Spring, 2oo9   Problem Set #5
Distributed: Tues., 14 Apr. o9   Due: Tues., 21 Apr. o9

   One of the most important measurements at the NSCL involves separating the pulse heights and times of flight (TOF) of secondary beams for event-by-event particle identification. In a recent experiment a 500μm thick silicon PIN was used to identify ^{66}Fe and ^{67}Co ions (fully stripped) at the experimental endstation. The two ions had the same magnetic rigidity of $B\rho = m\gamma\beta/q = 3.66$ Tm. The TOF was measured over a distance of 20.97 meters. The PIN detector was connected with a very short cable to a (charge sensitive) preamplifier with a gain of 1.000 V/GeV of injected charge. The preamp was then connected by a 50 ns long RG58C/U cable (e.g., Table 16.1 in text) to a main amplifier that split the input signal between a timing-filter amplifier (TFA, CR-RC network) and a shaping amplifier (SA, CR-(RC)^3 network). Finally, the logic signals for the TOF measurement were created in a Tennelec TC-455 constant-fraction discriminator (f=0.2) with the appropriate cable delays. The rise time of the signal from the preamp was 100 ns and the time constants in the TFA were set to 250 ns.

1. What is the value of the ENC in electrons if the RMS white noise from the preamp was observed to be 10 mV?

2. What is the maximum signal-to-noise ratio of the tail-pulse from the preamp when the ^{66}Fe passed through the detector?

3. Make an estimate of the maximum signal-to-noise ratio for the pulse after passing through the cable and splitting in the main amplifier. You can assume that the white noise is not attenuated by the cable.

4. The TOF was measured between a fast signal from a scintillator connected to a PMT (having a time width of 0.25 ns) and the signal from the TFA. What is the expected width in ns for the observed TOF for the ^{66}Fe fragments if the TFA preserved the signal-to-noise ratio of the preamp signal?

5. What is the time resolution for this TOF measurement?

6. This TOF was measured with a 2048 channel time-to-digital convertor (TDC) and the full-scale was set to 100 ns. How long did the start pulse from the scintillator have to be delayed in ns to put the TOF in the middle of the measurement scale?

7. What is the expected FWHM of the observed TOF in "channels" in the TDC?