

Beta Spectrometry Working Group

http://www.nucleide.org/ICRM_BSWG.htm





NPL 2016 | Xavier Mougeot





- General considerations
- Projects
- Theory
- Measurements & Simulations
- Evaluation & Dissemination
- Outlook







General considerations





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History

ICRM Working Groups website

Update on http://physics.nist.gov/ICRM/working_groups.html

ICRM Working Groups

ICRM activities are largely the responsibility of its working groups. Each group is guided by a coordinator who acts as a centre for ideas and communications a interest and assigned coordinators:

- <u>Alpha-Particle Spectrometry</u>: S. Pommé, European Commission, Joint Research Centre (EC-JRC), Institute for Reference Materials and Measurements (I e-mail: <u>stefaan.pomme@ec.europa.eu</u>
- <u>Beta-Particle Spectrometry</u>: X. Mougeot, Laboratoire National Henri Becquerel (LNE-LNHB), CEA-Saclay, F-91191 Gif-sur-Yvette Cedex, France, e-mail: <u>xavier.mougeot@cea.fr</u>
- <u>Gamma-Ray Spectrometry</u>: O. Sima, University of Bucharest, Faculty of Physics, 425 Atomistilor Str. RO-077125, Bucharest-Magurele, Romania, e-mail: <u>Octavian.Sima@partner.kit.edu</u>
- Liquid Scintillation Counting: K. Kossert, Physikalisch-Technische Bundesanstalt (PTB), Bundesalle 100, D-38116 Braunschweig, Germany,
 a mail: karsten kossert@inth.de

Beta Particle Spectrometry Working Group

This Working Group is devoted to the development of the metrological aspects of beta-particle spectrometry and its applications. This includes, but is not restricted to:

- Theory
 - Beta (β±) 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: Geant4, Penelope, etc.
- Evaluations and dissemination
 - Confidence and uncertainties on experimental shape factors
 - Evaluation procedure for establishing recommended experimental shape factors
 - Mean energies, log ft values, database

Other suggested topics are welcome.





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Dedicated website

http://www.nucleide.org/ICRM_BSWG.htm





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Dedicated website

Summary of interests

International Committee for Radionuclide Metrology (I.C.R.M.) Beta Particle Spectrometry Working Group

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Theory

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Experiments

- Instrumentations used for beta spectrometry
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Interested communities in radionuclide metrology are: nuclear decay data, liquid scintillation counting, ionizing chambers, 4π β-γ counting,

Any experimental shape factor found in the literature can be sent to the coordinator who will keep up-to-date a dedicated database.

Any other suggested topic is welcome. If you want to participate to this working group, please E-mail your contribution to the coordinator: xavier.mougeot@cea.fr







Projects

EMPIR Project MetroBeta "Radionuclide beta spectra metrology" (2016 - 2019)

This project proposes both theoretical and experimental approaches to improve the knowledge of beta spectra. On the theoretical side, the existing knowledge of the calculation of development of beta spectrometry with metallic magnetic calorimeters, a class of cryogenic detectors operating at very low temperature, and solid scintillators containing the beta with unprecedented precision and, in particular in the case of metallic magnetic calorimeters, low systematic errors. Comparison of the newly calculated and measured spectra, as

Coordinator: Mark A. Kellett (mark.kellett@cea.fr)

Website: http://metrobeta-empir.eu/

Meetings

MetroMRT Workshop - Paris, France, 21st-22nd May 2014. Website: http://projects.npl.co.uk/metromrt/

ICRM 2015, 20th International Conference on Radionuclide Metrology and its Applications - Vienna, Austria, 8th-11th June 2015. First meeting of the Beta Particle Spectrometry Working Group.

Kick-off meeting of MetroBeta - Saclay, France, 5th-6th July 2016.

6th Decay Data Evaluation Project Workshop and ICRM Working Group meetings - National Physical Laboratory, Teddington, UK, 19th – 22th September 2016.







Software

BetaShape

The BetaShape program has been developed for improving the nuclear data related to beta emission properties. The theoretical model was implemented with analytical calcuvatures as well as beta and neutrino spectra for single and multiple transitions are provided. A database of experimental shape factors is also included and the uncertainties f

Link: http://www.nucleide.org/logiciels.htm

Working Group reports

Annual reports of the Working Group are available here:

- 2014: ICRM_BetaWG_Report_2014.pdf
- 2015: ICRM_BetaWG_Report_2015.pdf

Scientific publications

Relevant articles, books and reports for beta spectrometry and its applications will be listed here after agreement of the members of the Working Group.

Any other relevant topic?







Projects





The MetroBeta EMPIR project

http://metrobeta-empir.eu/



This project proposes both theoretical and experimental approaches to improve the knowledge of beta spectra. On the theoretical side, we will use the existing knowledge of the calculation of nuclear wave functions to account for the nuclear structure effect on these spectra. On the experimental side, we propose the development of beta spectrometry with metallic magnetic calorimeters (MMCs), a class of cryogenic detectors operating at very low temperature, and solid scintillators containing the beta emitters in the structure of the scintillator crystal. These detectors have the potential to measure the shapes of beta spectra with unprecedented precision and, in particular in the case of metallic magnetic calorimeters, low systematic errors. Comparison of the newly calculated and measured spectra, as well as the application of several complementary detection techniques, will validate the quality of the spectra.



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Work packages

- WP1: Theoretical calculations of beta spectra
- WP2: High-resolution beta spectrometry based on Metallic Magnetic Calorimeters
- WP3: Measurements of beta spectra with other methods
- WP4: Comparison and validation of measurements
- WP5: Creating Impact

LNHB is highly involved, together with PTB, CMI, IRA, UHEI, UMCS, Gonitec

- Coordination of the project (Mark A. Kellett)
- Coordination of WP1 (X. Mougeot)
- Scientific work scheduled in WP1, WP2, WP4, WP5

Would you like to mention any other project related to this Working Group?







Theory







Today and tomorrow

Beta (β^{\pm}) transitions

First release of the BetaShape program. Improved calculations of β emission properties (mean energies, log*ft* values) compared to the LogFT program. Beta and neutrino spectra are provided. A database of experimental shape factors is included.

Electron capture (ε) transitions

Not included in BetaShape. Improved calculations on going based on bound wave functions determined for the atomic exchange effect in β transition. Preliminary results for ¹³⁸La (see ICRM 2015) seem very promising. Expected for ICRM 2017.

Atomic effects

- Screening and exchange effects are calculated for allowed β transitions.
- Overlap, exchange, shake-up and shake-off effects are considered for allowed and forbidden unique ϵ transitions.

Influence of the nuclear current

The nuclear current will be included in β calculations for allowed and forbidden unique transitions within the EMPIR MetroBeta project.

Does anyone would like to participate?







- The physics modelling has already been detailed on Tuesday morning during the DDEP meeting. Any question?
- Short examples: Bi-214 decays and A=46 mass chain
- In practice: running BetaShape on your own computer







Measurements & Simulation





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Previous work at LNHB

PhD thesis of Charlène Bisch

defended 26 September 2014

















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Previous work at LNHB: ⁹⁹Tc









Previous work at LNHB: unfolding



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Previous work at LNHB: unfolding





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Previous work at LNHB: unfolding

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Future apparatus at LNHB

PIPS Xray Liquid nitrogen 17 cm Thin source Pump Gauge This detection system will be developed by a PhD student who should Autoradiography start in 2017. 4π geometry + coincidences \rightarrow minimization of distortion **Expected great decrease Expected energy** of uncertainties threshold at 5 keV



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- Techniques for new beta measurements
- Source preparation techniques
- Data analysis and unfolding methods
- A decay module for Penelope has been developed (PenNuc). A Geant4 module, better than the existing one and using DDEP data would be very useful. LNHB plans to do it. Is anyone interested in?
- Comparison of results from Penelope and Geant4 (and other Monte Carlo codes?) for a specific detection geometry.
- List of the most relevant radionuclides for metrological applications and for end-users. In MetroBeta: ¹⁴C, ³⁶CI, ⁹⁹Tc, ¹⁵¹Sm.







Evaluation & Dissemination







- Maybe as a simple online table at the beginning.
- Database can be hold at LNHB.
- Collection of all measured beta spectra, all experimental shape factors.
- Published results should be preferred for their traceability and the description of the experiments.
- Only single transitions? What about cumulative beta spectra following a decay?
- Next question is obvious: should this WG recommend beta spectra or shape factors for users?







Recommended spectra

- This task is clearly not trivial.
- An evaluation process has to be established, in close relation with the Nuclear Decay Data Working Group.
- Many difficulties will occur:
 - Different definitions of the Fermi function
 - Different methods for establishing the experimental shape factors
 - How to define and manage the uncertainties?
 - Influence of the endpoint energy
 - Influence of the experimental analysis (source thickness, unfolding process, etc.)
- This study will be useful to establish a strong process for measurements and analysis of beta spectra.
- Dissemination: β spectra for single transitions, total spectra, ASCII files, online access, etc.







Outlook







- Next meeting could be in Buenos Aires for ICRM 2017 conference. Short talks could be given about the above mentioned points.
- Thank you for being involved!









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