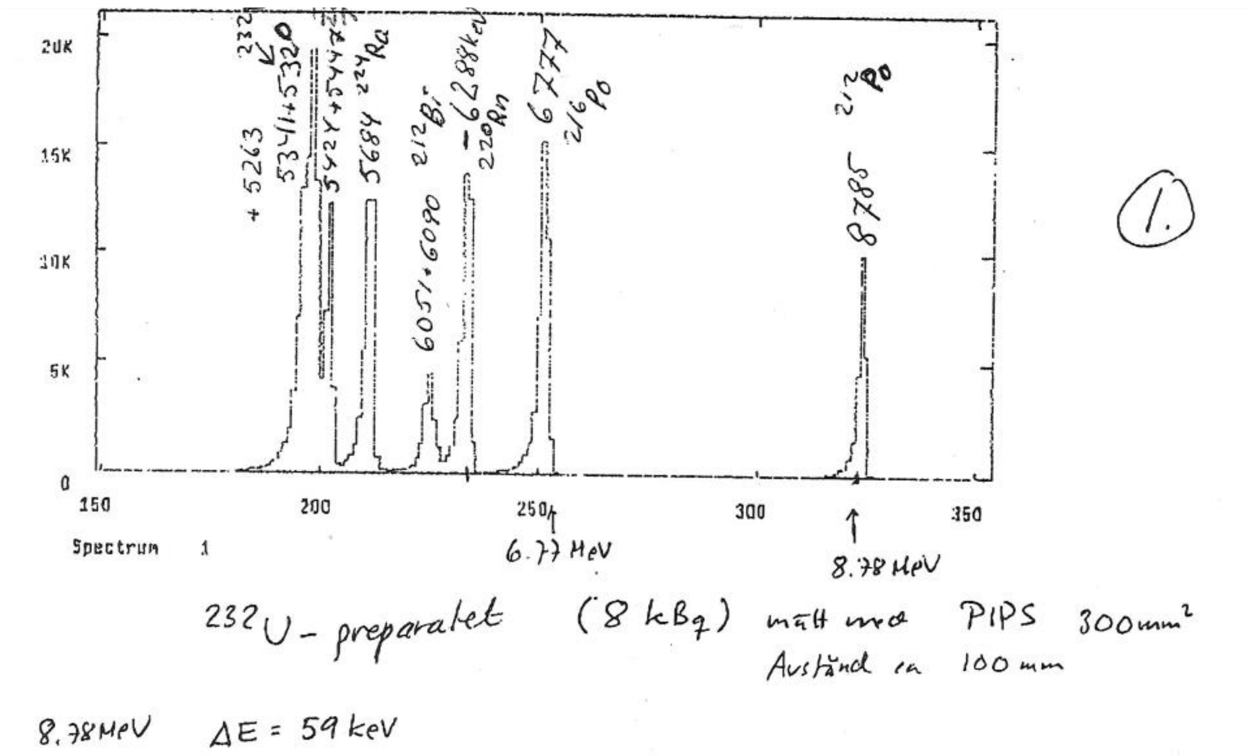
Laboratory instruction SENSOR DEVICES

Examination: It is **compulsory** to **attend** the laboratory work. A set of given questions should be answered and should be handed in by each lab group at the end of the lab.

Station 4 is not scheduled, and is examined by a written report instead. The report should be handed in by latest 20:th of December 2016.

Appendix
Uranium-232 decay chain



Station 1.Cleanroom processing lab in sensor devices (S237 cleanroom)

Steps	Processing	Measurement	Notes
Already done	Starting wafer		
Already done	Standard Cleaning		
1	Evaporation of Aluminium, 1000Å		
2	Spinning of resist, 4000 rpm, 1.8 um positive resist, front		
3	Bake, 115 ºC, 1 min hotplate,		
4	Patterning mask 2		
5	Development 1 min/rinsing		
6	Inspection		
7	Etching of Aluminium/ rinsing		
Out of time	Measurement		

Questions

Marking of wafer. The starting material is commercial *n*-type Si (100) wafers with100 mm diameter. Note the specified resistivity and thickness of the wafer:

ρ = ________________________Ωcm,   Thickness=_________________µm

Metalization

Note the base pressure in the evaporator:__________________________________

Why is it important to immediately load the wafers in the evaporator or furnace after standard cleaning?

What more types of metal deposition methods more than evaporation are possible?

Photolitography

Note the exposure time and dose:___________________________s ________________________ mJ/cm^2

Why is the yellow room provided with a yellow filter? How is the resist affected by UV-light?

What task has the HMDS? How thick will the resist layer be? ______________µm

What is specific about the lithographical technique used? What is its resolution?

How do you evaluate the quality of your lithography pattern after exposure?

Was it acceptable or does it need to be improved?

Aluminium Etching

What acids are used in aluminium etching?

Measure the approximate etching time for the aluminium etch.

Oral presentation.

Make notes during the processing and present the process flow.

Answer the questions above.

Station 2. Measure the spectrum of Am and U (S111 electronics student lab)
WARNING: TAKE CARE WHEN HANDELING RADIOACTIVE ELEMENTS. USE PINCETT AND WASH YOU HANDS AFTERWARDS.

Use the MCA (Multi channel analyzer) to measure the spectrum of radioactive sources. The measurement should be done in vacuum.

Preparation before lab:

- Find an external reference for the expected energy of alpha particles from Americium-241 (The energies from Uranium-232 is provided in Appendix).

Station 2, task 1

- Take the spectrum of both Am and U in (vacuumed chamber).
- Replicate the spectrum, either by exporting it from the software, by copying the screen or by drawing it.
- Compare the spectrum you achieved with the provided spectrum. Identify important peaks of the spectrum and calculate the energy scale of the measurement you performed.

The energy scale at this measurement is ___________________ keV/channel

Station 2, task 2

- Open the valve and compare how the Uranium spectrum changes due to filtering in air.
- Replicate the "in air" spectrum and discuss the differences.

Station 3. Radiation shielding and dosimetry (S111 electronics student lab)

Measurement: Intensity attenuation
Equipment: Geiger counter, shielding plates (lead, silicon and paper), radioactive materials.
You are provided with three radioactive sources.
Alfa source: Am – 241
Beta source: Sr – 90
Gamma source: Cs – 137

For each source, measure the intensity I_0 of the unshielded source with the Gieger counter. Measure how the intensity I changes with the shielding thickness t. Fill in the tables below with measured intensity I (number of count) and plot the normalized intensity against the thickness of shield.

Preparation before lab:

What is mean range Rm and/or the extrapolated range Re for particles and the absorption coefficient for photons. Check which equations to use in the lab.

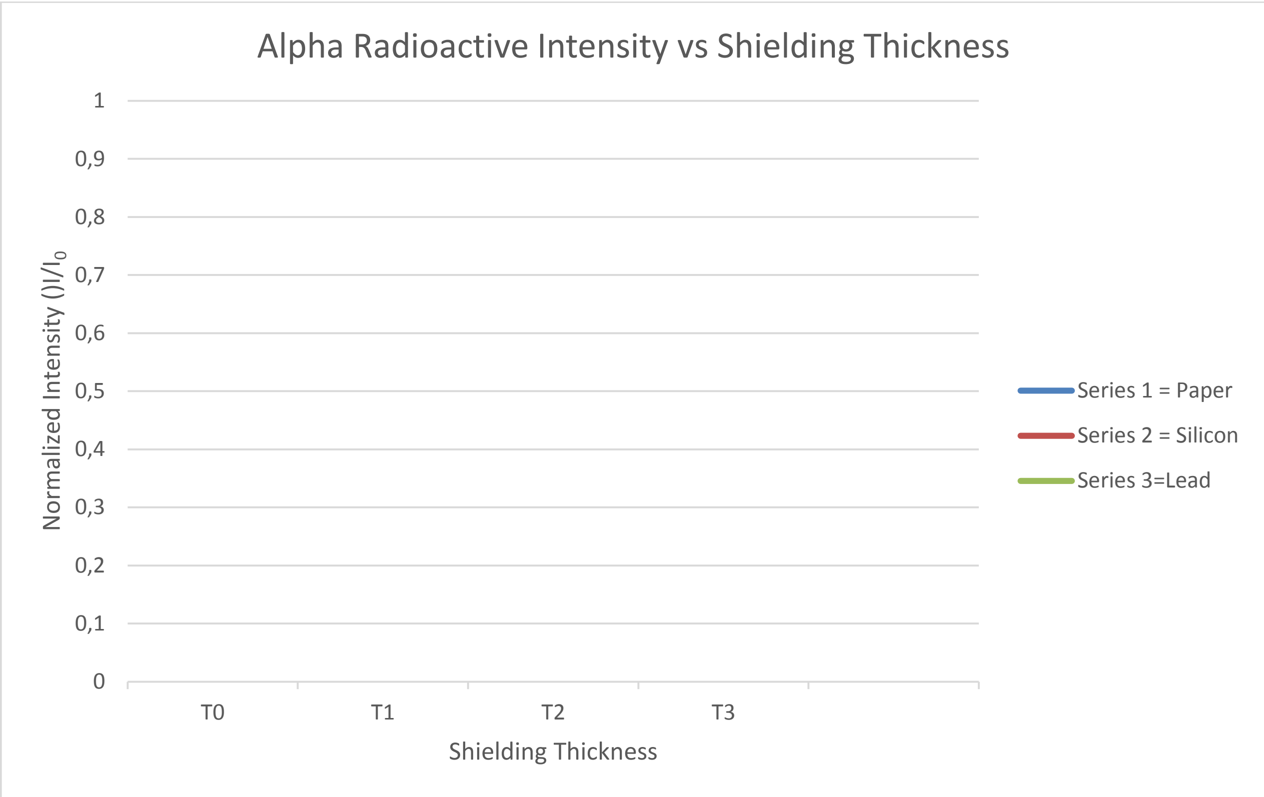
Station 3, tasks:

- Sketch the graphs for each source on the following papers.
- For each source, estimate the mean range Rm and/or the extrapolated range Re for particles and the absorption coefficient for photons.

Alpha Source: Am-241

Count rate table

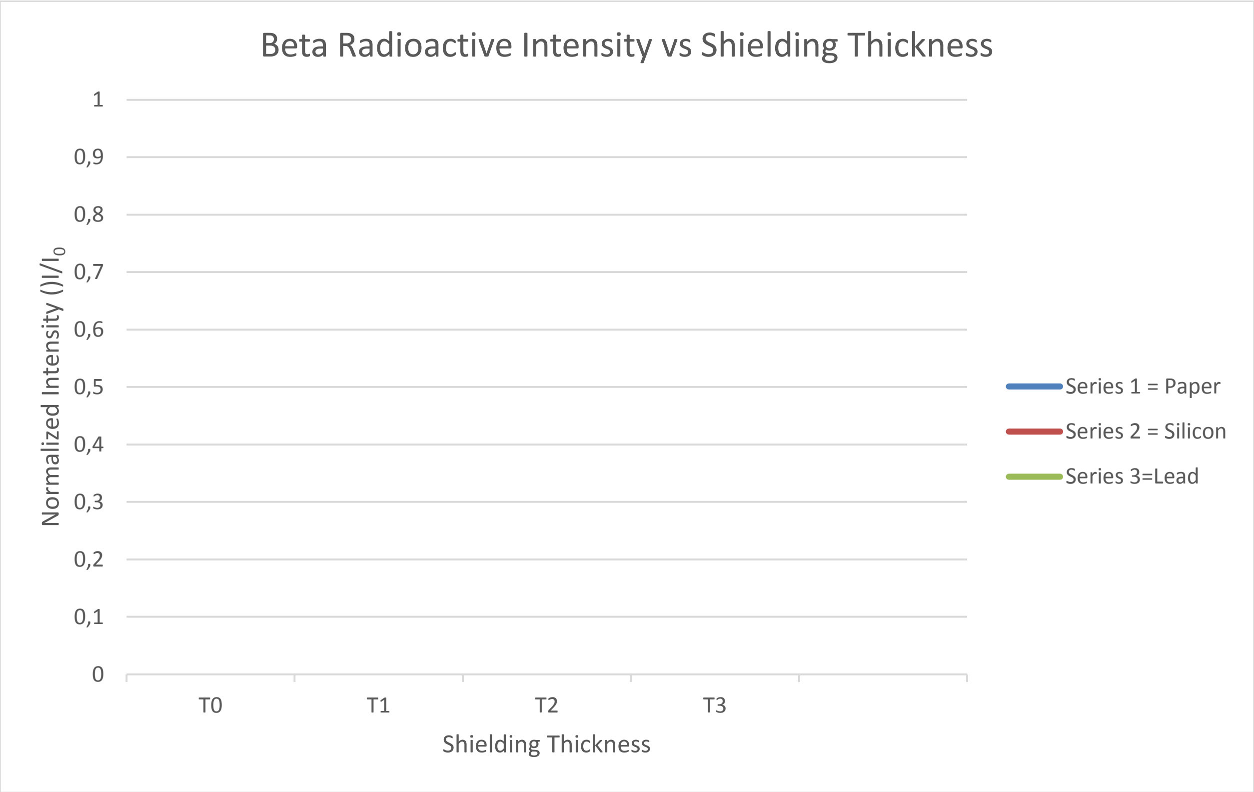
Shields	Thickness T_0 = 0mm	Thickness T_1 = _____	Thickness	Thickness T_2 = _____	Thickness	Thickness T_3 = ______	Thickness
Paper							
Shields	Thickness T_0 = 0mm	Thickness T_1	Thickness	Thickness T_2	Thickness	Thickness T_3	Thickness
Silicon							
Shields	Thickness T_0 = 0mm	Thickness T_1	Thickness	Thickness T_2	Thickness	Thickness T_3	Thickness
Lead							



Beta Source: Sr – 90

Count rate table

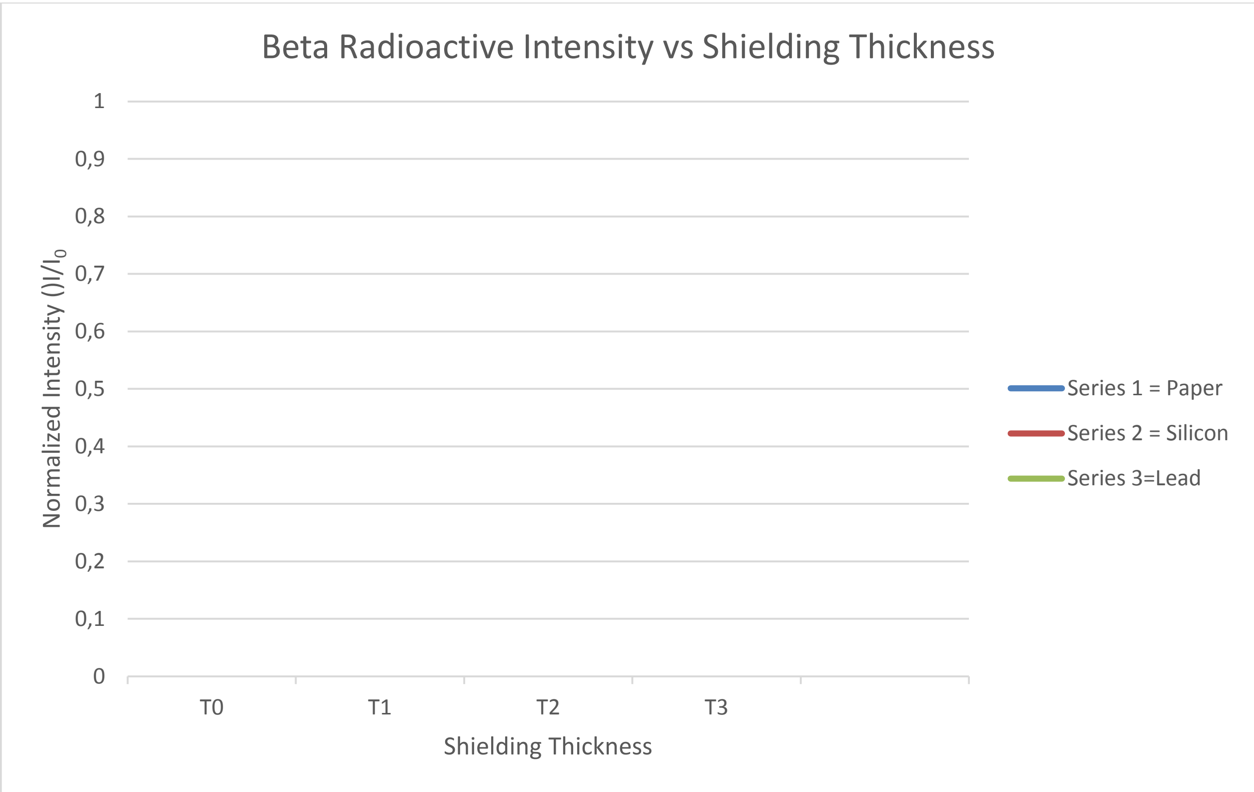
Shields	Thickness $T_0 = 0mm$	Thickness $T_1 =$ _____	Thickness	Thickness $T_2 =$ _____	Thickness	Thickness $T_3 =$ ______	Thickness
Paper							
Shields	Thickness $T_0 = 0mm$	Thickness T_1	Thickness	Thickness T_2	Thickness	Thickness T_3	Thickness
Silicon							
Shields	Thickness $T_0 = 0mm$	Thickness T_1	Thickness	Thickness T_2	Thickness	Thickness T_3	Thickness
Lead							



Gamma source: Cs – 137

Count rate table

Shields	Thickness T_0 = 0mm	Thickness T_1 = _____	Thickness	Thickness T_2 = _____	Thickness	Thickness T_3 = ______	Thickness
Paper							
Shields	Thickness T_0 = 0mm	Thickness T_1	Thickness	Thickness T_2	Thickness	Thickness T_3	Thickness
Silicon							
Shields	Thickness T_0 = 0mm	Thickness T_1	Thickness	Thickness T_2	Thickness	Thickness T_3	Thickness
Lead							



EL004A: Station 4. Simulation of radiation shielding (Home task)
This station has no specific scheduled laboration time, the task should be done during the course.
A written report on the simulation project should be handed in. ***The report can be done by a group****. The report expected is a "simple report" describing the results brief conclusions. The report should be handed in before 30:th of November.*

MAIN TASK
You should develop you skill to be able to do radiation simulations using free softwares. Two software are to be used, "Rad Pro Calculator" and XOP.

Rad Pro Calculator
Rad Pro Calculator is found on http://www.radprocalculator.com/ , it can either be used as a web interface or downloaded as a windows application.

- Use your measurements from station 3 of unshielded activity for the Am-241, Sr-90 and Cs-137. Use the Rad Pro Calculator to calculate the dose rate (in mSv) achieved by a student that directs the source to his/hers body at a distance of 10 cm. (Use Dose-Rate\Gamma Activity and Dose-Rate\Beta Activity.)
- The maximum legal dose for a worker or student in radiation physics is 50 mSv/year. Calculate the maximum time the student can be exposed to the each of the source in the previous example. (Use Dose-Rate\Alara Calculations.)

Activity is measured in Bq, referring to counts/second. Am241 has a gamma particle with energy 59 keV. How is the intensity of Alfa-particles influenced by 10 cm air?

XOP
The simulation software XOP is a freeware for calculation of energy dependent X-ray and Gamma-ray attenuation. It can be downloaded from:
http://www.esrf.eu/Instrumentation/software/data-analysis/xop2.3
To get XOP working for Windows 7 (64 bit), unzip this file from:
http://apachepersonal.miun.se/~bornor/sensor/bin.x86.zip and replace the folder bin.x86 in your installation.

- Use XOP to calculate the attenuation achieved when shielding the Cs gamma source used in the dosimetry task in the lab course. Compare with your measurements. *The Cs-137 decay change has a gamma emission with energy 662 keV.*
- Use XOP to calculate the attenuation of the gamma contribution from the Am alfa source used in the same lab. *Am241 has a gamma emission with energy 59.5 keV. Discuss how this peak is affected by the absorption in the sensor compared to the Alfa-peaks.*
- Use XOP to achieve the attenuation graph for the three sensor materials Si, CdTe and GaAs.
- Calculate the necessary thickness of a sensor of each material that should absorb at least 10% of the gammas for Cs-137 and Am-241 gammas respectively.

Use XOP to calculate

- The spectrum of the X-ray source 60 keV and 100 keV (tungsten target)
- The spectrum of the X-ray source after a 1 mm Aluminium filter
- The spectrum of the X-ray source after a 500 µm thick silicon sensor.
- The spectrum of the X-ray source after absorbed in a 500 µm thick CdTe sensor.
- The spectrum of the X-ray source after absorbed in a 500 µm thick GaAs sensor.

Discuss how much the spectrum is distorted for each sensor material. Discuss what spectrum will actually be measured.

Save the tube output using Xtube_W\File\Write files for xop/optics and change source in XPOWER to xop/source Flux. Show Cumulative transmission Intens after oe #1.