LED Testing - methods

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Light Naturally

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CIE

- CIE 84:1989

  The measurement of luminous flux

- CIE 177:2007

  Colour Rendering of White LED Light Sources

- CIE 127-2007

  Measurement of LEDs

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IESNA Standards Activities on LED/SSL

Published

- LM-79-08 Electrical and Photometric Measurement of SSL Products
- LM-80-08 Measuring Lumen Maintenance of LED Light Sources
- RP-16-10 Terminology on light emitting diodes added

Under development

- **TM-21** Projecting Long Term Lumen Maintenance of LED Light Sources
- **LM-82** Characterization of LED Light Engines and Integrated LED Lamps as a Function of Temperature
- LM-xx Photometric Measurements of High Power LEDs (Ohno, WG chair)
- LM-xx Measurement of Lumen maintenance of LED lamps, light engines, and LED luminaires.

Discussing

- **Revision of LM-79**, LM-80
- Measurement of AC-driven h.p. LEDs
- Measurement of waveforms of SSL products

Purpose of Test Methods

- Create a level playing field
- Allow manufacturers to specify performance of products
- Provide information for designers and consumers
- Allow benchmarking of product categories for regulation
- Allow compliance check testing

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Energy Efficient Lighting Products

For lighting products the key parameters for energy efficiency are:

- □ total flux and
- □ luminous efficacy

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Total Flux measurement

- 2 fundamental methods/equipment

Goniophotometry   Integrating Sphere

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Comparison (relative)

- Goniophotometer
- Expensive
- Slow
- Traditionally for directional and non directional lamps

- Integrating Sphere
- Inexpensive
- Fast
- Traditionally for non directional lamps

Cost of equipment and test procedure

- Goniophotometer

- Asset: ~ AUD $1M

- Test: ~ AUD $1,000

  per lamp

- Integrating Sphere

- Asset: ~ AUD $50,000

- Test: ~ AUD $100

  per lamp

Compliance check testing

□ Prefer the less expensive Integrating Sphere test method if accurate with acceptable precision for directional and non-directional lamps.

□ From cost perspective, this allows for a greater market surveillance in order to protect the consumer and the suppliers
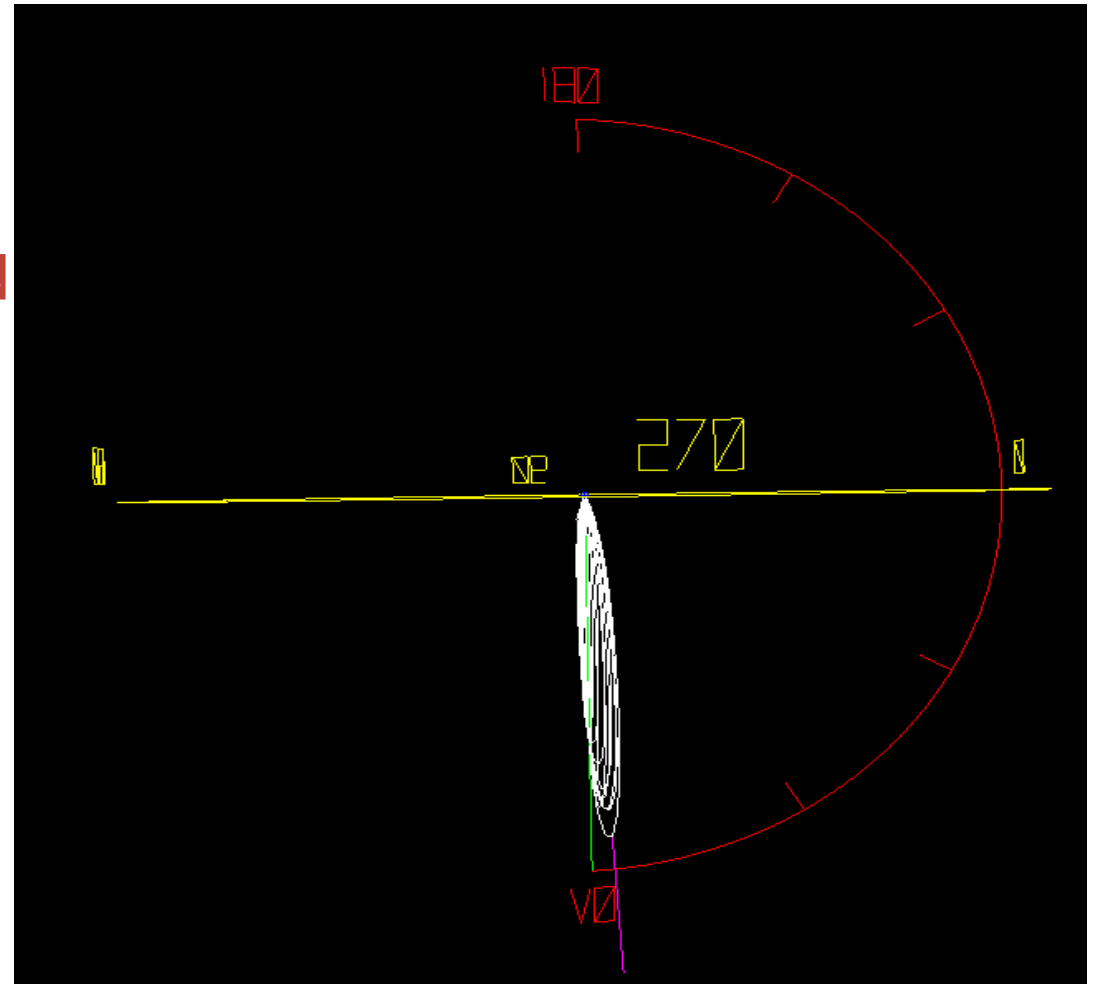
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Goniophotometry - explained
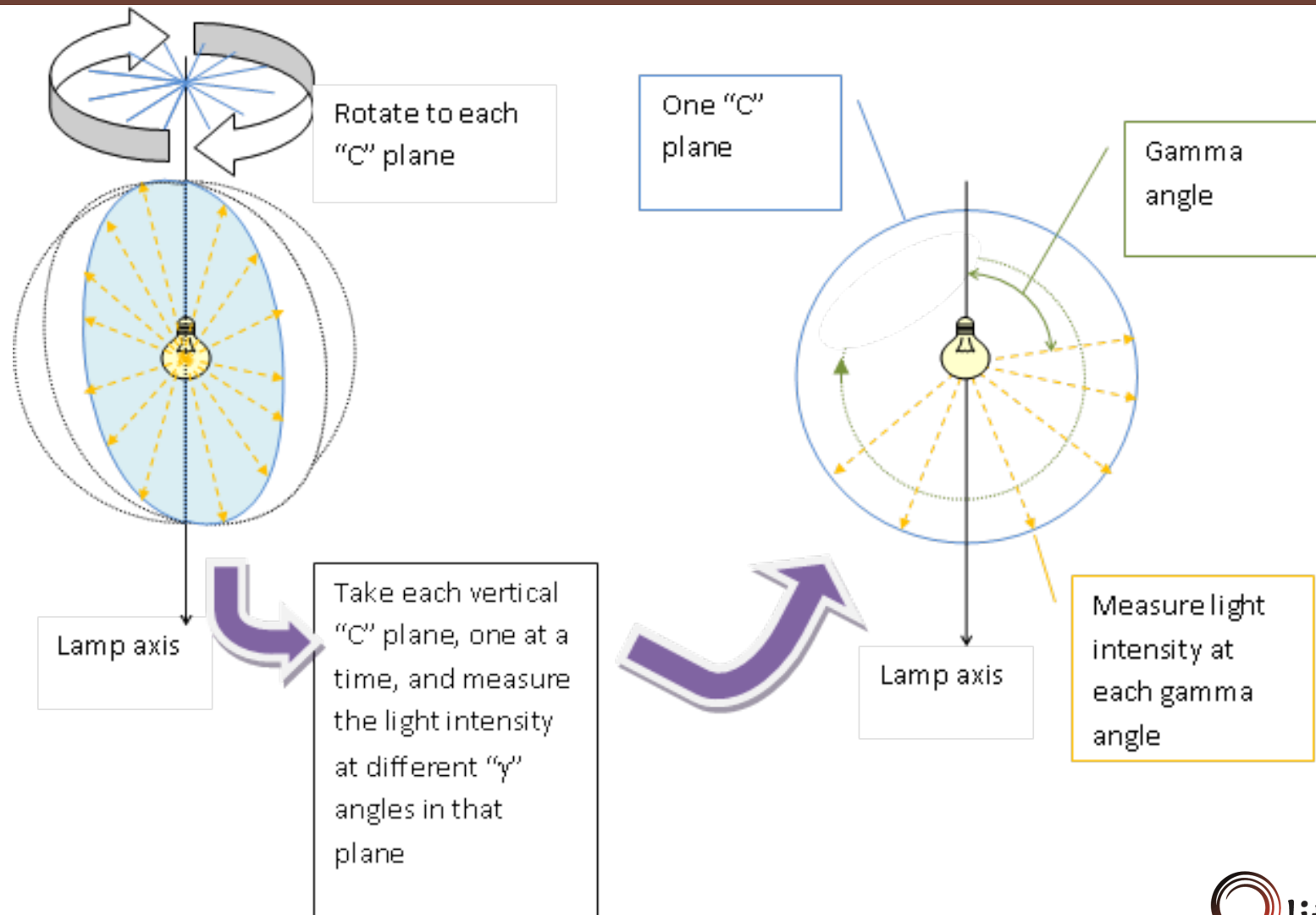
Goniophotometry - explained

- ☐ Measure light intensity in many directions

- ☐ Determine the total amount of light using 3 D geometry and interpolation

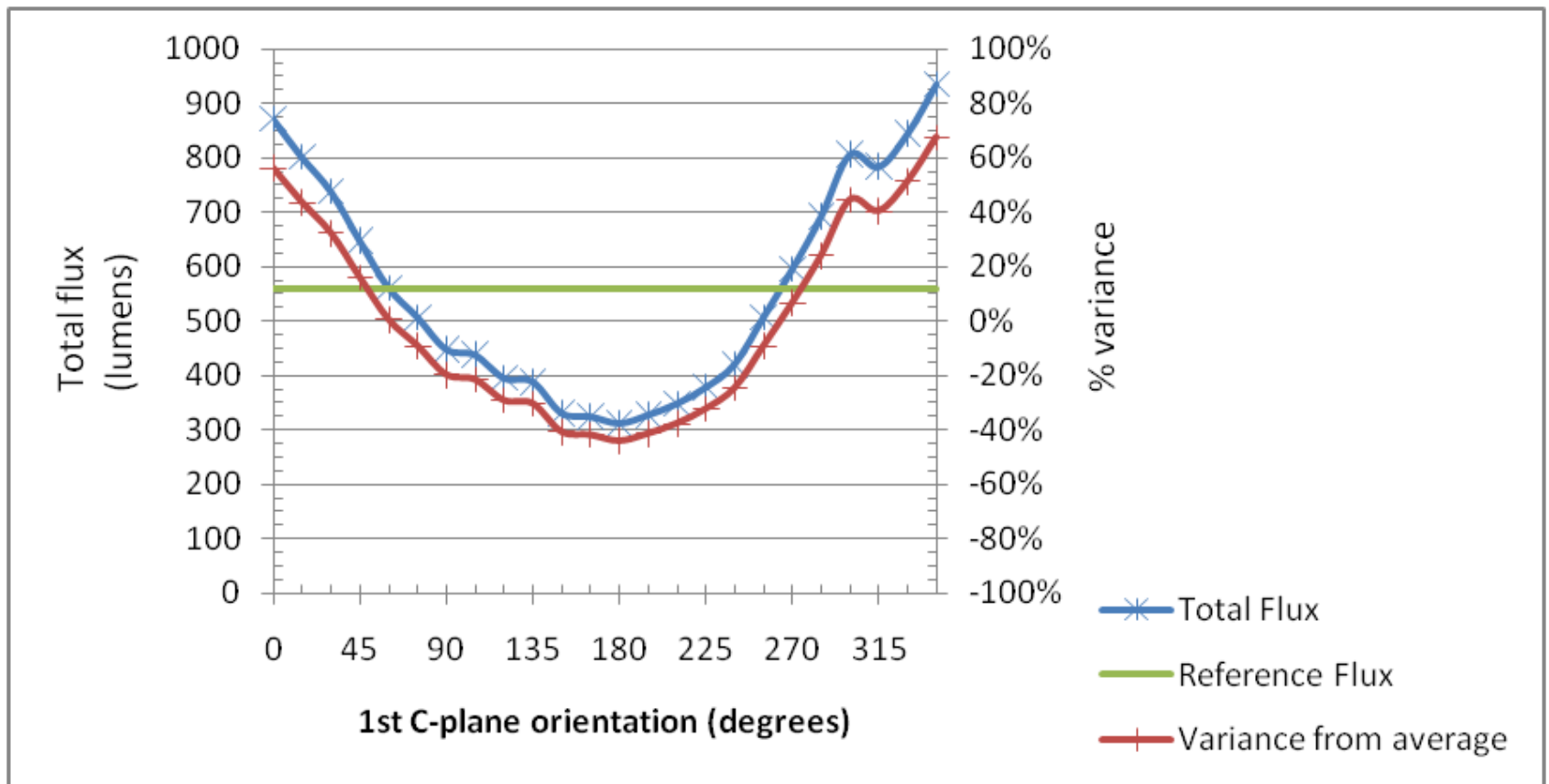- ☐ Accuracy of the result is determined by the number of measurement points taken

Goniophotometry - Accuracy

- Example lamp
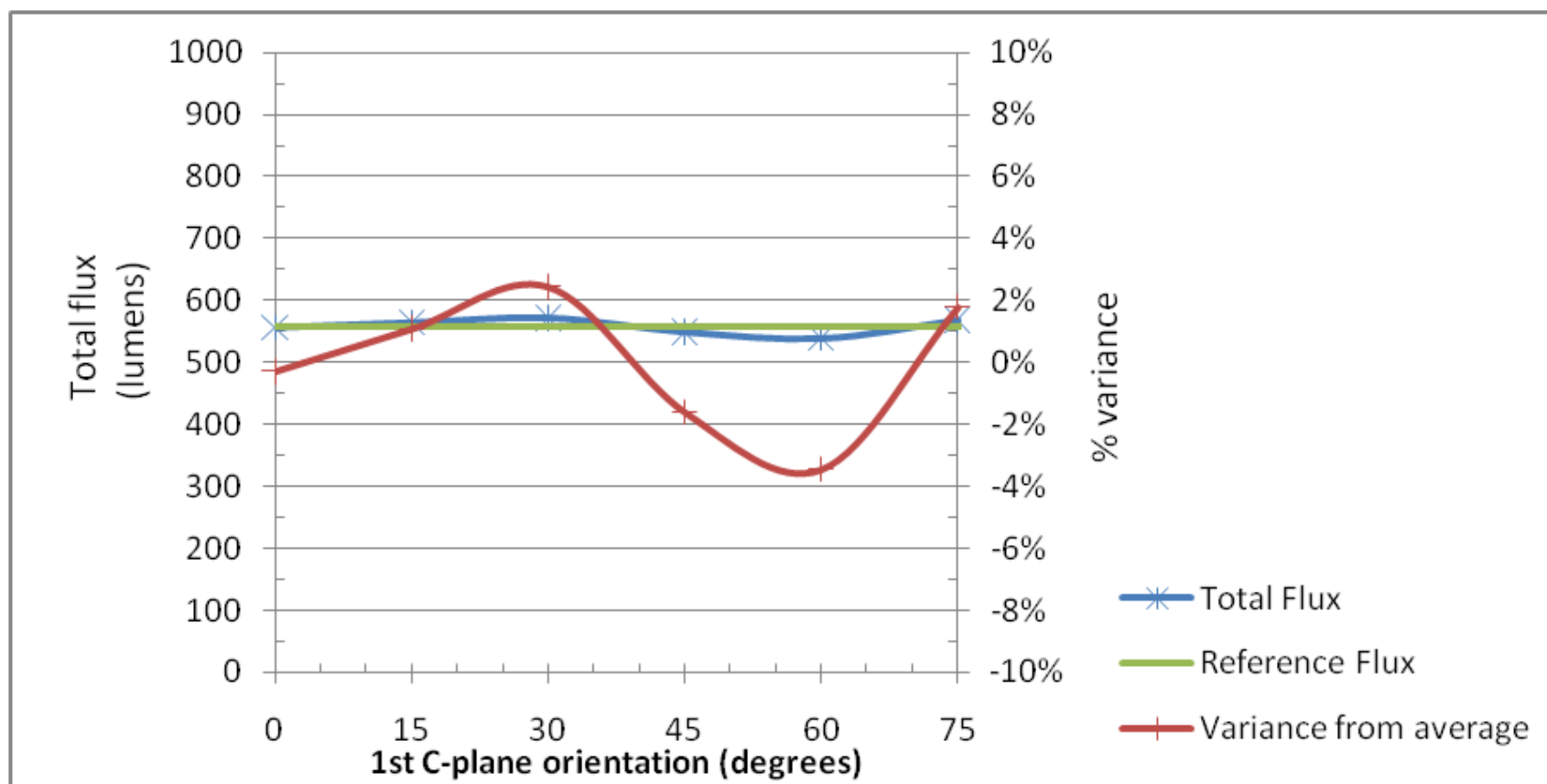 - 12 planes measured
  - 558 lumens calculated

Goniophotometry - Accuracy
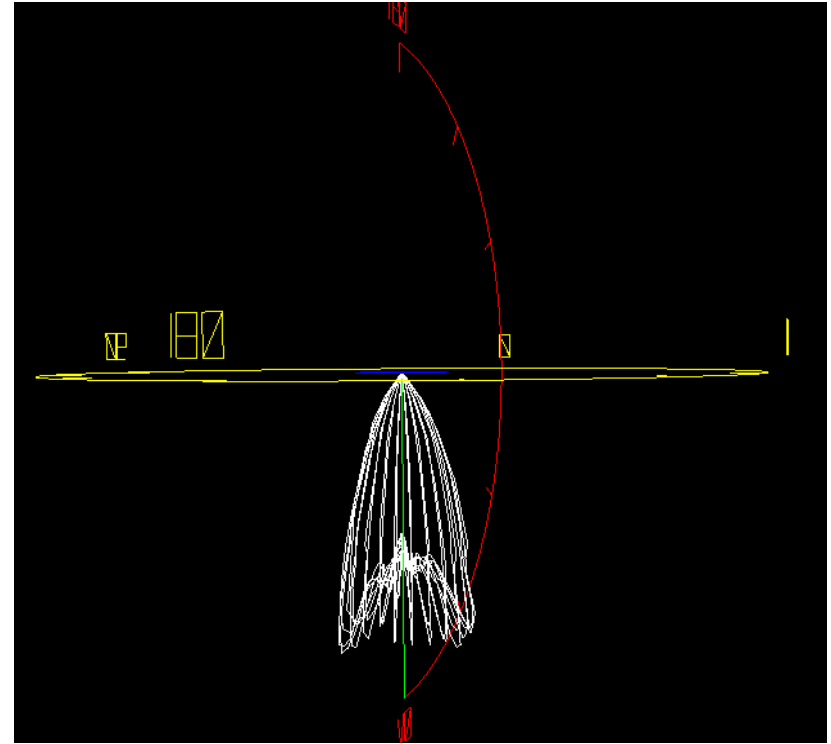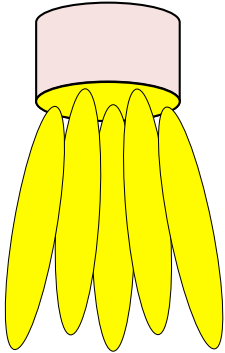
☐ Measuring only half of one plane

Goniophotometry - Accuracy

□ Measuring 2 full planes

Goniophotometry – Multi source LED

□ Becomes problematic for multiple source LED products

□ The interpolation between points becomes risky

Integrating Sphere

- All light from the lamp is captured within the sphere

- The light measured by a detector is proportional to the total amount of light emitted by the lamp

- No information about light distribution is obtained
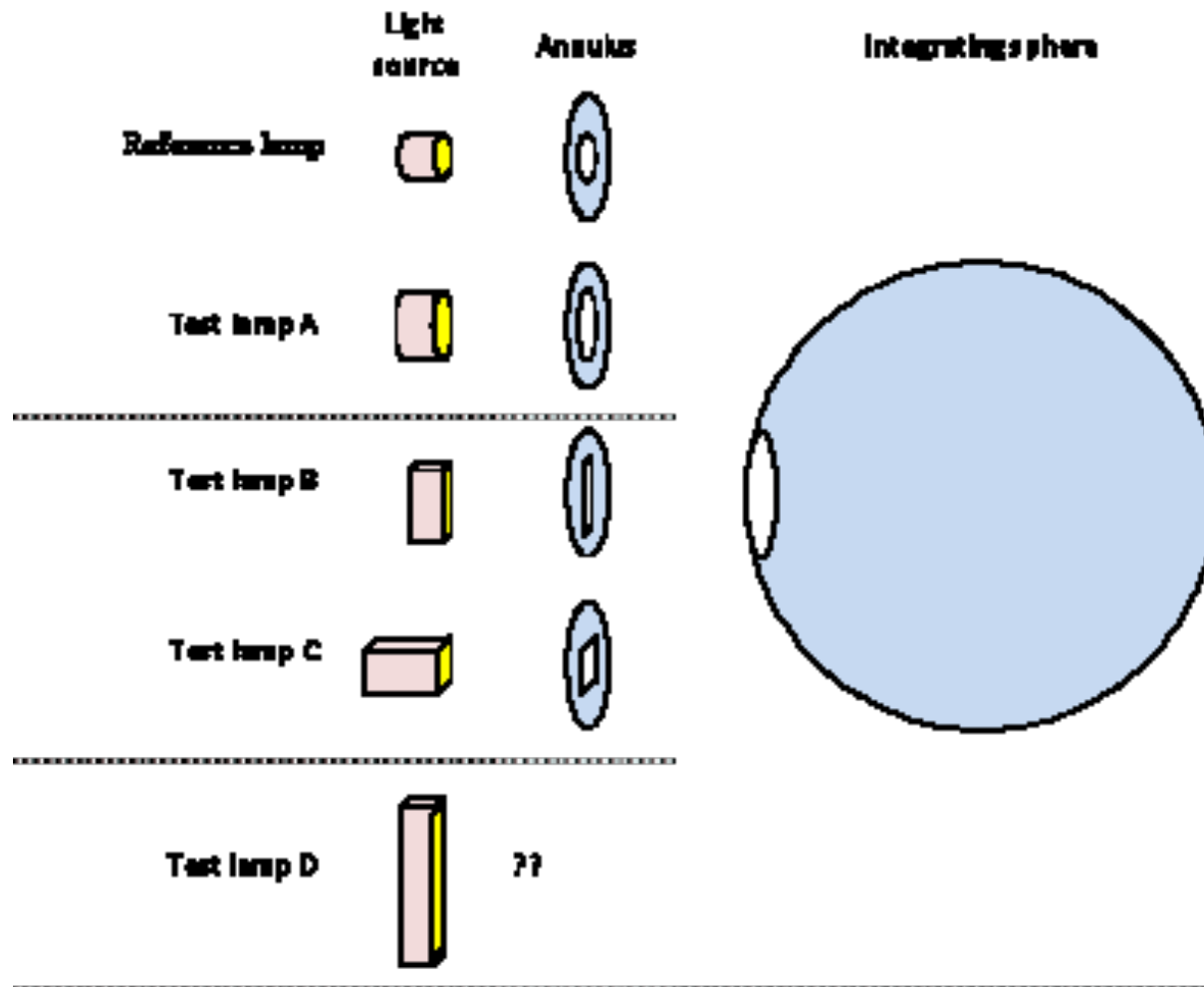
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Integrating Sphere - CIE method

□ CIE84

□ Externally ported test for strongly directional lamps
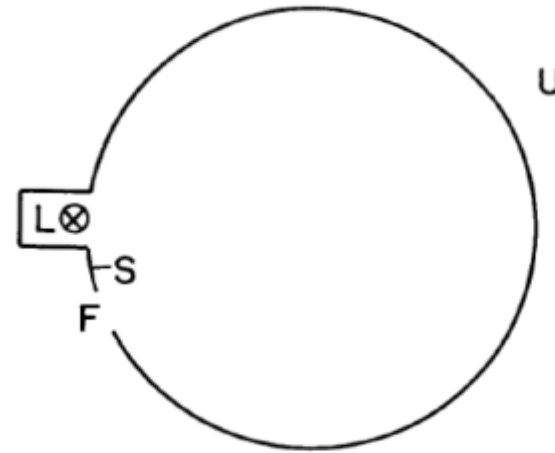
L Light source

F Sphere port for photometer head

S Screen

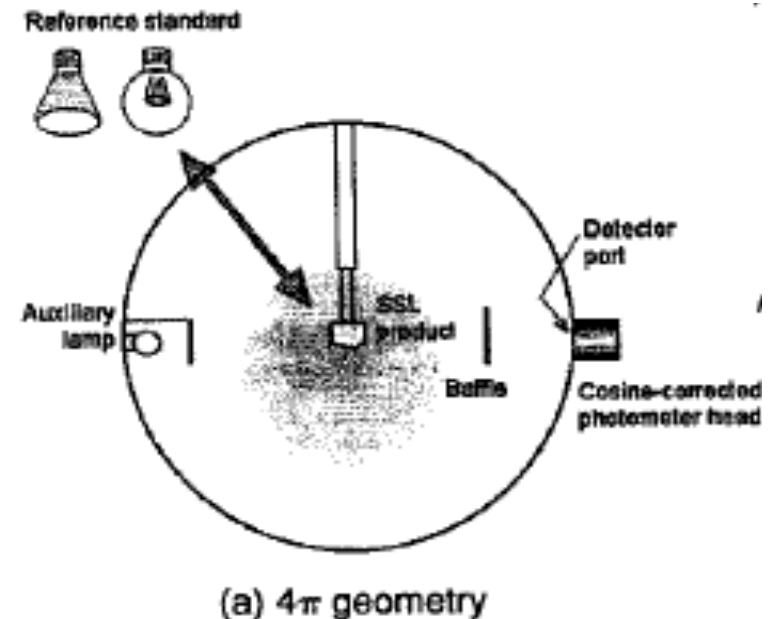U Integrating sphere

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Integrating Sphere - CIE method
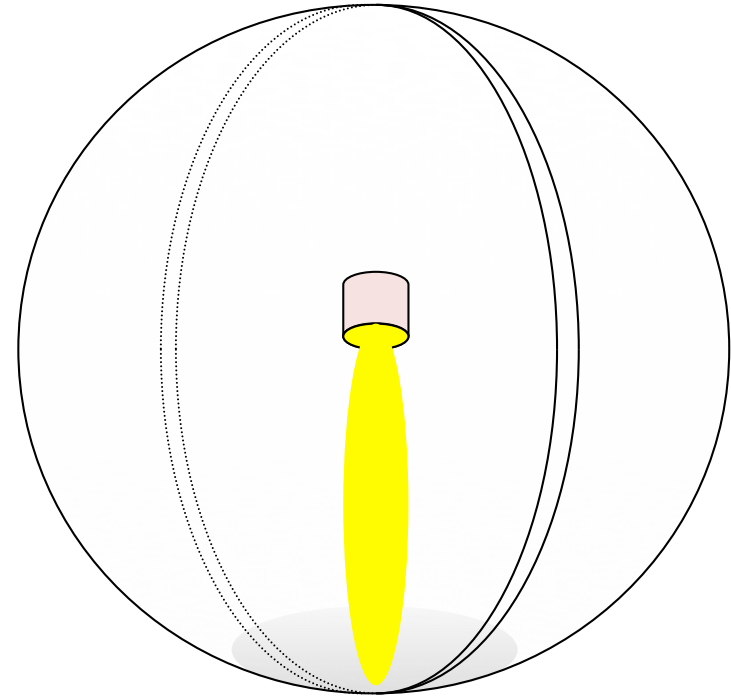
☐ Issues with lamp size and shape with the port

Integrating Sphere – IESNA method

- Internally mounted lamp
- Directed down to base of sphere

(a) 4π geometry

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Integrating Sphere – IESNA method

□ Potential issue with narrow beam lamp to base of sphere where dirt and dust collects
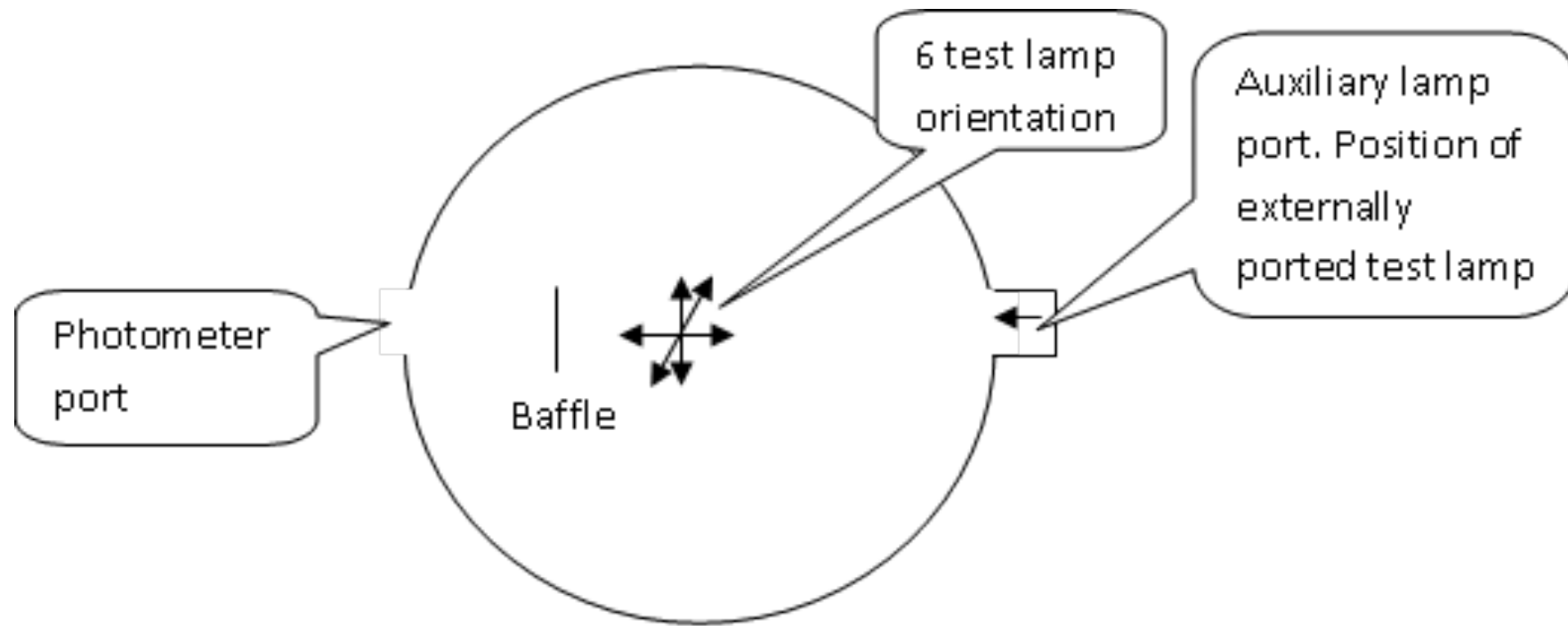
Research into preferred test lamp orientation in Sphere

The test lamp orientations investigated were

☐ Externally ported test lamp (at Auxiliary port)

☐ Centrally located and facing:

  ☐ towards the auxiliary lamp (ie away from baffle)

  ☐ vertically down

  ☐ towards the baffle

  ☐ in (ie horizontally and away from sphere opening)

  ☐ out (ie horizontally and towards sphere opening)

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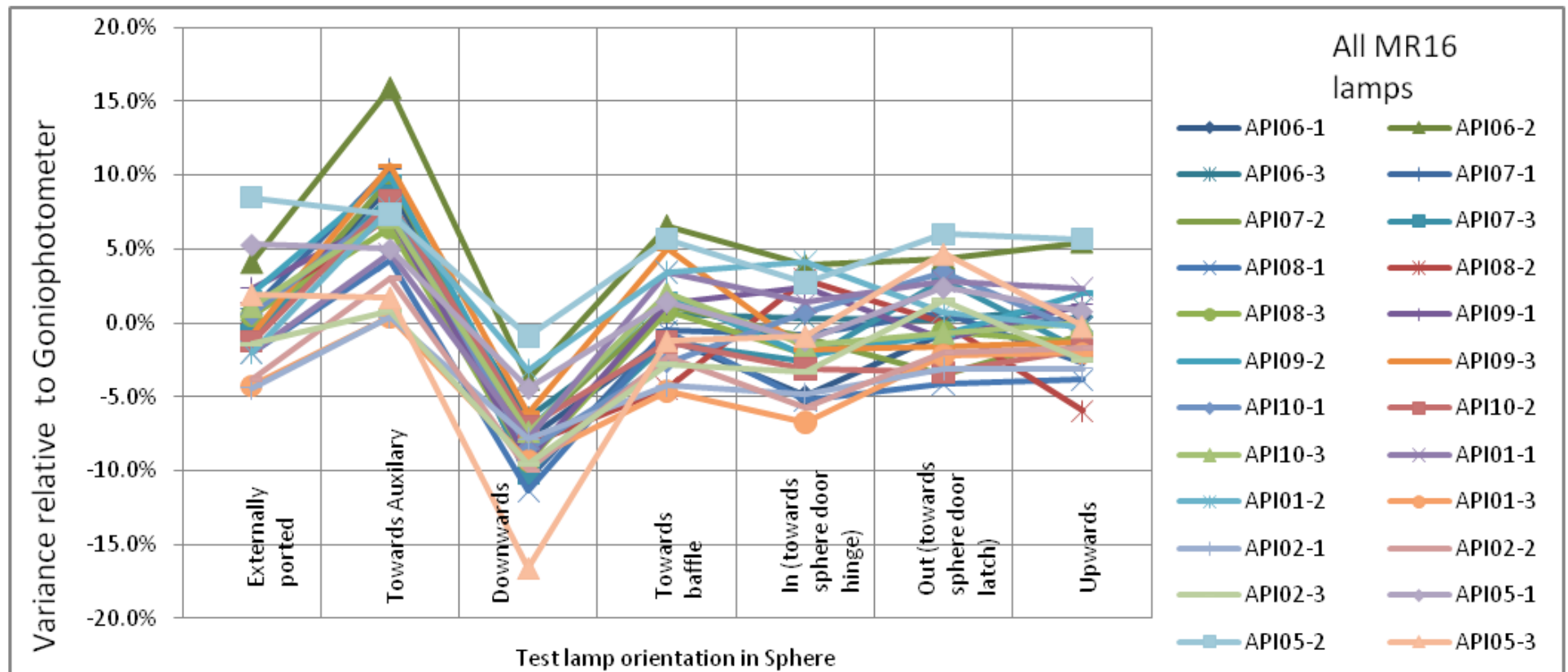# Research into preferred test lamp orientation in Sphere

Research into preferred test lamp orientation in Sphere

☐ Comparison between different orientation results
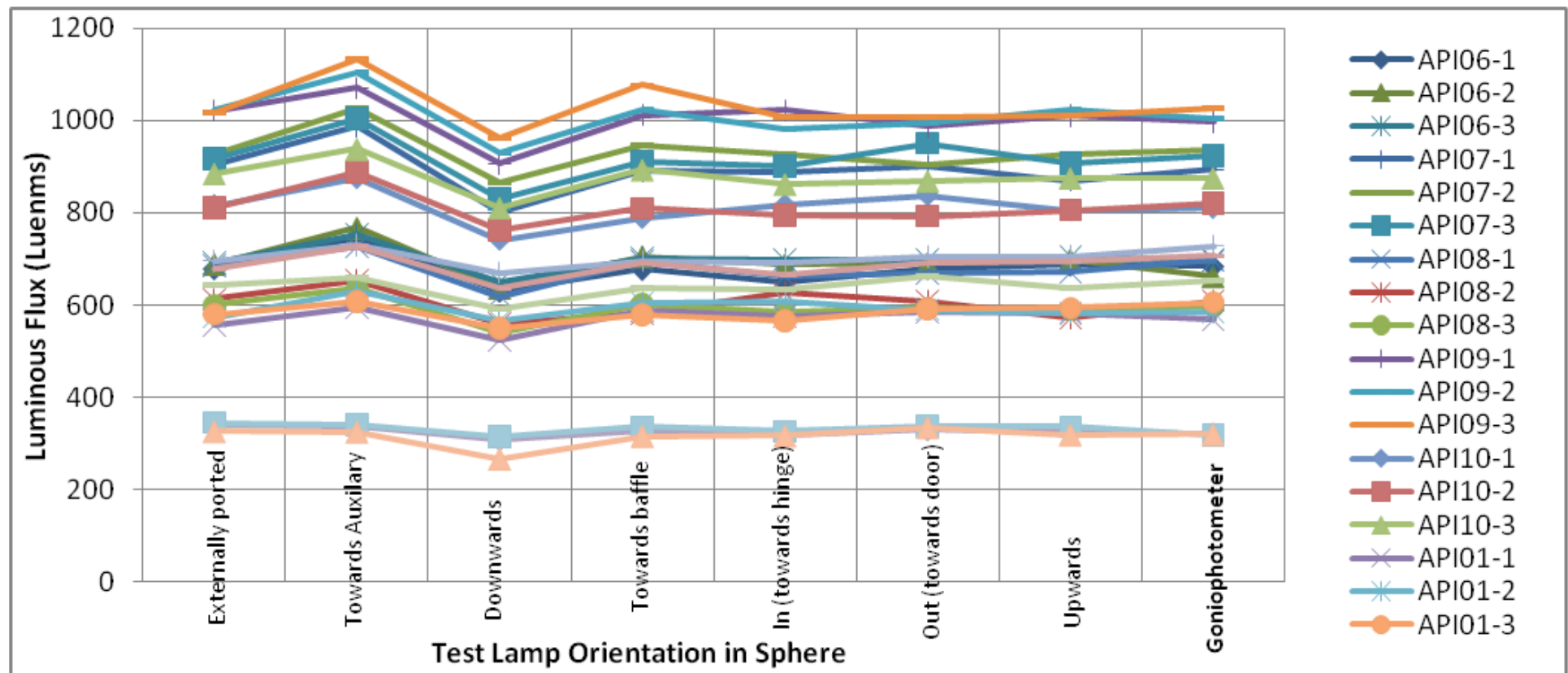
Research into preferred test lamp orientation in Sphere

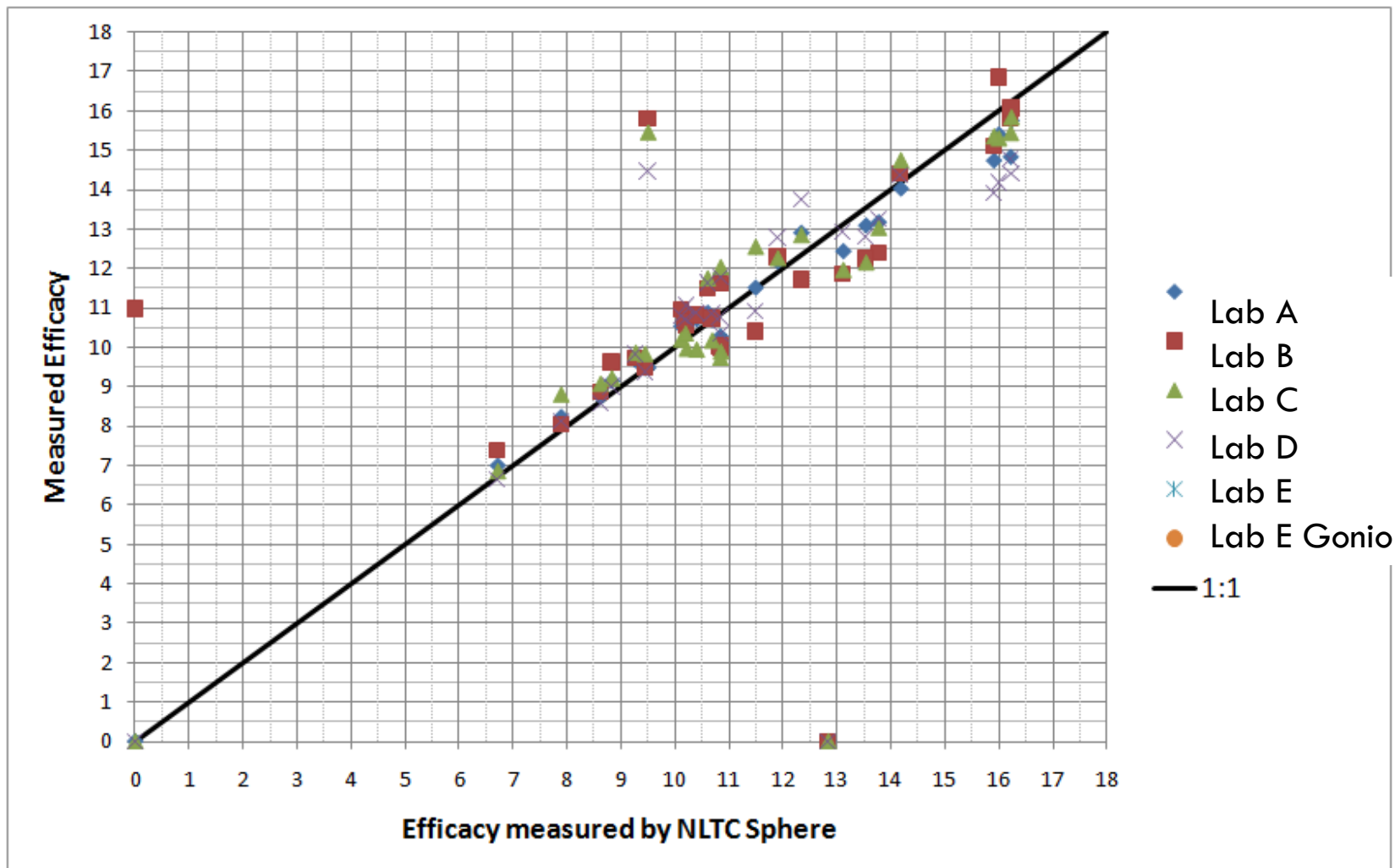☐ Comparison between different orientation results

Round Robin tests with industry

- Round Robin of tests conducted on 90 lamps
  - Participation by 6 laboratories (China, Europe, Australia)
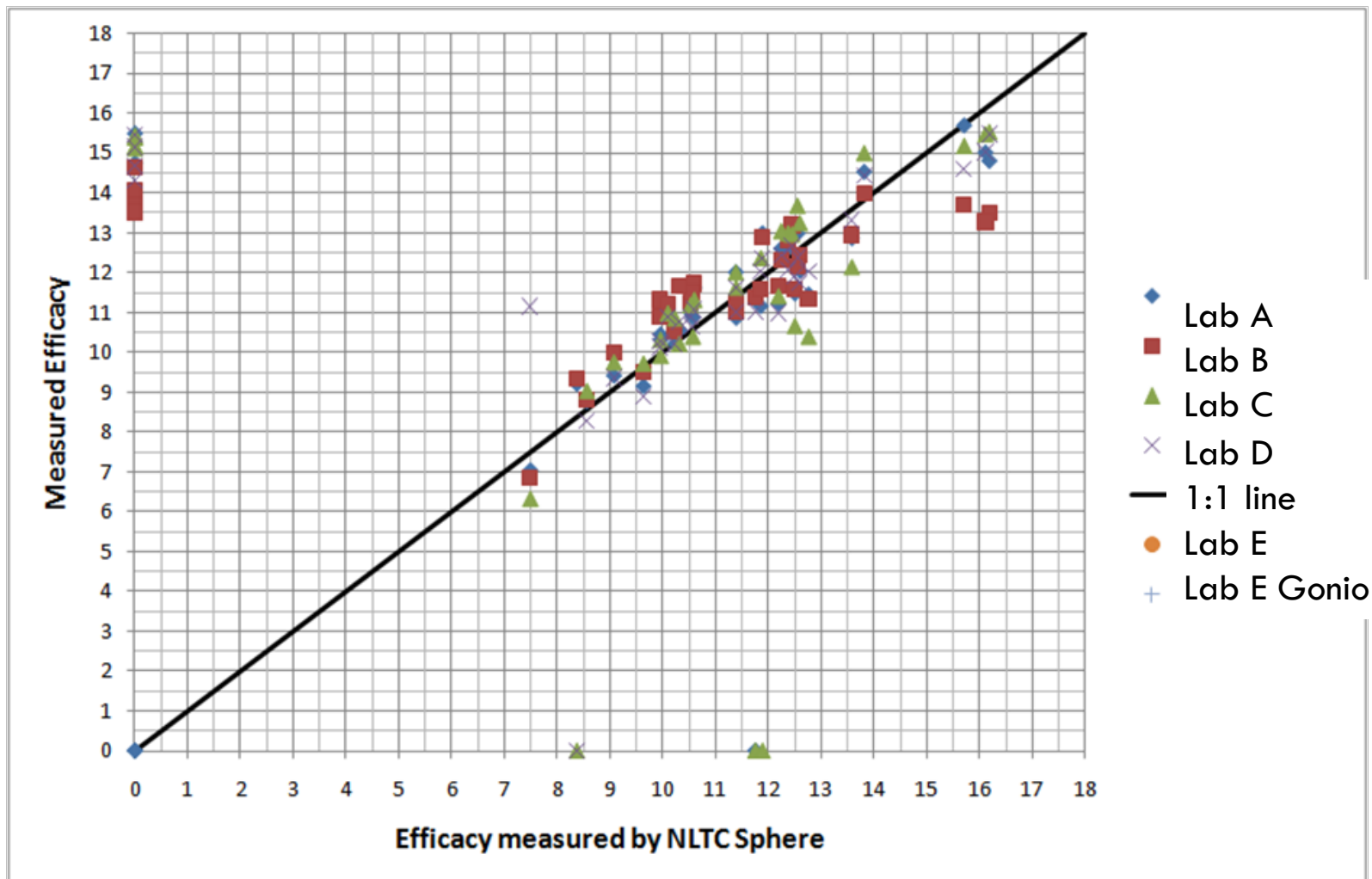 - Test method refined during Round Robin

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Round Robin tests with industry

□ Results – narrow beam

Round Robin tests with industry

☐ Results – wide beam

Round Robin tests with industry

- Conclusions to Round Robin
  - Participants agreed that the test method could provide accurate total flux measurements
  - Documentation of the test method required some refinement (incorporating technical issues highlighted during Round Robin)
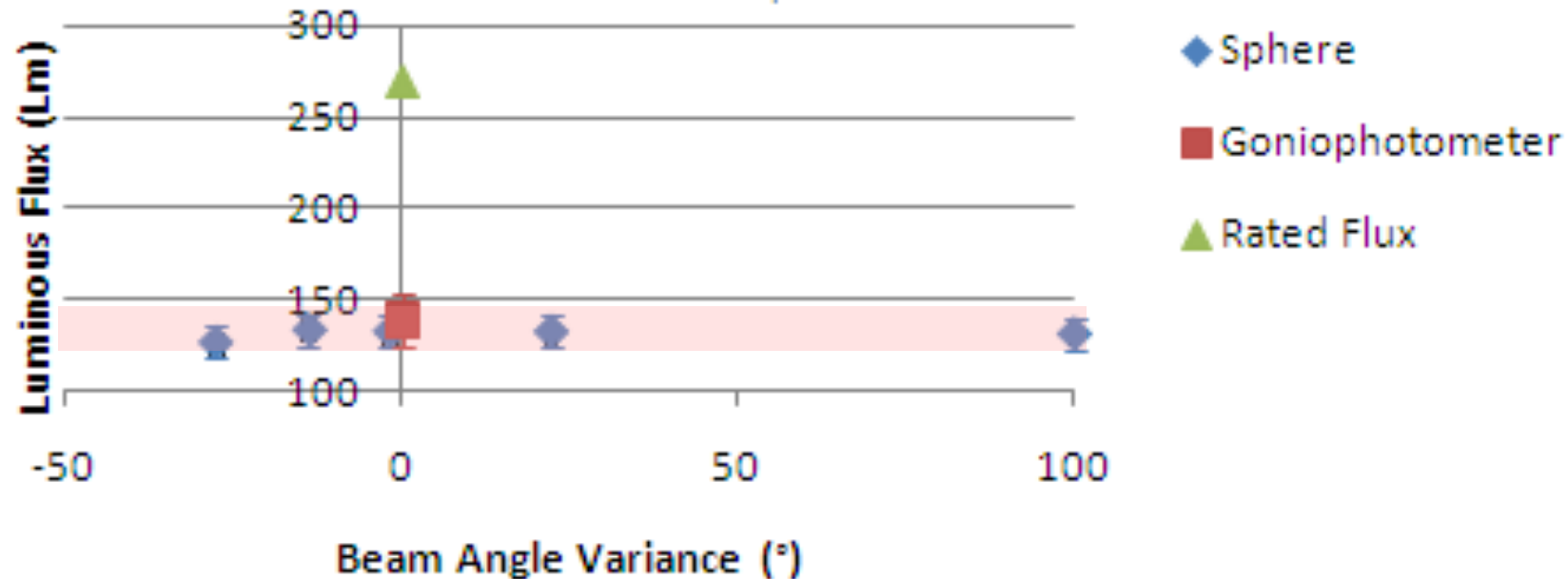
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Tests on Directional LEDs

☐ Tests were conducted on sample LED products using goniophotometer (many measurement points) and integrating sphere (method from Round Robin)

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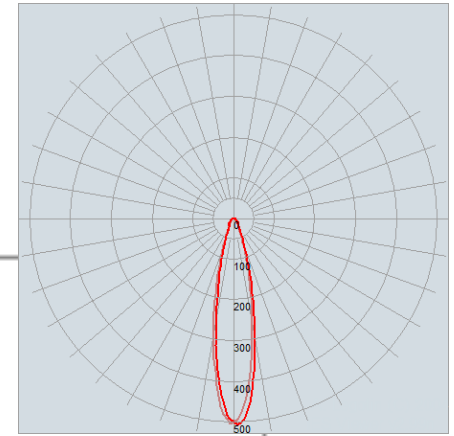
LED Results

LN40: Variance of Integrating Sphere Test Luminous Flux values across Reference Standard Lamp Beam Angles

Gonio error 5.9% Sphere error 6.5%

LED Results

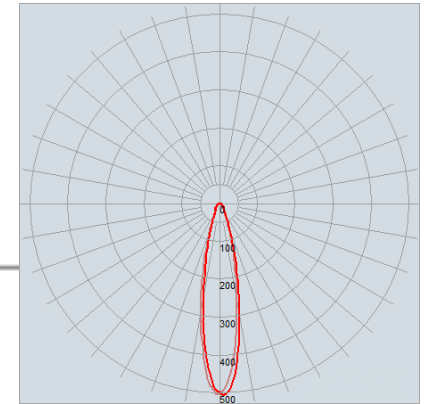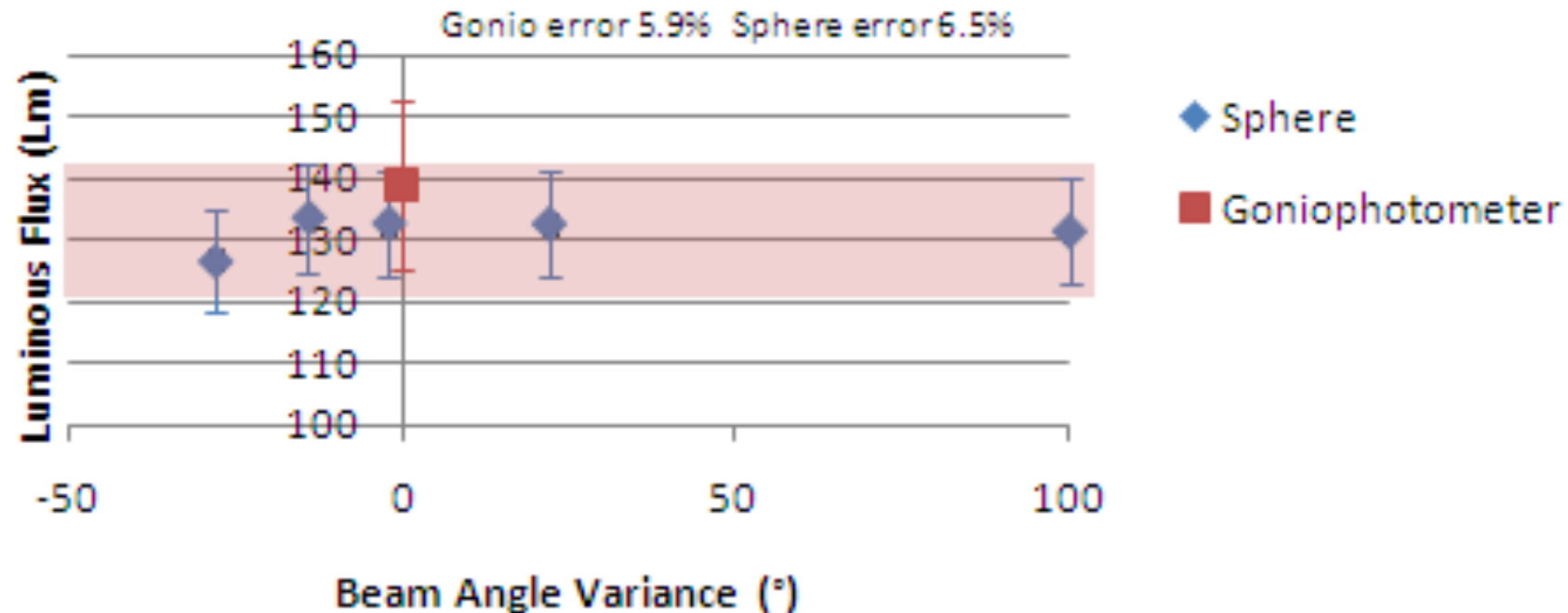**LN40: Variance of Integrating Sphere Test Luminous Flux values across Reference Standard Lamp Beam Angles**

Gonio error 5.9% Sphere error 6.5%

◆ Sphere

■ Goniophotometer

Luminous Flux (Lm) — vertical axis: 100, 110, 120, 130, 140, 150, 160

Beam Angle Variance (°) — horizontal axis: -50, 0, 50, 100

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LED Results

UK09A: Variance of Integrating Sphere Test Luminous Flux values across Reference Standard Lamp Beam Angles
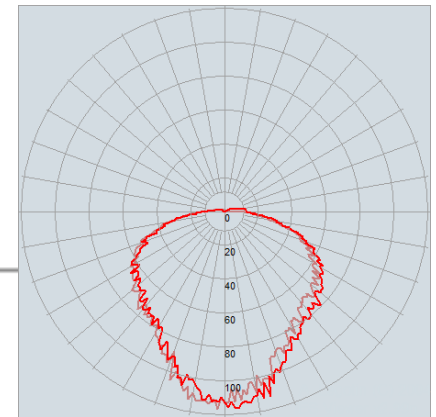
Gonio error 5.9%   Sphere error 6.5%

♦ Sphere
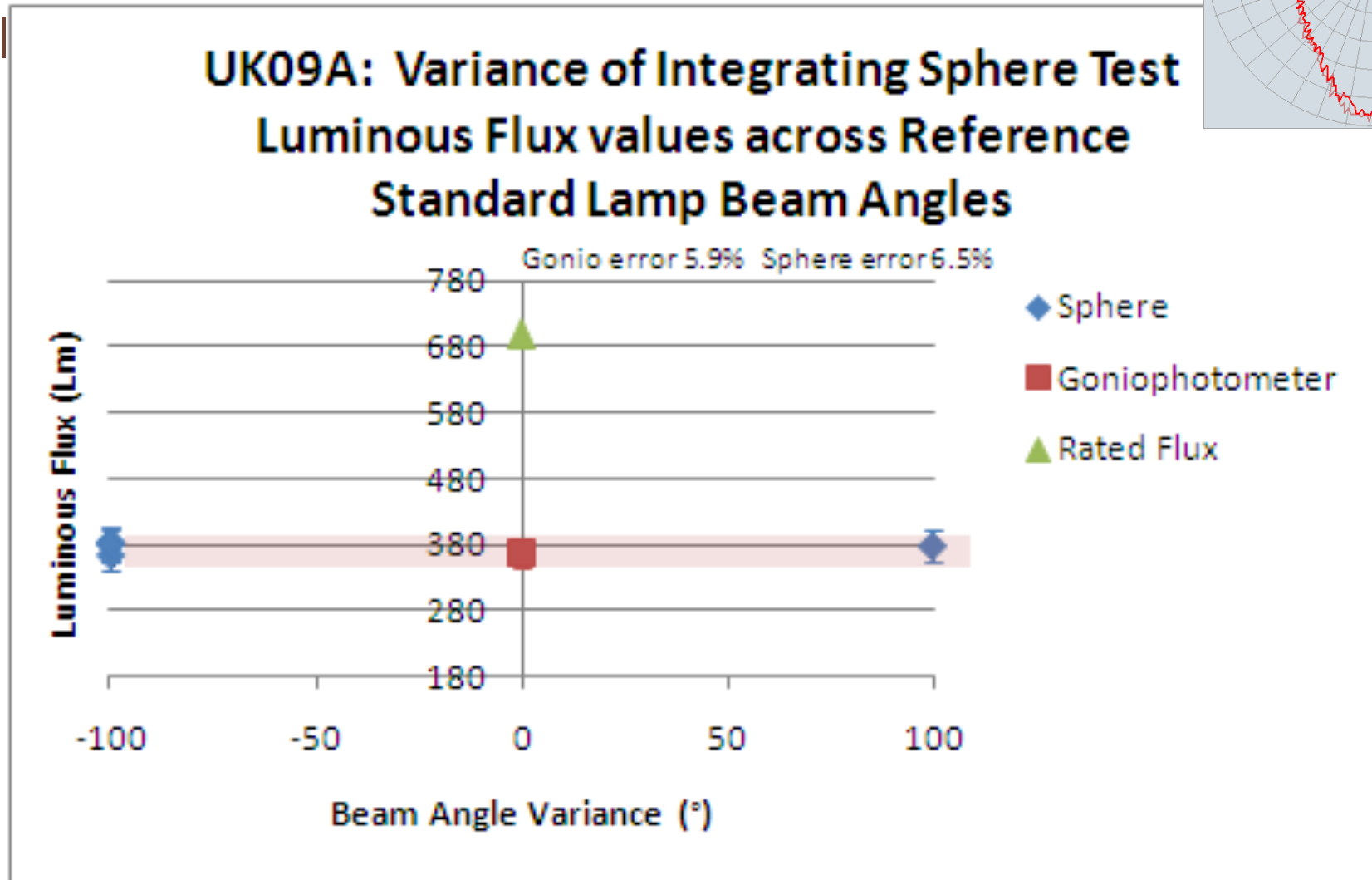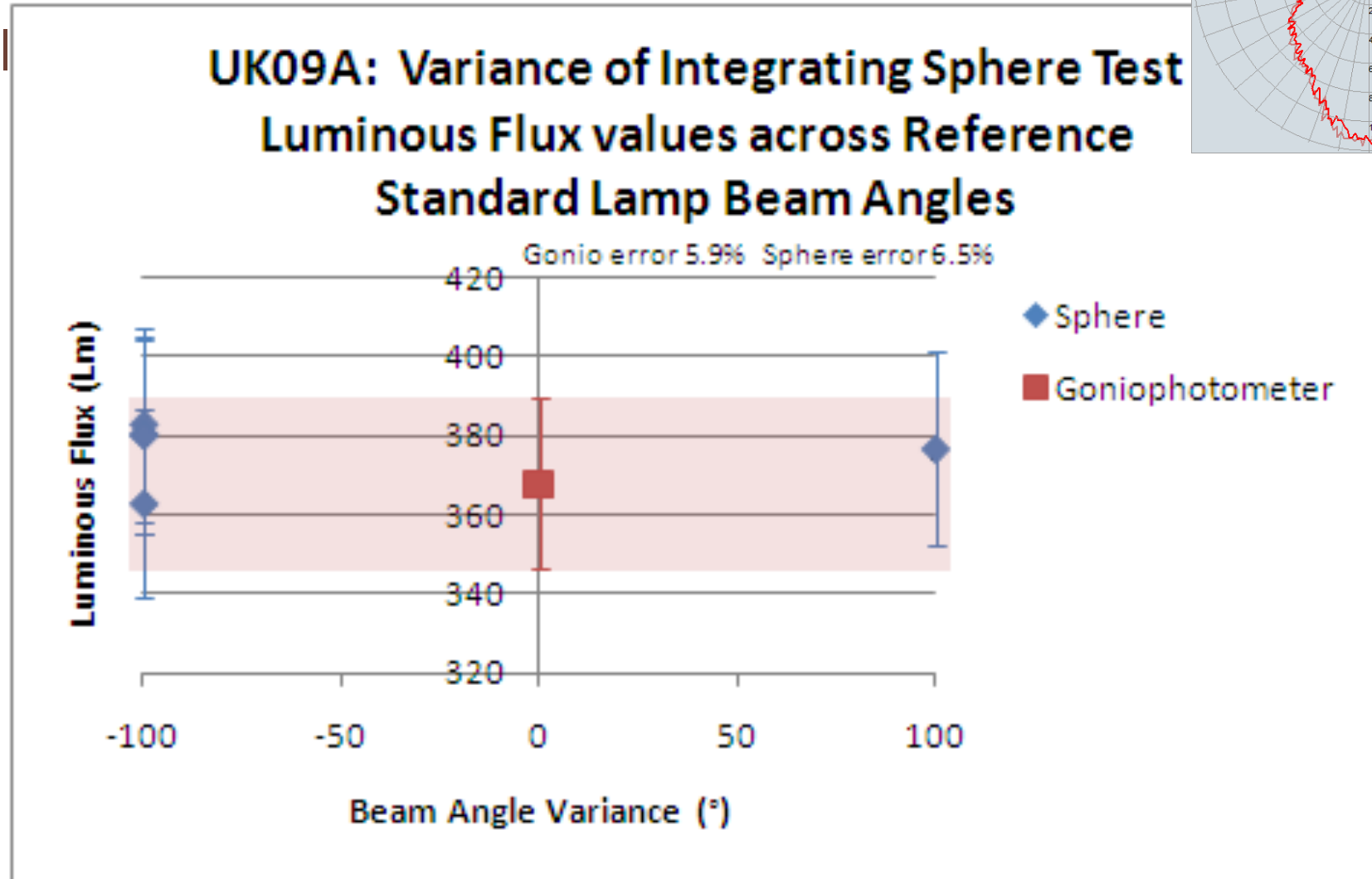
■ Goniophotometer

▲ Rated Flux

LED Results

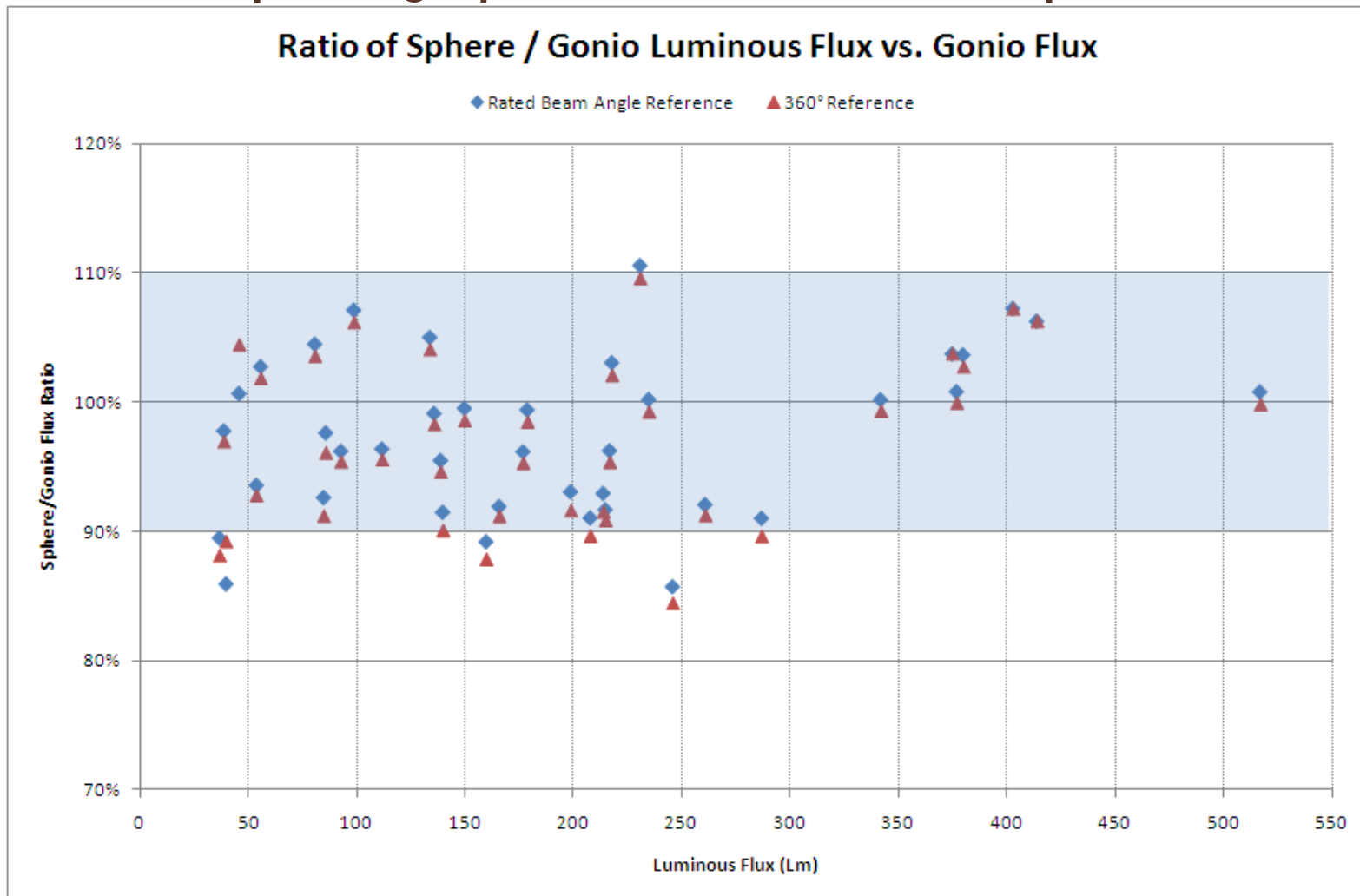UK09A: Variance of Integrating Sphere Test Luminous Flux values across Reference Standard Lamp Beam Angles

LED Results

□ Comparing sphere reference lamp methods

Summary

- Test methods have different levels of accuracy and precision
- Need methods which meet the needs of
  - Manufacturers
  - Designers and consumers
  - Governments (benchmarking, compliance)
    - For lighting products key parameters for energy efficiency are total flux and luminous efficacy

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Suggested strategy for Gov'ts

- Have availability of inexpensive test method (with acceptable measurement tolerance) for compliance check testing

- Consider using more expensive test method (with smaller measurement tolerance) for products which have inconclusive check test results

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Caution

- □ Need to give careful consideration to the implications on available test methods of any exotic performance measures

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