



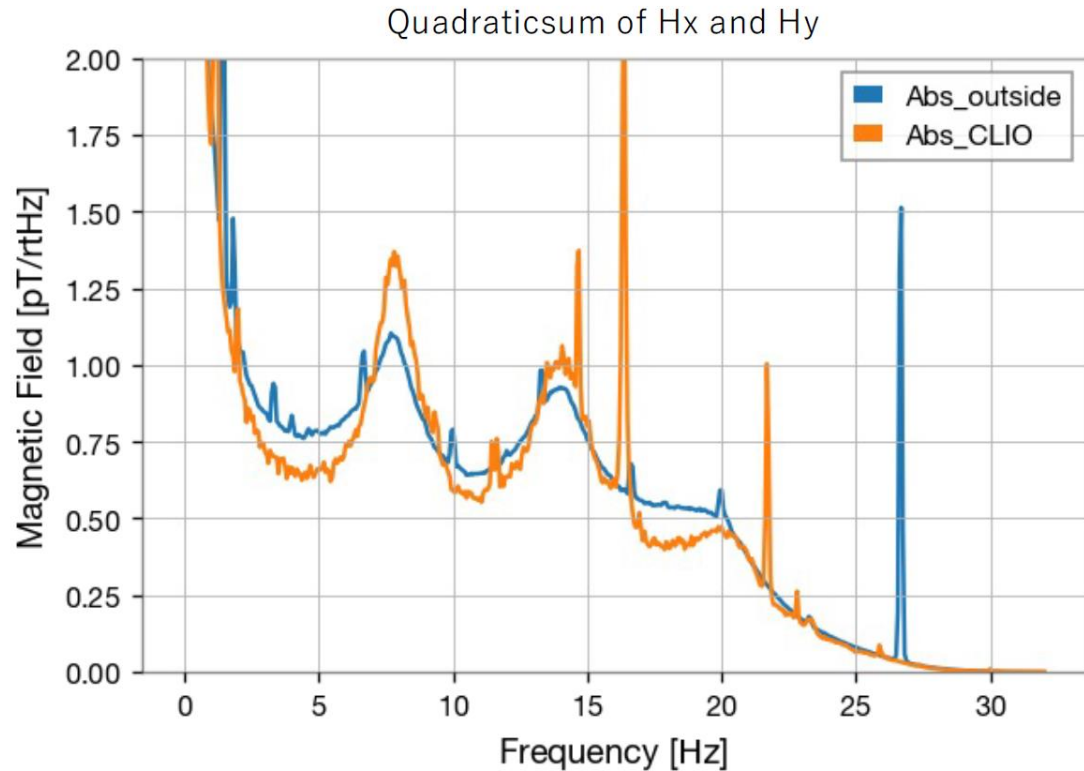
*Schumann resonances along  
Virgo vacuum tubes  
(preliminary)*

Federico Paoletti, Irene Fiori, Maria Tringali

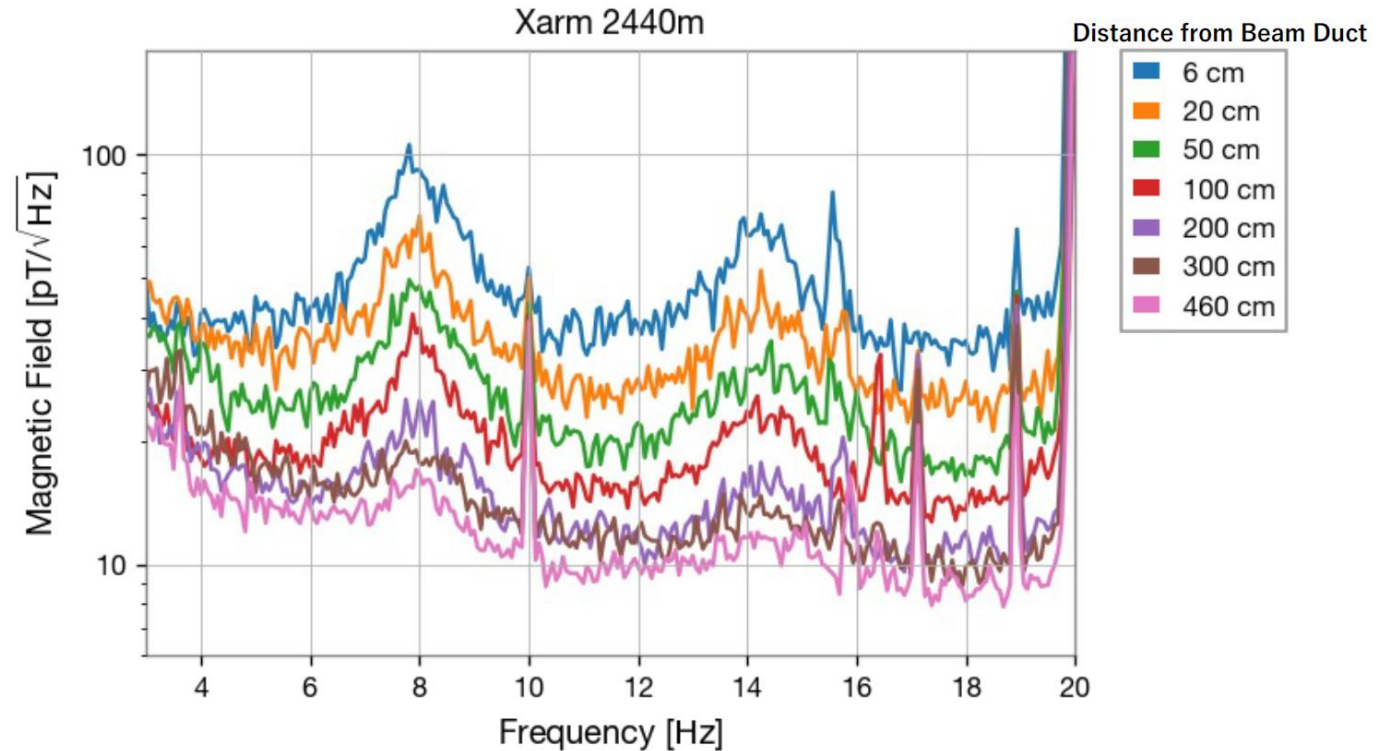
VK PEM meeting 27th Oct. 2022

# Motivations

- Recent KAGRA measurements (\*) shows an amplification of Schumann resonances if measured near the 3km arm vacuum tubes



KAGRA external (Blue) and along CLIO (Orange)

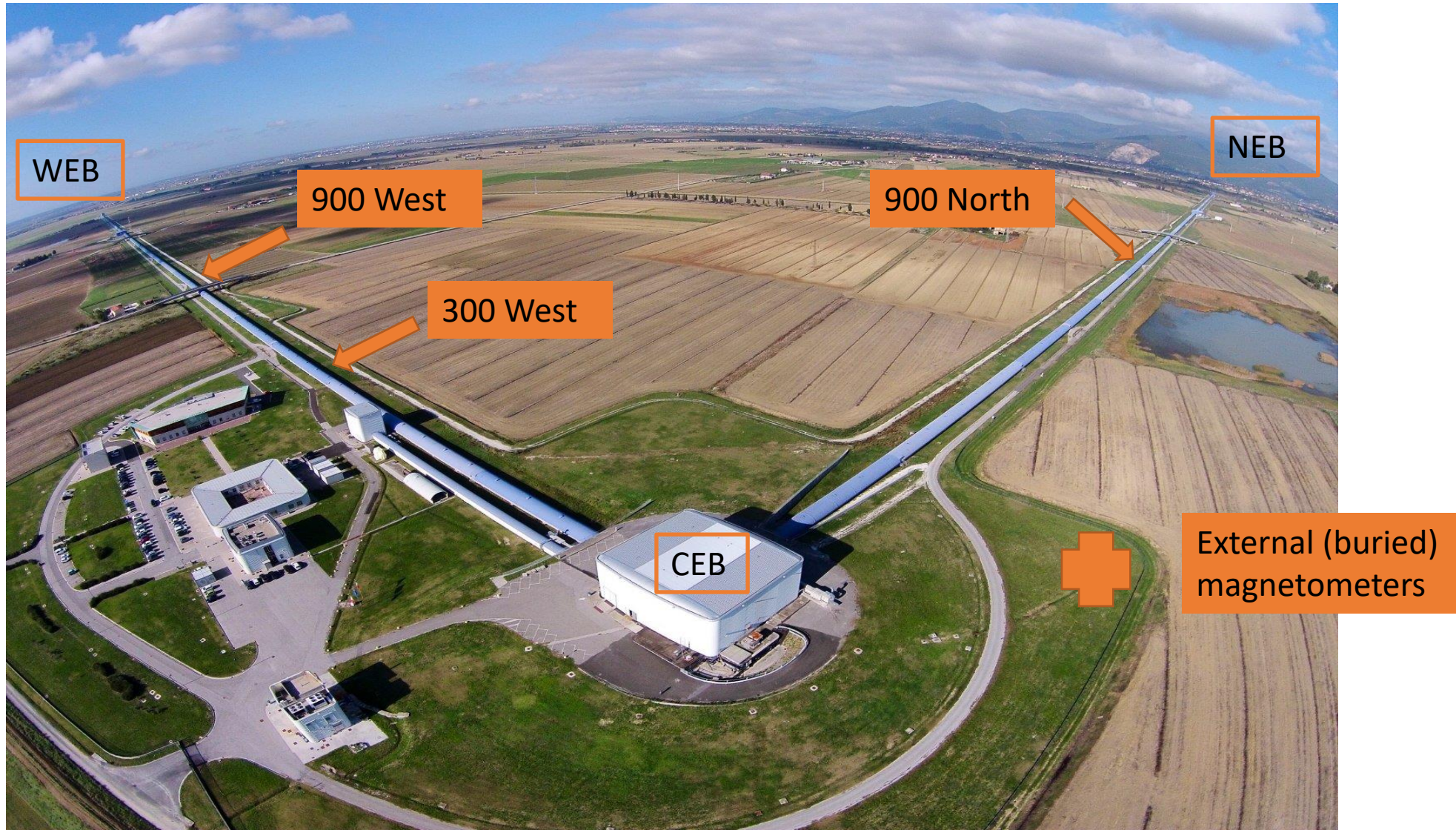


KAGRA vs distance from the vacuum tube

We report of preliminary measurements made in the proximity of Virgo arm vacuum tubes



# Location of measurements at Virgo

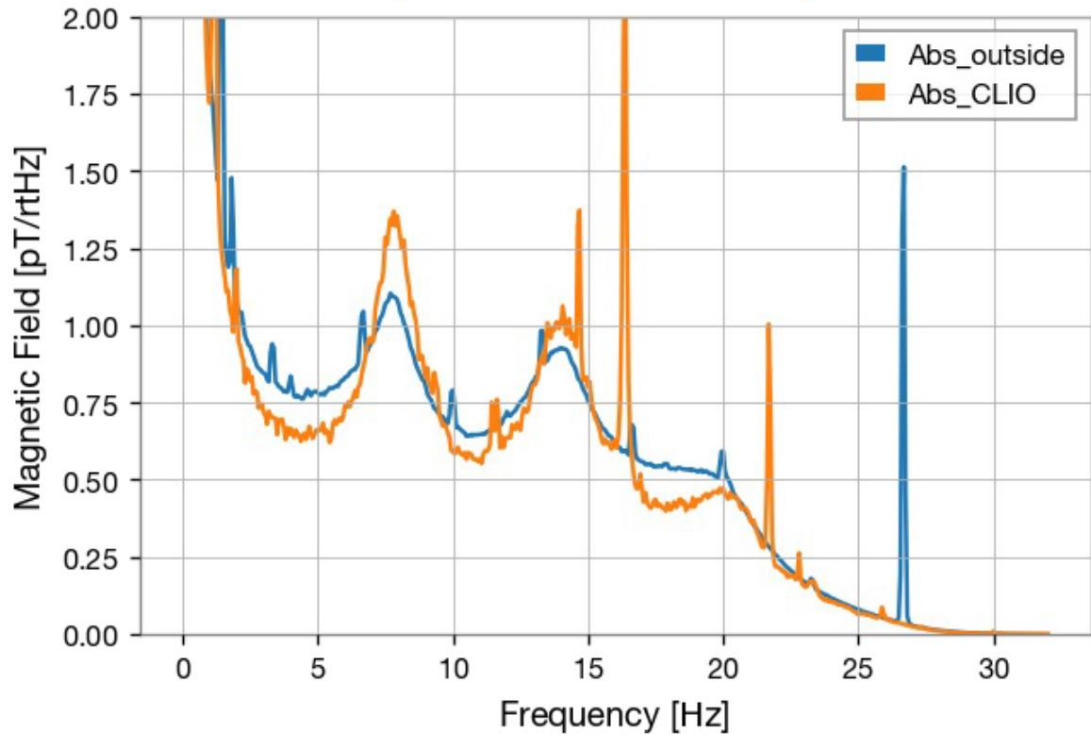




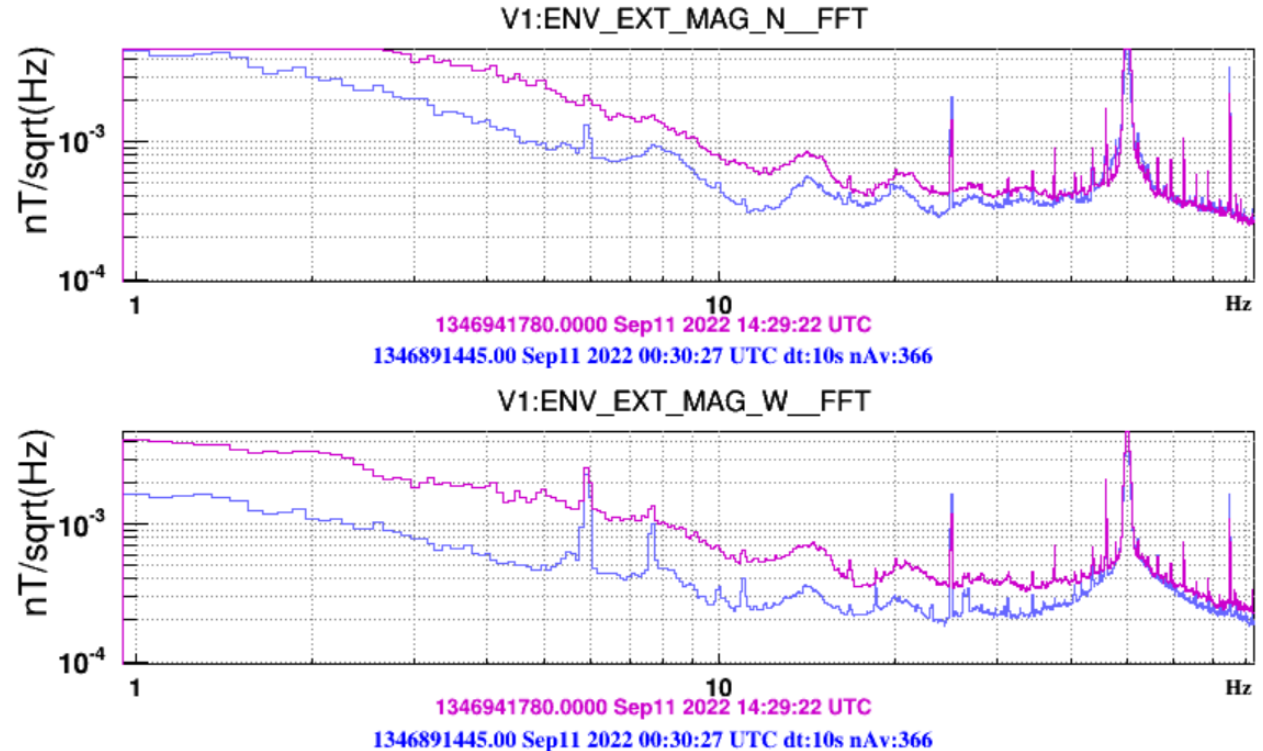
# Variability Day - Night

- Virgo Schumann levels have variability during the day
- No relevant difference (outside) between KAGRA and Virgo

Quadraticsom of Hx and Hy



KAGRA external (Blue) and along CLIO (Orange)



EXTERNAL Virgo magnetometers  
(Violet: in the afternoon Blue: during night)

We made all the measurements in the afternoon, when signals should be higher

# Probe and datalogger used



Triaxial magnetic sensor **Stefan Mayer Instruments model FL3-100**  
SIMILAR to Bartington model MAG-03MC100

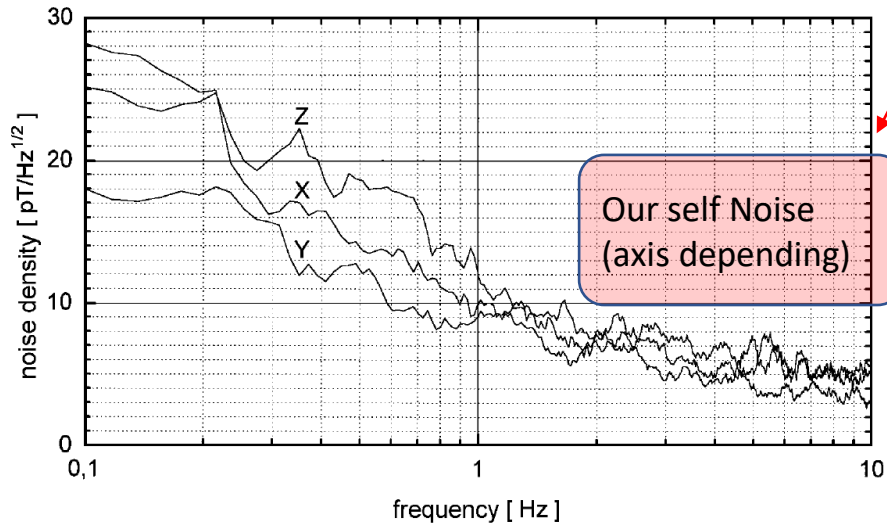
Orientation with the Virgo tube

we never had a noise lower than  $10\text{pT}/\sqrt{\text{Hz}}$  at 10 Hz

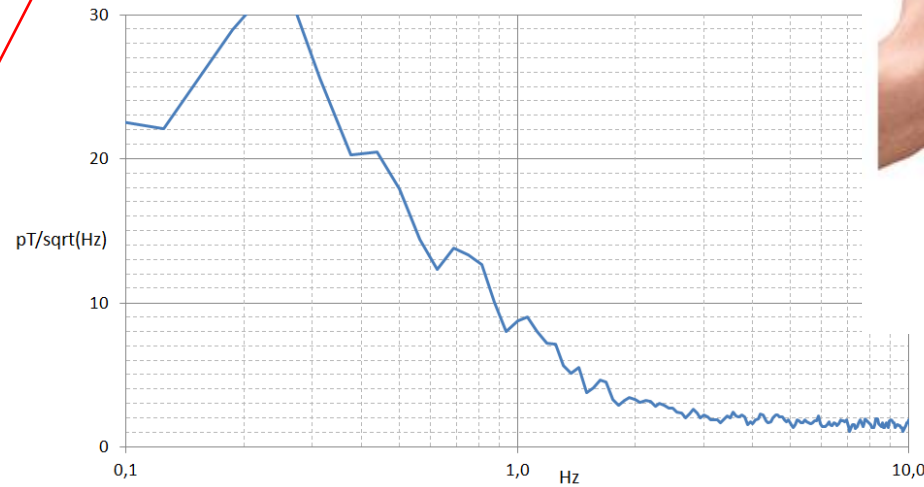
Data Logger is **Crystal Instruments CoCo 80**



Noise spectrum of fluxgate sensor FL3-100, serial no. 023

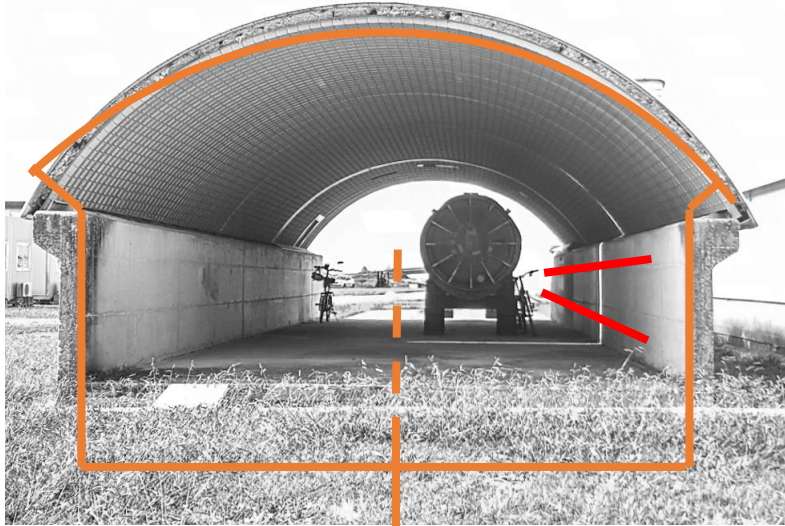


CoCo-80 datalogger intrinsic noise





# Layout of Virgo tubes



Every 15 or 30 meters along the tunnel there is a "ring" made with a copper strip, electrically connected to the **Iron metallic cover** and **to the ground** below the concrete (to avoid lightning problems)

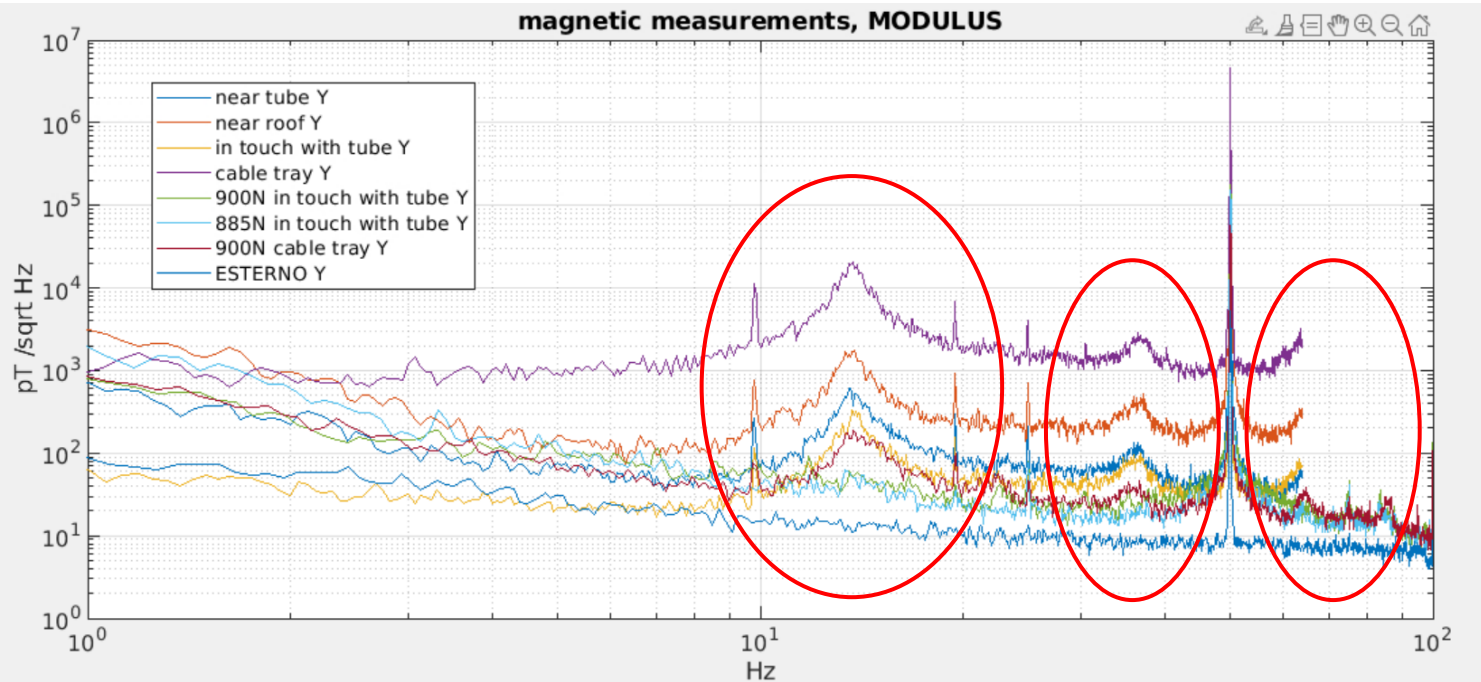
Another (underground) copper strip runs under the full length of the arms



The vacuum tube is grounded to all this "Farady cage style" structure **every 600m** (at each pumping station) (measured tube resistivity is  $50 \mu\Omega/\text{m}$  @  $150^\circ \text{C}$ )

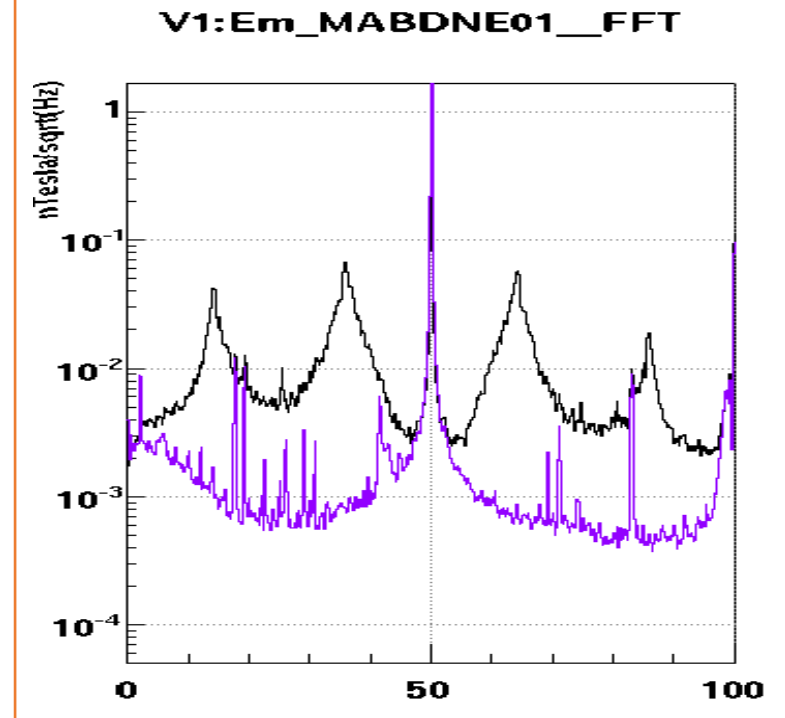
# 300m West

- We start measurements at 300m West position (probe few cm apart from the tube)



But we were heavily "masked" by the **noise** propagated along the Mains cable tray, generated by the UPS supplying the first vacuum station at 600m West (they are running from CEB for all the path)

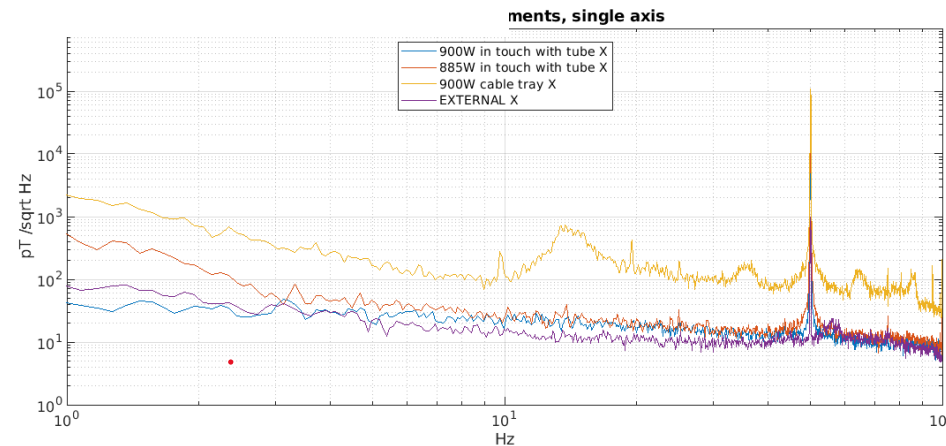
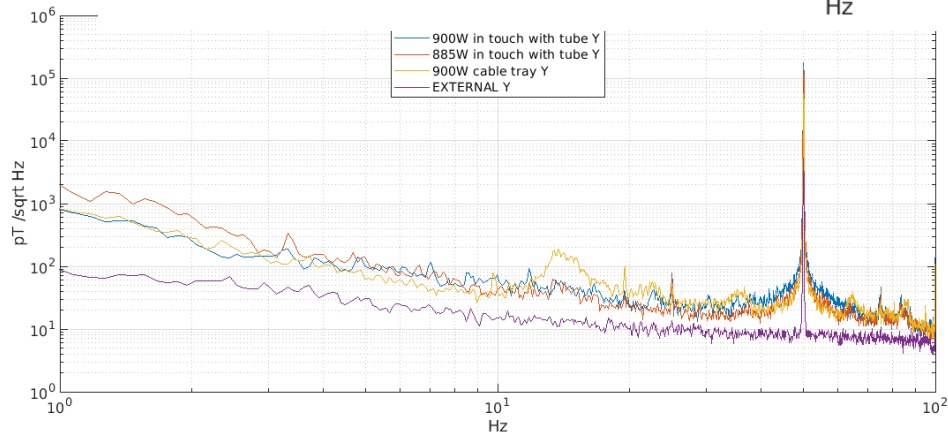
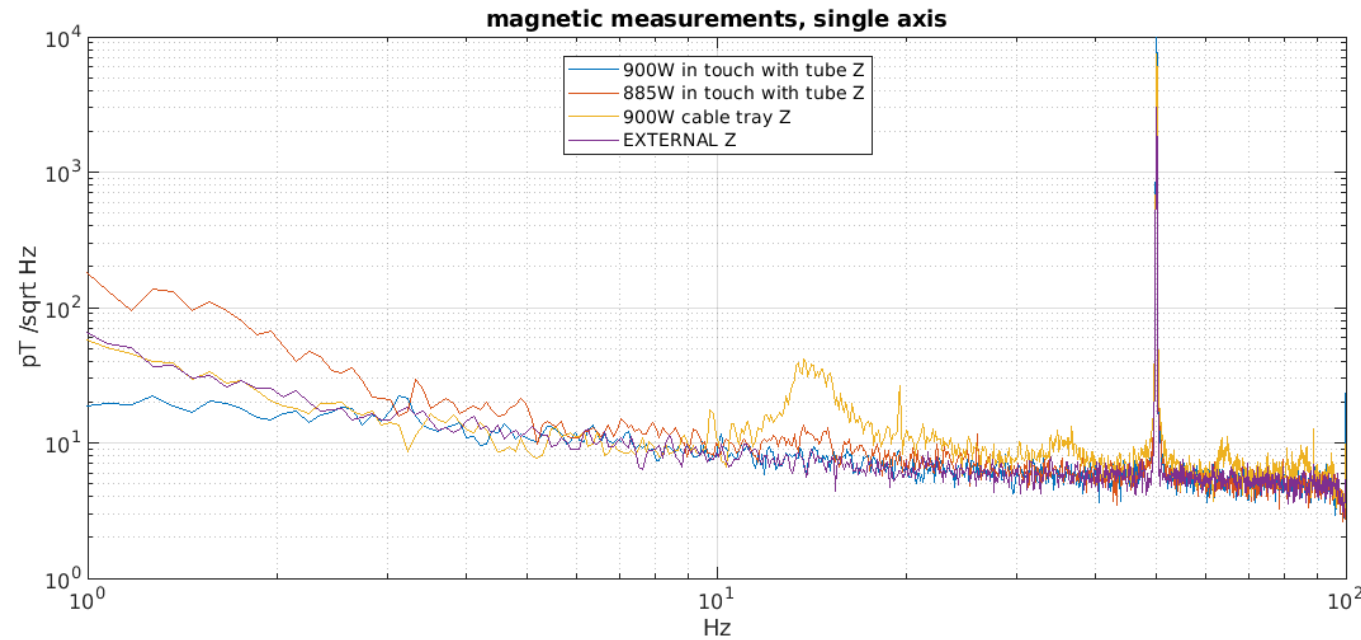
This is an "old" friend (discovered year 2012), see [elog 30827](#)





- We then moved to 900m West, where no Mains cables are running behind the vacuum tube

NO evidence of Schumann resonances down to the probe noise level even when touching the vacuum tube with the probe (the 14Hz bump is a leakage of the noisy Mains cables)



"EXTERNAL" is a reference measurement done in a quiet place, where external buried Virgo magnetometers are



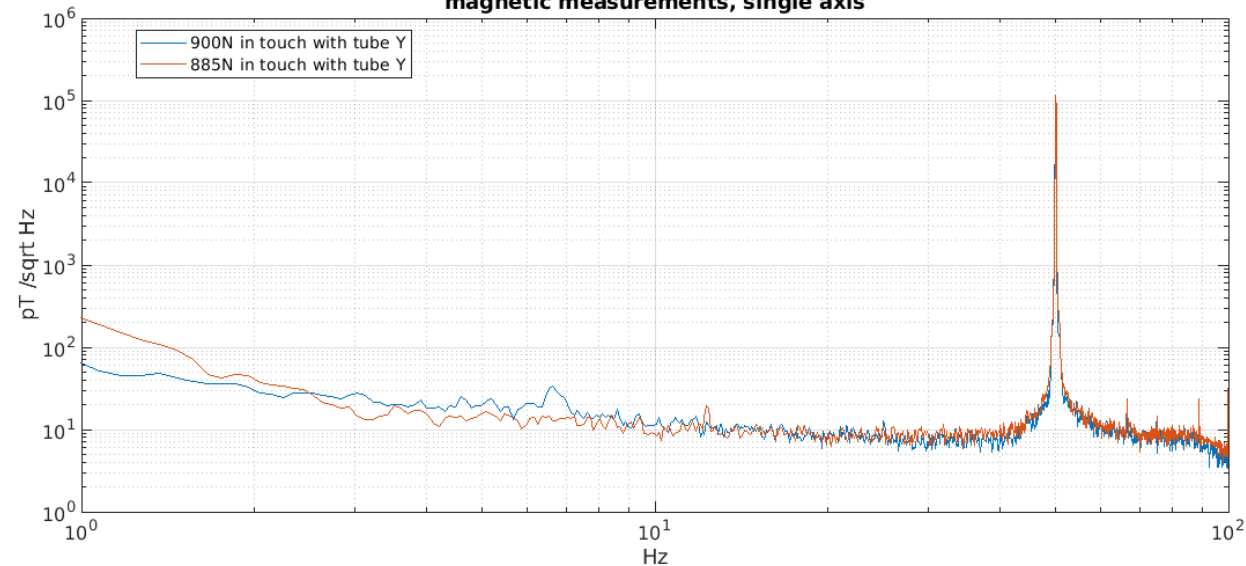
# 900m North

- Thinking about a dependence on the orientation of the Virgo arms, we repeated the measurement 900m North

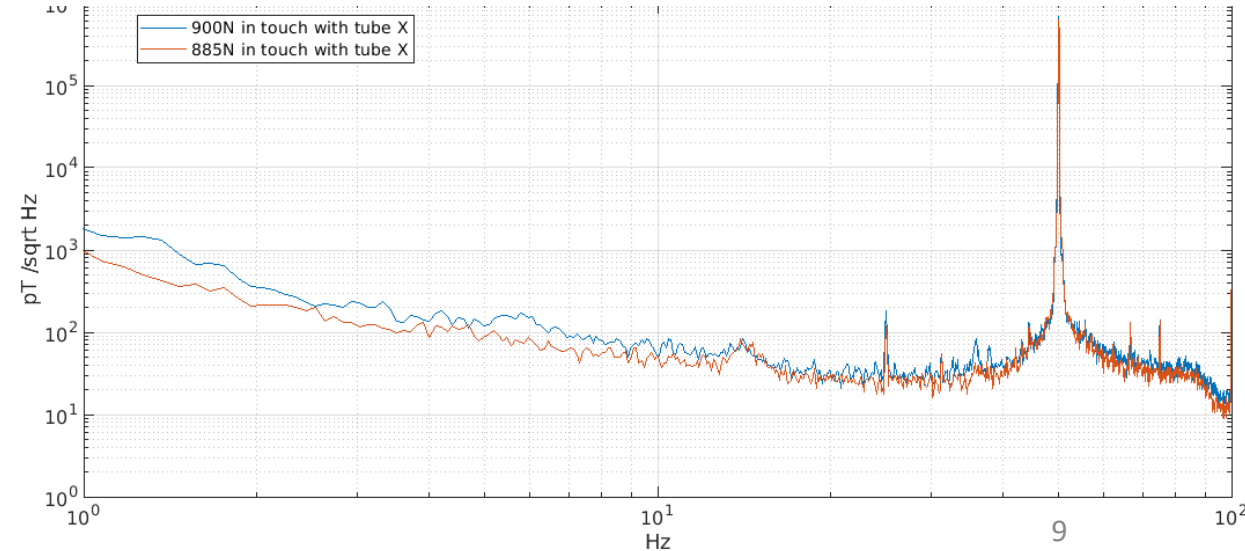
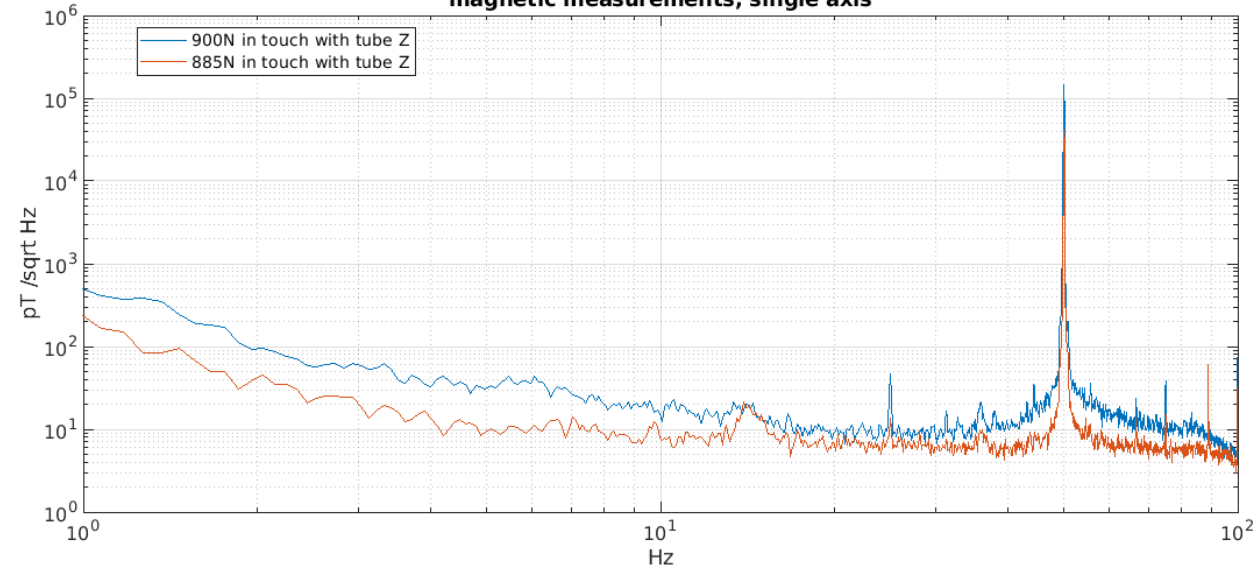
Again NO evidence of Schumann resonances

Even there we found what we think is the leakage of the Mains cables

magnetic measurements, single axis



magnetic measurements, single axis

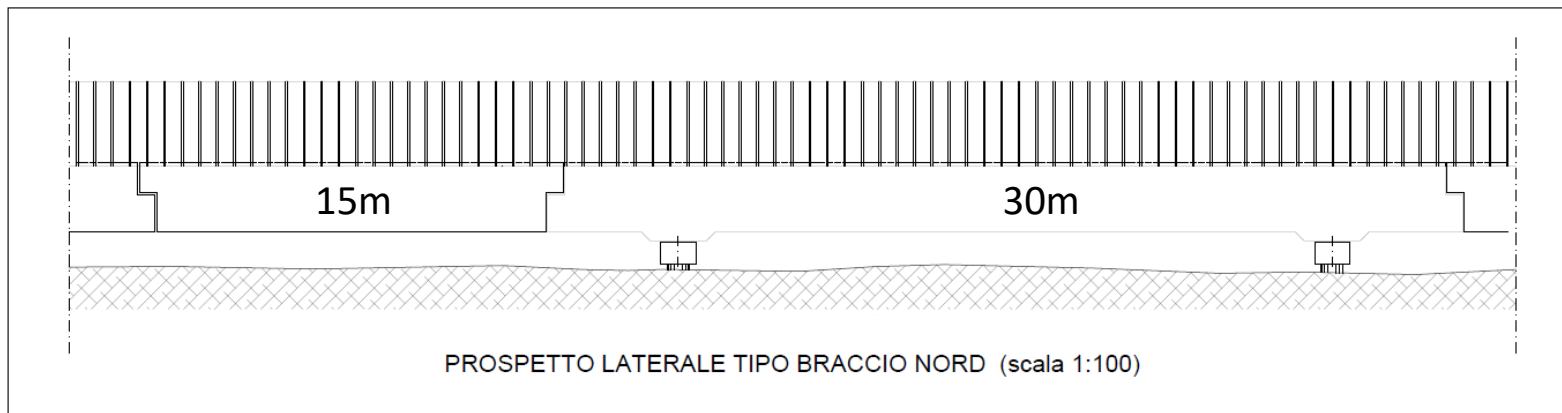
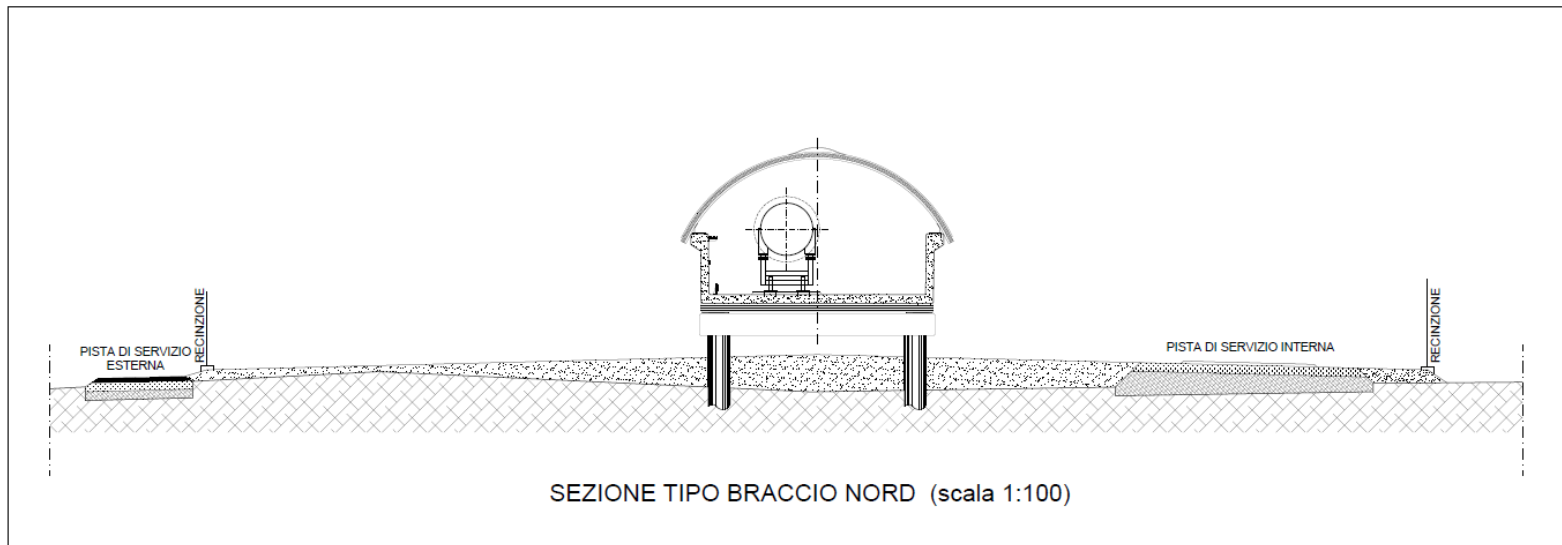


# Conclusion (preliminary)

---

- We made measurements of the magnetic noise level with a probe "in contact" over the 3km Virgo vacuum tubes
- We found no evidence of an increase in Schumann resonances down to the noise level of the probe (axis dependent: from 10 to 20 pT/sqrt(Hz) on the second 14Hz resonance)
- We should compare how the vacuum tubes (KAGRA and Virgo) are electrically connected to ground/earth (Could the amplification seen in KAGRA be created by a 3km long "coil"? And the absence of the latter in Virgo due to the 600m "virtual" grounded chunks of tube?)
- Consider also the tunnel cover (Iron, high permeability, connected to ground AND to the tube every 600m)





Thank you for your  
attention