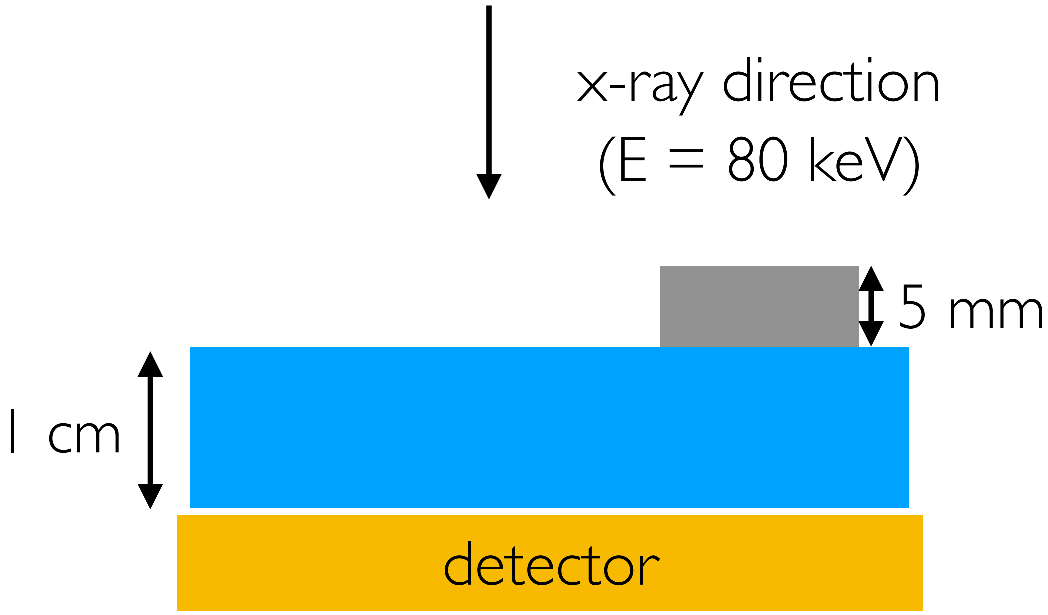
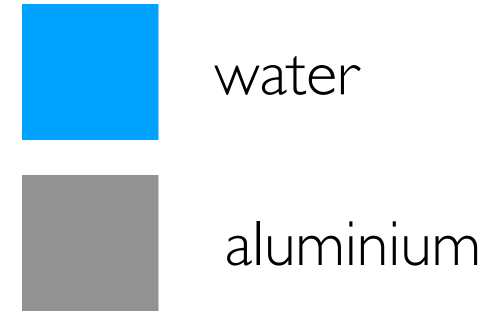
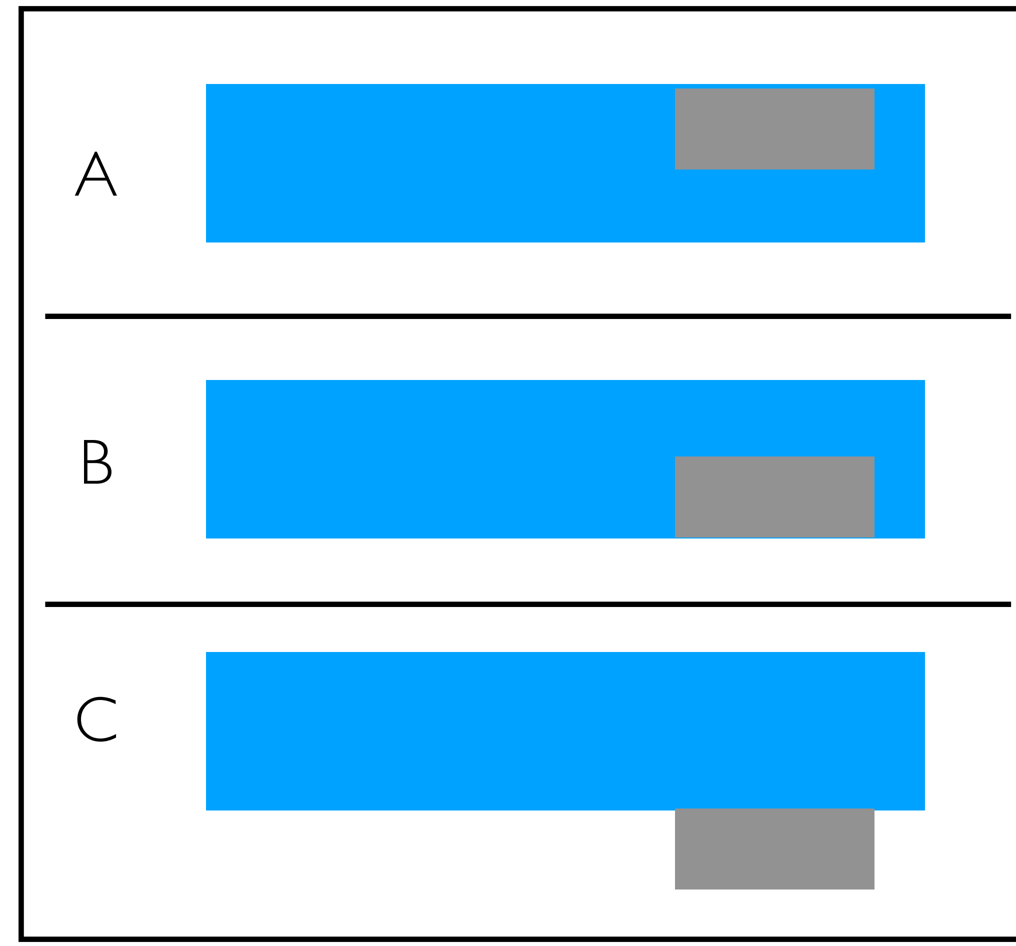


O



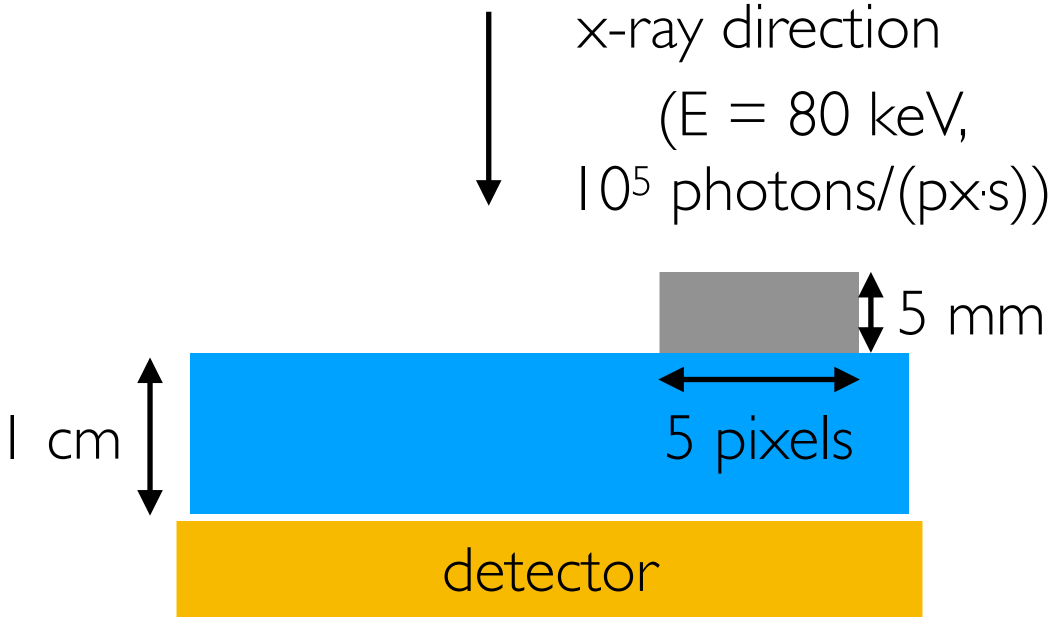


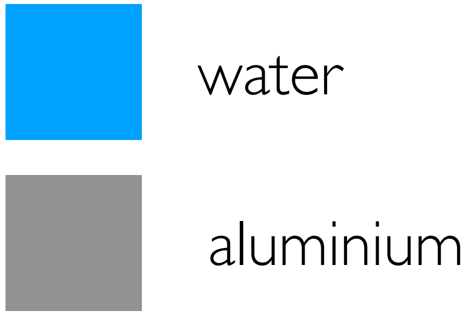
E 1. Introduce necessary symbols and write an expression for the object contrast (considering the Al-block as the object) in the situation above.

E 2. Estimate the object contrast using NIST-tables and the numerical values for thickness given in the figure.

E/C 3. Consider now to substitute the object O in the figure above with A, B and C, respectively and make a prediction for each of the objects as to whether the object contrast will be the same as for O or will change. Motivate your answer.

E/C 4. Now calculate the object contrast for the cases A, B and C and compare your result with your prediction. If the result does not match the prediction explain why and, in particular try to understand what went "wrong" in your prediction.



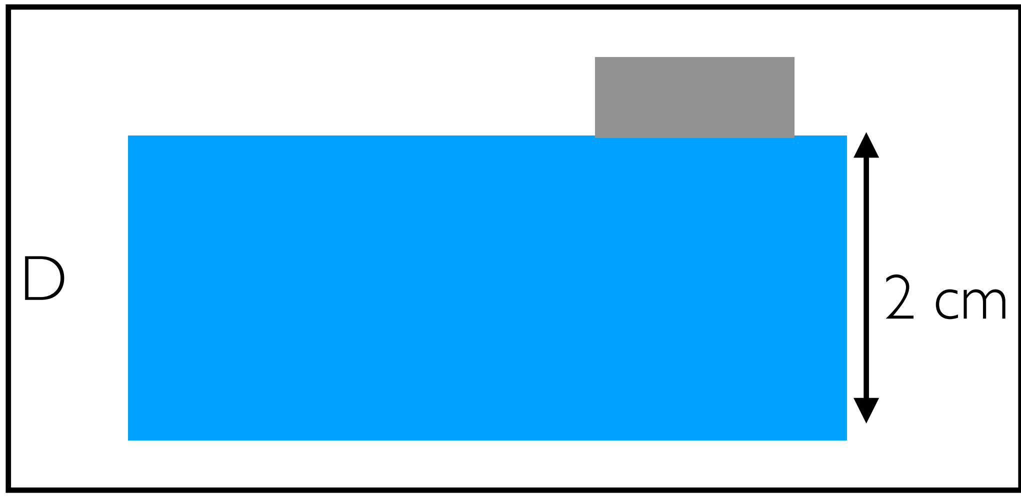


E 1. Calculate SDNR for an acquisition of 1 s, 10 s and 20 s

E 2. Estimate the object contrast for E = 60 keV and 30 keV. Use these results, together with the previous calculation at 80 keV to discuss the object contrast trend with energy. Do you have an explanation for this trend?

E/C 3. Calculate the also SDNR when the energy is 60 keV and 30 keV for the different acquisition times. Make a table with object contrast and SDNR at the three different energies and times. What is the trend of SDNR with time? And with energy? Is it the same as for object contrast? Why?

E/C 4. Considering an energy of 60 keV, calculate now the SDNR (10 s acquisition) and the object contrast for object D shown on the right. Compare with the results for object O. What can you learn from this?



E 1. Draw the spectrum from an x-ray tube operated at an acceleration voltage of A kV and with an anode current of B mA. Put labels on the axis (both quantities and units) and describe the different features of the spectrum.

E 2. Choose a point of the curve and describe what information its coordinates give you. (E.g. in a graph showing the average selling price / m^2 of an apartment in Stockholm against time, the coordinates of a randomly chosen point, say (24 April 2018, 93000 SEK) show the date and the average selling price per squared meter at that date).

E 3. What quantity is represented by the integral of the spectrum?

E 4. Draw now on the same graph (using another colour or line style) the spectrum when the tube is operated at:

   1. 2A kV and B mA
   2. A kV and 2B mA

E 5. Still on the same graph draw the spectrum you would obtain after filtering the original spectrum (A kV, B mA) with a filter.

C 6. In clinical imaging a typical voltage choice is 80-120 kV, depending on the specific imaging task and the spectrum is always filtered. Taking in consideration what you have learned with your previous exercise on SDNR can you explain why filtering is useful?

E 7. Draw the emission spectrum from ^{60}Co and discuss its features.

C/A 8. Consider having a detector for which you have the data from an efficiency calibration measurement shown in figure 1 on next page. The calibration was performed with the following calibration sources: ^{57}Co, ^{60}Co ,and ^{131}I. The simplified decay schemes for the sources are also reported on the next page. The detector scintillation crystal is NaI. Draw now the spectrum from ^{60}Co that you expect being measured by the detector.

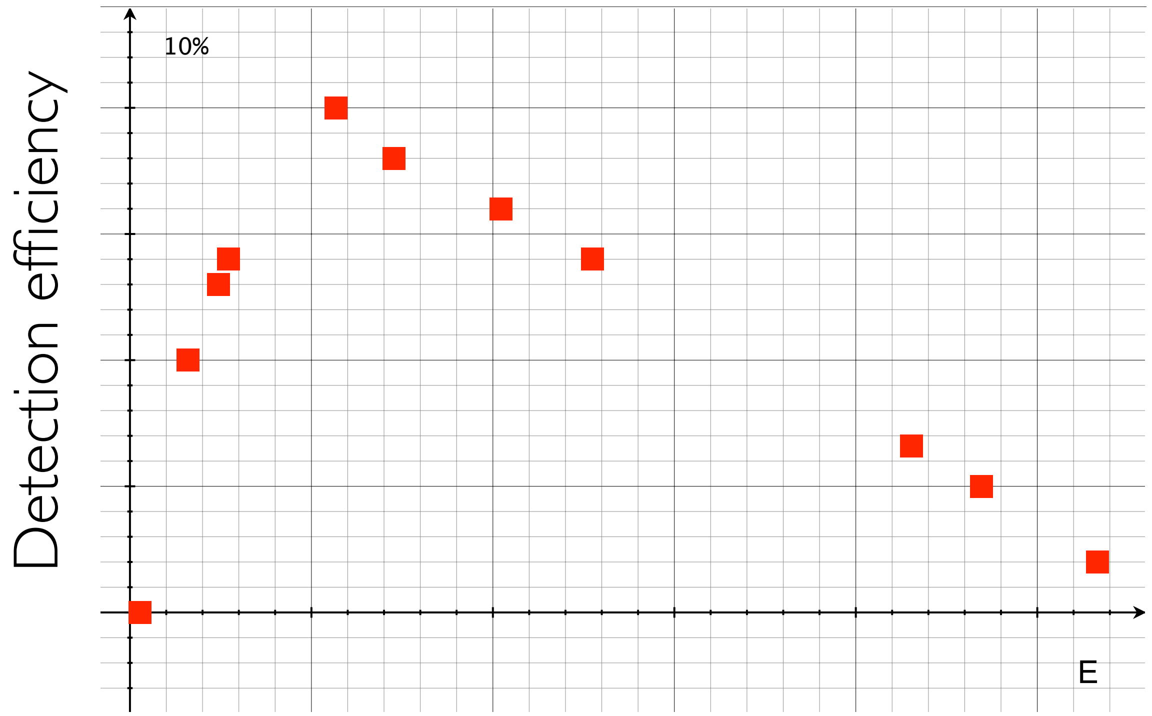


Figure 1: Calibration measurements for our detector

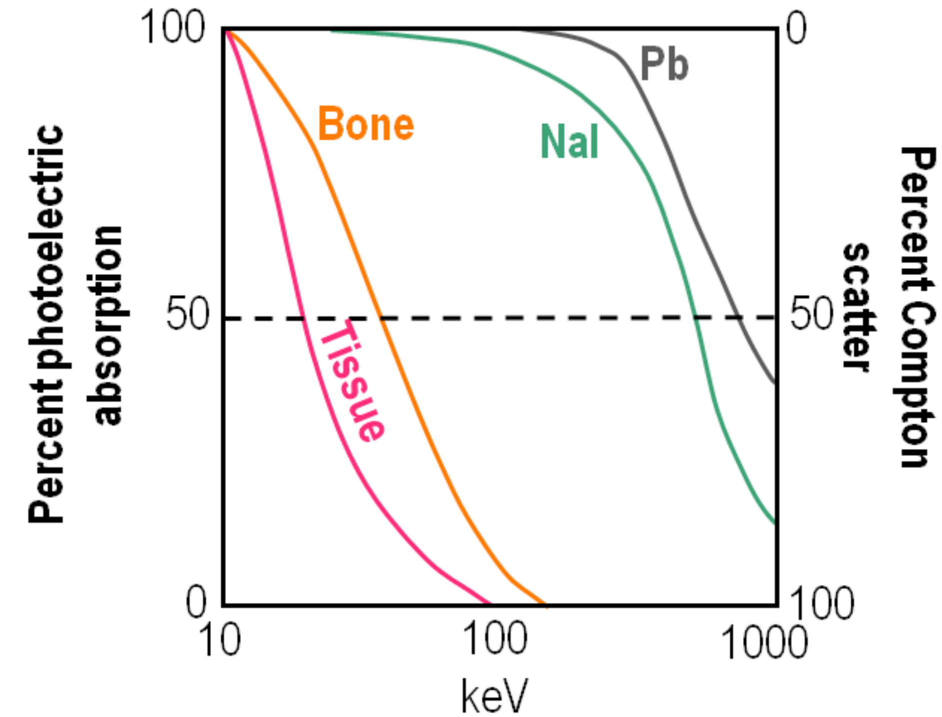


Figure 2: PE and Compton fraction for chosen materials as function of photon energy

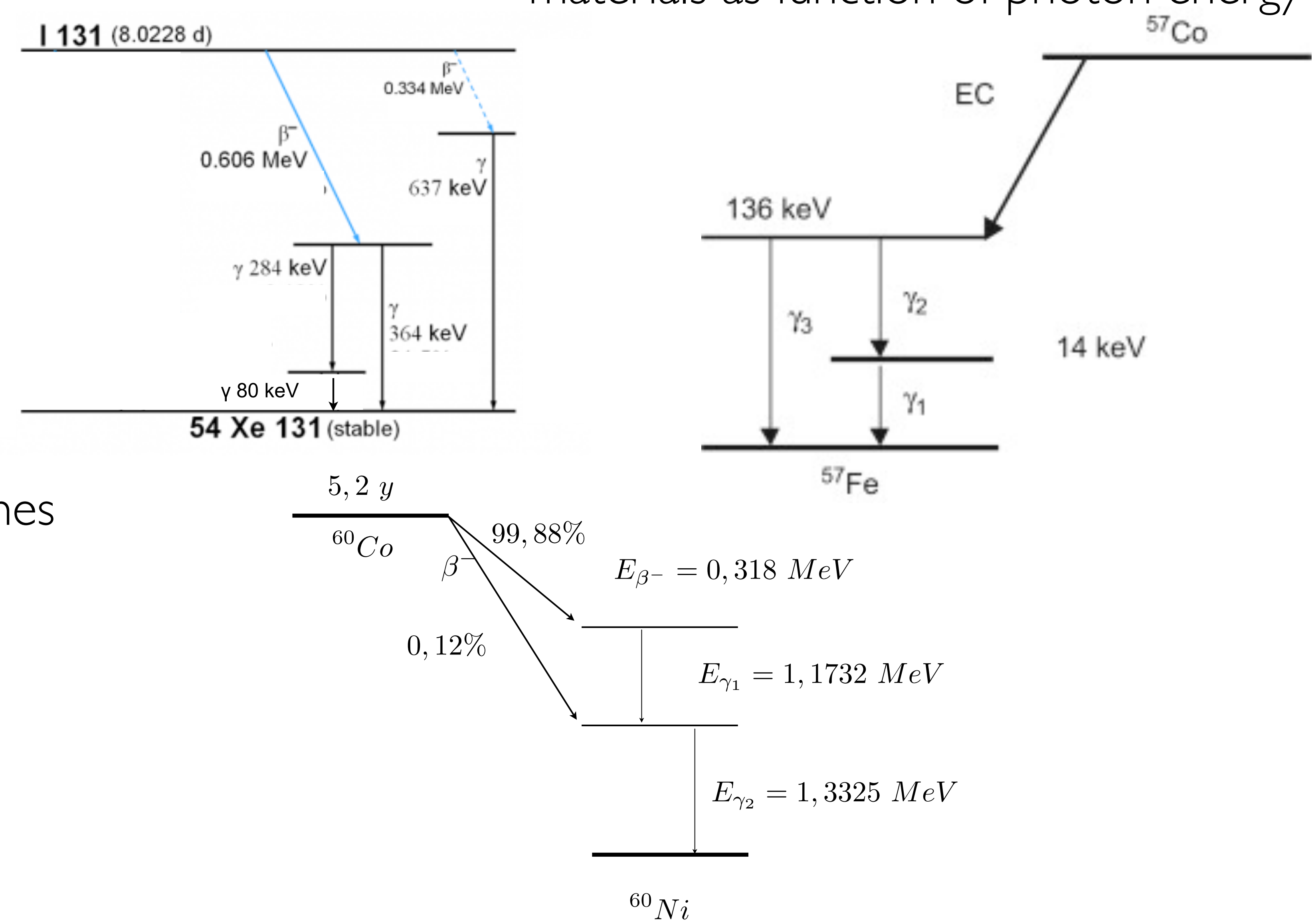
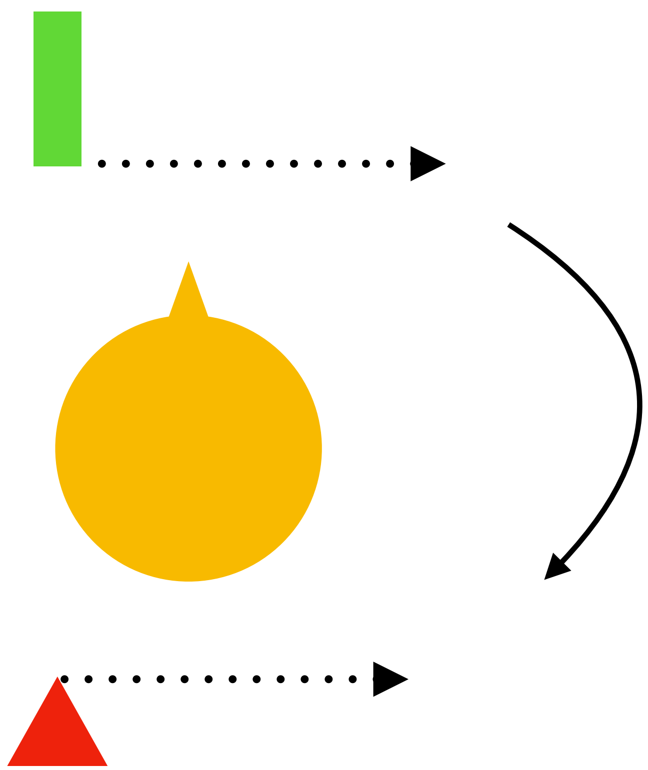
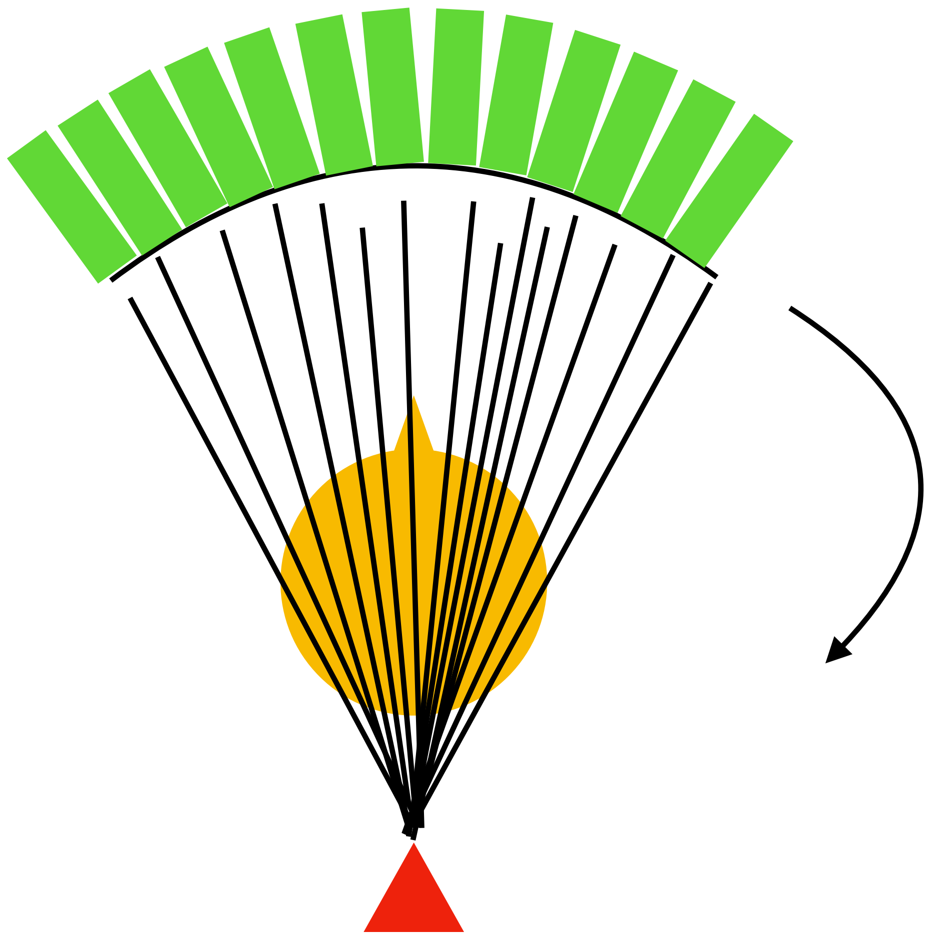


Figure 3: Simplified decay schemes
For the calibration sources.



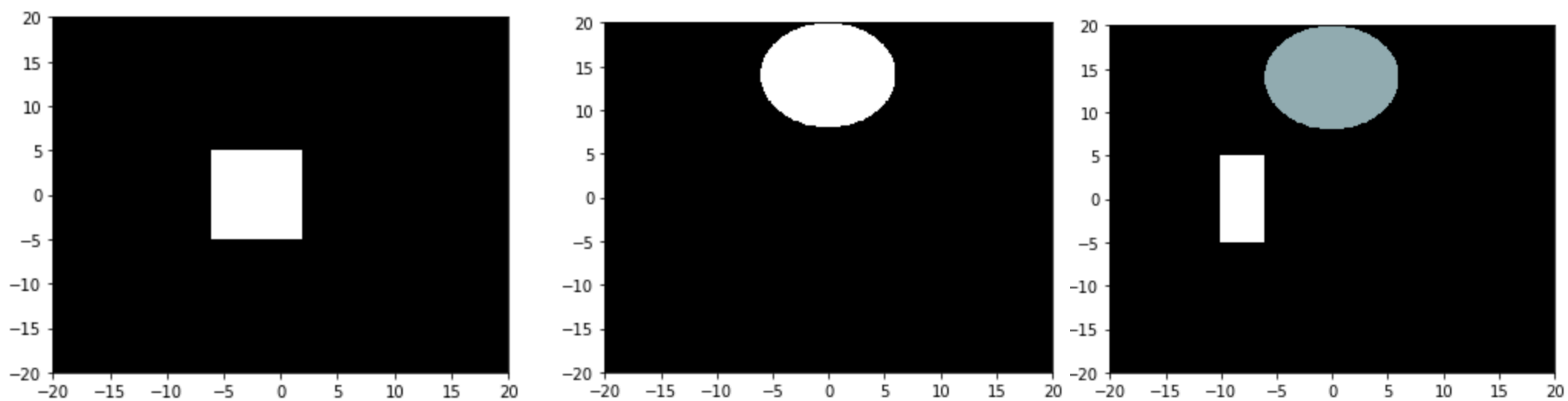
I generation CT



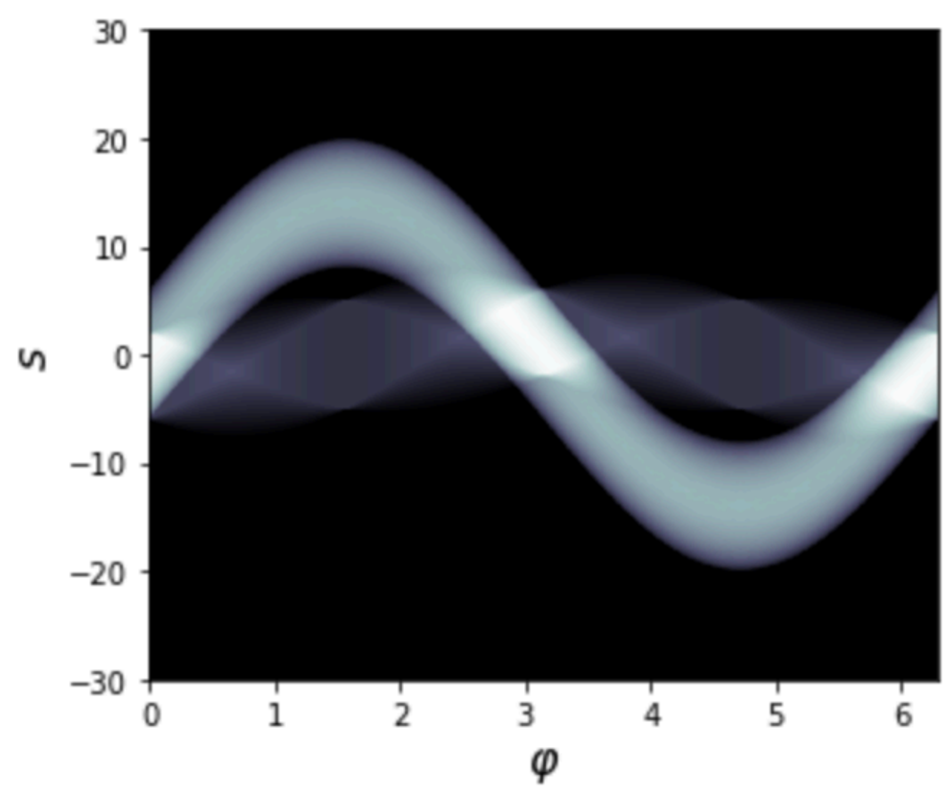
II generation CT

C/A Discuss advantages and disadvantages of the two. (Do not consider cost)

E 1. Consider the objects in the figure below and draw the sinogram for each of them. Be careful in labelling the axis of the sinogram and in making sure that the object dimensions and position within the field of view are reflected in the sinogram, as well as the difference in attenuation. (Brighter colour means higher attenuation)



E 2. Draw the object corresponding to the sinogram below.



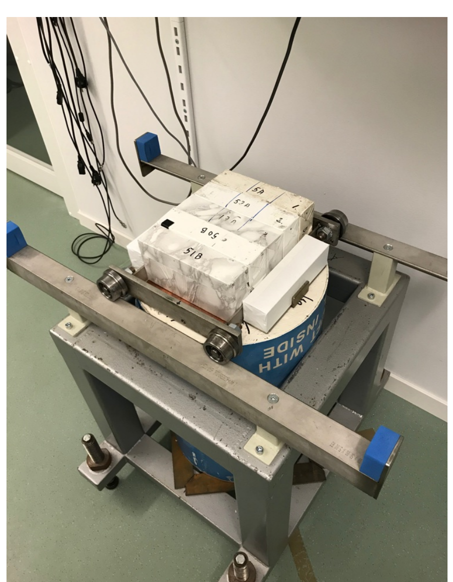
E 1. Define detection efficiency, geometric efficiency and intrinsic efficiency of a detector.

E 2. Suggest at least one method/experiment for measuring detection efficiency and intrinsic efficiency of a detector.

E 3. Consider a detector with a CsI crystal with thickness 8 mm and a front face of 2 times 3 cm^2. The detector is enveloped in a 0,2 mm aluminium cover. Consider also a source emitting photons of energy 120 keV. The source, with an activity of 5 MBq can decay by different mechanism and 120 keV-photons are emitted only 32% of the times. Estimate the detector count rate when:

1. The source is put on the detector
2. The source is put 10 cm away from the detector
3. The source is put on a lead block covering the entire detector. The lead block has a hole which is 0,5 cm in diameter and it is 10 cm long.

C/A 4. Monitoring the presence of activity can be considered as the task of distinguishing the signal from the activity to the one from no activity. In other words, the problem of detecting activity can be formulated as evaluating the SDNR between the signal from a source and the signal when no source is present. Considering the detector and the source in point 3 above (take the case for the source on the detector), estimate the minimum acquisition time needed for being sure of the presence of the source on the detector.



How much time do you need to know whether or not the source is on the detector, without opening the hatch?

E 1. Describe an x-ray tube, its main components and their function.
E 2. Which different kinds of x-ray tubes do you know?
E 3. Which construction parameters influence the output spectrum of an x-ray tube? How?
E 4. What is beam hardening?
E 5. What is the Heel effect?
E/C 6. In which way are beam hardening and Heel effect important for medical imaging?
E 7. How does a ionisation chamber work? (Describe its parts and function and the mechanism of detection)
E 8. How does a scintillation detector work?(Describe its parts and function and the mechanism of detection)
E 9. How does a semiconductor-based detector (direct detection) work? (Describe its parts and function and the mechanism of detection)