MeV-Bremsstrahlung Generation by 200 mJ Ultrashort Laser Pulses ◇

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When a 200-mJ/160-fs Ti:Sapphire laser pulse is focused into an underdense plasma at an intensity greater than 10^{18} W/cm^2, relativistic self-focusing and relativistic electrons accelerated up to multi-MeV in forward direction are expected. Penetrating into a solid target, these electrons generate Bremsstrahlung containing γ-quanta in the MeV-range. For the above-mentioned laser pulse, which can be delivered by the MPQ ATLAS system, 10^{10} relativistic electrons with an effective temperature T_e of 0.83 MeV are predicted by 3D PIC simulations [1]. Furthermore, simulations using the Monte-Carlo-code GEANT [2] yield $5 \cdot 10^7$ γ-quanta for an aluminum target. The experiment shown in Fig. 1 was performed to verify these predictions.

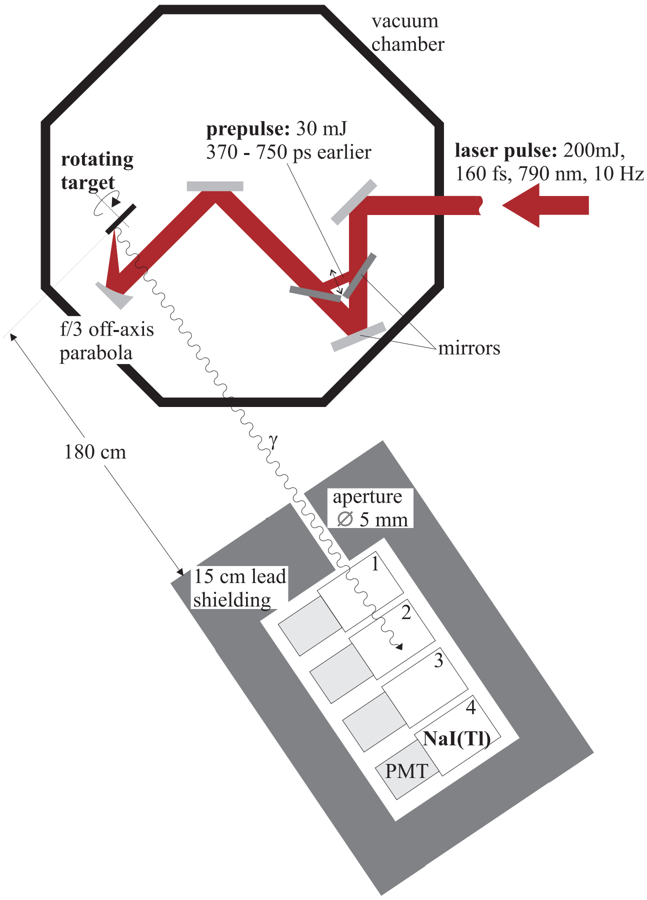

Fig. 1: Experimental setup.

The laser pulse was split into a pre- and a main pulse and both were focused onto a solid target. The prepulse produced a homogeneous underdense plasma on the target surface. Several hundred ps later the main pulse interacted with this plasma. Targets made of aluminum, copper, tantalum, and 100 μm Makrofol $C_{16}O_3H_{14}$ on a tantalum-substrate were employed. The γ-rays were measured by an array of four hexaconical, 12-cm-thick NaI(Tl) scintillators coupled to photomultipliers. These scintillators were arranged in such a way that each detector simultaneously served as an attenuating filter for the following one. Fig. 2 shows the pulse-height spectrum of 2000 shots as it was measured by the second detector using a tantalum target.

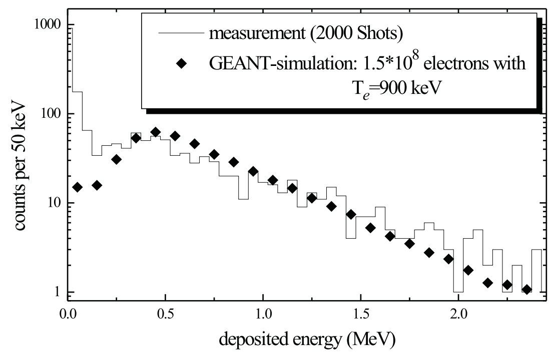

Fig. 2: Pulse-height spectrum compared to the distribution predicted by the GEANT code.

The mean energy deposited in the four detectors is shown in Fig. 3. Comparison of simulations with the measurements leads to $T_e = 0.9$ MeV (Fig. 2) which is in reasonable agreement with the predicted temperature. The number of relativistic electrons is a factor of 30 less than predicted [1] probably due to shot-to-shot fluctuations of the laser performance. Since the focused intensity is close to the threshold for the onset of self-focusing, such fluctuations can be critical for the generation of MeV-electrons.

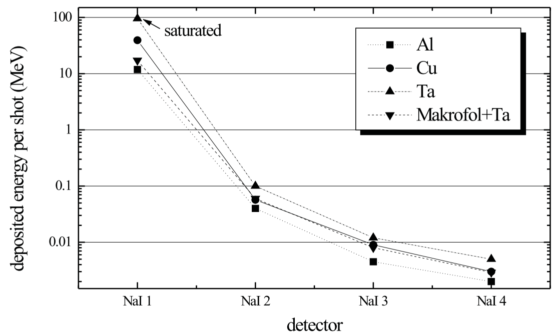

Fig. 3: Mean energy per shot deposited in the four detectors.

References

[1] A. Pukhov and J. Meyer-Ter-Vehn, *Relativistic Nonlinear Optics in Plasmas by 3D PIC Simulations*, to be published in: *Proc. Conf. on Superstrong Fields in Plasmas*, Varenna (1997)

[2] R. Brun *et al.*, *GEANT User's Guide*, CERN report DD/EE/82 (1982)

◇ Research supported by the Commission of the EC within the framework of the Association Euratom – MPI für Plasmaphysik. We acknowledge the courtesy of the MPI für Kernphysik, Heidelberg for providing the NaI-detectors.