Modeling metal materials in Radiance based on Bidirectional Reflection Distribution measurement

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Solar Energy Research Institute of Singapore (SERIS)

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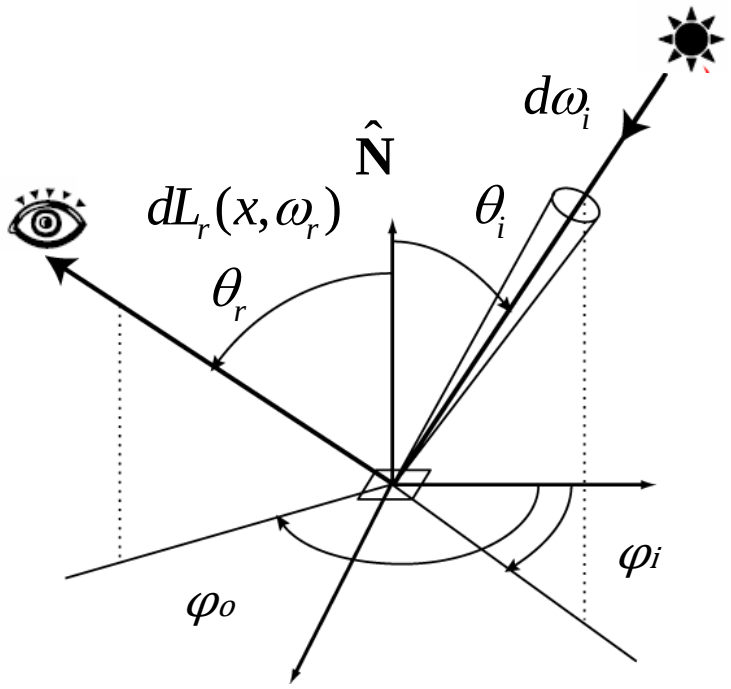
Definition of the BRDF



The **Bidirectional Reflectance Distribution Function** (**BRDF**) is a four-dimensional function that defines how light is reflected at an surface.

$$f(\theta_i, \varphi_r, \theta_o, \varphi_r) = \frac{dL_r(\theta_r, \varphi_r)}{dE_r(\theta_i, \varphi_i)}$$

$dLr(\theta_i, \varphi_i)$ Radiance at surface in direction (θ_i, φ_i)
$dEr(\theta_o, \varphi_o)$ Irradiance at surface in direction (θ_o, φ_o)

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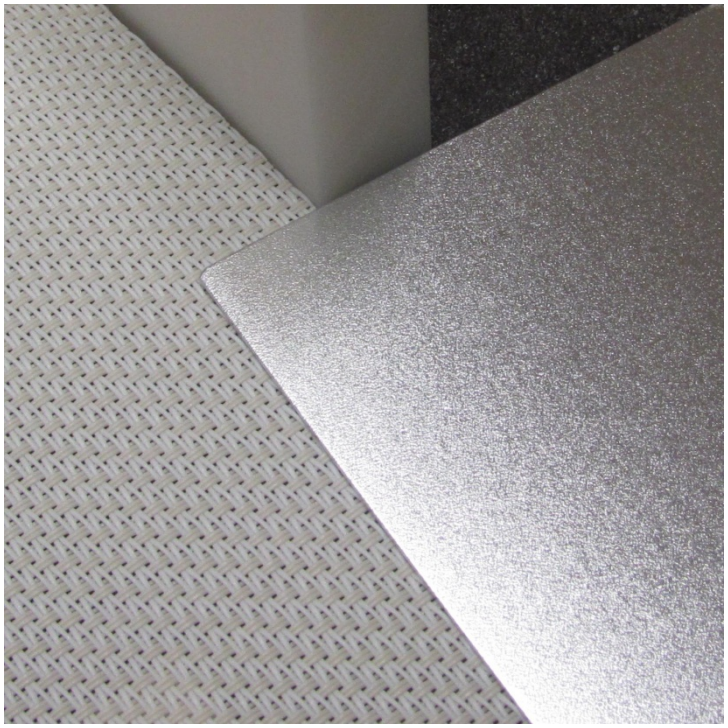
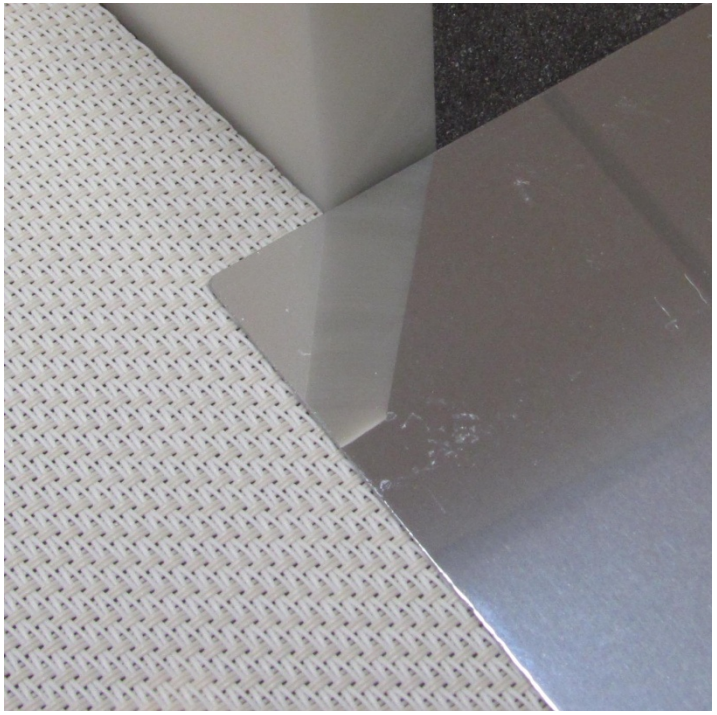
Metal samples



Scattering aluminum
frontside mirror
miro20-2000



Clear aluminum
frontside mirror
miro4-4000

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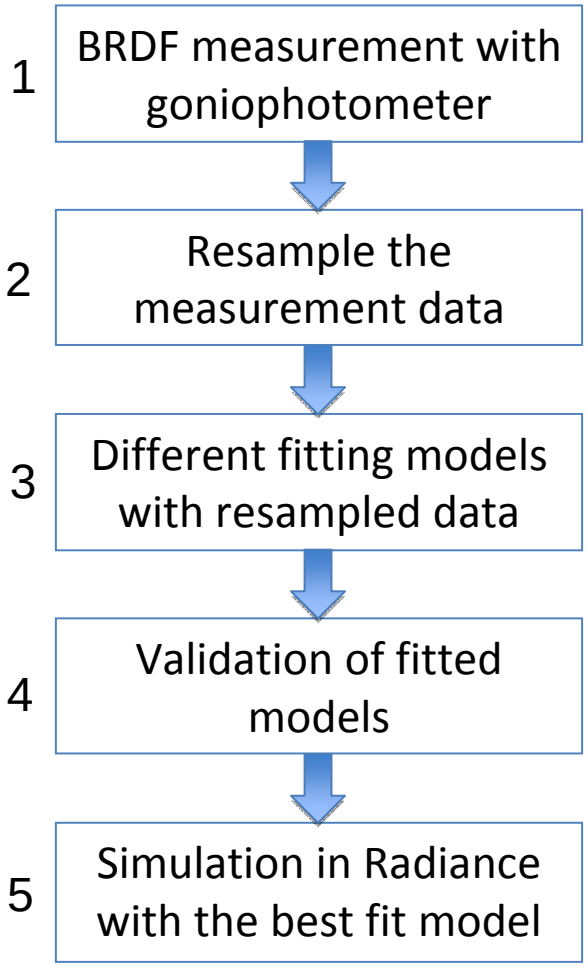
Modeling procedure



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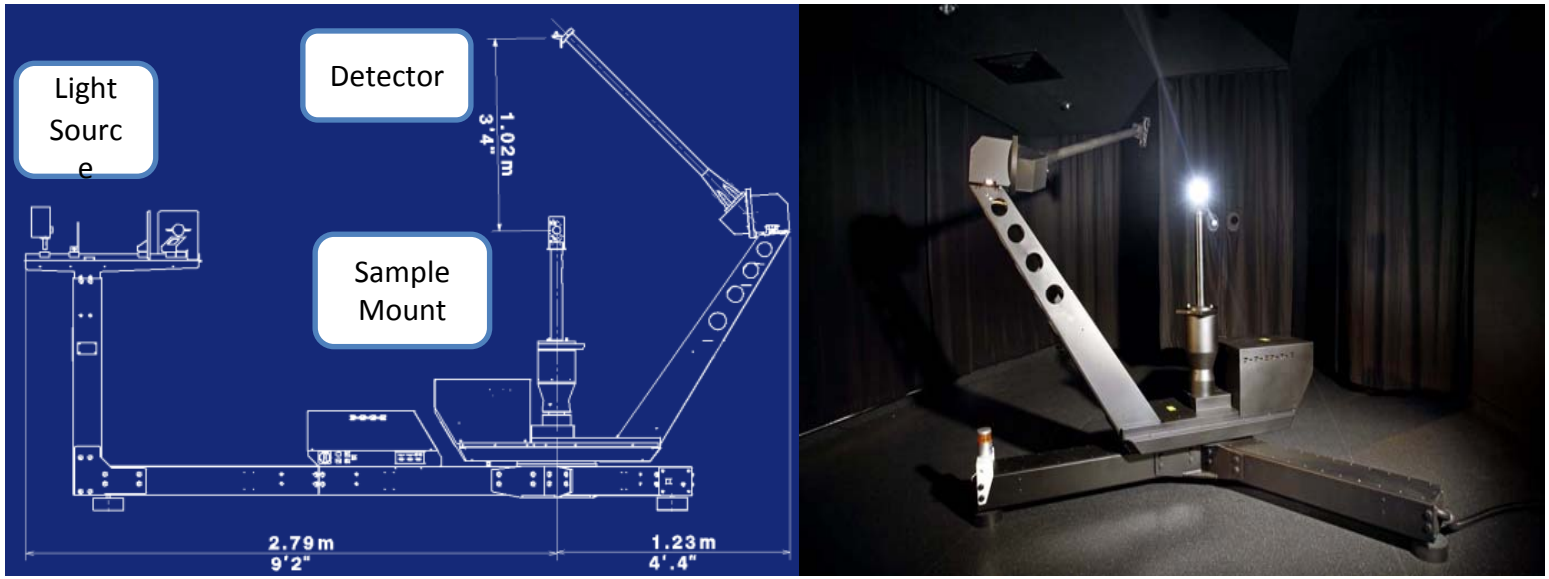
1. Measurement of BRDF

Goniophotometer Laboratory in SERIS



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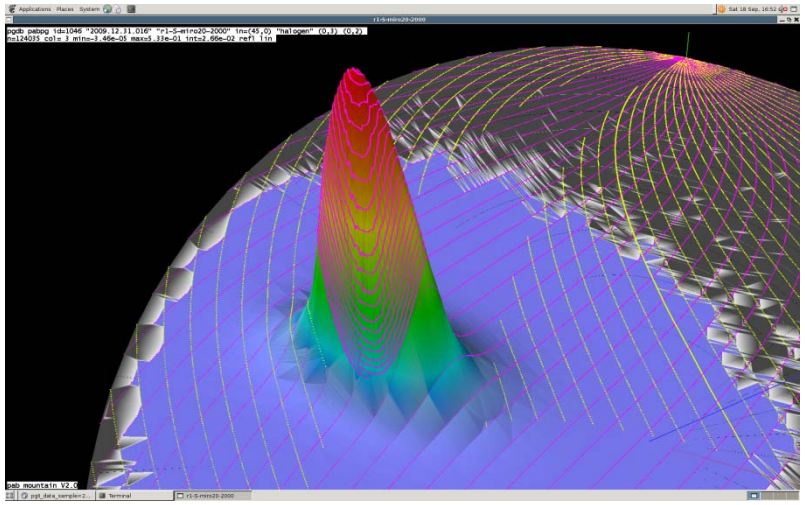
2.1 Resample data



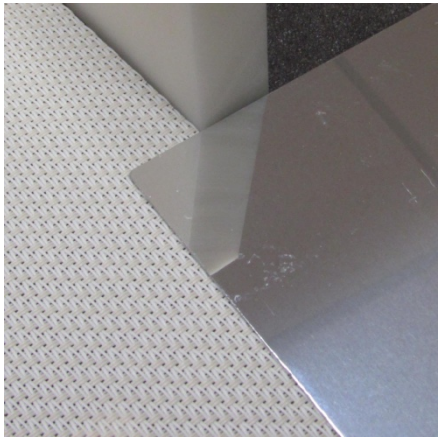
Motivation of data resampling:

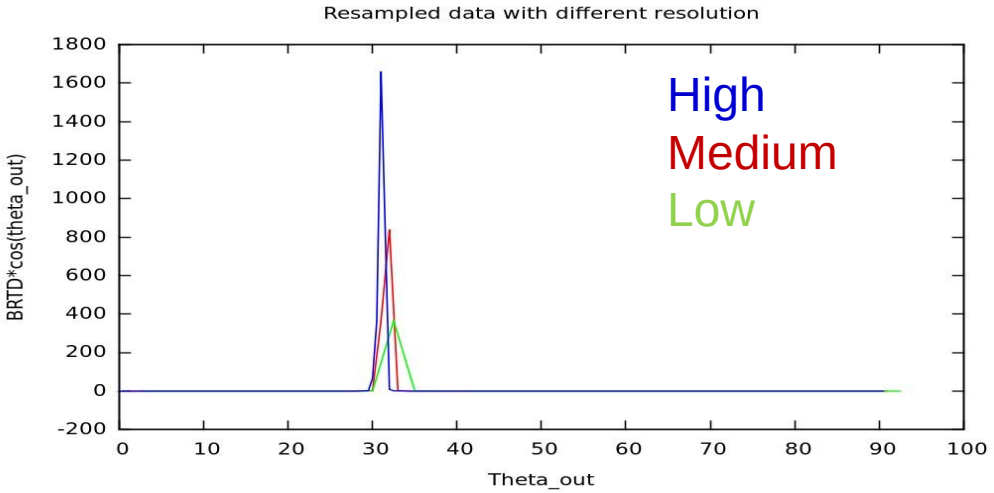
- Computationally demanding to fit tabulated BRDF data to analytical models
  - Data for one incident angle has over 14,0000 data points and file size is over 4 MB
  - Fitting could not finish in reasonable time

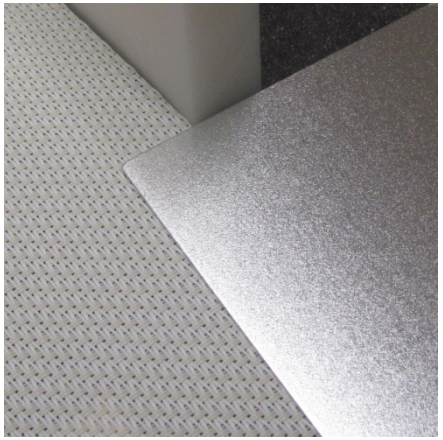
- After data resampling
  - File size for one incident angle usually below 100KB
  - Fitting time reduced to several minutes

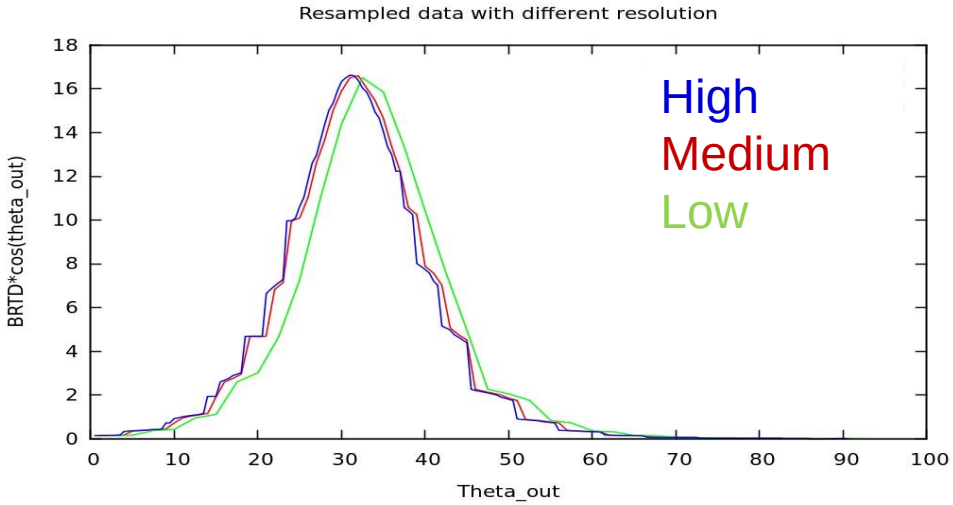
2.2 Resample data

Finding the right resolution for resampling



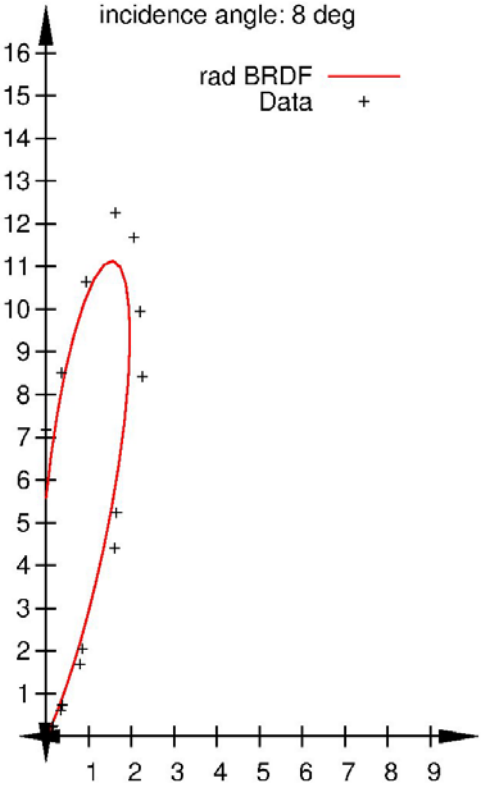




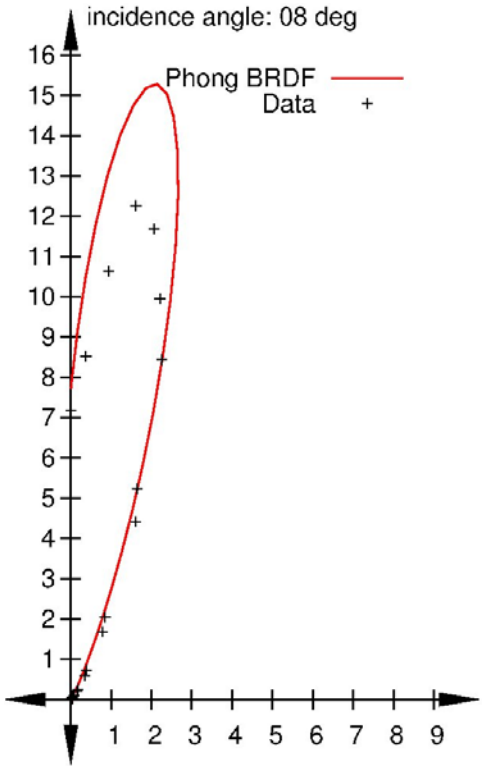


3.1 Different fitting models

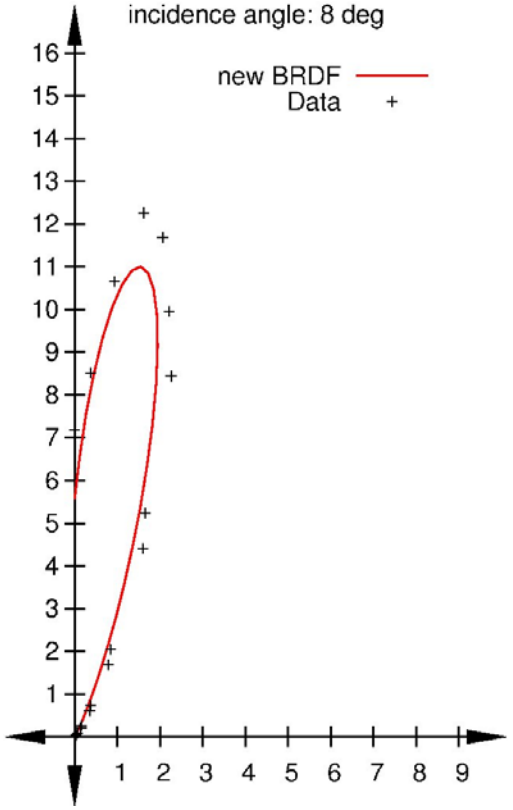
Scattering aluminum at 8 deg incident angle



Radiance Metal Model



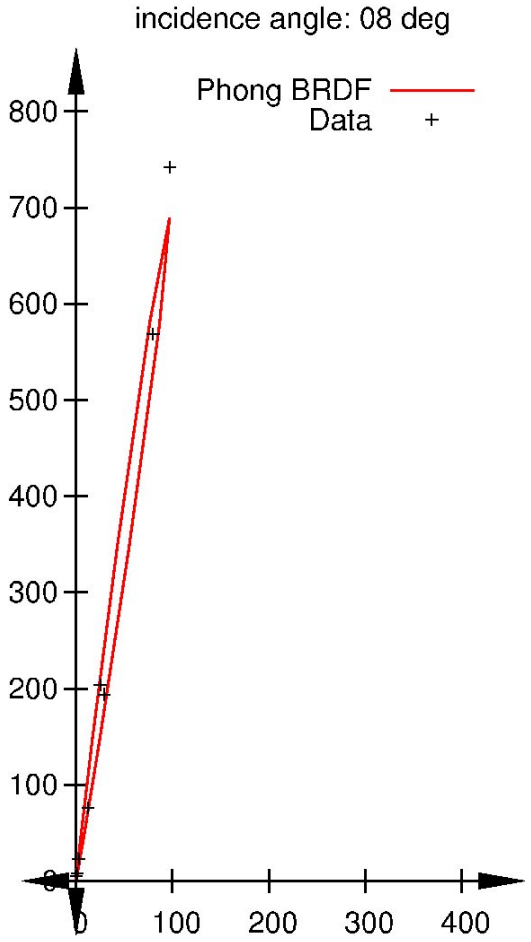
Phong Model



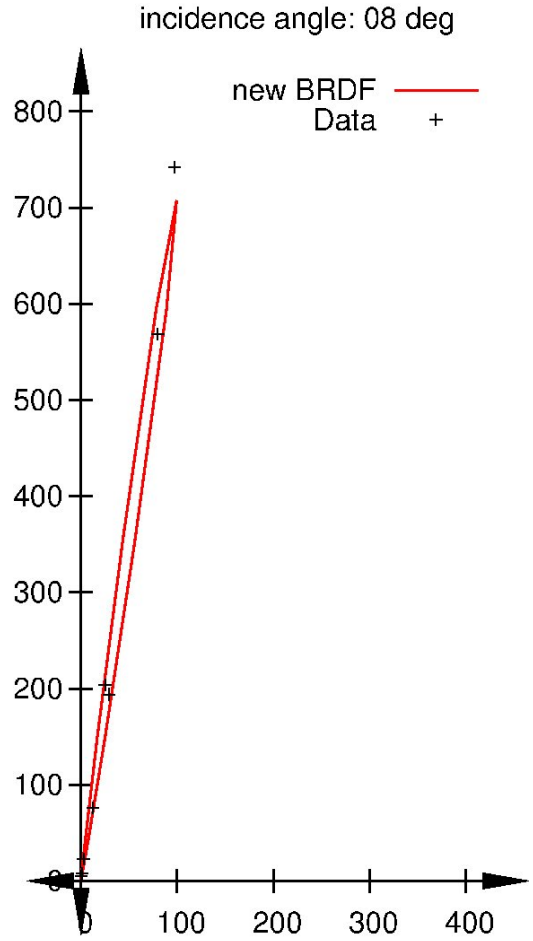
New BRDF model

3.2 Different fitting models

Clear aluminum at 8 deg incident angle



Phong Model



New BRDF model

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4. Validations of fitting models

Scattering aluminum at all incident angles

Incident angle\BRDF models	Default radiance model	Phong	New
5	699.54	603.91	606.88
8	437.47	408.46	409.27
15	279.43	291.01	272.65
30	116.38	172.13	115.60
45	87.86	252.13	86.066
60	45.57	591.80	44.73
Overall	1666.25	2319.44	1535.196

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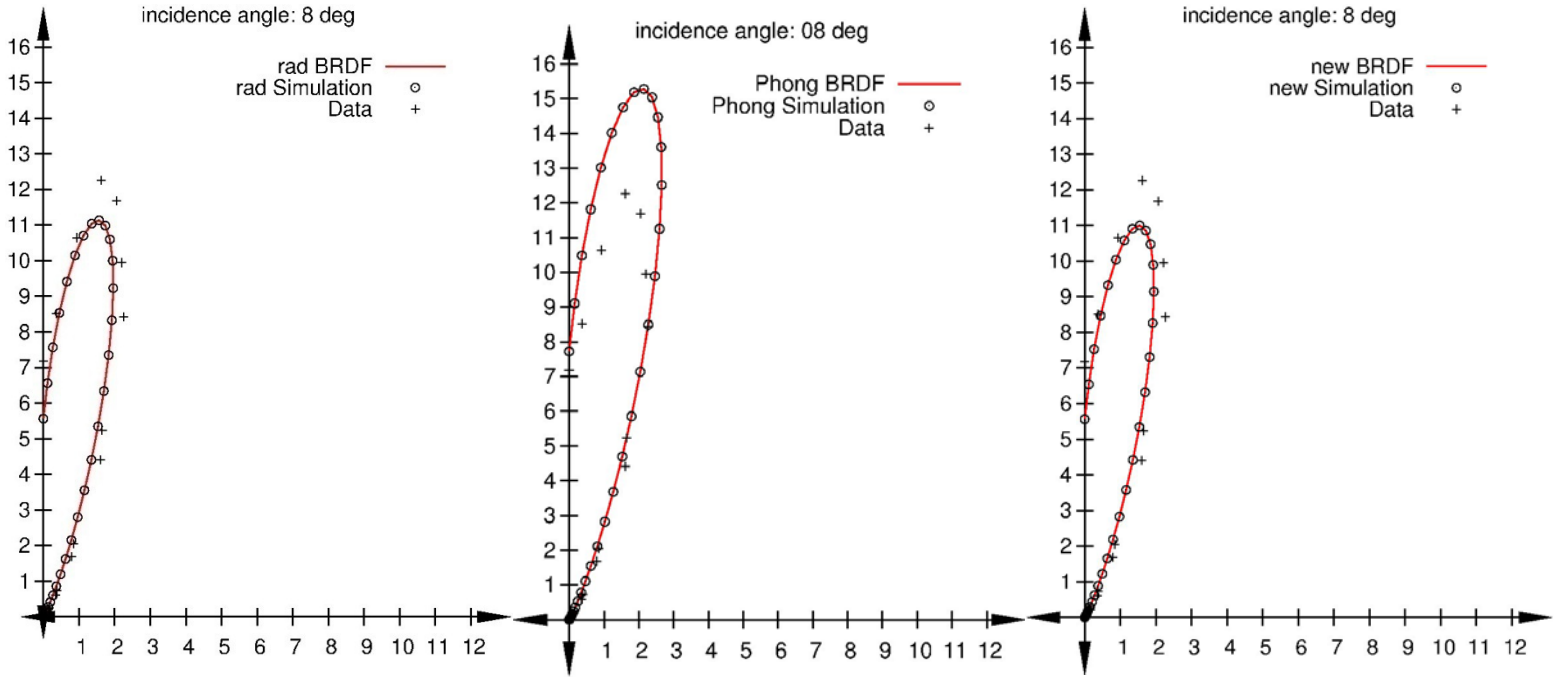
5.1 Radiance Simulation

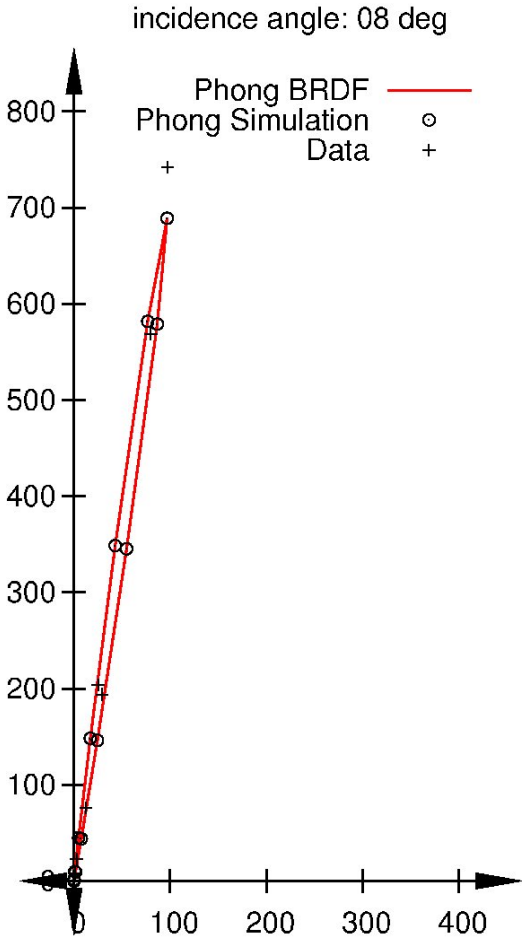
Scattering aluminum



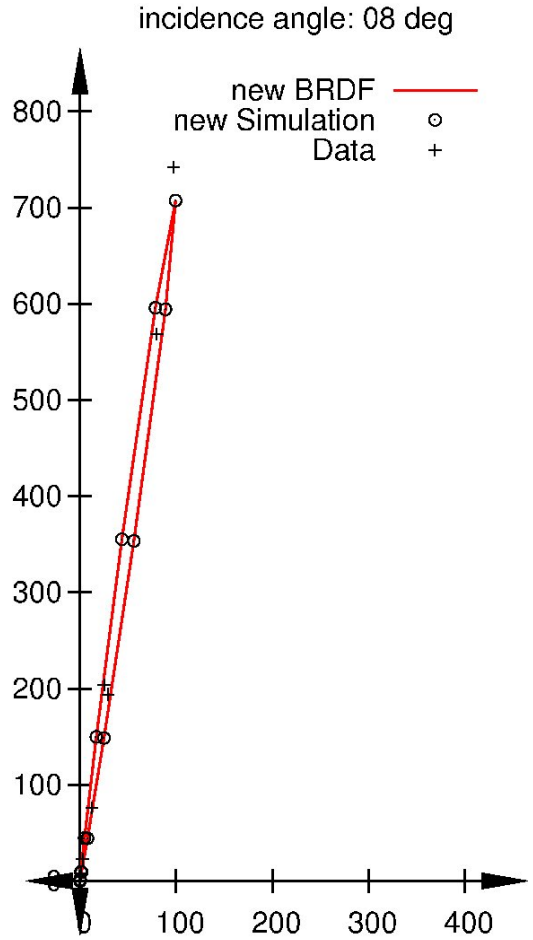
Radiance Metal Model | Phong Model | New BRDF model

5.2 Radiance Simulation

Clear aluminum

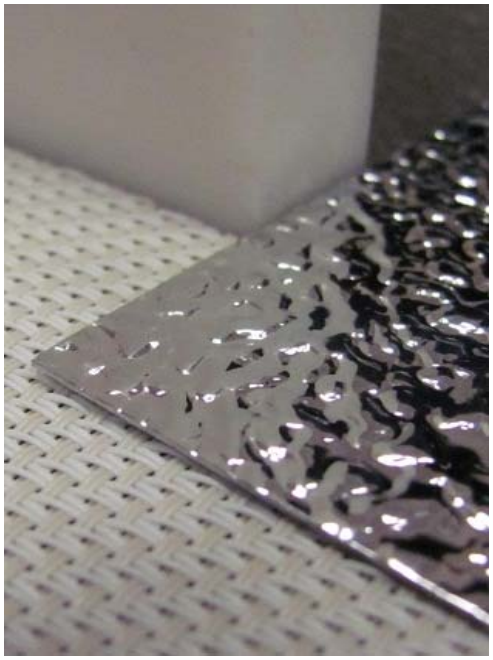


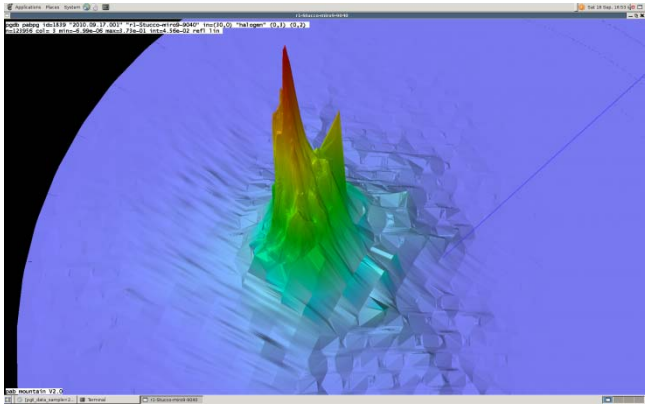
Phong model



New BRDF model

Conclusions





- Radiance calculation could be as accurate as the fitted analytical BRDF model
  - In order to minimize systematic error, various BRDF models should be tested to find an optimum fit for the measured data

- Future works include testing more materials including anisotropic samples and improve resampling method for specula reflection.

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