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Laser Wakefield Acceleration to Energies in the GeV Regime

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For the creation of matter-antimatter pairs from the quantum vacuum via the Breit-Wheeler effect, an intense laser and energetic γ-rays need to interact. At the Stanford Linear Accelerator Center the Breit-Wheeler experiment in the perturbative regime has been accomplished in 1997 but was never implemented in the non-perturbative regime. At the moment, this experiment is in preparation in a fully laser-driven set-up using Laser Wakefield Acceleration (LWFA) at the Ludwig-Maximilian-Universität München. In the experiment an initial multi-GeV electron beam will be sent onto a Bremsstrahlung-converter to generate γ-rays. LWFA has been improved to reach multi-GeV electron energies in recent years. However, building a reliable, stable source with quasi-monoenergetic bunches over 2 GeV, showing low divergence and pointing jitter, still holds challenges. Essential is the careful design of gas targets. These have to provide homogeneous densities over a few centimetres. In preparation for this, Computational Fluid Dynamic simulations were conducted to design centimetre-long gas nozzles. First LWFA results can be shown with energies reaching over 1.5 GeV using these nozzles and energies reaching over 2 GeV with a gas cell. Moreover, different injection techniques using these targets were tested with the goal to obtain quasi-monoenergetic electron bunches in the GeV regime.

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