## IV EXPERIMENTAL RESULTS

The experimental results presented in this section was carried out using the identical UNU/ICTP plasma focus facility at the Plasma Research Laboratory, University of Malaya. The base pressure for this particular device is ~0.1 torr, the device is operated at ~14kV throughout this series of experiments. Signals from the five channels together with a reference signal from high voltage probe are recorded simultaneously by a fast 1 GSa/sec logic analyser (HP 16500A). A typical print out of current and voltage signals on a long time scale of 1 μs/div is shown in Fig.6 [screen display is also shown for completeness of data presentation].

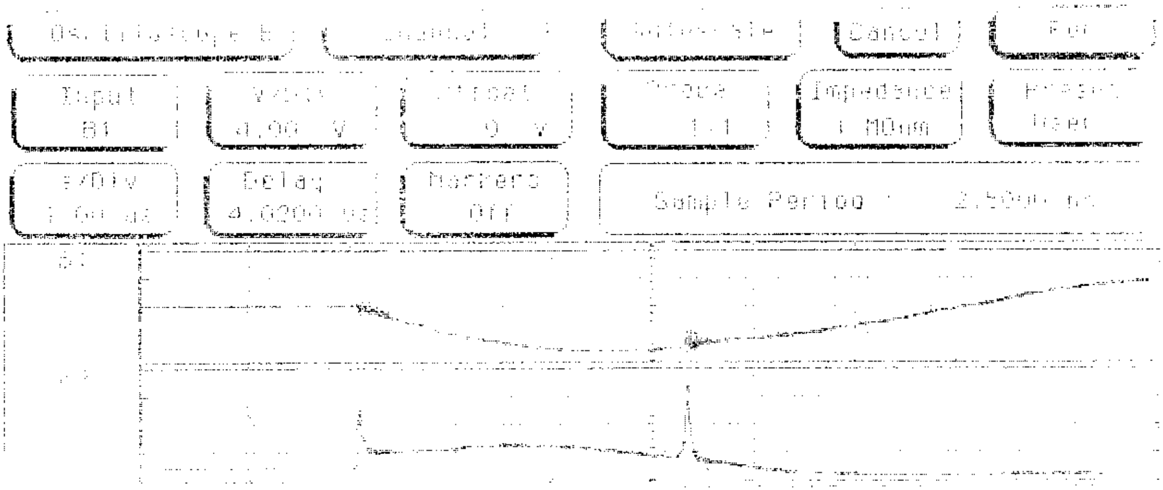


Fig.6 A sample of print out from DSO

top trace B 1 -- current signal

lower trace B 2 -- voltage signal

Next, x-ray emissions from various gases will be presented.

## 4.1 X-ray emission from deuterium ($D_2$) gas

Fig.7 Shows soft x-ray signal from multichannel spectrometer channels 1,2,3 together with high voltage reference signal. It is clearly seen that soft x-ray signals coincide with successive plasma compressions. Hard x-ray signal as detected by the photomultiplier assembly also shows three dominants peaks, while the bottom signal comes from gas ionization chamber (XRD). It is estimated that high energy electron beams up to 150kV are responsible for hard x-ray emission. In some experimental shorts, multichannel spectrometer shows third pulse in the signal, but no spike is observed from the high voltage signal, this third x-ray signal is attributed to the copper $k_\alpha$, line radiation. The origin of this $k_\alpha$ , either from the copper anode or copper vapour plasma, may be traced from time-resolved pinhole photography.

If soft x-ray emission from $D_2$ gas is assumed to be predominantly Bremsstrahlung radiation, and that no impurity is present. Then the curves of $I/I_o$ against the aluminium foil thickness can be computed as shown in Fig.8, for various electron temperature. The experimental ratio of $I/I_o$ obtained from the five channels simultaneously for three discharges have been fitted to the curves. For reference, raw data of $I/I_o$ is presented in table 3

**Table 3**

| channel | shot #143 | | shot #149 | | shot #229 | |
|---|---|---|---|---|---|---|
| | I | $I/I_o$ | I | $I/I_o$ | I | $I/I_o$ |
| 1 | 1.75 V | 1.0 | 1.4 V | 1 | 1.3 V | 1 |
| 2 | 1.25 V | 0.7 | 750 mV | 0.52 | 800 mV | 0.6 |
| 3 | 250 mV | 0.1386 | 600 mV | 0.138 | 250 mV | 0.186 |
| 4 | 250 mV | 0.1347 | 200 mV | 0.135 | - | - |
| 5 | 250 mV | - | - | - | - | - |

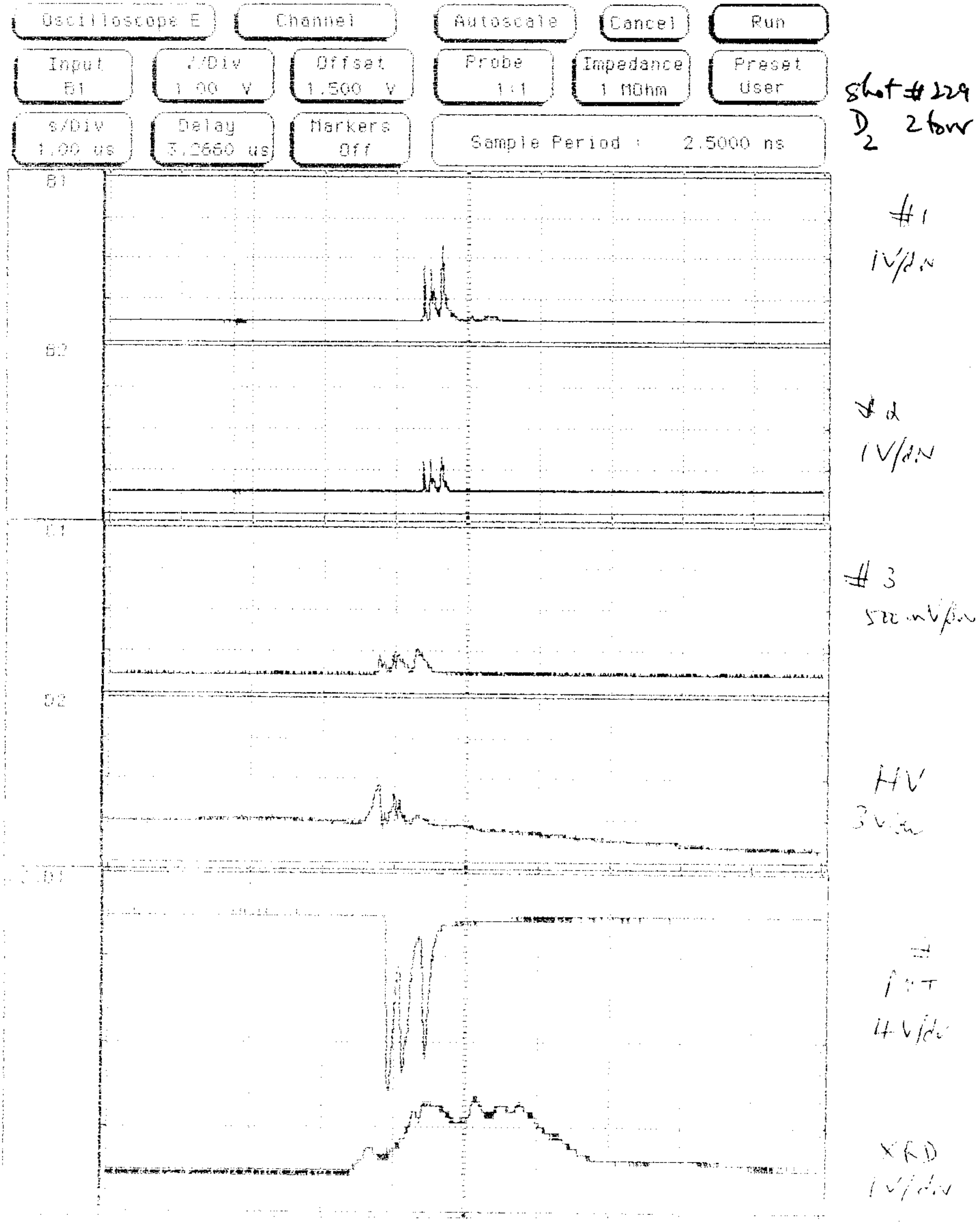


Fig.7 Print out for experimental shot #229 in deuterium gas, pressure ~2 torr, V~14kV

traces B1,B2,C1 - soft x-ray signals channels 1,2,3

trace $D_2$ - high voltage probe signal

trace $C_2$ - hard x-ray signal as detected by PMT

trace $D_1$ - signal from gas ionization chamber (XRD)

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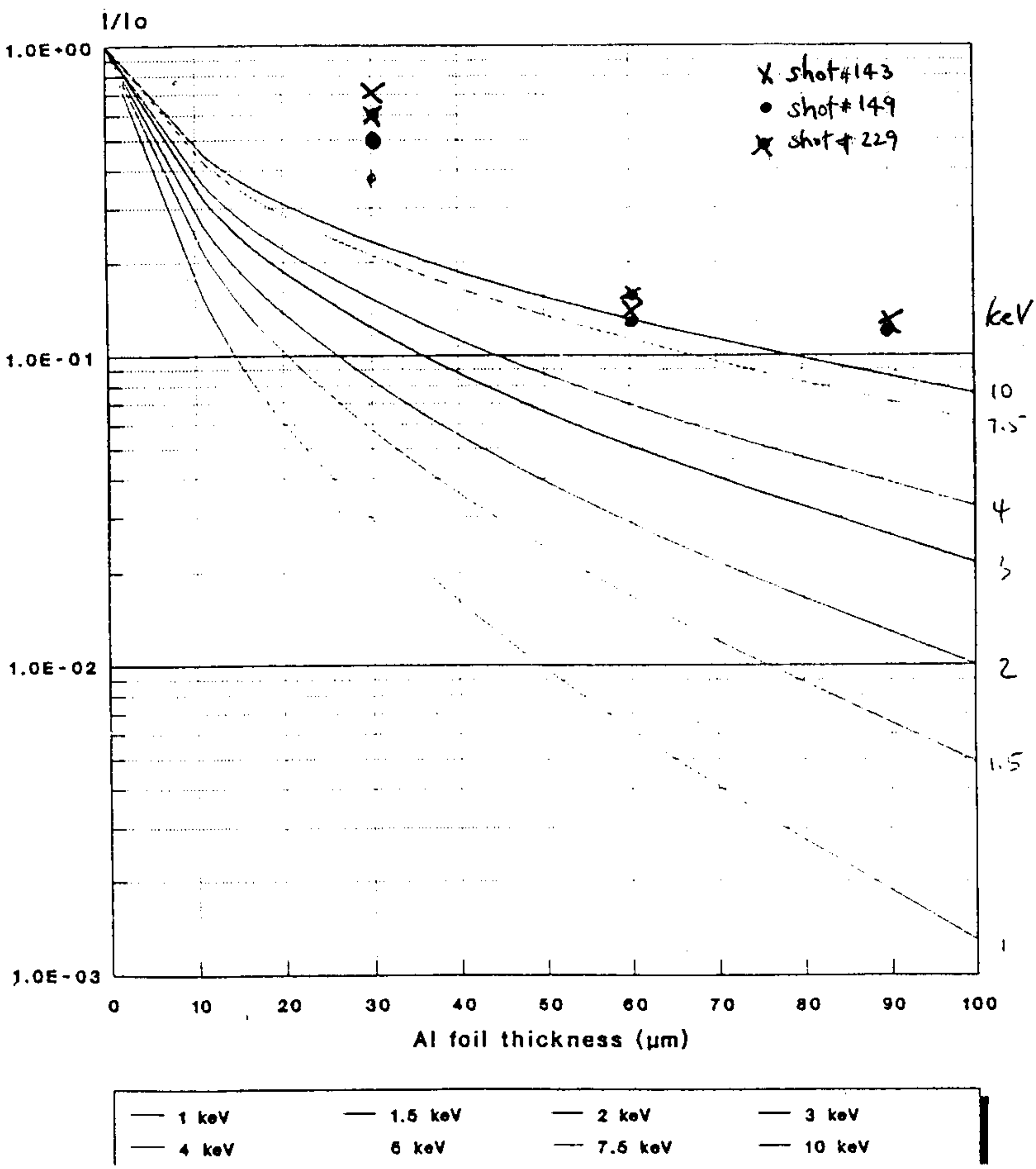


Fig.8 Absorption curves of aluminium for Bremsstrahlung radiation at various electron temperature. Experimental points from $D_2$ plasma for three differrent shots are superimposed on the curves.
[calibrated graph is taken from Instruction manual ICAC-UM/ DXS-3 type B]

From Fig.8 all experimental points are higher than 10 keV curve. The probable electron temperature inferred from the graph is ~10keV which is rather high. This inconclusive result could be tested again by operating the plasma focus in cleaner condition (ie. lower base pressure).

## 4.2 X-ray emission from argon (Ar) plasma

A complete x-ray signal from five channels is shown in Fig.9, for argon plasma operated at ~0.7 torr, V~14kV. The reason for change in pressure to ~0.7 torr is that this setting is best for focussing of argon. As expected, the first peak in x-ray signals coincides with high voltage spike or maximum plasma compression, subsequent soft x-ray at ~250 ns later may be due to copper line radiation from plasma. Again, the electron temperature inferred from the graph of $I/I_o$ vs. aluminium foil thickness is estimated to be ~1.5 keV, this is in good agreement with the result obtained at Trieste [14].

## 4.3 X-ray emission from nitrogen ($N_2$) plasma

For nitrogen gas, the plasma focus is best operated at pressure ~0.8 torr and charging voltage ~14kV. Fig.11 shows soft x-ray signals coincide with high voltage signal. It is also noted that after $5^{th}$ or $6^{th}$ shots, the magnitude of the first x-ray peak diminishes due to dirty plasma condition. The second x-ray pulse also gets larger due to copper vapour contamination.

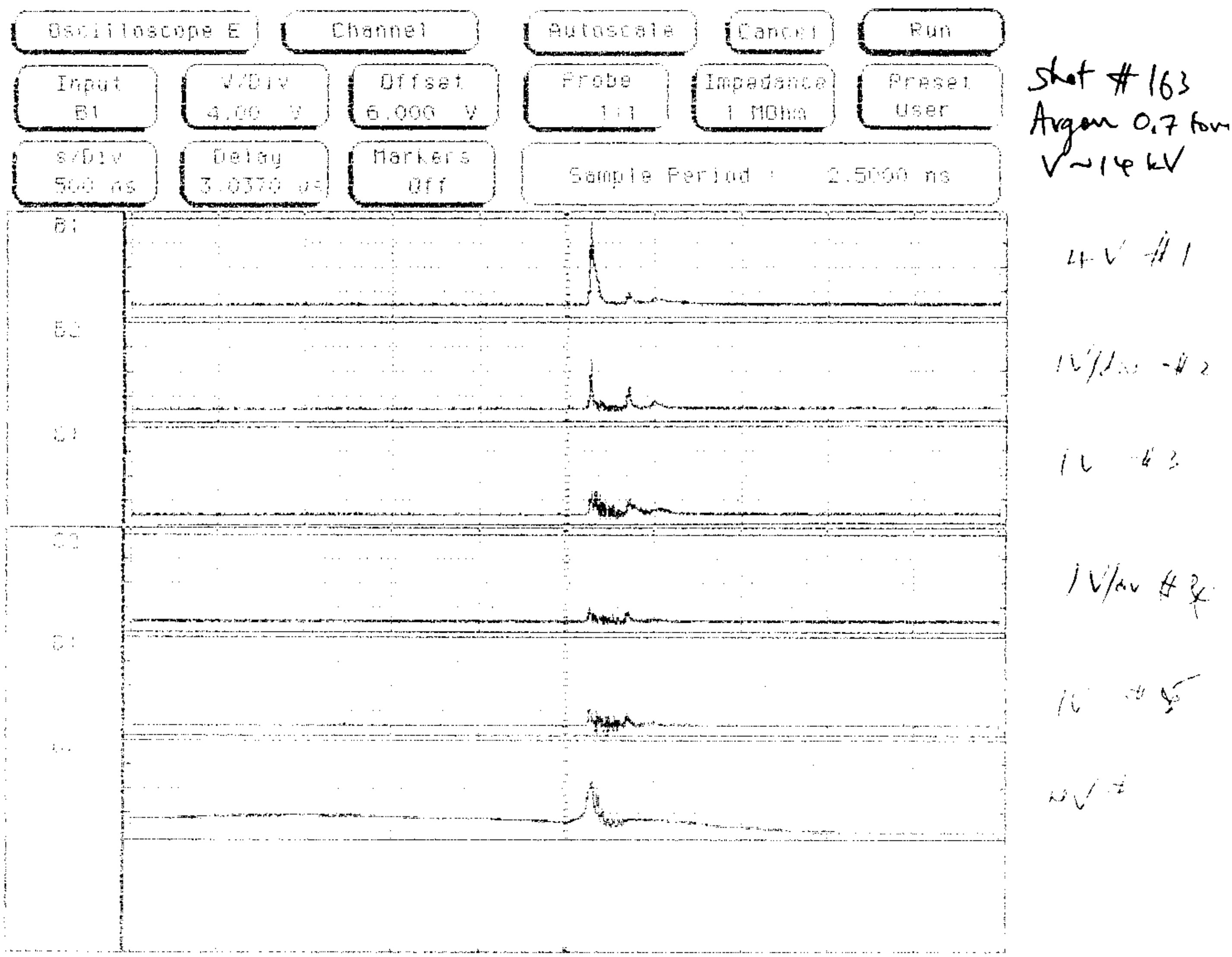


Fig.9 Simultaneous x-ray signals from five channels, the last trace is high voltage reference signal.

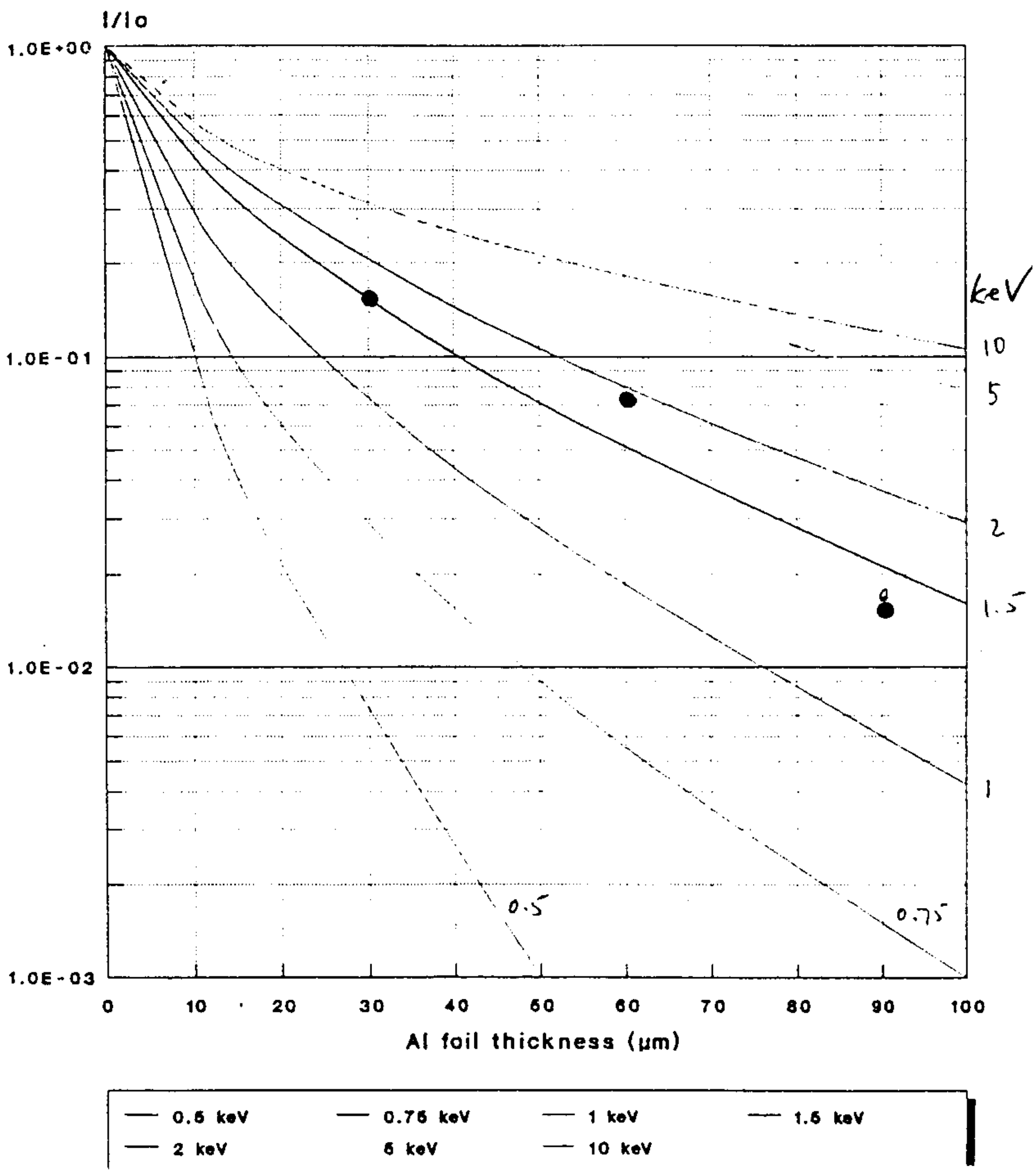


Fig.10 The graph of x-ray intensity ratio vs. aluminium foil thickness superimposed with experimental points. [calibrated graph is taken from Instruction Manual [CAC-UM/DXS-3 type B]

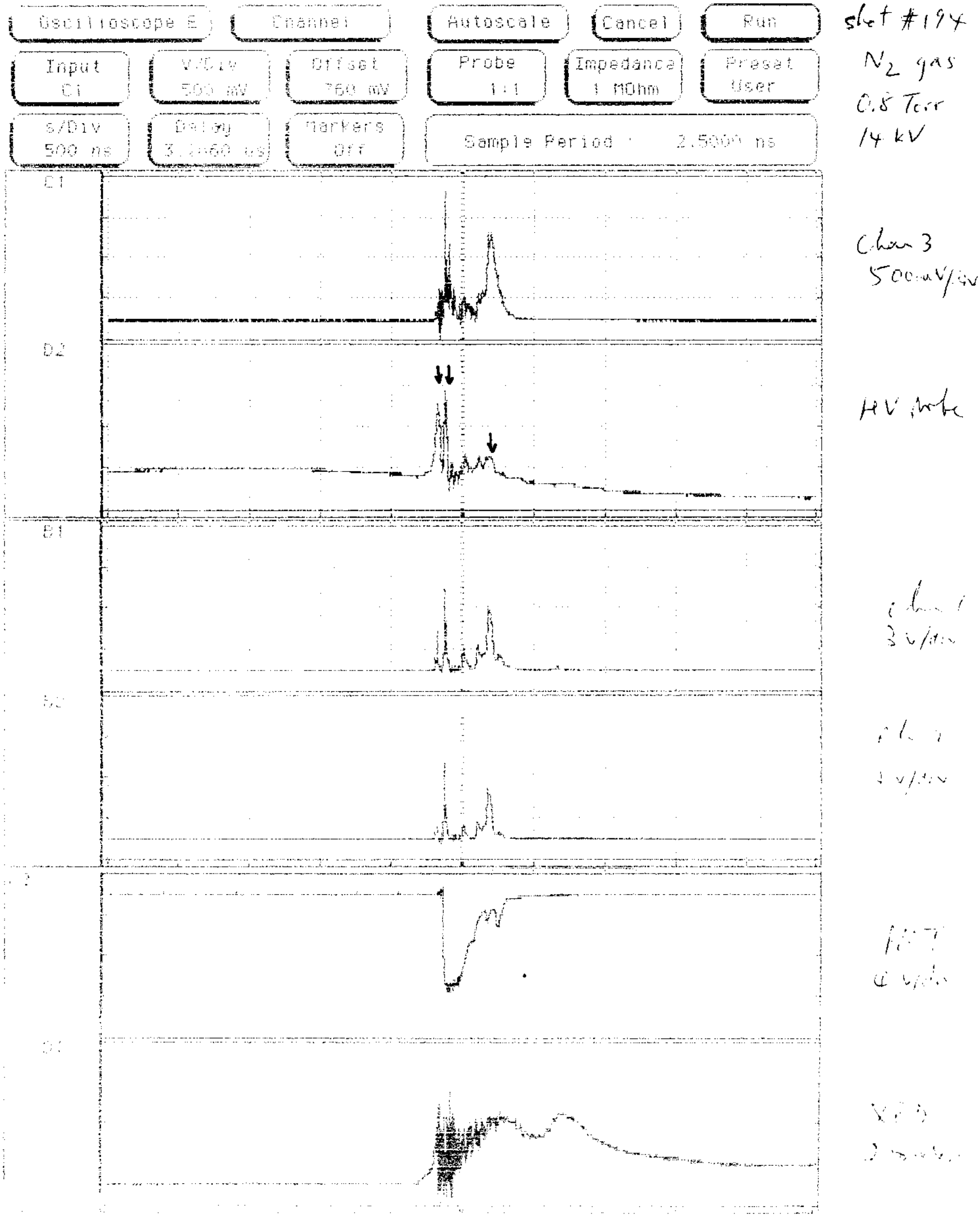


Fig.11 Print out of signal from nitrogen plasma