Coordinator's Report
Beta-Particle Spectrometry Working Group

Background

The Beta Particle Spectrometry Working Group is devoted to the development of the metrological aspects of beta spectrometry and its applications. This includes:

- Theory. Beta ($\beta^{\pm}$) and electron capture (ε) transitions; Theoretical shape factors and influence of the nuclear current; Atomic effects.
- Experiments. Instrumentations used for beta spectrometry; Techniques that need beta information; Confidence on experimental shape factors; Data analysis and unfolding methods.
- Simulations. Confidence on the physical processes: low energies, radioactive decays, atomic rearrangements; Comparison of the results of different codes.
- Evaluations. Confidence and uncertainties on experimental shape factors; Procedure for establishing recommended shape factors; Mean energies, log *ft* values, database.

Interested communities in radionuclide metrology are: nuclear decay data, liquid scintillation counting, ionising chambers, 4π β-γ counting.

Recent and on-going activities

- A dedicated website was created in 2016 and can be found at the following address: http://www.lnhb.fr/icrm_bs_wg/. The recent developments of LNHB website have led to some technical delays. The Working Group section is expected to be updated by the end of 2019, together with other related improvements.

- Theory

  i) Further developments of calculations of electron capture decays. Precise atomic energies and radiative corrections have been demonstrated to be of high importance for accurate theoretical predictions.

  ii) Inclusion of the nuclear structure in beta decay calculation has been conducted through the determination of single particle nuclear matrix elements. Formalism has been explicitly extended to electron captures.

  iii) A new version of the BetaShape code is expected to be released in June 2019. This version will include improvements in the calculation of radiative corrections for beta decays and an update of the database of experimental shape factors. In addition, calculation of electron capture decays will be included, with provision of capture probabilities and capture-to-positron probabilities for all subshells, log(ft) values and splitting of the branch between capture and beta plus transitions. This new version will be made available for the community at the same address: http://www.lnhb.fr/activites-recherche-developpement/logiciels-traitement-spectres/

- Simulation

  i) A decay module for Geant4 has been developed at LNHB, in the same spirit as the PenNuc module developed by CIEMAT with support from LNHB, but with improvements such as a coupling with the BetaShape code. This module was

presented at the ICRM 2019 conference (May 27-31, 2019) and will be made available for the community.

ii) An unfolding algorithm has been developed at PTB based on Monte Carlo simulations (EGSnrc). The purpose is to correct a ^{36}Cl spectrum measured with a metallic magnetic calorimeter for the distortion due to the escape of bremsstrahlung photons. A similar algorithm has been developed at LNHB using Geant4 and Penelope simulations and applied to beta spectra measured with silicon detectors.

- Measurements

  i) Beta spectra of ^{14}C, ^{36}Cl, ^{99}Tc and ^{151}Sm decays have been measured with metallic magnetic calorimeters at LNHB and PTB.

  ii) Beta spectra of ^{87}Rb and ^{176}Lu decays have been measured with solid scintillator crystals at TU Delft (Gonitec).

  iii) A magnetic spectrometer has been developed at IRA (CHUV) dedicated to beta spectrometry and beta spectra of ^{36}Cl, ^{60}Co, ^{99}Tc and ^{134}Cs decays have been measured.

  iv) A detection system based on silicon detectors in a quasi-4π configuration is being developed at LNHB and preliminary beta spectra of ^{14}C, ^{36}Cl and ^{99}Tc decays have been measured.

- Evaluations

  The BetaShape program is the reference code for DDEP evaluations. A database of published experimental shape factors, as comprehensive as possible, is being developed and will be made available on the Working Group website.

Related projects

- European metrology project (EURAMET, EMPIR programme) MetroBeta 15SIB10, 2016-2019. Website: http://metrobeta-empir.eu/. Partners are from Czech Republic, France, Germany, Netherlands, Poland and Switzerland.

  Summary. The MetroBeta project is taking both theoretical and experimental approaches to improving the knowledge of beta spectra. On the theoretical side, existing knowledge of the calculation of nuclear wave functions is being used to take into account the nuclear structure effect on these spectra. On the experimental side, beta spectrometry with MMCs is being developed, as well as solid scintillators containing the beta emitters in the structure of the scintillator crystal. Comparison of the newly calculated and measured spectra will validate the quality of the spectra.

- European metrology project (EURAMET, EMPIR programme) MetroMMC 17FUN02, 2018-2021. Website: http://empir.npl.co.uk/metrommc/. Partners are from France, Germany, Portugal, South Korea and United Kingdom.

  Summary. The main objective of the MetroMMC project is to improve the knowledge of electron capture decay and subsequent atomic relaxation processes. New theoretical calculation techniques and extensive experiments using MMCs will be developed to determine important decay data which are relevant for primary activity standardisations in radionuclide metrology, in cancer therapy on the DNA level, and when studying the

early history of the solar system. The experimental parts will be complemented with a new approach based on microwave coupled resonators.

Recent and future meetings

- Joint radionuclide metrology meetings took place at NIST (September 10-14, 2018):

  i) Decay Data Evaluation Project (September 10-11, 2018)

  ii) Nuclear Decay Data Working Group (September 11, 2018)

  iii) Beta-Particle Spectrometry Working Group (September 11, 2018)

  iv) Radionuclide Metrology Technique Working Group (September 12, 2018)

  v) NIST - BIPM Workshop on low electrical current measurement for radioactivity metrology (September 13, 2018)

  vi) MetroBeta Workshop (September 14, 2018)

- A Working Group meeting took place in Salamanca during the ICRM 2019 conference (May 27-31, 2017). Four presentations were given:

  i) M. A. Kellett (LNHB), Overview of the MetroBeta Project

  ii) K. Kossert (PTB), Comparison and validation of beta spectra measurements

  iii) X. Mougeot (LNHB), How to include nuclear structure in beta decay calculations

  iv) D. Arnold (PTB), Overview of the MetroMMC project

- The next Working Group meeting will take place alongside the next DDEP workshop and the ICRM Nuclear Decay Data Working Group meeting.

On behalf of the Beta-Particle Spectrometry Working Group,

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