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OF NAI DETECTORS

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A LED SYSTEM TO CONTROL THE GAIN STABILITY OF NAI DETECTORS

M. Anghinolfi, M. Castoldi

Istituto Nazionale di Fisica Nucleare - Sezione di Genova
Via Dodecaneso, 33 - 16146 GENOVA ITALY

M. Albicocco

Istituto Nazionale di Fisica Nucleare
Laboratori Nazionali di Frascati - Frascati

Abstract.

An on-line LED pulser is proposed to control the overall gain (optical contacts, photomultipliers, cables and electric circuits) of a scintillator telescope. Corrections to long term gain fluctuations are discussed.

1. Introduction

Sodium iodide crystals are often used as charged-particle spectrometers at intermediate energies: the large dimensions, relative fast response and good linearity make these detectors suitable for experiments where wide solid angle and intermediate (few %) resolution are required. Unfortunately the total energy resolution and data reliability are often affected by the poor stability of the coupled phototubes. Infact many authors have observed gain fluctuations in fast phototubes wich are strongly correlated to the counting rate variations on the detector (1,2). Using pulsed accelerators we have detected both short time fluctuations, related to the sudden rise of the peak current and long time fluctuations following changes in the average beam current.

When the energy loss in the scintillator is measured the fast gain variations (1) lead to a decrease of resolution which generally remain inside the few percent limit; instead slow gain fluctuations, which can be as large as 20%, make very difficult the analysis when long collection times are necessary.

In this work we describe an on-line LED system, designed to control the overall stability of a charged particle detector in (γ , p) experiments, which can be however applied to a large class of scintillator spectrometers.

2. Experimental set-up

The charged particle spectrometer was, in our case, a scintillation telescope composed by a 3 mm thick NE102 dE plastic in coincidence with a 12 cm NAI energy detector.

Two green LED (HLMP - 3950) were positioned at the edge of each scintillator: in the plastic scintillator the optical contact was acheaved by a small lucite light-guide, since no detailed pulse-height control was required in the dE-branch. In the NaI

crystal good light collection was instead obtained inserting the LED inside a cylindrical hole carved in the edge of the lucite interface which is provided by the manufacturer to match the XP2041 phototube to the flat scintillator surface (fig.1a). The HLMP-3950 LED proved to be stable inside $1 \div 2 \%$ during several hour tests. Corrections to few percent fluctuations in the energy spectrum were however necessary in our experimental condition: the LED's stability was therefore continuously monitored using a high stability HP 5082-4207 photodiode. In order to get maximum sensitivity a 2π collection angle was obtained by direct optical contact of the sensitive photodiode surface to the LED light source (fig.1b,c) The low sensitivity of the fast HP 5082-4207 photodiode requires, for acceptable statistical uncertainty, a minimum light flux which would correspond, in fig.1 geometry, to overrange

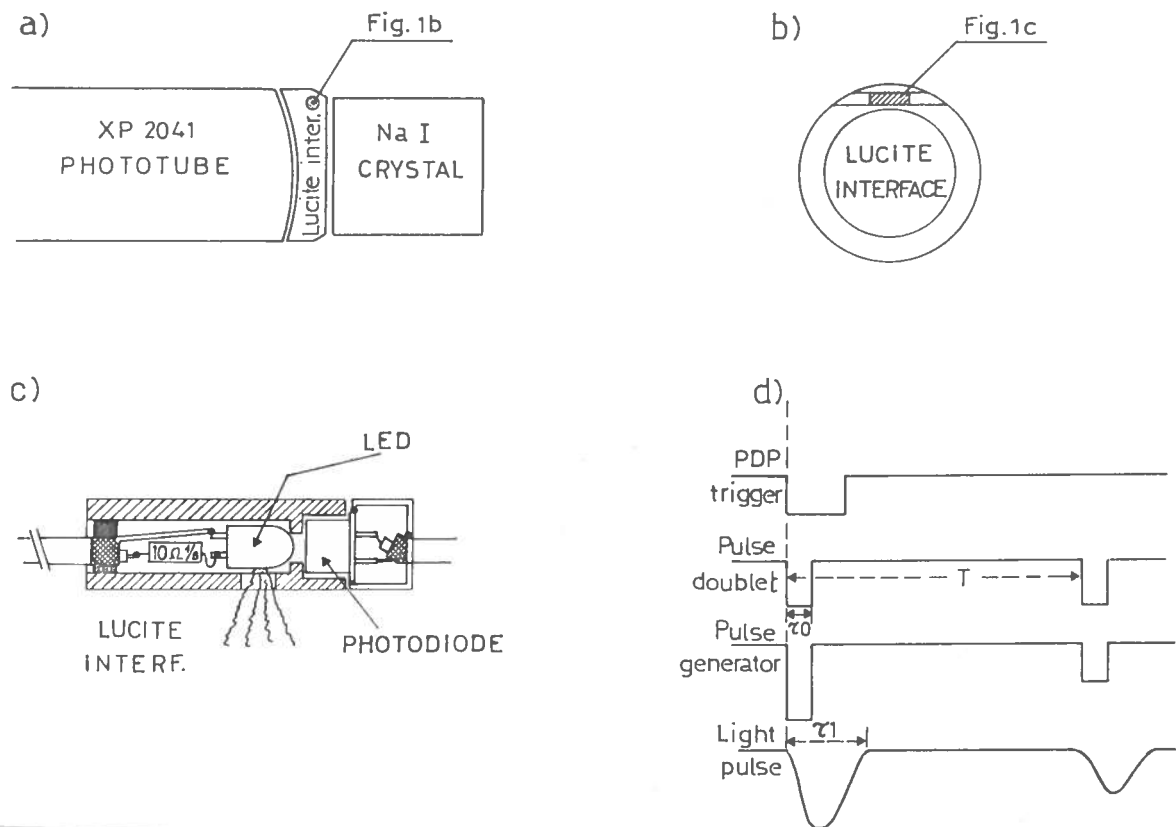


Fig.1 - Light pulser geometry in the lucite interface in successive details (a)-c)); d): trigger logic of the calibration pulses.

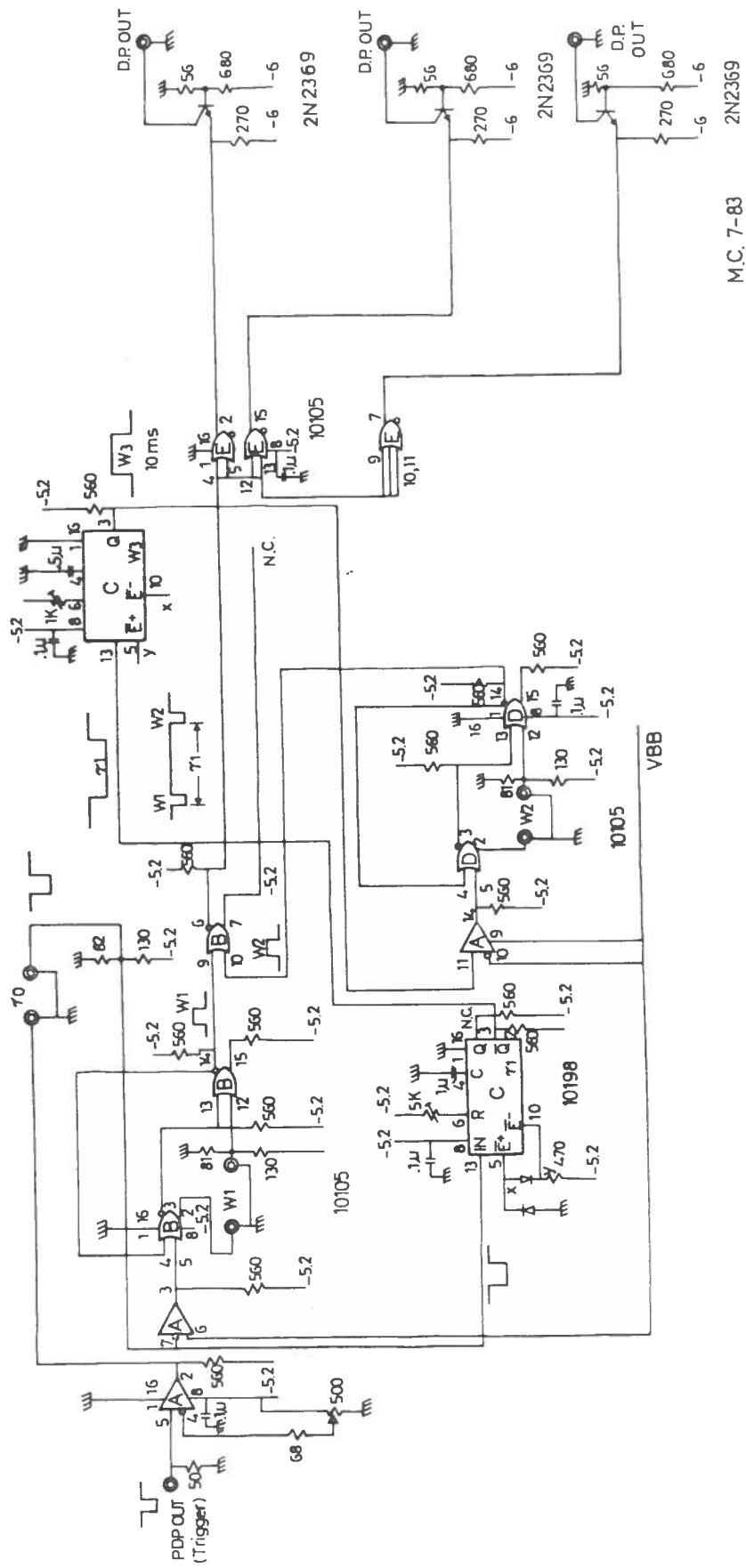
energy pulses at the phototube anodes: the light beam was therefore collimated toward the phototube by a calibrated hole as shown in fig.1c.

Since a complete linearity test of the whole system was required the LED was triggered by the pulse doublet of fig.1d): the time interval T between the two pulses was chosen to be 10 ms, well above the CAMAC conversion time. The couple of NIM pulses, having a separately calibrated width τ_0 ($\tau_0 \cong 30$ ns for both), is generated by the leading edge of a NIM pulse from the computer (fig.1d). These pulses are used to trigger a two level LED driver which systematically sets the first trigger at the lower level and the second at the higher one. The final light pulses observed at the phototubes anodes exhibit a 1:2 height ratio, calibrated to equivalent energies of respectively 50 and 100 MeV in the E scintillator, but a slightly longer width τ_1 ($\tau_1 \cong 100$ ns). The electronic circuit of the pair generator and of the LED driver are reported in detail in fig.2,3).

The stability control of the LED pulser is obtained integrating the current pulse from the HP 5082-4207 photodiode by a low noise, high stability FET preamplifier (3). The pulse height analysis of the phototube and photodiode current output is performed using fig.4) system which is, for the anode pulses, the same used in the actual experiment.

3. Data analysis

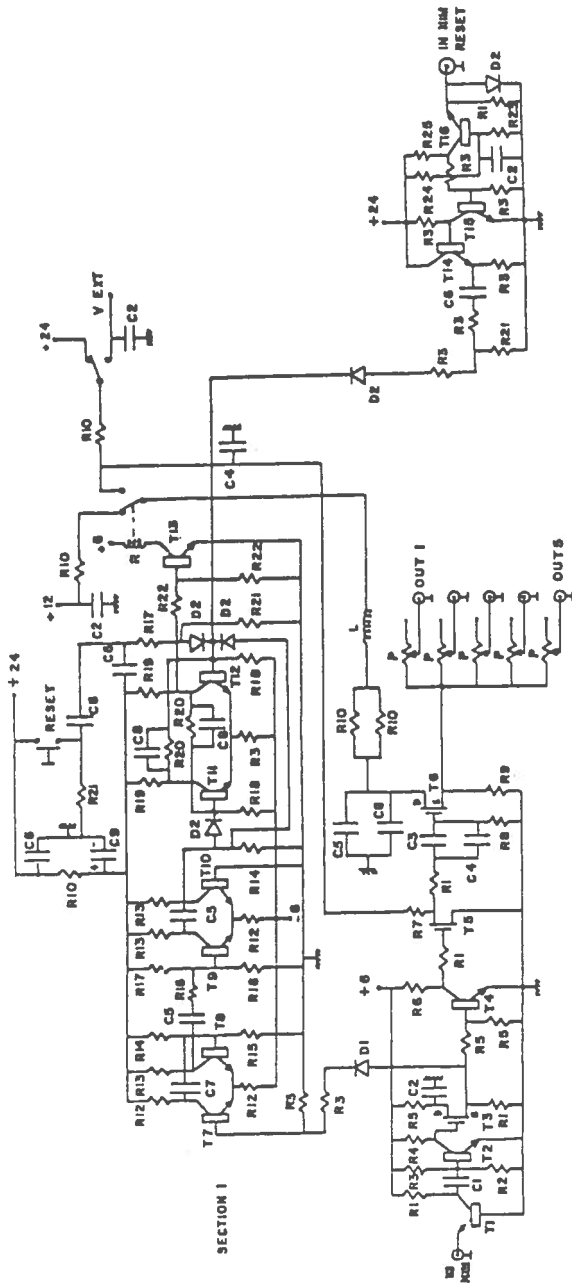
Tests were regularly performed in 10 minutes during several days and the results are reported in fig.5). The upper rows show the integrated photodiode outputs Q1, Q2 and the corresponding integrated anode outputs E1, E2 as a function of time for the pulse doublet. If a linear response function is assumed for the system the energy output E of ADC1 (fig.4) is related to the input



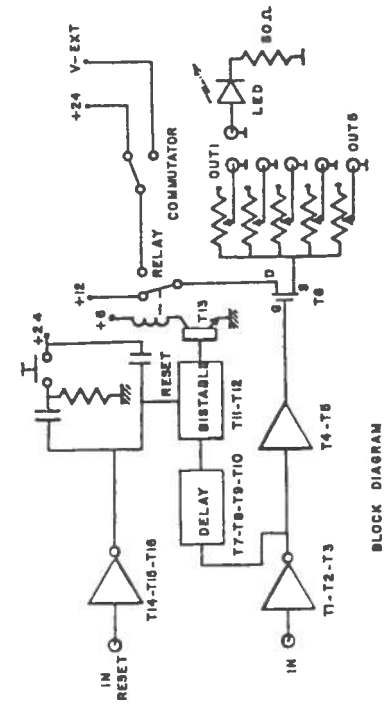
M.C. 7-83

2N2369

Fig.2 - Electronic schema for the generator of the pulse doublets



ELECTRICAL CIRCUIT



BLOCK DIAGRAM

- R1-50Ω
- R2-200
- R3-1 k
- R4-100
- R5-22
- R6-120
- R7-100/25 W
- R8-1M
- R9-100 /1/2 W
- R10-10/1/2 W
- R11-12 k
- R12-620
- R13-2.2 k
- R14-100 k
- R15-3.3 k
- R16-330
- R17-10 k
- R18-6.2 k
- R19-4.3 k
- R20-18 k
- R21-50 k
- R22-22 k
- R23-150
- R24-7.5 k
- R25-2.7 k
- C1-100 pF
- C2-0.1 μF
- C3-47 pF
- C4-10 nF
- C5-1 nF
- C6-2.2 μF
- D1=D2 IN4148
- T1-T2-T4 BSX27-2N2369
- T3-T5-T6 2N5661
- T7-T8 2N2369
- T9-T10 2N2219A - BSX30
- T11-T12 " "
- T13-T14 " "
- T15-T16 " "
- P - 1 k non inductive resistor

If not specified, resistances are of 1/4 W.

Fig.3 - Electronic schema for the LED driver.

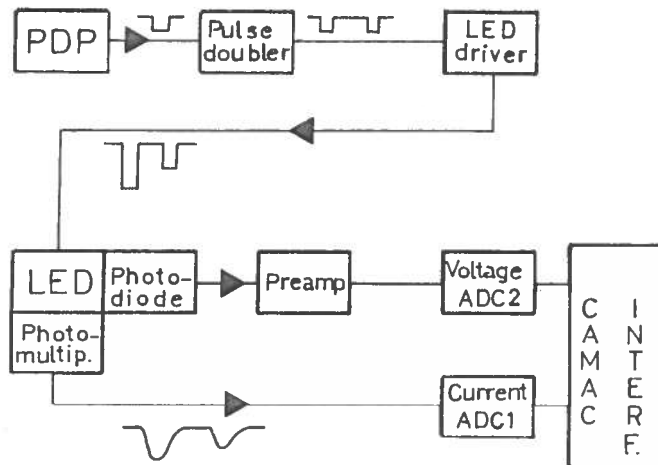


Fig.4 - Experimental set-up.

current pulse in the phototube by

$$E = a \int i dt + b \approx a'Q + b$$

where a is the photomultiplier gain in MeV/Coul. and b the overall pedestal in MeV. The integrated input current is proportional to the output Q of Voltage ADC2: a simultaneous measurement of E and Q affords therefore an accurate control of the system amplification and pedestal. The preamplifier stability and absolute gain are periodically controlled recording the ADC2 output corresponding to a standard pulse input.

The corresponding effective amplification a and bias b are separately reported in the two lower rows: fig.5 results show the remarkable stability of the LED pulser during several hours run which confirm the validity of the present calibration procedure. The observed E fluctuations are to be mostly ascribed to variations of the phototube gain, since the bias remained fairly constant during the whole experiment. These variations were found to be often correlated to counting rate fluctuations or interruptions.

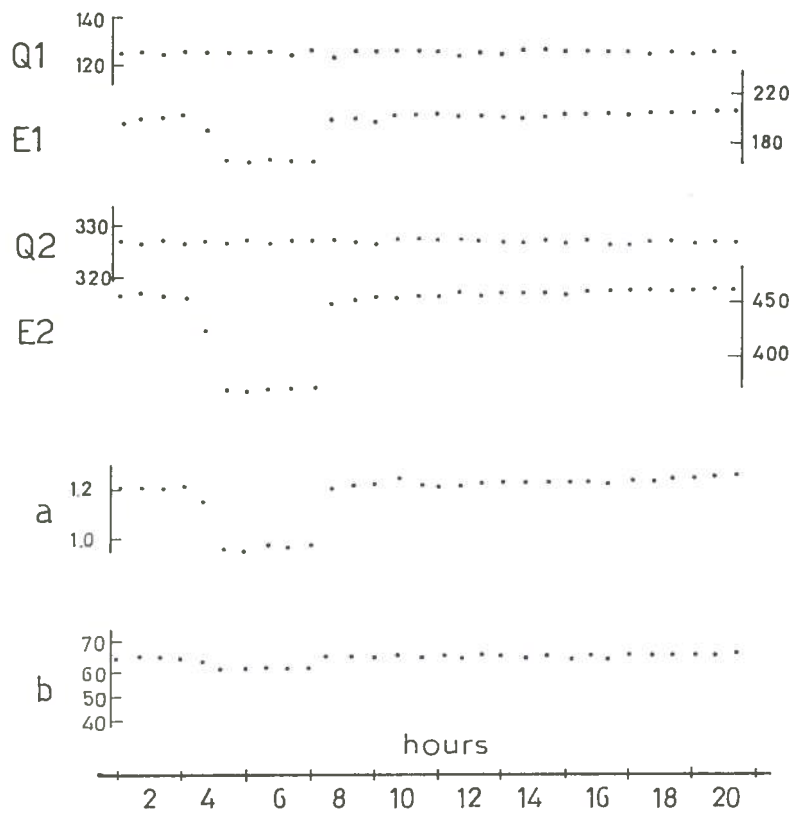


Fig.5 - Long term stability: the meaning of the symbols is explained in the text.

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R E F E R E N C E S

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