New measurements on an improved 3" Hamamatsu photomultiplier for the KM3NeT Neutrino Telescope

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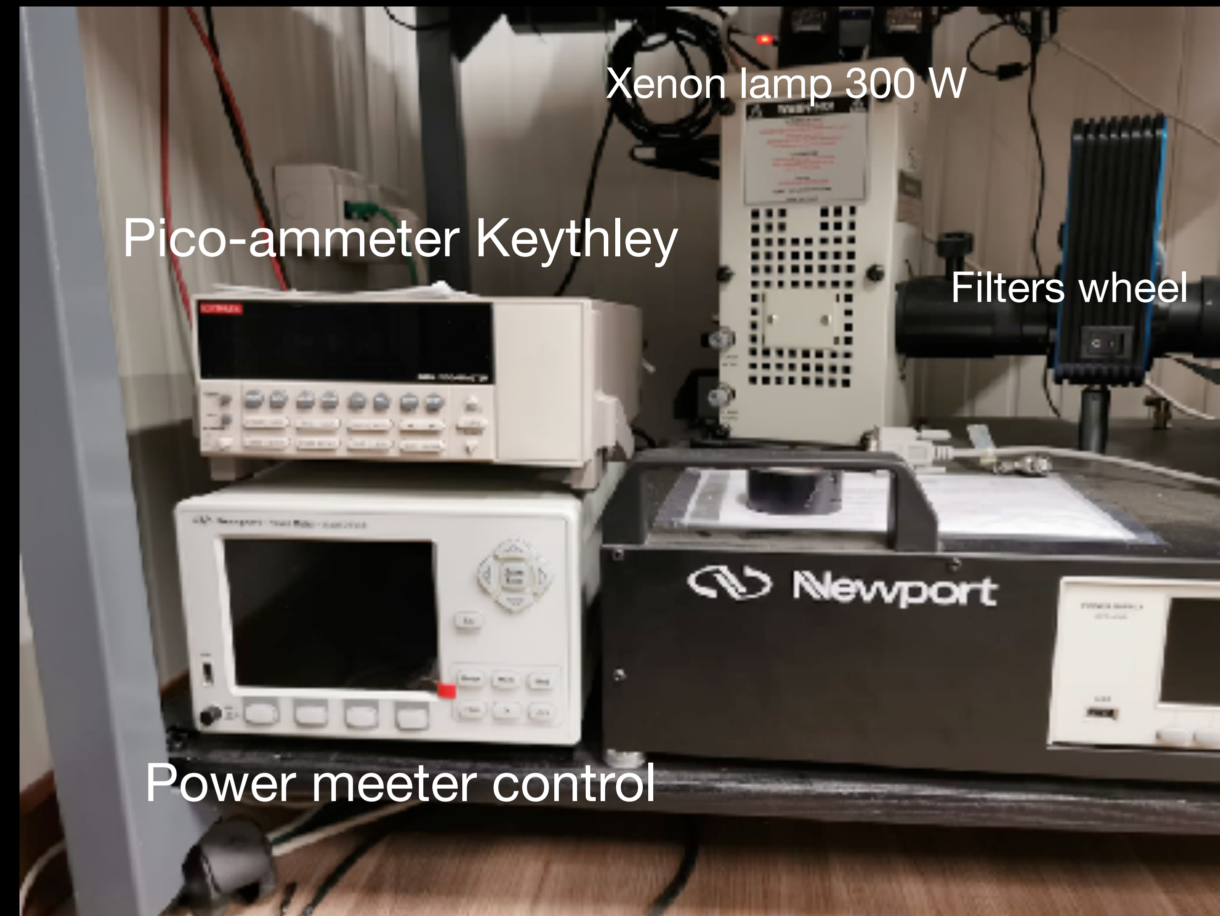
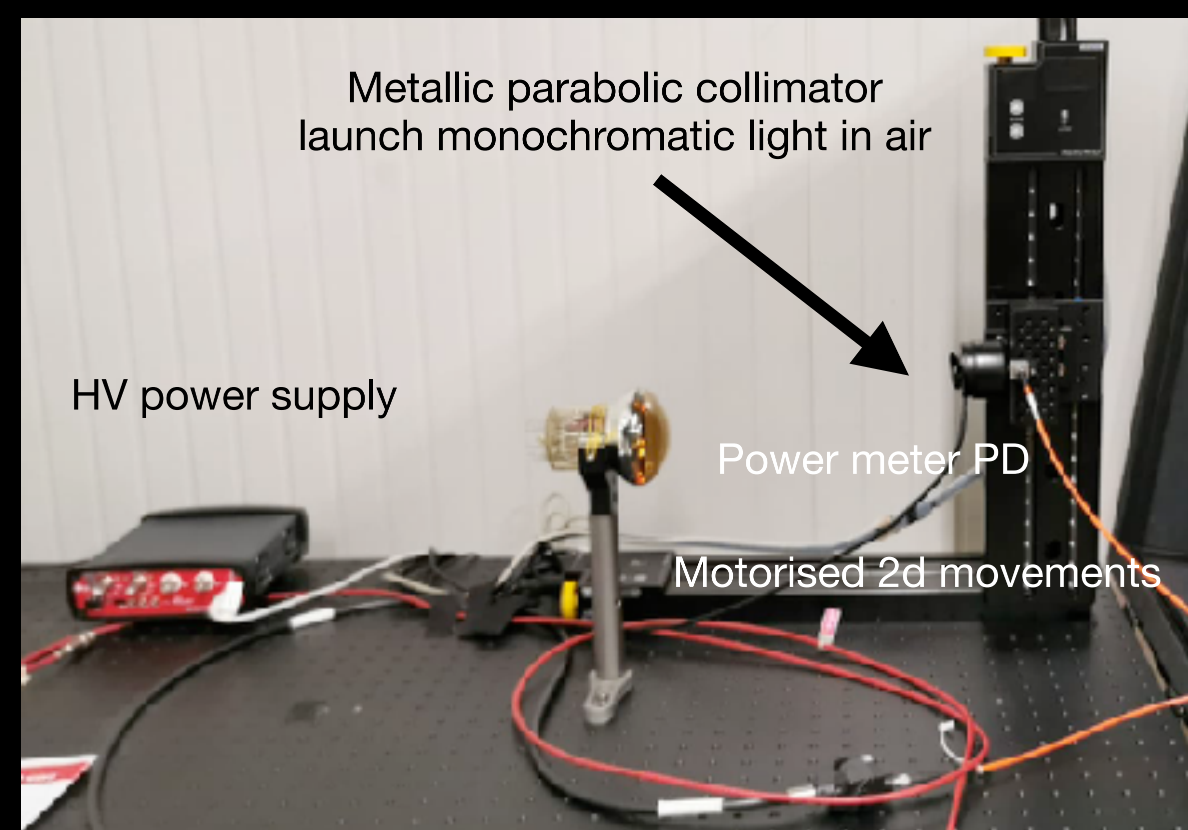
on behalf of KM3NeT collaboration

Summary

- Describe the new setup for Quantum Efficiency at INFN-Capacity lab in Caserta
- Show the QE measurements and compare the OLD R12199 (cfr. 2018 *JINST* **13** P05035) to the NEW R14374 PMTs
- Describe the special R14374 UBA increased QE PMT under test for possible future improvements
- Compare the time characteristics of a 500 set of new R14374 PMT using the Dark box apparatus to the old 3” PMT
- Conclusions

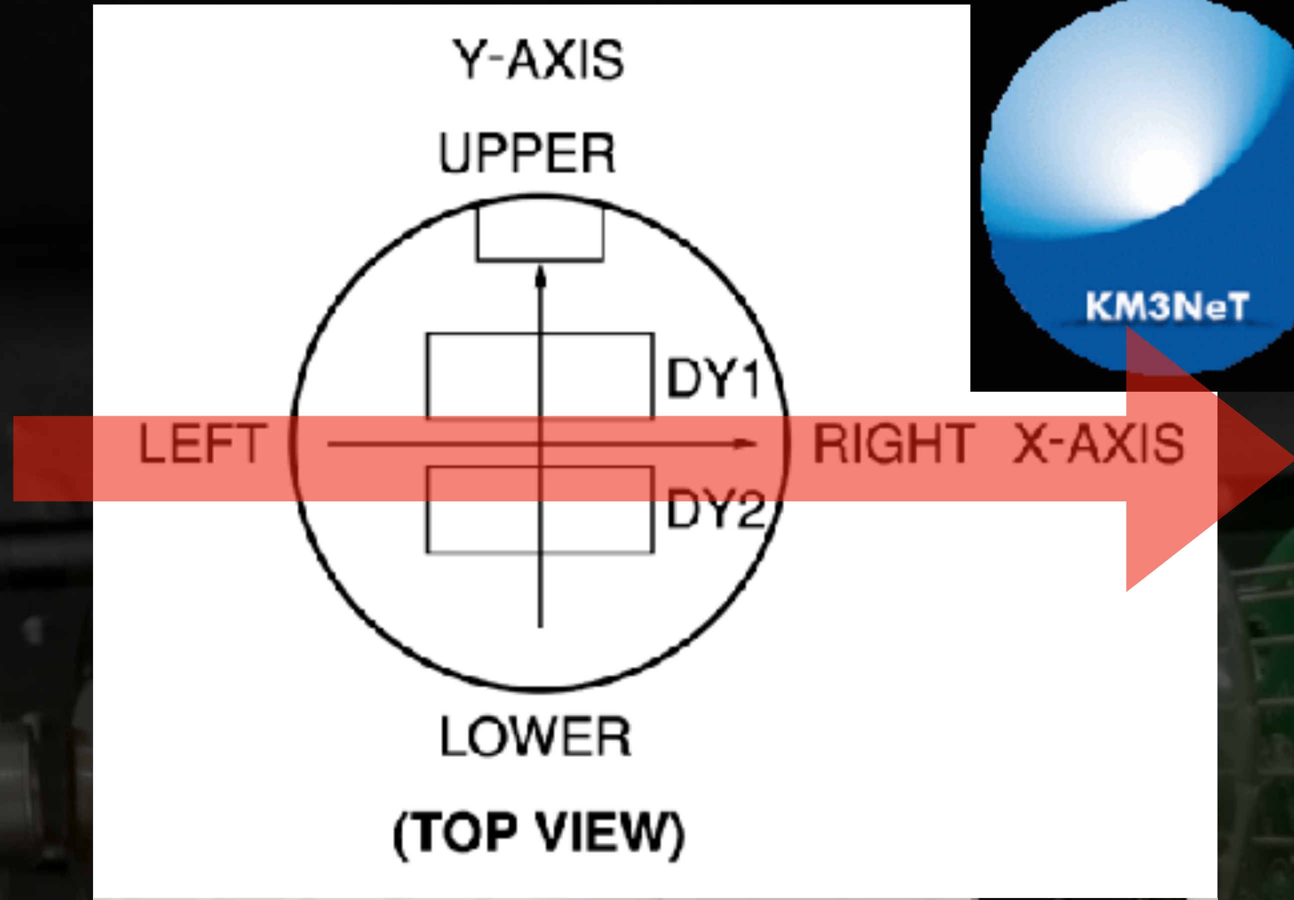
Experimental apparatus at CAPACITY lab of Caserta - INFN

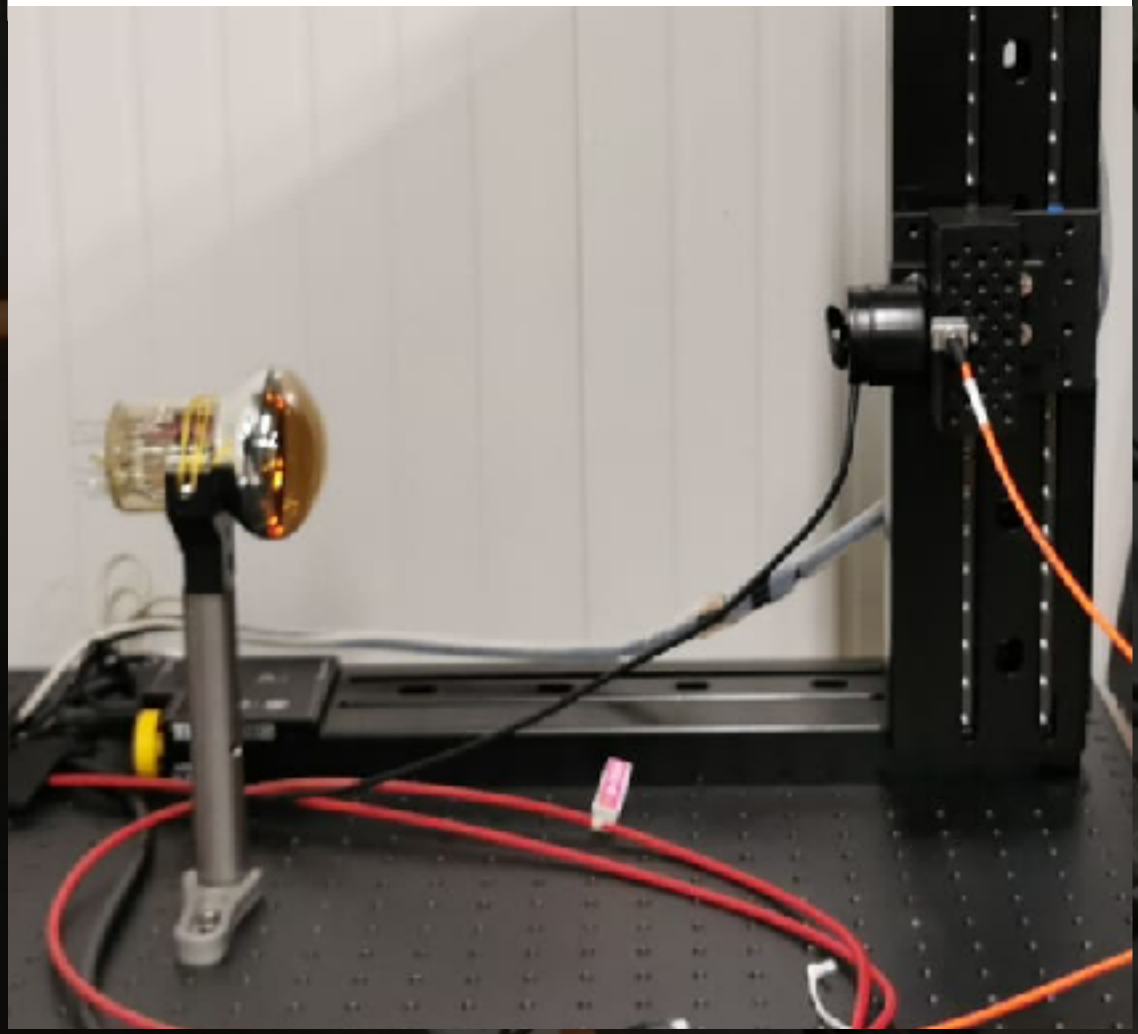




Experimental solutions

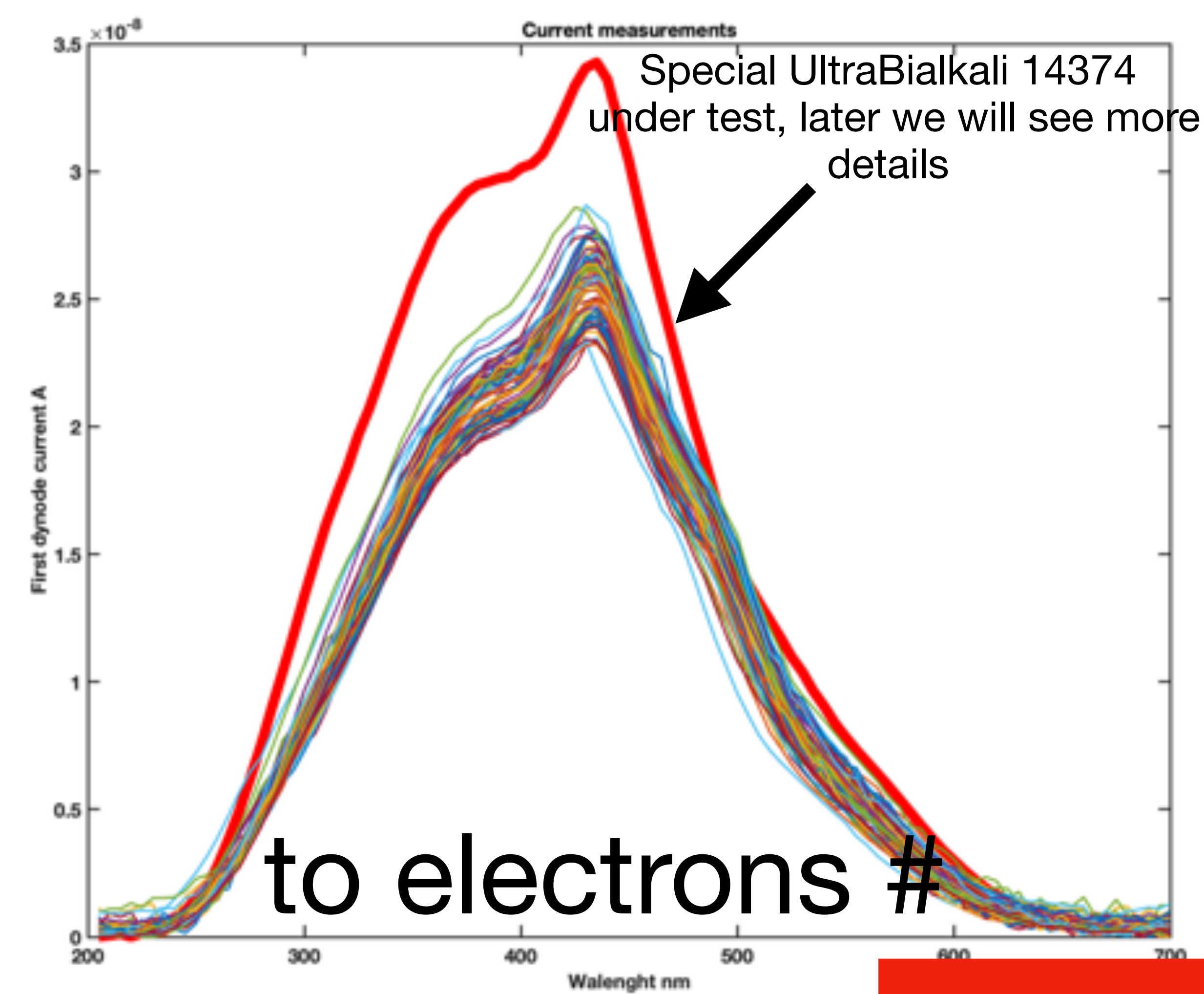
- 2D cathode scan is performed by programming the head motion in a comb movement shape.
- Custom code to read the Keythley pico ammeter via RS232 with instrument control toolbox.
- Cathode at -100 V respect to the first dynode grounded together with all the 9 remaining dynodes and anode in order to collect all possible electrons escaping from the first dynode

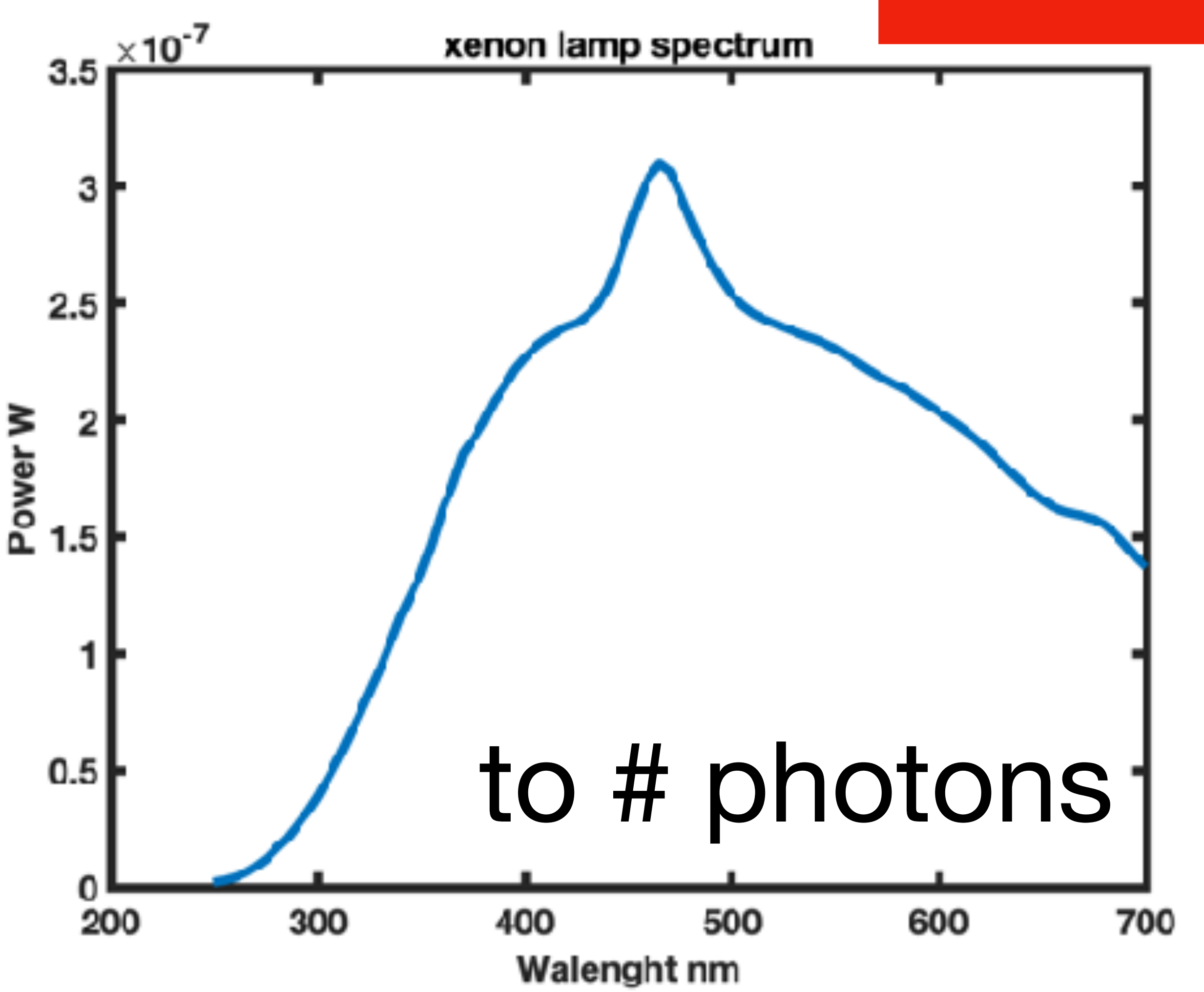


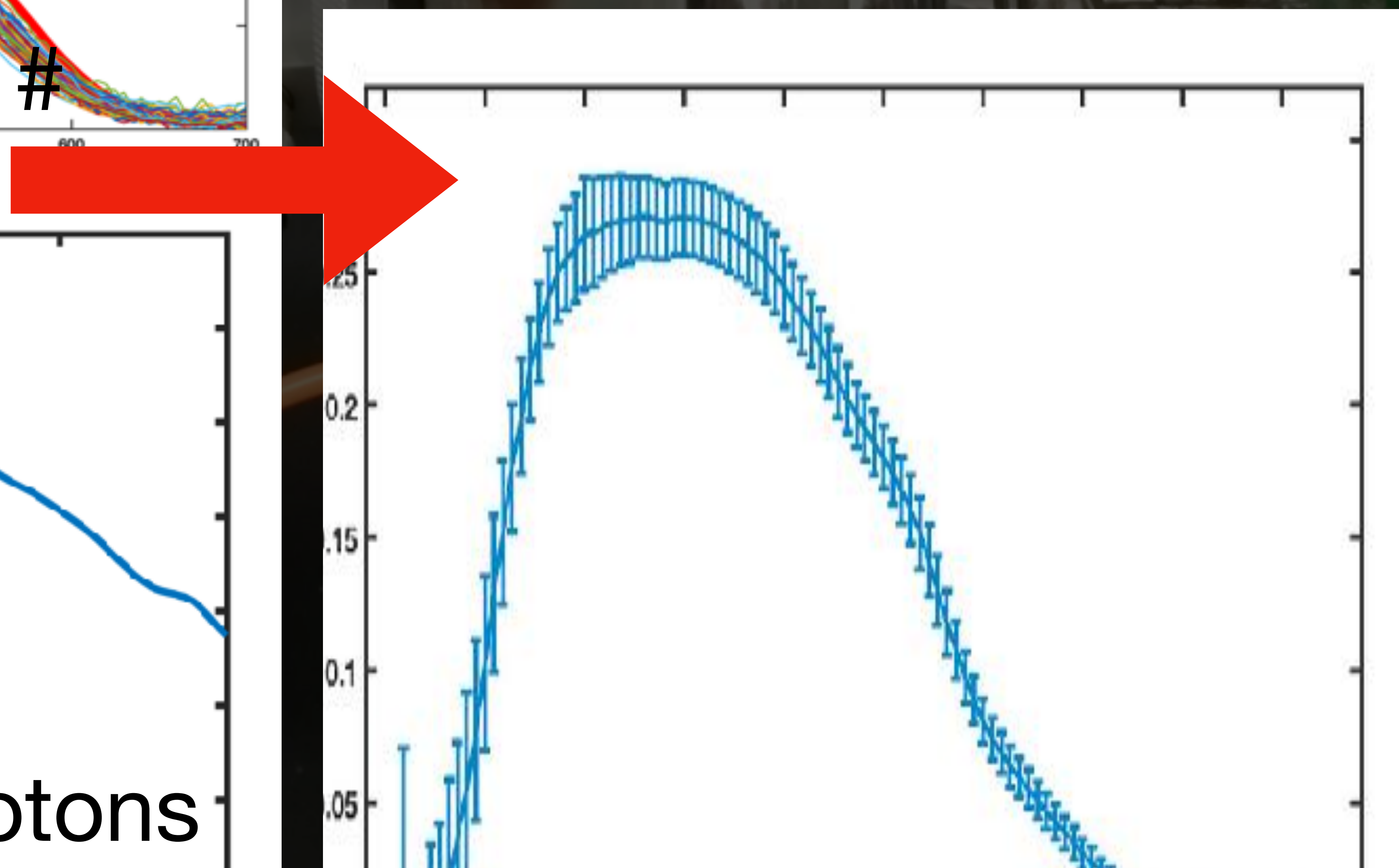


Method

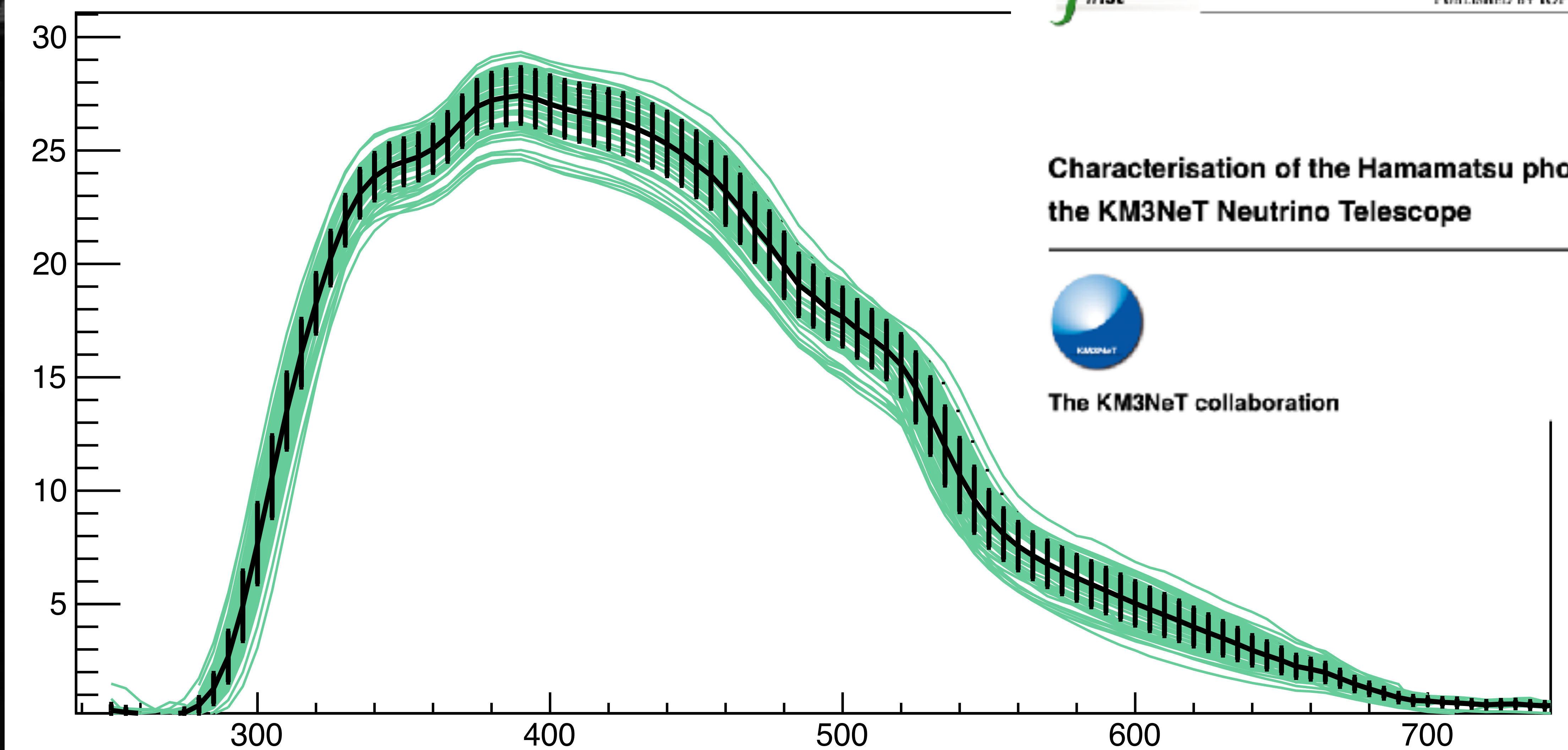
- We acquire a reference power spectrum every ten current spectra and measure PMT current vs Wavelength (use the monochromator scan function) and store it for post processing.







Former measurements on the R12199 performed at ECAP on a 46 pcs. set



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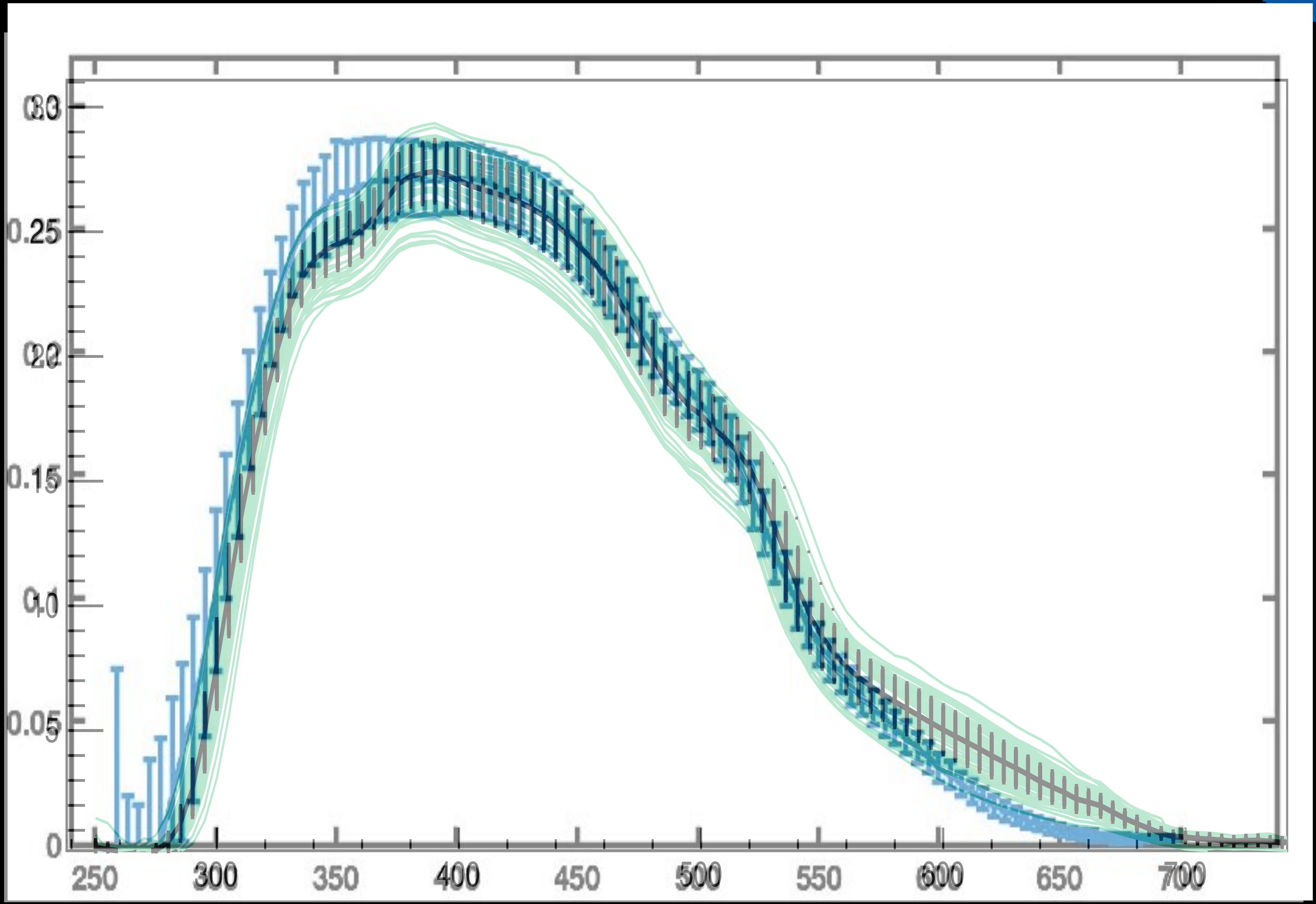
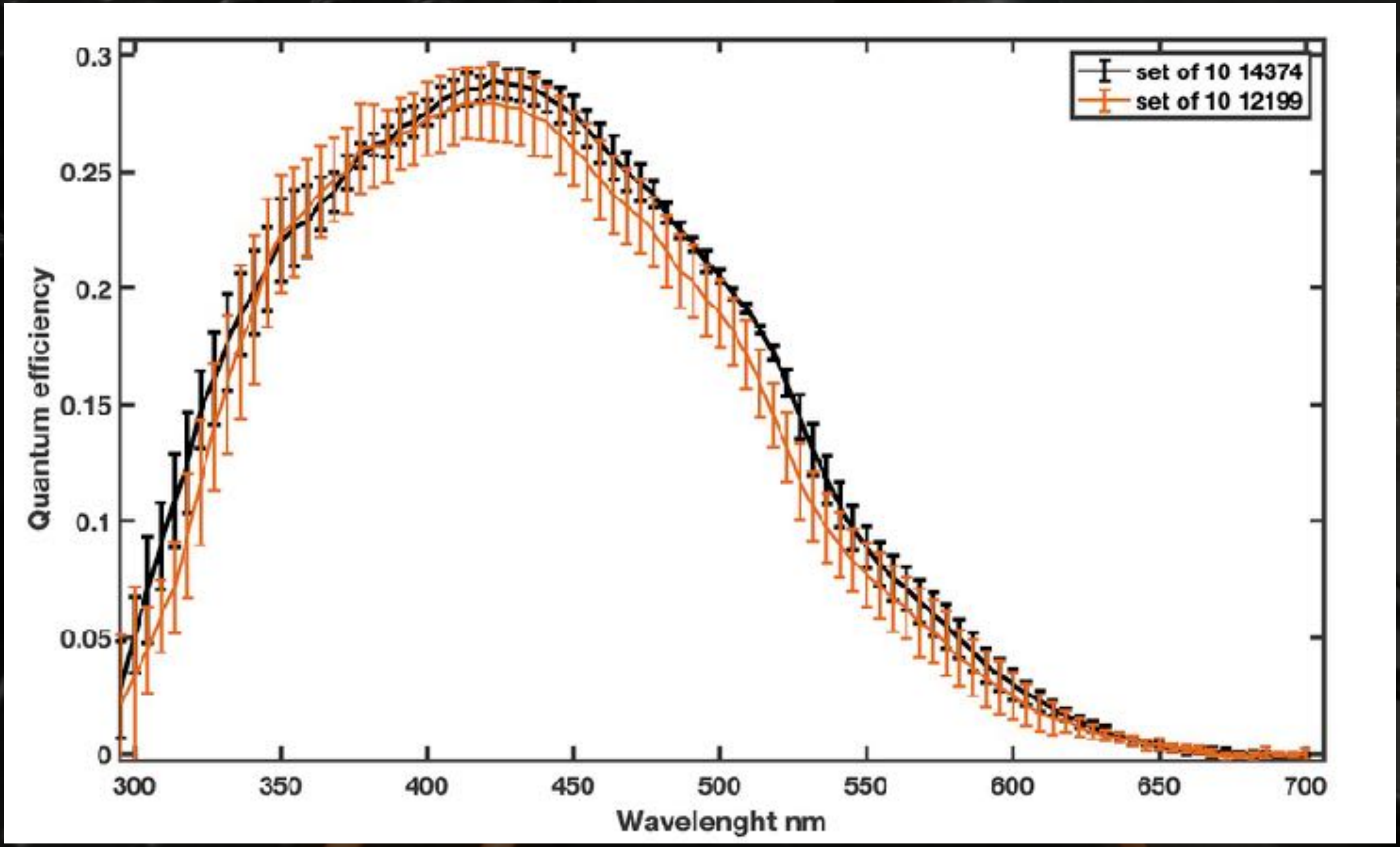
Characterisation of the Hamamatsu photomultipliers for the KM3NeT Neutrino Telescope

The KM3NeT collaboration

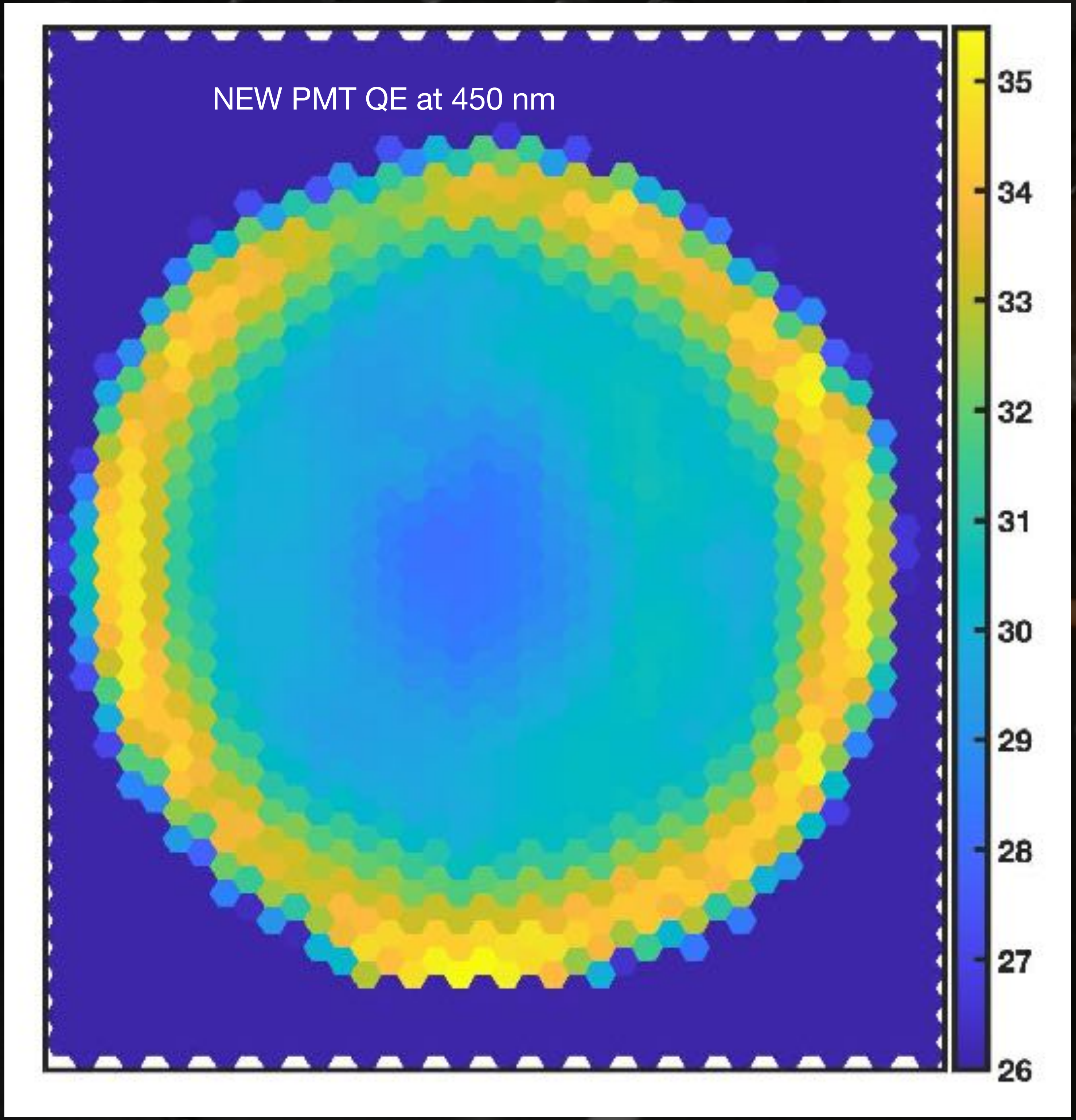
Comparing former measurements of ECAP with the new ones performed over a set of 200 PMTs



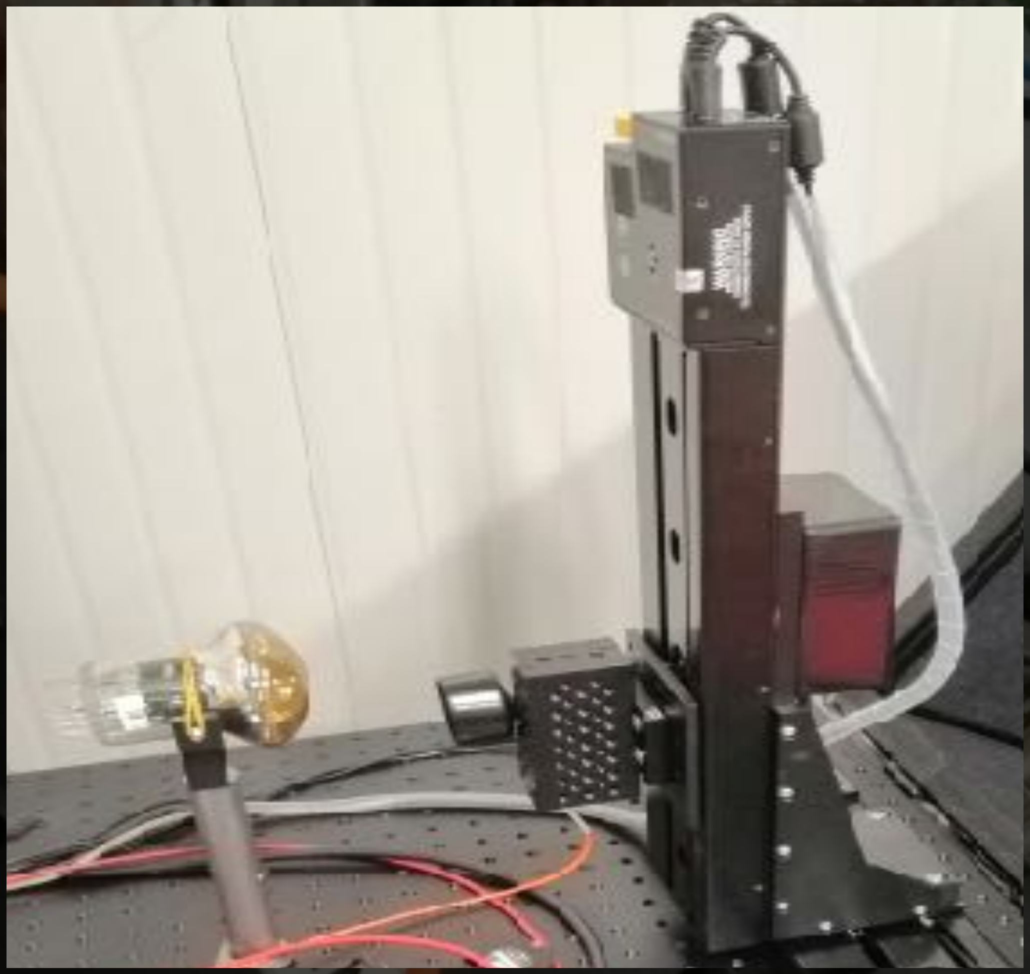
Small subset comparison :
average values of QE for OLD and NEW pmt by using
THE SAME EXPERIMENTAL SETUP in CASERTA



Spatial uniformity



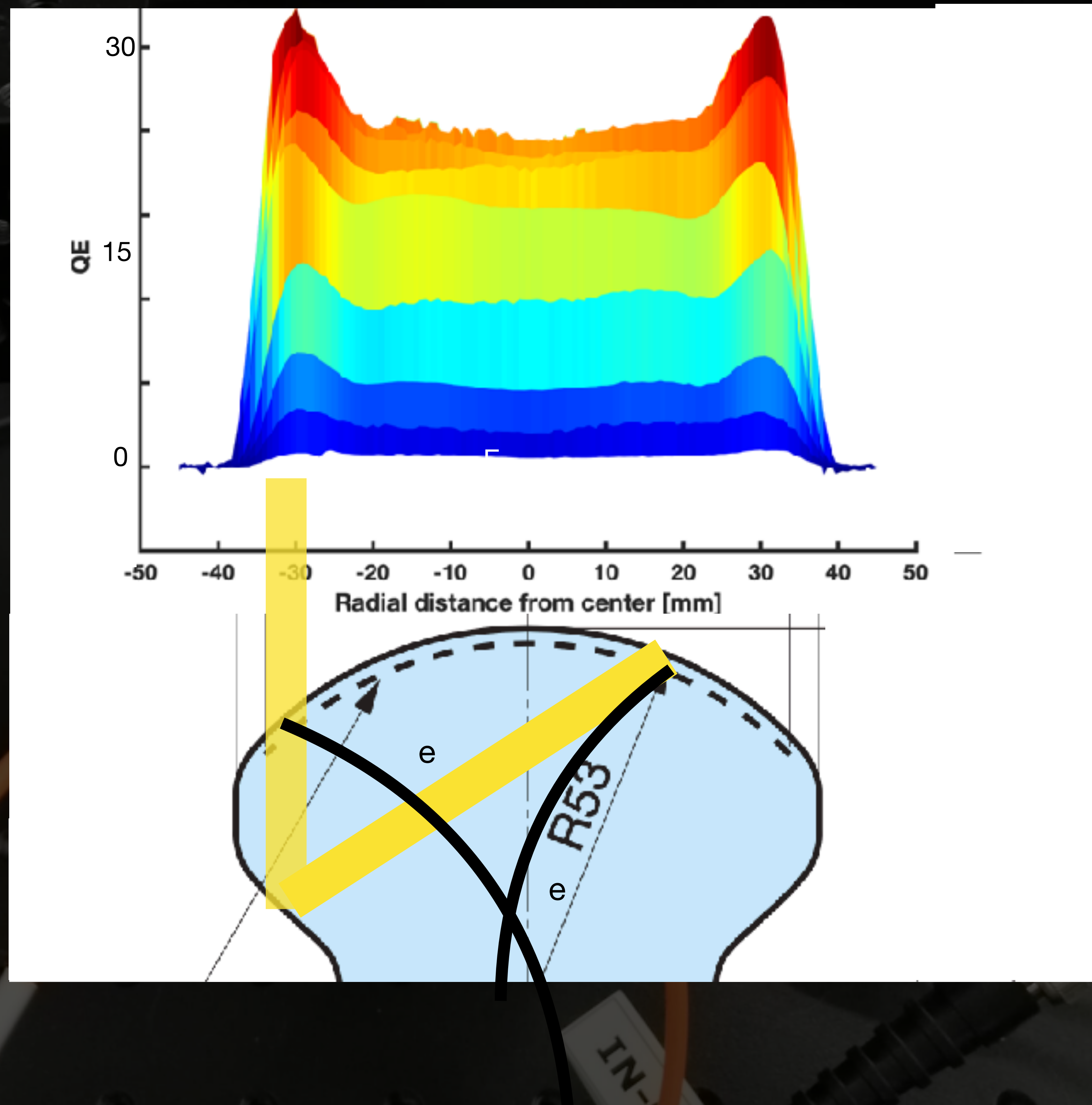
By using the 2D stage it was possible to program and execute the scan of the photocathode.
The central part is less sensitive than the borders where
there is a clear increase, mainly due to reflected light that stimulates the photoelectric emission twice.



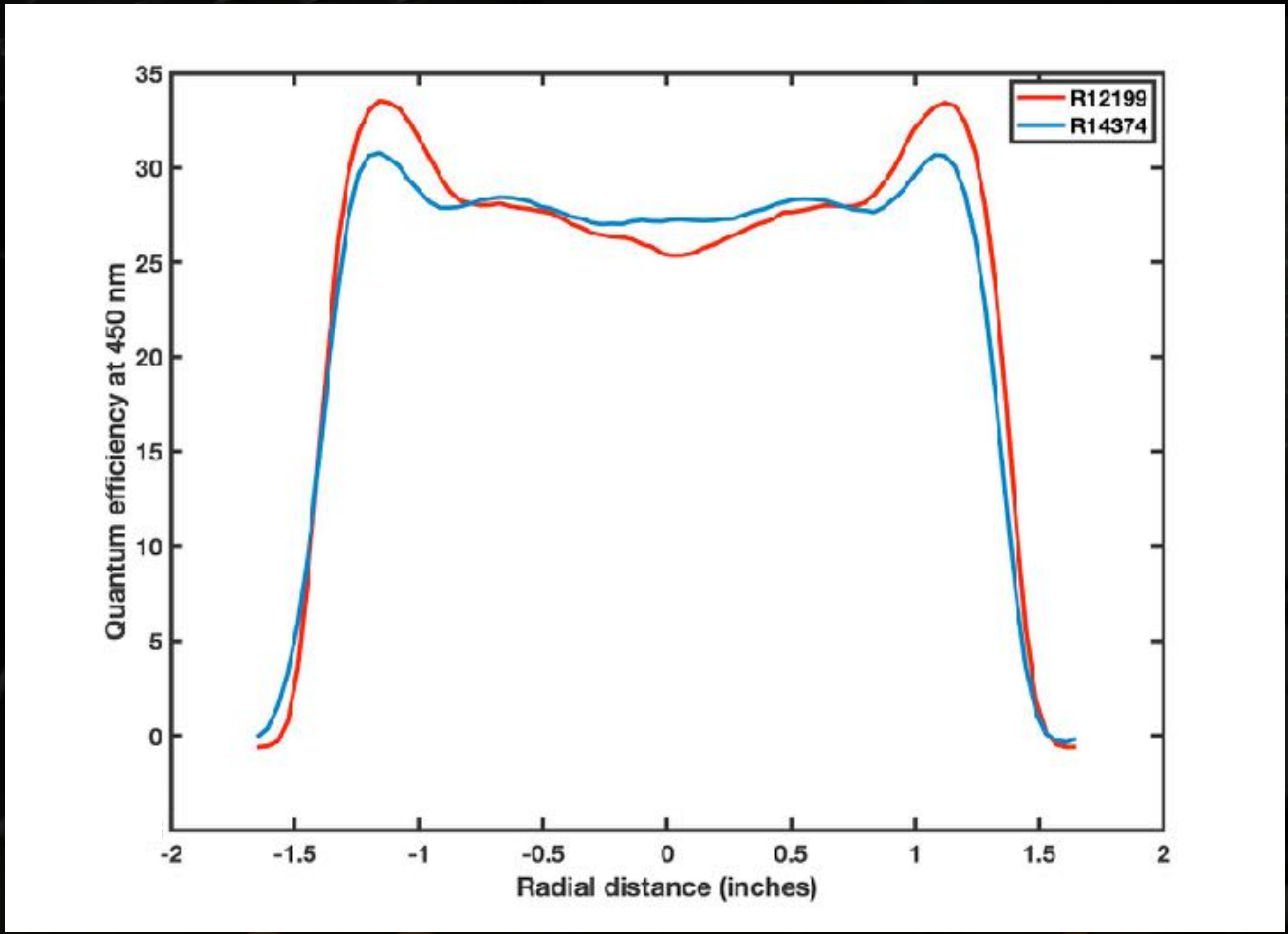
Radial uniformity vs wavelength

Evidences:

- The QE is minimal at the center at normal incidence
- The inner borders of the PMT "mushroom" is internally coated with a metal sheet (i.e a perfect mirror for all the wavelengths)
- This effect is documented by producers but not fully explained



Radial homogeneity comparison between old (red) and new (blue) PMTs



A special version of 14374 with increased QE is under test

Contents lists available at ScienceDirect

Nuclear Instruments and Methods in Physics Research A

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Latest bialkali photocathode with ultra high sensitivity

Kimitsugu Nakamura*, Yasumasa Hamana, Yoshihiro Ishigami, Toshikazu Matsui

ARTICLE INFO

ABSTRACT

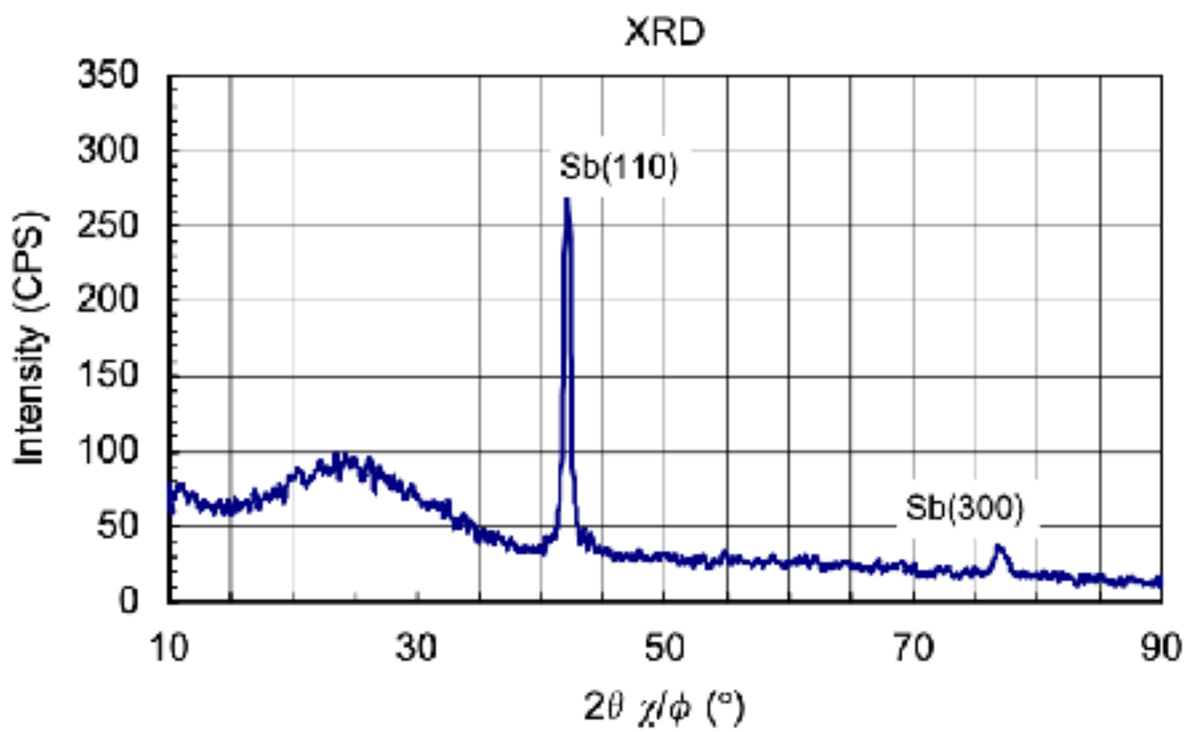


Fig. 1. The X-ray diffraction analysis result of Sb thin film.

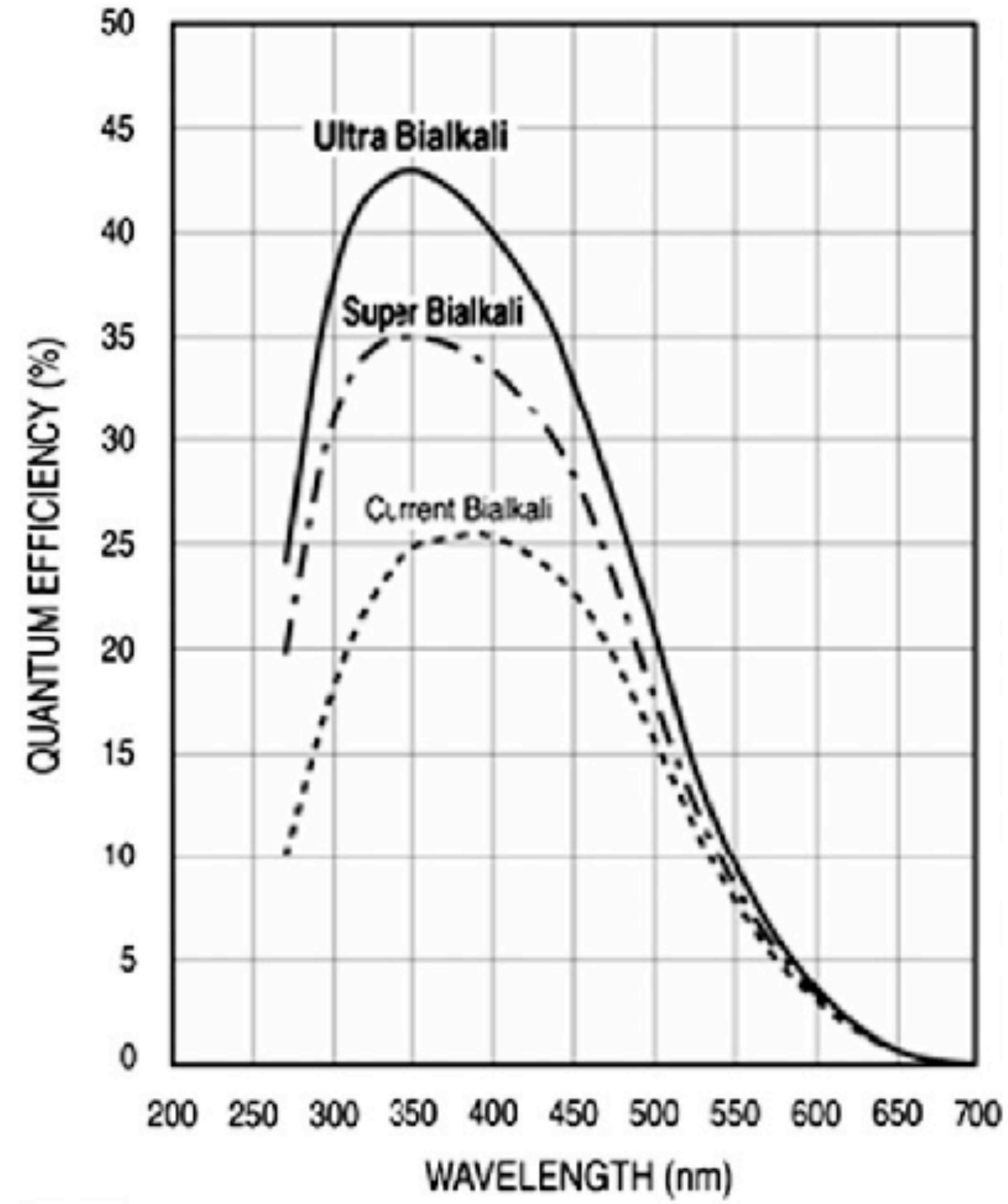
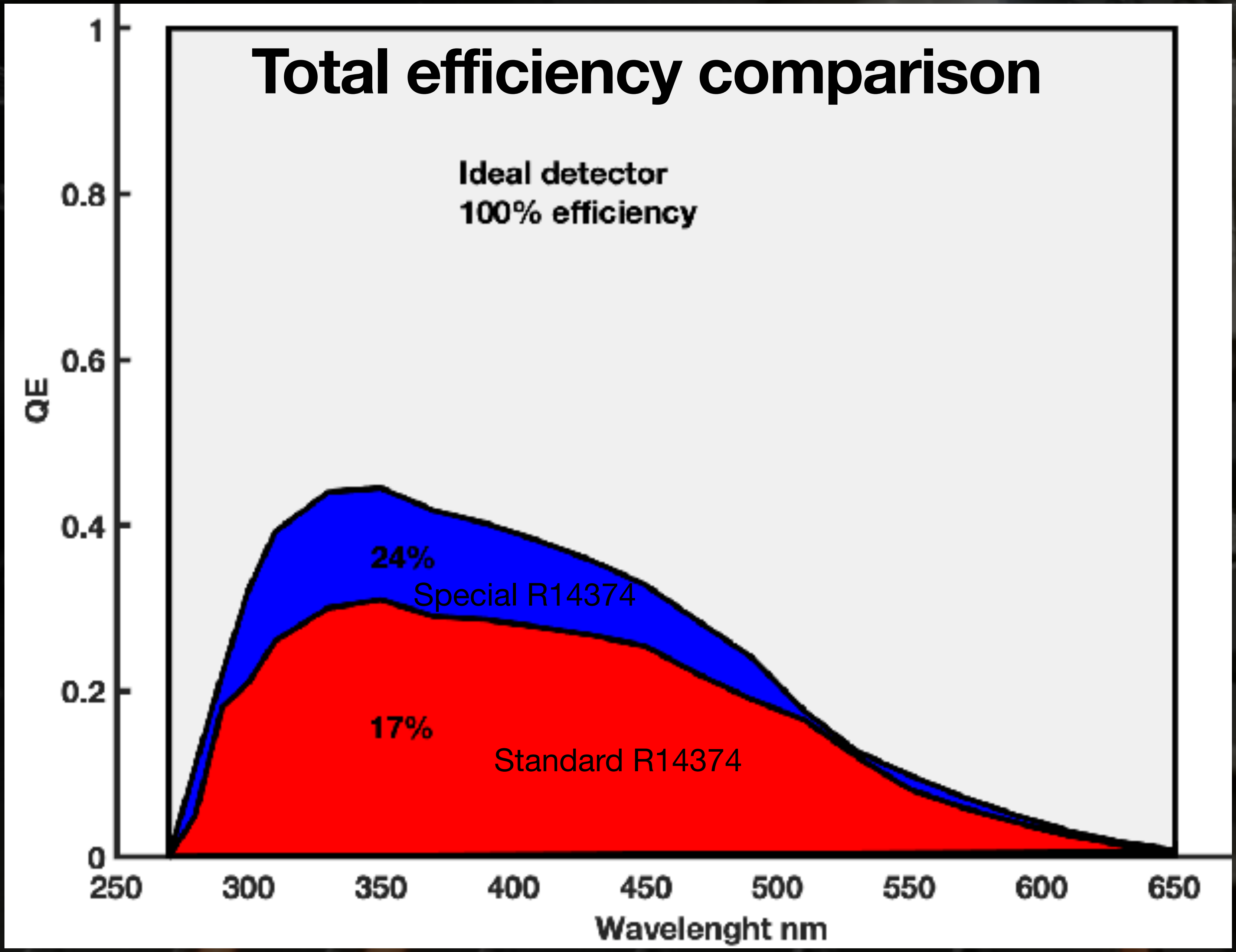


Fig. 2. Typical QE curves for UBA, SBA and standard bialkali photocathodes.

Crystallinity of the Antimony coating plays the fundamental role of improving QE in bialkali photocathodes

A special version with increased QE is under test



+41%

The DARK box apparatus for timing properties measurements

M.C. Mollo et al.
The Dark Box instrument for fast automatic testing of the photomultipliers for KM3NeT
Volume 236 - The 34th International Cosmic Ray Conference (ICRC2015)

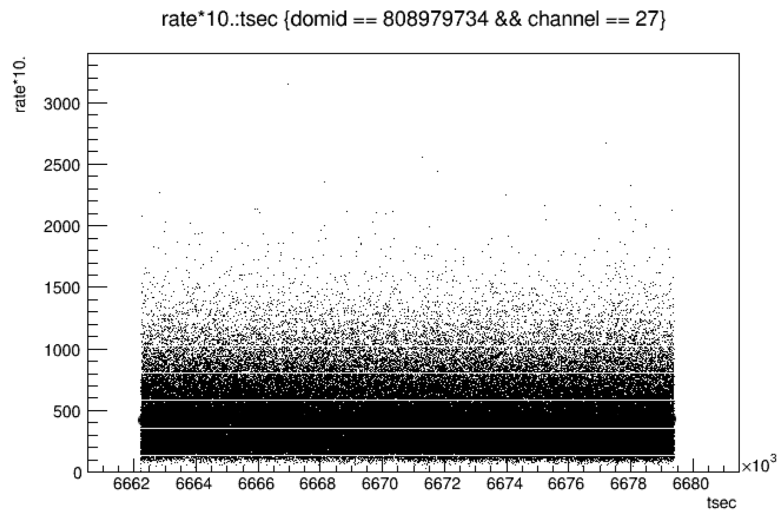
Some Time characteristics of concern

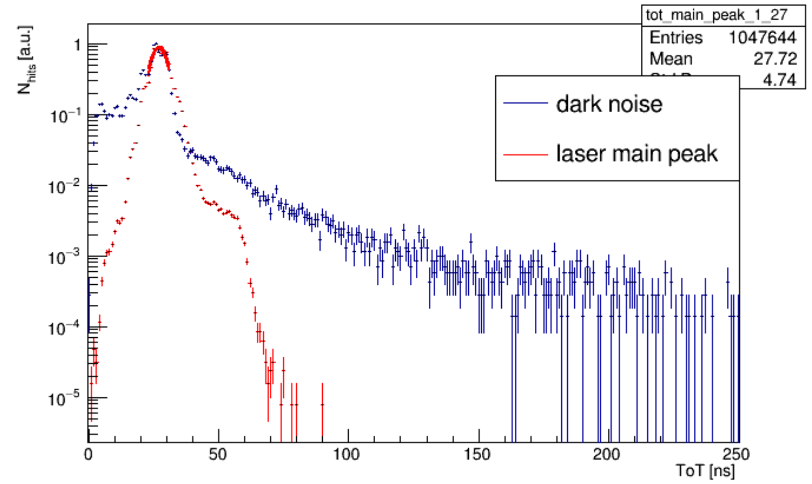
- **<u>After-pulses:</u>** *are spurious pulses that appear in the wake of true pulses.*
 they can limit the number of true pulses that can be registered.
After-pulses have two main causes:
   (a) light emitted by electrodes due to electron bombardment.
   (b) ionisation of residual gas traces.

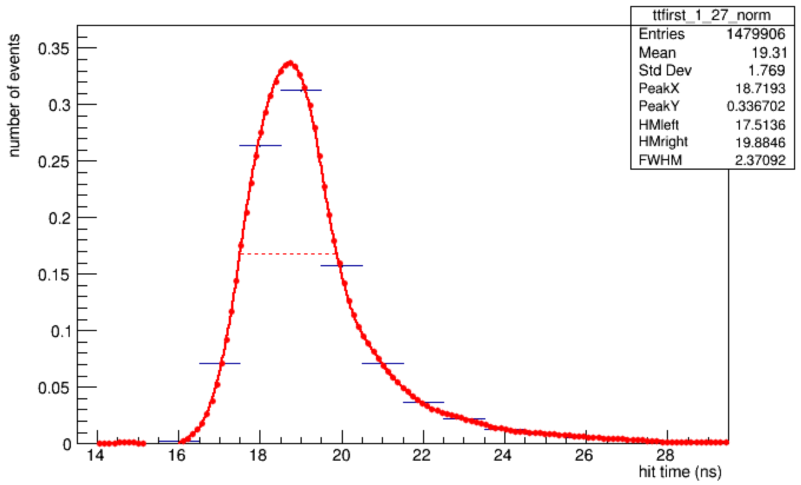
- **<u>Dark counts</u>:** *A small amount of current flows in a photomultiplier tube even when operated in a completely dark state.*
   (c) Thermionic emission
   (d) Leakage current
   (e) Photocurrent produced by scintillation from glass envelope or electrode supports
   (f) Ionisation current from residual gases (ion feedback)

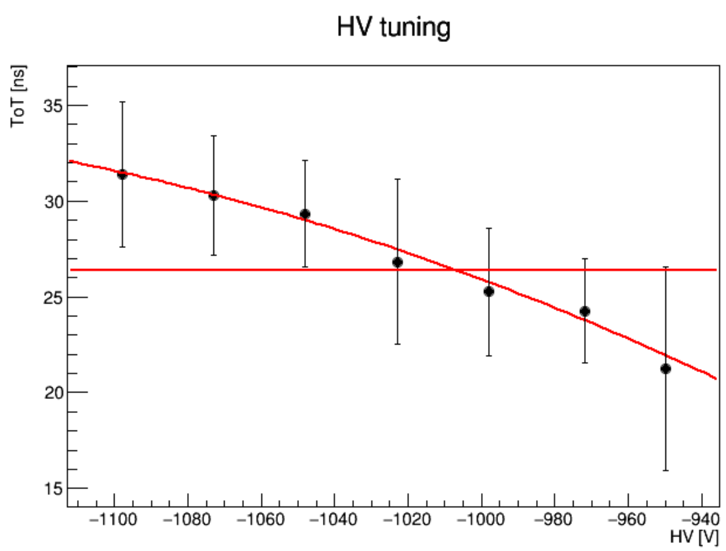
- **<u>The *transit-time spread*</u>:** ***variations in the single photoelectron transit time***

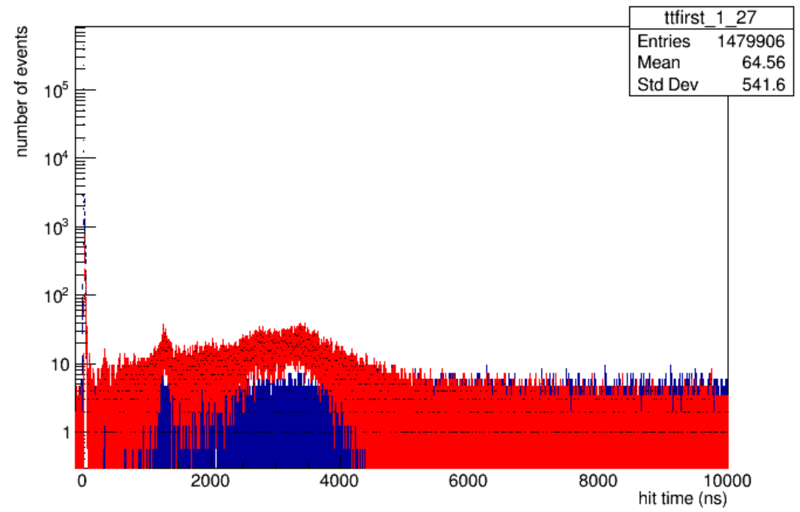
DarkBox test summary (Test #14374_12)
PROMIS ID: 007C3D
Quality : GREEN
UPI : UNKNOWN
Tuned HV : -1007.16 V
DarkRate : 432.07 Hz
ToT peak : 27.4373 ns
Prepulses : 0.000218372%
Delayed : 1.75792%
Afterpulses : 3.05738%
TT peak (fit): 18.7193 ns
TT FWHM (fit): 2.37092 ns
TT peak : 19 ns
TT FWHM : 2 ns







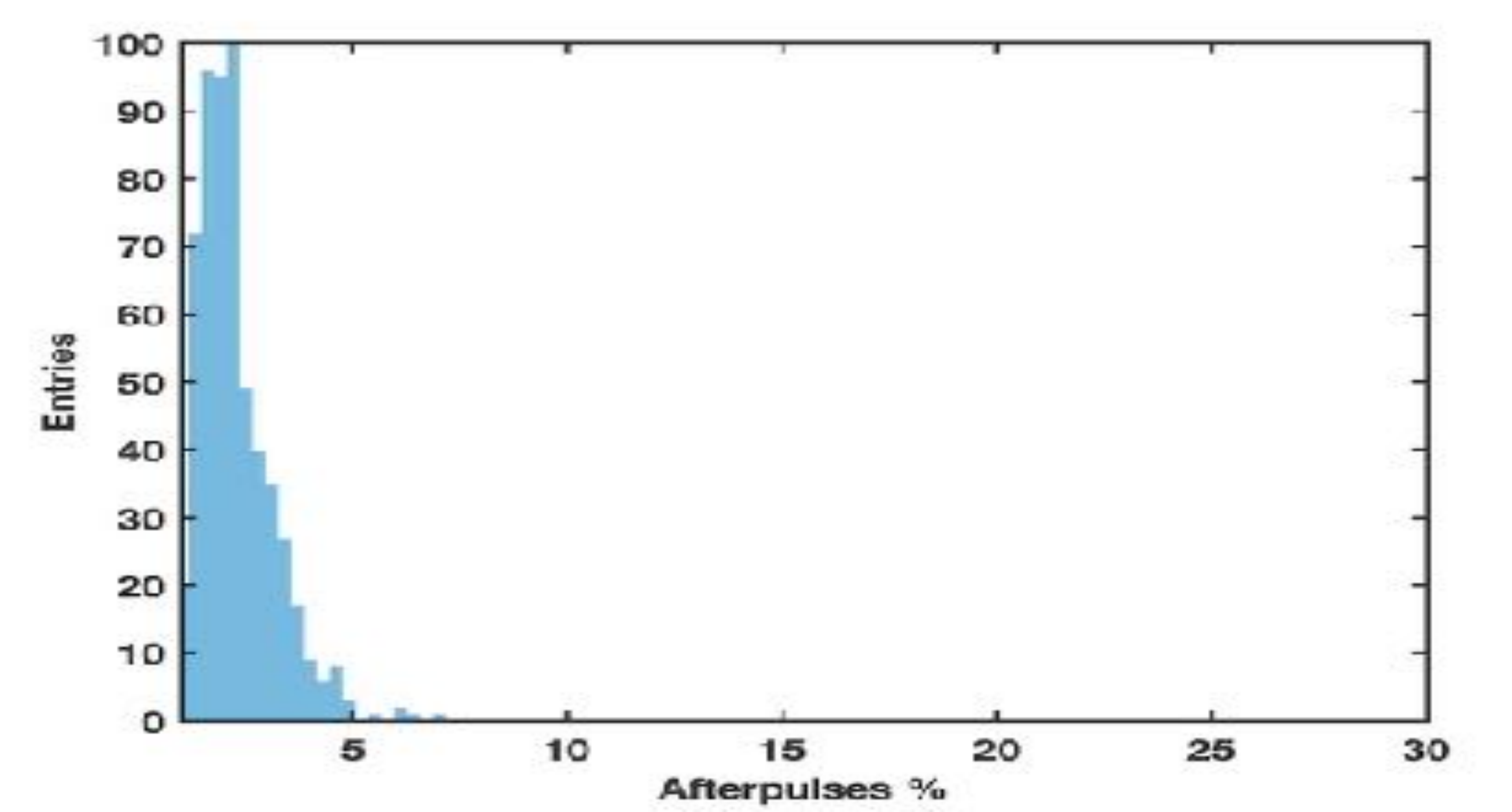


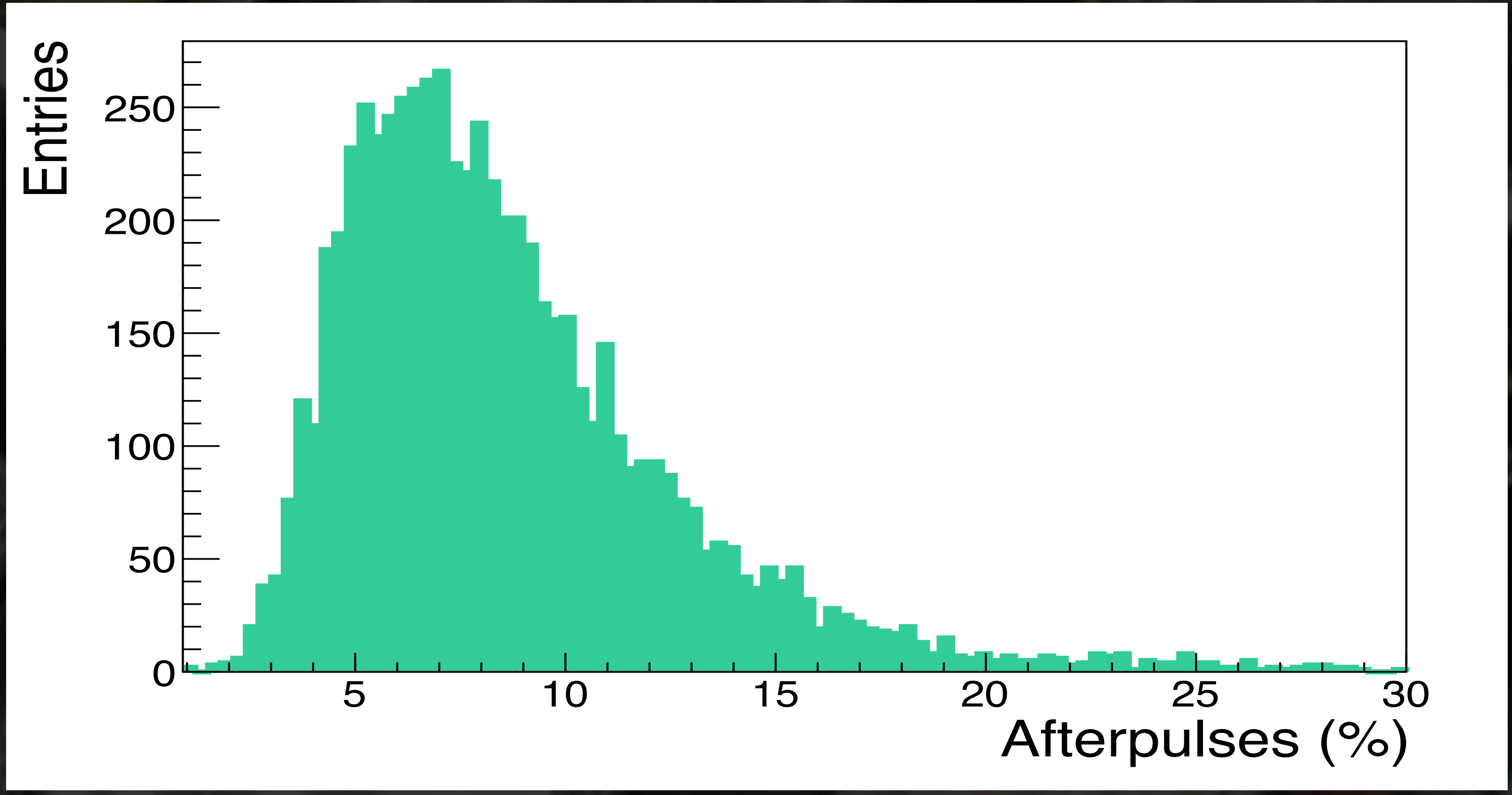


Time properties and dark counts are studied by means of the Dark Box instrument using the digital base

After-pulses measurements

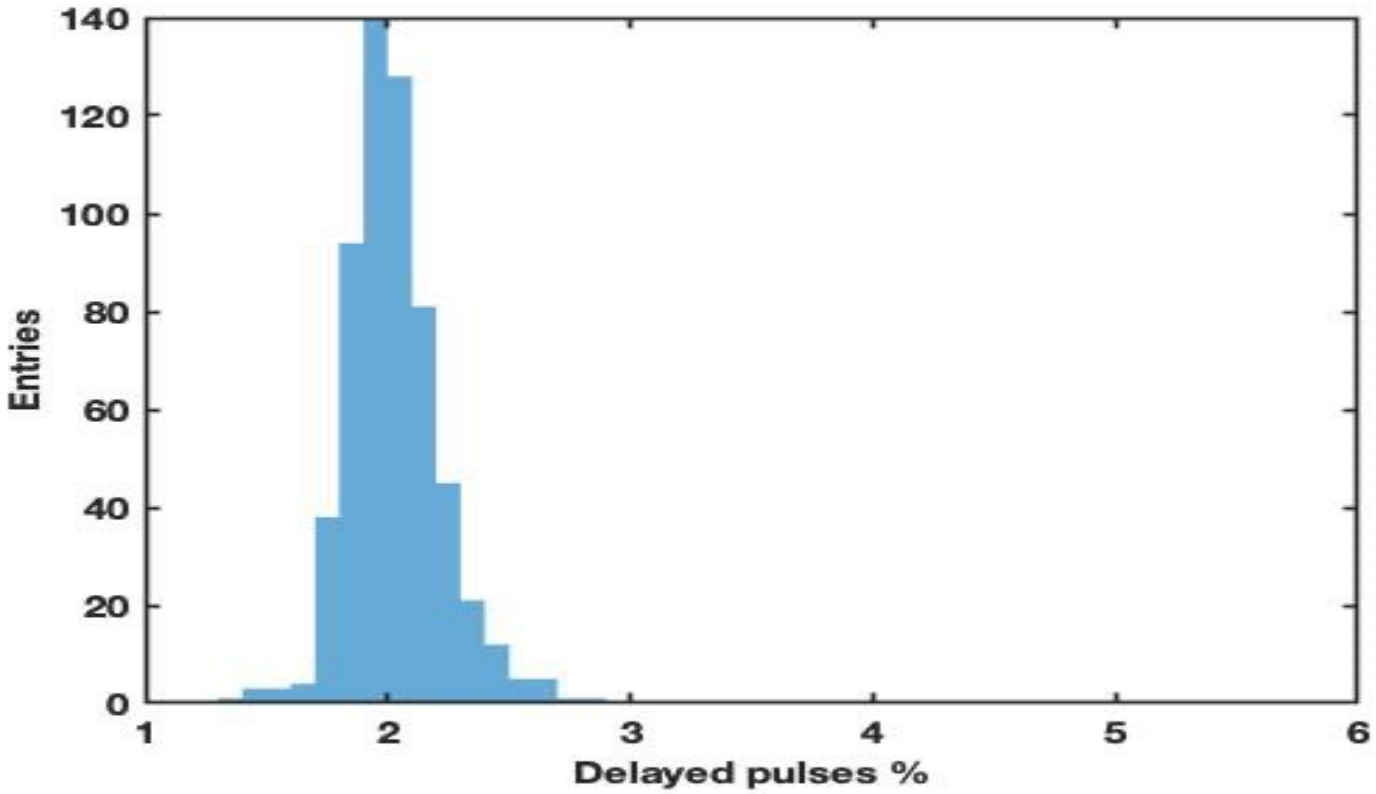
between 100 ns and 10 μs

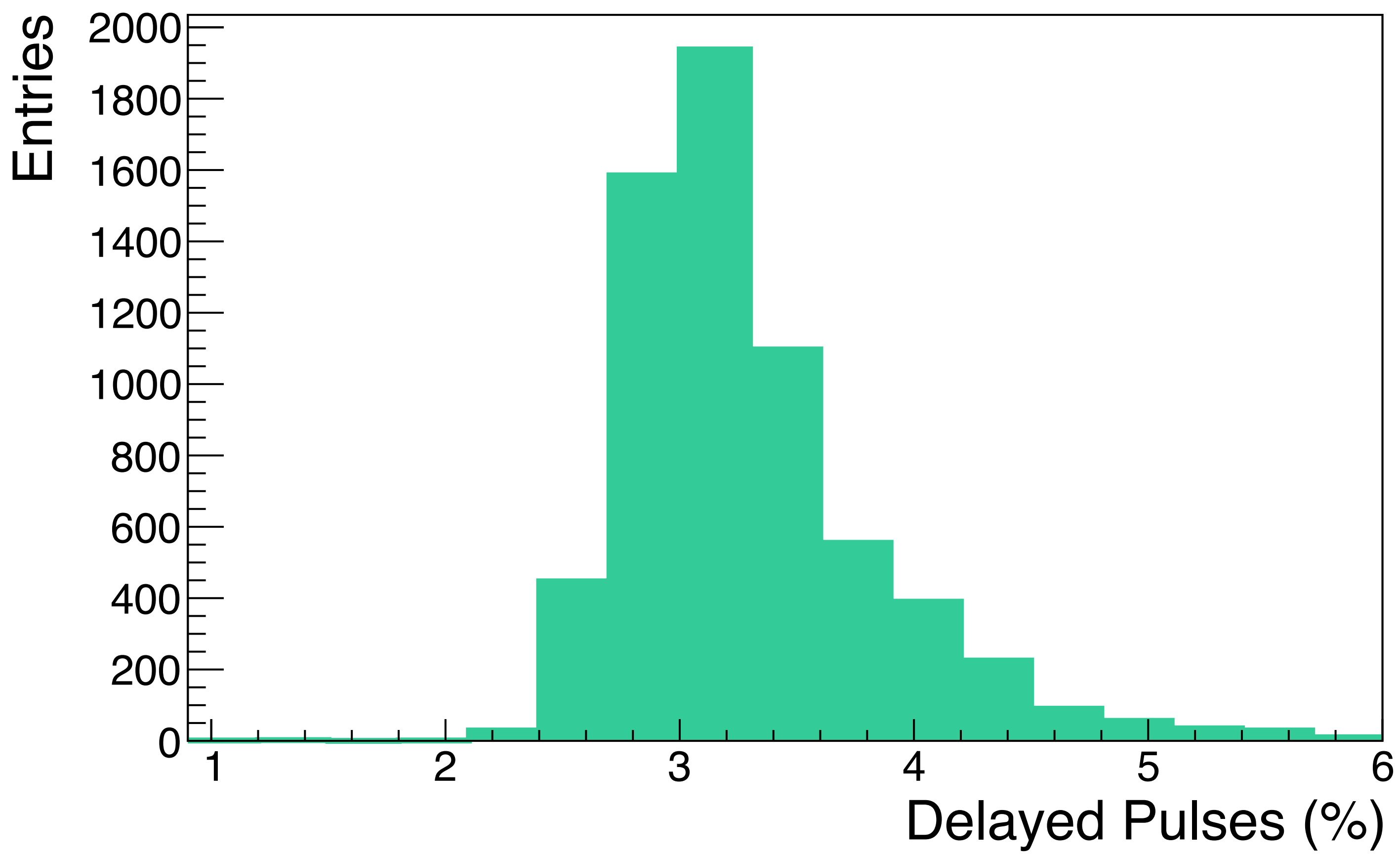




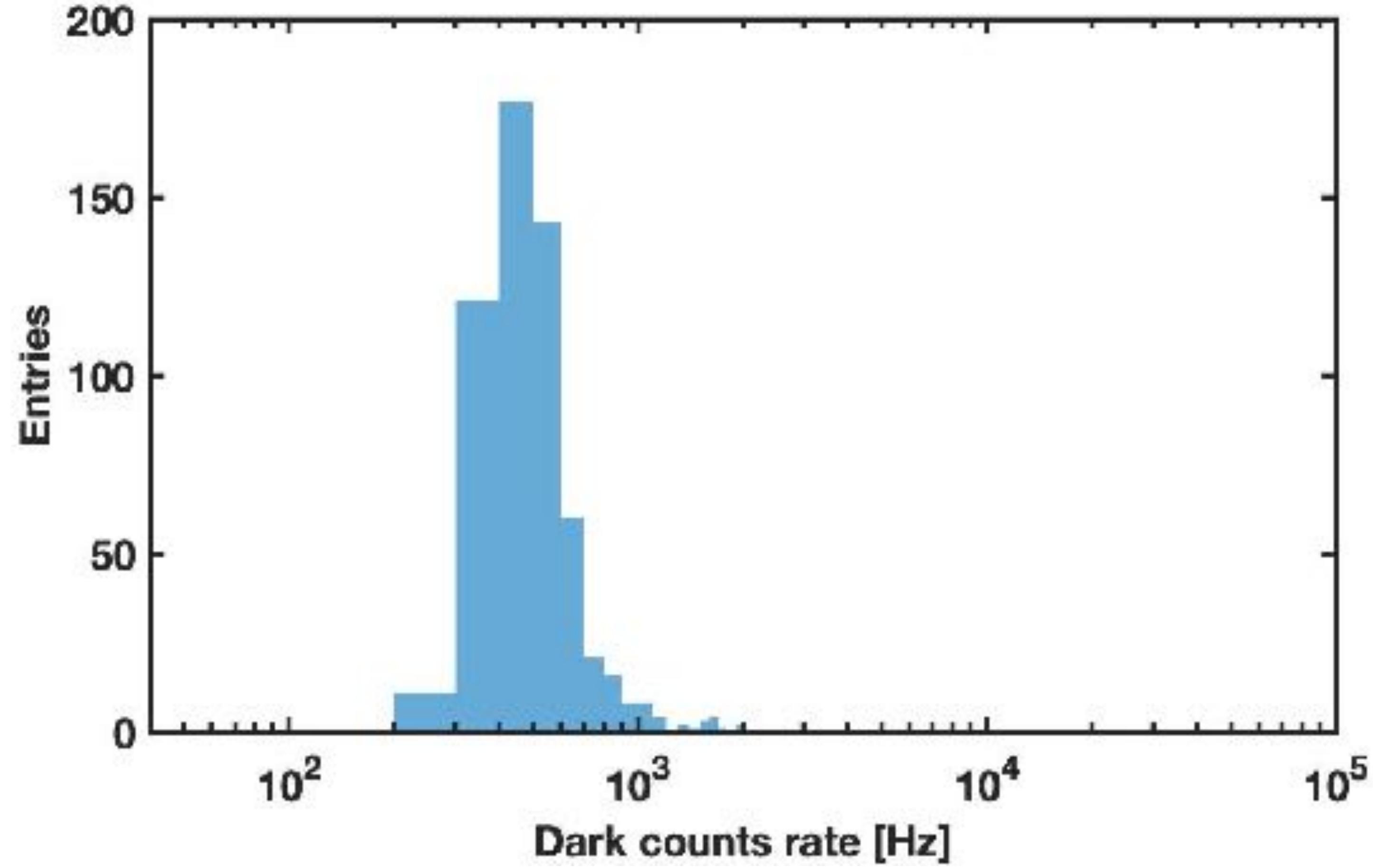
Delayed pulses

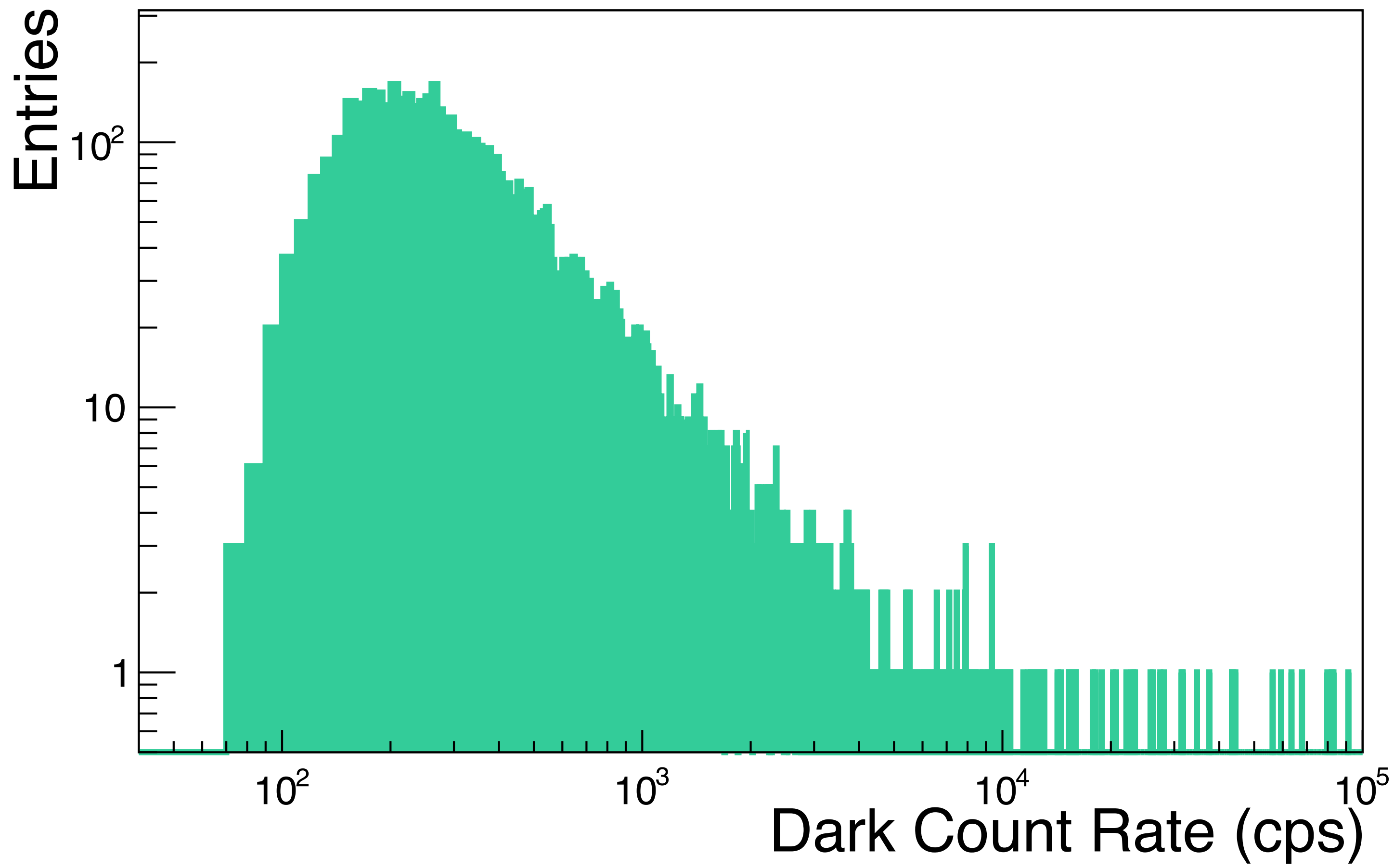
between 15 ns and 60 ns



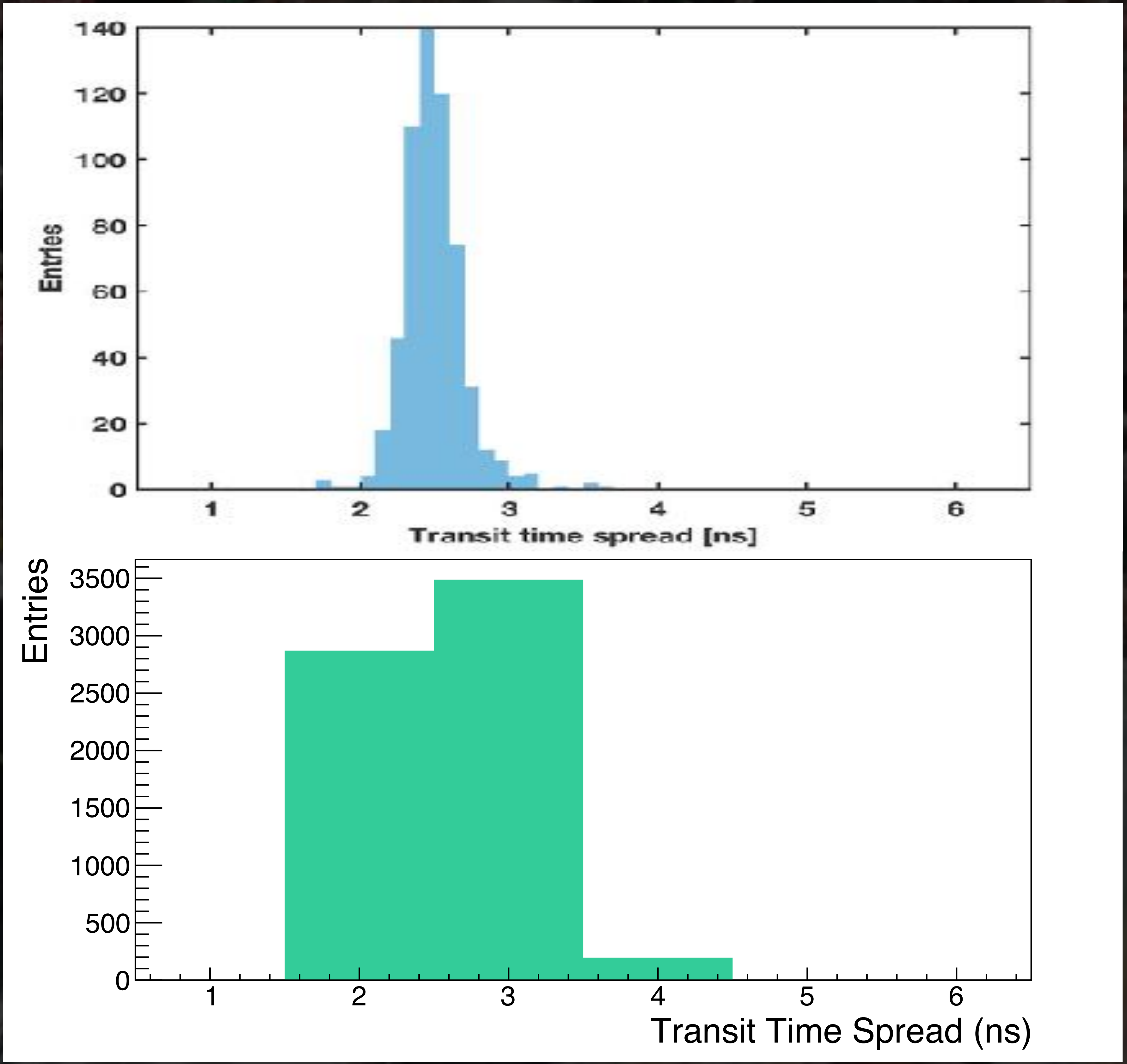


Dark counts rate





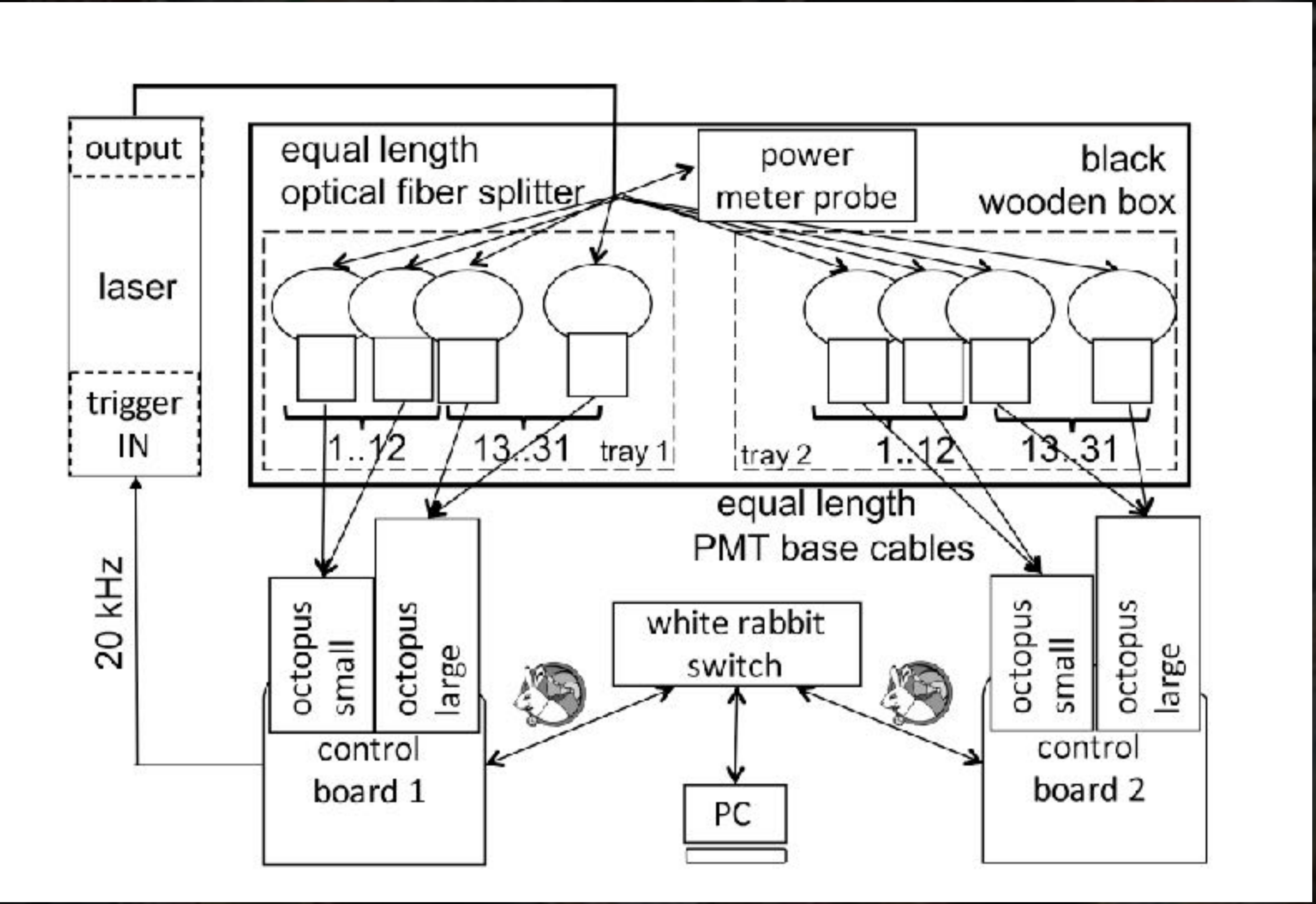
Transit time spread comparison



Conclusions

- The new QE setup in Caserta is now fully operative
- New R14374 shows a better spatial QE uniformity and same QE over wavelength
- A comparison between old and new PMT with the same setup is done
- The DarkBox is again operative in Capacity lab for PMTs timing characterisation
- 500 pcs of R14374 PMTs have been measured showing far better timing properties

The DARK box apparatus for timing properties measurements



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Radial variations vs wavelength