Escola Universitària Politècnica de Mataró. EUPMT

THERMAL IMAGING

Virginia Espinosa Duró

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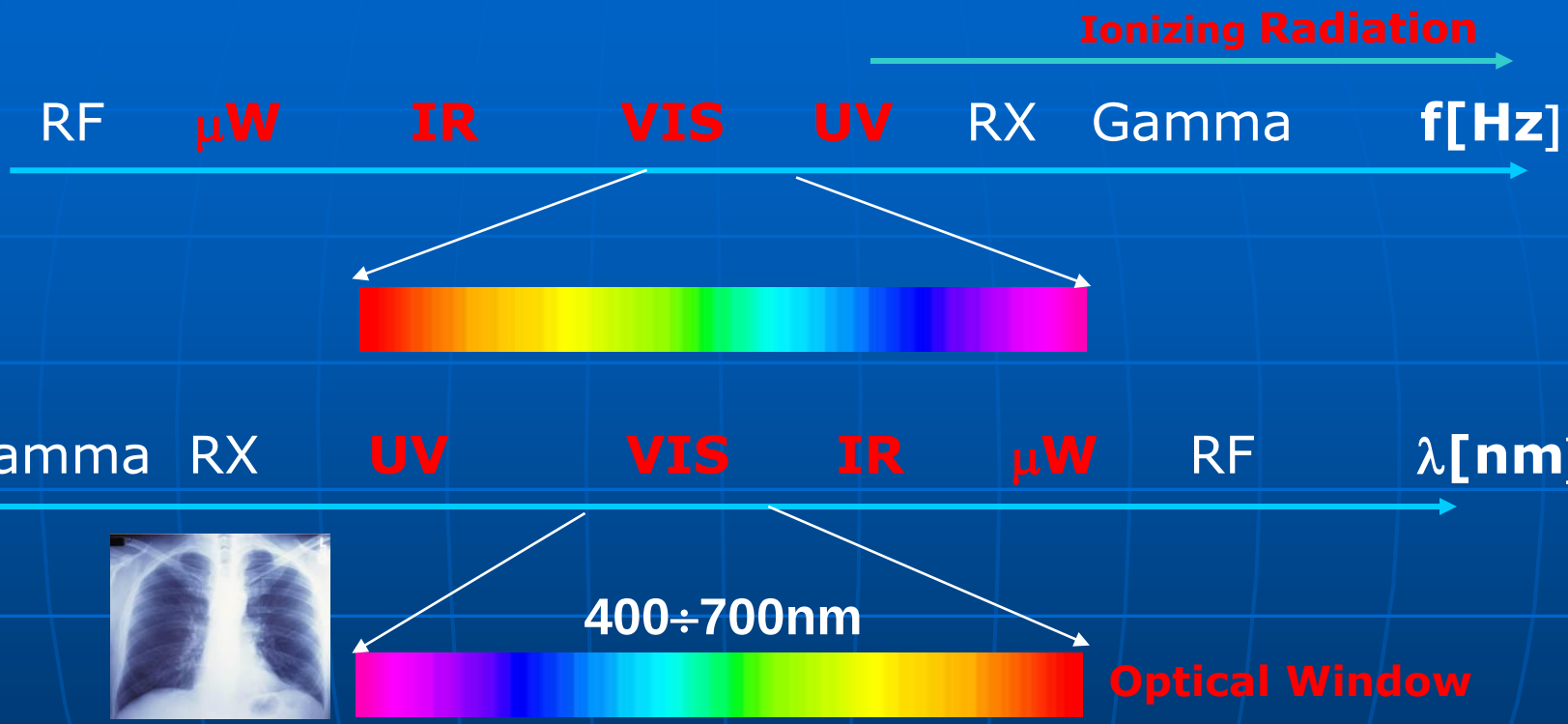
Brno University of Technology. Czech Republic.

Outline

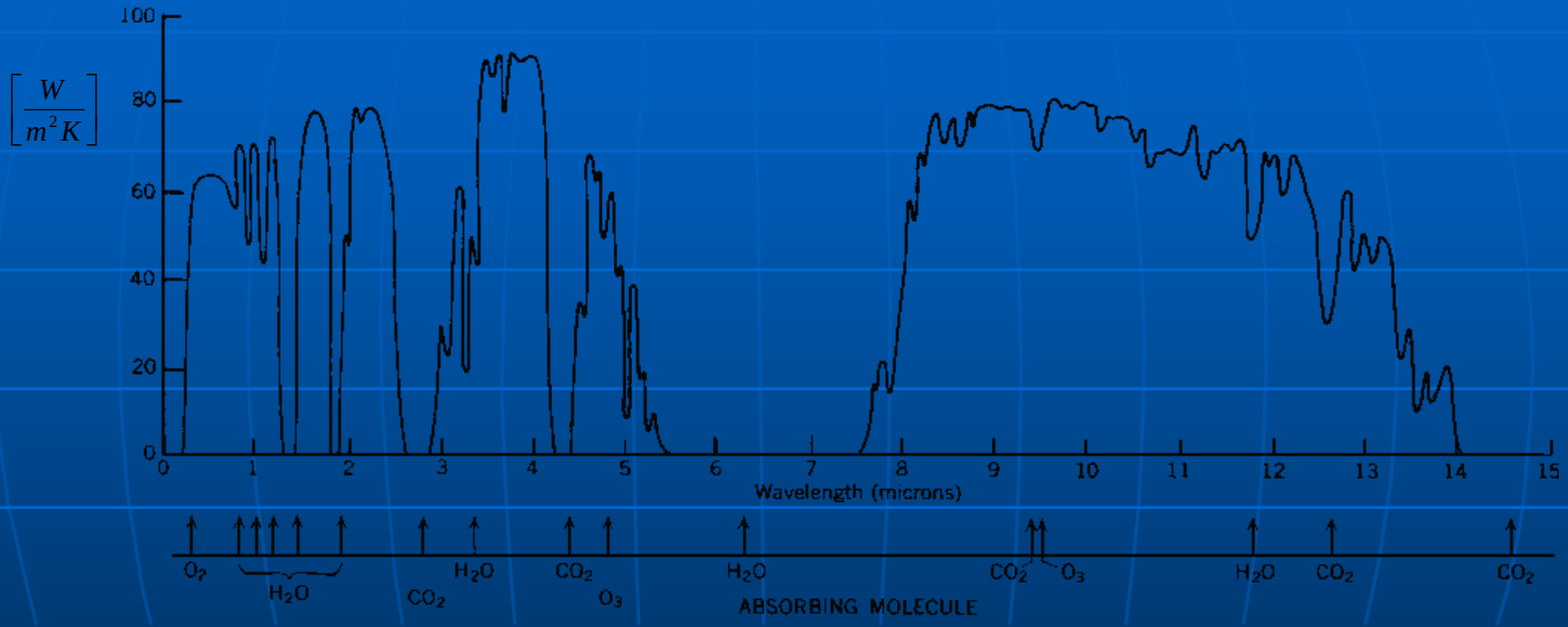
- Introduction
- IR Detection.
- Thermal Imaging Cameras.
- Examples
- Applications

EM Spectrum



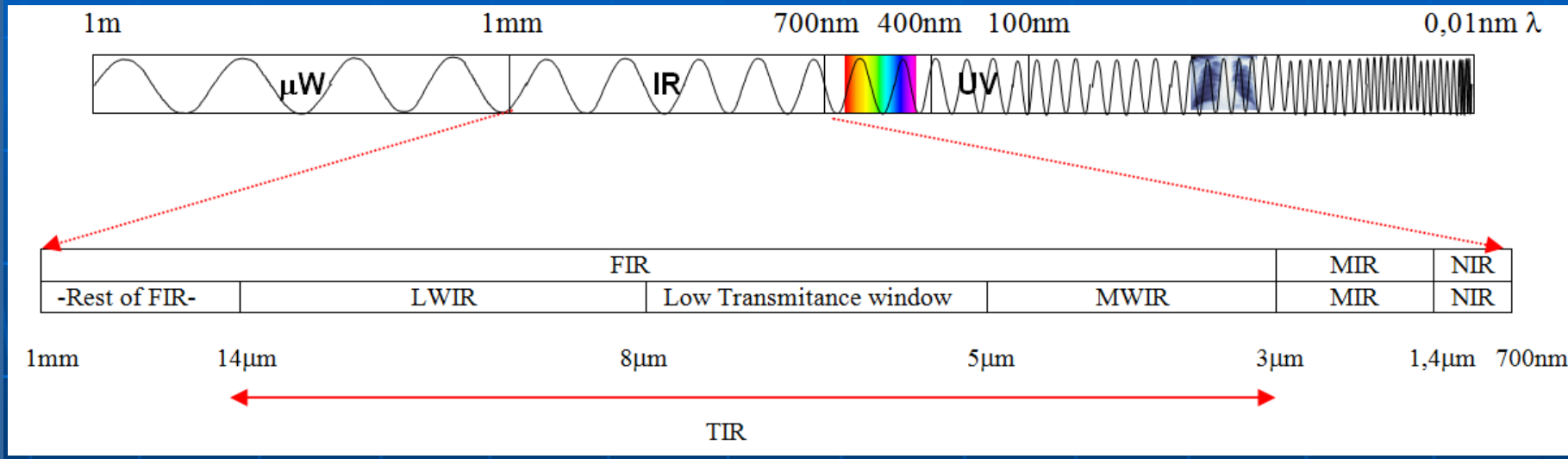
- While optical window comprises a narrow portion of the spectrum, IR spectrum comprise a broad range from 700nm to 1mm, being a large region of EM waves.

ATMOSPHERIC TRANSMITANCE in the region of the IR spectrum



- The remaining portions of The IR spectrum are called *Atmospheric Transmission Windows*, and allow define the infrared channels that are usable at technologic level.

IR BANDS



Recommended division by **CIE (Commission Internationale de l'Éclairage;** International Commission on Illumination).

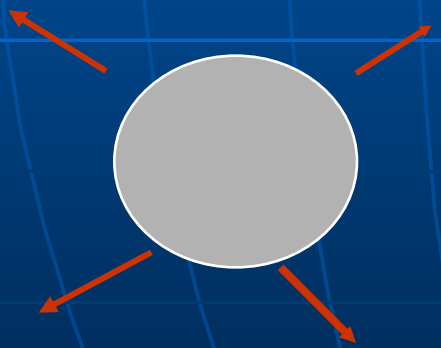
Stefan- Boltzmann Law

- **BOLTZMANN:**

  Any body who has a T> 0 K (absolute zero) emits EM radiation (Basically IRR).

- Total Radiation:

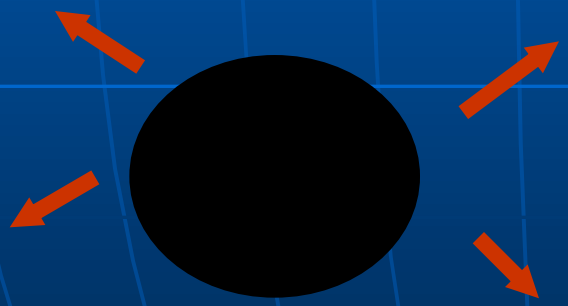
$$W = \sigma \varepsilon T^4$$



- W: Emitted Radiation **[W/cm²]**
- σ: Boltzmann Ct: $5{,}67.10^{-12}$ W/cm^2K^{-4}
- ε: Emissivity $[0<\varepsilon<1]$;
- T: Temperature [K]

BLACK BODY

- Màximum Emissivity $\varepsilon=1$.
- It no reflects nor transmits radiation, and 100% of incident radiation is absorbed.
- In the real world there are no objects that are perfect absorbers, reflectors, or transmitters, although some may come very close to one of these properties.

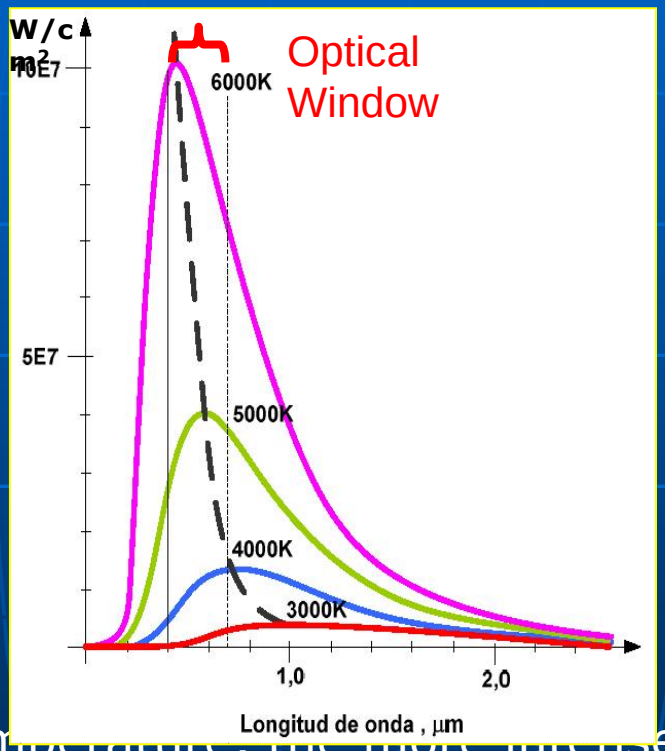


$$W=\sigma T^4$$

- W: Emitted Radiation
- σ: Boltzmann Ct.
- T: Temperature [K]

PLANK'S LAW: the *spectral radiant emittance* of the blackbody.

- These curves show the radiation per λ unit and area unit.

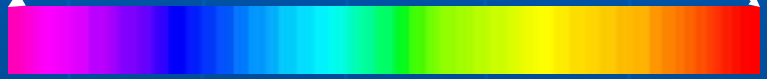


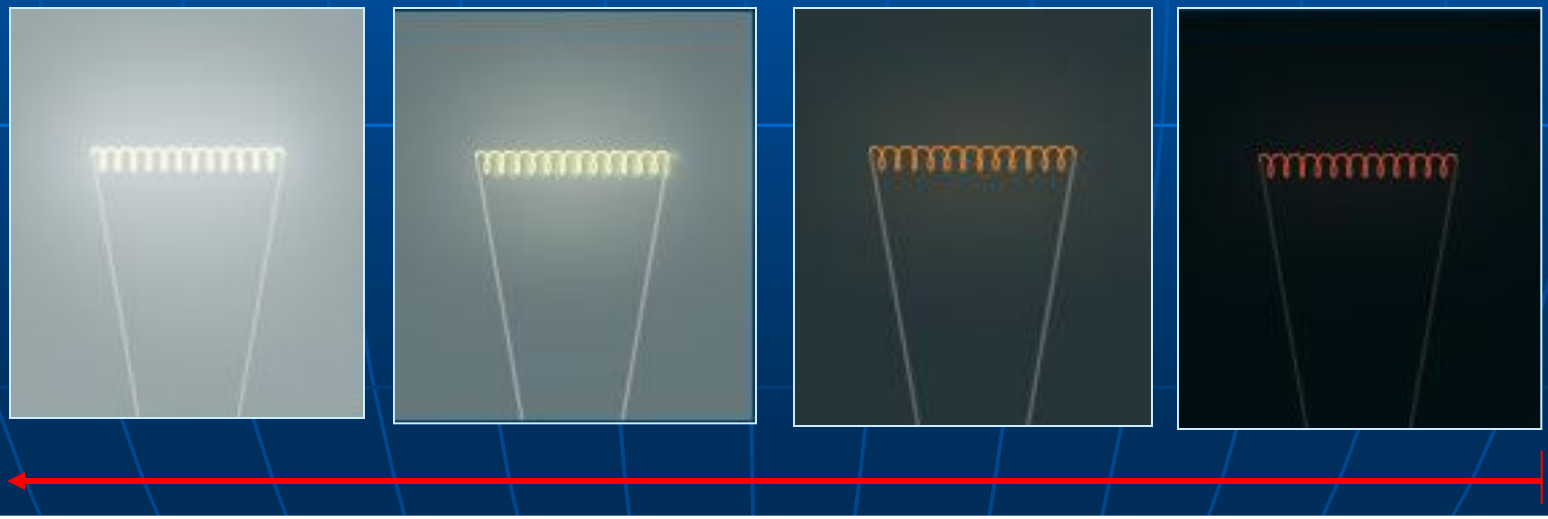
- The higher the temperature, the more intense the emitted radiation.

The Ligth Bulb: A clear example

Gamma RX UV VIS IR μW RF λ

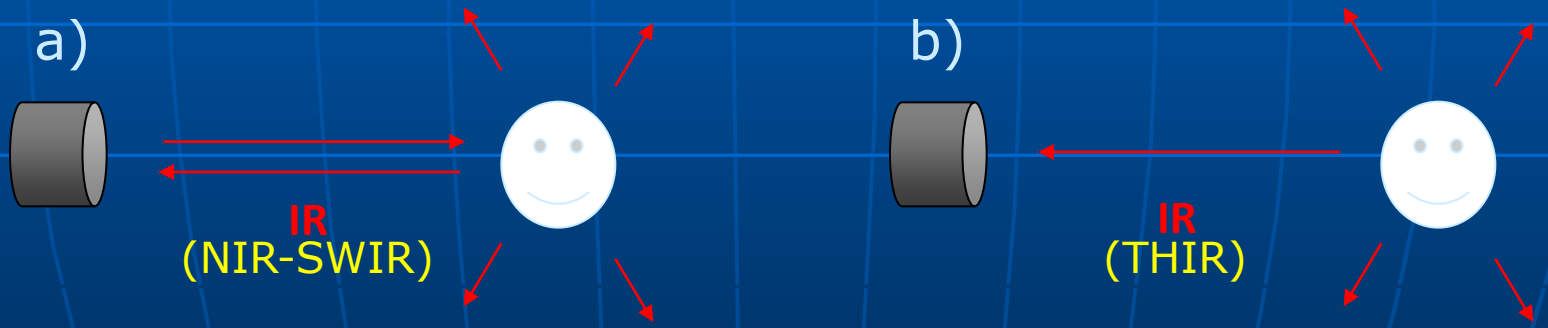
400÷700nm





Approaches for IR Detection: Active & Passive IR Detection Units

- The existing approaches for IR detection may be classified into two categories:
  - **a) ACTIVE DETECTORS**
  - **b) PASSIVE DETECTORS**



Active IR sensors generate a multiple **beam** pattern of modulated IR Energy and react to a change in the modulation of the f, or an interruption in the received E.

Passive IR sensors detect EM radiated energy generated by external sources, particularly the thermal energy emitted by people in the THIR range.

a) Cameres provided with Active Sensors (NIR-SWIR)

- High performance NIR-SWIR camera
- Requirements: Lighting system.

Same scene taken with Visible and SWIR camera.

Passive IR Sensors

- **b1) THERMAL SENSORS:**
  - They respond to radiant energy in a way that causes a change of state in the bulk material.
  - **Indirect Parameters** for measuring:
    - **R / V**
    - **Expansion/Contraccion**
    - **Change The state (solid, liquid…)**
    - **Químical Changes**
    - **Biologic Response**
    - **….**
  - **TYPES OF SENSORS: Pirometers, Bolometers, Termistors,…**
- **b2) QUANTUM SENSORS**

  They directly detect the Fotons Energy radiated by the objects.

b1) BOLOMETER

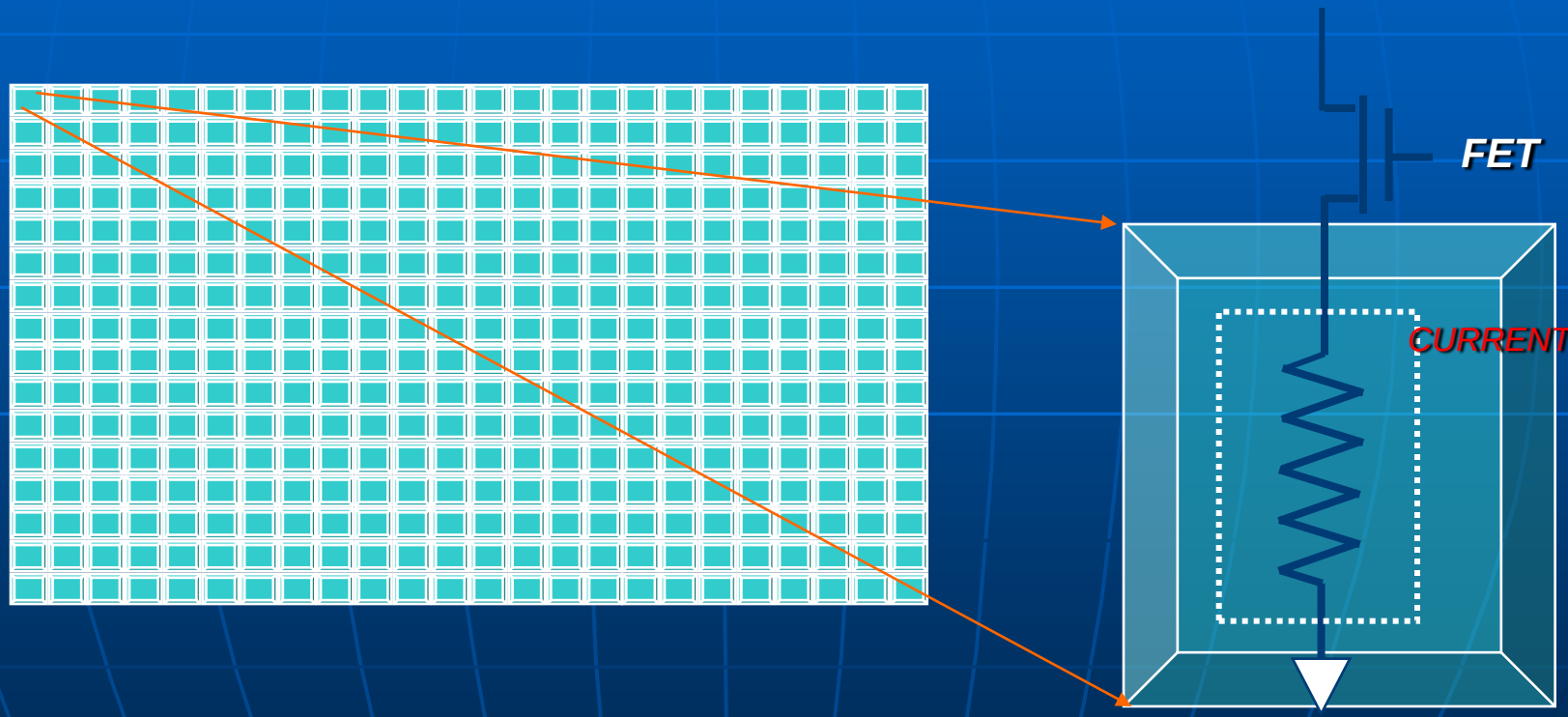
- **Bolometer: TERMORESISTENCE**
- **The Bolometer Effect:** Change of R who have experienced drivers for a change of temperature.

$$\Delta T \Rightarrow \Delta R$$

- **Advantage:** ⇑ Integration capacity ⇒ **Microbolometers**
- **Disadvantage:** ↓ **Speed response.**
- **Classification:**
  - **Uncooled Microbolometers**
  - **Cooled Microbolometers**

UFPA Sensor

- **UFPA:** Uncooled Focal Plane Array
  Bidimensional matrix of μbolometers.



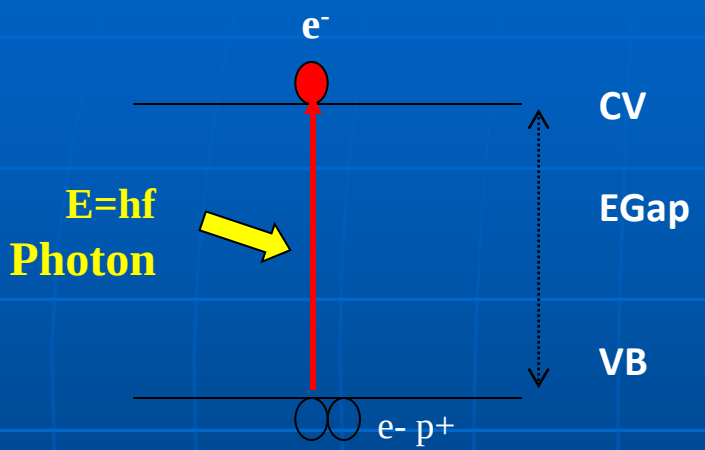
- LWIR Detection.

CFPA Sensor

- **CFPA:** Cooled Focal Plane Array:
  Bidimensional matrix of μbolometers
- The Sensor
- **Cryocooler:** *Device that lowers the sensor temperature even to cryogenic temperatures.*
  - [Liquid N] ; Crycooler
  - Peltier Cell ;
  - Stirling Cooler ; Crycooler

  This reduction in sensor temperature is necessary to reduce thermally-induced noise to a level below that of the signal from the scene being imaged.
- MWIR & LWIR Detection.

b2) Quantum Sensors

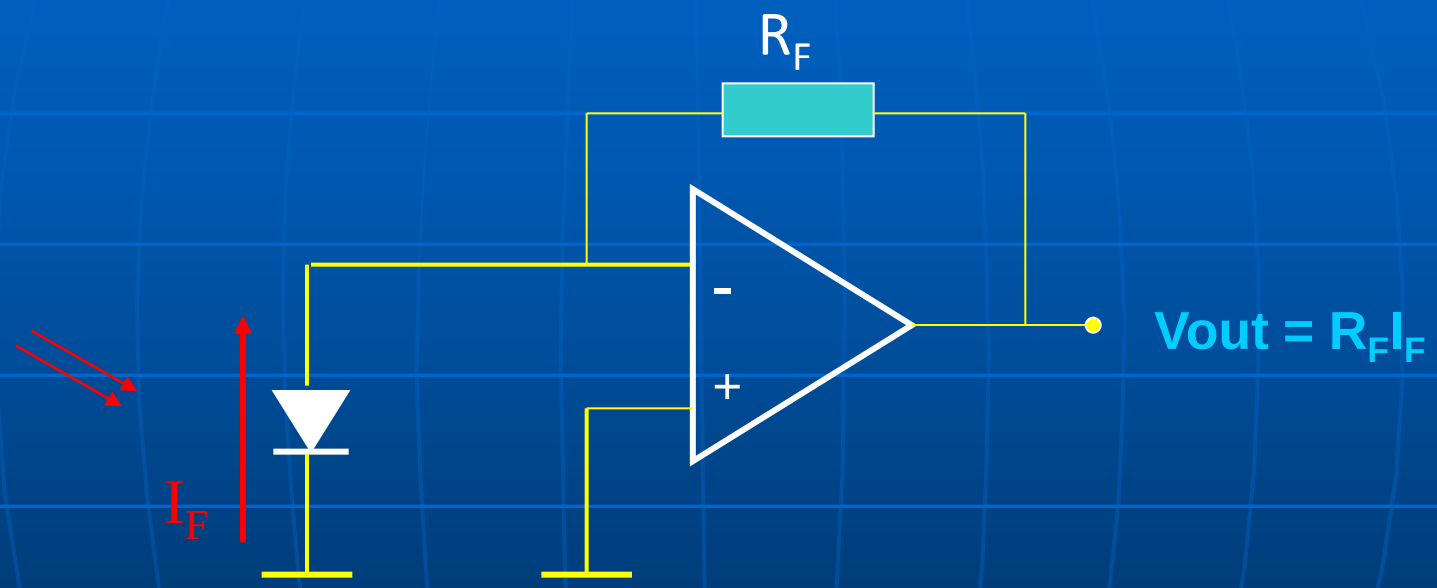


The operation of a quantum detector is based on the change of state of electrons in a crystal structure reacting to incident photons.

- Incident photons allow an electron to jump from the VB to the CB.
- This energy is related to a certain wavelength

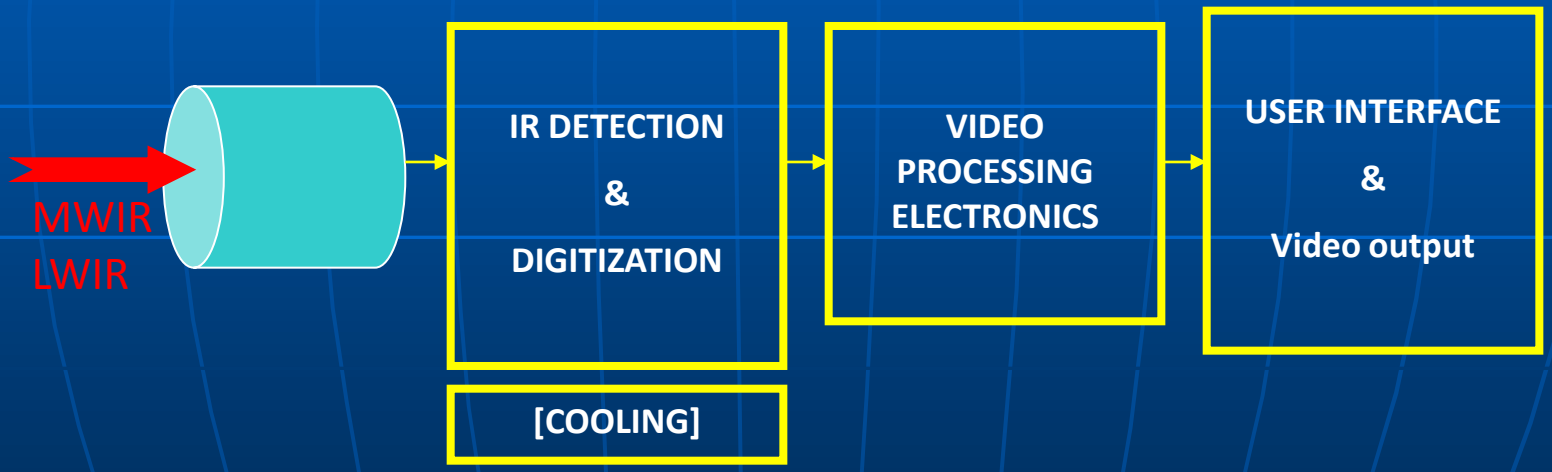
Materials: MCT (HgCdTe), InGasAs, InSb

Signal Conditioning

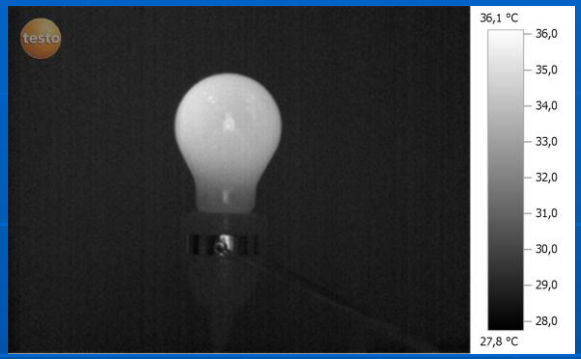


THERMAL IMAGING CAMERAS

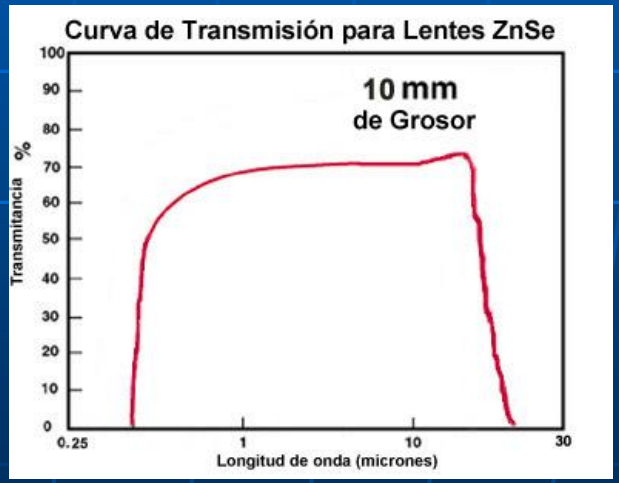
- Also called ***Thermal Imagers***



Special Optical Lens:

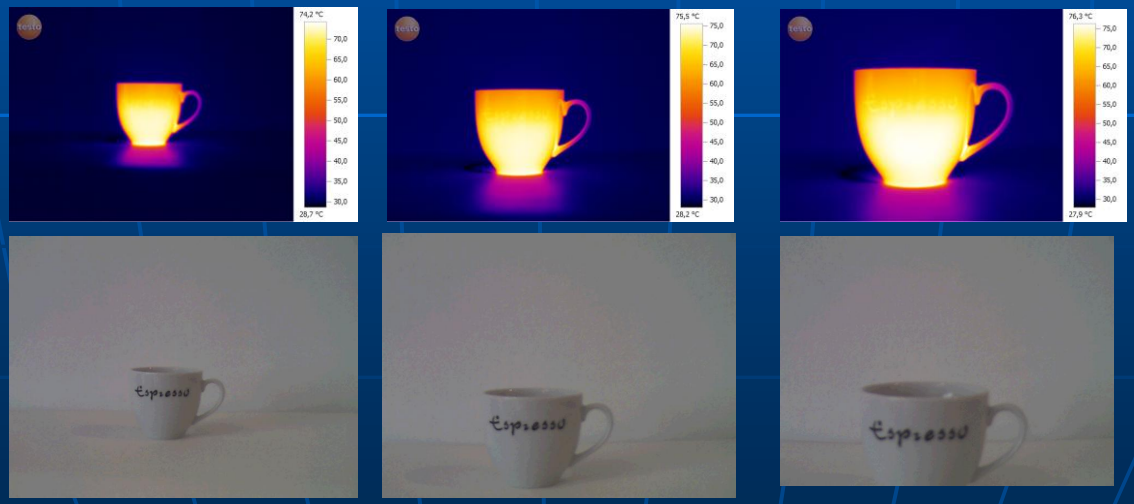


- Materials:
  - Si (SWIR)
  - Ge (LWIR)
  - ZnSe
  - and others.



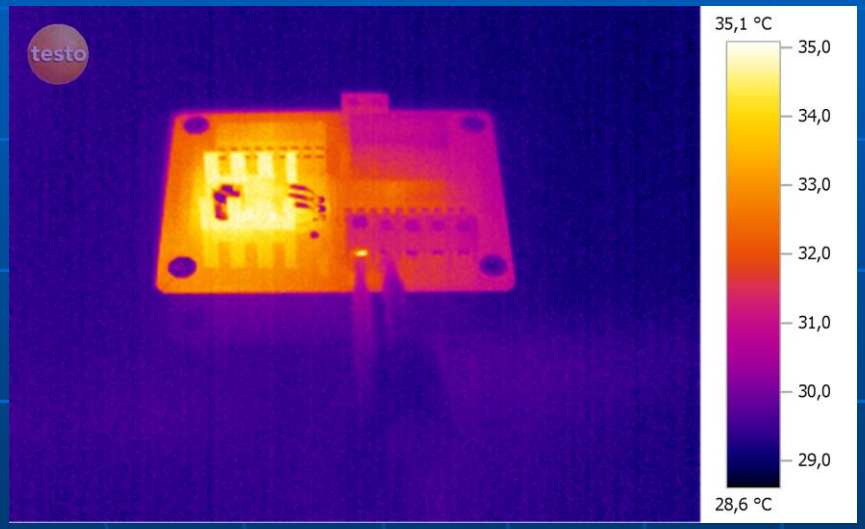
Viewing VIS & THIR SPECTRUM

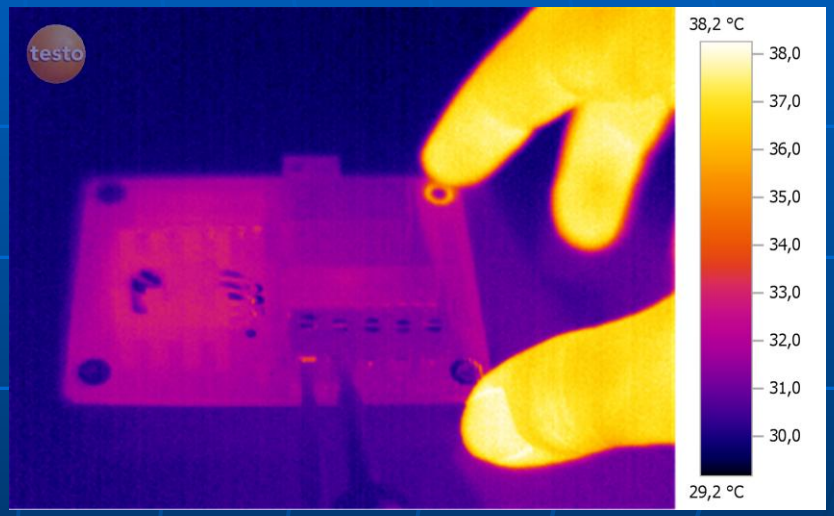
- Parallax Error in short distance (≠FOV)



Fusion

Autoscale

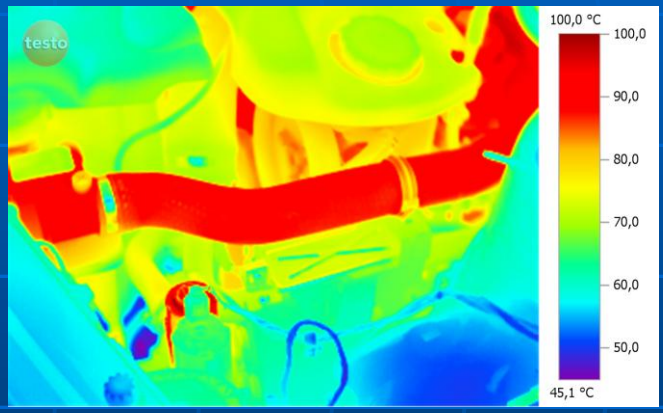




- Automatic range is function of the max and minimum temperatures of the scene.

Palettes

Iron Palette



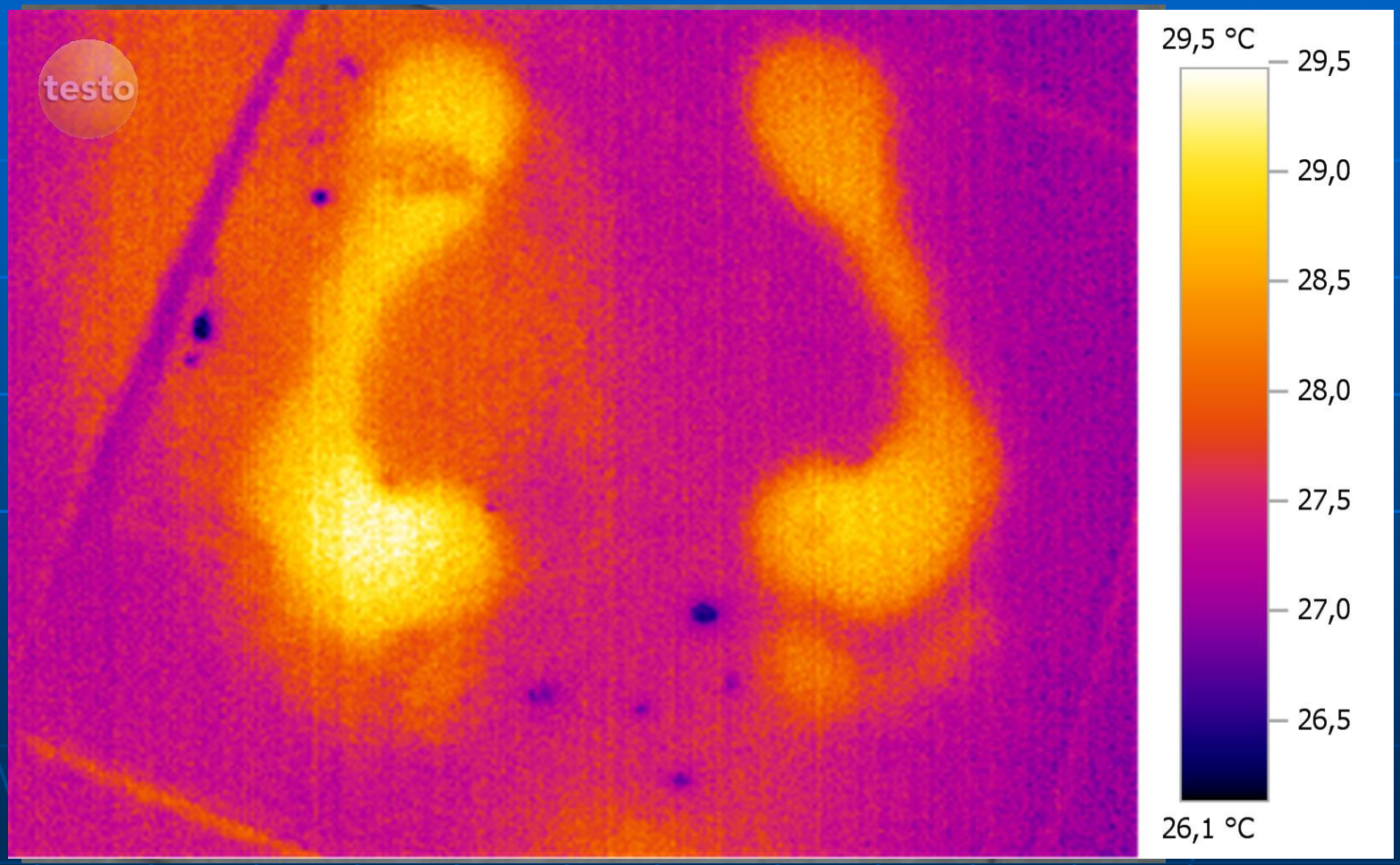
Rainbow Palette

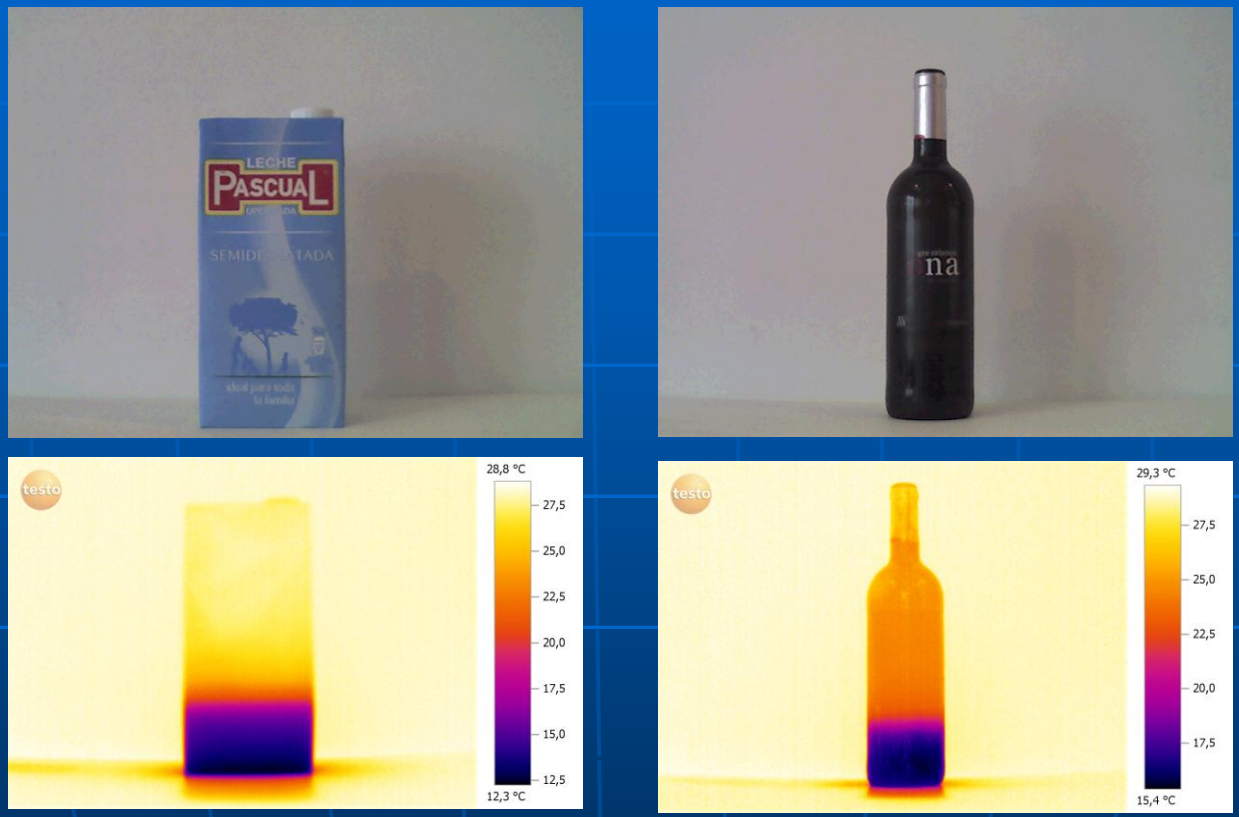
KEY FACTORS

- Wavelength response
- Sensitivity.
- Resolution

- Callenges:
  - Parallax Error
  - AF
  - Crycoolers with longer lifes.

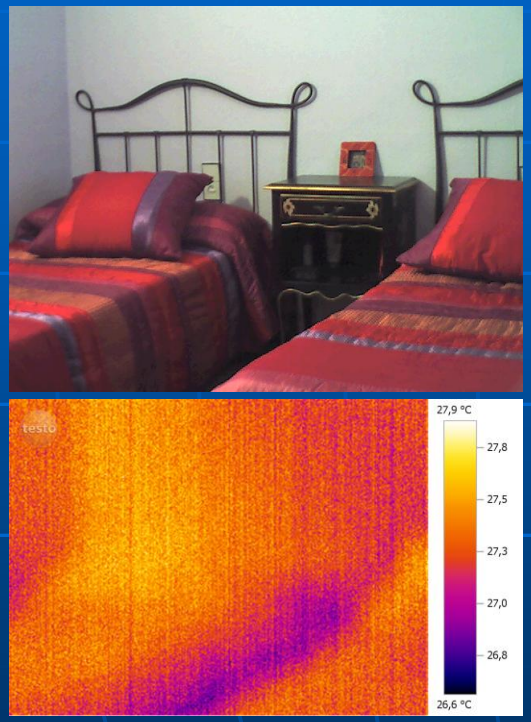
Thermal Imaging

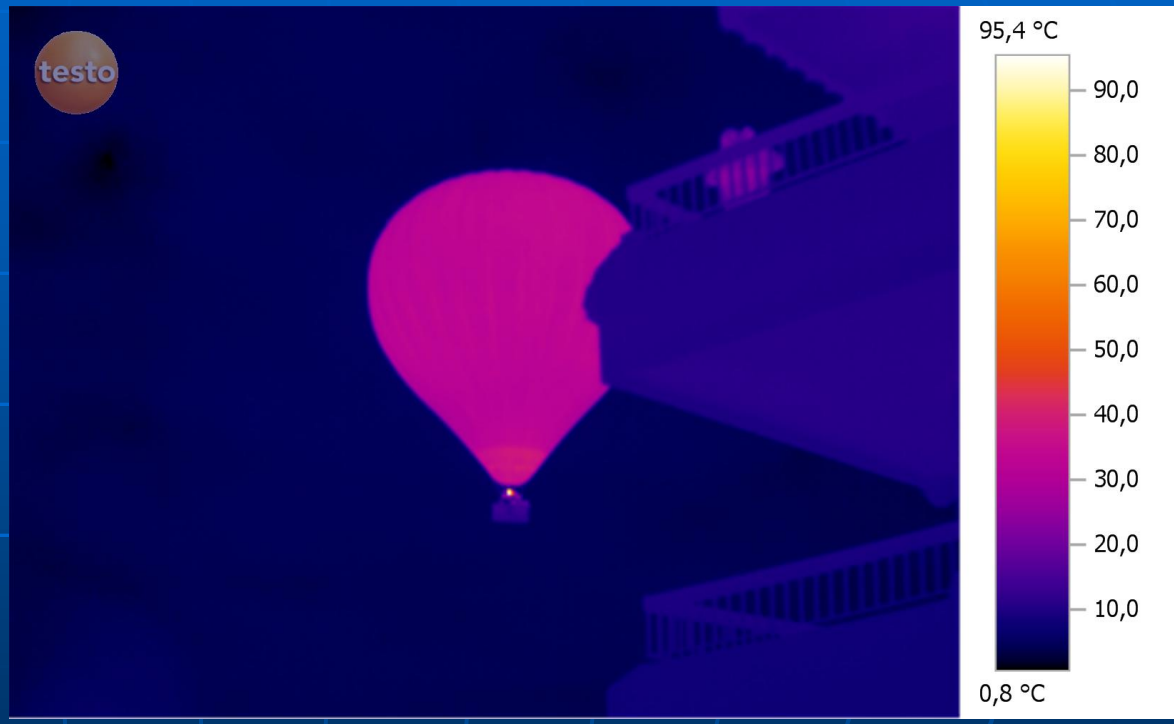




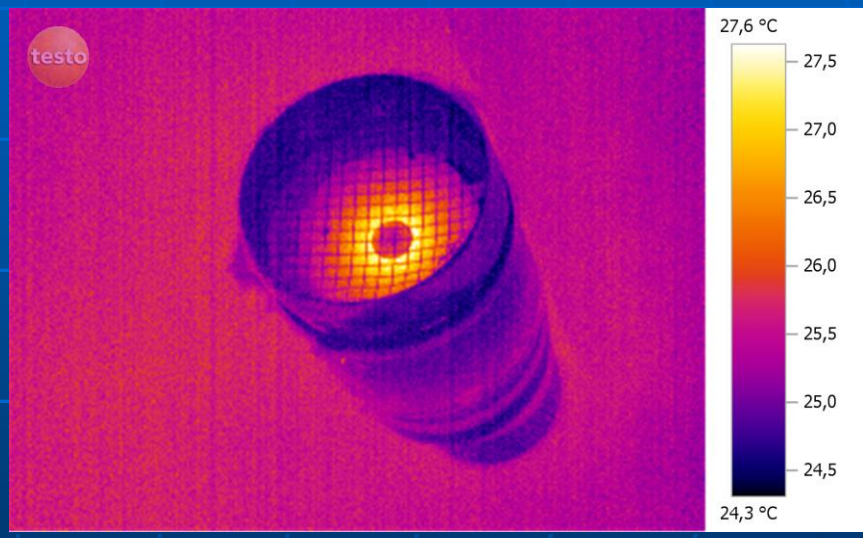
Nowadays, quality control methods to assert the right filled of different containers based on thermographic systems are being introduced in the industry.

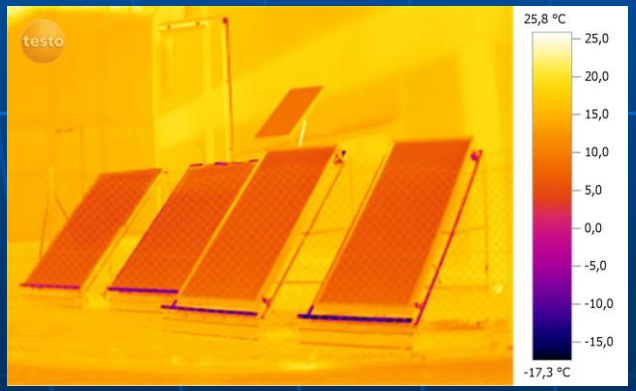
Contrast

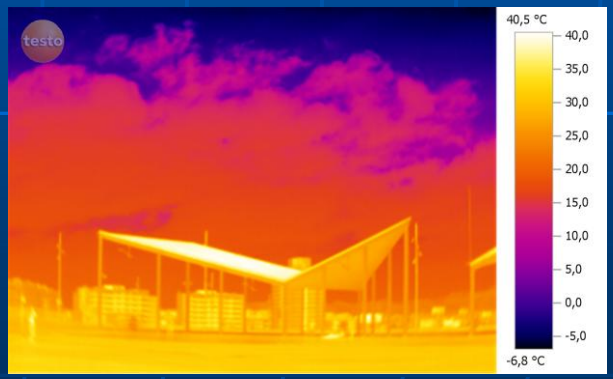




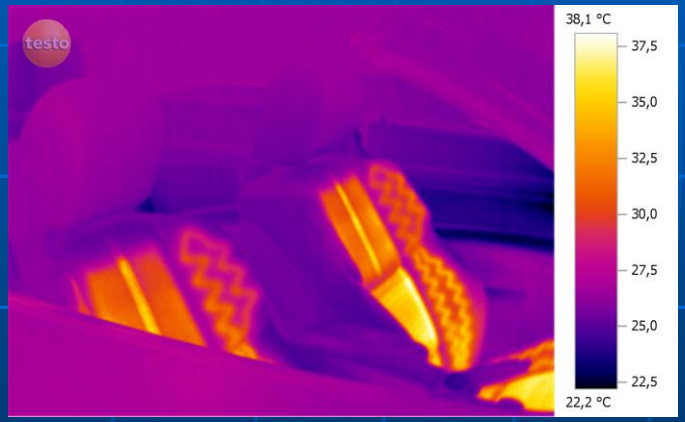
Maintenance & Inspection



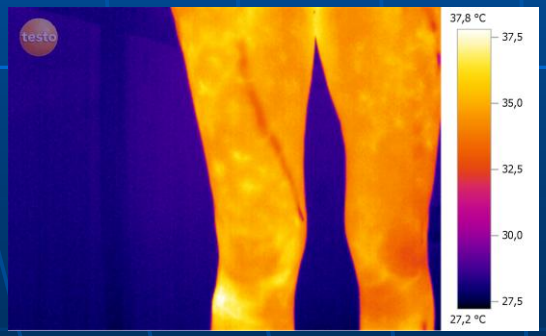

testo
25,8 °C
25,0
20,0
15,0
10,0
5,0
0,0
-5,0
-10,0
-15,0
-17,3 °C

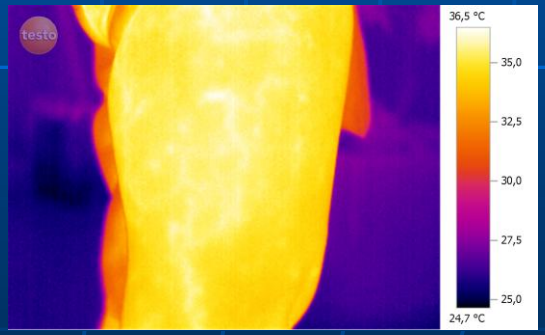

testo
40,5 °C
40,0
35,0
30,0
25,0
20,0
15,0
10,0
5,0
0,0
-5,0
-6,8 °C

Development of thermal devices and systems

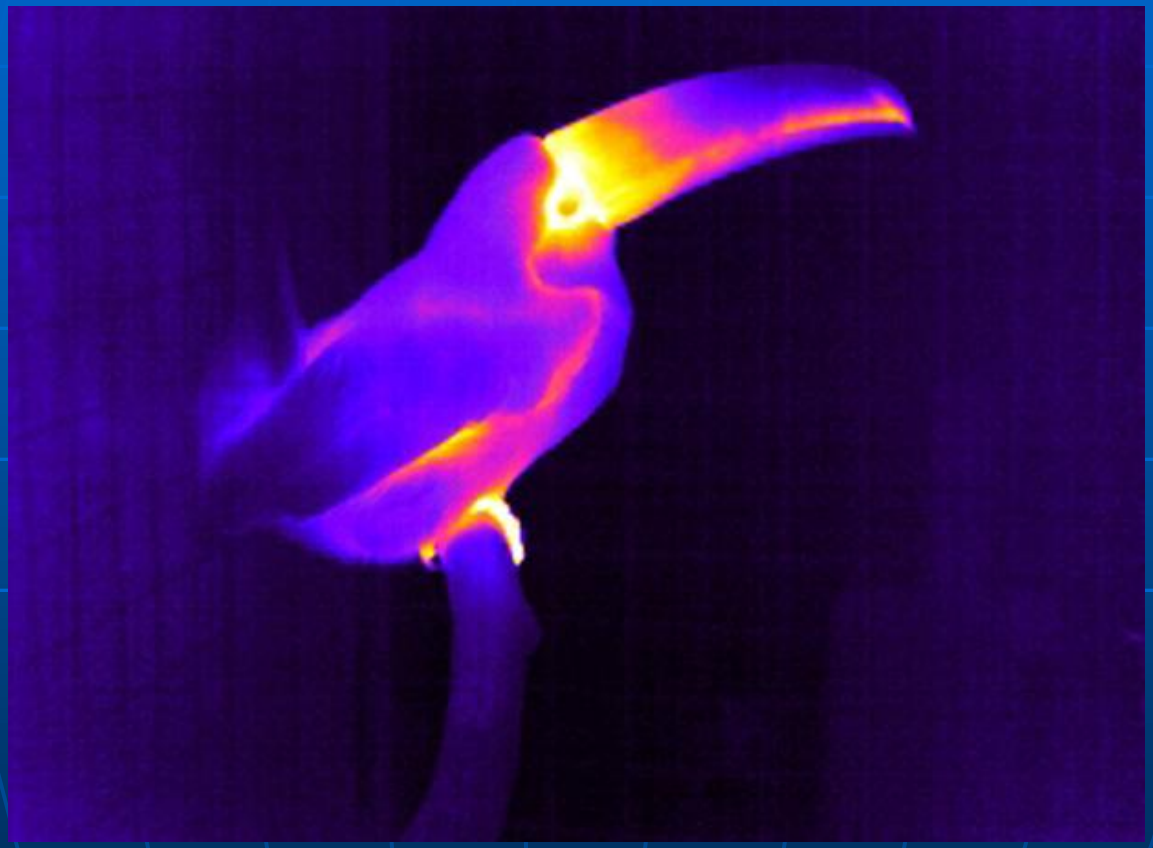


Medical Support





Science Research Support



- *Thank you for your attention*