

Effects of light exposure and temperature on the quantum efficiency of PMTs for the KM3NeT Neutrino Telescope

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KM₃NeT Experiment

2 neutrino telescopes:

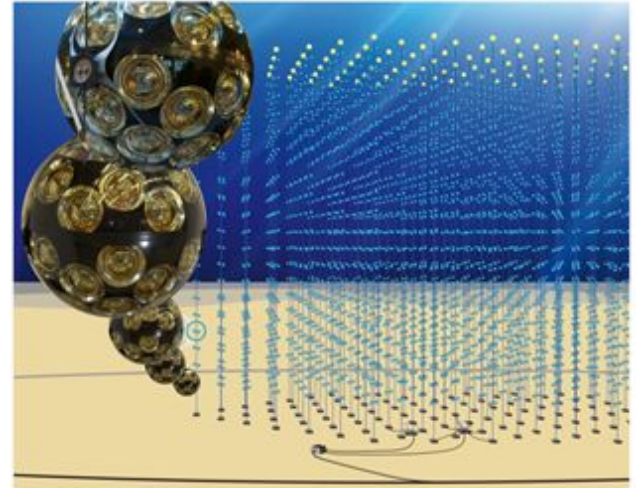
- **ARCA** off the coast of Sicily (Capo Passero) @~3.5 km of depth
- **ORCA** off the coast of France (Toulon) @~2.5 km of depth

ARCA
studies on astrophysical neutrino sources

ORCA
studies on neutrino oscillations and mass ordering

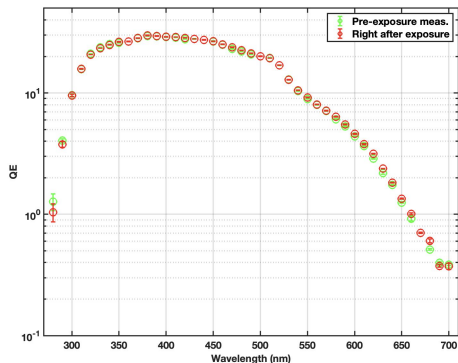
Principle

Instrumenting a large volume of water to exploit the production of Cherenkov light induced by charged particles produced by the interaction of neutrinos



Motivation of the work

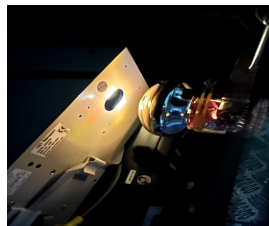
- **Photomultiplier Tubes (PMT)** are extraordinarily sensitive to low-intensity light
- **Quantum Efficiency (QE)** is crucial for accurately detecting photons and discerning the energy, direction, and characteristics of incident particles



- Very sensitive devices. They can suffer damage to the *photocathode coating*

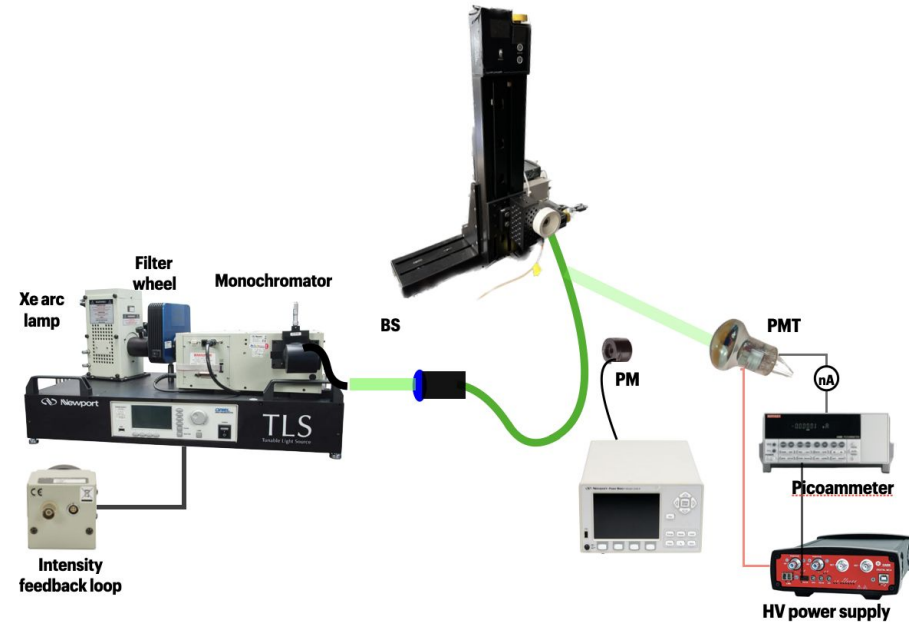


- Study on the damage threshold and recovery time of Hamamatsu **bialkali SbKCs metal-coated photomultipliers** exposed to light and thermal stress



Experimental setup

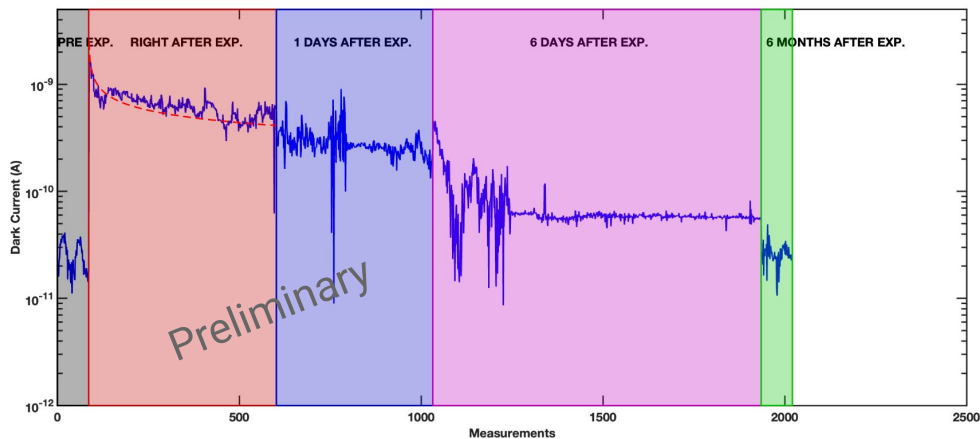
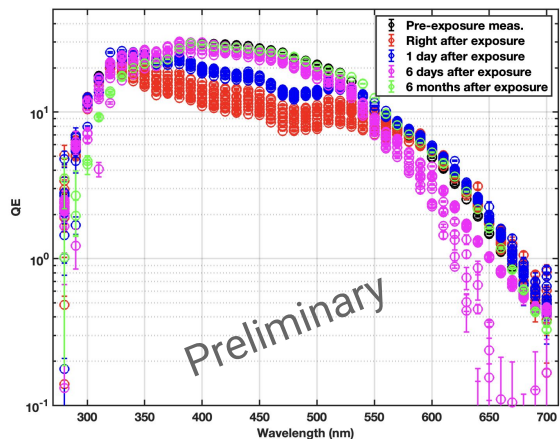
- **Newport TLS 260** tunable light source (300-watt xenon arc lamp)
- **Newport 918D-UV-OD3R** NIST calibrated power probe
- **Newport 2936 R** base for power probe connection and reading
- **Keithley 6485** picoammeter for measuring current
- **Parabolic mirror collimator** (RC02FC-F01-UV-enhanced from Thorlabs)
- Thermo-electrically cooled silicon photo-diode for active stabilization
- **LTS300C** stages from **Thorlabs** for controlling Z and X axis



Lamp exposure results

23 hours of exposure to the Xe lamp light

Lamp Irradiance = 1.22 W/cm^2
Solar Irradiance = 85.35 mW/cm^2 at $\lambda = 555 \text{ nm}$



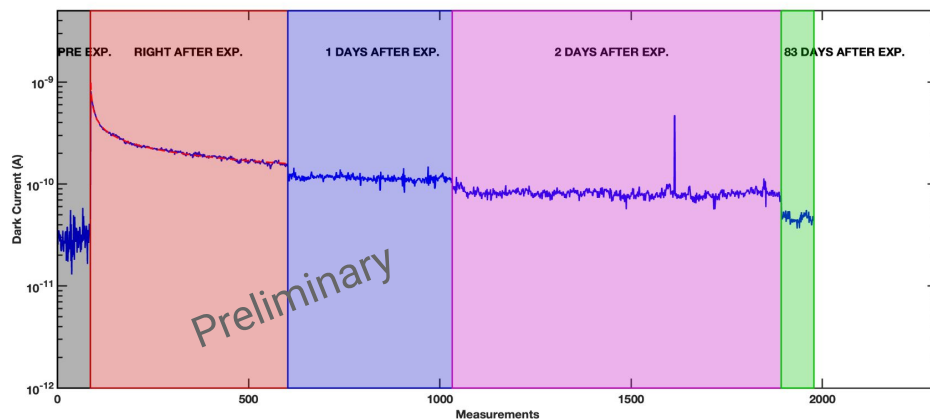
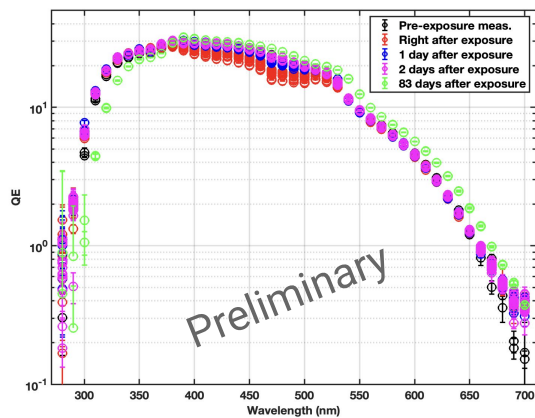
Left - **Quantum Efficiency** evolution as a function of wavelength before and after exposure. Right - **Dark Current** evolution as a function of the number of measurements

No permanent damage. Only a **temporary decrease in QE**, with a maximum reduction of about 60%, is observed in the wavelength range between 300 and 500 nm

The **Dark Current** showed alterations, gradually returning to its initial state following a **power law**

Thermal exposure results

2 days at 90° C and one day at 180° C



Left - **Quantum Efficiency** evolution as a function of wavelength before and after exposure. Right - **Dark Current** evolution as a function of the number of measurements

No permanent damage. Only a **temporary decrease in QE**, with a maximum reduction of about 15%, is observed in the wavelength range between 300 and 500 nm

The **Dark Current** showed alterations, gradually returning to its initial state following a **power law**

Summary

- Several PMTs were subjected to light and thermal stress in order to evaluate their under different conditions and to identify damage thresholds and recovery times;
- PMTs exposed to light stress were subjected to direct light from a **300-watt Xenon arc lamp** for cycles of different durations;
- PMTs exposed to thermal stress were placed in an oven for cycles of different temperatures and durations;
- In both situations:
 - No PMT showed irreversible damage (*except in one case -> See poster*);
 - a temporary decrease in **QE** was observed;
 - In these cases as well, the **dark current** follows an exponential decay law after exposure.