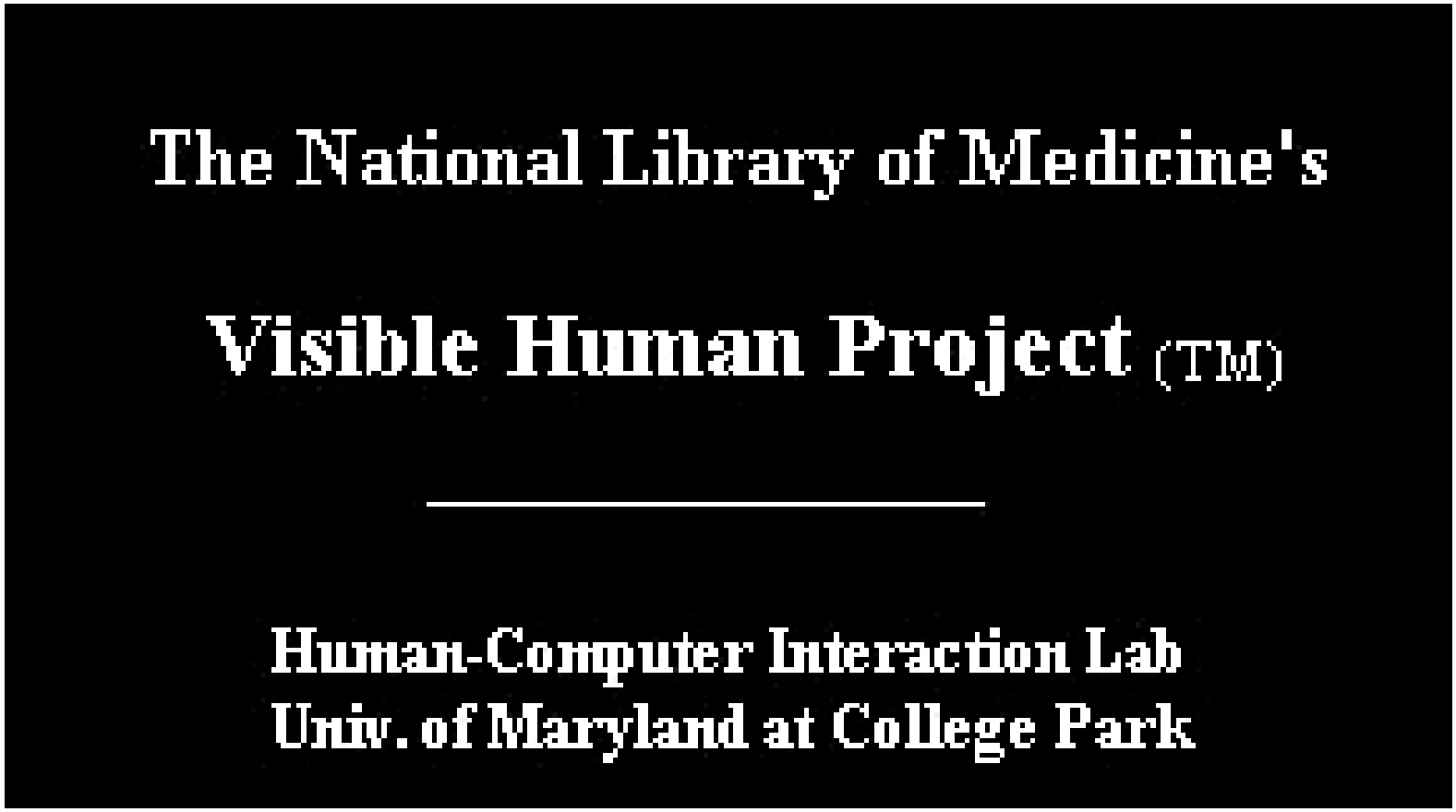
Kako stvari delujejo?

Medicinsko slikanje

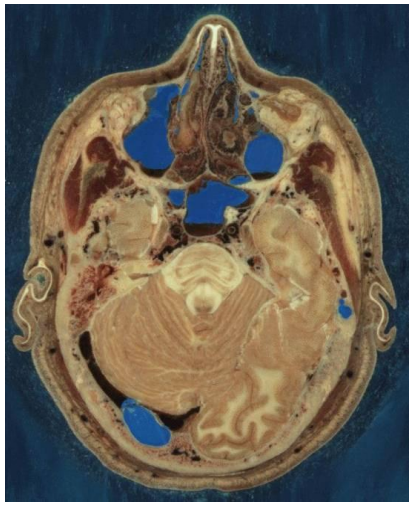
visible human project



Tehnike slikanja

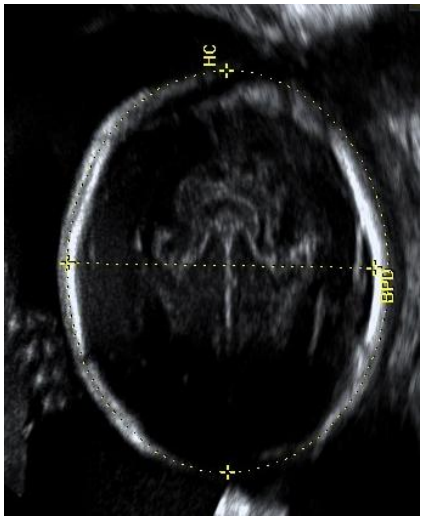
ultrasonografija
radiografija
slikanje gama (PET)
MRI

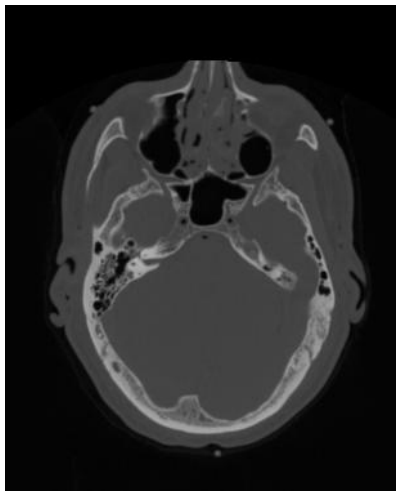
(termografija, optoakustično slikanje…)

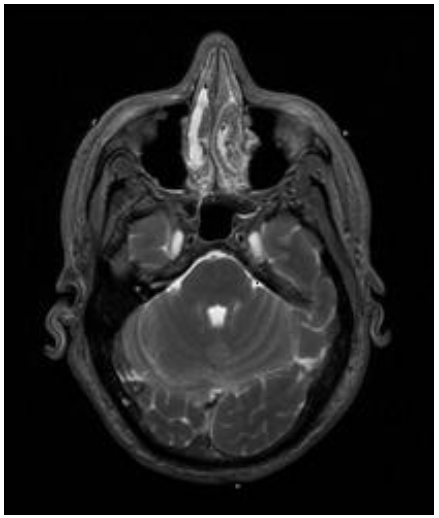


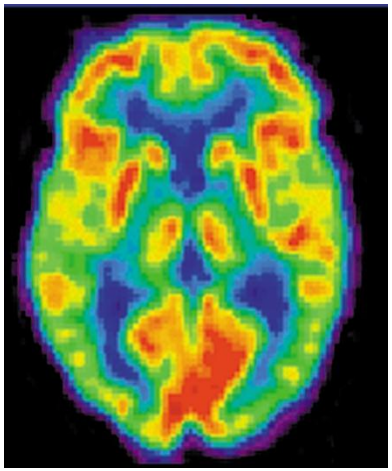
primerjava

optika





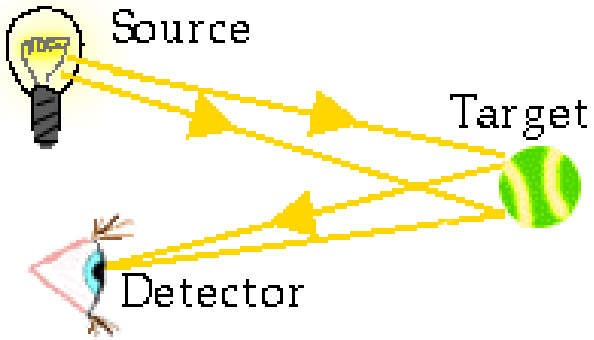




UZ CT MRI PET

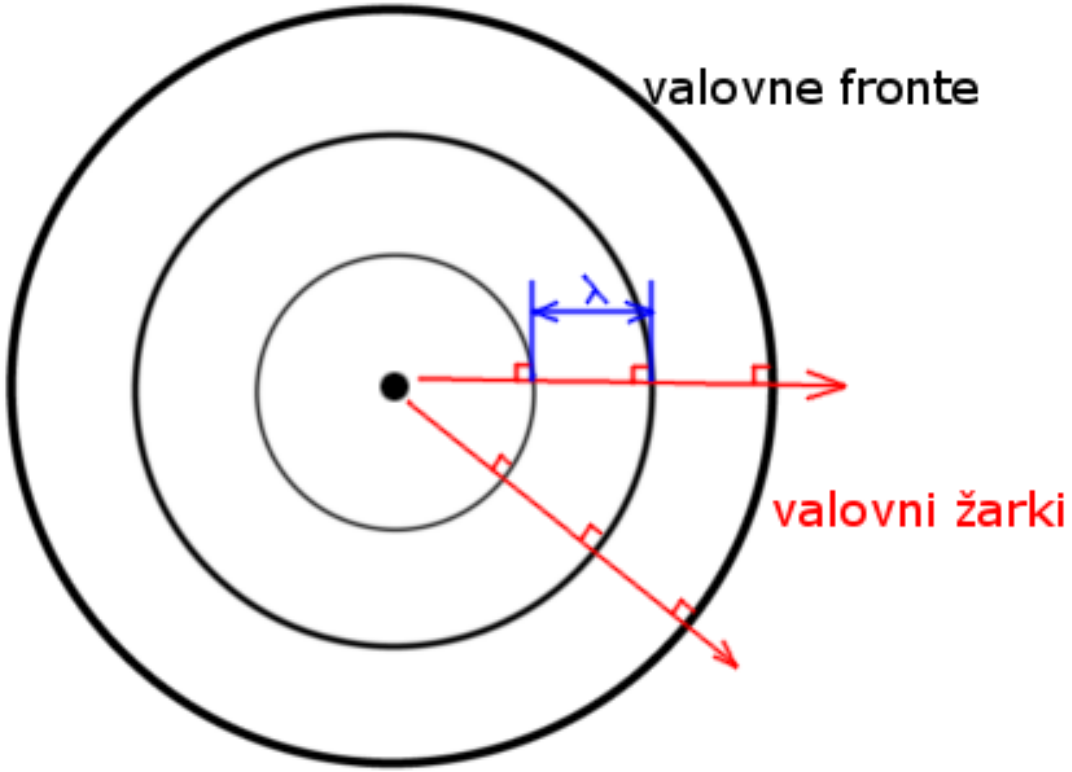
zaznavanje okolice

elektromagnetno valovanje

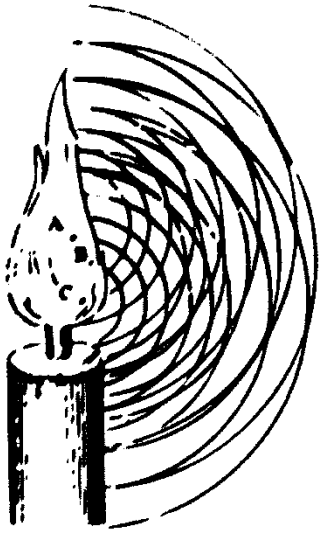


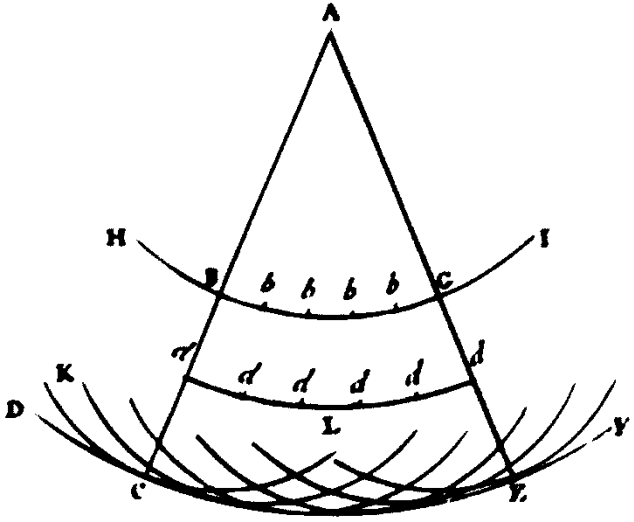
zvočno valovanje

Valovanje v 2 in 3D – žarki, valovne črte/ploskve



Christiaan Huygens (1629–1695),
Nizozemski fizik in matematik.





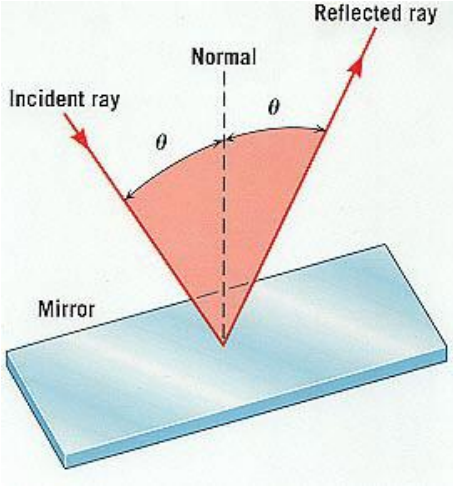
Huygensove risbe

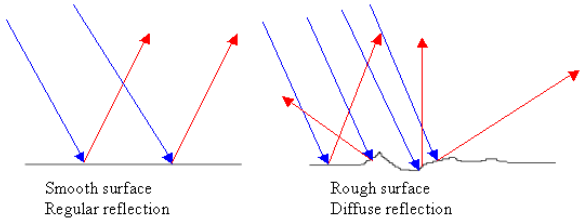
“Vse točke na valovnem čelu so izvori sekundarnih krogelnih (krožnih) valov ”.

==

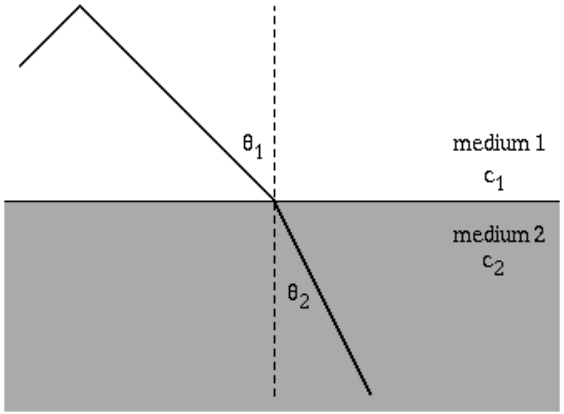
Valovno čelo je vsota številnih delnih krogelnih valov.

odboj

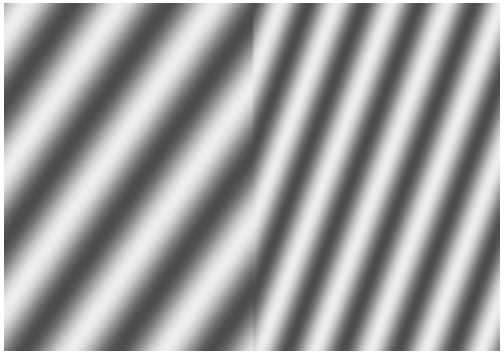




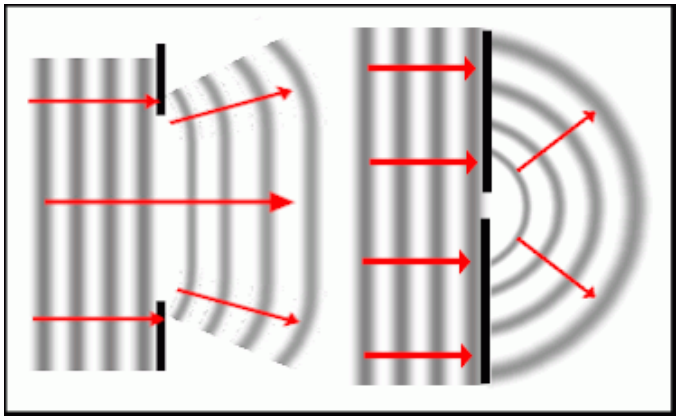
lom

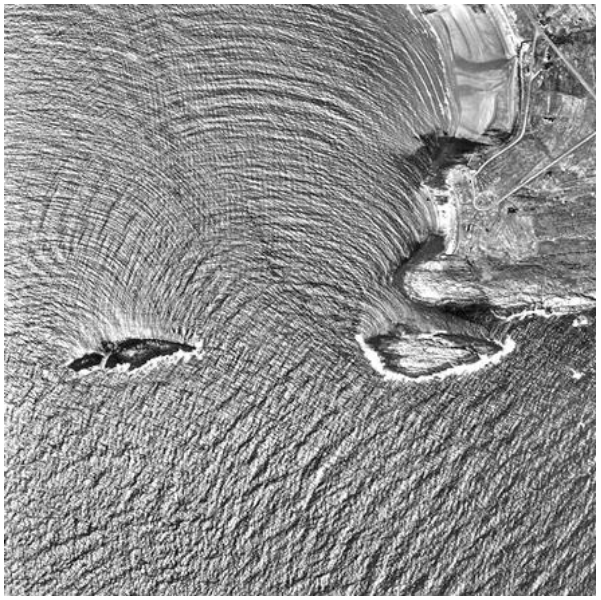


$$\frac{\sin\alpha}{\sin\beta} = \frac{c_1}{c_2} = \frac{n_2}{n_1}$$

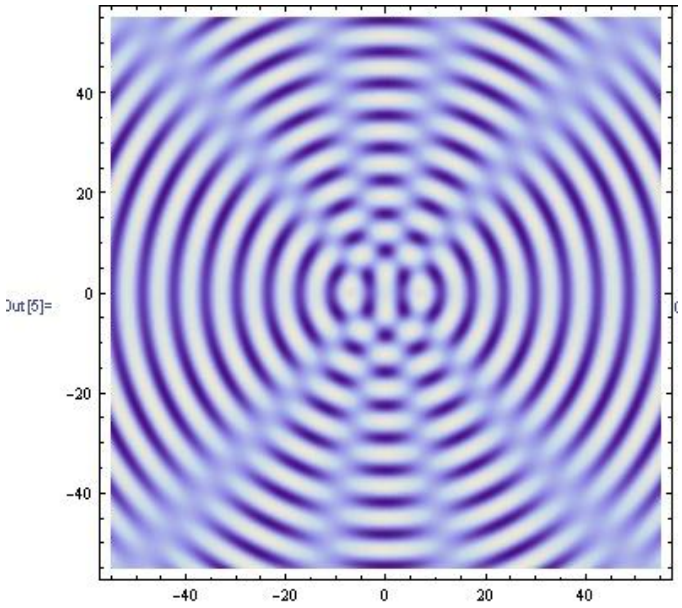


uklon





interferenca



absorpcija

Gostota energijskega toka – sorazmerna kvadratu amplitude

$$j = j_0 e^{-\mu d}$$

Absorpcijski koeficient < atenuacijski koeficient
Absorpcija : absorpcija + sipanje

$$L_{\mathrm{dB}} = 10 \log_{10} \left(\frac{P_1}{P_0} \right)$$

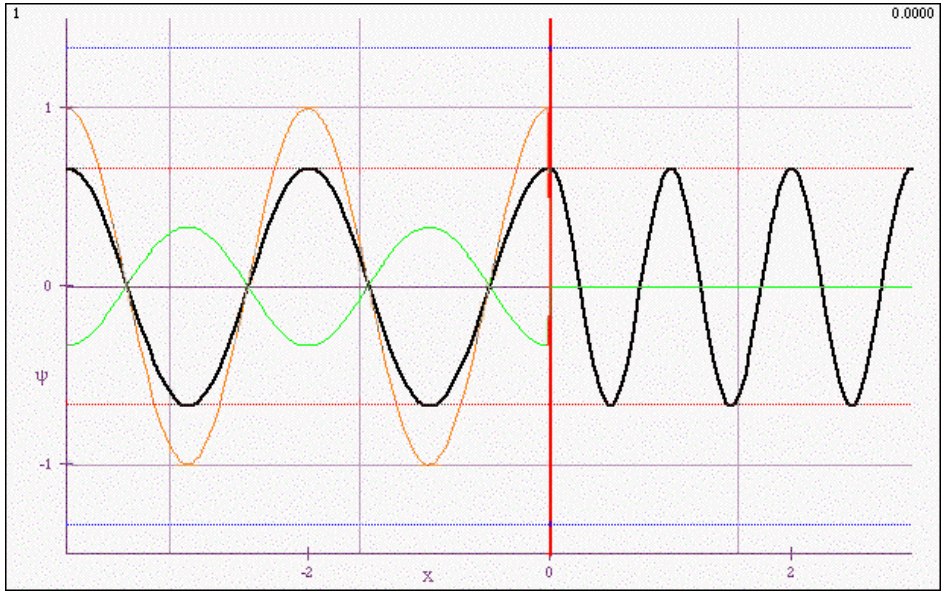
Kaj pomeni zmanjšanje za 10 dB, kaj za dvakrat, kako se pri tem spremeni amplituda?

Atenuacijski koeficent opiše zmanjšanje signala

$$\mathrm{Attenuation} = \alpha[\mathrm{dB}/(\mathrm{MHz\ cm})] \cdot \ell[\mathrm{cm}] \cdot \mathrm{f}[\mathrm{MHz}]$$

Odboj valovanja na meji

$$\tilde{A}_0 = A_0 e^{i(kx-\omega t)}$$



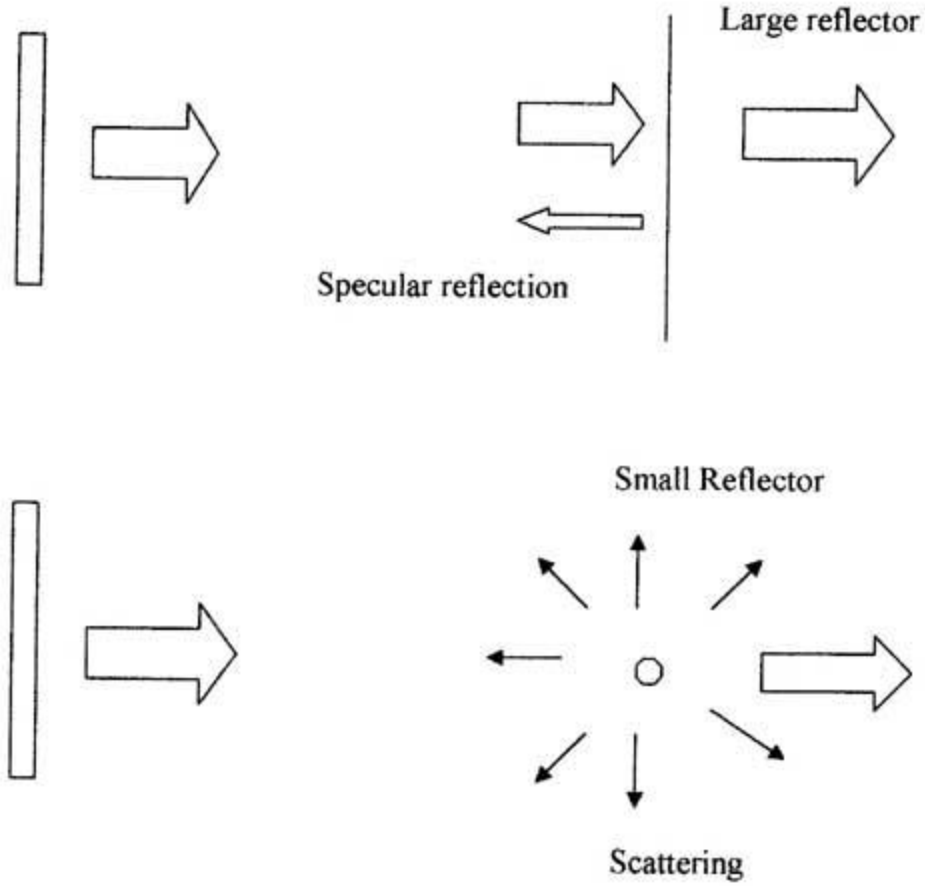
$$\tilde{A}_1 = A_1 e^{i(k'x-\omega t)}$$

$$\tilde{A}_2 = A_2 e^{i(-kx-\omega t)}$$

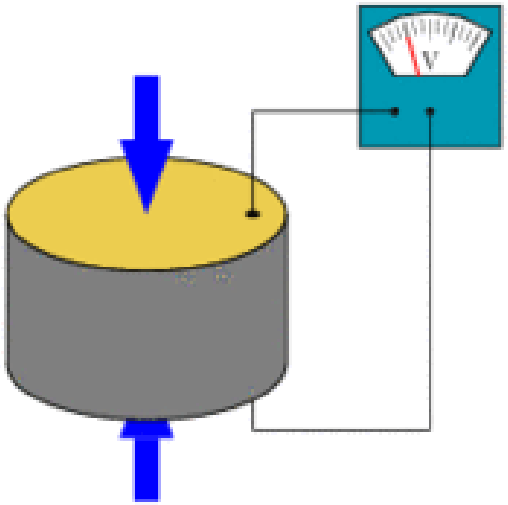
$$A_2 = A_0 \frac{1-\frac{k'}{k}}{1+\frac{k'}{k}}$$

$$\tilde{A}_0 + \tilde{A}_2 = \tilde{A}_1 \qquad \tilde{A}_0' + \tilde{A}_2' = \tilde{A}_1'$$

sipanje – difuzni odboj valovanja



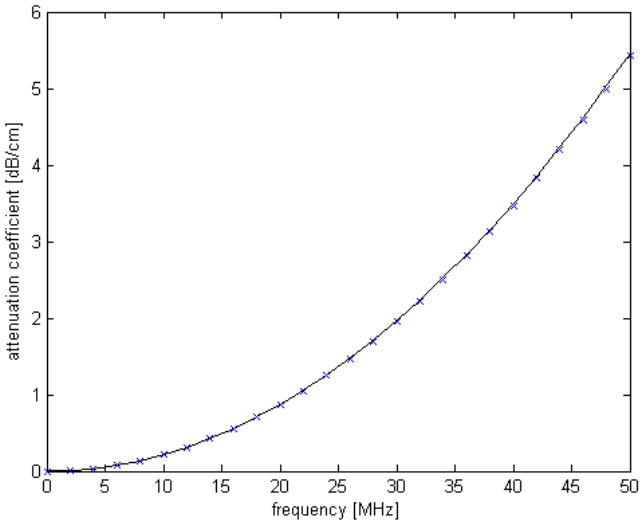
piezoelektričnost



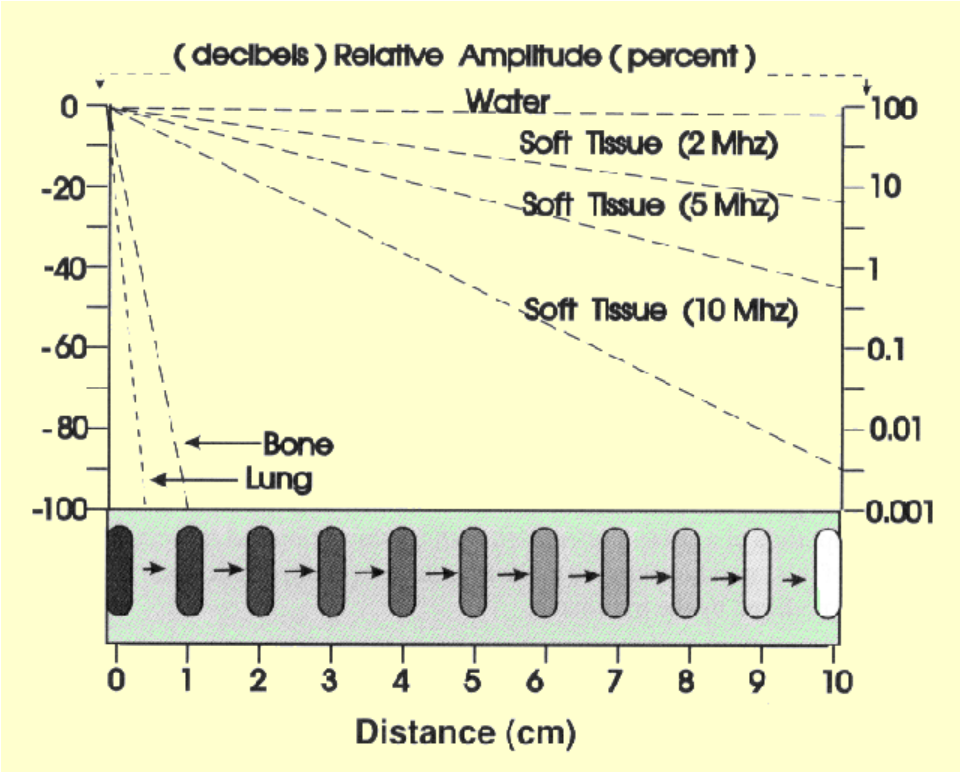
kremen (kvarc)

absorpcija zvoka

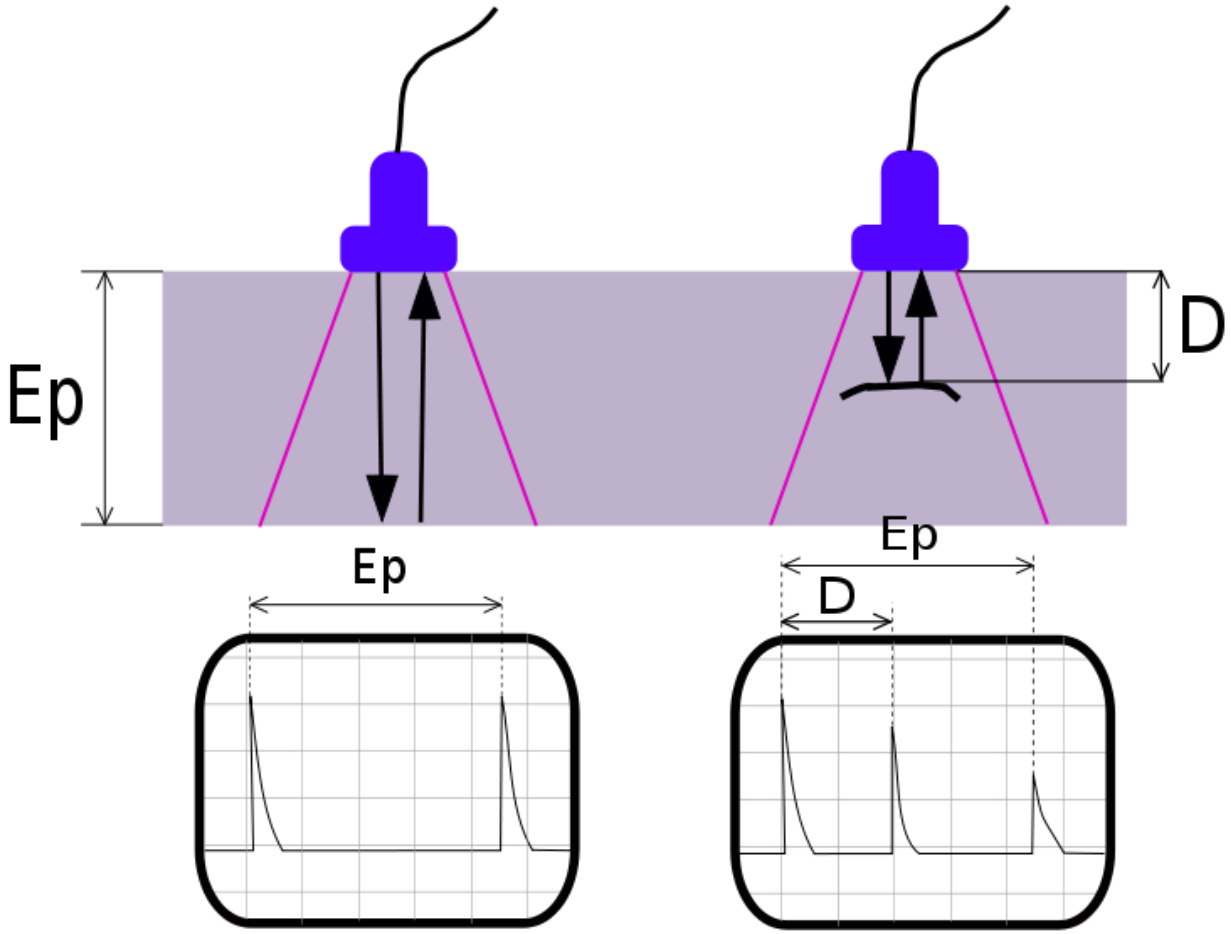
Uz v vodi



vdorna globina



princip



slikanje z ultrazvokom - sonografija

prednosti

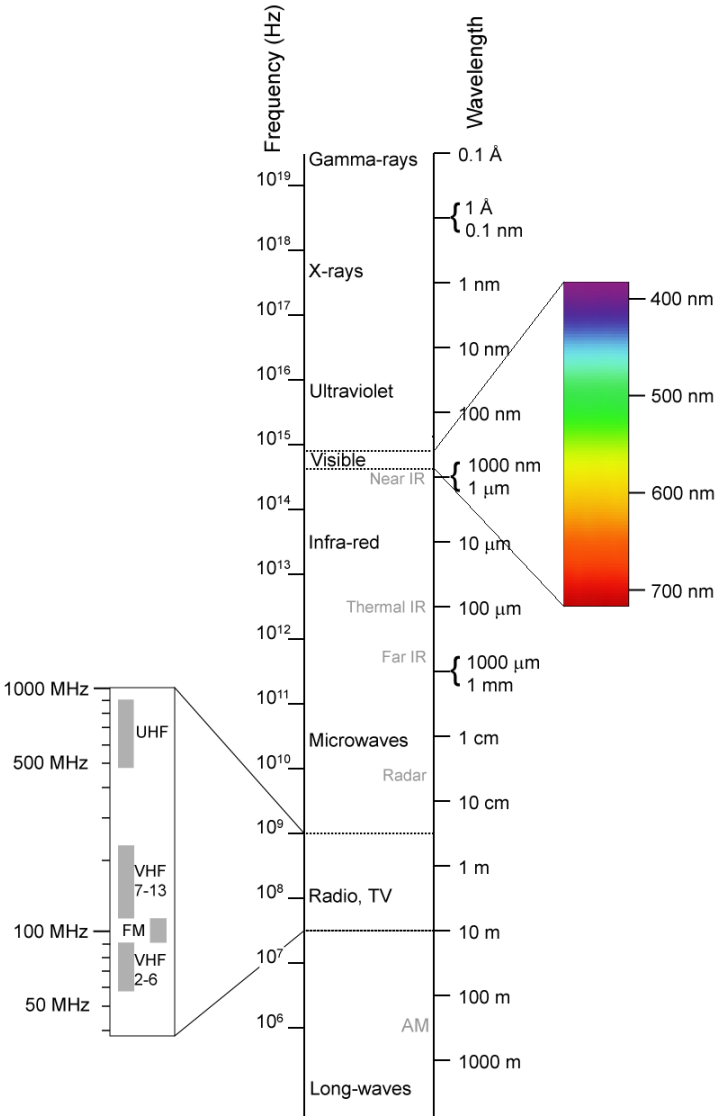
2 – 18 MHz

- mehko tkivo, površina kosti
- “neposredni prenos”
- ni stranskih učinkov, neinvazivno
- enostavna oprema
- poceni

slabosti

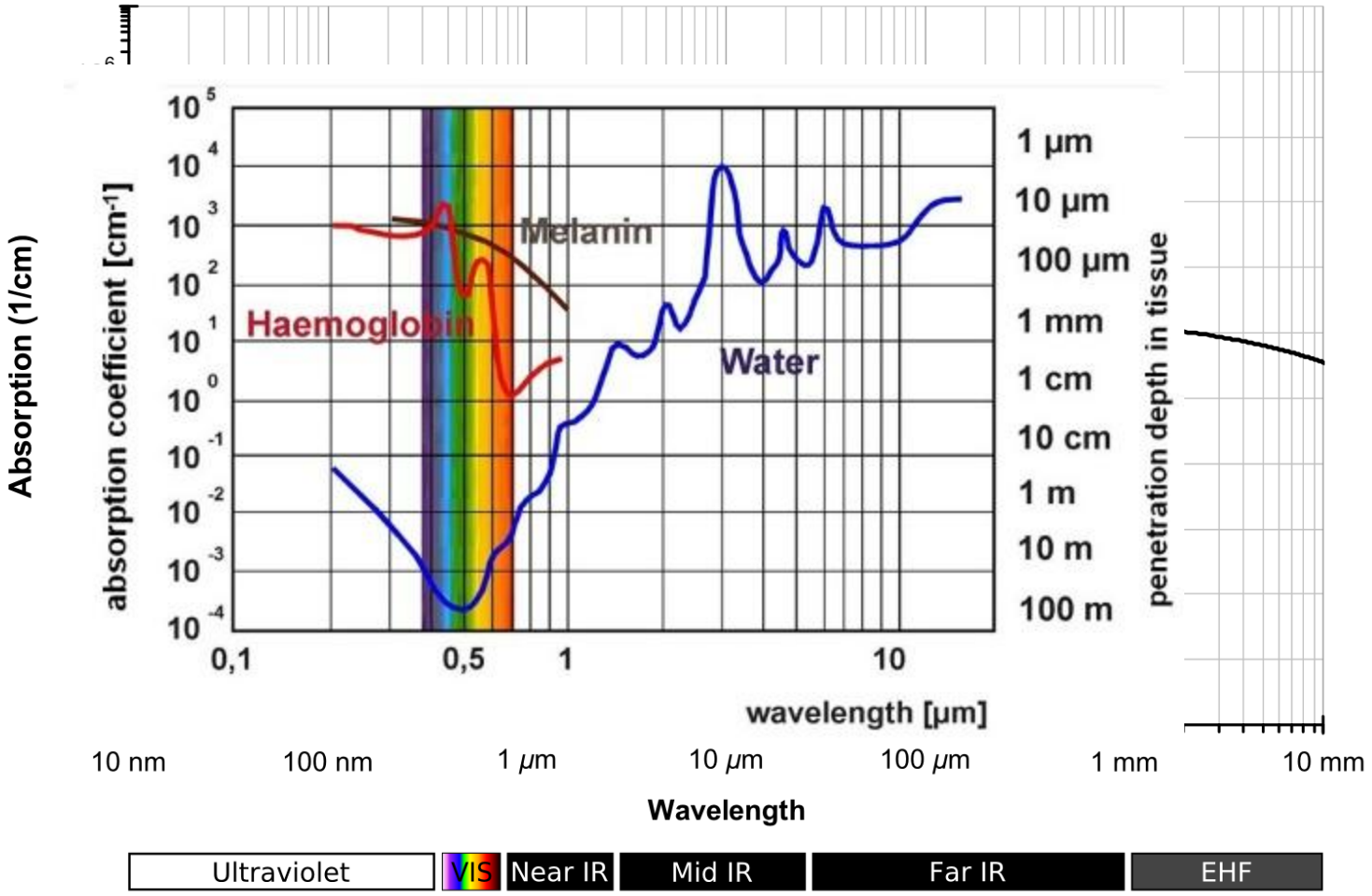
- ne prodre skozi kosti – neprimeren za možgane
- motijo plini
- oteženo globinsko slikanje
- slabo razmerje signala in šuma
- potrebuje izkušenega operaterja

elektromagnetno valovanje



CLASS	FREQUENCY	WAVELENGTH	ENERGY
γ	300 EHz	1 pm	1.24 MeV
HX	30 EHz	10 pm	124 keV
	3 EHz	100 pm	12.4 keV
SX	300 PHz	1 nm	1.24 keV
	30 PHz	10 nm	124 eV
EUV	3 PHz	100 nm	12.4 eV
NUV	300 THz	1 µm	1.24 eV
NIR	30 THz	10 µm	124 meV
MIR	3 THz	100 µm	12.4 meV
FIR	300 GHz	1 mm	1.24 meV
EHF	30 GHz	1 cm	124 µeV
SHF	3 GHz	1 dm	12.4 µeV
UHF	300 MHz	1 m	1.24 µeV
VHF	30 MHz	10 m	124 neV
HF	3 MHz	100 m	12.4 neV
MF	300 kHz	1 km	1.24 neV
LF	30 kHz	10 km	124 peV
VLF	3 kHz	100 km	12.4 peV
VF/ULF	300 Hz	1 Mm	1.24 peV
SLF	30 Hz	10 Mm	124 feV
ELF	3 Hz	100 Mm	12.4 feV

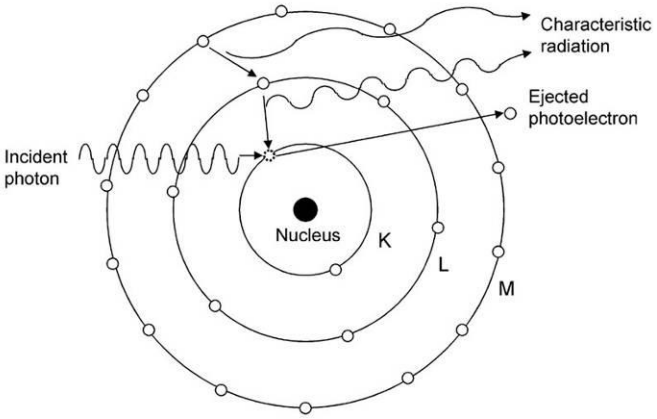
absorpcija EMV v tkivu

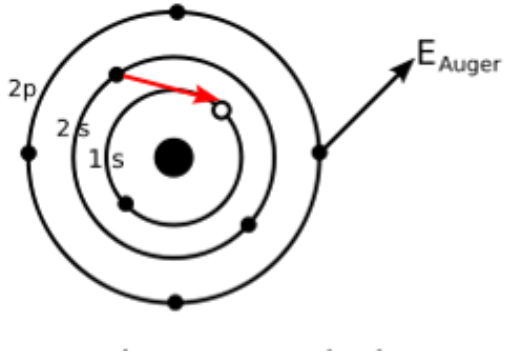


Interakcija ionizirajočih fotonov s snovjo

Interakcija fotonov -1

Fotoefekt (vaja FP 68: $E=h\nu - A_i$)

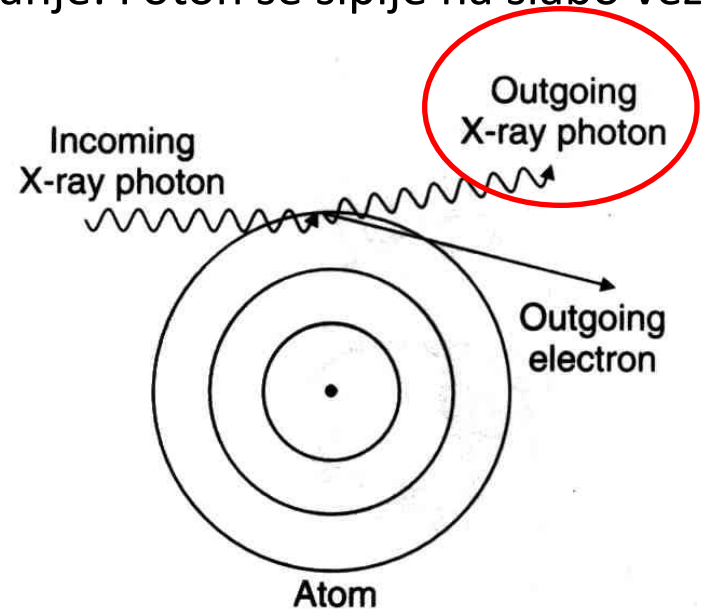




Interakcija ionizirajočih fotonov s snovjo

Interakcija fotonov -2

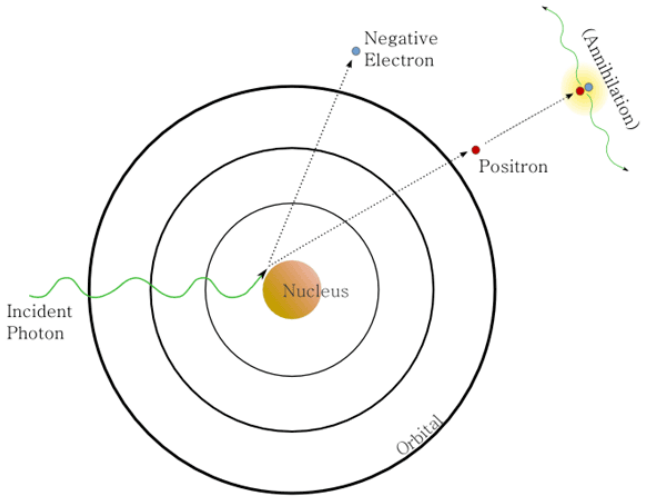
Comptonsko sipanje: Foton se siplje na slabo vezanih elektronih.



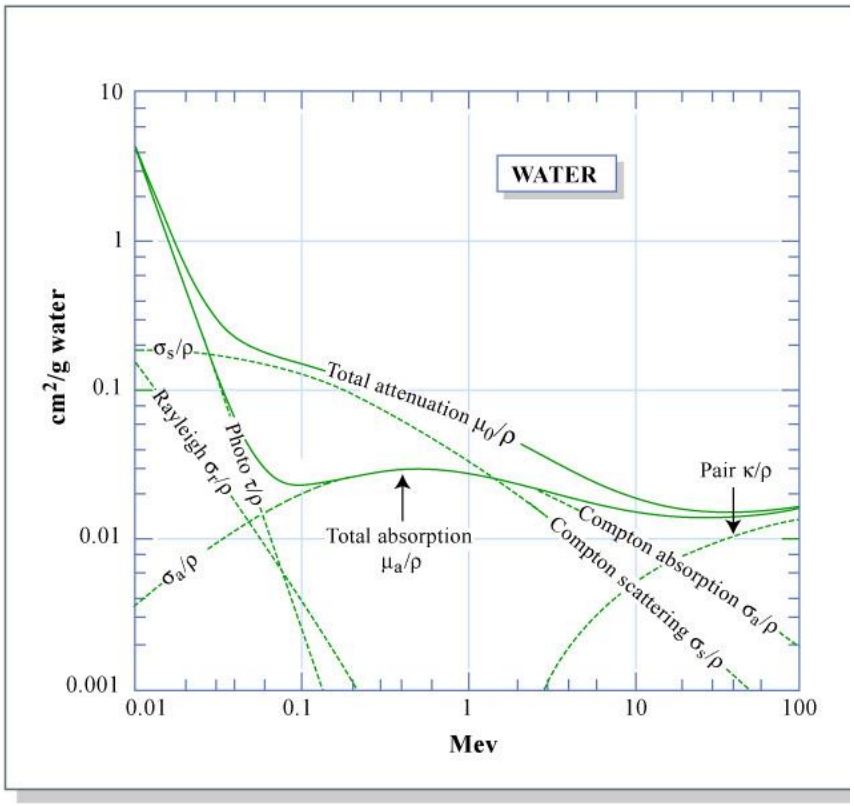
Interakcija ionizirajočih fotonov s snovjo

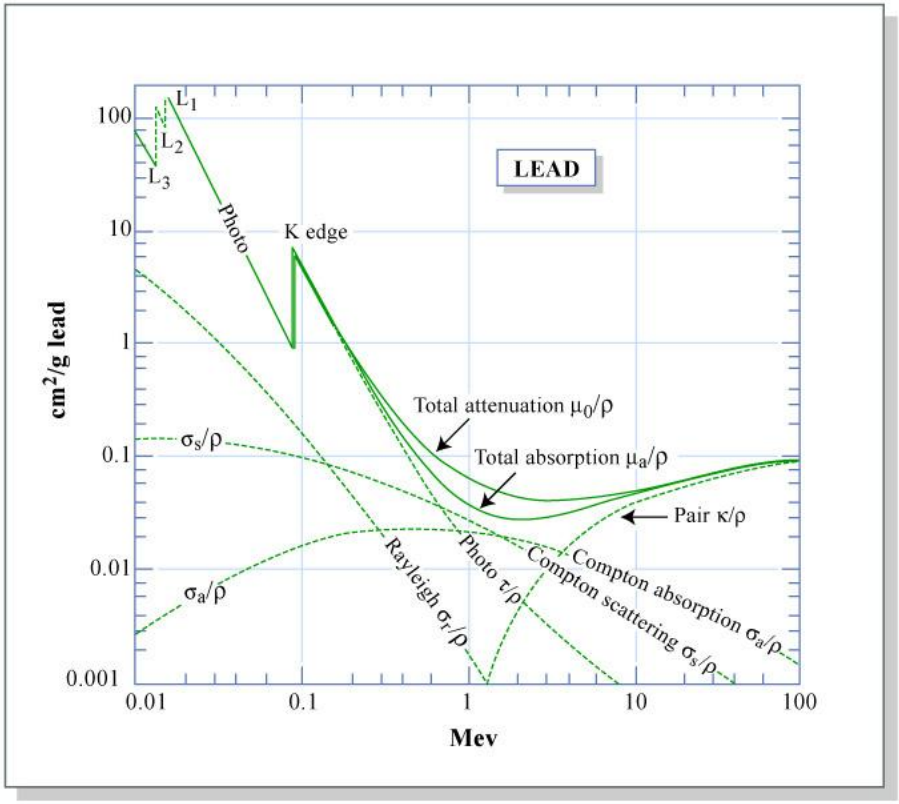
Interakcija fotonov -3

Produkcija para elektron in pozitron



Interakcija fotonov s snovjo

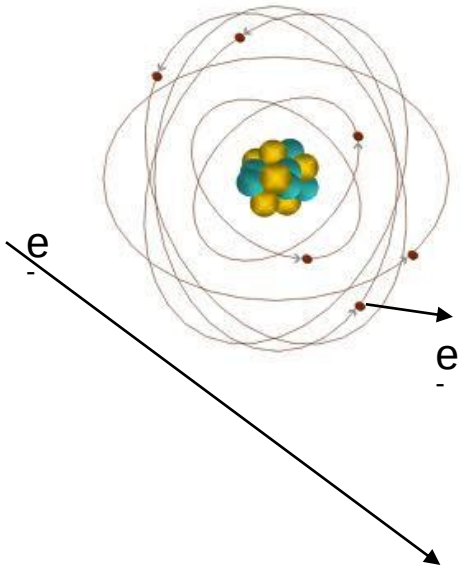




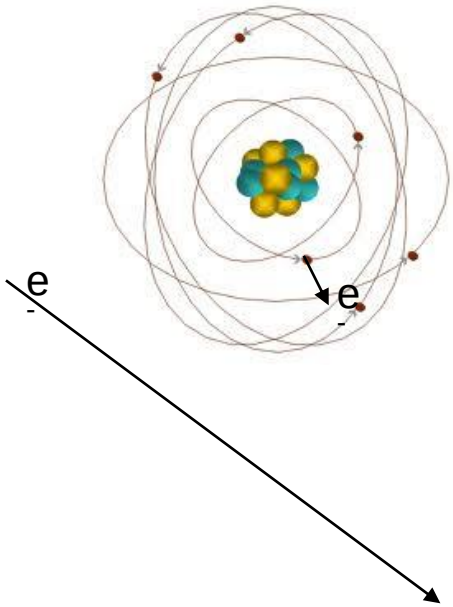
Interakcija delcev s snovjo

- Nabiti delci interagirajo predvsem preko štirih procesov:

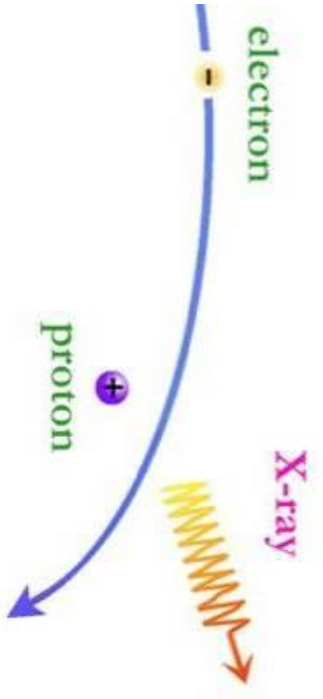
ionizacija



vzbujanje



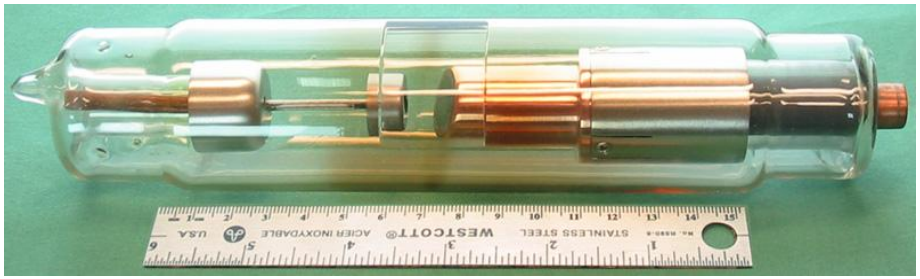
zavorno sevanje

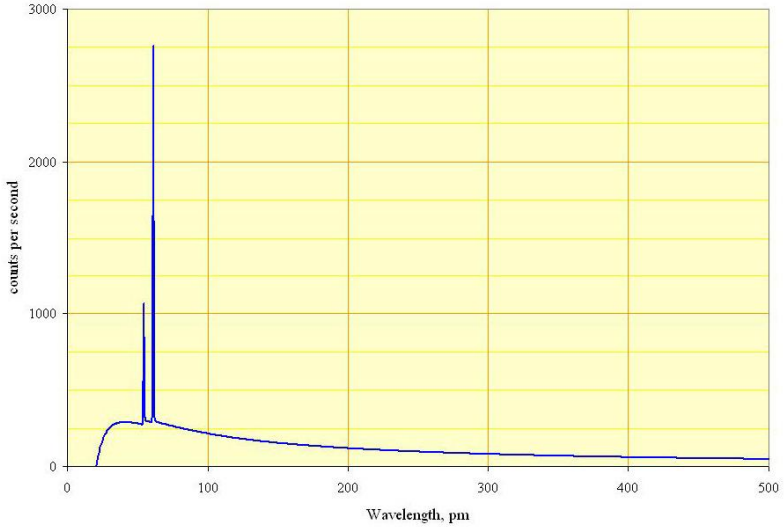


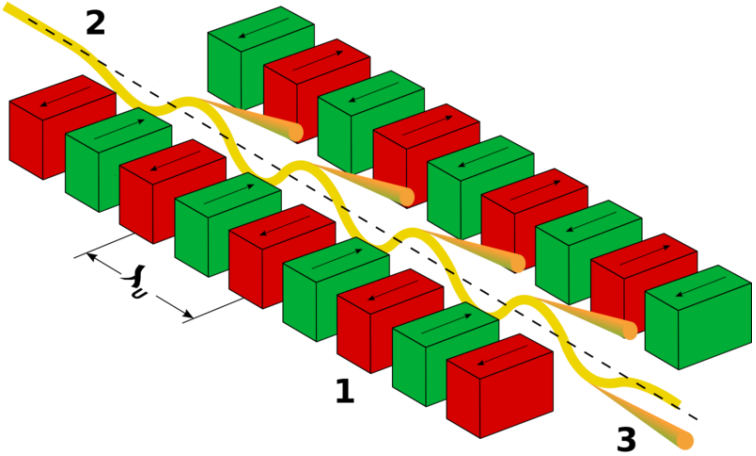
Čerenkovo sevanje

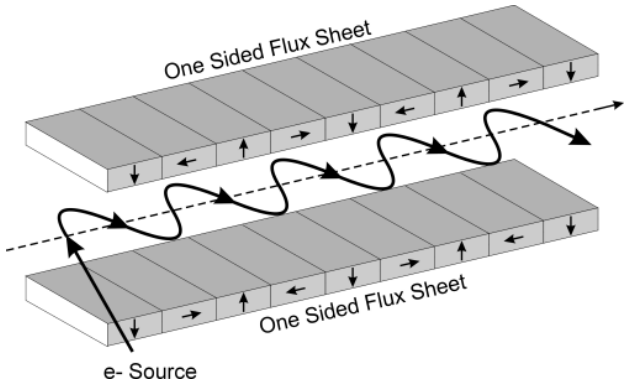
rentgen - vir

rentgenska cev
rentgenska fluorescenca
pospeševalniki delcev
(undulator, wiggler)



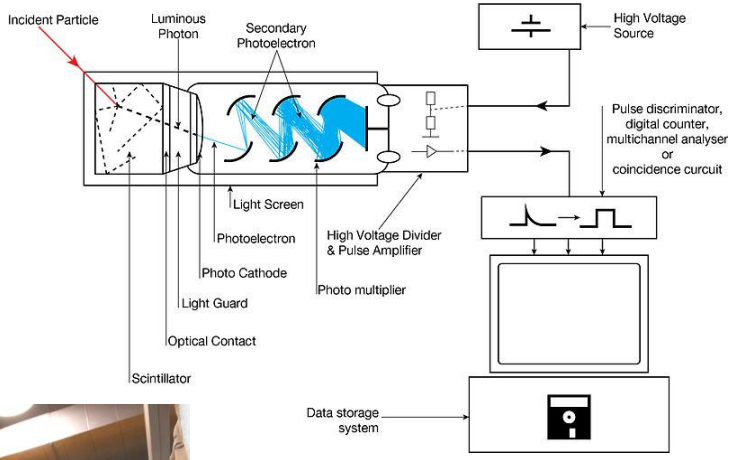


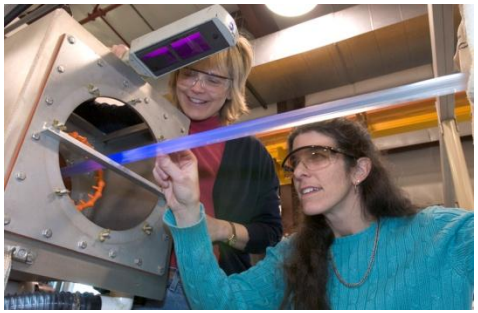


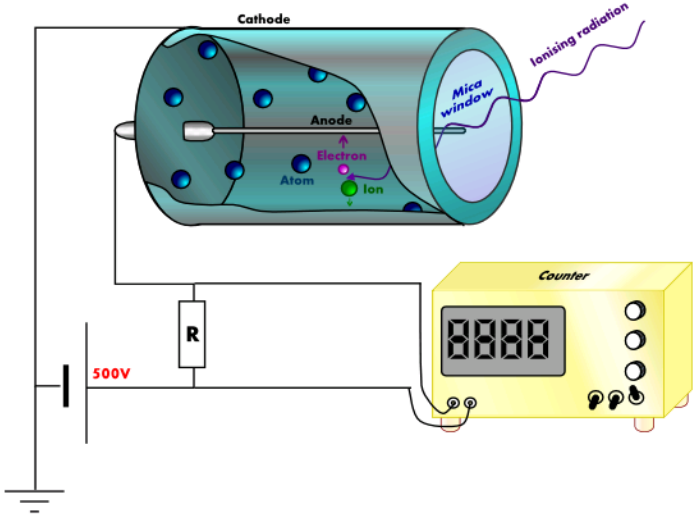


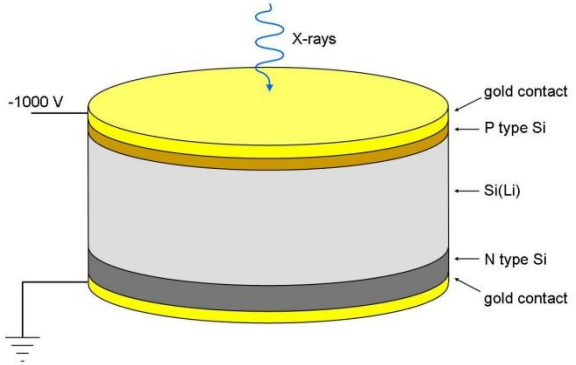
rentgen - detekcija

proporcionalni števci
polprevodniški detektorji
fotografski film
scintilatorji



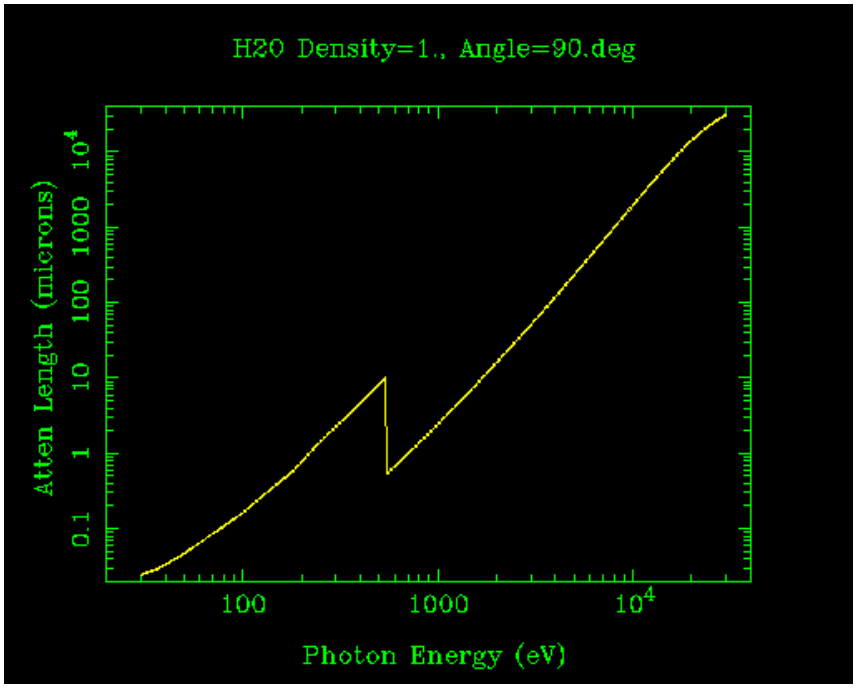


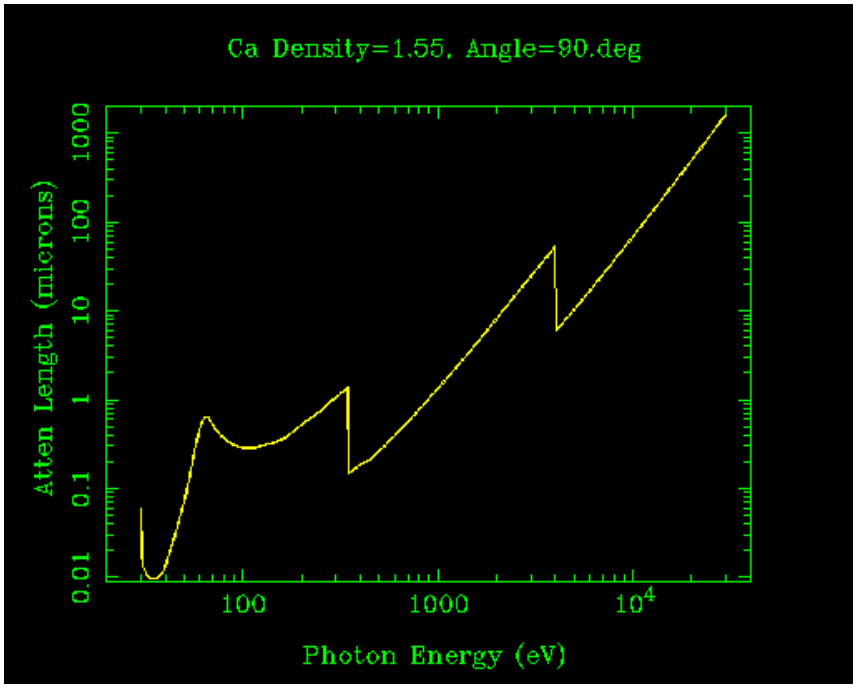




rentgen - absorpcija

Absorpcijski koeficient

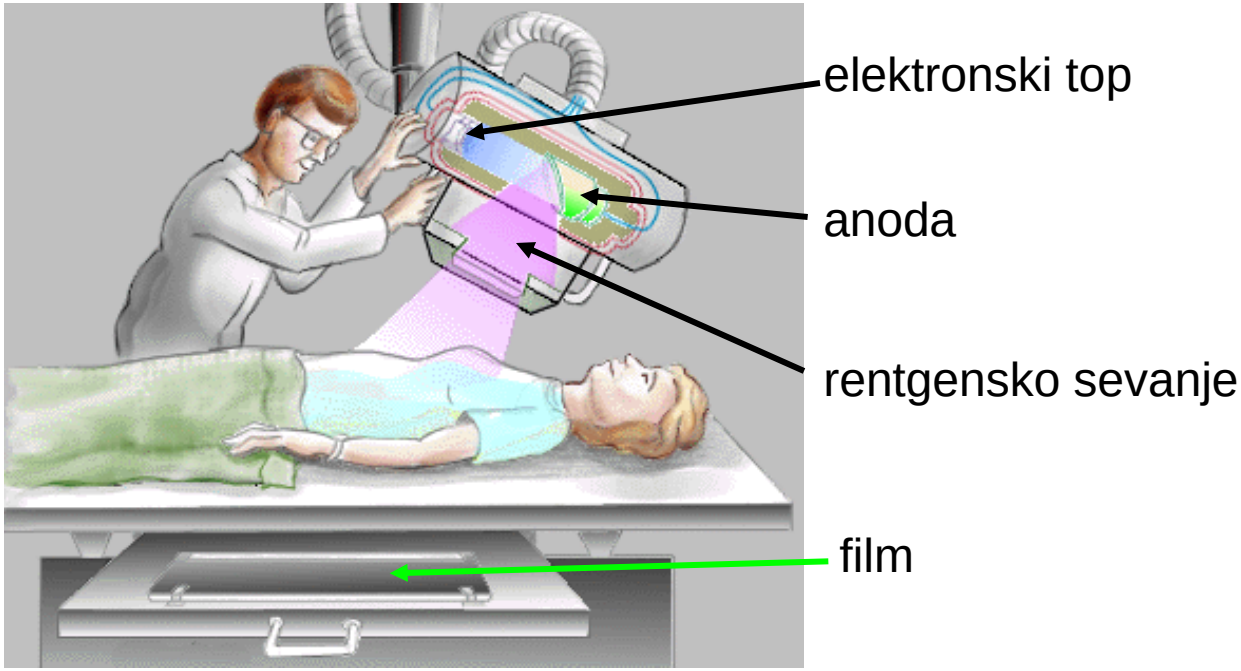




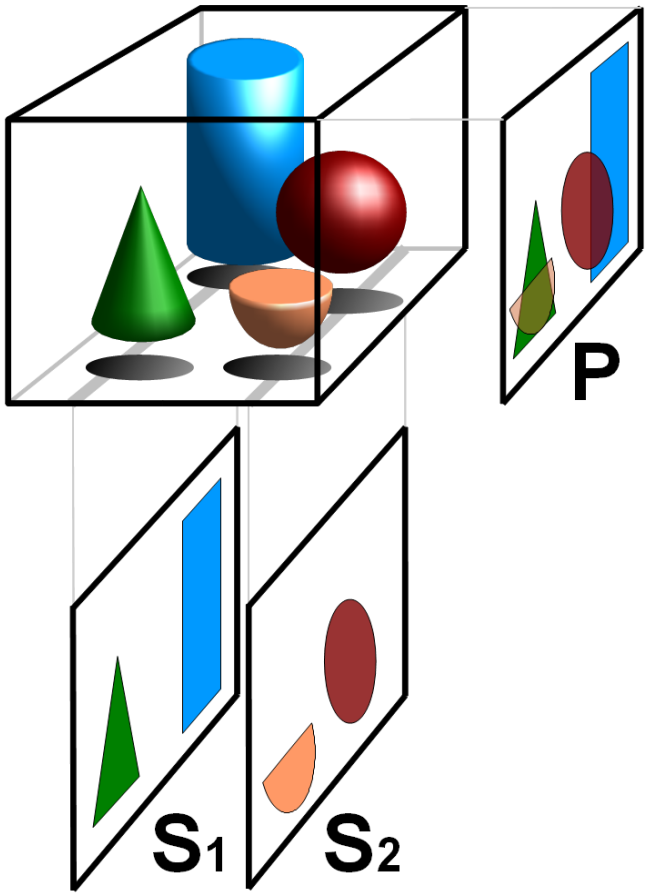
http://henke.lbl.gov/optical_constants/atten2.html

rentgen (x-rays)

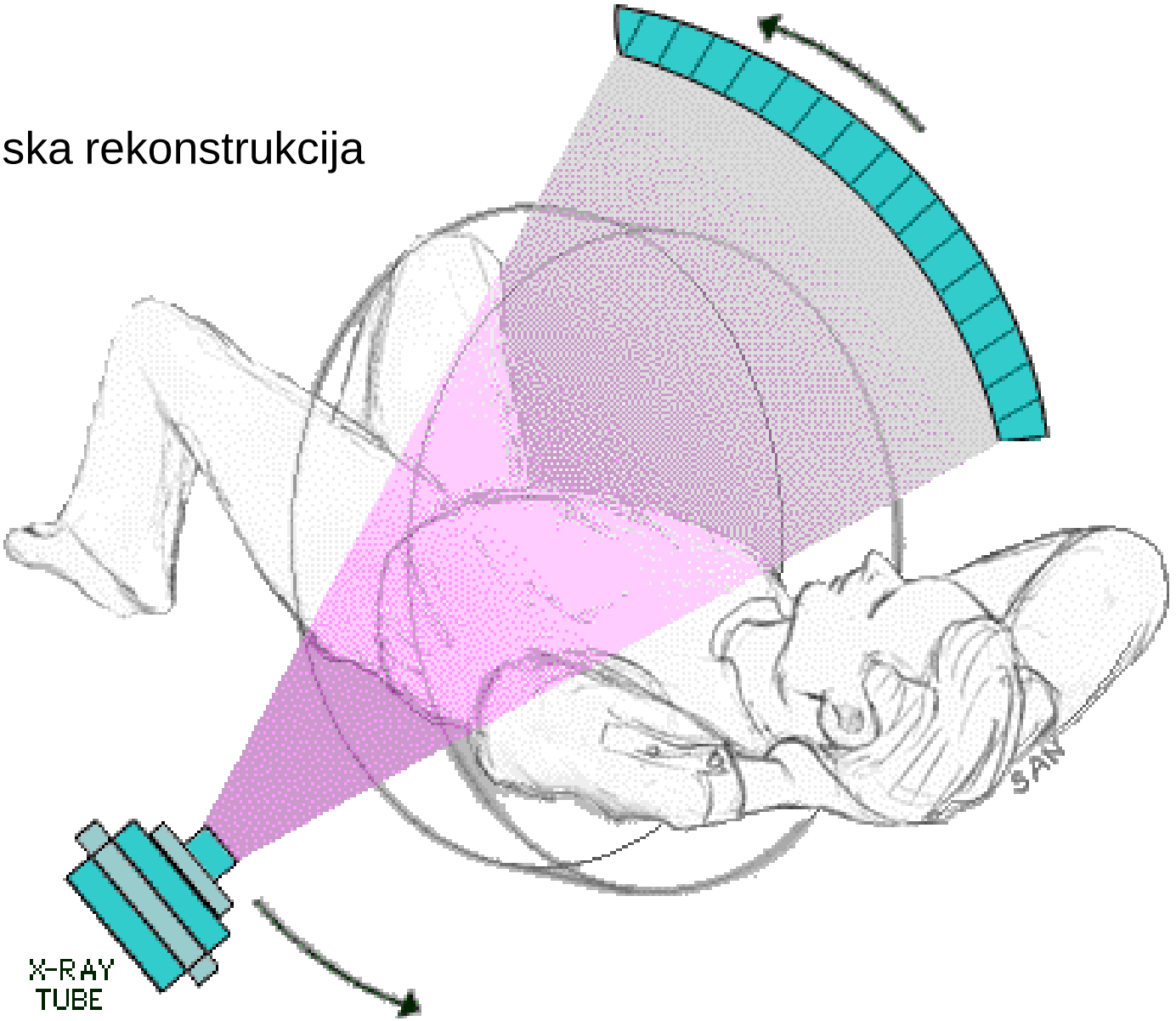
• rentgensko sevanje – zavorno sevanje hitrih elektronov na anodi (volfram, baker)
• presevajo telo, zazna jih fotografska plošča
• absorpcija v tkivu – sorazmerna z gostoto tkiva (močneje v Ca kot v H, C, O)
• fotoni počrnijo ploščo
• kontrastna sredstva – tekočine s težjimi elementi (jod, barij)



tomografija vs. projekcija



projekcijska rekonstrukcija

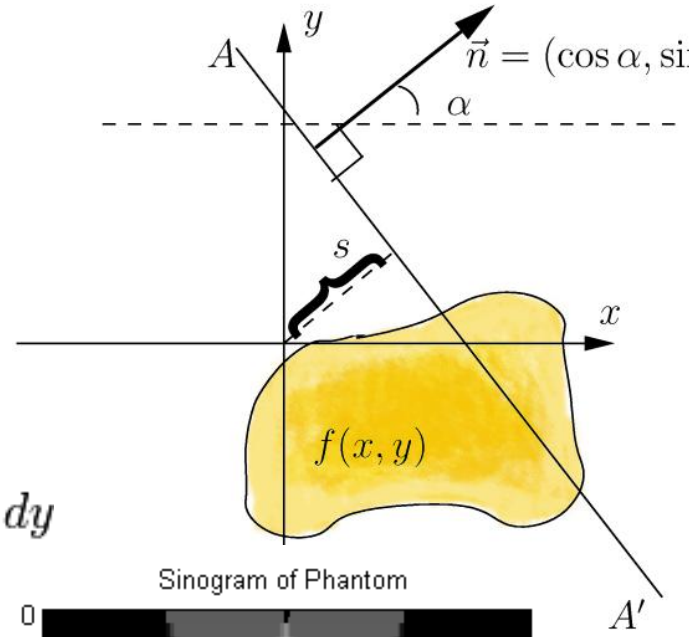


$$I = I_0 \exp\left(-\int \mu(x,y)\, ds\right)$$

$$p(r,\theta) = \ln(I/I_0) = -\int \mu(x,y)\, ds$$

$$x\cos\theta + y\sin\theta = r$$

$$p(r,\theta) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} f(x,y)\delta(x\cos\theta + y\sin\theta - r)\, dx\, dy$$



p - Radonova transformacija
(ali sinogram)