Your Streets, Night Skies, and Budget: A Report from Flagstaff's Dark Skies Summit

Jeffrey Hall, Lowell Observatory
Chris Luginbuhl, Flagstaff Dark Skies Coalition
Steven Hill, City of Flagstaff

At issue:

Dark-sky protection has a 60-year history in Flagstaff

- Initiated in 1958 by observatories
- Many other benefits (health, ecological, tourism, visual)

Advent of LED technology for outdoor lighting creates problems

- Unfiltered LEDs are have a blue-rich spectrum
- Most filtered LED spectra seriously degrade dark skies, both visually and (acutely) for astronomy

At issue:

Astronomy is a quarter billion dollar investment locally
One size does not fit all, however

DARK SKIES AND EMERGING TECHNOLOGY CONFERENCE

August 18-20, 2014, High Country Conference Center

Sponsors: City of Flagstaff, Lowell Observatory, The Keystone Center

Observatories
International Dark-Sky Association
National Parks, AZ State Parks, Game & Fish, BLM
Flagstaff, Pinetop, Phoenix, Tucson, Sedona
ADOT
Hubbell, Acuity, DeTect, Chips & Wafers

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Dark Skies and Emerging Technology Conference

DARK SKIES & EMERGING TECHNOLOGIES: A SUMMIT AND CALL TO ACTION TO PROTECT OUR NIGHT SKIES

Please click here for the Dark Skies and Emerging Technologies Summit - Final Report

For access to videos of presentations on Day 1 and Day 2 of the Summit, as well as PowerPoint presentations, please click here.

For additional resources and literature on night skies protection please click here.

The Colorado Plateau and adjoining areas of the American Southwest have some of the most pristine, clear, and accessible skies in the developed world. On August 18-20, 2014, the Keystone Center joined with Lowell Observatory and the City of Flagstaff to host a summit to find common solutions to the proliferation of blue-rich and poorly-filtered LED outdoor lighting that threatens the ability to view night skies for scientific, recreational and cultural purposes and disrupts important circadian rhythms of humans and other living organisms.

The Summit brought together more than 160 attendees including community planners, highway engineers and

www.keystone.org/darkskies

Principles of Lighting

- **James Benya**, Benya Burnett Consultancy
- **Deborah Burnett**, Benya Burnett Consultancy
- **Chris Luginbuhl**, Astronomer, United States Naval Observatory

Keynote speakers

- **Chad Moore**, Night Skies Program Manager, National Park Service
- **Dr. Richard Stevens**, Professor and Cancer Epidemiologist, University of Connecticut
- **Dr. Ron Gibbons**, Director, Center for Infrastructure-based Safety Systems, Virginia Tech Transportation Institute

Lunchtime talks

- **Scott Kardel**, Acting Executive Director, International Dark-Sky Association
- **Carl Rountree**, Director, National Landscape Conservation System for the Bureau of Land Management

TAKEAWAY:
How can we help you?

Dark-sky protection is not just about astronomy

Flagstaff (and Coconino County) have world-leading OLCs, and we have formed a multi-stakeholder group to assist with implementation of dark-sky friendly lighting

We are working to evaluate LED lighting evolution impacts and to capture those impacts in code

- for various types of lights (FLED, PCALED, NBALED, other NB wavelengths)
- both for an extremely sensitive area like Flagstaff
- and in other areas (cities, towns, parks and monuments…)

Jeffrey Hall, Lowell Observatory, jch@lowell.edu

Outdoor Lighting, Lamp Types and Light Pollution

Christian B. Luginbuhl

Dark Sky Partners, LLC

Outdoor Lighting, Lamp Types and Light Pollution

Huge and increasing interest in new LED lighting technology

Potential for energy savings

Potential for maintenance savings

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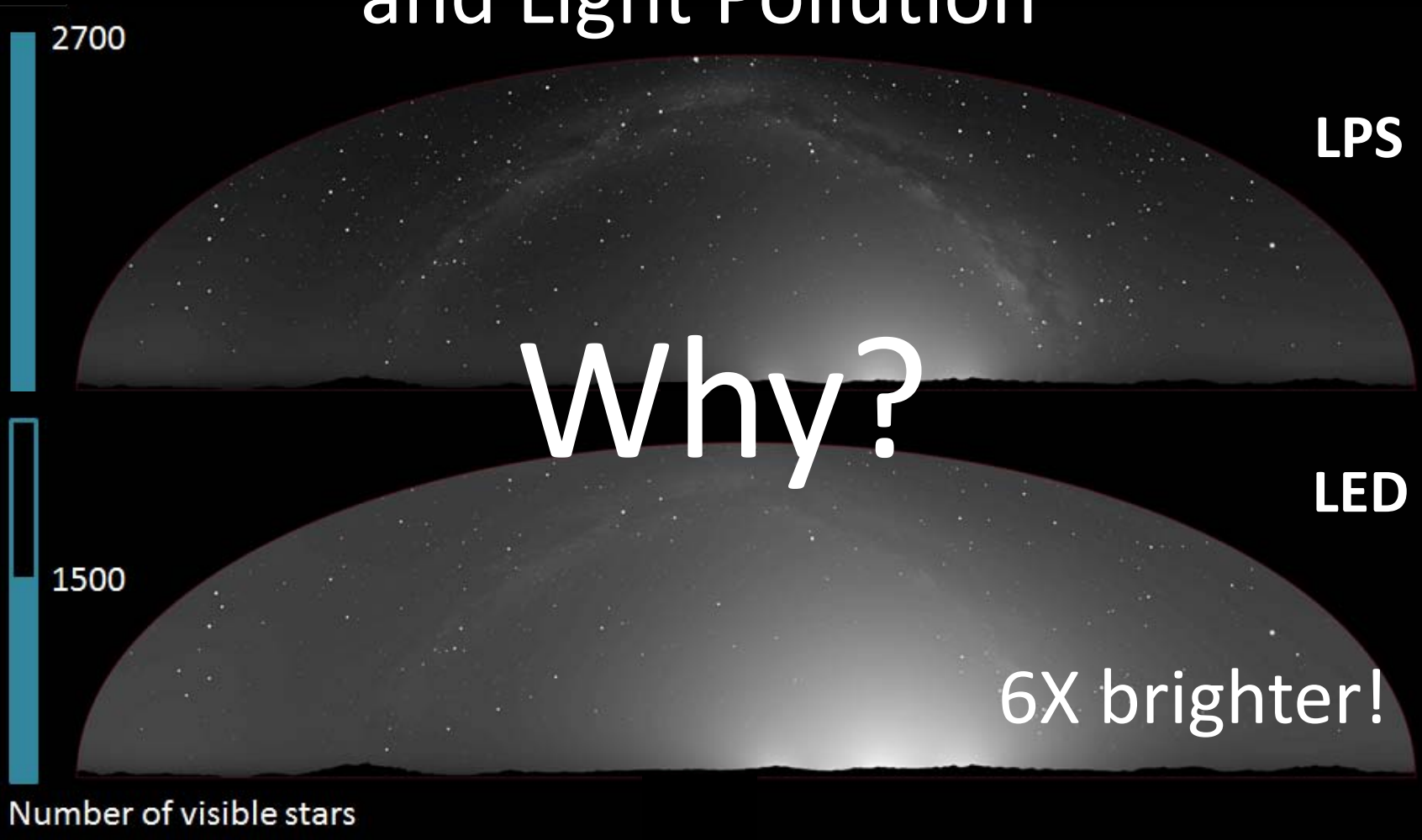
Why are astronomical observatories and “dark sky” groups raising an alarm?

Outdoor Lighting, Lamp Types and Light Pollution

Outdoor Lighting, Lamp Types and Light Pollution

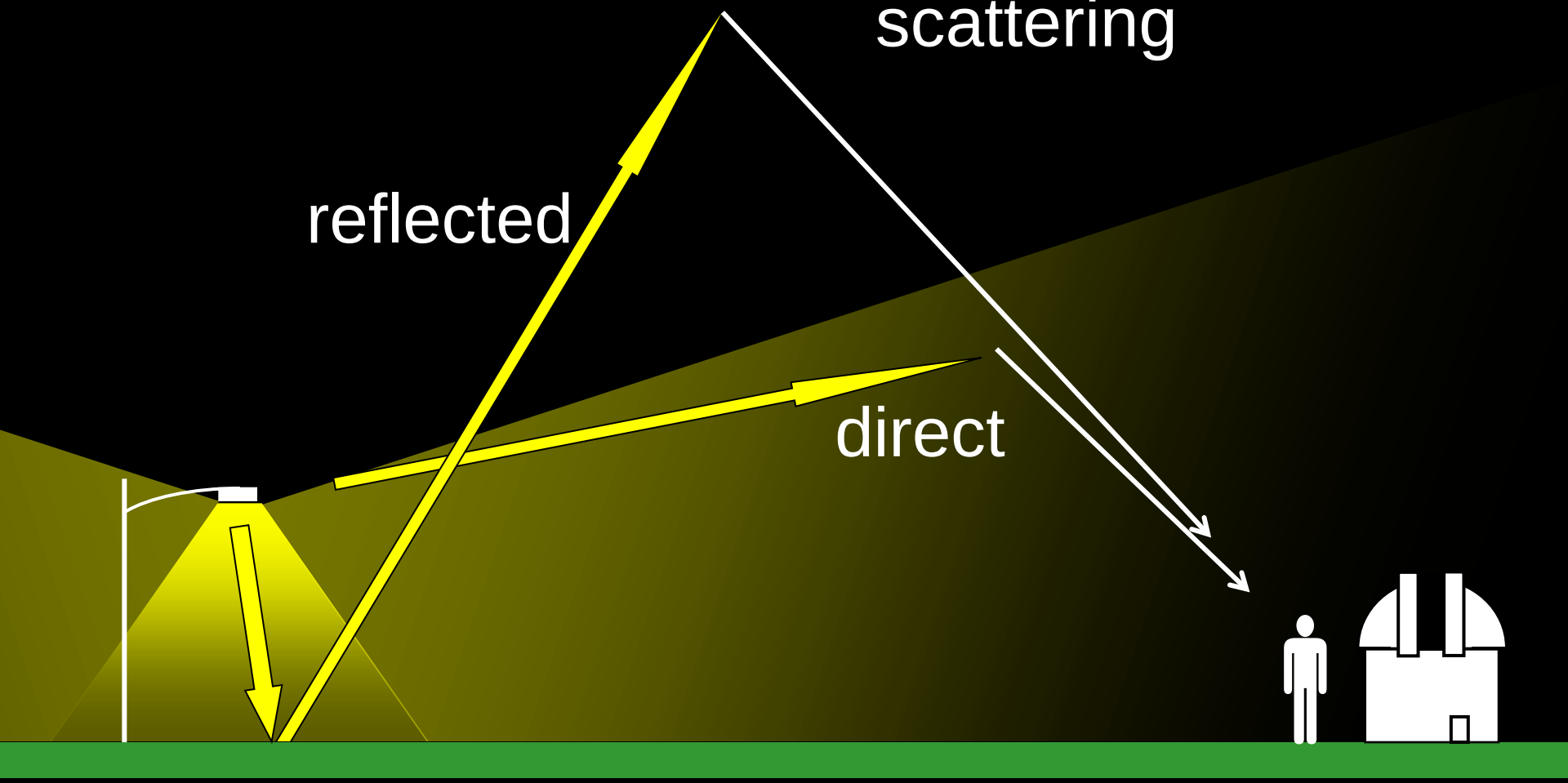


Outline

Visible Sky Glow

- What causes sky glow?
- Why does light color matter?
  - Spectral response of the eye at different light levels
  - Lighting levels in the night environment
- Lamp types, spectra, and light pollution
  - Lamp types and visibility on the ground
  - Lamp types and sky glow
  - Star visibility
  - Spectral interference

What causes sky glow?



How do we measure sky glow?

- People (naked eye)

- Astronomy (instruments)

How do we measure sky glow?

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Visual Sky Glow

Outdoor Lighting Sources

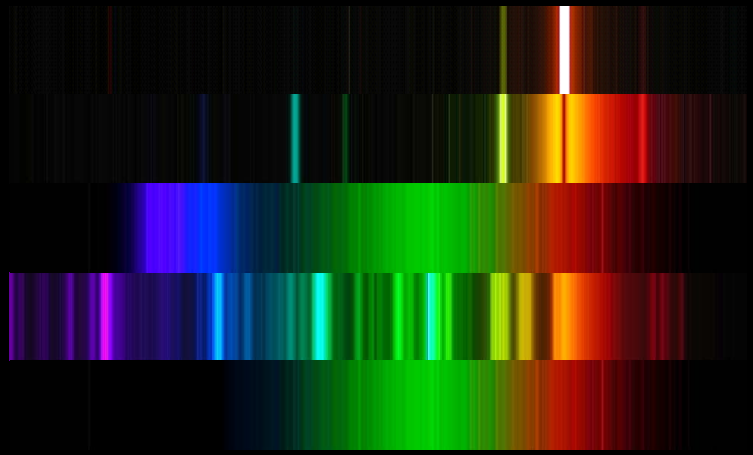
How do they affect sky glow?

Outdoor Lighting Sources

How do they affect sky glow?

Lamp Types

- Low-Pressure Sodium
- High-Pressure Sodium
- LED (2400K 5100K CCT)
- Metal Halide (4100K CCT)
- Filtered LED



Outdoor Lighting Sources

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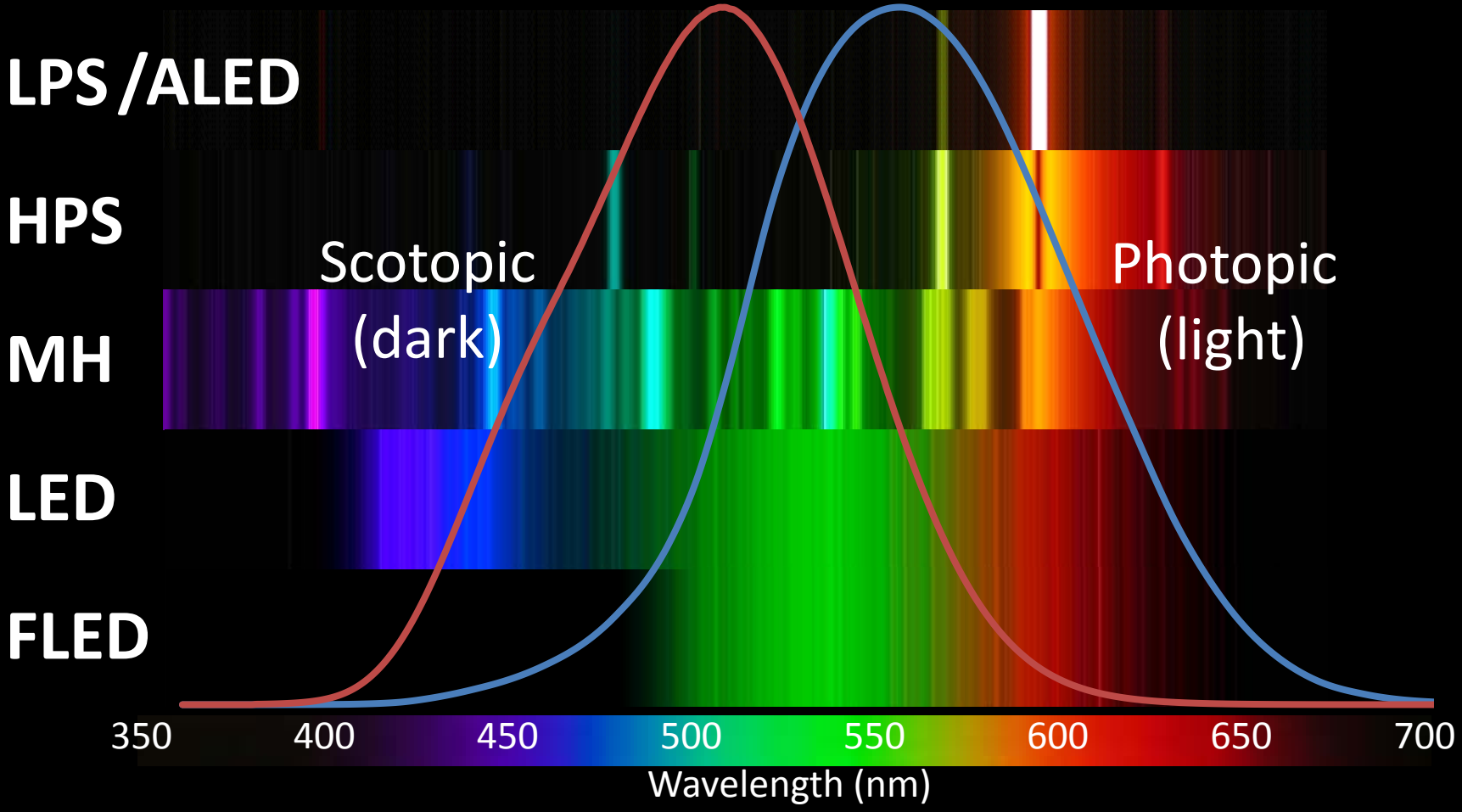
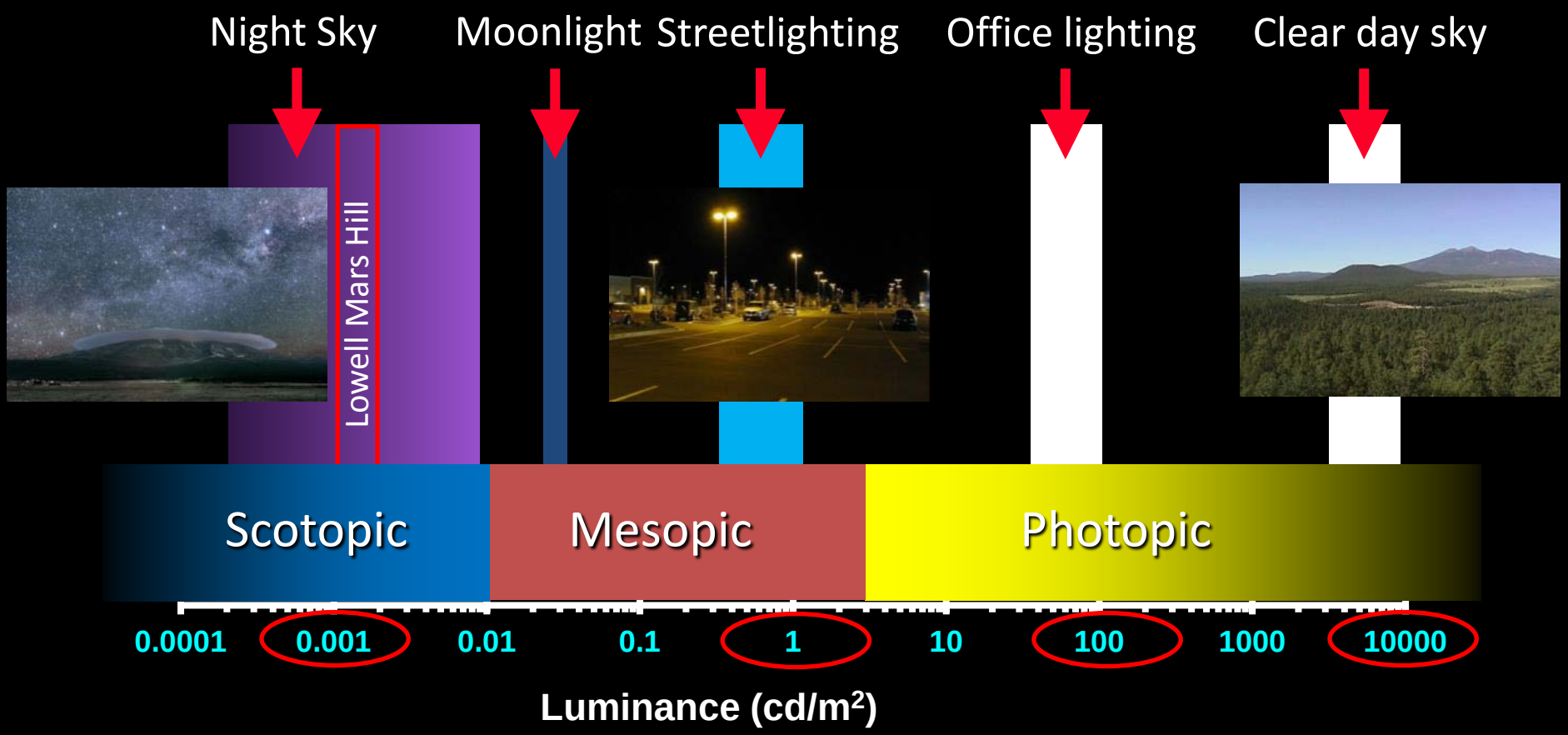


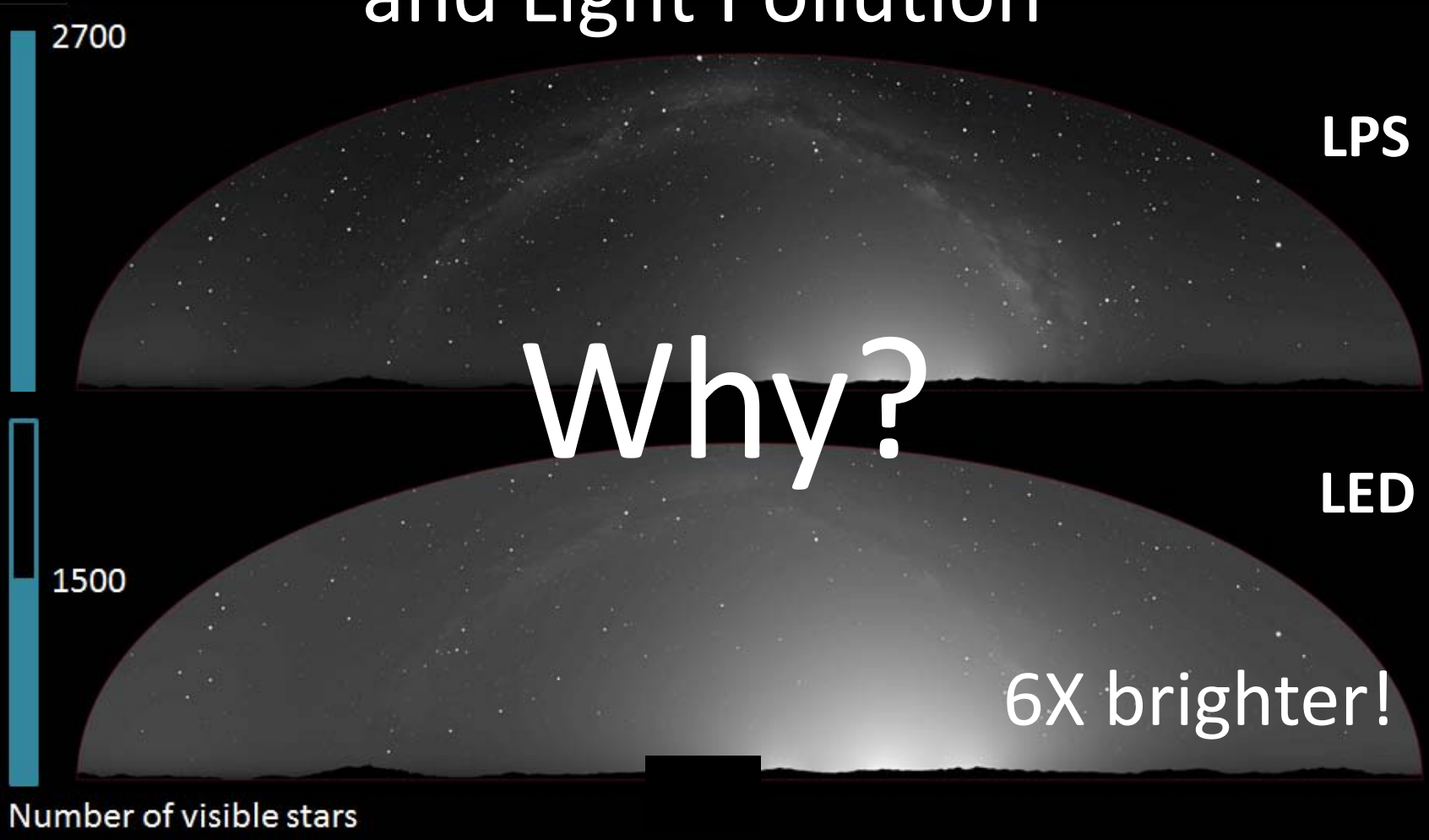
Visual sky glow

How does the eye perceive it?

Brightness (luminance) ranges



Outdoor Lighting, Lamp Types and Light Pollution



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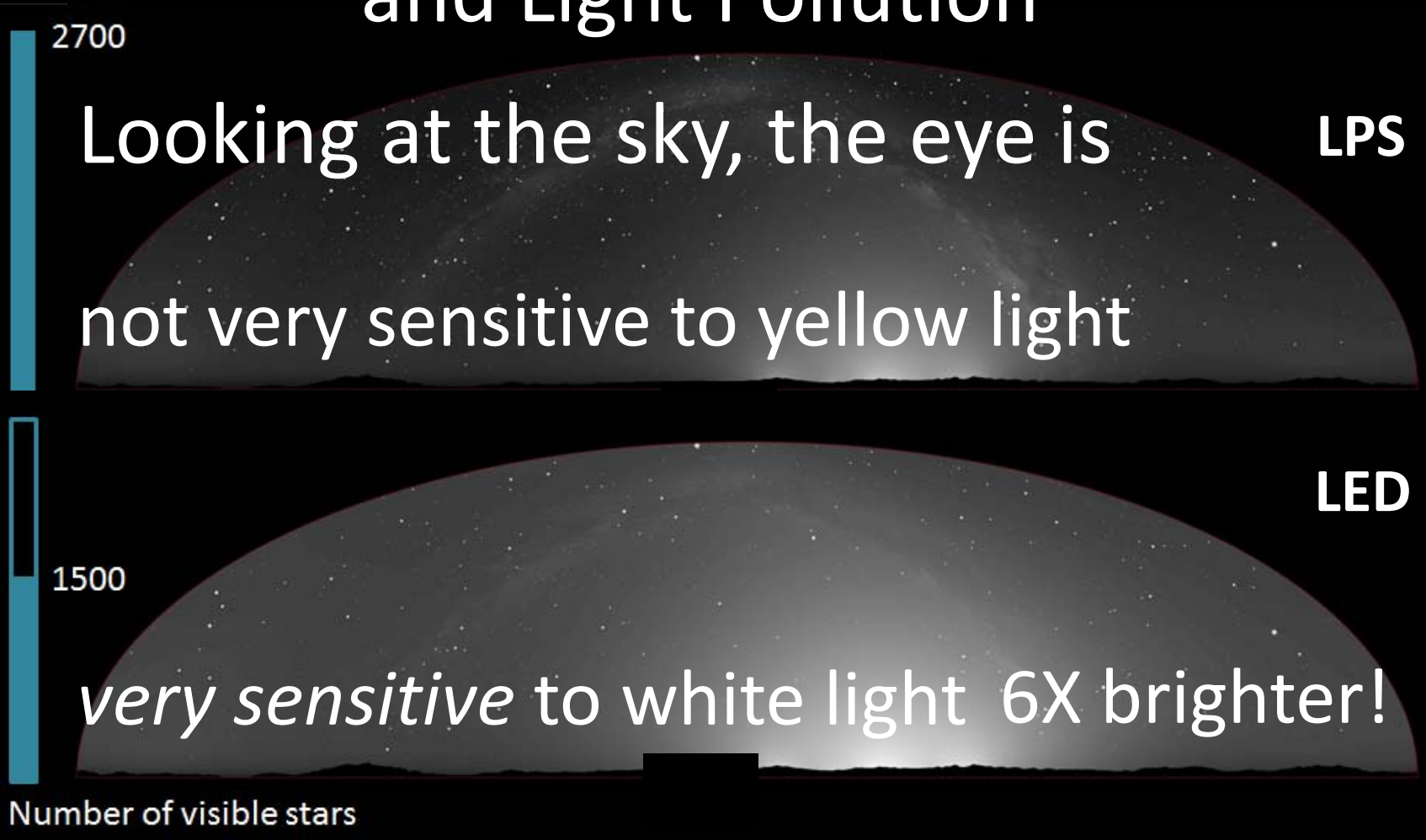

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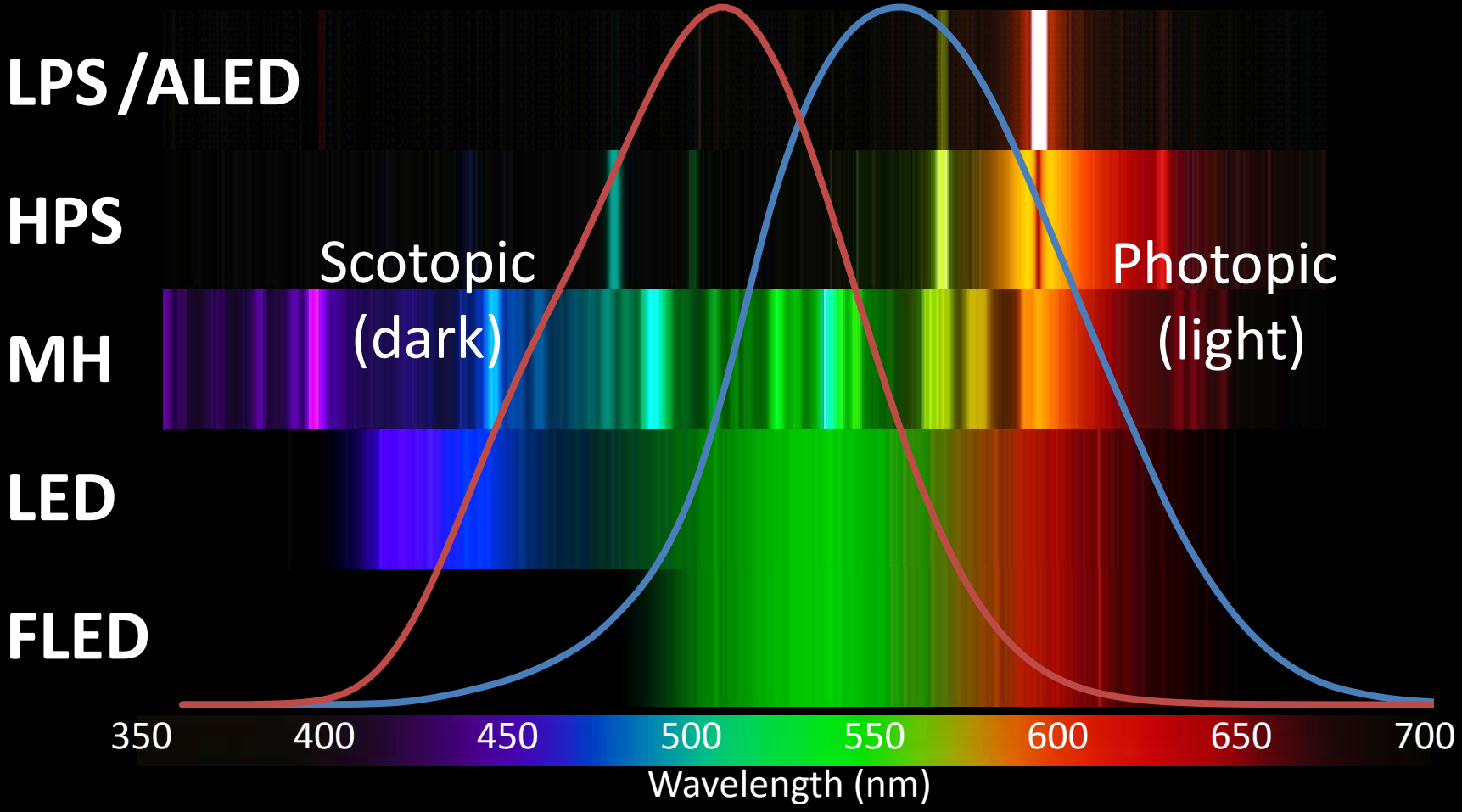

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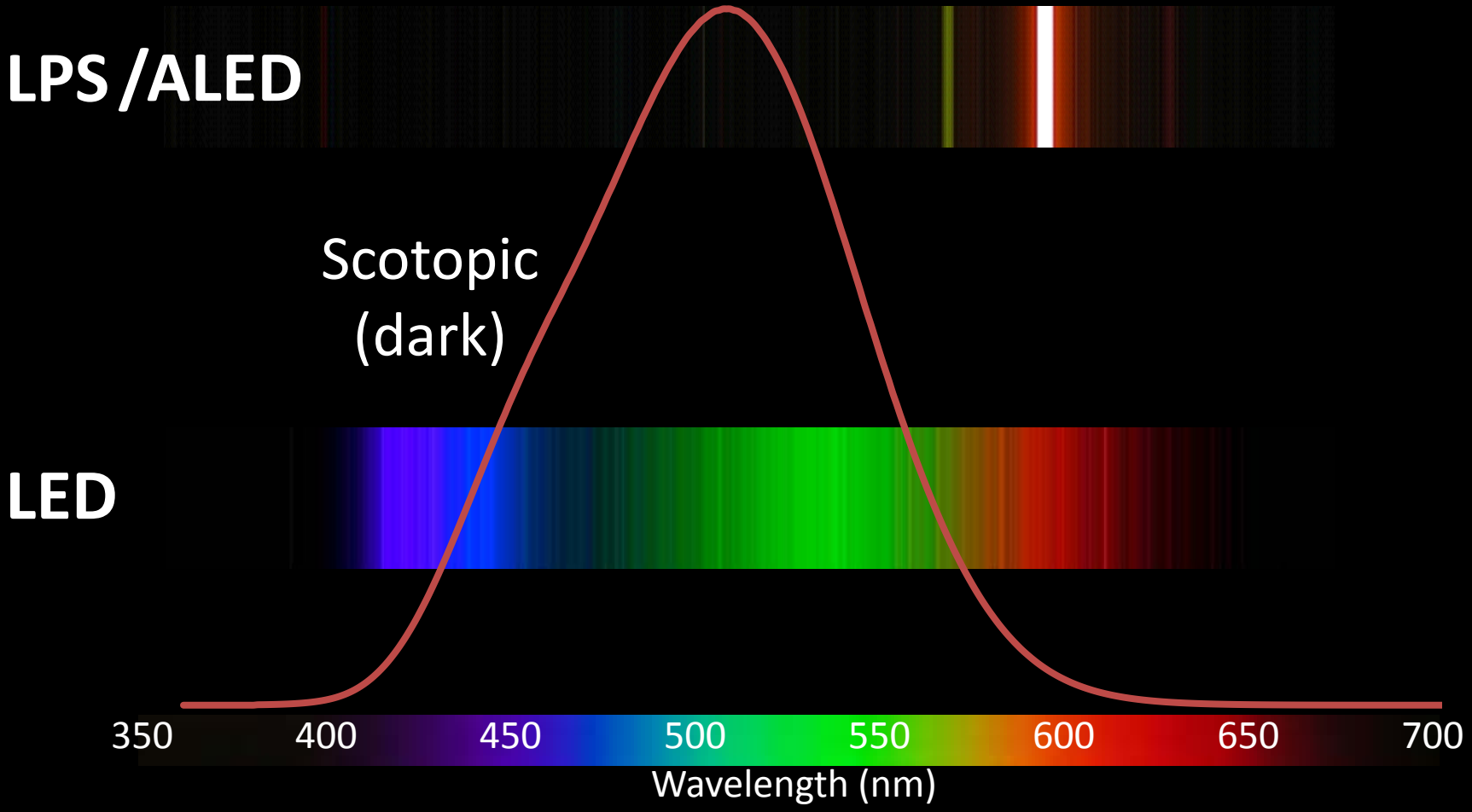

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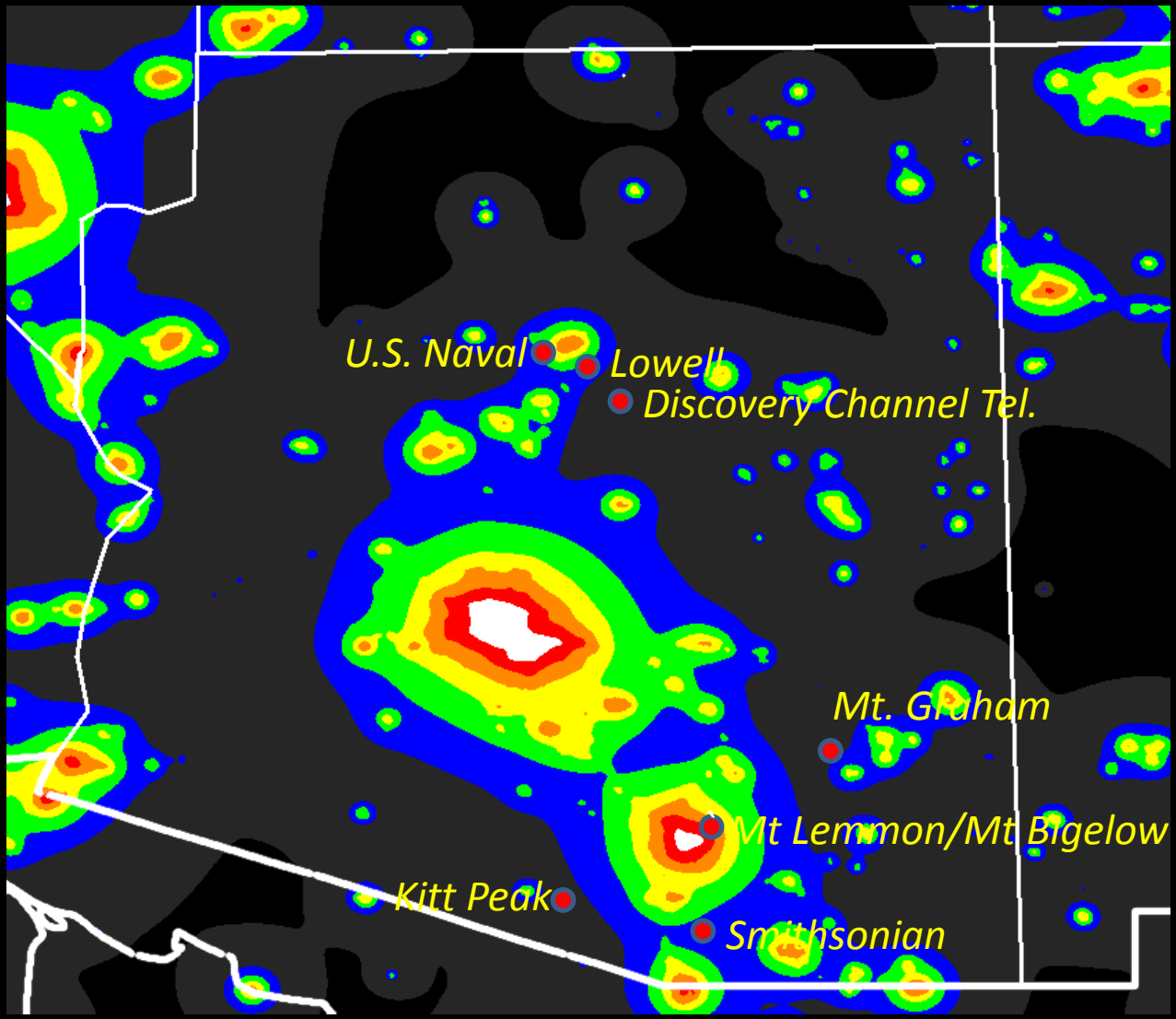
Major observatory sites in Arizona



Lamp Spectra

Our Light vs. Starlight

350nm

Starlight

Lamp Spectra

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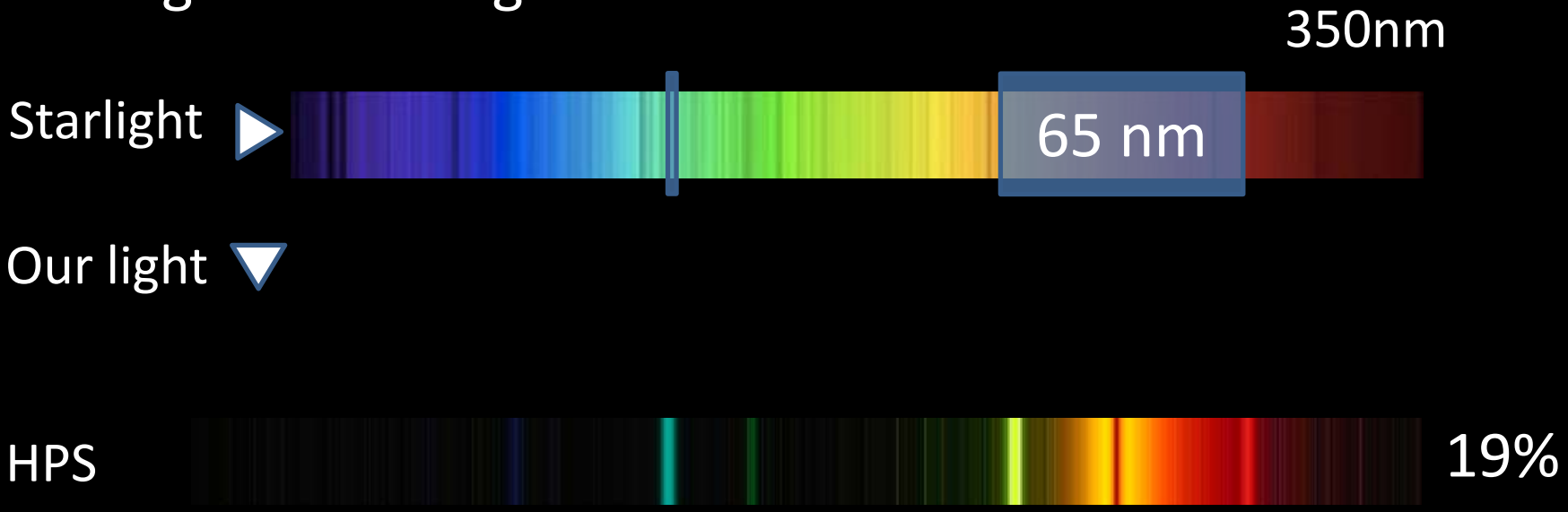

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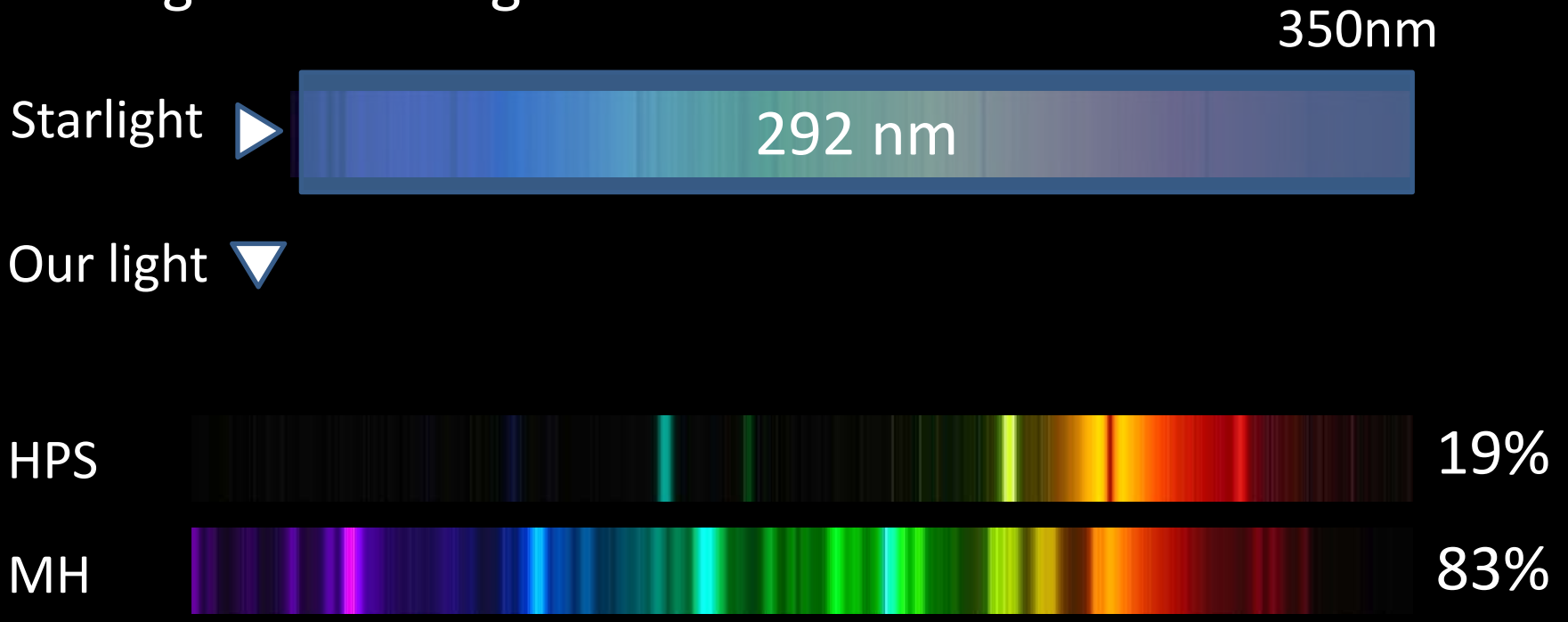

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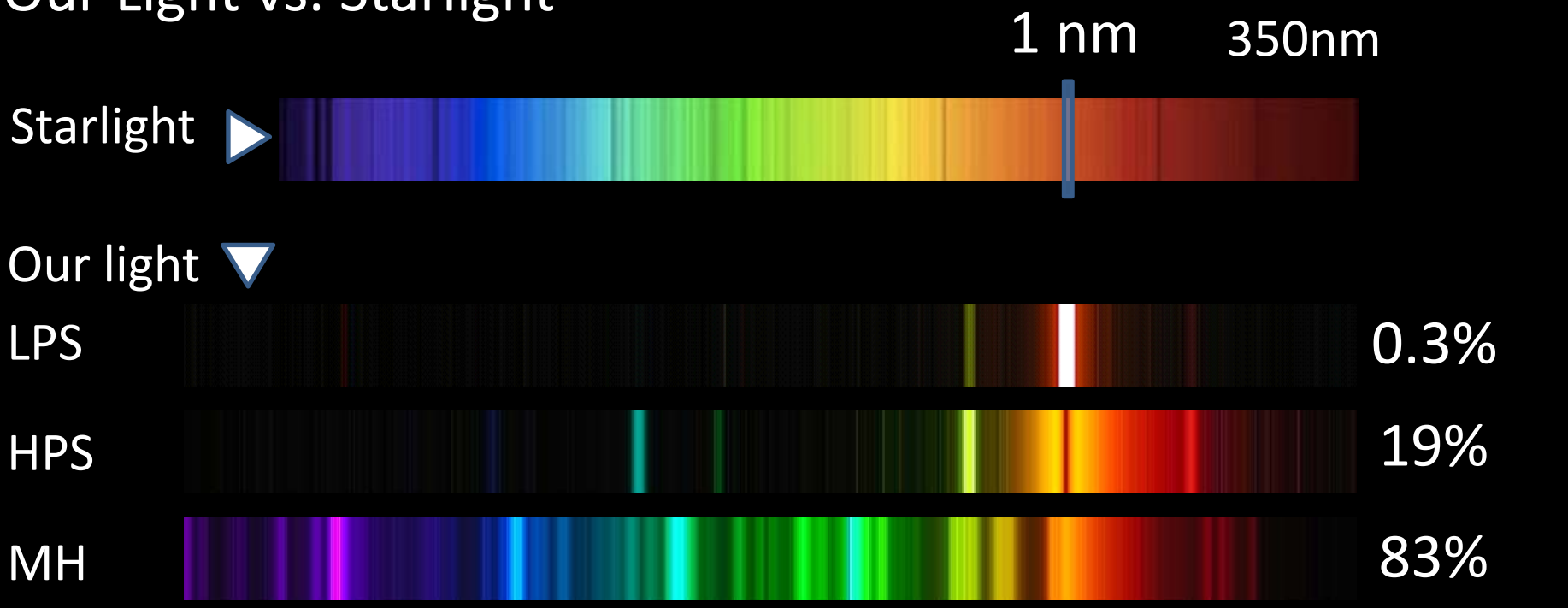

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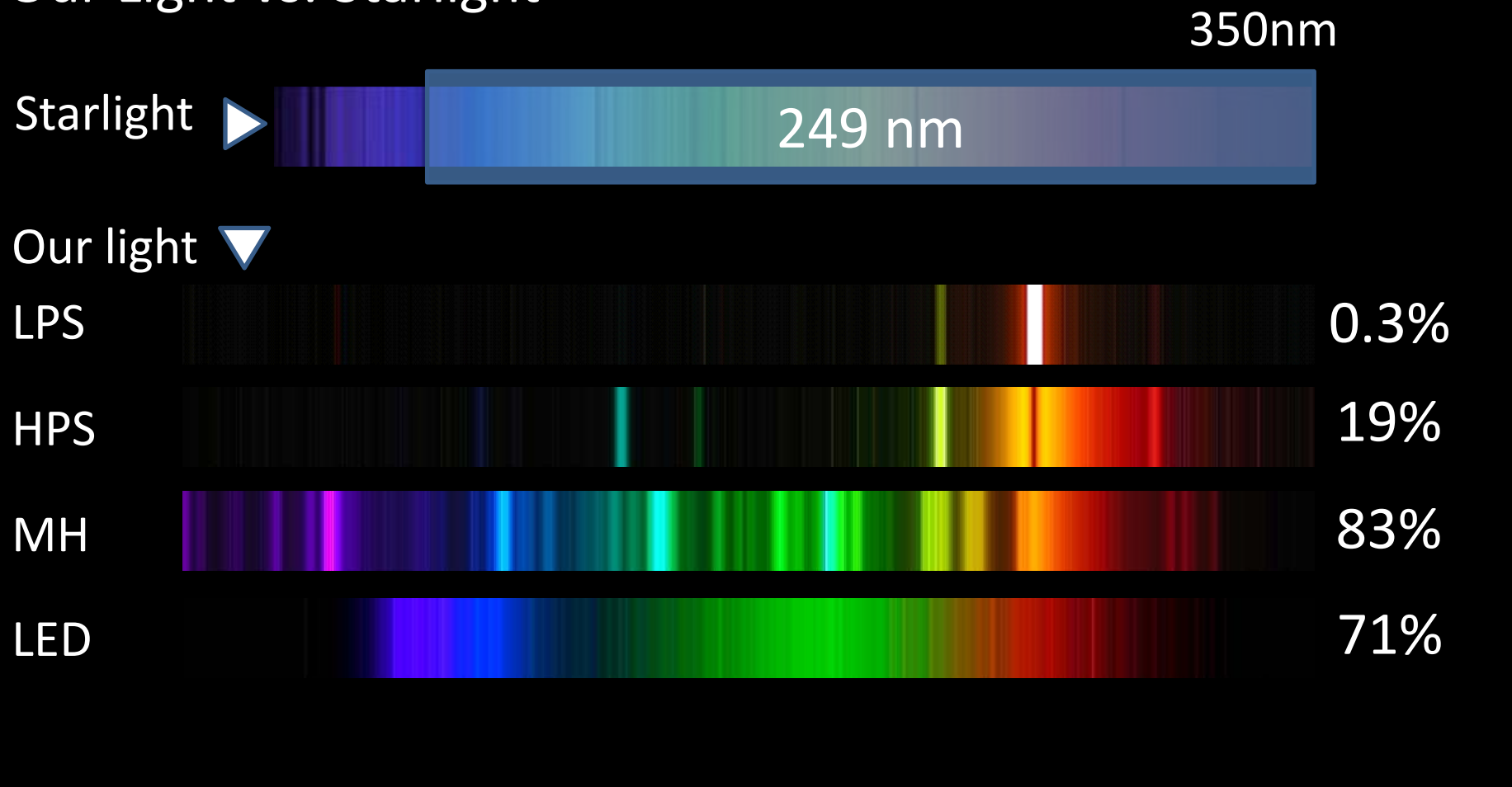

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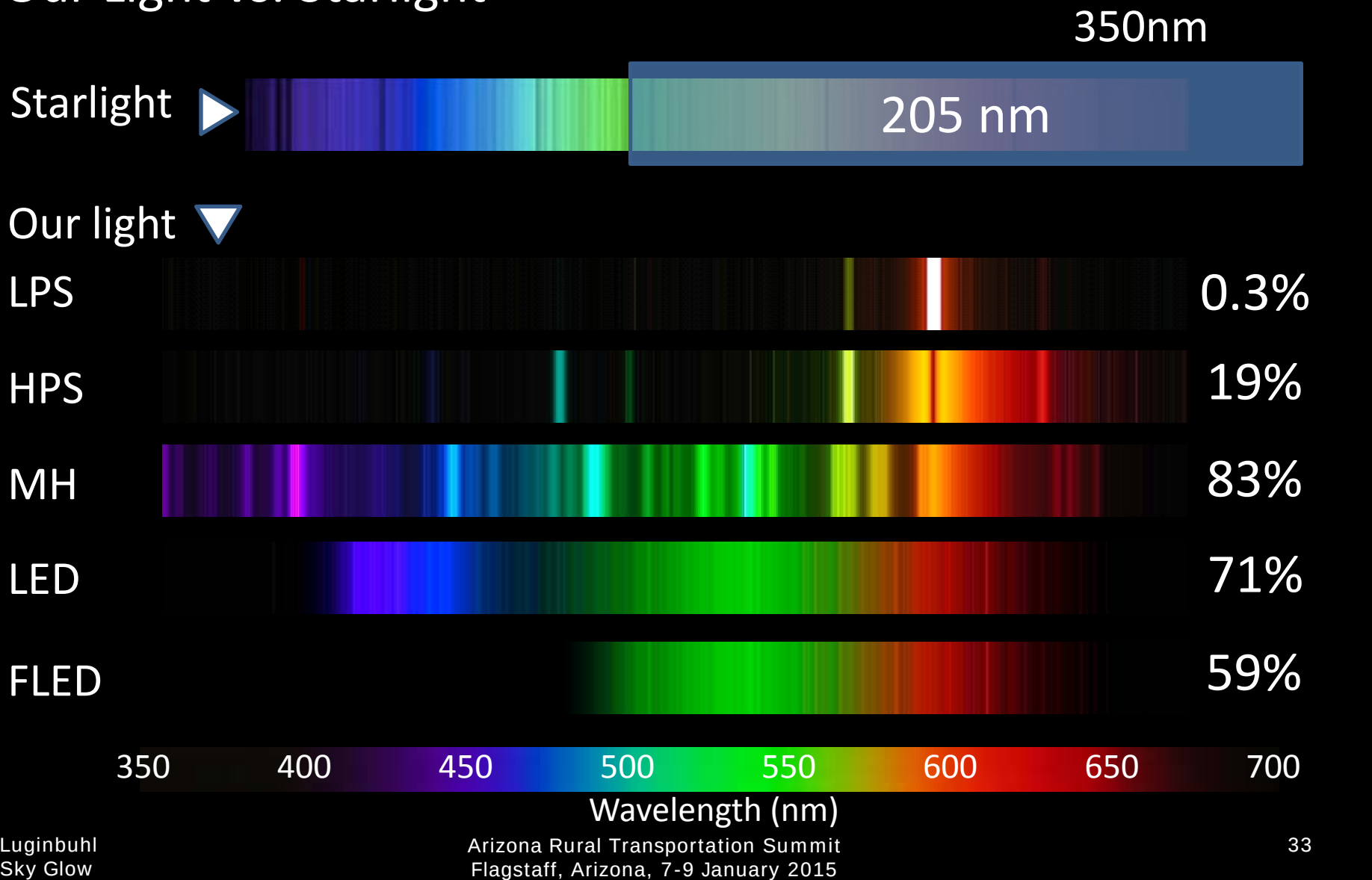

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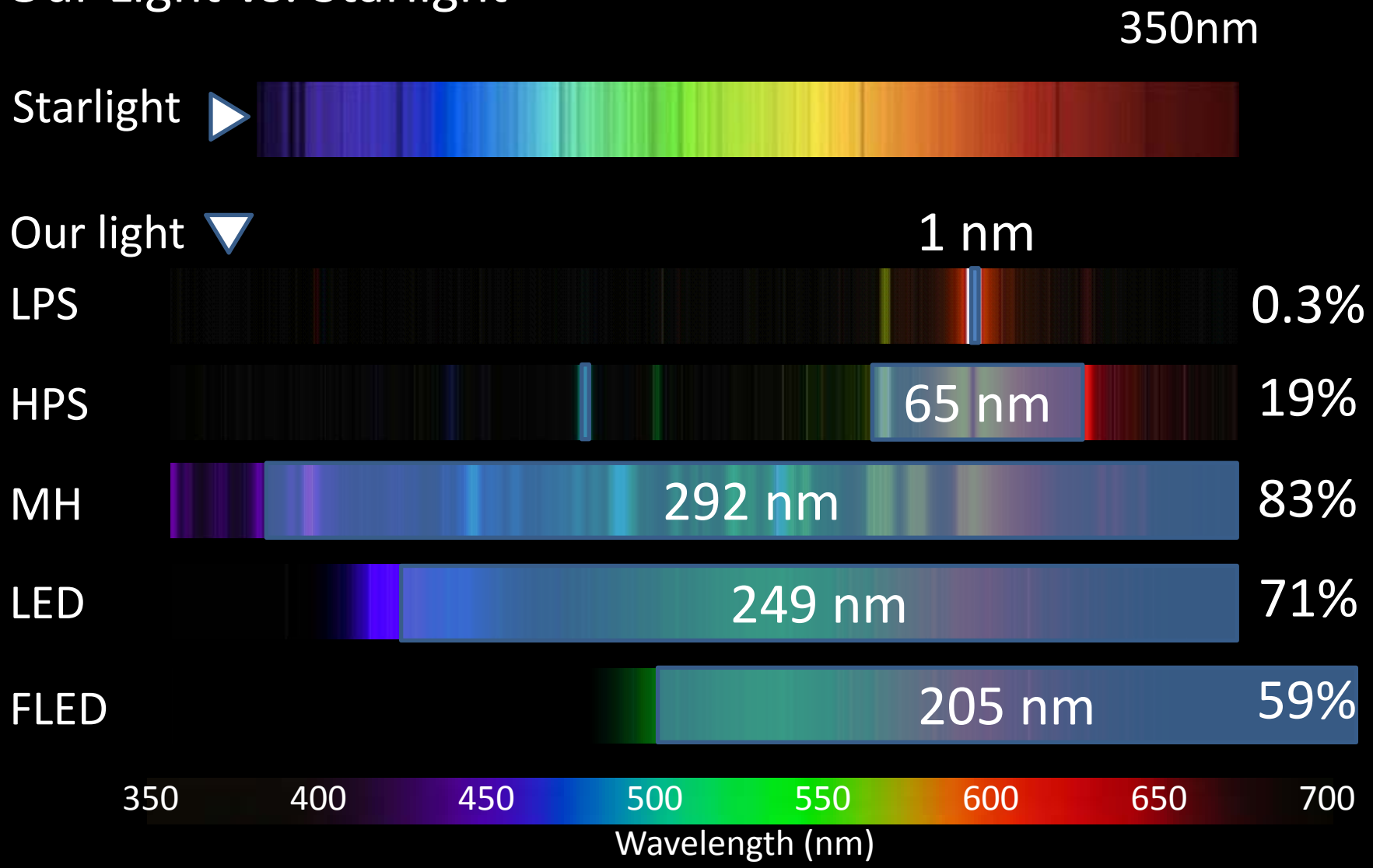

Conclusions

- Professional (instrumental) astronomy
  - Minimum spectral coverage

LPS	ALED	HPS	FLED	LED	MH
1	34	65	205	249	292

Conclusions

- Professional (instrumental) astronomy
  - Minimum spectral coverage

LPS	ALED	HPS	FLED	LED	MH
1	34	65	205	249	292

- Visual (naked eye) astronomy
  - Minimum blue/green (scotopic brightness)

LPS	ALED	HPS	FLED	LED	MH
1.0	1.0	2.4	3.6	4.3-8	8

Outdoor Lighting, Lamp Types and Sky Glow

Christian B. Luginbuhl

Dark Sky Partners, LLC

Visual sky glow
How does the eye perceive it?

- We can see with light levels from daylight to starlight
  - over 10 million to one range!
- Spectral response depends on light level

10,000,000 : 1

Visual sky glow
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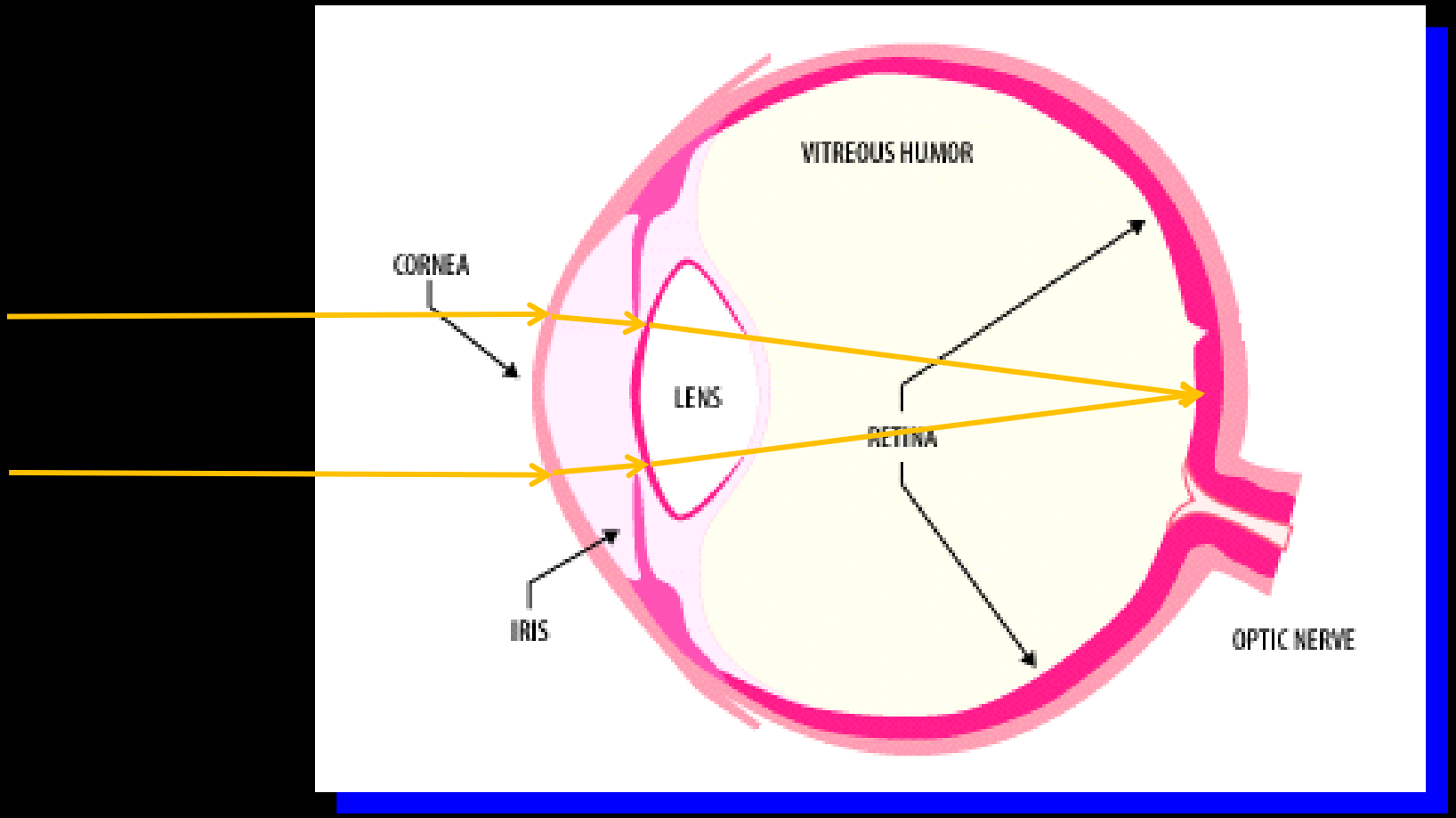
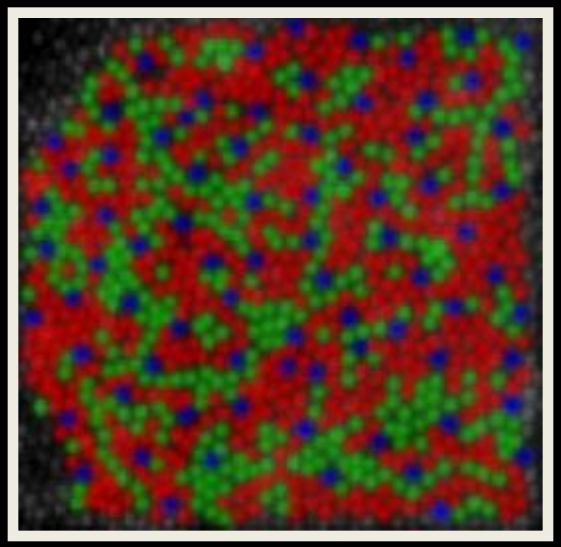
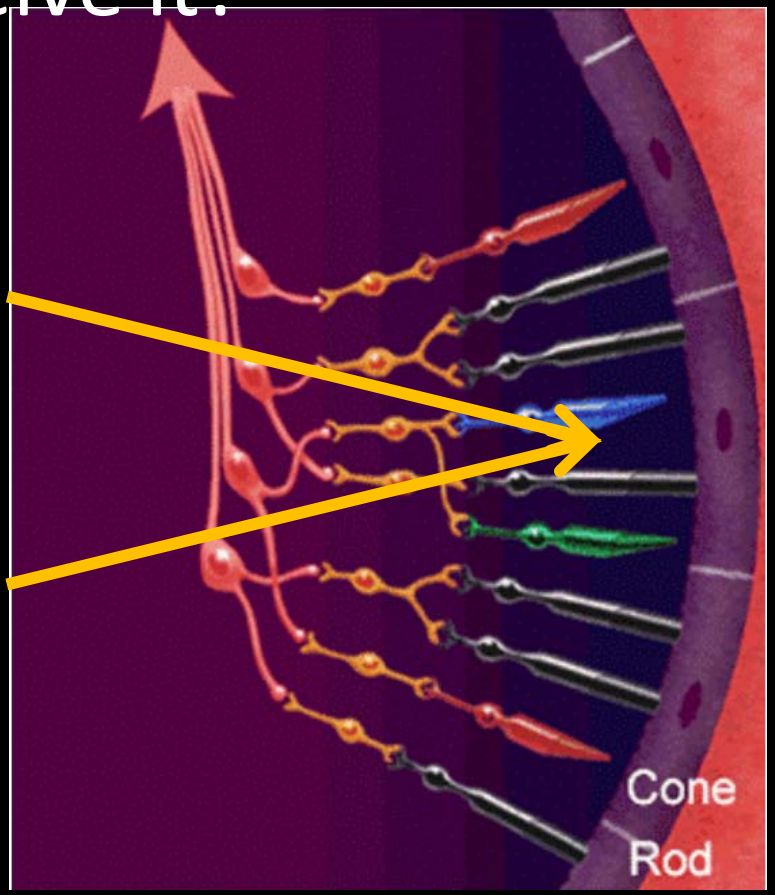


Visual sky glow
How does the eye perceive it?

Photoreceptors in the Retina



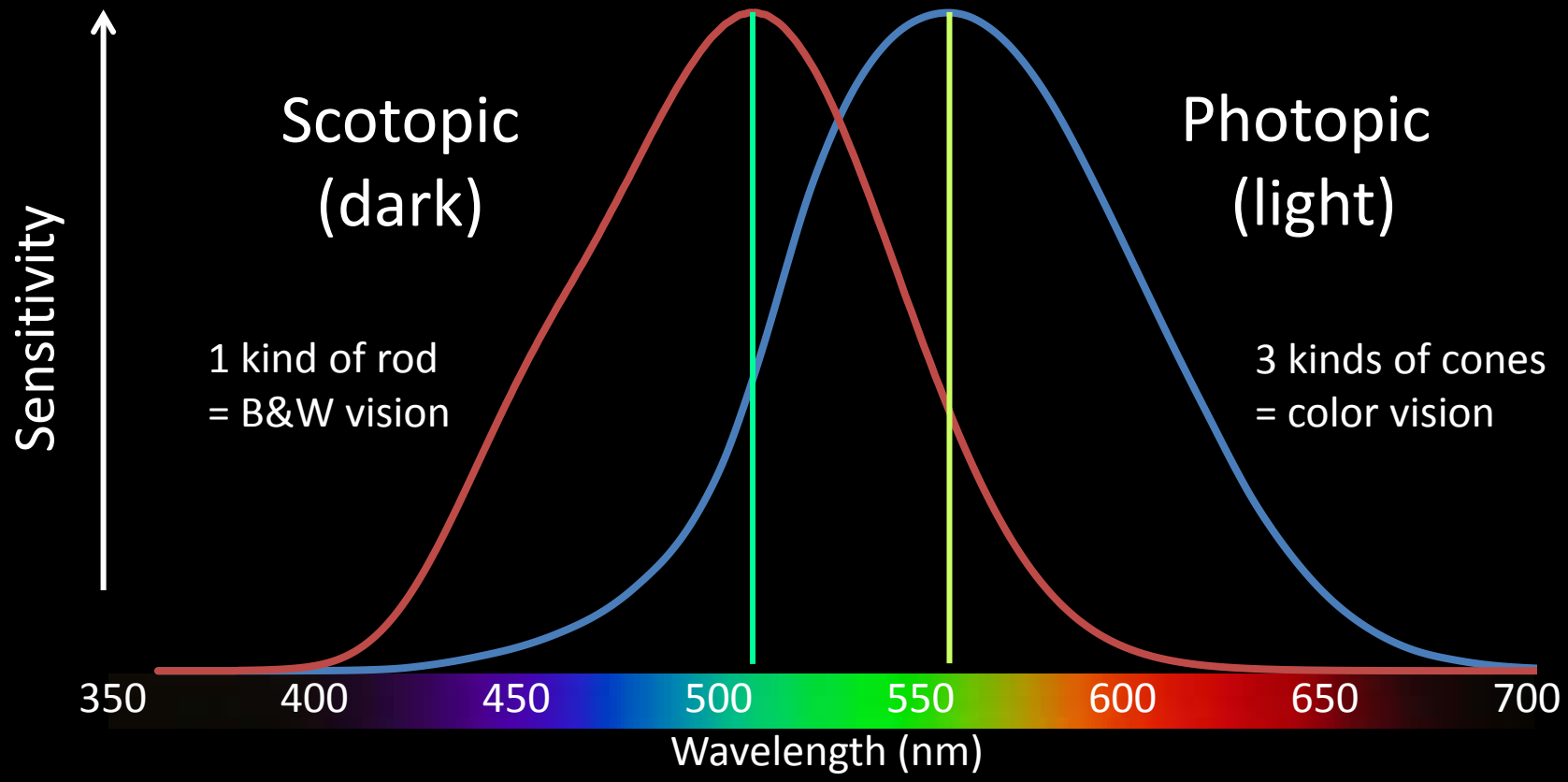
False-color photomicrograph of the retina



Visual sky glow

How does the eye perceive it?

Spectral sensitivity – not all colors are equal



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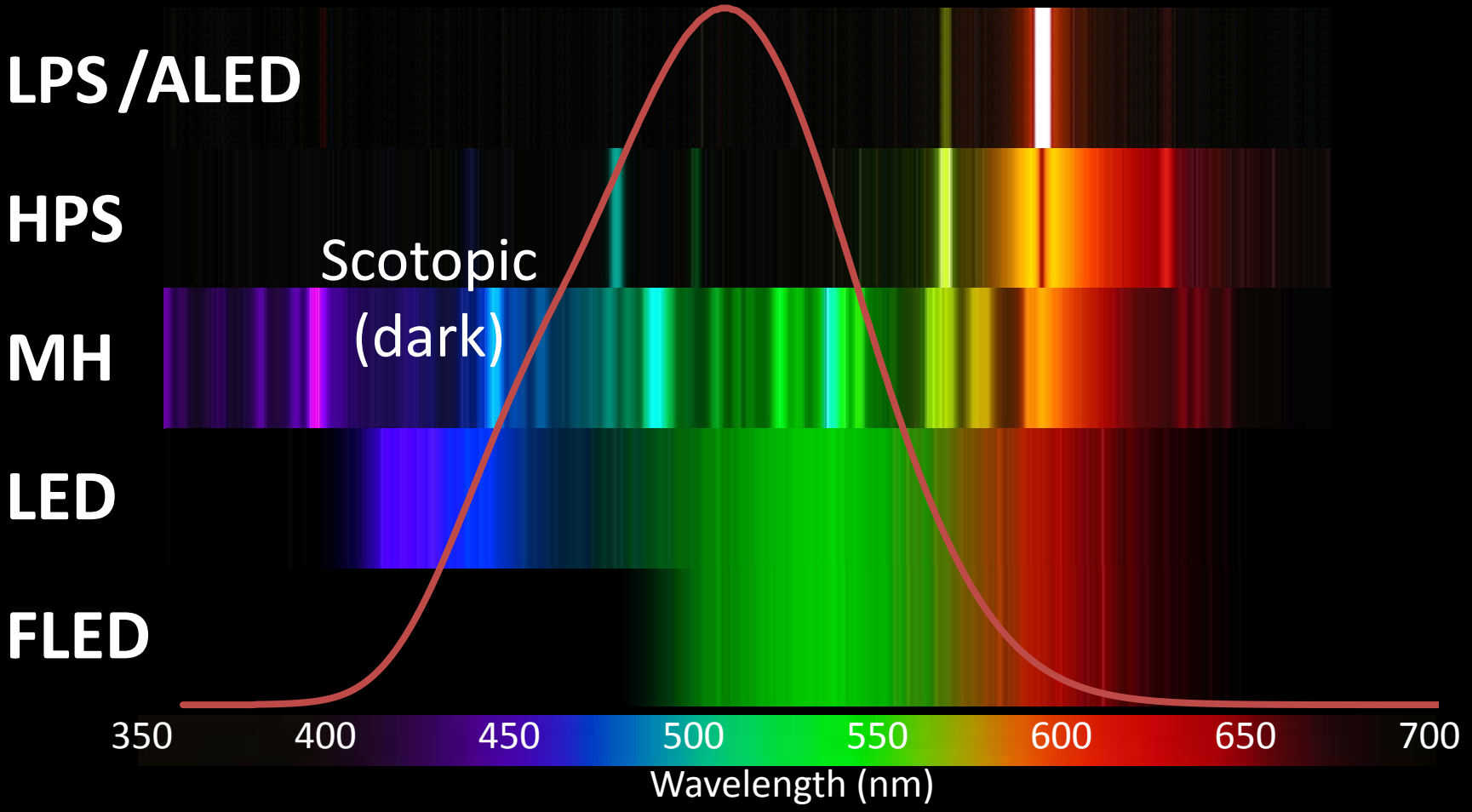
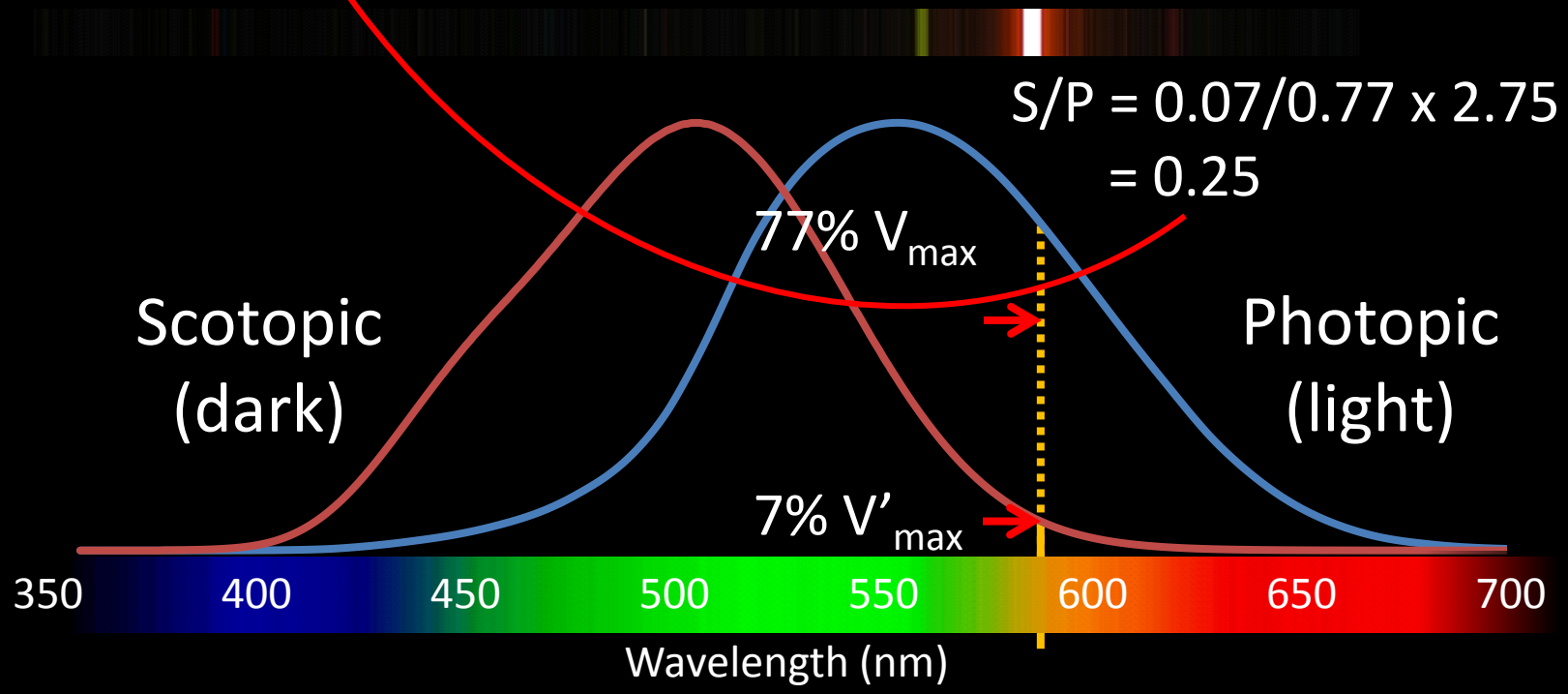


Outdoor Lighting Sources

Scotopic to photopic ratios – S/P

	LPS	ALED	HPS	LED 2400K	LED 5100K	CMH 4100K	FLED
S/P	0.25	0.25	0.65	1.1	2.0	1.6	0.92



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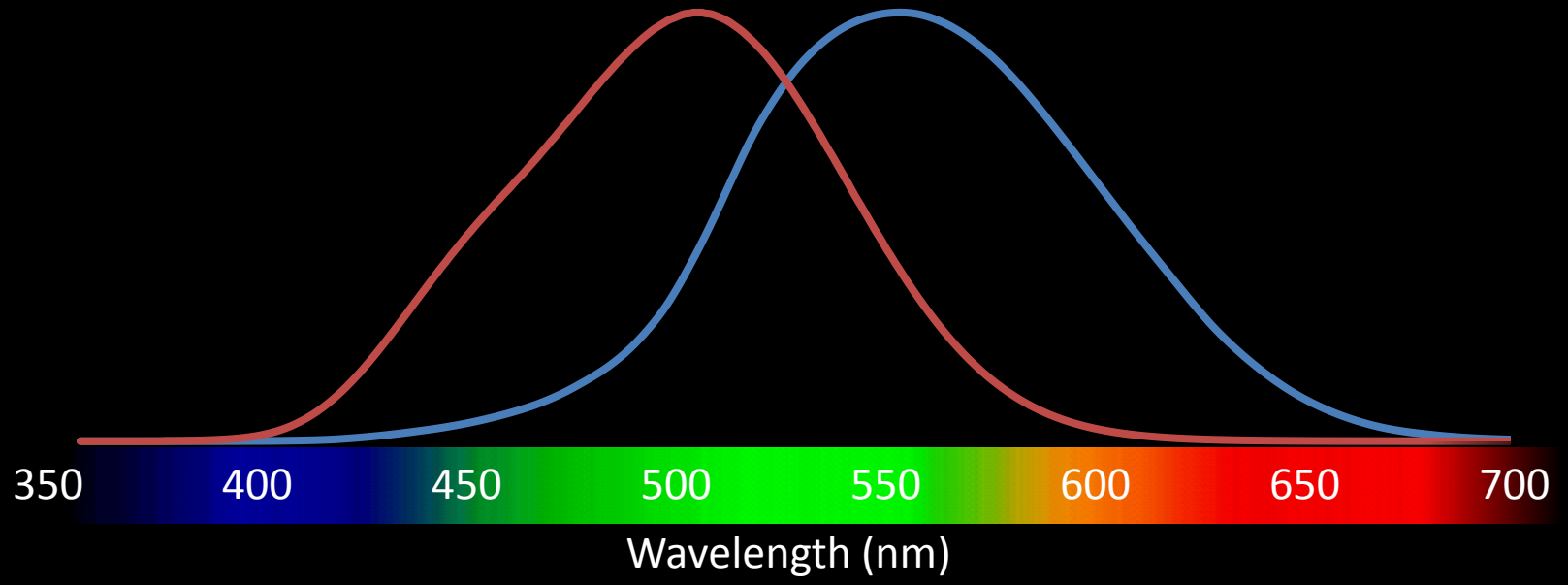
-- /HPS	0.4	0.4	**1.0**	1.7	3.1	2.5	1.4



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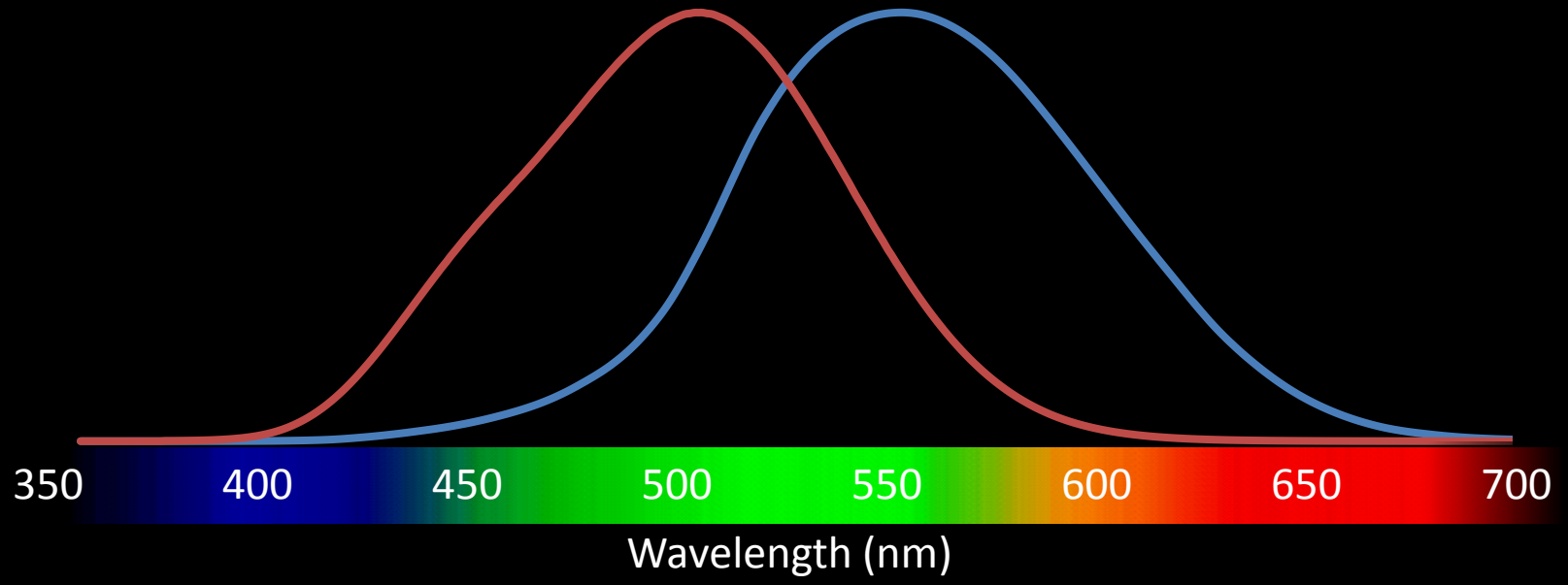
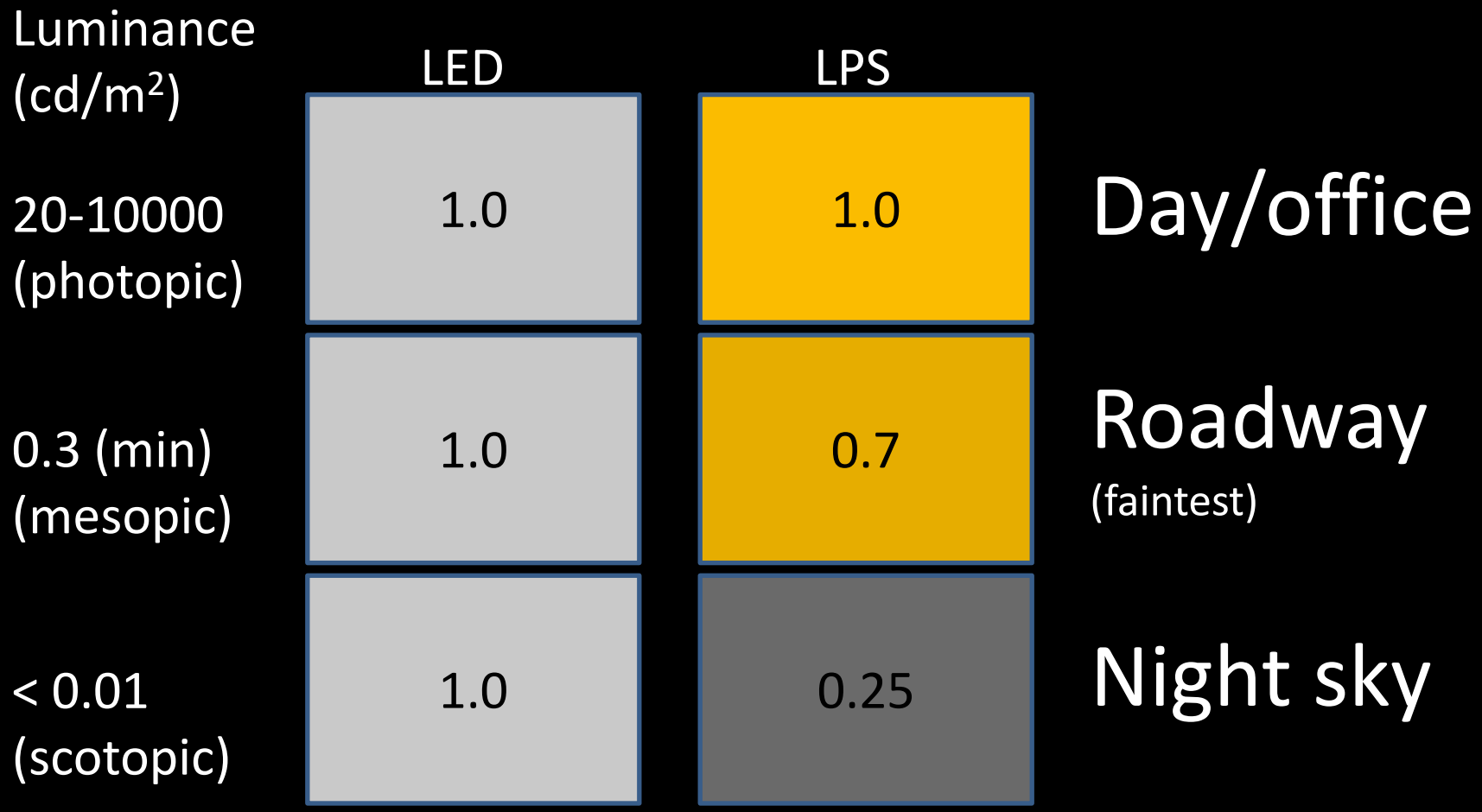
-- /LPS	**1.0**	1.0	2.6	4.4	8.0	6.4	3.7



Outdoor Lighting Sources

Spectrum, luminance, and visual brightness



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