high-power LEDs as light-source in scanning gonio-photometer for BSDF scatter measurements

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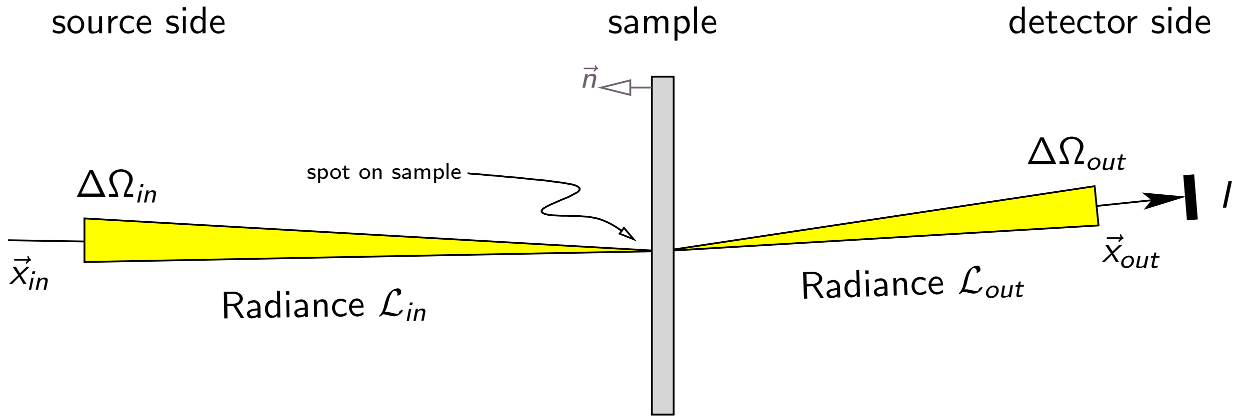
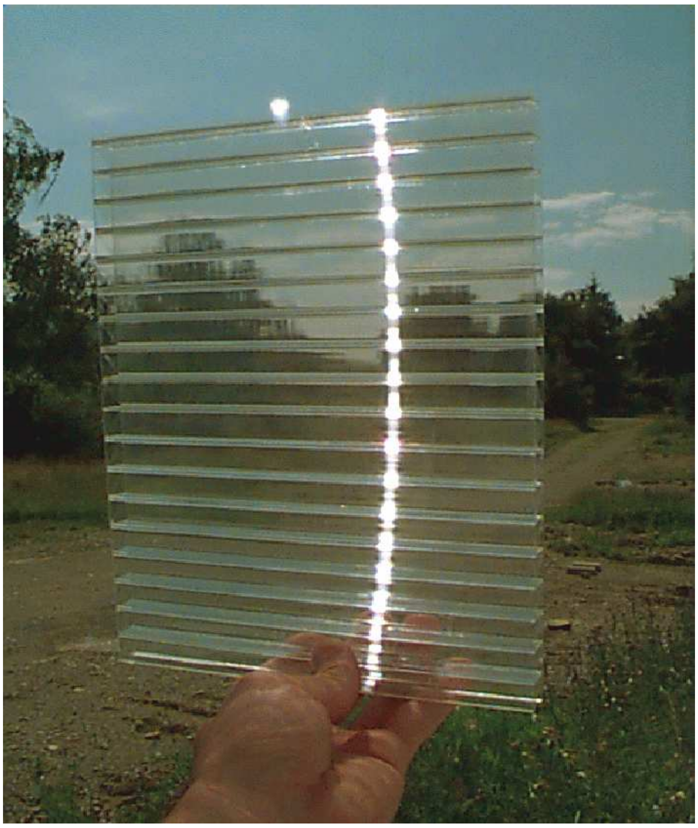
Bidirectional Scatter Distribution Function, BSDF

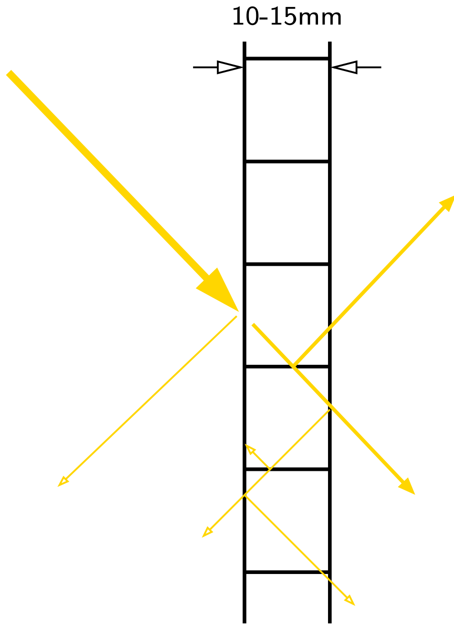


measured signal I at detector:

$$\int_{\vec{x}_{out}}^{\Delta\Omega_{out}} \cos(\theta_{out}) \underbrace{\int_{\vec{x}_{in}}^{\Delta\Omega_{in}} BSDF(\vec{x}_{in}, \vec{x}_{out}) \cos(\theta_{in})\ \mathcal{L}_{in}(\vec{x}_{in})\ d\Omega_{in}}_{\mathcal{L}_{out}(\vec{x}_{out})}\ d\Omega_{out} = I(\vec{x}_{out}) \quad (1)$$

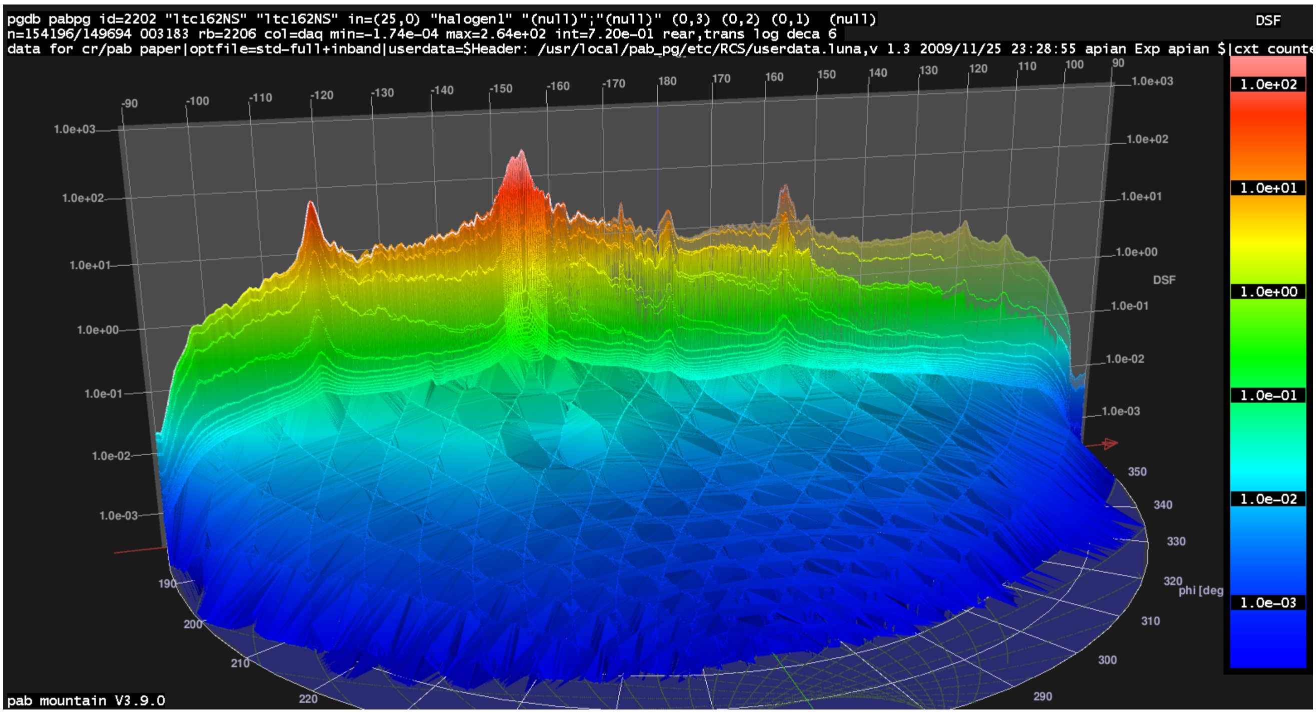
material with complex BSDF, roofing material





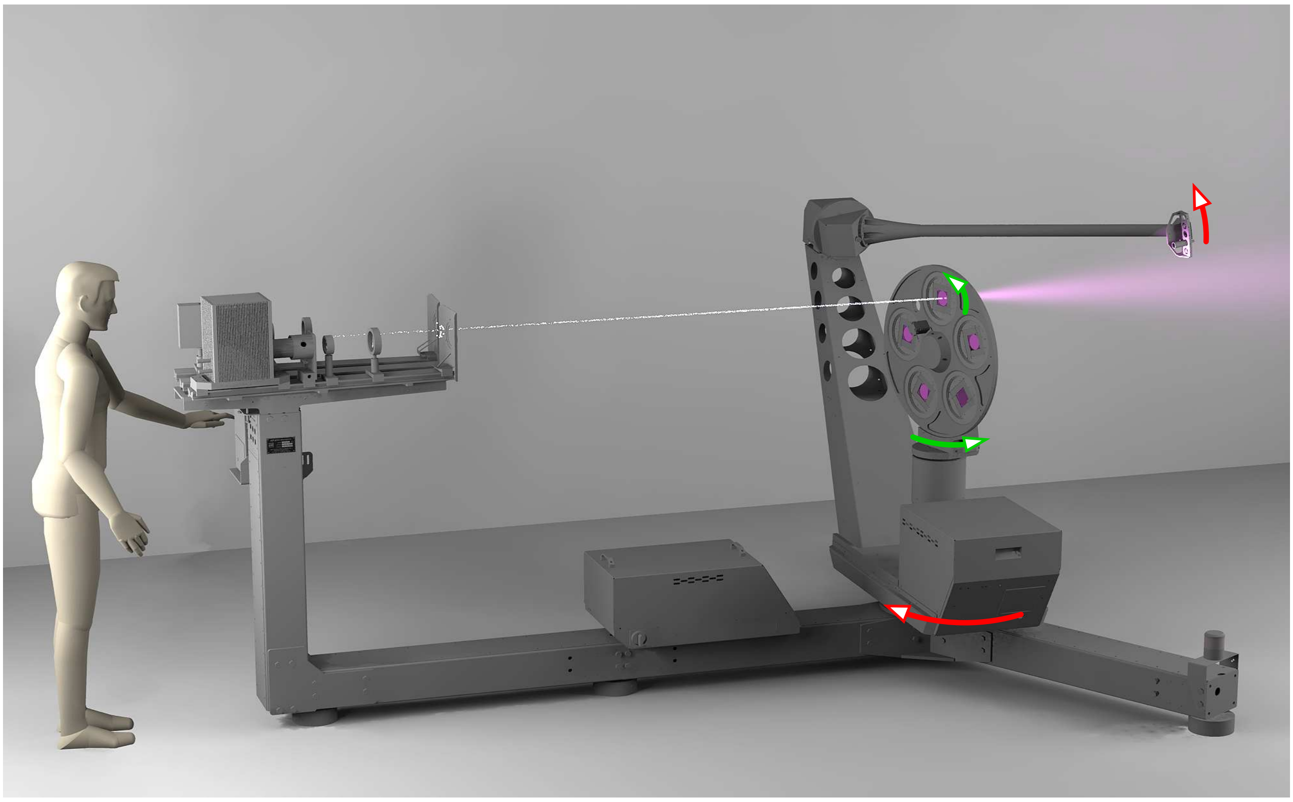
extruded polycarbonate roofing material

transmission BSDF of clear roofing material



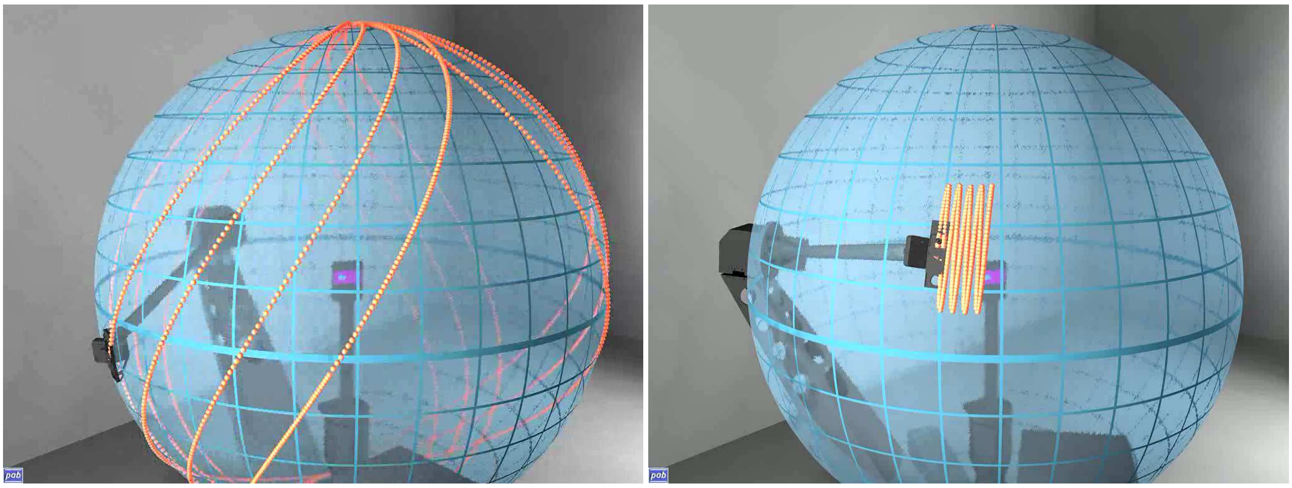
data display of the transmission hemisphere, a motivation for high angular resolution:
'ridge' BSDF, with redirected peaks and background scatter
⇝ input to glare analysis, *Stadium Australia*, Sydney Olympics 2000

PG2 scanning gonio-photometer



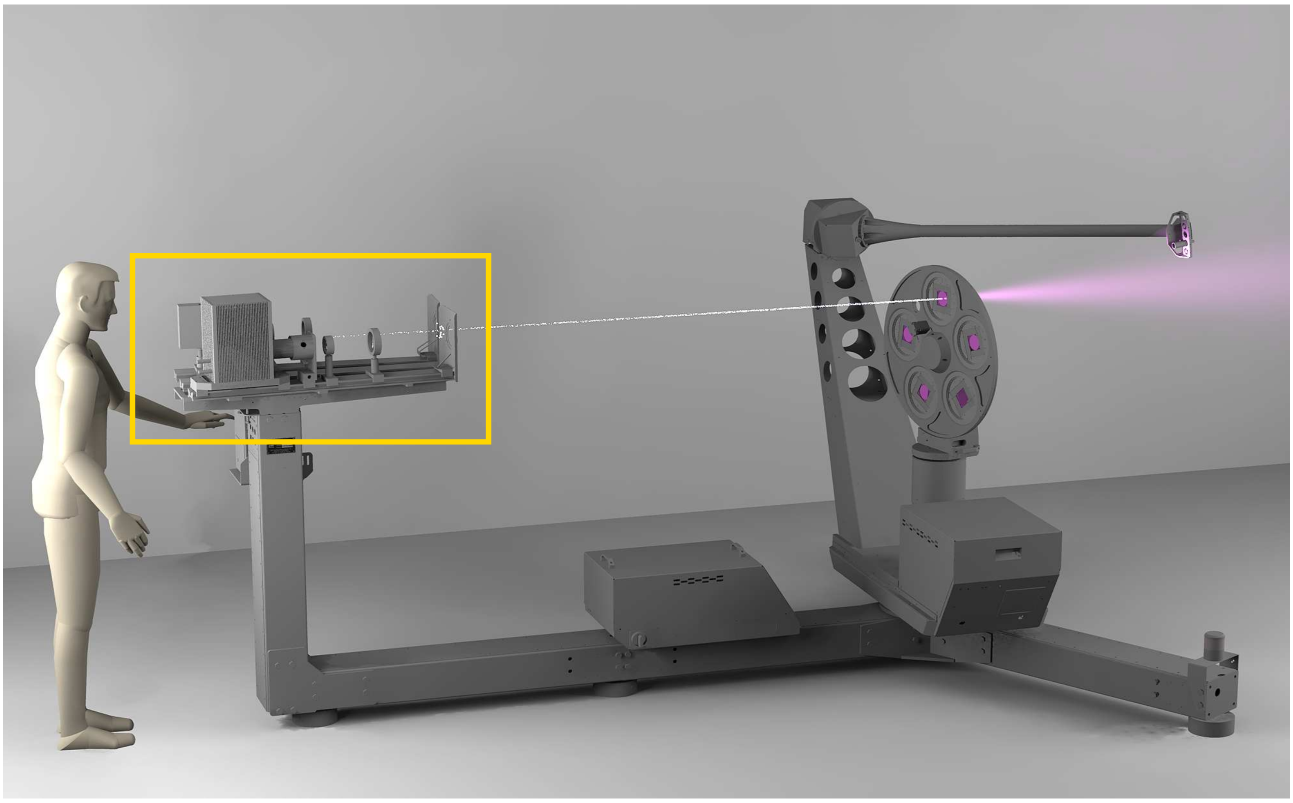
PG2: 2 incident angles, 2 outgoing angles: out-of-plane BSDF

detector scan paths

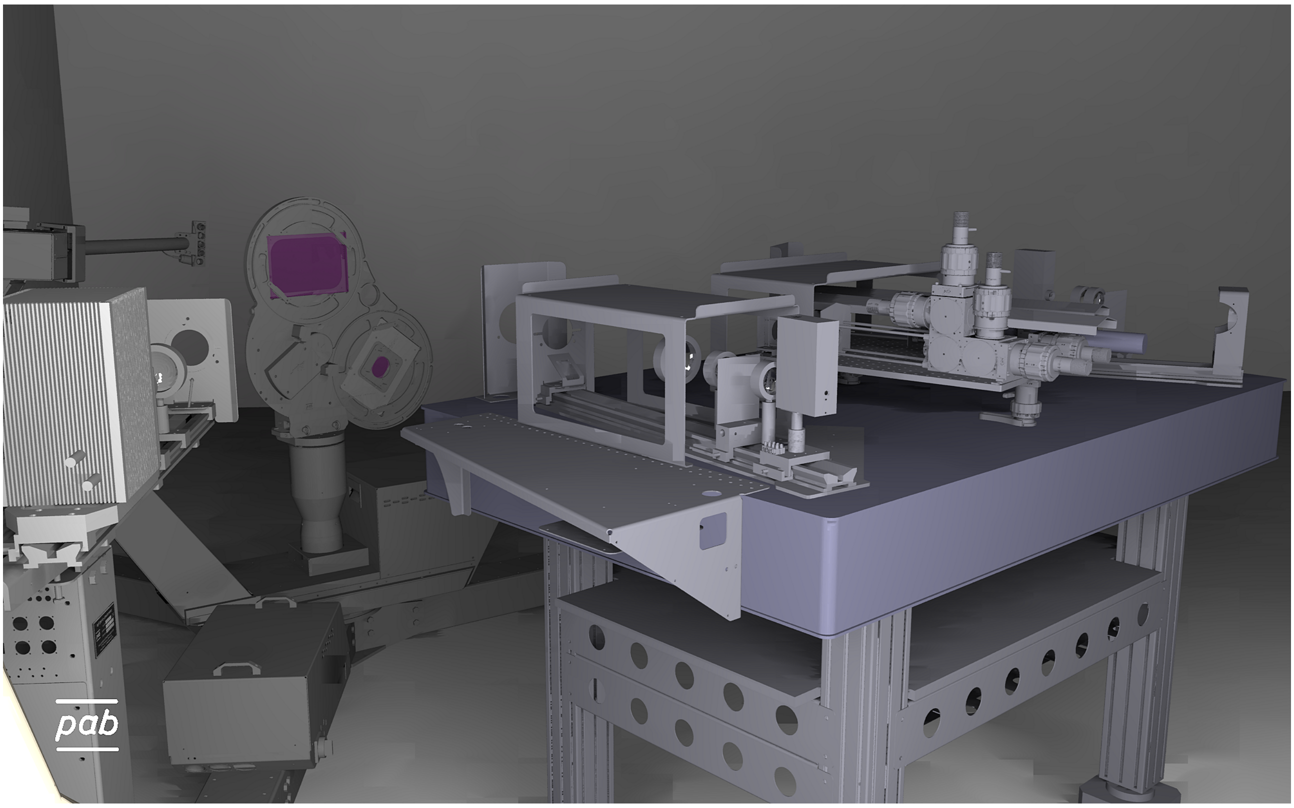


- detector on-the-fly measurements @ 1kHz sample-rate
- adaptive scan-paths
- choice of detectors: fast Si / Ge / InGaAs sensor cells or slower spectrometer ($\Delta\lambda \approx 5nm$)

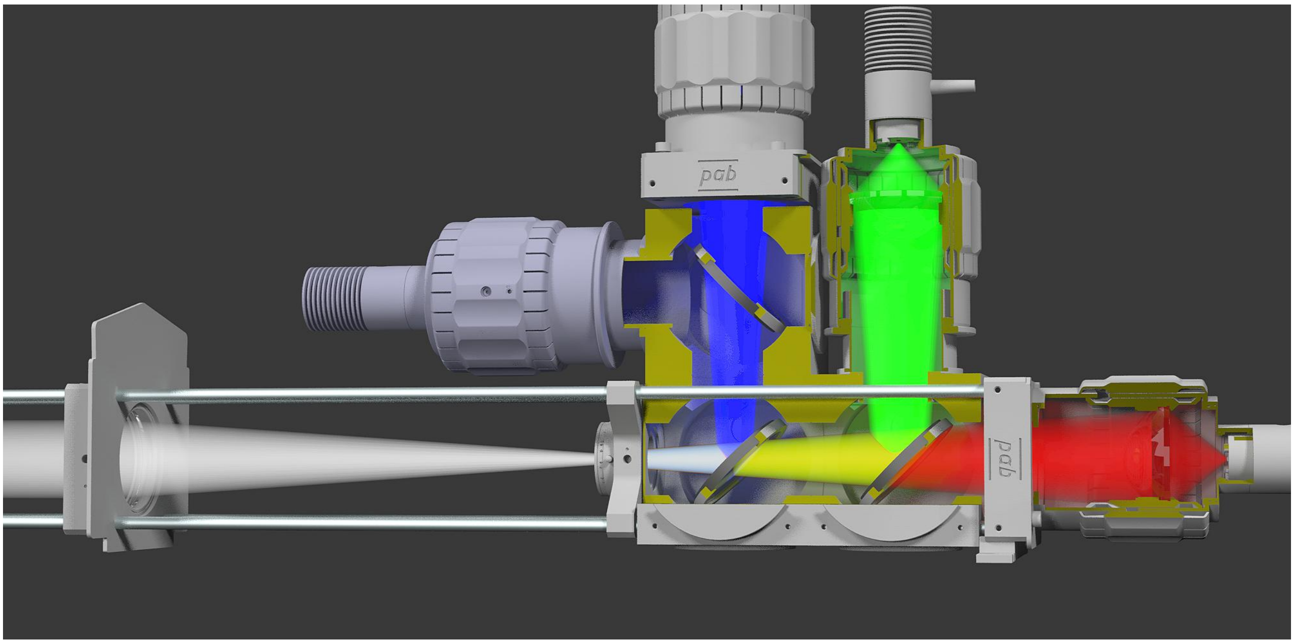
source subsystem of *PG2* gonio-photometer



new source table at pab

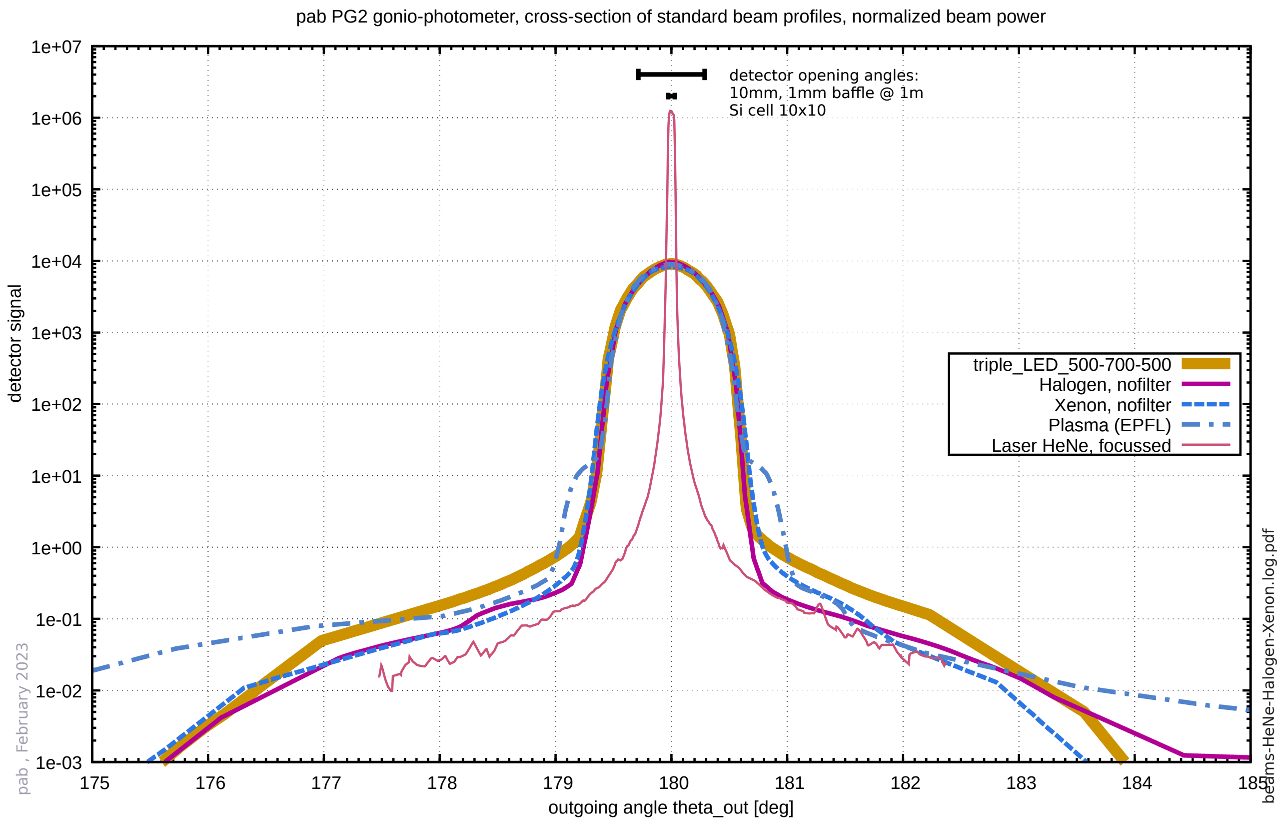


new triple or quad LED source



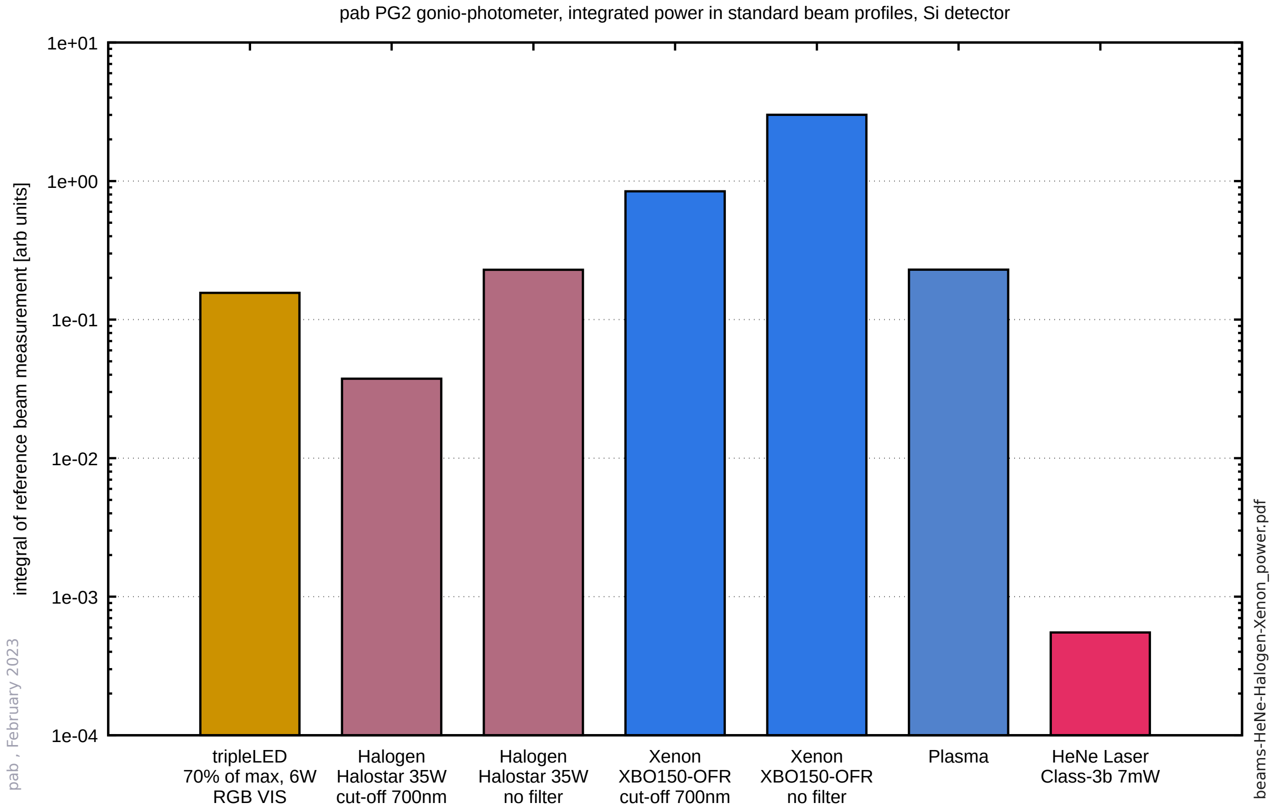
combined beams of 3 or 4 LEDs , beam direction right to left

test for "signature": LED / Halogen / Xenon



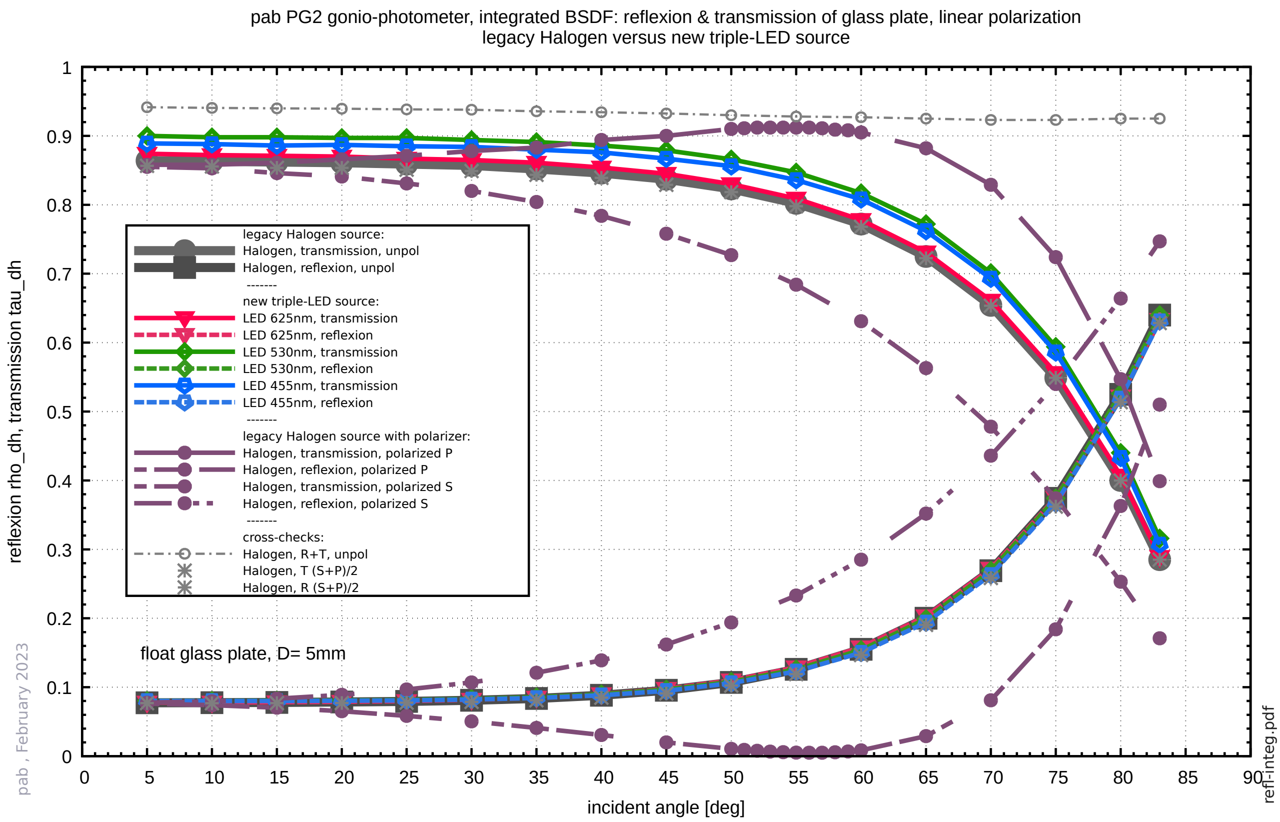
beams normalised, integral = 1: LED beam-shape comparable to Halogen/Xenon

test for integral beam power



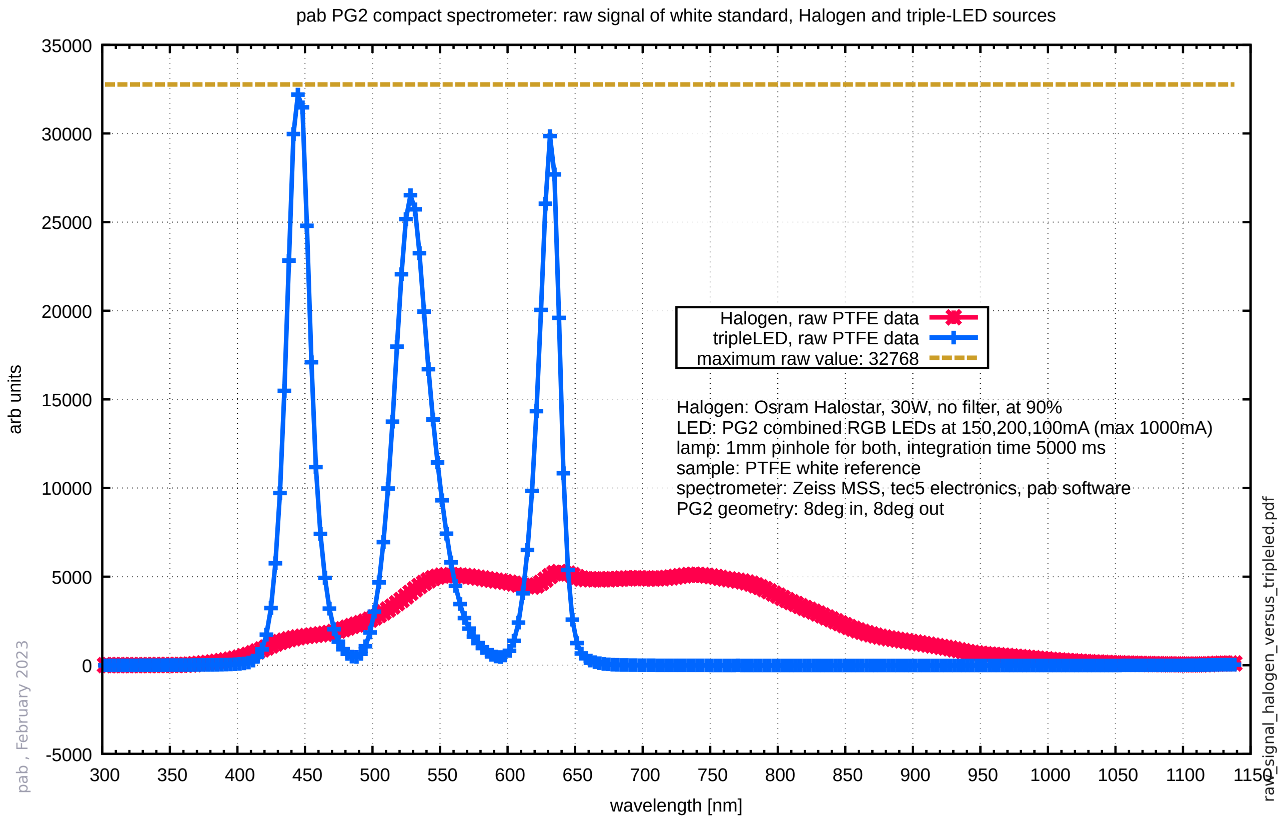
more beam power as Halogen, especially in VIS and "blue" end of spectrum. Xenon still of interest for high power applications. Note logarithmic Y scale.

test for polarisation: Brewster angle of a glass plate



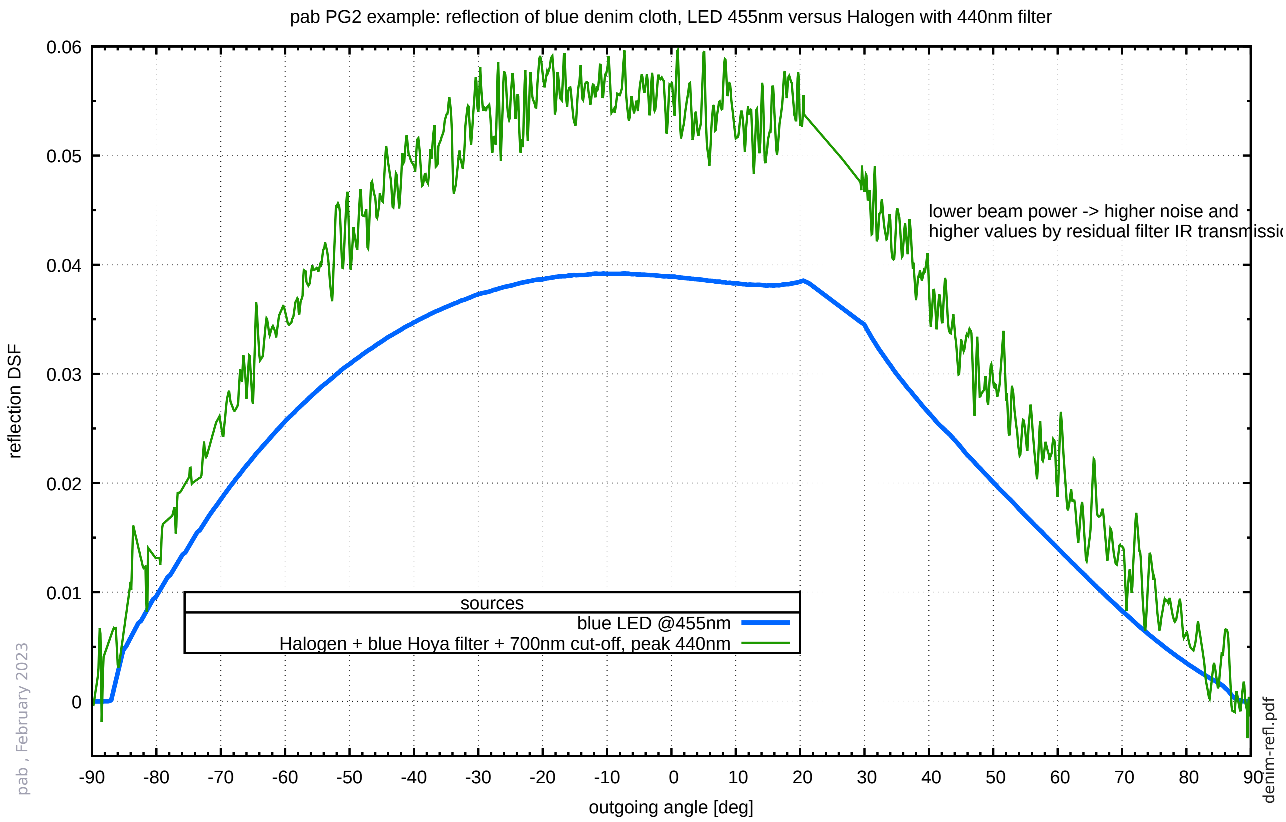
no polarisation effects found for combined LED: data of glass plate matches that of unpolarised Halogen, plus lower absorption in green channel

spectrometric raw signal



spectral width of primary LEDs would leave spectral "gaps" for measurements with spectrometer. Note that LEDs are not running at full power.

example DSF "blue denim", spectral range 450nm



blue LED has significantly better SNR. And it avoids cross-talk from residual IR in Halogen spectrum that skews data.

conclusions of coaxial triple LEDs tests

- preferable over Halogen / Xenon for 3-channel RGB BSDF
- significant better SNR at the short-end of VIS spectrum
- spectral emittance well defined compared to filters:
  narrow singular peak, no residual IR
- no polarisation effects noticeable, despite dichroic mirrors
- Xenon remains choice to resolve BSDFs with low values
- off-the-shelf + custom components work best

currently operating PG2 gonio-photometers

- Ecole Polytechnique Fédérale de Lausanne, EPFL, CH
  RGL *Realistic Graphics Lab*, group of Prof. Wenzel Jakob
- Fraunhofer Institute for solar Energy Systems, FhG-ISE, DE
  solar materials, group of Dr. Helen Rose Wilson
- Lucerne University of Applied Sciences and Arts, HSLU, CH
  Solar Energy Research Institute of Singapore, SERIS
  building materials, group of Dr. Lars Grobe
- Lawrence Berkeley National Lab, LBNL, CA, USA
  window materials, group of Dr. Eleanor Lee
- Zumtobel Lighting GmbH , Austria
  material modelling for artificial lighting
- pab-opto / pab Ltd
  industrial consulting
- on the PG2 gonio-photometer: www.pab.eu www.pab.nz

happy measurements, thank you

$RCSfile: main.tex,v $ $Revision: 1.18 $ $Date: 2023/02/19 00:43:49 $
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