LABORATORI NAZIONALI DI FRASCATI
SIS – Pubblicazioni

LNF–99/015(NT)
16 Giugno 1999

NERO, AN INSTRUMENT TO MEASURE LIGHT ATTENUATION LENGTH IN WATER

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Abstract

We have built a demonstrator to prove the feasibility of a new instrument to measure the attenuation length of light in very clean waters. The demonstrator has been tested successfully and we are now designing a final version for immersion into the deep.

PACS.: 06.70.Dn

1 INTRODUCTION

The attenuation length of light in the green - blue range of frequencies in water is one of the most important numbers to be measured to design a large area deep sea Cerenkov detector for neutrinos. We know that it lies somewhere around 50 m, but a small difference implies a third power influence on the number of optical modules needed to fill a given amount of water. Somebody said that this number should not be measured in meters, but in million dollars (or EUROs).

Quite a few measurements exist of λ, but more are necessary. For example, talking to oceanographers it appears that nobody can guess at the stability of λ over periods of months and years.

Deep sea water is very close to theoretical "clean water" in attenuation length, thus making the measurement very difficult.

2 METHODS OF MEASUREMENT

Many instruments are commercially available to for the measurement of λ. However, they are usually designed to handle rather dirty water, to deduce information on environmental variables in different wavelengths. This is the case for the AC-9 that was used by our group to compare different sites. Although extremely accurate, and therefore adequate for the purpose of comparing different situations, the AC-9 needs, to produce an absolute number, the knowledge of the parameters of "clean water", that must be derived from the literature. This implies an error that is difficult to estimate, and that could result in several meters difference.

It is possible to design an instrument to measure the attenuation length without depending on the characteristics of clean water. Such an instrument must be capable of measuring the attenuation for different lengths of water, thus allowing to derive the attenuation parameters directly.

3 DESIGN

The schematic design of such an instrument is shown in Fig. 1.

A light source in the blue range is made up by a blue LED, a pinhole collimator and a lens with 10 cm focal length. The collimated beam thus generated is sent through a "chinese hat" rotating device, then reflected back from a "corner cube" whose distance is modified by a mechanical or hydraulic system and sent on a light detector again using a focusing lens.

The chinese hat allows continuous calibration of the light production/detection system, going through 3 states: system reference power with reflection by the mirrors, water measurement through the holes and background measurement in between. The corner cube allows an easy alignment of the whole system.

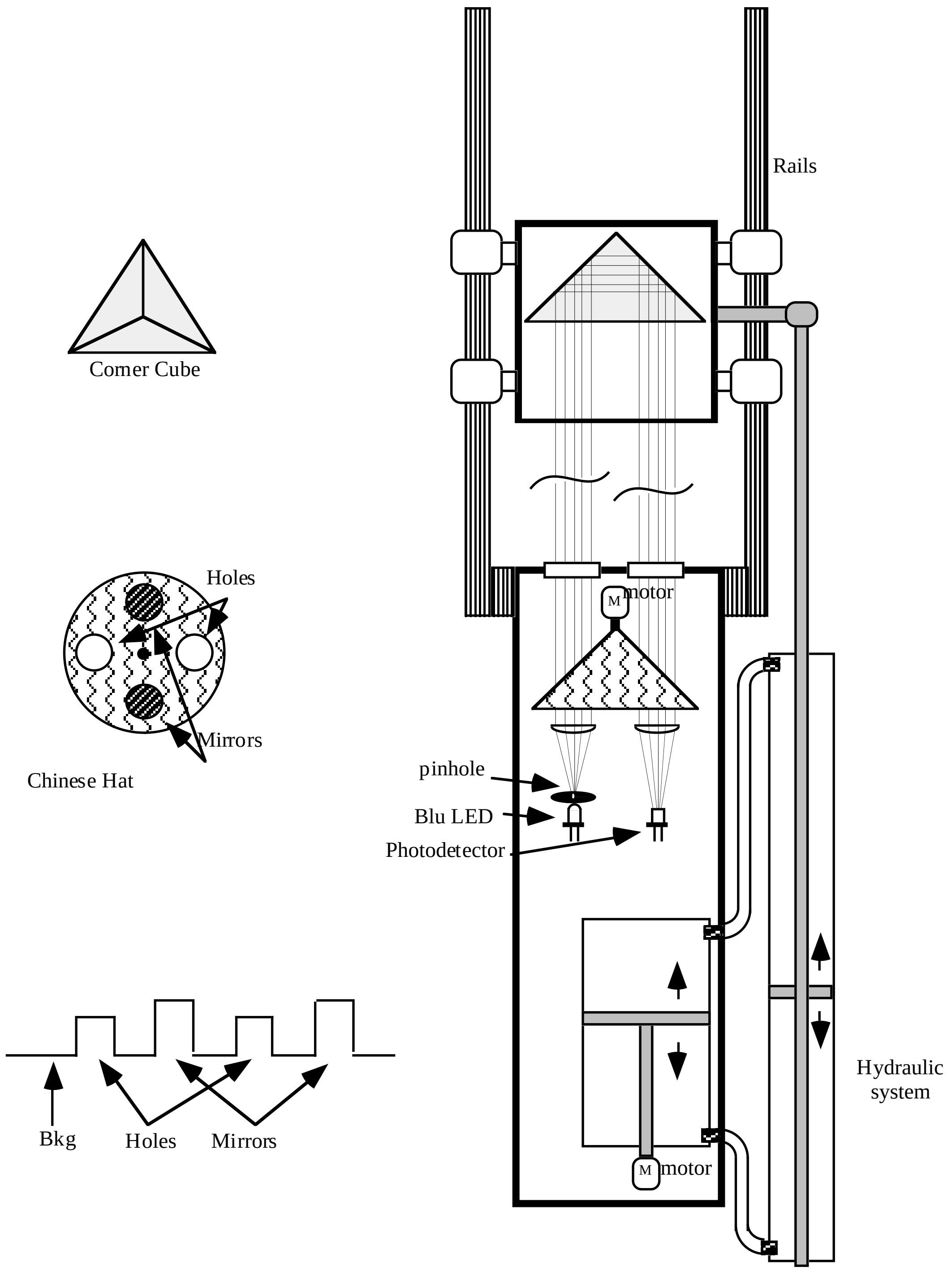

FIG. 1: Schematic design of a multiple distance water light attenuation instrument.

4 DEMONSTRATOR

To prove the feasibility of the instruments we have built a demonstrator (NERO) See Fig. 2.

NERO is made up of a black plexiglass box, 130x25x25 cm^3. It contains two plexiglass rails on which an aluminum cylinder containing the corner cube can be moved remaining aligned with the two holes servicing the light source and detector. The optical system is identical to the one shown in fig. 1.

The system has been built and tested at the University of Cagliari and performed according to expectations (see Fig. 3).

The black box was first filled with water from the tap, then emptied, cleaned and filled again with deionized water.

Measurements were performed at two different wavelengths: blue and red.

The measured data were normalized to 1, fitted to an exponential with very good fit parameters and the results are shown in Fig. 3. It should be noticed that the data for deionized water and red light are in very good agreement with the literature.

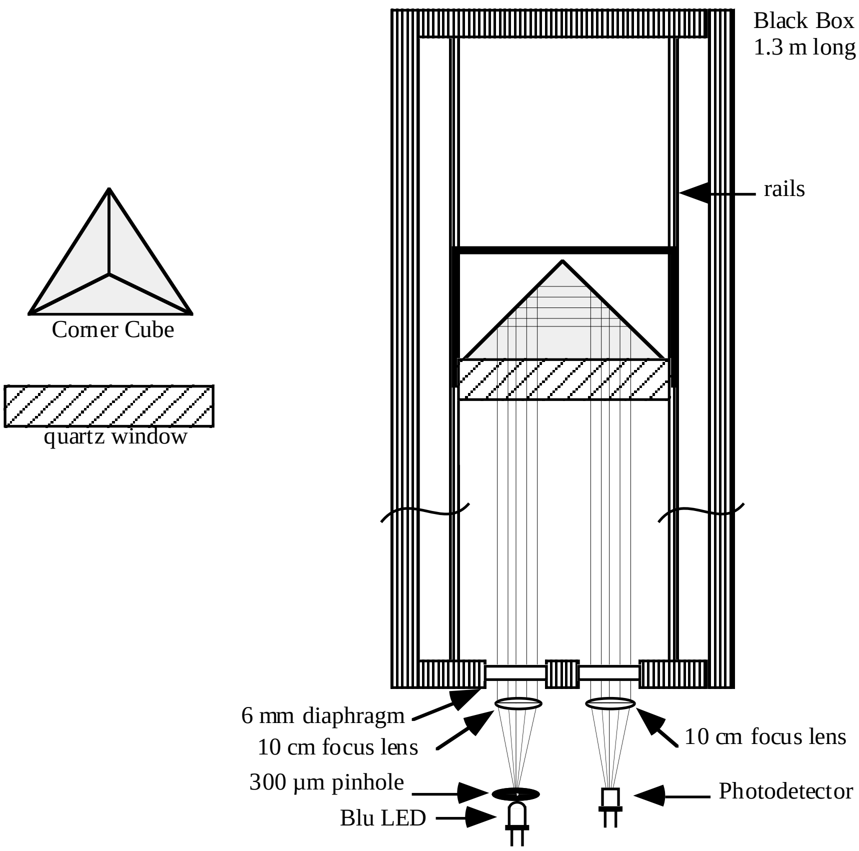

FIG. 1: NERO, the demonstrator for the instrument.

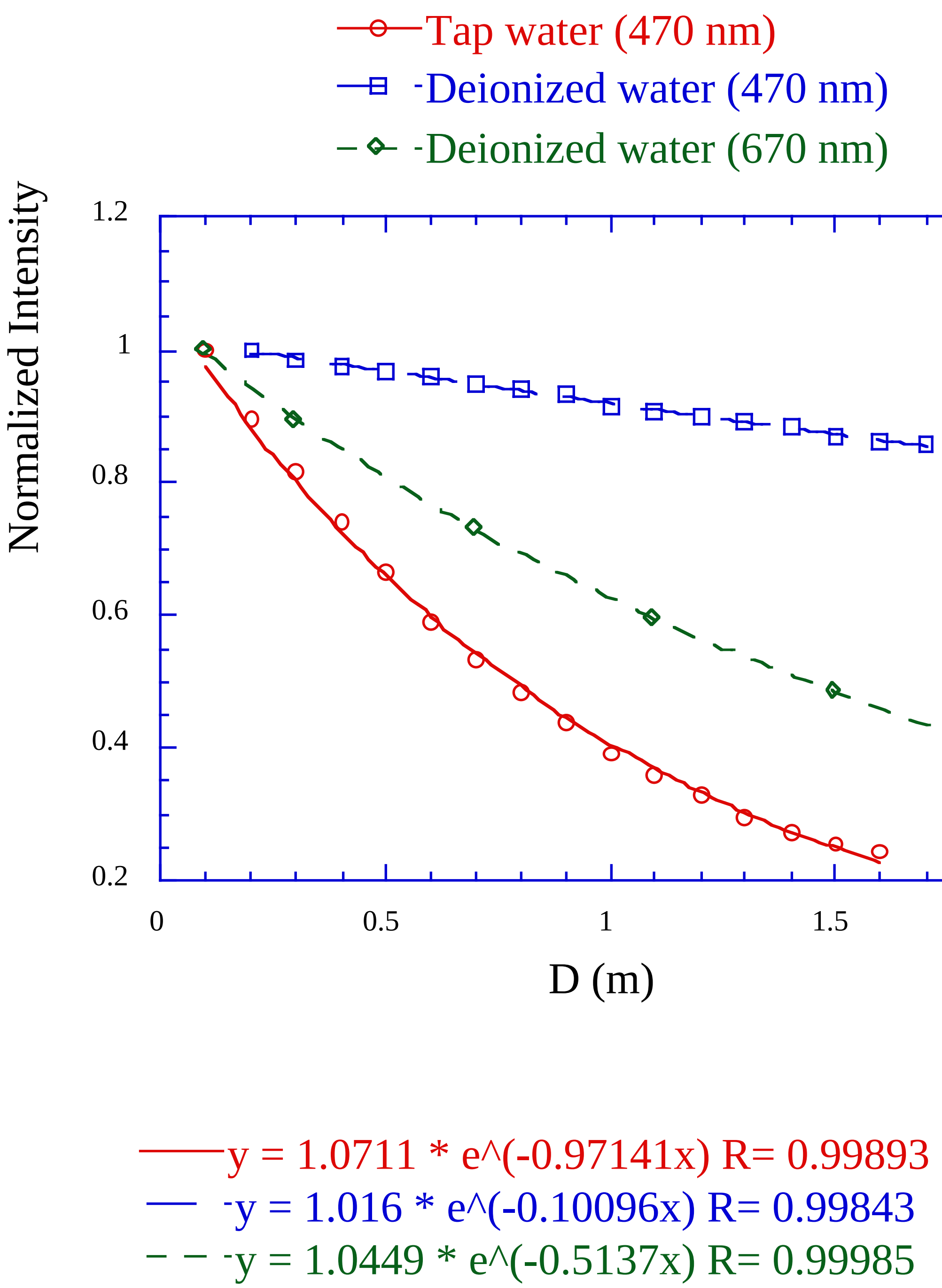

FIG. 3: Results from NERO.

5 THE FUTURE

Many things are missing from NERO that should be present in the final design (NERONE):

- Automatic Movement of the Corner Cube along the rails: we are considering both a hydraulic system and a mechanical one for this purpose
- Larger Corner Cube to simplify the alignment
- Chinese hat system with synchronization to the DAQ system
- Deep underwater mechanics and electronics
- Pressure Vessel
- Communication system.

We are now working on the complete design for the 4000 m underwater system.

6 ACKNOWLEDGEMENTS

The apparatus has been built at the Cagliari INFN machine shop. We want to thank M. Arba and M. Tuveri for their clever works.

We would like to thank Dr. Flavio Graziottin of Idronaut Srl for the loan of the data acquisition system and stimulating discussion.

We are grateful to Dr Giuseppe Molesini (Istituto Nazionale di Ottica, Firenze) for his invaluable support in the design of the optical system.

8 REFERENCES

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