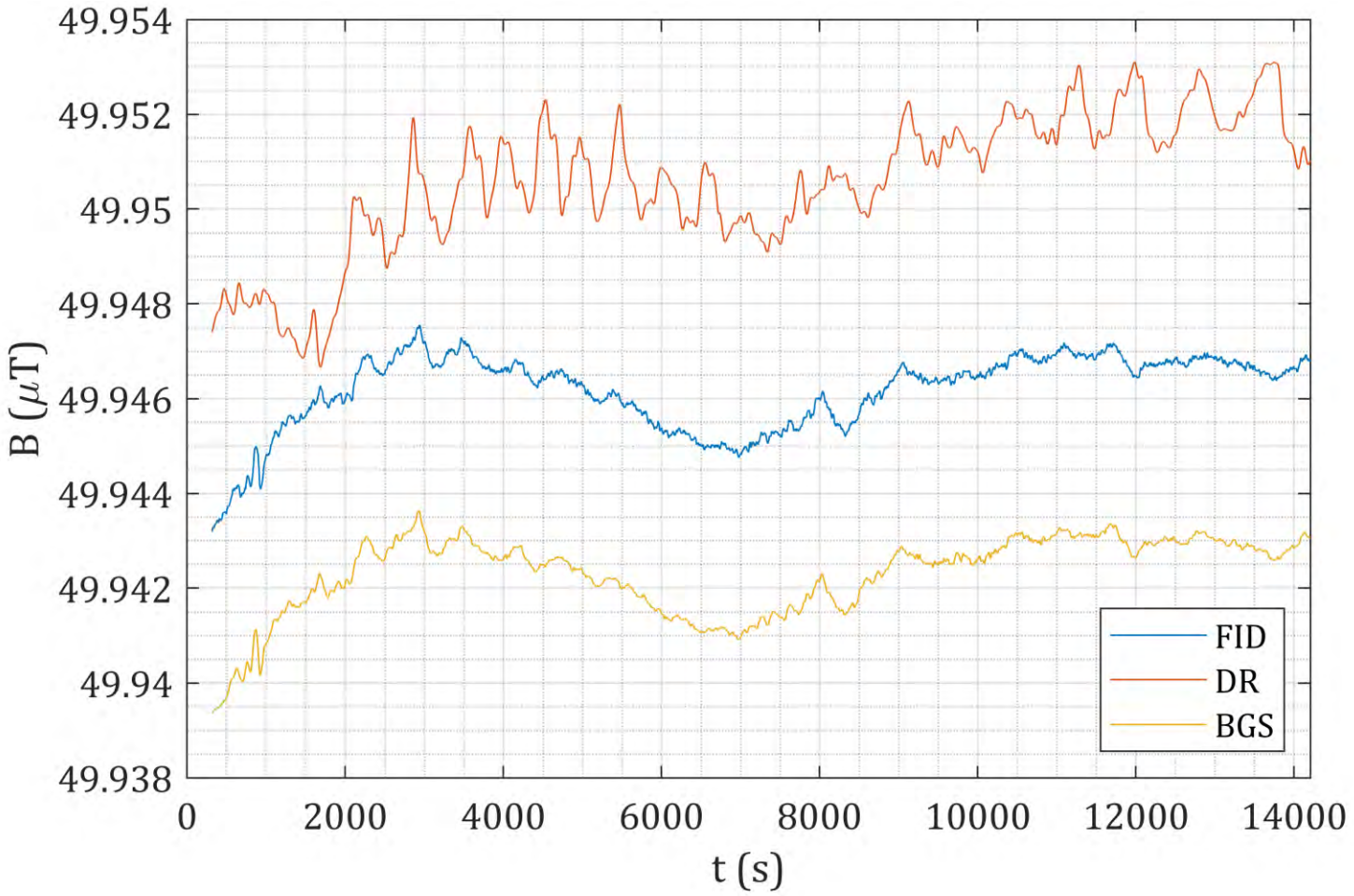
Ground station comparison

- Comparison of magnetometers
  - Free-induction decay
  - Double resonance
  - BGS standard



Data vertically offset for clarity

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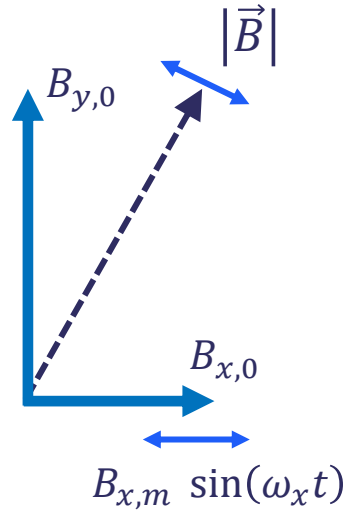
Vectorisation of scalar magnetometer

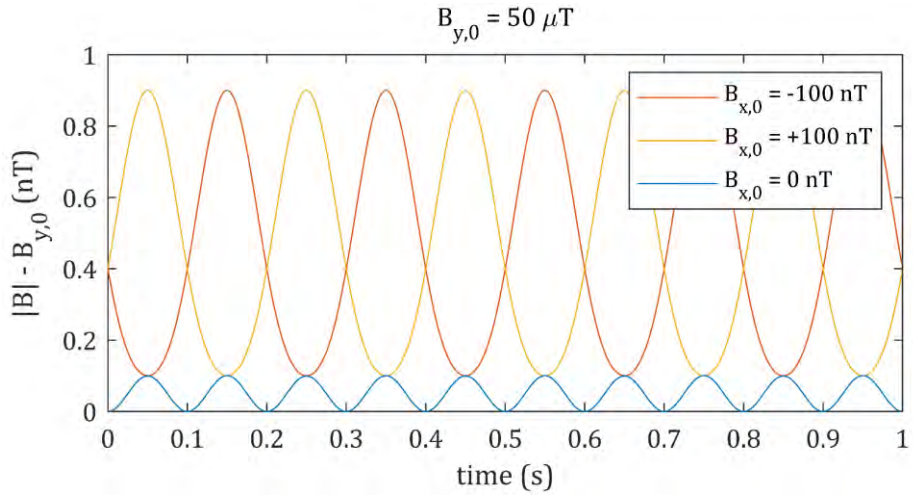
$$|\vec{B}|^2 = \sum_i B_i{}^2$$

- Consider the case with static fields $B_{y,0}$, $B_{x,0}$ and a modulation $B_{x,m}$:

⇨ $$|B(t)|^2 = B_{y,0}{}^2 + \left(B_{x,0} + B_{x,m}\sin(\omega_x t)\right)^2$$

⇨ $$|B(t)|^2 = \underbrace{B_{y,0}{}^2 + B_{x,0}{}^2 + \frac{B_{x,m}{}^2}{2}}_{\text{Static}} + \underbrace{2B_{x,0}B_{x,m}\sin(\omega_x t)}_{1f} - \underbrace{\frac{B_{x,m}{}^2}{2}\cos(2\omega_x t)}_{2f}$$





M. Bulatowicz et al., Sensors **23**, 4253 (2023)

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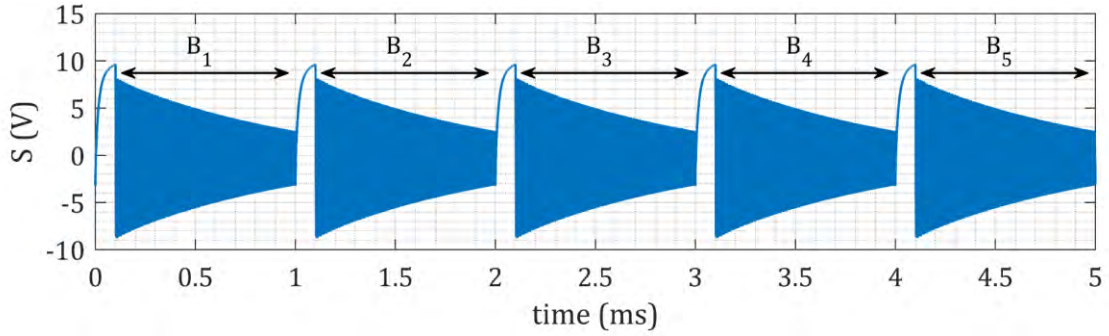
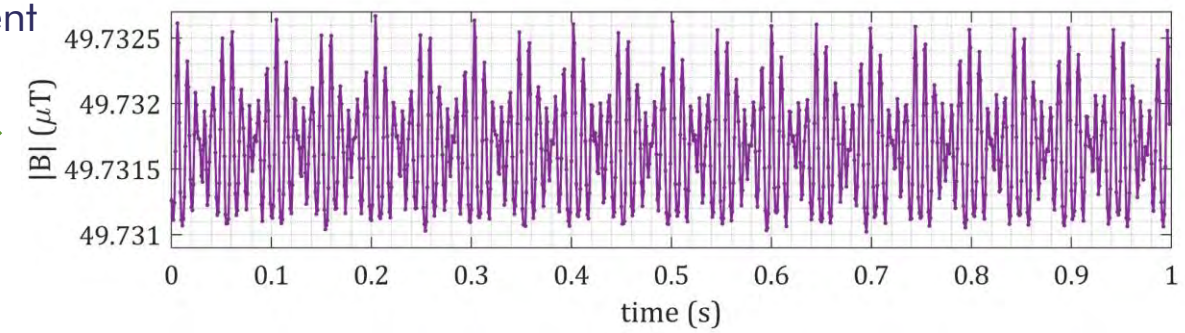
Vector data acquisition and processing

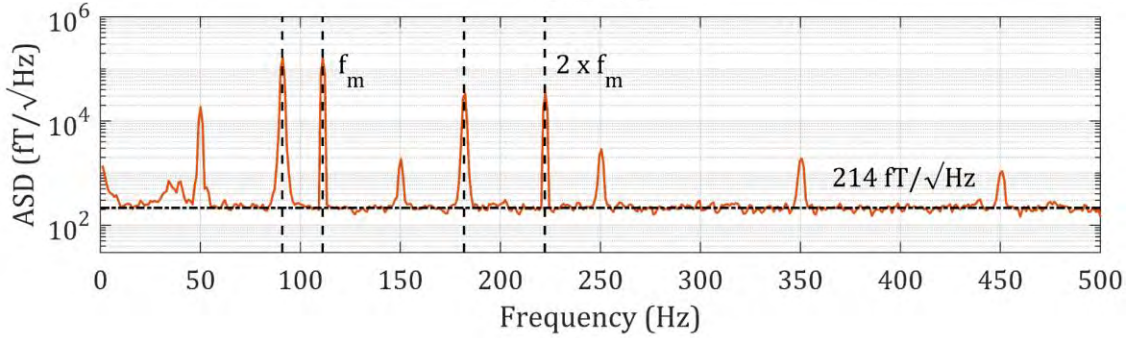
FID signal train

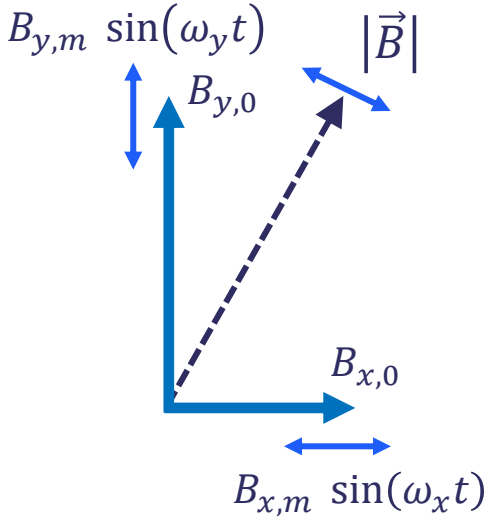


Scalar measurement



Magnetic spectrum





Vector components:

- $B_x = B_{x,0}$
- $B_y = B_{y,0}$
- $B_z = \sqrt{|B|^2 - {B_x}^2 - {B_y}^2}$

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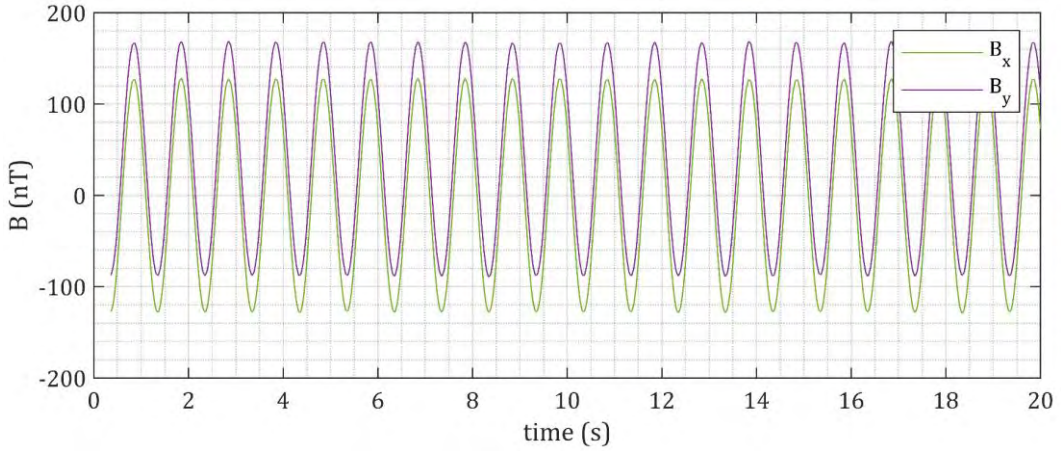
Vector data acquisition and processing

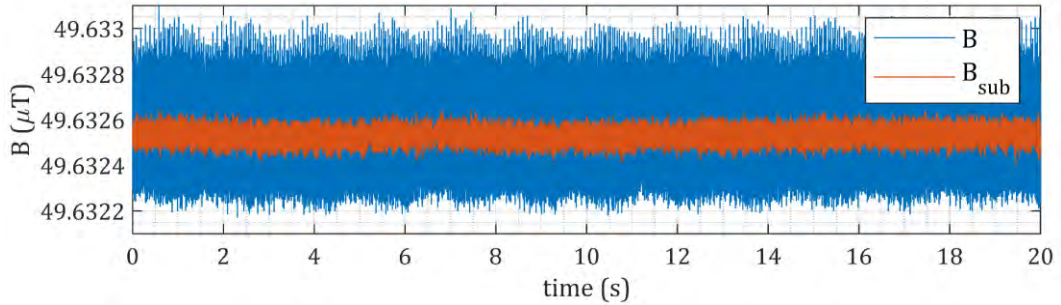
- Bx and By modulated at 91 Hz and 111 Hz, respectively.
- An additional slow modulation at 1 Hz applied along each axis.
- Vector components reconstructed by demodulating at 1st and 2nd harmonics.

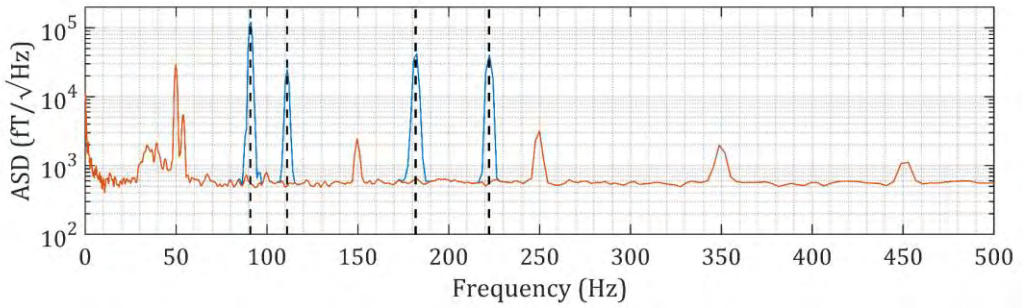
Scalar signal recovery:

$$B_{sub} = B - \sum_i B_m^i \cos\left(2\pi f_m^i t + \varphi_i\right)$$

- Calculate amplitudes B_m^i and phases φ_i.
- Modulated components subtracted from B.
- Sensitivity recovered across full frequency range in absence of modulation.







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Space-suitable

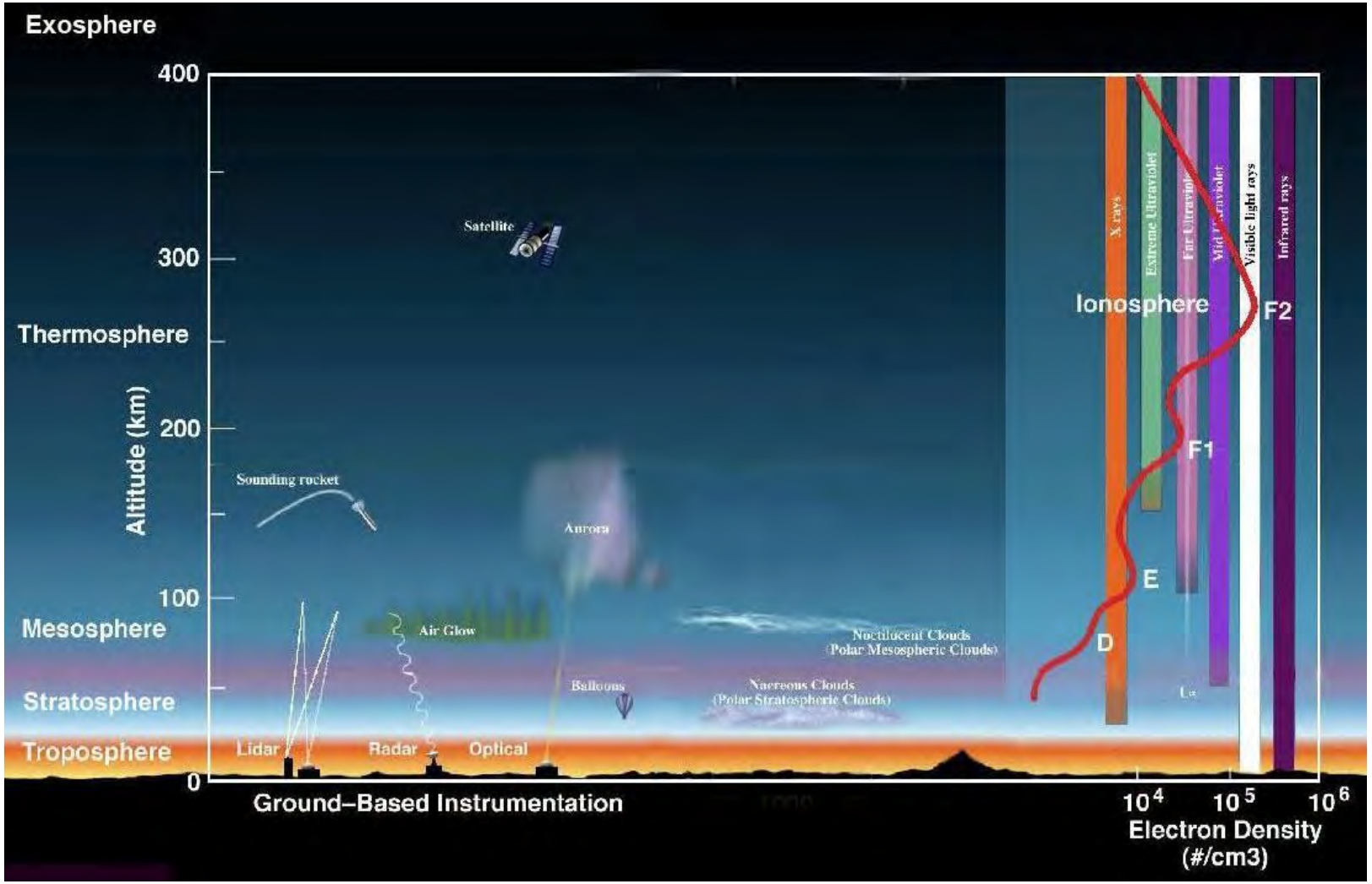
Radiation Effects

SWaP

Vacuum compatibility

Mechanical

Temperature Effects



climate.nasa.gov

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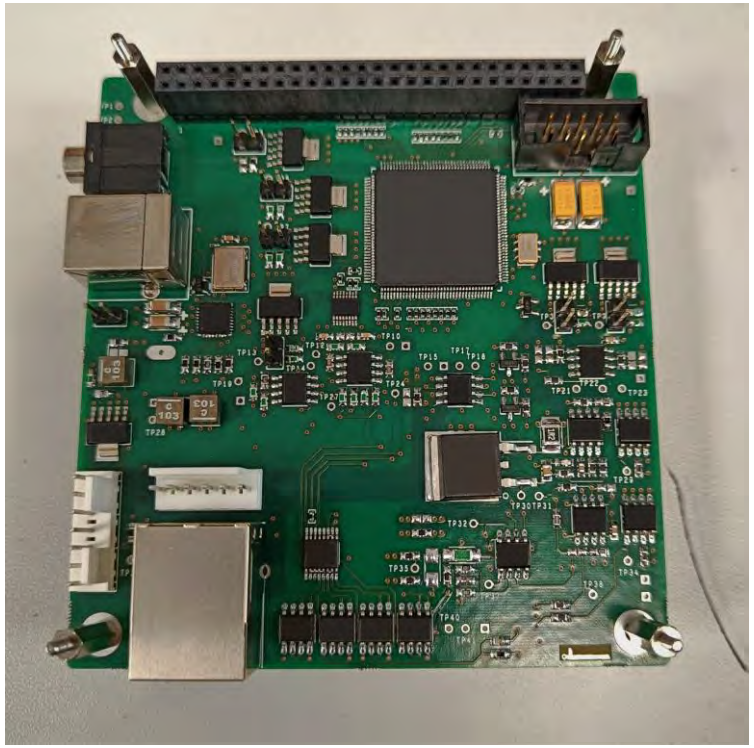
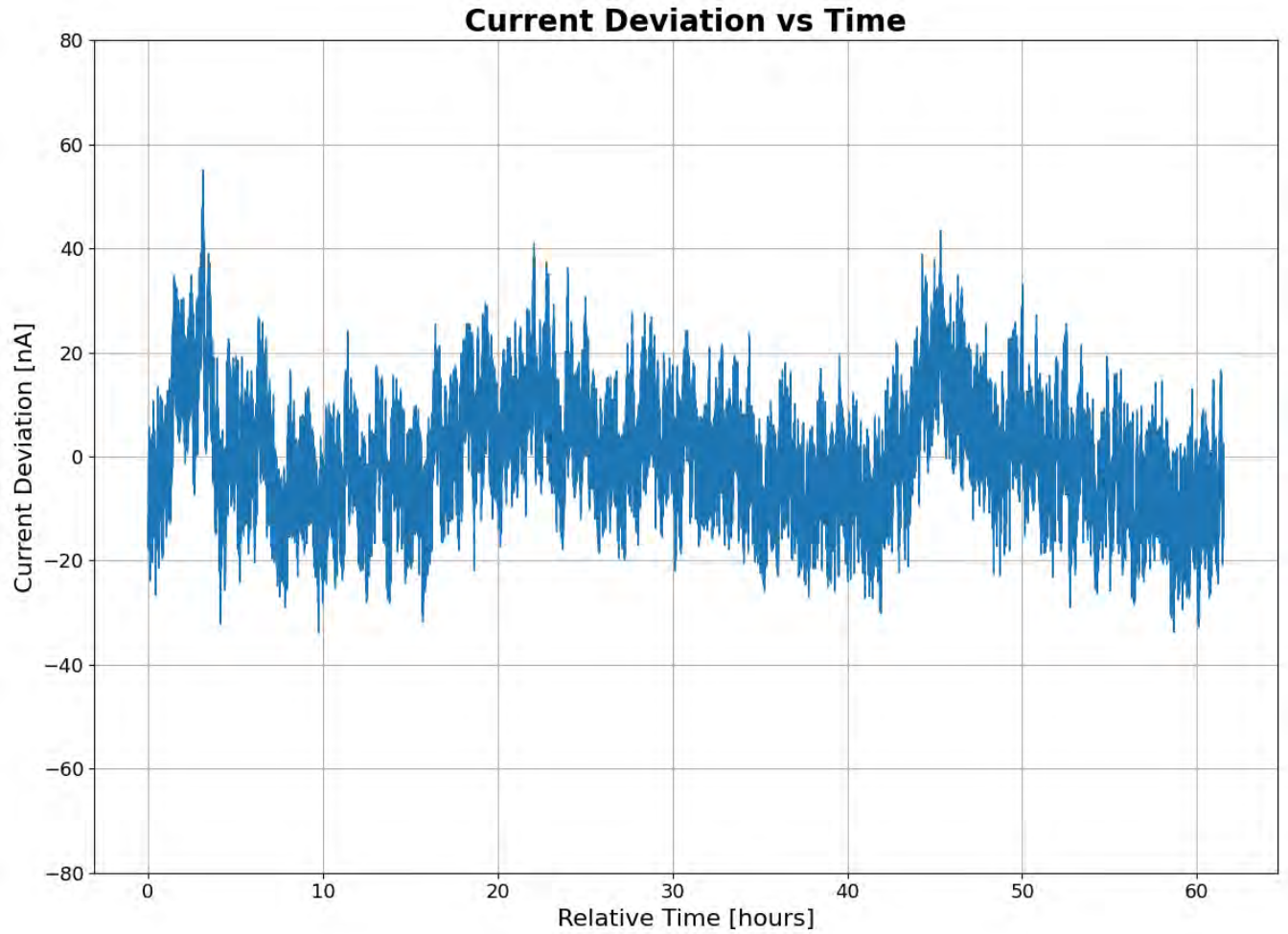
Electronic control





Ambient operation: exceeds stability requirements x10

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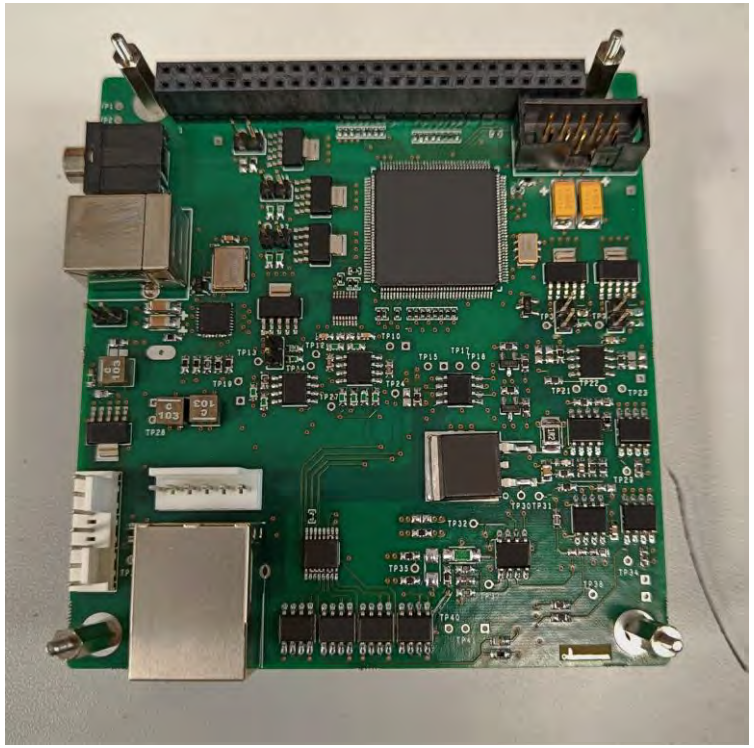
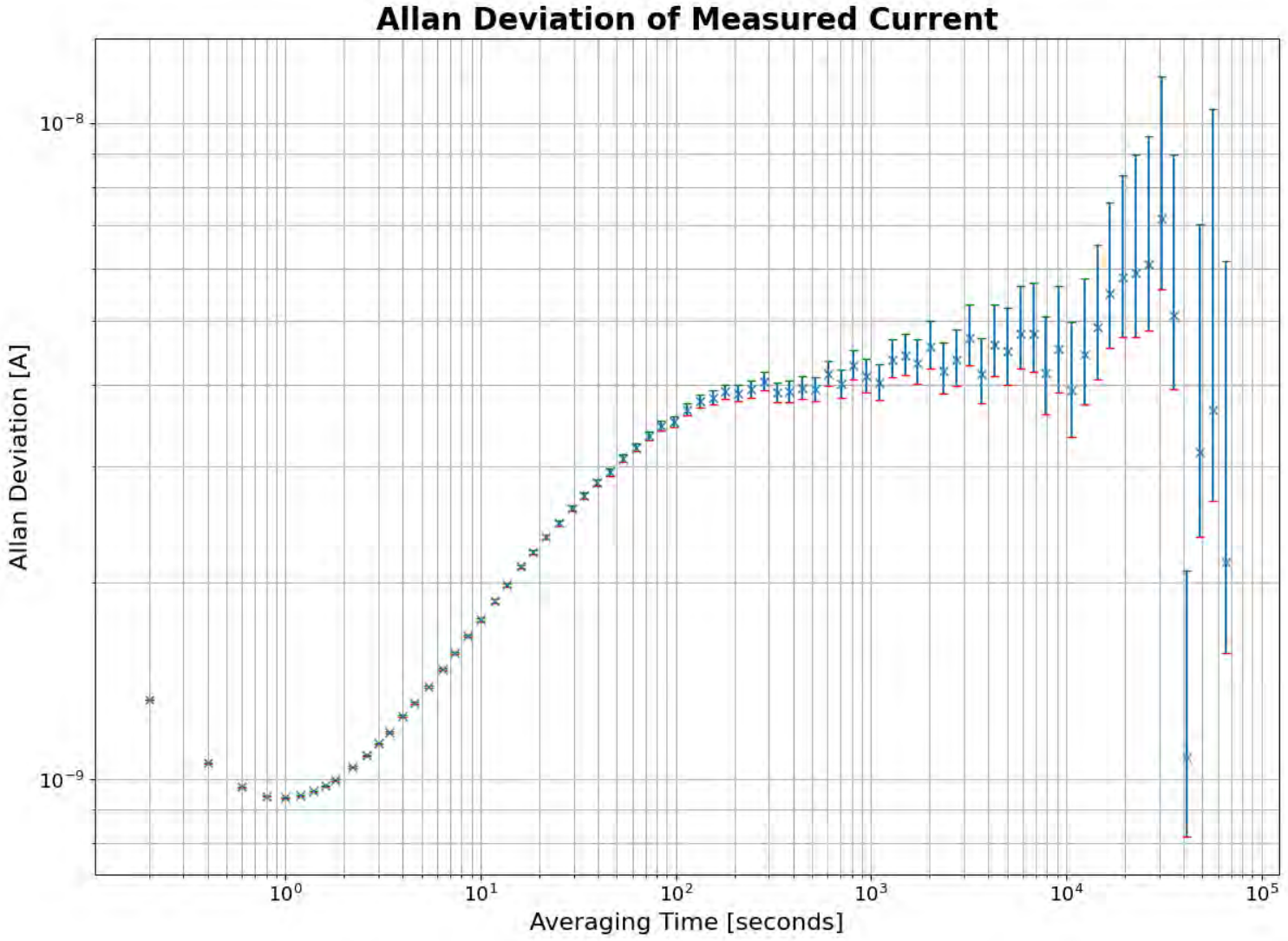
Electronic control





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CEOI Pathfinder

BGS

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iota

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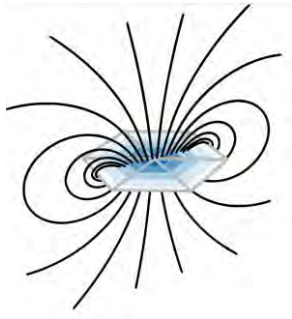


Quantum In Space

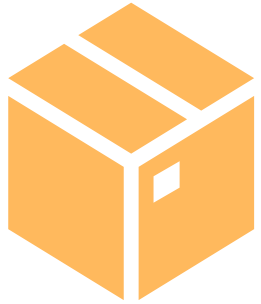
Sensors based on vapour cell technology

Acceleration

Rotation

Magnetic field

Clocks



Quantum Memories (QKD)

Radiometry

Thanks

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