Seismic measurements in Virgo WEB

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Outline

- What is newtonian noise?
- Experiment and data acquisition
- The data
- Analysis of the data
- Current status and next steps



Newtonian Noise Data Acquisition System System Overview



- Use existing sensors with digital output
- Sensors are connected by cables to avoid unnecessary electromagnetic interferences
- Array can be used for extended period of time so the powering is done over the cable
- All sensors are synchronized with respect to GPS recovered UTC
- The data and clock transmission use RS485 interface with 1Mbaud speed rate
- Array can contain up to 128 sensors

Newtonian Noise Data Acquisition: Sensors



- Every sensor contains one vertical inductive geophone with 4,5Hz natural frequency, analog front-end and ADC providing 24 bit samples with up to 1000 SPS rate
- The sensors are manufactured by Innoseis are provided by Nikhef
- They are designed to work outdoor, so had to be modified to serve our purposes



Newtonian Noise Data Acquisition System Sensor Interface



- Minimum interference to the working system is required
- Provides power supply, synchronization signal and data exchange interface over long distance cable
- Uses low cost CAT6 Cable and RJ45 connectors
- Sensor Interface provides galvanic isolation between the bus and the sensor, including data lines, 1PPS signal and power supply
- It is placed together with the sensor in the same enclosure

Newtonian Noise Data Acquisition System: Central Unit





- Power Supply- provides constant 12 V voltage with sufficient current to power all sensors, monitors and limits the current on every bus
- GPS Receiver recovers and distributes the 1PPS (Pulse Per Second) signal for synchronizing all sensors, 1 PPS signal is distributed differentially to all sensors
- Every bus contains separate microcontroller to receive the data from the sensors and to store them in SD memory card

Newtonian Noise Data Acquisition System: Array deployment

On January 18th and 19th, the array of 38 indoor and 9 outdoor sensors was deployed. Indoor sensors were placed on the floor using double side adhesive tape to improve the movement motion to the sensor. Outdoor sensors were partially dug into the ground to protect them from the wind caused noise picking.

Indoor sensors were connected with the CAT6 Ethernet cables in star - bus topology, with Central Unit in the middle and sensors organized with 6 separate buses. Indoor sensors were synchronized using centrally distributed 1PPS signal received by GPS receiver with external antenna, outdoor sensors used built-in GPS receivers to timestamp the data.





The data

- Available at http://foka.ise.pw.edu.pl/virgo
- Both as csv and hdf format
- Please email me tb@astrouw.edu.pl if you want to use the data

Spectra

Feb 5th, 4am



Feb 5th 2pm



Variability



Variability







Wiener filtering exercise

- Choose one sensor
- Use other sensors to reproduce its signal
- How good can this be done?
- How many sensors we need?









Sensors on platform, target 30

Coherence and its implications

Real part of coherence at 10Hz, 15Hz and 20 Hz





Real part of coherence at 10Hz, 15Hz and 20 Hz





Data: 18020500

All sensors in WEB









Data: 18020500

Sensor array on platform (13

















Data: 18020500



-3020 -3015 -3010 -3005 -3000 -2995 -2990 X [m]

Seismic wave velocity

• Use the coherence map

• Fit

$$Re(\gamma) = \cos(2\pi r/\lambda) \exp(-r/l)$$

- Use the wavelength and frequemcy to estimate speed
- Platform and floor separately
- Fits to 2 min pieces of data

On the platform





Attenuation length platform



Attenuation length floor



Velocity fits as a function of time



Attenuation fits as a function of time



Data analysis summary

- The WEB has quite complicated seismic field
- Wiener filter methods should work with ~10+ sensors
- Seismic speeds rise with freuquency from 0.2km/s @ 3Hz to 0.8km/s @ 30Hz
- Above ~10Hz waves attenuated on the scale similar to platform size

Next steps

- An array to be deployed @NEB before ER14
- May stay there for a long time
- Hope to have some data with running interferometer
- After O3: array in central building
- Permanent arrays