A Diode-Pumped DP2-447 Blue Laser for Monitoring CMS Lead Tungstate Crystal Calorimeter at the LHC

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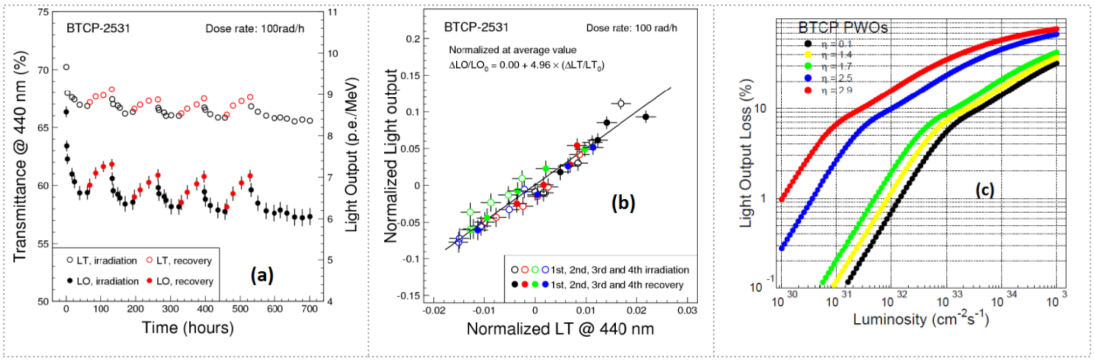
(On behalf of the CMS ECAL group)

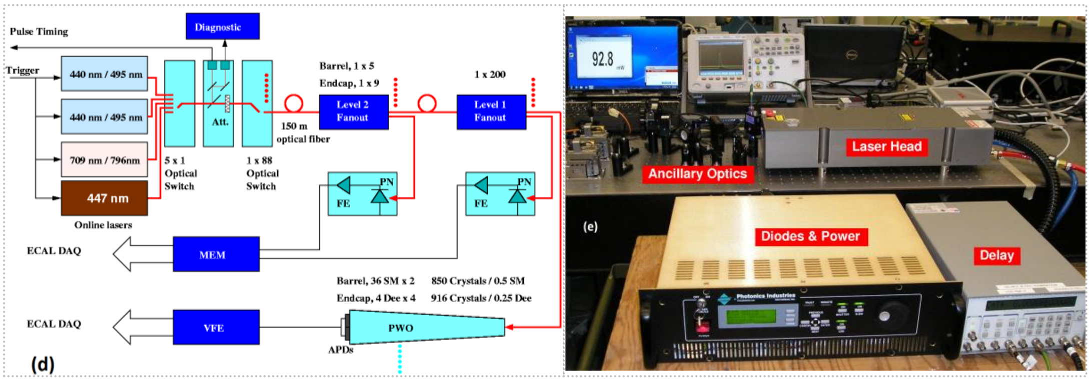
Abstract

Monitoring the transparency of the lead tungstate crystals of the CMS electromagnetic calorimeter (ECAL) plays a crucial role in maintaining the ECAL energy resolution. To meet the stringent requirements on the light monitoring precision and stability a new commercial diode-pumped blue laser ("DP2-447") has been commissioned and installed at CERN for the 2012 operation of the CMS ECAL. The laser unit has a simple structure and is expected to be more reliable than the existing lamp-pumped lasers used by the monitoring system. The stability of critical quantities such as the intensity, width and timing, is better than that of the lamp-pumped lasers. The characteristics of the new blue laser will be elaborated. Its performance *in-situ* in CMS will be described and the prospects for improving the light monitoring precision will be discussed.

The 76,000 lead tungstate ($PbWO_4$) crystals in the CMS electromagnetic calorimeter (ECAL) are radiation hard to high integrated dose, but suffer from dose rate dependent radiation damage. The light Higgs discovery potential is directly related to the energy resolution of the ECAL at LHC, and thus requires precision calibration. During the time needed to accumulate sufficient statistics for the inter-calibrations by using physics events $PbWO_4$ crystals experience radiation damage during beam on and recovery during beam off as illustrated in Fig.(a). The excellent linearity of the correlation between the light output and transmission shown in Fig.(b) indicates that the variations of crystal's light output may be calculated and therefore corrected for by using the variations of crystal's transparency measured at 440 nm. Fig.(c) shows the extrapolated light output loss of $PbWO_4$ crystals at different pseudo-rapidity as function of luminosity.



A light monitoring system has been designed and constructed by the Caltech and Saclay groups for the CMS $PbWO_4$ crystal calorimeter. Fig. (d) shows that the monitoring laser pulses selected by a 5 × 1 fiber optical switch are distributed via a 1× 88 switch to one of 88 calorimeter elements. A two stage distribution system mounted on each calorimeter element delivers monitoring laser pulses to each individual crystal. The laser pulse intensity measured by the ECAL readout device is normalized to that measured by the reference PN diodes. The APD/PN ratio is the monitoring signal, which is a measure of crystal's transparency. The stability of APD/PN ration is required to be 0.2% to achieve the 0.5% inter-calibration precision.



Three laser systems (two 440/495 nm and one 709/796 nm) are Quantronix custom-made Ti:Sapphire lasers pumped by commercial DC Kr lamp pumped Nd:YLF lasers. The lamp pumped Nd:YLF laser has been obsolete starting 2005. The manufacture support has also been stopped starting 2012. It thus is important to replace the lamp-pumped Quantronix lasers with more stable diode-pumped lasers. Fig. (e) shows a diode pumped $Nd:YVO_4$ (Photonics Industries DP2-447) laser which was commissioned in Spring, 2012. Fig.(f) shows the laser pulse energy, width and center timing as a function of the diode pumping current. The result of a long term test of about 3 days is shown in Fig.(g), indicating that the instabilities of pulse energy, width and timing are < 1%, < 2% and < 1ns respectively. This stability provides a good foundation for precision monitoring. The performance of this laser system *in-situ* at LHC will be reported and the prospects for improving the monitoring precision will be discussed.