British Geological Survey
NATURAL ENVIRONMENT RESEARCH COUNCIL

LANCASTER UNIVERSITY

Developing a Raspberry Pi magnetometer for schools in the UK

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We describe our efforts to build a magnetic field sensor to be deployed in schools across the United Kingdom, adding to the existing variometer network from AuroraWatch set up by the University of Lancaster (Figure 1).

The aim is to encourage students from 14-18 years old to look at how sensors can be used to collect geophysical data and integrate it together to give a wider understanding of physical phenomena.

A second aim is to provide useful data on the spatial variation of the magnetic field for analysis of geomagnetic storms, alongside data from the BGS observatory and SAMNET variometer network.

The system uses a Raspberry Pi computer as a logging and data transfer device, connected to a set of miniature fluxgate magnetometers. The system has a nominal sensitivity of around 1 nT RMS (~1 part in 50,000) in each component and is relatively low-cost at about £250 per unit. We intend to build 10 systems initially. In this poster we show results from the build and testing of the sensor and examples of recorded horizontal field.

Figure 1: Location of BGS observatories in the UK (yellow) and the currently operating AuroraWatch magnetometers (blue).
The test system described in this poster is located in Edinburgh (white).

A three-axis Raspberry Pi magnetometer

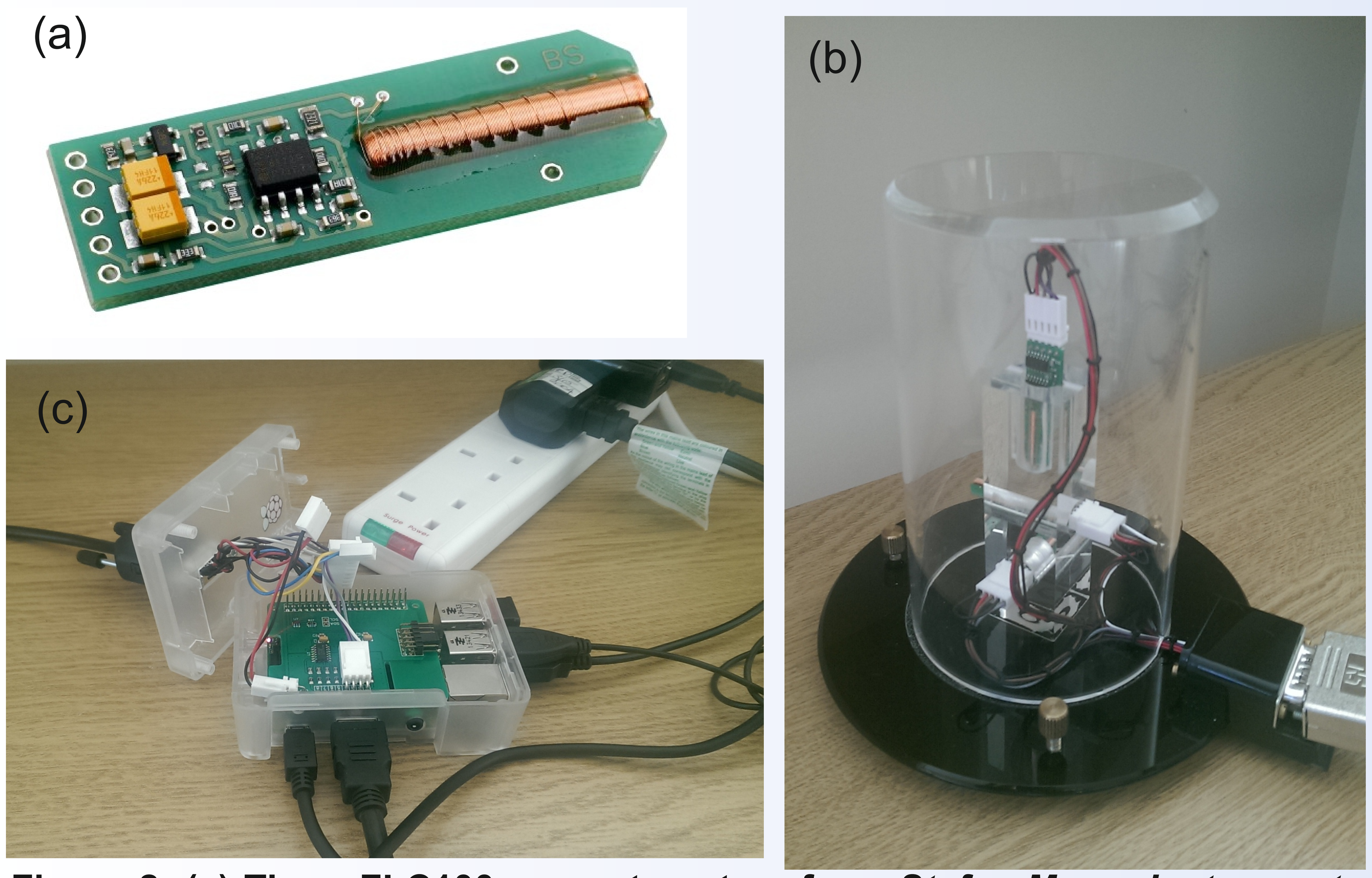

Figure 2: (a) Three FLC100 magnetometers from *Stefan Mayer Instruments* are mounted (b) orthogonally (North, East and Down) into a perspex block and wired together to common power and ground. The FLC100 magnetometers output a voltage proportional to the strength of the magnetic field. The output voltage is digitised by (c) an *AB Electronics* 17-bit digitiser connected to a Raspberry Pi computer. Software written in Python is used to read and record the values of the magnetic field from each component.

Panel (d) shows an example system connected to a monitor and keyboard.

Sensitivity and noise tests

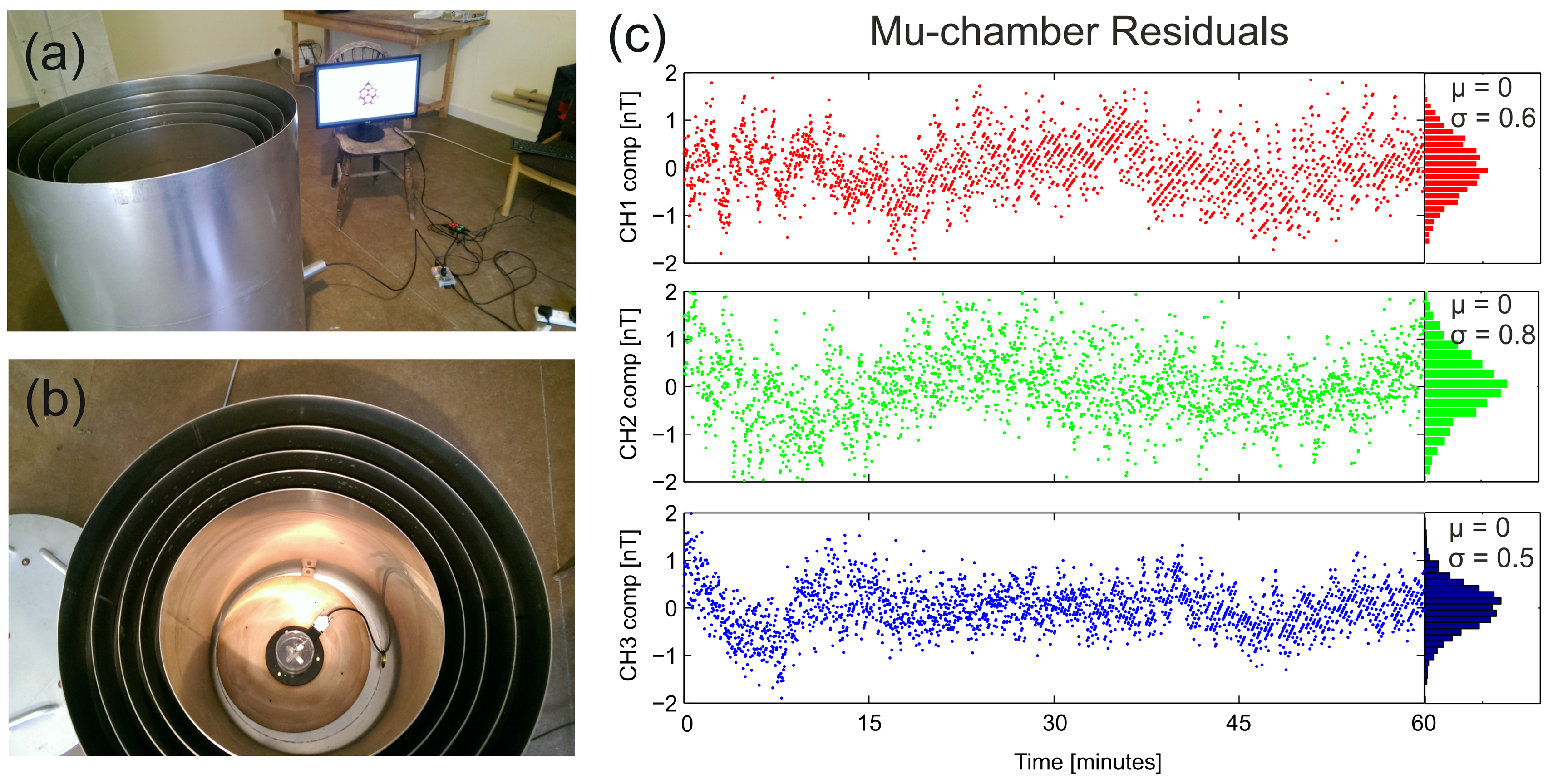

Figure 3: To test the performance of the system, the sensor block was placed into a mu-chamber (a,b) which reduces the background magnetic field to around 10 nT and damps short period variations. Data from the sensors were recorded at a cadence of 2 seconds for several hours. (c) The residuals (once the backgroud average has been removed) show an approximately Gaussian distribution with standard deviation of less than 1 nT.

Comparison to Observatory Instruments

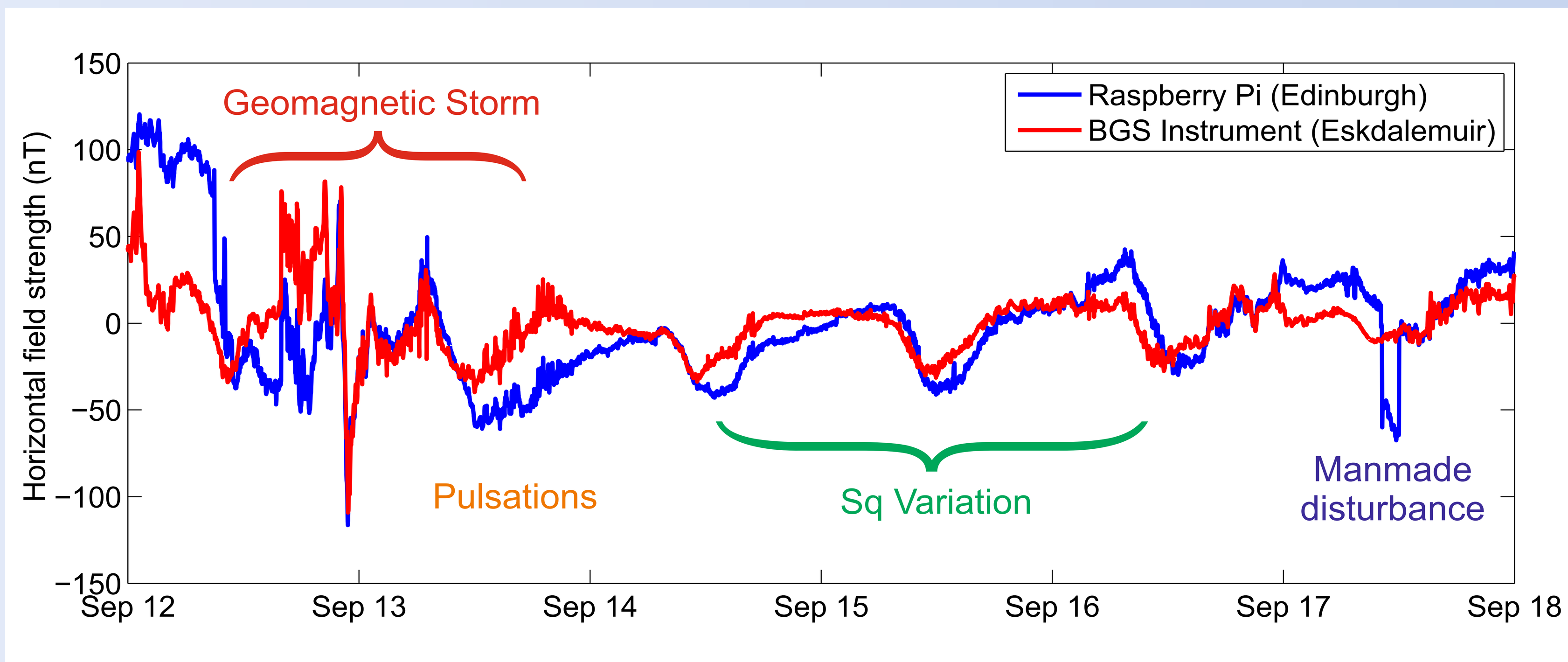

Figure 4: Six days of Horizontal component variation from the Raspberry Pi magnetometer recorded in the BGS office in Edinburgh are compared with data from the Eskdalemuir observatory (approx. 100km southward). The instrument detects phenomena such as storms, pulsations, Sq variation. It is also sensitive to local (manmade) disturbances. Data cadence is 5 seconds.

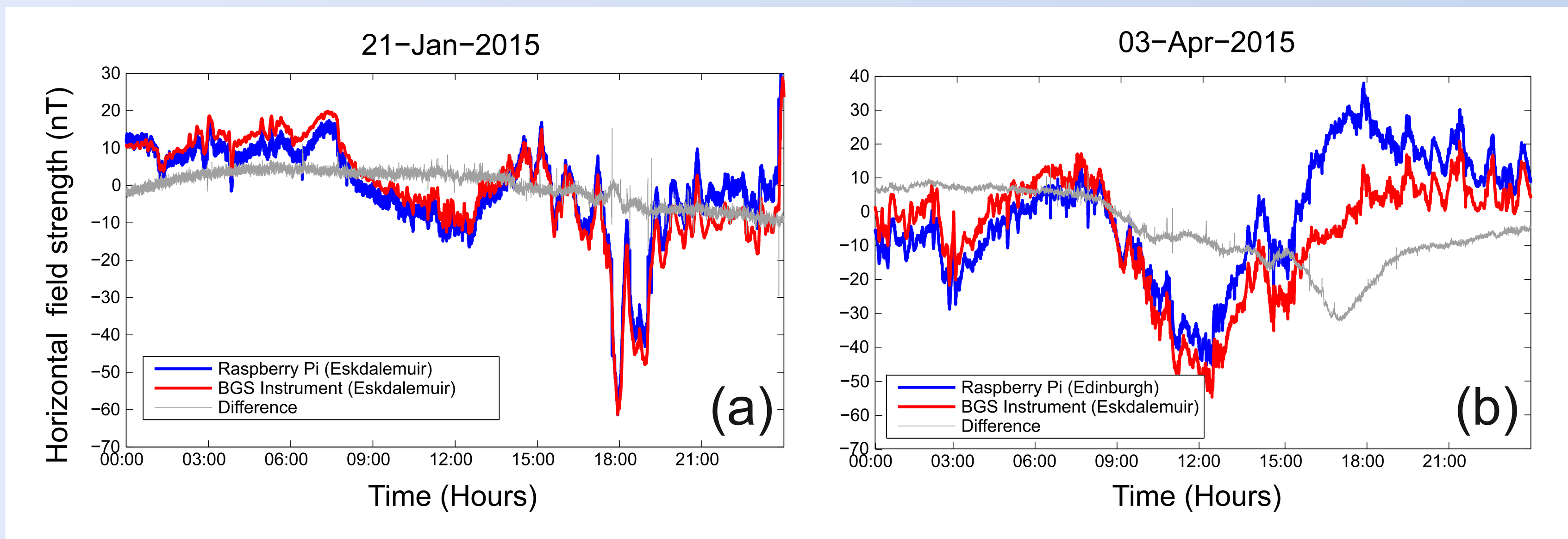

Figure 5: Detailed variation of the Horizontal component of the Raspberry Pi magnetometer compared with Eskdalemuir observatory data for two different days and locations.
(a) 21-Jan-2015: Data recorded in the Non-Magnetic Laboratory in Eskdalemuir . The differences are small and long-period. The RMS of the residuals is ~1.5 nT, using an older version of the digitiser.
(b) 03-Apr-2015: Data recorded in the BGS office in Edinburgh. The instrument is not temperature controlled, so responds to the cooling and warming of the air, particularly in (b) during the afternoon when the sun shines through the window. Data cadence is 5 seconds. A new model of the Raspberry Pi (B+) and digisiter reduces the RMS of the residuals (with background removed) to ~0.7 nT.

Next steps

We aim to complete the build and testing of the 10 Raspberry Pi magnetometers for deployment into schools by September 2015. The programme will run for a further 15 months in collaboration with the schools to understand how the systems behave in real-world environments and to develop educational materials (e.g. notes/code).

We hope the variation data collected will be useful for educational purposes but also for space weather applications and analysis. A better knowledge of the spatial variation of the magnetic field during large storms will be useful for induction studies e.g. for GIC and for understanding peak rates of change of the magnetic field.

Acknowledgements

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Want to make your own Raspberry Pi Magnetometer?

AuroraWatch: http://aurorawatch.net/ and http://aurorawatch.lancs.ac.uk/
Raspberry PI computer: https://www.raspberrypi.org/
FLC100 Fluxgate Magnetometers: http://www.stefan-mayer.com/
AB Electronics 17-bit digitiser: https://www.abelectronics.co.uk/
Accessories: http://www.modmypi.com

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