Low Radioactivity Techniques 2006 Aussois

The BiPo detector for ultralow radioactivity measurements

Mathieu Bongrand

LAL – Paris XI / Orsay University

Outlines

- BiPo detector : principle and designs
- Background
- BiPo prototype and status
- Summary

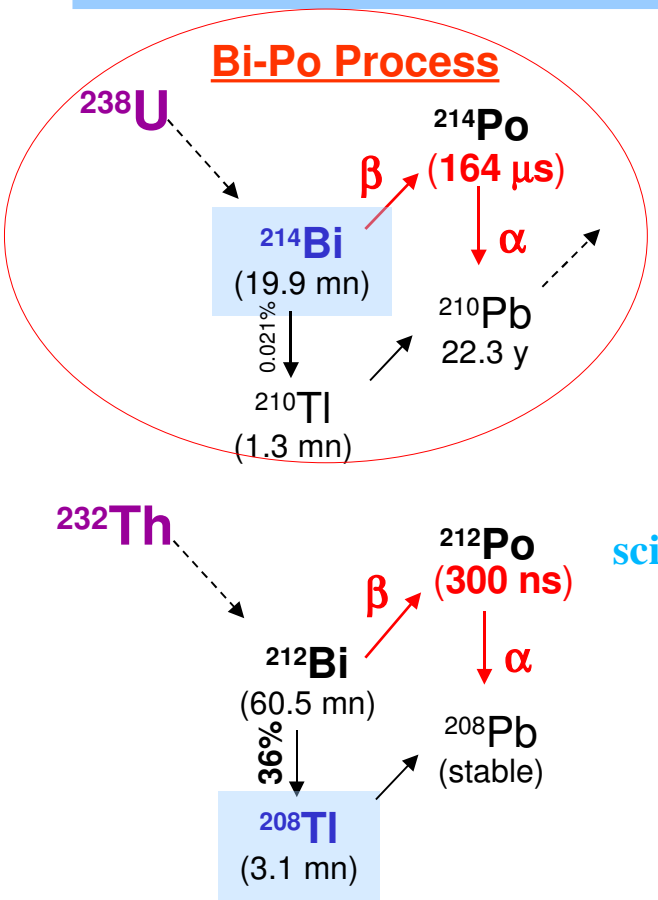
BiPo Detector : principle and design

BiPo detector : goal and principle

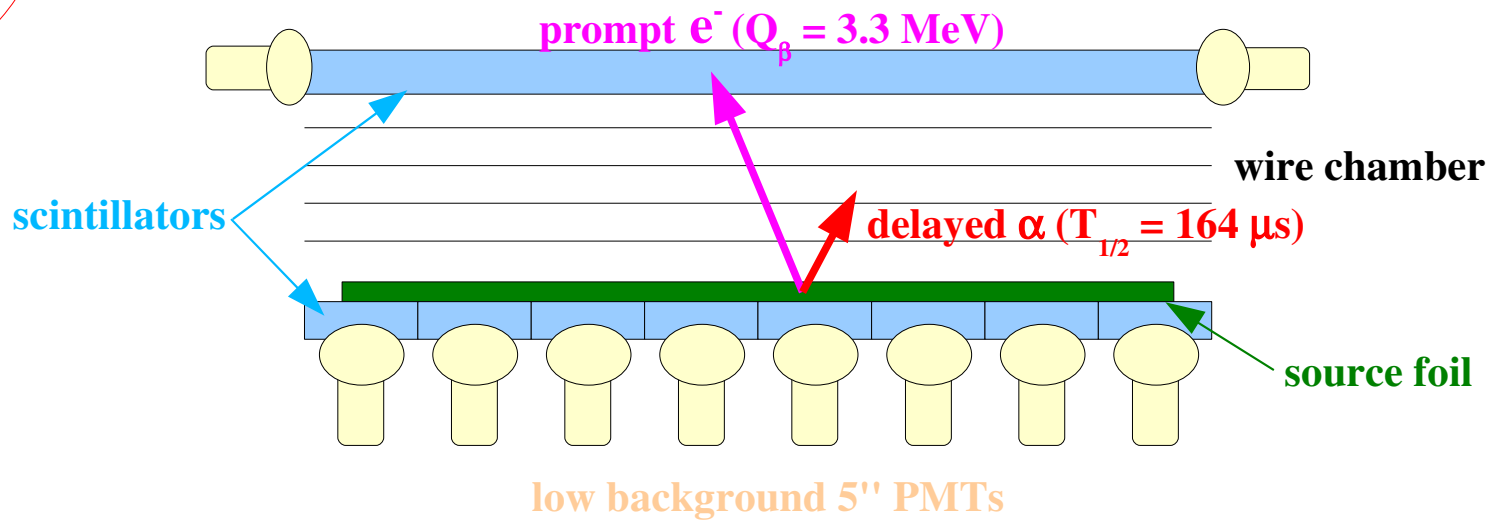
Measure the radiopurity in ^{208}Tl and ^{214}Bi of SuperNEMO source foils before installation

Goal : 5 kg of foils (12 m^2, 40 mg/cm^2) in 1 month with a sensitivity of :

^{208}Tl < 2 µBq/kg and ^{214}Bi < 10 µBq/kg



A possible design

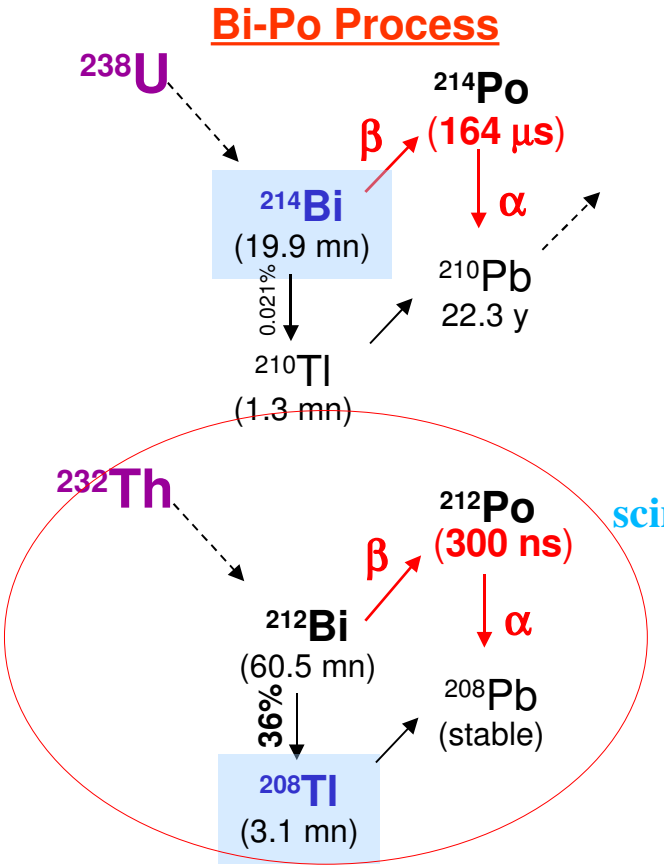


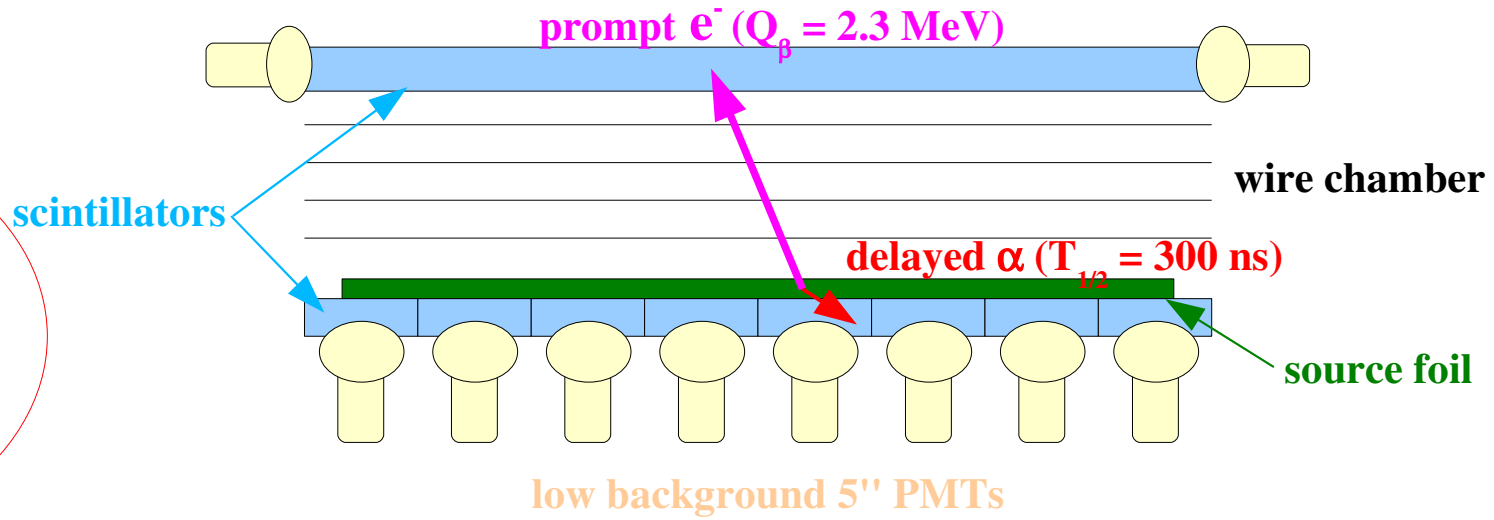
BiPo detector : goal and principle

Measure the radiopurity in ^{208}Tl and ^{214}Bi of SuperNEMO source foils before installation

Goal : 5 kg of foils (12 m^2, 40 mg/cm^2) in 1 month with a sensitivity of :

^{208}Tl < 2 µBq/kg and ^{214}Bi < 10 µBq/kg



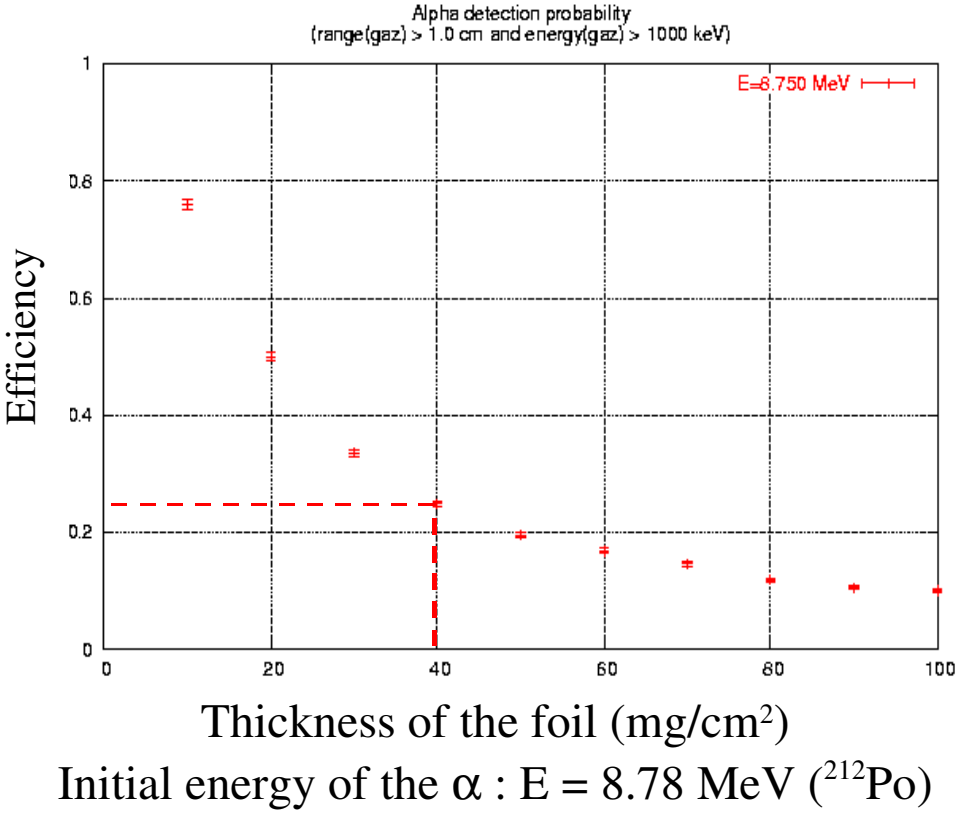


Alpha tagging efficiency

GEANT 4 simulations :

25 % α escaping the foil with energy > 1 MeV

(Due to quenching 40 keV are deposited in the scintillator)



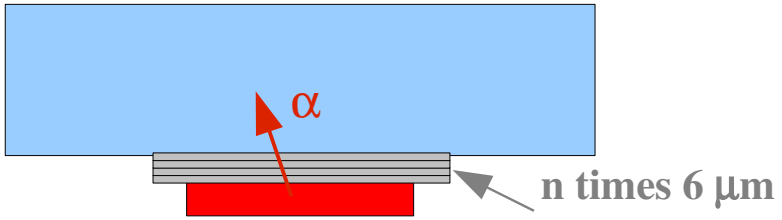
Initial energy of the α : E = 8.78 MeV (^{212}Po)

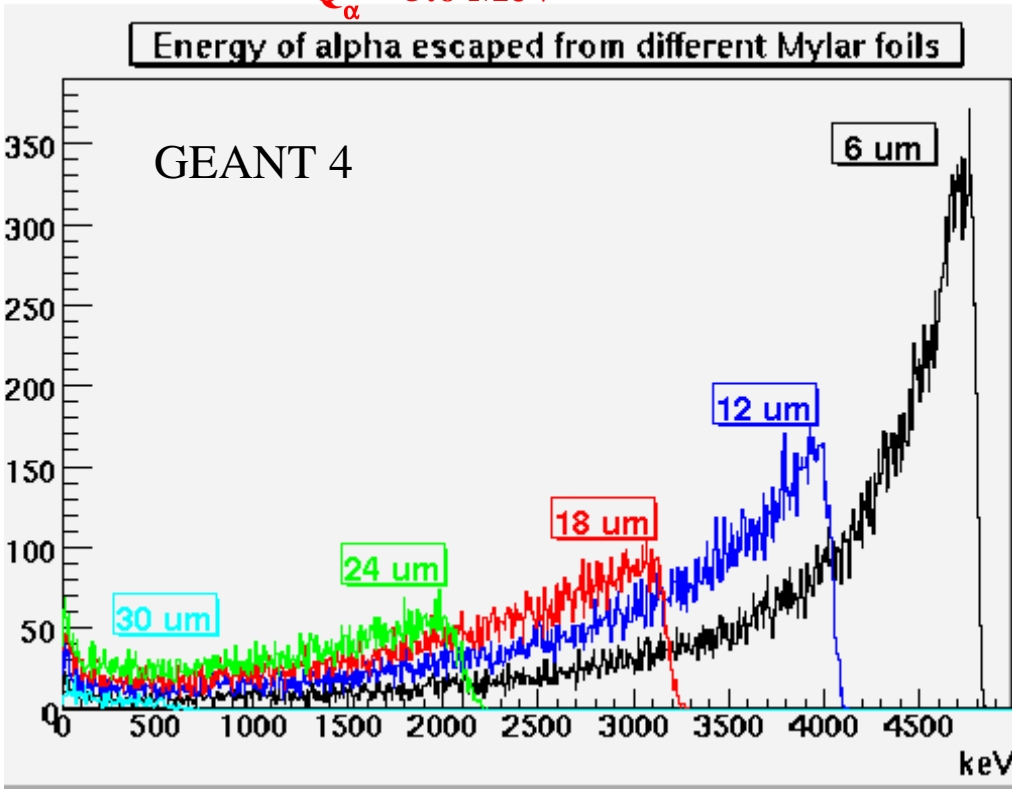
For 5 kg of ^{82}Se source foil (~ 12 m^2 and 40 mg/cm^2) :

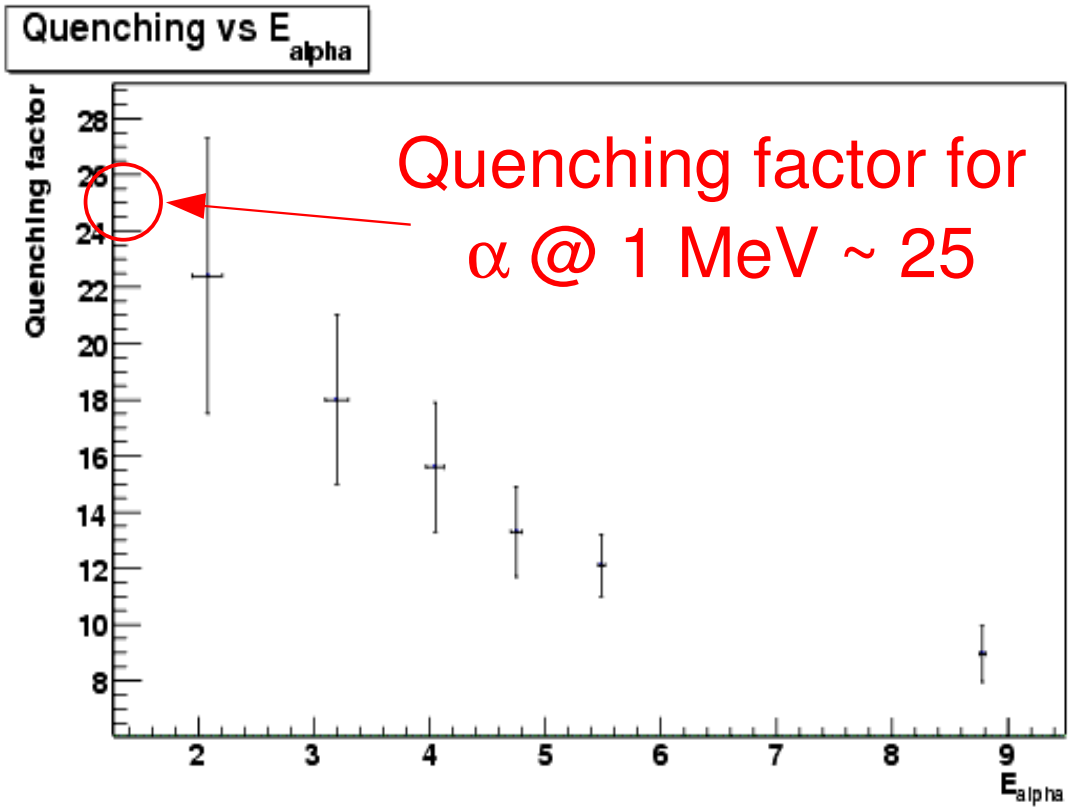
- 2 μBq/kg in ^{208}Tl = 52 BiPo events / month (e^-, delayed α)
- ε ~ 25 % ⇒ 12 events / month

Measurement of alpha quenching

Alphas energy is reduced by pilling-up 6 µm mylar foils







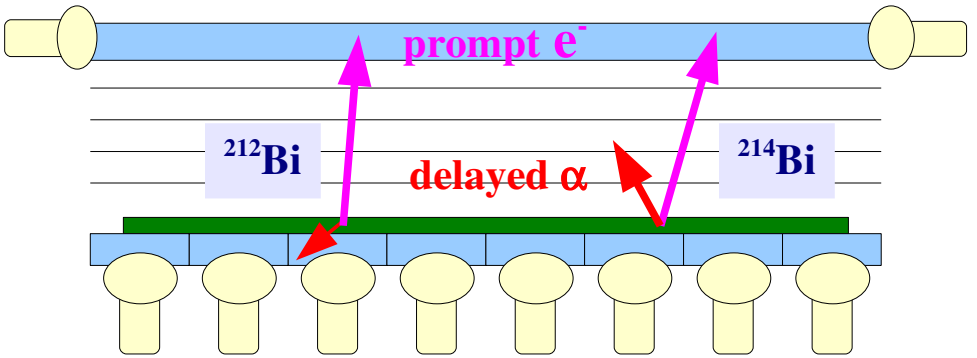
α @ 1 MeV→ ~ 40 keV deposited in the scintillator (NEMO 3 threshold)

2 possible designs

- Scintillators calorimeter + tracking detector

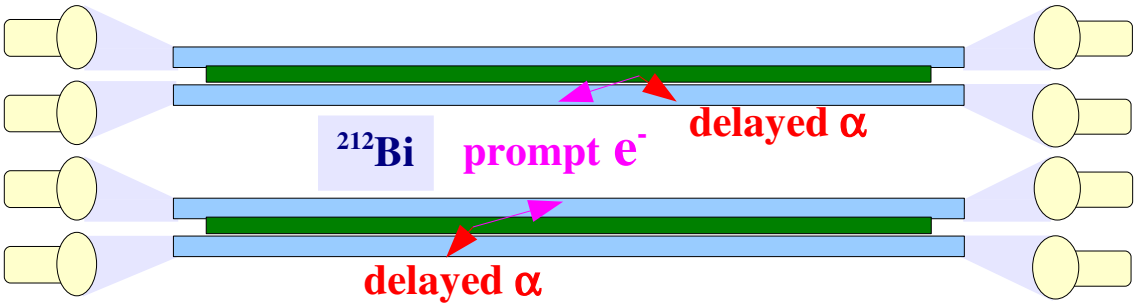
  (NEMO 3 technique) :

  - ε ~ 6 %
  - ^{212}Bi and ^{214}Bi measurements



- Multilayer scintillator plates (MOON 1 technique) :

  - ε ~ 25 %
  - no ^{214}Bi measurements

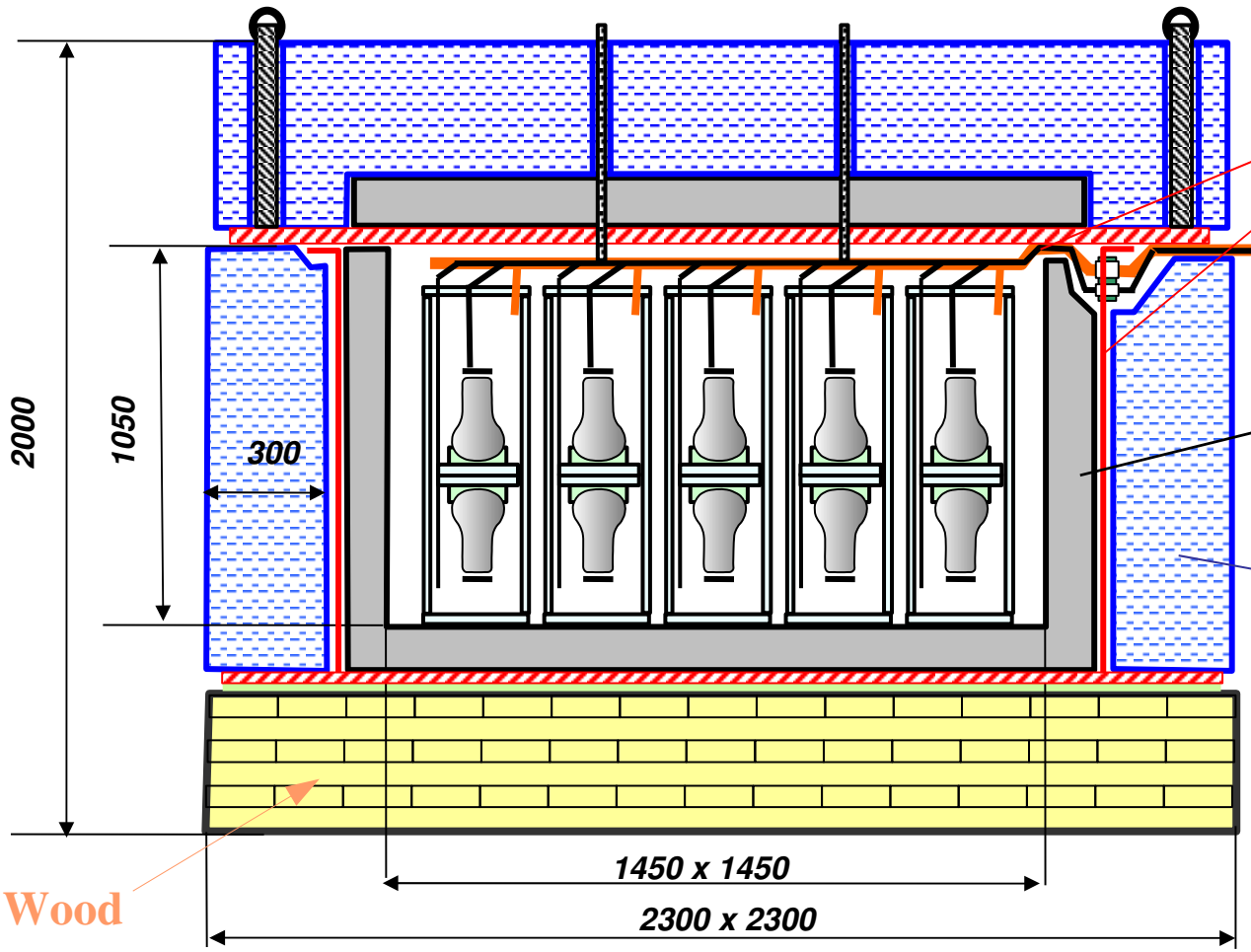


This 2 designs will be tested during the R&D phase

Background

Shielding Test Facility : phase I

The 2 designs will be tested in a shielding facility in the Canfranc Underground Laboratory



Radon-tight tank (pure iron)

Radon free air

Lead shield (13 tons)

Water shield

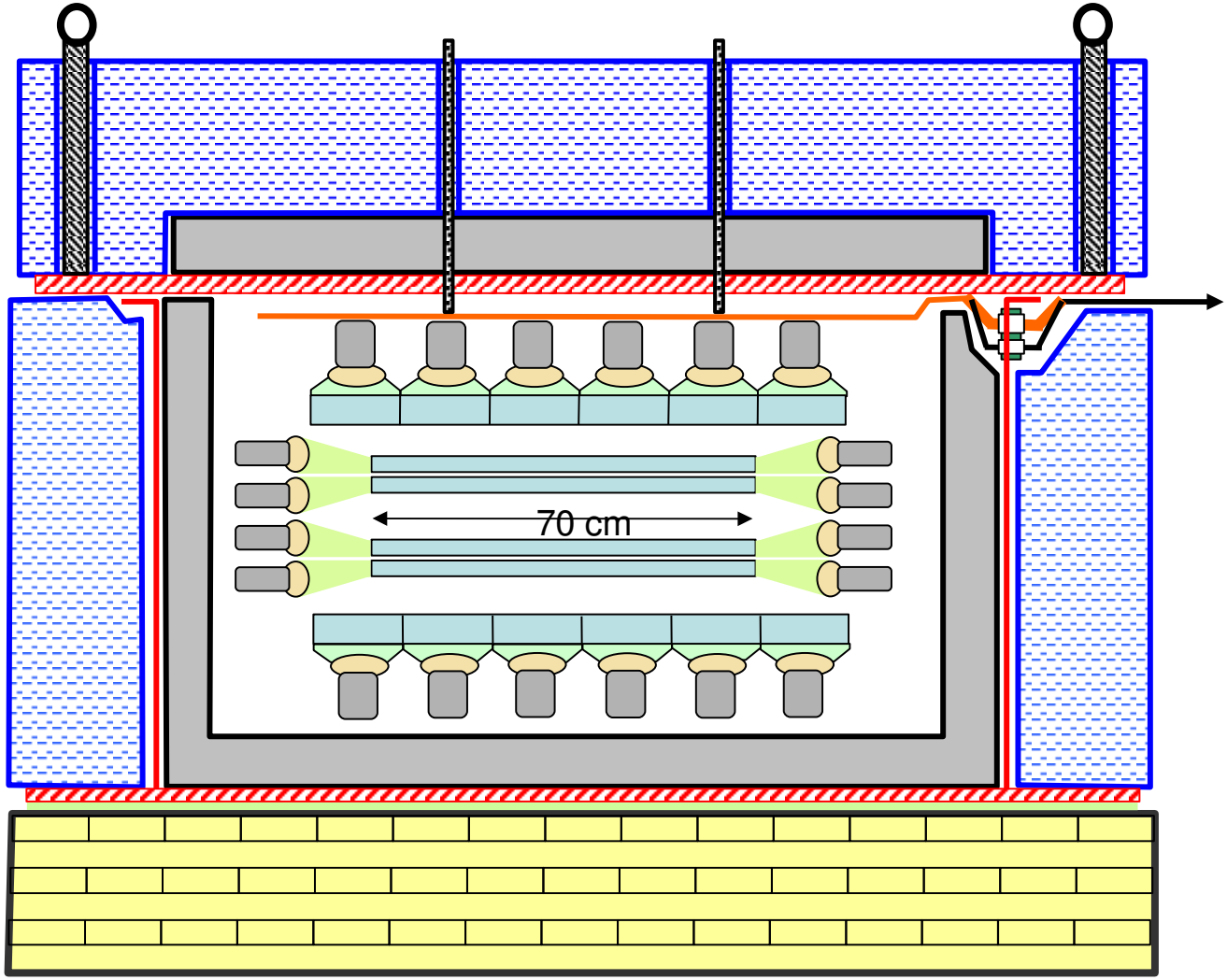
Shielding Test Facility :

external : 2.3 m x 2.3 m x 2 m

internal : 1.45 m x 1.45 m x 1.05 m

Up to 25 capsules can be installed

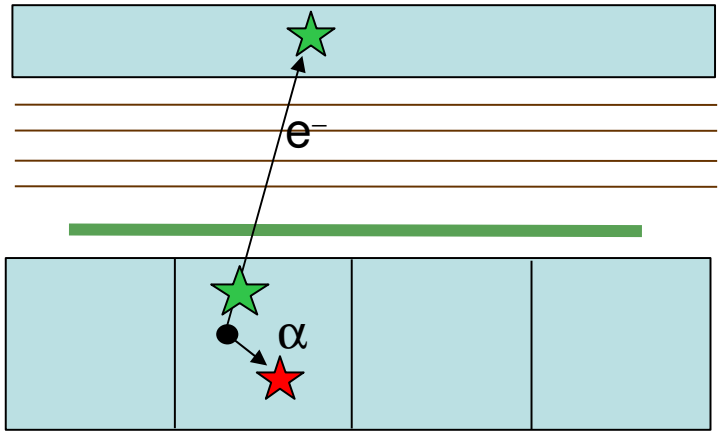
Shielding Test Facility : phase II



Main background

^{212}Bi bulk contamination

Prompt e , T_0

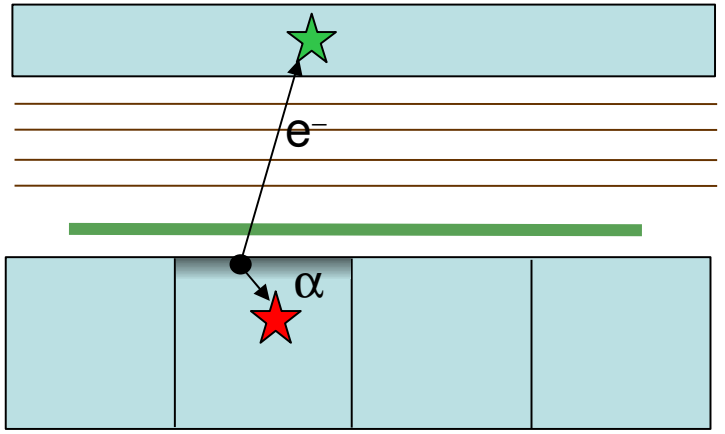


Prompt e$^-$, T_0

Bkg event rejected

^{212}Bi surface contamination

Prompt e , T_0



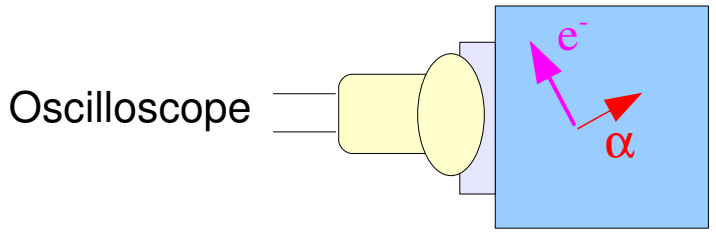
Delayed α, $T_{1/2}$ ~ 300 ns

Bkg event NOT rejected

An electron from ^{212}Bi deposits ~ 50 keV in average in 100 μm of scintillator

NEMO 3: ^{212}Bi bulk contamination

Very simple measurement :



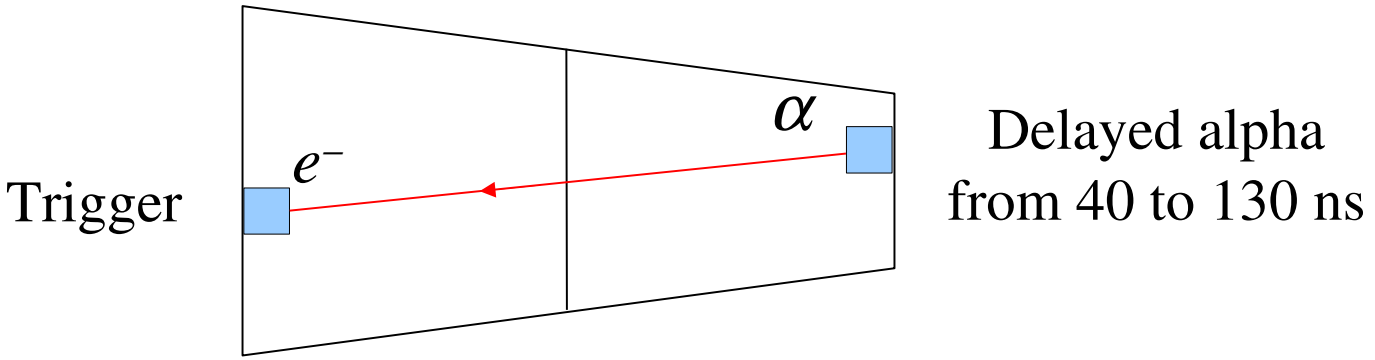
$E_\alpha = 8.8$ MeV

~ 1 MeV deposited

No events observed in 3 days :

$A(^{212}Bi) < 3$ μBq/kg

NEMO 3 : ^{212}Bi surface contamination



NEMO 3 scintillator wrapped with aluminised mylar
(standard aluminium)

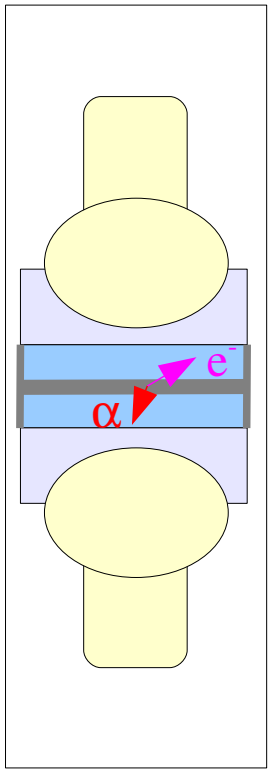
^{212}Bi surface activity : 150 µBq/m^2

Our hypothesis : aluminised mylar contamination
(not scintillators surface contamination)

BiPo prototype

BiPo prototype : background measurements

Surface contamination and random coincidences measurements

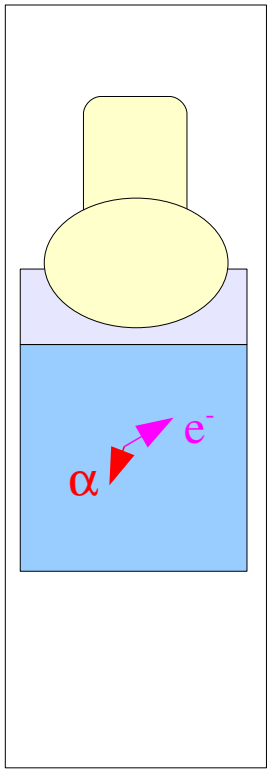


- First capsule :
  - 2 scintillators 20 x 20 x 1 cm^3 from NEMO 3 production
  - scintillators spottered with ultrapure aluminium
  - installation in Canfranc Underground Laboratory in October, 17th

If ^{212}Bi surface contamination 150 µBq/m^2 comes from scintillators : 8 events / month / capsule

BiPo prototype : soon

Surface and bulk contamination measurements



- Second capsule :
  - 2 scintillators 20 x 20 x 1 cm^3
  - scintillators wrapped with aluminised mylar (standard Al - NEMO 3 like) for surface contamination measurements
- Third capsule :
  - 1 scintillator 20 x 20 x 20 cm^3 for bulk contamination measurements
- Later : serial production of capsules

Summary

- BiPo detector is needed to measure the radiopurity of SuperNEMO source foils

  (^{208}Tl < 2 μBq/kg and ^{214}Bi < 10 μB/kg)
- BiPo prototype is dedicated to background measurements
- A first capsule will be installed October, 17th in Canfranc
- A Shielding Test Facility is being constructed
- The 2 BiPo possible designs will be tested in this shielding in Canfranc