Nishina School
Training B: NaI Scintillator

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1 Orientation

The following is a list of questions that should be answered and discussed during the orientation.

- What is the main use of NaI detectors?
- What are basic quantities characterizes gamma detectors? (Resolution, Efficiency, peak to total ratio)
- interaction of γ rays with matter
  - How is the detection of gamma rays different from the detection of charged particles?
  - What processes are involved in gamma ray detection?
  - How does the energy of the outgoing photon depend on scattering angle. How can this be calculated? What does the Klein-Nishina formula describe?
  - What is the definition of the linear attenuation coefficient? How does it typically look as a function of γ energy
- pulse height (=energy) spectrum
  - What is a full-energy peak? Compton-edge? Backscatter peak? Single, double escape peak? Annihilataion peak?
  - What is the FWHM, σ or a peak? How are they related?
  - What is centroid of a peak? How is it determined? What is its precision (1σ uncertainty) assuming a peak width of 1σ and N counts in the peak? What is the meaning of "a 68% confidence interval"?
- How does a PMT work?

- What is the plateau curve?

- Signal processing and electronics modules
  - What is the difference between a logic and analog signals?
  - How fast are typical “fast” signals? How fast are typical “slow” signals?
  - What logic standards are most common?
  - What is pre-amplifier, shaper, fast amplifier, timing filter amplifier, discriminator, TAC?
  - What types of discriminators exist?
  - How do the signals look to go into and that come out of these modules?
  - cables and connectors: BNC, SHV, LEMO, ...
  - HV supplies
  - ADC, gated and not gated operation
  - TDC, common start, common stop
  - multi channel analyzer

- What is a γ-ray source?
  - How can they be used to measure the (absolute) full energy peak efficiency?

2 Training

The most important task is to **write** a **logbook** about everything you do and everything you observe. It should be written, so that if you (after, say, 1 year) or someone else looks at it, knows exactly what was done.

Concerning the electronics modules: there are manuals where their operation is described in detail. If something is not clear, the manual should be consulted. When cabling up the electronic circuits always check the input and output signals.

The following should be done:

- connect HV to the NaI(Tl) detector; connect signal out put to oscilloscope; raise HV slowly (typical -1200 V for this detector[1]) until signals can be observed on the oscilloscope.

- Do you remember the rate of cosmic rays? What particles are these? How many should you see per second? Do you “see” them?

[1] **NB: polarity and voltage can be very different for other PMTs; for some it might be too low, others will be destroyed. So always check the data sheet, or raise HV very carefully.**

- Place a known γ ray source near the detector. Can you see the transition using the oscilloscope?
- Connect the shaping amplifier. Can you distinguish the different γ energies on the oscilloscope now? What shaping time should you use?
- Connect the shaper output to the ADC.
- Look at pulse height spectrum and interpret it (with no γ source and with two different γ sources (probably ^{60}Co and ^{22}Na)
- Remove source and measure the plateau curve (Which HV range? Which HV steps?)
- Decide optimal HV and use that during the remainder of the training.
- Adjust shaper gain to so that γ rays up to 3 MeV can be measured
- Measure room BG spectrum; identify the most prominent peaks.
- Measure ^{60}Co spectrum; perform an energy calibration; What is the resolution of the detector?
- How can you find out easily if the two γ rays of ^{60}Co are emitted simultaneously? (Hint: What happens when two γ rays enter the detector? Estimate the probability of two randomly emitted γ rays being measured simultaneously? What time-window should be used?)
- If there is time: measure the relative efficiency of the detector as a function of distance of the source from the detector. Can you also estimate the absolute efficiency, without knowing the source strength?