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A ONE MEV/NUCLEON HEAVY ION LINEAR ACCLERATOR

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Introduction

The linear accelerator, which is being constructed at Orsay, is planned to inject a heavy ion beam into the median plane of the Orsay variable energy cyclotron. Heavy ions will be stripped in the central region and reaccelerated to the final energy given by the relation[1]:

$$E(\text{MeV}) = 70\ Zi^2 / A$$

To achieve a good stripping efficiency the linear accelerator energy was chosen around 1 MeV/nucleon and the ratio $Zi/A \geq 0.1$ will give the possibility to accelerate a continuous beam of ions with mass up to 30-40 and with a pulsed beam the ion's mass 80.

Ion Source

Heavy-ions-multicharged-source requires a high power supply for our discharge, focusing and analyzing systems. For a Morosov source[2], with our pulses of 40 A, the total power supply can be reached 120 kW. So, to facilitate the technological problems in power and space, a low input energy has been chosen, corresponding to a voltage of 140 kV, which allows the use of insulated transformer to provide power supply on the HT terminal.

Accelerating Cavity

Continuous beam and low energy injection leads to a low R. F. frequency and to abandon the Alvarez structure, the volume and rf power of which becomes prohibitive.

A better-fit structure can conveniently be done by a system based on a quarter-wave resonant line, already used in Manchester[3]. Calculations in twin line structure, carried out by means of the method followed by the CEVIL[4], showed that it was possible to obtain greater shunt impedance[5]. Measurements and calculations on a quarter-scale model (Fig. 1) confirmed that the shunt impedance reaches 60 M Ω/m, e.g. 240 kW for a final energy of 1.16 MeV/nucleon.

Main-characteristics of the structure follow:

Resonant Frequency:	25 MHz
4 Associated Quarter-Waves:	total length: 10 m
Maximum Peak Voltage Input:	130 kV
Output:	550 kV (Fig. 2)
Maximum Power of Zi/A = 0.1:	240 kW
Drift Tubes Number:	54
Overvoltage Coefficient:	Q = 6000
Vacuum System:	One 30,000 1/sec oil diffusion pump with two refrigerated baffles.
Operating Pressure:	2 x 10-7 torr
Radio-Frequency Amplifier:	One CFTH delivering 300 kW for continuous operating and 400 kW for pulse operating with pulse from 0.8 to 2.5 ms duration and from 2 to 16 ms repetition.
Cavity Coupling:	75 Ω feeder with rotatable loop.

A cross-section of the structure is given in Fig. 3.

Focusing System

A few years ago many focusing systems were suggested which used the electric field itself to obtain focusing effect; this can be realized if we abandon the cylindrical character of the electric field in the gap. Generally modifications of the drift tube shape or the g/L ratio increase the maximum electric field e.g. increase the length of the machine.

It could be expected that grids consisting of two parallel bands and twisted at 90° between two consecutive drift tubes (Fig. 4) would give a field dissymmetry similar to that of rectangular boxes.

Calculations were made by the Smith and Gluckstern method but with different radial impulses in two planes[7]. It was found that phases greater than -20° leads to stable motion (Fig. 5) and transparency would increase by a factor 1.5.

Measurements on a linear accelerator, already used for another focusing system[8], have been made with the following parameters:

Voltage Injection:	17.6 kV
RF Peak Voltage:	7.5 to 11 kV
sy Calculated:	-20°
Zi/A = 0.25	
Frequency = 20 MHz	
Drift Tubes Number:	23
Total Length:	1.20 m
Grids Diameter:	12 and 15 mm (Fig.6)
Diameter of the Injection Aperture:	6 mm
Accelerating Mode:	$L = \beta\ \lambda/2$
g/L Ratio:	0.37

The total measured efficiency was 14% without buncher. The theoretical values of the efficiency (transparency included) was between 12.8% and 16.6%. On the Fig. 7 we can see the energy spectrum with a fundamental peak near 200 KeV and with an energy spread of ± 0.5% at half width. With buncher (Fig. 8) the measured efficiency reaches 35 %, e.g. it increases the beam by a factor 2.4 which is a low value due to the length of the drift space.

Conclusion

In order to obtain the maximum efficiency, particularly in the range of mass 80, where the beam source current is not very important, this new grids structure could be interesting. With a shunt impedance of 60 MΩ/meter at 25 MHz the RF structure can be easily used for a continuous beam which is an important improvement. In the same way a harmonic bunching system is now being studied which will give a bunching factor greater than the usual 3.

References

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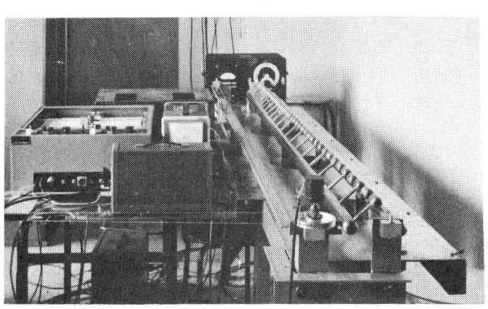

Fig. 1. View of the quarter scale RF structure model.

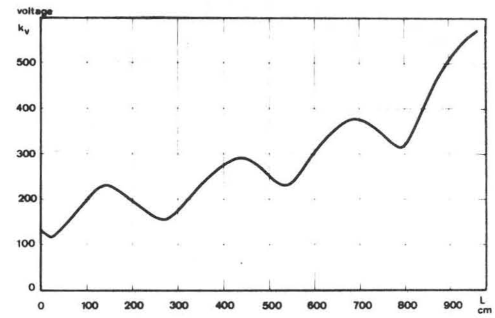

Fig. 2. Voltage distribution vs accelerator length.

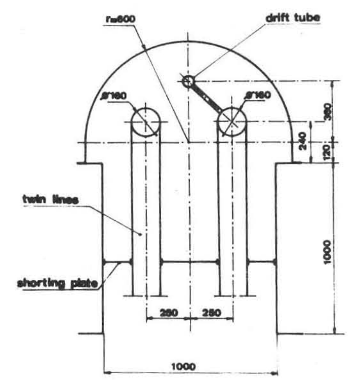

Fig. 3. Cross section of resonant line through the shorting plate.

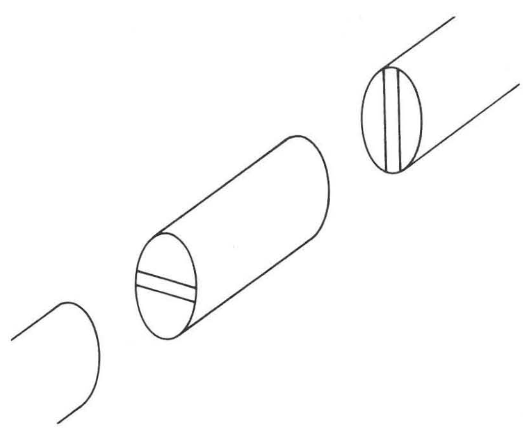

Fig. 4. Schematic view of the focusing system.

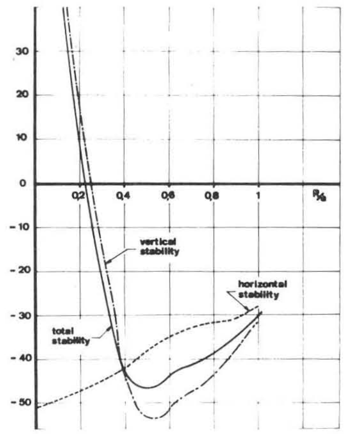

Fig. 5. Radial stability vs r/a for the grids of Orsay with g/L = 1/2.7 and g/a = 2.

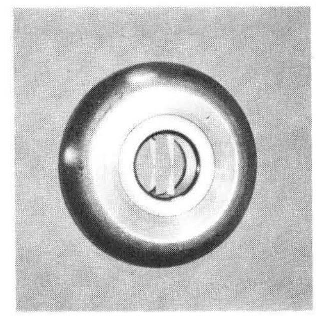

Fig. 6. View of grids.

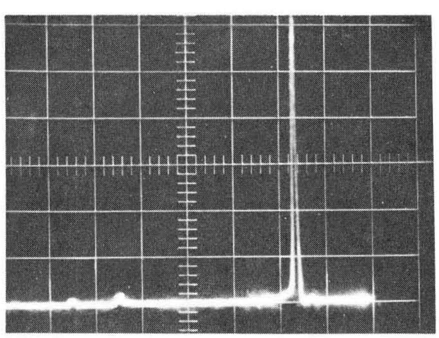

Fig. 7. Energy spectrum: maximum peak is near 200 KeV (23 KeV/square).

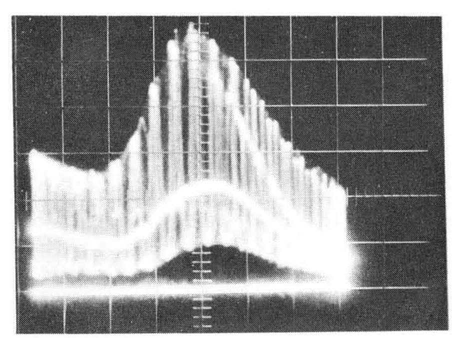

Fig. 8. Output beam with a modulated phase buncher.