NPS Calorimeter Prototype status

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1 Prototype cosmic tests

The Gain Monitoring System was tested by taking long overnight run. The input light was from a blue LED driven at frequency 0.8 Hz. The supply voltage on the prototype PMTs was 1.3 kV. The system performed stable (fig. 1).

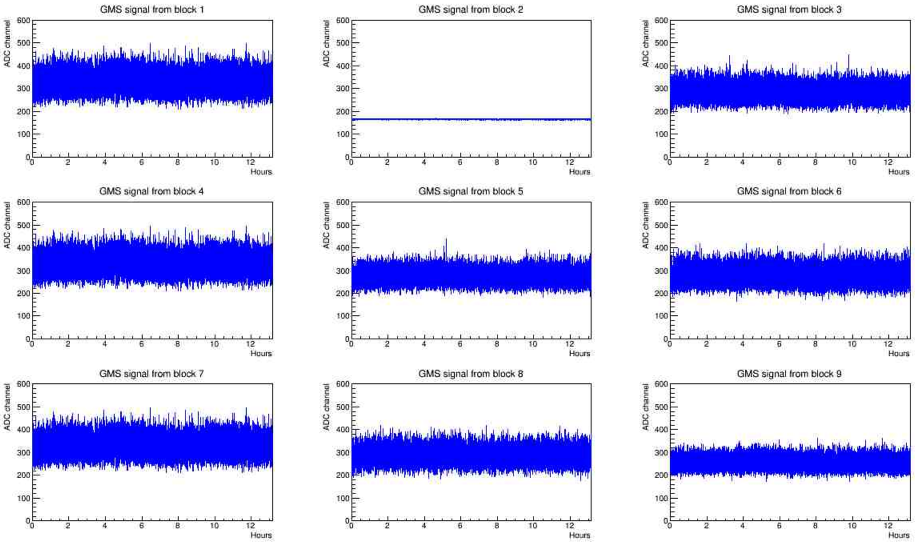

Figure 1: Unfolding of the Prototype ADC signals in time from a GMS test run. Note that channel 2 was down due to faulty base.

The PMT signals are distributed ~5% wide, typically, which is larger by 2 or 3% than expected from the Poisson distribution (fig. 2).

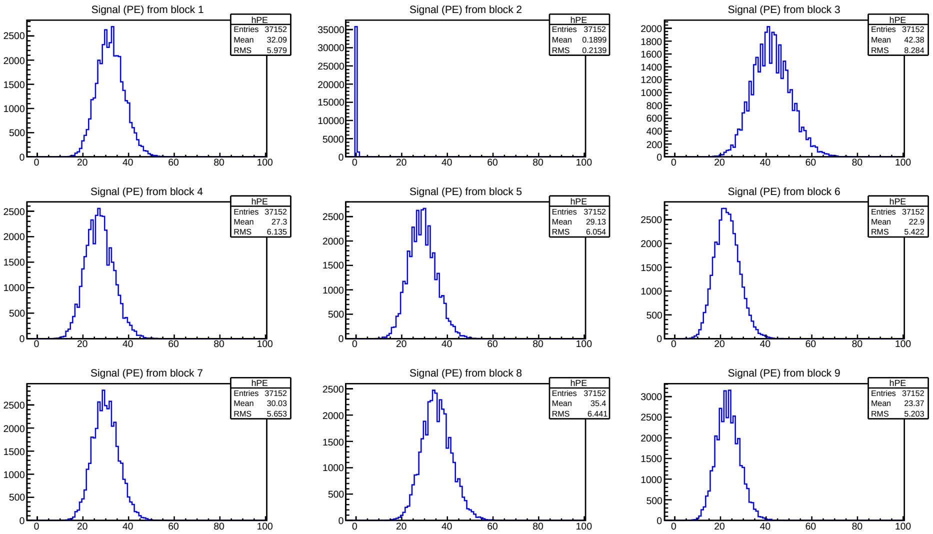

Figure 2: PMT signals in p.e. units from the GMS test run.

The GMS system, operated at low light intensities was used to calibrate the detector (figs. 3, 4).

The faulty base on PMT in channel 2 had been replaced, and detector was tested with cosmic rays. The PMT supply voltages were raised from 1.3 to 1.4 kV, which allowed cleaner separation of SPE signals from pedestals, hence better calibration with GMS.

The amplitude of PMT signals from cosmic rays passing at ∼12.5 cm from PMTs is typically $40-50$ photoelectrons (fig.5). The summed signal is ∼150 p.e.-s (fig.6). Given lead tungstate thickness of 6 cm, density 8.3 g/cm^3, energy loss of 1.6 $MeV/(g/cm^2)$ for ∼4 GeV muon, this implies ∼1.9 photoelectrons per MeV of deposited energy.

A significant fraction of low amplitude signal (∼1 p.e.) was detected in cosmic tests as previously. Note that presented data were obtained with a black Tedlar film covering fronts of the blocks. This rules out cross talk between the blocks via leakage of light from the front sides as a significant source of the low amplitude signals.

A series of tests, both with cosmics and GMS have been conducted in order to pin down the cause of low amplitude signals. Cross talk between channels via light leak from rear side of the crystals into the adjacent PMTs seems the most plausible source of the signals. The other 2 sources under

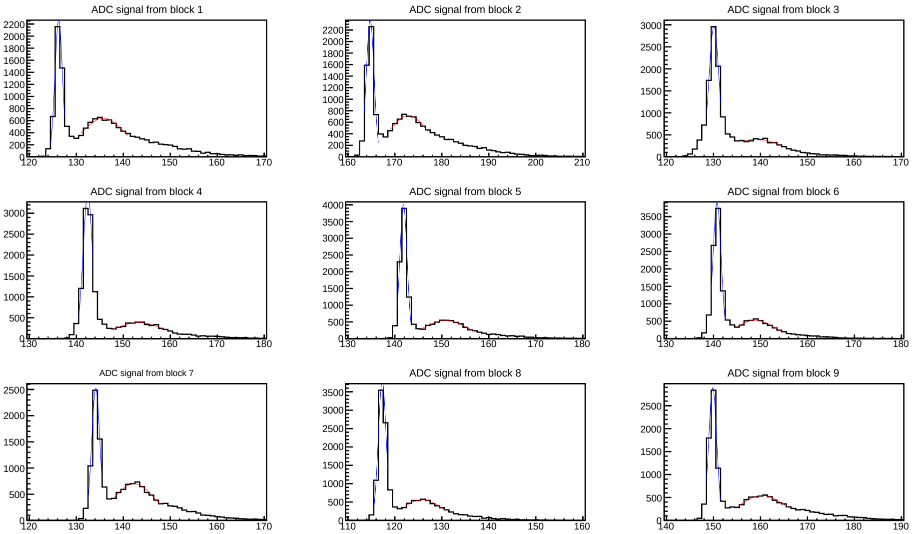

Figure 3: Pedestal and single photoelectron signals from PMTs obtained with GMS system operation.

consideration, the light leak through the front face of the crystals and knock on electrons seem of less significance.

The construction of detector has been modified based on the findings. The PMTs are wrapped in black Tedlar film. The rear surfaces of blocks adjacent to PMTs are also covered with Tedlar film. The optical insulations are extended by ∼5 mm behind the fronts of the blocks. Also, 12 infrared LEDs are mounted in front of the blocks in the middle row (4 LEDs per block). Currently the detector is under cosmic test in order to see effects from the modifications.

2 Crystal radiation and tests

The $3\times3\times16\ cm^3$ crystal was exposed to infra-red light of 940 nm wavelength from a set of 4 TSAL-7400 IR LEDs from the radiated end, then from a set of 2 blue and 2 red LEDs. The transparency had been measured in transverse direction at ∼1 cm from the end just before radiation, after 3 hours of IR curing, after 20 hours of IR curing and after 48 hours of blue light curing (fig. 7, top panel). No sign of spontaneous curing in 20 days after 271 krad radiation was noticed. No definite sign of curing was seen from LEDs (fig. 7,

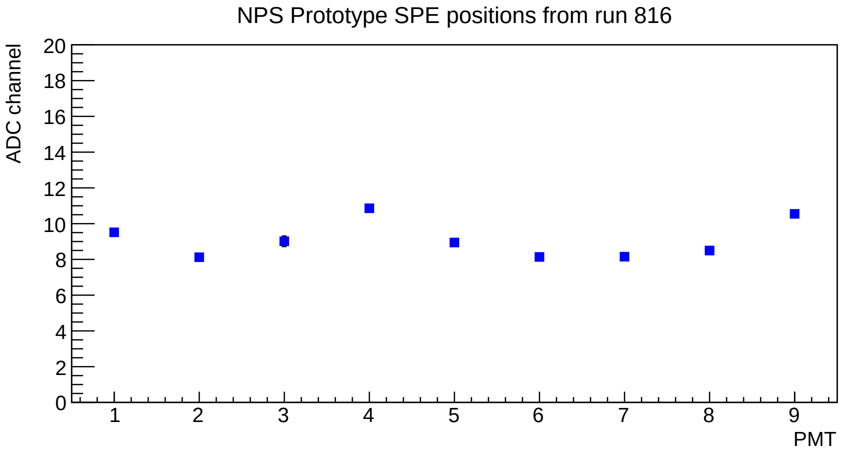

Figure 4: Amplitudes of PMT single photoelectron signals obtained with GMS system.

bottom panel).

In parallel, control measurements of the spared SICCAS crystal were taken. The crystal was measured longitudinally, through 20 cm thickness(fig. 8). The 4 measurements agree with each other within ±1% (absolute).

3 Estimates for PbWO radiation effects for 3 cm thickness

Figures 9 and 10 show transmittance of PbWO crystals from BTCP and SICCAS as measured at CalTech. The crystals are measured in longitudinal direction, through 22 cm before and after radiation at different rates, after equilibrium in radiation damage is reached. At 400 rad/h rate (relevant to us) equilibrium is reached at 25 krad integral dose. At 420 nm wavelength (maximum of effect from radiation) the transmittance is decreased by 14% and 11% for the BTCP and SIC crystals respectively. Assuming uniform radiation along the crystals, This means 1.5% or 2% effect for 3 cm thickness (marginal for our accuracies).

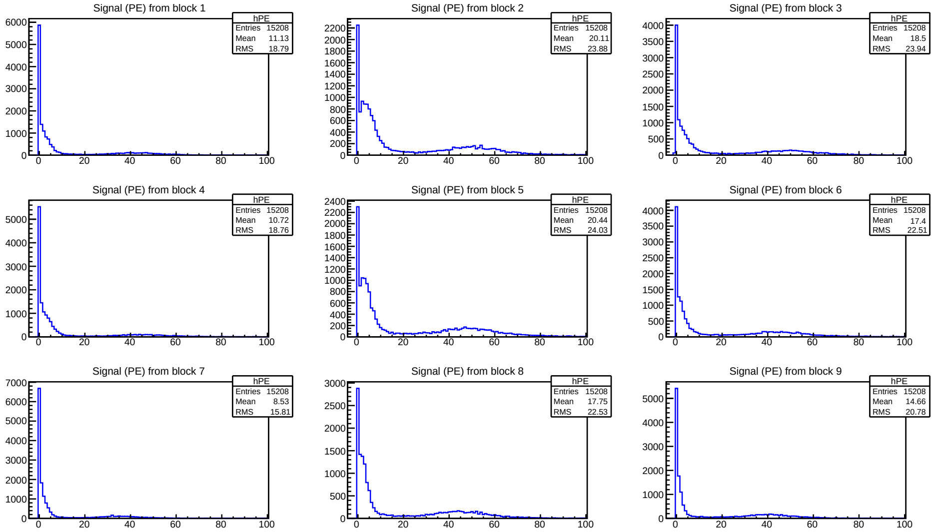

Figure 5: PMT signals (in p.e. units) from cosmic rays passing at ∼12.5 cm distance from PMTs.

4 Plans for weeks ahead:

1. Take cosmic run with re-assembled Prototype to check effect from optical isolation on the low amplitude signals.
2. Run tests in concurrent mode, with detection of signals from cosmic rays when IR curing LEDs are on.
3. Give the spared SICCAS crystal to RadCon for radiation and measure its transmittance in the longitudinal direction.

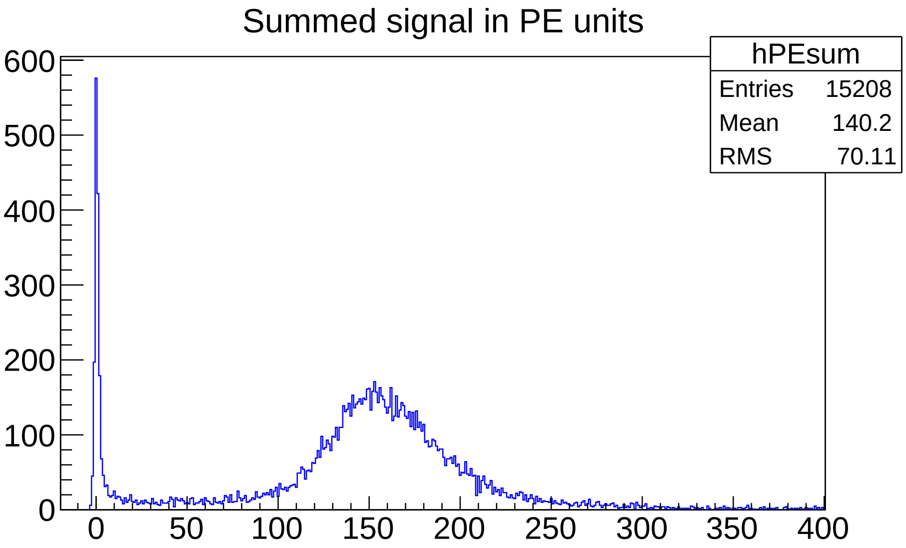

Figure 6: Summed signal (in p.e. units) of the Prototype from cosmic rays passing at ∼12.5 cm distance from PMTs.

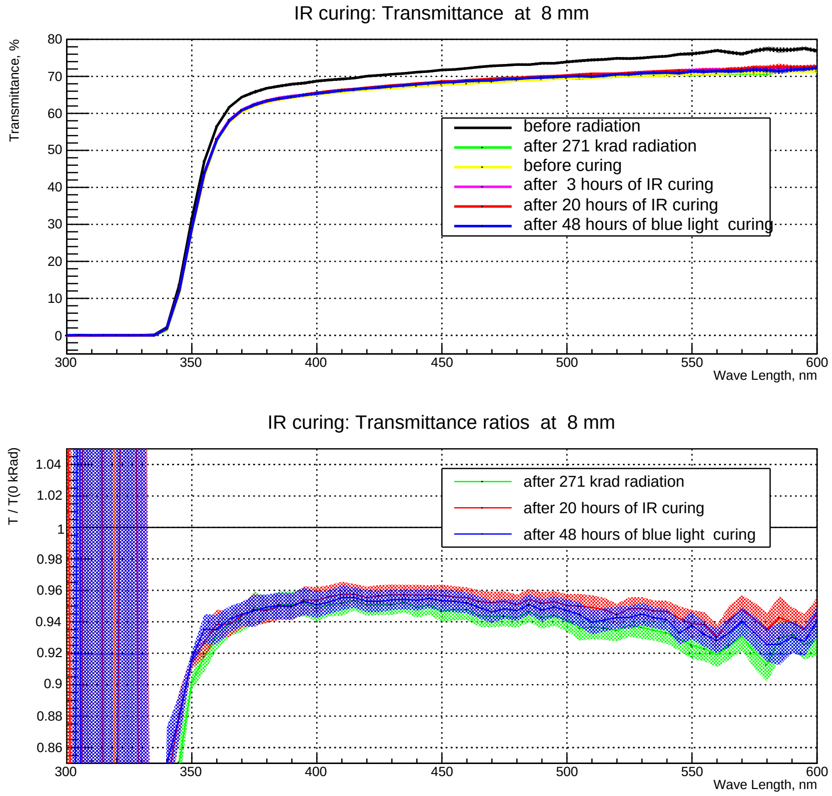

Figure 7: Top: transparency of the $3 \times 3 \times 16\ cm^3$ crystal in transverse direction at 8 mm distance from the radiated end, before and after exposing to IR and blue light from LEDs. Bottom: ratios of transparency after 271 krad radiation and before radiation, after 20 hours of IR curing and before radiation, and after 48 hours of curing with blue light and before radiation.

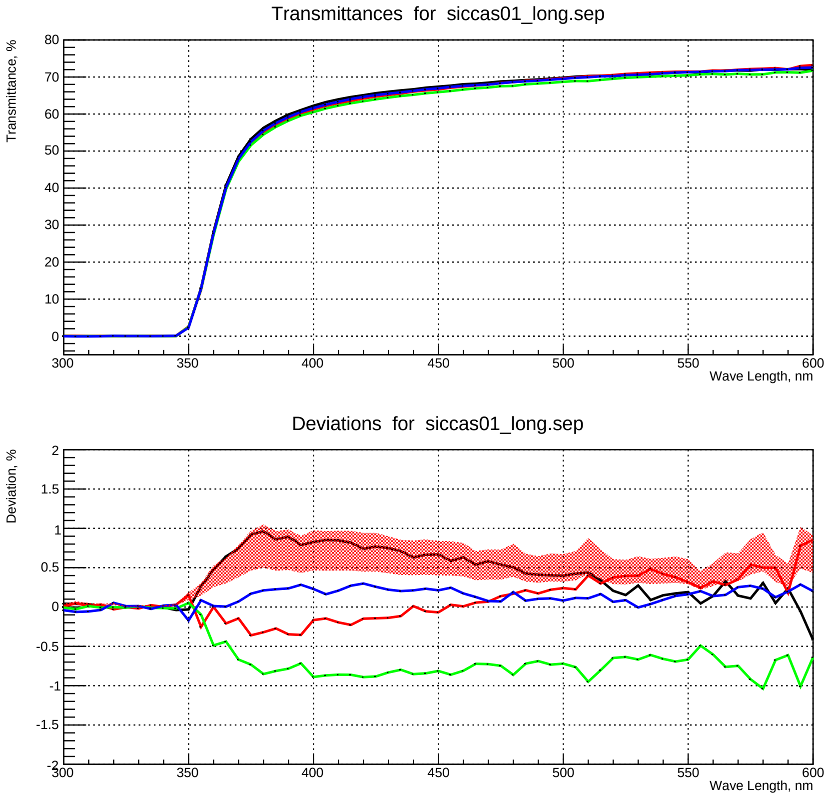

Figure 8: Results from 4 transparency measurements of SICCAS 01 crystal in longitudinal direction, through 20 cm thickness. Top: measured transparencies. Bottom: deviations of transparencies from mean value. The shaded red area indicates RMS of distribution of transparencies.

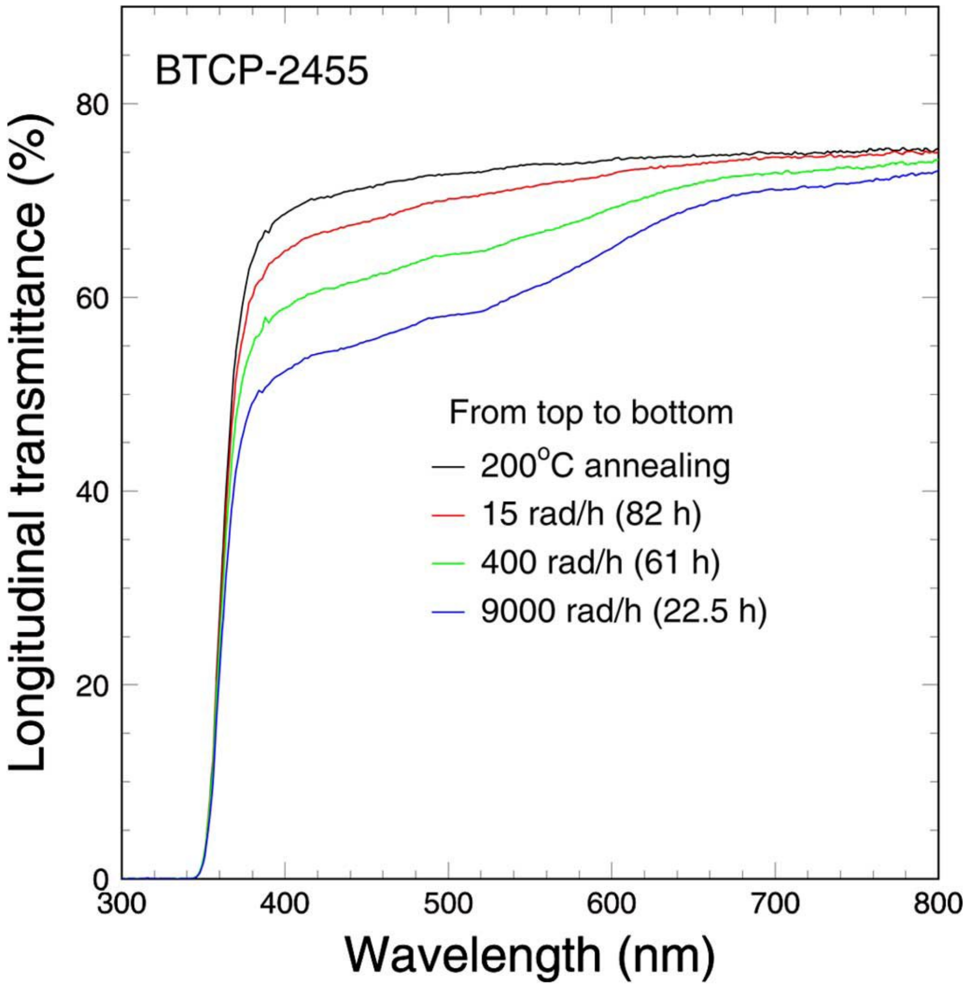

Figure 9: Transmission of BTCP PbWO crystal measured in longitudinal direction through 22 cm (from J. Chen et al, IEEE Trans. in Nucl. Sci., v. 54, no. 2, 2007, p.375).

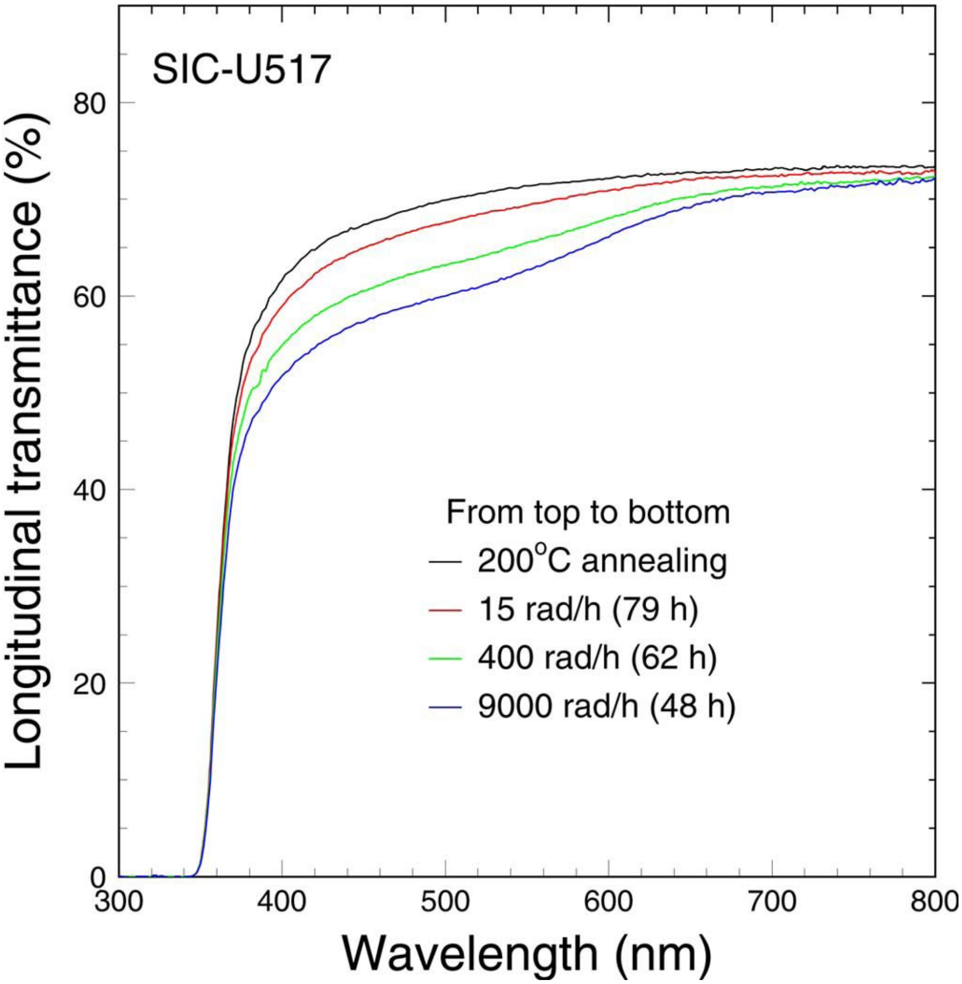

Figure 10: Transmission of SICCAS PbWO crystal measured in longitudinal direction through 22 cm (from J. Chen et al, IEEE Trans. in Nucl. Sci., v. 54, no. 2, 2007, p.375).