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EARLY-TIME MEASUREMENTS OF SOFT X-RAY EMISSION IN AN OMEGA-UPGRADE LASER-PRODUCED PLASMA

Semi-Annual Report
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EARLY-TIME MEASUREMENTS OF SOFT X-RAY EMISSION IN AN OMEGA-UPGRADE LASER-PRODUCED PLASMA

Beginning in January 1997 (following arrival of the FY-97 funding) we have been preparing for our first series of experiments under this grant at the University of Rochester Laboratory for Laser Energetics (LLE) on the Omega Upgrade laser facility, now scheduled to commence June 2, 1997. For these experiments we have purchased (just arrived) a four-channel gated-stripline microchannel plate (MCP) detector to be coupled to our soft x-ray flat-field grazing incidence spectrograph used previously at LLE. This will permit time-resolved "snapshots" of the complete spectra with a resolution to times as short as 180 ps per strip. An advantage of this technique over the streak camera used previously is the lack of any carbon absorbers such as in the thin plastic cathode required for the streak camera. This eliminates absorption in the 30-44 Å spectral region in which we are interested for intermediate-Z target materials such as Mg, Al and Si. An auxiliary turbomolecular-drag pump has also been installed in order to obtain the necessary vacuum for optimum MCP operation.

As part of this planning, we have been fortunate to have the cooperation of Drs. Jacques Delettrez and Reuben Epstein at LLE in performing numerical hydrodynamic and spectral modeling. A number of cases have been computed for various layers of coatings on spherical microballoons filled with neon at 1 and 10 atmospheres of pressure. Aluminum and magnesium layers of thicknesses varying from 500 Å to 5000 Å in alternate outer/inner positions have been modeled, as has a CH overcoating of 1 μm thickness. An example of the results for 2000 Å of Mg over 2000 Å of Al with a CH overcoating is shown in Figs. 1 (hydrodynamics) and 2 (H- and He-like "alpha" spectra) for a 1-ns wide flat-top pulse with 150 ps rise and fall ramps. Further calculations are continuing at present with a 1-ns Gaussian pulse as used previously in experiments at LLE; and a sample spectral plot similar to Fig. 2 is shown in Fig. 3. Also modeled under this collaboration were 1996 experiments which are described in the final report being prepared for the FY-96 grant.

In February 1997 we had the opportunity to perform experiments at the Lawrence Livermore National Laboratory (LLNL) using the NOVA laser multibeam facility with a nominally 1-ns pulse, along with a 100 TW short (~400 fs) pulse laser, the latter used both by itself and also superimposed on the NOVA beam. This was an initial attempt to observe laser-induced satellites excited by a short pulse in a preformed plasma. Targets used in these experiments consisted of Saran polycarbonate film [which includes chlorine (Cl)] as well as magnesium (Mg), titanium (Ti), yttrium (Y) and tin (Sn). A LLNL flat-field soft x-ray spectrograph with a variable-ruled grating was used to disperse the spectrum, which in turn was swept temporally with a LLNL x-ray streak camera and recorded photographically. The entire assembly was mounted inside the vacuum chamber for maximum photon collection. In addition, a three-meter grazing incidence spectrograph was used to obtain high resolution spectra, and a silicon crystal spectrograph for hard x-rays, in collaboration with a team visiting from the Naval Research Laboratory. Preliminary results show strong lines from the medium-Z materials in the soft x-ray spectral region and a hard x-ray continuum through 1/16 inch of lead with the heavier materials. The spectral analysis is continuing.

In addition to the experiments coming up at LLE in June 1997, we also anticipate performing experiments during this Spring and/or summer at the Los Alamos National Laboratory (LANL) using the TRIDENT two-beam facility. These will most likely involve planar targets with the same layer configurations as numerically designed for the LLE Omega-Upgrade spherical target experiments.

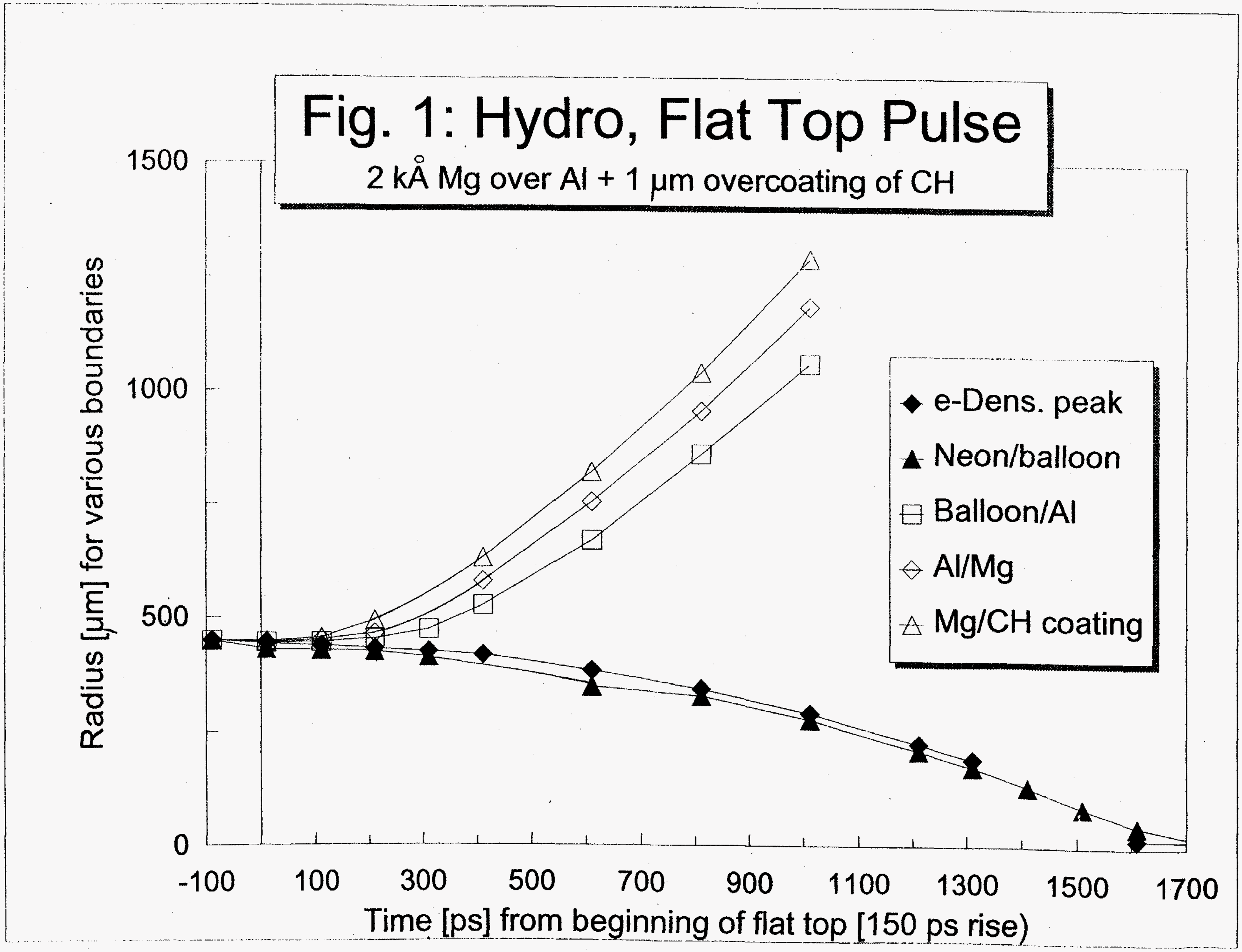
Fig. 1: Hydro, Flat Top Pulse
2 kÅ Mg over Al + 1 μm overcoating of CH
Radius [μm] for various boundaries
1500
1000
500
0
-100
100
300
500
700
900
1100
1300
1500
1700
Time [ps] from beginning of flat top [150 ps rise)
e-Dens. peak
Neon/balloon
Balloon/Al
Al/Mg
Mg/CH coating

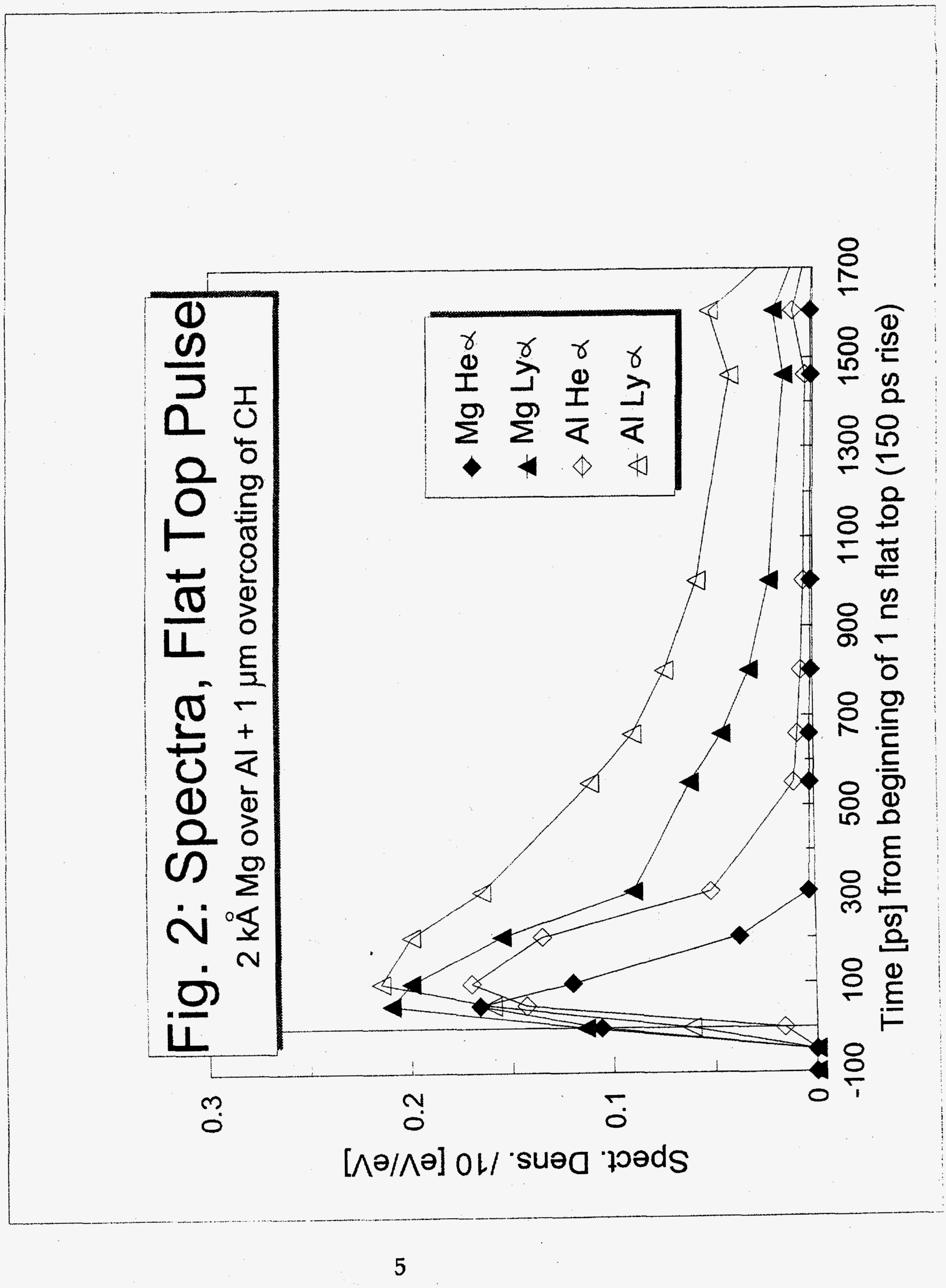

Fig. 2: Spectra, Flat Top Pulse

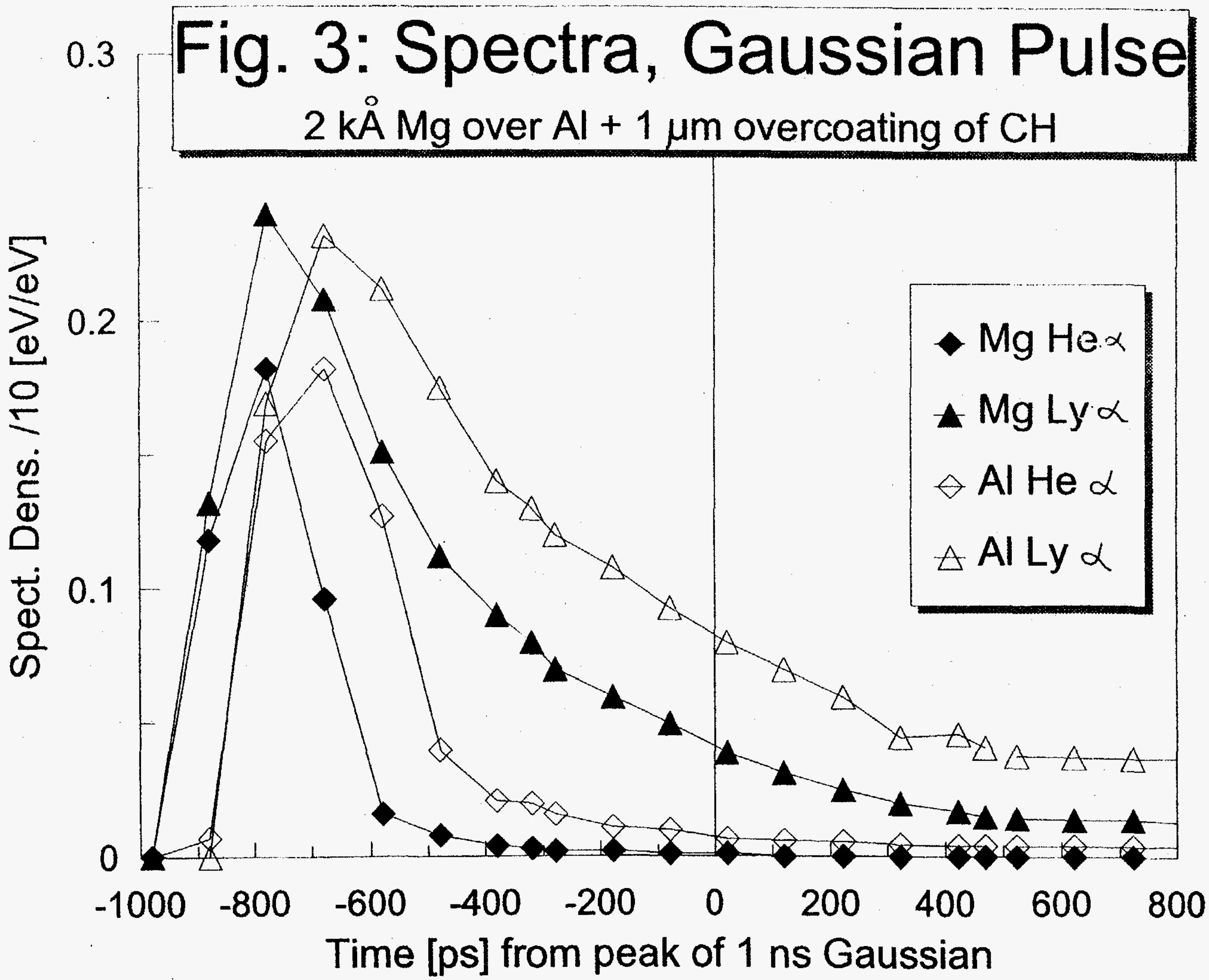
Fig. 3: Spectra, Gaussian Pulse
2 kÅ Mg over Al + 1 μm overcoating of CH
Spect. Dens. /10 [eV/eV]
0.3
0.2
0.1
0
-1000
-800
-600
-400
-200
0
200
400
600
800
Time [ps] from peak of 1 ns Gaussian
Mg He α
Mg Ly α
Al He α
Al Ly α