Flux-O-Meter

Making luminous flux measurements more accessible

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Funded by EPA

Lighting Research Center

Luminous Flux, Lumens, Total Light Output... Who cares?

- Lighting practitioners use illuminance (lux, footcandles) and luminance (cd/m^2, footlamberts)
- Luminaires are characterized by intensity, intensity distributions, luminance
- Flux measurements are usually confined to
  - National labs
  - Lamp Manufacturers
- The current practice suffices if we don't care about total system efficacy.

Luminous flux is key to the issue of generating and controlling light efficiently.

- Standard photometric reports do not reveal system efficacy
- Luminaire efficiency does not fully take into account thermal, positional and ballast effects (system issues)
- Based on relative photometry
  - Numbers scaled to rated lamp light output

Luminaire Efficiency Rating (LER)

- Works well for well characterized systems
- Insufficient data available for CFL and lower volume/specialty lamps and ballasts
- Gets complicated for universal ballasts, different operating positions, atypical luminaire configurations, etc.
- Errors from –23% to +86% for CFL luminaires
  - NLPIP Specifier Reports: Energy-Efficient Ceiling Mounted Residential Luminaires (1999)

Must measure flux to determine true system efficacy

Traditional Flux Measurements

- Integrating Spheres
  - Very sensitive to departures from ideal
  - Substitution method is the practical means
  - Requires calibrated flux standards – expensive, delicate!

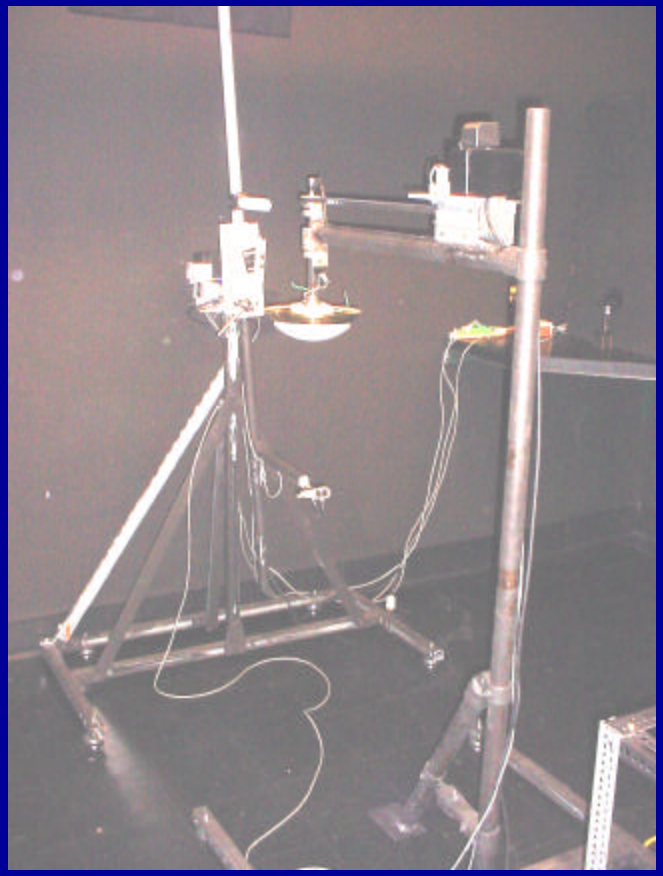
Goniometers

- Requires large test distance, large spaces
- Sensitive to stray light (need dark room)
- Integrate intensity over solid angle to get flux
- Only a few facilities have one

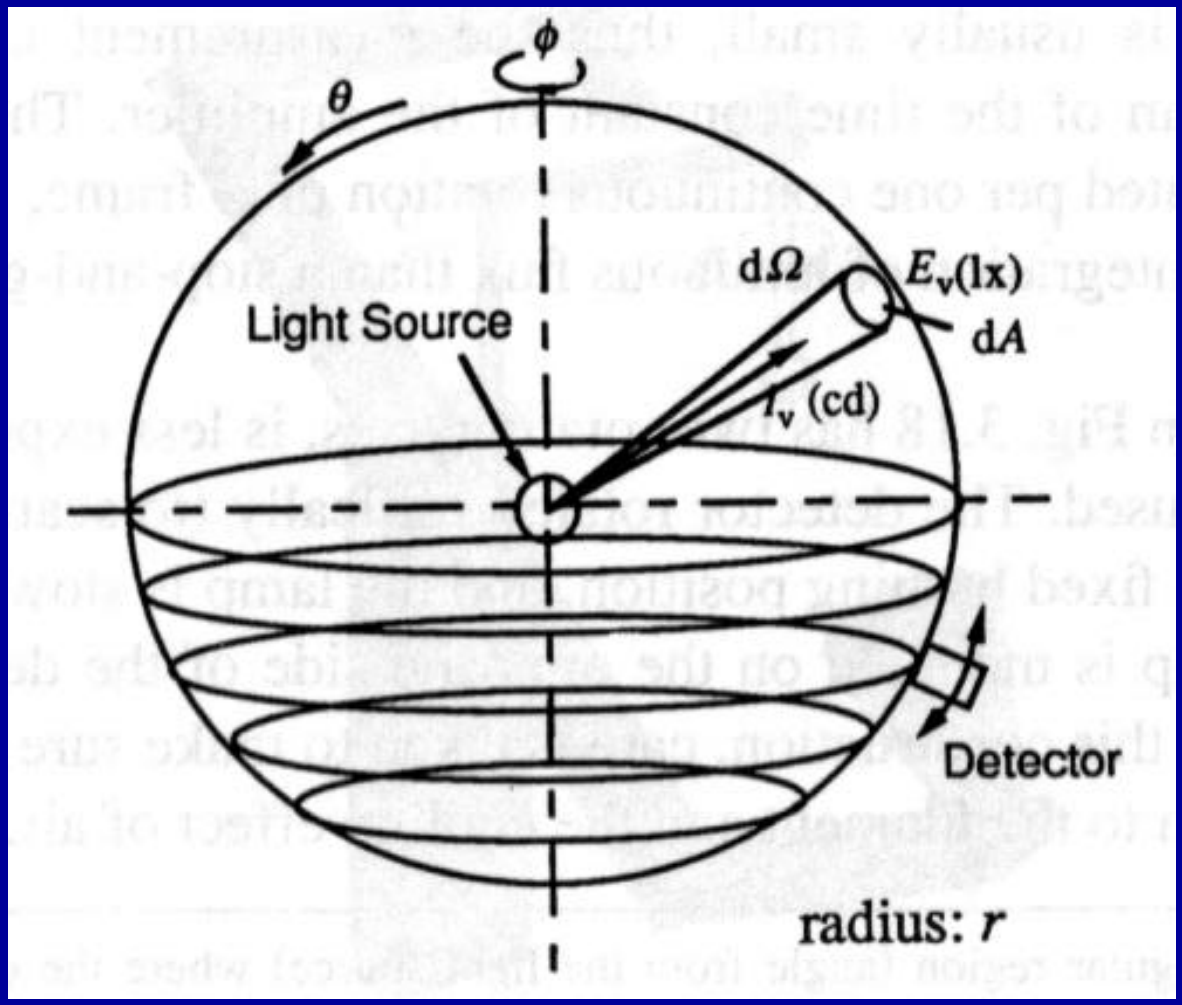
Alternate Method

Illuminance Sampling

- Measure the illuminance at many points around the source (an imaginary sphere)
- Integrate over area



Integrating illuminance over area



$$Flux = \int_{sphere} EdA$$

Benefits / Limitations

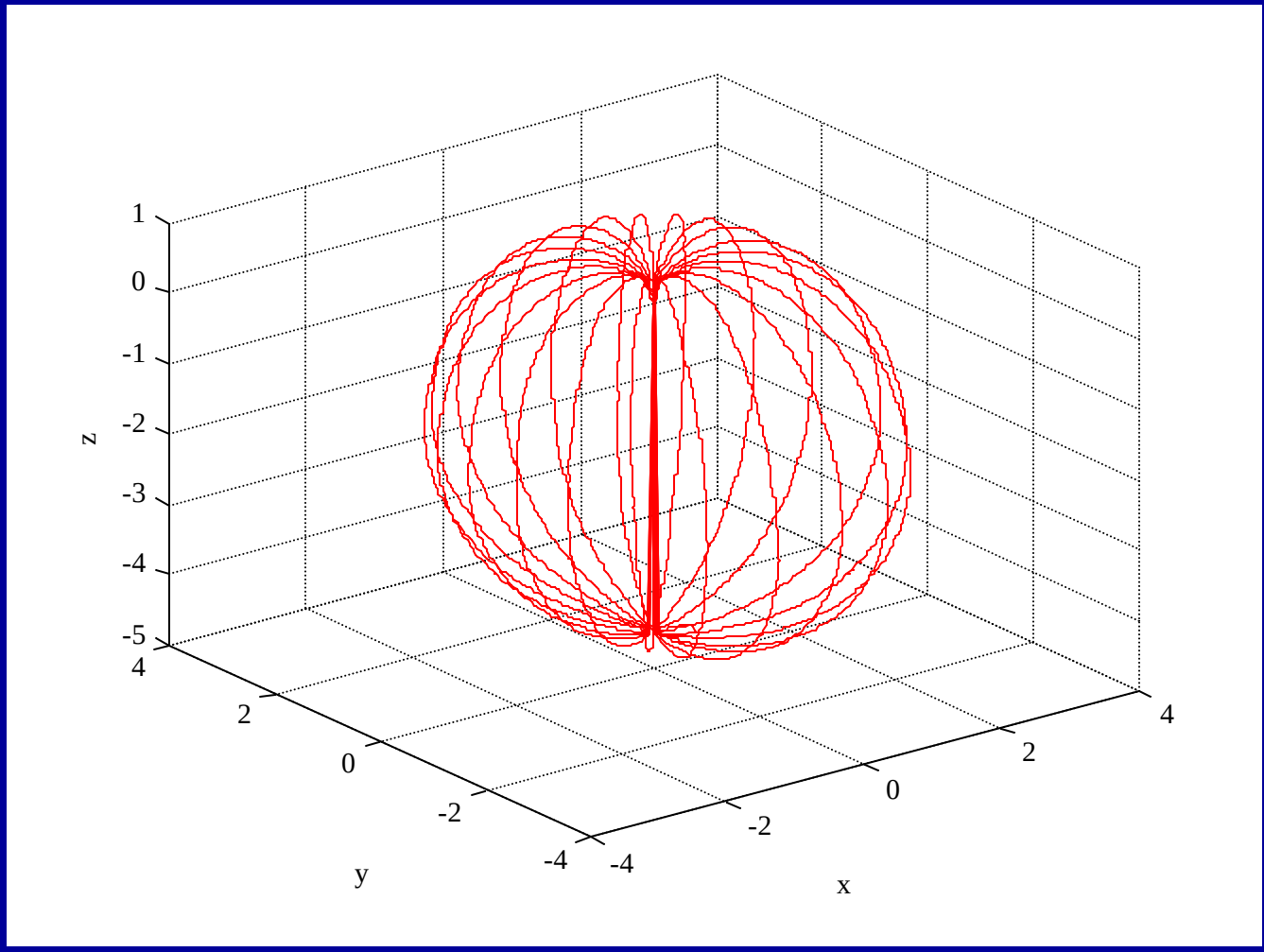
- No minimum distance requirements
- No flux standards
- Not sensitive to positioning of source (?)
- Not sensitive to source size (?)
- Not sensitive to distribution (beam vs. blob) (?)

- Only gives total flux (no distribution data)
- Sensitive to stray light (requires black surroundings
- Rotation axes must be perpendicular

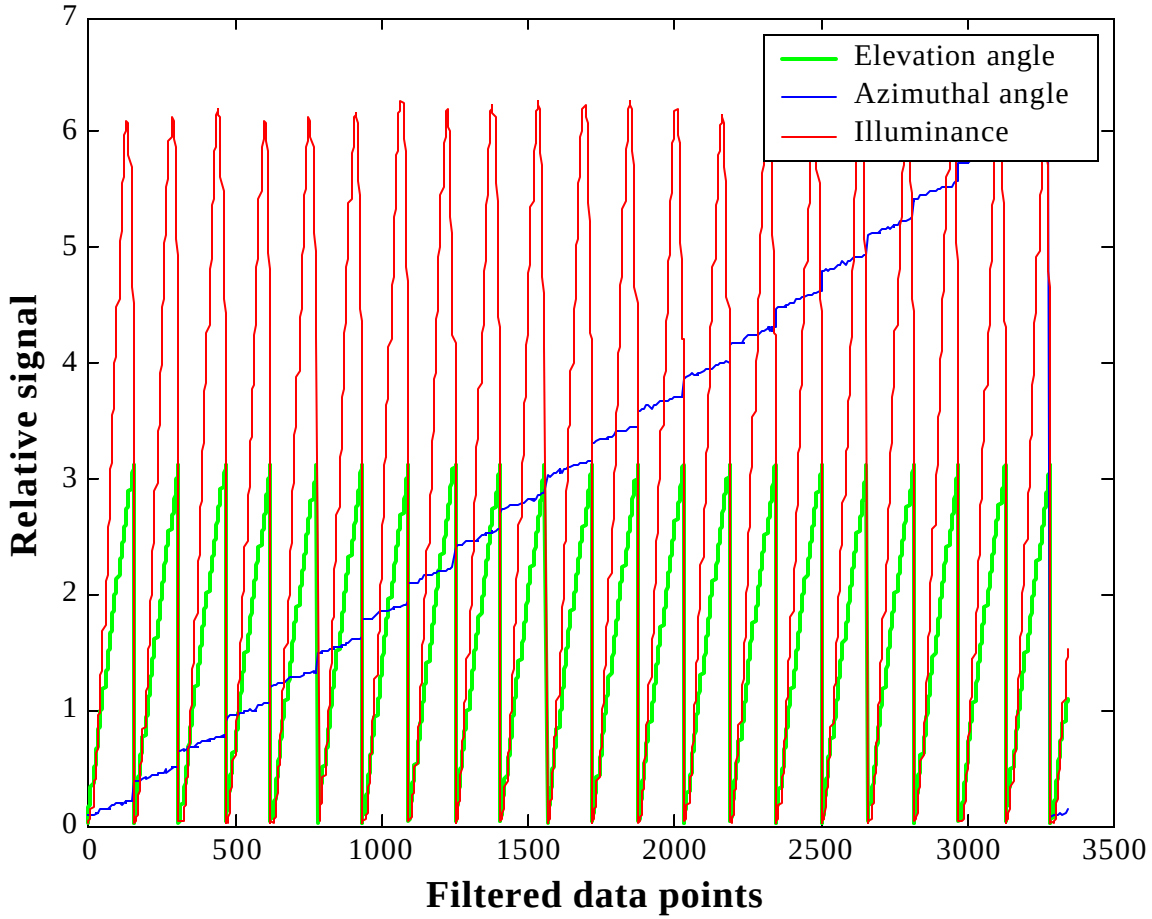
Apparatus

- Low-cost approach
  - Exploits rapid sampling, low-cost, 12-bit computer data acquisition boards
  - Inexpensive motion control
    - Analog encoders (rotary variable resistors)
    - Continuous motion (no feedback motion control)
  - Cost: < $1000 plus computer, software

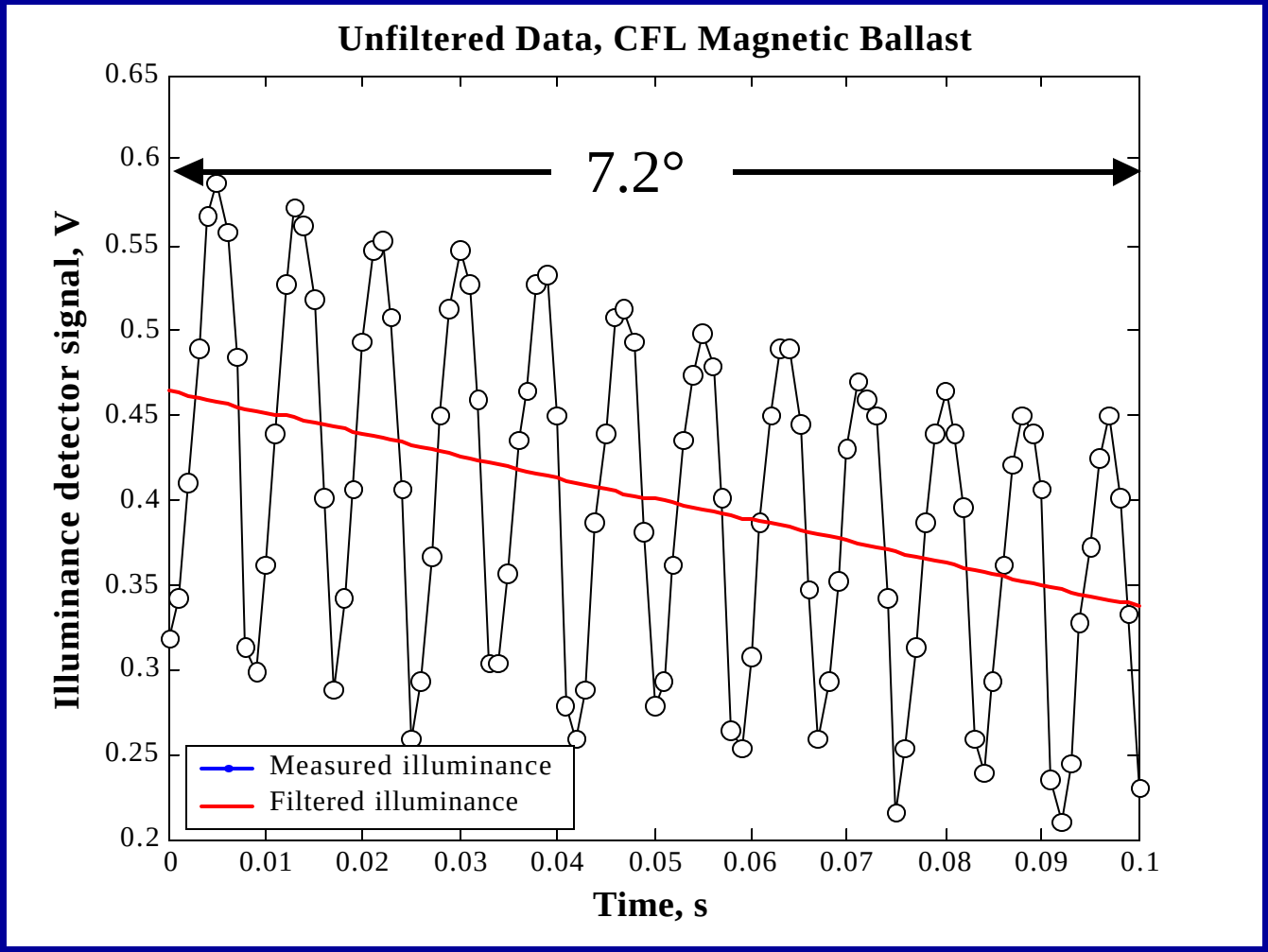
How it takes measurements



How it takes measurements



Dealing with Modulated Light Sources



Comparison with Integrating Sphere

		Lamp Type		
	60W A-19	100W A-19	60W R-Lamp	28W CFL Screwbase
Sphere (lm)	811	1576	477	1443
Flux-O-Meter (lm)	828	1610	496	1387
Difference (%)	2.1	2.1	3.9	-4.0

Fixture Comparison with Goniometer

	20W Circline (bare lamp)	Fixture #1	Fixture #2	Fixture #3
Goniometer (lm)	1232	818	1132	640
Flux-O-Meter (lm)	1272	872	1190	673
Difference (%)	3.2	6.4	5.0	5.0