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Diamonds for Beam Instrumentation

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Diamond detectors are currently exciting a lot of attention. Their high radiation tolerance, their rapid response in the order of nanoseconds, and the low dark current in the order of pico-ampere make them excellent particle detectors. It has long been known that diamonds fluoresce and generate electrical signals when irradiated. The emergence of single-crystal and poly-crystalline CVD diamond made it possible to provide detector material with precise shapes, and uniform and predictable properties, while modern electronics make it possible to fully exploit the pico-second structure of the diamond response. These basic ingredients provide all that is needed for an extremely wide range of high-energy particle monitors and counters. Photons can be monitored above 5.5 eV using a diode configuration in which the photo-excitation current is measured. Diamond fluorescence monitors are widely used in the range of 2 keV up to 50 keV. Above 50 keV, the photo-ionised electrons start to create ionization in their own right and diamond detectors configured as ionization chambers can be used, even for single-photon detection. For neutrons, a diamond ionisation monitor can be used with a converter from thermal energies up to 6 MeV and from this energy upwards there is no need for the converter. Recent tests at n_TOF (CERN) have gone up to 1 GeV neutrons. For electrons, diamond is used in the ionization mode and is frequently configured as a quadrant monitor in synchrotron light sources. Possibly the main advance in diamond detectors is currently in the detection of protons and ions. Giga-particle counting up to 3.5 TeV has been demonstrated at the LHC (CERN) and carbon ions have been calorimetrically measured in the energy range of 30 MeV at ISOLDE (CERN). The development of diamond detectors is a field where the basic physics is known, but technology is constantly pushing the boundaries outwards.

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