

MATERIAL TESTING

tkLayout developers meeting

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Testing algorithm

1. Build test case with controlled amount of material
2. Get elements **coordinates**
 - from tklayout run
3. Build model with **expected** material in each element
4. **Calculate** thickness in radiation length
5. Correlate tklayout **output** with **expected** calculation

Expected material

	Unit= g/m (linear dens.)	Unit= mm (thickness)	Unit= g (weight)
Module Service=false	Module $\times moduleLength$ No accumulation No conversion Scaling possible	Module $\times moduleSurface \times \rho$ (sensor surface) No accumulation No conversion Scaling possible	Module $\times 1$ No accumulation No conversion Scaling possible
Module in ring R of N Service=true	Following sections $S_{R+1} \dots S_i \dots S_N$ $\times numModules_R \times supportLength_i$ Accumulation Conversion(1:1 by default, with warning) Scaling possible	Following sections $S_{R+1} \dots S_i \dots S_N$ $\times supportSurface_i \times \rho$ Accumulation Conversion(1:1 by default, with warning) Scaling possible Deprecated warning	N/A
Rod (barrel, endcap) Service=false	All sections $S_1 \dots S_i \dots S_N$ $\times numModules_1 \times supportLength_i$ No accumulation No conversion Scaling not possible	All sections $S_1 \dots S_i \dots S_N$ $\times supportSurface_i \times \rho$ No accumulation No conversion Scaling not possible	N/A
Rod (barrel, endcap) Service=true	All sections $S_1 \dots S_i \dots S_N$ $\times numModules_1 \times supportLength_i$ No accumulation Conversion Scaling not possible	All sections $S_1 \dots S_i \dots S_N$ $\times supportSurface_i \times \rho$ No accumulation Conversion Scaling not possible Deprecated warning	N/A

Compute expected material for g/m unit

Cylinder, L g/mm of material M

$$\frac{X_0}{X_{0M}} = \frac{L}{2\pi r \cdot X_{0M}} \cdot \frac{e^\eta + e^{-\eta}}{2}$$

Disk, L g/mm of material M

$$\frac{X_0}{X_{0M}} = \frac{L}{\pi(r_1 + r_2) \cdot X_{0M}} \cdot \frac{e^{2\eta} + 1}{e^{2\eta} - 1}$$

- ✓ For **layers** rods, L is:
 - the set material multiplied by the number of rods
- ✓ For **disks** “rods”, L is:
 - the set material multiplied by the number of modules of the first ring

Compute expected material for mm unit

Cylinder, L mm of material M

$$\frac{X_0}{X_{0M}} = \frac{L \cdot \rho_M}{X_{0M}} \cdot \frac{e^\eta + e^{-\eta}}{2}$$

Disk, L mm of material M

$$\frac{X_0}{X_{0M}} = \frac{L \cdot \rho_M}{X_{0M}} \cdot \frac{e^{2\eta} + 1}{e^{2\eta} - 1}$$

- ✓ For layers and disks rods, L is:
 - the set material (not replicated for rod or modules)

Compute expected material for g unit

Cylinder, L g of material M

$$\frac{X_0}{X_{0M}} = \frac{L}{2\pi r(z_2 - z_1) \cdot X_{0M}} \cdot \frac{e^\eta + e^{-\eta}}{2}$$

Disk, L g of material M

$$\frac{X_0}{X_{0M}} = \frac{L}{\pi(r_2^2 - r_1^2) \cdot X_{0M}} \cdot \frac{e^{2\eta} + 1}{e^{2\eta} - 1}$$

- ✓ Unit g can't be used for rods in layers and disks

Tests map

		Unit= g/m (linear dens.)		Unit= mm (thickness)		Unit= g (weight)	
		Service=false	Service=true	Service=false	Service=true	Service=false	Service=true
Module	Barrel	test4, test5					
	Endcap	test6bis, test14					
Rod	Barrel	test1a, test1b, test1c, test1d, test2, test5, test7 ¹ , test8 ¹ , test9 ¹ , test10 ¹ , test10bis ¹ , test10ter ¹ , test11 ² , test11bis ²		test3bis, test3ter	test3, test3quater	N/A	N/A
	Endcap	test15bis	test6, test15	test12bis	test12	N/A	N/A

¹Test conversions

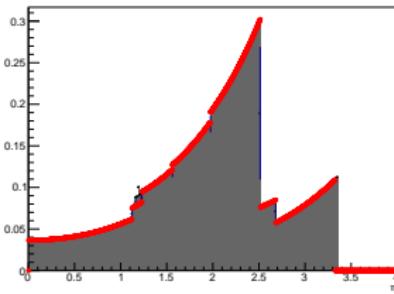
²Test scaling

Test1a

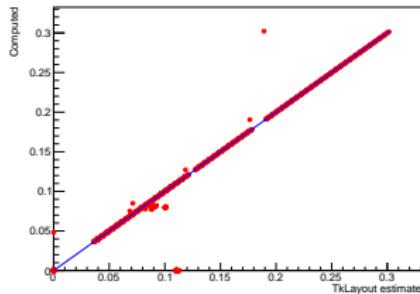
100g/m of Cu in the rods of the first layer of the pixel barrel

- ✓ 12 rods
- ✓ $L = 1200$ for every element

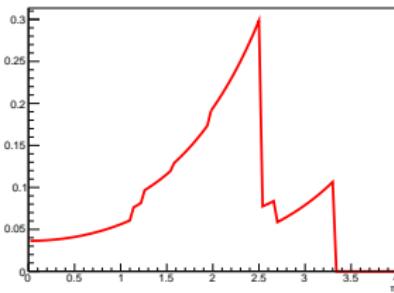
TkLayout estimate vs computed



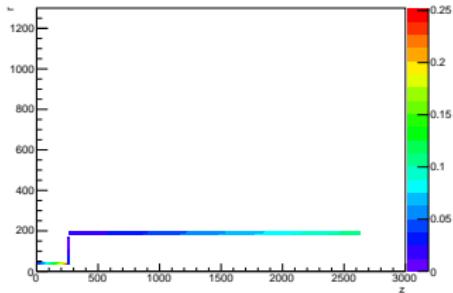
Correlation



Computed function



Computed map

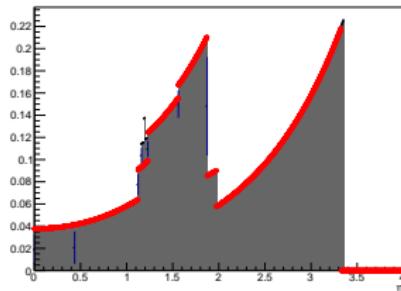


Test1b

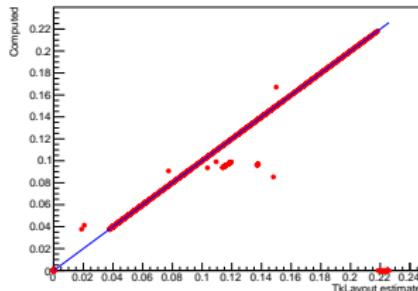
100g/m of Cu in the rods of the second layer of the pixel barrel

- ✓ 24 rods
- ✓ $L = 2400$ for every element

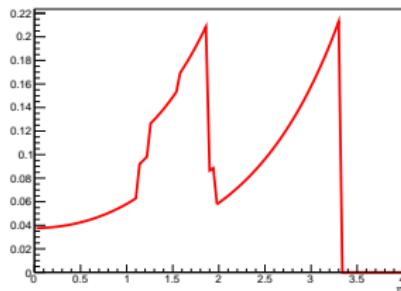
TkLayout estimate vs computed



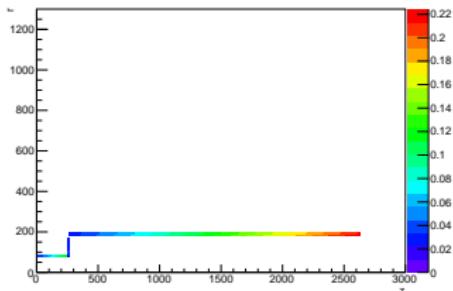
Correlation



Computed function



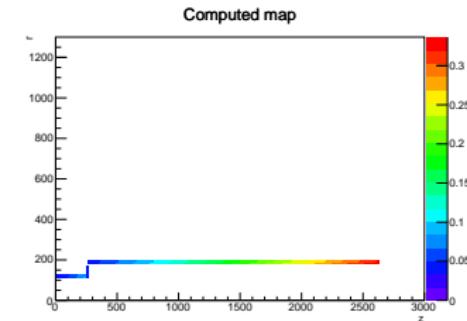
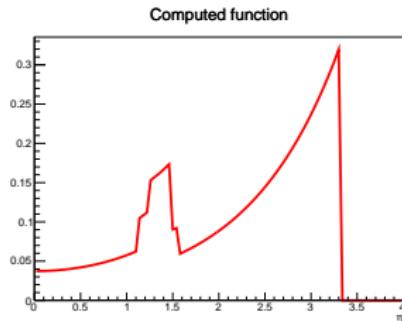
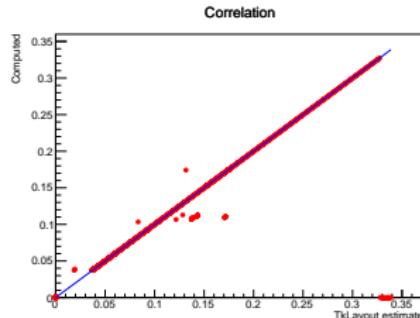
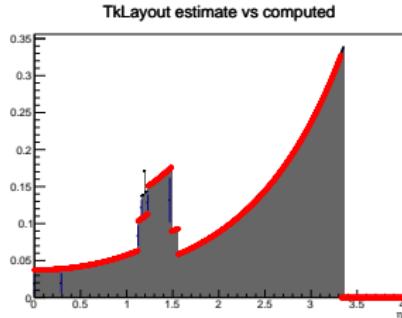
Computed map



Test1c

100g/m of Cu in the rods of the third layer of the pixel barrel

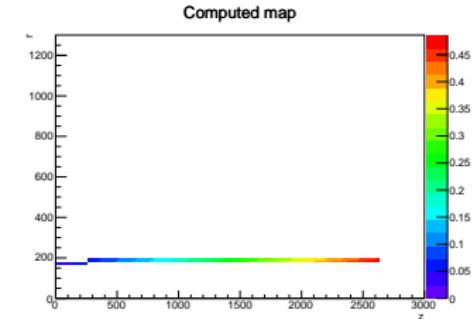
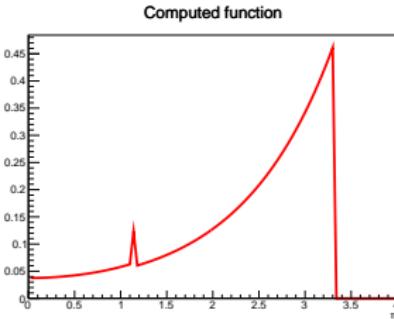
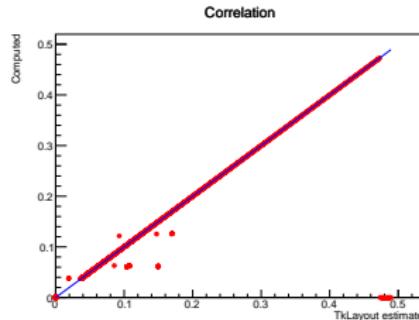
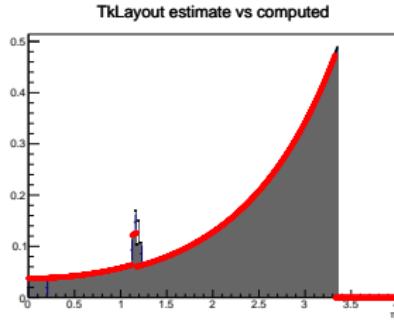
- ✓ 36 rods
- ✓ $L = 3600$ for every element



Test1d

100g/m of Cu in the rods of the fourth layer of the pixel barrel

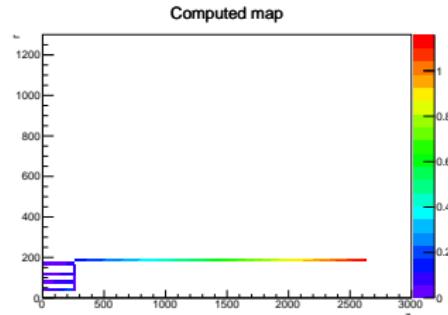
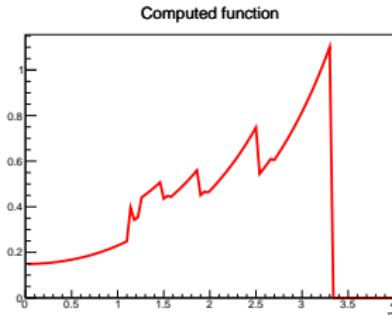
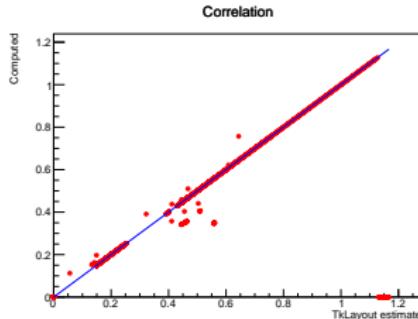
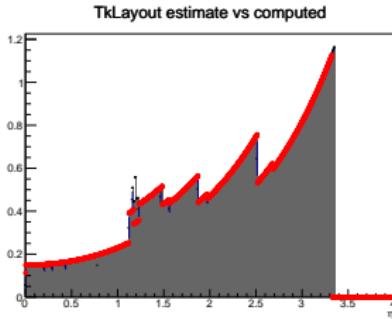
- ✓ 52 rods
- ✓ $L = 5200$ for every element



Test2

100g/m of Cu in the rods of all the layers of the pixel barrel

- ✓ $L = \text{rods} * 100$ for layers
- ✓ $L = L_{\text{inLayer}} + L_{\text{inDisk}}$ for disks and last cylinder

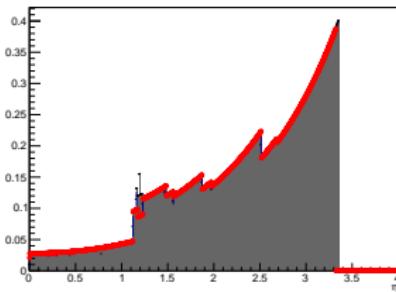


Test3

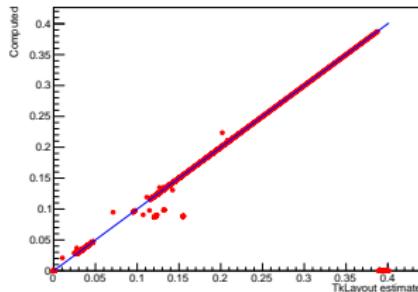
0.1mm of Cu in the rods of all the layers of the pixel barrel, exiting

- ✓ $L = 0.1$ for layers
- ✓ $L = L_{inLayer} + L_{inDisk}$ for disks and last cylinder (**deprecated feature**)

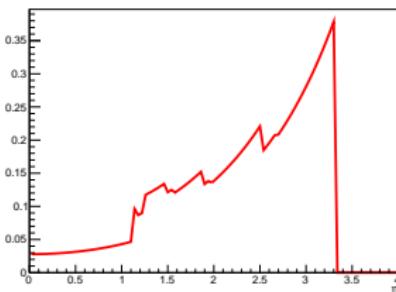
TkLayout estimate vs computed



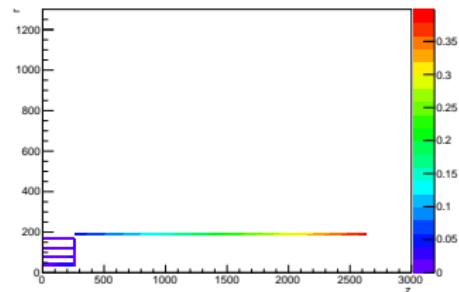
Correlation



Computed function



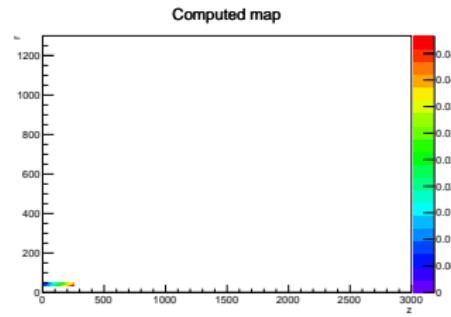
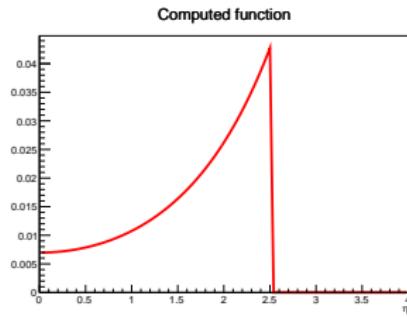
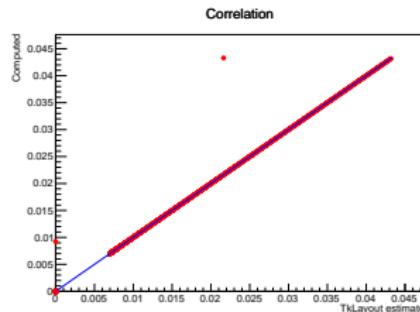
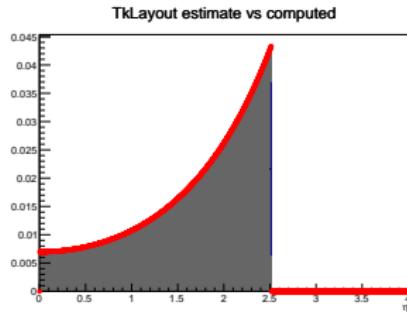
Computed map



Test3bis

0.1mm of Cu in the rods of first layer of the pixel barrel, not exiting

✓ $L = 0.1$ for all elements

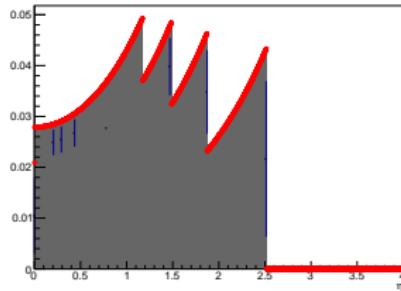


Test3ter

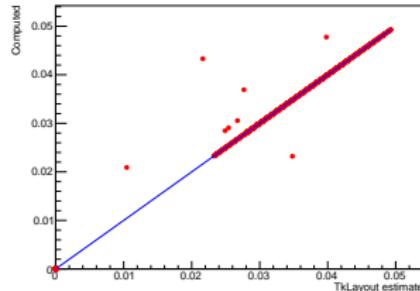
0.1mm of Cu in the rods of all the layers of the pixel barrel, not exiting

✓ $L = 0.1$ for layers

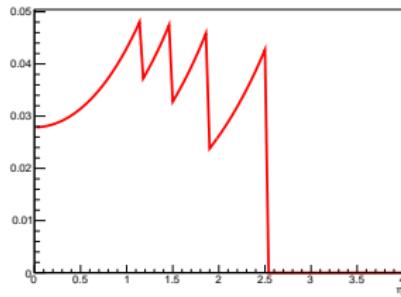
TkLayout estimate vs computed



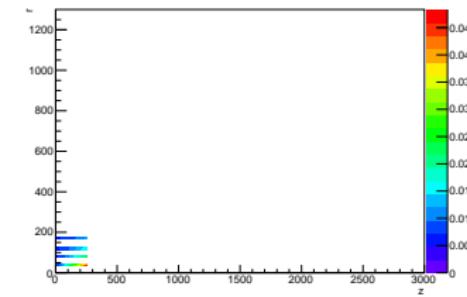
Correlation



Computed function



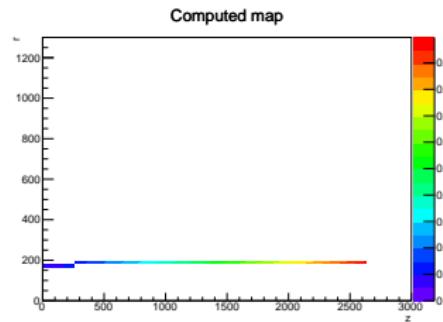
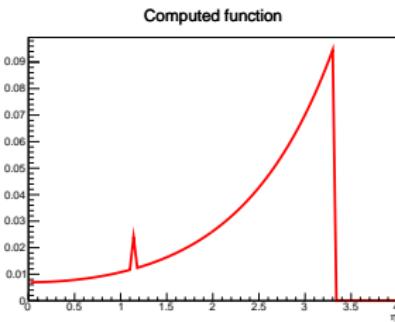
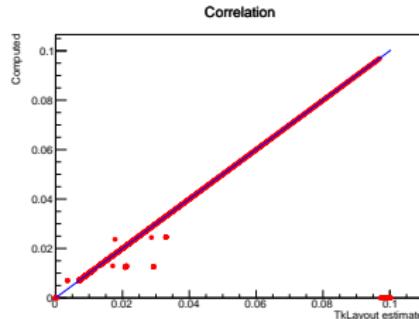
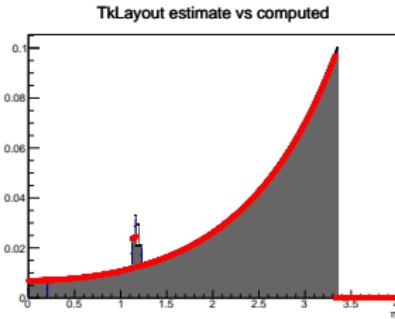
Computed map



Test3quater

0.1mm of Cu in the rods of first layer of the pixel barrel, exiting

✓ $L = 0.1$ for all elements

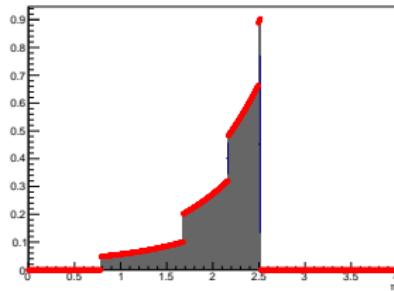


Test4

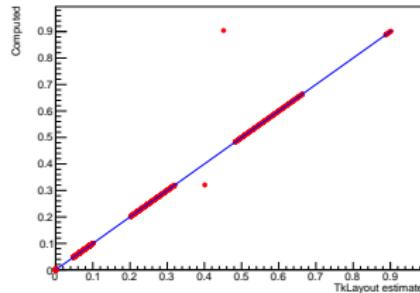
100g/m of Cu exiting from modules of the first layer of the pixel barrel

✓ $L = (\text{rods} * 100) + L_{\text{previousCylinder}}$ for cylinders

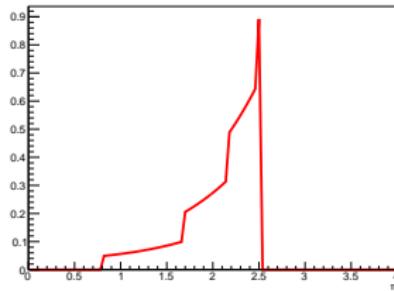
TkLayout estimate vs computed



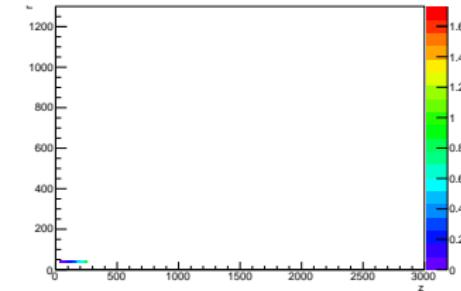
Correlation



Computed function



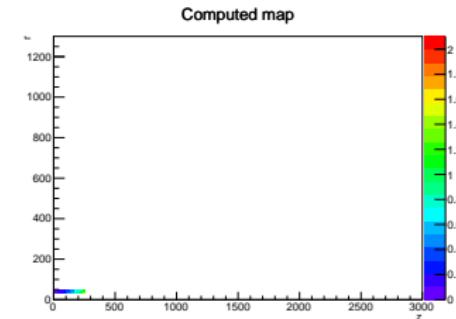
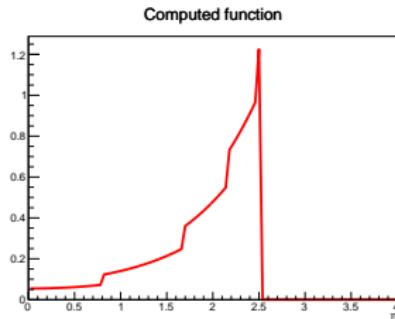
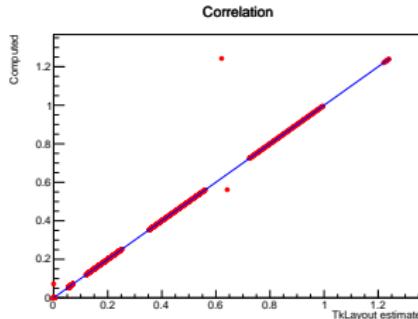
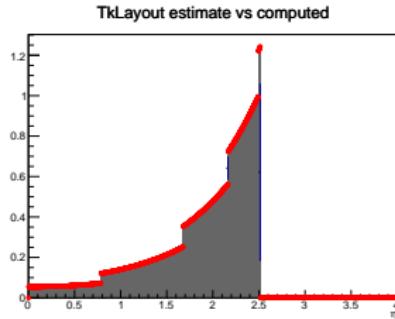
Computed map



Test5

100g/m of Cu exiting from modules and 150g/m in the rods

- ✓ $L = (\text{rods} * 100) + L_{\text{previousCylinder}}$ for cylinders
- ✓ $L = (\text{rods} * 150)$ in layer

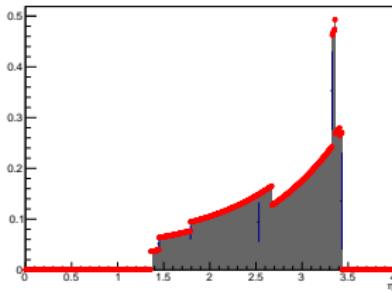


Test6

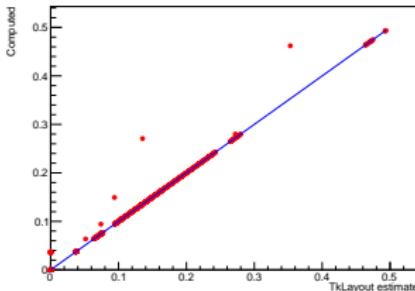
100g/m of Cu in the first disk of pixel endcap

- ✓ 24 modules on first ring of disk
- ✓ $L = (24 * 100)$ in every element

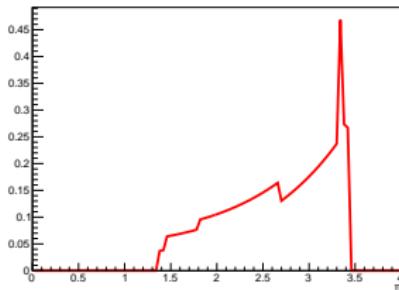
TkLayout estimate vs computed



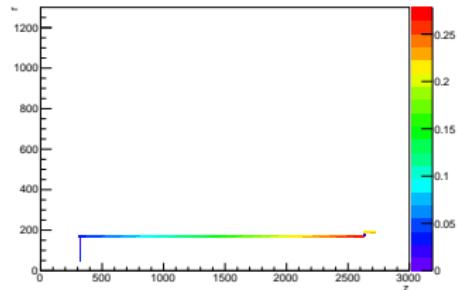
Correlation



Computed function



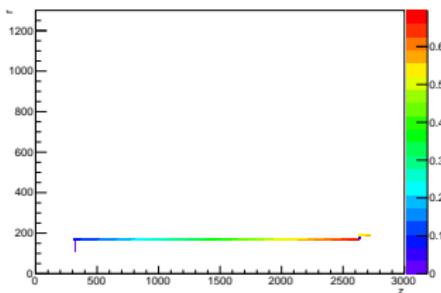
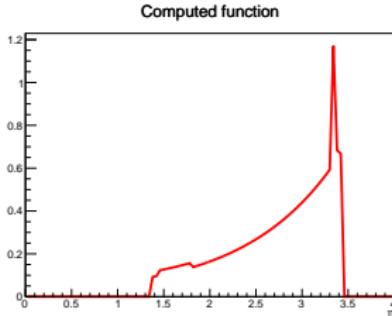
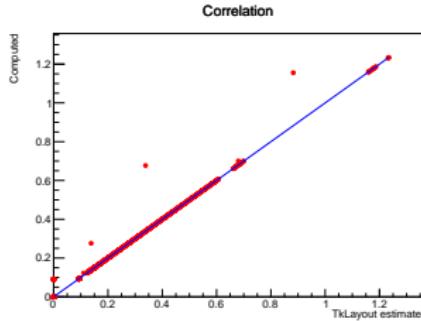
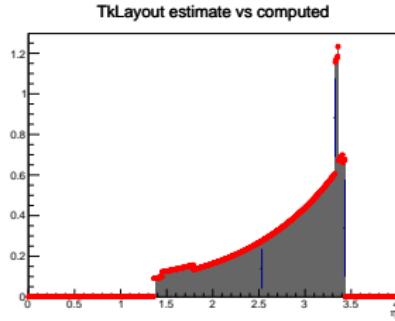
Computed map



Test6bis

100g/m of Cu exiting from the first disk modules of pixel endcap

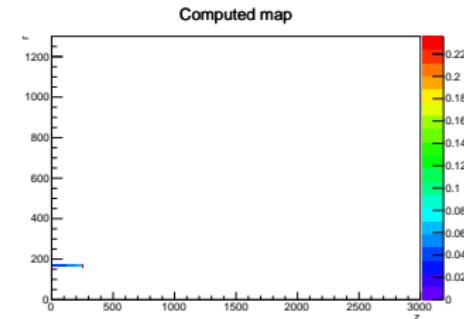
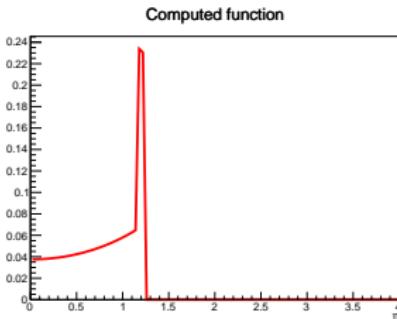
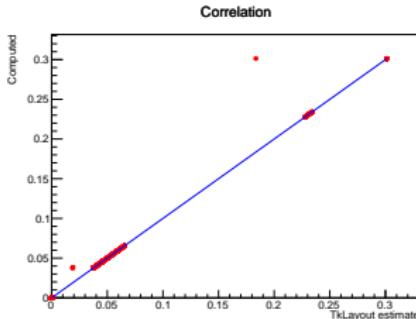
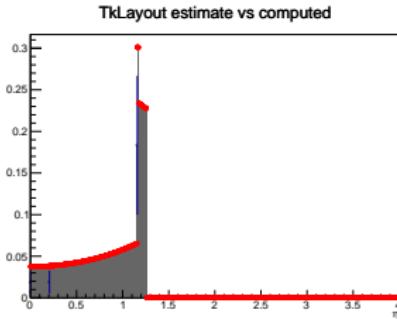
- ✓ 24 modules on first ring of disk, 36 on second
- ✓ $L = (24 * 100)$ in service disk, $L = (60 * 100)$ in others



Test7

100g/m of Cu in the fourth layer and conversion 1g/m → 0.1g locally

- ✓ $L = (\text{rods} * 100)$ in layer
- ✓ $L = (\text{rods} * 100 * 0.1)$ in flange

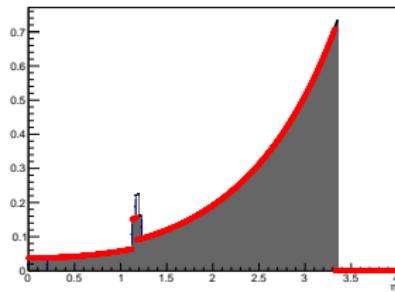


Test8

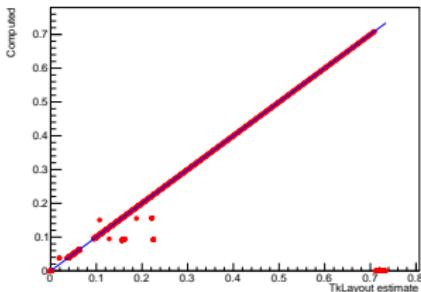
100g/m of Cu in the fourth layer and conversion $1g/m \rightarrow 1.5g/m$ exiting

- ✓ $L = (\text{rods} * 100)$ in layer
- ✓ $L = (\text{rods} * 150)$ in second cylinder

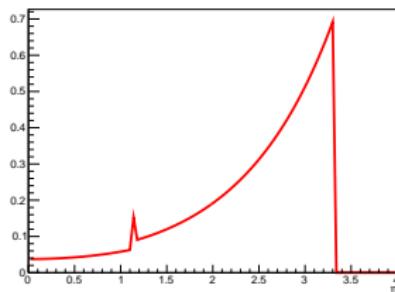
TkLayout estimate vs computed



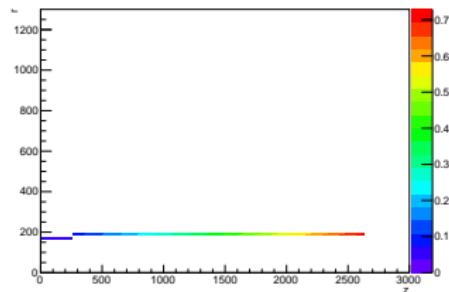
Correlation



Computed function



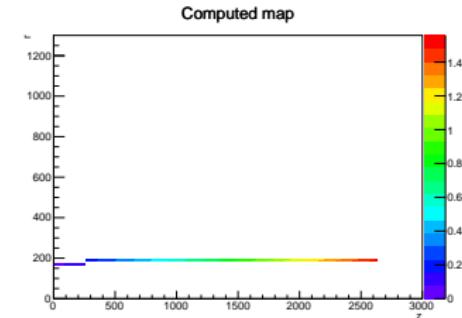
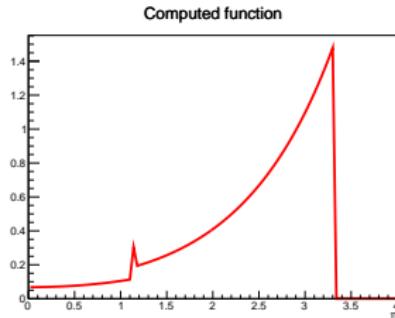
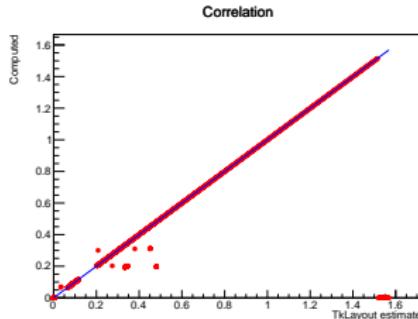
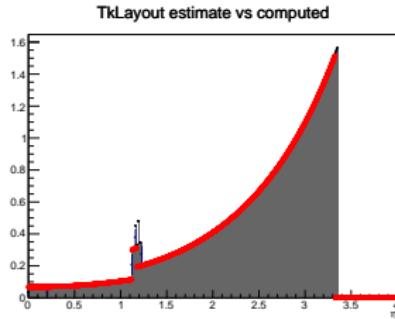
Computed map



Test9

100g/m of Cu and 150g/m of Al in the fourth layer and conversions

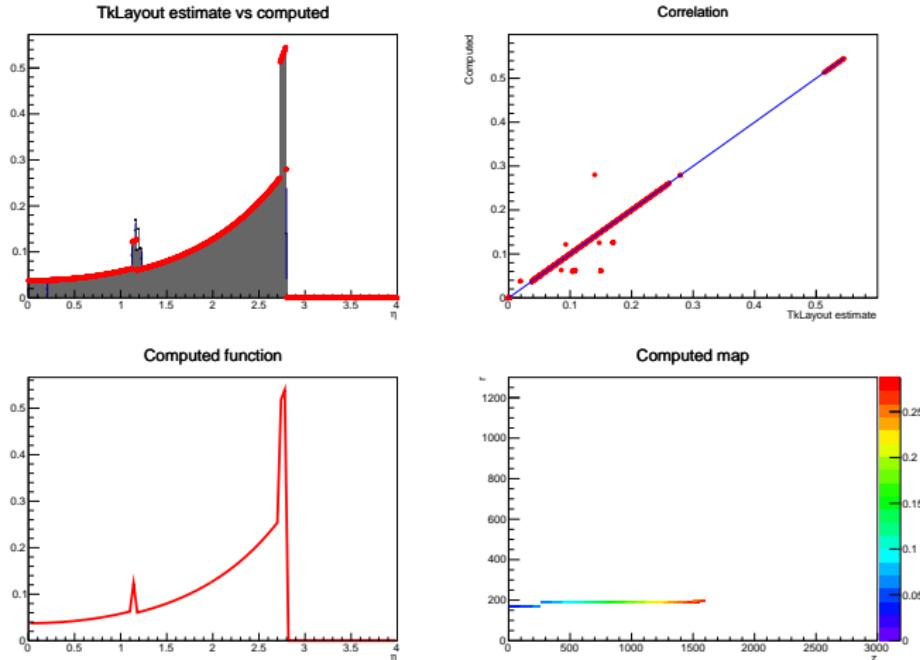
- ✓ $1\text{g}/\text{m} \text{Cu} \rightarrow 2\text{g}/\text{m} \text{Cu}$ exiting
- ✓ $0.1\text{g}/\text{m} \text{Al} \rightarrow 0.15\text{g}/\text{m} \text{Al}$ exiting



Test10

100g/m of Cu in the fourth layer and conversions

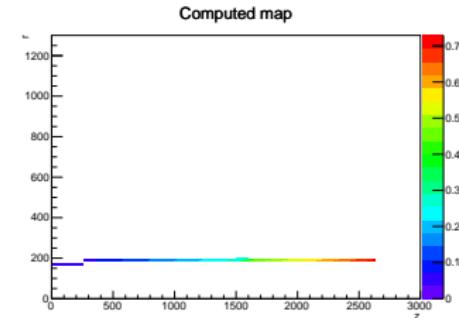
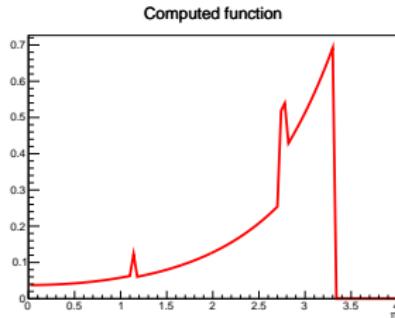
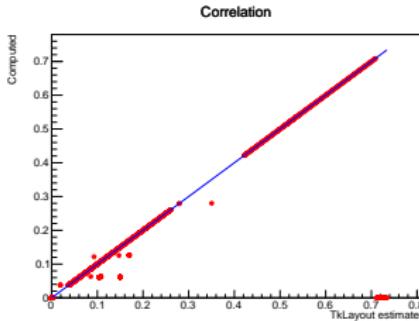
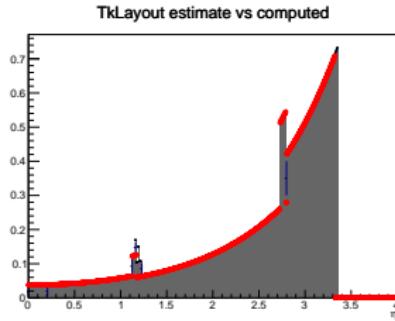
- ✓ $1\text{g}/\text{m} \rightarrow 1\text{g}/\text{m}$ exiting in the flange
- ✓ $1\text{g}/\text{m} \rightarrow 0.1\text{g}$ local in the second level



Test10bis

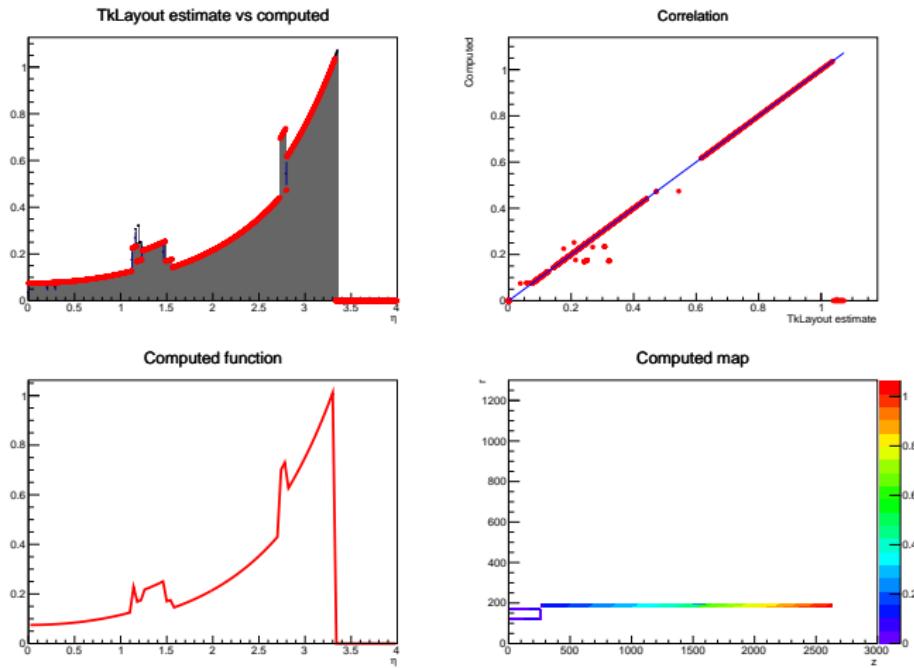
100g/m of Cu in the fourth layer and conversions

- ✓ $1\text{g}/\text{m} \rightarrow 1\text{g}/\text{m}$ exiting in the flange
- ✓ $1\text{g}/\text{m} \rightarrow 0.1\text{g}$ local + $1.5\text{g}/\text{m}$ exiting in the second level



Test10ter

Same as test10bis plus 100g/m of Cu in the third layer with no destination for second level conversion

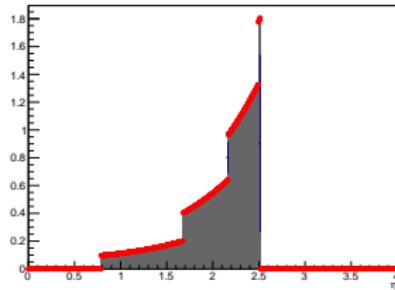


Test11

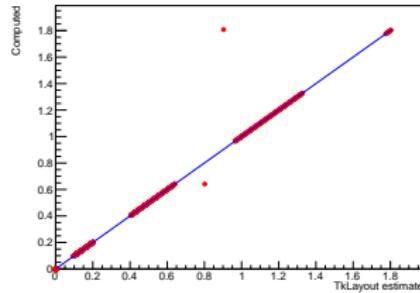
$100g/m$ of Cu exiting from modules of first layer with

✓ scaling with reference strip numbers halved

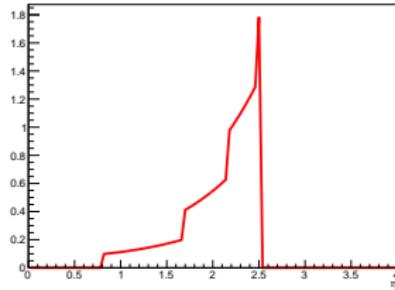
TkLayout estimate vs computed



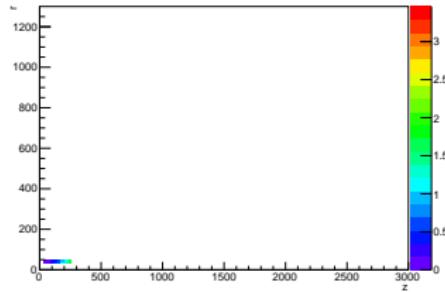
Correlation



Computed function



Computed map

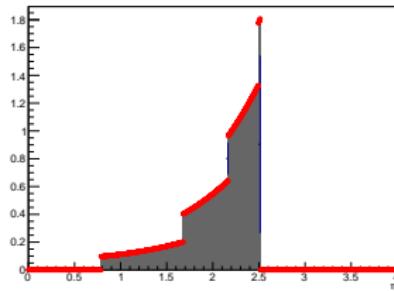


Test11bis

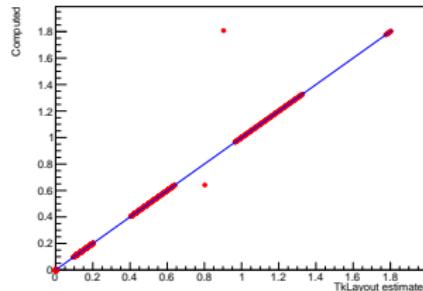
100g/m of Cu exiting from modules of first layer with

✓ scaling with reference segment numbers halved

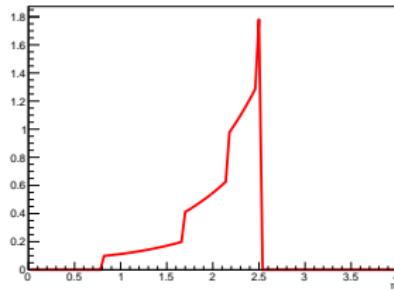
TkLayout estimate vs computed



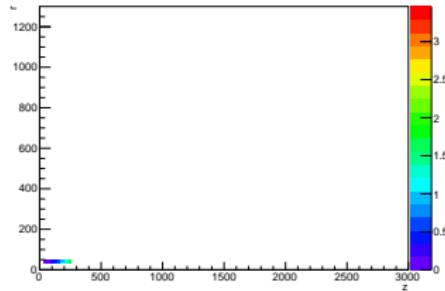
Correlation



Computed function



Computed map



Expected elements

test1a

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,35.837,250.5,45.837,H,1200,g/m,12.86,8.96
255.6,35.837,265.6,73.847,V,1200,g/m,12.86,8.96
255.6,73.847,265.6,114.538,V,1200,g/m,12.86,8.96
255.6,114.538,265.6,166.368,V,1200,g/m,12.86,8.96
260.5,184.368,2632.87,194.368,H,1200,g/m,12.86,8.96
```

test1b

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,73.847,250.5,83.847,H,2400,g/m,12.86,8.96
255.6,73.847,265.6,114.538,V,2400,g/m,12.86,8.96
255.6,114.538,265.6,166.368,V,2400,g/m,12.86,8.96
260.5,184.368,2632.87,194.368,H,2400,g/m,12.86,8.96
```

test1c

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,114.538,250.5,124.538,H,3600,g/m,12.86,8.96
255.6,114.538,265.6,166.368,V,3600,g/m,12.86,8.96
260.5,184.368,2632.87,194.368,H,3600,g/m,12.86,8.96
```

test1d

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,166.368,250.5,176.368,H,5200,g/m,12.86,8.96
260.5,184.368,2632.87,194.368,H,5200,g/m,12.86,8.96
```

test2

```
zMin(mm),rMin(mm),Zmax(mm),Rmax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
//layers
0.1,35.837,250.5,45.837,H,1200,g/m,12.86,8.96
0.1,73.847,250.5,83.847,H,2400,g/m,12.86,8.96
0.1,114.538,250.5,124.538,H,3600,g/m,12.86,8.96
0.1,166.368,250.5,176.368,H,5200,g/m,12.86,8.96
//rings
255.6,35.837,265.6,73.847,V,1200,g/m,12.86,8.96
255.6,73.847,265.6,114.538,V,3600,g/m,12.86,8.96
255.6,114.538,265.6,166.368,V,7200,g/m,12.86,8.96
//final layer
260.5,184.368,2632.87,194.368,H,12400,g/m,12.86,8.96
```

test3

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
//layers
0.1,35.837,250.5,45.837,H,0.1,mm,12.86,8.96
0.1,73.847,250.5,83.847,H,0.1,mm,12.86,8.96
0.1,114.538,250.5,124.538,H,0.1,mm,12.86,8.96
0.1,166.368,250.5,176.368,H,0.1,mm,12.86,8.96
//rings
255.6,35.837,265.6,73.847,V,0.1,mm,12.86,8.96
255.6,73.847,265.6,114.538,V,0.2,mm,12.86,8.96
255.6,114.538,265.6,166.368,V,0.3,mm,12.86,8.96
//final layer
260.5,184.368,2632.87,194.368,H,0.4,mm,12.86,8.96
```

test3bis

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,35.837,250.5,45.837,H,0.1,mm,12.86,8.96
```

test3ter

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,35.837,250.5,45.837,H,0.1,mm,12.86,8.96
0.1,73.847,250.5,83.847,H,0.1,mm,12.86,8.96
0.1,114.538,250.5,124.538,H,0.1,mm,12.86,8.96
0.1,166.368,250.5,176.368,H,0.1,mm,12.86,8.96
```

test3quater

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,166.368,250.5,176.368,H,0.1,mm,12.86,8.96
260.5,184.368,2632.87,194.368,H,0.1,mm,12.86,8.96
```

test4

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
35.5,35.837,105.5,45.837,H,1200,g/m,12.86,8.96
105.5,35.837,175.5,45.837,H,2400,g/m,12.86,8.96
175.5,35.837,245.5,45.837,H,3600,g/m,12.86,8.96
245.5,35.837,250.5,45.837,H,4800,g/m,12.86,8.96
```

test5

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
//modules effects
35.5,35.837,105.5,45.837,H,1200,g/m,12.86,8.96
105.5,35.837,175.5,45.837,H,2400,g/m,12.86,8.96
175.5,35.837,245.5,45.837,H,3600,g/m,12.86,8.96
245.5,35.837,250.5,45.837,H,4800,g/m,12.86,8.96
//rod effect
0.1,35.837,250.5,45.837,H,1800,g/m,12.86,8.96
```

test6

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
//disks
316.97,44.733,326.97,110.655,V,2400,g/m,12.86,8.96
316.97,110.655,326.97,159.99,V,2400,g/m,12.86,8.96
//long layer
308.97,165.09,2632.87,175.09,H,2400,g/m,12.86,8.96
//final layer
2632.97,184.368,2722.97,194.368,H,2400,g/m,12.86,8.96
//conjunction disk
2632.97,174.99,2642.97,184.268,V,2400,g/m,12.86,8.96
```

test6bis

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
//disk (only the second)
316.97,110.655,326.97,159.99,V,2400,g/m,12.86,8.96
//long layer
308.97,165.09,2632.87,175.09,H,6000,g/m,12.86,8.96
//final layer
2632.97,184.368,2722.97,194.368,H,6000,g/m,12.86,8.96
//conjunction disk
2632.97,174.99,2642.97,184.268,V,6000,g/m,12.86,8.96
```

test7

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,166.368,250.5,176.368,H,5200,g/m,12.86,8.96
250.6,156.368,255.6,176.368,V,520,g,12.86,8.96
```

test8

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,166.368,250.5,176.368,H,5200,g/m,12.86,8.96
260.5,184.368,2632.87,194.368,H,7800,g/m,12.86,8.96
```

test9

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,166.368,250.5,176.368,H,5200,g/m,12.86,8.96
0.1,166.368,250.5,176.368,H,7800,g/m,24.01,2.7
260.5,184.368,2632.87,194.368,H,10400,g/m,12.86,8.96
260.5,184.368,2632.87,194.368,H,11700,g/m,24.01,2.7
```

test10

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,166.368,250.5,176.368,H,5200,g/m,12.86,8.96
260.5,184.368,1550,194.368,H,5200,g/m,12.86,8.96
1500,194.468,1600,199.468,H,520,g,12.86,8.96
```

test10bis

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,166.368,250.5,176.368,H,5200,g/m,12.86,8.96
260.5,184.368,1550,194.368,H,5200,g/m,12.86,8.96
1500,194.468,1600,199.468,H,520,g,12.86,8.96
```

test10ter

```
zMin(mm),rMin(mm),Zmax(mm),rMax(mm),direction,quantity,unit,X0(g/cm2),density(g/cm3)
0.1,166.368,250.5,176.368,H,5200,g/m,12.86,8.96
260.5,184.368,1550,194.368,H,5200,g/m,12.86,8.96
1500,194.468,1600,199.468,H,520,g,12.86,8.96
```