Physics 198, Spring Semester 1999 Helmuth Spieler
Introduction to Radiation Detectors and Electronics

Problem Set 8: Due on Tuesday, 30-Mar-99 at begin of lecture.
Discussion on Wednesday, 31-Mar-99 at 12 – 1 PM in 347 LeConte.
Office hours: Mondays, 3 – 4 PM in 420 LeConte

1. A Ge diode gamma-ray detector system has a resolution of 1.8 keV FWHM at a peaking time of 2 μs. The desired energy range is 2 MeV.

   a) What ADC resolution is required?

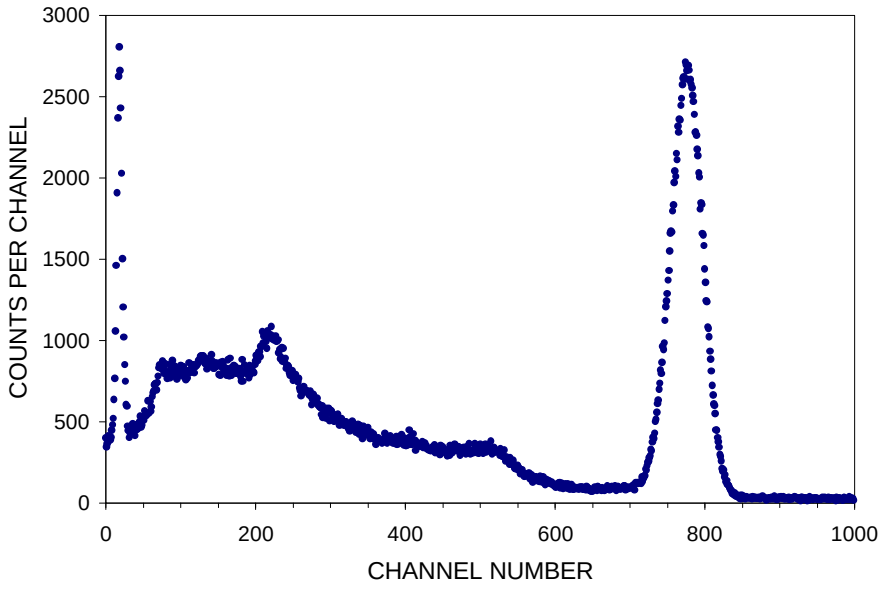
   b) If a straight-line fit of the form

   $$E = k \cdot N_{ch} + E_0$$

   is to provide adequate energy calibration, what is the allowable integral non-linearity?

   c) A Wilkinson ADC with a 400 MHz clock is used for the measurement. What is the conversion time for the 1.33 MeV line of ^{60}Co?

2. A NaI(Tl) scintillator shows the following spectrum when exposed to a ^{137}Cs source.



   a) A Wilkinson ADC with a 100 MHz clock was used for the measurement. The shaper was set to a peaking time of 0.5 μs. The total input counting rate was 5×10^4 s^{-1}. What was the dead time?

b) The spectrum shown above was taken with more ADC resolution than needed. What is the minimum conversion range (number of channels full-scale) required for this spectrum? How many bits are required for the data word?

c) What is the dead time for the conversion range determined in b)? What is the maximum counting rate that will not increase the dead time beyond the value determined in a)?

3. A precision time-of-flight system has a time resolution of 20 ps rms. The maximum flight time to be measured is 100 ns.

a) What is the required resolution of the time digitizer (TDC)? Keep in mind that the number of measurement bins corresponding to an n bit data word is 2^n.

b) The time digitizer uses a capacitor charging scheme coupled with a Wilkinson ADC. The start pulse switches on a current source that charges up a memory capacitor of 100 pF. The stop pulse switches off the current source, establishing a voltage on the capacitor that is proportional to $t_{stop} - t_{start}$. If a stop pulse does not occur within the TDC range, internal reset circuitry discharges the capacitor and allows acceptance of a new start pulse after 0.5 μs. Both start and stop inputs are disabled until the reset or conversion sequences are complete.

Full scale corresponds to a voltage of 5 V on the capacitor. What is the charging current?

c) The Wilkinson ADC that measures the capacitor voltage uses a 50 MHz clock. What is the maximum conversion time and the required discharge current?

d) The system is used at an accelerator that provides very sharp (~ ps) beam pulses at a bunch frequency of 5 MHz. Beam particles impinge on a target. A detector placed at a known distance from the target determines the time-of-arrival of the reaction products. The accelerator control system provides a timing pulse synchronized with the particle bunches for use as a time reference. How do you connect the detector and beam pulses to the start and stop inputs of the time digitizer?