Dependency on the Silicon Detector Working Bias for Proton-Deuteron Particle Identification at Low Energies

≻ G_{ASPARD} H_{YDE} T_{RACE} Collaboration Meeting ≺

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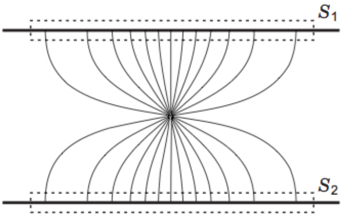
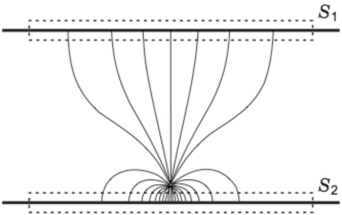
Outline

1. How the E-field affects the charge collection.
   - Some theory
   - Some experimental data
2. The Factor of Merit (FoM).
   - Mathematical equation
3. PSA on the 500μm NTD at different working bias (GHT experiment, February 2012)
   - Looking at the current signal pulses
   - The algorithm
   - Results
4. What now?

Charge generation theory

Some theory I





- Integrating the field on a Gaussian surface S: $\oint_S \vec{E} d\vec{a} = q$
- @ midway induced charge on S_x is $-q/2$.
- More field lines when close to S_x so induced charge increases.
- a charge moving from S_1 to S_2 will inicially induce most of its charge on S_1.
- shifting proportionally to S_2 as it moves toward it.
- If S_1 & S_2 form a closed circuit a current can be measured.

Some theory II

- Instantaneous current in terms of the weighting field:

$$i_k = -q\vec{\nu} \cdot \vec{E}_q$$

- $\vec{E}_q$ is determined by applying unit potential to the k electrode and zero to all others.
- For parallel plates:

$$E = \frac{V_{bias}}{d} \quad \& \quad E_Q = \frac{1}{d}$$

- the E gives the motion of the charge carrier:

$$\nu = \mu E = \mu \frac{V_{bias}}{d}$$

- Therefore, the induced current is given by:

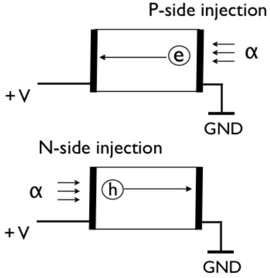
$$i = q\nu E_Q = q\mu \frac{V_{bias}}{d}\frac{1}{d} = q\mu \frac{V_{bias}}{d^2}$$

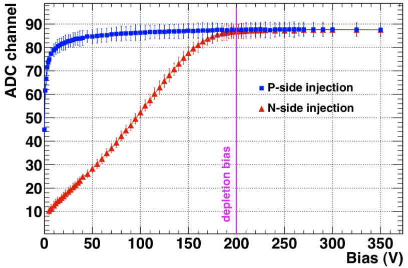
- and the collection time (i.e. time required to traverse the distance d):

$$t_c = \frac{\nu}{d} = \frac{d^2}{\mu V_{bias}}$$

Some experimental data

Charge collection efficiency plot





- t_c much longer for N-side injection
- E_{max} @ P- decreasing to E_{min} @ N-sdie.
- P-side injection need lower bias for collecting charges.
- N-side injection reveals appropriate depletion value.

Mathematical equation (The Factor of Merit FoM)

The old fashion way

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PULSE SHAPE DISCRIMINATION IN INORGANIC AND ORGANIC SCINTILLATORS. I

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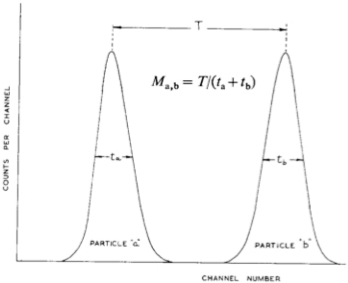
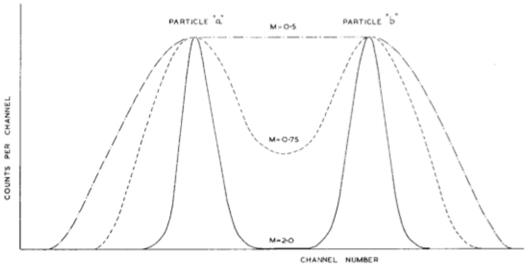
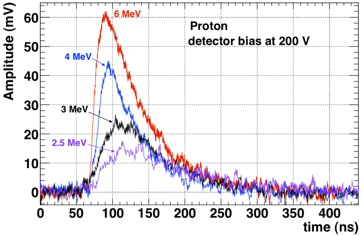
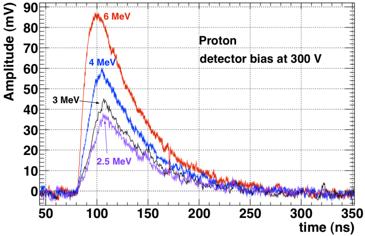




Complex noise contributions

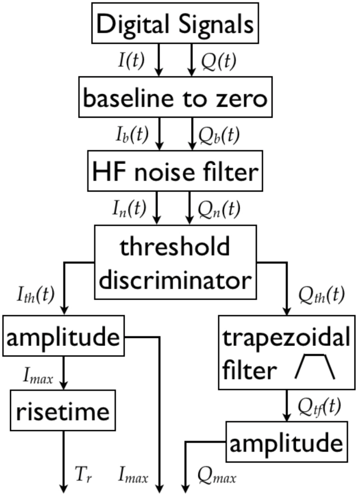
- Different sources of noise: external EM, electronics & detector.
- Limits the ability to distinguish signal levels or measure them precisely.
- In semiconductor detectors baseline noise is critical.
- Low frequency noise, its spectrum becomes nonuniform whenever the fluctuations are not purely random in time (carriers are trapped and then released).
- High sampling digitazer may be another source of noise.





The algorithm

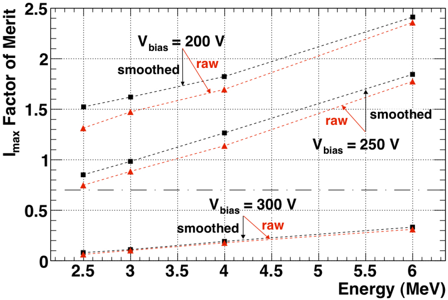
Ditigal Pulse Shape Analysis

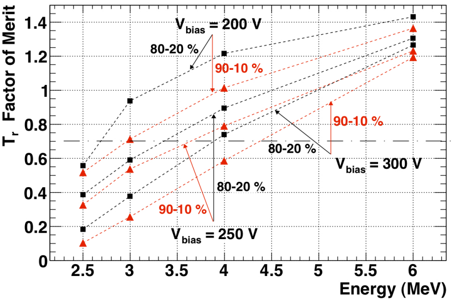


- Experimental conditions will dictate the final algorithm.
- General algorithms will serve as monitor during experiments.
- A trade-off between effectiveness and cpu process time.
- Reliable as your electronics.
- Aim to be stored in a FPGA for online analysis.
- Neuronal networks approach is quite good.

Results, p & d identification (GHT Experiment, Feb 2012)

Bias effect on PSA





- Overbias $\Rightarrow$ ν_{sat} and is not longer field dependent.
- Identification better at V_{depl}.
- Noise reduction algorithm works.
- Time measurements affected by noise. Best look at $80 - 20\%$.
- Identification also better V_{depl}.
- Higher energy less differences.

What now?

Future steps

- We've already "extrapolated" our results to strips detectors (It'll be shown in this meeting).
- Is the identification limit of p-t-d around 1 MeV?
- what about our FEE?
- We should think about cooling down ($< 0^\circ$ C)

THANKS FOR YOU ATTENTION