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Beam test results of PADME full carbon active diamond target

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Summary. — A full carbon diamond detector is proposed for the active target of 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 dark photons in e^+e^- annihilation (M. Raggi *et al.*, *Adv. High Energy Phys.* **2014** (2014) 959802). This paper presents the preliminary results of a beam test done in November 2015 of the PADME active target prototype.

1. – Active target and beam test setup

A thin CVD polycristalline diamond film provided by Applied Diamond ($2 \times 2\,\text{cm}^2$, $50\,\mu$m thick) has been irradiated by means of an ArF excimer laser (wavelength $\lambda = 193\,\text{nm}$ and pulse duration $\tau = 20\,\text{ns}$) in the L3 Lecce Laser Laboratory in order to produce graphitic strips useful as ohmic electrodes on diamond [1]. The strips, 18 on both diamond surfaces, orthogonally oriented in the two views, have a pitch of 1 mm and an inter-strip dead gap of 0.15 mm. The data collected in the beam test at BTF allow to measure the spatial resolution, the time resolution and the charge collection distance (CCD). The beam is composed of 450 MeV e^+ or e^- in 10 ns long bunches at the rate of 50 Hz with an average multiplicity of 10000 particles. Charge amplifiers (CSA) and voltage amplifiers (RF) with different gain values were used to read the signal on each strip. The output signals were digitized at 1 GS/s with 12 bit resolution using a V1742 Caen digitizer. Special runs at 5 GHz have been taken for time resolution studies.

The amplifiers were calibrated by injecting a known charge $Q = C\Delta V$, where ΔV is the amplitude of a low-frequency square wave and C is the AC calibration coupling capacitance of 1 pF. The measured equivalent input noise of the amplifiers connected to the strips is about 1 fC for the CSA (due to the cable length of about 25 cm) and of about 4 fC for the RF.

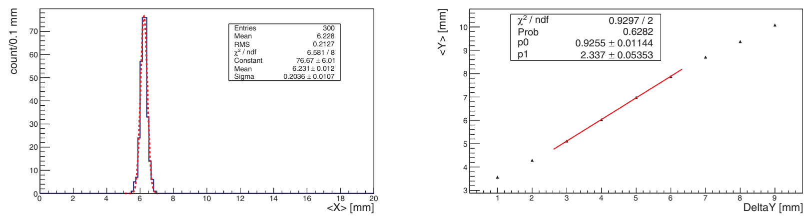

Fig. 1. – Average beam position along X (left) and measured Y beam position (right).

2. – Results

The beam profile has been measured along X and Y coordinates and the average beam position in both views has been extracted using the charge centroid method. Figure 1 (left) shows a typical distribution of the average beam position along the X coordinate, from which a resolution of 0.2 mm can be extracted, which is better than the experiment requirement. Figure 1 (right) shows the average beam position reconstructed along the Y coordinate moving the detector in steps of 1 mm. A good correlation between the reconstructed beam position and the applied shift is observed.

The arrival time of the bunch of particles is obtained by the intersection of the baseline with a linear interpolation of the signal leading edge up to the 75% of the pulse height. In a run collected at a sampling rate of 5 GS/s, the distribution of the difference between the arrival times of the two adjacent strips with the highest collected charge gives a time resolution of about 2 ns.

The CCD of the diamond film is estimated using the relation: $\mathrm{CCD} = \Delta \times Q_c/Q_g$, where Δ is the diamond thickness, Q_c is the collected charge, Q_g is the generated charge, which is estimated as $Q_g = \Delta \times 36\,\mathrm{e}^-/\mu\mathrm{m} \times N \times f_a$, being $36\,\mathrm{e}^-/\mu\mathrm{m}$ the average charge released by a m.i.p., N the multiplicity of the bunch and f_a the active area fraction. The measured CCD is about 11 μm with an uncertainty of about 8%, in agreement with the value provided by the supplier.

3. – Conclusions

The full carbon diamond detector appears to be a good candidate for the PADME active target, based on the beam test results concerning the CCD, the spatial resolution and response uniformity.

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