



Dutch
Metrology
Institute

Division 2: Physical Measurement of Light and Radiation

Paul Dekker, 22 januari 2018

Eindhoven, The Netherlands

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Inhoud

- Introductie VSL
- Wat, waarom en hoe metrologie?
- Voorbeelden van typische kalibratie opstellingen
- Update Divisie 2 CIE



VSL

VSL maakt meetresultaten van bedrijven, laboratoria en instellingen direct herleidbaar naar internationale standaarden.

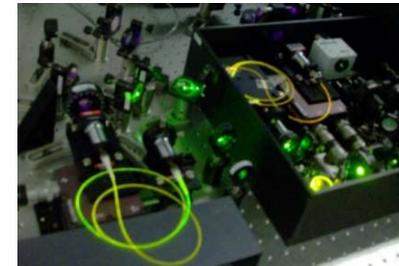
VSL beheert en ontwikkelt in opdracht van de Nederlandse overheid dé nationale meetstandaarden en levert een belangrijke bijdrage aan de betrouwbaarheid, kwaliteit en innovatie van producten en processen in bedrijfsleven en samenleving.

History

- 1799: **Jean Henri van Swinden** presents the original meter to French government
- 1929: The Netherlands join the Metre Convention
- 1989: Founding of **Nederlands Meetinstituut (NMI) Van Swinden Laboratory**
- 2001: Transfer of ownership to **TNO**
- 2009: NMI Van Swinden Laboratory -> **VSL**
- 2016: Major shareholder **First Dutch Innovations**



Jean Henri van Swinden





VSL organisatie

Kalibratie & Referentiematerialen

- Beheer van meetstandaarden
- Kalibraties
- Referentiematerialen
- Internationale vergelijkingen

Customized Applied Metrology

- Consultancy
- R&D contracten
- Internationale projecten, training

Onderzoek & Ontwikkeling

- Ontwikkeling en beheer van meetstandaarden
- Internationale herleidbaarheid
- R&D voor metrologie en meetsystemen





VSL Algemeen - Technologieën



Lengte



Temperatuur en
luchtvochtigheid



Electriciteit



Tijd en
frequentie



Viscositeit



Chemie



Stroming - gas



Optica



Massa



Stroming - vloeistof



Ioniserende straling



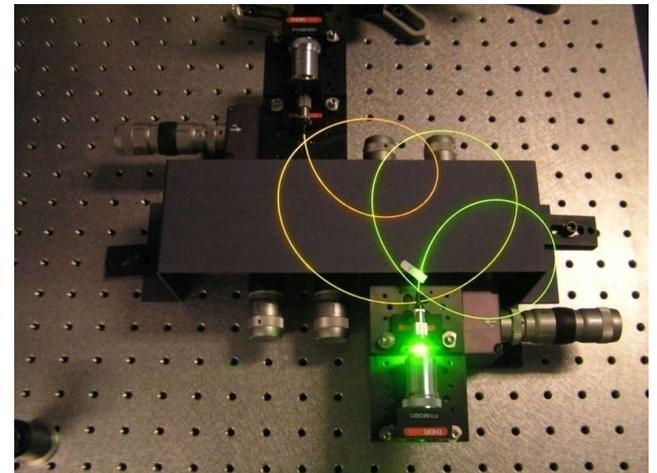
Druk



VSL Optica

De technologie Optica

- Levert internationaal erkende **herleidbaarheid** naar de nationale meetstandaarden op het gebied van fotometrie en radiometrie
- Levert metrologisch **advies** op dit gebied
- Organiseert **ringvergelijkingen**
- Neemt deel aan **onderzoeks- en ontwikkelprojecten** in internationaal verband

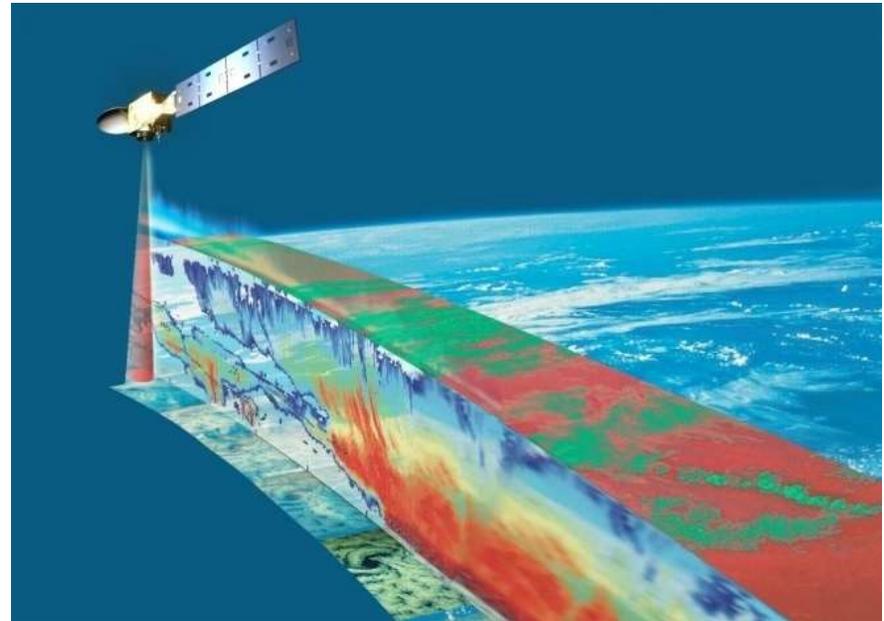




VSL Optica – thema's



Verlichting

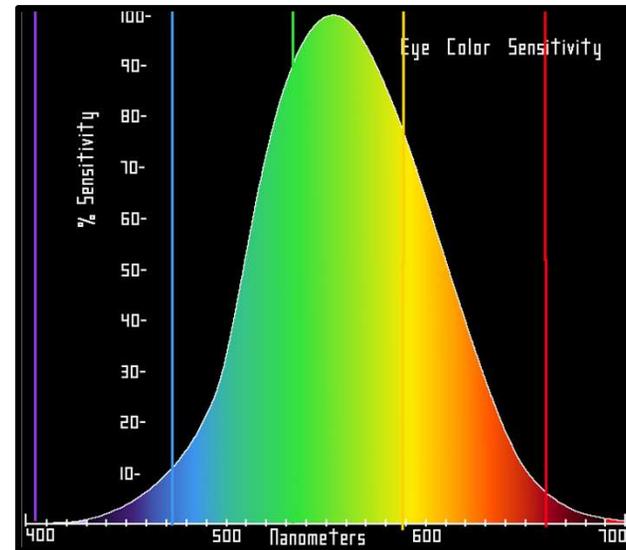
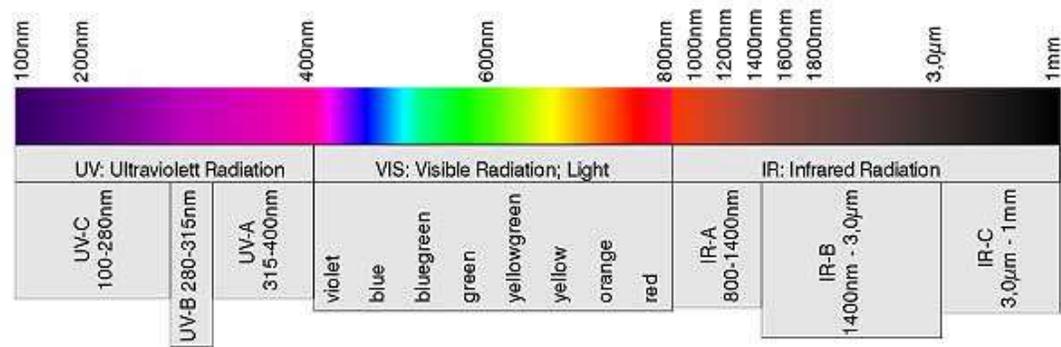


Ruimtevaart / aardobservatie

Radiometrie & Fotometrie

- Radiometrie : meting van de hoeveelheid optische straling (vermogen) in UV, VIS, IR

- Fotometrie : meting van het visuele effect van optische straling, zoals waargenomen door het menselijk oog (380-780nm)





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Wat is metrologie?

Metrologie: De wetenschap van het meten

- **Betrouwbaar meten vereist herleidbaarheid naar internationaal erkende meetstandaarden.**
 - Niet onderbroken keten van vergelijkende metingen
 - Grootheid; Eenheid; Getal; Onzekerheid
- **Herleidbaar meten is belangrijk voor:**
 - (Internationale) handel
 - Consumenten bescherming
 - Fabricage



Zonder meetstandaarden gaat het mis...



NASA Mars Climate Orbiter

Crashed 23 september 1999 (125 M\$).

“Navigation error, because NASA subcontractor Lockheed Martin used imperial units (pound-seconds) instead of the metric units (newton-seconds).”



Zonder meetstandaarden gaat het mis...

Air Canada Flight 143 – Gimli Glider

Boeing 767 from Ottawa to Edmonton runs into trouble, because of a miscalculation of the amount of fuel.

“Instead of 22,300 kg of fuel, they had 22,300 pounds on board - less than half the amount required to reach their destination.”



Zonder meetstandaarden gaat het mis...



Uit onderzoek naar de oorzaak van de crash zal later blijken dat een van de hoogtemeters van het vliegtuig tijdens de landing niet goed werkte. Hierdoor nam het vliegtuig, dat op de automatische piloot vloog, te veel gas terug. Toen het vliegtuig de grond raakte, brak het in drie stukken. Aan boord waren 127 passagiers en zeven bemanningsleden. Vijf passagiers en vier bemanningsleden kwamen om, 117 mensen raakten gewond.





Global standards organisation

- International **Metre Convention**
- **CIPM/BIPM**
- **CIPM MRA** (Mutual Recognition Arrangement) => guarantee international acceptance
- **CCPR**(Wereldwijde technische commissie radiometrie en fotometrie)
- Regional Metrology Organisations (RMOs):
Europe: **Euramet** (Regional Metrology Organisation)
- National Metrology Institutes (NMIs)
Netherlands: **VSL**



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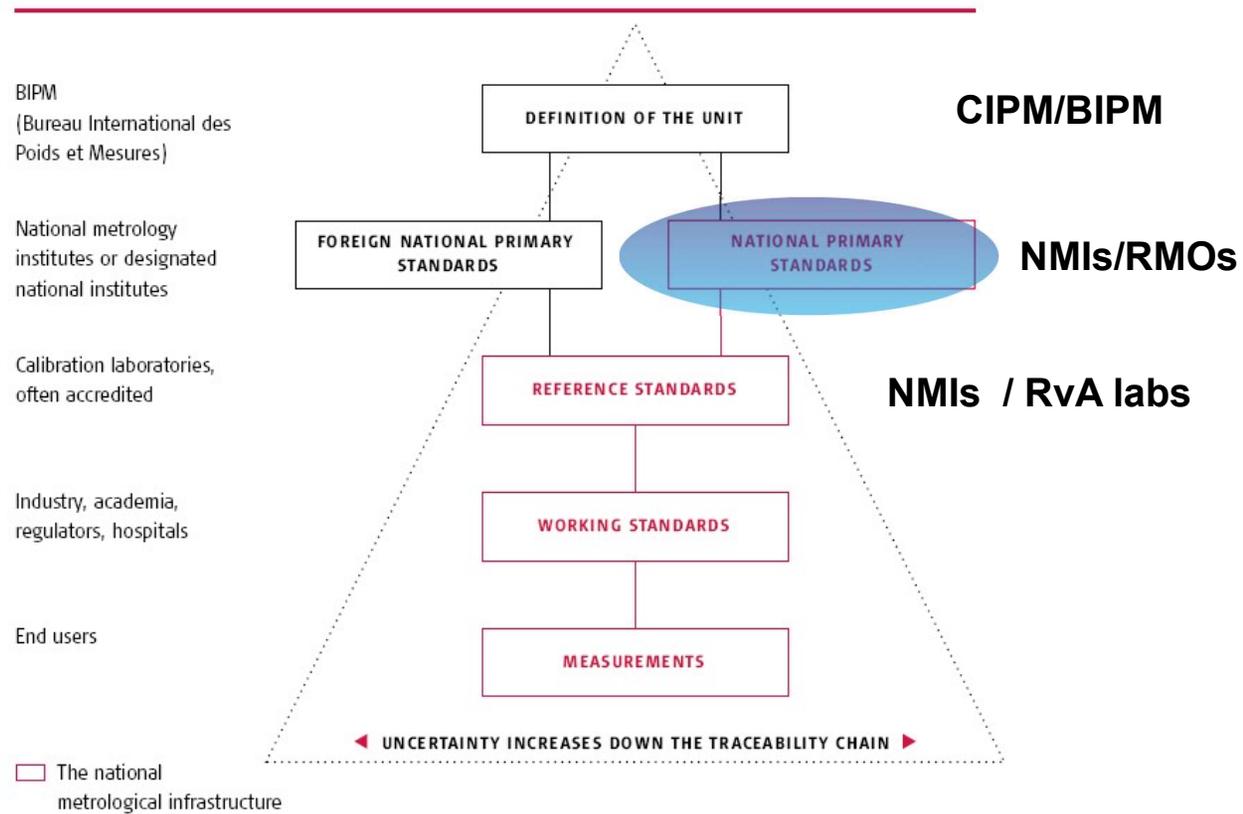
Regionale Metrologie Organisaties (RMOs)



Herleidbaarheid

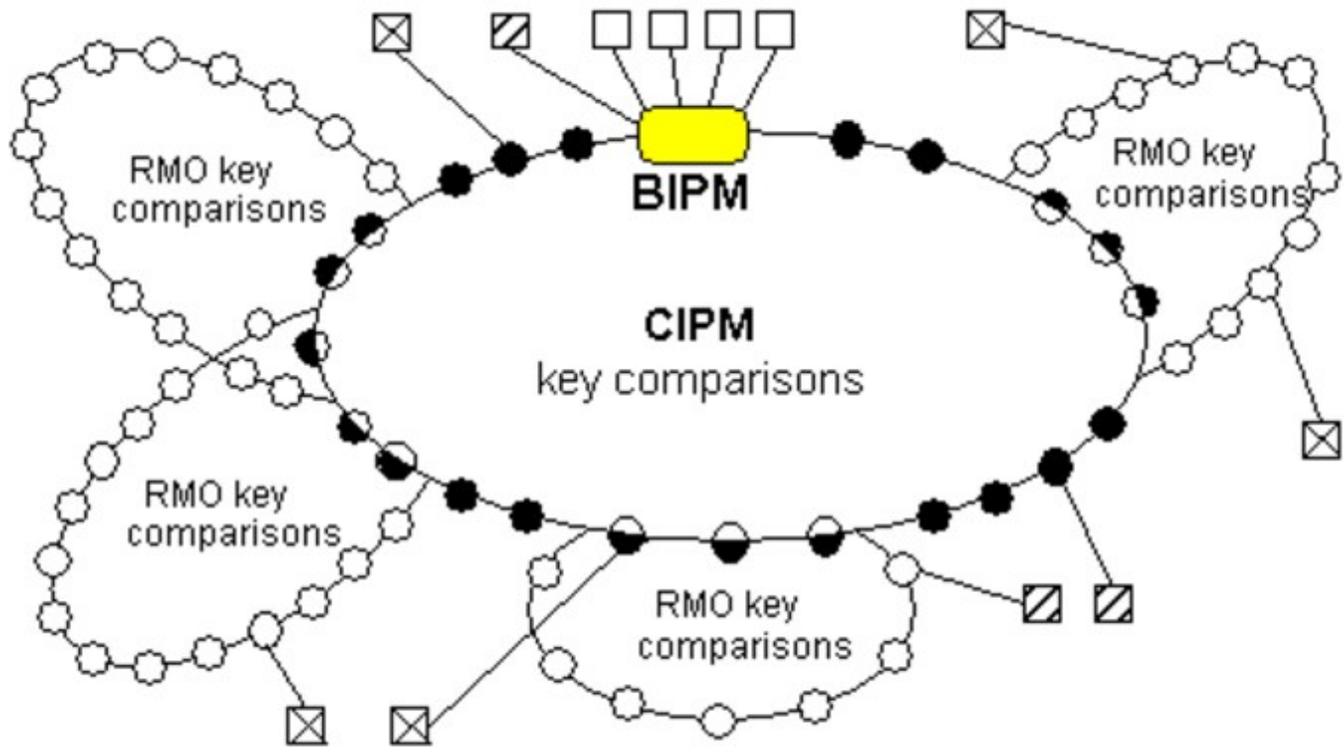
- Internationale herleidbaarheid
 - Geeft vertrouwen aan kalibraties
 - Maakt kalibraties wereldwijd vergelijkbaar
 - Geeft inzicht in onzekerheid

Figure 1: The traceability chain



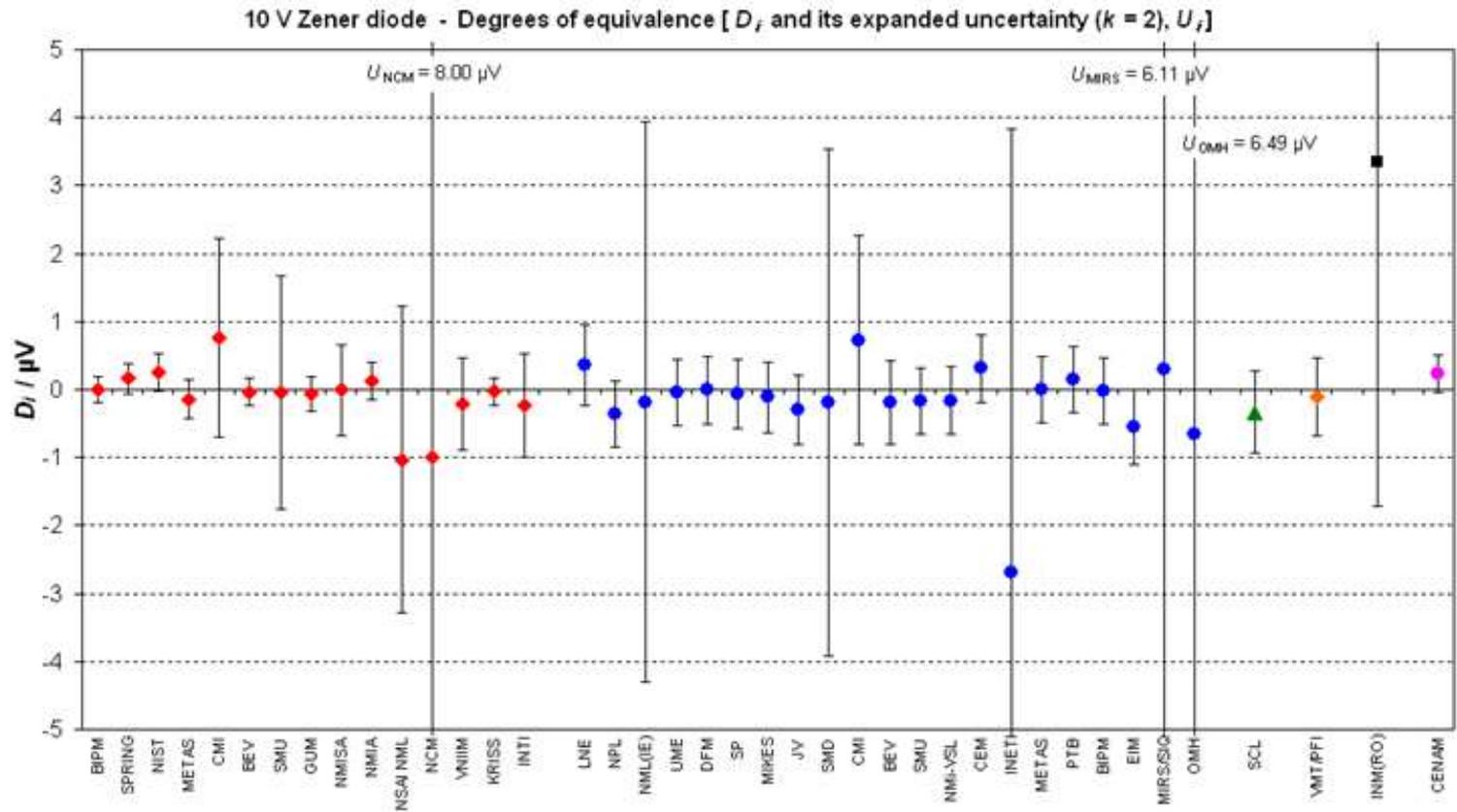


Key comparisons





VSL Degree of equivalence





The BIPM key comparis: x +

← → ↻ 🏠 🔒 kcdb.bipm.org

Add to the favorites bar by selecting ☆, or by getting them from another browser. [Import your favorites](#)

Bureau International des Poids et Mesures

Home | **Key and supplementary comparisons** | Calibration and Measurement Capabilities - CMCs

KCDB home Version française

The BIPM key comparison database

➤ **What's new ?**

- [Acoustics, ultrasound and Vibration - COOMET](#)
17 January 2018
- [Key Comparison - BIPM.EM-K11.a and b](#)
15 January 2018
- [All news](#)

➤ **Related links**

- [KCDB Statistics](#)
- [KCDB FAQs](#)
- [KCDB Reports](#)
- [CIPM MRA](#)
- [JCRB](#)
- [Find my NMI](#)
- [Metrologia](#)

➤ **Contact us**

- BIPM.KCDB@bipm.org

➔ **in support to the Mutual Recognition Arrangement of the CIPM (CIPM MRA) of national measurement standards and of calibration and measurement certificates issued by national metrology institutes**

Participants in the CIPM MRA (Appendix A)

List of national metrology institutes and designated institutes that are participant in the Arrangement.

[access to the list](#)

Key and supplementary comparisons (Appendix B)

Information on CIPM (Comité International des Poids et Mesures) and RMO (Regional Metrology Organization) key and supplementary comparisons, together with results interpreted in terms of equivalence.

Search comparisons : ✓

[advanced search](#)

Calibration and Measurement Capabilities – CMCs (Appendix C)

Quantities for which calibration and measurements certificates are recognized by institutes participating in the Arrangement.

Search CMCs : ✓

[advanced search](#)

List of key comparisons (Appendix D)

List together with a short description of the key comparisons recorded.

[access to the list](#)



GUM: Guide to the Expression of Uncertainty in Measurement

 In order to benefit fully from the hyperlinking between the documents, the reader is advised to download all JCGM documents presently available in one ZIP file.

→ The fundamental reference document is the *Guide to the Expression of Uncertainty in Measurement (GUM)*:

<p>↘ <i>Evaluation of measurement data – Guide to the expression of uncertainty in measurement</i> JCGM 100:2008 (GUM 1995 with minor corrections)</p> <p>Note: JCGM 100:2008 is also available in HTML form from the JCGM portal on ISO's website.</p>	
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→ The JCGM Working Group 1 (JCGM-WG1) is producing a series of documents to accompany the GUM. The first four of these documents have been approved and are available for download as PDF files. Printed copies are available for purchase from ISO.

<p>↘ <i>Evaluation of measurement data – An introduction to the "Guide to the expression of uncertainty in measurement" and related documents</i> JCGM 104:2009</p>	
<p>↘ <i>Evaluation of measurement data – Supplement 1 to the "Guide to the expression of uncertainty in measurement" – Propagation of distributions using a Monte Carlo method</i> JCGM 101:2008</p>	
<p>↘ <i>Evaluation of measurement data – Supplement 2 to the "Guide to the expression of uncertainty in measurement" – Extension to any number of output quantities</i> JCGM 102:2011</p>	
<p>↘ <i>Evaluation of measurement data – The role of measurement uncertainty in conformity assessment</i> JCGM 106:2012</p>	
<p>↘ <i>Evaluation of measurement data – Concepts and basic principles</i></p>	



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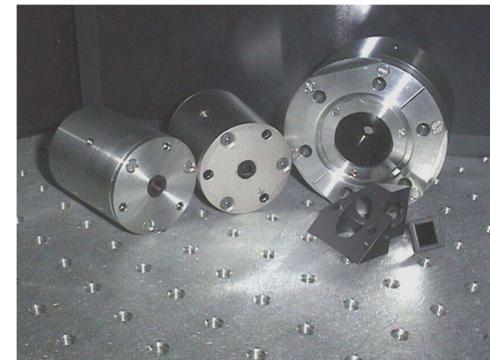
Kalibratiefaciliteiten

VSL Optica - Faciliteiten

- Faciliteiten voor het uitvoeren van kalibraties van:
 - **Lichtbronnen**
Kalibratie van de output van een lichtbron
 - **Detectoren**
Kalibratie van detector-respons op een bekende input

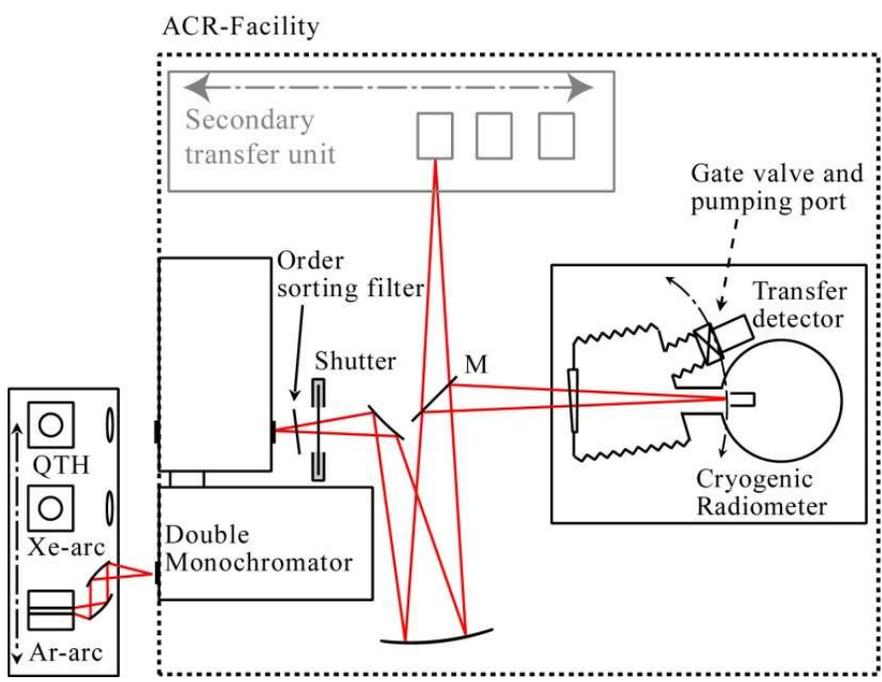
- Grootheden:
 - Totale lichtstroom: Lichtstroom lm en Radiant flux, $\frac{W}{nm}$
 - Lichtsterkte (cd)
 - Luminantie, $\frac{cd}{m^2}$ en Radiantie $\frac{W}{nm \cdot m^2 \cdot sr}$
 - Verlichtingsterkte: Illuminantie, $lx = \frac{lm}{m^2}$ en Irradiantie, $\frac{W}{m^2 \cdot nm}$

- Overige aspecten
 - Ruimtelijke verdeling van licht
 - Kleurparameters (Kleurtemperatuur, xyz-coördinaten)
 - Energie-efficiëntie (Lumen per Watt elektrisch vermogen)

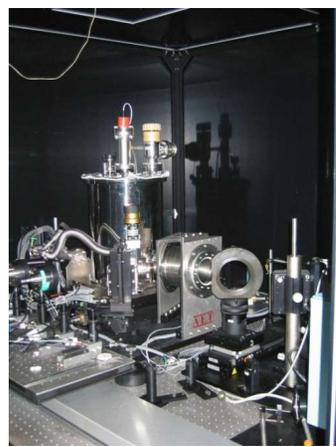




ACR facility for detector calibration



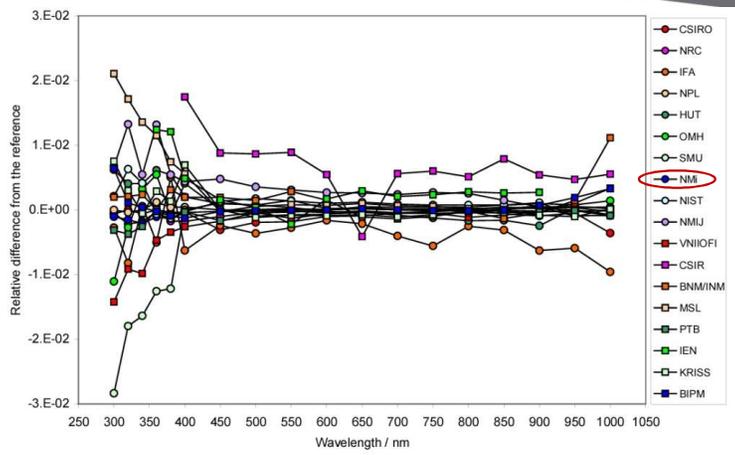
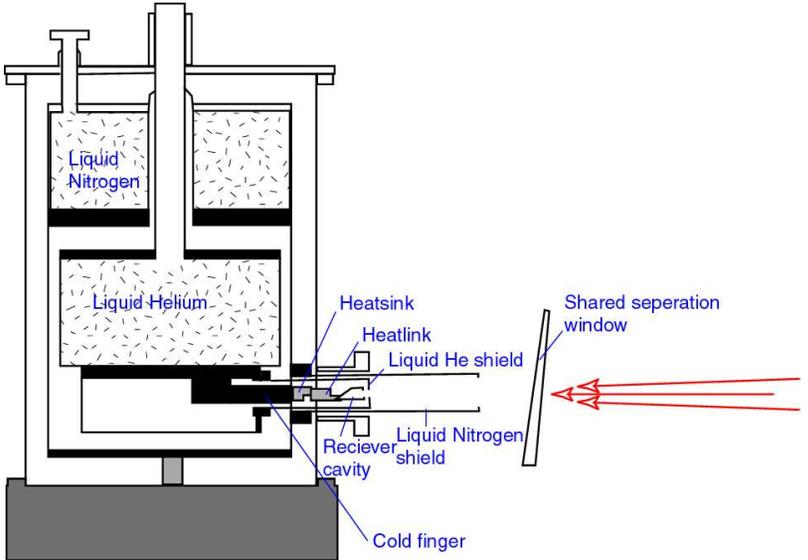
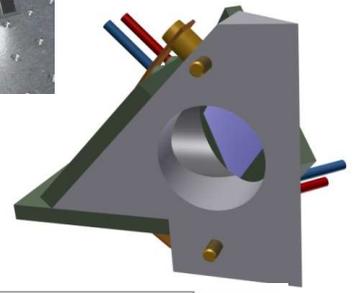
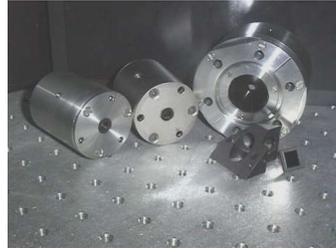
- Provides absolute flux with tunable wavelength
- Wavelength range: 190 – 2400 nm
- Calibration of spectral responsivity of detectors
- Proven international equivalence



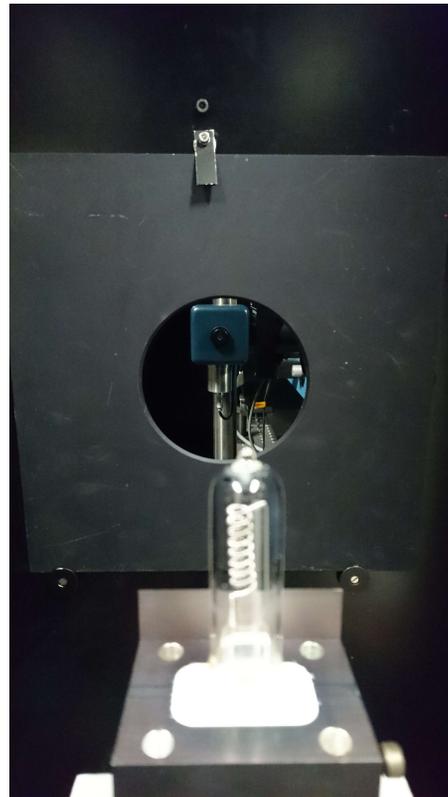
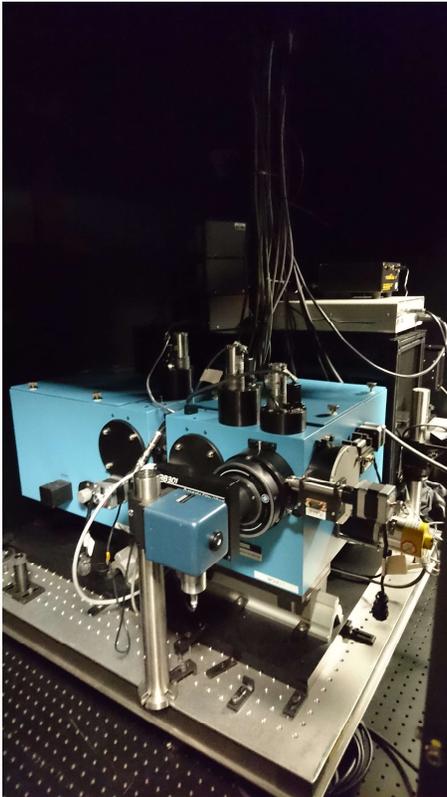


Absolute Cryogenic Radiometer

- Absolute optical power measurement
- Based on electrical substitution
- Noise Equivalent Power $\approx 9 \text{ nW}$



Irradiance calibration of source



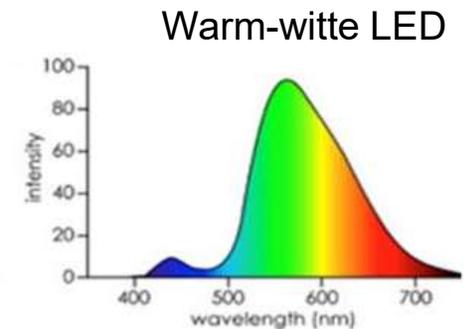
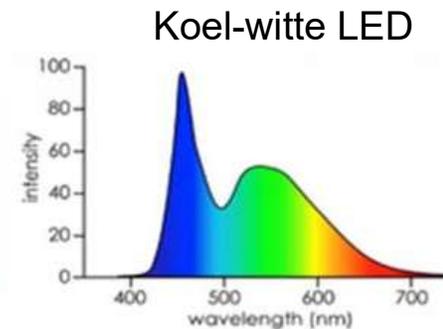
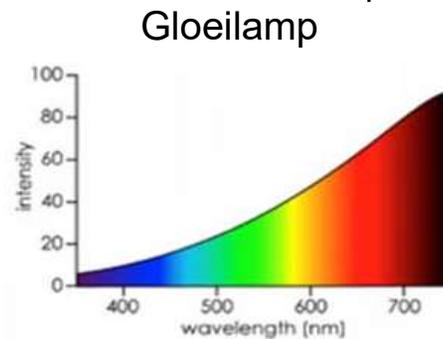
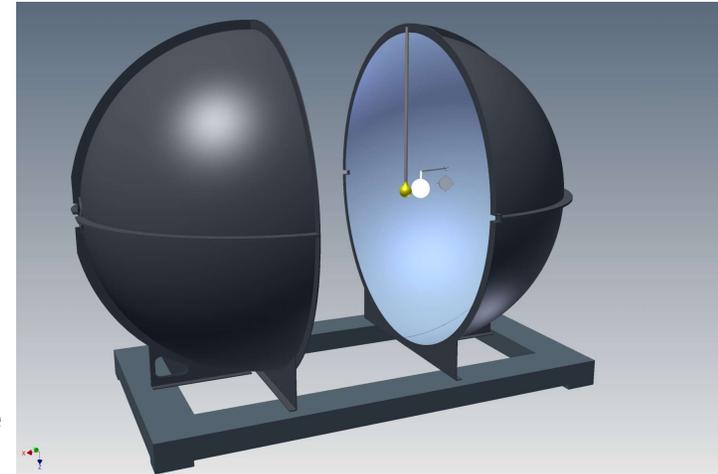
- Wavelength range:
250 nm - 2000 nm
- Calibration of spectral irradiance of sources

$$\frac{W}{m^2 \cdot nm}$$

Verlichting - Lichtstroom

- Totale lichtstroom (Lumen) van een lamp of armatuur
- Vergelijking met referentie-lamp
- Gemeten d.m.v. integrerende bol met een diameter van 3 meter
- Tegelijk wordt elektrisch vermogen gemeten → energie-efficiëntie

- Gloeilamp
 - Bijna perfecte overeenkomst met spectrum van kalibratie lampen
- LED-lamp
 - Andere samenstelling van het lightspectrum
 - Nauwkeurige metingen vereisen correctie voor spectrum





International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

17.03.01 DD Report 2017



International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

CIE (D2) main activities since last meeting

- new CIE publications
- Division D2/NC/BA ballots
- News from CIE



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Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission

D2 publications since Melbourne Meeting

- CIE 226:2017 High-Speed Testing Methods for LEDs
- CIE 225:2017 Optical Measurement of High-Power LEDs
- CIE TN 007:2017 Interim Recommendation for Practical Application of the CIE System for Mesopic Photometry in Outdoor Lighting



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D2 publications since Melbourne Meeting

- x043:2016 Proceedings of the 4th CIE Expert Symposium on Colour and Visual Appearance 6 – 7 September 2016, Prague, Czech Republic
- 220:2016 Characterization and Calibration Methods of UV Radiometers
- CIE TN 005:2016 Specifying Product Performance for Mesopic Applications
- CIE TN 004:2016 The Use of Terms and Units in Photometry – Implementation of the CIE System for Mesopic Photometry



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Internationale Beleuchtungskommission

New TCs

- New JTC Proposal: The measurement of sparkle and graininess (xD Reflect)
- New TC Proposal: Guidance relating to $0^\circ:d$ ($d:0^\circ$) reflectance instruments
- New TC Proposal: Characterization and measurement of LED light sources with dynamic control
- New TC Proposal: New TC on reference spectrum for LEDs
(Future Photometry Based on Solid-State Lighting)



Future Photometry Based on Solid-State Lighting (SSL) Products

Need for the JRP

Phasing out of incandescent lamps (EU 2020 Energy Strategy)

- **Incandescent calibration lamps are phasing out as well!**

High uncertainties in SSL luminous efficacy (lm/W) measurements

- **IC2013 Comparison: ± 5 % spread with over 100 test laboratories**

Standardisation, International Commission on Illumination (CIE)

- **Urgent need for LED Illuminants for Photometry and Colorimetry**



Objectives

Develop new LED-based standard lamps for photometric calibrations

- **Replace old luminous intensity and luminous flux standard lamps**

Reduce uncertainties of SSL efficacy at test laboratories down to 1 %

- **Utilising the new calibration lamps and measurement methods**

Develop new Standard Illuminant LED in collaboration with CIE

- **Allow official calibration of photometers using white LED sources**

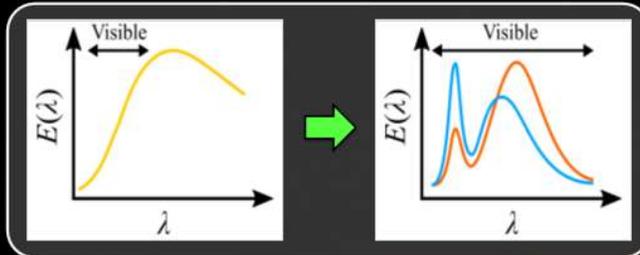
Scientific Excellence: New System of Photometry Based on White LEDs

WP1: Photometric standards based on white LED-sources

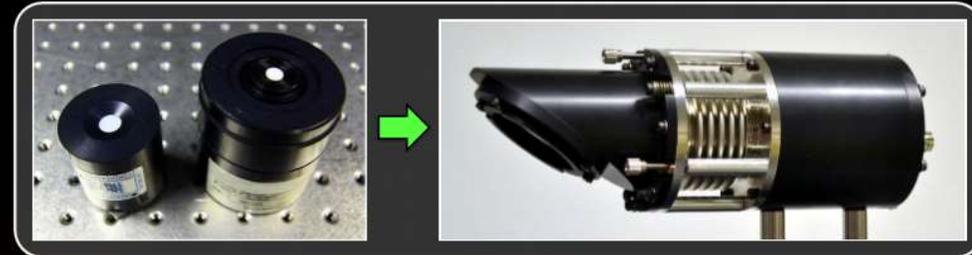
- Standard Illuminant LED based on spectra of white SSL products
 - Replace old CIE Standard Illuminant A in photometry
 - Reduce spectral errors to 1/3 in measurements of SSL
- Photometric LED standard lamps: Luminous intensity and flux
 - Replace old incandescent standard lamps in photometry

WP2: Realisation of LED-based photometric scale

- PQED-reference photometers without optical $V(\lambda)$ -filters
 - Replace $V(\lambda)$ -filtered reference photometers at NMIs
 - Target uncertainty 0.2 % in white LED illuminance
- First ever comparison with LED-based transfer standards
 - Replace old incandescent lamps in intercomparisons

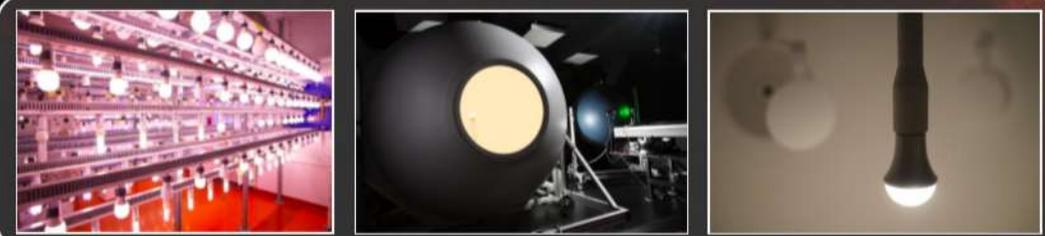


New LED-based photometric standard lamps for luminous intensity and luminous flux



New Reference PQED-photometers without optical $V(\lambda)$ -filters for NMIs

Future Photometry Based on Solid-State Lighting (SSL) Products



Reliable testing of SSL products by lowering uncertainties at test laboratories



Measurement of light with photometers calibrated using LED standard lamps

WP3: Transfer of luminous flux to test laboratories

- Novel fish-eye camera for spatial correction of SSL products
- Full characterisation of the DC- and AC-operated flux lamps
 - Luminous flux and spectral radiant flux to test laboratories
- First ever luminous flux comparison using LED standard lamps
 - Demonstration of 1 % uncertainty of SSL luminous efficacy

WP4: Creating impact

- Revolutionary photometric system with full support for SSL
- Excellent connections with CIE, *Actions by new standards*
- Business opportunities for European industrial partners
- Reliable testing of new SSL products coming to market
 - Achieving the goals of EU2020 energy-saving strategy



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New: reporterships / Research Fora / Liaisons

- New Research Forum Proposal: BRDF data handling and visualization
xD Reflect
- New Reportership Proposal: Metrology of laser-based lighting
- New Reportership Proposal: Measurement of Effective Intensity of Flashing
Lights
- New Liaison Proposal: International SSL Alliance

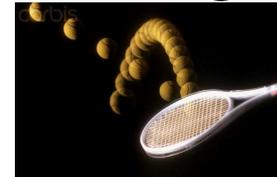


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Urgent TCs

- TC 2-83: CIE Standard on test methods for OLED light sources
- TC 2-86: Glare Measurement by Imaging Luminance Measurement Device (ILMD)
- TC 2-88: Standard Reference Solar Spectra for Industrial Applications
- TC 2-89: Measurement of Temporal Light Modulation of Light Sources and Lighting Systems





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Internationale Beleuchtungskommission

New Research Fora

1 TITLE: MATTERS RELATING TO TEMPORAL LIGHT MODULATION

Name and contact details of proposed convenor: Jennifer Veitch, j_a_veitch@jdarchitect.ca

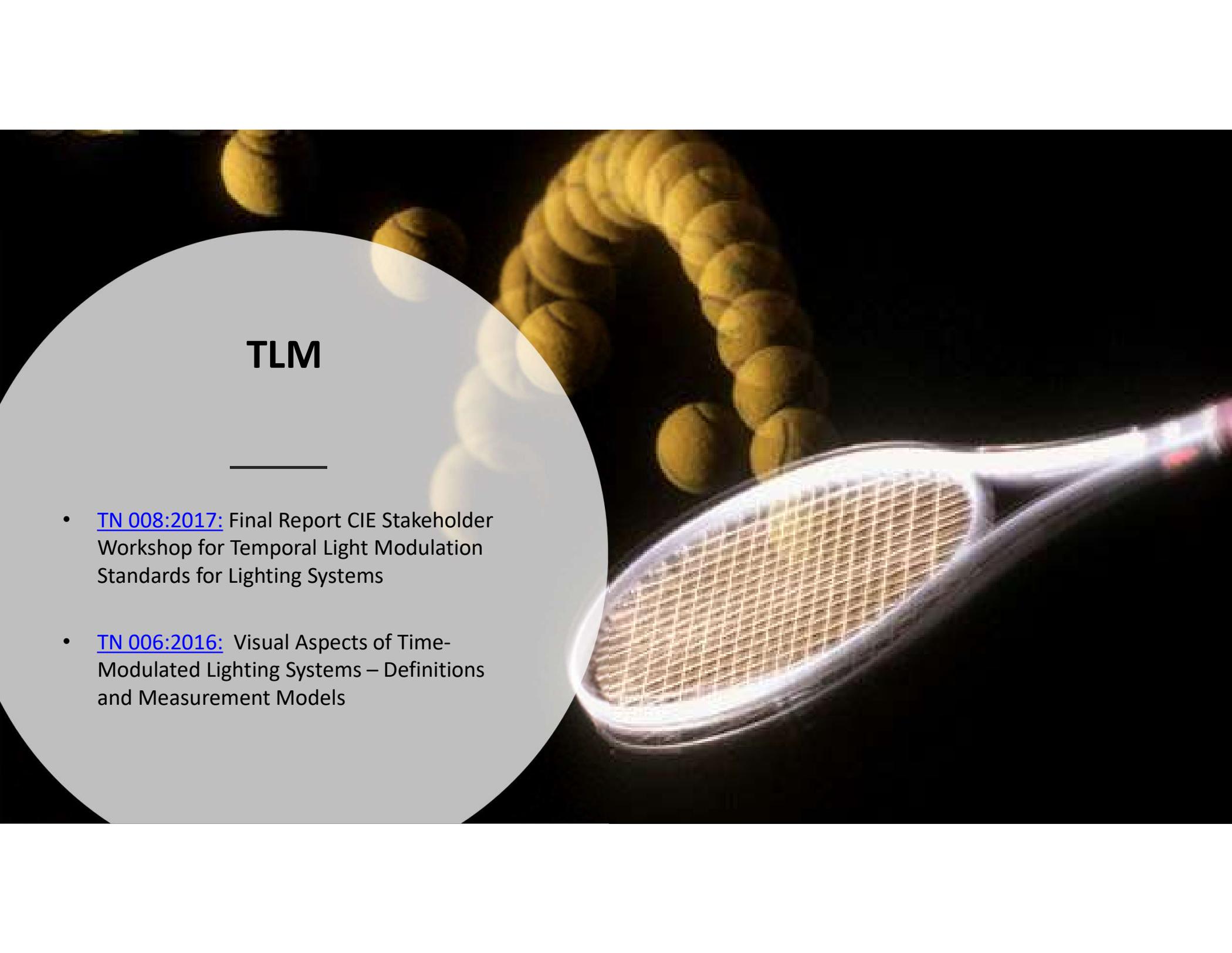
Which field is your proposal intended to cover?

This cover all matters related to temporal light modulation, as outlined in CIE TN 008:2017

2 SCOPE

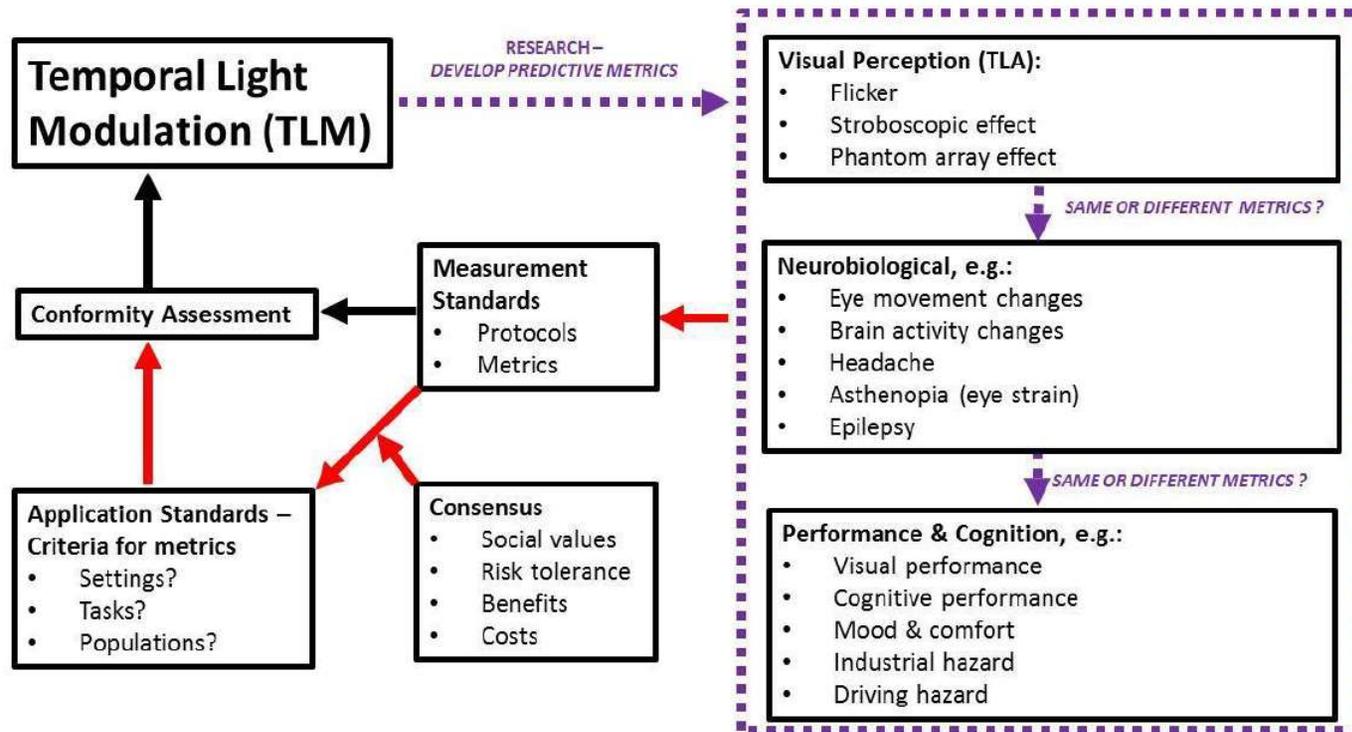
This research forum follows the CIE Stakeholder Workshop for Temporal Light Modulation Standards for Lighting Systems and is one of the tasks specified in the road map in TN 008:2017. The RF will provide a discussion and information- and data-sharing platform for all aspects of temporal light modulation of lighting systems. These can include discussions relating to the measurement of TLM waveforms (informal discussions in support of TC 2-89), visual performance, or health effects of TLM, prediction of these effects from metrics that may be proposed, and application-specific considerations related to lighting systems used in any setting. It is intended to use this platform to involve other stakeholders, bringing in all experts with a genuine interest in the topic so that CIE builds on its leadership in this topic area.

Note that the scope includes the involvement of all CIE Divisions.

A tennis racket and a string of tennis balls are shown against a dark background. The racket is in the foreground, and the balls are in the background, creating a sense of depth. The racket's strings are illuminated, and the balls are also lit, with some appearing as bright spots.

TLM

- [TN 008:2017](#): Final Report CIE Stakeholder Workshop for Temporal Light Modulation Standards for Lighting Systems
- [TN 006:2016](#): Visual Aspects of Time-Modulated Lighting Systems – Definitions and Measurement Models





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D2 Ballots since last meeting

- LB D02-1608 NC/DIV/BA commenting on DIS 017:2016 ILV 2nd Ed.
- **LB D02-1607: new TC on TLA / change of reporters**
- **LB D02-1606: creation of new TC on revision of CIE 85 (solar spectrum)**
- LB D02-1605 D2 voting on AD of TC 2-47
- LB D02-1604 D2 voting on AD/TN(2) of TC 2-65
- LB D02-1603 D2 voting on AD/TN(1) of TC 2-65



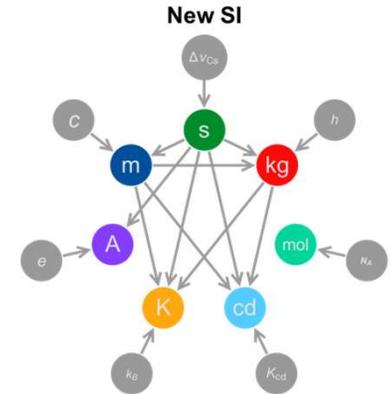
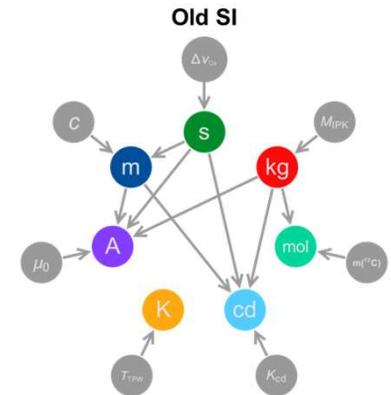
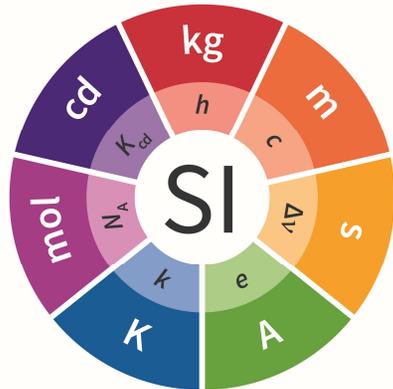
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D2 Ballots since last meeting

- LB D02-1708 DIV voting on AD/TR of TC 2-64
- LB D02-1707 DIV voting on AD/TR of TC 2-63
- LB D02-1706 DIV voting on AD/TN of DR 3-32
- LB D02-1705 DIV commenting on ED/TN of DR 3-32
- LB D02-1704 DIV voting on AD/TN of JTC 1
- LB D02-1703 DIV commenting on ED/TR of TC 2-64
- LB D02-1702 DIV commenting on ED/TR of TC 2-63
- LB D02-1701 DIV commenting on ED/TN of JTC 1

Herdefinitie van SI-stelsel: kilogram, ampere, kelvin & mole

- Het SI-stelsel is een wereldwijde aanpak en benadering
- Het SI-stelsel gebruikt regels van de natuur om regel voor meten te creëren
- De wijzigingen aan het SI-stelsel vormen een springplank voor toekomstige innovatie



<https://www.bipm.org>



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MoU between CIE and EURAMET



Signed May 2017: Dr Beat Jeckelmann and Dr. Yoshi Ohno



Division 2 Annual Meeting 2018 Eindhoven

- Tue, June 12, 2018: Workshop on selected LED related topics organized NSVV
- Wed, June 13, 2018: D2 meeting
- Thu, June 14, 2018: TC meetings
- Fri, June 15, 2018: TC meetings



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Vragen?

pdekker@vsl.nl