Methods of optical measurement for directional light/LED-sources and luminaires.

There are several normalized goniometric and other principles to measure the directional light output of LEDs, luminaires and displays (e.g. in automotive).

We are providing an overview and discuss the differences between near field and far field measurements, type A – B – C – D gonios, projection and conoscopic measurements and linking that to examples such as LEDs, headlights, street lights and living room lighting.

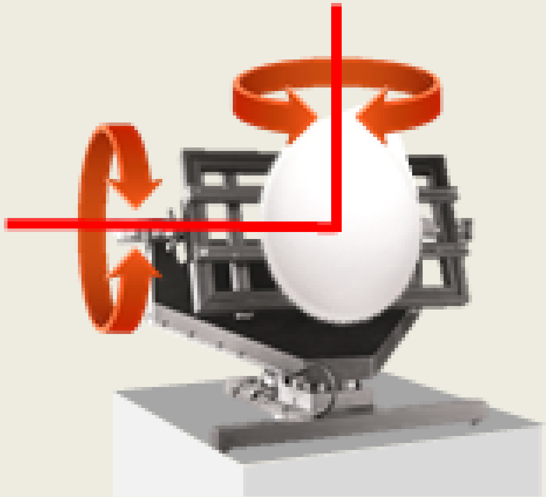
`

Pieter Kramer, Laser2000

What is this lecture about: how to measure Light over Angle

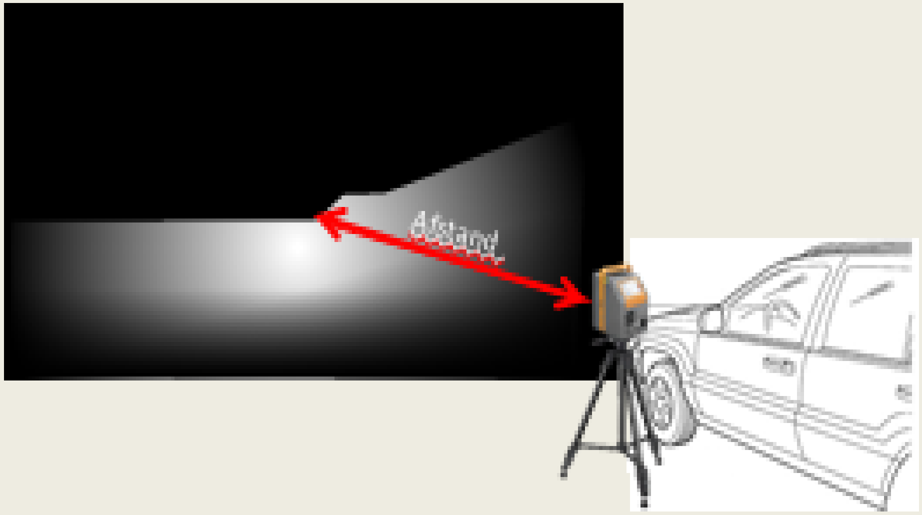
Goniometrische meting

- Far-Field Goniometer
- Near-Field Goniometer



Single-Shot meting

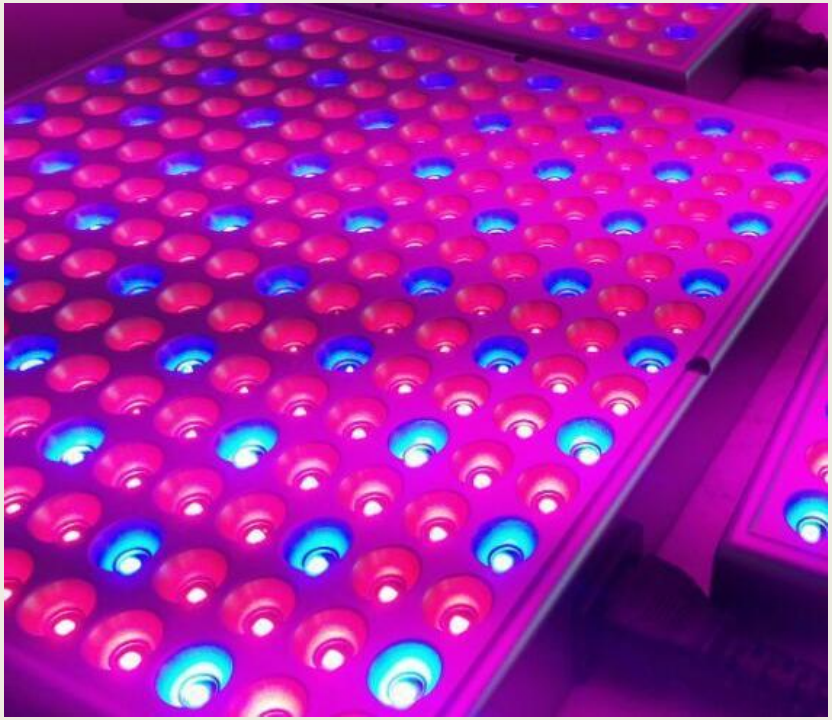
- Belichting op een muur
- Conoscopische meting



Light over Angle

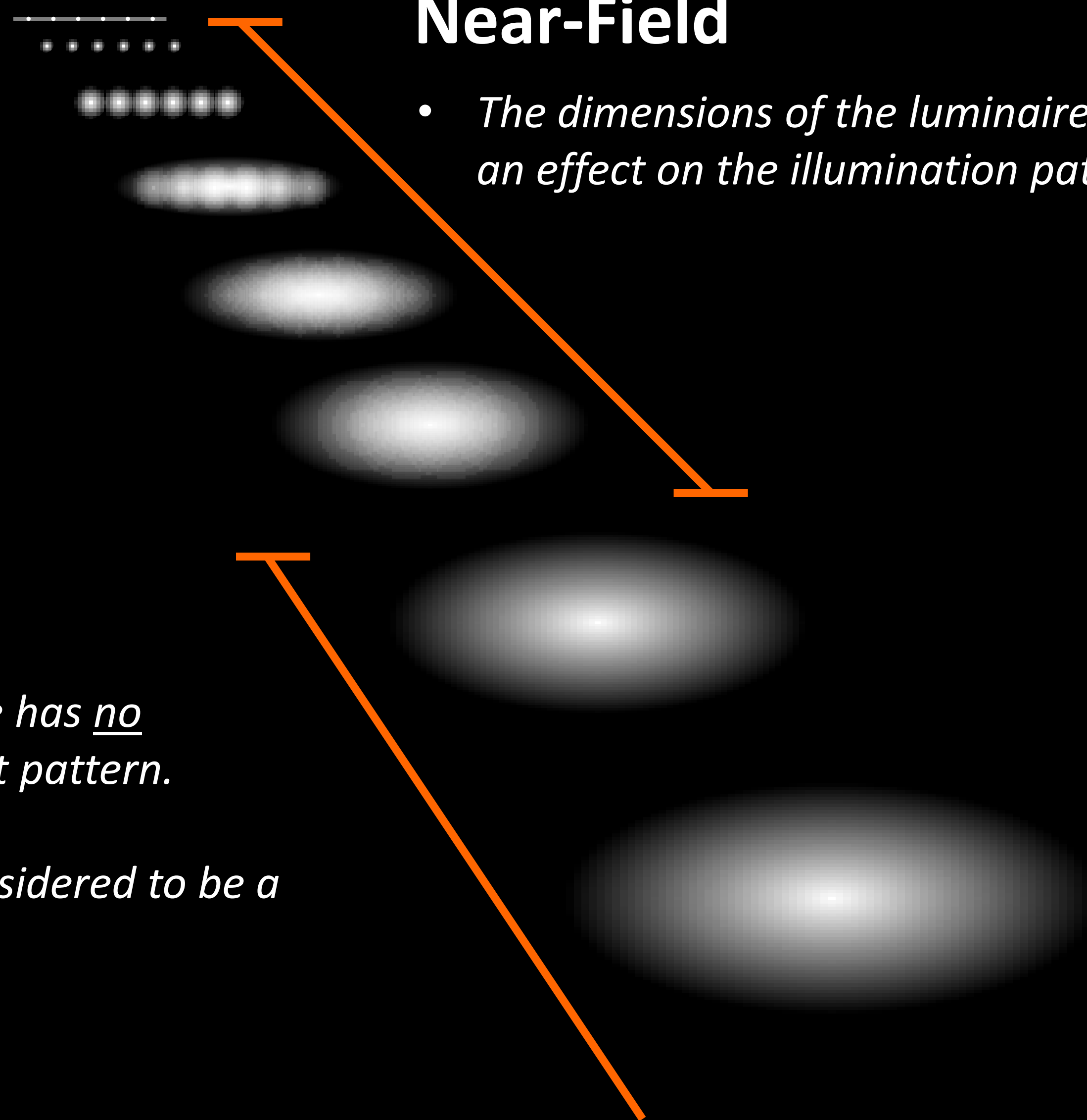
colorimetric thoughts outside this presentation

- Is the light spectrally uniform ?
- Or are there coloured edges ?
- Are there intentional radial colour differences?
- Should PAR performance be measured, or Watts, instead of lumens ?



Topics in this presentation

- **Theory near-field versus far field**
- Goniometer far field
- Goniometer near field
- Type A-B-C-D goniometer
- Summary and applications
- Wall projection method
- Conoscopic method



Near-Field

- *The dimensions of the luminaire have an effect on the illumination pattern*

Far Field

- *Size of the luminaire has <u>no influence</u> of the light pattern.*

- *The luminaire is considered to be a point-source*

Near Field versus Far Field software modelling

- Far field; light propagation model is simulated by coming from a point source, even if the luminaire is large. Suitable for long distance modeling.
- Near field; the light propagation model uses the actual point on the luminaire where the light-ray departed. Suitable for short distance modeling and luminaire design.

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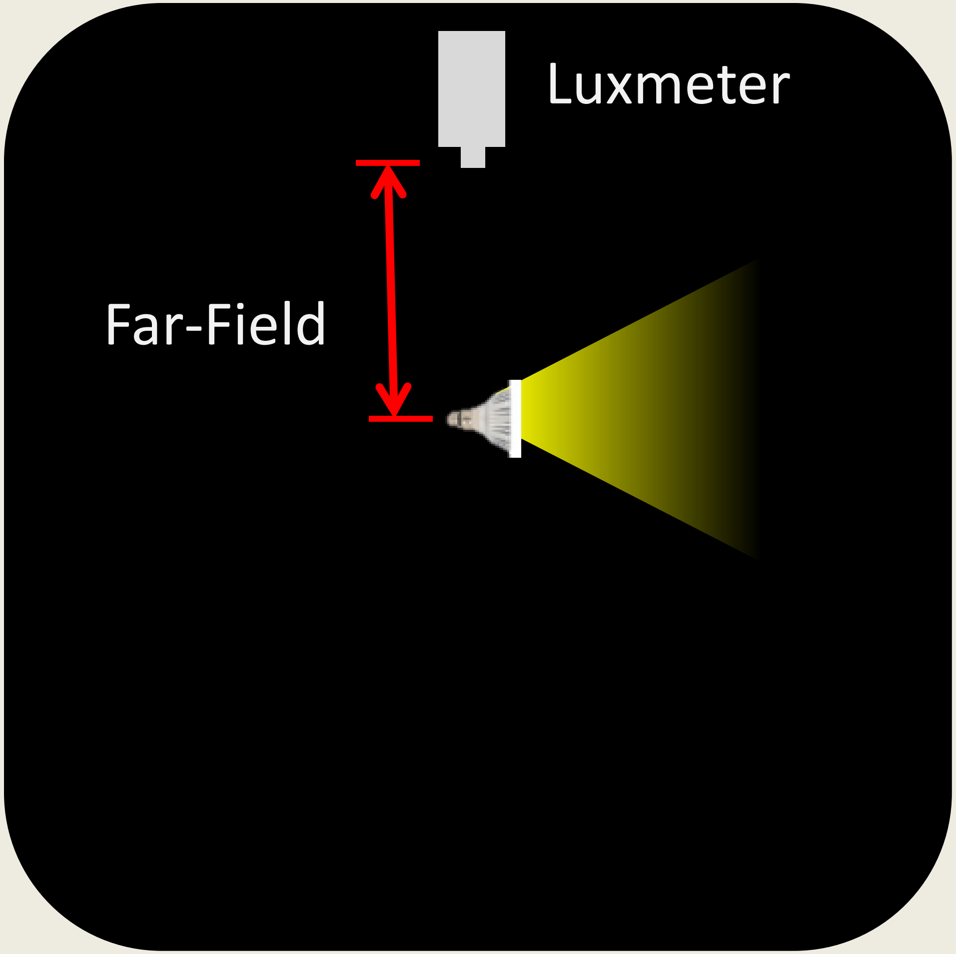
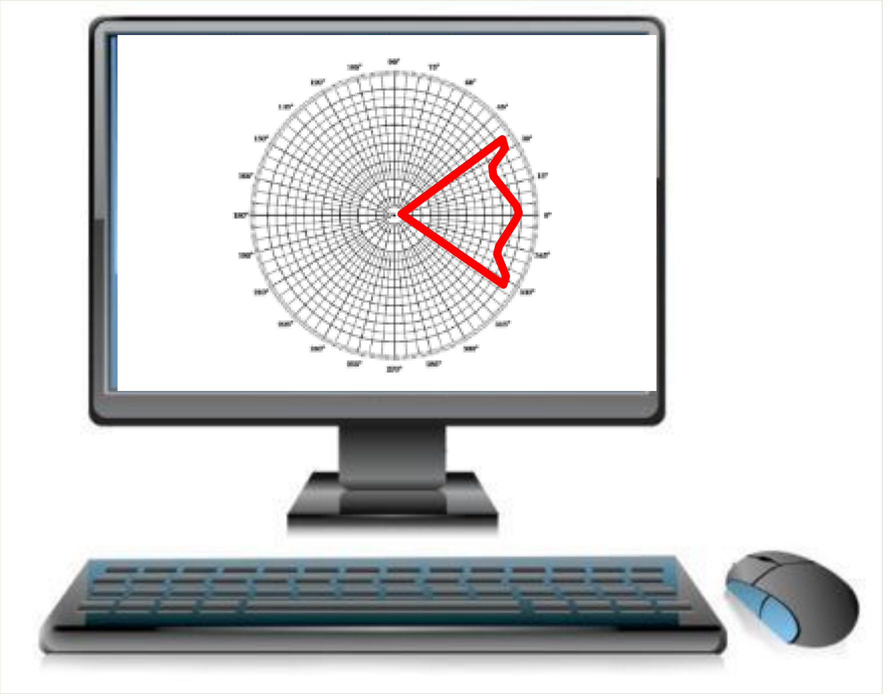
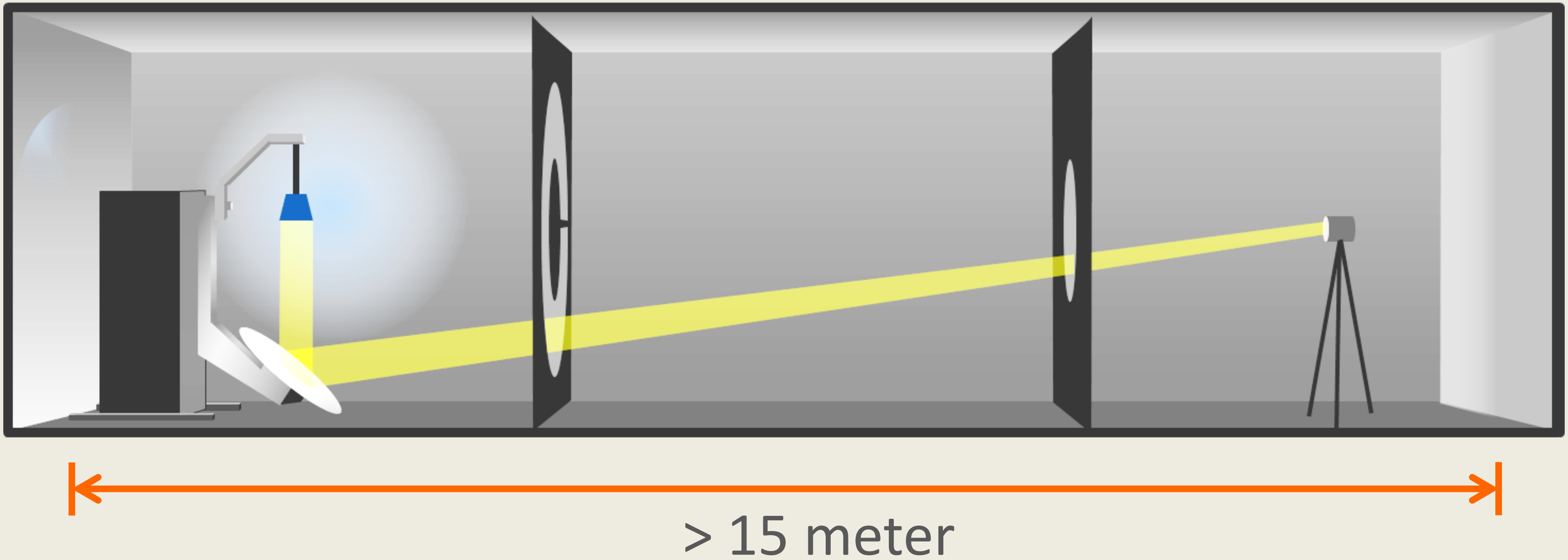
Far-Field Goniometer



- Polar Plot
- IES of LDT file

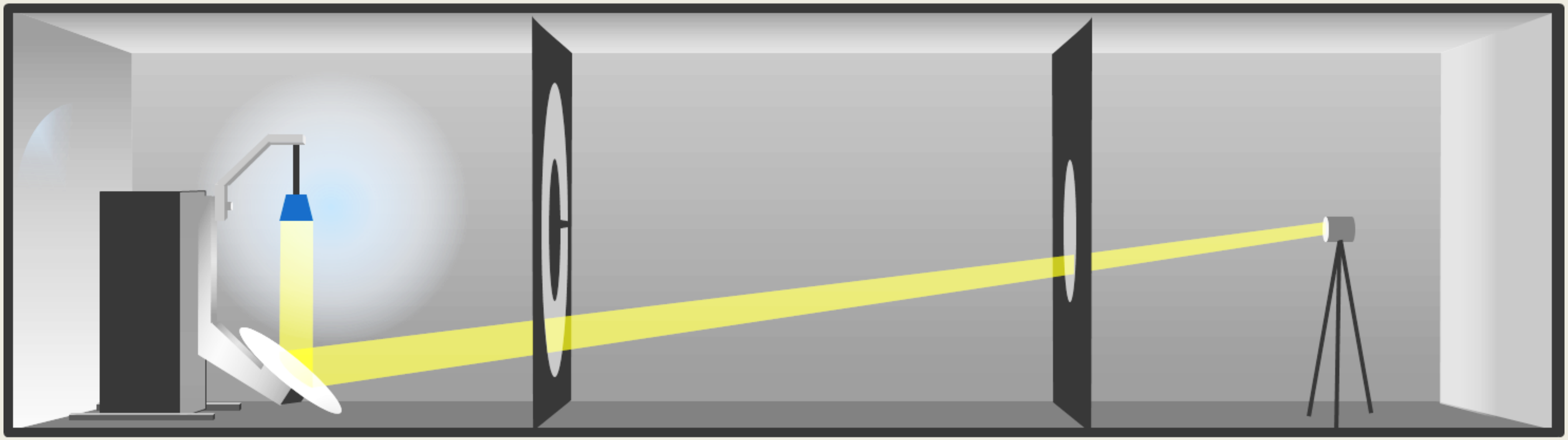


Far-Field Goniometer



Far-Field Goniometer

- Slow measurement; >30 min. to hours
- Large angle distribution; 360° around light source
- Requires very much lab space; >15 x 3 meter
- Measurement data valid only for ‘Far-Field’
- Unique purpose instrument
- Expensive; 200kE



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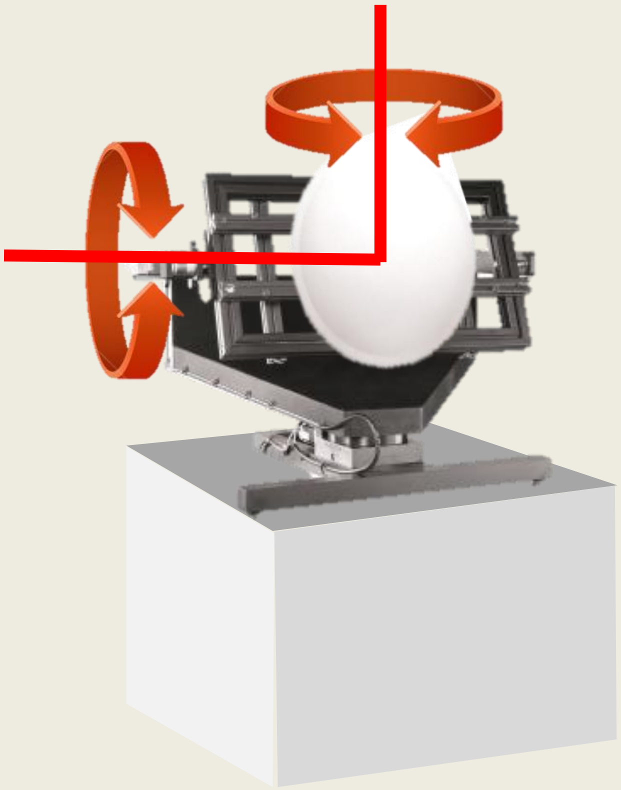
- Extra:
  - Software output file formats
  - LM-IESNA standards

Near-Field Goniometer

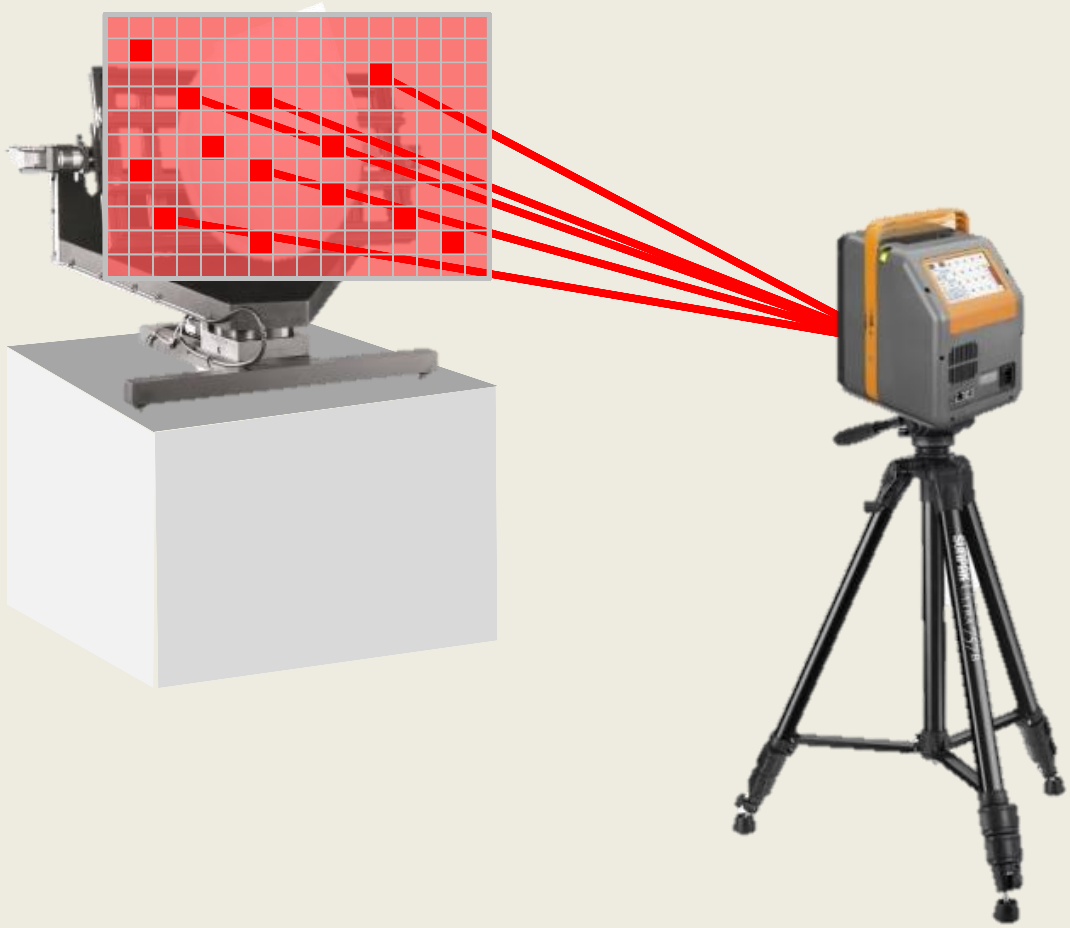
2-axis goniometer



Imaging
Photometer

Near-Field Goniometer

Simultaneous registration of milions of rays



Camera with colorimetry or spectrometry

Near-Field applicaties

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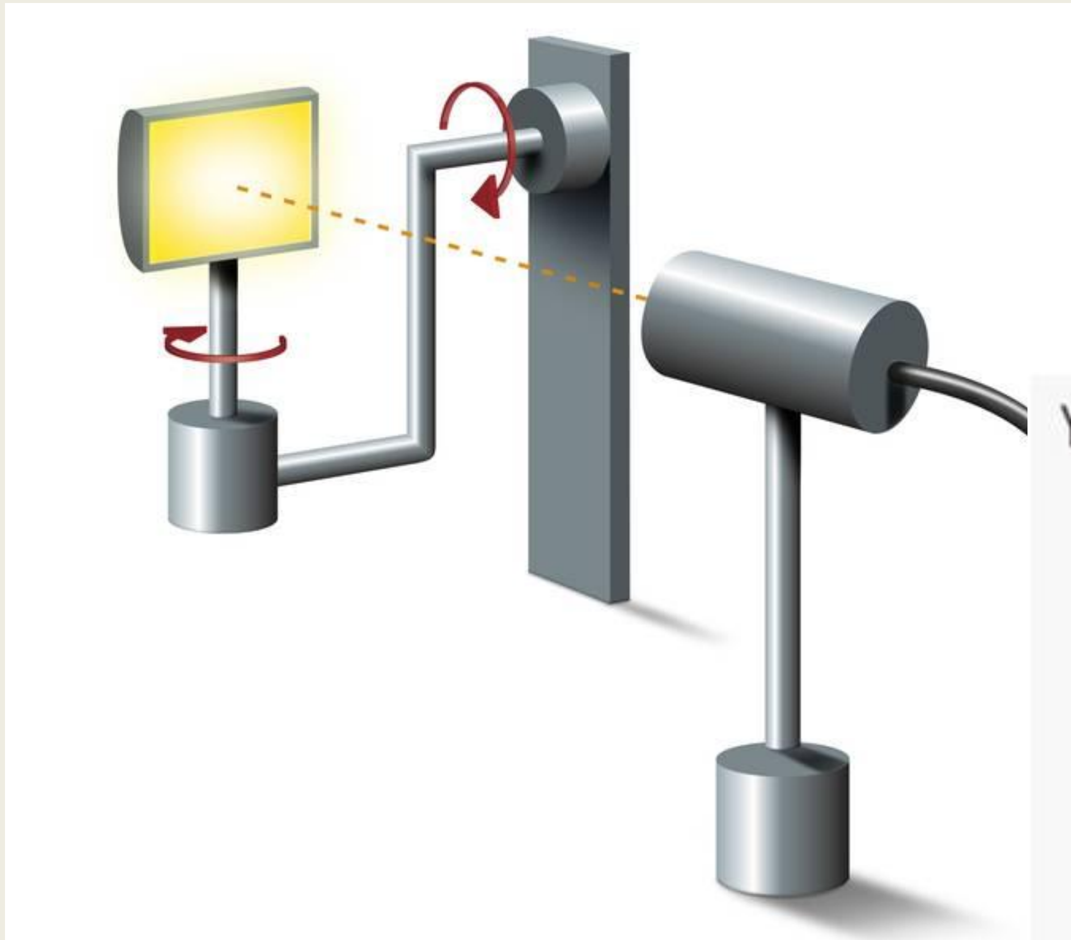
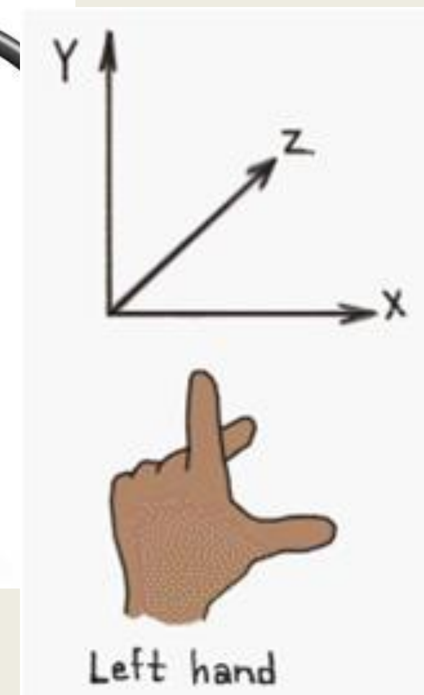
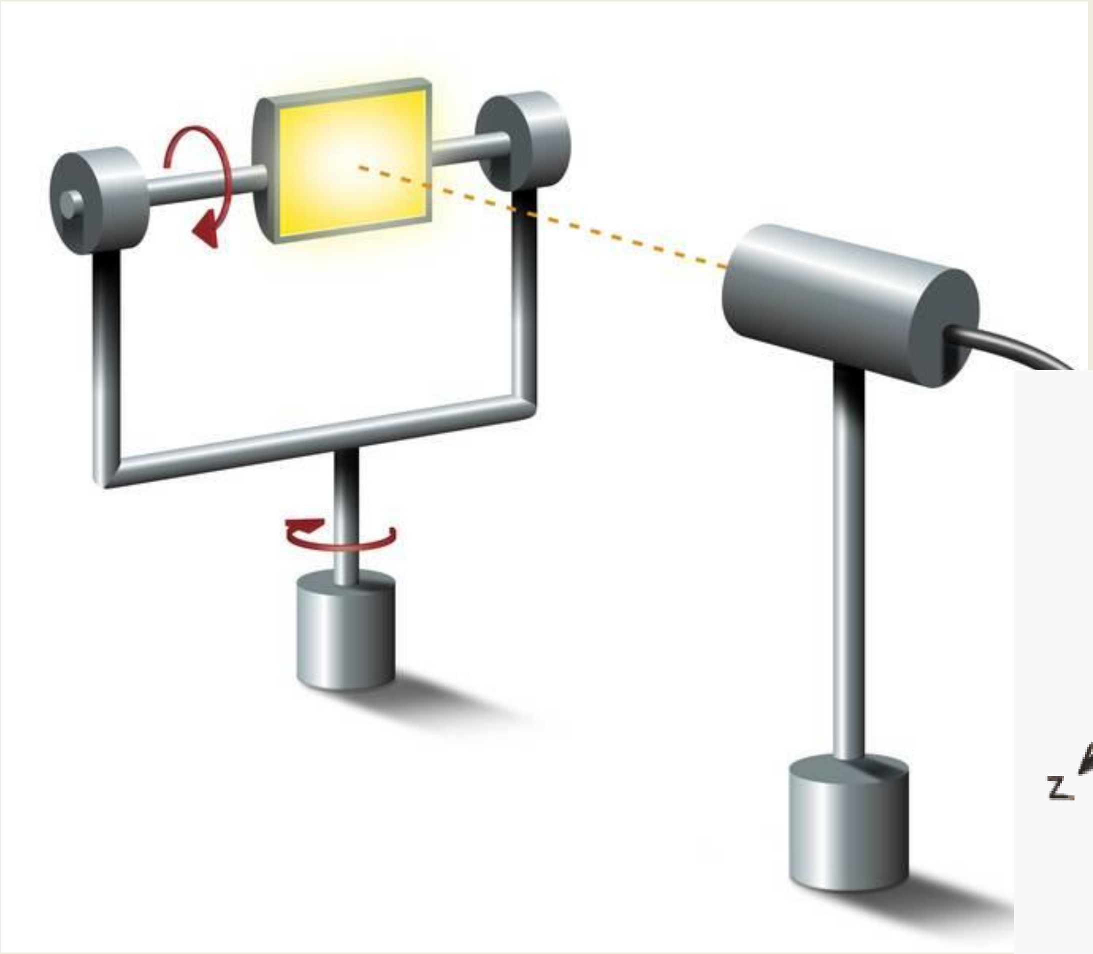
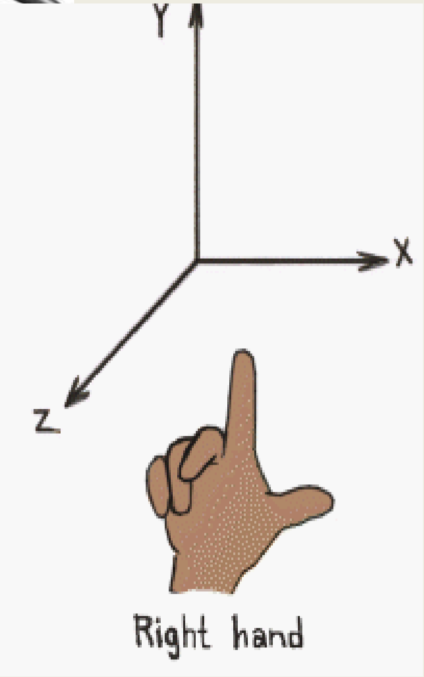
Type A Goniophotometer



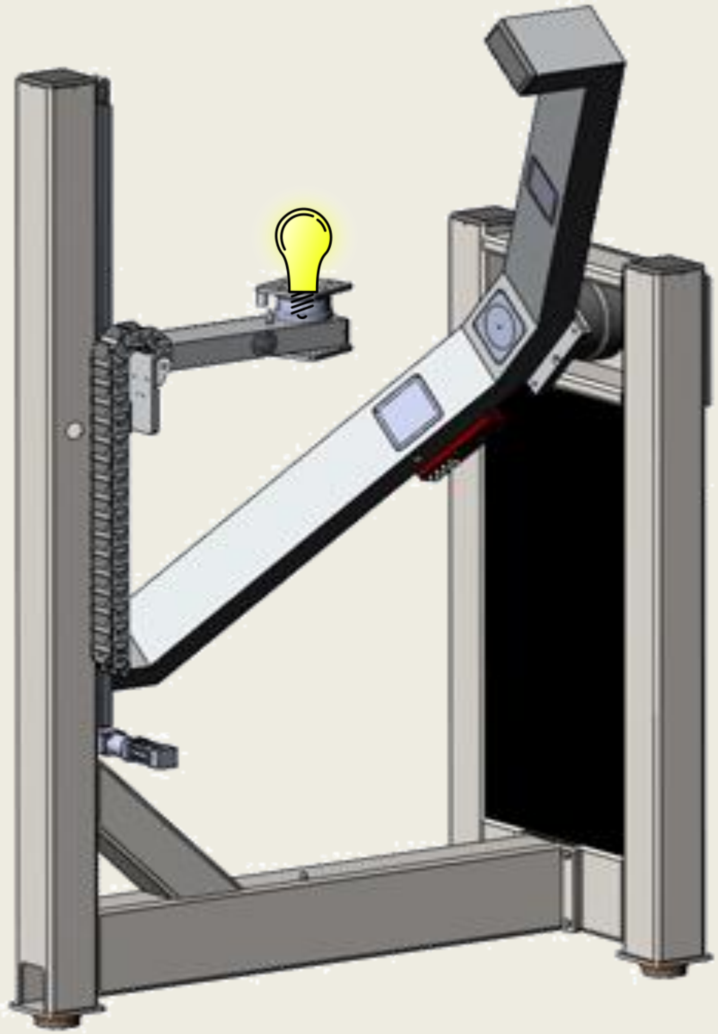


Type B Goniophotometer

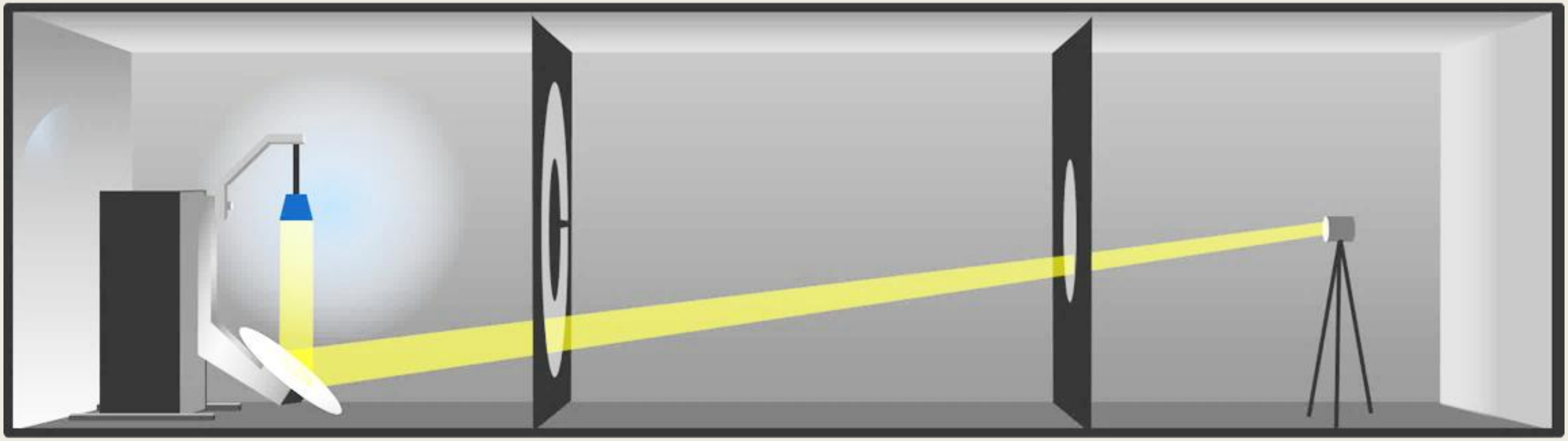




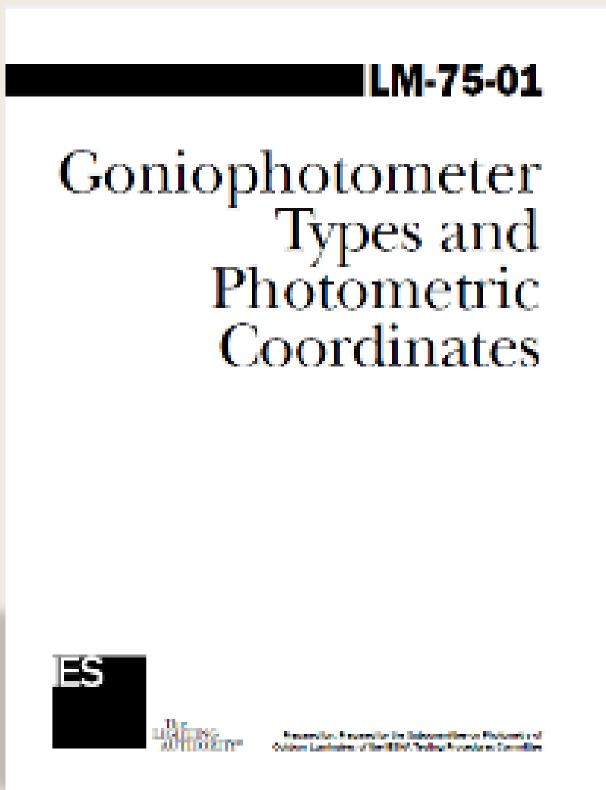
Type C Goniophotometer Moving Detector



Type C Goniophotometer
Moving Mirror

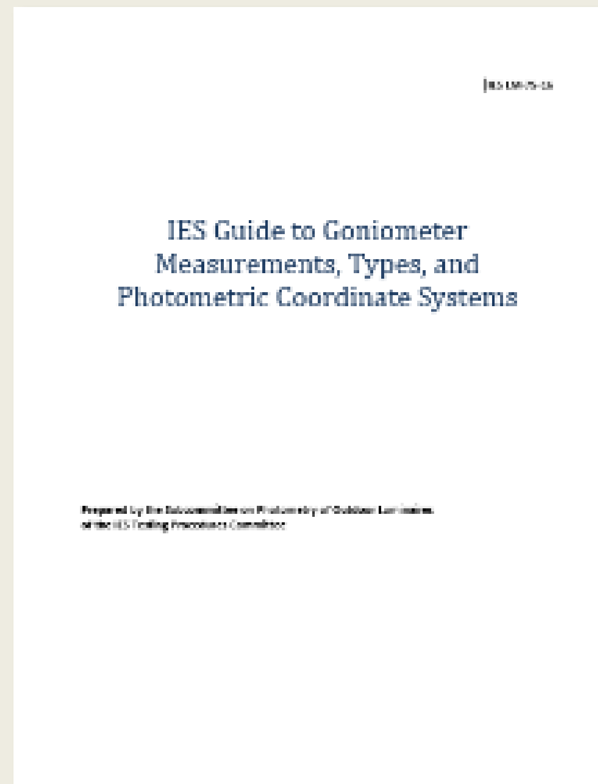


New Type D,
being Proposed in IES LM-75-16


LM-75-01

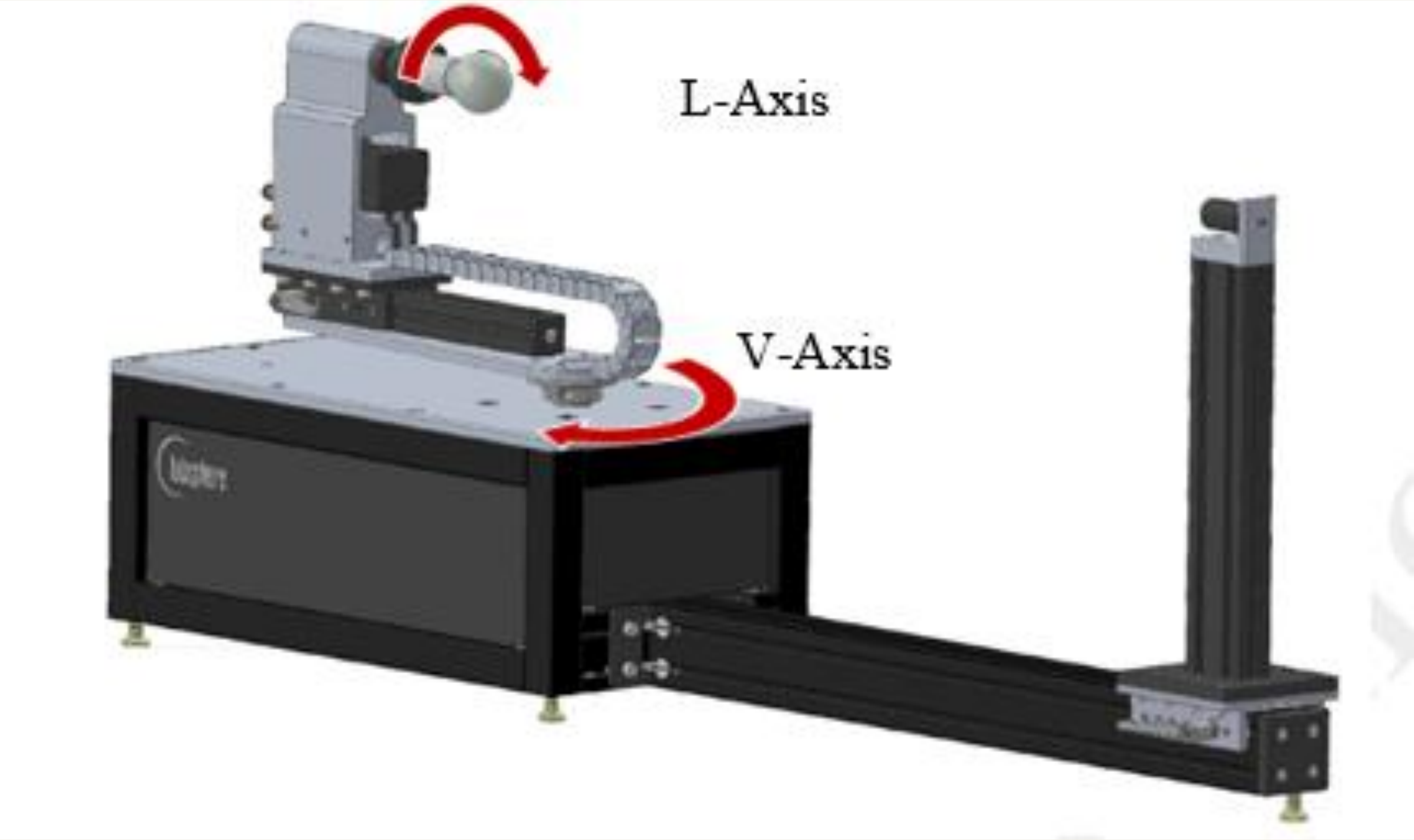
Goniophotometer Types and Photometric Coordinates

Addition of Type D Goniophotometer


IES Guide to Goniometer Measurements, Types, and Photometric Coordinate Systems

Source: IES TPC

Type D Goniophotometer



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- Wall projection method
- Conoscopic method

Applications and their standards

- Type A:
  - Automotive Lighting and Optical Systems
  - Traffic Signals
  - Retro-reflectors
- Type B:
  - Floodlight photometric data is traditionally presented in this coordinate system
- Type C
  - Commonly used in the certification photometry of interior and street lighting
- Type D
  - Lamps and LED modules
  - Testing light source optics
  - R&D

Summary type A-B-C-D

	Type A	Type B	Type C	Type D
Application	Automotive Lighting and Optical Systems Traffic Signals Retro-reflectors	Photometry of Floodlights	Photometry of Interior lamps and Luminaires and Street Lighting	Lamps and LED modules Testing light source optics R&D
Ideal for Sources:	Not sensitive to orientation to earth's gravity	Not sensitive to orientation to earth's gravity	Sensitive to orientation to earth's gravity	Not sensitive to orientation to earth's gravity
Typical Space Requirement	18m distance for headlamps and fog lamps 8m for automotive signal	Source Dependent 5x max source dimension	Moving Mirror: 10m x 13m x 6m Moving Detector 4m x 5m x 4m	Benchtop
Typical Max Sample Size	1.2m x .6m	1.2m x .6m	Moving Mirror: 1.6m x 1.6m Moving Detector 0.3m x 0.3m	0.3m x 0.3m
Cost	$$	$$	$$$	$

Is this all there is?

- Ofcourse not.....

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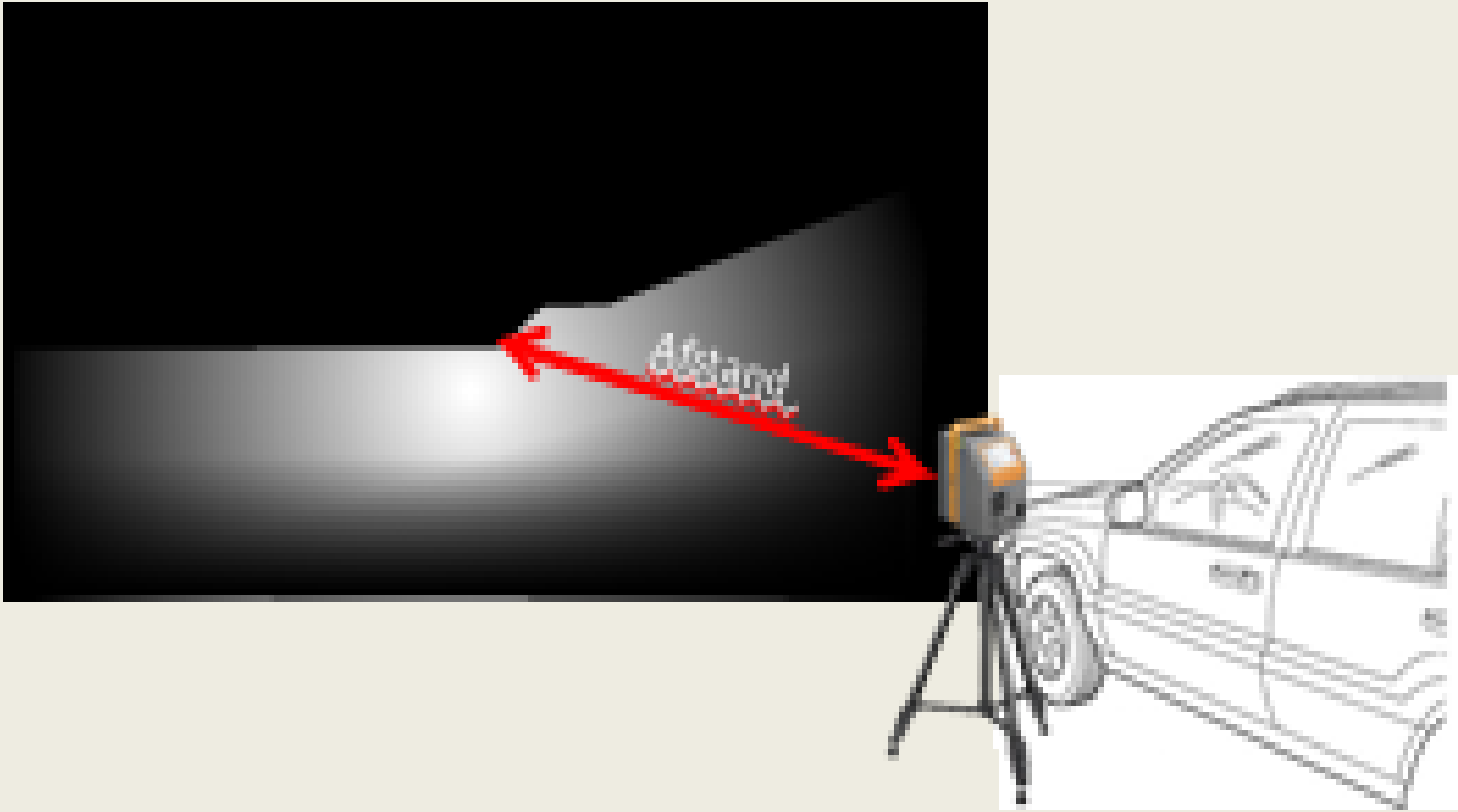
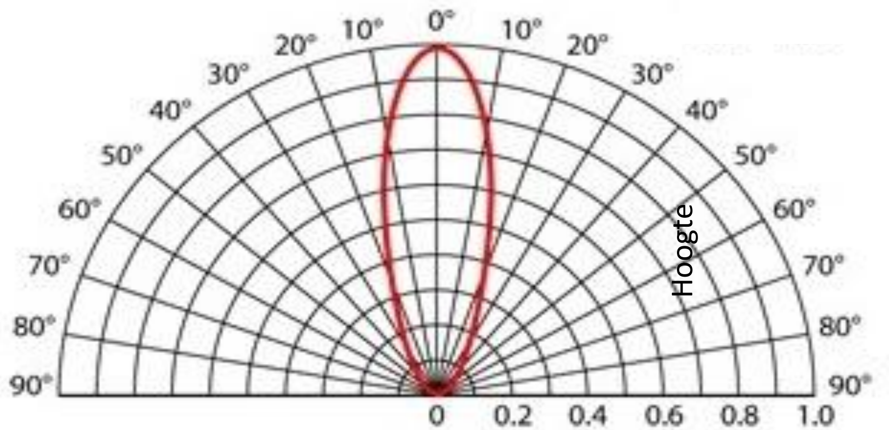
Wall projection method

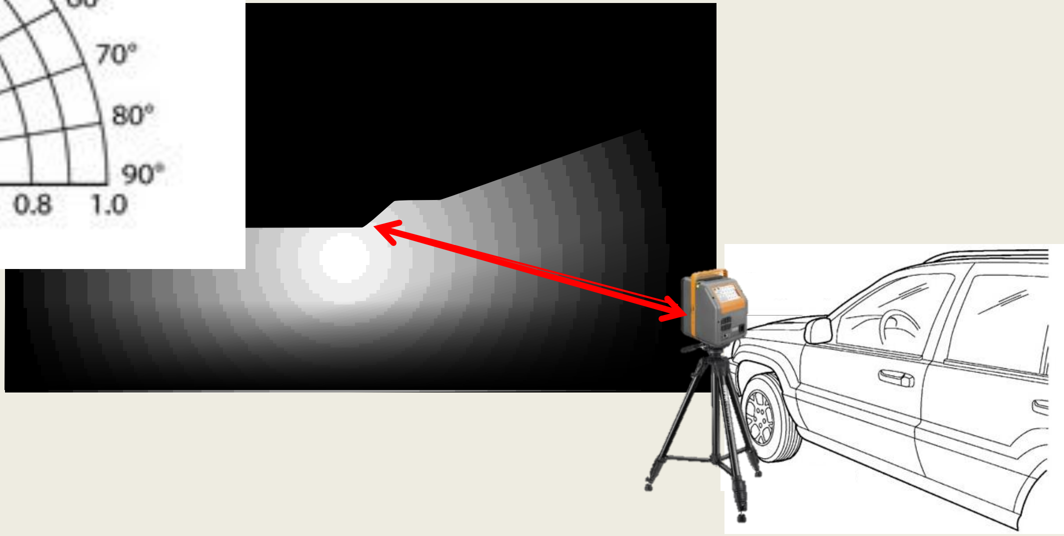


Wall projection

Because we know the dimensions of the test setup, angles are calculated. The spot light is converted into a



Angular plot
(IES or LDT file)



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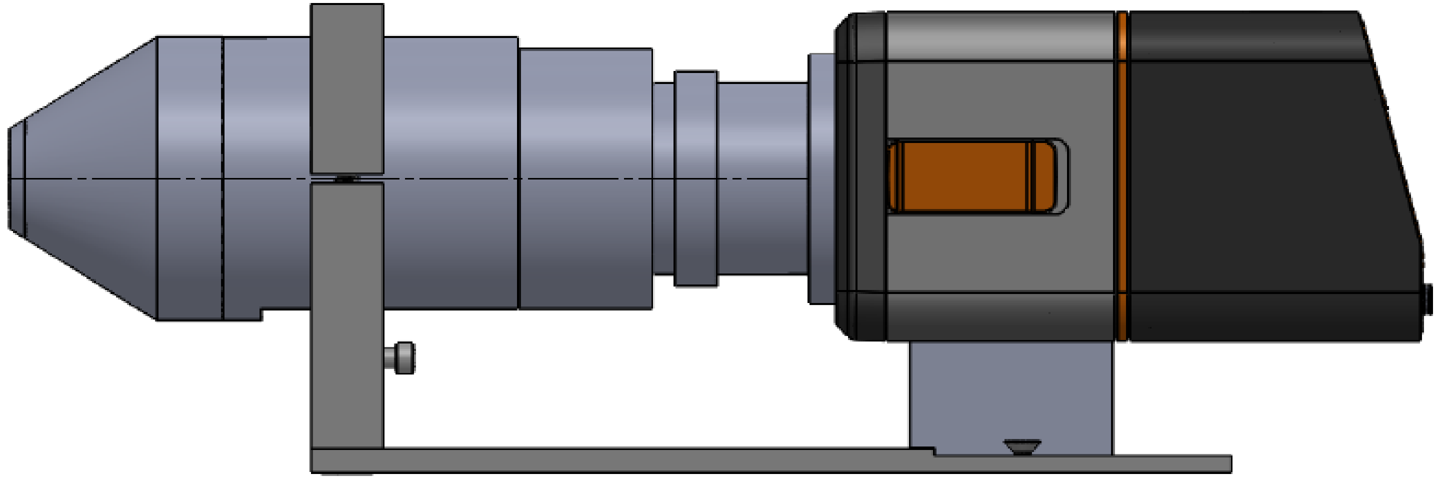
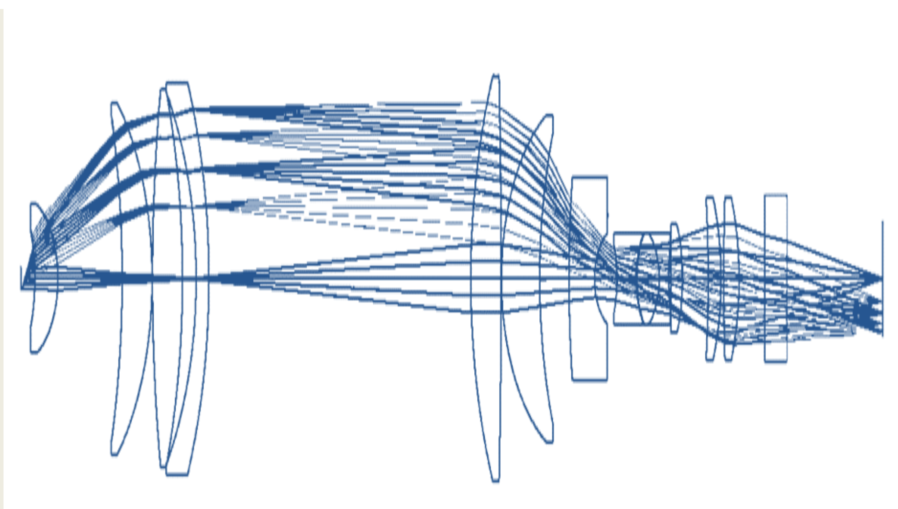
- **Conoscopic method**

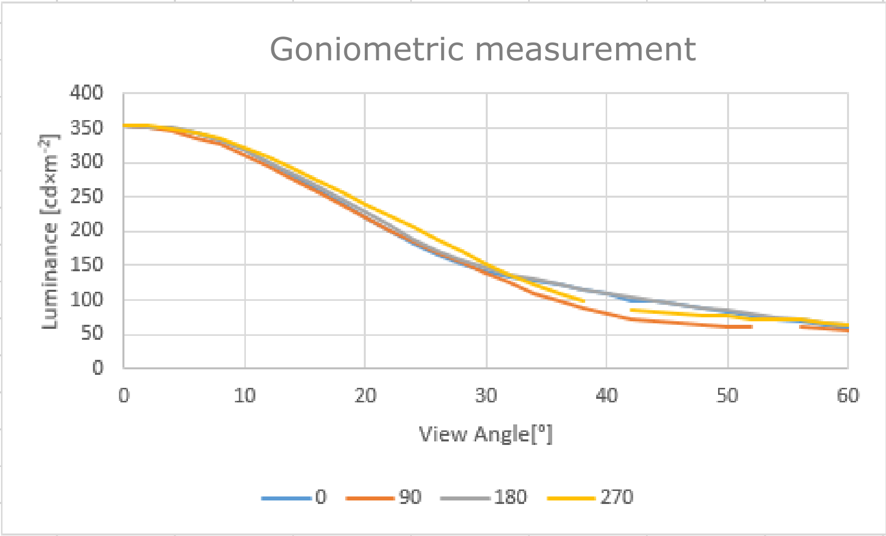
Conoscopic method

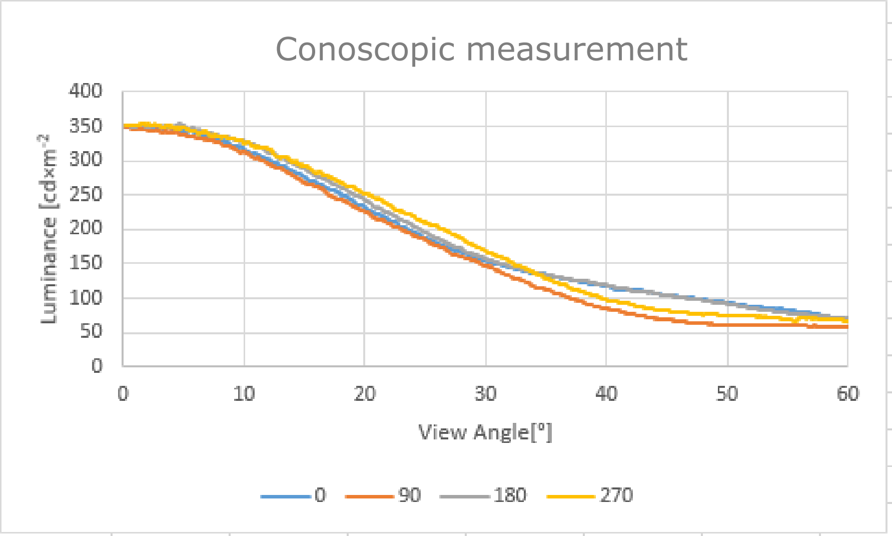




Conoscopic method

Conoscope measurement vs. Goniometer measurement

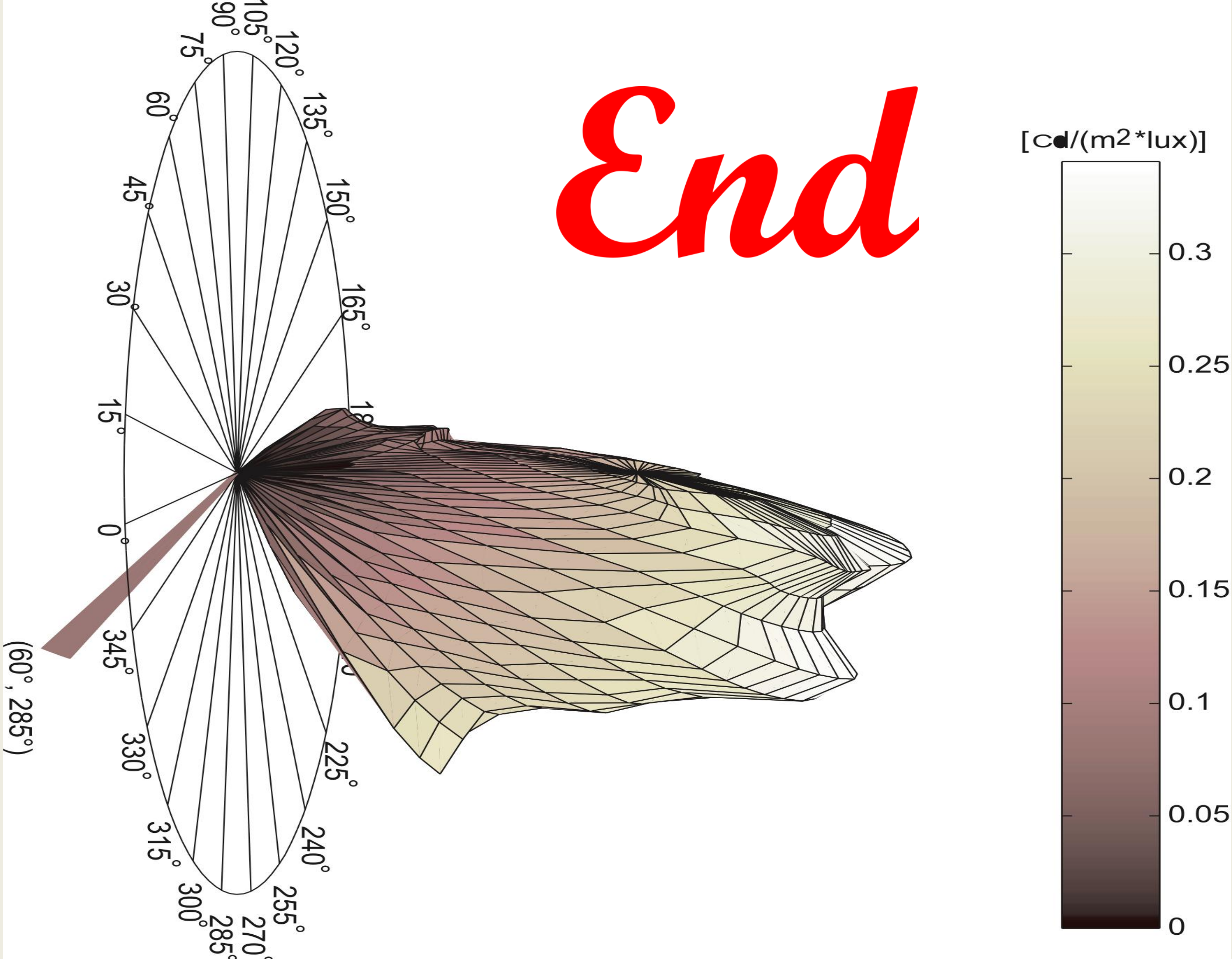




Summary of technologies

	Far-Field	Near-Field	Muurprojectie	Conoscope
Speed	Uren	Uren	Seconden	Seconden
Dimension setup	>15 x 3 m	5 x 4 m	10 x 6 m	1 x 0.5 m
Angle range	360°	360°	30-40°	120°
Flexibility	vaste detector	camera	camera	camera
Cost	50 – 200 k€	50 – 70 k€	25 – 50 k€	25 – 50 k€

End

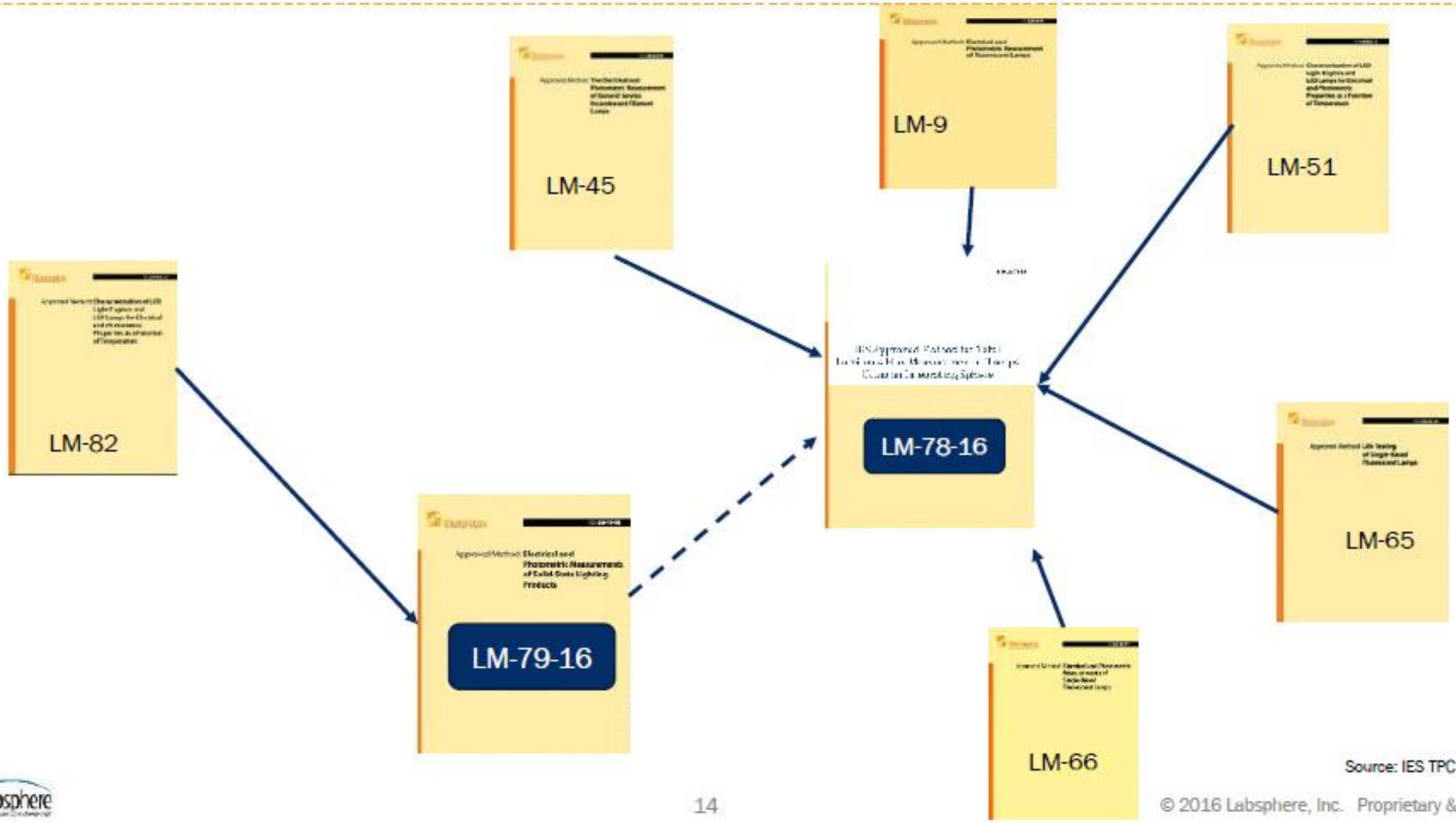

[cd/(m2*lux)]
0.3
0.25
0.2
0.15
0.1
0.05
0
(60°, 285°)
0°
15°
30°
45°
60°
75°
90°
105°
120°
135°
150°
165°
225°
240°
255°
270°
285°
300°
315°
330°
345°

Extra's

LM- IESNA approved method:

- 9 elec & phot ms of fluorescent lamps
- 20 phot testing of reflector-type lamps
- 45 elec &phot ms of general incandescent filament lamps
- 51 elec & phot ms of high intensity discharge lamps
- 54-99 lamp seasoning
- 58 guide to spectroradiometric measurements
- 59 elec & phot ms of low pressure sodium lamps
- 66 elec & phot ms of single ended compact fluorescent lamps
- 78 total lum flux ms of lamps using a integrating sphere photometer
- 79 elec & phot ms of solid-state lighting products, sphere & gonio
- 80 ms lumen maintenance of LED light sources
- 82 char LED light engines elec & phot, as a function of Temperature. It is essential LM-790 + Temp.

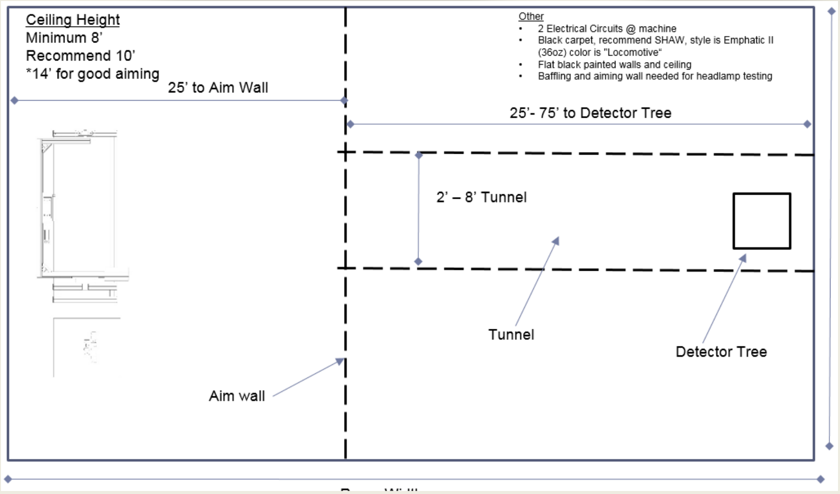
Primary Revisions Proposed in LM-79-16



Source: IES TPC Sub B and Sub S

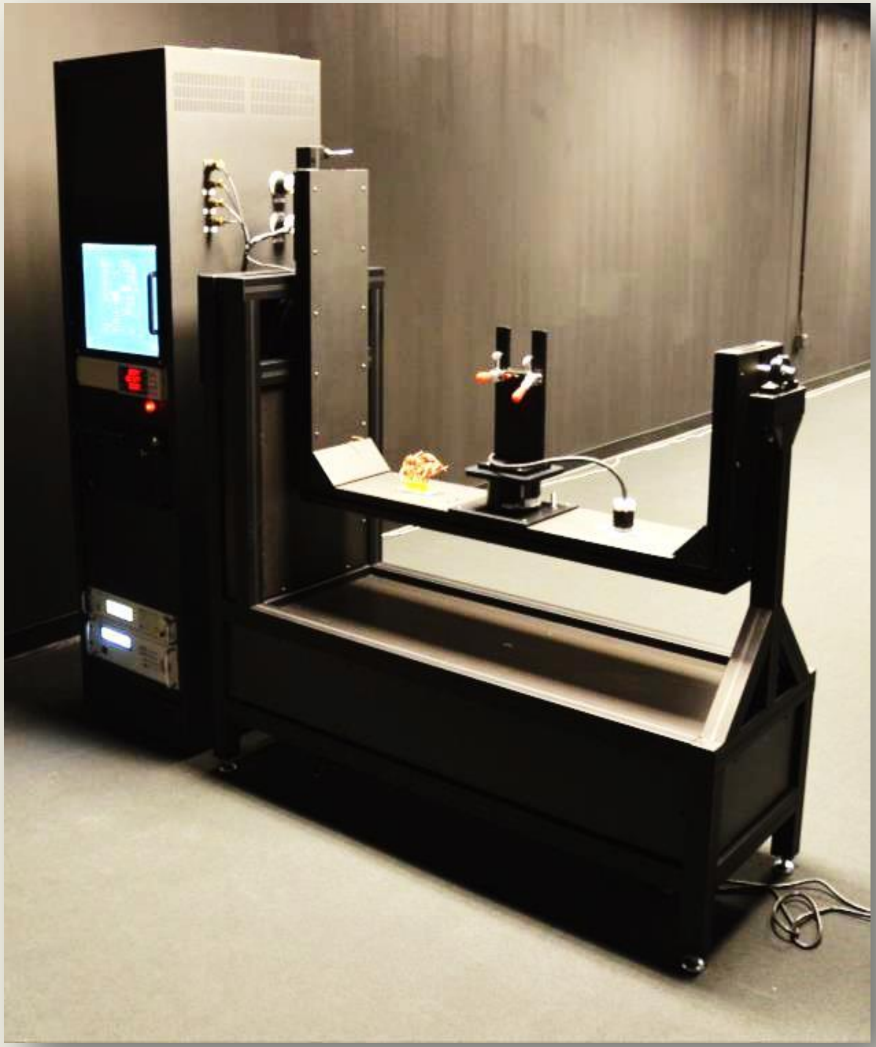
Typical Set-up for Type A

- Free standing Gonio and Sensor Tree
- Ceiling Height: Recommend 10’ to 14’
- Room Width
  - Minimum 25’
  - Actual length depends on type of lamp tested and certification requirements
- Room Length: Minimum, typically 25’
- Other
  - 2 Electrical Circuits @ machine
  - Black carpet
  - Flat black painted walls and ceiling
  - Baffling and aiming wall needed for headlamp testing



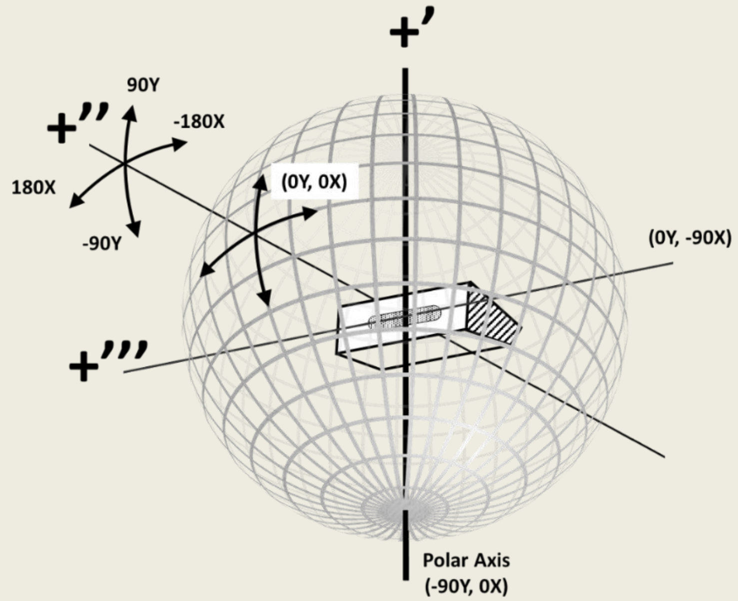
Type A Goniophotometer

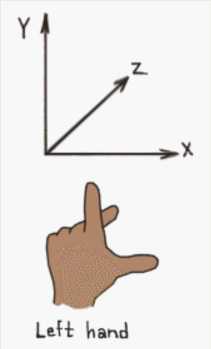
- The photodetector is fixed, while the light source is rotated about the *X* (+’) and *Y* (+’’’) axes
- The light source is first rotated about the *X* axis to the desired *X* ordinate.
- Then rotated about the *Y* axis, through the full range of *Y* ordinates, until a full plane of data has been gathered.
- Not suitable for use with position-sensitive light sources.



Type A Coordinate System

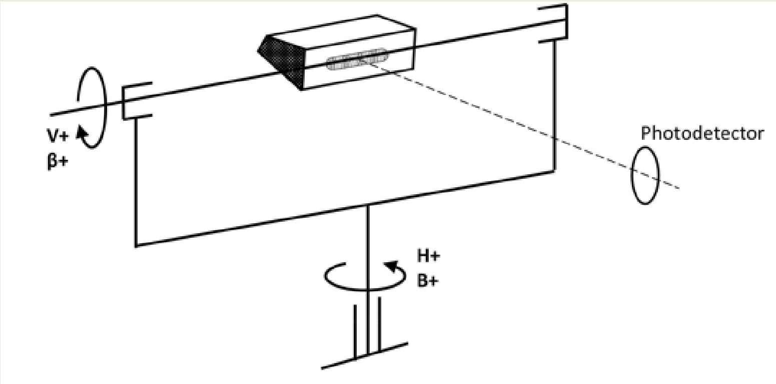
- Type A polar axis is vertical
- Is a left -handed system.
  - How do you know it's a Type A?
    - Using your left hand point your thumb in the direction of the positive polar axis (+'), your index finger in the direction of the reference axis (+'').
    - Your middle finger will point in the positive direction of the third axis (+"').
- The vertical Y angles range from −90° (nadir) to 90° (zenith)
- The horizontal X angles range in value from −180° to 180°





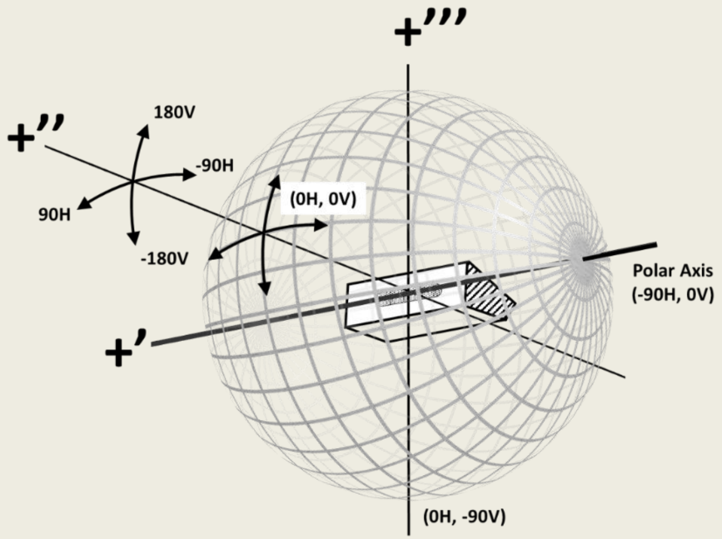
Type B Goniophotometer

- The photodetector is fixed, while the light source is rotated about the *V* (+’) and *H* (+’’’) axes
- The light source is first rotated about the *V* axis to the target the desired *V* ordinate.
- Then rotated about the *H* axis, through the full range of *H* ordinates, until a full plane of data has been measured.
- Like the Type A, it is not suitable for use with position-sensitive light sources.



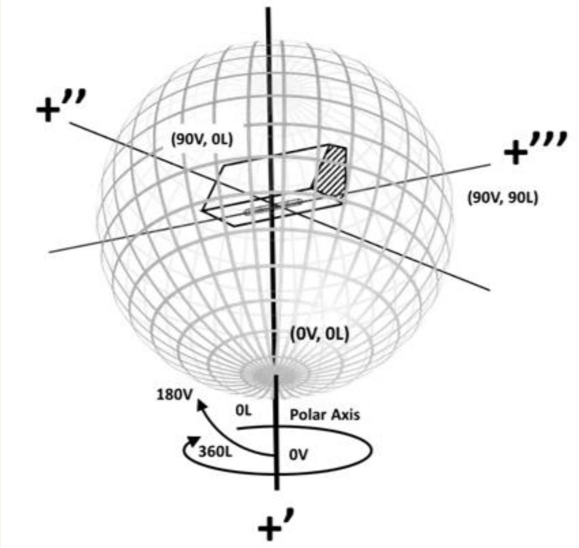
Type B Coordinate System

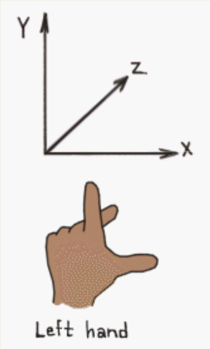
- Type B polar axis is oriented horizontally (like Type A on its side)
- Is a left -handed system.
  - How do you know it's a Type B?
    - Using your right hand point your thumb in the direction of the positive polar axis (+'), your index finger in the direction of the reference axis (+'').
    - Your middle finger will point in the positive direction of the third axis (+''').
- The horizontal H angles range from –90° to 90°
- The vertical V angles range in from –180° to 180°, where -90° would be at nadir and 90° at zenith.



Type C Coordinate System

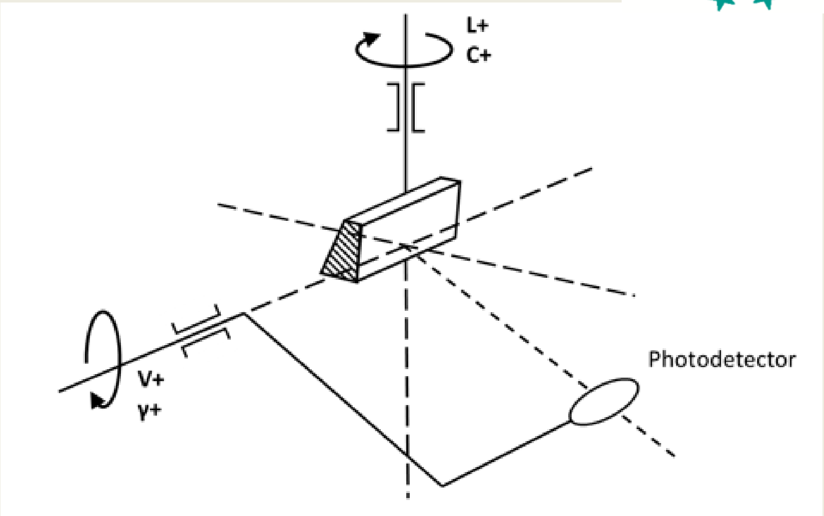
- The Type C polar axis is vertical
- Is also a left-handed system.
- The vertical V angles range in value from 0° (nadir) to 180° (zenith)
- The lateral L planes range in value from 0° to 360°
- The direction of increasing lateral angles is clockwise when viewing the luminaire along the polar axis from the (0V, 0L) point.

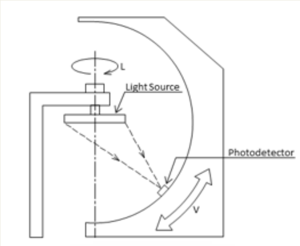


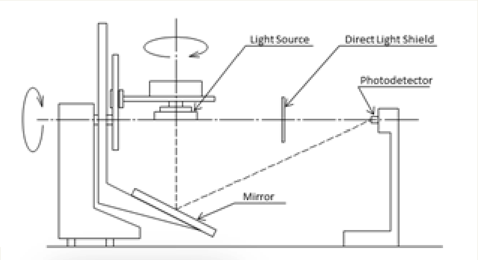


Type C Goniophotometer

- The light source suspended in a fixed orientation with respect to the gravity, rotating only around a vertical *L* (+‘) axis.
- Either the photodetector or a mirror is rotated around the light source in a vertical plane (around the *V* (+‘’) axis).
- The light source is rotated about the *L* axis to the desired Lateral angle, then the mirror or photodetector is rotated about the horizontal *V* axis to obtain a plane of Vertical data.
- The rotation of the luminaire is in the counter clockwise direction when viewed along the polar axis from nadir.
- In all Type C goniophotometers, the attitude of the light source is fixed with respect to the gravity
- Ideal for measuring the light output of position-sensitive light sources.







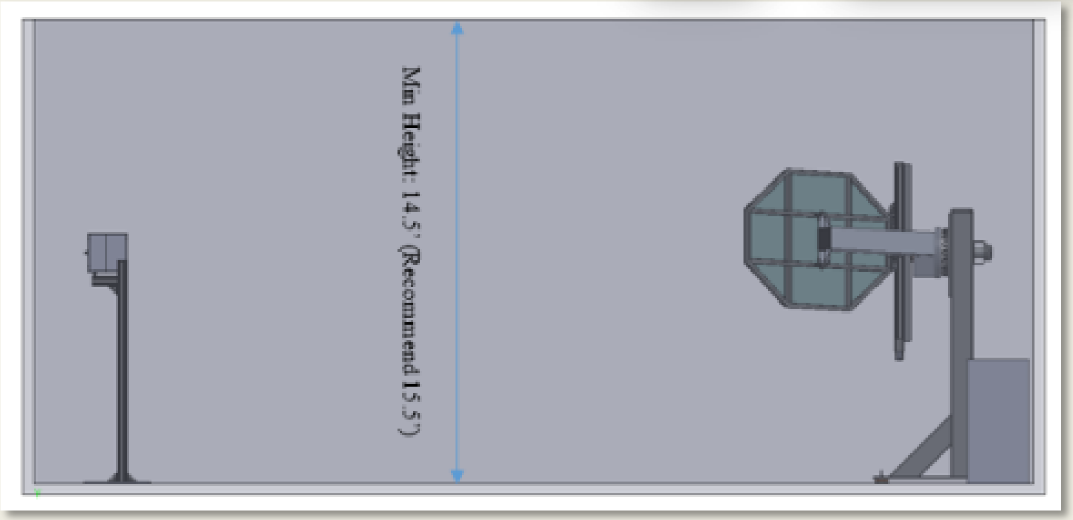
Type C Moving Detector

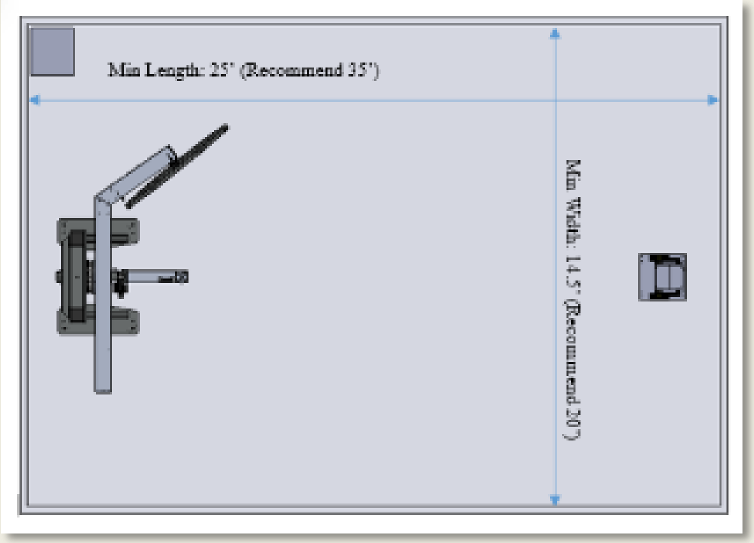
Type C Moving Mirror

Setting up a Lab - Goniophotometer

- Maximum DUT Dimension drives Gonio geometry
- Site Audit and Installation Guidance







Software output files for reporting, design and raytracing

- IES / EULUMDAT / LDT
- Source models for raytracing FF or NF
- FRED/Zemax/Lighttools/...