FIELD REVERSED THETA PINCH TC–I UNICAMP

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Field reversed configuration TC–I device is 16 cm diameter, 1 meter long with two mirror coils and 30 kJ field reversed theta pinch working for over two years at University of Campinas. Its implosion dynamics and field reversal parameters have been studied using flux excluded loops, internal magnetic probe, visible spectroscopy, photodiode array and image converter camera. The vacuum vessel is a pyrex tube of 11,5 cm diameter pumped with a liquid nitrogen cooled diffusion pump to a base pressure of 6 x 10^{-7} Torr. The schematic view of the machine and experimental set up are shown in fig. 1.

As first step, the implosion phase of the FRC formation was studied by the analysis of light emission and electromagnetic probe signals. In the fig. 2 we show the influence of the internal probe for separatrix radius measurements. In the case of absence of internal probe the pinch effect is faster and is more stable towards the end of implosion phase. The influence of the probe seems to start at about 2μsec after the main bank discharge start. The internal probe influence can also be seen by end-on framing image converter camera in the fig. 3 where the light emission region is stronger and broadened for the presence of internal magnetic probe. The internal magnetic probe has been inserted in order to check the field reversal existency where after its confirmation it has been taken out for further studies.

In order to obtain plasma described above one characteritic feature to be mentioned is the use of home made externally adjustable field distortion switch with crow–bar shown in fig. 4. Each capacitor bank of TC–I device has been switched with a nonuniform field distortion start switch working at atmospheric pressure. The materials used to build this switch is nylon, brass and aluminium, and also is possible to be operated with internal gas pressure with small modifications. In this kind of switch it is necessary a calibration procedure in order to set the trigger electrode at the right position. In fig. 5 we have obtained a calibration curve with breakdown voltage for three distinct cases. The curve A is the case without the trigger electrode between two discharge electrodes, the curve B is the case with the trigger electrode at midplane position without trigger pulse line connection. The curve C is the same situation as case B but with the trigger line connection which makes the trigger electrode polarized with half voltage of main bank through a voltage divider.

For the curves A, B and C we usually use the curve C due to the linear behavior for all voltages. Once the breakdown calibration curve is obtained we usually operate the switch at gap distance as close as possible to breakdown distance, usually at 90% of calibration distance in order to have lower jitter operation possible.

In figure 6–a is shown the typical discharge signal obtained by Rogowski loop around one of TC–I solenoid. This signal is the result of 5 superimposed discharges. In figure 6–b is the case when crow–bar is applied, and gives e–folding decay time of 16 μsec.

By changing the coax cable length from start switch situated near the capacitor bank to transmission plate at theta–pinch solenoid and increase of 50% in the number of cable, we have decreased the rise time from 5.0 μsec to 4.5 μsec but we did not observe any appreciable modification on the plasma parameters as were observed when the gas from helium to hydrogen was changed.

While the best pressure operation for He gas was determined to be 10mTorr with ion temperature reaching 70 eV as been reported previously [1], for the hydrogen the best pressure operation is 3mTorr and the ion temperature was measured by taking the Doppler broadening of Hα, CII, CIII, CIV, SiIV, line giving 186 eV (SiIV line) [2].

An interesting result which [illegible] appearence of cusp type plasma during the formation phase [illegible] of 0.25 B_i [illegible] applied, as being discussed in other work presented at current workshop [2].

Another result which we get is the appearance of a plasma where near the end of first implosion a second layer of plasma appears forming [illegible]. This effect can also be observed in magnetic field mapping by internal probe measurements which presents two magnetic field peaks, at r = 1.5 cm and r = 4.0 cm (see ref 3).

References

[1] E.A. Aramaki et al, Nuclear Instr. and Methods in Phys. Res., A280, 597, 1989.

[2] E.A. Aramaki et al, presented at current IV Latin–American Workshop on Plasma Physics.

[3] M. Machida et al, presented at current IV Latin–American Workshop on Plasma Physics.

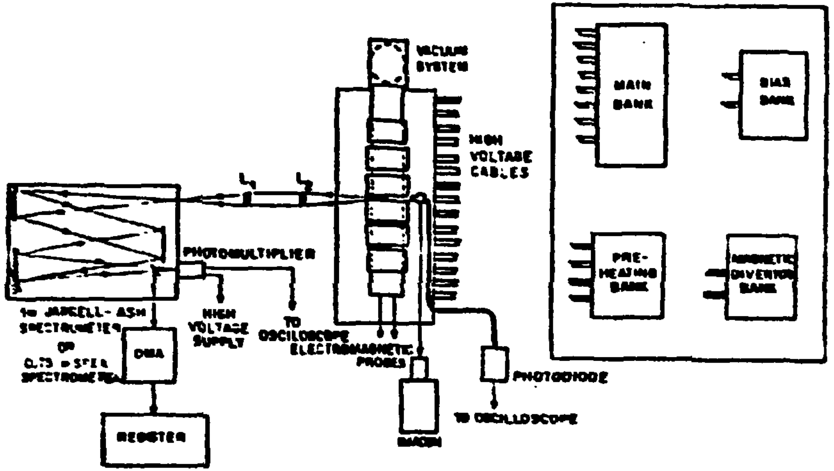

Fig. 1 - Schematic view of TC-I FRC device.

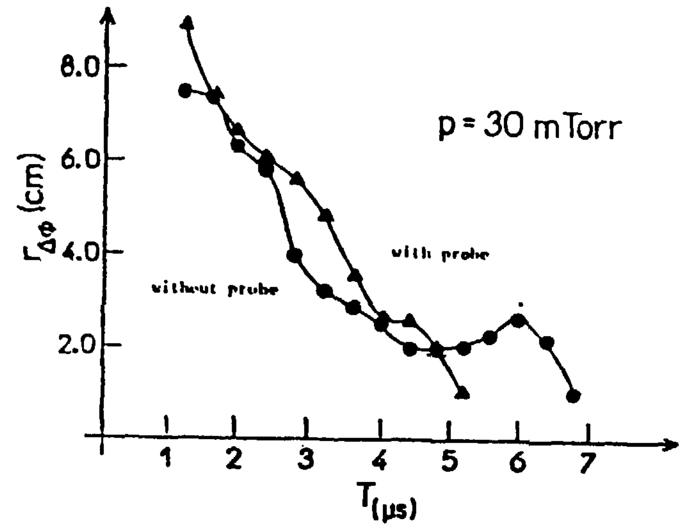

Fig. 2- Flux excluded signals with and without internal magnetic probe.

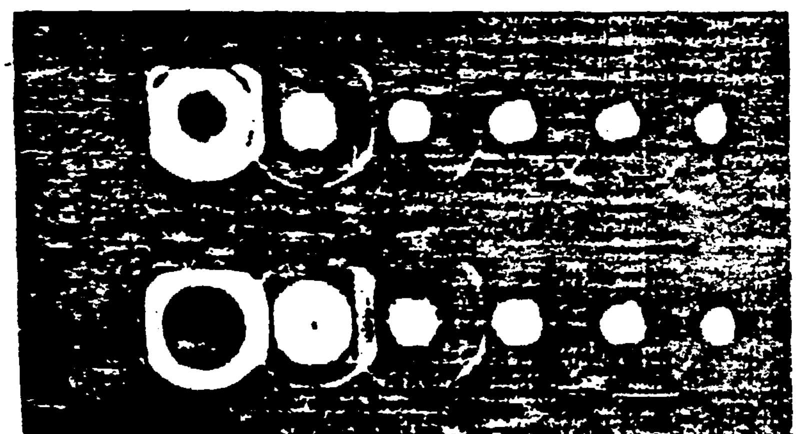

Fig. 3a - End-on framing picture with internal probe, start from bottom to top and let to right with 0.5μs for each

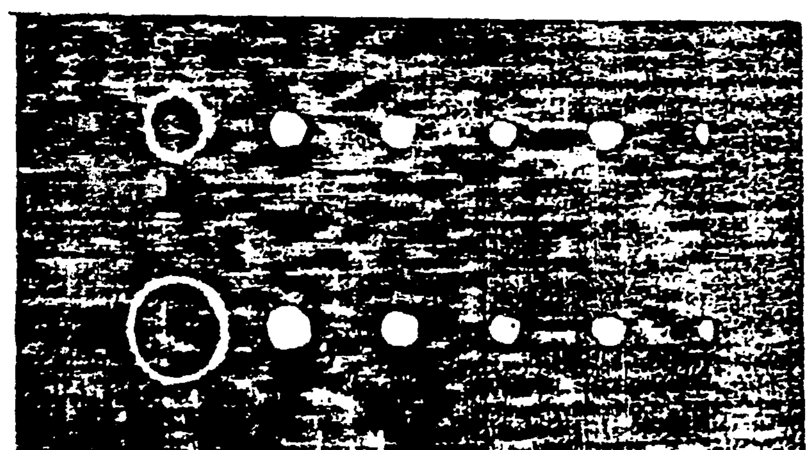

Fig. 3b - Same as 3a, without internal probe.

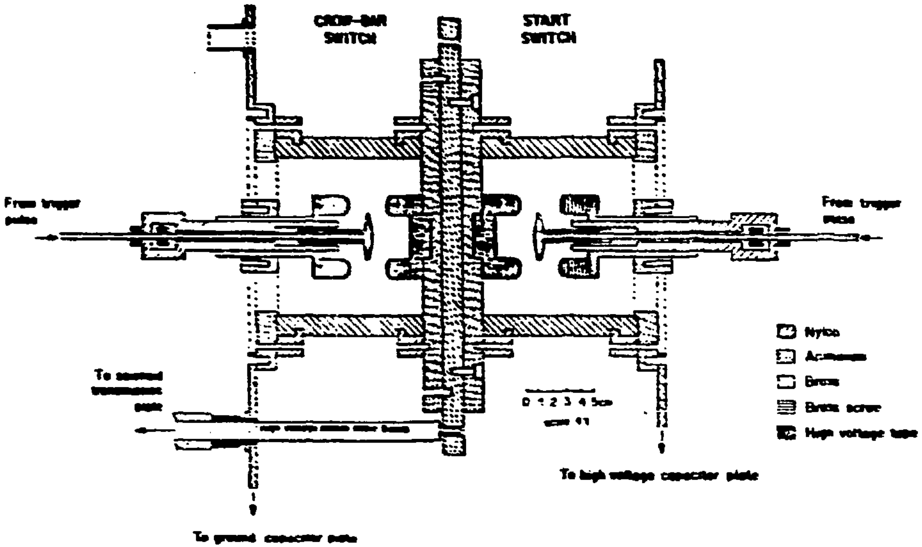

Fig. 4 - Externally adjustable field distortion switch with crow-bar.

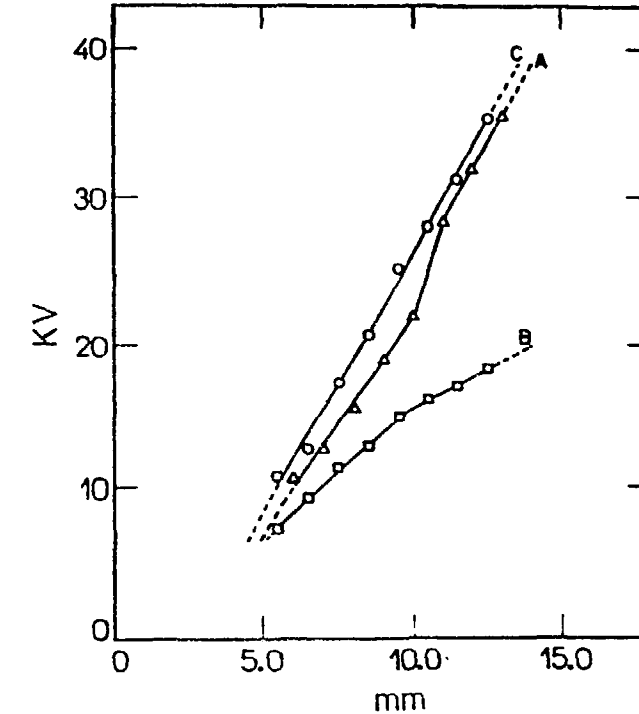

Fig. 5 - Selfbreakdown calibration curve:
A-without trigger electrode
B-without trigger pulse line connection
C-with trigger pulse line connection

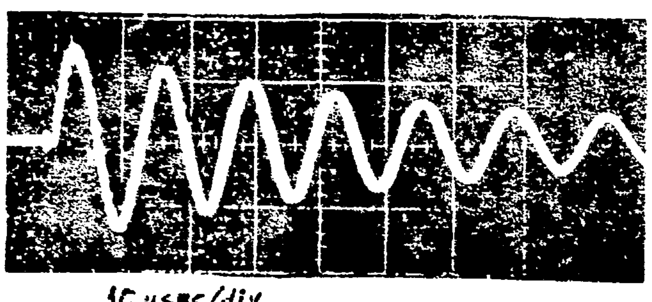

Fig. 6a - Five superimposed main bank discharge signals without

Fig. 6b - Main bank discharge with crow-bar.