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A Microchannel Plate Pinhole Camera for 20-100 KeV X-Ray Imaging*

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Abstract

We present the design and construction of a sensitive pinhole camera for imaging suprathermal x-rays. Our device is a pinhole camera consisting of four filtered pinholes and microchannel plate electron multiplier for x-ray detection and signal amplification. We report successful imaging of 20, 45, 70, and 100 keV x-ray emissions from the fusion targets at our Novette laser facility. Such imaging reveals features of the transport of hot electrons and provides views deep inside the target.

Introduction

Imaging high energy x-ray emission from laser fusion targets is important because such images provide views deep inside the target and reveal the features of transport of hot/superhot electrons. These electrons can cause target preheat and are detrimental to efficient target implosion. We report here successful imaging of 20, 45, 70 and 100 keV x-ray emissions from the fusion targets at the Novette laser facility.

Microchannel Plate Pinhole Camera

Our imaging device is a pinhole camera which consists of four pinholes and a microchannel plate (MCP) for x-ray detection and signal amplification. A schematic of such a high sensitivity imaging system is shown in Fig. 1. The pinhole channels are 127, 254, 508 and 508 μm in diameter on a 1.5-mm-thick Au disk. The axes of the channels are tapered such that the lines of sight converge on the target.

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**Deceased.

Since the sensitivity of the MCP is nearly flat for 20-100 keV x-rays,[1] the energy coverage of each channel is determined by the K-edge filters and the suprathermal x-ray spectrum which is typically an exponentially decaying function of the x-ray energy. Figures 2 through 5 show the photon distributions for the 20, 45, 70 and 100 keV channels obtained respectively with 50 μm Ag, 381 μm Dy, 254 μm Au and 381 μm U filters and a suprathermal x-ray spectrum of 24 keV temperature. An example of the number and fluence of such x-rays from laser-plasma interaction is given in Fig. 6.

Experimental Results

Figure 7 shows an example of the images obtained for a 1.2 mm diameter, 5 μm thick Au disk target irradiated with the 0.53 μm Novette laser at 4.4 KJ and $3.5 \cdot 10^{15}$ w/cm^2. The beam spot diameter was about 0.4 mm. The camera was behind the disk looking from 18° with respect to the disk plane. At 70 and 100 keV, the x-ray flux is low and relatively large pinholes are required even though the MCP is sensitive enough for single photoelectron detection. For planar targets, the origin of the suprathermal x-rays appears to be centered at the place where the laser is focused. The 20 keV glow is larger at the front than the back of the disk, with the shadow of the relatively cold gold disk edge producing the gap. The 45 and 70 keV x-rays show no such structure because the gold is much more transparent to these x-rays.

In addition to the higher sensitivity of our imaging system over conventional pinhole cameras with x-ray films, the gateable MCP offers a unique opportunity for development of time-resolved framing cameras for high energy x-rays.

Reference

1. K. W. Dolan and J. Chang, SPIE 106 178 (1977).

Figure Captions

Fig. 1 A schematic of a high sensitivity microchannel plate pinhole camera for x-ray imaging.

Figs. 2-5 The photon distributions for the 20, 45, 70 and 100 keV channels using respectively a 50 μm Ag, a 381 μm Dy, 254 μm Au and 381 μm U filter and a suprathermal x-ray spectrum of 24 keV temperature.

Fig. 6 An example of the number and fluence of suprathermal x-rays of 24 keV temperature from laser-plasma interaction.

Fig. 7 Images of a Au disk target irradiated with 0.53 μm laser at 4.4 kJ and $3.5 \cdot 10^{15}$ w/cm^2. Au disk 1200 μm dia. 5 μm thick, beam spot dia. 400 μm.

Schematic of a high sensitivity microchannel plate pinhole camera for 20–100 keV X-ray imaging

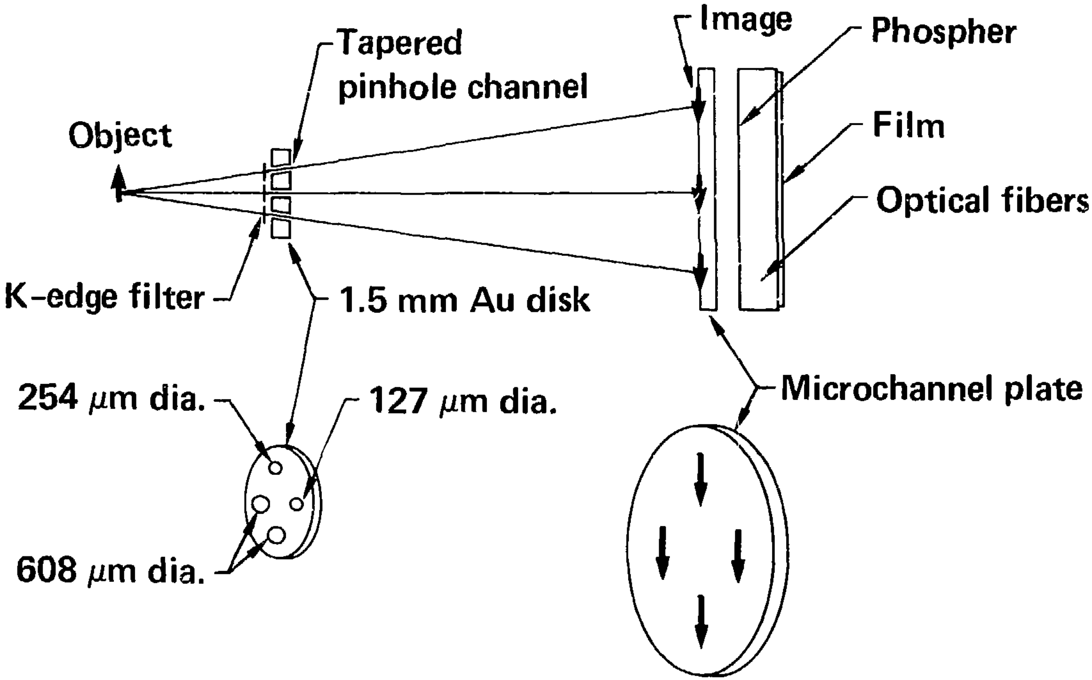
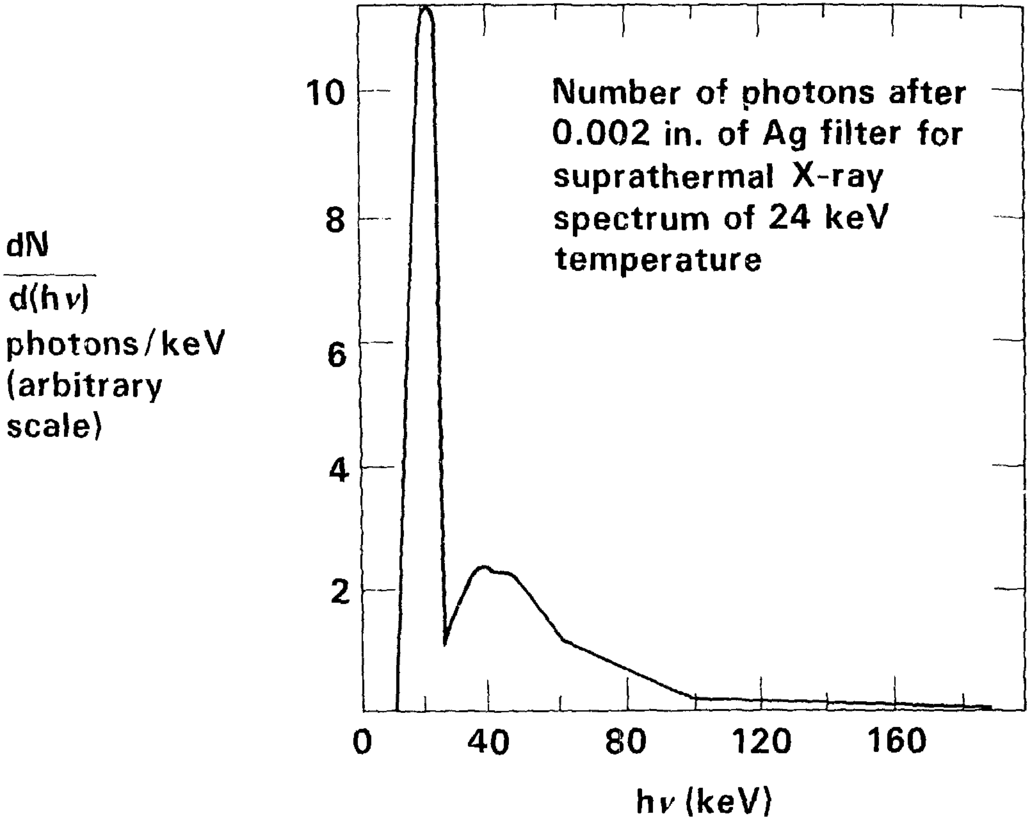


Fig. 1

15-25.5 keV channel



Number of photons after 0.002 in. of Ag filter for suprathermal X-ray spectrum of 24 keV temperature

Fig. 2

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40-53.8 keV channel

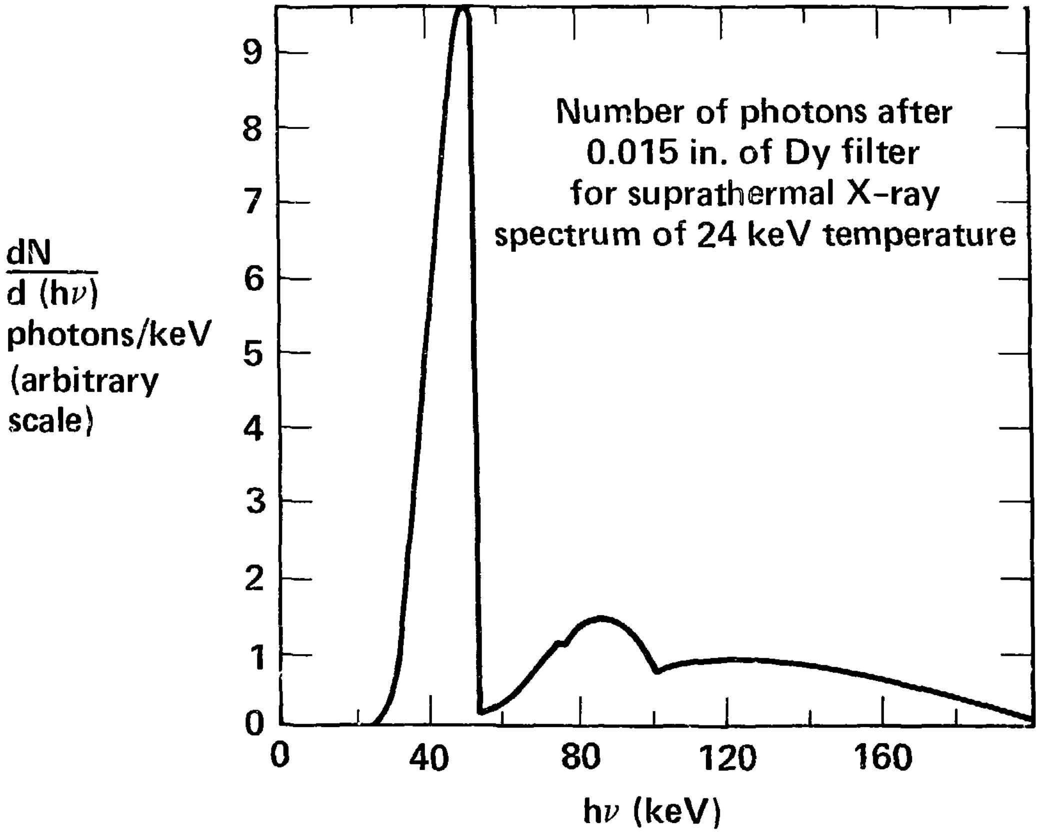


Fig. 3

54-80.7 keV channel

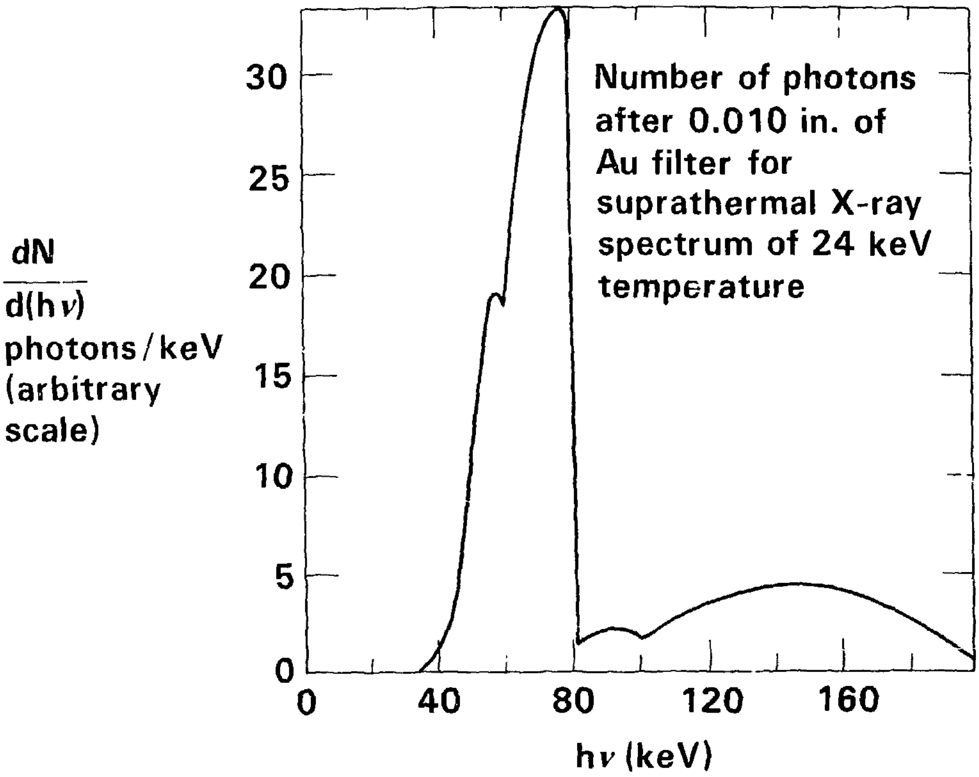
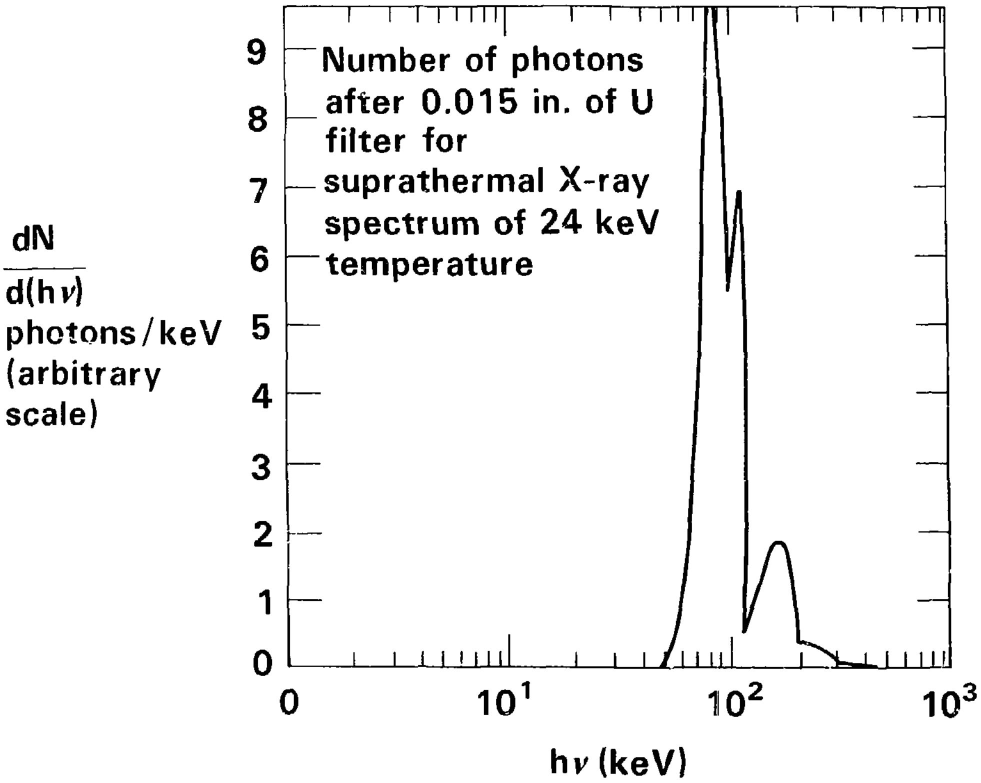


Fig. 4

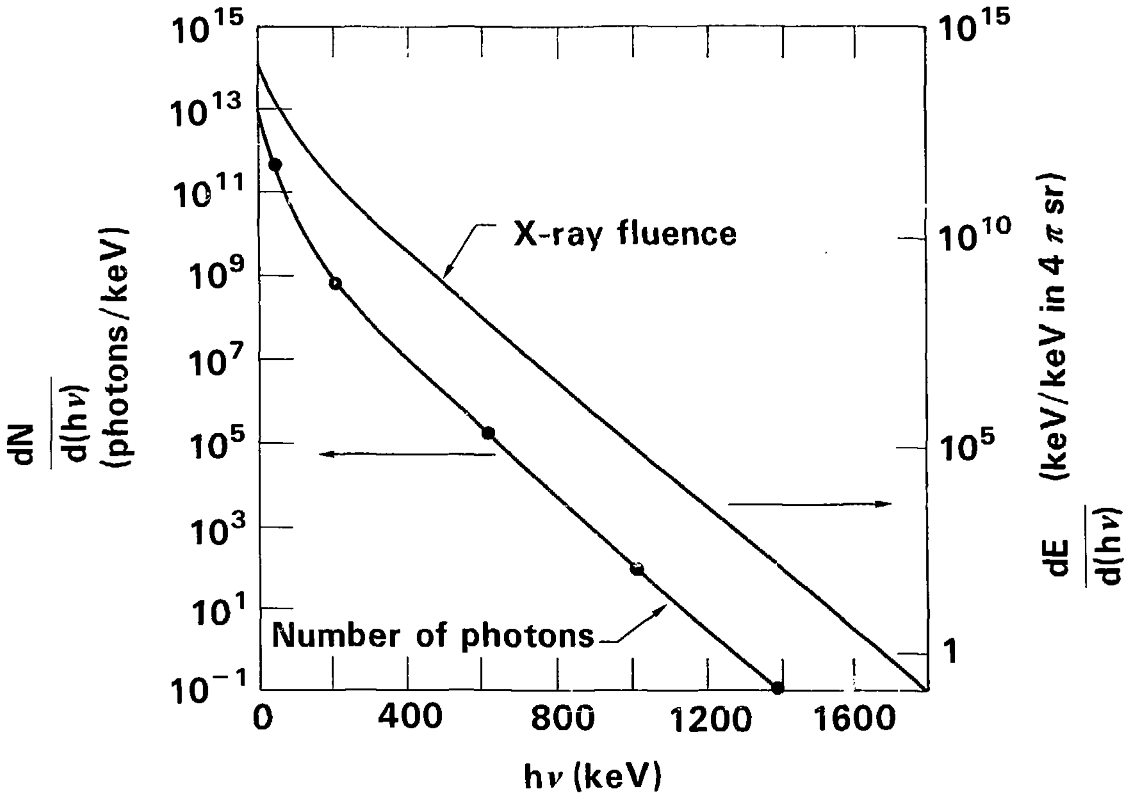
70-115.6 keV channel



Number of photons after 0.015 in. of U filter for suprathermal X-ray spectrum of 24 keV temperature

Fig. 5

Number and fluence of x-rays for 24 eV suprathermal temperature



20-50-0684-1849

Fig. 6

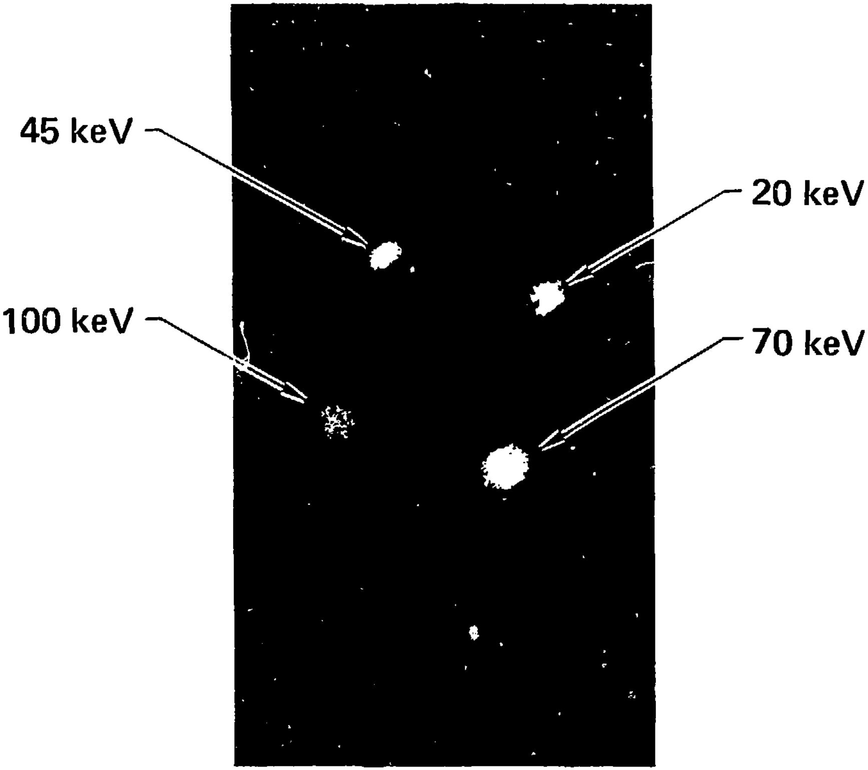


Fig. 7