



Sensor devices Radiation laboration





Mittuniversitetet

Outline



"Sensor components" and "Sensor technology" is given in period 2 (nov-dec)

Laborations

•IV and CV characterisation of a silicon sensor

•Radioactive spectrum

•RGB-sensors for temperature measurement measurement

•Screening of radioactivity

•Simulation of radiation absorption



Types of radiation

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- Alfa-radiation
 - Helium ions (light ions)
- Beta-radiation,
 - Electrons
- Gamma-radiation
 - Elektromagnetic waves, photons
 - Light (visible, UV, IR)
 - X-ray photons "transition of orbital electrons"
 - Gamma-photons "de excitations processes in nuclei, nuclear reaction and pair production"



Interaction of radiation with matter MIUN.SE



Electromagnetic spectra

$$E = hv.$$

$$h = 6.626 \times 10^{-34}$$
 J-s.

E=energy *v*=frequency



Photon flux absorption



The photon flux after an absorber is given by

$$I = I_0 \cdot e^{-\mu}$$

Where μ is the absorbers *linear attenuation coefficient*. The value of μ varies with photon energy and The *mean free path* λ is the average distance treveled in the absorber before an interaction takes place.

$$\lambda = \frac{1}{\mu}$$

It is practical to normalize with density and use the mass attenuation coefficient μ/ρ



XOP simulator



XOP (X-ray Oriented Programs) freeware developed at ESRF for synchrotron community applications Relatively easy to use, for Windows XP, Mac OS, Linux, UNIX

- modeling of x-ray sources
 (e.g., synchrotron radiation sources, such as undulators and wigglers)
- characteristics of optical devices (mirror, filters, crystals, multilayers, etc.)
- multipurpose data visualizations and analyses



http://www.esrf.eu/Instrumentation/software/data-analysis/xop2.3



Other simulators

GEANT-4 <u>http://geant4.cern.ch</u> Freeware developed at cern, complex to use, for LINUX





MCNP <u>https://laws.lanl.gov/vhosts/mcnp.lanl.gov/</u> Licens from Los Alamos, complex to use, for LINUX or Windows (e.u. DOS)





Interaction of radiation with matter

Photons are transported deep into a material. Absorption is a statistical process.

Heavy particles first looses energy (scatters)

before they are absorbed. Absorption takes place close to the surface.





Interaction of radiation with matter





Radiation protection



http://fancyschmancy.blogg.se



Two types of biological impact MIUN.SE

When radiation interacts with biological tissue, energy is transferred to the atoms in the cell.

- Ionizing radiation: The transferred energy is high enough to ionize an atom, i.e. an electron is kicked out of the atom. The atom will be strongly reactive and react chemically with a neighbor atom to regain balance.
- Non-ionizing radiation: The energy is not enough to ionize atoms, instead the energy is deposited as heat. Heat is defined as vibrations or movement among the atoms in a molecular structure.







Ionizing radiation leads to free radicals in water (or tissue)





(a) Decomposition of water into radicals due to the action of ionizing radiation.



(b) Spontaneous ionic dissociation of water.

Figure 2.1. Radiolysis of water. Schematic representation of a water molecule and its dissociation into two radicals HO. and H. due to the action of radiation. The term *radical* is used to describe an atom or a group of atoms containing an unpaired electron which results in great chemical reactivity (radicals are represented by adding a . to the chemical symbol). A radical can be neutral or charged (*radical ion*). The radicals HO. and H. which are produced in the course of radiolysis of water (a) are very reactive, a property which distinguishes them from the ions OH⁻ and H⁺ formed in the spontaneous ionic dissociation of water (b); the latter do not have unpaired electrons and are chemically unreactive. After [8].











Damage on cellular level



If the DNA is damaged and can not be repaired then the cell will either:

- Die (most likely)
- Stop functioning and instead start to reproduce uncontrollable (becoming a cancer tumor)
- Mutate, i.e. get an other function than it had before.



ALARA



As Low As Reasonable Achievable

International philosophy and sometimes also juridical principle for work with radiation.

Radiologic work should be approved by the national authority :









Radiation to cure cancer

Biological damage from ionizing radiation is a relatively exact science. Radiation therapy of cancer to give a tumor exactly the radiation dose that will kill all cells in the tumor, but not all surrounding healthy tissue cells. Cells that are strongly reproducing (cancer- and fetus cells) are more sensitive to radiation while cells that are not reproducing are relatively insensitive to ionizing radiation.

Oncology is non surgery treatment of tumor deceases.





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