

DEVELOPMENT OF A MOBILE GAMMA-RAY LaBr₃:Ce DETECTOR SYSTEM FOR IN-SITU RADIONUCLIDE ANALYSIS AT TENORM CONTAMINATION SITES



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WHERE IT ALL STARTED



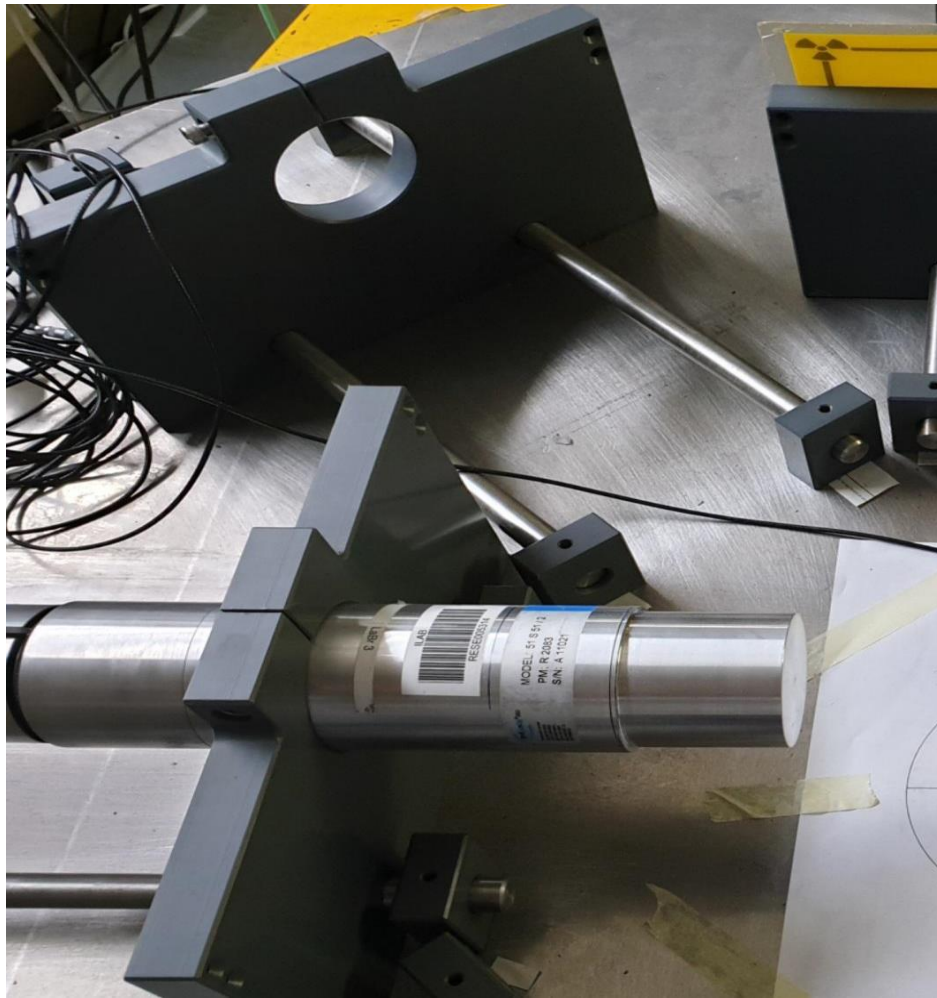
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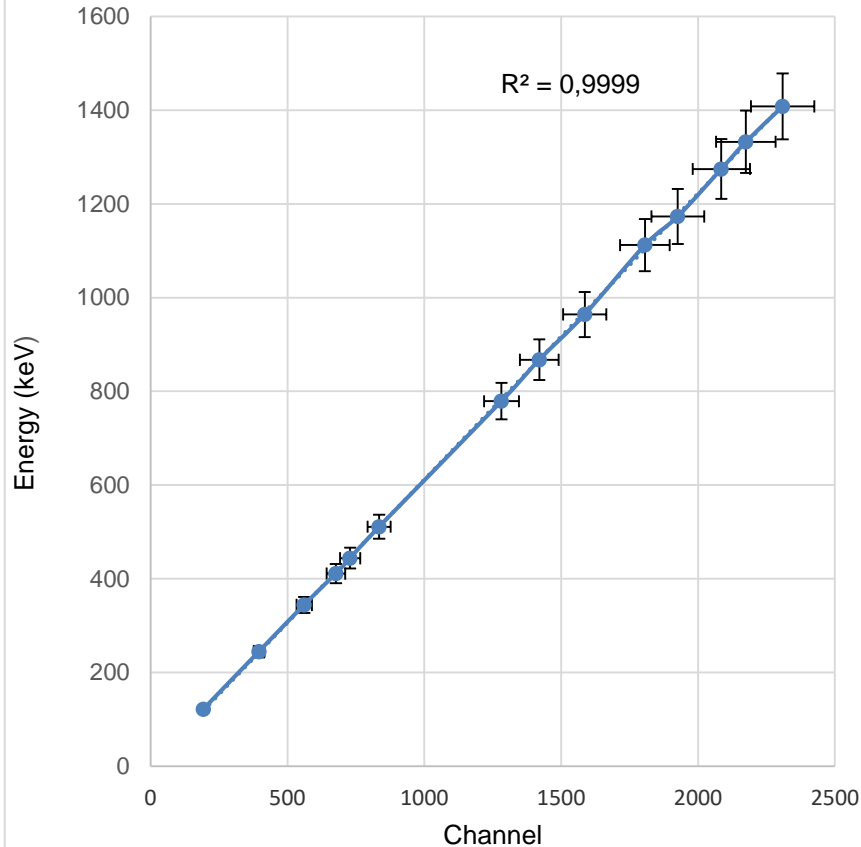
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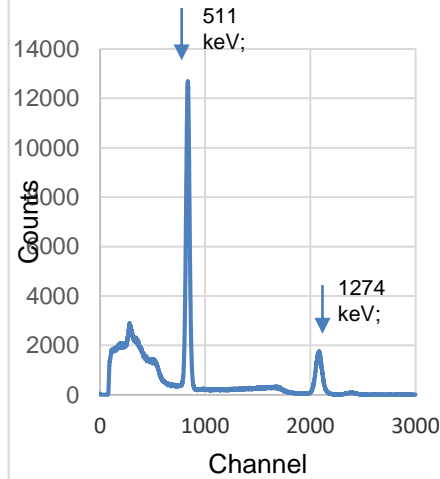


WHERE IT ALL STARTED

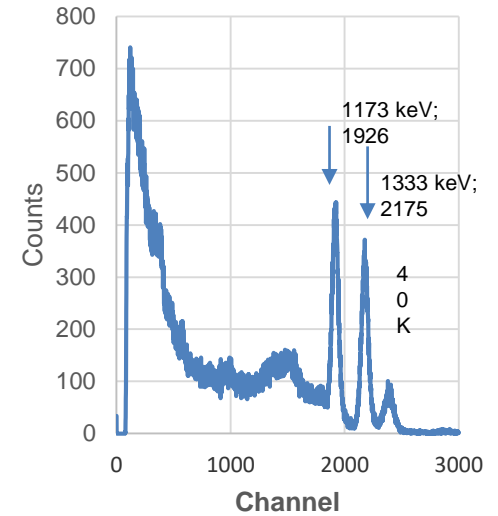
LaBr₃:Ce detector energy calibration



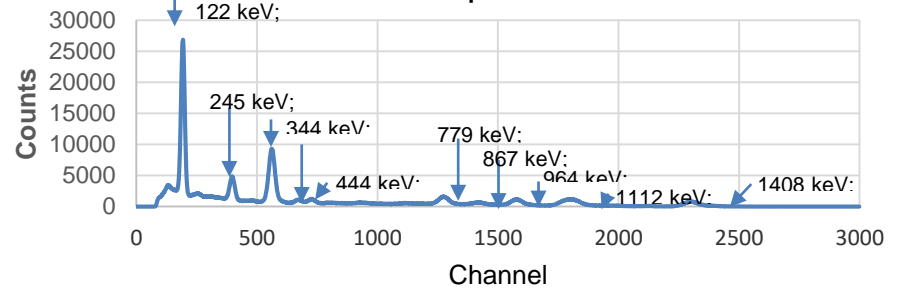
²²Na spectrum

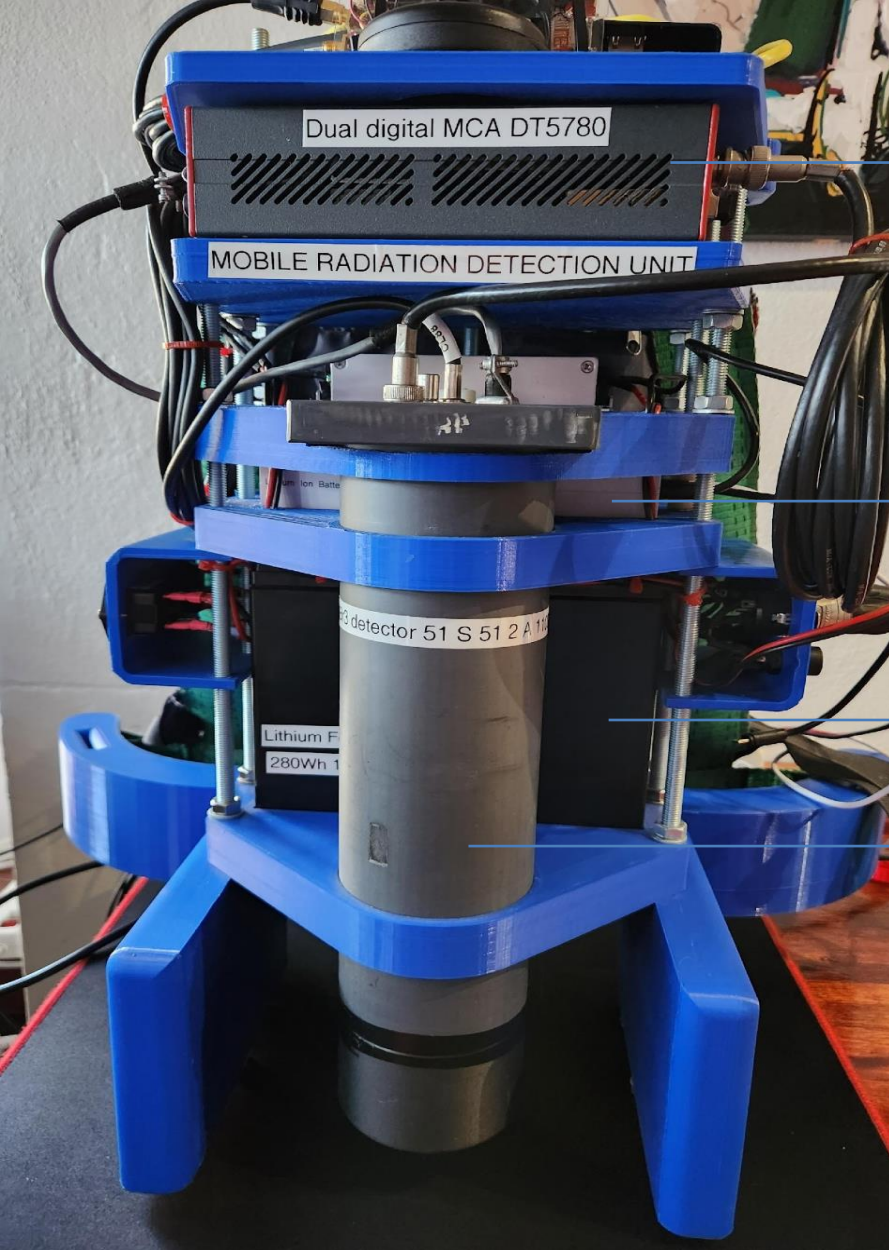


⁶⁰Co spectrum



¹⁵²Eu spectrum



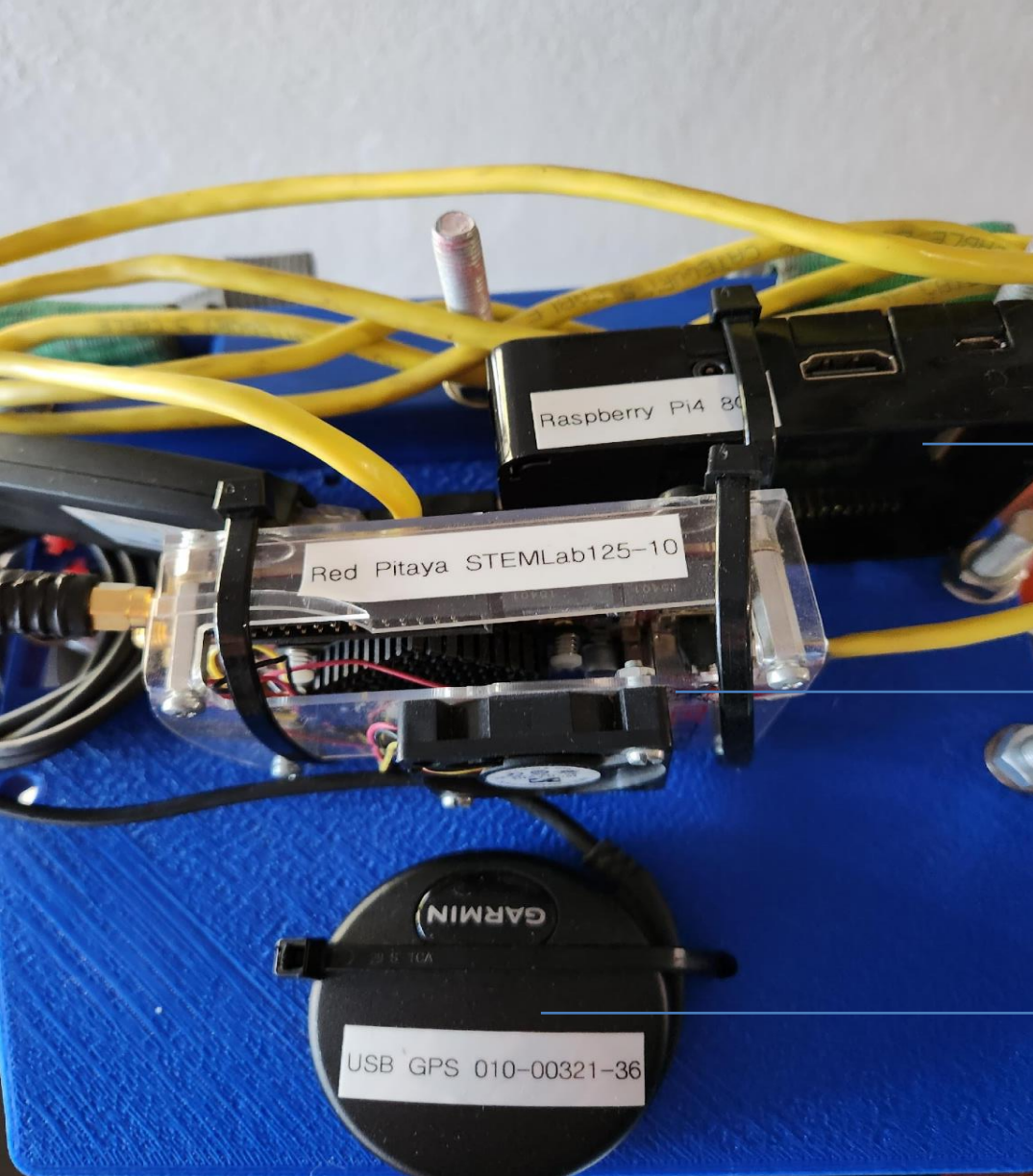


Multichannel
analyser

Power bank (Li-ion
battery)

LiFePO₄ battery

LaBr₃:Ce detector



Raspberry Pi

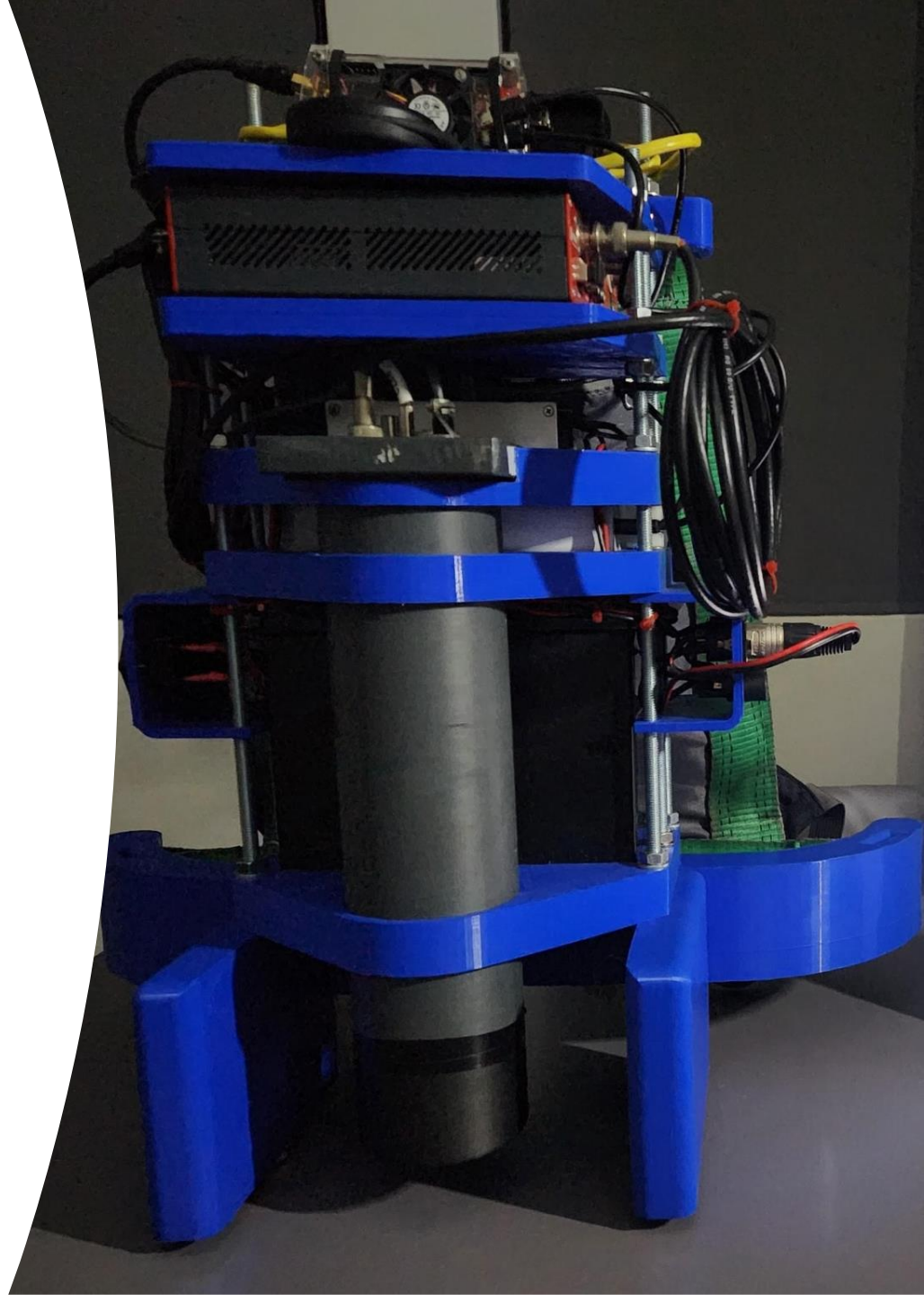
Red Pitaya DFT
spectrum
analyser

GARMIN
UPS GPS

MOBILE RADIATION DETECTION UNIT

Why use a 2"x2" LaBr₃:Ce detector?

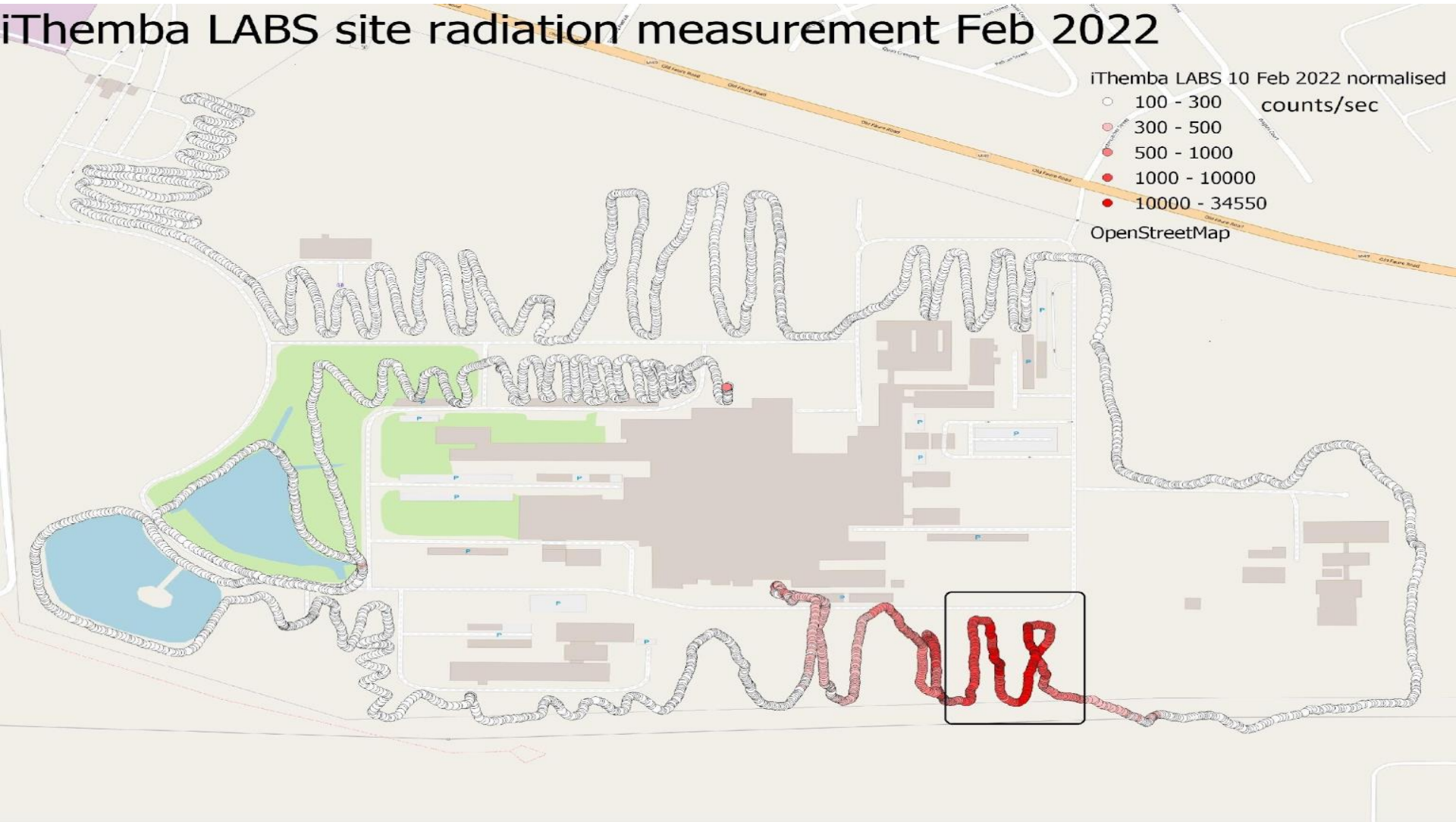
- Compared to the conventional NaI:TI detector:
- More than two-fold better peak resolution (3%) compared to NaI:TI (6-7%) at 662 keV.
- Good photon detection efficiency.
- The size and mass of the detector allows mobile applications.





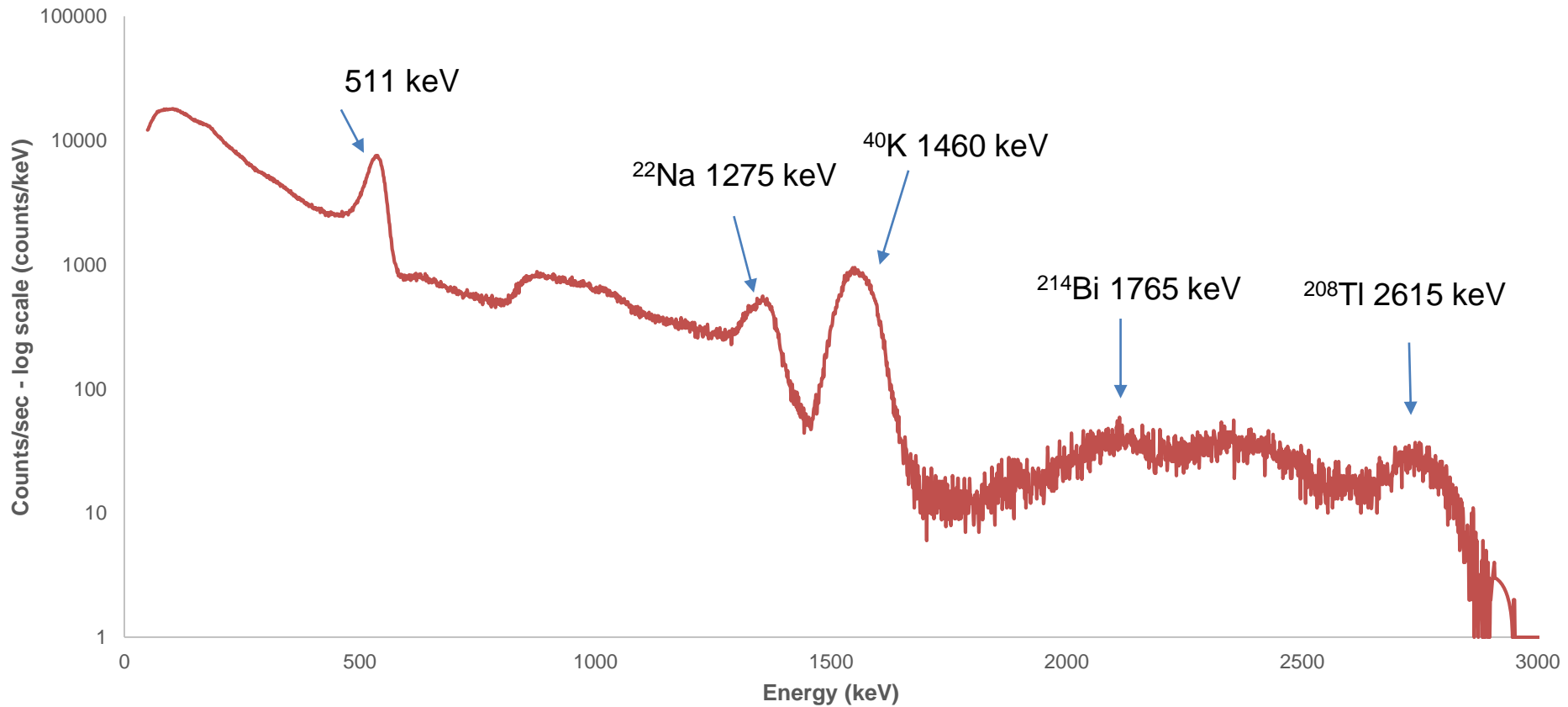
EXPERIMENTAL AND RESULTS

iThemba LABS site radiation measurement Feb 2022



EXPERIMENTAL AND RESULTS

iThemba LABS site spectrum - February 2022



EXPERIMENTAL AND RESULTS



PHOSPHATE MINING AND URANIUM



During Dec 2013/Jan 2014 a leak at the Bosveld Phosphate mine led to the spillage of processed water into the Selati River which runs through the KNP.

This mine produces phosphoric acid which is used in fertiliser production.

Rehabilitation of affected areas was done early 2015.

(Mail and Guardian, March 2015).

EXPERIMENTAL

Calibration of the MRDU was done at the National Energy Corporation of South Africa.

The MRDU was used to do in situ measurements:

- In the KNP: The Olifants River where no radionuclide contamination is expected, and at the rehabilitated Selati River site.
- Close to the WFS, West-Rand.

Real-time spectra and data will be used for conclusions.



EXPERIMENTAL AND RESULTS

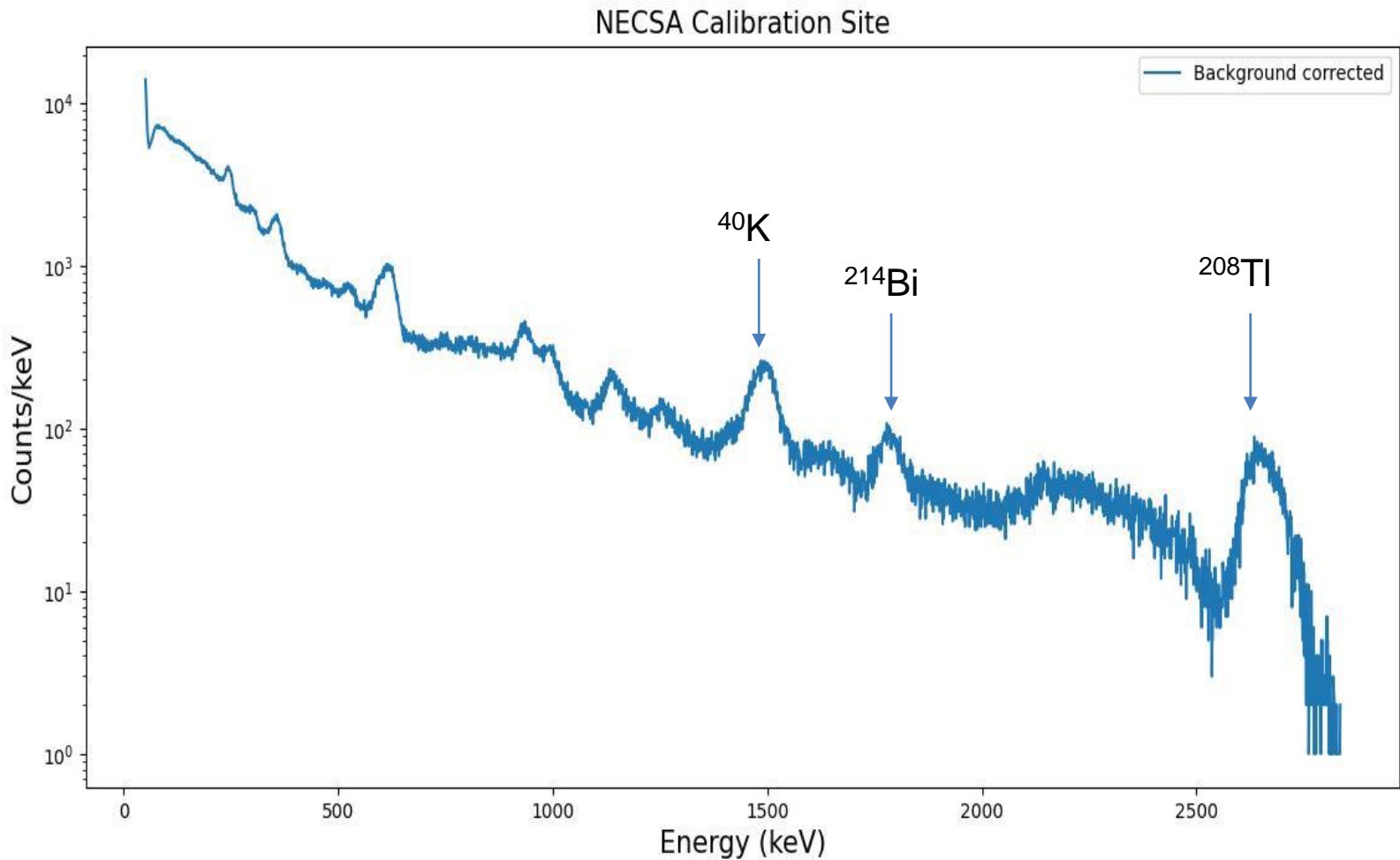


EXPERIMENTAL AND RESULTS

NECSA calibration site: up/down narrow measurement



EXPERIMENTAL AND RESULTS



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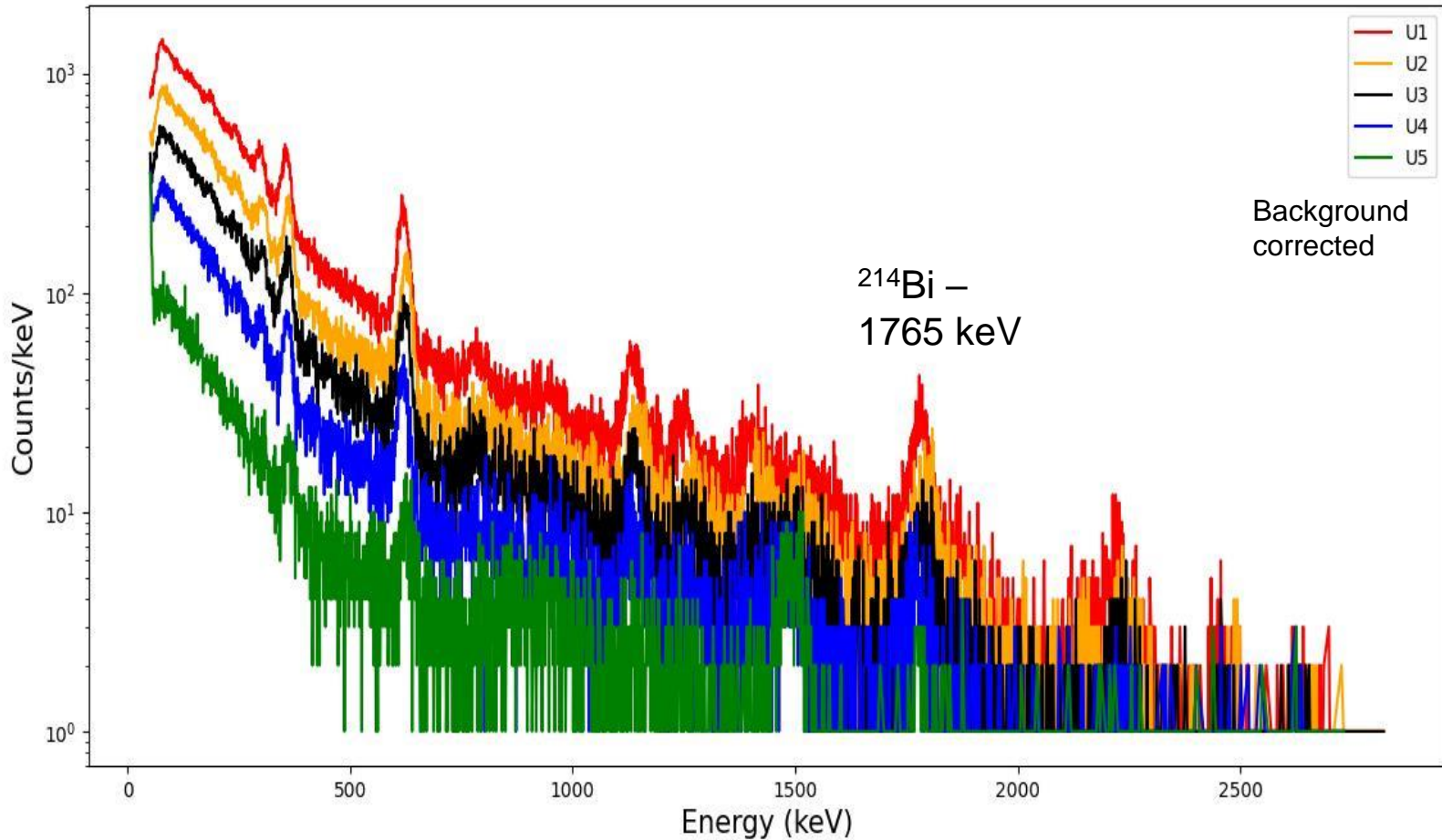
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NECSA Calibration Site - Uranium Pads



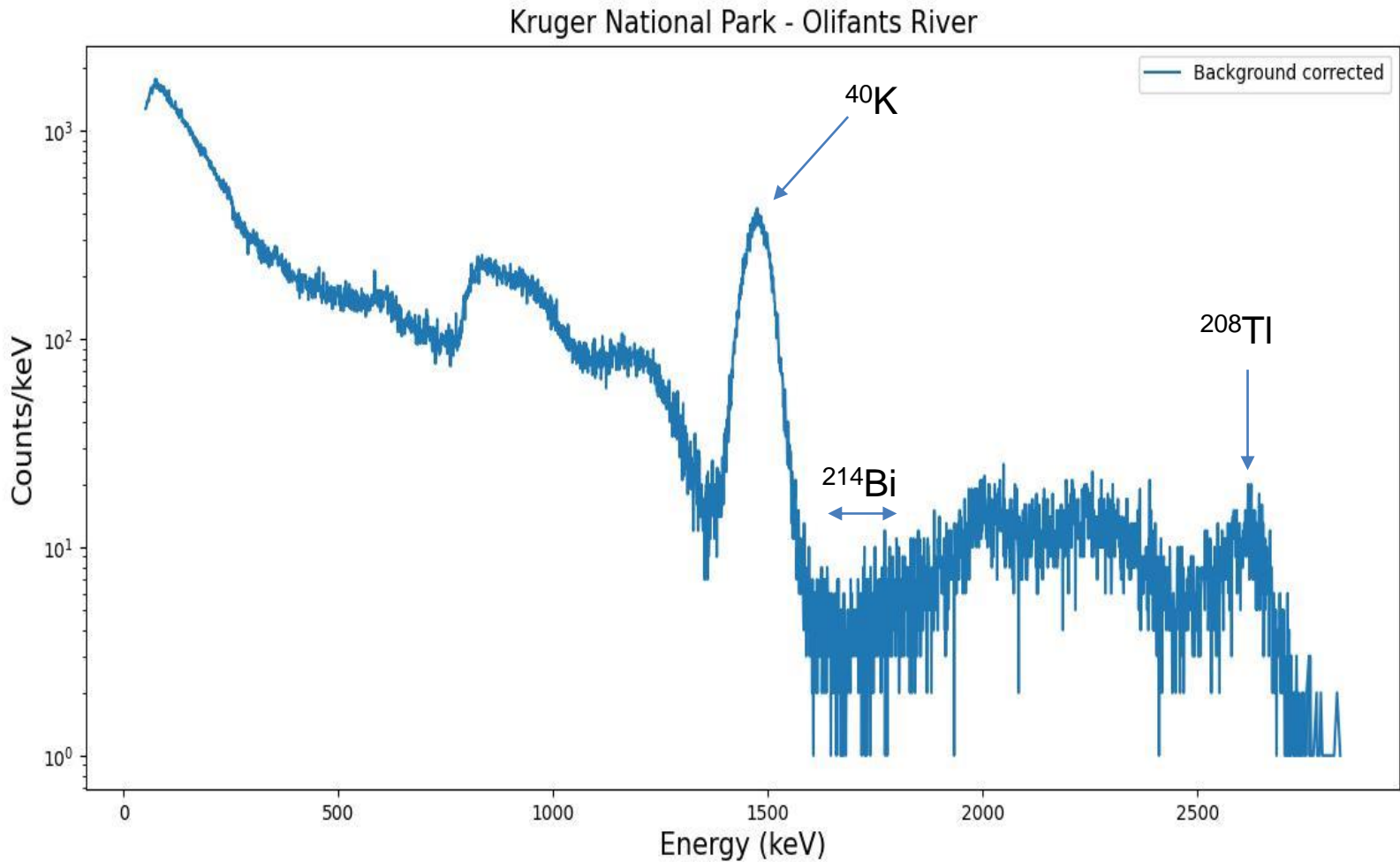
EXPERIMENTAL AND RESULTS



EXPERIMENTAL AND RESULTS



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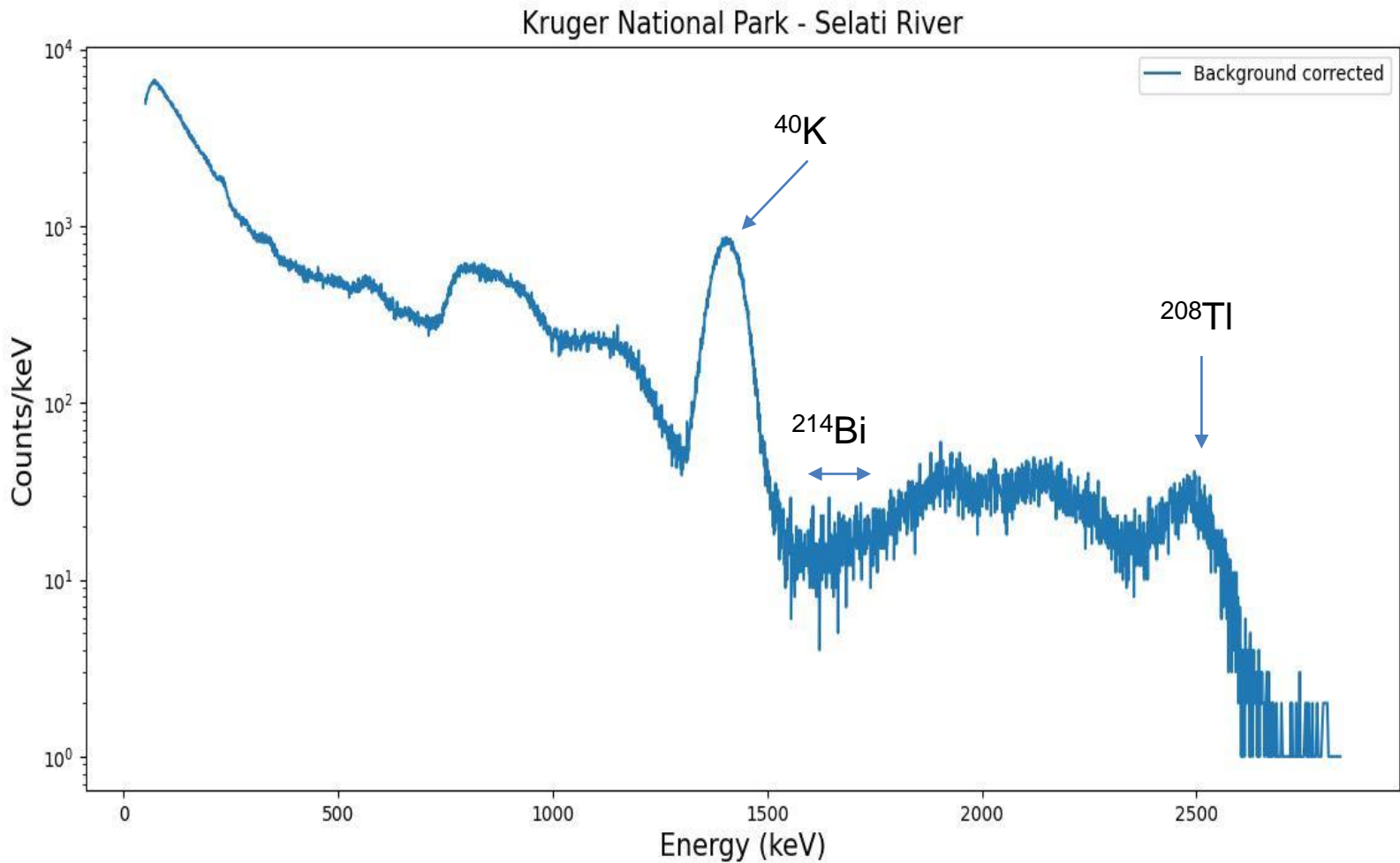
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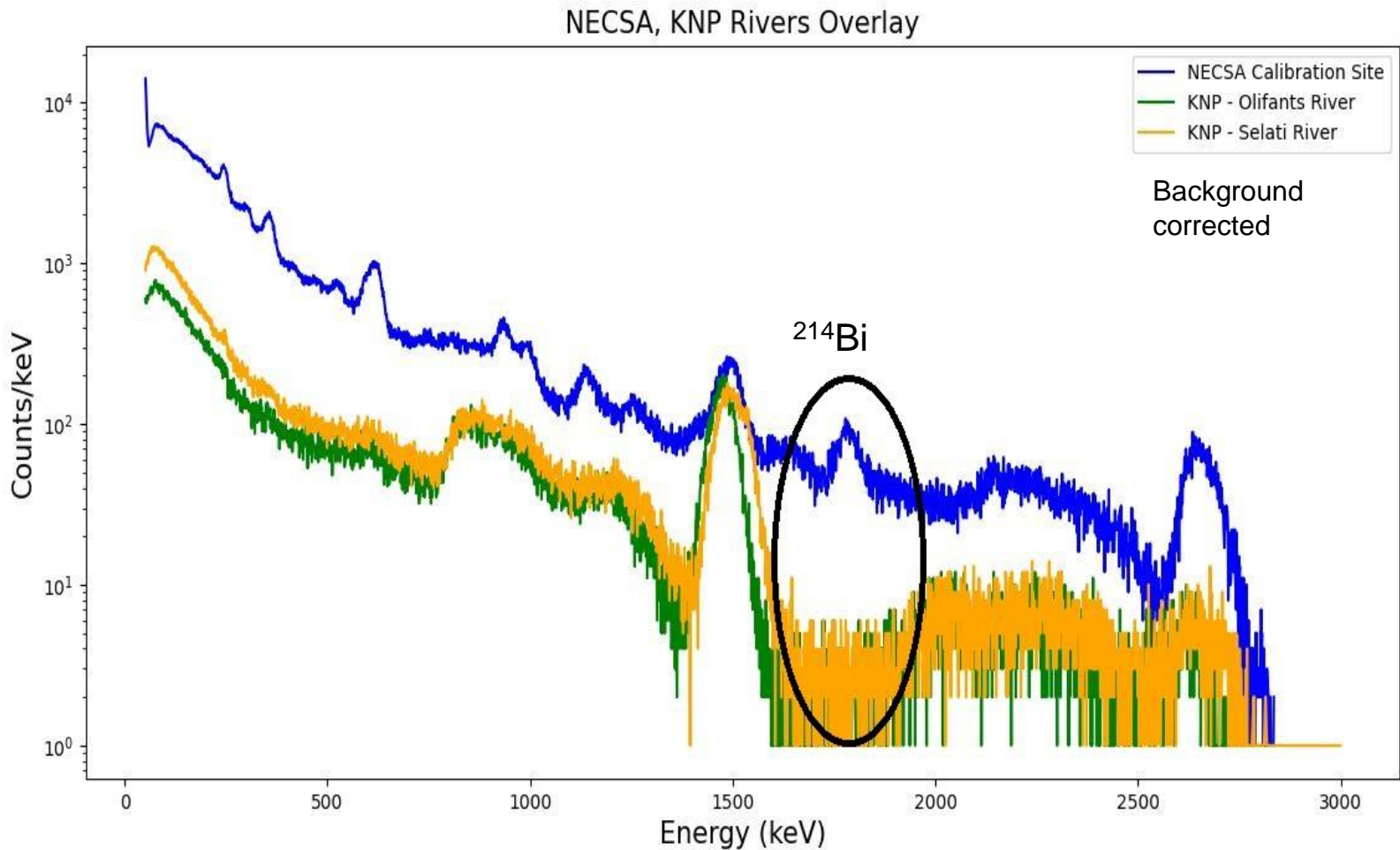
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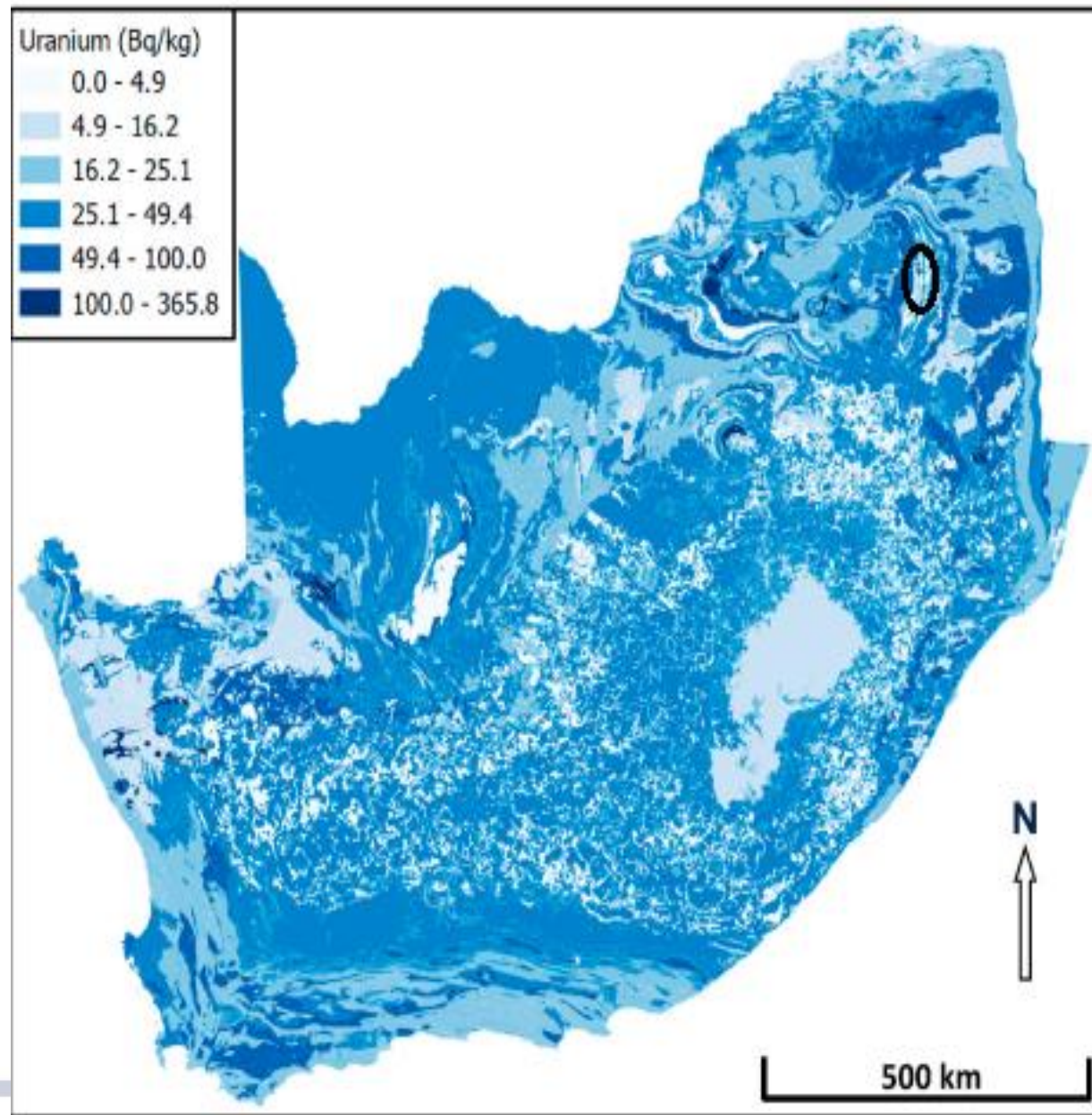


EXPERIMENTAL AND RESULTS



Geological distribution of uranium in SA.

Bezuidenhout, J. (2021). Estimating indoor radon concentrations based on the uranium content of geological units in South Africa, *Journal of Environmental Radioactivity*, 234.



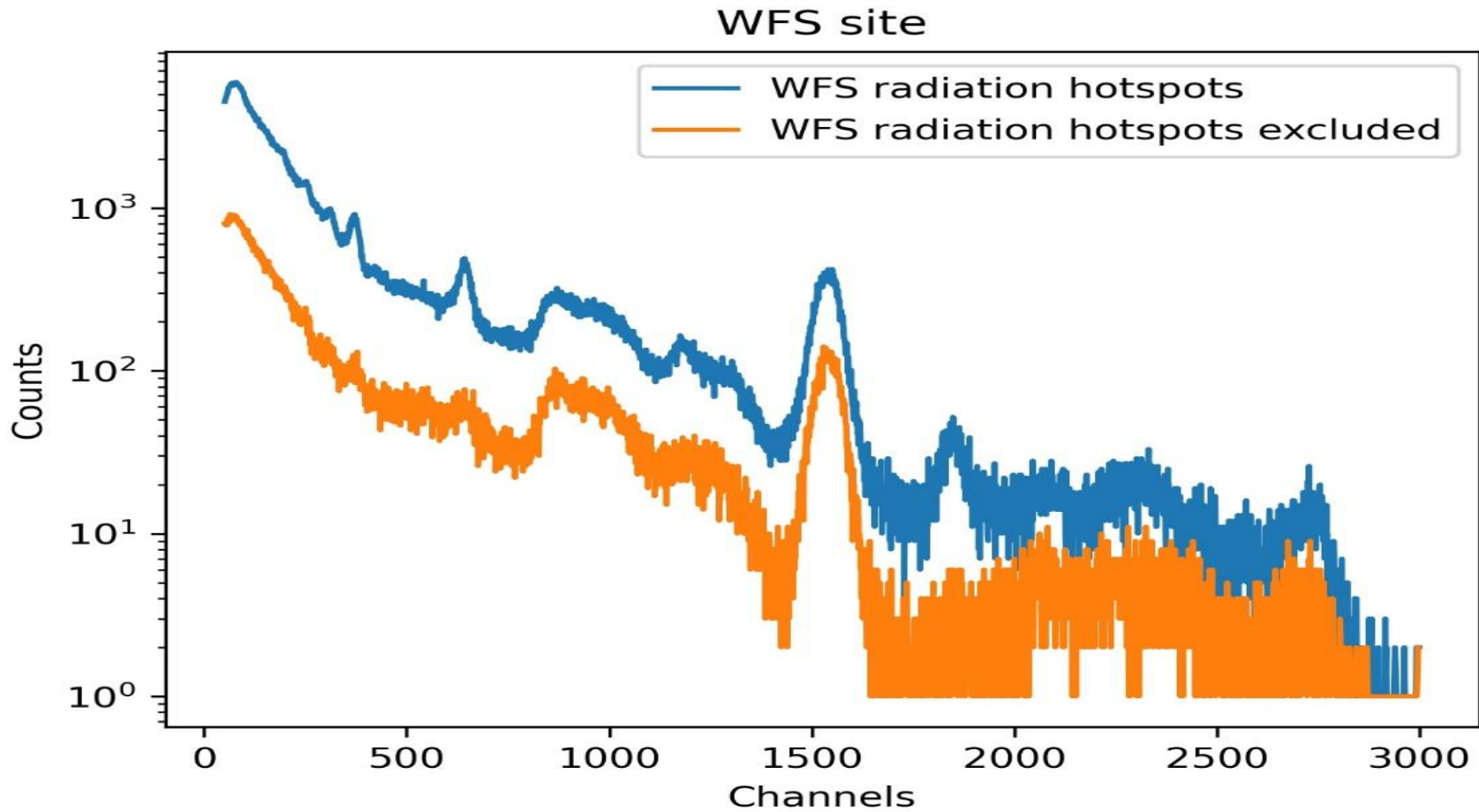
EXPERIMENTAL AND RESULTS



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EXPERIMENTAL AND RESULTS



EXPERIMENTAL AND RESULTS

- During a previous discussion (SAIP conference 2021) the influence of the solid angle on the detection limit of radiation measurements using the LaBr₃:Ce detector has been discussed.
- During these measurements the height of the MRDU above the ground surface was approximately 848 mm.
- However, this height will fluctuate slightly during in situ measurements because of the robustness of terrestrial environments.
- The detection limit for uranium (1765 keV) was calculated as approximately 246 Bq/kg.
- van Niekerk, F., Jones, P., and Johnson, S. (2021). Investigation of the relation between limit of detection and solid angle by measuring standard radioactive sources with a LaBr₃:Ce detector. *SAIP2021 Proceedings*, SA Institute of Physics.

EXPERIMENTAL AND RESULTS

	Activity concentration (Bq/kg)	mg/kg (ppm converted)	ICP-MS (ppm)
KNP - Mamba Weir	<200	<16	<2
KNP – Spill site	<200	<16	<2
WFS site	597 (24)	48	50

CONCLUSION

- Real-time data obtained at the calibration site and the sites under investigation showed satisfactory spectral sensitivity and peak resolution.
- Conclusions can be made about the “what, how much and where” regarding radiation in various terrestrial environments.
- The MRDU proved to be effective for doing measurements in hostile environments.

THANK YOU!



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