Stray field impacts on CLIC

Collaboration on possible stray field effects on CLIC
CERN CLIC project – MFGI (Geological and Geophysical Institute of Hungary)
2016
1 July, 2017: ~~MFGI~~ → MBFSz (Mining and Geological Institute of Hungary)

to learn on natural AND man-made sources of **dynamic** magnetic fields
to discuss possible mitigation strategies

(natural) noises 1) in the **nT range** 2) at CERN 3) frequency band mHz-kHz
1) we are used to it: INTERMAGNET standard for geomagnetic observatories requires 1 nT absolute accuracy in all components (continuously)
achieved by a combination of a 3-component variometer + absolute measurements (total field magnetometer + directional measurements)
Variometer: typically fluxgate recorded with 1-10 pT resolution (noise 10-20 pT @ 1 Hz)
Absolute m. for weekly calibration: PPM (proton-precession mm.) + DI

First measurements

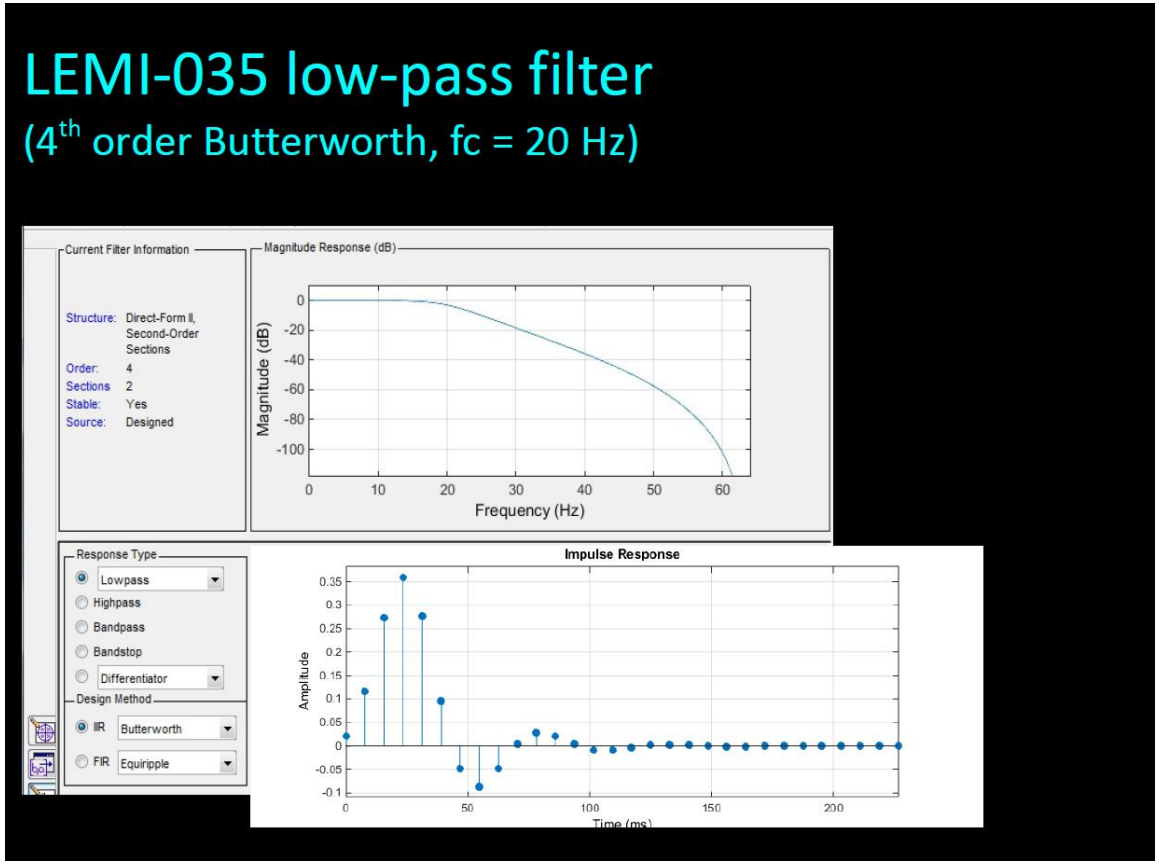
LEMI-035 magnetometer

MAIN TECHNICAL PARAMETERS

Measurement range	± 70000 nT
Magnetic field variation range (w/o additional compensation)	± 1000 nT
Analog output sensitivity	5 mV/nT
Analog output range	± 4.8 V
Frequency band, 4th order Butterworth low-pass filter	0…20 Hz
Noise level at 1 Hz	< 10 pT

Sampling rate 128 Hz, but....

LEMI-035 fluxgate



The instrument is not the optimal one (measurement range too small: 1 microT , observable bandwidth to small: up to few Hz, not radiation hard)

First measurements

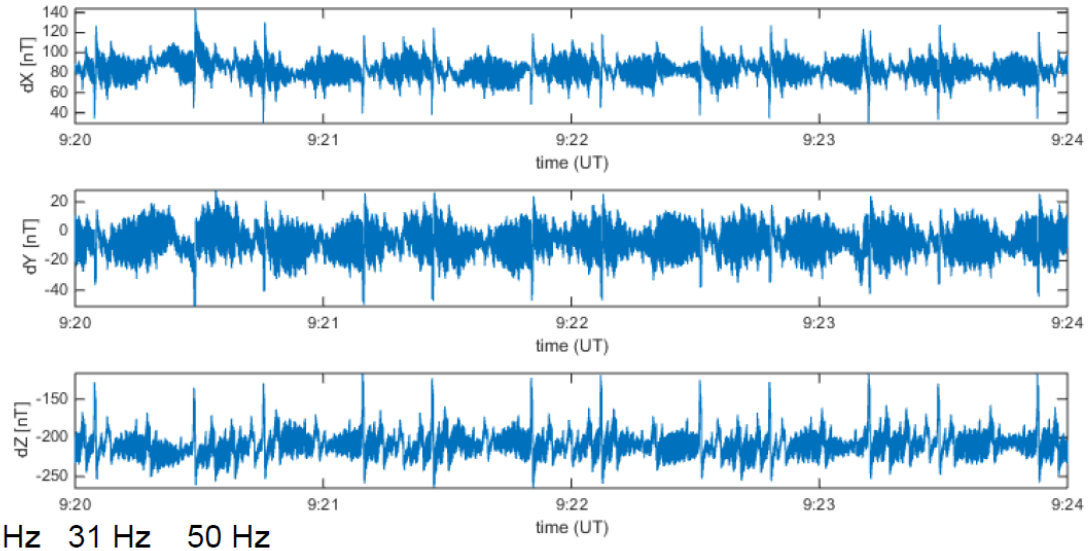
First surprizes

June 2016: ‚first measurement campaign'
rather ad hoc measurements to become familiar with the environment/instrument

1) We could make meaningful measurements even in this noisy environment (Klystron galery of CTF3, in CTF3 along the beam, etc.: signal came from the PS)
2) unexpectedly large magnetic fields were observed e.g. in AD hall (several microT), around the PS ring (hundreds of nT), at XBOX, etc
3) large variations (both in magnitude and direction) within short distance: most probably from underground stray currents (not from propagating waves)
4) We could identify most of the sources (PS cycle, AD signal, currents flowing along the waveguide in XBOX, aircon, signal from people walking by / moving cars, etc.

Just one example

At the aircon



15.3 Hz 31 Hz 50 Hz

21 June

January 2017 campaign

1)Define the natural baseline

Search for a location with minimum background technical noise level
Several CERN properties visited
None of them suitable

2) Measurements at the XBOX (see Eduardo Marin Lacoma's talk)

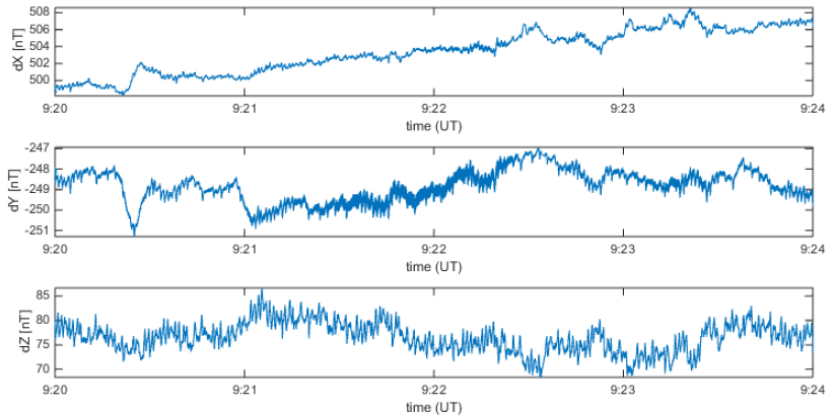
Cleanest at CERN

Define the baseline

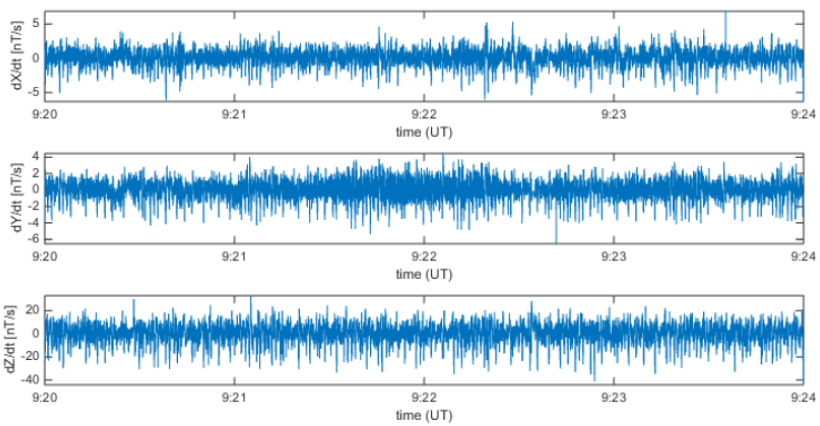
Search for a location with minimum noise level

1) Near MAF (in the middle of the small hill) (June 2016)

Near Magnetic Assembly Facility on the hill
(in the middle of the ring)



Rate of change near Magnetic Assembly Facility on the hill
(calculated from 16 Hz samples)



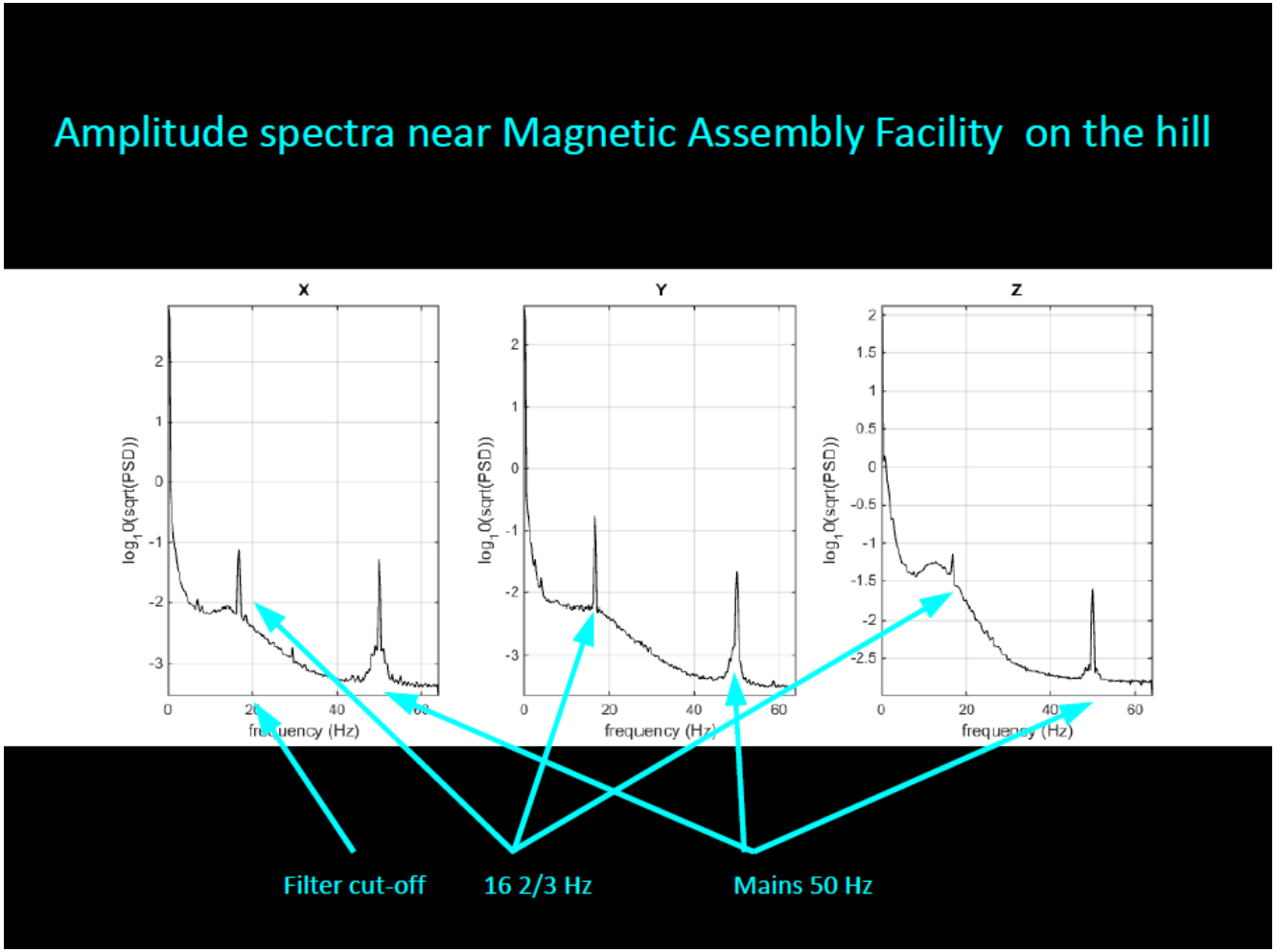
24 June

Peak-to-peak: ~4 nT (X), 4-6 nT (Y), 30-40 nT (Z)

Cleanest nearby

Recorded spectrum

50 Hz mains, 16.66 Hz (Swiss railway? or 3-phase)

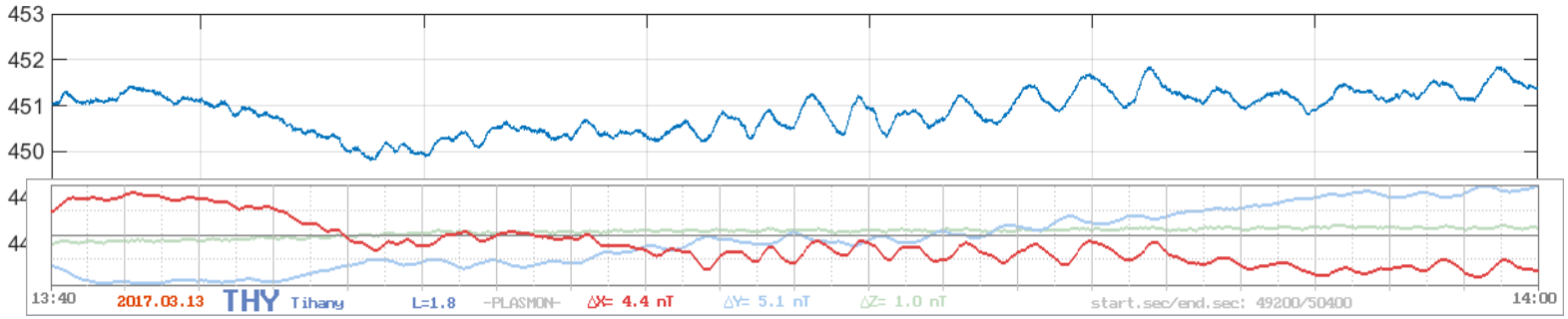


Cleanest nearby outside CERN

Define the baseline

Search for a location with minimum background noise level
We found clean signal, no (man-made) nose in the DC-5 Hz band near CERN on the hillside of Jura

At least for the half an hour period when we recorded variations

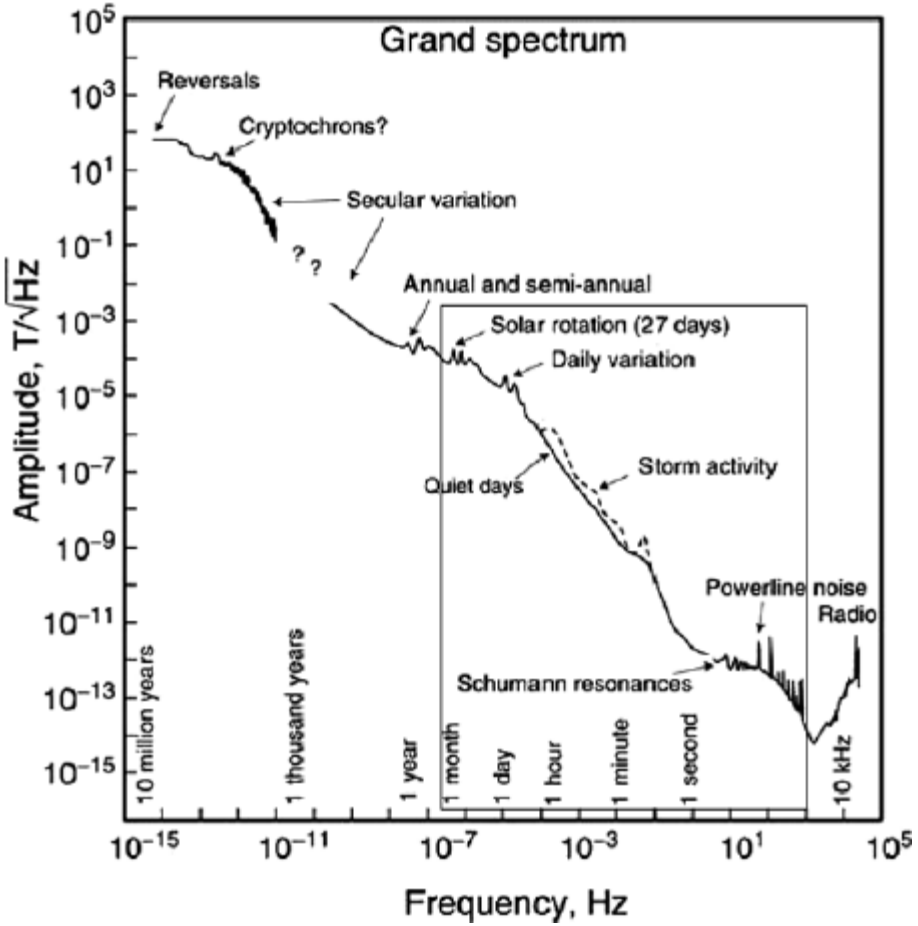


Conclusions

1) high technical noise level at CERN (observed up to ULF-ELF range)
2) most of thenoise is probably from underground/along the waveguide stray currents induced by technical environmental sources/on-site equipment (to be confirmed)
3) spatial variations on short scales (even meters?) observed
4) sensor was only roughly oriented and leveled → limited value of directional information needed for source localization

Plans

1) Start measurements at the variation station in Jura
to monitor local natural disturbances with possible impact
//geomagnetic storm effects will be introduced by C. Beggan
ULF waces (B. Heilig), MHD and beyond (D.H. Lee)//
2) Properly planned systematic surveys needed to map sources of stray fields
3) Make use of multicomponent observations for directional information
(orientation)
4) fluxgate measurements for the low frequencies (below few Hz) are valuable,
but baseline jump-problem (automated compensation to keep
the signal within a microT range)
2) extend observations to higher frequencies
to ELF (3 Hz-3 kHz in atmospheric science), VLF range (3-30 kHz)
note: E engineers use different terminology!! (defined by ITU)
CLIC purchased a search coil instrument (LEMI-144)
Advantage of search coil: rate of change m., broad band, low noise
goal 1 to construction of a „source-map” for noises
We need expertise on the ELF-VLF sources (J. Lichtenberger)


Grand spectrum
Reversals
Cryptochrons?
Secular variation
? ?
Annual and semi-annual
Solar rotation (27 days)
Daily variation
Storm activity
Quiet days
Powerline noise
Radio
Schumann resonances
Amplitude, T/√Hz
Frequency, Hz
10 million years
1 thousand years
1 year
1 month
1 day
1 hour
1 minute
1 second
10 kHz
10^5
10^3
10^1
10^-1
10^-3
10^-5
10^-7
10^-9
10^-11
10^-13
10^-15
10^-15
10^-11
10^-7
10^-3
10^1
10^5