ISTITUTO NAZIONALE DI FISICA NUCLEARE

Sezione di Milano

INFN/TC-84/23
18 Ottobre 1984

R.Bassini, I.Iori, A.Moroni and G.Taiocchi:

A COMPACT ELECTRONIC APPARATUS FOR THE BRAGG-CURVE ANALYSIS IN AXIAL IONIZATION CHAMBERS

Servizio Documentazione
dei Laboratori Nazionali di Frascati

Istituto Nazionale di Fisica Nucleare
Sezione di Milano

INFN/TC-84/23
18 Ottobre 1984

A COMPACT ELECTRONIC APPARATUS FOR THE BRAGG-CURVE ANALYSIS IN AXIAL IONIZATION CHAMBERS

R.Bassini, I.Iori, A.Moroni
INFN - Sezione di Milano, and Dipartimento di Fisica dell'Università di Milano

G.Taiocchi
Ditta TAKES, Ponteranica Bergamo

ABSTRACT

An electronic device dedicated to the analysis of the anodic signal of axial chambers has been constructed. The output signals consist of coincident analogic pulses for energy, Bragg-peak, energy loss and range. A description and the first tests with heavy ion beams are presented.

1.- INTRODUCTION

In recent years gas ionization chambers of the axial type, i.e. with the drift electric field parallel to the particle track, have gained in importance among heavy ion detecting systems[1-3].

The problem of the electronic handling of the anodic signal, which specularly reproduces the specific ionization of the ion in the detector, has been faced using waveform digitizers (a method that has still to be fully investigated[4,5]), or using standard analogic NIM modules[1-3].

In the last way the ion identification (energy, atomic number and, in some case, mass number, can be obtained from the Bragg-signal through the following quantities:

- the total energy E from the integration, over the time, of the specific ionization;
- the Bragg-peak amplitude from its maximum;
- the energy loss ΔE from the trailing part;
- the range R from the time length.

The task of extracting these four quantities and of presenting them to the data acquisition system as coincident pulses requires about a dozen of standard modules.

The apparatus here presented has been projected to allow a compact, simple to use, flexible and low cost device for the Bragg-signal handling. Furthermore coincident output pulses and the possibility of coincidences with other detectors are assured.

These peculiarities are expecially important in view of a large solid angle multi-chamber detecting system, for which axial chambers seem particurarly suited.

The characteristics and the performances of the apparatus prototype are hereafter described.

2.- DESCRIPTION OF THE APPARATUS.

The Bragg-signal analyser system (BSA-system) consists of two sections: the preamplifier-amplifier (BSA-PA) and the analyser (BSA).

The first section has to be located directly on the detector.

2.1.- BSA-PA

Fig. 1 shows a simplified block diagram for the preamplification-amplification section. Through the resistors R1, R2 the appropriate high voltage is supplied to the anode of the detector. The charges induced on the anode by the electrons drifting in the anode-grid region are fed by C2 to the A1 FET, which feedback capacitor is C4. A protection circuit has been introduced, to avoid FET damages. To minimize the influence of noises in the long connection to the BSA module, the integrated charge signal is immediately amplified to about 4 Volt through A2.

The time constant R5xC4 is $\sim$5 nsec so that the influence on the Bragg-signal (a few μsec long) is restricted to $\sim$0.1%. At this purpose

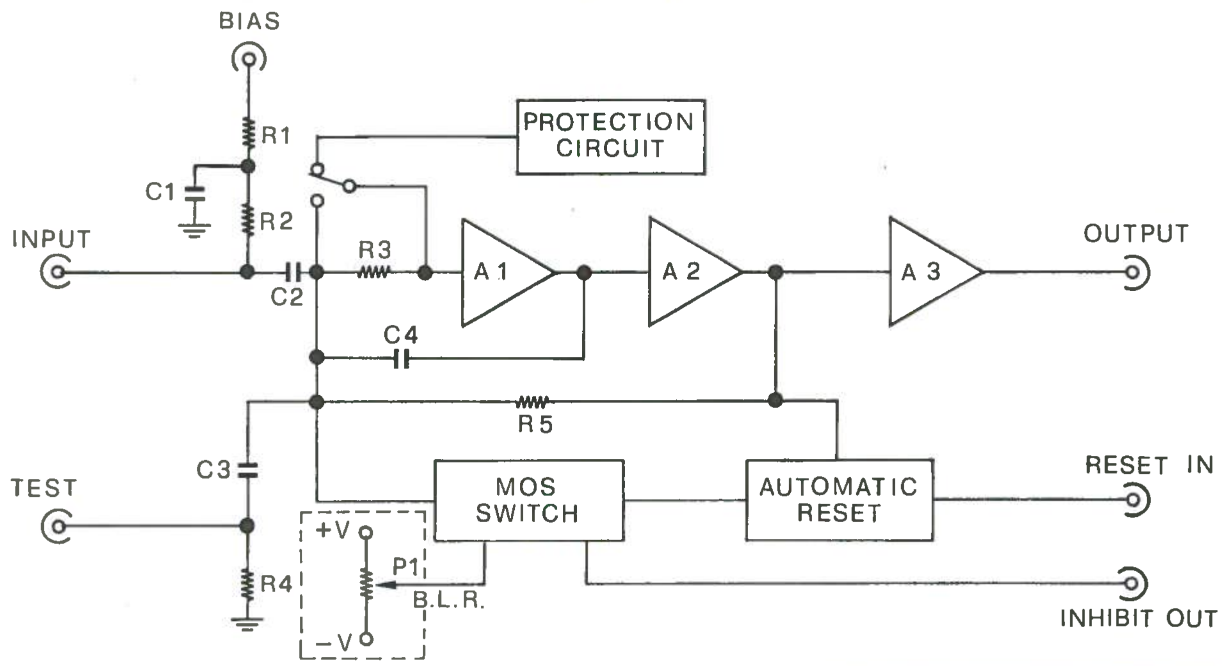


FIG. 1 - Block diagram for the preamplifier-amplifier.

R5xC4 could be increased further on, but in such way microphonic oscillations would not be suitably filtered. A3 assures a correct impedance matching with the BSA module.

The RESET IN signal, generated by the BSA module at the end of the analysis of each event, enables the AUTOMATIC RESET. This circuit, through the MOS SWITCH, restores the initial conditions of A1.

The AUTOMATIC RESET circuit contains also two comparators, which serve to check that the amplification stage is not operating out of the linear region. Whenever this happens, the AUTOMATIC RESET is enabled and a logic signal (INHIBIT OUT) is also generated to inhibit the BSA operation.

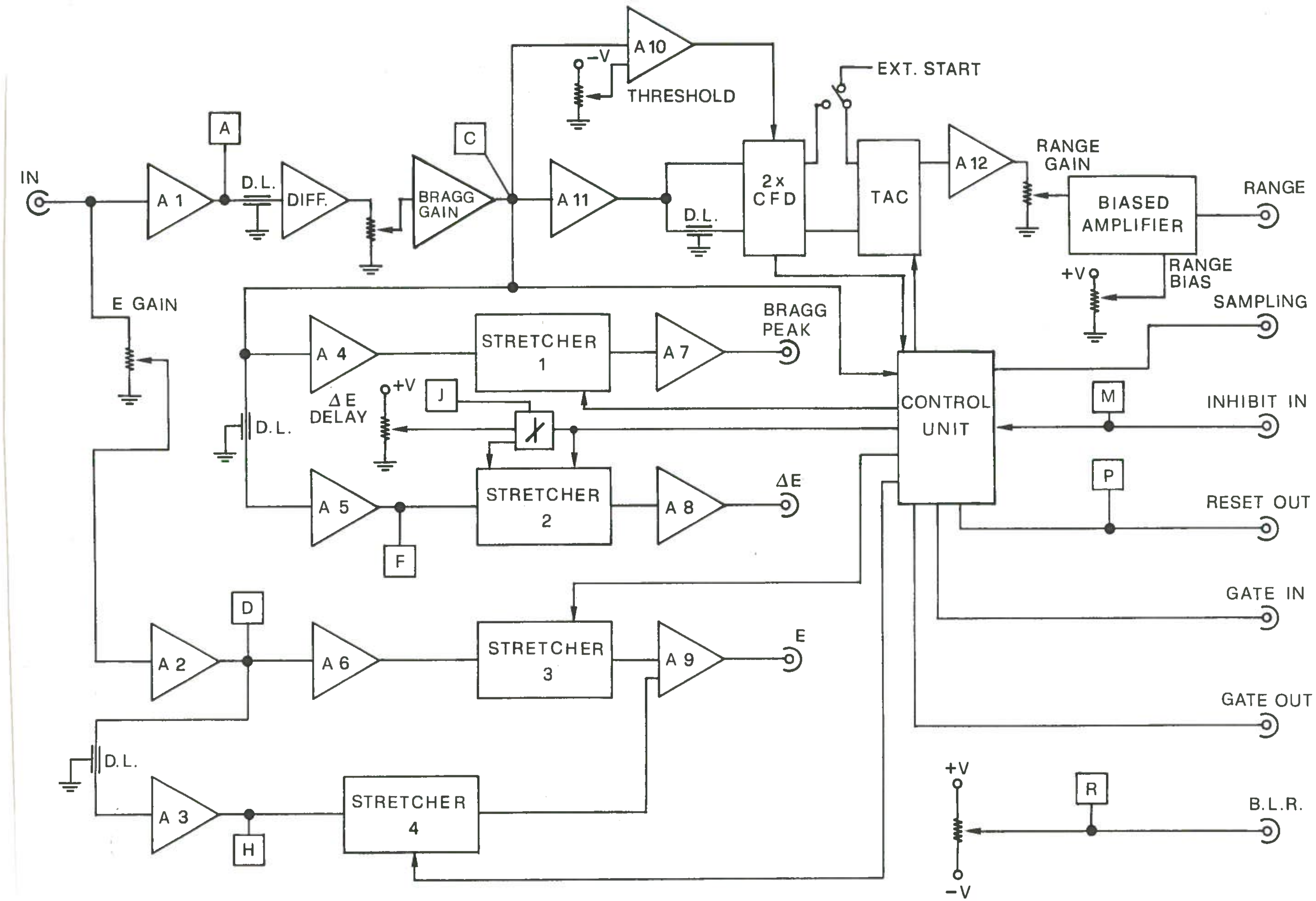
The BLR (Base Line Regulation), physically located in the BSA module, allows to adjust the level of the output signal.

2.2.- BSA

The block diagram of the analysing section is shown in Fig. 2. The signal coming from the BSA-PA output follows two different paths.

a) In the first, the maximum amplitude and the base line value are stored in the stretchers 3 and 4 and subtracted in A9 (Fig. 3a), giving the E information.

b) Along the second path the integrated charge-signal is differentiated by an operational amplifier and a delay line of 0.33 μsec, a value approximately equal to the transit time of the electrons in the grid-anode region.



<u>FIG. 2</u> - Bragg-signal analyser block diagram. The test points are as follows: A input signal, C gained Bragg-signal, D gained input signal, F delayed Bragg-signal, H delayed input signal, J ΔE delay, M inhibit pulse from BSA-PA, P reset pulse to BSA-PA, R level for BLR of BSA-PA.

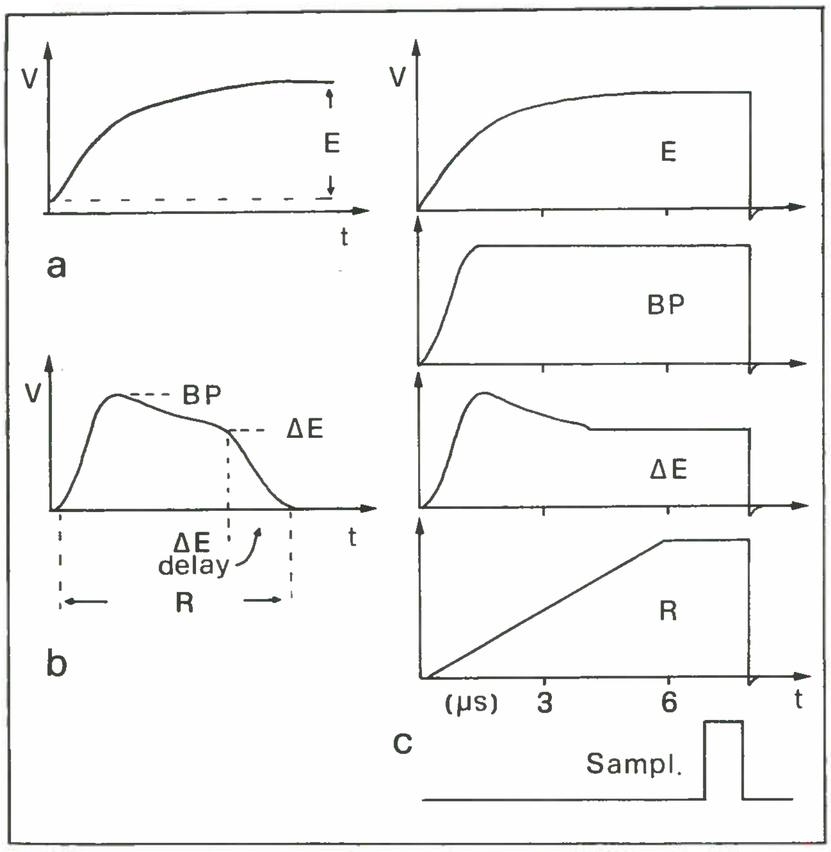


FIG. 3 - a) Extraction of E from the input pulse and b) of BP, ΔE, R from the Bragg-signal. c) Coincident output signals.

The resulting pulse resembles the Bragg-curve and is used to obtain the other wanted parameters. The stretcher 1 stores the maximum of the Bragg-signal, that is the Bragg-peak (BP) amplitude. The stretcher 2 stores an amplitude value (ΔE) in the trailing part of the signal. The time distance from the chosen point (Fig. 3b) to the end of the signal can be selected, in the range 0.5-2.5 μsec, using the ΔE delay potentiometer.

The range value is obtained as the time distance from the leading to the trailing part of the Bragg-signal using two constant fraction discriminators (CFD) and a time to amplitude converter (TAC) followed by a biased amplifier.

It is also possible to use an external START signal (for instance from fast detectors as PPACs or MWPCs), while the Bragg-peak occurence can be used as the STOP signal. This possibility allows to investigate the use of the rising time of the Bragg-signal as a parameter for the ion identification[6].

The CONTROL UNIT checks the stretchers and the TAC generating a logic signal when the analysis has been completed, that is all the output signals are present. This logic pulse has to be used as sampling trigger for ADCs and assures coincident signals for the data acquisition system. It could be used to trigger linear gates on the output signals but in this way it is no more possible to monitor the signal history (Fig. 3c), which is important for a prototype.

The end of the SAMPLING pulse enables a "general reset" to restore the initial conditions of the BSA and, through the RESET OUT, of the BSA-PA. The general reset is also enabled by the INHIBIT pulse from the BSA-PA section. The RESET, INHIBIT and SAMPLING connections are adapted to 50 Ohm impedance.

Fig. 4 shows in some detail the circuit used for the stretchers, based on two operational amplifiers. If the PEAK pulse is present, OA1 charges Cx up to the maximum value of the input signal. When the input voltage decreases, the polarization of the diodes D1 and D2 is inverted and the voltage across Cx, present also in the OA2 output, keeps constant. Cx in fact could be discharged only by the polarization current of OA2, however during the required storage time ($< 10\ \mu$sec) this effect is negligible. Finally, the transistors T2 and T3, triggered by the DISCHARGE pulse, reset the Cx charge to the initial zero value.

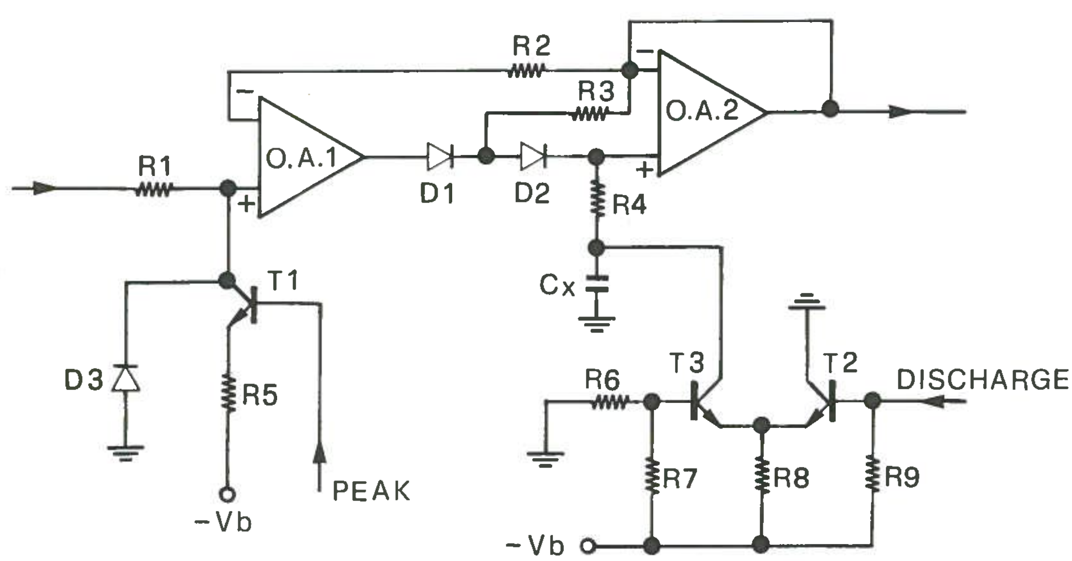


FIG. 4 - Stretcher circuit (see text).

Fig. 5 is a photograph of the two-slots BSA module. The ten-turn potentiometers (for E gain, BP gain and threshold, R bias and gain) are visible, together with the ΔE delay and base line (zero) trimmers. On the front panel the connections for the following signals are also visible: E, BP, ΔE, R, nine test points (cfr. Fig. 2) and gate in, gate out.

The last two connections allow coincidences with other detectors.

A Cannon connector (for RESET, INHIBIT and BLR) and the switch and connector for the eventual external START signal are located on the rear panel.

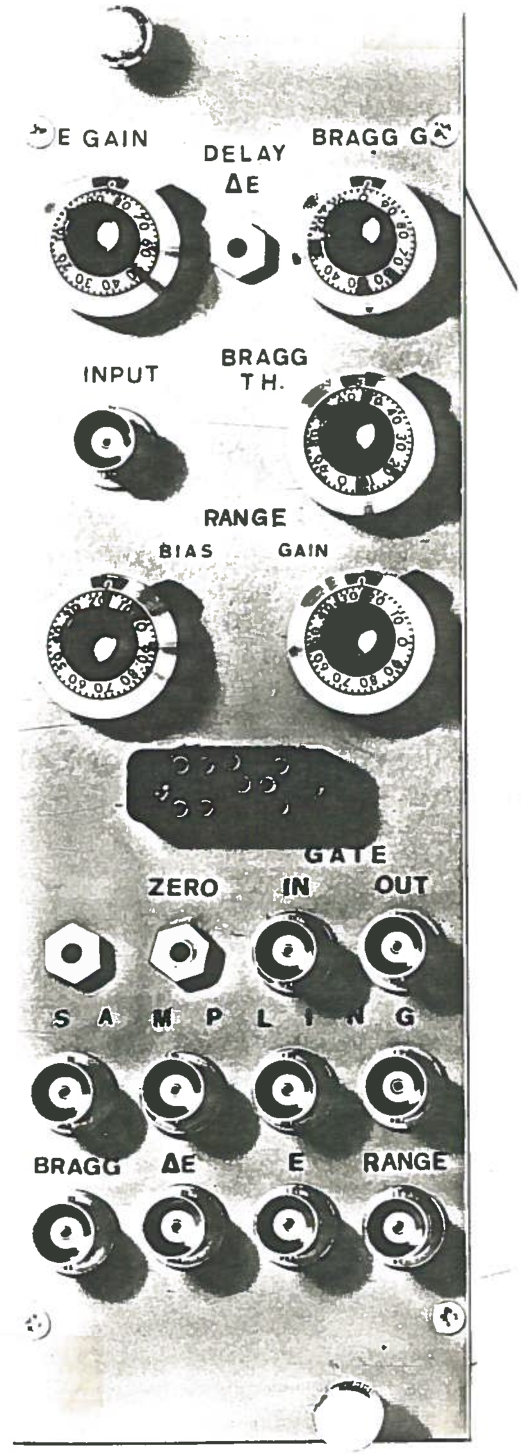


FIG. 5 - Front-panel view of the BSA module.

3.- PERFORMANCES

The BSA system has been tested at the LNL Tandem facility and compared to the standard electronics using 143 MeV ^{32}S beam and Au, Al, Ni targets (150, 80, 500 $\mu g/cm^2$ respectively thick). The Bragg-chamber, described elsewhere[(3)], was operated in P10 mixture with 1450 (1700) V as grid (anode) voltage. The reported experimental results refer to counting rates up to 1 kHz.

The BSA energy resolution is 0.73% (1.4%, 1.6%) for Au (Al, Ni) target. Same results have been obtained with the standard preamplifier-amplifier chain (Ortec 142B, 572 or Canberra 2021, 8 μsec shaping time). Only for the elastic scattering on Au a slightly better value (0.62%) has been obtained.

The Z resolving power, obtained using the BP information and 5 MeV energy bins is $Z/\Delta Z \sim 55$ for projectile-like fragments. The BP value (for Z = 16) is constant within 1% down to an energy of $\sim$65 MeV. These values refer either to the BSA module or to the standard amplifiers (Canberra 2021, Silena 7611/L) with 0.25 μsec shaping time.

Introducing an RC circuit (6.8 kΩ, 12 pF) on the bandwith control of the operational amplifier used to obtain the Bragg signal, Z resolving powers up to 78 have been measured. The BP variation as a function of energy is within 1% for $E > \sim 75$ MeV (Z = 16). Same results have been obtained with standard amplifiers and 0.5 μsec shaping time.

The energy loss and range resolutions for the BSA system are ~ 2-3% and 3-4% respectively. The corrisponding values for standard modules (Ortec 460, 474, 467, 473A, 542) are ~2.5-3% and 1.5-3%. The last result suggests the need of some improvement in the timing part of the BSA module.

The BSA system has been assembled with low cost components and we believe that high quality components will improve the performances of the apparatus and, in particular, the energy resolution.

However the main problem is the MOS SWITCH in the preamplifier. It does not operate satisfactorily at counting rates higher than 2.5 kHz. Its substitution with an optoelectronic feedback and the needed circuit refinements are already in progress.

4.- CONCLUSIONS

For the first time an electronic device, dedicated to the analysis of the anodic signal of an axial ionization chamber, has been built. The very first tests with heavy ion beams have shown that it can be used, satisfactorily and right now, to obtain energy and atomic number informations from the Bragg chamber, presently dedicated to the study of heavy ion reaction mechanisms.

REFERENCES

(1) - C.R.Gruhn, M.Bini, R.Legrain, R.Loveman, W.Pang, M.Roach, D.K.Scott, A.Shotter, T.J.Symons, J.Wounters, M.Zisman, R.Devries, Y.C.Peng and W.Sondheim, Nuclear Instr. and Meth. 196, 33 (1982).

(2) - Ch.Schiessl, W.Wagner, K.Hartel, P.Kienle, H.J.Korner, W.Mayer and K.Rhem, Nuclear Instr. and Meth. 192, 291 (1982).

(3) - A.Moroni, I.Iori, Li Zu Yu, G.Prete, G.Viesti, F.Gramegna and A.Dainelli, Nuclear Instr. and Meth. 225, 57 (1984).

(4) - G.R.Gruhn, Symposium on H.I. Physics from 10 to 200 MeV/n, Report BNL 51115 (1979), p. 471.

(5) - J.M.Asselineau, J.Duchon, M.L'Haridon, P.Mosrin, R.Regimbart and B. Tamain, Nuclear Instr. and Meth. 204, 109 (1983).

(6) - A.Oed, P.Geltenbort, F.Gonnenwein, T.Manning and D.Souque, Nuclear Instr. and Meth. 205, 455 (1983).