Innovative bidirectional video-goniophotometer combining transmission and reflection measurements

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Assessment of Bidirectional Transmission (Reflection) Distribution Functions (BT(R)DFs)

To allow the integration of advanced daylighting systems in buildings and benefit from their potential as energy-efficient strategies, a detailed knowledge of their directional optical properties is necessary. These properties are described by the **Bidirectional Transmission (or Reflection) Distribution Function**, abbreviated **BT(or R)DF**, that expresses the emerging light flux distribution for a given incident beam direction. An original experimental method for their assessment was first developed for transmission measurements: the light emerging from the sample is reflected by a **diffusing triangular panel** towards a **CCD camera**, which provides a picture of the screen in its entirety. Within six positions of the screen and camera around the sample (each separated by a 60° rotation from the next one), a complete and **continuous** investigation of the transmitted or reflected light is achieved in a **time-efficient** way.

The camera is used as a **multiple-points luminance-meter** and calibrated accordingly. A luminance mapping of the projection screen is carried out by capturing images of it at different integration intervals, thus avoiding over and under-exposure effects, and appropriately combining the latter to extract BT(R)DF data at a **pixel level resolution**.

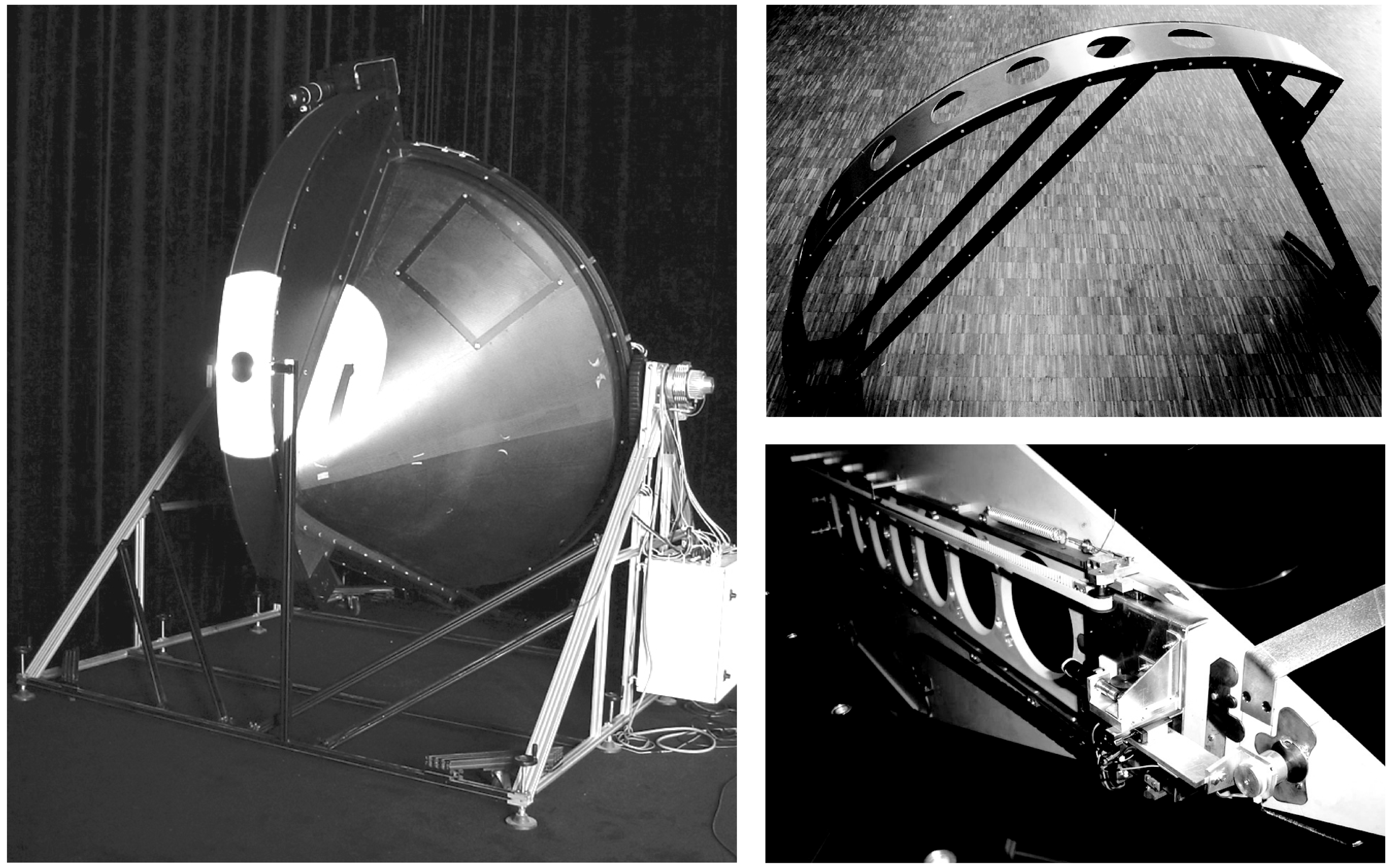
Additional constraints in reflection mode

For five out of the six screen positions (unless incidence is normal), the detection principle can be kept identical as in transmission mode, except that light flux must penetrate the measurement space in a way that the **beam is restricted to the sample area only**. As there is one position (all six for normal incidence) where the screen obstructs the incoming light flux, a special opening in the latter is required to let the beam reach the sample, producing a **blind spot** at that specific screen position (and only in reflection mode).

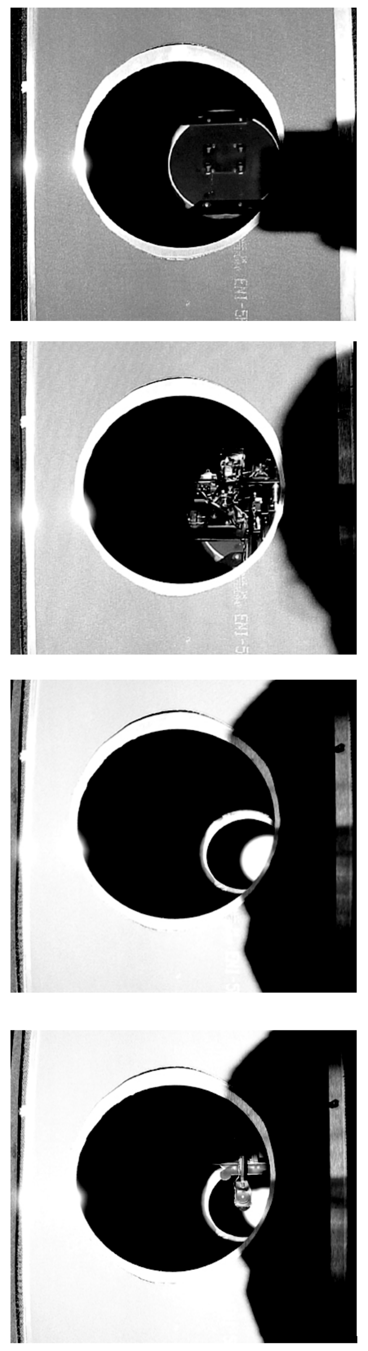
Final concept for BRDF measurements

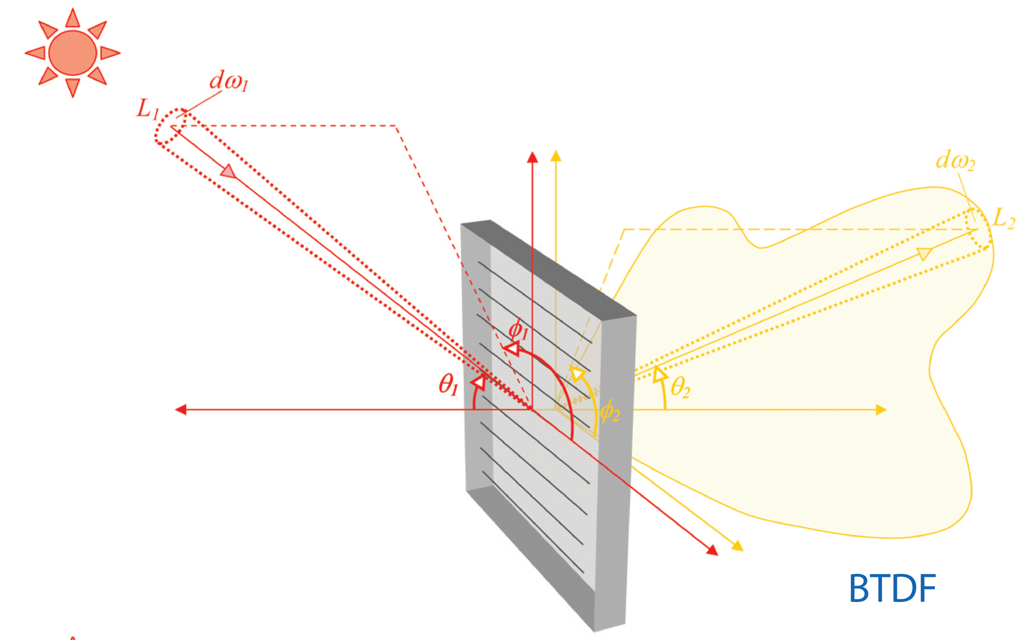
In order to control precisely the illuminated sample area and thus minimize the parasitic reflections and blind zone, a **quarter-circular frame** supports a **perforated sheet** on which a **motorized strip** showing one circular aperture is unrolling, of diameter equal to the sample's and facing the light source for any incident altitude angle. The sheet's elliptic openings are of dimensions given by the apparent sample surface (accounting for inclination angle) and are correspondingly positioned on the quarter circle arc. The **projection screen** concept relies on the removal of **elliptic covers** allowing a minimal loss of information on the emerging light distribution and negligible parasitic reflections around the sample area.

Structural components of the BTRDF goniophotometer: envelope, metal sheet with cut-out ellipses, motorized projection screen

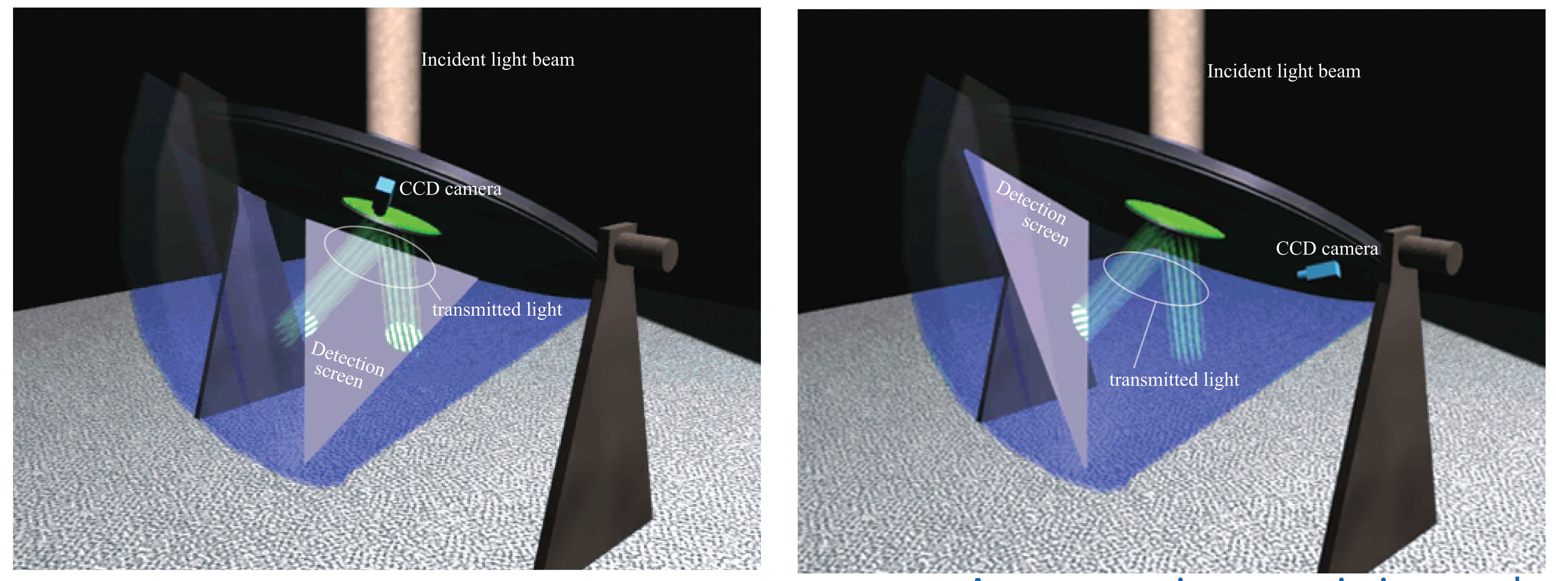


Extraction sequence

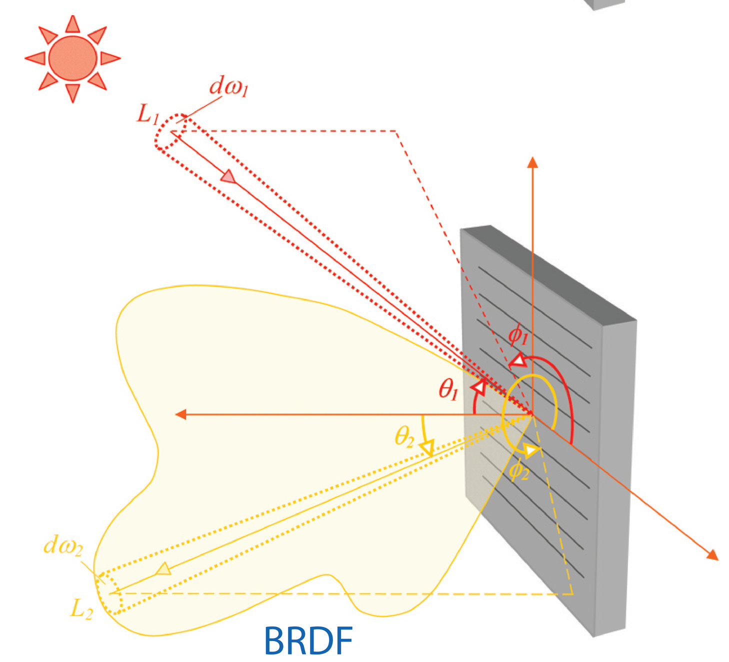




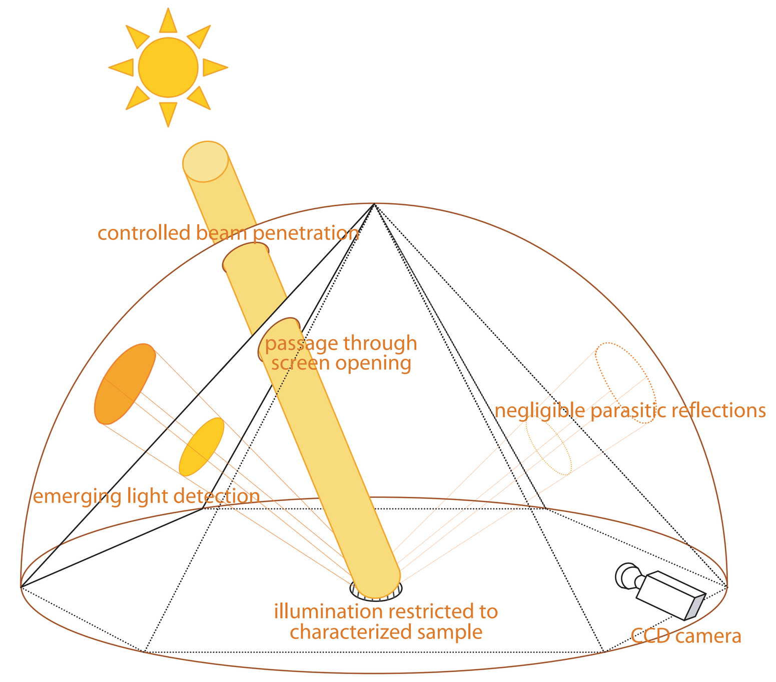
BTDF

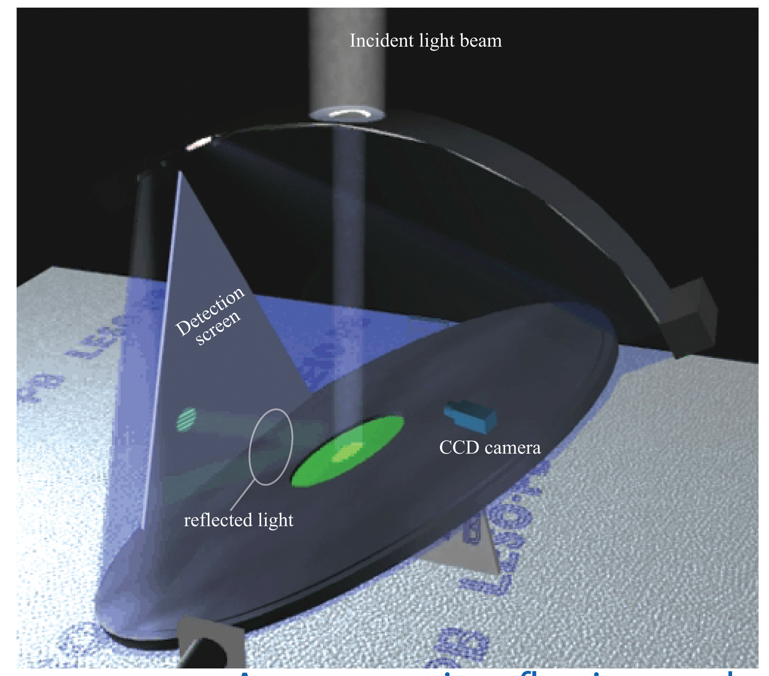


Assessment in transmission mode



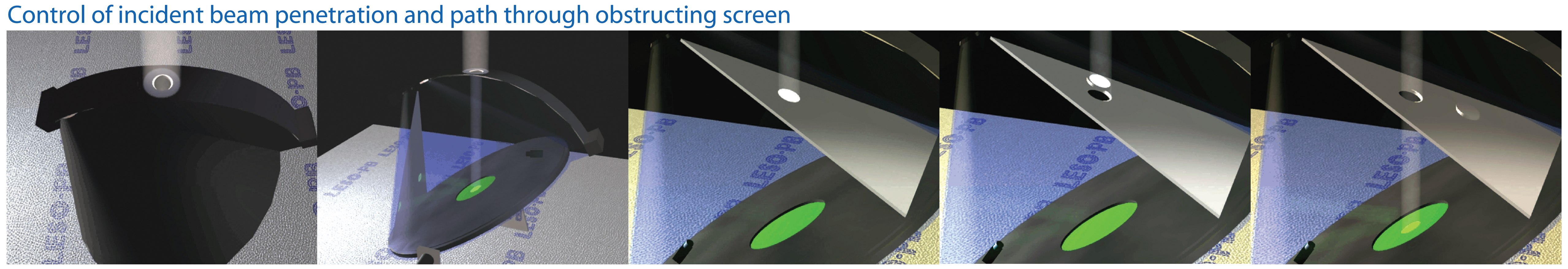
BRDF





Assessment in reflection mode

Control of incident beam penetration and path through obstructing screen



Measurement space envelope

It consists of a **carbon fiber cap** strengthened by a **structural metallic frame** that also supports a **static stainless-steel perforated sheet** on which a moving **synthetic strip** can glide. The latter selects the elliptic hole through which the incident light's path will be adequately controlled (according to the altitude angle).

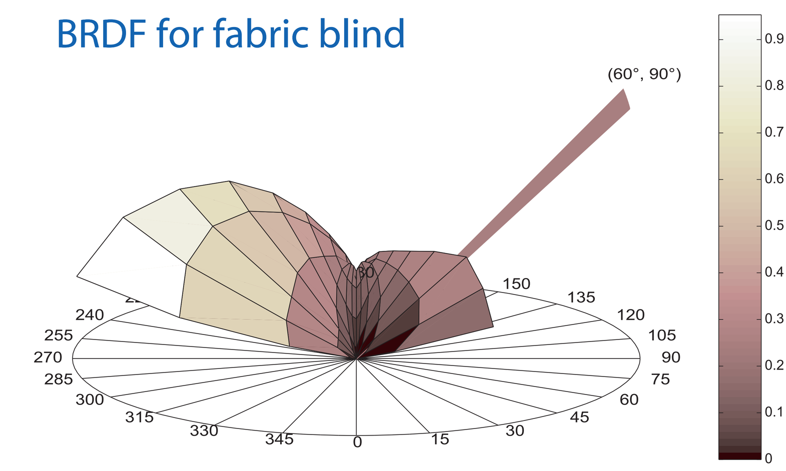
Diffusing projection screen

The screen surface is coated with a **lambertian** paint (perfectly diffusing). The **elliptic screen covers** are extracted by a ``permanent electro-magnet'' (PEM), mounted on a small **wagon** and running on rails. An additional mechanism inserts four screw-like pins in slots carved in each cover and thus ensures a reliable lifting and repositioning.

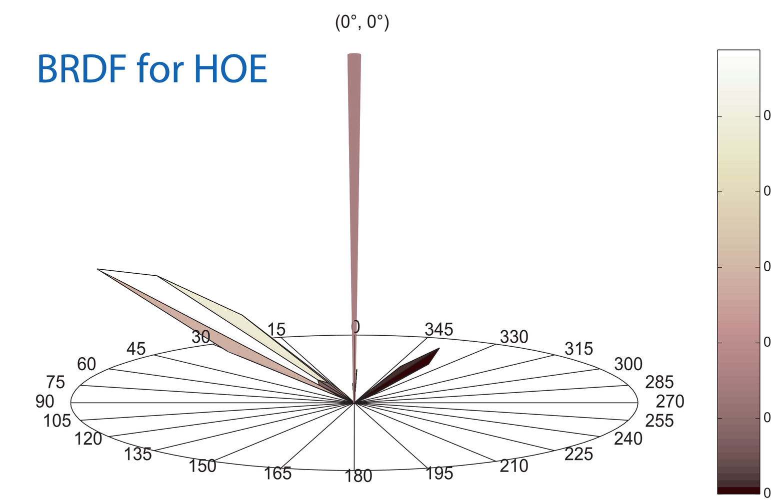
BRDF data

An **in-depth validation** of both BTDF and BRDF was conducted, based on **different approaches**. These studies led to a relative error on BT(R)DF data of only **10%**, allowing to confirm the high accuracy and reliability of this novel device.

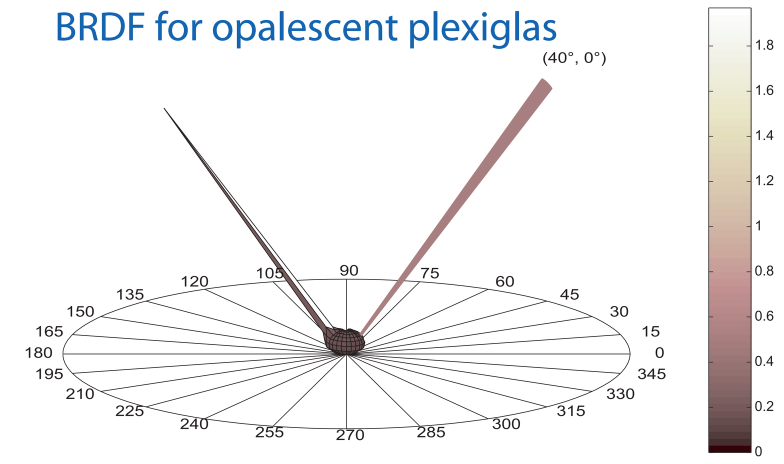
BRDF for fabric blind



BRDF for HOE



BRDF for opalescent plexiglas



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