VI. Summary

1. All electronic detector measurements

    minimum detectable signal (detect presence of hit)
    amplitude
    timing
    position

    depend on signal-to-noise ratio.

2. Maximize the signal

    Maximizing the signal also implies reducing the capacitance at the electronic input node. Although we want to measure charge, the primary electric signal is either voltage or current, both of which increase with decreasing capacitance.

2. Minimize the Noise

    reduce noise sources in the detector
    (parasitic resistances, leakage current)

    Choose the input transistor to match the application.

    At long shaping times FETs (JFETs or MOSFETs) are best.
    At short shaping times, bipolar transistors tend to prevail.

3. Select the appropriate shaper and shaping time

    In general, short shaping times will require higher power dissipation for a given noise level than long times.

    The shaper can be optimized with respect to either current or voltage noise (important in systems subject to radiation damage)

    The choice of shaping function and time can significantly affect the sensitivity to external pickup.

4. Position-sensitive detectors can be implemented using either interpolation techniques or direct readout.

   Interpolating systems reduce the number of electronic channels but require more complex and sophisticated electronics.

   Direct readout allows the greatest simplicity per channel, but requires many channels, often at high density (good match for monolithically integrated circuits).

5. Segmentation improves both rate capability and noise (low capacitance). It also increases radiation resistance.

6. Timing systems depend on slope-to-noise ratio, so they need to optimize both rise-time and capacitance.

   Relatively long rise-times can still provide good timing resolution (<< rise-time), if the signal-to-noise ratio is high.

   Variations in signal transit times and pulse shape can degrade time resolution significantly.

7. Electronic noise in practical systems can be predicted and understood *quantitatively*.

8. From the outset, systems must consider sensitivity to spurious signals and robustness against self-oscillation.

   Scrutinize signal return paths!

   Poor system configurations can render the best low-noise front-end useless, but proper design can yield “laboratory” performance in large-scale systems.

9. Although making detectors “work” in an experiment has relied extensively on tinkering and “cut-and-try”, understanding the critical elements that determine detector performance makes it much easier to navigate the maze of a large system.

   It is more efficient to avoid problems than to fix them.

   A little understanding can go a long way.