Determination of the activity meter calibration factor for ^{188}Re

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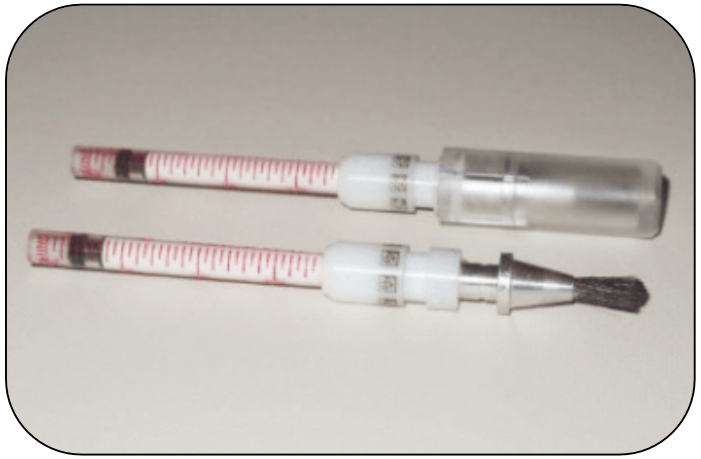
Rhenium-SCT®

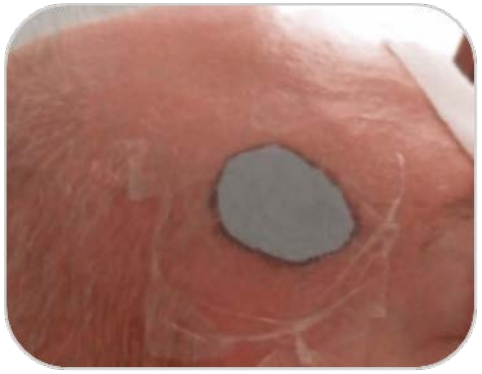
^{188}Re
β-emitter (maximum energy 2.12 MeV)
γ-emitter (Iγ of 15% at 155 keV)
Half life of 17.0 h
Penetration range of β-radiation in human tissue of 1 cm, 92% of the dose deposited within the first 3 mm

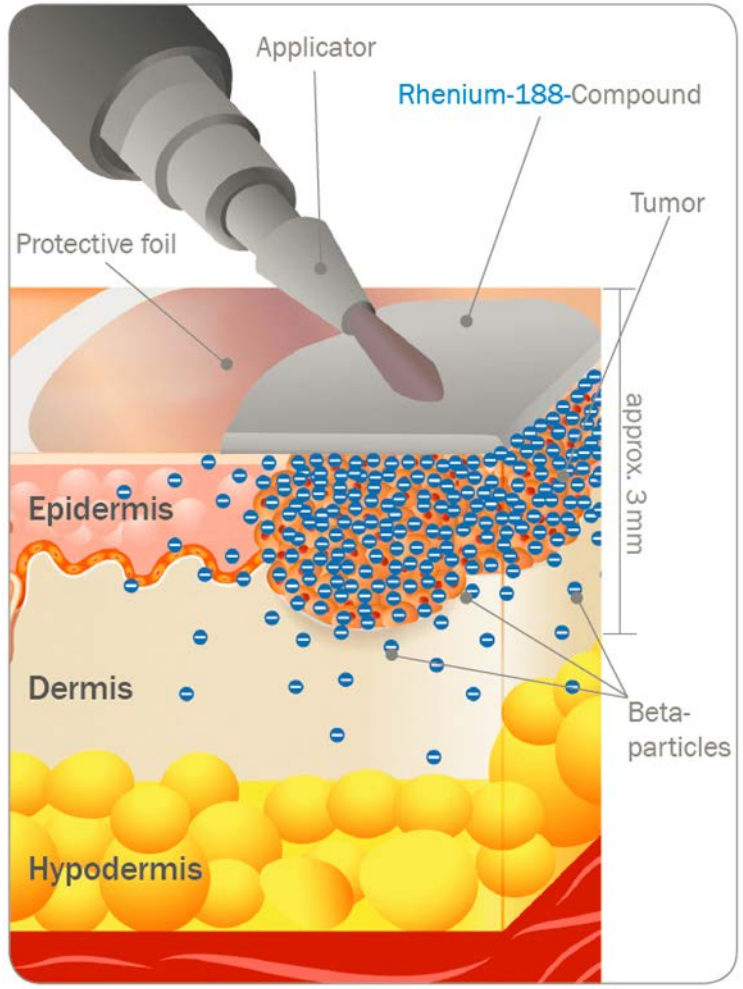


- Epidermal surface treatment developed by Oncobeta GmbH
- Plastic ampoule (“carpoule”) filled with ^{188}Re bound to a fluid resin
- Specially designed applicator

Rhenium-SCT®

- The planning of the therapy requires the calculation of the volume of the tumor
- The maximum depth of the lesion is determined with a biopsy
- The area that has to be treated is defined and measured (within a margin of safety)
- The lesion is covered with a protective film and the resin is applied over it
- The activity is assessed as the difference of the activity in the carpoule before and after application

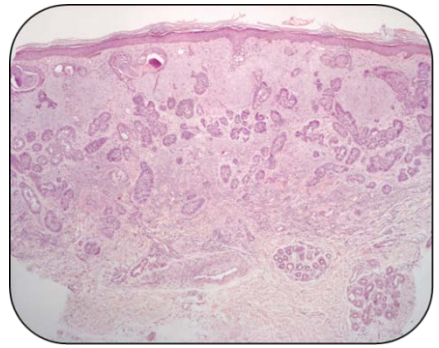




Determination of contact time

Contact time for the treatment is calculated depending on:

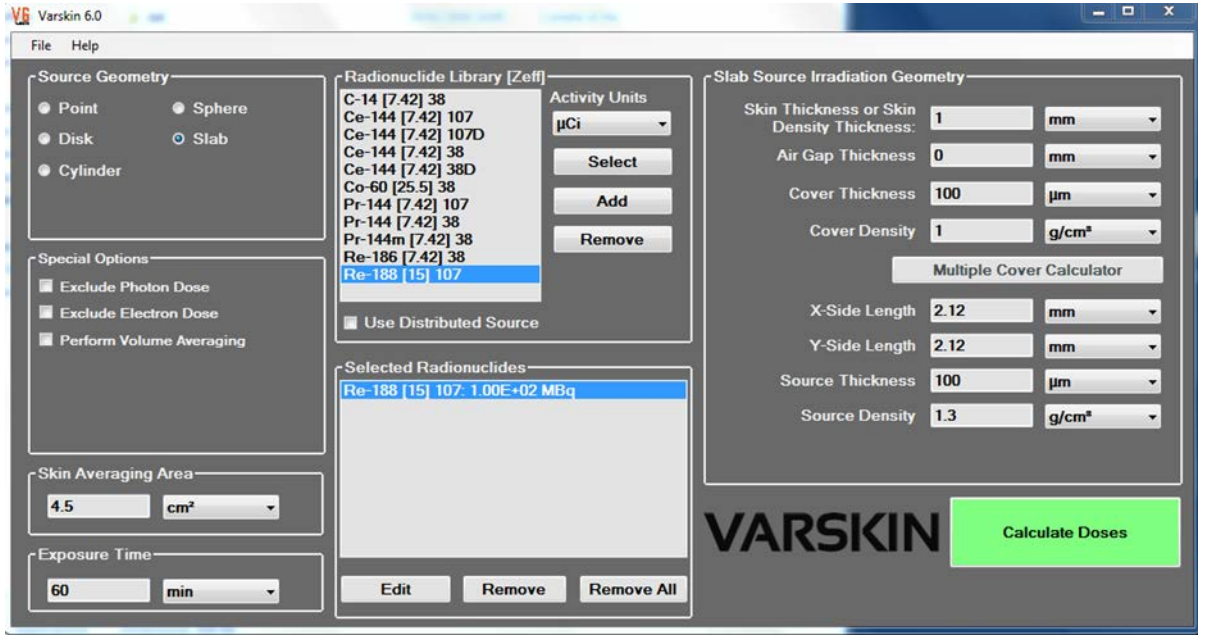
- Area of the lesion
- Depth of the lesion
- Prescribed dose (usually 35-50 Gy)
- Initially applied activity



Validated code Varskin by NRC:

- Reference code for the determination of superficial contamination
- Application for therapy planning in experimental phase

U.S.NRC
United States Nuclear Regulatory Commission
Protecting People and the Environment



Rhenium-SCT®

- The film is removed after the treatment
- Patients subjected to this therapy has shown high percentage of tumor remission following one or two treatment sessions

•Carrozzo AM, Sedda AF, Muscardin L, Donati P, Cipriani C. Dermo beta brachytherapy with 188-Re in squamous cell carcinoma of the penis: a new therapy. *Eur J Dermatol 2013*

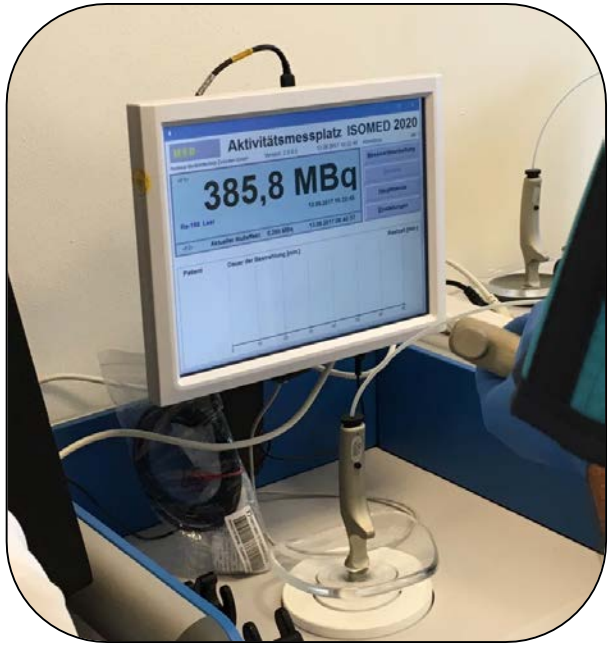
•Sedda AF, Rossi G, Cipriani C, Carrozzo AM, Donati P. Dermatological high-dose-rate brachytherapy for the treatment of basal and squamous cell carcinoma. *Clin Exp Dermatol 2008*

Activity meters

- Activity is the most important parameter in the definition of treatment time
- Activity meters are used in Nuclear Medicine to determine the activity in radiopharmaceutical preparations (few MBq to hundred GBq)
- Ionization current is converted to activity through a calibration factor

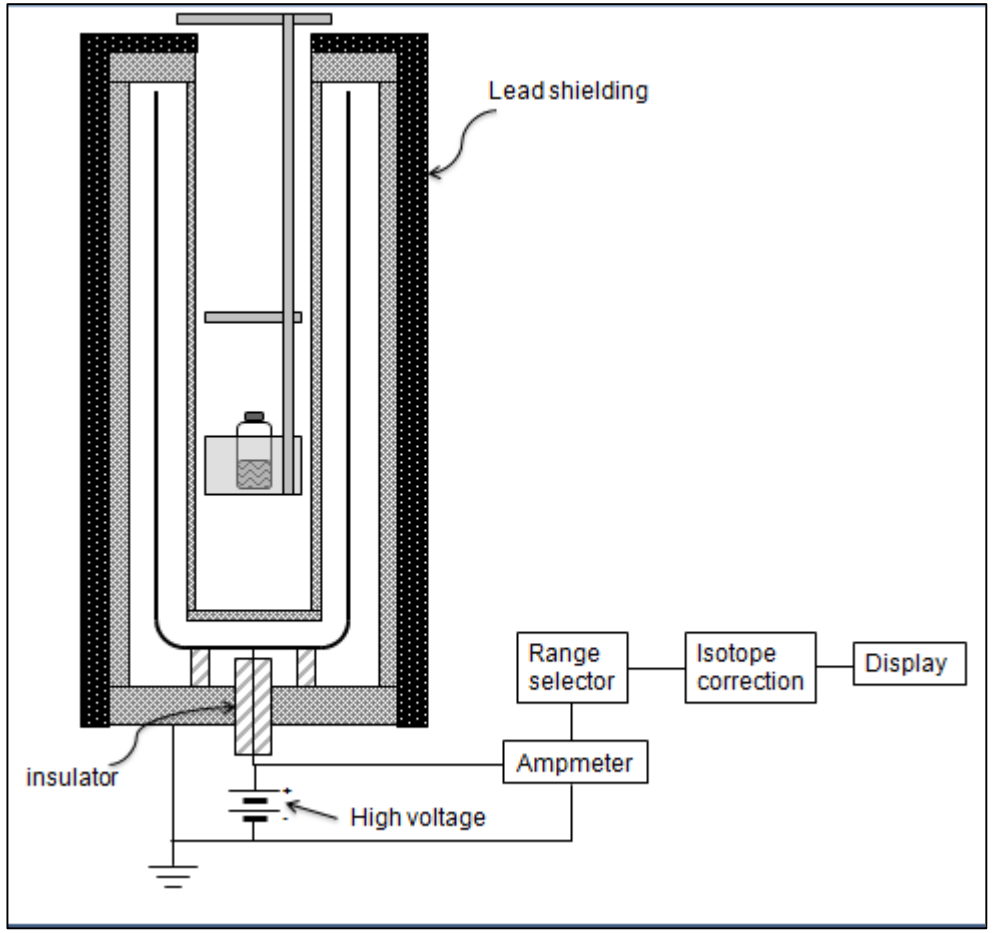
$$A = k \cdot I$$

Radionuclide Shape Material Position Filling



Calibration of activity meters

- Calibration factors can be determined with a reference standard source for the specific radionuclide
- Certified sources for ^{188}Re traceable to the BIPM international standards are not currently available
- Indirect calibration can be performed using a source whose activity is assessed with an independently calibrated equipment, e.g. a multichannel analyzer



Aim: determination of calibration factors for ^{188}Re for two activity meters of our Nuclear Medicine department

Materials and methods

Activity meters

Capintec CRC15

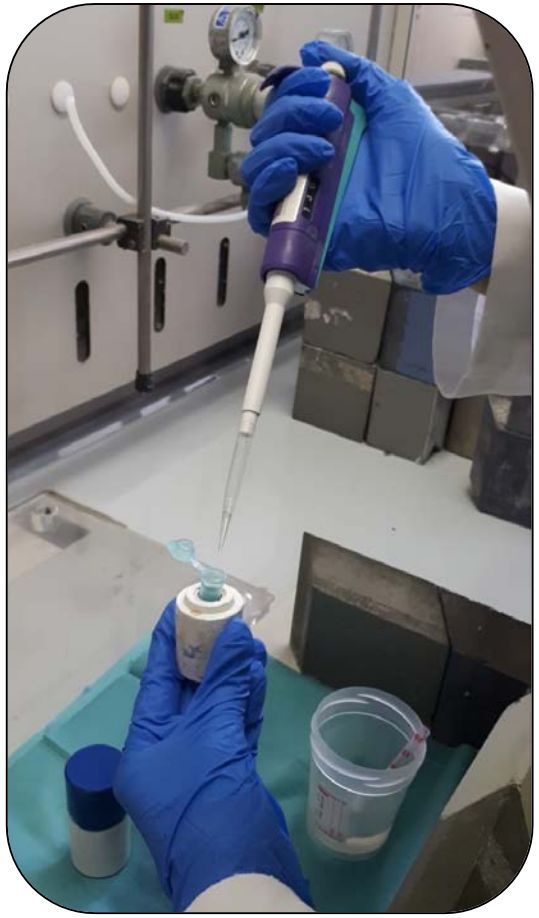
Mec-Murphill MP-DC

Sources

Point-like sources

5 ml vials

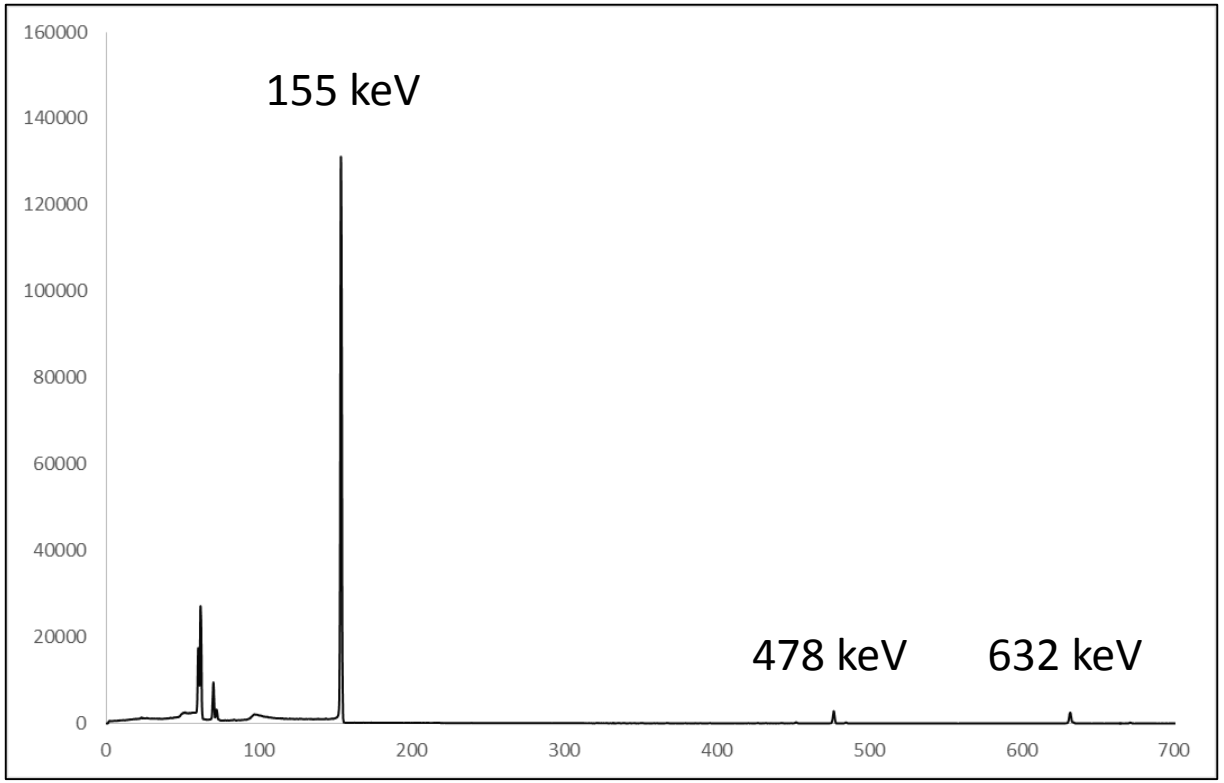
Materials and methods



- A stock solution of ^{188}Re was obtained by dissolving residual the resin in ethanol
- Samples were prepared in sets of three to reduce uncertainties
- For point-like geometry, we considered volumes of 10, 20 and 30 µl to check for relevant variations of the calibration factor
- The ionization current produced by the samples was measured with the activity meters

Materials and methods

- The activity of each sample was quantified with a multichannel analyzer equipped with an HPGe detector calibrated according to the IEC 61452 standard
- The measurement was performed after appropriate waiting time to achieve a dead time always below 2%
- The procedure was repeated for four different treatment sessions (total of 12 samples for each geometry)



Data analysis – MecMurphil MP-DC

$$K = \frac{A_{old}}{A_{new}}$$

A_{old} = activity displayed using ^{137}Cs factor

A_{new} = activity determined with the spectrometry

K = calibration factor for ^{188}Re (relative to ^{137}Cs)

Data analysis - Capintec CRC15

$$K = \frac{A_{old}}{A_{new}}$$

A_{old} = activity displayed using ^{99m}Tc factor

A_{new} = activity determined with the spectrometry

K = calibration factor for ^{188}Re (relative to ^{99m}Tc)

Data analysis

The error was assessed as:

$$\delta K = K \cdot \sqrt{\left(\frac{A_{old}}{\delta A_{old}}\right)^2 + \left(\frac{A_{new}}{\delta A_{new}}\right)^2}$$

δA_{old} = accuracy of the electrometer + random fluctuations in measurements (<2%)

δA_{new} = systematic error of the spectrometry system + random errors in the standardization of ^{188}Re samples

Results

Final results were determined as averages of the factors calculated during the different sessions

	Point-like sources	5ml solutions
MecMurphil MP-DC (relative to ^{137}Cs)	4,58 ± 0,06	4,48 ± 0,09
Capintec CRC15 (relative to ^{99m}Tc)	2,22 ± 0,04	2,48 ± 0,05

Conclusions

- Appropriate, quantitative calibration is fundamental for ALL Nuclear Medicine radiation measuring equipment. This is particularly relevant in the case of activity meters, given their role in measuring the activity administered to patients
- We developed and demonstrated a procedure that can be reproduced in many laboratories, for different radionuclides in the absence of a reference source
- Calibration of the activity meter can be traced back to the one of the multichannel analyzer obtained with a certified reference solution
- Determination of factors with uncertainty typically below 3%

Future developments

- Implementation and validation of a Monte Carlo model to determine the calibration factor for more complex geometries