Illumination System for LSST Science Raft Testing

Jason Brooks[a], Justine Haupt[a], Homer Neal[b], Andrei Nomerotski[a]

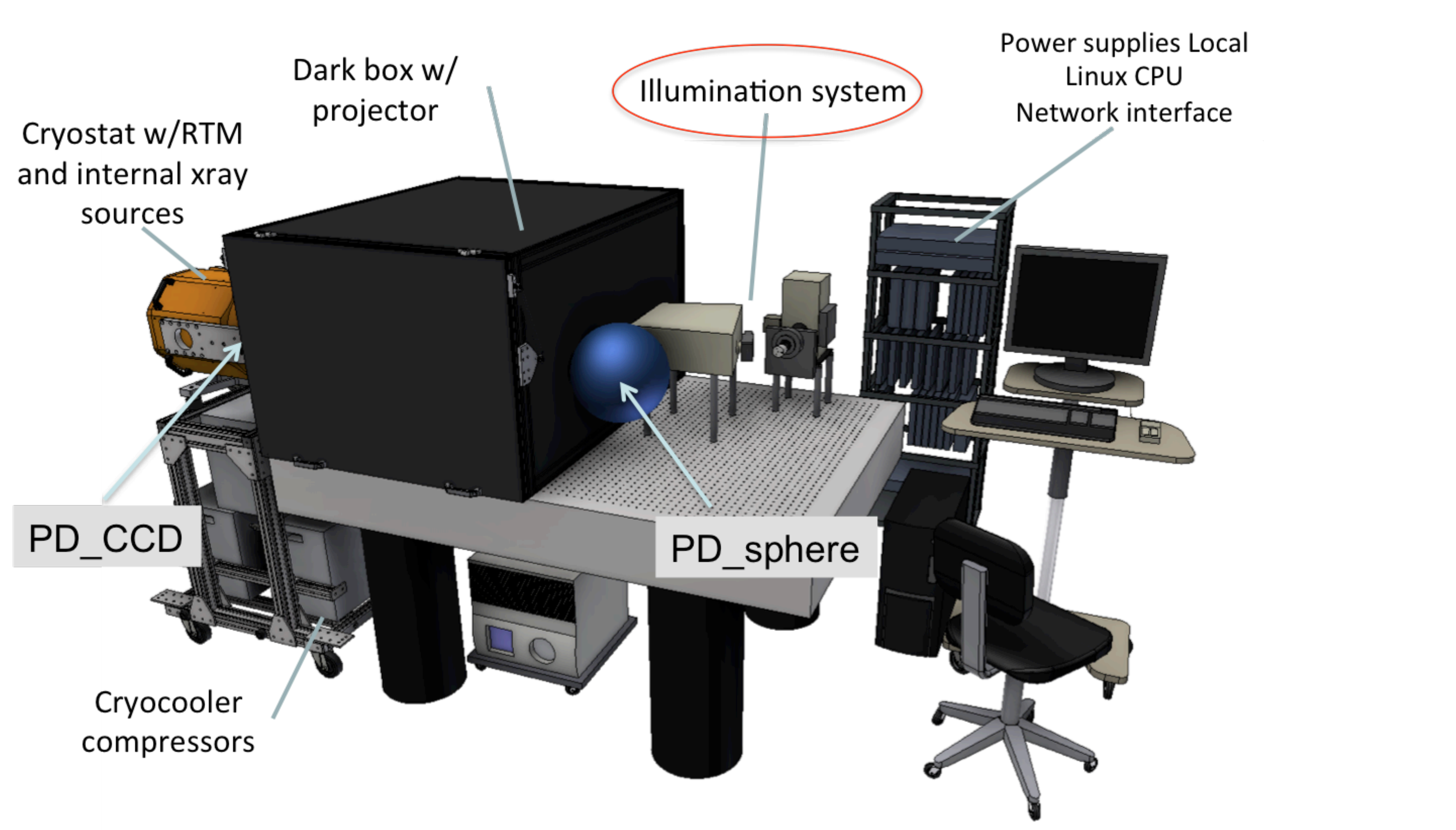
[a] Brookhaven National Laboratory, Upton, NY 11973
[b] SLAC National Accelerator Laboratory, Menlo Park, CA 94025

Introduction

Illumination System of Test Stand 8 (TS8) in the cleanroom at BNL will be used for electro-optical testing of LSST Science Rafts. To characterize it we studied the absolute values and uniformity of the light flux arriving on to the CCD location as a function of the wavelength. Calibration of the monochromator was performed comparing the Xe emission lines to the corresponding National Institute for Standards and Technology (NIST) data. The latter measurement could also be relevant to determine the calibration accuracy for the LSST band-pass filters.

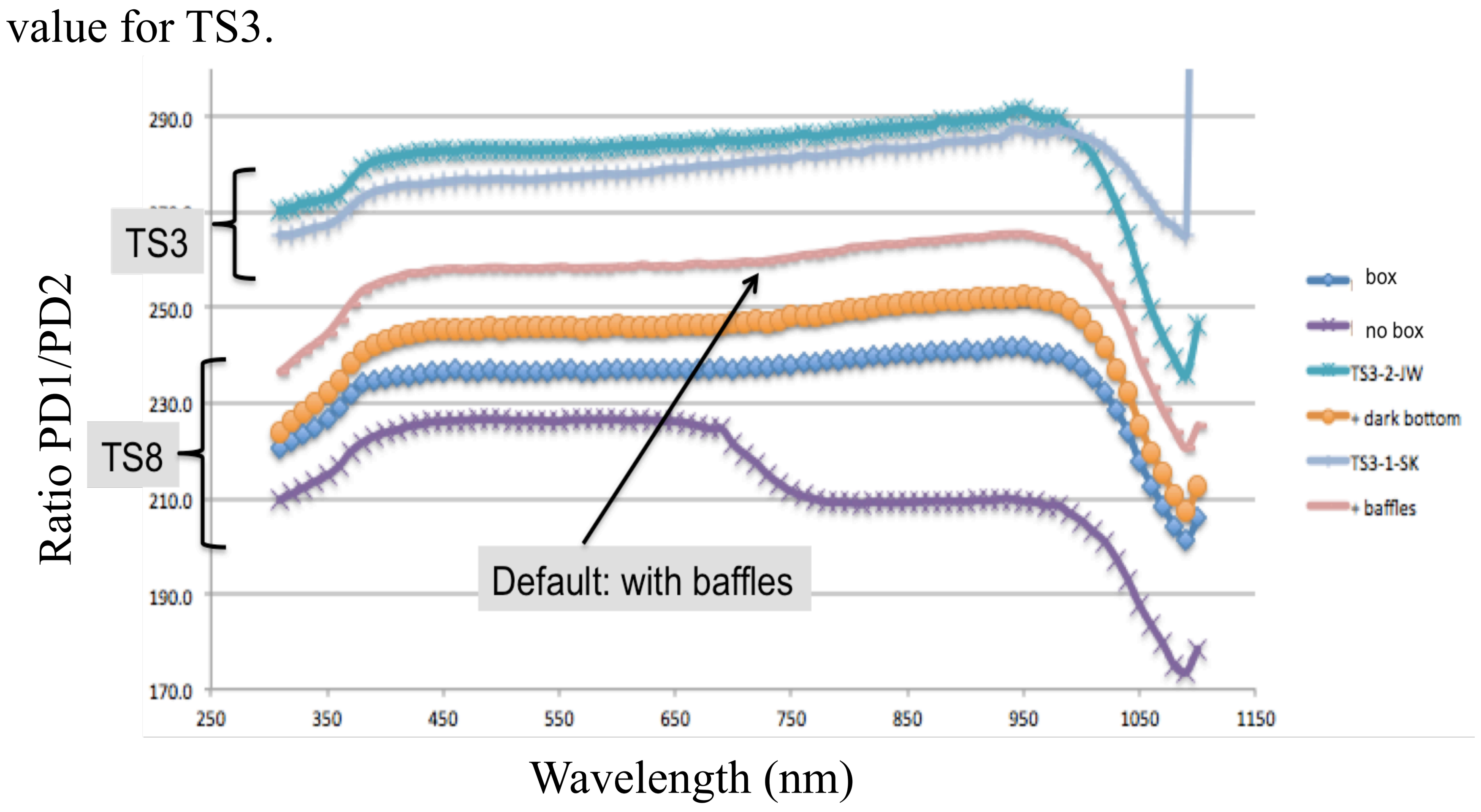
Illumination System Setup

The Illumination System consists of a monochromator connected to a 300W Xenon lamp, and a remotely operated shutter that controls when light from the lamp enters the monochromator through a filter and slit of adjustable width. Light coming out of the monochromator passes another adjustable slit before entering an integrating sphere. Inside the integrating sphere is a photodiode (PD_sphere) connected to a picoammeter that monitors the intensity of light coming out of the monochromator. Next, light leaves the integrating sphere and passes into a large dark box with baffles to minimize reflections. This now collimated light strikes the end of the box where the CCD cryostat will be placed. A second photodiode (PD_CCD) is placed at the location of the CCD to record the flux arriving to the end of the box.



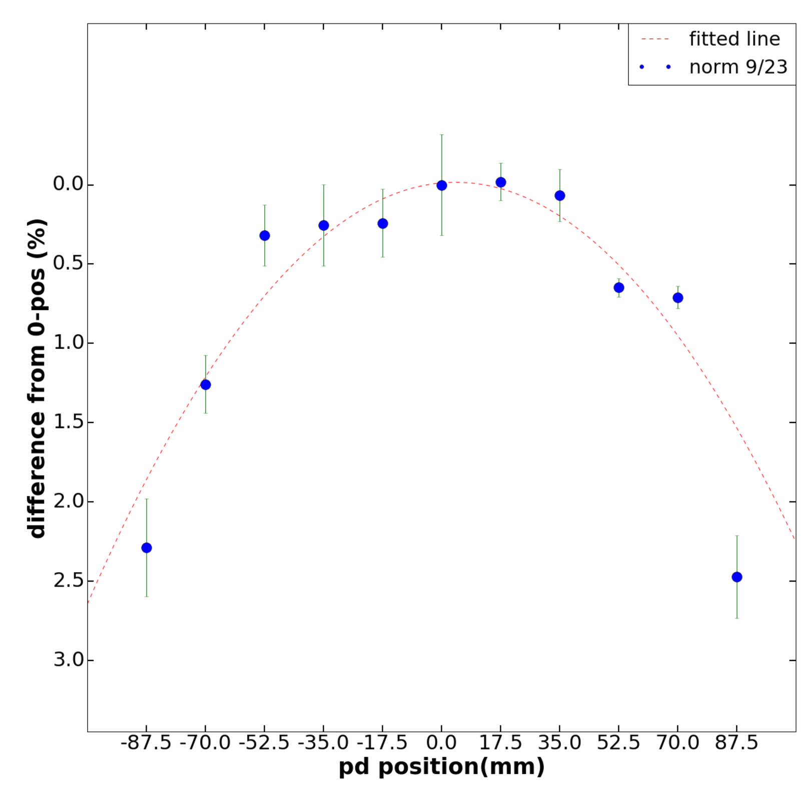
Absolute Flux Measurement

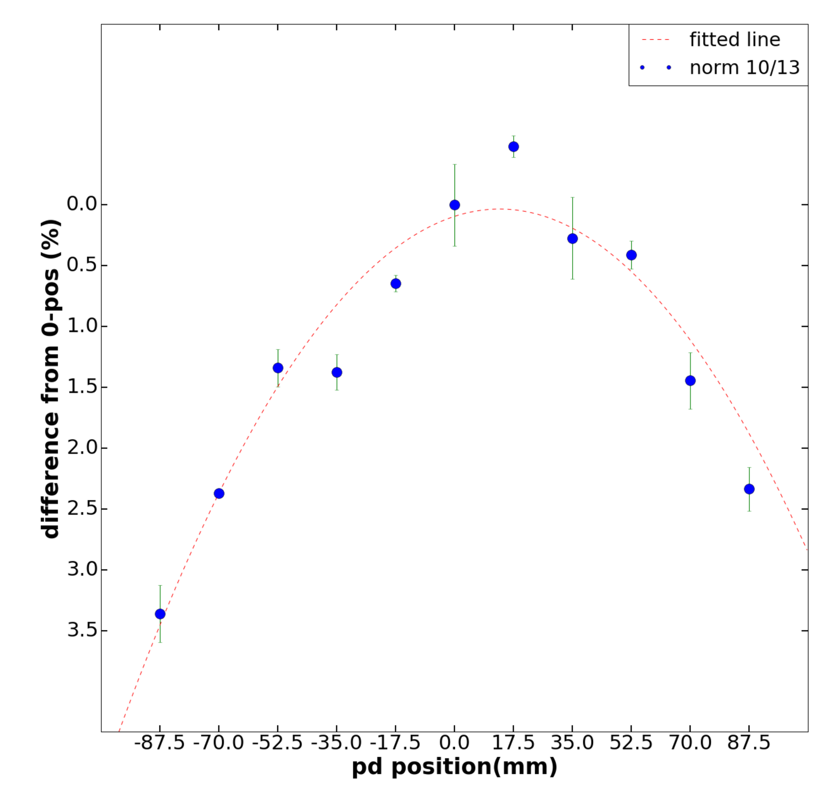
The absolute flux was measured using a NIST calibrated PD (Hamamatsu S2281) with a known area. The flux is higher than 100ke for 10 sec exposures for 250W lamp power in the range from 340 to 1030 nm. To study possible QE systematics we measured the ratio (current at PD_CCD)/(current at PD_sphere) for changing conditions of the dark box and PD_CCD location, some of it shown in the figure below. Difference between TS3 and TS8 is due to different sphere diameter, surface of smaller sphere (TS3) is brighter giving a larger ratio value for TS3.



Flux Uniformity

We recorded currents from the picoammeters connected to the photodiodes. The shutter was opened and closed at timed intervals while multiple data points were recorded during each interval. An average closed shutter baseline value was subtracted from the average open shutter value to produce the results from each data run. Data shown below has been normalized to the current measured at the integrating sphere. Left plot shows data taken along a diagonal of the backplate in the dark box, and the right plot below shows data taken along the opposite diagonal at a different day. Red dashed line shows a linear fit using the fitting equation $y = ax^2+bx+c$. The difference between the two measurements can be interpreted as a systematic uncertainty.

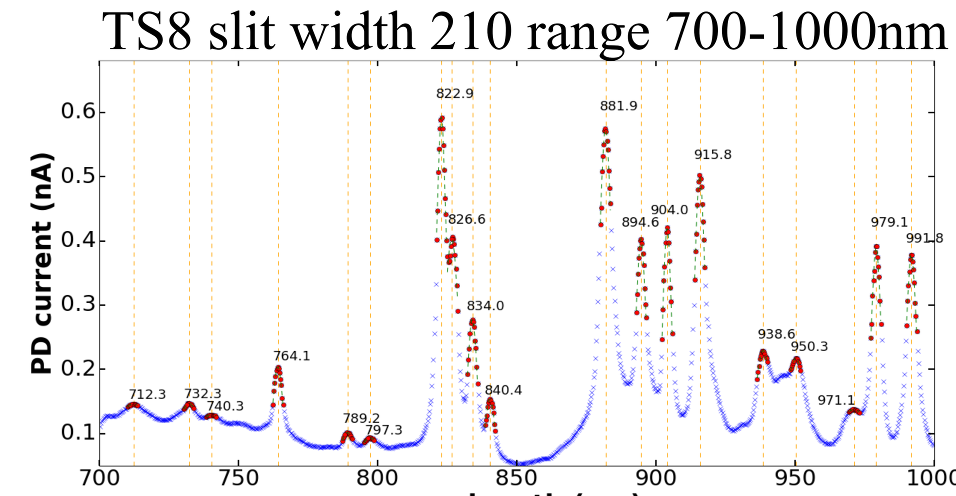




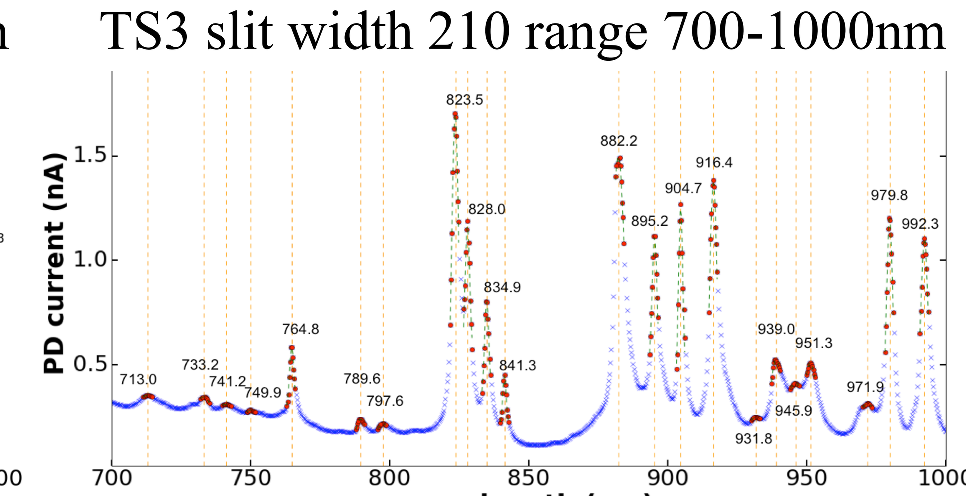
Xe Lamp Wavelength Calibration

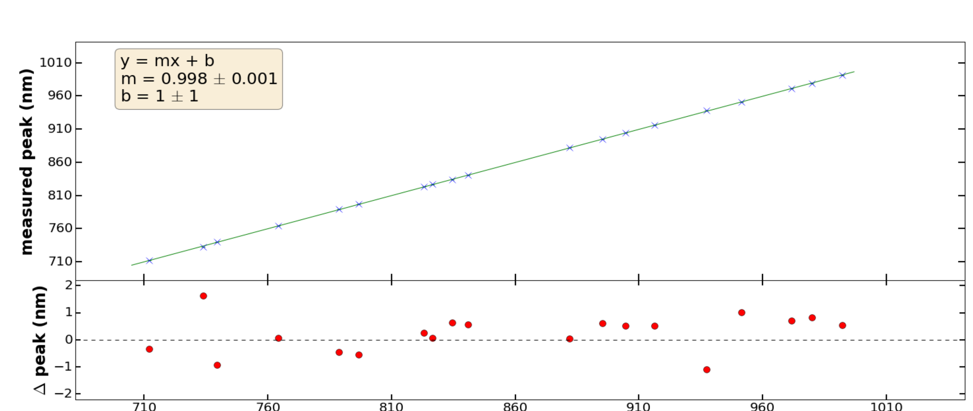
Measurements were also taken to characterize the monochromator. Data was taken by incrementing the wavelength of light coming from the device in steps of 0.3 nm. Slit width in the monochromator was set to 210μm. A linear fit is applied to the data where measured peaks align with the peaks for Xenon recorded by NIST. Δpeak represents the quantity (NIST Peak–Measured Peak). For comparison, the same data taken at TS3 is included as well. The width of the peaks (sigma of fitted Gaussian) is about 1 nm, and the fit uncertainty on the peak positions is about 0.1 nm.

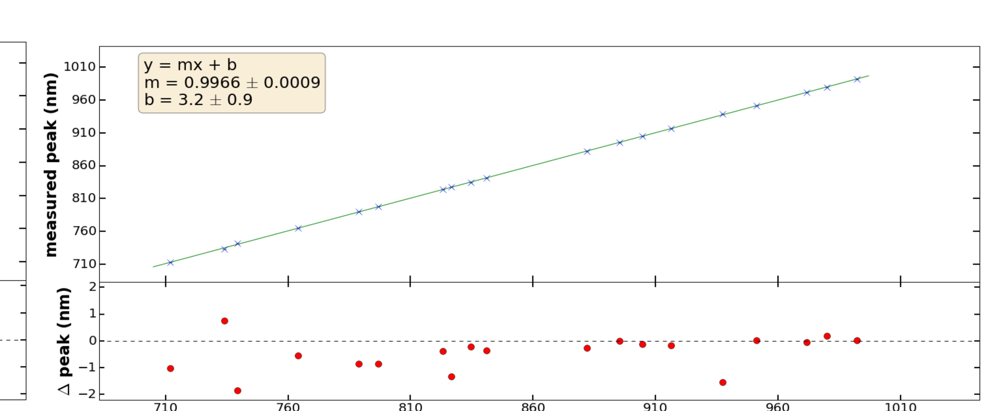
TS8 slit width 210 range 700-1000nm



TS3 slit width 210 range 700-1000nm







Conclusions

The TS8 illumination system produces enough flux for the raft testing. The intensity of the light striking the raft center falls off by about 2% near the raft edge. The measured Xe lamp emission lines align closely with NIST emission lines; fit parameters show slopes close to unity. We conclude that the wavelength uncertainty with this setup is better than 1nm.

We would like to thank Peter Takacs and Ivan Kotov for their assistance throughout this project. This project was supported in part by the U.S. Department of Energy, Office of Science, Office of Workforce Development for Teachers and Scientists (WDTS) under the Science Undergraduate Laboratory Internships Program (SULI).