Single Crystal Diamond Detectors

$\succ$ G_{ASPARD} H_{YDE} T_{RACE} Collaboration Meeting $\prec$

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Outline

1. Introduction.
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2. Diamonds for Nuclear Spectroscopy
    - Charge collection efficiency
    - Energy resolution
3. PSA on diamonds
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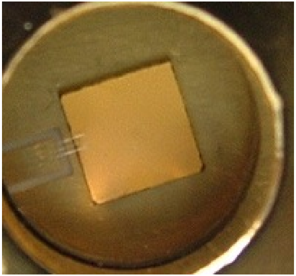
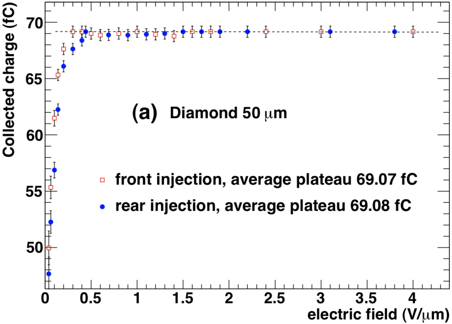
    - Transit time and mobility
4. Diamond applications @ UHU.
    - Time structure of ns duration bunches

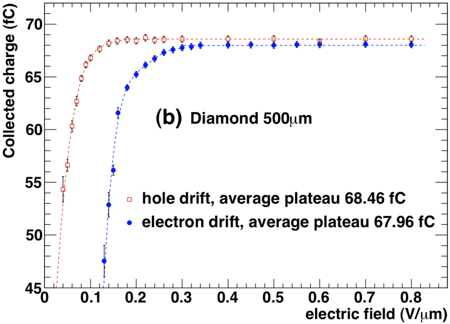
Why diamonds?



- Wide band-gap energy $\approx$ 5.5 eV.
- Low leakage current (i.e. low readout noise) and low sensitivity to visible light.
- High carrier mobility permits rapid response.
- Radiation hardness due to its crystallographic structure.
- Low dielectric constant i.e. low capacitance.
- Tissue equivalent material because the atomic number is nearly equal to the average atomic number of human soft tissue ($\approx$ 7.4).

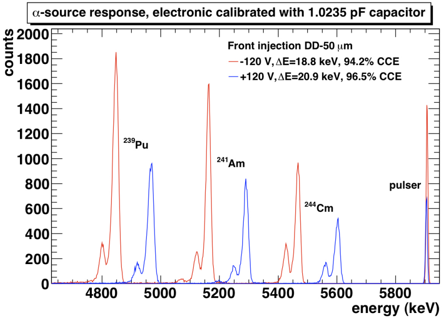
Collection efficiency

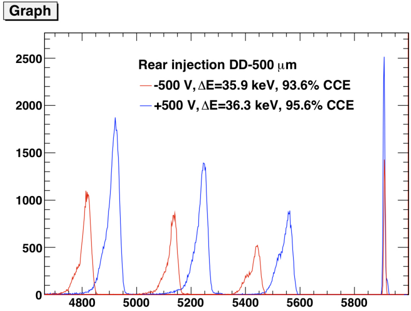




- Detector thickness is affecting the behavior of the charge carriers.
- High purity diamonds is limited by both thickness and dimentions (tipical size $4mm \times 4mm$).
- Standard thickness are $300 - 500\mu m$

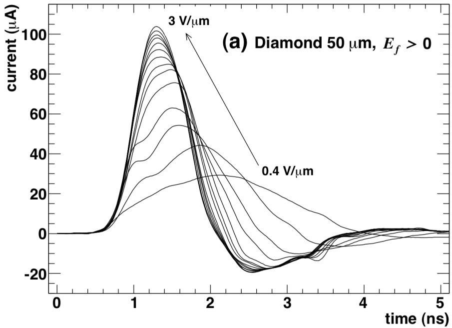
Energy resolution

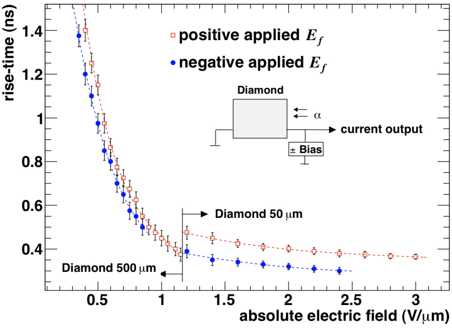




- Energy resolution as good a Si detector.
- Thiner diamond shows better resolutions than thicker ones.
- Trapping effect may be involved in this.

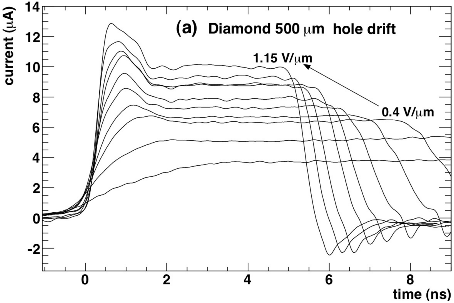
Sub-nanosecond regime

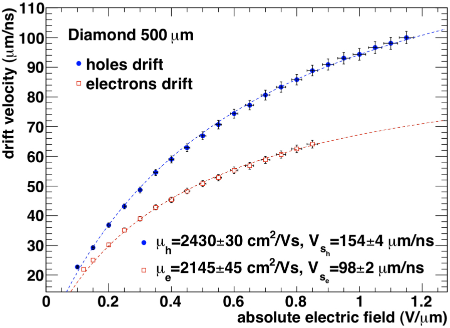




- Thin diamond detectors produce very fast current signal.
- Risetime of a few hundreds of pico-seconds.
- Very fast electronics is required ($>$ GHz).

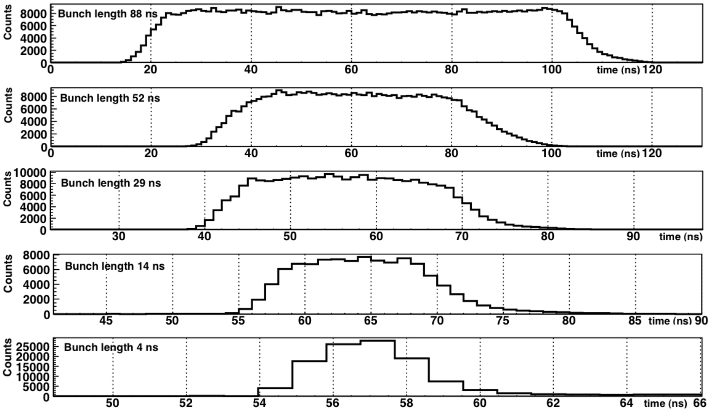
Transient time & mobility





- Assuming homogeneous E-field $\nu_{dr} = \frac{d}{t_{tr}}$
- Mobility can be estimated from $\frac{\mu E}{1 + \frac{\mu E}{V_{sat}}}$

Time structure of ns bunches



- A beam monitoring system using SC-DD for the measurement of bunch time profile has been developed making use of TAC electronics.
- J.A. Dueñas et. al, NIMA 641 (2011) 33 – 36