Analysis of ACCOS system results reproducibility and results of first pre-mass production PWO certification

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LAPP-EXP –99.07

october 1, 1999

Analysis of ACCOS System results reproducibility and results of first pre-mass production PWO certification

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Abstract

One of the most important requirement of the ACCOS system is the reproducibility of the results of measurements. Series of measurements dedicated to the analysis of the results reproducibility were made. The data presented show high reproducibility of the measurement results obtained with the ACCOS system and allow one to consider this system suitable for certification of the PWO crystals in conditions of long-term mass production.

The first full-sized tests of the PWO crystals on the ACCOS system were carried out with the purposes of fine-tuning a method for the routine certification of the crystals parameters and to test the system itself. The PWO crystals produced at the Bogoroditsk Techno-Chemical Plant in the framwork of the mass production preparation were used for these tests. In total, 35 full-sized PWO elements including 20 crystals of the first pre-mass production lot of 100 PWO crystals were analysed. The results presented show that the proposed approach to the PWO crystals certification and the equipment for its realization, including the ACCOS system allow one to provide reliable certification of the scintillators for CMS ECAL construction.

Analysis of the reproducibility of the measurement results obtained with the ACCOS system

One of the most important requirement of the ACCOS system is the reproducibility of the results of measurements [1]. A series of measurements was made dedicated to the analysis of the results reproducibility. During this research repeated measurements ,made after switching off the system for different period of time (from tens of minutes up to 2 days) ,were carried out.

A series of 10 measurements was carried out in order to verify the reproducibility of the results of light yield and scintillation kinetics measurements. On Fig. 1 (a, b) there are typical results of measurements of light yield (a) and scintillation kinetics (b) obtained for crystal No.2098R at the position of the gamma-quanta source at 135 mm from the front side of the crystal. For all measured crystals the light yield results deviation did not exceed 0.6%, and deviation of the scintillation kinetics result did not exceed 3%.

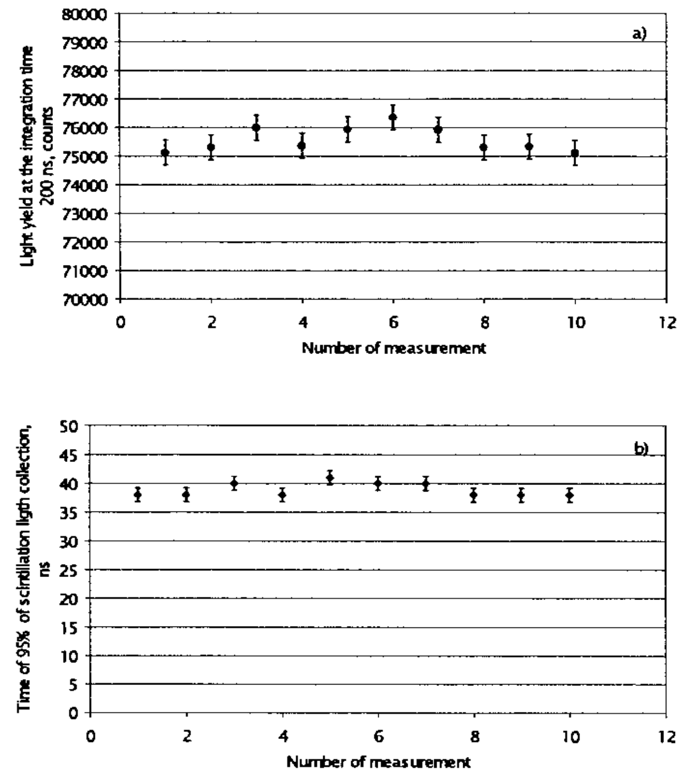

Fig.1 (a, b). Light yield (a) and scintillation kinetics (b) obtained for crystal No.2098R in a series of 10 measurements at the position of gamma-quanta source at 135 mm from the front side of the crystal.

A series of 19 measurements was carried out in order to analyse the reproducibility of the results of the measurements of the optical longitudinal transmission of PWO crystals. On Fig. 2 there is a typical histogram of the deviation of results of longitudinal optical transmission measurements for crystal No. 2098R at the chosen wavelength of 380 nm which is important as an indirect method of radiation hardness evaluation [2]. A table 1 presents the average measurement errors of the longitudinal optical transmission for the measured wavelengths. The errors for wavelengths 330 nm and 340 nm were not included in the table because at these wavelengths the longitudinal transmission of the 230 mm length crystal is close to zero.

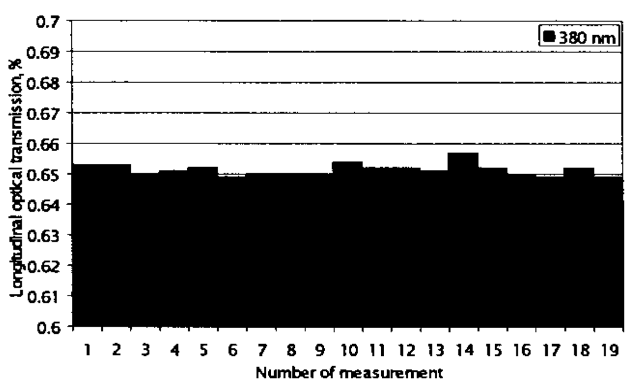

Fig. 2. Longitudinal optical transmission for crystal No. 2098R at the chosen wavelength of 380 nm obtained in a series of 19 measurements.

Table 1. Measurements errors of the longitudinal optical transmission for all measured wavelengths

Wavelength, (nm)	360	380	405	420	450	492	620	700
Average error, (%)	0.53	0.3	2.1	1.4	0.4	0.7	2.0	0.4

A series of additional tests dedicated to the analysis of the error of the baseline measurements was carried out for the spectrometer of the longitudinal transmission measurements. During this series 15 measurements of optical transmission of the air gap between the output lens and the photodetector were carried out. Figure 3 shows a typical histogram of the deviation of results of longitudinal optical transmission measurements for the air gap on the all controlled wavelengths checked. The average error for all wavelengths is 0.4%.

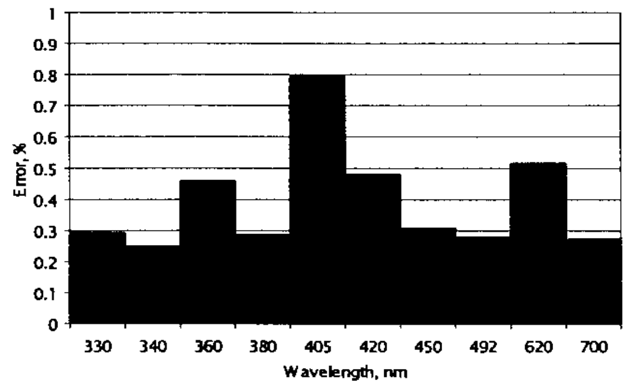

Fig. 3. Optical transmission of air for all controlled wavelengths obtained in a series of 15 measurements.

A series of 10 measurements was carried out in order to analyse the reproducibility of the transverse optical transmission measurements. Figure 4. shows a typical histogram of the deviation of results of transverse optical transmission measurements for crystal No. 2098R at the chosen wavelength of 405 nm corresponding to the point of the transition of the transverse transmission curve to the plateau. Table 2 presents the average measurement errors of the transverse optical transmission for the measured wavelengths.

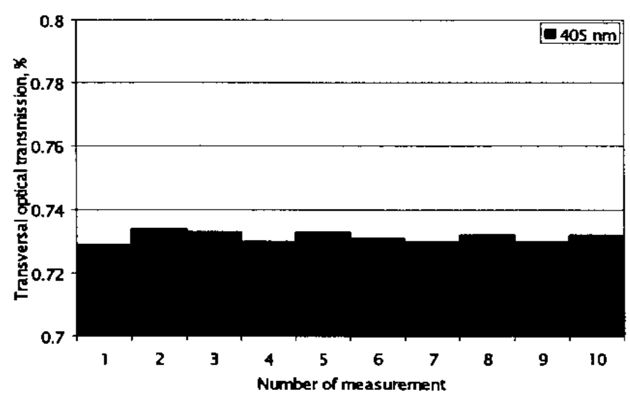

Fig. 4. Transverse optical transmission measurements for crystal No. 2098R at the chosen wavelength of 405 nm obtained in a series of 10 measurements.

Table 2. Measurement errors of transverse optical transmission for all the measured wavelengths

Wavelength (nm)	330	340	360	380	405	420	450	492	620	700
Average error (%)	3.0	0.4	0.3	0.3	0.4	0.6	0.3	0.5	0.3	0.4

So, the data presented show a high reproducibility of the measurement results obtained with the ACCOS system and allow one to consider this system suitable for certification of the PWO crystals in conditions of long-term mass production.

Results of the first pre-mass production PWO certification carried out at CERN on the ACCOS system

The first full-sized tests of the PWO crystals on the ACCOS system were carried out with the purposes of fine tune a method for the routine certification of the crystal parameters and to test the system itself. In these test the PWO crystals produced at the Bogoroditsk Techno-Chemical Plant in the framwork of preparation for the mass production were used. In total, 35 full-sized PWO elements including 20 crystals of the first pre-mass production lot of 100 PWO crystals were analysed [3]. The results obtained are presented as a series of histograms of the distribution of values of the certified crystal parameters.

On Fig. 5 (a, b) we show the results of the light yield (a) and scintillation kinetics (b) measurements for the PWO crystals. As one can see, all crystals analysed satisfy t the specification requirements of these parameters.

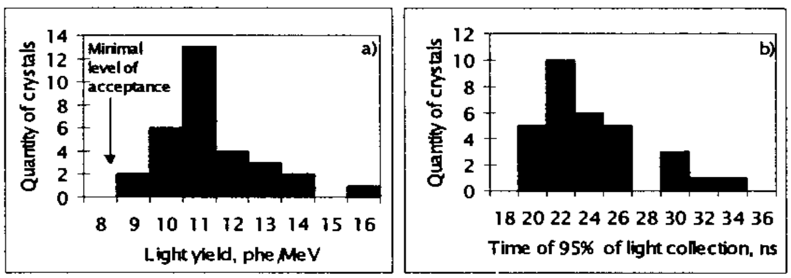

Fig. 5 (a ,b) Distribution of the light yields (a) and scintillation kinetics (b) of the PWO crystals.

On Fig. 6 (a, b) are the results of light yield non-uniformity measurements in two regions: from 35 to 115 mm (a) and from 115 to 185 mm (b) from the front side of the crystal. As one can see, the light yield non-uniformity of the majority of crystals exceeds the limitation of the specification. However, these crystals havenot passed through a special treatment of light yield uniformization. A special treatment for the light yield non-uniformity optimization is still under development at CERN.

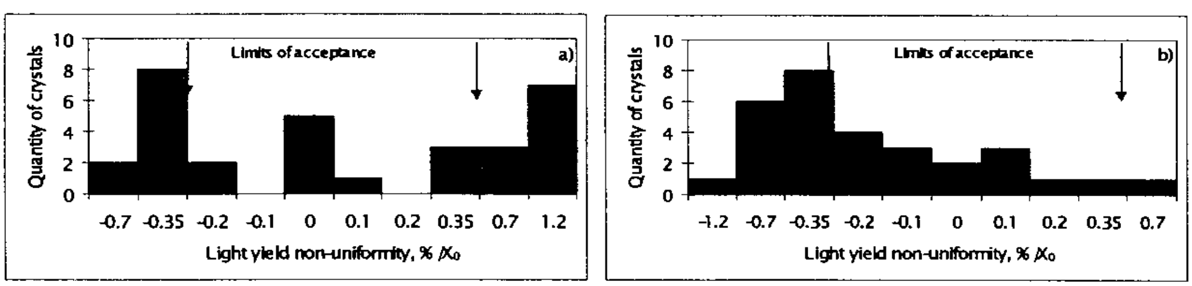

Fig. 6 (a, b). Distribution of the light yield non-uniformity in two regions: from 35 to 115 mm (a) and from 115 to 185 mm (b) from the front side of the crystal.

On Fig. 7 (a-c) are the results of the PWO crystal longitudinal optical transmission measurements at different wavelengths: 350 nm (a), 420 nm (b) ,and 600 nm (c). On Fig. 7 (d) are the results of the measurements of the longitudinal transmission spectra slope in the region between 340 and 380 nm. As one can see, the majority of the crystals satisfy the specification requirements for this criterion.

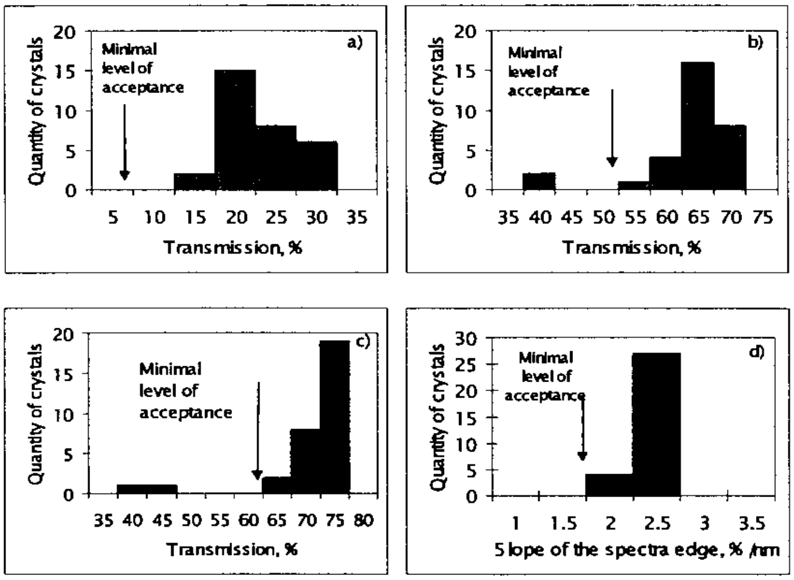

Fig. 7 (a-d). Distribution of the longitudinal optical transmission measurements at different wavelengths: 350 nm (a), 420 nm (b), and 600 nm (c) and slope of the longitudinal transmission spectra in the region between 340 and 380 nm (d).

On Fig. 8 (a, b) are the analysis results of the distribution of wavelength $\Delta\lambda$ of transverse optical transmission spectra at the level of transmission of 50% for crystals produced during technology tuning (a) and for crystals of the first pre-mass lot of 100 crystals (b). As one can see, the majority of the crystals satisfy the specification requirements for this criterion.

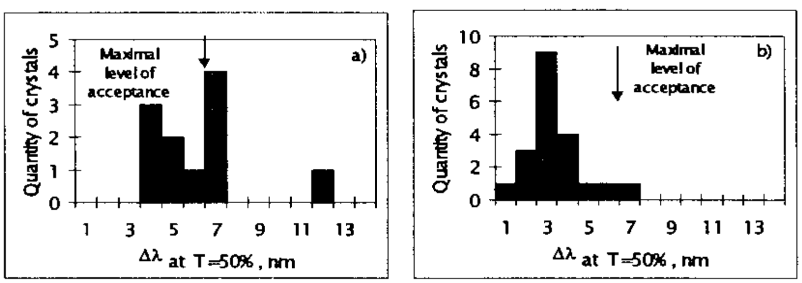

Fig. 8 (a, b). Distribution of wavelength $\Delta\lambda$ of transverse optical transmission spectra at the level of transmission of 50% for crystals produced during technology tuning (a) and for crystals of the first pre-mass lot of 100 crystals (b).

During these tests special attention was paid to the comparison of the results of crystal parameters measurements obtained on the ACCOS System with the results obtained on standard laboratory equipment.

Figure 9 shows a correlation between the results of the light yield measurements obtained on the ACCOS System and on the pulse-height analysis system with a PM XP2262. The correlation is approximated by linear function. On Fig. 10 (a, b) there are correlations between the results of the light yield non-uniformity measurements in two distance regions: from 35 to 115 mm (a) and from 115 to 185 mm (b) from the front side of the crystals, obtained on the ACCOS System and on the pulse-height analysis system with a PM XP2262. The correlations are approximated by linear function.

As one can see there is a good agreement between the results obtained on the ACCOS System and the results obtained on standard laboratory equipment.

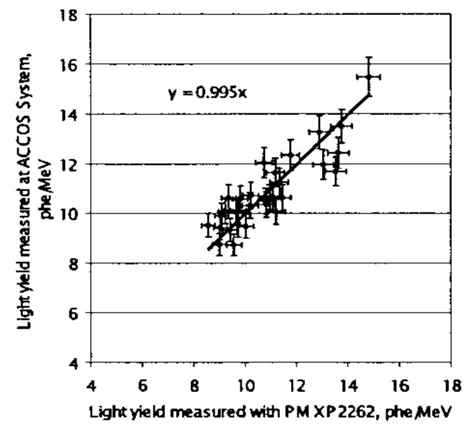

Fig. 9. Correlation between the results of the light yield measurements obtained on the ACCOS System and on the pulse-height analysis system with a of PM XP2262.

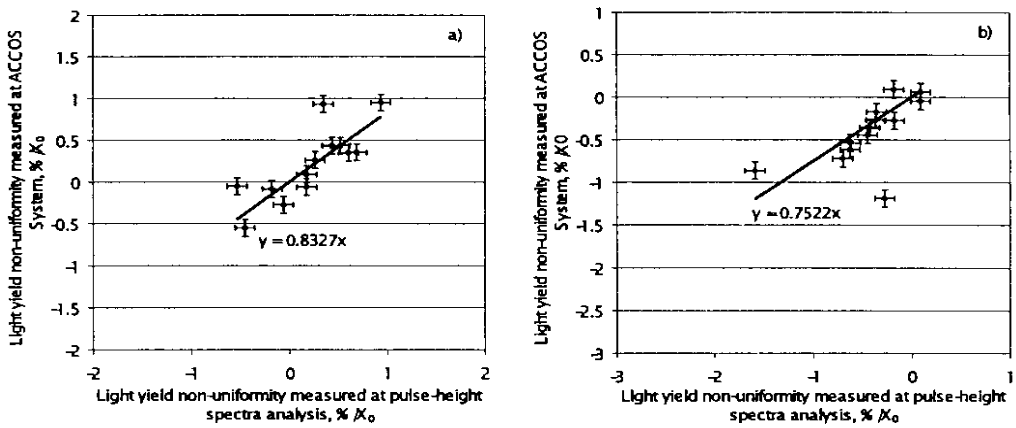

Fig. 10 (a, b). Correlations between the results of the light yield non-uniformity measurements in two distances regions: from 35 to 115 mm (a) and from 115 to 185 mm (b) from the front side of the crystals, obtained on the ACCOS System and on the pulse-height analysis system on the base of PM XP2262.

The results presented show that the proposed approach to the PWO crystals certification and equipment for its realization, including the ACCOS system, allow one to provide reliable certification of the scintillators for CMS ECAL construction.

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