MEASURING NEAR-INFRARED LIGHT SOURCES FOR DRIVER MONITORING SYSTEMS (DMS)

Matt Scholz, Radiant Vision Systems

IN-VEHICLE SENSING SYSTEMS

Automotive Interior Monitoring Systems (IMS)

Image Source:
Continental.com

Driver Monitoring Systems (DMS)

- Presence detection
- Eye/gaze/eyelid tracking
- Head position
- Facial recognition for ID
- Facial expression for mood
- Steering hand presence
- Steering/pedal use
- Biometrics (heart rate)

Occupant Monitoring Systems (OMS)

- Presence detection
- Body position/posture
- Facial recognition for ID
- Door open/closed
- Seatbelt fastened/unfastened
- Biometrics (heart rate, respiration, temperature)

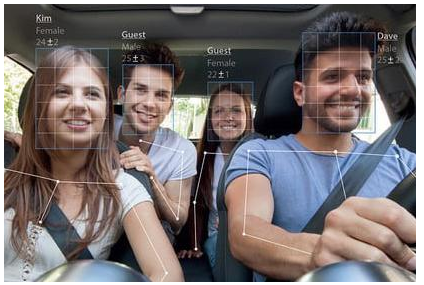
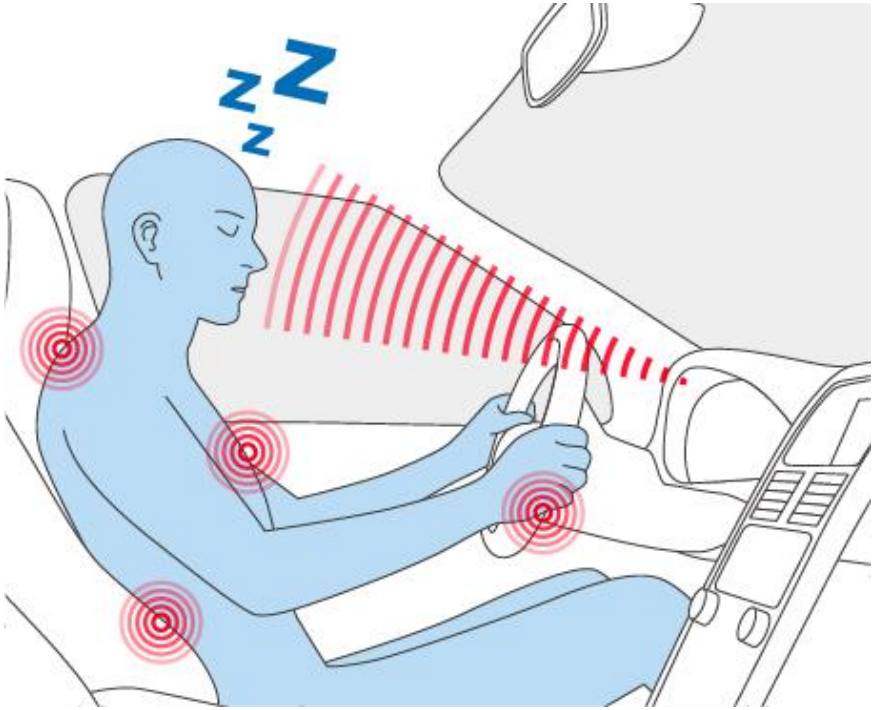


Image Source:
Cipia.com

REGULATIONS: EUROPEAN UNION

- *MANDATE: NEW VEHICLES AS OF 2022*
- System: DMS
- Safety systems mandated by EU GSR:
  - Driver drowsiness and attention warning
  - Advanced driver distraction warning
  - Emergency braking systems
  - Intelligent speed assistance
  - Emergency lane-keeping systems
- 21,337 fewer EU car-related deaths projected through 2037 with these systems



Read More:

- https://eur-lex.europa.eu/eli/reg/2019/2144/oj

REGULATIONS: UNITED STATES

- *COMING SOON…*
- System: DMS
- SAFE ("Stay Aware for Everyone") Act of 2020
- Research initiated to determine final ruling to install DMS to eliminate:
  - Driver distraction
  - Driver disengagement
  - Automation complacency
  - Misuse of ADAS

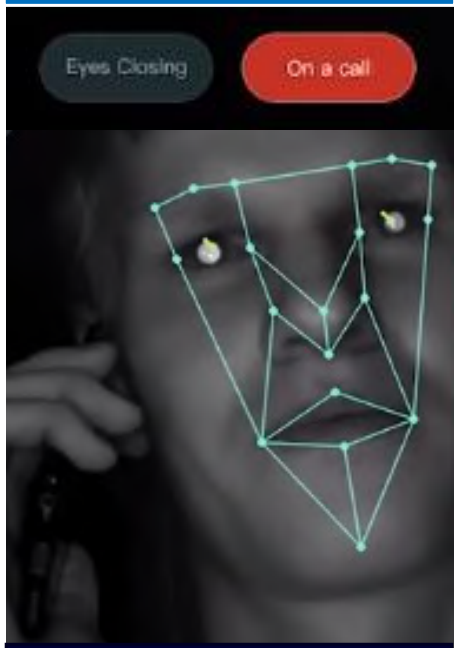
Read More:

- https://www.congress.gov/bill/116th-congress/senate-bill/4123/text

IN-VEHICLE SENSING TECHNOLOGY

RADIANT VISION SYSTEMS

VISION

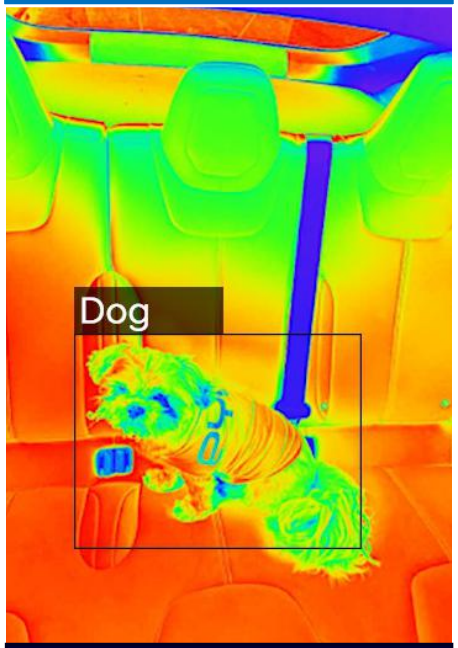


NXP

RADAR

bitsensing

THERMAL (IR)



eyeris

EKG/ECG

B Secur
Connecting Your Heart

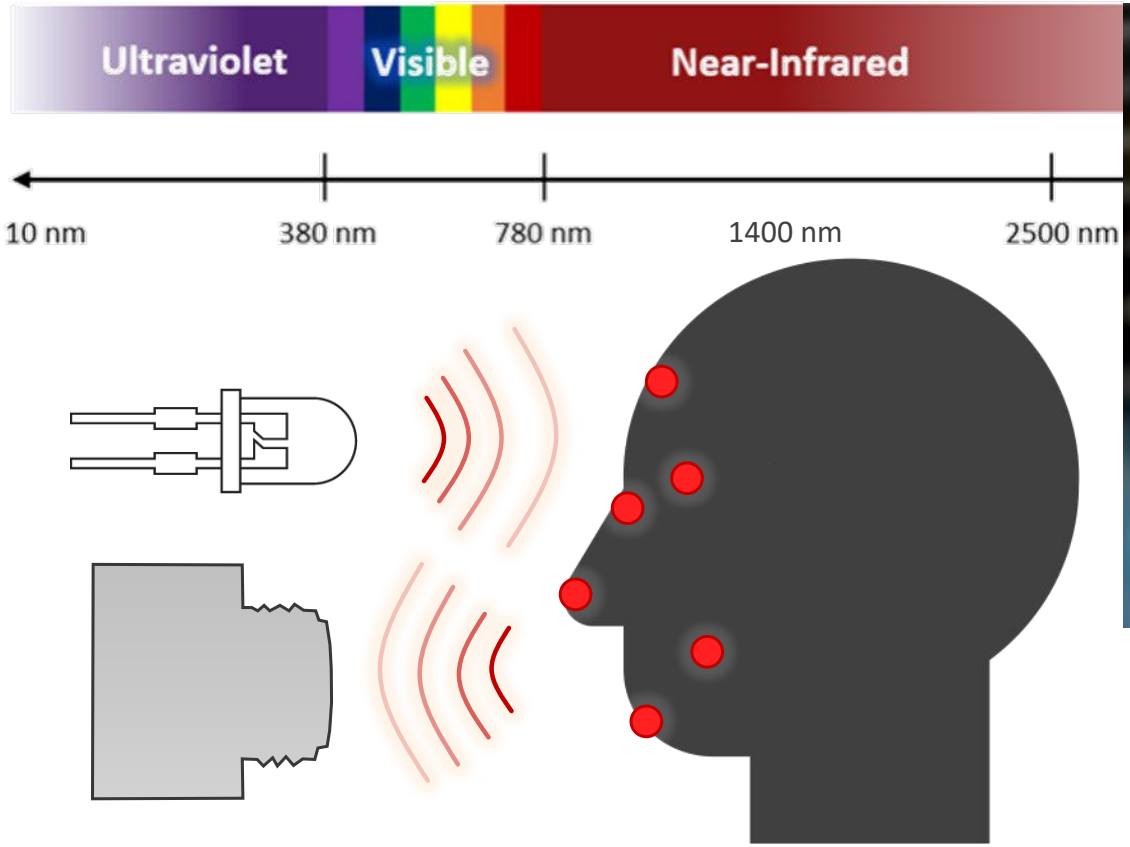
IN-VEHICLE SENSING TRENDS

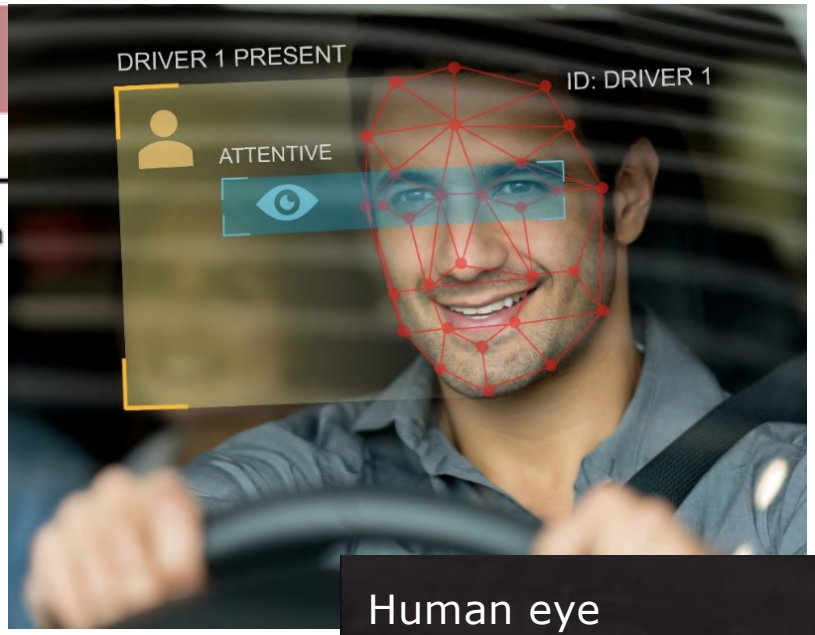
RADIANT VISION SYSTEMS

OEM	Technology	Type	Primary Sensing Method	In-Vehicle Functions
Audi	AI:ME (concept)	DMS/Driver Assistance System	Near-infrared	• Eye/gaze tracking
BMW	i Interaction EASE (concept); Extended Traffic Jam Assistant System	DMS/Driver Assistance System	Near-infrared (EASE); Vision Camera (EJAS)	• Eye/gaze tracking • Head motion/position • Responsive AR-HUD (EASE)
GM	Cadillac Super Cruise System	DMS/Driver Assistance System	Near-infrared, Steering sensors	• Eye/gaze tracking • Head motion/position • Steering hand presence
Hyundai	Driver State Warning (DSW); Rear Occupant Alert	DMS; OMS	Near-infrared (DMS); Radar, Ultrasound (OMS)	• Eye/gaze tracking • Facial recognition • Personalization • Child/occupant presence
Ford	Co-Pilot360	DMS/Driver Assistance System	Near-infrared	• Eye/gaze tracking • Head motion/position
Mazda	i-ACTIVSENSE	DMS/Driver Assistance System	Near-infrared	• Eye/gaze tracking • Head motion/position
Mercedes-Benz	*2021 S-Class*	Driver Assistance System	Near-infrared	• Eye/gaze tracking
Nissan	ProPILOT	DMS/Driver Assistance System	Near-infrared, Steering sensors	• Eye/gaze tracking • Head motion/position
Subaru	DriverFocus (EyeSight Driver Assist)	DMS/Driver Assistance System	Near-infrared	• Eye/gaze tracking • Head motion/position • Facial recognition
Tesla	*TBD*	OMS	Radar	• Child/occupant presence
Toyota	Lexus Safety System (LSS)/ Safety Sense	Driver Assistance System	Radar, Camera	• Eye/gaze tracking • Head motion/position

*Multiple Sources. See "**A Comprehensive Survey of Driving Monitoring and Assistance Systems"** by Muhammad Qasim Khan and Sukhan Lee, as well as OEM announcements.*

NEAR-INFRARED LIGHT/CAMERA SYSTEMS





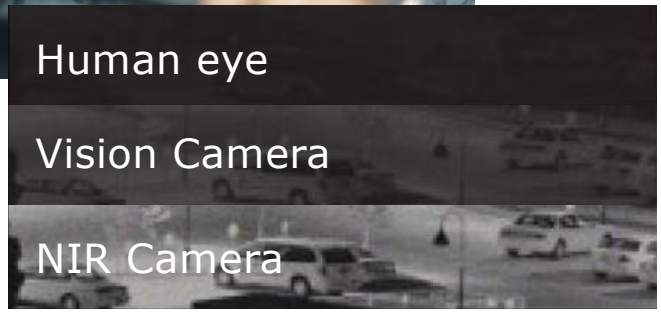
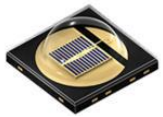


Image Source

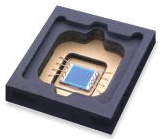
NEAR-IR LIGHT SOURCES

Features and Applications of LEDs and Lasers

NIR LIGHT SOURCE COMPARISON



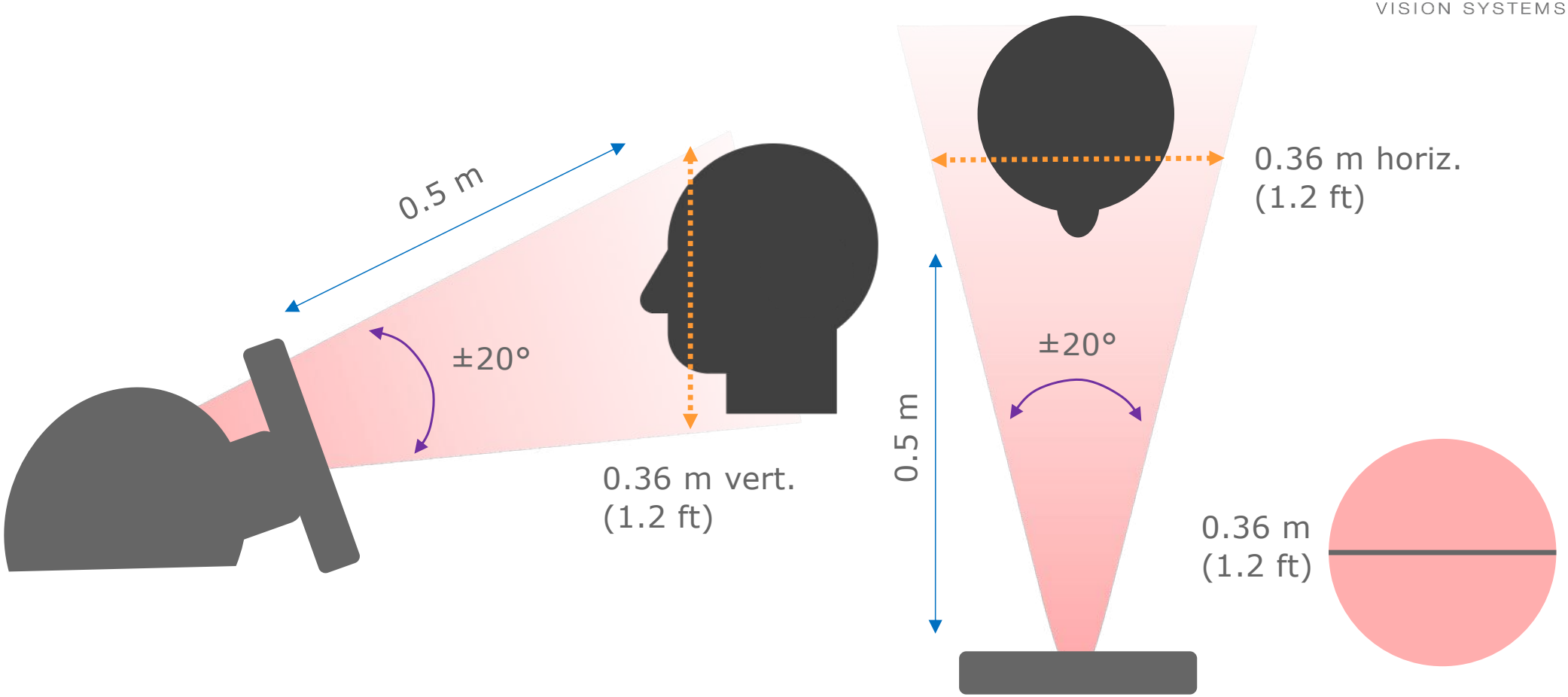
Example LED. Source: Osram



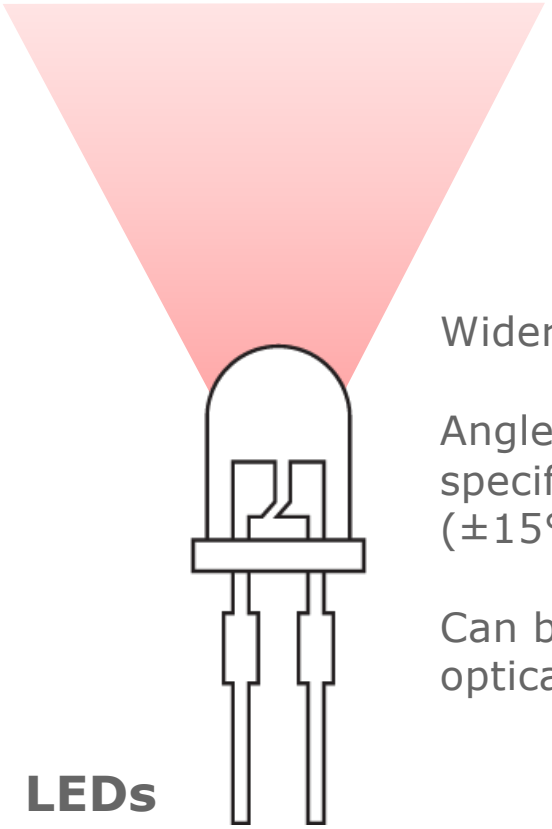
Example VCSEL. Source: Finisar

	LED	VCSEL
Spot Size	100 µm	35 µm
Beam Angle	≤120°	≤20° (no diffraction)
Beam Quality	Lambertian; Low coherence	Low-divergence; High coherence
Range	Shorter	Longer
Response (Rise/Fall Time)	~10 ns (Source: Lumileds)	< 1 ns (Source: Lumileds)
Operating Temperature	-40 to ~125°C	-20 to ~85°C
Stability vs. Temperature	~0.25 nm/°C (Source: Lumileds)	~0.07 nm/°C (Source: Lumileds)
Eye Safety	"Intrinsically Safe"	Requirements per class
Cost	Lower	Higher
Application	Illumination; Stereo Vision; TOF	Patterns (Structured Light); TOF

BEAM ANGLE



BEAM ANGLE

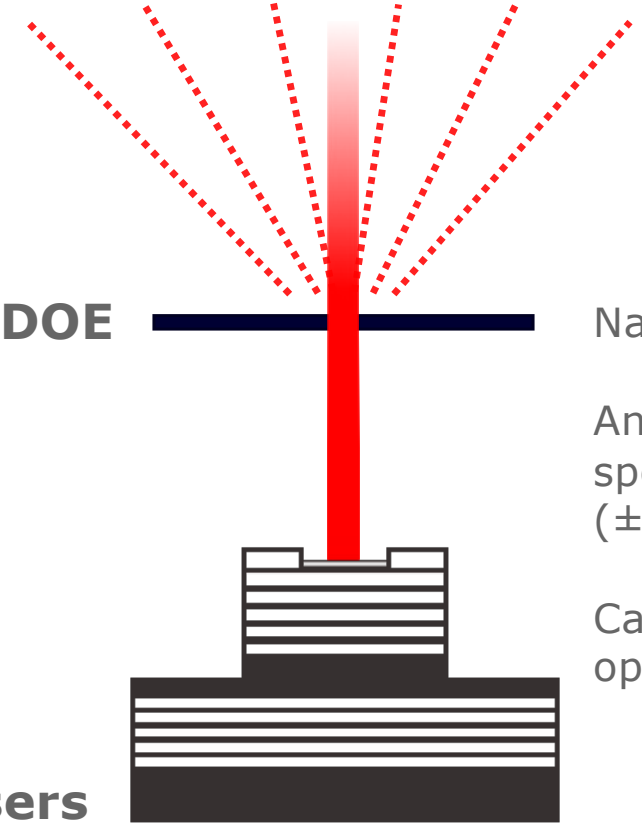


LEDs

Wider beam angle

Angle defined in source specifications (±15°, ±25°, etc.)

Can be narrowed using optical elements



Lasers

Narrower beam angle

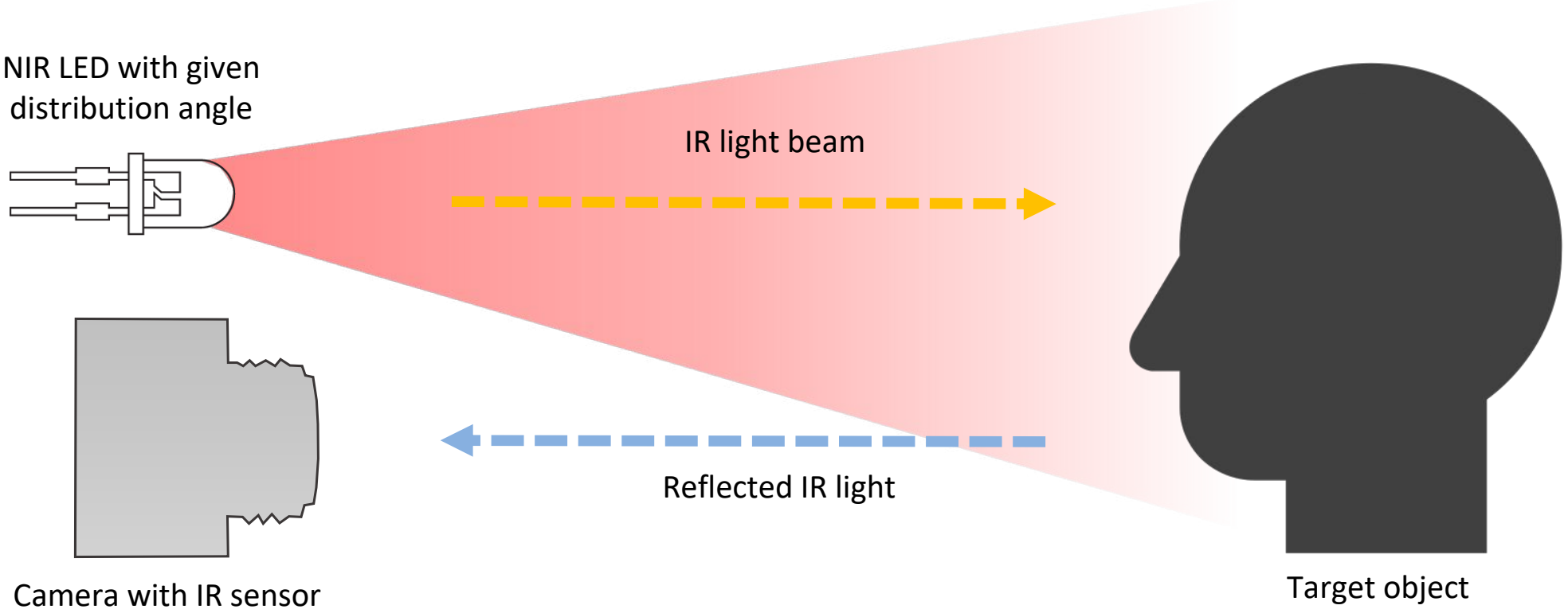
Angle defined in source specifications (±6°, ±15°, etc.)

Can be diffracted using optical elements

APPLICATIONS: 2D SENSING (LED)

RADIANT VISION SYSTEMS

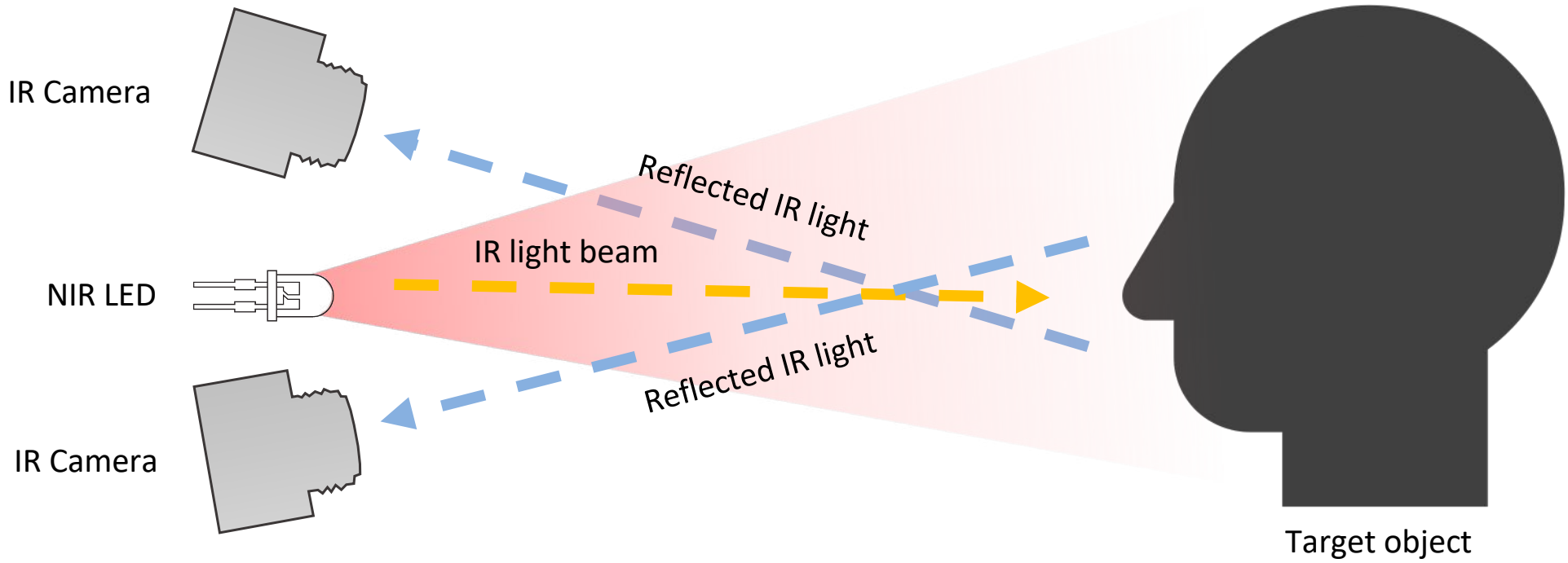
Illumination



APPLICATIONS: 3D SENSING (LED/LASER)

RADIANT VISION SYSTEMS

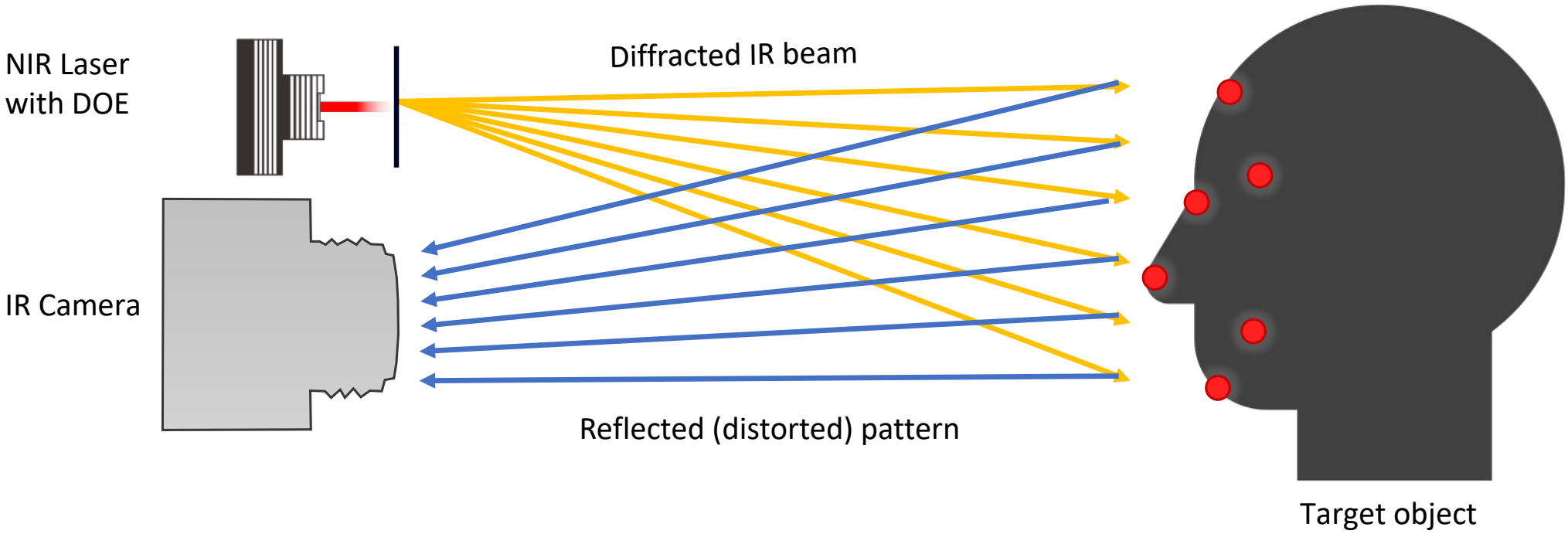
Stereo Vision

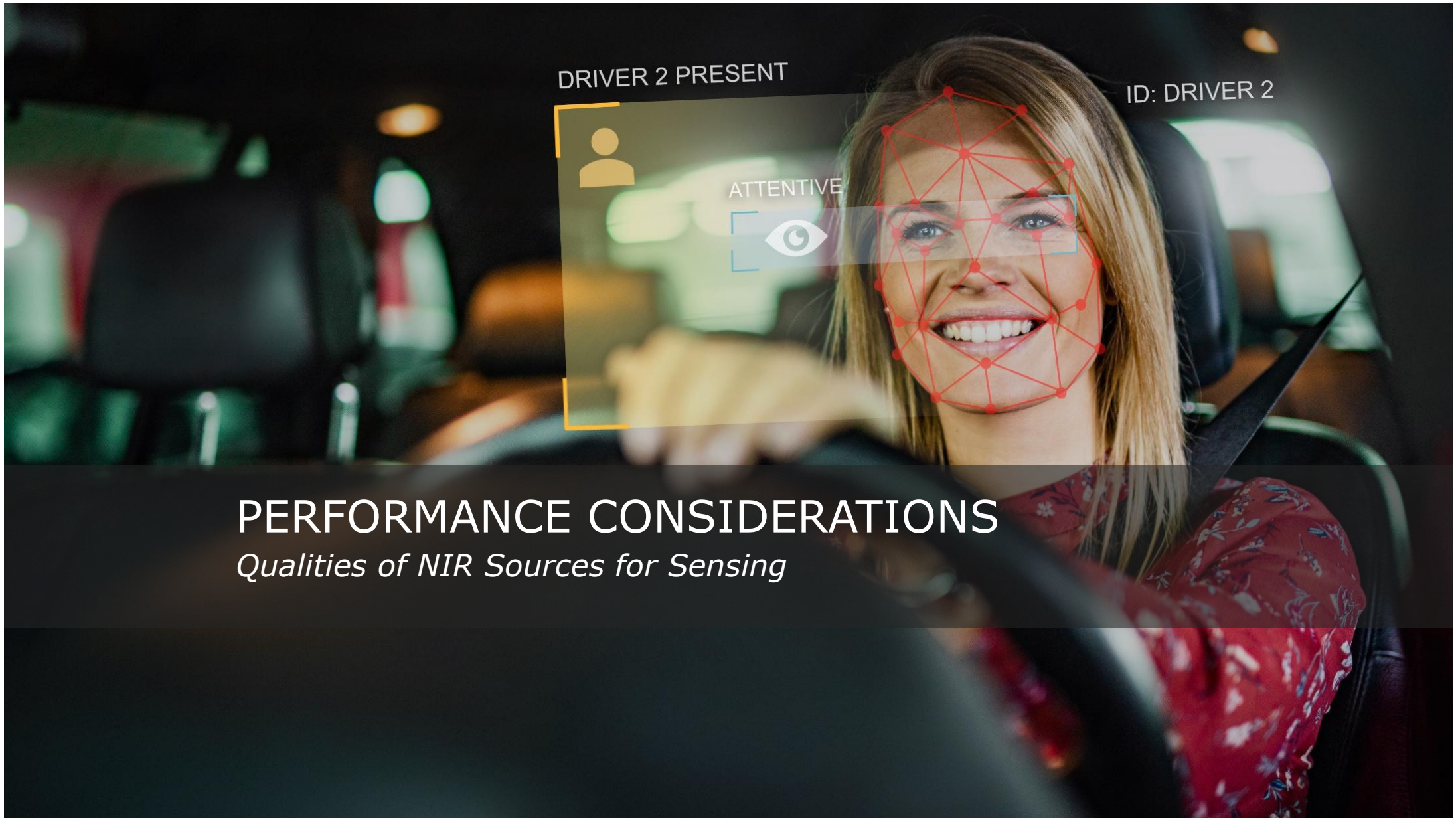


APPLICATIONS: 3D SENSING (LASER)

RADIANT VISION SYSTEMS

Structured Light Patterns

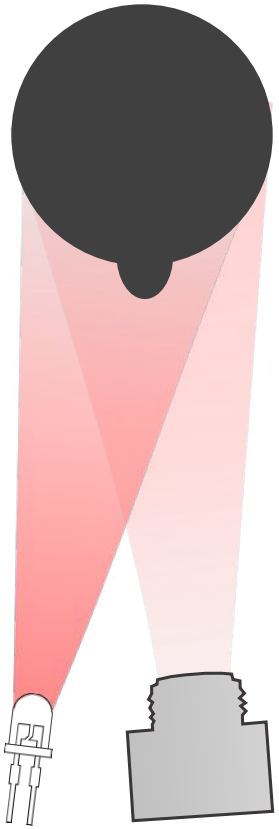




PERFORMANCE CONSIDERATIONS

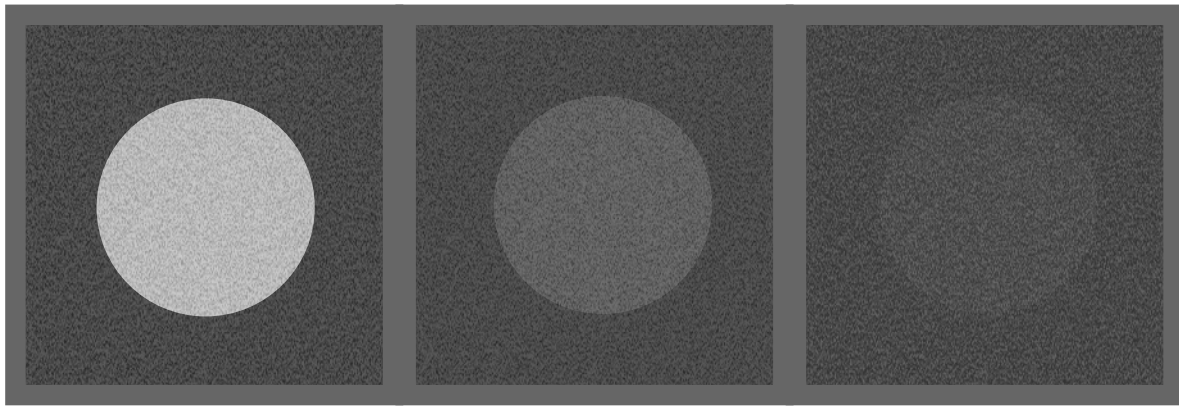
Qualities of NIR Sources for Sensing

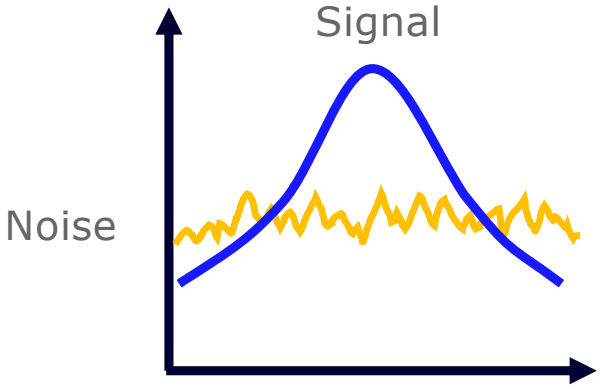
SUFFICIENT INTENSITY

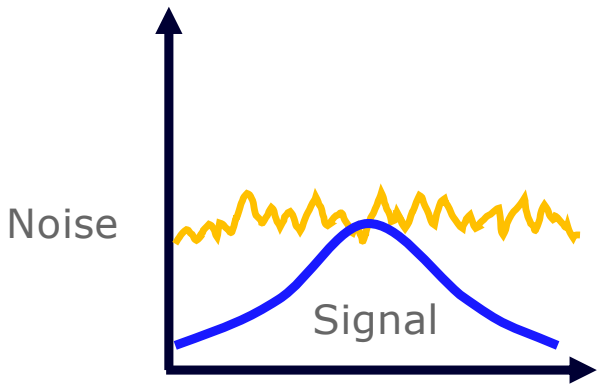


LED/Laser

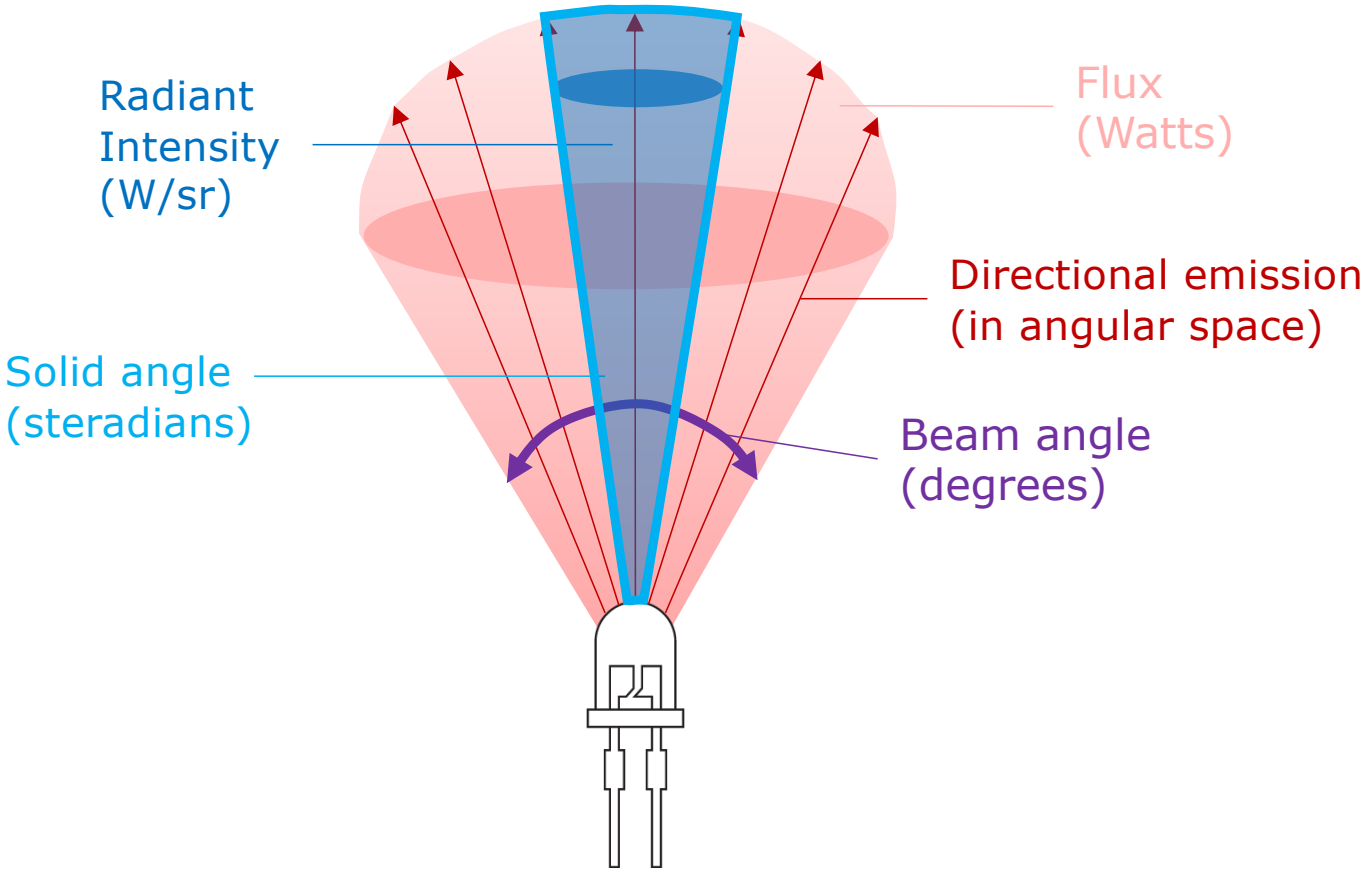
IR Camera







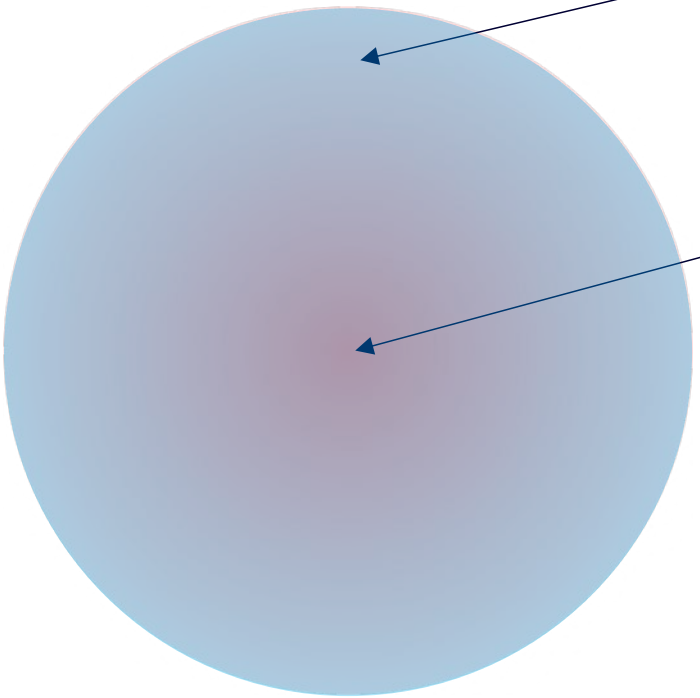
POWER OVER ANGLE



DISTRIBUTION INTEGRITY

RADIANT VISION SYSTEMS

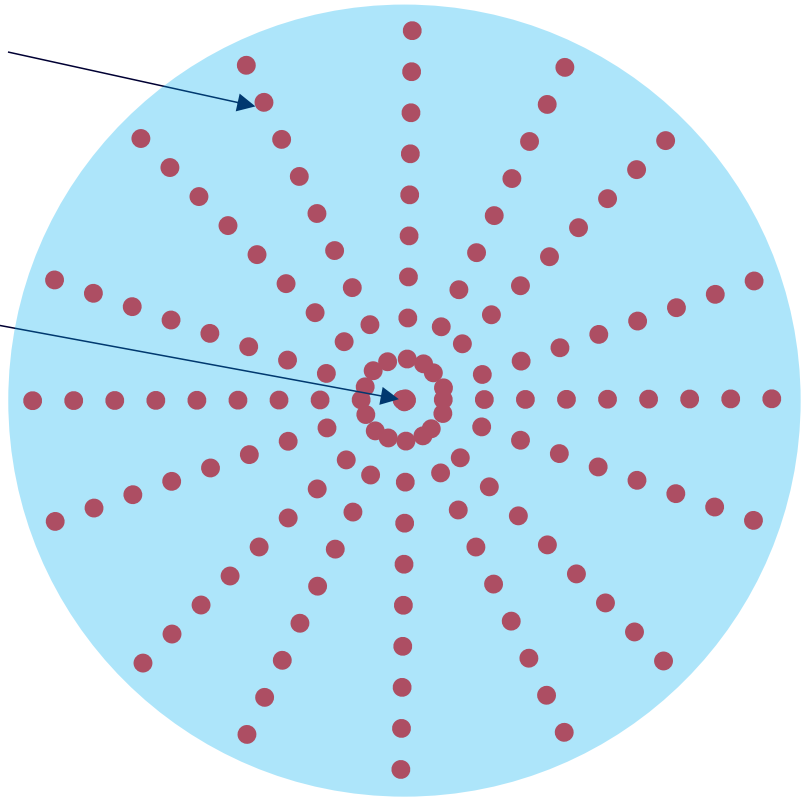
What is the intensity of this spot?

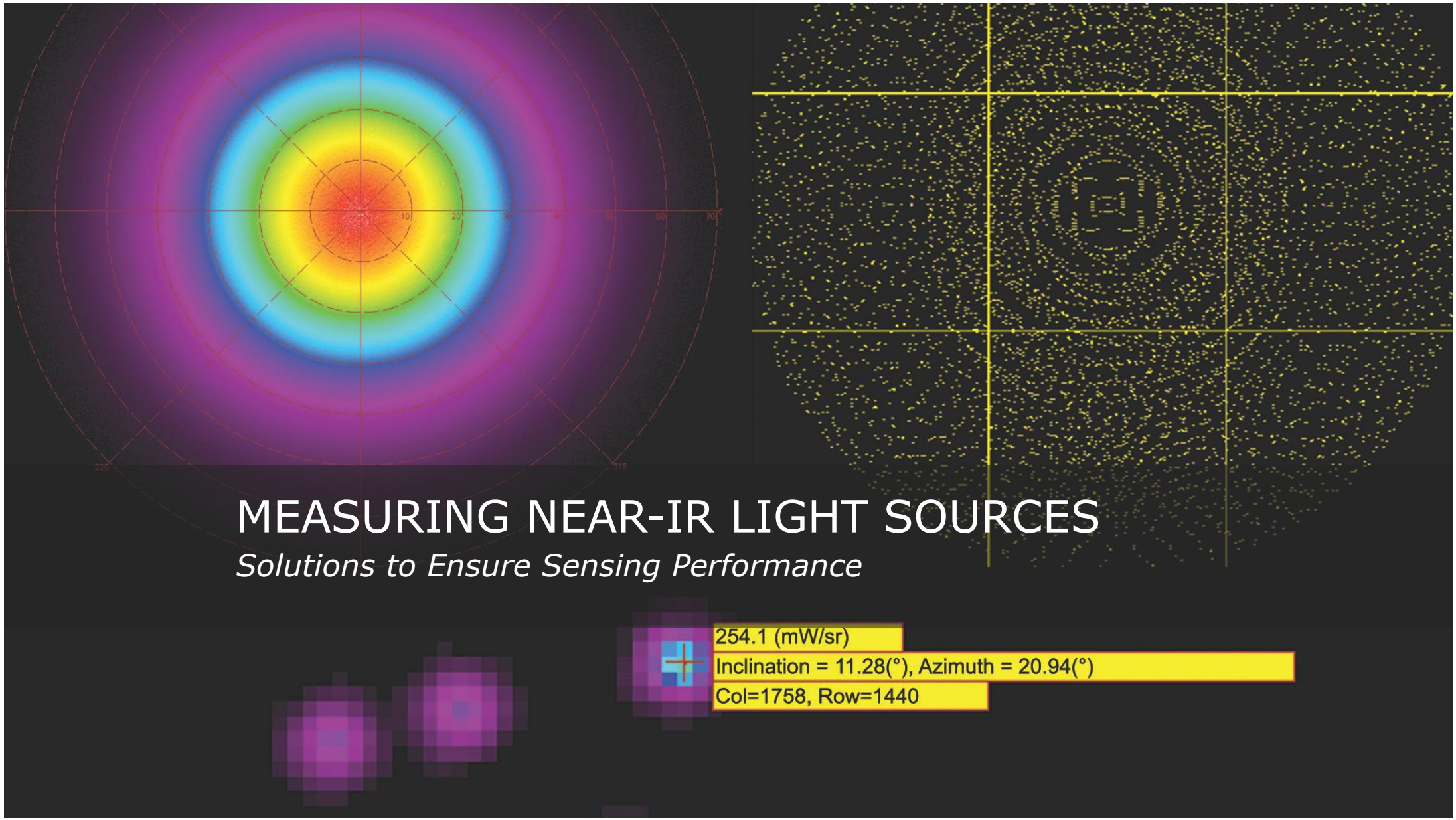


Of this spot?

Are all spots uniform?

Is the distribution angle, inclination, azimuth, pattern correct?



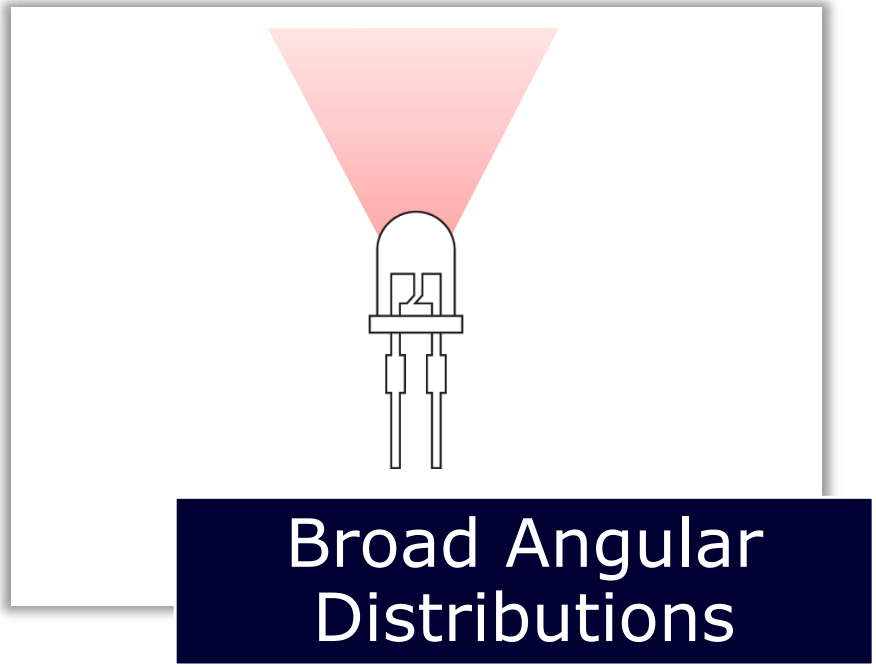


MEASURING NEAR-IR LIGHT SOURCES

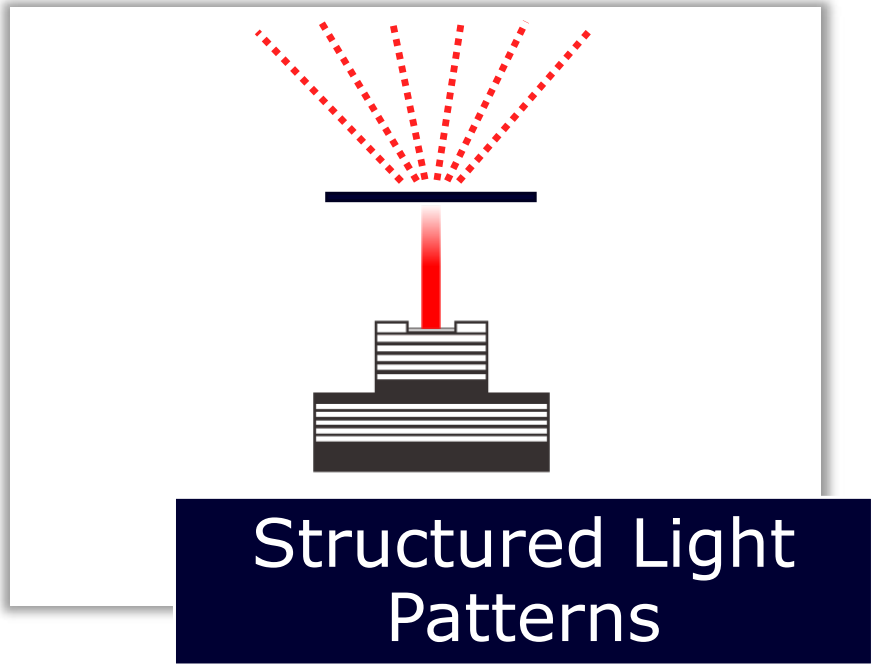
Solutions to Ensure Sensing Performance

MEASUREMENT CONSIDERATIONS

We need measurement solutions that address multiple geometries—including pattern, direction, and angle.



Broad Angular Distributions



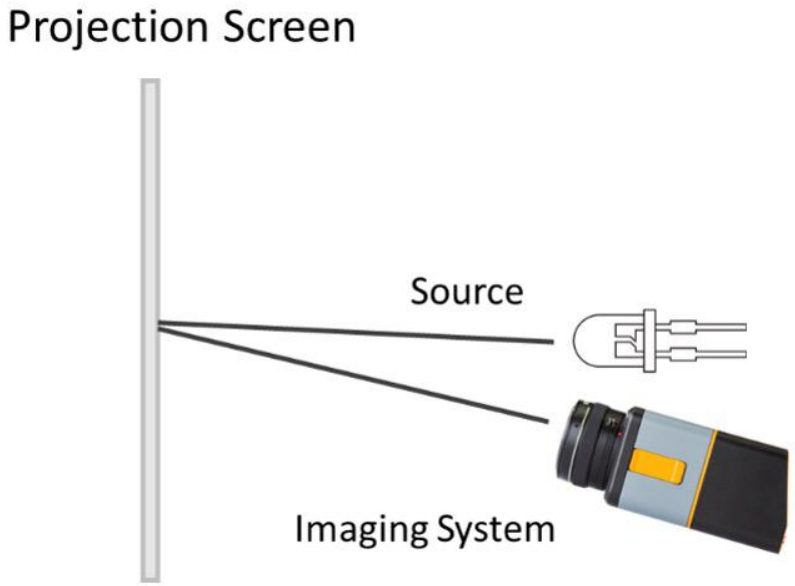
Structured Light Patterns

INDIRECT REFLECTANCE MEASUREMENT

RADIANT VISION SYSTEMS

Beam/Pattern on a Wall

- Cast light on a wall/screen and measure with imaging system
- Measure irradiance of LED beam
- Measure structured light emissions and verify dot position against a target pattern or coordinates
  - *Pass/fail on pattern match*



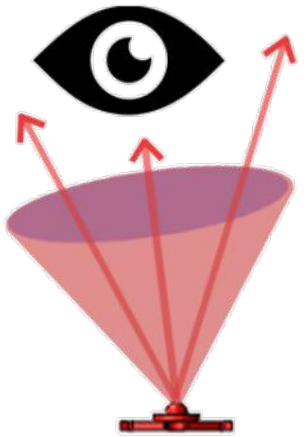
DIRECT ANGULAR MEASUREMENT

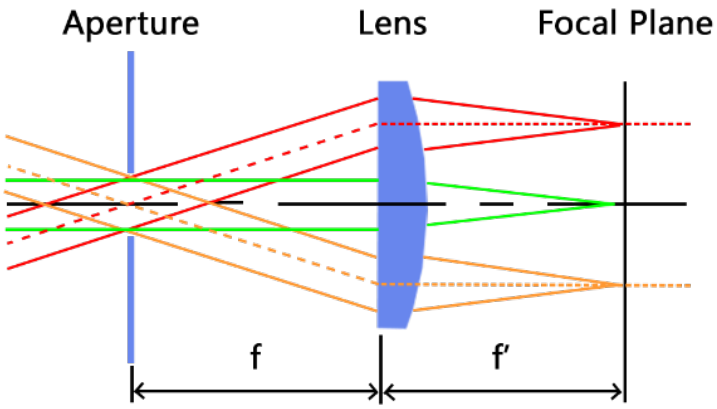
- **Goniometer**
  - Rotate source relative to a photodetector or camera to capture intensity data at each angle
  - More images, higher resolution
    - *Full resolution at each degree*
  - Output IES, EULUMDAT, ray set files

DIRECT ANGULAR MEASUREMENT

Fourier Optic Lens

- Lens and radiometric imager
  - *850/940 nm light sources*
  - *Angular FOV to ±70 degrees*
- Instantly measure full cone of data in a single image
- No rotation of photodetector or source to capture distribution
- Angular resolution to ~0.05° per sensor pixel

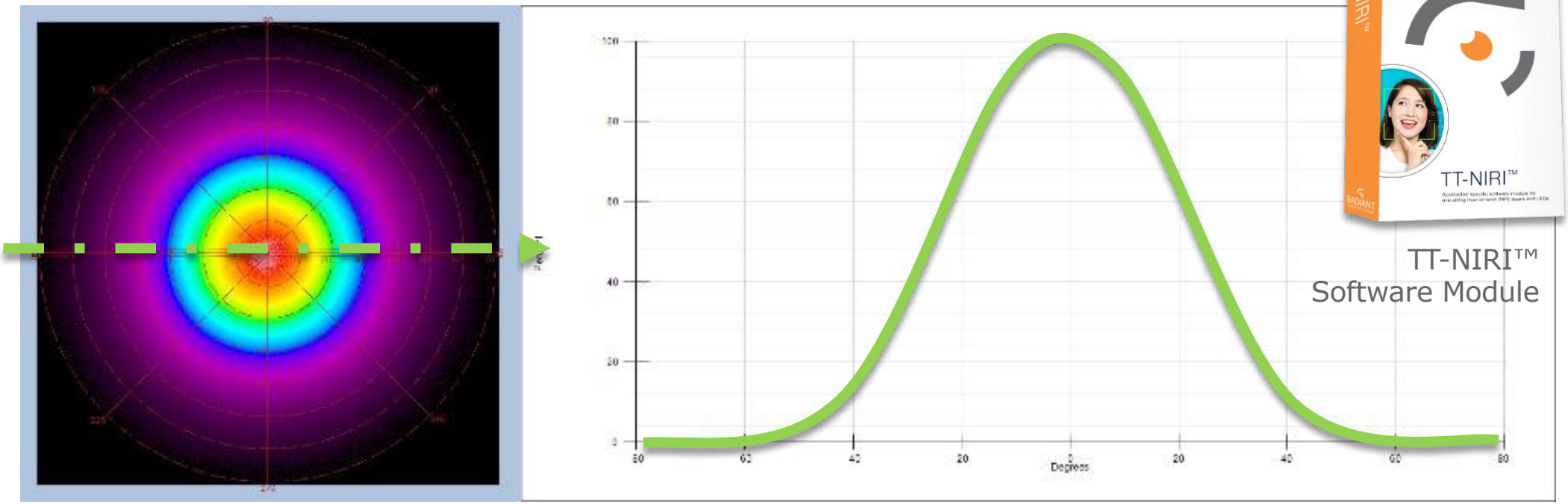





NIR MEASUREMENT SOFTWARE
Automated Light Source Analysis & Data Output

DIRECT ANGULAR MEASUREMENT

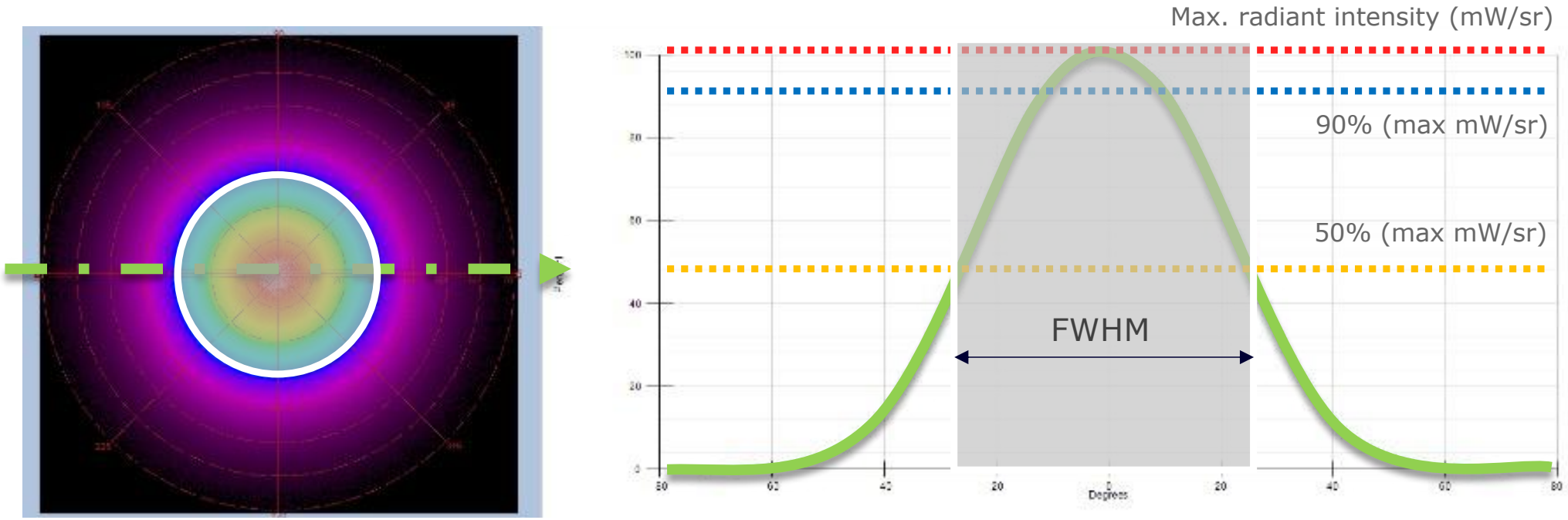
Radar plot showing **radiant intensity as function of angle** of an NIR LED light source.



TT-NIRI™
Software Module

DIRECT ANGULAR MEASUREMENT

Full-width half-max (FWHM) of the angular cross-section defines the primary area for intensity measurement.



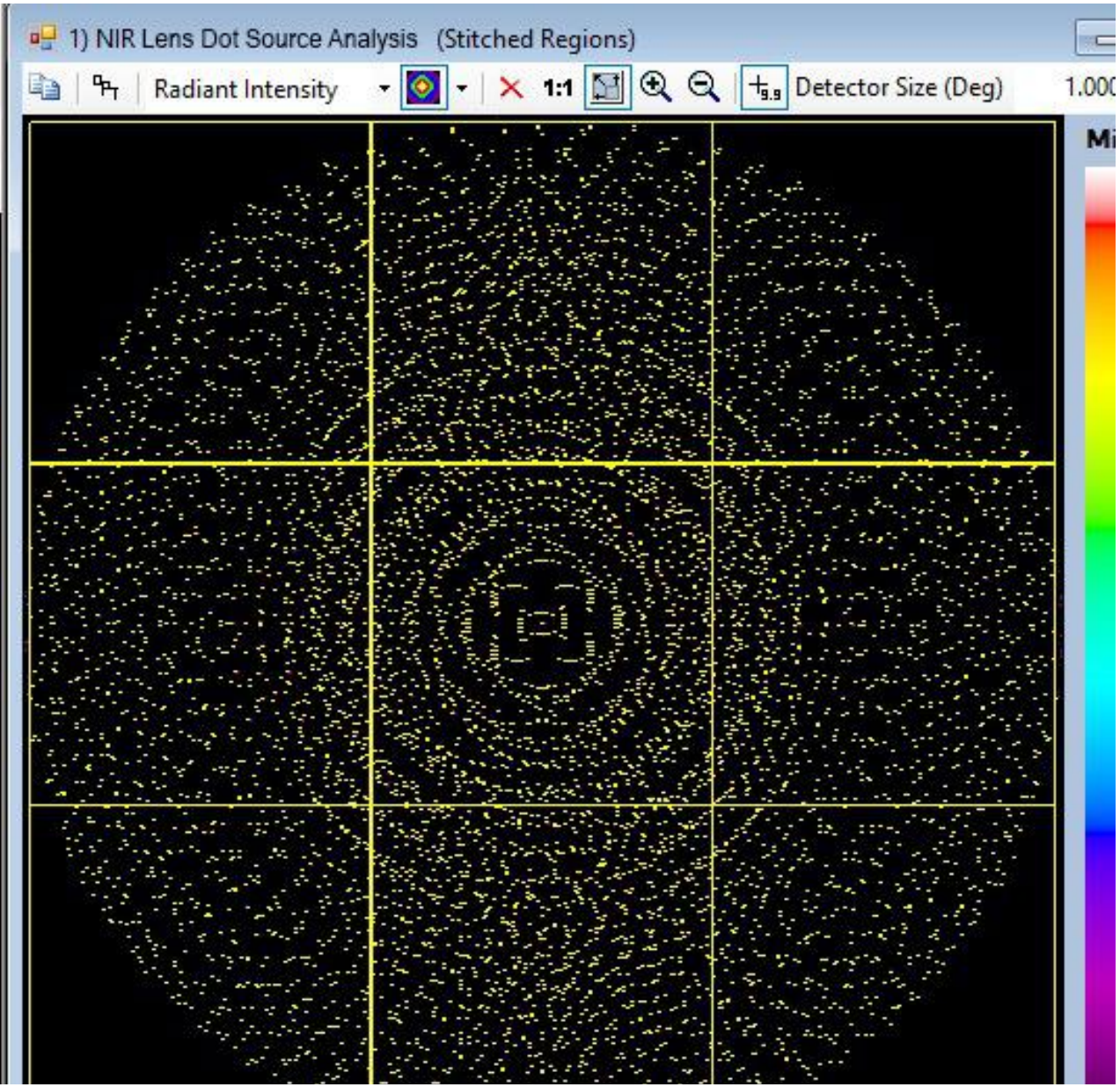
Run Sequence

Save Sequence | Save Sequence As

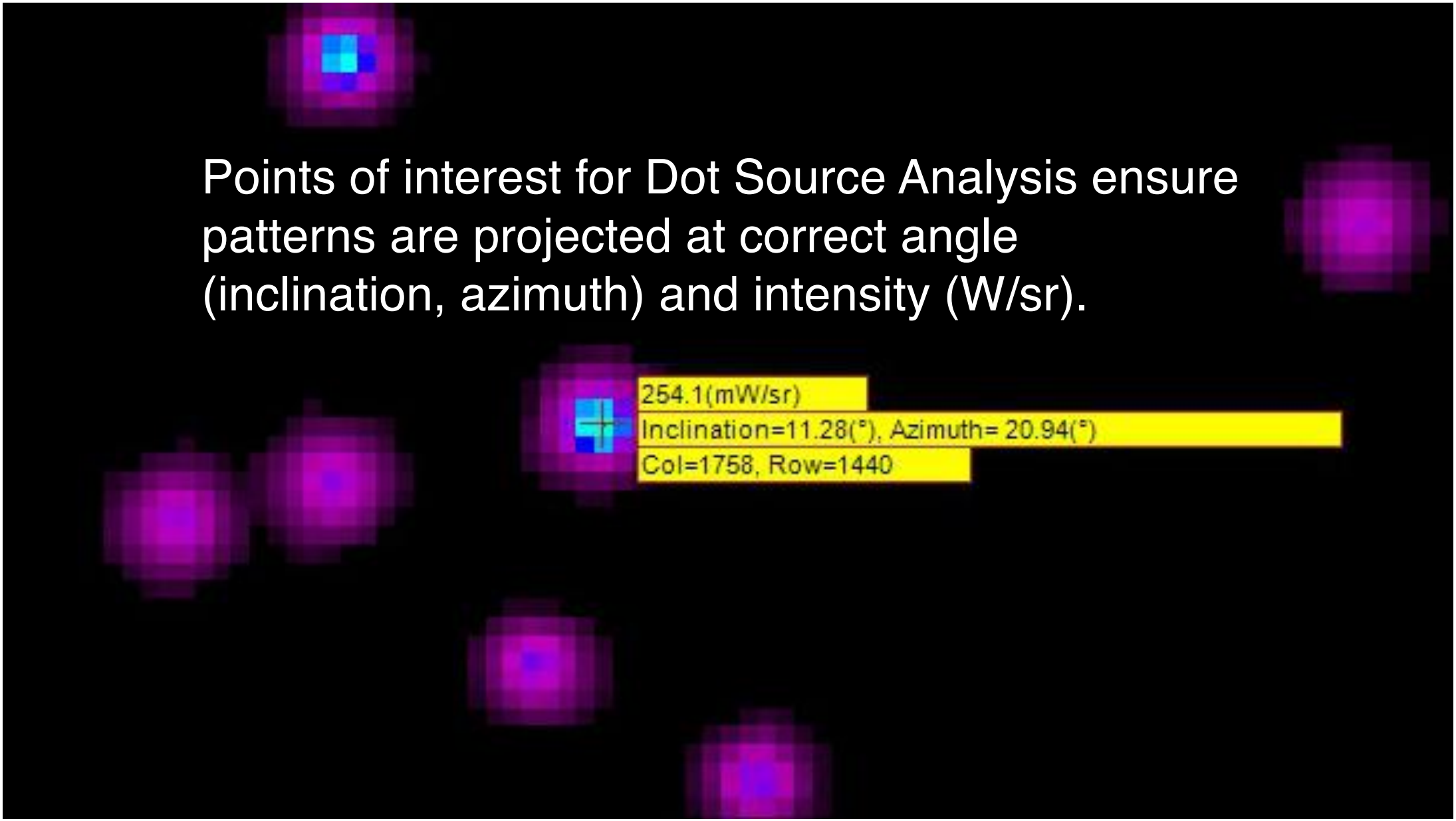
Add Step | Copy Step | Delete Step

	Select	Measurement Setup	Analysis	Edit
1	☑	NIR Conoscope	Dot Source Analysis	Edit
2	☑	NIR Conoscope	Dot Source Analysis	Edit
3	☐	NIR Conoscope	Total Flux	Edit
4	☑	NIR Conoscope	POI Total Power	Edit
5	☑	NIR Conoscope	MaxPower	Edit
6	☐	NIR Conoscope	Pixel Solid Angle	Edit
7	☐	NIR Conoscope	Flood Source Analysis	Edit

DOT SOURCE ANALYSIS



Points of interest for Dot Source Analysis ensure patterns are projected at correct angle (inclination, azimuth) and intensity (W/sr).



CHOOSING A MEASUREMENT SOLUTION

RADIANT VISION SYSTEMS

Ideal for:	LED	Laser	Wide Beam	Structured Light	Angular Output	Radiant Intensity (Direct Output)	Irradiance/ Reflectance (Indirect Output)	R&D/ Lab	Production Testing
Beam/Pattern on a Wall	X	X	X	X			X	X	
Goniometer	X		X		X	X		X	
Fourier Optic Lens	X	X	X	X	X	X		X	X

Radiometric Imaging System (ProMetric® Imaging Radiometer)

Goniometric System (SIG-400)

Fourier Optic Lens System (NIR Intensity Lens)

THANK YOU!

Questions? Contact Matt.Scholz@RadiantVS.com
RadiantVisionSystems.com