# A NEW MULTI-SPHERE HDRI CALIBRATION SYSTEM

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# WHAT IS HDRI?

**H**igh **D**ynamic **R**ange **I**maging

Human Eye Sensitivity: 0.000,000,1 cd/$m^2$ – 1,000,000 cd/$m^2$

Adapted Human Visual System Range: 1,000:1 – 10,000:1

Standard Visual Display Terminal Range: 300:1

*Source: NREL

# WHAT IS HDRI?

**Underexposed:**

# WHAT IS HDRI?

**Properly Exposed:**

# WHAT IS HDRI?

**Overexposed:**

# WHAT IS HDRI?

**HDR Image:**

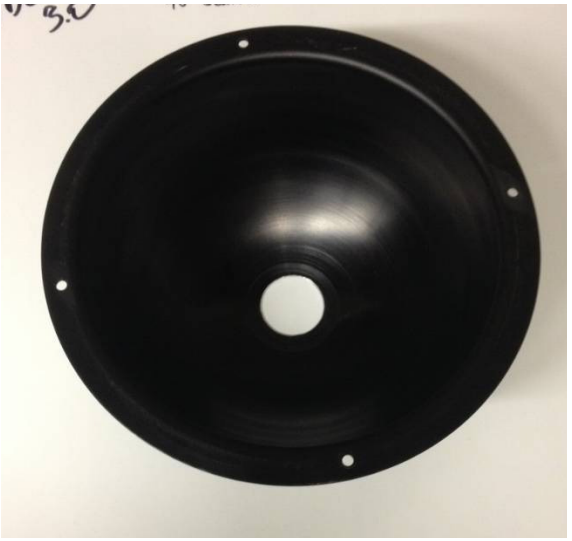
***Created using WebHDR**

# WHAT IS HDRI?

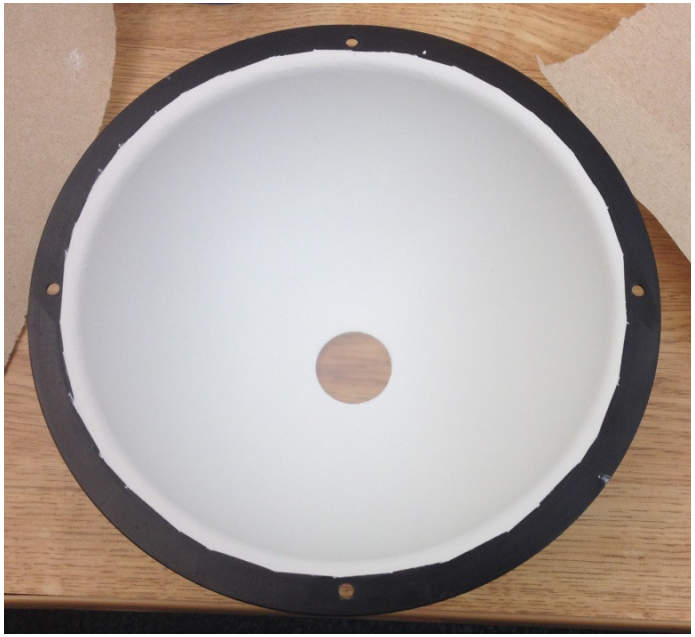
# MOTIVATION

- Luminance Mapping
- Understand Limitations and Errors Associated with HDRI
- Validate Methods of HDRI Calibration
- Luminance Based Photometry Research

# APPARATUS

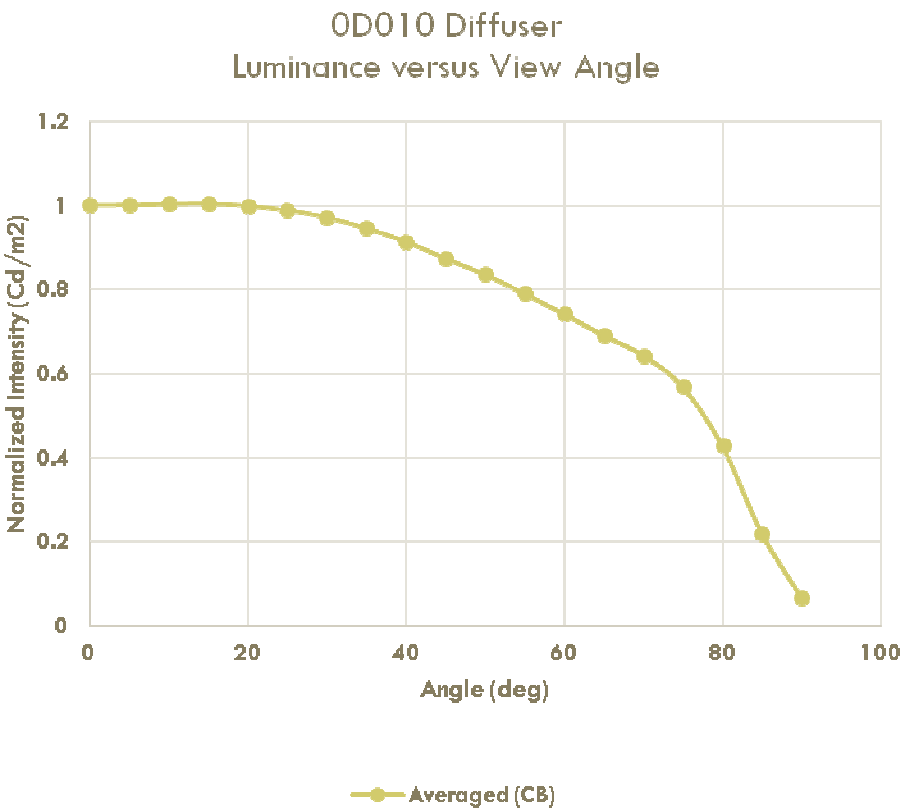


- Anodized black aluminum sphere halves
- Primed with a white aluminum primer paint
- Applied 5+ coats of barium-sulfate/white latex paint mixture



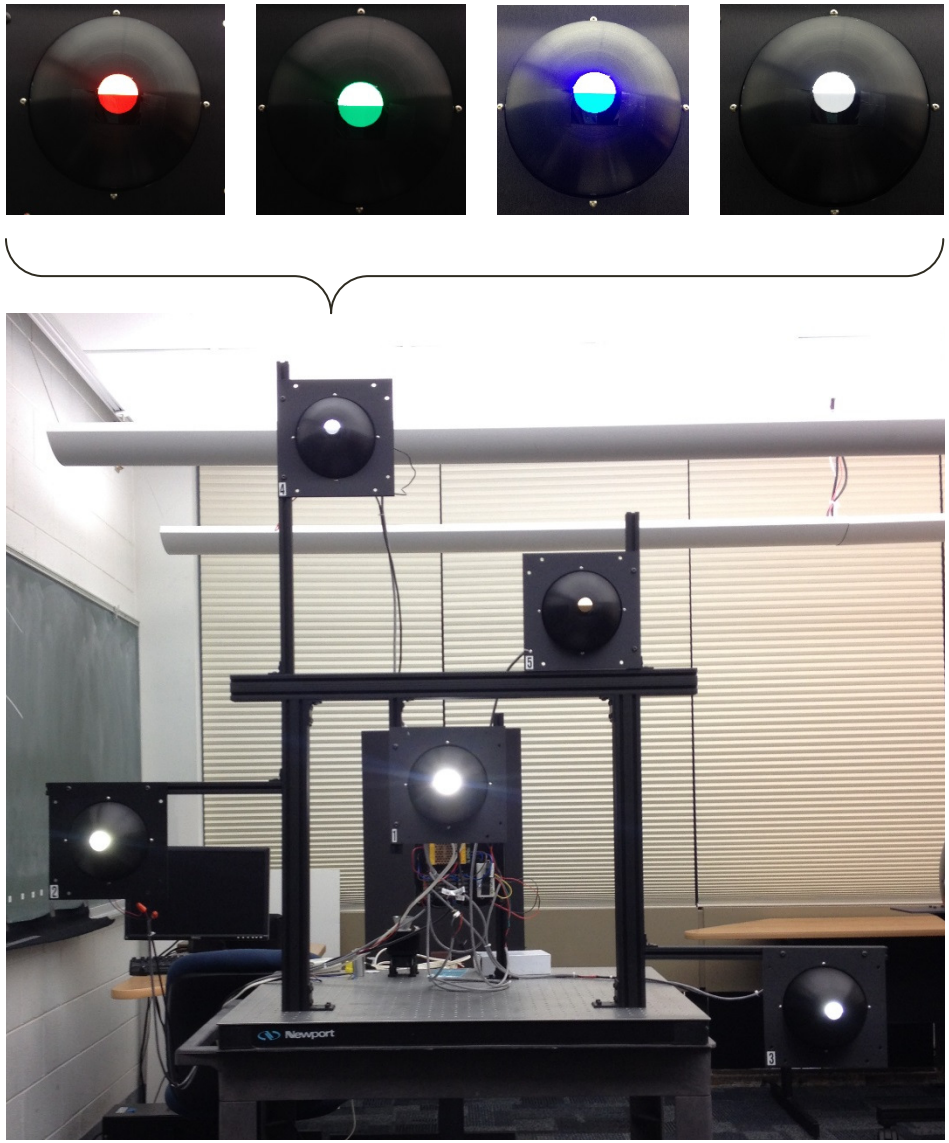
# APPARATUS

- Verified luminance uniformity of lens across lens and view angle
  - Avg Luminance: 57,850 Cd/m$^2$
  - Range: 612 Cd/m$^2$
  - Avg Max:Min Ratio: 1.01
- Used Minolta Luminance Meter LS-110



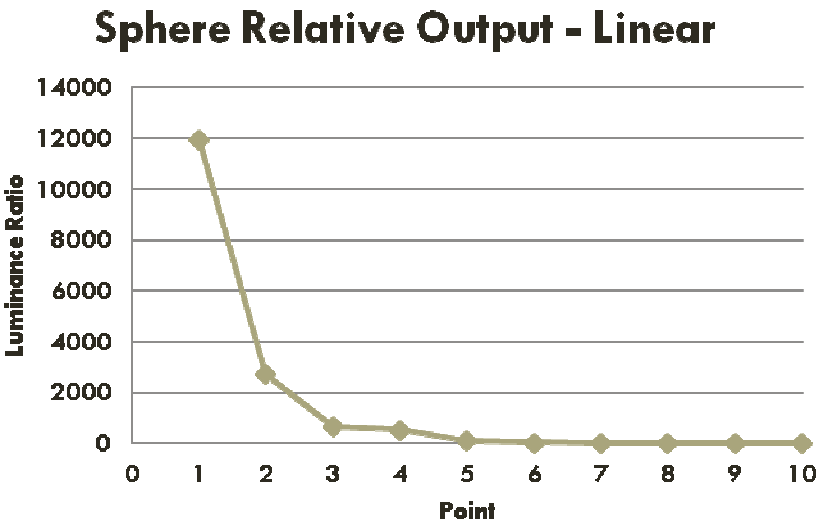
# APPARATUS

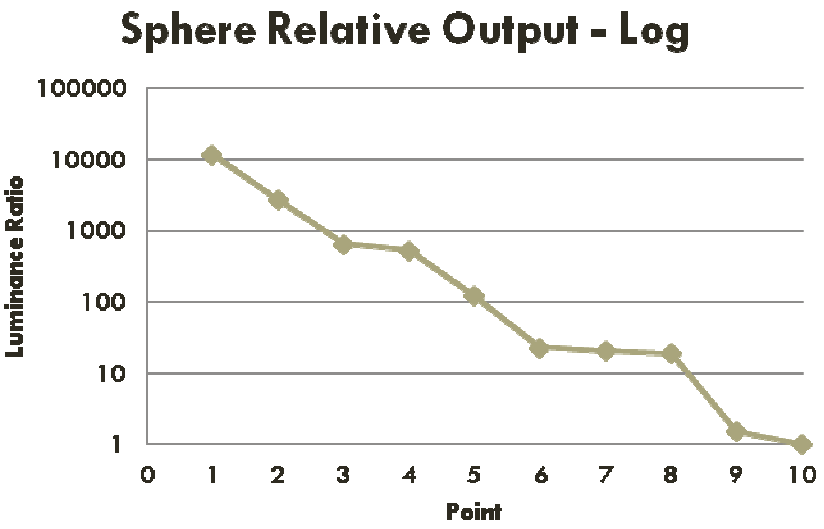
- Final setup uses 5 spheres
  - Sphere 1: ~124,500 cd/m$^2$
  - Sphere 2: ~31,000 cd/m$^2$
  - Sphere 3: ~6,800 cd/m$^2$
  - Sphere 4: ~250 cd/m$^2$
  - Sphere 5: ~200 cd/m$^2$
- Sphere 4 has RGBW options
- Nikon D5200 DSLR
  - 18-55mm zoom lens
- Neutral Density Filters applied to lower halves of lenses



# APPARATUS

| Sphere Output - Ordered by Magnitude | | | |
|---|---|---|---|
| Point | Sphere | Measure Luminance | Ratio |
| 1 | 1 | 112350 | 11984 |
| 2 | 2 | 25650 | 2736 |
| 3 | 3 | 6129.5 | 653.8133 |
| 4 | 1 with ND Filter | 4989 | 532.16 |
| 5 | 2 with ND Filter | 1152.5 | 122.9333 |
| 6 | 3 with ND Filter | 213.75 | 22.8 |
| *7* | *4 (Blue)* | *195.75* | *20.88* |
| 8 | 5 | 178.4 | 19.02933 |
| *9* | *4 with ND Filter (Blue)* | *14.18* | *1.512533* |
| 10 | 5 with ND Filter | 9.375 | 1 |



# TERMINOLOGY

- F-stop: Aperture size of camera, the smaller the number the bigger the opening
- Exposure: Shutter speed, amount of time for light to enter
- ISO: Sensitivity of the camera, lower ISOs (lower sensitivity) produces less “noise” in images

# PROCESS

- Camera Setup:
  - ISO: 100
  - Active D-Lighting Turned Off
  - Focal Length: 18mm
- Apertures Tested:
  - F22 , F9, F3.5
- Took 5 images with each aperture, increasing shutter speed by a factor of 8
  - 1/4000 sec
  - 1/500 sec
  - 1/60 sec
  - 1/8 sec
  - 1 sec

# SOFTWARE OVERVIEW

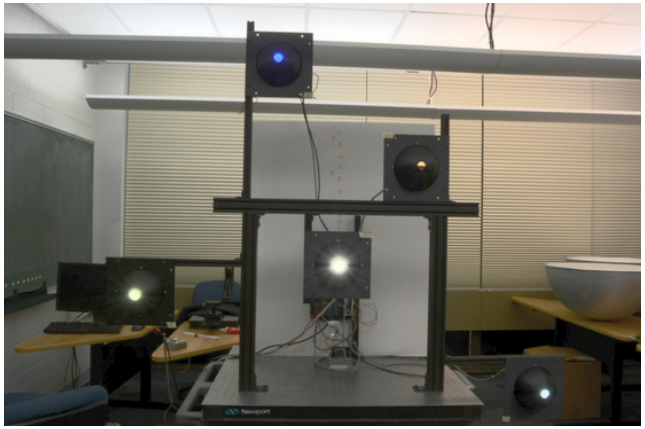
- HDRI images were composed using 4 free, publicly available software:
  - HDRGEN (Mac Only)
  - RAW2HDR (Mac Only)
  - LuminanceHDR (Ver. 2.4.0)
  - Bracket (Ver. 1.0.0 Beta)
- Photosphere used to view and analyze HDR images
- Note: WebHDR and Photosphere create HDR images using the HDRGEN engine

# SOFTWARE AVAILABILITY

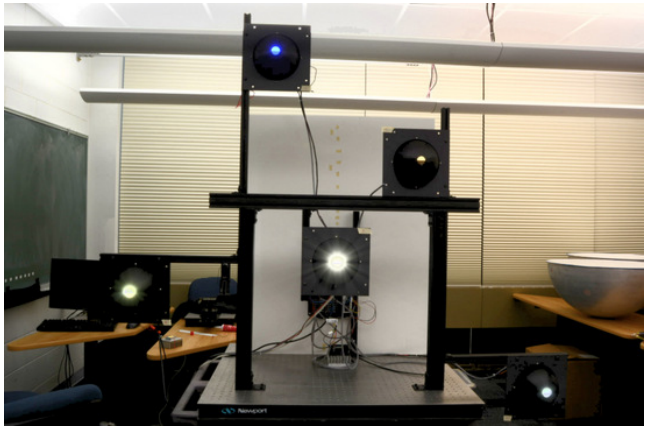
- HDRGEN
  - Available on Mac only
  - http://www.anyhere.com/
- RAW2HDR
  - Available on Mac only
  - http://www.anyhere.com/gward/pickup/raw2hdr.tgz
- LuminanceHDR
  - Available on any platform
  - http://qtpfsgui.sourceforge.net/
- Bracket
  - Available on any platform
  - http://www.ceng.metu.edu.tr/~akyuz/bracket/bracket.html
- WebHDR
  - Available online
  - Same engine as HDRGEN
  - http://www.jaloxa.eu/webhdr/roll-your-own.shtml

# SOFTWARE PERFORMANCE

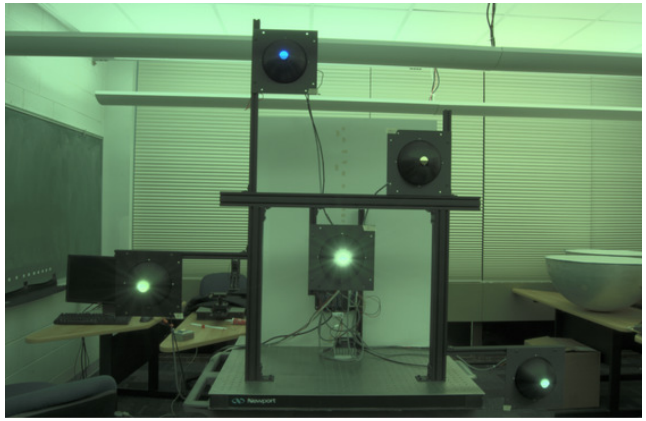
- HDRGEN



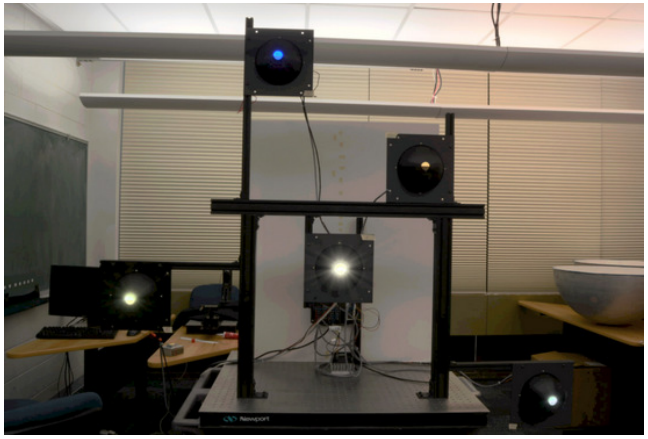
- Luminance HDR



- RAW2HDR



- Bracket



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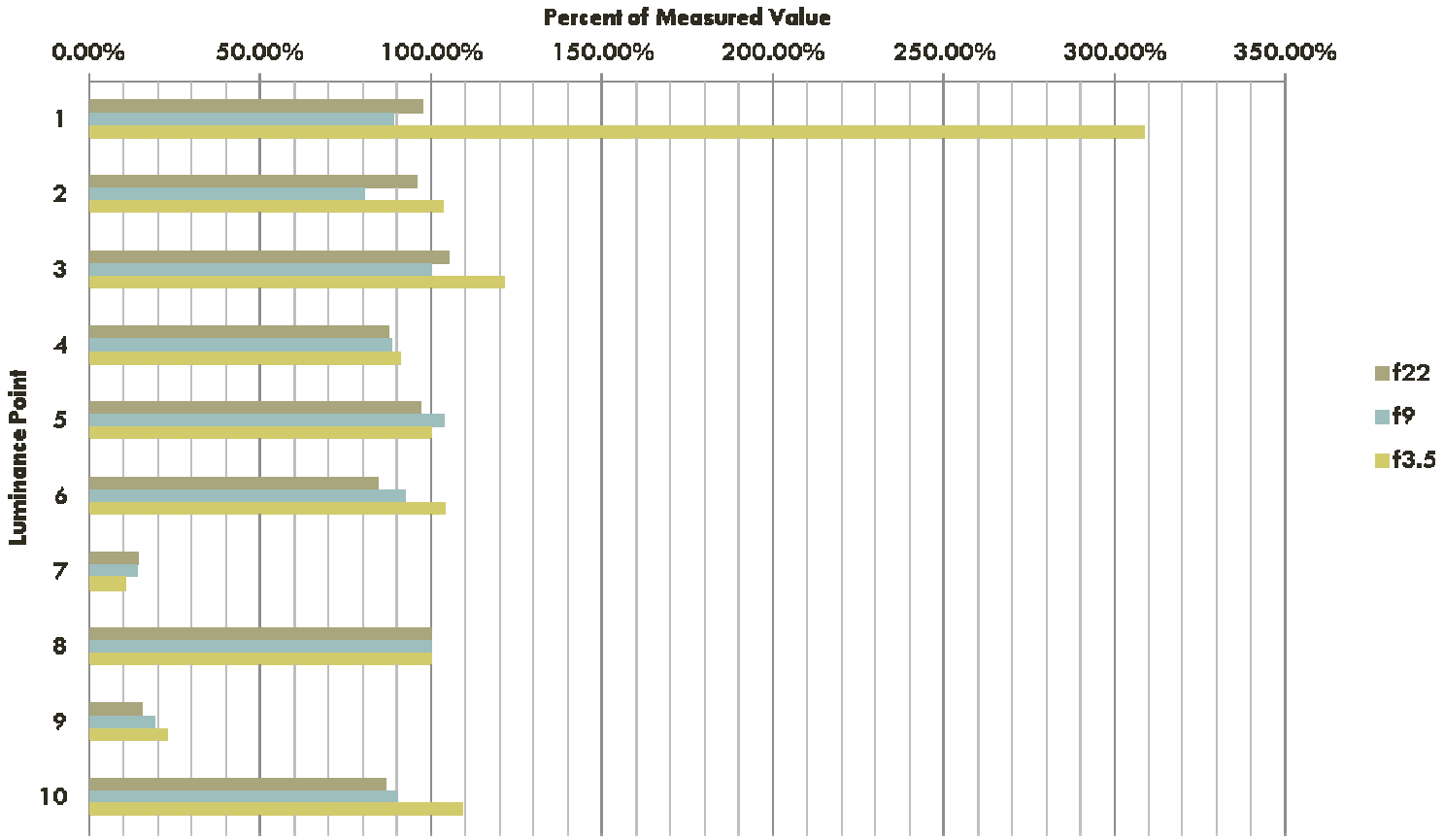
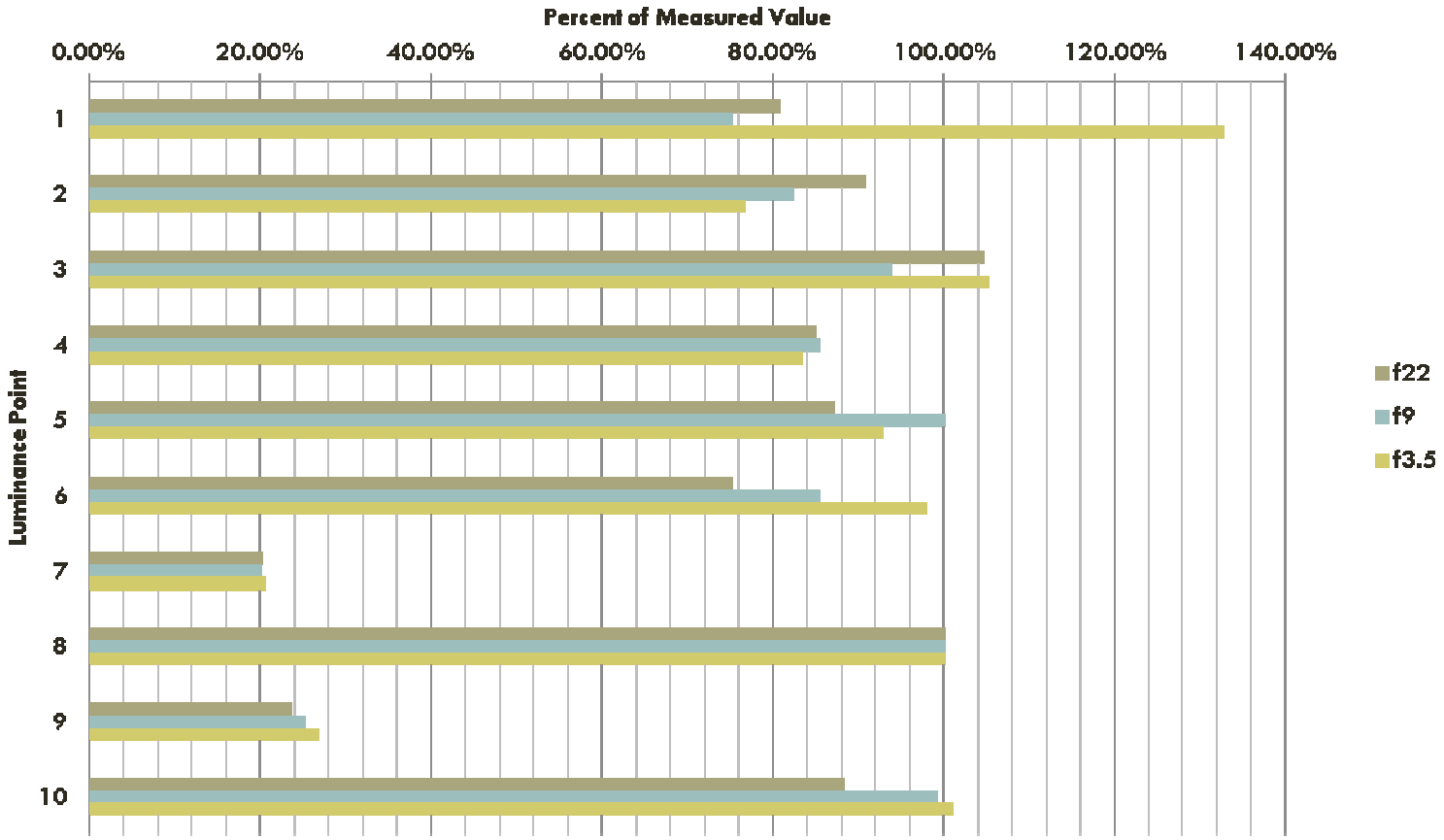
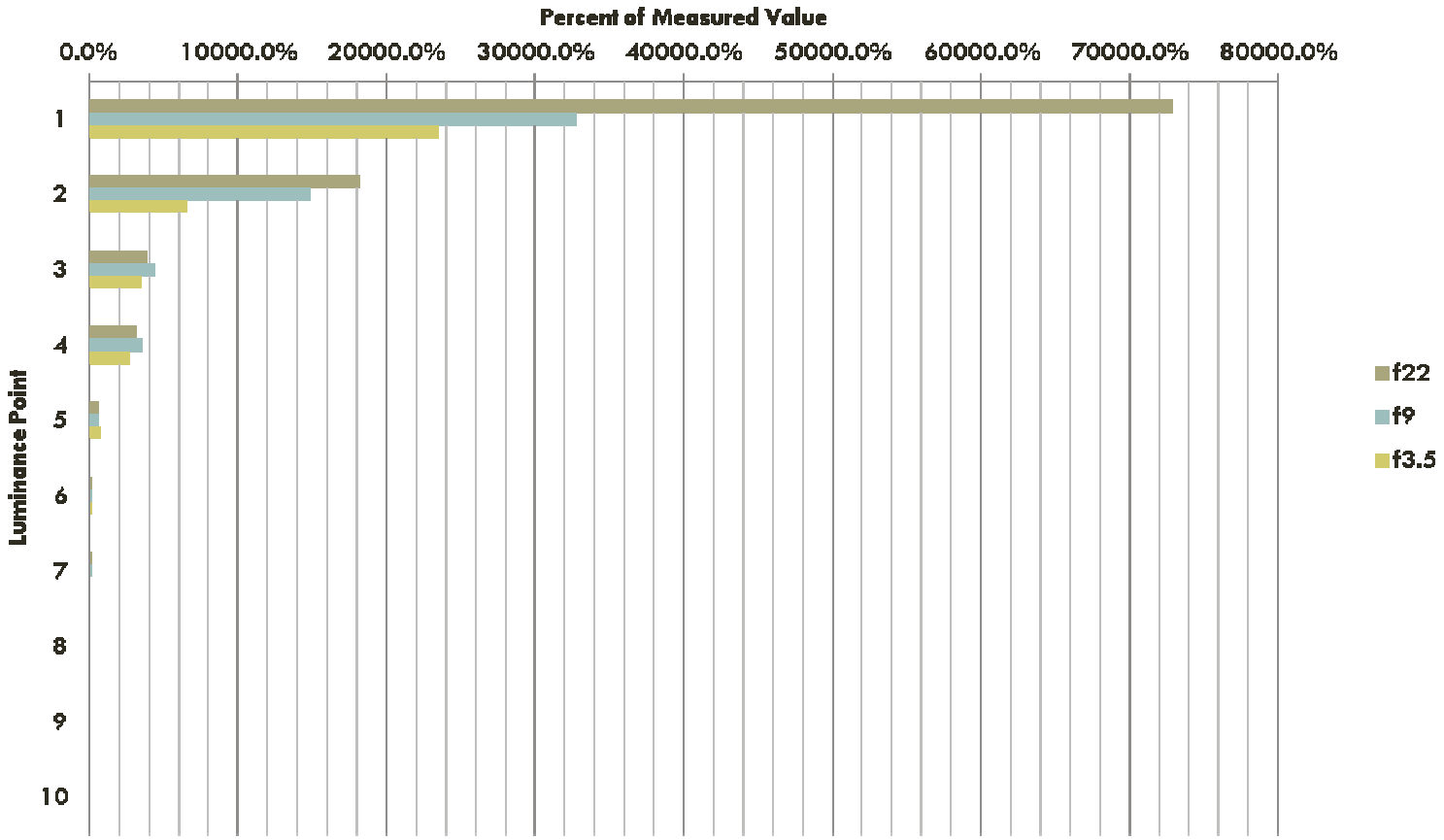
# SOFTWARE PERFORMANCE – HDRGEN



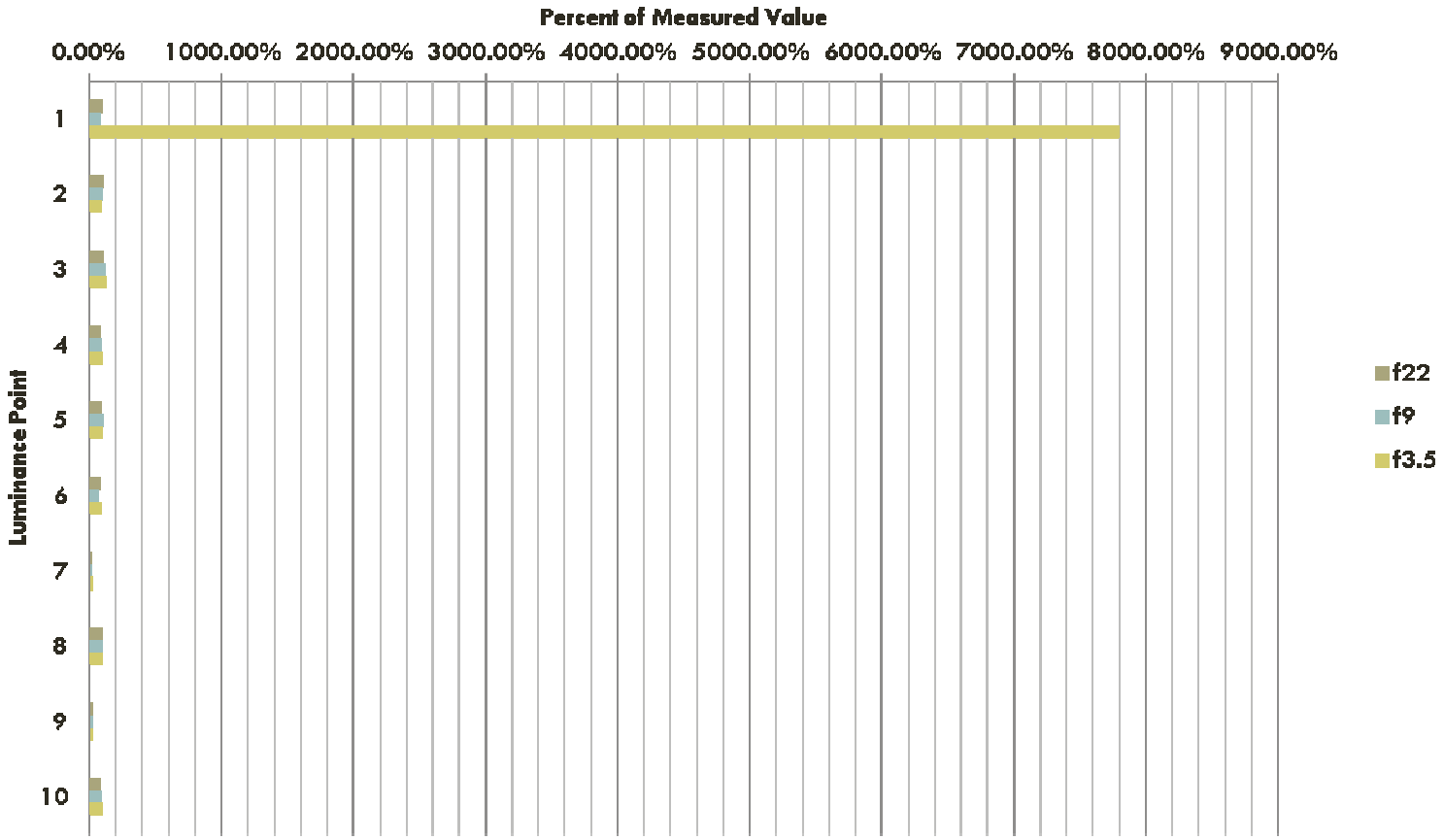
# SOFTWARE PERFORMANCE – RAW2HDR



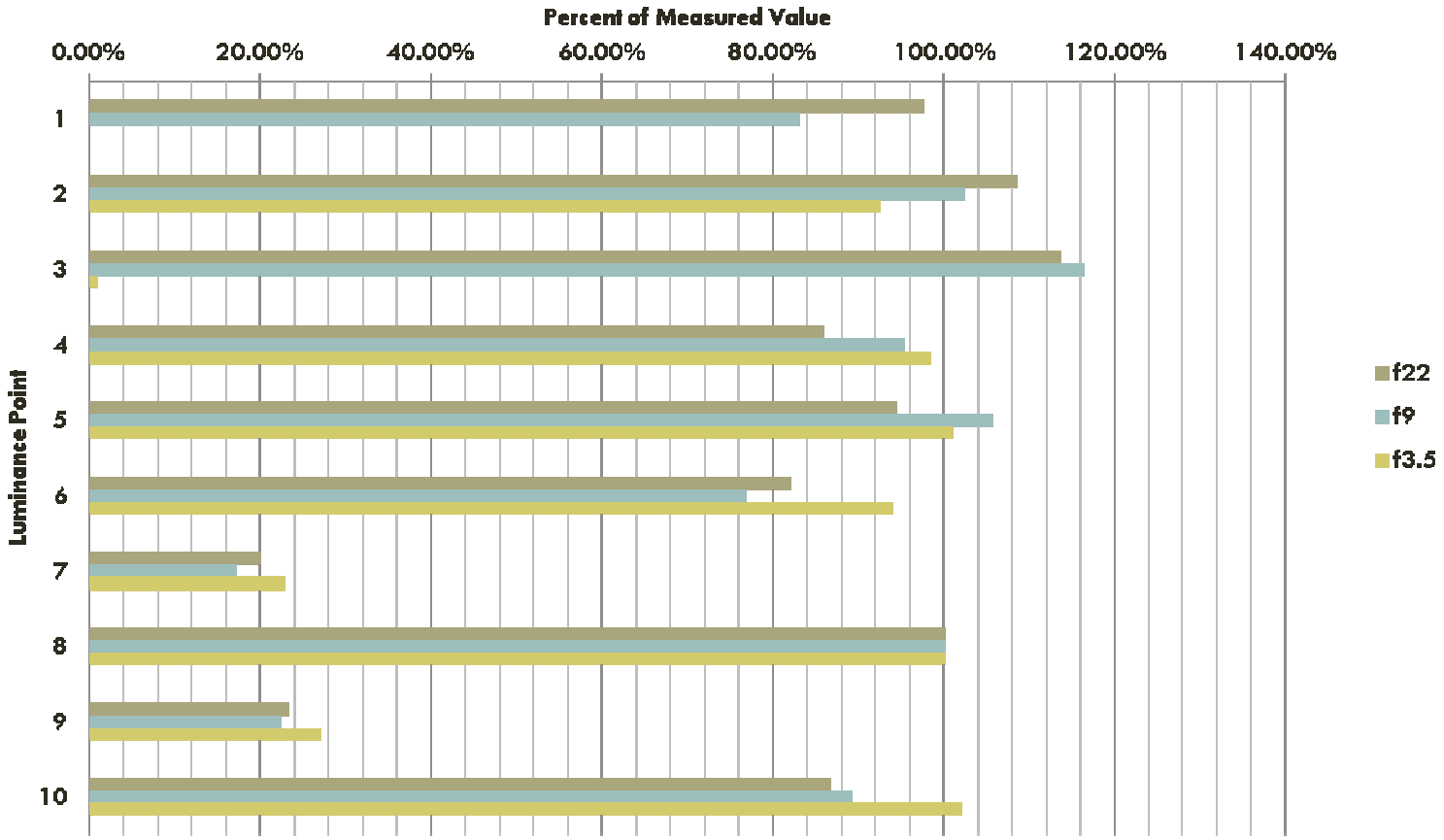
# SOFTWARE PERFORMANCE – LUMINANCE HDR



# SOFTWARE PERFORMANCE – BRACKET



# SOFTWARE PERFORMANCE – BRACKET



# PRELIMINARY CONCLUSIONS

- Smaller apertures are better for high luminances.
- Luminance measurements of saturated color are unreliable.
- HDRGEN and RAW2HDR are best performing options.
- LuminanceHDR performs very poorly.

# FUTURE PLANS

- Vignetting Effects
- Color Effects
  - Spectral Sensitivity of Camera vs Luminance Meter
- Apply to Luminance Photometry of Inhomogeneous Luminaires

# ACKNOWLEDGEMENTS

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# QUESTIONS OR SUGGESTIONS?

# REFERENCES

DiLaura, David L., MS, and Wai-Lam Chu, FIES. "Improved Near-Field Illuminance Calculations Using Far-Field Photometry and Luminance Scans." *Journal of the Illuminating Engineering Society* (1995). PDF.

Guglielmetti, Rob, and Jennifer Scheib. *High Dynamic Range Imaging Workshop*. N.p.: National Renewable Energy Laboratory, 2013. PPT.