

BiPo-3 : Status Report

ISOTTA Meeting
1–2 December 2014

- Very short remind of the BiPo-3 detector
- Background measurement
- Latest results of the first SuperNEMO enriched ^{82}Se foils
- Latest results of Vikuiti and polyethylene samples for $\beta\beta$ bolometers experiments

The BiPo-3 detector

Measure the purity in ^{208}Tl and ^{214}Bi of the SuperNEMO source foils

Measure 3.6 m² of foils (40 mg/cm²) in \sim 6 month with a sensitivity of

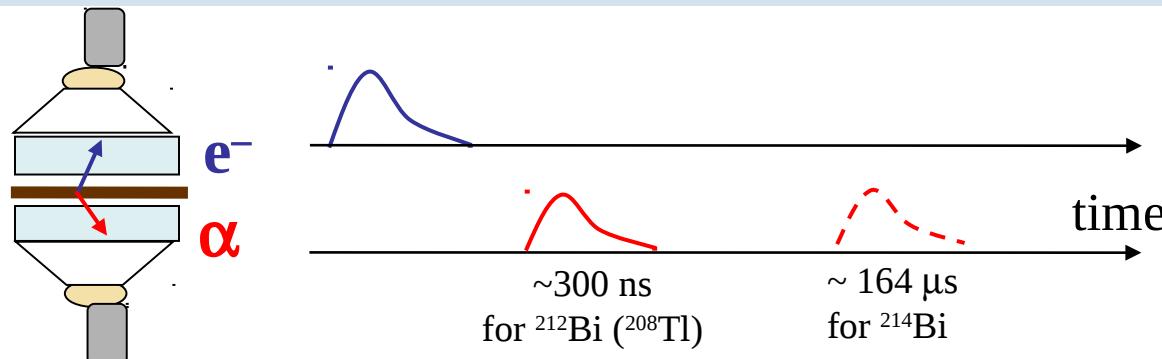
$$^{208}\text{Tl} < 2 \mu\text{Bq/kg} \quad \text{and} \quad ^{214}\text{Bi} < 10 \mu\text{Bq/kg}$$

Detect the BiPo decay cascade: β + delayed α



Sandwich of two low radioactive thin polystyrene scintillators (2 x 300 x 300 mm)

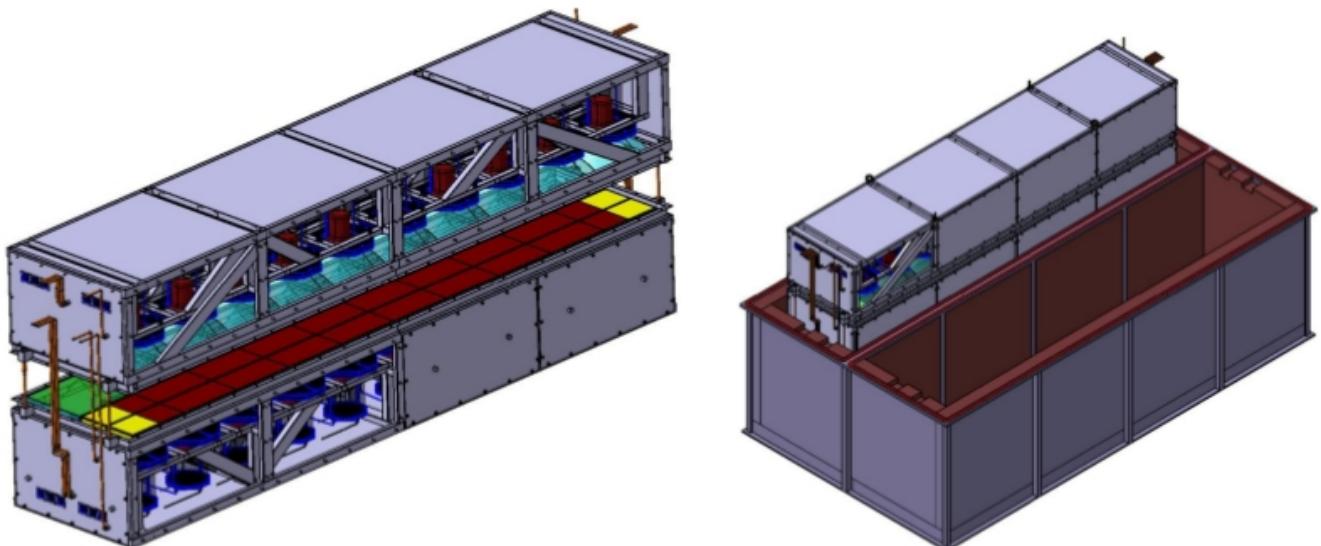
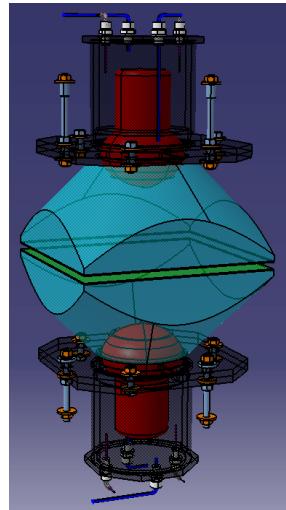
Time topology signature: 1 prompt hit (β) + 1 delay hit (α) and no coincidence



The BiPo-3 detector

Canfranc Underground Laboratory (Spain)

- BiPo-3 composed of two modules
- Each module :
 - 2×20 polystyrene scintillators
 - coupled to 5 low radioactive PMTs
 - scint. : $300 \times 300 \times 3$ mm 3
 - 200 nm ultrapure Al on scint. surface
- Total active area of BiPo-3 (two modules)
 $S = 2 \times 1.8 = 3.6$ m 2

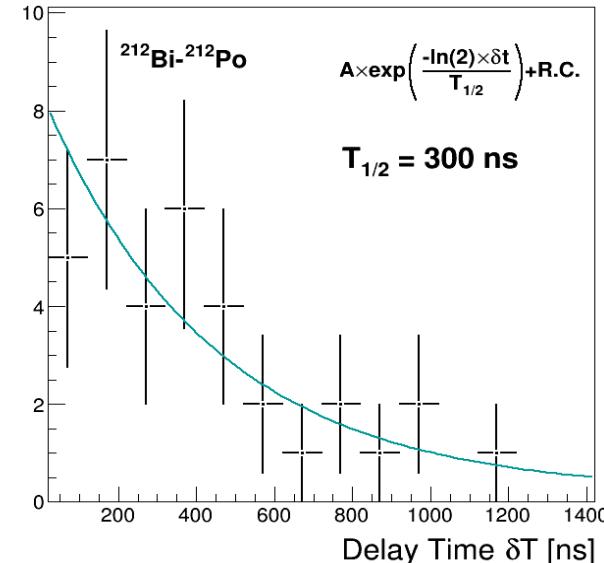
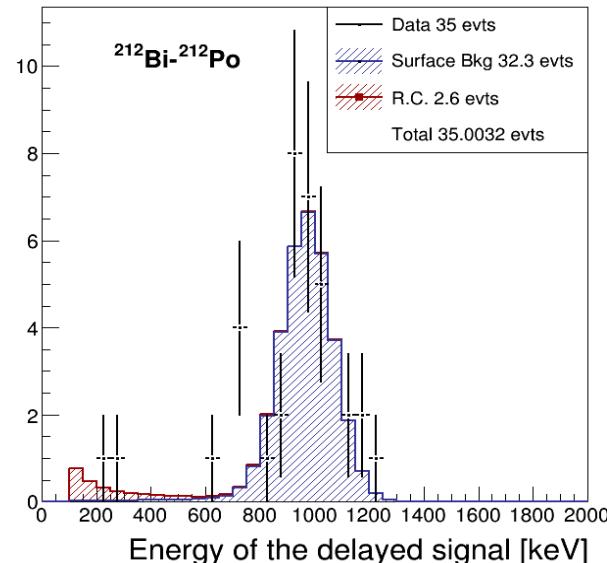
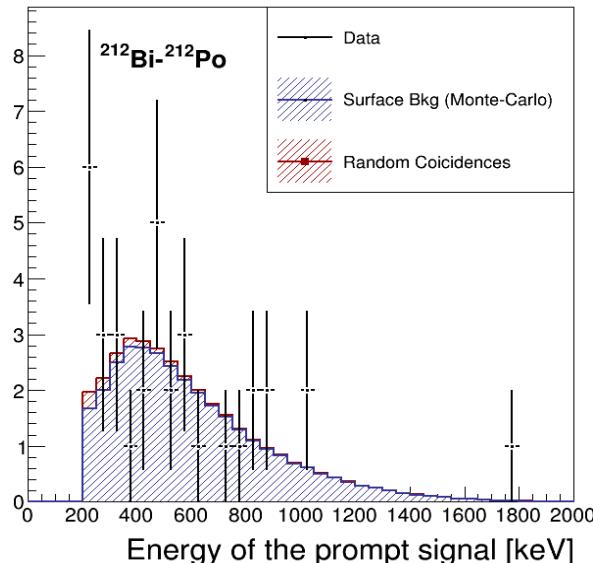


Measurement of the BiPo-3 background

Three background measurements have been performed

Detector closed without any foil : $\epsilon(^{212}\text{BiPo}) = 28.9\ \%$

A total of 35 $^{212}\text{BiPo}$ events observed after 229 days \times 3.13 m² scint.



- Bkg due to ^{208}Tl contamination on the surface of the scintillators :

$$A(^{208}\text{Tl}) = 1.0 \pm 0.2 \text{ } \mu\text{Bq/m}^2 \text{ scint.}$$

~ 1 $^{212}\text{BiPo}$ cts/month per BiPo-3 module, with the screening (~ 0.4) of a sample

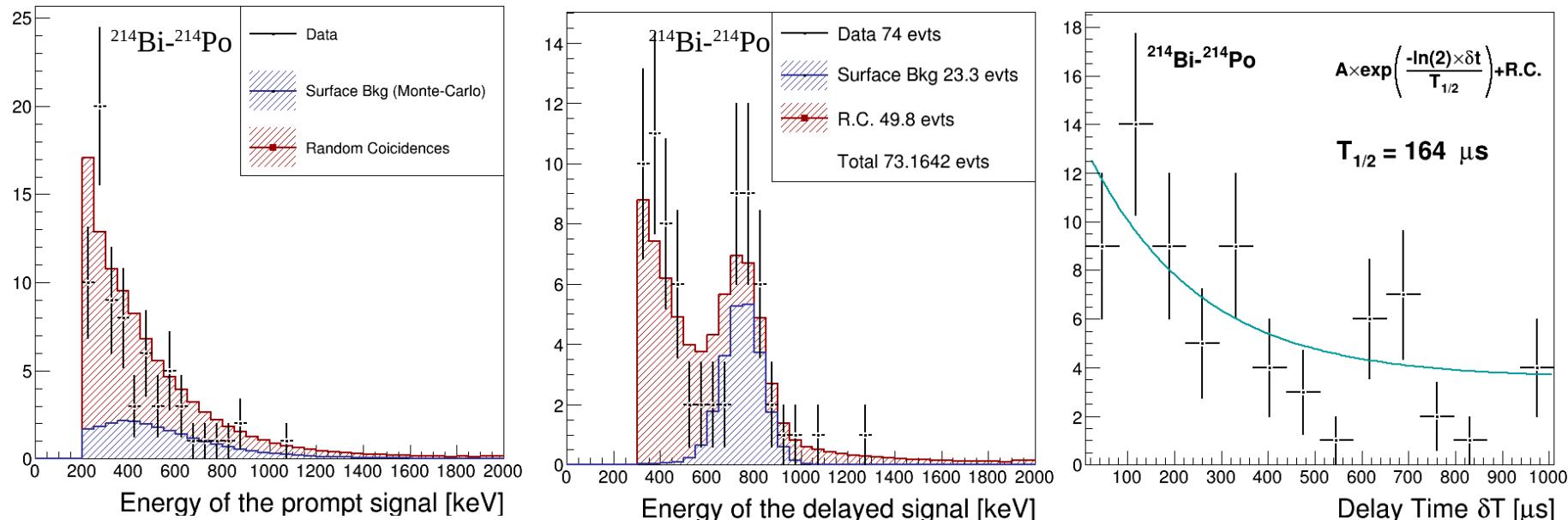
- Random coincidences are negligible
- Bkg ~ 0 if one requires $E(\text{delay } \alpha) < 700$ keV
- The results of the three bkg measurements are compatible

The results of the three bkg measurements are compatible

	Time (Days)	Scint. surface (m ²)	$^{212}\text{BiPo}$ candidates	A(^{208}Tl) $\mu\text{Bq}/\text{m}^2$ scint. [90% C.L.]
Module 1	79.5	2.70	9	0.91
Old shield				
Module 1	47.9	3.24	7	0.99
Final shield				
Module 2	101.6	3.42	19	1.18
Final shield				

Measurement of the BiPo-3 background

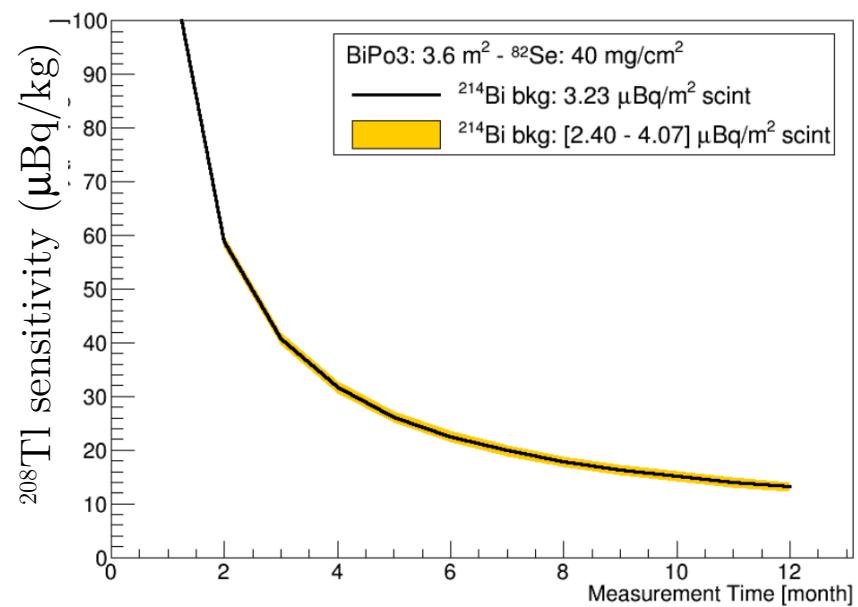
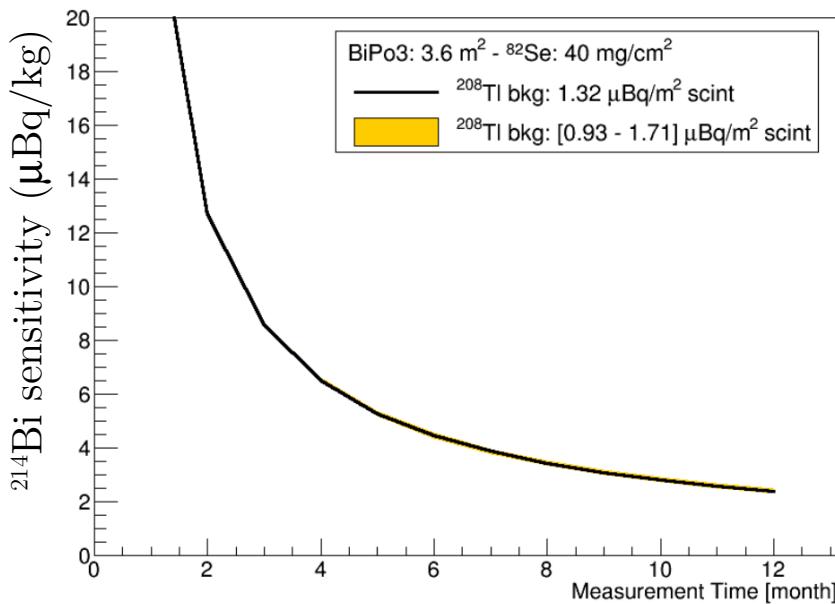
A total of 74 $^{214}\text{BiPo}$ candidates observed after 184 days \times 3.13 m² scint.



- Two components of background for BiPo :
 - Surface contamination on the scintillator ($\sim 25.9\%$)
 $A(^{214}\text{Bi}) = 1.8 \pm 0.4 \mu\text{Bq}/\text{m}^2 \text{ scint.}$
 $\sim 1.7 \text{ }^{214}\text{BiPo cts/month per BiPo-3 module with the screening} (\sim 0.4) \text{ of a sample}$
 - Random Coincidences ($\sim 70\%$)
 $\sim 9 \text{ R.C./month and per BiPo-3 module}$
- The results of the three bkg measurements are compatible
- $E(\text{delay } \alpha) > 300 \text{ keV}$ in order to reject external Radon bkg

Expected sensitivity

Assuming SuperNEMO Se-82 foils (40 mg/cm²)



With 6 months of measurement

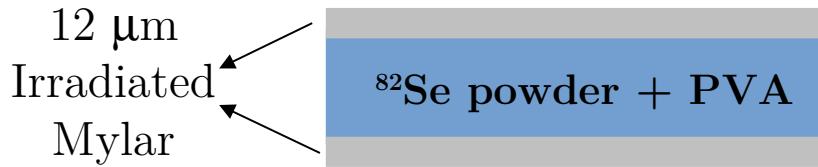
$$A(^{208}\text{Tl}) < 4 \mu\text{Bq}/\text{kg} \text{ (90 \% C.L.)}$$

$$A(^{214}\text{Bi}) < 22 \mu\text{Bq}/\text{kg} \text{ (90 \% C.L.)}$$

Measurement of the first SuperNEMO ^{82}Se foil

Two ^{82}Se Strips ($\sim 300\text{g } ^{82}\text{Se}$)
installed mid-August 2014
in half of a module

Second half used to control
the background



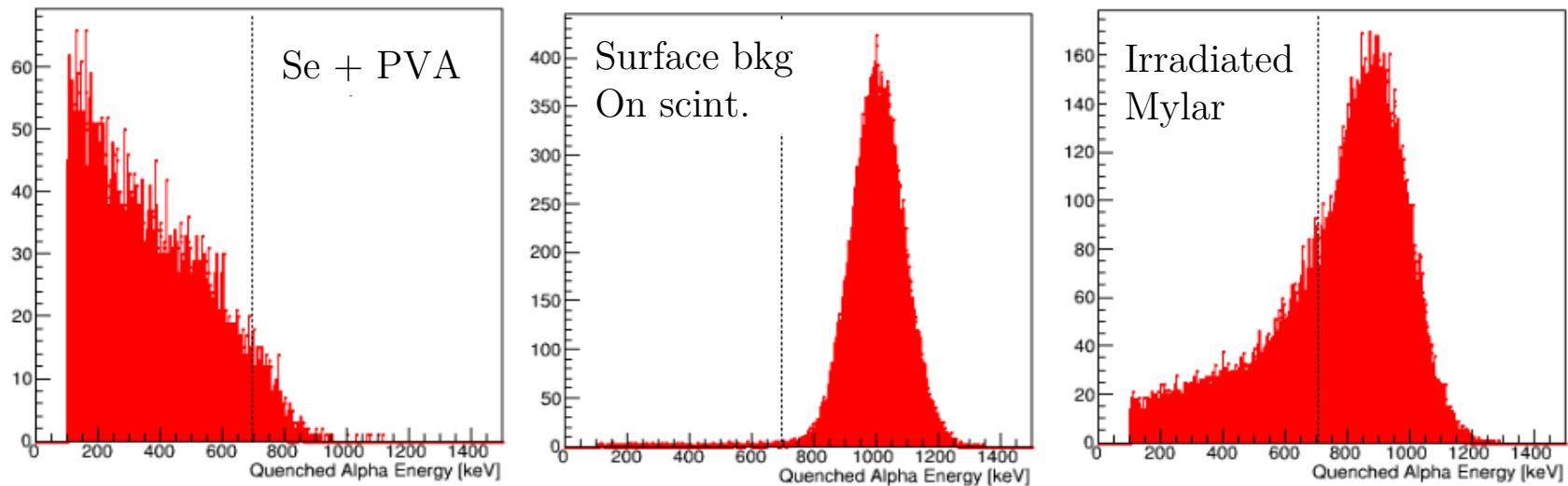
Irradiated mylar has been already measured separately in BiPo-3 :

$$A(^{208}\text{Tl}) = 139 [64 - 229] \mu\text{Bq/kg} \ (90 \% \text{ C.L.})$$

- We present here the measurement in BiPo-212 (^{208}Tl)
- We have analysed 74.2 days of collected data
- Analysis in BiPo-214 is in progress
- Two new foils have been delivered today in Orsay :
They will be installed begining dec. 2014

Measurement of the first SuperNEMO ^{82}Se foil

Energy spectrum of the delayed α calculated by Monte-Carlo
 $\rightarrow E(\alpha) < 700$ keV allows to reject surface bkg and most of the BiPo events from irradiated mylar



$^{212}\text{BiPo}$ efficiency calculated by Monte-Carlo

Criteria	Se+PVA	Irradiated Mylar	Surf. Bkg
$E_{\text{delay}} > 100\text{keV}$	2.95 %	9.2 %	12.0 %
$100 < E_{\text{delay}} < 700 \text{ keV}$	2.8 %	2.75 %	0.12 %

Measurement of the first SuperNEMO ^{82}Se foil

- Mass $^{82}\text{Se} + \text{PVA} = 232.6 \text{ g}$
- Mass irradiated mylar = 20.8 g
- Surface scint = 1.26 m²
- T_{obs} = 74.22 days

Criteria	BiPo Candidates	Expected Surf. Bkg	Expected Irrad. Mylar
$E(\alpha) > 100 \text{ keV}$	3	1.8 ± 0.3	$3.0 [1.4 - 5.0]$
$100 < E(\alpha) < 700 \text{ keV}$	0	0.02 ± 0.004	$0.9 [0.4 - 1.5]$

No event observed, 0.4 bkg events expected \rightarrow 2.04 signal event excluded (90% C.L.)



$A(^{208}\text{Tl}) < 27 \mu\text{Bq/kg} \text{ (90 \% C.L.)}$

Control of the background with the 2nd half of the detector empty

Criteria	BiPo Candidates	Expected Surf. Bkg	Observed bkg in agreement With the expected level
$E(\alpha) > 100 \text{ keV}$	3	4.1 ± 0.8	

Main other BiPo-3 results for SuperNEMO

Irradiated mylar

Channel	Time	Surface	Mass	BiPo	Expected	A($\mu\text{Bq}/\text{kg}$)
	(days)	(m^2)	(g)	candidates	Bkg	(90 % C.L.)
$^{212}\text{BiPo}$	44.3	1.62	214	18	3.8 ± 1.1	$\mathbf{A(^{208}\text{Tl}) = 139 [64 - 229]}$
$^{214}\text{BiPo}$	32.4	1.44	190	20	2.8 ± 0.8	$\mathbf{A(^{214}\text{Bi}) = 1063 [618 - 1637]}$

Raw mylar (before irradiation and cleaning process)

Channel	Time	Surface	Mass	BiPo	Expected	A($\mu\text{Bq}/\text{kg}$)
	(days)	(m^2)	(g)	candidates	Bkg	(90 % C.L.)
$^{212}\text{BiPo}$	42.7	0.81	108.1	0	0.01 ± 0.001	$\mathbf{A(^{208}\text{Tl}) < 34}$
$^{214}\text{BiPo}$	31.1	0.81	108.1	13	12.1 ± 2.9	$\mathbf{A(^{214}\text{Bi}) < 210}$

Mesh (Tulle similar ad wedding dress...)

Channel	Time	Surface	Mass	BiPo	Expected	A($\mu\text{Bq}/\text{kg}$)
	(days)	(m^2)	(g)	candidates	Bkg	(90 % C.L.)
$^{212}\text{BiPo}$	110.6	1.44	70.6	96	18.0 ± 5.3	$\mathbf{A(^{208}\text{Tl}) = 316 [222 - 407]}$
$^{214}\text{BiPo}$	98.0	1.35	66.2	62.6	17.3 ± 4.5	$\mathbf{A(^{214}\text{Bi}) = 482 [274 - 681]}$

Polyethylene for $\beta\beta$ bolometer experiments

- Mass Polyethylene = 64.3 g
- Surface scintillator = 1.44 m²
- Exposure Time = 76.54 days
(14 Feb. - 28 May 2014)

Criteria	$\epsilon(\text{BiPo})$ Polyethylene	$\epsilon(\text{BiPo})$ Surf. Bkg With Polyethyl	BiPo candidates	Expected Surf. Bkg	$A(^{208}\text{Tl})$ (90 % C.L.)
$E(\alpha) > 200\text{keV}$	9.4 %	14.2 %	3	2.4 ± 0.5	$< 78 \mu\text{Bq/kg}$
$200 < E(\alpha) < 700 \text{ keV}$	6.9 %	0.2 %	2	0.03 ± 0.007	$< 113 \mu\text{Bq/kg}$

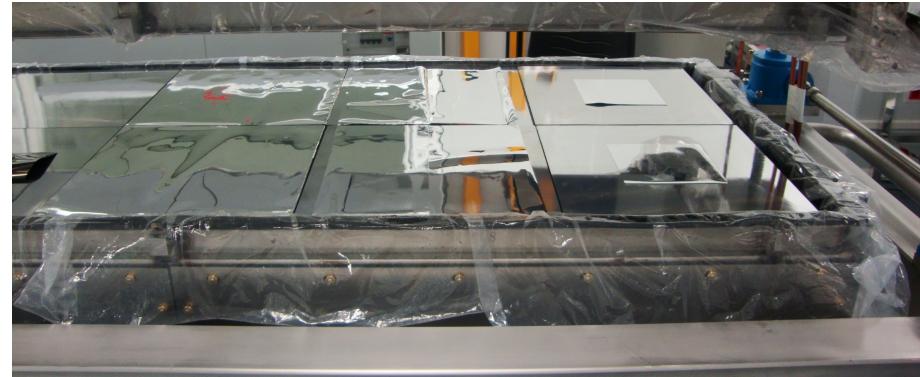


$A(^{208}\text{Tl}) < 78 \mu\text{Bq/kg} \text{ (90 \% C.L.)}$

Unexpected bkg below 200 keV
observed also in other samples during the same period

Vikuiti for $\beta\beta$ bolometer experiments

- Mass Vikuiti = 31.3 g
 - Surface scintillator = 1.08 m²
 - Exposure Time = 50.74 days
(11 Sep. - 06 Nov. 2014)
- Measurement still running...



Criteria	$\epsilon(\text{BiPo})$ Vikuiti	$\epsilon(\text{BiPo})$ Surf. Bkg With Vikuiti	$\epsilon(\text{BiPo})$ Surf. Bkg Without Viskuiti	BiPo Candidates	Expected Surf. Bkg
$E(\alpha) > 100\text{keV}$	12.0 %	13.7 %	28.9 %	0	\pm
$100 < E(\alpha) < 700 \text{ keV}$	9.1 %	0.1 %	0.2 %	0	0



$A(^{208}\text{Tl}) < 84 \mu\text{Bq/kg} \text{ (90 \% C.L.)}$

Measurement still running... results will be updated...

Control of the background with the 2nd half of the detector empty

Criteria	BiPo Candidates	Expected Surf. Bkg
$E(\alpha) > 100 \text{ keV}$	2	4.5 ± 0.9



Observed bkg in agreement
With the expected level

Conclusions

- Two BiPo-3 modules running in Canfranc LSC since 2013
- First SuperNEMO foils measured since Aug. 2014

Preliminary results

Se+PVA $A(^{208}\text{Tl}) < 27 \mu\text{Bq/kg}$ (90 % C.L.)

Irradiated mylar : $A(^{208}\text{Tl}) = [64 - 229] \mu\text{Bq/kg}$ (90 % C.L.)

SE+PVA in sandwich with irradiated mylar :

OK for SN demonstrator (7kg Se, 3y)

Irradiated mylar must be replaced by purer matrice for SuperNEMO (100 kg Se, 5y)
Results in Bi-214 will delivered soon...

- Polyethylene and Vikuiti are clean in ^{208}Tl (^{232}Th)

Polyethylene : $A(^{208}\text{Tl}) < 78 \mu\text{Bq/kg}$ (90 % C.L.)

Vikuiti : $A(^{208}\text{Tl}) < 84 \mu\text{Bq/kg}$ (90 % C.L.)

Results in Bi-214 will delivered soon...

Hector has finished his post-doc : he is now in APC on Double-Chooz
Physicists involved in BiPo today :

- Pia (50%)
- Xavier Sarazin (50%)
- Mathieu Bongrand (data files management, 10%)



Hector Gomez facing the first Se-82 foils just before its installation inside BiPo-3

Extra Slides

Validation of the BiPo-3 efficiency with a calibrated aluminium foil

Thickness = 85 μm , Mass = 224 g

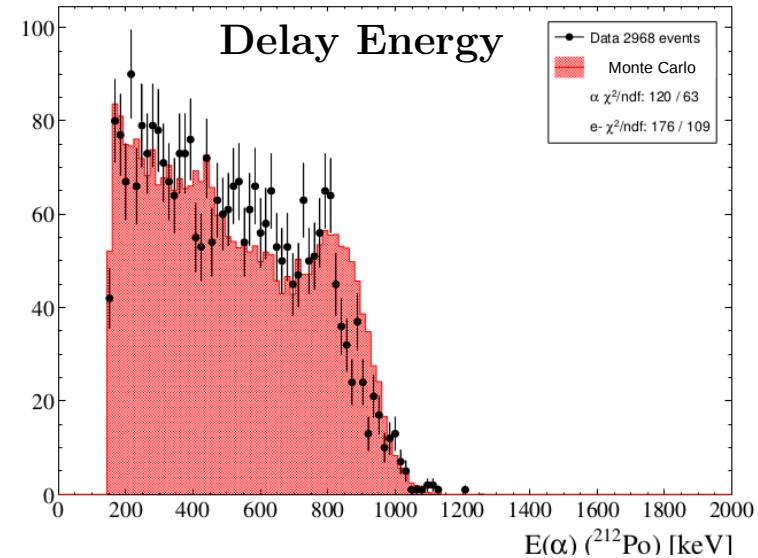
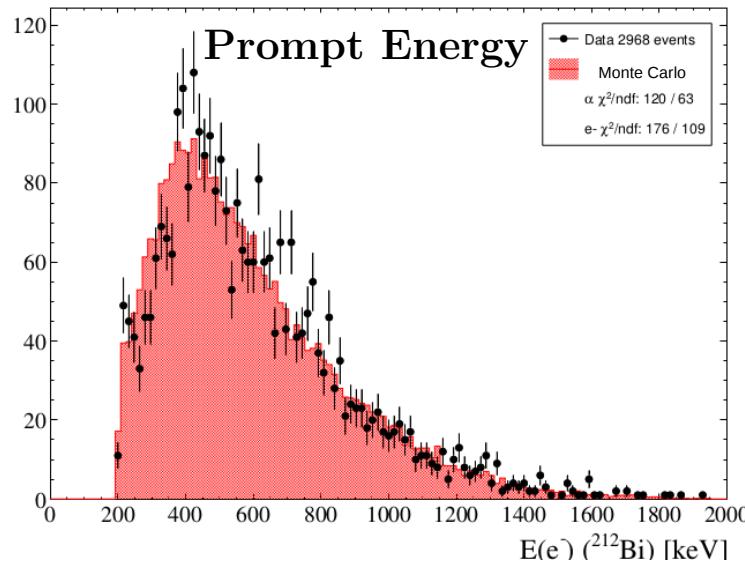
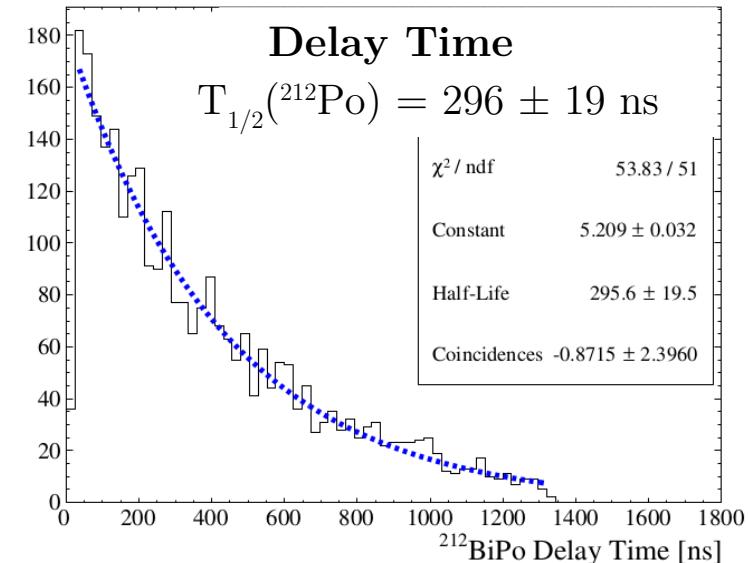


HPGe: $A(^{208}\text{Tl}) = 61 \pm 5$ (syst) mBq/kg

2968 $^{212}\text{BiPo}$ events in 24.1 days

Monte-Carlo: $\epsilon(^{212}\text{BiPo}) = 5.3$ %

\Rightarrow BiPo : $A(^{208}\text{Tl}) = 67 \pm 5$ (syst) mBq/kg



Validation of the BiPo-3 efficiency with a calibrated aluminium foil

Thickness = 85 μm , Mass = 224 g

$^{214}\text{Bi} - ^{214}\text{Po}$

HPGe: $A(^{214}\text{Bi}) = 13.2 \pm 2.6(\text{stat}) \pm 1.0(\text{syst}) \text{ mBq/kg}$

354 $^{214}\text{BiPo}$ events in 11.9 days

Monte-Carlo: $\epsilon(^{212}\text{BiPo}) = 3.3 \%$

$\Rightarrow \text{BiPo : } A(^{214}\text{Bi}) = 12.7 \pm 2.1(\text{syst}) \text{ mBq/kg}$

