A DIAMOND ACTIVE TARGET FOR THE PADME EXPERIMENT

A diamond detector is proposed as a carbon active target for PADME, an experiment which uses the positron beam of the BTF (Beam Test Facility at the Laboratori Nazionali di Frascati) to search for the production of hypothetical dark photons in $e^+e^-$ annihilation.

In order to enhance the dark photon signal with respect to the bremsstrahlung background, a low Z thin target is required. In addition, the knowledge of the position of the positron bunch hitting the target can improve the missing mass resolution, thus increasing the statistical significance of the signal. The above requirements can be satisfied by an active target made of detector-grade polycrystalline CVD diamond with strip electrodes on both sides of the film connected to adequate front-end and readout electronics. Traditionally, the electrodes on diamond are made of three layers of metals. The first, closest to the diamond, is a Carbide-former such as Titanium, Tungsten or Chromium. A diffusion barrier is then applied, typically Palladium or Platinum, before the final layer made of gold. Wire-bonding is typically used to interconnect the electrodes to the individual signal buses on the pc-board.

For PADME we intend to build a full carbon device with nano-graphitic strip electrodes. In the L3 laboratory at the Università del Salento a 193 nm UV ArF excimer laser is used to irradiate a detector-grade diamond film, inducing the production of nano-graphite, and building a pattern of conductive strips. Past measurements showed that a diamond detector with graphitic contacts in a pad geometry is capable of detecting ionizing radiation in counting mode. No evidence of inefficiency and of polarization of the material, leading to a decrease of the signal with time, was found. Signal speed, noise, response stability and resistance to radiation damage were observed to be comparable to those measured in diamond detectors with traditional electrodes.

Two prototypes of the active target, 2x2 cm$^2$ with, respectively, 100 and 50 µm thickness, were built and characterised with high multiplicity electron bunches at BTF. The readout strips (1 mm pitch in orthogonal directions on the two sides of the film) are, in one case, Cr-Au metallic electrodes, deposited by thermal evaporation with a commercial technology. For the other detector, they are constructed with the in-house technology of graphitization by the UV excimer laser.

We report on results from beam tests of the active target prototypes readout by several kinds of front-end electronics and we discuss the performance expected in the PADME experiment.