Comment on "Table-Top Laser-Based Source of Femtosecond, Collimated, Ultrarelativistic Positron Beams"

Sarri *et al.* [1] have reported the generation of low divergence (~3 mrad), high-density (10^{14} cm^{-3}) positron beams using millimeter-scale converter targets and a 50 pC, 200 MeV laser-wakefield accelerated (LWFA) electron source. It was argued that the positron divergence was dominated by the pair-production birth cone angle $\theta_{e^+} \approx 1/\gamma_{e^-}$. The small, energy-independent divergence value was used to infer a positron beam density of 2×10^{14} cm^{-3} from a 4.2 mm Ta converter target where the divergence and yield measurements agreed with their Monte Carlo (MC) simulations. We have repeated these simulations using experimental conditions and disagree with the reported density, divergence, and yield values by up to factors > 50. We find that a divergence on the order of milliradian is not physical and can only be achieved if inelastic particle scattering is omitted in the calculations.

We performed MC GEANT4 simulations [2] using experimental parameters with a total of 10^7 initialized electrons with a spectrum matching the fit reported in Ref. [1] and scaled to the experimental charge. Electrons had a 1.4 mrad full width at half maximum Gaussian divergence, an initial Gaussian spot radius of 5 μm [3], and were positioned 5 cm from the tantalum converter targets of various thickness, t. A summary of the results is listed in Table I. A linear extrapolation of the electron spectrum was assumed below 80 MeV and results in an overestimation of our total density values.

The simulation results for energy dependent yield, spot radius, divergence, and density are shown in Fig. 1. Spot is defined as a radius encircling 50% of the particles. Emitted positrons were temporally convolved with a 30 fs electron bunch. Straggling in the target is found to decrease the average positron density by 30% for the thin target and 2.4× for the thick target compared to a 30 fs pulse. It is clear that these millimeter-scale, high-Z targets are highly collisional and small angle scattering dominates the spatial and angular profiles of emitted positrons, which cannot be neglected [4].

TABLE I. Peak density, divergence, and yield for the subset of target materials. Divergence values are for 140 MeV positrons. N_{e^+} is taken for $90 < E_{e^+}(\text{MeV}) < 120$. n_{e^+} is measured at the rear target surface.

Mat.	t (mm)	n_{e^+} ($cm^{-3} \times 10^{12}$)	$n_{e^+}^{\text{Sarri}}$	θ_{e^+} (mrad)	$\theta_{e^+}^{\text{Sarri}}$	N_{e^+} ($\times 10^5$)	$N_{e^+}^{\text{Sarri}}$
Ta	1.4	34.1		44	2.3 ± 0.2	2.4	0.8 ± 0.2
Ta	2.8	11.2		56	2.7 ± 0.3	4.9	2.1 ± 0.3
Ta	4.2	3.4	200	63	2.7 ± 0.3	5.7	3.8 ± 0.3

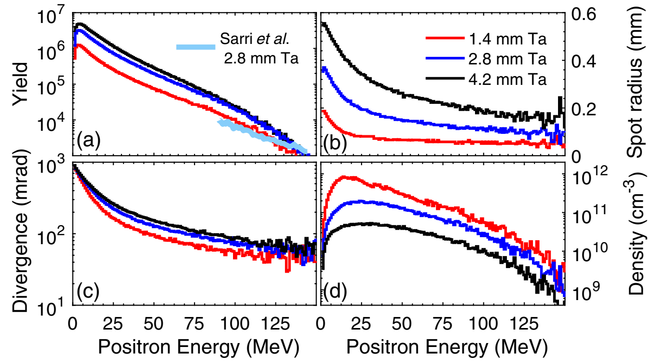

FIG. 1. MC results of (a) positron yield, (b) spot radius, (c) divergence, and (d) density for three tantalum targets using identical initial electron conditions. All physical values have been normalized to bin size (1 MeV).

Our simulations show a total density 60× less than the results of Ref. [1] due to the large divergence despite our positron yields being up to 3× larger [see for example Fig. 1(a)]. The highest positron density is achieved with a *thinner* tantalum foil for which transverse scattering is minimized. This contradicts a central conclusion presented in Ref. [1], where a higher density was inferred for the 4.2 mm Ta case by incorrectly assuming a 75 μm spot radius for all energies. The Geant4 results presented here were confirmed by independent calculations using the MC code MCNP6 [5] and particle-in-cell code LSP [6].

The large discrepancies discussed here are particularly important for the proposed use of LWFA electrons as a positron source for advanced accelerator concepts and scaled laboratory astrophysics studies. Determining whether LWFA-generated positron beams can reach densities sufficient to observe collective effects and plasma-plasma interactions should be revisited.

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