

ENV training Outline

Introduction – Environmental noise hunting, WHAT IS IT?

Part I – Sensors and channels (Irene)

Part II – Experimental techniques (Federico)

Part III – Data analysis techniques (Irene)

ENV training session Part I Sensors and Channels

Irene Fiori on behalf of the ENV team

VIR-0947A-19

Virgo training sessions

September 26 2019

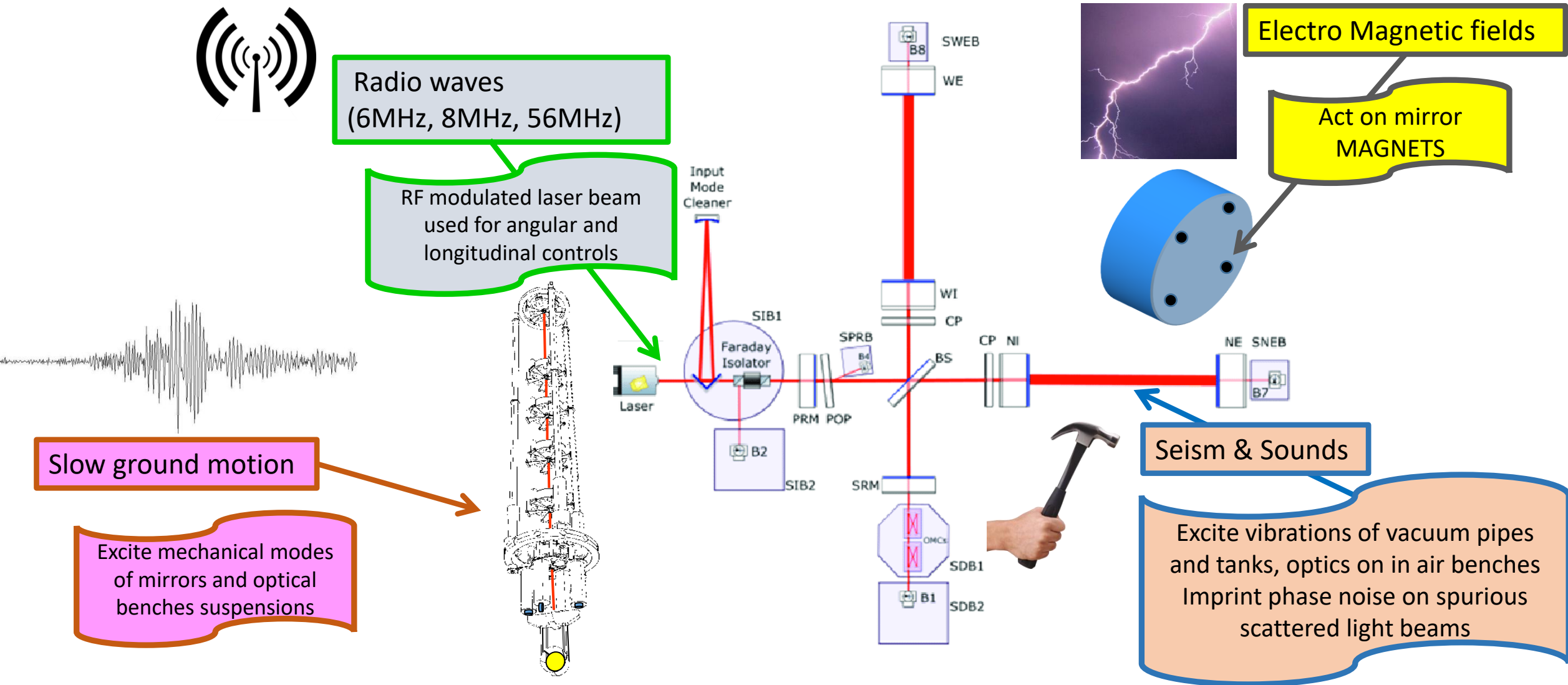
Outline of Part I

- Introduction: what is ENV noise disturbing Virgo?
- Environmental sensors
 - Type
 - Location
 - What they measure
- Channels
 - Names
 - Where to find the data

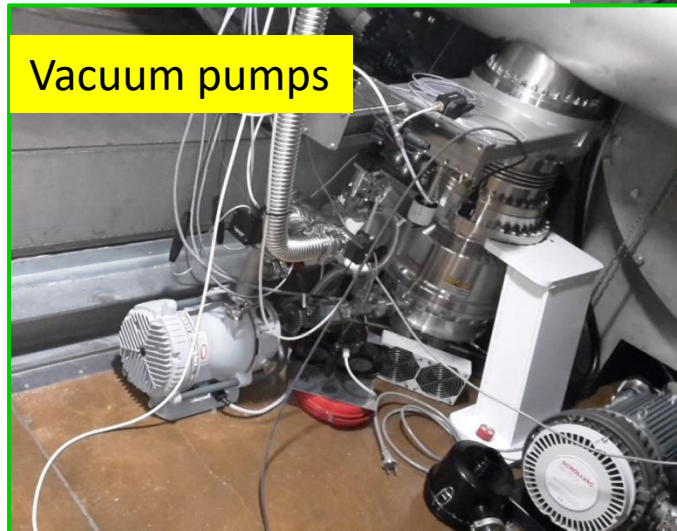
Introduction

Environmental noise hunting, WHAT IS IT?

Environmental influences on GW interferometer



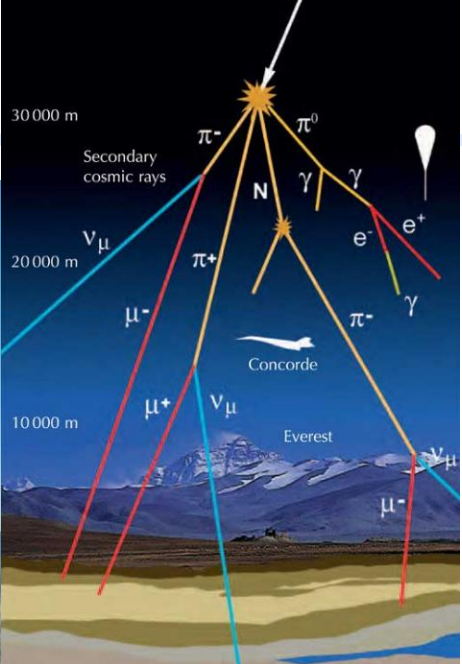
Self-inflicted noise



Electrical system, cables
Illumination,
Uninterruptible Power
Supply



Distant but loud



Part I

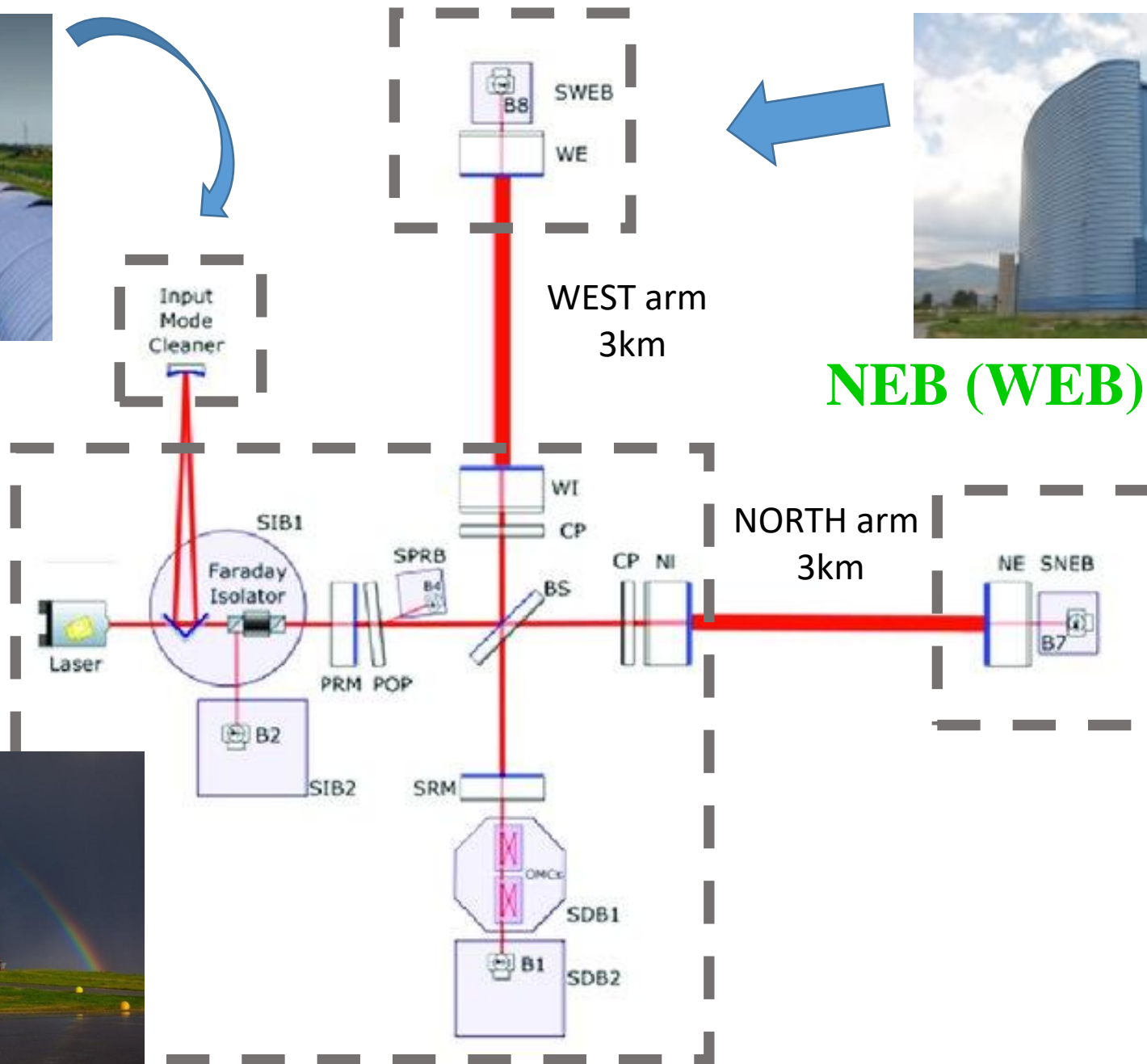
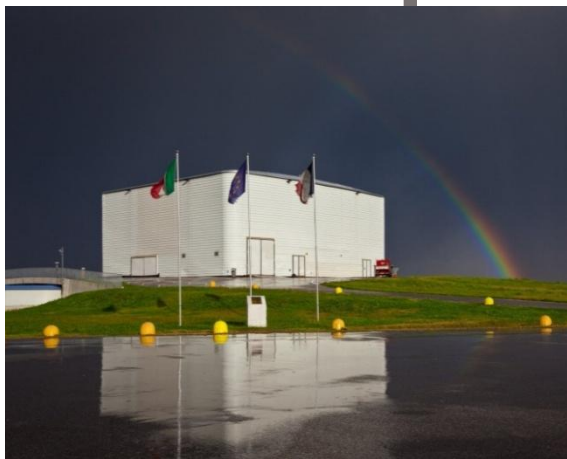
Sensors and channels

MCB



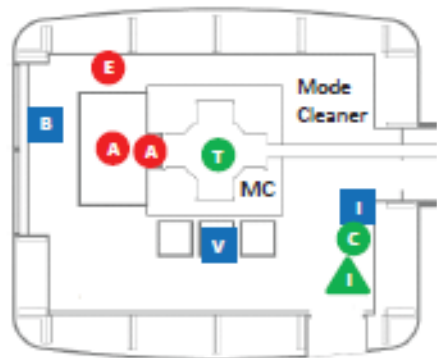
NEB (WEB)

CEB

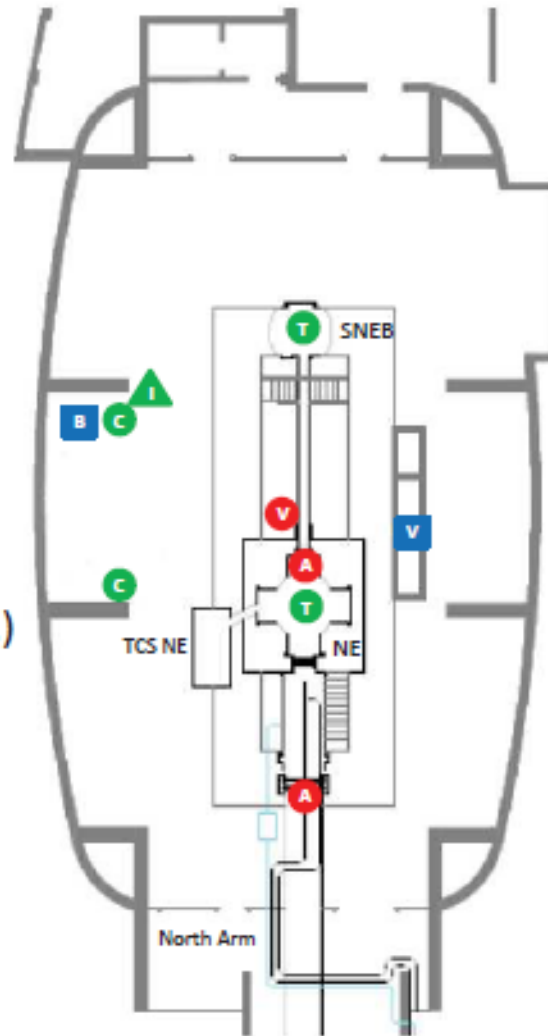


ENV probes

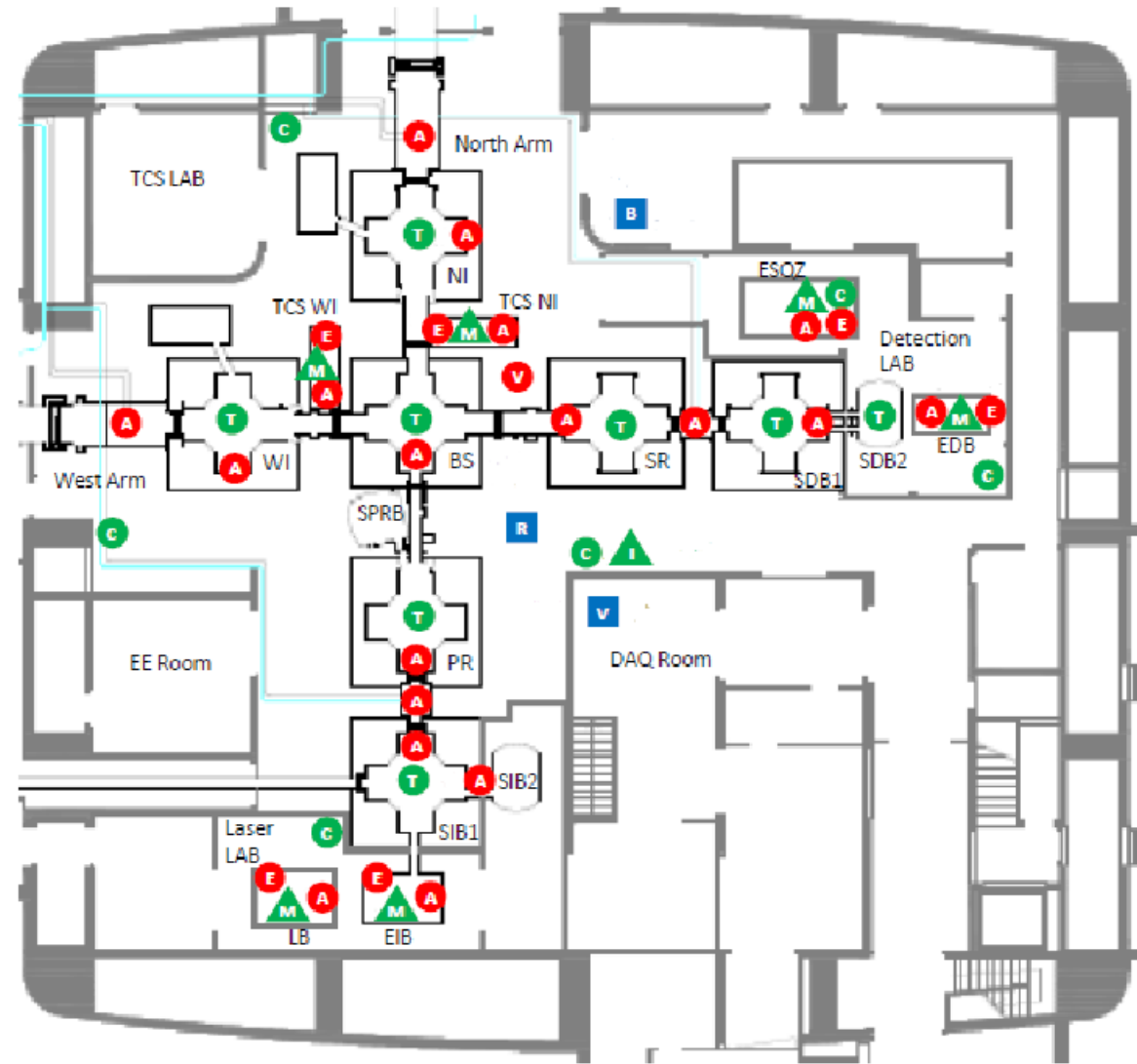
MCB and NEB (WEB)



- A** Accelerometer
- E** Episensor
- V** Velocimeter
- T** Thermometer
- C** Comb. (temp.+press.+hum.)
- M** Microphone
- I** Infrasound microphone
- B** Magnetometer
- V** Voltage probe
- I** Current probe
- R** Radio frequency antenna



CEB



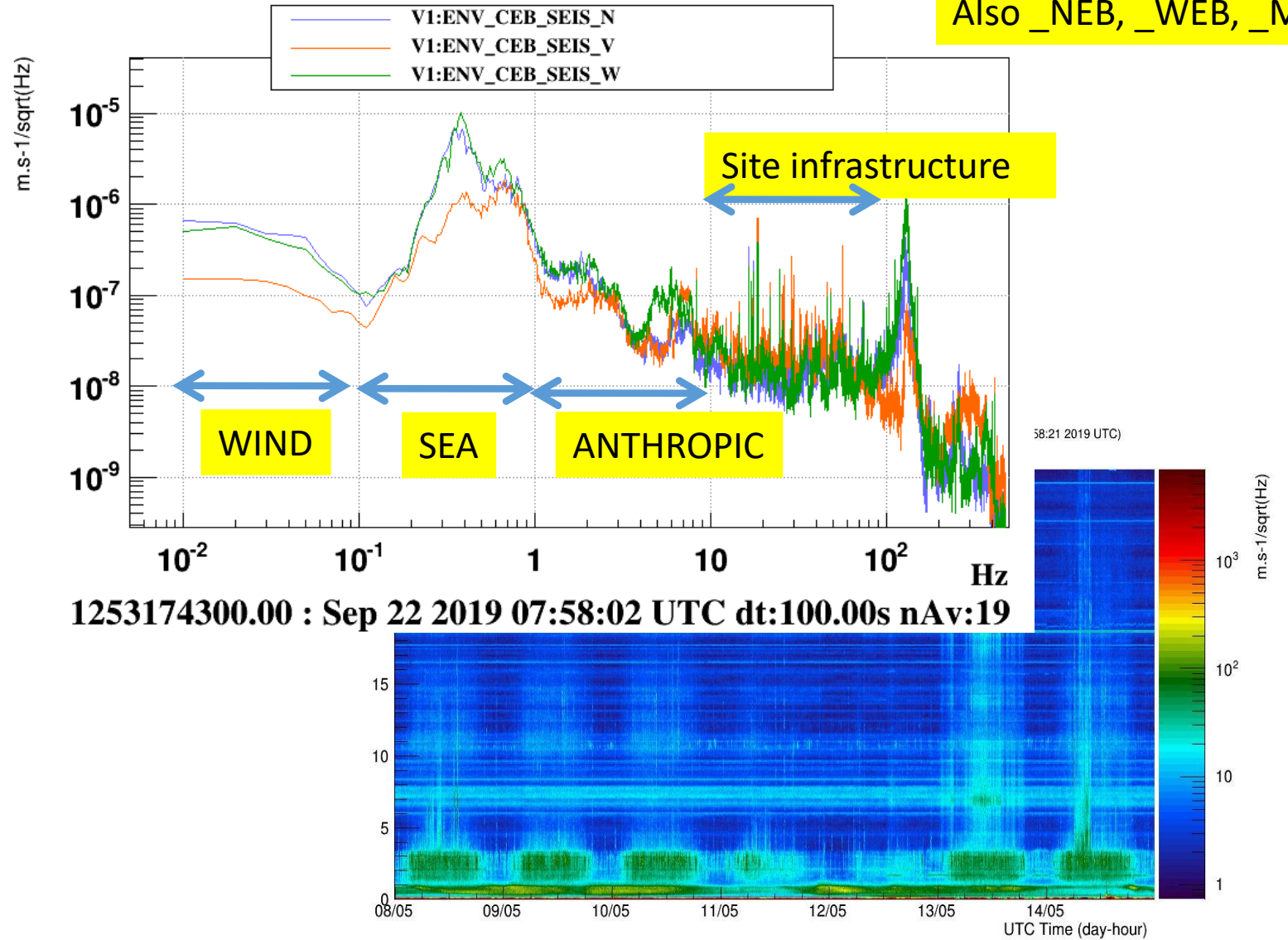
Building monitors

V1:ENV_CEB_SEIS_N
V1:ENV_CEB_SEIS_V
V1:ENV_CEB_SEIS_W
Also _NEB, _WEB, _MCB

- SOIL VIBRATIONS



**GURALP velocimeter
0.1Hz to 100Hz**



Building monitors

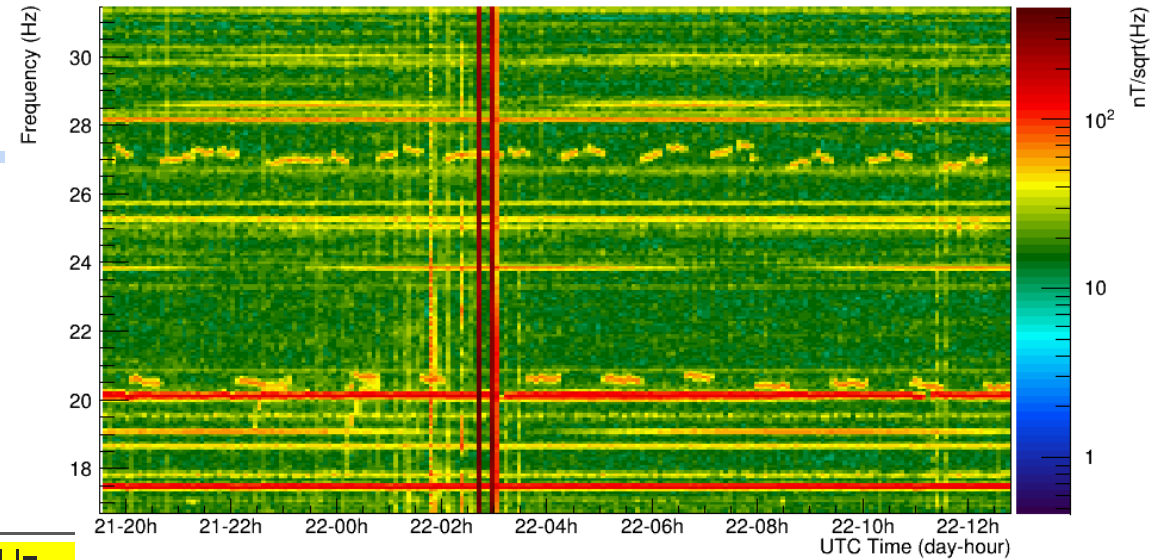
- MAGNETOMETERS



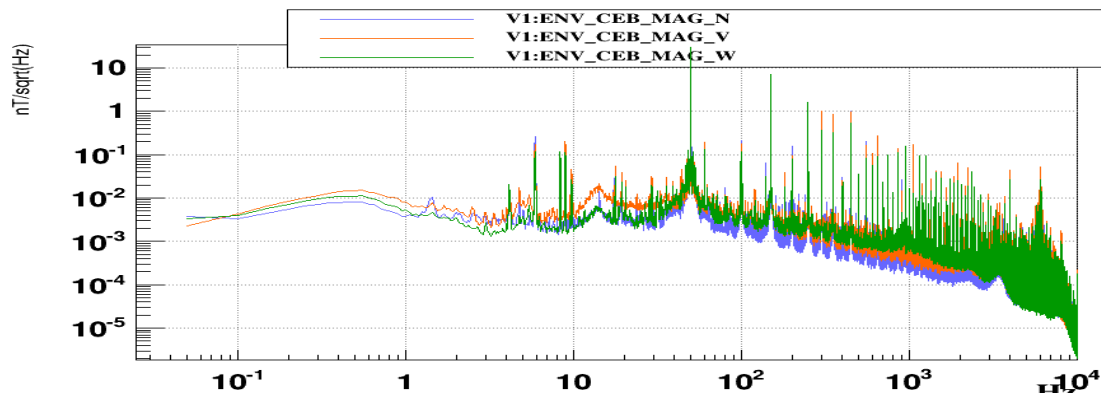
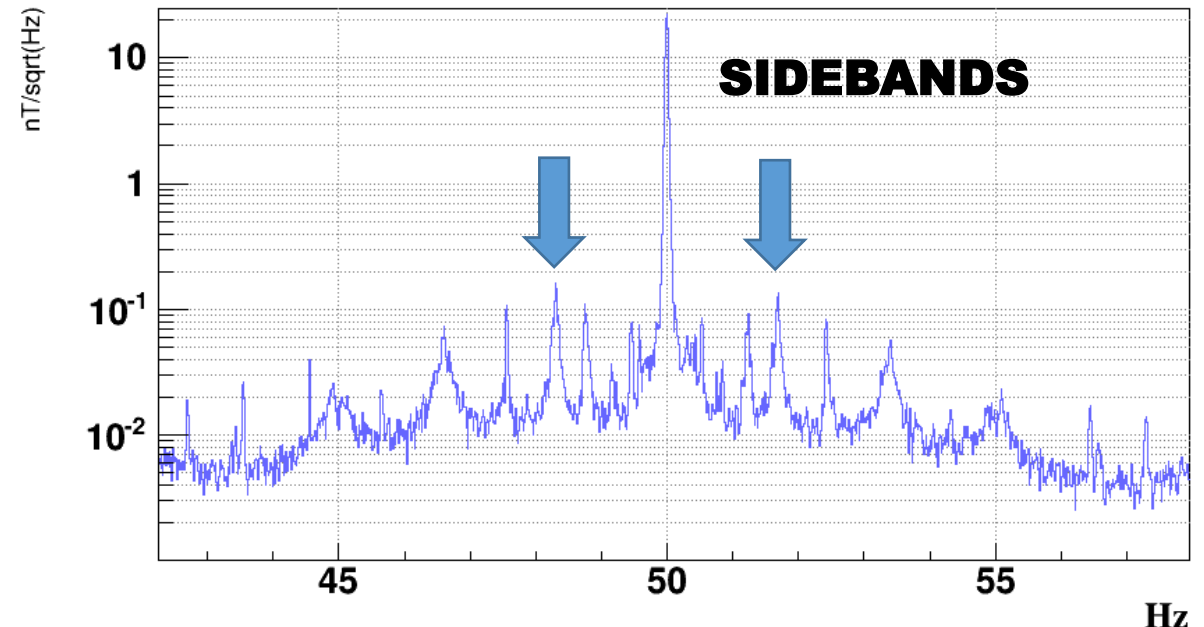
**Magnetometers
0.1-10kHz**

```
V1:ENV_CEB_MAG_N : 20000.00Hz
V1:ENV_CEB_MAG_V : 20000.00Hz
V1:ENV_CEB_MAG_W : 20000.00Hz
```

_NEB, _WEB, _MCB



V1:ENV_CEB_MAG_W__FFT



1240706890.00 : May 1 2019 00:47:52 UTC dt:20.00s nAv:30

1253196760.00 : Sep 22 2019 14:12:22 UTC dt:100.00s nAv:10

Building monitors

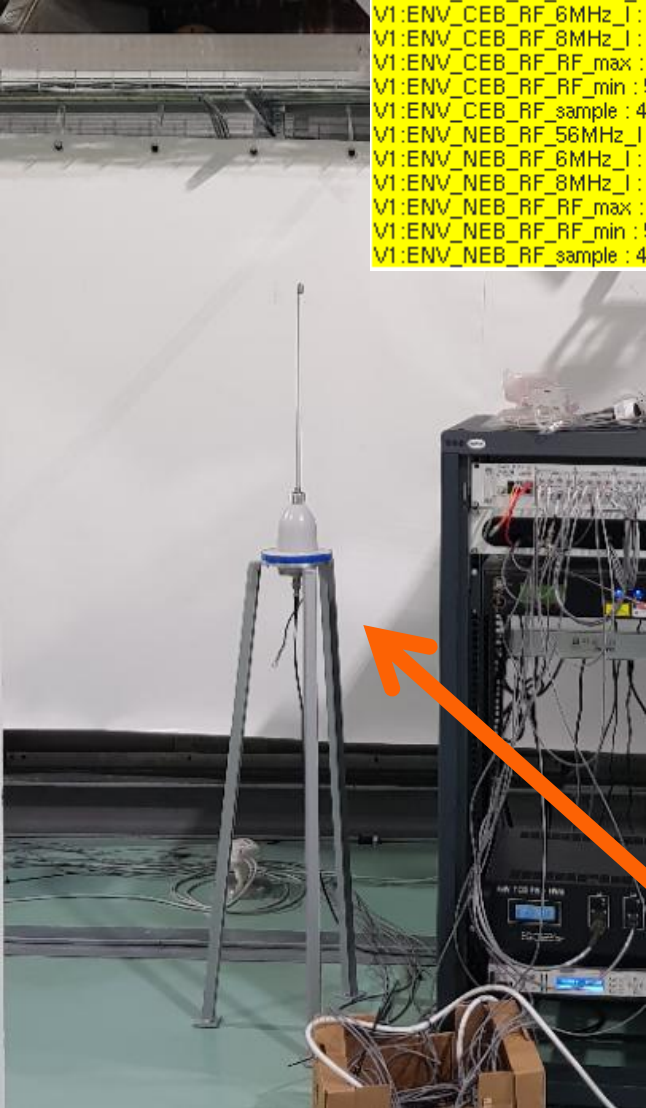
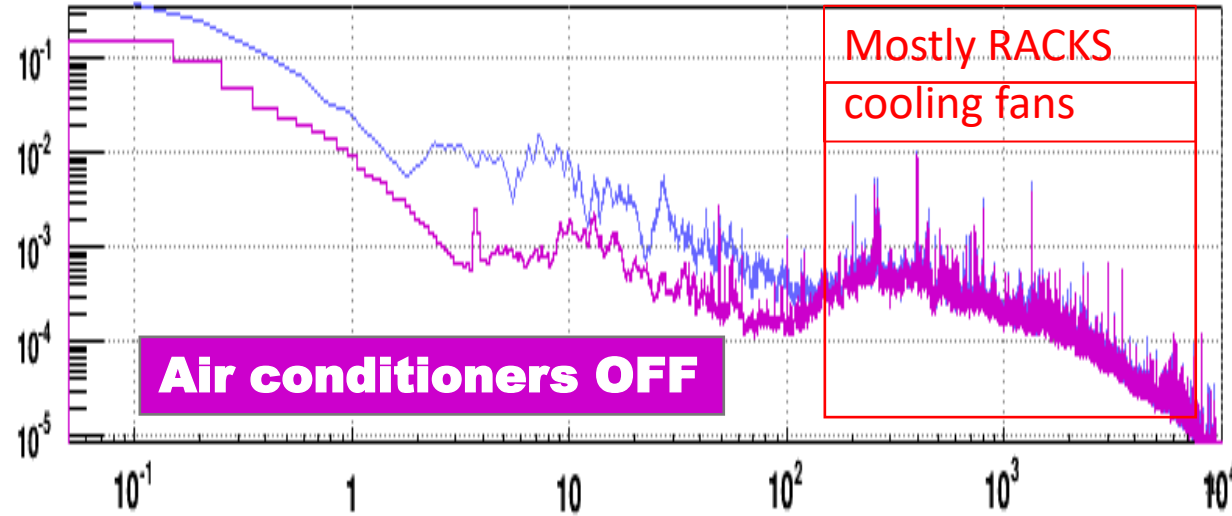
```
V1:ENV_CEB_RF_56MHz_I : 20000.00Hz
V1:ENV_CEB_RF_6MHz_I : 20000.00Hz
V1:ENV_CEB_RF_8MHz_I : 20000.00Hz
V1:ENV_CEB_RF_RF_max : 50.00Hz
V1:ENV_CEB_RF_RF_min : 50.00Hz
V1:ENV_CEB_RF_sample : 400000000.00Hz
V1:ENV_NEB_RF_56MHz_I : 20000.00Hz
V1:ENV_NEB_RF_6MHz_I : 20000.00Hz
V1:ENV_NEB_RF_8MHz_I : 20000.00Hz
V1:ENV_NEB_RF_RF_max : 50.00Hz
V1:ENV_NEB_RF_RF_min : 50.00Hz
V1:ENV_NEB_RF_sample : 400000000.00Hz
```

```
V1:ENV_CEB_MIC
V1:ENV_MCB_MIC
V1:ENV_NEB_MIC
V1:ENV_WEB_MIC
```



**Microphone
Infra sound
0.1 – 10kHz**

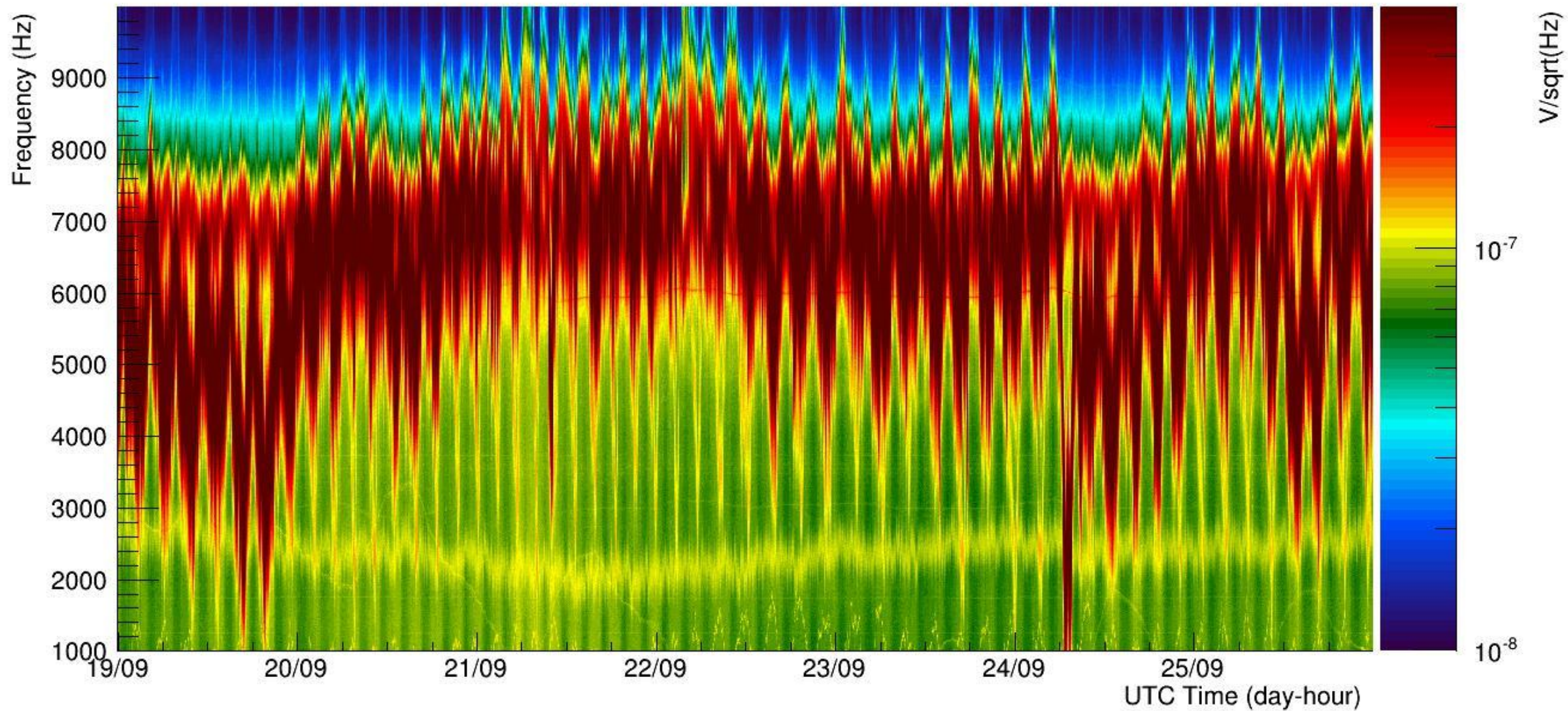
V1:ENV_CEB_MIC_FFT



**RF antenna:
signal is demodulated around Virgo's
Laser modulation frequencies: 6MHz, 8MHz, 56MHz
20kHz sampling**



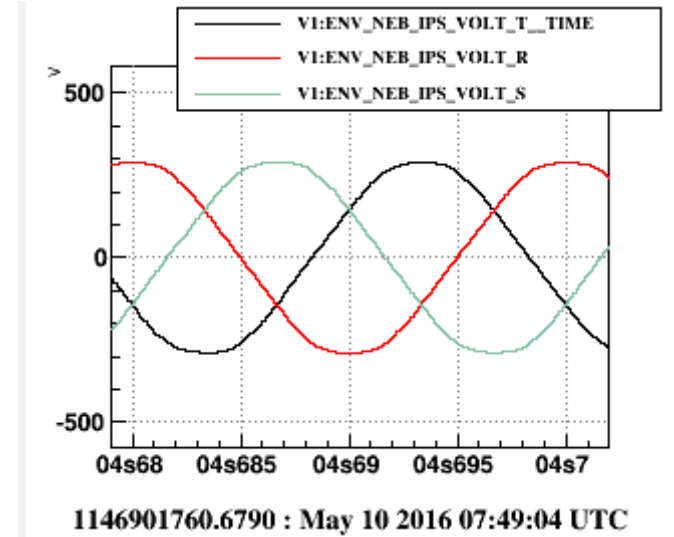
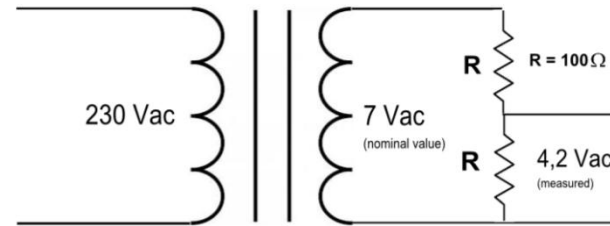
Spectrogram of V1:spectro_ENV_CEB_RF_6MHz_I_300_100_0_0 : start=1252886320.000000 (Wed Sep 18 23:58:22 2019 UTC)



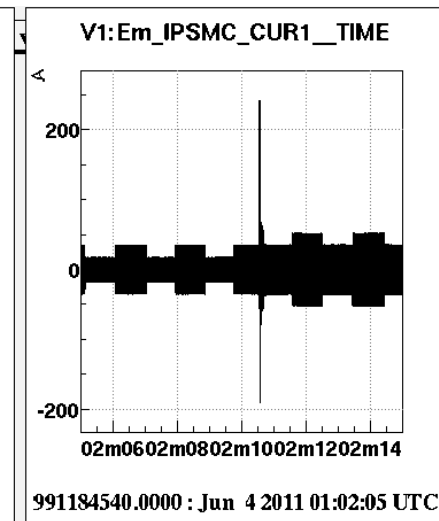
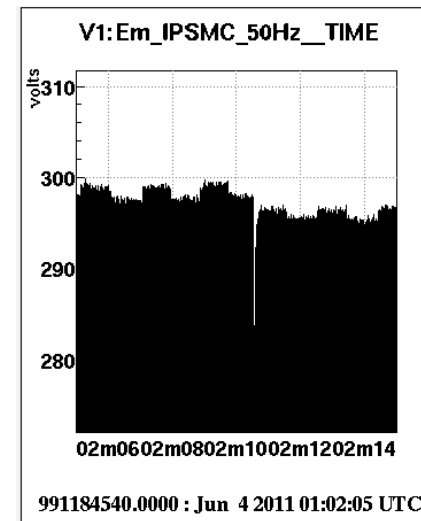
Building monitors

3 PHASES of MAINS

- Voltage monitors



- Current monitors



ENV probes

IN-AIR BENCH

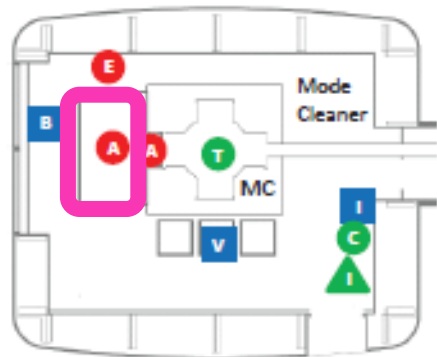
SUSPENDED IN_VACUUM BENCH

Acoustically isolated area

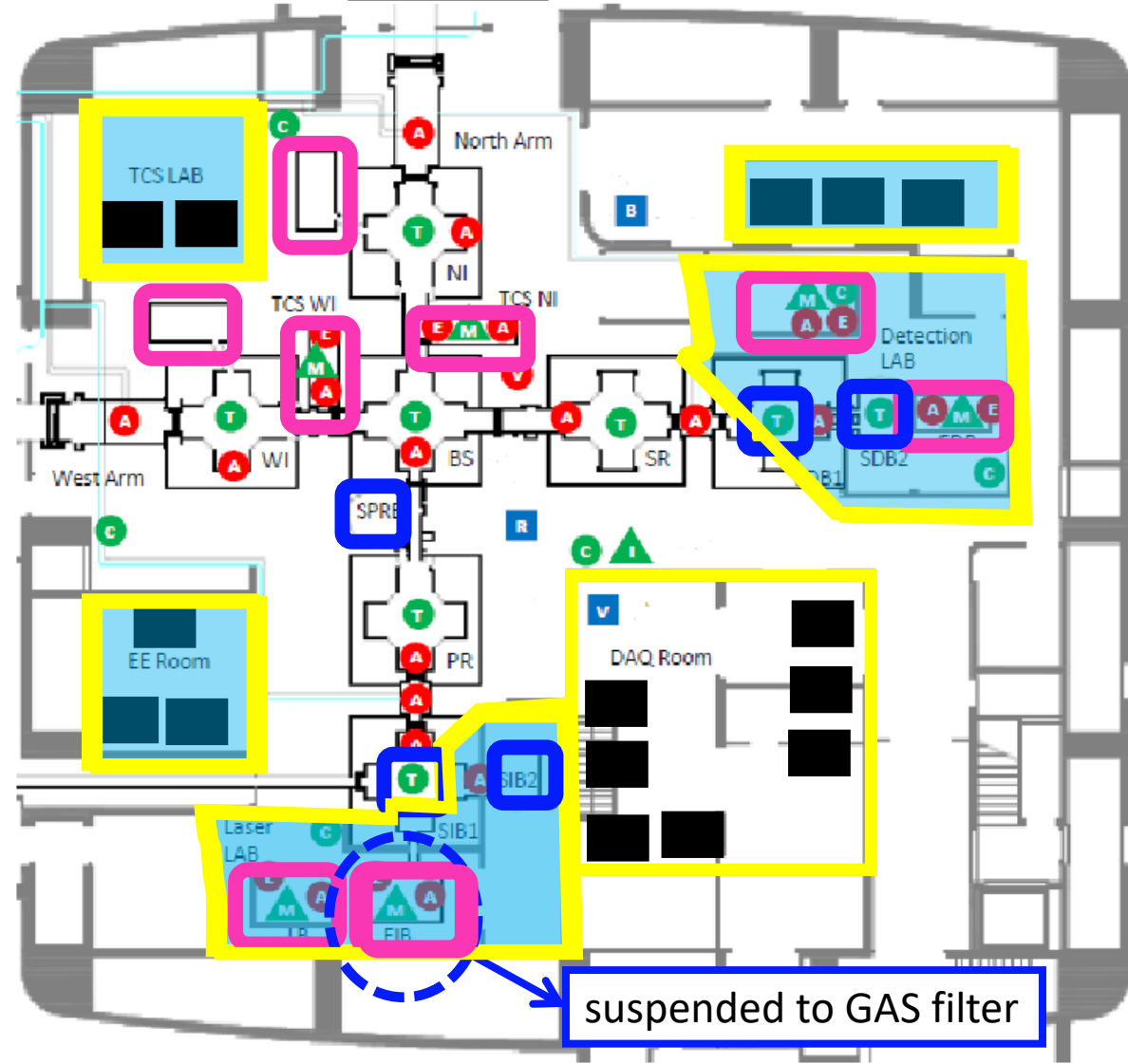
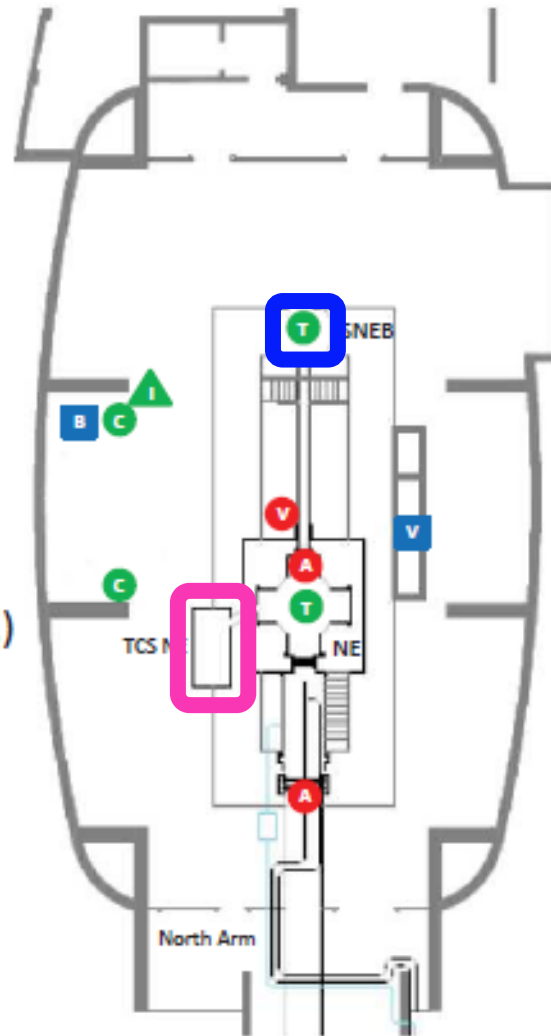
MCB and NEB (WEB)

■ = Electronic racks

CEB



- A Accelerometer
- E Episensor
- V Velocimeter
- T Thermometer
- C Comb. (temp.+press.+hum.)
- M Microphone
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Monitor of in-air benches

- 1 Microphone
- 1 Accelerometer (high frequency)
- 1 Tri-axial accelerometer (low frequency)
- 1 Temperature + Humidity sensor attached to bench
- 1 Temperature + Humidity + Pressure in the Clean Room

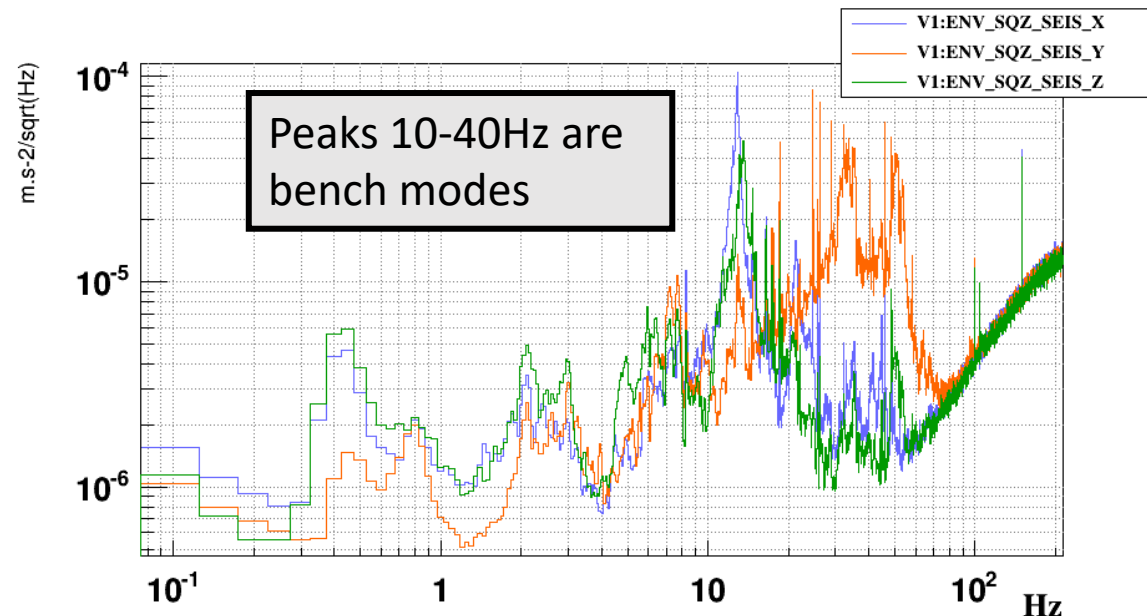
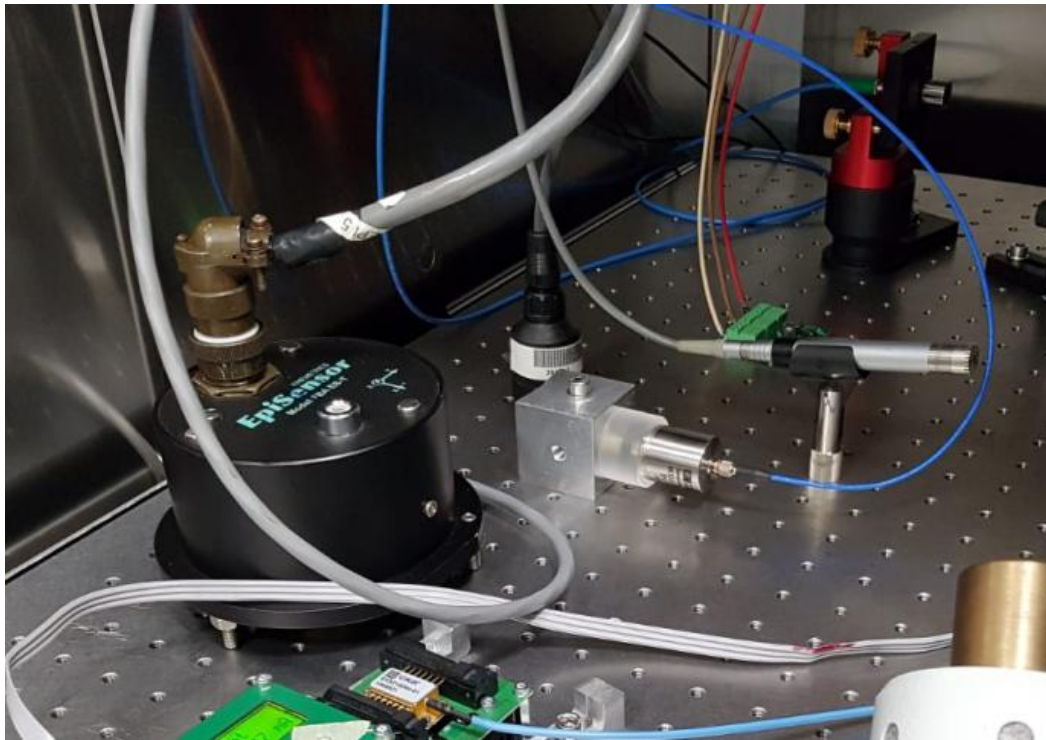
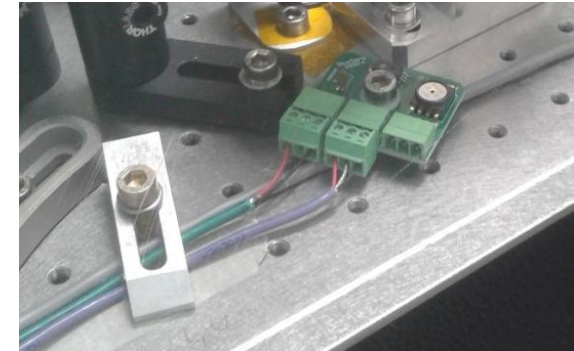
V1:ENV_EDB_ACC_Z : 10000.00Hz
 V1:ENV_EDB_HU : 1.00Hz
 V1:ENV_EDB_MIC : 20000.00Hz
 V1:ENV_EDB_PRES : 1.00Hz
 V1:ENV_EDB_SEIS_X : 1000.00Hz
 V1:ENV_EDB_SEIS_Y : 1000.00Hz
 V1:ENV_EDB_SEIS_Z : 1000.00Hz
 V1:ENV_FDR_TF : 1.00Hz

Also:
 LB,EIB,SQZ,TCS_CO2_NI
 TCS_CO2_WI, EMCB

1Hz-500Hz



10Hz-2kHz



1240707370.00 : May 1 2019 00:55:52 UTC dt:20.00s nAv:78

ENV probes

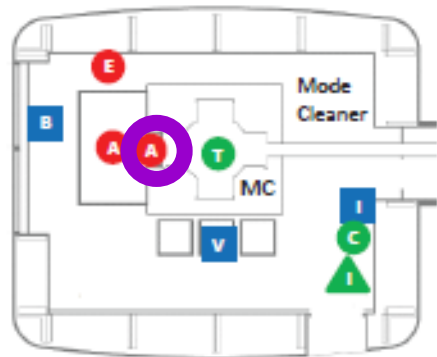
Vacuum chambers

Cryogenic vacuum traps

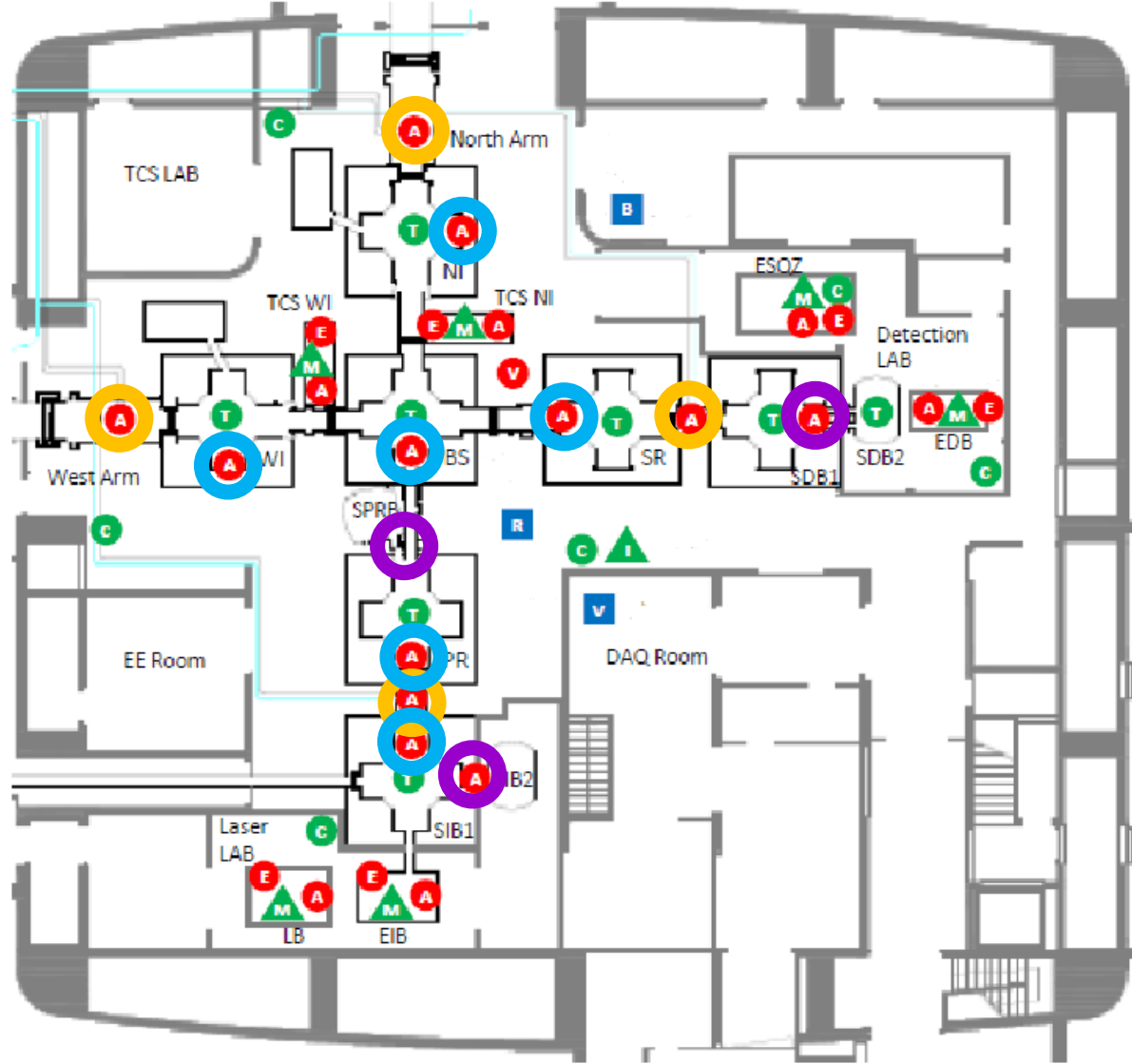
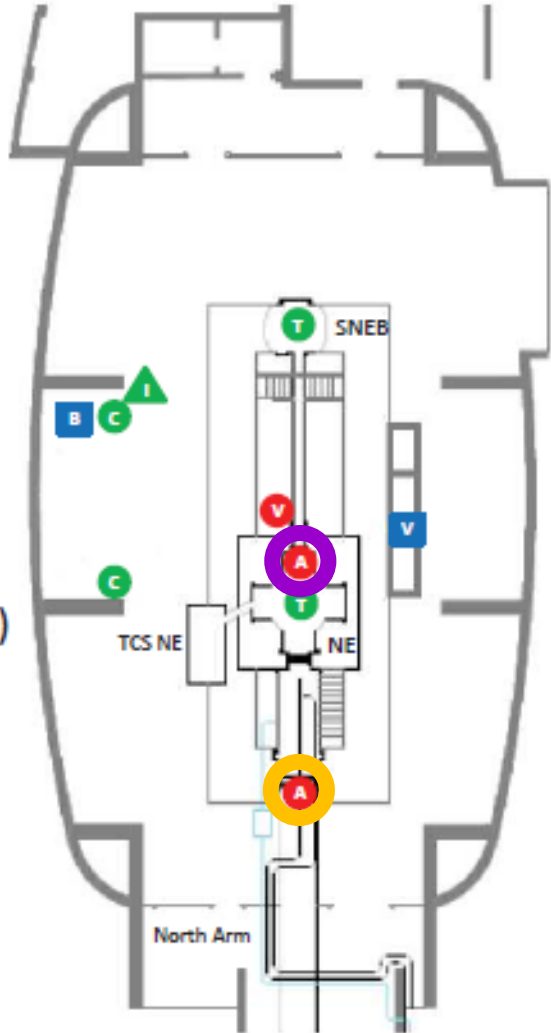
View-ports

MCB and NEB (WEB)

CEB



- A** Accelerometer
- E** Episensor
- V** Velocimeter
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- B** Magnetometer
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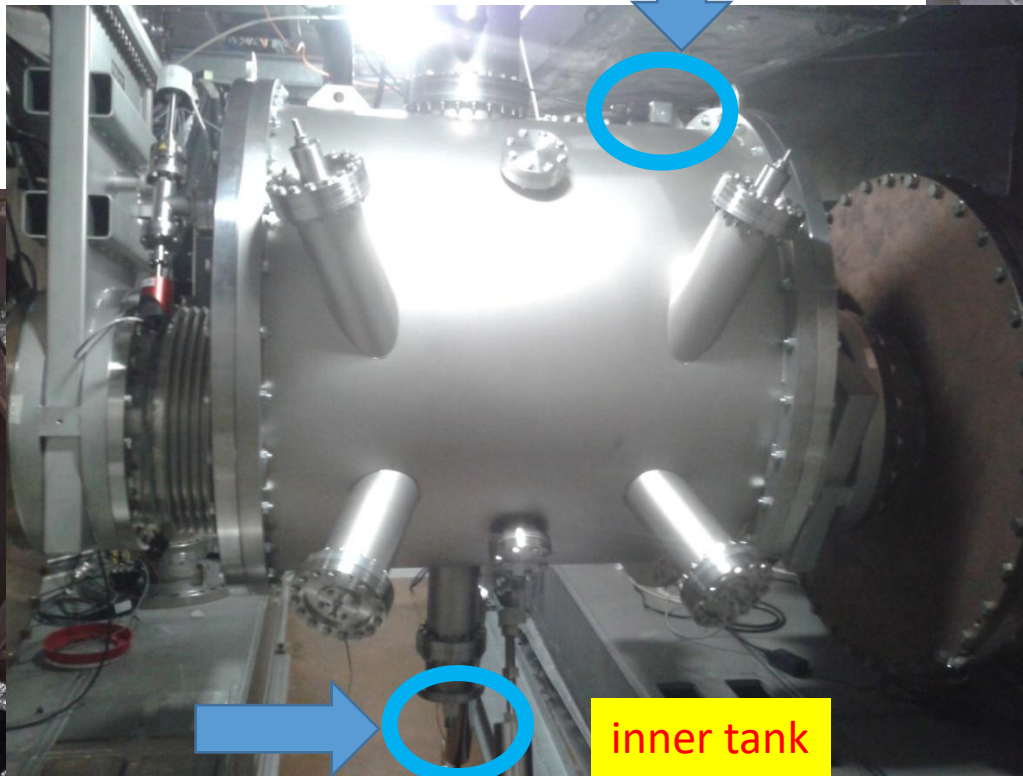
Monitor of critical spots

Possible sources of back-scattering:

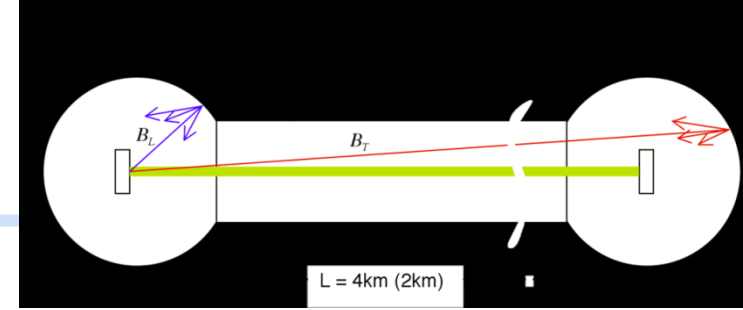
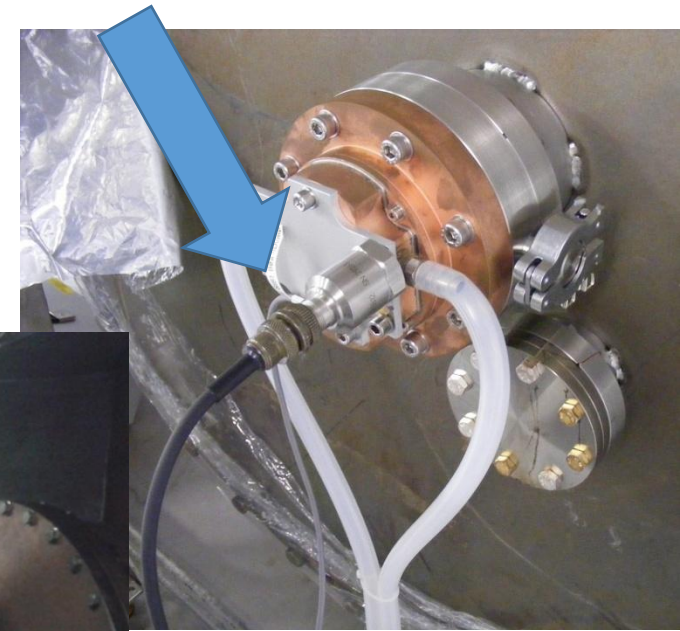
- Optical windows
- Beam dumps
- Cryogenic traps

TOT of 36 accelerometers

```
V1:ENV_BS_ACC_Z : 10000.00Hz
V1:ENV_DT_ACC_Z : 10000.00Hz
V1:ENV_DT_CT_ACC_Z : 10000.00Hz
V1:ENV_DT_CT_FINGER_ACC_Y : 10000.00Hz
V1:ENV_EDB_ACC_Z : 10000.00Hz
V1:ENV_EIB_ACC_Y : 10000.00Hz
V1:ENV_EMCB_ACC_Y : 10000.00Hz
V1:ENV_IB_ACC_X : 10000.00Hz
V1:ENV_IB_BD_ACC_Z : 10000.00Hz
V1:ENV_IB_CT_ACC_X : 10000.00Hz
V1:ENV_IB_CT_FINGER_ACC_Y : 10000.00Hz
V1:ENV_LB_ACC_Y : 10000.00Hz
V1:ENV_MC_ACC_Z : 10000.00Hz
V1:ENV_NEB_ACC_EAST_WALL : 10000.00Hz
V1:ENV_NE_ACC_Z : 10000.00Hz
V1:ENV_NE_CT_ACC_Z : 10000.00Hz
V1:ENV_NI_ACC_X : 10000.00Hz
V1:ENV_NI_CT_ACC_Z : 10000.00Hz
V1:ENV_NI_LINK_ACC_Z : 10000.00Hz
V1:ENV_PR_ACC_Z : 10000.00Hz
V1:ENV_PR_LINK_ACC_Z : 10000.00Hz
V1:ENV_SIB2_ACC_Z : 10000.00Hz
V1:ENV_SPRBLINK_ACC_Z : 10000.00Hz
V1:ENV_SPRB_ACC : 10000.00Hz
V1:ENV_SQZ_ACC_Y : 10000.00Hz
V1:ENV_SQZ_PIPE_ACC_Y : 10000.00Hz
V1:ENV_SR_ACC_Z : 10000.00Hz
V1:ENV_TCS_CO2_NI_ACC_Y : 10000.00Hz
V1:ENV_TCS_CO2_WI_ACC_Y : 10000.00Hz
V1:ENV_WE_ACC_Z : 10000.00Hz
V1:ENV_WE_CT_ACC_Z : 10000.00Hz
V1:ENV_WE_TOP_ACC_X : 10000.00Hz
V1:ENV_WI_ACC_X : 10000.00Hz
V1:ENV_WI_CT_ACC_Z : 10000.00Hz
```



outer tank

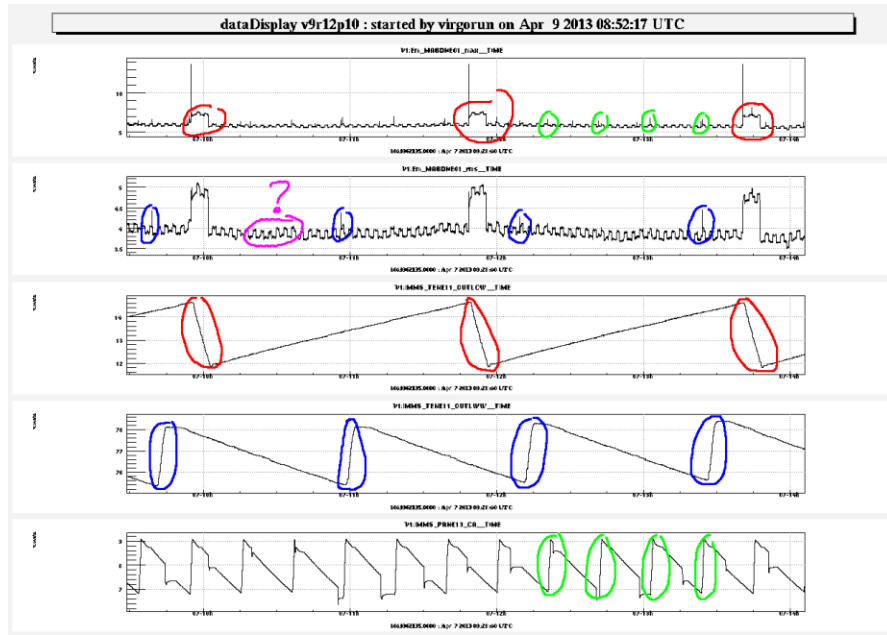


AUXILIARY slow monitors

- Monitors of infrastructure 1 Hz sampling
(**V1:INF_*** **V1:HVAC_*** **V1:VAC_***)
- Air&Water Temperature&Pressure
- Power consumption of big switching loads (chillers, heaters)
- Illumination (*LUX*)
- Air conditioners Hot&Cold loops
- Vacuum valves, LN2 levels, residual gas pressure, ...

```

V1:INF_CEB_CW_PRES_IN:1.00Hz
V1:INF_CEB_CW_PRES_OUT:1.00Hz
V1:INF_CEB_Class100_HUM:1.00Hz
V1:INF_CEB_Class100_TE:1.00Hz
V1:INF_CEB_Class1_HUM:1.00Hz
V1:INF_CEB_Class1_TE:1.00Hz
V1:INF_CEB_ENTRANCE_W_LUX:1.00Hz
V1:INF_CEB_HALL_N_PRES:1.00Hz
V1:INF_CEB_HALL_TE:1.00Hz
V1:INF_CEB_HALL_W_PRES:1.00Hz
V1:INF_CEB_LUX:1.00Hz
V1:INF_CEB_PRES_OUT:1.00Hz
V1:INF_CEB_TE_IN:1.00Hz
V1:INF_CEB_TE_OUT:1.00Hz
V1:INF_CEB_WW_PRES_OUT:1.00Hz
V1:INF_CEB_WW_TE_IN:1.00Hz
V1:INF_CEB_WW_TE_OUT:1.00Hz
    
```

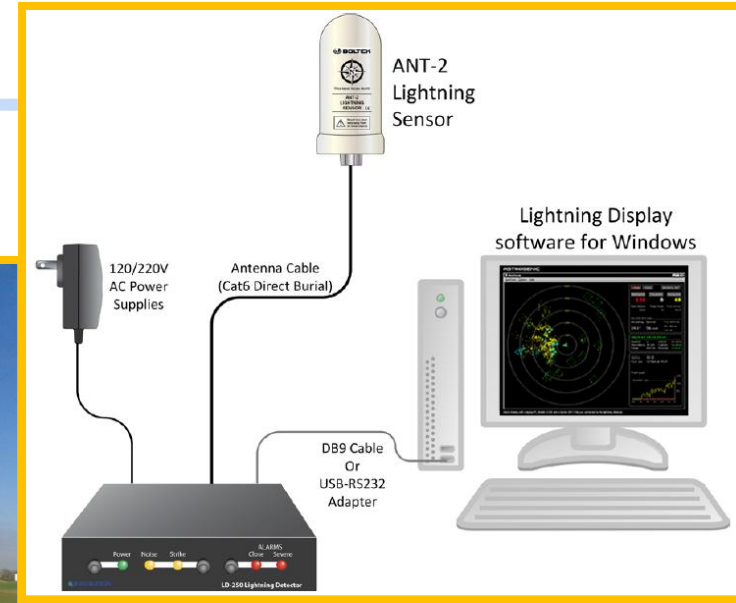


External monitors

- Weather station and Lightning detector**

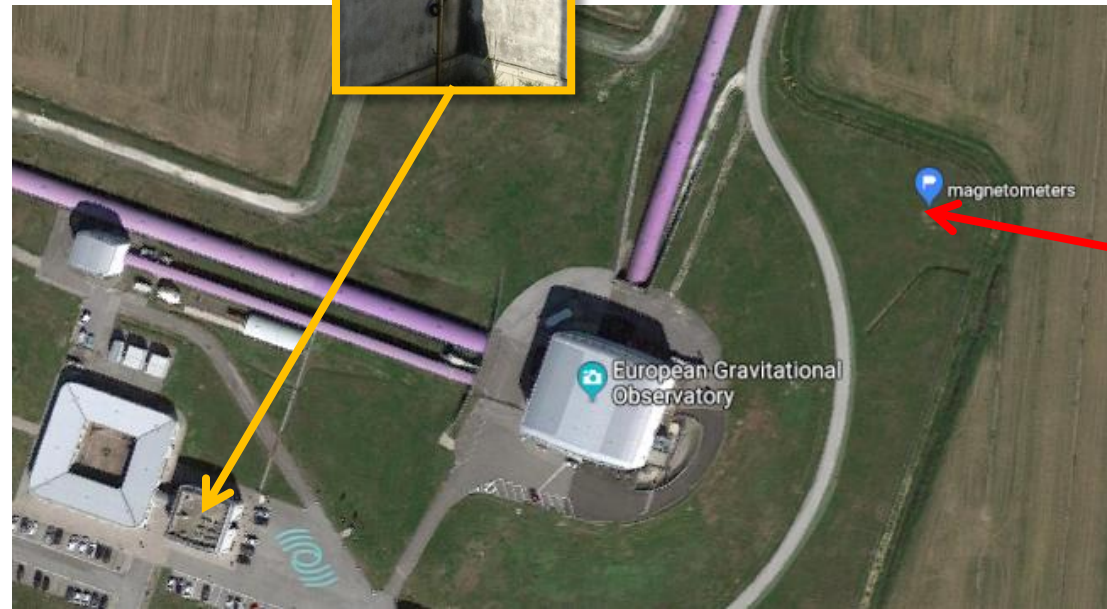
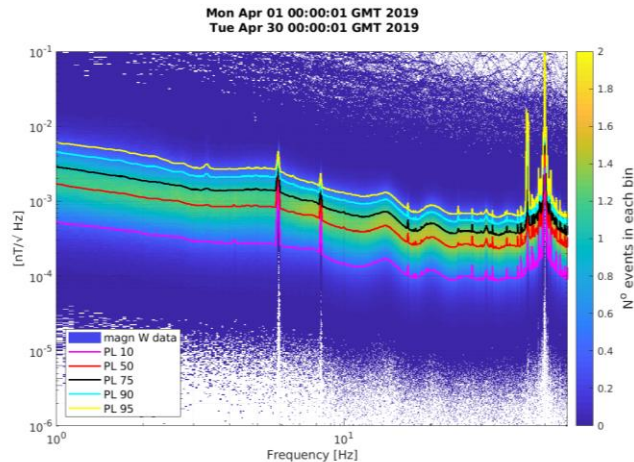
```
V1:ENV_METEO_HU : 1.00Hz
V1:ENV_METEO_PRES : 1.00Hz
V1:ENV_METEO_RAIN : 1.00Hz
V1:ENV_METEO_TE : 1.00Hz
V1:ENV_METEO_WIND_DIR : 1.00Hz
V1:ENV_METEO_WIND_SPD : 1.00Hz
```

```
V1:ENV_ZeusAZ : 1.00Hz
V1:ENV_ZeusCD : 1.00Hz
V1:ENV_ZeusN : 1.00Hz
V1:ENV_ZeusSpm : 1.00Hz
V1:ENV_ZeusUD : 1.00Hz
```



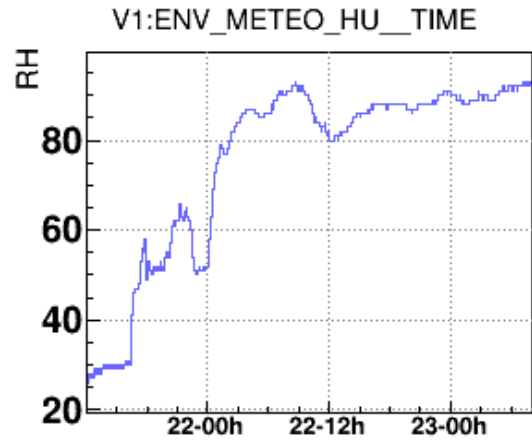
- External magnetometers**

```
V1:ENV_EXT_MAG_N : 2000.00Hz
V1:ENV_EXT_MAG_W : 2000.00Hz
```

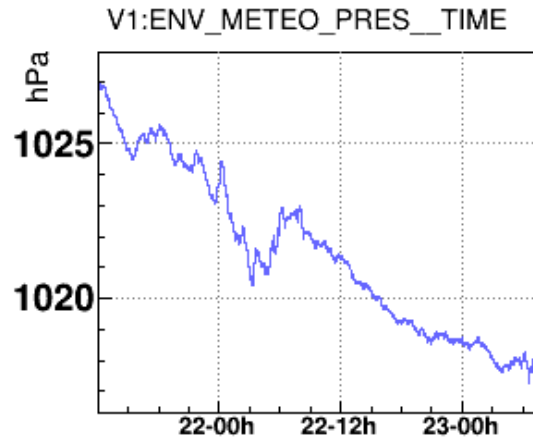


External monitors

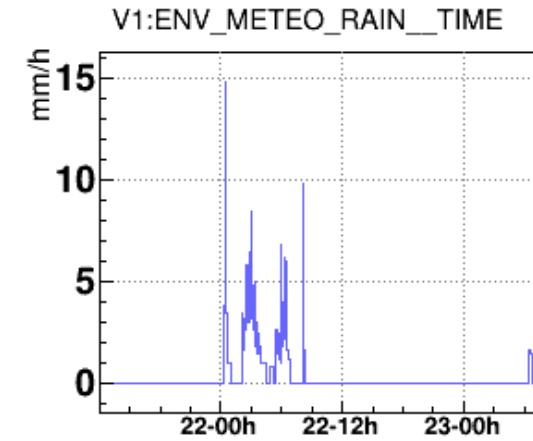
dataDisplay v10r9p1 : started by fiori on Sep 23 2019 08:22:33 UTC



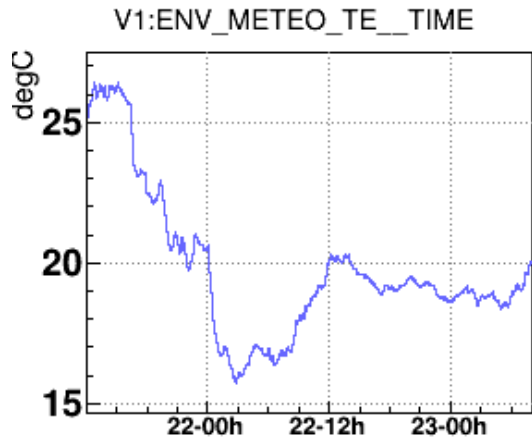
1253102459.0000 : Sep 21 2019 12:00:41 UTC



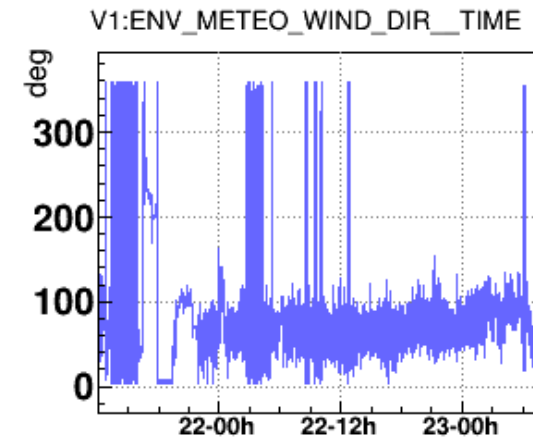
1253102459.0000 : Sep 21 2019 12:00:41 UTC



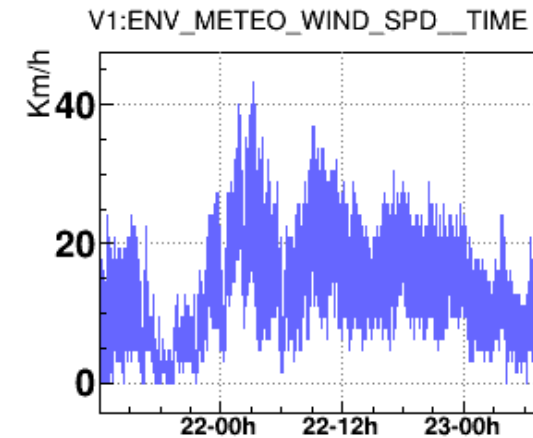
1253102459.0000 : Sep 21 2019 12:00:41 UTC



1253102459.0000 : Sep 21 2019 12:00:41 UTC



1253102459.0000 : Sep 21 2019 12:00:41 UTC



1253102459.0000 : Sep 21 2019 12:00:41 UTC

Environmental probes DOCUMENTATION

MAPS:

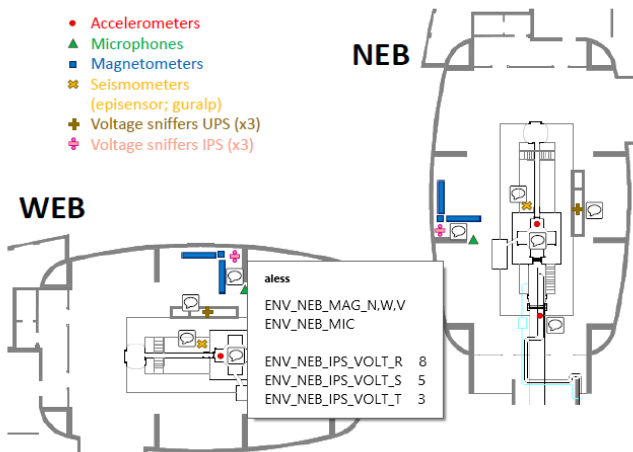
- HARDWARE inventory [MAP http://slwebtest.virgo.infn.it/ifoapp/](http://slwebtest.virgo.infn.it/ifoapp/)
- [ENV_maps_24_07_2018.pdf](#) (with location of FAST and SLOW probes)
- [Map_ENV_sensors_cirone.pdf](#) (with location of FAST probes, and associated NAMES)
- INF sensors interactive MAP <https://scientists.virgo-gw.eu/IMMS/>

SENSORS specs:

- <https://scientists.virgo-gw.eu/EnvMon/sensorDocs.htm>

FAST sensors with Channel names
(pdf file)

- Accelerometers
- ▲ Microphones
- Magnetometers
- ✦ Seismometers
(episensor; guralp)
- ⊕ Voltage sniffers UPS (x3)
- ⊖ Voltage sniffers IPS (x3)



IFN sensors interactive map

Channel name conventions

V1:ENV_**LOCATION(****_SUBLOCATION)****_SENSOR(****_DIRECTION)**

CEB = Central Building (NEB,WEB,MCB)
LLR = Laser Lab Room
....
BS = Beam Splitter
....
EIB = External Injection Bench
....

CT = CryoTrap
CHILLER
HEATER
LINK = link pipe
....

SEIS
ACC
MAG
MIC
VOLT
CURR
TE
HU
PRES
RF
....



Z is along beam

Orthogonal triplets:
X,Y,Z → Z is along beam direction, Y is vertical
N,W,V → N= along N arm, W=W arm, V= vertical

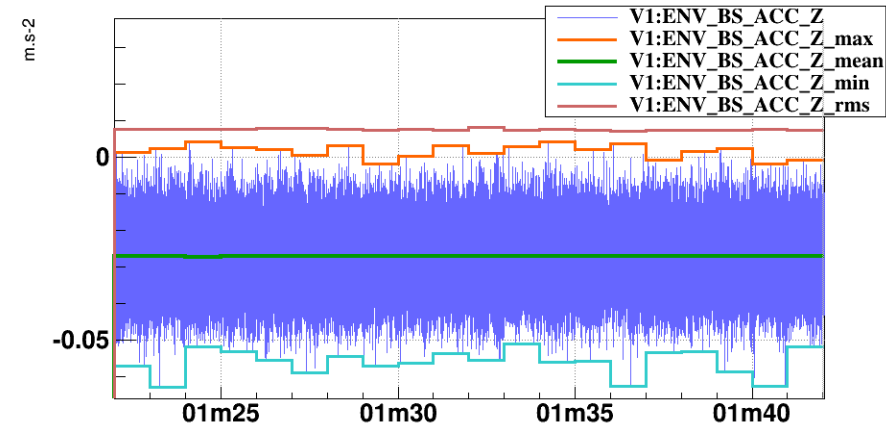
Channel naming conventions
VIR-0223B-14
<https://tds.virgo-gw.eu/ql/?c=10250>

For a more complete description
CHANNEL DATABASE
<http://slwebtest.virgo.infn.it/ifoapp/>

DATA streams: OFFLINE

• “RAW”:

- All channels with full sampling (1Hz, 1kHz,.... 20kHz,....)
- File list [/virgoData/ffl/raw.ffl](#) (to load in dataDisplay, or your own Matlab or Python script)
(updated every 5-10minutes)



• “TREND”:

Quick look over long time stretches

- Only channels sampled at 1Hz or less
- **min, max, mean, rms** of each raw channel (computed over 1s)
- File list [/virgoData/ffl/trend.ffl](#) (updated every 30minutes)
- **BRMS channels**: RMS computed over given band, **DQ_BRMSMon***, **Hrec**, several ENV channels

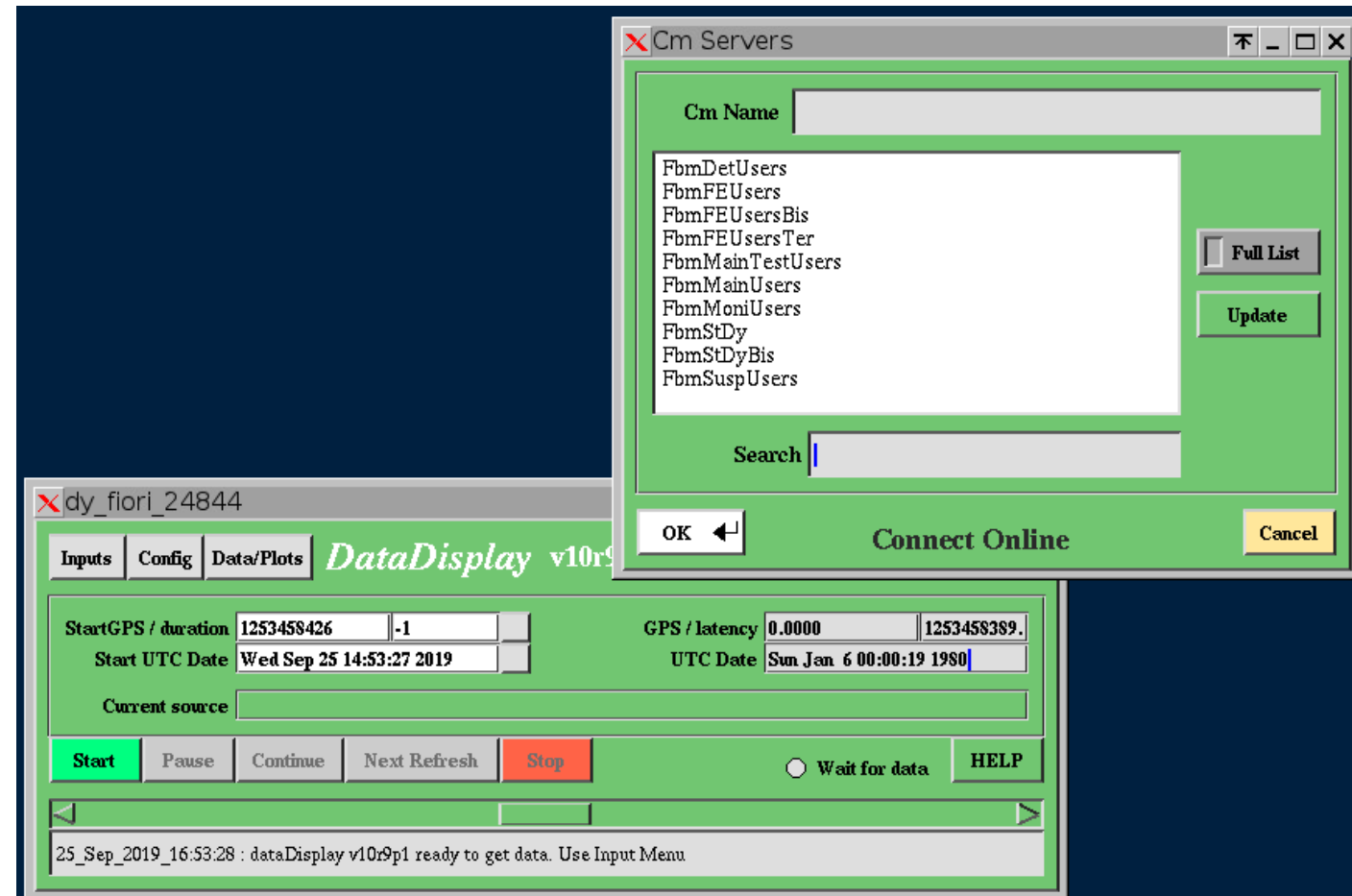
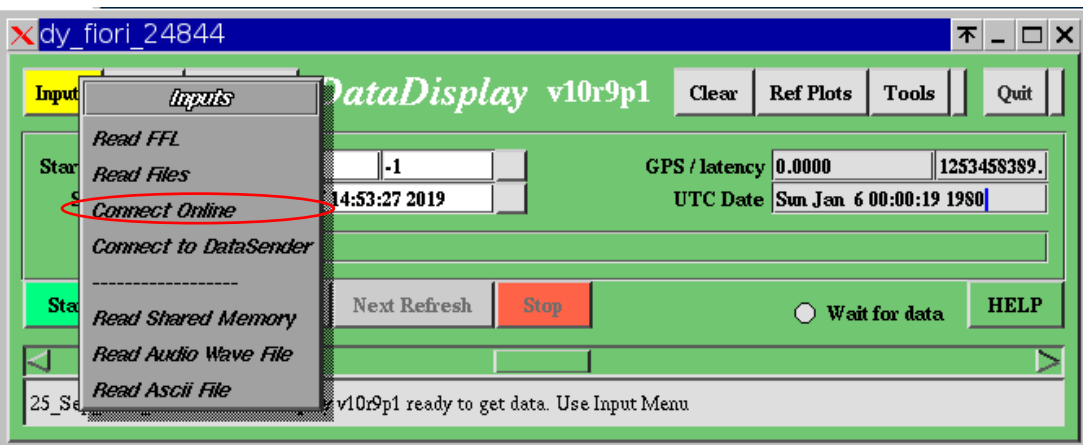
```
V1:DQ_BRMSMonHrec_BRMS_HREC_HOFT_FREQ_BAND_110_130_Hrec_hoft_16384Hz : 1.00Hz  
V1:DQ_BRMSMonHrec_BRMS_HREC_HOFT_FREQ_BAND_1350_1750_Hrec_hoft_16384Hz : 1.00Hz  
V1:DQ_BRMSMonHrec_BRMS_HREC_HOFT_FREQ_BAND_153_160_Hrec_hoft_16384Hz : 1.00Hz  
V1:DQ_BRMSMonHrec_BRMS_HREC_HOFT_FREQ_BAND_160_190_Hrec_hoft_16384Hz : 1.00Hz  
V1:DQ_BRMSMonHrec_BRMS_HREC_HOFT_FREQ_BAND_19_24_Hrec_hoft_16384Hz : 1.00Hz  
V1:DQ_BRMSMonHrec_BRMS_HREC_HOFT_FREQ_BAND_205_210_Hrec_hoft_16384Hz : 1.00Hz
```

```
V1:DQ_BRMSMon_BRMS_ANTHROPIC_SEIS_1Hz_5Hz_ENV_CEB_SEIS_N : 1.00Hz  
V1:DQ_BRMSMon_BRMS_ANTHROPIC_SEIS_1Hz_5Hz_ENV_CEB_SEIS_V : 1.00Hz  
V1:DQ_BRMSMon_BRMS_ANTHROPIC_SEIS_1Hz_5Hz_ENV_CEB_SEIS_W : 1.00Hz  
V1:DQ_BRMSMon_BRMS_ANTHROPIC_SEIS_1Hz_5Hz_ENV_EIB_SEIS_X : 1.00Hz  
V1:DQ_BRMSMon_BRMS_ANTHROPIC_SEIS_1Hz_5Hz_ENV_EIB_SEIS_Y : 1.00Hz  
V1:DQ_BRMSMon_BRMS_ANTHROPIC_SEIS_1Hz_5Hz_ENV_EIB_SEIS_Z : 1.00Hz
```

Very useful to look for time evolution of noise and correlate with slow trends

DATA streams: ONLINE

- Use dataDisplay as an Oscilloscope ...



END of part I

