Gamma-tracking and sensitivity to gamma-emitting backgrounds in SuperNEMO

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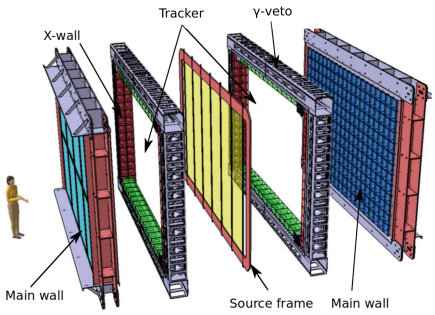
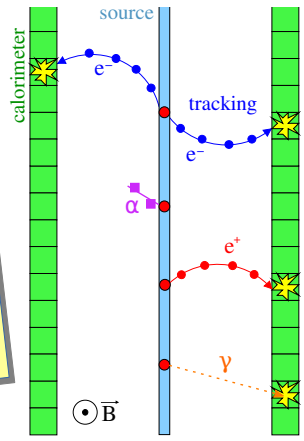
The SuperNEMO experiment

SuperNEMO module overview



The **SuperNEMO experiment** is looking for the **neutrinoless double beta decay** using **tracking and calorimetry techniques**. This unique design provides a powerful background rejection through **individual particle identification**.

Electron : a long negatively curved track
Alpha : a short delayed track
Positron : a long positively curved track
Gamma : unassociated calorimeter hit(s)



The γ-tracking algorithm

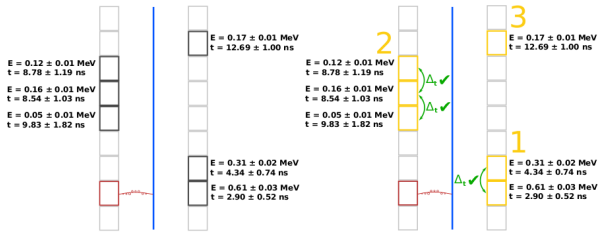
The calorimeter scintillator blocks size was increased compared to NEMO3 in order to reach a **50-80 % detection efficiency** for **gamma particles**. However, the latter may not be contained in a single calorimeter block and can interact with several ones. Hence the need for a dedicated reconstruction procedure called **γ-tracking**.

The **γ-tracking algorithm** uses the **calorimeter informations** to reconstruct the **γ particles paths** based on **Time-Of-Flight** computations :

- **I.** The experimental signature of a γ particle is one or more calorimeter blocks triggered to which no track is associated.
- **II.** The neighbouring unassociated calorimeter hits are gathered into clusters.
- **III.** and **IV.** The clusters are then linked together based on Time-Of-Flight computations translated into a probability P.

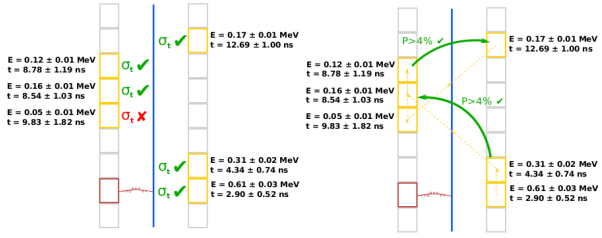
I. Unassociated calorimeter hits

II. Clustering : 3 clusters with Δ_t < 2.5 ns



III. Tracking : 1 hit will not be used (σ_t>1.5 ns)

IV. Tracking : linking clusters with P>4%

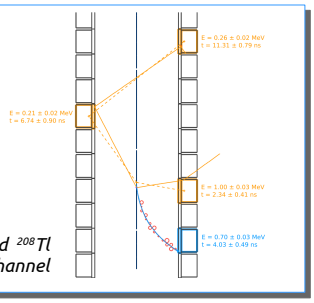


A **faithful gamma reconstruction** is not only useful for the study of **background** events but also for the search of other **rare processes** such as the double beta decay to an **excited state** of the daughter nuclei where one or more γ particles are emitted along with the electrons.

Demonstrator sensitivity to γ-emitting backgrounds

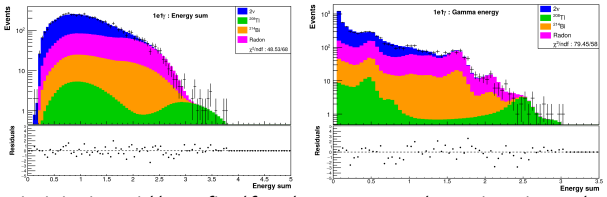
The **NEMO technique**, not only provides a **powerful background rejection**, but also gives acces to a variety of **channels** which can be used to **measure the different background contributions** both internal (from the source foil) and external. The most harmful backgrounds for the 0νββ search in SuperNEMO will be, beside the irreducible **2νββ process**, a contamination of the source foils in **^{208}Tl and ^{214}Bi**. Both isotopes decay emitting **one electron and up to 3 gamma particles**.

The collaboration has developped its own **simulation and reconstruction software** based on GEANT4. A variety of algorithms have been designed in order to obtain an **efficient and faithful event reconstruction**.



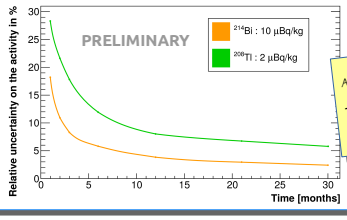
Example of a reconstructed ^{208}Tl event in the 1e2γ event channel

A special care during the source production is taken to keep **very stringent background levels** : A(^{208}Tl)<2μBq/kg and A(^{214}Bi)<10μBq/kg. These contamination levels can be measured by simultaneously **fitting discriminating variables** in the 1e1γ and 1e2γ channels.



Discriminating variables are fitted for a demonstrator pseudo-experiment i.e. 17.5 kg.y of ^{82}Se and A(^{208}Tl) = 2 μBq/kg, A(^{214}Bi) = 10 μBq/kg and A(Radon) = 150 μBq/m³ . (left) Electron and gamma energy sum. (right) Gamma energy

The activities at stakes are very low, and measuring accurately such background levels becomes a challenge in itself. The figure below shows the evolution of the **measurement uncertainty** on **^{208}Tl and ^{214}Bi activities** for the demonstrator.



Activity measurement with a 10% uncertainty :
– in 2 months for 10 μBq/kg of ^{214}Bi
– in 8 months for 2 μBq/kg of ^{208}Tl

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