# Tools: ELF sensors & modelling

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# Introduction

In the context of the BBEMG the University of Liège develops two tools:

1. A new ELF magnetic field exposure probe that can be manufactured at low cost
   - Version 1 designed, manufactured and tested in 2021-2025
   - Successful proof-of-concept: specifications compatible with BBEMG research objectives
   - Version 2 currently being designed, with the aim of manufacturing a batch of probes that can be deployed in the field
2. A numerical simulation tool to predict ELF electric and magnetic fields near powerlines and underground cables

# Use-cases for the ELF probe

| | Sampling periodicity | Duration | Range |
|---|---|---|---|
| **50Hz monitoring agriculture** | 1 min → 1 h | Max. possible | 0.1 μT → 100 μT |
| **50Hz monitoring wearable / general public** | 2 s → 1 min | Min. 24 h | 0.1 μT → 100 μT |
| **50Hz monitoring wearable / professionals (e.g. ELIA)** | 1 s → 1 min | Min. 8 h | 0.1 μT → 10 mT |
| **50Hz monitoring fixed (lines, cables, transformers, residential installations)** | 1 min → 1 h | Min. 24 h | 0.1 μT → 100 μT |
| **50Hz cartography (e.g. urban, on bikes at max. 20 km/h)** | Min. possible (target: 0.5 s) | Min. 2 h | 0.1 μT → 100 μT |

(EMDEX II min. sampling 1.5 s - EMDEX HIGH FIELD max. field 12 mT)

# Version 1 of the ELF probe

Focus on satisfying the low magnetic field use-cases (0.1 μT to 100 μT)

Version 1 circuit board incorporates

- Magnetic field sensor
- Low-power microcontroller
- Bluetooth communication
- GPS receiver
- Memory
- Batteries

Encapsulated in weather-resistant enclosure

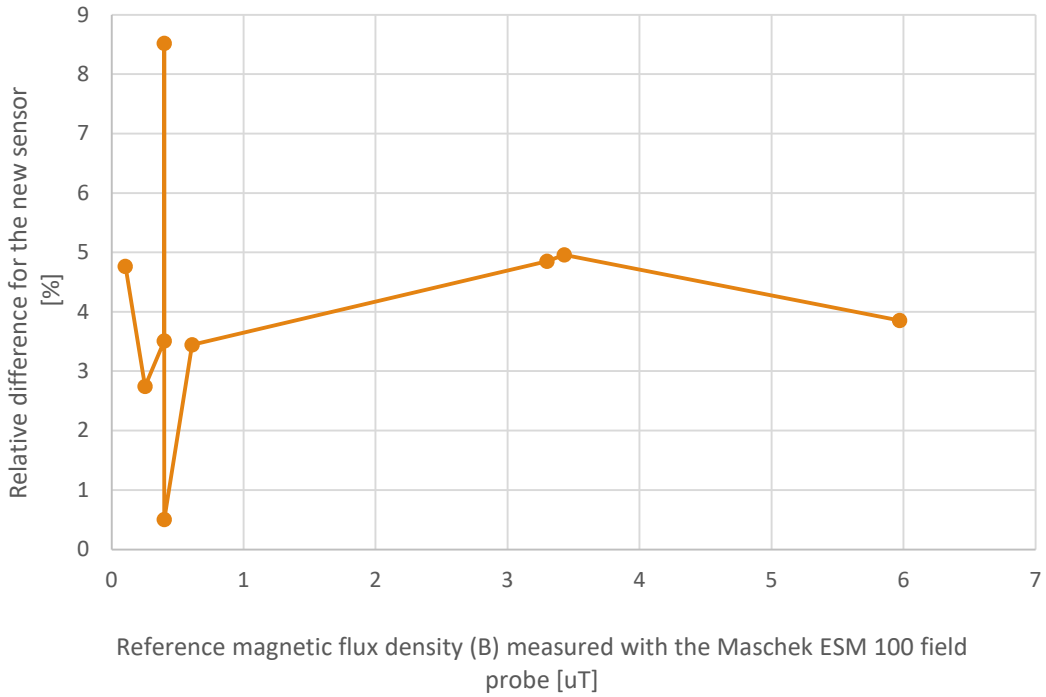

EMDEX II next to Version 1

# Version 1 of the ELF probe

| Measured loop current / Distance from the loop / Measurement axis | Theoretical value [uT] | Maschek EMS 100 (reference) [uT] | Version 1 (AK sensor) [uT] |
|---|---|---|---|
| 19.70 A / 1 m / Z-axis | 3.94 | 3.43 | 3.6 |
| 19.47 A / 0.6 m / Z-axis | 6.49 | 5.97 | 6.2 |
| 10.82 A / 0.6 m / Z-axis | 3.6 | 3.3 | 3.46 |
| 0 A / 0.6 m / Z-axis | 0 | 0.002 | 0.005 |
| 0.845 A / 0.6 m / Z-axis | 0.282 | 0.255 | 0.262 |
| 2 A / 0.6 m / Z-axis | 0.667 | 0.61 | 0.631 |
| 1.316 A / 0.6 m / Z-axis | 0.437 | 0.399 | 0.413 |
| 1.316 A / 0.6 m / X-axis | 0.437 | 0.399 | 0.433 |
| 1.316 A / 0.6 m / Y-axis | 0.437 | 0.399 | 0.401 |
| 0.361 A / 0.6 m / Y-axis | 0.12 | 0.105 | 0.11 |
| 0 A / 0.6 m / Y-axis | 0 | 0.001 | 0.0025 |

Validation in the ACE laboratory of the University of Liège

# Version 1 of the ELF probe



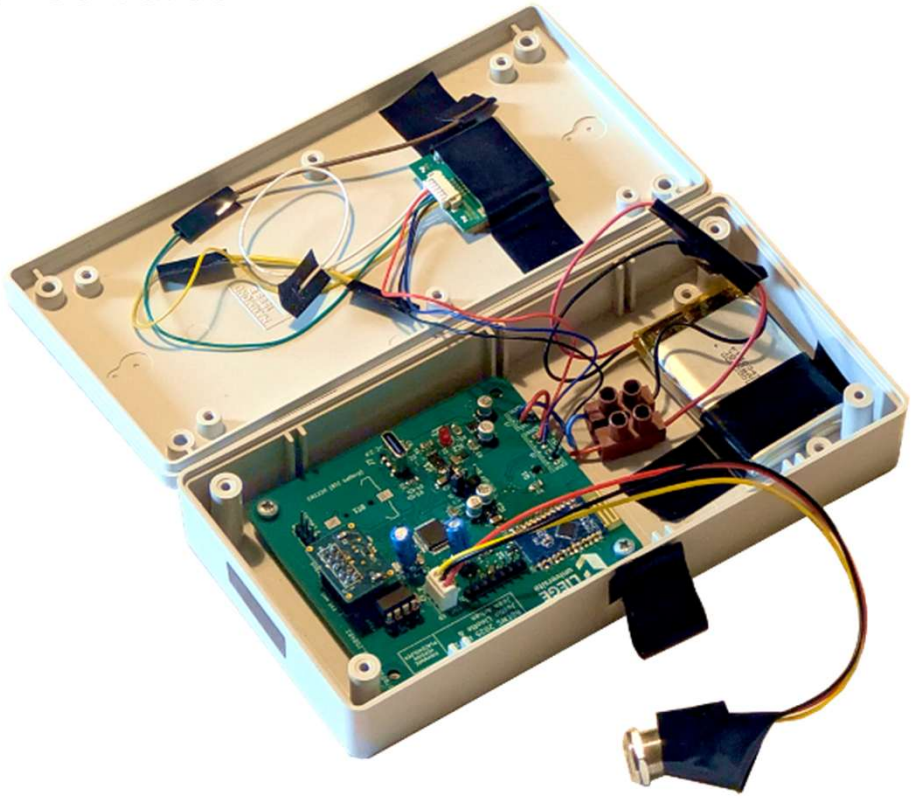

Validation in the ACE laboratory of the University of Liège

# Version 1 of the ELF probe

Bill of materials for Version 1 is about 100 euros

Most expensive parts:

- Rechargeable batteries
- Weather-resistant enclosure
- Memory



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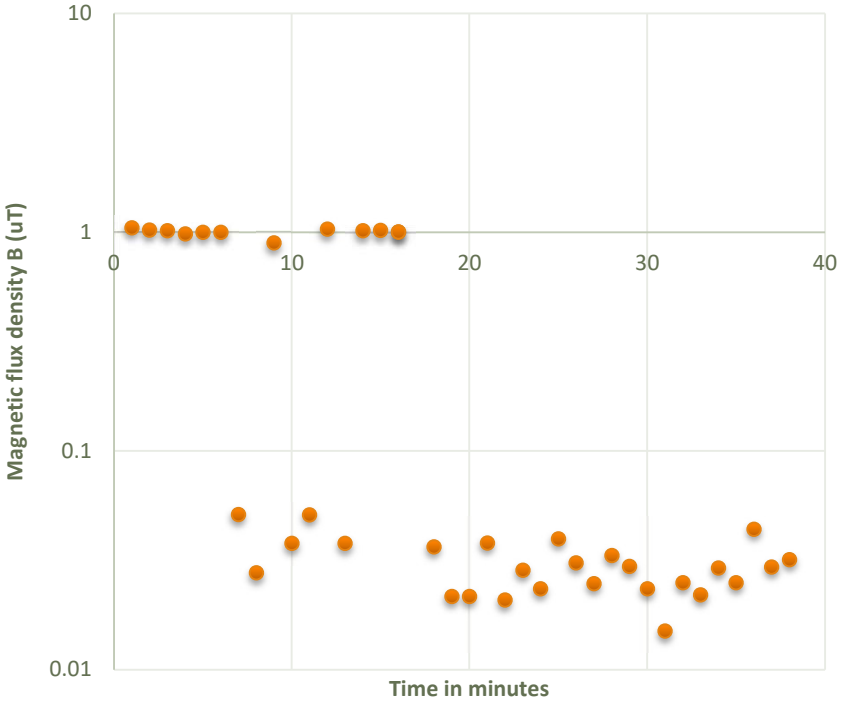
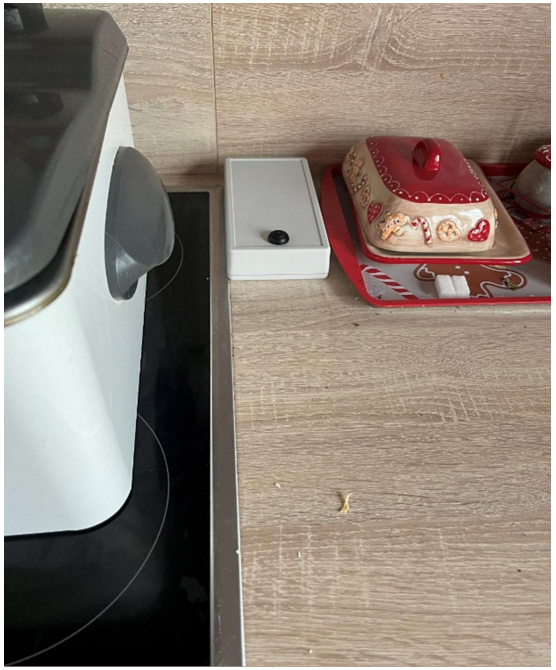
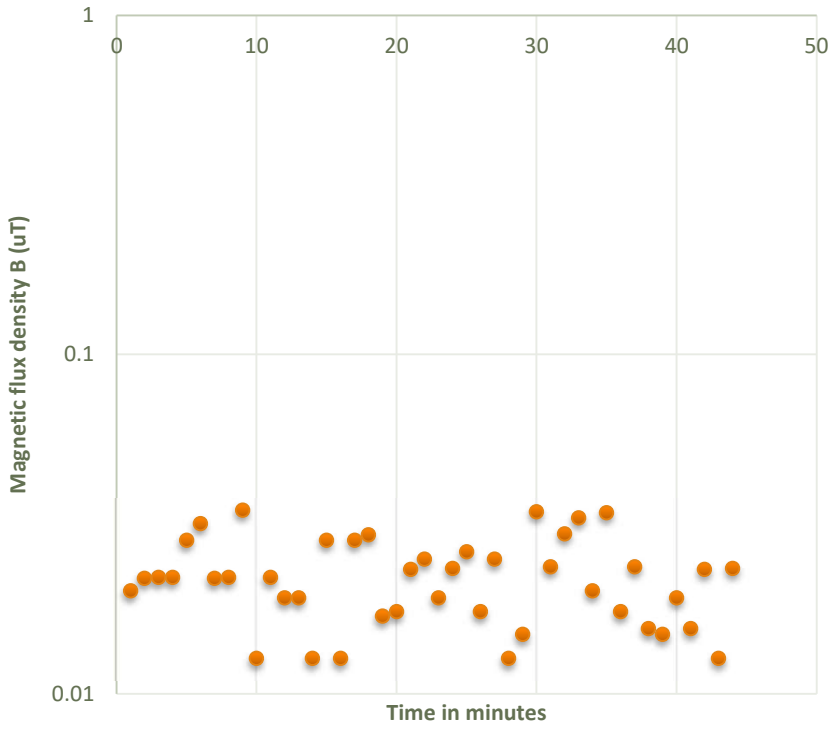


Typical measurement in a kitchen close to a fryer

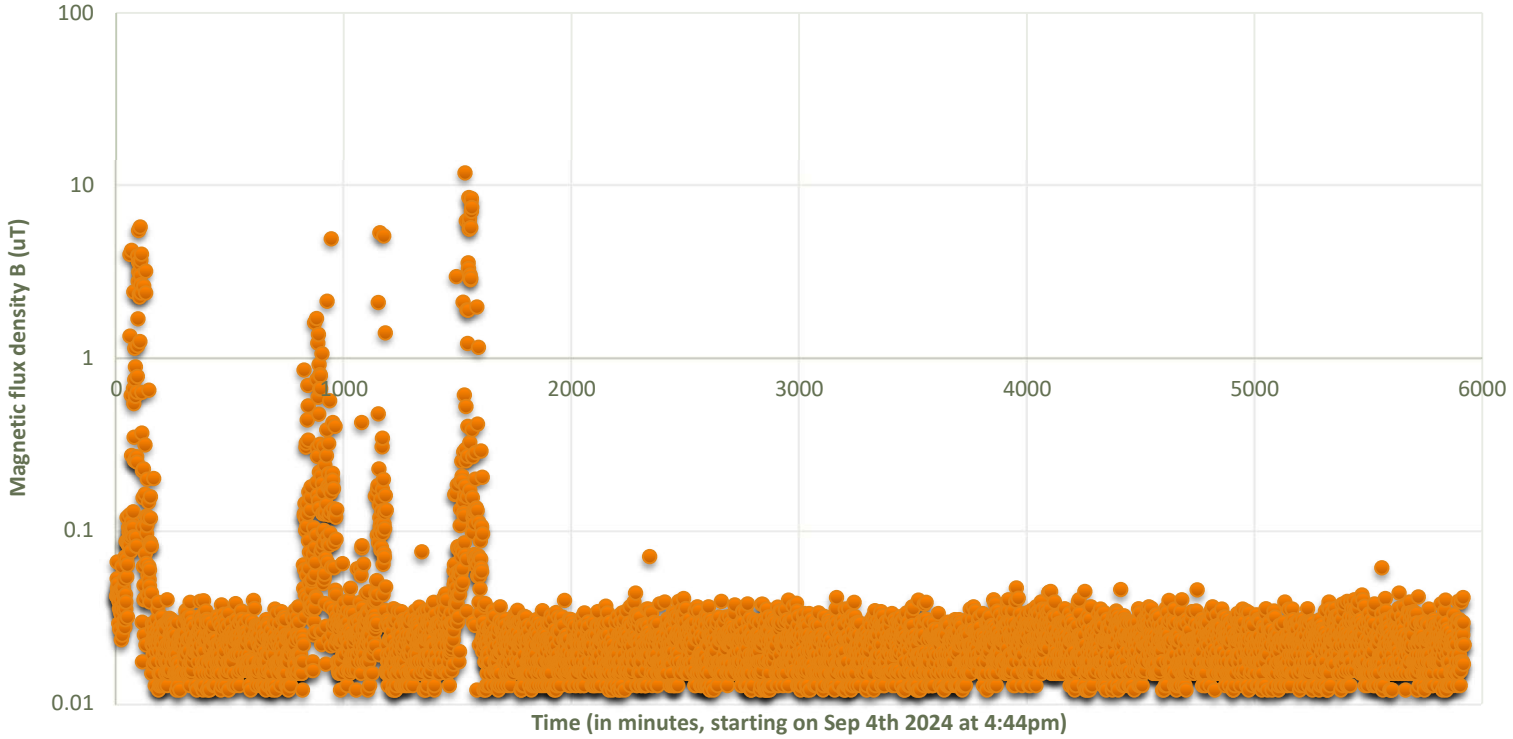
# Version 1 of the ELF probe





Typical measurement on an office desk

# Version 1 of the ELF probe




Multi-day measurement with home-work commute

# What's next?

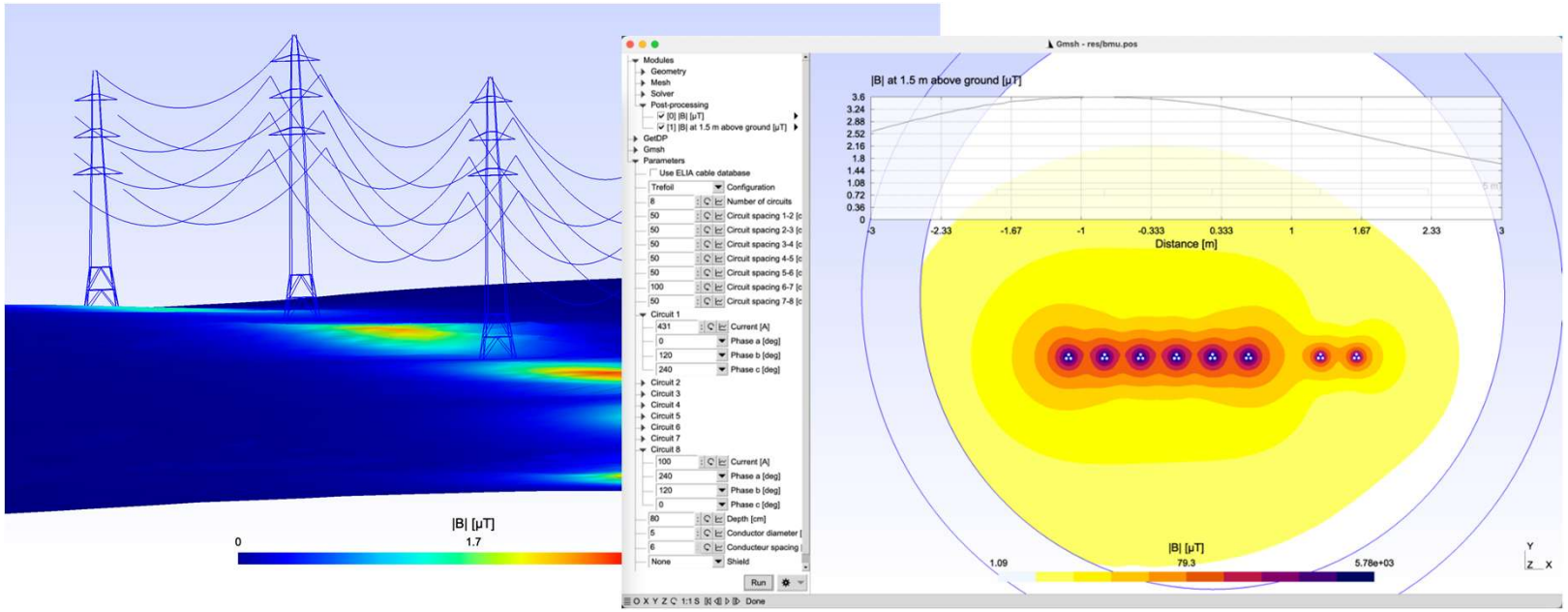
Version 2 of the ELF probe is under development:

- Microcontroller replaced with more powerful chip for faster data processing
- Lithium-Ion battery to improve autonomy (> 7 days)
- Optimization of the PCB layout to reduce footprint
- Dedicated button for Bluetooth control
- Electromagnetic compatibility validation
- Software interface running on smartphones and tablets, to
  - display and retrieve the measurement data
  - configure the main functions of the probe (sampling rate, sampling periodicity)

# Numerical simulation tool

Based on open source Gmsh & GetDP software developed at ULiège – now handles

- 3D power lines with true topography
- General cable configurations



Thanks for your attention

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