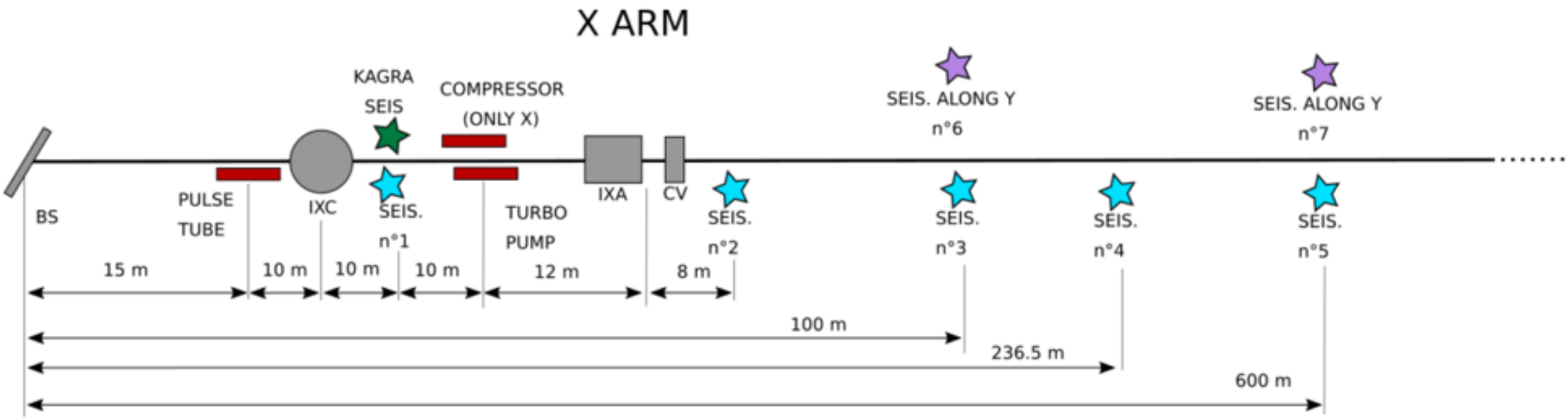
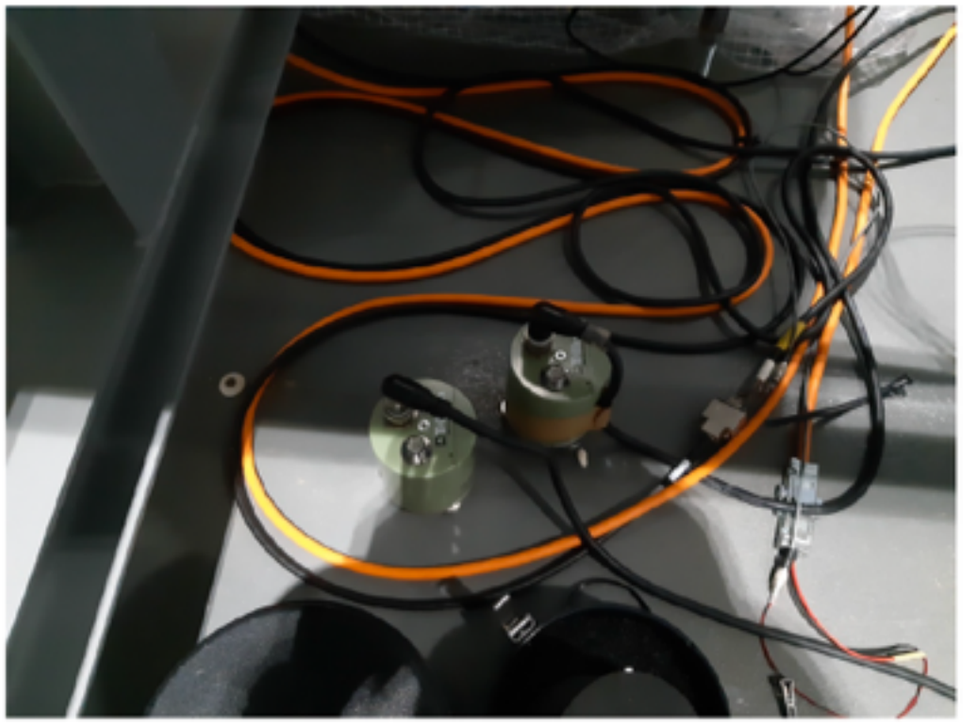
# NN from surface displacement

Main analyzer : Francesca Badaracco and Jan Harms
2020/12/22
Proxy report by Takaaki Yokozawa

# What we measured

- Around Nov. 2019 during commissioning of noise hunting



- Measured spectrum by seismometer at various position
- Velocity estimation in KAGRA

# What we measured

- Find the maximum wave vector for each frequency

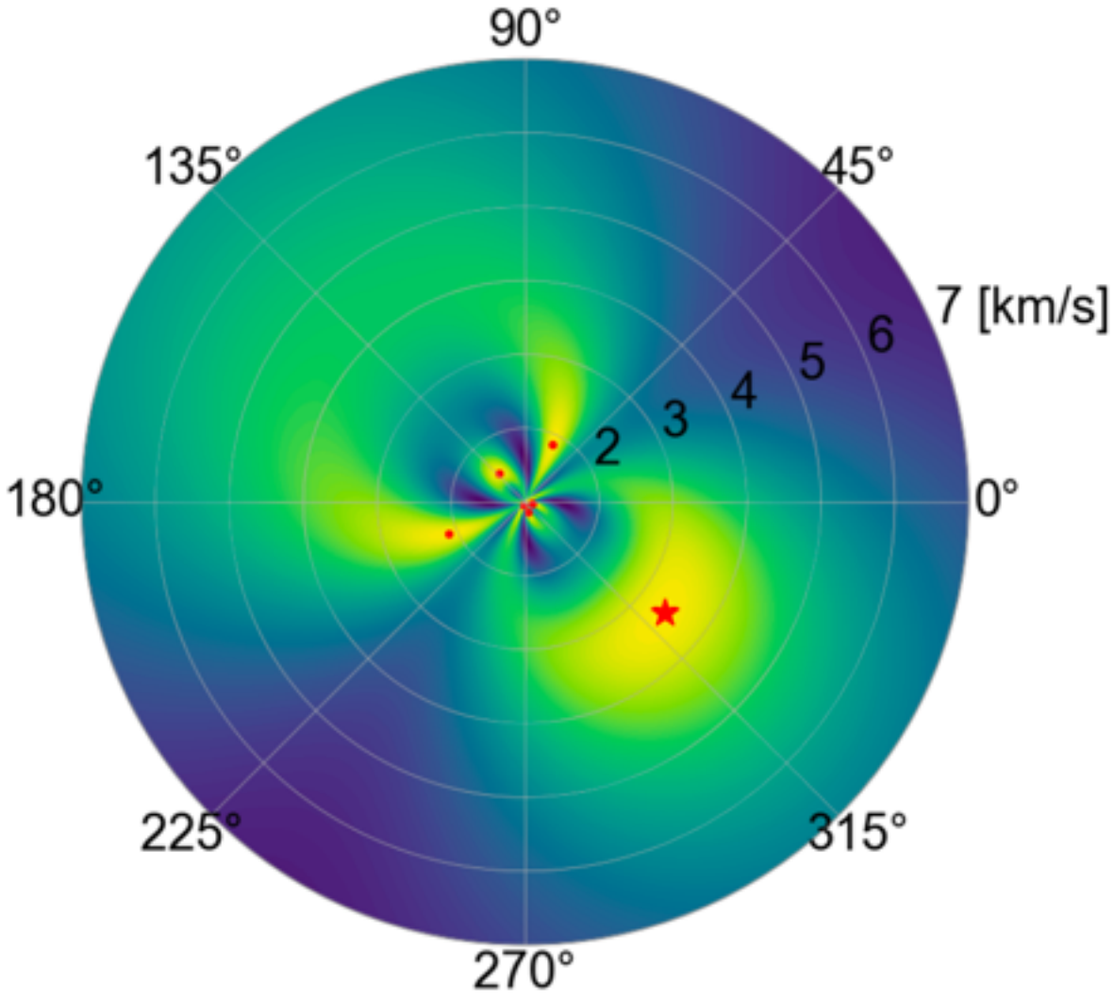
To extract the velocity values we used the Bartlett beamforming technique [19], the aim of which is finding what values of the wave vector, $\mathbf{k}$, maximise the output power of the array:

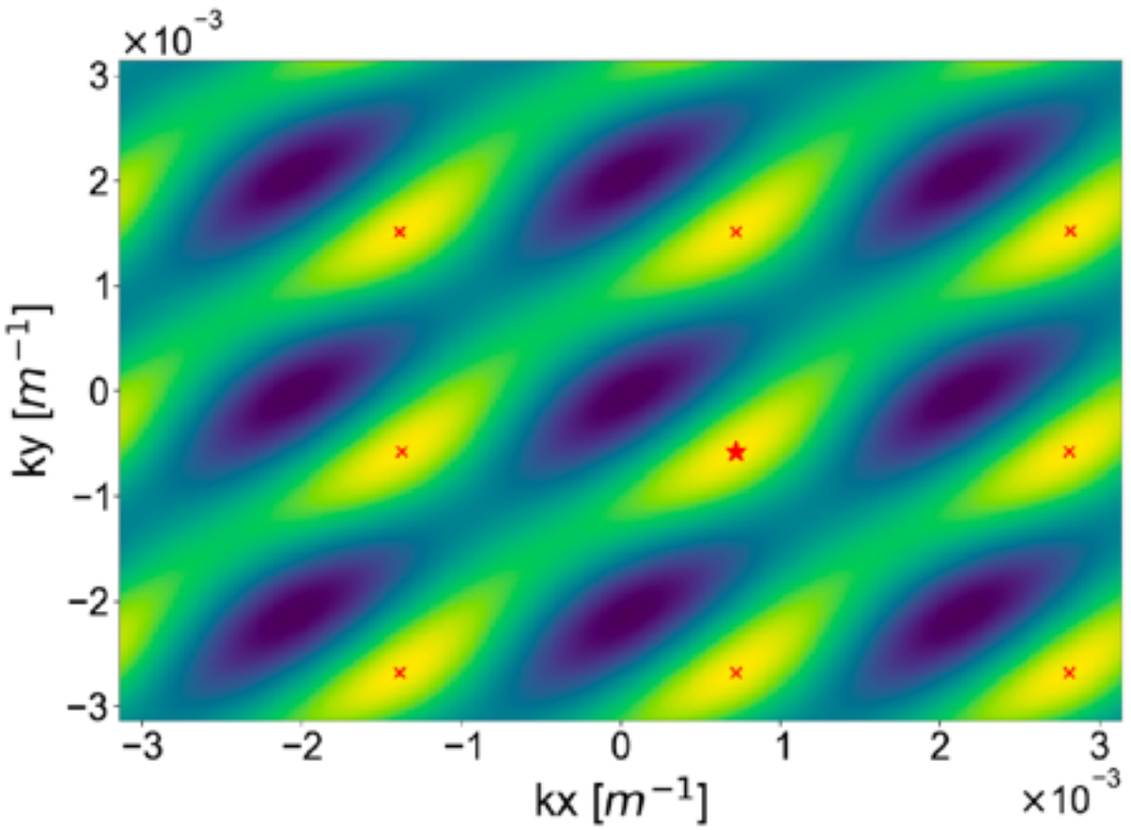
$$P_Y(\mathbf{k}) = \frac{\mathbf{a}^H(\mathbf{k})\hat{\mathbf{R}}\mathbf{a}(\mathbf{k})}{\mathbf{a}^H(\mathbf{k})\mathbf{a}(\mathbf{k})} \quad (1)$$

- R : Cross correlation, a : Noise source

# Velocity at KAGRA

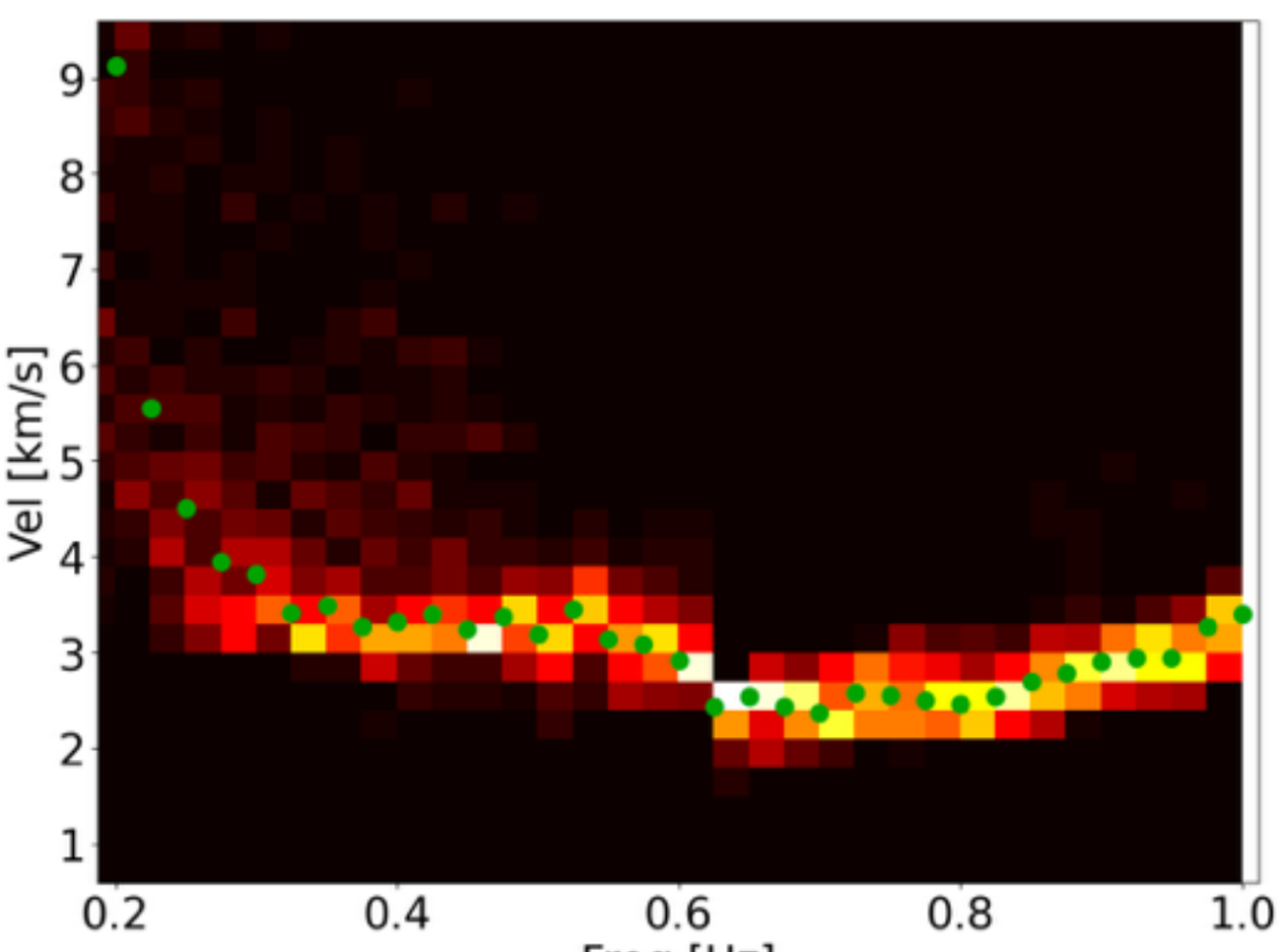
- But because of the number of the seismometer, many alias occurred
  - One is physical signal and the others are fake.
  - To find the physical signal, they tried to evaluate using ranking statistics for each frequency region
    - Sorry, we need more discussion about it, we will skip it



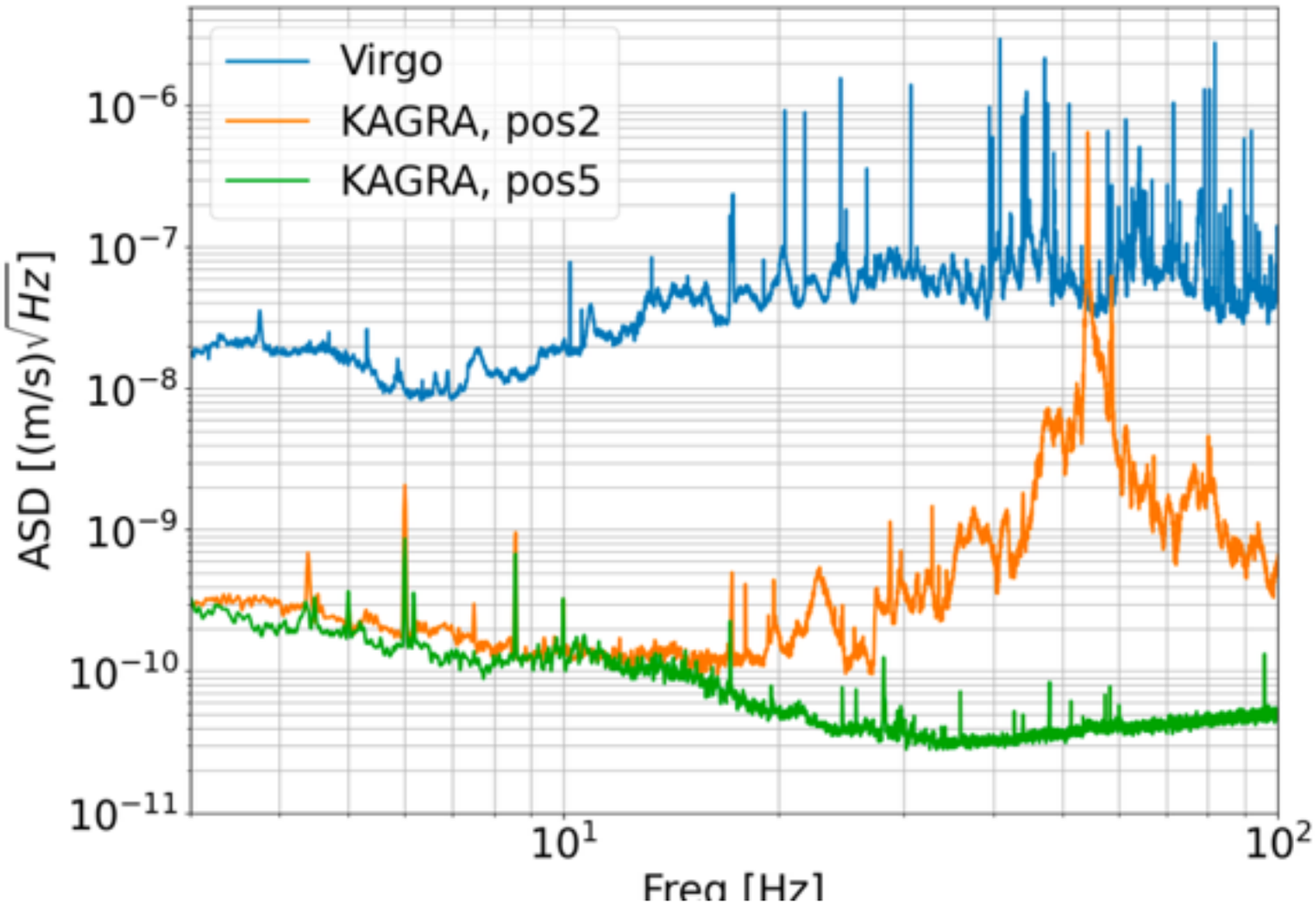



# Velocity at KAGRA

- They concluded
  - Detect the diminishing from 0.2 Hz to 0.6 Hz, that is agreement with other studies
  - the velocity of Rayleigh waves propagated from the surface in the mountain



# NN estimation in KAGRA




- The spectrum comparison between KAGRA and Virgo
  - KAGRA is much smaller
  - High frequency at pos2, KAGRA may come from sound from air compressor

# NN estimation in KAGRA

is the same as that in the other positions showed in Figure 13. To estimate the NN from body waves, we use the following model [12]:

$$S\left(\delta a^P;\omega\right) = \left(\frac{8}{3}\pi G\rho_0\right)^2 S\left(\xi^P;\omega\right) \tag{4}$$

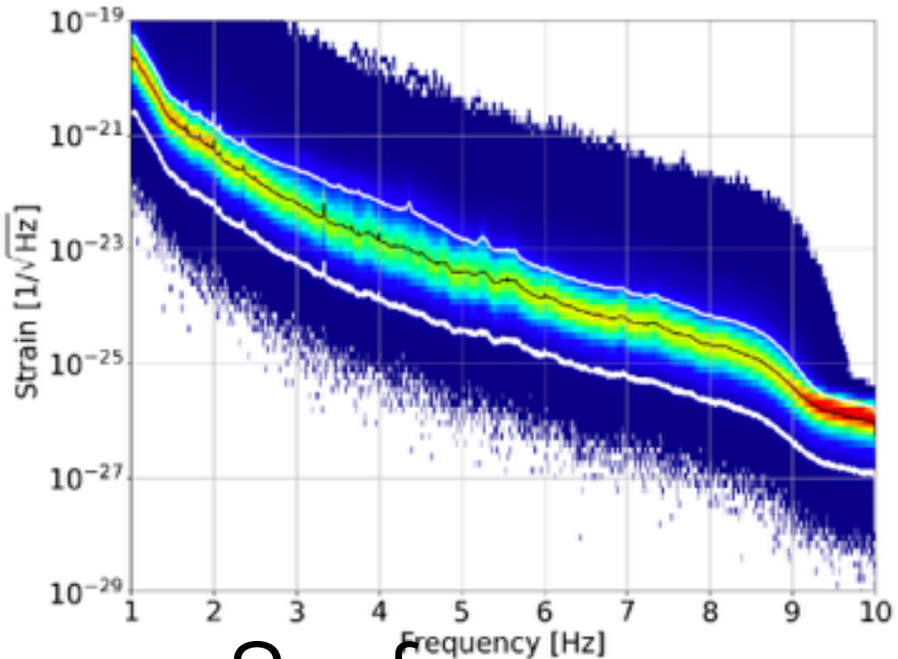
which is valid in an infinite and homogeneous space filled by a P wave seismic field. Here $S\left(\delta a^P;\omega\right)$ represents the PSD of the NN acceleration on the test mass provoked by the seismic displacement caused by a P wave with PSD: $S\left(\xi^P;\omega\right)$. Using only the

For completeness, we can also check the Rayleigh waves contribution to the NN by using [12]:

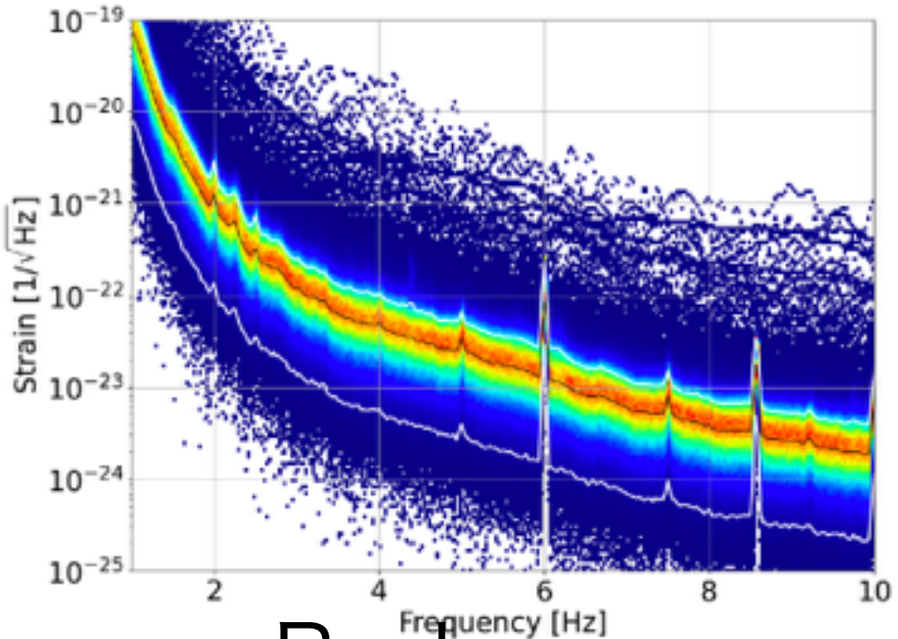
$$S^R\left(\delta a_x;\omega\right) = (2\pi G\rho_0\gamma(\nu)e^{-hk_\rho})^2\frac{1}{2}S\left(\xi;\omega\right) \tag{5}$$

where $G$ is the gravitational constant, $\gamma = 0.8$ accounts for the suppression of NN due to sub-surface (de)compression of soil by Rayleigh waves and it depends on ground properties. For the average density of the homogeneous medium we took that of the gneiss: $\rho = 3000\,\mathrm{kg/m^3}$, while $S(\xi;\omega)$ is the PSD of vertical surface displacement and $h = 200\,\mathrm{m}$ is the depth of the test mass with respect to the surface. Finally, for

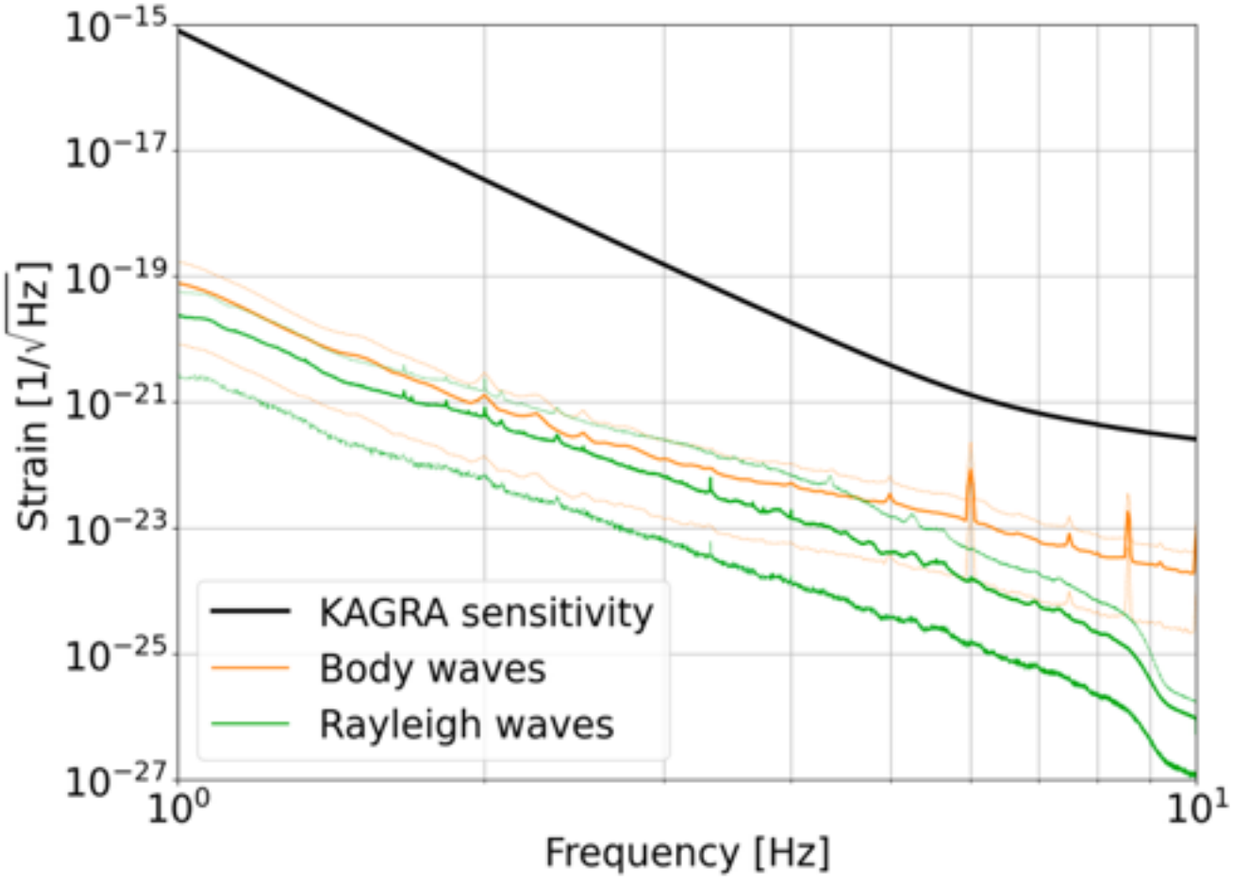
# NN estimation in KAGRA

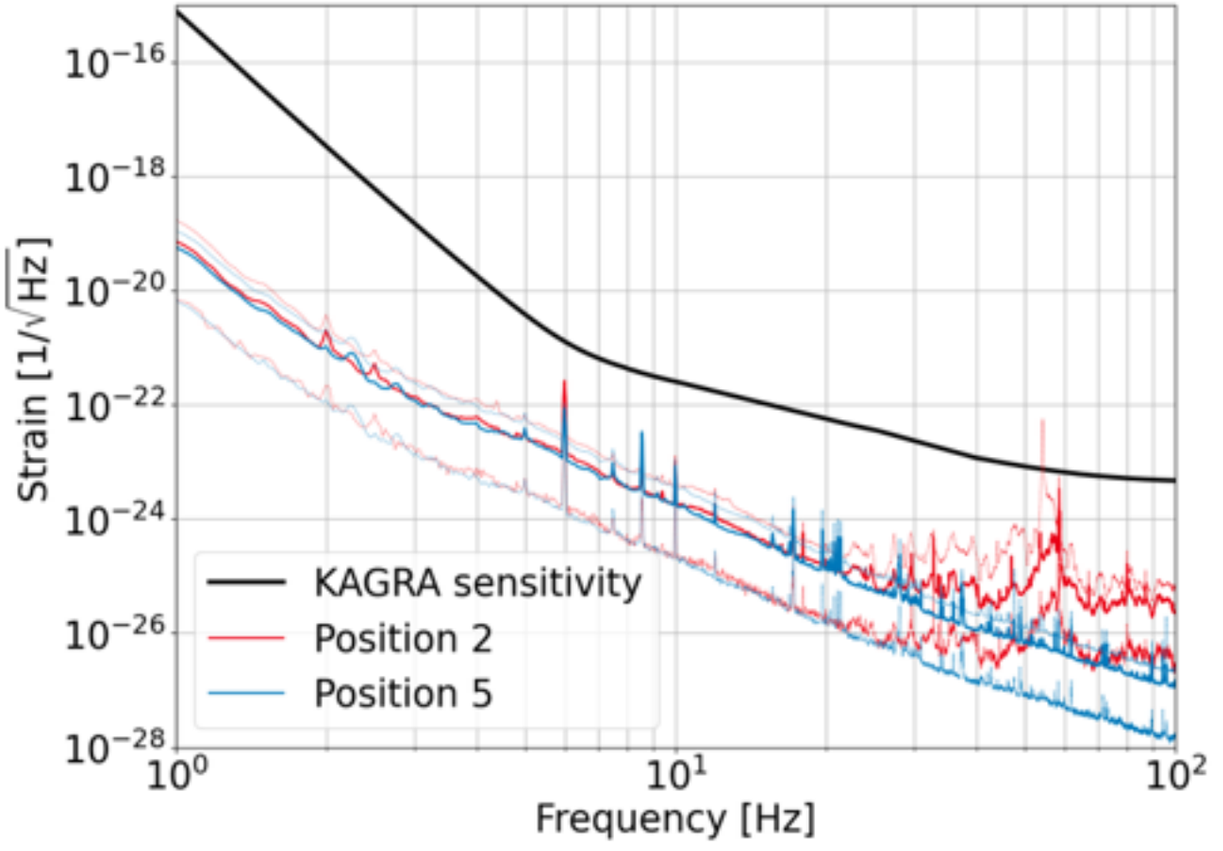



Surface wave




Body wave



# NN estimation in KAGRA