FLUKE

INFRA RED BASICS

IRT Calibration

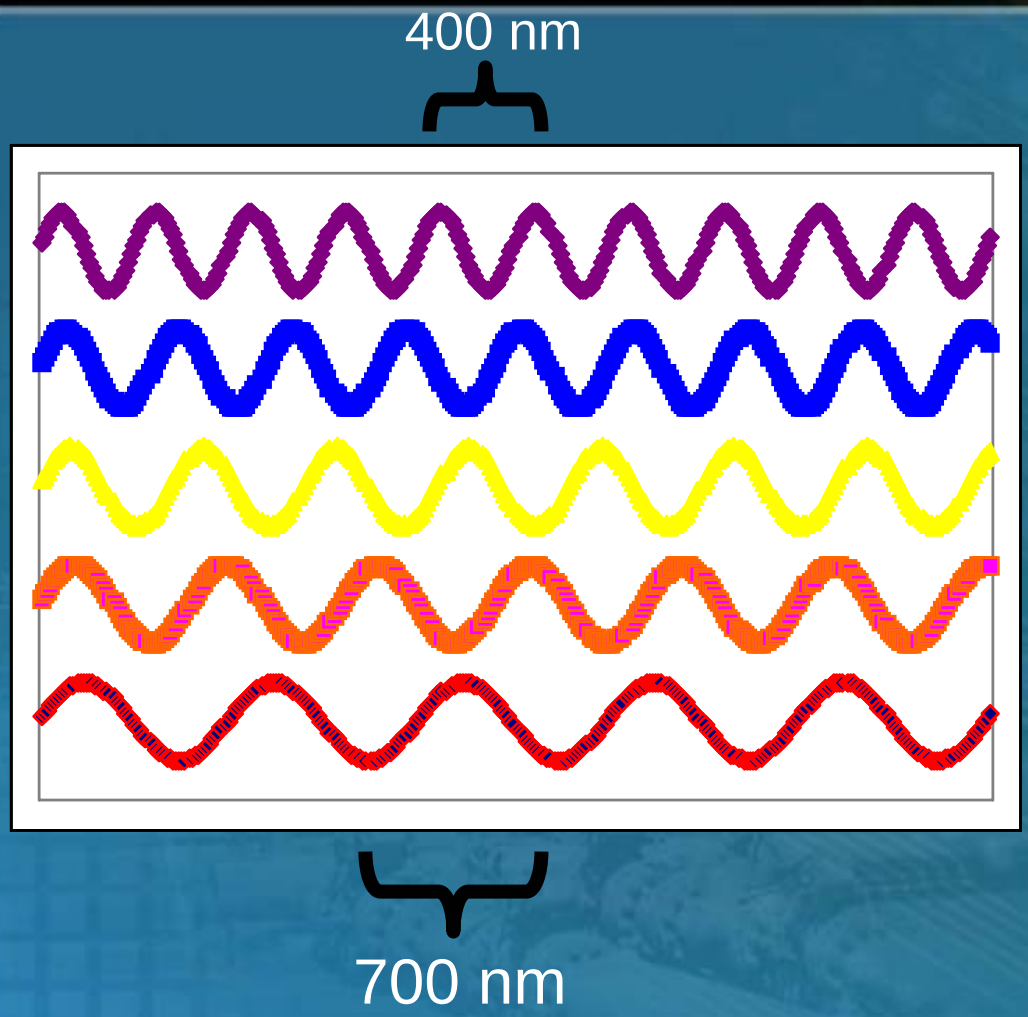
IR Calibration Challenges

- Describe the principles underlying non-contact temperature measurement
- Emissivity
- Calibration geometry
  - Spot size
  - Distance from temperature source
  - Size of Source
- Radiometric traceability
- Background temperature and humidity
- Introduction to new calibrators

Radiation Thermometers

- Temperature causes the surfaces of objects to radiate light in many colors
- Intensity of the colors of that light depends on temperature
- There is a pattern in the intensity of the colors that makes radiation thermometers possible
- To “emit”…

Light Waves



Important ranges…

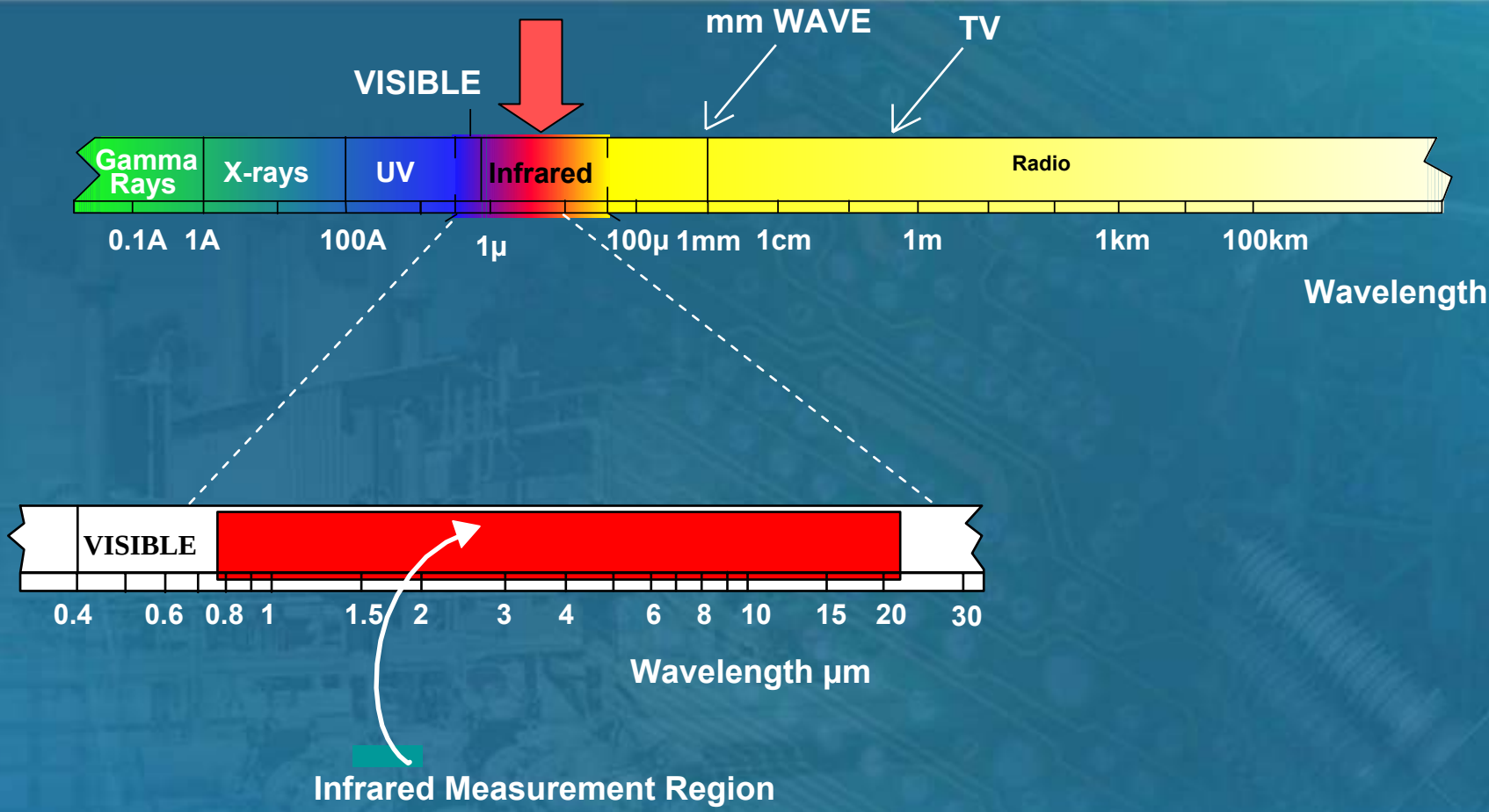
0.4 to 0.7 μm

0.7 to 1000 μm

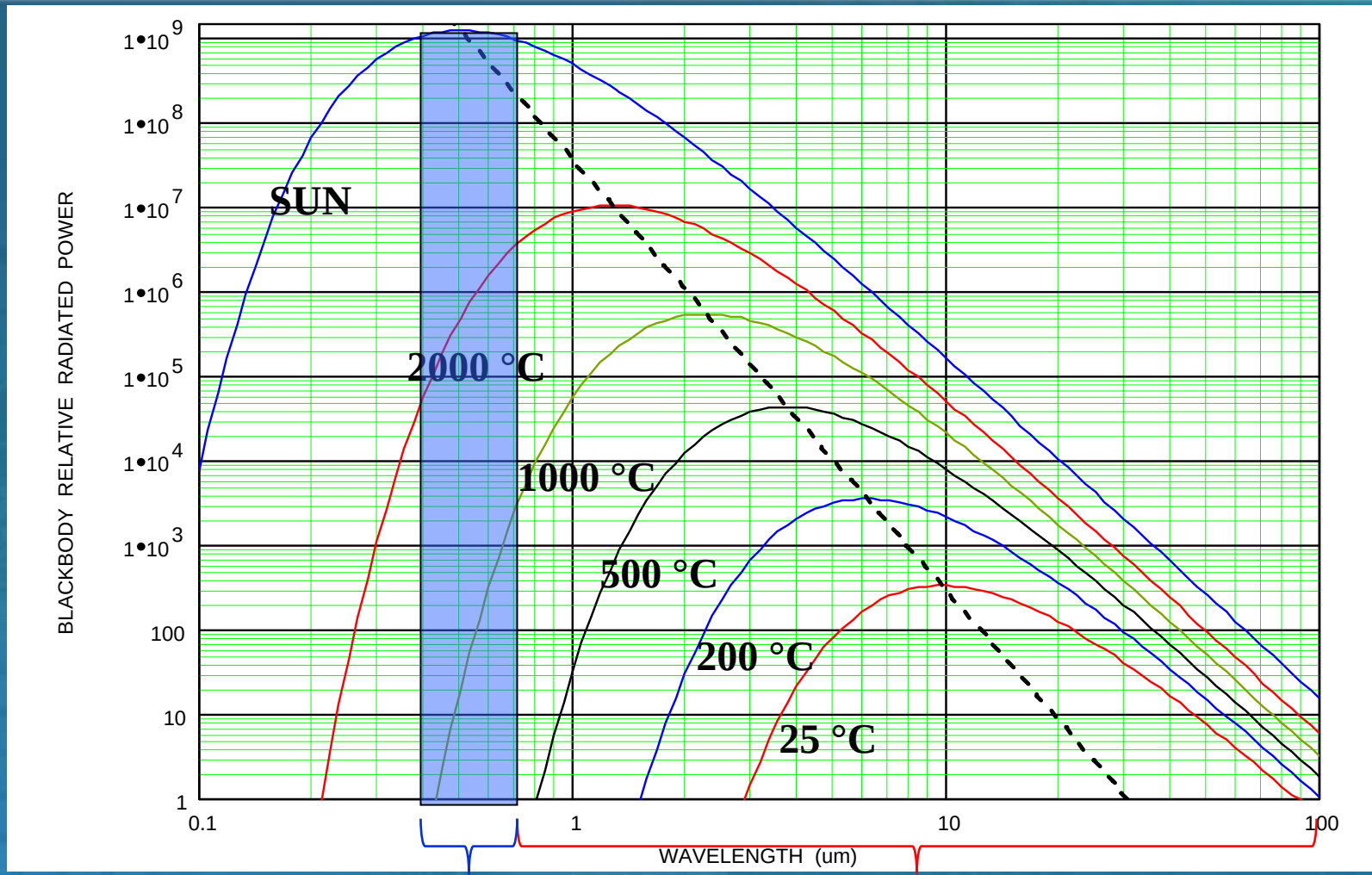
0.7 to 14 μm

8 to 14 μm

Electromagnetic Spectrum

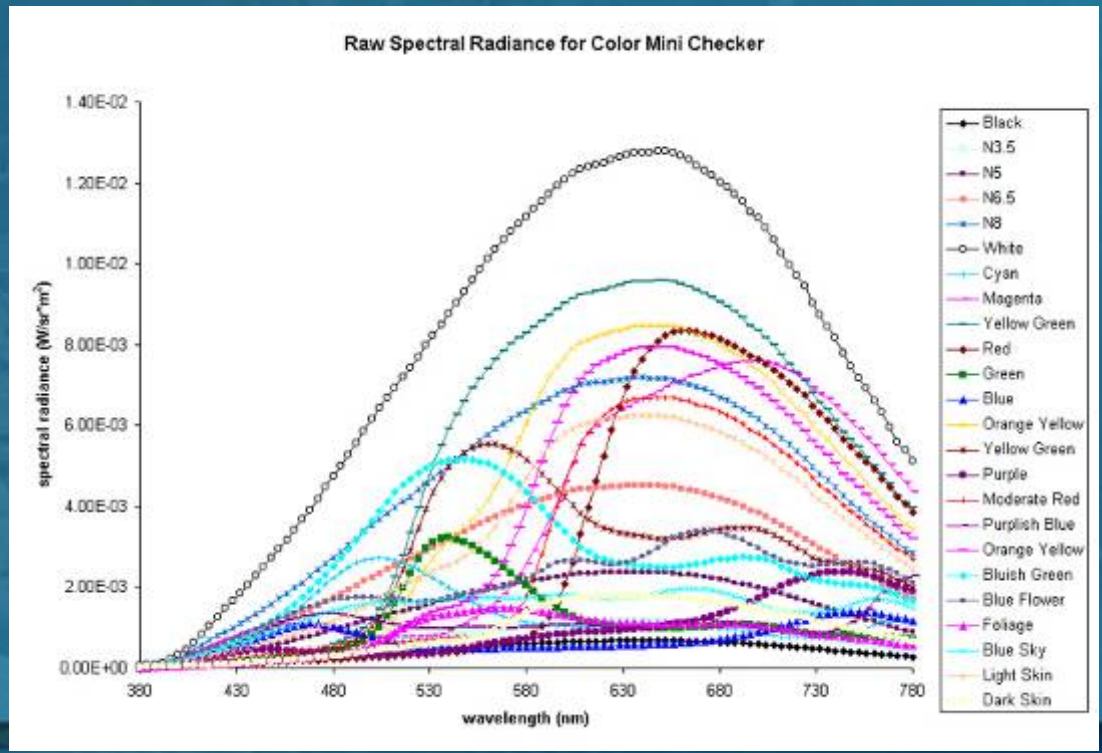


Radiated Power &Temperature

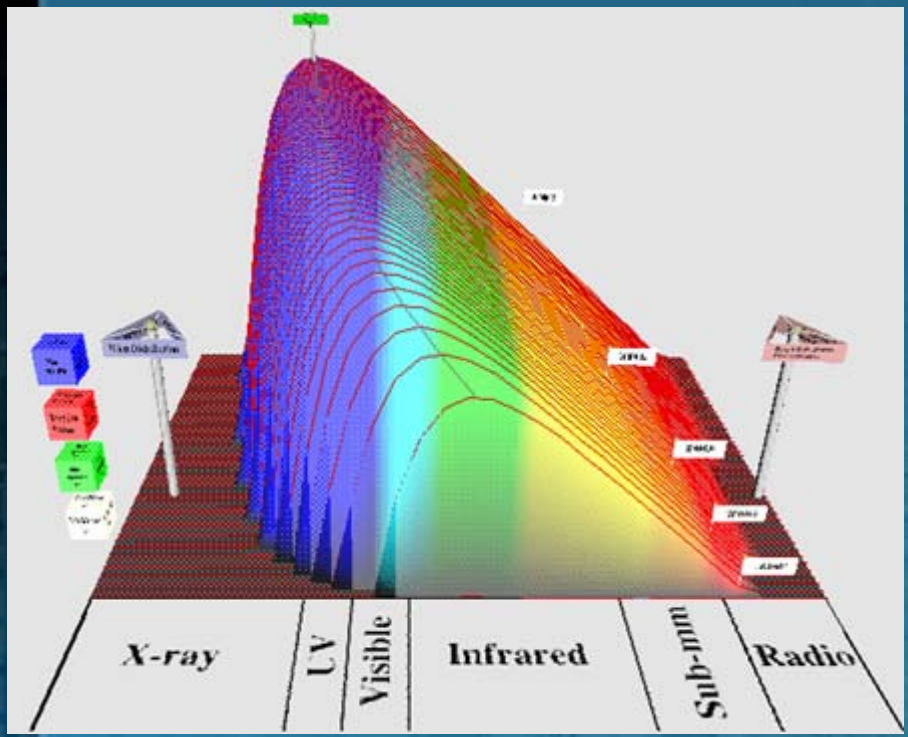


Spectral Radiance

- “Optical brightness” = “spectral radiance” = “energy level”
- Varies with temperature and wavelength
- Independent of distance and surface size
- Every object is unique
- Depends on emissivity



Emissivity



- Ratio of spectral radiance of a real surface to that of an ideal surface
- Example
  - Perfect emitting body: 10,000W/m^2
  - Real surface: 9,500 W/m^2
  - Emissivity = 0.95
- Blackbodies absorb light
- Objects at equilibrium absorb and emit at the same rate

Kirchoff's Law

- Of energy received, %Emitted + %Transmitted + %Reflected = 100%
- Transmission assumed (and usually is) 0 at the wavelength of interest
- Example

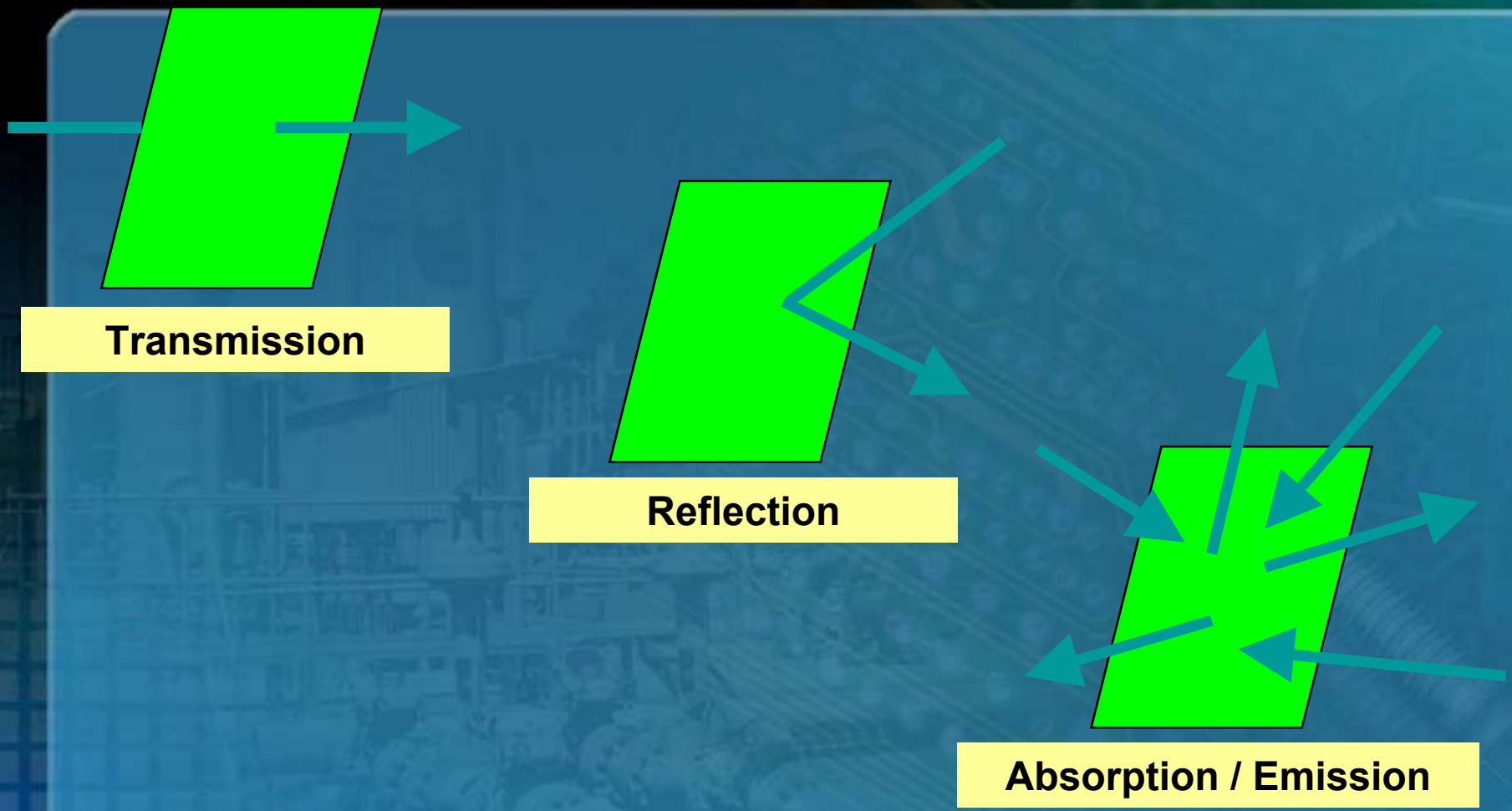
  If emissivity = 0.95 then 5% of ambient energy is not absorbed and emitted – rather, it is reflected.
- Troublesome conditions:

  Low emissivity (low signal-to-noise)

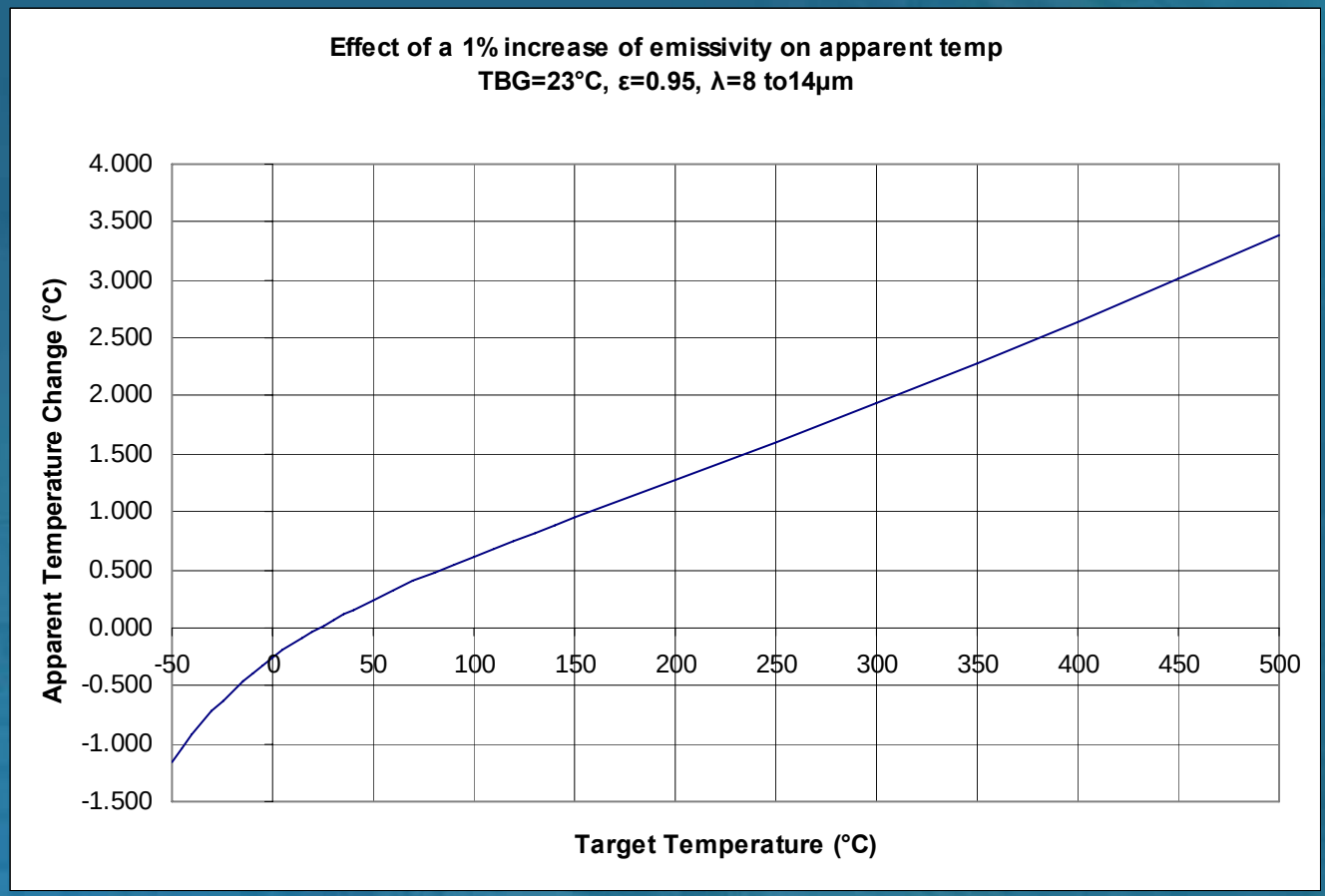
  Very cold temperatures

  Much hotter emitter nearby

Energy Received Goes…

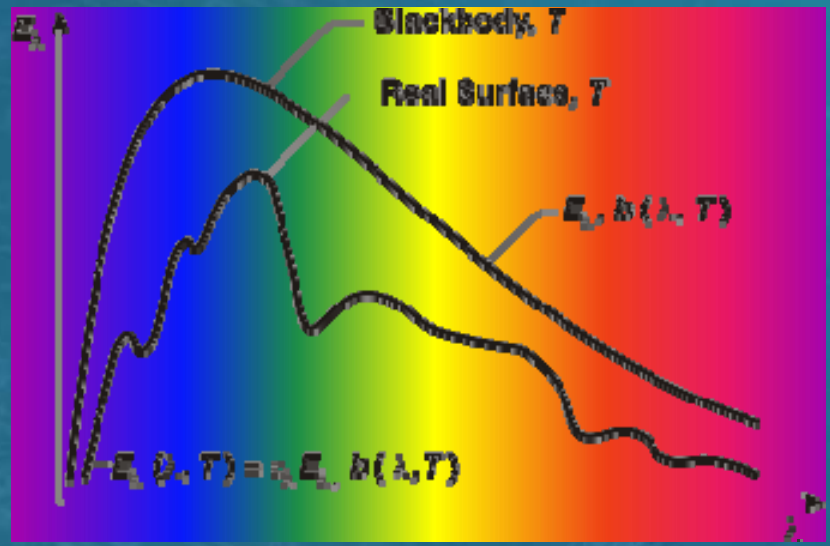


Emissivity / Apparent Temperature



Wavelength Dependence

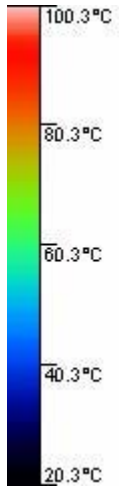
- Temperature calculations depend on emissivity
- Emissivity depends on wavelength, so emissivity must be determined at a specific wavelength
- To be useful, a calibrator must be calibrated at a documented wavelength
- Theoretical blackbodies and graybodies have constant emissivity
- Non-graybodies do not



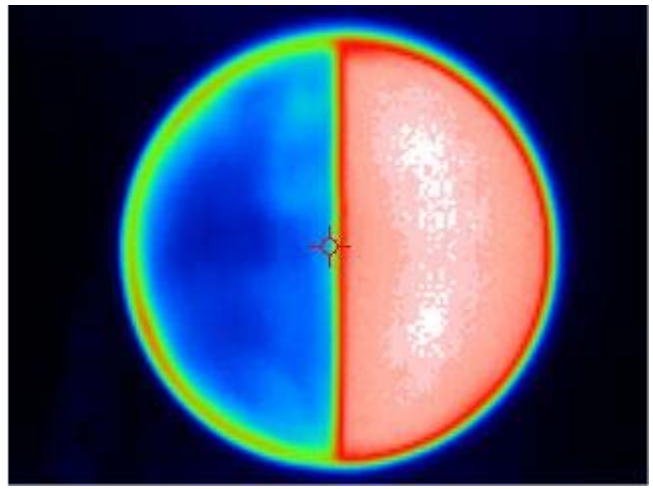
Emissivity Matters

Left Side: Bare Metal (ε=0.2)

Right Side: Painted (ε=0.95)



Why does one side look colder?



Answer: Emissivity (ε)

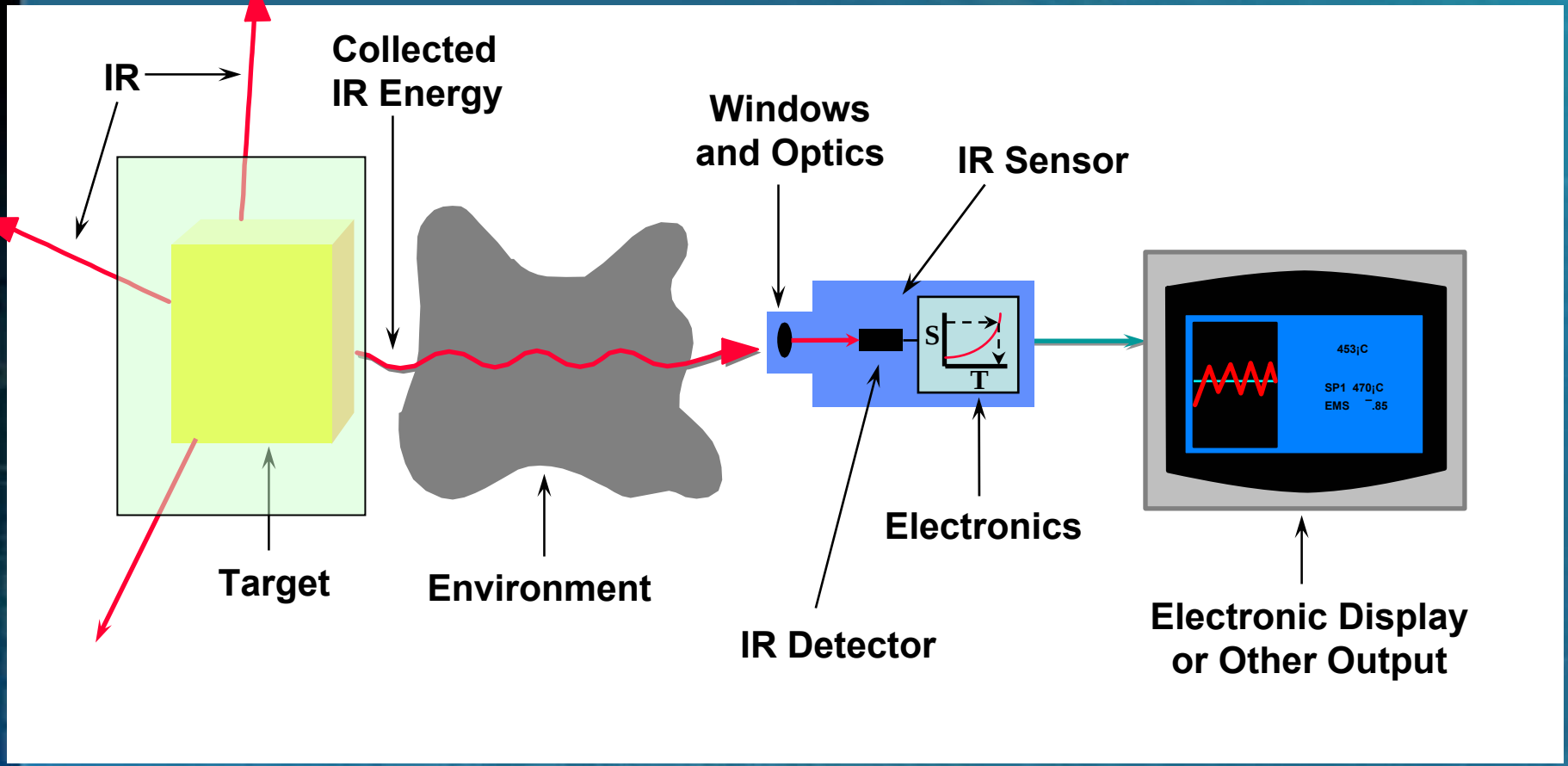
IR Thermometer Accuracy

- Historically difficult to make accurate measurements
- Historically good for high temperatures, difficult-to-reach objects, sterile objects, moving objects, and diagnostics
- Improvements important to
  - Medicine
  - Food storage
  - Process control
  - Preventive maintenance

Infrared Thermometers are Special

- Good news: based on laws of thermodynamics
- Remember, this is for non-contact thermometers! - The surface of the object is the sensor!

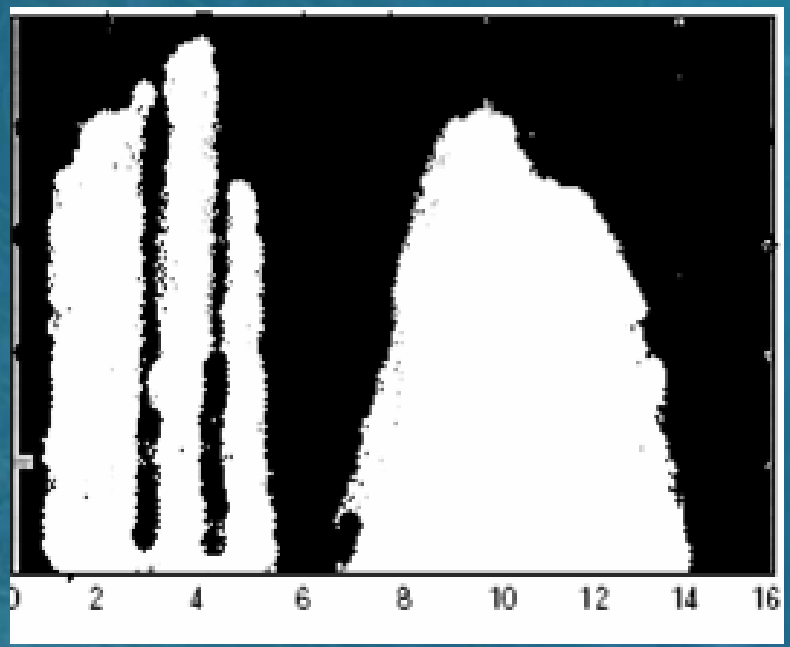
IR Radiation From the Target



Transmission Through Air

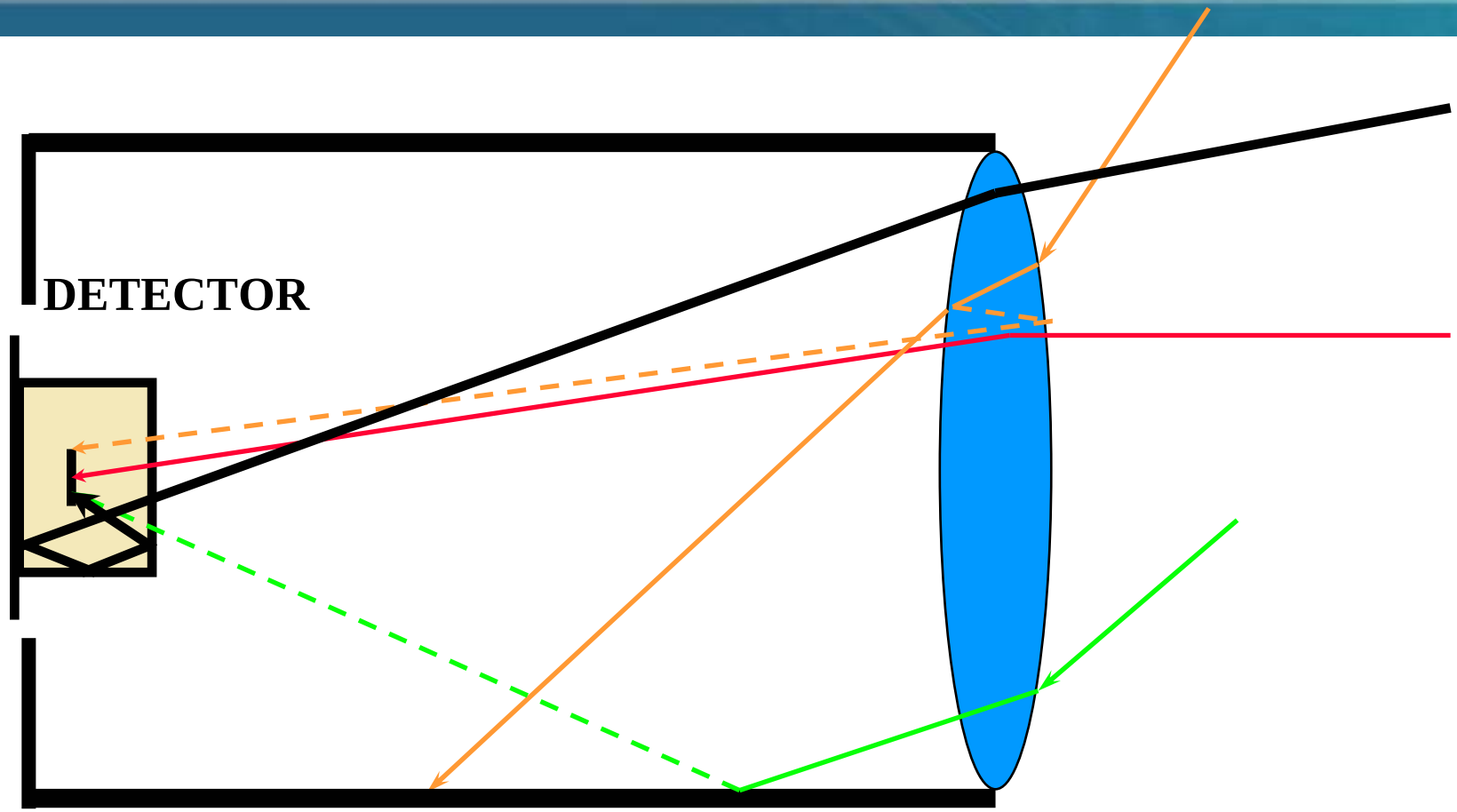
- Air between the object and the detector is a problem
- Transparency depends on wavelength
- Water vapor and carbon dioxide absorb radiated energy
- Scatter from dust and dirt
- Unwanted radiation from warm particulates
- Reflection of light from warm bodies nearby
- 8-14 a fair solution, but distance matters

Transmission by wavelength



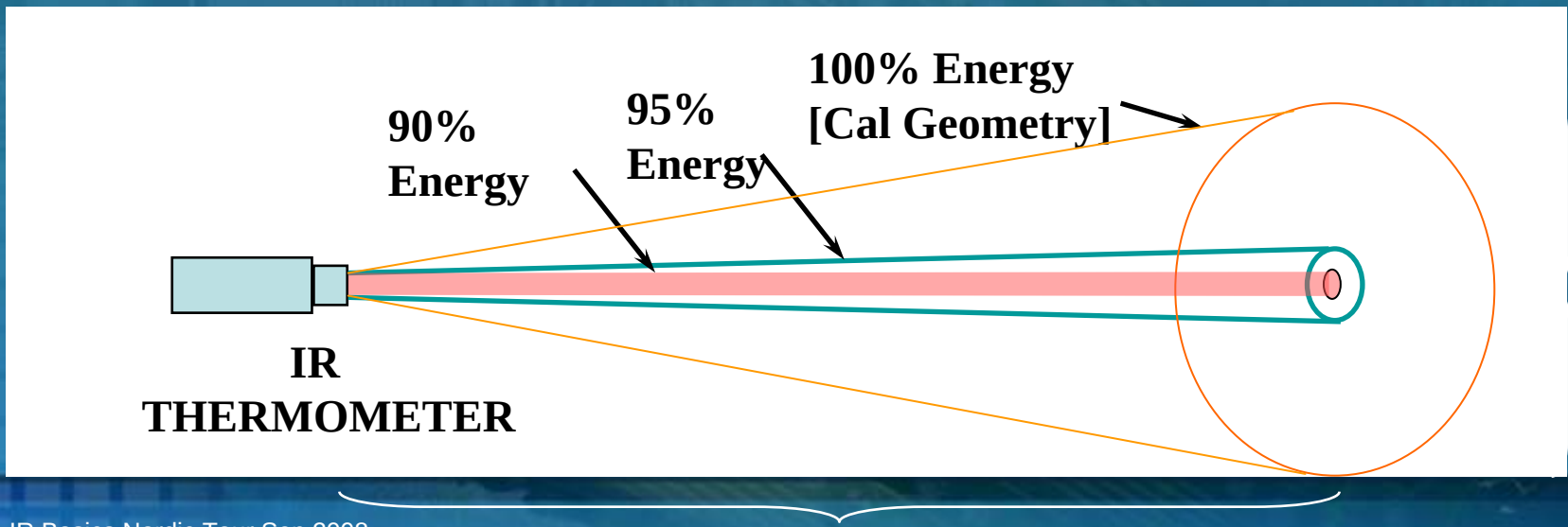
Wavelength in micrometers

Optical Scatter



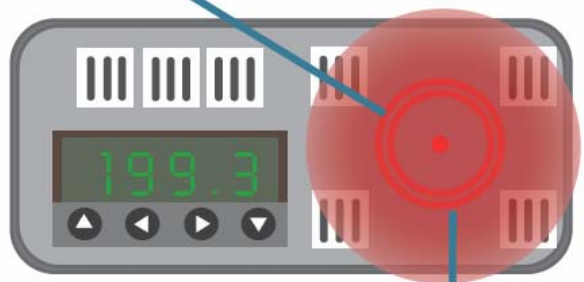
Calibration Geometry

- Laser guides misleading?
- Field of view is a cone, so spot grows with distance
- Distance-to-spot ratio
- Fuzzy spot, peripheral vision, scatter



Size of Source Has an Effect

Scatter in this thermometer causes cold/inconsistent temperature readings on ***smaller*** surfaces

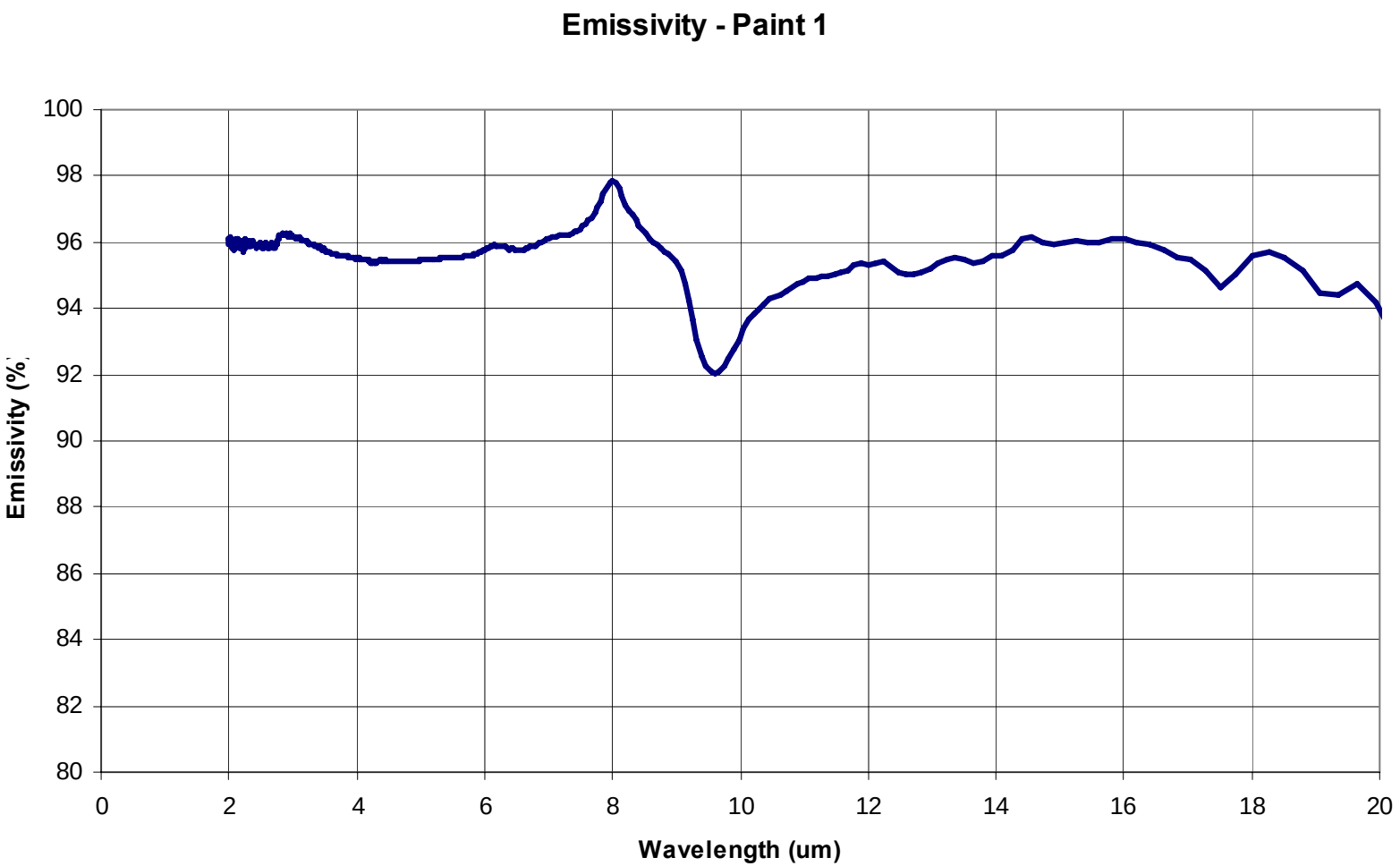


= IR thermometer field of view

Practical Graybody Calibrators

- Typically (always until now!) contact calibration with PRT or TC
- Calibrating internal control probe and not the surface
- Thermal losses at the surface should be corrected for
- Emissivity should be accounted for
- Remember… Knowing the emissivity of the source is critical

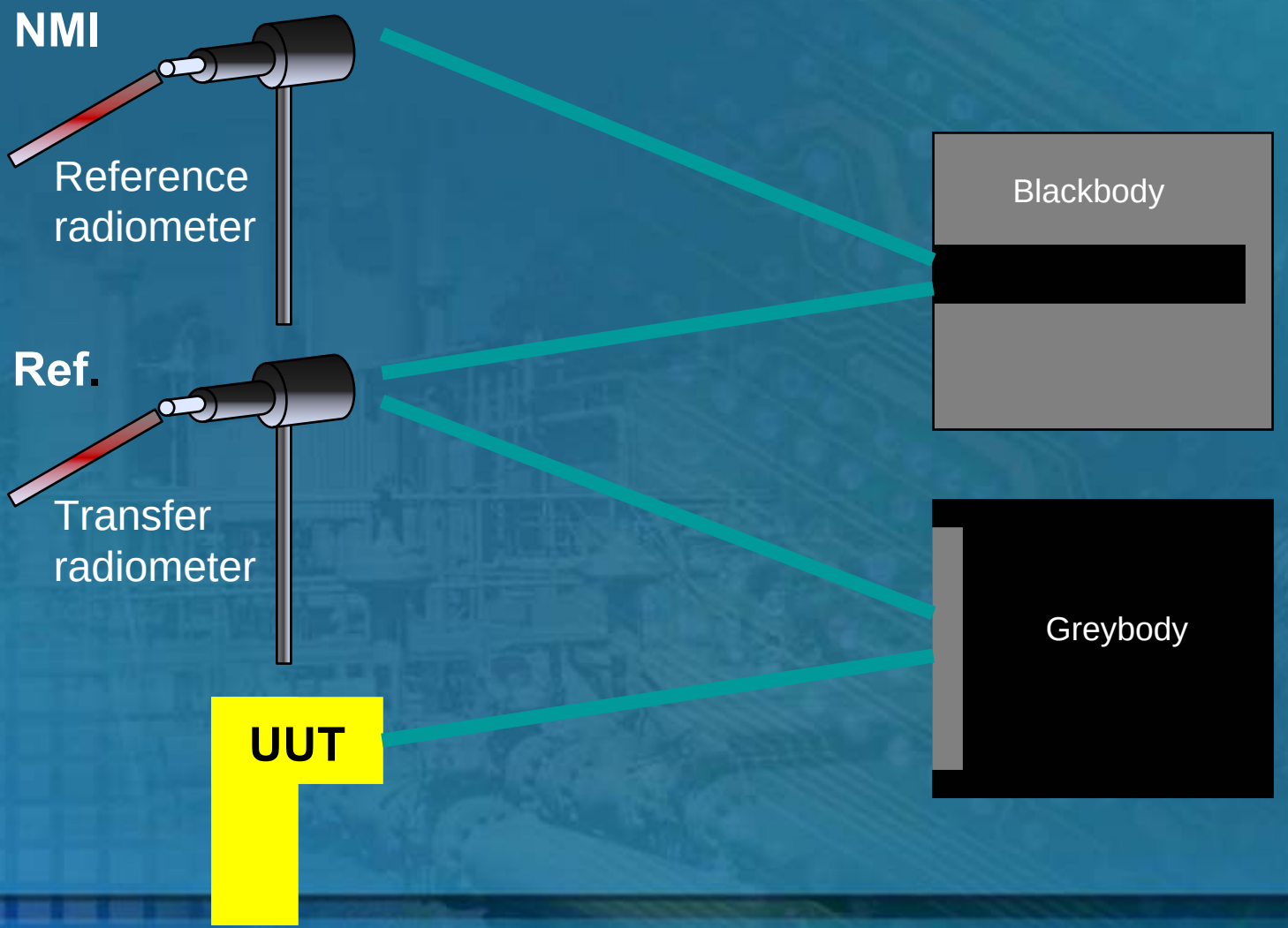
Radiometric 1



A Better Way: Include the Sensor!

- Radiometric calibration
  - Reference pyrometer
    - Calibrated with blackbodies near E = 1.00
  - Account for emissivity, wavelength, and surface temperature in the…
    - calibration of the reference
    - calibration of the source
    - calibrations done by the source
  - More accurate than contact cal for non-contact calibrator
  - Targets calibrated with traceable reference IRTs provide traceable calibrations – targets calibrated through contact or surface sensors do not!

IR Traceability



Radiometric Calibration = Traceable Calibration

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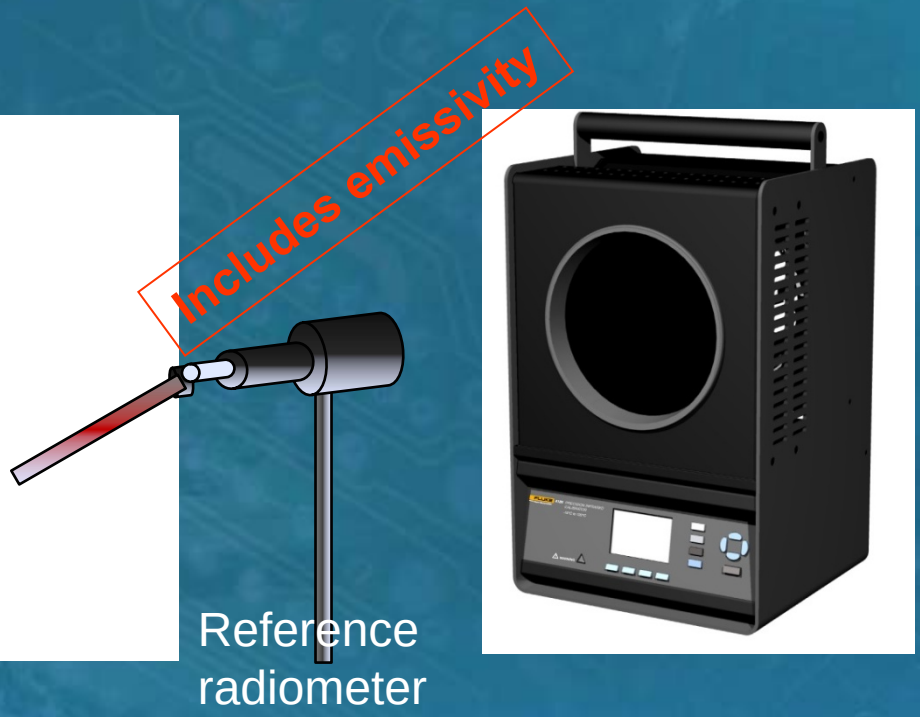
Hart Scientific

Contact Calibration

Radiometric Calibration



Summary

- Surface is the sensor – emissivity must be understood and accounted for
- Field of view not what it appears to be – and manufacturers know it. Size matters!
- Calibration geometry matters.
- Contact thermometers don’t make for traceable non-contact thermometer calibrations

Ideal Source for IR Thermometer Calibration

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- Two products
  - 4180: -15°C to 120°C
  - 4181: 35°C to 500°C
- High accuracy based on apparent temperature:
  - 4180: ±0.25°C to ±0.55°C
  - 4181: ±0.30°C to ±1.50°C
- Target size of 15 cm (6 inches)
- Variable emissivity from of 0.9 to 1.0
- Fully accredited radiometric calibration

New! 418X

Features and Benefits

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Features	Benefits
Six inch (152 mm) Target Size	Accuracy and consistency (size-of-source effect), Also correct size for thermal imager calibration
Radiometric Calibration (accredited)	Accuracy, consistency, traceability,
Stable and uniform target	Calibration accuracy and consistency
Compensation for thermometer emissivity setting	Easy to use (eliminates difficult mathematics), Simplifies variable emissivity calibration, Solves critical traceability issue
Stability icon and alarm	Visually and audibly indicates when ready for measurement

Easy to use display

- See key data such as the temperature, emissivity settings, and graphic stability indicator on the main display
- Easy to navigate menu driven interface

Emissivity compensation

- Thermometer emissivity settings cause errors if they don’t match the target
- Emissivity-related corrections can be performed automatically by these new calibrators

Unique target cover

- Prevents frost from affecting target emissivity
- Optionally use with dry-air or nitrogen for improved results

Questions?