

BiPo Prototype Measurements for SuperNEMO

- Objectives and principles
- Prototypes
- First results

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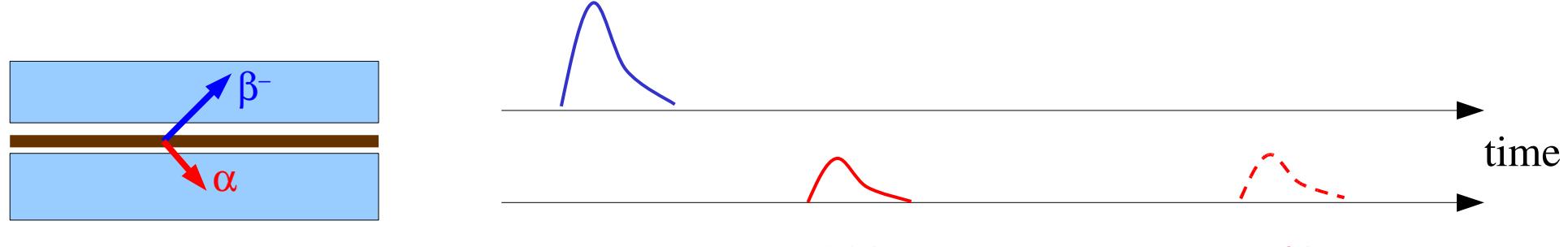
Objectives

- Measure the radiopurity in ^{208}Tl and ^{214}Bi of $\beta\beta$ source foils (SuperNEMO) or other thin materials
- Goal : 10 m² of foils (40 mg/cm²) in 1 month with sensitivities :
 - bulk contaminations : $^{208}\text{Tl} < 2 \mu\text{Bq/kg}$ & $^{214}\text{Bi} < 10 \mu\text{Bq/kg}$
 - surface contaminations : $^{208}\text{Tl} < 0.1 \mu\text{Bq/m}^2$ & $^{214}\text{Bi} < 0.5 \mu\text{Bq/m}^2$
- Detection of BiPo decay cascade : β + delayed α



Experimental principle

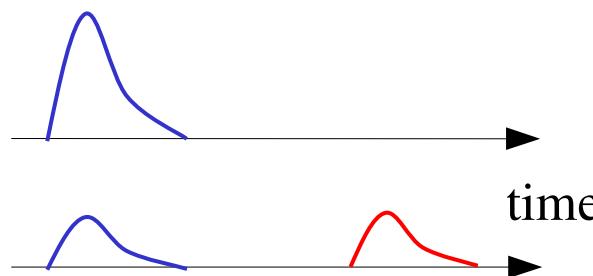
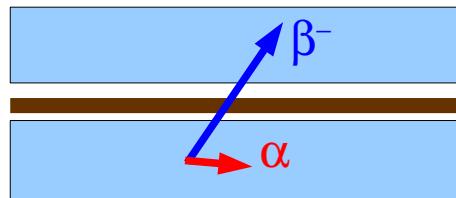
- Sandwich of 2 plastic scintillators around the foil + PMTs
- BiPo signature : 1 hit + 1 delayed hit



- $E_{\text{threshold}}(\beta) = 150 \text{ keV}$
- No hit in time in the opposite scintillator (background rejection)
- $E_{\text{threshold}}(\alpha) = 1 \text{ MeV} \Leftrightarrow 40 \text{ keV}$ because of the quenching
- GEANT4 simulation of bulk contamination in selenium foil :
 $\epsilon = 6.5 \%$

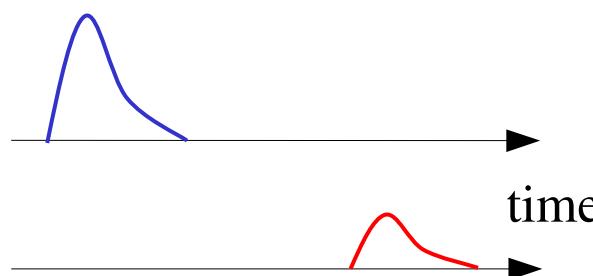
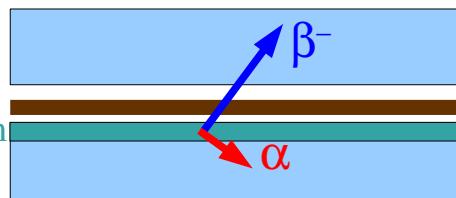
Backgrounds

- Random coincidences :
 - single counting rate : τ_1 ($\beta^- > 150$ keV) & τ_2 ($\alpha > 1$ MeV)
 - $\sqrt{\tau_1 \tau_2} \sim 40$ mHz for ^{208}Tl & ~ 10 mHz for ^{214}Bi
- Bulk contaminations of the scintillators :



⇒ REJECTED

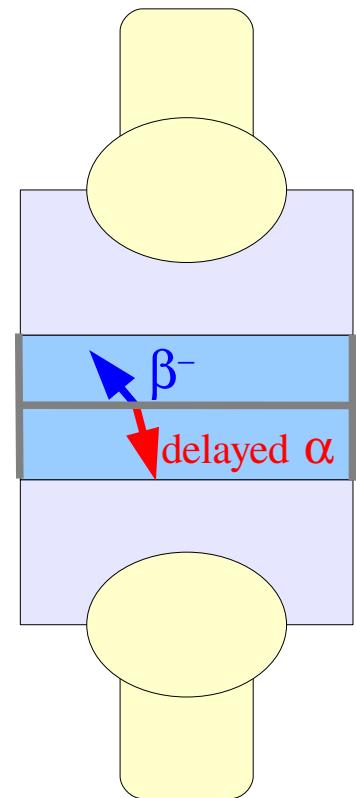
- Surface contamination of the scintillators :



⇒ NOT REJECTED

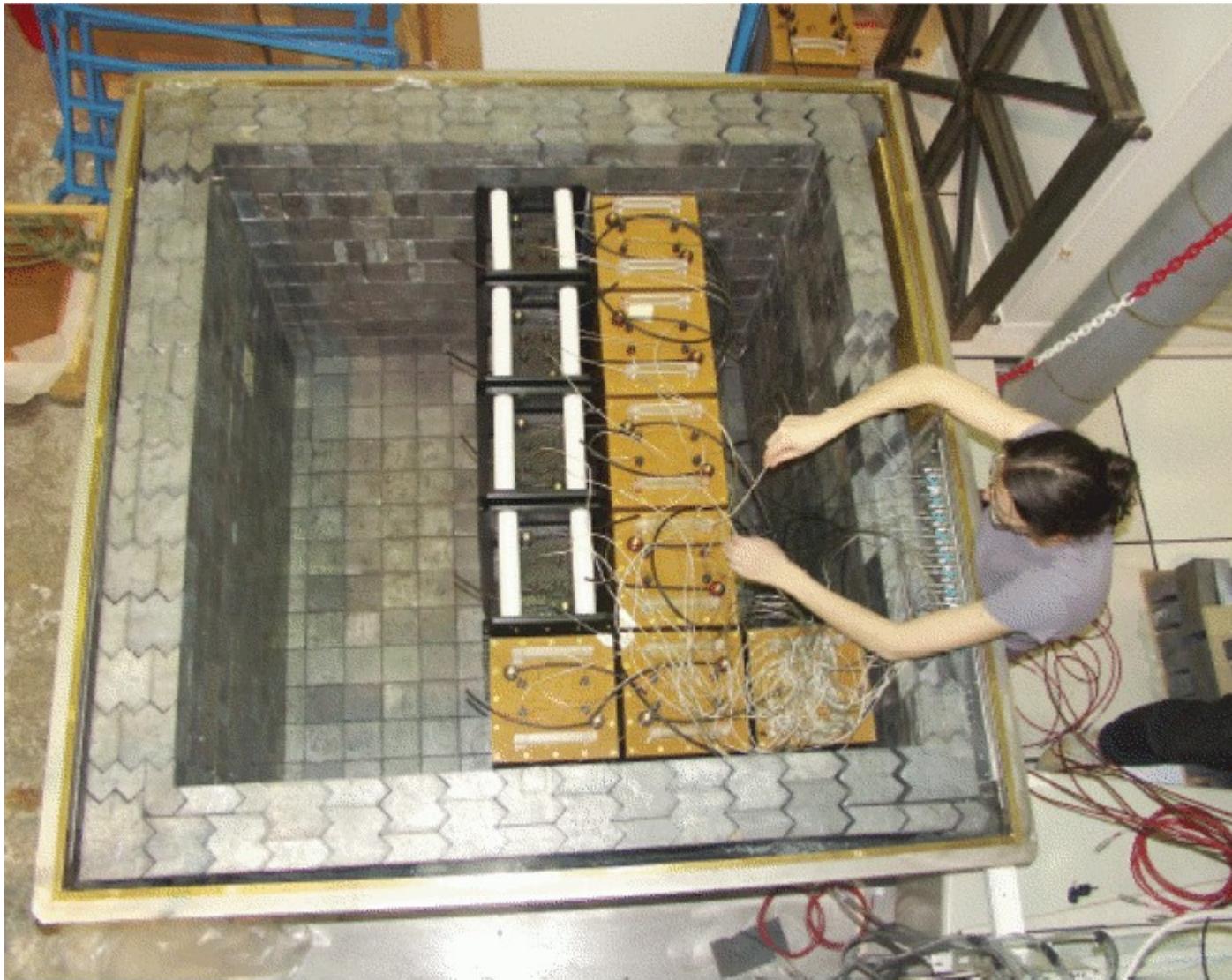
BiPol prototype

- Modules :
 - 20x20x1 or 20x20x0.3 cm³ polystyrene scintillators
 - surface sputtered with pure aluminum (200 nm)
 - 5" low activity PMTs (Hamamatsu from NEMO3)
- Shielding :
 - 15 cm of low activity lead + 3 cm of pure iron
 - radon free air
- Increasing number of modules in LSM since June 2007
- 18 modules running since February 2008 in LSM



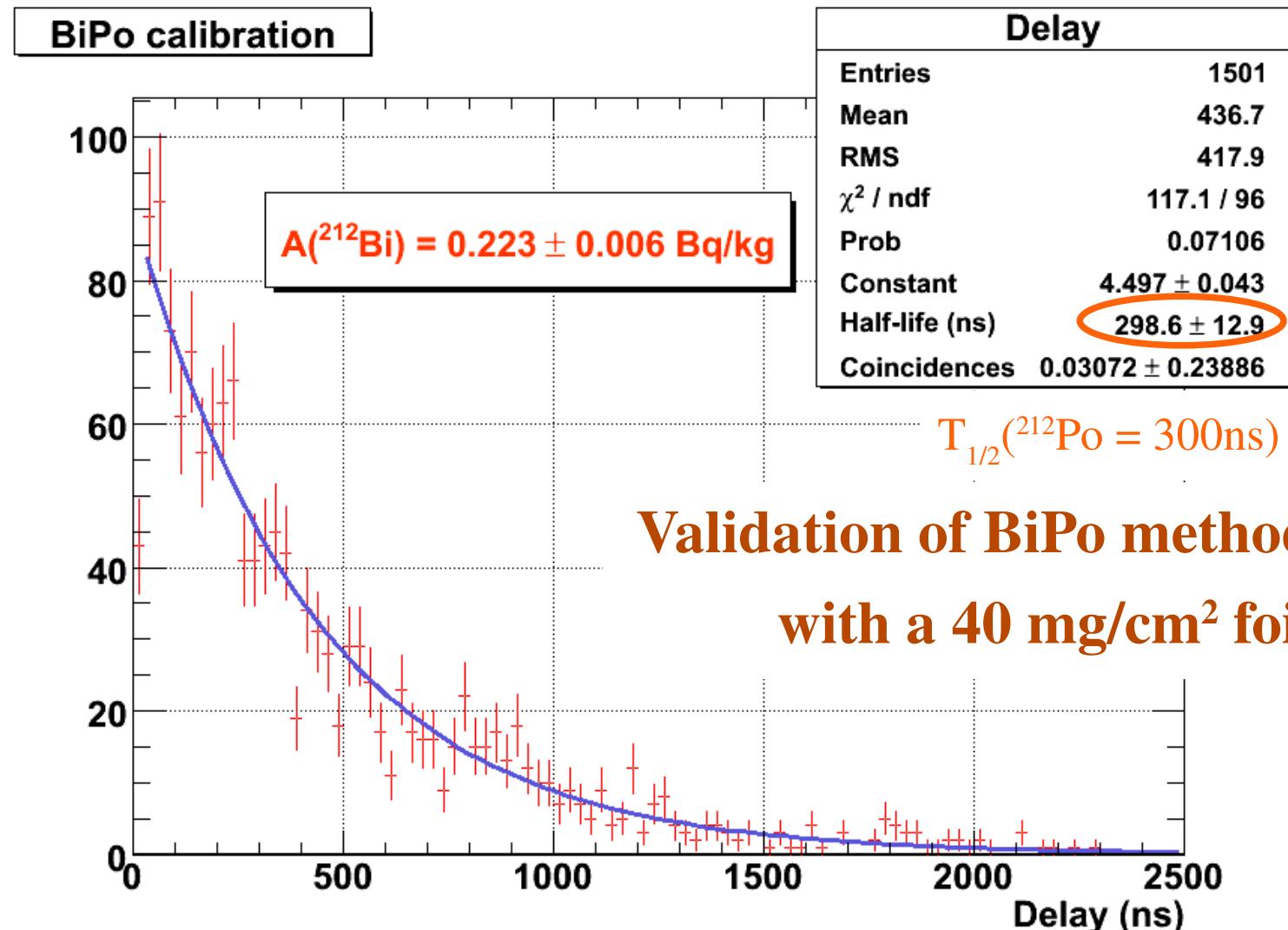
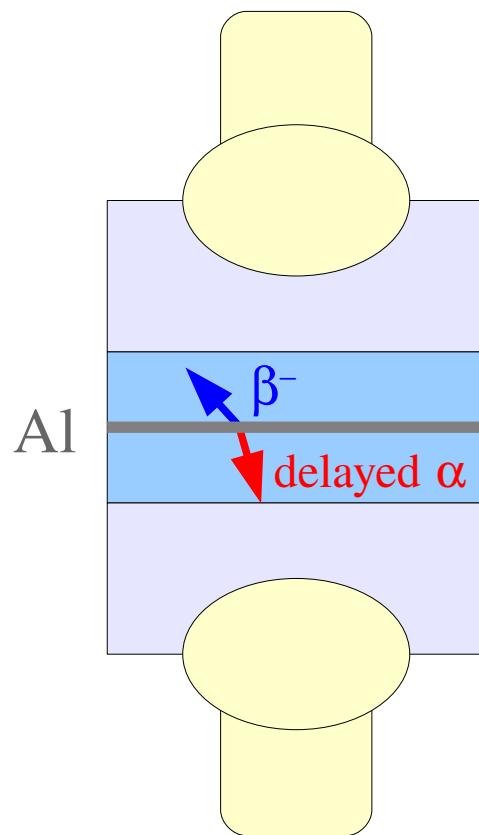
$$S = 0.72 \text{ m}^2$$

Pictures



BiPo calibration

- Aluminum calibration foil with a known contamination in ^{228}Th
(Ge measurement: $A(^{228}\text{Th}) = 0.29 \pm 0.03 \rightarrow A(^{212}\text{BiPo}) = 0.19 \pm 0.03 \text{ Bq/kg}$)

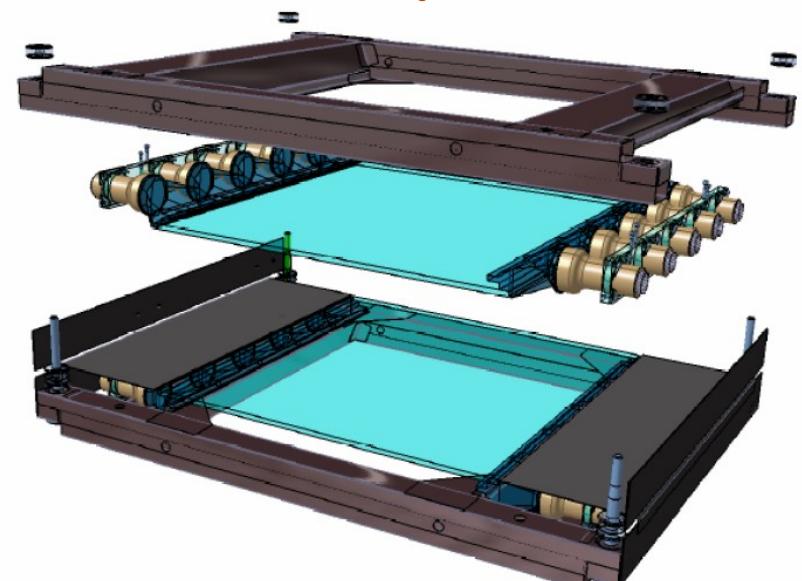


Very preliminary results

- Total surface x time exposure is now : **2 m² x month**
- Preliminary results for 10 modules in 2 month (0.8 m² x month) :
- **7 BiPo events observed**
- Cleaning processes are under investigation
- If we extrapolate to a 10 m² BiPo detector the sensitivity is :
 $A(^{208}\text{Tl}) < 7.5 \mu\text{Bq/kg}$ in a month for 4 kg of selenium (40 mg/cm²)

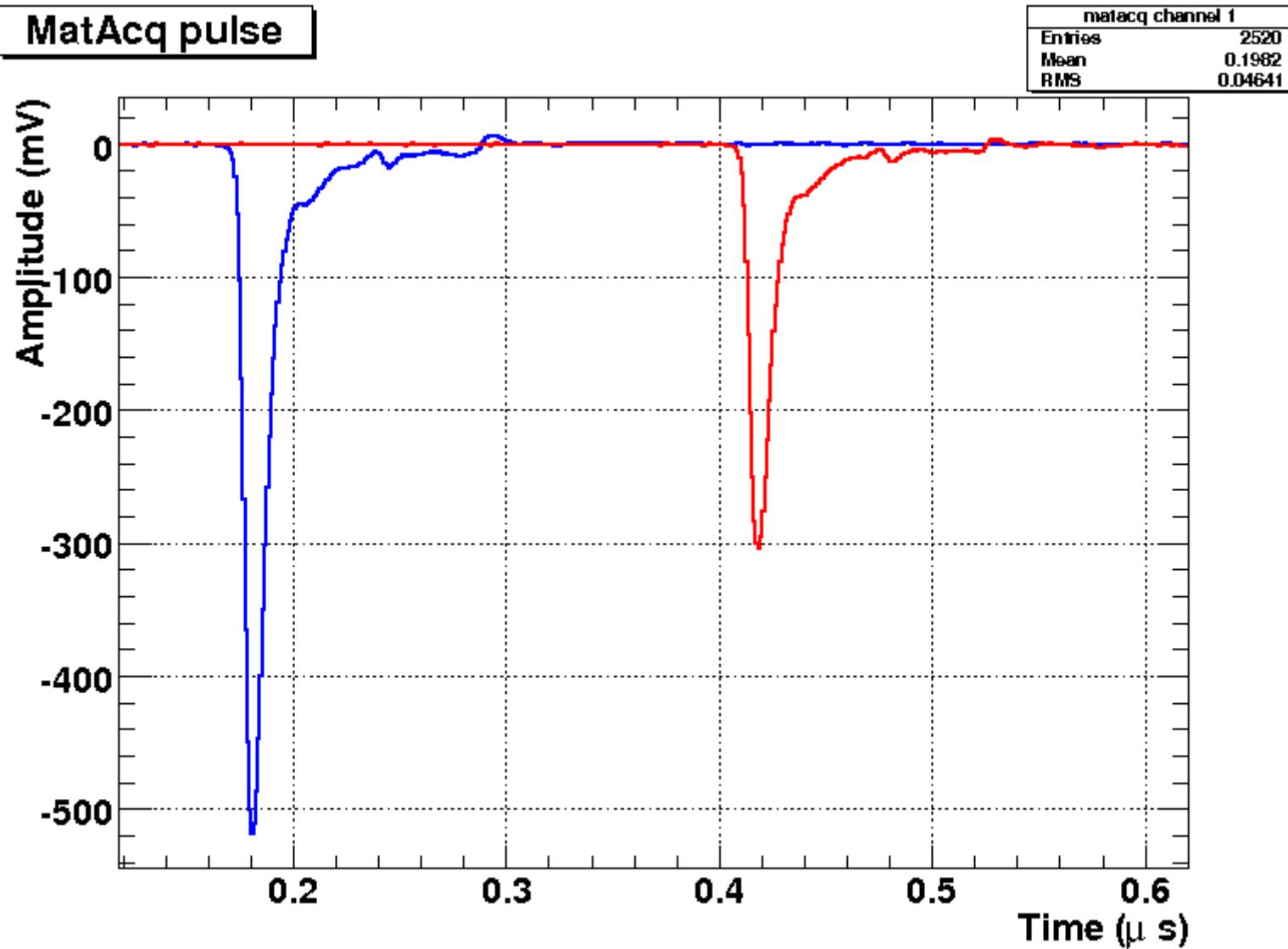
Conclusions

- Measurement of ^{212}Bi (^{208}Tl) contamination in a 40 mg/cm^2 foil (like SuperNEMO 2β foils) was demonstrated
- Very good preliminary sensitivity extrapolated to a 10 m^2 BiPo detector in 1 month for 4kg selenium: $A(^{208}\text{Tl}) < 7.5 \mu\text{Bq/kg}$
- Not yet the objectives but better than existing possibilities
- BiPo2 prototype: scintillators plates $75 \times 75 \text{ cm}^2$ directly molted (radiopurity)



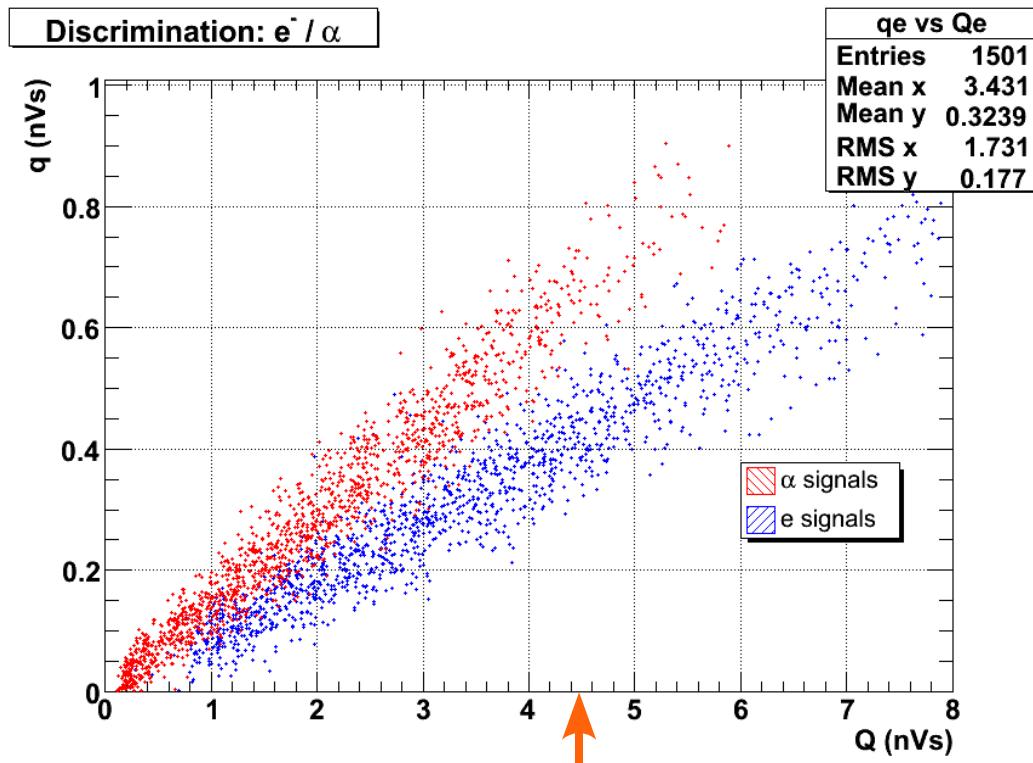
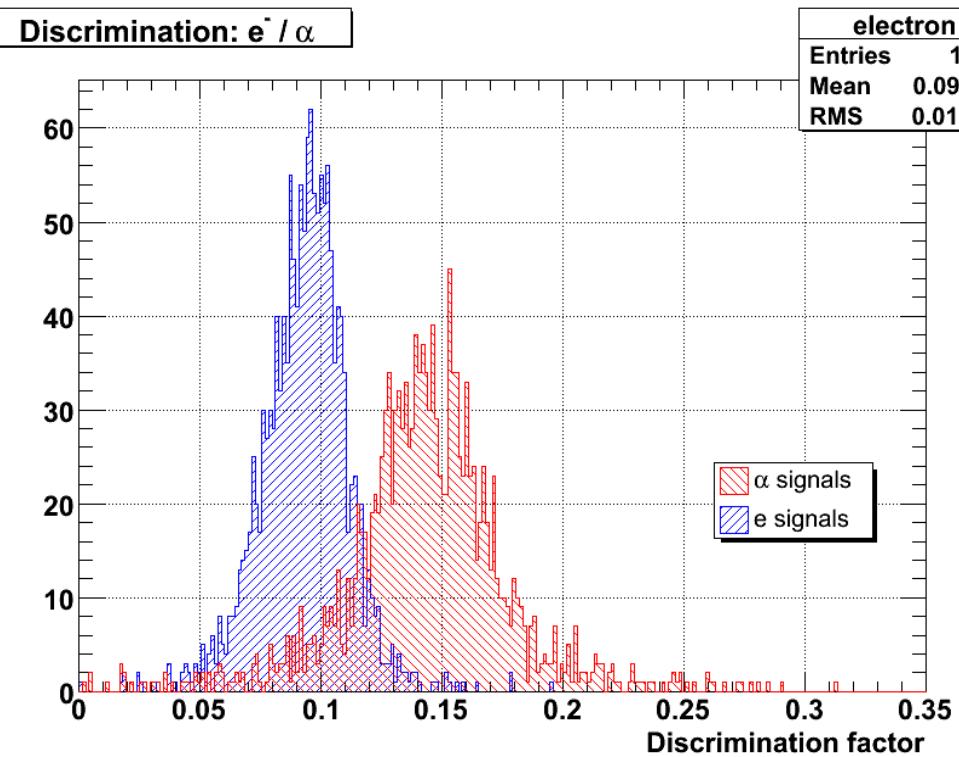
Backup slides

BiPo event



β/α discrimination in BiPo1

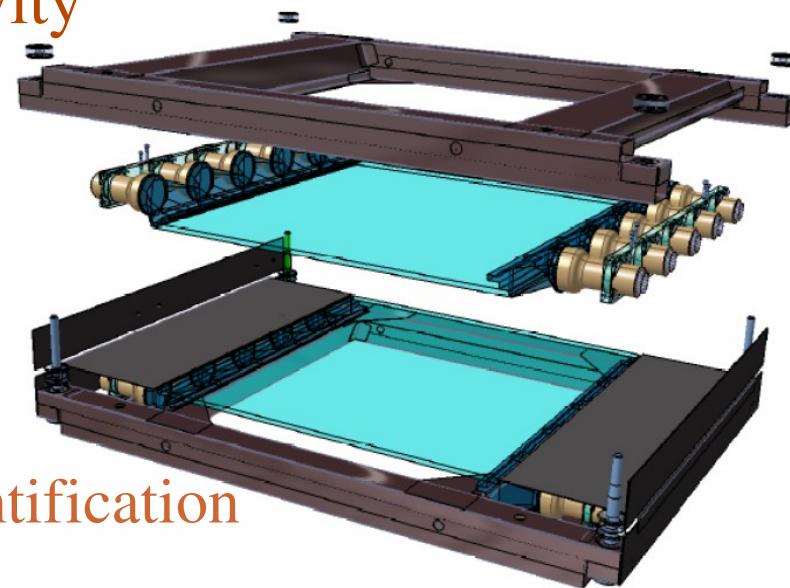
- Looking for the discrimination on the BiPo events from the aluminum calibration foil
- Discrimination factor $\chi = \text{tail to total charge ratio } (q/Q)$



- 90 % of α conserved with $\sim 20\%$ of e^- contamination $\sim 1\text{ MeV}$
- Discrimination difficult at low energy

BiPo2

- Scintillators plates 75x75 cm² directly molted (radiopurity)
- Light collected by total internal reflectivity
- Advantages :
 - more compact detector & less PMTs
 - if good spatial resolution :
less random coincidences & hot spots identification
- Prototype under assembly in Orsay
 - test of energy threshold & spatial resolution in March
 - installation in LSM for background study end of March
 - preliminary result with 75x75 cm² plate : $\sigma_{xy} \sim 5 \text{ cm}$



From NEMO3 to SuperNEMO

$$T_{1/2}(\beta\beta 0\nu) > \ln 2 \times \frac{N_A}{A} \times \frac{M \times \epsilon \times T_{obs}}{N_{exclus}}$$

NEMO-3

^{100}Mo	Isotope
7 kg	Isotope mass M
8 %	Efficiency ϵ
$^{208}\text{TI}: < 20 \mu\text{Bq/kg}$	Internal contamination
$^{214}\text{Bi}: < 300 \mu\text{Bq/kg}$	^{208}TI and ^{214}Bi in $\beta\beta$ foil

15% @ 1MeV

Energy resolution (FWHM)

SuperNEMO

^{150}Nd or ^{82}Se
100-200 kg
~ 30 %
$^{208}\text{TI} < 2 \mu\text{Bq/kg}$
if ^{82}Se : $^{214}\text{Bi} < 10 \mu\text{Bq/kg}$

7% @ 1 MeV

$T_{1/2}(\beta\beta 0\nu) > 2 \times 10^{24} \text{ y}$
 $\langle m_\nu \rangle < 0.3 - 1.3 \text{ eV}$

$T_{1/2}(\beta\beta 0\nu) > 2 \times 10^{26} \text{ y}$
 $\langle m_\nu \rangle < 40 - 110 \text{ meV}$

SuperNEMO

Modular design : ~ 100 kg of enriched isotopes (20 modules)

- Tracking detector:

Drift chamber ~3000 cells in Geiger mode

- Calorimeter:

~ 1000 scintillators + PMTs

