AD-A160 303 INTENSE EXCITATION SOURCE OF BLUE-GREEN LASER(U) 1/1
HAMPTON UNIV VA DEPT OF PHYSICS AND ENGINEERING STUDIES
K S HAN 15 OCT 85 N00014-80-C-0957

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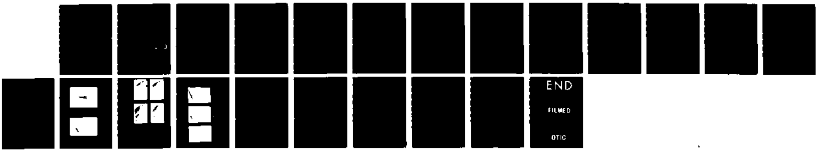

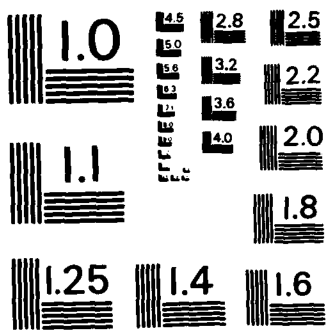

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20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

Under ONR grant No. N00014-80-0957, an intense and efficient excitation source for blue-green lasers useful for the space-based satellite laser applications, underwater strategic communication, and measurement of ocean bottom profile is being developed. The source in use, hypocycloidal pinch plasma (HCP), and a newly designed dense-plasma focus (DPF) can produce intense uv photons (200-300nm) which match the absorption spectra of both near uv and blue green dye lasers (300-400nm).

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During the current project period, the successful enhancement of blue-green laser output of both Coumarin 503 and LD490 dye through the spectral conversion of the HCP pumping light has been achieved with a converter dye BBQ. The factor of enhancement in the bule-green laser output energy of both Coumarin 503 and LD490 is almost 73%. This enhancement will definitely be helpful in achieving the direct high power blue-green laser (>1MW) with the existing blue green dye laser.

On the other hand the dense-plasma focus (DPF) with new optical coupling has been designed and constructed. For the optimization of the DPF device as the uv pumping light source, the velocity of current sheath and the formation of plasma focus have been measured as function of argon or argon-deuterium fill gas pressure. Finally, the blue-green dye laser (LD490) has been pumped with the DPF device for preliminary tests.

Experimental results with the DPF device show that the velocity of the current sheath follows the inverse relation of $(\text{pressure})^{0.5}$ as expected. The blue-green dye (LD490) laser output exceeded 3.1mJ at the best cavity tuning of laser system. This corresponds to 3J/cm^3 laser energy extraction.

In order to find the optimum condition of the DPF device for pumping LD390 dye laser (λlaser max.=390 nm), the measurement of the emission spectra at the 350nm has been done. The result indicates that near uv light produced by plasma focus with argon fill gas pressure 0.2 torr is 10^5 times more intense than that with other fill gas pressure.

Intense Excitation Source of Blue-Green Laser

Under

(ONR Grant No. N00014-80-C-0957)

Annual Summary Report

October 15, 1985

Principal Investigator

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Hampton University

Hampton, Virginia 23668

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An Intense Excitation Source of Blue-Green Laser

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In order to accomplish a better energy transfer to the pumpband of Coumarin 503 dye from the HCP pumping light, a dye mixture of Coumarin 503 and BBQ was dissolved in a P-dioxane solvent. In other words, the converter dye

BBQ absorbs light in a region 282-336nm of the HCP pump source spectrum where the primary lasing dye Coumarin 503 absorbs little. On the other hand the converter dye BBQ fluoresces near 380nm which lies in the absorption band 343-411nm of the primary dye Coumarin 503. The converter dye takes photons from a part of the pumping spectrum that are not normally utilized in the lasing process and converts these photons to a region where they can be absorbed by the lasing dye. The overall effect of such a scheme provides more photons in the laser dye absorption band and effectively reduces the threshold. The selection of Coumarin 503 as a primary dye and BBQ as a converter dye was made because they dissolve well in the common solvent P-dioxane. For the enhancement of blue-green laser output, another dye mixture of LD490 and BBQ in ethylalcohol was also tested.

Figure 1 shows a typical oscillogram of blue-green laser signal (top) and the HCP pumping light (bottom). Figure 2 shows absorption spectrum of Coumarin 503 and BBQ (---), Coumarin 503 (——), and BBQ (-・・-) respectively. This figure definitely indicates an increase of absorption energy at the pumping band of Coumarin 503 pumping band (390nm). Figure 3 shows that the laser output of Coumarin 503 is a function of dye concentration of BBQ. Experimental results show that the laser output energy of Coumarin 503 dye increases from 2.2mJ and reaches maximum 3.8mJ when the dye concentration of BBQ is increased from zero to 8%. Thus, the laser output increase of 73% has been achieved. The higher concentration of BBQ leads to a decrease of enhancement and beyond 40% of BBQ results even a decrease of the output below that the Coumarin alone. The reason for this behavior is under study and an explanation may be found from the overlap of the absorption curves of the two dyes used. Table 1 summarizes the results of dye mixture parameters and Coumarin 503 laser outputs. Figure 4 shows that the laser output of LD490 dye is a function of

Table 1 Dye mixture parameters and C503 laser outputs

$C(503), \times 10^{-4}$ mol/l	$C(BBQ), \times 10^{-5}$ mol/l	T,%	E,mJ	E_o,mJ	E_o/E
0.3	0.15	10	0.32	0.9	2.8
0.8	0.4	10	7.7	14	1.8
2.5	1.4	20	1.2	2	1.7

dye concentration of BBQ. The result also indicates 73% increase of laser output as the dye concentration of BBQ increases from zero to 2%. The results of this experiment will be published in Applied Physics Letters shortly.

As mentioned in the last year's proposal, a new dense-plasma focus (DPF) device and laser system have been constructed and installed (Fig. 5). Using the DPF device, the velocity of current sheath and the series of streak photographs of plasma focus formation have been measured as a function of argon or argon deuterium combination gas pressure. Experimental results (Fig. 6) indicates that the velocity of the current sheath is proportional to $P^{-.46}$ where P is fill gas pressure. Hence the velocity of the current sheath follows the snow plow model ($v \sim P^{-0.5}$) as we expected. Fig. 7 shows streak photographs of the plasma focus formation viewed from the side (a) and the top (b) of the center electrode of the DPF where the operating condition was 0.3 torr of argon and 0.7 torr of deuterium. The top view indicates that the plasma focus has a diameter of 3mm and lasts for 0.6μs. Figure 8a shows the side view by a streak photograph of the plasma focus with the operating condition of 0.3 torr argon fill gas, B=0 and B=60 gauss. Figure 8b also shows the streak photograph of the plasma focus with 0.5 torr argon, B=0 and B=60 gauss. Figure 9 shows the side-on streak photograph of the plasma focus with 10%, 20%, 30% of argon in 1 torr of deuterium and B=60 gauss. Experimental results definitely indicate that the plasma focus lasts longer with external magnetic field B and is more intense as expected. More studies are needed to give an optimum fill gas pressure of argon/deuterium and the external magnetic field B. Figure 10 shows a typical output voltage (top), pumping light (middle) and laser output (bottom) oscillogram of the DPF device.

In order to determine the optimum operating conditions of the DPF device for pumping blue-green laser (LD490 dye), at first, laser output energy were measured as a function of argon fill gas pressure (Fig. 11), dye concentration (Fig. 12), and transmission of output mirror (Fig. 13). As the result of optimzation of the DPF and laser system, the maximum untuned laser output exceeded 2.1mJ. The optimum operating conditions of the system were argon gas pressure 0.3Torr, LD490 dye concentration 6×10^{-4} mol/liter and 10% output transmission mirror. The laser output 2.1mJ corresponds to the energy density $3 J/cm^3$ which is much higher than the typical flashlamp-pumped dye laser. The details of experimental results are reported in the conference of 1985 International IEEE Plasma Science (Ref. 10).

For the next phase we are in the process of measuring the emission spectra of the DPF pumping light as a function of argon or argon/deuterium fill gas pressure. Especially the 350-400nm emission spectra will be studied as a function of fill gas pressure in order to find the optimum condition of the DPF device for pumping LD390 dye laser ($\lambda_{laser\ max.}$=390nm). Figure 14 shows the peak power of near uv light (~350nm) produced by plasma focus in the DPF device as a function of argon fill gas pressure. The result shows that the peak power output is at a fill gas pressure of 0.2 torr and 10^5 more intense than that at other fill gas pressure. This surprisingly intense light of this magnitude might be superadiant and susuitable for pumping LD390 dye laser.

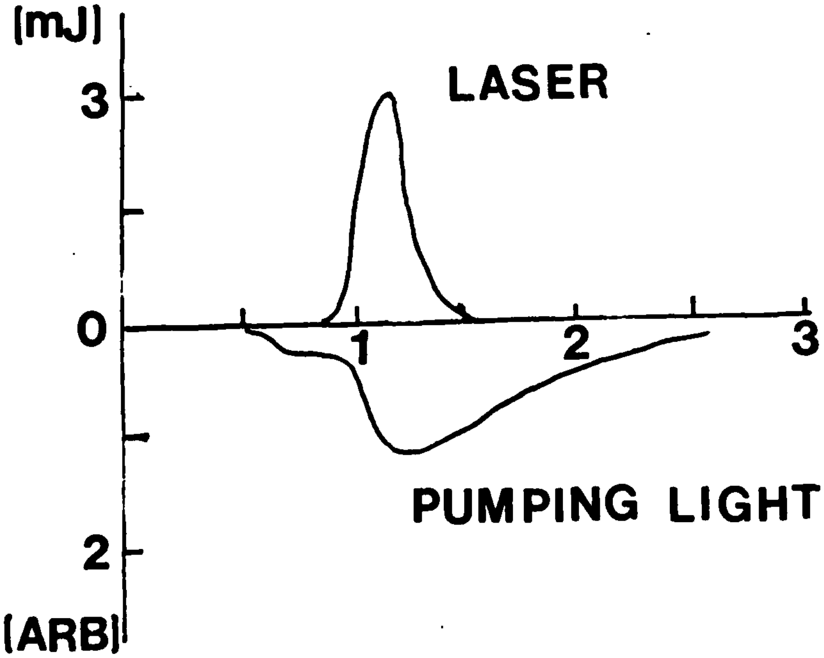


Fig. 1 Blue-green laser (coumarine 503 dye) and pumping light signal from HCP operated at an input energy of 0.9 kJ, argon 1 Torr, 20% transmission output mirror.

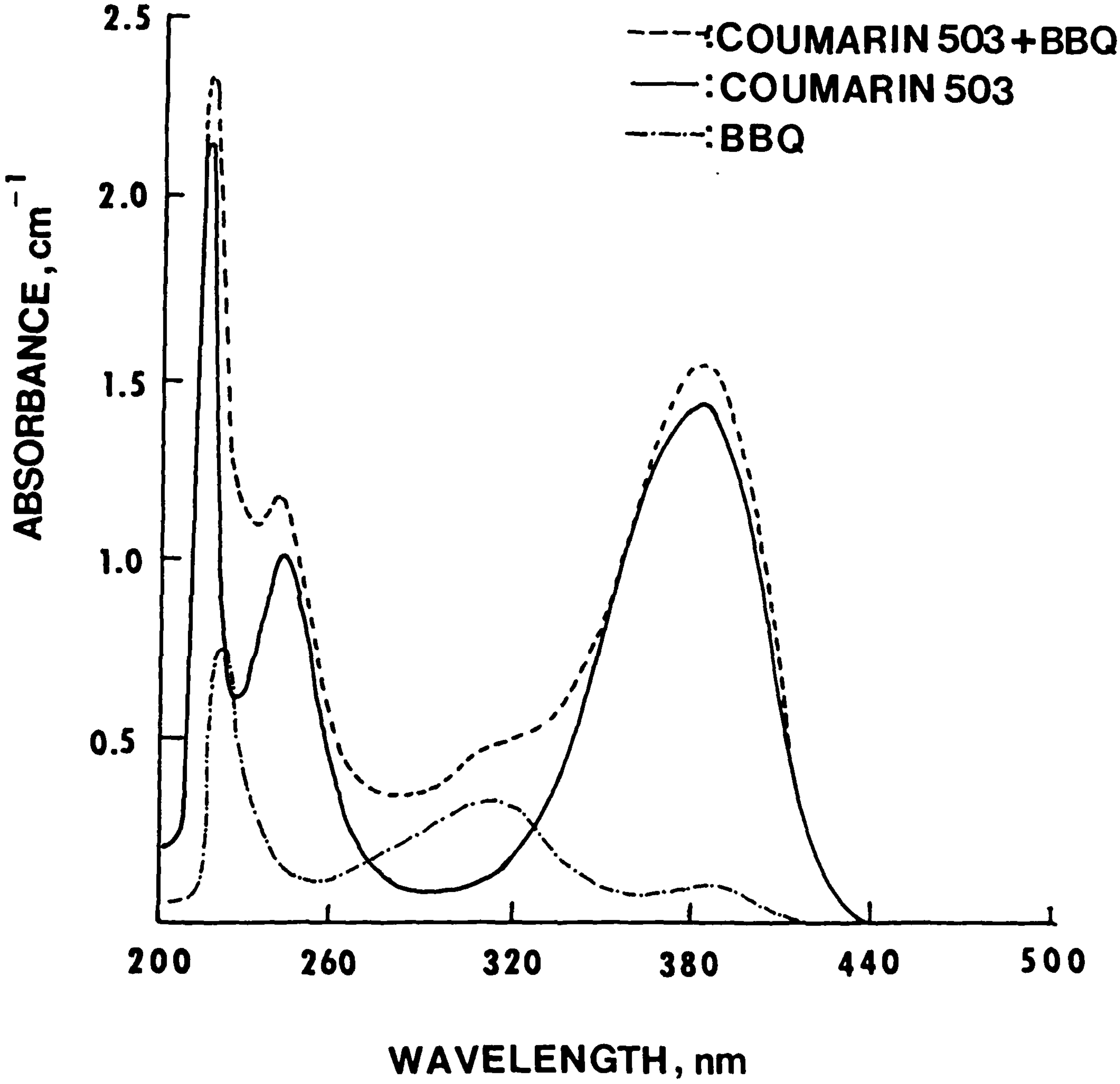


Fig. 2 Absorption spectra of Coumarin 503+BBQ(---), Coumarin 503(—), BBQ(-·-·-) are function of wavelength in nanometer.

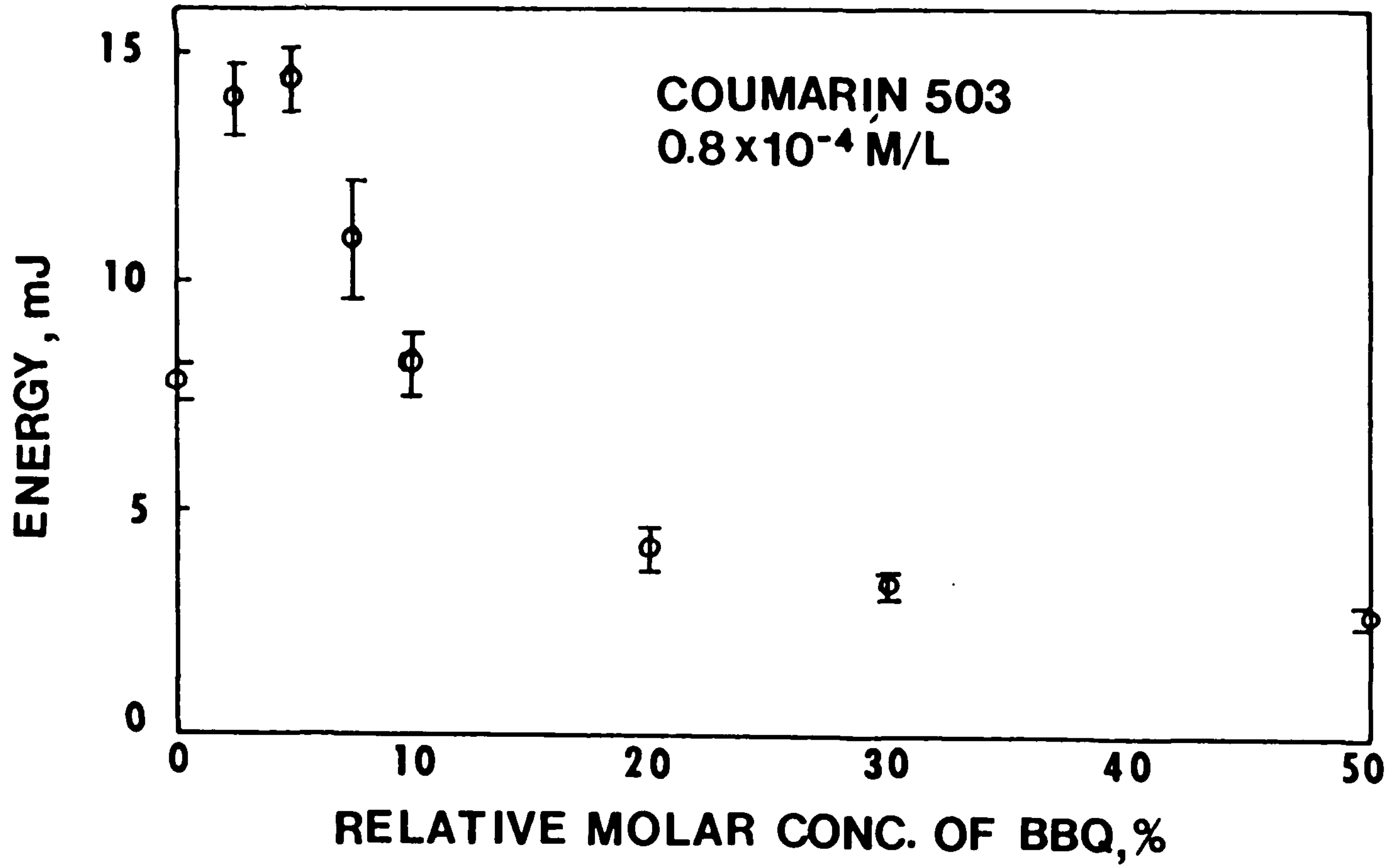


Fig. 3 Blue-Green Laser output energy (Coumarin 503 dye) as a function of BBQ dye (as a spectrum converter dye). BBQ dye concentration is relative to Coumarin 503 dye concentration.

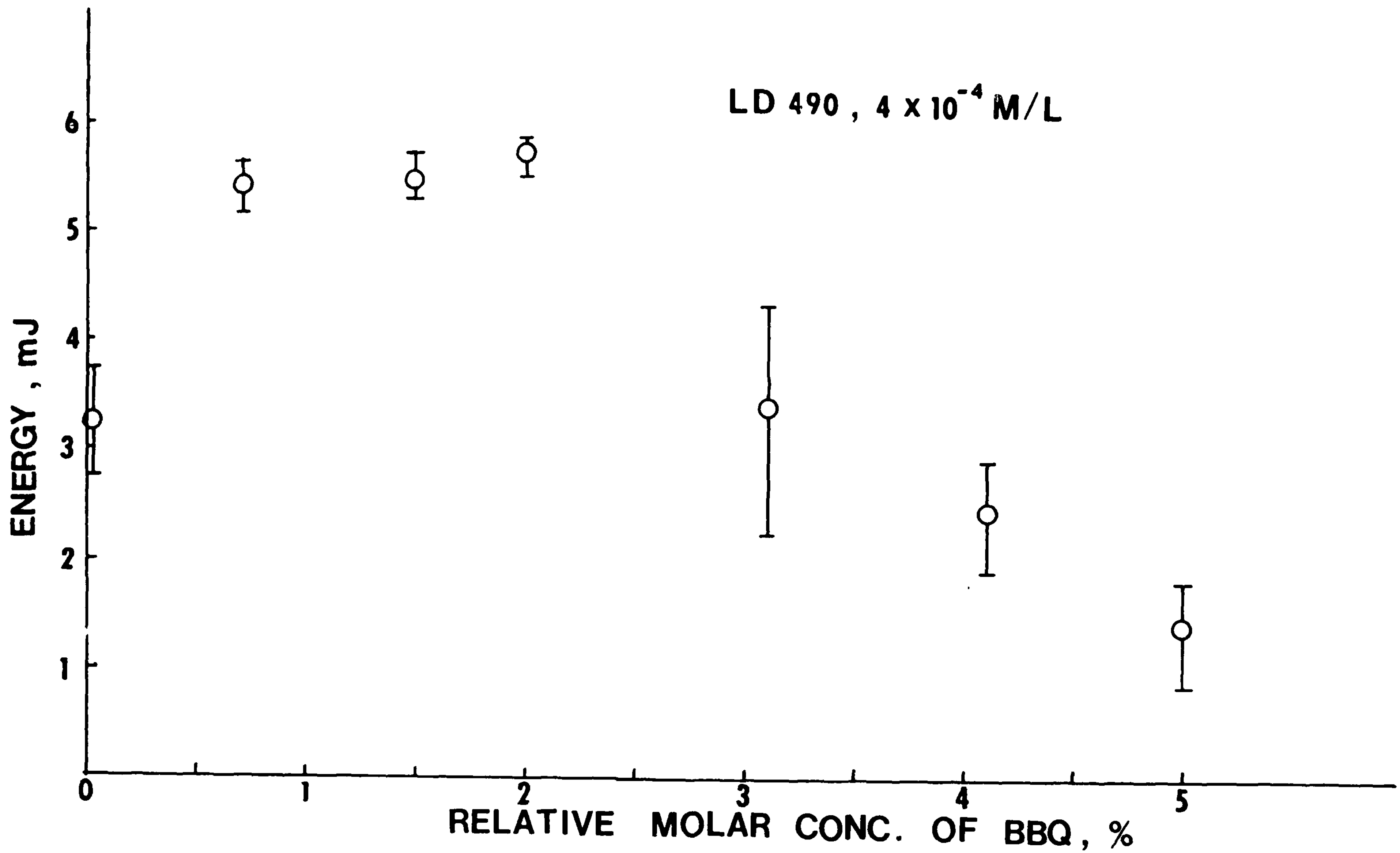
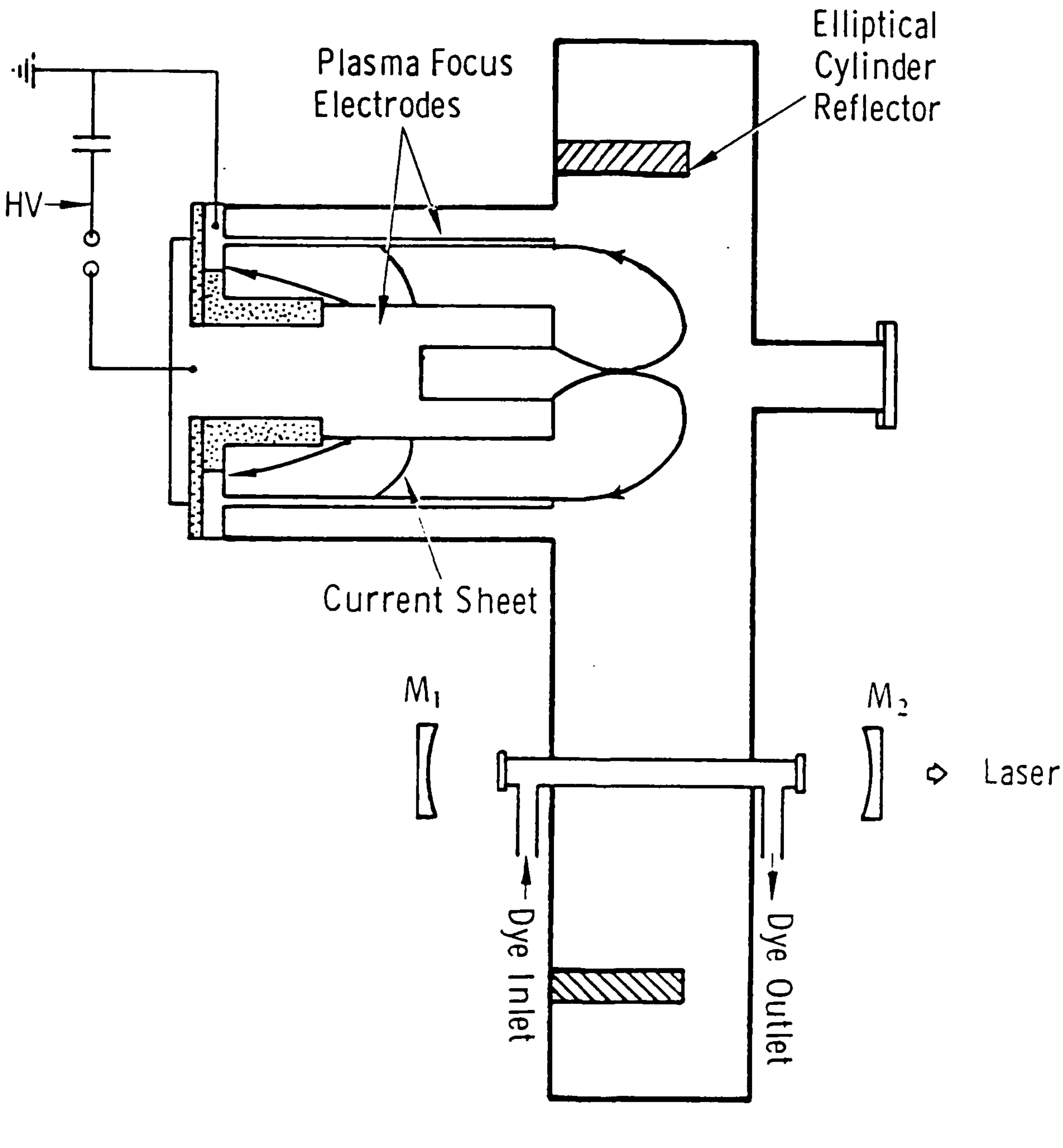


Fig. 4 Blue-green laser output energy (LD490 dye) as a function of BBQ (as a spectrum conversion dye). BBQ dye concentration is relative to *Coumarin 503* concentration.

EXPERIMENTAL SETUP



ȷ. 5 Experimental arrangement of the dense plasma focus and dye laser system.

VELOCITY of CURRENT SHEATH vs PRESSURE

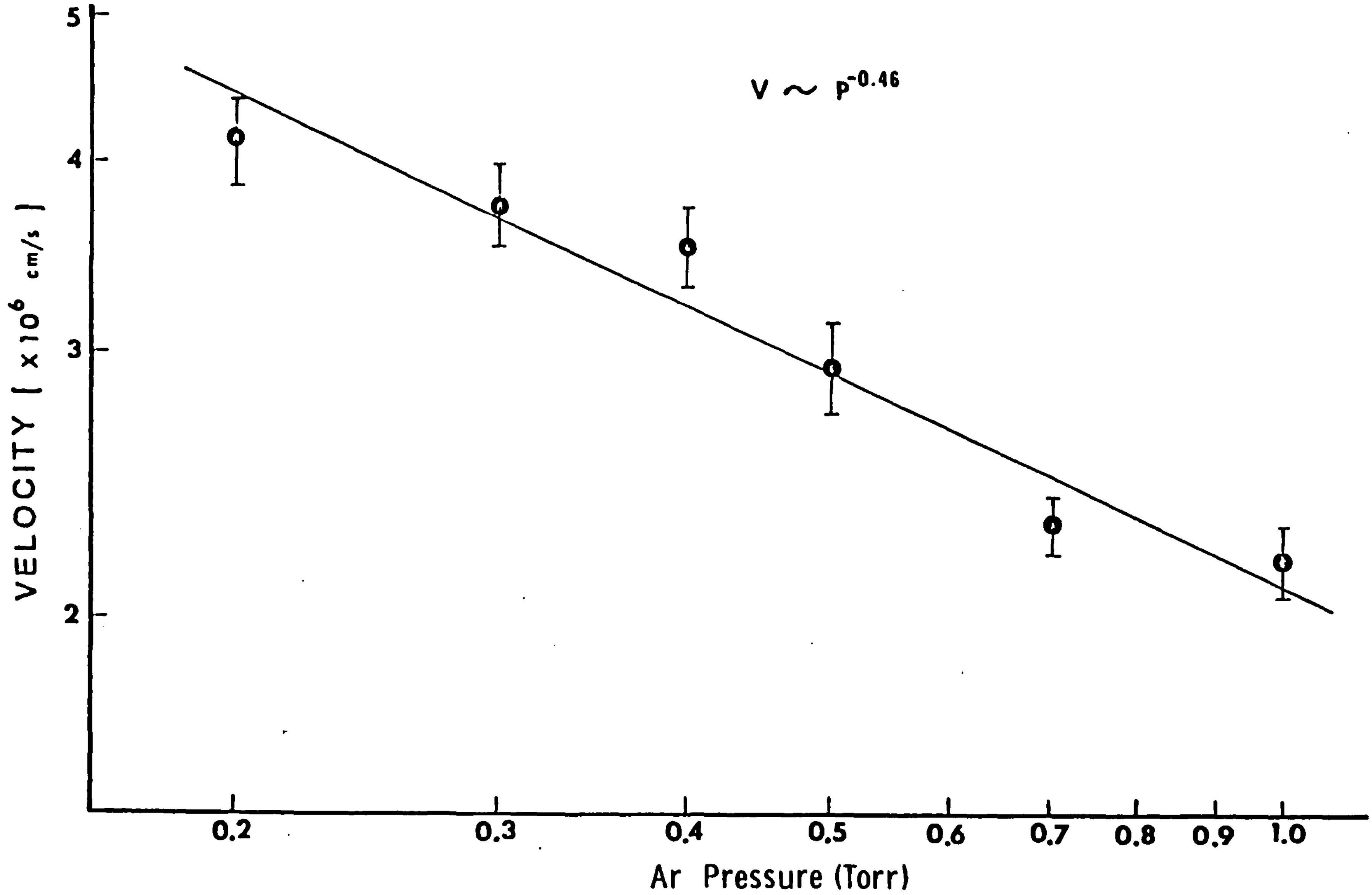
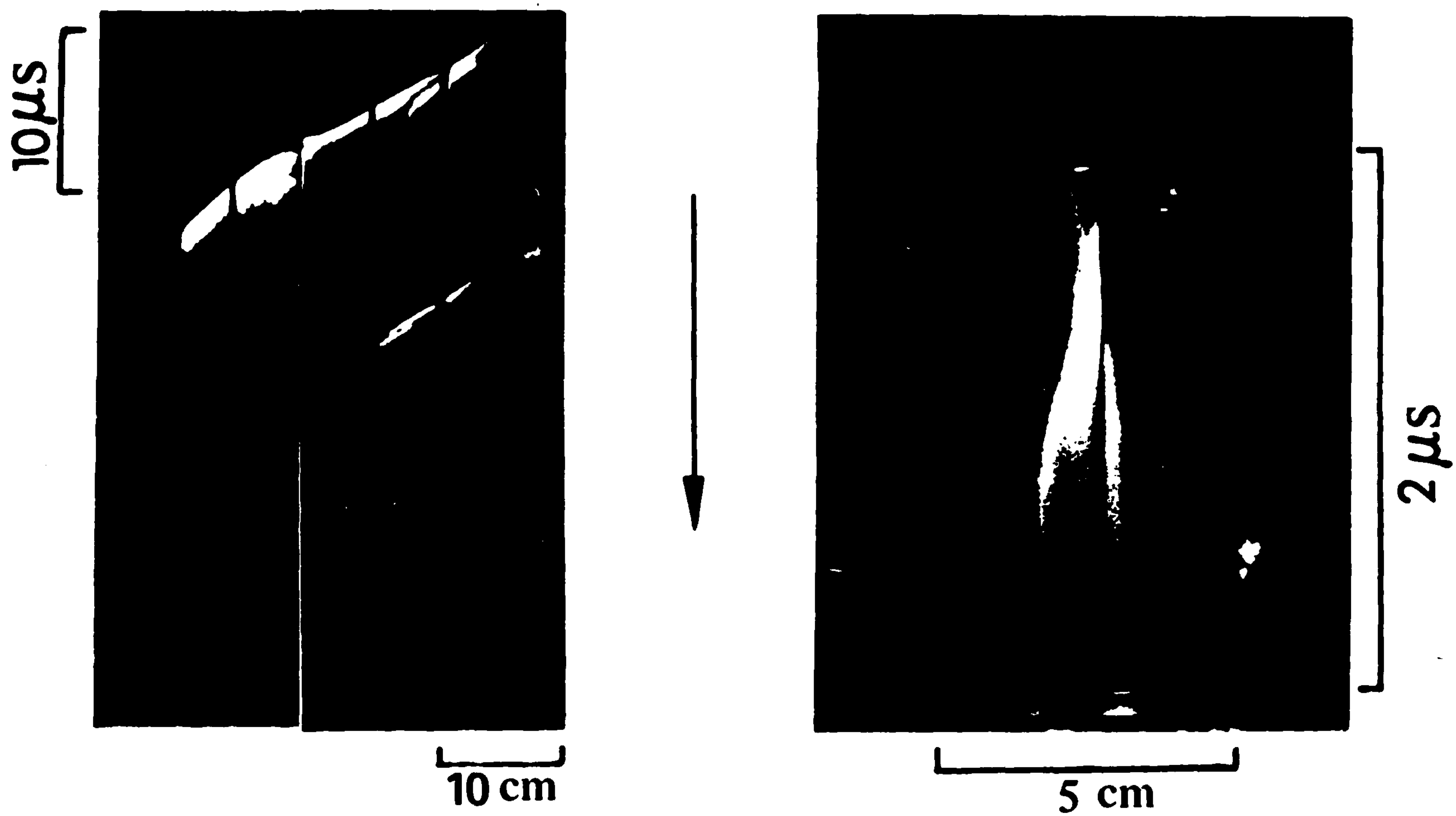


Fig. 6 Average speed of current sheath of the plasma pumping source. as a function of argon fill gas pressure.

STREAK PHOTOGRAPH



0.3 Torr Ar + 0.7 Torr D_2

Fig. 7 Streak photograph of plasma focus discharge with fill gas of 0.3 torr of argon and 0.7 torr of deuterium.

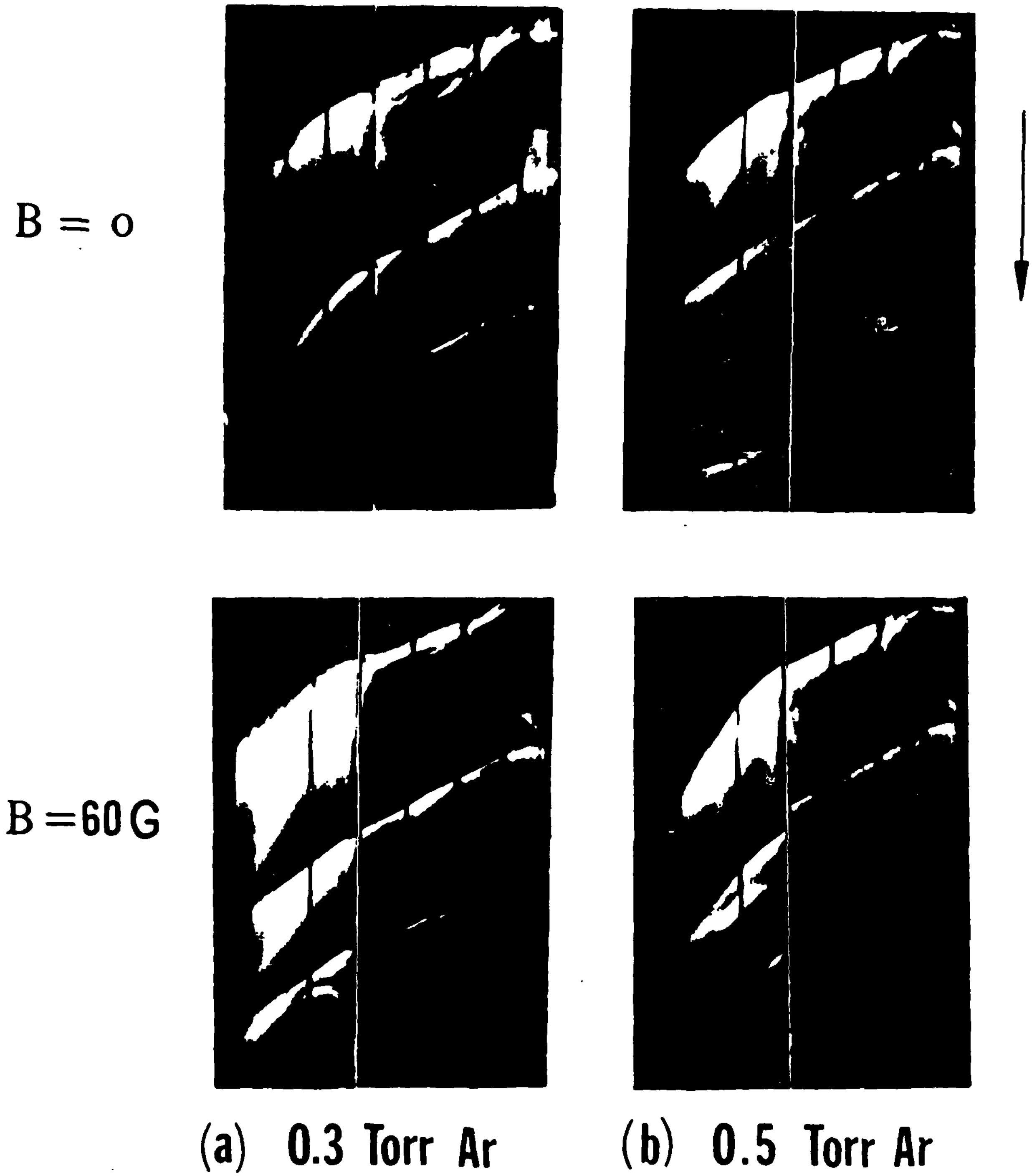


Fig. 8 Side view of streak photograph of plasma focus discharge: B=0 case (top) and B=60 gauss case (bottom).

SIDE - ON STREAK PHOTOGRAPHS

(g) 10% Ar (h) 20% Ar (i) 30% Ar

TOTAL PRESSURE ; 1 TORR WITH D_2

Fig. 9 Side view of streak photograph of plasma focus discharge with argon fill gas pressure in 1 torr of deuterium at B=60 gauss.

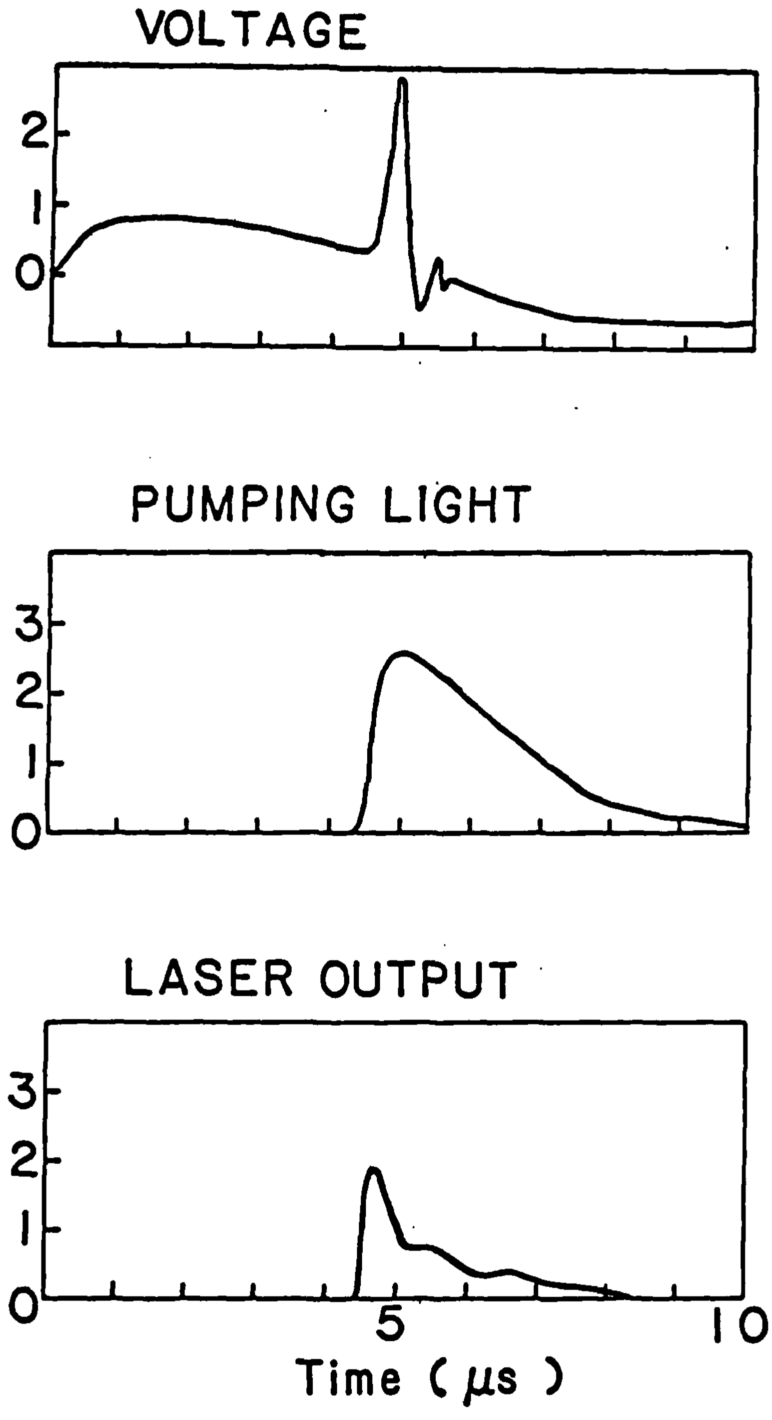


Fig. 10 Typical voltage (top), pumping light (middle) and laser output energy (bottom) oscillograpm. Sweeping speed 1 s/div.

DYE LASER OUTPUT ENERGY vs. PRESSURE

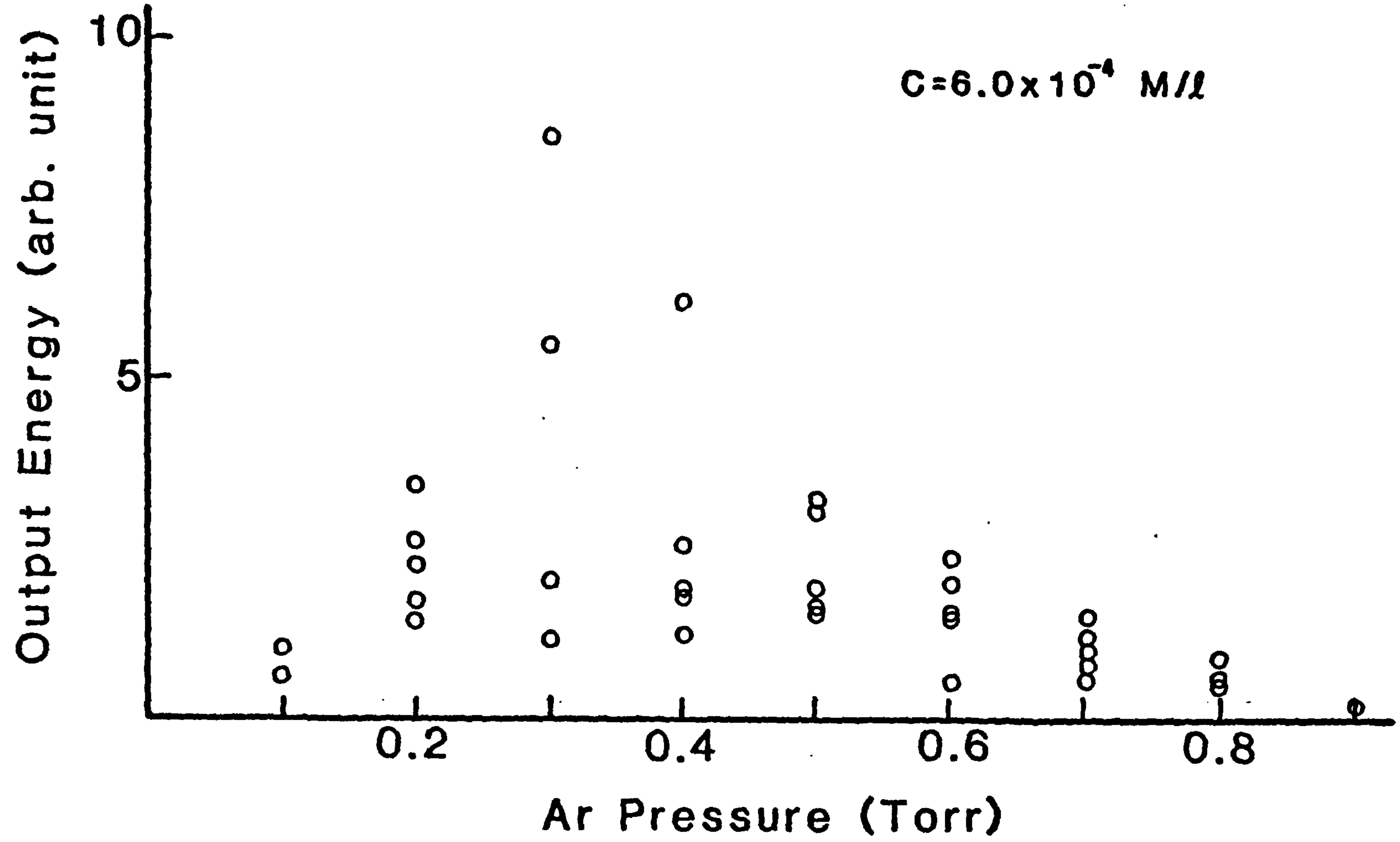


Fig. 11 Dye (LD490) laser output energy as a function of argon fill gas pressure.

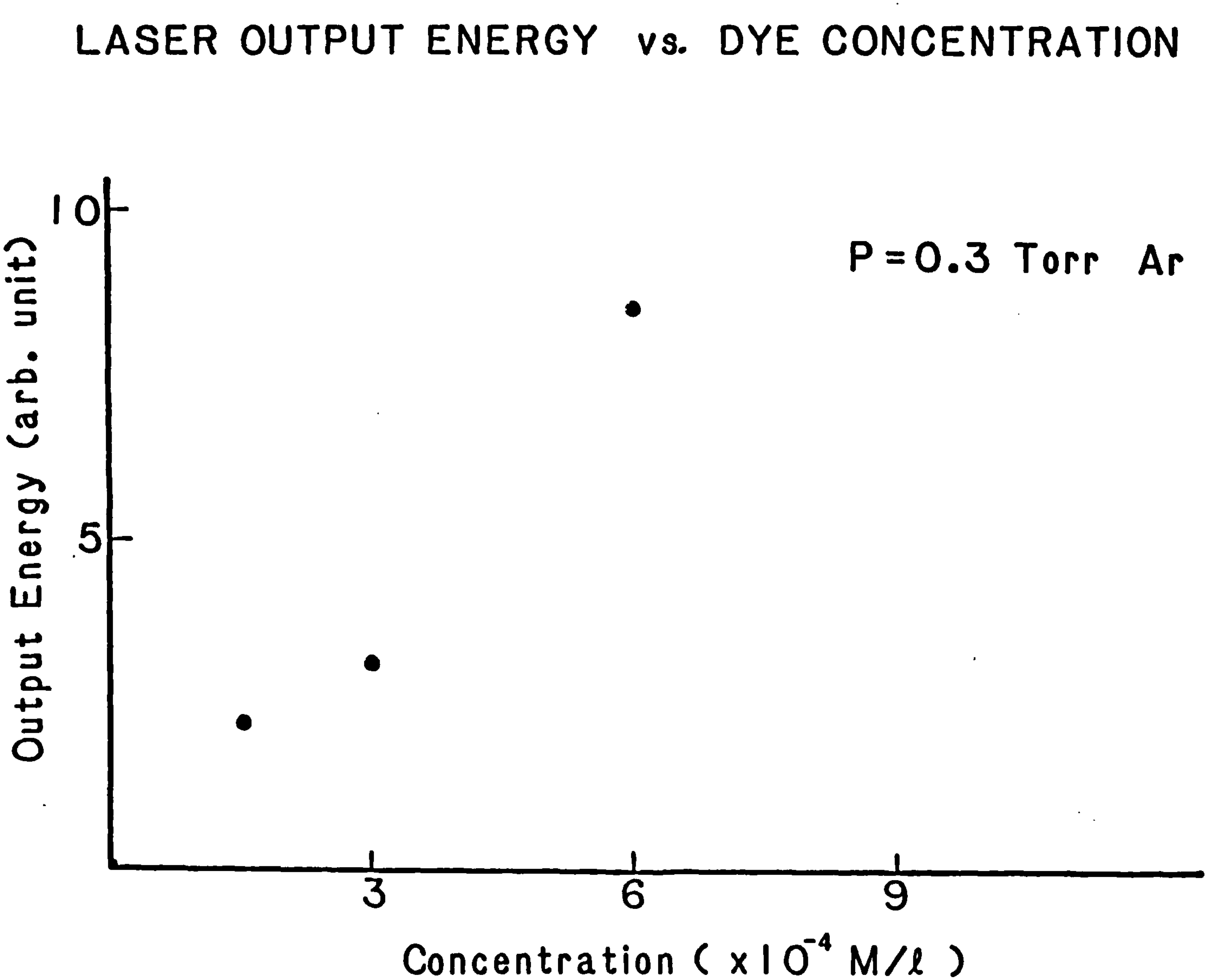


Fig. 12 Dye (LD490) laser output energy as a function of dye concentration.

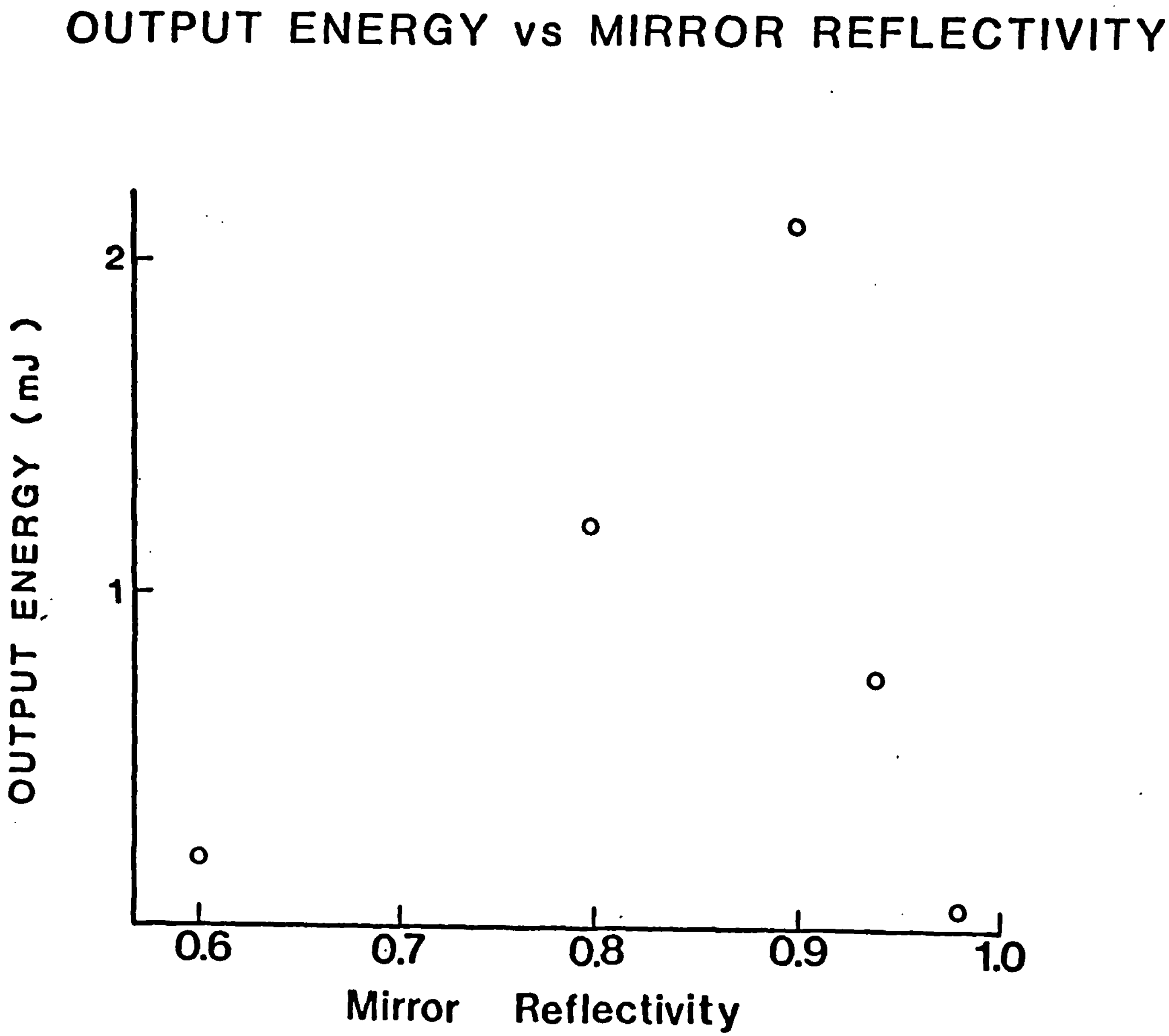


Fig. 13 Laser output energy as a function of laser mirror reflectivity.

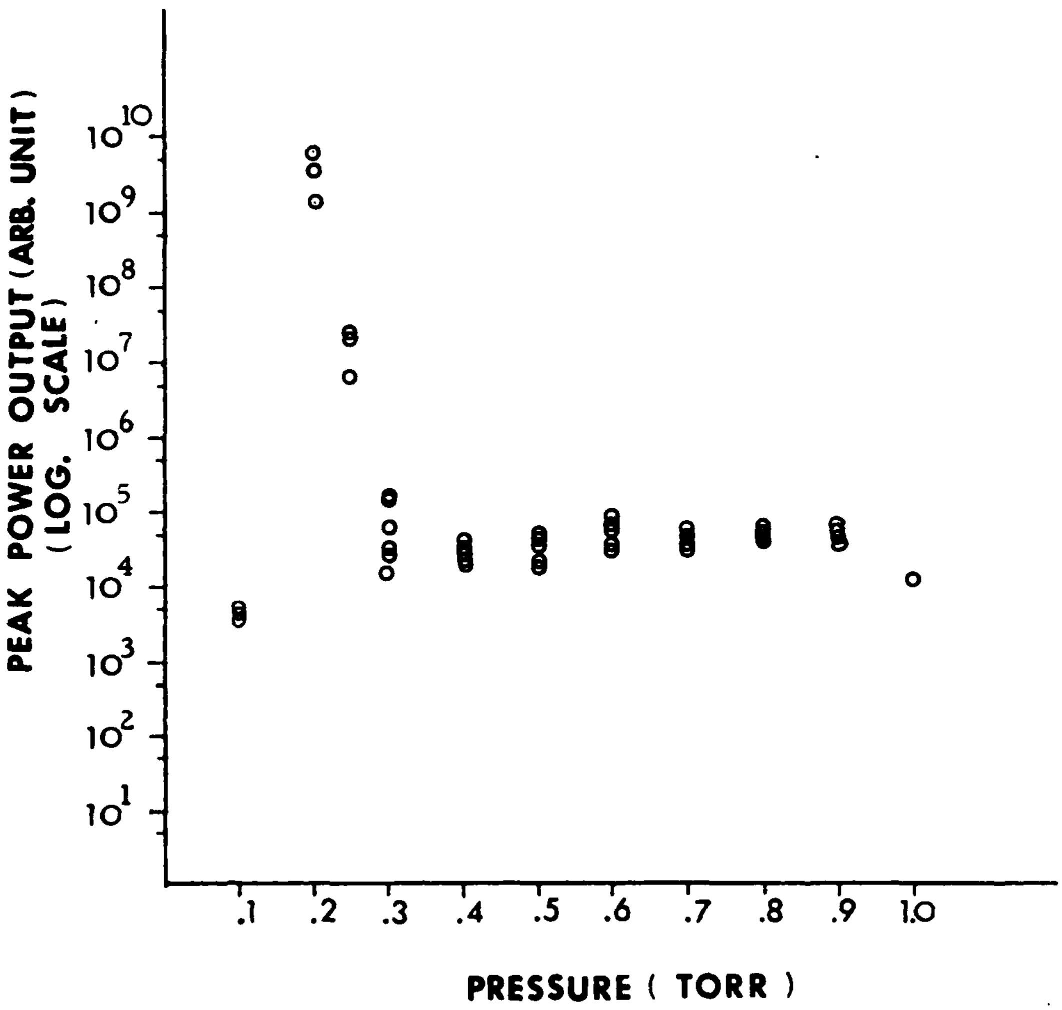


Fig. 14 Radiative peak power output at =350nm, which is produced by dense plasma focus, is as a function of argon fill gas pressure of DPF device.

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