

## ***R&D and Status of the LED System for Hyper-K's LED-mPMT Module***

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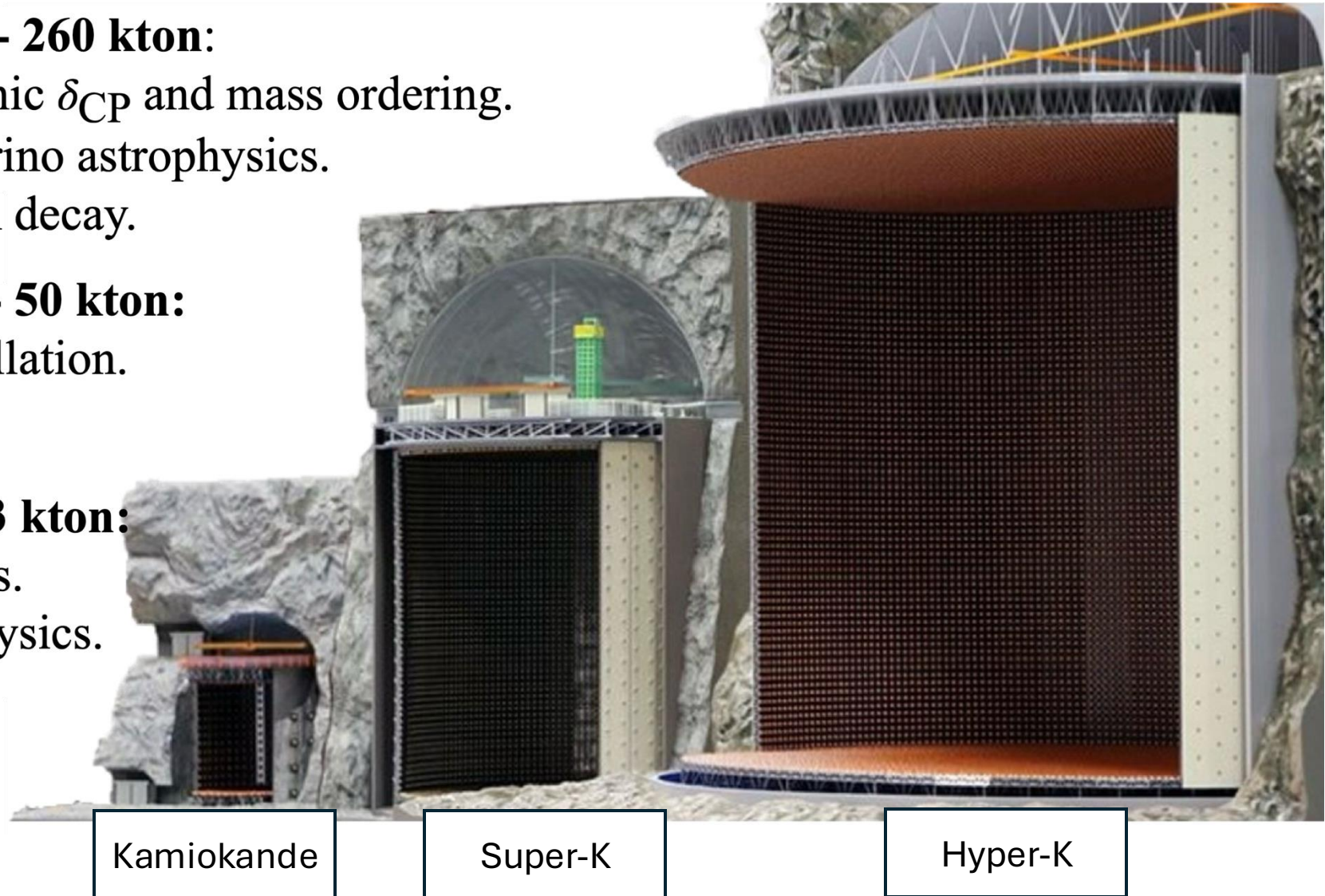
for the Hyper-K Collaboration

University of Regina

CAP Congress 2025

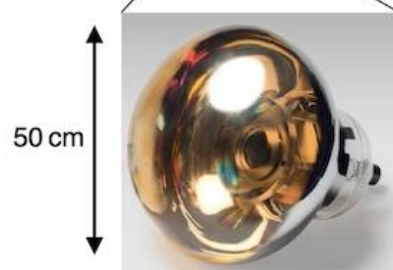
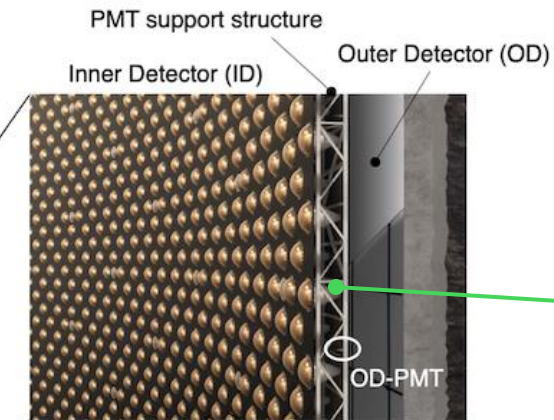
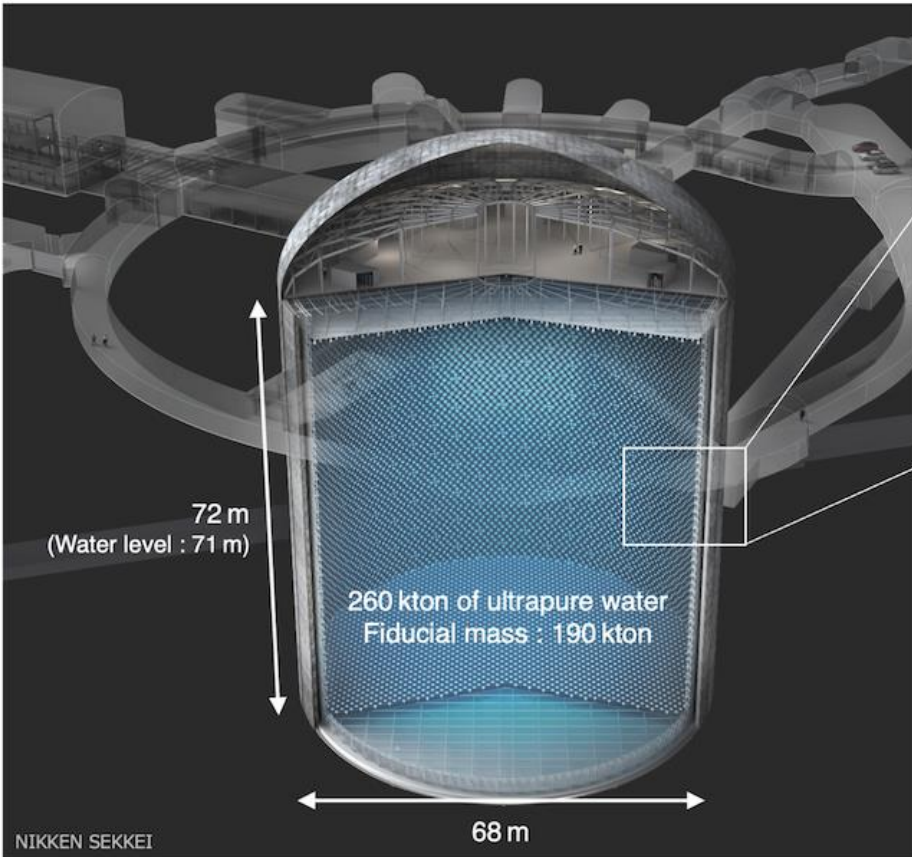
## 2 Kamioka Experiments

- **Hyper-Kamiokande (2027) - 260 kton:**
  - Toward discovery of leptonic  $\delta_{CP}$  and mass ordering.
  - Higher sensitivity for neutrino astrophysics.
  - Extended search for proton decay.
- **Super-Kamiokande (1996) - 50 kton:**
  - Discovery of neutrino oscillation.
  - Limits for proton decay.
- **Kamiokande (1983-1996) - 3 kton:**
  - Supernova 1987A neutrinos.
  - Advent of neutrino astrophysics.



### 3 Hyper-K Main Detector

- *Larger statistics and new photo-sensor technologies.*
- **Target:** 260 kton of ultra pure water,  $\sim 8$  times the fiducial mass of Super-K.
- **ID Photo-sensors:** 20,000 new ultrasensitive 50-cm PMTs and 1,000 multi-PMTs.



$\sim 20,000$  R12860 PMTs

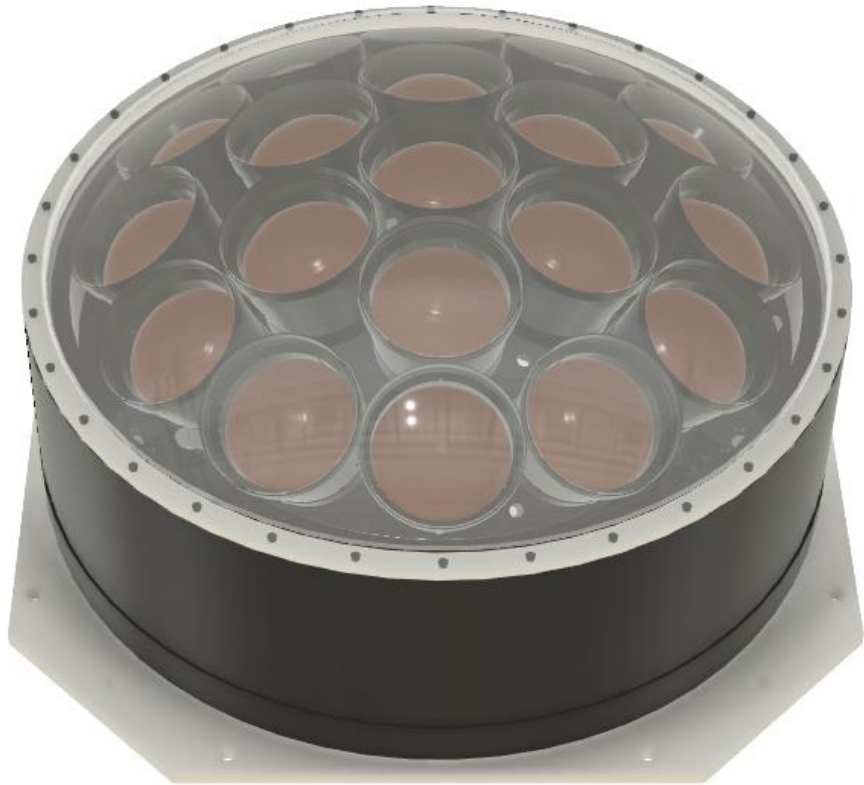


1,000 multi-PMT systems  
(WCTE Iteration. Photo by Mohit Gola @ TRIUMF)

## 4 LED-mPMT: Introduction

- The mPMT system contains 19 fast 8-cm PMTs.
- LED-mPMT will replace 5 PMTs with fast-pulsing UV light sources.

800 mPMT System



200 LED-mPMT System



LED System



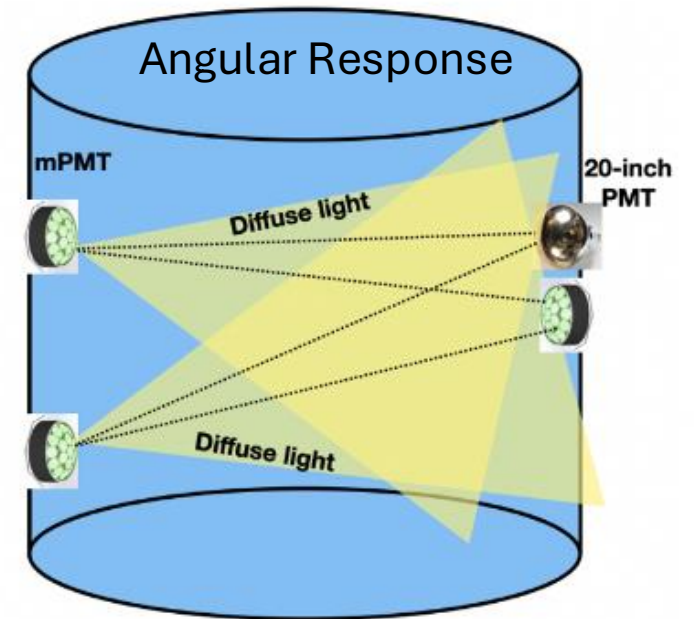
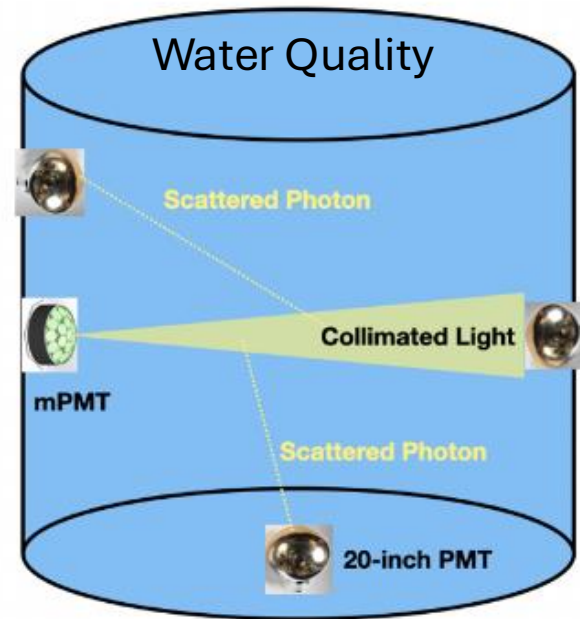
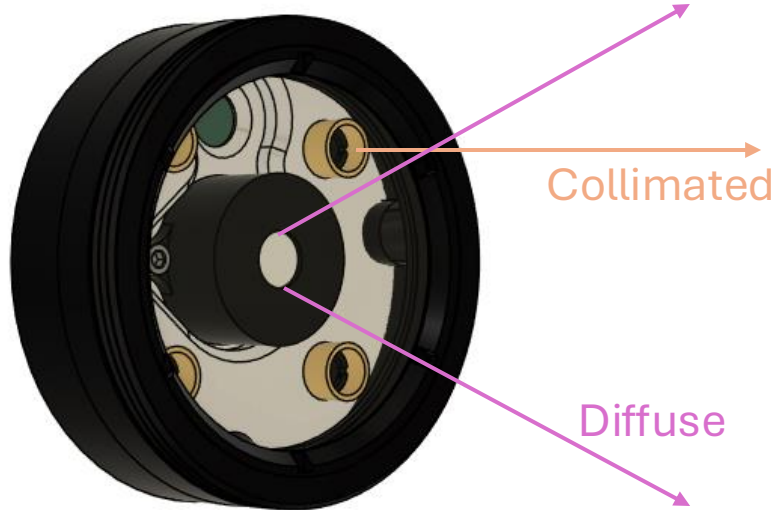
Hamamatsu R14373 PMT

***Segmented light collection and excellent timing resolution!***

# 5 Objectives

- **LED-mPMTs produce light while mPMTs calibrate this light.**
- ***Collimated light:***
  1. Position-dependent detection of impurities in the water (such as bacteria).
  2. Measure light transmission and infer water attenuation effects on Cherenkov light.
- ***Diffuse light:*** Measure the angular response and relative timing of the 50-cm PMTs.

## ***Sub-nanosecond pulsing***

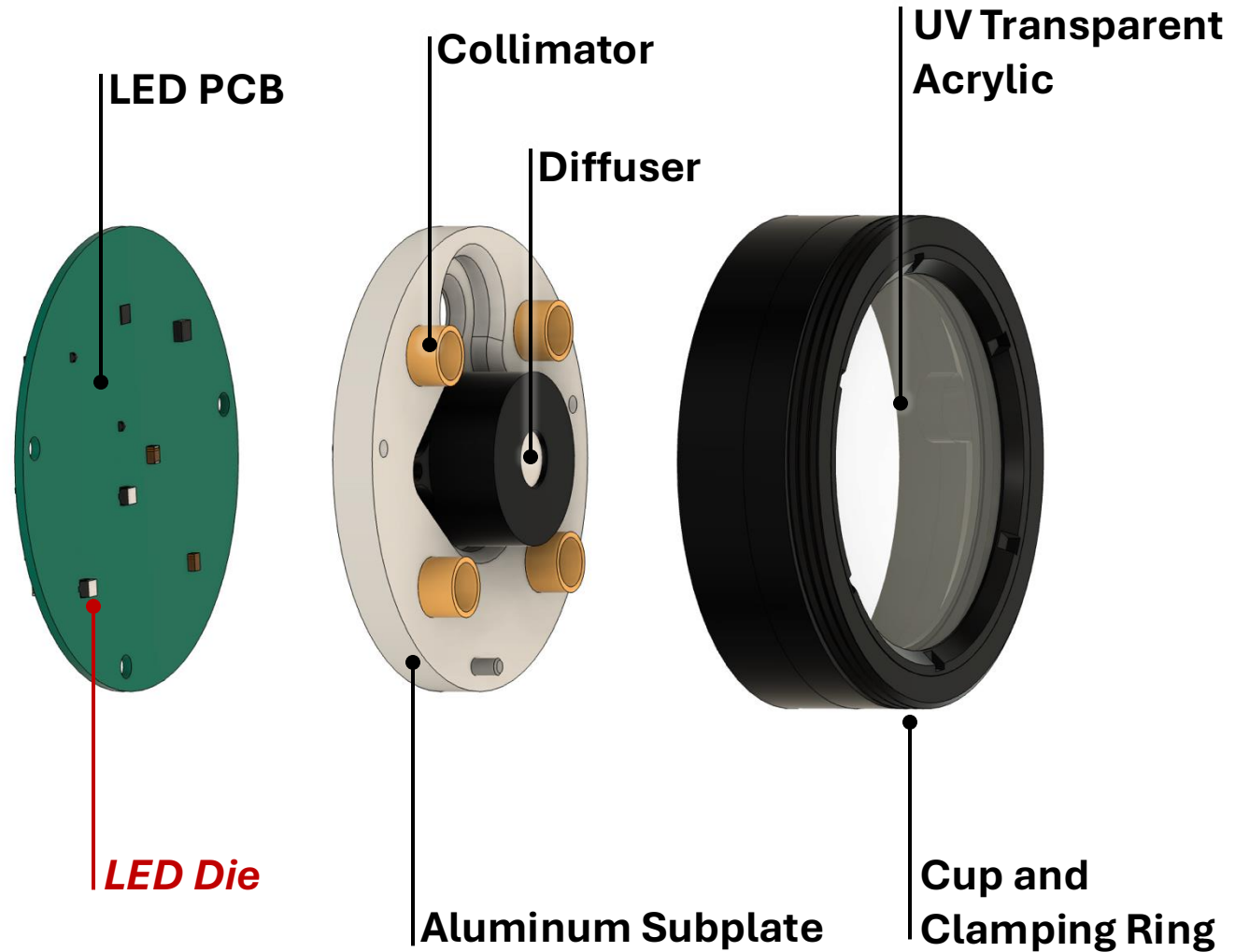


***All about improving systematic uncertainties!***

# 6 LED System: Components



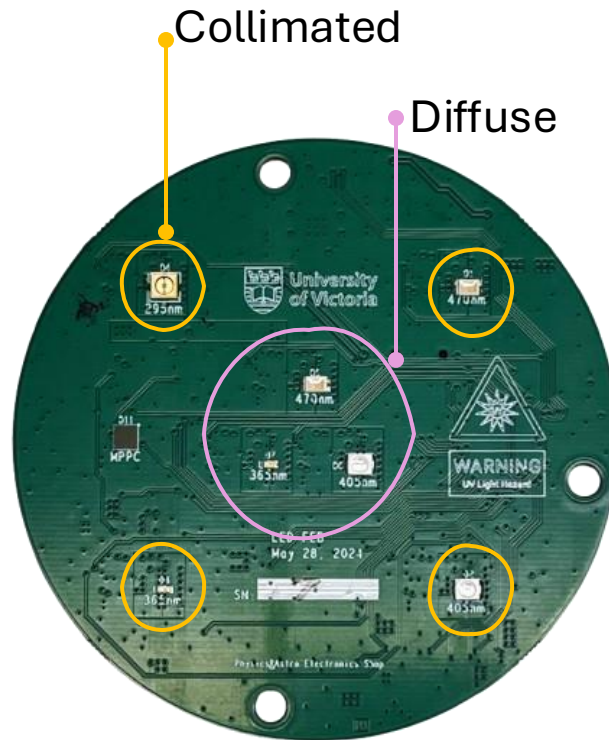
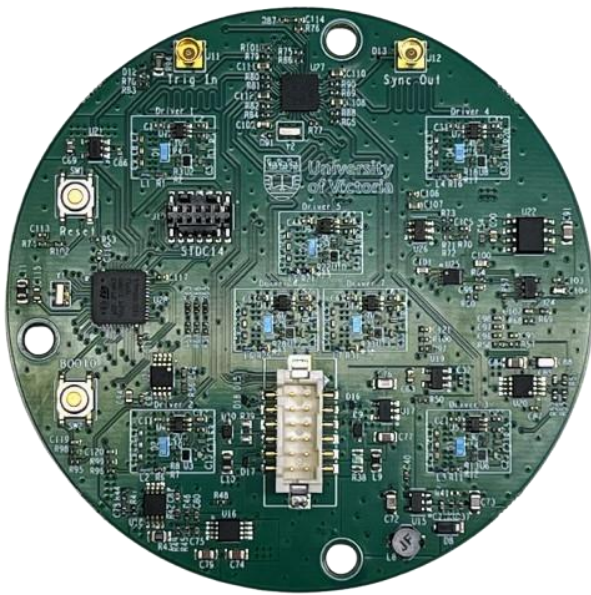
LED System with Latest Diffuser Design



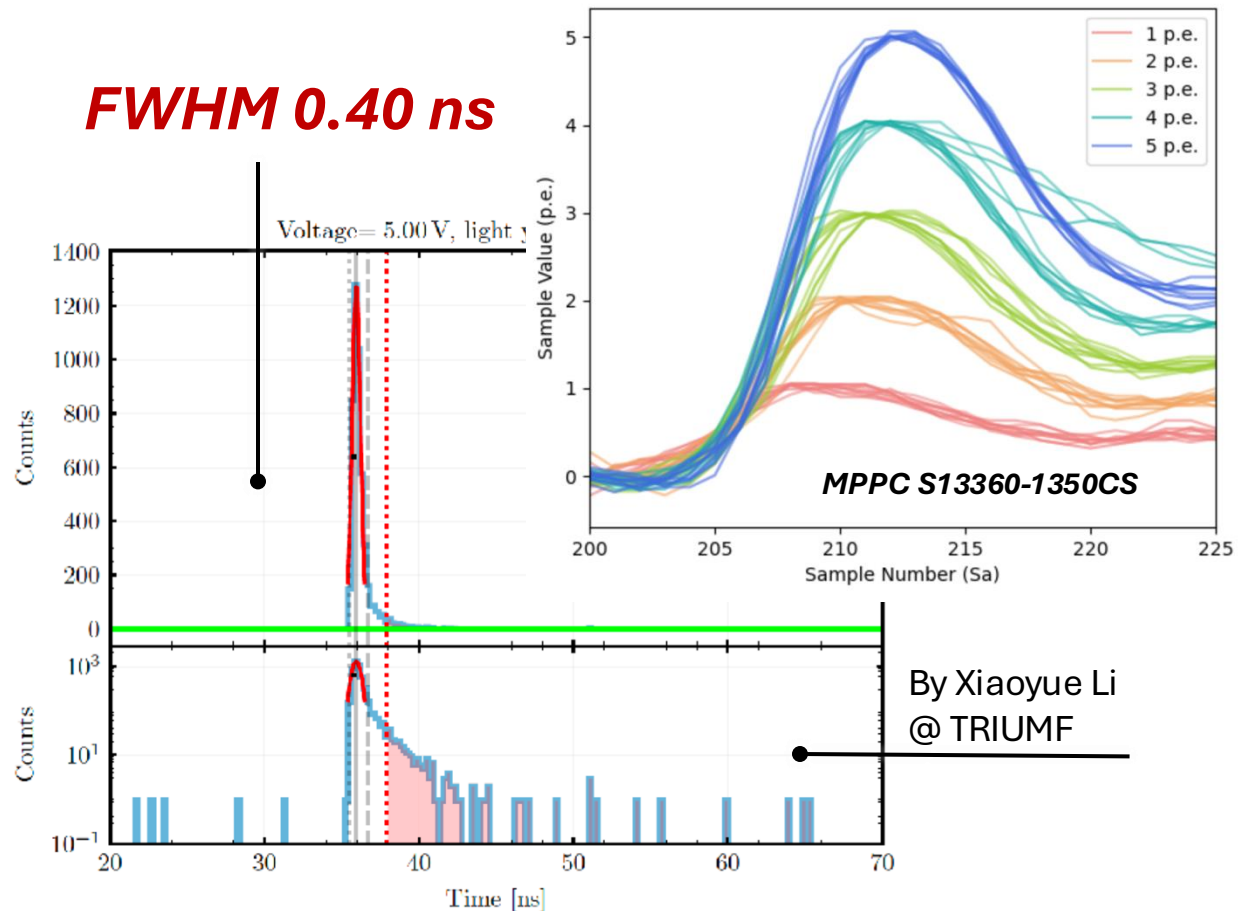
# 7 LED System: Electronics

- 7 fast-pulsing LEDs: 4 for collimated, and 3 for diffuse light sources.
- **Type A.** Collimated wavelengths: 470, 405, 365, 295 nm. Diffuse: 470, 405 and 365 nm.

LED Driver Electronics



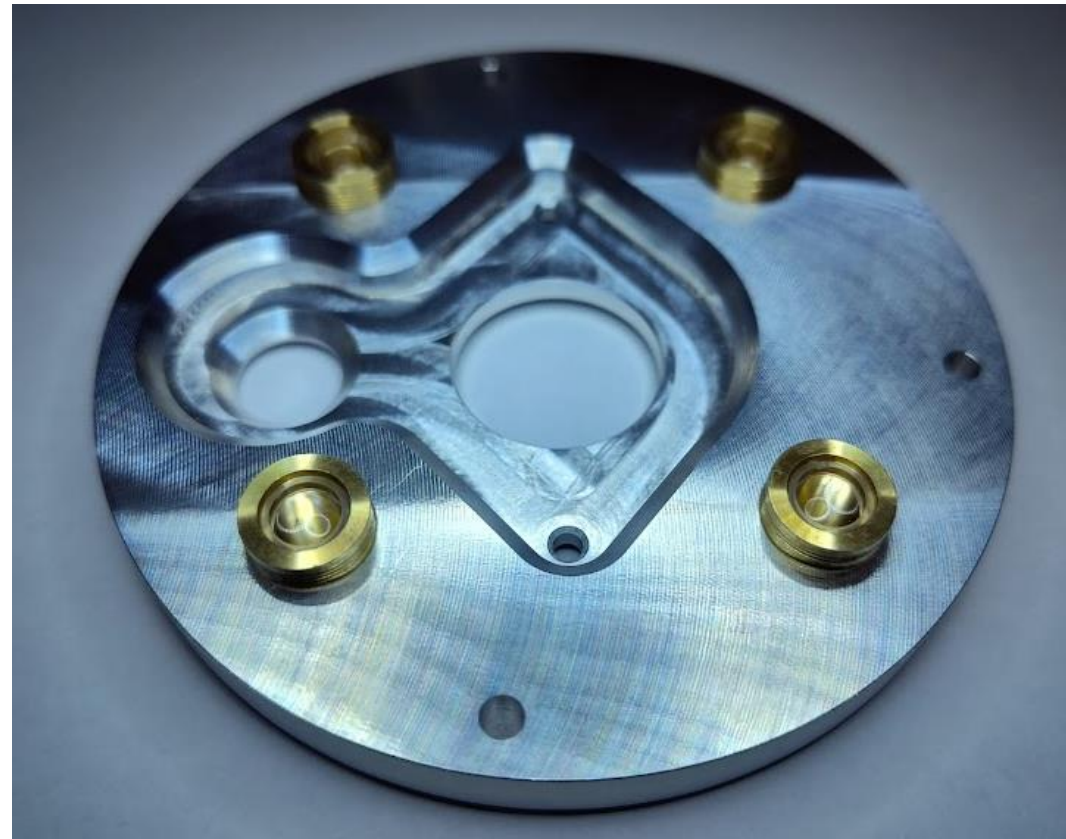
“MACH II” Type A Iteration of LED Frontend Board/  
Design by Nick Braam @ Uvic.



Signals and Timing for 470 nm LED.

## 8 LED System: Collimators

- Pinhole disk and acrylic/ quartz lenses are pressed into the collimator holders at Uvic.
- Aluminum subplates are manufactured by a company in Regina.

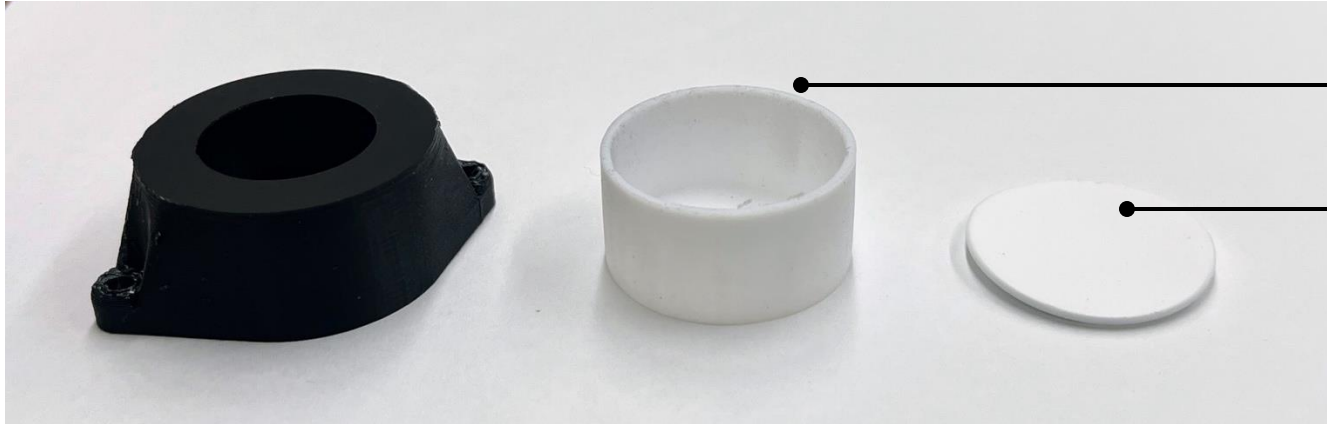


*The aluminum plates are also anodized!*

Collimators installed at Uvic/ Photos by Nick Braam @ Uvic

# 9 LED System: Diffusers

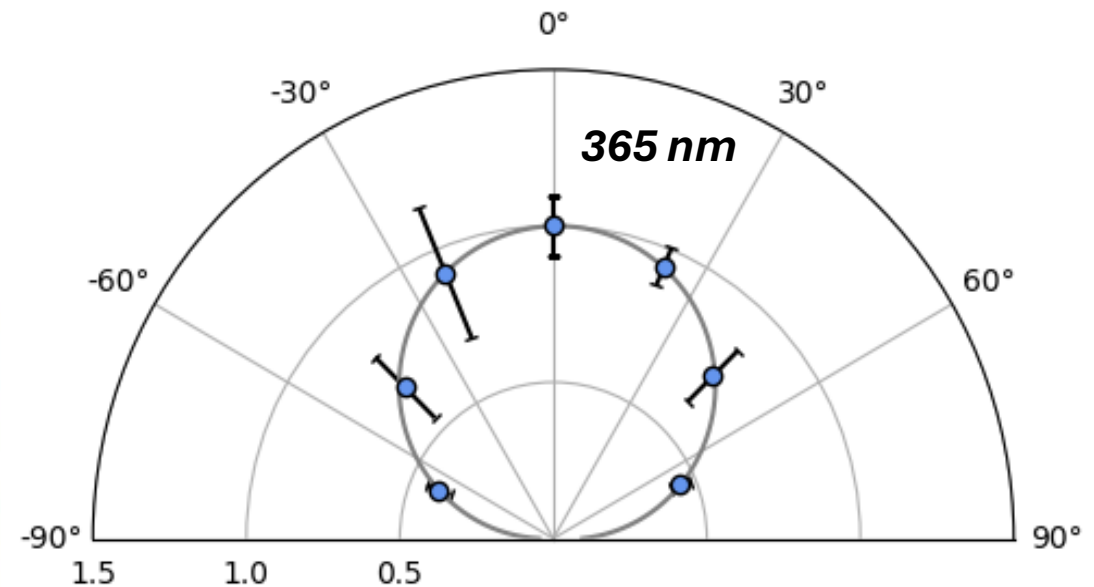
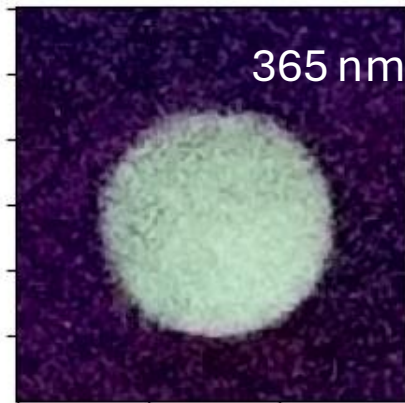
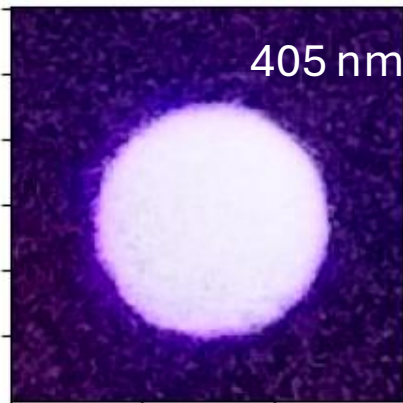
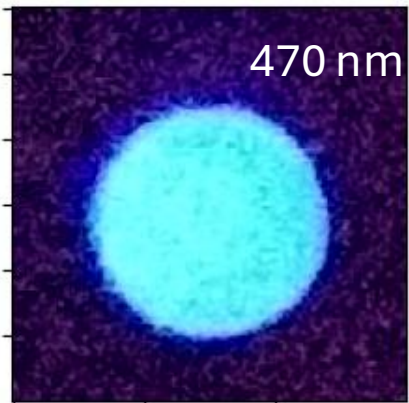
- Aiming for 1-2% light uniformity, using a two-step diffuser.



PTFE

Optical PTFE (Germany)

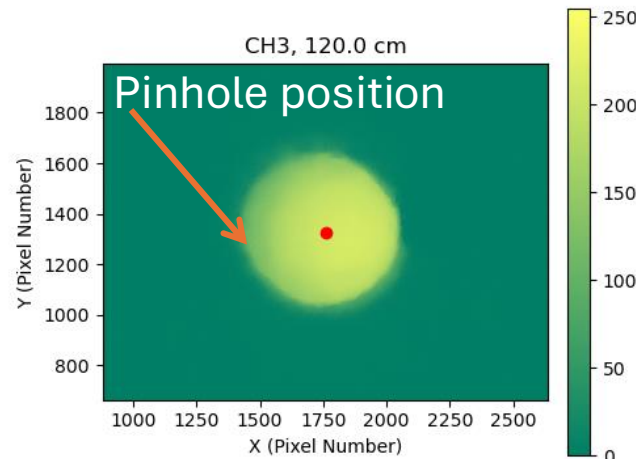
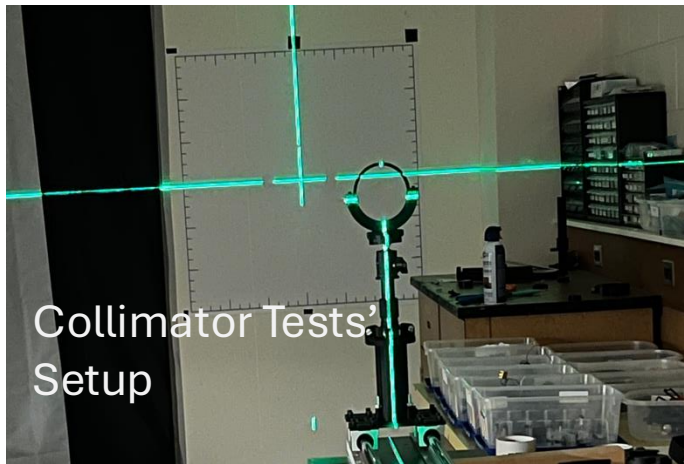
Diffuser by Xiaoyue Li @ TRIUMF/  
Sleeve by Nick Burril @ Carleton.



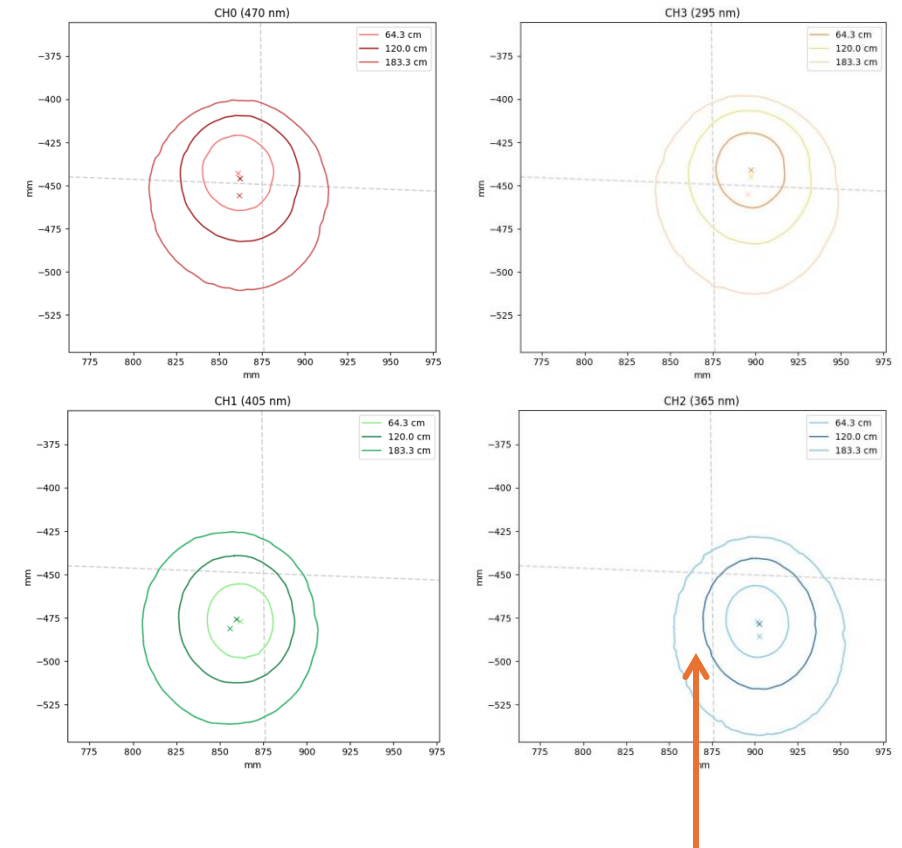
Light Output Measured with a PD/  
**Follows closely to a cosine law**

# 10 LED System: Quality Control

- At URegina, we are developing automated test stands for quality control.
- LED quality, collimator alignment and uniformity, diffuser uniformity, etc.

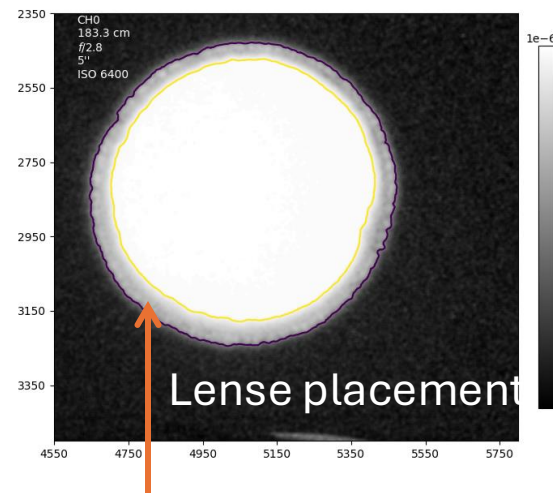
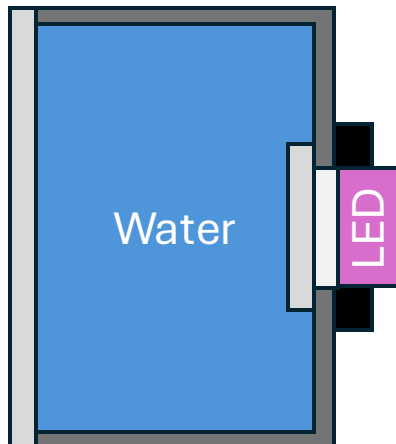


### Collimators' relative alignment



### Diffuser Tests' Setup

GoPro 10



# 11 LED System: Status & Plans



LED System #1 Ready to be Tested

- Our objective is to build and test 1050 LED systems for the Hyper-K tank.
- Pre-production run underway: **Building 20 LED systems by end of June.**
  - 5 of these prototypes will be installed in a LED-mPMT prototype at Carleton.
  - Current prototypes utilize 3D-printed PLA, but special Nylon will be used in the future.
  - PCBs manufacture by PCBWay under production (**ETA: June 17!**).
- Working toward automation analysis tools for quality control.

# 12 LED System: Pre-production



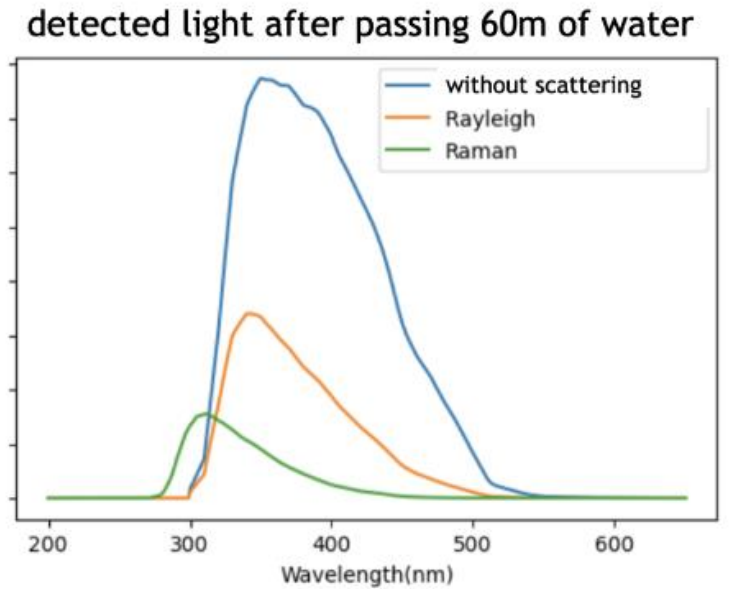
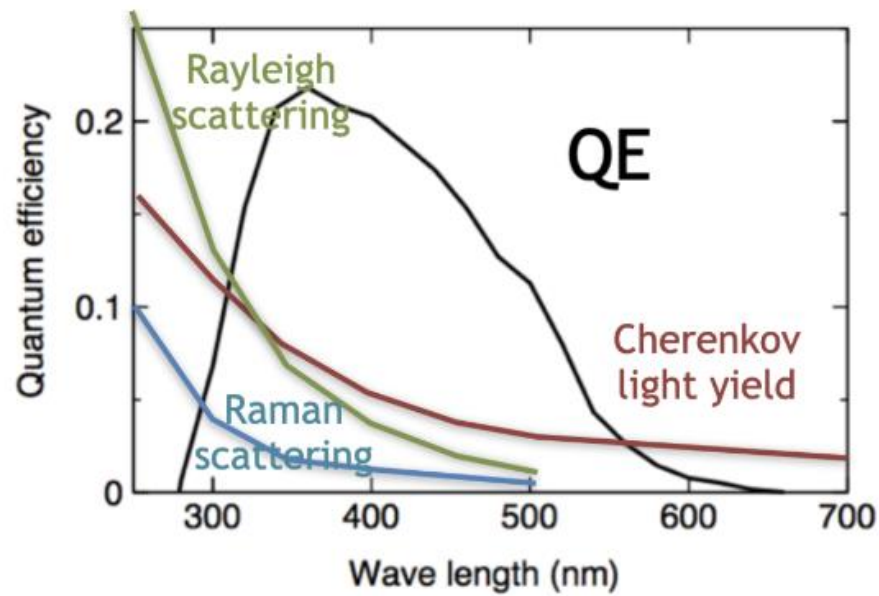
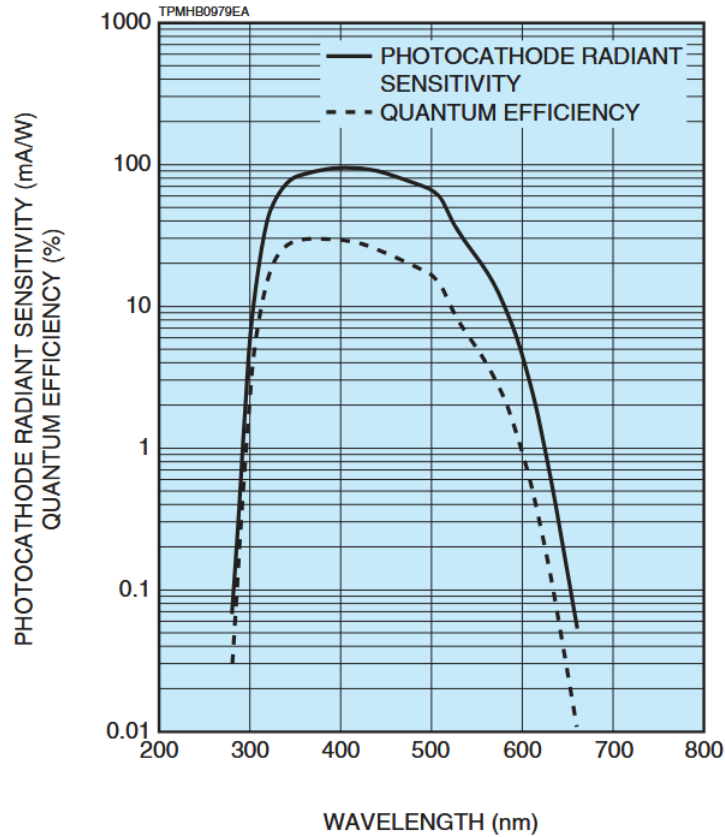
Pre-production of 20 LED System at Regina/ Photos by Nikolas Boily @ URegina.

# 13 Conclusions

- HK-Canada is developing the LED-mPMT module and LED systems.
  - **Measure angular response of 50-cm PMTs in the Hyper-K tank.**
  - **Monitor water quality and measure attenuation effects in Cherenkov light.**
- Pre-production run underway: Building 20 LED systems by the end of June.
- **Development of experimental test stands for quality control at URegina.**
- Aiming toward mass production and readiness for Hyper-K's start of operation.
- *Controlling systematics in neutrino-vertex reconstructions.*

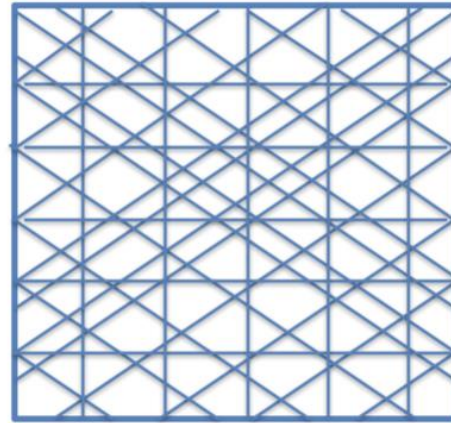
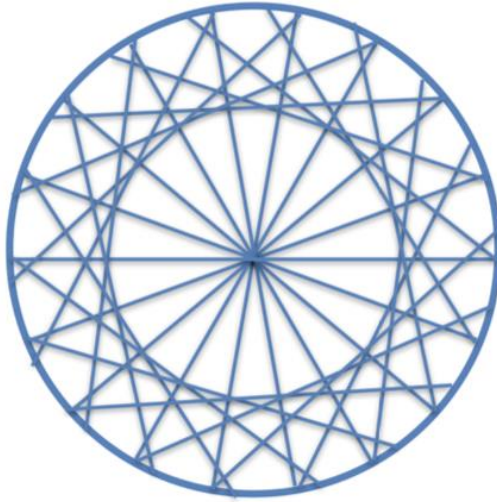


# 14 Backup Slides: Wavelengths



# 15 Backup Slides: LED-mPMT Positions

Collimated



Diffuse

