

Calibration of Radon Dosimetry System with Radon Chamber in Self-decay Mode

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I. INTRODUCTION

Radon is estimated to cause a significant portion of all cancer cases in Europe causing avoidable deaths. To minimize the public exposure to radon in Slovakia, the Slovak University of Technology in Bratislava (STU) in close cooperation with and Slovak Institute of Metrology (SMU) started collaborating on the development and implementation of a certified methodology on radon dosimetry utilizing solid-state nuclear track detectors. The SMU operates the Air Radon Secondary Standard comprising a radon chamber operated in self-decay mode and calibrated radon atmosphere monitoring system AlphaGUARD. To complement the Air Radon Standard, the STU laboratory acquired the TASLImage™ system for radon and neutron dosimetry, TASTRAK CR-39 type detectors, and diffusion containers. The analysis is focused on the determination of calibration factors for original and self-developed diffusion chambers and the TASLImage™ system for average radon activities of 5 kBq.m⁻³ and different irradiation times varying from 12 hours to 21 days.

II. METHODS AND TECHNIQUES

AiRneSt – Air radon standard

• Secondary standard of Radon in air, based on a radon calibration chamber

• Consists of tree main parts:

✓ Radon source

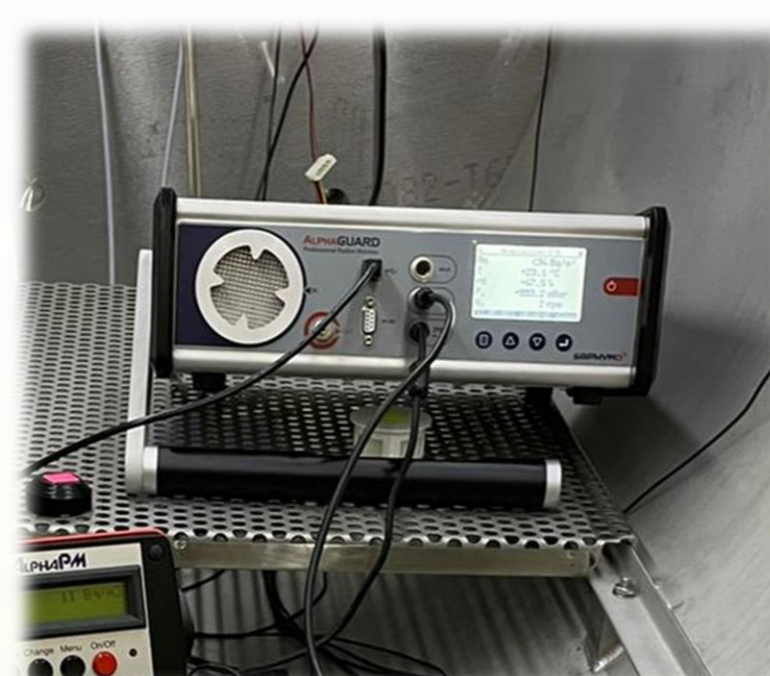
- Encapsulated dry flow source containing radium salts
- Manufactured by CMI
- Concentration range within the range from 100 Bq.m⁻³ to 100 kBq.m⁻³

✓ Radon chamber

- Horizontal cylinder is made from stainless steel
- Diameter of 0.8 m and length of 2.0 m
- The inner volume of the chamber is approx. 1 m³
- The standard working pressure is within 980 hPa and 990 hPa.

✓ Electronic measuring system

- Temperature, pressure and humidity
- The AlphaGUARD DF2000 CMR used to monitor the radon atmosphere



- The chamber is equipped with the points for sampling the radon atmosphere into the Lucas Cell or other gas vessels.
- Can be operated in diffusion or flow mode.

TASLImage™ system

• Newly quired radon and neutron dosimetry system based the Solid-State Track Detectors (TASTRAK CR-39)

• The system consists of:

✓ Etching equipment

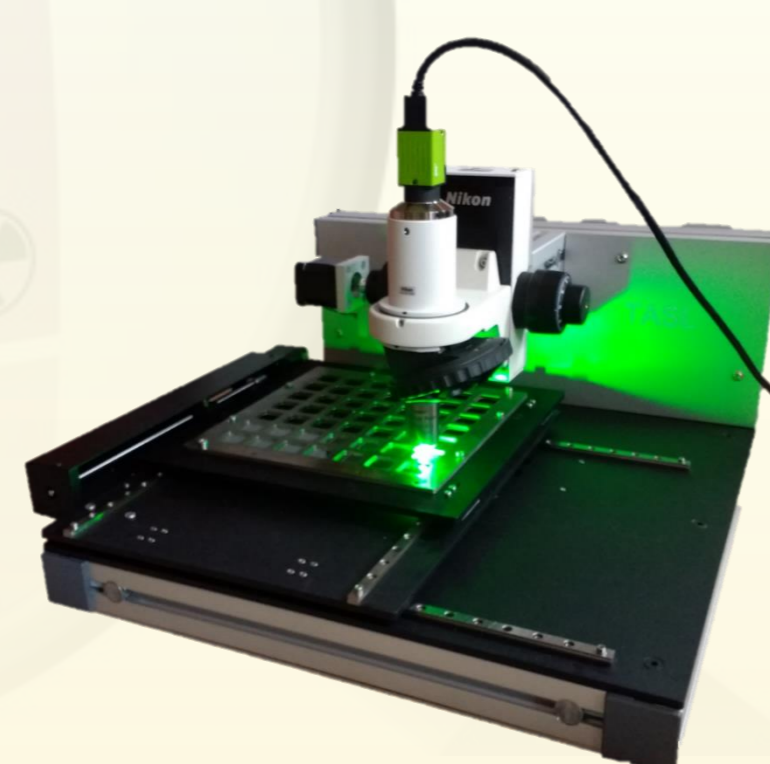
- Thermostatic bath, Etching baths
- Cradle with holders
- Dryer machine

✓ Scanning equipment

- 2-axis movable pad
- Microscope connected with CCD camera
- PC with read-out software

✓ TASTRAK detectors and diffusion chambers

- Dimensions of 25 x 25 x 1.5 mm³
- Poly allyl diglycol carbonate (PADC)
- Diffusion chamber suppress the effect of short-lived decay products



In-house developed diffusion chamber

• Aim to propose a design with fast diffusion rate.

• To accommodate to decay mode of Radon chamber.

• Diffusion chamber design:

- ✓ Cylindrical shape
- ✓ Large diffusion area
- ✓ HEPA filter used to avoid aerosol penetration
- ✓ Vertical placement of the SSTD



Measurement conditions

• Mean specific activity in the chamber of 5 kBq.m⁻³

• Measurement time – 24h, 48h, 72h, 120h, 504h

• 40 SSTD evaluated – 20 in TASL chambers and 20 in In-house chambers

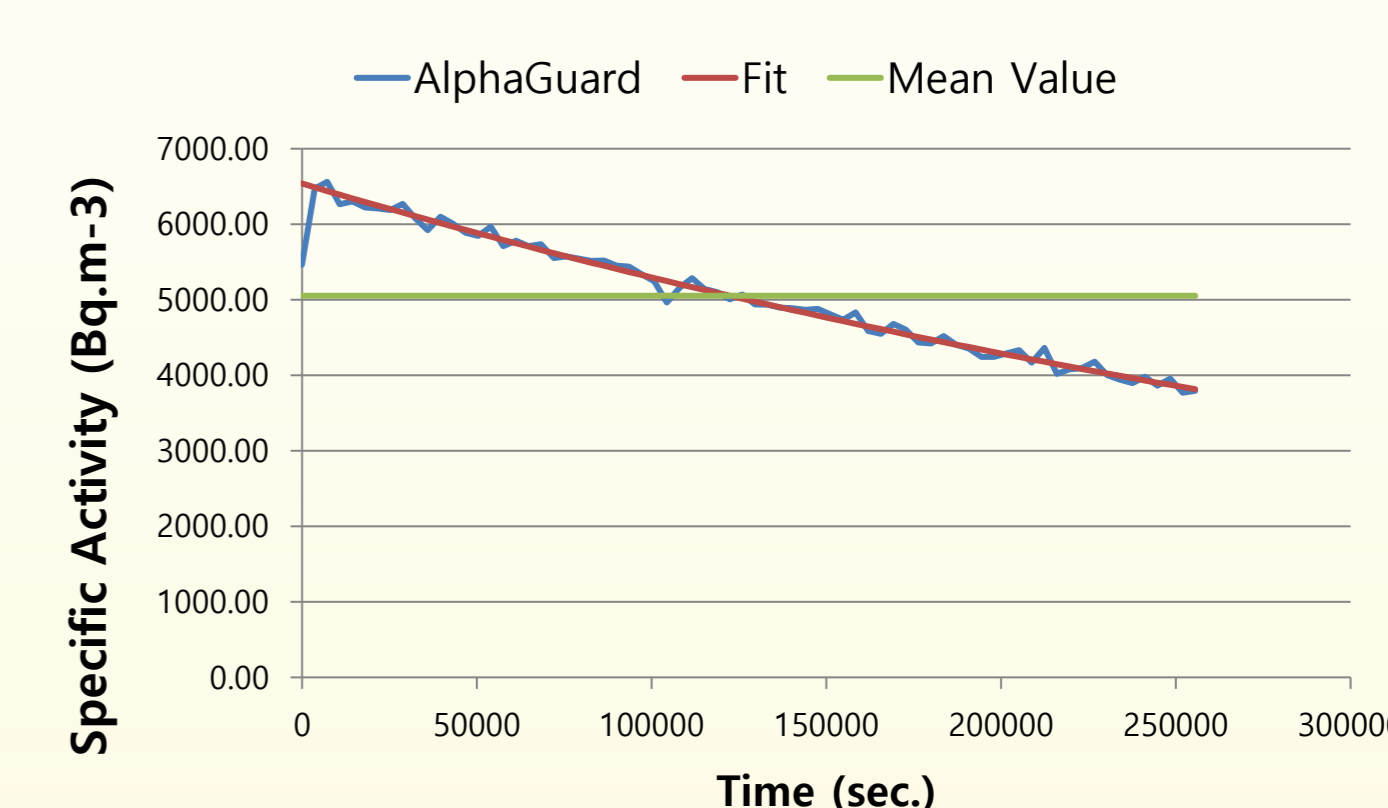
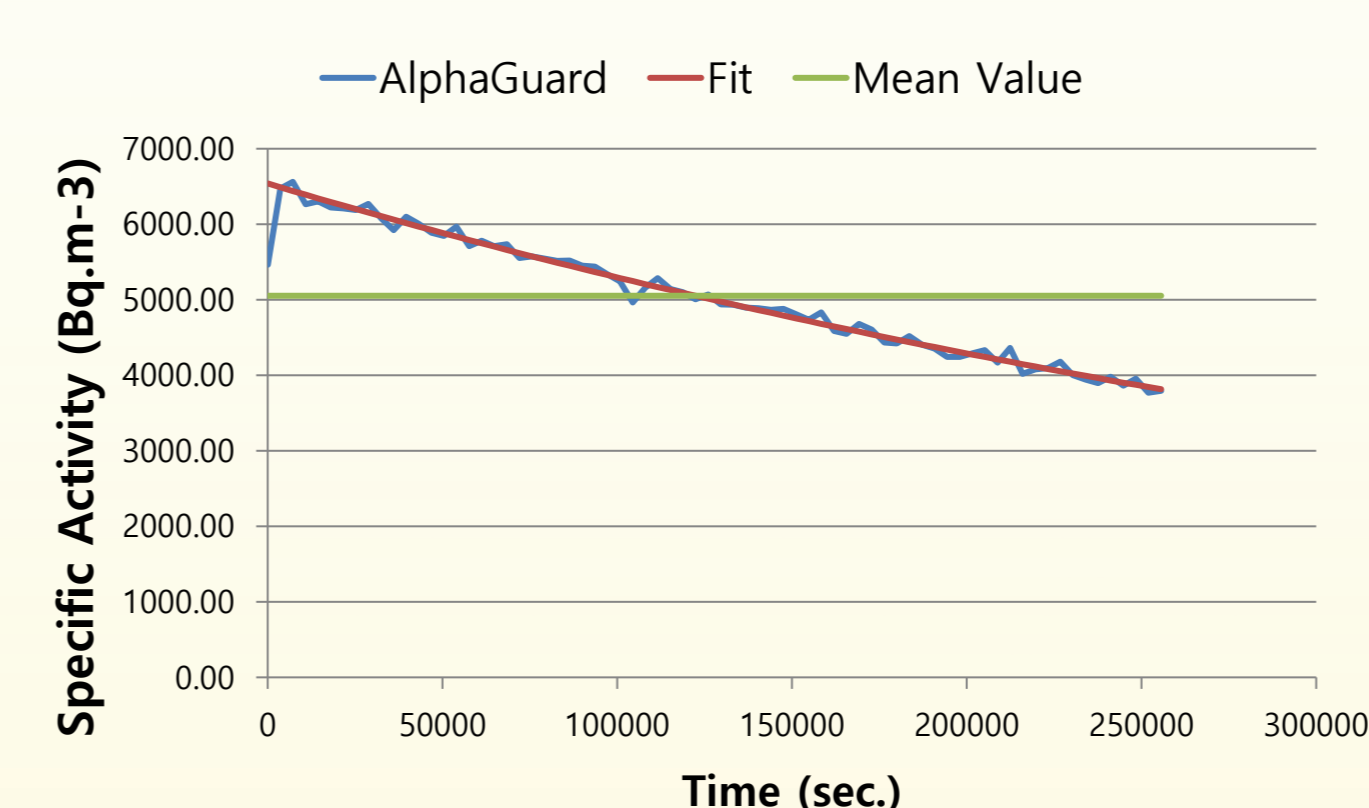
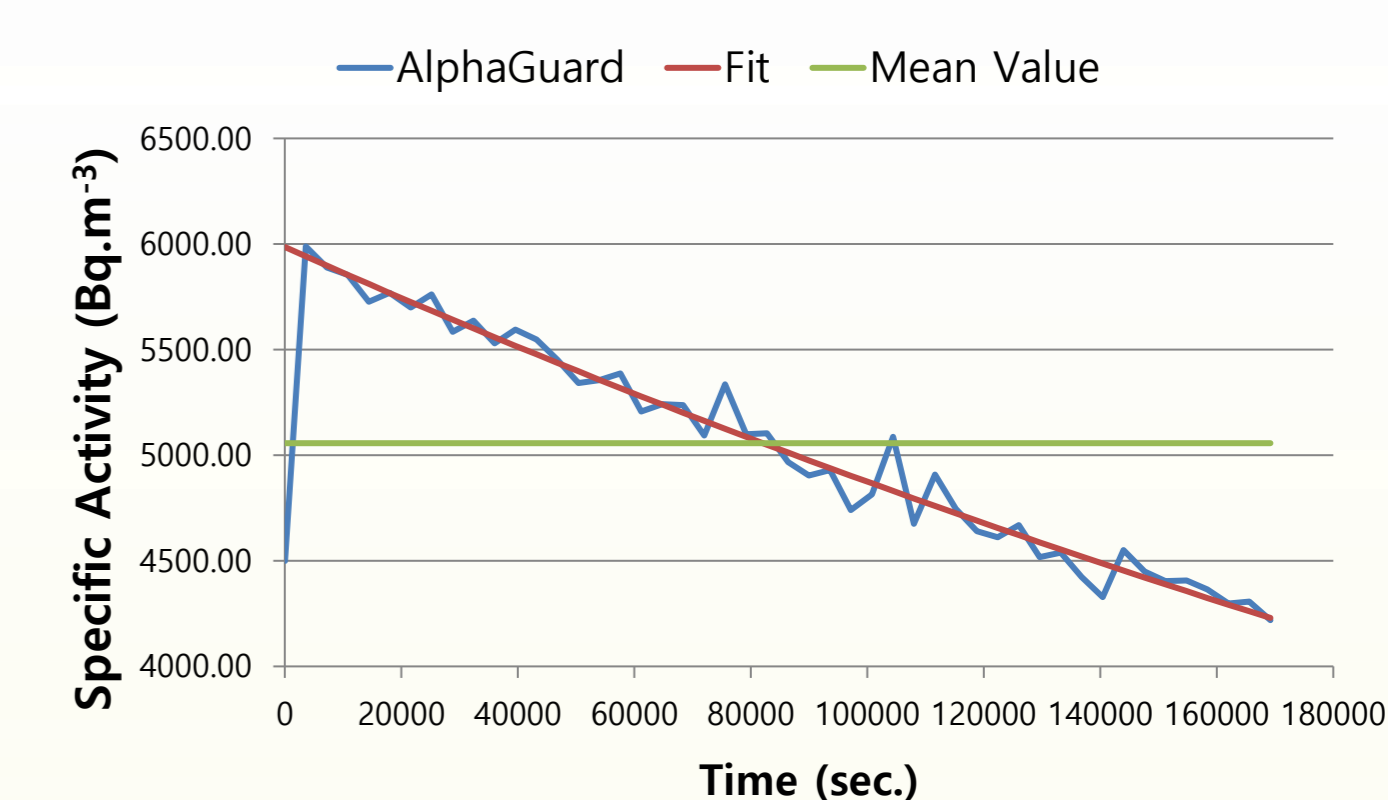
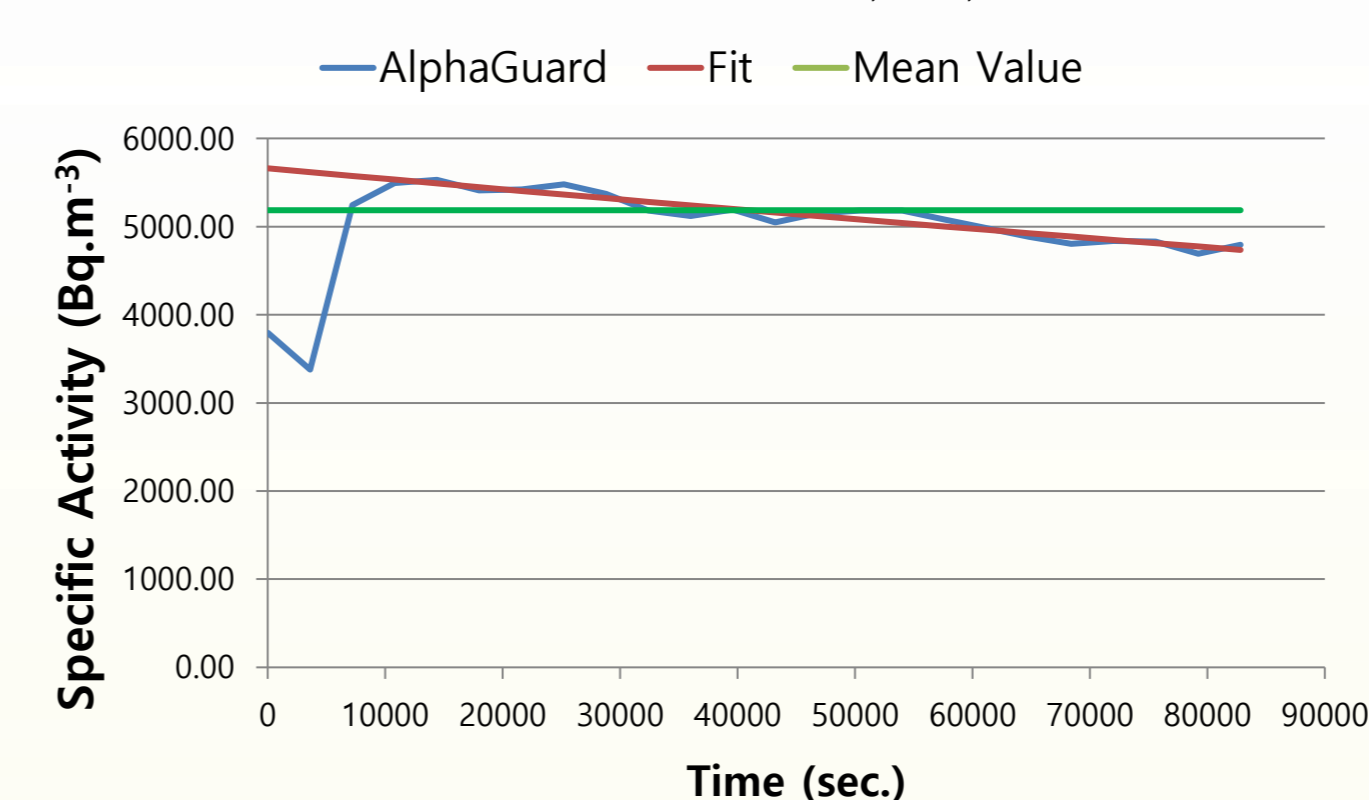
• Multiple scans approach applied

RESULTS

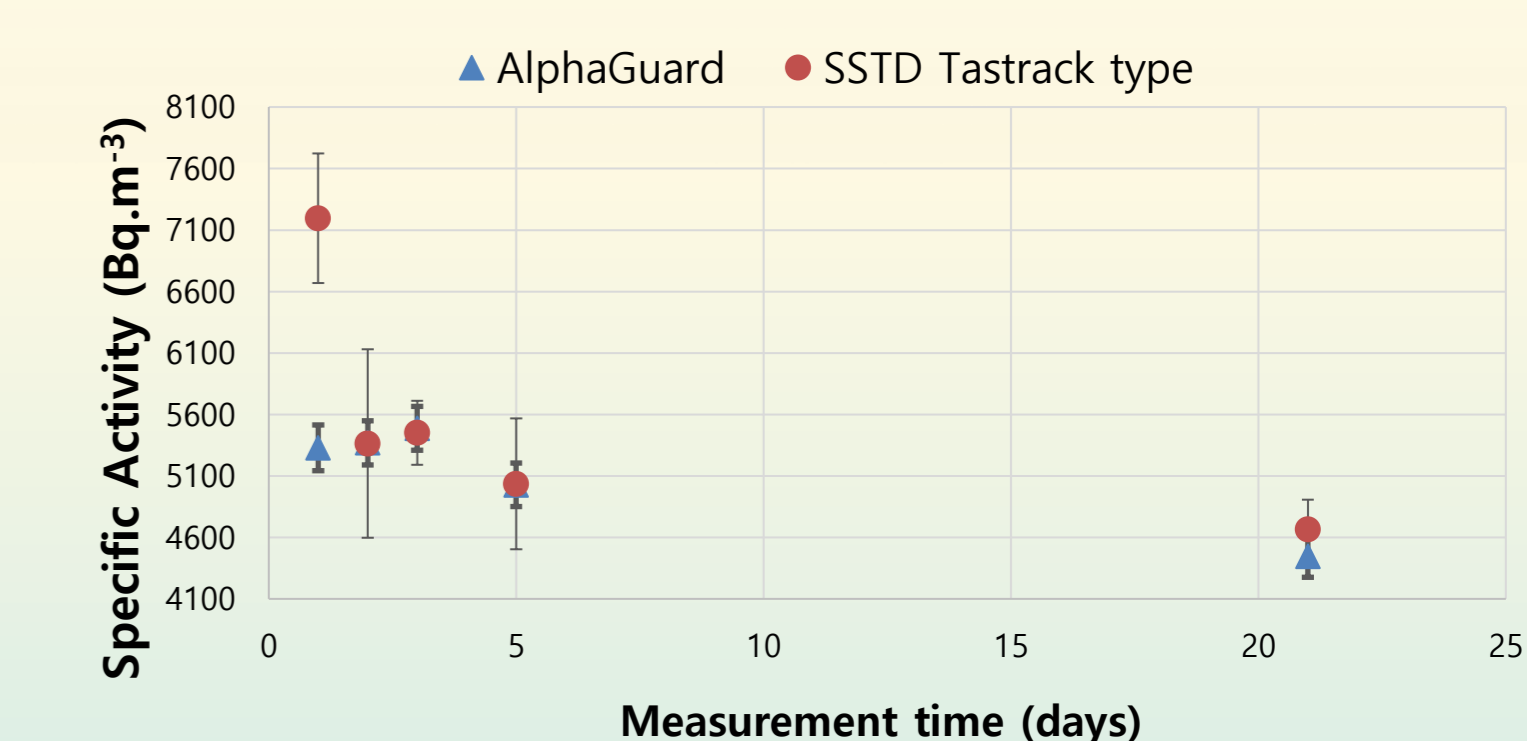
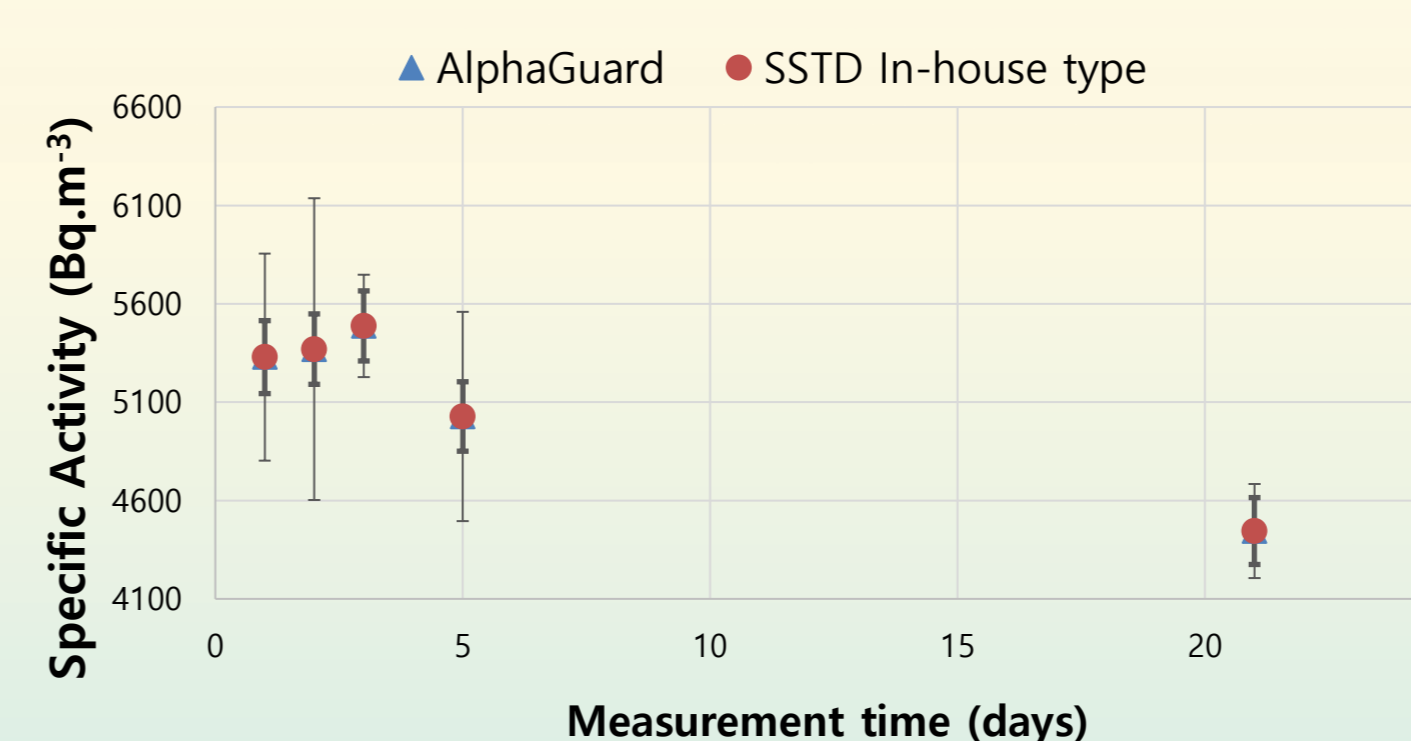
AlphaGuard detector

• The radon atmosphere inside the chamber is monitored by the calibrated AlphaGuard detector

- ✓ Works on the principle of an ionization chamber
- ✓ **The radon activity is measured in predetermined intervals and stored for evaluation**
- ✓ The data are corrected by the correction factors considering current pressure and temperature in the chamber during measurement.
- ✓ **The mean values of radon activities were used as reference values**
- ✓ Calculated from the integral of fitted functions corresponding to each measurement
- ✓ Calculated decay constant of radon was compared to the theoretical value and agreement in all measurements were achieved
- ✓ Relevant fits shown for 1d, 2d, 3d and 21 d.



Comparison of TASLImage results to reference values



V. CONCLUSIONS

• Measurements are still ongoing.

- ✓ Experiments at the level of 1 kBq.m⁻³ already performed
- ✓ The specific activity of 5 kBq.m⁻³ needs more measurements
- ✓ Measurements up to 10 kBq.m⁻³ are planned.
- ✓ **Based on the results standardized Radon measurement process at the STU will be developed.**
- ✓ **Final goal is the qualified methodology for SSTD metrology of radon activity.**

✓ The In-house diffusion chambers provided very good flexibility and applicability in laboratory conditions.

✓ SSTD processing and evaluation procedures are at satisfactory level.

ACKNOWLEDGEMENTS