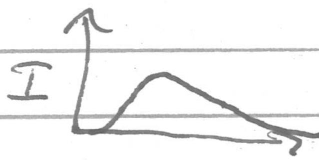
Electronics

analog electronics

Need to retrieve signal from individual detector sensor

→ eg. current

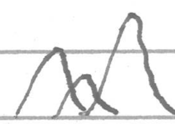


Several aspects of pulse that are important:

a) above threshold & w/ respect to noise?
b) what is event rate?
c) optimal energy measurement
d) when does signal arrive

For instance, a drift detector such as LAr can accrue charge over long time

- may be $\gg$ event time



- may need to modify pulse to take 1st part of charge
  → ignore rest
  → i.e. juggles energy resolution with event rate

↗ problem with overlapping signals

Generally must digitize signal to enable analysis

Direct Radiation Detection

Energy deposited in a material
- converted to charge pairs (ie. current)
  - generally ∝ energy
  - can be very low charge (10^{-16} C)

Need to integrate + amplify the signal since so small : Preamplifier
- have problem that noise can be significant + reduce resolution

- noise more of a problem when capacitance of sensor + preamp larger

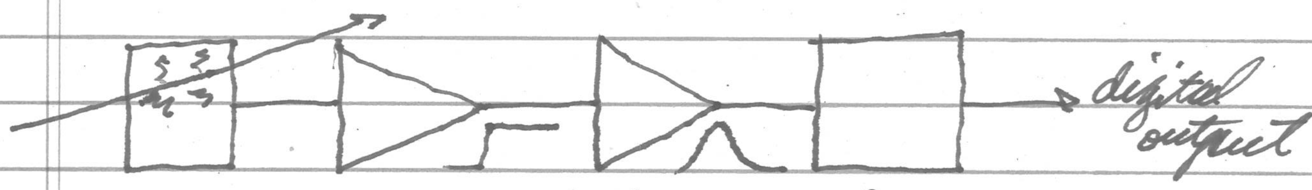
~~Also~~ Noise
- variations in apparent signal due to random processes
  - ~~thermal electrons~~
  - electrical interference ...
- will have a range of ~~freq~~ characteristic frequencies

- Expected signal will have a more restricted range of frequency components

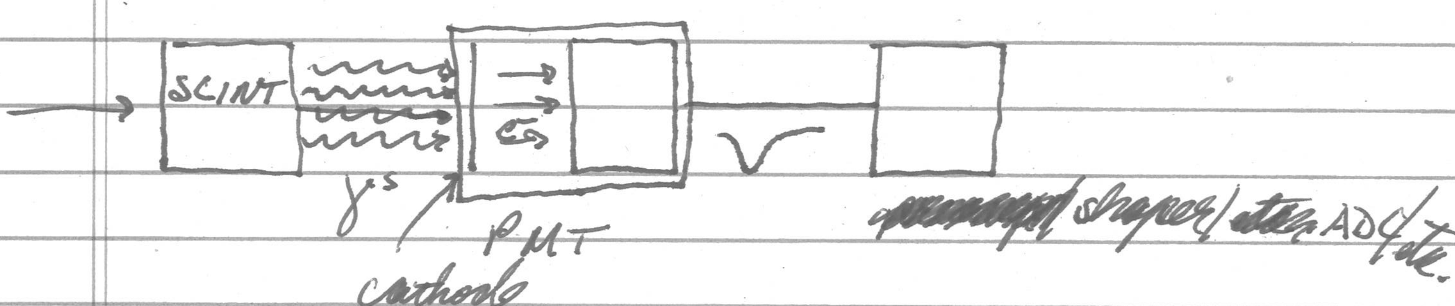
Shaper : reduce bandwidth + control duration of signal pulse

Example Analog Pipelines

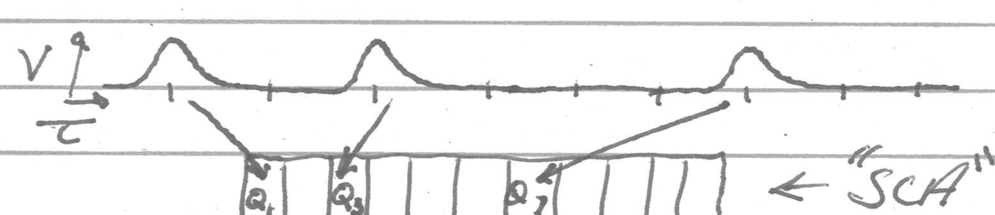
Direct detection case:



Indirect detection case: (e.g. PMT + scintillator)



Some fraction of events will generally be recorded (triggering)
- → until decision made, need to "buffer" or hold analog signals
- output of preamp / shaper can be used to charge a capacitor

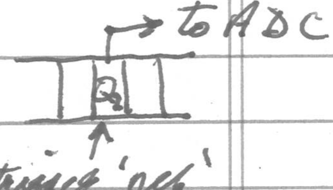


switched capacitor array: each event sent to different capacitor 'cell'

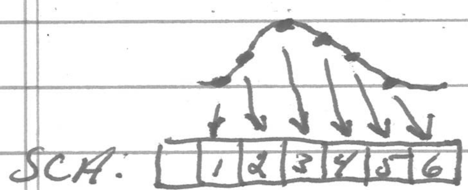
The buffered signals are stored according to timing + control signals in electronics

- critical to ~~make~~ synchronize all cells of a detector for a given event
  - you need to know exactly what SCA cells make whole event

- when trigger indicates to readout a given event ~~relevant~~
  - all SCA cell contents corresponding to that event are digitized



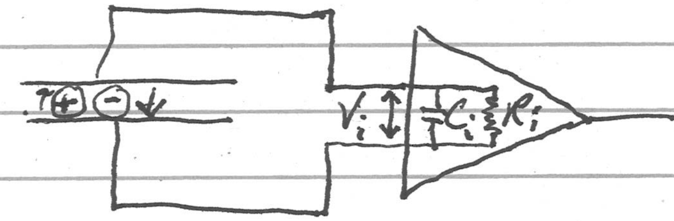
For wide pulses, may choose to 'sample' pulse several times



eg. <u>ATLAS LAr Calorimeter</u>

Charge-sensitive Amplifier

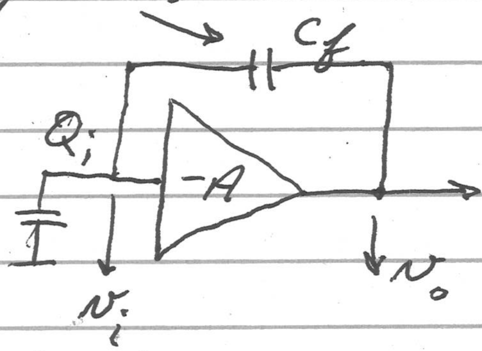
Consider detector element, an ionization medium



C_d (detector capacitance)

- can have a problem that output signal height depends on C_i

Use inverting amplifier and feedback capacitor



($R_i \sim \infty$, so no current thru amplifier)

- A is voltage gain, $v_o = -A v_i$

$\therefore\ \Delta v = v_f = v_o - v_i = \underline{(A+1)\, v_o}$

charge on C_f: $\boxed{Q_f = C_f v_f = C_f (A+1) v_o}$

Because no current in amplifier,

$$Q_f = Q_i$$

$$C_i = \frac{Q_i}{v_i} = C_f(A+1)$$

This gives the voltage output per unit input charge

$$\underline{A_Q} = \frac{\Delta v_o}{\Delta Q_i} = \frac{A\cancel{v_i}}{C_i\cancel{v_i}} = \frac{A}{(A+1)C_f} \sim \boxed{\frac{1}{C_f}} \quad (A \gg 1)$$

→ gain ~~is~~ determined by feedback capacitor

<u>Calibration</u>

→ can use this system with a test input before the preamp