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Design and characterisation of tunable high gradient permanent magnets quadrupoles

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The design and the characterization of high gradient permanent magnet (PM) quadrupoles, so-called "QUAPEVA" with variable strength are presented. The quadrupole structure is composed of a Halbach ring in the centre and four PM cylinders around. The central magnet provides a fixed gradient of 160 T/m. The four PM cylinders are used to achieve the gradient tuning range from 100 T/m to 200 T/m thanks to their rotation around their axis. Each tuning magnet can be controlled independently, enabling tuning the gradient without field asymmetry and without magnet centre variation. Seven quadrupoles has been built with different lengths in order to fulfil the integrated gradient requirements (from 3T to 21T). They are now used to focus electrons generated by laser plasma acceleration for a free electron laser application on the COXINEL ERC Advanced Grant Experiment. For this application, high gradient quadrupoles are required due to the large divergence of the electron beam. Furthermore a wide gradient tuning necessary in order to run at different energies can only be achieved with PM technology.

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