Single-crystal CVD diamond detectors for neutron spectroscopy of d-d and d-t fusion reactions

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cividec
Instrumentation

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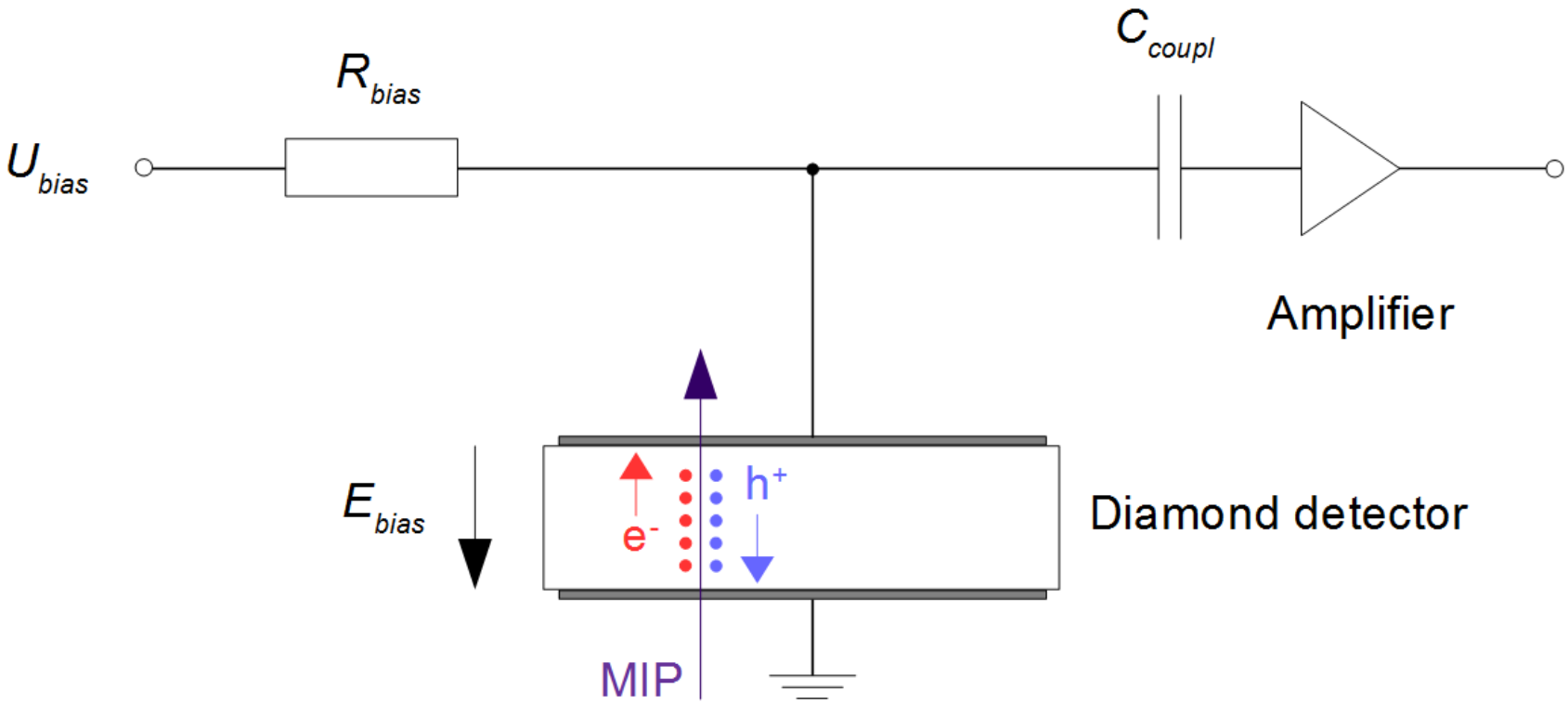
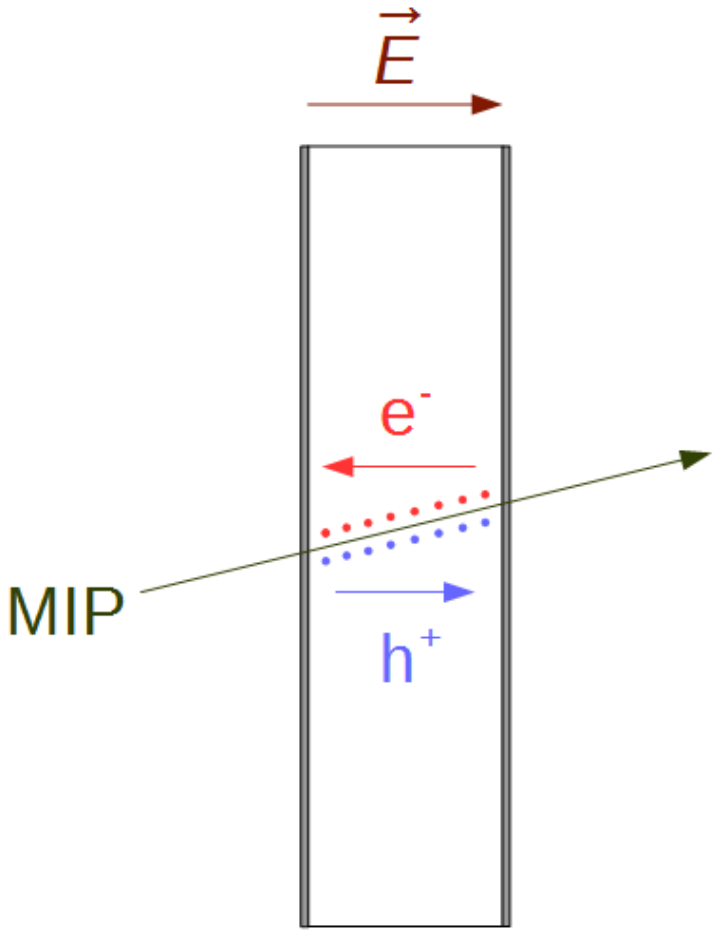
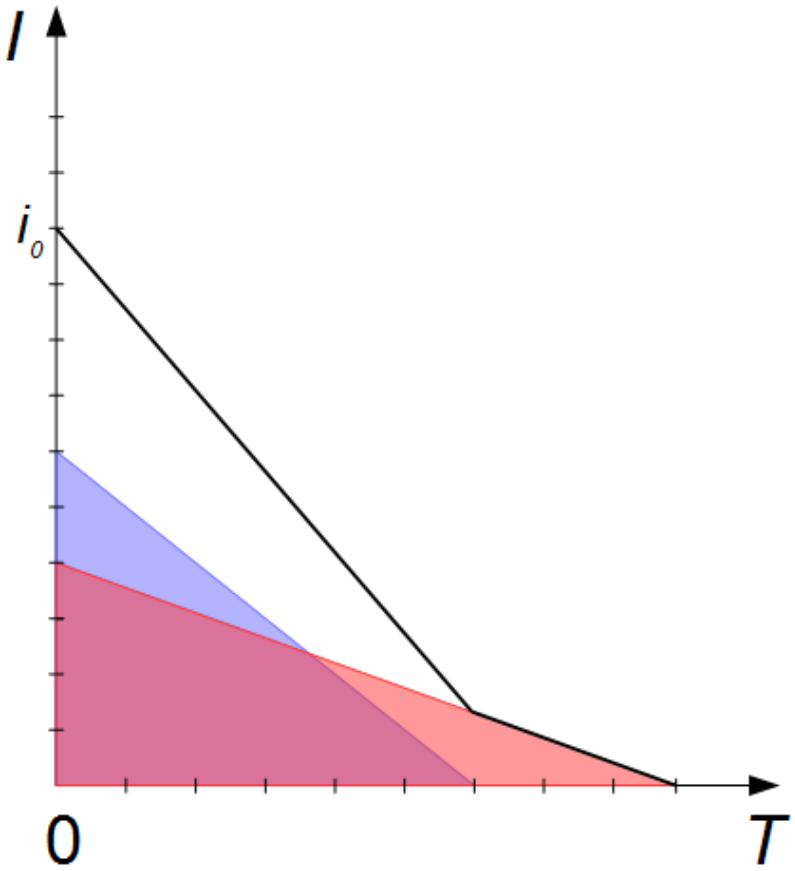
Diamond detector operation

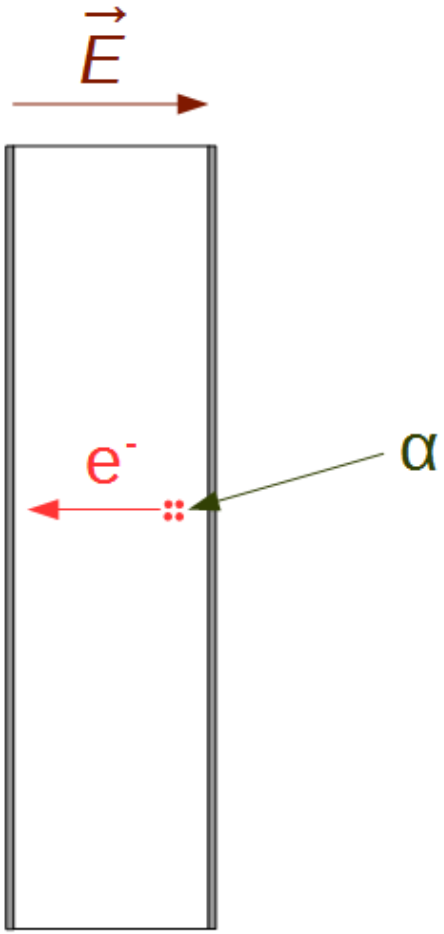


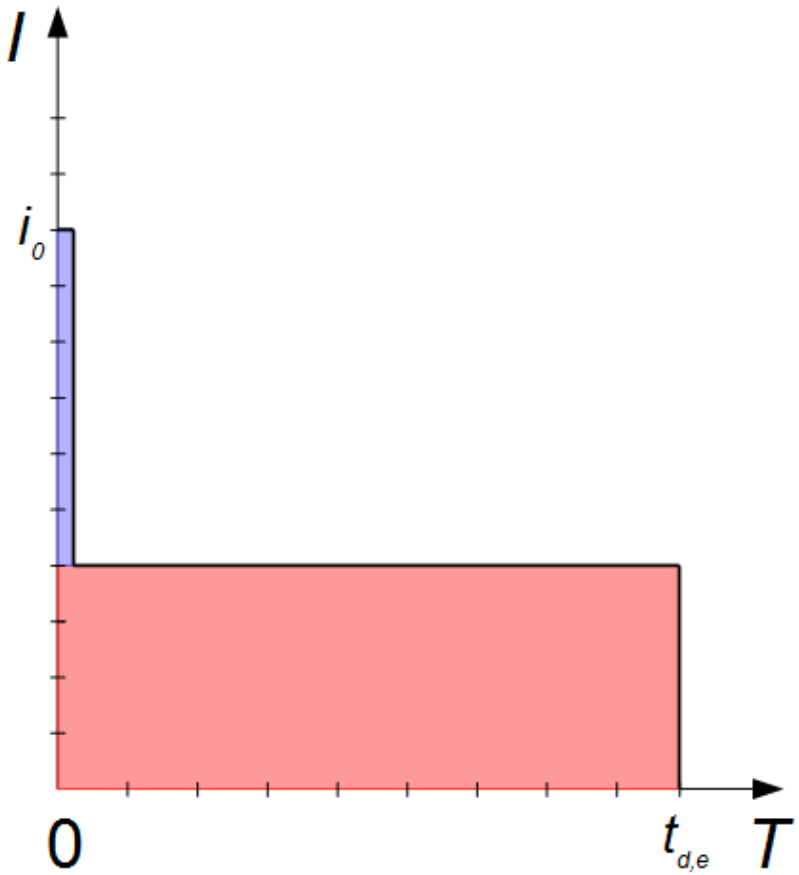
Uniform ionization profile



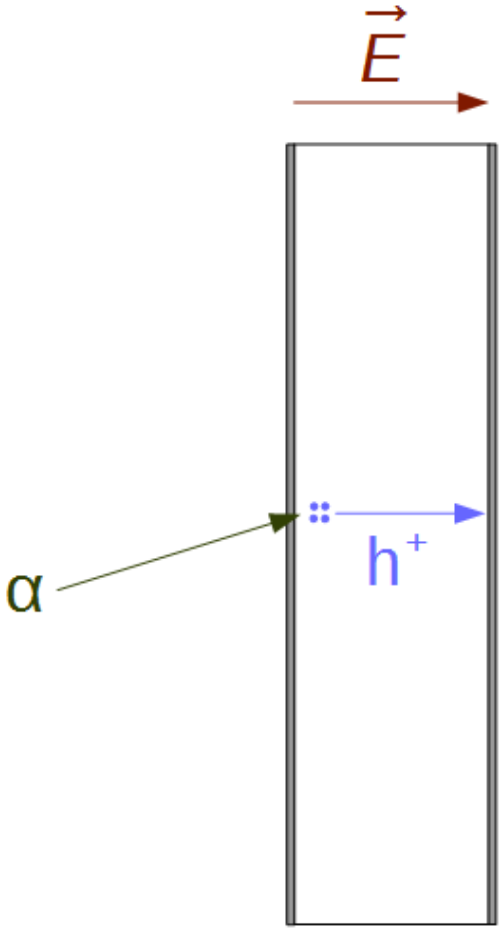


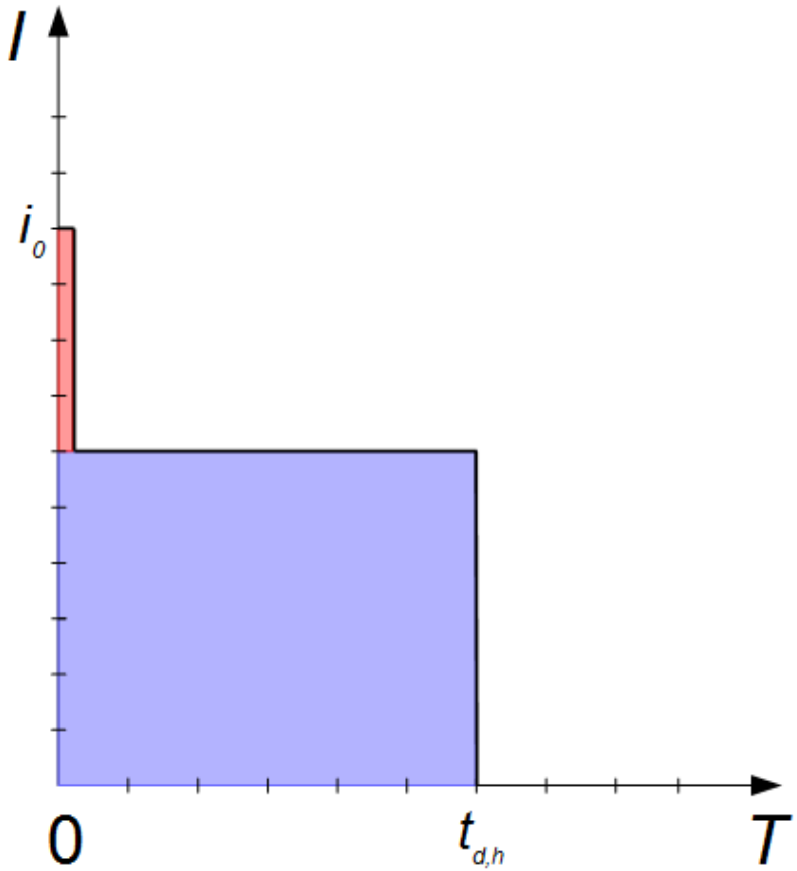
Electron drift profile



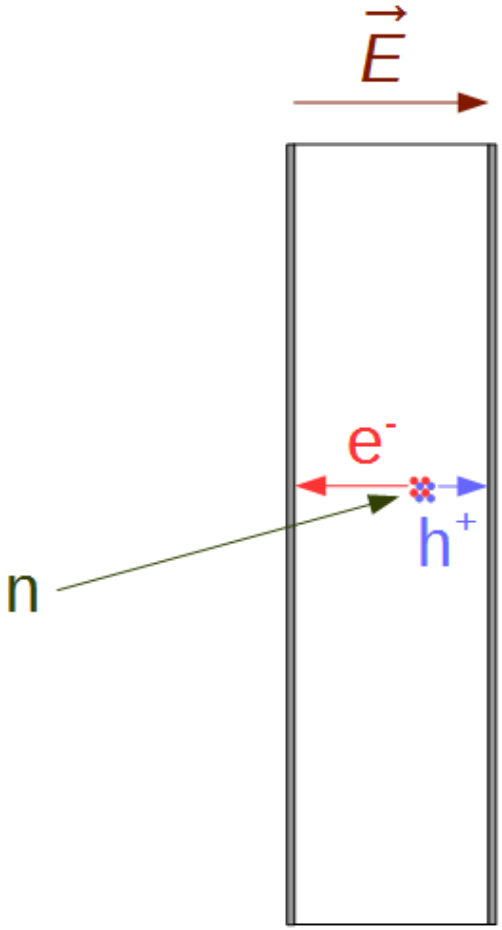


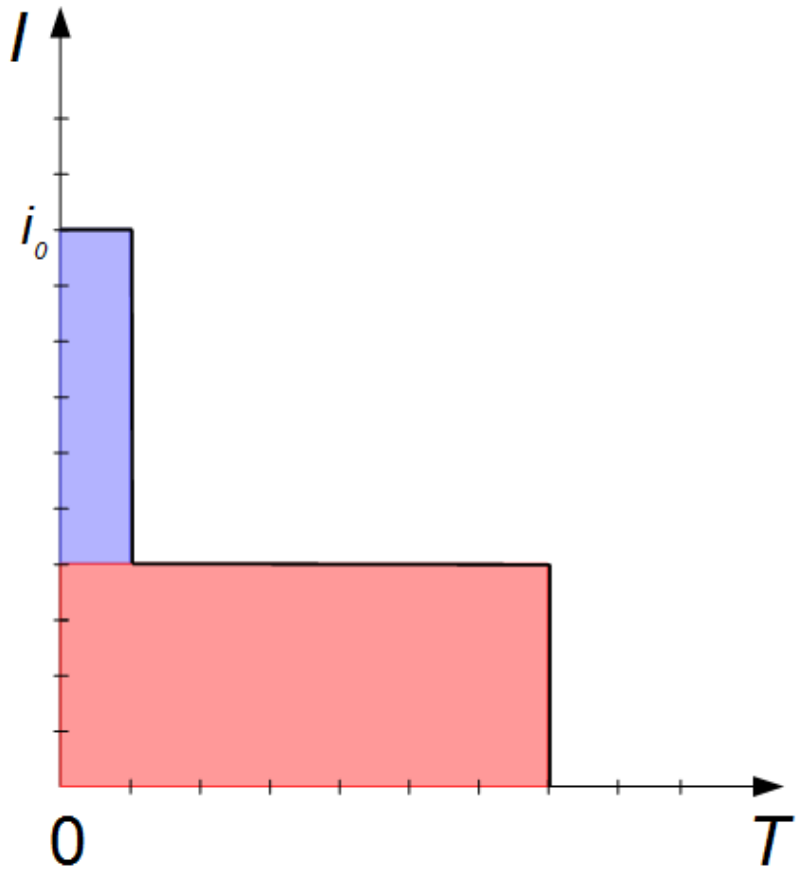
Hole drift profile



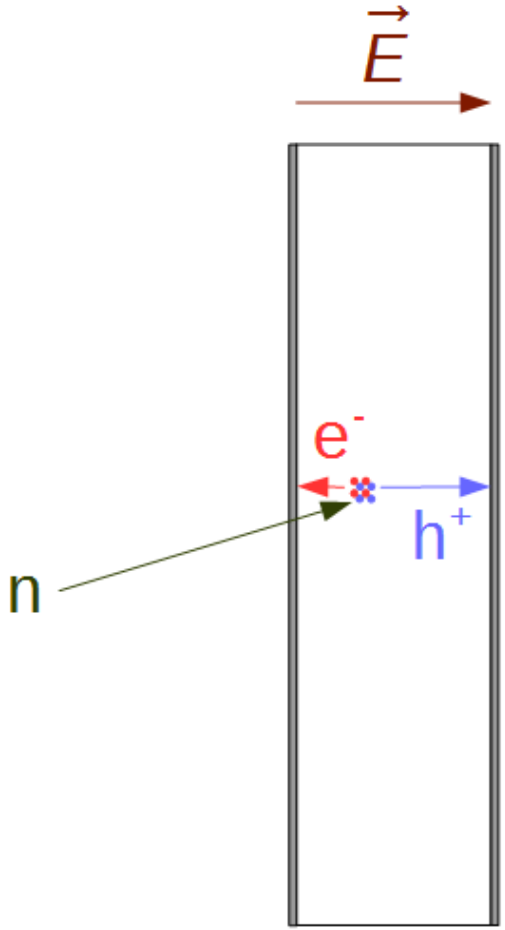


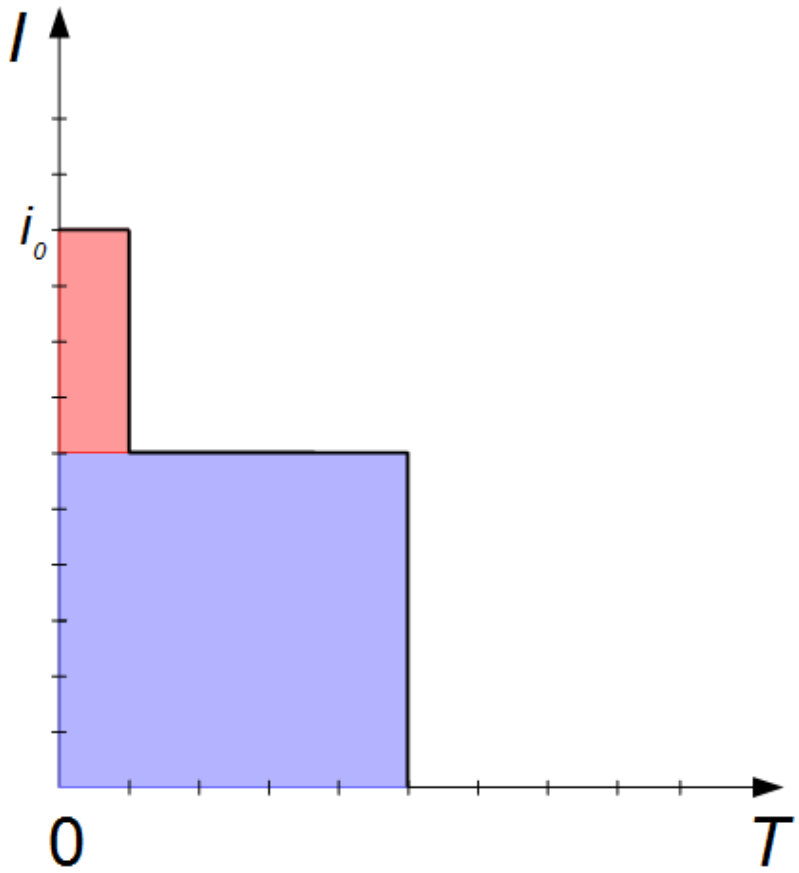
Electron-dominated profile



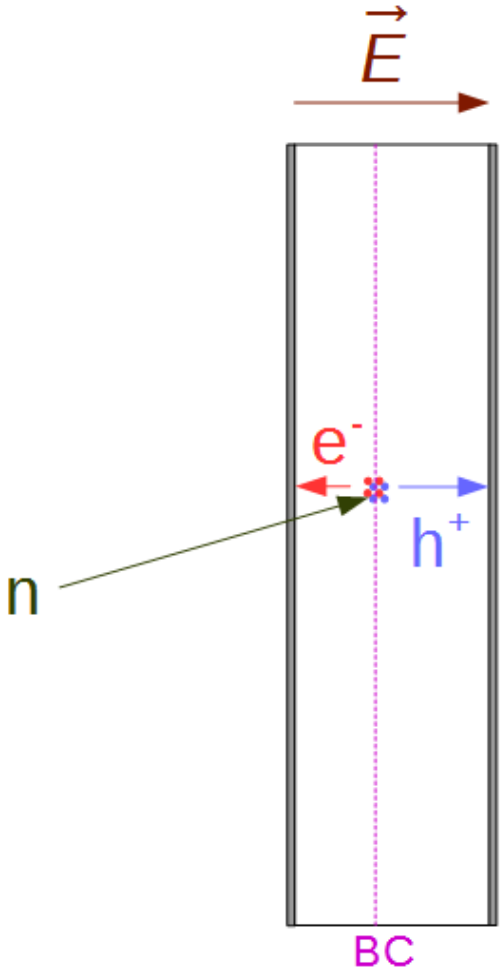


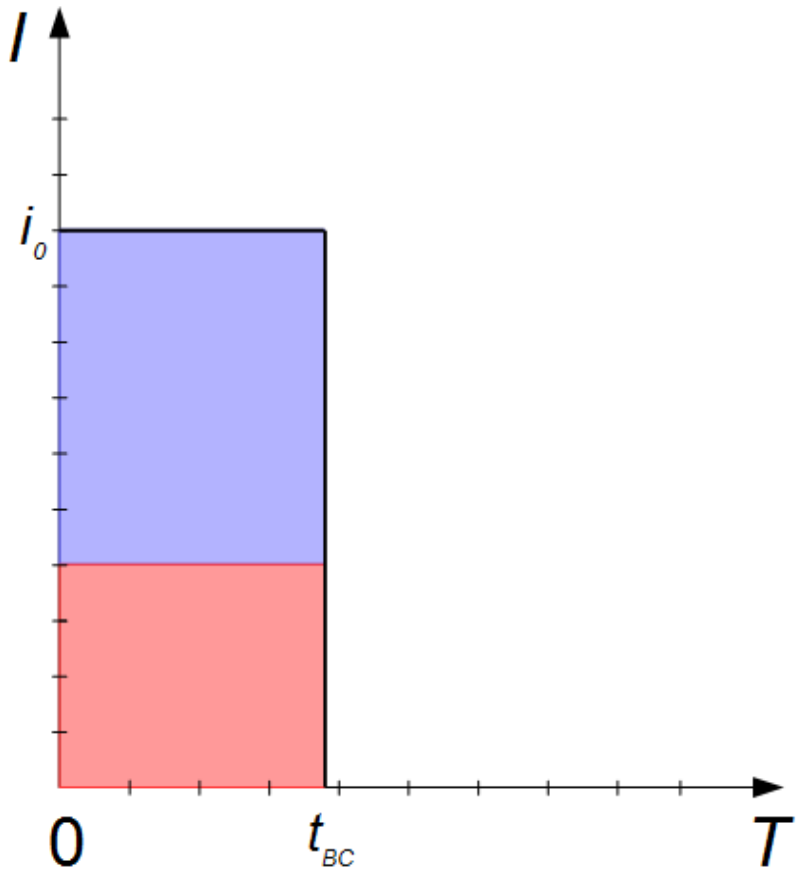
Hole-dominated profile



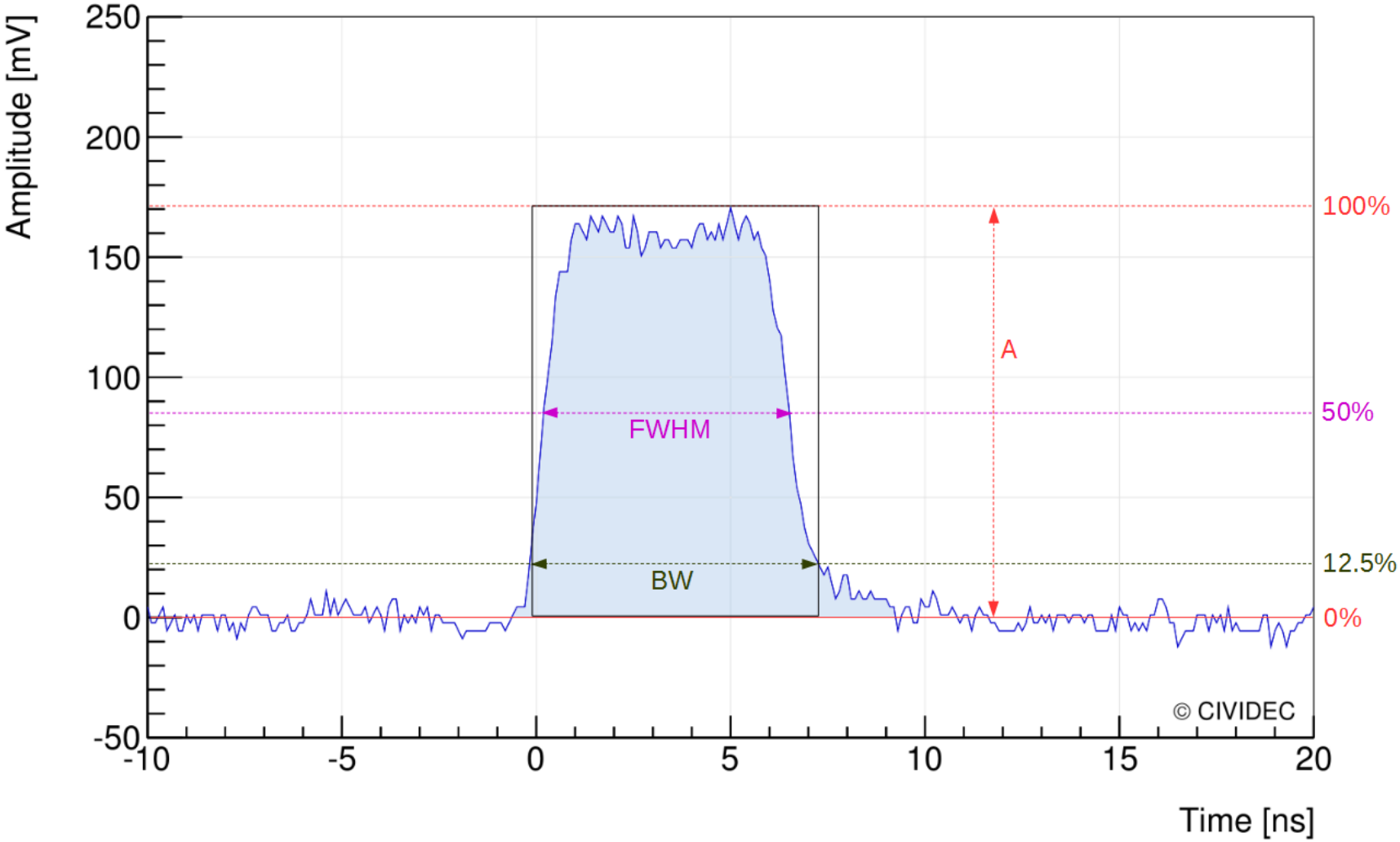


Ballistic center interaction profile

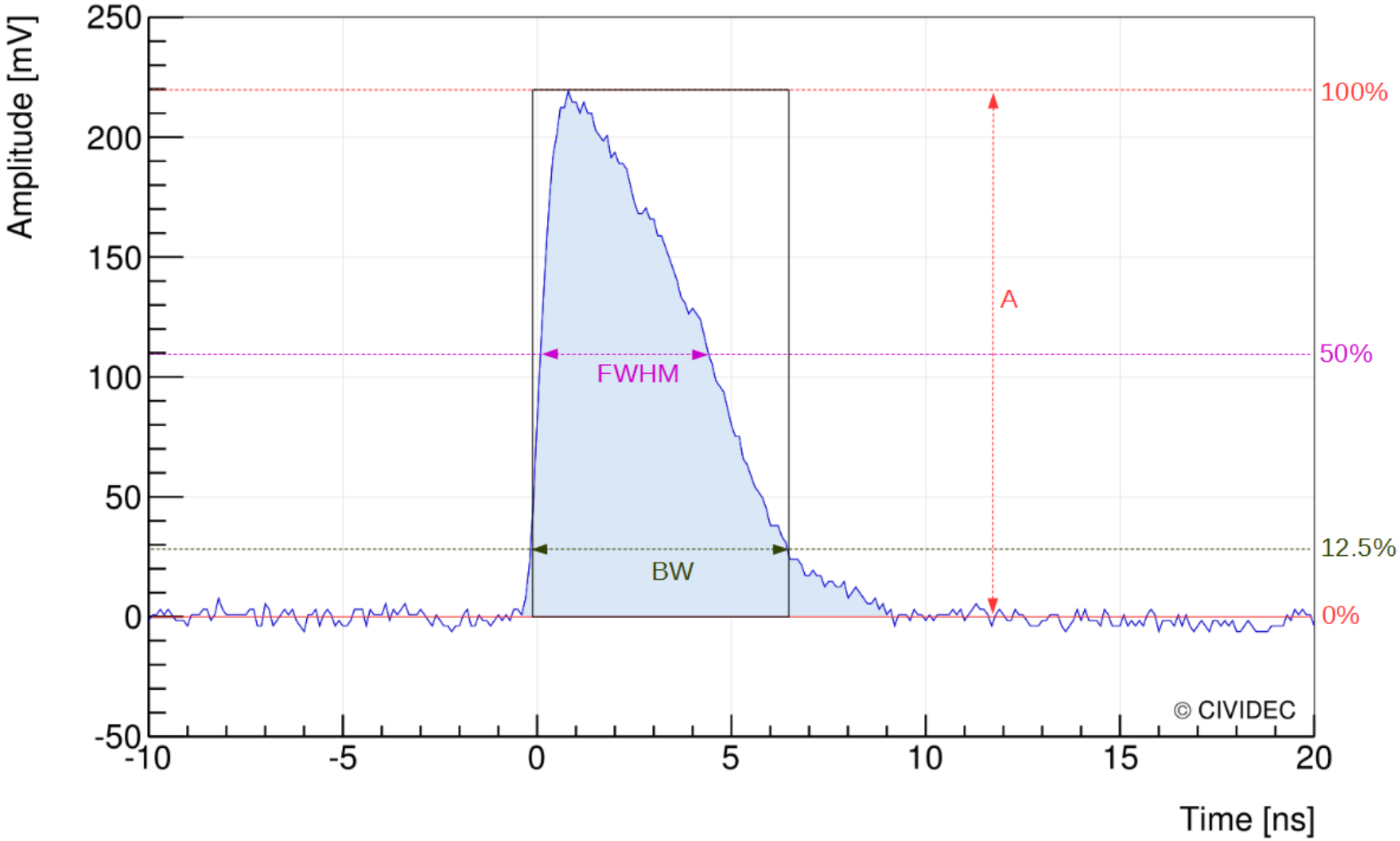




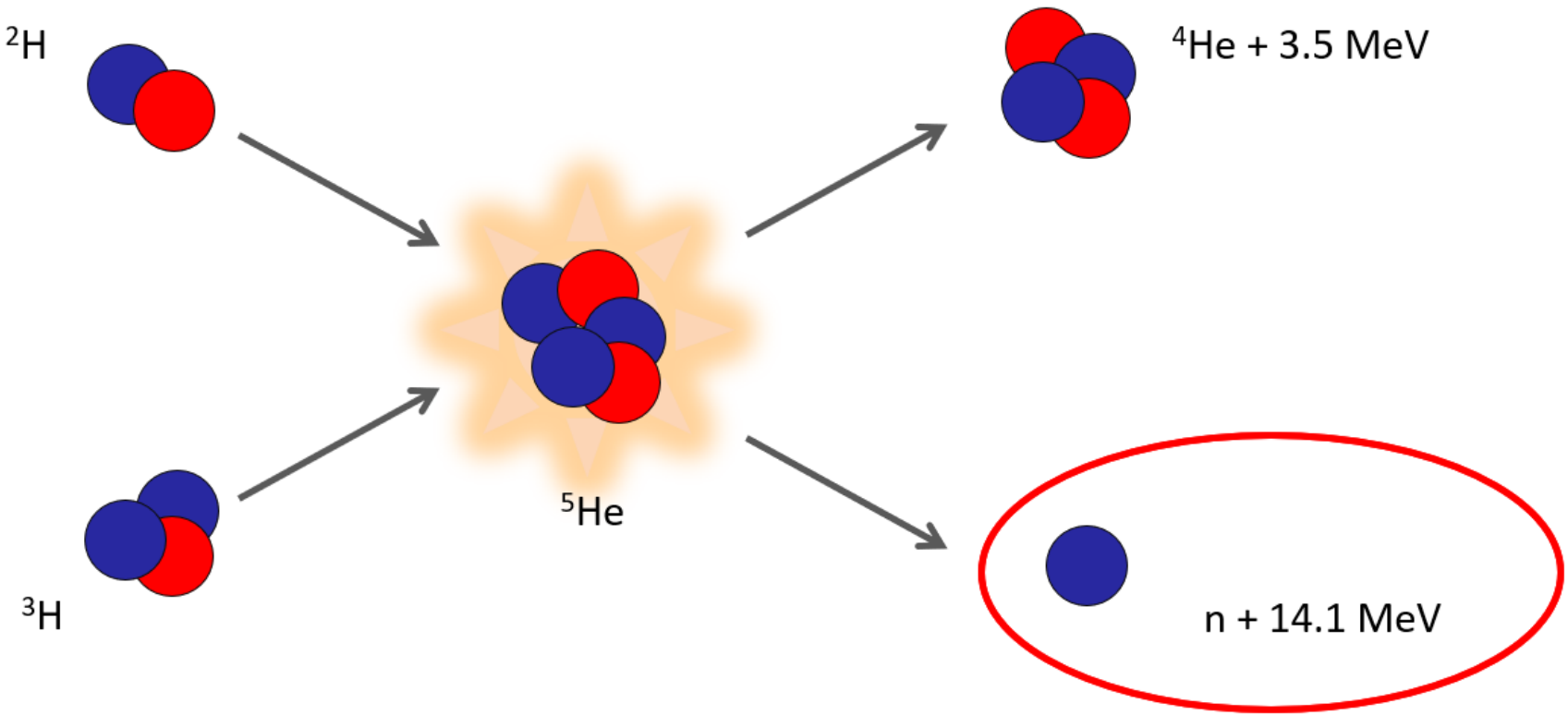
Pulse-shape analysis - Rectangle



Pulse-shape analysis - Triangle

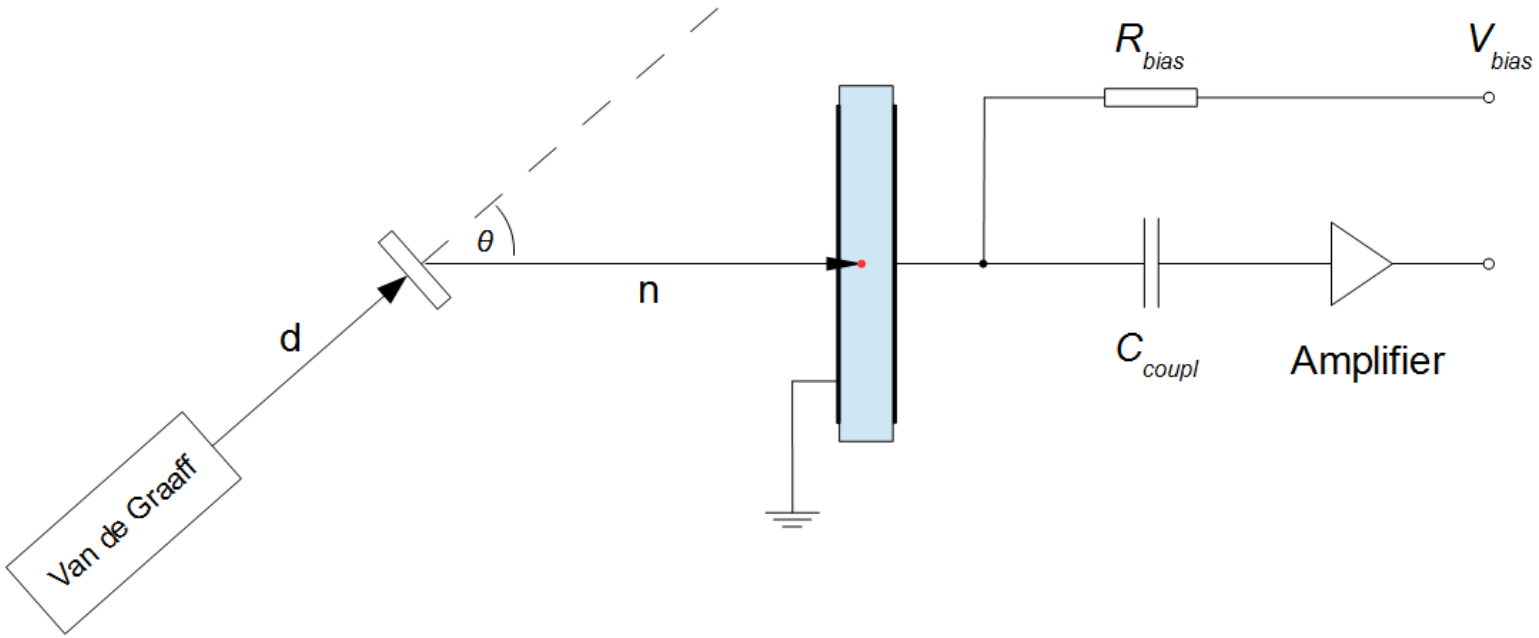


d-t neutrons

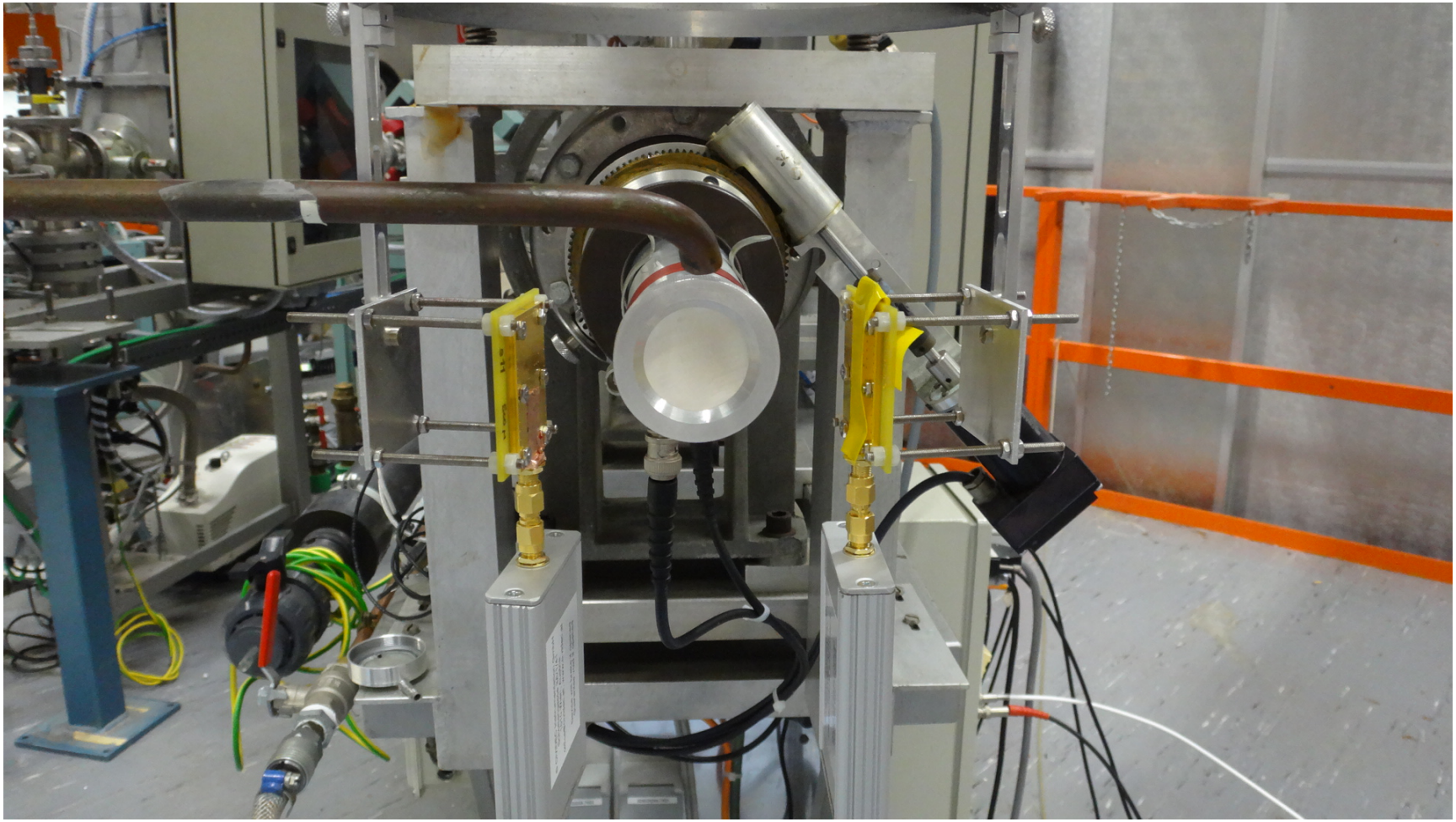


Measurement setup (I)

- 7 MV Van de Graaff accelerator, EC-JRC (Geel, Belgium)
- Quasi-monoenergetic neutron beam via T(d,n)^{4}He reaction
- Deuteron (2 MeV) on Ti/T target
- Detector positions: 98° (E_n=14.3 MeV), 45° (E_n=17.0 MeV)



Measurement setup (II)

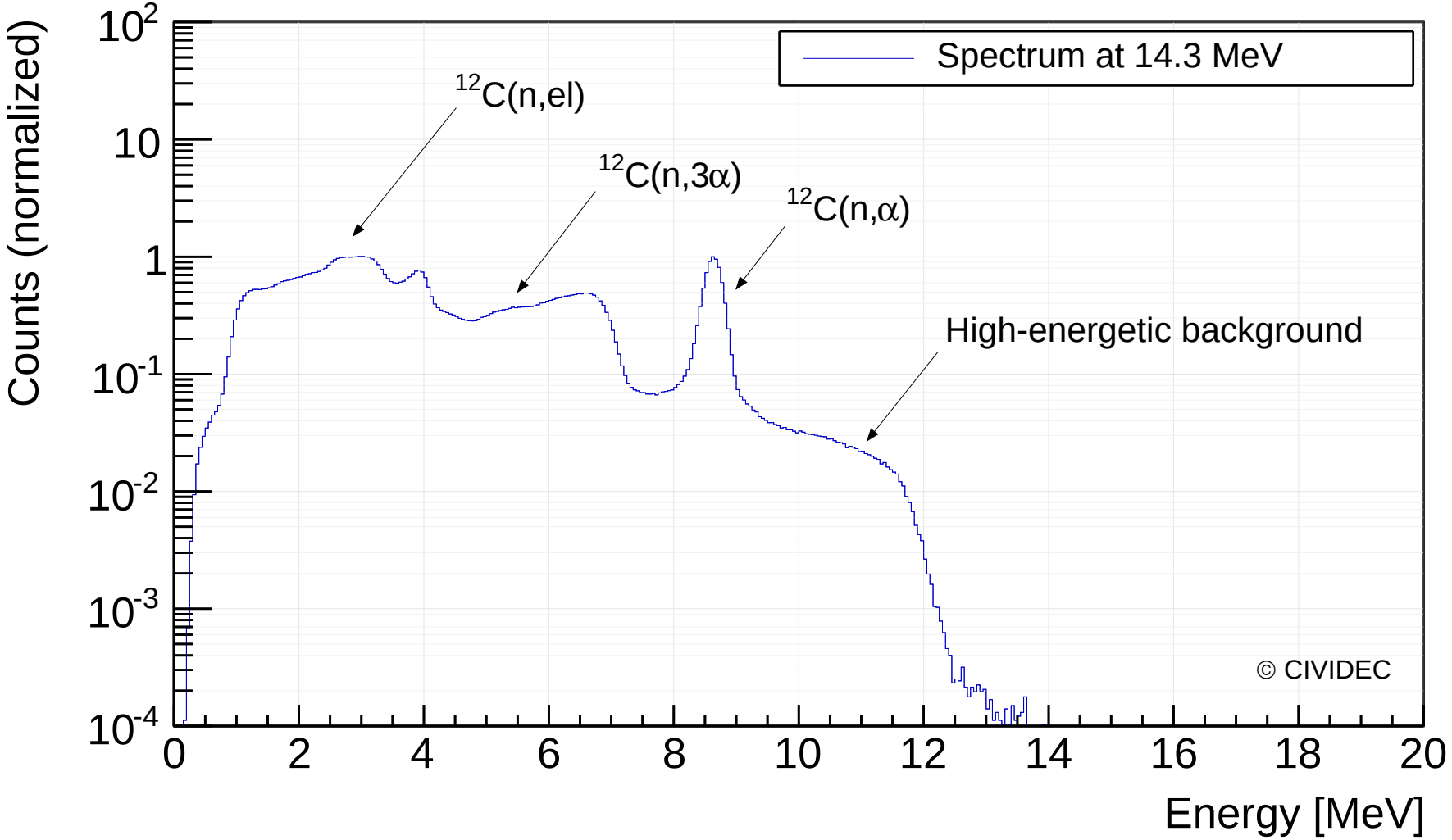


Measurement setup (III)

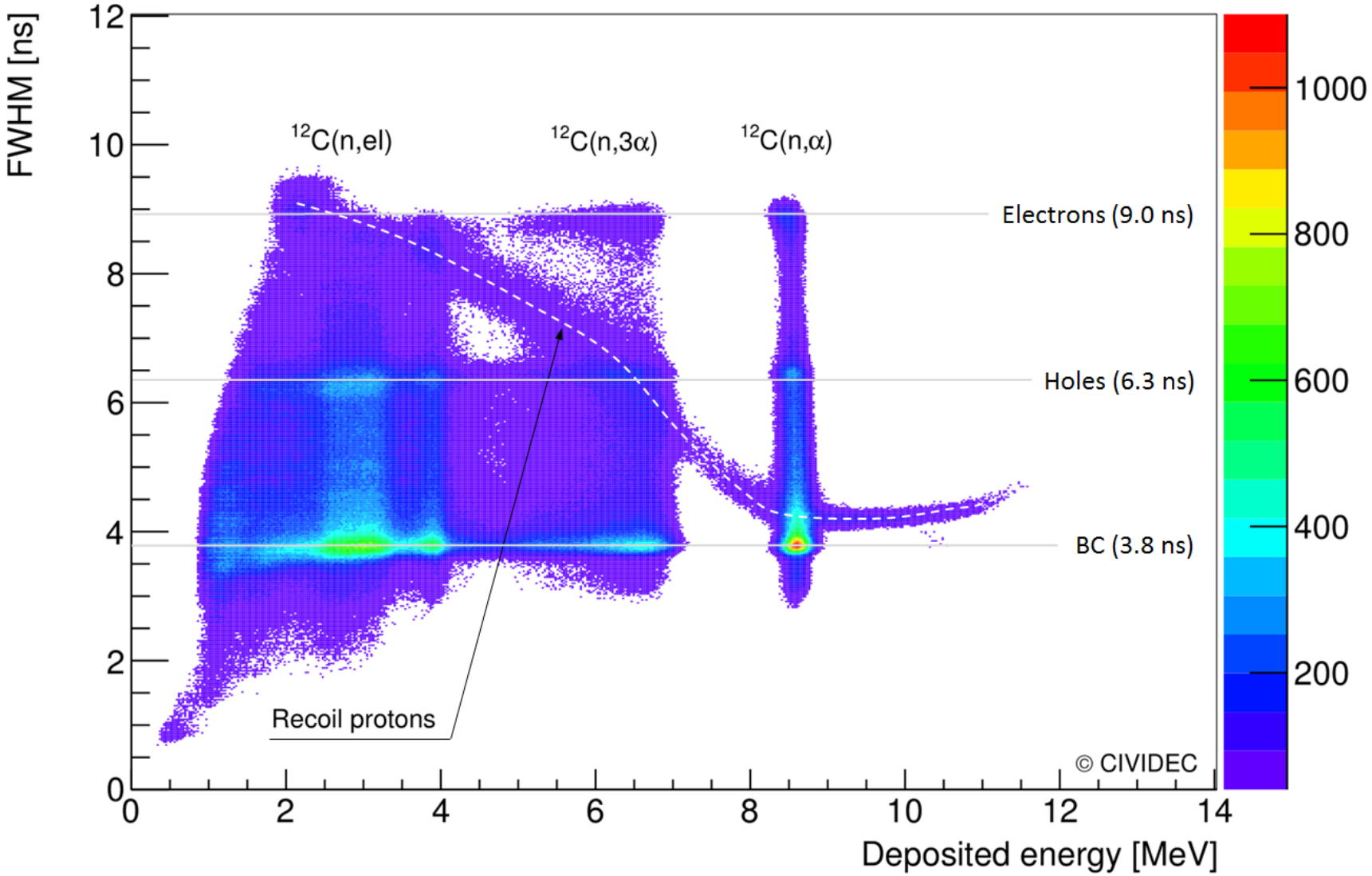
- CIVIDEC B1 Single-Crystal Diamond Detector
  - Thickness 500 μm
  - Active area 4 mm $\times$ 4 mm
  - Bias electric field 1 V/μm
  - Diamond detector was used as a sample and as a sensor
- CIVIDEC C2 Broadband Amplifier
  - Analogue bandwidth 2 GHz
  - Equivalent input current noise 0.4 μA
- LeCroy Waverunner oscilloscope
- Dedicated pulse-shape analysis for background rejection
- Cross section of ^{13}C(n,α)^{10}Be was measured relatively to ^{12}C(n,α)^{9}Be

Measured deposited energy spectrum at 14.3 MeV (I)

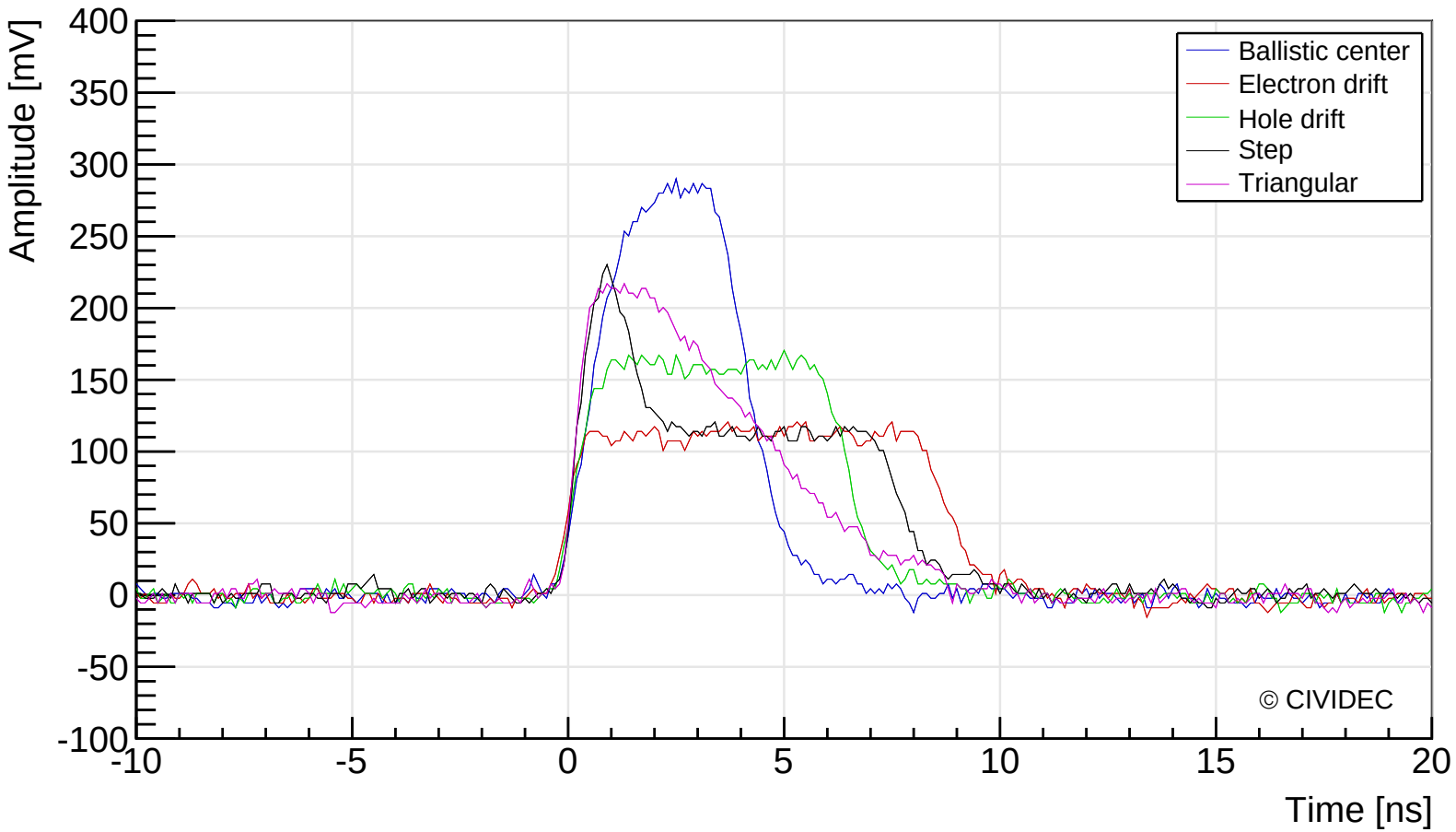
$^{12}C(n,\alpha_0)^{9}Be$: mean 8.6 MeV
$^{13}C(n,\alpha_0)^{10}Be$: mean 10.5 MeV



FWHM vs. energy, 14.3 MeV neutrons



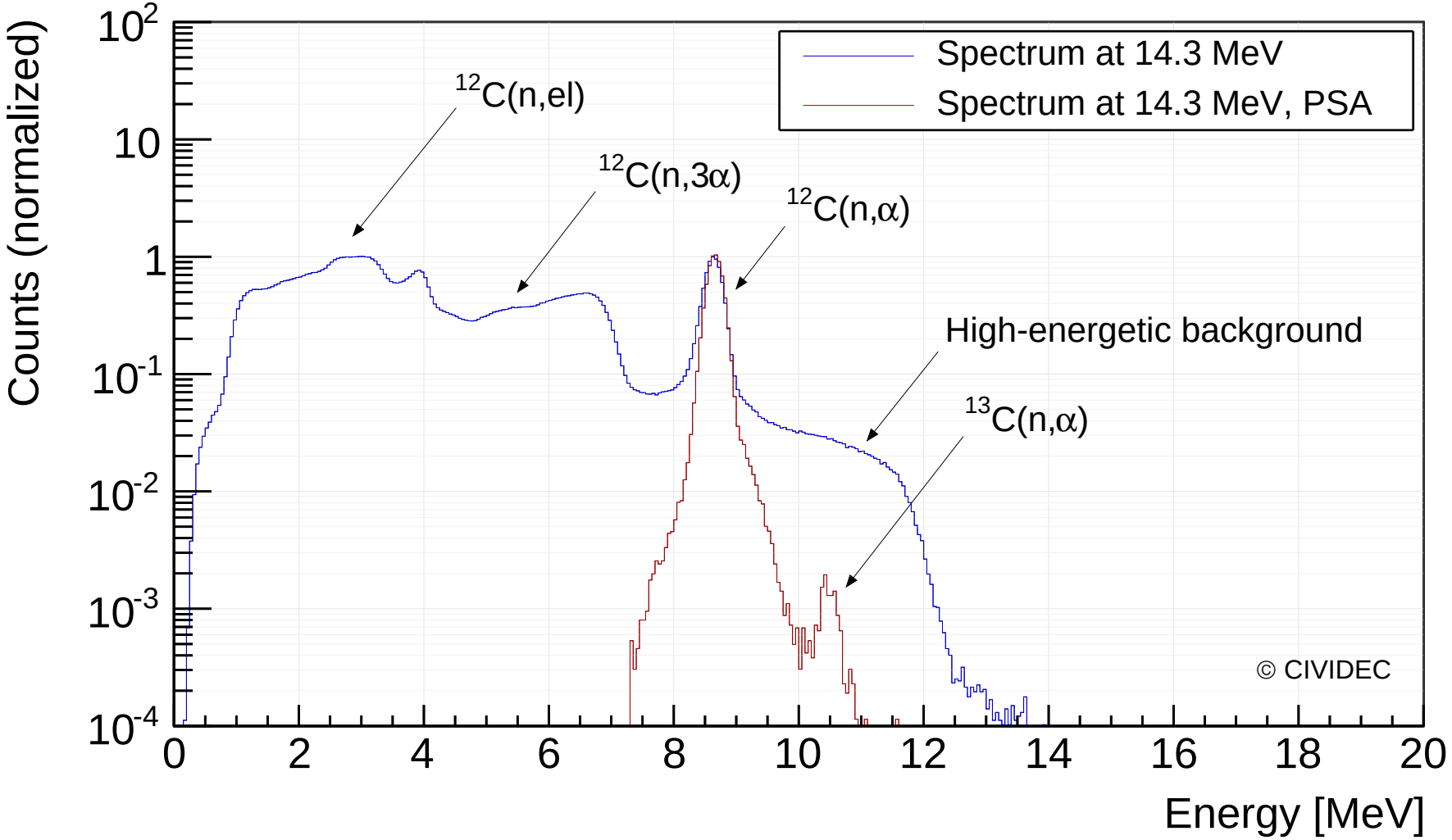
Pulse shapes, 14.3 MeV neutrons



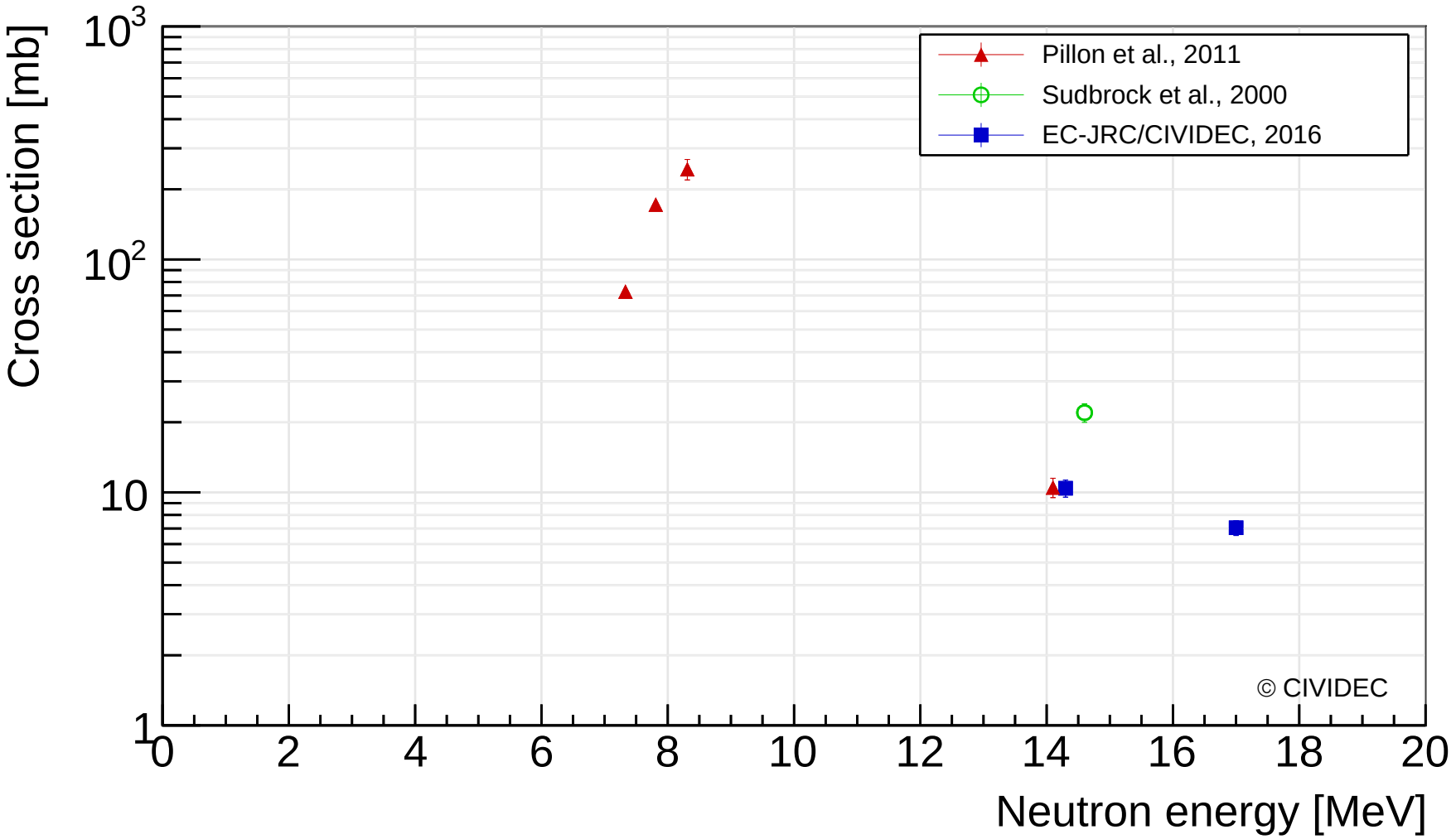
- Fast neutrons interacting in the *ballistic center* produce **rectangular** pulses with a minimum **drift time**

Deposited energy spectrum at 14.3 MeV (II)

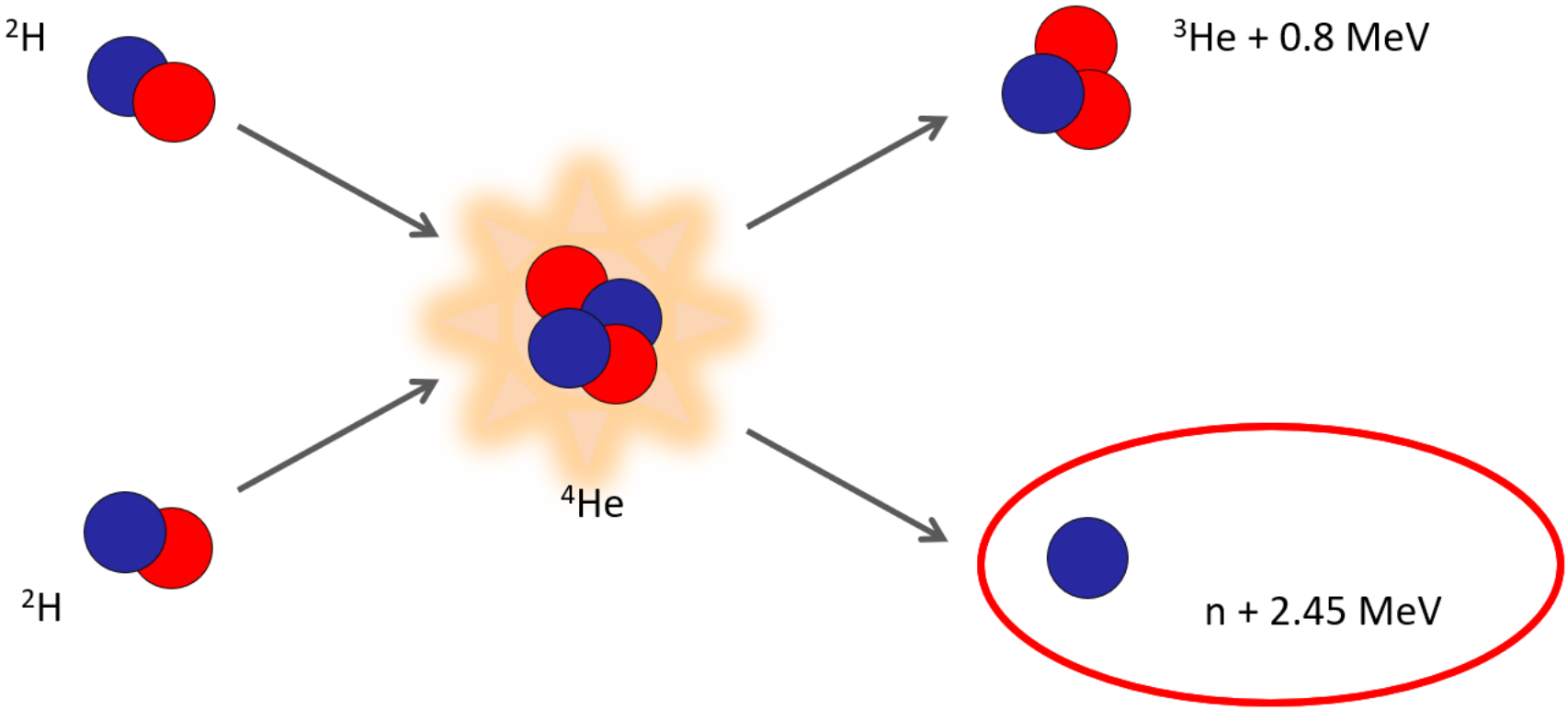
$^{12}C(n,\alpha_0)^{9}Be$: mean 8.6 MeV
$^{13}C(n,\alpha_0)^{10}Be$: mean 10.5 MeV



$^{13}C(n,\alpha_0)^{10}Be$ cross section

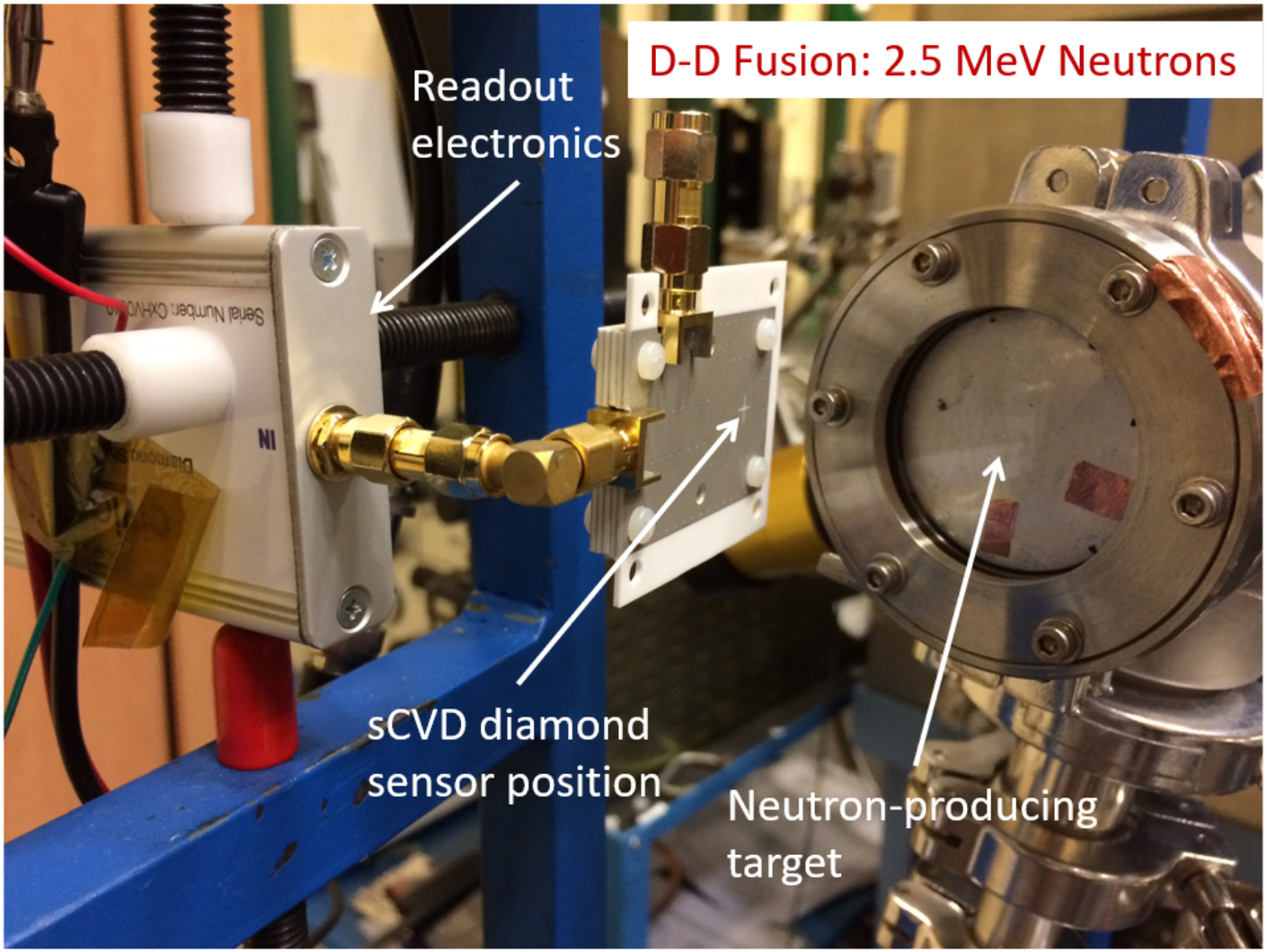


d-d neutrons

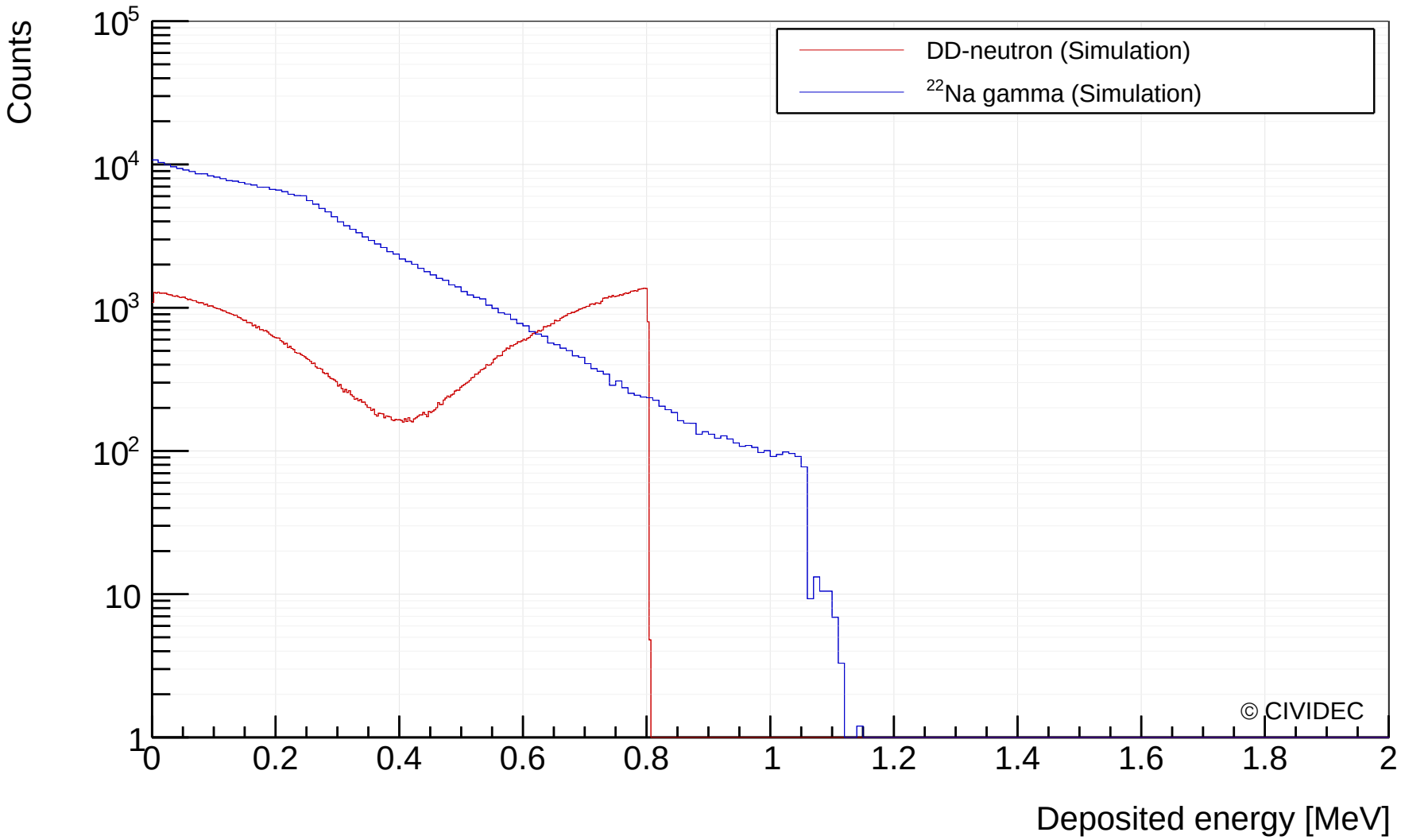


Measurement setup

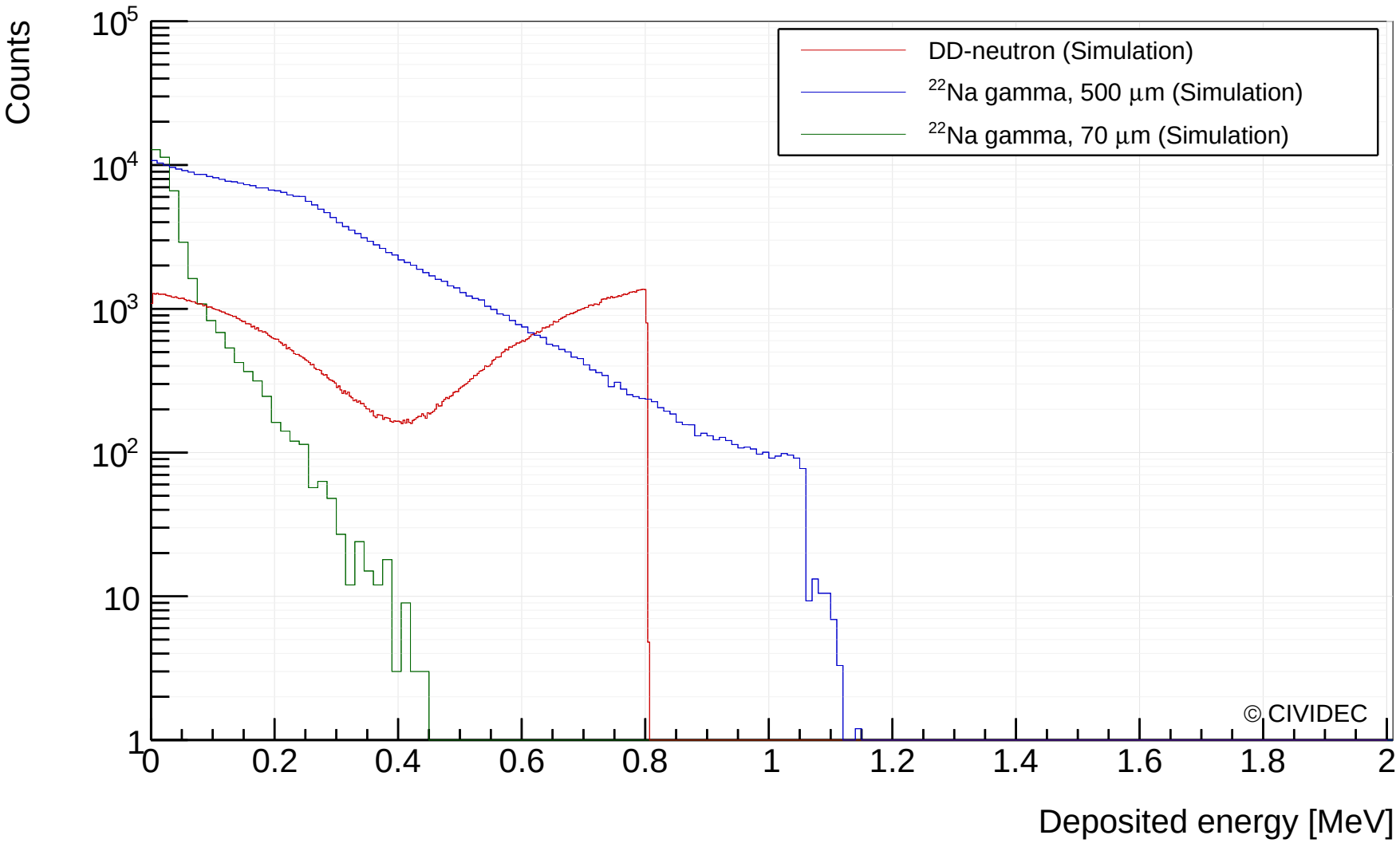
- CNA HiSPANoS (Seville, Spain)



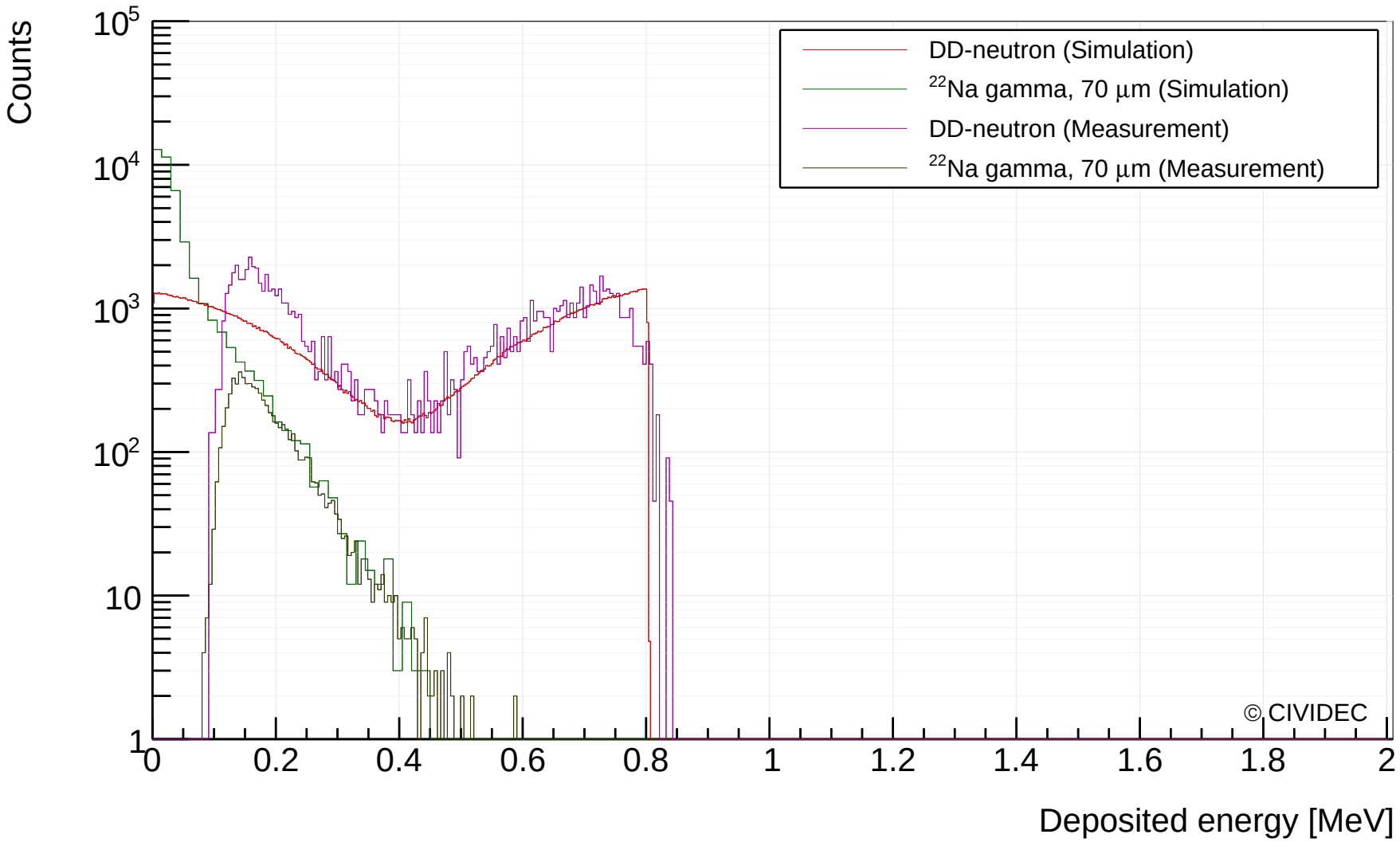
Deposited energy spectra of neutrons and gamma (I)



Deposited energy spectra of neutrons and gamma (II)



Deposited energy spectra of neutrons and gamma (III)



Conclusions

- Neutron spectroscopy with sCVD diamond detector allows discrimination of different types of particle interactions based on a pulse-shape analysis of the detector current.
- Spectroscopy and flux measurements with d-t neutrons (14.1 MeV): Pulse-shape analysis provides background rejection.
- Spectroscopy and flux measurements with d-d neutrons (2.5 MeV): Background rejection with a thin diamond.

Thank you for your attention!