, 0>, <1, 1, 0.1>
00047         }
00048         emittance
00049         {
00050             front_surface
00051             {
00052                 on
00053                 angular_distribution
00054                 {
00055                     lambertian
00056                 }
00057                 spatial_distribution
00058                 {
00059                     uniform
```

```
00060             }
00061         }
00062         back_surface
00063         {
00064             off
00065         }
00066         left_surface
00067         {
00068             off
00069         }
00070         right_surface
00071         {
00072             off
00073         }
00074         top_surface
00075         {
00076             off
00077         }
00078         bottom_surface
00079         {
00080             off
00081         }
00082     }
00083 }
00084 emittance
00085 {
00086     radiometric 1
00087     measured_whole on
00088     aim_sphere <0, 90>
00089 }
00090 point_at <0, 0, 3>
00091 }
```

Radiance: CCD (6)

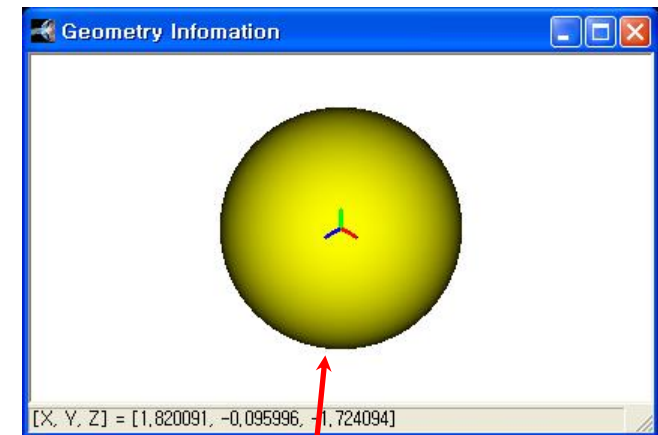
```
00118 #declare TestLens =
00119 optical
00120 {
00121     circular center_thickness 0.1
00122     { 0.2, 0.1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00123     { -0.2, 0.1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0 }
00124     spectrum {
00125         discrete off
00126         standard_e
00127     }
00128     ior 1.5
00129     surface {
00130         both {
00131             probabilistic_split on
00132         }
00133     }
00134     rotate<90,0,0>
00135     translate<0,0,1.85>
00136 }
00137
00138 BL
00139 ImgBox
00140 #if(Lens_flag)
00141     TestLens
00142 #else
00143 #end
```


Image RBT

Image RBT: Target System (1)

```
Simple.rwz
00001 global_settings {
00002     rays {
00003         trace_off_ratio 0.01
00004         total_ray_number 10000
00005         max_trace_level 10
00006         trace_path_view 100
00007         split_ray off
00008     }
00009 }
00010
00011 camera {
00012     location <10, 10, 10>
00013     look_at <0, 0, 0>
00014 }
00015
00016 //nextstep에 의한 반경 변화
00017 #declare radius1 = 0.5 + nextstep * 0.5;
00018 #declare distance1 = nextstep*10;
```

Loop Index 증가에 따라
반경 증가 **nextstep = 1 ~ n**



Loop Index 증가에 따라
반경
Spectrum
Flux 변화

Image RBT: Target System (2)

```
00020 #declare SphereSource0 =
00021 light_source
00022 {
00023     <0, 0, 0>
00024     // 루프에 따라 스펙트럼 변화
00025     spectrum {
00026         3,
00027         <400, $x0 -1 >,
00028         <550, $x1 -1 >,
00029         <650, $x2 -1 >
00030     }
```

Loop Index 증가에 따라
spectrum 세기 분포 변화
\$x0 = 1 ~ n
\$x1 = 1 ~ n
\$x2 = 1 ~ n

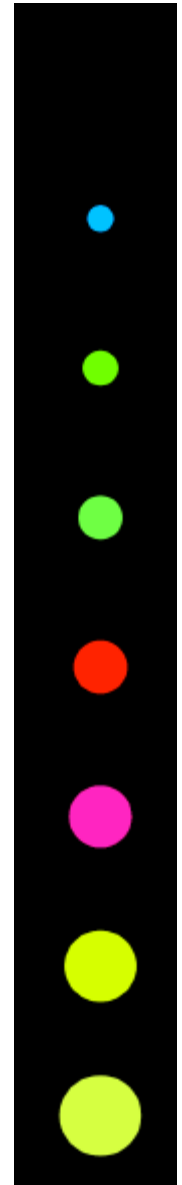
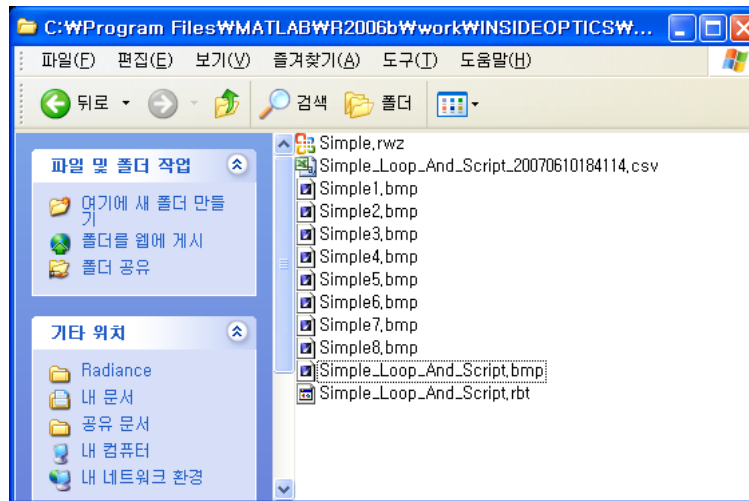
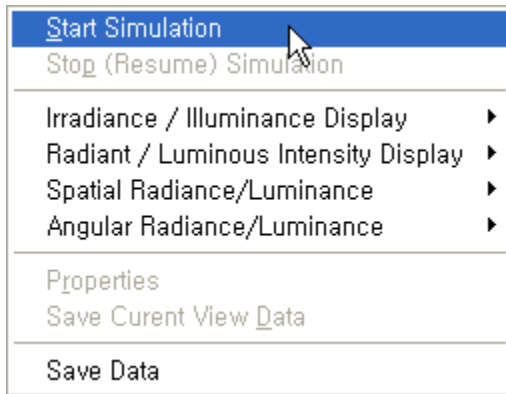
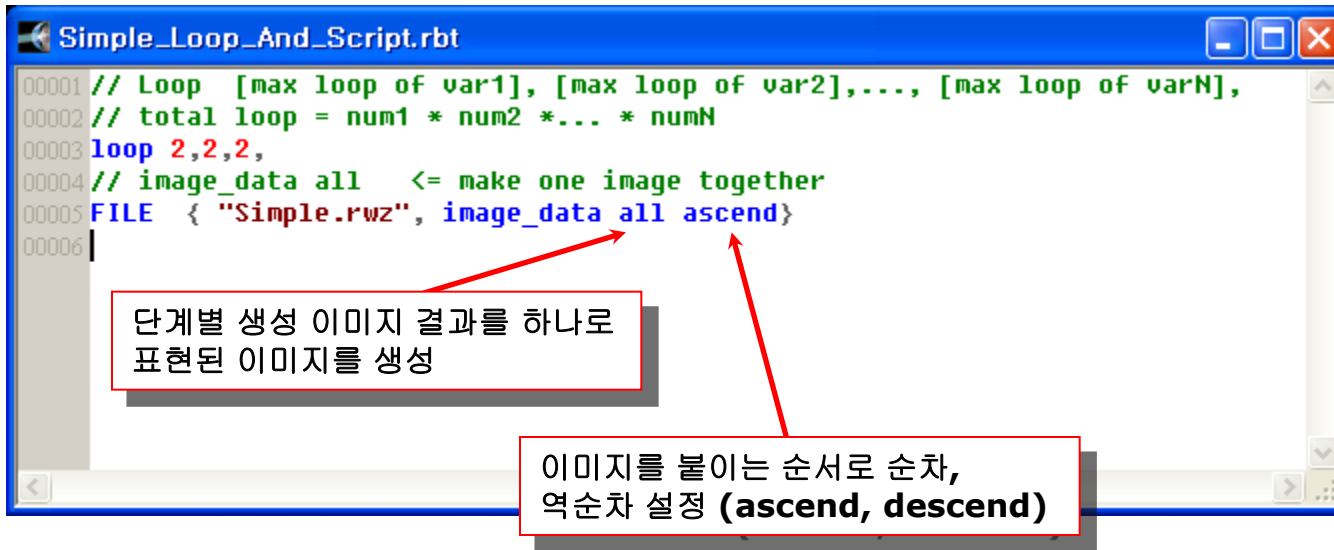
```
00031 object_light
00032 {
00033     surface
00034     sphere
00035     {
00036         <0, 0, 0>, radius1
00037     }
00038     emittance
00039     {
00040         angular_distribution
00041         {
00042             lambertian
00043         }
00044         spatial_distribution
00045         {
00046             uniform
00047         }
00048     }
00049 }
```

Image RBT: Target System (3)

```
00050  emittance
00051  {
00052      // 파워 변화
00053      radiometric $x0 + $x1 * 10 + $x2 * 100
00054      measured_whole on
00055      aim_sphere <0, 180>
00056  }
00057  point_at <0, 0, 2>
00058 }
00059
00060 SphereSource0
```

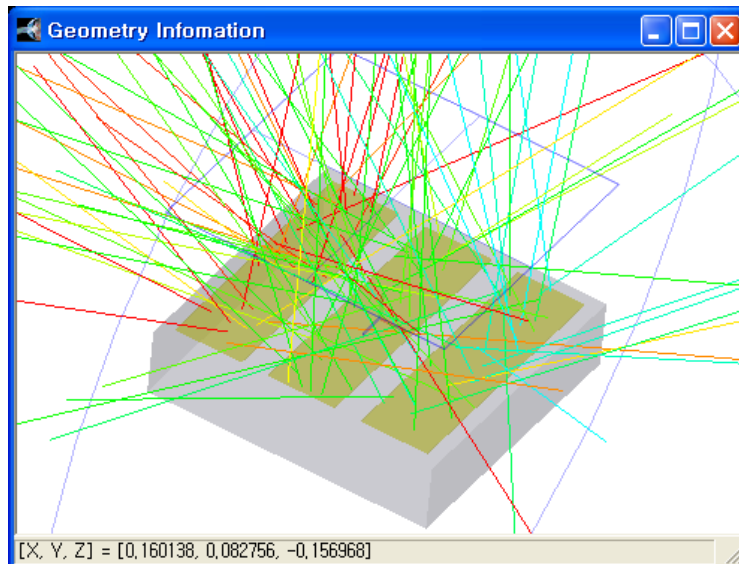
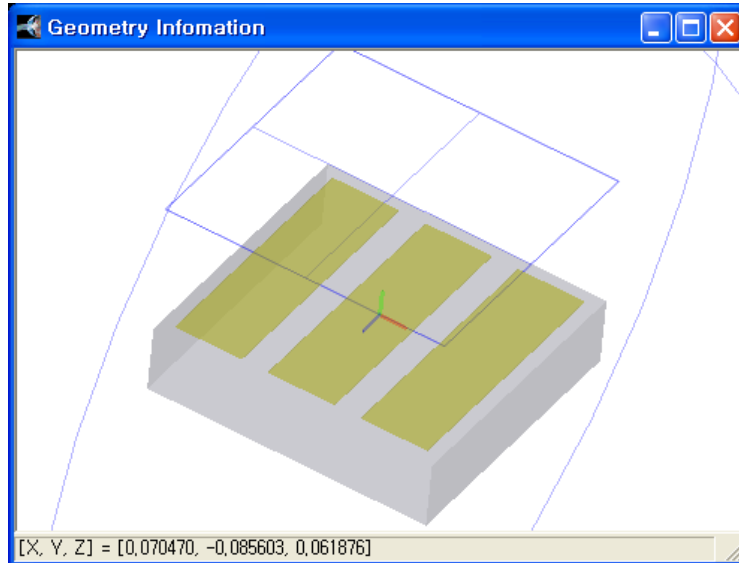
Loop Index 증가에 따라
Flux 세기 변화
\$x0 = 1 ~ n
\$x1 = 1 ~ n
\$x2 = 1 ~ n

Image RBT:



Color Mix

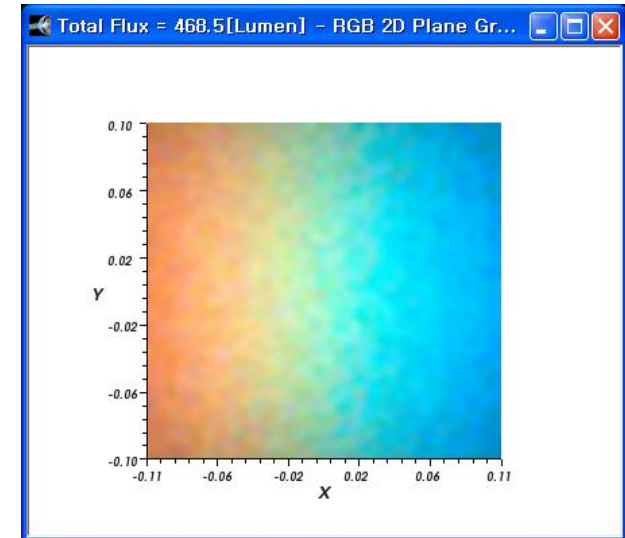
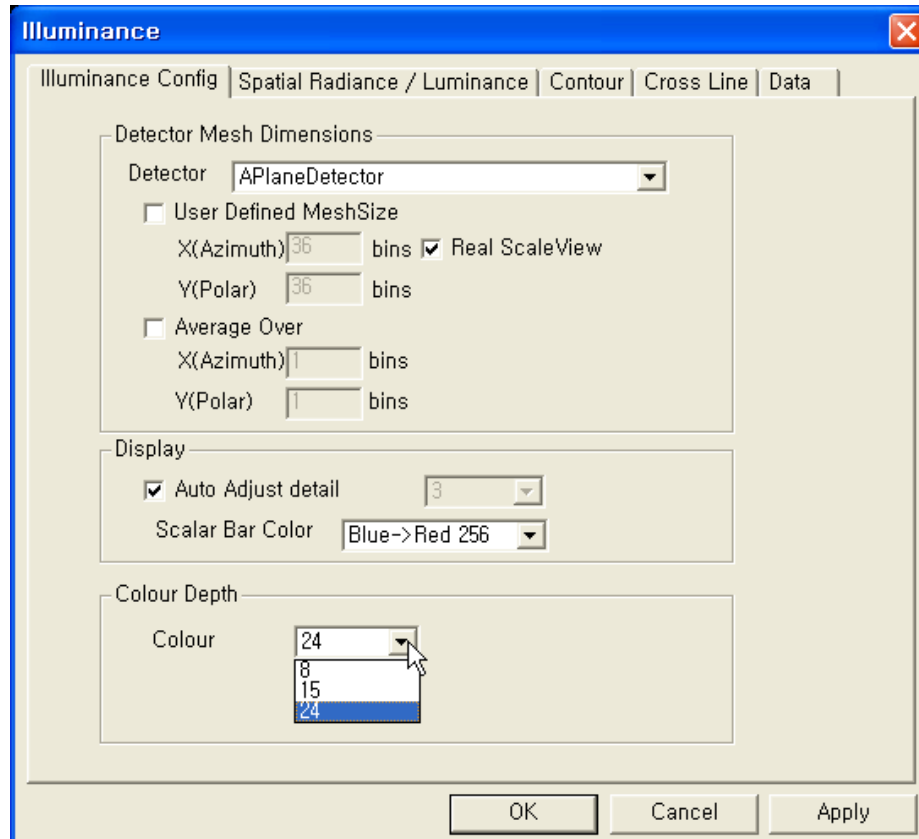
Color Mix: Pixel – Lambertian R,G,B (1)



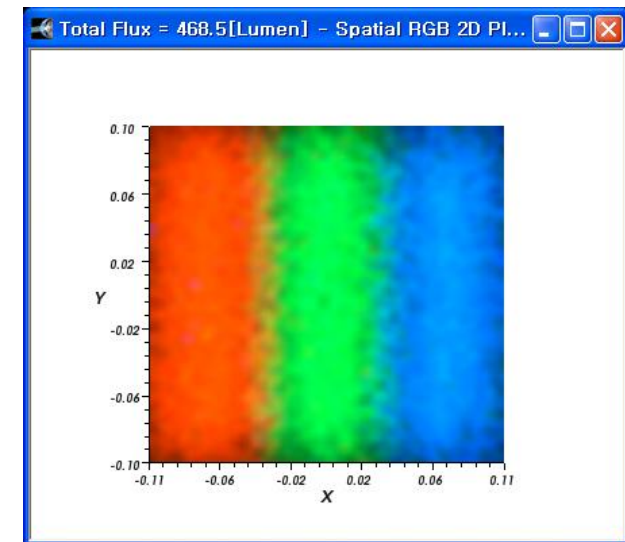
```
Single_Pixel.rwz
00001 #declare TestObject_Flag = 0;
00002 #declare AimAngle_End = 90;
00003 #declare PlaneDetector_Pos = 0.01;
00004 #declare SubPixel_W = 0.050;
00005 #declare SubPixel_H = 0.180;
00006 #declare SubPixel_I = 0.001;
00007 #declare SpaceW = 0.020;
00008 #declare Pixel_W = SubPixel_W*3+SpaceW*3;
00009 #declare Pixel_H = SubPixel_H+SpaceW;
00010 #declare NumW = 1;
00011 #declare NumH = 1;
00012 #declare Display_W = NumW*Pixel_W;
00013 #declare Display_H = NumH*Pixel_H;
00014 #declare Power = 1000;
00015 #declare Ratio_R = 26;
00016 #declare Ratio_G = 60;
00017 #declare Ratio_B = 14;
00018 #declare Power_R = Power/(NumW*NumH)*(Ratio_R/(Ratio_R+Ratio_G+Ratio_B));
00019 #declare Power_G = Power/(NumW*NumH)*(Ratio_G/(Ratio_R+Ratio_G+Ratio_B));
00020 #declare Power_B = Power/(NumW*NumH)*(Ratio_B/(Ratio_R+Ratio_G+Ratio_B));
00021 #declare Substrate_T = 0.05;
```

```
00023 global_settings {
00024     rays {
00025         trace_off_ratio 0.000001
00026         total_ray_number 1000000
00027         max_trace_level 100
00028         trace_path_view 100
00029         split_ray off
00030     }
00031 }
```

Color Mix: Pixel – Lambertian R,G,B (2)– Plane Color

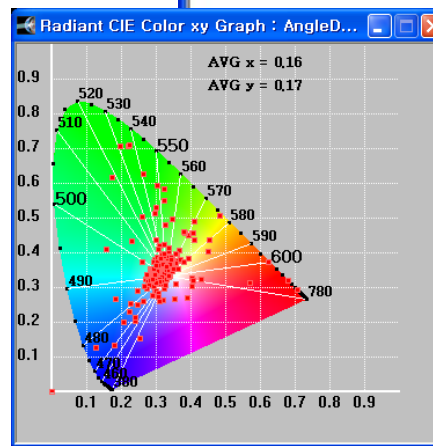
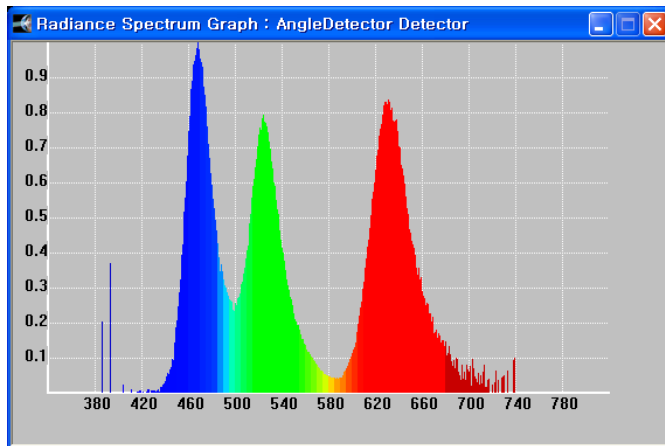
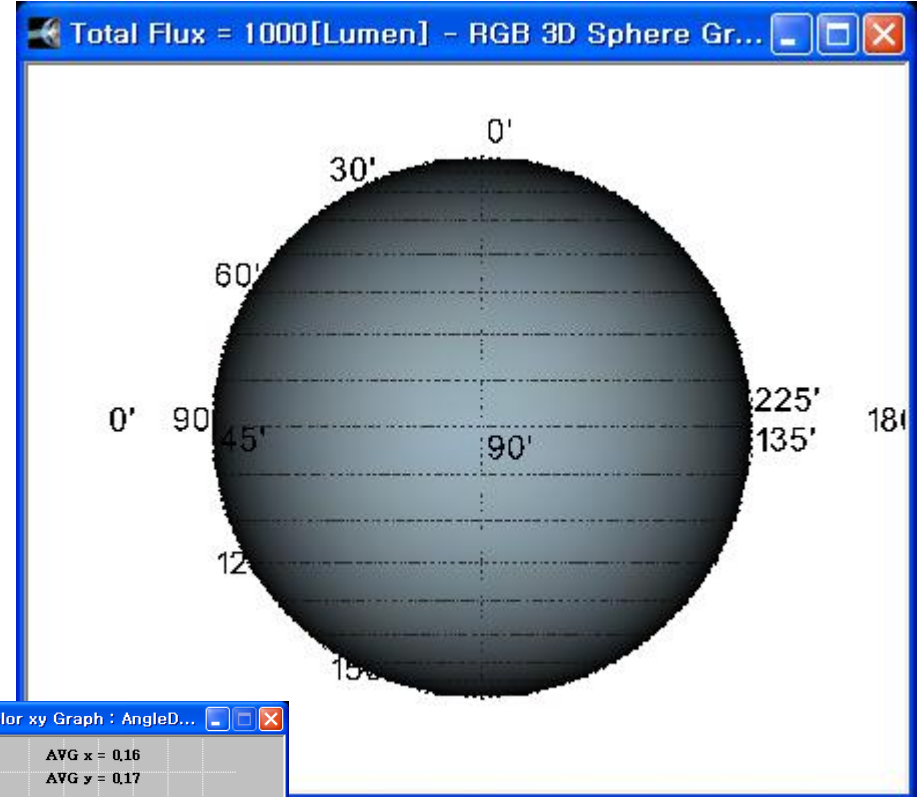
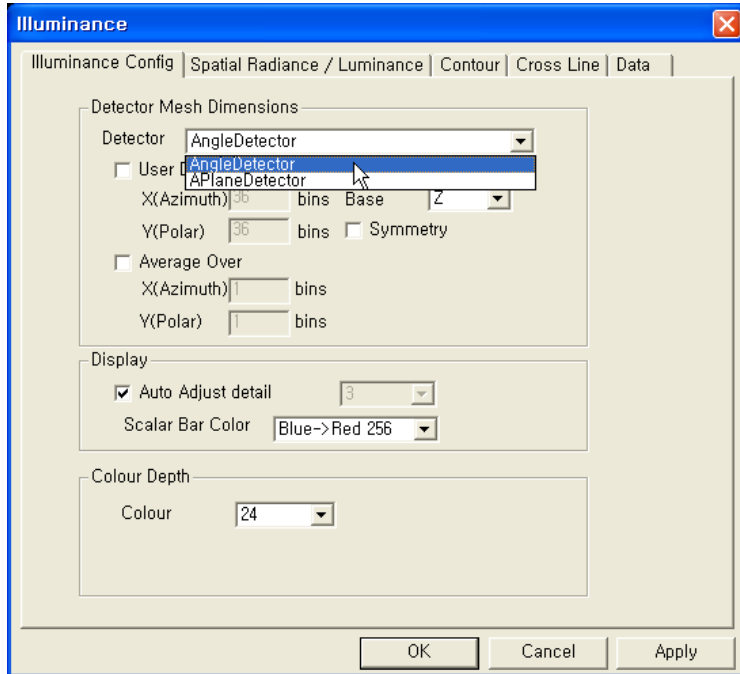


<Illuminance RGB>

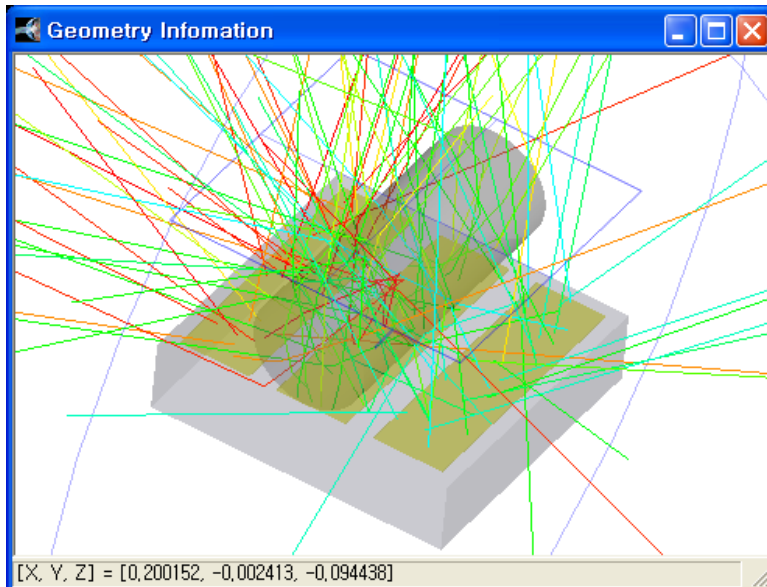
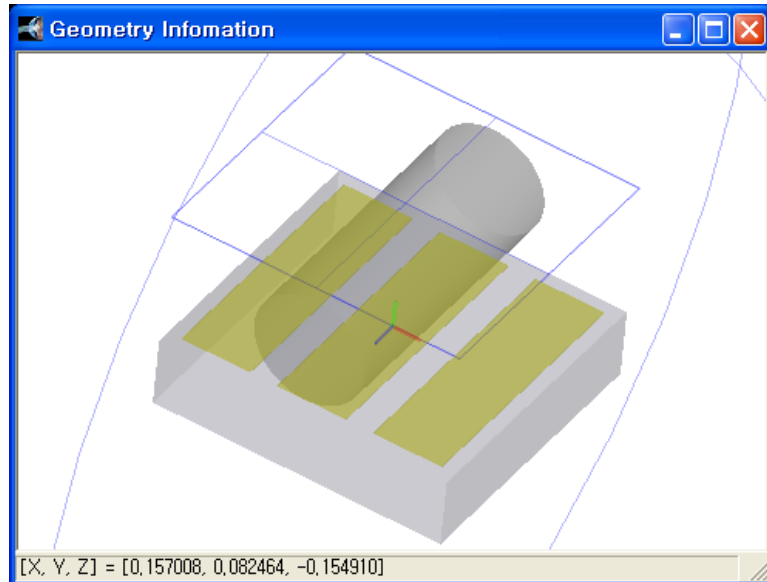


<Luminance RGB>

Color Mix: Pixel – Lambertian R,G,B (3) – Angular Color

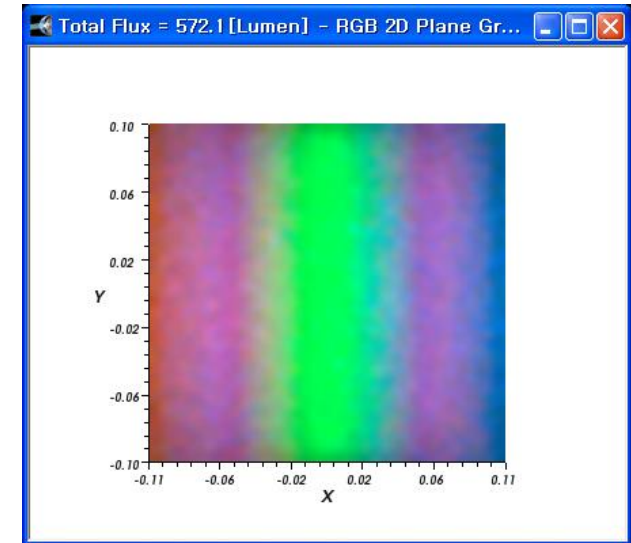
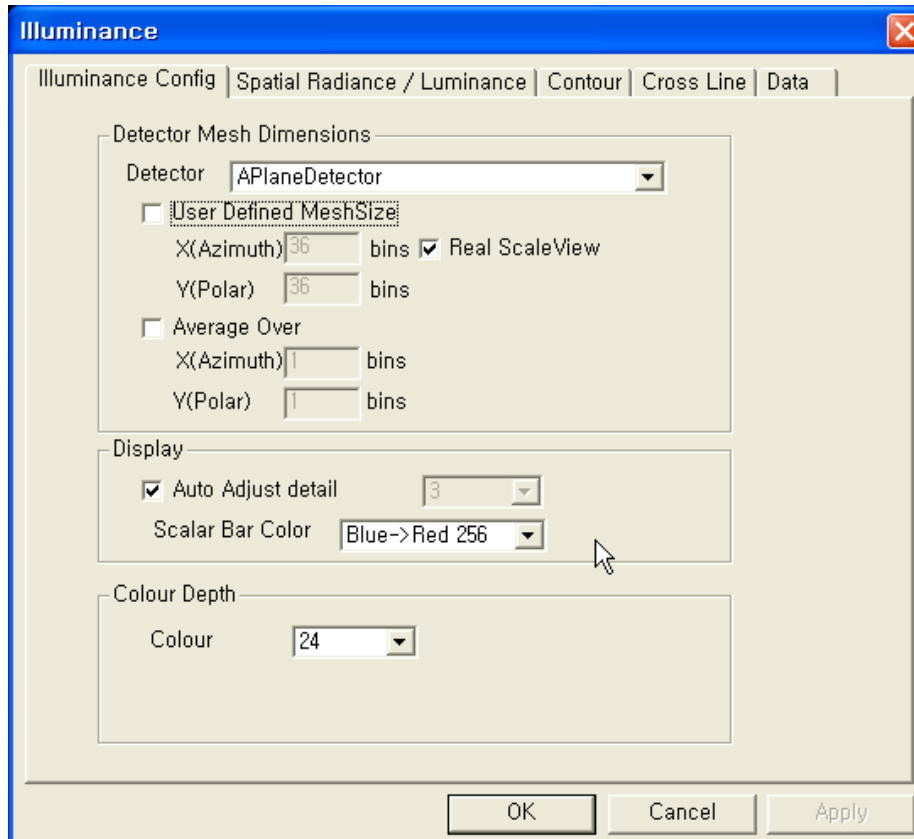


Color Mix: Pixel – Lambertian R,G,B (4)

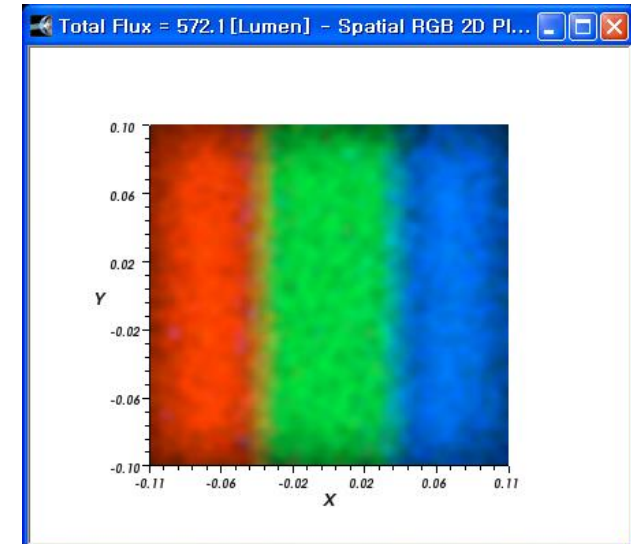


```
Single_Pixel.rwz
00001 #declare TestObject_Flag = 1;
00002 #declare AimAngle_End = 90;
00003 #declare PlaneDetector_Pos = 0.01;
00004 #declare SubPixel_W = 0.050;
00005 #declare SubPixel_H = 0.180;
00006 #declare SubPixel_T = 0.001;
00007 #declare SpaceW = 0.020;
00008 #declare Pixel_W = SubPixel_W*3+SpaceW*3;
00009 #declare Pixel_H = SubPixel_H+SpaceW;
00010 #declare NumW = 1;
00011 #declare NumH = 1;
00012 #declare Display_W = NumW*Pixel_W;
00013 #declare Display_H = NumH*Pixel_H;
00014 #declare Power = 1000;
00015 #declare Ratio_R = 26;
00016 #declare Ratio_G = 60;
00017 #declare Ratio_B = 14;
00018 #declare Power_R = Power/(NumW*NumH)*(Ratio_R/(Ratio_R+Ratio_G+Ratio_B));
00019 #declare Power_G = Power/(NumW*NumH)*(Ratio_G/(Ratio_R+Ratio_G+Ratio_B));
00020 #declare Power_B = Power/(NumW*NumH)*(Ratio_B/(Ratio_R+Ratio_G+Ratio_B));
00021 #declare Substrate_T = 0.05;
```

Color Mix: Pixel – Lambertian R,G,B (4) – Plane Color

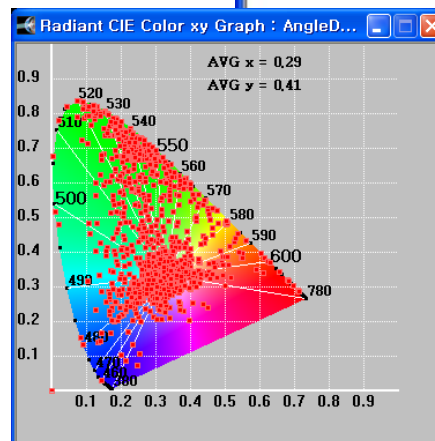
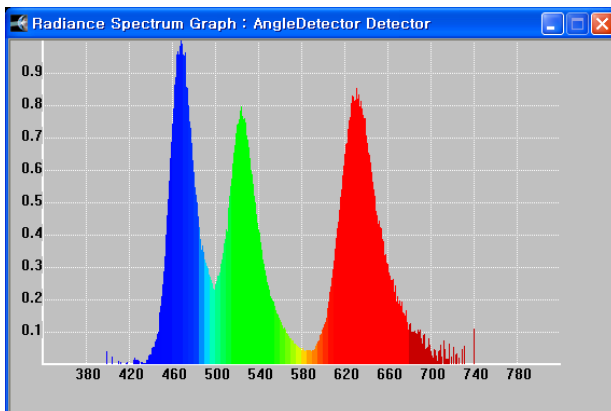
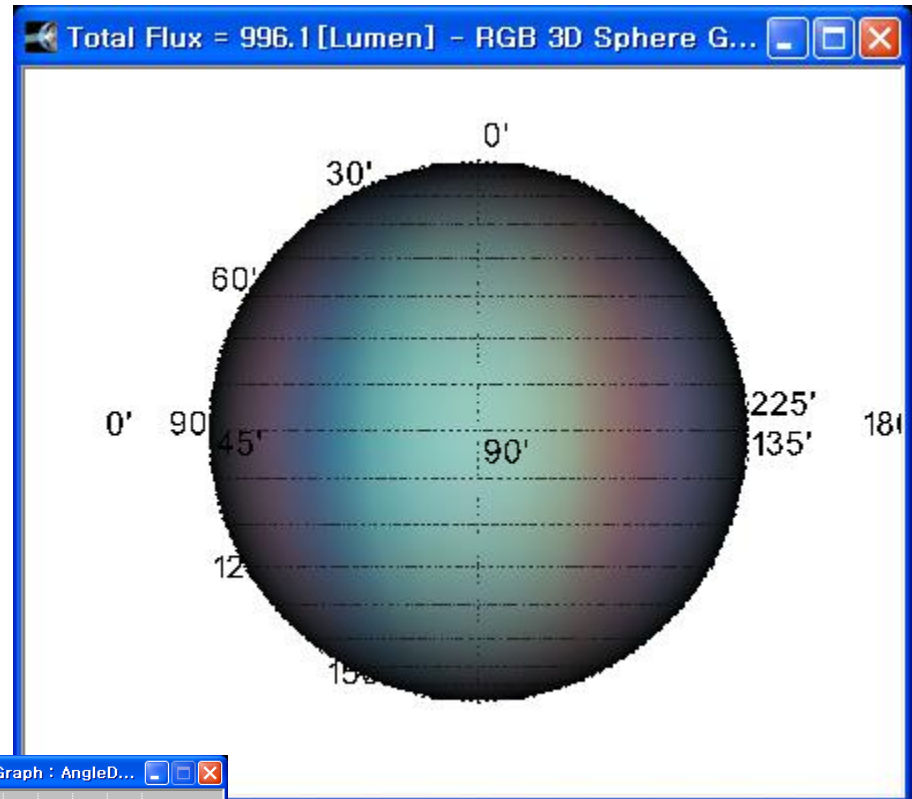
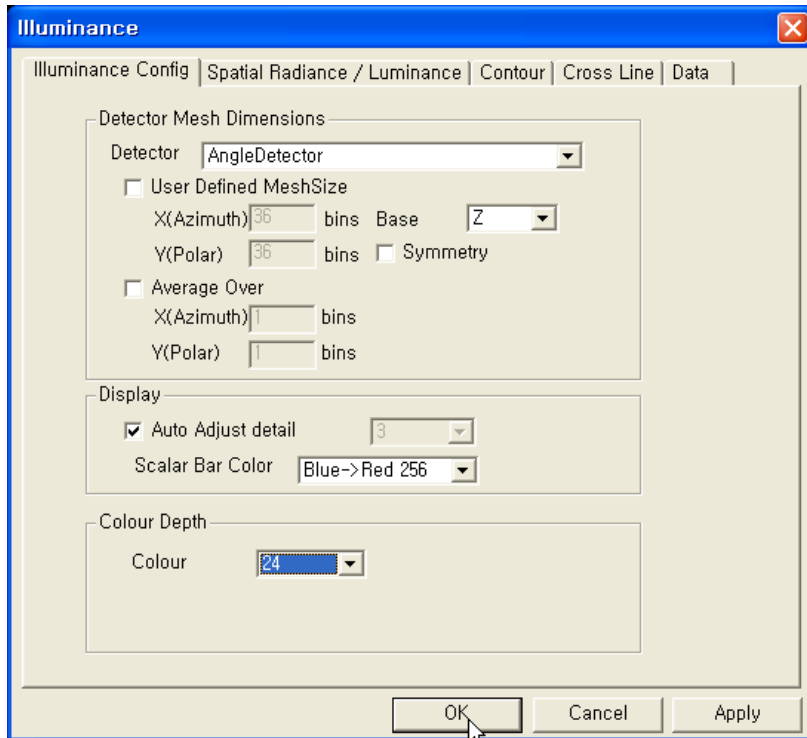


<Illuminance RGB>



<Luminance RGB>

Color Mix: Pixel – Lambertian R,G,B (5) – Plane Color



Color Mix: Pixel – Lambertian R,G,B (6)

```
00033 #declare SubPixel_R =
00034 light_source
00035 {
00036     <0, SubPixel_I/2, 0>
00037     spectrum {
00038         discrete off
00039         "RED.spc"
00040     }
00041     object_light
00042     {
00043         surface
00044         box
00045         {
00046             <-SubPixel_W/2, 0, -SubPixel_H/2>, <SubPixel_W/2, SubPixel_I, SubPixel_H/2>
00047         }
00048         emittance
00049         {
00050             front_surface
00051             {
00052                 off
00053             }
00054             back_surface
00055             {
00056                 off
00057             }
00058             ...
00205         emittance
00206         {
00207             photometric Power_B
00208             measured_whole off
00209             aim_sphere <0, AimAngle_End>
00210         }
00211         point_at <0, 1, 0>
00212     }
```

Color Mix: Pixel – Lambertian R,G,B (7)

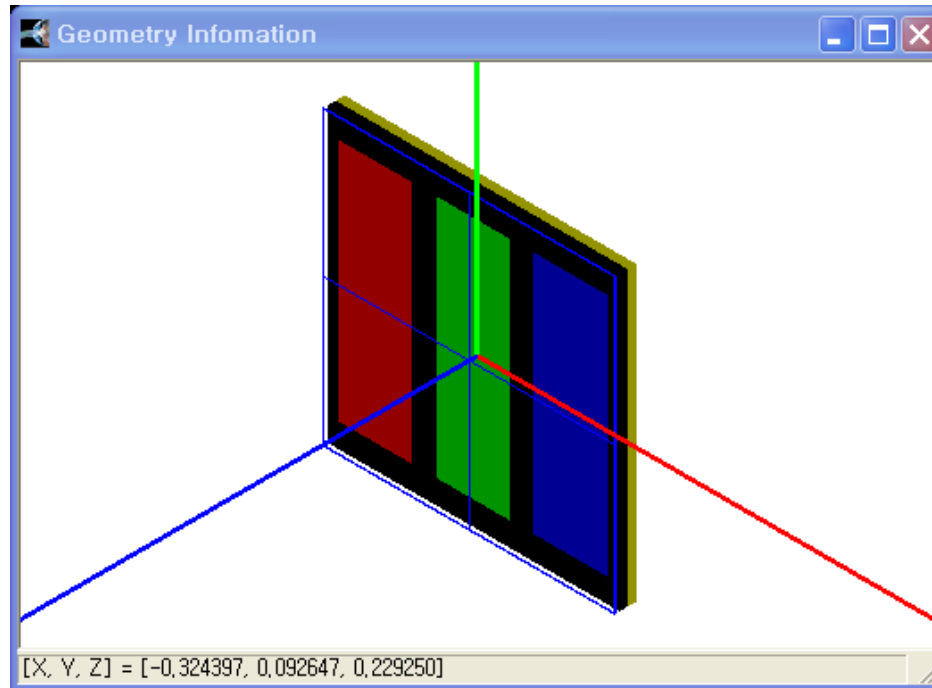
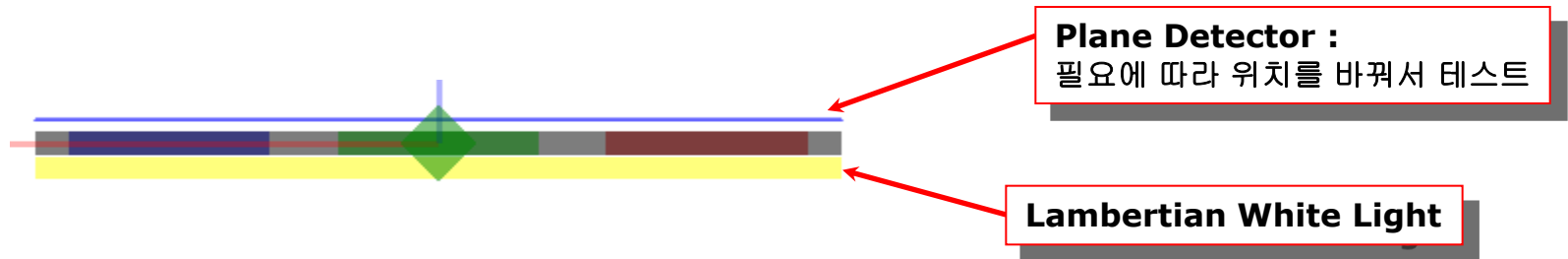
```
00214 #macro ArraySubPixel_R()
00215 #local Count_i=0;
00216 #while (Count_i < NumW)
00217     #local Count_j=0;
00218     #while (Count_j < NumH)
00219         object{
00220             SubPixel_R
00221             translate <-Display_W/2+SpaceW/2+SubPixel_W/2+Pixel_W*Count_i,0,0>
00222             translate <0,0,-Display_H/2+SpaceH/2+SubPixel_H/2+Pixel_H*Count_j>
00223         }
00224         #local Count_j=Count_j+1;
00225     #end
00226     #local Count_i=Count_i+1;
00227 #end
00228 #end
```

```
00275 A1_Sub
00276 ArraySubPixel_R()
00277 ArraySubPixel_G()
00278 ArraySubPixel_B()
```

```
00280 #declare TestObject =
00281 cylinder
00282 {
00283     <0, 0, -0.1>, <0, 0, 0.1>, 0.04
00284     spectrum {
00285         discrete off
00286         standard_e
00287     }
00288     ior 1.5
00289     surface {
00290         both {
00291             probabilistic_split on
00292         }
00293     }
00294     translate<0,0.05,0>
00295 }
00296
00297 #if(TestObject_Flag)
00298     TestObject
00299 #else
00300 #end
```

Color Filter

Color Mix: Geometry



Color Mix: Script (1)

```
00021 #declare Pixel_W=0.360;  
00022 #declare Pixel_H=0.360;  
00023 #declare Pixel_T=0.010;  
00024 #declare SubPixel_W=0.090;  
00025 #declare SubPixel_H=0.300;  
00026 #declare SubPixel_T=0.011;  
00027 #declare Space_W=(Pixel_W-SubPixel_W*3)/3;  
00028 #declare Space_H=(Pixel_H-SubPixel_H)/2;
```

Pixel 과 **SubPixel**의 치수 정의

```
00081     emittance  
00082     {  
00083         radiometric 1  
00084         measured_whole on  
00085         aim_sphere <0, 90>  
00086     }  
00087     point_at <0, 0, 3>  
00088 }
```

← **Emitting** 각도제한

Color Mix: Script (2)

```
00021 #declare Pixel_W=0.360;
00022 #declare Pixel_H=0.360;
00023 #declare Pixel_T=0.010;
00024 #declare SubPixel_W=0.090;
00025 #declare SubPixel_H=0.300;
00026 #declare SubPixel_T=0.011;
00027 #declare Space_W=(Pixel_W-SubPixel_W*3)/3;
00028 #declare Space_H=(Pixel_H-SubPixel_H)/2;
```

Pixel 과 **SubPixel**의 치수 정의

```
00034 spectrum {
00035     discrete off
00036     standard_d65
00037 }
```

표준광원 D65 white

```
00081 emittance
00082 {
00083     radiometric 1
00084     measured_whole on
00085     aim_sphere <0, 90>
00086 }
00087 point_at <0, 0, 3>
00088 }
```

Emitting 각도제한

Color Mix: Script (3)

```
00103 #declare SubPixel_R =
00104 box
00105 {
00106     <-SubPixel_W/2, -SubPixel_H/2, -SubPixel_T/2>,
00107     color <1, 0, 0>
00108     ior 1.5
00109     surface {
00110         both {
00111             transmittance{1}
00112             reflectance{0}
00113         }
00114         front_surface{
00115             in{
00116                 coating{ "Red_Filter.coa" }
00117             }
00118         }
00119     }
00120     translate<-SubPixel_W-Space_W,0,0>
00121 }
```

Surface Spectrum 파일

Color Mix: Coating File Format

Red_Filter.coa

	0	10	20
1 9	17		
2 0			
3 375	0	0.1945	
4 400	0	0.0688	
5 425	0	0	
6 450	0	0	
7 475	0	0	
8 500	0	0	
9 525	0	0	
10 550	0	0	
11 575	0	0	
12 600	0	0.5924	
13 625	0	0.9073	
14 650	0	0.8856	
15 675	0	0.9514	
16 700	0	0.9065	
17 725	0	0.9364	
18 750	0	0.9491	
19 775	0	0.9245	
20 10			
21 375	0	0.1945	
22 400	0	0.0688	
23 425	0	0	
24 450	0	0	
25 475	0	0	
26 500	0	0	
27 525	0	0	
28 550	0	0	
29 575	0	0	
30 600	0	0.5924	
31 625	0	0.9073	
32 650	0	0.8856	
33 675	0	0.9514	
34 700	0	0.9065	
35 725	0	0.9364	
36 750	0	0.9491	
37 775	0	0.9245	

입사각도 갯수, 파장 갯수

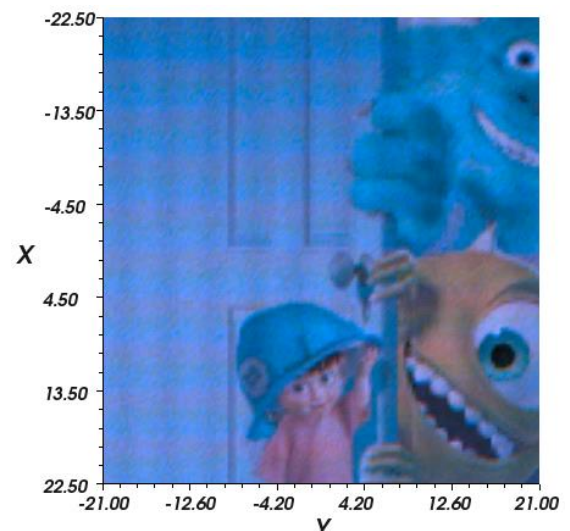
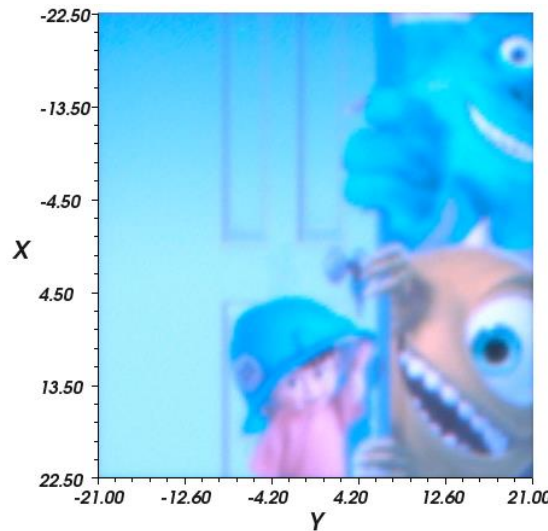
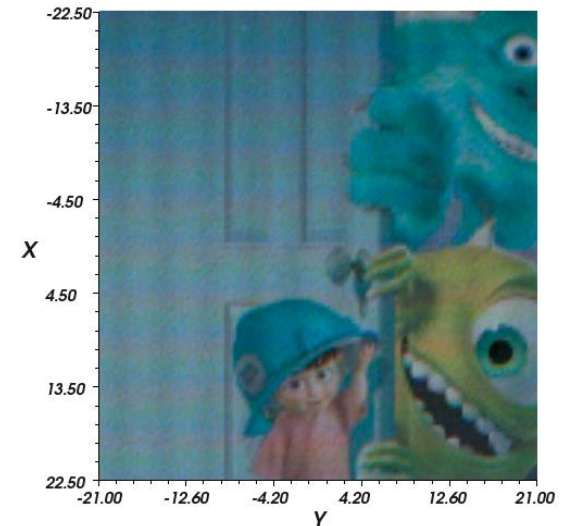
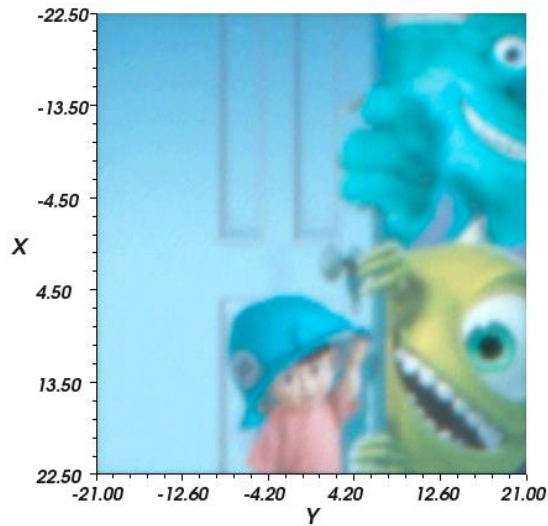
입사각도 0도

파장, 반사, 투과

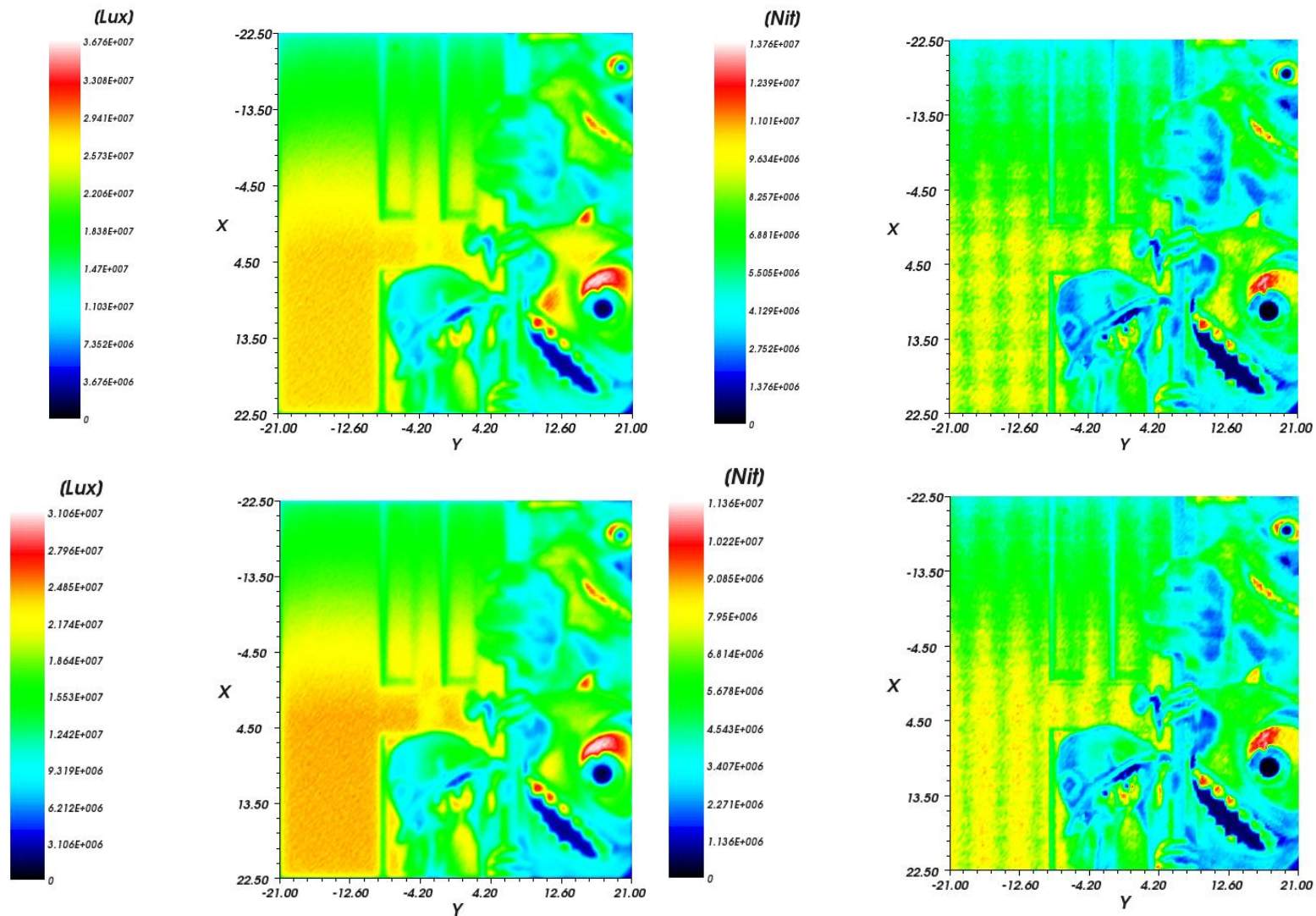
입사각도 10도

Display Image Simulation

Display Simulation: [Open 50%, R:G:B=2:4:1, 1:1:1]

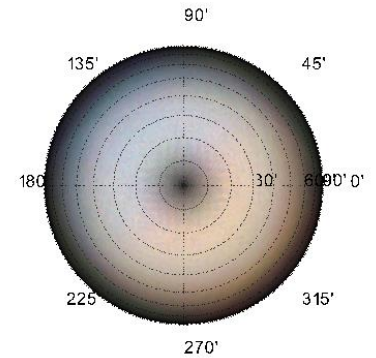
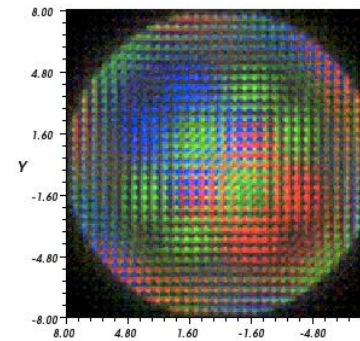
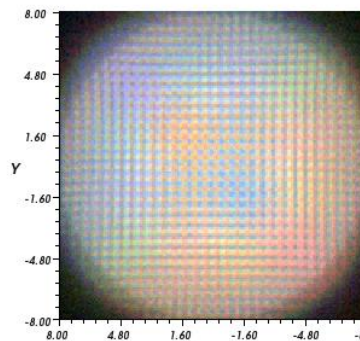
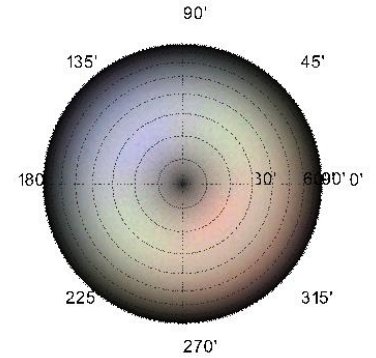
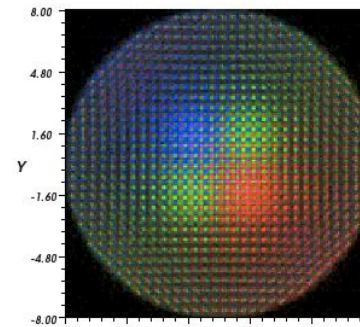
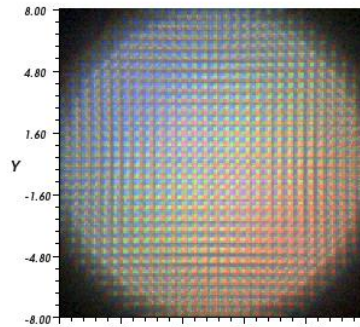
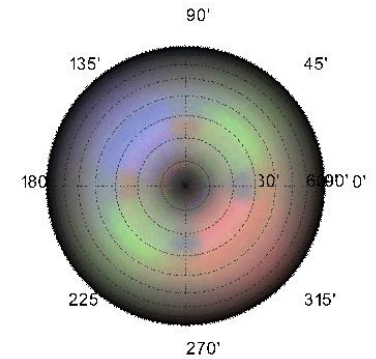
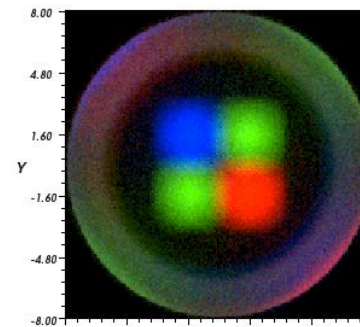
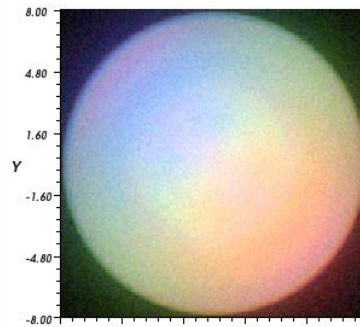
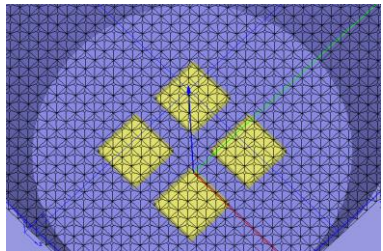
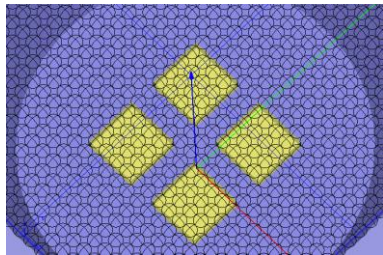
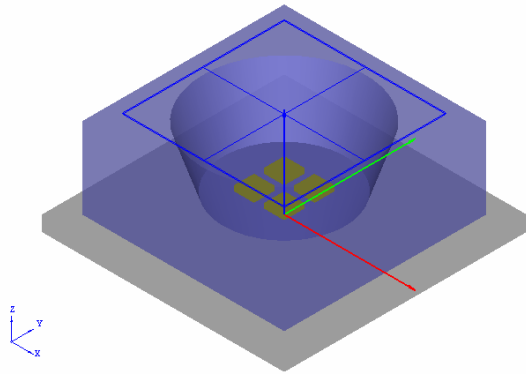


Display Simulation: [Open 50%, R:G:B=2:4:1, 1:1:1]



LED Packaging

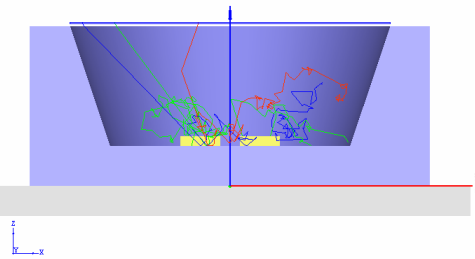
LED BLU Design: Emitting Unit Design (2)



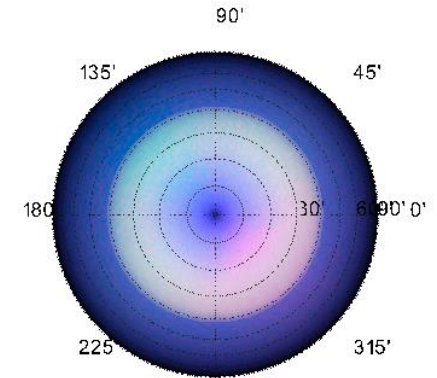
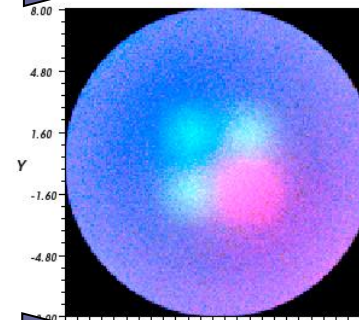
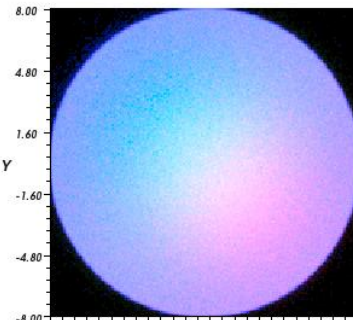
<Illuminance R,G,B>

<Luminance R,G,B>

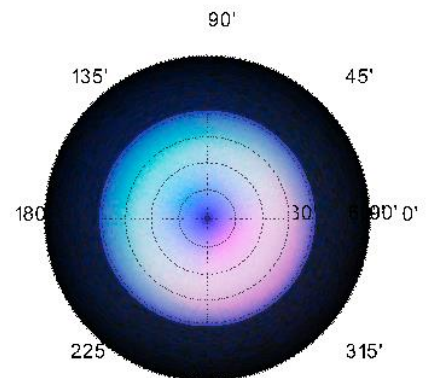
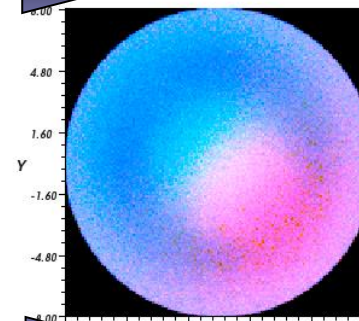
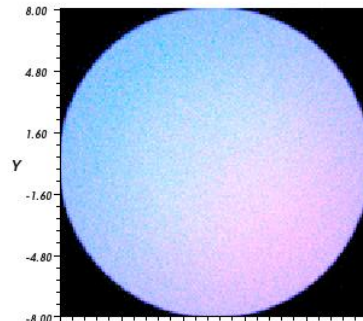
LED BLU Design: Emitting Unit Design (3)



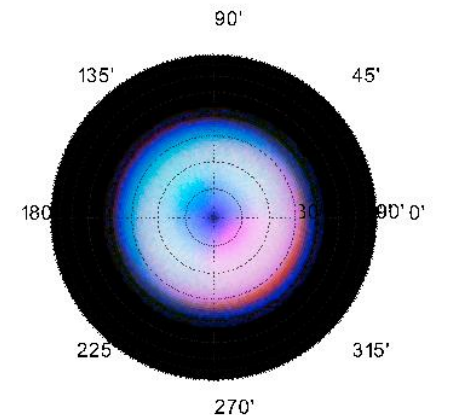
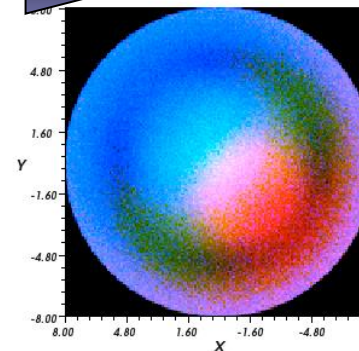
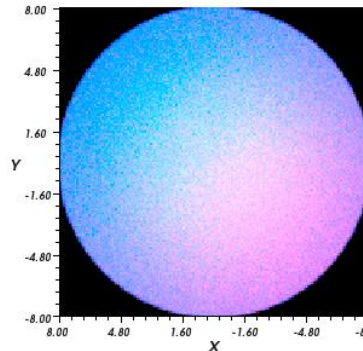
Bead Size 500nm



Bead Size 1000nm



Bead Size 2000nm



<Illuminance R,G,B>

<Luminance R,G,B>

270°