measuring & modelling BSDF step 1: Radiance **plastic, metal, trans** parameters based on material data

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10th *Radiance* workshop, Lawrence Berkeley National Laboratory

Contents

most frequently used materials in Radiance

- basic materials: `plastic, metal, trans` et al ..

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void plastic mywood
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5   0.1   0.2   0.22    0.01   0.2
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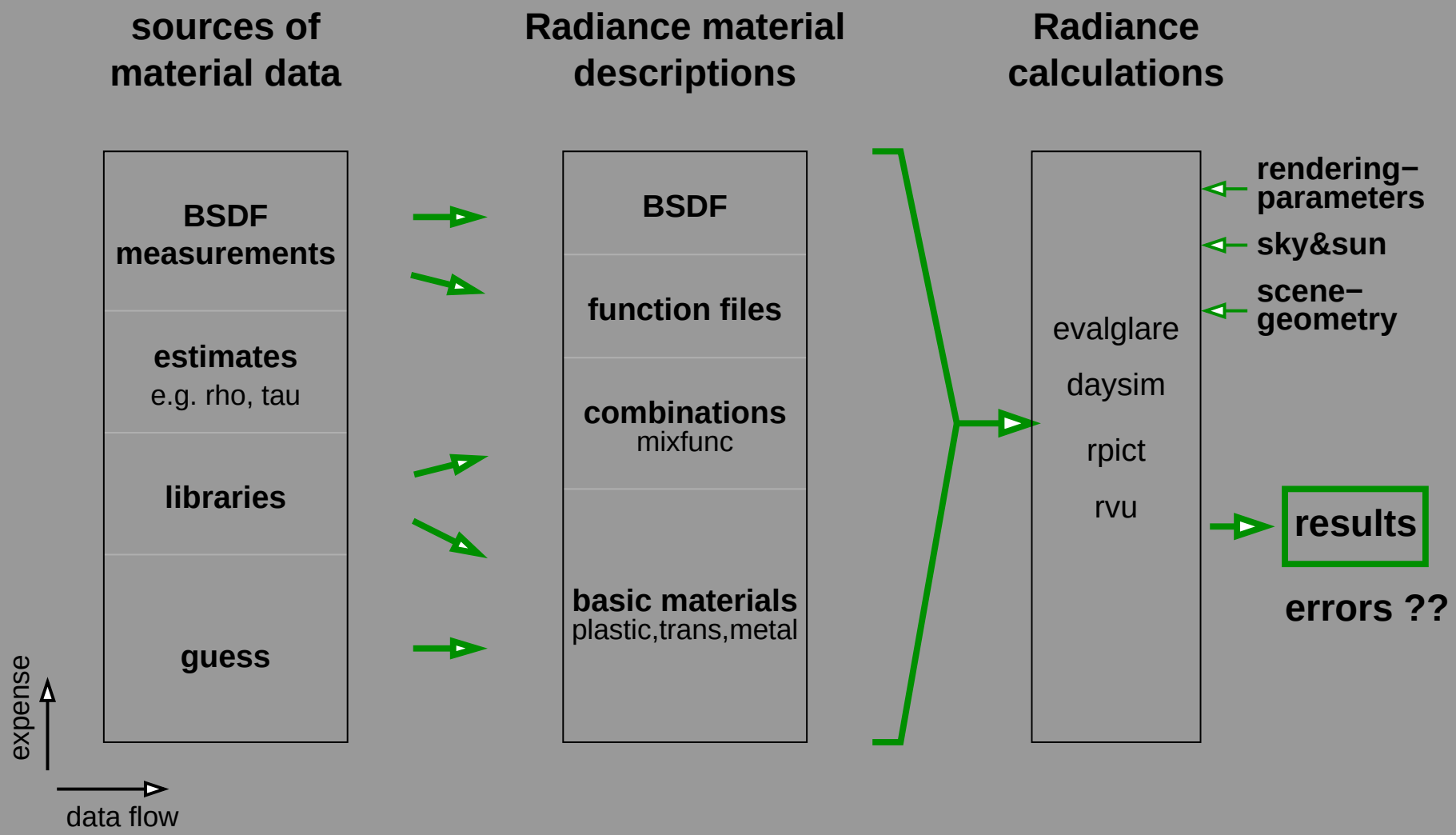
... suitable candidates for comparison to measured BSDF data,

let's have a look at the general framework...

sources and models of material data



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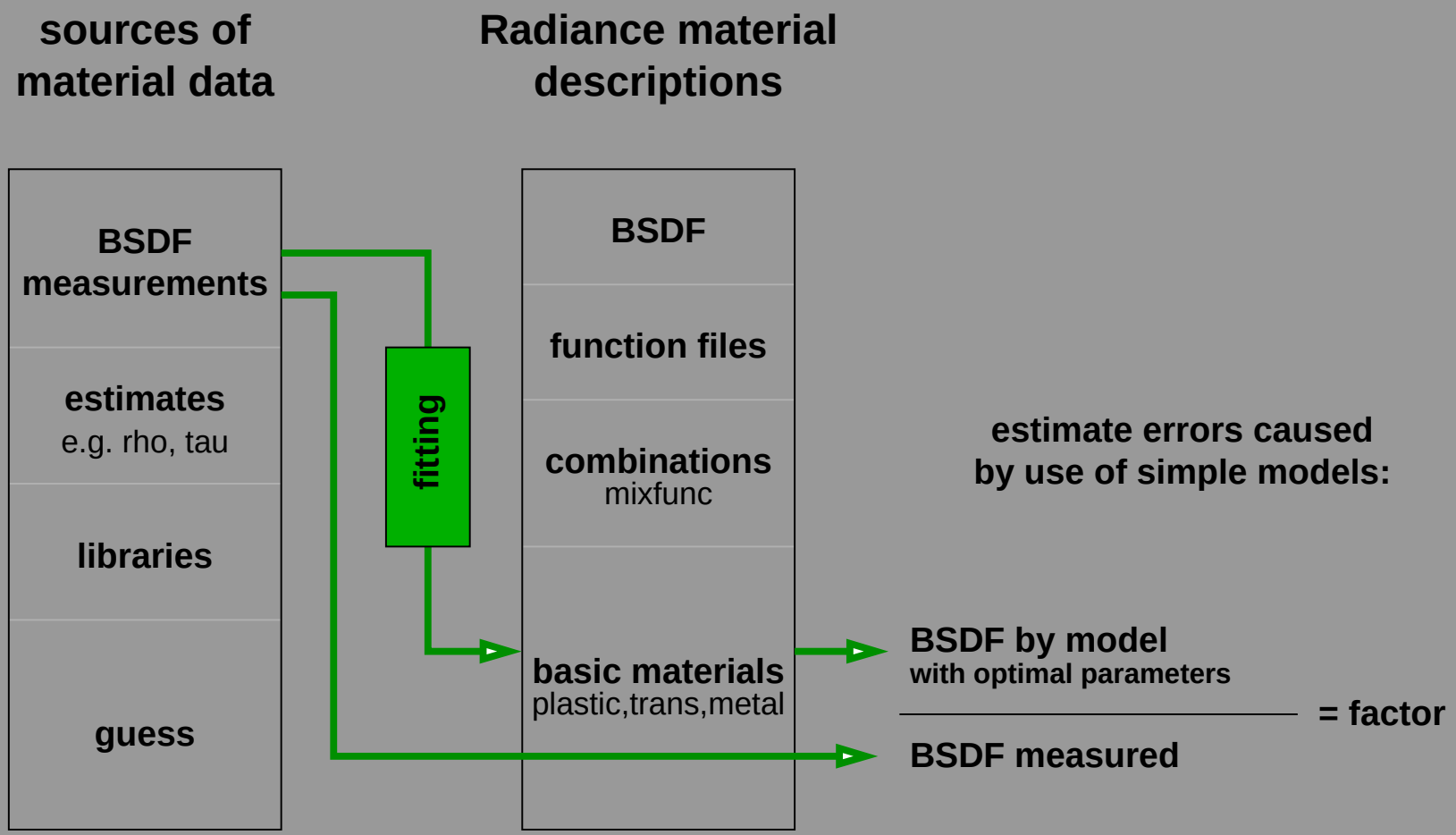
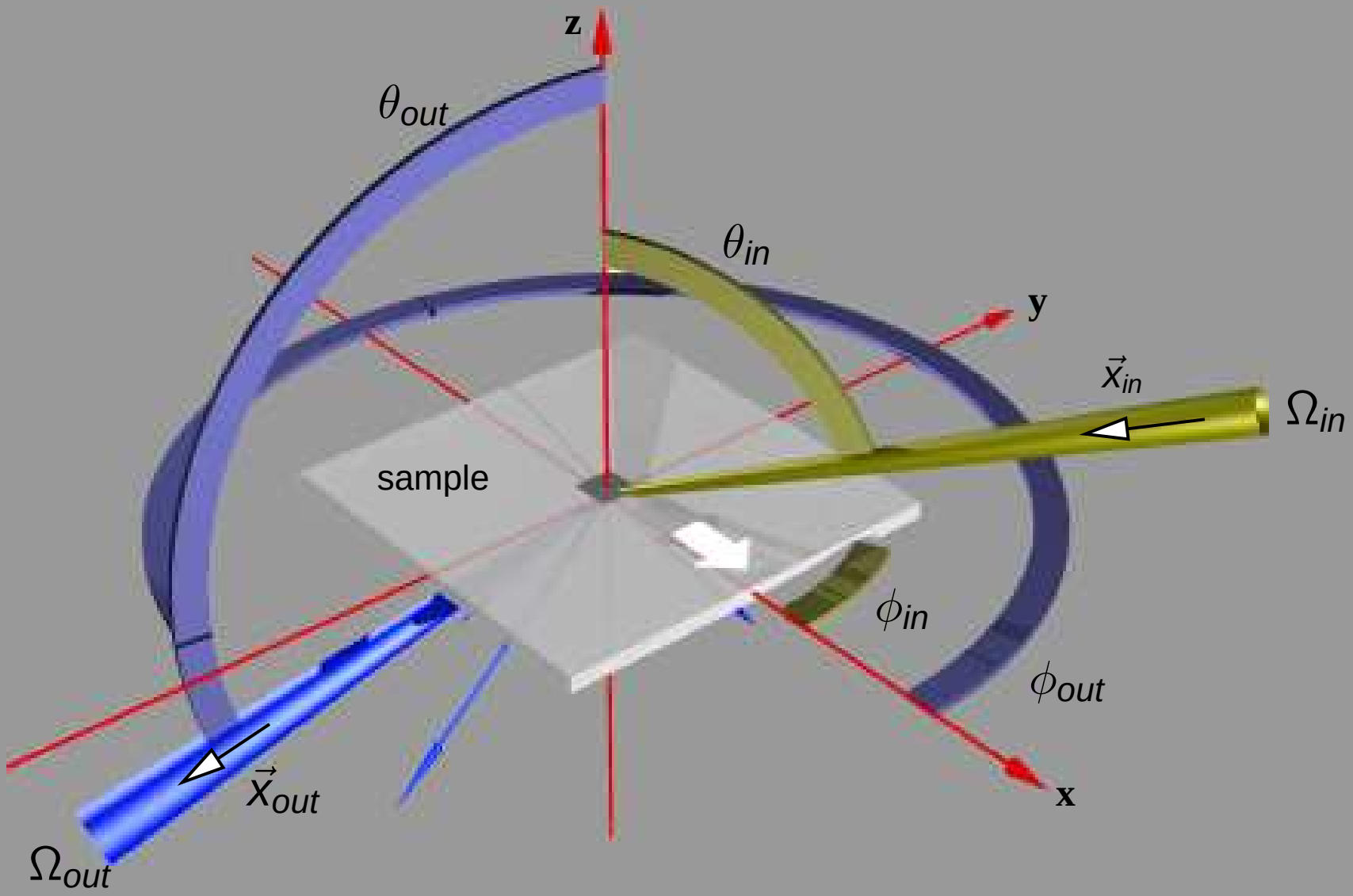


some details

... let’s do some math and details ...

coordinate system



the defining formula

Definition

$$\mathcal{L}_{out}(\vec{x}_{out}) = \int_{\vec{x}_{in}}^{\Omega_{in}=2\pi} BSDF(\vec{x}_{in}, \vec{x}_{out})\ \mathcal{L}_{in}(\vec{x}_{in})\ \cos(\theta_{in})\ d\Omega_{in}$$

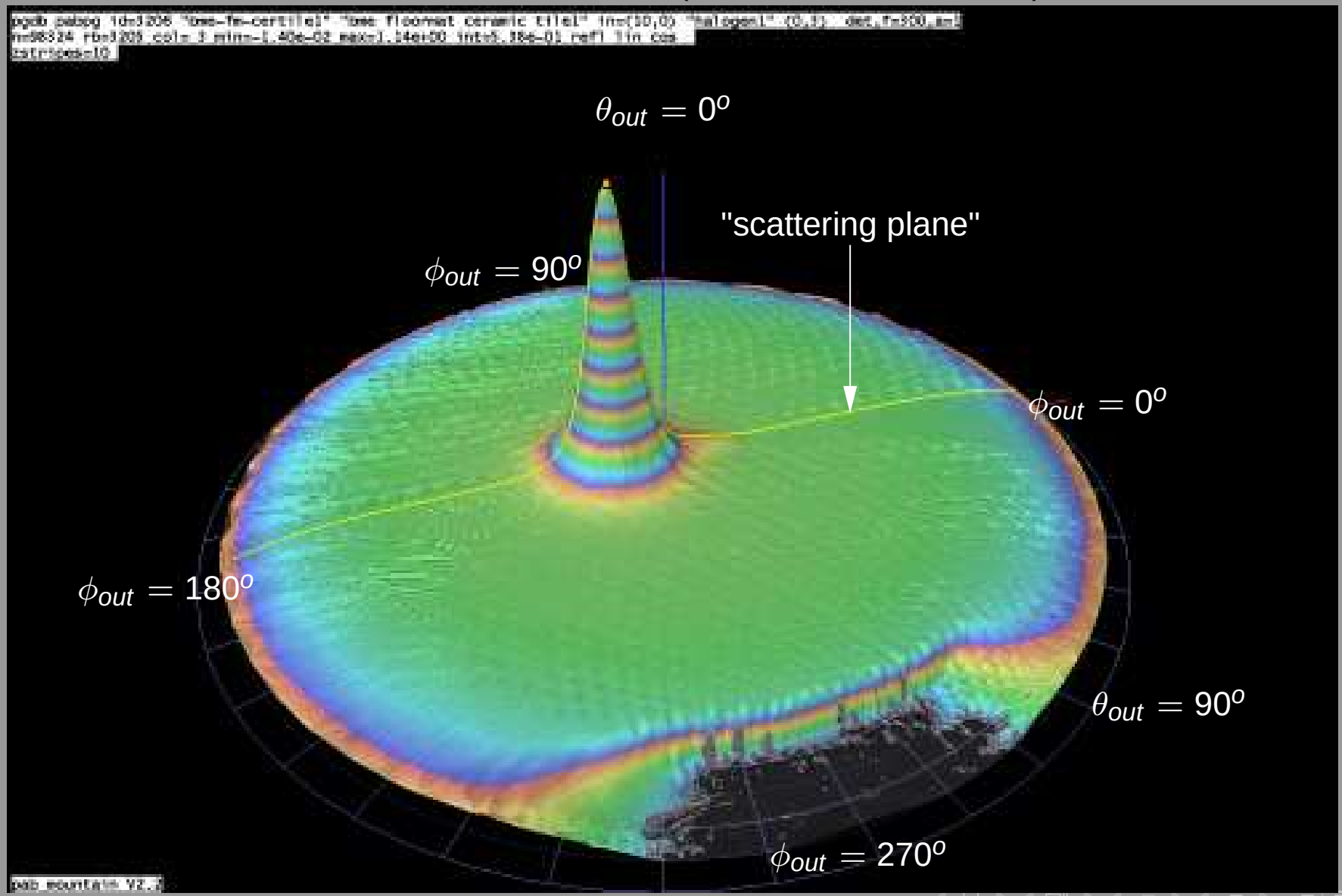
- 4 variables: $BSDF(\vec{x}_{in}, \vec{x}_{out}) = BSDF(\theta_{in}, \phi_{in}, \theta_{out}, \phi_{out})$
- $BSDF > 0$ and may be > 1
- ideal diffuse surface: $BSDF(\vec{x}_{in}, \vec{x}_{out}) = const$
- transmission: $\tau_{dh}(\vec{x}_{in}) = \int BSDF(\vec{x}_{in}, \vec{x}_{out})\ \cos(\theta_{out}) d\Omega_{out}$
- errors in BSDF propagate to radiance $\mathcal{L}_{out}$
  $\rightsquigarrow$ errors in glare analysis and irradiance on other surfaces

$\mathcal{L}_{out}$ outgoing, $\mathcal{L}_{in}$ incident radiance, $\int_{\vec{x}_{in}}^{\Omega_{in}=2\pi}$ integral over hemisphere, Ω_{in} inf. solid angle

see pab talk at 2010 workshop for more math

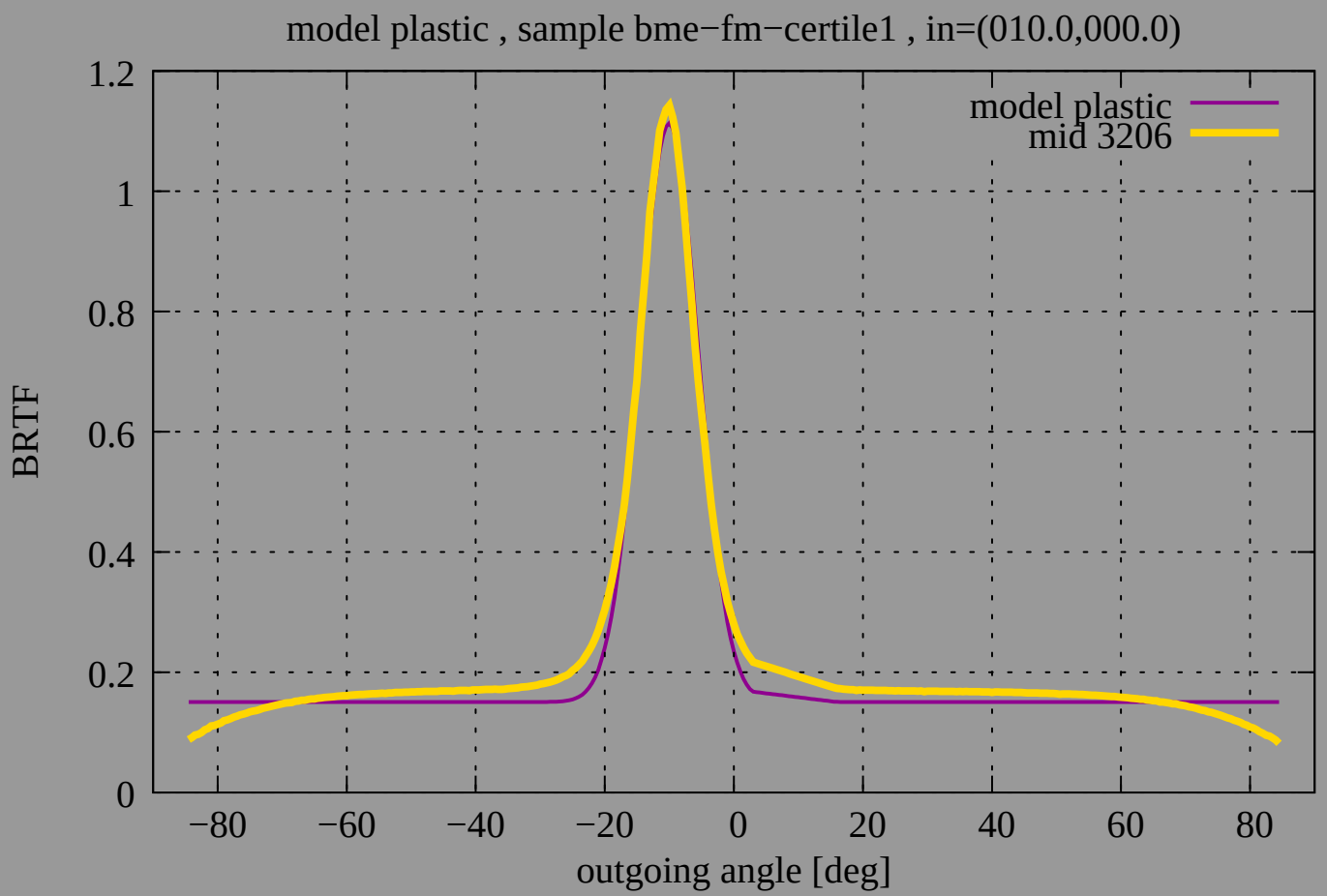
visualising BSDF 3D

display of reflection part of $BSDF(10^o, 0^o, \theta_{out}, \phi_{out})$



visualising BSDF 2D

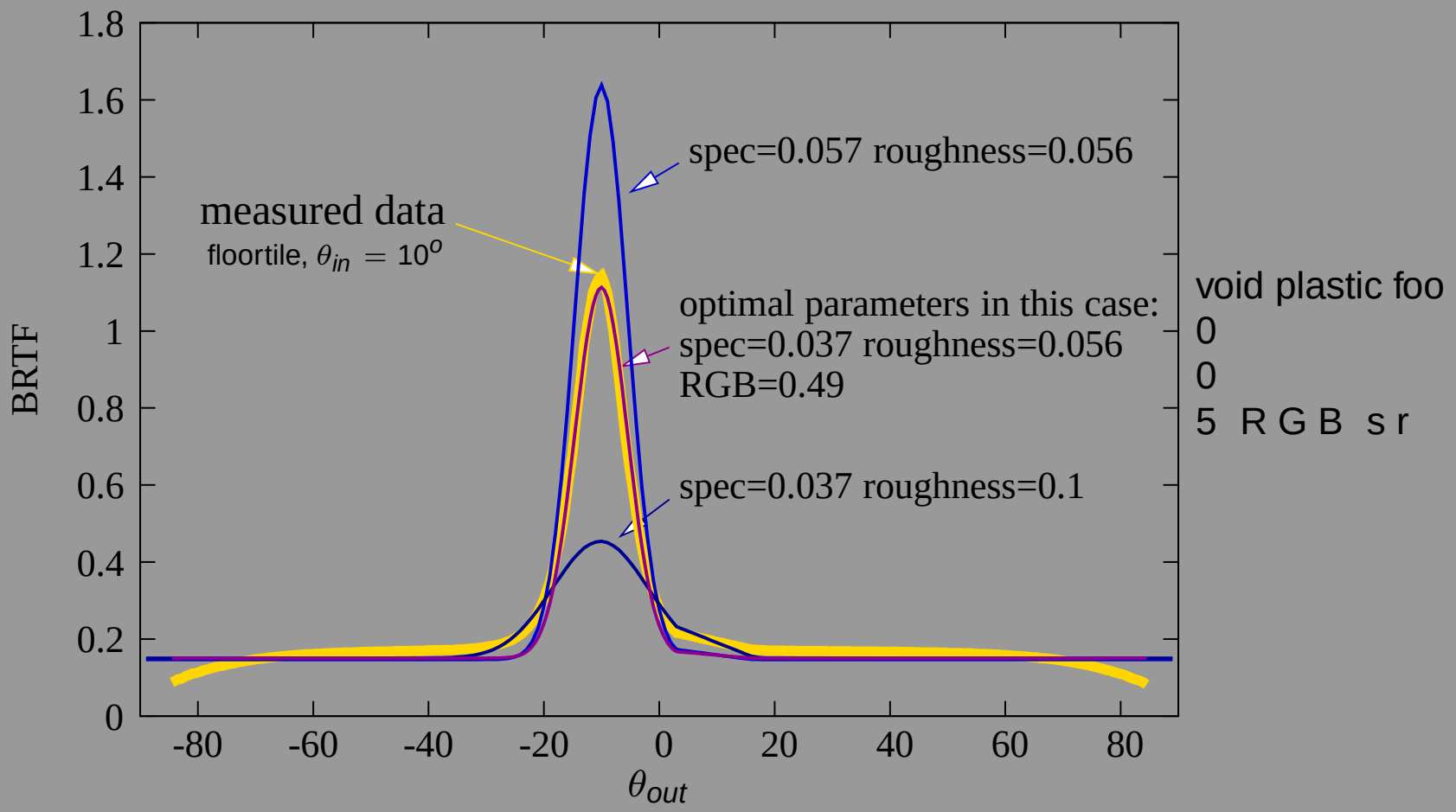
plot of 2D cut along scattering plane:



Radiance BSDF model: `plastic`

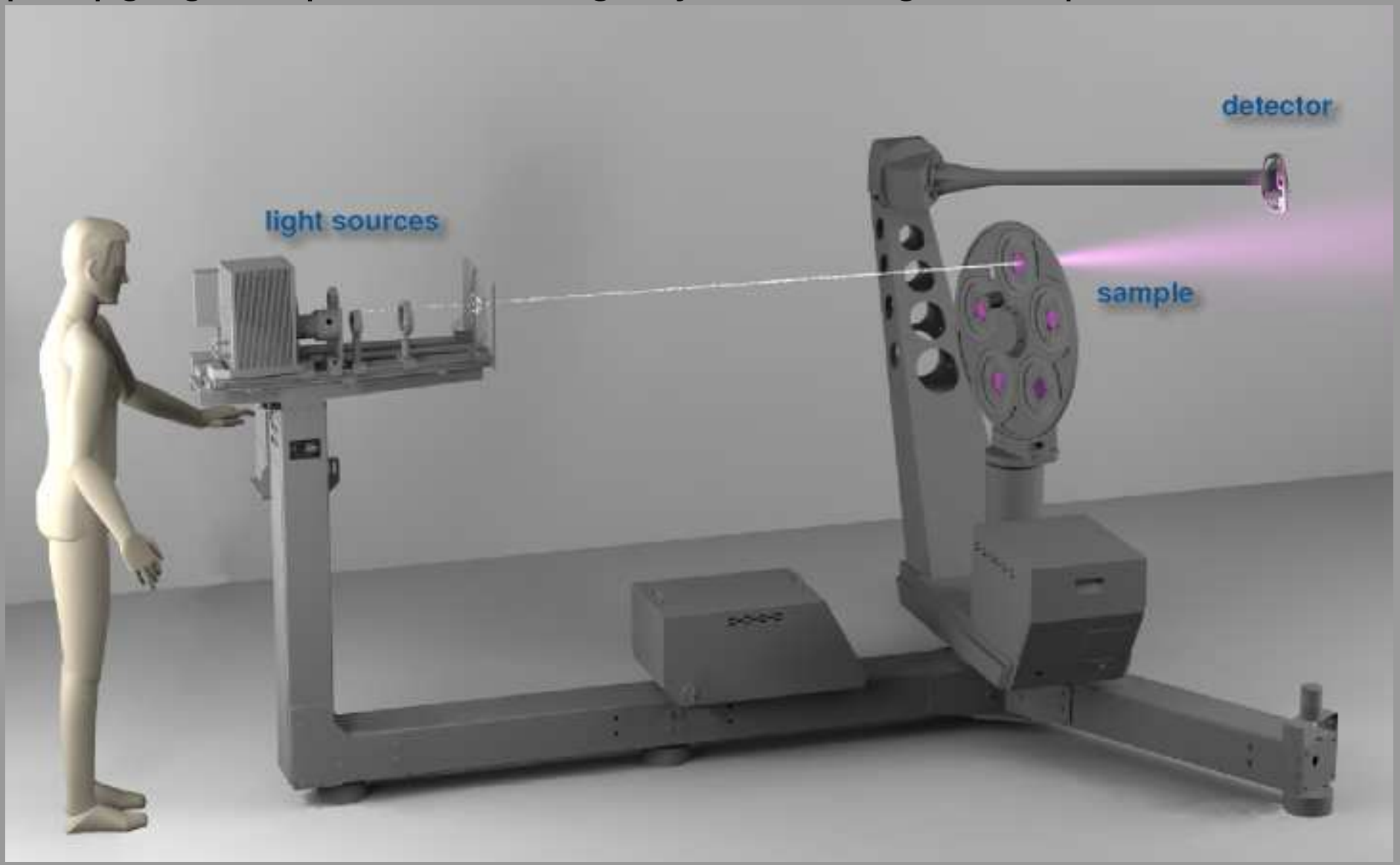
”plastic” Gaussian-Ward BSDF model: constant + Gaussian

$$\approx (RGB - s) + \frac{s}{r^2}\, e^{-(\theta/r)^2}$$



BSDF data source

pab pgII gonio-photometer, high dynamic range, fast, precise:



BSDF measurement statistics

side note: currently installed pgII gonio-photometers at SERIS, LBNL, industrial and pab Ltd now accumulated

- approx 600 samples
- around 12000 measurements
- approx 100 million BSDF data-points

fitting process, from data to model parameters

for each material and incident direction (θ_{in}, ϕ_{in}):

1. measure dataset $BSDF(\theta_{in}, \phi_{in}, \theta^i_{out}, \phi^i_{out}), i = [1... \approx 80000]$
2. run fit program to find optimal parameters $a_1 ... a_N$ of model
3. $\Rightarrow$ set of parameters $a_1 ... a_N$ for each incident direction
4. get error $\chi := \sum_i (BSDF_i^{model} - BSDF_i^{data})^2$ and min/max factors
5. generate graphics, repeat process for next incident angle

generate web-page

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real situation:

- a_i do depend on incident angle
- χ is not negligible (model shape doesn't match data)
- some systematic errors between model and data

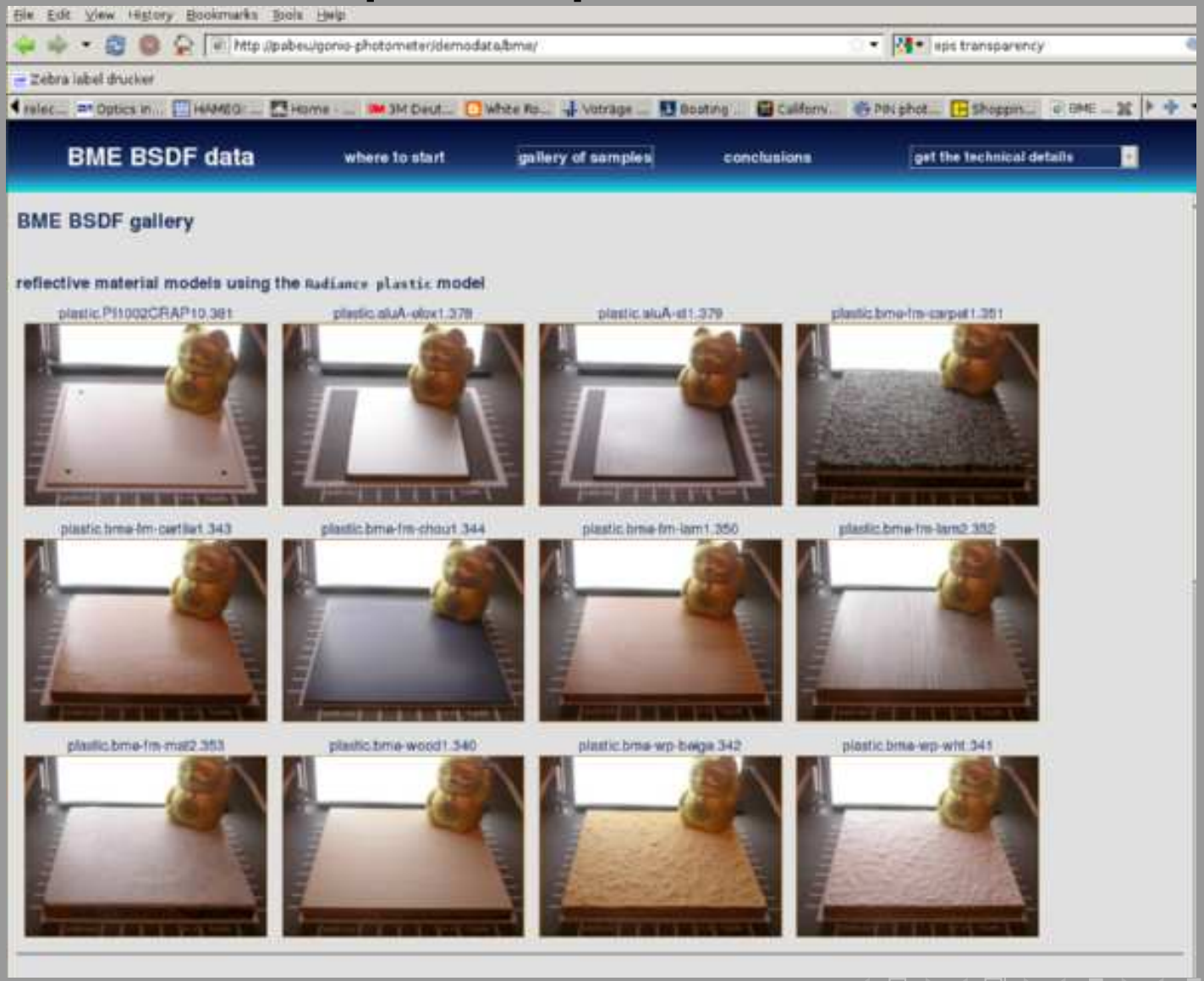
parameter numbering on BME web-pages

technical note:
generic numbering of model parameters for these fits:

```
void plastic myplast
0
0
5  R G B  specularity roughness
    a1          a2          a3
```

”building material examples” web page

http://www.pab.eu/bme



conclusions from BME measurements:

for practitioners

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  typically around 20% error

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- BME BSDF data available with high resolution, low error
- results and BME web-pages with details

...thanks

last slide.

- yours to discover: **www.pab.eu/bme**
- more BSDF math at 2010 pab workshop talk,
  plus more measurement details: www.pab.eu/radiance

- happy rendering
- thank you for joining workshop and thanks for your attention

`$RCSfile: brtf-talk-2011.tex,v $ $Revision: 1.25 $ $Date: 2011/08/24 14:24:31 $`

compiled using LaTeX *beamer* class

thanks to Terry&Brian and their sun deck