Studies for Alpha Particle Spectroscopy using TASTRAK (CR-39) Detectors

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Passive Nuclear Track Detectors (PNTDs)

Advantages:

(a) Intrinsic thresholds of registration.

(b) Offer a good charge resolution.

(c) Simplicity and ease of use. Since they do not require power for their operation it is easy to obtain large arrays, and they can be positioned in regions of interest without requiring permanent monitoring.

Disadvantages:

(a) Long measurement time.

(b) Slow processing of the recorded information.

(c) The existence of a background from radiation sources.

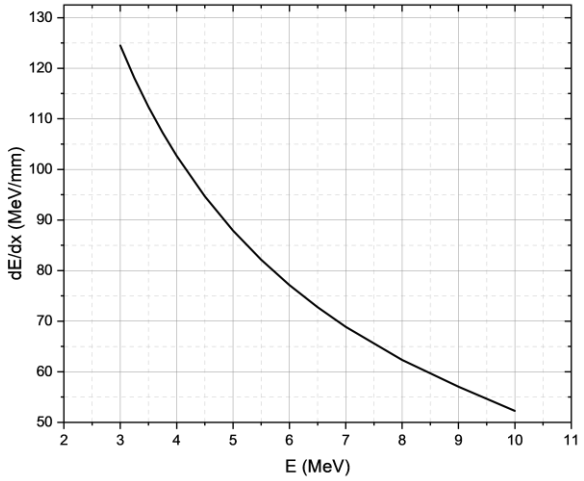
(d) The quality of the results dependent on the optimal choice of etching conditions.

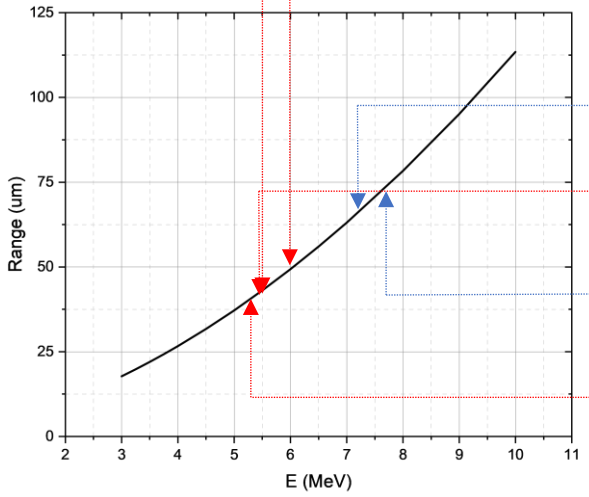
Interaction with material detector and relevant processes necessary for detection

Bethe-Bloch equation: $$S = -\frac{dE}{dx} \cong \left(\frac{e^2}{4\pi\varepsilon_0}\right)^2 \frac{4\pi z^2}{m_e v^2} NZ \left[ln\left(\frac{2m_e v^2}{I}\right) - ln\left(1 - \left(\frac{v}{c}\right)^2\right) - \left(\frac{v}{c}\right)^2\right]$$

For non-relativistic alpha particle (with mass M and kinetic energy E) the maximum energy transferred in head-on collision is $\cong 4E\frac{m_e}{M}$, and thus $S \propto \left(\frac{z}{v}\right)^2$ and $S \propto \frac{Mz^2}{E}$. For the medium: $S \propto ZN$.

CR-39

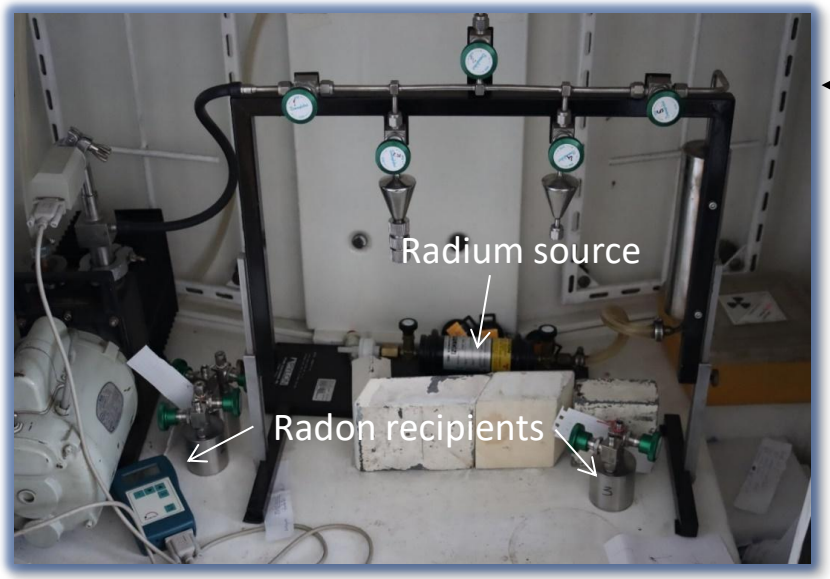




Radon's progeny decay

Decay and half-life	Fraction produced per atom of ^{226}Ra	Emitted particle and energy	Fraction of α particles
$^{222}_{86}Rn\ (3.82d) \rightarrow\ ^{218}_{84}Po$	100%	$E_\alpha = 5.49MeV$	99.92%
$^{218}_{84}Po\ (3.05\ m) \rightarrow\ ^{214}_{82}Pb$	100%	$E_\alpha = 6.0MeV$	99.98%
$^{218}_{85}At\ (1.5\ s) \rightarrow\ ^{214}_{84}Po$	0.02%	$E_\alpha = 6.69MeV$	89.91%
$^{218}_{86}Rn\ (35ms) \rightarrow\ ^{214}_{84}Po$	0.1%	$E_\alpha = 7.13MeV$	99.87%
$^{214}_{83}Bi\ (19.7m) \rightarrow\ ^{214}_{84}Po$	99.9%	$E_\alpha = 5.45MeV$	0.011%
$^{214}_{84}Po\ (164\mu s) \rightarrow\ ^{210}_{82}Pb$	99.96%	$E_\alpha = 7.69MeV$	99.99%
$^{210}_{84}Po\ (138.4d) \rightarrow\ ^{206}_{82}Pb$	99.99%	$E_\alpha = 5.30MeV$	99.998%
Continue, up to $^{206}_{82}Pb$ (stable)			

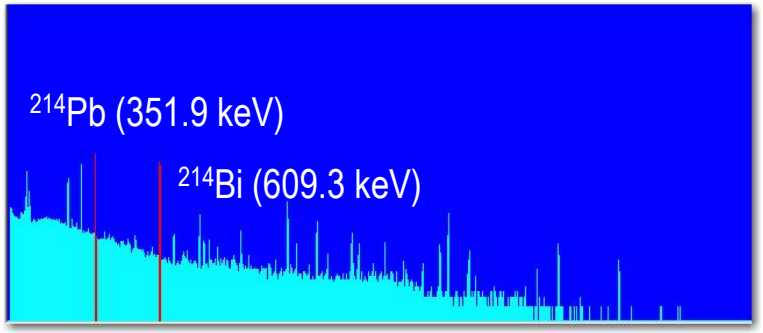
Experimental aspects, results and analysis



1. Radon Source Preparation

2. Radon Source Activity Measurement with HPGe detector

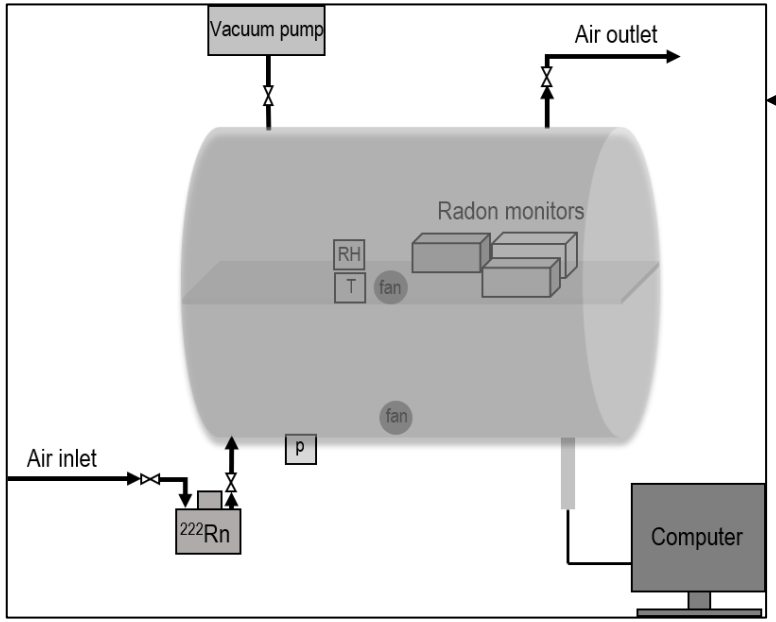
PNTDs type TASTRAK



Gamma ray energy spectrum of ^{222}Rn descendants

Lalau, I., Zadehrafi, M., Teodorescu, C., Ioan, M.-R., Antohe, A., & Luca, A. (2023). Performance evaluation of radon monitors at IFIN-HH, Romania. Applied Radiation and Isotopes, 201, 111030. https://doi.org/10.1016/j.apradiso.2023.111030

Experimental aspects, results and analysis



3. PNTDs and AG Exposure in the Radon Chamber

4. PNTDs Etching

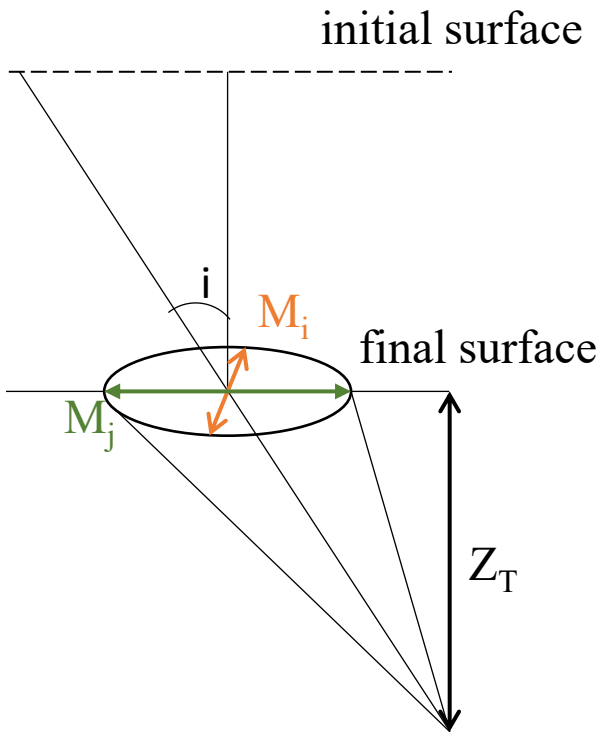
5. Evaluation

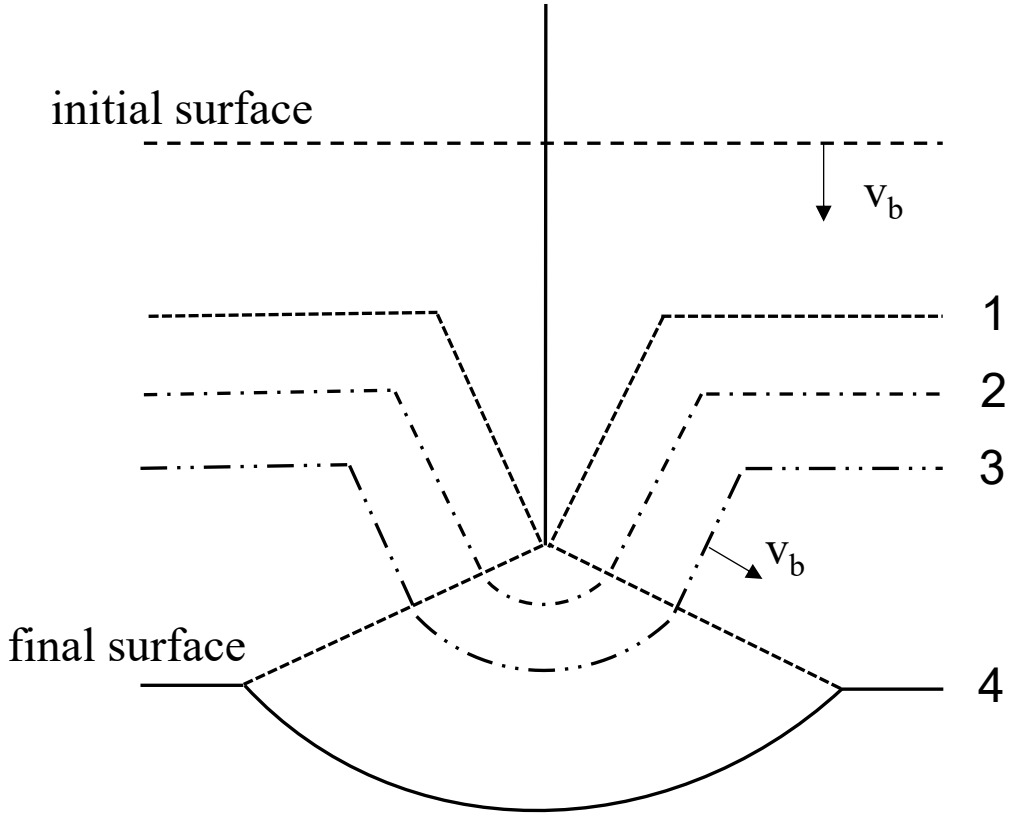
PNTDs type TASTRAK

Etching parameters	Value
Temperature	80oC
Time	6 h
NaOH density	1.18 g/cm3

Lalau, I., Zadehrafi, M., Teodorescu, C., Ioan, M.-R., Antohe, A., & Luca, A. (2023). Performance evaluation of radon monitors at IFIN-HH, Romania. Applied Radiation and Isotopes, 201, 111030. https://doi.org/10.1016/j.apradiso.2023.111030

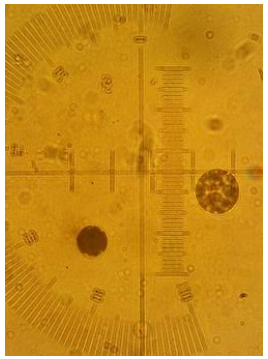
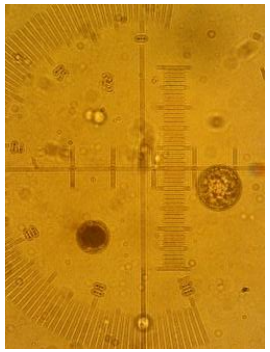
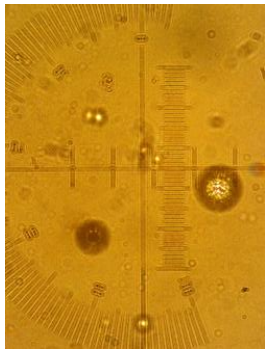
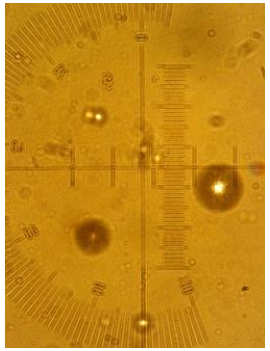
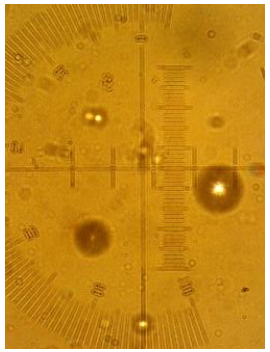
Experimental aspects, results and analysis



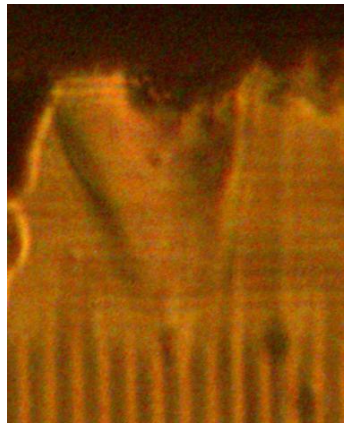


Etching process

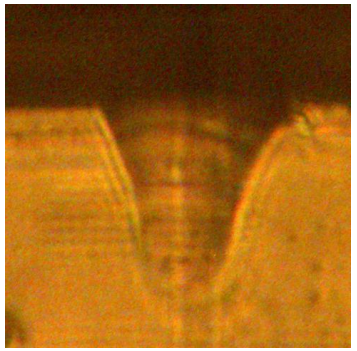
Experimental aspects, results and analysis

				
a) Image of two types of defects, 1 (right) and 2 (left); on the detector surface	b) Same images at 10 microns penetration depth	c) Same images at 20 microns penetration depth	d) Same images at 30 microns penetration depth. Stopping depth for type 2. Approximate value.	e) Same images at 35 microns penetration depth. Stopping depth for type 1. Approximate value.

Correlation of the diameter of the track versus the penetration depth

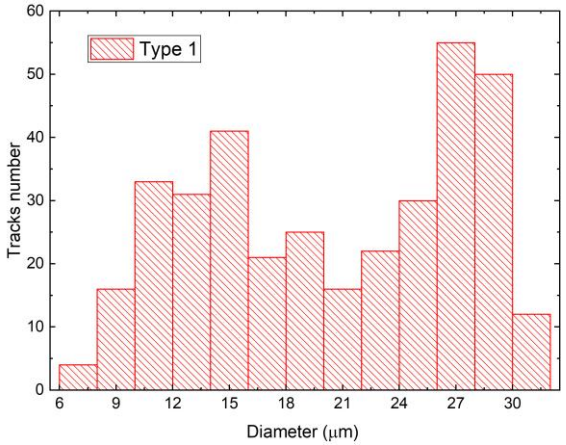


Type 1 track

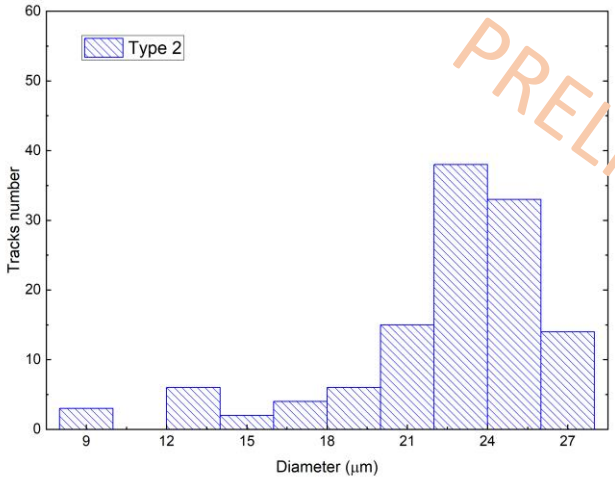


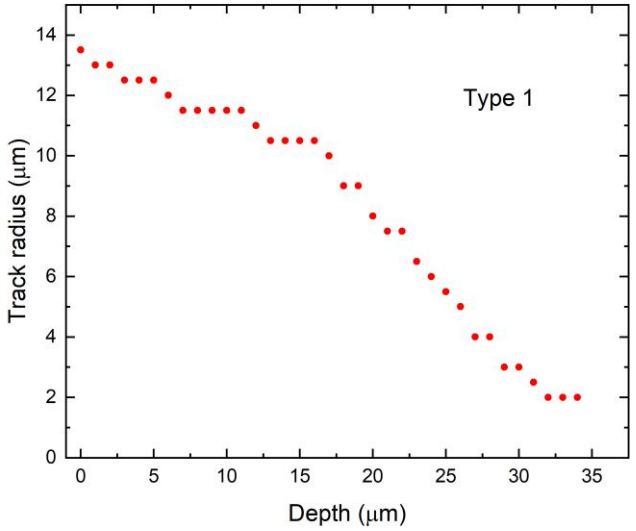
Type 2 track

Experimental aspects, results and analysis

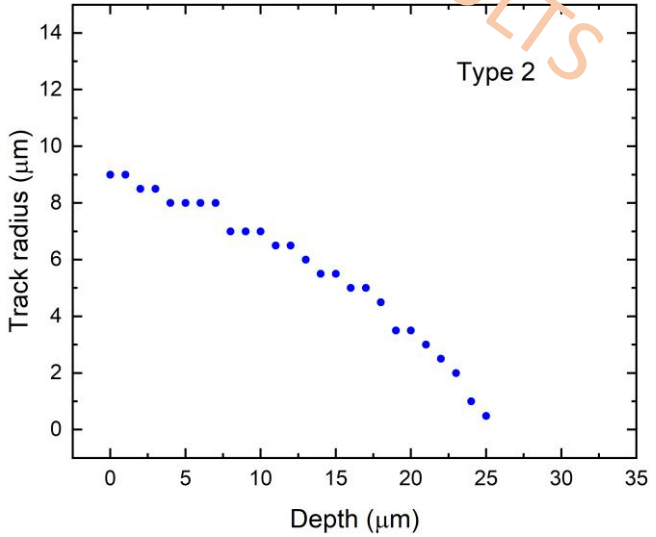


Histograms for type 1 and type 2 tracks





Measured track radius as a function of depth (particle range)



Conclusions

- PNTDs were exposed to radon in the radon chamber
- Two types of tracks have been identified
- The track radius as a function of depth was determined
- Further analysis will be performed