Laboratoire National Henri Becquerel

French national metrology institute for ionising radiation

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Metrology in France

LNE : French National Metrology Institute

The LNE network is composed of 10 Designated Institutes to cover the SI units

The *Laboratoire national Henri Becquerel* is the **Designated Institute for ionising radiation** and is responsible for the Bq, Gy and Sv units

Activity Metrology Laboratory (MA)

- Radionuclide standardisation
- Detector calibration (dose calibrator)
- Industry and nuclear medicine
- Nuclear data evaluation
- Research for new detection methods

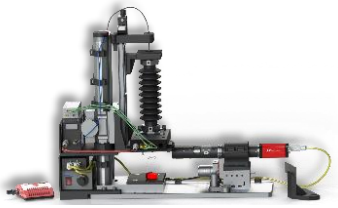
Dosimetry Metrology Laboratory (MD)

- Dosimeter calibration
- Beam accelerator characterisation
- Radiotherapy and radioprotection
- Research for new detection methods

Radioactivity laboratory: LNHB-MA

Alpha activity measurements

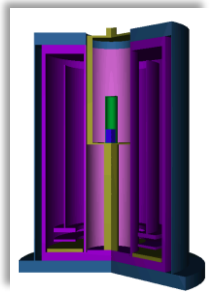
Radioactive gas atmosphere preparation



Portable TDCR system with volume measurement

Coincidence counting

Primary gas measurements



Monte-Carlo simulation

The **Radioactivity laboratory (LNHB-MA)** is in charge of primary metrology for the measurement of activity and the transfer of references to accredited calibration laboratories and users in the fields of application such as: nuclear medicine, nuclear industry, environmental monitoring.

To address these problems, the LNHB-MA technical platform includes the means of preparing primary and secondary sources and measurements adapted to the diversity of physical forms of radionuclides, their period and their decay scheme.

The LNHB-MA is also in charge of the evaluation and the publication of nuclear and atomic data associated with the decay of radionuclides (periods, energies and emission intensities of the different radiations emitted, decay schemes…).

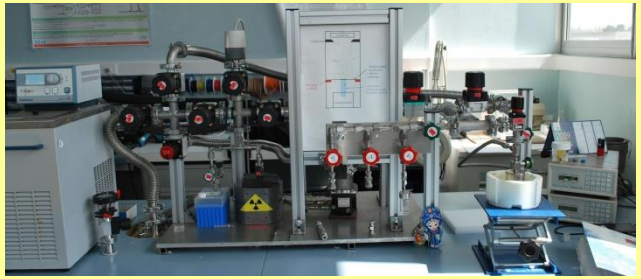
Radioactivity metrology

Goal: develop and disseminate national standards of various radionuclides suited to the needs of users

Means: measurement systems, radiochemistry, source preparation, Monte Carlo simulation

Skills: specific know-how, expertise, experience, …

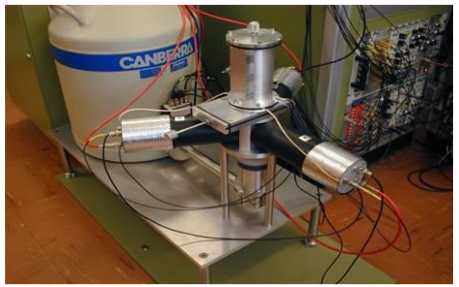
Radiochemistry: ion chromatography and capillary electrophoresis



Radon-222 primary standard

Monochromatic X-ray source

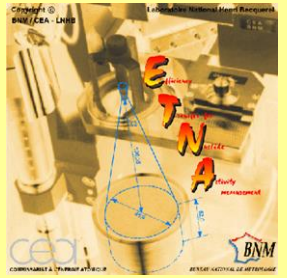
TDCR counter (LSC)

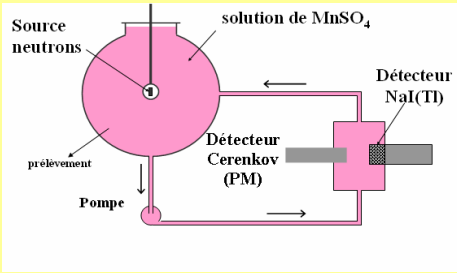


Coincidence counting

Cryogenic detectors

Software for spectrometry





Manganese bath for neutron emission rates

Radioactive source preparation

- **Primary standards laboratory with primary and secondary measurement methods**
  - **Production of radioactive sources traceable to** NF EN ISO **17025 (French COFRAC accreditation**)
  - Authorisation to hold and use **> 150 isotopes**

Gloveboxes (shielded or not)

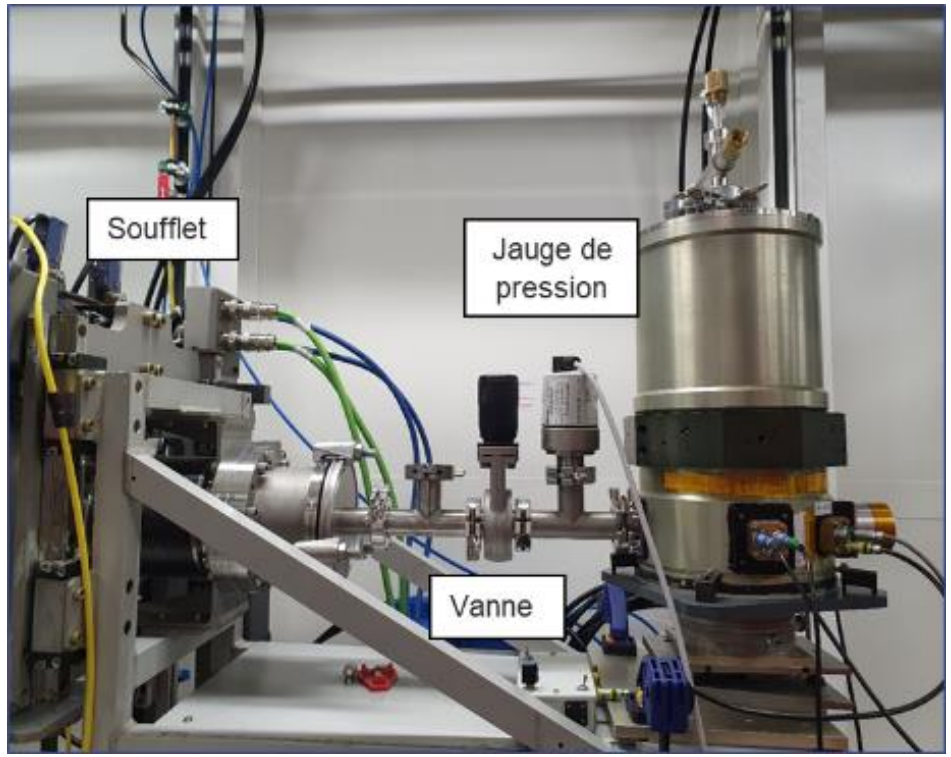
High activity shielded cells with remote handling

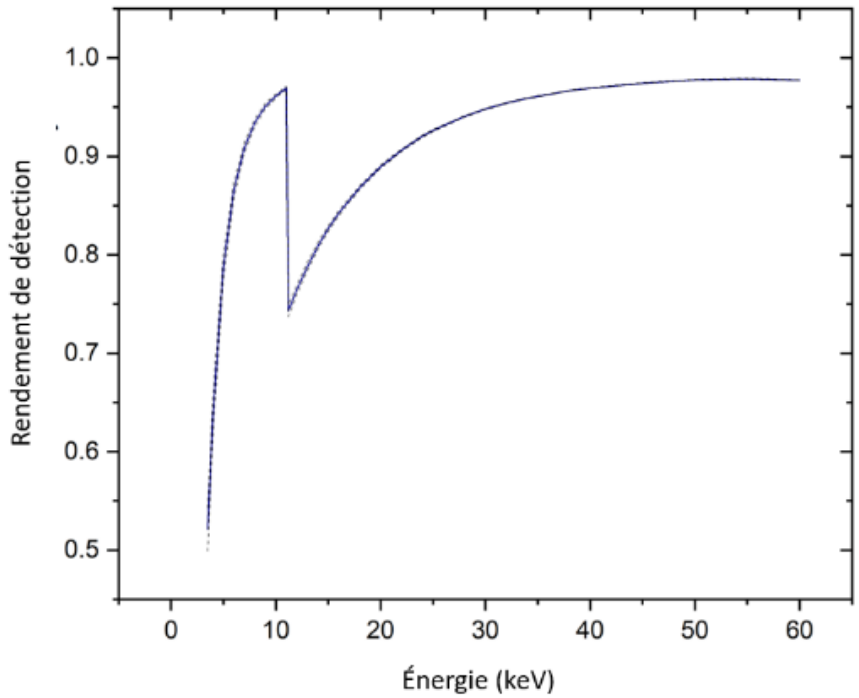
Ventilated chemistry hoods

Radiochemcial laboratory

Radiochemical separation

Absolute calibration of semi-conductor X-ray spectrometer





Absolute calibration using BOLUX

- Use of a cryogenic radiometer with electrical substitution (BOLUX 'BOLometer for Use in field of X-rays')
- Its efficiency is defined by comparing the rise in heat produced by the incident radiation with that induced by electrical power on the BOLUX

Research & Development: on-site primary method

On site calibration by liquid scintillation and TCDR technique

- Tested in Orsay Hospital with ^{18}F and ^{11}C

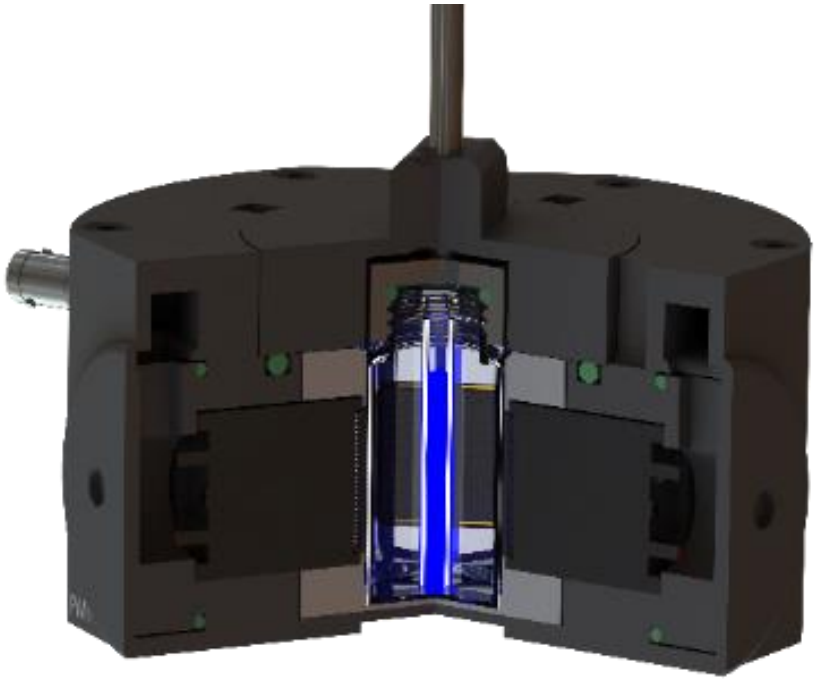
Ref: B. Sabot, C. Dutsov, P. Cassette, K. Mitev, Performance of portable TDCR systems developed at LNE-LNHB, NIM-A 1034 166721

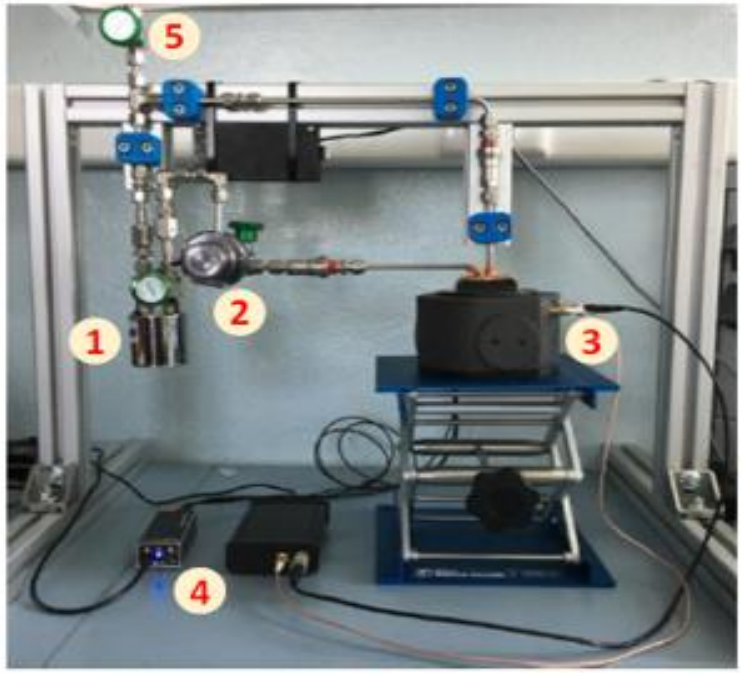
- Tested in Gotenborg Hospital with ^{211}At in the Framework of COST action.

Limitations

- Liquid scintillation source preparation
- Limited mass activity (maximum 400 kBq per LS sample)

Research & Development: radioactive gases

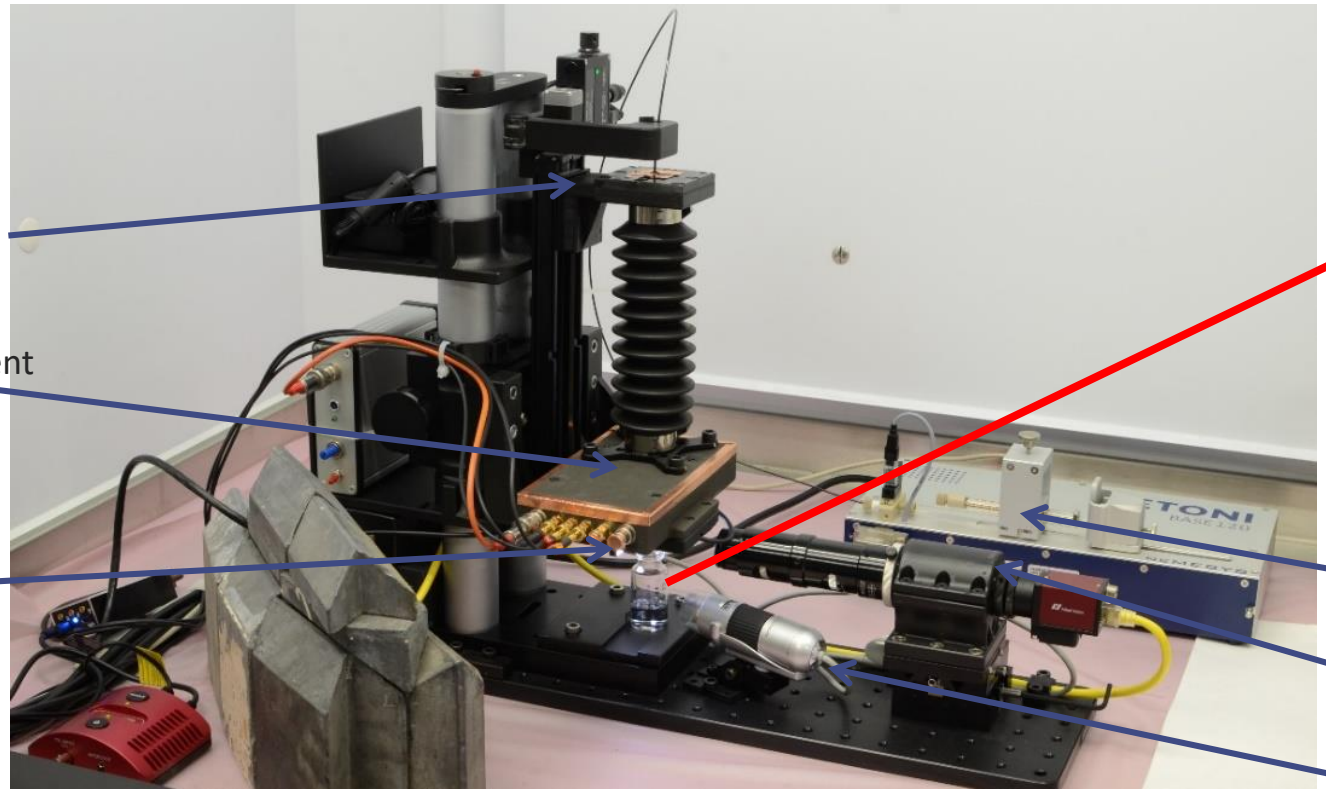


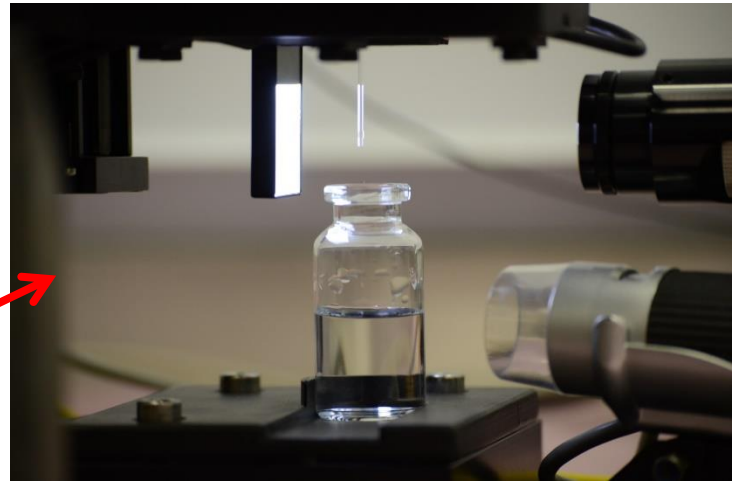


Using the portable TCDR technique

- Development of Metal Organic Frameworks (MOFs) by another CEA laboratory to trap the radioactive gas
- Use of the LNHB-MA gas bench to expose the MOF to a known radioactivity concentration
- Use of the TDCR technique to measure the light emitted by the MOF

Research & Development: pharmaceuticals





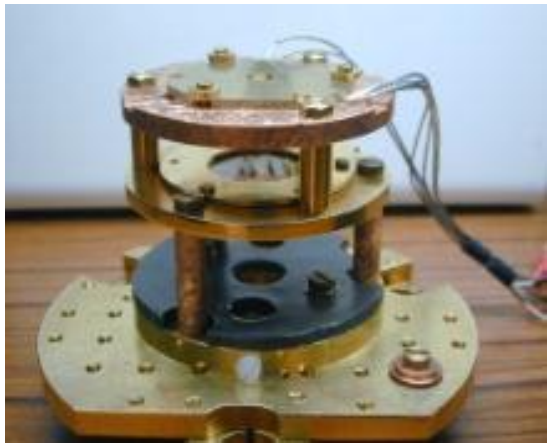
Vial containing a radiopharmaceutical solution

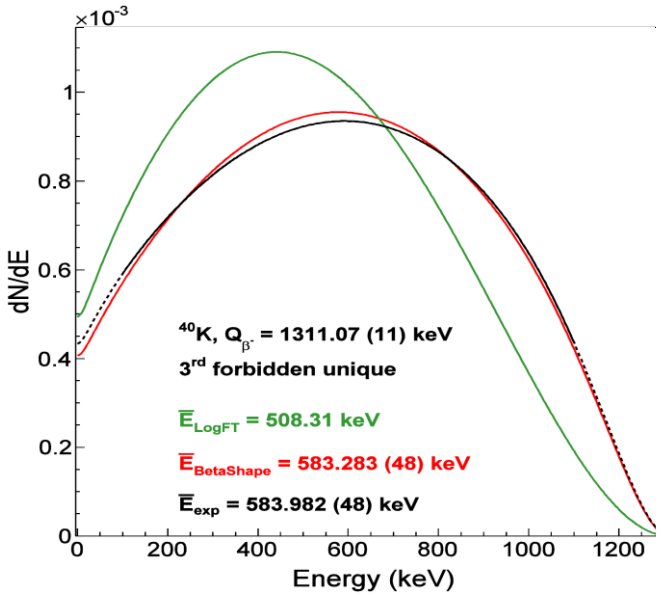
Recent development

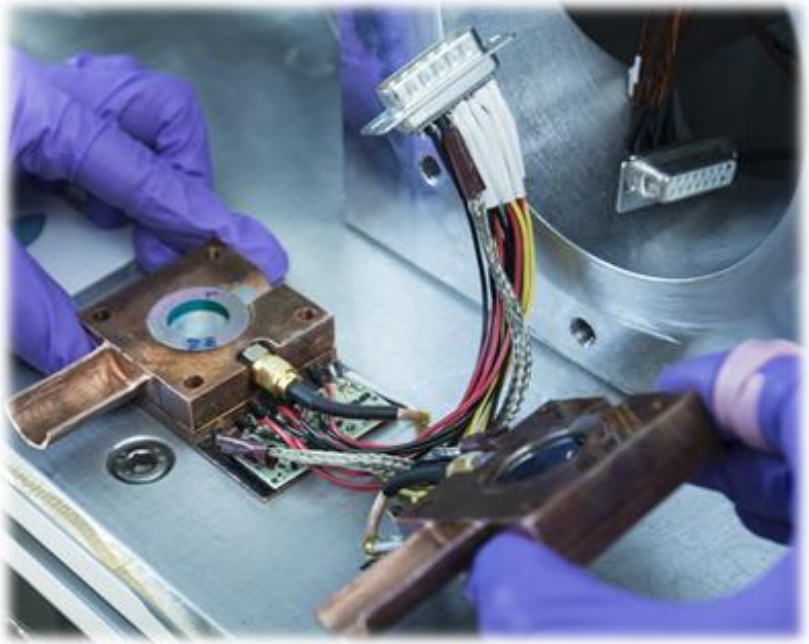
- ❑ Common work with LNE-CETIAT (primary laboratory for microfluidic measurments)
- ❑ Sampling in vial with volume measurement (1 µL) and activity measurement ➔ Volume activity measurement
- ❑ Tested in Orsay Hospital with ^{18}F and ^{11}C with hundreds of $MBq \cdot g^{-1}$

Ref: B. Sabot, et al, Development of a portable device for primary measurement of the volume activity of radiopharmaceuticals, oral pres, ICRM 2023.

Research & Development: beta spectrometry



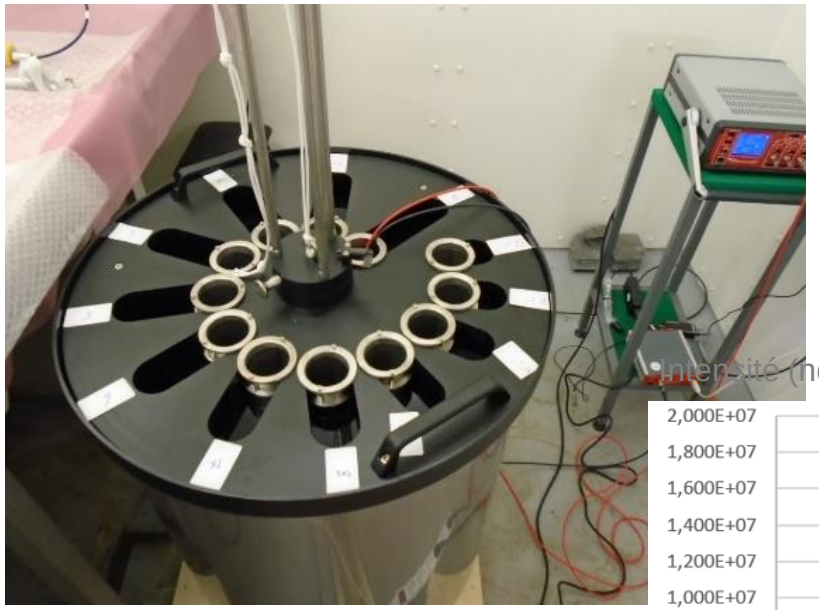


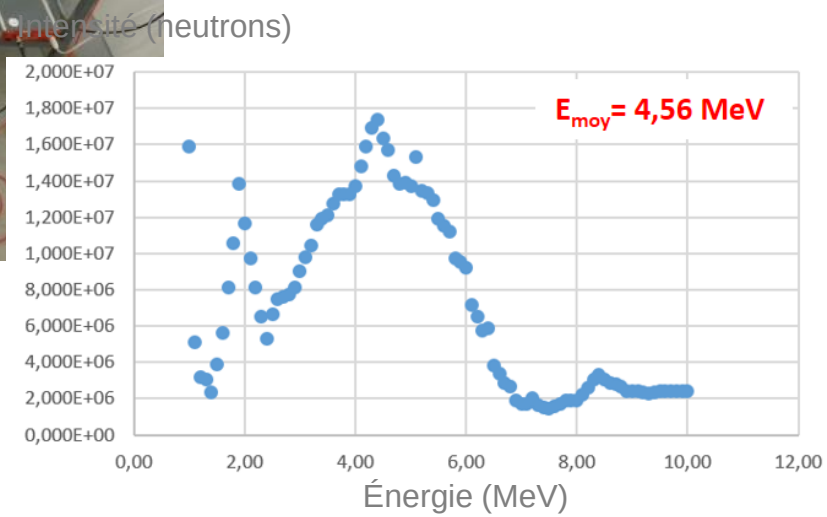


Recent developments

- Development of cryogenic detectors to measure beta spectra with unprecedented precision (limited to low activi8ty sources and low end-point energies)
- Development of a semi-conductor based spectrometer with vacuum chamber
- Development of the BetaShape code and improvements in the calculations to include nuclear structure phenomena

Research & Development: neutron spectrometry



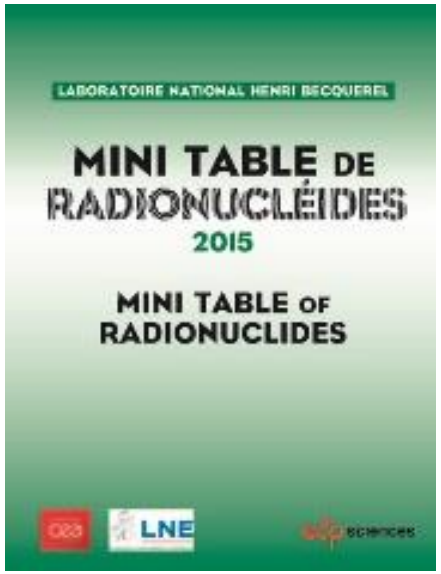


Manganese bath for neutron emission rate measurements

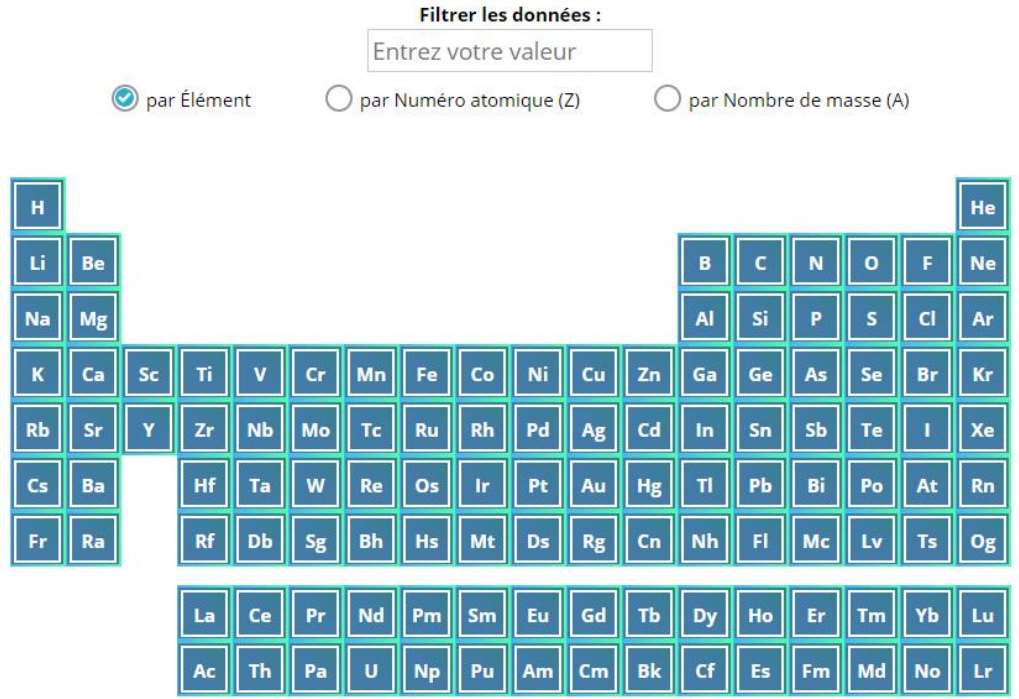
Recent developments

- ❑ Development of AQUASPEC a system to measure neutron emission spectra
- ❑ A container filled with water to thermalise the neutrons
- ❑ Development by our CEA colleagues of discriminating plastic scintillators
- ❑ Testing of reconstruction algorithms
- ❑ Comparison of measured spectra with ISO standards

Measurement and evaluation of nuclear data

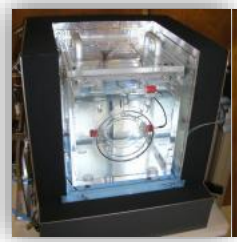


http://www.lnhb.fr/home/nuclear-data/nuclear-data-table/



- Measurement of decay scheme data: half-lives, emission intensities
- Evaluation and publication of decay schemes
- Coordination of the Decay Data Evaluation Project (DDEP)

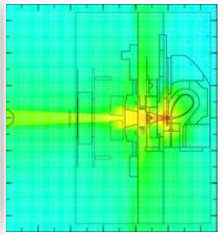
Dosimetry laboratory: LNHB-MD



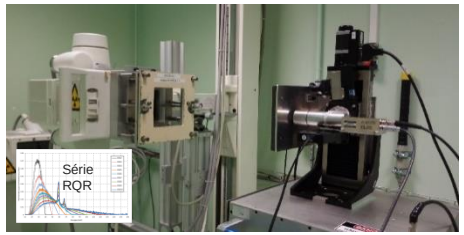
Calorimeters

Ionometry

Passive dosemeters



Activation calculations



X-ray spectrometry

The **Dosimetry Laboratory (LNHB-MD)** is in charge of primary metrology for the dose and transfer of references to accredited calibration laboratories and users of application areas such as radiotherapy, radiodiagnostics, radiation protection and industrial irradiation.

The LNHB-MD technical platform includes radiation sources adapted to these different problems, as well as equipment and dosimetric techniques adapted to the transfer of references in these fields. The activities dedicated to the field of radiotherapy are located on the DOSEO platform.

The LNHB also has calculation means (clusters) essentially intended for the implementation of Monte-Carlo codes of radiation interaction in matter for the determination of correction factors and the design of detection devices.

Dosimetry metrology

Goal: develop and disseminate national standards suited to the needs of users

Means: reference radiation beams, measurement systems, Monte Carlo simulation

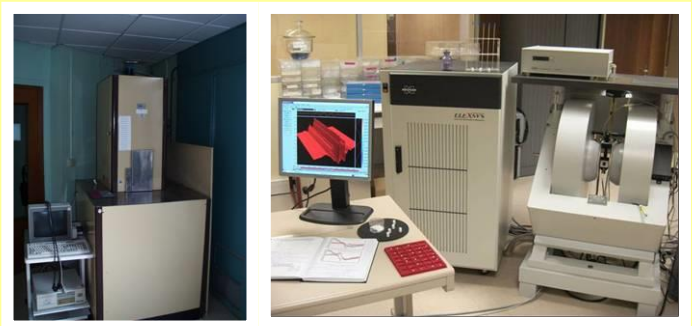
Skills: specific know-how, expertise, experience, …

External radiotherapy

Radio-diagnostic

Graphite calorimeter

Brachytherapy



Industrial irradiation and EPR

Beta dosimeter

Conclusion

- ✓ The LNHB is the French metrology institute for ionising radiation
  - ✓ Covering radioactivity (Bq) and dosimetry (Gy, Sv)

- ✓ The LNHB has many years of experience in the development of measurement methods and instrumentation

- ✓ The LNHB participates in many European and international research projects, and also directly with industrial partners

- ✓ The LNHB provides metrological traceability for the needs of the nuclear industry and nuclear medicine and is involved in aspects of fundamental physics research

Thank you for your attention