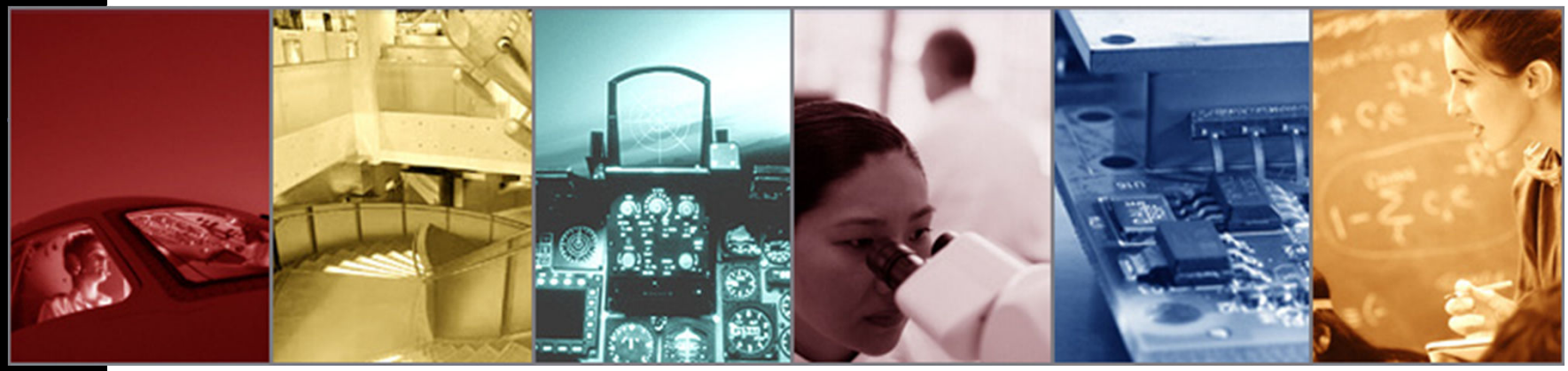


How to use the new TracePro Solar Utility for comprehensive solar calculations

Presented by :

Lambda Research Corporation
25 Porter Rd.
Littleton, MA 01460

TracePro

Lambda Research Corporation

Moderators:
Andy Knight
Technical Sales Manager
Dave Jacobsen
Senior Application Engineer
Lambda Research Corporation

Presenter:
Michael Gauvin
Vice President of Sales
Lambda Research Corporation

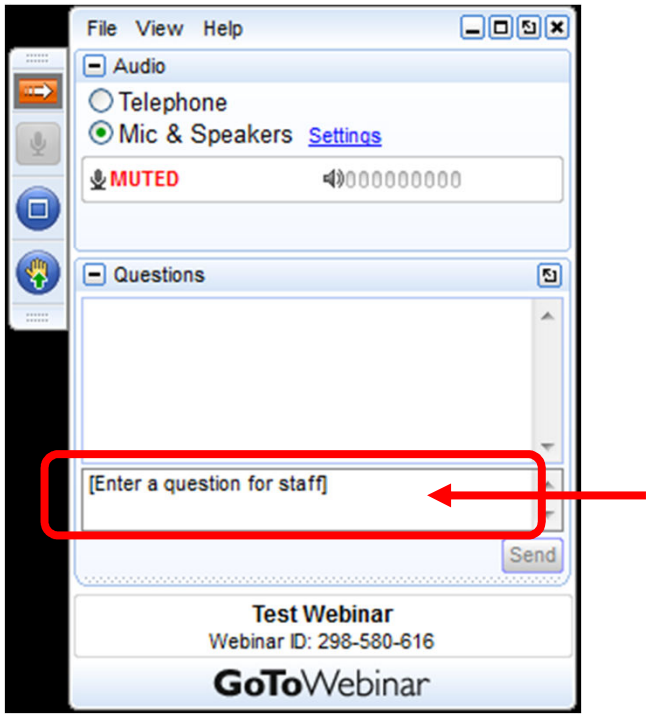
TracePro

Lambda Research Corporation

Format

- A 30-40 minute presentation followed by a question and answer session

- Please submit your questions anytime using Question box in the GoToWebinar control panel



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Additional Resources

- Past TracePro Webinars
  - http://www.lambdares.com/webinars/
- TracePro Tutorial Videos
  - http://www.lambdares.com/videos/
- TracePro Tutorials
  - http://www.lambdares.com/technical_support/tracepro/tutorials/
- Information on upcoming TracePro Training Classes
  - http://www.lambdares.com/technical_support/training/

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Current TracePro Release

- **TracePro 7.2.5** – Released Oct. 23, 2012

- These releases can be downloaded by anyone with a current Maintenance and Support Agreement

- www.lambdares.com

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Outline

- Introduction to the New TracePro Solar Utility
  - Solar concentrator simulation with TracePro
  - The Solar Utility indepth
- Solar Utility User Interface Overview
  - Setup window
  - 3D View window
  - Result Viewer window
- Demonstration of Solar Utility
  - The first step : The basic steps to use the utility
  - Design, Optimize and Analyze
    - Pub. No.:US20120073626

TracePro

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An Introduction to New TracePro Solar Utility

To analyze solar collector systems over time, TracePro now has an automated utility to help run these simulations.

TracePro

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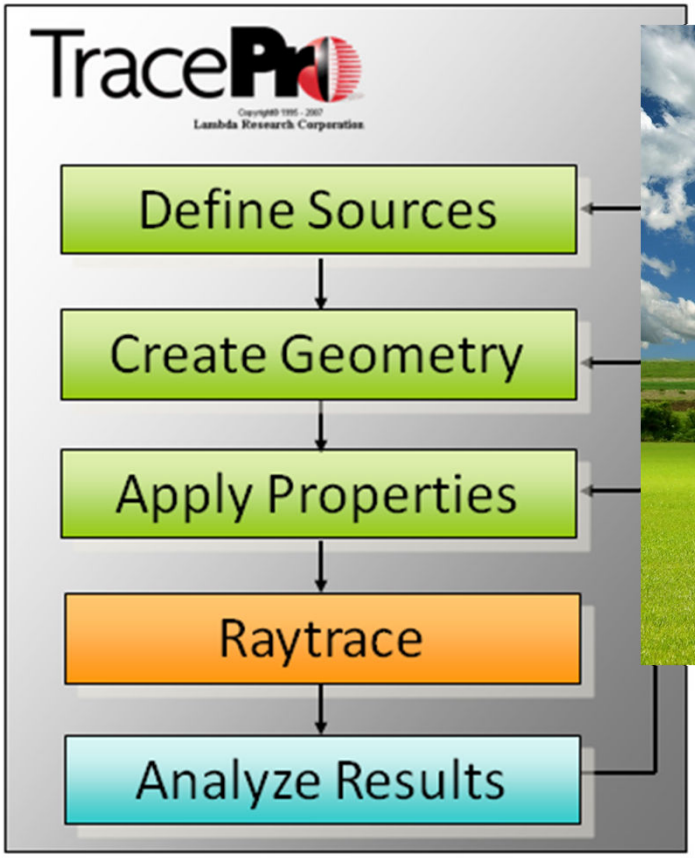
Solar collector simulation using TracePro's solar utility

First Create the Solar Collector System in TracePro, raytrace and check results



TracePro

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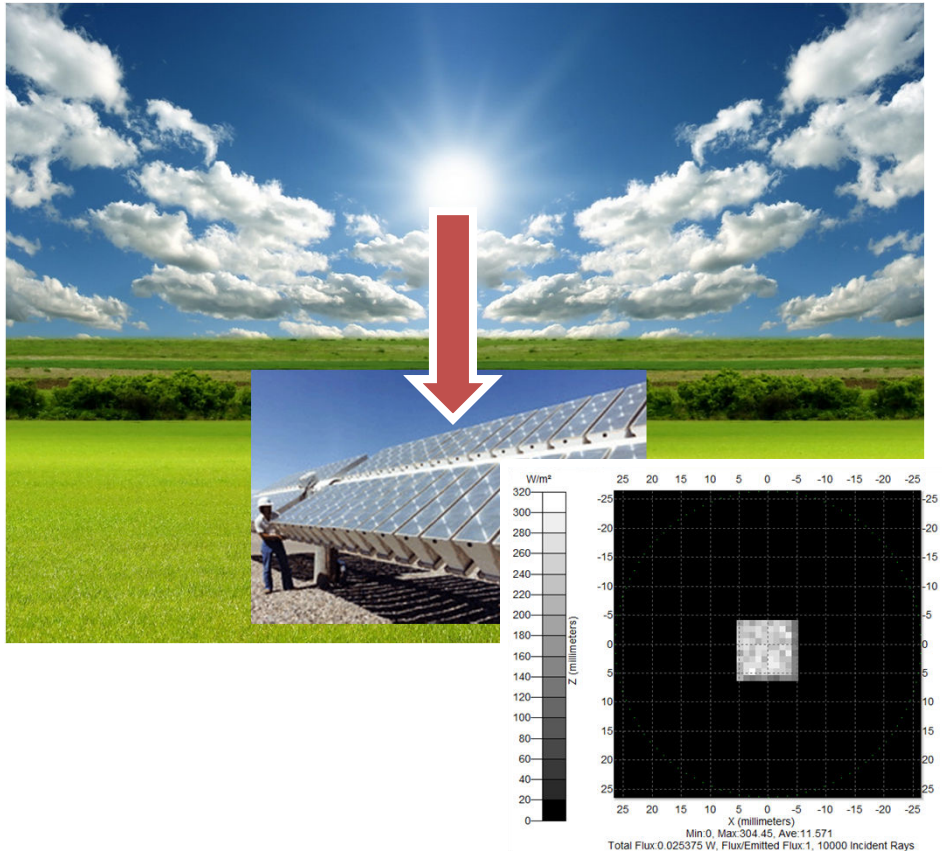
Solar collector simulation using TracePro's solar utility

- Easy light source
- Advanced optical geometries
- Accurate & high-speed raytrace
- Comprehensive analysis tools



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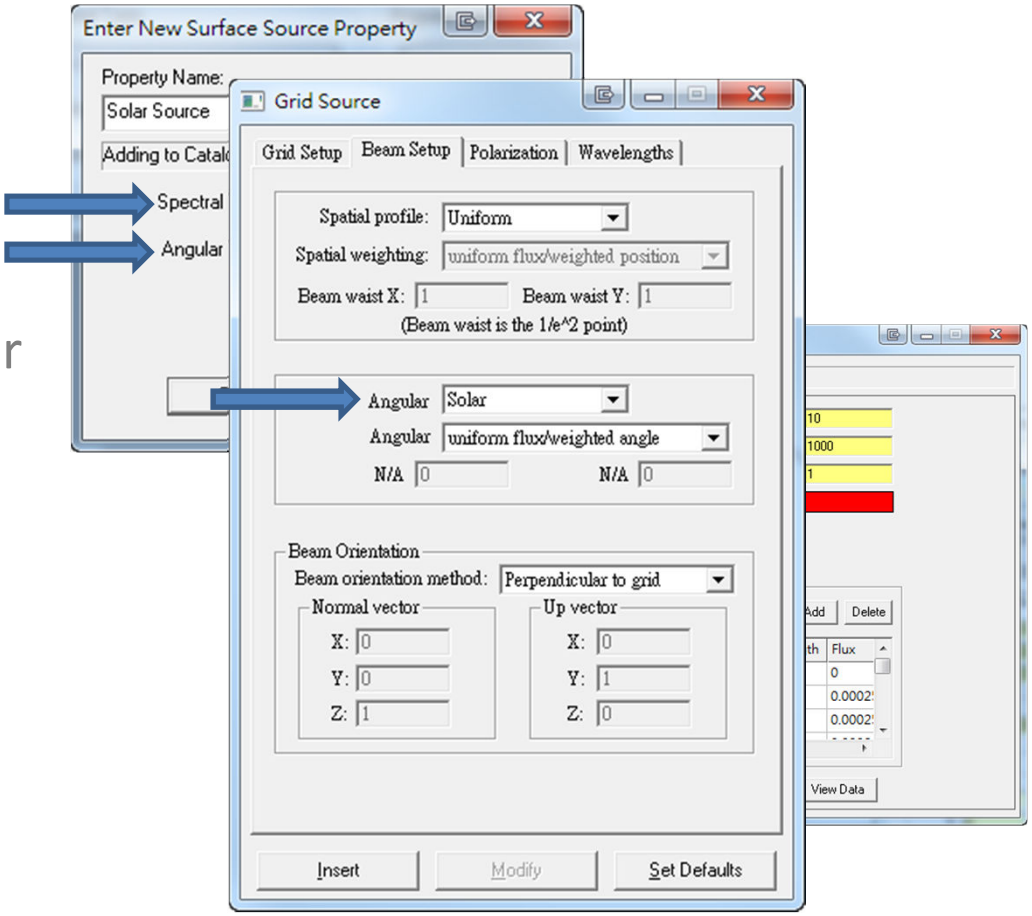
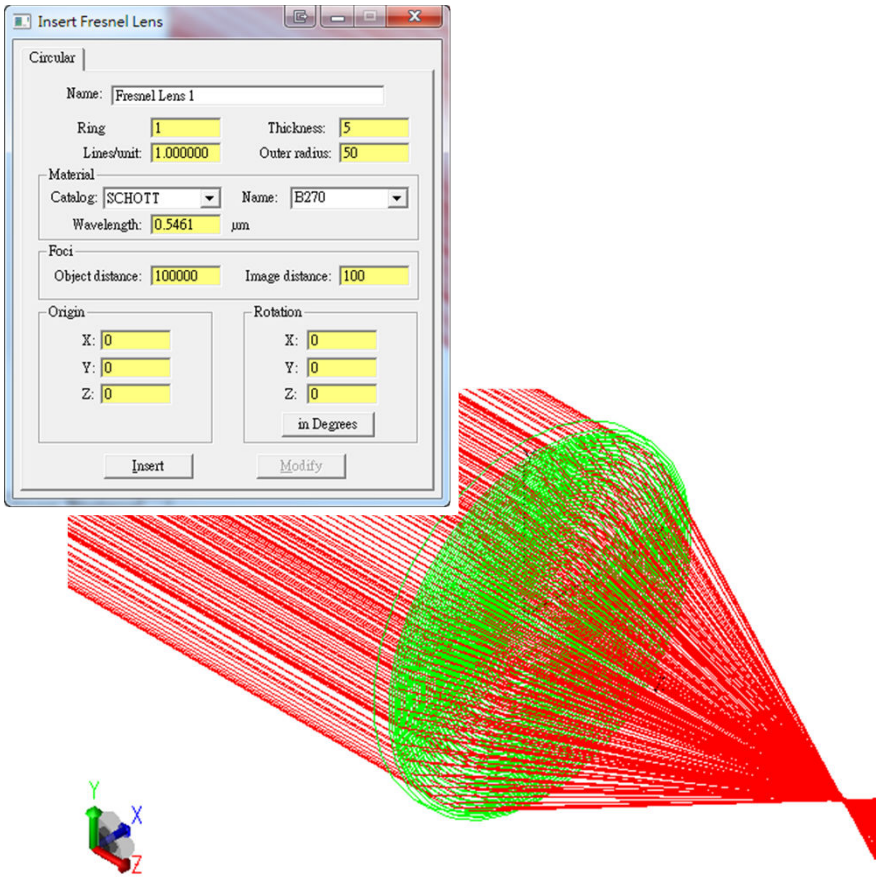
Cont'd

- Easy light sources :
  - Grid source
    - Angular => Solar
  - Surface source
    - ASTM E490



Cont'd

- Advanced TracePro Optical geometries:
  - Fresnel lens
    - Insert Fresnel lens
    - Revolve thin Sheet
  - Reflective concentrator
    - 3D Compound
      - CPC, CEC
    - Rectangular concentrator



Cont'd

- Advanced optical geometries:
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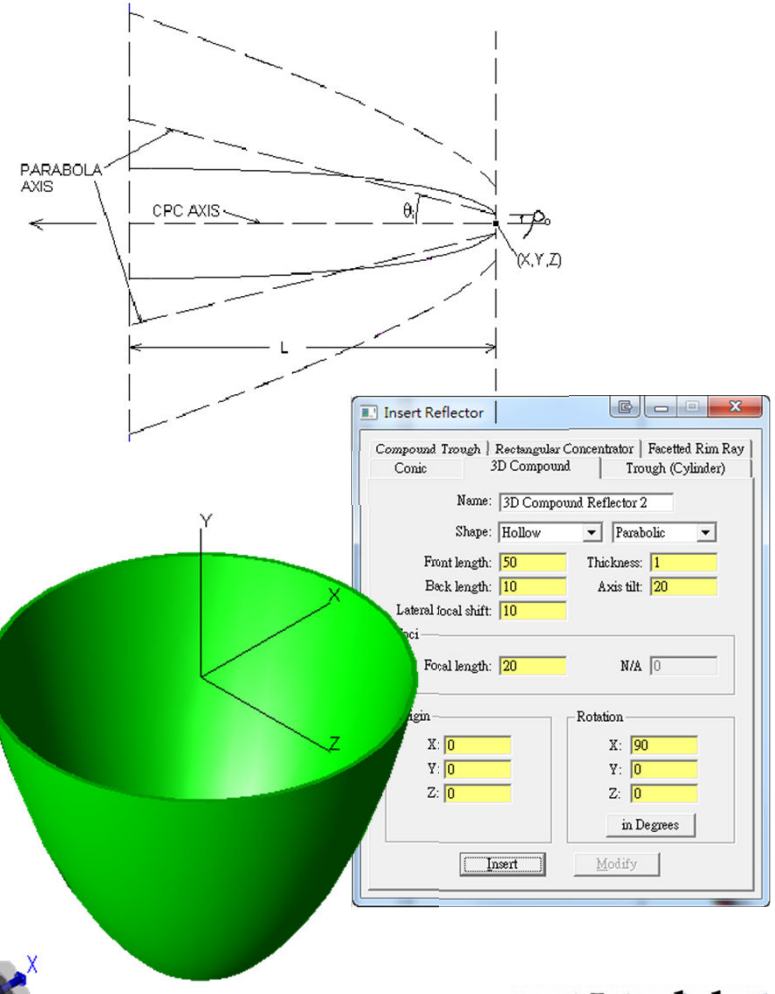
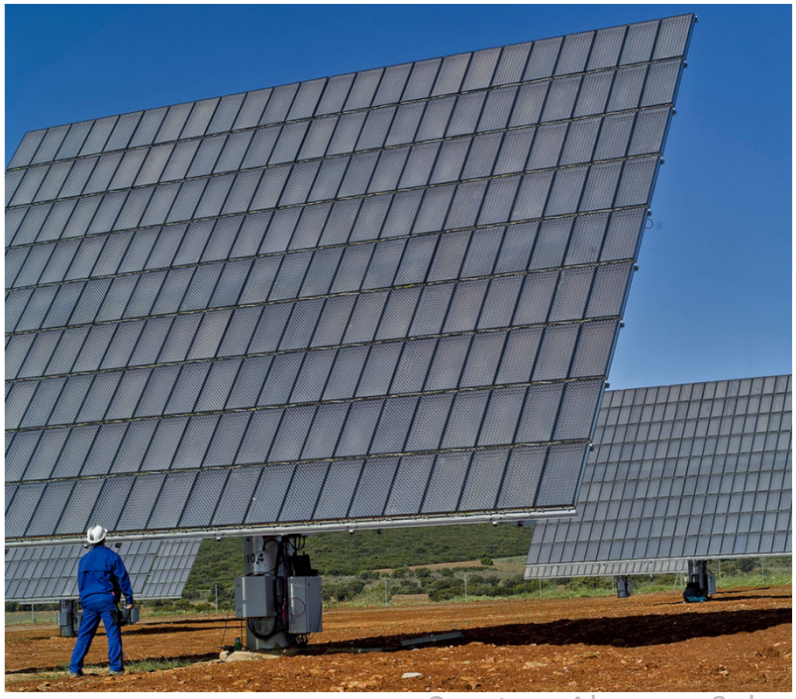
    - Insert Fresnel lens
    - Revolve thin Sheet
  - Reflective concentrator
    - 3D Compound
      - CPC, CEC
    - Rectangular concentrator



Cont'd

- Accurate & high-speed raytrace engine:
  - Material and surface properties
  - Multi-threaded raytracing
- Comprehensive analysis tools:
  - Irradiance map, Candela map
  - Ray sorting
  - Path sort table



Courtesy Abengoa Solar.

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The Solar Utility

1. Considers the position of the sun
2. Based on the entrance pupil of the solar collection system to create a correct sun model
3. Automated simulation
4. Complete Analysis Capabilities

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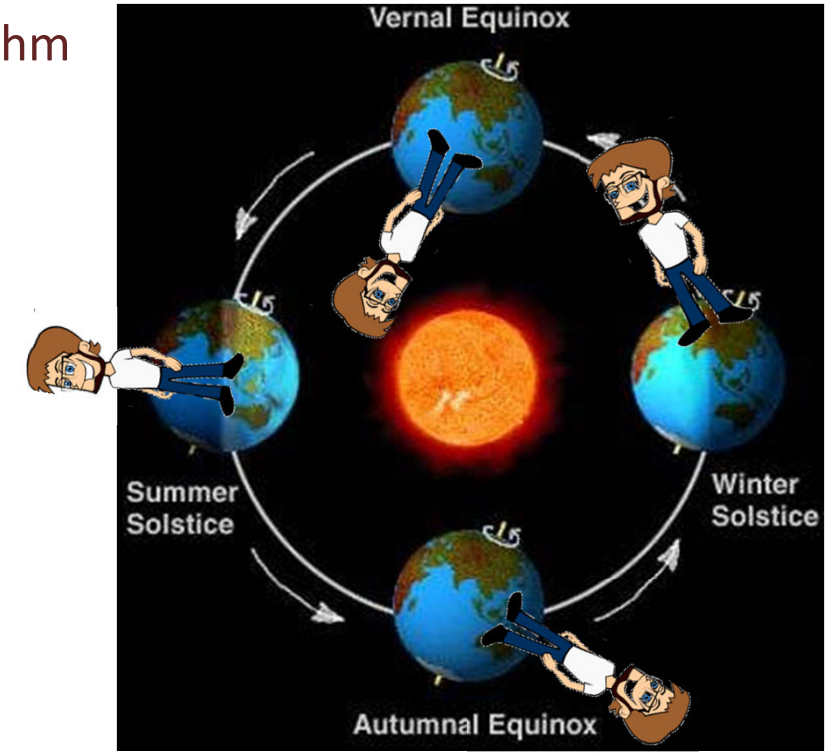
Sun trajectory

- Solar utility includes:
  - NREL's Solar Position Algorithm (SPA)
    - Date
    - Longitude & Latitude
    - Time Zone
    - Altitude, Tilt
- To define a correct light source
  - Incident direction
  - Total flux of incident ray
  - Sun model
    - Geometry
    - Irradiance(W/m^2)
    - Wavelength(s)



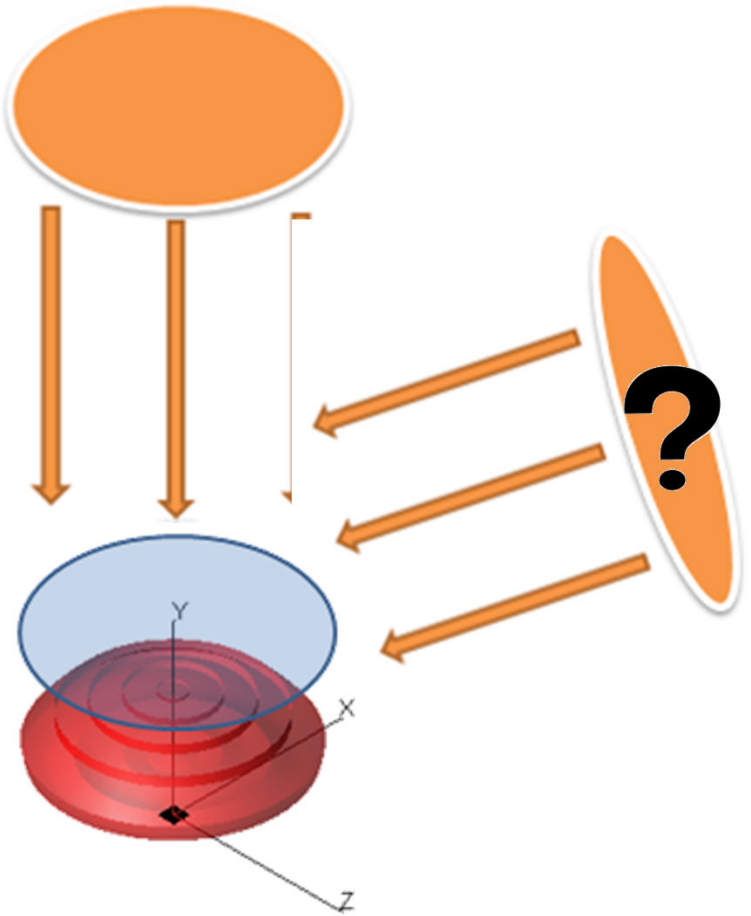
Courtesy NASA

National Renewable Energy Laboratory

Sun model

- What we know:
  - Is an almost-parallel light source
  - Irradiance of the sun's surface (W/m^2)
  - Entrance pupil of device
- What we don't know:
  - Light source shape
- The sun created by Solar Utility

  For each time calculation whatever the sun position is, all rays from the source pass through the device's entrance pupil.
  - Based on sun position, the



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Automation simulation

- Time period
  - From xxxx/xx/xx xx:xx:xx
  - To xxxx/xx/xx xx:xx:xx
- Steps/Interval
  - N times in the assigned time period
  - xx:xx:xx as simulation interval
- Time filter

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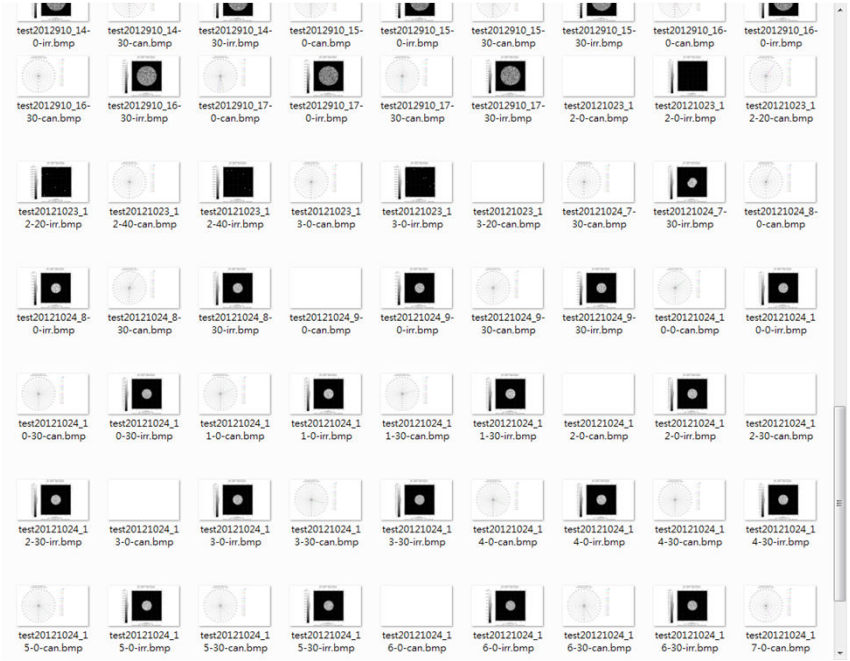
Analysis tool

- Flux-Date 2D Chart
- Flux-Date Table
- Irradiance & Candela map viewer
- Total collected energy
- Flux Report (in Final 7.3 release)



User Interface Overview

Just 3 panels : Setup, 3D view and Result viewer

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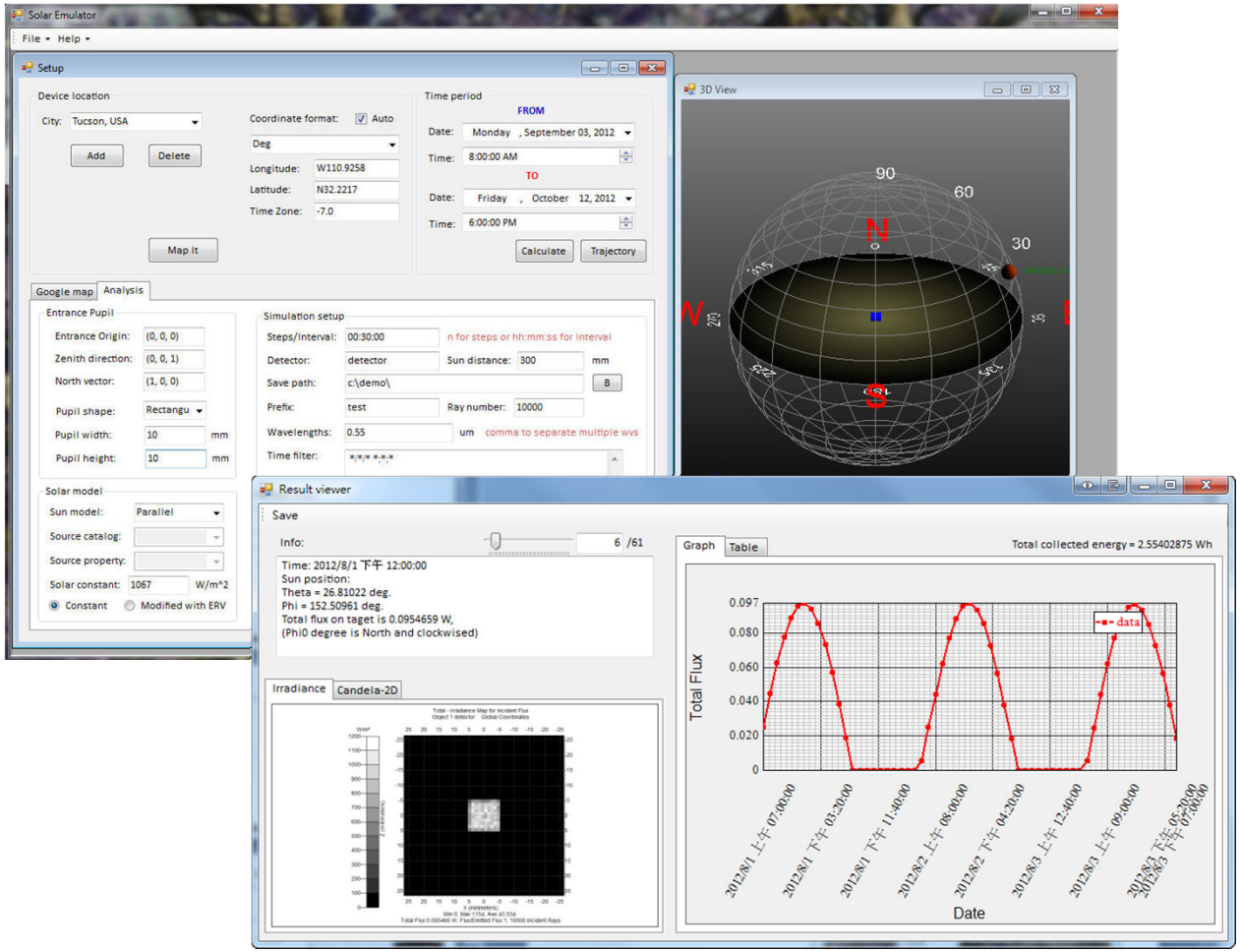
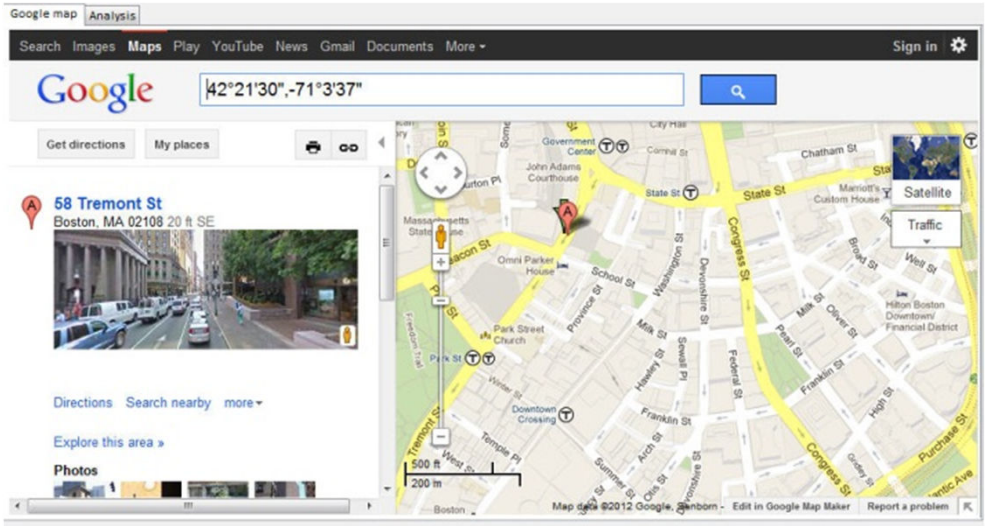
User Interface

- Setup
- 3D view
- Result viewer



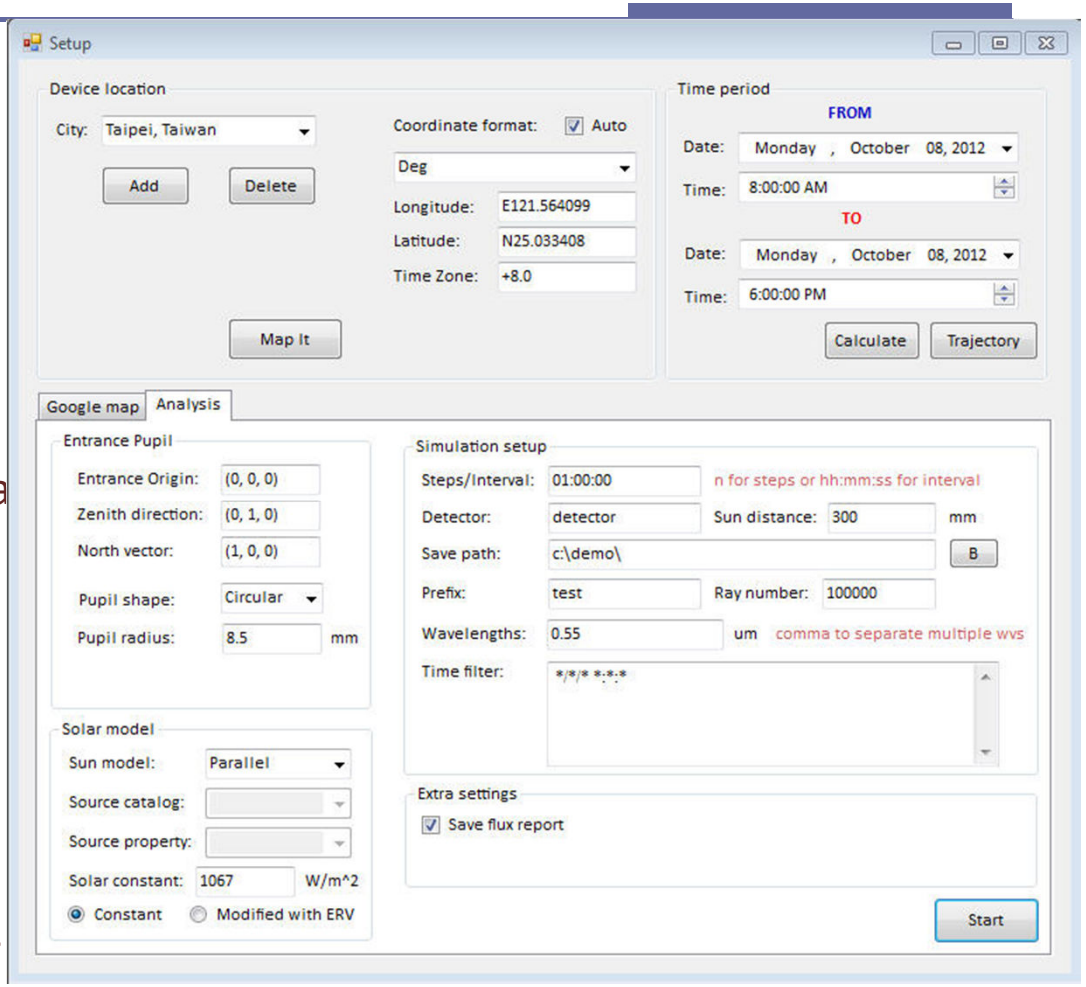
Setup – Device location

- Coordinate info :
  - Format
  - Longitude
  - Latitude
  - Time zone
  - Altitude & Tile
- Google map
  - Map it
  - Search => What's here
- City database
  - Add/Delete capability



Setup – Analysis

- Time period
- Optical parameters
  - Entrance pupil
  - Solar flux
- Simulation setup
  - Steps/Interval
  - Detector's surface na
  - Sources
    - Parallel
    - Source Property
    - Source Catalog
    - Wavelength
    - Ray Number
    - Sun distance
  - Path of the file folder



TracePro filter

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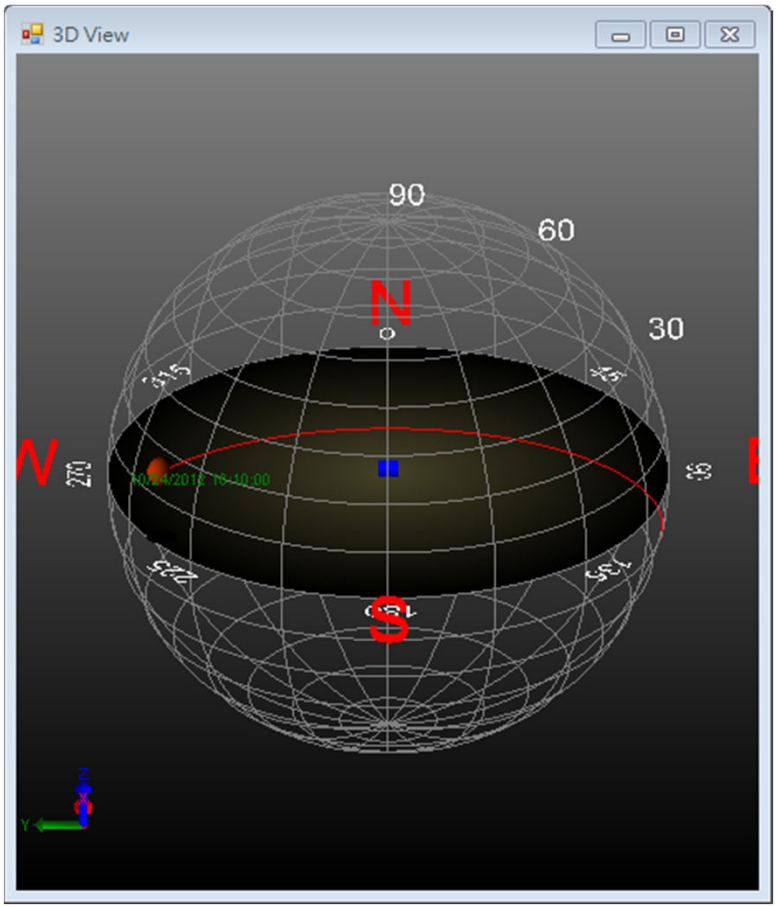
3D view

- Linked with Zenith direction and North vector
- “Calculate” the position of sun
- “Trajectory” of the sun path for the time period
- When the utility is analyzing for periods of time, the sun position is automatically updated



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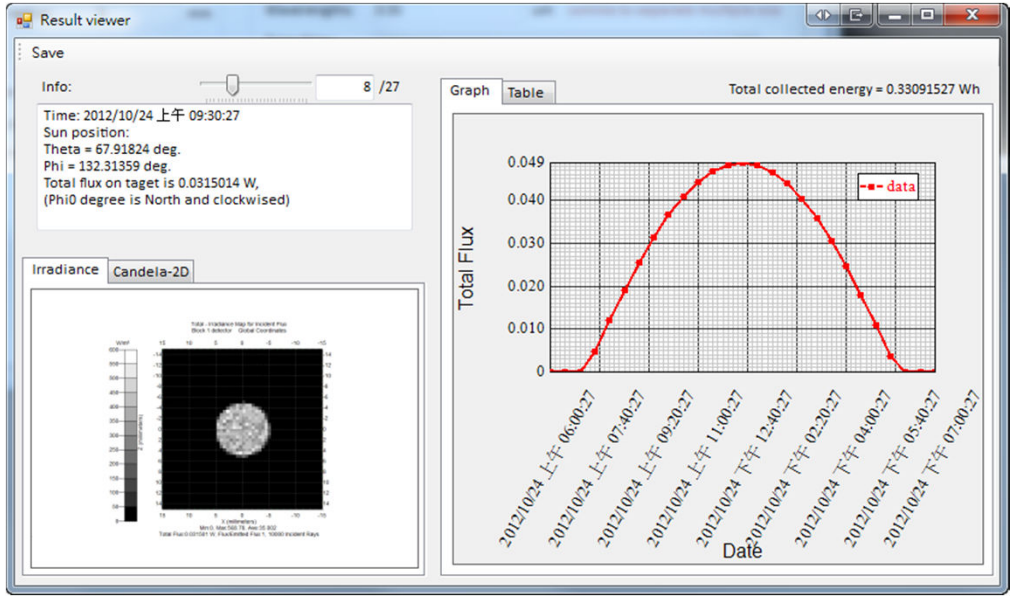
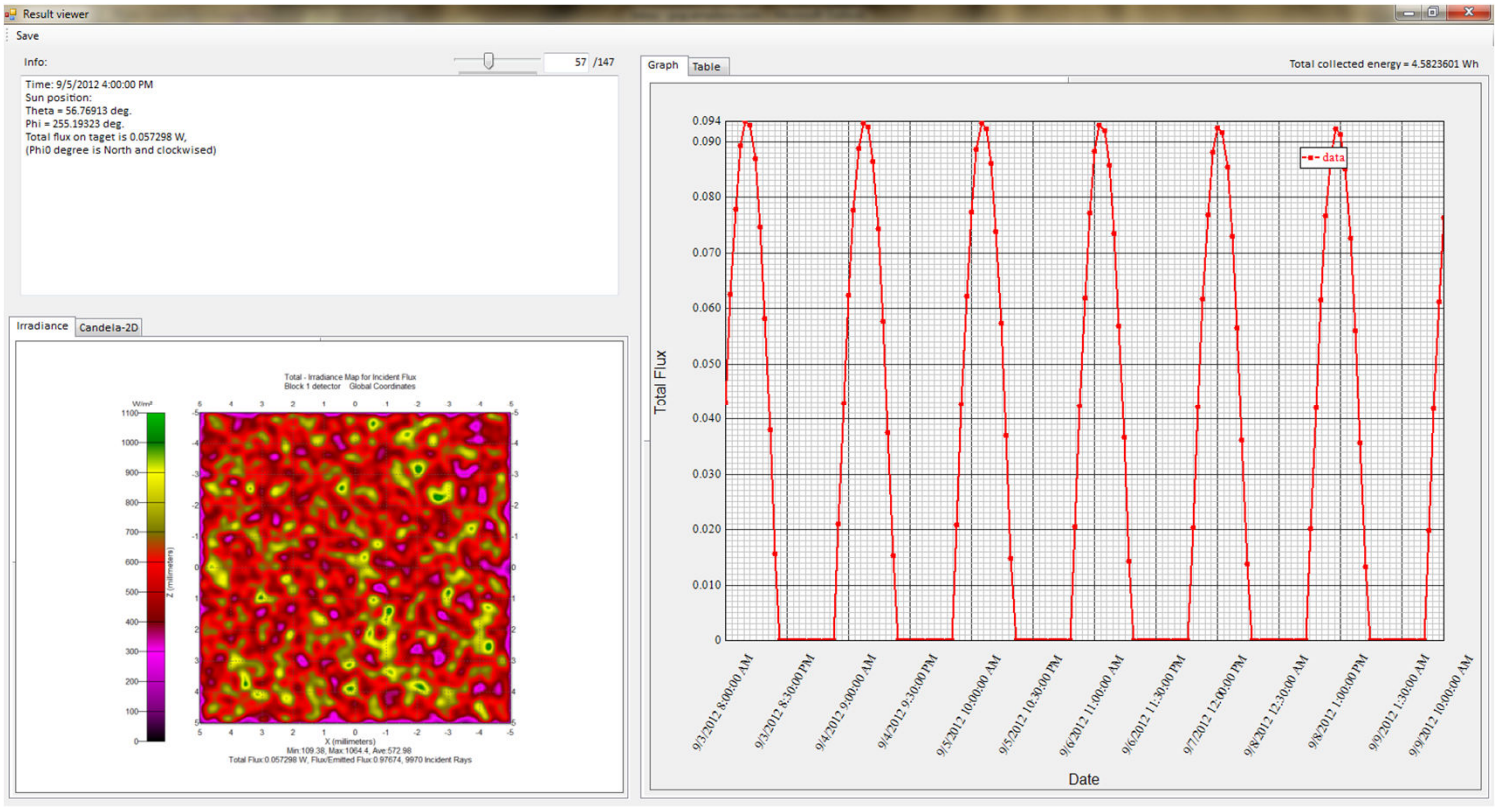
Result viewer

- Flux-Date Chart
- Flux-Date Table
- Irradiance & Candela viewer
  - Select a result
  - Zoom it
  - Information of sun
- Total collected energy



Result viewer



The Solar Result Viewer shows either irradiance or candela maps, and a graph or table of the power on the target over the period calculated.

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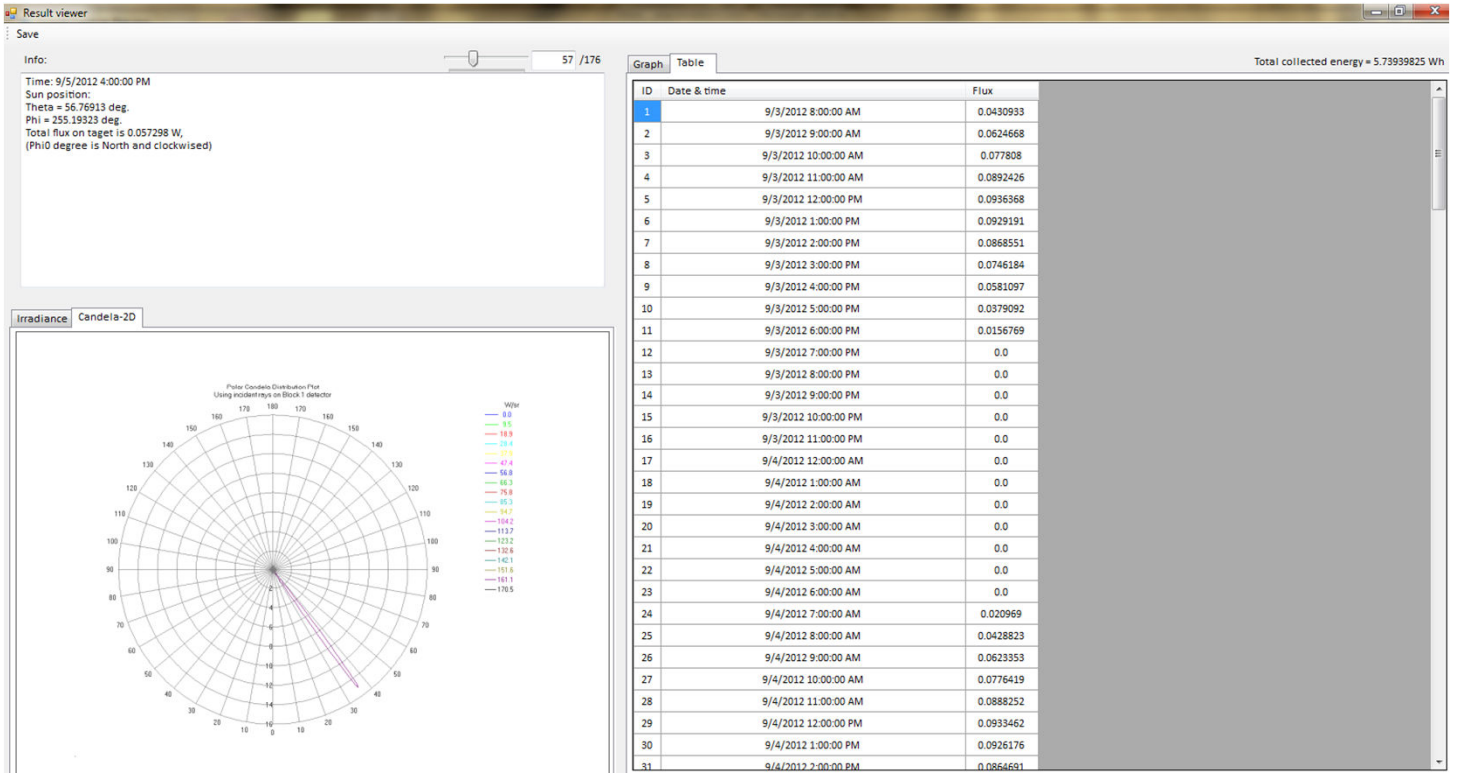
Result viewer



The Solar Result Viewer showing a candela maps and tabular results over the period calculated. Clicking on the Table brings up the associated irradiance or candela map. You can also use the slider on the top of the dialog window to select the iteration.

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Result viewer

TracePro Release: 7 3 0
Flux Report for C:\Lambda\tracepro_examples\Solar Utility\three pieces.OML
Wavelength information in microns: All wavelengths and totals
Data generated at 11:12:14 November 27, 2012

Object Name : Material Property Surface Name : Surface Property	Surface Area [sq mm]	Wavelength [microns]	Number of Rays	Incident Flux [Watts]	Absorbed [Watts]	Lost Flux (All Types) [Watts]	Lost Flux -> Escape [Watts]	Lost Flux -> Flux Threshol [Watts]	Lost Flux - [Watts]	Lost Flux - [Watts]	Lost Flux - [Watts]	Lost Flux - [Watts]	Lost Flux -> Other [Watts]
Top Fresnel Lens : Plastic -> pmma		0.55 (Sun/Emitter)		0.141145228	0								
		Totals:		0.141145228	0								
Surface 0 : Default-<None>	7.877640415	0.55 (Sun/Emitter)	5800	0.005129512	0	0.001831442	0.001740365	9.11E-05	0	0	0	0	0
		Totals:	5800	0.005129512	0	0.001831442	0.001740365	9.11E-05	0	0	0	0	0
Surface 1 : Default-<None>	3.330902535	0.55 (Sun/Emitter)	3195	0.002367583	0	0.000178098	0.000147155	3.09E-05	0	0	0	0	0
		Totals:	3195	0.002367583	0	0.000178098	0.000147155	3.09E-05	0	0	0	0	0
Surface 2 : Default-<None>	46.01601948	0.55 (Sun/Emitter)	37275	0.027633563	0	0.01009436	0.009664166	0.000430193	0	0	0	0	0
		Totals:	37275	0.027633563	0	0.01009436	0.009664166	0.000430193	0	0	0	0	0
Surface 3 : Default-<None>	14.97518238	0.55 (Sun/Emitter)	12852	0.008950075	0	0.001052088	0.000865237	0.000186851	0	0	0	0	0
		Totals:	12852	0.008950075	0	0.001052088	0.000865237	0.000186851	0	0	0	0	0
Surface 4 : Default-<None>	59.34921944	0.55 (Sun/Emitter)	57964	0.040227224	0	0.010109915	0.009506321	0.000603594	0	0	0	0	0
		Totals:	57964	0.040227224	0	0.010109915	0.009506321	0.000603594	0	0	0	0	0
Surface 5 : Default-<None>	21.89474013	0.55 (Sun/Emitter)	27684	0.016258344	0	0.001825646	0.001527611	0.000298035	0	0	0	0	0
		Totals:	27684	0.016258344	0	0.001825646	0.001527611	0.000298035	0	0	0	0	0
Surface 6 : Default-<None>	70.96428146	0.55 (Sun/Emitter)	62083	0.045804119	0	0.011978516	0.011121997	0.000856519	0	0	0	0	0
		Totals:	62083	0.045804119	0	0.011978516	0.011121997	0.000856519	0	0	0	0	0
Surface 7 : Default-<None>	27.92629506	0.55 (Sun/Emitter)	28268	0.019833433	0	0.003903712	0.003487404	0.000416308	0	0	0	0	0
		Totals:	28268	0.019833433	0	0.003903712	0.003487404	0.000416308	0	0	0	0	0
Surface 8 : Default-<None>	82.42077814	0.55 (Sun/Emitter)	55406	0.040026992	0	0.01142036	0.010619953	0.000800408	0	0	0	0	0
		Totals:	55406	0.040026992	0	0.01142036	0.010619953	0.000800408	0	0	0	0	0
Surface 9 : Default-<None>	2.289560646	0.55 (Sun/Emitter)	2457	0.001596916	0	0.000351952	0.000306334	4.56E-05	0	0	0	0	0
		Totals:	2457	0.001596916	0	0.000351952	0.000306334	4.56E-05	0	0	0	0	0
Surface 10 : Default-<None>	6.110349739	0.55 (Sun/Emitter)	4497	0.002956488	0	0.000857996	0.000773056	8.49E-05	0	0	0	0	0

The flux report (available in the final 7.3 release) is written out for each sun position into the directory specified by the user in the analysis tab with the inputted prefix filename, time and txt file extension. It is best to import each text file into Excel using delimited characters (TracePro uses tab delimiters) which correctly places the output information into columns for easy visualization as shown above.

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Demonstration of Solar Utility

It is very easy to setup and simulate a series of solar system simulations with this new utility.

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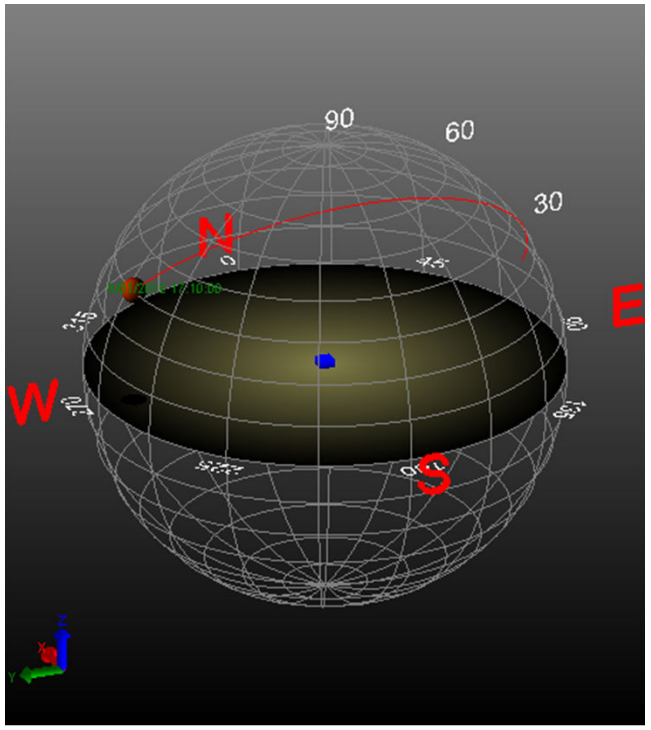
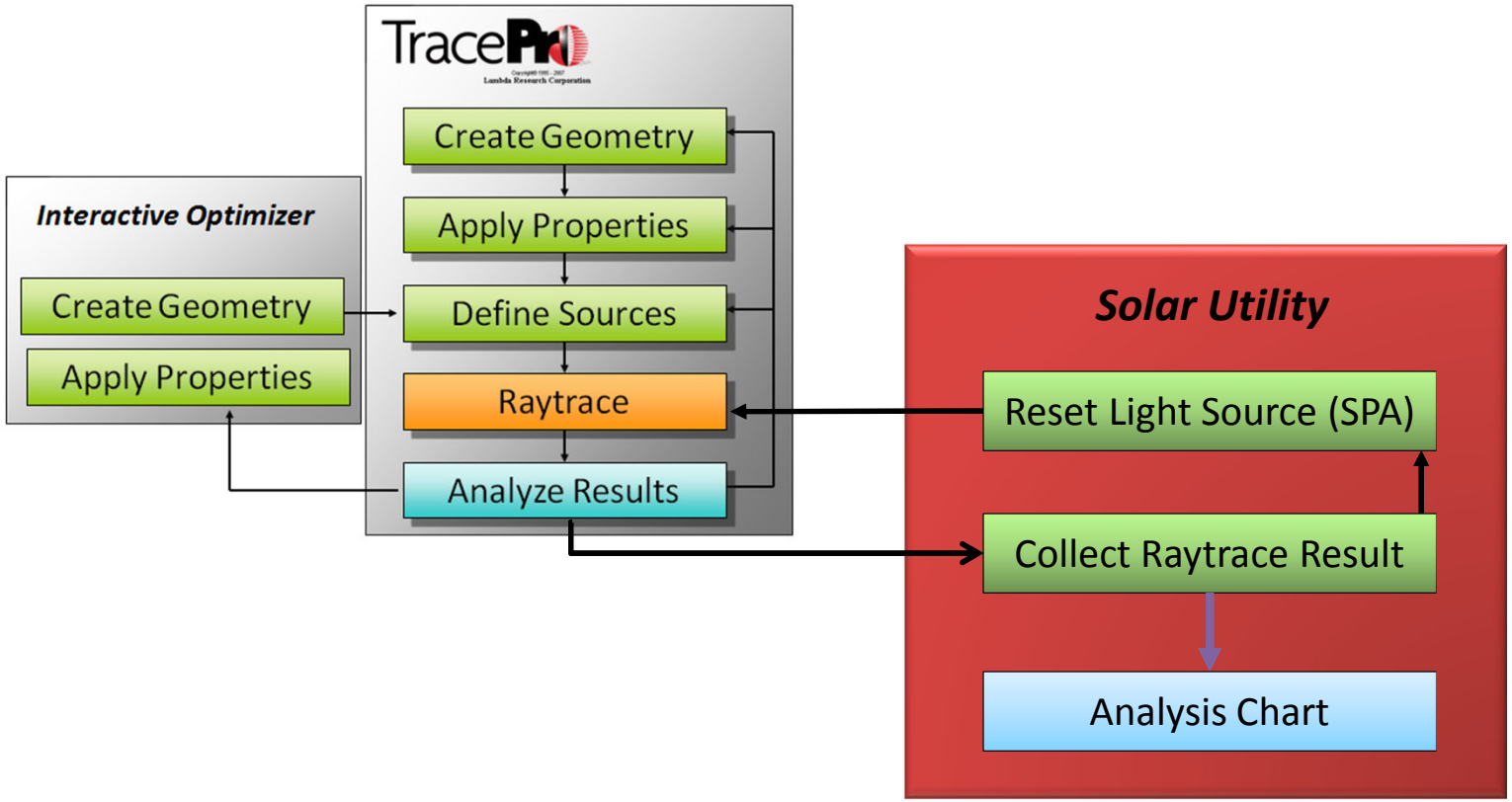
Steps to run a complete series of solar simulations

- In TracePro
  - Create the solar collector geometry
  - Insert a receiver with one surface named “detector” as defined in the solar utility analysis tab to match
  - Pre-define all Irradiance and Candela map options
- In Solar Utility
  - Add a new city into database or use an existing predefined location
  - Set the target time period
  - Set interval to one hour
  - Use Trajectory button to test
  - Select sun model, parallel or Surface Source Property
  - Specify solar constant or Earth Radius Vector (ERV) option
  - Press Start button
- Check the simulation results

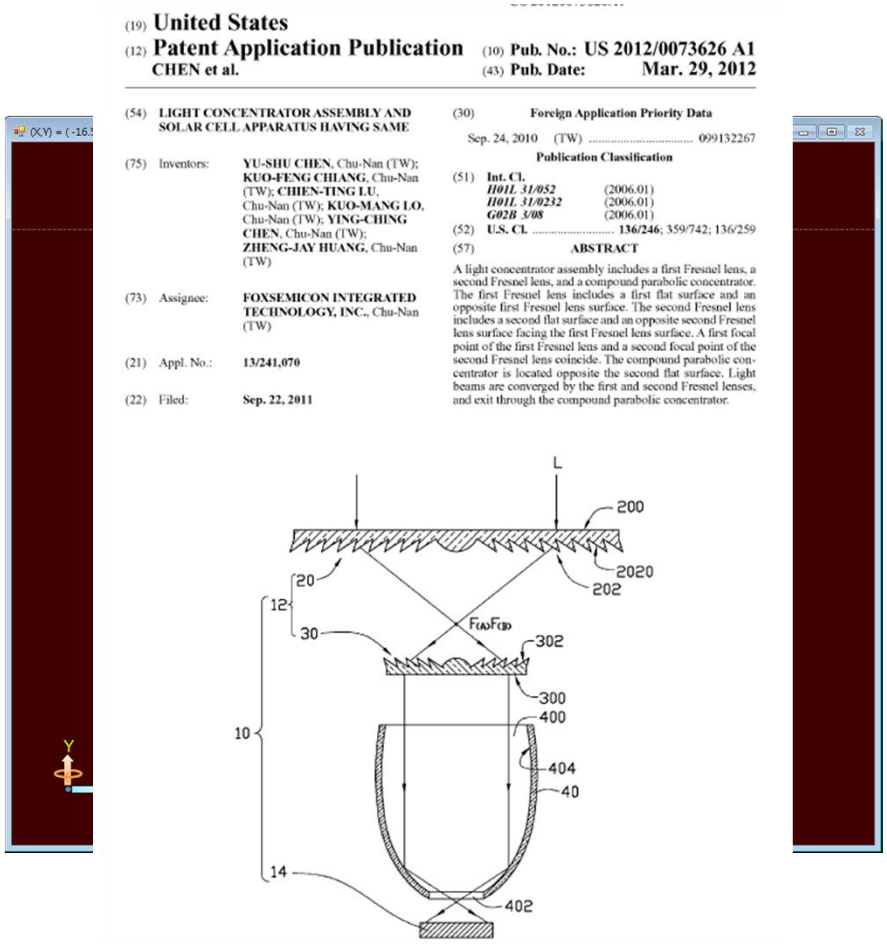


Design, Optimize and Analyze



Design, Optimize and Analyze

- Pub. No.:US20120073626
- Model
  - 2 Fresnel lens + 1 CPC
  - Model created by Interactive Optimizer
- Open Solar utility and set up filter
- Analyze the result



(19) **United States**
(12) **Patent Application Publication**
CHEN et al.

(10) **Pub. No.: US 2012/0073626 A1**
(43) **Pub. Date: Mar. 29, 2012**

(54) **LIGHT CONCENTRATOR ASSEMBLY AND SOLAR CELL APPARATUS HAVING SAME**

(75) Inventors: **YU-SHU CHEN**, Chu-Nan (TW); **KUO-FENG CHIANG**, Chu-Nan (TW); **CHIEN-TING LU**, Chu-Nan (TW); **KUO-MANG LO**, Chu-Nan (TW); **YING-CHING CHEN**, Chu-Nan (TW); **ZHENG-JAY HUANG**, Chu-Nan (TW)

(73) Assignee: **FOXSEMICON INTEGRATED TECHNOLOGY, INC.**, Chu-Nan (TW)

(21) Appl. No.: **13/241,070**

(22) Filed: **Sep. 22, 2011**

(30) **Foreign Application Priority Data**

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H01L 31/052 (2006.01)
H01L 31/0232 (2006.01)
G02B 3/08 (2006.01)

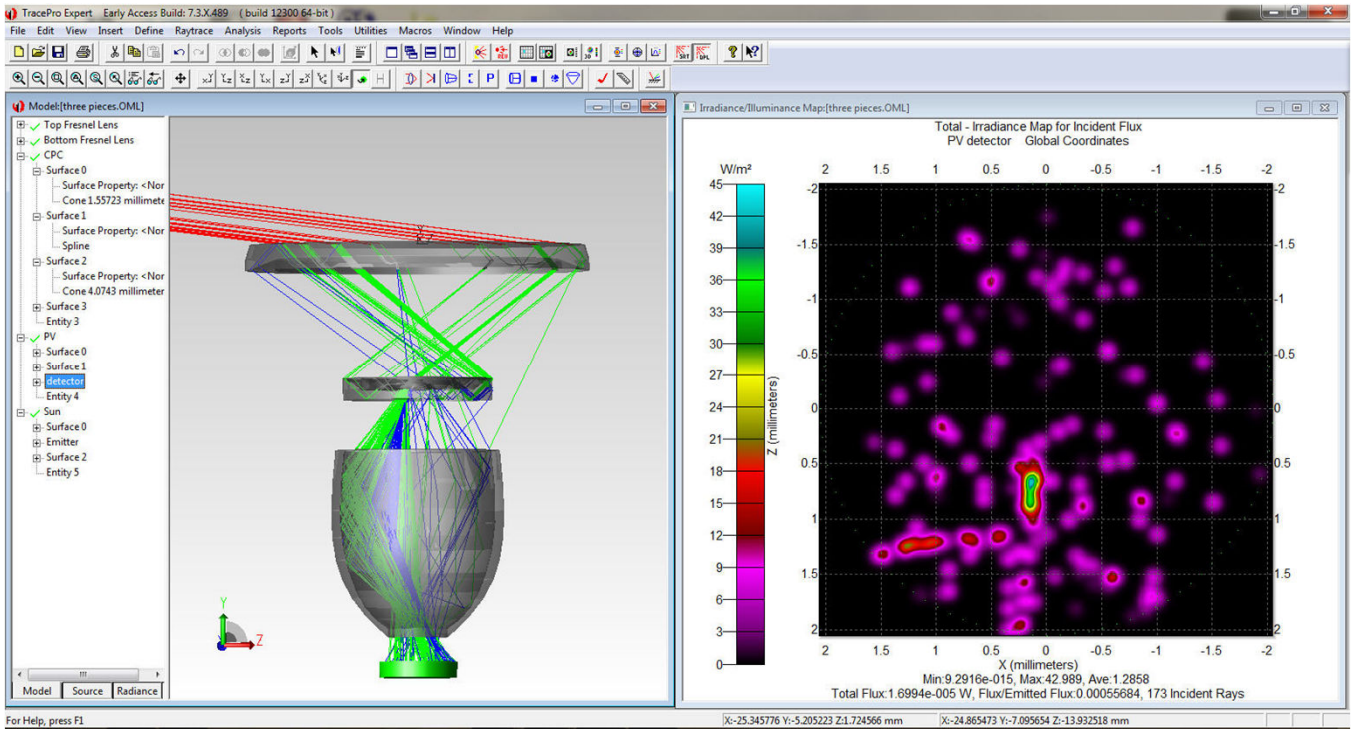
(52) **U.S. Cl.** **136/246**; 359/742; 136/259

(57) **ABSTRACT**

A light concentrator assembly includes a first Fresnel lens, a second Fresnel lens, and a compound parabolic concentrator. The first Fresnel lens includes a first flat surface and an opposite first Fresnel lens surface. The second Fresnel lens includes a second flat surface and an opposite second Fresnel lens surface facing the first Fresnel lens surface. A first focal point of the first Fresnel lens and a second focal point of the second Fresnel lens coincide. The compound parabolic concentrator is located opposite the second flat surface. Light beams are converged by the first and second Fresnel lenses, and exit through the compound parabolic concentrator.

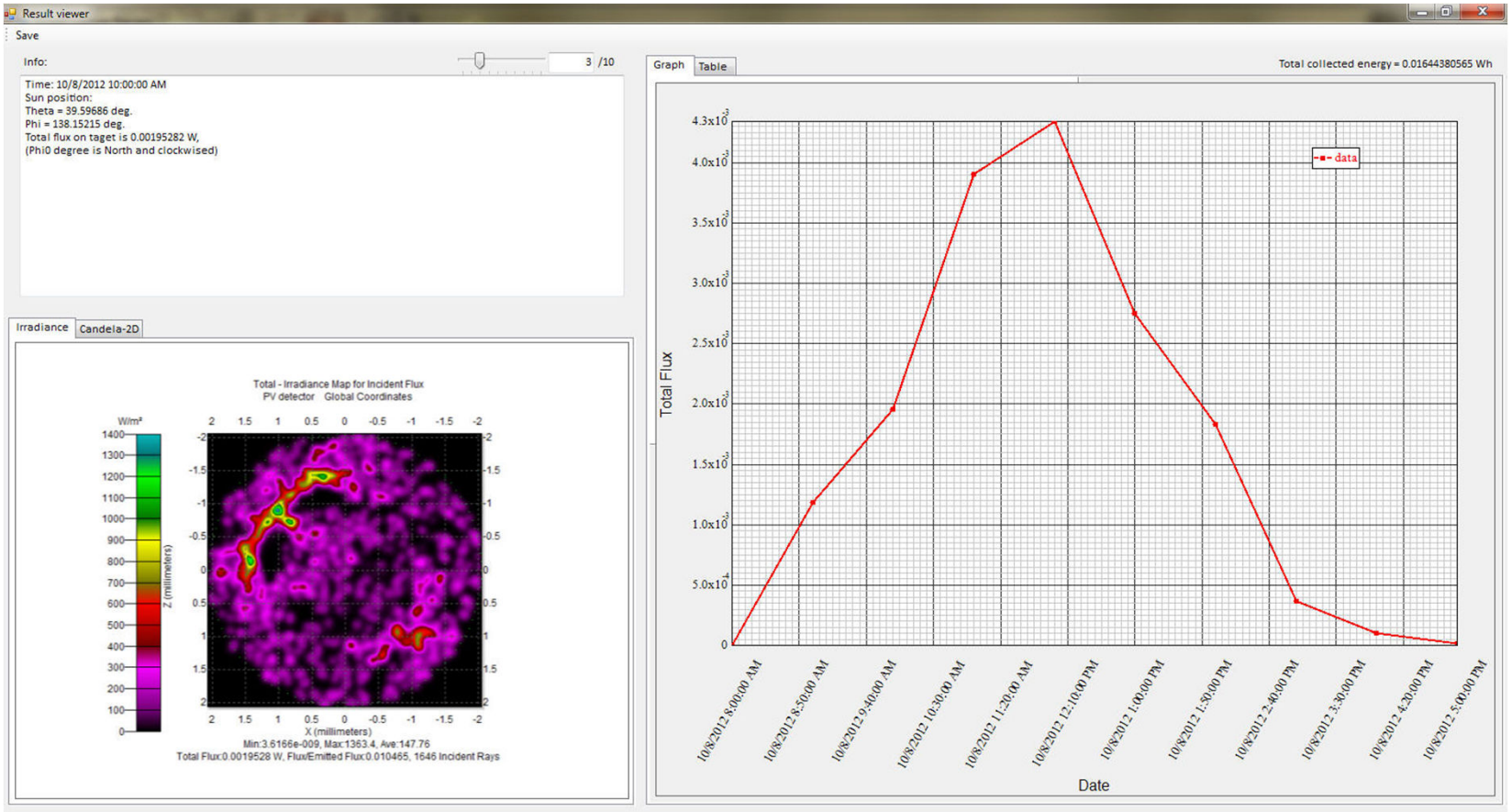
Output explanation of this 2 Fresnel Lens/CPC System

The results of the 2 Fresnel lens and one CPC system are quite poor. This is due to the fact that this system was intended for use with an one axis solar tracking system. Without the solar tracking the system works poorly except when the sun is directly overhead. So although it system works poorly this is a great example for the solar utility which prove its inefficiency over time. You can see the irradiance results at 5PM in the figure shown below.



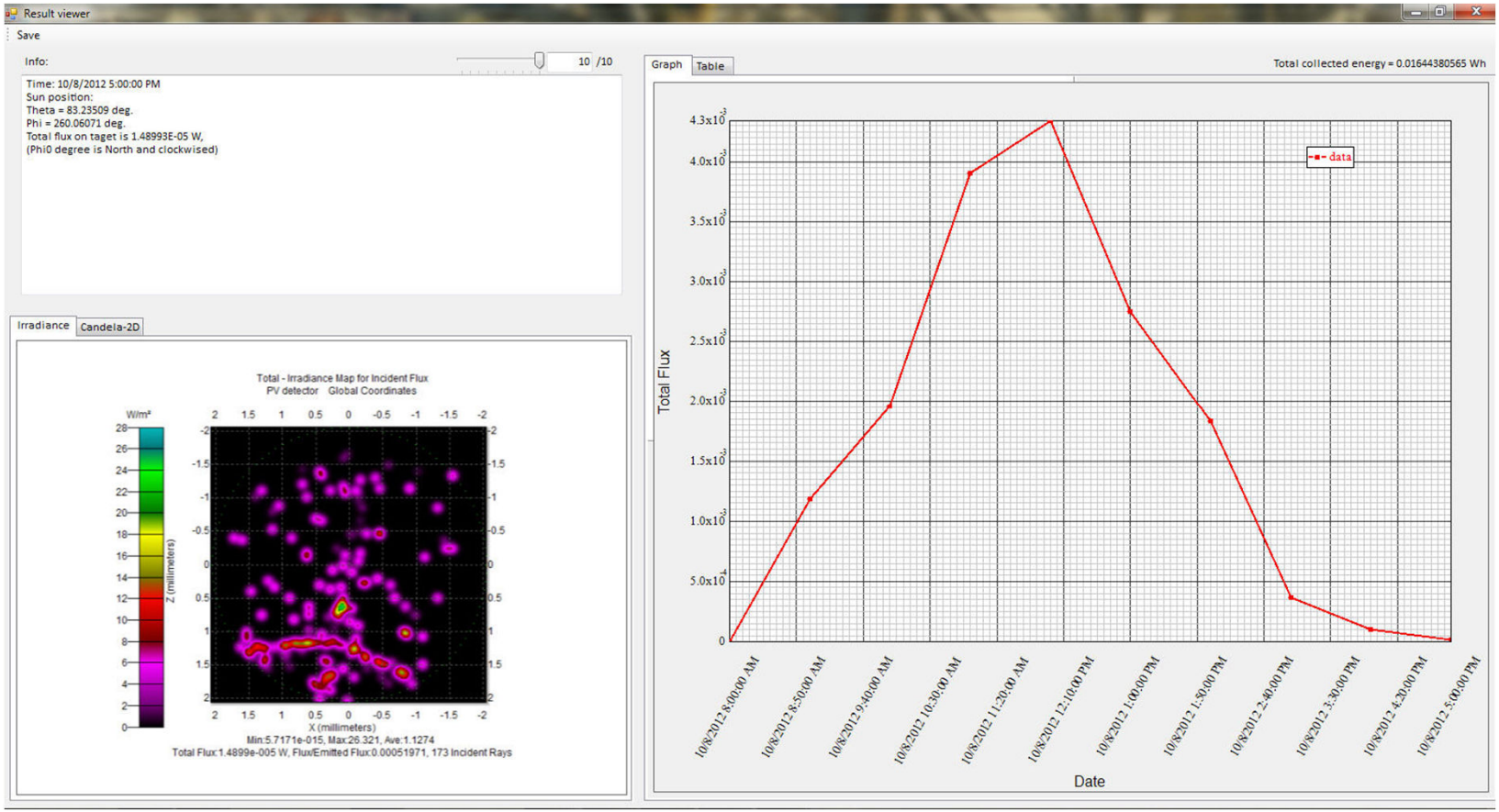
Output explanation of this 2 Fresnel Lens/CPC System

Shown in the bottom left hand image is the irradiance map for the 10AM Sun position



Output explanation of this 2 Fresnel Lens/CPC System

Shown in the bottom left hand image is the irradiance map for the 5PM Sun position



Live Demonstration

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- The example files, recorded session and slides for this webinar will be placed in the webinar section of the Lambda Research Website for later viewing and use.
- The new Solar Utility will be released with TracePro 7.3
- Features to come in later releases, indirect sun contribution, and solar tracking
- The Solar Utility is in Early Access Now, Please try it out and lets sales@lambdares.com have your feedback

  Download TracePro 7.3 Early Access from www.lambdares.com

TracePro

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Q & A

Thank You

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