SuperNEMO

Objectives

Status on the main R&D tasks

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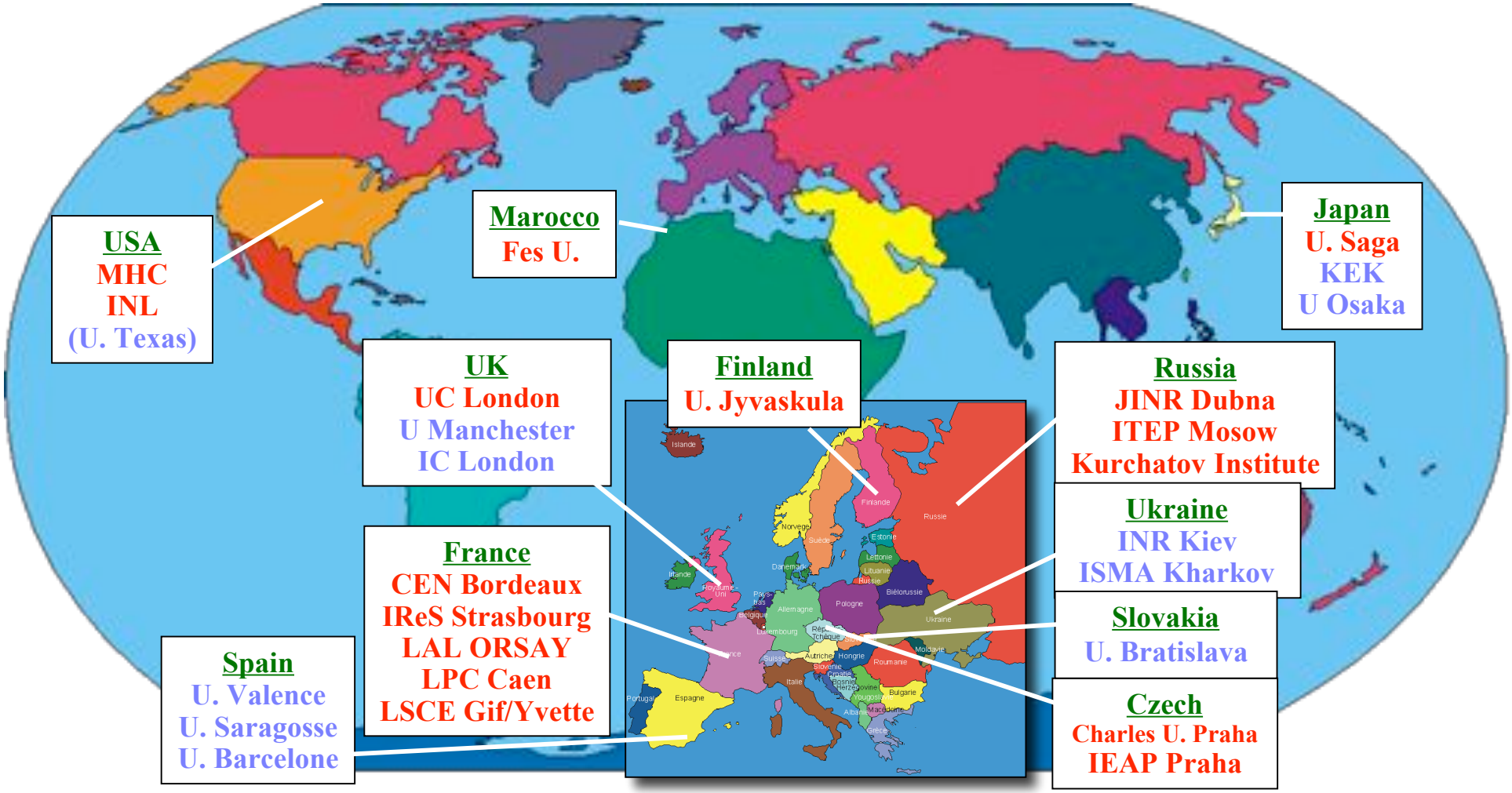
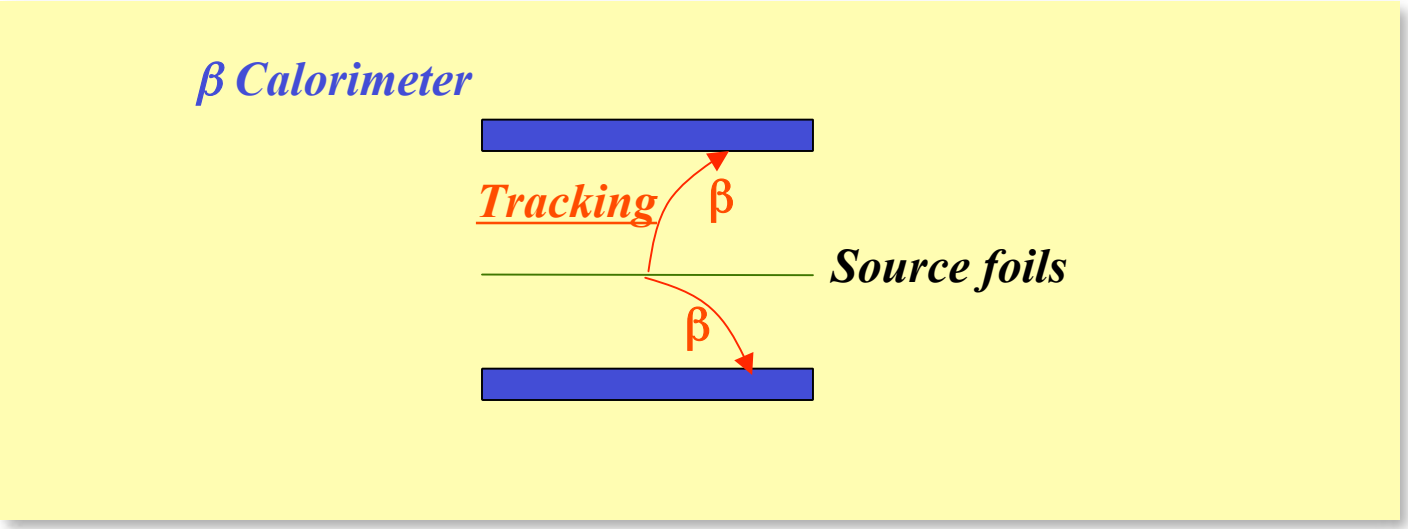
SuperNEMO project collaboration

NEMO3 collaboration + new labs ~ 60 physicists, 11 countries, 27 laboratories



SuperNEMO: A tracko-calo detector to reach $\langle m_\nu \rangle \leq 50$meV

Following NEMO3 technical choices and knowledge…:



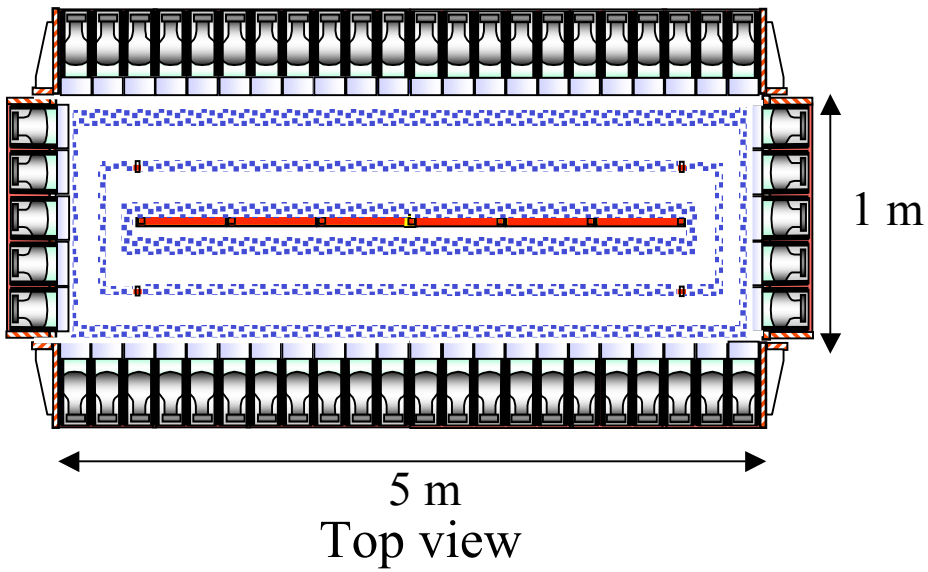
Advantages:

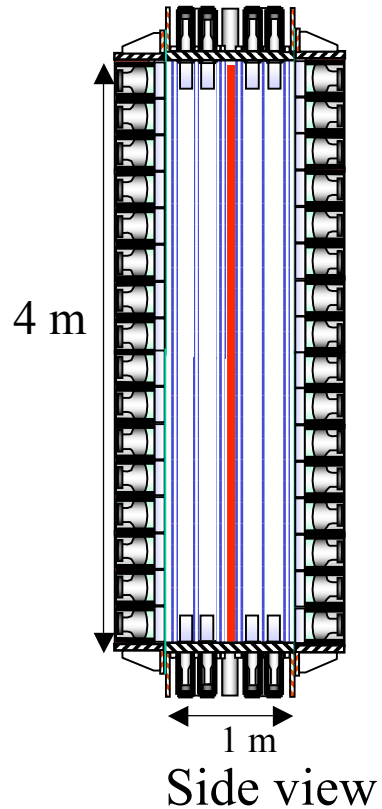
- **Direct signature of the 2 electrons**
- **3 observables: - total deposited energy**
  - individual energy
  - angular corelation
- **Possibility to measure various isotopes**

Possible SuperNEMO design

Planar and modular design: ~ 100 kg of enriched isotopes (20 modules × 5 kg)

1 module: Source (40 mg/cm^2) 4 x 3 m^2
Tracking : drift chamber ~3000 cells in Geiger mode
Calorimeter: scintillators + PM ~1 000 PM if scint. blocs
~ 100 PM if scint. bars





From NEMO3 to SuperNEMO… objectives

$$T_{1/2}(\beta\beta0\nu) > \ln 2 \times \frac{N_{avo}}{A} \times \frac{M \times \varepsilon \times T_{obs}}{N_{exclu}}$$

NEMO-3		SuperNEMO
^{100}Mo	Choice of isotope	^{150}Nd or ^{82}Se
7 kg	Isotope mass **M**	100-200 kg
8 %	Efficiency $\varepsilon(\beta\beta0\nu)$	~ 30 %
^{208}Tl < 20 μBq/kg ^{214}Bi < 300 μBq/kg	N_{exclu} = f(BKG) *Internal contaminations* *^{208}Tl and ^{214}Bi in the ββ foil*	^{208}Tl < 2 μBq/kg *(If ^{82}Se*: ^{214}Bi < 10 μBq/kg)
8% @3MeV	Energy resolution FWHM(calorimeter)	4% @3MeV
$T_{1/2}(\beta\beta0\nu) > 2.\ 10^{24}$ y $\langle m_\nu \rangle < 0.3 - 1.3$ eV	**SENSITIVITY**	$T_{1/2}(\beta\beta0\nu) > 10^{26}$ y $\langle m_\nu \rangle < 50$ meV

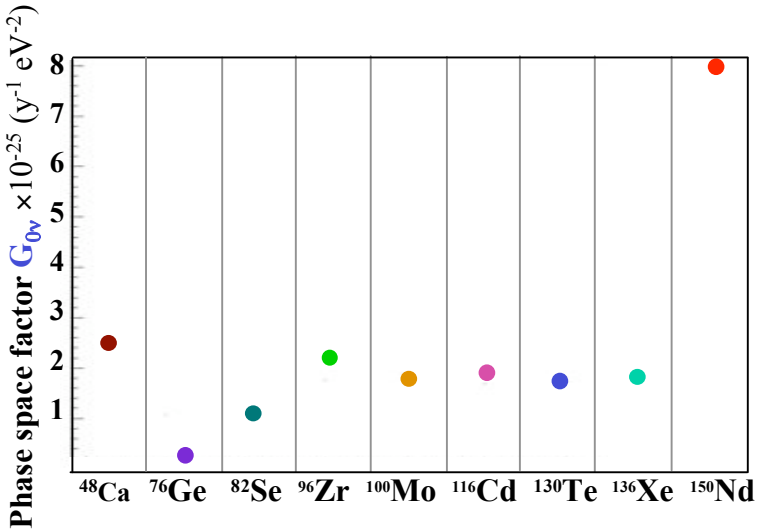
Main R&D tasks:

1) ββ source production **2) Radioprurity** **3) Energy resolution**

+ Tracking, Electronics, DAQ, Software, Mechanics, Theory

SuperNEMO ββ source: ^{150}Nd or ^{82}Se

	^{150}Nd	^{82}Se
	$Q_{\beta\beta}$=3.367 MeV	$Q_{\beta\beta}$=2.995 MeV
	$T_{2\nu}$= 10^{19} y	$T_{2\nu}$= 9 10^{19} y
Backgrounds		
• ββ2ν	0.22 evts /100kg.y	0.27 evts /100kg.y
• Contaminations in ββ sources: ^{214}Bi	<300 μBq/kg (=NEMO3)	<10 μBq/kg
• Contaminations in ββ sources: ^{208}Tl	< 2 μBq/kg	< 2 μBq/kg
Phase space factor $G_{0\nu}$		
$\frac{1}{T_{0\nu}} = G_{0\nu} M_{0\nu}^2 \langle m_\nu \rangle^2$	$G_{0\nu}$ = 8.0 10^{-25} y^{-1} eV^{-2}	$G_{0\nu}$ = 1.08 10^{-25} y^{-1} eV^{-2}



^{150}Nd

The best choice for :

- Phase space

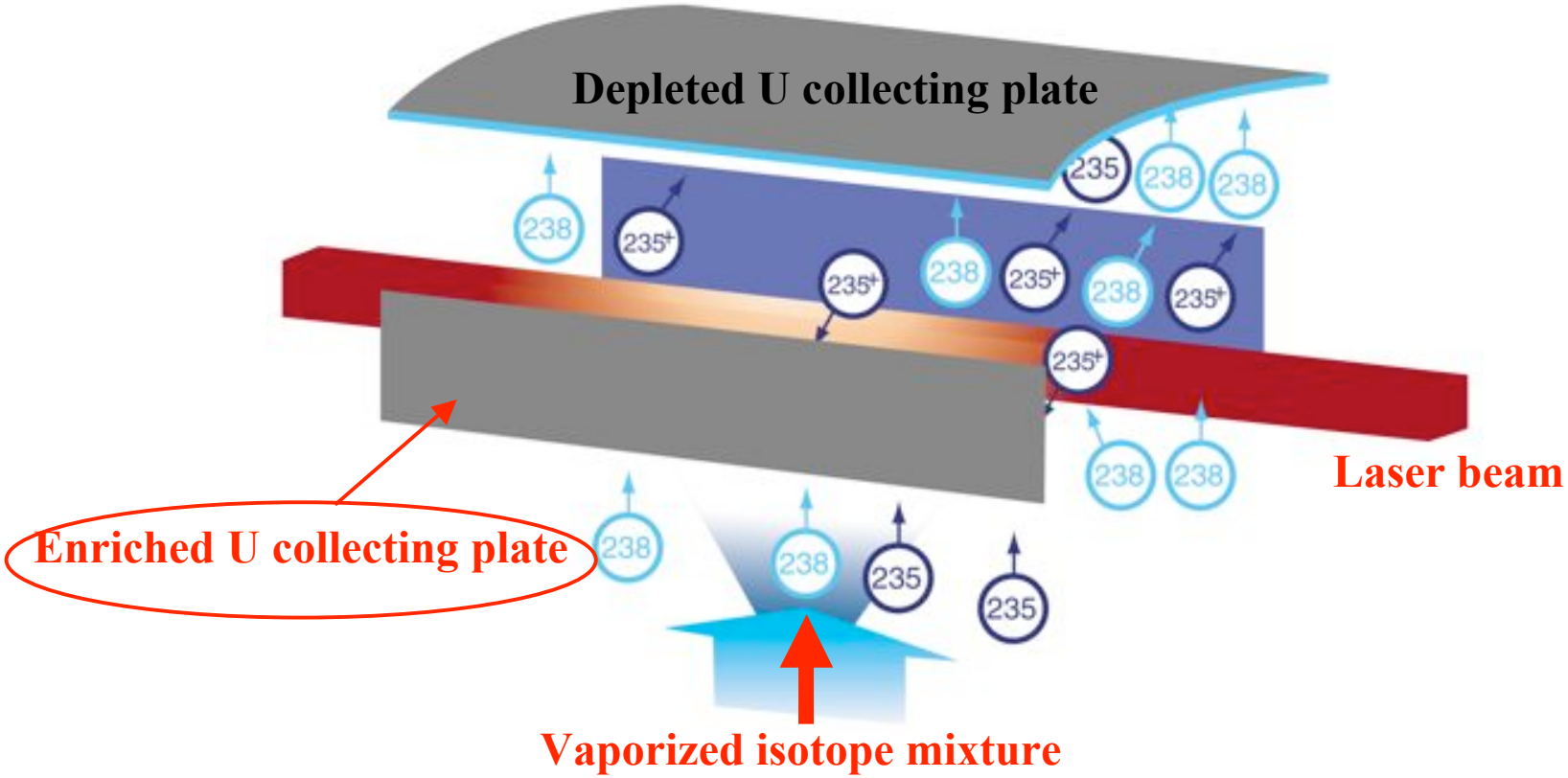
- Backgrounds

- and also.. SUSY ββ0ν, excited states ββ0ν

^{150}Nd production: The Laser Method (AVLIS)

AVLIS: Atomic Vapor Laser Isotope Separation

Selective photoionization based on :
isotope shifts in the atomic absorption optical spectra
U + 3 selective photons → $^{235}U^{+}$ + e^{-}



^{150}Nd production: possibility in France ?

2000-2003: R&D with MENPHIS demonstrator facility (CEA/Pierrelatte - France)

Main results for the process :

- **204 kg of enriched uranium at ≈ 2.5 % mean (predicted) value of enrichment**
- **Production raise: few kg/h for U**

~2000kg natural U evaporated
~400 assay measurements

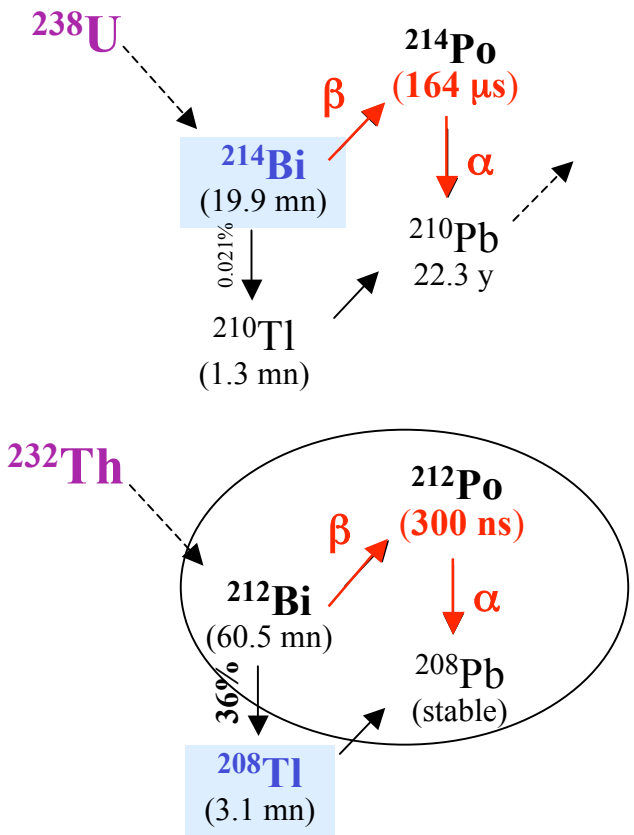
Restart MENPHIS… for ^{150}Nd ?

- **Technicaly possible:** **Nd has been already enriched at 60% ^{150}Nd**
- **Raisonable production raise:** **few weeks for 100 kg**
- **Several interested experiments:** **SuperNEMO, SNO+, MOON, DCBA** ***(Letter of Interest – July 2006)***

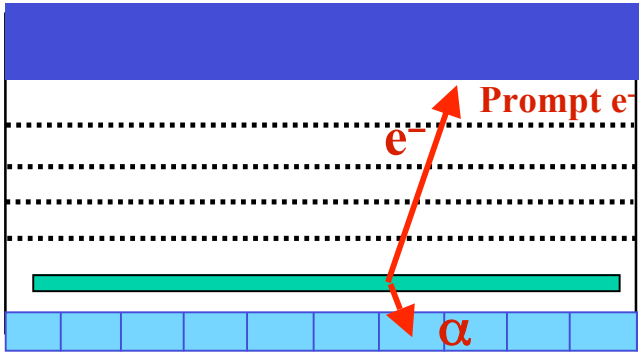
BiPo detector: Measurement of materials radiopurety

- **BiPo detector: a dedicated detector to measure:**
  - ^{208}Tl < 2 µBq/kg & ^{214}Bi < 10 µBq/kg
  - for 12m^2 thin foils = ββ foils just before introduction in SuperNEMO
  - 5 kg/month

- **Based on: Bi-Po effect :**



Q_β (^{212}Bi) = 2.2 MeV



e- calorimeter: Scintillators + PM

Tracking: wire chamber

Source foils to measure 12m^2

α calorimeter: Scintillators + PM

Delayed α

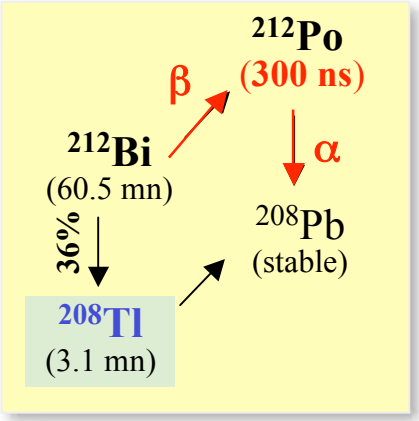
$T_{1/2}$ ~ 300 ns $E_{deposited}$ ~ 1 MeV

BiPo detector : an ultra low background detector

With **5 kg of ββ source foil** (~ 12 m^2, 40 mg/cm^2)

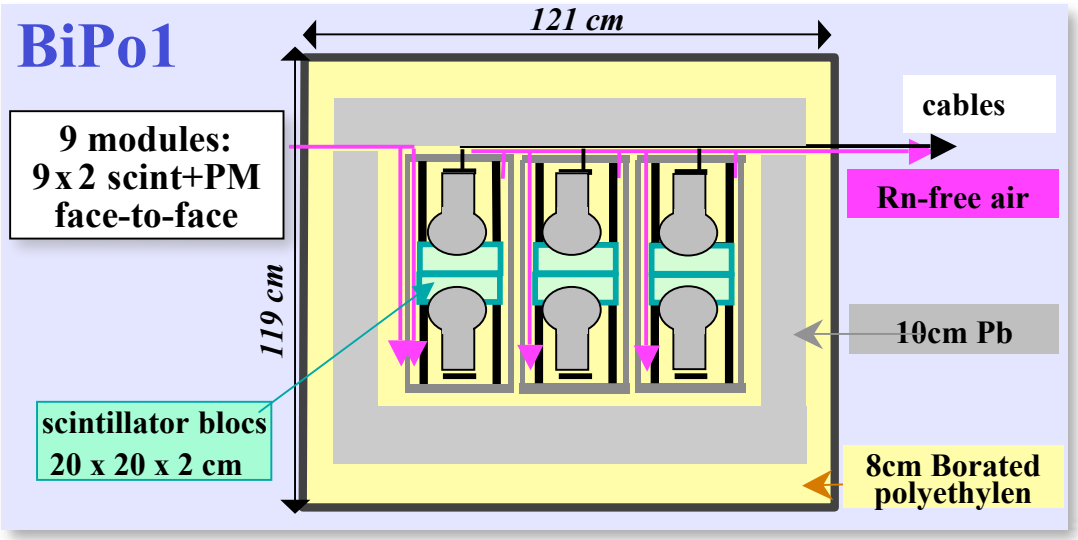
2 μBq/kg of ^{208}Tl ➡ 50 (e^-, delay α) ^{212}Bi decays / month

ε ~ 6 % ➡ **3 decays / month**

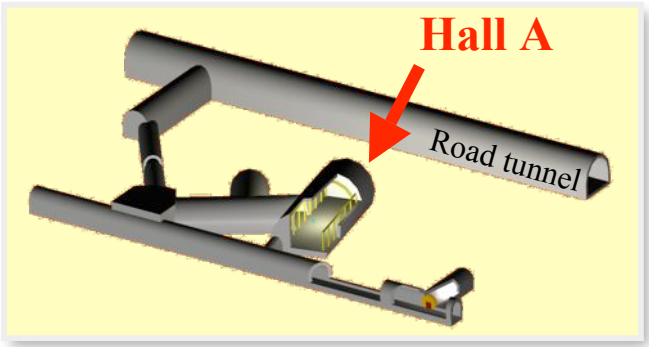


BiPo1 prototype:

Background measurement: - Random coincidence
- scintillator surface contamination in ^{212}Bi



Installed in October 2006
In LSC :Canfranc laboratory



Calorimeter R&D

R&D calorimeter :

- **to reach 4% (FWHM) at 3 MeV (7% at 1 MeV)**
- **Optimise the number of channels, the detector geometry…**

Tests realised with e- spectrometer

Scintillators

=> ligth yield, homogeneity

Plastic scintillators - Collaboration Karkhov, Dubna (PICS)
(Improvement Polystyrene, Dev. Polyvinylxylène ?)
Liquid scintillators
Wrappring tests : chimical treatement (karkhov)

Photomultipliers

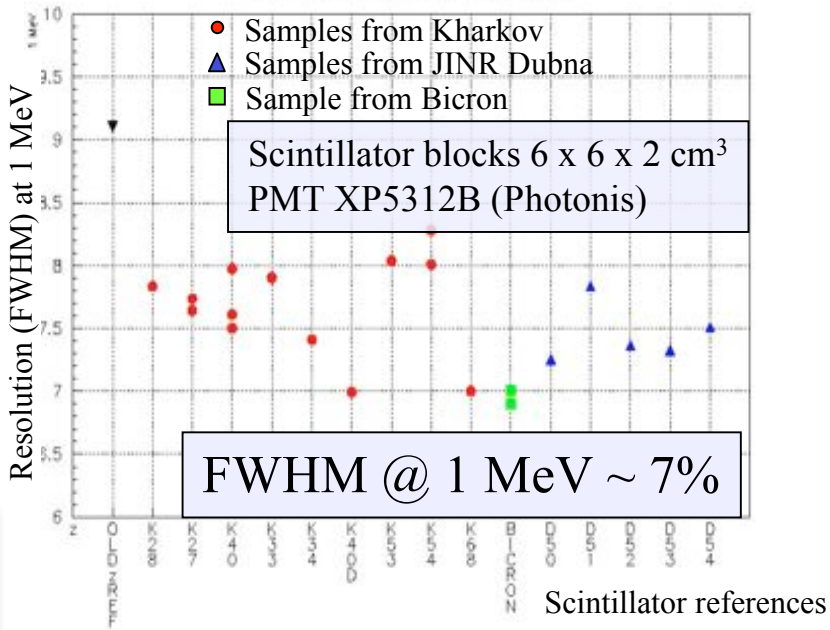
⇒ Quantum efficiency, collection efficiency
⇒ Low radioactivity

PHOTONIS/IN2P3 agreement
Tests with Hamamatsu and ETL PMT (US & UK)

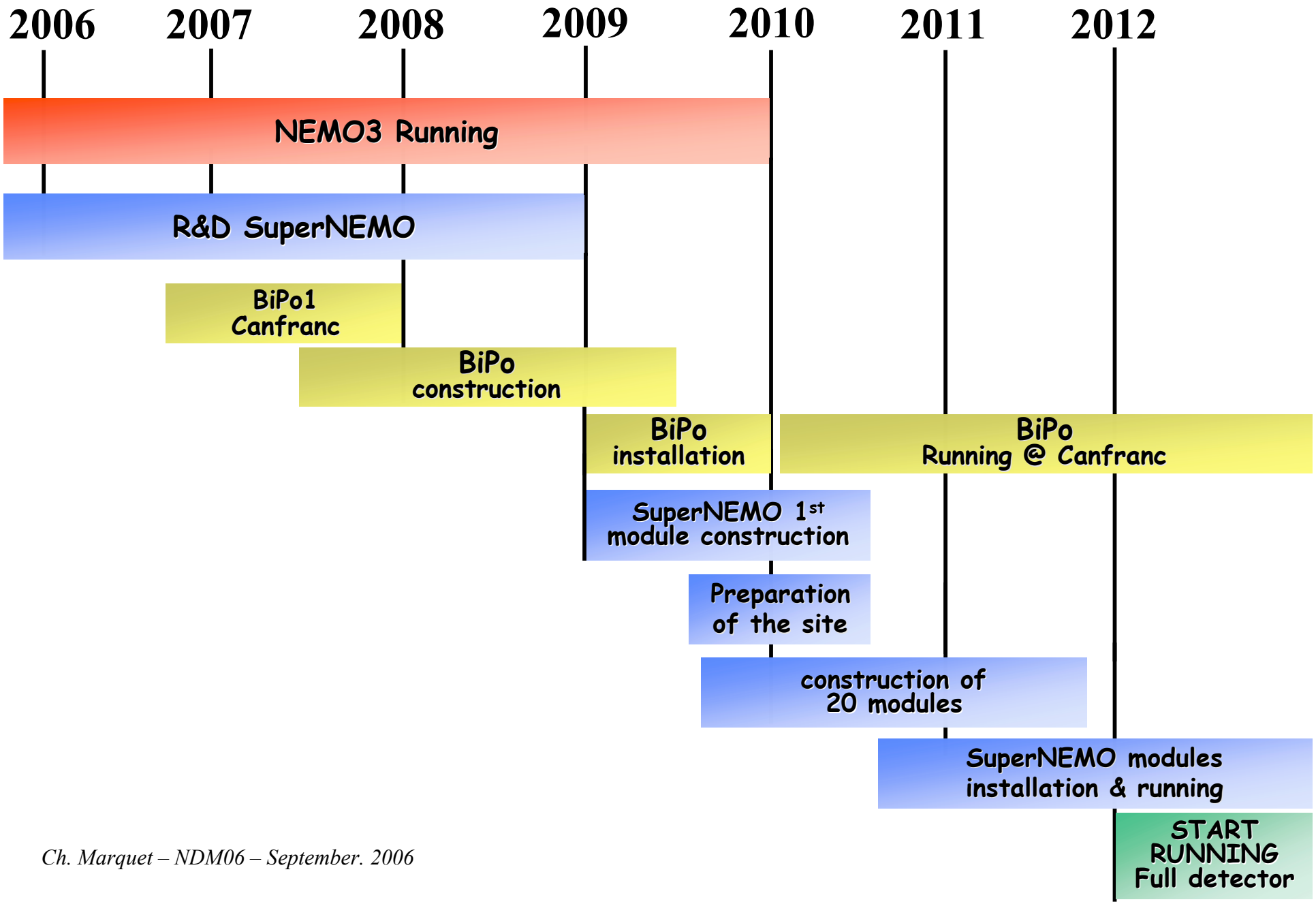
Geometry

=> Compacity +nb of channels + light collection

blocs shape
Separation e- calorimeter and γ tagging



Schedule summary



Summary

SuperNEMO project is the next-generation ββ0ν Tracko-Calo experiment with a sensitivity on $<m_\nu> \leq 50$meV

R&D has started 1 year ago (for 3 years):

- **- A possibility to produce large mass of ^{150}Nd ?**
  - ^{82}Se enrichment and purification in progress (funded by ILIAS)
- **- New detector "BiPo" to measure ^{214}Bi and ^{208}Tl ultra-low activities (prototype under construction – funded by ANR-France)**
- **- FWHM=4% (@3MeV) already reached for little size scintillators**
  - Agreements for R&D with PM and scintillator production factories

First SuperNEMO module could be running in 2010
Full detector could operate in 2012