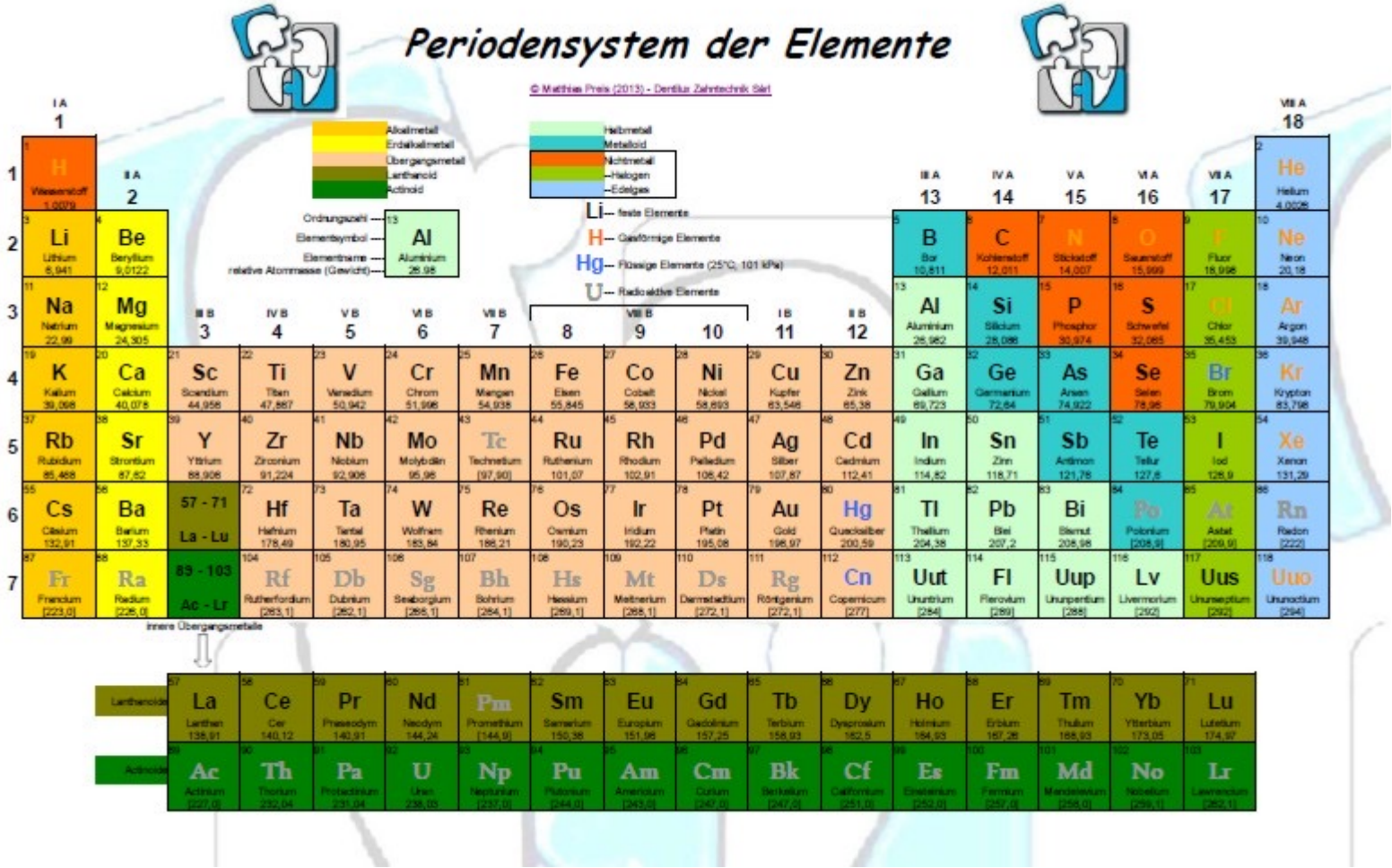
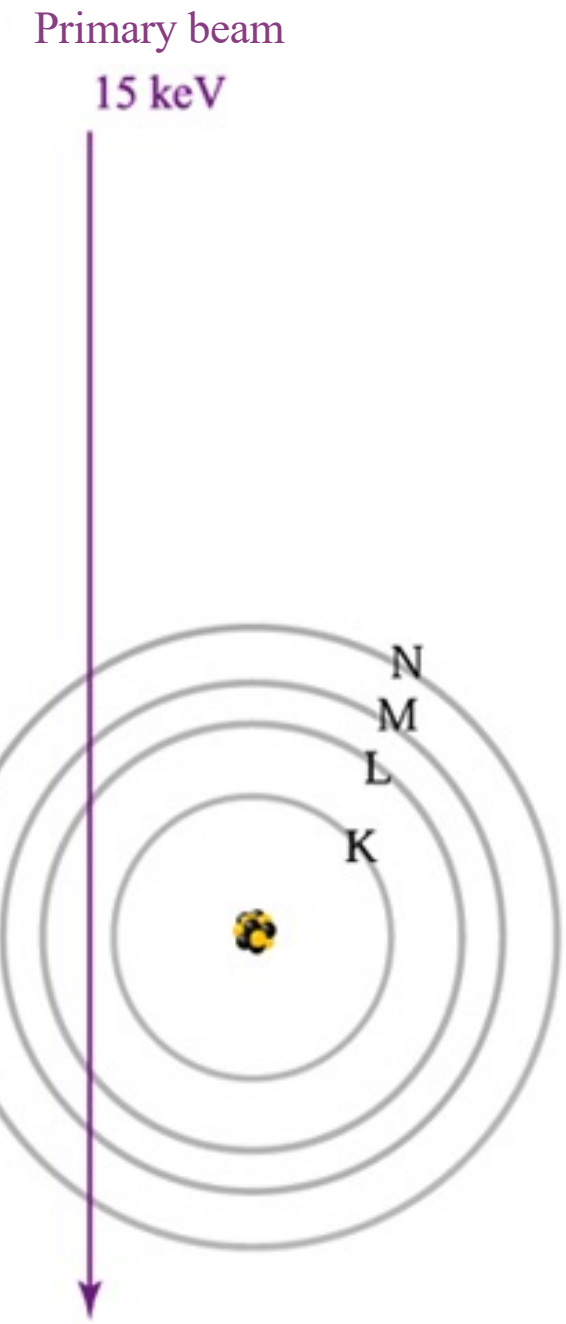
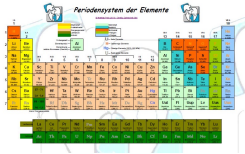
Theory:
Interaction of electrons with matter



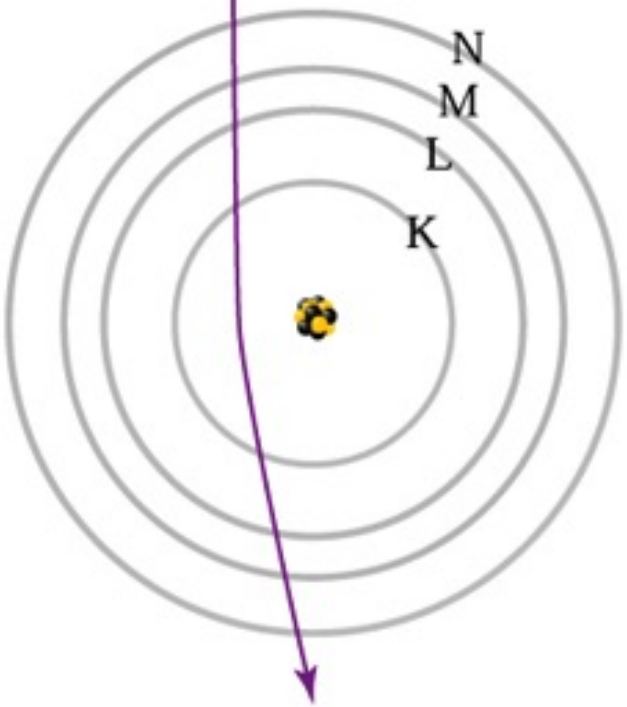
http://www.dentilux.com/services/services.htm

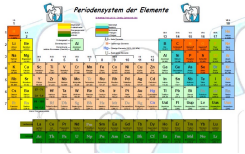

Primary beam
15 keV
N
M
L
K



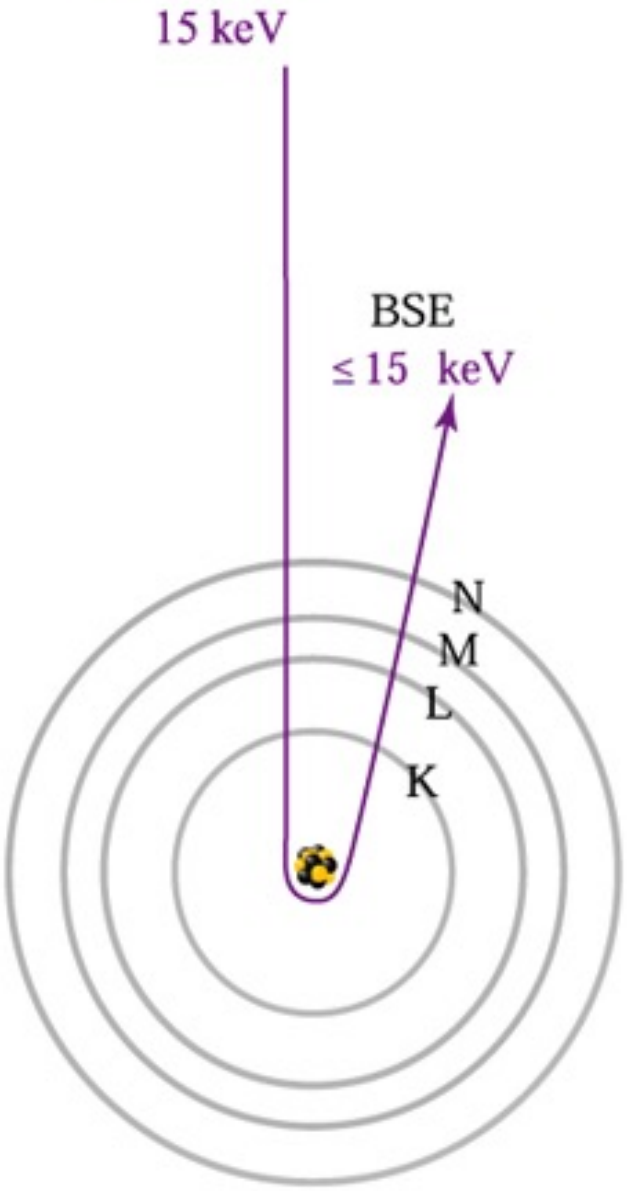
Primary beam

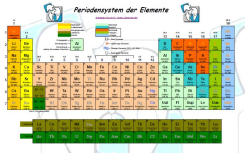
15 keV





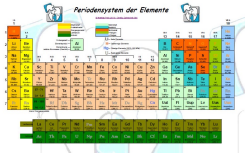
Primary beam

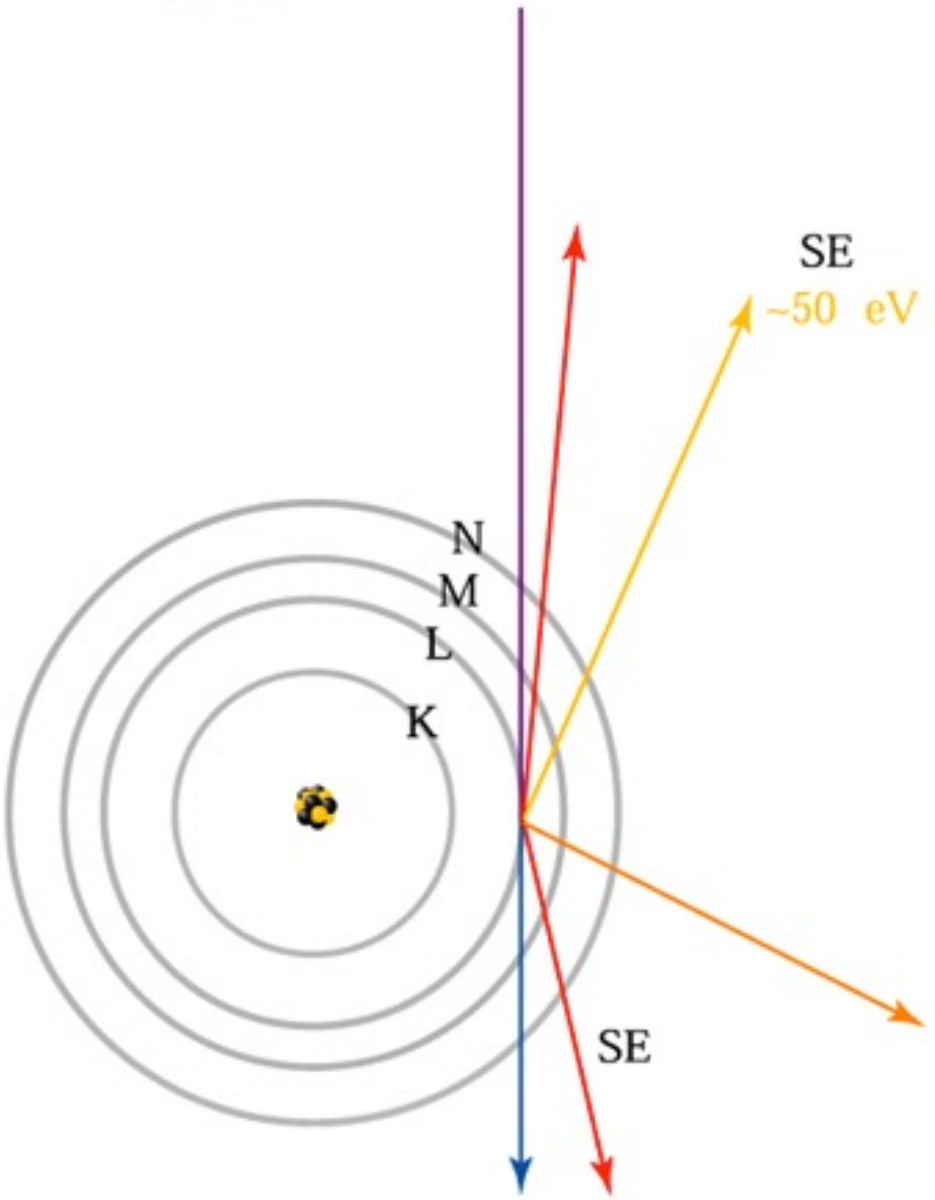




Primary beam

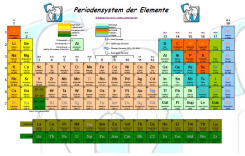
15 keV

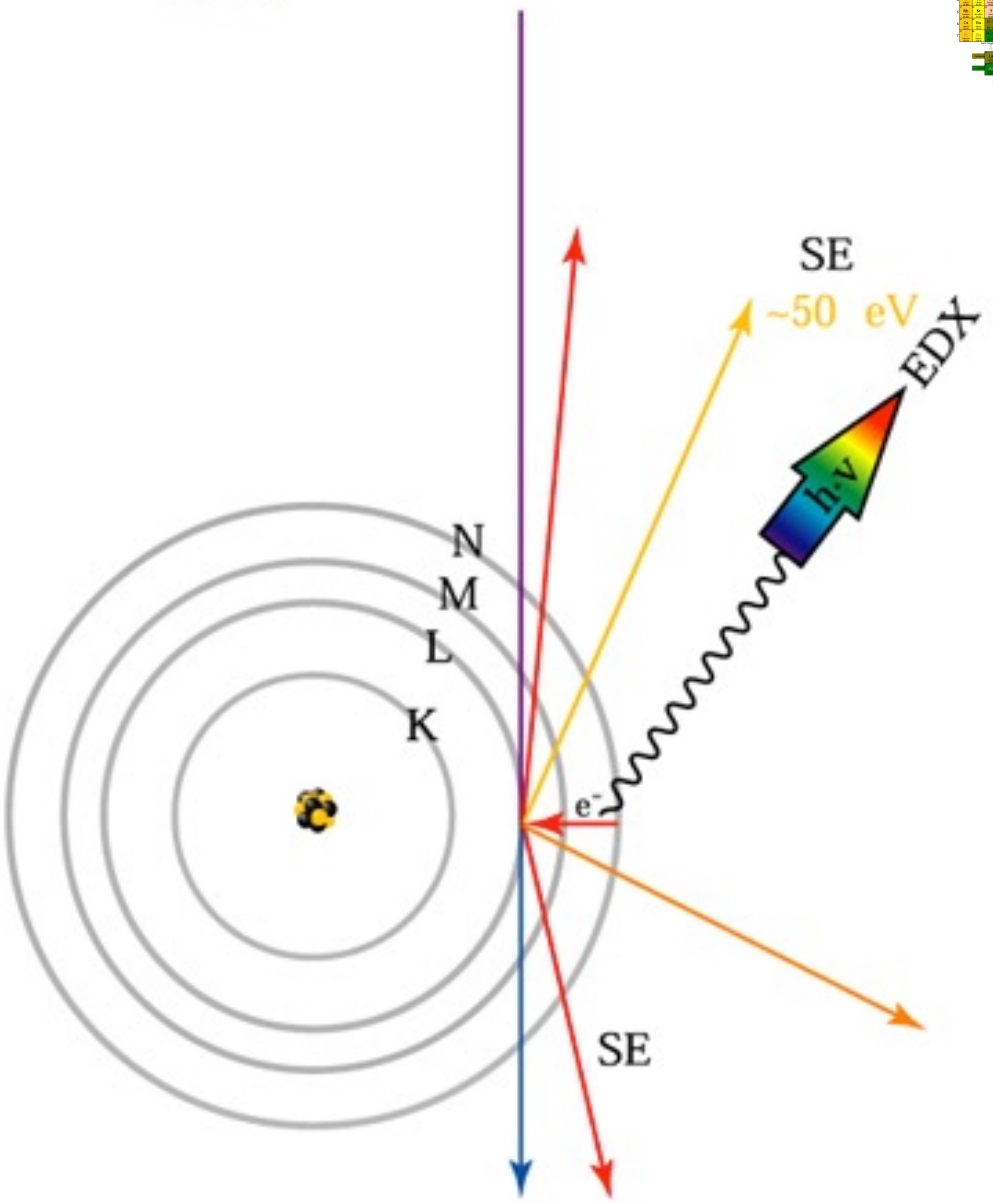




Primary beam

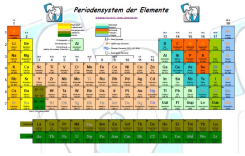
15 keV

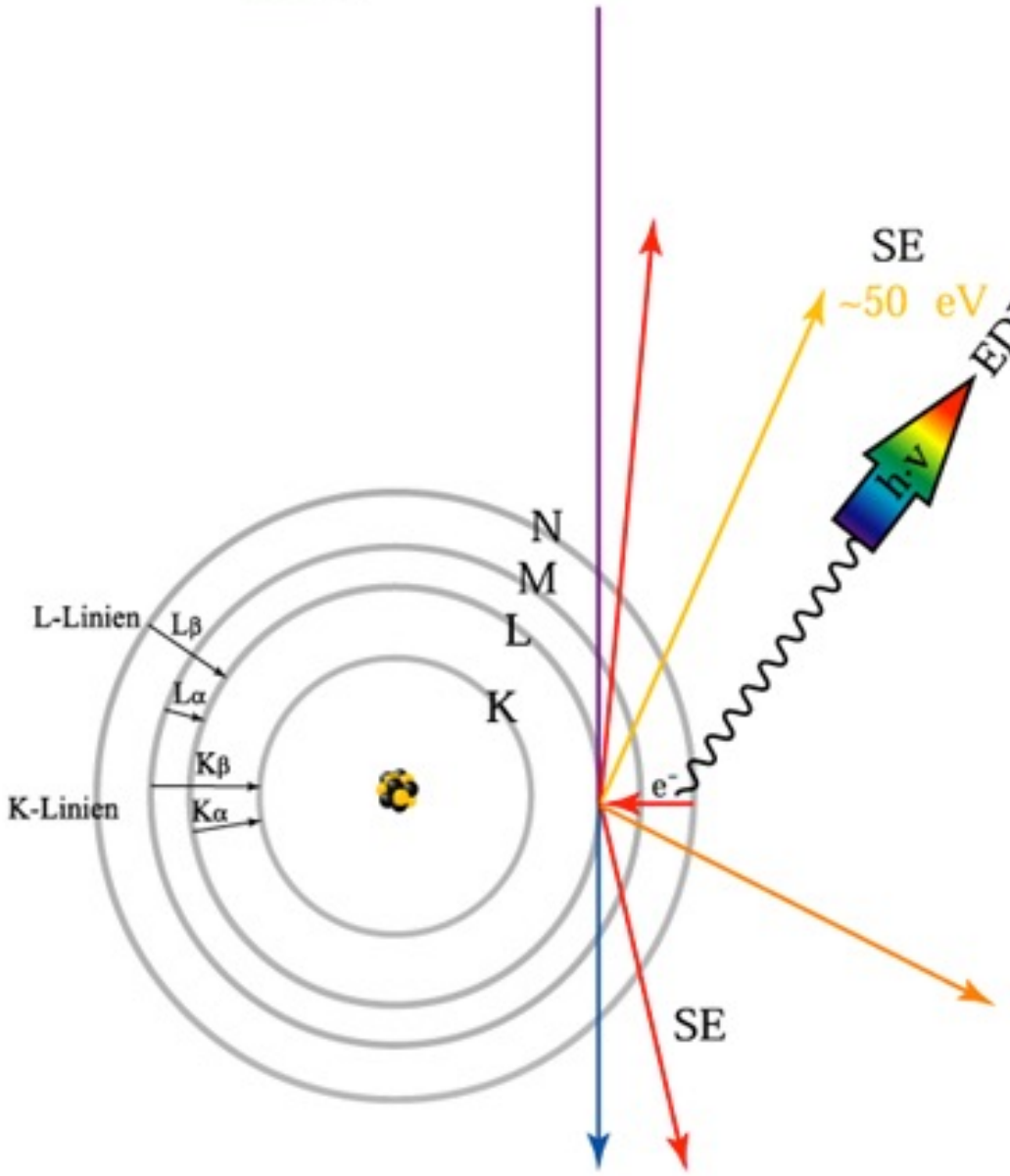




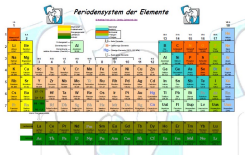
Primary beam

15 keV





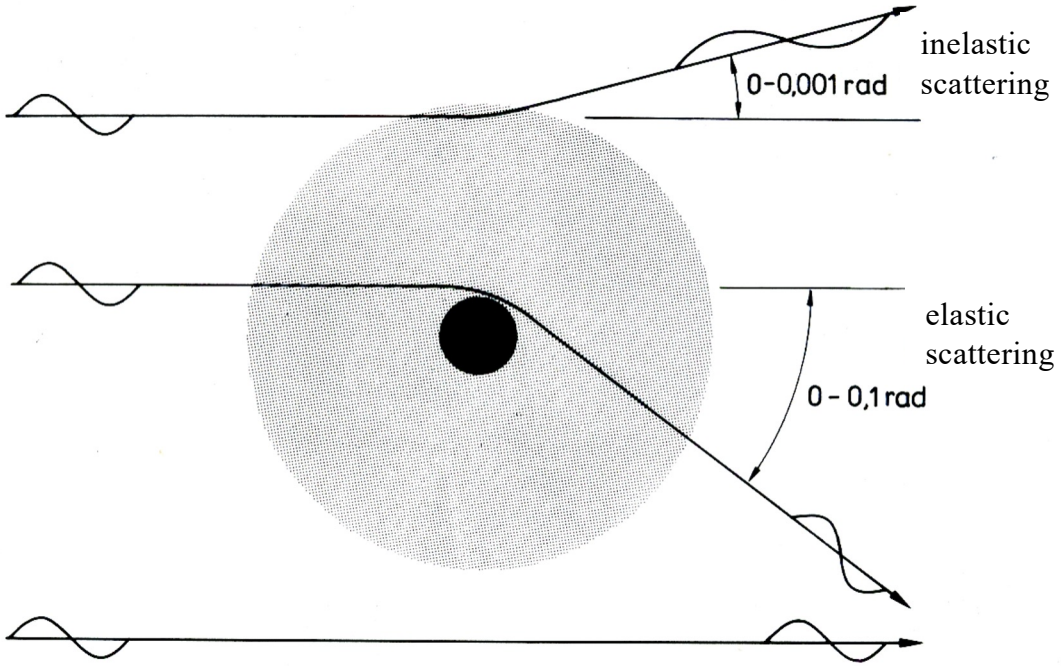
Scattering: With or without energy loss

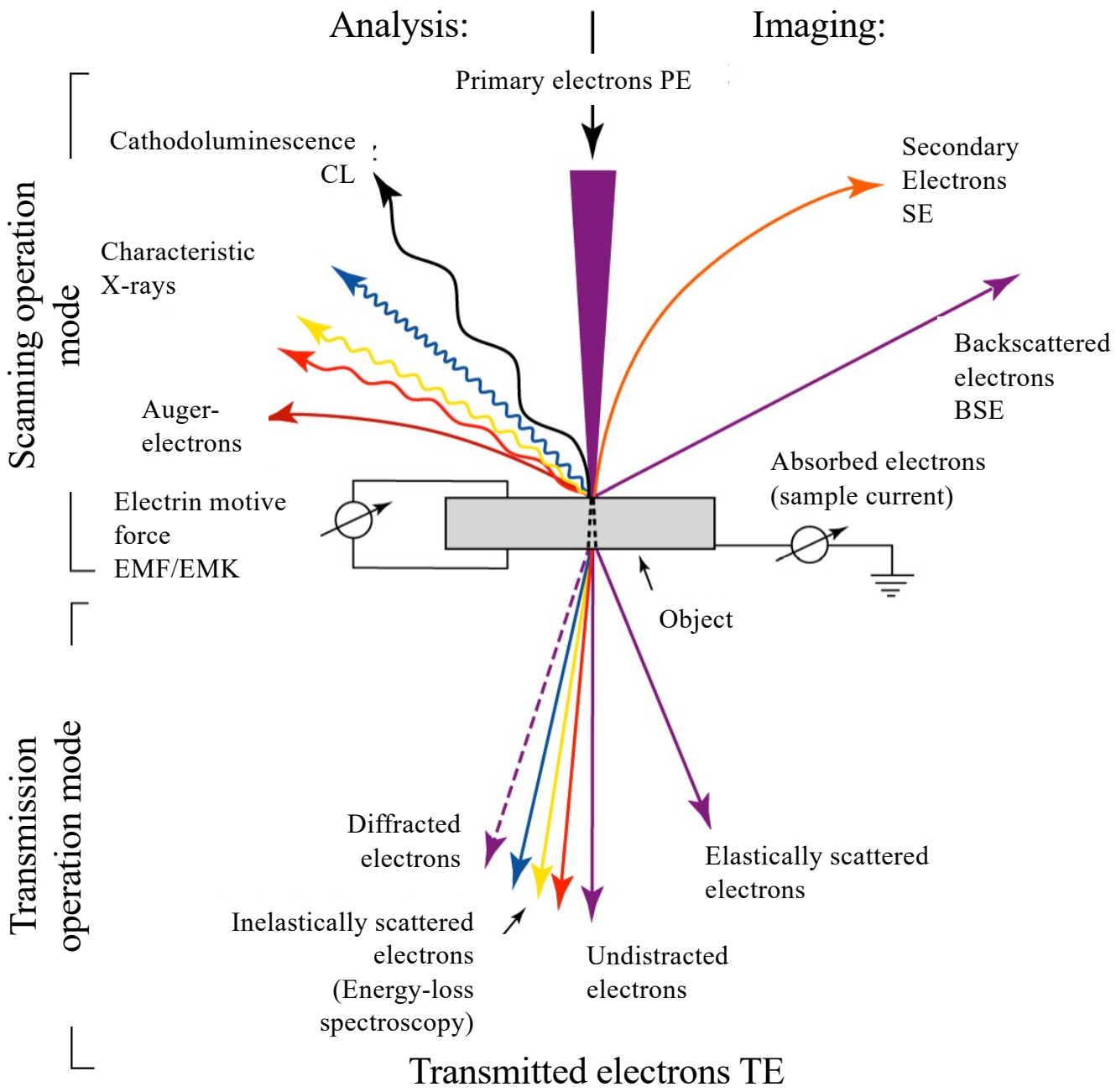


• Interaction of electrons with sample atoms

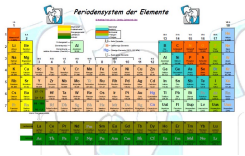
• elastic scattering
(nucleus – electron)
no energy exchange
scattering angle > 10^{-1}

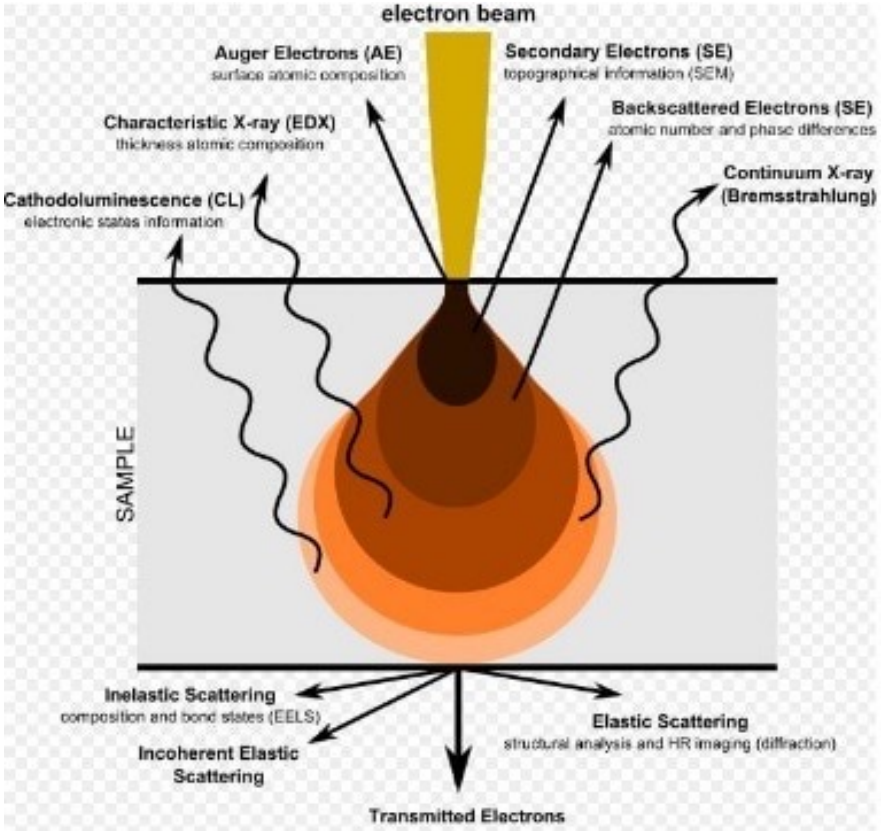
• inelastic scattering
(electron – electron)
energy loss
scattering angle very small :10^{-3} – 10^{-5}





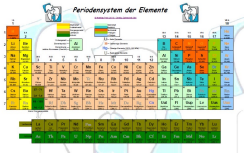
Origin of signals in the SEM

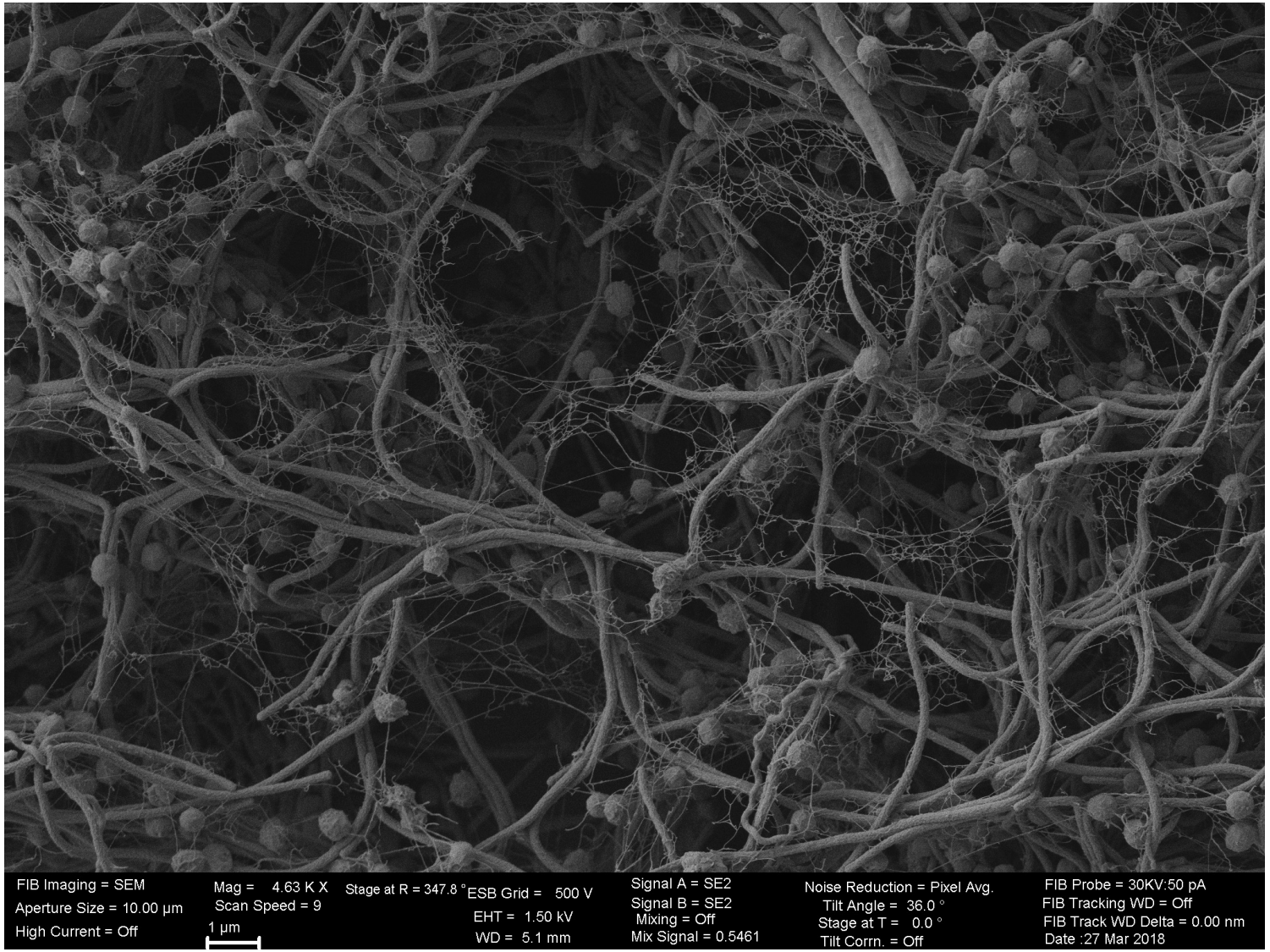




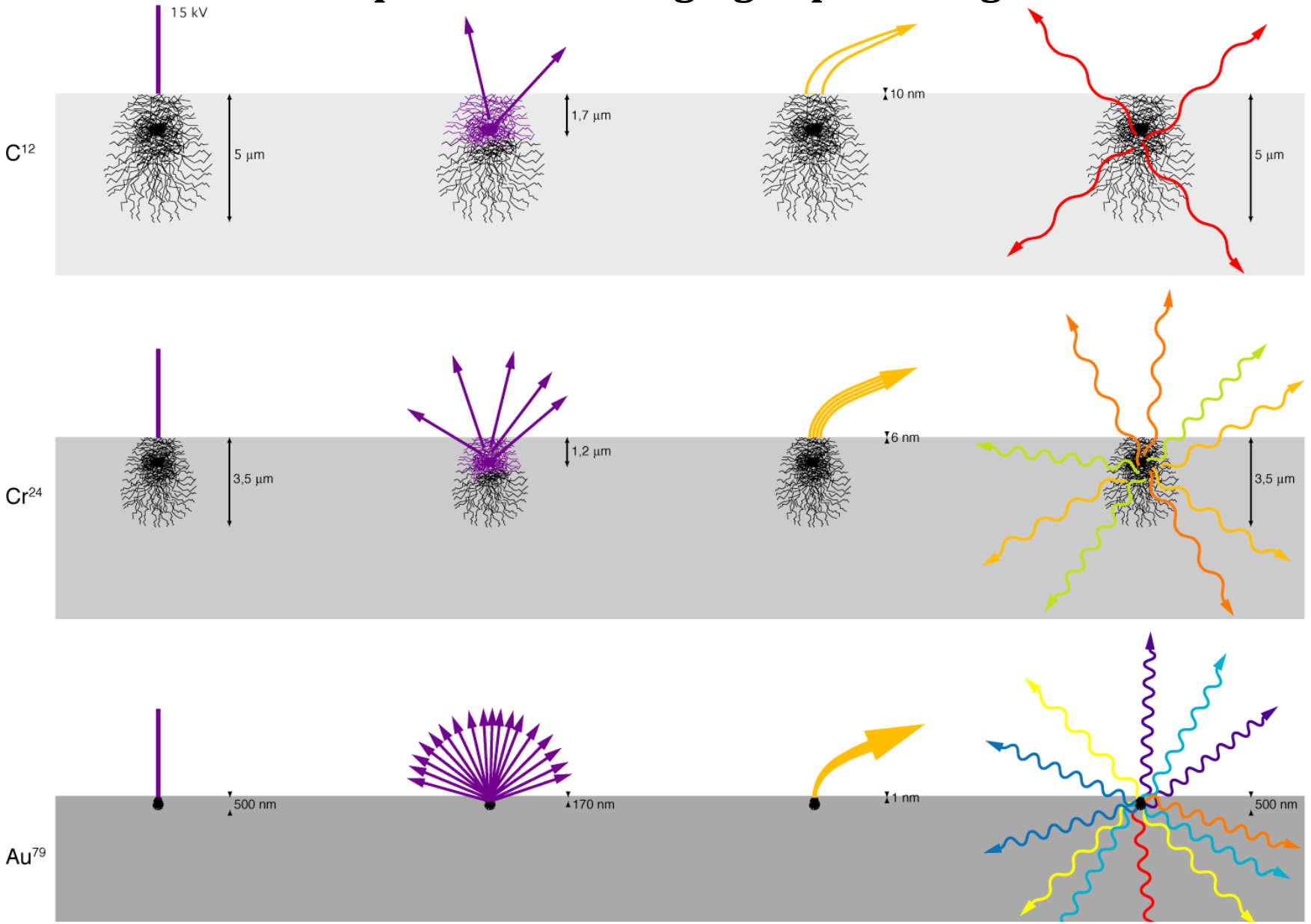
https://www.thermofisher.com/blog/microscopy/wp-content/uploads/sites/12/2019/11/electron-matter-interaction-volume.jpeg

„Image formation“ in the SEM

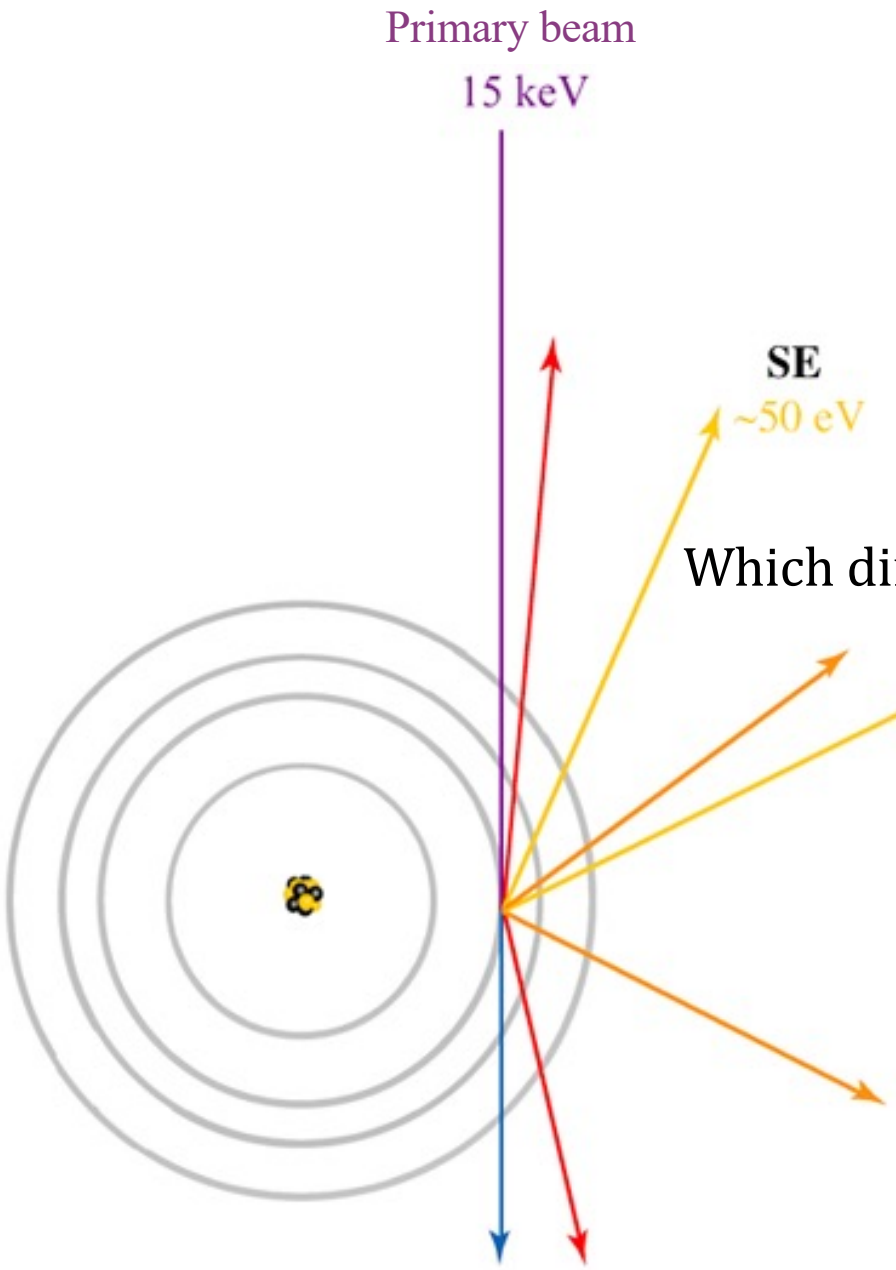




Comparison of emerging depths of signals

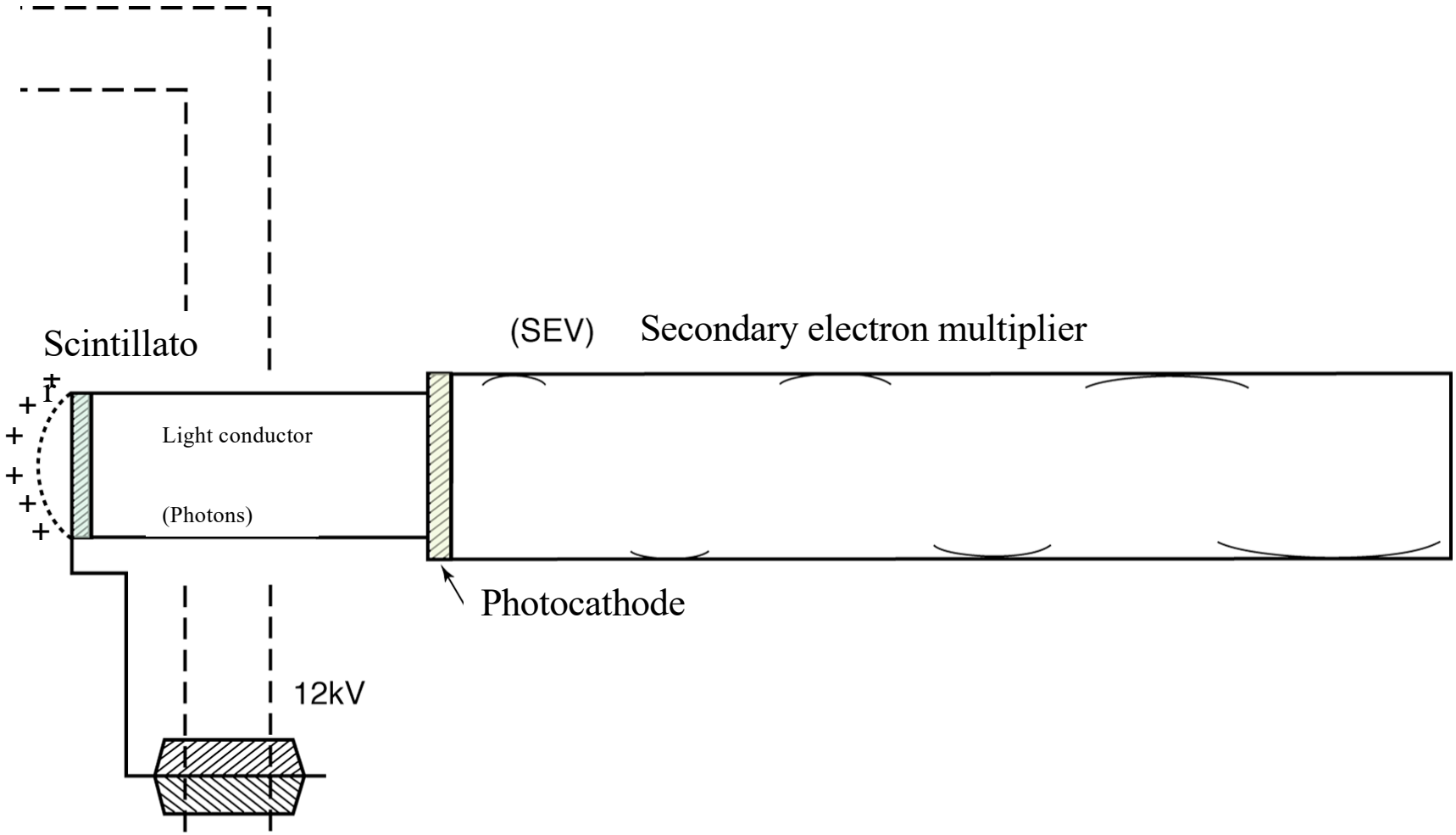


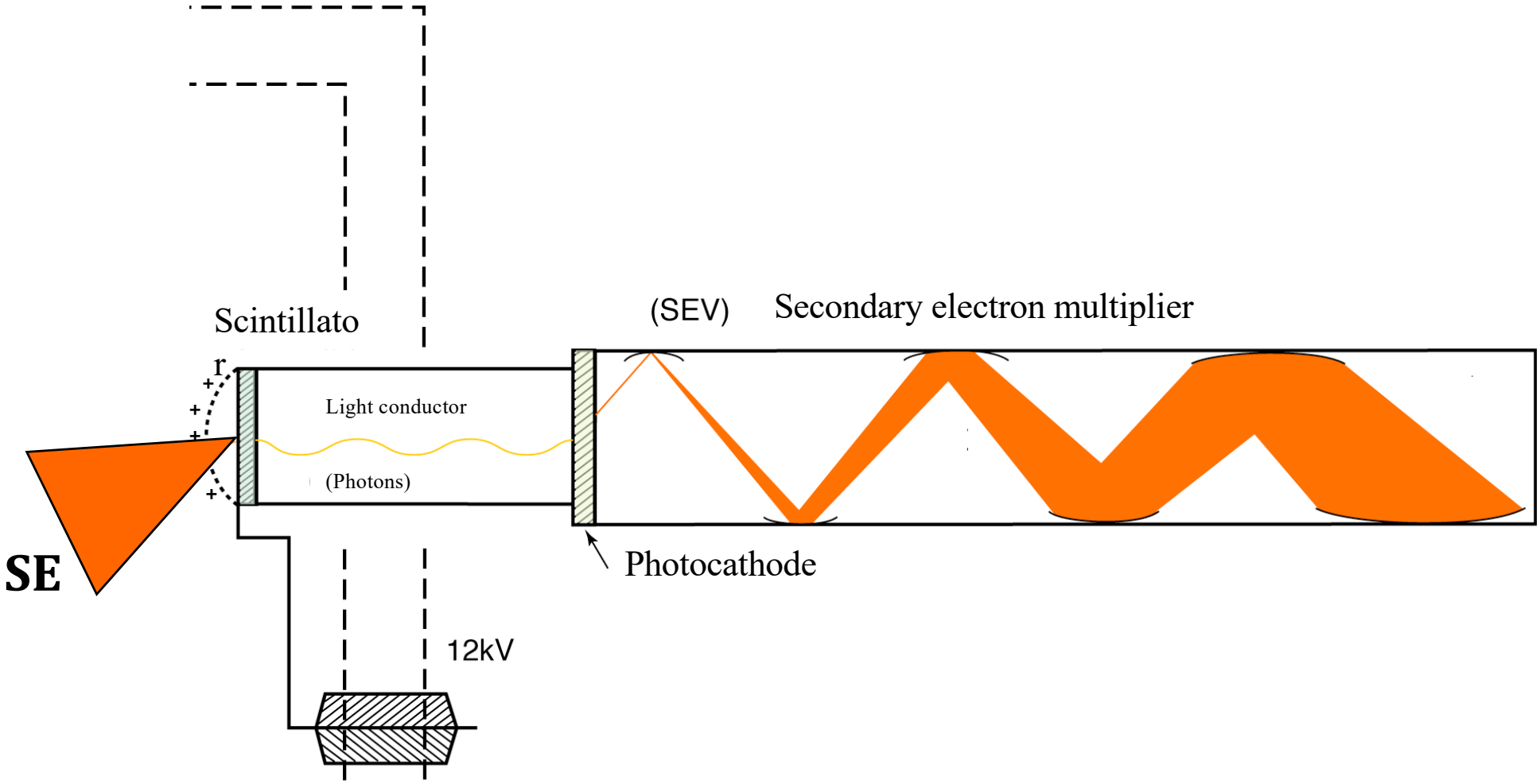
From the electron beam to the SE-image



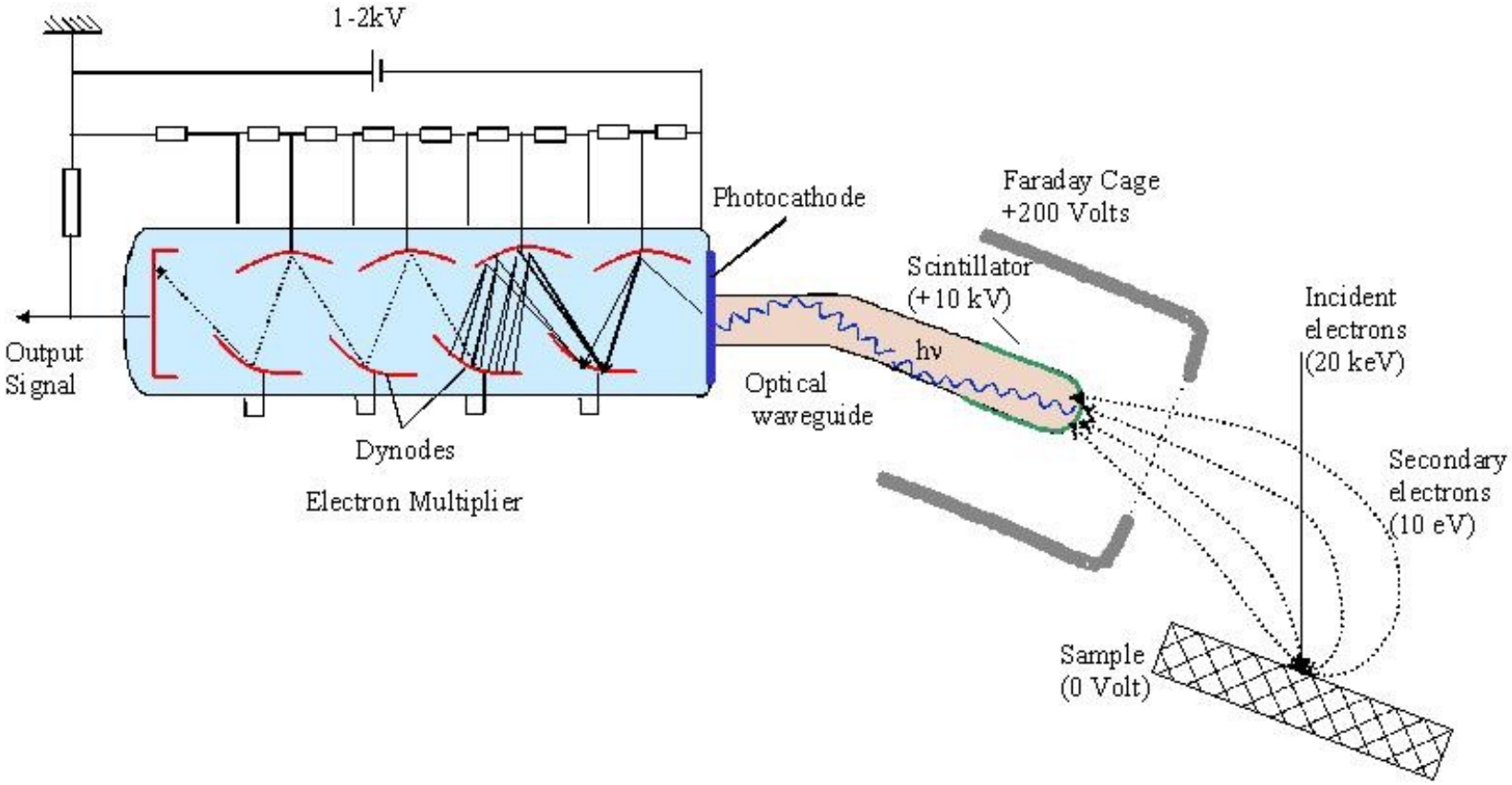
Which direction is the detector, please?

Secondary electron detector

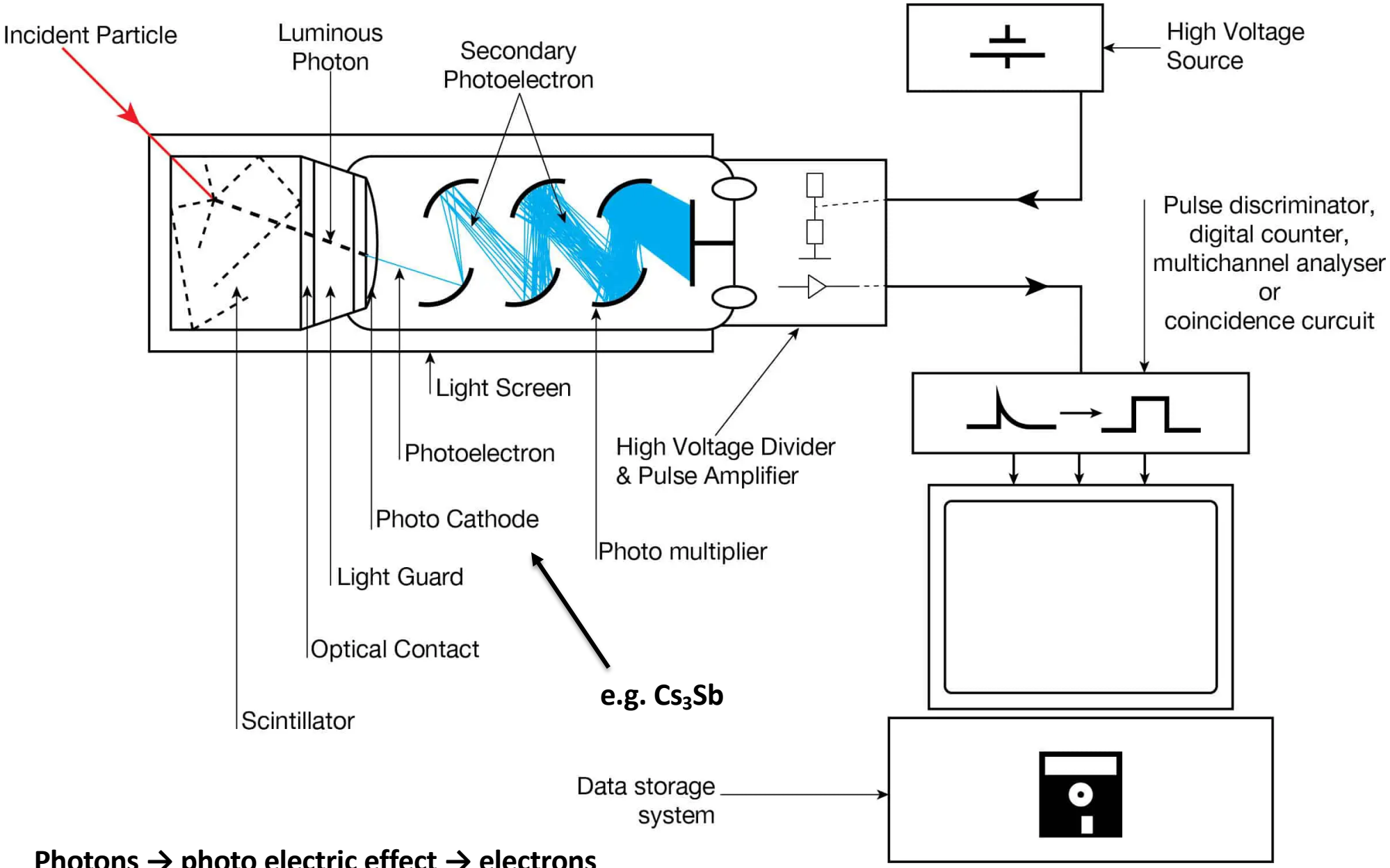




Everhart-Thornley-detector



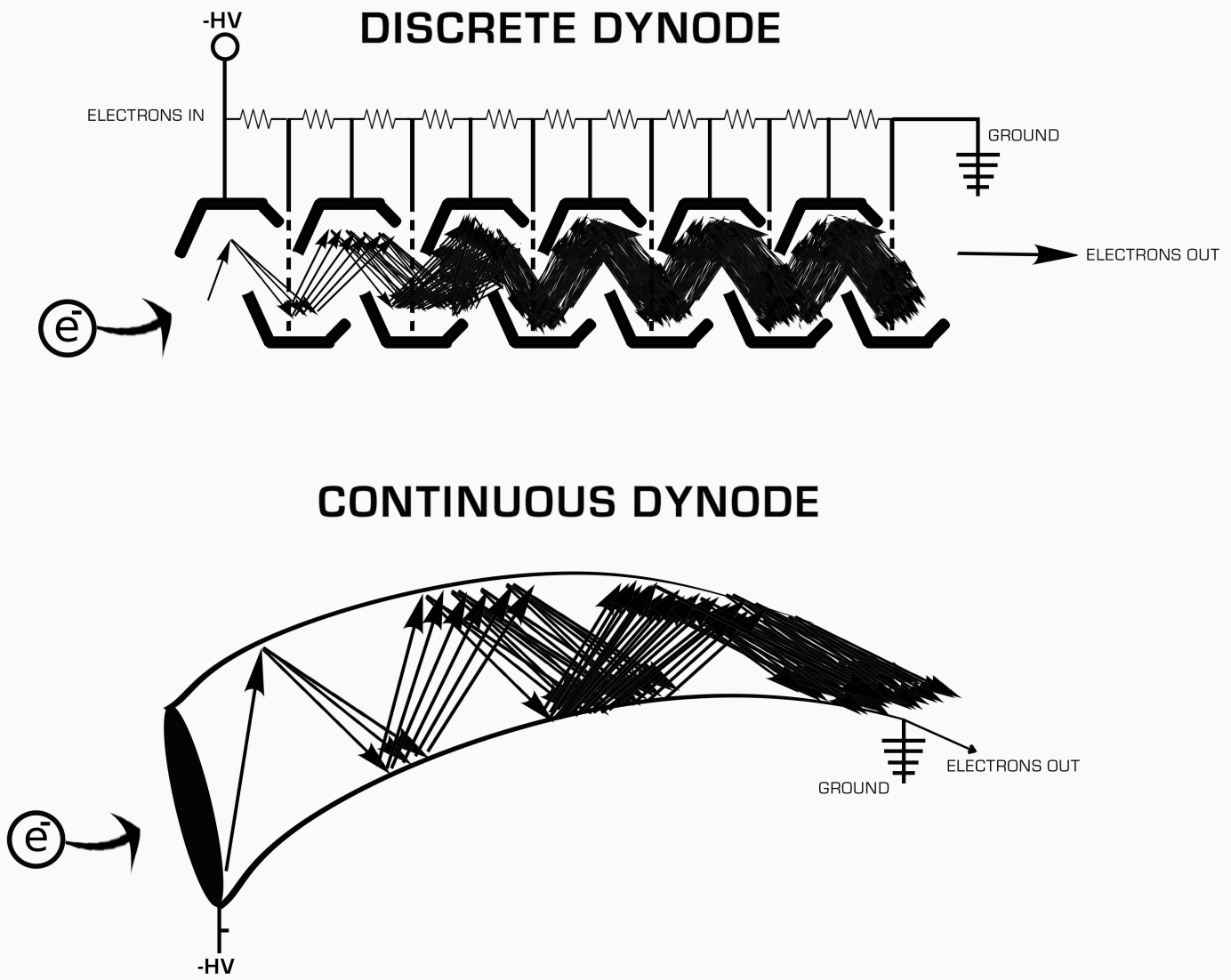
SE-detector: photo cathode



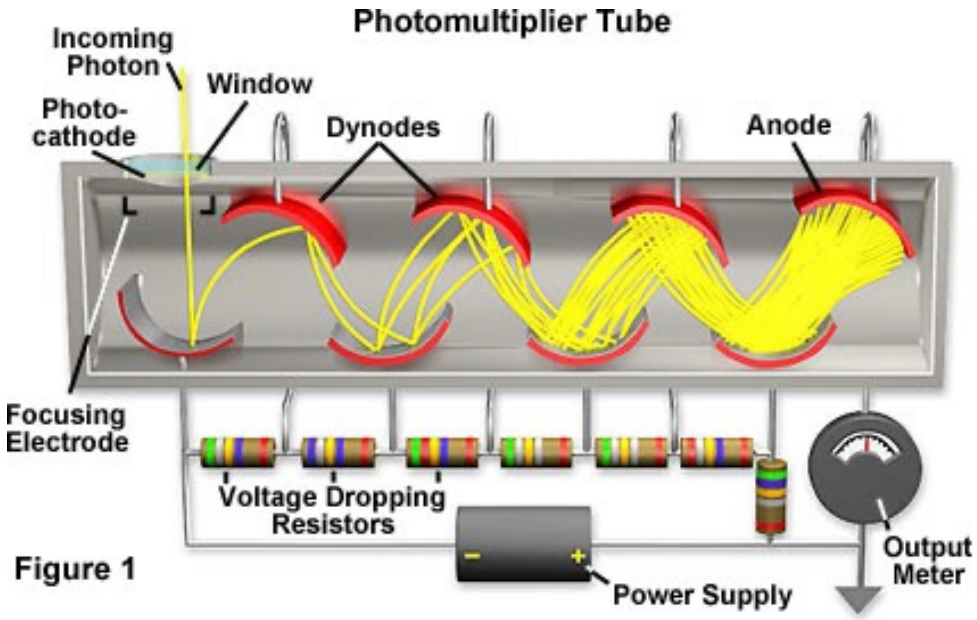
Photons → photo electric effect → electrons

https://www.radiation-dosimetry.org/de/was-ist-photokathode-und-dynode-in-der-photovervielfacherrohre-definition/

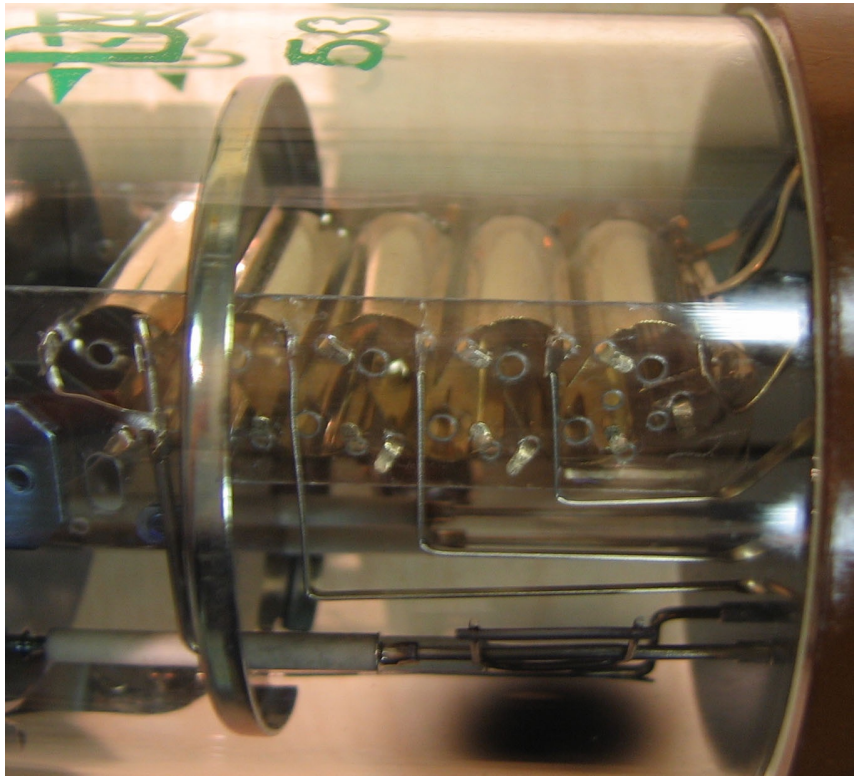
Dynodes



Dynodes

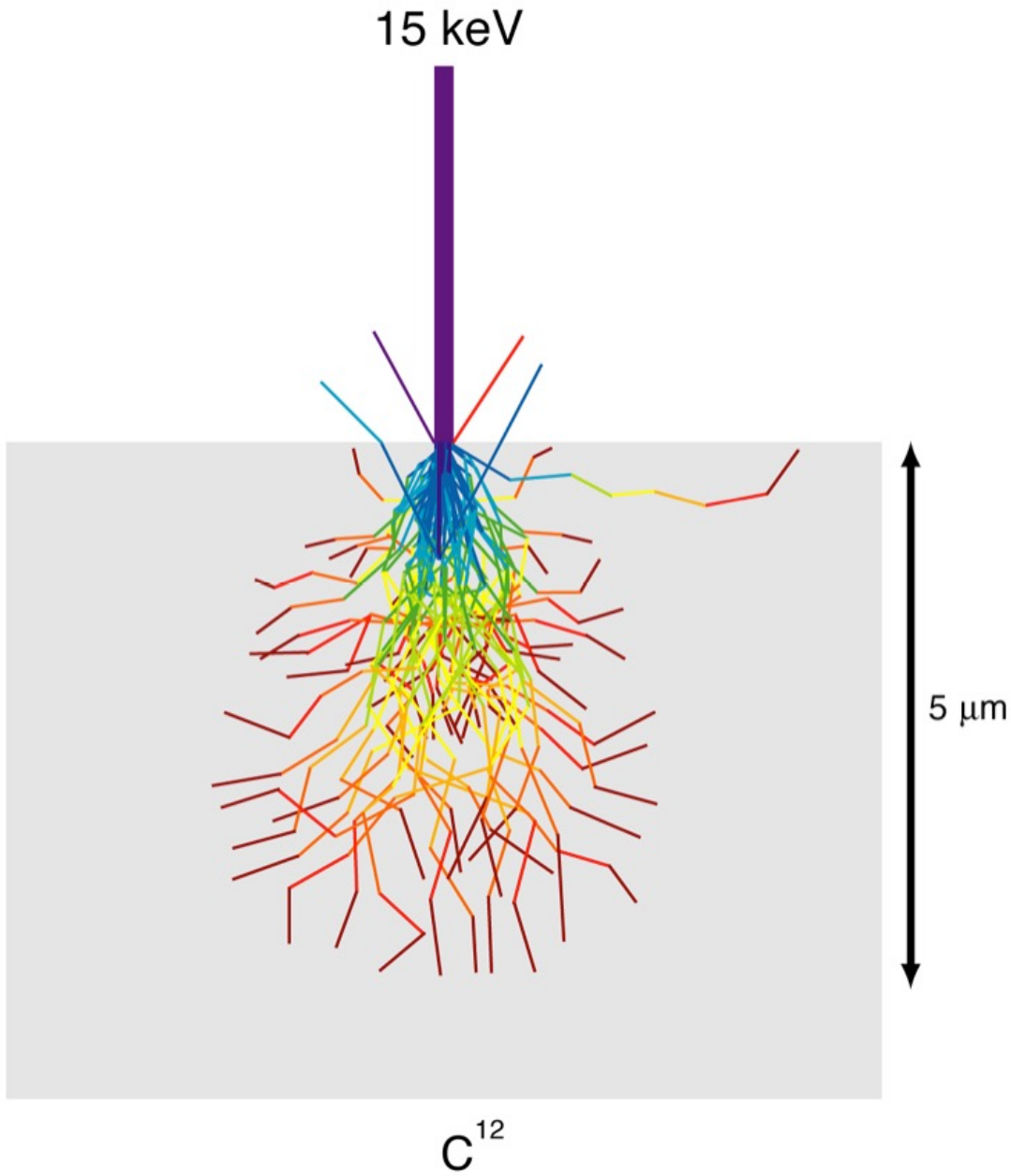


https://www.olympus-lifescience.com/de/microscope resource/primer/digitalimaging/concepts/photomultipliers/

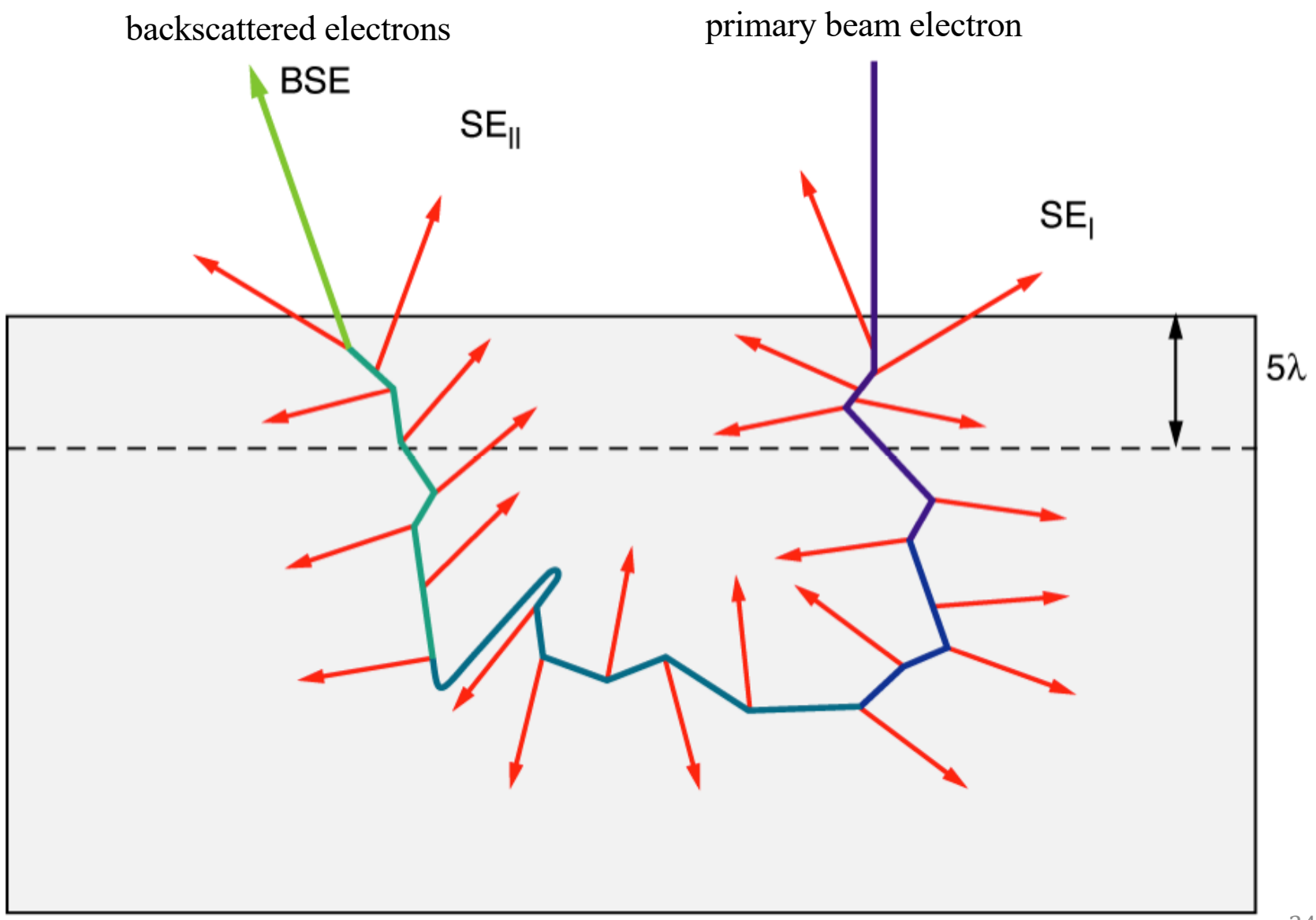


https://de.wikipedia.org/wiki/Dynode

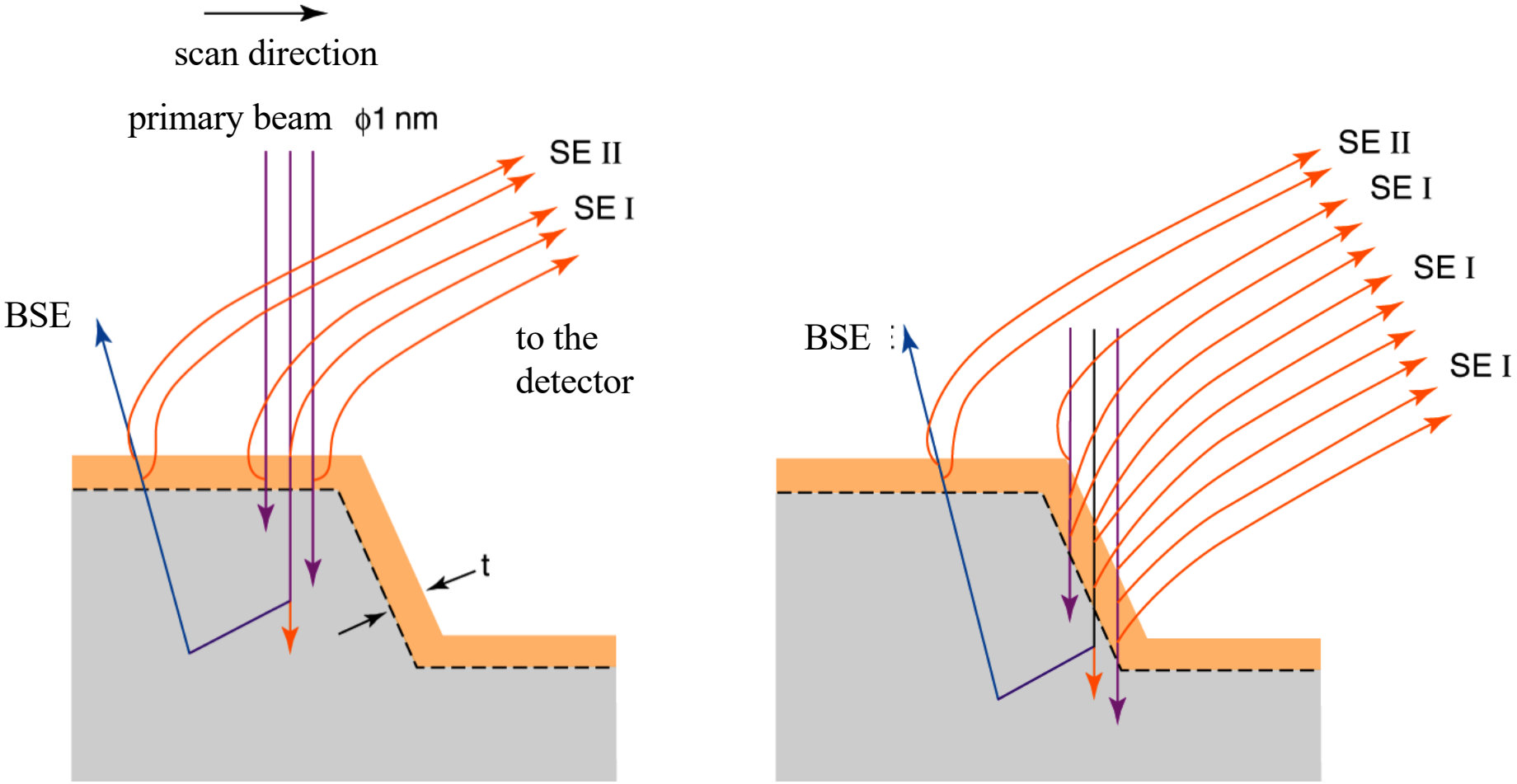
The path of primary/secondary electrons



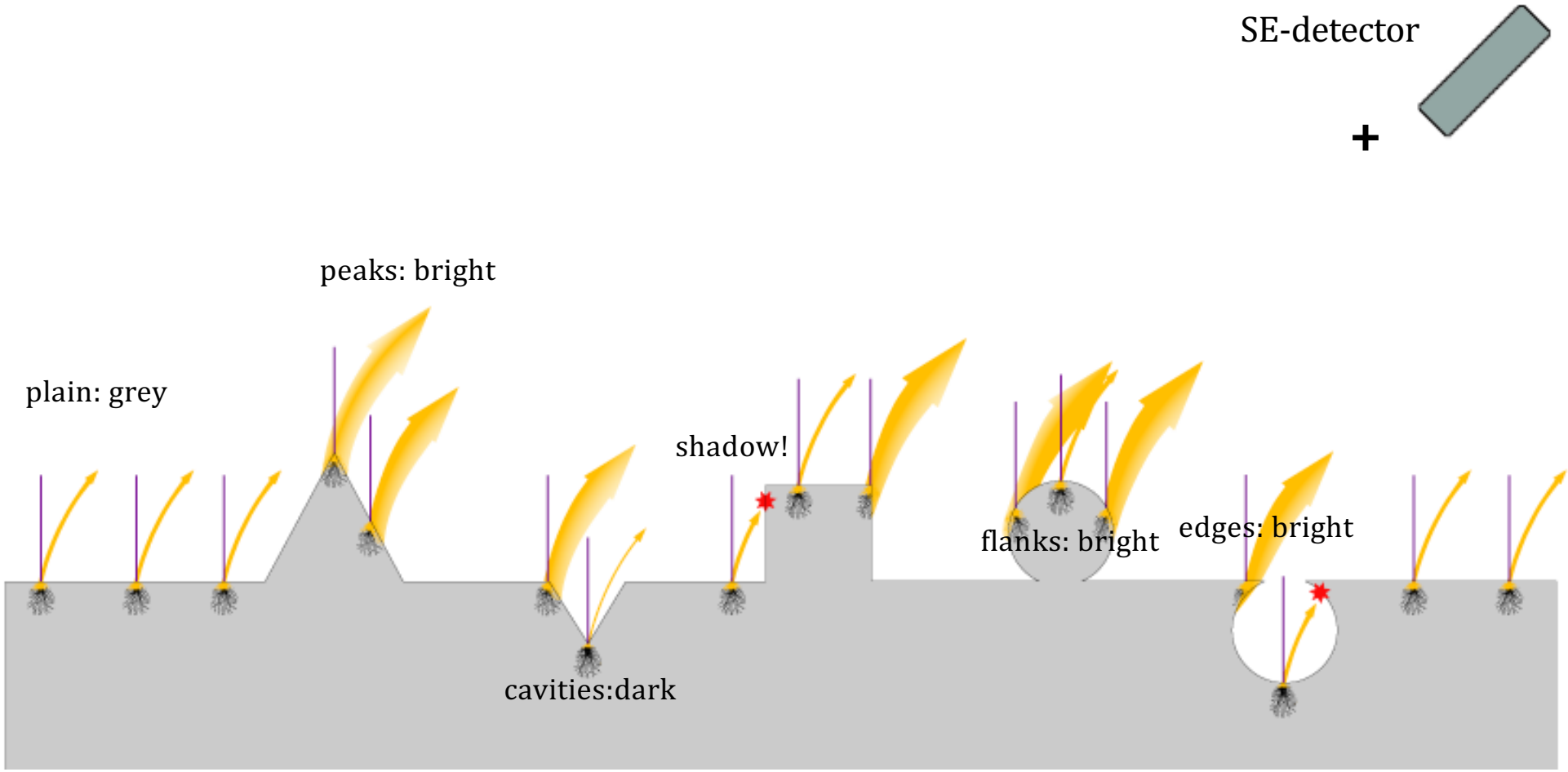
SE I – SE II – BSE



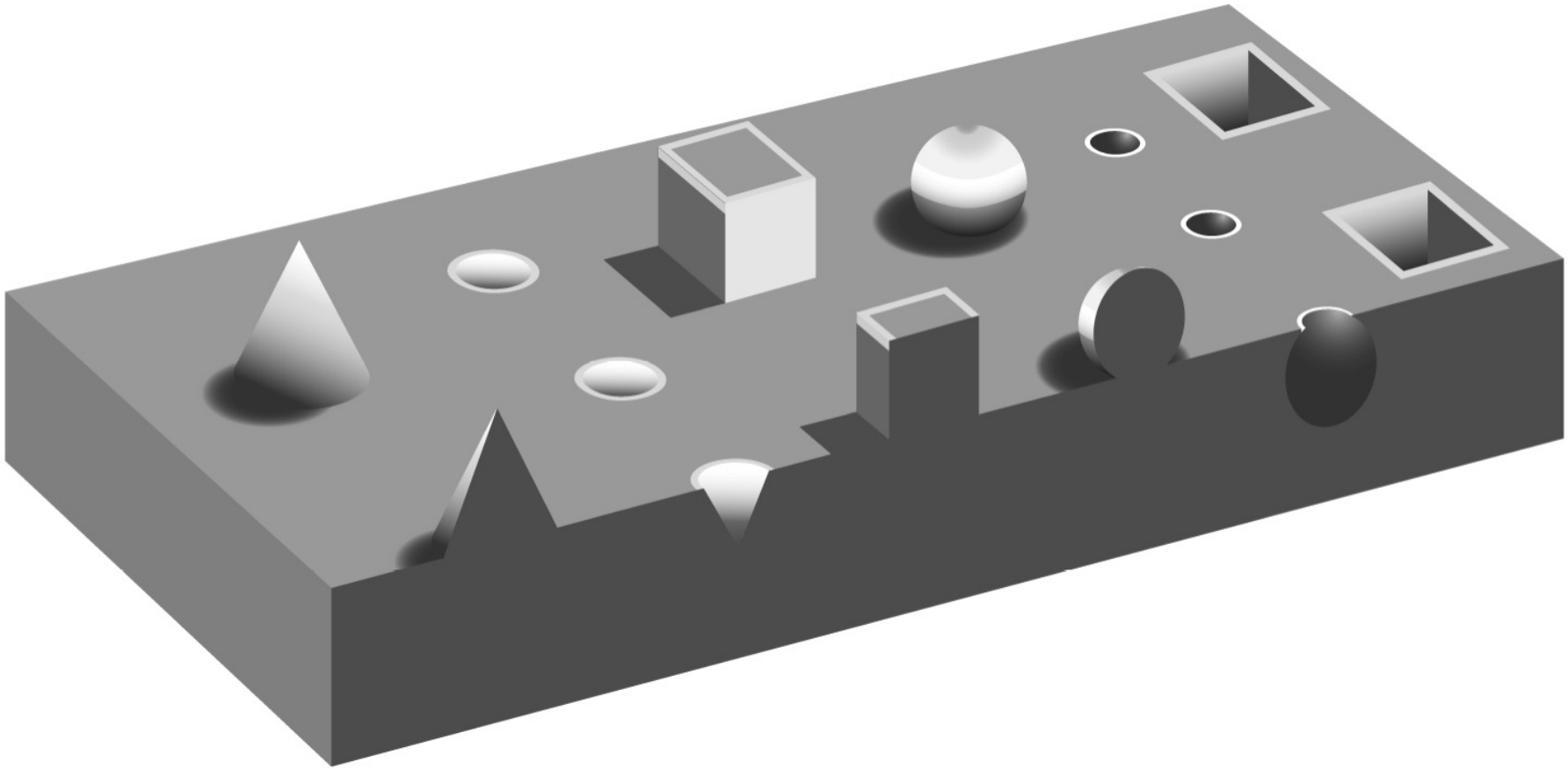
SE: „from plain to incline“



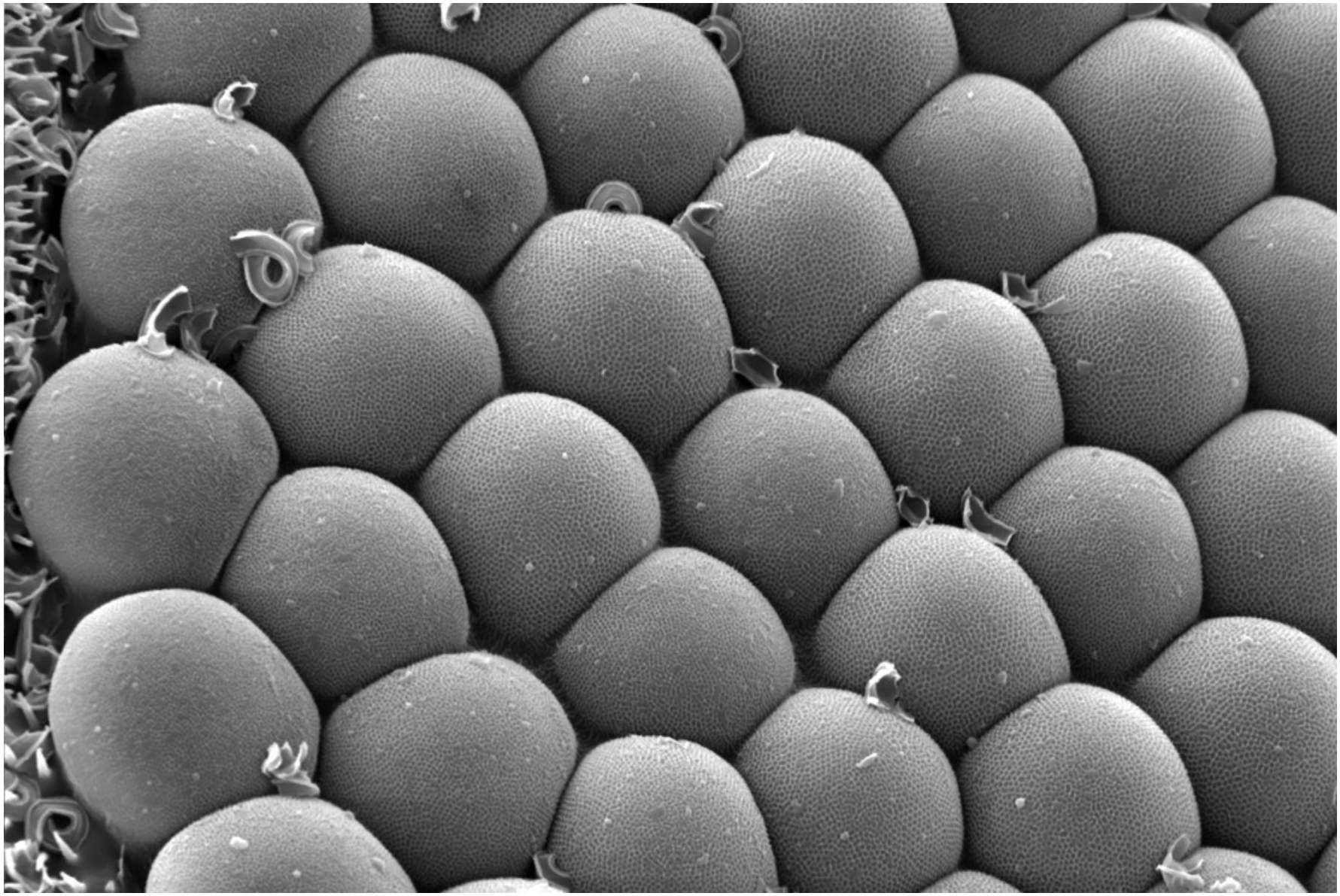
Getting into the 3rd dimension using the “topography contrast“



Topography contrast



Topography contrast



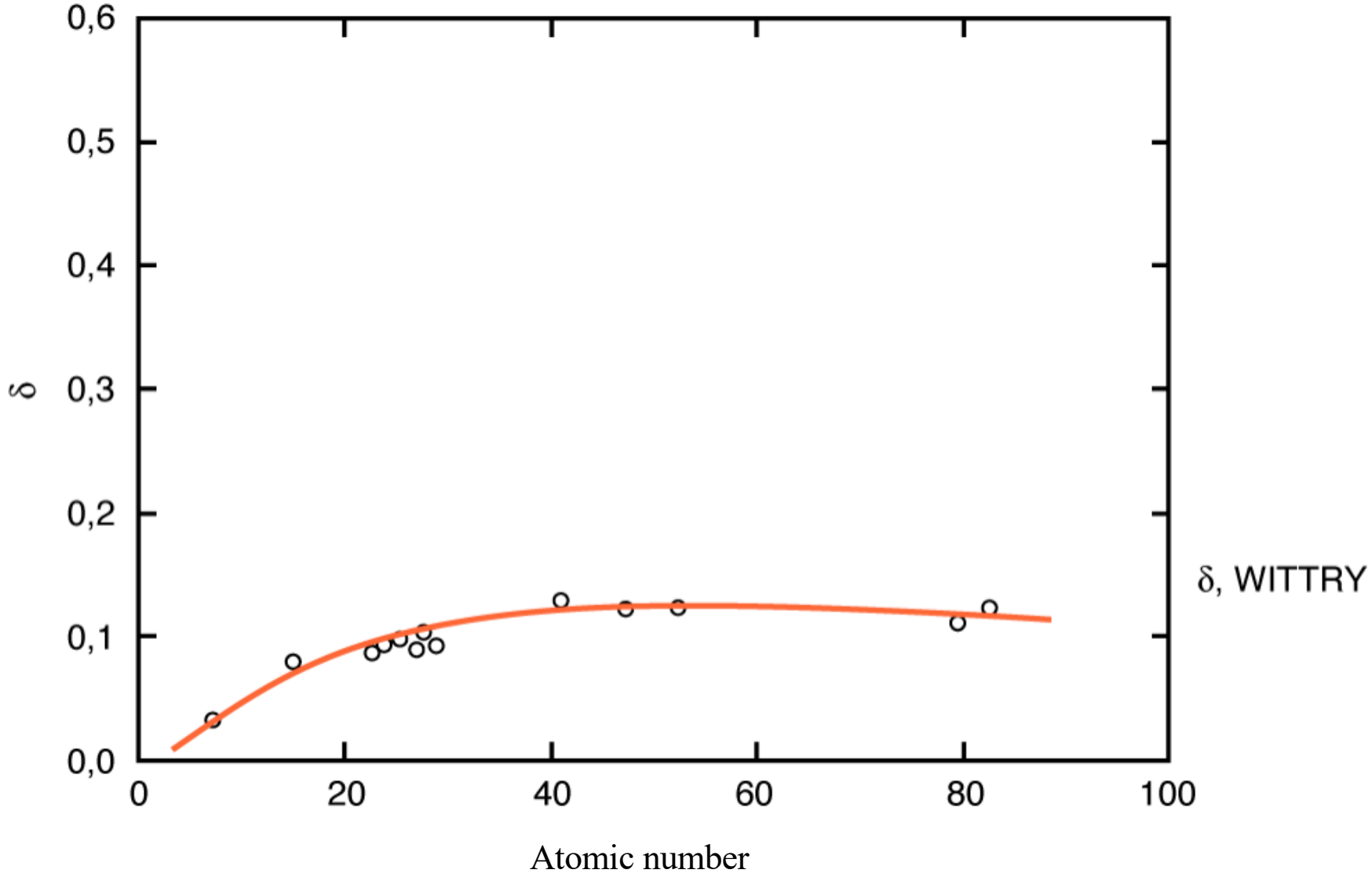
Resolution: why is the cathode type and beam diameter so important?

https://i.weltbild.de/p/nagelbild-pin-art-071465579.jpg?tr=tr%3An-maxsize&iv=26

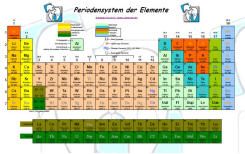
Resolution: why is the cathode type and beam diameter so important?

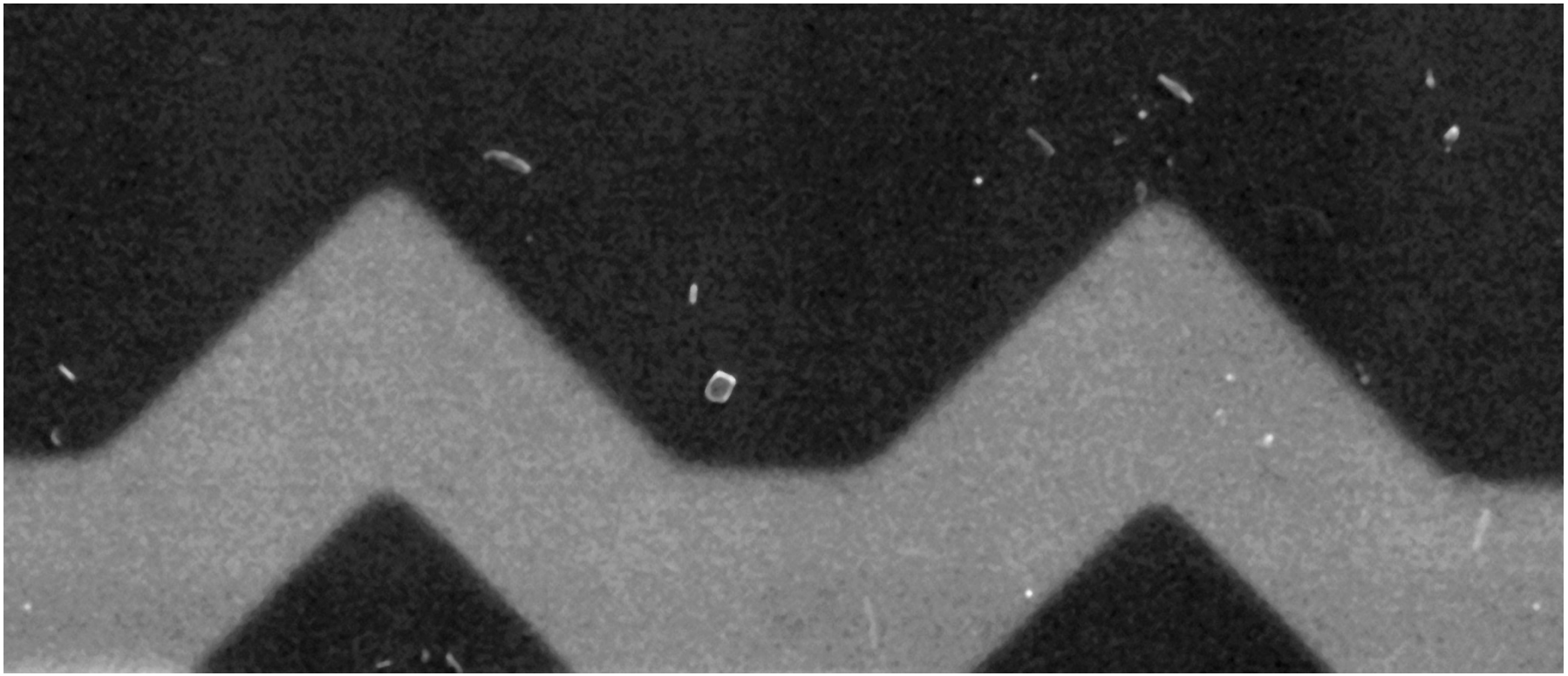
https://i.weltbild.de/p/nagelbild-pin-art-071799810.jpg?tr=tr%3An-maxsize&iv=26

Atomic number and SE-yield



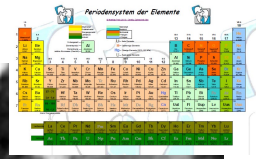
Material contrast





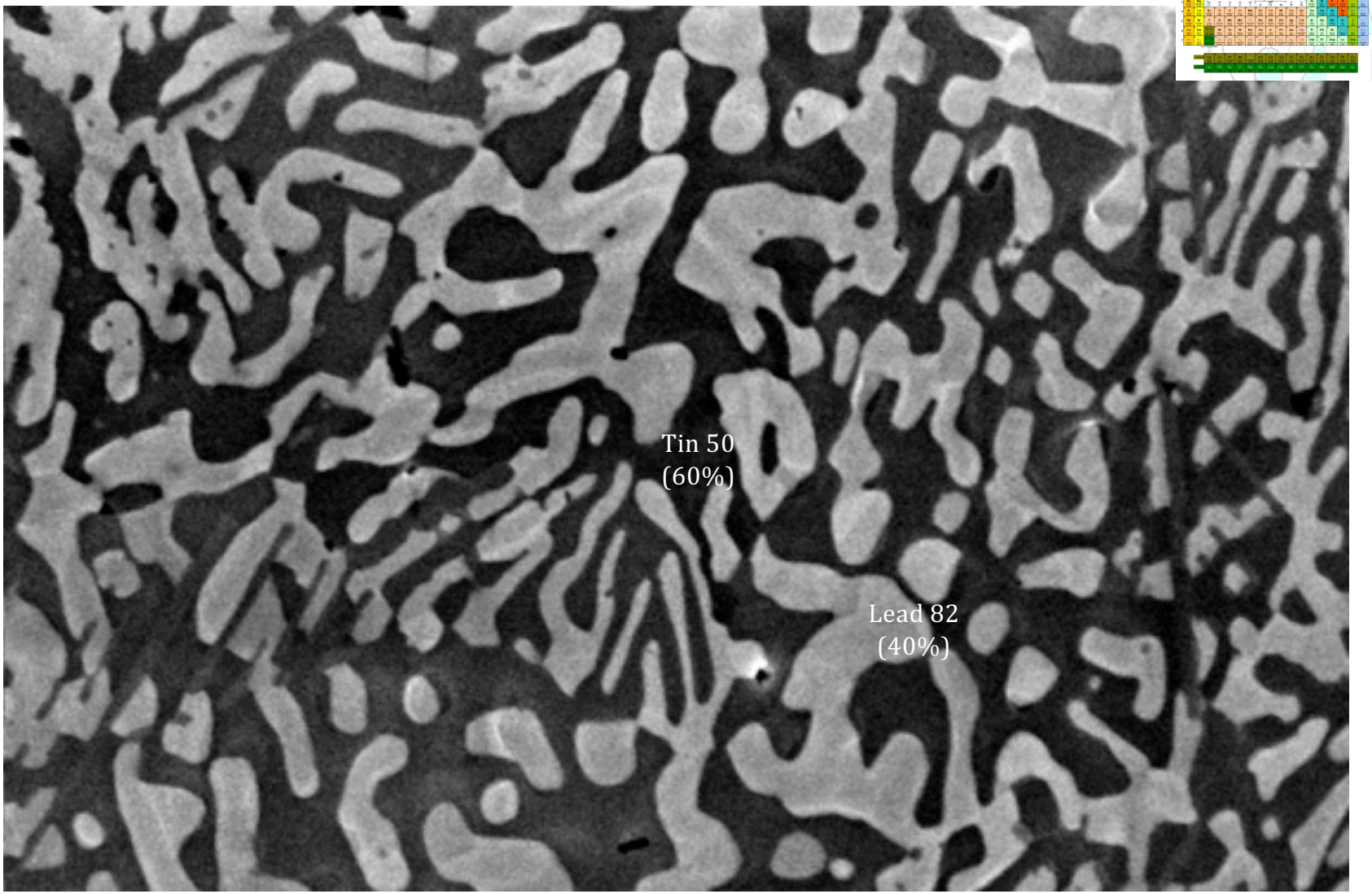
SE-image (8 kV) smooth surface of a semiconductor

Material contrast



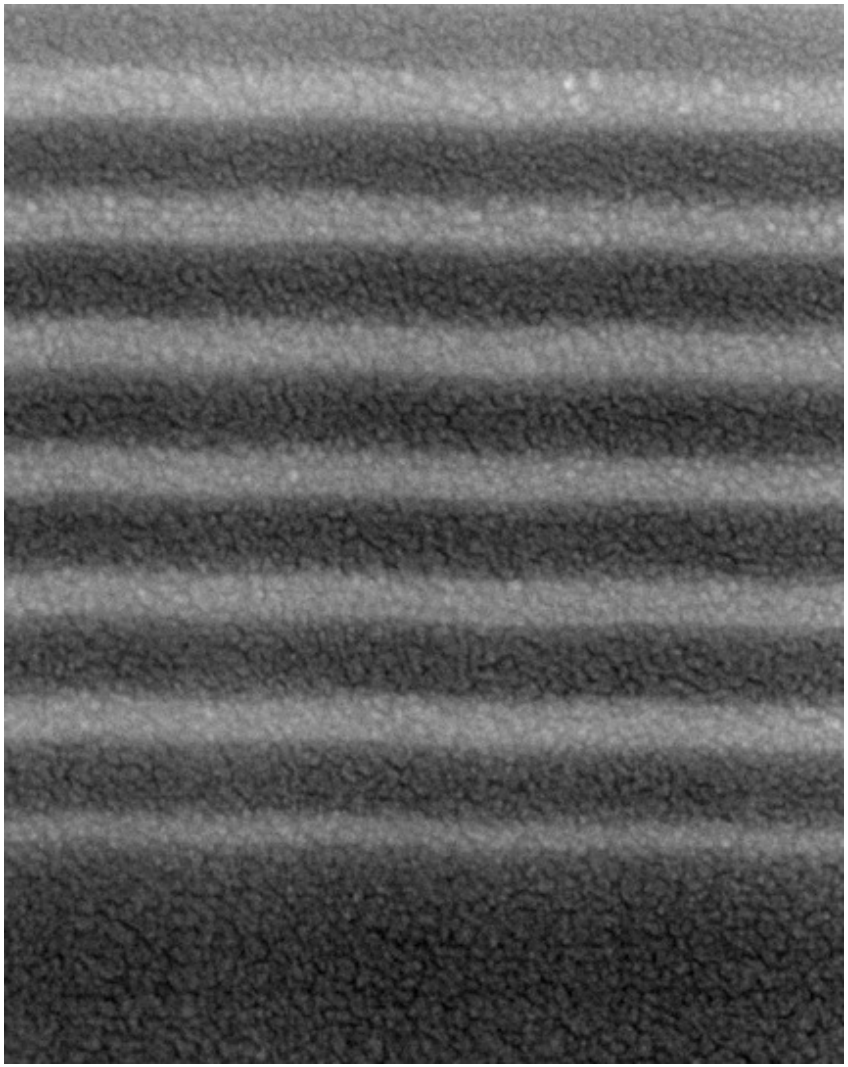
SE-image (10 kV) smooth surface of an old kitchen knife

Material contrast



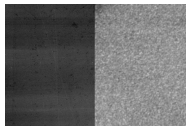
SE-image (8 kV) smooth surface of tin-solder/brazing solder

Material contrast



SE-image (20 kV) fracture surface from glass with blooming in a layer sequence

Material contrast or „micro roughness“



2 different materials?