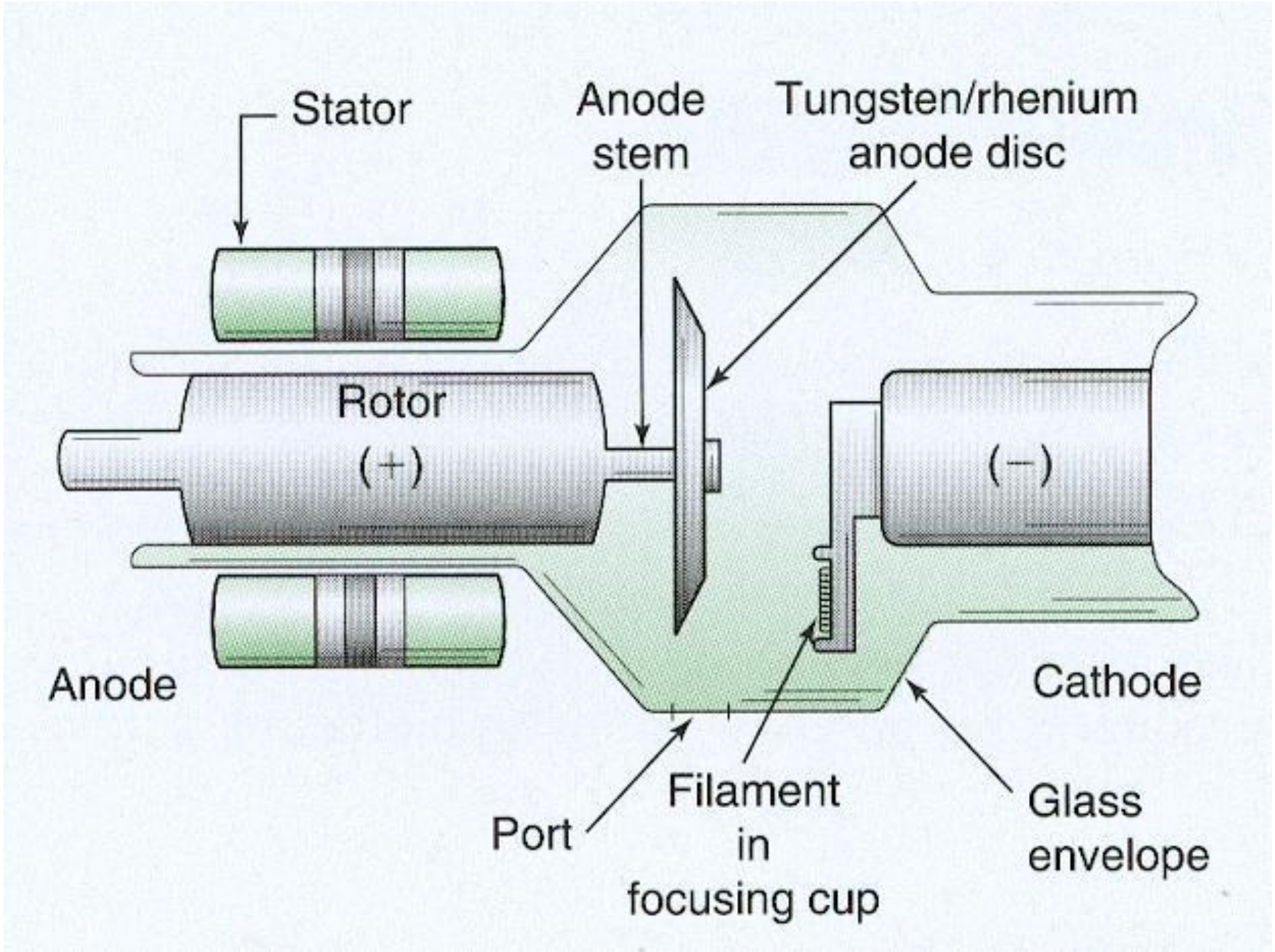
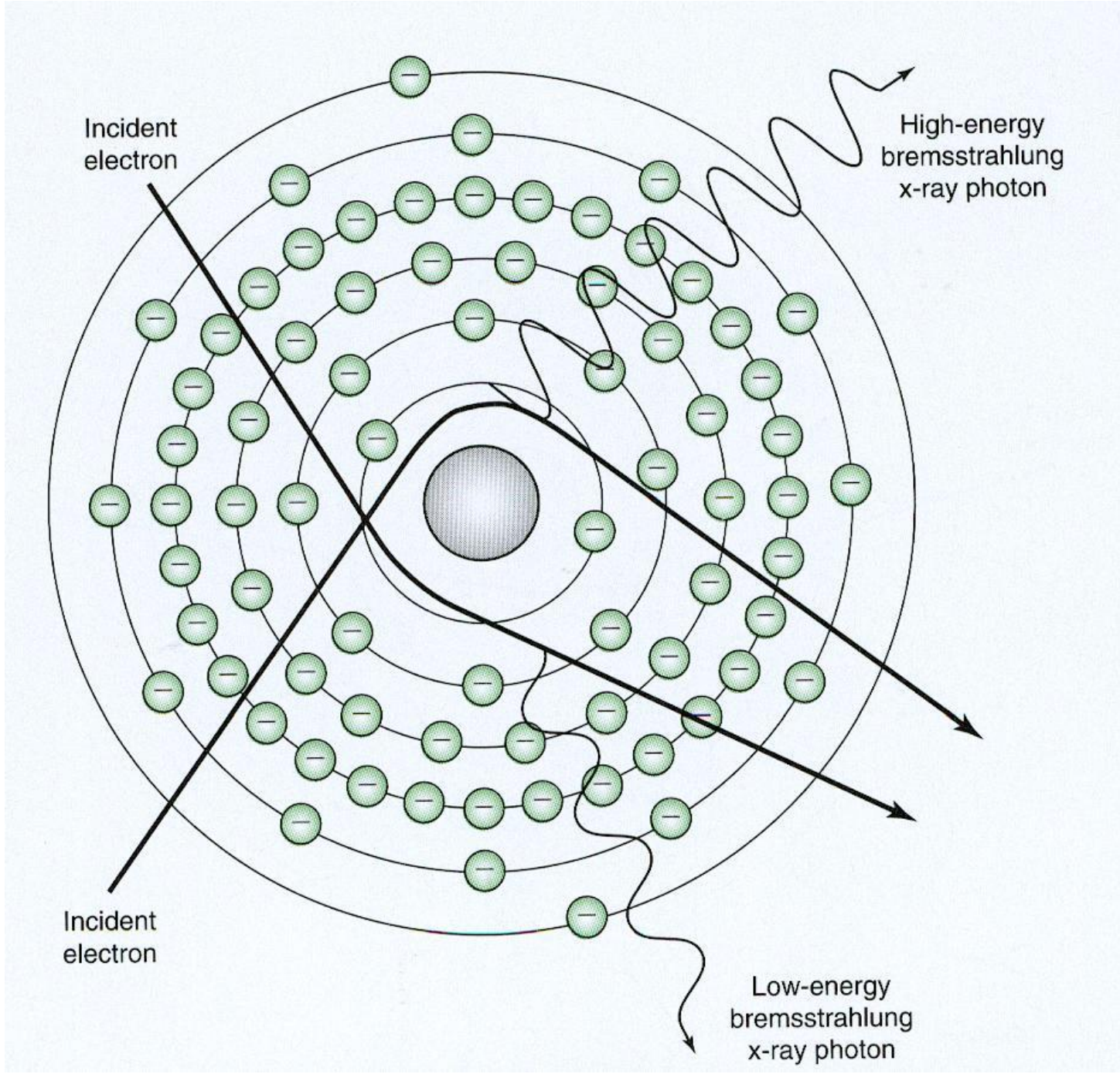
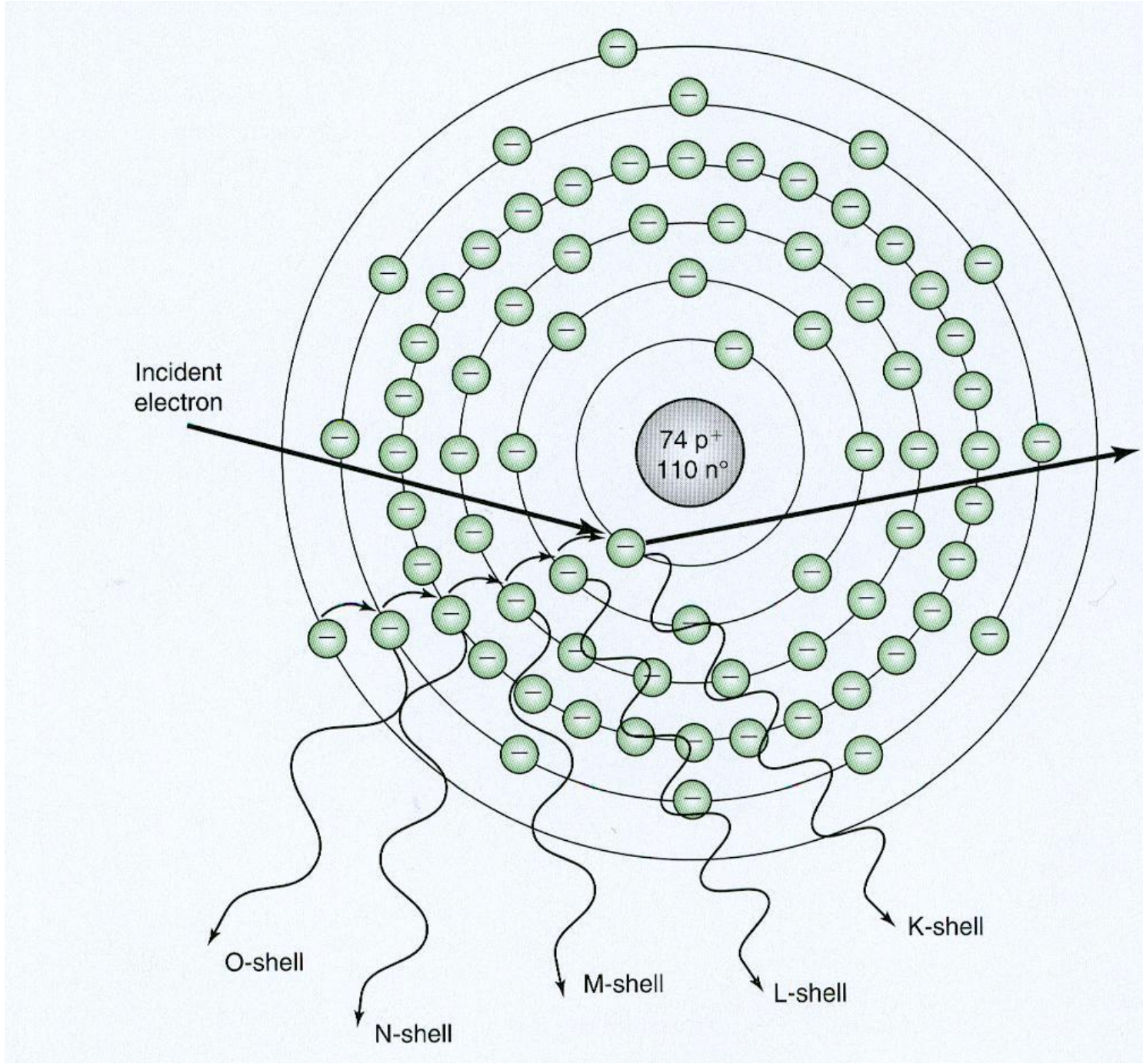
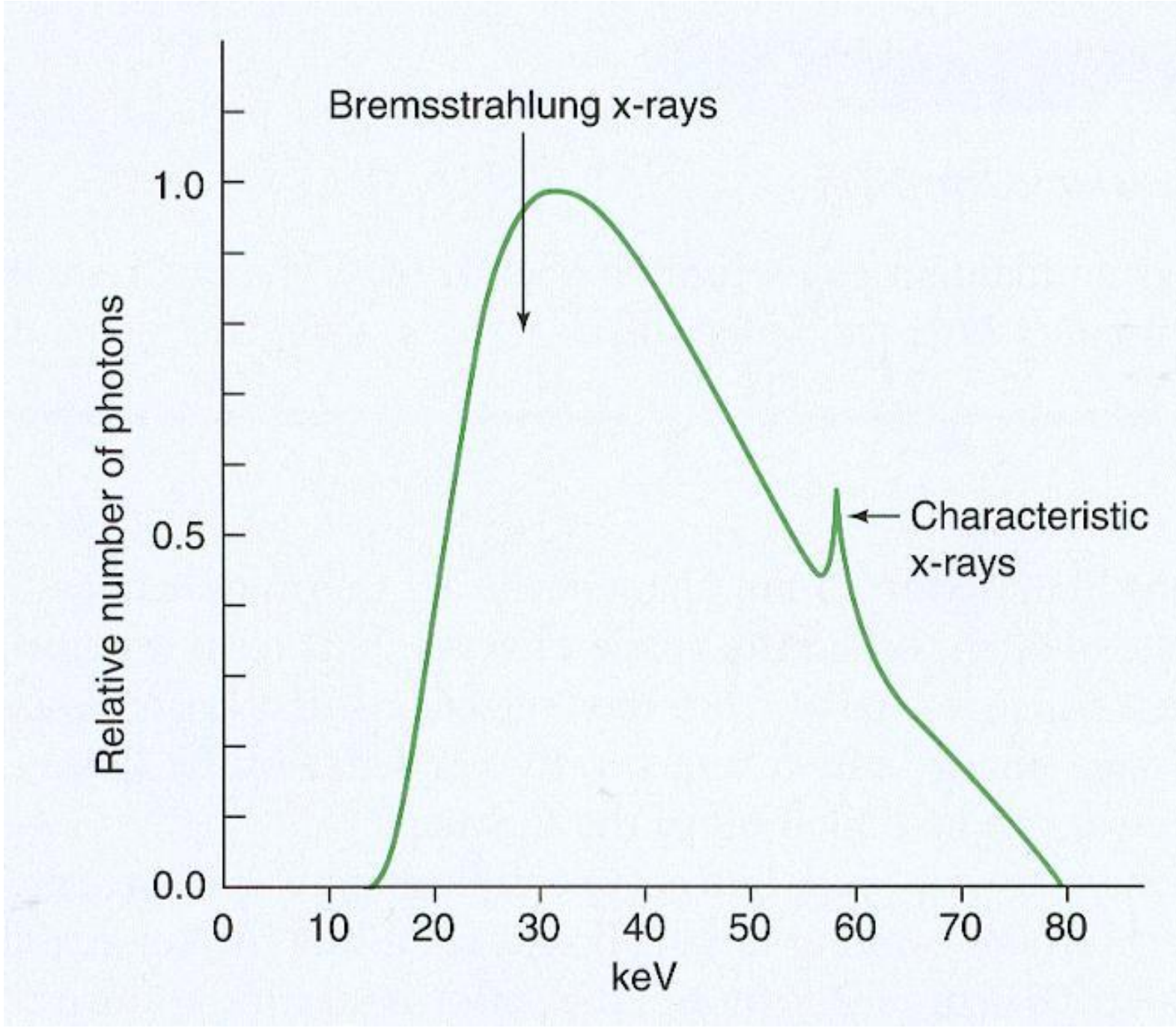
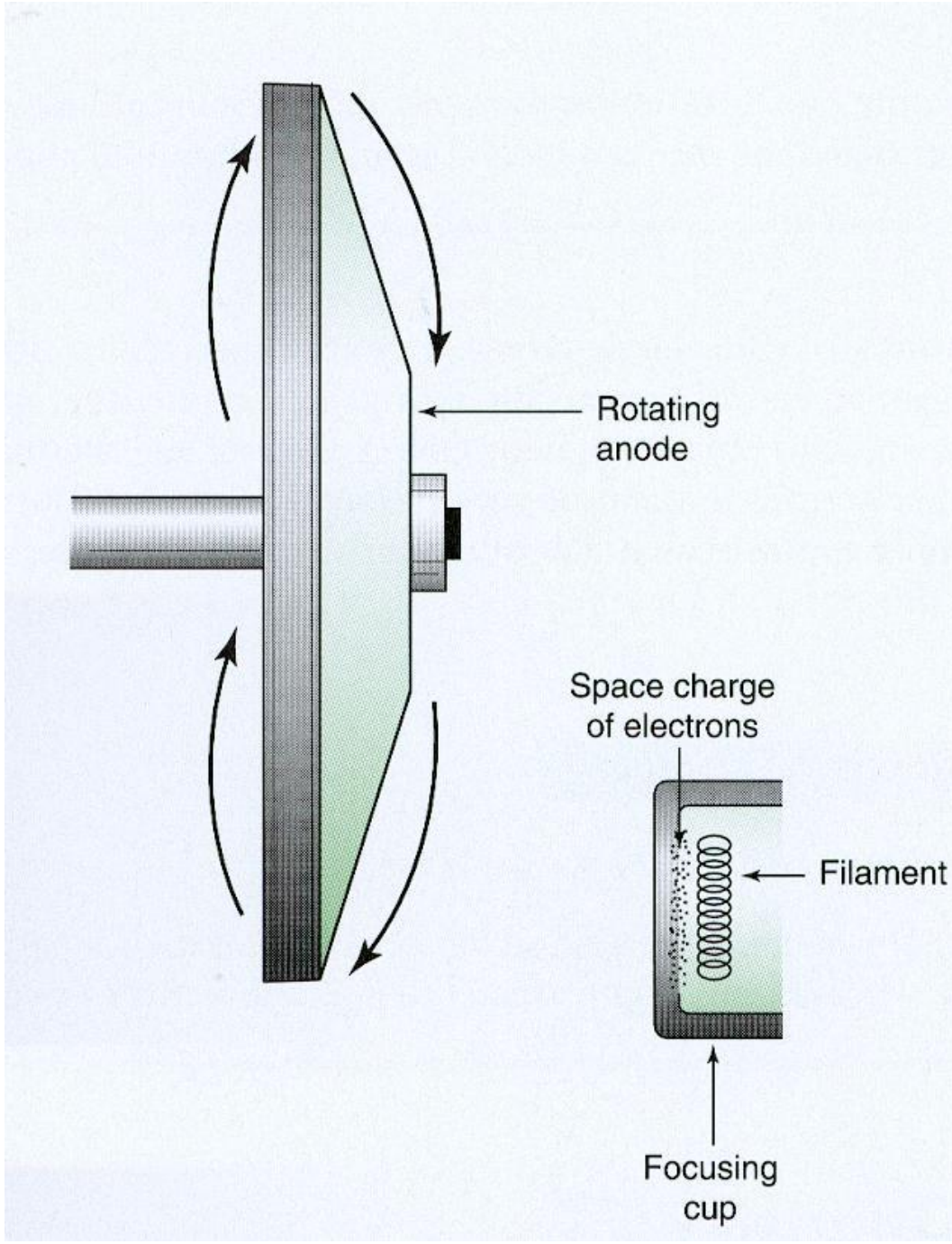
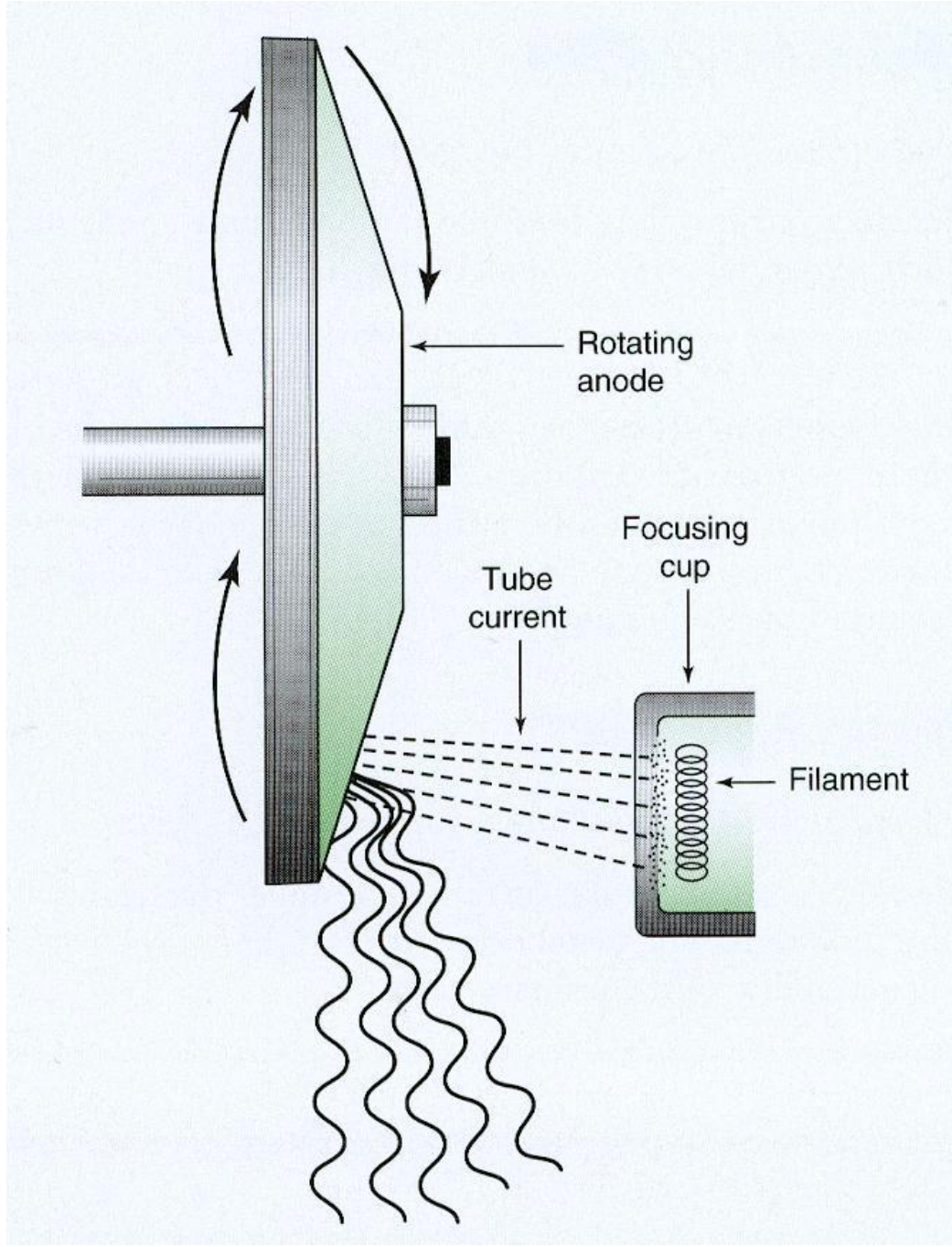

Stator
Anode stem
Tungsten/rhenium anode disc
Rotor
(+)
(−)
Anode
Cathode
Port
Filament in focusing cup
Glass envelope

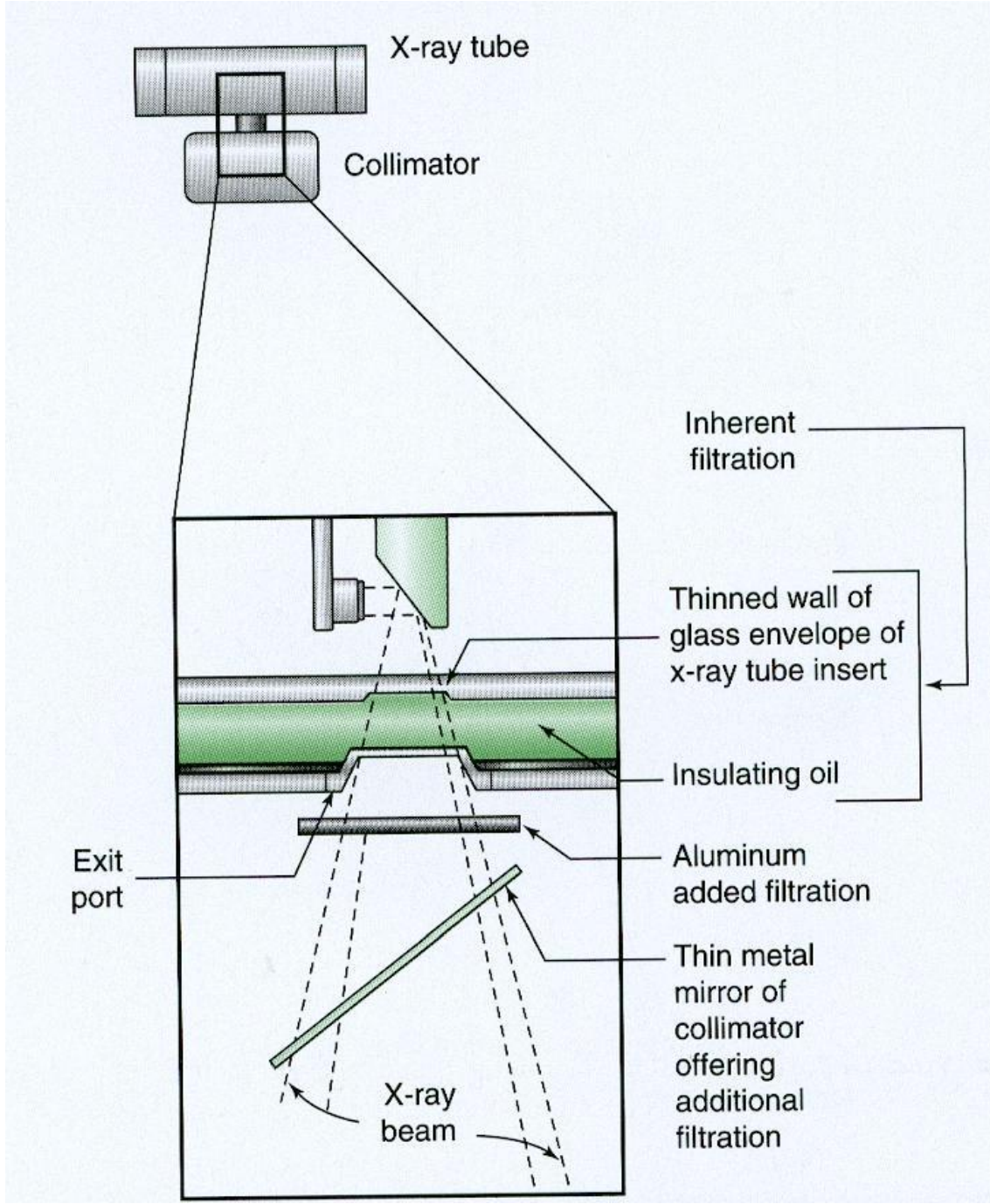

Incident
electron
High-energy
bremsstrahlung
x-ray photon
Incident
electron
Low-energy
bremsstrahlung
x-ray photon

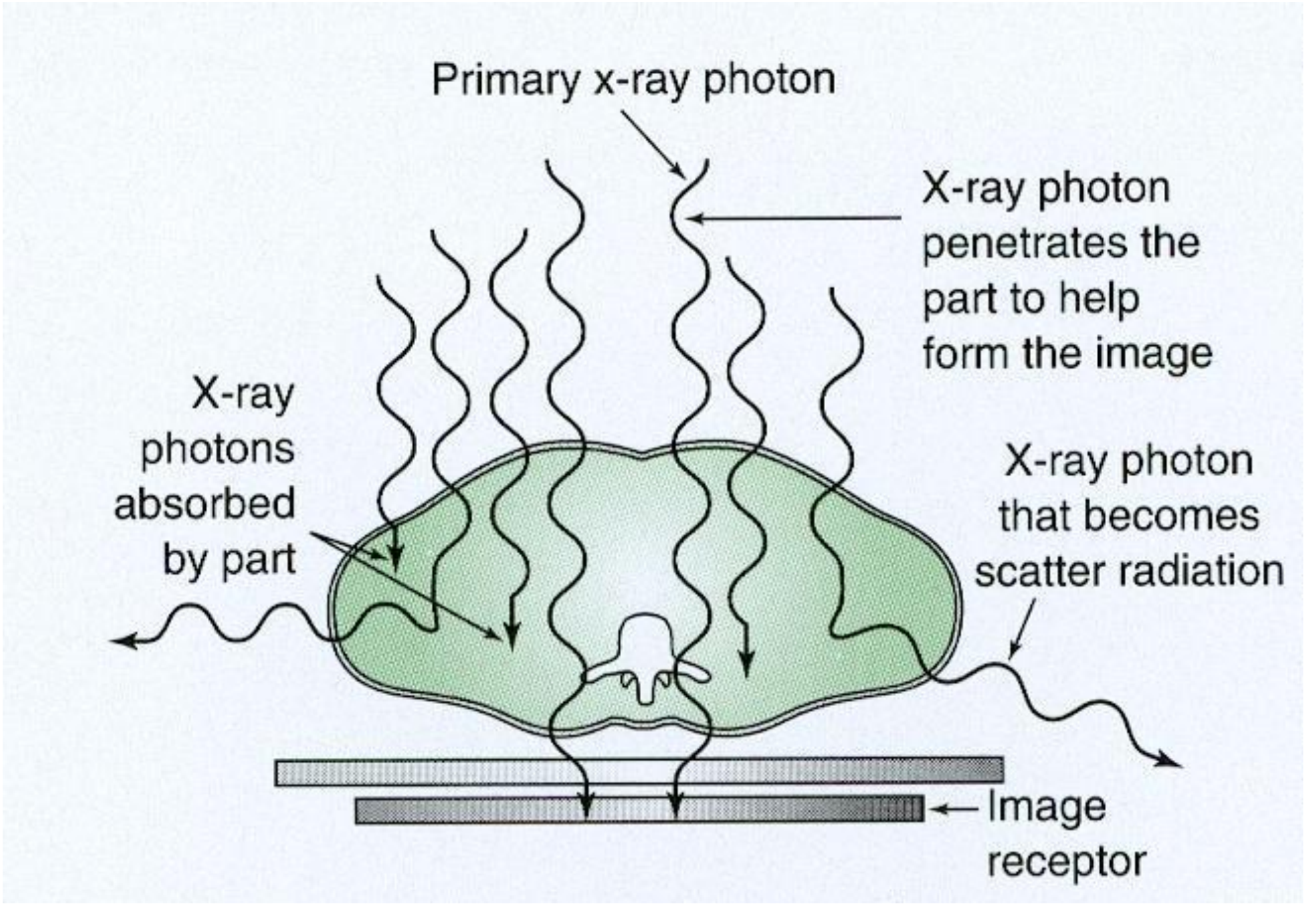

Incident
electron
74 p+
110 n°
O-shell
N-shell
M-shell
L-shell
K-shell


Bremsstrahlung x-rays
Characteristic
x-rays
Relative number of photons
1.0
0.5
0.0
0
10
20
30
40
50
60
70
80
keV


Rotating
anode
Space charge
of electrons
Filament
Focusing
cup


Rotating
anode
Focusing
cup
Tube
current
Filament

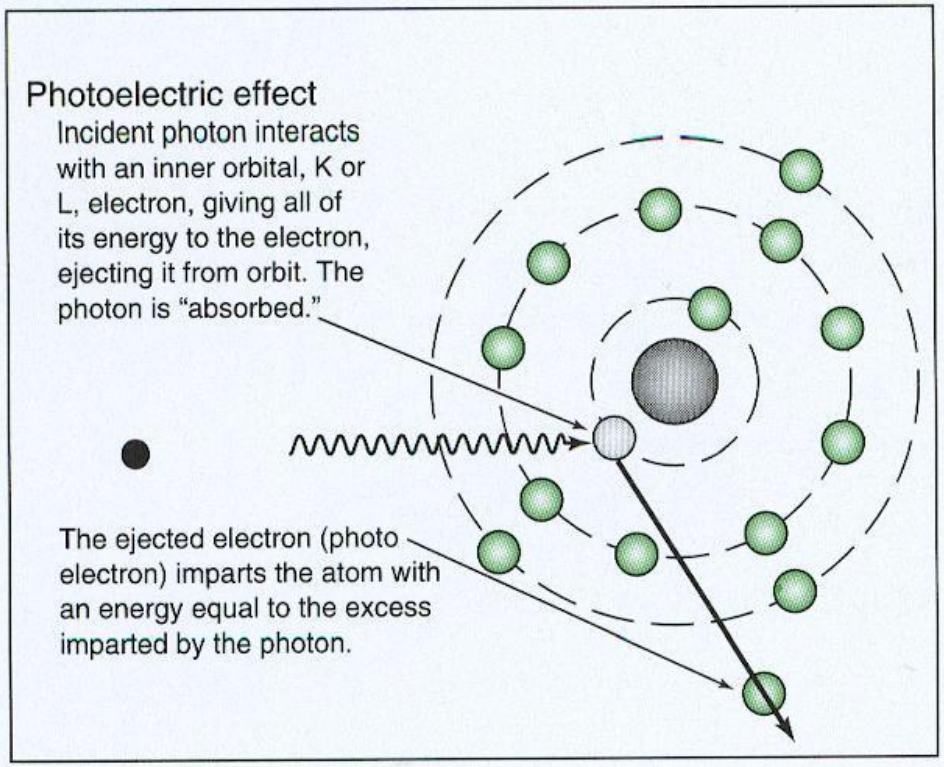

X-ray tube
Collimator
Inherent filtration
Thinned wall of glass envelope of x-ray tube insert
Insulating oil
Exit port
Aluminum added filtration
Thin metal mirror of collimator offering additional filtration
X-ray beam


Primary x-ray photon
X-ray photon penetrates the part to help form the image
X-ray photons absorbed by part
X-ray photon that becomes scatter radiation
Image receptor

Photoelectric effect

Incident photon interacts with an inner orbital, K or L, electron, giving all of its energy to the electron, ejecting it from orbit. The photon is "absorbed."

The ejected electron (photo electron) imparts the atom with an energy equal to the excess imparted by the photon.

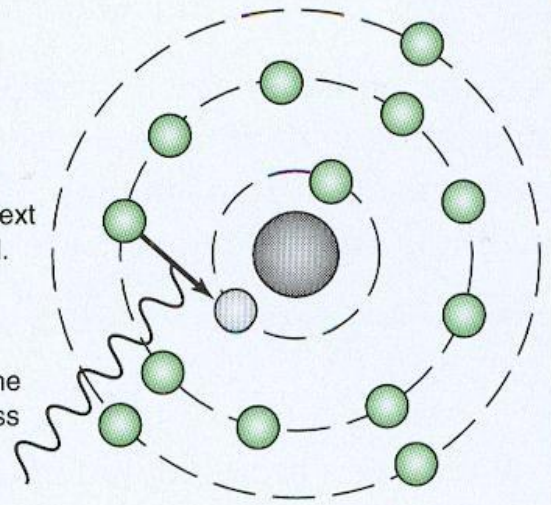


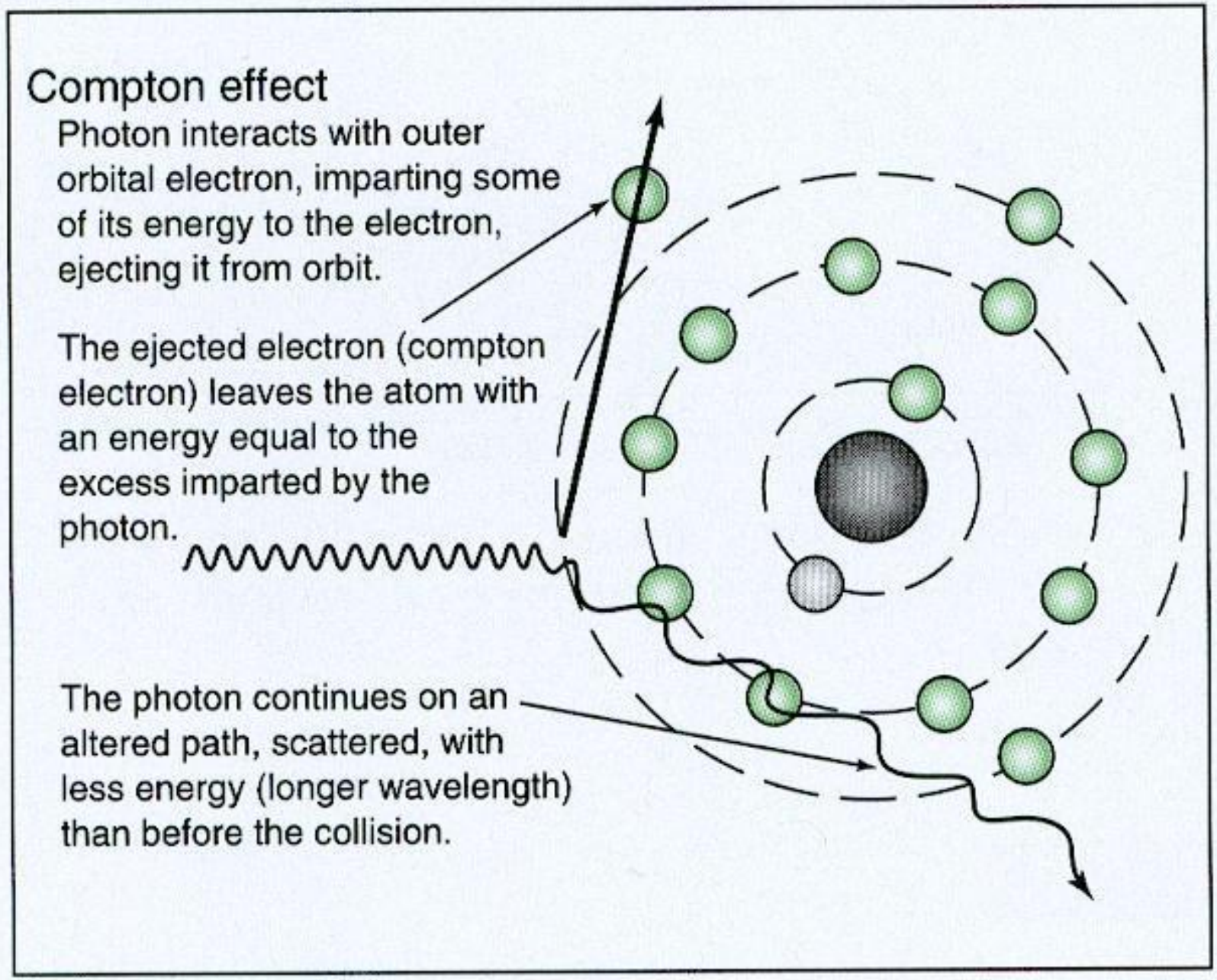
Photoelectric effect

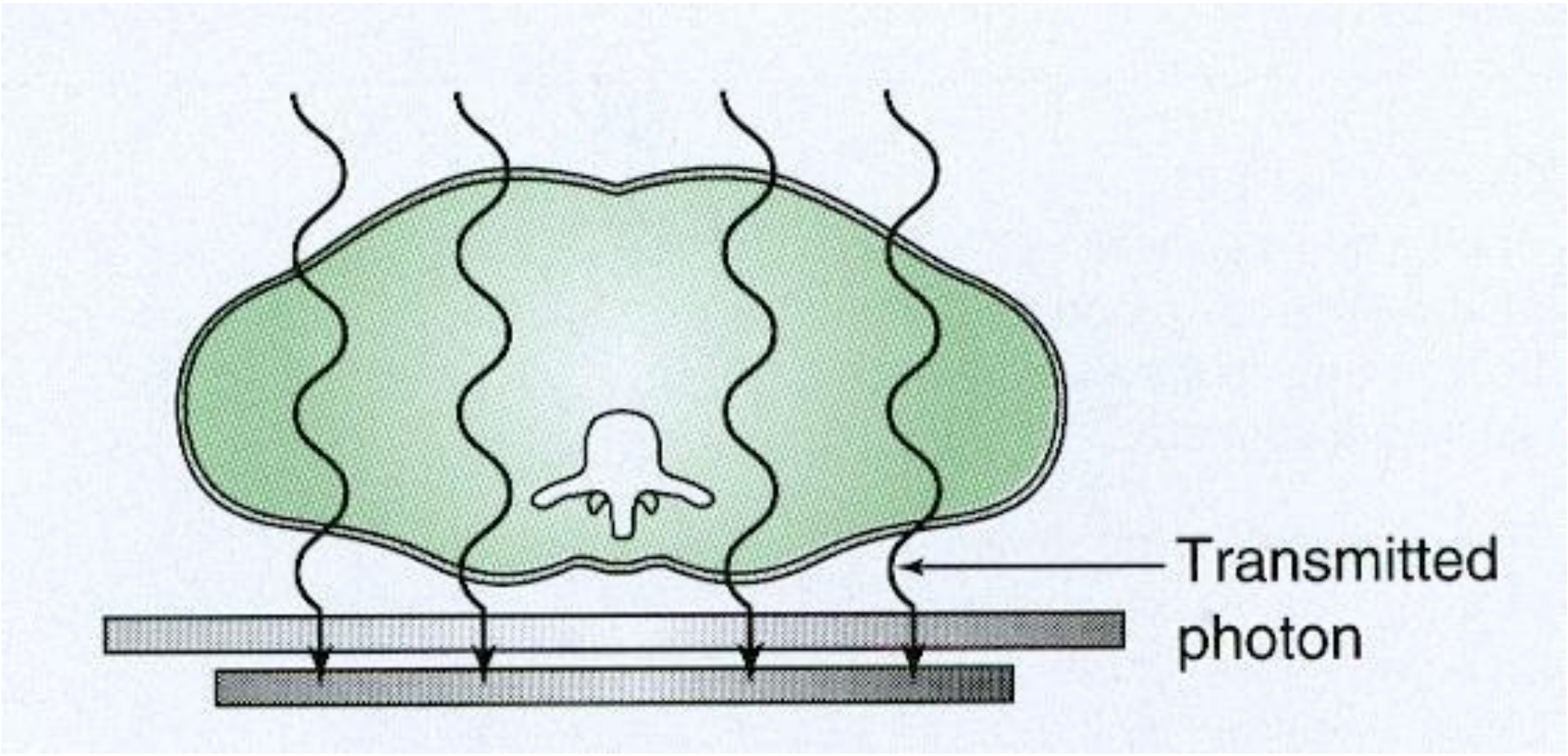
There is a vacancy in the inner orbital, K or L, which must be filled.

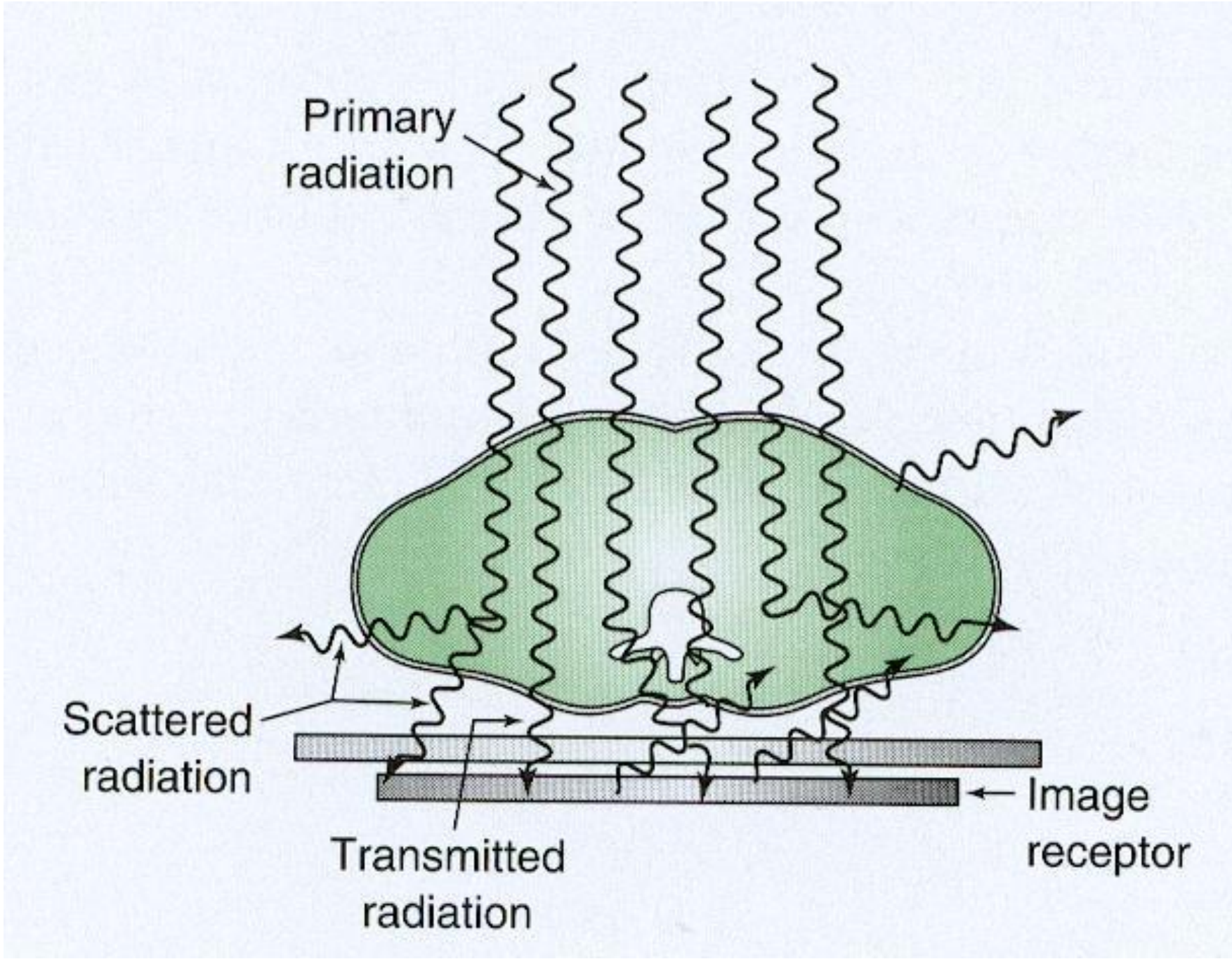
One of the electrons from outer orbital, usually the next orbit out, drops to the void.

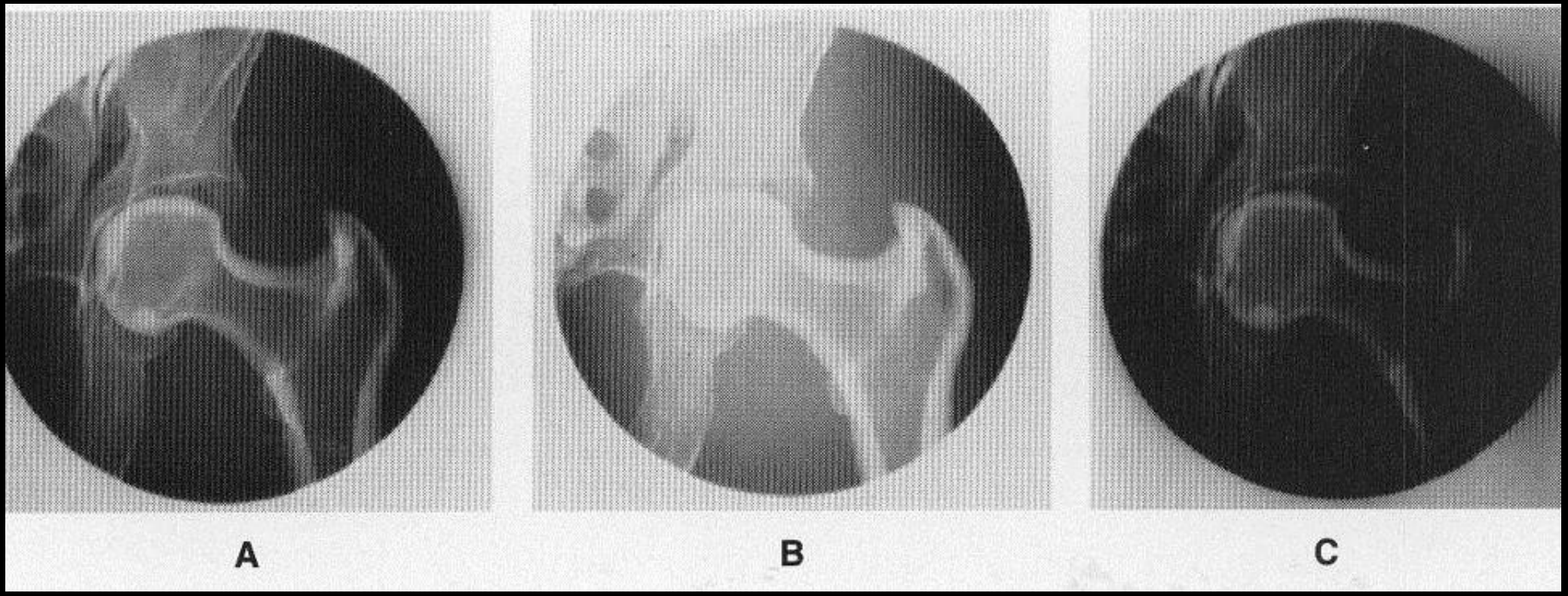
As the electron drops to the void, it may shed its excess energy as a secondary photon.



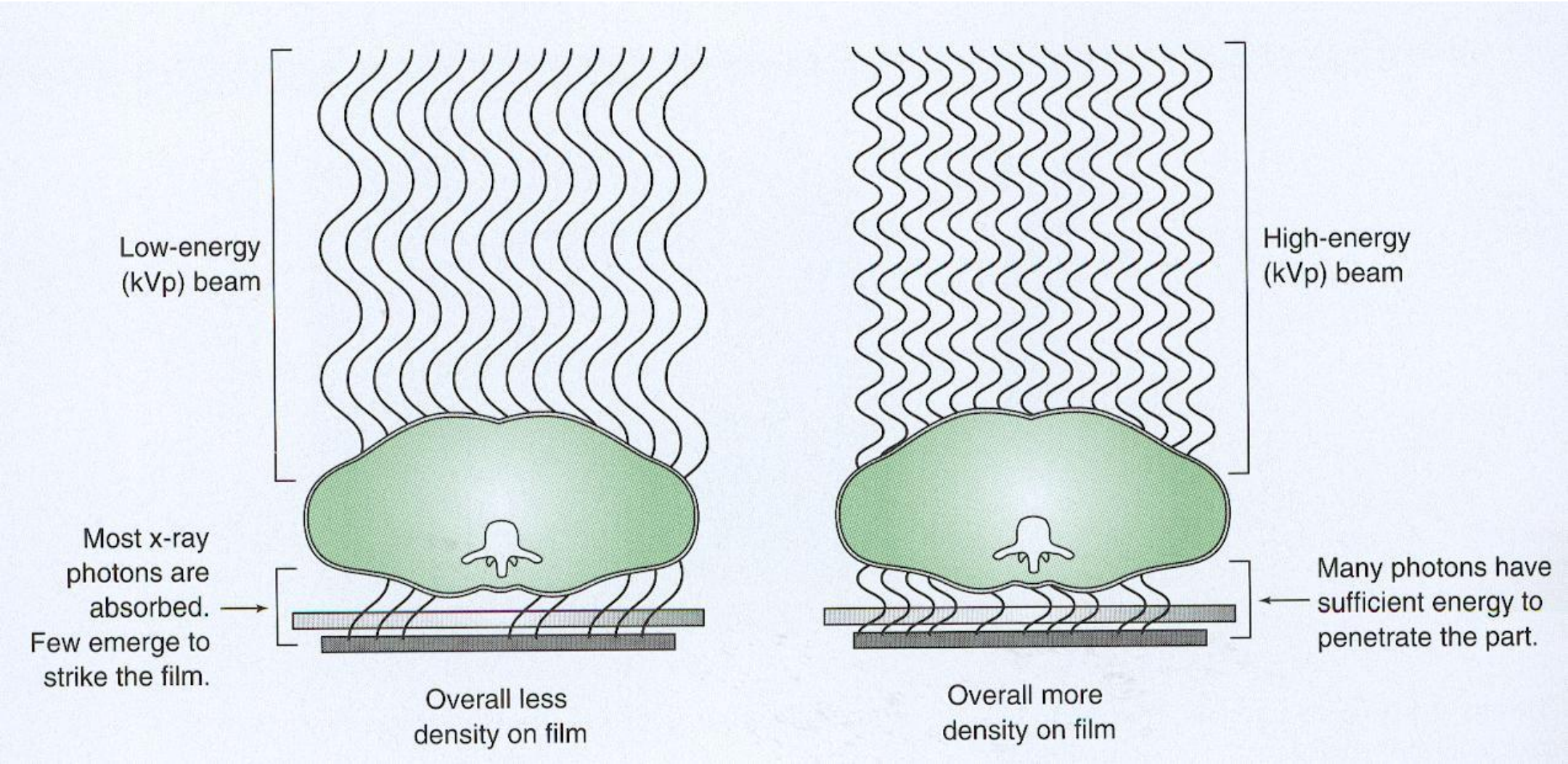

Compton effect
Photon interacts with outer orbital electron, imparting some of its energy to the electron, ejecting it from orbit.
The ejected electron (compton electron) leaves the atom with an energy equal to the excess imparted by the photon.
The photon continues on an altered path, scattered, with less energy (longer wavelength) than before the collision.


Transmitted
photon

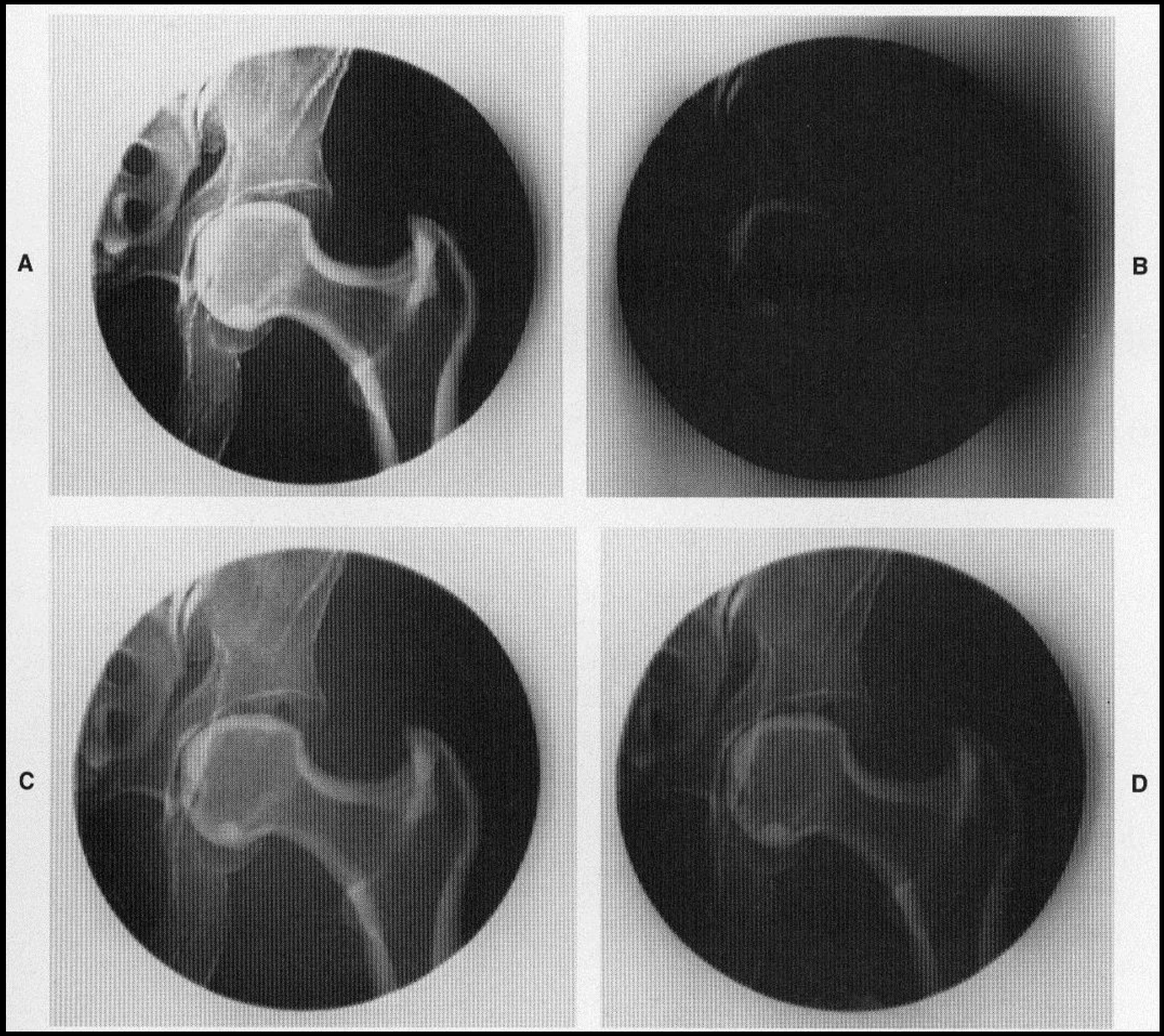

Primary
radiation
Scattered
radiation
Transmitted
radiation
Image
receptor



mAs ½ mAs mAs x 2


Low-energy
(kVp) beam
Most x-ray
photons are
absorbed.
Few emerge to
strike the film.
Overall less
density on film
High-energy
(kVp) beam
Many photons have
sufficient energy to
penetrate the part.
Overall more
density on film

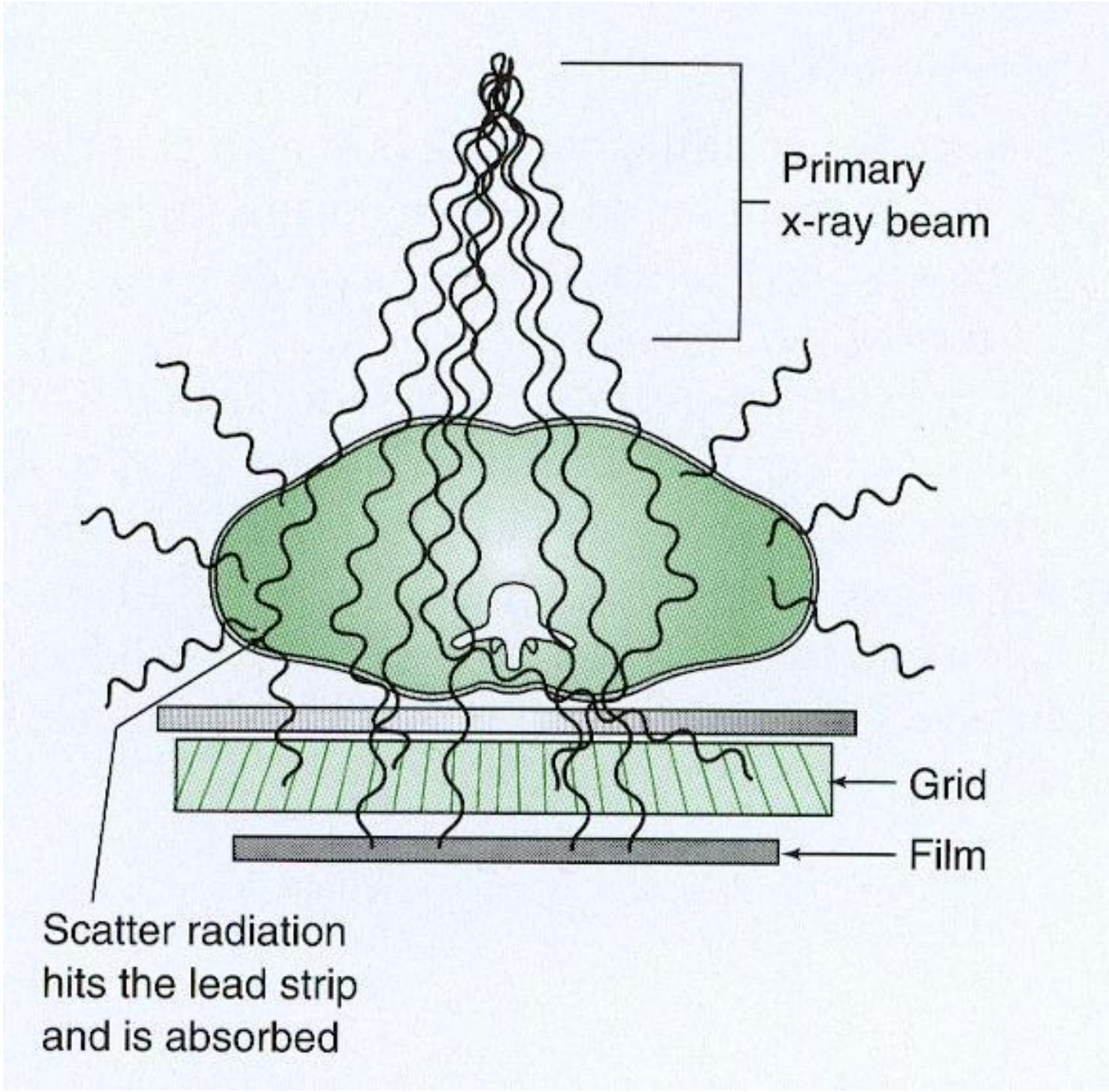
50 kV

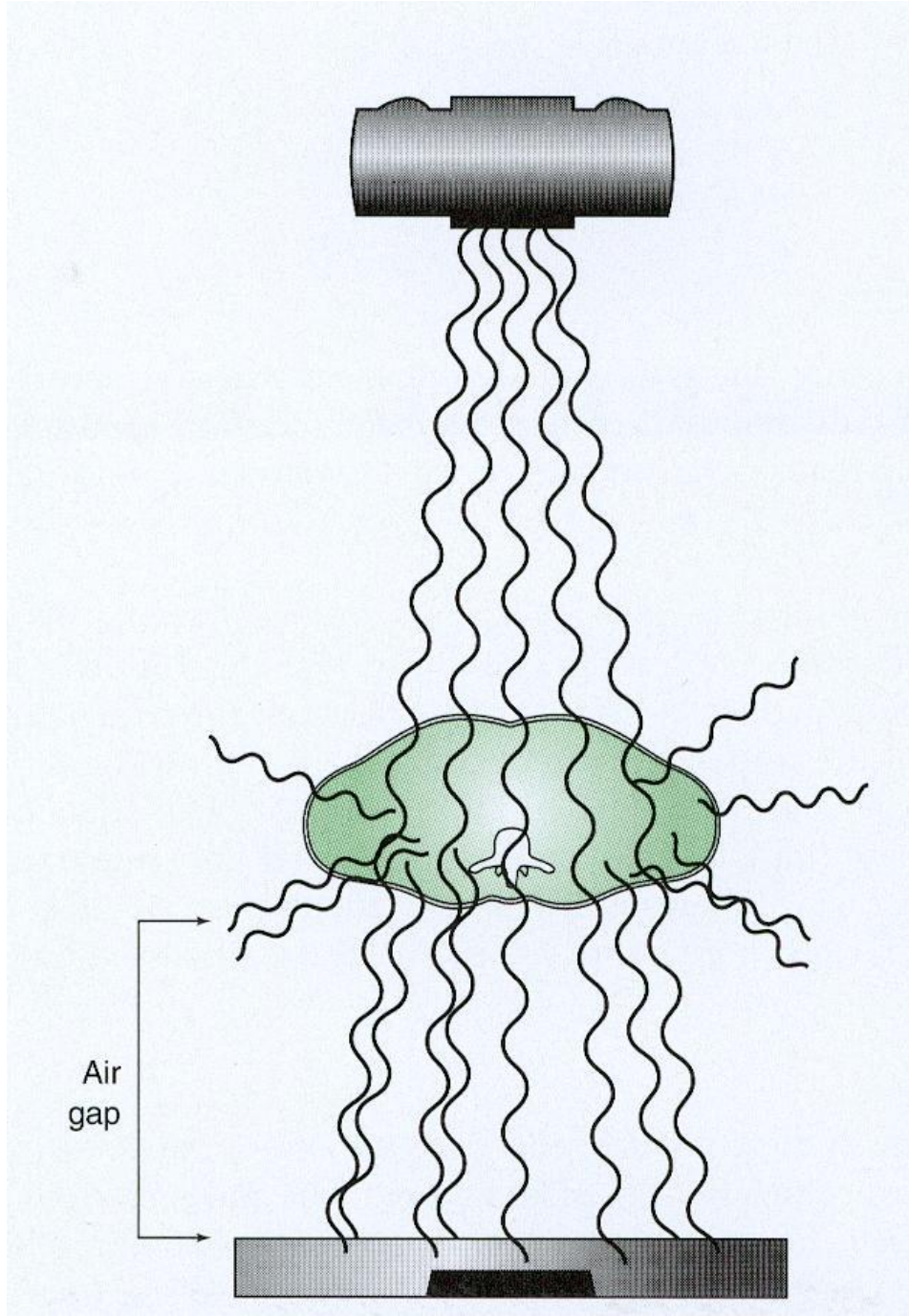


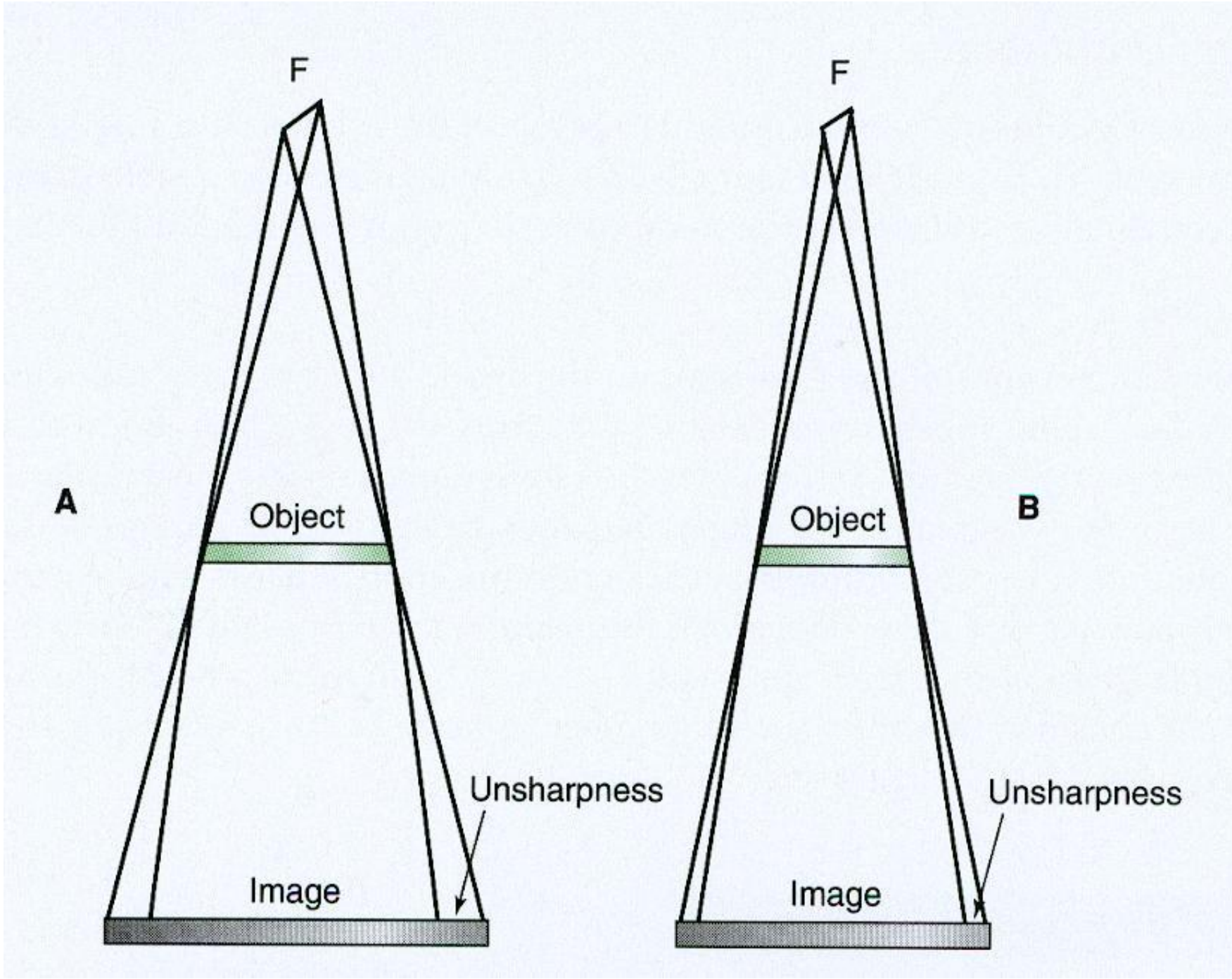
+10

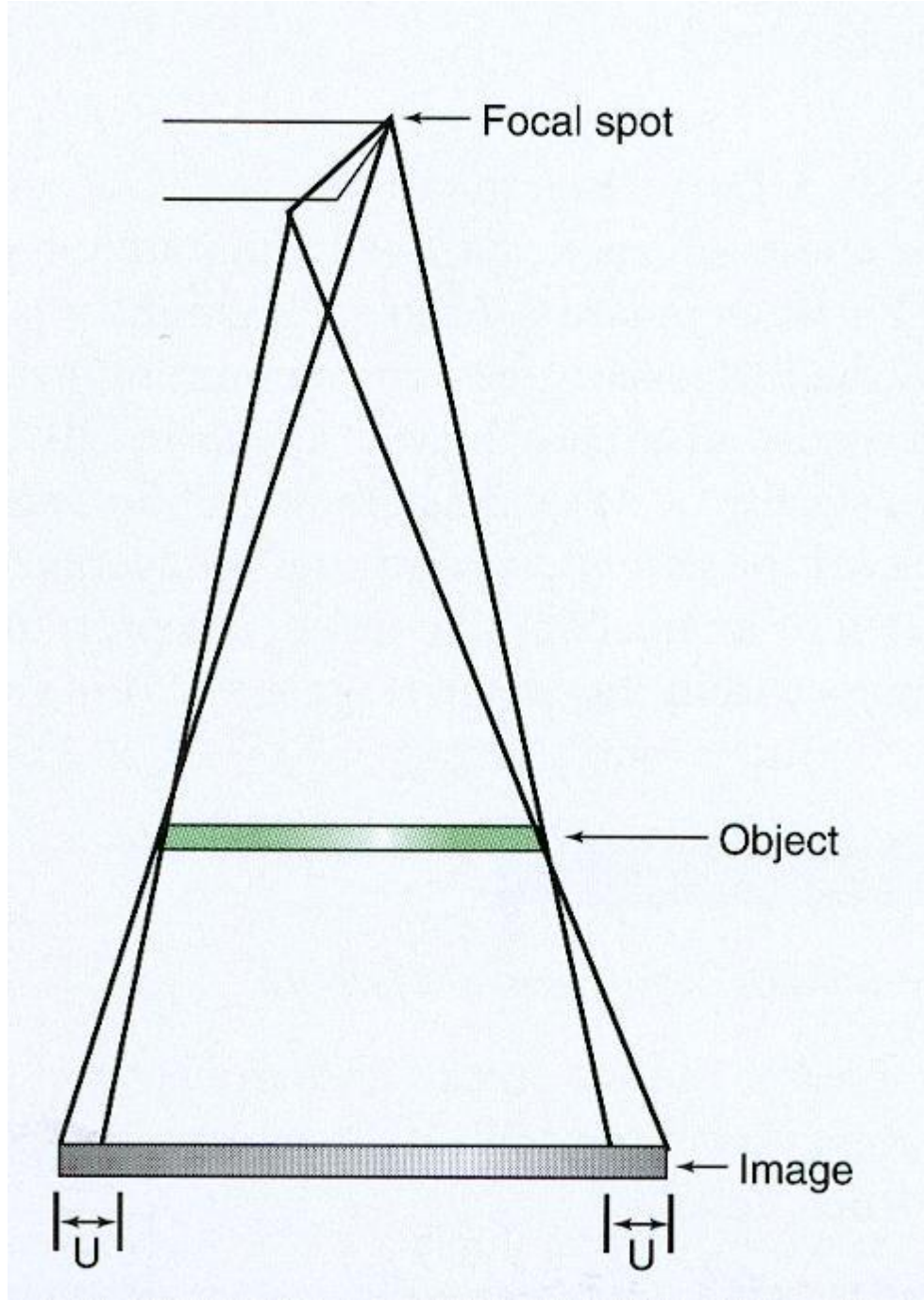
90 kV

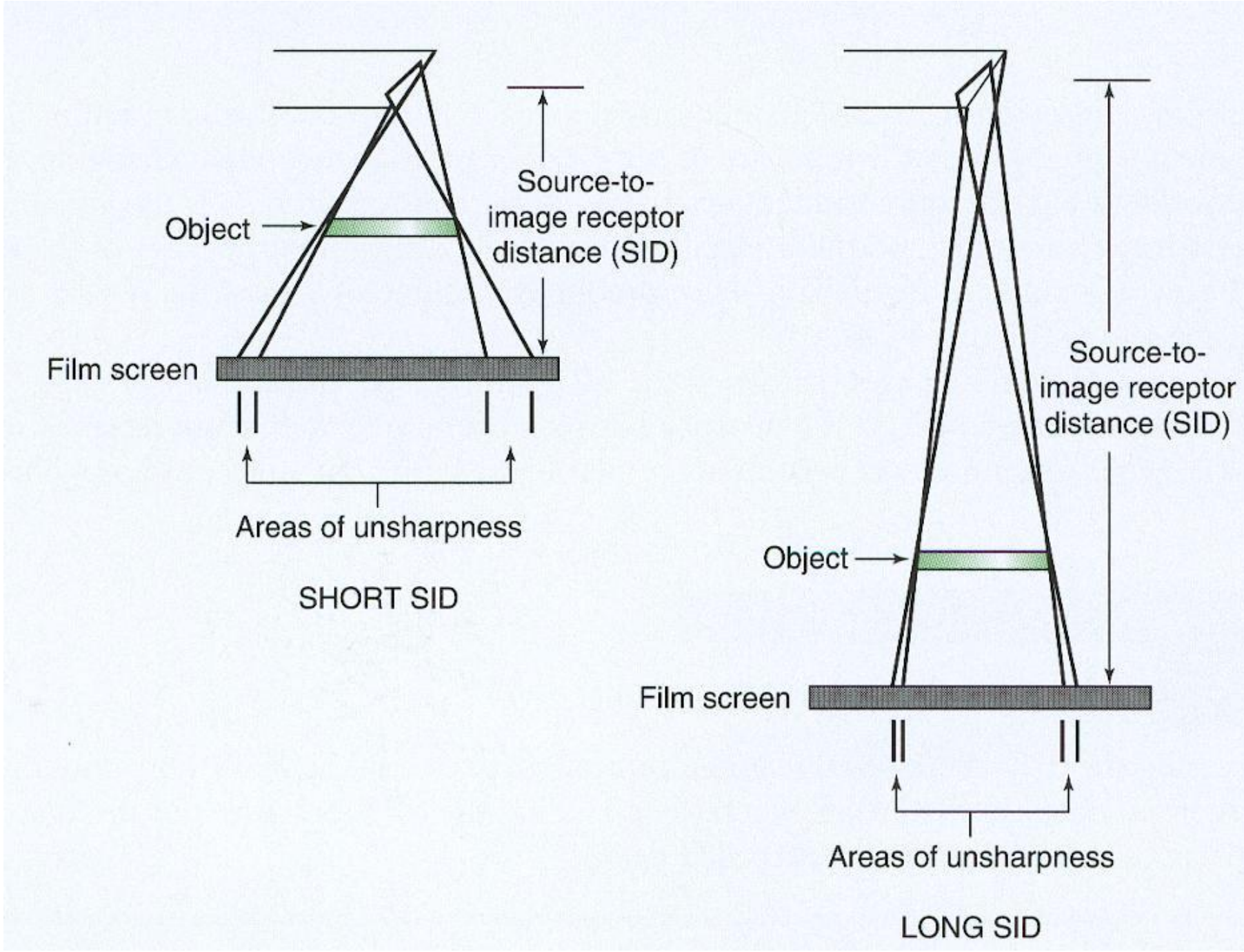
+10

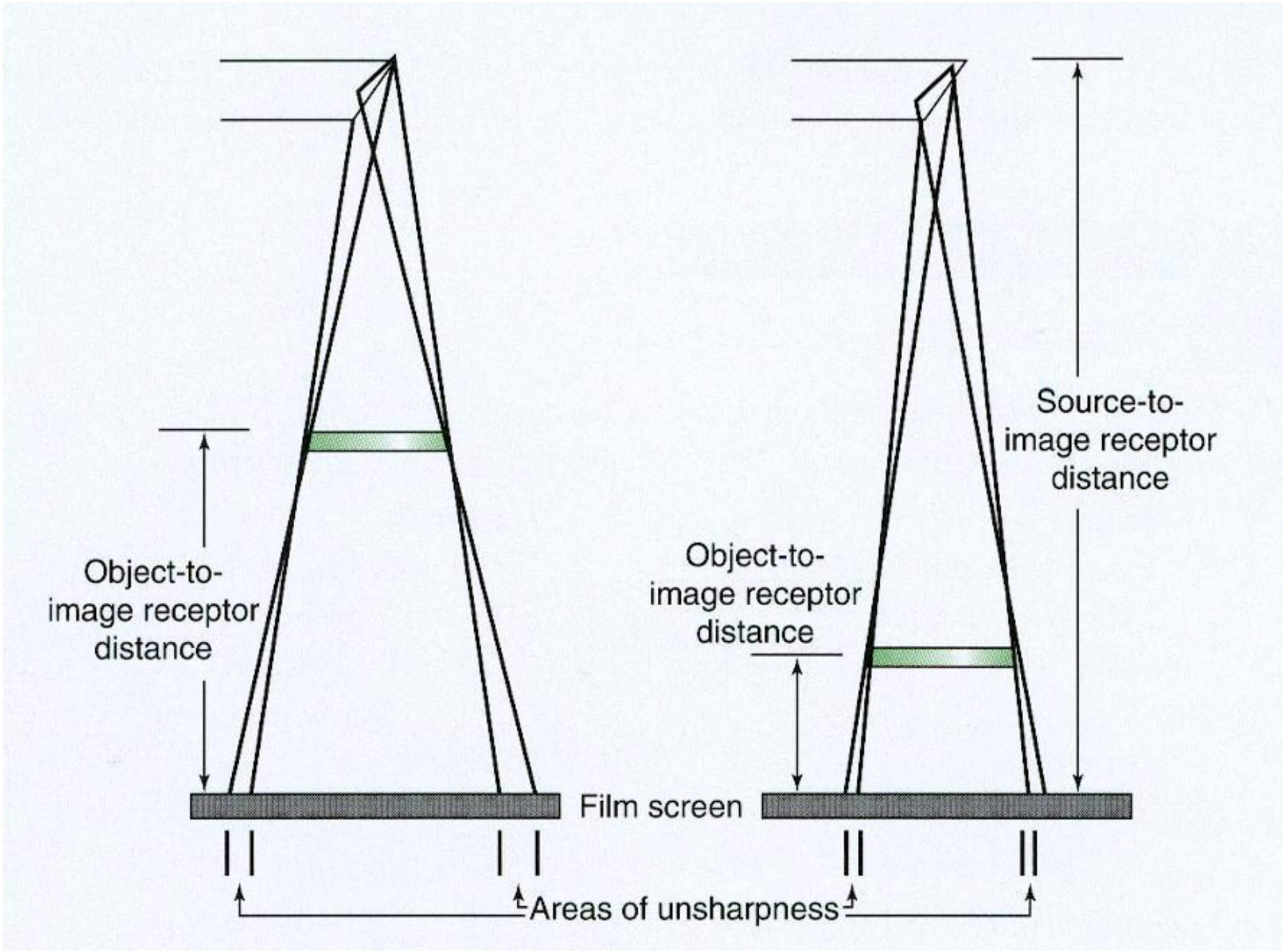

Primary
x-ray beam
Grid
Film
Scatter radiation
hits the lead strip
and is absorbed

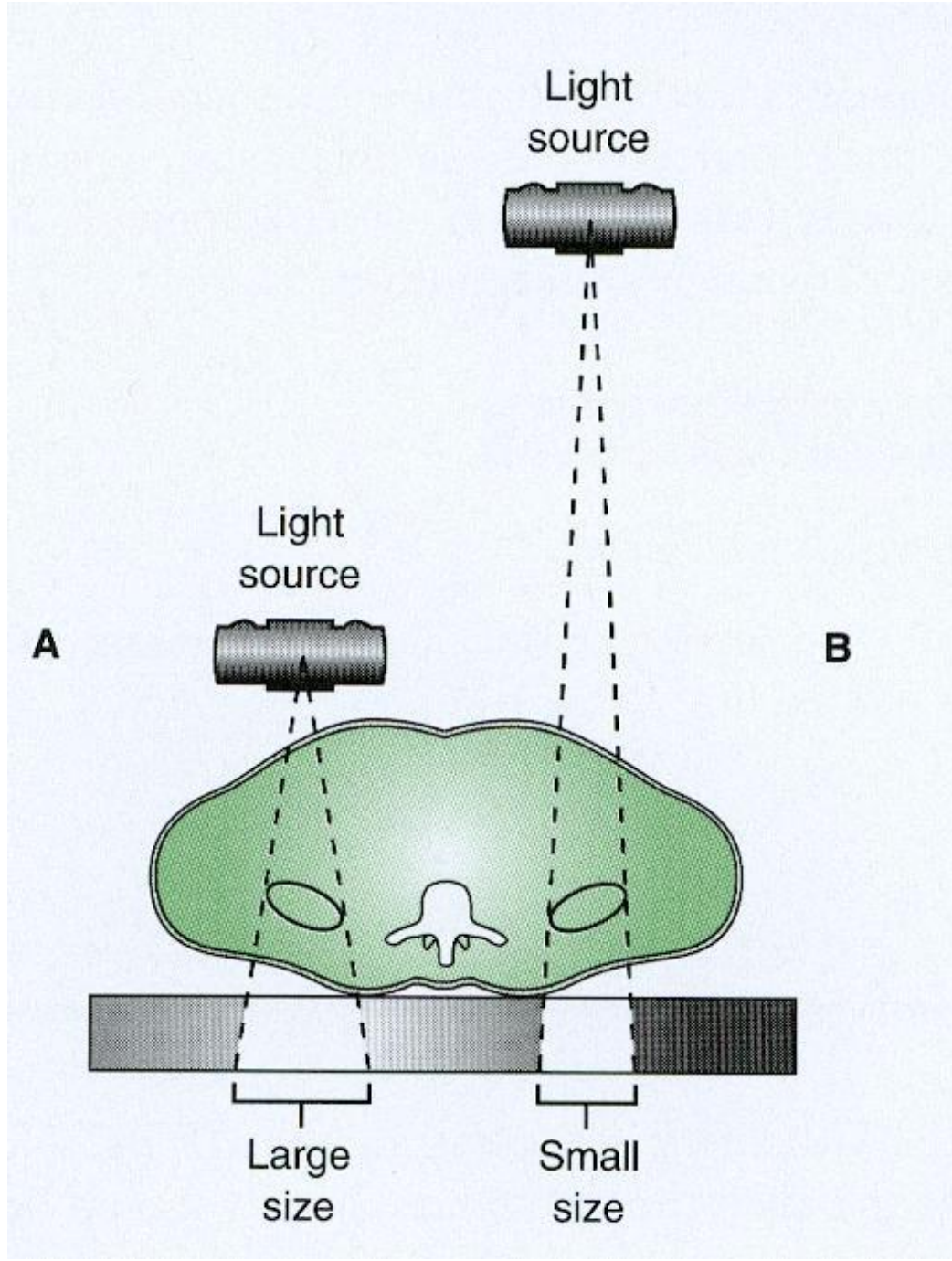

Air
gap

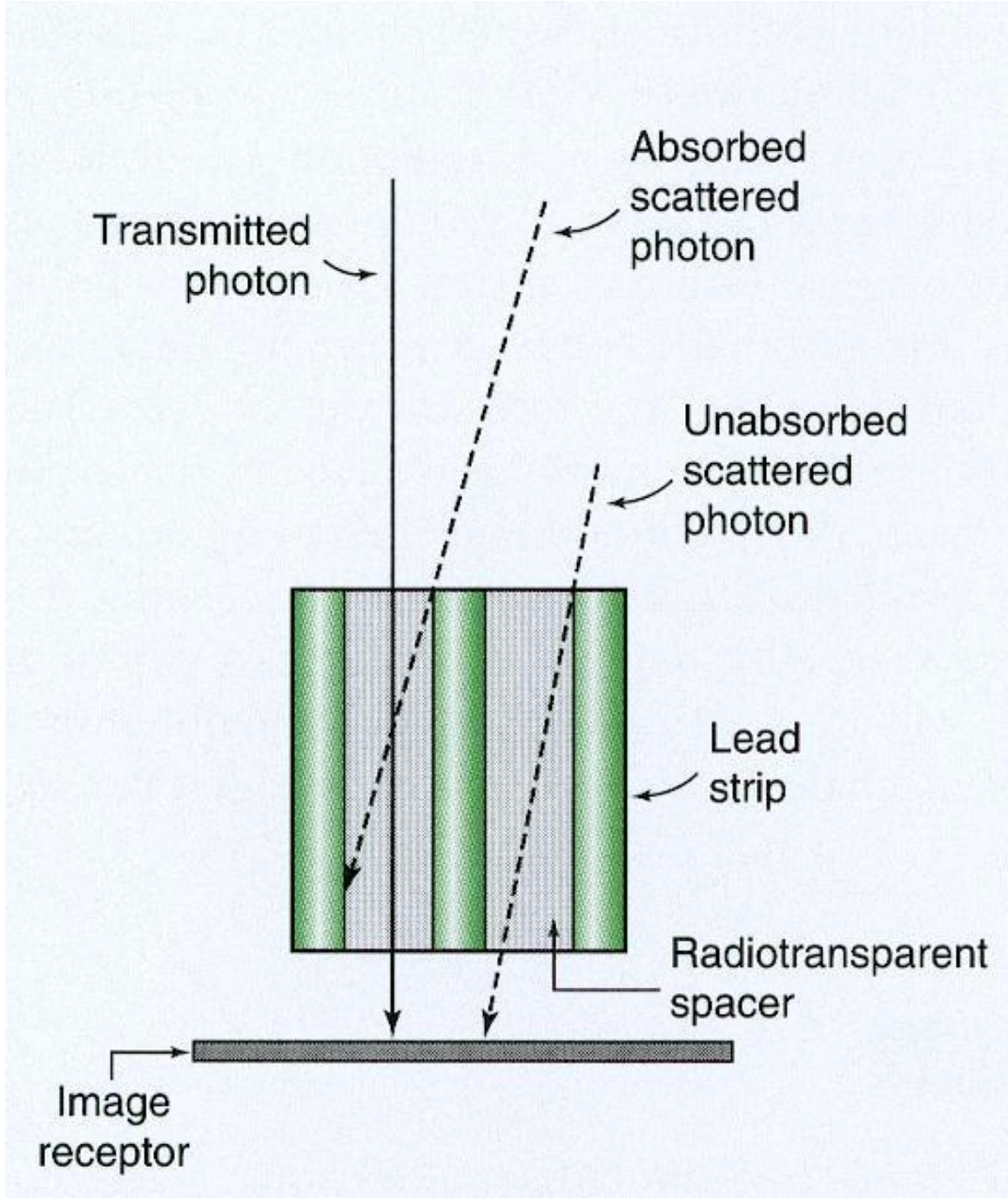

F
A
Object
Unsharpness
Image
F
Object
B
Unsharpness
Image

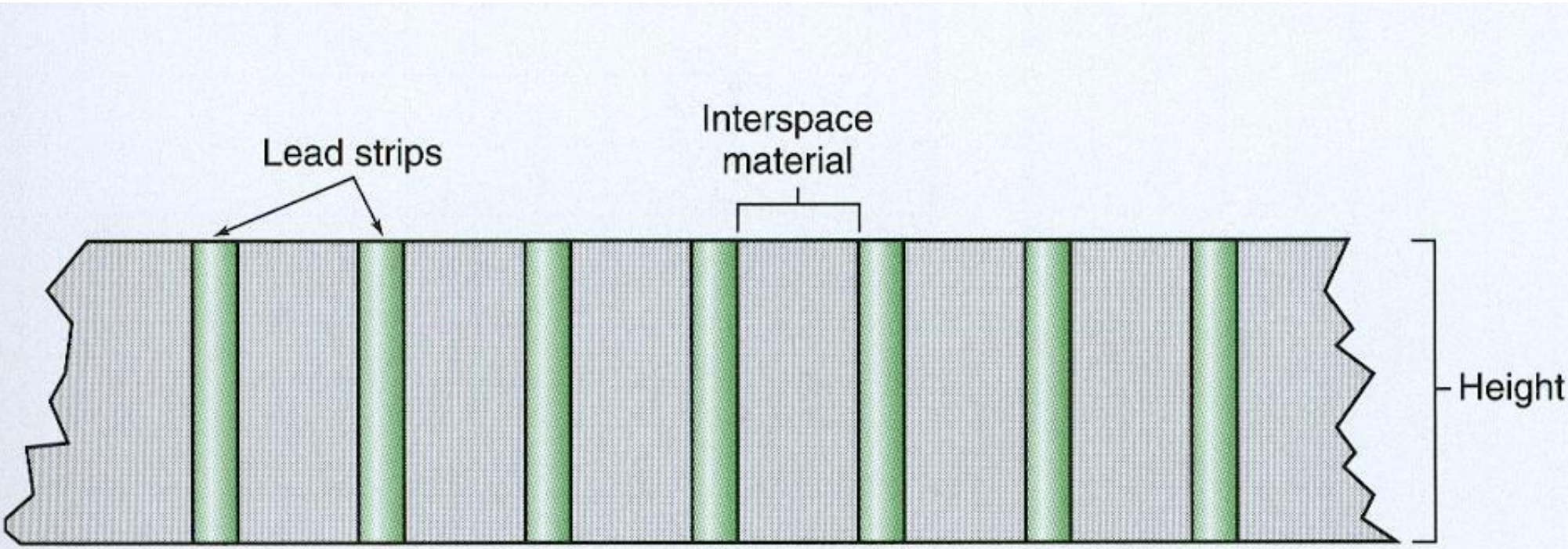

Focal spot
Object
Image
U
U


Source-to-
image receptor
distance (SID)
Object
Film screen
Areas of unsharpness
SHORT SID
Source-to-
image receptor
distance (SID)
Object
Film screen
Areas of unsharpness
LONG SID

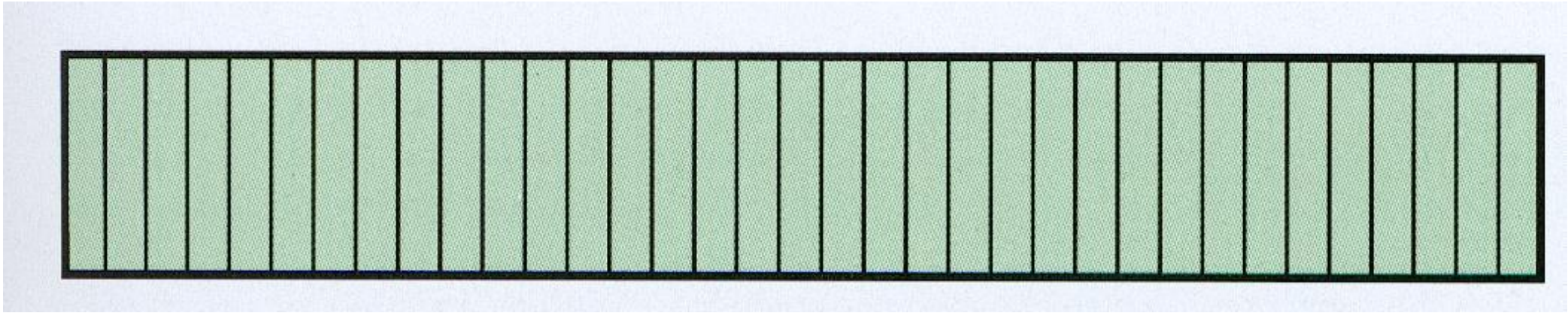

Object-to-
image receptor
distance
Film screen
Areas of unsharpness
Object-to-
image receptor
distance
Source-to-
image receptor
distance

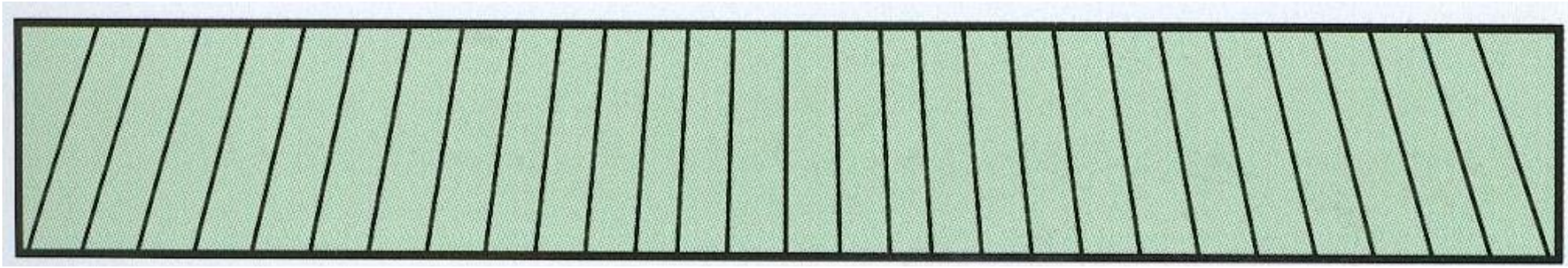

Light
source
Light
source
A
B
Large
size
Small
size

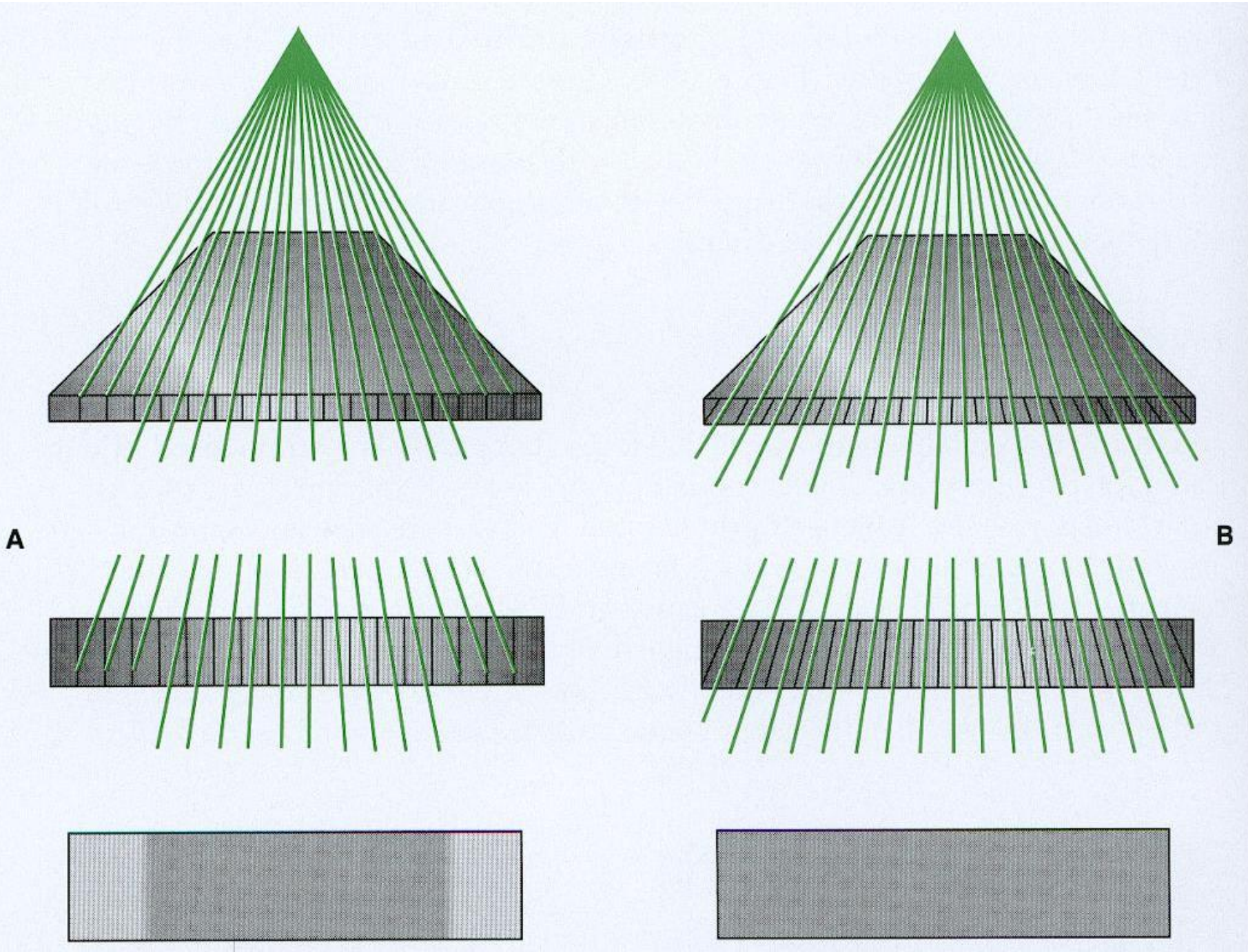

Absorbed
scattered
photon
Transmitted
photon
Unabsorbed
scattered
photon
Lead
strip
Radiotransparent
spacer
Image
receptor

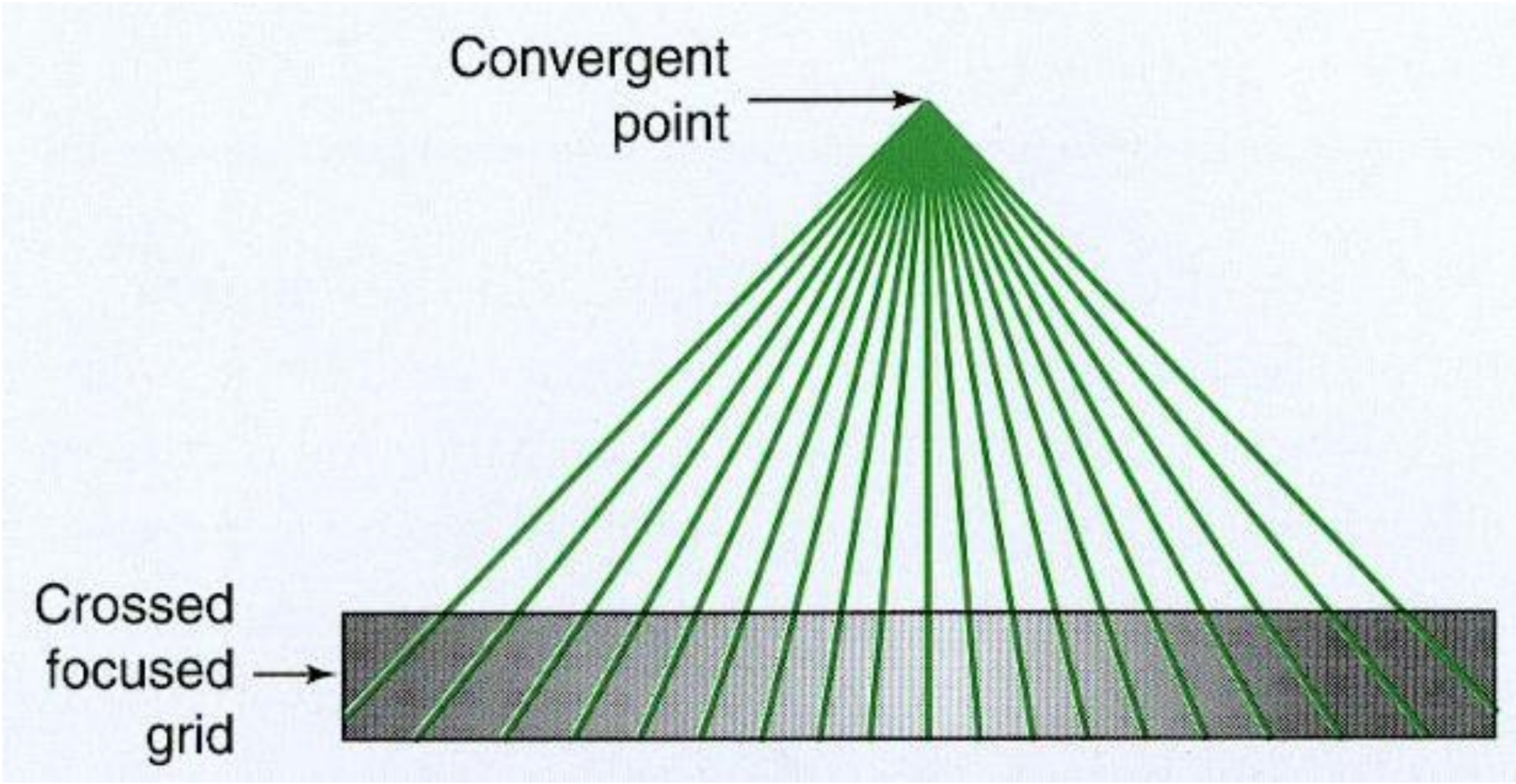


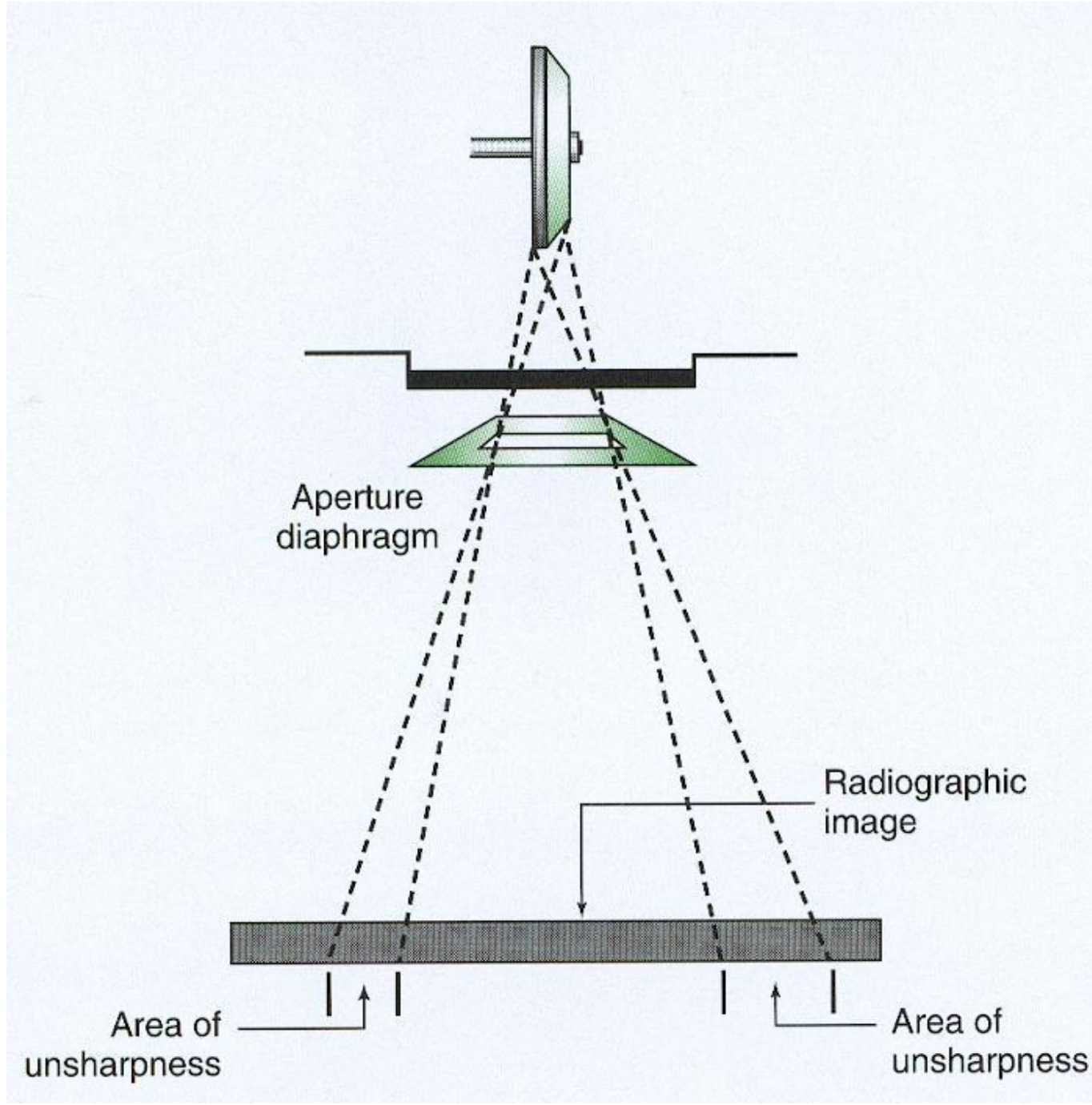
$$\text{Grid ratio: } \frac{\text{Height}}{\text{Width of interspace}}$$

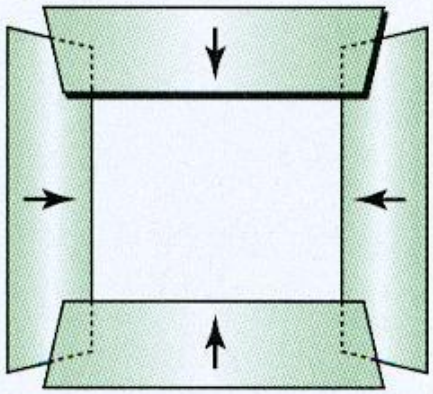




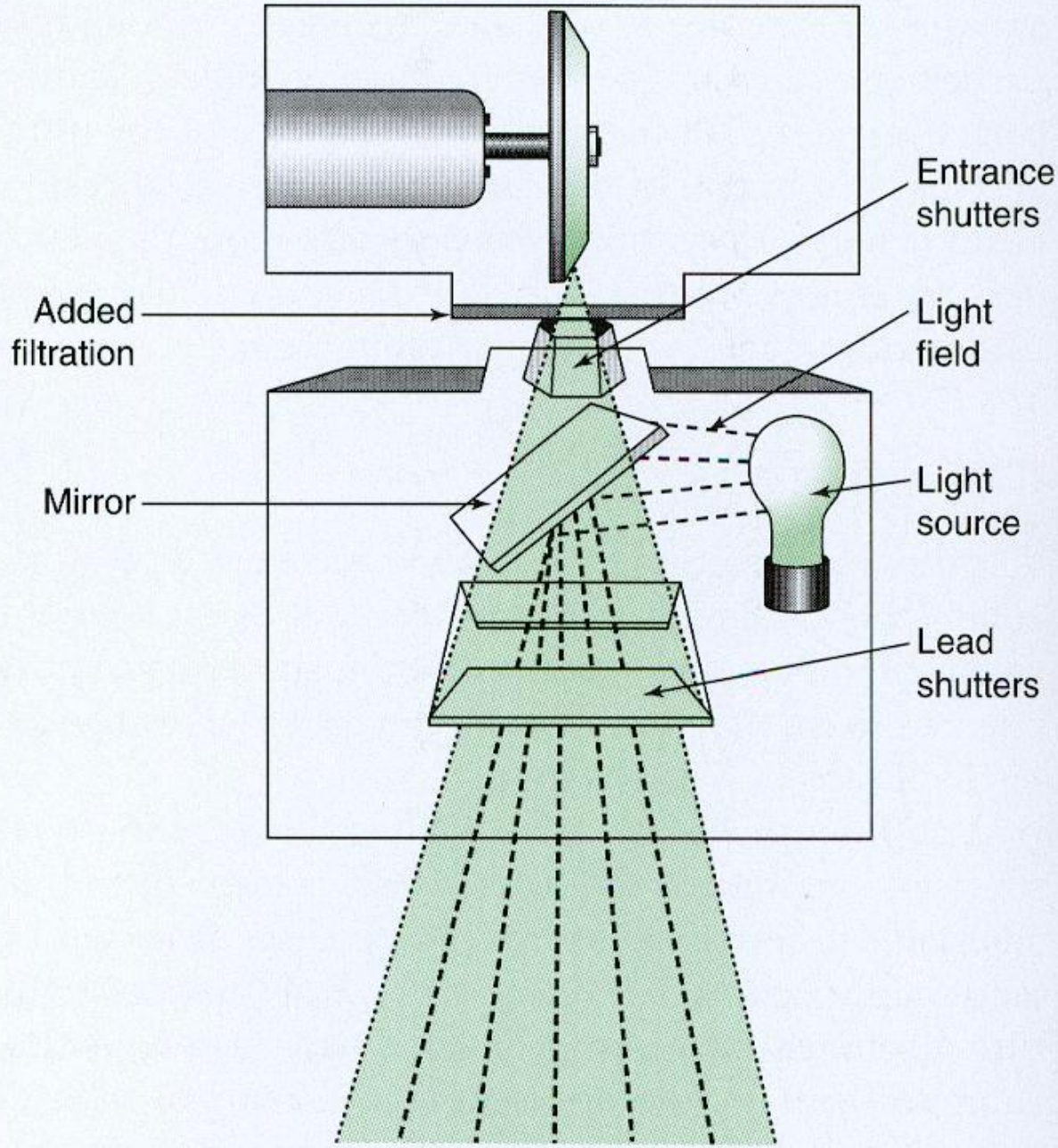

A
B

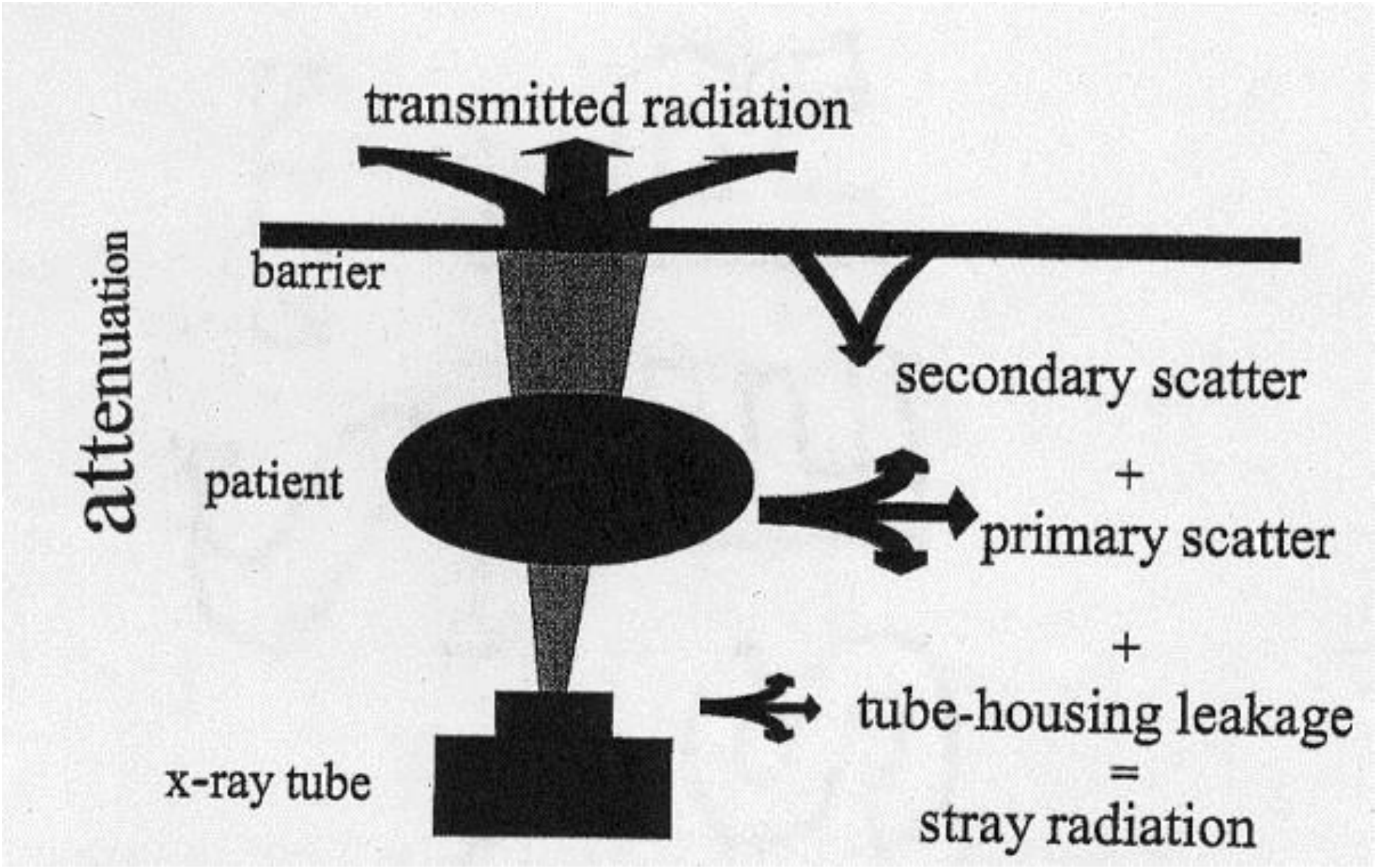

Convergent
point
Crossed
focused
grid

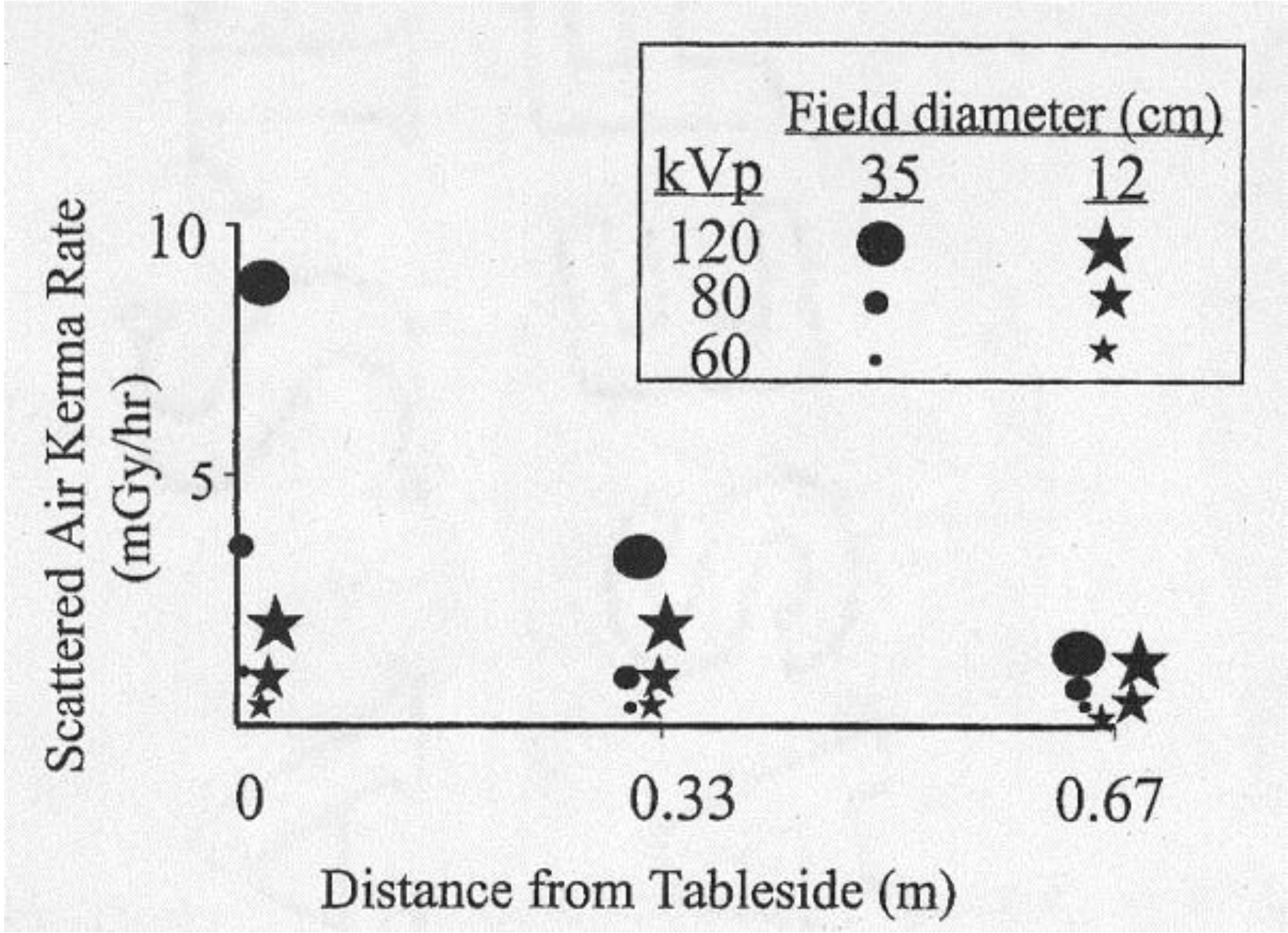

Aperture
diaphragm
Radiographic
image
Area of
unsharpness
Area of
unsharpness

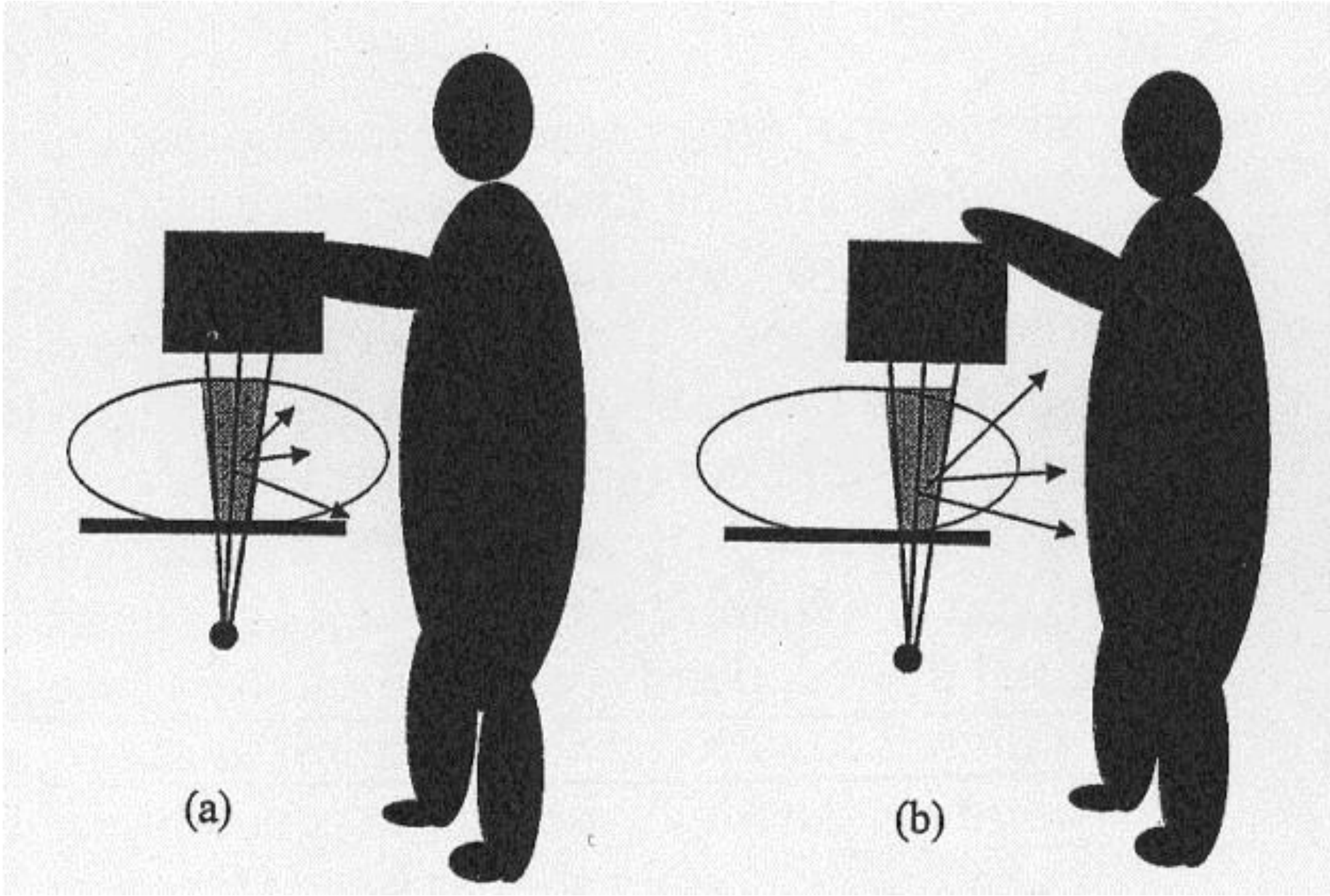


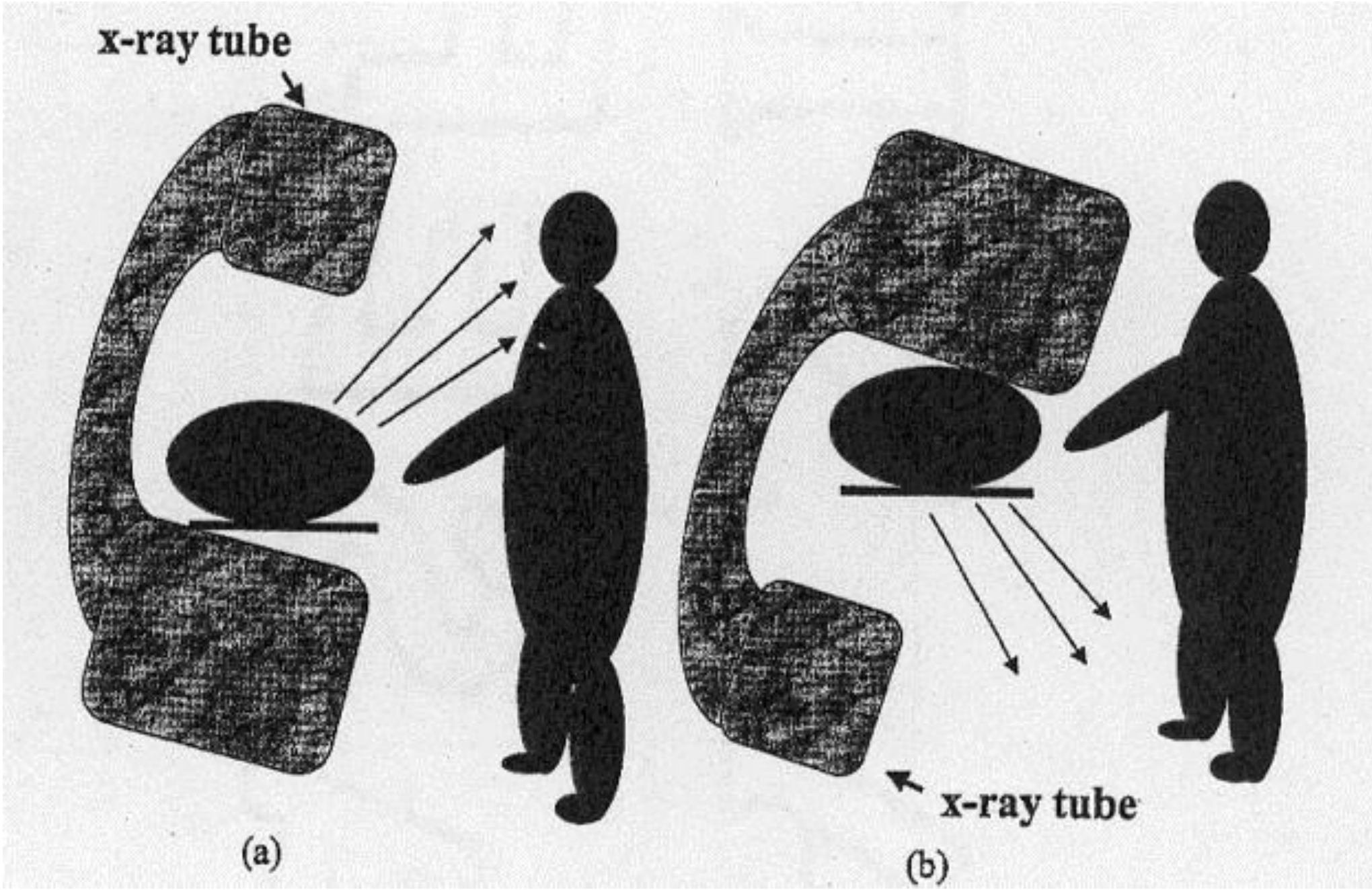
Top view
lead shutters

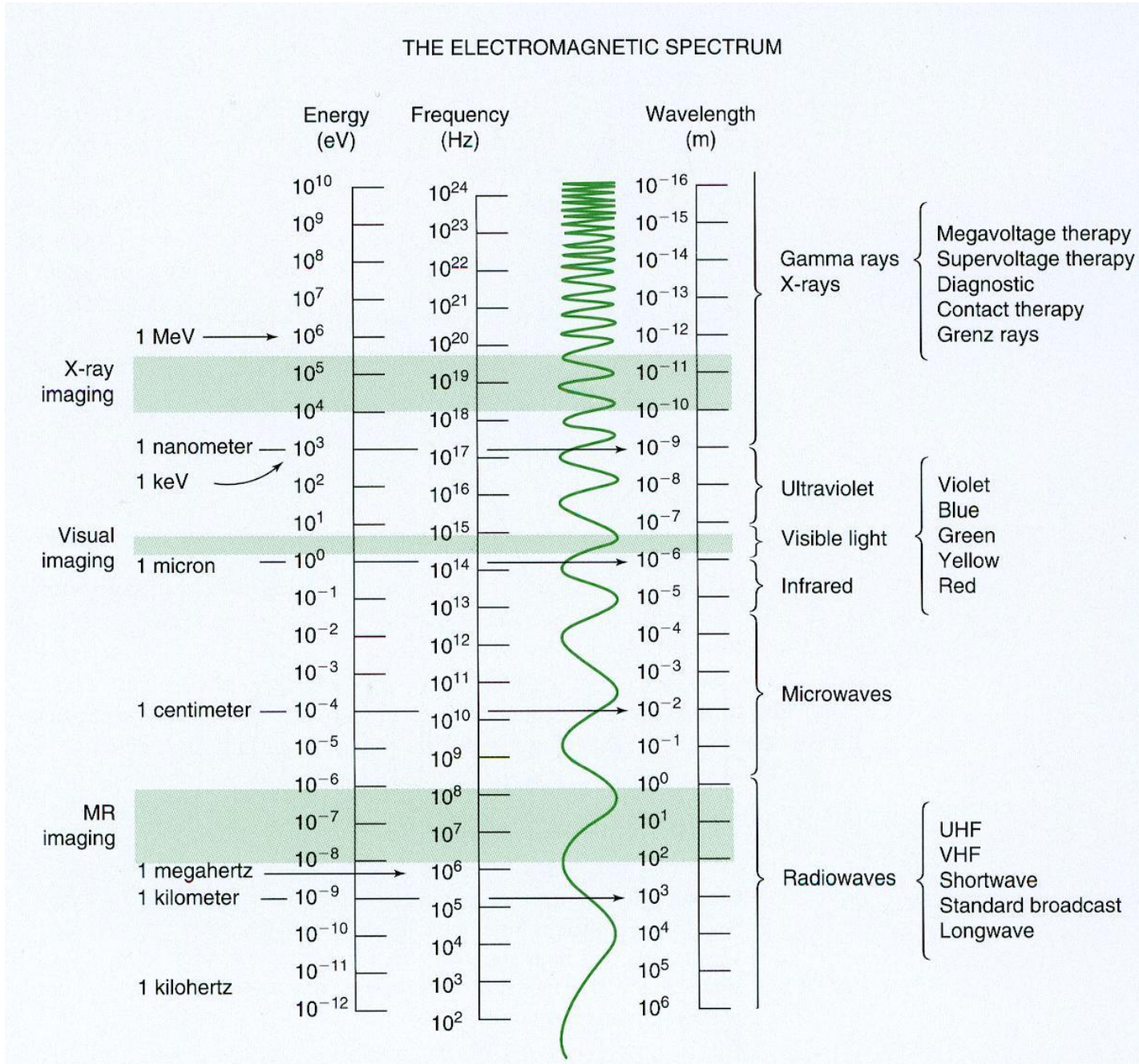



transmitted radiation
barrier
attenuation
secondary scatter
patient
+
primary scatter
+
tube-housing leakage
=
stray radiation
x-ray tube


Field diameter (cm)
kVp
35
12
120
80
60
Scattered Air Kerma Rate (mGy/hr)
10
5
0
0.33
0.67
Distance from Tableside (m)


(a)
(b)


x-ray tube
x-ray tube
(a)
(b)


THE ELECTROMAGNETIC SPECTRUM
Energy (eV)
Frequency (Hz)
Wavelength (m)
10^{10} 10^{9} 10^{8} 10^{7} 10^{6} 10^{5} 10^{4} 10^{3} 10^{2} 10^{1} 10^{0} 10^{-1} 10^{-2} 10^{-3} 10^{-4} 10^{-5} 10^{-6} 10^{-7} 10^{-8} 10^{-9} 10^{-10} 10^{-11} 10^{-12}
10^{24} 10^{23} 10^{22} 10^{21} 10^{20} 10^{19} 10^{18} 10^{17} 10^{16} 10^{15} 10^{14} 10^{13} 10^{12} 10^{11} 10^{10} 10^{9} 10^{8} 10^{7} 10^{6} 10^{5} 10^{4} 10^{3} 10^{2}
10^{-16} 10^{-15} 10^{-14} 10^{-13} 10^{-12} 10^{-11} 10^{-10} 10^{-9} 10^{-8} 10^{-7} 10^{-6} 10^{-5} 10^{-4} 10^{-3} 10^{-2} 10^{-1} 10^{0} 10^{1} 10^{2} 10^{3} 10^{4} 10^{5} 10^{6}
1 MeV
X-ray imaging
1 nanometer
1 keV
Visual imaging
1 micron
1 centimeter
MR imaging
1 megahertz
1 kilometer
1 kilohertz
Gamma rays
X-rays
Megavoltage therapy
Supervoltage therapy
Diagnostic
Contact therapy
Grenz rays
Ultraviolet
Visible light
Infrared
Violet
Blue
Green
Yellow
Red
Microwaves
Radiowaves
UHF
VHF
Shortwave
Standard broadcast
Longwave