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

US National Committee of the CIE
http://www.cie-usnc.org

CIE Webinar : Datasets

Jennifer Veitch (CIE President)

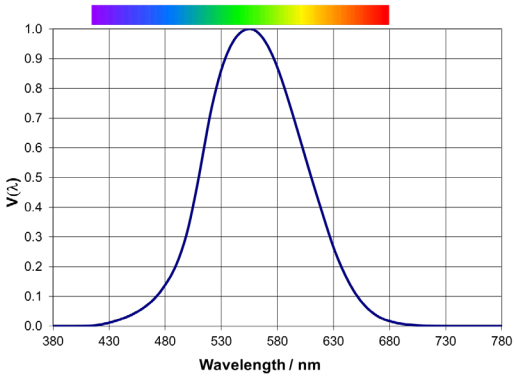
Peter Blattner (Chair of CIE TG Digital Products)

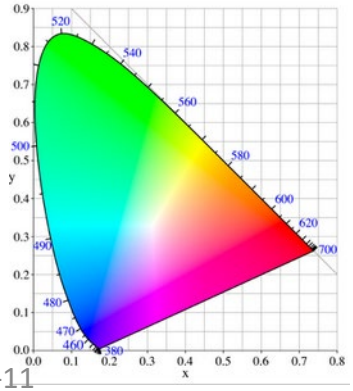
Central Bureau
Babenbergerstraße 9/9A, A-1010 Vienna, Austria
T: +43 1 714 31 87
ZVR: 640982399
E-Mail: ciecb@cie.co.at

What is the CIE?

http://www.cie-usnc.org

The International Commission on Illumination (CIE) is a **global non-profit** organization dedicated to advancing the **science, technology, and art of light and lighting**, encompassing the full range of related topics including **scientific fundamentals** such as **vision**, **colour**, the **metrology** of optical radiation, **photobiology**, and **photochemistry**, as well as lighting applications indoors, outdoors, and in image technology. The CIE provides a forum for diverse **open expert discussion** and information exchange within, between, and beyond these fields.





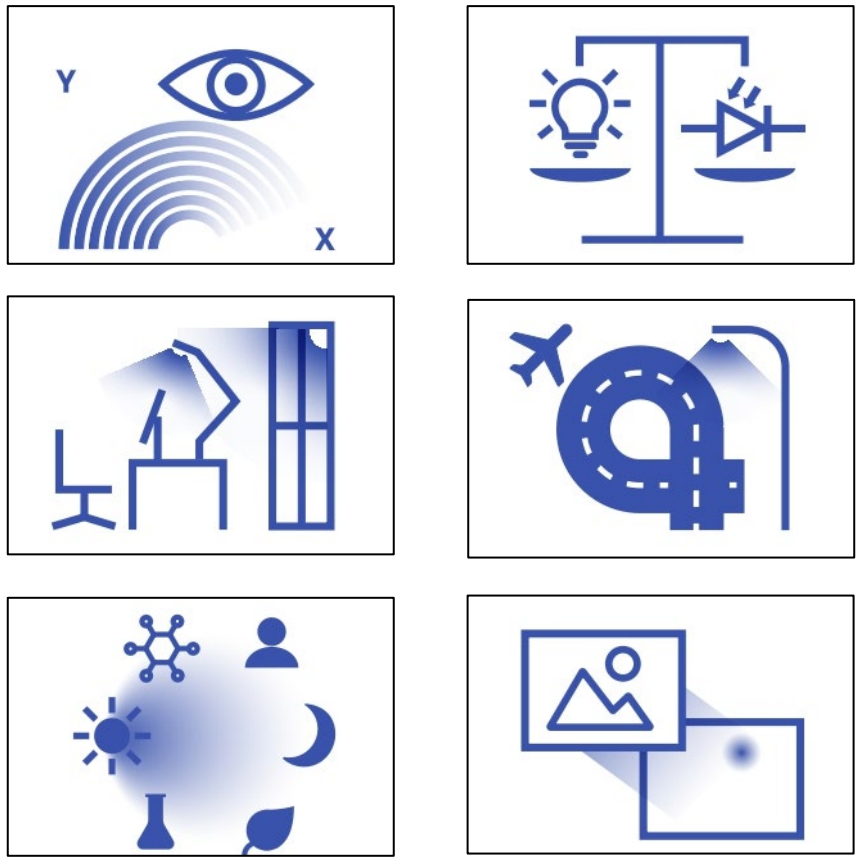
Our activities

http://www.cie-usnc.org

- Support science, promote discussion and information exchange
- Develop and promote consensus within our scope with publications

How we work

US National Committee of the CIE
http://www.cie-usnc.org



- Our 6 Divisions each establish work plans in which technical committees (TCs) form to address a specific question; some may be inter-divisional, and others may be joint with another organization.
- TC proposals are reviewed and approved by the national members in the sponsoring Division(s) and by the CIE leadership.
- TCs must have at least 5 expert members from 5 countries to initiate work.
  - TC Chair accepts members on the basis of having relevant expertise and willingness to contribute.

National Committees (not complete)

China

NC CIE Italia

Switzerland

US National Committee of the CIE
http://www.cie-usnc.org

Austria

Hungary

Sweden

Belgium

US National Committee of the CIE

Netherlands

International Commission on Illumination
Commission Internationale de l'Eclairage
Internationale Beleuchtungskommission
Canadian National Committee Comité national canadien

Germany

Norway

Turkey

Serbia

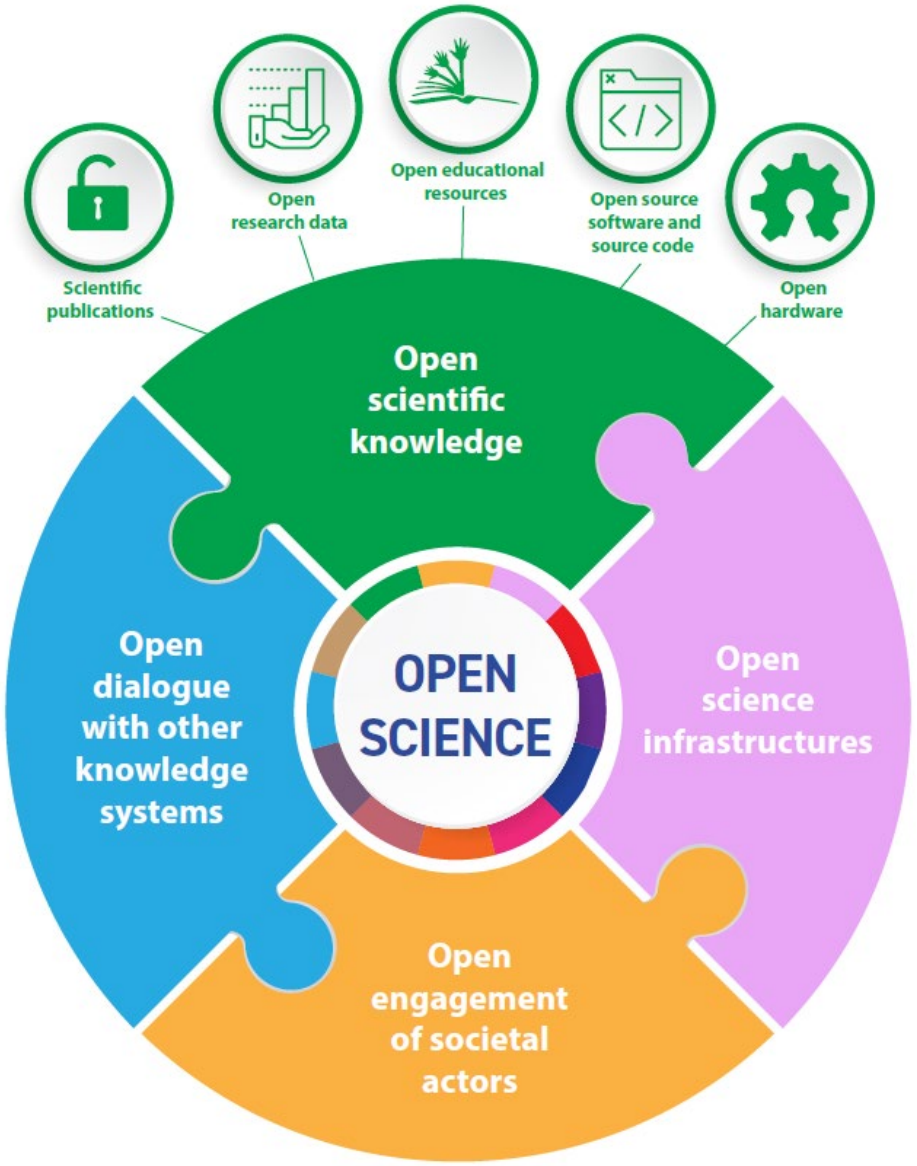
Netherlands

NC Israel

Spain

Australia

http://www.cie-usnc.org



Open science:

- increases scientific collaborations and sharing of information for the benefits of science and society;
- makes multilingual scientific knowledge openly available, accessible and reusable for everyone; and
- opens the processes of scientific knowledge creation, evaluation and communication to societal actors beyond the traditional scientific community.

https://www.unesco.org/en/open-science

Joint Statement of Intent on the digital transformation in the international scientific and quality infrastructure

CIPM Digital SI

ISO
(Sergio Mujica Secretary-General)

CIPM
(Wynand Louw President)

ISC
(Mathieu Denis Science Dir.)

CODATA
(Barend Mons President)

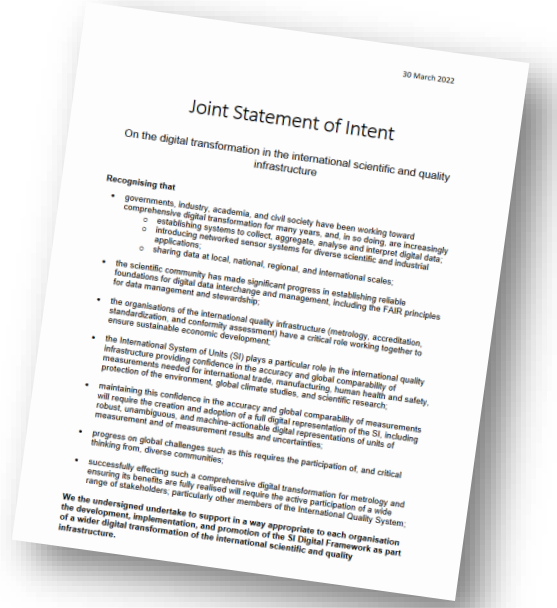
CIE
(Peter Blattner President)

IEC
(Philippe Metzger Secretary-General & CEO)

ILAC
(Etty Feller Chair)

IMEKO
(Frank Härtig President)

CIML
(Roman Schwartz President)



30 March 2022

Joint Statement of Intent

On the digital transformation in the international scientific and quality infrastructure

Recognising that

- governments, industry, academia, and civil society have been working toward comprehensive digital transformation for many years, and, in so doing, are increasingly
  - establishing systems to collect, aggregate, analyse and interpret digital data;
  - introducing networked sensor systems for diverse scientific and industrial applications;
  - sharing data at local, national, regional, and international scales;
- the scientific community has made significant progress in establishing reliable foundations for digital data interchange and management, including the FAIR principles for data management and stewardship;
- the organisations of the international quality infrastructure (metrology, accreditation, standardization, and conformity assessment) have a critical role working together to ensure sustainable economic development;
- the International System of Units (SI) plays a particular role in the international quality infrastructure providing confidence in the accuracy and global comparability of measurements needed for international trade, manufacturing, human health and safety, protection of the environment, global climate studies, and scientific research;
- maintaining this confidence in the accuracy and global comparability of measurements will require the creation and adoption of a full digital representation of the SI, including robust, unambiguous, and machine-actionable digital representations of units of measurement and of measurement results and uncertainties;
- progress on global challenges such as this requires the participation of, and critical thinking from, diverse communities;
- successfully effecting such a comprehensive digital transformation for metrology and ensuring its benefits are fully realised will require the active participation of a wide range of stakeholders, particularly other members of the International Quality System;

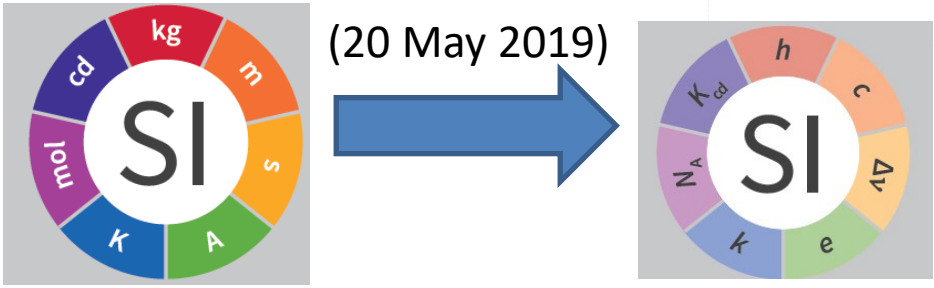
We the undersigned undertake to support in a way appropriate to each organisation the development, implementation, and promotion of the SI Digital Framework as part of a wider digital transformation of the international scientific and quality infrastructure.

https://www.bipm.org/en/liaison/digital-transformation

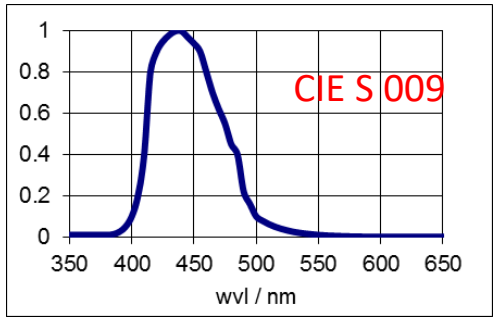
CIE - CIPM Agreement

http://www.cie-usnc.org

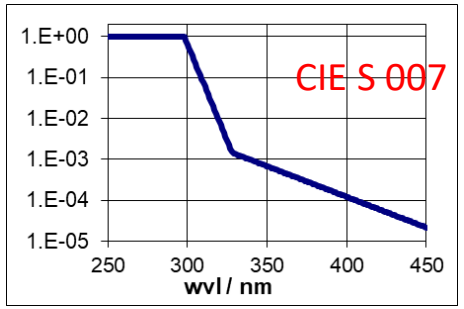
- CIPM : defines units



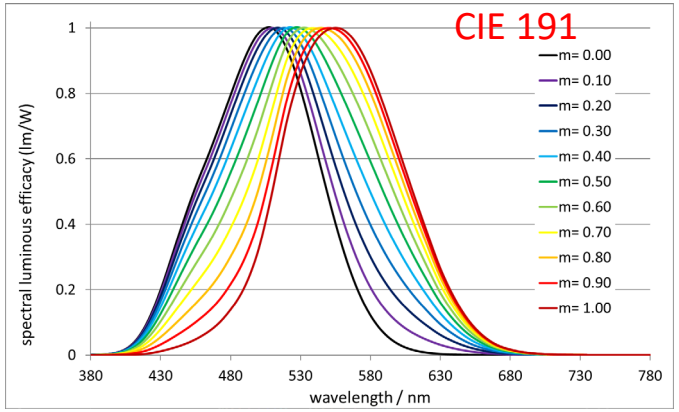
- CIE: quantities (in the field of light and lighting) and action spectra



BLH



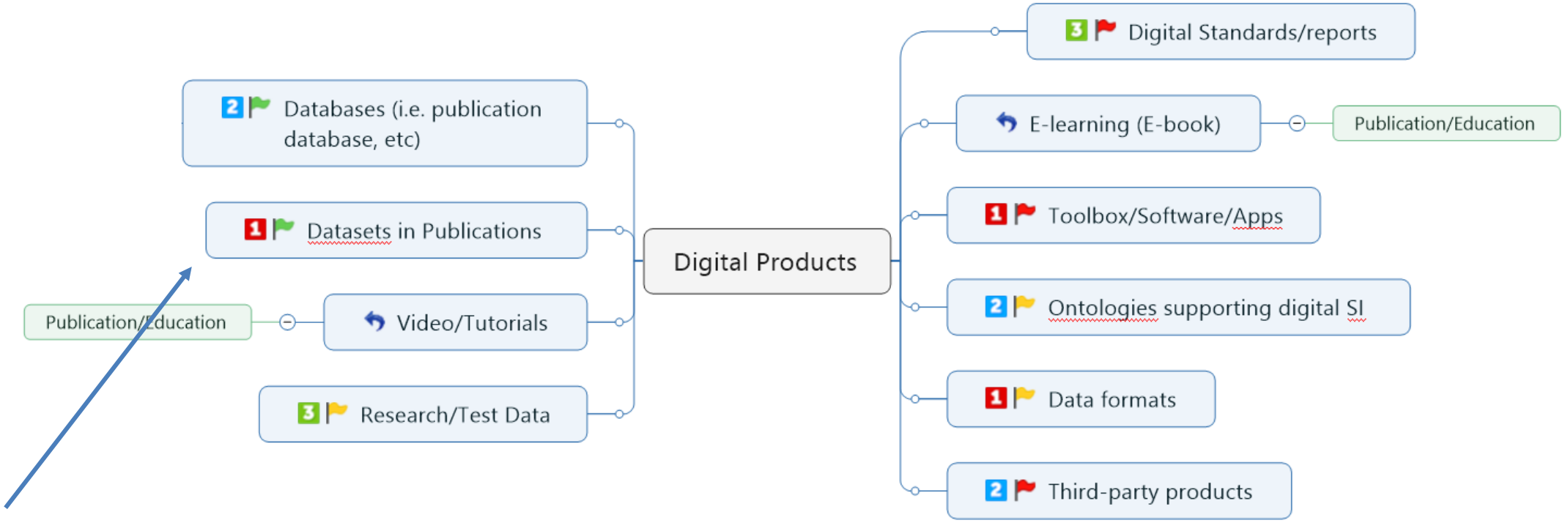
erythma



mesopic observer

CIE Board Task Group *Digitalization*: Brainstorming

US National Committee of the CIE
http://www.cie-usnc.org



Make Datasets available under the FAIR principle

Low Hanging Fruit
Intermediate Complexity
Difficult

High Priority
Mid Priority
Low Priority

ISBN 978-3-902842-24-4
DOI: 10.25039/TR.018.2019

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

TECHNICAL REPORT

The Basis of Physical Photometry, 3rd Edition

10 Tables

Table 1 – Values of spectral luminous efficiency for photopic vision, $V(\lambda)$ (λ in standard air)

λ/nm	$V(\lambda)$	λ/nm	$V(\lambda)$	λ/nm	$V(\lambda)$
360	0,000 003 917 000 0	401	0,000 433 714 700 0	442	0,025 610 240 000 0
361	0,000 004 393 581 0	402	0,000 473 024 000 0	443	0,026 958 570 000 0
362	0,000 004 929 604 0	403	0,000 517 876 000 0	444	0,028 351 250 000 0
363	0,000 005 532 136 0	404	0,000 572 218 700 0	445	0,029 800 000 000 0
364	0,000 006 208 245 0	405	0,000 640 000 000 0	446	0,031 310 830 000 0
365	0,000 006 965 000 0	406	0,000 724 560 000 0	447	0,032 883 680 000 0
366	0,000 007 813 219 0	407	0,000 825 500 000 0	448	0,034 521 120 000 0
367	0,000 008 767 336 0	408	0,000 941 160 000 0	449	0,036 225 710 000 0
368	0,000 009 839 844 0	409	0,001 069 880 000 0	450	0,038 000 000 000 0
369	0,000 011 043 230 0	410	0,001 210 000 000 0	451	0,039 846 670 000 0
370	0,000 012 390 000 0	411	0,001 362 091 000 0	452	0,041 768 000 000 0
371	0,000 013 886 410 0	412	0,001 530 752 000 0	453	0,043 766 000 000 0
372	0,000 015 557 280 0	413	0,001 720 368 000 0	454	0,045 842 670 000 0
373	0,000 017 442 960 0	414	0,001 935 323 000 0	455	0,048 000 000 000 0
374	0,000 019 583 750 0	415	0,002 180 000 000 0	456	0,050 243 680 000 0
375	0,000 022 020 000 0	416	0,002 454 800 000 0	457	0,052 573 040 000 0
376	0,000 024 839 650 0	417	0,002 764 000 000 0	458	0,054 980 560 000 0
377	0,000 028 041 260 0	418	0,003 117 800 000 0	459	0,057 458 720 000 0
378	0,000 031 531 040 0	419	0,003 526 400 000 0	460	0,060 000 000 000 0
379	0,000 035 215 210 0	420	0,004 000 000 000 0	461	0,062 601 970 000 0
380	0,000 039 000 000 0	421	0,004 546 240 000 0	462	0,065 277 520 000 0
381	0,000 042 826 400 0	422	0,005 159 320 000 0	463	0,068 042 080 000 0
382	0,000 046 914 600 0	423	0,005 829 280 000 0	464	0,070 911 090 000 0

Overview of published datasets (not complete)

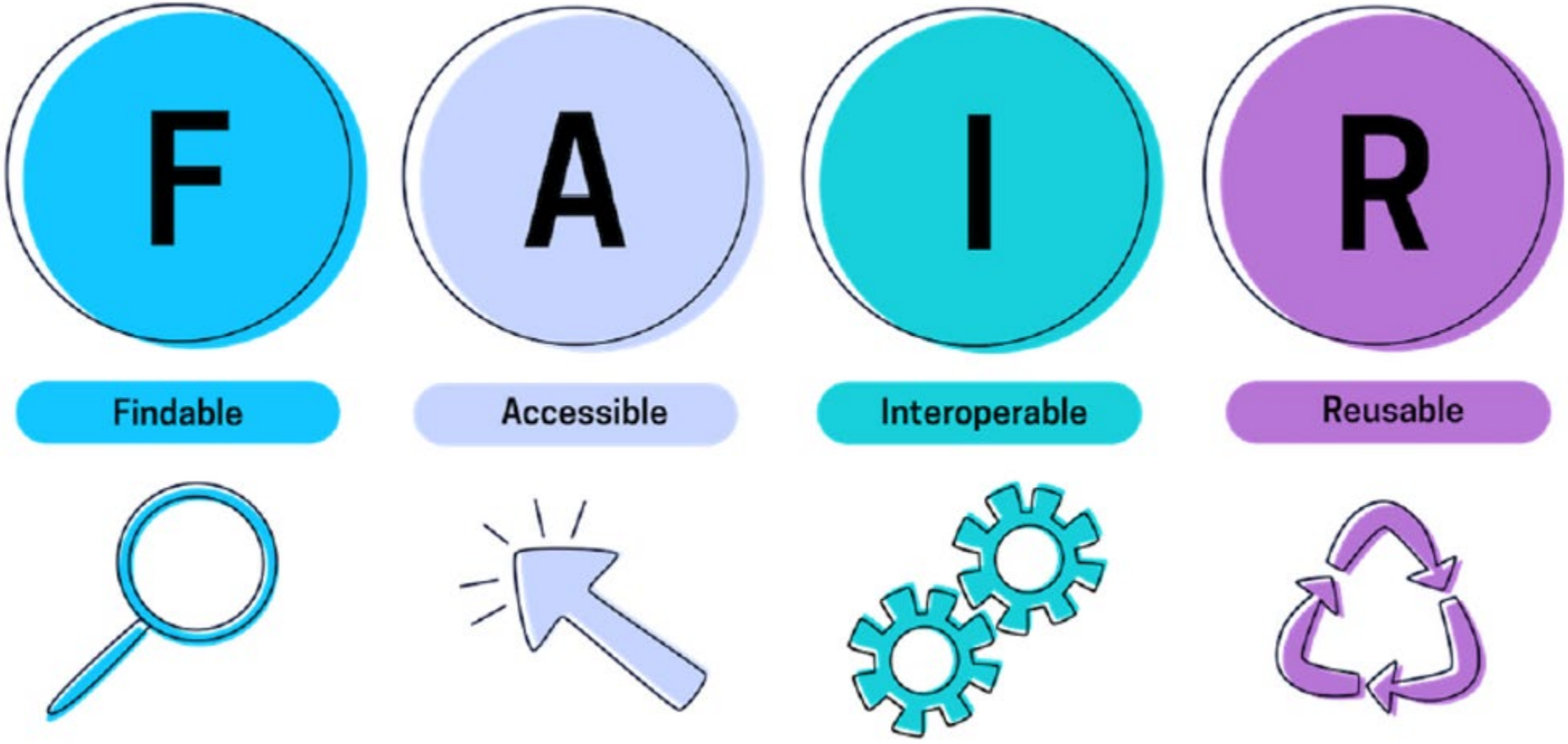
US National Committee of the CIE
http://www.cie-usnc.org

- Free available available through CIE webpage
  - CIE 015:2018: selected tables (5 nm)
  - CIE 184:2009: spectral transmittance
  - CIE S 026:2018: toolbox, action spectra
- Free available through other sources:
  - CIE 13.3:1995 spectral radiance values
  - CIE 018: 2019 1-nm luminous efficiencies
  - CIE 224:2017 toolbox
  - CIE 015:2018 most of the tables
  - CIE 170-2:2015: Cone fundamentals
  - ISO/CIE 11664-x Colorimetry series

«It is better if we publish our data than others do.»

FAIR Principle

https://www.go-fair.org/fair-principles



FAIR Principle

- ***Findable***
  - Persistent identifier (e.g. DOI)
  - Rich metadata
- ***Accessible***
  - Metadata freely accessible (Data not necessary)
  - Metadata schema is published
- ***Interoperable***
  - Established Data-format,
  - Format description publically available
- ***Reusable***
  - Information about the license shall be provided
  - metadata and data should be well-described so that they can be replicated and/or combined in different settings.

Metadata

- Metadata (or metainformation) is “(structured) data that provides information about other data“ but not the content of the data (Wikipedia)

Data

360	0,000 003 917 000 0
361	0,000 004 393 581 0
362	0,000 004 929 604 0
363	0,000 005 532 136 0
364	0,000 006 208 245 0
365	0,000 006 965 000 0
366	0,000 007 813 219 0
367	0,000 008 767 336 0
368	0,000 009 839 844 0
369	0,000 011 043 230 0
370	0,000 012 390 000 0
371	0,000 013 886 410 0
372	0,000 015 557 280 0
373	0,000 017 442 960 0

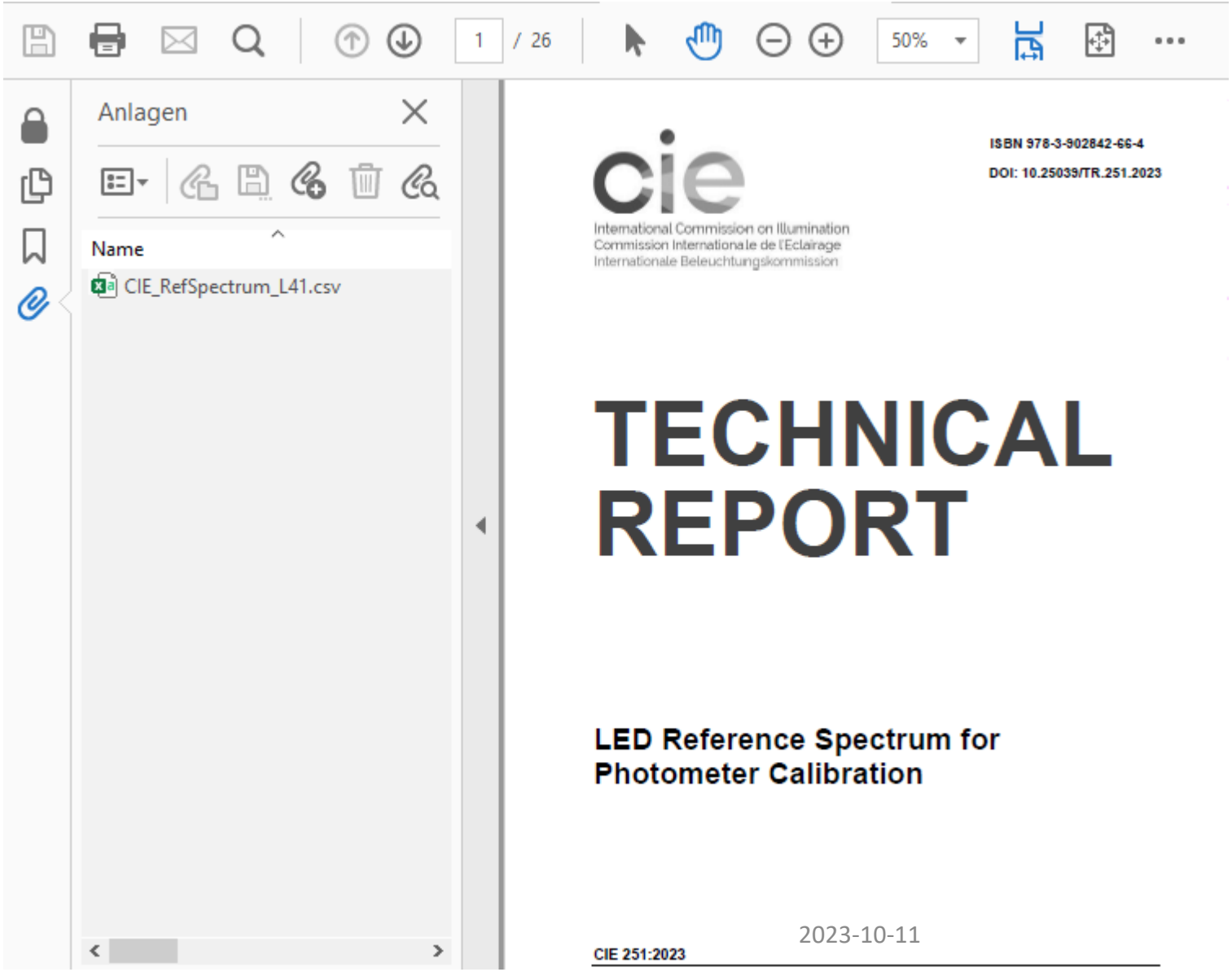
Metadata

-Author
-Filesize
-Number of Columns
-Date of Creation
-Version
-Data-Format
-….

-> (Meta-)Data Model / Schema

http://www.cie-usnc.org

Where to find the datasets ?
Embeded into CIE Publications



PDF/A-3
ISO 19005-3
Machine readable

Where to find the datasets?

US National Committee of the CIE
http://www.cie-usnc.org

- https://cie.co.at/data-tables

CIE 1931 chromaticity coordinates of spectrum loci, 2 degree observer
CIE 1931 colour-matching functions, 2 degree observer - 5nm
CIE 1931 colour-matching functions, 2 degree observer
CIE 1964 chromaticity coordinates of spectrum loci, 10 degree observer
CIE 1964 colour-matching functions, 10 degree observer

CIE 1931 COLOUR-MATCHING FUNCTIONS, 2 DEGREE OBSERVER

data →

Data set: CIE_xyz_1931_2deg.csv

Description: CIE 1931 colour-matching functions (x_bar, y_bar, z_bar), 2 degree observer, 1 nm wavelength steps, original source: CIE 018:2019, Table 6

metadata →

Metadata file: CIE_xyz_1931_2deg.csv_metadata.json

Related CIE publication 1: CIE 018:2019 The Basis of Physical Photometry, 3rd Edition

Related CIE publication 2: CIE 015:2018 Colorimetry, 4th Edition

Related CIE publication 3: ISO/CIE 11664-1:2019(E) Colorimetry — Part 1: CIE standard colorimetric observers

Checksum (md5): 17cca777db64b17170f06f67ce9d3ab7

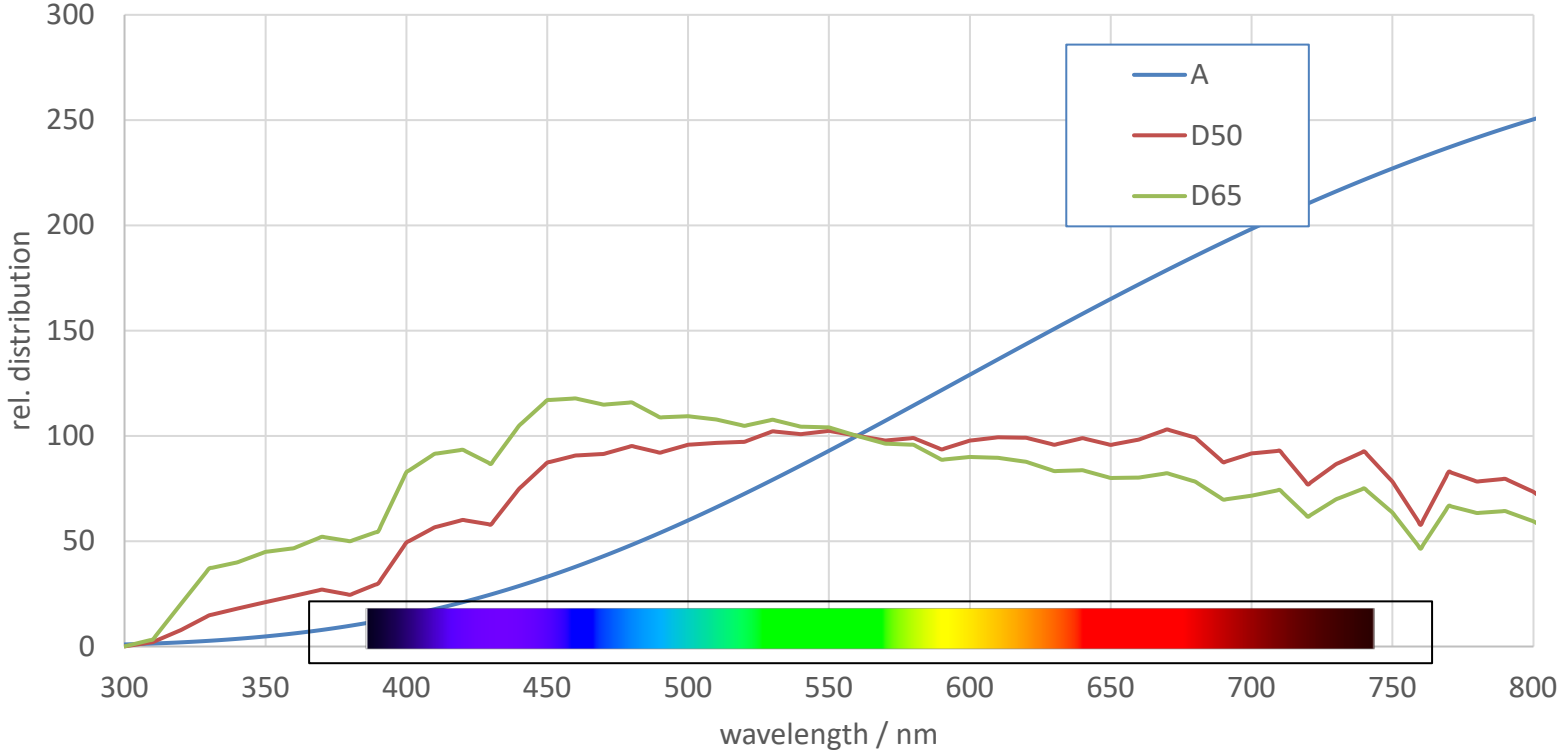
How to link to this page by DOI: 10.25039/CIE.DS.xvudnb9b

How to cite this data set: CIE 2018, CIE 1931 colour-matching functions , 2 degree observer (data table), International Commission on Illumination (CIE), Vienna, Austria, DOI:10.25039/CIE.DS.xvudnb9b

Which data sets are available?

US National Committee of the CIE
http://www.cie-usnc.org

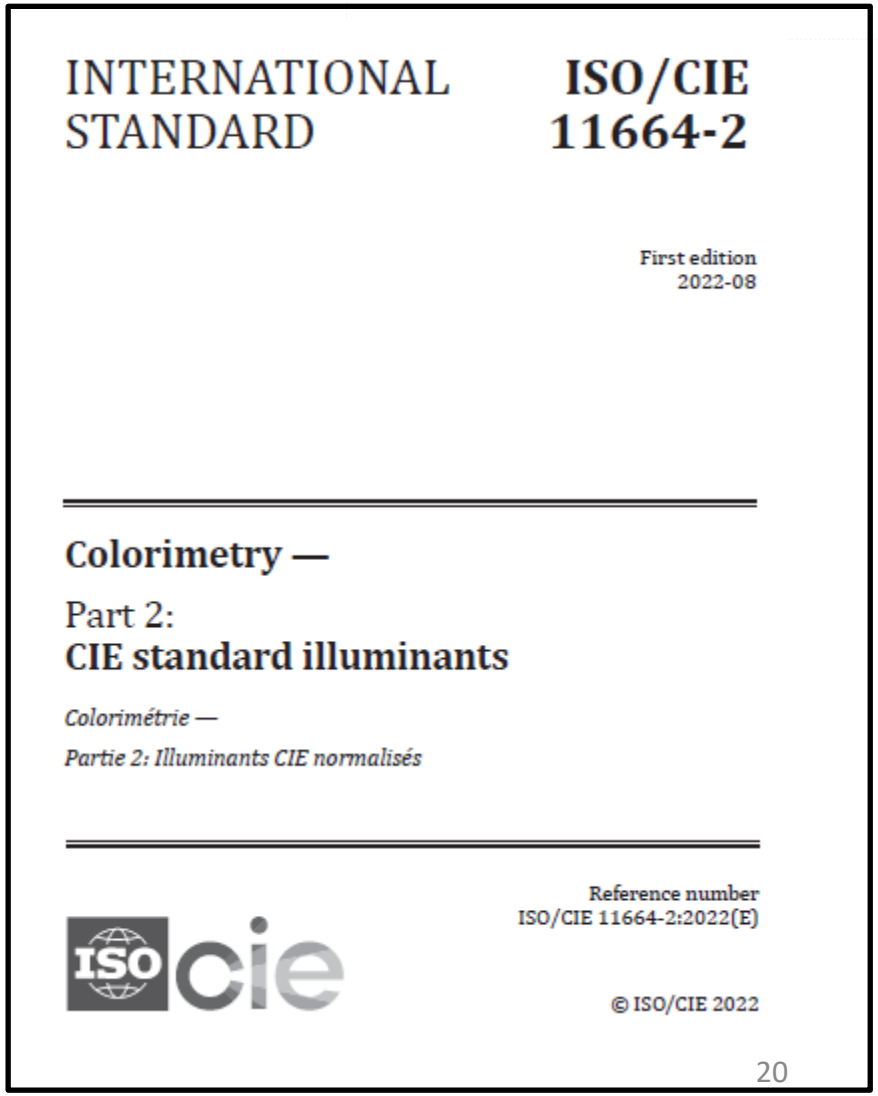
CIE Standard Illuminants



https://doi.org/10.25039/CIE.DS.8jsxjrsn

https://doi.org/10.25039/CIE.DS.etgmuqt5

https://doi.org/10.25039/CIE.DS.hjfjmt59



INTERNATIONAL STANDARD

ISO/CIE 11664-2

First edition
2022-08

Colorimetry —

Part 2:
CIE standard illuminants

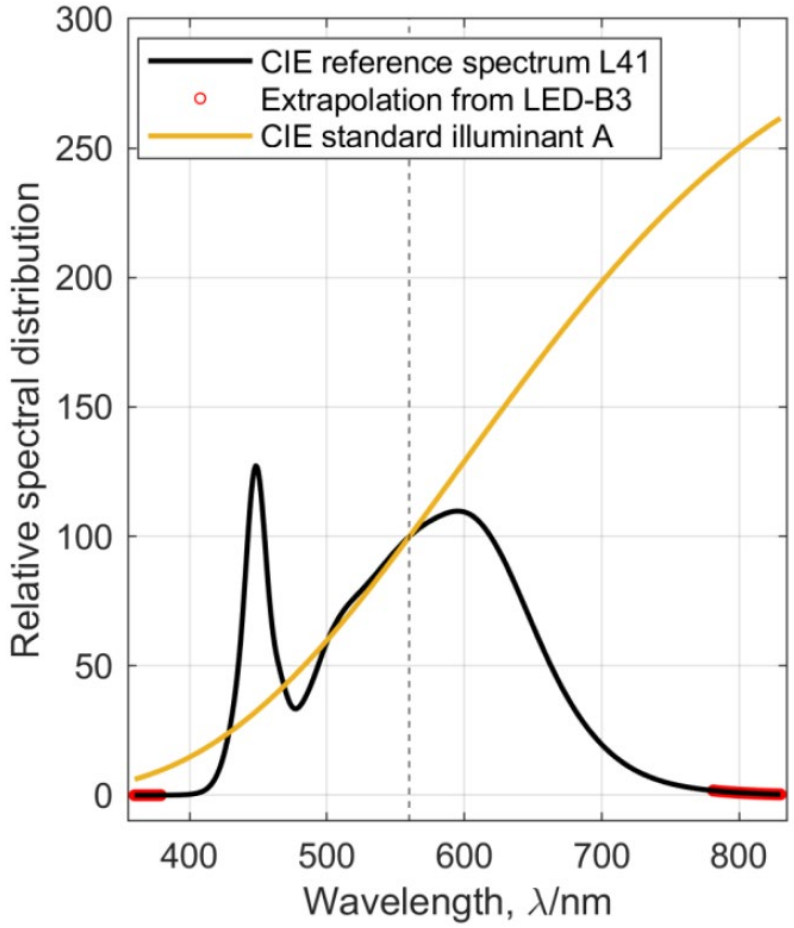
Colorimétrie —

Partie 2: Illuminants CIE normalisés

Reference number
ISO/CIE 11664-2:2022(E)

© ISO/CIE 2022

LED Reference Spectrum



https://doi.org/10.25039/CIE.DS.van56dfj

ISBN 978-3-902842-66-4
DOI: 10.25039/TR.251.2023

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

TECHNICAL REPORT

LED Reference Spectrum for Photometer Calibration

CIE 251:2023

US National Committee of the CIE
http://www.cie-usnc.org

Cone-Fundamentals

US National Committee of the CIE

http://www.cie-usnc.org

CIE cone-fundamental-based spectral tristimulus values for 2 degree field size

CIE cone-fundamental-based spectral luminous efficiency function for 2° field size in terms of energy

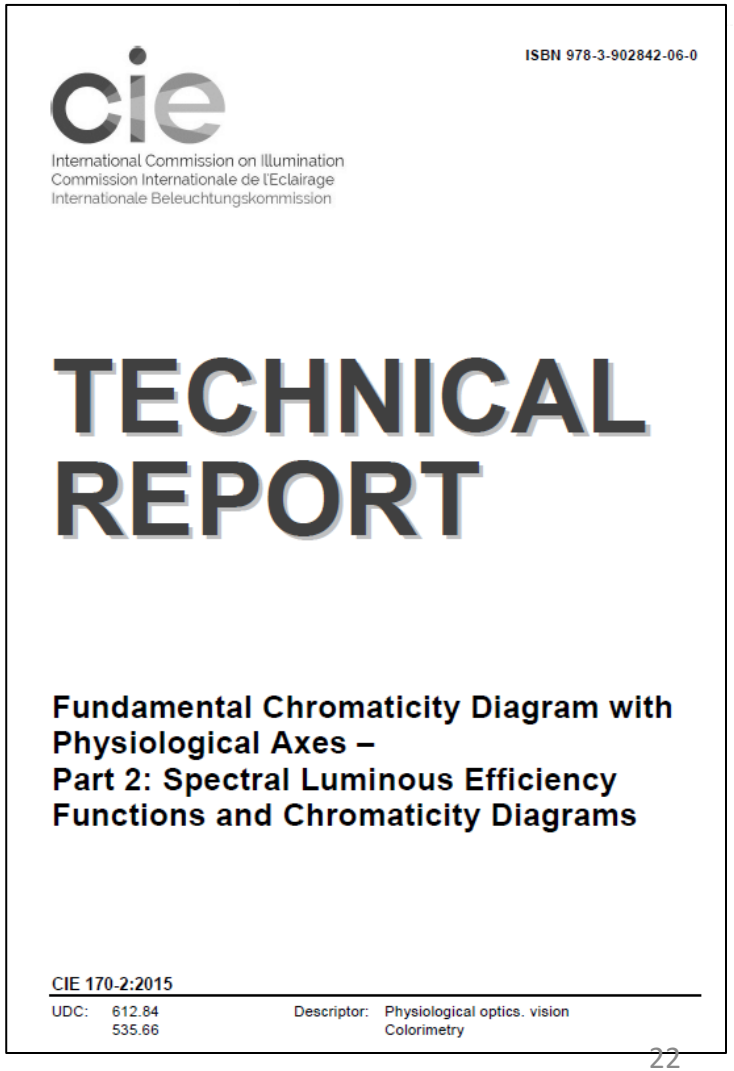
CIE cone-fundamental-based spectral tristimulus values for 10°field size

CIE cone-fundamental-based spectral luminous efficiency function for 10° field size in terms of energy

CIE 2006 LMS cone fundamentals for 2° field size in terms of energy

CIE 2006 LMS cone fundamentals for 10° field size in terms of energy

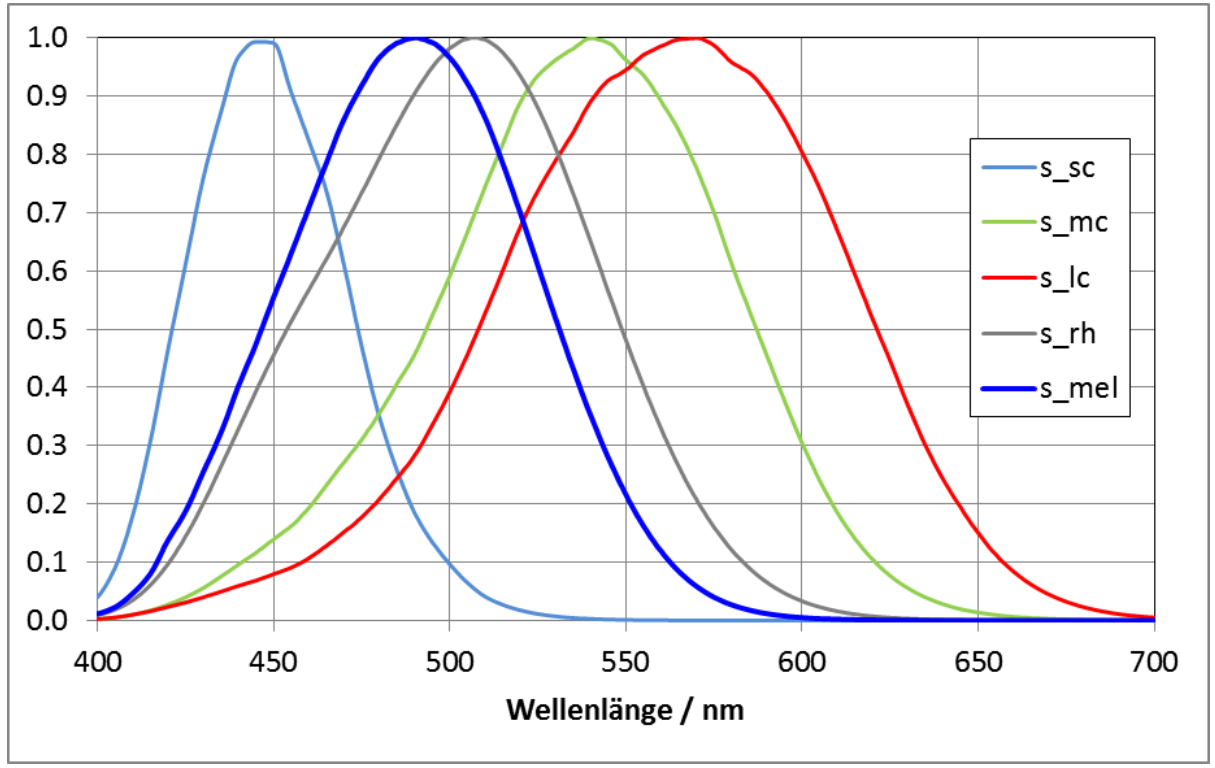
2023-10-11



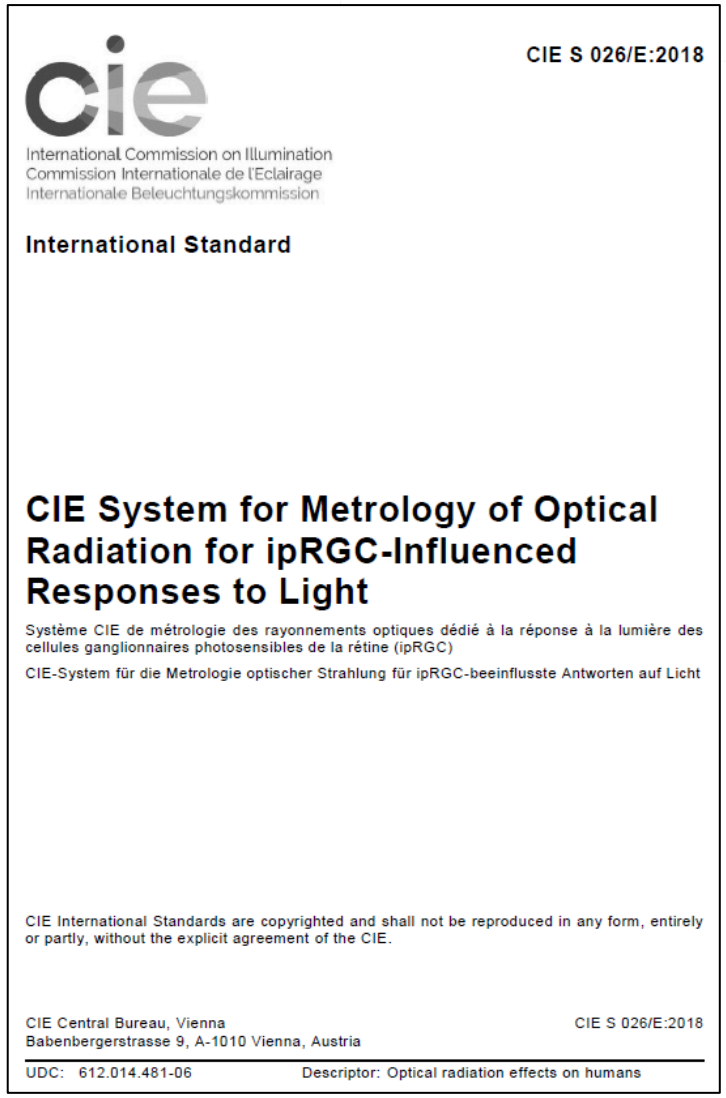
CIE S 026 – *CIE System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light*

Action Spectra

US National Committee of the CIE
http://www.cie-usnc.org



https://doi.org/10.25039/CIE.DS.vqqhzp5a



CIE S 026/E:2018

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

International Standard

CIE System for Metrology of Optical Radiation for ipRGC-Influenced Responses to Light

Système CIE de métrologie des rayonnements optiques dédié à la réponse à la lumière des cellules ganglionnaires photosensibles de la rétine (ipRGC)

CIE-System für die Metrologie optischer Strahlung für ipRGC-beeinflusste Antworten auf Licht

CIE International Standards are copyrighted and shall not be reproduced in any form, entirely or partly, without the explicit agreement of the CIE.

CIE Central Bureau, Vienna
Babenbergerstrasse 9, A-1010 Vienna, Austria
CIE S 026/E:2018

UDC: 612.014.481-06 Descriptor: Optical radiation effects on humans

Many more…

US National Committee of the CIE
http://www.cie-usnc.org

- CIE 1931 chromaticity coordinates of spectrum loci, 2 degree observer
- CIE 1931 colour-matching functions, 2 degree observer
- CIE 1964 chromaticity coordinates of spectrum loci, 10 degree observer
- CIE 1964 colour-matching functions, 10 degree observer
- Spectral radiance factors of 99 test samples for the CIE colour fidelity index calculation
- Relative spectral power distributions of illuminants representing typical LED lamps

Data

- CSV (comma separated values) without header row
  - Platform independent
  - Language independent
  - Open format according RFC4180

```
360,0.000129900000,0.0000039170000,0.000606100000
361,0.000145847000,0.0000043935810,0.000680879200
362,0.000163802100,0.0000049296040,0.000765145600
363,0.000184003700,0.0000055321360,0.000860012400
364,0.000206690200,0.0000062082450,0.000966592800
365,0.000232100000,0.0000069650000,0.001086000000
366,0.000260728000,0.0000078132190,0.001220586000
367,0.000293075000,0.0000087673360,0.001372729000
368,0.000329388000,0.0000098398440,0.001543579000
369,0.000369914000,0.0000110432300,0.001734286000
```

Metadata

- CIE Metadata schema is based on a widely used schema
  - **Datacite.org** (https://schema.datacite.org/meta/kernel-4.4/)

- With additional fields (i.e. checksum, validation, additional information)

- Established structured format: **JSON**

https://doi.org/10.25039/CIE.SC.4taqevcd

Extract of a metadata-file

DOI prefix for CIE


```
{
    "identifier": {
        "identifier": "10.25039/CIE.DS.xvudnb9b",
        "identifierType": "DOI"
    },
    "creators": [
        {
            "name": "International Commission on Illumination (CIE)",
            "nameType": "Organizational"
        }
    ],
    "titles": [
        {
            "title": "Colour-matching functions of CIE 1931 standard colorimetric
            observer"
        }
    ],
    "publisher": "International Commission on Illumination (CIE), Vienna, AT",
    "publicationYear": "2019",
```

CIE-metadata: Checksums

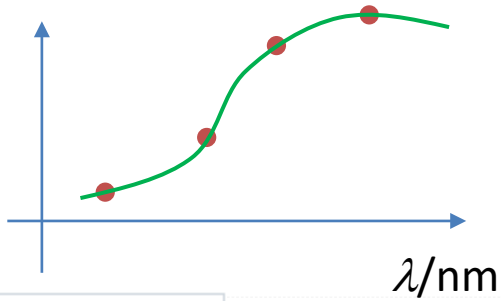
US National Committee of the CIE
http://www.cie-usnc.org

```
"checksums": [
    {
        "hashMethod": "md5",
        "checksum": "17cca777db64b17170f06f67ce9d3ab7"
    },
    {
        "hashMethod": "sha256",
        "checksum":
        "fa663e3535a7e0763a745993a1f0a192eb0275ac46ad2d1befd7626841e713c1"
    }
],
```

Windows-cmd:

certutil -hashfile "CIE_xyz_1931_2deg.csv" MD5

CIE-metadata: Interpolation




```
"interpolationMethod": "linear",
```

Value	Descrition
"nearest"	Chooses the Y value corresponding to the X value that is nearest to the current xi value
"linear"	Sets the interpolated values to points along the line segments connecting the X and Y data points
"cubic-spline"	Guarantees that the first and second derivatives of the cubic interpolating polynomials are continuous, even at the data points
"cubic-Hermite"	Guarantees that the first derivative of the cubic interpolating polynomials is continuous and sets the derivative at the endpoints to certain values in order to preserve the original shape and monotonicity of the Y data.
"Sprague"	Sprague 5 point interpolation as outlined in CIE 167:2005
"Lagrange"	Lagrange Interpolation
"useRelatedDataset"	In some cases interpolation is not recommended but a dataset with different wavelength range is recommended. Example is the 5 nm spectral data given in CIE 015. For those the 1 nm data should be used as published with CIE 018:2019. The related dataset should be stated in the corresponding relatedIdentifier field.
"useRelatedFormula"	In some cases interpolation is not recommended but an explicitely formula shall be used. Example is the Standard illuminant A. The reference to the formula shall be described in the description of the dataset
":unal"	unallowed, suppressed intentionally
":unap"	not applicable, makes no sense

CIE-metadata: Column Headers

US National Committee of the CIE
http://www.cie-usnc.org


```
"columnHeaders": [
    {
        "title": "lambda",
        "unit": "nm",
        "quantity": "wavelength",
        "wavelength_first": 360,
        "wavelength_last": 830,
        "wavelength_step": 1
    },
    {
        "title": "x_bar(lambda)",
        "unit": "dimensionless",
        "quantity": "colour-matching function",
        "wavelength_first": 360,
        "wavelength_last": 830,
        "wavelength_step": 1
    },
```

How to use?

US National Committee of the CIE
http://www.cie-usnc.org

CIE 1931 COLOUR-MATCHING FUNCTIONS, 2 DEGREE OBSERVER

data →

Data set: CIE_xyz_1931_2deg.csv

Description: CIE 1931 colour-matching functions (x_bar, y_bar, z_bar), 2 degree observer, 1 nm wavelength steps, original source: CIE 018:2019, Table 6

metadata →

Metadata file: CIE_xyz_1931_2deg.csv_metadata.json

Related CIE publication 1: CIE 018:2019 The Basis of Physical Photometry, 3rd Edition

Related CIE publication 2: CIE 015:2018 Colorimetry, 4th Edition

Related CIE publication 3: ISO/CIE 11664-1:2019(E) Colorimetry — Part 1: CIE standard colorimetric observers

Checksum (md5): 17cca777db64b17170f06f67ce9d3ab7

How to link to this page by DOI: 10.25039/CIE.DS.xvudnb9b

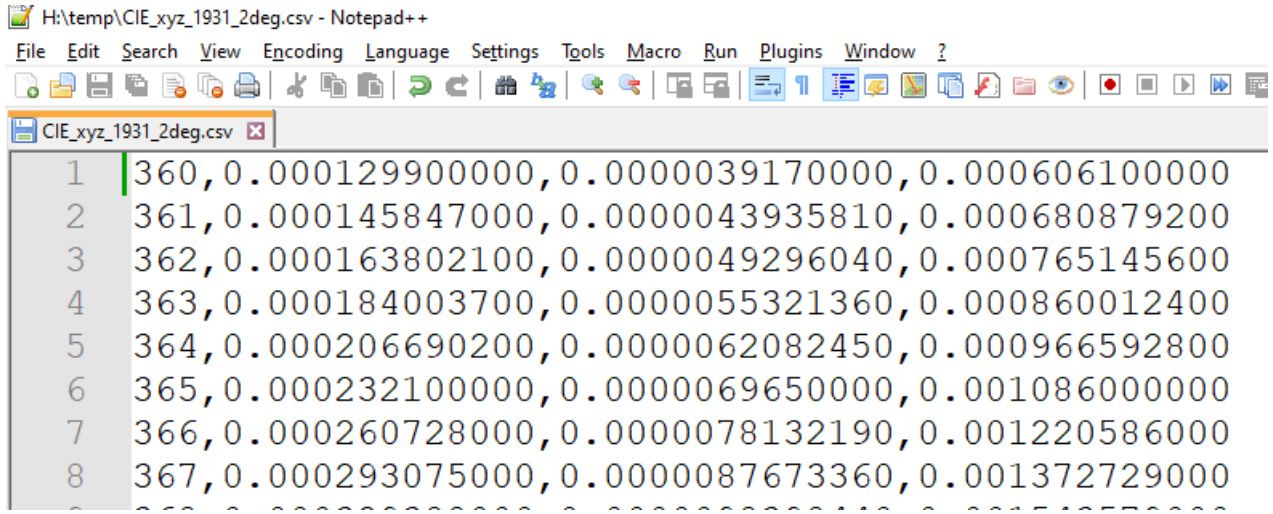
How to cite →

How to cite this data set: CIE 2018, CIE 1931 colour-matching functions , 2 degree observer (data table), International Commission on Illumination (CIE), Vienna, Austria, DOI:10.25039/CIE.DS.xvudnb9b

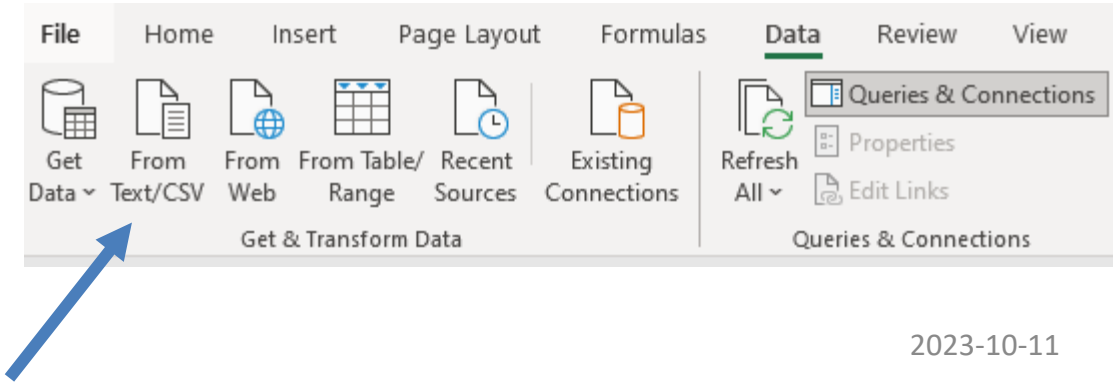
How to read the CSV-files

US National Committee of the CIE
http://www.cie-usnc.org

- Python®,Matlab®,LabView® built-in functions
- Text-editor



- Excel:



How to read the metadata?

- Matlab®

```
>> str = fileread('CIE_xyz_1931_2deg.csv_metadata.json’);
>> data = jsondecode(str);
```

- Python:

Python3

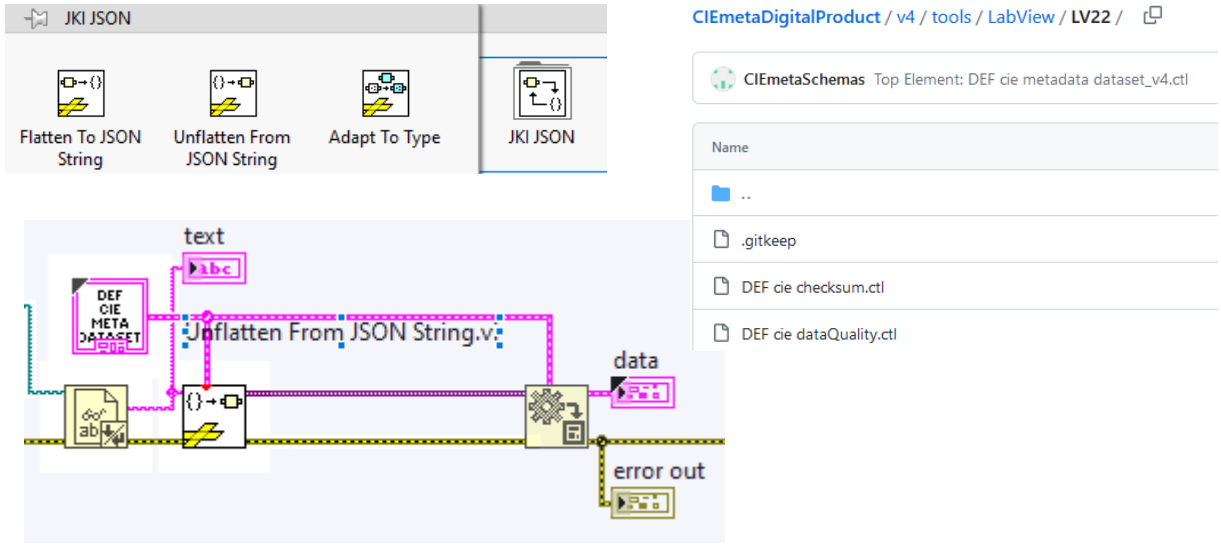
```
# Python program to read
# json file

import json

# Opening JSON file
f = open('data.json')

# returns JSON object as
# a dictionary
data = json.load(f)
```

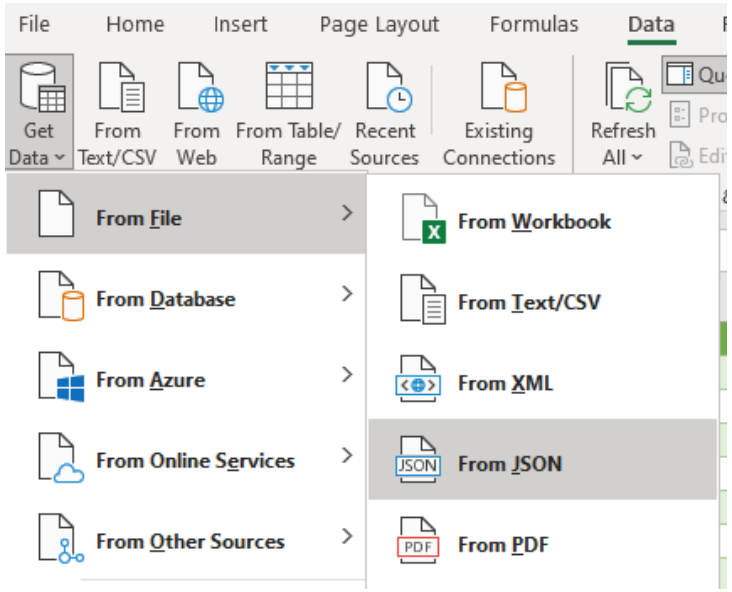
- LabView



How to use the metadata

US National Committee of the CIE
http://www.cie-usnc.org

- Excel®



Name	Value
identifier	[Record]
types	[Record]
datatableInfo	[Record]
creators	[List]
titles	[List]
subjects	[List]
alternateIdentifiers	[List]
relatedItems	[List]
formats	[List]
descriptions	[List]
rightsList	[List]
checksums	[List]
publisher	International Commission on Illumination (CIE), Vienna, AT
publicationYear	2019
language	en
schemaName	CIEmetaDigitalProduct
schemaVersion	4
schemaURL	https://doi.org/10.25039/CIE.SC.4taqevcd

https://doi.org/10.25039/CIE.SC.4taqevcd

CIEmetaDigitalProduct_Importer	
Version	4.0
DOI of Schema	https://doi.org/10.25039/CIE.SC.4taqevcd
	0. accept security alerts. This workbook uses "power query"
	1. copy the filepath into Cell B11
	2. update data
	3. be aware that the number of rows will update (use name of tables to access data)
Parameter	Value
FilePath	\\METASFS01.AD.METAS\HOME$\OFFICE\BP\temp\CIE_xyz_1931_2deg.csv_metadata.json
titles	Colour-matching functions of CIE 1931 standard colorimetric observer
fileName	CIE_xyz_1931_2deg.csv
identifier	10.25039/CIE.DS.xvudnb9b
publicationYear	2019
formats	text/csv
descriptions	CIE 1931 colour-matching functions (x_bar, y_bar, z_bar), 2 degree observer, wavelength range: 360 nm to 830 nm, wavelength increment: 1 nm, original source: CIE 018:2019, Table 6.

Further activities

US National Committee of the CIE
http://www.cie-usnc.org

New Technical Committees in proposal development and approval or establishment

Division 2	Standard File Format for Electronic Transfer of Optical Radiation Data for Luminaires, Lamps and LED modules
Division 2	Software Validation Spectra, Derived Quantities and Metrics

- «FAIR» International Lightning Vocabulary (https://cie.co.at/e-ilv)
- Toolboxes, API,…