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A LED System to Control the Gain Stability of NaI Detectors.

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

PACS. 29.40. – Radiation detectors.

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 in which 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. In fact many authors have observed gain fluctuations, in fast phototubes which are strongly correlated to the counting rate variations on the detector (1,2). Using pulsed accelerators we have detected

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(1) F. CELANI, A. CODINO, U. CORÀ, R. FALCIONI, G. FELICI, G. LEVY, B. PIAZZOLI, G. MANNOCCHI, G. BOLOGNA, P. PICCHI and S. FELICIANO: *Nucl. Instrum. Methods*, **190**, 71 (1980).

(2) W. L. REITER and G. STENGL: *Nucl. Instrum. Methods*, **169**, 469 (1980).

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 achieved 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

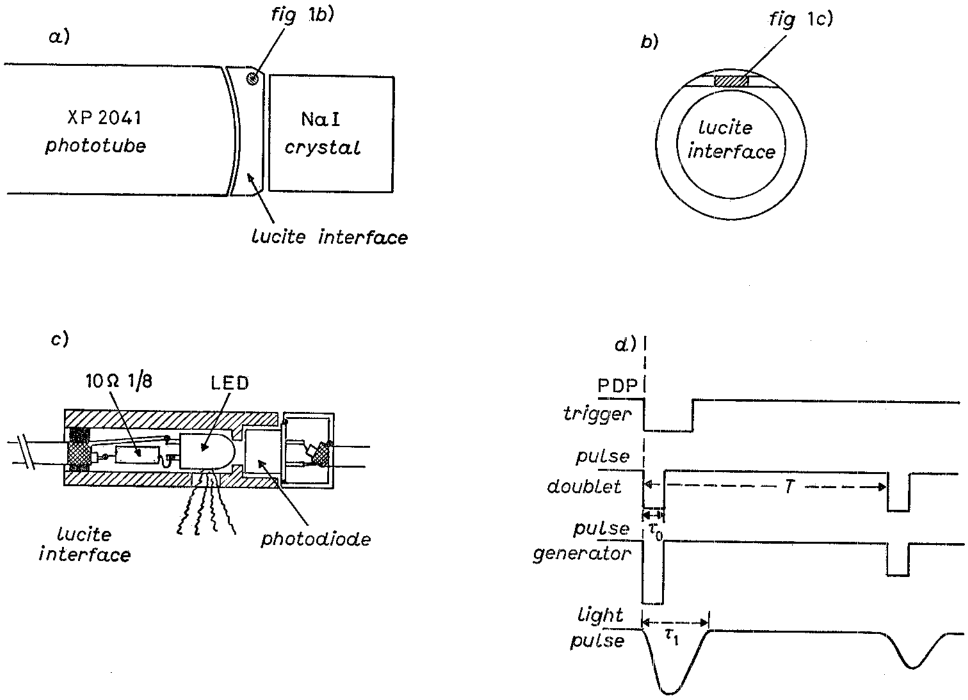

Fig. 1. – Light pulser geometry in the lucite interface in successive details (*a*)-*c*)); *d*) trigger logic of the calibration pulses.

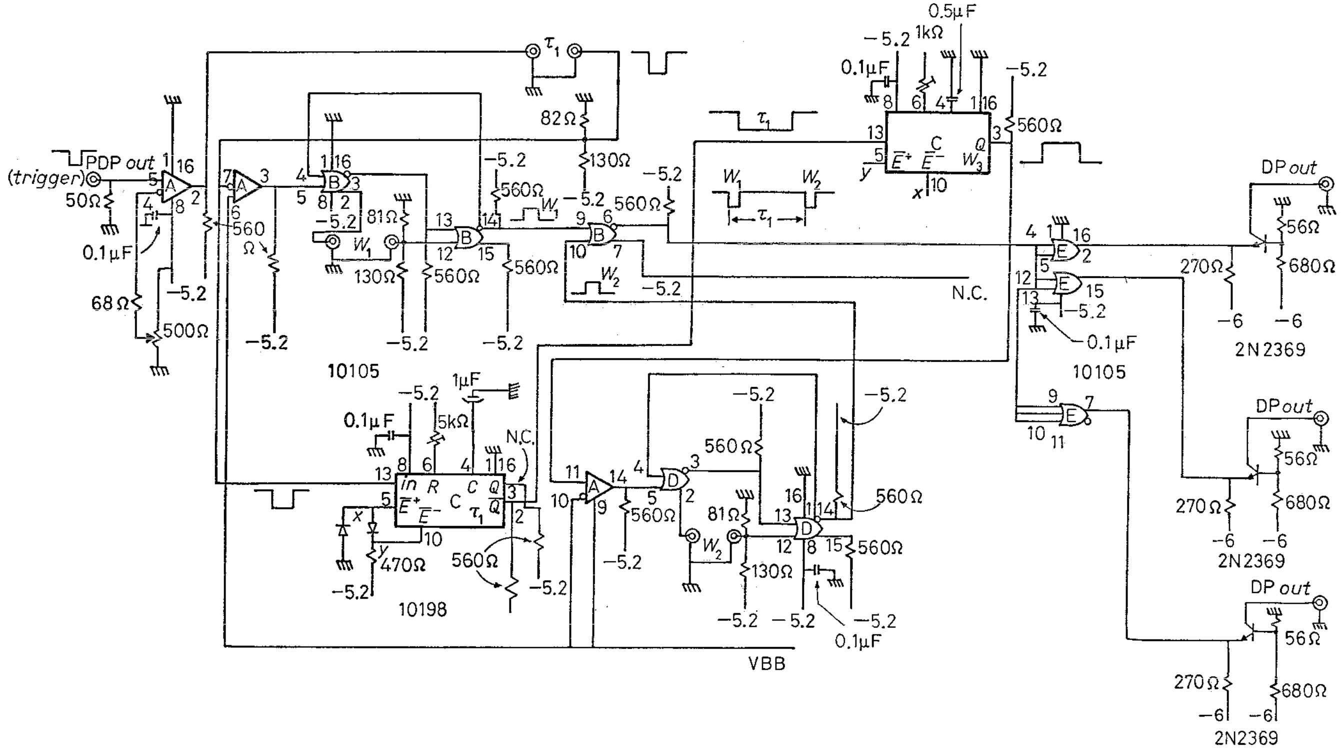

Fig. 2. – Electronic scheme for the generator of the pulse doublets.

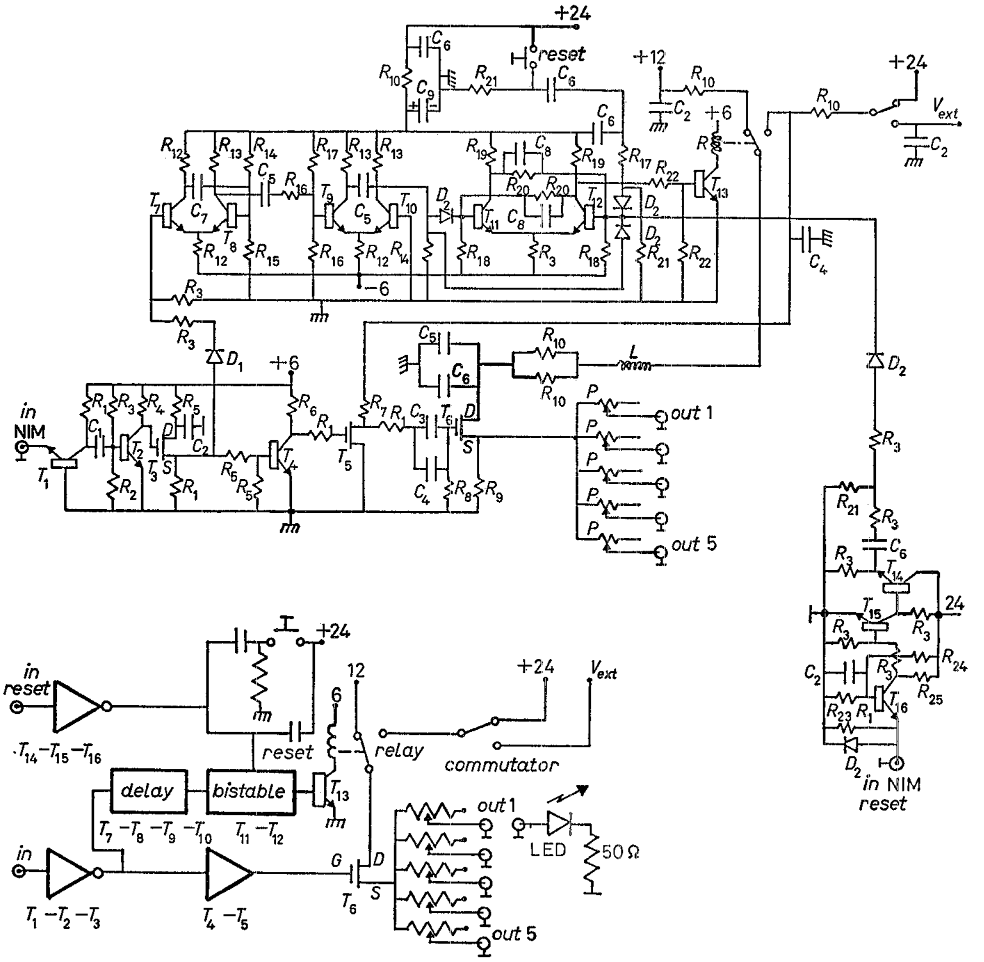

Fig. 3. – Electronic scheme for the LED driven: the list of components is the following.

$R_1 = 50\ \Omega$	$R_{10} = 10\ \Omega$, 0.5 W	$R_{19} = 4.3\ \text{k}\Omega$	$C_1 = 100\ \text{pF}$	D_1, D_2 1N4148
$R_2 = 200\ \Omega$	$R_{11} = 12\ \text{k}\Omega$	$R_{20} = 18\ \text{k}\Omega$	$C_2 = 0.1\ \mu\text{F}$	T_1, T_2, T_4 2N2369
$R_3 = 1\ \text{k}\Omega$	$R_{12} = 620\ \Omega$	$R_{21} = 50\ \text{k}\Omega$	$C_3 = 47\ \text{pF}$	T_3, T_5, T_6 2N6661
$R_4 = 100\ \Omega$	$R_{13} = 22\ \text{k}\Omega$	$R_{22} = 22\ \text{k}\Omega$	$C_4 = 10\ \text{nF}$	T_7, T_8 2N2369
$R_5 = 22\ \Omega$	$R_{14} = 100\ \text{k}\Omega$	$R_{23} = 150\ \Omega$	$C_5 = 1\ \text{nF}$	T_9, T_{10} 2N2219A
$R_6 = 120\ \Omega$	$R_{15} = 3.3\ \text{k}\Omega$	$R_{24} = 7.5\ \text{k}\Omega$	$C_6 = 22\ \mu\text{F}$	T_{11}, T_{12} 2N2219A
$R_7 = 100\ \Omega$	$R_{16} = 330\ \Omega$	$R_{25} = 2.7\ \text{k}\Omega$	$C_7 = 20\ \text{nF}$	T_{13}, T_{14} 2N2219A
$R_8 = 1\ \text{M}\Omega$	$R_{17} = 10\ \text{k}\Omega$		$C_8 = 15\ \text{nF}$	T_{15}, T_{16} 2N2219A
$R_9 = 100\ \Omega$, 0.5 W	$R_{18} = 6.2\ \text{k}\Omega$		$C_9 = 10\ \mu\text{F}$	P – 1 kΩ resistor

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

Since a complete linearity test of the whole system was required, the LED was triggered by the pulse doublet of fig. 1*d*): 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 $\tau_0(\tau_0 \simeq 30$ ns for both), is generated by the leading edge of a NIM pulse from the computer (fig. 1*d*)). 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 $\tau_1(\tau_1 \simeq 100$ 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

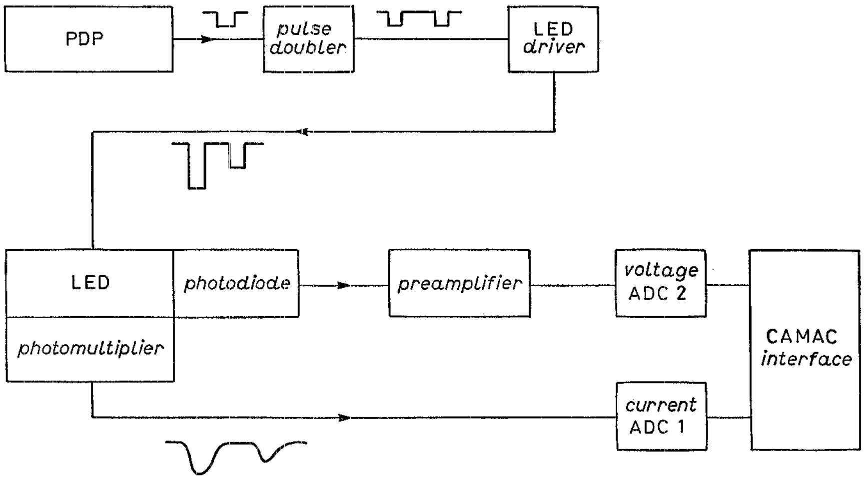

Fig. 4. – Experimental set-up.

preamplifier (³). The pulse height analysis of the phototube and photodiode current output is performed using the system of fig. 4 which is, for the anode pulses, the same used in the actual experiment.

3. – Data analysis.

Tests were regularly performed every 10 min 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 current pulse in the phototube by

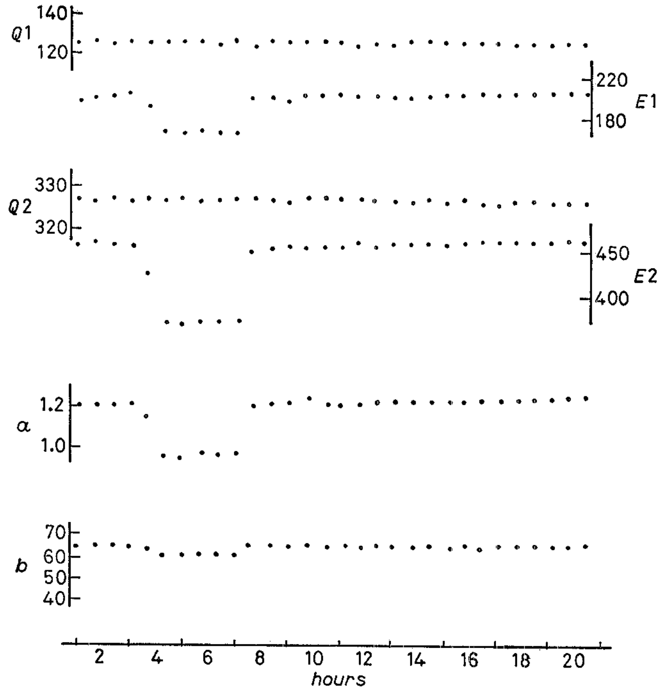

Fig. 5. – Long-term stability: the meaning of the symbols is explained in the text.

$$E = g\int i\,\mathrm{d}t + b$$

(³) F. Celani: private communication.

where g is the photomultiplier gain in MeV/Coulomb and b the overall pedestal in MeV. The integrated input current is proportional to the output Q of voltage ADC2: $\int i\,dt = a'Q$. 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 g and bias b are separately reported in the two lower rows: fig. 5 results show the remarkable stability of the LED pulser during a run of several hours while observed E fluctuations are to be mostly ascribed to variations of the phototube gain, since the bias remained fairly constant during the whole experiment. The effect of these variations on the collected events is evident: fig. 6*a*) shows a proton spectrum (row data) of the $D(\gamma, \mathrm{p})\mathrm{n}$ reaction at a fixed laboratory angle.

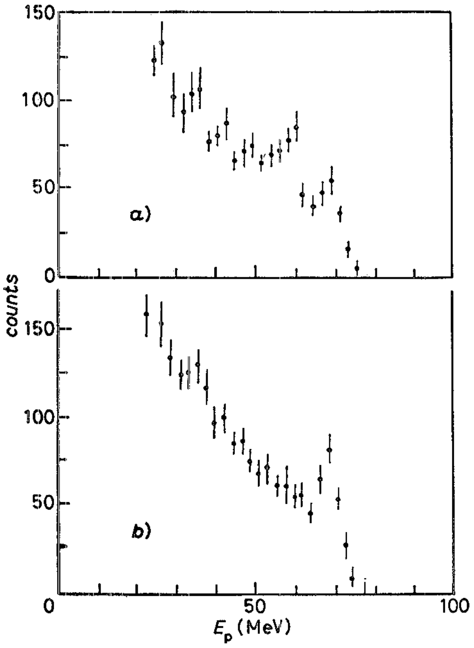

Fig. 6. – Collected proton spectrum with (*a*)) and without (*b*)) gain fluctuation correction.

Since the incident photon beam consists of a monochromatic peak plus a continuous bremsstrahlung tail, the corresponding proton spectrum should still mantain an analogous shape. Nevertheless no resolved peak is present (fig. 6*a*)) unless gain fluctuations are properly corrected. In this case the event of energy E', collected at phototube gain g', is recorded as $E = E'g/g'$ that is as if the phototube had a constant gain g during the whole collection time. Figure 6*b*) shows the effect of the correction on the spectrum of fig. 6*a*): the photoproton peak is now evident thus confirming the validity of the present calibration procedure.

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We are indebted to Prof. G. RICCO for many useful discussions and suggestions.

● RIASSUNTO

Si descrive un sistema a LED per il controllo on-line del guadagno globale (contatti ottici, fotomultiplicatori, cavi e circuiti elettrici) di un telescopio E, $\mathrm{d}E/\mathrm{d}x$ a scintillazione. Si discute inoltre la correzione delle fluttuazioni del guadagno a lungo termine.

Резюме не получено.

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