

Infrarödfotografering

(nära IR, $0.7 < \lambda < 1 \mu\text{m}$)



Användningsområden:

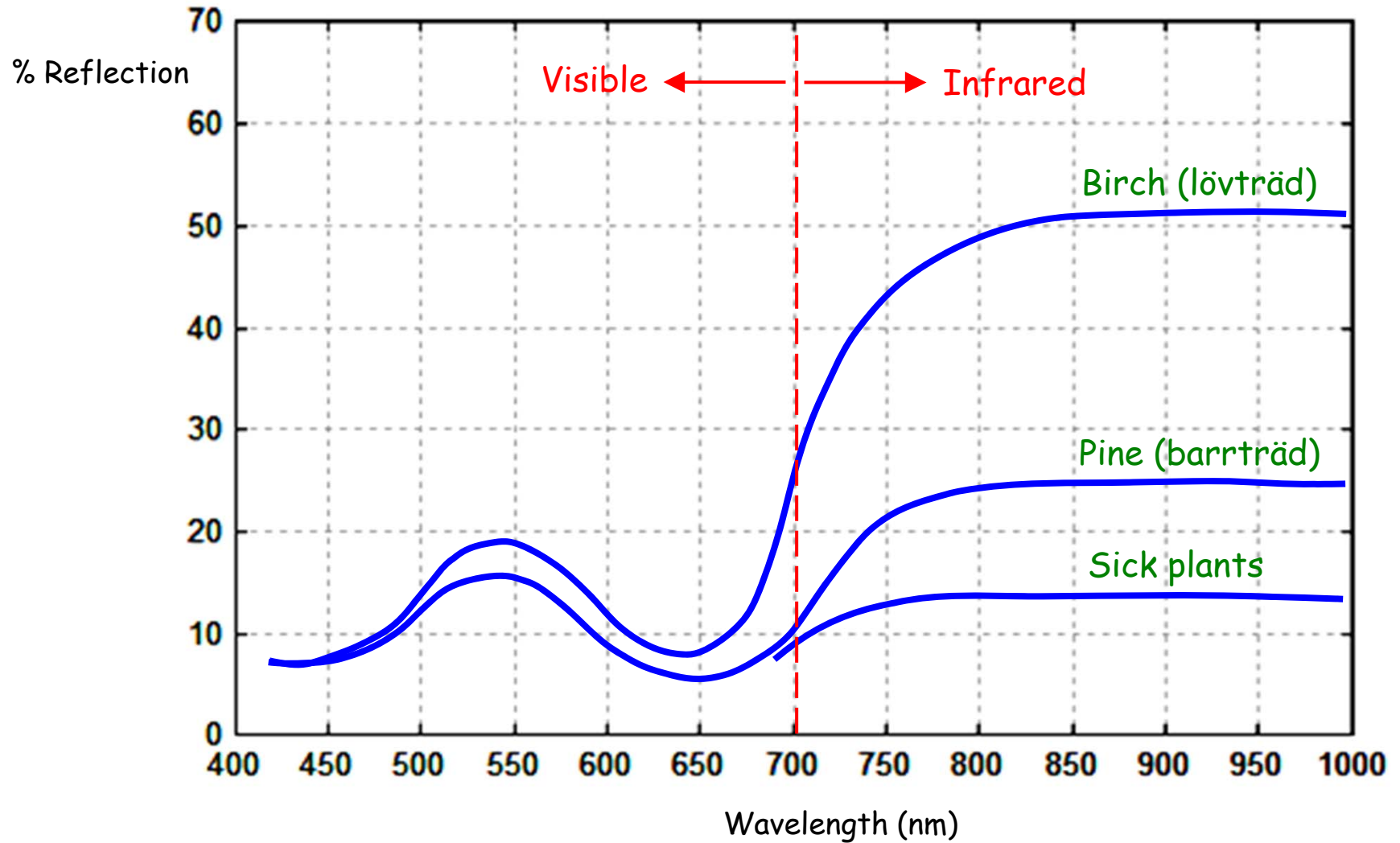
- Minska effekten av dis
- Fjärranalys (sjuka & friska växter)
- Medicin (bättre vävnadspenetration)
- Kriminalteknik (avslöja förfalskningar)

etc.

OBS! Blanda inte ihop med termovision

(λ ca. $10 \mu\text{m}$)

Spectral reflectance curves for vegetation



Spectral sensitivity of sensor

Typical performance

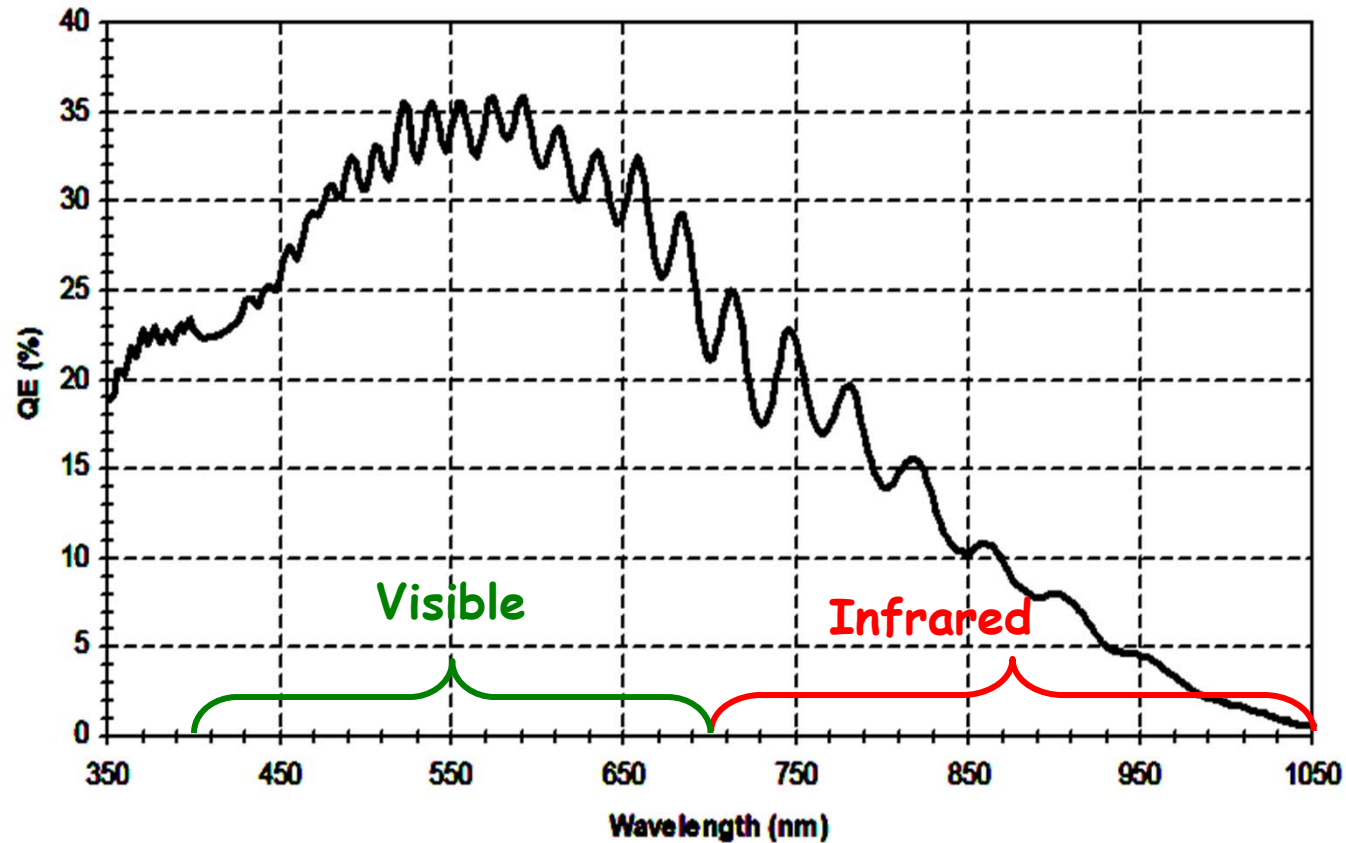


Figure 1: Spectral Response of a CMOS Image Sensor

Digital cameras are equipped with IR absorption filters (can sometimes be removed)

B&W infrared
photographs taken
with "black filter"
(transmitting only IR)



Blue sky appears black (no
IR). Vegetation is bright
(strong IR reflection)

Color-infrared camera

MS4100

High Resolution 3-CCD Digital Multispectral Camera

The MS4100 high-resolution 3-CCD camera brings you the ultimate in digital imaging quality. Our color-separating optics work in concert with large-format progressive scan CCD sensors to maximize resolution, dynamic range, and field-of-view.

The MS4100 is available in two spectral configurations - RGB for high quality color imaging and color-infrared for multispectral applications.

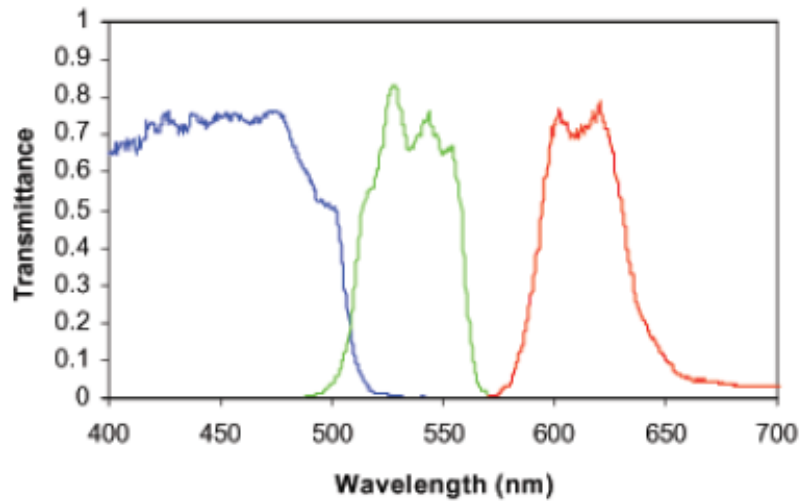
The HDTV one-inch sensor format provides the large pixel and sensing area needed to deliver wide coverage and high dynamic range. Advanced features such as exposure control and white balance maximize



S N A P S H O T

- Color separating prism with three CCD imaging sensors
- 1920(H) x 1080(V) resolution (x3) for 6.2 Million pixels of data
- Image 3 spectral bands from 400 -1000 nm
- Standard models for RGB and CIR
- Contact factory for custom multispectral configurations
- Wide Field-of-View, 60 degrees with 14 mm, f/2.8 lens
- Acquire and display composite, false color, or individual color plane images
- Frame rate of 10 fps

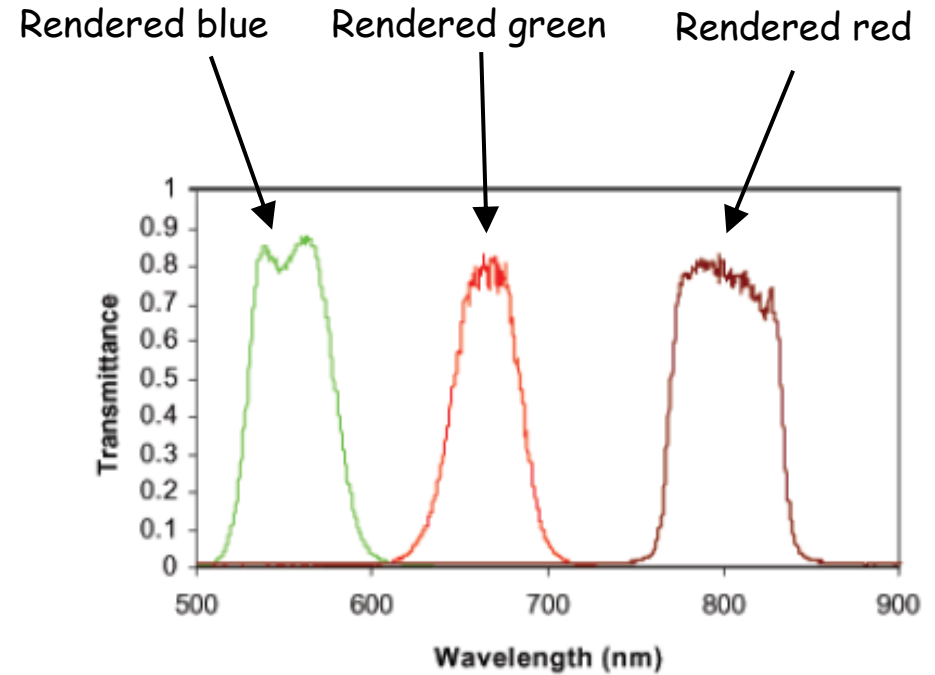
Camera configurations



RGB CONFIGURATIONS

Acquires separate Red, Green, and Blue image planes

Standard camera



CIR CONFIGURATIONS

Color-Infrared imaging acquires Red, Green and Near Infrared bands approximating Landsat satellite bands.

Color-infrared

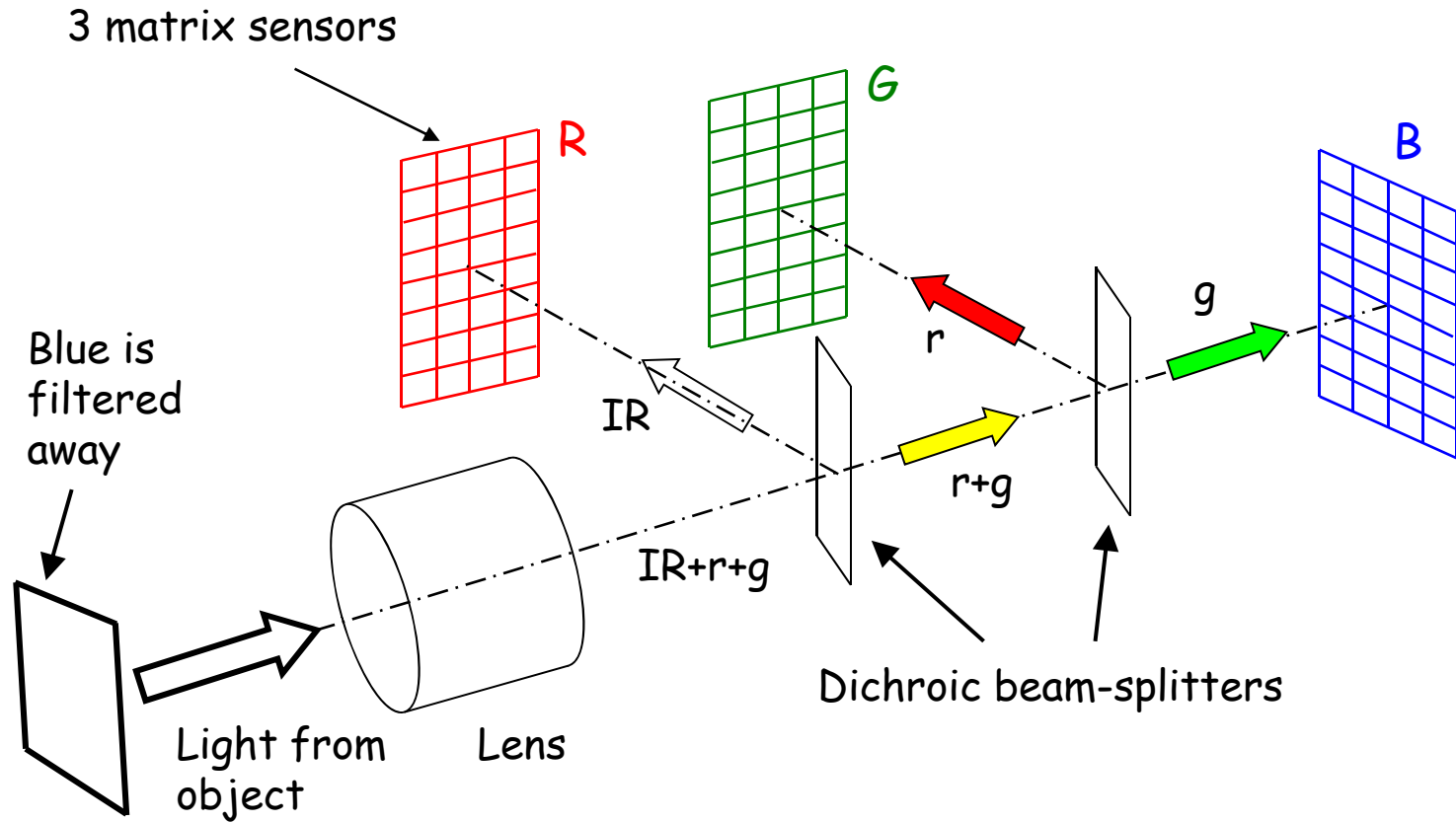
IR-färgbilder har en förskjuten färgskala

(Gäller både film- och digitalkameror)

<u>Motiv</u>	<u>Bild</u>
IR	Rött
Rött	Grönt
Grönt	Blått
Blått	Svart

(Laboration 6)

Color-infrared camera with 3 sensors





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Ultraviolettfotografi

(vanligen $300 < \lambda < 400$ nm)

2 olika principer:

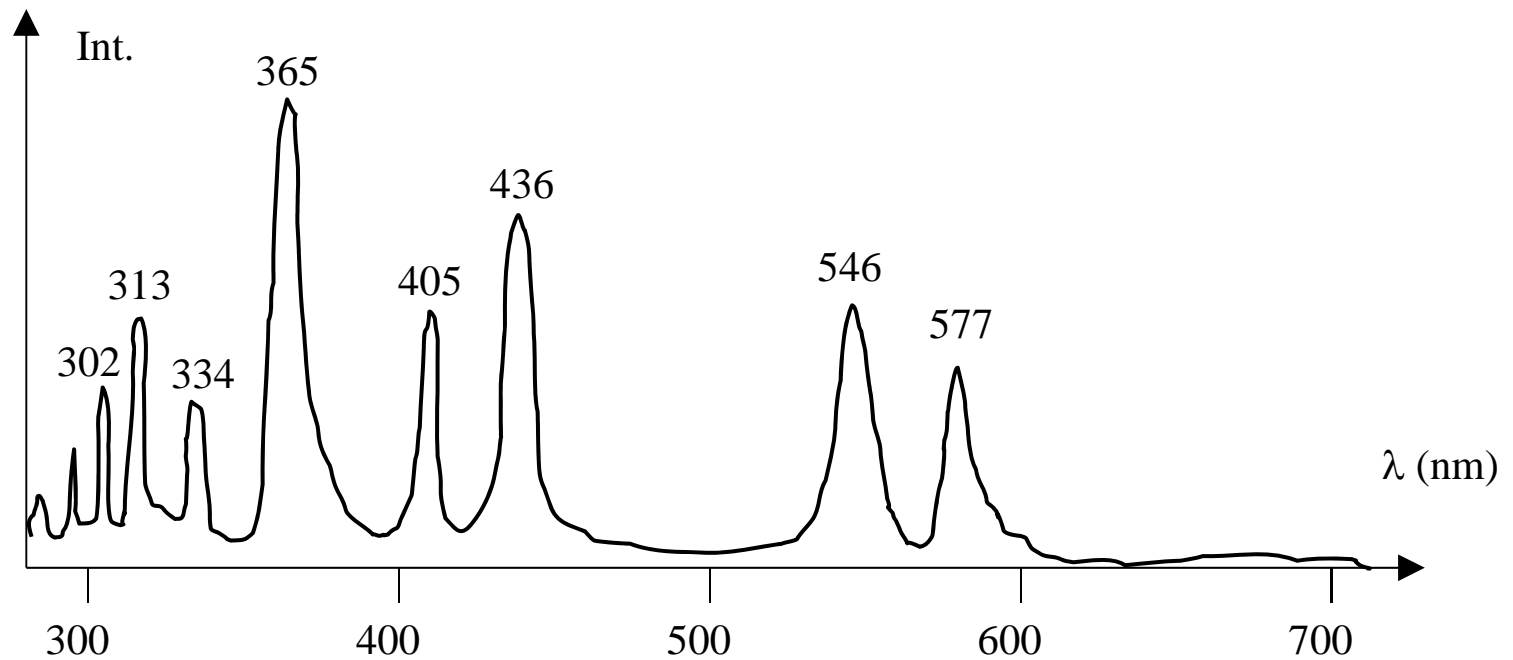
1. Reflekerad UV fotograferas (svårt med vanlig digitalkamera)
2. Belys med UV. Fotografera synligt fluorescensljus (lätt med vanlig digitalkamera)

Användningsområden:

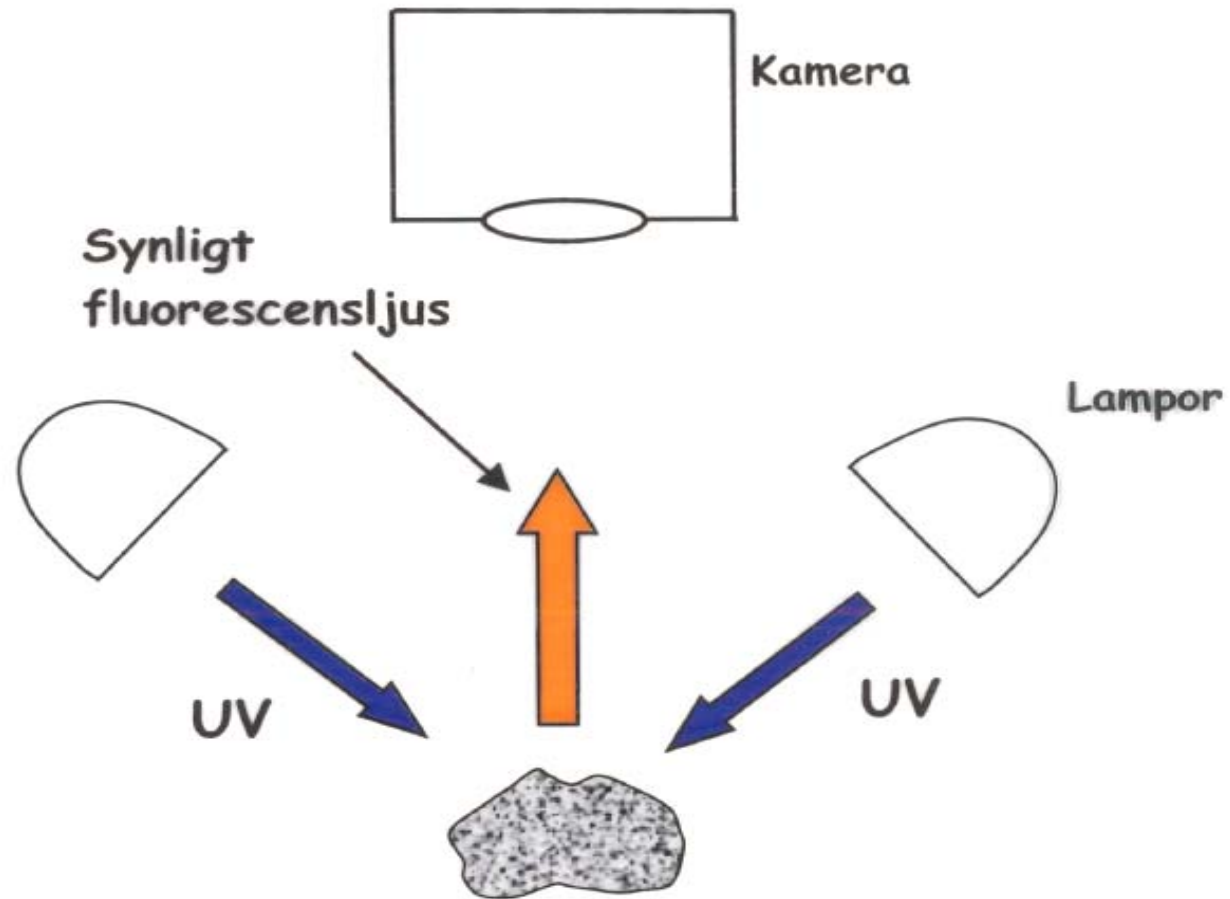
- "Häftiga effekter", t.ex. discobelysning (fluorescenseffekt).
- Klarare bilder av mineral och fossil.
- Medicin (t.ex hudpigment)
- Kriminalteknik (avslöja förfalskningar)

etc.

Spectrum of Hg high-pressure lamp



Fluorescensfotografi



Detecting counterfeit money



Also traces at crime scenes etc.



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Röntgenfotografi ($0.001 \text{ nm} < \lambda < 50 \text{ nm}$)

Hård

Mjuk

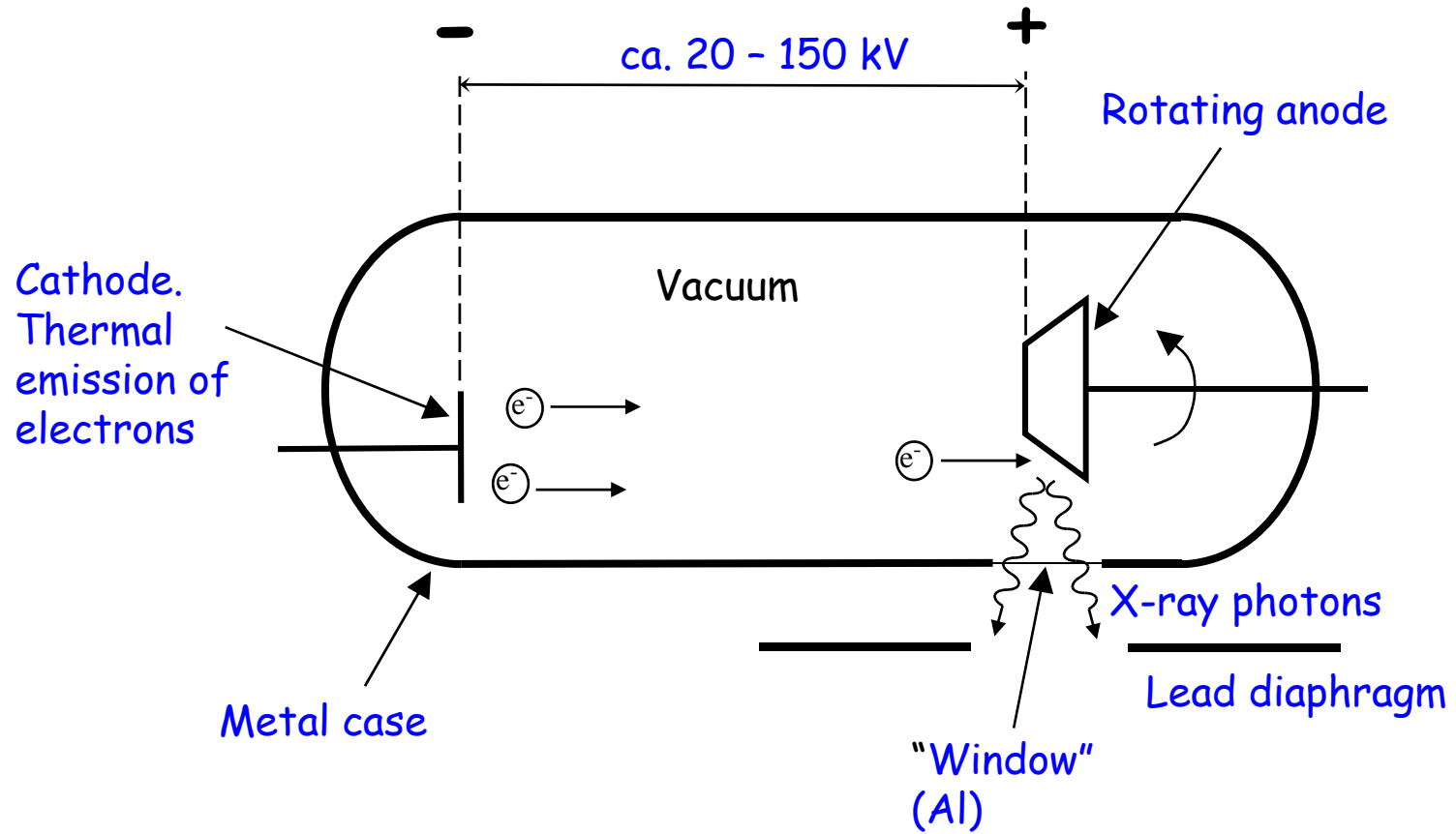
Röntgen har stor penetrationsförmåga
(större ju kortare våglängd).
Medicinsk röntgen ca. 0.01 - 0.1 nm.

Användningsområden:

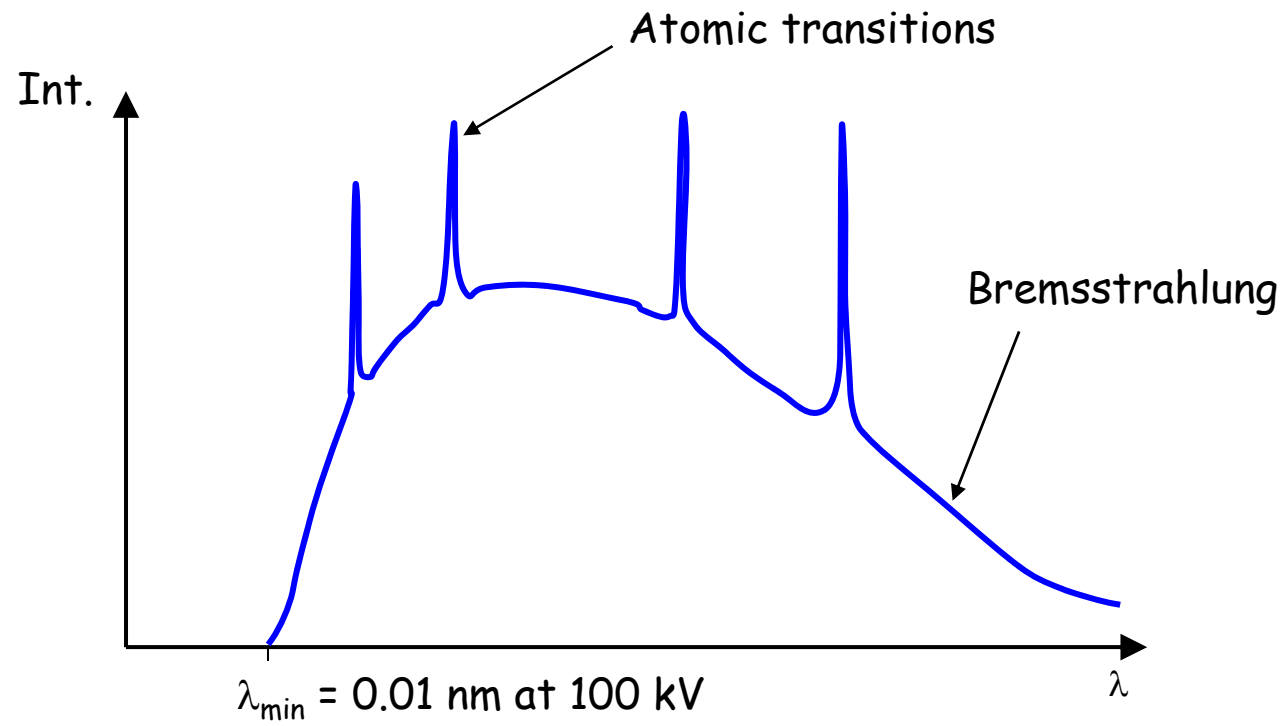
Medicin

Industri (t.ex. koll av svetsfogar & flygplansvingar)

X-ray tube



Typical X-ray spectrum



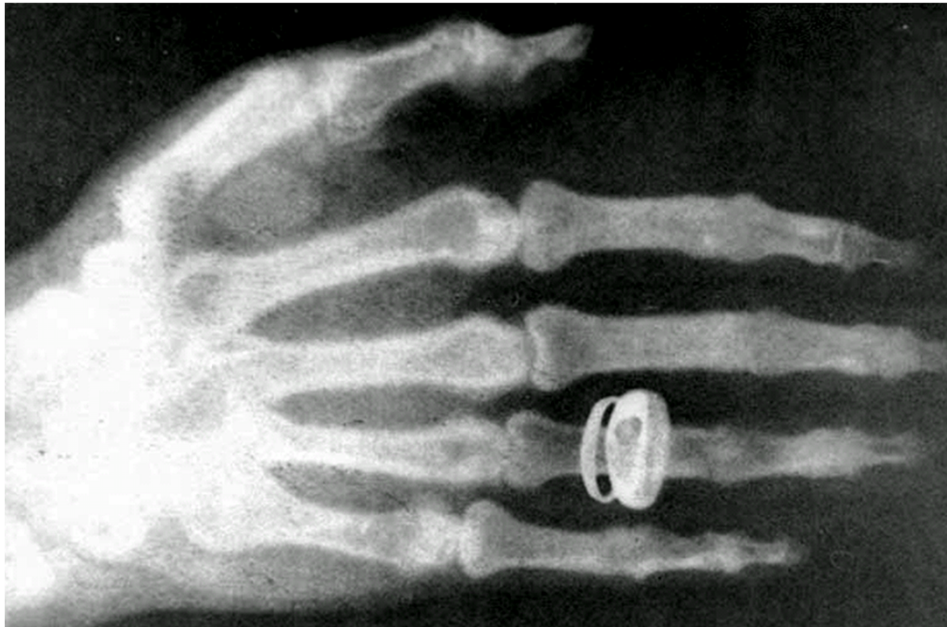


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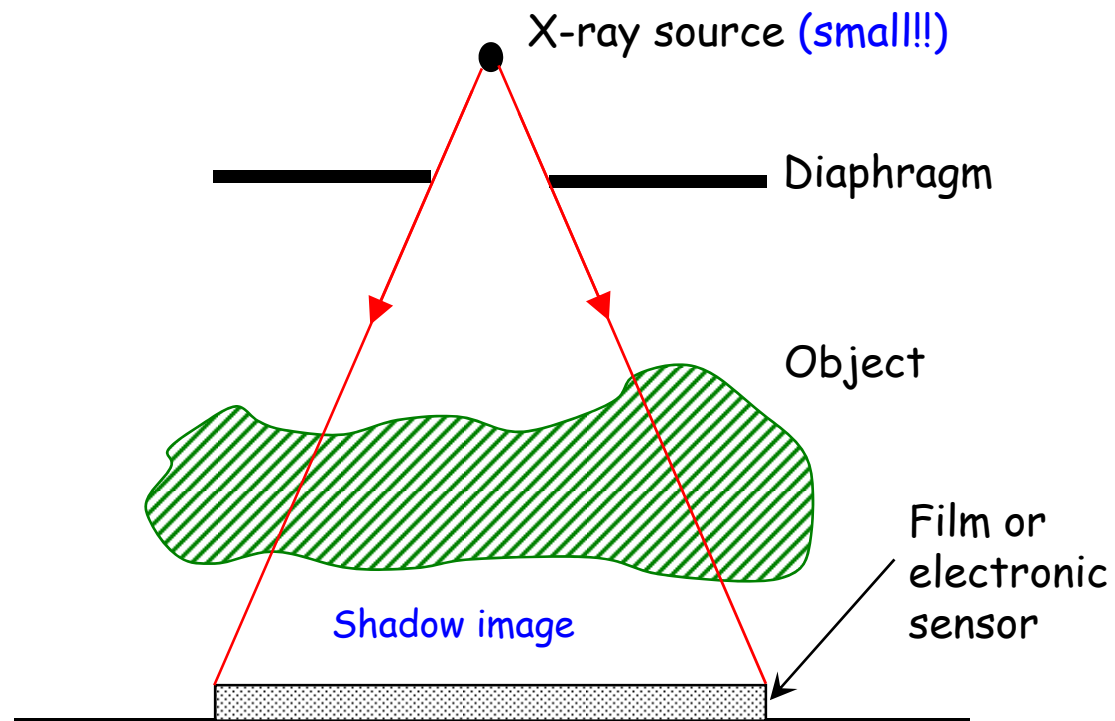
Wilhelm Conrad Röntgen (1845-1923)

Nobel Prize 1901

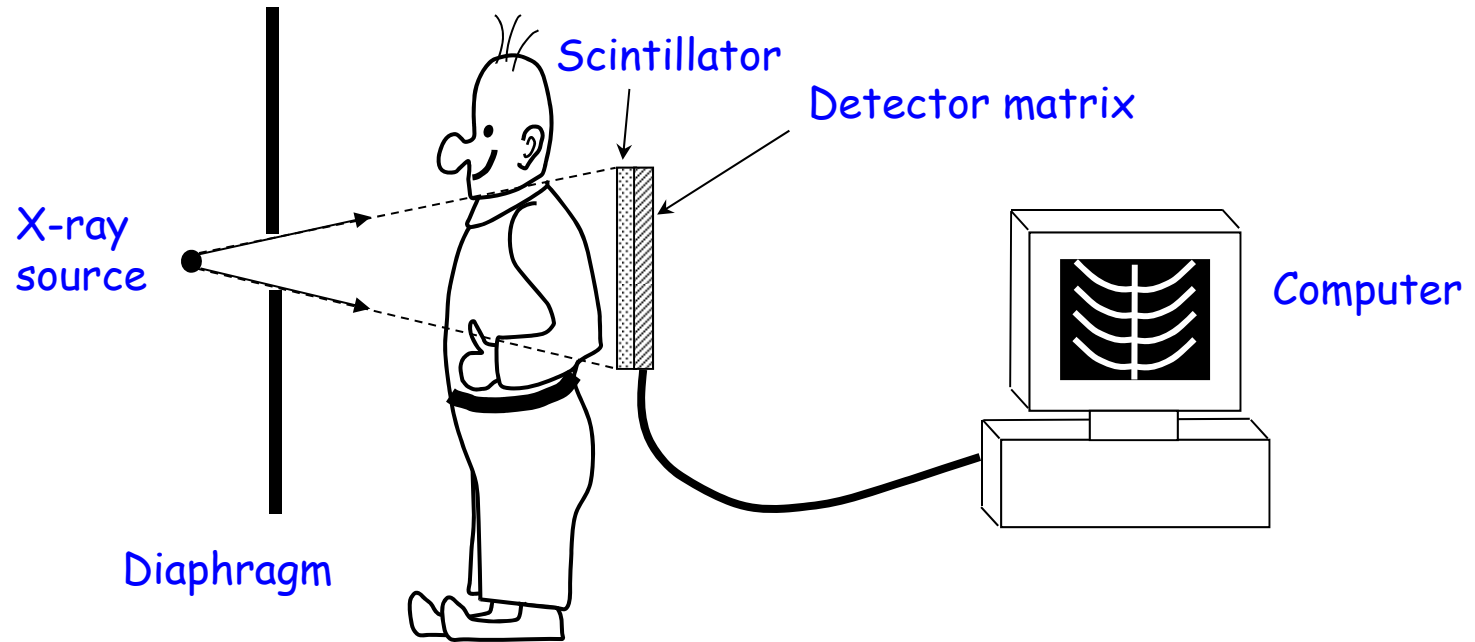


X-ray photograph produced during
Röntgen's lecture in Würzburg 23
January 1896.

Set-up for X-ray photography



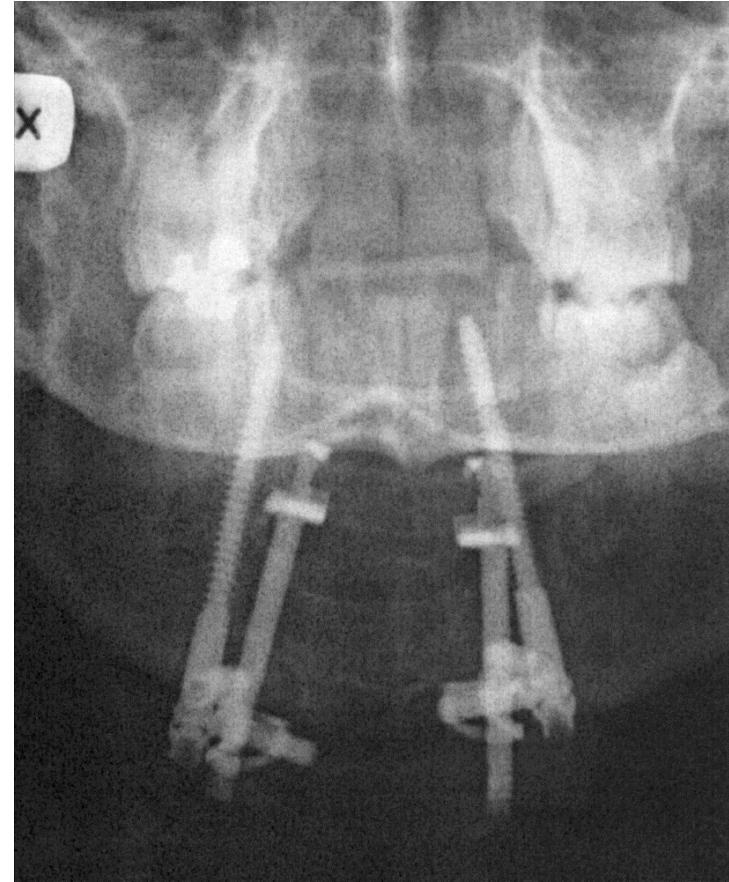
At the hospital



X-ray images of neck region



Side view



Front view



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High speed photography

- Single shot with short exposure time
- Strobe-photo (multiple exposures on single frame)
- High-speed film or video



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High speed video

- CMOS sensor is commonly used
1. Short exposure time = Strong illumination is needed
 2. Read-out speed of data



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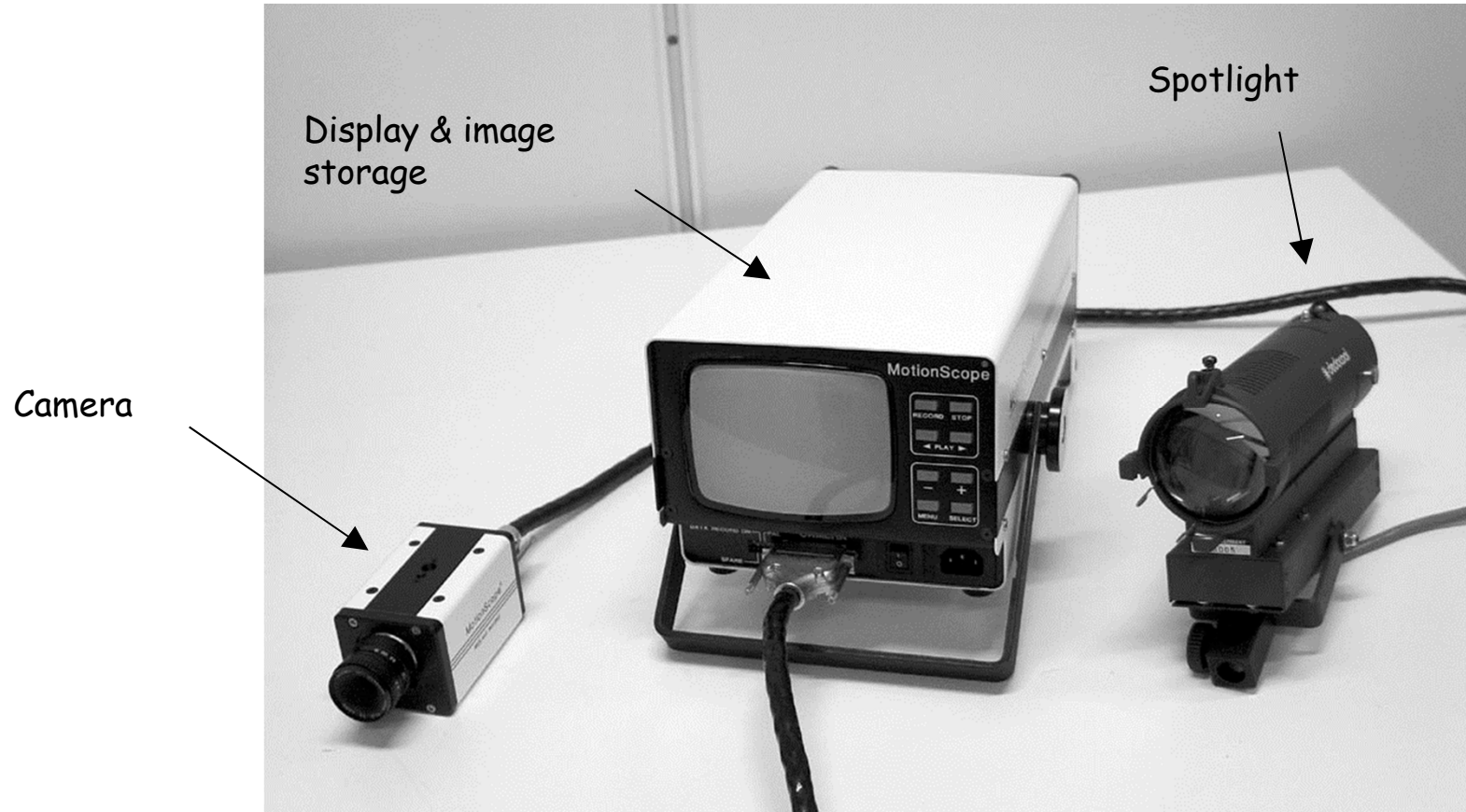
Great flexibility due to CMOS sensor

Example:

Sample Frame Rates and Resolutions

Frames/Second	4:3*
≤1000	1504x1128
2000	1056x792
3,000	832x632
5000	640x480
10,000	416x320
20,000	256x192
30,000	192x152
50,000	96x72
100,000	32x24

Redlake video used in lab. session 6



250 frames/sec. Min. exposure time 1/5000 sec.

Strobo-photo

Multiple flash exposures on a single picture frame

Darkened room

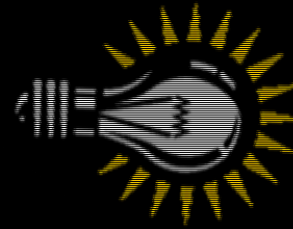
Ordinary camera is okay

Open shutter

Action!

Close shutter

View result



Strobo-photo of fast-moving objects (bullets etc.):

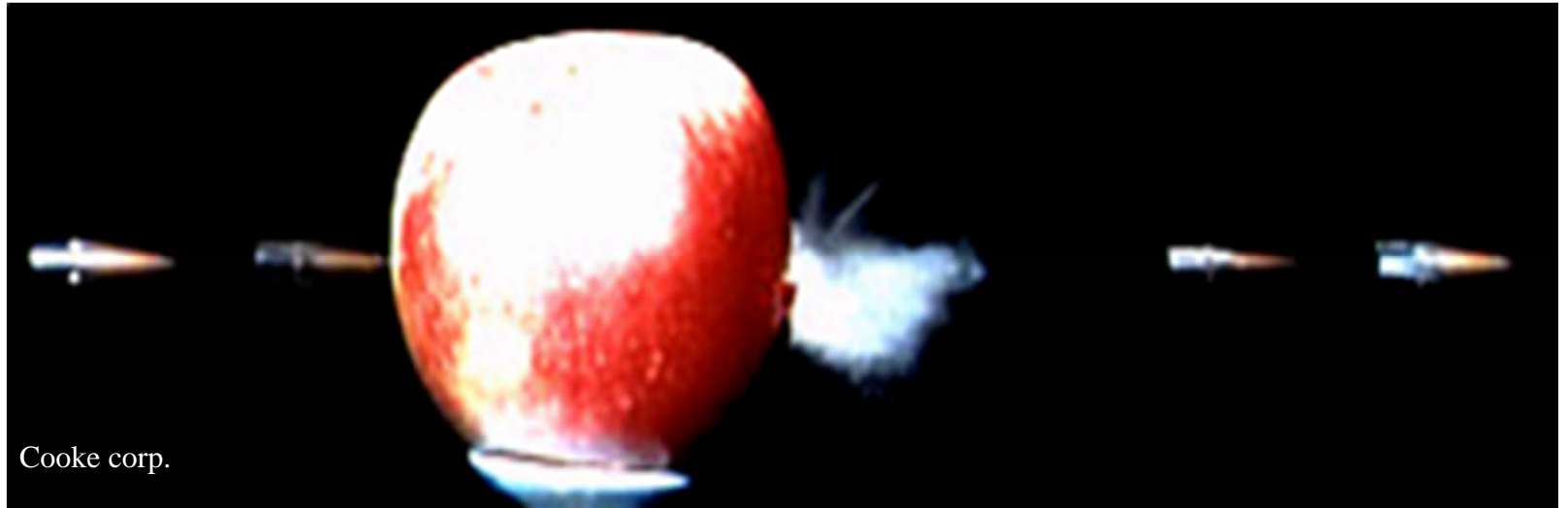


Image courtesy of The Cooke Corporation, www.cookecorp.com.

Estimate! {

- Flash duration $\approx 1 \mu\text{s}$
- Time interval between flashes $\approx 100 \mu\text{s}$



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Thermal imaging

(Termovision)

Detects electromagnetic radiation with wavelengths around $10 \mu\text{m}$

Applications:

- Detection of heat leaks
- Detection of overheating machines
- Spotting missing persons
- Surveillance (no illumination needed)

etc.

Thermal cameras are mounted on police helicopters

Compact hand-held camera



FLIR i7

En liten infraröd revolution

-  IR-upplösning: 120x120 bildpunkter
-  Punkt-, områdes- och isothermmätning
-  Kompakt storlek, låg vikt: 340 g
-  Termisk känslighet: NETD 100 mK
-  Lättanvänd autofokus
-  Kan lagra upp till 5 000 JPEG-bilder
-  2,8-tums LCD-färgskärm
-  Batteriets drifttid: 5 timmar
-  Praktiskt galleri med miniatyrbilder

FLIR i7 från FLIR Systems är en liten, praktisk och prisvärd värmekamera. Den är fantastiskt lätt att använda – ingen tidigare erfarenhet krävs. FLIR i7 är utrustad med en pålitlig kombination av funktioner som gör att du snabbt kan upptäcka fuktproblem, bristande isolering, läckor i ventilation och luftkonditionering samt elektriska eller mekaniska problem i samband med förebyggande underhåll.

Programvaran FLIR QuickReport™ finns på 21 olika språk och gör det enkelt att skapa rapporter av analysresultaten i din dator



Typical performance for a R&D (research and development) thermal camera:

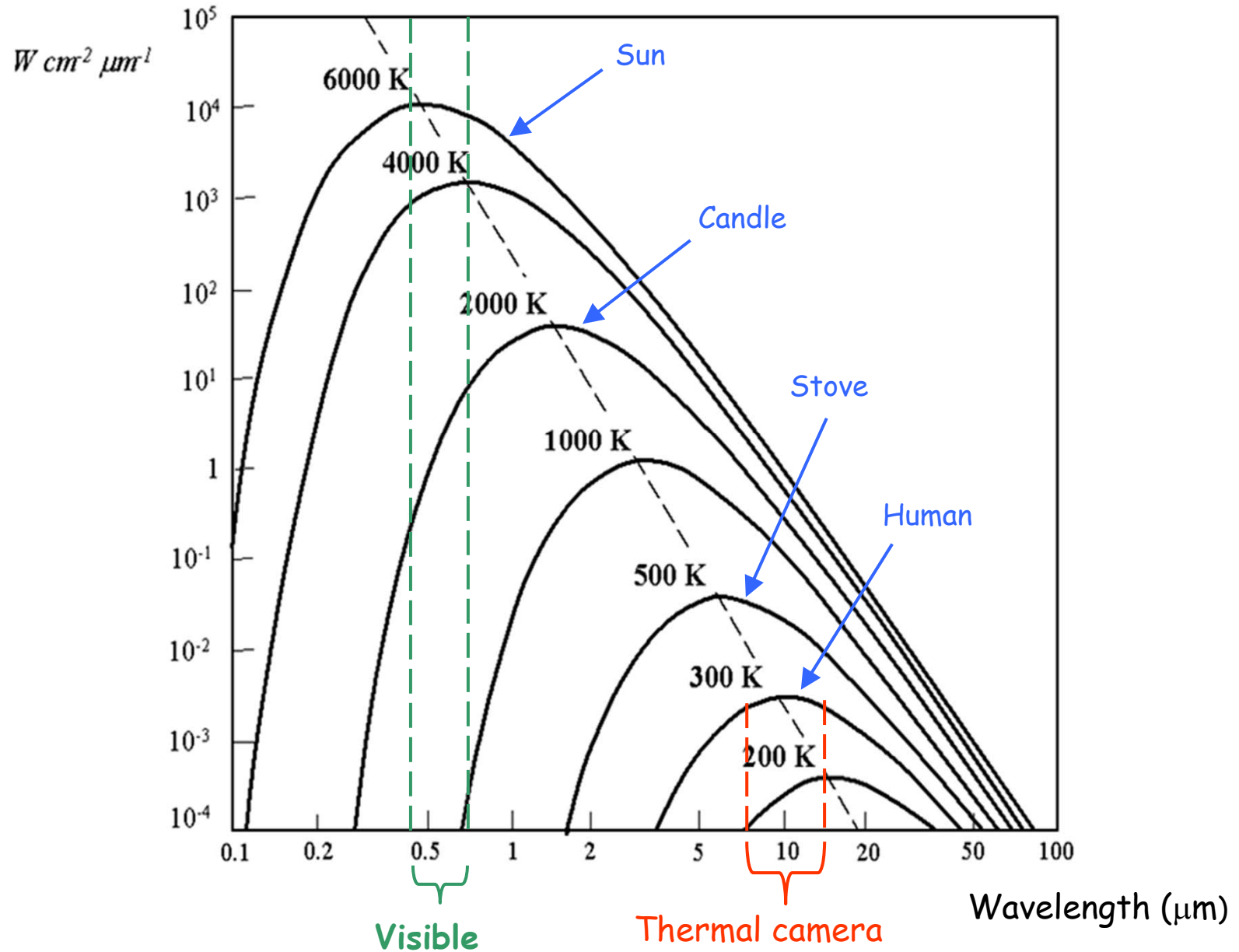
640 x 480 pixel uncooled microbolometer sensor

17 mm pixel center-to-center distance

50 frames per second (video rate)

Germanium (plus some other material) lens with F-number 1.0

Spectral emission curves for bodies at different temperatures





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Uncooled microbolometer focal plane array

Typical array size approx. 300 x 200 pixels. Infrared radiation increases the pixel temperature, thereby causing a change in resistance.

Typical material = vanadium oxide (temp. coefficient of resistance 2-3%/K).