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# Summary of low-frequency magnetic field tests on a range of medical and research instruments in 2013 and 2014

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# Summary of low-frequency magnetic field tests on a range of medical and research instruments in 2013 and 2014

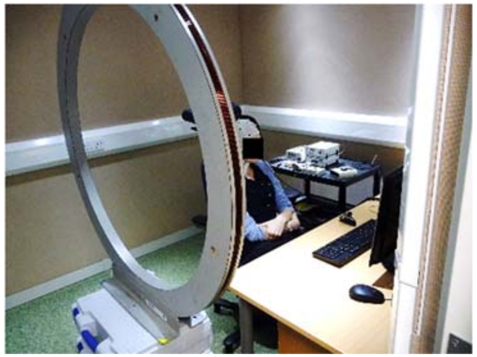
All these tests were carried out using a 1.2m diameter EMCO coil driven by a 1kW DC-coupled audio amplifier, in 2013 and 2014.

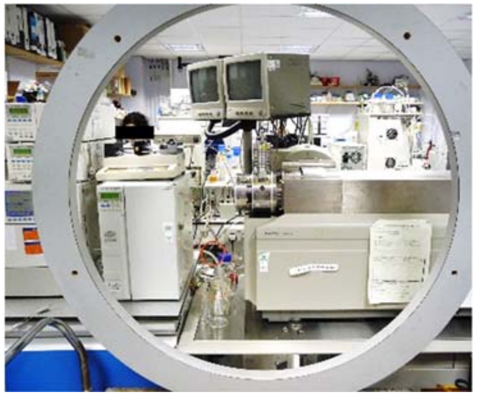
The field strength along the axis of the coil was calibrated, so that where it was not possible to place the equipment under test (EUT) actually in the centre of the coil, the field actually applied to the EUT could be calculated.

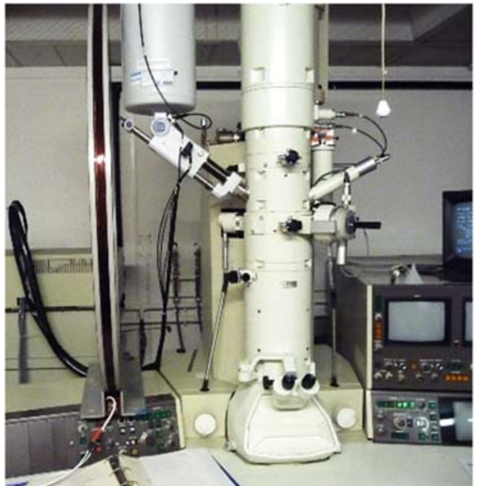
All three axes were tested with the EUTs set-up in the worst likely scenarios in each case, and the worst-case susceptibilities are reported in this summary. In all cases the equipment was operated by its usual experienced operators, whilst they were measuring their usual samples (whether human, animal, or mineral). The equipment's experienced operators were the only judges of whether interference with their instruments was evident, or not.

I recommend that that these results are assumed to have an error band of up to ±10dB.

Keith Armstrong, 25 August 2018,
keith.armstrong@cherryclough.com







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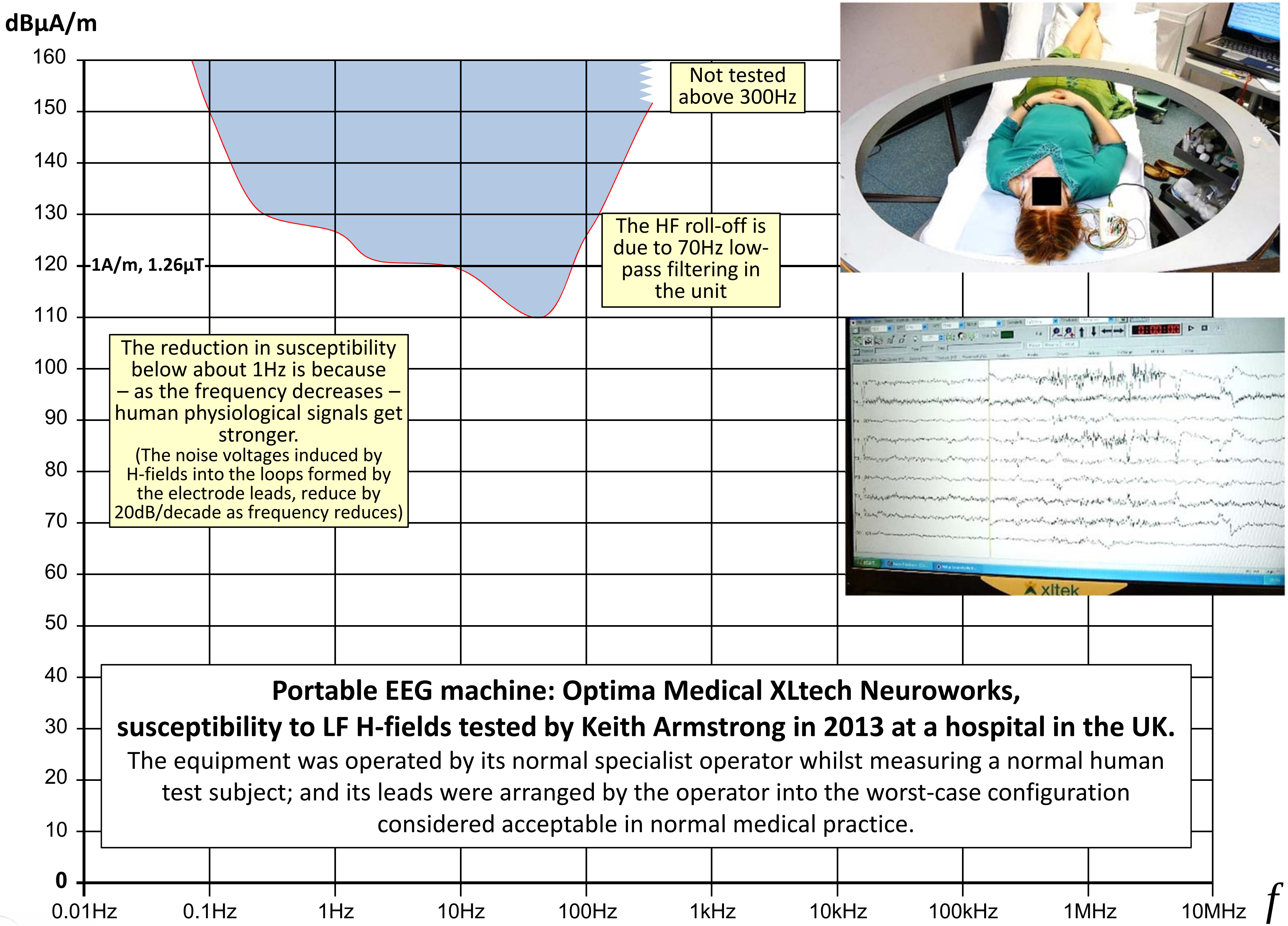
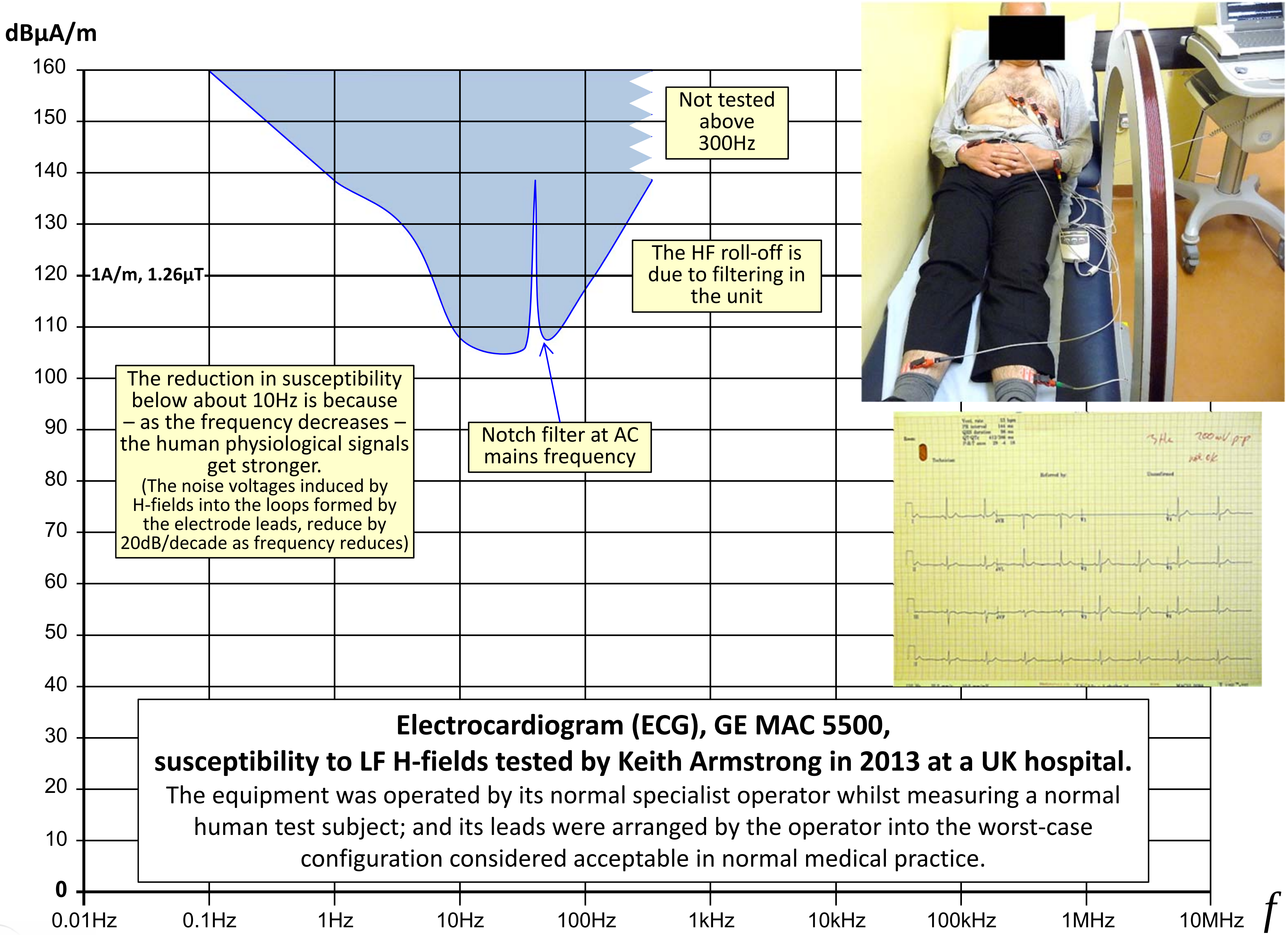



**Portable EEG machine: Optima Medical XLtech Neuroworks,**
**susceptibility to LF H-fields tested by Keith Armstrong in 2013 at a hospital in the UK.**

The equipment was operated by its normal specialist operator whilst measuring a normal human test subject; and its leads were arranged by the operator into the worst-case configuration considered acceptable in normal medical practice.




**Electrocardiogram (ECG), GE MAC 5500,**
**susceptibility to LF H-fields tested by Keith Armstrong in 2013 at a UK hospital.**

The equipment was operated by its normal specialist operator whilst measuring a normal human test subject; and its leads were arranged by the operator into the worst-case configuration considered acceptable in normal medical practice.

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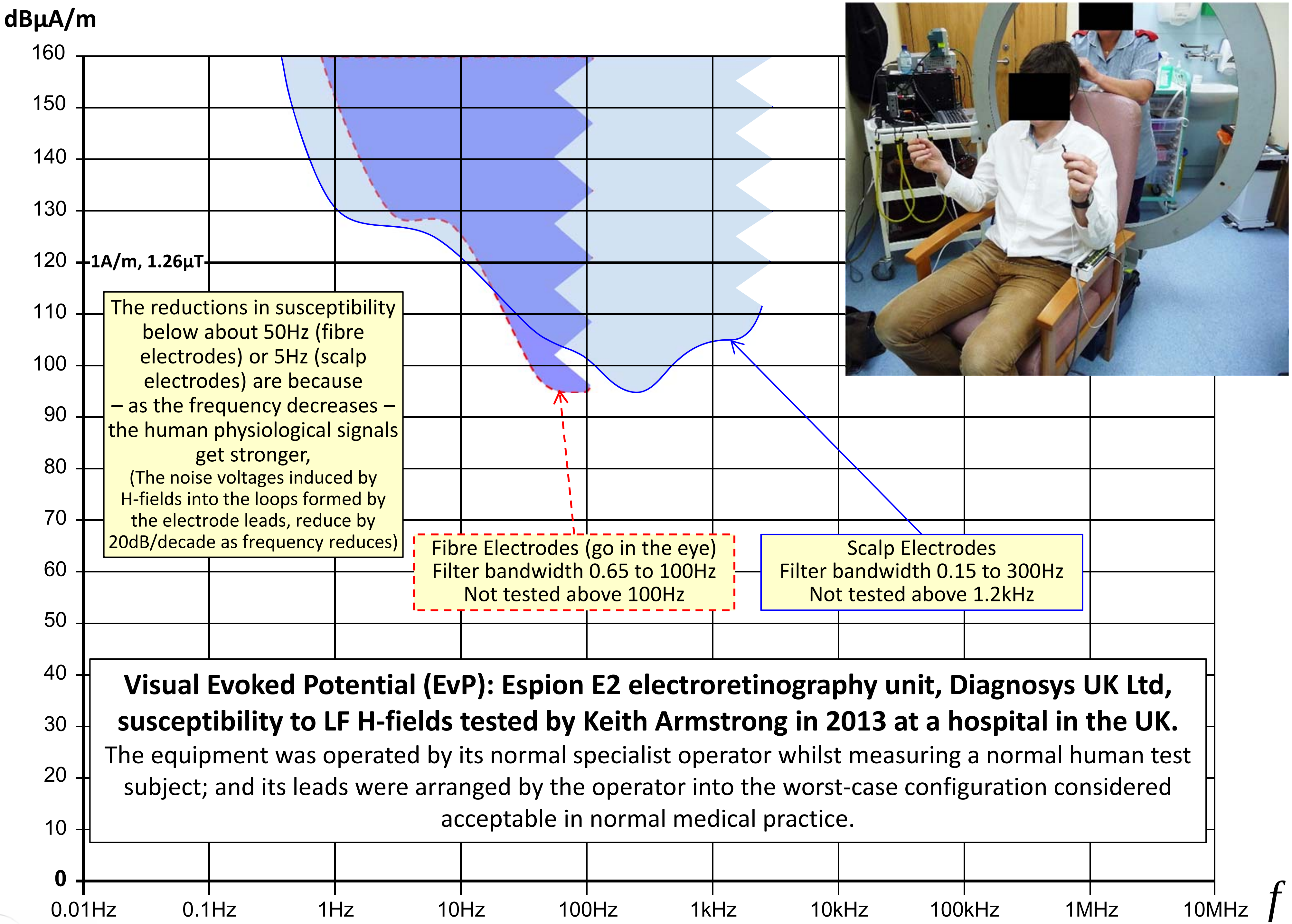
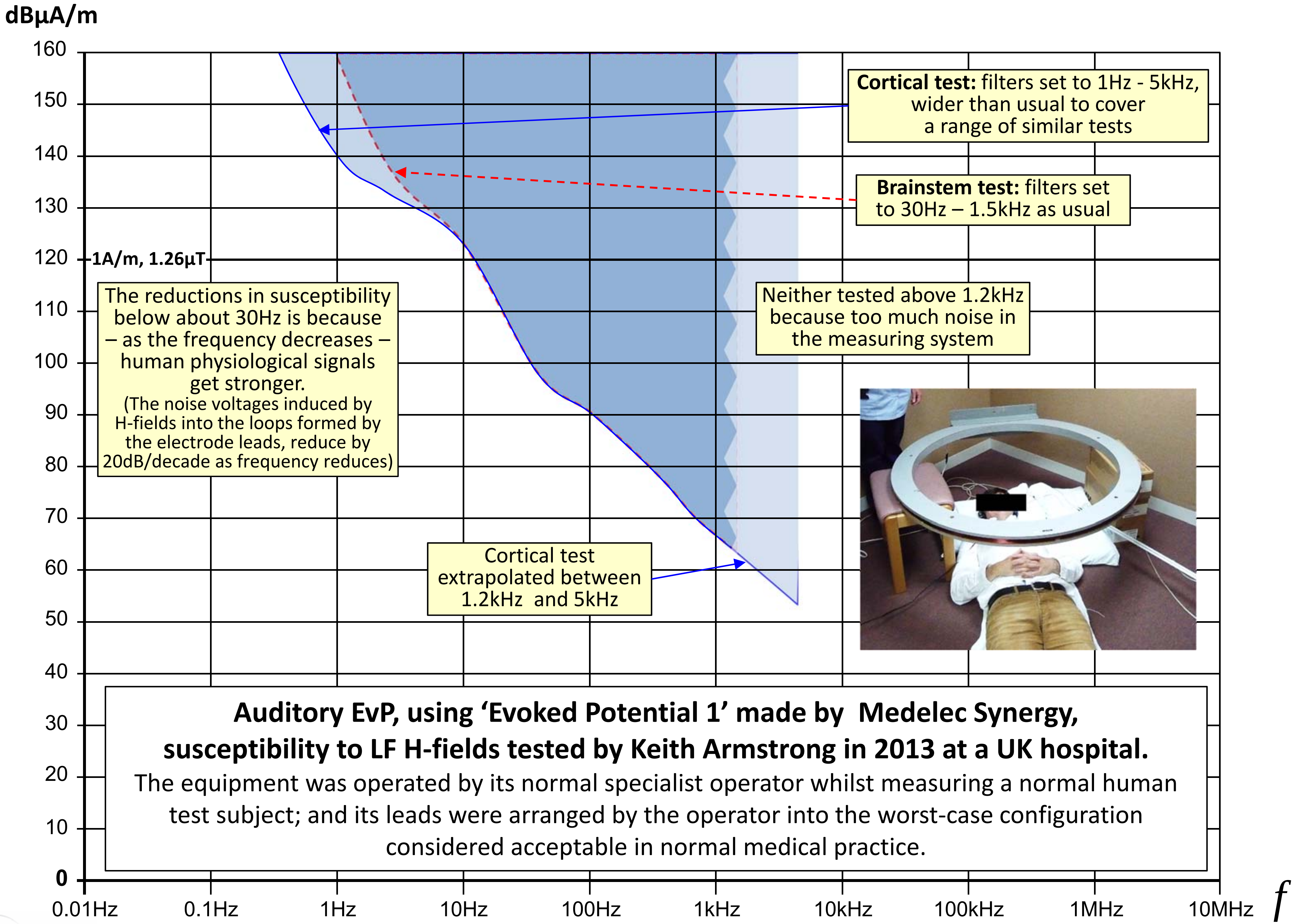


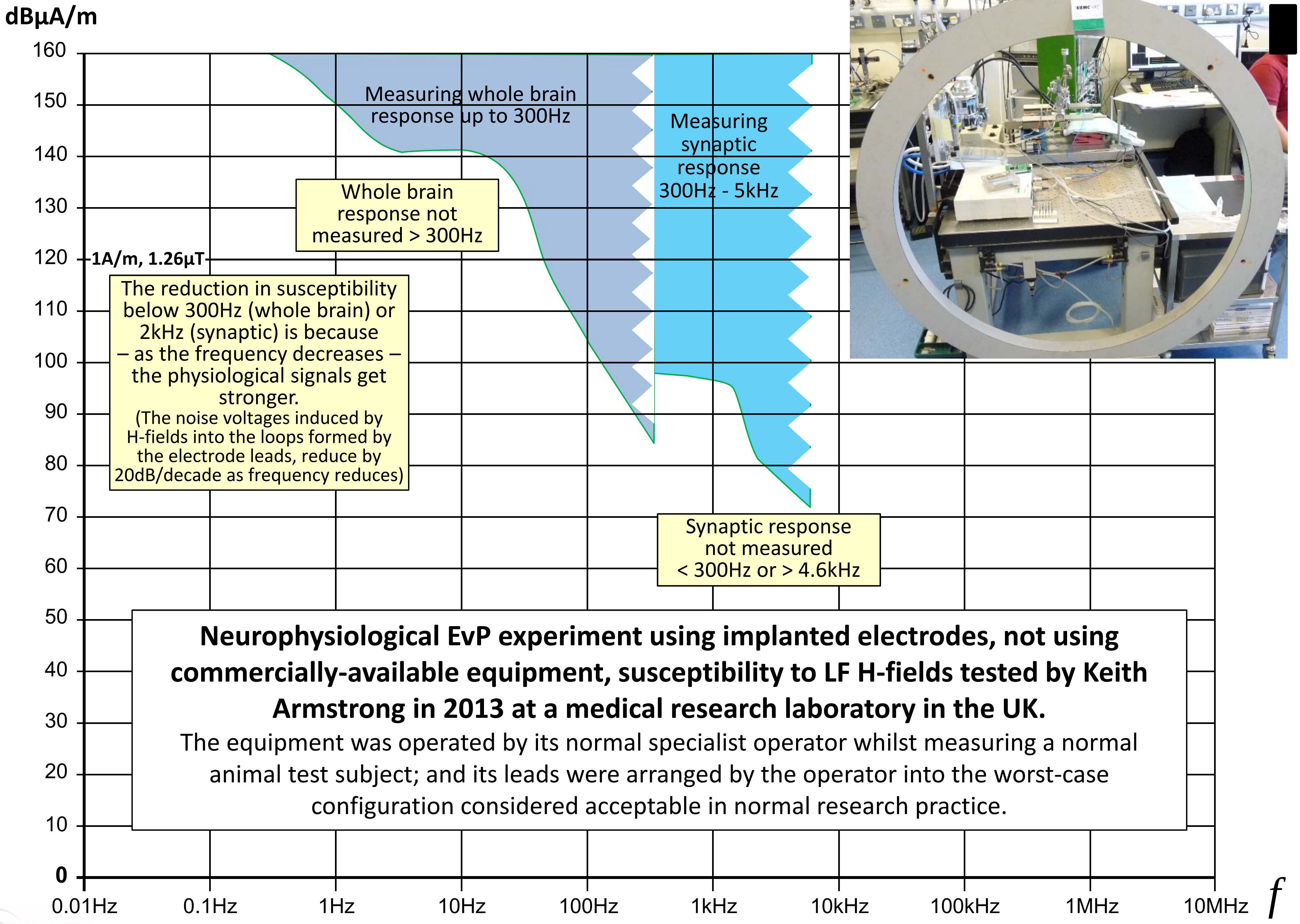

**Visual Evoked Potential (EvP): Espion E2 electroretinography unit, Diagnosys UK Ltd, susceptibility to LF H-fields tested by Keith Armstrong in 2013 at a hospital in the UK.**

The equipment was operated by its normal specialist operator whilst measuring a normal human test subject; and its leads were arranged by the operator into the worst-case configuration considered acceptable in normal medical practice.



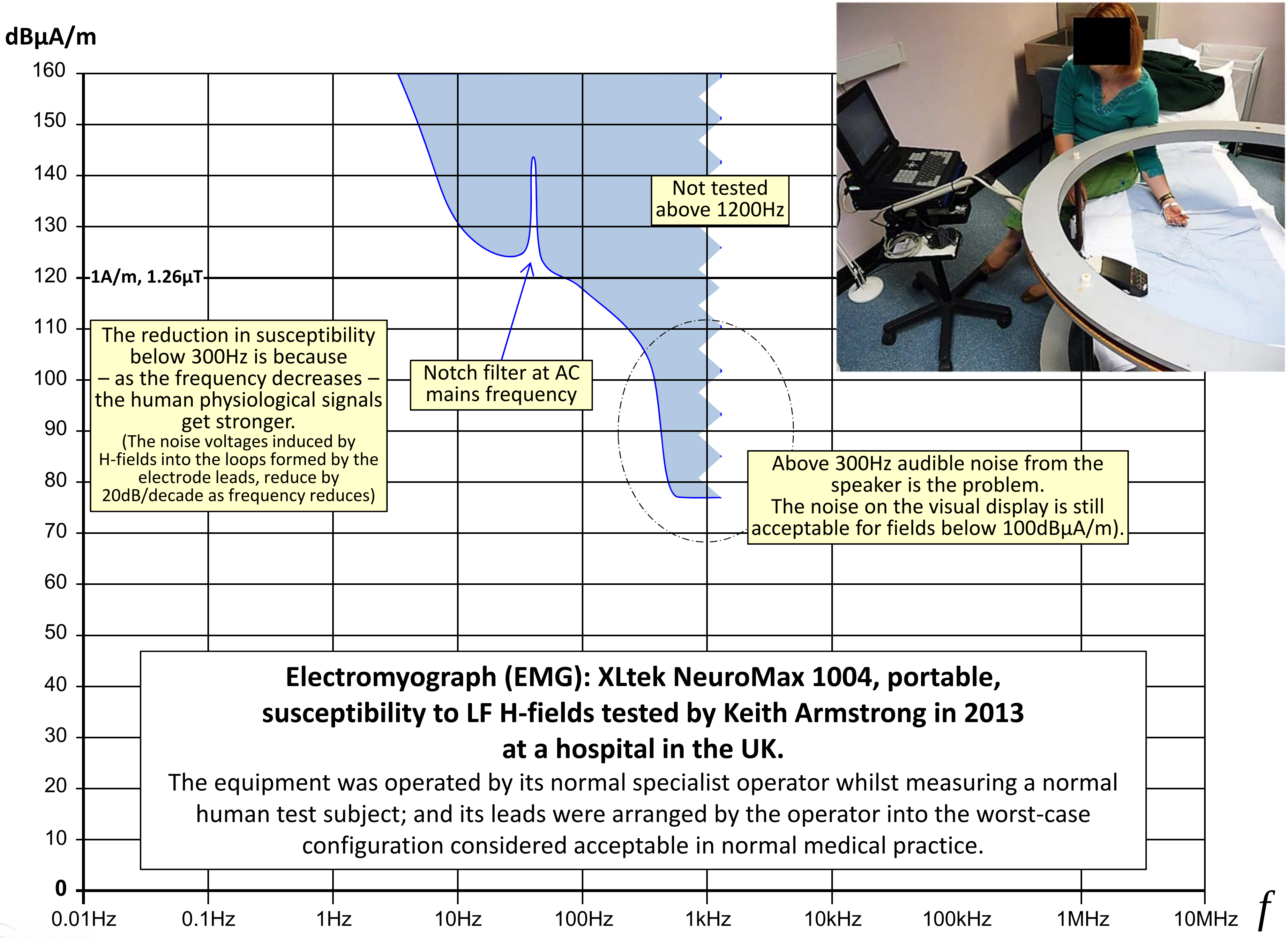

**Auditory EvP, using 'Evoked Potential 1' made by Medelec Synergy, susceptibility to LF H-fields tested by Keith Armstrong in 2013 at a UK hospital.**

The equipment was operated by its normal specialist operator whilst measuring a normal human test subject; and its leads were arranged by the operator into the worst-case configuration considered acceptable in normal medical practice.



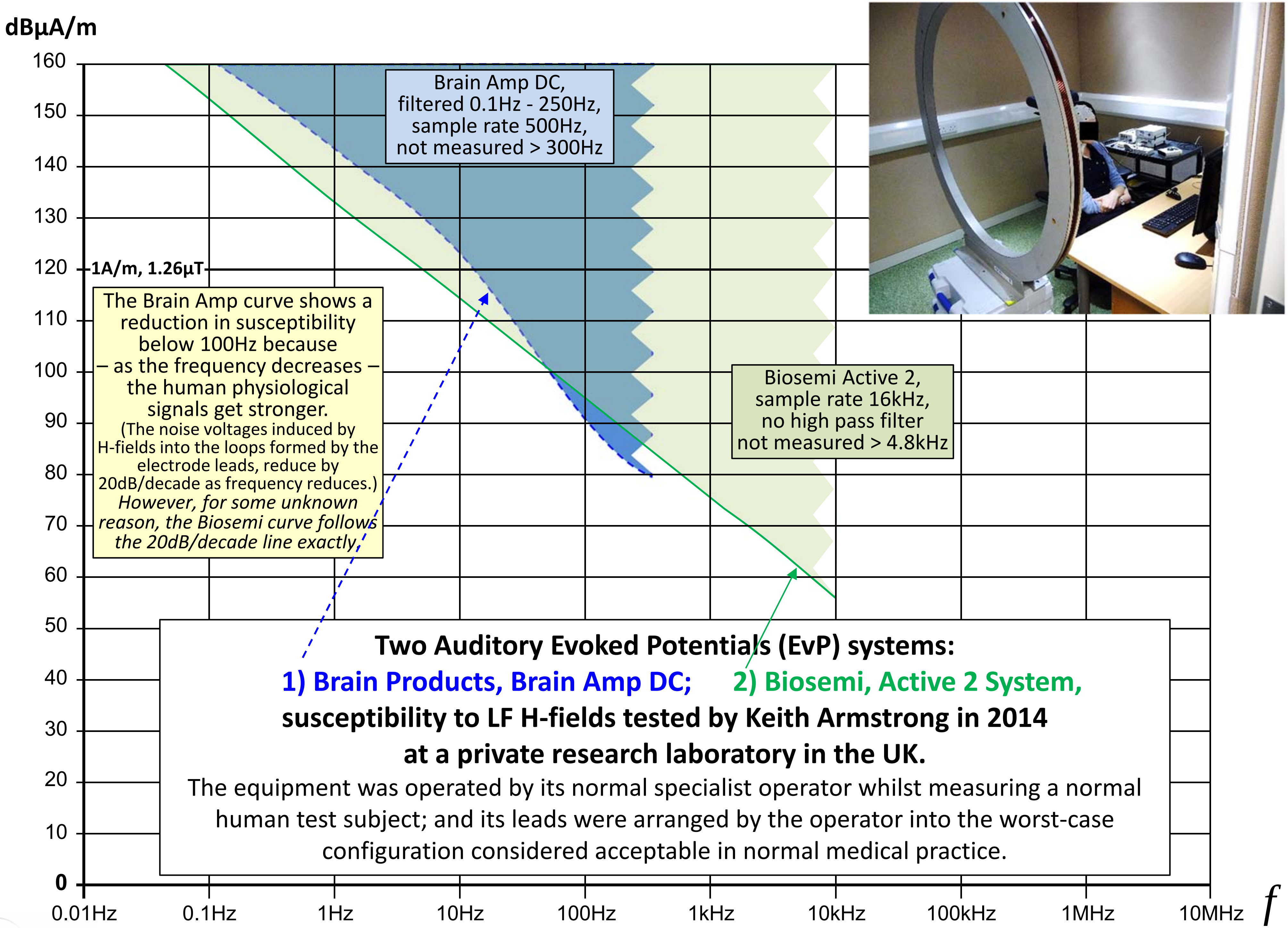

**Neurophysiological EvP experiment using implanted electrodes, not using commercially-available equipment, susceptibility to LF H-fields tested by Keith Armstrong in 2013 at a medical research laboratory in the UK.**

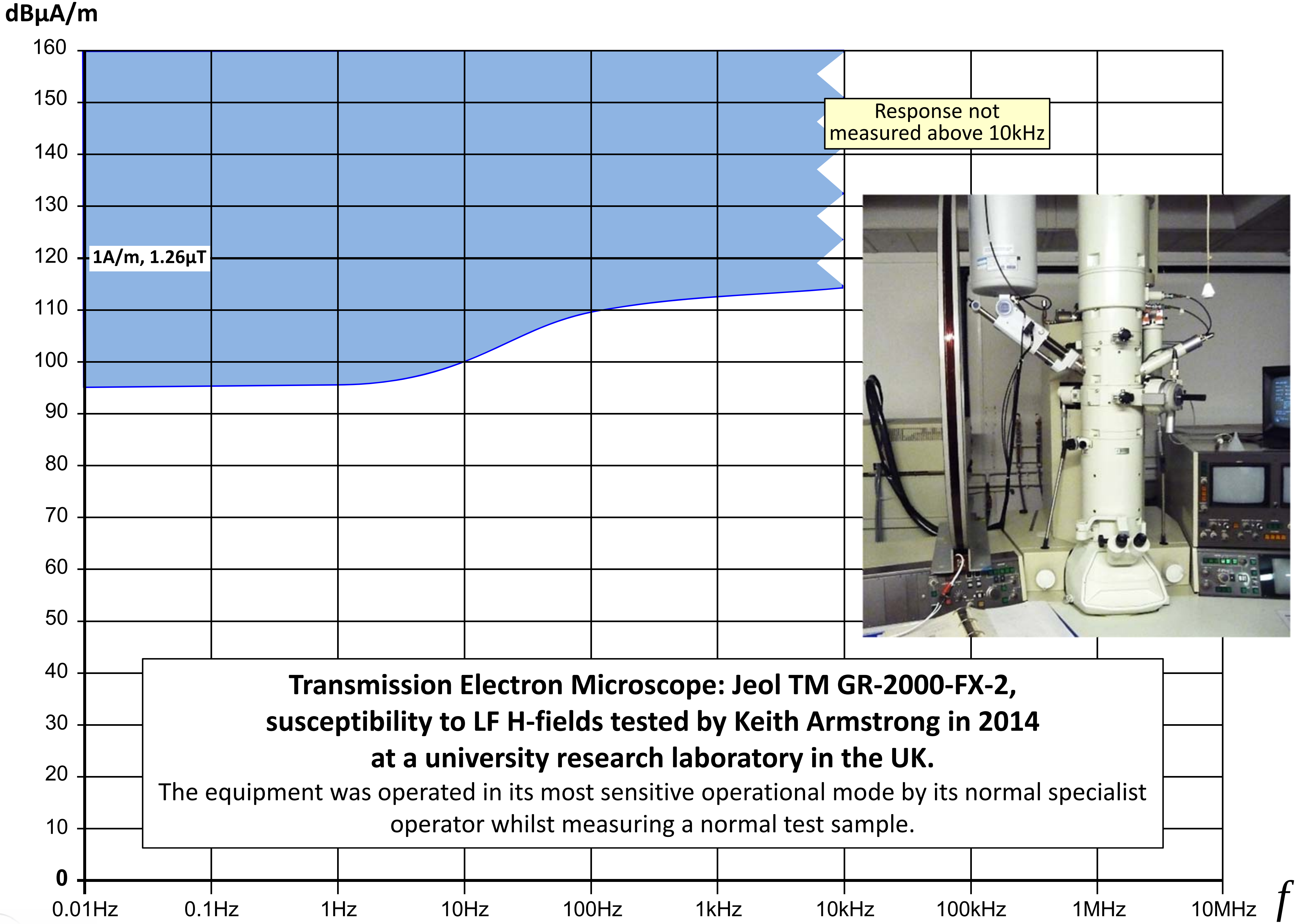
The equipment was operated by its normal specialist operator whilst measuring a normal animal test subject; and its leads were arranged by the operator into the worst-case configuration considered acceptable in normal research practice.




**Electromyograph (EMG): XLtek NeuroMax 1004, portable, susceptibility to LF H-fields tested by Keith Armstrong in 2013 at a hospital in the UK.**

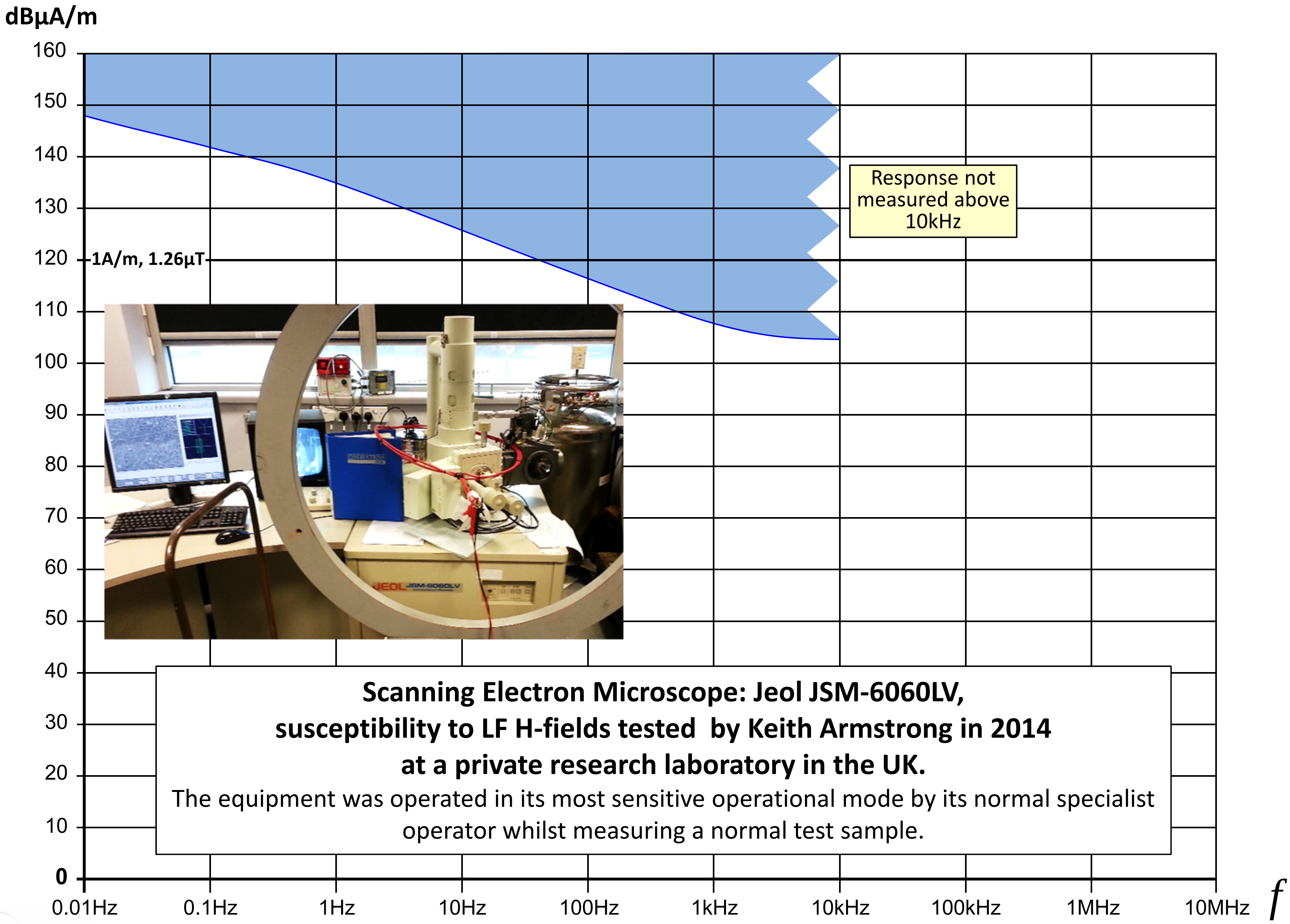
The equipment was operated by its normal specialist operator whilst measuring a normal human test subject; and its leads were arranged by the operator into the worst-case configuration considered acceptable in normal medical practice.


dBµA/m
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
1A/m, 1.26µT
0.01Hz
0.1Hz
1Hz
10Hz
100Hz
1kHz
10kHz
100kHz
1MHz
10MHz
f
Brain Amp DC, filtered 0.1Hz - 250Hz, sample rate 500Hz, not measured > 300Hz
The Brain Amp curve shows a reduction in susceptibility below 100Hz because – as the frequency decreases – the human physiological signals get stronger.
(The noise voltages induced by H-fields into the loops formed by the electrode leads, reduce by 20dB/decade as frequency reduces.)
However, for some unknown reason, the Biosemi curve follows the 20dB/decade line exactly.
Biosemi Active 2, sample rate 16kHz, no high pass filter not measured > 4.8kHz
Two Auditory Evoked Potentials (EvP) systems:
1) Brain Products, Brain Amp DC; 2) Biosemi, Active 2 System,
susceptibility to LF H-fields tested by Keith Armstrong in 2014
at a private research laboratory in the UK.
The equipment was operated by its normal specialist operator whilst measuring a normal human test subject; and its leads were arranged by the operator into the worst-case configuration considered acceptable in normal medical practice.



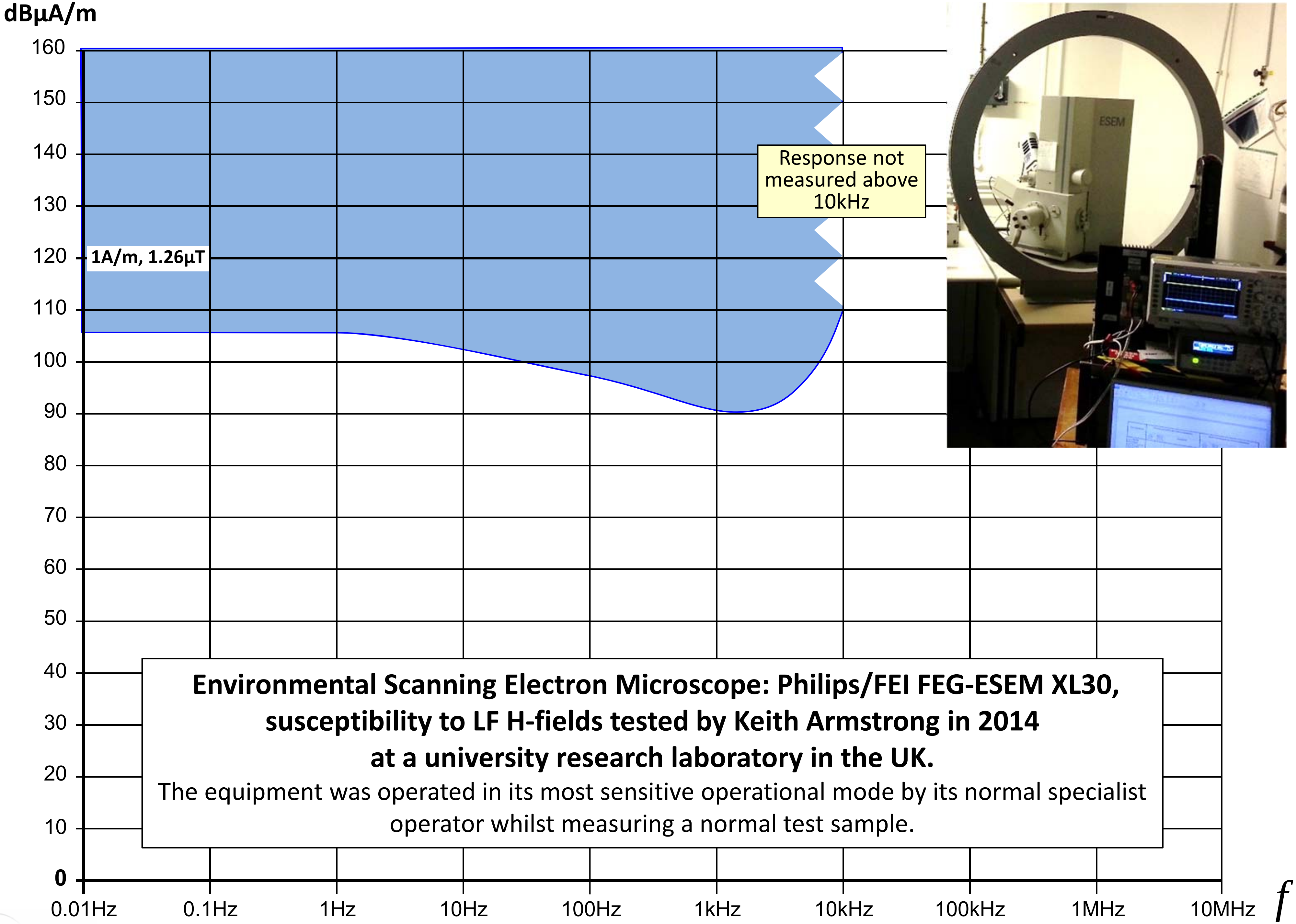

**Transmission Electron Microscope: Jeol TM GR-2000-FX-2, susceptibility to LF H-fields tested by Keith Armstrong in 2014 at a university research laboratory in the UK.**

The equipment was operated in its most sensitive operational mode by its normal specialist operator whilst measuring a normal test sample.



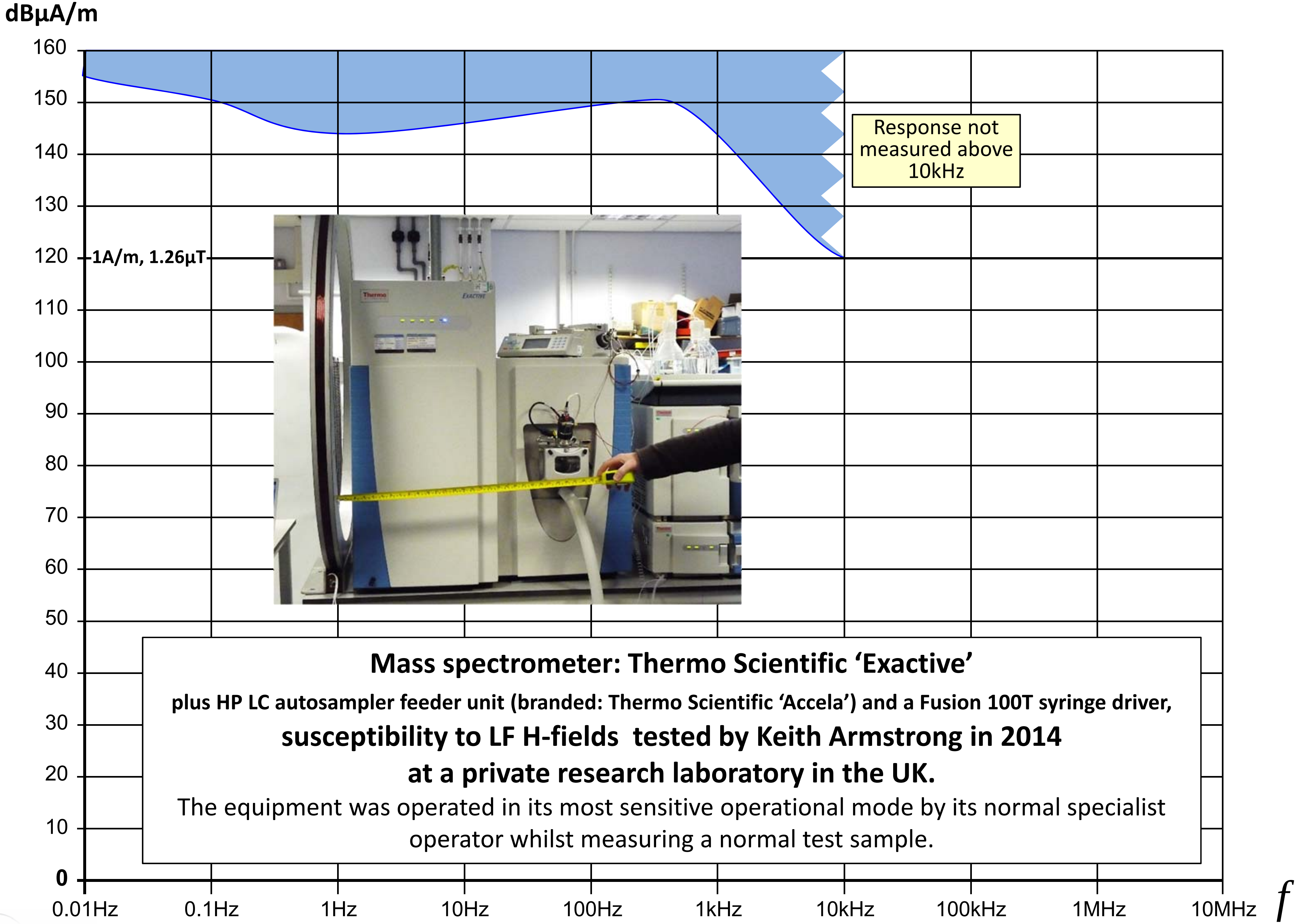

**Scanning Electron Microscope: Jeol JSM-6060LV, susceptibility to LF H-fields tested by Keith Armstrong in 2014 at a private research laboratory in the UK.**

The equipment was operated in its most sensitive operational mode by its normal specialist operator whilst measuring a normal test sample.




**Environmental Scanning Electron Microscope: Philips/FEI FEG-ESEM XL30, susceptibility to LF H-fields tested by Keith Armstrong in 2014 at a university research laboratory in the UK.**

The equipment was operated in its most sensitive operational mode by its normal specialist operator whilst measuring a normal test sample.




**Mass spectrometer: Thermo Scientific 'Exactive'**

**plus HP LC autosampler feeder unit (branded: Thermo Scientific 'Accela') and a Fusion 100T syringe driver,**

**susceptibility to LF H-fields tested by Keith Armstrong in 2014**

**at a private research laboratory in the UK.**

The equipment was operated in its most sensitive operational mode by its normal specialist operator whilst measuring a normal test sample.

# Other equipment tested for LF H-field susceptibility in 2013 and 2014:

1. **Echocardiogram**, GE VIVID 7 using: 3MHz probe; 3D probe or Standalone probe:
   OK below 9.2 µT (7.3 A/m) p-p DC-10kHz, UK hospital in 2013

2. **Gamma Camera**, Philips 'Brightvue', dual-headed:
   OK below 100 µT (79 A/m) p-p DC-1kHz, UK hospital in 2013

3. **Radiation Dose calibrator**, Capintec CRC15W; and three different types of "Series 900 Minimonitor" **radiation detectors** each using a different type of sensor (Type 44A scintillation detector; 'Compensated GM tube' ionisation chamber, and a 'Type D GM probe' ionisation chamber): all OK below 68 µT (54 A/m) p-p DC-1kHz, UK hospital in 2013

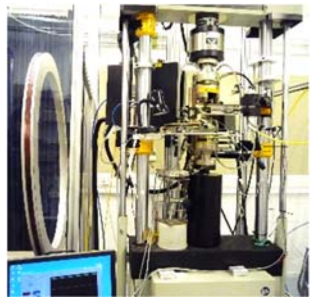
4. **X-ray photoelectron spectrometer**, VG Scientific Escalab Mk 2:
   OK below 57 µT (45 A/m) p-p DC-1kHz, university research laboratory in 2014

5. **Mass Spectrometer**, Waters Quattro Ultima, S/No VE460; with Syringe pump (Harvard Apparatus, Category No. 55-2275) and Agilent 1100 series LC (comprising several units: Degasser G1379A; Pump G136A; Autosampler G1367A; Thermostat G1330B; Oven G1316A and Controller G1323B):
   OK below 100 µT (79 A/m) p-p DC-1kHz; and below 10 µT (7.9 A/m) p-p 1-5kHz, university research lab in 2014

6. **Mass Spectrometer**, ToF-SIMS (time-of-flight secondary ion mass spectrometer), made by IONTOFF GmbH:
   OK below 100 µT (79 A/m) p-p DC-1kHz; and below 10 µT (7.9 A/m) p-p 1kHz - 5kHz, private research lab in 2014

7. **Mass Spectrometer**, Applied Biosystems 'MDS SCIEX' = 'ABI 4000 QTRAP', plus Shimadzu Column Oven CTO-10A, Shimadzu SIL-HT autosampler, two Shimadzu pumps LC-10ADVP, and a Harvard Apparatus syringe driver:
   OK below 300 µT (238 A/m) p-p DC-1kHz; and below 40 µT (32 A/m) p-p 1kHz - 5kHz, private research lab in 2014

8. **Thermomechanical Fatigue tester**, Instron 8862:
   OK below 60 µT (47 A/m) p-p DC-1kHz; and below 20 µT (16 A/m) p-p 1-5kHz, university research laboratory in 2014



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