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Report on Simulations of the Royle-Sentoku-Fuchs Experiment

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A series of calculations have been performed to reproduce the experimental results presented by Royle at the Fast Ignition Workshop, November, 2012. This note summarizes the results of these simulations.

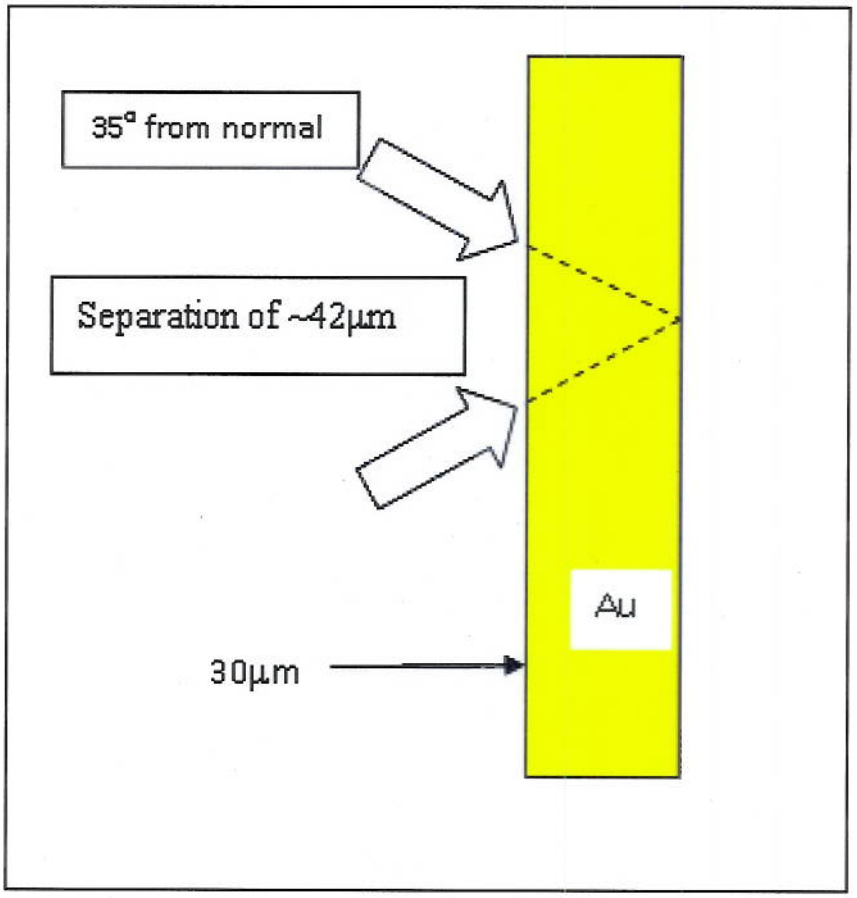
The calculations consist of coupling the hydro-radiation code HYDRA with the PIC code ZUMA. This combination tracked fast electrons in ZUMA for 500ps, linked the heating history to HYDRA, repeated the same 500ps period in HYDRA with the heating source, and then iterated back to ZUMA. The geometry roughly mocks up the experiment of two laser beams incident on a Au foil 30μm thick, as shown in figure 1. In a 2D approximation to two incident laser beams, electrons were injected in an annular beam, 10μm wide and with a mean radius of 21μm. In ZUMA, the electrons are tracked in 3D velocity space. The electrons were given a ponderomotive birth distribution for a constant laser intensity of 5 10^{19} W/cm^2 for 1μm laser light, a conversion efficiency of 52%, and a pulse length of 2ps. The birth angular distribution of the electrons was a cone of half angle 50°. To match the experiment, the center of this cone would be inclined by 35° (with respect to the normal to the target surface) toward the axis. In these simulations, a low density (10^{-3}g/cc) occupies the space behind the Au foil. As a diagnostic, the simulations had a thin C foil placed 20μm behind the rear surface of the Au; it would not have influenced the behavior in the Au foil.

Without any angle of inclination, the electron density, the B_θ field, and the material temperature at the end of the laser pulse, 2ps, are shown in figure 2. By contrast, with the 35° angle of inclination, the results are shown in figure 3. The tendency of the electron beam to bunch on the axis is clearly much more pronounced with the 35° angle of incidence. In fact, the centroid of the beam has moved at an angle of about 65°, much more than the 35° given at launch.

There are rather large electric fields in the region of the beam focusing as indicated in figure 4, with values in the well focused simulation of ZRAC typically greater than 4 10^9 V/m. By contrast, the simulation with normal incidence (ZRAG) shows lower, less tightly concentrated electric field.

In short, these simulations show qualitatively the same focusing effect observed in the experiment.

Figure 1



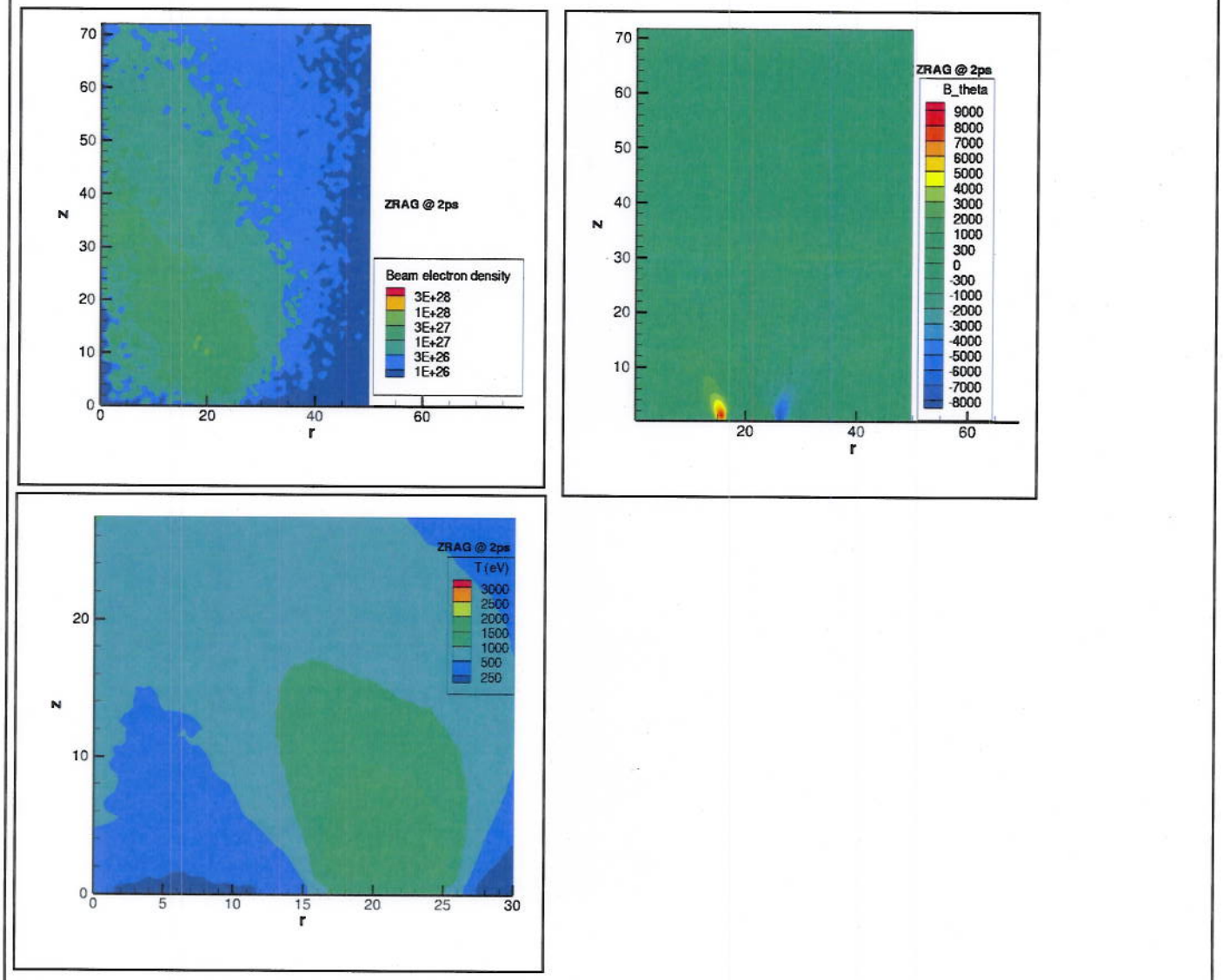


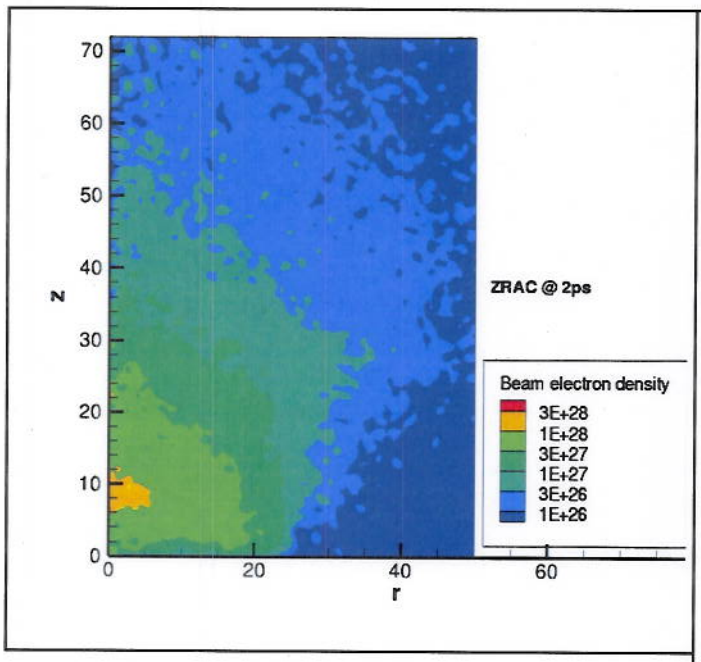
Figure 2 Results of a simulation with 0° angle of inclination.

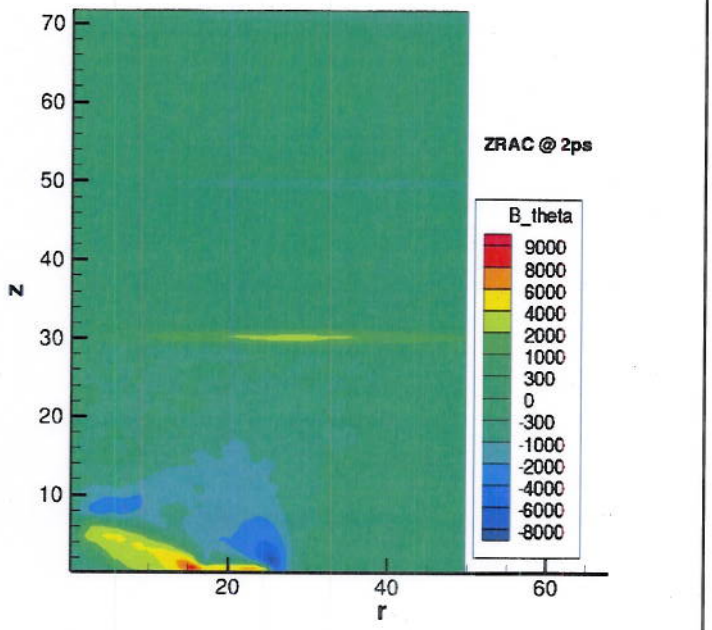
The three plots depict the electron density, B_θ, and material temperature at 2ps for electrons launched with 0° angle of inclination with respect to the axis of symmetry, normal to the surface of the Au foil.

The 2D axis of symmetry is the vertical z axis. The spatial units are microns.

The Au foil occupies the volume from Z of 0 to 30μm and R of 0 to 50μm. The Au foil has density of 19.2g/cc.

The units of electron density are $\#/m^3$, and the units of B_θ are tesla.





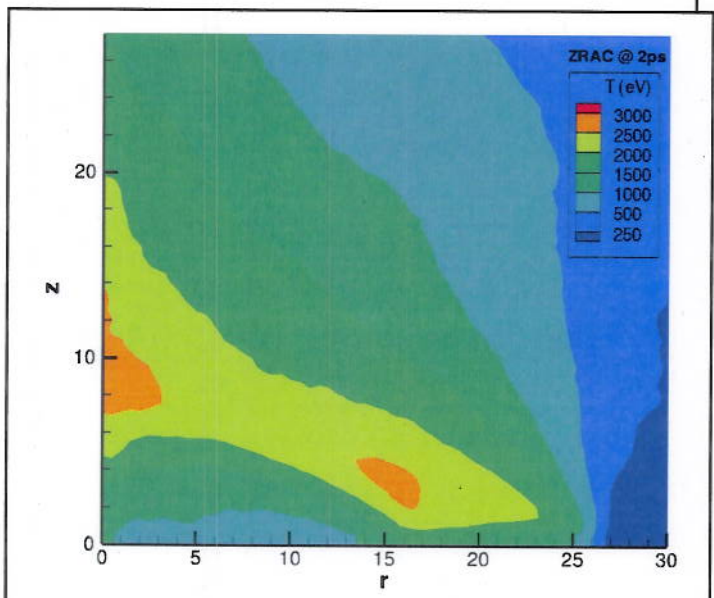


Figure 3 Results of a simulation with 35° angle of inclination.

As in Figure 2, the three plots depict the electron density, B_θ, and material temperature at 2ps for electrons launched with 0° angle of inclination with respect to the axis of symmetry, normal to the surface of the Au foil.

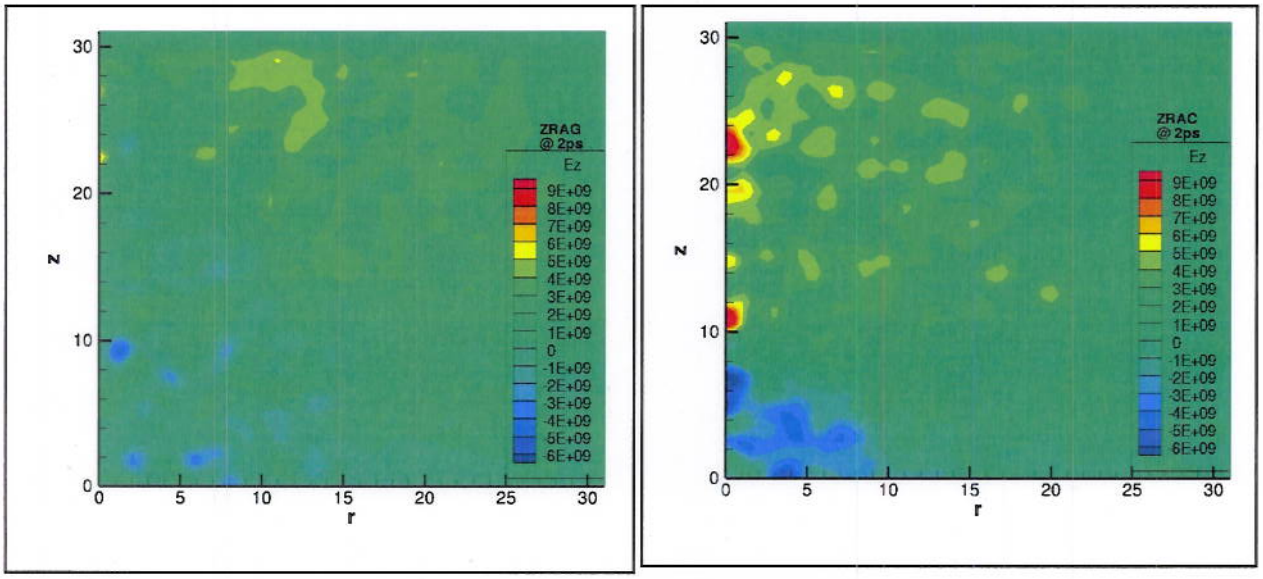


Figure 4

These two plots show E_z at 2ps for annular beams with 0° (ZRAG) and 35° (ZRAC) angle of incidence. The units of the electric field are V/m.