The MetroBeta Project

(2016 – 2019)

Mark A. Kellett

MetroBeta Workshop, NIST, 14 September 2018

The MetroBeta Project :: Introduction

This project takes both theoretical and experimental approaches to improving the knowledge of beta spectra.

Theory:

- **the calculation of nuclear wave functions is being included to account for the nuclear structure effect on the beta spectra.**

Experimental development of:

- **metallic magnetic calorimeters (MMCs), a class of cryogenic detectors operating at very low temperature (~few mK),**
- **solid scintillators containing the beta emitters in the structure of the scintillator crystal,**
- **magnetic beta spectrometer.**

Comparison of the calculated and measured spectra, as well as the application of conventional detection techniques, i.e. Si(Li) detectors, will validate the quality of the spectra.

The effect of this improved knowledge of beta spectra on the absolute measurement of the activity (the becquerel) of beta emitting radionuclides will be determined.

The MetroBeta Project :: Overview

Short Name	Organisation legal full name	Country
CEA	Commissariat à l'énergie atomique et aux énergies alternatives	France
CMI	Cesky Metrologicky Institut Brno	Czech Republic
PTB	Physikalisch-Technische Bundesanstalt	Germany
Gonitec	Gonitec BV	Netherlands
UHEI	Ruprecht-Karls-Universitaet Heidelberg	Germany
UMCS	Uniwersytet Marii Curie-Sklodowskiej	Poland
CHUV	University Hospital of Lausanne	Switzerland

http://metrobeta-empir.eu/

WP No	Work Package Title	Active Partners
WP1	Theoretical calculations of beta spectra	CEA; UMCS
WP2	High-resolution beta spectrometry based on Metallic Magnetic Calorimeters (MMCs)	PTB; CEA; UHEI
WP3	Measurements of beta spectra with other methods	CHUV; CMI; Gonitec
WP4	Comparison and validation of measurements	PTB; CEA; CHUV
WP5	Creating impact	CMI; all partners
WP6	Management and coordination	CEA; all partners

The MetroBeta Project :: Objectives

- **Five Objectives**

1. **To improve modern measurement techniques for silicon detectors (Si(Li)), solid scintillator crystals ($LaBr_3$/$CeBr_3$) and magnetic spectrometers for the measurement of beta spectra. (WP3)**
2. **To optimise Metallic Magnetic Calorimeters (MMCs) and measure new high resolution beta spectra for low (<100 keV) and intermediate (<1 MeV) end-point energy pure beta emitters Sm-151, C-14, Tc-99 and Cl-36. (WP2)**
3. **To improve theoretical computation methods and compare the measured and calculated beta spectra. (WP1 and WP4)**
4. **To investigate the effect of improved beta spectra on absolute activity measurements (the becquerel) and measure Bremsstrahlung cross-sections to quantify their effect. (WP4)**
5. **To facilitate the take up of the technology and measurement infrastructure developed by the project by the measurement supply chain (accredited laboratories, instrumentation manufacturers) and end users (the nuclear medicine community and the nuclear power industry). (WP5)**

The MetroBeta Project :: Theory

- **CEA has produced a first version of a code, BetaShape, for the calculation of theoretical shape factors with a simplified analytical model to determine the nucleon wave functions.**
- **UMCS have solved the problem of stabilisation of the Woods-Saxon Universal parameterisation of the nuclear mean-field Hamiltonian.**
- **UMCS has worked on the uncertainty associated with the nuclear structure modelling and on dealing with nuclear deformation.**

The MetroBeta Project :: Conventional Detectors

- **CMI, using the Si(Li) detector with a specially designed and purpose-built collimator, has measured beta spectra for Sr-89, Sr-90, Y-90, Pm-147 and Tl-204, and also mixed spectra of Y-90 and Sr-90 with varying compositions.**

- **Gonitec advanced with the measurements with solid scintillator crystals. Ongoing for the long-lived Lu-176 and additional work to measure the beta spectrum of Rb-87 has been completed and the end-point value is consistent with the atomic mass evaluation.**

- **CHUV is commissioning a magnetic spectrometer. New sources for the energy and efficiency calibration have been produced. The acquisition chain has been optimised allowing measurement down to 20 keV.**

The MetroBeta Project :: Metallic Magnetic Calorimeters

- **PTB has commissioned their new cryogenic system and achieved a stable 7mK.**
- **Fabrication of the new detector module at PTB has been finalised. Reliable mounting of MMC- and SQUID chips as well as electrical connections and heat sinking have been tested. The first test cooldown to mK temperatures of the detector module was successfully performed.**
- **UHEI produced two MMC detector wafers, and detector chips have been electrically tested at room-temperature and 4.2K. Cryogenic electrical functionality characterisation of the detectors has been performed at PTB and CEA.**
- **CEA has started with the preparation of nanocomposite gold absorbers. A gold nanofoam with pore sizes sufficiently small for nano-constrained crystallisation seems to be feasible. Tests of the absorption of carrier solutions into the nanofoam are in progress.**
- **CEA has continued testing source/absorber production techniques, to ensure optimised MMCs are available. C-14, Tc-99 and Sm-151 have been measured.**

The MetroBeta Project :: Activity Measurements

- **PTB investigated with LSC the theoretically calculated spectra. Impressive results on Co-60 were obtained and presented at the ICRM 2017 conference (May 2017) and an article is in press.**

The MetroBeta Project :: Summary

The main outcomes of this project will be the following:

- **A new theoretical model describing the shape of beta spectra and its implementation in a freely distributed code**
- **Access to improved beta spectra for the metrology and wider stakeholder community, and their use in international absolute activity comparisons**
- **The uptake of project results into applications libraries used by the nuclear power industry, nuclear medicine, etc.**
- **Better assessments of patient doses due to the improved measurement chain due to improved beta spectra**
- **Knowledge transfer to developing NMIs and laboratories in the use of experimental techniques owing to the availability of Good Practice Guides**

The project will be a success if the stakeholders opt to embrace the above outcomes.

Thank you for your attention

Commissariat à l'énergie atomique et aux énergies alternatives
Institut List | CEA SACLAY NANO-INNOV | BAT. 861 – PC142
91191 Gif-sur-Yvette Cedex - FRANCE
www-list.cea.fr

Établissement public à caractère industriel et commercial | RCS Paris B 775 685 019