Plasma parameters investigation for heterogeneous low-density load on high current generator

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The goal of this work was to investigate plasma parameters for heterogeneous low-density load on high current generator Angara 5-1. The load consisted of two agar-agar columns and CD_2 neck between them. Low density load containing deuterium atoms are the most suitable for modeling fusion experiments for ICF purposes. The experiments were carried out on Angara-5-1 device (currents up to 3,5 MA with 120 ns increasing time).

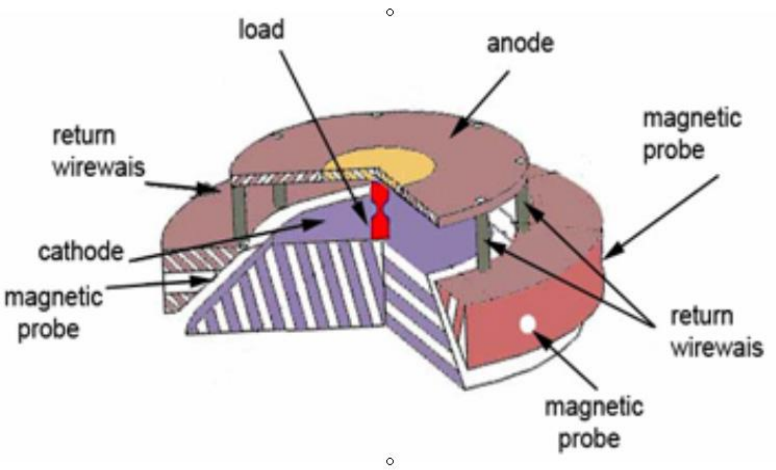

Fig.1 Target unit of Angara 5-1.

Experiments with currents 1,5-2MA have shown that the most suitable substance for a load is microporous deuterated polyethylene with small density (50-100 mg/cm^3)[1]. Use composite profiled load which central part produced from microporous deuterated polyethylene[2], has allowed to transmit effectively energy from generator to a target.

The central part of load was produced from microporous deuterated polyethylene with density of 100mg/sm^3 and diameter (1-1,3) mm. Spatial-time Z-pinch parameters were studied by frame photography in soft x-ray spectral region with 5 ns exposure and optical streak camera with 2ns time resolution. The structure of high-temperature plasma in soft x-ray range was registered using time integrated three pinhole cameras with apertures of 50 mkm with different filters. Vacuum photoemission detectors were used for measuring x-ray radiation intensity. Also VUV and X-ray spectroscopy methods were used to estimate plasma parameters. Neutrons energy was measured by a time of flight method, for measuring of total neutron yield from the load neck the activation detector was used.

The neck luminance observed by streak-camera in visible range (slit is parallel to the load axis) began from about 30 ns. Diameter of neck was equal ≈ 1mm during ~100 ns. Maximal plasma compression attending x-ray and neutron emission was observed on the current front (about 90 ns after the current beginning). Soft x-ray pulses with energy E > 0,8 keV had 3-4 ns duration.

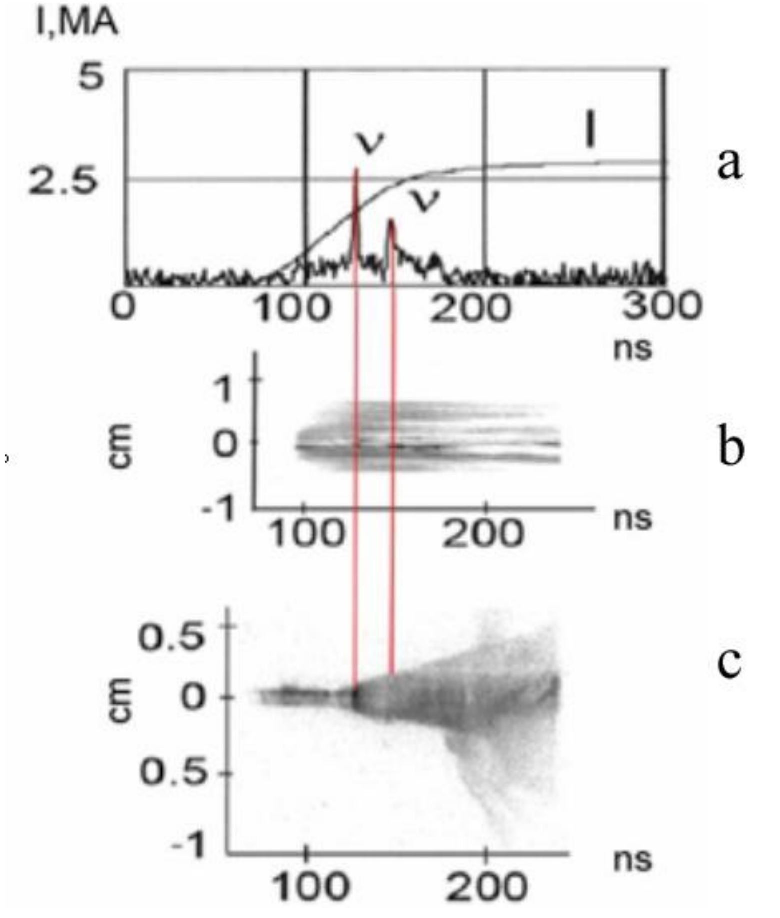

Fig.2 (a) Current and soft x-ray signals; (b) streak-camera imagine (slit is perpendicular to the load axis), (c) streak-camera imagine (slit is parallel to the load axis).

From t≈110 ns plasma expansion in radial direction with v ~4×106 cm/s was observed.

On streak-camera photography with slit installed parallel to the load axis bright plasma formations was observed with a size of ~100 μm and 4-8 ns duration were observed near t

≈120 ns.

In the same time plasma formations illuminating in soft x-ray range appeared in the load neck. Size of hot spots, registered by time integrated pinhole cameras was 200-300 microns for E > 0.6 keV energy region.

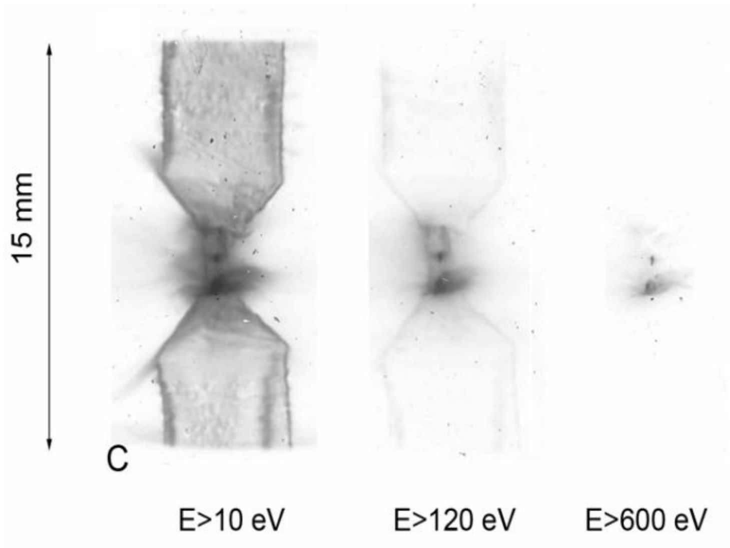

Fig.3 Time-integrated pin-hole camera imagines with different filters.

Also the plasma VUV spectra were registered by grazing incidence spectrograph. Lines if FeXVI – FeXVIII were observed. Electron temperature estimation made by method suggested in [3] (λ_{max} = 60 Å) gave Te ~ 300 eV.

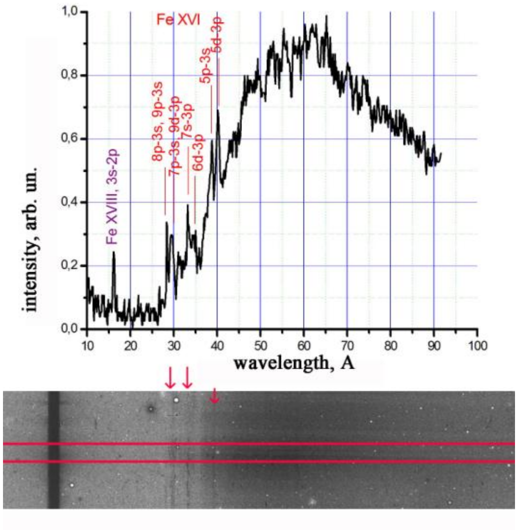

Fig.4 EUV plasma spectrum. Red lines correspond to the photometric measurements area.

The neutron yield depended on a load configuration. The maximal neutron yield was observed in case of decreasing neck length and using the composite load with copper conical columns and achieved about $3x10^{10}$. Average neutron energy measured by time of flight method in the radial direction (at angles 90^0 to a load axis) was close to 2,5 MeV.

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