TechnoTeam
Bildverarbeitung GmbH

Far-field measurements with RIGO801 near-field goniophotometers

Introduction

TechnoTeam Bildverarbeitung GmbH
Werner-von-Siemens-Straße 5
98693 Ilmenau
Germany
http://www.technoteam.de

Knut Bredemeier

Developing Engineer – Near-field goniophotometer

knut.bredemeier@technoteam.de

1. Basic principles

Far-Field measurement

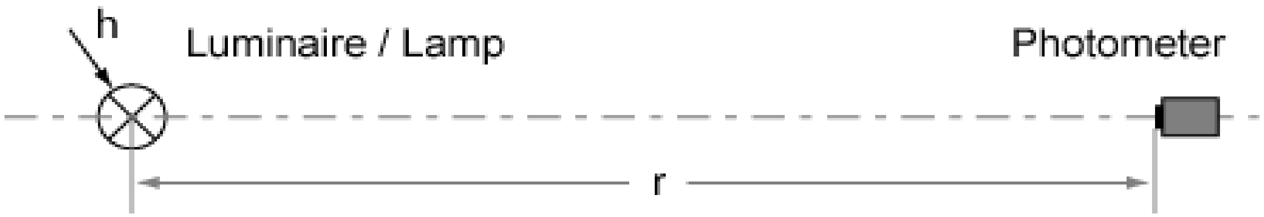
- Illuminances measured at a large distance to the light source are directly calculated (approximation) to luminous intensities
- Luminous flux can be calculated from the luminous intensity distribution or by calculating the integral of the measured illuminances

Near-Field measurement

- Luminance images are captured around the light source by using a luminance measuring camera
- The luminance images are transformed to ray sets that can easily be calculated to the luminous intensity distribution (LID)
- Luminous flux can be determined on the basis of the measured luminance images or by calculating the integral of the measured illuminances in case of an available photometer head mounted next to the camera

2. Principle of far-field goniophometer systems

- Measurement of luminous intensity values using a single illuminance meter at a far field distance to the light source



Error [%]	r/h
0.1	31.6
0.5	14.1
1	**9.95**
5	4.36
10	3

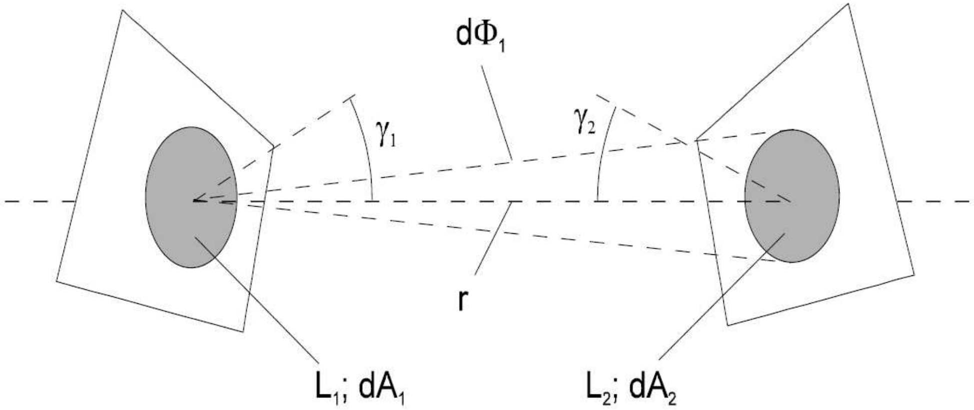
(Lambert radiation!)

$$I = E \cdot r^2$$

2.1 Photometric distance law

- Calculation of luminous intensities from illuminances

$$E = \int L(\gamma_1) d\Omega_{p2} \quad [\text{lx}]$$



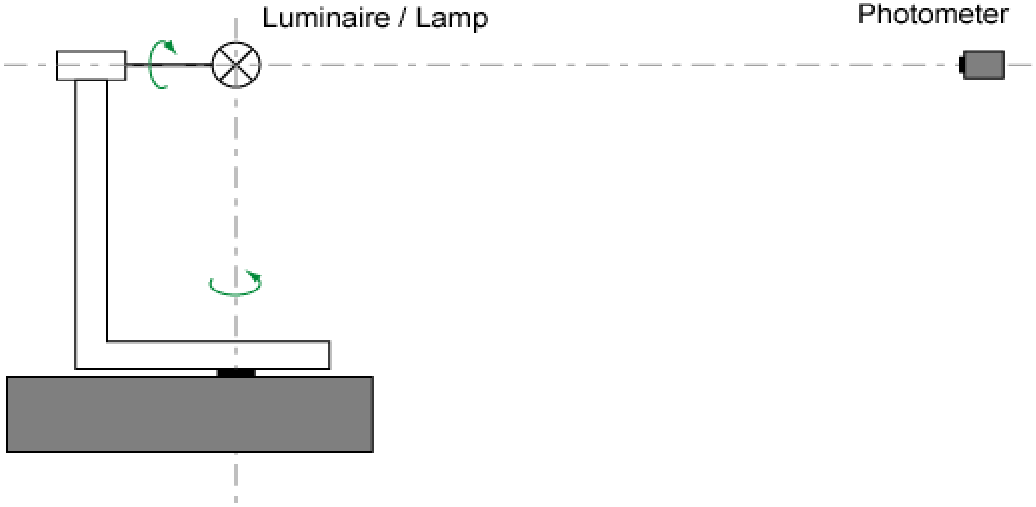
For small solid angles following approximation can be done

$$E \approx L(\gamma_1)\Omega_{p2} = \frac{I(\gamma_1)}{r^2} \cos \gamma_2 \Omega_0$$

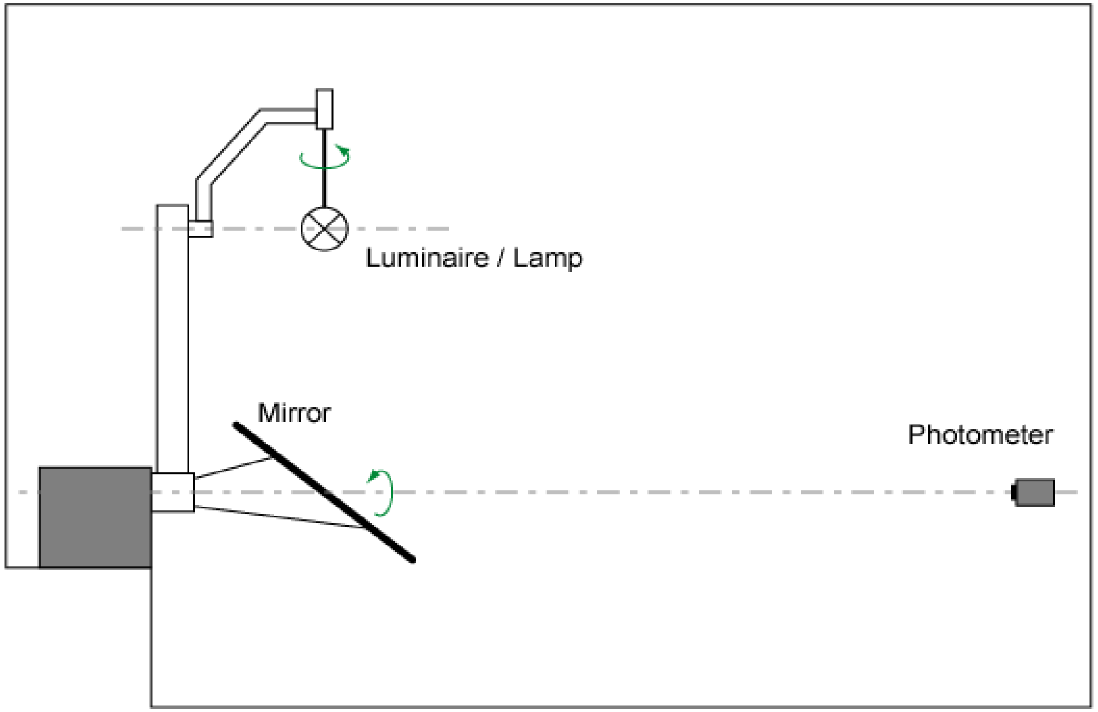
Photometric distance law

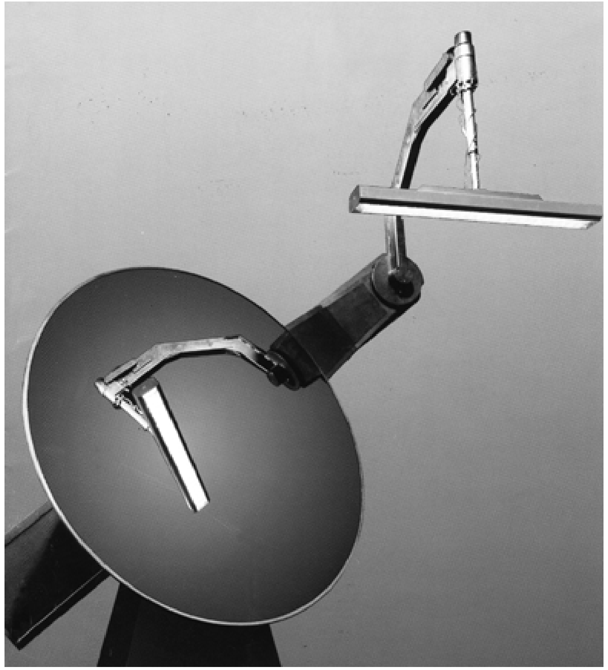
Small solid angles ➔ Point source ➔ Large distance

2.2 Rotating luminaire goniophotometer



2.3 Rotating mirror goniophotometer





2.4 Far field goniophometer – advantages / disadvantages

Advantages

+ A simple and direct measuring method

Disadvantages - Rotating luminaire goniophotometer

- Moved luminaire / lamp (→ Instable lamp operation)

Disadvantages - Rotating mirror goniophotometer

- Large (→ Large laboratory with complex air-conditioning system)

- Expensive

- Sensitive mirror

- Moved luminaire / lamp (up and down -> temperature zones)

- Weak sensitivity for low luminous flux light sources (e.g. single LED)

3. Principal of the RiGO801 near-field goniophometers

Idea of Prof. Riemann → **Ri**emann **Go**niophotometer, Patent 1991

DEUTSCHES PATENTAMT

Deutsches Patentamt · 80297 München

München, den 05. 01. 94
Ferndurchwahl: (089)2195-2705

Aktenzeichen: P 41 10 574.5-52
Anmeldernr.: 4412559
RIEMANN U.A.

Patentanwälte
Dr. Liedtke und Partner
Postfach 9 56

99019 Erfurt

EINGEGANGEN 12. Jan. 1994

Erteilungsbeschluß

Auf die Anmeldung P 41 10 574.5-52 des/der Herrn, Frau, Firma

Riemann, Manfred, Prof. Dr.sc.techn., 98693 Ilmenau, DE; Schmidt, Franz, Dr.sc.techn., 98693 Ilmenau, DE; Poschmann, Ralf, Dipl.-Ing., 98693 Ilmenau, DE;

wird ein vom 31.03.1991 an laufendes Patent

unter der Bezeichnung

Verfahren und Anordnung zur Messung der Lichtstärkeverteilung von Leuchten und Lampen

mit den Unterlagen gemäß beigefügter Ablichtung des Vordrucks P2480, die Bestandteil dieses Beschlusses ist,

erteilt.

Das Patent führt die Nummer 4110574.

Empfangsbescheinigung 11.04.97 DEUTSCHES PATENTAMT

① Sendungen des Deutschen Patentamts sind zu richten an:
(In der Anschrift Straße, Haus-Nr. und ggf. Postfach angeben)
Dr. Pöhner, Dr. Liedtke & Partner
Patent- und Rechtsanwälte
Waidmühlenweg 31
Postfach 956
99019 Erfurt

Antrag auf Eintragung eines Gebrauchsmusters

Aktenzei[redacted] 297 06 488.6 [redacted]t vergeben)

② Zeichen des Anmelders/Vertreters (max. 20 Stellen): 1923
Telefon des Anmelders/Vertreters: 0361/2606898
Datum: 08.04.97

③ Der Empfänger in Feld ① ist der
☐ Anmelder ☐ Zustellungsbevollmächtigte ☒ Vertreter
ggf. Nr. der Allgemeinen Vollmacht

④ **Anmelder** (…r auszufüllen, wenn …eichend von Feld ①)
TechnoTeam Bildverarbeitung GmbH
Ehrenbergstr. 11
98693 Ilmenau

Vertreter

⑤ (soweit bekannt) Anmeldercode-Nr. | Vertretercode-Nr. 21 40 94 | Zustelladreßcode-Nr.

⑥ **Bezeichnung der Erfindung**
Anordnung zur Messung der Lichtstärkeverteilung von Leuchten und Lampen

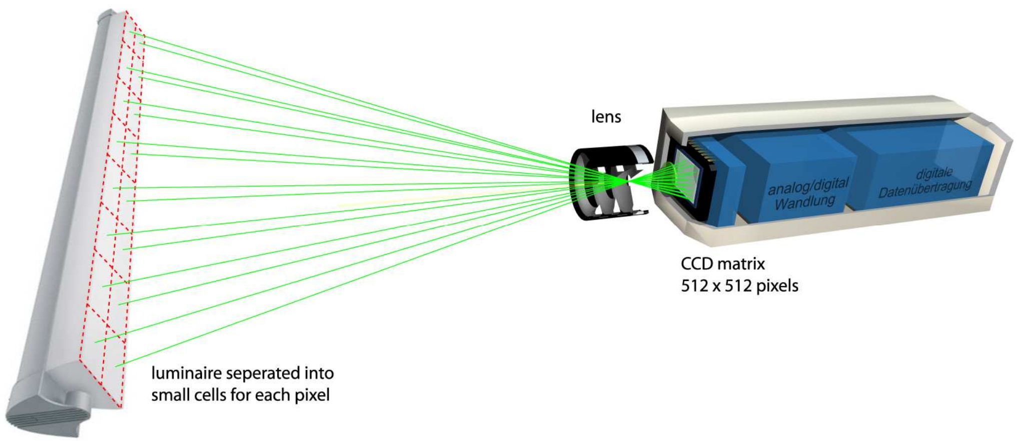
⑦ **Sonstige Anträge** (s. Kostenhinweise auf der Rückseite)
☐ **Aussetzung** der Eintragung und Bekanntmachung für ________ Monate *(Max. 15 Monate ab Anmelde- bzw. Prioritätstag)*
☐ **Recherchenantrag** - Ermittlung der öffentlichen Druckschriften (§7 Gebrauchsmustergesetz)
☐ **Lieferung von Ablichtungen** der im Recherchenverfahren ermittelten Druckschriften

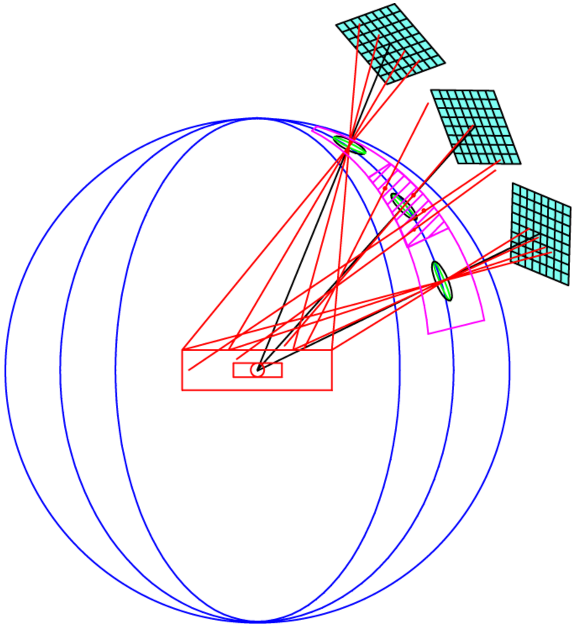
⑧ **Erklärungen**
☐ **Teilung/Ausscheidung** aus der Gebrauchsmusteranmeldung → Aktenzeichen: G | Anmeldetag:

3.1 CCD luminance measuring camera

- A Luminance measuring camera (CCD) is moved around the measuring object
- The pixels of the CCD sensor can be regarded as small single sensors (512x512 px)
- The area of each pixel represents a very small solid angle that measured a portion of luminous flux

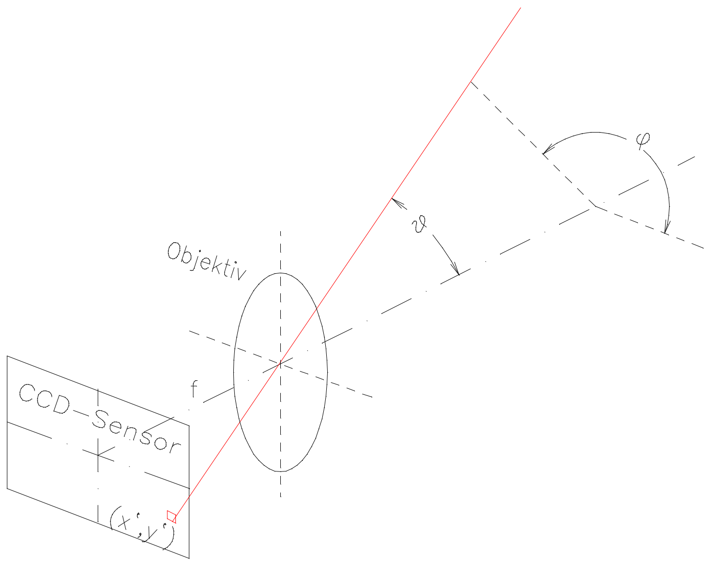
→ **Far field conditions at a close distance**

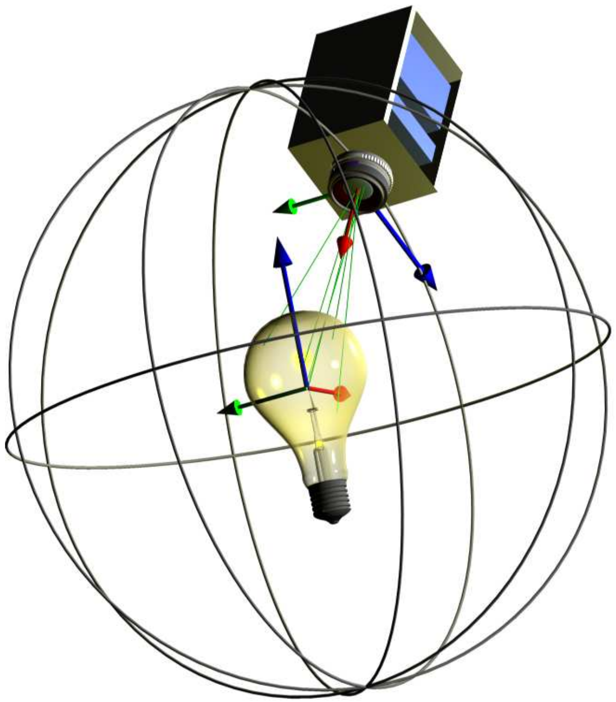




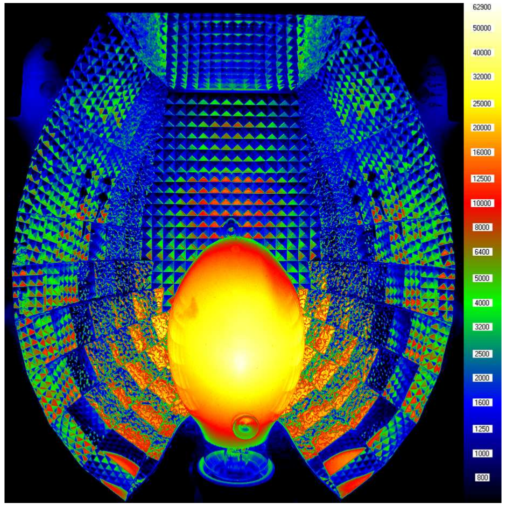
3.2 Calculation of ray - directions

- The luminous flux portion measured by a pixel is represented as a vector
- With the exact knowledge of the optical imaging system (lens) the vector direction for each pixel can be calculated precisely





3.3 Calculation of ray – amplitudes



The camera measures luminance values of each pixel

$$L(x', y') \quad [\mathrm{cd/m^2}]$$

Weighting with the corresponding solid angles

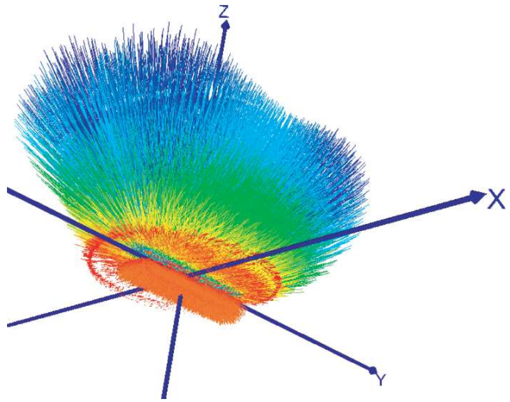
$$\Delta\Omega(x', y') \quad [\mathrm{sr}]$$

→ **Luminous flux portions** $\Delta\Phi(x', y') \quad [\mathrm{lm}]$

Calculation of direction and amplitude for each pixel
→ Ray bundle for each image

Ray bundles of all images
→ **Complete ray set**

$$\Phi(x, y, z, \vartheta, \varphi)$$

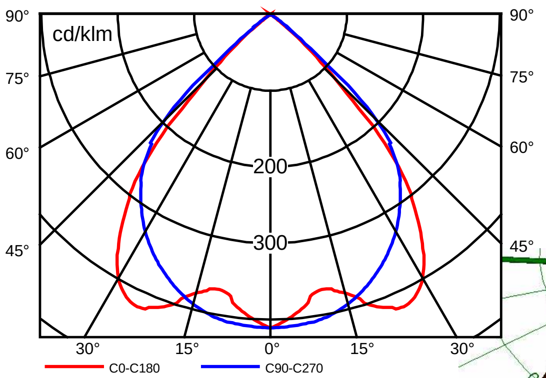


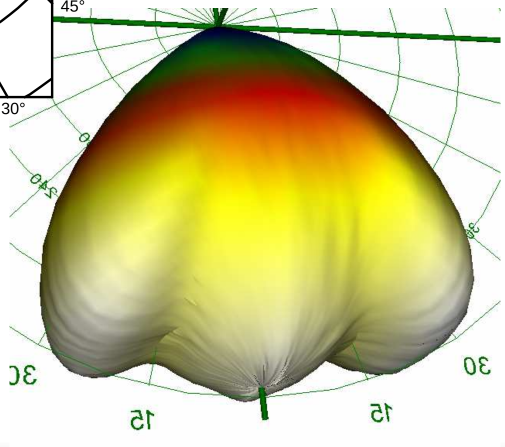
Complete description of light output characteristic

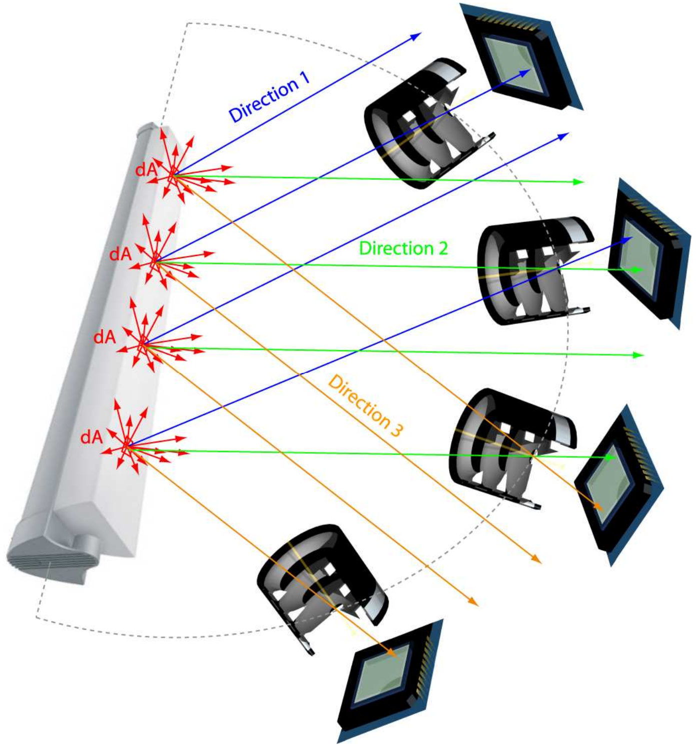
3.4 Far-field luminous intensity distribution from ray sets

- All rays are accumulated in direction cells (standard algorithm)
  → **Luminance intensity distribution**

$$I(\vartheta,\varphi)]$$







3.5 Luminous flux measurement using the photometer

- RiGO801 goniophotometers use an additional illuminance meter
- Robust method to measure the luminous flux by integration of illuminance values on a closed surface around the object

$$\Phi = \int E dA \quad [lm]$$

- Also Photometer based LID measurements of small objects
- Simple calibration procedure by measuring a luminous flux standard lamp

3.6 Advantages of RiGO 801

- Relative small and lightweight construction
  → No extra large laboratories required
- Measuring object is not moved
  → Stable conditions of light output
- Hanging and upstanding support
  → Easy measurement of direct indirect luminaires
- Fast measurements
  → e.g. 25 minutes for 2.5°x 2.5°)
- High resolution
  → Up to 0.1°x 0.1°possible
- Easy alignment of the light source by using the camera
- Position independent measurement by principle
  → No need to consider the light centroid
- Luminance measuring camera
  Luminance images can be used for different tasks

→ Cost-efficient regarding to conventional goniophotometers

3.7 RiGO801 and the standards

- DIN 5032-1, Part 1: Photometrical methods
  → The type of movement (movement on a virtual spherical surface) is mentioned
- DIN EN 13032-1 (Partial replacement of DIN 5032-1)
  → Measurement of luminous intensity by integrating luminances mentioned
- Work in the technical committee FNL-3 (DIN), Dr. Schmidt
  → Luminance measurement and near field goniophotometer
- Work in CIE committee (TC2-62), Dr. Krueger
  → Technical recommendation which includes the near-field goniophotometers

→ RiGO801 technique established at several large luminaire and lamp manufacturers

3.8 References

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- University of Tehran [1]
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- Zumtobel STAFF GmbH & Co. KG, DE [10]

[1] RiGO801 – Luminaire [2] RiGO801 – Lamps [3] RiGO801 – LED [4] Special