# A new modular Cosmic Ray detector

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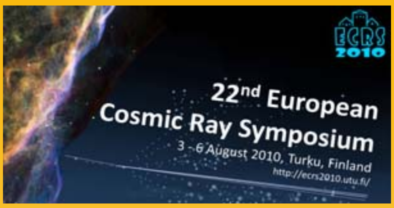


## 1. Introduction

Since the beginning of 2002 several tests have been performed at SVIRCO Observatory & Terrestrial Physics Laboratory (IFSI-Roma/INAF) to evaluate the performances of helium proportional counters and their utilization in neutron detectors with different geometries. At first helium counter performances were investigated by recording simultaneous data from a completely bare counter, a second counter provided with moderator (polyethylene tube) and a third one operating in a lead free NM-64 configuration (neutron flux meter). Afterwards one boron trifluoride counter of SVIRCO detector was replaced with a helium one to verify its proper response to the nucleonic component of incoming cosmic rays and its compatibility with the $^{10}BF_3$ counters.
Finally, with the financial support of the Italian PNRA, a 3NM-64_$^3$He was assembled and accurately calibrated in Rome. Then it was shipped to the Antarctic Laboratory for Cosmic Rays on King George Island (South Shetlands), where it has been operating since January 2007.
The geometry of this detector is just the same of the standard 3NM-64 one, with regard to the polyethylene reflector, moderator and the lead producer whereas the proportional counters are the LND 25373 (length 190.8 cm, diameter 5.08 cm).

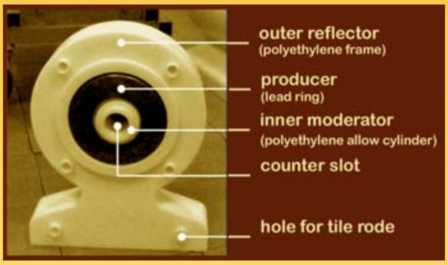


*Fig. 1. The components of the new modular structure.*

## 2. The mobile neutron detector

Another LND helium counter was tested at SVIRCO with the aim to realize a mobile neutron detector to be used for measurements outside the Observatory. The shorter LND 25382 tube (length 65.2 cm) has the same 2 inch diameter design of the longer LND 25373. Actually this diameter is very common for helium counters which are available in a wide set of sensitive length just in this size. This opportunity suggested us the design of a modular neutron monitor with an adaptable structure for proportional counters with different lengths.
A first small mobile detector was built with a modular geometry at SVIRCO & TPL during 2006. Its overall dimensions, without the hand-cart, are: width 37 cm, height 50 cm, length 79 cm and its total mass is about 265 Kg.

## 3. The modular Cosmic Ray detector

With the aim to realize a new instrument for continuous cosmic ray registration with a higher counting rate and reliability, we determined to use the LND 25373 helium counter again, since we had investigated its performances on the long term.
In March 2010 a bigger modular detector was assembled and equipped with one LND 25373 tube. In this configuration the detector has reached the length of 216 cm with a mass of ~ 800 Kg. Either neutron detectors are realized with the same modules (7 for the small one, 23 for the other) and are closed by a plate at their both ends. The frontal plate has a hole for the tube and a bay for the electronic box, which is fixed on the counter head, whereas the rear one is plane. Each module (Fig. 1) is composed by a polyethylene round shaped frame (outer reflector) with a tongue and groove joint to lock into one another. The central hole of the frame encloses a lead ring (producer) housing an interlocking polyethylene allow cylinder (inner moderator) which is the modular slot of the proportional counter. Four tie-rods block in the whole frame preventing any movement of the single elements which are boxed up with a strict mechanical accuracy.
The step by step assembly of the new modular neutron monitor is shown in Figure 2.
Despite its overall weight, only one operator is required to set up the whole detector, as the modular design has made each loose component reasonably light, since the weight of the heaviest element (lead ring) is about 23 Kg. As a result of its geometry the modular detector can also be moved from an observational site to another in a very easy way.


*Fig. 2. Step by step assembly of the new modular Cosmic Ray detector.*

## 4. Testing the modular detectors

The mobile neutron monitor, equipped with the helium counter LND 25382, has been operating since the end of 2006 contemporary with the standard 20NM-64 detector of SVIRCO. The test has been running in a separated room, close to the Observatory, to verify the reliability of the new detector in various environmental/operating conditions. We looked forward to a higher overall temperature coefficient of the new mobile detector with regard to the standard neutron monitor, since BP-28 ($^{10}BF_3$) counters are characterized by a negative coefficient which partially balances the positive ones of the other detector components (lead and polyethylene). Moreover the 3NM-64_$^3$He, we had tested in the past, proved to be fairly affected by temperature variations although the positive coefficient of LND 25373 helium counters. Nevertheless, an unexpected large instrumental temperature sensitivity was ascertained and a good correspondence in the records was found only when both the detectors were kept at the same fixed temperature. The daily normalized counting rates of the two monitors, together with the instrumental temperature as a function of time are shown in Figure 3 for the period January-April 2009.

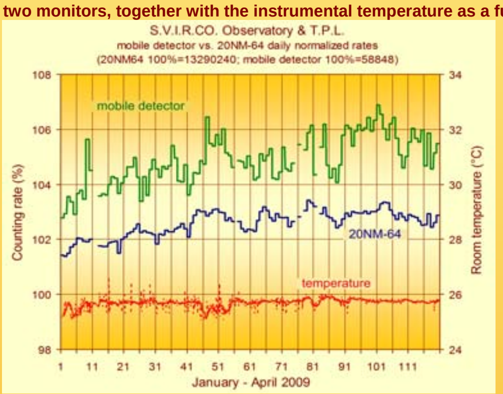


*Fig. 3. Time history of the nucleonic intensity recorded by the mobile neutron detector and by the standard 20NM-64 (left scale). Time history of the hourly and daily instrumental temperature (right scale).*

On April 1st, 2010 a new modular bigger detector has been included in the test run (Fig. 4). Actually it has been showing a significantly smaller temperature sensitivity despite it was assembled with the same modules and electronics used for the smaller detector. The reason for this discrepancy must be fully ascribed to the two different types of tubes, as the instrumental temperature effects appear hugely larger and non-linear on the detector with the shorter counter. A bare standard BP-28 counter, complete with its moderator tube, has been also added in the tests which are still in progress to fix the instrumental temperature effects together with other environmental factors on the performances and reliabilities of both the modular detectors. In the upper and middle panels of Figure 5 it is reported the time history of the normalized daily rate of each detector for the period 1 April to 13 July. In the lower panel of the same figure and for the same period, it is shown the time histories of the measured instrumental temperatures: T1 inside the Observatory (20NM-64) and T2 inside the room housing the other monitors (modular, mobile and bare BP-28).

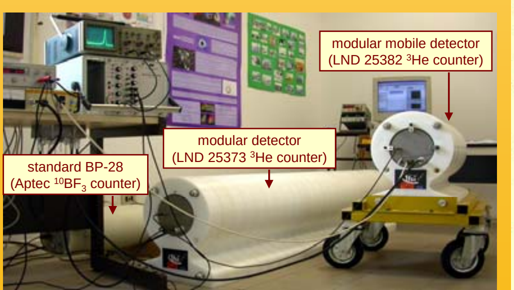


*Fig. 4. Testing the modular detectors.*

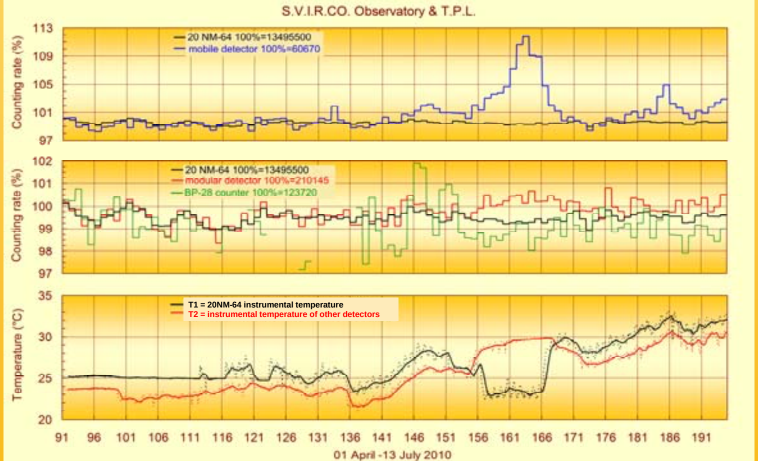


*Fig. 5. Time history of the mobile daily normalized rate vs. the 20NM-64 normalized rate (upper panel). Time history of the modular and BP-28 daily normalized rates vs. the 20NM-64 normalized rate (middle panel). Time history of the measured instrumental temperatures (lower panel).*

**Acknowledgements.** *This work is based upon research supported by IFSI-Roma/INAF and Italian National Antarctic Research Program.*