Questions for electron positron annihilation

N 1. **Question**: In the hypothesis of an infinitely extended detector, how would the final detected energy spectrum look like? Infinitely extended? -> same spectrum all direction?

Y 2. **Question**: From the comparison between NaI and NE102A, it appears that the Compton contribution is quite similar for the two scintillators, while the photoelectric and pair production are significantly greater in NaI. Why does this make the NaI scintillator the preferential detector for detection and energy measurements of gamma-rays?

Y 3. **Question**: Which is the present activity of the source now?

Y 4. **Question**: To convince yourself about the role of Pb as a shielding material, do the following exercise: Knowing the activity of the source and the energy of the emitted photons, which is the rate of photons that will still survive after the 5 cm Pb thickness? In appendix A you will find the information required for this exercise.

Y 5. **Question**: According to the Swiss regulation, the maximum dose limit for non exposed persons corresponds to 1 mSv/year. The same regulation provides a table which defines the dose induced by every different isotope [11]. In case of 22Na, a quantity h10 = 0.33 (mSv/h)/GBq is assigned. This h10 quantity represents the dose2 acquired at a distance of 1 m from a radioactive source with an activity of 1 GBq. Knowing that the dose scales linearly with the source activity, and scales with 1/distance2 , you can calculate the total dose that you will accumulate during the experiment. You need to give a reasonable estimation of the time exposure and working distance. Notice that what you compute here refers to the non shielded source: the actual dose after the shielding will be totally negligible

Y 6. **Question**: The distances and dimensions of the scintillators are given. Assuming a full detection efficiency in the scintillators, can you estimate the expected rate of events detected by each one of the scintillators? (You might use the information contained in Appendix A for a more realistic estimation, which also takes into account the real detection efficiency).

Y 7. **Question (3.1):** Record now one scope screenshot (in persistence mode) on the USB stick (use the PRINT button).
   Repeat all the above steps - including the record of the typical screenshot - for the dynode signal (i.e. negative polarity) (you must now obviously trigger the scope on negative threshold).

8. **Question**: For the dynode signal, together with the screenshot, record also one waveform (SAVE/RECALL button). From the analysis of this curve (possibly a fit), could you estimate the typical fluorescence decay time of NaI(Tl)? Compare your result with the one you find in literature. Why would it be wrong to extract the fluorescence decay time from the anode pulse?

Y

Y -> fucked up the conversion from negative to positive polarity but only fix this if you have time

Y?

9. **Question**: Look at the analogue signals acquired in persistence mode. On top of an almost continuous distribution of signals of varying amplitude in the full range, a more pronounced line is evident (i.e. higher frequency of events with this exact amplitude), both for anode and dynode. What does this line represent?

Y

10. **Question**: Write down in your logbook the HV value for which PMT saturation starts to occur, and draw a sketch of the shape of the saturated signal.

Y

11. **Question (3.2 – why are there multiple discriminator outputs):** Looking at the dynode pulse shape, do you understand where do these discriminator multiple outputs come from?

12. **Question**: Insert the PMT counting curve in the report and define the HV working point. Set this HV values on both PMT's (we assume PMT1 and PMT2 behave similarly). Check on the scope the anode and dynode signals of both PMT's and record some screenshots. Write down in your logbook also the signal characteristics (pulse height range, pulse height at the photo-peak, peaking time) for anode and dynode of PMT1 and PMT2. Compare the measured counting rates with the expected ones you computed in Section 2.2.

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13. ~~**Question**: Insert the PMT counting curve in the report and define the HV working point. Set this HV values on both PMT's (we assume PMT1 and PMT2 behave similarly). Check on the scope the anode and dynode signals of both PMT's and record some screenshots. Write down in your logbook also the signal characteristics (pulse height range, pulse height at the photo-peak, peaking time) for anode and dynode of PMT1 and PMT2. Compare the measured counting rates with the expected ones you computed in Section 2.2.~~

Y

14. **Question (3.3.1 – hand-made spectrum)**: The obtained plot(s) must be included and discussed in the report. What does it represent? Compare it with the ones sketched in Figure 1.3 and recognize its main features: photo-peak, Compton-edge. Do you understand what is the tail at energies larger than the photo-peak?

Y

15. **Question (3.3.2)**: In the logbook sketch the measured energy spectrum and understand it. Mark and identify its various structures (photo-peaks, Comptonedges. . .).

Y

The first discussion done - more to come with calibration

16. **Question (3.3.2)**: Compare and study the two spectra obtained with SCA+scalar and with MCA. Compared with the theoretical spectrum of Figure 1.3, the measured spectra contain several additional structures and details beside the photo-peak and the Compton continuum. Also with the help of the literature, try to understand all the details of the measured spectrum. The understanding of this spectrum is a key point of the experiment. Discuss it with the assistant.

Add to 3.3.2

17. **Question (3.3.2)**: Keeping in mind the first method you used for the spectra acquisition (with SCA), do you understand now the role of a device like the MCA? Which is the meaning of "channels" in the MCA for this particular application?
18. **Question (3.3.3 - FWHM)**: Write down in your logbook these values, together with their uncertainties. Determine the detector energy resolution (equation 1.9) at 511 keV and 1.275 MeV.
19. **Question (3.3.3)**: Write down the Compton edge positions (ADC counts) in your logbook. Give also an estimate of their corresponding uncertainties. Compute the energy corresponding to those points (equation 1.6).
20. **Question (3.3.3)**: Extract the calibration curve (Energy vs. ADC channel) using the 4 determined points, including the error bars and perform a linear fit. Is the detector linear?
21. **Question (3.3.3)**: From the MCA spectrum, read out the position (in ADC channel) of the low energy peak and write it in your logbook. Using the energy calibration derived before, calculate its energy in keV. What can this peak be?
22. **Question (3.4.1)**: Send the coincidence output (after the D.TRIGGER) into the scalar: Which rate of coincidence do you measure? Compare it with the rate of single detectors (i.e. no coincidence) that you have measured before. Can you justify the difference between the two count rates? (Tip: observe what happens on the scalar when you remove one of the two PMT's from the coincidence, by switching off the coincidence button).
23. **Question:** Draw the spectrum in your logbook. In the report include the measured spectrum, both in linear and logarithmic scale.
24. **Question**: Compare the photon energy spectra measured with the gate (coincident with a photon in the opposite detector) and without the gate. Comment extensively about their similarities and differences. This is the core of the experiment. Discuss it with the assistant.