Precision measurements in the β-decay of ^{6}He : Status of the b-STILED project

Romain Garreau[1], X. Fléchard[1], O. Naviliat-Cuncic[1,2,3], M. Kanafani[1], T.E Haugen[2], L. Hayen[1], S. Leblond[4], E.Liénard[1], X. Mougeot[4], Anjli Rani[1], J-C. Thomas[5], S. Vanlangendonck[6]

[1]Université de Caen Normandie, ENSICAEN, CNRS/IN2P3, LPC Caen, 14000 Caen, France
[2]Facility for Rare Isotope Beams and Department of Physics and Astronomy, Michigan State University, East Lansing 48824 MI, USA
[3]International Research Laboratory Nuclear Physics and Nuclear Astrophysics, CNRS-MSU, East Lansing 48824 MI, USA
[4]Université Paris-Saclay, CEA, List, Laboratoire National Henri Becquerel (LNE-LNHB), 91120 Palaiseau, France
[5]GANIL, CEA/DRF-CNRS/IN2P3, Bd Henri Becquerel, 14076 Caen, France
[6]KU Leuven, Instituut voor Kern - en Stralingsfysica, Celestijnenlaan 200D, B-3001 Leuven, Belgium

Context and experimental setup

Test **Standard Model of particle physics** (SM) to search for **new physics** using β energy spectrum shape

$$N(E) \propto F(Z,E)(1+\eta)pE(E-E_0)^2\left(1+\frac{m_e}{E}b_{GT}\right)$$

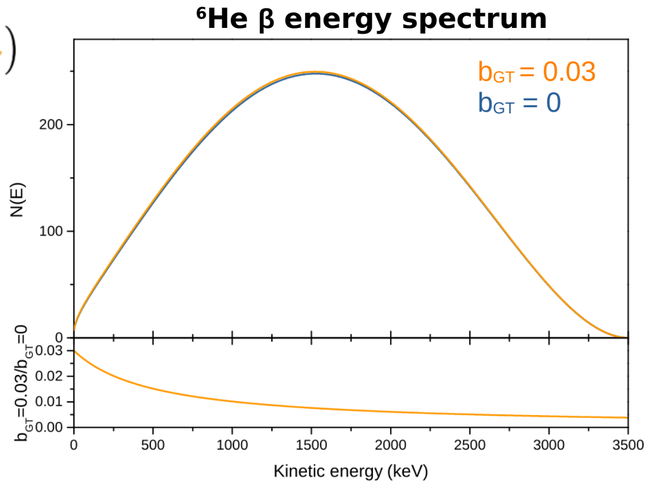
Fermi function — Theoretical corrections — Phase space

E : Total energy
E₀ : Endpoint energy

- **Fierz interference term** extraction from a clean spectrum of **^{6}He**

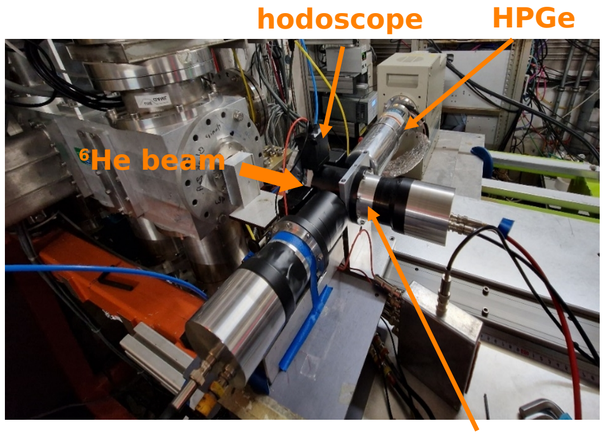
-**$b_{GT} \neq 0$**, (exotic interactions)

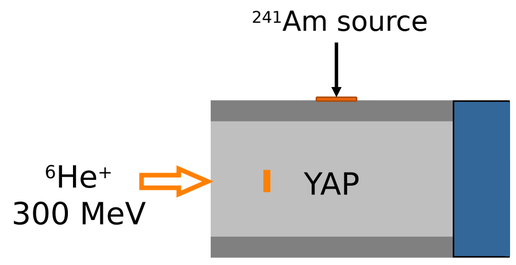
^{6}He β energy spectrum



Precision goal : **$\Delta b_{GT} = 4\times10^{-3}$**

Implantation of **^{6}He** beam in **4π geometry** at **300 MeV**



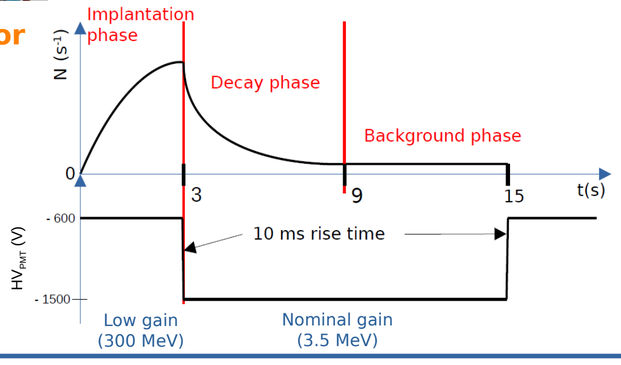


→ eliminate backscattering losses
→ almost full energy deposition (bremmstrahlung losses)

Measurement cycle :

Beam switched On/Off

PMT voltage low/high
→ Access implantation energy



Contamination Study : Estimate of systematic effect

Direct implantation may induce presence of **contamination** that can **influence** the **shape** of the energy spectrum

→ Can be a **limitating effect** we need to take into account

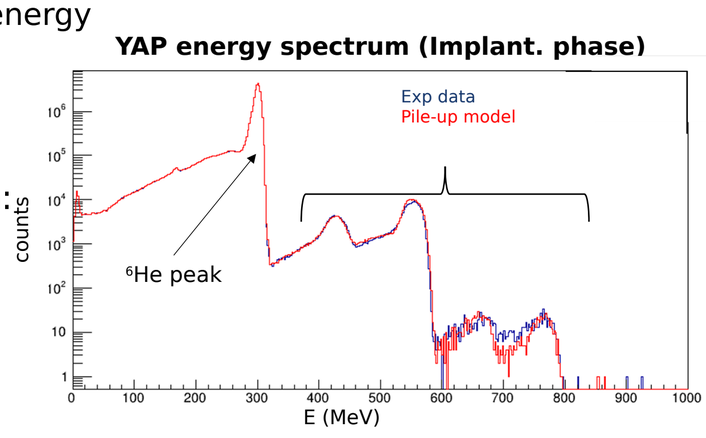
Contamination → **2 origins:** Impurities & induced contaminants

1.Beam impurities:

Potential contamination in the beam
↳ Should appear at same energy per nucleon

Comparison with simulation:
-Pure ^{6}He
-Beam time structure
-Aquisition characteristics

YAP energy spectrum (Implant. phase)



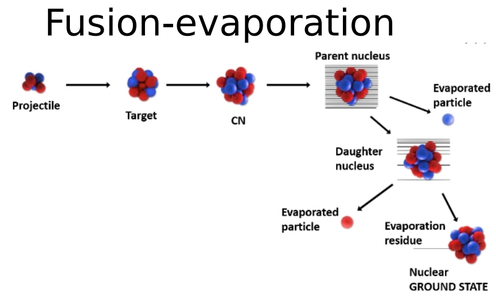
No visible contaminant (> 0,001 %)

2.Beam induced contaminants:

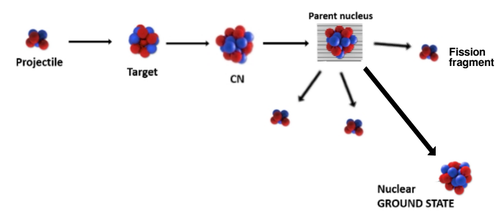
High energy beam (~50 Mev/n) → Nuclear reactions

2 Processes

Fusion-evaporation



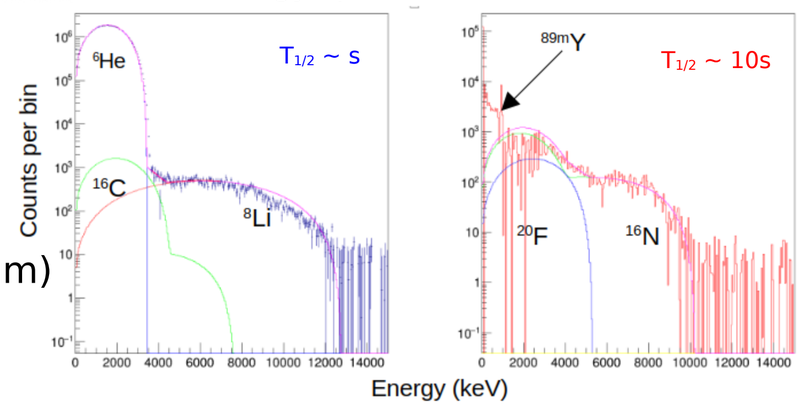
Multi-fragmentation



Beta energy spectra with half life selection

Identification with :

→ **endpoint**
→ **half-life**
→ **γ ray emission**
(HPGe energy spectrum)



Estimate using theoretical spectra and half-life selection

• **Results:**

Isotope	$T_{1/2}$ (s)	$E_{\beta max}$ (MeV)	Intensity (%)
^{8}Li	0.84	12.97	~0.07
^{16}C	0.747	4.66	~0.12
^{16}N	7.13	10.42	~0.20
^{20}F	11.163	7.02	~0.04
^{89M}Y	15.66	E_γ = 0.909	~0.14

Assuming **20 %** uncertainty ➡ $\Delta b_{GT\,(Cont)} \approx 10^{-3}$

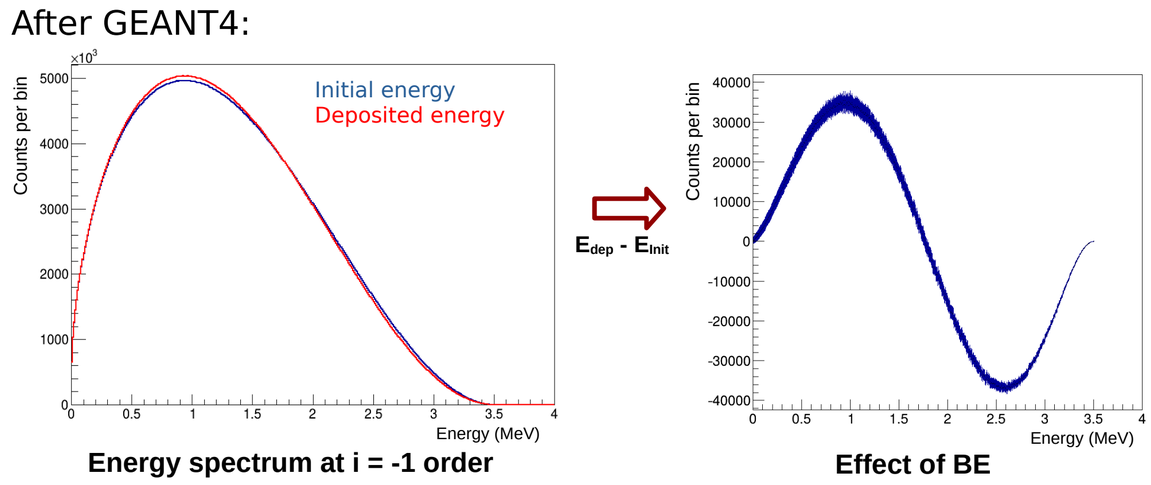
Simulation and Outlook

Bremsstrahlung Escape (BE) simulation:
- **Loss of energy** from Bremstrahlung photons
↳ **Simulation** to estimate the effect

Beta energy spectrum expressed as: $N(E)=F(Z,E)pE(E-E_0)^2\cdot\sum_{i=-1}^{1}E^i$

Generating events : $g_i=F(Z,E)pE(E-E_0)^2\cdot E^i$

After GEANT4:



Energy spectrum at i = -1 order — **Effect of BE**

Deducing BE **function** f_i (**Linear interpolation**)

Outlook:

Fit of data using the following **model:**

$$F(E)=N\sum_{i=-1}^{1}\alpha_i[g_i(E)+f_i(E)]$$

α_i : equations containing theoretical corrections and physical parameters ($b_{GT} \propto \alpha_{-1}$)

Influence of **contaminants** will be **included**