Quality of $PbWO_4$ Crystals Manufactured at SICCAS*

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The electromagnetic target calorimeter of the future $\overline{P}$ANDA detector is based on $PbWO_4$ scintillator crystals of improved, so called PWO-II quality. These crystals provide a nearly doubled luminescence output and a superior radiation hardness comparad to PWO-I quality. These improvements are mandatory for the challenging aim to detect high energy photons from 15 GeV down to a few tens of MeV. To reach this goal, the calorimeter has to be operated at a low temperature of T = -25°C. The extremely high radiation hardness of the crystals is required since thermally activated recovery processes are drastically suppressed. Therefore, the maximum loss of light output due to the deterioration of the optical transparency is primarily determined by the concentration of intrinsic defects created during the growing process. One can overcome or at least significantly compensate the damage by the recently discovered new effect of stimulated recovery [1].

Before completing the production of the total number of ≈11,000 PWO crystals for the barrel part of the calorimeter the former manufacturer BTCP (Bogoroditsk Technical Chemical Plant) in Russia went out of business due to lack of funding for the missing 8,350 crystals. The barrel section comprises 11 different geometries in two symmetric versions. Presently, the company SICCAS at Shanghai is the only active manufacturer of PWO crystals. Therefore, an R&D project has been restarted to inspect and further improve the quality of crystals to meet the $\overline{P}$ANDA-EMC requirements. Tab. 1 summarizes the relevant parameters of the quality specifications.

Parameter	Unit	Limit
Light yield LY measured at T = +18°C, polished crystal	phe/MeV	≥16.0
LY(100 ns)/LY(1 μs) light yield integrated over 100 ns and 1 μs		> 0.9
Induced absorption coefficient Δk measured at RT, integral dose: 30 Gy	m^{-1}	≤ 1.1

Table 1: Some relevant quality specifications.

Within this project 25 full size crystals of geometry type 11L have been produced and completely tested at the facilities at Giessen and CERN. In the latter case, the semi-automatic testing machine ACCOS has been used to determine the geometrical dimensions, the optical performance, luminescence parameters like the relative light yield and decay kinetics. At the detector laboratory and radiation facility at Giessen, the absolute light yield at different operating temperatures as well as the radiation hardness were tested with gamma rays originating from a set of ^{60}Co sources.

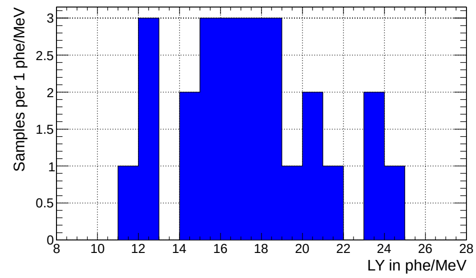

Figure 1: Distribution of absolute light yield measured at T = +18°C for all 25 PWO crystals.

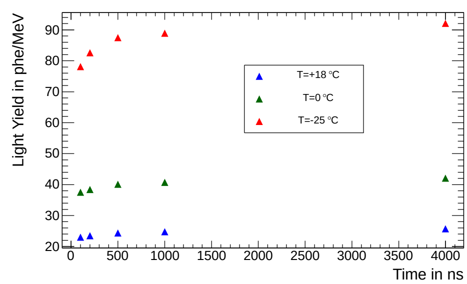

Figure 2: Light yield of one PWO sample (#120904) as function of and integration time for selected temperatures.

Figs. 1 and 2 illustrate the determined light yield at +18°C and the increase at lower temperatures as a function of integration time. Most of the crystals reach the limits and show no dominant slow scintillation components. The optical performance delivers sufficient transmittance over the relevant wavelength region. However, the required radiation hardness, expressed by the change of absorption coefficient at 420 nm due to an integral radiation dose of 30 Gy need further improvement of the used raw material or the growing technology. Fig. 3 shows the distribution of the obtained Δk values.

References

[1] V. Dormenev et al., Nucl. Instr. and Meth. in Phys. Res. A 623 (2010) 1082-1085.

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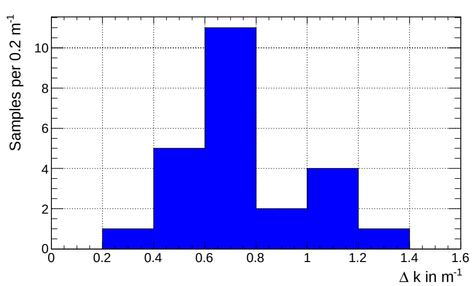

Figure 3: Distribution of the measured Δk values at 420 nm.