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Tunable High Gradient Quadrupoles For A Laser Plasma Acceleration Based FEL

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Laser Plasma Acceleration (LPA) is capable of producing a GeV beam within a centimetre accelerating distance, but with a rather high initial divergence and large energy spread. COXINEL aims to demonstrate a compact Free Electron Laser using such a source, where a specific transport line with adequate elements is used, such as tunable high gradient quadrupoles for handling the divergence. An innovative permanent magnet based quadrupole (QUAPEVA) made of two quadrupoles superimposed capable of generating a gradient of 210 T/m is presented. The first quadrupole consists of magnets shaped as a ring and attaining a constant gradient of 160T/m, and the second one made of four cylindrical magnets surrounding the ring and capable of rotating around their axis to achieve a gradient tunability of +/-50 T/m. Each tuning magnet is connected to a motor and is controlled independently, enabling the gradient to be tuned with a rather good magnetic center stability (+/-20 µm) and without any field asymmetry. The measurements and field optimization of seven quadrupoles with different magnetic lengths are reported. A set of QUAPEVA triplet, installed at COXINEL, achieved good focusing and enabled beam based alignment.

Primary author: Mr GHAITH, Amin (SOLEIL)

Co-authors: Mr MARTEAU, Fabrice (Synchrotron SOLEIL); Dr COUPRIE, Marie-Emmanuelle (Synchrotron SOLEIL); Mr VALLEAU, Mathieu (Synchrotron SOLEIL); Mr N'GOTTA, Patrick (Synchrotron SOLEIL)

Presenter: Mr GHAITH, Amin (SOLEIL)

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