SRT-s07 *MetroBeta*

# Radionuclide beta spectra metrology

The EMPIR initiative is co-funded by the European Union's Horizon 2020 research and innovation programme and the EMPIR Participating States

## Need for and aim of the project

**To reduce the uncertainty on absolute activity measurements (the becquerel) by improving knowledge of beta spectra.**
***MetroBeta* will develop a code to calculate beta spectra and will deliver metallic magnetic calorimeters capable of measuring these spectra.**

### *Objectives*

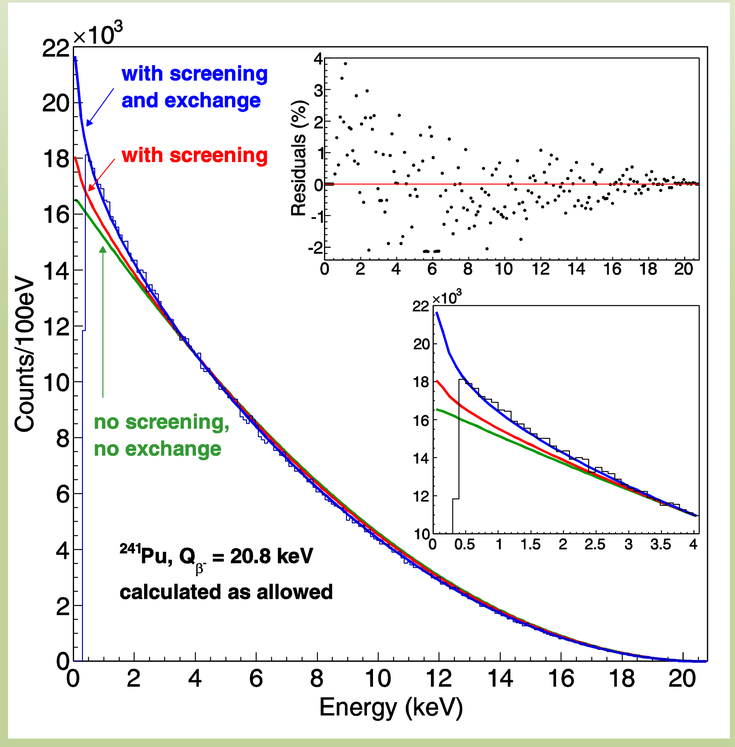
***Improved absolute activity measurements for pure beta emitters – the becquerel***

- Improve current predictions of beta decay spectra
- Couple beta spectra shape calculations to nuclear structure, including complete uncertainty propagation
- Develop a measurement system based on metallic magnetic calorimeters (MMCs) capable of testing these predictions
- Validate the results using other more conventional experimental techniques, e.g. Si(Li), magnetic spectrometer, and develop solid crystal scintillators
- Assess the effect of Bremsstrahlung on absolute activity measurements
- Prediction of beta spectral shapes through a validated code
- Apply this new understanding of beta spectra shapes to absolute activity measurements – the becquerel – in order to reduce the overall uncertainty

## Scientific & technical excellence

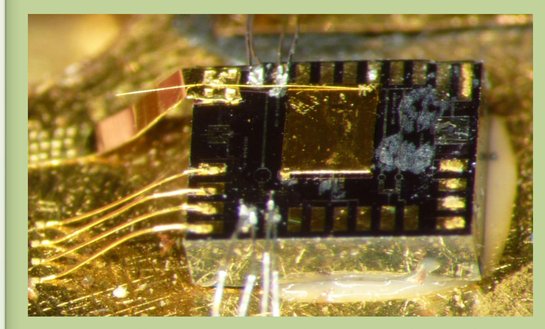
### *WP1: Theoretical calculations: CEA, UMCS*

- The three-body beta decay process generates a continuous energy spectrum, the shape of which is influenced by the nature of the transition: “allowed” or “forbidden”.
- Calculations must take into account both atomic and nuclear structure – these are under control in their respective communities, but they must be unified into a single model that accounts for the weak interaction.
- From a metrological perspective the evaluation of the uncertainties is paramount. This issue is to be addressed in the present project.
- The ultimate goal is to calculate each specific transition, particularly those of higher order, both unique and non-unique.

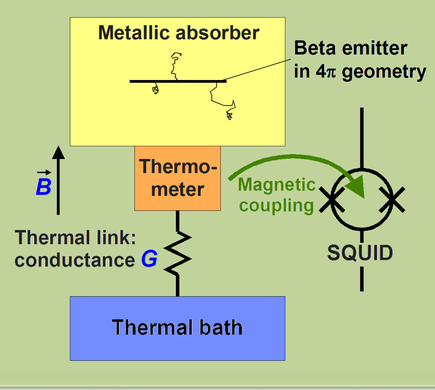


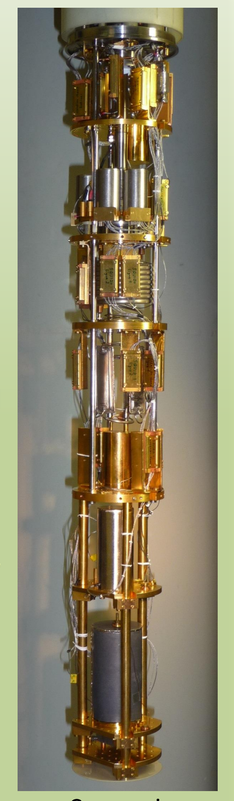

### *WP2: Development of MMCs: PTB, CEA, UHEI*

- Design, fabrication and characterisation of novel Metallic Magnetic Calorimeter (MMC) detectors, optimised for high-resolution beta spectra measurements for both low (< 300 keV) and medium (< 1 MeV) beta endpoint energies
- Improve existing techniques for source/absorber preparation, investigate innovative techniques to improve their performance, and develop new absorber designs, e.g. bi-layer absorbers to minimise Bremsstrahlung energy losses
- Develop and construct a new MMC-based spectrometer for radionuclide metrology based on a state-of-the-art millikelvin refrigerator
- Perform beta spectra measurements of pure beta emitters, ranging in end point energy from 77 keV (Sm-151) to 710 keV (Cl-36)
- Measurements to be performed at two facilities



Metallic Magnetic Calorimeter (MMC)

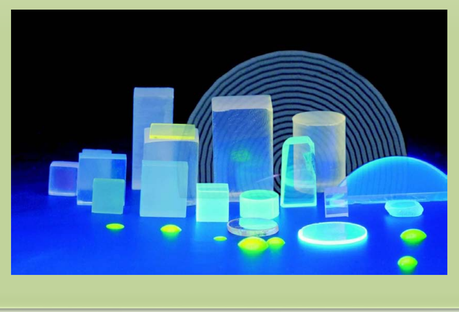


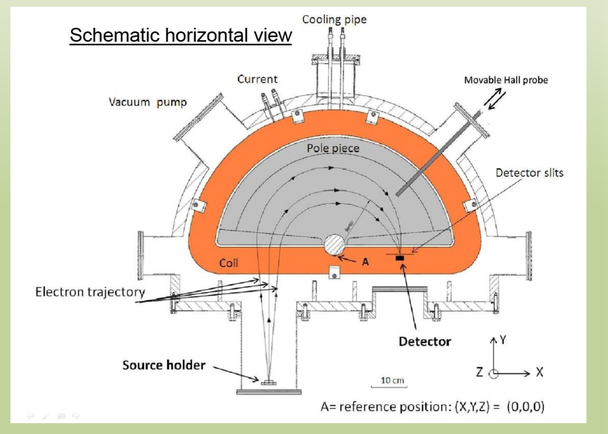



Cryogenic assembly

### *WP3: Measurements with other methods: IRA, CMI, Gonitec*

- Measurements with a Si(Li) detector
- Develop solid scintillator crystals
- Measurements with a magnetic spectrometer

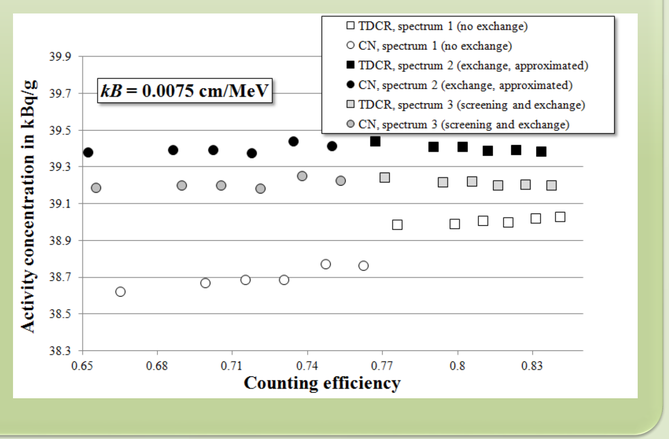





Magnetic Spectrometer

### *WP4: Comparison of calculated and measured spectra: PTB, CEA, IRA*

- Links the two main parts of this project by comparing theoretical and experimental spectra
- Ascertain the effect that beta spectral shapes have on absolute activity measurements (the becquerel) made using LSC techniques
- Measure the cross-sections of Bremsstrahlung production for low energy electrons (< 2 MeV) and their effect on absolute activity measurements




### *WP5: Creating impact: CMI, CEA, PTB, UHEI, UMCS, IRA, Gonitec*

- Metrology: Improved activity (becquerel) standards
- Medical: Reduced dose uncertainties
- Nuclear data: Lower uncertainties, better decay schemes
- Industry: Better knowledge of decay heating
- Economy: Lower margins, higher electricity production
- Dissemination and use of results: project website, workshops, training courses, conferences and scientific publications in peer-reviewed journals.
- Links to: IAEA, BIPM, ICRM, NMIs, OECD/NEA, fundamental neutrino physics, nuclear industry, radiation monitoring

## Quality and efficiency of the project

***The consortium includes the major forces in Europe in the fields of beta decay and nuclear structure theory, MMC fabrication and utilisation, and beta measurements with other techniques***

### Consortium

PTB – Physikalisch-Technische Bundesanstalt Braunschweig und Berlin
CMI – Czech Metrology Institute
cea – From research to industry
CHUV – Institut de radiophysique
GONITEC
UMCS – Uniwersytet Marii Curie-Skłodowskiej w Lublinie
Universität Heidelberg – Zukunft seit 1386

### Potential collaborators

BIPM
Ciemat – Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas
VF – Flexible solutions
KRISS – Korea Research Institute of Standards and Science
envinet – Nuvia Group
Subatech
IAEA – International Atomic Energy Agency
INFN – Istituto Nazionale di Fisica Nucleare
National Nuclear Laboratory

### Four Technical Work Packages (Project Budget: 1.132 M€)

- **WP1: Theoretical calculations of beta spectra (22 pm)**
- **WP2: High-resolution beta spectrometry based on Metallic Magnetic Calorimeters (61 pm)**
- **WP3: Measurements of beta spectra with other methods (28 pm)**
- **WP4: Comparison and validation of measurements (16 pm)**
- **WP5: Creating impact (12 pm)**
- **WP6: Management (11 pm)**