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V.I.Kryshkin, L.K.Turchanovich, V.G.Vasil'chenko

LIGHT YIELD DEPENDENCE OF SCINTILLATOR EXITED WITH UV LASER AND RADIOACTIVE SOURCE ON RADIATION DOSE

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Abstract

Kryshkin V.I. et al. Light yield dependence of scintillator exited with UV laser and radioactive source on radiation dose: IHEP Preprint 95-120. – Protvino, 1995. – p. 4, figs. 4, refs.: 2.

The scintillator light yield dependence on radiation dose was studied up to 1 Mrad. The results are independent of the fact whether the scintillator is exited with a UV laser or radioactive source, which allows one to control all the elements of scintillator calorimeters with the UV laser.

Аннотация

Васильченко В.Г. и др. Зависимость световыхода сцинтиллятора, возбуждаемого ультрафиолетовым лазером и радиоактивным источником, от радиационного облучения: Препринт ИФВЭ 95-120. – Протвино, 1995. – 4 с., 4 рис., библиогр.: 2.

Зависимость световыхода сцинтиллятора от радиационного облучения измерена до 1 Мрад. Результаты измерения не зависят от того, измеряется ли эта зависимость с помощью ультрафиолетового лазера или с помощью радиоактивного источника, что позволяет контролировать ультрафиолетовым лазером все элементы сцинтилляционного калориметра.

To control the performance of scintillator calorimeter radioactive sources or light pulses (lasers or diodes emitting light in the visible wavelength region, see, for example, [1]) are commonly used. Radioactive source calibration allows one to measure the light attenuation length of a scintillator and its uniformity, to use the absolute calibration scale obtained in a test beam as a reference when transporting the calorimeter to the experimental setup. Besides, this method can be used for a quality control at the assemblage stage. The disadvantages of it are the following:

– a complicated mechanics is needed to move a radioactive source along each scintillator;

– the measurement is time consuming;

– photodetectors must have an additional DC current output;

– stability, linearity, dynamical range, timing of the system (photodetectors, amplifiers, ADC) and determination of the photoelectron yield cannot be checked.

With the light pulses one can control the whole chain starting from the photodetectors except for the scintillators. Although the radiation hardness of plastic scintillators as the diviation of the light yield and transparency from their initial values are the main parameters which are to be checked.

If a scintillator light yield were unambiguously connected to the scintillator radiation damage, the functionality of the UV light control would be greatly enhanced.

We measured scintillator light yield against the radiation damage when exiting the scintillator with a radioactive source and UV light. The scintillator based on polystyrene doped with 1.5% pTP and 0.05% POPOP had the following dimensions: 140 x 28 x 4 mm. The narrow side of the scintillator was coupled to the photocathode of FEU-84, a black paper was glued to the opposite side. The samples were irradiated in a flux of γ-quanta from ^{137}Cs radioactive sources with a dose rate of 6 rad/s (or 190 Mrad/yr) in room temperature air.

The layout of the measurements is presented in fig.1. The scintillator was exited by a nitrogen laser (λ_{em}=337 nm) with 5 ns duration at 10 Hz frequency and by the radioactive source ^{90}Sr. In the first case the phototube pulse height was measured up to 3% precision by ADC with 90 ns length gate. When the scintillator was irradiated by ^{90}Sr, the DC current was measured with 2% precision.

The dependence of the phototube signal on the distance between the photocathode and the source is shown in fig.2 for different irradiation doses. The measurements are normalized at X=53 mm for the scintillator before irradiation. The dependence of the phototube signal on the dose for X=53 mm is presented in fig.3. The recovery of the scintillator light yield after irradiation is shown in fig.4. Within the errors both methods have yielded the same results.

Thus if each scintillator in the calorimeter tower is illuminated in turn by UV light the following conclusions can be drawn:

– if the pulse height from a single scintillator drops then something has gone wrong with light collection from the scintillator;

– if the pulse height from all scintillators drops proportionally then the most probable reason lies in the photodetector, high voltage supply or ADC;

– if the pulse height from several scintillators, say, in the shower maximum, drops, the scintillators have been radiation damaged.

Thus the UV laser can control all the elements of scintillator calorimeter. It is well-known [2] that the scintillator light yield exited by UV light does not depend on magnetic field in contrast to that exited with a radioactive source, which is an additional advantage for the UV light monitoring.

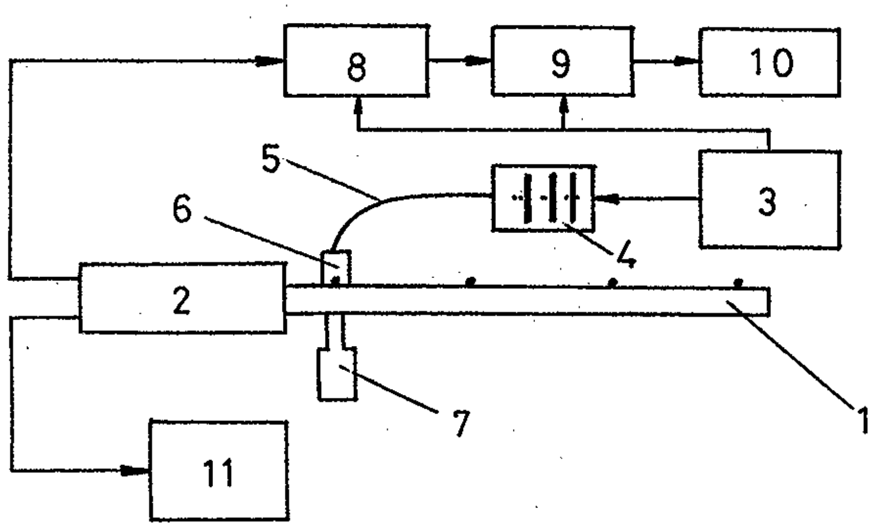

Fig. 1. The layout of measurements: 1 is a scintillator; 2 is a phototube FEU-84-3; 3 is a nitrogen laser LG-15U; 4 is a neutral filter; 5 is a quartz fibre; 6 is an optical connector; 7 is a radioactive source ^{90}Sr; 8 is ADC; 9 is data aquisition system; 10 is a personal computer; 11 is a digital voltmeter.

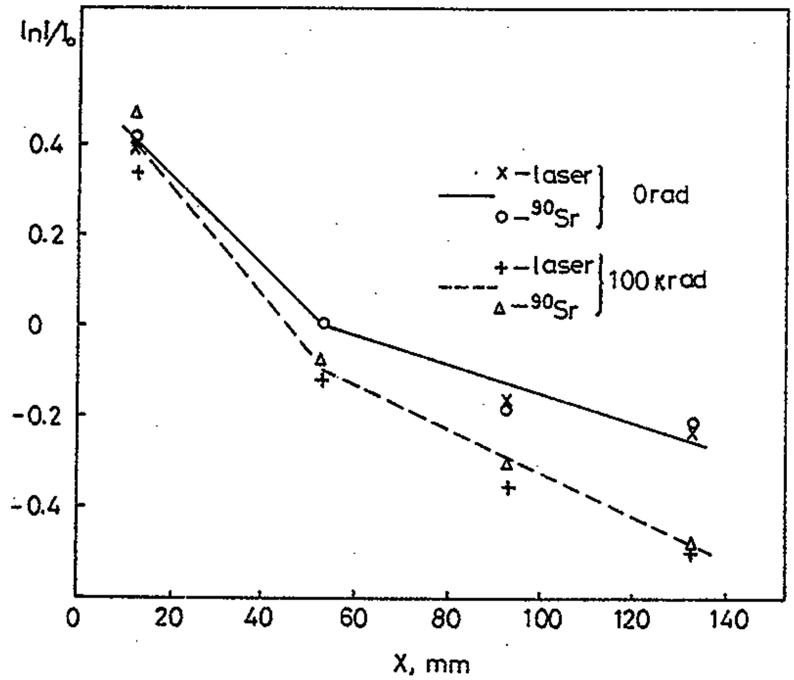

Fig. 2. The scintillator light yield dependence on the distance between the photocathode and the source (the laser or the radioactive source) without irradiation and for 100 krad absorbed dose (lines are drawn by hand to guide the eye).

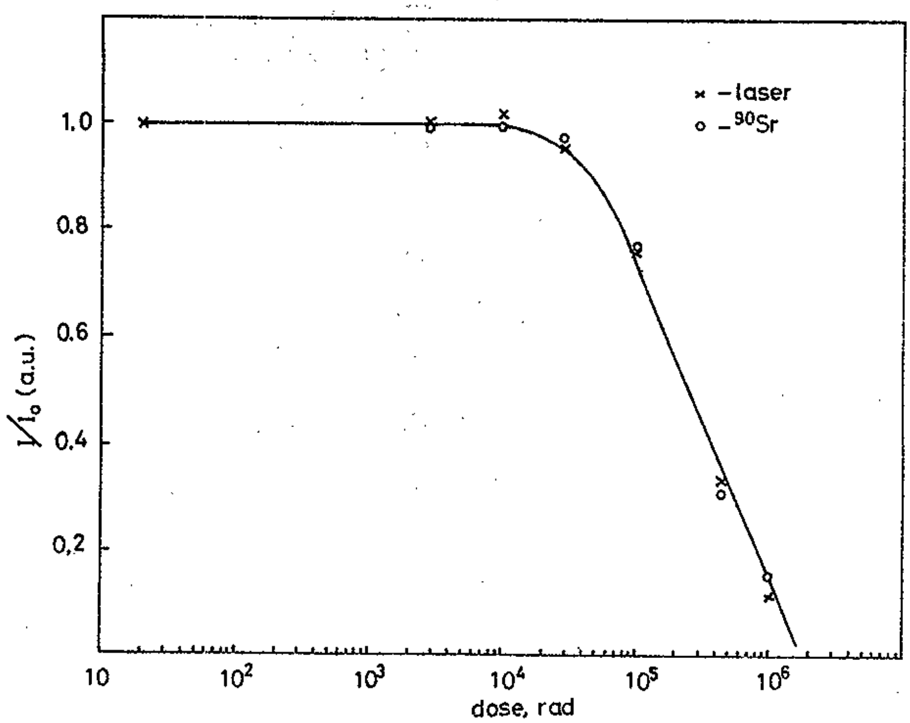

Fig. 3. The ratio of the light yield before and after irradiation as a function of the total dose (lines are drawn by hand to guide the eye).

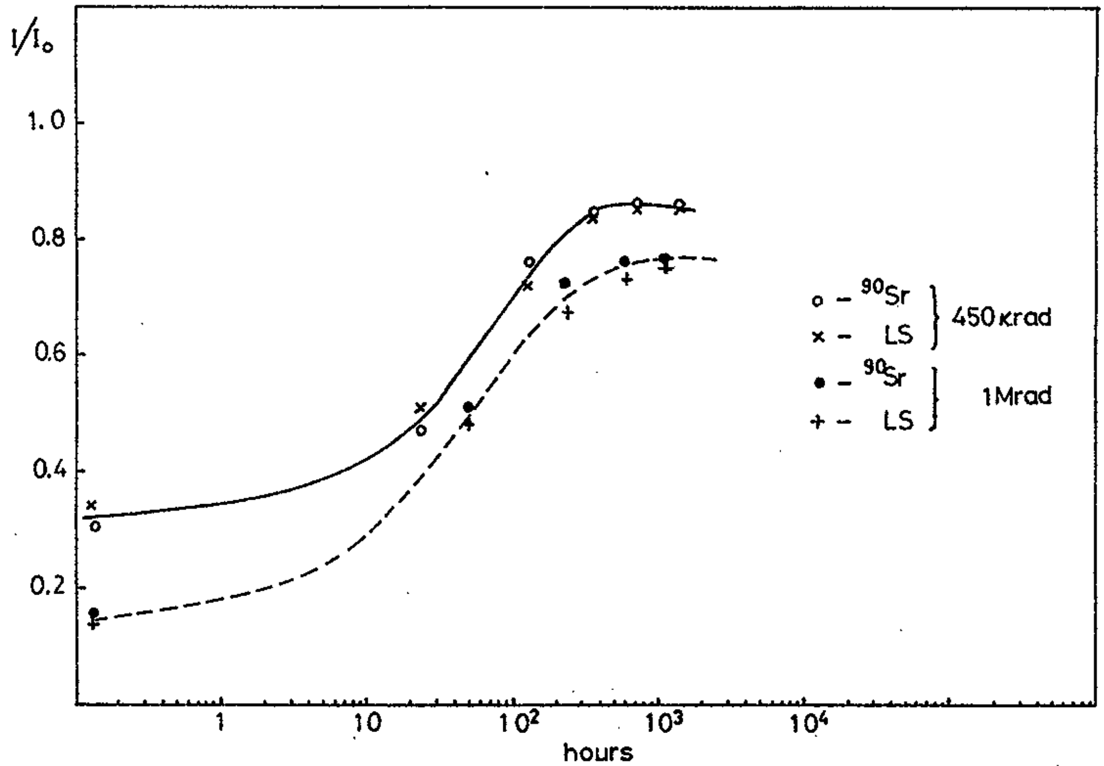

Fig. 4. The recovery of the scintillator light yield vs time after 450 krad irradiation (solid line) and 1 Mrad irradiation (dotted line) (lines are drawn by hand to guide the eye).

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В.Г.Васильченко и др.
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ГНЦ РФ Институт физики высоких энергий
142284, Протвино Московской обл.

Индекс 3649

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