The measurement of the pure CsI crystals scintillation properties

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This report describes the tests of 3 new pure cesium iodide scintillation crystals which were produced in Kharkov(Ukraine).

Pure CsI crystal is known as having the fast scintillation ($\tau \approx 10$ ns) contaminated with slow component ($\tau \sim 1000$ns). Due to the fast scintillation these crystals are proposed to use for the BELLE calorimeter upgrading.

The main goal of this work was to determine the number of photoelectrons (p.e.) in a signal per 1 MeV of deposited energy, ratio of the fast component intensity to total one (so called fast/total) and nonuniformity of light output for each crystal.

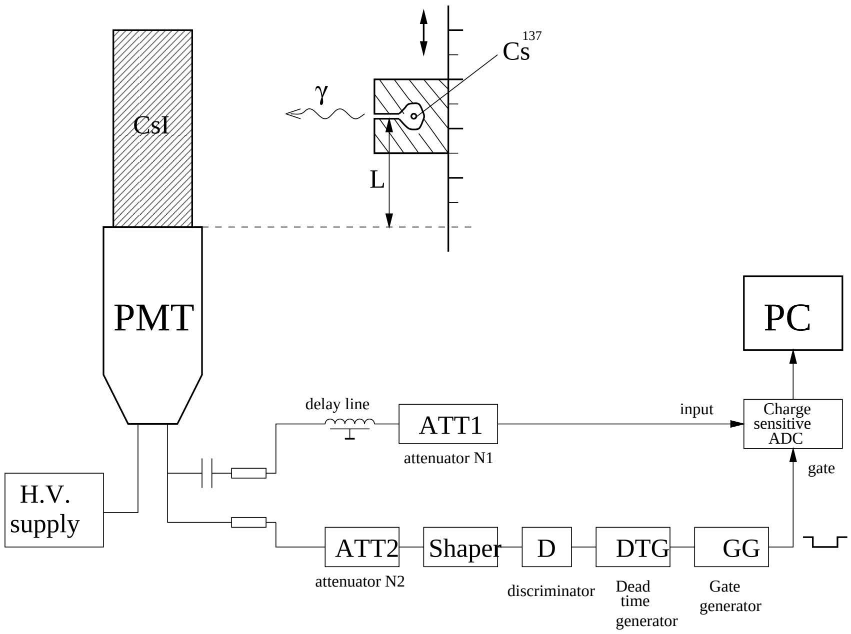

Figure 1: **Scheme of experimental setup.**

A scheme of experimental setup is shown in the Fig. 1

The γ-quanta from the collimated ^{137}Cs source ($E_\gamma = 662$ KeV) penetrated into the CsI, providing the light flashes. The light signal is transformed into electrical one by photomultiplier tube (PMT HAMAMATSU H3177 S/N BA 0754).

The current pulse from PMT is integrated by charge sensitive ADC during the time interval which is defined by gate generator (see Fig. 1). An information from ADC is passed to PC, where a histogram of collected charge distribution is filled.

The crystals of truncated pyramid geometry (base $\approx 6 \times 6$ cm, top $\approx 5 \times 5$ cm, length=30 cm) have all polished surfaces. Each crystal was wrapped with a white porous teflon foil of 200 μm thick as a diffusive reflector, which was covered by aluminized mylar film. PMT can be coupled to crystal with an optical contact (OC) or without it. The light read out was performed always from the larger edge of the crystal.

To calibrate the scale of the histogram in p.e. a single electron peak was measured. For that the pulse height spectrum without any scintillator and source was collected. This spectrum is provided mostly by the single electrons of thermoemission from photocathode.

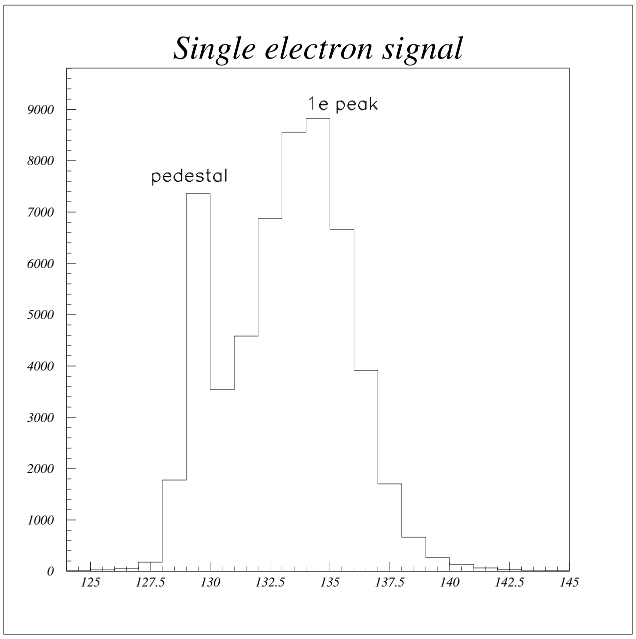

Figure 2: **Single electron peak.**

In the Fig. 2 the single electron peak can be clearly seen (right) while the left edge of the histogram corresponds to the pedestal. So, the number of ADC channels per one electron is:

$$A_{1e} = A_{peak} - A_{pedestal}.$$

To ensure in a good work of experimental setup we performed measurements with reference (test) crystal first which has well-known characteristics. The sizes of the test crystal are $3.5 \times 3.5 \times 4 cm^3$.

For fast component measurement the gate width of $\tau = 100$ ns was used, while for the total signal it was $\tau = 1000$ ns.

The Fig. 3 shows fast component and total signal spectra for the test crystal. Also we studied the dependence of a signal on the gate width τ. The results presented in Fig. 4 shows that the light output is not saturated yet at 1 μsec and the slow component has, probably, much longer decay time.

Then we studied three crystals of pure Cesium Iodide:

I — Crystal M.C.07-300.61,6
003 02.01

II — Crystal M.C.07-300.60,5
001 02.01

III — Crystal M.C.07-300.60,5
002 02.01

The histograms for fast and total signal spectra for the I-st crystal are presented in the Fig. 5. The Fig. 6 shows the light output in dependence of the position of the collimator – L (see Fig. 1). The PM position is at L=0. The light output from the narrow side of pyramide is less than at wide one. Since the natural nonuniformity of the pyramide has the opposite trend the present effect can be explained by the scattering or absorbtion of the light inside crystal. Such centers looking like light fog can be really observed. We define the nonuniformity as:

$Nonun = \frac{max - min}{average}$,where:
max — maximal value of a signal spectrum peak (in p.e.);
min — minimal value of a signal spectrum peak (in p.e.);
$average = \frac{max+min}{2}$.

The results for all crystals are presented in a table 1.

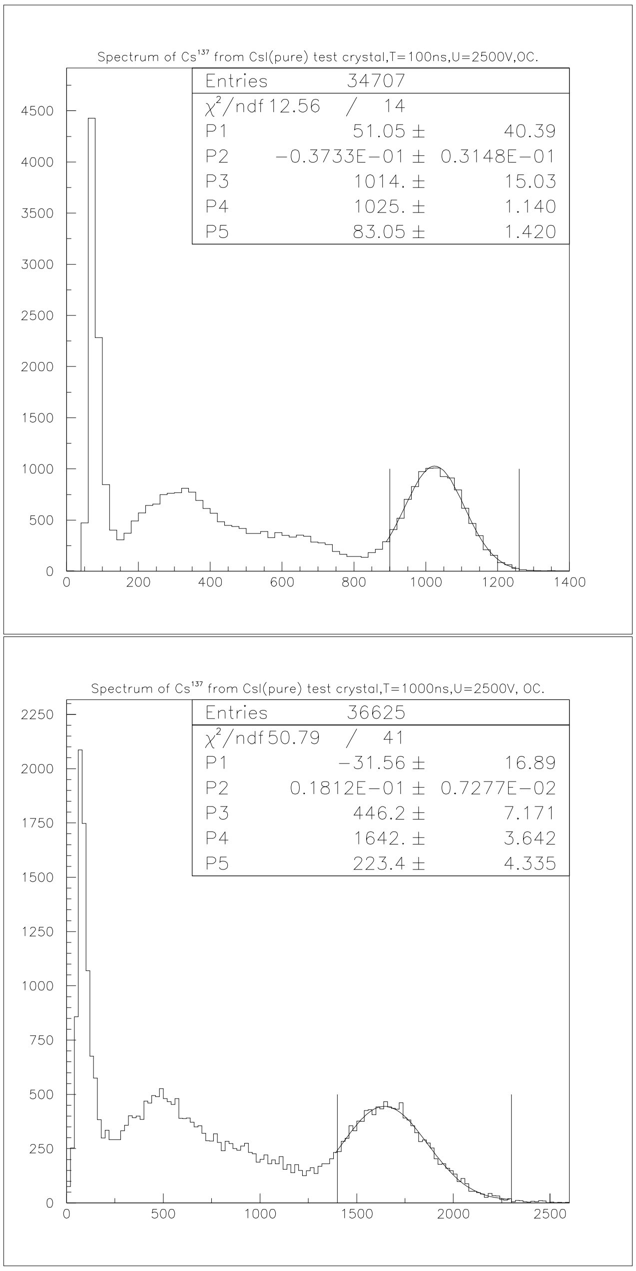

Figure 3: **Fast component and total signal spectra for test crystal.**

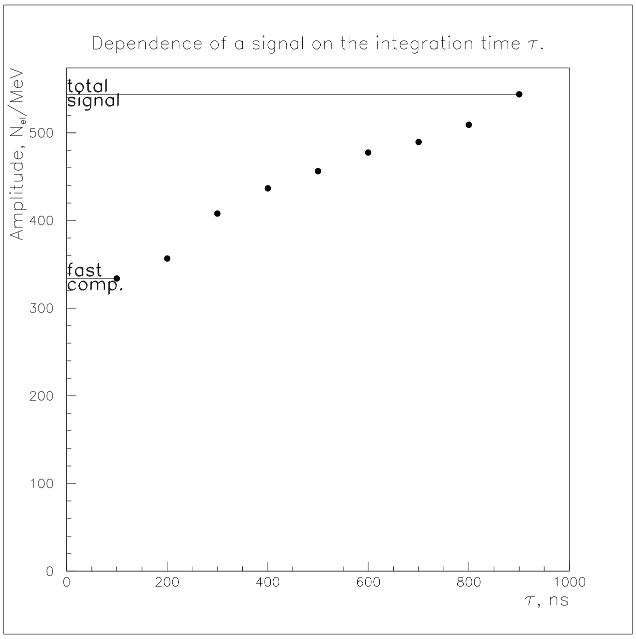

Figure 4: **Dependence of a signal from test crystal on the integration time τ.**

Table 1: **Results of measurements**

Crystal	$N_{p.e.}$/MeV, $\tau = 100ns$ no OC.	$\frac{fast}{total}$ no OC.	$N_{p.e.}$/MeV, $\tau = 100ns$ with OC.	$\frac{fast}{total}$ with OC.	$Nonun.$ with OC.
test	216	0.62	334	0.61	—-
I	—-	—-	154	0.73	0.12
II	—-	—-	202	0.69	0.22
III	—-	—-	236	0.70	0.26

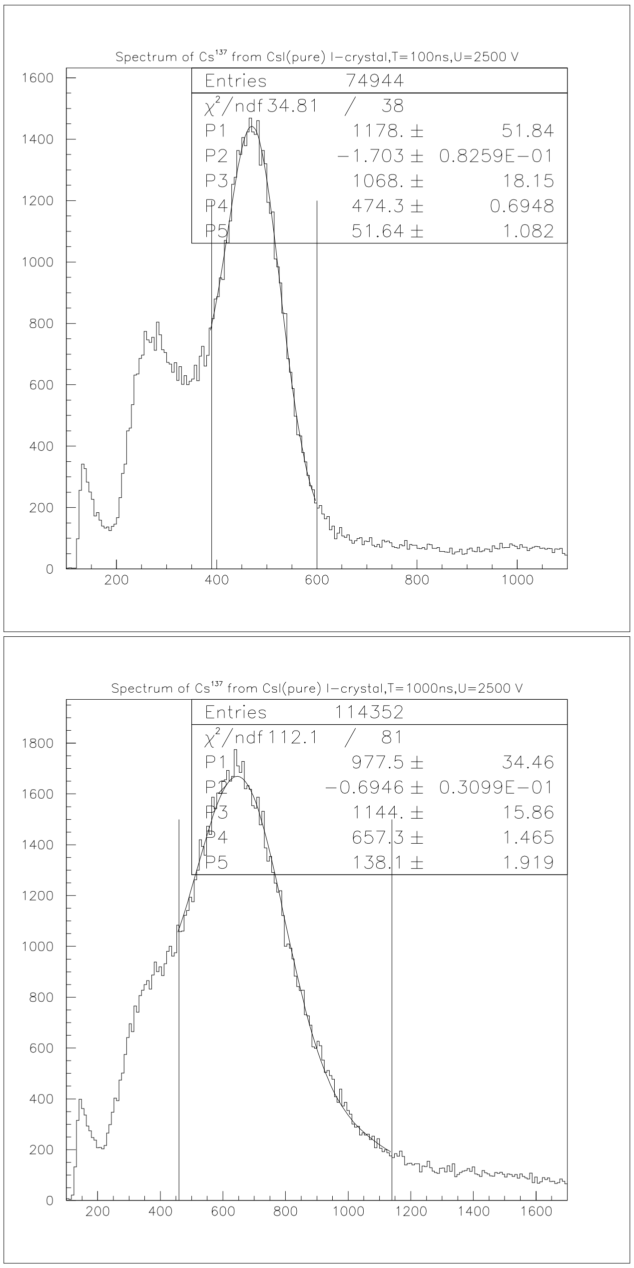

Figure 5: **Fast component and total signal spectra for the 1-st crystal.**

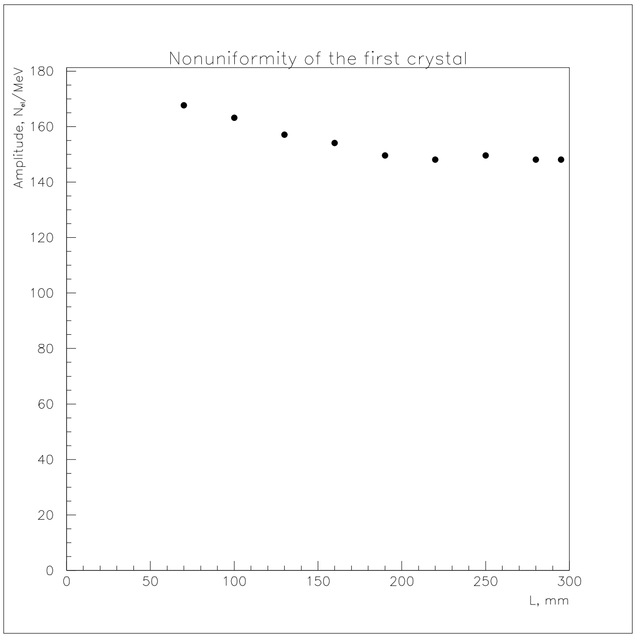

Figure 6: **Dependence of the 1-st crystal signal on the position of collimator. The PM position is at L=0**

As it is seen from the Table measured light output is high than it was assumed for earlier estimation (it was expected as 100-120 ph.e. per 1 MeV), while the light output uniformity does not satisfy to the specifications (10%). The "fast to total" ratio meets the usual requirements.