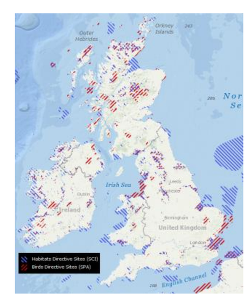
New detectors for live-monitoring of radionuclides in wildlife

Ross Fawkes[1], Nicholas A. Beresford[1,2], Peter H. Burgess[3], Michael D. Wood[1]

[1]*University of Salford*, [2]*NERC-CEH*, [3]*Radiation Metrology Ltd.*

1. Why are new methods needed?



In the UK, most environmental radiological risk assessments focus on protected species in accordance with the EC Birds and Habitats Directives [1]. To help with these assessments, various modelling tools have been developed [e.g. 2].

Modelling tools predict whole body radionuclide activity concentrations, generally using simple concentration ratios ($CR_{wo\text{-}media}$). In terrestrial environments, $CR_{wo\text{-}soil}$ is determined by

$$CR_{wo-soil} = \frac{\text{Biota whole-body activity concentration (Bq kg}^{-1}\text{ fresh mass)}}{\text{Soil activity concentration (Bq kg}^{-1}\text{ dry mass)}}$$

For the purposes of compliance monitoring, it would be beneficial to verify predicted whole body activity concentrations. As many assessment species are protected, there is growing interest in non-lethal monitoring techniques such as live-monitoring.

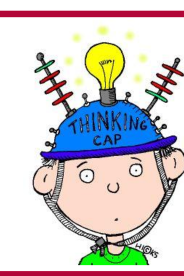
Limitations of current live-monitoring methods

- Not specifically designed for animal monitoring and requires some samples to be destroyed [3] or transported [4] in order to verify results.
- Usually large and often impractical [5] or has serious limitations [6] making it unsuitable for long term field research.

2. Project Aim

Develop new methods and technologies for measuring radionuclide activity concentrations in wildlife, without the need to destroy the target organism.

3. Designing the detector



Key design considerations include wildlife and site characteristics (Box 4), range of radionuclides (Box 5), detector materials (Box 6) and data processing (box 7).

4. Wildlife and site characteristics

Target species

- Selection of UK wildlife, with a focus on protected species [1].
- Target sizes will cover a range of protected species geometries.

Target environments

- Selected from review of Natura 2000 sites [1].
- Consider site conditions such as humidity and temperature.

Animal behaviour

- Minimisation of animal stress requires short scan times.
- Animal species will influence counting time as well as design of holding apparatus.

5. Radionuclides to consider

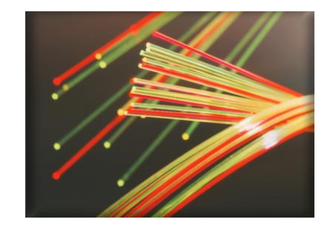
Target radionuclides

- Those currently present in UK regulated discharges with a focus on beta and gamma emitting radionuclides.
- Will need to consider discharge profiles and the influence of background radiation.

Detection limits

- Likely radionuclide activity ranges need to be identified to assist with material selection.
- Theoretical approach using data collected in wildlife studies [7][8]
- ERICA tool used to back-calculate whole-body activity concentrations giving rise to a screening dose rate of 10 µGy h^{-1} [2]
- Detection limit will be below this back-calculated value.

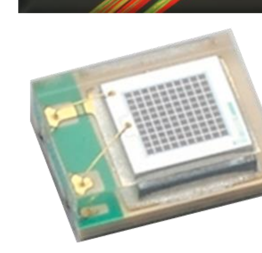
5. Materials



Detector material and photomultiplier tube (PMT)

- Wildlife, environmental and radionuclide characteristics will inform review and selection of appropriate materials and technologies.

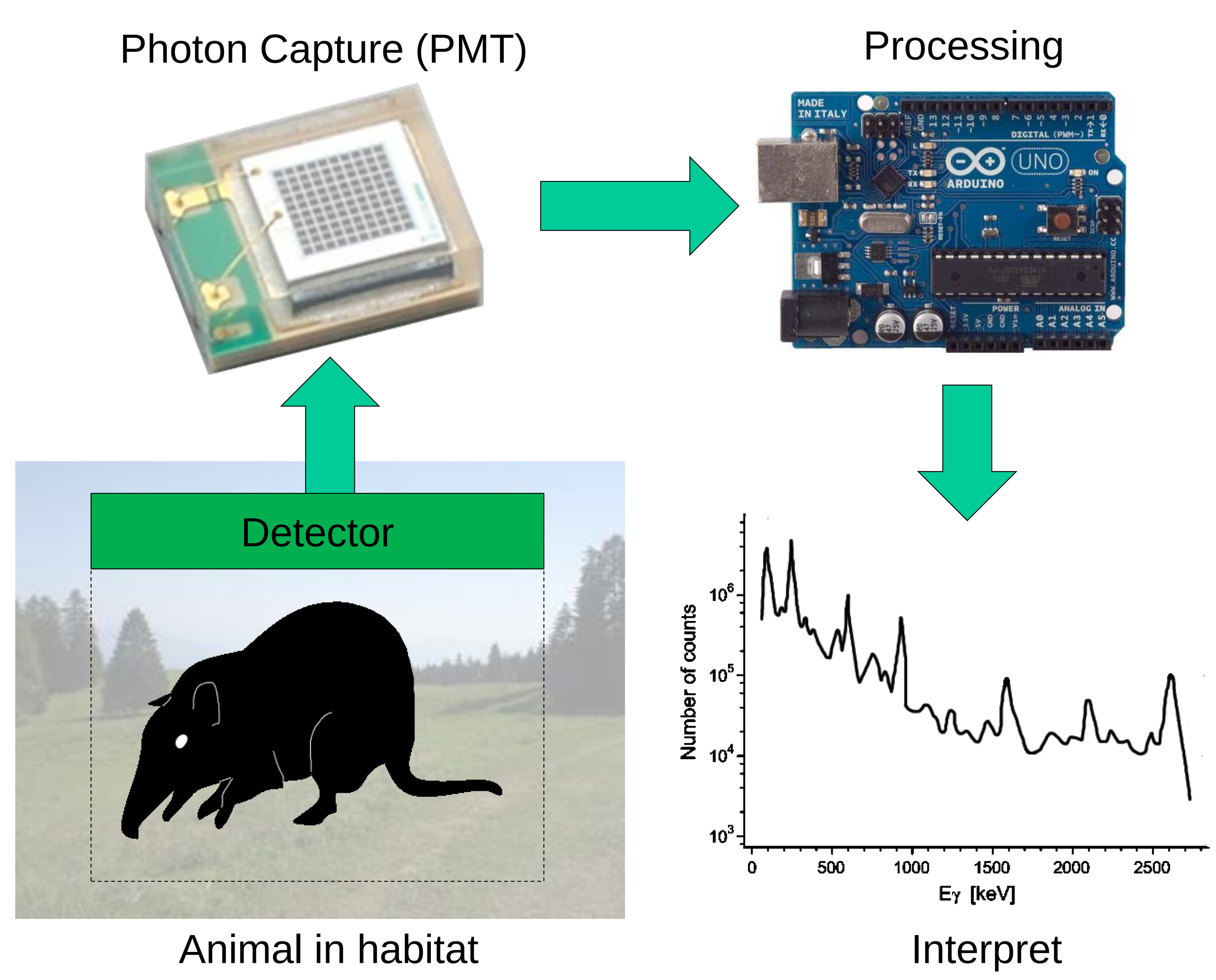
Dimensions, weight and power



- Materials must use a suitable power draw that will prolong the use of the device in the field.
- Device dimensions and weight must allow for easy portability.

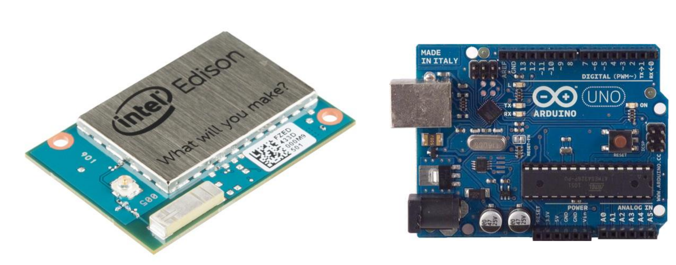
Shielding

- Available physical shielding and software filtering (background compensation) methods will be reviewed.
- Amount and type of physical shielding will be determined from background radiation profiles and from an analysis of the detector material (and material orientation).



6. Processing

Processing requirements



- Properties of radionuclides (Box 5) and selected detector materials (Box 6) will inform processing requirements.
- An evaluation of available (small) microprocessors will identify the most suitable.
- Small size and low power draw will be limiting factors.

7. Testing

Test of device without organisms

- Initial testing and calibration of a fully constructed prototype will be competed using radioactive phantoms that have been constructed using animal and radionuclide parameters identified in boxes 4 and 5.

Test of device using live organisms

- Comparison of measurements collected using the device on live animals under field conditions to measurements collected by laboratory based gamma detectors.
- The laboratory analysis will require destructive sampling of some organisms.

References

[1] COPPLESTONE, D., WOOD, M. D., BIELBY, S., JONES, S. R., VIVES, J. & BERESFORD, N. A. 2003. Habitats regulations for Stage 3 assessments : radioactive substances authorisations. Environment Agency R&D Technical Report P3-101/SP1a.

[2] BROWN, J. E., ALFONSO, B., AVILA, R., BERESFORD, N. A., COPPLESTONE, D., PRÖHL, G. & ULANOVSKY, A. 2008. The ERICA Tool. Journal of environmental radioactivity, 99, 1371-83.

[3] HOWARD, B. J., BERESFORD, N. A., BURROW, L., SHAW, P. V. & CURTIS, E. J. C. 1987. A comparison of caesium 137 and 134 activity in sheep remaining on upland areas contaminated by Chernobyl fallout with those removed to less active lowland pasture. Journal of the Society for Radiological Protection, 7, 71.

[4] MIDDLETON, G. Tennesse Department of Environment and Conservation DOE Oversight Division Environmental Monitoring Report January through December 2011. 2011. 80-82.

[5] BONDARKOV, M. D., MAKSIMENKO, A. M., GASCHAK, S. P., ZHELTONOZHSKY, V. A., JANNIK, G. T. & FARFÁN, E. B. 2011. Method for simultaneous 90Sr and 137Cs in-vivo measurements of small animals and other environmental media developed for the conditions of the Chernobyl exclusion zone. Health physics, 101, 383-92.

[6] DIRECT INDUSTRY. 2015. Available: http://www.directindustry.com/prod/baltic-scientific-instruments/portable-spectrometers-nitrogen-cooled-56918-969675.html [Accessed 30th January 2015].

[7] ENVIRONMENT AGENCY, ENVIRONMENT AND HERITAGE SERVICE, FOOD STANDARDS AGENCY & SCOTTISH ENVIRONMENT PROTECTION AGENCY 2013. Radioactivity in Food and the Environment, 2012.

[8] IAEA. 2010. Handbook of parameter values for the prediction of radionuclide transfer in terrestrial and freshwater environments, TECHNICAL REPORTS SERIES No. 472. Vienna.

Acknowledgements

This work is being funded through the TREE project as part of the NERC Radioactivity And The Environment (RATE) programme. For more information see **www.ceh.ac.uk/tree**