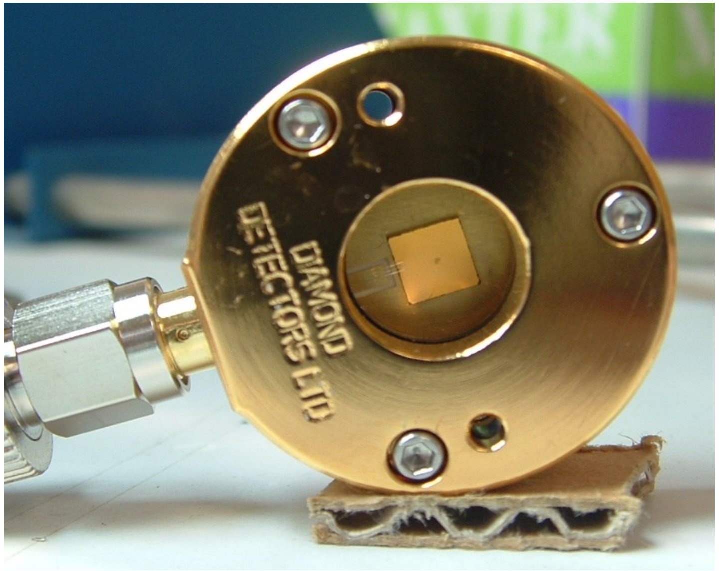
Jose A. Dueñas, University of Huelva (Spain) jose.duenas@dfa.uhu.es

TIMING PROPERTIES OF THIN SC-CVD DIAMOND DETECTORS

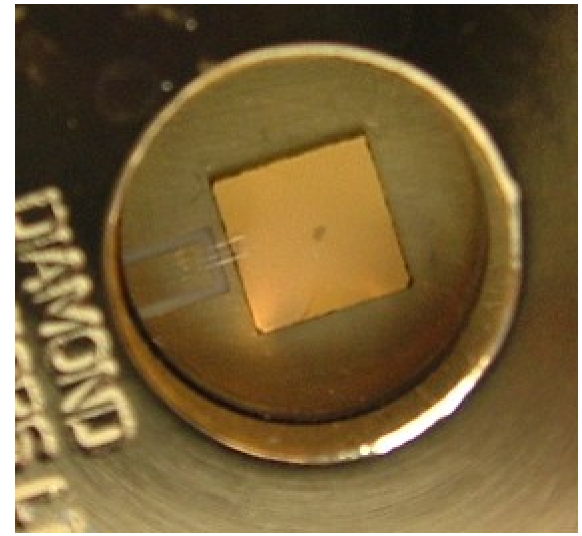


J.A. Dueñas & I. Martel
Department of Applied Physics
University of Huelva (Spain)

Jose A. Dueñas, University of Huelva (Spain) jose.duenas@dfa.uhu.es

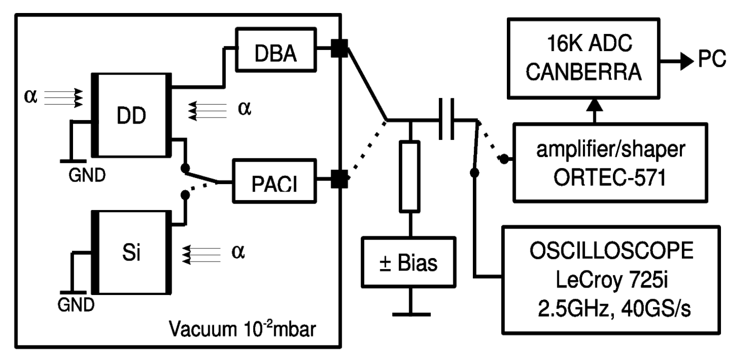
The detector

- SC-CVD diamond film 50 µm thickness (4×4 mm^2).
- Ohmic contacts: DLC (3 nm) / Pt (16 nm) / Au (200 nm).
- Al wire bonding connections.
- Transmission type mounting.
- Final capacitance of the detector 9.5 pF.



The experimental Setup

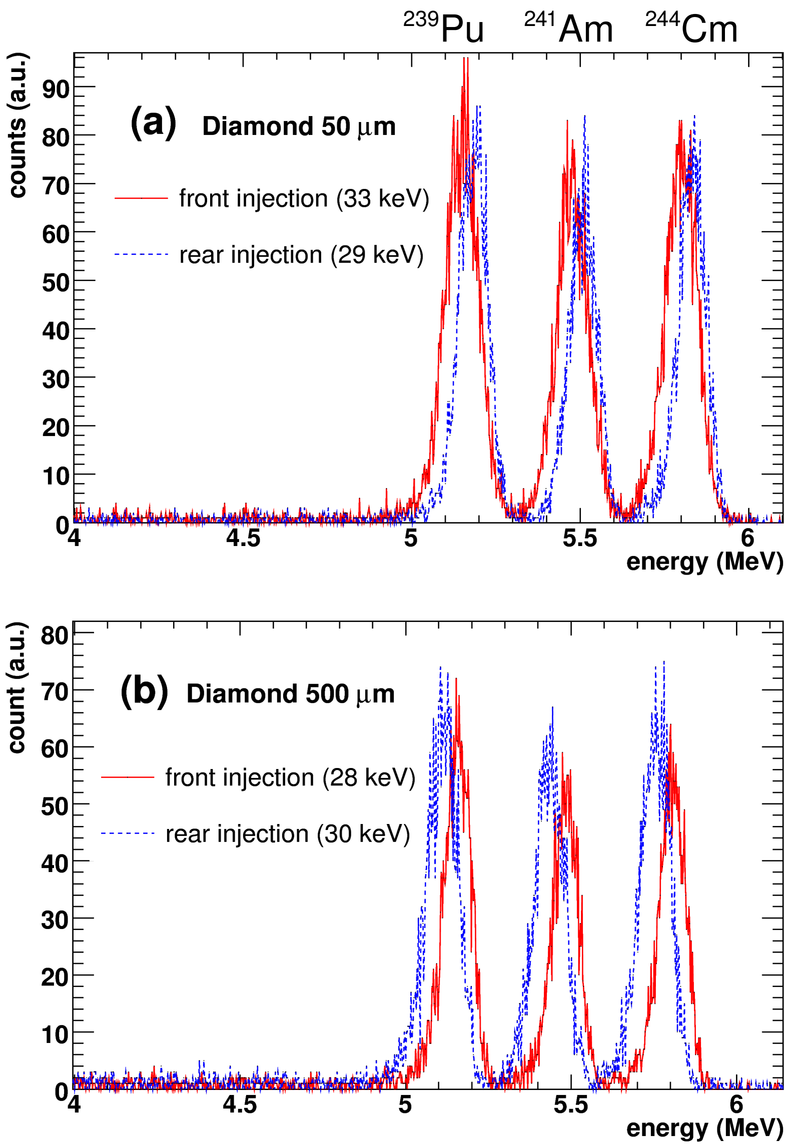
- Electronics ≤ 500 MHz for spectroscopy.
- Electronics ≤ 2.5 GHz for time resolution.
- SC-CVD diamond 500 µm (same contacts) 3.3 pF.
- Front & Rear α-injection, or ± bias.



Jose A. Dueñas, University of Huelva (Spain) jose.duenas@dfa.uhu.es

Energy resolution

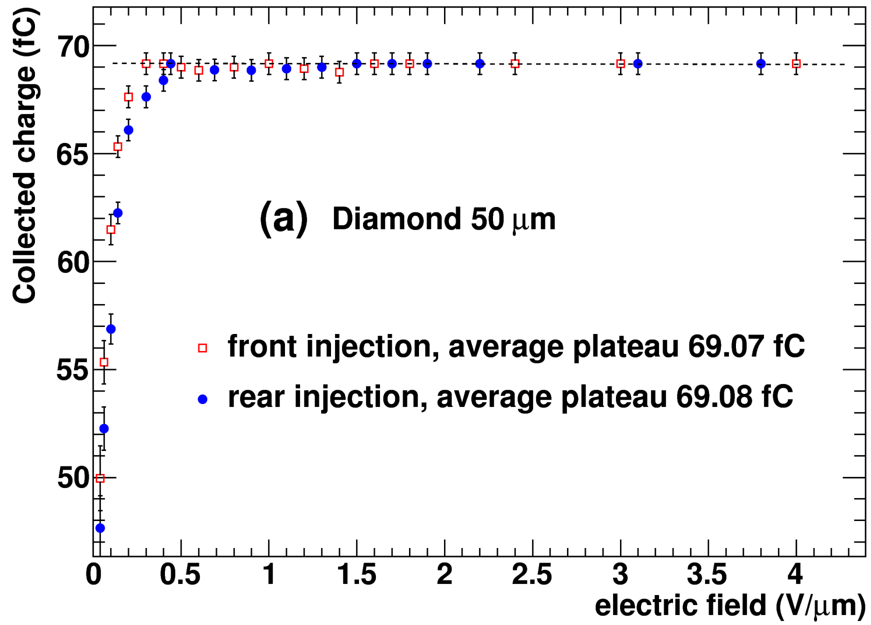
- $\Delta E \approx 30$ keV (2.4 V/μm for DD-50μm).
- Comparable to good Si detectors.
- $\Delta E \approx 17$ keV reported for DD-300μm.
- Energy shift between front & rear injection:
    - Radiation-induced polarization effect i.e. field distribution modified by trapped charges in the proximity of contacts.

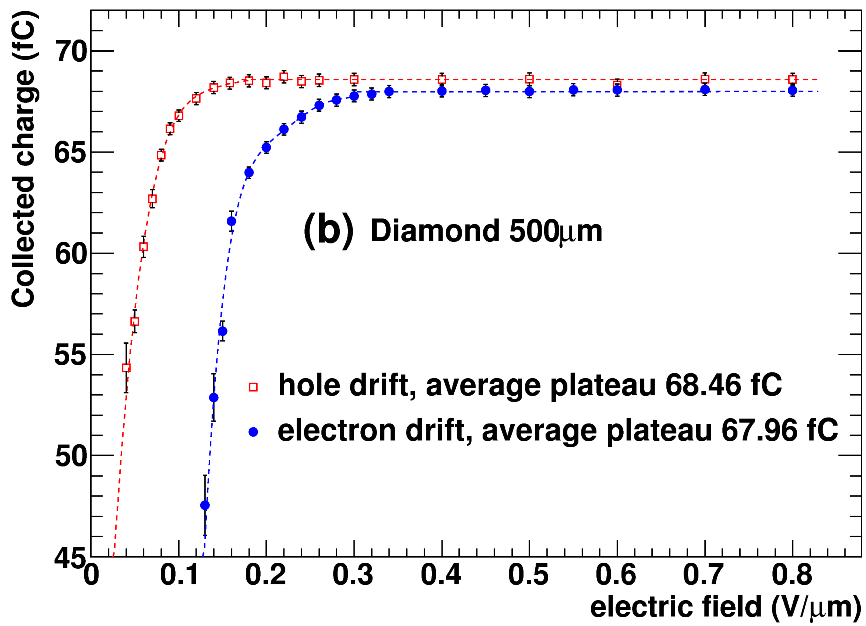


Jose A. Dueñas, University of Huelva (Spain) jose.duenas@dfa.uhu.es

Charge collection efficiency (CCE)

- Obtained from a charge sensitive preamp.
- Calibration of the electronics with the Si-300 μm.
- 100% CCE for DD-50 μm no matter injection side.
  - α-penetration ≈13.5 μm (no charge drift)
- CCE for DD-500 μm depents on the charge:
  - 99% hole drift (front injection).
  - 98% electron drift (rear injection). Needs higher electric field for charge collection. Indication of trapping.





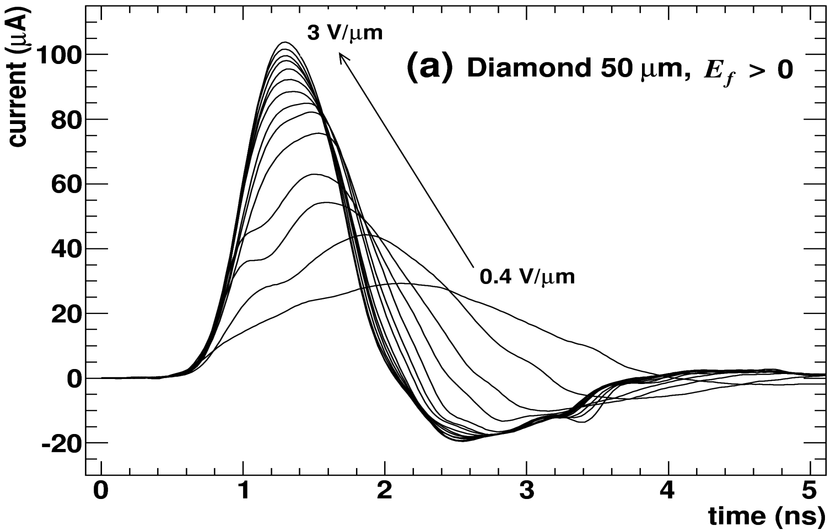
Jose A. Dueñas, University of Huelva (Spain) jose.duenas@dfa.uhu.es

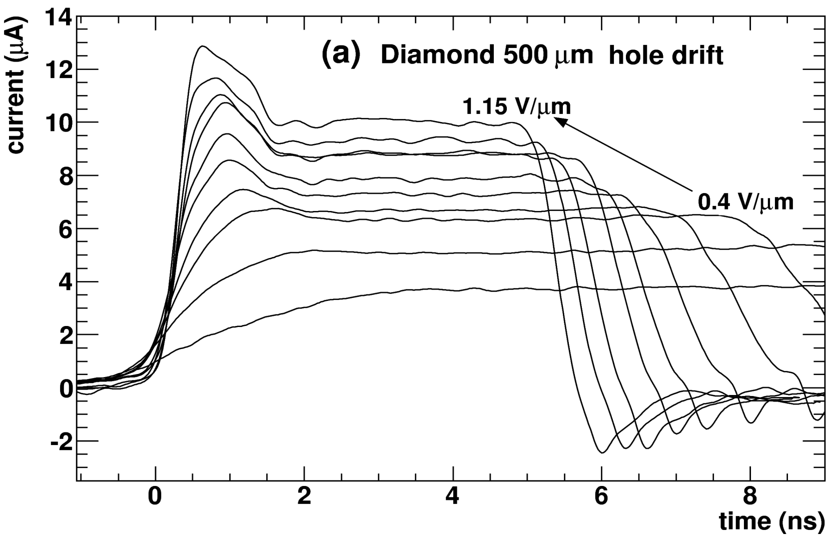
Universidad de Huelva

Física Aplicada

Pulse shape analysis (PSA)

- Fast electronics and good impedance matching.
- Transit time as FWHM:
  - DD-50 μm, 0.94 / 1.15 ns for E_f>0 / E_f <0.
  - DD-500 μm, 4.9 / 7.8 ns for hole / electron drift.
- For 1 V/μm holes & electrons same contribution.
- Signal "undershoot" due to impedance mismatch.
- The "overshoot" of the DD-500 μm caused by charges close to the injection electrode.

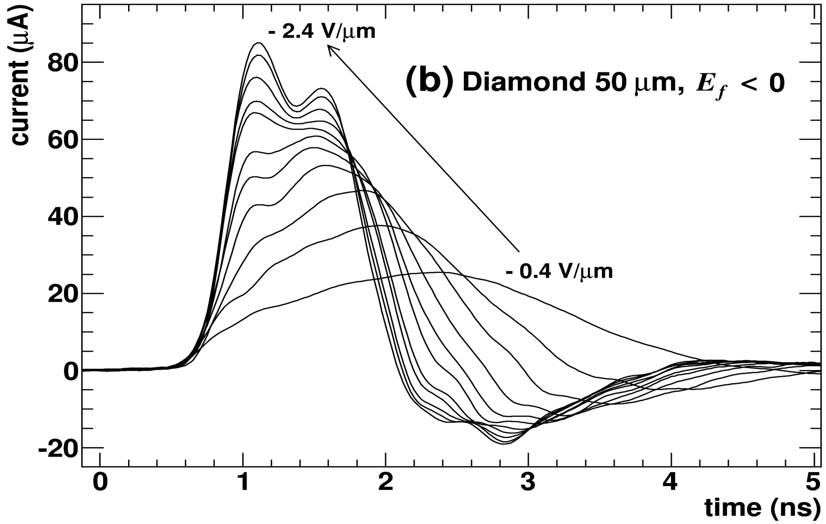


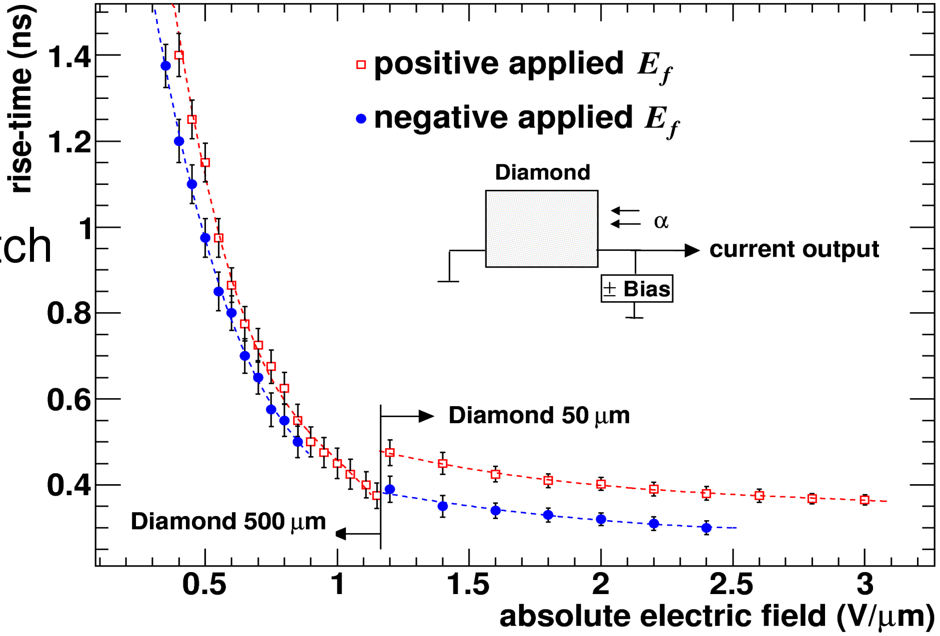


Jose A. Dueñas, University of Huelva (Spain) jose.duenas@dfa.uhu.es

Trapping effect

- DD-50 μm pulse made of two peaks for E_f <0.
- Electrons take longer to be collected.
- Rise time measurements indicate so.
- Time difference is affected by the E_f <0.
- Transition between curves caused by mismatch
- How much due to bulk and to electrodes??





Jose A. Dueñas, University of Huelva (Spain) jose.duenas@dfa.uhu.es

Parameters

TABLE I
DIAMOND DETECTOR (DD) PARAMETERS SUMMARY. THE e AND h SUBSCRIPTS DENOTE ELECTRON AND HOLE RESPECTIVELY.

	DD-500 μm	DD-50 μm
ΔE	28 keV	33 keV
ε_{Dia}	12.7 ± 0.1 eV	12.7 ± 0.1 eV
CCE_h	99 %	100 %
CCE_e	98 %	100 %
N_{eff_h}	2.27×10^{11} cm^{-3}	1.26×10^{13} cm^{-3}
N_{eff_e}	3.78×10^{11} cm^{-3}	1.26×10^{13} cm^{-3}
t_{tr_h}	4.9 ns^a	0.94 ns ^{c}
t_{tr_e}	7.8 ns^b	1.15 ns ^{d}
v_{s_h}	154 ± 4 μm/ns	
v_{s_e}	98 ± 2 μm/ns	
μ_h	2430 ± 30 cm^2/Vs	
μ_e	2145 ± 45 cm^2/Vs	
τ_h	2 ± 0.5 μs	
τ_e	0.45 ± 0.1 μs	

^{a} $E_f = 1.15\ V/\mu\text{m}$ ^{c} $E_f = 3\ V/\mu\text{m}$
^{b} $Ef = -0.85\ V/\mu\text{m}$ ^{d} $E_f = -2.4\ V/\mu\text{m}$

Jose A. Dueñas, University of Huelva (Spain) jose.duenas@dfa.uhu.es

Universidad de Huelva
Física Aplicada

Near future work

- Study trapping at the bulk-electrode interface.
  - Asymmetric schottky (Al) - ohmic contacts (DLC/Pt/Au).
- Time resolution with a diamond telescope dE = 50 μm, E = 500 μm.
  - three year ago we obtained <100 ps with dE = 110 μm, E = 300 μm.
- Radiation hardness of the samples.

We are opened to suggestions and collaborations

CARAT Advanced Diamond Detectors

Universidad de Huelva Física Aplicada

Jose A. Dueñas, University of Huelva (Spain) jose.duenas@dfa.uhu.es