

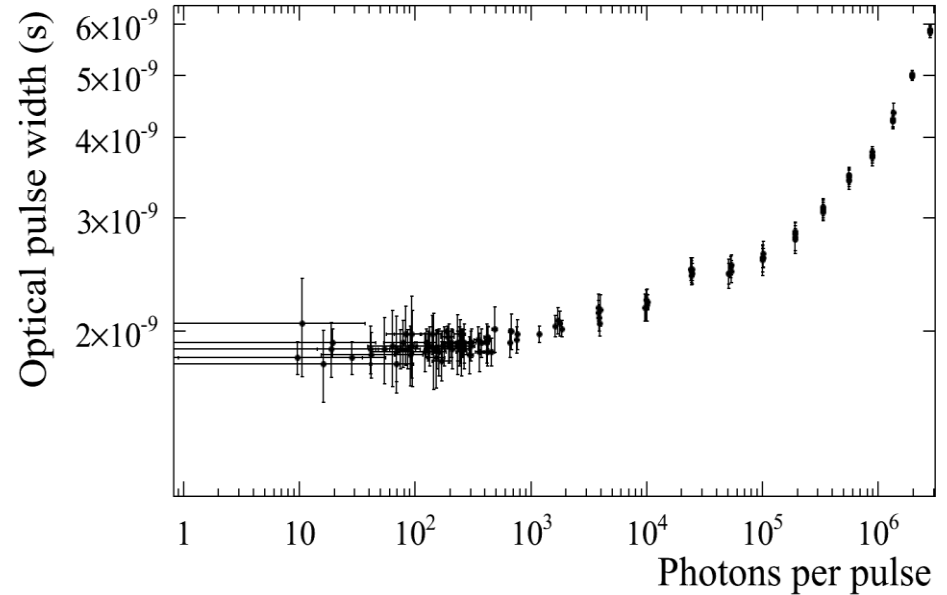
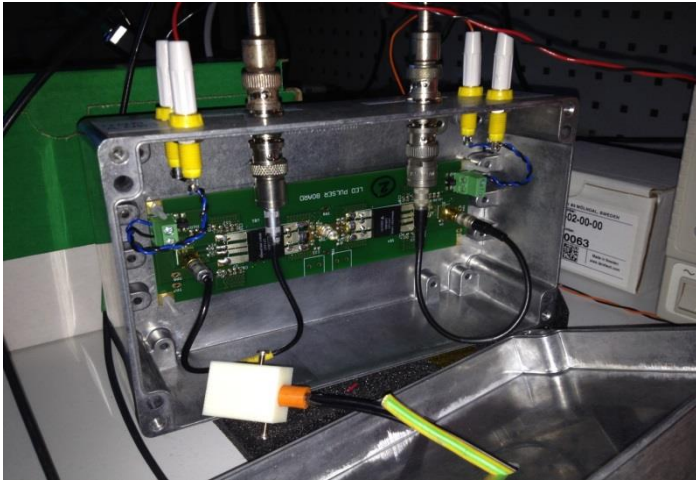
# Optical Calibration of Water Cherenkov Detectors: Summary

 JENNIFER Meeting, QMUL  
September 2016

# Pulsed LED Calibration System

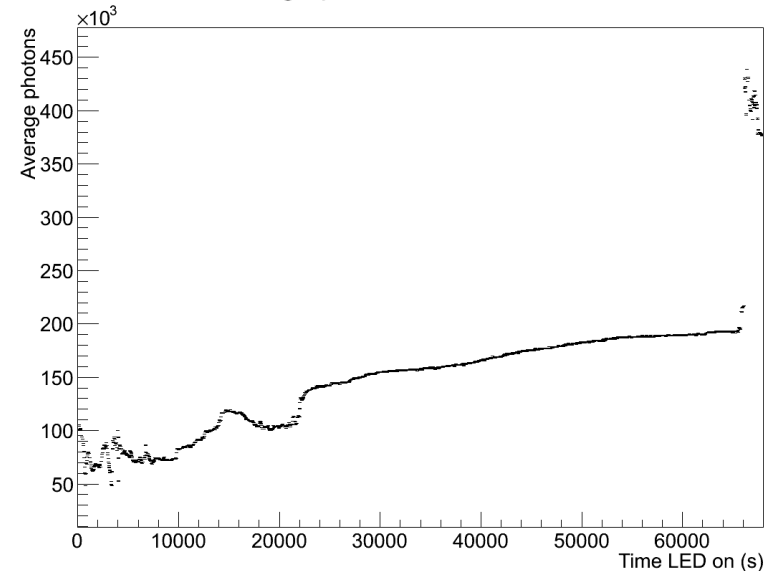
- We are developing an optical calibration system to obtain a good understanding of the PMT response in Hyper-Kamiokande, to enable accurate determination of detector properties and water parameters
- This is crucial to allow HK to achieve the sensitivity required for a number of key physics analyses
- Use pulsed LEDs driven via a quad-MOSFET system that ensures short pulse duration with high photon production
- R&D has been ongoing and has led to some key improvements

# Board Version 1

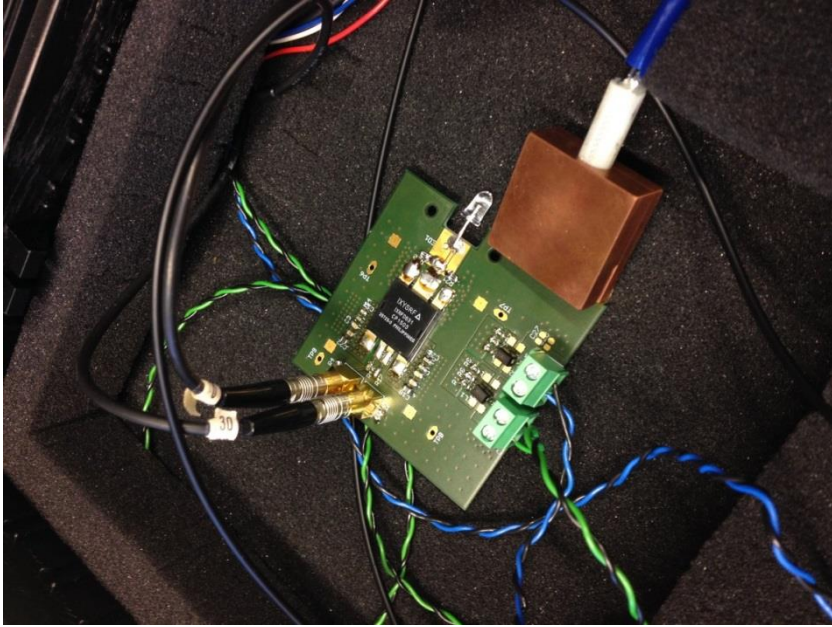


- Generally good performance
- Some stability issues that are important to either understand (temperature) or eliminate (EM pulses, jitter, etc)

Average photons vs LED on time

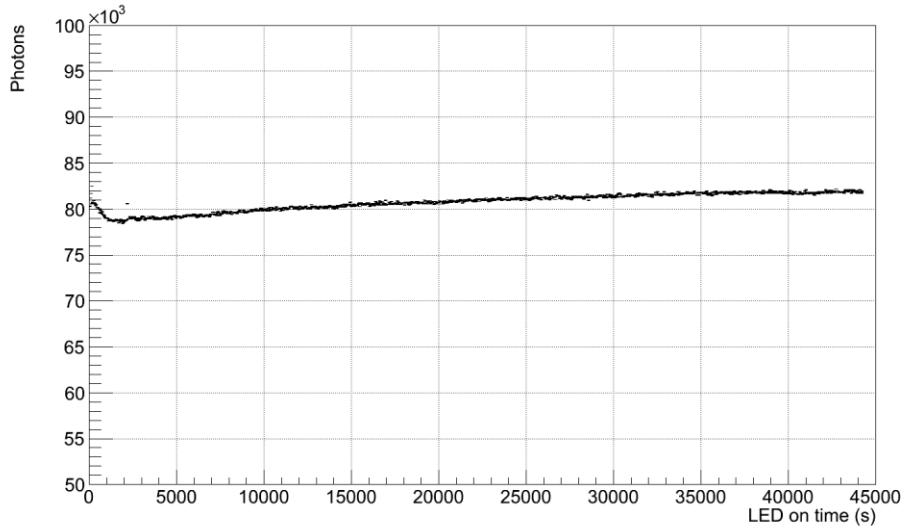


# Board Version 2.0

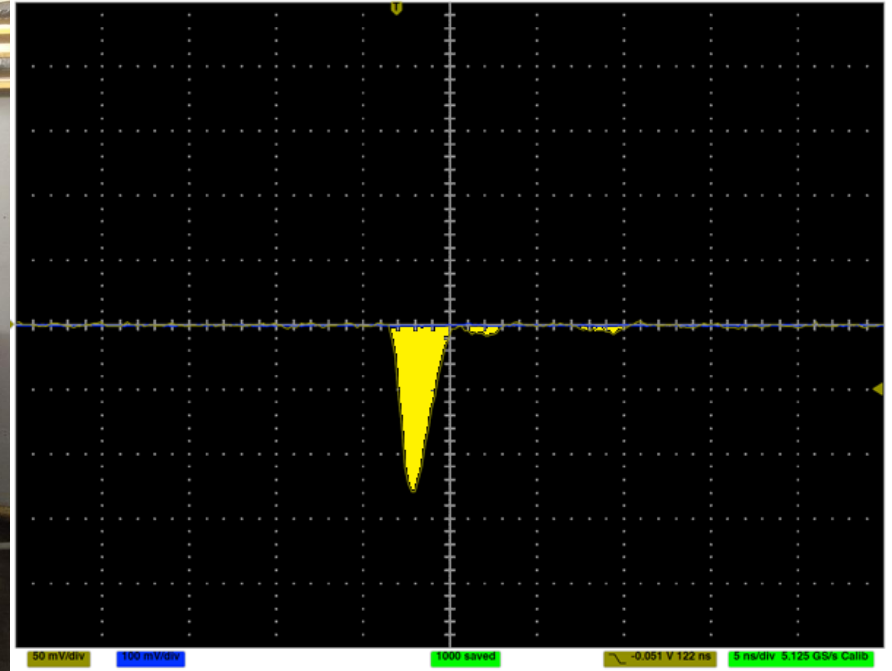


- New board design to tackle stability issues
- Key changes: component upgrades, smaller footprint, MOSFETs on opposite sides of board
- Preliminary results indicate stability is much improved, but more testing needed

Photons vs LED on time



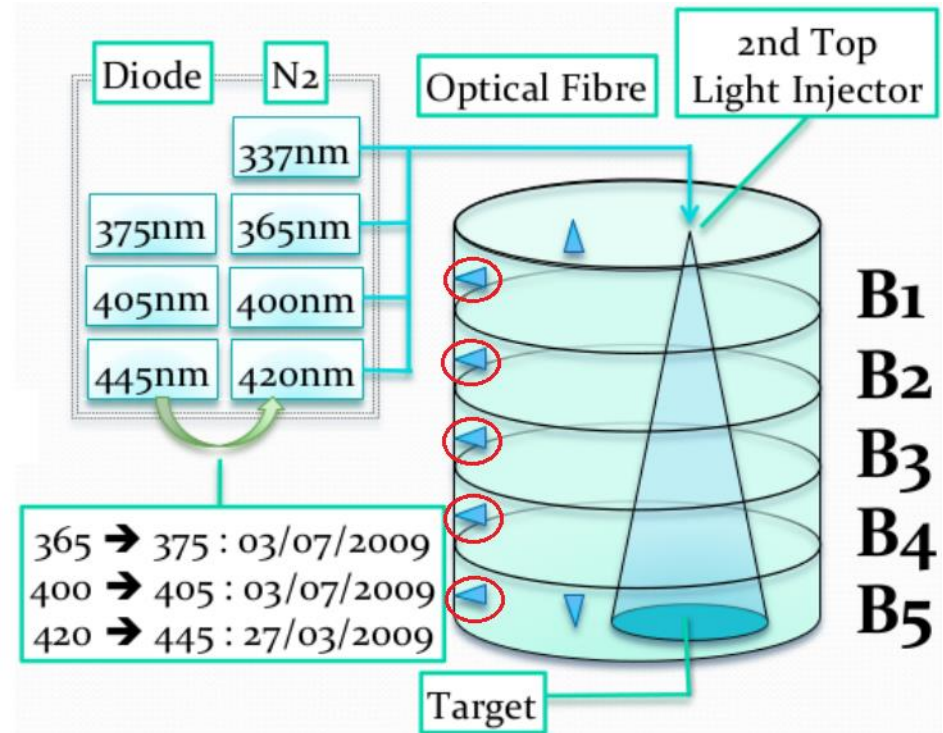
# Testing Output Underwater



- Have installed a water tank in the Liverpool basement to test key optical parameters of fibre output underwater
- At a very early stage, but we aim to investigate opening angle and intensity profile of light emission from bare fibre, and fibre connected to a diffuser

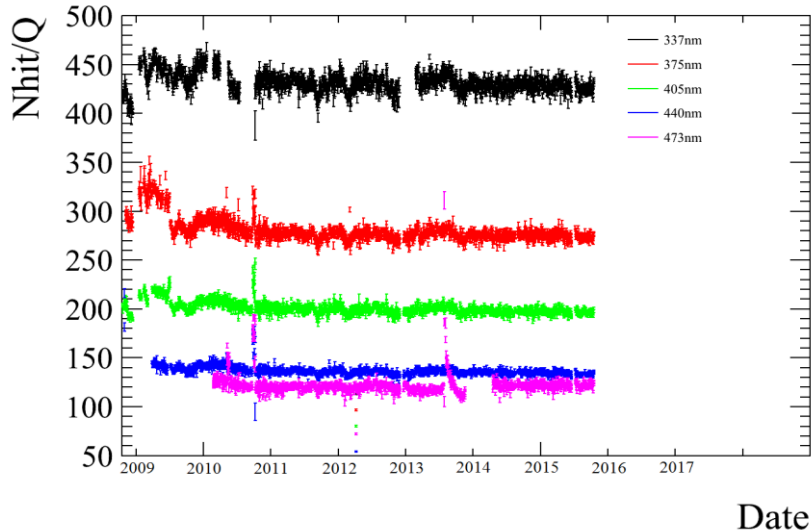
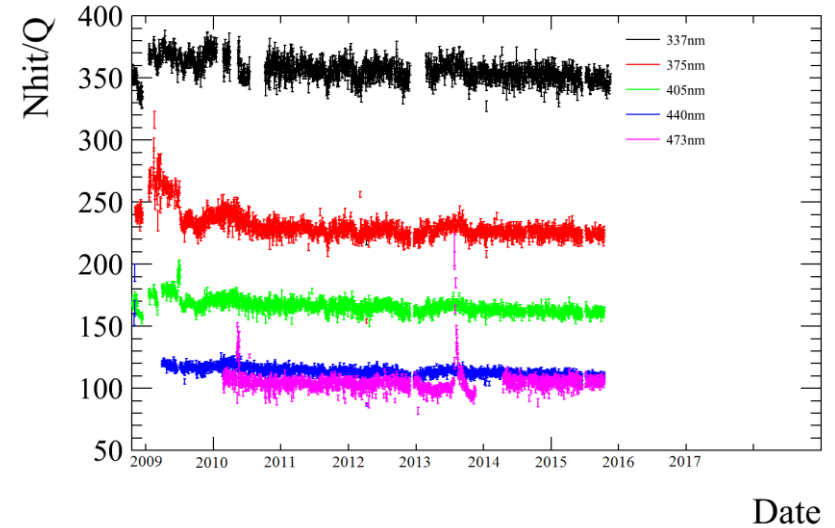
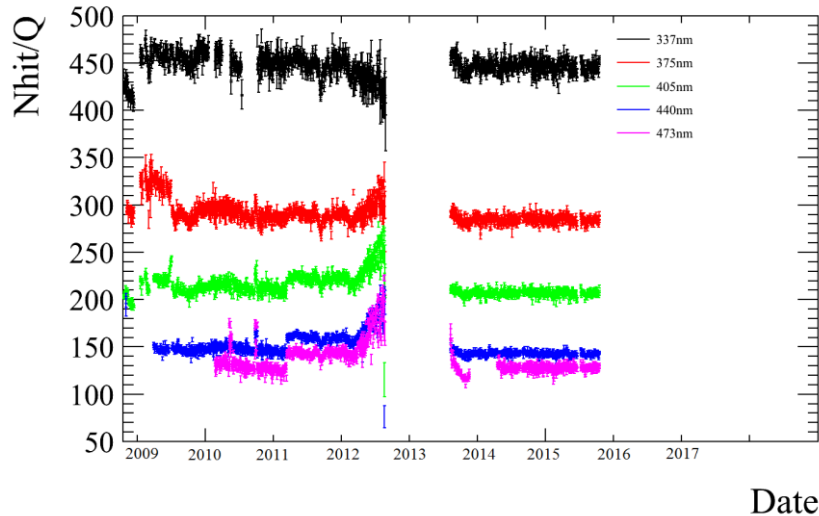
# SK Optical Calibration

- Eventually we would like to install a prototype system in an unused injection point of Super-Kamiokande's calibration system
- We are also now involved in the SK optical calibration group, and are contributing to the analysis of water laser data
- We want to further the current SK calibration analysis to investigate the potential depth dependence of the absorption and scattering parameters of the water





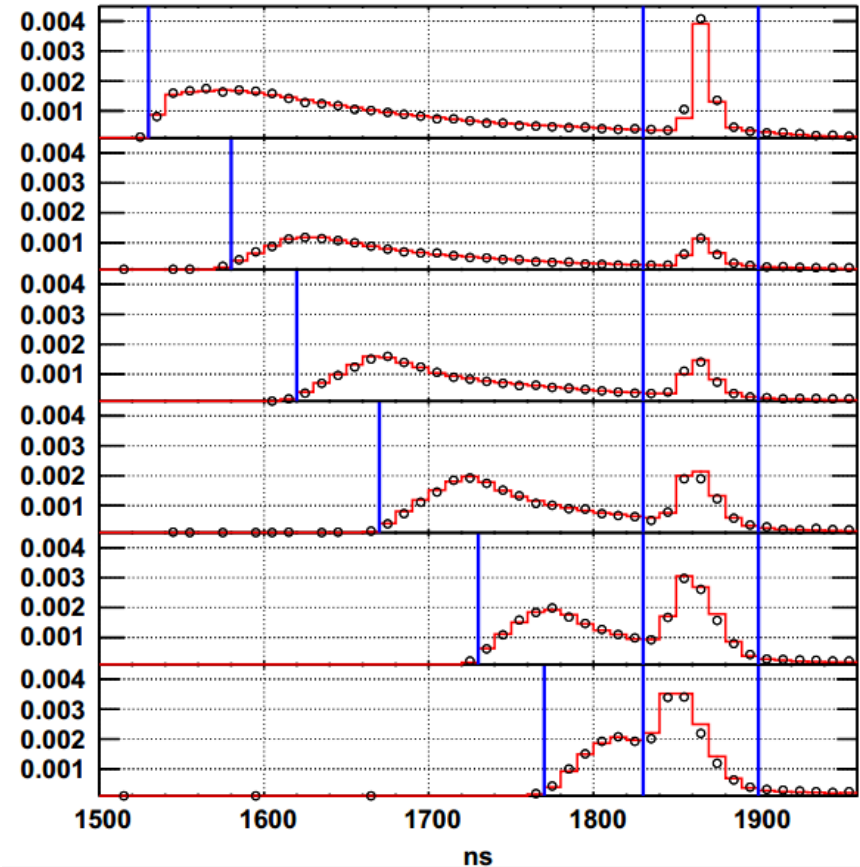
# SK Optical Calibration



- Data from all 5 barrel injectors has been investigated and found to be suitable for analysis (shown are tank top, centre, bottom)

# SK Optical Calibration

- Now we aim to follow the existing calibration analysis
- Want to measure the TOF corrected scattered light timing distributions
- Generate MC with various water parameters, determine parameters through  $\chi^2$  minimisation with data distributions



Plot from SK calibration paper: NIM A 737C (2015)



# Conclusions

- R&D is ongoing into pulsed LED system for optical calibration of HK PMTs
- Development of water tank for measurement of optical properties of underwater fibre emission is progressing well
- We have established a link with the SK calibration group, and aim to eventually deploy a prototype calibration system in SK
- Also contributing to ongoing SK calibration analyses, hoping to determine the depth dependence of water scattering and absorption parameters

# Thanks To JENNIFER

- Thanks to funding from JENNIFER, we have been able to establish a close link with the SK calibration group, particularly the water laser group
- This work has been presented at HK calibration meetings in Kashiwa and London, and an SK meeting in Toyama
- We have also undertaken shifts in the mine at SK
- Members of our group will spend most of November at SK, undertaking shifts, attending the SK collaboration meeting, and assisting with ongoing work on the tank