



The Abdus Salam
**International Centre
for Theoretical Physics**



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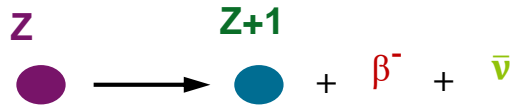
DEVELOPMENT OF A 4π MEASUREMENT SYSTEM FOR THE METROLOGICAL STUDY OF BETA SPECTRA

IAEA-ICTP Workshop on Nuclear structure and Decay data | 19 Oct. 2018

list
cea tech



Why Beta spectra studies?



Metrology



Health



Energy



Research

Need of precise knowledge of beta spectrum :

- ✓ **Ionizing radiation metrology** – Activity measurement by LSC and TDCR methods
- ✓ **Nuclear industry** – residual power in nuclear reactor
- ✓ **Medical Care** – Radiotherapy, dose deposition in the biological cell
- ✓ **Fundamental research** – Rarely studied since 1970's, the studies performed so far was mainly on allowed and first forbidden non-unique transitions

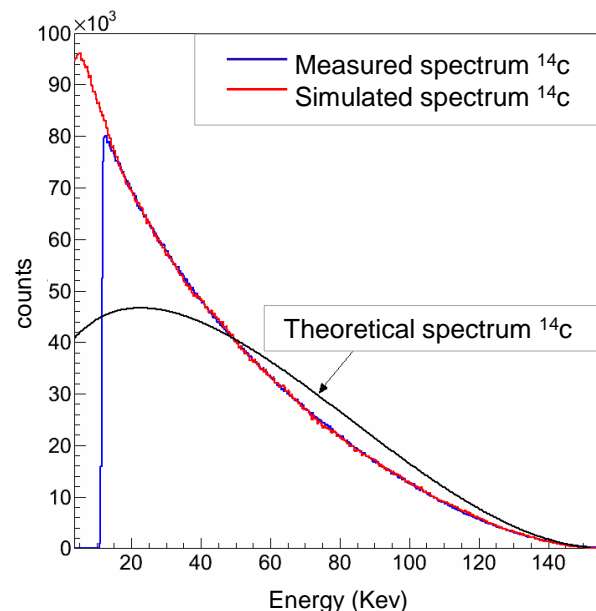
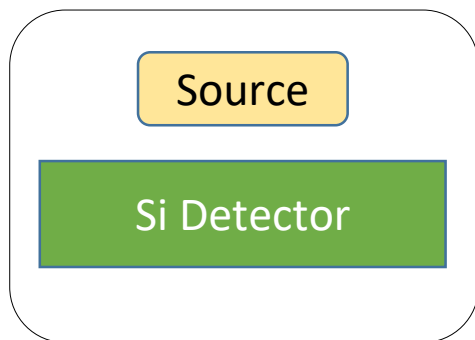
Ongoing developments at LNHB on theoretical calculations for the beta spectrum for all type of transitions

X. Mougeot, C. Bisch, Phys. Rev. A 90, 012501 (2014)
X. Mougeot, Phys. Rev. C 91, 055504 (2015)
X. Mougeot, EPJ Web. Conf. 146, 12015 (2017)
L. Hayen et al., Rev. Mod. Phys. 90, 015008 (2018)

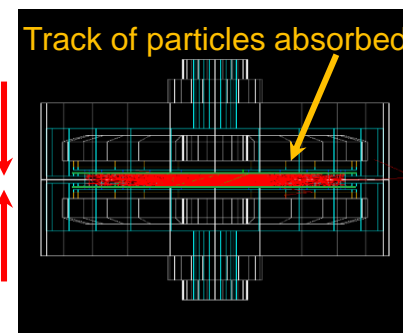
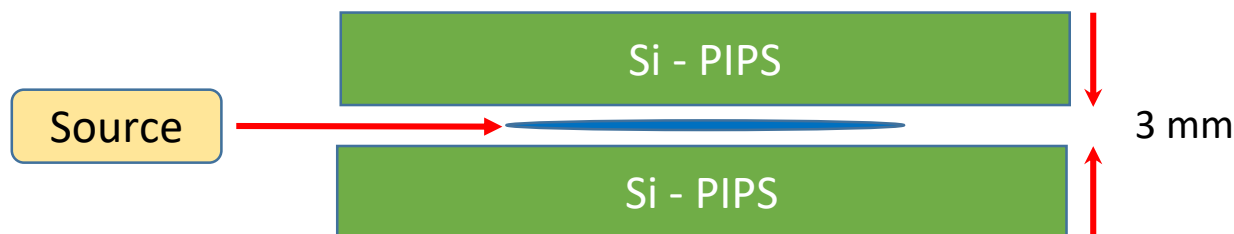
➔ Not enough precise experimental shape factors for the validation of theoretical models

Measurement system development

Previous configuration



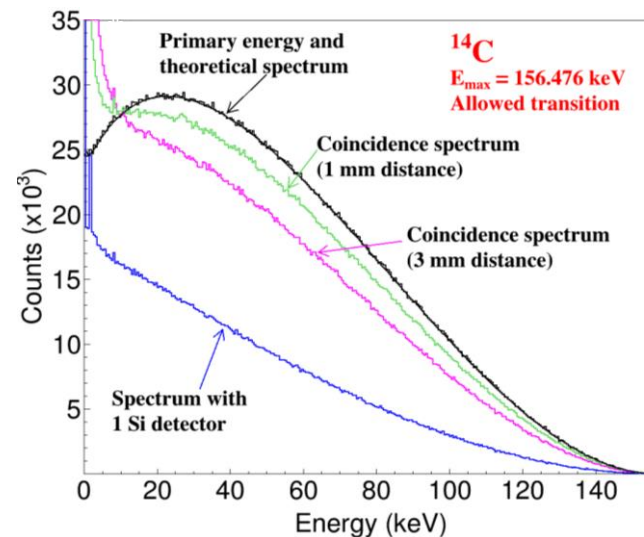
New configuration



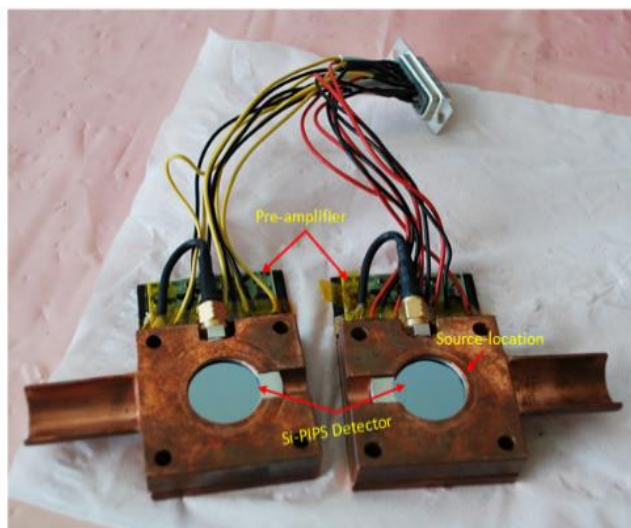
- Monte Carlo simulations for the influence of scattering and backscattering → measurements to get all the kinetic energy of the emitted electron.
- The almost 4π configuration for Si-PIPS detectors each 1 mm thick and 300 mm² surface area has been designed and tested using 3D printing.

Measurement system

- Monte Carlo Simulations with PENELOPE.
- The theoretical spectrum of ^{14}C with BETASHAPE, a code for theoretical calculations, is used as input of the simulation.
- Preamplifiers fixed on the dedicated copper plate with STYCAST®.
- Temperature precisely controlled using thermal sensor.



Effect of varying the distance between the two silicon detectors.



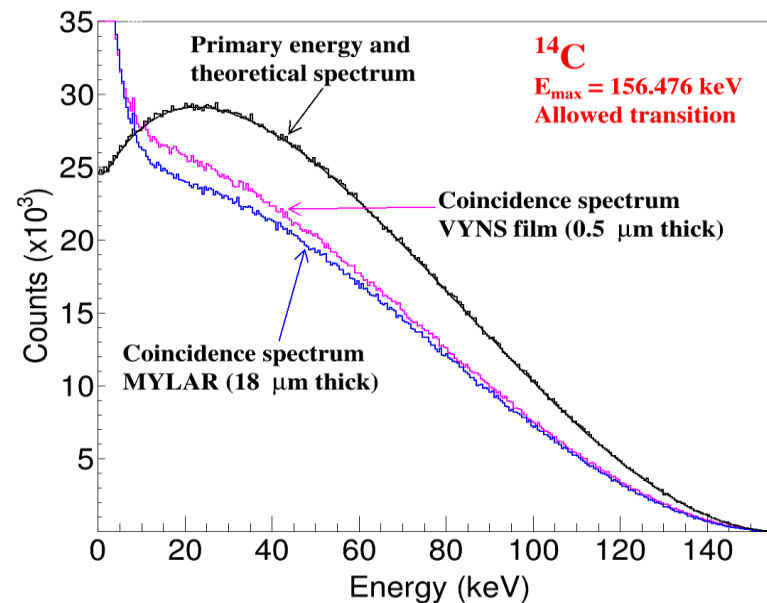
Detector Assembly



Experimental Set-up

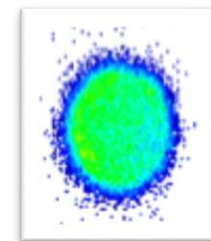
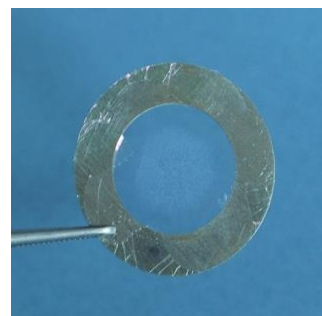
Radioactive Source

Monte Carlo study for self-absorption within the source body.



Effect of source support material on the beta spectrum shape of ^{14}C .

VYNS film, $0.5 \mu\text{m}$ thick with 10 nm radioactive deposit adopted as source support

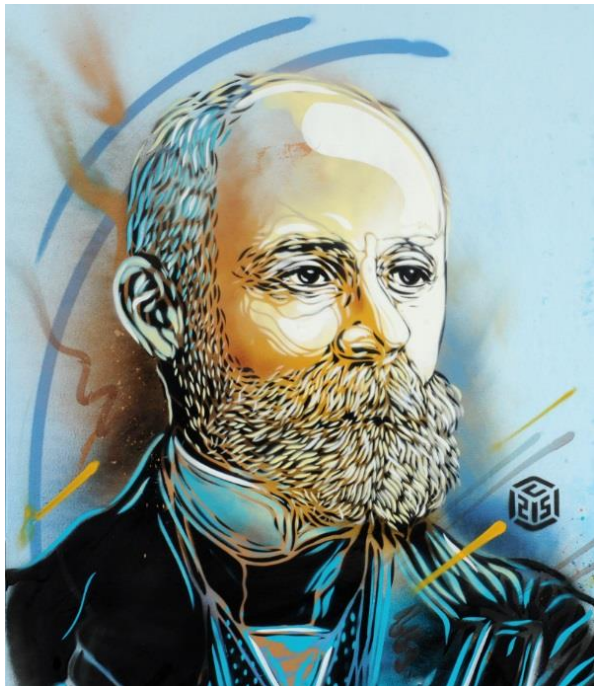


Autoradiography

VYNS Film. Quality of the radioactive deposit analyzed by autoradiography.

Upcoming analysis

- Ongoing measurement of ^{207}Bi decay. Radioactive material deposited on a 0.5 μm thick VYNS film.
- Measurement will be carried out for ^{14}C , ^{36}Cl , ^{99}Tc and ^{151}Sm (radioactive sources already prepared).
- In order to extract the experimental shape factor, implementation of an unfolding process using Monte Carlo simulations.
- Comparison of results with existing published measurements and with the high precision measurements performed at LNHB with Metallic Magnetic Calorimeters (MMC).
- Comparison of the extracted shape factors with theoretical predictions.
- Adaptation of the apparatus to 5 mm thick Si(Li) detectors for the measurement of the beta spectra of higher maximum energies.



Thank you for your attention

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