Journal of Physics: Conference Series **203** (2010) 012131 doi:10.1088/1742-6596/203/1/012131

The BiPo detector

S Cebrian, on behalf of the SuperNEMO Collaboration

Universidad de Zaragoza, Pedro Cerbuna 12, 50009 Zaragoza, Spain

E-mail: scebrian@unizar.es

Abstract. The BiPo detector is intended to measure extremely low radioactive contaminations of ^{208}Tl and ^{214}Bi in very thin layers like the SuperNEMO double beta decay source foils. A modular prototype with 20 capsules (the so-called BiPo1) is running in the Modane Underground Laboratory (France). New approaches based on a more compact geometry (BiPo2) and on the use of the Phoswich technique have been also taken into account and the corresponding prototypes are running at the Modane set-up too. First measurements for samples of interest, with a sensitivity unreachable by Ge detectors, have started. Description of prototypes, results validating the detection techniques and estimates of sensitivity are presented here.

1. Principle and prototypes

The goal of the BiPo detector is to measure ultra-low levels of impurities in double beta source foils reaching activities of A(^{208}Tl)<2 μBq/kg and A(^{214}Bi)<10 μBq/kg, by registering BiPo events in the natural chains as a delayed coincidence between electrons and alpha particles using a sandwich of two plastic scintillators (see Fig. 1). Photomultiplier (PMT) signals are sampled by MATACQ VME digitizing boards (12 bit resolution) at 1 GS/s in 2.5 μs. A new trigger board for measuring also ^{214}BiPo events has been recently installed.

BiPo1 prototype consists of 20 capsules (with total surface of 0.8 m^2) made of polystyrene scintillators (20×20×0.3 cm^3 each) coupled to low radioactive 5-inch PMTs. It is running at Modane Underground Laboratory since February 2008, based on a standard technique with very good proven sensitivity and having a good β/α discrimination capability. One of these capsules has a Phoswich design, with fast BC400 (300 μm) and slow BC444 (10 mm) scintillators read by the same PMT; this approach offers a powerful β/α discrimination and the possibility of running with only one PMT per capsule. A more compact design, using less PMTs and offering spatial resolution has been implemented in the BiPo2 prototype, consisting of two plastic scintillators BC408 (75×75×1 cm^3, total surface of 0.56 m^2) coupled each to 10 low radioactive 3-inch PMTs. Both the Phoswich capsule and the BiPo2 prototype are running at Modane since July 2008.

The next step is the construction of the BiPo3 detector, foreseen for 2010, using 36 capsules (total surface of ∼3.5 m^2) with organic plastic scintillators (30×30×0.2 cm^3 each) coupled to low radioactive 5-inch PMTs.

2. Results

The detection technique and efficiency for BiPo1 were validated with an Al foil of known activity and a successful method for β/α discrimination was developed (see details in [1]). Background measurements taken in last months have allowed to identify BiPo events, having the proper time interval between β-α signals (see an example of time interval distribution in Fig. 2), and

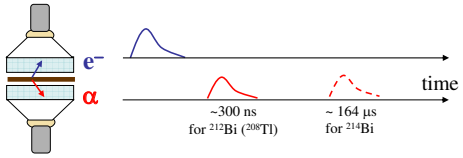

Figure 1. Basic design of the BiPo detector to identify BiPo events.

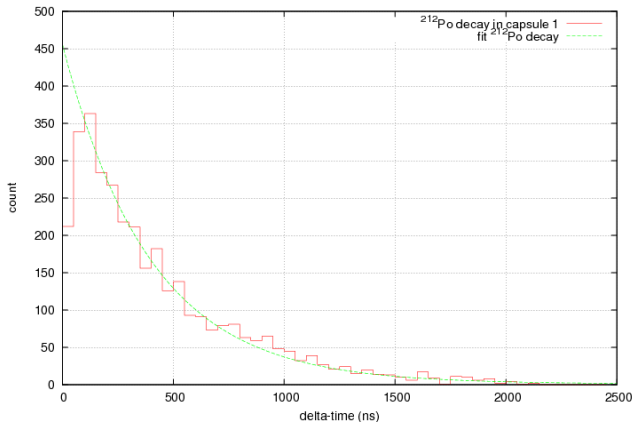

Figure 2. Distribution of time intervals between β-α signals in BiPo1 background measurements and the corresponding exponential fit. ^{212}Bi half-life (299 ns) is well reproduced.

to measure a surface activity on ^{208}Tl of (1.4±0.2) μBq/m^2 (32 events in 258 days $\times$ m^2). Assuming this background, a sensitivity of $\sim$3 μBq/kg of ^{208}Tl could be at reach in a 6-month measurement in BiPo3 for a ^{82}Se double beta foil.

Proper distributions of time intervals between β-α signals for identified BiPo events have been also obtained for both the Phoswich capsule and the BiPo2 prototype in measurements with Al foils. The β/α discrimination power is being carefully studied for the Phoswich capsule and a background measurement is running since April 2009 in order to estimate its sensitivity. For BiPo2, a position reconstruction method has been proposed and checked with calibration sources, and will be validated with measurements being taken presently using an Al foil cut like a draughtboard.

3. Summary and outlook

The detection technique of the BiPo detector has been validated in all prototypes for ^{212}BiPo events and measurements for ^{214}BiPo events have already started. Now, the sensitivity goal is at reach in BiPo1 and first sample measurements are underway using this prototype. Construction of a medium BiPo detector (BiPo3) is foreseen in the very next future in order to qualify the first foils for the SuperNEMO experiment [2].

Acknowledgments

We would like to deeply acknowledge Professor Julio Morales, who passed away just when TAUP2009 was being held, for his dedicated work and always kind friendliness.

References

[1] Bongrand M (on behalf of the SuperNEMO Collaboration) 2008 *Journal of Instrumentation* **3** P06006
[2] Vala L (on behalf of the NEMO3 and SuperNEMO Collaborations) 2009 *Nucl. Phys.* B *(Proc. Suppl.)* **188** 62