



Design Verification and Analysis Tools in TracePro

Presented by :
Lambda Research Corporation
25 Porter Rd.
Littleton, MA 01460
www.lambdares.com





Moderator:
Andy Knight
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Lambda Research Corporation

Presenter:
Dave Jacobsen
Senior Application Engineer
Lambda Research Corporation



Format

- A 25-30 minute presentation followed by a 10-15 minute question and answer session
- Please submit your questions anytime using Question box in the GoToWebinar control panel



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Current TracePro and OSLO Releases

TracePro 7.0.3

OSLO 6.5.2

Available for download from our website by users with current maintenance and support agreements

In this webinar you will:

- See the design verification and analysis tools available in TracePro
- Learn how to apply these tools to your design
- Gain and understanding as to how these tools can help in your design and verification process

In this webinar you will:

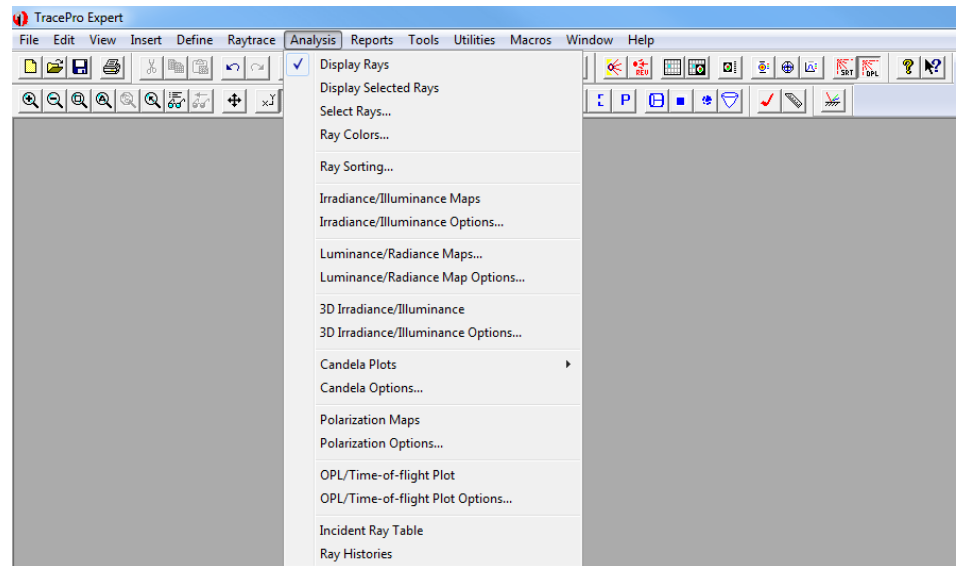
- Find out how these tools can be used to check tolerances in your design
- Have your questions answered in the Question and Answer Session

What is design verification and analysis?

- Checking to see if your design meets the desired goals
- Examples of design goals:
 - Flux, Irradiance, or Illuminance targets
 - Beam pattern
 - Color (mixing, color coordinates, CCT)
 - Uniformity
 - Luminous or Radiant Intensity
 - Radiance or Luminance targets
 - Efficiency

What are some of the design verification and analysis tools available in TracePro?

- Irradiance and Illuminance Maps
- Candela Plots
- Luminance and Radiance Maps
- Flux Reports
- Incident Ray Table
- Ray Histories



What are some of the design verification and analysis tools available in TracePro?

•Irradiance and Illuminance Maps

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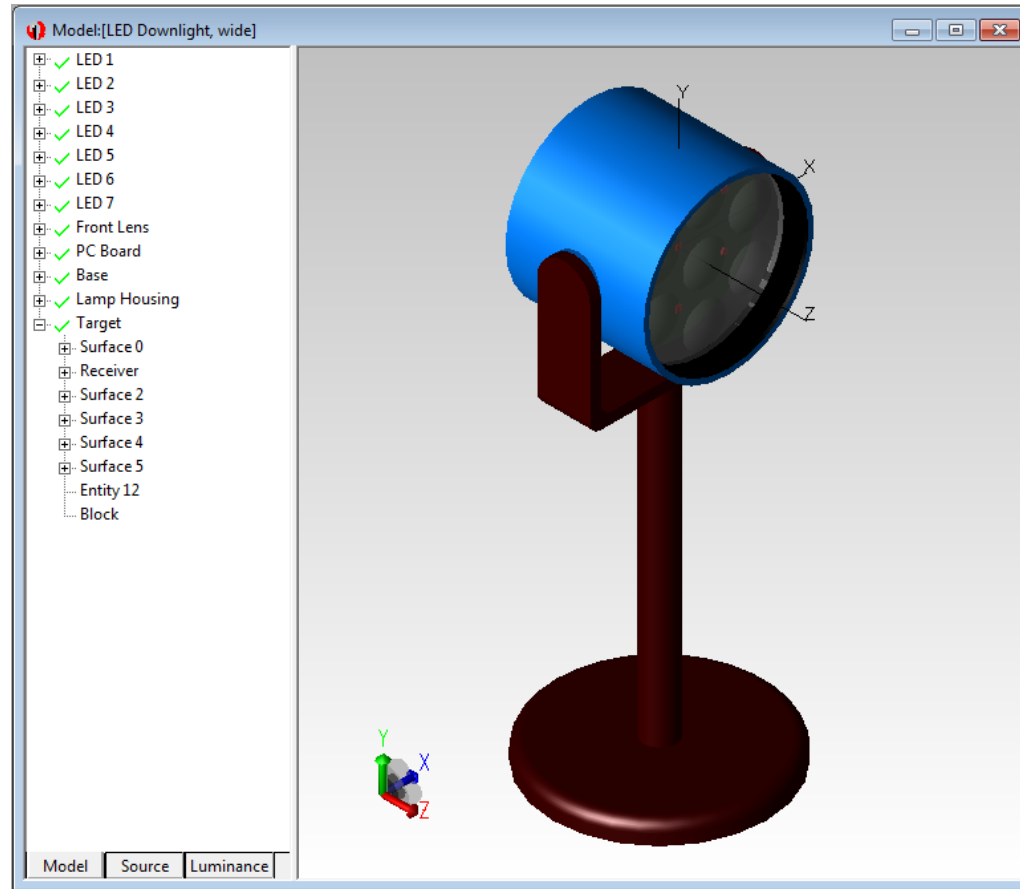
Irradiance/Illuminance Map

- Displays spatial distribution of incident and absorbed light on a selected surface
- Flux and Flux per Unit Area
 - Irradiance: Radiometric units (watts, watts/m², watts/ft²)
 - Illuminance: Photometric units (lumens, lux, ft-candles)
 - Units can be changed at Raytrace->Raytrace Options->Options->Analysis Units
- Uniformity
- Efficiency
- Relief Plots

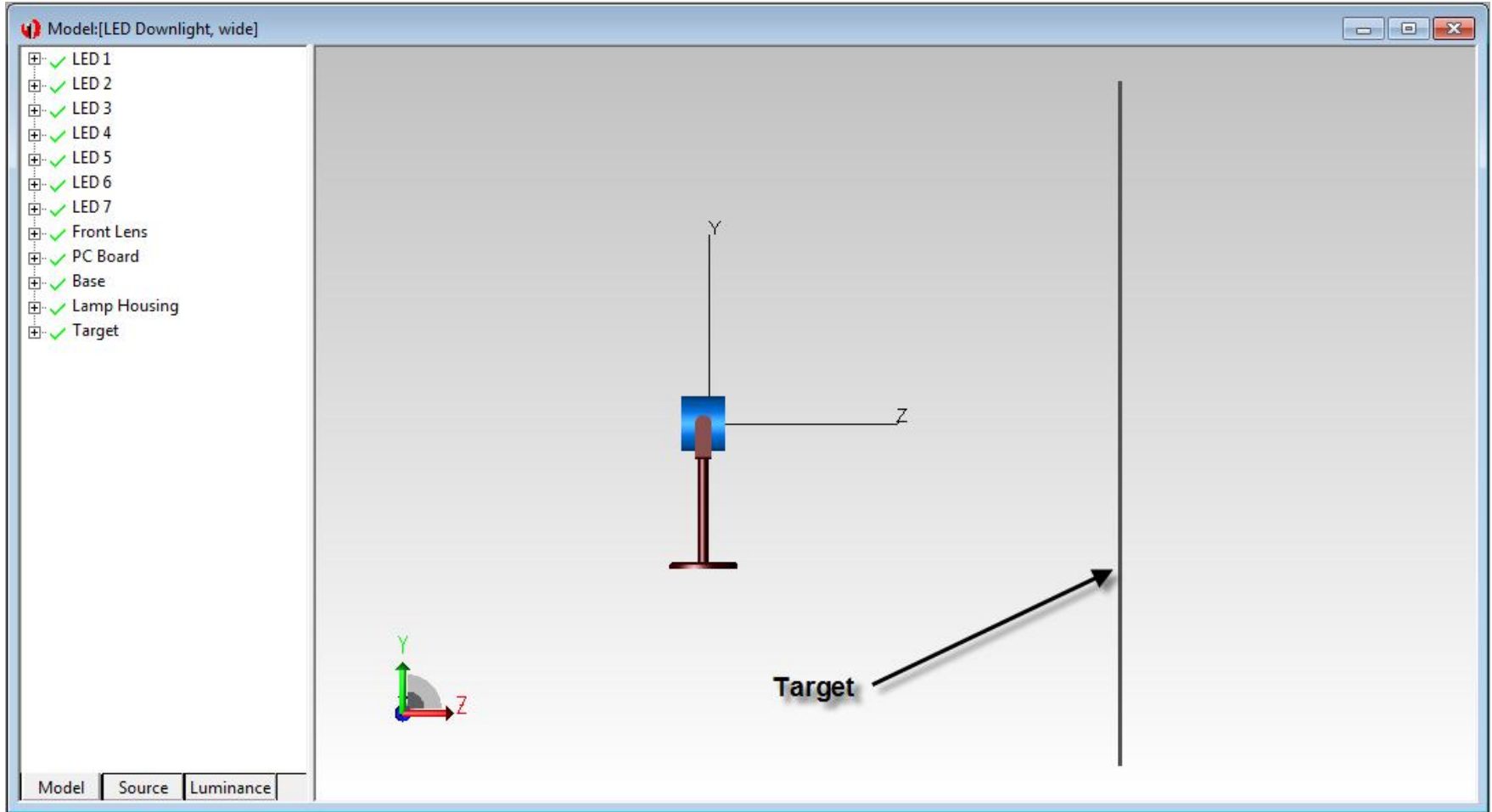
Irradiance/Illuminance Map

- Profiles
- Contour Plots
- CIE Color Coordinates (xy and $u'v'$)
- Correlated Color Temperature
- TrueColor

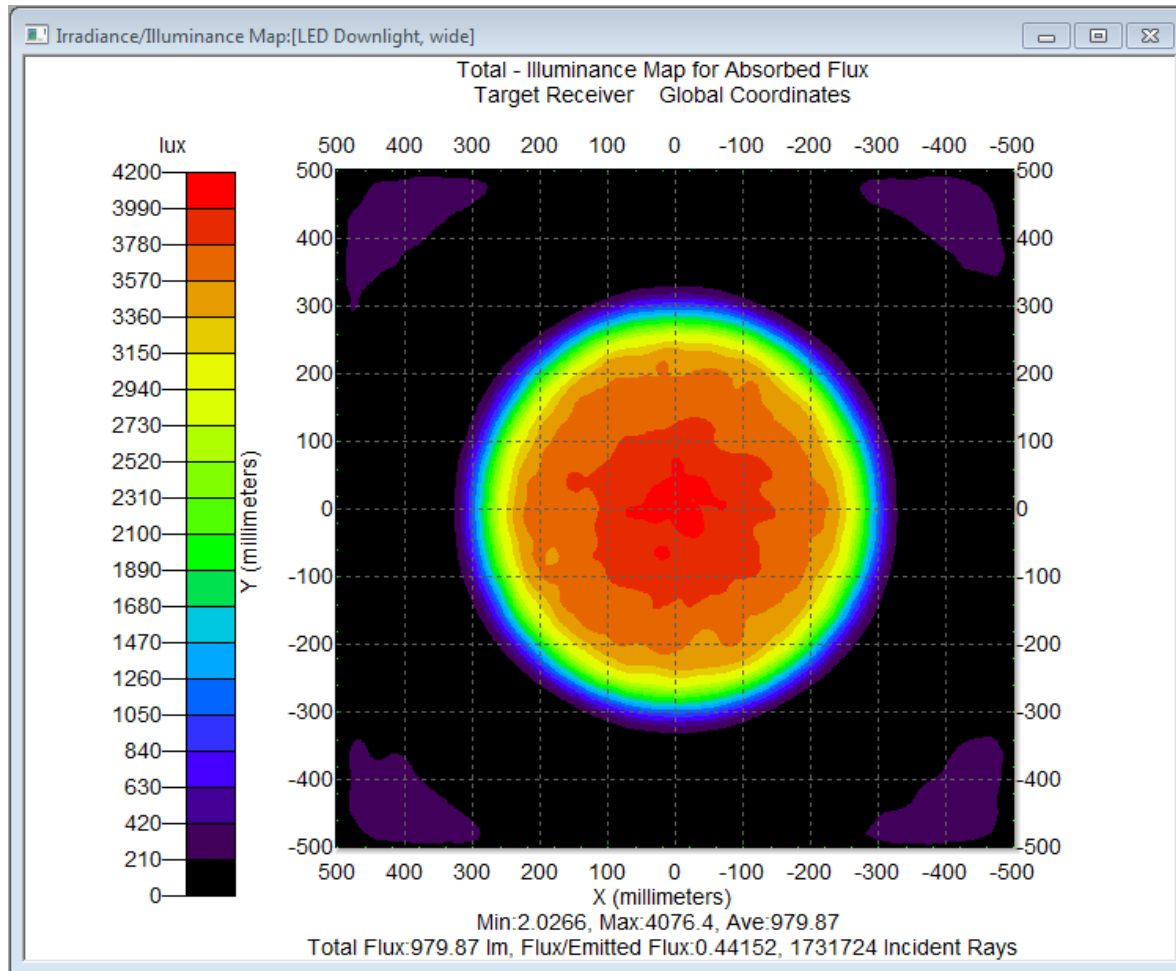
Irradiance/Illuminance Map LED Spotlight Example



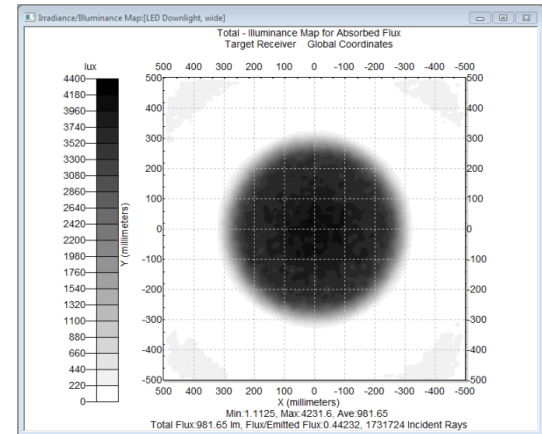
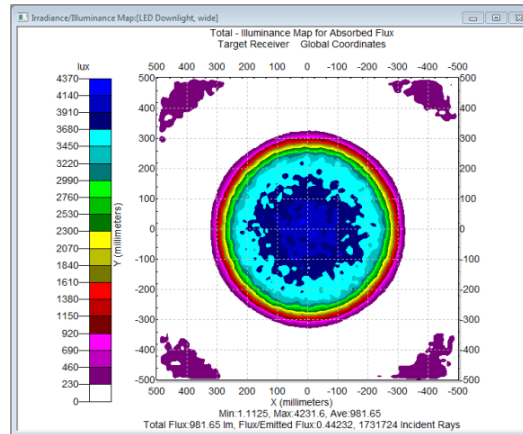
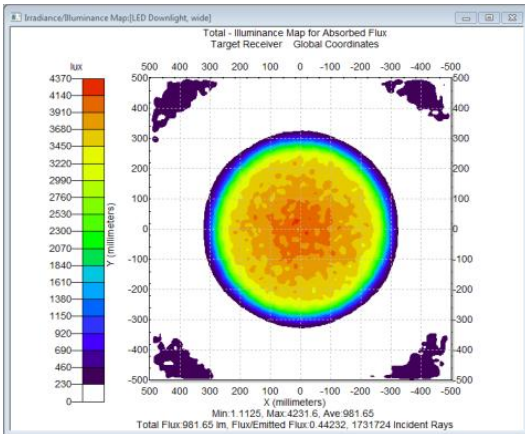
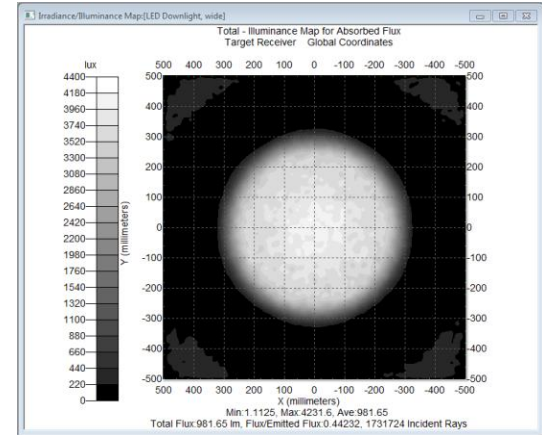
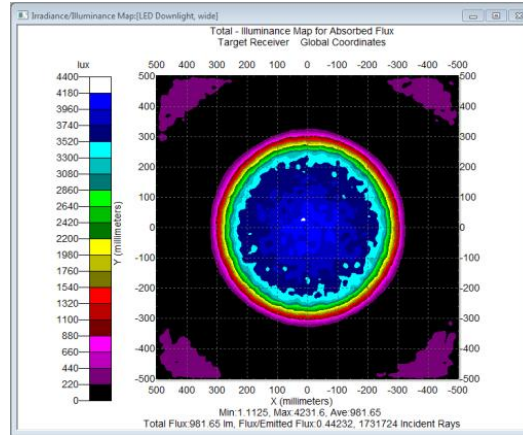
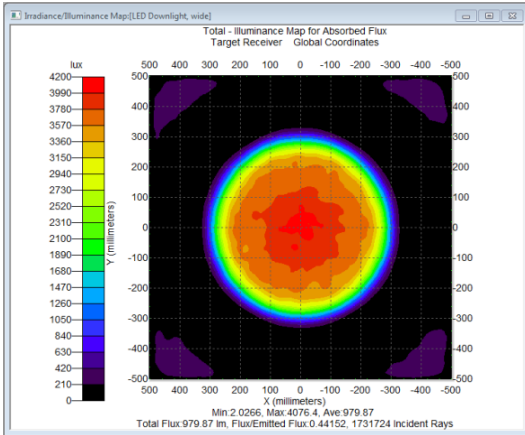
Irradiance/Illuminance Map LED Spotlight Example



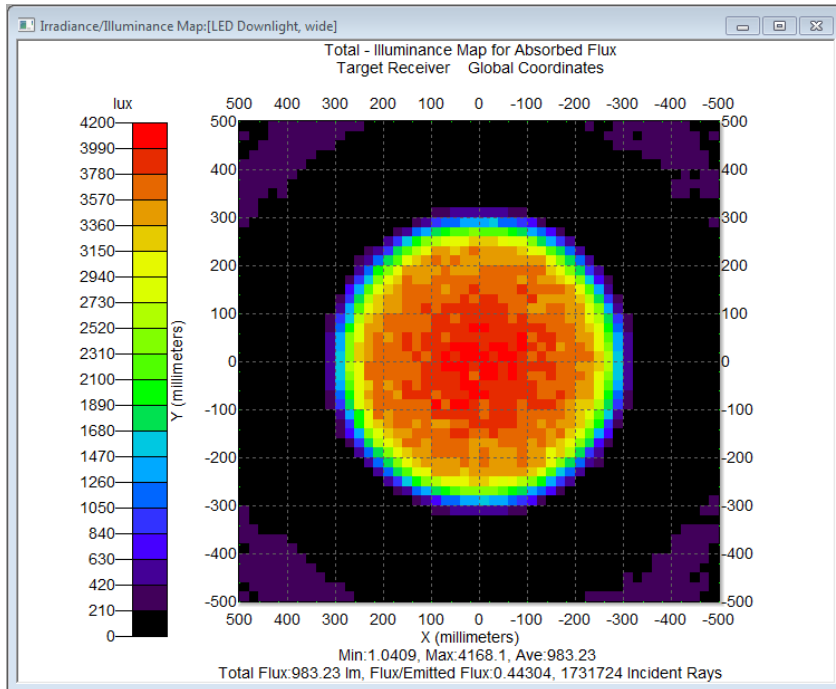
Irradiance/Illuminance Map



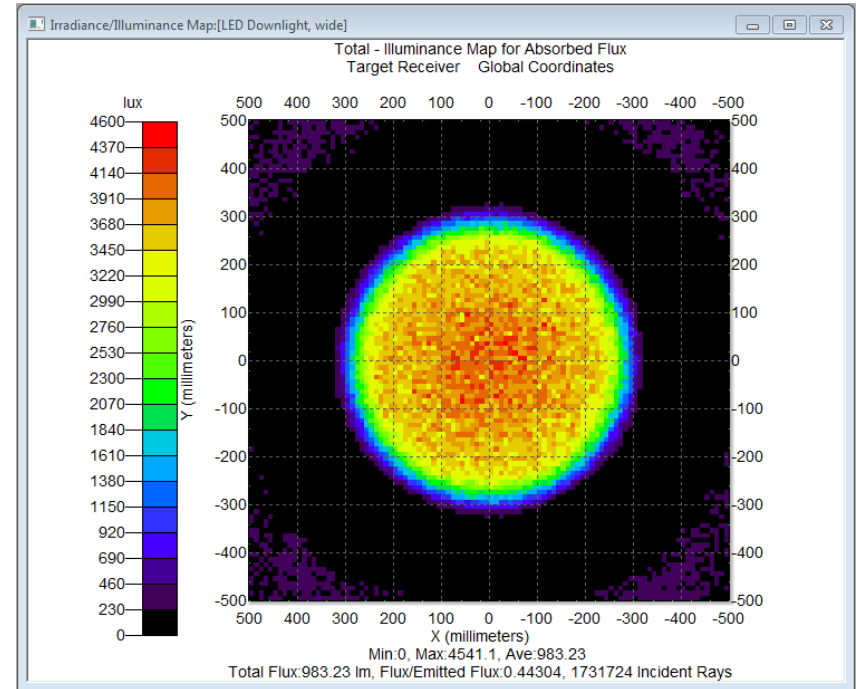
Irradiance/Illuminance Map – Color Options



Irradiance/Illuminance Map – Pixel Count

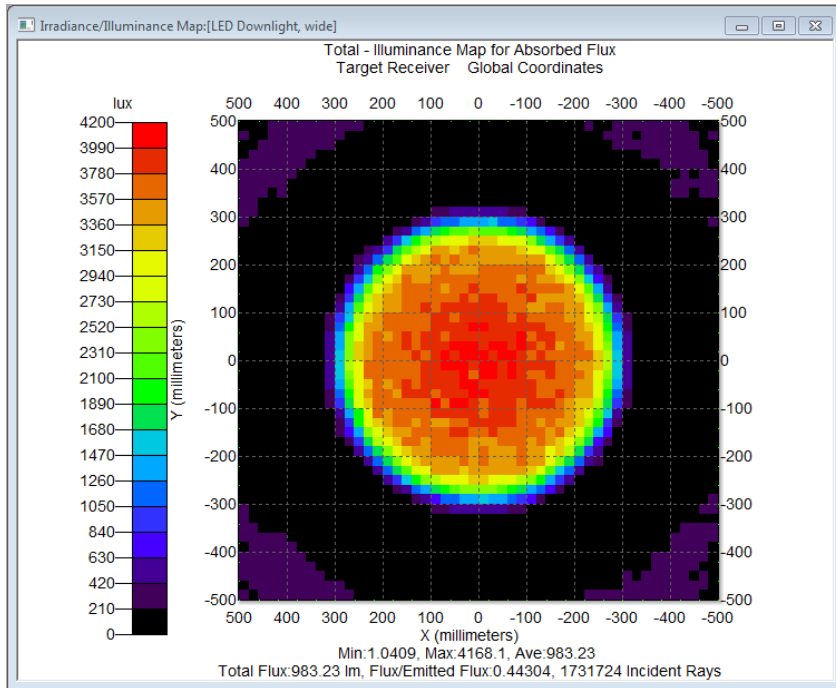


50 x 50 Pixels

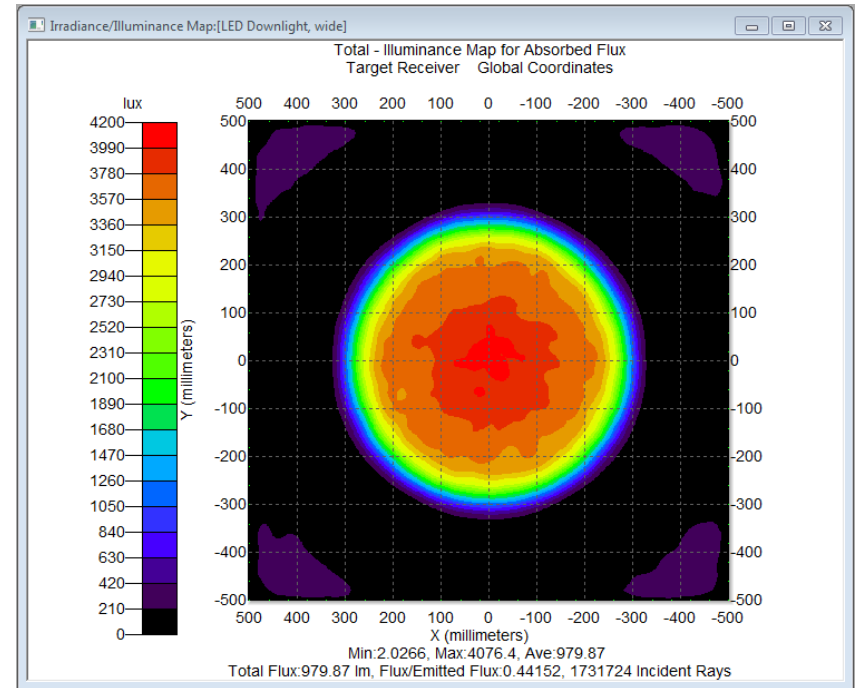


100 x 100 Pixels

Irradiance/Illuminance Map – Smoothing

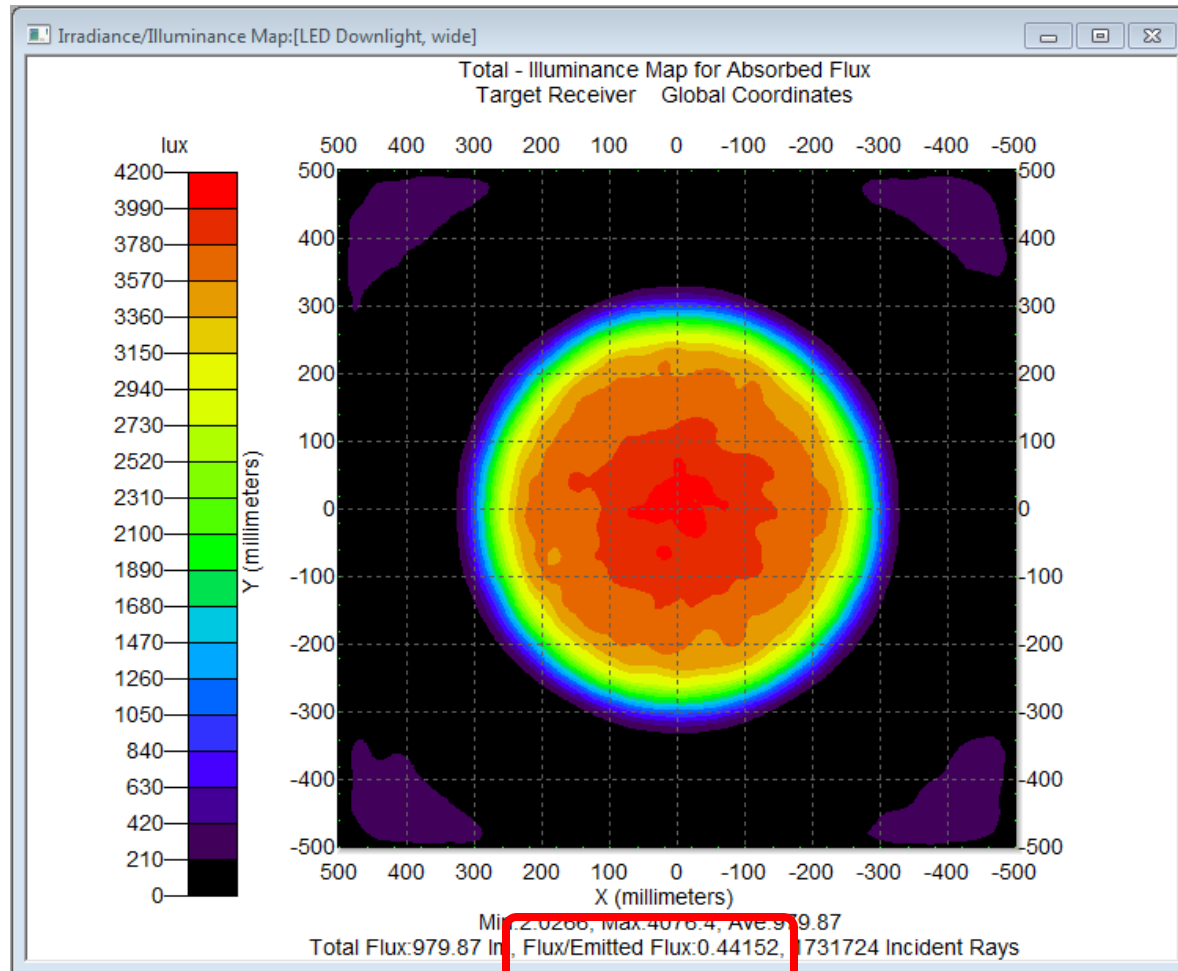


No Smoothing



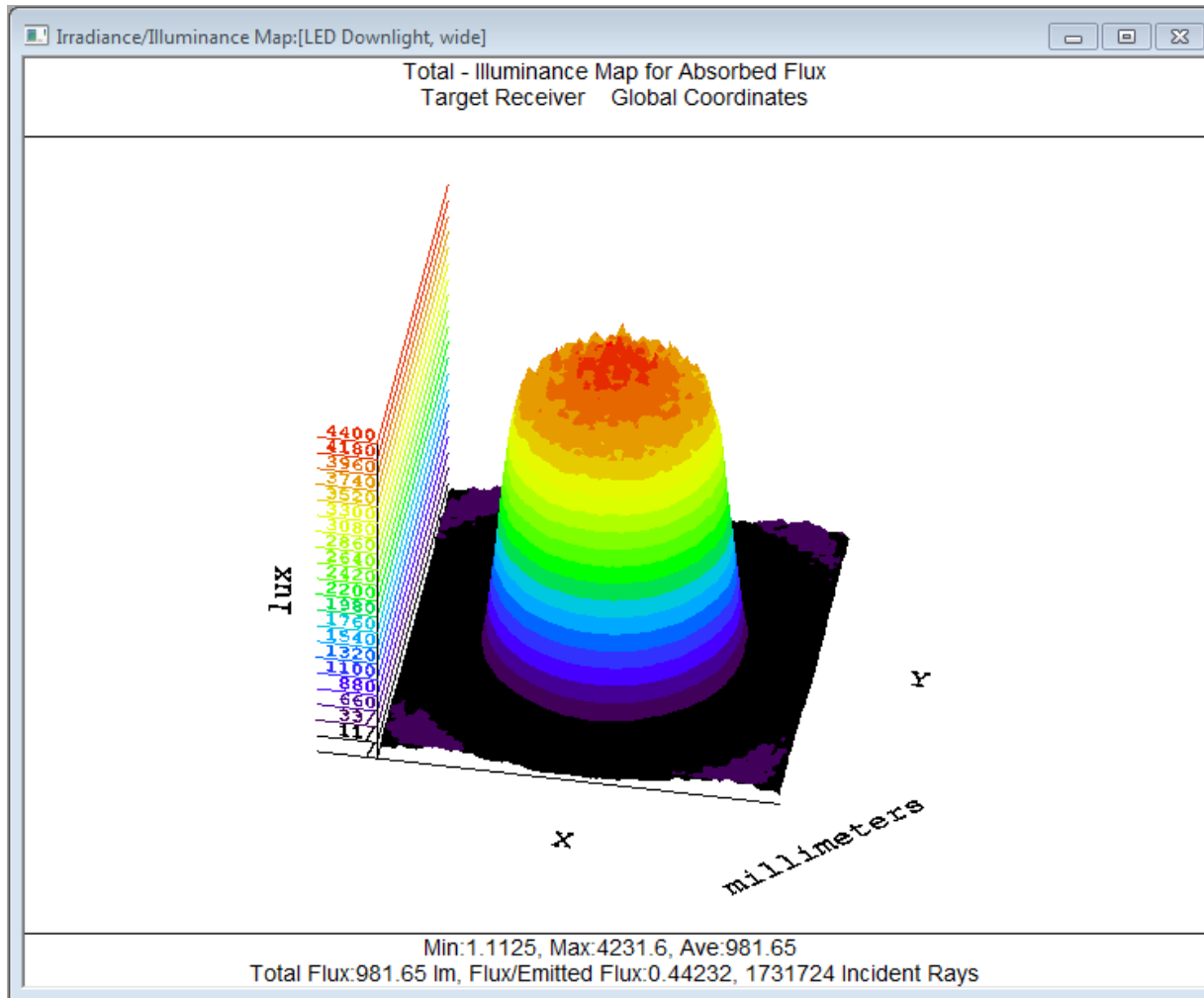
Smoothing

Irradiance/Illuminance Map - Efficiency

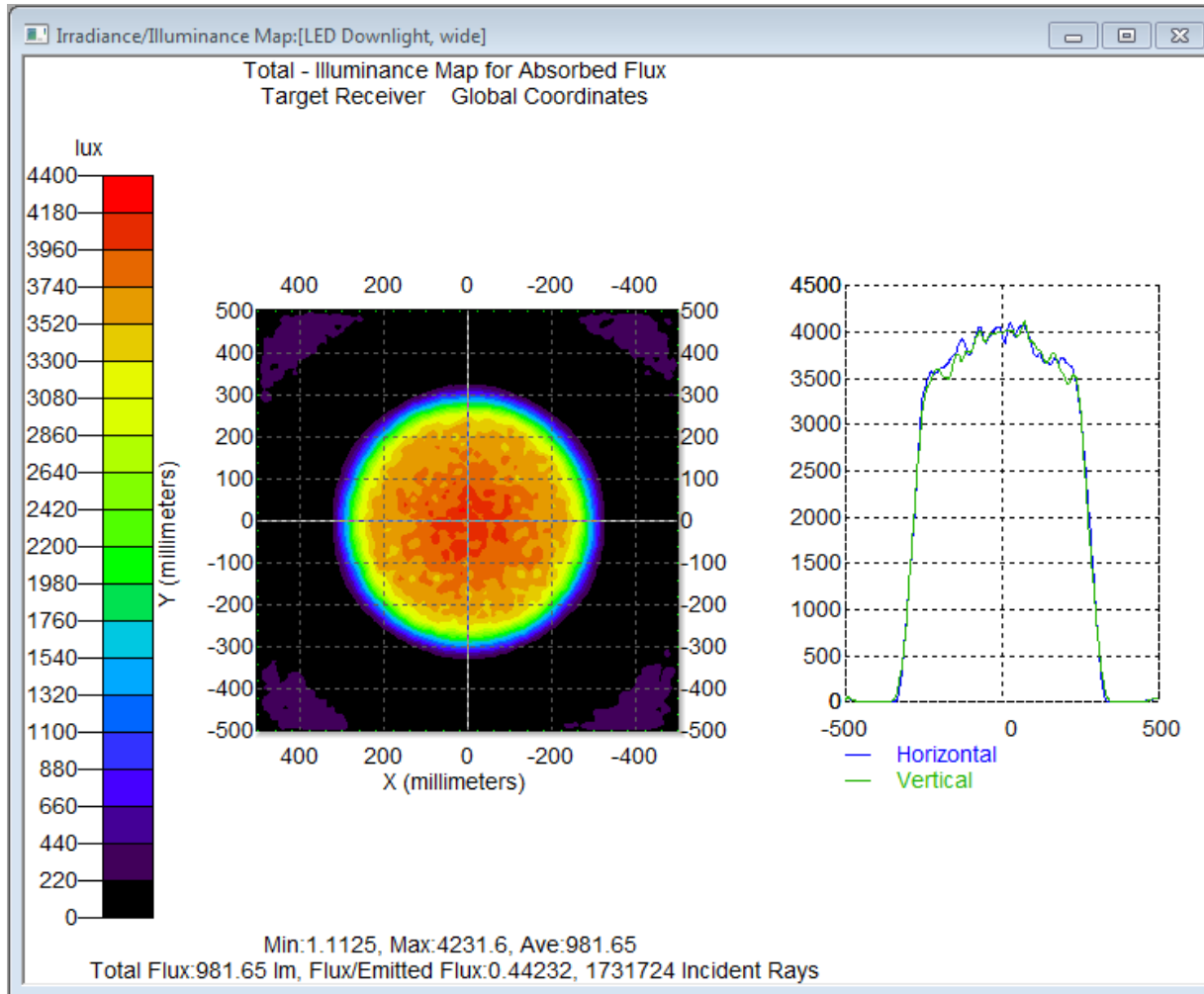


Efficiency

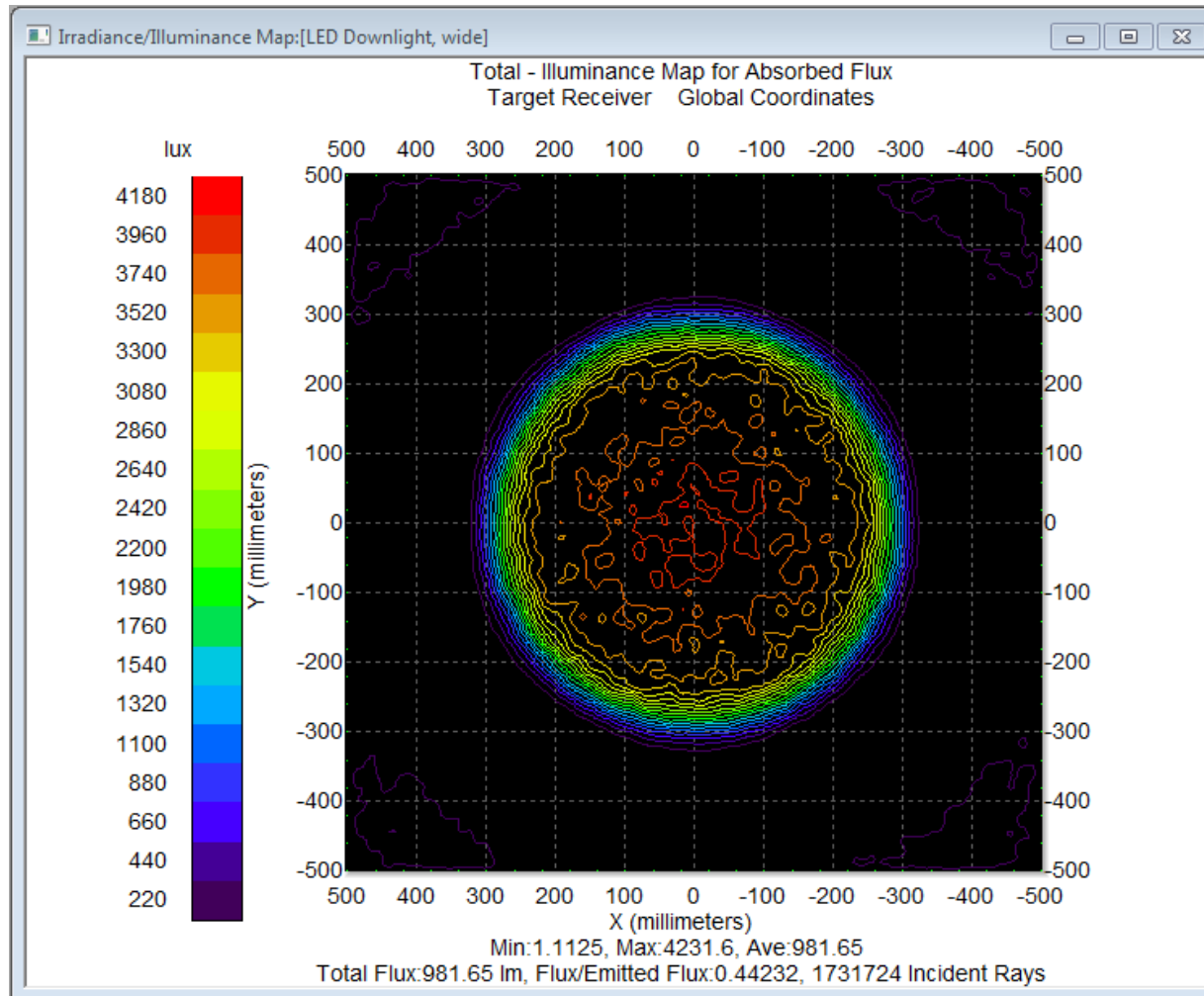
Irradiance/Illuminance Map – Relief Plot



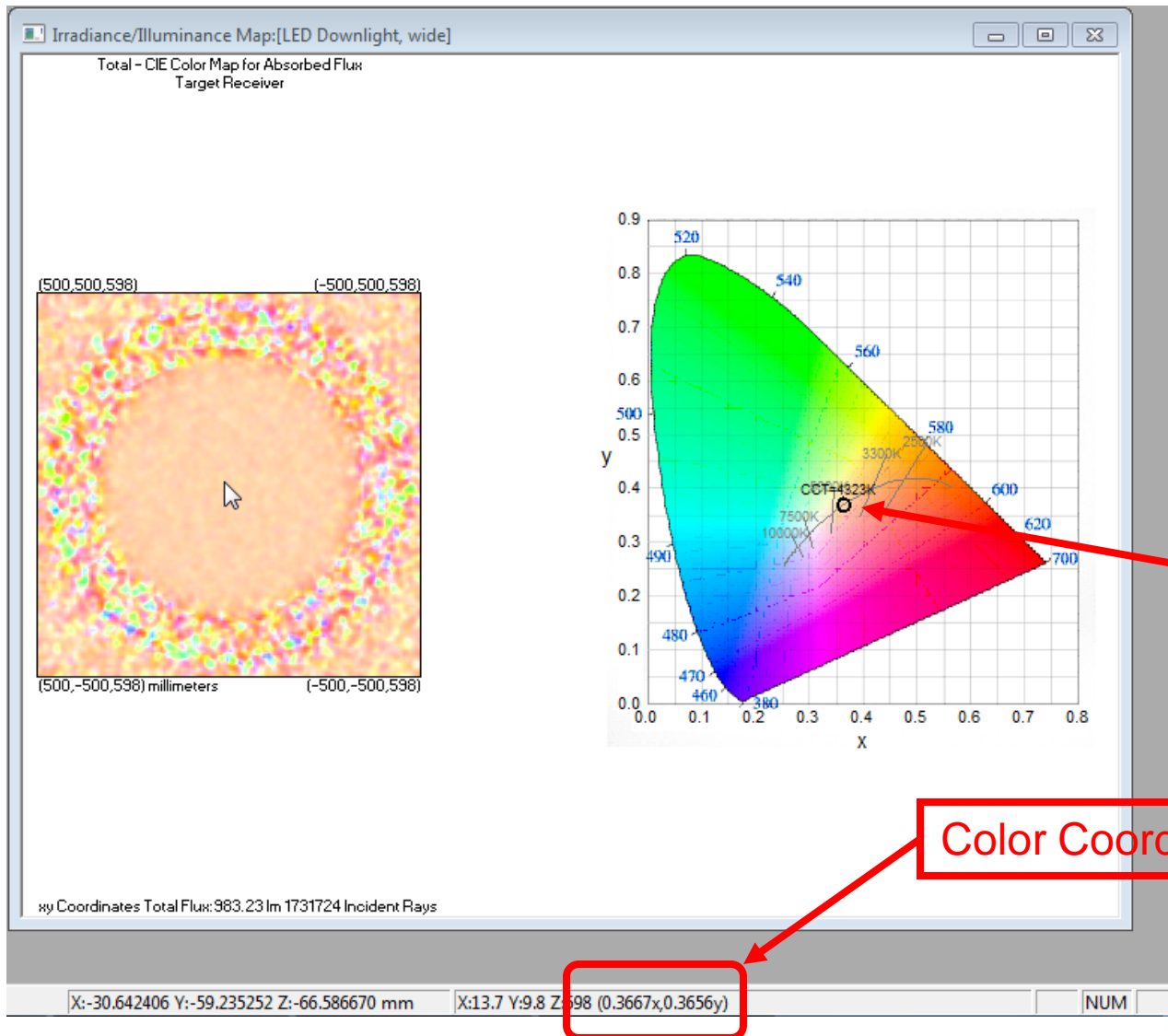
Irradiance/Illuminance Map – Profiles



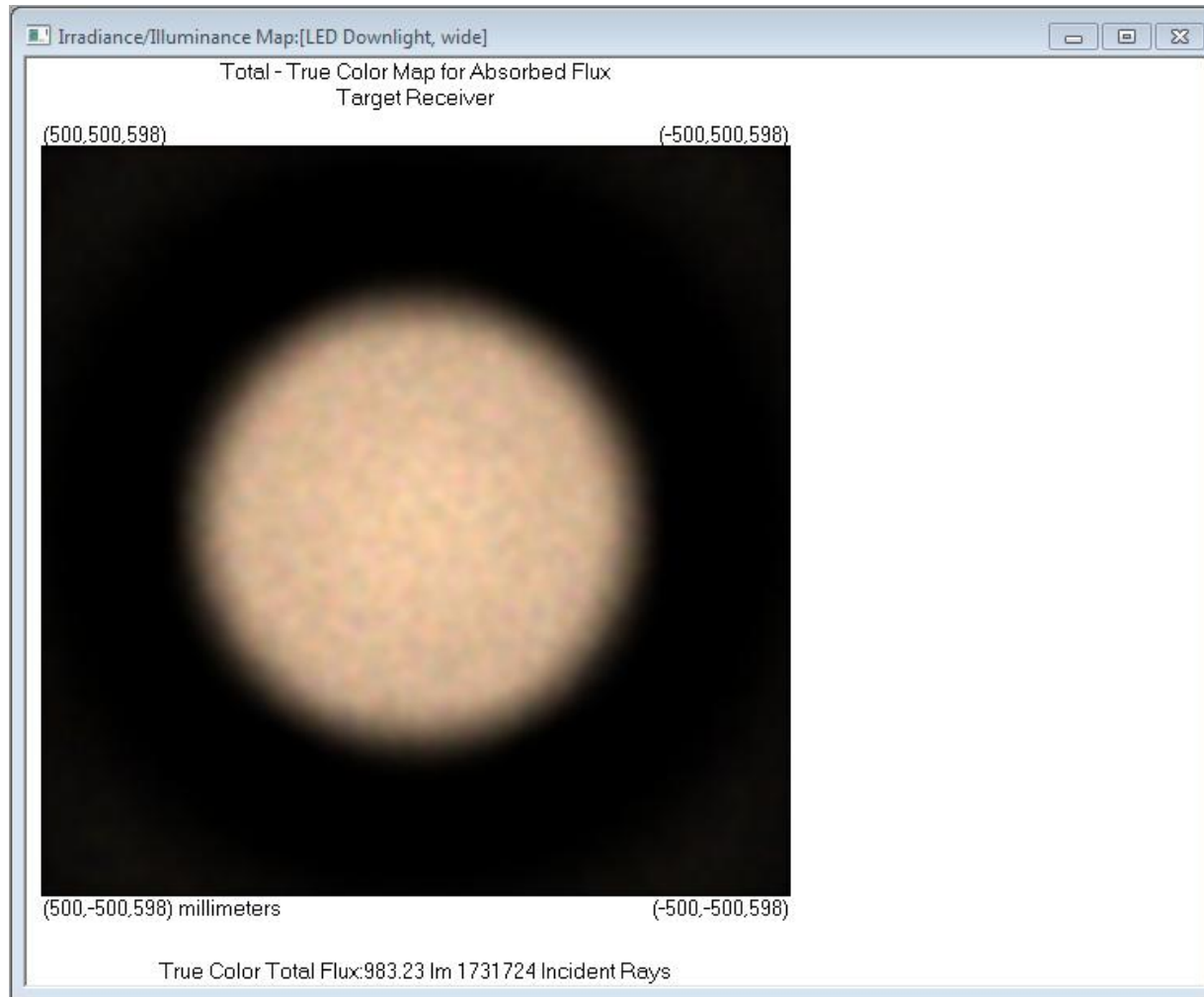
Irradiance/Illuminance Map – Contours



Irradiance/Illuminance Map – Color



Irradiance/Illuminance Map – TrueColor



What are some of the design verification and analysis tools available in TracePro?

- Irradiance and Illuminance Maps

- Candela Plots**

- Luminance and Radiance Maps

- Flux Reports

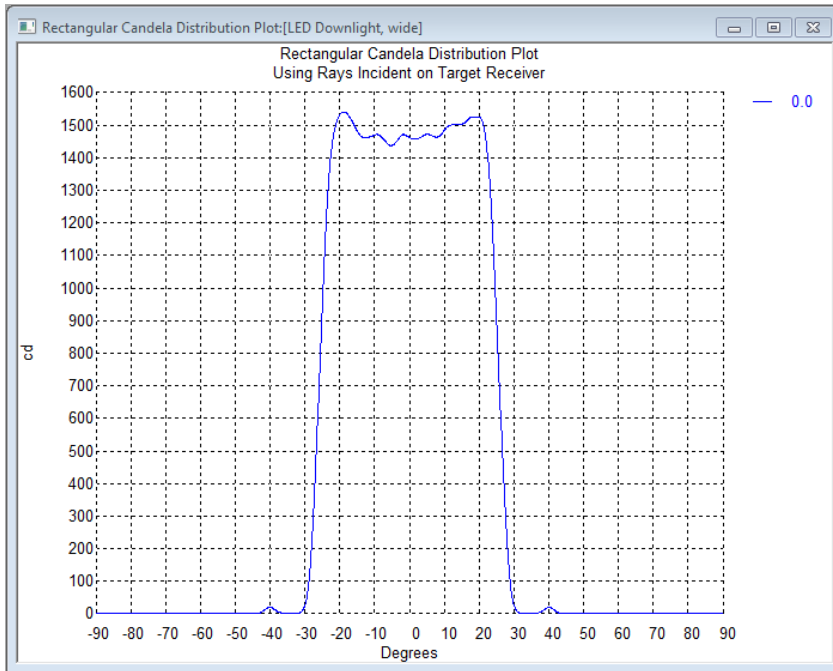
- Incident Ray Table

- Ray Histories

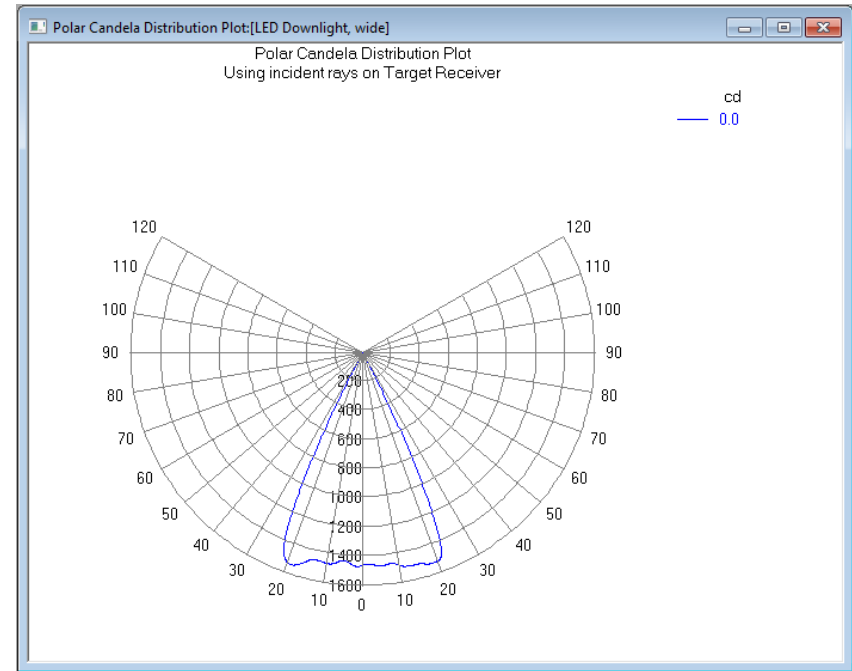
Candela Plots

- Displays angular distribution of light
- Radiant and Luminous Intensity
 - Radiometric units (watts per steradian)
 - Photometric units (candela)
- Iso-Candela and Candela Distributions
- Export IESNA and Eulumdat files
 - Please see our October 2010 webinar on this subject
 - <http://www.lambdares.com/webinars/>

Candela Plots – Candela Distributions



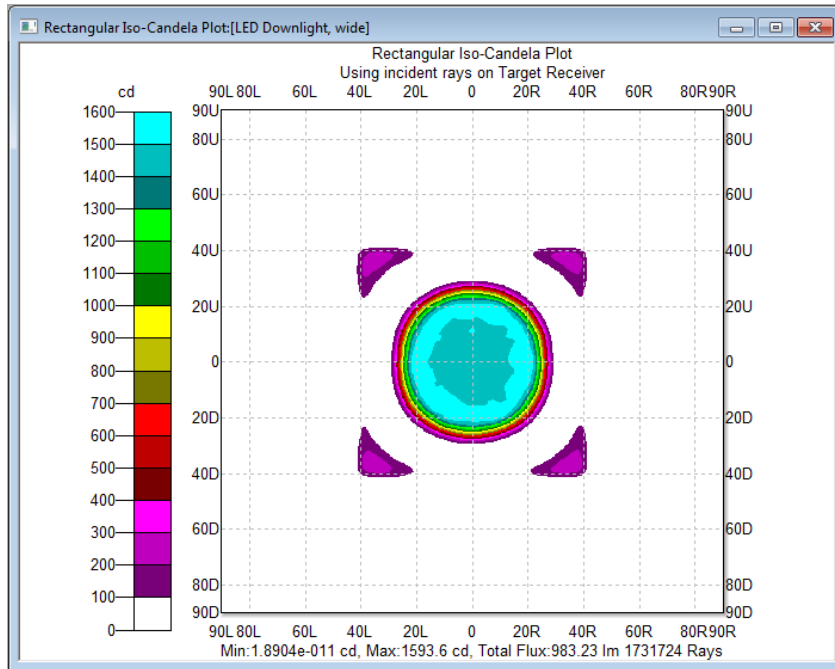
Rectangular



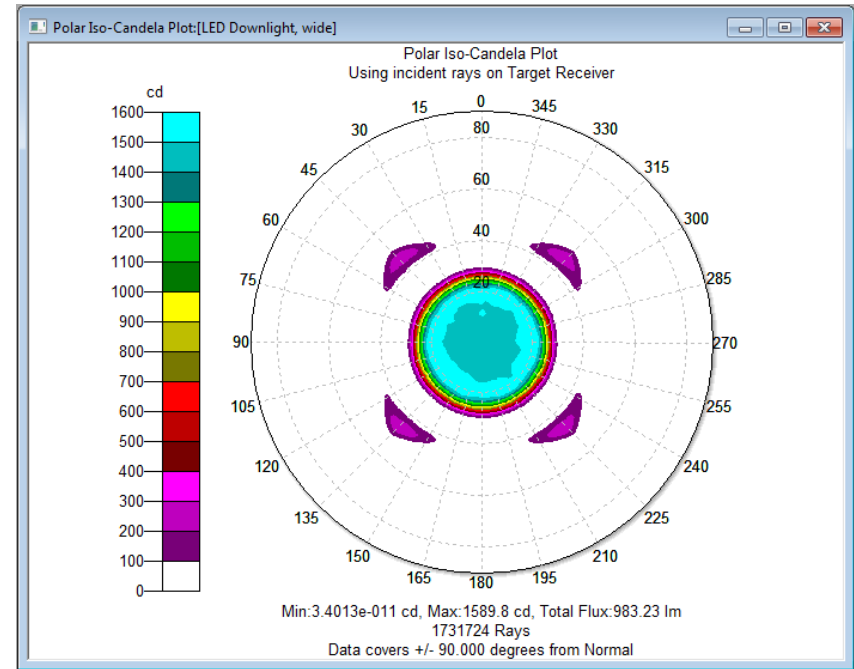
Polar

Slices of the sphere containing the source

Candela Plots – Iso-Candela



Rectangular



Polar

Rectangular Iso-Candela shows intensity as a function of horizontal and vertical angles.

Polar Iso-Candela shows intensity as a function of polar and azimuth angles.

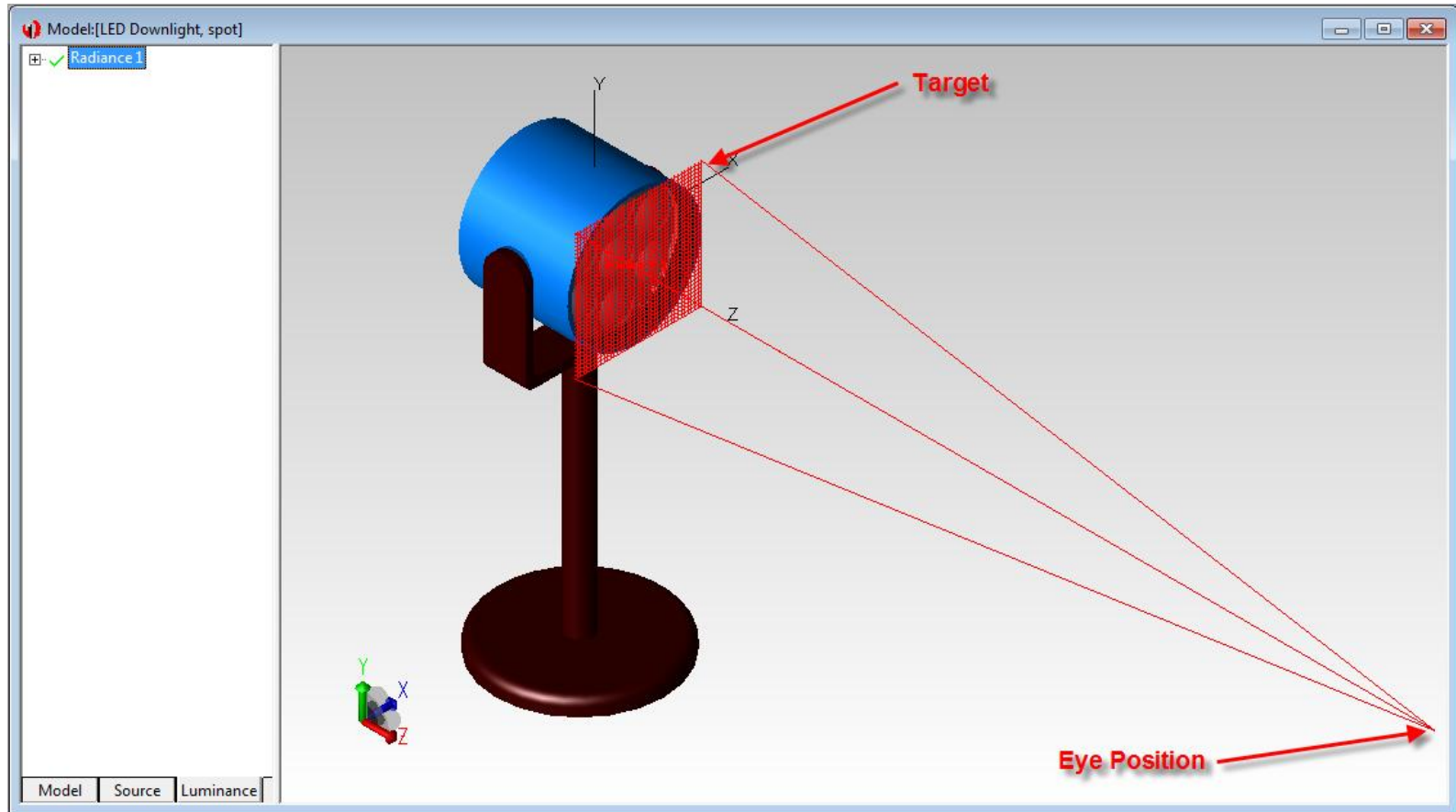
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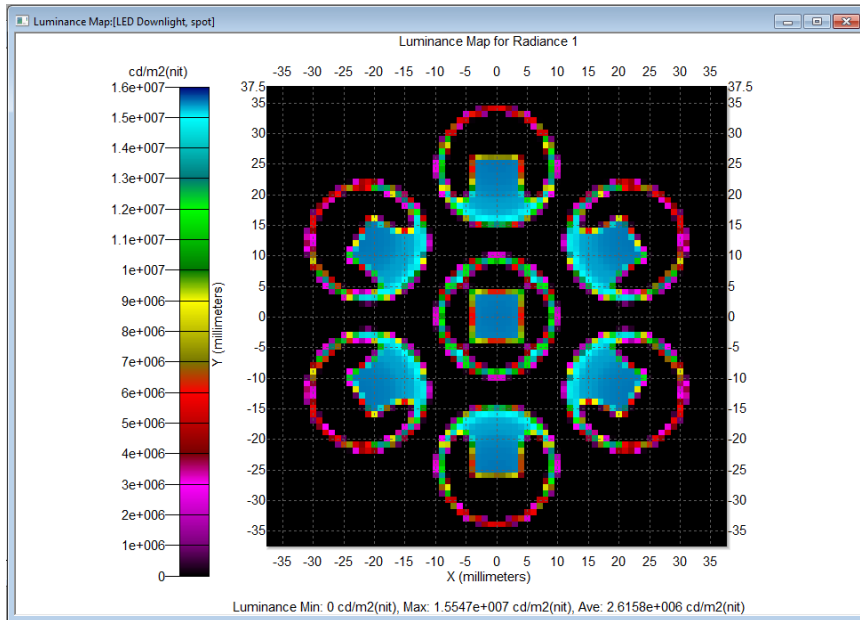
Luminance and Radiance Maps

- Displays luminance or radiance of a source or surface
- Radiance and Luminance
 - Radiometric units ($\text{w/m}^2\text{-sr}$)
 - Photometric units (cd/m^2 (nit), footlambert, millilambert)
- TrueColor mode

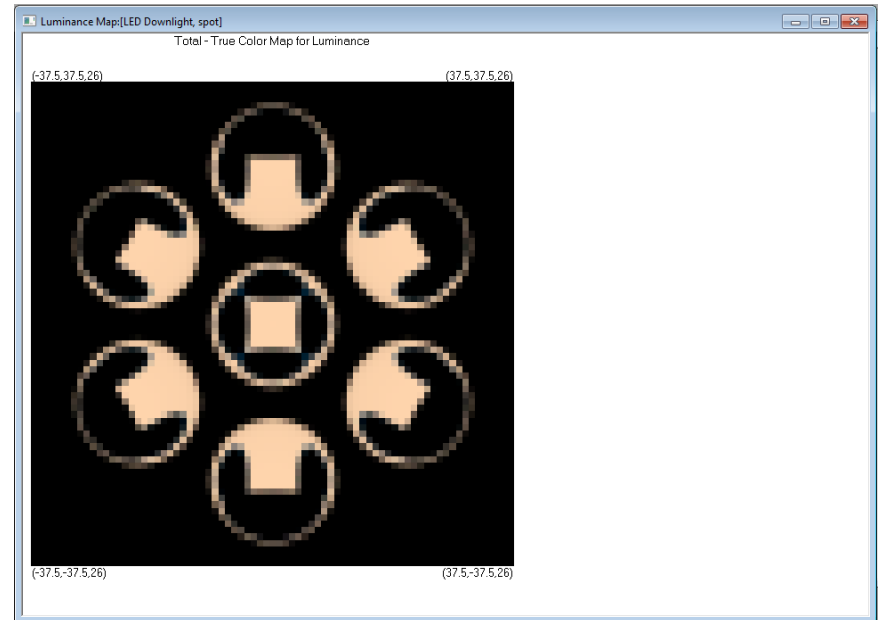
Luminance and Radiance Maps



Luminance and Radiance Maps



Luminance



TrueColor

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Flux Reports

- Displays flux on all surfaces in a model
- Includes Number of Rays, Incident, Absorbed, and Lost Flux for each object, surface, source, and wavelength

Flux Report:[LED Downlight, wide]

Source selection: All Sources Display Selected Objects
Wavelength selection: all wavelengths & totals Display All Objects

Object Name	Material Catalog	Material Property	Surface Area	Wavelength (Source)	Number	Incident	Absorbed	Lost (All Types)	Lost-> Escaped Model	Lost-> Flux Threshold	Lost-> Total
Surface Name	Surface Catalog	Surface Property	[sq mm]	[µm]	of rays	[lumens]	[lumens]	[lumens]	[lumens]	[lumens]	[lumens]
Receiver	Default	Perfect Absorber	1000000	0.447756 (LED 1/Emitter)	3578	1.45274757455448	1.45274757455448	0	0	0	0
				0.485565 (LED 1/Emitter)	4199	8.73490982224463	8.73490982224463	0	0	0	0
				0.552057 (LED 1/Emitter)	7799	90.8784839593213	90.8784839593213	0	0	0	0
				0.607399 (LED 1/Emitter)	7074	44.4515601545722	44.4515601545722	0	0	0	0
				0.66459 (LED 1/Emitter)	3086	1.72633732185862	1.72633732185862	0	0	0	0
				0.447756 (LED 2/Emitter)	3378	1.35279347504499	1.35279347504499	0	0	0	0
				0.485565 (LED 2/Emitter)	4001	8.19580356332991	8.19580356332991	0	0	0	0
				0.552057 (LED 2/Emitter)	7539	86.8076258128063	86.8076258128063	0	0	0	0
				0.607399 (LED 2/Emitter)	6862	42.7346047468124	42.7346047468124	0	0	0	0
				0.66459 (LED 2/Emitter)	3030	1.66527756774851	1.66527756774851	0	0	0	0
				0.447756 (LED 3/Emitter)	3408	1.36861212186367	1.36861212186367	0	0	0	0
				0.485565 (LED 3/Emitter)	4017	8.23741408308157	8.23741408308157	0	0	0	0
				0.552057 (LED 3/Emitter)	7562	87.138201302189	87.138201302189	0	0	0	0
				0.607399 (LED 3/Emitter)	6725	41.8062389072523	41.8062389072523	0	0	0	0
				0.66459 (LED 3/Emitter)	2991	1.65677224822668	1.65677224822668	0	0	0	0
				0.447756 (LED 4/Emitter)	3335	1.33529770396035	1.33529770396035	0	0	0	0
				0.485565 (LED 4/Emitter)	4010	8.26177407671120	8.26177407671120	0	0	0	0

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- Ray Histories

Incident Ray Table

- Displays information on each ray hitting a selected surface
- Includes Flux, X,Y,Z position, and X,Y,Z direction vectors for each ray as well as polarization information
- Can be used to create a File Source in TracePro
- Can be used in conjunction with Display Selected Rays to show each ray path graphically

Incident Ray Table

TracePro Expert

File Edit View Define Raytrace Analysis Reports Tools Utilities Macros Window Help

Model:[LED Downlight, wide]

- LED 1
- LED 2
- LED 3
- LED 4
- LED 5
- LED 6
- LED 7
- Front Lens
- PC Board
- Base
- Lamp Housing
- Target
- Surface 0
- Receiver
- Surface 2
- Surface 3
- Surface 4

Incident Ray Table:[LED Downlight, wide]

Target Receiver
Tabular display is limited to 50000 rows.

Ray Number	Wavelength	Source	Start Ray	Ray Node	Type	History	Flux	X Pos.	Y Pos.	Z Pos.	X Vec.	Y Vec.	Z Vec.	S0	S1	S2	S3
1	0.447756	LED 1/Emitter	1	4	SpecTran		0.000412707	-135.501	155.536	597.5	-0.215277	0.246817	0.944848	1.7706e-005	1.64969e-007	1.10766e-007	0
2	0.447756	LED 1/Emitter	4	4	SpecTran		0.000413033	-68.5035	-30.5536	597.5	-0.115567	-0.0477514	0.992151	1.772e-005	2.39392e-009	3.84685e-008	0
3	0.447756	LED 1/Emitter	5	4	SpecTran		0.000411085	273.356	63.3818	597.5	0.411864	0.0972948	0.906036	1.76364e-005	-4.97835e-007	1.16037e-007	0
4	0.447756	LED 1/Emitter	8	4	SpecTran		0.000412926	138.478	-21.8514	597.5	0.224066	-0.033294	0.974005	1.77154e-005	-1.20235e-007	-1.18542e-008	0
5	0.447756	LED 1/Emitter	9	4	SpecTran		0.000412202	159.837	-140.631	597.5	0.250306	-0.217152	0.9435	1.76843e-005	-2.78836e-007	-1.78068e-007	0
6	0.447756	LED 1/Emitter	13	4	SpecTran		0.000412114	-189.147	-155.558	597.5	-0.29255	-0.240029	0.925635	1.76805e-005	2.10494e-007	-2.80497e-007	0
7	0.447756	LED 1/Emitter	15	4	SpecTran		0.000411261	-262.041	-43.2973	597.5	-0.397871	-0.0650478	0.915132	1.76439e-005	-1.44341e-007	-4.69373e-007	0
8	0.447756	LED 1/Emitter	16	4	SpecTran		0.00041298	-121.241	-34.0793	597.5	-0.19807	-0.0544936	0.978672	1.77177e-005	-2.08643e-008	9.01477e-008	0
9	0.447756	LED 1/Emitter	18	4	SpecTran		0.000409733	-20.9308	295.115	597.5	-0.032788	0.438518	0.898124	1.75784e-005	-1.99847e-007	6.39756e-007	0
10	0.447756	LED 1/Emitter	22	4	SpecTran		0.000412315	-172.067	112.359	597.5	-0.269529	0.174184	0.947108	1.76892e-005	2.50566e-007	1.93831e-007	0
11	0.447756	LED 1/Emitter	23	4	SpecTran		0.000411546	-217.048	-117.62	597.5	-0.331046	-0.182159	0.925865	1.76562e-005	1.09089e-007	-4.30109e-007	0
12	0.447756	LED 1/Emitter	24	4	SpecTran		0.00041205	124.550	-182.234	597.5	0.20362	0.200220	0.924121	1.76782e-005	1.26762e-007	2.81022e-007	0

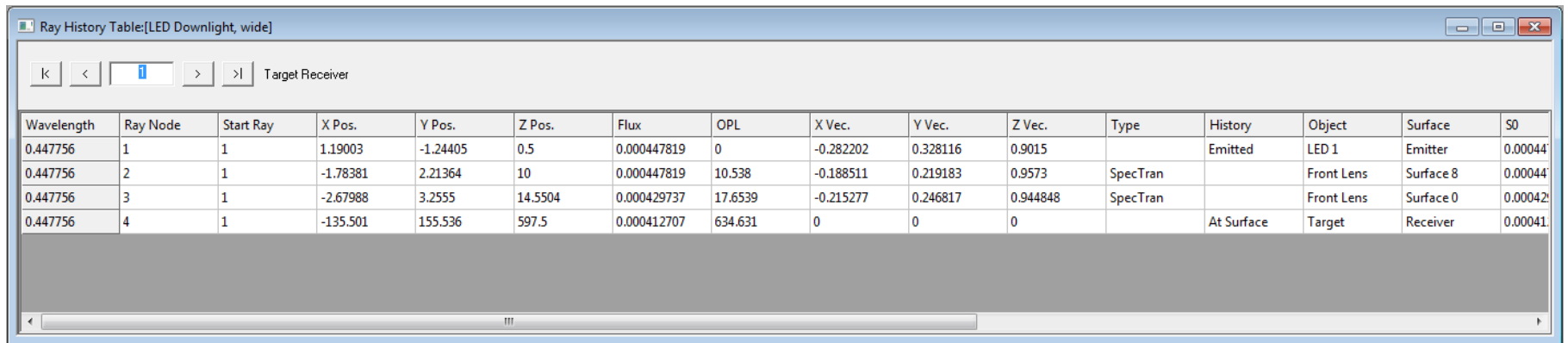
For Help, press F1 | X:0.000000 Y:77.406654 Z:-88.900154 mm | X:0.000000 Y:-162.072647 Z:-35.205322 mm | NUM

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Ray Histories

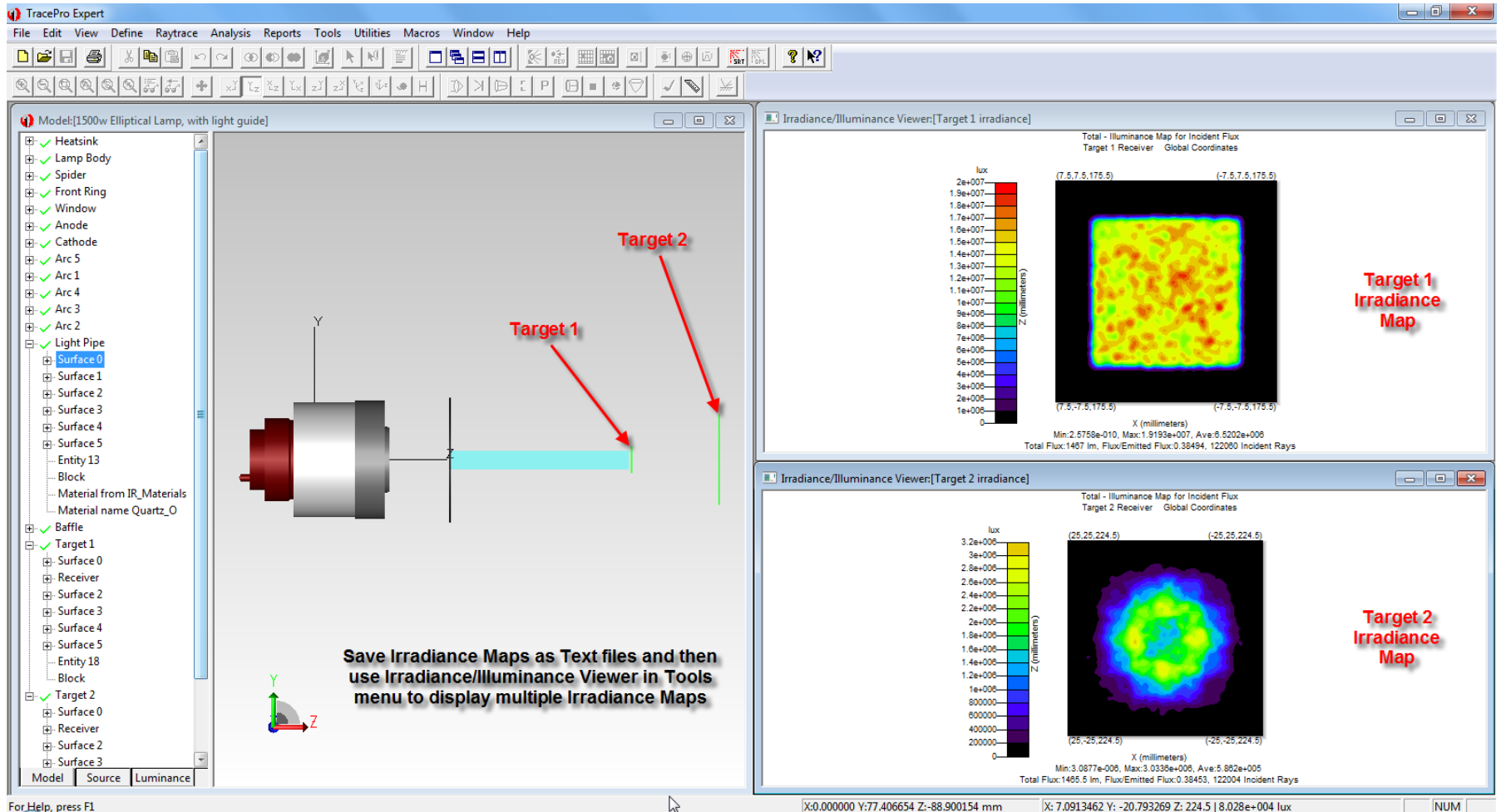
- Displays the path of each ray through a system in tabular format
- Includes Flux, X,Y,Z position, and X,Y,Z direction vectors for each ray as well as polarization and optical path length data



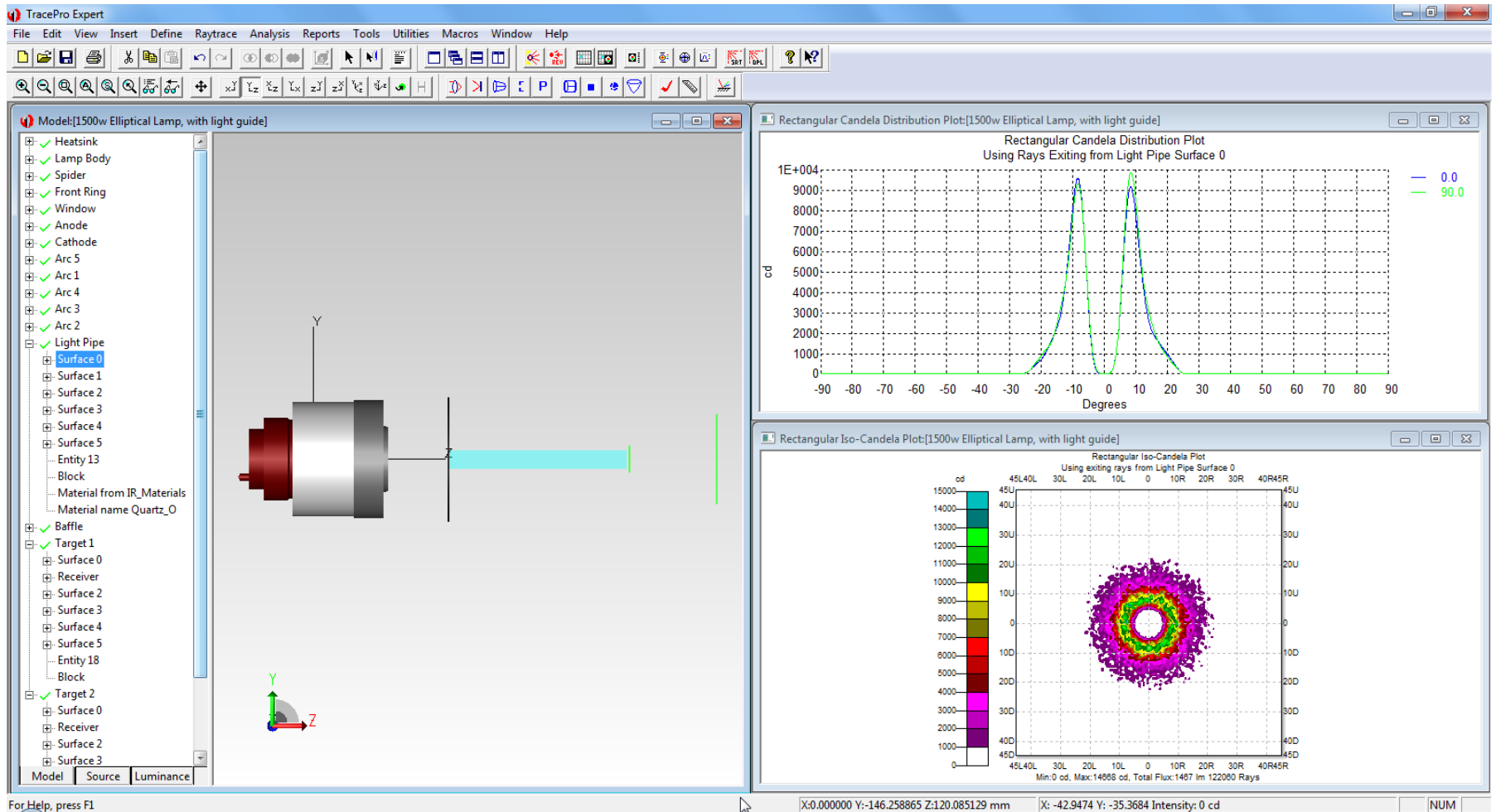
Wavelength	Ray Node	Start Ray	X Pos.	Y Pos.	Z Pos.	Flux	OPL	X Vec.	Y Vec.	Z Vec.	Type	History	Object	Surface	S0
0.447756	1	1	1.19003	-1.24405	0.5	0.000447819	0	-0.282202	0.328116	0.9015		Emitted	LED 1	Emitter	0.00044
0.447756	2	1	-1.78381	2.21364	10	0.000447819	10.538	-0.188511	0.219183	0.9573	SpecTran		Front Lens	Surface 8	0.00044
0.447756	3	1	-2.67988	3.2555	14.5504	0.000429737	17.6539	-0.215277	0.246817	0.944848	SpecTran		Front Lens	Surface 0	0.00042
0.447756	4	1	-135.501	155.536	597.5	0.000412707	634.631	0	0	0		At Surface	Target	Receiver	0.00041

Using the Design Verification and Analysis Tools in TracePro

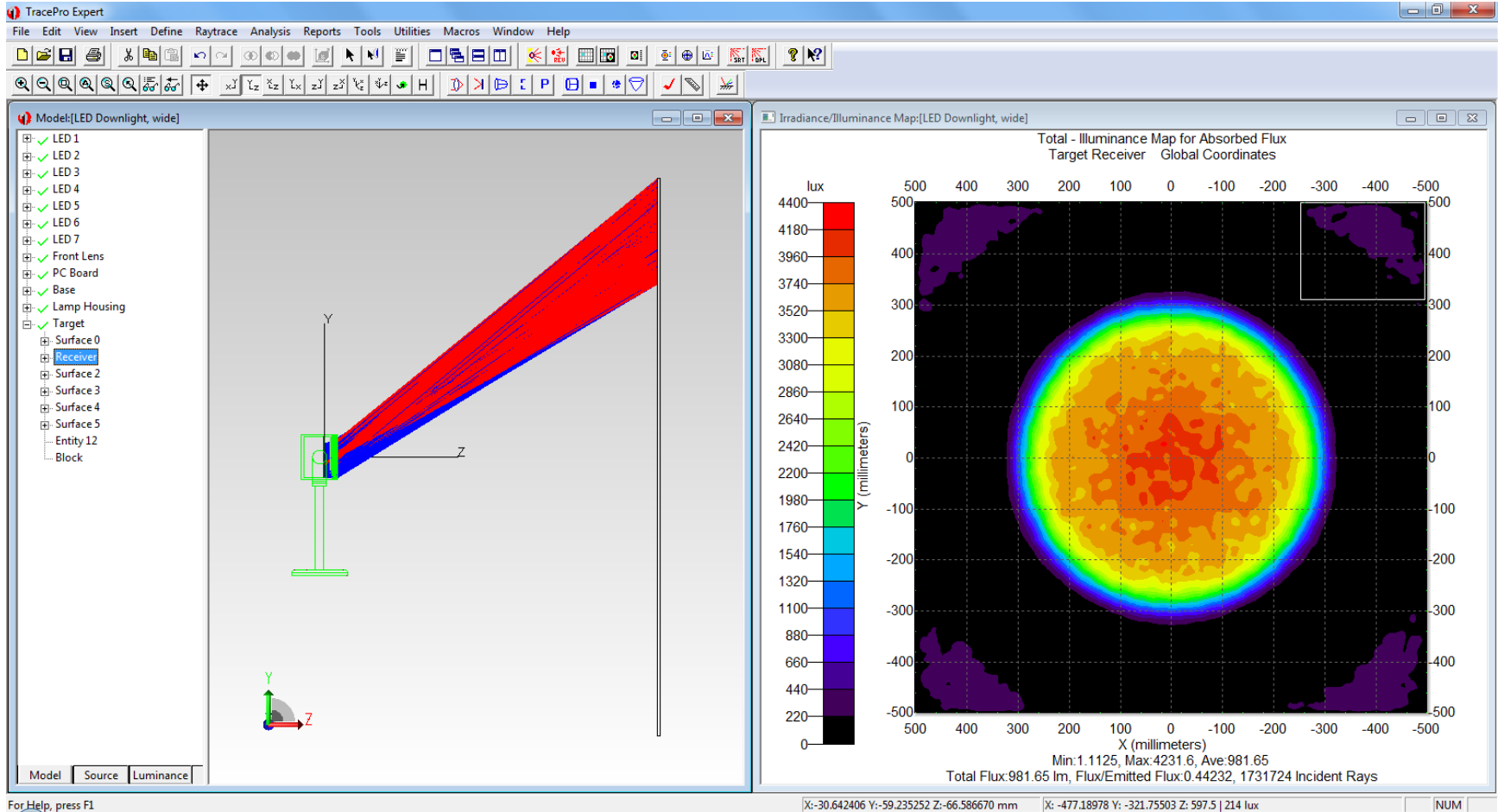
Xenon Lamp with Elliptical Reflector



Xenon Lamp with Elliptical Reflector

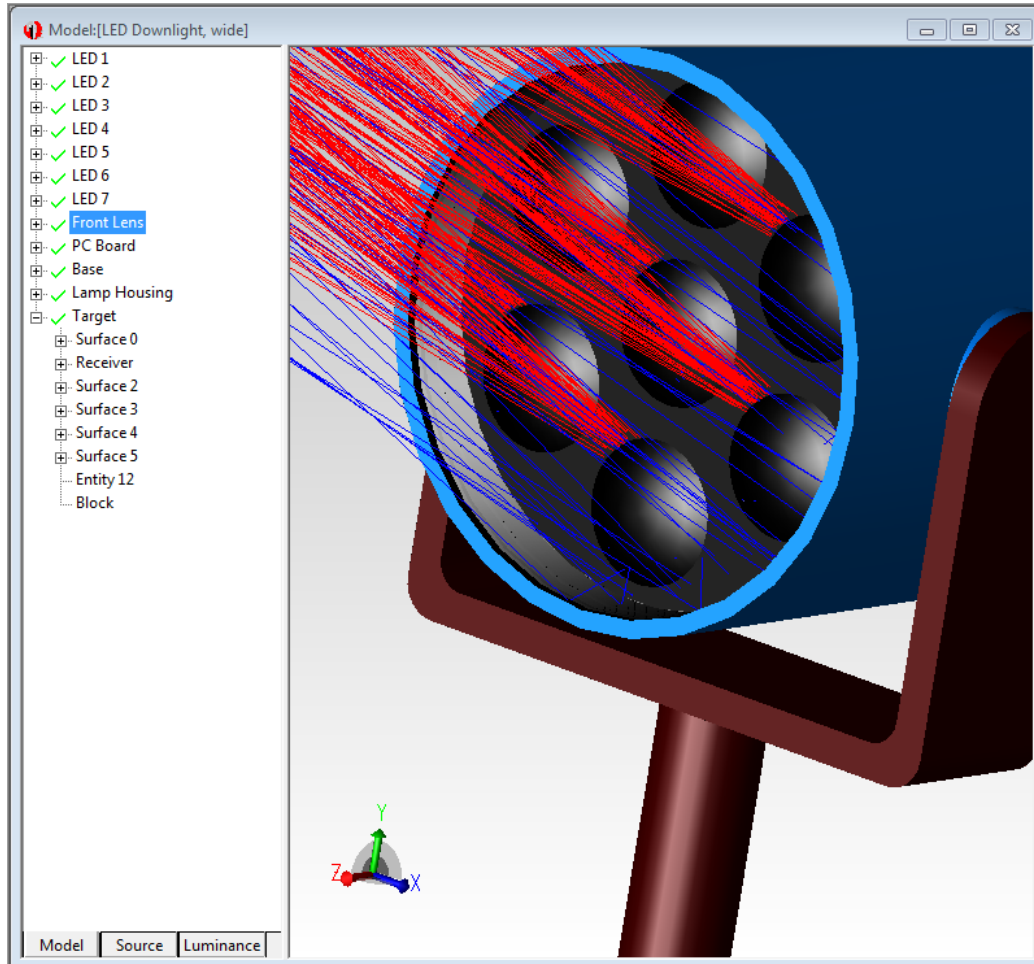


Irradiance/Illuminance Map – Display Selected Rays

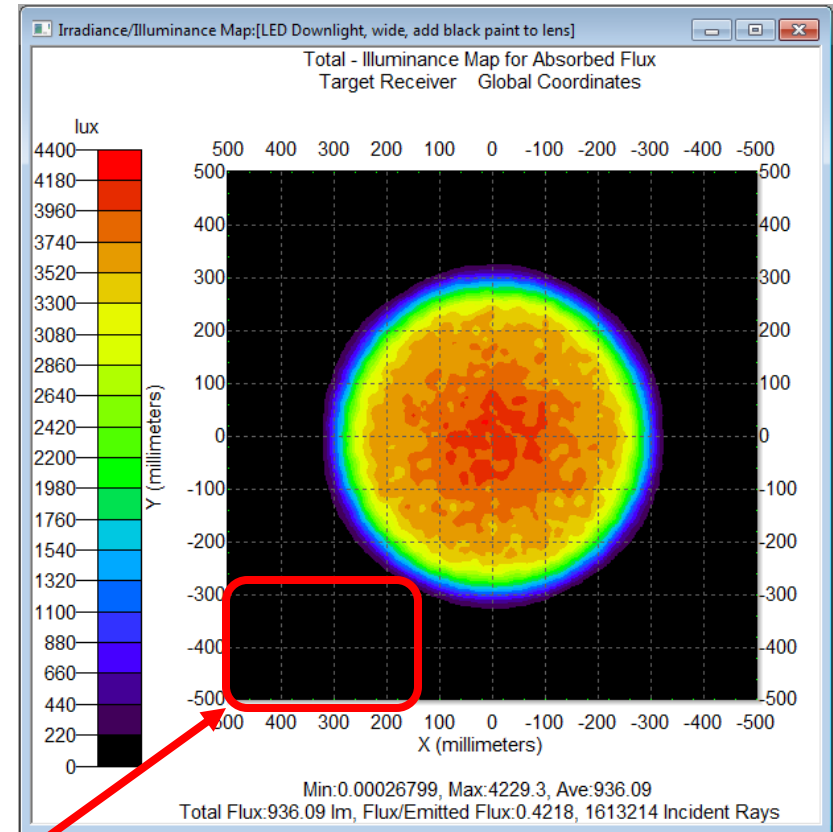
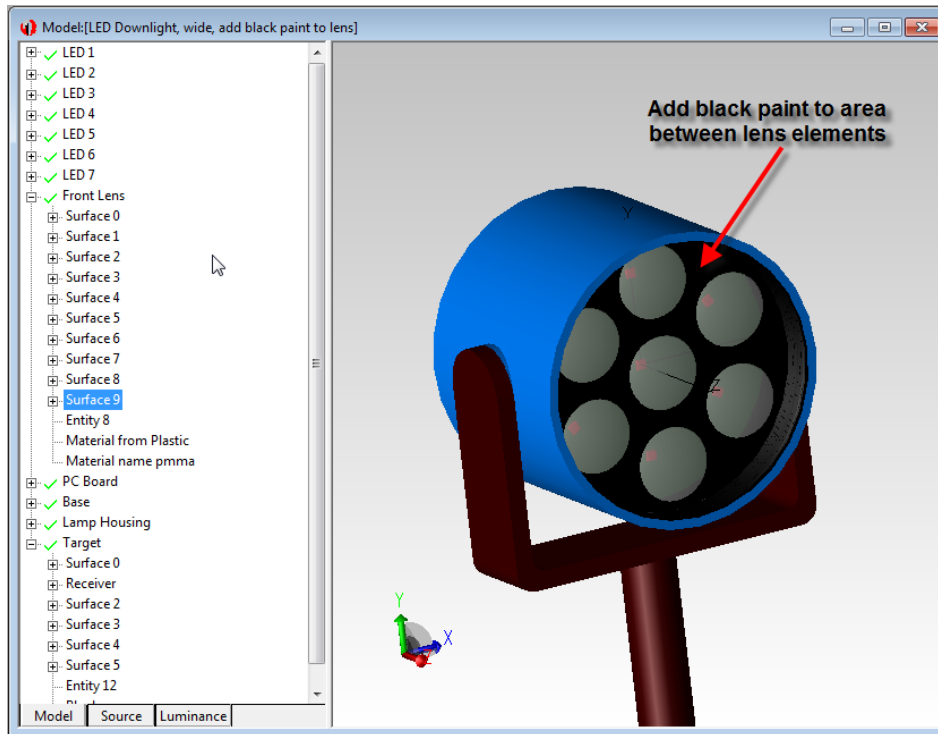


Use Shift+Left Mouse Button to drag a box around the area of interest

Irradiance/Illuminance Map – Display Selected Rays



Solving Problem Identified Using Irradiance Map and Display Selected Rays



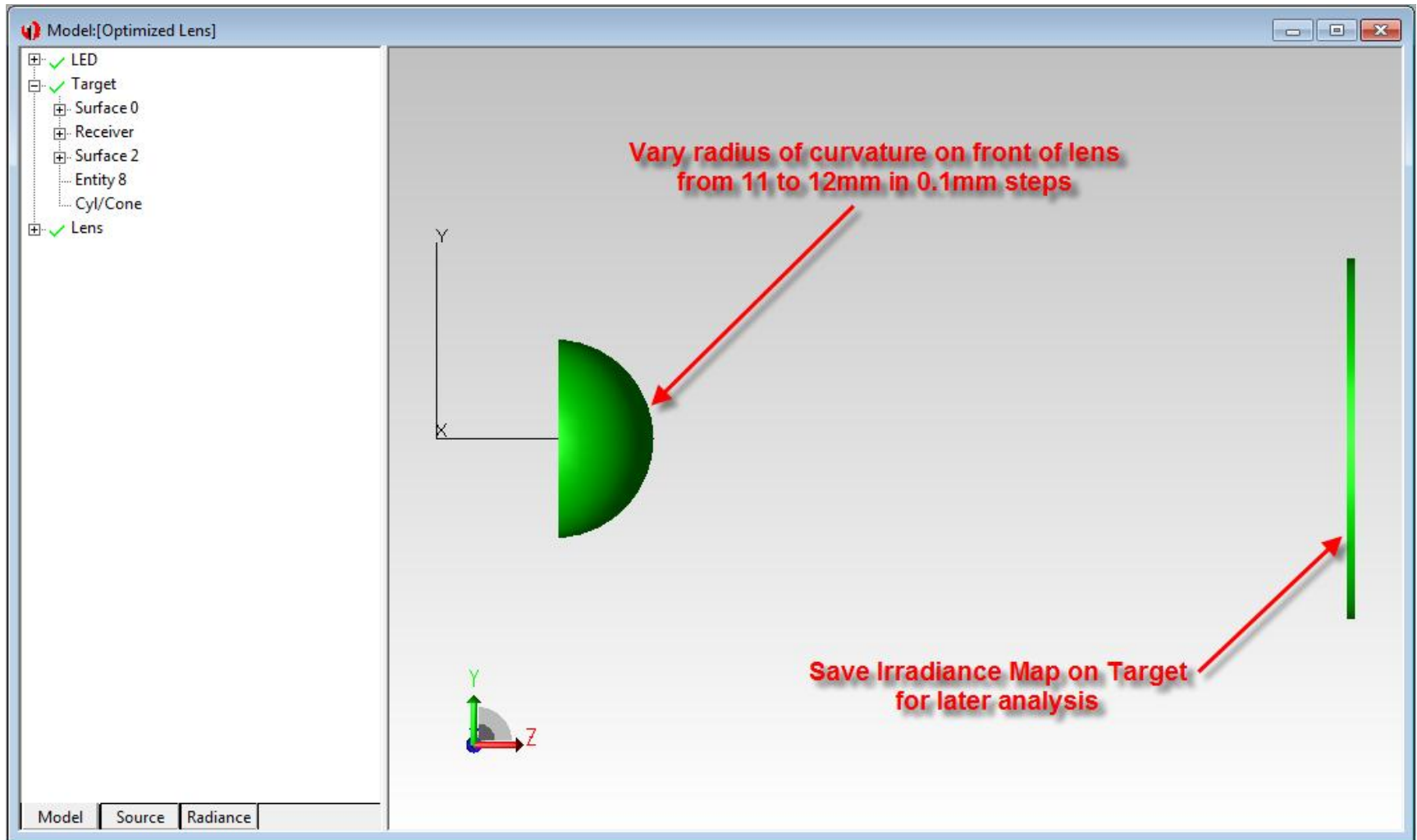
Stray light is eliminated

Checking Design Tolerances using the Analysis Tools in TracePro

Checking Design Tolerances

- Vary parameters of model elements
- Check results using the analysis tools in TracePro
- Scheme Macro language in TracePro can be used to automate the process

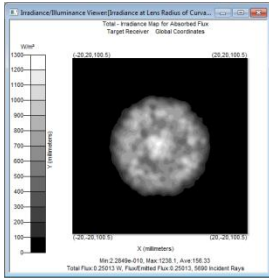
Checking Design Tolerances



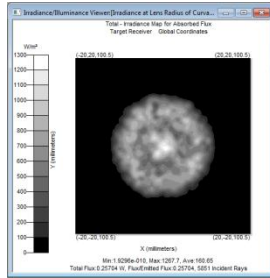
Checking Design Tolerances – Scheme Macro

```
(define demo ;; This is the optimizing part of the macro.
(lambda (from to steps) ;; Read in the start and finish radii and the number of steps in between.
  (define inc (/ (- to from) (- steps 1))) ;; Calculate the value of the steps or intervals between start and finish.
  (do ((i 0 (+ i 1))) ((= i steps)) ;; Loop through for each step.
    (define radius (+ from (* i inc))) ;; Define the radius of curvature of the lens for this step.
    (define lens
      (insert:lens-element "Plastic" "pmma" -40 9 radius 11)) ;; Draw the lens with the radius of curvature from above.
    (property:apply-name lens "Lens") ;; Name the lens.
    (entity:move (entity:get-by-name "Lens") 0 0 15) ;; Move the lens.
    (view:set-display-rays #f) ;; Turn off ray display in TracePro.
    (raytrace:source) ;; Run the raytrace
    (edit:select (entity:get-by-names "Target" "Receiver")) ;; Select the "Receiver" surface of the "Target" object.
    (analysis:irradiance-smooth #t) ;; Turn on smoothing in irradiance map.
    (analysis:irradiance) ;; Open Irradiance Map.
    (analysis:refresh) ;; Refresh the Irradiance Map.
    (window:horizontal-tile) ;; Tile the windows in the model.
    (set! IrradianceMap (string-append rootPath "Irradiance at Lens Radius of Curvature_" (number->string radius) "_mm.txt")) ;; Generate name for Irradiance Map to be save.
    (analysis:irradiance-save IrradianceMap) ;; Save current Irradiance Map with above name.
    (set! Average (analysis:get-current-irradiance-average)) ;; Set variable Average to Average Irradiance from Irradiance Map.
    (set! Maximum (analysis:get-current-irradiance-max)) ;; Set variable Maximum to Maximum Irradiance from Irradiance Map.
    (set! Uniformity (/ Maximum Average)) ;; Calculate Uniformity by dividing Max irradiance by Avg irradiance.
    (print (string-append "Uniformity at lens radius of " (number->string radius) "mm = " (number->string Uniformity))) ;; Print result of uniformity calculation.
    (if (< Uniformity BestUniformity) ;; Determine if current Uniformity is better than previous BestUniformity.
      (set! BestRadius radius) ;; If yes, set BestRadius equal to Radius. If no, change nothing.
      (if (< Uniformity BestUniformity) ;; Determin if current uniformity is better than previous BestUniformity.
        (set! BestUniformity Uniformity) ;; If yes, set BestUniformity equal to current Uniformity.
        (print (string-append "Best Radius = " (number->string BestRadius) "mm")) ;; Print current best radius.
        (print (string-append "Best Uniformity = " (number->string BestUniformity))) ;; Print current best uniformity.
        (newline)
        (system:sleep 1000) ;; pause
        (entity:delete (entity:get-by-name "Lens")) ;; Delete the lens from the model before starting look again.
      )
    )
  (define Bestlens
    (insert:lens-element "Plastic" "pmma" -40 9 BestRadius 11)) ;; Draw the lens using the BestRadius from the optimization.
  (property:apply-name Bestlens "Lens")
  (entity:move (entity:get-by-name "Lens") 0 0 15)
  (raytrace:source) ;; Run a raytrace.
  (analysis:refresh) ;; Refresh the Irradiance Map.
  (set! IrradianceMap (string-append rootPath "Irradiance Map of Optimized Lens.txt")) ;; Give the Irradiance Map file a name.
  (analysis:irradiance-save IrradianceMap) ;; Save the Irradiance Map.
  (set! filename (string-append rootPath "Optimized Lens.oml")) ;; Give the model a filename.
  (file:save-as filename) ;; Save the model.
  )
)
```

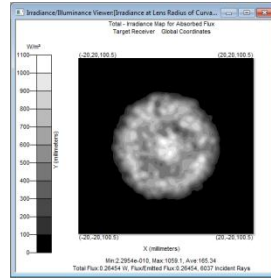
Checking Design Tolerances



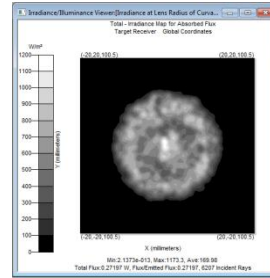
Curv = 11mm



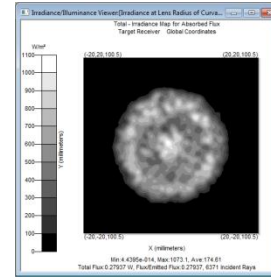
Curv = 11.1mm



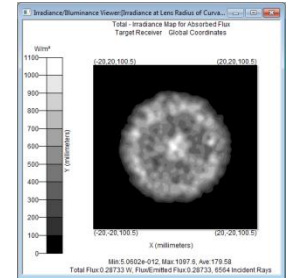
Curv = 11.2mm



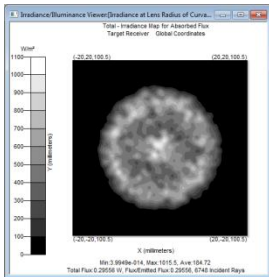
Curv = 11.3mm



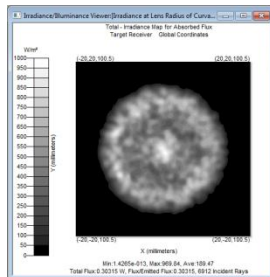
Curv = 11.4mm



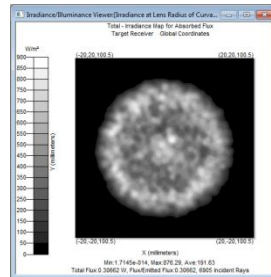
Curv = 11.5mm



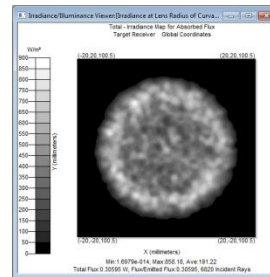
Curv = 11.6mm



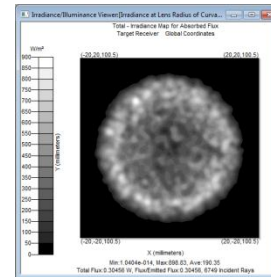
Curv = 11.7mm



Curv = 11.8mm



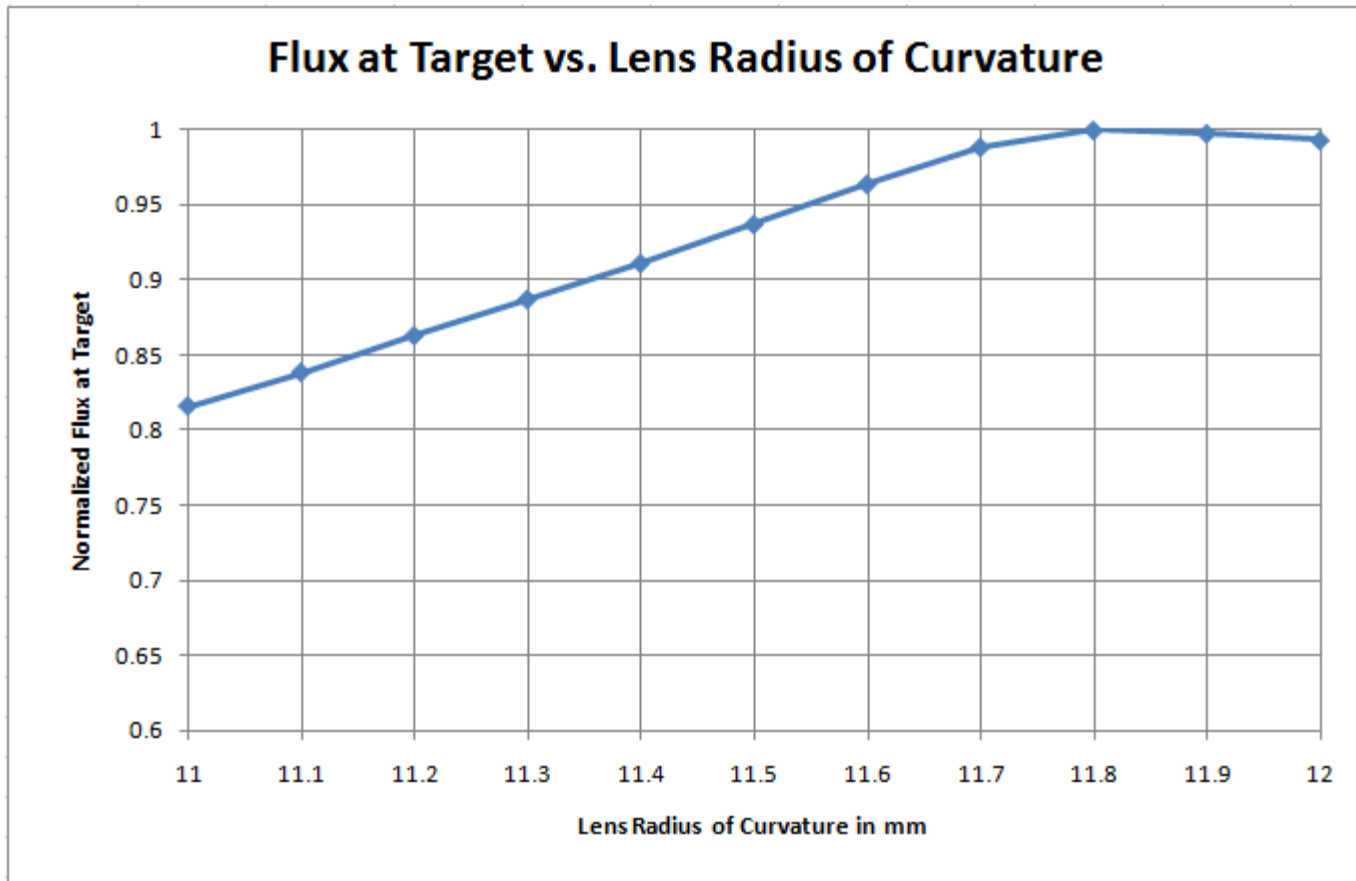
Curv = 11.9mm



Curv = 12mm

Irradiance Maps resulting from varying lens radius of curvature from 11-12mm in 0.1mm steps

Checking Design Tolerances



Thank You

Questions and Answers

**For Additional Information
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